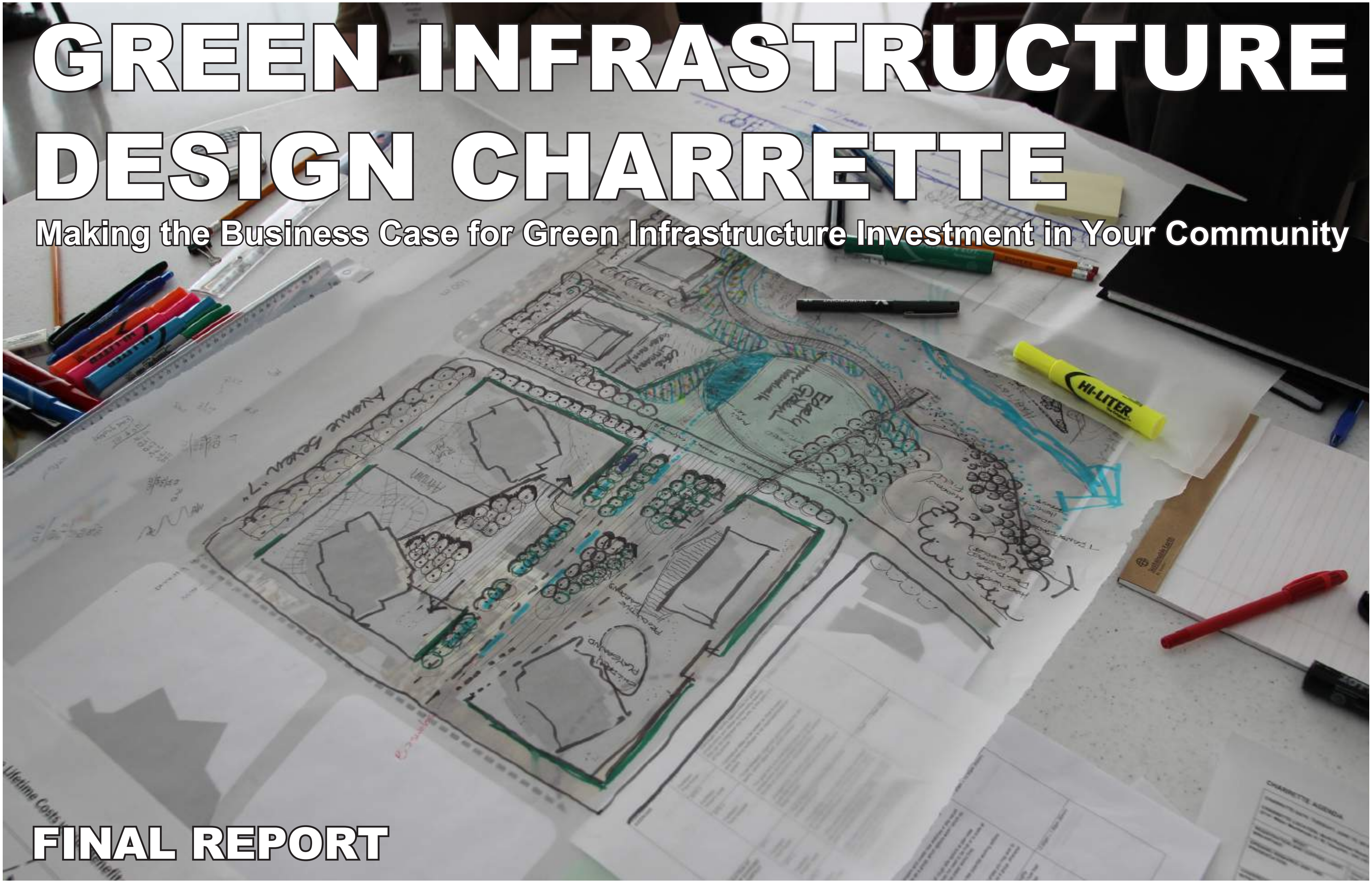
GREEN INFRASTRUCTURE DESIGN CHARRETTE

Making the Business Case for Green Infrastructure Investment in Your Community



FINAL REPORT

GREEN ROOFS FOR HEALTHY CITIES
www.greenroofs.org

In association with:

ONTARIO PARKS ASSOCIATION
Protecting Tomorrow Today

Green Infrastructure ONTARIO COALITION

HORTICULTURAL TRADES ASSOCIATION
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The Green Infrastructure Design Charrette Final Report is presented by Green Roofs for Healthy Cities with financial support from the George Cedric Metcalf Charitable Foundation in collaboration with the Ontario Parks Association (OPA), Green Infrastructure Ontario Coalition (GIO), Green Infrastructure Foundation (GIF) and the Landscape Ontario Horticultural Trades Association (LOHTA).

Green Roofs for Healthy Cities (GRHC) - North America Inc. is a not-for-profit industry association working to promote the green roof and wall industry throughout North America. It is managed under contract to the Cardinal Group Inc., the firm that originally established the organization, and run by an independent board. GRHC's mission is to develop and protect the market by increasing the awareness of the economic, social and environmental benefits of green roofs, green walls, and other forms of living architecture through education, advocacy, professional development and celebrations of excellence. GRHC organizes a national annual conference called *CitiesAlive* (www.citiesalive.org), a regional conference called *Grey to Green* (www.greytogreenconference.org), publishes the *Living Architecture Monitor* magazine (www.livingarchitecturemonitor.com), and provides a wide range of member services. (www.greenroofs.org)

The **Green Infrastructure Foundation** (GIF) was founded in 2007 to respond to the need for greater awareness and resources to promote green infrastructure in local communities. GIF is a tax-exempt, charitable organization affiliated with Green Roofs for Healthy Cities (GRHC), a membership based industry association and the leading entity for promoting the green roof and wall industry in the U.S. and Canada. The Green Infrastructure Foundation works with Green Roofs for Healthy Cities to deepen and broaden public awareness of the multiple benefits of green roofs, green walls and urban forests as part of the built environment.

Ontario Parks Association (OPA) is committed to civic beautification, the advancement, protection and conservation of parks, open space and the environment as we practice "Protecting Tomorrow Today" in the province of Ontario. OPA, a non-profit, charitable organization founded in 1936, offers services emphasizing quality and accessible education and professional development, networking, information, communication and advocacy for persons participating in the parks services. (www.ontarioparksassociation.ca)

Green Infrastructure Ontario Coalition (GIO) is an alliance of organizations that share a common vision for a healthy, green Ontario where the economic, social, environmental and health benefits of green infrastructure are fully realized. The coalition traces it roots back to a day-long meeting and visioning session held at Artscape Wychwood Barns in September 2009. Sixty people representing municipal and provincial governments, conservation authorities, the landscape trades and environmental organizations came together to discuss shared interests, concerns and ideas related to green infrastructure. (www.greeninfrastructureontario.org)

Started in 1973, the **Landscape Ontario Horticultural Trades Association** (LOHTA) is a vibrant association representing over 2,000 horticultural professionals. Their members include landscape, maintenance and snow management contractors, landscape designers, lawn care operators, garden centre owners, arborists, nursery growers, interior landscapers, and irrigation and landscape lighting contractors. (www.landscapeontario.com)

The goal of the **George Cedric Metcalf Charitable Foundation** is to enhance the effectiveness of people and organizations working together to help Canadians imagine and build a just, healthy, and creative society. (www.metcalffoundation.com)

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This report was prepared by Green Roofs for Healthy Cities (GRHC) with financial assistance provided by the George Cedric Metcalf Charitable Foundation.

EXECUTIVE SUMMARY

Introduction

Each year we spend billions of dollars of taxpayer money on traditional grey infrastructure, such as roads and sewers. Unquestionably, we need to make these investments. But what if we had a billion dollars, or say even one hundred million dollars to invest on living green infrastructure, such as trees, wetlands, green roofs and walls. What would our community look like? How would we invest the money to maximize the benefits? How many local jobs could we create? What, if any, return on public investment would there be in five, twenty-five or fifty years?

We need to be able to envision a greener and healthier future for our communities and understand the cost and benefits of implementation. The Green Infrastructure Design Charrette Pilot Project was designed to help community leaders examine how living green infrastructure investment might look on the streets, roofs and walls of their own communities and what the resulting public costs and benefits would be. Living green infrastructure is all too often taken for granted, or not even factored in to the development and redevelopment of communities.

The project consisted of the following elements:

- Organizing a one day Green Infrastructure Design Charrette with multi-disciplinary volunteers to redesign specific neighbourhoods in need, with fifteen generic types of green infrastructure as their tools.

- Development and customization of a Cost-Benefit Matrix of monetary values that can be tailored to each community and be used to generate aggregate level financial analysis of the proposed designs emerging from the charrette process.

- Producing a final report that combines images of the redesigned neighbourhoods with customized cost-benefit valuations in order to encourage policy and program changes that will lead to implementation.

The Green Infrastructure Design Charrette Final Report describes the methods and outcomes of four green infrastructure design charrettes that resulted in site redesigns in the cities of Vaughan, Oshawa, London, Toronto, Mississauga, and Brampton.

In each community, the project team worked with community leaders to select two or three sites for the Charrette and encouraged them to pick areas that needed green infrastructure investment, and that had diverse land uses. For each area of roughly four to ten city blocks, background information was provided by city officials on land use, types of buildings, utility corridors, characteristics of the community etc. These form the basis of opportunities and constraints.

Charrette participants from different disciplines (planning, landscape architecture, architecture, engineering) and community representatives were invited to participate in the one day event.

The charette participants were briefed on each site during a conference call before the charrette, as well as on the fifteen types of green infrastructure that could be applied. In some cases, the teams identified additional elements, such as solar panels to include in their work, although these were not included in the cost-benefit analysis. During the charrette, 8 to 12 participants per site were guided by a facilitator through a process of identifying major opportunities and constraints associated with the site, and working towards a final design product, to scale, on the maps and tracing paper provided. The discussions were lively, and many professionals left their ‘silos’ to engage in a healthy discussion about what was possible or not, and why.

For each type of green infrastructure utilized, the teams were required to measure, using maps to scale, the total area in square metres of each type of green infrastructure. Some teams utilized all fifteen types of green infrastructure, while others chose fewer, depending on site constraints. The area of each type of green infrastructure selected was then used to estimate the resulting public costs and benefits from values customized for the local community in the Cost-Benefit Matrix. Each group was provided with the opportunity of presenting their work, details of which are included in this report, along with a summary of the major public costs and benefits derived from each site redesign.

EXECUTIVE SUMMARY

Before and after rendering of a streetscape redesign using green infrastructure in Windsor. Credit: Grace Yang.

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

- Green Roofs (Extensive and Intensive)
- Green Façades (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)

High, Medium and Low monetary values (financial values per square metre) for 10 types of benefits that result from the fifteen generic types of green infrastructure were derived through a combination of an extensive literature review, an expert peer review and consultation with local community leaders. The Cost-Benefit Matrix is focused on public benefits at an aggregate scale. The return on investment (ROI) provided by this analysis does not incorporate discount rates on capital, or the effects of inflation. Due to the difficulties associated with deriving monetary values for many of the benefits of green infrastructure, the cost-benefit analysis tends towards being conservative in its nature. The following costs and benefits are included in the Cost-Benefit 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

Not every type of green infrastructure provides the same range of benefits, and charrette participants were asked to identify when green infrastructure provided additional urban food production benefits. Each charrette team produced a written description of each site, the ideas they developed, the square metres of each type of green infrastructure incorporated in the redesign, as well as a variety of drawings and sketches to illustrate their work. This data forms the body of this report. Information on total area of each form of green infrastructure was analyzed with customized values in a Cost-Benefit Matrix to provide aggregate scale cost-benefit data for each site redesign.

The customized Cost-Benefit Matrix provides aggregate cost-benefit analysis for each site. In the case of Vaughan, data from all three sites is aggregated together. The 50 year return on public investment is calculated by adding all of the costs over this period and subtracting all of the benefits.

Vaughan Findings
For the purposes of the cost-benefit analysis the City of Vaughan requested that all three separate site redesigns be evaluated as a whole. The amalgamated area is referred to as the Edgeley Pond site.

The site plans work within the context of the Vaughan Metropolitan Centre (VMC) Secondary Plan as well as the draft VMC Streetscape and Open Space Plan. The plans aim to help ensure that the revitalized Black Creek becomes an integral part of the green public infrastructure within the Vaughan Metropolitan Centre in its design concept and through the provision of design guidelines. The plans incorporate the idea of opening up spaces with a view to the pond and softening building edges.

The Edgeley Pond site redesign incorporated 84,212 m^2 of new green infrastructure into the area, as well as 500 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at $7,605,656 with an annual maintenance requirement of $957,924. The 50 year public return on investment is an estimated $17,256,197. The investment in significant green infrastructure should also improve significantly the saleability of residential and commercial spaces, and their property value. Direct, indirect, and induced job-creation values for the Edgeley Pond site total 215.76 job-years after year one and 1,126.67 job-years after fifty years.

Oshawa Findings
The Oshawa design charrette incorporated three sites for redesign. Site 1 - Simcoe Street South ‘A’ featured 33,495 m^2 of new green infrastructure into the area, as well as 5,858 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at $6,294,530 with an annual maintenance requirement of $891,107. The 50 year public return on investment is an estimated $20,320,621. Direct, indirect, and induced job-creation values for Site 1 total 164.13 job-years after year one and 958.17 job-years after fifty years.

Site 2 - Simcoe Street South ‘B’ incorporated 78,743 m^2 of new green infrastructure into the area, as well as 7,058 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at $6,833,073 with an annual maintenance requirement of $508,877. The 50 year public return on investment is an estimated $40,346,651. Direct, indirect, and induced job-creation values for Site 2 total 136.03 job-years after year one and 597.68 job-years after fifty years.

Site 3 - Wentworth Cedar incorporated 76,043 m^2 of new green infrastructure into the area, as well as 5,200 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at $8,108,726 with an annual maintenance requirement of $897,421. The 50 year public return on investment is an estimated $37,447,260. Direct, indirect, and induced job-creation values for Site 3 total 197.19 job-years after year one and 997.73 job-years after fifty years.

London Findings
The London design charrette incorporated two sites for redesign. Site 1 - Central Downtown London featured 109,115 m^2 of new green infrastructure into the area, as well as 5,355 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at $20,523,645 with an annual maintenance requirement of $2,367,205. The 50 year public return on investment is an estimated $48,636,030. Direct, indirect, and induced job-creation values for Site 1 total 490.12 job-years after year one and 2,596.12 job-years after fifty years.

Site 2 - Downtown London Gateway incorporated 81,605 m^2 of new green infrastructure into the area, as well as 13,253 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at

$8,501,928 with an annual maintenance requirement of $324,435. The 50 year public return on investment is an estimated $53,214,946. Direct, indirect, and induced job-creation values for Site 2 total 154.08 job-years after year one and 447.45 job-years after fifty years.

Grey to Green Conference - Toronto Findings

The *Grey to Green* conference was host to the final design charrette. We invited three municipalities to submit one site each for redesign. Toronto submitted Site 1 - Carlaw + Dundas. This site incorporated 100,069 m^2 of new green infrastructure into the area, as well as 3,500 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at $18,647,957 with an annual maintenance requirement of $556,355. The 50 year public return on investment is an estimated $31,920,761. Direct, indirect, and induced job-creation values for the Toronto site total 348.88 job-years after year one and 1,362.94 job-years after fifty years.

Grey to Green Conference - Mississauga Findings

Mississauga submitted Site 2 - Rathburn District. This site incorporated 139,000 m^2 of new green infrastructure into the area, as well as 4,000 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at $12,917,650 with an annual maintenance requirement of $1,125,448. The 50 year public return on investment is an estimated $44,489,325. Direct, indirect, and induced job-creation values for the Mississauga site total 230.49 job-years after year one and 722.76 job-years after fifty years.

Grey to Green Conference - Brampton Findings

Brampton submitted Site 3 - Etobicoke Creek Revitalization. This site incorporated 53,536 m^2 of new green infrastructure into the area, as well as 2,250 m^2 of agricultural focused green infrastructure uses. The capital investment is estimated at $3,550,467 with an annual maintenance requirement of $242,731. The 50 year public return on investment is an estimated $20,106,082. Direct, indirect, and induced job-creation values for the Brampton site total 66.02 job-years after year one and 290.97 job-years after fifty years.

Conclusions and Next Steps

Current policy, planning, finance and development practices grossly undervalue the contribution that green infrastructure makes in our communities. This results in suboptimal infrastructure investment, unnecessary expenditures on grey infrastructure, and communities that are far less healthy and sustainable than they would be otherwise.

This pilot project has made some important progress to begin a discussion at the local, neighbourhood level about a different development and redevelopment path. This path recognizes and values the contribution that green infrastructure can make to address stormwater and urban heat island challenges, provide local employment and improve the health and sustainability of local communities. Hopefully this will contribute to the larger discussion about how best to allocate public funds in order to maximize our return on investment and prepare us for the negative impacts of climate change.

We plan to continue to refine the data in the Cost-Benefit Matrix, with additional monetization of benefits and more detailed financial analysis. The project team also plans to work with the communities profiled in this report to move some of the proposed projects towards implementation. Efforts are also underway to engage additional communities throughout Ontario and around North America in this exercise of imagining what might be possible if we redesigned our communities with green infrastructure in mind.

Before and after rendering of neighbourhood green infrastructure redesign in Philadelphia. Credit: City of Philadelphia.

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Each year we spend billions of dollars of taxpayer money on traditional grey infrastructure, such as roads and sewers. Unquestionably, we need to make these investments. But what if we had a billion dollars, or say even one hundred million dollars to invest on living green infrastructure, such as trees, wetlands, green roofs and walls. What would our community look like? How would we invest the money to maximize the benefits? How many local jobs could we create? What, if any, return on public investment would there be in five, twenty-five or fifty years? The more than 150,000 professionals who already work to grow, manufacture, design, install and maintain green infrastructure throughout Ontario don't tend to think in these large scale terms. They are often focused on small projects, and concerned with maximizing aesthetics. So what would happen in our communities if we started to think big, think in grey infrastructure terms?

They may or may not understand that living green infrastructure provides a wide array of public services in addition to its traditional aesthetic benefits. These services are rarely quantified and seldom included in policies around infrastructure expenditures. In the United States, many jurisdictions have begun to embrace green infrastructure as a means of meeting their stormwater quality and quantity goals. Yet in Ontario we need, now more than ever, to be able to envision a greener and healthier future for our communities. We need to better understand the costs and benefits of widespread green infrastructure implementation to complement our grey infrastructure investments, and so that we can allocate scarce public resources for the best possible public return on investment.

The goals of the Green Infrastructure Design Charrette Pilot Project are to explore the answers to these big picture questions in several different communities by engaging municipal leaders, engineers, planners, designers and community activists. We challenged participants to think about the best place in their community, and describe its attributes. We then asked participants to think about the possibilities of significant green infrastructure investment in their community. We engaged in a discussion about what is important to them, and what the potential public benefits from this type of investment might be.

The Green Infrastructure Design Charrette Pilot Project was designed to help community leaders to examine how living green infrastructure investment might work on the streets, roofs and walls of their own communities. Living green infrastructure is all too often taken for granted, or not even factored in to the development and redevelopment of communities.

The project consisted of the following elements:

- Organizing a one day Green Infrastructure Design Charrette with multi-disciplinary volunteers to redesign specific neighbourhoods in need, with fifteen generic types of green infrastructure as their tools.

- Development and customization of a Cost-Benefit Matrix of monetary values that can be tailored to each community and to be used to generate aggregate level financial analysis of the proposed designs emerging from the charrette process.

- Producing a final report that combines images of the redesigned neighbourhoods with customized cost-benefit valuations in order to encourage policy and program changes that will lead to implementation.

This report contains a description of the Green Infrastructure Design Charrette Pilot Project and the outcomes of the four green infrastructure design charrettes that resulted in site redesigns for the cities of Vaughan, Oshawa, London, Toronto, Mississauga, and Brampton.

In each city, we worked with community leaders to select two or three sites for the charrette and encouraged them to pick areas that needed more green infrastructure, and that had diverse land uses. For each area of roughly four to ten city blocks background information was provided by city officials on land use, types of buildings, utility corridors, characteristics of the community etc. This information forms the basis of opportunities and constraints that define what is needed and what is possible for each site.

Design participants from different disciplines (planning, landscape architecture, architecture, engineering) and community representatives were invited to participate in the one day event.

The charette participants were briefed on each site during a conference call before the charrette, as well as on the fifteen types of green infrastructure that could be applied. In some cases, the teams identified additional elements, such as solar panels to include in their work, although these were not included in the cost-benefit analysis. During the charrette, 8 to 12 participants per site, were guided by a facilitator through a process of identifying major opportunities and constraints associated with the site, and working towards a final design product, to scale, on the maps and tracing paper provided. The discussions were lively, and many professionals left their 'silos' to engage in a healthy discussion about what was possible or not, and why.

For each type of green infrastructure utilized, the teams were required to measure, using maps to scale, the total area in square metres of each type of green infrastructure. Some teams utilized all fifteen, while others chose fewer, depending on site constraints. For example, a five block area encompassed by a school yard may allow for the implementation of 500 m^2 of bioswales, the planting of street trees encompassing a canopy of 6,000 m^2 at maturity, and 2,000 m^2 of extensive green roofs on three buildings, and 200 m^2 of planting beds. The area of each type of green infrastructure selected was then used to estimate the resulting costs and benefits, from values customized for the local community in the Cost-Benefit Matrix.

Each group was provided with the opportunity of presenting their work, details of which are included in this report, along with the cost-benefit values derived for each site at 1-year, 5-year, 25-year and 50-year intervals.

While there are an infinite number of variations of green infrastructure technologies and designs, we selected generic types in order to facilitate the aggregate cost benefit analysis. Generic types of green infrastructure allow us to provide standardized values for costs and benefits that can be customized for each community.

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

Extensive Green Roof

Ellis Creek Water Recycling Facility extensive green roof. Petaluma, CA.

A green roof — also known as a "vegetated roof," "living roof," or "eco-roof "— is an extension of an existing roof which involves a high quality waterproofing and root repellent system, a drainage system, filter cloth, a lightweight growing medium, irrigation system and plants. Green roof implementation involves the creation of "contained" green space on top of a human-made structure, below; at, or above grade, but in all cases the plants are not planted in the "ground."

Green roof systems may be modular, with drainage layers, filter cloth, growing media and plants already prepared in movable, often interlocking grids or trays, or loose-laid/ built-up where each component of the system may be installed separately.

This form of green infrastructure contains a growing medium of 6'' or less, is often inaccessible and has a low amount of plant diversity (often only succulents). Extensive green roofs are also lightweight, low-maintenance, and more suitable for larger roof areas and retrofit projects, with limited structural loading capacity.

Intensive Green Roof


Visionaire condominium private intensive green roof. New York, NY.

An intensive green roof is similar to an extensive green roof. However, intensive green roofs differ in that they contain a growing medium of 6'' or greater (even as much as 48"), are always accessible to building occupants and have a much higher amount of plant diversity than extensive green roofs (primarily due to deeper growing medium and greater structural loading capacity). Intensive green roofs in turn offer a larger amount of recreational and design opportunities than extensive green roofs. An average depth of 20" (50.8 cm) of growing media covering the green roof is used for intensive green roofs in the Cost-Benefit Matrix.

Green Façades


Green façade system in MFO Park. Zürich, CH.

Green façades are systems in which vines and climbing plants or cascading groundcovers grow into supporting structures that are purposely designed for their location. Plants growing on green facades are generally rooted in soil beds at the base or in elevated planters at intermediate levels or on rooftops.

The values presented for green façade estimates assumes an average wall 20' (6.1 m) in height and 50' (15.24 m) in width, requiring access for scissors lifts, platforms and or ladders for installation.

The green façade valuation process has encompassed three different façade systems. The included systems are single vertical stainless steel cables (24" OC, 1 vine per cable), trellis panel, and stainless steel cable net (40 x 60 mm). Each of these systems allow vines to grow without attaching themselves directly to the building envelope.

Living Wall - Interior


Drexel University interior living wall. Philadelphia, PA.

Living wall systems (also known as Biowalls) are composed of pre-vegetated panels, modules, planted blankets or bags that are affixed to a structural wall or freestanding frame. This form of green infrastructure is considerably more complicated than green façades and more resource intensive. These systems are irrigated and feature either a hydroponic or soil based growing system. Interior living wall costs include lighting and controls, frame, fertilizer injection, irrigation/ sensors/ controls, tray and drain, and mechanical connections.

Design factors such as irregular shapes and smaller sizes might increase costs as will difficult access for maintenance. Costs may also be influenced by remote locations, nature of access to local certified installers and qualified maintenance personnel, greenhouse jurisdictions/permitting which will vary by site, microclimate, and project.

Living Wall - Exterior


Drew School exterior living wall. San Francisco, CA.

An exterior living wall holds exactly the same properties as the aforementioned interior living wall. Some utilize removable containers or felt to hold growing medium, while others use hydroponics.

Due to the context of interior versus exterior placement more benefits may be attributed to the exterior living wall. This created the need for a separate section and analysis of a living wall in an exterior context.

Exterior walls are not generally found in colder climates. The freeze and thaw cycles make it difficult to provide sufficient water to keep the plants alive.

Rain Garden


Rain garden. Princeton, NJ.

A rain garden is a topographical depression in the ground designed to receive surface runoff. The main benefits associated with a rain garden are the collection and storage of rainwater, permitting it to be filtered while slowly being absorbed into the surrounding soil. Bioretention uses the natural properties of soils, plants and associated microbial activity to infiltrate water and remove pollutants from stormwater runoff. A rain garden can be designed in various ways but the most common form consists of a shallow, excavated depression with layers of stone, prepared soil mix, mulch and specially selected native vegetation that is tolerant to road salt and periodic inundation.

This type of green infrastructure features vegetation that is compatible with wet soil conditions and often uses native plantings as a primary option. This form of green infrastructure is not always submerged in water, but contains the biophysical properties to absorb large amounts of water.

Bioswale


Curbside bioswale. Portland, OR.

A bioswale drains, infiltrates and directs the flow of rainwater. It is designed to attenuate and treat storm water runoff for a defined volume of water.

Bioswales are designed to detain, infiltrate and convey flows to the storm sewer system or directly to the receiving water. They help slow and filter water to enhance sedimentation, soil infiltration and evapotranspiration by plants and/or grasses. Bioswales also provide some aesthetic value in sidewalks and may act as traffic calming elements. This form of green infrastructure is similar to the aforementioned rain garden (bioretention) but differs in that bioswales are:
• Often intimately integrated into existing stormwater conveyance systems
• Designed to direct the flow of rainwater, typically to grey infrastructure
• Specified to treat and attenuate a specific volume of runoff

Permeable/Porous Paver


Permeable paver driveway. Houston, TX.

Permeable/ porous pavers refer to many forms of durable surface material applied to an area intended to sustain traffic (vehicular or foot). Permeable/ porous pavers provide a surface layer that allows rainfall to percolate into an underlying reservoir, where it either infiltrates into underlying soils or is removed by subsurface drains. Porous pavement allows water to pass through because it has a certain amount of void space within the material.

This form of green infrastructure may include but is not limited to the use of materials such as: porous asphalt, plastic, concrete, soil and minimal plant material.

These materials are then filled with gravel, soil, or vegetated soil as seen in the image. Permeable/ porous paver can also include modular pavers with gapped joints to allow water to percolate through. The behaviour of both models of permeable and porous paver are very similar, thus they have been combined.

Small Tree


Acer ginnala. Common Name: Amur Maple

Trees are a common form of green infrastructure in urban areas. They help to retain runoff from streets, sidewalks, and parking areas, provide air quality and urban heat island benefits. For the purposes of this pilot program, trees are categorized as being either small, medium or large. We provide a wide range of cost and benefit values, with the benefits for larger trees factoring in faster than those for smaller trees. The full benefits of trees are associated significantly with their canopy area at maturity, at approximately 20 years. A small tree is categorized as 24 feet (7.2 m) in height or smaller. The canopy of a small tree is categorized as being 26 feet (7.9 m) across or less (McPherson et al., 2003). The study uses an average leaf surface area of 1,111 ft^2 (103.22 m^2) for small trees to calculate dollar per square metre benefits. This likely underestimates the value of trees because of overlapping leaves.

Where possible native species should be selected. A few examples of small trees include, but are not limited to: Trident Maple, Japanese Maple, Amur Maple, Eastern Redbud, or Holly Oak.

Although not all trees bear fruit that can be consumed by humans, this project acknowledges the potential for a small tree to bear fruit and thereby create urban agriculture potential. A number of communities have established community orchards to take advantage of the many benefits of fruit bearing trees. Local food production benefits have been incorporated into the cost-benefit analysis.

Medium Tree

Gleditsia triacanthos var. inermis. Common Name: Thornless Honeylocust.

The medium tree category has an average height of 36 feet (11 m). The canopy of a medium tree is categorized as being 27 feet (8.2 m) on average. For the purposes of this project all benefits are calculated for the tree at maturity. The study uses an average leaf surface area of 2,434 ft^2 (226.13 m^2) for medium trees to calculate dollar per square metre benefits (McPherson et al., 2003). Where possible native species should be selected.

A few examples of medium trees include, but are not limited to: Pear Tree, Thornless Honeylocust, Sourwood, Raywood Ash or Linden.

Although not all trees bear fruit that can be consumed by humans, this project acknowledges the potential for a medium tree to bear fruit (upon correct species selection) and create urban agriculture potential.

Large Tree

Quercus palustris. Common Name: Pine Oak

The large tree category grows to an average of 44 feet (13.4 m) in height or taller. The canopy of a large tree is categorized as being 30 feet (9.1 m) or wider. The study uses an average leaf surface area of 3,056 ft^2 (283.91 m^2) for large trees to calculate dollar per square metre benefits (McPherson et al., 2003). Where possible native species should be selected.

A few examples of large trees include, but are not limited to: Autumn Blaze Maple, Grand Fir, Sycamore Maple, Sugar Maple or Douglas Fir.

Although not all trees bear fruit that can be consumed by humans, this project acknowledges the potential for a large tree to bear fruit (upon correct species selection) and create urban agriculture potential.

Wetland

Wetland treatment for parking lot runoff. Denver, CO.

Wetlands are areas where water either covers the soil, or where there is a high saturation of water in the soils at various times of the year. This project defines 'wetlands' in broad based terms and encompasses: bogs, fens, swamps, marshes, shallow waters, or stormwater management ponds.

This form of green infrastructure is a key part of the hydrological cycle and helps to moderate ground water levels and urban runoff. Wetlands can be either naturally occurring or engineered. For the purposes of this pilot project a capital cost and annual maintenance cost has been applied to the generic wetland typology. There are very significant differences in the costs of development wetlands. In the case of a naturally occurring wetland capital costs would not apply. Both existing and built wetlands will require maintenance and or monitoring, however this cost is very low.

Planting Bed

Horticultural display, Casa Loma. Toronto, ON.

Planting beds, also referred to as horticultural displays, encompass a wide variety of planting arrangements including: formal gateway plantings, community gardens, perennial and annual beds, shrub beds, feature gardens, raised planters, mosaiculture, or food production gardens.

This form of green infrastructure also includes groundcovers and tall shrubs.

Turf - Active

Whirlpool Golf Course. Niagara Falls, ON.

Active turf includes highly maintained areas used for sport and recreation. Examples of this form of green infrastructure include: soccer fields, baseball fields, cricket pitches, football fields, golf courses or bowling greens.

Active turf is considered on or adjacent to active trails and or natural sports or recreation fields. An important distinguishing point for this study's assessment of active turf is that it only considers living turf and not artificial. Active turf may use sand or native soils and a drainage layer. Sand based systems have better drainage capability than native soils which hold more water and nutrients. Athletic fields may be built to collect and reuse stormwater.

Turf - Naturalized

Bowmont Natural Environmental Park. Calgary, AB.

Naturalized turf or meadowland shares some similar properties to that of an extensive green roof, differing in terms of height above grade and depth of growing medium. Therefore, many benefits calculated in the extensive green roof section are attributed to naturalized turf as well. Examples of the naturalized turf can be found in: hydro corridors, meadowlands, ravines, general parkland, valley land, conservation lands or naturalized areas.

This form of green infrastructure includes any natural turf areas in passive use settings.

At the end of the design process each team was asked to produce a written description of each site, the ideas they developed, the square metres of each type of green infrastructure, as well as a variety of drawings and sketches to illustrate their work. This data forms the body of this report. Information on total area of each form of green infrastructure was applied to the customized Cost-Benefit Matrix to provide the aggregate cost-benefit for each site. In the case of Vaughan, data from all three sites is aggregated together.

One of the challenges facing the greater utilization of green infrastructure is that we do not properly value the many benefits they provide. Green infrastructure is not even considered a capital asset in how we conduct our financial analysis of local government assets. Senior levels of government do not typically invest in green infrastructure as a component of infrastructure spending programs.

The 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 for the design work emerging from the charrettes.

The Cost-Benefit Matrix is a tool in the form of an Excel spreadsheet that provides approximate values for the design work carried out in the Green Infrastructure Design Charrette. The values that the Green Infrastructure Cost-Benefit 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, per se, but rather about hitting the dartboard and thereby starting the conversation around the tangible benefits that green infrastructure can offer each community. The cost-benefit analysis aims to help spur and facilitate a conversation with political leaders, community leaders and civil servants in communities around the valuation of green infrastructure investments and future policy directions.

One of the reasons why we do not properly value the benefits of green infrastructure in our communities has to do with complexity. This complexity takes many forms. Conducting the cost-benefit analysis at an aggregate level, and focusing on the dollars/square metre provides us with some additional latitude in dealing with the challenge of monetizing the benefits of green infrastructure. Some of these challenges, and how we tried to overcome them, are described below:

Challenge

• There are a diverse range of green infrastructure types, and applications within each type. For example, one can plant a seedling, or a 40 inch diametre mature tree.

Solution

• We searched through the literature and identified generic types of green infrastructure for which performance variables could be applied. In some instances, such as trees, we used small, medium and large, and then calculated the benefits after a 5 or 10 year period, during which time they would be able to mature.

Challenge

• There are different performance values from the same types of green infrastructure in different locations. For example, an extensive, light weight green roof may retain 100% of the stormwater in Arizona which falls each year, but only 50% of the stormwater falling in Vancouver.

Solution

• Where there is a wide range of performance values, we tried to establish a mean value and then provide a high, medium and low value, that can be customized by the local community.

Challenge

• There are many performance values, such as human health benefits, for which there are few methods of measuring their impact, and even fewer measures of monetizing their value. For example, a community with more greenery may be less violent and have less crime but how does one measure the monetary benefit to society?

Solution

• From the comprehensive list of benefits, we only used benefits for which there is literature on their performance and monetization of them. Although it is well established, we were not able to monetize the ability of green infrastructure to extend the life expectancy of grey infrastructure. In total, we were only able to address 10 benefits, and not all of these apply to each of the fifteen generic types of green infrastructure. Further research work is planned to improve the performance assessment and monetization of additional benefits, such as the recreational value of additional parkland.

Challenge

• Monetizing the values of performance benefits relies on many non-market methods, such as hedonic pricing. Even when methods are reliable, the costs and benefits can vary significantly from community to community.

Solution

• We used the literature on benefits from a variety of sources, as well as market research on capital and maintenance costs. In order to address wide ranges in estimates, we used a high, medium and low, set of values that can be selected by local communities. We also subjected the research to a peer review process to gain valuable insight into how to approach certain values and insure integrity between the values.

Challenge

• The allocation of costs and benefits between public and private entities is not always clear. In some instances governments may require the private sector to build green infrastructure, while the public sector maintains it, for example.

Solution

• We focused the cost benefit analysis almost entirely on public benefits, factoring in private costs when it was clearly the case. The Matrix allows for the sharing of capital and maintenance costs between public and private entities, but the benefits are public.

Challenge

• Most local communities and governments do not have a good handle on the costs and benefit data for the types of benefits we are measuring. For example, few communities know how much a cubic metre of stormwater costs to manage. In some cases, this information lies between different government agencies and levels of government.

Solution

• In the future, we need to zero in on the most important data inputs from local communities and governments and work to customize the Cost-Benefit Matrix this way, rather than through a consultative approach.

Despite these challenges, we believe that the Cost-Benefit Matrix is a unique and valuable tool that can help promote better decision-making around infrastructure planning and investment. It provides users with an opportunity to customize all of the 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 Cost-Benefit Matrix contains our assessment of whether the costs and benefits are community based, private, or shared (see page 18). In some cases opportunities for subsidy in the form of a green roof incentive may be considered, splitting the cost burden. However, the Matrix does not distinguish between different public entities or departments within a local government. These aspects of the analysis are very community specific. The focus is largely in the public realm, and can be direct and indirect in their nature. 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 in this report understates the full impact of green infrastructure investment relative to its 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.

The Cost-Benefit Matrix begins an important conversation around big picture investment in green infrastructure and what benefits will be seen in return.

For more information about the methods used in this project, please see Appendix I.

PROJECT INTRODUCTION

⟶ About the Cost-Benefit Matrix

Generic Green Infrastructure Type	Generic Benefits (Identified from Literature)														
	$\$/m^2$ (Annual)			$\$/m^2$ (Capital)			$\$/m^2$ (Annual)			$\$/m^2$ (Annual)			$\$/m^2$ (Annual)		
	Stormwater Management			Creation of Habitat/ Biodiversity			Increase in Air Quality			Green House Gas Sequestration			Reduction in Urban Heat Island Effect		
	Low (L)	Med (M)	High (H)	Low (L)	Med (M)	High (H)	Low (L)	Med (M)	High (H)	Low (L)	Med (M)	High (H)	Low (L)	Med (M)	High (H)
Extensive Green Roof	0.85	1.21	1.57	4.31	5.56	6.8	0.0521	0.0673	0.0839	0.00154	0.00198	0.00286	1.981	2.476	2.971
Intensive Green Roof	1.9	2.72	3.54	4.31	36.13	67.95	0.07	0.08	0.1	0.00154	0.00234	0.0039	2.377	2.971	3.565
Green Façade	0.09	0.12	0.16	4.31	5.22	6.12	0.04168	0.0521	0.06252	0.00154	0.00198	0.00286	1.12	1.4	1.68
Living Wall - Interior	0	0	0	0	0	0	0.04168	0.0521	0.06252	0.00154	0.00198	0.00286	0	0	0
Living Wall - Exterior	0.18	0.24	0.32	4.31	4.88	5.44	0.04168	0.0521	0.06252	0.00154	0.00198	0.00286	1.12	1.4	1.68
Rain Garden	0.12	0.24	0.36	4.31	36.13	67.95	0.04168	0.0521	0.06252	0.00154	0.00198	0.00286	1.981	2.476	2.971
Bioswale	1.55	1.94	2.33	4.31	36.13	67.95	0.07	0.08	0.1	0.00154	0.00234	0.0039	2.377	2.971	3.565
Permeable Surface - Porous Paver	0.36	1.19	2.01	0	0	0	0	0	0	0	0	0	0	0	0
Tree - Small	0.036	0.045	0.055	4.31	36.13	67.95	0.027	0.034	0.04	0.0021	0.0027	0.0039	2.852	3.565	4.278
Tree - Medium	0.037	0.046	0.055	4.31	36.13	67.95	0.017	0.021	0.025	0.0021	0.0027	0.0039	3.422	4.278	5.134
Tree - Large	0.034	0.042	0.051	4.31	36.13	67.95	0.018	0.023	0.028	0.0021	0.0027	0.0039	4.107	5.134	6.161
Wetland	0.98	2.51	4.03	4.31	36.13	67.95	0.04168	0.0521	0.06252	0.0231	0.0619	0.136	2.377	2.971	3.565
Planting Bed	0.096	0.12	0.144	4.31	5.22	6.12	0.07	0.08	0.1	0.00154	0.00198	0.00286	2.377	2.971	3.565
Turf - Active	0.096	0.0224	0.36	4.31	5.22	6.12	0.04168	0.0521	0.06252	0.00129	0.00166	0.00239	1.5848	1.981	2.3772
Turf - Naturalized	0.12	0.18	0.24	4.31	36.13	67.95	0.0521	0.0673	0.0839	0.00154	0.00198	0.00286	1.981	2.476	2.971

Generic Green Infrastructure Type	$\$/m^2$ (Annual)			job years/m^2 (Capital)			job years/m^2 (Annual)			$\$/m^2$ (Annual)			$\$/m^2$ (Annual)		
	Reduction in Building Energy			Job Creation from Capital Expenditure			Job Creation from Annual Expenditure			Property Value/ Taxation Revenue			Urban Food Production		
	Low (L)	Med (M)	High (H)	Low (L)	Med (M)	High (H)	Low (L)	Med (M)	High (H)	Low (L)	Med (M)	High (H)	Low (L)	Med (M)	High (H)
Extensive Green Roof	1.776	1.83	2.207	0.00225	0.00357	0.0055	0.00003	0.00006	0.00011	6	7.06	12	0	0	0
Intensive Green Roof	1.776	2.207	2.648	0.0045	0.006689	0.0099	0.00015	0.0005351	0.0011	9	11	20	16	88	160
Green Façade	0.005	0.009	0.012	0.00225	0.0053514	0.011	0.00015	0.0003568	0.0011	1.4	2.7	3.9	0	0	0
Living Wall - Interior	0	0	0	0.020182	0.064871	0.118403	0.00323	0.006721	0.01184	1.4	2.7	3.9	16	88	160
Living Wall - Exterior	0.005	0.009	0.012	0.016146	0.048	0.094722	0.00323	0.006721	0.01184	1.4	2.7	3.9	16	88	160
Rain Garden	0	0	0	0.0008315	0.0020353	0.0038007	0.000062	0.000092	0.000136	0	0	0	0	0	0
Bioswale	0	0	0	0.001453	0.00288	0.004973	0.000062	0.000092	0.000136	0	0	0	0	0	0
Permeable Surface - Porous Paver	0	0	0	0.00113	0.002112	0.003552	0.000003	0.000004	0.0000005	0	0	0	0	0	0
Tree - Small	0.005	0.008	0.011	0.000029	0.000104	0.000213	0.000003	0.000004	0.000006	9	9.5	10	0.63	0.8	0.96
Tree - Medium	0.006	0.01	0.014	0.000013	0.000047	0.000097	0.000001	0.000002	0.000003	9	9.5	10	0.96	1.2	1.45
Tree - Large	0.009	0.016	0.022	0.000011	0.000038	0.000077	0.000001	0.000001	0.000001	9	9.5	10	1.3	1.61	1.93
Wetland	0	0	0	0.000205	0.000303	0.000446	0.000002	0.000005	0.000009	0.022	0.028	0.034	0	0	0
Planting Bed	0	0	0	0.001615	0.002592	0.004026	0.000062	0.000092	0.000136	0	0	0	16	88	160
Turf - Active	0	0	0	0.000141	0.000209	0.00031	0.000003	0.000017	0.000033	6	7.06	12	0	0	0
Turf - Naturalized	0	0	0	0.000013	0.000063	0.000136	0.000001	0.000007	0.000013	6	7.06	12	0	0	0

Public/ Private	
Public	
Private	
None	

VAUGHAN CHARRETTE REPORT

The first Green Infrastructure Design Charrette was held on Tuesday, June 10, 2014 as a full-day design event in Vaughan, Ontario.

All three sites are found within the Vaughan Metropolitan Centre (VMC), are designated as an Urban Growth Centre by the Provincial Growth Plan, and as a Regional Centre in the Region of York's Official Plan. The VMC is embedded in the heart of a major regional industrial area and transportation network. The site of the VMC is currently a combination of developed commercial property, light industrial development property, and undeveloped land. Highway 407 bounds the southern edge and Highway 400 bounds the western edge of the VMC.

A planned primary intensification area is located on the west side of Highway 400. The vast majority of land within the VMC is privately owned which poses the most creative implementation challenge to establish a cohesive and connected public realm. Along with the regional roads and railway linkages, the VMC is well positioned in close proximity to Pearson International Airport.

The VMC is envisioned to develop as a green and sustainable city area. The site of the VMC is approximately 190 hectares and as a designated urban growth centre, by 2031 it will accommodate:

- Population potential: 25,000 new residents
- Minimum of 12,000 residential units
- Employment potential: 11,000; 5,000 will be office jobs
- Projected office development: ~140,000 m^2
- Projected retail development: ~70,000 m^2

The VMC is centred on the planned subway station at Highway 7 and Millway Avenue, along with a regional bus terminal and vivaNext rapidway connections which together meet and form the future Anchor Mobility Hub at the heart of the VMC. The TTC Toronto-York Spadina Subway Line Extension includes a new subway station located in the Vaughan Metropolitan Centre at the corner of Highway 7 and Millway Avenue. The subway connects Vaughan to downtown Toronto and forms a major catalyst for the redevelopment efforts.

Mayor Maurizio Bevilacqua, City of Vaughan, addresses Vaughan Green Infrastructure Design Charrette participants. Credit: Green Roofs for Healthy Cities.

At full build-out, the VMC will be comprised of over 30 city blocks. Due to its significant size, the VMC will be comprised of distinct development precincts including residential neighbourhoods, office districts, employment areas and mixed-use areas, all linked by a robust system of parks, public squares and open spaces and a fine-grain grid pattern of streets. All three selected sites for redesign fall within the Station Precinct, which is part of the core of the VMC and connected with the central Anchor Mobility Hub.

The VMC is a strategic location for the concentration of the highest densities and widest mix of uses in the City, allowing it to become a multi-faceted and dynamic place to live, work, shop and play, attracting activity throughout the day. All three sites selected for the design charrette redesign are located within the highest density zone, permitting a maximum of 25 storeys and 4.5 floor space index.

The selected sites each interface with the Black Creek Stormwater Pond and Park and provide an interesting frontage and interface with the Streetscape and Open Space Plan framework. As catalyst projects, each

Context map of Vaughan Metropolitan Centre. Credit: City of Vaughan.

of these selected sites feature exciting mixed use development proposals, with the first project, Expo City, currently under construction as the first high density redevelopment in the VMC.

Each of the sites are positioned in close relationship with one another as part of a larger redevelopment block, with each project sharing an interface with the Edgeley Pond; the City's largest landholdings in the VMC to be developed as a future wetland park and amenity for the community. Individually, and together, these projects present an exciting opportunity to rethink the use and application of green infrastructure as part of a larger urban system, sparking ideas about the transformative potential of great design for the future success and sustainability of the VMC.

A key concept in the VMC Streetscape and Open Space Plan is that of the Blue Network which celebrates the presence of water in the VMC. The objectives of the Blue Network are to create a visible urban network of water for the downtown and to minimize the impact of development on the natural water cycle through:

- A revitalized Black Creek
- Special blue streets with LID measures to treat water and act as a design feature
- Parks and Open Spaces with large areas to infiltrate, filter and store water.
- Mature Street Trees - in certain locations, the use of below-grade structural soil cells will allow for the capture, conveyance, filtration, and storage of stormwater.
- Individual Development Sites encouraged to contribute to the blue network through the site design applications

As a green framework for the VMC, the parks and open space system are important to achieving the vision of the VMC Secondary Plan and providing the foundation for a distinct, walkable and successful public realm.

In the northeast quadrant of the VMC, of which the sites are a part, there is a lack of classified parks and urban squares. However, Black Creek will act as a major amenity for the community that should be designed to relate to the larger open space and pedestrian network. Throughout the VMC, intersections are organized into a hierarchy of gateway, major, and minor intersection types. These types are used to join varying conditions together at the streetscape level to create a unified public realm. The site area includes an important gateway intersection to convey a strong sense of arrival, with major and minor intersections fronting the development lands and with a major view corridor opening into the Black Creek Park and pond.

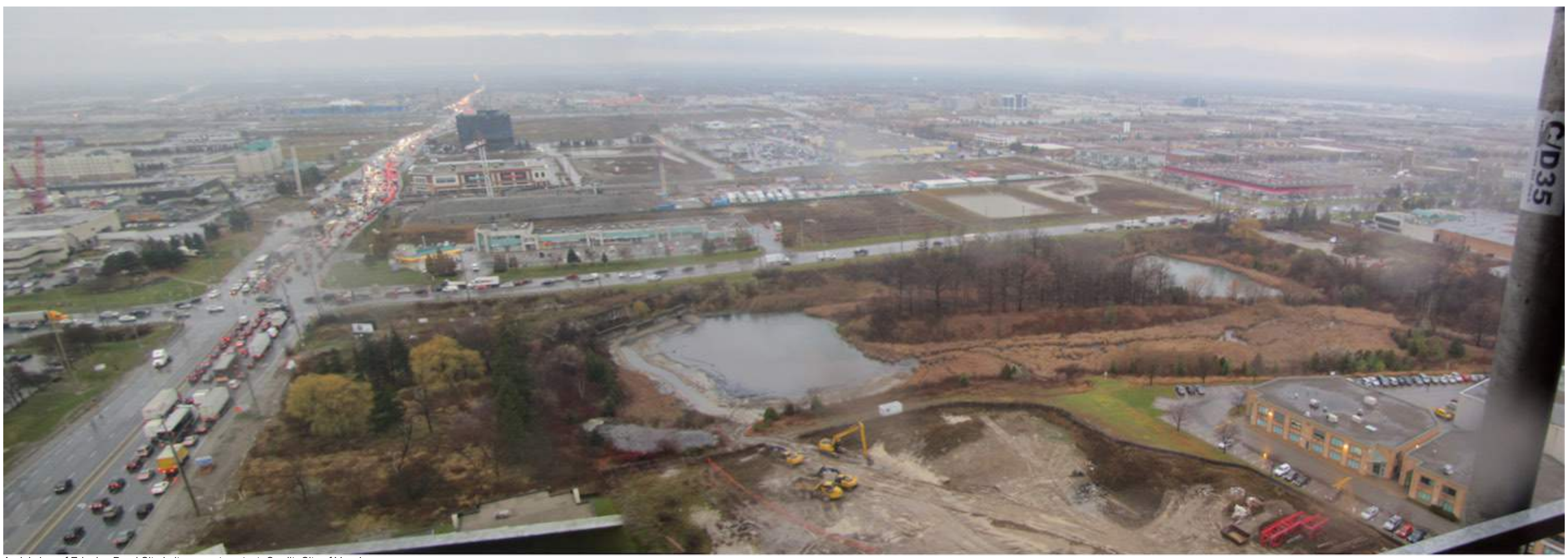
The Streetscape and Open Space Plan also includes the concept of 'The Loop' as an iconic pedestrian and cycling path that weaves through the four precincts in the VMC, and symbolically connects with all three of the selected sites.

The Black Creek corridor is seen as a unique feature with the opportunity to be a focal point of the VMC. Through the VMC Secondary Plan, the Black Creek corridor is positioned as a signature feature that will create identity for the new downtown, attract investment along its frontage, support urban growth, and add value as the prominent open space amenity and natural heritage feature for the VMC community.

The Black Creek Stormwater Pond and Park is important from a social, environmental, and economic perspective. The site is underperforming as a stormwater management facility through its inability to meet current regulatory requirements. The primary engineering goals for the site are to improve water quality levels, provide erosion control measures, and meet rigorous water storage requirements to support urban growth. The challenging nature of the site and its requirements will necessitate complex technical solutions.

The revitalization of Black Creek is larger than solving water management issues – it is also about exploring innovative landscape approaches that connect the park with its emerging urban context and facilitate multi-platform use and programming. Establishing a landscape and urban design driven concept, rather than adopting a functional engineering solution for the site will help create the framework for a great urban environment in the VMC.

Design charrette participants used this background information to inform their design process and final site plans to bring a vision for the future of this key development block and public amenity. In the following sections we will introduce each site by its existing context through a site overview, redesign concepts as envisioned by the participants, a site plan, as well as area take-offs for the newly imagined green infrastructure set to be used on the sites. In the conclusion section of this report an aggregate level cost-benefit analysis will be conducted for all three sites as an amalgamated site for the Edgeley Pond area.

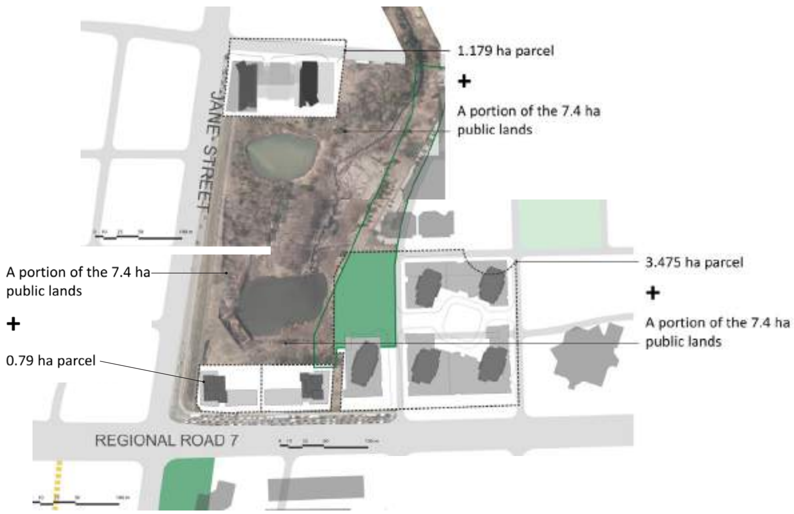


Aerial view of Edgeley Pond Site in its current context. Credit: City of Vaughan.

VAUGHAN

⟶ Context, Sites & Goals

The Municipal Servicing Class Environmental Assessment Master Plan prepared a preliminary concept for the facility that “identified the maximum achievable volume within the pond block area established by the Secondary Plan. Two forebays were also incorporated into the preliminary concept to receive runoff from the east and west sides of the facility, to provide water quality treatment for drainage from the VMC area, and to maintain a low flow area for the continued ecological and hydraulic functioning of the main branch of Black Creek.”



Context map of Edgeley Pond Site. Credit: City of Vaughan.

Purpose/ Goals:
- Major natural open space feature of the VMC
- Stormwater management/ flood control
- Connect people to the water
- Urban amenity
- Microclimate control

Target:
- 60% tree cover in plantable areas
- Protection and enhancement of natural heritage features by maintaining existing high quality planting where possible
- Water quality storage requirements for the pond were evaluated based on Ministry of Environment (MOE) criteria for Enhanced Protection (80% long-term TTS removal) for the areas for which flows could be directed to the planned forebays

Development Parcel Opportunities
- Interface with Public Open Space as an Amenity: Views, Passive Recreation, Ecological and Water Management Functions
- A Linked Green System: Parks, schools, recreational trail (‘The Loop’), streets, mews, a revitalized Black Creek
- Integration with ‘Blue Streets’ (L.I.D)
- Full Block Development – Collaboration between individual developments to implement sustainable infrastructure and a strong public realm that will tie development sites together
- Creates a District Identity with unified elements: Marketing
- Proximity to Subway + Rapid Transit
- Gateway Site
- Planned Urbanization of Highway 7 and Jane Street
- Interim design solutions (phasing)

Potential Constraints
- Wide Right of Ways on Highway 7 and Jane Street as Pedestrian Barriers
- Vehicle Traffic Volume, Noise, and Air Pollution from Highway 7 and Jane
- Below-Ground Water levels
- Soil types and conditions

VAUGHAN: SITE 1

⟶ Existing Site Plan

For Site 1, the design team embraced the concepts of opening up of space and massing of nature. The concept of landform building is used to disguise grey infrastructure such as above ground parking in a way that is scaled and buried. The site redesign embraces the hiding of forced grey infrastructure specified for the site and covers the newly found landform with green infrastructure.

To embrace the concept of massing of nature the Site 1 team specified extensive green roofs to be installed on building footprints and on top of the above grade parking garages. Moving forward with the green roofing concept, an intensive green roof is envisioned to be installed on the site as a workable plot for condo owners on the building footprint on the west side of the site.

Three proposed walkways over Edgeley Pond will continue the concept of massing of nature and the hiding of grey infrastructure with green. These walkways will contain shaded canopies that call for the installation of green façades along the envelope.

The team has specified the use of interior living walls on site through a green wall entrance corridor. The interior living walls will be 45 m^2 and placed on either side of the atrium. Exterior living walls have been specified on the south facing walls of the north tower. These walls have been set in place to hide essential grey infrastructure while creating a massing sense of nature. To navigate the issue of limited underground parking capability on site and the impending realization that above ground parking will likely be a reality, the design team chose to continue with its theme of hiding grey infrastructure. The parking lot façade has been specified to be greened using green façade systems to again create a flow and massing of natural components on site.

The walkway through the pond is lined on either side with bioswales to absorb potential runoff and to add a beautification element to the site. The bioswales will also help define the path and act as a deterrent measure to keep persons on the path. A similar function is repeated on other walkways on site through standard planting beds featuring both ornamental and native plantings.

Permeable paver is used throughout the site where the roadway load requirement is low. The Site 1 team has specified that all driveways and walkways on site are permeable. This function allows rainwater to penetrate the soil and enter into Edgeley Pond. Rainwater will be filtered numerous times through the established massing of nature from vertical contexts of living walls and green façades down to the bioswales and finally into the Edgeley Pond wetland.

Rainwater will also be harvested through cistern technology on site that will help irrigate the green walkway canopy. The team also explored concepts of wind turbine technology on both towers as well as solar panel technology integration on the upper levels of the south facing building envelope.

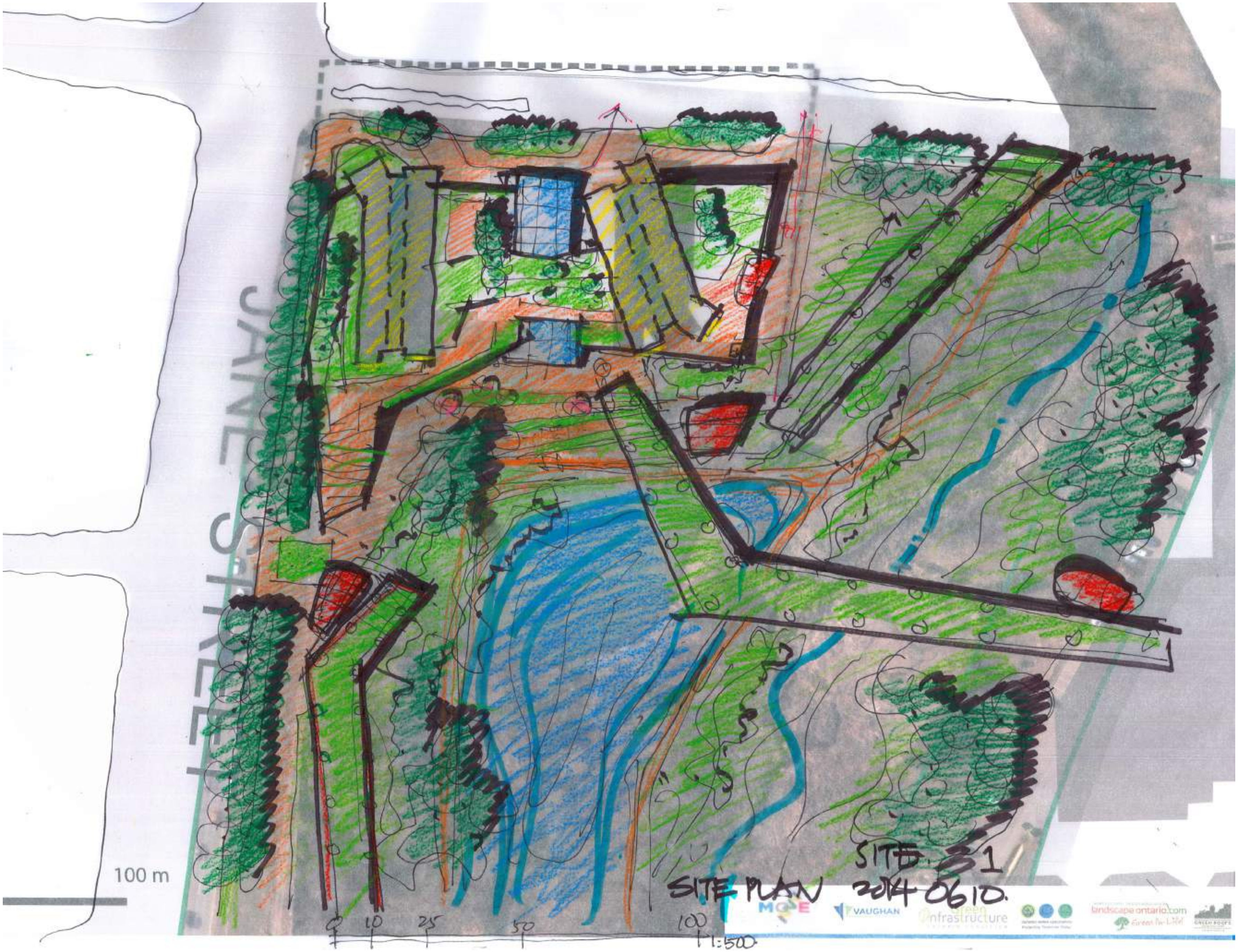
To attain satisfactory canopy cover the site features a variety of tree plantings on site ranging from small to large trees. To act as a buffer from the existing roadways eight large trees are specified for the frontage of the property. Densely tree lined property frontage will help combat pollution in the form of visual, physical and noise that is produced by automobile traffic while acting as a visual symbol and gateway to the site; a site that integrates green infrastructure into grey to create more functional and beautiful spaces.

VAUGHAN: SITE 1

⟶ Redesign Concepts

VAUGHAN: SITE 1

⟶ Proposed Site Plan



VAUGHAN: SITE 1

⟶ Green Infrastructure Area Totals

For Site 1 to achieve its newly realized goals and redesign concepts a number of green infrastructure elements were applied to the site as mentioned above. Area take-offs of the site plan and green infrastructure specification are totalled as follows.

The Site 1 team specified 1,665 m^2 of extensive green roof to be installed on building footprints and the above grade parking garages. The team also called for 250 m^2 of intensive green roof to be installed on the site as a workable plot for condo owners on the west side of the site.

The walkway canopy on three walkways over the pond was redesigned for an installation of 2,220 m^2 green façade. Interior amenity space considered for site redesign called for two 45 m^2 interior living walls on either side of the atrium, totalling 90 m^2 total installation of interior living wall. Exterior living wall systems totalled 900 m^2 to be installed over the north tower, on the south facing wall, as well as a sectional living wall on the above grade parking façade.

Bioswales proposed on the walkway through the pond were measured at 170 m^2. The team specified 900 m^2 of permeable paver to be used on all driveways and walkways.

To attain satisfactory tree canopy, cover 17 small trees,7 medium trees, and 30 large trees are featured throughout the site, as well as 8 large trees on the frontage of the property. Finally, the walkways are lined with 3,400 m^2 planting beds.

Other on site interventions that are not included in the cost-benefit analysis include a cistern to provide for a rain water system though the green walkway canopy, the potential of wind turbines on both towers, as well as solar panels installed on south facing building façade 30 to 36 stories, 3 metres wide, massing 270 m^2 of solar panel on site.

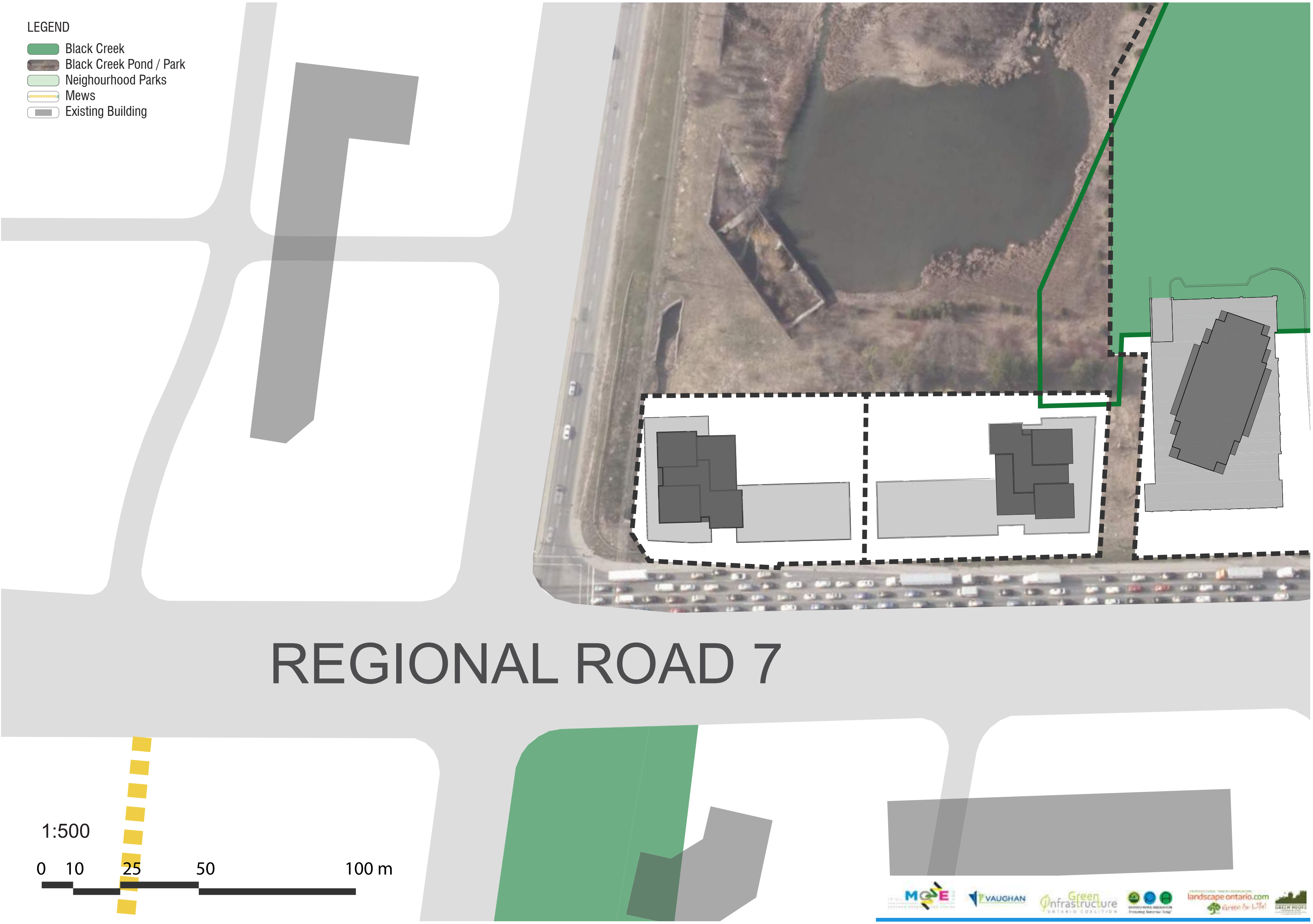
For the purposes of the cost-benefit analysis the City of Vaughan has requested that all three separate site redesigns be evaluated as a whole. The amalgamated area will be known as the Edgeley Pond site.

Area take-offs for the Edgeley Pond site are as follows: extensive green roof installations total 3,290 m^2; intensive green roof installations total 2,850 m^2 with another 2,380 m^2 dedicated to roof top urban agricultural use; green façades total installation is 2,690 m^2; interior living walls total installation 90 m^2; exterior living walls total installation 4,700 m^2; rain gardens total installation 1,775 m^2; bioswales total 1,120 m^2; permeable paver totals 5,775 m^2; small trees total 25 trees; medium trees total 417 trees; large trees total 139 trees; newly constructed wetlands total 1,380 m^2, with the existing wetland of the Edgeley Pond site totalling an additional 74,000 m^2; planting beds total 4,210 m^2; active turf totals 2,250 m^2 and passive turf totals 5,355 m^2.

The site plans work within the context of the VMC Secondary Plan as well as the draft VMC Streetscape and Open Space Plan. The plans aim to help ensure that the revitalized Black Creek becomes an integral part of the green public infrastructure within the Vaughan Metropolitan Centre in its design concept and through the provision of design guidelines. The plans incorporate the idea of opening up spaces with a view to the pond and softening building edges.

VAUGHAN: SITE 2

⟶ Existing Site Plan



VAUGHAN: SITE 2

⟶ Redesign Concepts

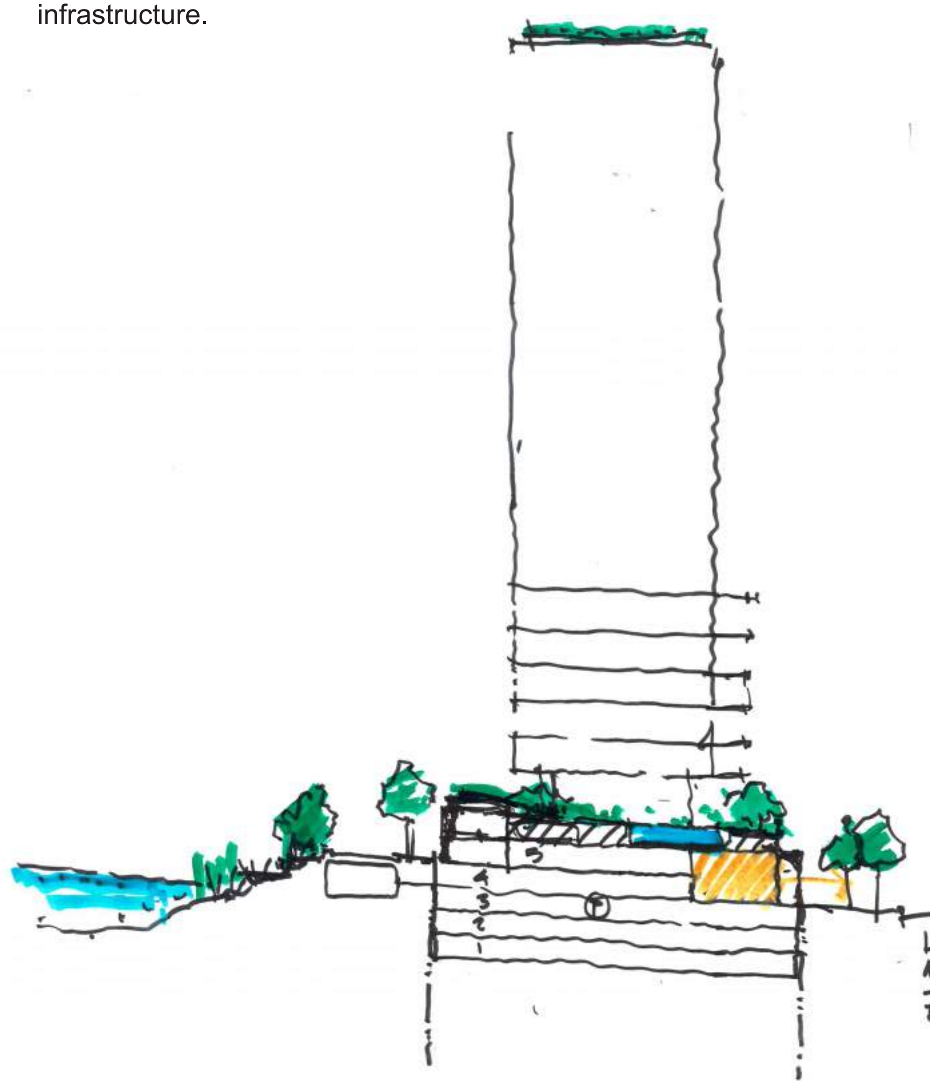
Site 2 incorporates a variety of concepts and infrastructure to create a re-envisioned area that features a tapering of green spaces and a green vertical progression to negotiate a seamless transition from the natural (Edgeley Pond) to the urban (development).

The street edge at Jane Street and Highway 7 would feature trees and shrub plantings to act as a buffer from arterials. This will provide a forest feel while addressing issues of noise, visual, and physical pollution/ nuisance caused by vehicular traffic. Along the Jane Street corridor an open channel will be integrated to maintain fish habitat and connectivity to the southern Black Creek corridor.

The intersection of Jane Street and Highway 7 would incorporate ‘Edgeley Heritage’ through fruit trees as well as retail fruit stands to commemorate the old community of Edgeley Pond. The area will act as an open invitation to the public amenity of Edgeley Pond and ‘The Loop’ through a naturalized context and open viewscape to the park. The intersection area would also have a canopy/ shelter area with solar option to provide shade. Trees and walkways are defined with rain gardens feeding into silva cell planting systems. Stormwater will not only be naturally managed, but will be used as an art form for ecorevelatory design and education in the communal area.

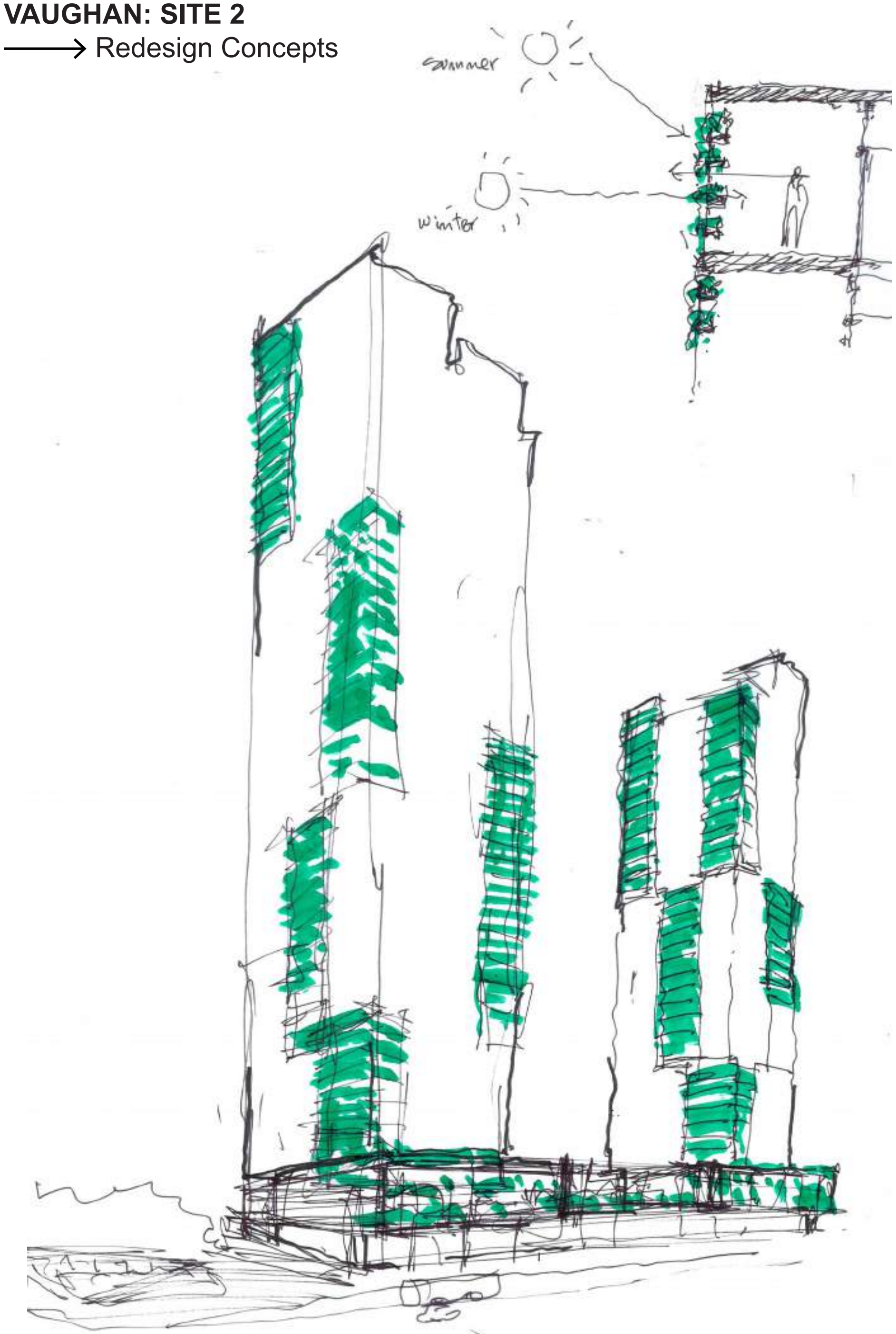
To the north of the site a private lane for the proposed development is required. The Site 2 team has specified this area as a narrow roadway comprised of porous paver. The streetedge will be tree lined and feature bioswales with no curb or gutter, embracing the woonerf streetscape concept. The lack of a clearly defined barrier created by grey infrastructure will embrace the notion of a transitional habitat toward Edgeley Pond/ Park. Lay-by/ on street parking with permeable paver will be offered on the private lane, with emphasis placed on pedestrian centric connectivity, bike friendly development though cyclist lanes and connectivity to the proposed cyclist loop trail along Edgeley Pond.

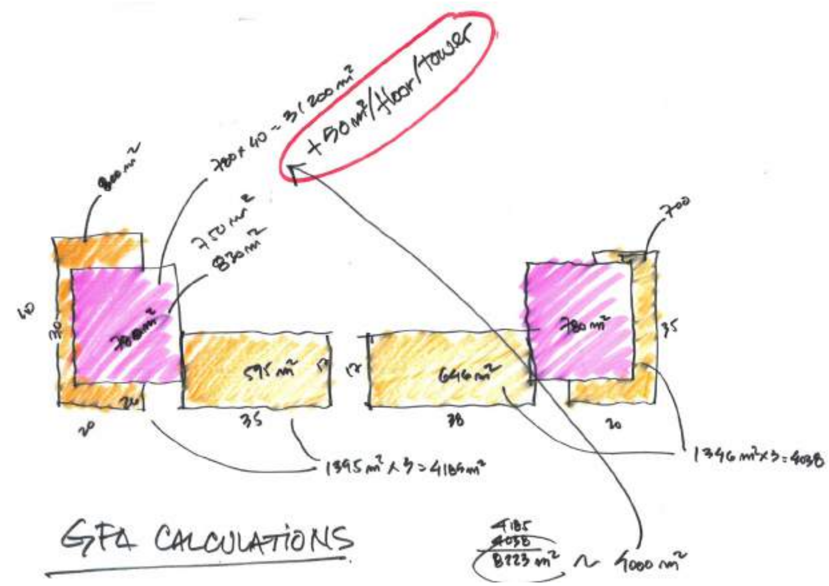
The building component of Site 2 called for a tapered or stepped garden design as seen in the sketches provided. This will allow for open green community spaces at various levels, ranging from public, semi-public to private. The building design embraces rain water harvesting through on site cistern use and communal grey water. Community gardening is offered at public and private levels through the tapering of green space ranging from ground level to intensive green roof at the lower-level building rooftop. Extensive green roofs are specified on the point towers. The team specified solar panels on overhangs/ building canopies as well as an emphasis on indoor and outdoor bicycle parking amenity. Green façades were used in sections on the southern portions of the point towers and a living wall was specified for the building entrance/ foyer as a means of homage to Edgeley Pond and to symbolize the integration between grey and green infrastructure.



VAUGHAN: SITE 2

⟶ Redesign Concepts





VAUGHAN: SITE 2

⟶ Proposed Site Plan

VAUGHAN: SITE 2

⟶ Green Infrastructure Area Totals

The Site 2 redesign employs 1,625 m^2 of extensive green roof that would cover the two point tower roofs found on the site. At the building podium 500 m^2 of intensive green roof and 2,380 m^2 of urban agriculturally focused intensive green roof are specified for residents of the building to grow food and help develop a sense of community.

South facing walls of the point towers are envisioned as staggering living wall systems set back into the building envelope. These living walls total 3,800 m^2 of installation on the site.

The design team used 375 m^2 of rain garden on site, as well as 550 m^2 of bioswale to help combat and filter stormwater that will flow into Edgeley Pond and move into Black Creek.

Permeable pavers are used on site for the private access laneway as well as portions of sidewalks and parking lots, these interventions total 4,325 m^2. To meet canopy coverage targets the site features 8 small trees, 49 medium trees, and 37 large trees situated throughout the site both on ground level as well as on the green roofed (intensive) podium.

To allow for adequate movement of water from Edgeley Pond into the southern Black Creek 930 m^2 of wetland has been added at the southwest portion of the site.

Outside of the site boundary on the other side of the private access lane constructed of permeable paver 5,355 m^2 of naturalized turf acts as a buffer to the approaching Edgeley Pond to help smoothen the transition from urban to natural in a seamless fashion.

For the purposes of a the cost-benefit analysis the City of Vaughan has requested that all three separate site redesigns be evaluated as a whole. The amalgamated area will be known as the Edgeley Pond site.

Area take-offs for the Edgeley Pond site are as follows: extensive green roof installations total 3,290 m^2; intensive green roof installations total 2,850 m^2 with another 2,380 m^2 dedicated to roof top urban agricultural use; green façades total installation is 2,690 m^2; interior living walls total installation 90 m^2; exterior living walls total installation 4,700 m^2; rain gardens total installation 1,775 m^2; bioswales total 1,120 m^2; permeable paver totals 5,775 m^2; small trees total 25 trees; medium trees total 417 trees; large trees total 139 trees; newly constructed wetlands total 1,380 m^2, with the existing wetland of the Edgeley Pond site totalling an additional 74,000 m^2; planting beds total 4,210 m^2; active turf totals 2,250 m^2 and passive turf totals 5,355 m^2.

The site plans work within the context of the VMC Secondary Plan as well as the draft VMC Streetscape and Open Space Plan. The plans aim to help ensure that the revitalized Black Creek becomes an integral part of the green public infrastructure within the Vaughan Metropolitan Centre in its design concept and through the provision of design guidelines. The plans incorporate the idea of opening up spaces with a view to the pond and softening building edges.

VAUGHAN: SITE 3

⟶ Existing Site Plan

VAUGHAN: SITE 3

⟶ Redesign Concepts

The Site 3 team aimed to address connectivity for pedestrians and cyclists along the stormwater management pond to other VMC sites and with the nearby developments.

The site will have a strong focus on cultural heritage interpretation and integration with natural heritage through its design. Given the context of the site in proximity to Edgeley Pond a strong emphasis on stormwater management and naturalized stormwater management through the pond. The site creates a smooth transition from urban spaces to natural spaces, including the importance of viewscapes to natural areas.

The Site 3 team plan aims to activate privately owned public space through a number of design interventions. This site redesign calls for an enlarged urban square for amenity space that creates an opening up of views to naturalized green space.

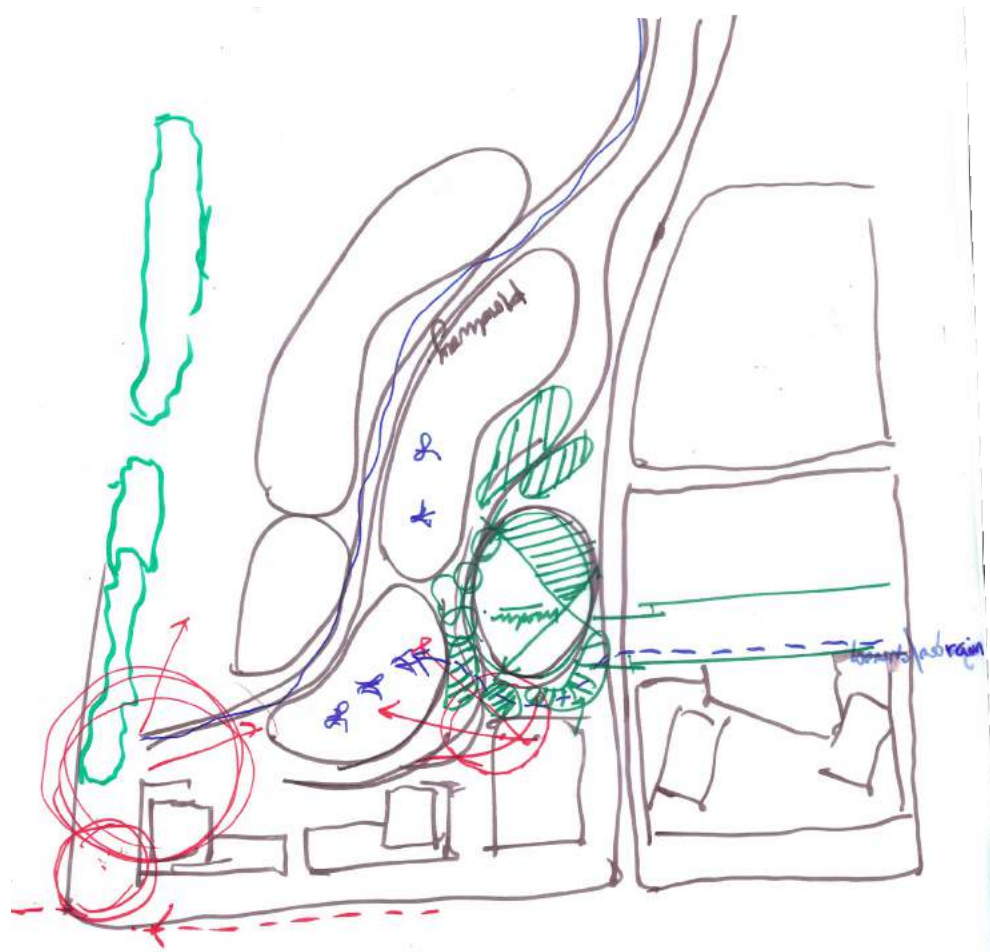
The site navigates natural and cultural heritage interpretation though the use of green façades on podium walls, bioswales bounding vehicular laneway, dense tree canopy areas as well as green roof installation on building podiums. Through the use of this green infrastructure on the site not only will the strong emphasis on naturalized stormwater management be realized, but it will also help create a smooth transition from urban to natural space on the site.

Pedestrian and cyclist connectivity is addressed through safety-first development of table top traffic calming. This helps negotiate the transition from urban area to green space by changing material use and elevation of north-south roadway.

The site redesign is guided by the principle of creating Edgeley Green/ Edgeley Grove. Transitions of natural elements are a reoccurring theme that sees on site bioswales moving into rain gardens and ultimately the wetland. Edgeley Green/Edgeley Grove creates a variety of amenity spaces, including active transportation, quiet space, and multi-purpose green space that can remain comfortably in flux. This green space allows for a multi-layer trail system creating east west pedestrian and cyclist connection from Jane Street. The team also made note that the naturalized stormwater management pond requires a closer look to create natural features at edges rather than standard engineered slopes.

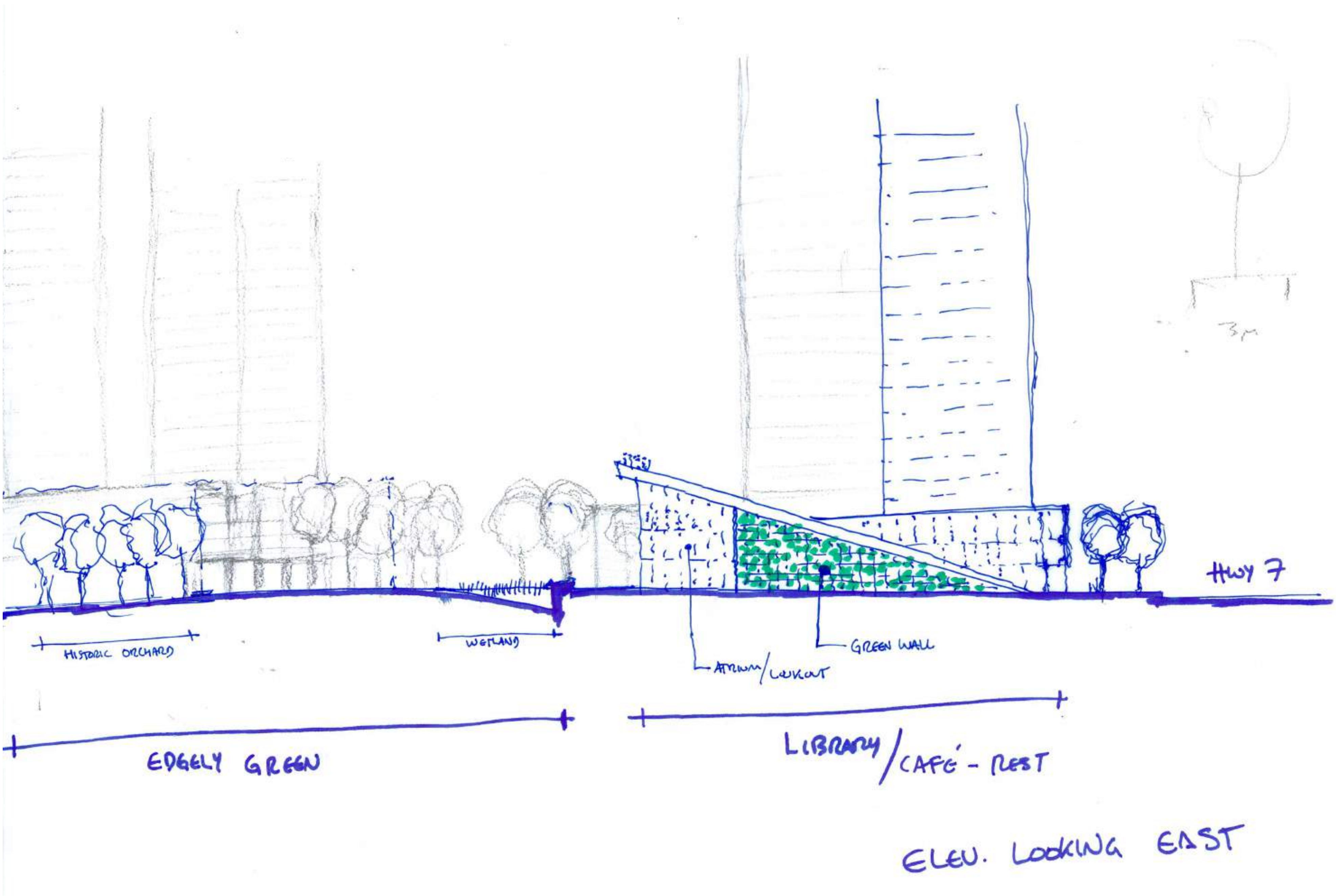
Through the use of an orchard/grove feature the cultural heritage of the previous Edgeley Pond community is addressed, while providing shade and quiet space to the new residents of the prospective community.

The site creates a context to which the introduction of civic programming becomes possible. This can be achieved through the proposed library that overlooks Edgeley Pond and the newly imagined naturalized space. The library would become a focal point for community gathering.



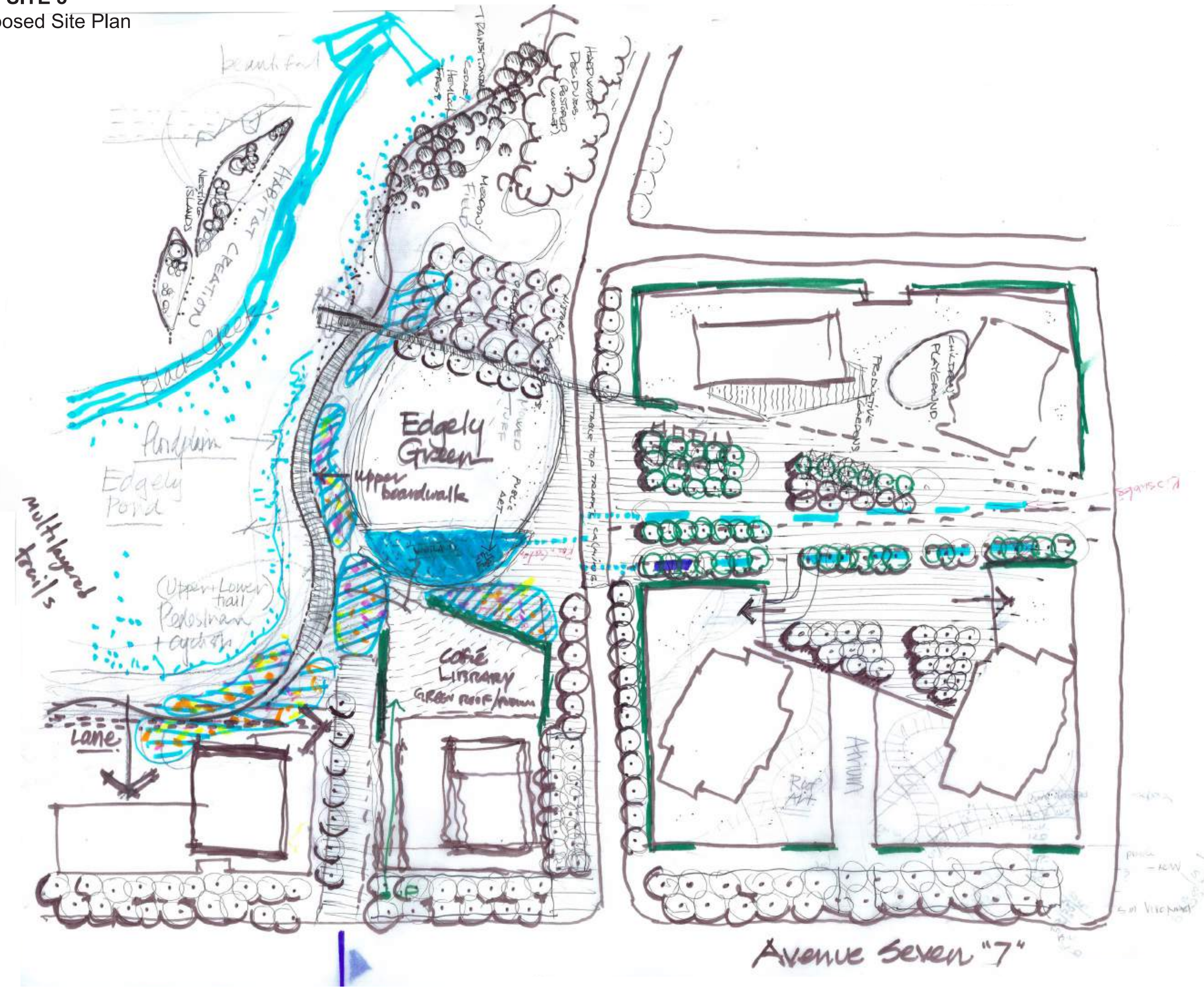
VAUGHAN: SITE 3

⟶ Redesign Concepts



VAUGHAN: SITE 3

⟶ Proposed Site Plan



VAUGHAN: SITE 3

⟶ Green Infrastructure Area Totals

The Site 3 team has specified 2,100 m^2 of intensive green roof to be installed on the building podium to act in tandem with 470 m^2 of green façades planted in-situ, climbing up the three-story podium.

1,400 m^2 of rain garden is used on the site for Edgeley Green as well as a 450 m^2 wetland area and 2,250 m^2 of active turf. Together these forms of green infrastructure create a transitional natural element acting as a transitional space from urban to natural. The site's urban square features 400 m^2 of bioswale and 550 m^2 of permeable paver.

Between both the Site 3 team's proposed Edgeley Green and urban square 74 medium trees will be planted on site. The team also specified planting of 64 large trees along Highway 7, rebranded as 'Avenue 7'. In addition to the 64 large trees, Avenue 7 will also feature 810 m^2 of planting beds both ornamental and natural in plant material.

For the purposes of a the cost-benefit analysis the City of Vaughan has requested that all three separate site redesigns be evaluated as a whole. The amalgamated area will be known as the Edgeley Pond site.

Area take-offs for the Edgeley Pond site are as follows: extensive green roof installations total 3,290 m^2; intensive green roof installations total 2,850 m^2 with another 2,380 m^2 dedicated to roof top urban agricultural use; green façades total installation is 2,690 m^2; interior living walls total installation 90 m^2; exterior living walls total installation 4,700 m^2; rain gardens total installation 1,775 m^2; bioswales total 1,120 m^2; permeable paver totals 5,775 m^2; small trees total 25 trees; medium trees total 417 trees; large trees total 139 trees; newly constructed wetlands total 1,380 m^2, with the existing wetland of the Edgeley Pond site totalling an additional 74,000 m^2; planting beds total 4,210 m^2; active turf totals 2,250 m^2 and passive turf totals 5,355 m^2.

The site plans work within the context of the VMC Secondary Plan as well as the draft VMC Streetscape and Open Space Plan. The plans aim to help ensure that the revitalized Black Creek becomes an integral part of the green public infrastructure within the Vaughan Metropolitan Centre in its design concept and through the provision of design guidelines. The plans incorporate the idea of opening up spaces with a view to the pond and softening building edges.

VAUGHAN: EDGELEY POND SITE

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	3290	0	$658,000	$11,515
Intensive Green Roof	4730	500	$1,961,250	$156,900
Green Façade	6490	0	$973,500	$64,900
Living Wall - Interior	900	0	$1,210,941	$339,093
Living Wall - Exterior	900	0	$968,751	$339,093
Rain Garden	1775	0	$202,528	$9,177
Bioswale	920	0	$148,543	$4,756
Permeable Surface - Porous Paver	5775	0	$683,818	$1,328
Tree - Small	6915	0	$40,245	$1,660
Tree - Medium	2580	0	$6,837	$284
Tree - Large	37192	0	$78,475	$2,975
Wetland	930	0	$15,782	$251
Planting Bed	4210	0	$611,797	$21,766
Turf - Active	2250	0	$26,393	$2,138
Tuf - Naturalized	5355	0	$18,796	$2,088
TOTAL	**84212**	**500**	**$7,605,656**	**$957,924**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

VAUGHAN: EDGELEY POND SITE

⟶ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	3290	0	$18,292	$18,376
Intensive Green Roof	4730	500	$188,960	$132,044
Green Façade	6490	0	$33,878	$10,274
Living Wall - Interior	900	0	$0	$49
Living Wall - Exterior	900	0	$4,392	$1,533
Rain Garden	1775	0	$64,131	$4,917
Bioswale	920	0	$33,240	$4,594
Permeable Surface - Porous Paver	5775	0	$0	$6,872
Tree - Small	6915	0	$249,839	$25,272
Tree - Medium	2580	0	$93,215	$11,243
Tree - Large	37192	0	$1,343,747	$194,057
Wetland	930	0	$33,601	$5,203
Planting Bed	4210	0	$21,976	$13,358
Turf - Active	2250	0	$11,745	$4,629
Tuf - Naturalized	5355	0	$193,476	$14,594
TOTAL	**84212**	**500**	**$2,290,492**	**$447,014**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

VAUGHAN: EDGELEY POND SITE

⟶ Estimated Job Creation

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	11.745	12.732	16.680	21.615
Intensive Green Roof	34.983	48.976	104.948	174.912
Green Façade	34.731	46.309	92.621	150.512
Living Wall - Interior	58.384	88.628	209.606	360.829
Living Wall - Exterior	43.200	73.445	194.423	345.645
Rain Garden	3.613	4.429	7.695	11.778
Bioswale	2.650	3.073	4.766	6.882
Permeable Surface - Porous Paver	12.197	12.312	12.774	13.352
Tree - Small	0.719	0.857	1.411	2.102
Tree - Medium	0.121	0.147	0.250	0.379
Tree - Large	1.413	1.599	2.343	3.273
Wetland	0.282	0.305	0.398	0.514
Planting Bed	10.912	12.849	20.595	30.278
Turf - Active	0.470	0.662	1.427	2.383
Tuf - Naturalized	0.337	0.525	1.274	2.212
TOTAL JOB CREATION	**215.76**	**306.85**	**671.21**	**1126.67**

VAUGHAN: EDGELEY POND SITE - CONCLUSIONS

⟶ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$18,292	$80,067	$327,164	$636,036
Intensive Green Roof	$188,960	$559,933	$2,043,824	$3,898,688
Green Façade	$33,878	$84,957	$289,272	$544,667
Living Wall - Interior	$0	$243	$1,217	$2,434
Living Wall - Exterior	$4,392	$12,015	$42,509	$80,626
Rain Garden	-$138,397	-$159,696	-$244,893	-$351,390
Bioswale	-$115,304	-$116,116	-$119,367	-$123,430
Permeable Surface - Porous Paver	-$683,818	-$656,098	-$545,218	-$406,618
Tree - Small	$209,594	$327,380	$798,527	$1,387,460
Tree - Medium	$86,378	$141,045	$359,710	$633,042
Tree - Large	$1,265,272	$2,217,703	$6,027,429	$10,789,585
Wetland	$17,819	$42,580	$141,625	$265,431
Planting Bed	-$589,821	-$631,858	-$800,007	-$1,010,194
Turf - Active	-$14,648	-$2,192	$47,630	$109,908
Tuf - Naturalized	$174,680	$237,207	$487,316	$799,951
TOTAL ROI FOR SITE REDESIGN	**$457,278**	**$2,137,170**	**$8,856,738**	**$17,256,197**

Site 1 Working Group. Credit: Green Roofs for Healthy Cities.

Site 2 Working Group. Credit: Green Roofs for Healthy Cities.

Site 3 Working Group. Credit: Green Roofs for Healthy Cities.

VAUGHAN
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Loy Cheah, York Region
Marina Haufschild, City of Markham
Chris Wolnik, City of Vaughan
Gaetano Franco, Castlepoint Investments
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Andy Lee, City of Vaughan

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Carolyn Woodland, Toronto and Region Conservation Authority
Junyan Zhang, Toronto and Region Conservation Authority

A special thank you to all of the participants as well as the following persons that dedicated their time, energy and expertise in the organization of the Vaughan Design Charrette, without your hard work and dedication this project would not have been possible:

Mayor Maurizio Bevilacqua, City of Vaughan
Amy Roots, City of Vaughan
Audrey Farias, City of Vaughan
Moira Wilson, City of Vaughan
Tony Iacobelli, City of Vaughan
John MacKenzie, City of Vaughan

The city of Vaughan is appreciative of the landowners' participation in this project, and it should be noted that the ideas generated during the charrette are purely conceptual and for the purposes of promoting green infrastructure education and awareness.

Oshawa
Prepare To Be Amazed

OSHAWA CHARRETTE REPORT

OSHAWA
⟶ Context, Sites & Goals

Based on climate projections outlined in *Durham Region's Future Climate (2040 - 2049)* study, it has become apparent that we now need to assess the implications for our physical infrastructure, business continuity, government services, food production, health and security. The report provides detailed climate projections for all eight local municipalities in the Region of Durham: Ajax, Pickering, Brock (Beaverton), Scugog (Port Perry), Clarington (Bowmanville), Uxbridge (Town of Uxbridge), Oshawa and Whitby.

Overall, Durham Region's climate in the 2040 to 2049 period can be described as: Considerably warmer with higher humidity; Less snow, more rain in winter; More frequent and intense summer rain events; Lower winds generally; and More extreme weather events with high winds and heavy rain.

About 16% more precipitation (snow and rainfall) overall
- ~50% increase in the one day maximum rainfall
- ~40% decrease in the one day maximum snowfall
- 100% increase in the number of days of rain greater than 25 mm
- 80% reduction in the number of days with snow more than 5 cm
- 146% more rain and 61% less snow in January
- 217% more rain and 75% less snow in February

Rainstorm events will be more extreme
- 15% increase in the potential for violent storms
- 53% increase in the potential for tornadoes
- 74% more rain in July and 79% more rain in August
- Average temperature increase of 4.0^{o}C/yr
- average winter temperatures increase by 5.8^{o}C
- average summer temperatures increase by 2.6^{o}C
- extreme daily minimum temperature "becomes less cold" by 12^{o}C
- extreme daily maximum temperature "becomes warmer" by 7.1^{o}C

Average windspeed about the same
- maximum hourly winds reduced
- maximum wind gusts reduced about 13% "Comfort" remains similar but with some extreme events
- humidity and temperature taken together as the Humidex remains similar (within 8% of present on average) for most of the year but shows increases in November (up 30%) and in May through to September (up15%) and pushes past the "dangerous" level (45) on several days
- Wind Chill is reduced by about 50% on average but is reduced 25-45% during the winter months

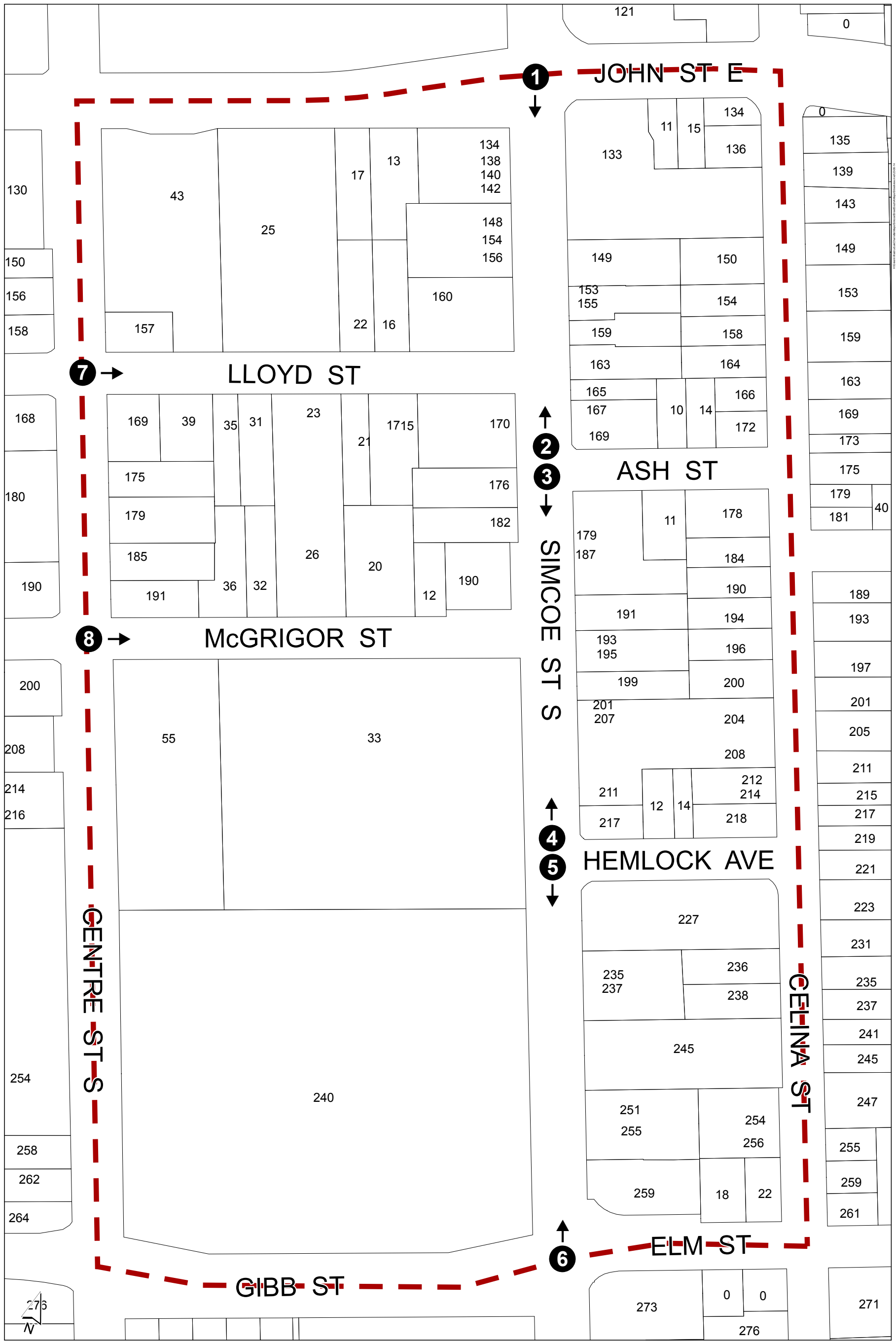

Mayor John Henry, City of Oshawa, addresses Oshawa Green Infrastructure Design Charrette participants. Credit: Green Roofs for Healthy Cities.

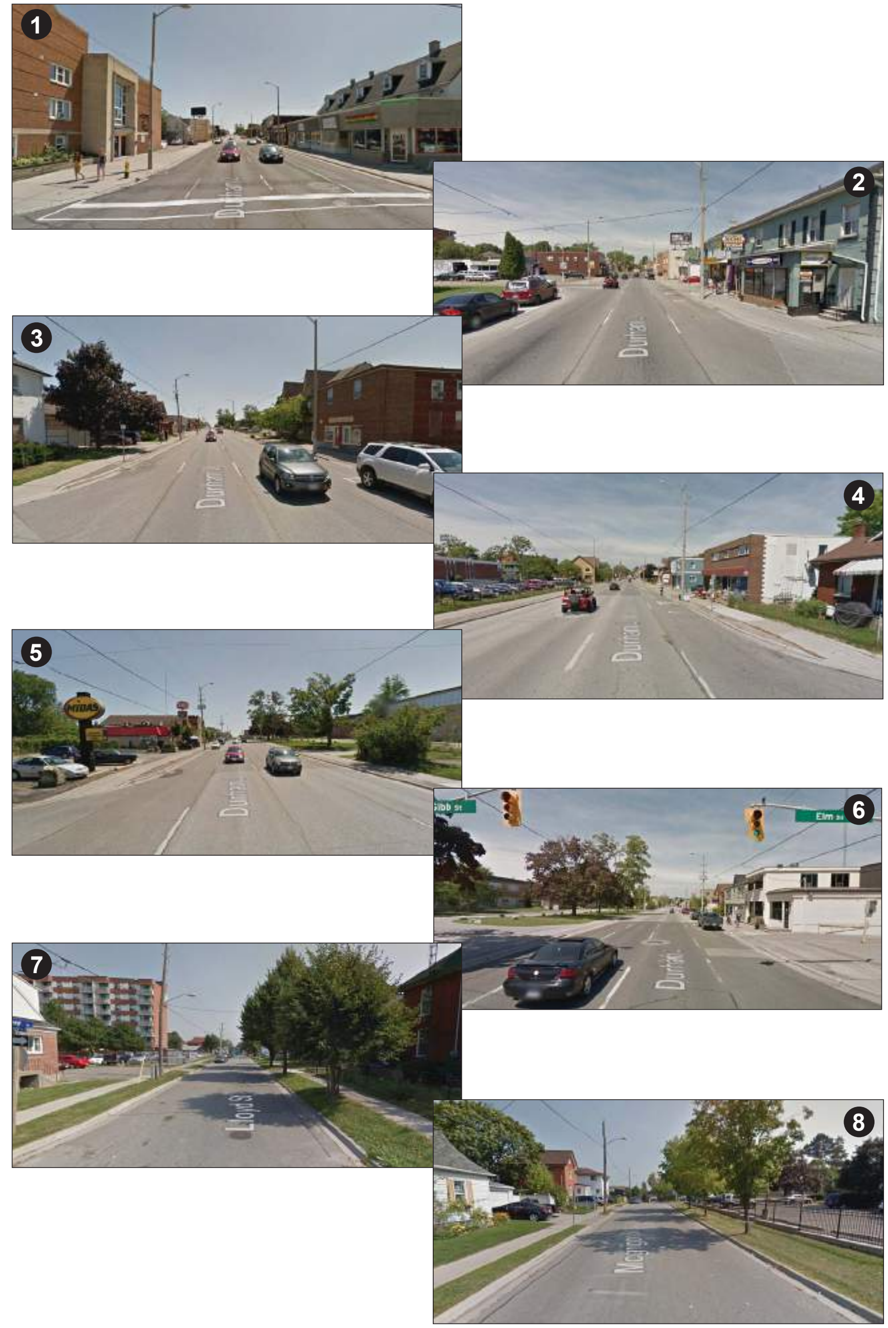
With looming indications suggesting increased possibilities of flooding, heat stroke, vector-born diseases, tornadoes, disruption to energy supply and many more we must ask ourselves: what can we do to protect ourselves and make our community more resilient to these coming changes? The Green Infrastructure Design Charrette aims to navigate some of these potential future threats by amalgamating the expertise of various sectors of the community to:
- identify implications;
- assess vulnerabilities;
- identify measures and actions to reduce impacts and increase resilience;
- assist in the development of a proposed Community Climate Adaptation Plan for adoption and implementation by the public and private sectors in Durham Region.

The full SENES report is available on request: climatechange@durham.ca.

OSHAWA: SITE 1 - SIMCOE STREET SOUTH 'A'

→ Existing Site & Streetscape Conditions





OSHAWA: SITE 1 - SIMCOE STREET SOUTH ‘A’

⟶ Redesign Concepts

The Simcoe Street South ‘A’ team arrived at the following concepts:

Green Roofs
- Extensive system on Simcoe School (retrofit)
- Extensive system on Seniors apartment (retrofit)

Exterior Living Wall
- Dental office on Gibb / Simcoe (retrofit)
- YWCA (retrofit)
- Simcoe School (retrofit)

Rain Garden
- YWCA along Simcoe side of building condition
- Along any building footprints that contain excess water runoff

Bioswale
- Along Centre Street South
- John Street to Gibb Street

Permeable/ Porous Paver
- Entire Simcoe School parking lot

Tree - Small
- Planted along walkway / promenade

Tree - Medium
- Planted along Celina Street, Lloyd Street, and Simcoe Street

Tree - Large
- Planted for two parkettes as seen in site plan

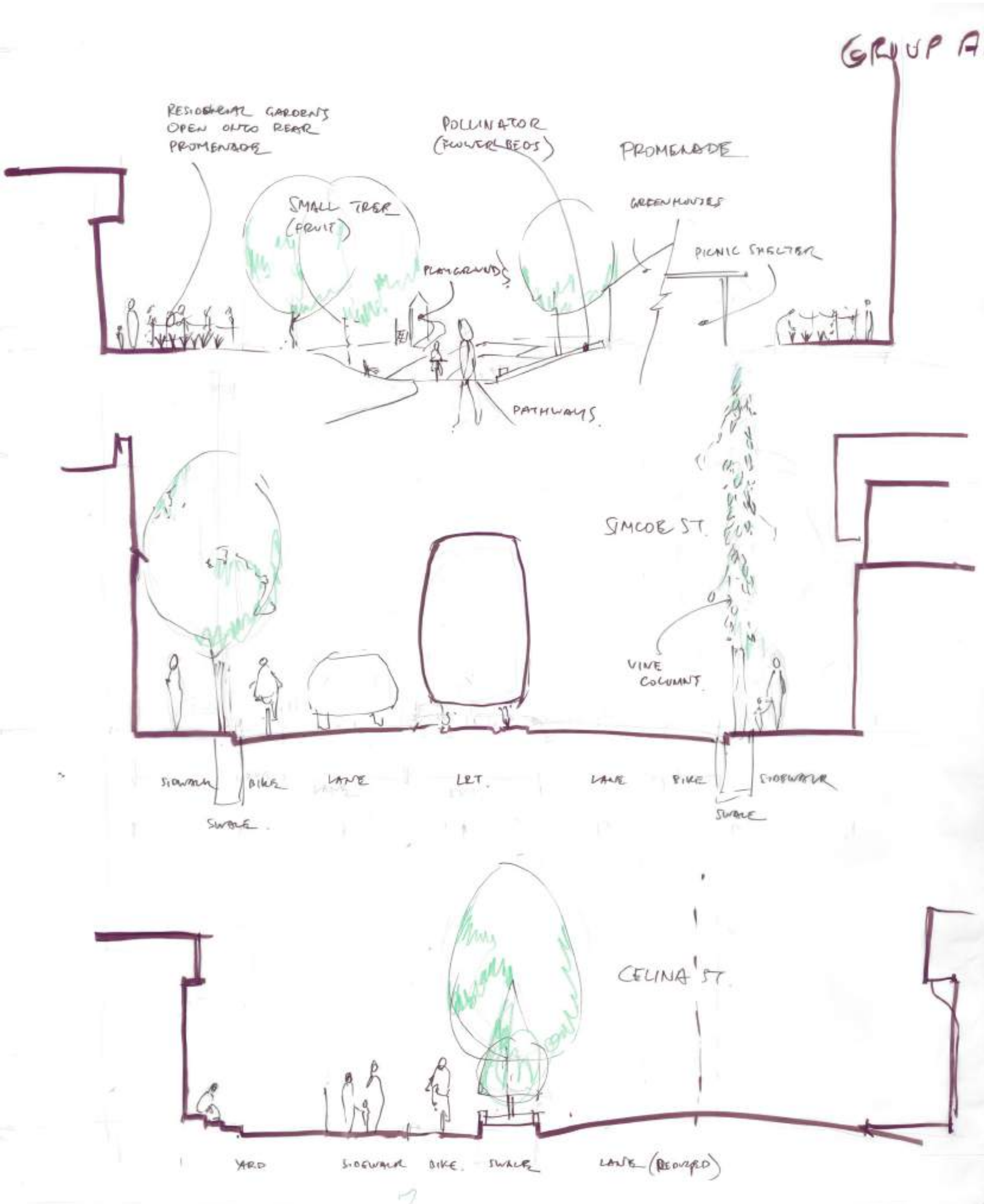
Planting Beds
- Along Alans Walkway
- Simcoe School pollinator garden & vegetable garden
- Soup kitchen (future location)

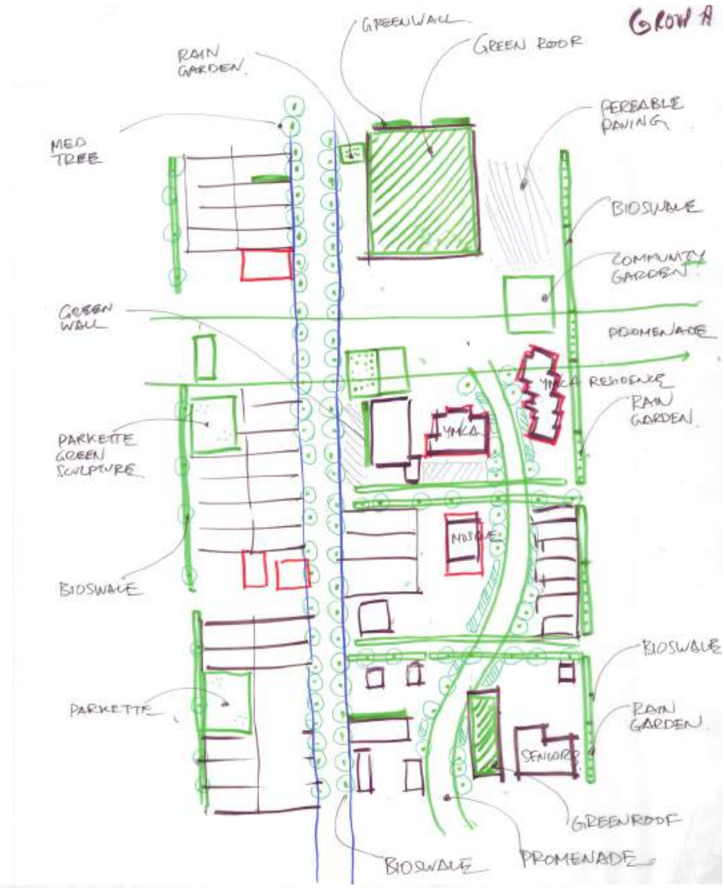
Active Turf
- Simcoe School playground and for new parkettes

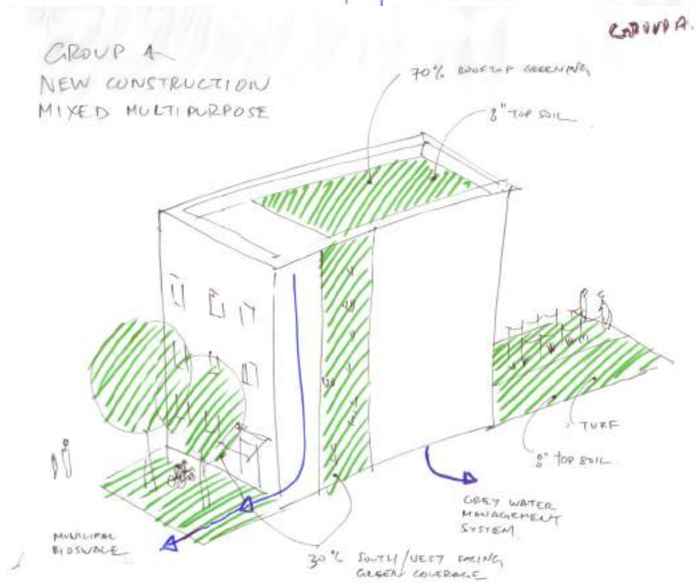
Visualization of site redesign concepts for Site 1 Simcoe Street South ‘A’. Credit: Green Roofs for Healthy Cities.

OSHAWA: SITE 1 - SIMCOE STREET SOUTH 'A'

⟶ Redesign Concepts







OSHAWA: SITE 1 - SIMCOE STREET SOUTH 'A'

⟶ Proposed Site Plan

OSHAWA: SITE 1 - SIMCOE STREET SOUTH ‘A’

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	4680	0	$936,000	$16,380
Intensive Green Roof	0	4000	$1,500,000	$120,000
Green Façade	0	0	$0	$0
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	1800	0	$1,937,502	$678,186
Rain Garden	10000	0	$1,141,000	$51,700
Bioswale	1750	0	$282,555	$9,048
Permeable Surface - Porous Paver	660	0	$78,151	$152
Tree - Small	0	1858	$10,813	$446
Tree - Medium	4522	0	$11,983	$497
Tree - Large	1703	0	$3,593	$136
Wetland	3200	0	$54,304	$864
Planting Bed	2080	0	$302,266	$10,754
Turf - Active	3100	0	$36,363	$2,945
Tuf - Naturalized	0	0	$0	$0
TOTAL	**33495**	**5858**	**$6,294,530**	**$891,107**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

OSHAWA: SITE 1 - SIMCOE STREET SOUTH 'A'

⟶ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	4680	0	$26,021	$26,139
Intensive Green Roof	0	4000	$144,520	$737,685
Green Façade	0	0	$0	$0
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	1800	0	$8,784	$3,066
Rain Garden	10000	0	$361,300	$27,701
Bioswale	1750	0	$63,228	$8,738
Permeable Surface - Porous Paver	660	0	$0	$785
Tree - Small	0	1858	$67,128	$9,763
Tree - Medium	4522	0	$163,380	$19,706
Tree - Large	1703	0	$61,529	$8,886
Wetland	3200	0	$115,616	$17,904
Planting Bed	2080	0	$10,858	$6,600
Turf - Active	3100	0	$16,182	$6,377
Tuf - Naturalized	0	0	$0	$0
TOTAL	**33495**	**5858**	**$1,038,545**	**$873,350**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

OSHAWA: SITE 1 - SIMCOE STREET SOUTH ‘A’

⟶ Estimated Job Creation

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	16.708	18.112	23.728	30.748
Intensive Green Roof	26.756	37.458	80.266	133.776
Green Façade	0.000	0.000	0.000	0.000
Living Wall - Interior	0.000	0.000	0.000	0.000
Living Wall - Exterior	86.400	146.889	388.845	691.290
Rain Garden	20.353	24.953	43.353	66.353
Bioswale	5.040	5.845	9.065	13.090
Permeable Surface - Porous Paver	1.394	1.407	1.460	1.526
Tree - Small	0.193	0.230	0.379	0.565
Tree - Medium	0.213	0.258	0.439	0.665
Tree - Large	0.065	0.073	0.107	0.150
Wetland	0.970	1.050	1.370	1.770
Planting Bed	5.391	6.348	10.175	14.959
Turf - Active	0.648	0.911	1.965	3.283
Tuf - Naturalized	0.000	0.000	0.000	0.000
TOTAL JOB CREATION	**164.13**	**243.53**	**561.15**	**958.17**

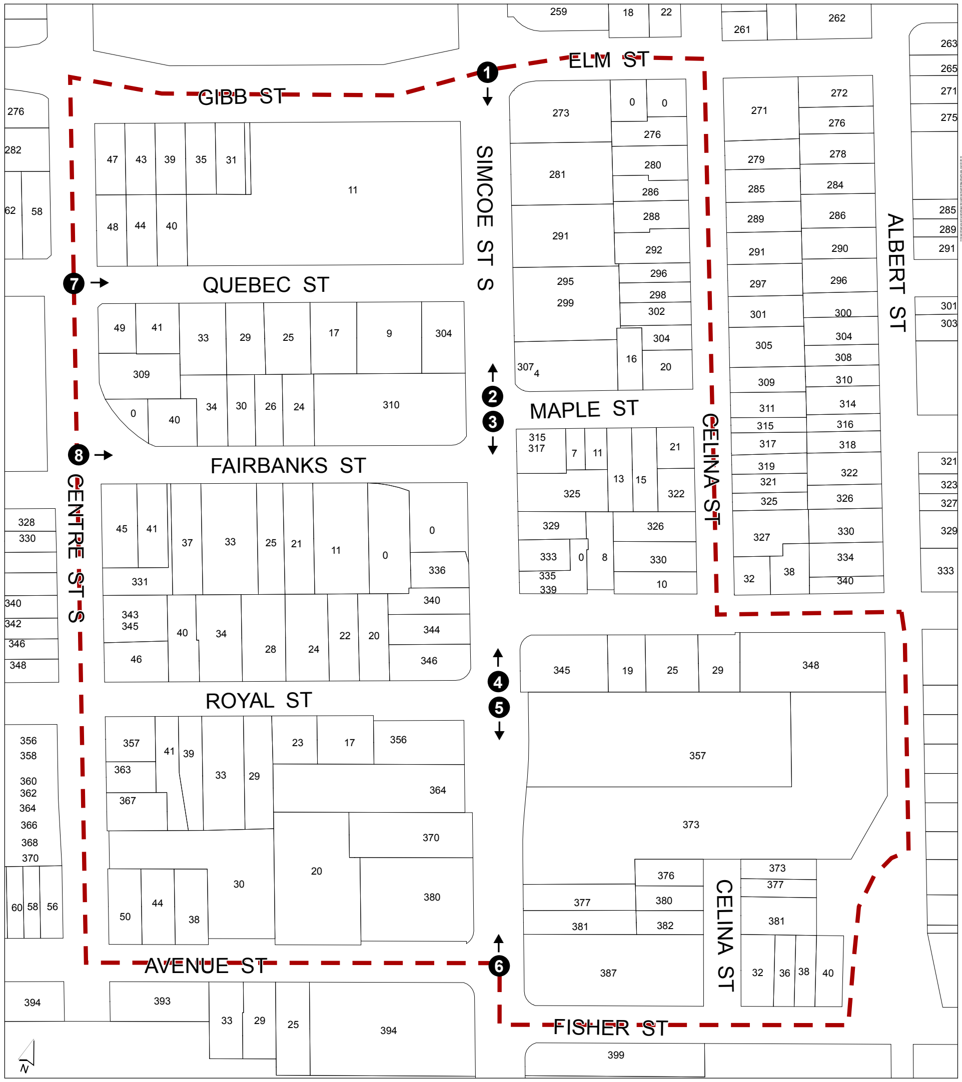
OSHAWA: SITE 1 - SIMCOE STREET SOUTH 'A' - CONCLUSIONS

⟶ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$26,021	$113,894	$465,389	$904,756
Intensive Green Roof	$144,520	$2,019,987	$9,521,854	$18,899,188
Green Façade	$0	$0	$0	$0
Living Wall - Interior	$0	$0	$0	$0
Living Wall - Exterior	$8,784	$24,031	$85,018	$161,251
Rain Garden	-$779,700	-$899,696	-$1,379,680	-$1,979,660
Bioswale	-$219,328	-$220,873	-$227,056	-$234,785
Permeable Surface - Porous Paver	-$78,151	-$74,983	-$62,311	-$46,471
Tree - Small	$56,315	$95,394	$251,712	$447,109
Tree - Medium	$151,397	$247,211	$630,469	$1,109,541
Tree - Large	$57,936	$101,547	$275,992	$494,049
Wetland	$61,312	$146,512	$487,312	$913,312
Planting Bed	-$291,408	-$312,177	-$395,253	-$499,098
Turf - Active	-$20,181	-$3,020	$65,624	$151,429
Tuf - Naturalized	$0	$0	$0	$0
TOTAL ROI FOR SITE REDESIGN	**-$882,483**	**$1,237,827**	**$9,719,069**	**$20,320,621**

OSHAWA: SITE 2 - SIMCOE STREET SOUTH ‘B’

→ Existing Site & Streetscape Conditions



Implementable ideas generated by the Simcoe Street South ‘B’ team include the following features:

- Bike lanes
- Urban growing space
- Buffer residence from main street
- Consolidate space and introduce green teaching areas
- Bioretention cells
- Rain water harvesting
- Tree planting and native plantings
- Increase parking density to open up green space
- Rainwater harvesting
- Design buildings to suit community
- Bioswales on major roadways- Bioretention before Oshawa Creek
- Create community focus areas
- Identify and protect stable residential areas
- Deal with stromwater within the community with natural features
- Intensify green areas on side of roads
- Green roofs
- Community Gardens
- Church- utilize and redesign
- Mid-rises with food and growing gardens
- Living walls on larger buildings
- Parking areas and paths permeable pavement features
- Involve community participation in development changes
- Building green redevelopment and intensification for loss of housing
- Increase green canopy
- Identify opportunity for developing LID projects
- Green roof on parking garage at Church and Gibb
- Medical centre could have additional green space
- Green roofs at Al-Azhar Academy
- All retrofits of parking areas should consider permeable area
- Roof top urban agriculture
- Infiltration trenches in parking areas or where applicable

Overall the concept of a greener community with features to bring the community together and more pleasant came out with the majority of the group B ideas. These varied, from implementing green roofs, permeable paving, to storm water management type features with a natural and green theme. Community gardens were also suggested within central locations with additional natural gardens throughout the area. Where possible the team also suggested rain gardens or naturalized planting beds. The streetscapes were suggested to have a large tree canopy added. Rainwater harvesting would also benefit this design with the water being used by local residents or the large cisterns being used for the public gardens.

The parking garages were to be 3 stories with intensive green roofs and green facades with rainwater harvesting. Streets beds varied from 3-5m. The bioswale design would be connected to a bioretention feature before it hit the Oshawa Creek.

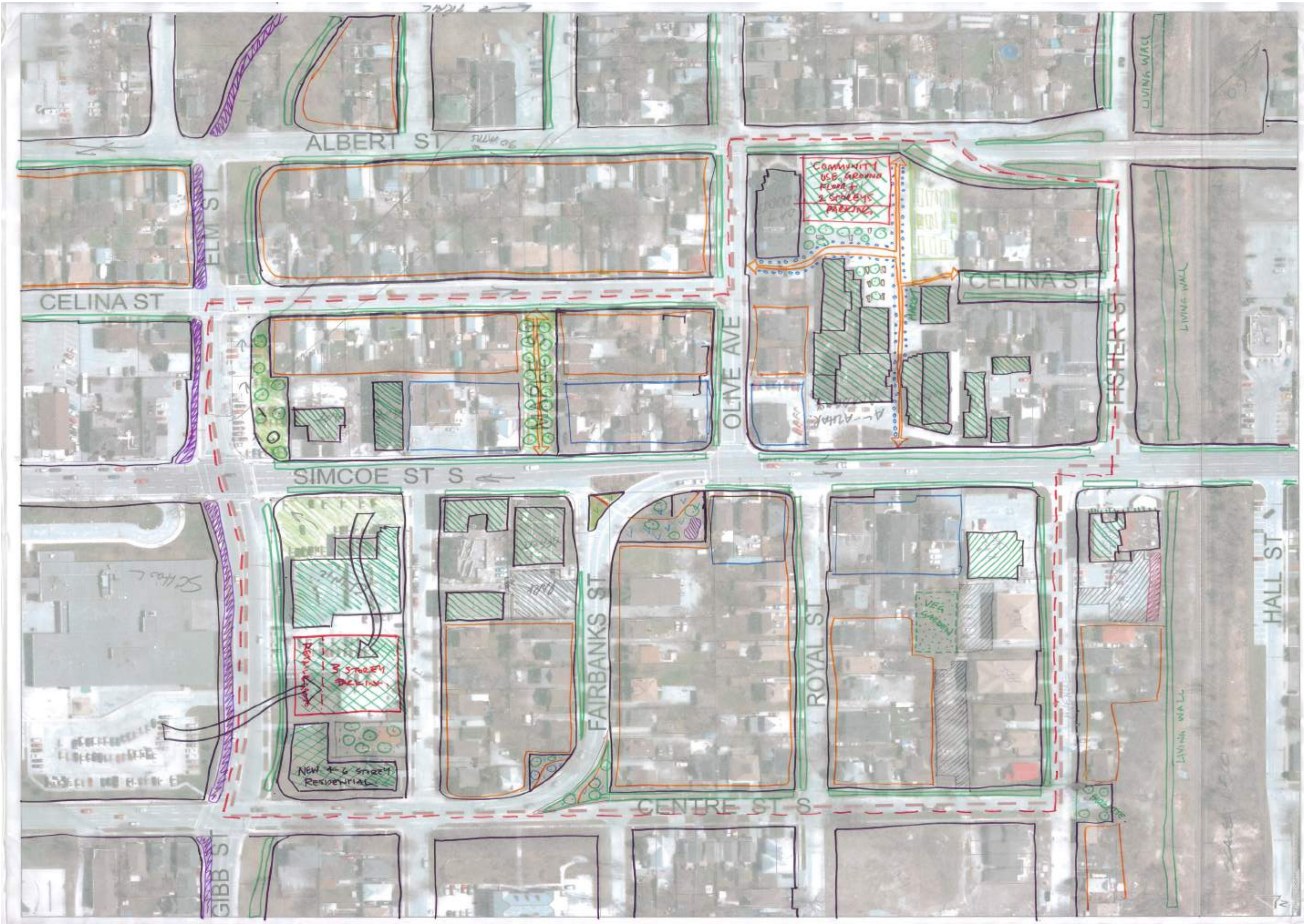
Concepts that didn’t make the cut:
- Roundabout at Gibb and Simcoe
- Identify street priorities- transit, pedestrian, vision etc
- Remove lights at Olive and use a roundabout at Fairbanks

Cost was the main factor for the disqualification for the roundabouts.

Implementation Ideas
- Expanding City of Oshawa Community Improvement Fund
- Community in Bloom initiatives to merchants
- Resident involvement in development of their community (active as well as consultative)

OSHAWA: SITE 2 - SIMCOE STREET SOUTH ‘B’

⟶ Proposed Site Plan



OSHAWA: SITE 2 - SIMCOE STREET SOUTH 'B'

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	2925	0	$585,000	$10,238
Intensive Green Roof	5780	4000	$3,667,500	$293,400
Green Façade	1060	0	$159,000	$10,600
Living Wall - Interior	100	0	$134,549	$37,677
Living Wall - Exterior	250	0	$269,098	$94,193
Rain Garden	100	0	$11,410	$517
Bioswale	1190	0	$192,137	$6,152
Permeable Surface - Porous Paver	2325	0	$275,303	$535
Tree - Small	5161	1858	$40,850	$1,685
Tree - Medium	0	0	$0	$0
Tree - Large	50252	0	$106,032	$4,020
Wetland	0	0	$0	$0
Planting Bed	8350	1200	$1,387,806	$49,374
Turf - Active	0	0	$0	$0
Tuf - Naturalized	1250	0	$4,388	$488
TOTAL	**78743**	**7058**	**$6,833,073**	**$508,877**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

OSHAWA: SITE 2 - SIMCOE STREET SOUTH ‘B’

⟶ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	2925	0	$16,263	$16,337
Intensive Green Roof	5780	4000	$353,351	$786,361
Green Façade	1060	0	$5,533	$1,678
Living Wall - Interior	100	0	$0	$5
Living Wall - Exterior	250	0	$1,220	$426
Rain Garden	100	0	$3,613	$277
Bioswale	1190	0	$42,995	$5,942
Permeable Surface - Porous Paver	2325	0	$0	$2,767
Tree - Small	5161	1858	$253,595	$28,625
Tree - Medium	0	0	$0	$0
Tree - Large	50252	0	$1,815,605	$262,200
Wetland	0	0	$0	$0
Planting Bed	8350	1200	$49,851	$241,502
Turf - Active	0	0	$0	$0
Tuf - Naturalized	1250	0	$45,163	$3,407
TOTAL	**78743**	**7058**	**$2,587,189**	**$1,349,526**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

OSHAWA: SITE 2 - SIMCOE STREET SOUTH 'B'

⟶ Estimated Job Creation

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	10.442	11.320	14.830	19.217
Intensive Green Roof	65.418	91.585	196.250	327.082
Green Façade	5.672	7.564	15.128	24.583
Living Wall - Interior	6.487	9.848	23.290	40.092
Living Wall - Exterior	12.000	20.401	54.006	96.013
Rain Garden	0.204	0.250	0.434	0.664
Bioswale	3.427	3.975	6.164	8.901
Permeable Surface - Porous Paver	4.910	4.957	5.143	5.375
Tree - Small	0.730	0.870	1.432	2.134
Tree - Medium	0.000	0.000	0.000	0.000
Tree - Large	1.910	2.161	3.166	4.422
Wetland	0.000	0.000	0.000	0.000
Planting Bed	24.754	29.147	46.719	68.684
Turf - Active	0.000	0.000	0.000	0.000
Tuf - Naturalized	0.079	0.123	0.298	0.516
TOTAL JOB CREATION	**136.03**	**182.20**	**366.86**	**597.68**

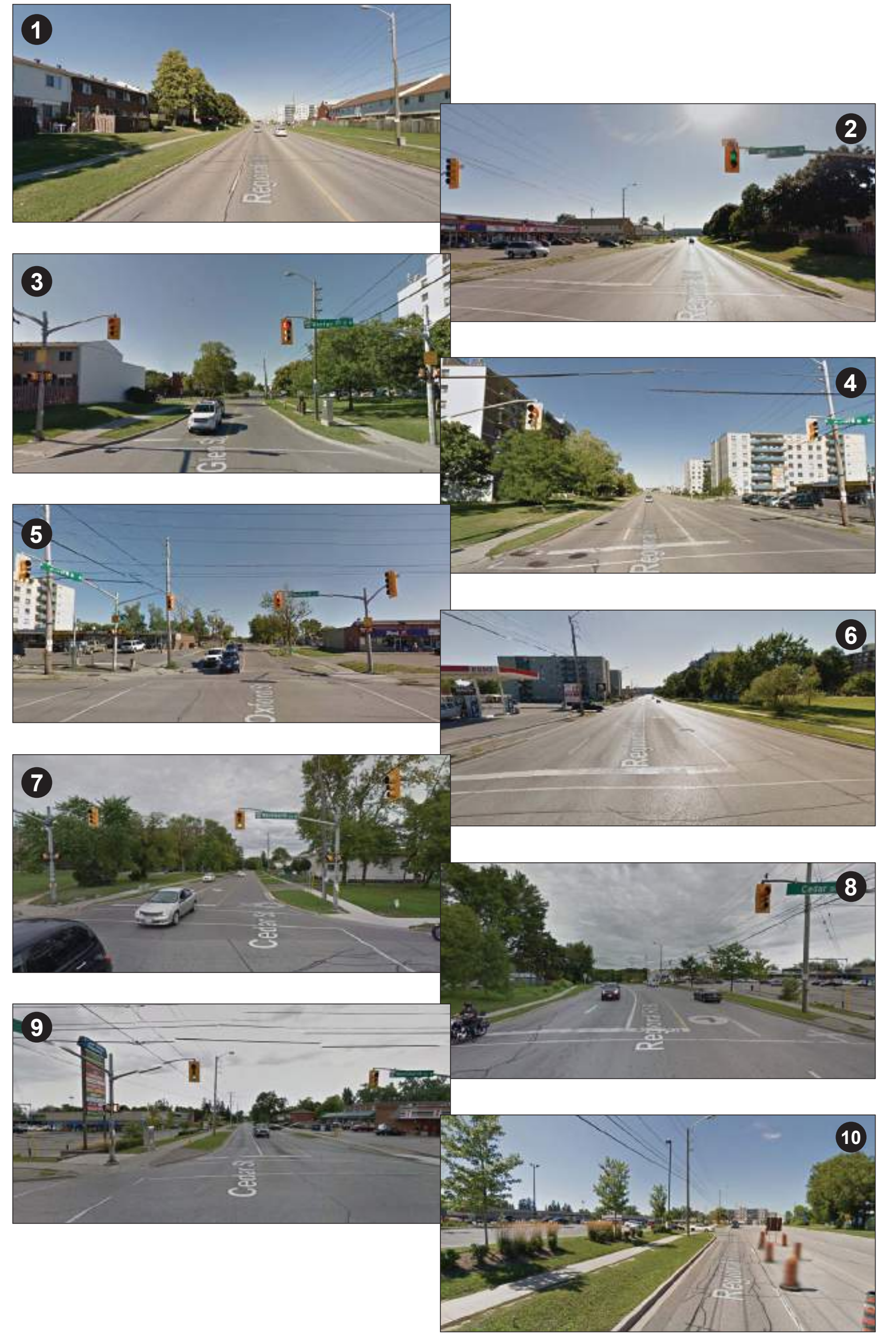
OSHAWA: SITE 2 - SIMCOE STREET SOUTH ‘B’ - CONCLUSIONS

⟶ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$16,263	$71,184	$290,868	$565,473
Intensive Green Roof	$353,351	$2,395,668	$10,564,933	$20,776,515
Green Façade	$5,533	$13,876	$47,246	$88,959
Living Wall - Interior	$0	$27	$135	$270
Living Wall - Exterior	$1,220	$3,338	$11,808	$22,396
Rain Garden	-$7,797	-$8,997	-$13,797	-$19,797
Bioswale	-$149,143	-$150,194	-$154,398	-$159,654
Permeable Surface - Porous Paver	-$275,303	-$264,143	-$219,503	-$163,703
Tree - Small	$212,745	$339,734	$847,691	$1,482,638
Tree - Medium	$0	$0	$0	$0
Tree - Large	$1,709,573	$2,996,451	$8,143,965	$14,578,356
Wetland	$0	$0	$0	$0
Planting Bed	-$1,337,955	-$905,313	$825,256	$2,988,468
Turf - Active	$0	$0	$0	$0
Tuf - Naturalized	$40,775	$55,371	$113,753	$186,730
TOTAL ROI FOR SITE REDESIGN	**$569,262**	**$4,547,001**	**$20,457,957**	**$40,346,651**

OSHAWA: SITE 3 - WENTWORTH CEDAR

⟶ Existing Site & Streetscape Conditions



OSHAWA: SITE 3 - WENTWORTH CEDAR

⟶ Redesign Concepts

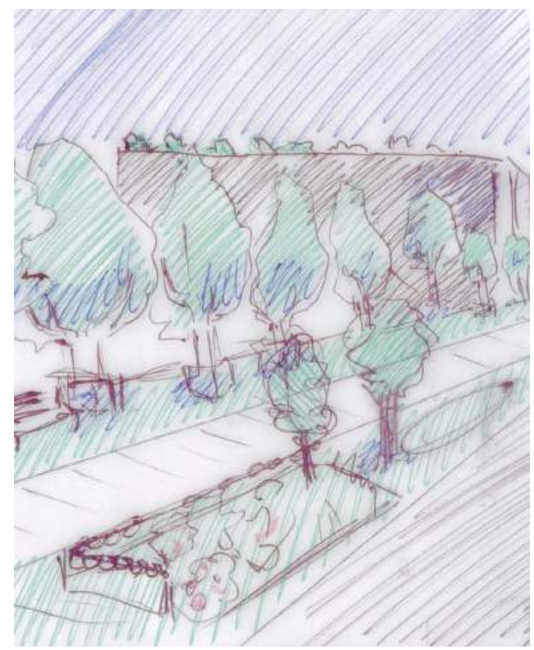
The Wentworth Cedar design team arrived at the following concepts:

Connectivity to valley
- Bike lanes along Wentworth
- Greenways
  - o Low impact development
  - o Permeable pavers
  - o Pedestrian and cyclist friendly (no automobiles)
  - o Connection of cul-de-sacs
  - o R.O.W. opportunities

Place-making (rebranding the community)
- Designing with green infrastructure
- Street tree planting intensification
- Bicycle infrastructure
- Bio-swale, bio retention
- Parkland design for all ages
- Community food hub infrastructure
- Reclaiming derelict land through programming

Programming
- Community resources/involvement
- Community oven
- Farmers market
- Community gardens
- Youth volunteer opportunities
- Involve whole community in creation of green spaces
- Personal empowerment/ownership

Implementation
- On-street/permit parking
- Salt treatment/alternatives
- Creating parks/playgrounds/green spaces
- Relocate utilities



Visualization of site redesign concepts for Site 3 Wentworth Cedar. Credit: Green Roofs for Healthy Cities.

OSHAWA: SITE 3 - WENTWORTH CEDAR

⟶ Proposed Site Plan

OSHAWA: SITE 3 - WENTWORTH CEDAR

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	15000	0	$3,000,000	$52,500
Intensive Green Roof	0	4000	$1,500,000	$120,000
Green Façade	250	0	$37,500	$2,500
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	1800	0	$1,937,502	$678,186
Rain Garden	0	0	$0	$0
Bioswale	720	0	$116,251	$3,722
Permeable Surface - Porous Paver	3600	0	$426,276	$828
Tree - Small	5677	0	$33,040	$1,362
Tree - Medium	18090	0	$47,939	$1,990
Tree - Large	11356	0	$23,961	$908
Wetland	8000	0	$135,760	$2,160
Planting Bed	4250	1200	$791,994	$28,177
Turf - Active	4000	0	$46,920	$3,800
Tuf - Naturalized	3300	0	$11,583	$1,287
TOTAL	**76043**	**5200**	**$8,108,726**	**$897,421**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

OSHAWA: SITE 3 - WENTWORTH CEDAR

⟶ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	15000	0	$83,400	$83,779
Intensive Green Roof	0	4000	$144,520	$737,685
Green Façade	250	0	$1,305	$396
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	1800	0	$8,784	$3,066
Rain Garden	0	0	$0	$0
Bioswale	720	0	$26,014	$3,595
Permeable Surface - Porous Paver	3600	0	$0	$4,284
Tree - Small	5677	0	$205,110	$20,748
Tree - Medium	18090	0	$653,592	$78,831
Tree - Large	11356	0	$410,292	$59,252
Wetland	8000	0	$289,040	$44,760
Planting Bed	4250	1200	$28,449	$228,493
Turf - Active	4000	0	$20,880	$8,229
Tuf - Naturalized	3300	0	$119,229	$8,993
TOTAL	**76043**	**5200**	**$1,990,615**	**$1,282,111**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

OSHAWA: SITE 3 - WENTWORTH CEDAR

⟶ Estimated Job Creation

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	53.550	58.050	76.050	98.550
Intensive Green Roof	26.756	37.458	80.266	133.776
Green Façade	1.338	1.784	3.568	5.798
Living Wall - Interior	0.000	0.000	0.000	0.000
Living Wall - Exterior	86.400	146.889	388.845	691.290
Rain Garden	0.000	0.000	0.000	0.000
Bioswale	2.074	2.405	3.730	5.386
Permeable Surface - Porous Paver	7.603	7.675	7.963	8.323
Tree - Small	0.590	0.704	1.158	1.726
Tree - Medium	0.850	1.031	1.755	2.659
Tree - Large	0.432	0.488	0.715	0.999
Wetland	2.424	2.624	3.424	4.424
Planting Bed	14.126	16.633	26.661	39.196
Turf - Active	0.836	1.176	2.536	4.236
Tuf - Naturalized	0.208	0.323	0.785	1.363
TOTAL JOB CREATION	**197.19**	**277.24**	**597.46**	**997.73**

OSHAWA: SITE 3 - WENTWORTH CEDAR - CONCLUSIONS

⟶ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$83,400	$365,046	$1,491,630	$2,899,860
Intensive Green Roof	$144,520	$2,019,987	$9,521,854	$18,899,188
Green Façade	$1,305	$3,273	$11,143	$20,981
Living Wall - Interior	$0	$0	$0	$0
Living Wall - Exterior	$8,784	$24,031	$85,018	$161,251
Rain Garden	$0	$0	$0	$0
Bioswale	-$90,238	-$90,874	-$93,417	-$96,597
Permeable Surface - Porous Paver	-$426,276	-$408,996	-$339,876	-$253,476
Tree - Small	$172,070	$268,769	$655,566	$1,139,062
Tree - Medium	$605,653	$988,953	$2,522,153	$4,438,653
Tree - Large	$386,331	$677,141	$1,840,382	$3,294,432
Wetland	$153,280	$366,280	$1,218,280	$2,283,280
Planting Bed	-$763,545	-$289,964	$1,604,361	$3,972,267
Turf - Active	-$26,040	-$3,897	$84,676	$195,392
Tuf - Naturalized	$107,646	$146,178	$300,307	$492,967
TOTAL ROI FOR SITE REDESIGN	**$356,891**	**$4,065,928**	**$18,902,075**	**$37,447,260**

OSHAWA: APPENDIX
→ Working Groups List


Site 1 Working Group. Credit: Green Roofs for Healthy Cities.

SIMCOE STREET SOUTH 'A'
SITE 1
Facilitator: Helen Break, City of Oshawa
Site Expert: Colleen Goodchild, City of Oshawa

Team:
Andrea Kirkwood, UOIT
Duncan Rowe, Read Jones Christoffersen Ltd.
Heather Kirby, Durham Sustainability
Graham MacInness, University of Guelph
André Voshart, Renew Canada


Site 2 Working Group. Credit: Green Roofs for Healthy Cities.

SIMCOE STREET SOUTH 'B'
SITE 2
Facilitator: Paul Ronan, Ontario Parks Association
Site Expert: Colleen Goodchild, City of Oshawa

Team:
Grant Cole, Oshawa Space Invaders
Tom Williams, XCG
Jessica Hawes, Brook McIlroy
Mary Drummond, Durham Integrated Growers
Geordie Lishman, Artist


Site 3 Working Group. Credit: Green Roofs for Healthy Cities.

WENTWORTH CEDAR
SITE 3
Facilitator: Vincent Javet, Green Roofs for Healthy Cities
Site Expert: Suzanne Ashton, City of Oshawa

Team:
David Mills, David Mills Architect
Mike Dymarski, University of Toronto
Michael Carswell, G.D. Biddle and Associates
Heather Brooks, CLOCA
Adam White, The Vault

A special thank you to all of the participants as well as the following persons that dedicated their time, energy and expertise in the organization of the Oshawa Design Charrette, without your hard work and dedication this project would not have been possible:

Mayor John Henry, City of Oshawa
Michelle Whitbread, City of Oshawa
Helen Break, City of Oshawa
Jerry Shestowsky, City of Oshawa
Colleen Goodchild, City of Oshawa
Suzanne Ashton, City of Oshawa

London
CANADA

LONDON CHARRETTE REPORT

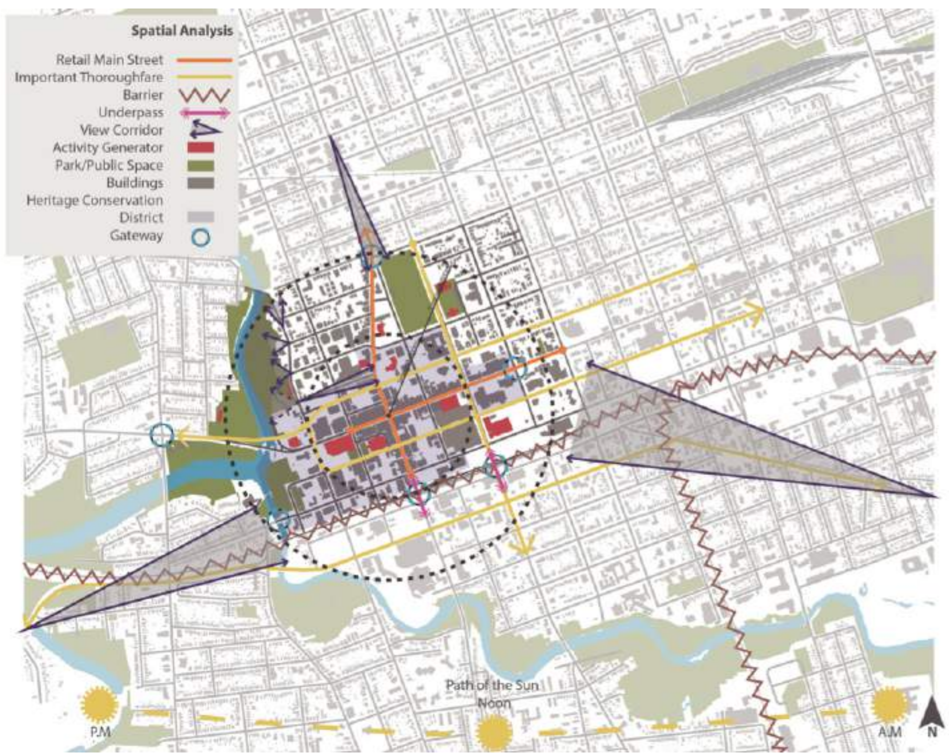
LONDON

⟶ Context, Sites & Goals

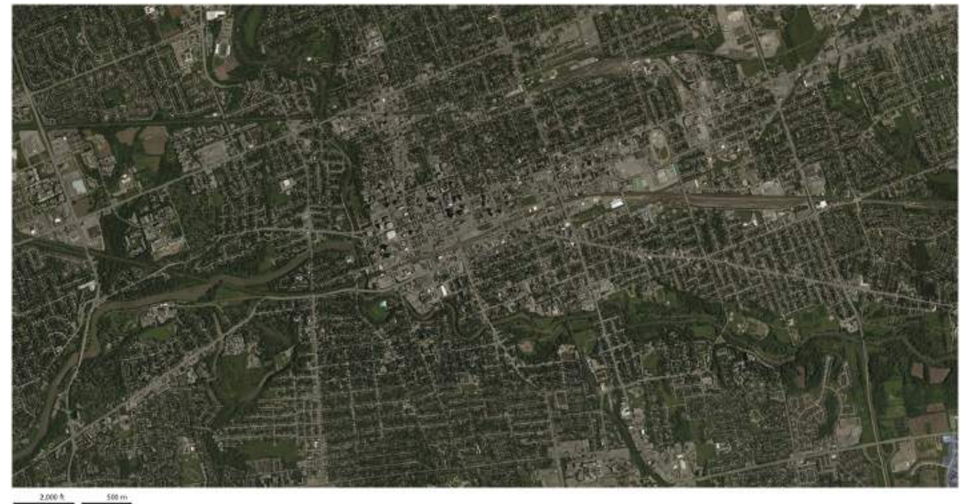
The City of London offers an interesting and relatively miniature version of a dichotomy that is all too common for the modern city.

What is compelling about the City of London is it serves as a comparatively small-scale expression of what is seen in almost all cases of urbanization at one stage or another. The core of downtown London is derelict of green infrastructure, but surrounded by a rich diversity of green infrastructure ranging from residential streets littered with mature street trees to the riparian vegetation along the meandering Thames River. Thus, the design challenge becomes an ideal case study in the greening of a downtown core.

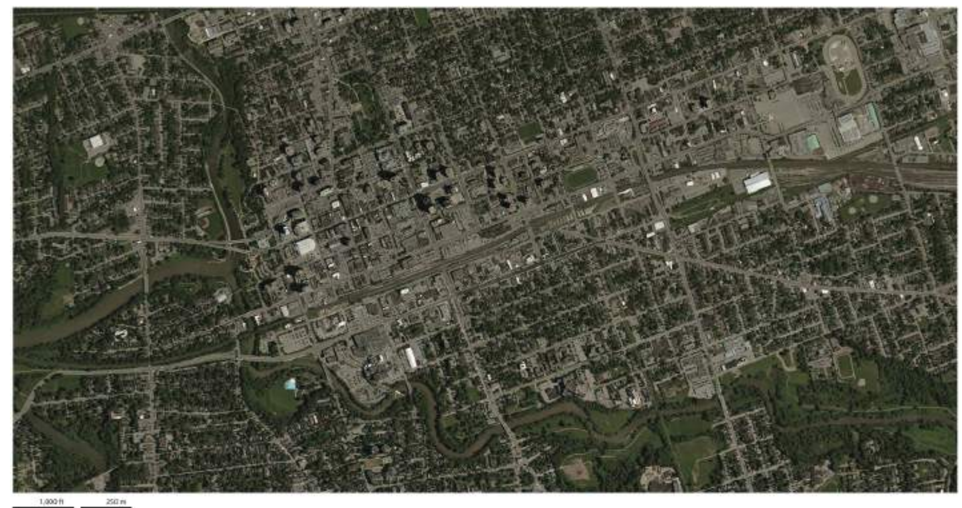
The Green Infrastructure Design Charrette participants examined the existing green networks of river systems, parklands and urban forests seen at the periphery of London's downtown core and symbiotically integrated new networks of green infrastructure into the current grey urban fabric of downtown London.



Spatial analysis of Downtown London. Credit: City of London.



Aerial view of Downtown London and surrounding area. Credit: Green Roofs for Healthy Cities/ Google.



Aerial view of Downtown London and surrounding area. Credit: Green Roofs for Healthy Cities/ Google.

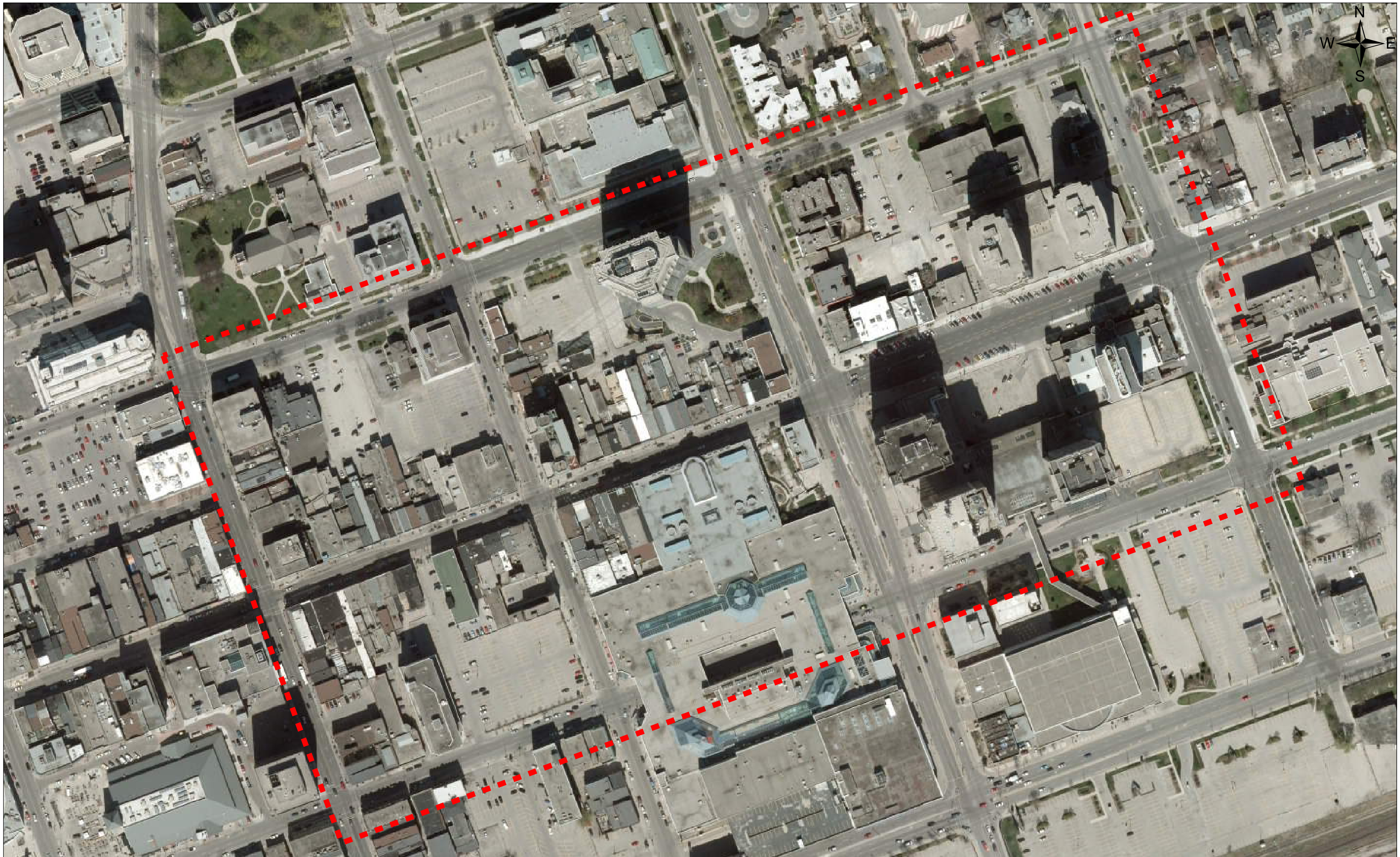
Pedestrian movement of Downtown London. Credit: City of London.

Bicycle network of Downtown London. Credit: City of London.

Vacant parcels of Downtown London. Credit: City of London.

LONDON: SITE 1 - CENTRAL DOWNTOWN LONDON

⟶ Existing Site Condition



Green Infrastructure Design Charrette - Central Downtown London [Site 1]

LONDON: SITE 1 - CENTRAL DOWNTOWN LONDON

⟶ Redesign Concepts

The Central Downtown London team arrived at the following concepts:

General Design Elements

• Green the streets

  o Planters
  o Trees
  o Curb extensions where on street parking remains – include trees and grass
  o Narrowing streets and increasing green space on boulevards
  o "Green-up" larger concrete pedestrian areas

• Intensify and improve access to existing green spaces
• New building structures at existing parking lots, combined with green roofs and potential water retention below
• Permeable paving at on street parking
• Narrow Dundas between Wellington and Waterloo
• Alley walk connections at mid blocks combined with native plantings
• Dundas is a flexible street between Richmond and Wellington
• Enhance Clarence St. gateway project with trees, planters
• Intensive green roof construction on large roof areas
• Extensive on all others, where practical
• Use street water run off to water street plantings
• Agriculture roof on Citiplaza Roof
• Urban orchard on other roof
• Parking lot shade structures (designed planting dividers)
• Irrigation consideration, water conservation, re-use Implementation Tools

Private Land

• Local improvement charge – water efficiency retrofit might apply to some green infrastructure site measures (in study)
• Discounted development charges related to avoided storm water management costs, combined storm water overflows, etc.
• Reduced storm water charges on water and sewer bills
• Bonusing and other non-mandatory incentives

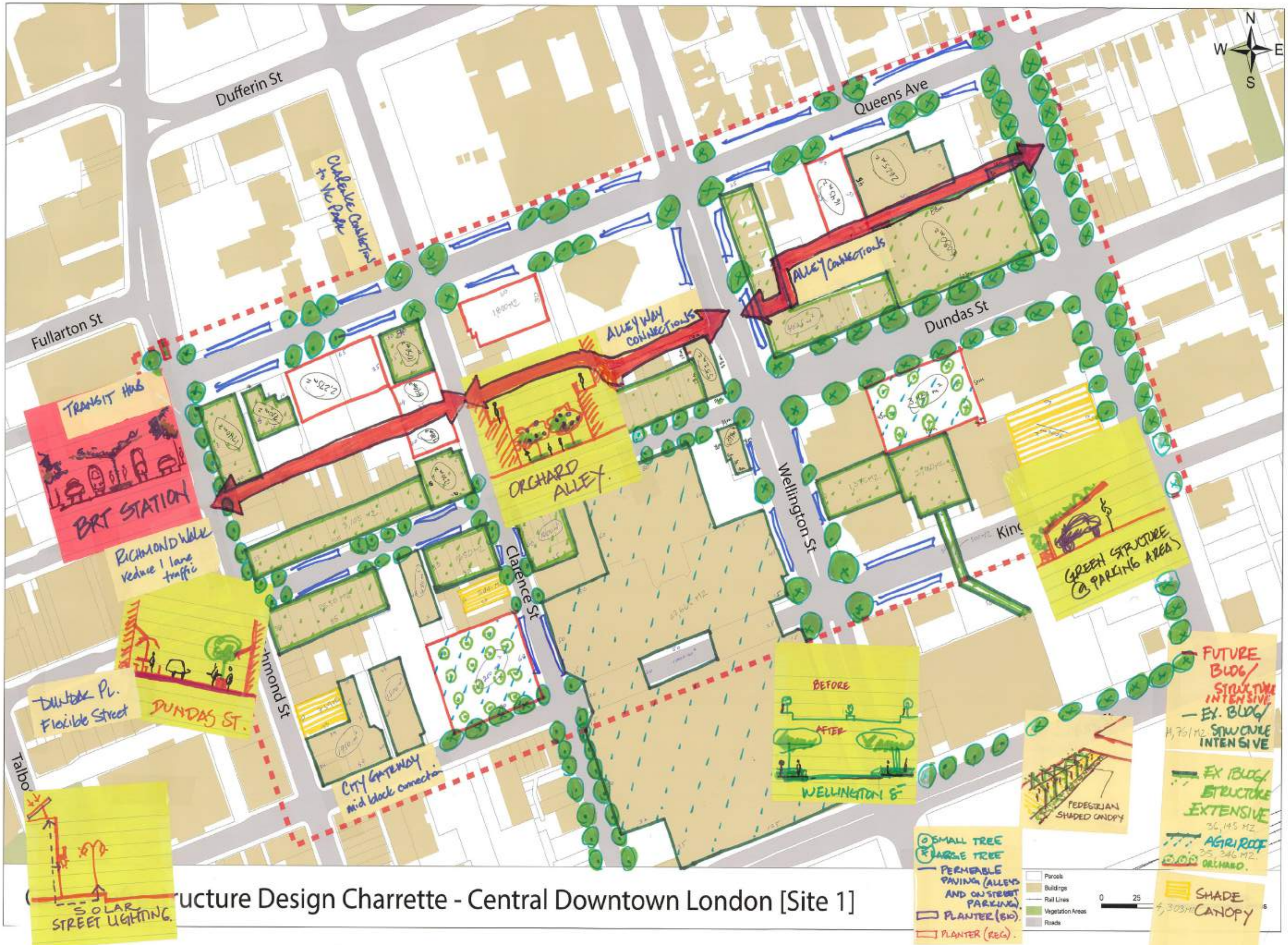
Public Land/Right of Way

• Incorporate green infrastructure into the new complete streets design principles for London

Existing streetscape of Downtown London's main street, Dundas St. Credit: City of London/ Google.

LONDON: SITE 1 - CENTRAL DOWNTOWN LONDON

⟶ Proposed Site Plan



LONDON: SITE 1 - CENTRAL DOWNTOWN LONDON

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	36160	0	$7,232,000	$126,560
Intensive Green Roof	14761	5355	$7,543,500	$603,480
Green Façade	0	0	$0	$0
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	4303	0	$4,631,706	$1,621,241
Rain Garden	0	0	$0	$0
Bioswale	1100	0	$177,606	$5,687
Permeable Surface - Porous Paver	6000	0	$710,460	$1,380
Tree - Small	17960	0	$104,527	$4,310
Tree - Medium	0	0	$0	$0
Tree - Large	28391	0	$59,905	$2,271
Wetland	0	0	$0	$0
Planting Bed	440	0	$63,941	$2,275
Turf - Active	0	0	$0	$0
Tuf - Naturalized	0	0	$0	$0
TOTAL	**109115**	**5355**	**$20,523,645**	**$2,367,205**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

LONDON: SITE 1 - CENTRAL DOWNTOWN LONDON

→ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	36160	0	$201,050	$201,964
Intensive Green Roof	14761	5355	$726,791	$1,111,884
Green Façade	0	0	$0	$0
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	4303	0	$20,999	$7,328
Rain Garden	0	0	$0	$0
Bioswale	1100	0	$39,743	$5,493
Permeable Surface - Porous Paver	6000	0	$0	$7,140
Tree - Small	17960	0	$648,895	$65,638
Tree - Medium	0	0	$0	$0
Tree - Large	28391	0	$1,025,767	$148,136
Wetland	0	0	$0	$0
Planting Bed	440	0	$2,297	$1,396
Turf - Active	0	0	$0	$0
Tuf - Naturalized	0	0	$0	$0
TOTAL	**109115**	**5355**	**$2,665,541**	**$1,548,979**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

LONDON: SITE 1 - CENTRAL DOWNTOWN LONDON

⟶ Estimated Job Creation

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	129.091	139.939	183.331	237.571
Intensive Green Roof	134.556	188.376	403.658	672.760
Green Façade	0.000	0.000	0.000	0.000
Living Wall - Interior	0.000	0.000	0.000	0.000
Living Wall - Exterior	206.544	351.146	929.556	1652.567
Rain Garden	0.000	0.000	0.000	0.000
Bioswale	3.168	3.674	5.698	8.228
Permeable Surface - Porous Paver	12.672	12.792	13.272	13.872
Tree - Small	1.868	2.227	3.664	5.460
Tree - Medium	0.000	0.000	0.000	0.000
Tree - Large	1.079	1.221	1.789	2.498
Wetland	0.000	0.000	0.000	0.000
Planting Bed	1.140	1.343	2.152	3.164
Turf - Active	0.000	0.000	0.000	0.000
Tuf - Naturalized	0.000	0.000	0.000	0.000
TOTAL JOB CREATION	**490.12**	**700.72**	**1543.12**	**2596.12**

LONDON: SITE 1 - CENTRAL DOWNTOWN LONDON - CONCLUSIONS

⟶ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$201,050	$880,004	$3,595,823	$6,990,596
Intensive Green Roof	$726,791	$3,663,674	$15,411,204	$30,095,616
Green Façade	$0	$0	$0	$0
Living Wall - Interior	$0	$0	$0	$0
Living Wall - Exterior	$20,999	$57,447	$203,239	$385,480
Rain Garden	$0	$0	$0	$0
Bioswale	-$137,863	-$138,835	-$142,721	-$147,579
Permeable Surface - Porous Paver	-$710,460	-$681,660	-$566,460	-$422,460
Tree - Small	$544,368	$850,289	$2,073,976	$3,603,584
Tree - Medium	$0	$0	$0	$0
Tree - Large	$965,862	$1,692,913	$4,601,116	$8,236,371
Wetland	$0	$0	$0	$0
Planting Bed	-$61,644	-$66,037	-$83,611	-$105,578
Turf - Active	$0	$0	$0	$0
Tuf - Naturalized	$0	$0	$0	$0
TOTAL ROI FOR SITE REDESIGN	**$1,549,102**	**$6,257,795**	**$25,092,566**	**$48,636,030**

LONDON: SITE 2 - DOWNTOWN LONDON GATEWAY

⟶ Existing Site Condition

Green Infrastructure Design Charrette - Downtown London Gateway [Site 2]

LONDON: SITE 2 - DOWNTOWN LONDON GATEWAY

⟶ Redesign Concepts

The Downtown London Gateway team arrived at the following concepts:

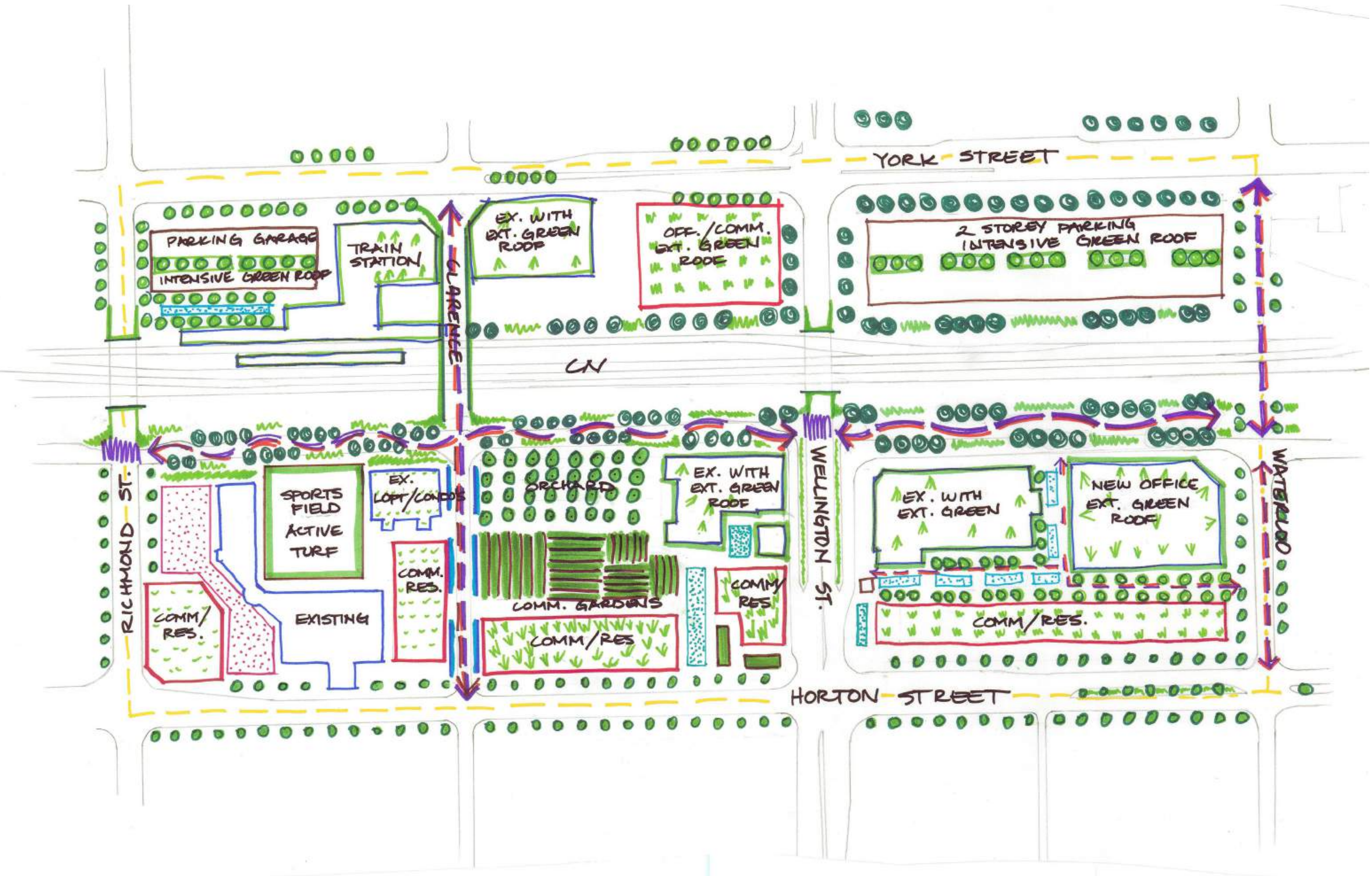
VIA Rail Station as London's 'Railway Gateway'
Work with CNR to establish a green way, including pedestrian and bike connectivity for broken Bathurst St. linkages (currently, informally used dirt footpaths exist) as well as landscape design and greening of rail safety infrastructure (i.e. green façdes on chain link fences)

• Expand existing district energy loop to serve the Downtown London Gateway; steam and chilled water
• New infill development to employ green building design principles, including site level green infrastructure
• Improve pedestrian and cycling linkages within the London Gateway and with downtown London and SoHo
• Add community green space, since there currently none (biophilic design)
• Where existing properties will remain, explore site retrofit opportunities (building integrated measures, e.g. green roofs, and site measures, e.g. permeable pavement, bioswales)

York St. Parkade
• Existing surface lot over contaminated site
• Assumes no interested brownfield development options
• Propose to build a multi-storey parkade to serve the London Convention Centre and new infill commercial in order to free up space for land based parking so it can be repurposed
• Roof utilizing intensive green roof design (trees, etc.) to provide shading for parked cars on top level

LONDON: SITE 2 - DOWNTOWN LONDON GATEWAY

⟶ Proposed Site Plan



LONDON: SITE 2 - DOWNTOWN LONDON GATEWAY

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	23515	0	$4,703,000	$82,303
Intensive Green Roof	2500	4000	$2,437,500	$195,000
Green Façade	880	0	$132,000	$8,800
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	0	0	$0	$0
Rain Garden	1275	0	$145,478	$6,592
Bioswale	180	0	$29,063	$931
Permeable Surface - Porous Paver	2300	0	$272,343	$529
Tree - Small	12902	0	$75,090	$3,096
Tree - Medium	0	5653	$14,981	$622
Tree - Large	34353	0	$72,485	$2,748
Wetland	0	0	$0	$0
Planting Bed	400	3600	$581,280	$20,680
Turf - Active	3300	0	$38,709	$3,135
Tuf - Naturalized	0	0	$0	$0
TOTAL	**81605**	**13253**	**$8,501,928**	**$324,435**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

LONDON: SITE 2 - DOWNTOWN LONDON GATEWAY

⟶ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	23515	0	$130,743	$131,338
Intensive Green Roof	2500	4000	$234,845	$758,739
Green Façade	880	0	$4,594	$1,393
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	0	0	$0	$0
Rain Garden	1275	0	$46,066	$3,532
Bioswale	180	0	$6,503	$899
Permeable Surface - Porous Paver	2300	0	$0	$2,737
Tree - Small	12902	0	$466,149	$47,153
Tree - Medium	0	5653	$204,252	$38,203
Tree - Large	34353	0	$1,241,174	$179,244
Wetland	0	0	$0	$0
Planting Bed	400	3600	$20,880	$646,292
Turf - Active	3300	0	$17,226	$6,789
Tuf - Naturalized	0	0	$0	$0
TOTAL	**81605**	**13253**	**$2,372,432**	**$1,816,317**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

LONDON: SITE 2 - DOWNTOWN LONDON GATEWAY

⟶ Estimated Job Creation

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	83.949	91.003	119.221	154.494
Intensive Green Roof	43.479	60.869	130.432	217.386
Green Façade	4.709	6.279	12.559	20.408
Living Wall - Interior	0.000	0.000	0.000	0.000
Living Wall - Exterior	0.000	0.000	0.000	0.000
Rain Garden	2.595	3.182	5.528	8.460
Bioswale	0.518	0.601	0.932	1.346
Permeable Surface - Porous Paver	4.858	4.904	5.088	5.318
Tree - Small	1.342	1.600	2.632	3.922
Tree - Medium	0.266	0.322	0.548	0.831
Tree - Large	1.305	1.477	2.164	3.023
Wetland	0.000	0.000	0.000	0.000
Planting Bed	10.368	12.208	19.568	28.768
Turf - Active	0.690	0.970	2.092	3.495
Tuf - Naturalized	0.000	0.000	0.000	0.000
TOTAL JOB CREATION	**154.08**	**183.42**	**300.76**	**447.45**

→ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$130,743	$572,270	$2,338,379	$4,546,014
Intensive Green Roof	$234,845	$2,182,479	$9,973,013	$19,711,181
Green Façade	$4,594	$11,520	$39,223	$73,853
Living Wall - Interior	$0	$0	$0	$0
Living Wall - Exterior	$0	$0	$0	$0
Rain Garden	-$99,412	-$114,711	-$175,909	-$252,407
Bioswale	-$22,559	-$22,718	-$23,354	-$24,149
Permeable Surface - Porous Paver	-$272,343	-$261,303	-$217,143	-$161,943
Tree - Small	$391,060	$610,826	$1,489,891	$2,588,722
Tree - Medium	$189,271	$342,974	$957,788	$1,726,305
Tree - Large	$1,168,689	$2,048,418	$5,567,333	$9,965,977
Wetland	$0	$0	$0	$0
Planting Bed	-$560,400	$983,660	$7,159,898	$14,880,196
Turf - Active	-$21,483	-$3,215	$69,858	$161,198
Tuf - Naturalized	$0	$0	$0	$0
TOTAL ROI FOR SITE REDESIGN	**$1,143,004**	**$6,350,199**	**$27,178,975**	**$53,214,946**

LONDON: APPENDIX
⟶ Working Groups List


Site 1 Working Group. Credit: Green Roofs for Healthy Cities.

CENTRAL DOWNTOWN LONDON
SITE 1
Facilitator: Jennifer Kirkham, Mischievous Cat Productions
Site Expert: Britt O'Hagan, City of London

Team:
Sandra Murillo, City of London
Britt O'Hagan, City of London
Aaron Rozentals, City of London
Kim Wood, City of London
Matt Feldberg, City of London
Scott Stafford, City of London
Imtiaz Shah, Upper Thames River Conservation Authority
John Devito, City of London


Site 2 Working Group. Credit: Green Roofs for Healthy Cities.

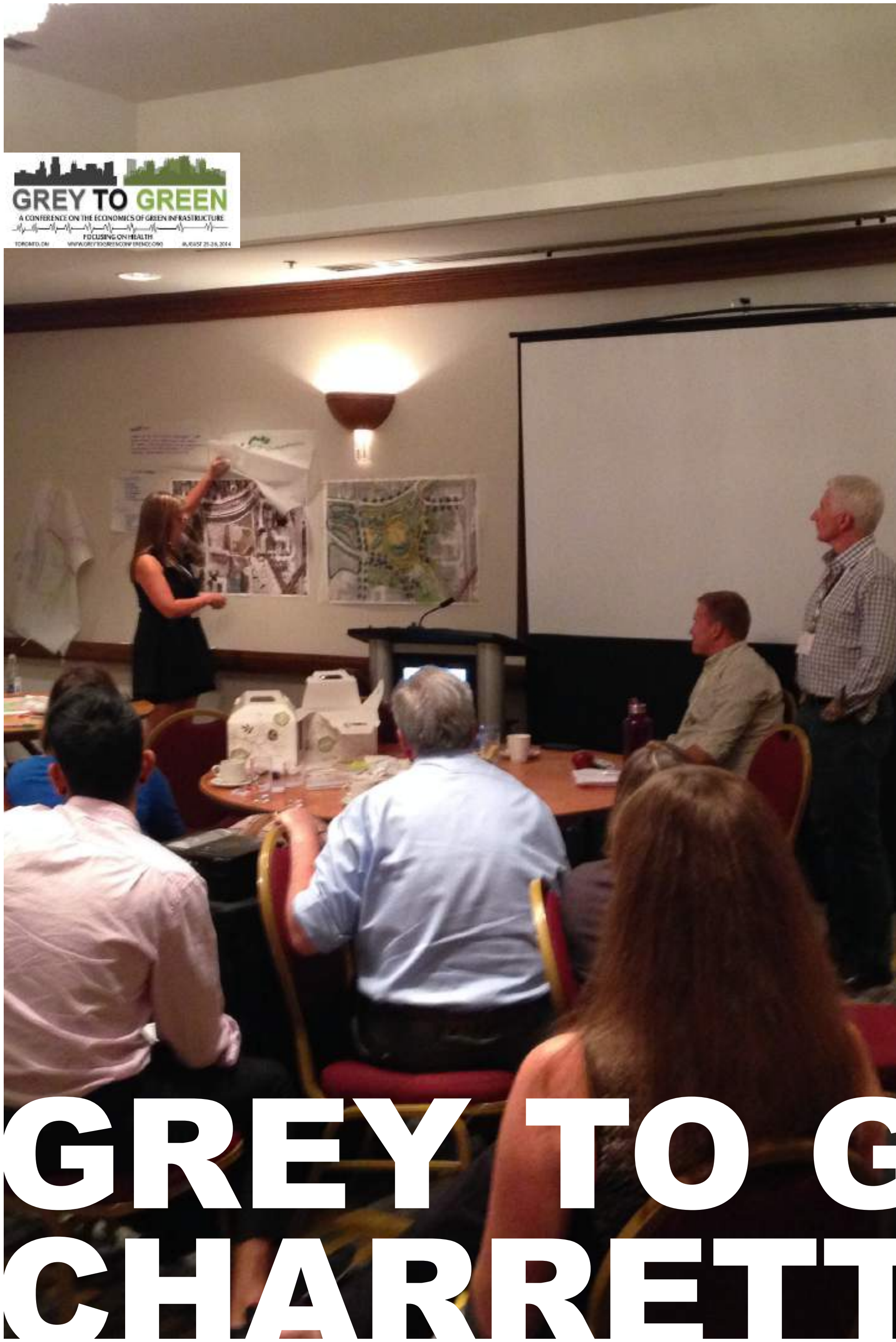
DOWNTOWN LONDON GATEWAY
SITE 2
Facilitator: Vincent Javet, Green Roofs for Healthy Cities
Site Expert: Chuck Parker, City of London

Team:
Ron Koudys, Ron Koudys Landscape Architects
Martha Berkvens, Ron Koudys Landscape Architects
Stephanie Wilson , City of London
Billy Haklander, City of London
Josh Ackworth, City of London
Robert Sutton, City of London
Jamie Skimming, City of London
Dean Sheppard, Reforest London

A special thank you to all of the participants as well as the following persons that dedicated their time, energy and expertise in the organization of the London Design Charrette, without your hard work and dedication this project would not have been possible:

Dianna Clarke, City of London
Jerzy Smolarek, City of London





GREY TO GREEN CHARRETTE REPORT

Grey to Green Conference
During the Grey to Green Conference the project team organized a one day charrette which featured one site from three different cities - Toronto, Mississauga and Brampton. Attendees to the conference as well as local representatives from each community were invited to attend.

Site 1 - Toronto - Project History/ Timeline
April1998 – Carlaw Area Study
- Residential uses proposed at 233 and 320 Carlaw prompted review of South Riverdale.
- Part II Official Plan policies.
- Study found that live/work uses were appropriate for the area.

June 2000 – Carlaw/Dundas Neighbourhood Improvement Plan
- Done is consultation with the neighbourhood.
- Provided recommendations for future development.

2003 – Dundas Carlaw Quarter (Draft) Capital Improvement Plan
- Brown + Storey Architects and Rodger Todhunter Associates
- Identifies public realm improvements.

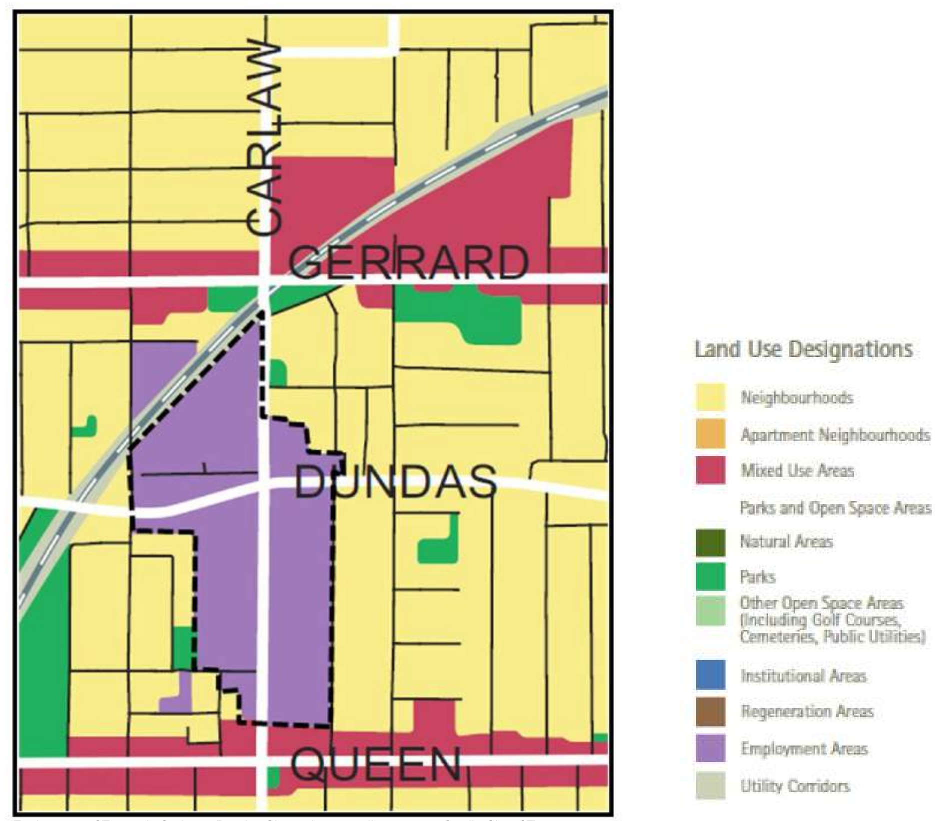
Neighbouhood Improvement Plan
1. Maintain existing mixed use character and affordability and improve stability.
2. Create “streetscape” standards.
3. Improve existing parks and create new open areas and green streetscapes.
4. Transportation: improve TTC, bicycle and pedestrian systems and coordinate parking.
5. Promote retail uses along street level.
6. Encourage a theme for the district that supports existing uses (film, photography, artisans).
7. Re-use existing buildings and preserve the heritage/historical structures.

Challenges
Zoning calls for a need to retain employment uses in the area, while addressing displacement of businesses and workers due to increasing real estate costs. Achieving public realm goals within a limited city budget.

Opportunities
Business investment in buildings and services can create a potential for community benefits paid by developers. The site has a strong public realm plan and good development precedents.

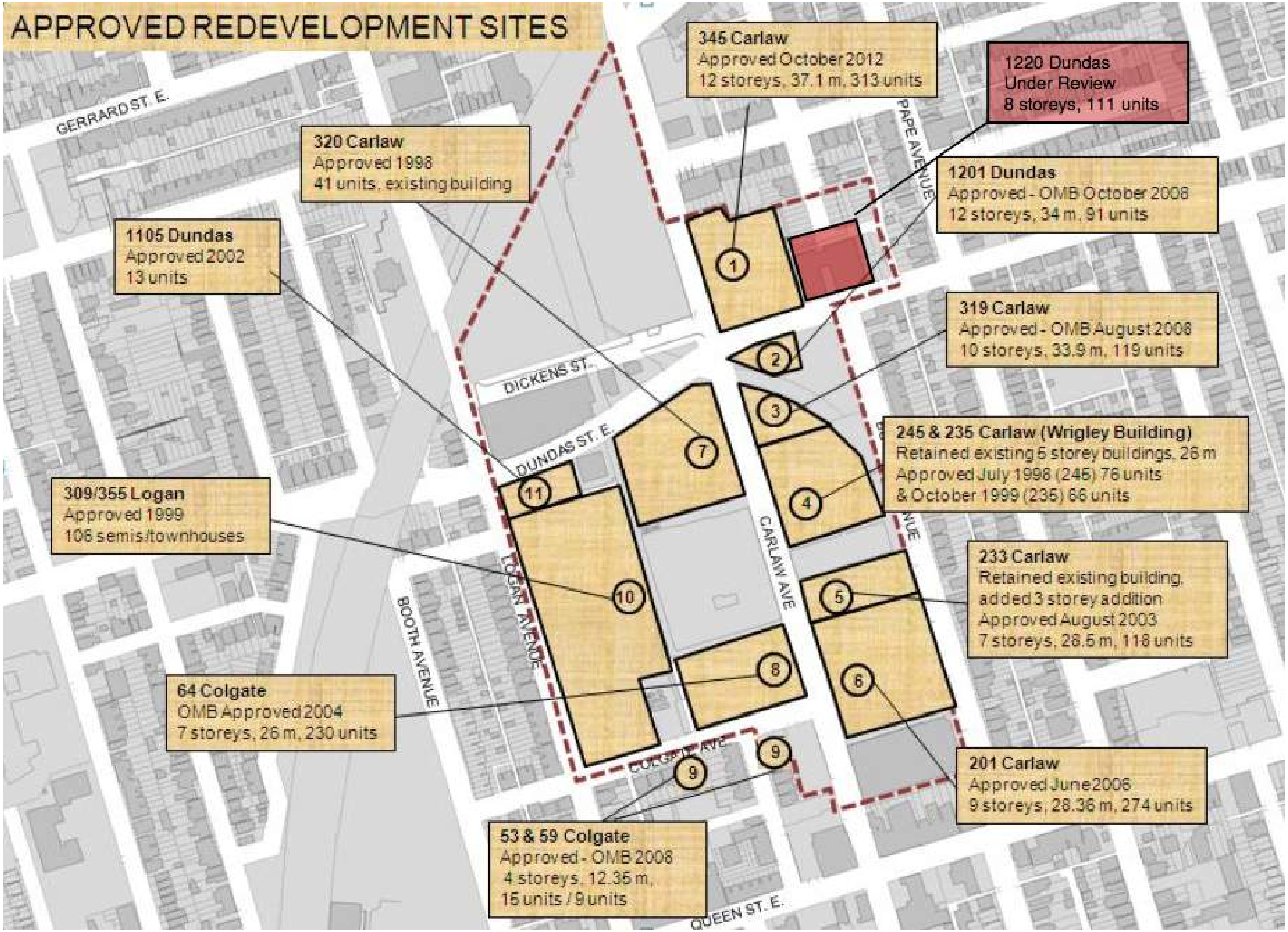
Carlaw + Dundas Assets...
This area is densely populated, making it safe for pedestrians. Buildings have an old industrial character with a mix of uses. The site is very accessible to the downtown core.

Room for Improvement...
The site requires more parkland/greenspace as well as a concentrated focus on pedestrian crosswalks, sidewalks, and streetscapes. Height restrictions on new development and traffic calming are essential.



Zoning map of Toronto's Carlaw + Dundas Site and surrounding context. Credit: City of Toronto.

⟶ Existing Site Plan



Approved development sites within Toronto's Carlaw + Dundas Site. Credit: City of Toronto.

The Toronto design team arrived at the following concepts:

Site Vision
A community where people live and work in a culture that adapts and changes while respecting the area's unique character and industrial heritage.

- Strengthen the Carlaw + Dundas area as a hub for small business and cultural activities
- Update and refresh earlier plans
- Create a plan to improve to streetscapes and other public spaces
- Develop a strategy to execute the improvements
- Establish policies to guide new development

Placemaking
- Public realm, built form, heritage, context, uniqueness

Quality of Life
- Amenities, community services, affordable

Economic Vibrancy
- Jobs, new businesses, live/work

Movement
- Walkable, safe, access to transit

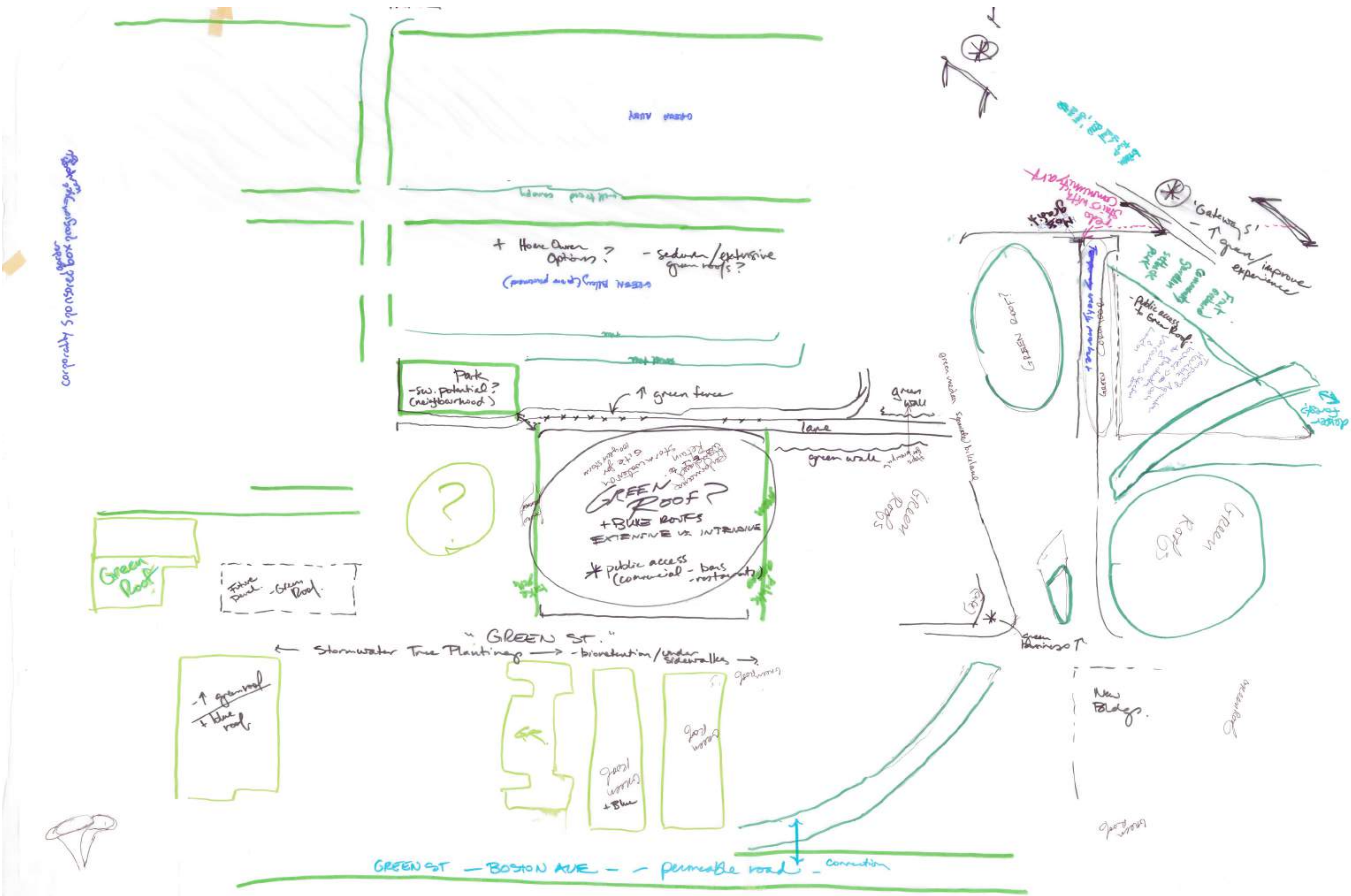
A new site and area specific policy is proposed for this area that would permit residential and live/work uses subject to:

- Compatibility of uses
- The scale of new development respecting and reinforcing the area context
- Separation of residential uses from the rail corridor
- A requirement that existing employment space be replaced in redevelopment
- Small scale retail, service and restaurant uses on Carlaw and Dundas would be permitted

Existing streetscape condition of Toronto's Carlaw + Dundas Site. Credit: City of Toronto.

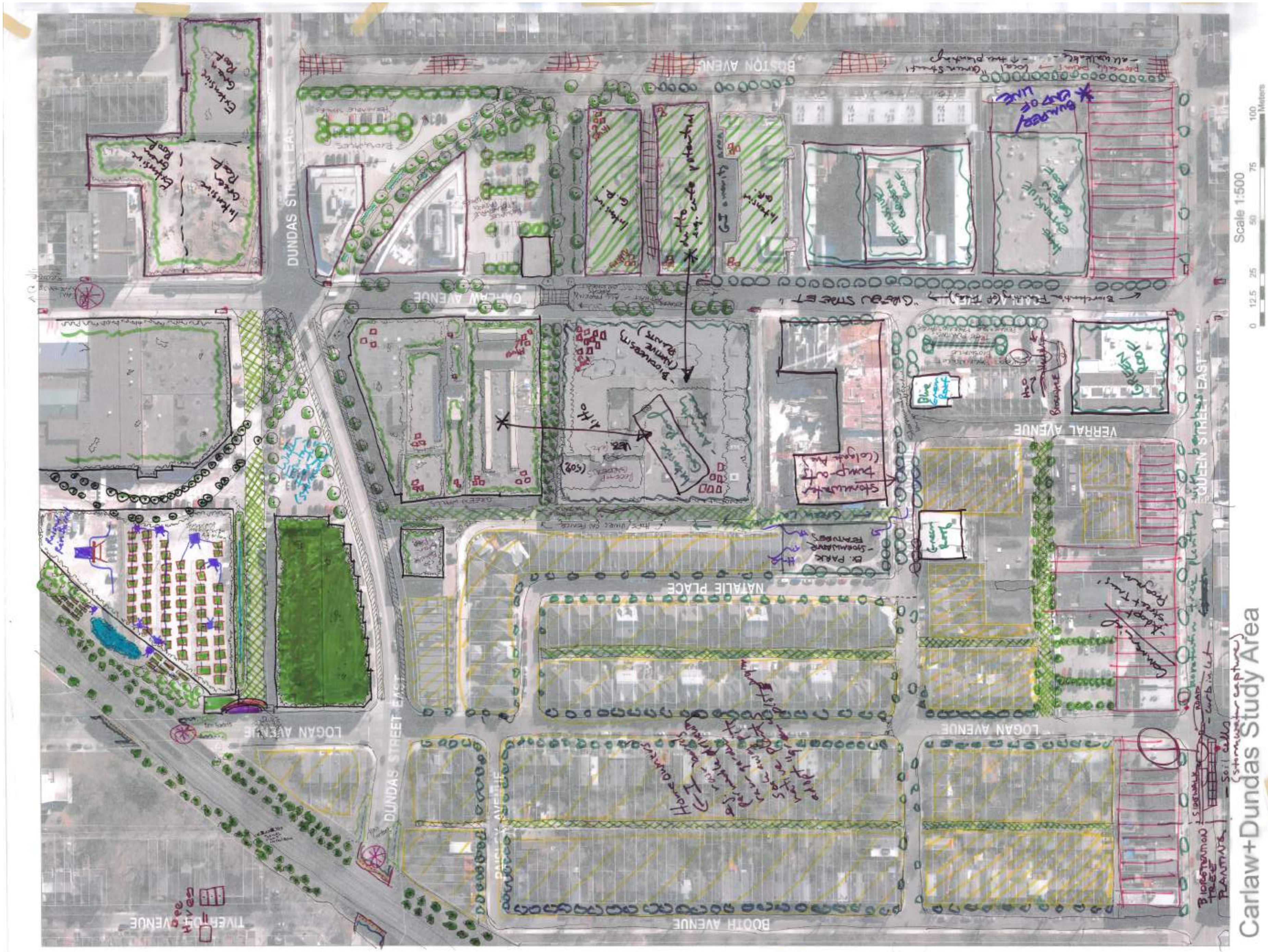
GREY TO GREEN CONFERENCE: SITE 1 - TORONTO

⟶ Redesign Concepts



GREY TO GREEN CONFERENCE: SITE 1 - TORONTO

⟶ Proposed Site Plan



GREY TO GREEN CONFERENCE: SITE 1 - TORONTO

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	23400	0	$4,680,000	$81,900
Intensive Green Roof	23200	3500	$10,012,500	$801,000
Green Façade	1530	0	$229,500	$15,300
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	420	0	$452,084	$158,243
Rain Garden	6425	0	$733,093	$33,217
Bioswale	5100	0	$823,446	$26,367
Permeable Surface - Porous Paver	13560	0	$1,605,640	$3,119
Tree - Small	4232	0	$24,630	$1,016
Tree - Medium	6783	0	$17,975	$746
Tree - Large	11619	0	$24,516	$930
Wetland	0	0	$0	$0
Planting Bed	0	0	$0	$0
Turf - Active	3800	0	$44,574	$3,610
Tuf - Naturalized	0	0	$0	$0
TOTAL	**100069**	**3500**	**$18,647,957**	**$1,125,448**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

GREY TO GREEN CONFERENCE: SITE 1 - TORONTO

⟶ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	23400	0	$130,104	$130,696
Intensive Green Roof	23200	3500	$964,671	$840,850
Green Façade	1530	0	$7,987	$2,422
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	420	0	$2,050	$715
Rain Garden	6425	0	$232,135	$17,798
Bioswale	5100	0	$184,263	$25,466
Permeable Surface - Porous Paver	13560	0	$0	$16,136
Tree - Small	4232	0	$152,902	$15,467
Tree - Medium	6783	0	$245,070	$29,558
Tree - Large	11619	0	$419,794	$60,624
Wetland	0	0	$0	$0
Planting Bed	0	0	$0	$0
Turf - Active	3800	0	$19,836	$7,817
Tuf - Naturalized	0	0	$0	$0
TOTAL	**100069**	**3500**	**$2,358,812**	**$1,147,550**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	83.538	90.558	118.638	153.738
Intensive Green Roof	178.596	250.032	535.776	892.955
Green Façade	8.188	10.917	21.835	35.483
Living Wall - Interior	0.000	0.000	0.000	0.000
Living Wall - Exterior	20.160	34.274	90.731	161.301
Rain Garden	13.077	16.032	27.854	42.632
Bioswale	14.688	17.034	26.418	38.148
Permeable Surface - Porous Paver	28.639	28.910	29.995	31.351
Tree - Small	0.440	0.525	0.863	1.287
Tree - Medium	0.319	0.387	0.658	0.997
Tree - Large	0.442	0.500	0.732	1.022
Wetland	0.000	0.000	0.000	0.000
Planting Bed	0.000	0.000	0.000	0.000
Turf - Active	0.794	1.117	2.409	4.024
Tuf - Naturalized	0.000	0.000	0.000	0.000
TOTAL JOB CREATION	**348.88**	**450.29**	**855.91**	**1362.94**

⟶ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$130,104	$569,472	$2,326,943	$4,523,782
Intensive Green Roof	$964,671	$3,275,412	$12,518,375	$24,072,080
Green Façade	$7,987	$20,028	$68,195	$128,404
Living Wall - Interior	$0	$0	$0	$0
Living Wall - Exterior	$2,050	$5,607	$19,837	$37,625
Rain Garden	-$500,957	-$578,055	-$886,444	-$1,271,932
Bioswale	-$639,183	-$643,688	-$661,707	-$684,231
Permeable Surface - Porous Paver	-$1,605,640	-$1,540,552	-$1,280,200	-$954,760
Tree - Small	$128,272	$200,358	$488,701	$849,130
Tree - Medium	$227,095	$370,816	$945,703	$1,664,311
Tree - Large	$395,278	$692,824	$1,883,004	$3,370,730
Wetland	$0	$0	$0	$0
Planting Bed	$0	$0	$0	$0
Turf - Active	-$24,738	-$3,702	$80,442	$185,622
Tuf - Naturalized	$0	$0	$0	$0
TOTAL ROI FOR SITE REDESIGN	**-$915,062**	**$2,368,521**	**$15,502,850**	**$31,920,761**

Green Development Strategy

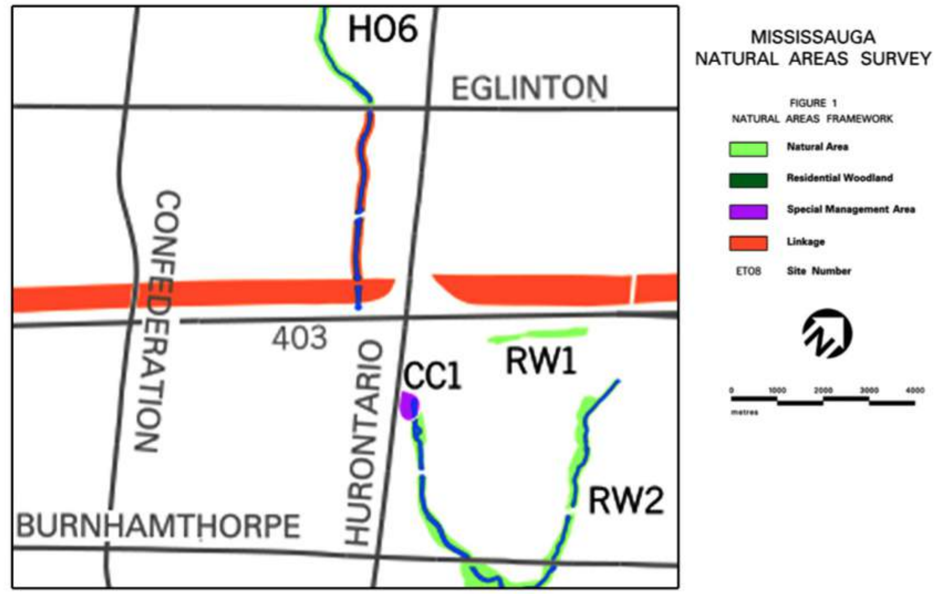
On July 7, 2010, City Council adopted the Green Development Strategy that focuses on achieving sustainability and environmental responsibility in new development in Mississauga. The key recommendations include striking up a Task Force, requesting that new development applications demonstrate LEED-NC Silver certification in addition to incorporating technologies outlined in Stage One Green Development Standards. The Planning and Building Department has developed a brochure, *Green Development Standards*, to promote the implementation of the Council supported initiative.

Opportunities

Planned reduction of block sized to a finer, pedestrian friendly grain
Opportunity for coordinated integration of green infrastructure in R.O.Ws
Developing a more urbane aesthetic that can be sold to retailers/ commercial property owners
Transit terminal provides a high-profile site for pilot projects
Potential for enhancement of both stormwater management and biodiversity within cooksville creek corridor

Potential Constraints

Utilities within the municipal right-of-way
Vehicular traffic volume
Wide right-of-ways create barriers to connectivity



Inventory of natural areas within and surrounding Mississauga's Rathburn District Site. Credit: City of Mississauga.

Land use and transportation map of Mississauga's Rathburn District Site. Credit: City of Mississauga.


Current site condition of Mississauga's Rathburn District Site. Credit: City of Mississauga.

GREY TO GREEN CONFERENCE: SITE 2 - MISSISSAUGA

⟶ Existing Site Condition

1 PLAYDIUM
2 GO CART TRACK
3 VACANT LAND
4 COOKSVILLE CREEK
5 LCBO STORE
6 BOSTON PIZZA
7 CRATE & BARREL
8 WHOLE FOODS
9 GO TRANSIT TERMINAL

scale 1:1000

RATHBURN DISTRICT

GREY TO GREEN CONFERENCE: SITE 2 - MISSISSAUGA
⟶ Redesign Concepts

The Mississauga design team arrived at the following concepts:

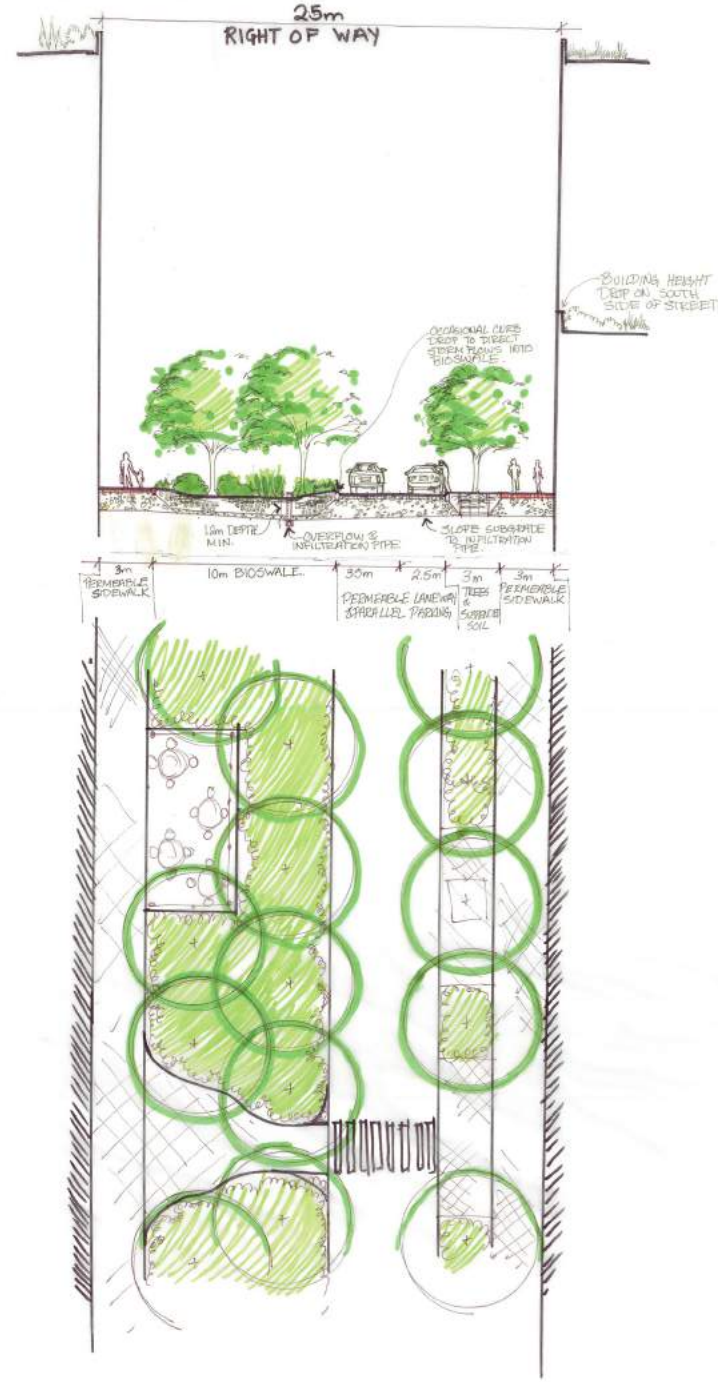
General Principles:
1. Complete green street approach with whole public right-of-way, with permeable and maximized root system for trees and to absorb run-off water

2. Green roofs on all structures (retrofit or rebuilt)
   - Intensive and accessible, using space on top of buildings and increasing more biodiversity

3. Bioswales for rainwater retention (bump-outs / benches over bioswale feature) 12 m

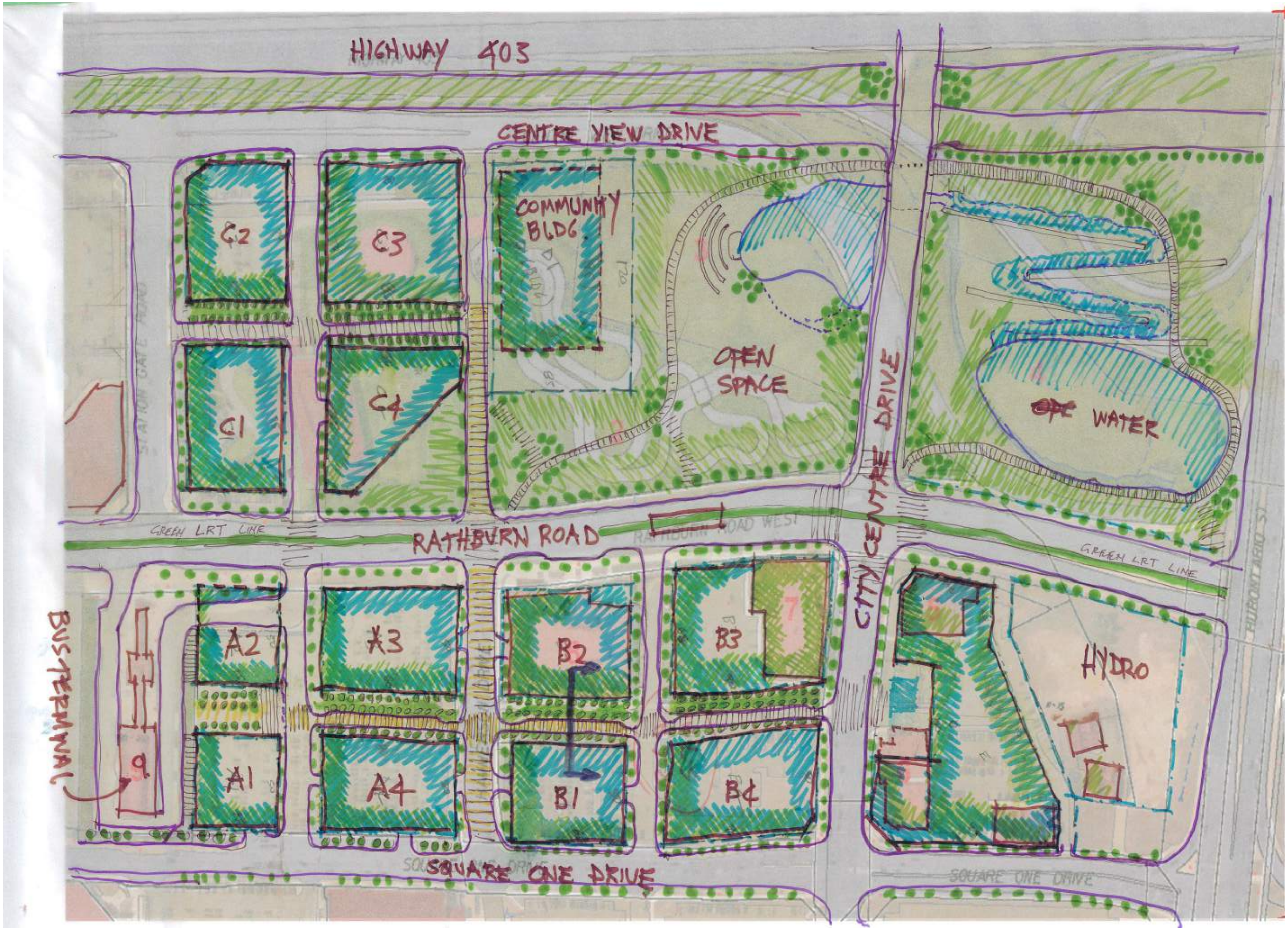
4. Green façades on all blank walls

5. Large eco-park with water landings feeding wetlands through stormwater systems; serves as extensions of bump outs



GREY TO GREEN CONFERENCE: SITE 2 - MISSISSAUGA

⟶ Proposed Site Plan



GREY TO GREEN CONFERENCE: SITE 2 - MISSISSAUGA

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	28000	0	$5,600,000	$98,000
Intensive Green Roof	10000	4000	$5,250,000	$420,000
Green Façade	0	0	$0	$0
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	0	0	$0	$0
Rain Garden	0	0	$0	$0
Bioswale	1750	0	$282,555	$9,048
Permeable Surface - Porous Paver	11500	0	$1,361,715	$2,645
Tree - Small	7225	0	$42,050	$1,734
Tree - Medium	22613	0	$59,924	$2,487
Tree - Large	22712	0	$47,922	$1,817
Wetland	3200	0	$54,304	$864
Planting Bed	0	0	$0	$0
Turf - Active	13000	0	$152,490	$12,350
Tuf - Naturalized	19000	0	$66,690	$7,410
TOTAL	**139000**	**4000**	**$12,917,650**	**$556,355**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

GREY TO GREEN CONFERENCE: SITE 2 - MISSISSAUGA

⟶ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	28000	0	$155,680	$156,388
Intensive Green Roof	10000	4000	$505,820	$821,899
Green Façade	0	0	$0	$0
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	0	0	$0	$0
Rain Garden	0	0	$0	$0
Bioswale	1750	0	$63,228	$8,738
Permeable Surface - Porous Paver	11500	0	$0	$13,685
Tree - Small	7225	0	$261,039	$26,405
Tree - Medium	22613	0	$817,008	$98,541
Tree - Large	22712	0	$820,585	$118,504
Wetland	3200	0	$115,616	$17,904
Planting Bed	0	0	$0	$0
Turf - Active	13000	0	$67,860	$26,743
Tuf - Naturalized	19000	0	$686,470	$51,780
TOTAL	**139000**	**4000**	**$3,493,305**	**$1,340,588**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

Estimated Job Creation

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	99.960	108.360	141.960	183.960
Intensive Green Roof	93.646	131.103	280.931	468.216
Green Façade	0.000	0.000	0.000	0.000
Living Wall - Interior	0.000	0.000	0.000	0.000
Living Wall - Exterior	0.000	0.000	0.000	0.000
Rain Garden	0.000	0.000	0.000	0.000
Bioswale	5.040	5.845	9.065	13.090
Permeable Surface - Porous Paver	24.288	24.518	25.438	26.588
Tree - Small	0.751	0.896	1.474	2.196
Tree - Medium	1.063	1.289	2.193	3.324
Tree - Large	0.863	0.977	1.431	1.999
Wetland	0.970	1.050	1.370	1.770
Planting Bed	0.000	0.000	0.000	0.000
Turf - Active	2.717	3.822	8.242	13.767
Tuf - Naturalized	1.197	1.862	4.522	7.847
TOTAL JOB CREATION	**230.49**	**279.72**	**476.63**	**722.76**

⟶ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$155,680	$681,419	$2,784,376	$5,413,072
Intensive Green Roof	$505,820	$2,669,954	$11,326,489	$22,147,158
Green Façade	$0	$0	$0	$0
Living Wall - Interior	$0	$0	$0	$0
Living Wall - Exterior	$0	$0	$0	$0
Rain Garden	$0	$0	$0	$0
Bioswale	-$219,328	-$220,873	-$227,056	-$234,785
Permeable Surface - Porous Paver	-$1,361,715	-$1,306,515	-$1,085,715	-$809,715
Tree - Small	$218,990	$342,057	$834,325	$1,449,660
Tree - Medium	$757,083	$1,236,219	$3,152,761	$5,548,439
Tree - Large	$772,662	$1,354,282	$3,680,764	$6,588,865
Wetland	$61,312	$146,512	$487,312	$913,312
Planting Bed	$0	$0	$0	$0
Turf - Active	-$84,630	-$12,665	$275,197	$635,024
Tuf - Naturalized	$619,780	$841,632	$1,729,038	$2,838,296
TOTAL ROI FOR SITE REDESIGN	**$1,425,655**	**$5,732,022**	**$22,957,490**	**$44,489,325**

Downtown Etobicoke Creek Revitalization Background

- Special Policy established in 1988; intense work to update 2010- 2014
- Joint Technical Team initiated in 2011 with representatives from TRCA and the City
- Feasibility Studies initiated in 2012 with consultants hired for Flood Mitigation and Urban Design and Land Use studies
- SPA report April 2013 outlining Feasibility Studies scope
- Feasibility Studies report May 29th, 2013 outlining preliminary concepts for flood mitigation and urban design
- Detailed work of consulting team (AMEC and TPP) – short list of options, modelling, alternatives/combinations, urban design concepts, estimates
- Status summary report to Council June 11th
- Concurrent studies - Sustainable Infrastructure, Transportation/mobility hub, beautification, capital
- Phase 2 studies initiated (Integrated Urban Flood Study)

Main attributes of the Downtown Etobicoke Creek Revitalization initiative:

- It can solve the flooding problems and result in a flood-free downtown
- It will create a very attractive feature of downtown and the city which is missing now, combining natural and man made open space, strong public realm, public art which will attract visitors, residents, businesses
- It can unleash the development potential of downtown (mixed use, residential, commercial, institutional) by removing flood related constraints and increasing its marketability
- It will create extensive economic development opportunities
- Opportunity for consolidation and development of the infrastructure (utilities, amenities)
- Opportunity for sustainable revitalization and management of the corridor, to implement low impact, environmentally sound principles, public health impact
- It will create a flexible, functional, appealing, comfortable place for gatherings, activities – a destination for the city
- It will build on the city's tradition and history creating a place with strong character and identity

Flood Mitigation Measures Study: Review & Key Issues

- Two mechanisms cause flooding in the SPA
  - Spill from Etobicoke Creek at Church Street
  - Upstream of by-pass channel
- Impacts all of SPA
  - Backwater from Etobicoke Creek
- Downstream of by-pass channel
- Impacts primarily east of Main Street
  - Each mechanism requires a distinct and separate solution to mitigate

Site history image, Rosalee Valley as a natural system. Credit: City of Brampton.


Site history image, Etobicoke River. Credit: City of Brampton.

GREY TO GREEN CONFERENCE: SITE 3 - BRAMPTON

⟶ Existing Site Condition

The Brampton design team arrived at the following concepts:

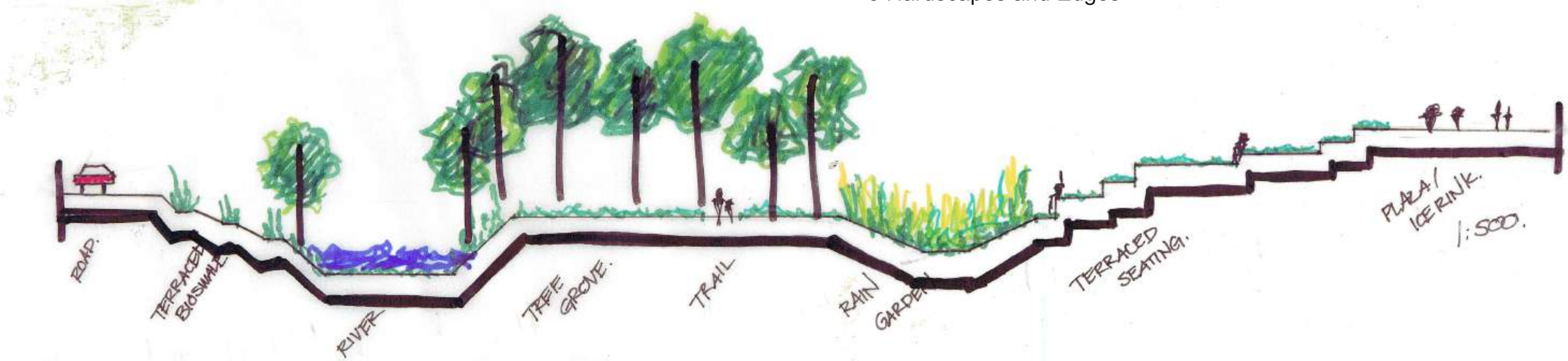
• Concept
To create an ecologically resilient urban development which reconciles the needs of users and the environment, while strengthening connections to the downtown and linking previously disconnected community spaces.

• Connection to downtown
• Pedestrian element
• Mixed-use mid-high density development
• Ecologically friendly

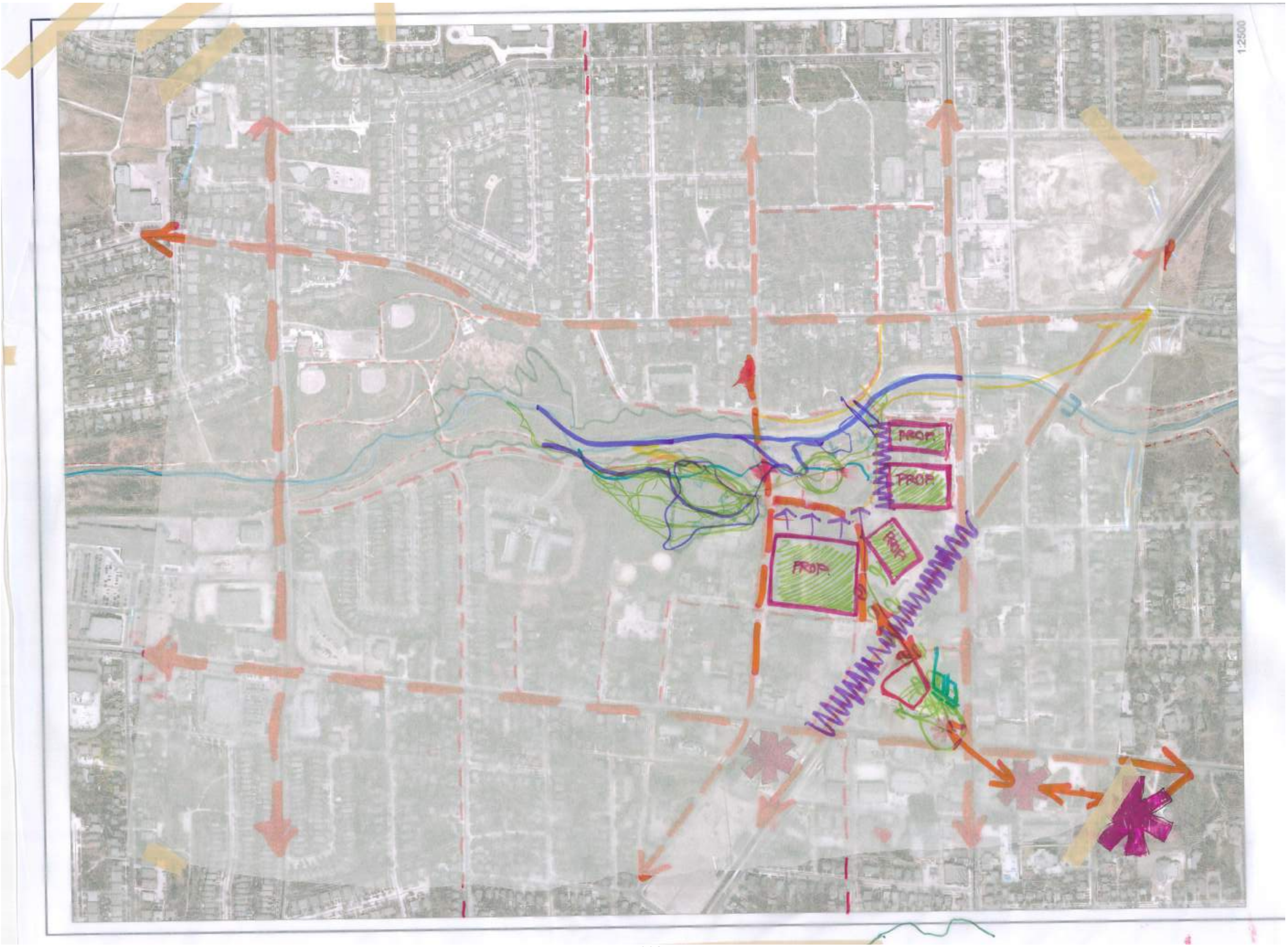
• Problems
- o Disconnects
- o Placelessness
- o No civic life
- o No biodiversity
- o Flooding
- o Lack in visual attraction

• Goals
- o Connected to downtown core
- o Biodiversity/ecological responsibility
- o Education
- o Stormwater management
- o Water -> Downtown core
- o Recreational space
- o Mixed-use development
- o Pedestrianization
- o Civic space
- o Heritage conservation (social/environmental)
- o Human scale

• Design elements/themes
- o Bioswales
- o Stormwater management pond
- o Inlet/outlet/catchment
- o Naturalization to mitigate flooding patterns
- o Meandering Marshland/Water
- o Connectedness through boardwalk pedestrian system
- o Elevated roadway
- o Accessibility and Safety
- o Hardscapes and Edges



→ Redesign Concepts



GREY TO GREEN CONFERENCE: SITE 3 - BRAMPTON

→ Proposed Site Plan

GREY TO GREEN CONFERENCE: SITE 3 - BRAMPTON

⟶ Green Infrastructure Area Totals: Estimated Project Costs

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL PROJECT COSTS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (cost to build)	Maintenance (annual cost to maintain)
Extensive Green Roof	650	0	$130,000	$2,275
Intensive Green Roof	4000	2250	$2,343,750	$187,500
Green Façade	1000	0	$150,000	$10,000
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	0	0	$0	$0
Rain Garden	5440	0	$620,704	$28,125
Bioswale	880	0	$142,085	$4,550
Permeable Surface - Porous Paver	0	0	$0	$0
Tree - Small	0	0	$0	$0
Tree - Medium	0	0	$0	$0
Tree - Large	17886	0	$37,739	$1,431
Wetland	3200	0	$54,304	$864
Planting Bed	0	0	$0	$0
Turf - Active	0	0	$0	$0
Tuf - Naturalized	20480	0	$71,885	$7,987
TOTAL	**53536**	**2250**	**$3,550,467**	**$242,731**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

GREY TO GREEN CONFERENCE: SITE 3 - BRAMPTON

⟶ Green Infrastructure Area Totals: Estimated Project Benefits

Generic Green Infrastructure Type	INPUT		ESTIMATED TOTAL BENEFITS	
	Area (m^2) (without intended agriculture use)	Area (m^2) of Agricultural Use Intended (added benefit, do not duplicate area)	Capital (one time)	Annual (on going)
Extensive Green Roof	650	0	$3,614	$3,630
Intensive Green Roof	4000	2250	$225,813	$448,633
Green Façade	1000	0	$5,220	$1,583
Living Wall - Interior	0	0	$0	$0
Living Wall - Exterior	0	0	$0	$0
Rain Garden	5440	0	$196,547	$15,069
Bioswale	880	0	$31,794	$4,394
Permeable Surface - Porous Paver	0	0	$0	$0
Tree - Small	0	0	$0	$0
Tree - Medium	0	0	$0	$0
Tree - Large	17886	0	$646,221	$93,324
Wetland	3200	0	$115,616	$17,904
Planting Bed	0	0	$0	$0
Turf - Active	0	0	$0	$0
Tuf - Naturalized	20480	0	$739,942	$55,814
TOTAL	**53536**	**2250**	**$1,964,768**	**$640,352**
	m^2 of Green	m^2 of Green	Capital ($)	Annually ($)

GREY TO GREEN CONFERENCE: SITE 3 - BRAMPTON

⟶ Estimated Job Creation

Generic Green Infrastructure Type	ESTIMATED JOB CREATION (person years of employment [direct, indirect and induced])			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	2.321	2.516	3.296	4.271
Intensive Green Roof	41.806	58.528	125.416	209.025
Green Façade	5.351	7.135	14.271	23.191
Living Wall - Interior	0.000	0.000	0.000	0.000
Living Wall - Exterior	0.000	0.000	0.000	0.000
Rain Garden	11.072	13.574	23.584	36.096
Bioswale	2.534	2.939	4.558	6.582
Permeable Surface - Porous Paver	0.000	0.000	0.000	0.000
Tree - Small	0.000	0.000	0.000	0.000
Tree - Medium	0.000	0.000	0.000	0.000
Tree - Large	0.680	0.769	1.127	1.574
Wetland	0.970	1.050	1.370	1.770
Planting Bed	0.000	0.000	0.000	0.000
Turf - Active	0.000	0.000	0.000	0.000
Tuf - Naturalized	1.290	2.007	4.874	8.458
TOTAL JOB CREATION	**66.02**	**88.52**	**178.50**	**290.97**

⟶ Estimated Cost-Benefit Analysis

Generic Green Infrastructure Type	ESTIMATED PUBLIC RETURN ON INVESTMENT (ROI)			
	YEAR 1	YEAR 5	YEAR 25	YEAR 50
Extensive Green Roof	$3,614	$15,819	$64,637	$125,661
Intensive Green Roof	$225,813	$1,396,229	$6,077,897	$11,929,981
Green Façade	$5,220	$13,090	$44,572	$83,924
Living Wall - Interior	$0	$0	$0	$0
Living Wall - Exterior	$0	$0	$0	$0
Rain Garden	-$424,157	-$489,435	-$750,546	-$1,076,935
Bioswale	-$110,290	-$111,068	-$114,177	-$118,063
Permeable Surface - Porous Paver	$0	$0	$0	$0
Tree - Small	$0	$0	$0	$0
Tree - Medium	$0	$0	$0	$0
Tree - Large	$608,482	$1,066,515	$2,898,650	$5,188,818
Wetland	$61,312	$146,512	$487,312	$913,312
Planting Bed	$0	$0	$0	$0
Turf - Active	$0	$0	$0	$0
Tuf - Naturalized	$668,058	$907,190	$1,863,721	$3,059,384
TOTAL ROI FOR SITE REDESIGN	**$1,038,051**	**$2,944,854**	**$10,572,066**	**$20,106,082**

Site 1 Working Group. Credit: Green Roofs for Healthy Cities.

Site 2 Working Group. Credit: Green Roofs for Healthy Cities.

Site 3 Working Group. Credit: Green Roofs for Healthy Cities.

TORONTO
SITE 1
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Michael Black, Carlaw + Dundas Community Initiative

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Paul Mankiewicz, The Gaia Institute
Katherine Camp, Pittsburgh Water & Sewer Authority
Hamid Karimi, DC Department of Environment
Peter Lowitt, Devens Enterprise
Jamie Unwin, York University

MISSISSAUGA
SITE 2
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Site Experts: Janet Squair, City of Mississauga
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Wayne Olson, A Development Consultancy (ADC)
Jeremy Calleros Gauger, ArquitectonicaGeo
Irene Marushko, University of Exeter, U.K.
Rohan Lilauwala, Green Roofs for Healthy Cities
Peter Ensing, DC Greenworks

BRAMPTON
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Connie Lin, Connie Lin Landscape Studio
Deborah Kenley, Credit Valley Conservation
Trish Clarke, Green Roofs for Healthy Cities
Kaleigh Nichols, Organic Farmstead

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Jeff Bayne, City of Mississauga
Laura Piette, City of Mississauga
Stefan Szczepanski, City of Mississauga
Brian Rutherford, City of Brampton
Alex Taranu, City of Brampton
Luke Jefferson, City of Brampton

CONCLUSIONS

⟶ Moving Forward

Green infrastructure has tremendous unrealized potential in communities throughout Ontario. There is significant enthusiasm among community leaders of all types to imagine a future for their community that embraces the widespread utilization of green infrastructure.

This project has been successful at engaging people in a discussion on the value of green infrastructure in their communities. The designs that were generated offer hope for many neighbourhoods that are green infrastructure challenged. The cost-benefit analysis provides a broader context for public officials in understanding the multiple benefits provided through investments of this nature. As we move beyond the pilot stage of this project we will work to generate more precise methods of providing a cost-benefit analysis of these projects. It is also our hope that the many leaders who have engaged in this project will be able to utilize this report to move policies and projects forward in their own communities.

APPENDIX I

APPENDIX I

⟶ Cost-Benefit Matrix Process

Many benefits of green infrastructure such as those related to health benefits currently elude our collective ability to provide monetary values. Another example of this is that green infrastructure can also contribute to generating additional employment by providing new opportunities for local food resources, or biomass for energy production, as well as new opportunities for recreational activities. Hence, green infrastructure can facilitate additional economic activity within your community. For the most part, these types of benefits lie outside the scope of the Cost-Benefit Matrix, but they may be important to your community and should be noted. Undoubtedly, many facets of benefits provided by green infrastructure are difficult to monetize or have been valued using different techniques such as increased quality of life or the happiness index.

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

Hence, there are important limitations in terms of monetizing the many social, economic and ecosystem or environmental benefits of green infrastructure. It is our systematic failure to recognize and integrate these values, which often results in policies and investment practices that lead to suboptimal outcomes for our communities.

One of the goals of this project is to begin to address the limitations of our current decision-making and evaluation processes. There are plans underway to roll out this project in cities across North America.

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

- Green Roofs (Extensive and Intensive)
- Green Façades (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 is an Excel spreadsheet that encapsulates a wide range of economic and biophysical research data tied to fifteen generic types of green infrastructure. The Matrix is comprised of the following components:

- Fifteen generic living green infrastructure types
- Two cost values per square metre derived from the literature and peer reviews for both capital and maintenance
- Ten 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 metre of implemented green infrastructure
- Values for job creation are expressed in person years of employment per square metre of implemented green infrastructure
- Values are often provided in high, medium and low ranges to facilitate customization
- Values may be expressed as one time capital cost or savings, or annual savings
- Property values require additional calculations based on city specific land value and millage rate input

The Matrix expresses most costs and benefits in dollars per square metre. This facilitates our 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 site redesigns from the Green Infrastructure Design Charrette. For example, charrette design teams may call for 1,000 square metres of extensive green roof to be developed. The area (1,000 square metres) provides the basis for estimating the resulting costs and benefits from the values ($\$/m^2$) in the Matrix.

For the purposes of the Green Infrastructure Design 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 a greater degree of benefits as they mature. The benefits, such as stormwater retention from trees are minimal in the first ten years but increase as trees reach maturity. The five, twenty-five and fifty year calculation of benefits takes this into account. Estimates of annual maintenance costs, given the high degree of importance associated with maintaining the performance of green infrastructure are provided.

The Cost-Benefit Matrix attempts to crudely decipher whether the costs and benefits are community based, private, or shared (see chart below). Latent benefits are felt by either public or private entities, even if the respective party does not make the initial investment. In some cases opportunities for subsidy in the form of a green roof incentive may be considered, splitting the cost burden. However, the Matrix does not distinguish between different public entities or departments within a local government. These aspects of the analysis are very community specific. The focused of benefits are largely on those in the general public realm and less on private green infrastructure investment.

As stated above the Matrix provides a simple return on investment at 1-year, 5-year, 25-year and 50-year time frames. It 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.

Precision, when it comes to green infrastructure benefits at an aggregate scale is costly to attempt, impossible to achieve, and quite frankly, unnecessary to the task at hand. In part, this is due to the complexities involved, and the fact that many important benefits cannot be expressed in monetary terms. For example, human health benefits that will result from widespread green infrastructure development, such as reduced rates of asthma in children or decreased levels of stress, are not included in the Cost-Benefit Matrix, because they 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.

The Cost-Benefit 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. There are several categories of wetland in the literature but only one is used. This is justified because the Green Infrastructure 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 Green Infrastructure Charrette in one day, and to derive average values, the types of green infrastructure have had to be simplified. Site-specific design and cost-benefit evaluation would employ a much greater level of design detail and performance research.

The second stage of aggregation concerns a comprehensive identification of benefits associated with green infrastructure that are both quantifiable and non-quantifiable as seen in the literature. The values included in the Green Infrastructure Cost-Benefit 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.

The 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, both physical and mental
- Fire retardation
- Local and regional job creation
- Enhanced photovoltaic panel performance
- Food production
- Biomass for energy production

Afterwards each benefit was evaluated on its ability to be monetizable or not. Only benefits that have been quantified were chosen for inclusion in this phase of the Cost-Benefit Matrix. It is however, the goal of the project to create a working platform upon 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

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. These values will 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 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 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. Values in performance are combined with values for the benefit in question. When combined a final valuation for each benefit specific to each form of green infrastructure's performance is realized. 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.

Afterwards, during the Green Infrastructure Charrette process participants are asked to redesign neighbourhoods using the fifteen generic types of green infrastructure used in the Cost-Benefit Matrix. This process involves exact scaled measurements to properly allow for a cost-benefit analysis following the charrette process.

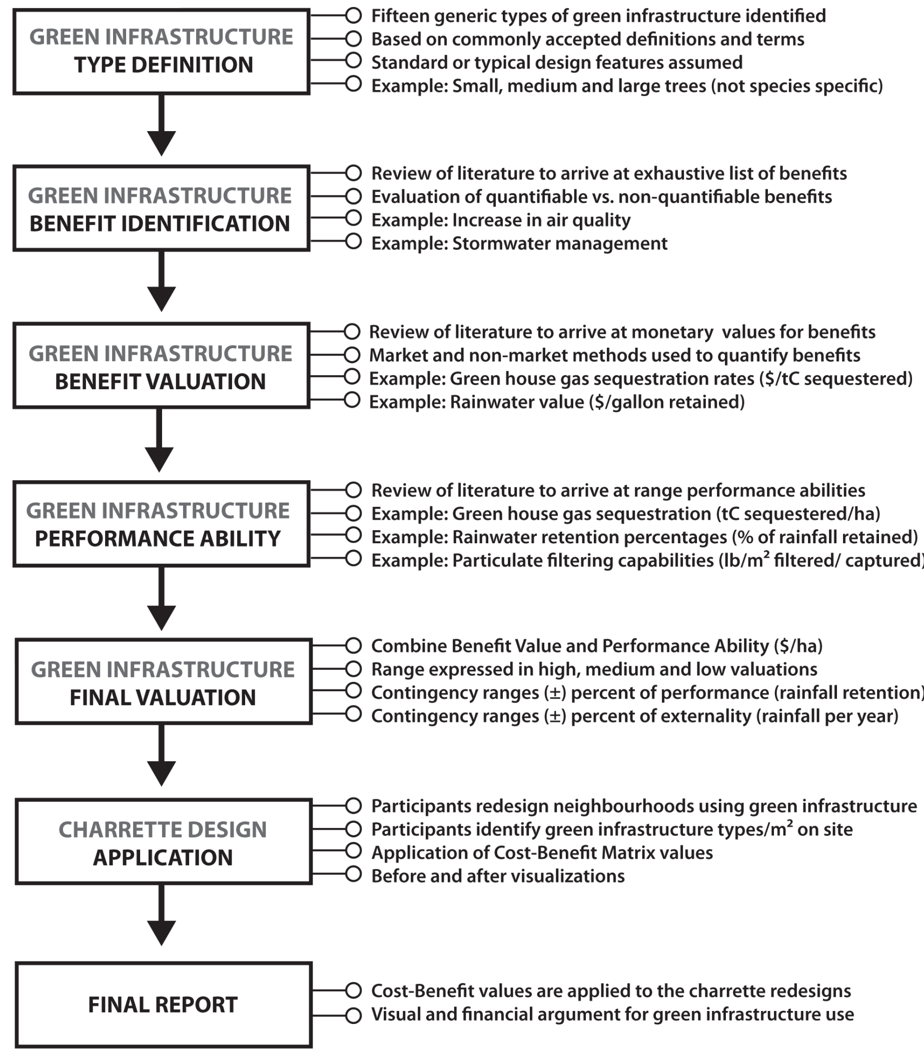
This report for your community is the end product of this project. The report is an amalgamation of all of the various stages discussed above. The report will provide your community with sketches and other visualization techniques as developed during the charrette process. The visual argument is paired with the financial argument expressed as a simple return on investment at 1-year, 5-year, 25-year and 50-year timeframes.

APPENDIX I

⟶ Cost-Benefit Matrix Process

The Cost-Benefit Matrix begins an important conversation around big picture investment in green infrastructure and what benefits will be seen in return. The framework for deriving Matrix cost values can be viewed in the form of a flow chart as seen on this page.

The flowchart expresses the full project process from the first stage of defining generic forms of green infrastructure, through to arriving at valuations for various forms of green infrastructure as discovered in the literature to the final report component after the design charrettes are complete. Examples are provided to help provide reference points of the process.













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