Ecological Infrastructures

Reconnecting The Fragments of
Garrison Creek through Four Frameworks

by

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Architecture

Waterloo, Ontario, Canada, 2021

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Garrison Creek is one of many ravines along Toronto' s waterfront which have undergone numerous transformations since the establishment of Toronto as a city. Accelerated urbanization of the downtown core and waste dumping in these creeks persuaded city officials towards hygienic interventions. Over the last century, sewage infrastructure overcame natural streams, ravine bridges were buried, and building parcels overlaid sloping topography. Reminders of the creek permeate the city through winding side streets, buried bridges and sunken parks.

Extreme urban flooding during the 8th of July, 2013 storm resurfaced questions to whether burying natural watersheds have been more beneficial or detrimental to the health of Lake Ontario. This thesis responds to the effects of climate change, rapid urban development and an aging sewage system by leveraging the buried Garrison Creek landscape through community design, homeowner initiatives and vacant building adaptations.

Through explorations of public park designs, historical infrastructures and storm water management alternatives, awareness of the natural and cultural potential of the former ravine will be addressed. The proposal focuses on reconnecting the creek through four frameworks; a heritage building retrofit, public park green infrastructure, arterial lane way design and rooftop catchment systems. The establishment of these four elements promotes a second life that once flowed through the former creek.

Acknowledgments

I would like to thank my supervisor John McMinn, for his continuous guidance and support throughout the entire process of this thesis. Thank you also to my committee Marie-Paule Macdonald for her insightful feedback on my work and guiding my research interests in the beginning. I would also like to thank Jonathan Enns and Cameron Parkin for participating in my committee and offering alternative perspectives to this thesis I would not have found on my own.

A special thanks to Trevor Whitten for taking the time to respond to my emails and sharing your knowledge, resources and experience regarding the Wellington Destructor heritage property. Your insight has been invaluable during tumultuous times.

I could not have done this without the continuous encouragement, motivation, and support from both family and friends. Thank you for always being there for me and supporting me. Lastly, thank you to my wife Jane, for believing in me during times of both discouragement and happiness.

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Introduction

In the year 2001, my family's house was situated in an area of Toronto between Black Creek and Humber River; two prominent ravines leading to Lake Ontario. I woke up one morning to my family's surprised reactions that our basement had flooded overnight. The same night, 3,000 other homes in the Greater Toronto Area had also reported complaints of their basement flooding because of heavy rainfall. Thirteen years later, the 8th of July in 2013 brought some of the worst flooding recorded in Toronto's history with an estimated 940 million dollars in damages, according to the Insurance Bureau of Canada.[1] Transit systems and highways came to a standstill, and beaches around the waterfront had to be closed. Our awareness of the hidden forces of buried rivers and watercourses only becomes prevalent when our daily lives are interrupted.

1 "Canada Inundated by Severe Weather in 2013," Insurance Bureau of Canada, January 20, 2014, http://www.ibc.ca/yt/resources/media-centre/media-releases/canada-inundated-by-severe-weather-in-2013-insurance-companies-pay-out-record-breaking-$3-2-billion-to-policyholders

It is evident that the combination of climate change, increased development in the Toronto region as well as aging sewage infrastructure, continues to intensify this problem of unfiltered stormwater entering our lakes. Landscape architect Michael Hough in his book *Cities and Natural Processes* highlights the lack of awareness regarding this complex issue among Toronto residents. Current storm sewer and catch basin engineering practices erase the paths from where stormwater originates and where it flows into. "Water is drained off streets, parking lots, pavements, plazas, school yards, front and back gardens and parks, and disappears from the human consciousness." [2] According to combined data from the city of Toronto' s WWTP (wastewater treatment plant) bypass reports, an average of 185 million liters of sewage bypass have been entering Lake Ontario every month for the past five years.[3] This is equivalent to 75 Olympic swimming pools of poorly treated sewage draining into Lake Ontario each month. Through continued large scale proposals and funding of Toronto' s concealed sewage infrastructure, this crucial city function within the public consciousness continues to be further distanced with the users of the city. Thus, the inhabitants of the city are not inclined and aware enough to protect both the water quality of Lake Ontario and its connected hydrological networks.

During the writing of the thesis, a global pandemic has also brought about an influx of public park use, causing levels of crowding in parks which have never historically been seen in Toronto. Based on data provided by Google Mobility for the "Toronto Region,"

2 Michael. Hough, Cities and Natural Process (London ; Routledge, 1995), 37.

3 City of Toronto, "Wastewater Treatment Plant Bypass Reports" (City of Toronto, November 17, 2017), https://www.toronto.ca/services-payments/water-environment/managing-sewage-in-toronto/wastewater-treatment-plant-bypasses/wastewater-treatment-plant-bypass-reports/.

park usage in Toronto increased by 94% in June, 100% in July, and 97% in August compared to the baseline.[4] This represents that park use has doubled in comparison to pre-pandemic levels. As the need for public parks increases, there is an opportunity to re-iterate the role of water in Toronto' s urban landscapes through both infrastructure and public awareness. How can citizens in Toronto begin to respond to the issue of stormwater through design interventions that enhance their experience and participation with the city' s buried ravine landscapes?

Thesis Structure

Garrison Creek has been synonymous to the most mentioned lost river in the history of Toronto. During a time where urban water continues to be celebrated within the architectural landscape realm, this river continues to flow out of sight beneath the city and separated from our physical awareness. Structured around the Garrison Creek sewer shed as the foundation for exploration, the first chapter titled "Watershed" focuses on the ecological formations of the historical ravine, the relationship of the creek to the historical context of Toronto' s industrial expansion, as well as the effects of the creek' s morphology over time on the city' s ecological stability. The second section "Stormwater" focuses on perceptions which led to the burial of watercourses in the city, the pressured conditions of stormwater infrastructure today, as well as considering additional alternative strategies for managing stormwater in the future. The third aspect "Social Awareness" describes the rise of community

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4 Google, "COVID-19 Community Mobility Report," February 25, 2021, https://www.google.com/covid19/mobility?hl=en.

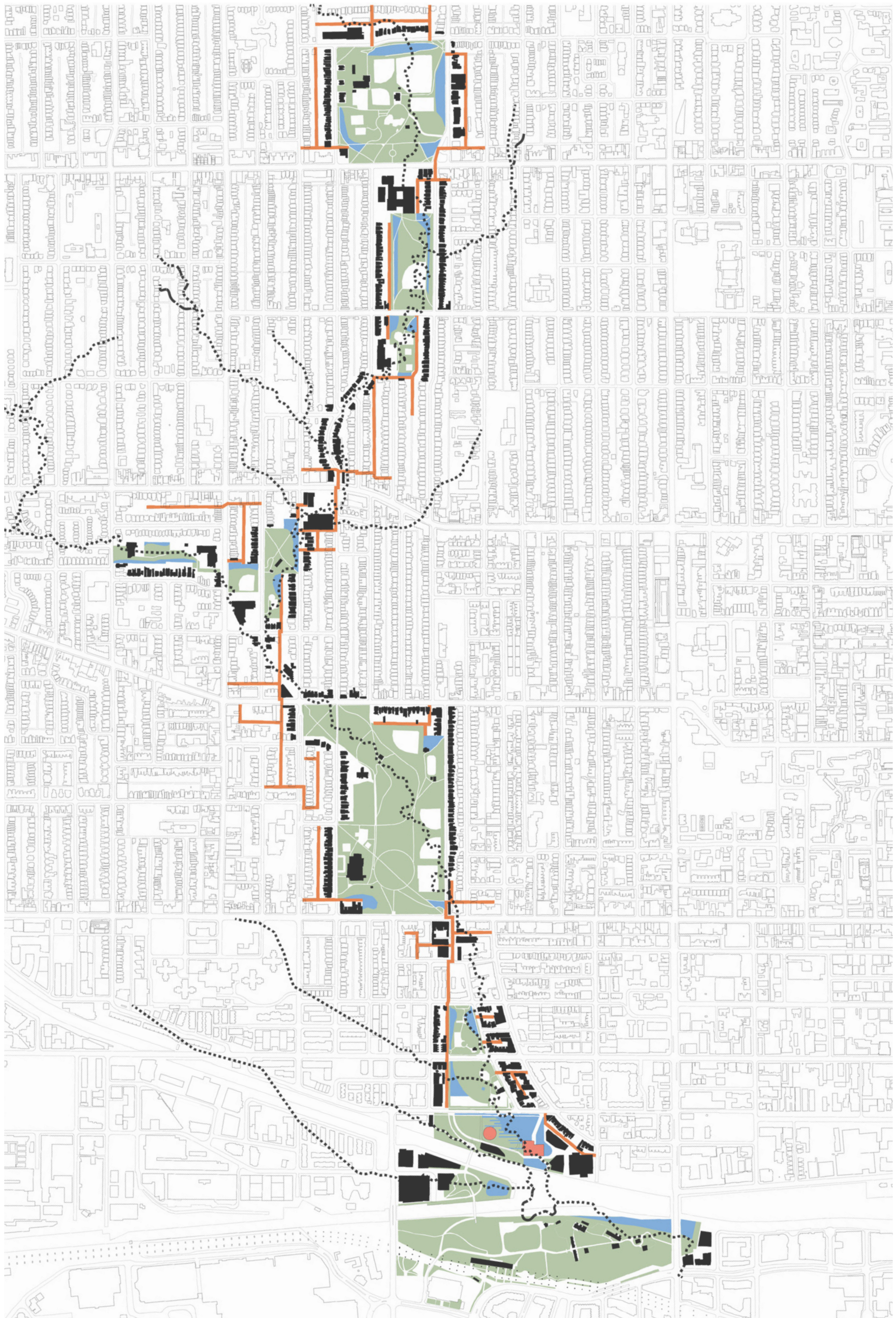
involvement within the city and how changing collective awareness, public environmental education, and neighborhood partnership can bring to light a new relationship between the users of the city and the parks that lie above the hidden ravine landscape. In the chapter “Case Studies” , examples of unbuilt proposals and built functioning systems illustrate how stormwater, city parks and buildings can bring forth watershed awareness and involvement.

Design Strategy

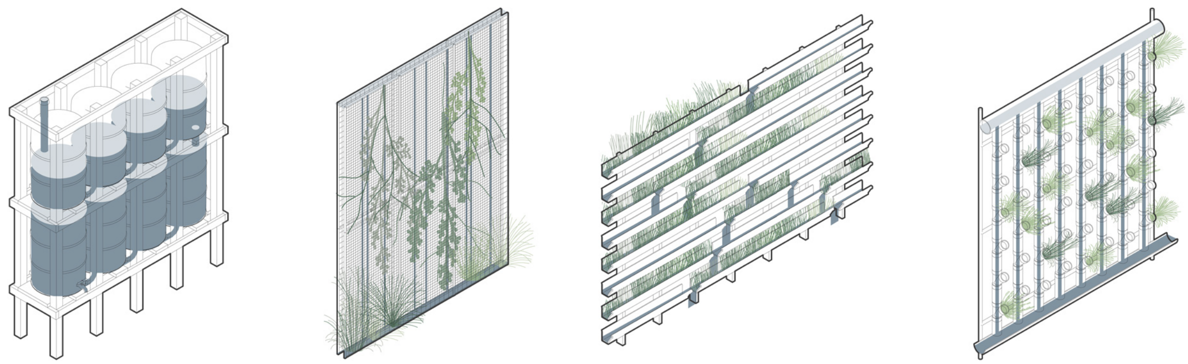
Presented in Chapter 5 “Ecological Infrastructures” , the thesis responds to the complex issues described in previous chapters and builds upon the 1996 schematic design proposal by Brown + Storey Architects' *Rainwater Ponds in an Urban Landscape*. The proposal incorporated the use of rainwater ponds as linkage elements between open park spaces from Christie Pits down to Trinity Bellwood' s Park, reconnecting city life with the historical layers of the ravine path from Garrison Creek to Lake Ontario. By combining urban park spaces with infrastructural stormwater features, the former history of the ravine would have the potential to be brought back into public eyes. For the purpose of this thesis, the scope of design has been limited to focus on the Stanley Park system, North of the Fort York Historic site, an area which has not been explored in the previous proposal by Brown + Storey. The complete neighborhood system and corresponding park along the creek are hypothesized to retain and treat stormwater runoff to relieve sewer pressures and increase lake water quality, while simultaneously connecting surrounding elements to selected park system in a similar fashion. Community interaction and awareness of water in the city are articulated through the design of four frameworks:

1. *Heritage Building* as a pilot project
2. *Open Park Spaces* as redesigned run-off infiltration zones
3. *Laneways* as arterial networks allowing water to flow into designated parks
4. *Rooftops* which expand rainwater catchment volume of the urban fabric

The combination of these four sections allows stormwater to be collected, treated, stored and reused, reducing pressures on existing centralized stormwater infrastructures. In conjunction, these proposed spaces allow park users, neighboring homeowners near the parks as well as tourists to interact and recollect the value of Garrison Creek within day-to-day city life. The inclusion of community-led stormwater engagement programs within the vacant heritage building will develop public opportunities and value towards Garrison Creek, providing precedent for future interventions of hidden ravine landscapes in Toronto. Surrounding the re purposed building will be re mediated stormwater park landscapes connecting to the adjacent park networks through rainwater collection and community driven production spaces.



0.1 _ Proposed Linkage Mapping



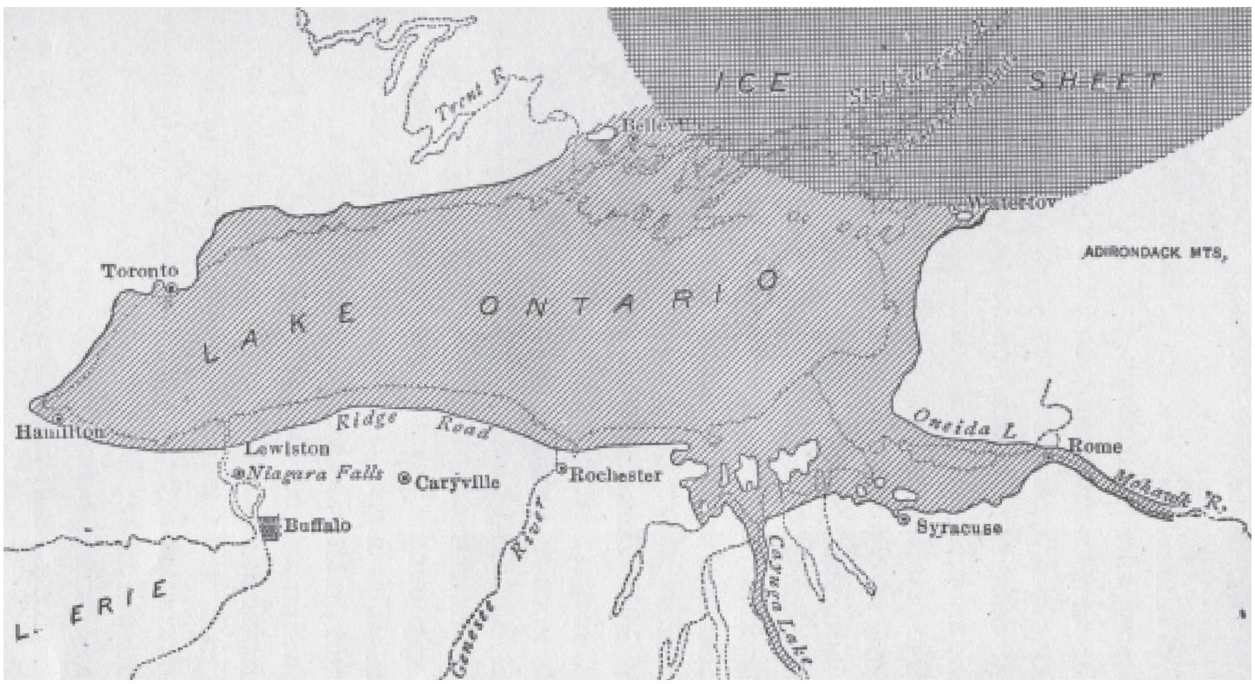
0.2 _ Homeowner Framework Kits

A kit of parts is illustrated within these park landscapes allowing nearby homeowners and park users to begin incorporating green infrastructure and stormwater management techniques on both public and individual property. The laneways form the arterial networks which bridge the gap between smaller private homeowner ground surfaces and large public park infiltration zones. Catchment areas and park systems expand beyond park boundaries, allowing physical and social connections to reach further into the community.

By collecting rainwater and incorporating it into these four elements Heritage Building, Open Park Spaces, Laneways and Rooftops, water systems are made visible to the public. While this thesis does not attempt to fully re-naturalize the creek to its former ecological function, the system of water traveling from component to component will begin to display water movements of Toronto and its redefined role with the cities landscape and its role with its users.

1_Watershed

Multiple layers of history tied to Garrison Creek will be revealed in this chapter, focused on the way geology has been shaped over generations by both Indigenous and European settlement. The relationship of the creek to the historical context of Toronto' s industrial expansion will also be described, as well as the effects of a growing city on the many creeks that divided the urban grid.



1.1 _ Wisconsin Glacial Sheet Drainage Map Into Former Lake Iroquois Boundary

1.1_Hydrological Beginnings

> *"The first considerations are historical geology and climate which, in conjunction, have interacted upon the river basin, for they have created the basic form. When this is understood, the various physio-graphic regions become clearly evident."* [1]

Early formations of the Garrison creek watershed would begin thirteen thousand years ago when the landscape of downtown Toronto was still covered by the Wisconsin glacial sheet of roughly two kilometers thick.[2] Various plants and animals occupying the land as well as rapid climatic swings began to layer and compress sedimentary deposits and fossils, forming the multi-layered till plane that would eventually become the foundation for the city. As the glaciers continued to melt further away from the shorelines, lake levels began to recede from the headwaters of Lake Iroquois, the larger predecessor of Lake Ontario. The edge of this lake remains as a steep bluff in the city of Toronto along Davenport Road.[3] By the process of melting glacial sheets and flash flooding from repeated extreme storms, small streams along the till planes of the exposed Iroquois lake bed eroded into deeper ravines, carving the shorelines down to Lake Ontario.[4] The first Indigenous settlers used these rivers and creeks for fishing and hunting as well as way finding trail routes down to the shores of Lake Ontario. Historical records document the presence of First Nations populations in the Toronto area up to 11000 years ago. [5]

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1 Ian L. McHarg, Design with Nature (Garden City, N.Y: Published for the American Museum of History by] Doubleday, 1971), 127.

2 "The Oak Ridges Moraine - A Ridge of Resources," Canadian Geoscience Education Network, 2014, https://www.cgenarchive.org/toronto-moraine.html.

3 Megan Davies, "Davenport Road' s Official Historical Representation," Davenport Road' s Official Historical Representation, June 10, 2015, https://www.sfu.ca/ipinch/outputs/blog/davenport-road-s-official-historical-representation/.

4 "Lost Rivers - Garrison Creek," Lost Rivers, accessed 2021, http://www.lostrivers.ca/GarrisonCreek.htm.

5 Davies, "Davenport Road' s Official Historical Representation."

1.2_Changing Histories

The years leading up to European settlement on the waterfront of Lake Ontario showed little ecological impact made by the First Nations over these 11000 years. The turning point first begins at the mouth of Garrison creek and the harbor in 1793, when Lieutenant Governor John Graves Simcoe directs the initial foundations of the Fort York garrison as a means of defense against American adversaries within the harbors mouth.[6] *(Fig. 1.2)* The siting of the fort also provided a stable natural water resource for the fort.[7] *(Fig. 1.3)* In 1805, 250 830 acres of land were settled between the British Crown and Mississauga' s of the Credit First Nations through the Toronto Purchase Treaty No. 13. The original treaty date of 1787 had been proven void as there was no direct land boundary agreement made between the Crown and the First Nations.[8]

Initial settlements which were divided up into orthogonal park lots along the creek began to be built as country estates by high income landowners.[9] Built up vegetation and ecological diversity over the several millenniums would make way for industrial expansion and resource extraction. *(Fig. 1.4)*

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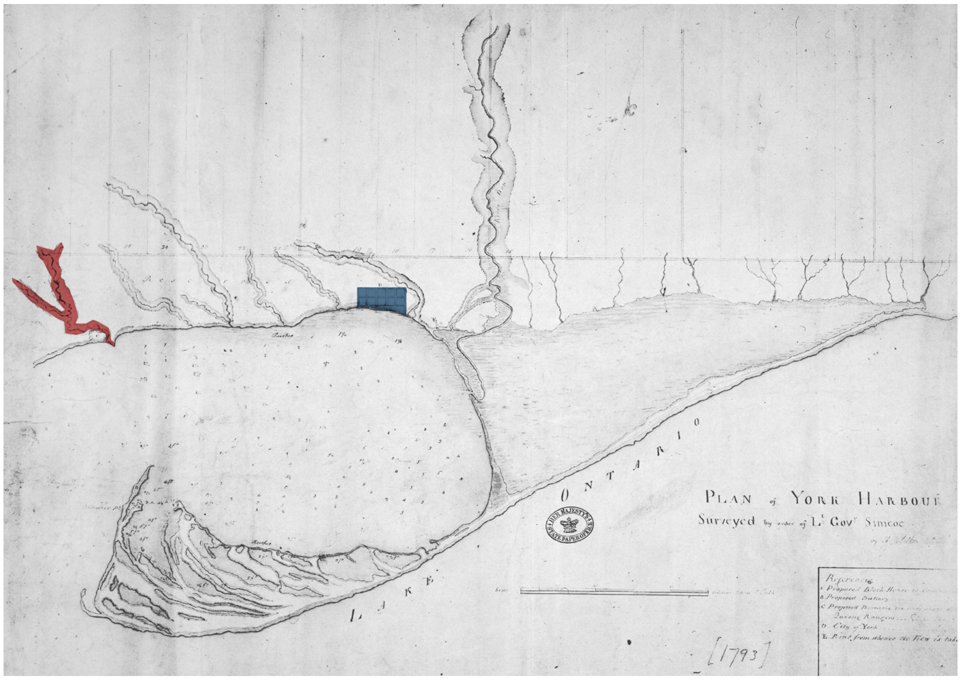
6 Carl Benn, "A Brief History of Fort York ," Friends of Fort York and Garrison Common, n.d., https://www.fortyork.ca/history-of-fort-york.html.

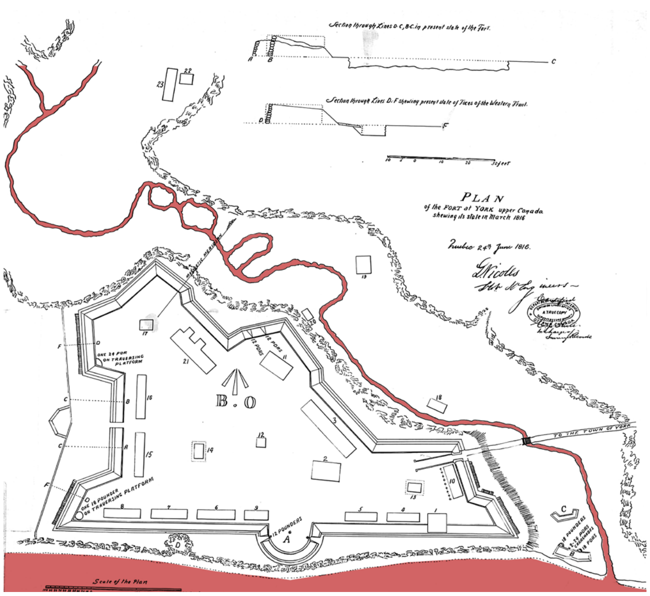
7 "Rainwater Ponds in an Urban Landscape," Garrison Creek Demonstration Project, March 31, 1996, 5.

8 Donna Duric, "The Toronto Purchase Treaty No. 13 (1805)," Mississaugas of the Credit First Nation, May 28, 2017, http://mncfn.ca/torontopurchase/.

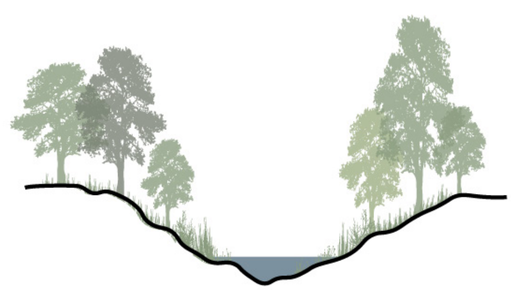
9 "Rainwater Ponds in an Urban Landscape," 19.



1.2 _ Harbor Survey of Showing Garrison Creek and First City Grid Establishment, 1793.

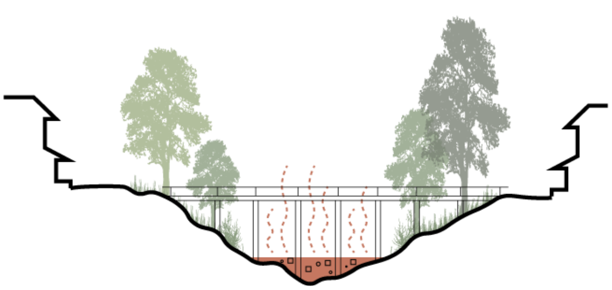


1.3 _ Plan of Fort York At the Mouth of Garrison Creek, 1816.

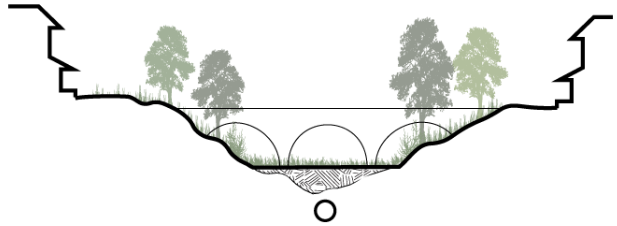


1.4 _ 11000 BCE - 1787 Section

1.5 _ Wesbroom Garrison Creek Aerial Lithography Showing Surrounding City Industry, 1886.



1.6 _ 1787 - 1884 Section



1.7 _ 1890 - 1960 Section

Water powered mills also began carving into river edges to capitalize on the production of flour, malt, lumber, textiles and paper.[10] The subsequent layout of the city grid also led to steel bridges being erected to allow for circulation over the low-lying areas of the creek. *(Fig. 1.5)* By 1842, rapid development forced the creation of private wells for drinking, while rivers and streams became responsible for transferring human waste towards Lake Ontario through backyard midden heaps and receptacles for solid waste. *(Fig. 1.6)*

The issue of the polluted watercourse was compounded when ships were unable to travel through the mouth of the harbor due to excessive waste flows.[11] Waterborne disease outbreaks such as cholera and typhoid further urged city officials to address this problem.[12] The first sewers along Garrison Creek were constructed in 1888, marking the beginning of the filling over the entirety of the creek with combined sewer lines, carrying both stormwater and sanitary sewage. The belief at the time was to direct sewage and storm water away from the creeks and into controlled treatment facilities away from the waterfront to stabilize the byproducts of city expansion within the ravine. The last remains of the creek were filled in by the 1920' s.[13] *(Fig. 1.7)*

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10 Gary Miedema, When the Rivers Really Ran: Water-Powered Industry in Toronto, ed. Wayne Reeves and Christina Palassio, HTO : Toronto' s Water from Lake Iroquois to Taddle Creek and Beyond (Coach House Books, 2011), 67.

11 Michael Cook, "Burying The Garrison Creek: A History," Http://Www.Vanishingpoint.ca/Garrison-Creek-Sewer-History, April 21, 2010.

12 Javed Noor, "Toronto Forged Its Identity amid Cholera Outbreak ," Toronto Star, March 7, 2009, https://www.thestar.com/life/health_wellness/2009/03/07/toronto_forged_its_identity_amid_cholera_outbreak.html.

13 Cook, "Burying The Garrison Creek: A History."

The ravines became temporary parkland again once the construction of the underground sewers was completed and the noxious fumes and visible wastewater had been diverted. This was an equilibrium point for the creek as the dramatic physical depressions and social relationships of the creek remained, whilst the sanitary and infrastructural requirements could still be satisfied.[14] *(Fig. 1.8)* More durable concrete bridges were made in place of the steel to cross the lower parkland. *(Fig. 1.9)*

Unfortunately, in the 1930' s, the Garrison lands turned into landfill sites for surrounding industrial lands and residential developments due to the limitations for further intensification in the city during the Post War. Bridges that were previously constructed to preserve the space below the ravine were buried, including the Crawford Bridge and Harbord Bridge.[15]

In its present condition, Garrison Creek has been largely covered over and filled in, but subtle geographic traces of the creek are still found throughout the city fabric. The curved side street of Niagara and Crawford Street as well as the sunken parks at Trinity Bellwood' s, Stanley Park, and Christie Pits all hint at the sunken landscape that was once much deeper. *(Fig. 1.10)*

This thesis proposal then begins to respond to the multi-layered landscape which reconsiders how the flow of the creek can be brought back into today' s city landscape through four components. *(Fig. 1.11)*

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14 "Rainwater Ponds in an Urban Landscape," 14.

15 "Rainwater Ponds in an Urban Landscape," 20.

1.8 _ Crawford Street Bridge, 1912.

1.9 _ Crawford Street Bridge, 1915.

1.10 _ 1960 - Present Section

1.11 _ Proposed Intervention Section

1802_ Initial Creeks and Rivers Before Major Settlement

1842_ Rapid Waterfront Expansion Along Lake Edge

1862 _ Further Fragmentations of Creeks and Rivers

1.12 _ Creek Disappearance Timeline 1802 - 1949

1869_ Last Open Remnants Before Construction of Sewer Lines

1909_ Complete Burial of Waterfront Watershed

1949 _ Remaining Rivers and Creeks in Surrounding Watersheds

With the burial of Garrison Creek and many other watercourses in the city, drainage patterns have been significantly altered, and this has had a detrimental effect within the history of Toronto during extreme weather and rainfall events.

1.3_Altered Water Cycles

In Gary Snyder' s The Place, The Region and The Commons, inherent connections between all scales on earth can be described as mosaics within larger mosaics - the land is comprised of multiple small regions, replicating larger and small patterns, varying according to geographic biota, watersheds, landforms, and elevations.[16] Garrison Creek was connected to a much larger hydrological system belonging to a network of drainage patterns North of the city. Redirecting the flow of water into sewers has permanently changed this relationship into other scales and systems, most notably the health of Lake Ontario.

> *"The benefits of well-drained streets and civic spaces are paid for by the costs of eroded stream banks, flooding, impaired water quality and disappearance of aquatic life."* [17]

Calculations show that in an urbanized area that has 50 percent impervious surfaces and is 50 percent sewered, the number of stream flows that equal or exceed the capacity of its banks, would, over a period of years, be increased nearly four-fold.[18] *(Fig. 1.13)* This effect was demonstrated in 1954 when Hurricane Hazel struck the city and 65 billion gallons of water flash flooded the remaining rivers in the city, destroying 500 homes and claiming 81 lives.[19]

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16 Gary Snyder, The Place, the Region, and the Commons, The Practice of the Wild (Berkeley, California: North Point Press, 1990), 27–28.

17 Michael. Hough, Cities and Natural Process (London ; Routledge, 1995), 35.

18 Bruce K. Ferguson, Introduction to Stormwater (New York: John Wiley, 1998).

19 Jay Young, "The Toronto Flood of 2013: Actions from the Past, a Warning for the New Normal?," Active History, July 16, 2013, http://

1.13 _ Urban Built Up Area of Greater Toronto Area From 1966 - 2002

History would repeat itself on July 2013 when 126mm of heavy rainfall fell in a single day, shutting down transit infrastructure, flooding bridge underpasses and damaging household properties with a recorded 850 million in insurance claims.[20] The Insurance Bureau of Canada has ranked it as the costliest natural disaster in Ontario' s history. 100-year storm events have become more common, with a recording of eight storms which have exceeded City design standards since the beginning of the 1980s.[21] The effects were so strong that in some areas of the city, extreme water pressures overwhelmed the existing system of tunnels through the sewer, exploding manhole covers. *(Fig. 1.14)*

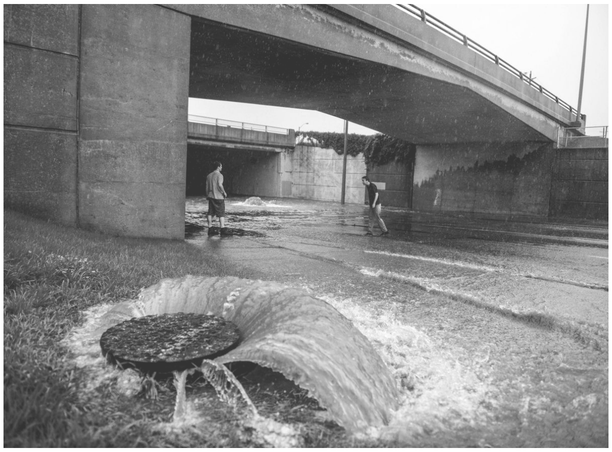
The effects of urbanization and the diminishing permeability within the downtown core are made evident through the way water travels through the ground post development. It is found that the levels of runoff within city fabric which usually consists of 75%-100% impermeable ground cover have roughly 45% higher runoff amounts compared to natural permeable ground cover. *(Fig. 1.15)*

This significant alteration of surface hydrology in the city is further reinforced by Hough where "...asphalt and concrete replace the soil, buildings replace trees, and the catch basin and storm sewer replace the streams of the natural watershed." [22] Within the context of Toronto, the amount

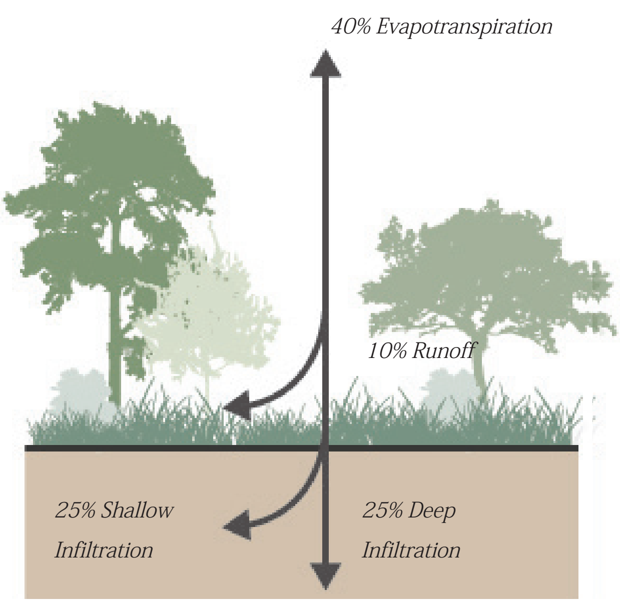
20 "Canada Inundated by Severe Weather in 2013," Insurance Bureau of Canada, January 20, 2014, http://www.ibc.ca/yt/resources/media-centre/media-releases/

21 Wayne Reeves and Christina Palassio, eds., HTO : Toronto' s Water from Lake Iroquois to Taddle Creek and Beyond (Directions) (New York: Coach House Books, 2011), 230, http://ebookcentral.proquest.com/lib/waterloo/detail.action?docID=760161.

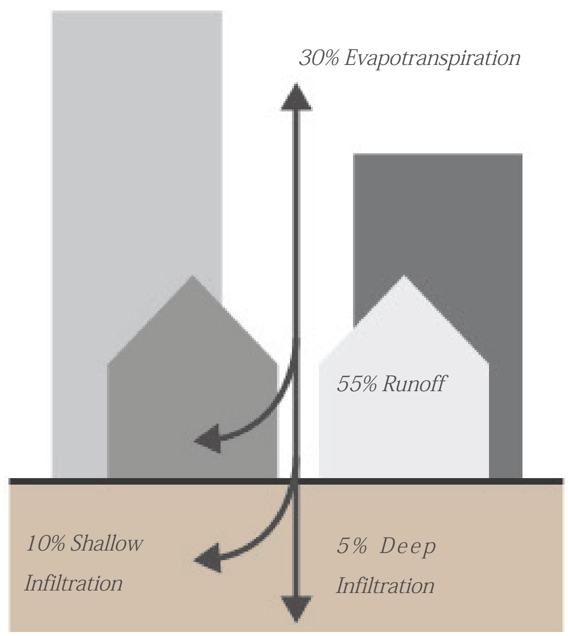
22 Hough, Cities and Natural Process, 30.



1.14 _ Overwhelmed Sewage Line During July Storm in Toronto, 2013.



Natural Permeable Ground Cover



75-100% Impermeable Ground Cover

1.15 _ Natural vs Urban Permeability

of urban expansion from 1966 to 2002 has been significant. The increase in impermeable surfaces has a large effect on how stormwater travels through the city. Originally half of the rainwater would be able to enter the ground directly, but now it must travel to the next most permeable infrastructure: sewers.

2_Sewers + Sewage

Top-down planning and infrastructure is implemented to produce an orderly, predictable, and stable environment. Through urban planning, physical intervention and regulatory frameworks, the containment, structuring and management of natural forces has defined Toronto' s approach to infrastructure for the last century.[1] This chapter expands on the provisioning of sewers in the city, the pressured conditions which face ageing stormwater infrastructure today, as well as bringing forth alternative strategies for managing stormwater and how they can begin to reconnect users of the city to dynamic processes of stormwater.

1 Marta Brocki and Nina-Marie Lister, "Embracing Complexity: Ecological Designs for Living Landscapes," Oz 36, 36, no. 1 (January 1, 2014): 38–39, https://doi.org/10.4148/2378-5853.1530.

2.1_Sanitary Motivations

The initial development of sewer systems began in 1835 as a response to the repeated outbreaks of waterborne diseases in the city such as cholera and typhoid. The repeated dumping of fecal matter from midden heaps and receptacles along the edges of creeks brought about calls to action for sanitary management in the city. Initially, it was the responsibility of individual homeowners to submit petitions and buy into the construction of sewage lines for each of their properties.[2] By 1848, councilors and unelected city employees such as City Engineers began to oversee the construction of the sewers, fueled by the medical theories of disease transmission within the city dubbed the 'sanitary idea' . The proliferation of the idea spread throughout residents in the city, further concerning the population for the need to convert the rest of the cities' creeks into sewers.[3]

While the perception of health and sufficient drainage of wastewater in the city was achieved, the problem now shifted to the lake. Misconceptions around Lake Ontario being large enough to dilute the sewage outflows from the city brought foul odors to the bay mouth of the harbor front alongside sludge recorded to be roughly three to four feet thick in 1908, limiting cargo shipment movement.[4] Suggestions around intercepting trunk sewers East-West to convey wastewater and stormwater from the combined sewers towards centralized treatment plants would be debated for around 60 years due to budgetary concerns until 1910 when construction began for Ashbridges Bay Wastewater Treatment Plant, the first in the city. *(Fig. 2.1)*

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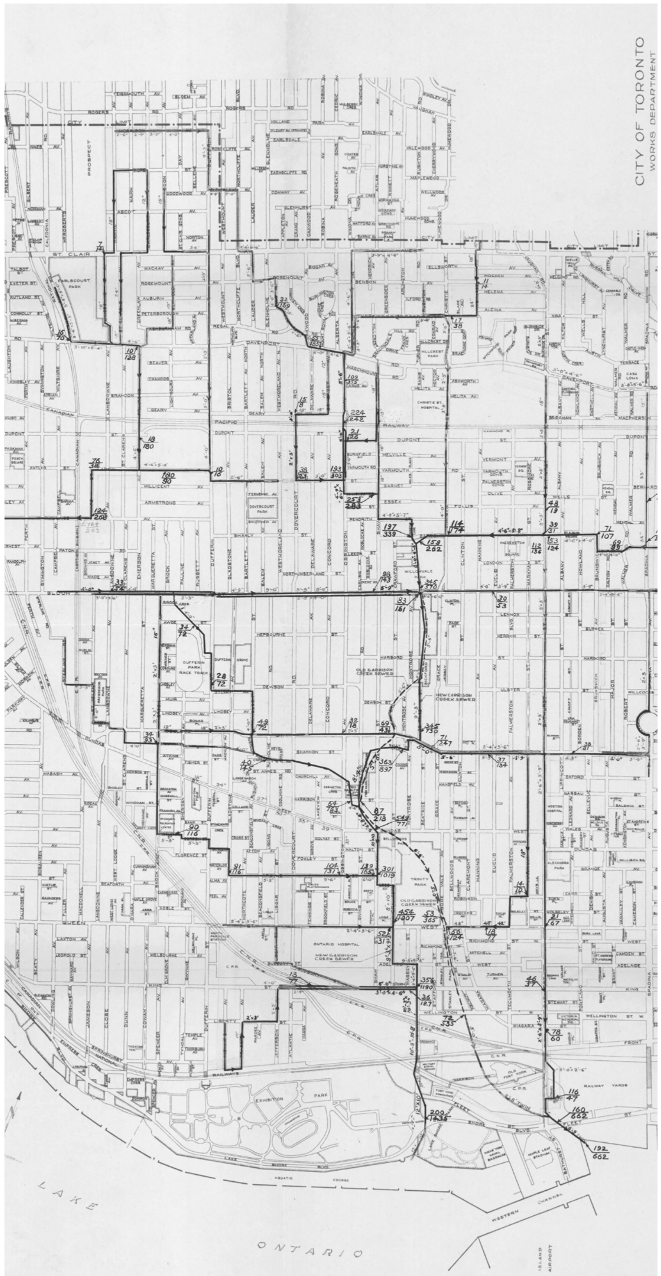
2 Catherine Brace, "Public Works in the Canadian City; the Provision of Sewers in Toronto 1870–1913," Urban history review 23, 23, no. 2 (March 1995): 34, https://doi.org/10.7202/1016632ar.

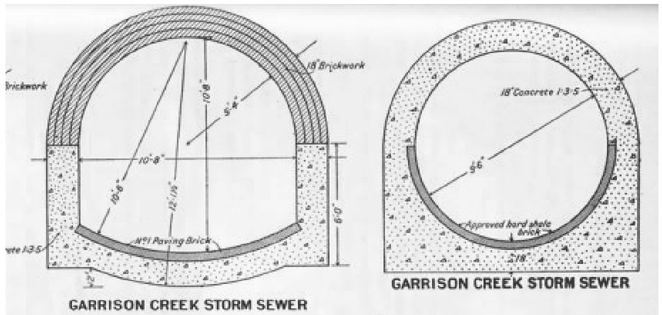
3 Brace, 37.

4 Brace, 41.

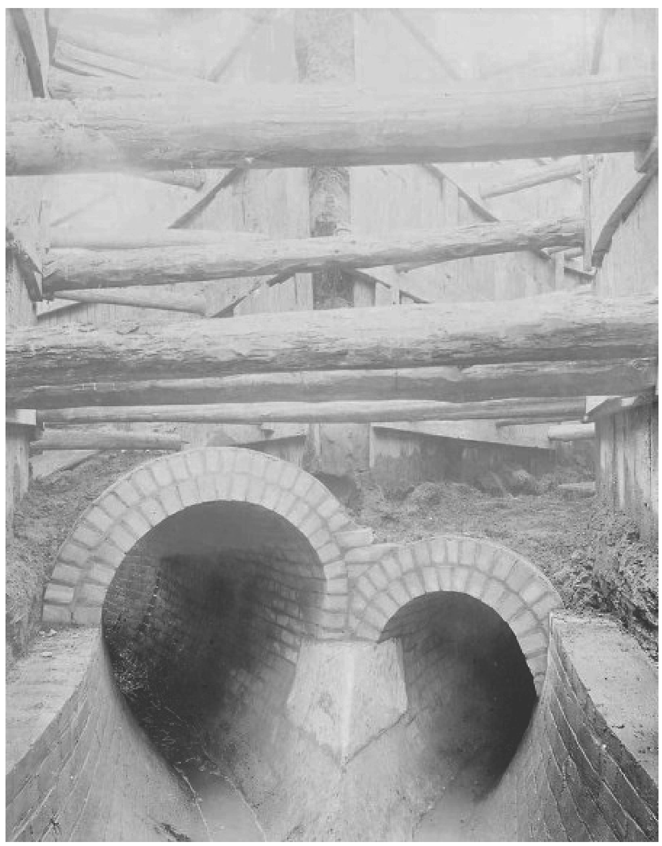
2.1 _ City of Toronto Proposed Intercepting Sewers and Outfalls, 1889.



2.2 _ Garrison Creek Sewer System Plan, 1956.

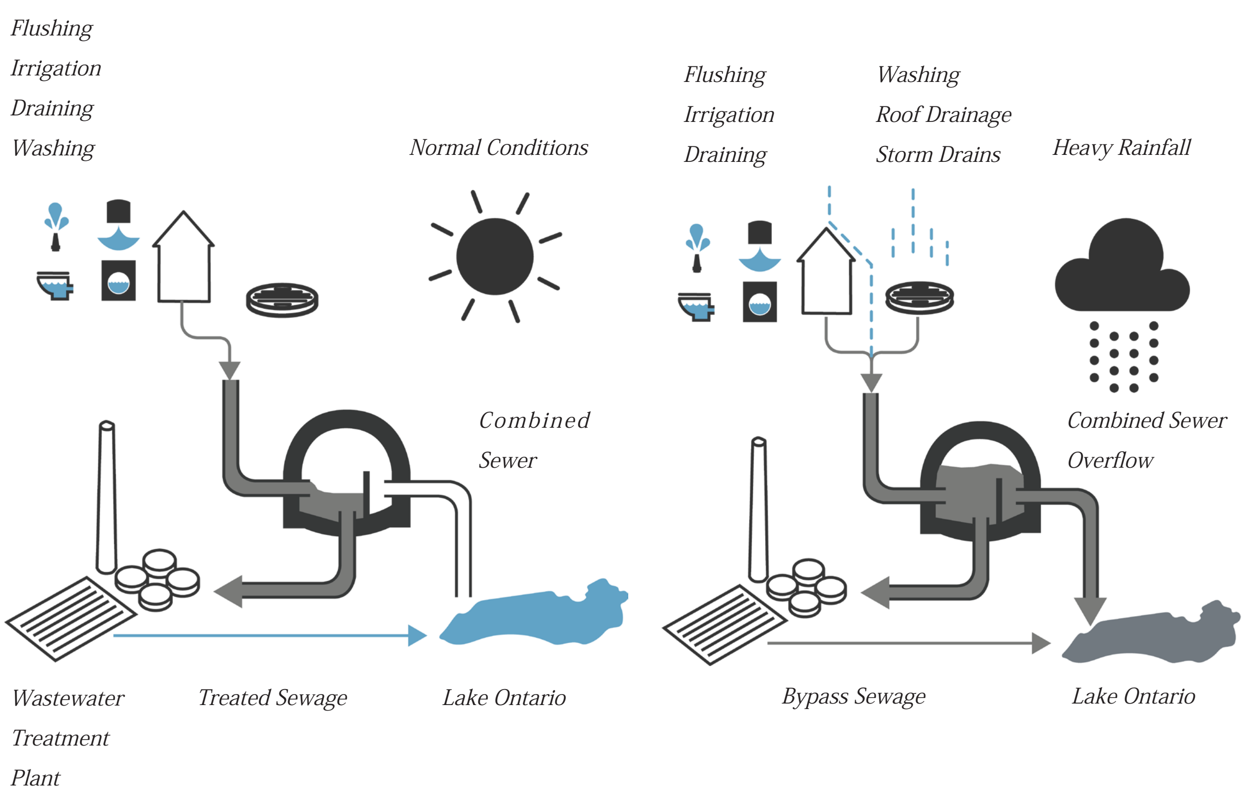


2.3 _ Garrison Creek Combined Sewer 10' Diameter Sections



2.4 _ Construction of Garrison Creek Sewer System, 1890.

2.5 _ Lake Ontario Closure After Heavy Rainfalls



2.6 _ Combined Sewer Overflow Event Diagram

By the 1960’ s four wastewater treatment plants in Toronto were completed. Presently, the design capacities for these trunk sewers did not account for the increase in runoff and intensification found in Toronto today. What results from this is a repeated pattern of diminished Lake quality after heavy rainfalls each year through the overburden of both the combined sewers that lead to the Lake and the bypasses it creates in these four treatment plants.

2.2_Ageing Sewage Networks

Stormwater management in Toronto still allows large amounts bypass through filtration plants during high rainfall through combined sewer overflows (CSO’ s). These discharges occur in 84 outfalls along the lake shore and are the prime cause of local bacterial spikes in water bodies, causing beach closures at the Lake Ontario waterfront.[5] *(Fig. 2.5)* Built from the 1890-1920s, the century old drainage system has been unable to keep up with the increase in hard scape intensification in the downtown core, exacerbating flood intensity and direct outflow volume towards the lake over the years. The 1,511 kilometer network of combined sewers that exist by Toronto’ s waterfront continue to require constant repair and replacement. *(Fig. 2.6)* The Canadian Infrastructure Report Card highlights that more than $80 billion will be needed to replace aging water infrastructure over the next 20 years. Another $20 billion must be set aside for upgrades of existing infrastructure to meet new federal wastewater regulations over the same period.[6]

5 “Rainwater Ponds in an Urban Landscape,” Garrison Creek Demonstration Project, March 31, 1996, 10.

6 “Canadian Municipal Water Priorities Report,” Canadian Municipal Water Consortium, 2014, 14, cwn-rce.ca.

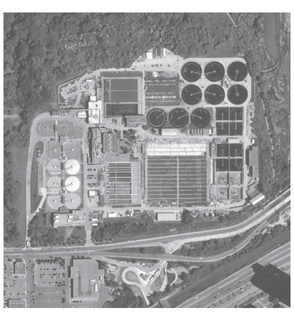
2.3_Wastewater Treatment Plants

The current systems which manage stormwater still lie in the four wastewater treatment sites near the mouths of creeks and ravines by Lake Ontario. *(Fig. 2.7)* Ashbridges Bay treatment plant is responsible for the majority of the trunk sewage that drains from the city through a large Eastern trunk sewer, serving over 1.5 million people as well as the majority of runoff from streets.[7] In extreme weather events, this filtration infrastructure can be easily overwhelmed. It is still evident that most of the water infrastructure in the GTA is not built to handle repeated storm events of such magnitude. Based on rainfall trends and data provided by yearly bypass reports at Ashbridges Bay Treatment Plant, an average of 185 million liters of sewage bypass have been entering Lake Ontario every month for the past five years.[8] *(Fig. 2.12)*

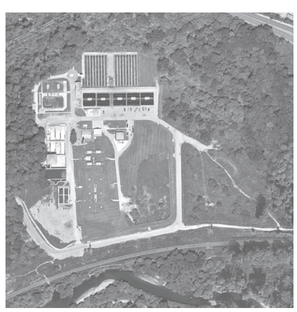
7 "Wastewater Treatment Plants & Reports," City of Toronto (City of Toronto, 2017), https://www.toronto.ca/services-payments/water-environment/managing-sewage-in-toronto/wastewater-treatment-plants-and-reports/.

8 City of Toronto, "Wastewater Treatment Plant Bypass Reports" (City of Toronto, November 17, 2017), https://www.toronto.ca/services-payments/water-environment/managing-sewage-in-toronto/wastewater-treatment-plant-bypasses/wastewater-treatment-plant-bypass-reports/.

2.7 _ Combined Sewer Areas and Daily Wastewater Treatment Plant Capacities



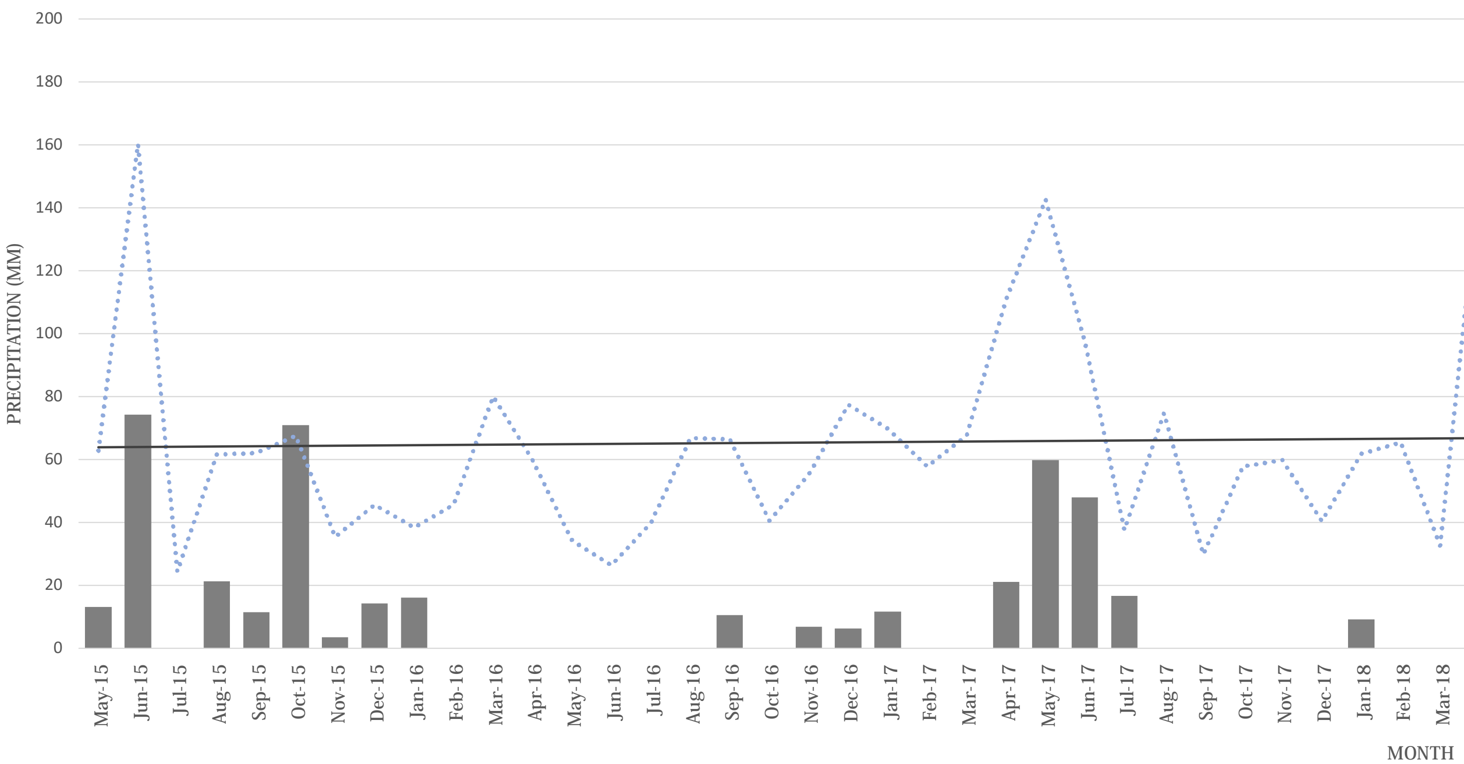
2.8 _ Humber



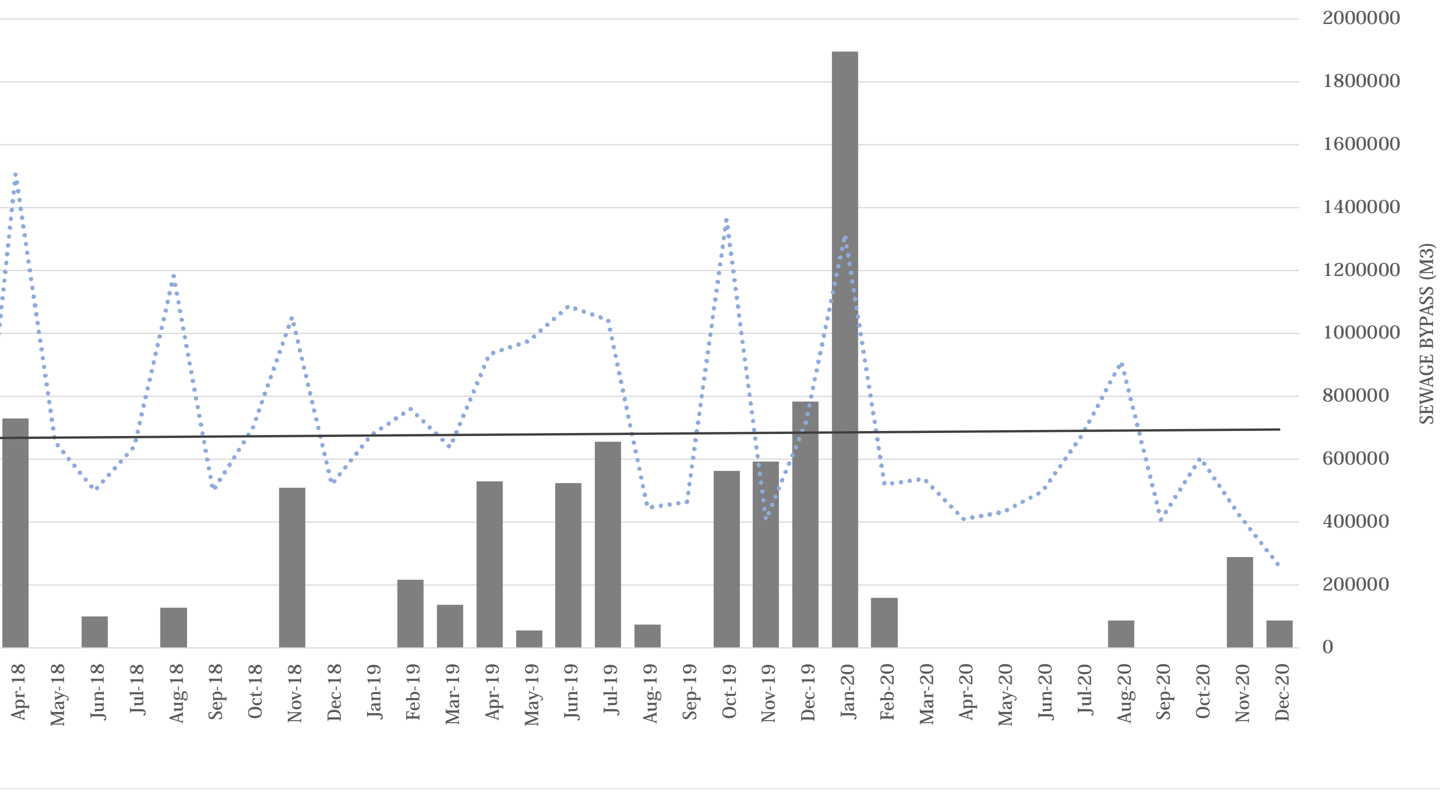
2.9 _ North Toronto

2.10 _ Ashbridges Bay

2.11 _ Highland Creek



2.12 _ Ashbridges Bay Wastewater Treatment Plant Sewage Bypass Volumes 2015 - 2020 in Cubic Meters


2000000
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
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SEWAGE BYPASS (M3)
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Feb-19
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Despite this, the City of Toronto continues to prioritize over-engineered solutions to keep up with the growing needs of city. Slated for completion in 2043, the multiphase construction for a three-billion-dollar waterfront infrastructure project promises to capture and store combined sewer overflows during heavy rainfalls by means of a 22 kilometer tunnel system, storage tanks and high rate ultraviolet disinfection facility at the Ashbridges Bay Treatment Plant.[9] *(Fig. 2.13)*

Because of the large-scale nature of the project, the benefits provided by the infrastructure upgrade will not be seen for another quarter of a century. While city officials do not hesitate to green-light generous amounts of funding towards centralized stormwater development, decentralized stormwater management continues to be a secondary consideration for mitigating stormwater runoff. In comparison, federal allocations for all green infrastructure projects in Ontario will be only $2.35 billion over the course of 11 years.[10]

Missed opportunities with water and the users of the city are made when the city continues to focus on the disconnected systems which conceal the relationships between infrastructure, the users of the services and the intertwined biophysical systems. Simultaneously, the illusion of an undisturbed landscape continues to be projected in contrast to the inherent manipulation happening beneath our feet.[11] In contrast, beginning to study localized, adaptive and decentralized filtration strategies is another strategy which has begun to reconnect stormwater with the public realm and the users of the city.

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9 Desmond Brown, "Toronto Launches $3B Project to Improve Water Quality in Lake Ontario and City' s Waterways | CBC News," CBC, December 14, 2019, https://www.cbc.ca/news/canada/toronto/toronto-storm-water-wastewater-management-program-1.5396886.

10 "Intergovernmental Infrastructure Funding in the 2021_2030 Recommended Capital Budget and Plan" (City of Toronto: City Manager and Chief Financial Officer and Treasurer, February 4, 2021), 9, https://www.toronto.ca/legdocs/mmis/2021/ex/bgrd/backgroundfile-163656.pdf.

11 Brocki and Lister, "Embracing Complexity: Ecological Designs for Living Landscapes," 39.

2.13 _ Portion of New Tunnel Construction - Coxwell Bypass Combined Sewer

2.4_Decentralized Stormwater Management

> *"water pollution issues are best addressed when they become part of an integrated design strategy that combines biology and technology, social and economic concerns."* [12]

Centralized stormwater management comprises of system where stormwater is directed and treated at a singular location. In contrast, decentralized stormwater management systems identify potentials for smaller scale, adaptable and shorter time frame integration of stormwater management in existing landscapes within the city. Currently, Ontario is not actively promoting the use of green infrastructure construction and subsequently decentralized stormwater management as a primary alternative over sewage infrastructure improvements. The only current policy tools that exist are best management practices, exploring approaches to integrate the economic value of green infrastructure, and guidance on the use of green infrastructure, according to Ontario's Flooding Strategy.[13]

Where flooding is seen as a threatening byproduct of dysfunctional sewer systems, decentralized stormwater management accepts and embraces these instabilities. In addition to the ability to decrease CSO peaks in city by absorbing water over longer periods of time *(Fig. 2.14)*, ecological, social and cultural improvements are revealed. Explicit connections can be made between the urban and natural realms as well as the community. Site-specific adaptations like those found in both existing ravine landscapes and parks in Toronto have already started to illustrate ways reconciliation can be made between

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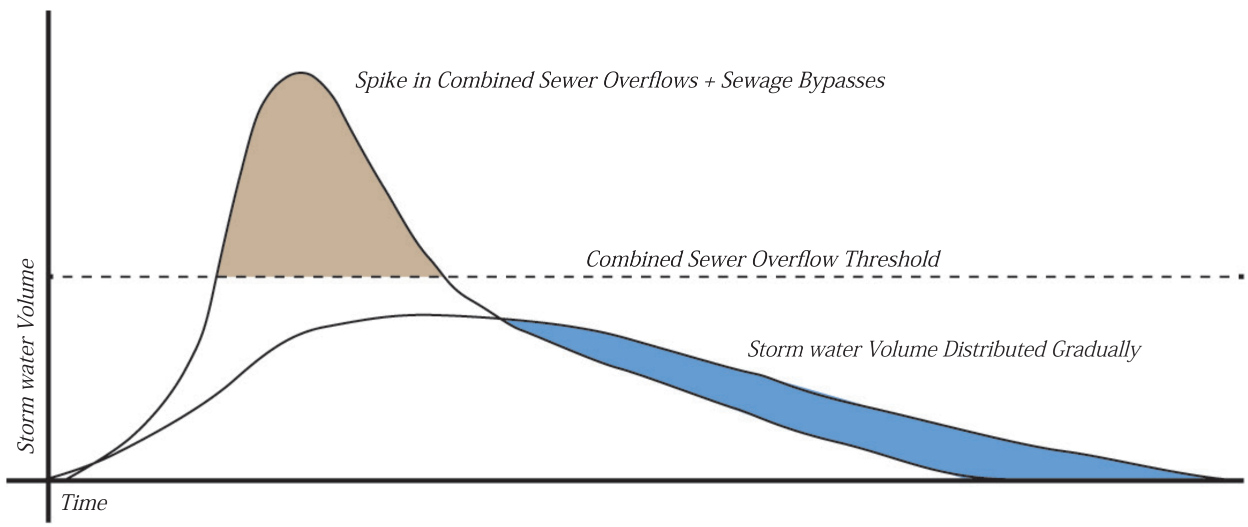
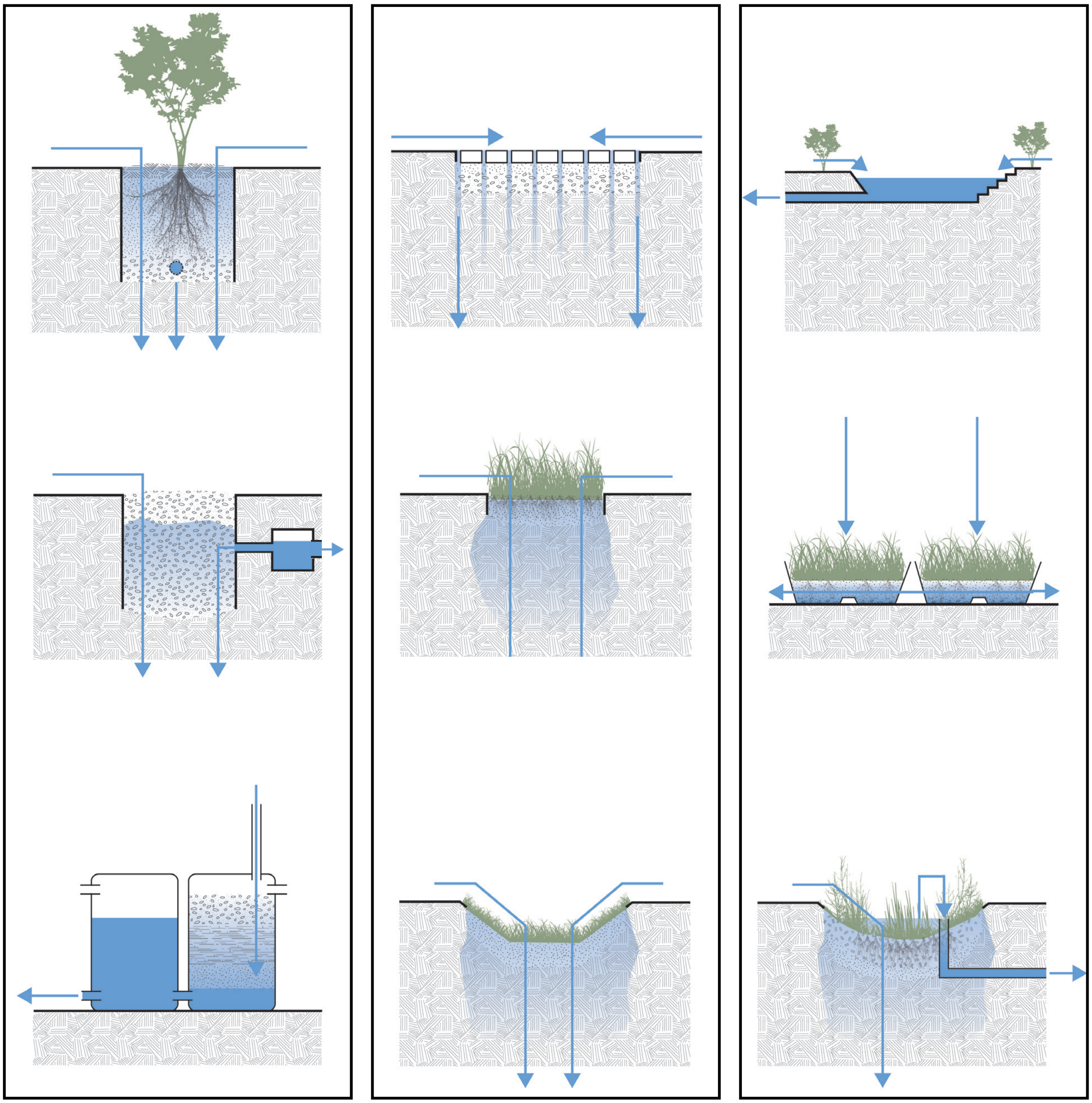
12 Michael. Hough, Cities and Natural Process (London ; Routledge, 1995), 69.

13 "Protecting People and Property: Ontario's Flooding Strategy," Ontario.Ca, March 9, 2020, https://www.ontario.ca/page/protecting-people-property-ontarios-flooding-strategy.



2.14 _ Urban vs Rural Rainfall Intensity



Point Management *Linear Management* *Area Management*

2.15 _ Decentralized Stormwater Management Types stormwater and the users of the city through public space design and intervention.

> *"Using strategic design, urban systems can be guided in ways that allow for the enhanced absorption and facilitation of physical and cultural change while maintaining the functions we depend on."* [14]

Beyond the benefits of taking the pressure off existing centralized stormwater infrastructures, decentralized stormwater management can connect to the physical urban surfaces of the city. Relationships between water and the public realm can be resurfaced, allowing for potential interactions that were not possible before.

Decentralized stormwater management can be categorized into three major types of systems: *Point Interventions, Linear Systems*, and *Area Volumes*. *(Fig. 2.15)* Within each form, there are three ways in which stormwater can be controlled: infiltration, retention and conveyance. Infiltration allows stormwater to enter directly into the ground at the source of the intervention, retention retains the stormwater in a specific location and conveyance allows the transport of stormwater to another location. These are the nine types of decentralized stormwater management that will be highlighted throughout the different case studies and the thesis intervention.

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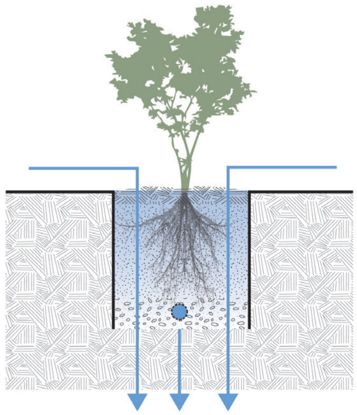
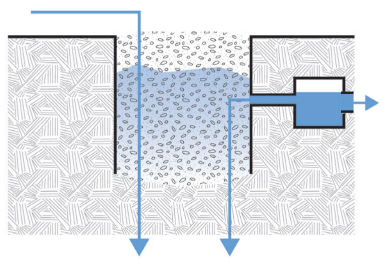
14 Brocki and Lister, 40.

Point Management



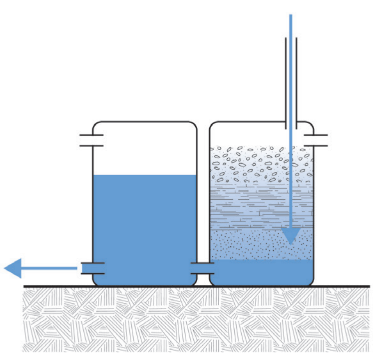
2.16 _ Stormwater Tree

Stormwater trees can provide economic and ecological benefits to cities. By transpiring rainfall through leaves and filtering stormwater as it travels through its soil and roots, groundwater quality is increased and a reduction in stormwater directed to sewers is achieved. Sited in a well or box to stabilize the soil from compaction and stormwater flow, these trees may also be connected in a linear fashion along under-drain pipes.



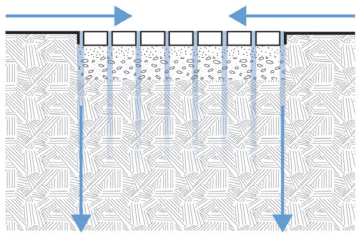
2.17 _ Infiltration Pit

Infiltration Pits/Trenches are dug trenches lined with geo-textile fabrics and then filled with granular stones, allowing surface runoff to be stored and gradually infiltrated into the ground. These pits are useful in the event that rain barrels are unable to be used for rainwater cannot be redirected to other zones such as sites closed off to perimeter open space. Excess flows may also be directed through pipes towards other management zones.



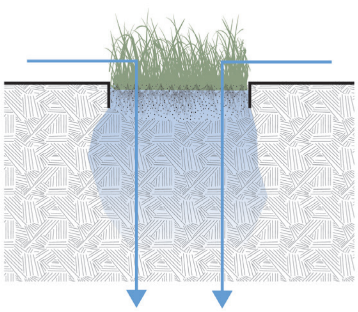
2.18 _ Rain Barrel

Rain barrels are a low-cost water retention and conveyance method which can be connected to roof downspouts or as independently localized catchment trays. Utilizing gravity and the weight of the water, spouts can control water flow for non-potable use such as washing cars, watering gardens and directing flow of storm water gradually back to sewers or to further downstream management zones. Filling barrels with bio-filtration media such as coarse gravel, sand and charcoal can further reduce pollutants.



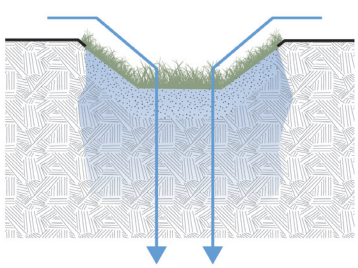
2.19 _ Permeable Paving

Permeable paving/interlocking/grid paver allow stormwater to infiltrate through the street surface at a gradual rate and are applicable in lower density zones with less vehicular traffic. The integration of permeable paving is most effective on shallow slopes of 5% or less to allow water to infiltrate and provide more efficient placement of temporary subsurface storage.



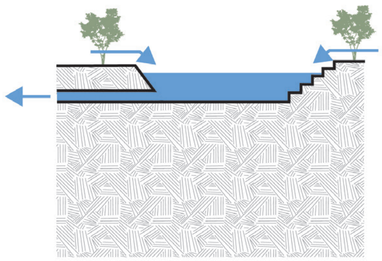
2.20 _ Grass Filter Strip

Most typically located adjacent to sidewalks and street curbs, grass strips provide reduction in runoff velocities, space for neighboring snow storage and sediment/pollutant filtration. While they have lower volumetric capacity than a swale, level grading provides easier pedestrian crossing and are one of the most cost-efficient methods of stormwater management at the expense of lower infiltration rate and capacity.



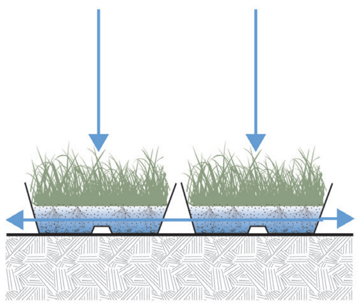
2.21 _ Swale

Applicable in low density and traffic contexts, swales provide space for plantings to increase habitat and green scape. The landscaped depressions capture and infiltrate stormwater runoff as it travels downstream. The are able to accommodate for low to moderate flows of runoff. Generally less than 2 feet in depth, they pose low safety risks and are less complex to adjust compared to hard edged planters.



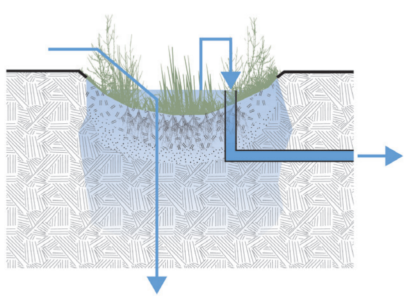
2.22 _ Wet Basin

Wet basins consist of an inlet source which gathers stormwater from neighboring sources of stormwater runoff and are captured and held in a large basin on-site, reducing the immediate runoff into sewer systems. While evaporation and transpiration occurs after rainfall, water can also be gradually redirected back into the centralized sewage infrastructure during lower peak flows, reducing the occurrence of combined sewer overflows and sewage bypasses.



2.23 _ Green Roof

Modular green roofs can provide a cost efficient and easy to construct retention system which promotes the growth of stormwater planting or gardening plants and increases homeowner accessibility to retrofitting existing roof planes. Through modular planters, blocks can be resized or arranged on diagonal slopes with the appropriate structural framework. During peak rainfalls, excess water continues to be filtered and drained beneath the planters and into the downspout.



2.24 _ Raingarden

Rain gardens utilize native shrubs, perennials and flowers within a small depression to temporarily hold and soak stormwater runoff from neighboring areas. Compared to a conventional grassed area, rain gardens allow for 30% more water to infiltrate the soil as well as remove up to 90% of nutrients and chemicals and up to 80% of sediments from stormwater runoff. Overflow spouts redirect rainwater if it exceeds a specified level.

The combination of decentralized stormwater management and existing infrastructures of the city can provide a multitude of benefits beyond simply just the improvement of water quality in Lake Ontario. New trends in the culture and perception of hidden water in the city have begun to highlight potential relationships between city users and the hidden narratives of city infrastructure. Conversations regarding ecological literacy in the city can initiate opportunities for community implementation and development.

3_Parks + Public Engagement

Rapid industrialization throughout the 18th and 19th century fueled the migrations of workers from rural to urban cores in Europe, which also translated into North American cities. The provision of public parks within urban centers were created to uplift the moral living standards of the city, thereby creating healthier spaces for relaxation and exercise.[1] Britain's first major parks such as the Royal Parks in London and Olmsted' s Central Park in New York were established during this period.[2] As cities began to urbanize at much faster rates, greater mobility, wealth and leisure time was created for citizens. Urban parks no longer satisfied the recreational needs of city users to connect with nature and the desire to leave the city to reconnect with rural surroundings increased.[3]

1 Michael. Hough, Cities and Natural Process (London ; Routledge, 1995), 11.

2 Ibid, 12.

3 Ibid, 12.

The assumption of urban parks as sole leisure spaces continues to be promoted today through the way parks are designed. In the case of Toronto's parks, they primarily consist of community leisure spaces such as baseball diamonds, splash pads and playgrounds. While these amenities cater to some of the needs of park users, there is a lack of awareness of the unbuilt environment and infrastructure which supports these leisure processes.[4]

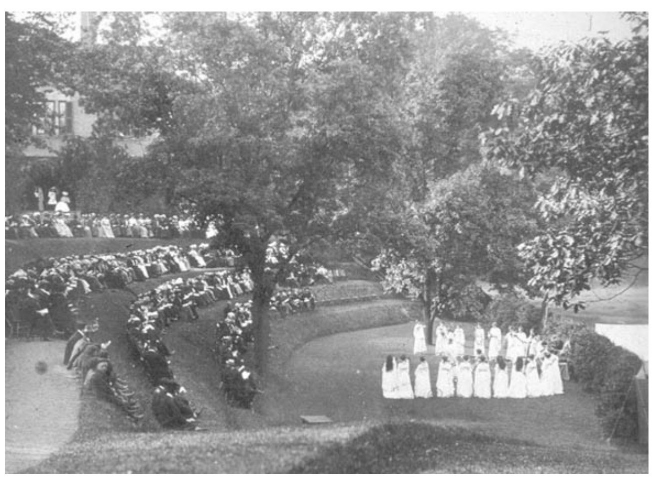
In 2020, due to gathering restrictions from a global pandemic, park usage has doubled in comparison to levels before the pandemic begun.[5] *(Fig. 3.1)* As public spaces become more frequently visited, there is an opportunity to raise public awareness through the integration of storm water management into urban landscapes. Through a shift in collective awareness in the city, increased public education in local urban spaces, and promotion of community involvement, green infrastructure in Toronto can become a commonplace restoration practice for parks along buried watershed landscapes. This chapter will exemplify the potential benefits of leveraging existing community initiatives that bring forth public awareness of decentralized storm water infrastructure in public park spaces of North America.

4 Hough, 24.

5 Google, "COVID-19 Community Mobility Report," February 25, 2021, https://www.google.com/covid19/mobility?hl=en.

3.1 _ Trinity Bellwoods Park Use During Quarantine Measures,2020.

3.2 _ Christie Sand Pits After Heavy Rainfall, 1910.



3.3 _ Amphitheater in Trinity Bellwood' s Park, 1915.

3.1_Reshaping Awareness

In Gary Snyder' s essay on the relationship between places and cultural identity, he believes awareness can be brought forth by tying personal experiences of a place to one' s memories, thus achieving greater connection to a site. As the explorer continues onward, the outlines of the larger region become part of their awareness.[6] The physical erasure of the ravines outlines which used to flow through the city removed the consciousness of the creek' s presence within park users of Toronto. The separation which has occurred through both city planning and rapid urban expansion has removed the ecological and social roles of the creek within the city. Spaces such as the large amphitheater in Trinity Bellwood' s park during the 19th century and the makeshift splash pad play areas after heavy rainfall have both been erased. *(Fig. 3.2, 3.3)*

The role of water in today' s city remains now as water and wastewater fees on monthly utility bills. By placing a fee on these services, we no longer associate or value these cycles within a larger ecological system or public infrastructural leisure space. Ecological scientist James Kay reinforces this notion of the extractive nature of our water and sewage infrastructure where the planning of urban environments has been largely influenced by economical imperatives over environmental or social reasons.[7] In order to shift towards social and cultural benefits of decentralized stormwater management, educating the current and future generation of city dwellers will need to be the first step.

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6 Gary Snyder, The Place, the Region, and the Commons, The Practice of the Wild (Berkeley, California: North Point Press, 1990), 27.

7 Hough, Cities and Natural Process, 2.

"By explicitly framing the situation, a fresh perspective can be made, which can then lead to clearer resolutions." [8]

As a result, the individual' s awareness and value of the landscape can begin to change. While the traditional park has long been planned for people, it is people who ultimately both shape and create them according to their needs, in ways that reflect contemporary needs.[9] There are numerous initiatives which have already begun sharing knowledge and stories regarding the buried watercourses in Toronto.

3.2_Public Education

Lost Rivers walks, initiated by Helen Mills in 1995, tells stories regarding historical and present landscapes of Toronto within local neighborhoods along streets and parks where buried rivers used to lie. Discussions around urban water and city ecosystems would be shared as well as practical day to day acts that citizens can do to change their environmental footprint.[10] The act of walking along the outlines of hidden creeks in combination with storytelling brings forward social connections to the walker and the site, creating newfound awareness of lost landscapes. *(Fig. 3.4)*

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8 James Kay, Systems Practice: A Way of Framing Environmental Situations (London: Springer London, 2003), 3, https://doi.org/10.1007/978-1-84996-125-7.

9 Hough, Cities and Natural Process, 118.

10 Wayne Reeves and Christina Palassio, eds., HTO : Toronto' s Water from Lake Iroquois to Taddle Creek and Beyond (Directions) (New York: Coach House Books, 2011), 212, http://ebookcentral.proquest.com/lib/waterloo/detail.action?docID=760161.

3.4 _ Human River Walks Across Harbord Street Bridge, 2011.

Rather than expediting natural exploration outside of the city, environmental messages can begin within cities where awareness of natural processes become commonplace activities ... Regenerative, ecologically rich, and frequently visited urban parks provide opportunities for ecological connection through direct experiences and individual interpretation.[11] At Evergreen Brickworks sited along the Don River, Watershed Consciousness by Ferruccio Sardella creates a living map of Toronto' s rivers and creeks, showcasing visual and physical connections to the larger hierarchal watershed processes in the city. *(Fig. 3.5)* Physical opportunities such as these allow students and younger generations to interact with and respond to rainwater and watersheds in the city.

Design symbolism for water and natural urban systems therefore needs to associate the identity of water through the diverse cultural landscape of the city. This lies at the heart of the urban experience and artistic form.[12] Temporary Nuit Blanche installations such as To Love You Deeply I Look to My Mind' s Eye by Christine Dewancker utilizes art to map and physically re-trace the former outlines of hydrological flows through Bickford park. *(Fig. 3.6)* The artist's aim was to reinforce the hidden geography within the landscape and the memories of the residents. Community participation further combines awareness and education to make meaningful changes within park spaces.

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11 Hough, Cities and Natural Process, 260.

12 Ibid, 80.

3.5 _ Evergreen Brickworks Watershed Green Wall

3.6 _ Nuit Blanche Light Installation Daylighting in Bickford Park, 2015.

3.3_Community Involvement

Community involvement is way for park users to be directly engaged in the development of the city' s existing parks sited along the Garrison Creek. Existing initiatives which support and encourage the participation of the local community within the city parks of Garrison Creek include Friends of Parks groups who actively contribute to the maintenance, wellbeing, and programming of events in parks, primarily consisting of nearby residents from varying ages and background. Their voluntary support helps to fund and enhance neighborhood parks.[13]

Sharing knowledge and commitment initiatives further fuels the potential for new functions to be implemented into city parks such as storm water management. Building off existing drainage patterns and water flows, or vacant buildings sited beside parks becoming re purposed for uses entirely different from their former function are not out of the ordinary.[14] The following examples highlight key projects which have implemented storm water management into existing parks, bringing forth greater awareness of water in the city through community involvement and design.

In Philadelphia, community artists and local Horticultural Society re-purpose 55 gallon food grade plastic barrels for supporting community building runoff and drainage. *(Figure 3.7)* Artwork promotes local talent as well as visual advocacy for managing storm water runoff. Reductions in costs are also achieved by sourcing underutilized materials through recycling and collection of these food barrels.

13 Leah Houston and Richard Rhyme, "Park Friends Group Guidebook," 2016.

14 Jane Jacobs, The Death and Life of Great American Cities (New York: Vintage Books; Random House, 1961), 403.

3.7 _ Painted Community Art Rain Barrels in Philadelphia

3.8 _ Philadelphia De-paved Backyard Into Rain Gardens

3.9 _ NYC Henry Street Raingarden Community Construction

3.10 _ Canoe Planter Installation in Roxton Road Parkette

Located also in Philadelphia is this example of a homeowner's backyard which has had its impermeable paver blocks replaced with a rain-garden, promoting individual involvement and creating neighborly awareness of managing stormwater on individual homeowner properties. *(Fig. 3.8)*

Community initiatives and volunteers also have the capability to implement small scale rain gardens for larger properties such as those found in smaller parks and community centers. This example for instance accommodates a 120 m^2 roof which can manage up 3000L of rooftop runoff. *(Fig. 3.9)*

This Community Canoe garden is part of the Homegrown National Park Project. Community Canoe gardens, installed in the parks of lost Garrison Creek, are planted with native flowers, attracting local wildlife such as bees, butterflies, and birds. *(Fig. 3.10)* Symbolism of the watercourses presence in the park landscape ignites passersby curiosity and promotes greater biodiversity within the city.

All these examples of community implementation of decentralized stormwater management illustrate the potential to combine the participation and resulting education and awareness that comes with constructing decentralized stormwater management with the ecological benefits of reducing local stormwater runoff volumes. When systems like this are implemented on a community wide scale, they begin to create new forms of hydrological, social and ecological networks in areas which may have been previously erased. The following chapter illustrates previous conceptual proposals which have began to initiate the reconnection of stormwater in the city with its parks and its users. Case studies which have been constructed locally and internationally begin to break down the different ways stormwater can be designed into existing parks and underutilized landscapes in the city.

4_Case Studies

Unbuilt park proposals and plans which sought to reconnect historical and programmatic landscapes back into the cities of Toronto and globally are first mentioned. Secondly, built local and international examples of decentralized storm water projects following the same design method of bringing together community awareness for watershed management and conservation through landscape and architecture are highlighted in this chapter.

Each built case study example highlights the use of stormwater conveyance as a method for creating awareness and public communication of the hidden hydrological systems of the city. Consequently, these projects all also reknit their new programs back into the existing landscape and complement or contrast the historical functions of the former landscape in a specific way. A comment from each project explains how the case study directly informed the following intervention strategies.

4.1_Unbuilt Park Proposals

Civic Improvements Mapping

Architect	Guild of Civic Art
Location	Toronto, Ontario
Project Date	1908
Proposed Uses	Playgrounds, Parks, Parkways, Diagonal Thoroughfares, Landmarks

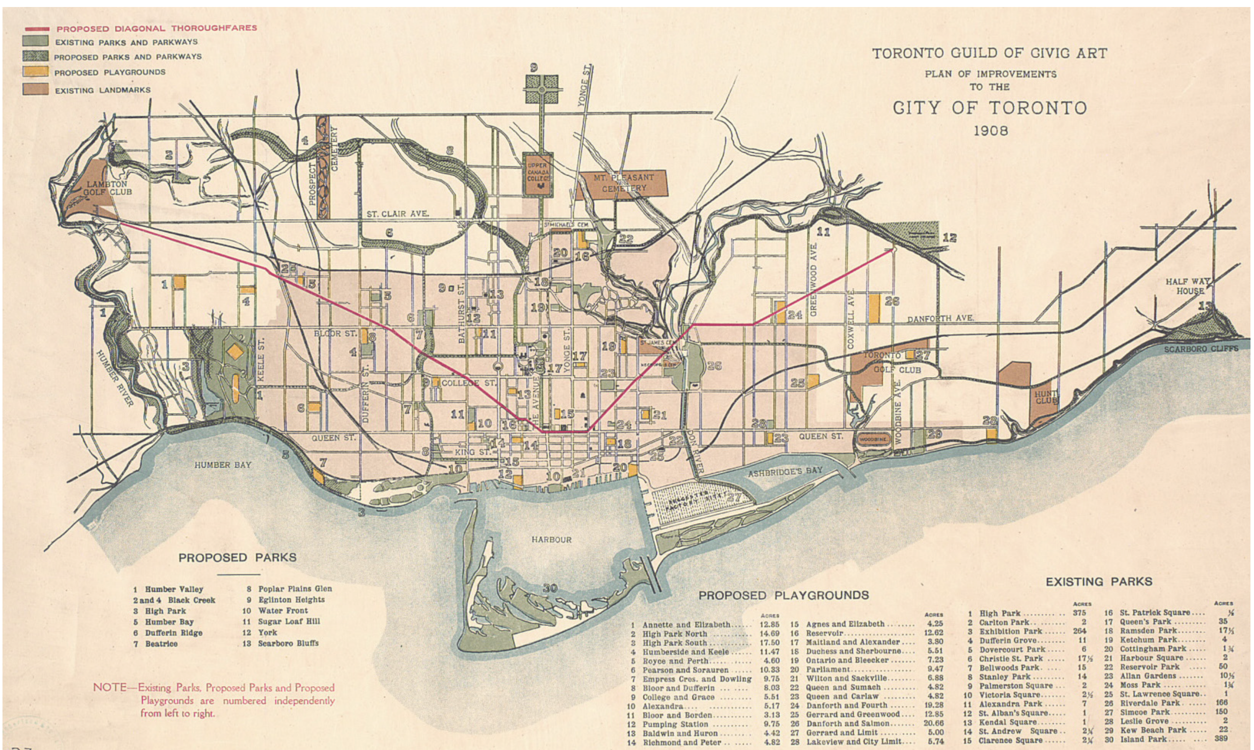
The first initial considerations for a connective recreational park system in Toronto originate during the start of the 20th century from a handful of architects, town planners, social reformers and artists. The plan responded to the need for youth recreational spaces, protected natural areas and efficient mobility to and from the downtown core.

Diagonal thoroughfares proposed to connect surrounding watershed landscapes, parks and landmarks together into a cohesive, accessible system, granting uninterrupted park landscapes down to Lake Ontario.[1] This plan is the first indicative consideration for connecting the separated plots of open park space along the Garrison Creek into an interconnected network of green spaces surrounding the city core. The plan however did not follow through with skeptic city officials who believed protecting natural landscapes at the time was unreasonable.[2] Thus, the rapid urbanization of the city kept parks separate to this day.

This mapping provides the initial foundation for establishing the idea of a holistic network of connected parks in the proposed intervention and aligns with views for further integration of park spaces and natural processes back into city circulation energetics.

1 Michael. Hough, Cities and Natural Process (London ; Routledge, 1995), 232.

2 Wayne Reeves and Christina Palassio, eds., HTO : Toronto' s Water from Lake Iroquois to Taddle Creek and Beyond (Directions) (New York: Coach House Books, 2011), 291, http://ebookcentral.proquest.com/lib/waterloo/detail.action?docID=760161.



4.1 _ Plan of Civic Guild Improvements Map

Garrison Creek Demonstration Project

Architect	Brown and Storey
Location	Toronto, Ontario
Project Date	1996
Proposed Uses	Public Square, Stormwater Conveyance, Splashpads, Rainwater Ponds

Commissioned by the Waterfront Regeneration Trust, Brown + Storey Architects illustrated the potential methods of integrating stormwater management into Toronto through the use of rainwater detention ponds along the Garrison Creek park network. Promoting new surrounding programs in the existing park spaces at the same time revealing the existing bridges which trace the historic routes of the buried Garrison Ravine.

The intention of the demonstration project would be to knit local neighborhoods along the North South axis back to the waterfront, catalyzing regenerative green spaces through these ponds.[3] These ponds also served to retain and filter the stormwater to be gradually introduced back into the existing sewer system as cleaner stormwater.[4]

This thesis builds upon the demonstration projects use of rainwater ponds centralized in each of the park spaces, a critical component of the proposal which carries over into the following intervention design. Park spaces contain higher levels of permeability in comparison to the rest of the city. Adding a pond or strategically sited infiltration area exponentially increases the holding capacity of the specified park area.

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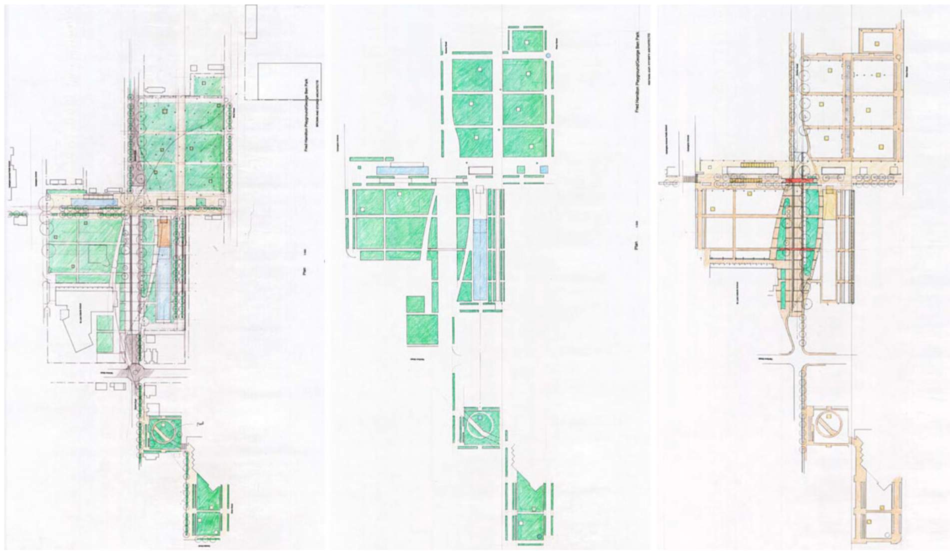
3 "Rainwater Ponds in an Urban Landscape," Garrison Creek Demonstration Project, March 31, 1996, 59.

4 Ibid. 40



4.2 _ Fred Hamilton Park Connection Plan Diagram

4.3 _ Daylighting Buried Bridges and Recreating Rainwater Ponds

Parc De La Villette

Architect	Rem Koolhaas, OMA
Location	Paris, France
Project Date	1982
Proposed Uses	Public Square, Museums, Restaurants. Art Installations

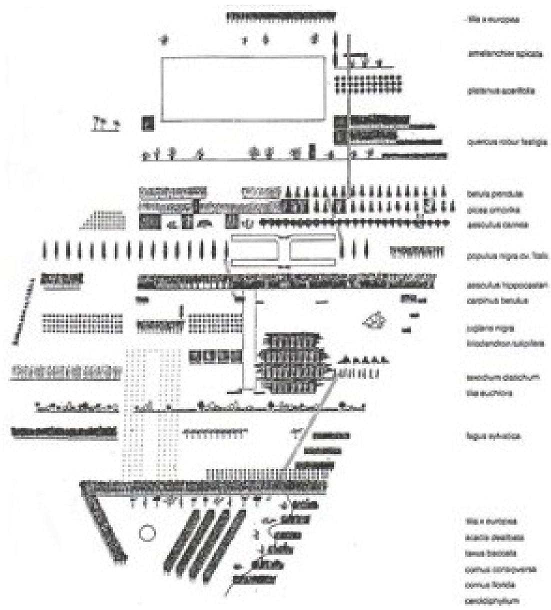
In a similar way to the local connective park proposals of the two former Toronto case studies, OMA' s method for the former slaughterhouse district in Paris promoted the use of various elements such as point grids/confetti and programmatic strips to condense and connect social activities within the constrained site boundaries of the open space, making the experience unique to the site each visit.[5]

Rather than relying on a predetermined park structure for program, specified uses are rather located within the architecture within the site.[6] Site improvisation based on the users of the park thus determine the required uses for each zone of the park. In response to the constantly changing processes of the city, the intention would be the space anticipates future change and adapts over time.

The following intervention utilizes the methodology of the strip strategy (Fig. 4.6) of the proposal and the understanding of the linear mosaic overlaid on the landscape to begin to break down existing uses and connections across site sections. The drawing methodology provides a tool to highlight potential unforeseen relationships through the sites topographical changes and identifies locations for new relationships of stormwater management on the selected site of intervention.

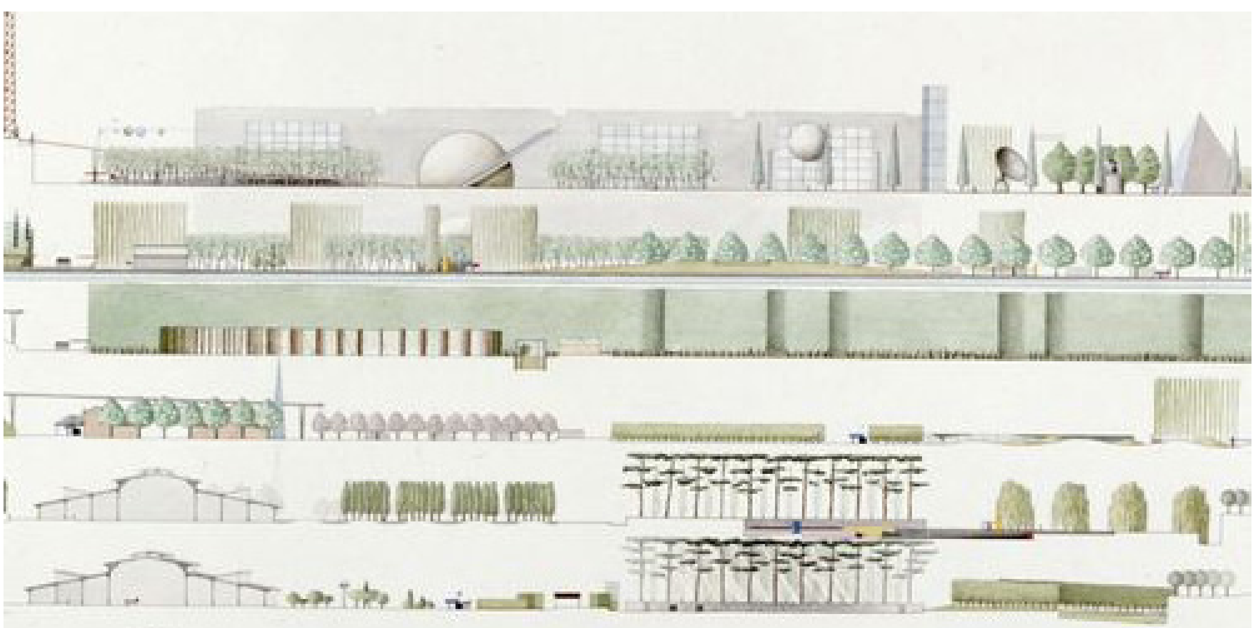
5 *"Parc de La Villette," OMA, accessed May 2, 2021, https://oma.eu/projects/parc-de-la-villette.*

6 *Ibid.*



4.4 _ Program Strips

4.6 _ Colorized Program Areas



4.5 _ Consecutive Detail Section Methods

4.2_Local Projects

Evergreen Brickworks

Architects	dtAh, Diamond Schmitt Claude Cormier E.R.A.
Location	Toronto
Project Completion	2010
Existing Use	Brickyard Quarry
New Use	Gardens, Exhibits, Trails Event Space, Cafes

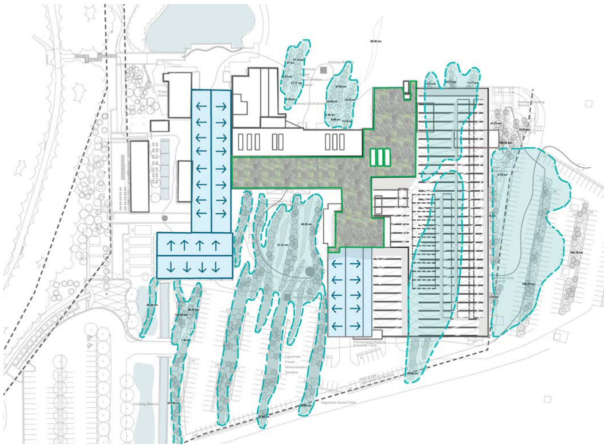
The Don Valley Brick Works was the primary source for pressed brick construction in Toronto from 1889 to 1984. Adaptive reuse of the quarry landscape and its brick manufacturing spaces brings forth new spaces for farmer markets, gardening in the city as well as community gathering venues. Environmental awareness group Evergreen leads many of the activities on site, promoting community engagement and education.[7]

Flood mitigation utilizes a series of ponds built by the within the Weston Family Quarry Garden. The ponds allow water from Mud Creek to filter naturally through channels planted with water-tolerant species to the storm water management ponds in the parking lot, before joining the lower portion of the Don River.

Elements which align with the intervention include themes of linking heritage spaces with environmental restoration practices of the surrounding landscape. The contrast between the industry which contributed to the degradation of the site has now transformed to its space of restoration.[8] This adaptive renewal cycle is also highlighted within the proposed intervention.

7 *"What Is Evergreen Brick Works? | Evergreen," accessed May 2, 2021, https://www.evergreen.ca/evergreen-brick-works/what-is-evergreen-brick-works/.*

8 *Michael. Hough, Cities and Natural Process (London ; Routledge, 1995), 92.*



4.7 _ Water Process Flow Diagram _ Evergreen

4.10 _ Remediation Ponds

4.8 _ Rainwater Cisterns for Gardening And Flushing

4.11 _ Evergreen Brickworks Outdoor Gardens

4.9 _ Evergreen Brickworks Outdoor Plaza

Sherbourne Commons

Architects	PFS Studio, Teeple Architects
Location	Toronto
Project Completion	2011
Existing Use	Brownfield Site
New Use	Playgrounds, Stormwater Treatment, Splashpads, Ice Rinks

The project consists of lake water intake facilities, clean water discharge channels, Sherbourne park channel, UV facility and pumping station. The stormwater management system is integrated into the public area infrastructure located in the East Bay front to invite the public to use the functional and sustainable green spaces. The reclamation of water from the waters edge is conveyed to the filtration facility which then transfers the water to a series of bio filtration towers, daylighting the processes of stormwater in the city. Sherbourne Common also became the first stormwater treatment facility to incorporate Ultraviolet treatment.[9]

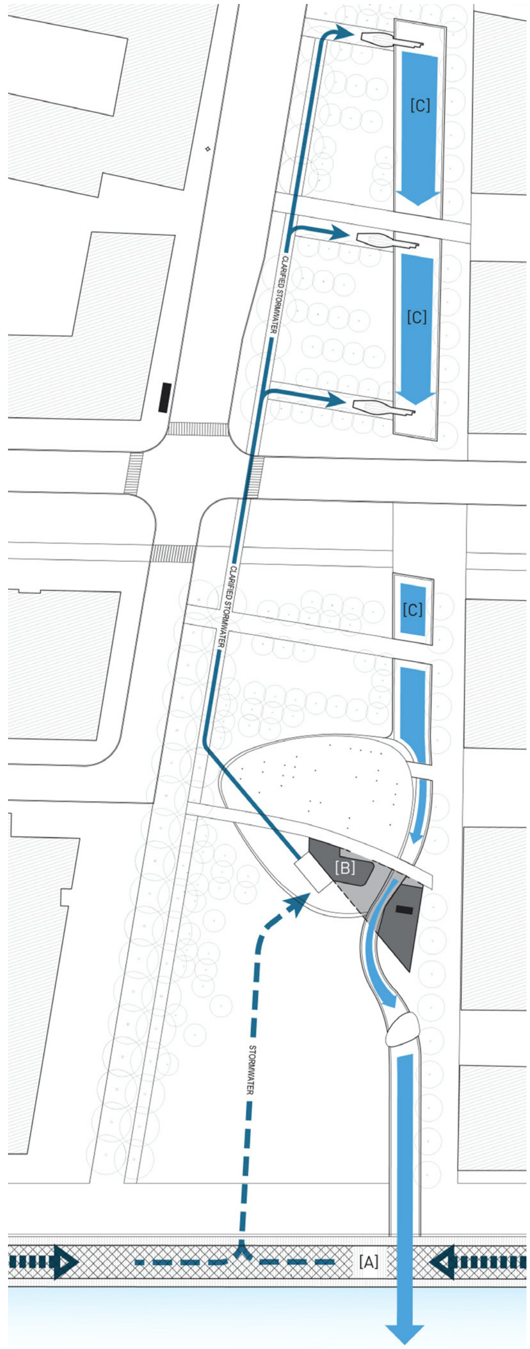
Aspects of the case study which are incorporated into the design include the methodology of stormwater terraces and bio swale systems which allow for increased stormwater runoff quality before entering back into Lake Ontario. In the case of the proposed intervention, water quality is increased as it is reintroduced back into the sewage network. Furthermore, bio swales allow for passive education of the filtration process of rainfall and provide interactive green spaces which serve both aesthetic and ecological functions.

9 "Sherbourne Common," Waterfrontoronto, accessed May 2, 2021, https://waterfrontoronto.ca/nbe/portal/waterfront/Home/waterfronthome/projects/sherbourne+common.

4.12 _ Sherbourne Commons Biofiltration Towers

4.13 _ Sherbourne Commons Biofiltration Detail

4.14 _ Raingarden Seating



4.15 _ Water Process Flow Diagram _ Sherbourne

4.3_Global Projects

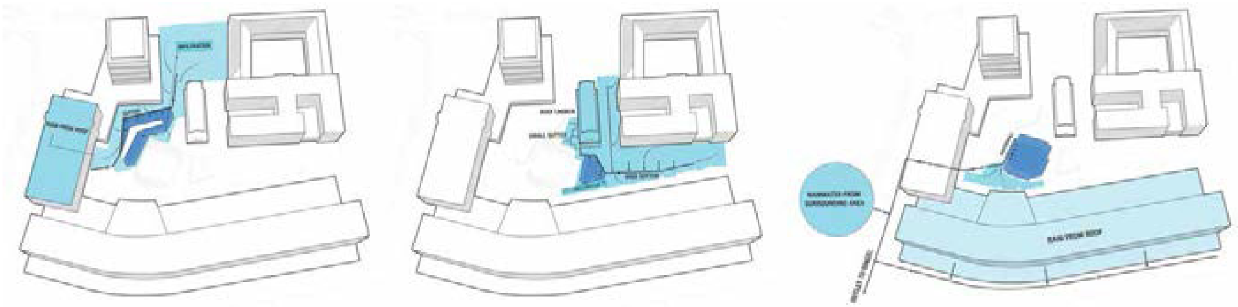
Benthemplein Watersquare

Architect	De Urbanisten
Location	Rotterdam, Netherlands
Project Completion	2014
Existing Use	Impermeable Plaza
New Use	Public Square, Stormwater Retention, Recreation

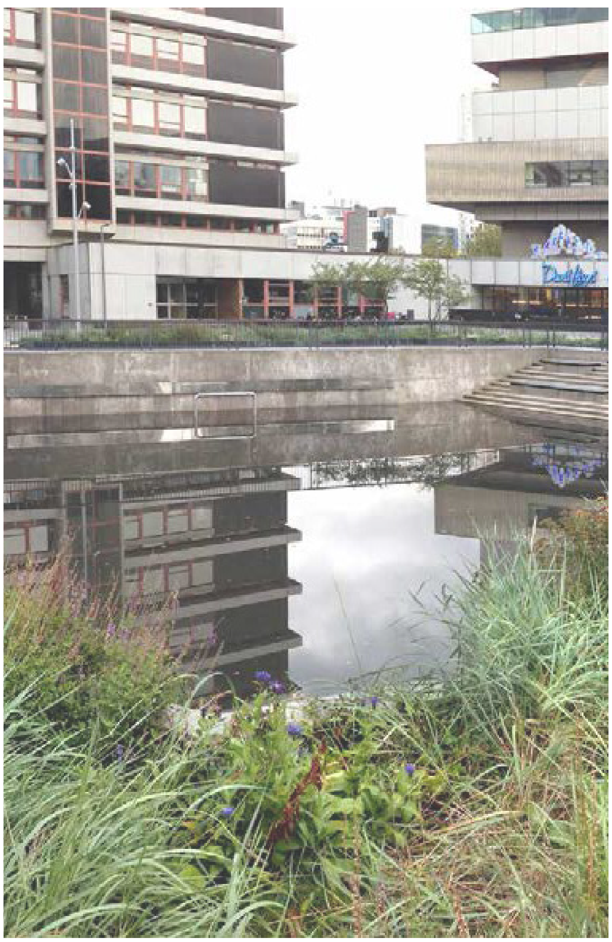
The conversion of a flat impermeable plaza into three distinct catchment basins for each of the surrounding developments was fueled by rising concerns of flooding in the region. Each of these catchment basins serve to redirect runoff from nearby rooftops of each building through designed stormwater features surrounding the plaza. These pieces of the infrastructure become integrated features in the design of the plaza surface and allow users to be in direct contact with moving stormwater flows and routes. Stormwater planting surrounding the basins provide further infiltration and filtration of stormwater runoff before re-entering back into the existing sewage infrastructure gradually. [10]

The incorporation of stormwater catchment areas for larger less permeable areas is also considered in the proposed intervention. Large multi functional seating and open space in the plaza has the potential to diversify uses and programs throughout the seasons. Neighboring conveyance elements can also be considered a design asset based on this case study and provide a framework to further implement the same strategies on the projected intervention site.

10 Dirk van Peijpe, "ZOHO Climateproof District - A Work In Progress," Urban Adapt, January 1, 2016, 42, https://www.urbanadapt.eu/wp-content/uploads/2016/01/URBANISTEN_climate_adaptive_ZOHO_lr-strippresentatie.pdf.



4.16 _ Water Process Flow Diagram _ Benthemplein Square



4.17 _ Urban Retention Plaza Filled With Water

4.18 _ Aerial View of Three Different Retention Plazas

Sidwell Friends Middle School Stormwater System

Architects	Kieran Timberlake Andropogon Associates
Location	Washington D.C., USA
Project Completion	2007
Existing Use	Institutional
New Use	Wetland Creation/ Filtration, Education Courtyard

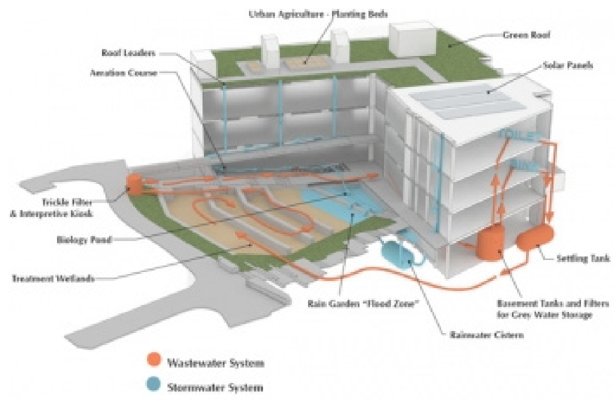
The remediation of a 50 year old institutional school and flat grassland has been excavated, revealing a new terraced wetland which treats and reuses gray water within the school building. Rainwater on the roof is absorbed through vegetation and open downspouts towards the open biological pond at the base of the building. The filtered gray water is reused for the flushing of toilets and terrace raingarden filter stormwater runoff from neighboring streets before entering the pond.

Materials on the site are reused or reclaimed such as the 100 year old wine barrel exterior cladding and the flooring and from salvaged harbor lumber.[1]

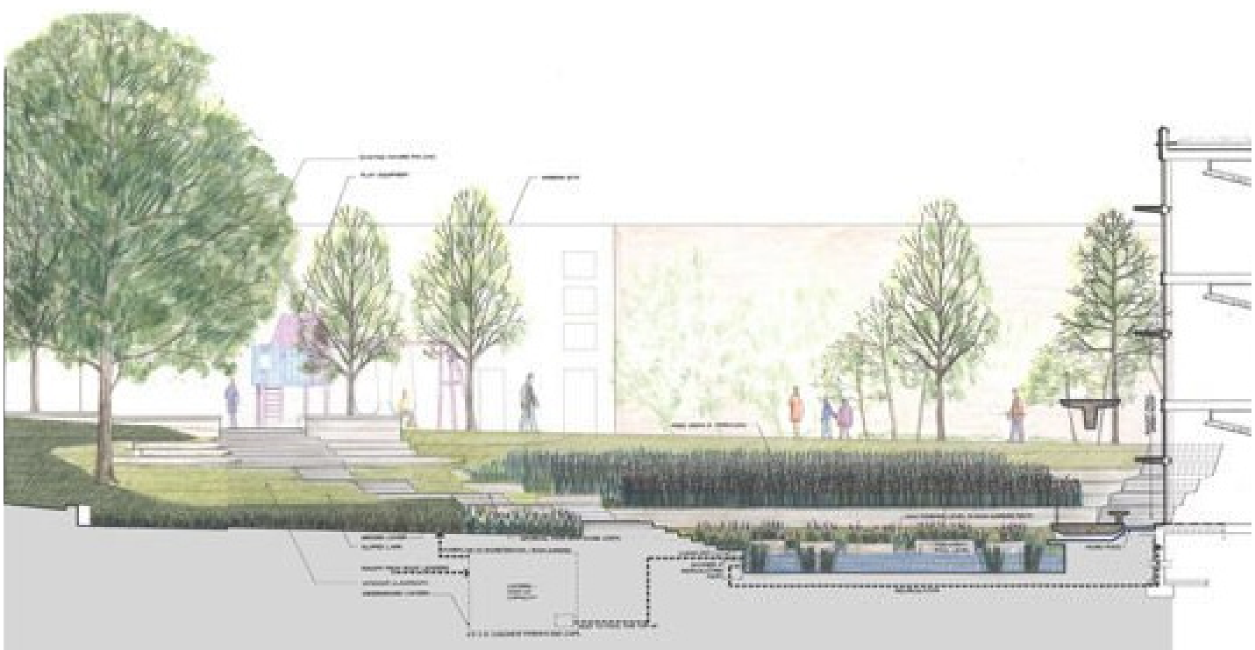
Elements of this case study which are integrated into the following design proposal include the consideration of a terrace raingarden system and stepped staircase to provide educational and community awareness through major circulation routes in the proposal. How the building systems interact with the surrounding landscape are also highlighted alongside the use of recycled materials in the intervention wherever possible. The addition of younger generations being exposed to systems provides further engagement opportunities.

1 "Sidwell Friends Middle School," Landscape Performance Series, 2014, https://www.landscapeperformance.org/case-study-briefs/sidwell-friends-middle-school.

4.19 _ Terraced Raingarden System and Lower Pond



4.21 _ Water Process Flow Diagram _ Sidwell School



4.20 _ Detail Sections of Terrace Raingarden and Public Stairwell

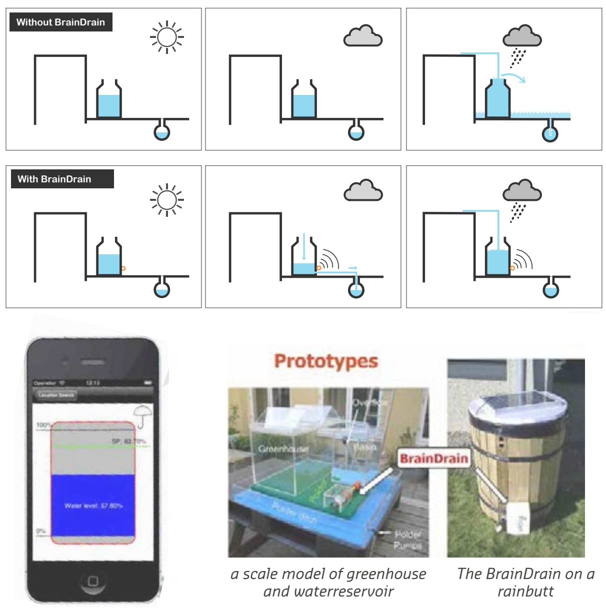
ZOHO - Rainbarrel

Architect	Studio Bas Sala, TU Delft, PV van Overloop
Location	Rotterdam, Netherlands
Project Completion	Ongoing
Existing Use	Feasibility Study
New Use	Participatory Water Storage, Education, Smart Control Devices

Situated near the Benthemplein water square, ZOHO - Rainbarrel is a rain water reuse and storage pilot project which aims to raise shared awareness among local homeowners and businesses of the potential for participatory stormwater management.[1] Educational programs within schools further raise awareness of the role stormwater may have in the future of the region. Additional research has been made into adaptive rainbarrel valves which respond to the changing weather patterns via a mobile application. Prototypes for various modular rain barrel systems have the ability to provide various uses and design capacities.

This case study provides the foundation for the intervention which brings forth community awareness and interaction through potential interactive and educational frameworks to teach homeowners and residents in the city to produce their own forms of decentralized stormwater management. The flexibility of the system provides a stepping stone for the secondary layers of interventions outlined in the next section.

1 *Dirk van Peijpe, "ZOHO Climateproof District - A Work In Progress," Urban Adapt, January 1, 2016, 55, https://www.urbanadapt.eu/wp-content/uploads/2016/01/URBANISTEN_climate_adaptive_ZOHO_lr-strippresentatie.pdf.*



4.22 _ Adaptive Rainbarrel Valves Via Smartphone App

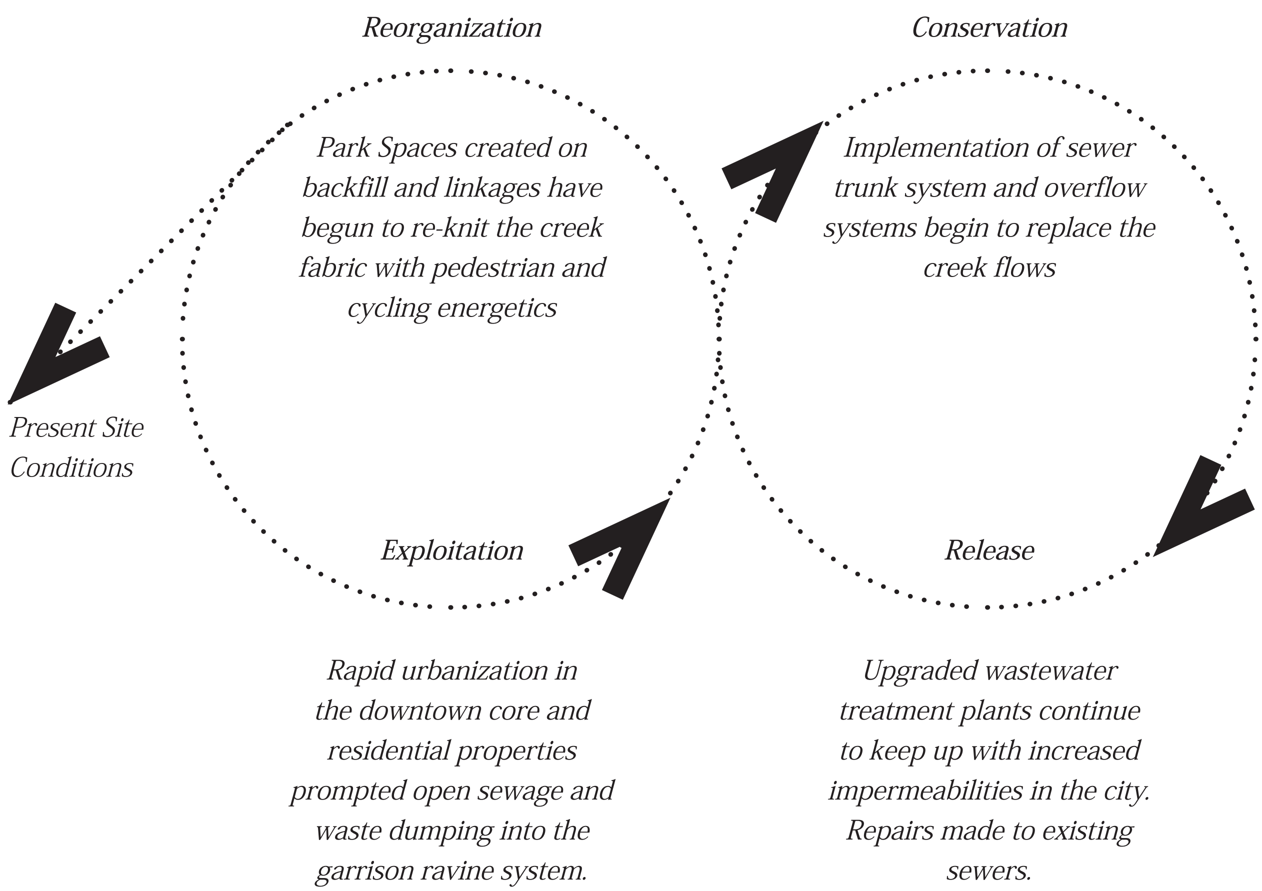
4.24 _ Rainbarrel Integrated Greenwall System

4.23 _ Constructed Rain barrels with Accessible Materials

4.25 _ Rainbarrel Irrigation, Car/Plant Wash Station

5_Ecological Infrastructures

Drawing from the previous case study examples, the proposed design in this chapter reintegrates the role of water into the city' s public spaces through a re-purposed heritage building, the surrounding public parks, the lane-ways which connect to these parks and the rooftops neighboring these lane-ways. What results from this is a new connective fabric which increases the conveyance and treatment of stormwater and rainwater through each of the sites but also provides new opportunities for public engagement and exploration.

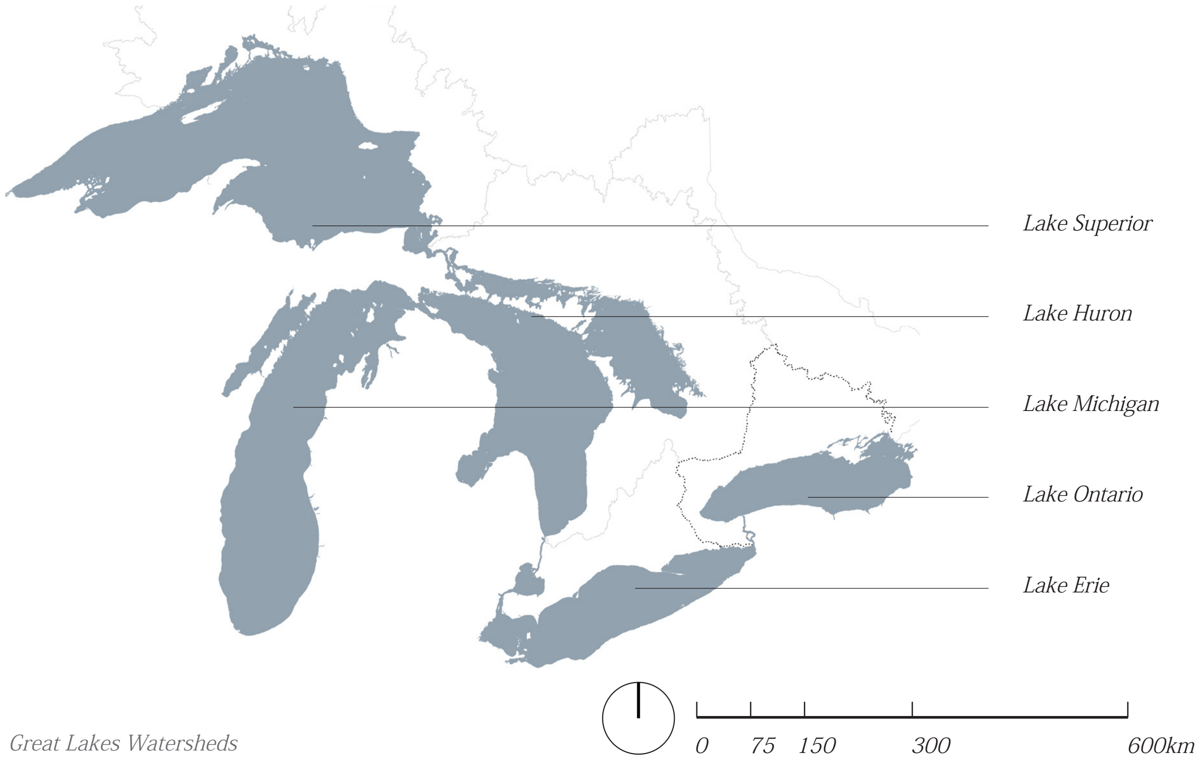


5.1 _ Adaptive Renewal Cycle of Garrison Creek Landscape

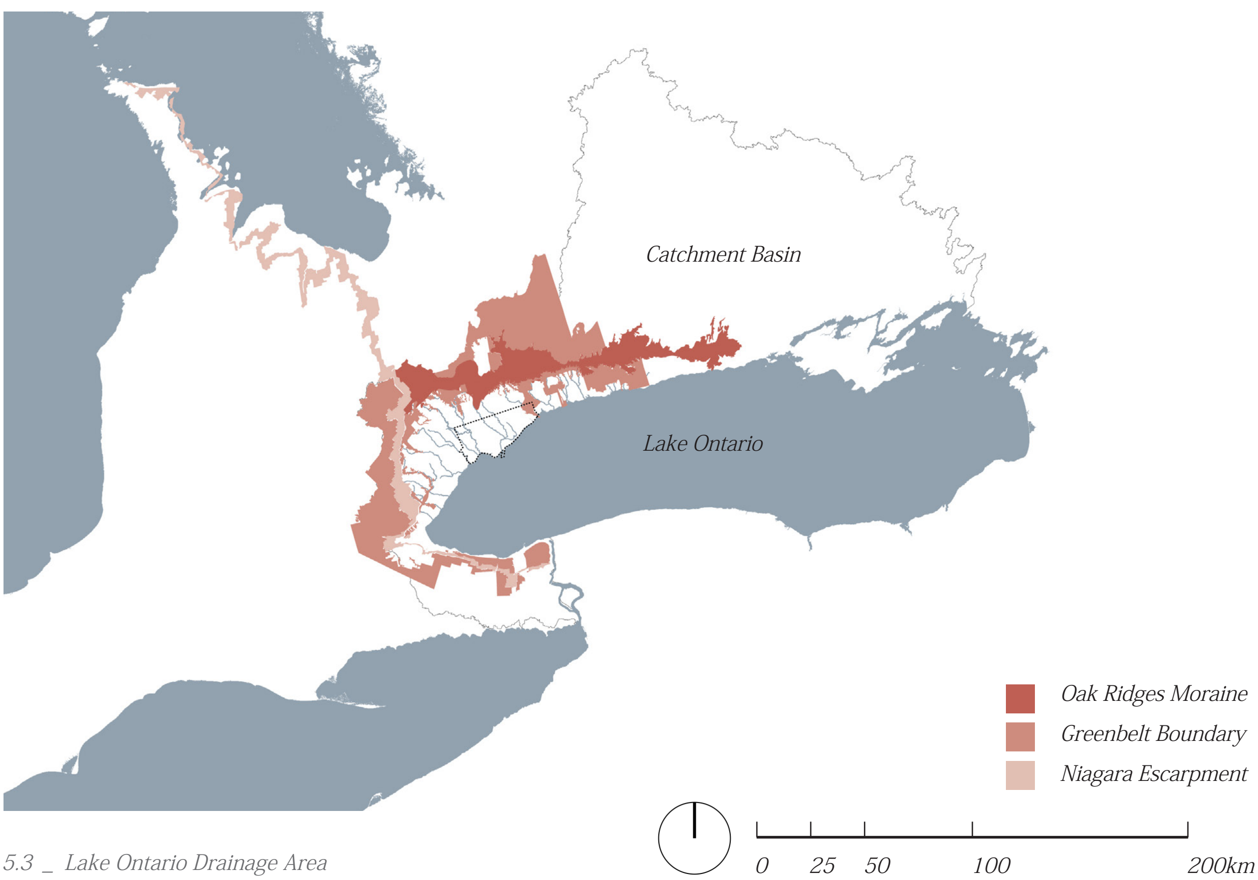
5.1_Site Analysis

The site analysis establishes the different layers of the existing landscape which affect the introduction of the four frameworks in the intervention. (Figure 5.1) Inspired by Holling's description of adaptive renewal cycles in landscapes, the Garrison Creek landscape represents the need for reorganizing existing elements in the site which serve more resilient and adaptable strategies that serve the increasingly complex energetics found in the city.

The site analysis covers three different scales, starting at the watershed scale, then moving to the ravine scale, and lastly focusing on the neighborhood scale of Stanley Park where the site intervention is located. Conceptual studies of the relative stormwater capacities is addressed, as well as creating the target volume of stormwater runoff to be designed for. From there, the four frameworks and selected site of intervention along the creek is introduced.



5.2 _ Great Lakes Watersheds

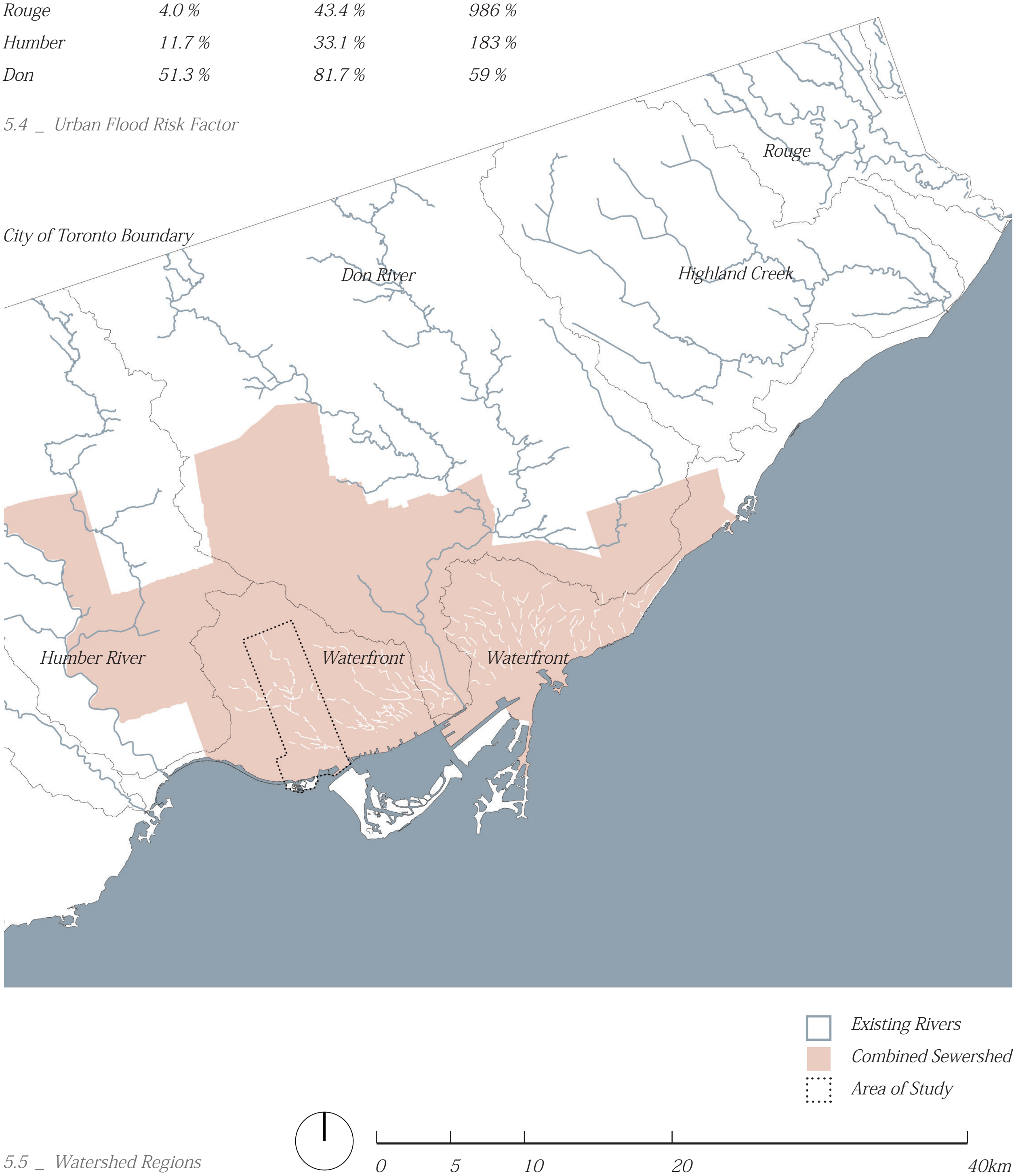


5.3 _ Lake Ontario Drainage Area

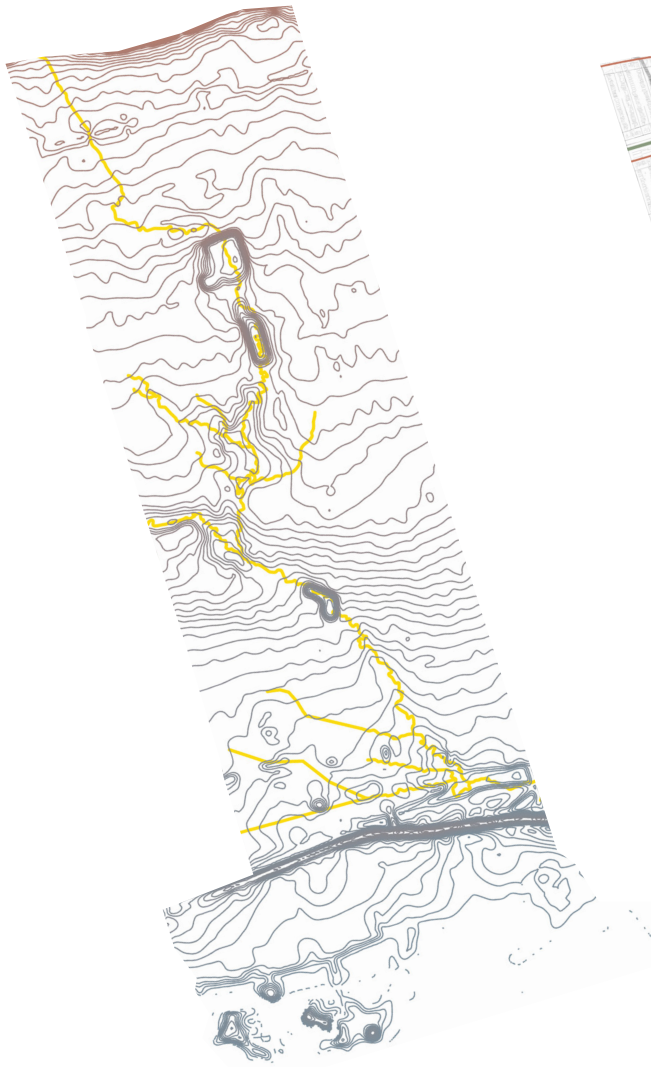
Urban Growth in Toronto Watersheds, 1966-2002, Flood Risk Factor

Watershed	Urban Area (1966)	Urban Area (2002)	Urban Coverage Increase
Waterfront	19.1 %	98.9 %	419 %
Highland	39.4 %	88.4 %	124 %
Rouge	4.0 %	43.4 %	986 %
Humber	11.7 %	33.1 %	183 %
Don	51.3 %	81.7 %	59 %

5.4 _ Urban Flood Risk Factor



5.5 _ Watershed Regions

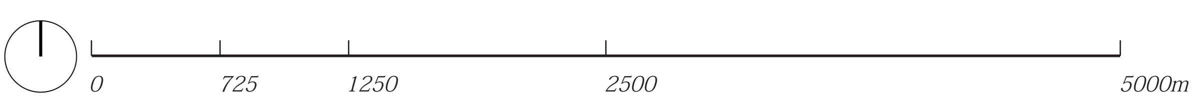


75M
0M
Former Garrison Creek Area

5.6 _ Topography and Drainage Flow

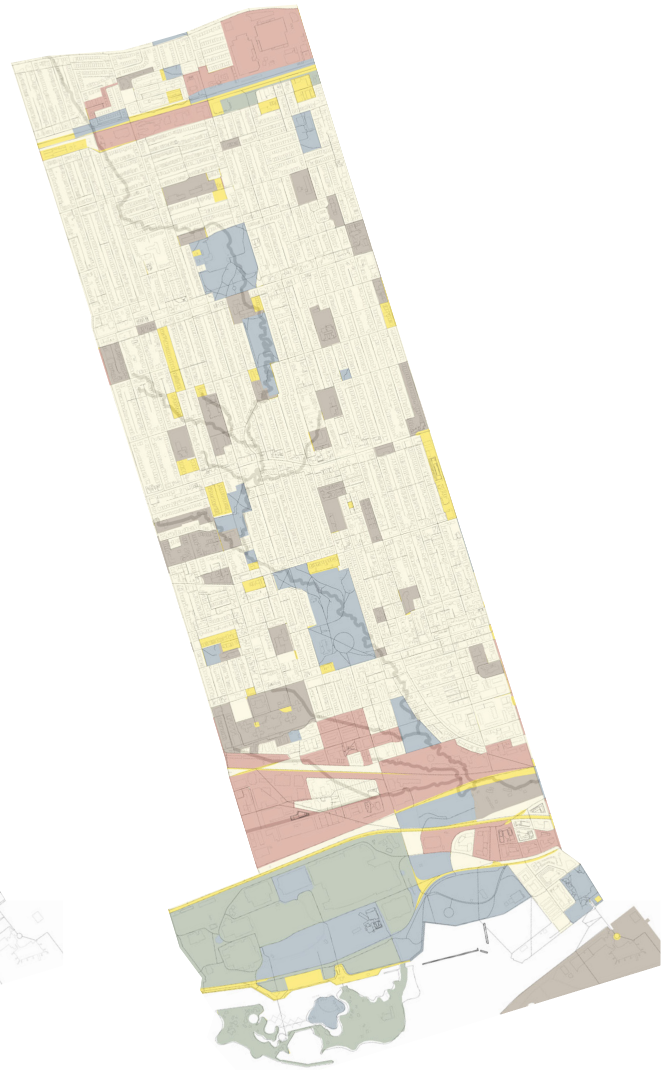
Overhead Expressway
Railroad Corridors
Major Streets
Former Garrison Creek Area

5.7 _ Major East-West Corridors



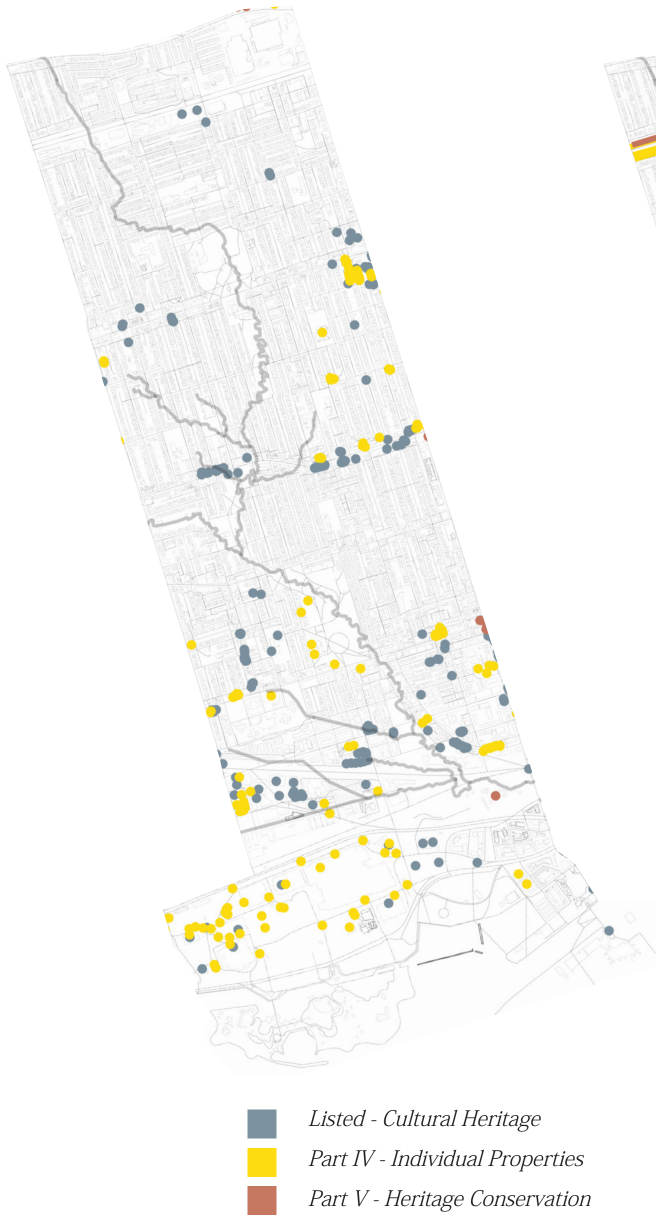
Designated Bike Paths

5.8 _ Bike Paths Near Creek

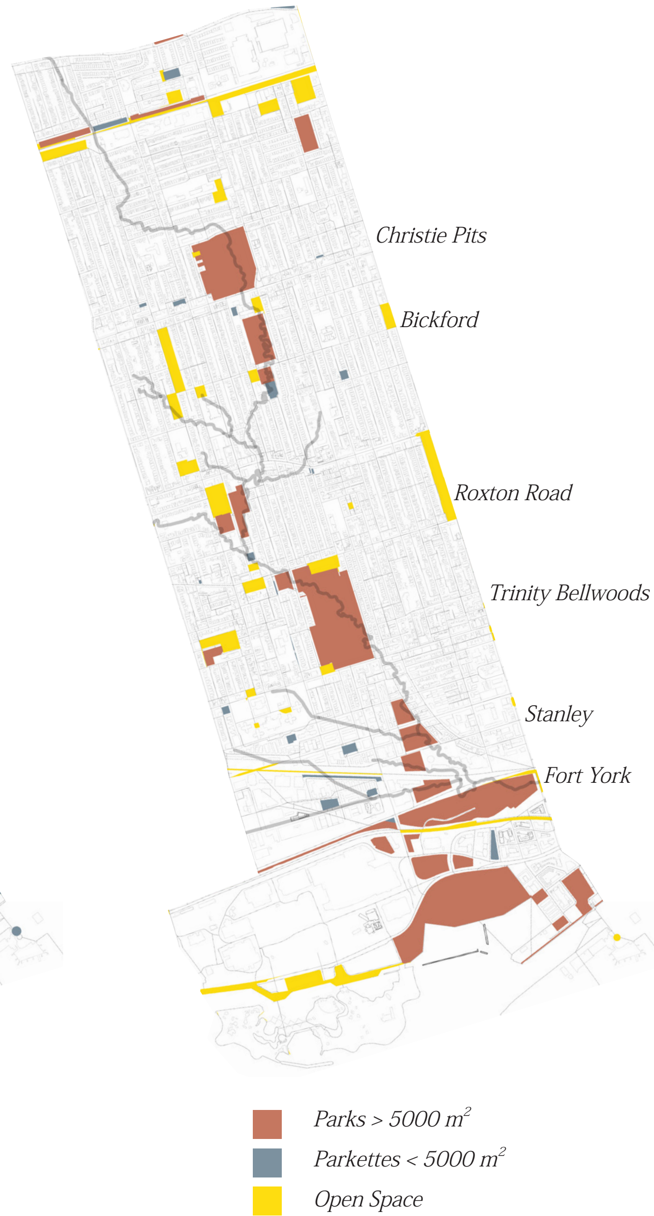


Residential
Institutional
Open Space
Parks and Recreation
Industrial
Commercial

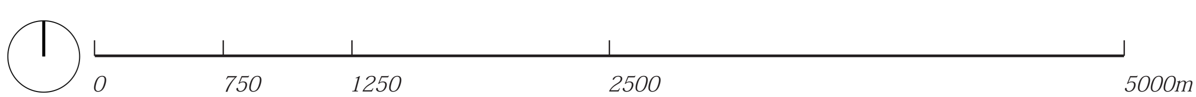
5.9 _ Zoning Categories



5.10 _ Heritage Buildings



5.11 _ Parks



5.12 _ Laneways

5.13 _ Rooftop Heights

5.2_Methodology of Relative Capacities

To highlight the required scales for decentralized stormwater management along the buried Garrison Creek, calculations for stormwater surface runoff coefficients need to be considered. The Rational Method for stormwater surface runoff rate is suitable for sites below 2500 hectares[1] :

$Q = iAC$

Q – Water Flow Rate (m^3 / day)
i – Rainfall Intensity (m/day)
A – Drainage Area (m^2)
C - Peak Flow Rate Coefficient

The following steps are used to size the decentralized stormwater management capacities and the subsequent systems based off a target storm intensity and/or treatment volumes for the following four types of components.

1. The desired rainfall intensity (i) is selected for the projected design. For the purposes of this study, data for Toronto' s rainfall in 2020 was found annually to be 699mm (Fig. 5.14) while the 95th percentile amount[2] of rainfall intensity is recorded at 27mm/day. (Fig. 5.15)

2. Drainage area (A) for each site is calculated based on an approximation of the topographical characteristics surrounding each park (Fig. 5.16).

3. Calculations for drainage runoff coefficient (C) are derived from GIS permeability mapping data image gradients. (Appendix 6.2, 6.3) The runoff coefficient is the percentage of rainfall that is transferred to runoff. The total runoff is the drainage area surrounding each park – multiplied by the calculated runoff coefficient. The function below is typically used by urban hydrologists to calculate the runoff coefficient.

runoff coefficient (C) = 0.05 + (0.009 x percentage imperviousness)

4. Allocate the total runoff volume to the required four components and projected capacities for each type, roof catchment, laneway transfer areas, park basin depths and heritage building rain barrels.

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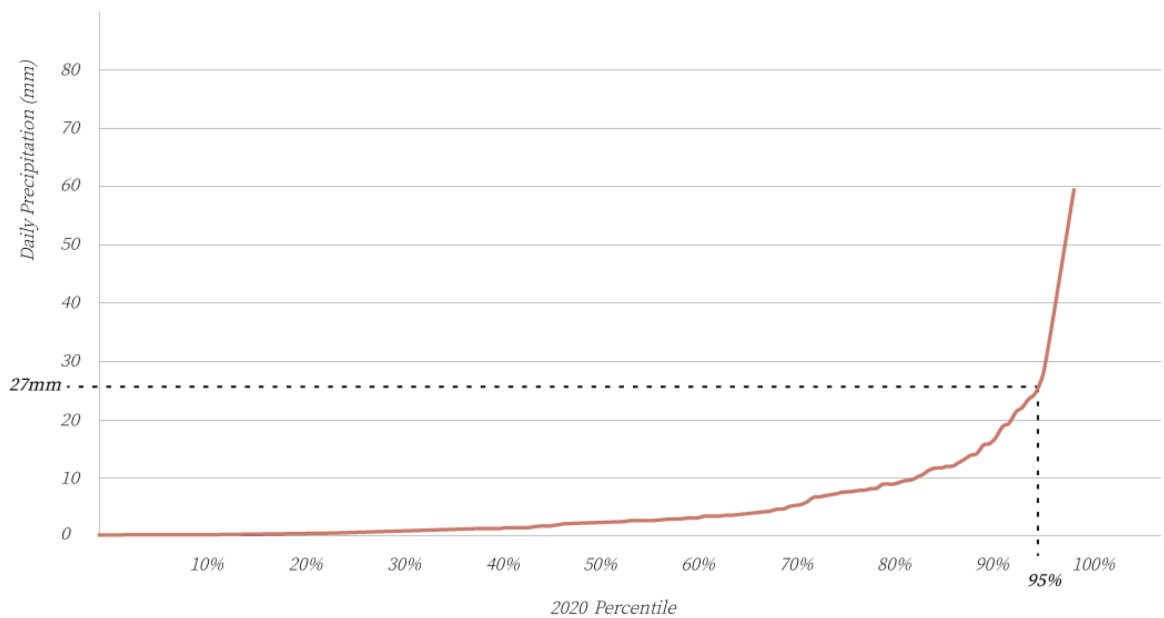
1 Ministry of Transportation Government of Ontario, "Stormwater Management Requirements for Land Development Proposals," Ontario Ministry of Transportation, July 17, 2017, http://www.mto.gov.on.ca/english/publications/drainage/stormwater/section10.shtml.

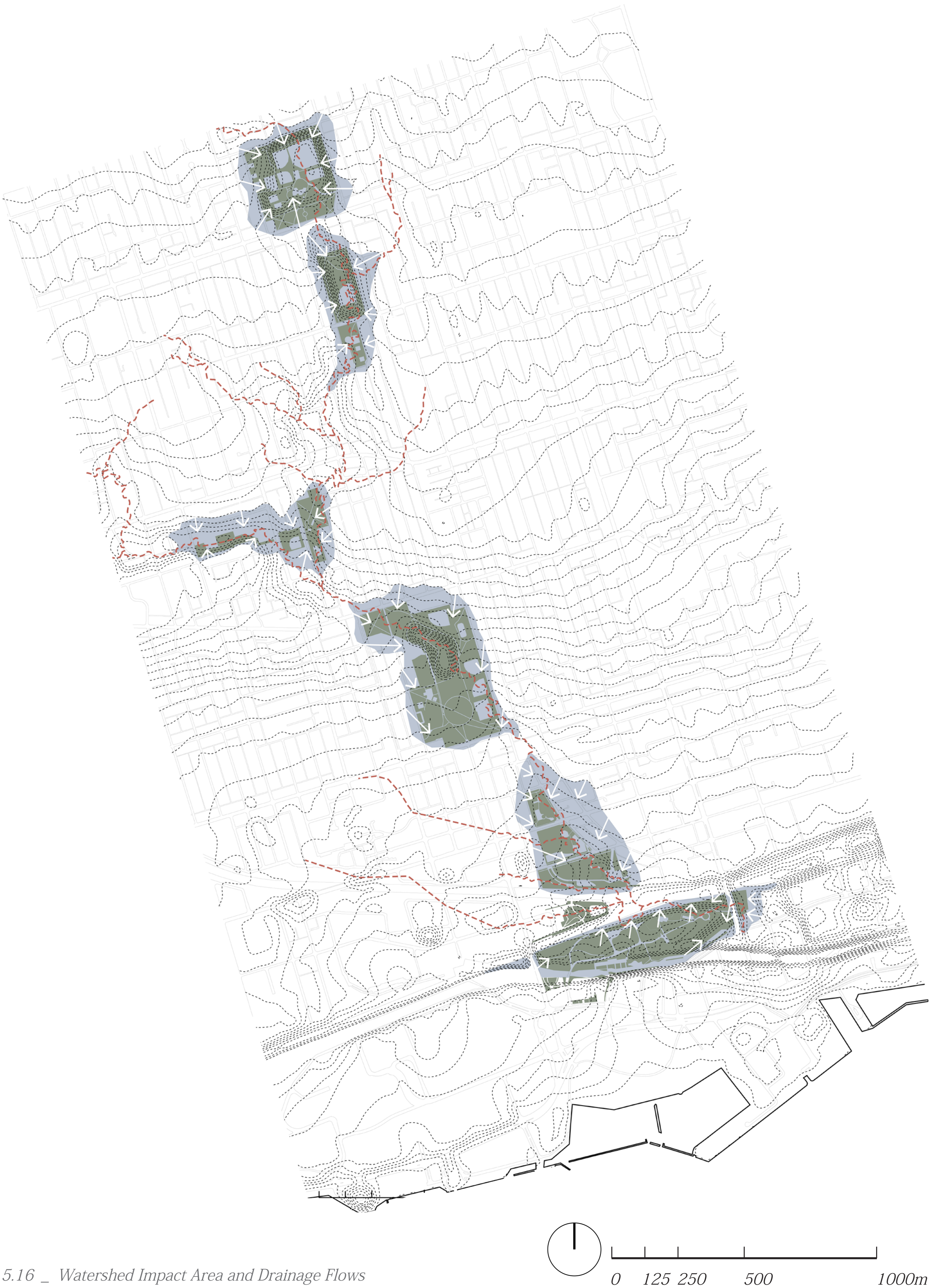
2 "Runoff Volume Control Targets for Ontario Final Report," Ministry of the Environment & Climate Change (55 Regal Rd, Unit 3 Guelph, ON, N1K 1B6: Aquafor Beech Ltd., October 27, 2016), 40, http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2017/012-9080_Runoff.pdf.

Month	Total Rainfall (mm)
Jan-20	131.4
Feb-20	52
Mar-20	53.8
Apr-20	41
May-20	43.2
Jun-20	49.8
Jul-20	67.6
Aug-20	91
Sep-20	40.8
Oct-20	60.4
Nov-20	42
Dec-20	26
Annual	699
Daily Average	1.915

5.14 _ Monthly/Annual/Daily Average Rainfall in Toronto, 2020.



5.15 _ Rainfall Percentile Graph in Toronto, 2020.



5.16 _ Watershed Impact Area and Drainage Flows

Catchment Location	Estimated Drainage Area (A)	Impermeability (%)	Runoff Coefficient (C)	90% Runoff Volume (Q)	Target Design Capacities In 55G (200L) Rainbarrels (L)
 Christie Pits Park	154000 m^2	40 %	0.41	1704 m^3	8520 Rainbarrels = 1 704 000 L
 Bickford Park	108500 m^2	41%	0.42	1230 m^3	6150 Rainbarrels = 1 230 000 L
 George Ben Park	125500 m^2	56 %	0.55	1863 m^3	9315 Rainbarrels = 1 863 000 L
 Trinity Bellwoods Park	252500 m^2	40%	0.41	2795 m^3	13 975 Rainbarrels = 2 795 000 L
 Stanley Park	128500 m^2	63 %	0.62	2151 m^3	10 755 Rainbarrels = 2 151 000 L
 Fort York Historic Site	185000 m^2	47 %	0.47	2347 m^3	11 735 Rainbarrels = 2 347 000 L

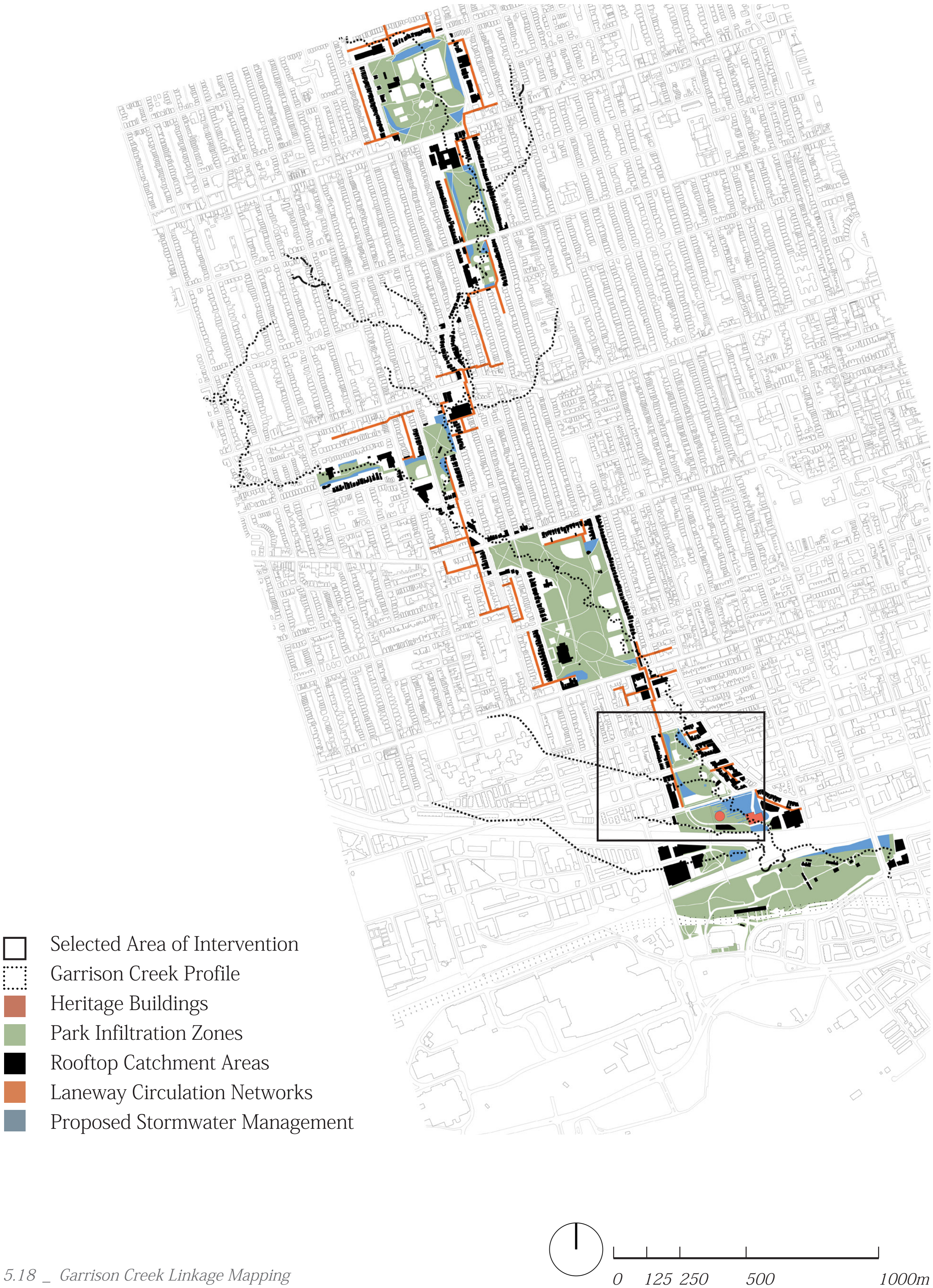
5.17 _ Water Treatment Volume Calculation Methodology

5.3_Four Frameworks

The complete neighborhood system and corresponding park along the creek retain and treat stormwater runoff to relieve sewer pressures and increase lake water quality, while simultaneously connecting surrounding elements to selected park system in a similar fashion. Community interaction and awareness of water in the city are articulated through the design of four components:

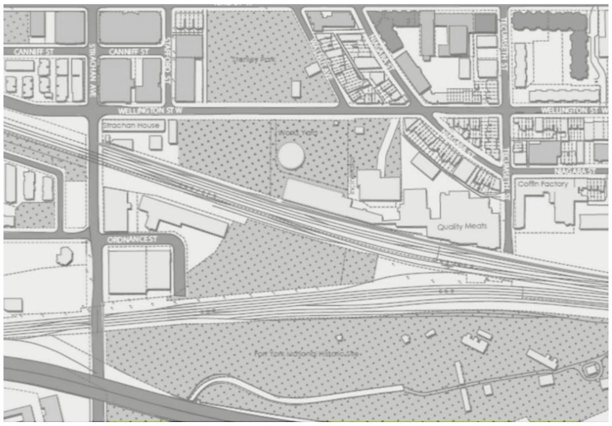
1. *Heritage Building* as a pilot project
2. *Open Park Spaces* as redesigned run-off infiltration zones
3. *Laneways* as arterial networks allowing water to flow into designated parks
4. *Rooftops* which expand rainwater catchment volume of the urban fabric

The combination of these four components allows stormwater to be collected, treated, stored and reused, reducing pressures on existing centralized stormwater infrastructures. In conjunction, these proposed spaces allow park users, neighboring homeowners near the parks as well as tourists to interact and recollect the value of Garrison Creek within day-to-day city life. The inclusion of community-led stormwater engagement programs within the vacant heritage building will develop public opportunities and value towards Garrison Creek, providing precedent for future interventions of hidden ravine landscapes in Toronto. Surrounding the re purposed building will be re mediated stormwater park landscapes connecting to the adjacent park networks through rainwater collection and community driven production spaces.



5.18 _ Garrison Creek Linkage Mapping

5.19 _ Aerial Site Photo of Stanley Park System
Source: Google Earth



5.20 _ *Future Strategy for Wellington Industrial Lands, 2016.*

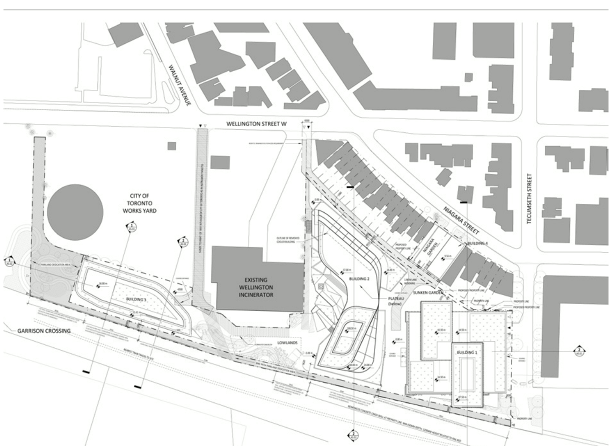
Additional Site Strategies

In addition to the four proposed frameworks, the design intervention complements proposed developments slated for the site surrounding the Wellington Destructor garbage incinerator heritage building. The three main goals which fall in-line with existing proposals are:

1. Protecting Heritage Buildings Via Adaptive Reuse

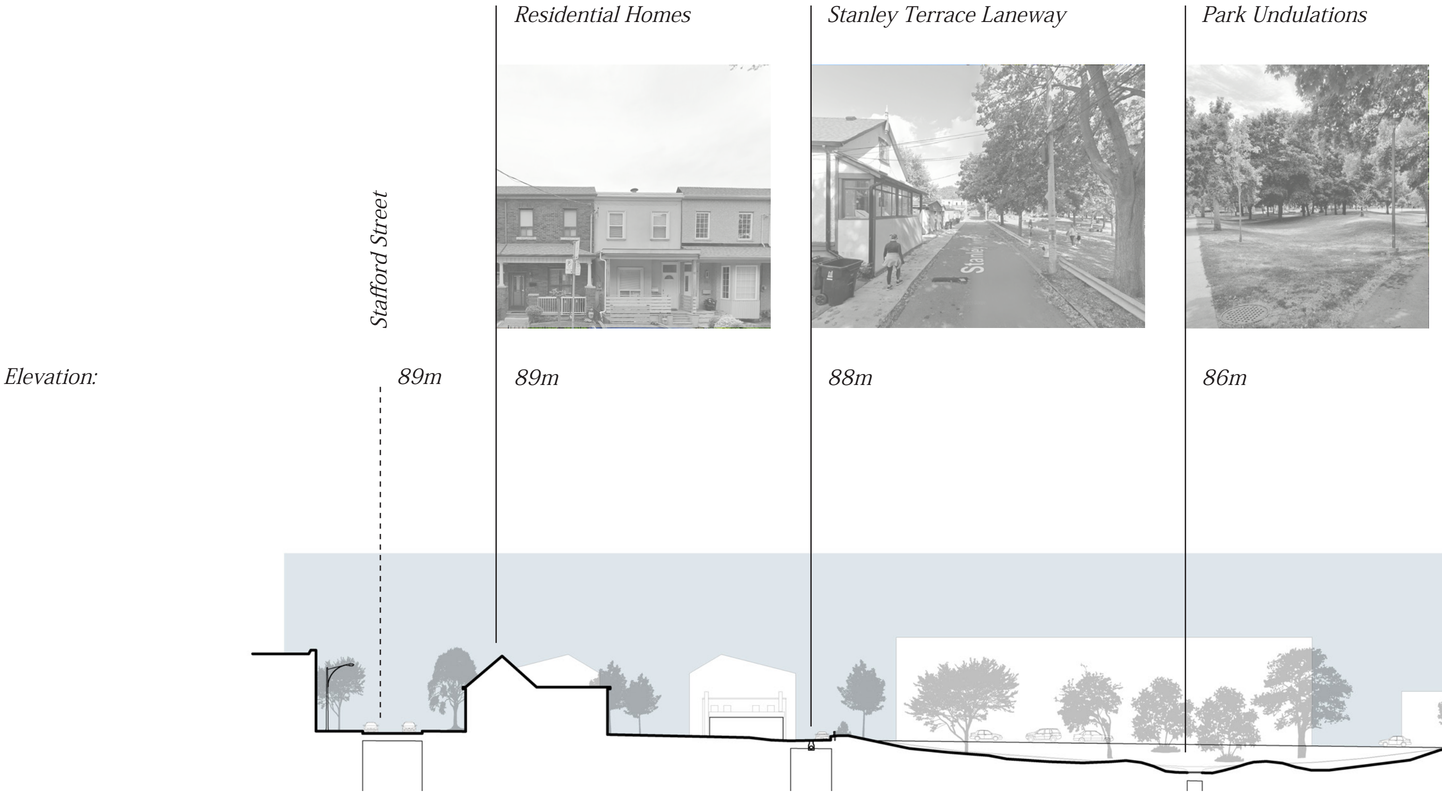
2. Reference Area's Contextual and Built Heritage

3. Enhance and Connect Existing Park Spaces

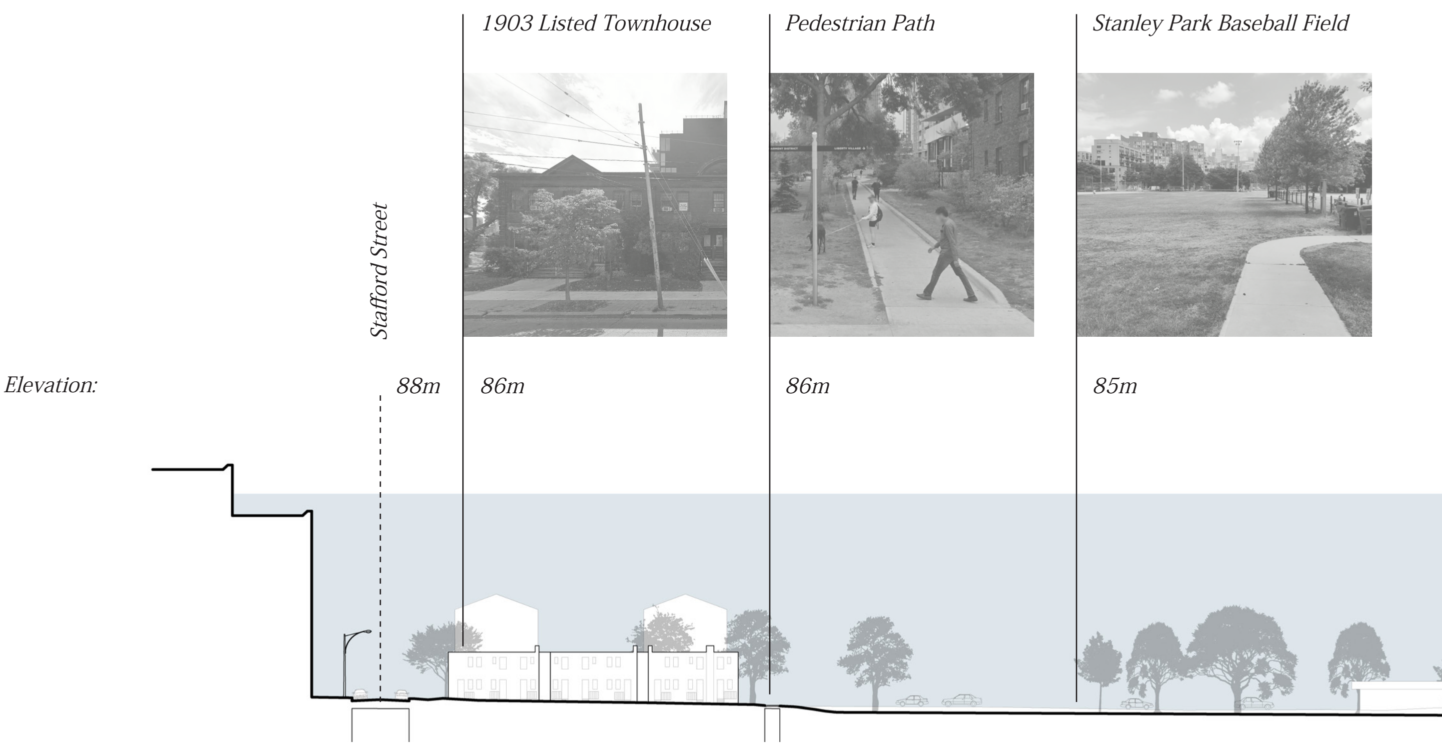


5.21 _ *Mixed Use Development Proposal, 2018.*

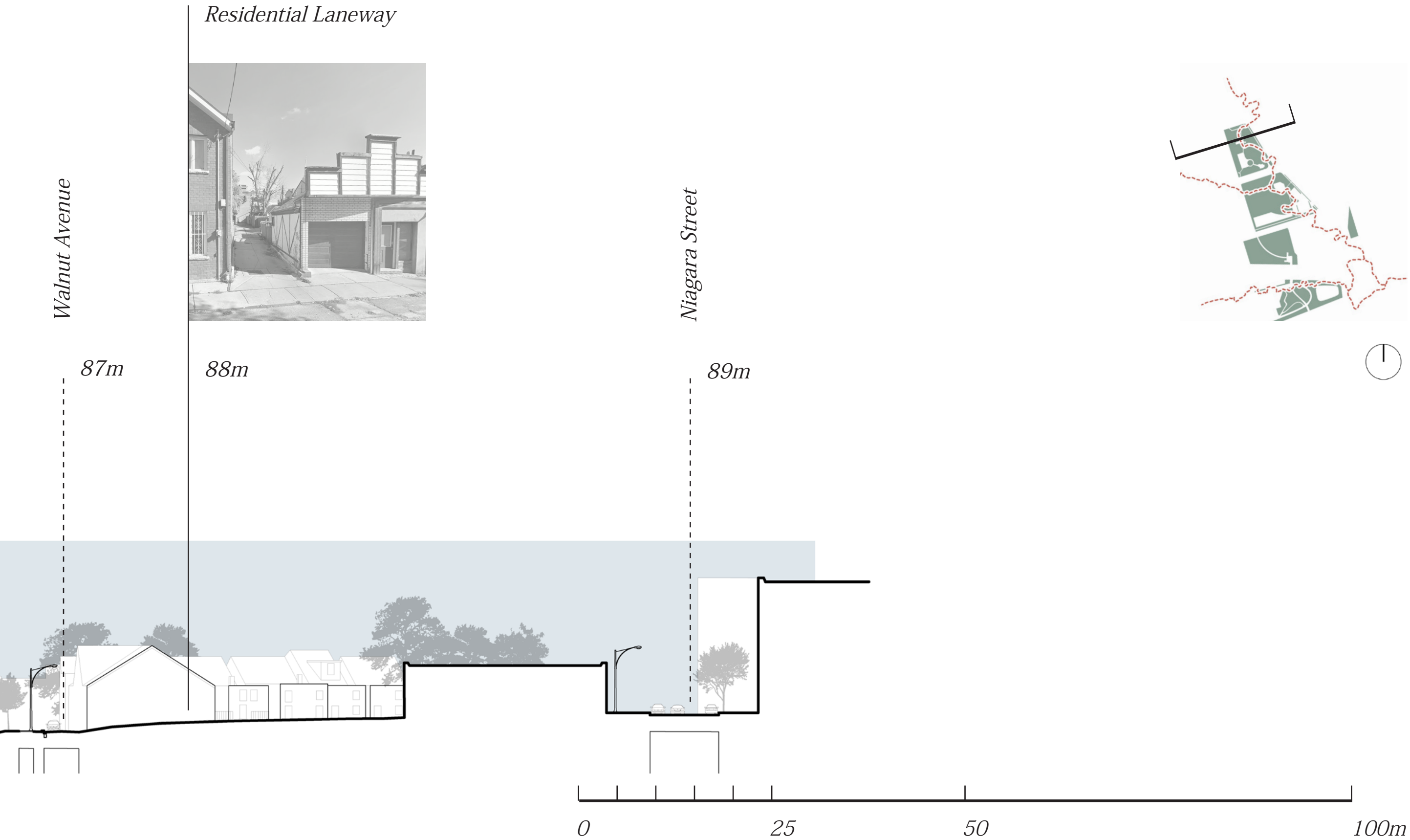
The focus of the intervention re-purposes the vacant incinerator heritage building as the initial component for the design intervention into a space which raises situational and community awareness for stormwater in urban landscapes of Toronto's parks. The maintenance works landscape surrounding the incinerator heritage building will be redefined as a park system which re-knits back to Stanley Park South to the West as well as the Fort York Pedestrian Bridge, promoting new cultural opportunities for citizen involvement and decentralized stormwater management strategies. The hidden Garrison Creek resurfaces through the various decentralized stormwater management methods throughout each of the parks.



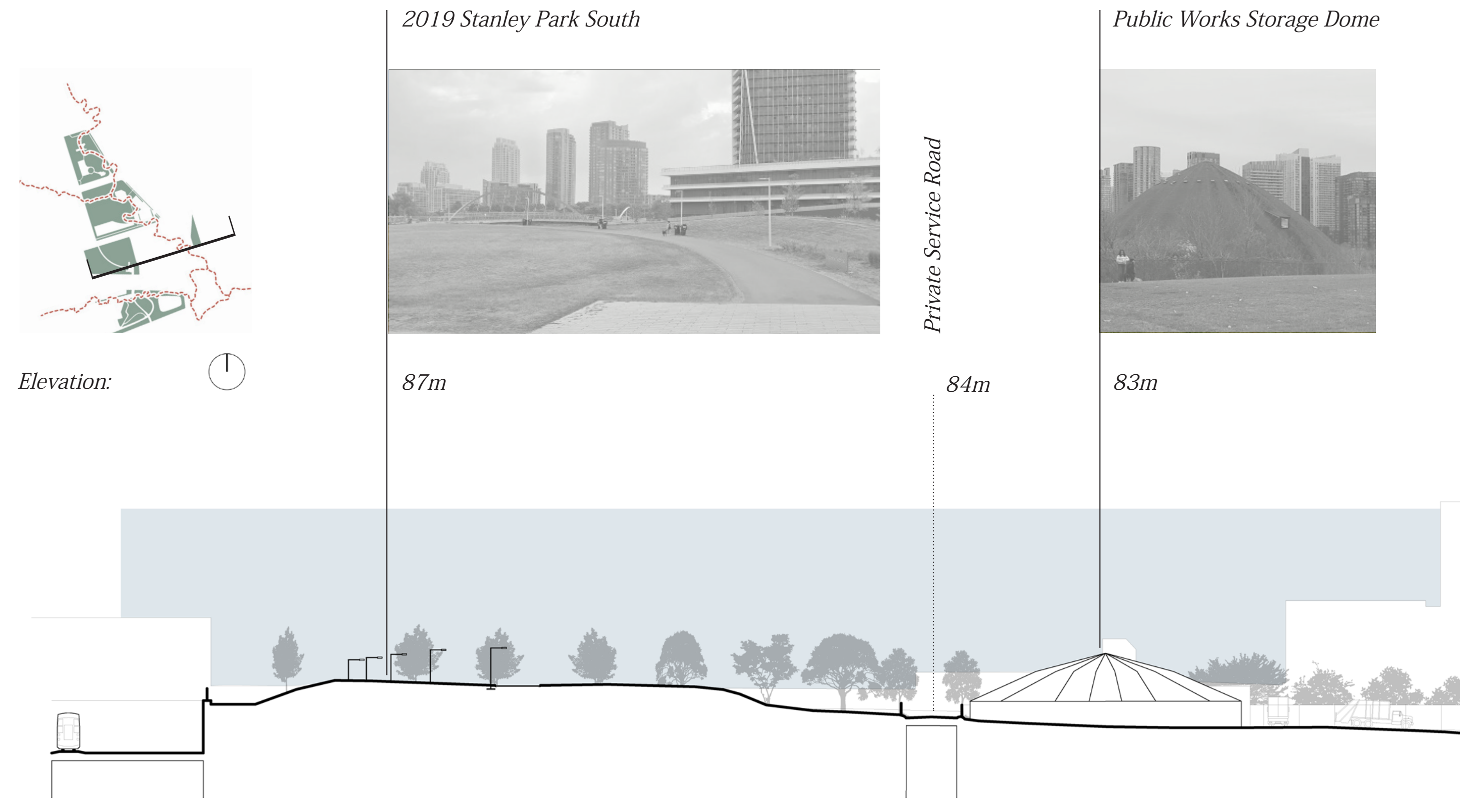
5.22 _ Existing Site Section Through Stanley Park North



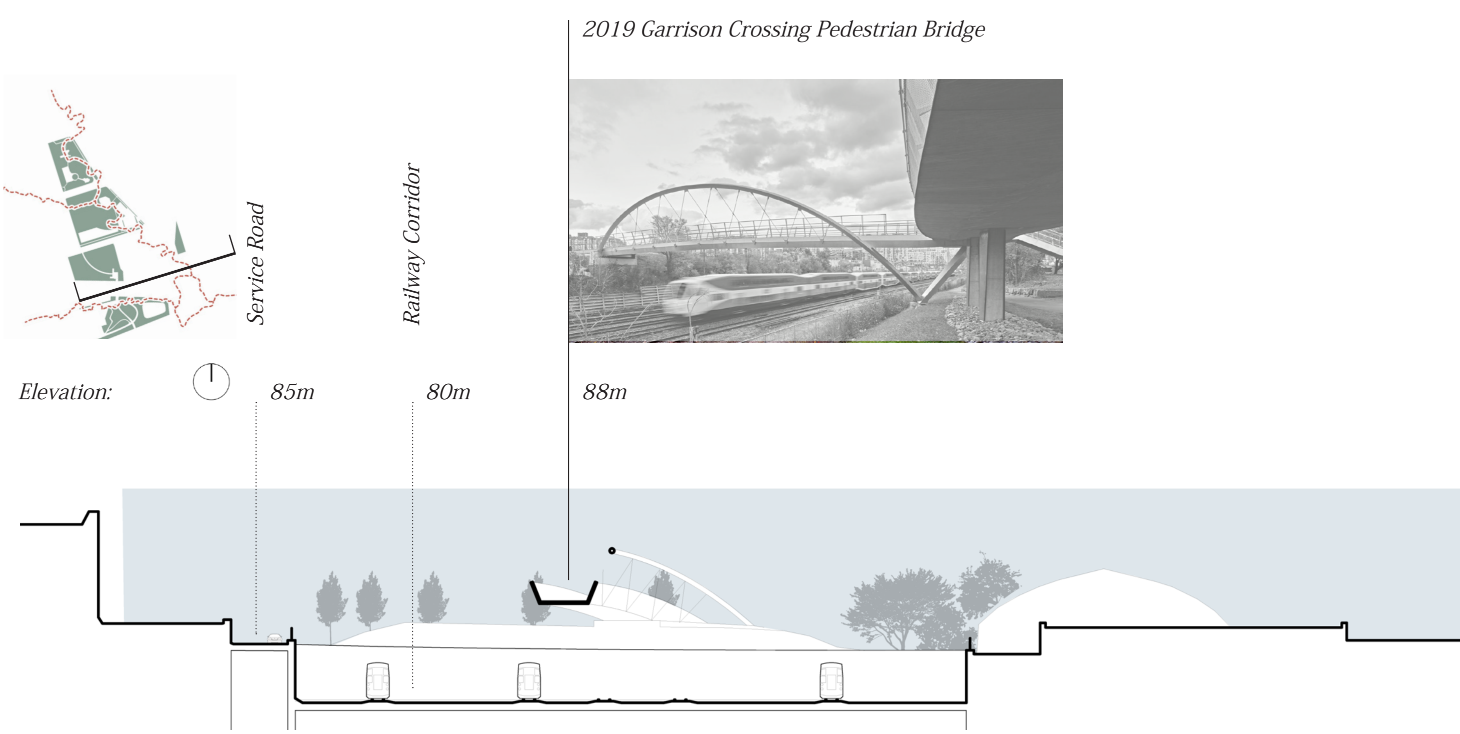
5.23 _ Existing Site Section Through Stanley Park


Residential Laneway
Walnut Avenue
Niagara Street
87m
88m
89m
0
25
50
100m

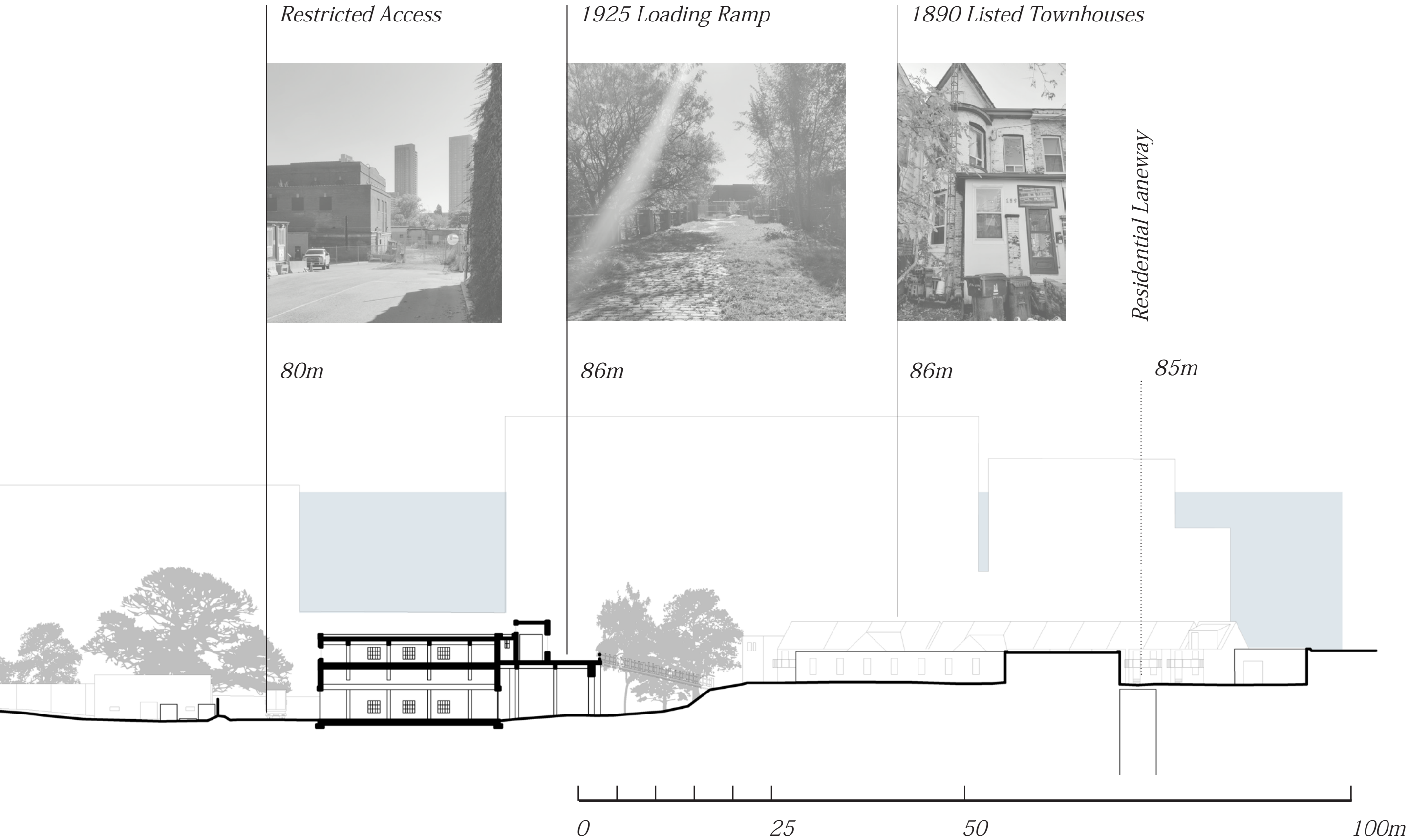

Public Washroom
1934 Perfume Factory
Commercial Laneway
Walnut Avenue
Niagara Street
85m
84m
85m
86m
88m
0
25
50
100m

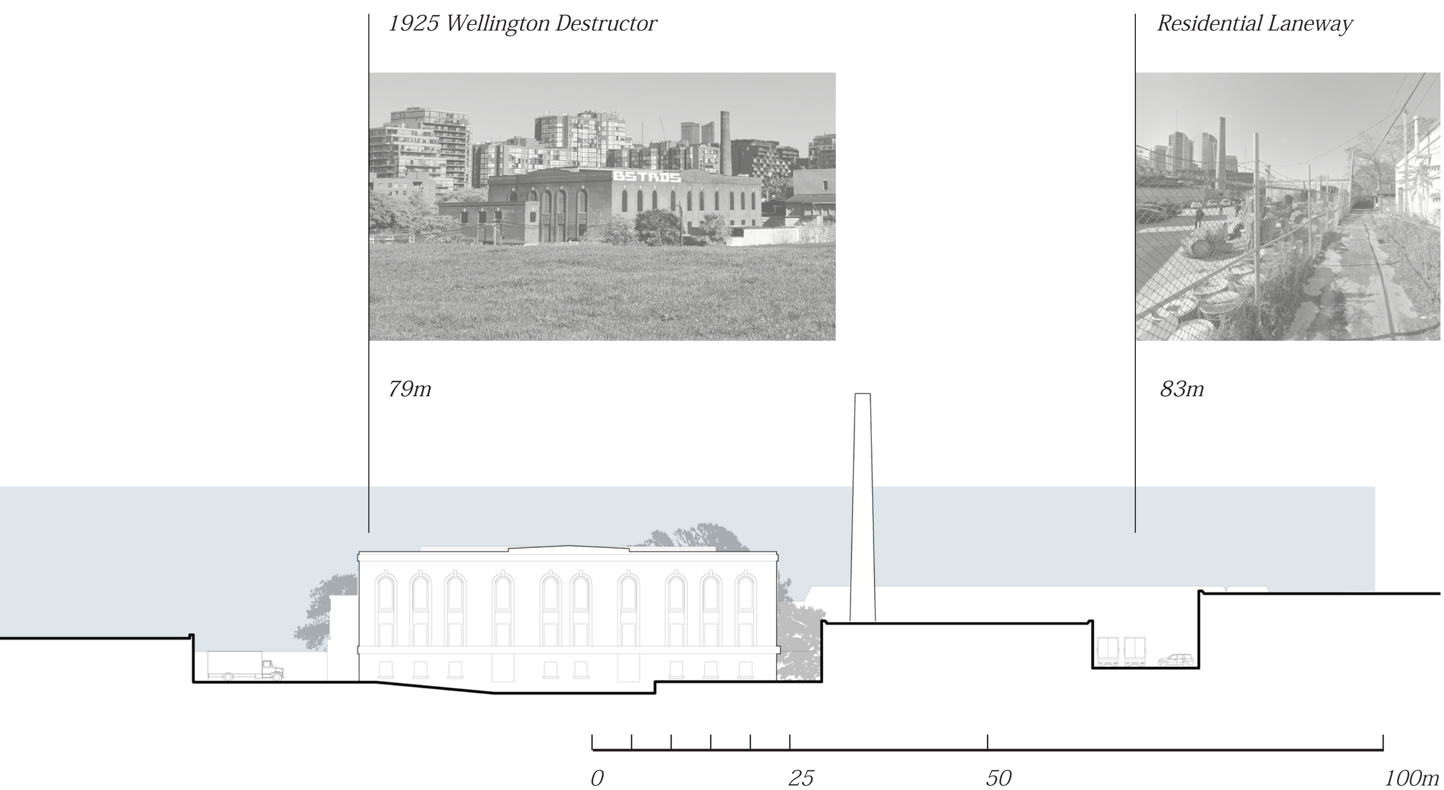


5.24 _ Existing Site Section Through Stanley Park South and Incinerator Building Property



5.25 _ Existing Site Section Garrison Common, Railway Lands and Incinerator Elevation


Restricted Access
1925 Loading Ramp
1890 Listed Townhouses
Residential Laneway
80m
86m
86m
85m
0
25
50
100m


1925 Wellington Destructor
Residential Laneway
79m
83m
0
25
50
100m

Surrounding the edges of Stanley Park's patches of open space are multiple types of building uses and various actors neighboring the site. Primary actors consist of residential and mixed use retail and residential spaces. A number of existing heritage building stock are sited near these parks. Proposed interventions highlight the presence of heritage buildings on site and strengthen the presence of these historic artifacts as another layer of the site's history.

Measurements

 # Of Heritage Buildings on Site

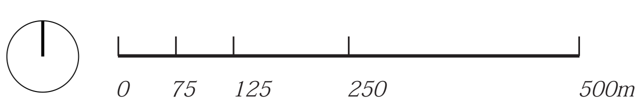
= 27

Total Heritage Rooftop Area Around Stanley Park

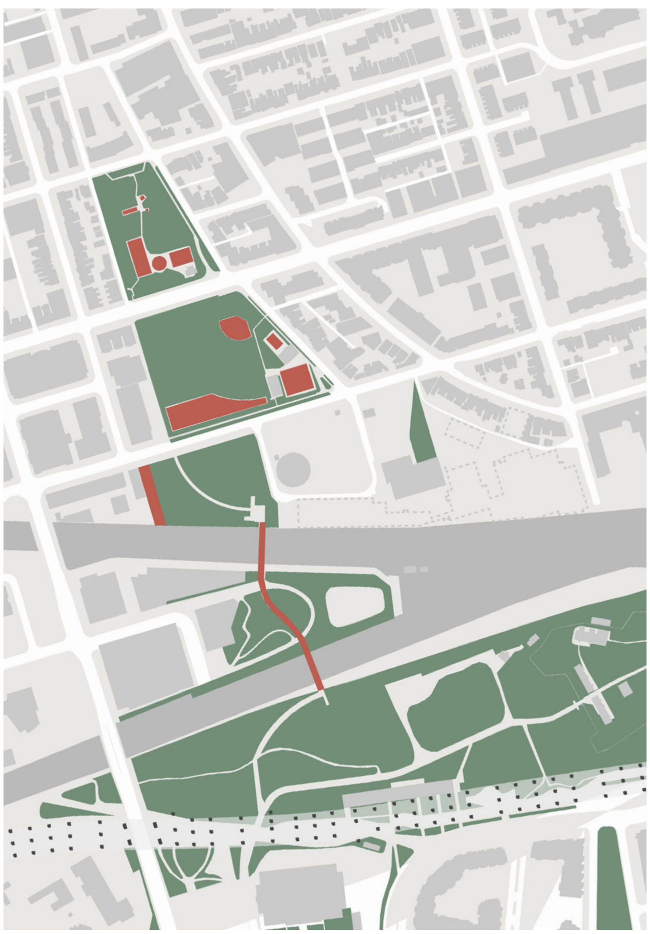
= 4600 m^2

- *Heritage Building*
- *Proposed Building Removals*
- *Retained Site Buildings*
- *Social + Cultural + Institutional*
- *Residential*
- *Mixed Use Retail + Residential*
- *Commercial*
- *Railway Corridor*
- *Gardiner Expressway*

5.26 _ Heritage Buildings and Surrounding Programs



Stanley Park North's existing uses are seating areas, basketball courts, children's playground and splash pad. Below that are baseball diamonds, off leash dog park, outdoor swimming pool and tennis court. Stanley Park South contains an existing community garden and a recently completed cycle/pedestrian bridge to park further South. Proposed interventions are designed to retain and complement existing uses and reduce the high impermeability and subsequent runoff at Stanley Park South.



5.27 _ Existing Park Activity Use Areas

Measurements

Stanley Park North
2 500 m^2 Impermeable
9 110 m^2 Permeable = 22% Impermeability

Stanley Park
6 170 m^2 Impermeable
14 340 m^2 Permeable = 30% Impermeability

Stanley Park South
16 540 m^2 Impermeable
12 670 m^2 Permeable = 57% Impermeability

Ordnance Triangle Park
5 920 m^2 Impermeable
10 320 m^2 Permeable = 36% Impermeability

Fort York Historic Site
27 690 m^2 Impermeable
103 110 m^2 Permeable = 21% Impermeability

Park Activity Zones

Circulation flows have been organized based on traffic density, road widths and adjacent land uses. Large amounts of activity exist on the major East-West streets cutting through each of the plots of open space, providing for ample opportunities to attract interest into the proposed interventions. For this thesis, the focus will be on re-purposing the existing laneway spaces which connect to surrounding parks.

5.28 _ Circulation Hierarchy

Measurements

 # Of Laneways Near Stanley Parks

= 6

Total Laneway Length Near Stanley Parks

= 580 m

Major Streets

Minor Streets

Laneways

Three major rooftop types surrounding the site. The selected rooftops highlighted are ones which are able to be connected to the proposed laneway interventions. The design proposal incorporates the future mixed use high rise development surrounding the heritage garbage incinerator, overlaid on top of the similarly proposed removal of existing buildings on the site.

Measurements

Flat Roof High Rise Total Area

Stanley Parks	*= 7 990 m^2*
Ordnance Triangle Park	*= 12 700 m^2*
Fort York Historic Site	*= 17 660 m^2*

Flat Roof Low/Mid Rise Total Area

Stanley Parks	*= 17 230 m^2*
Fort York Historic Site	*= 11 270 m^2*

Pitched Roof Residential Total Area

Stanley Parks	*= 10 820 m^2*

Salt Storage Dome Area

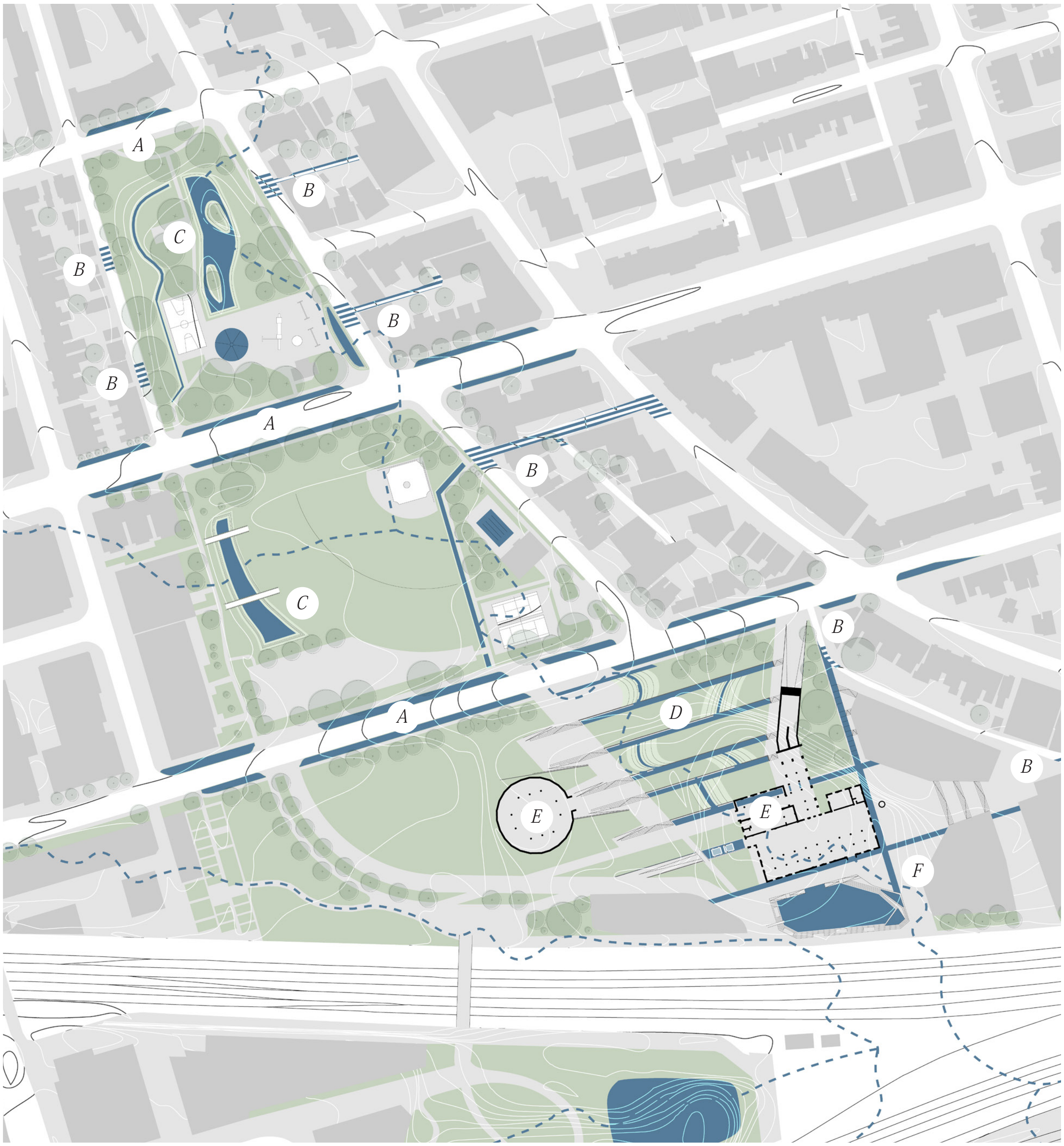
Stanley Parks	*= 1 010 m^2*

Total Stanley Parks Roof Area

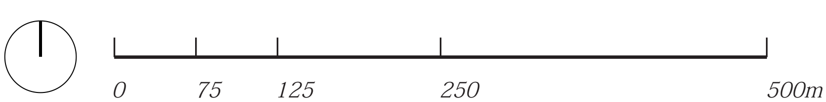
= 37 050 m^2

Flat Roof High Rise
Flat Roof Low/Mid Rise
Pitched Roof Residential
Salt Storage Dome

5.29 _ Rooftop Hierarchy



5.30 _ Overall Site Plan Intervention Areas



The site plan proposes multiple additions to the existing park network, creating various new zones:

A _ Stormwater curbs which direct, store, treat and slowly release filtered stormwater back into the sewage network gradually.

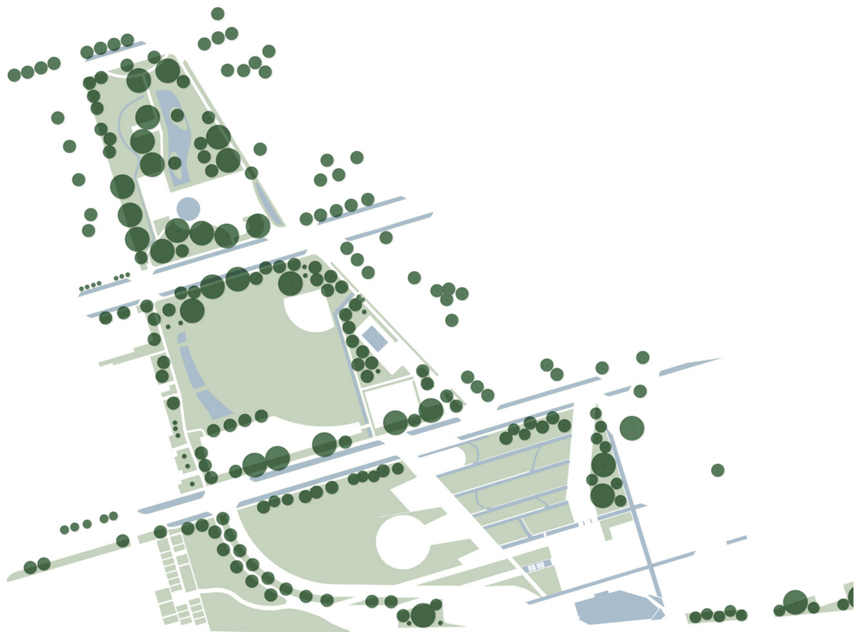
B _ Selected areas along minor streets for permeable paving and new speed bump and redefined park curbs allow water to infiltrate from neighboring laneways.

C _ High rate infiltration basins for each patch of green space which collect stormwater from neighboring laneways and buildings.

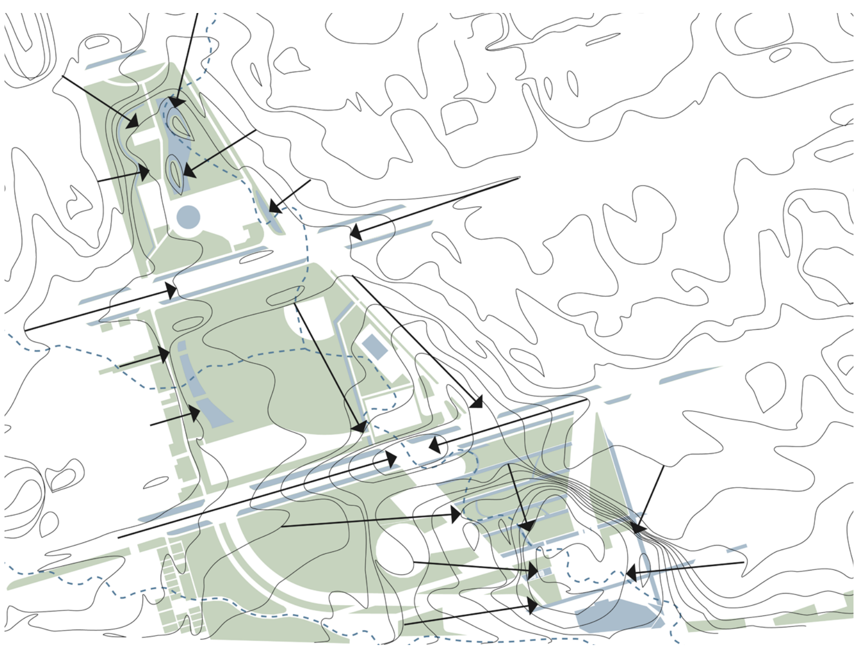
D _ Bio-filtration terrace system drawing stormwater from Wellington St West and from neighboring laneways and mixed use development.

E _ New greenhouse spaces which provide spaces for growing produce in the summer and stormwater vegetation in the winter.

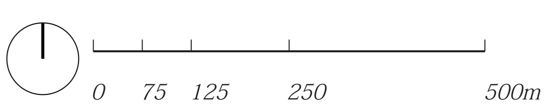
F _ A new public water square South of the re-purposed incinerator building which caters to both local residents and surrounding circulation from the pedestrian bridge.



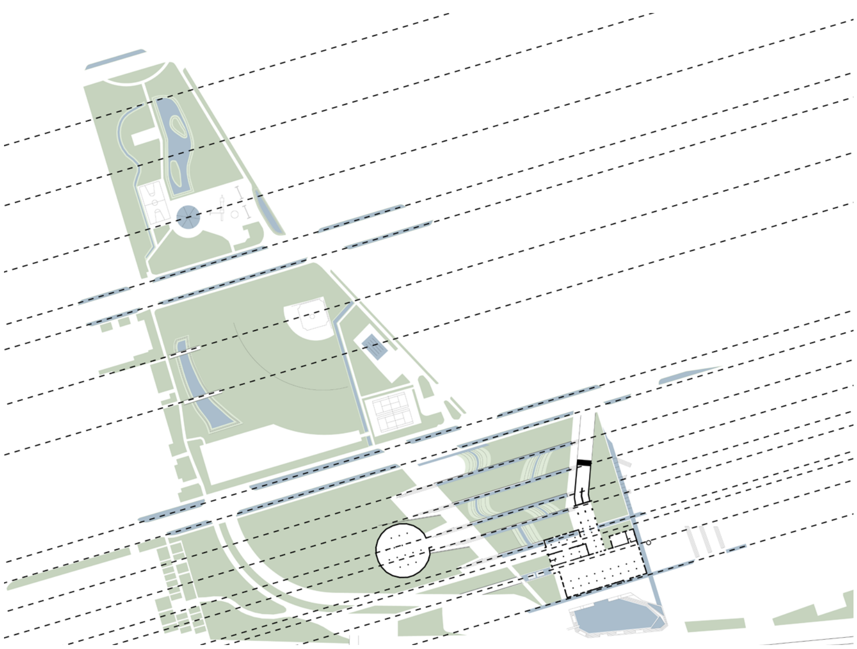
5.31 _ Existing Tree Cover



5.32 _ Topographic Secondary Drainage Flows

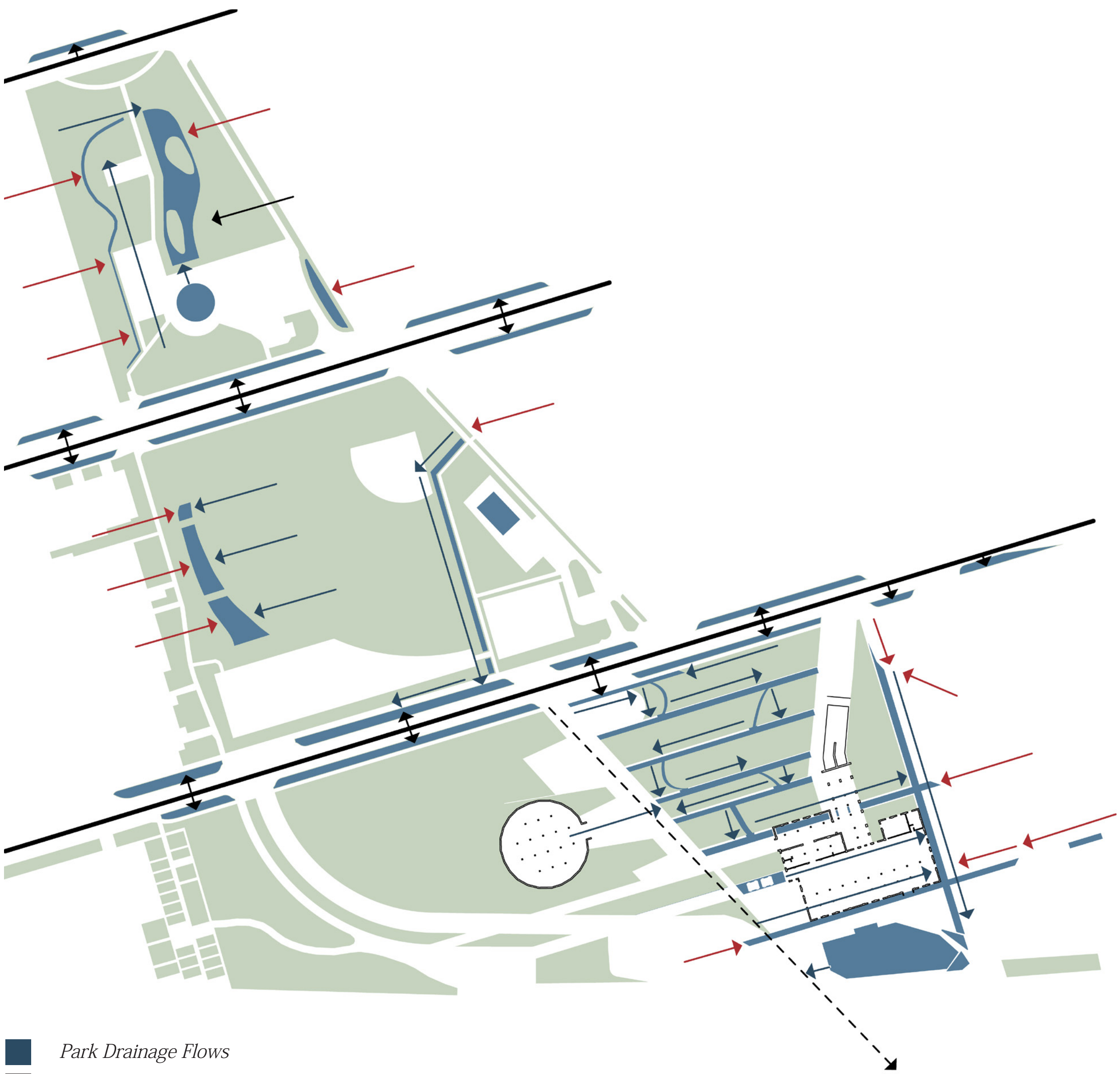


5.33 _ Circulation Routes



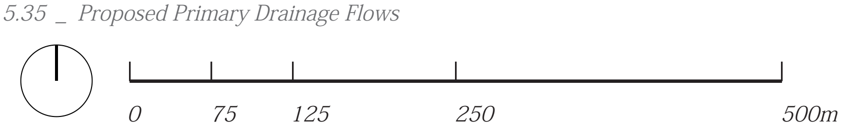
5.34 _ Linear East-West Mosaic

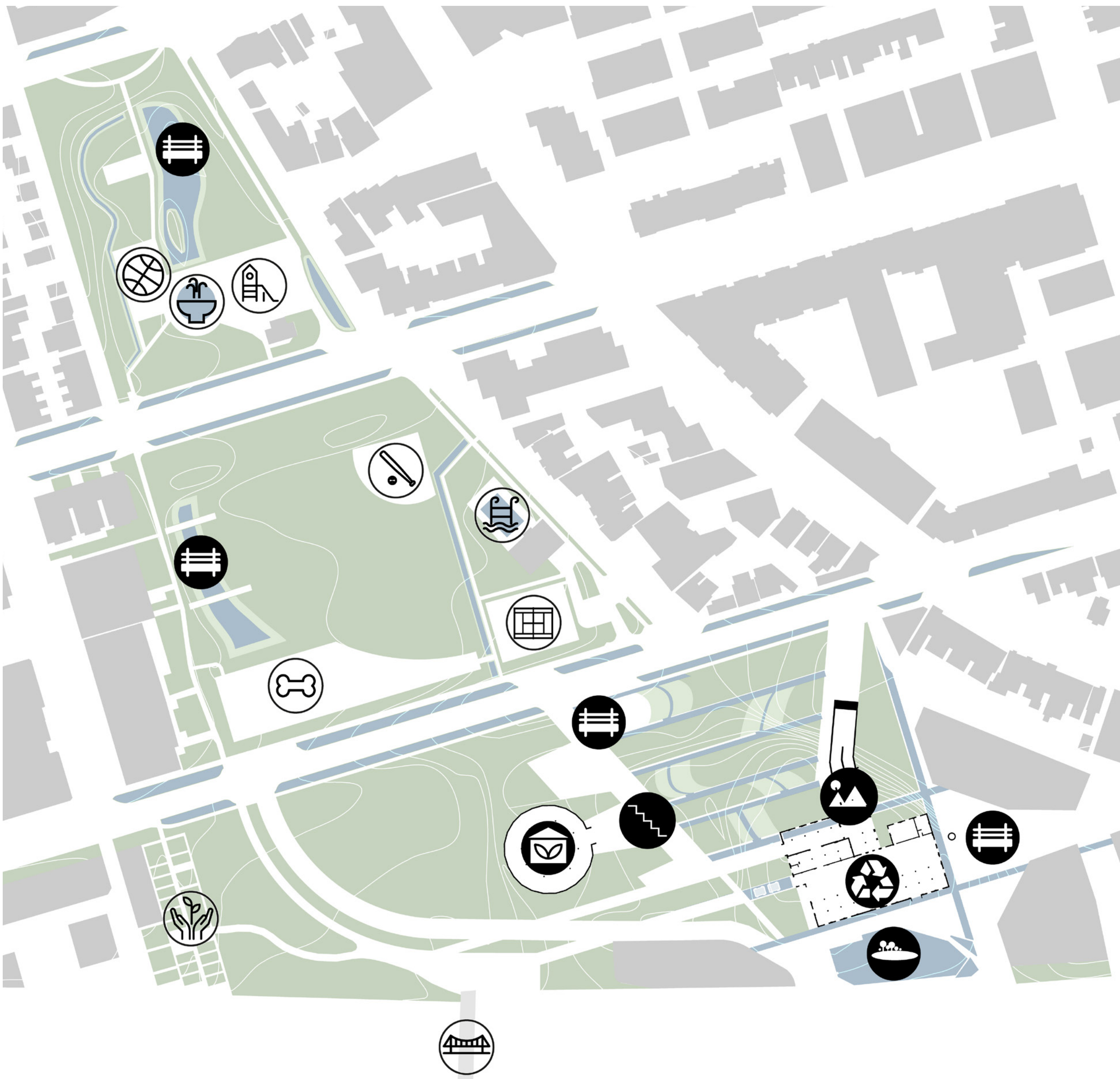
This set of diagrams shows the different layers which have affected the overall design of the site plan and the insertion of the four different frameworks/components.



Park Drainage Flows
Street Drainage Flows
Laneway & Rooftop Drainage Flows
Drainage to Existing Sewer System

5.35 _ Proposed Primary Drainage Flows





□ *Existing Programs*
■ *Proposed Programs*

5.36 _ Existing and New Program Uses

1_Heritage Building

Finished in 1925, the Wellington Destructor was an active solid waste garbage incinerator until the mid-1970s, and the site was changed to a transfer station by the 1980s. The site has been vacant and is now listed on the City of Toronto heritage register in June 2005, subject to future conversion of use. The proposed programs contrast the buildings former incineration uses.

Building Timeline

1923 - Construction begins on the Wellington Destructor

1925 - Wellington Destructor begins service as second largest incinerator in Toronto

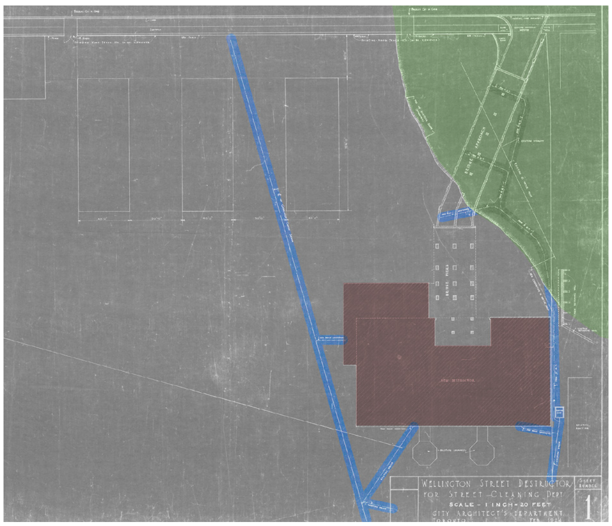
1950 - Department of Public Works receives numerous complaints regarding emissions of flaming paper and ash settling over surrounding neighborhood

1972 - City ordered to either renovate/close it and six other garbage incinerators, responsible for twenty percent of Toronto' s air pollution

1977 - Two brick chimneys demolished, continued to operate as Wellington Street Transfer Station

1986 - Destructor closes due to poor working conditions

2005 - Site listed as heritage property



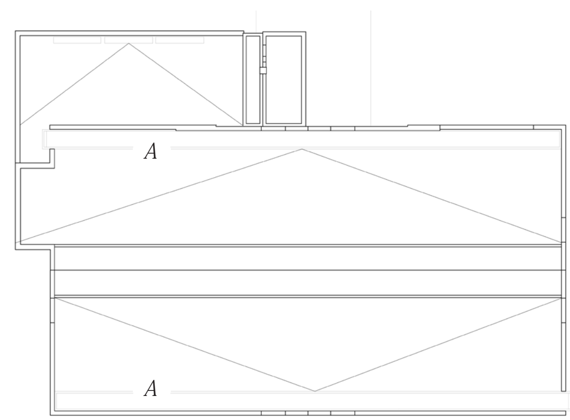
5.37 _ Existing Sewers & Existing Creek Edge Plan, 1924.

5.38 _ Existing Garbage Incineration Program, 1928.

5.39 _ Existing Open Space Beside Incinerator, 1925.

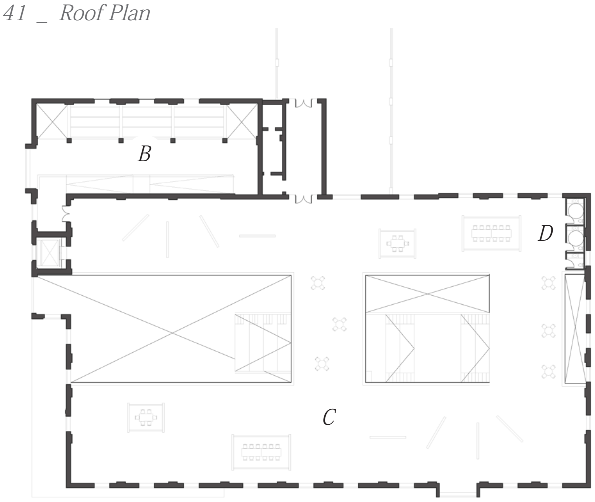
5.40 _ Moss Growth on Wellington Destructor Rooftop, 2016.

The re-purposed incinerator building serves as a new local control hub which serves to accommodate the dynamic controls of nearby retention systems. In the event of a heavy rainfall, servers located in the building provide signals to automatically release the remaining storage of water to get ready for the next heavy rainfall. Locating the system in the building provides opportunities for community education and engagement into emerging storm water management ecologies. Supplementary employment spaces, workshops for community gardens, cafe as well as outdoor/indoor gallery spaces provide further engagement with the surrounding context. The building provides space for existing park and community initiatives to collaborate and incorporate new stormwater planting methodologies throughout parks across the Garrison Creek network.

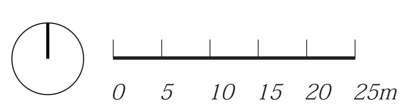


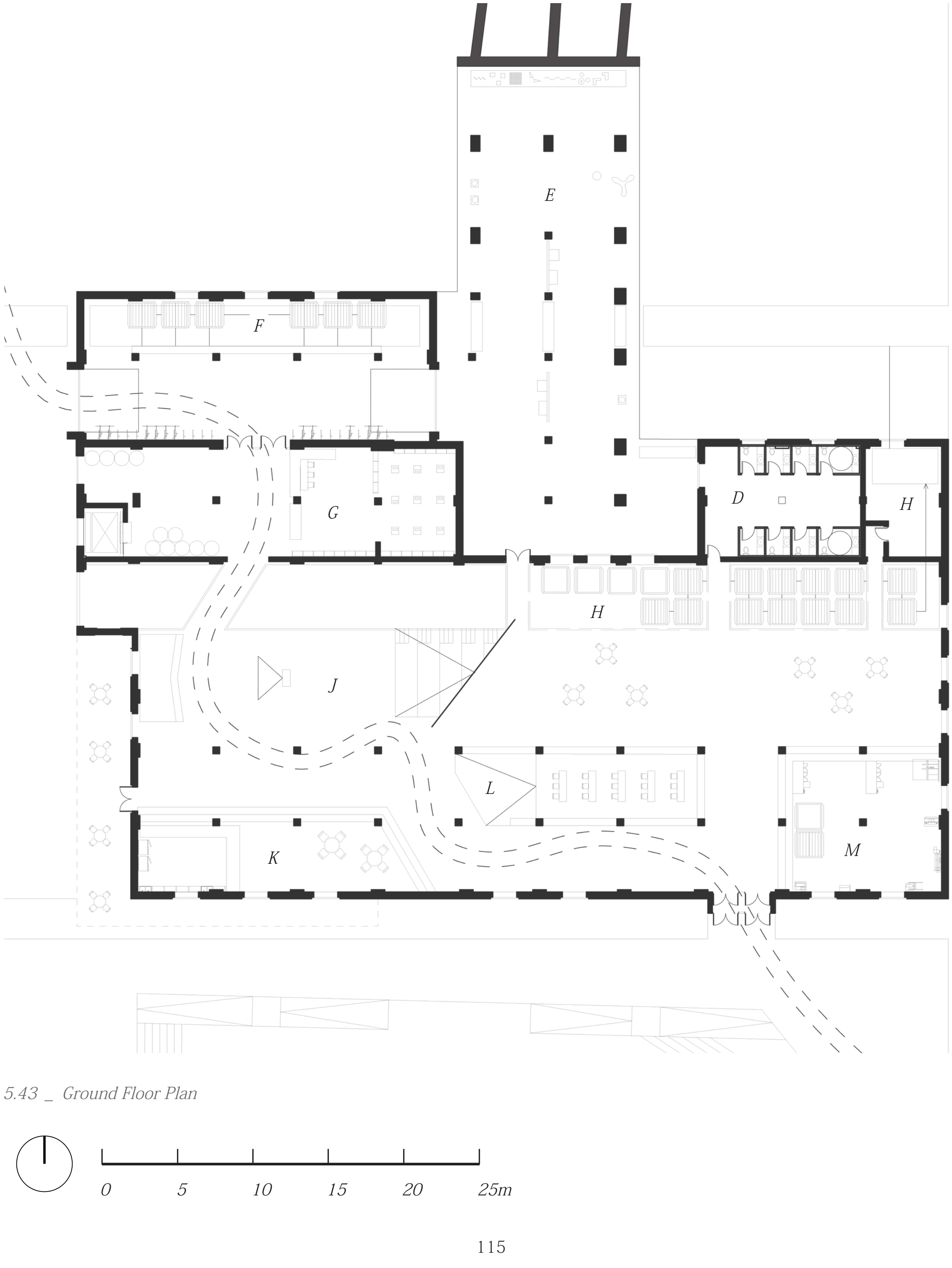
5.41 _ Roof Plan

A _ Modular Roof Gardens
B _ Diagonal Eaves Trough Planting Modules
C _ Community Group Meeting Spaces
D _ Rainwater Flushing Washrooms
E _ Outdoor Gallery
F _ DIY Greenwall Spaces
G _ Recycling Center & Admin
H _ Rainwater Harvesting System and Servers
J _ Creek Amphitheater
K _ Cafe
L _ Classrooms
M _ DIY Workshops



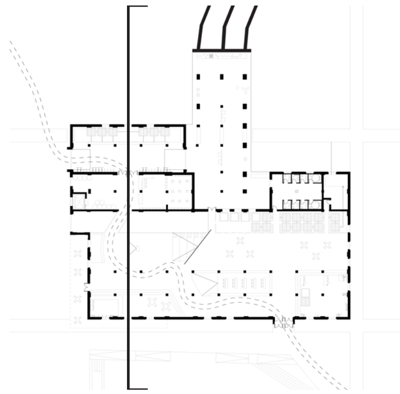
5.42 _ First Floor Plan

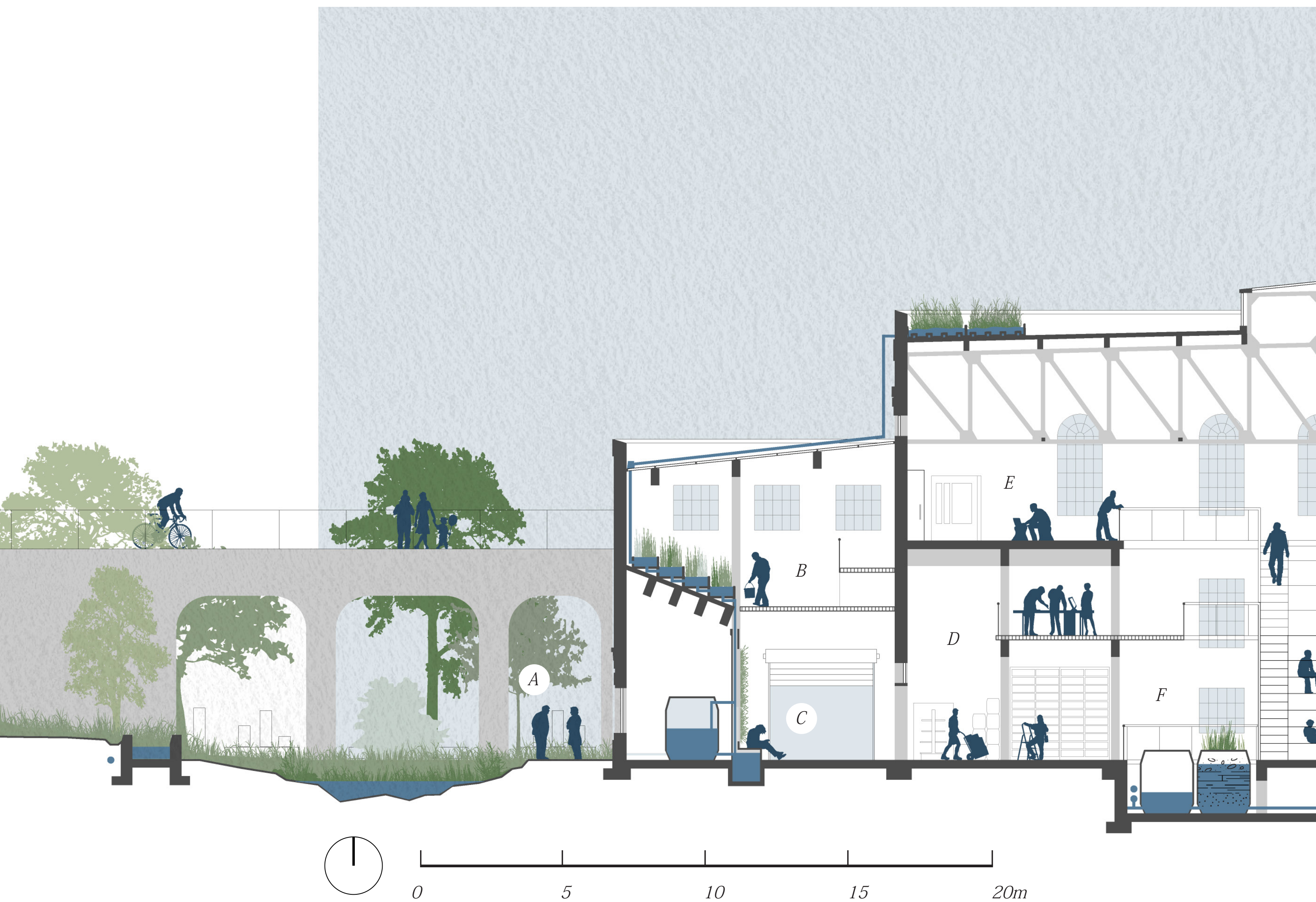




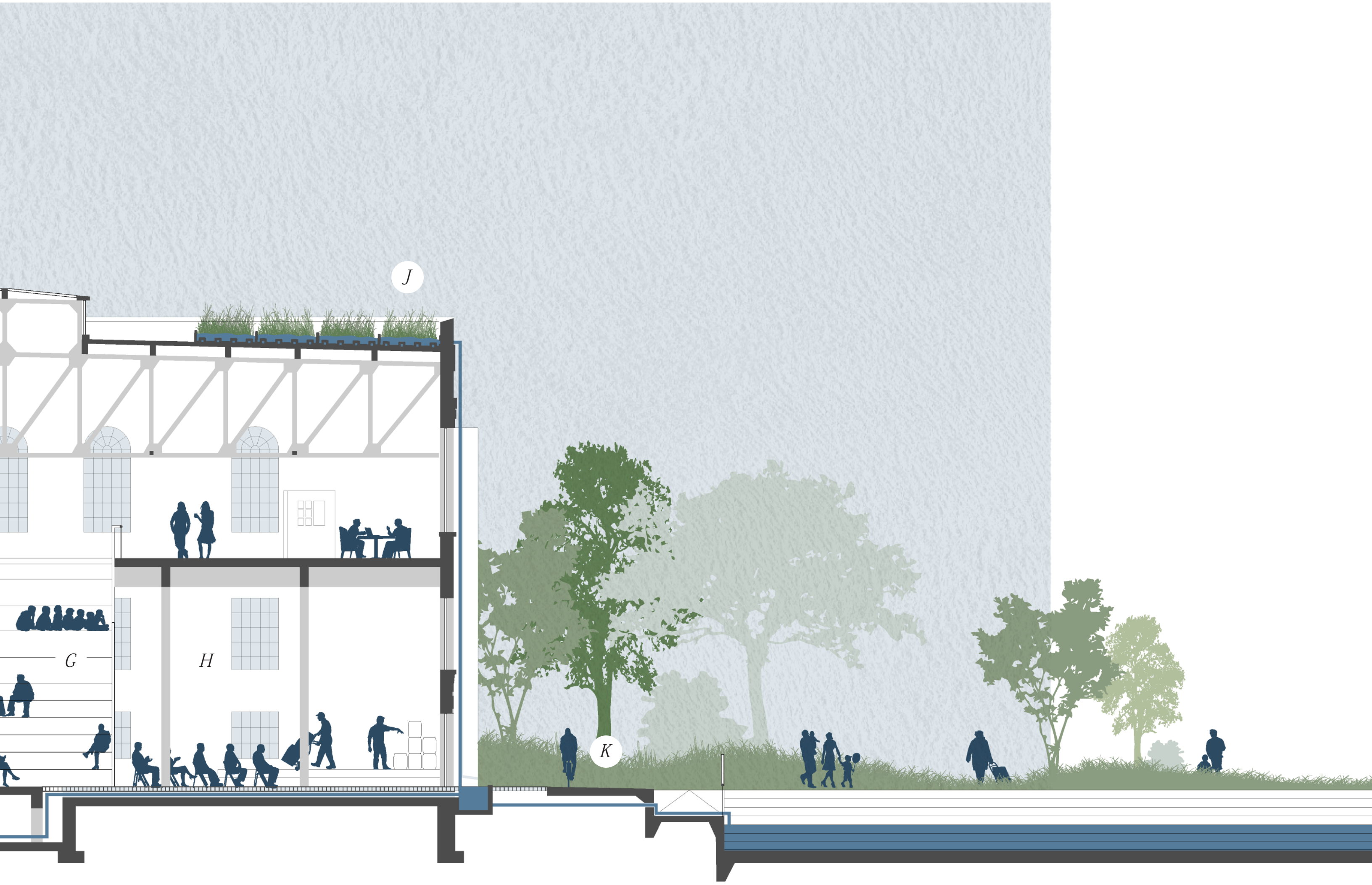
5.43 _ Ground Floor Plan

A _ Outdoor Gallery
B _ Diagonal Roof Planting System
C _ DIY Green Walls
D _ Recycling Center and Administration
E _ Community Meeting Spaces
F _ Rainwater Harvesting System
G _ Creek Amphitheater
H _ DIY Workshops
J _ Modular Roof Gardens
K _ Rainwater Basin Plaza



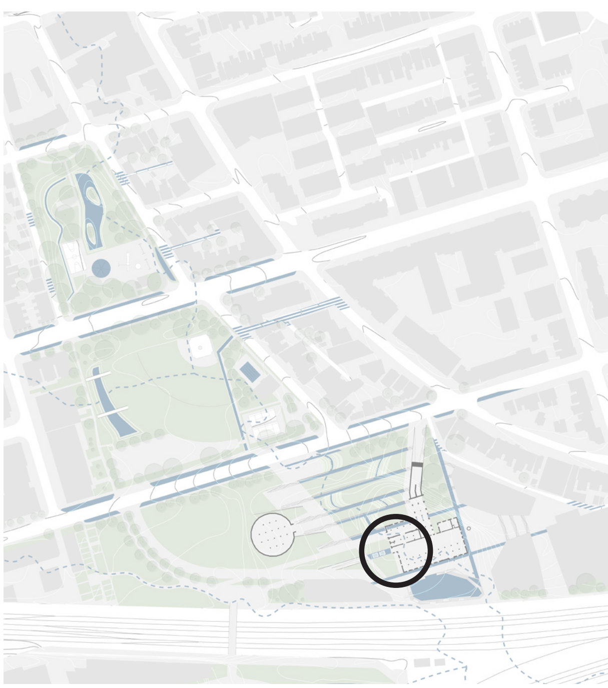


The public water square provides a central node for major storm water runoff from surrounding streets, laneways and rooftops to regulate storm water runoff speed into the existing sewer systems. It doubles as both a central public amphitheater during drier weeks and as a water feature during rainfalls. Public communication of stormwater systems occurs when users of the city travel through the site surrounding the retrofitted building. Various stormwater features are brought back to the public eye and aim to connect existing leisurely park uses with passive education through the designed landscape and active education within these redefined building programs.



5.44 _ East Program Section

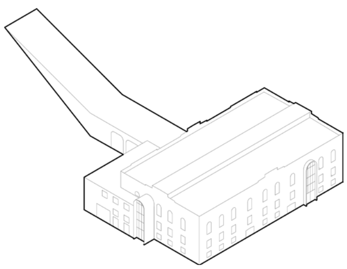
Remediation of the existing polluted site is achieved through stormwater bio remediation practices and replacement of impermeable asphalt areas with permeable paving systems. The addition of social programs such as outdoor seating for a cafe and stormwater retention features attract more users to the Eastern side of Stanley Park's existing circulation flows. Stormwater retention features utilize the rain barrels located on the interior of the building to supply the necessary rainwater to support the retention features during off peak rainfall.



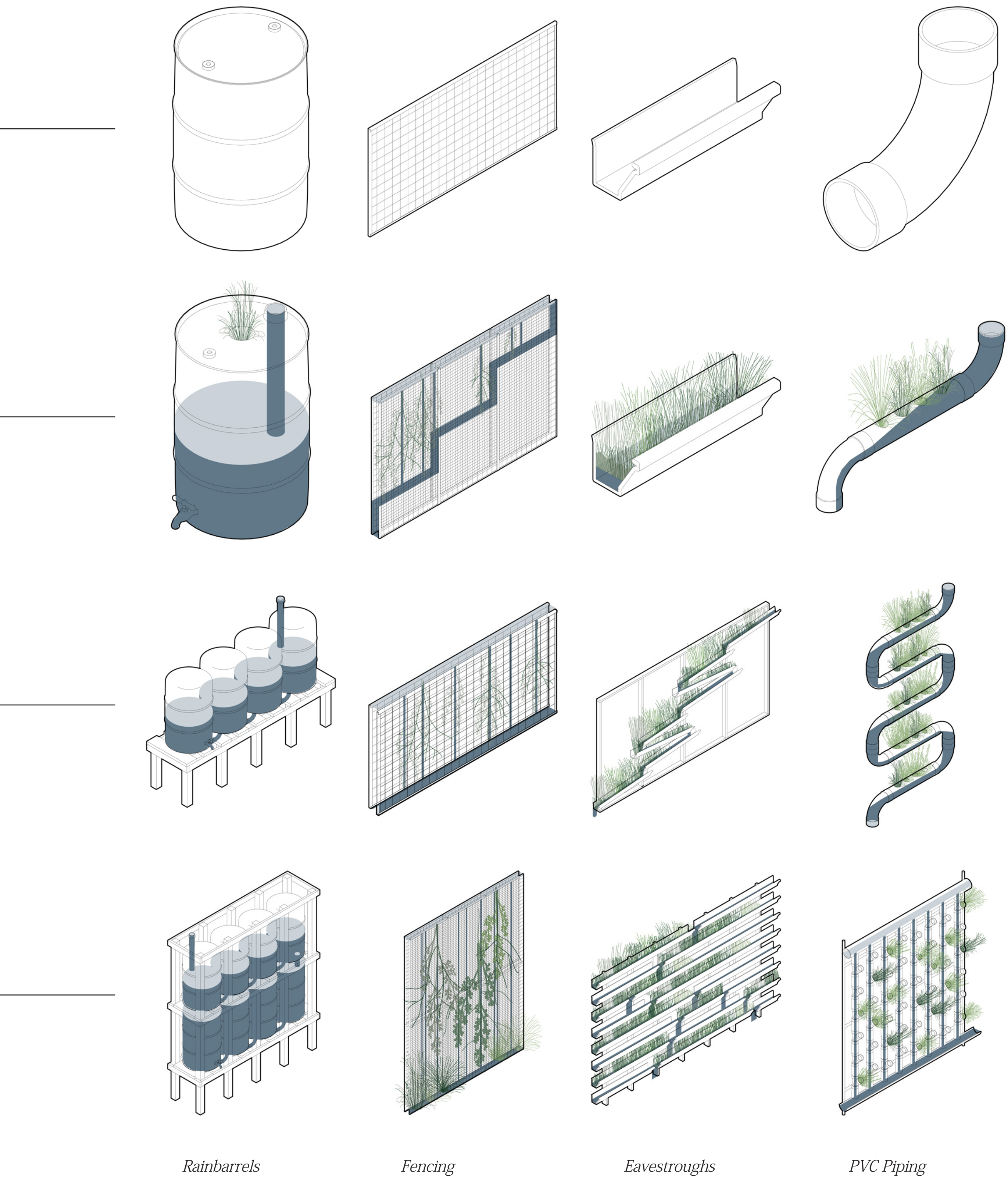
5.45 _ West Elevation Showing Bio filtration Swale, Permeable Paving and Cafe Overhang Stormwater Roof Addition

Framework Kits

Recycled materials are collected at the heritage building such as food grade rain barrels, leftover construction fencing, leaking eaves troughs and older PVC piping to be converted through the workshops to produced new residential stormwater components. Plants can also be harvested and utilized and placed within these components from the following green spaces. Homeowners also have the flexibility to plant their own produce and food. The kit of parts outlines the flexibility in application based on various requirements for roof area volume

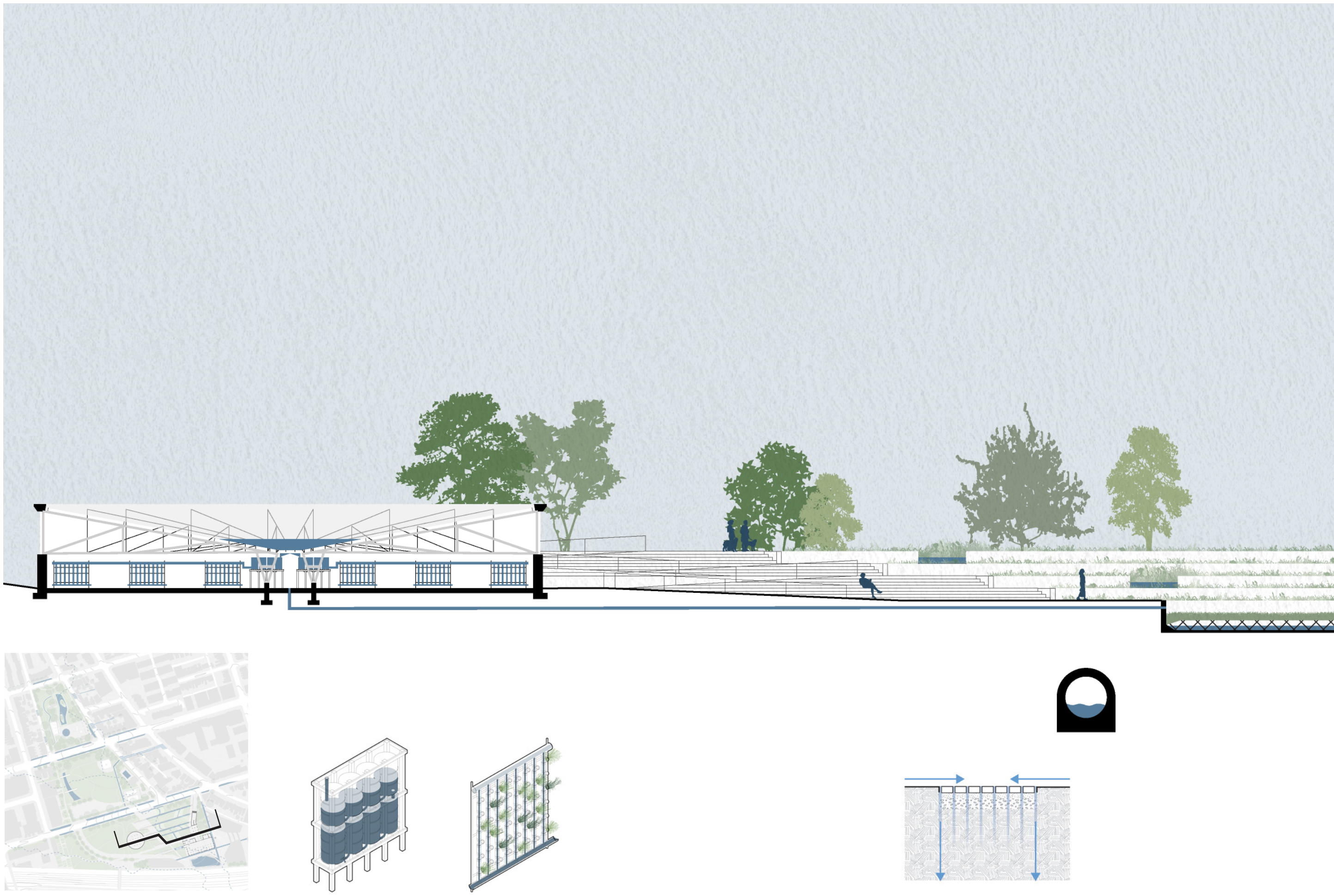


types, laneway lengths and target harvesting quantities. They may be combined together with other component types to complement each others uses, such as rain barrels supplying water in the event of lower rainfall to an eaves trough garden, or PVC piping transferring water between two fencing or eaves troughs panels. The inherent scalability of the system also allows for larger and smaller spaces to be accounted for, meaning condominium spaces may utilize a simple eaves trough component connected to the downspout system, or large high rise roof requiring multiple rain barrel towers for a roof hydroponics garden.



5.46 _ Potential Reconfiguration of Recycled Materials Through Education and Workshops Within Heritage Building

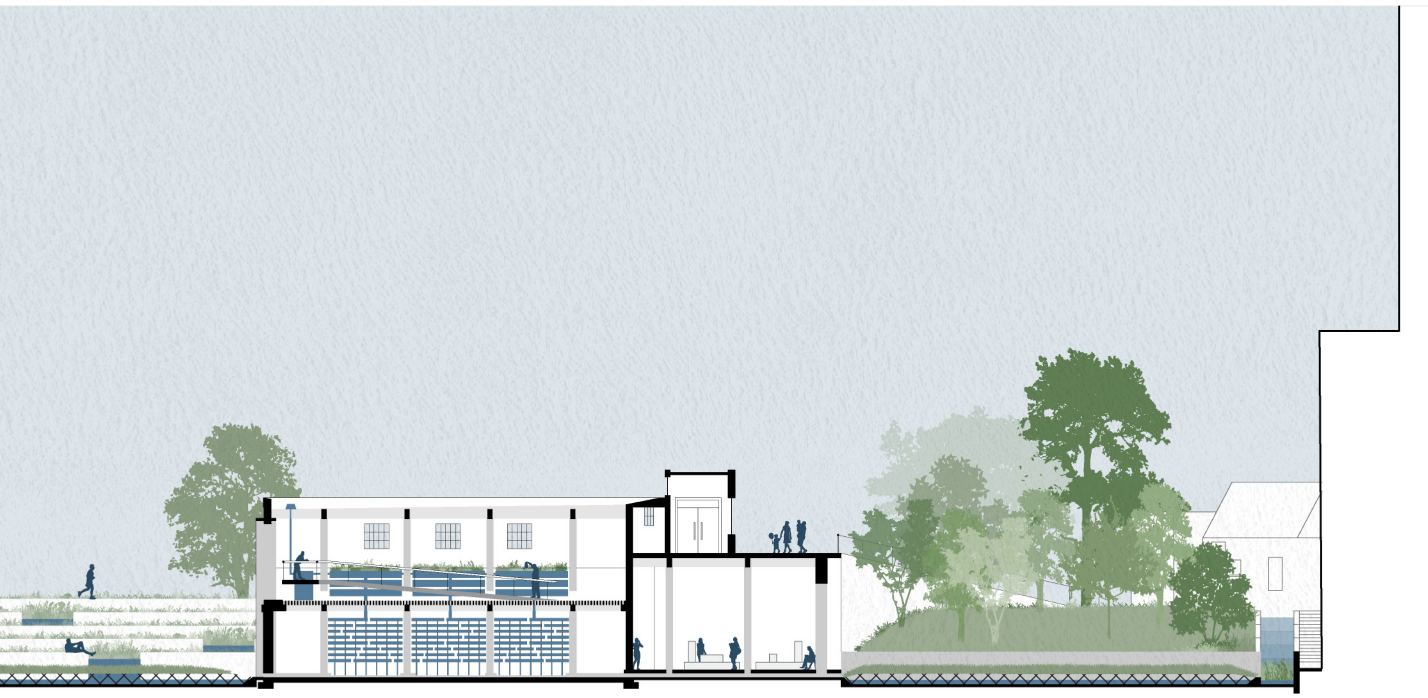
Productive Green Spaces

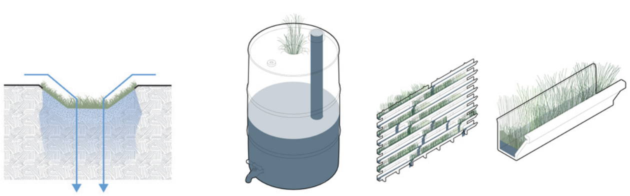


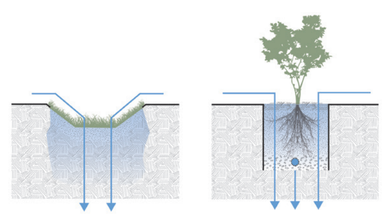
5.47 _ Section Through Greenhouses for Stormwater Planting and Produce

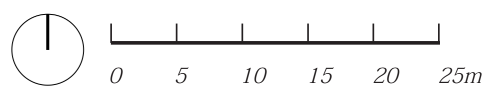
Re purposing the modular industrial salt storage building with a new transparent concave roof system allows for rainwater harvesting for stormwater planting and community gardening on site. Cycling between stormwater planting in the winter and food in the summer provides all year round use. PVC piping hydroponic systems are utilize rainwater combined with supplementary nutrients providing efficient planting growth.

Permeable paving systems situated throughout the surrounding landscape allow stormwater to be gradually introduced back into the local soil top layer. Due to the industrial areas volatile soil chemistry, a series of bio filtration swales with concrete foundations is utilized to prevent further contamination of rainwater as it travels through the terraced system from Wellington Street down to the water square.





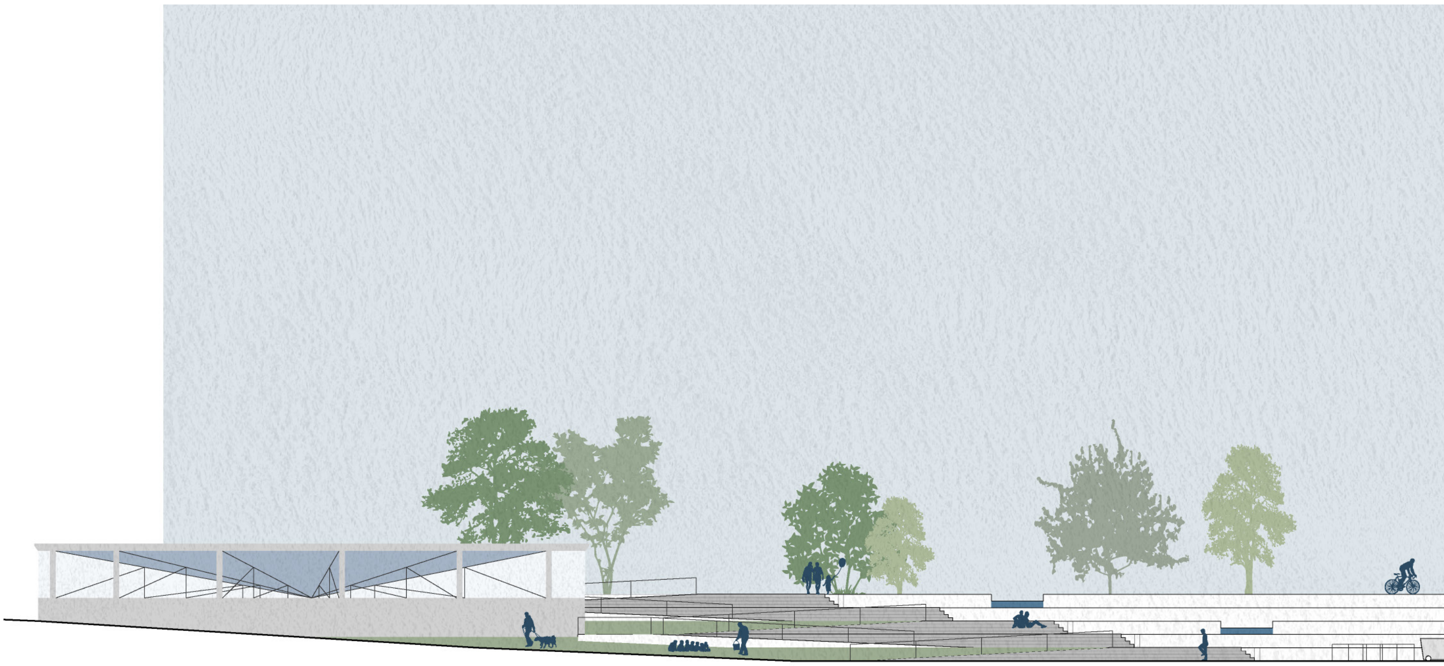




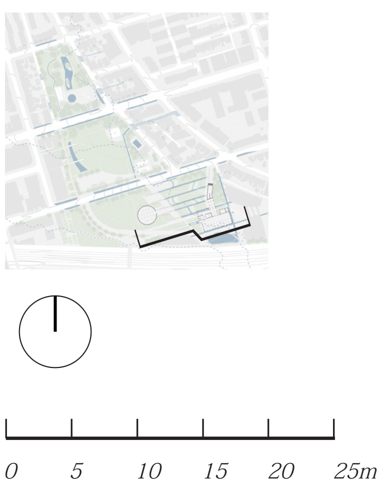
The North tipping floor addition of the incinerator building allows for retrofitting eaves trough planters which utilize rainfall from roof drainage, which is then collected into a rain barrel for irrigating the planting system. The eaves trough green wall provides an entrance moment showcasing visitors the recycled materials as a new form of awareness of stormwater flows and interaction with the sound of water.

The existing dense forest growth abutting the loading ramp to the incinerator building is retained as it holds vast potential for rainfall collection and filtration through existing roots and soil. Leaves provide ample evaporation of rainfall before it touches the ground. To the East, a cascading swale draws rainwater from the nearby laneway and also creates a moment of interaction of moving water as visitors move through the stairwell by the plaza.

2_Open Space Parks



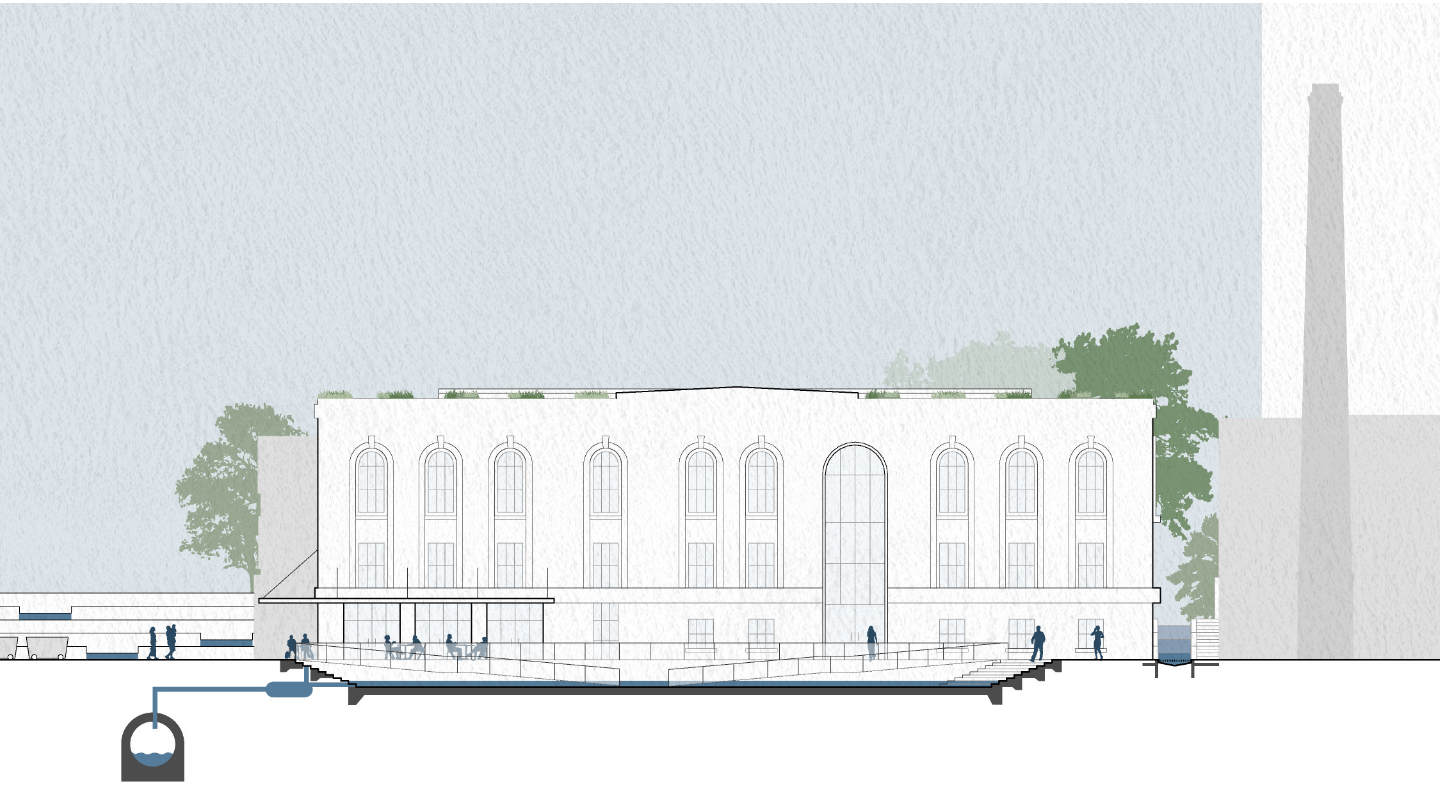
5.48 _ Water Square Section Landscape Zones

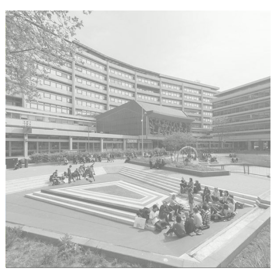


5.49 _ San Martín de la Mar Square Terrace Stairs

5.50 _ University of British Columbia Terraces

Circulation from Wellington Street and parks further North traverse down terraced steps alongside the bio-filtration swales, creating awareness of the filtration processes of stormwater runoff from the streets. Additional green space between each of the levels increases the overall usability of Stanley Park South for seating and relaxation and education.

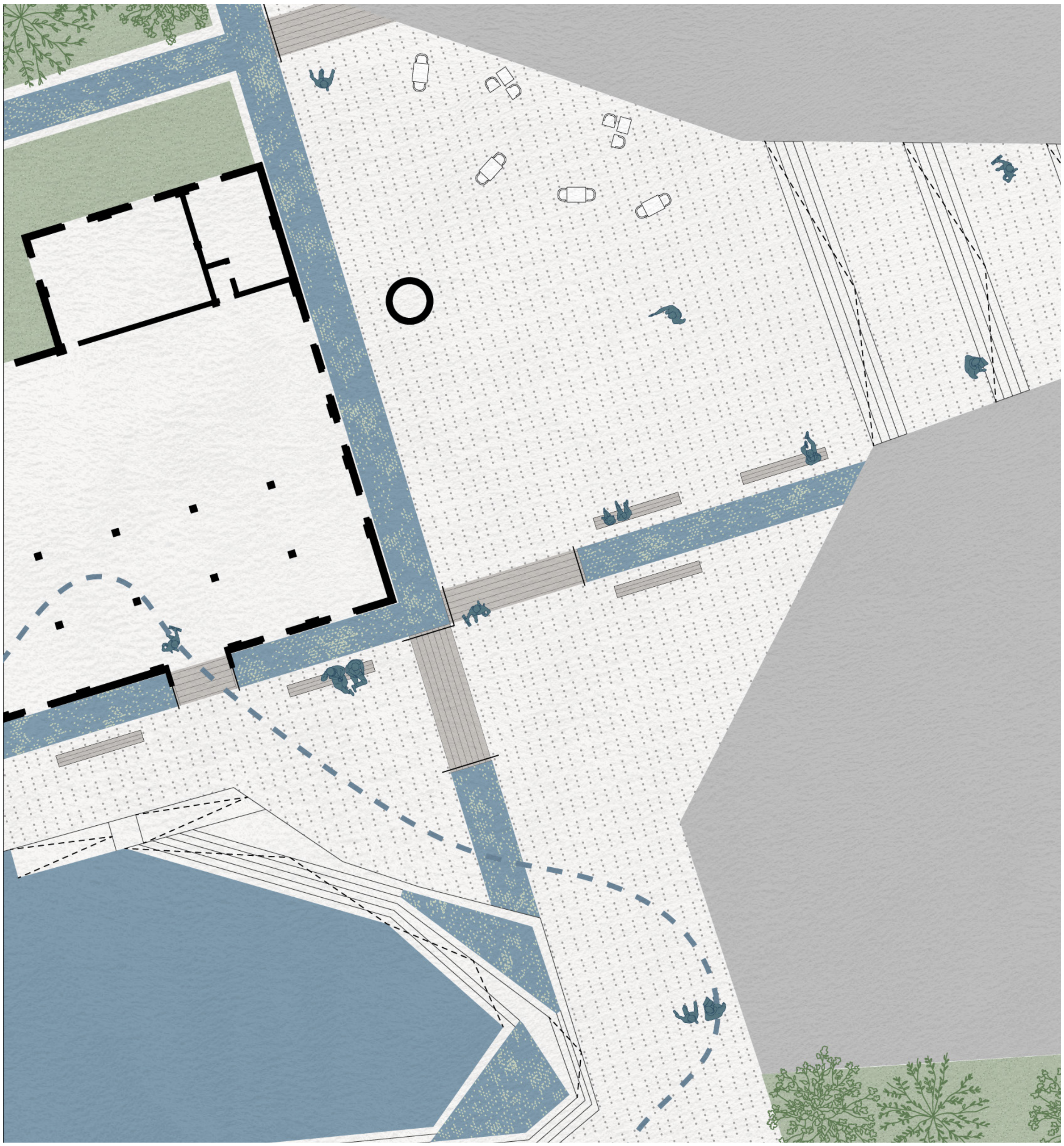




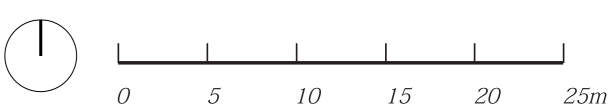
5.51 _ Westergasfabriek Park Stormwater Cafe

5.52 _ Waterplein Benthemplein Water Square

The large depression in the plaza collects stormwater from the proposed mixed use development rooftops, neighboring laneways as well as filtered conveyance from the terraced bio swales. A valve controlled by the heritage building servers responds to future rainfall forecasts as well as wastewater treatment plant flow capacities and adjusts the amount of stormwater to be reintroduced back into the existing combined sewer network. Nearby programs surrounding the plaza include cafe seating and retail spaces in the mixed use development nearby. The basin doubles as a skating rink in the winter months and as a meeting space/outdoor market in the summer.

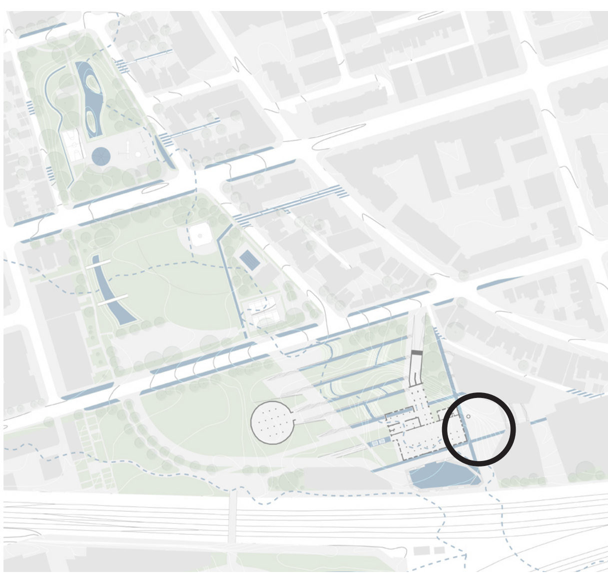


5.53 _ Stanley Park Baseball Diamond Infiltration Basin



5.54 _ Novartis Physic Garden Crossings, Switzerland

5.55 _ Benthemplein Water Channel, Rotterdam

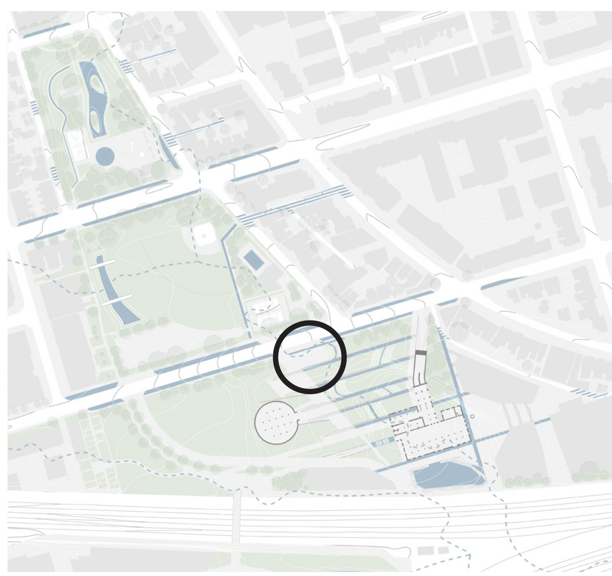


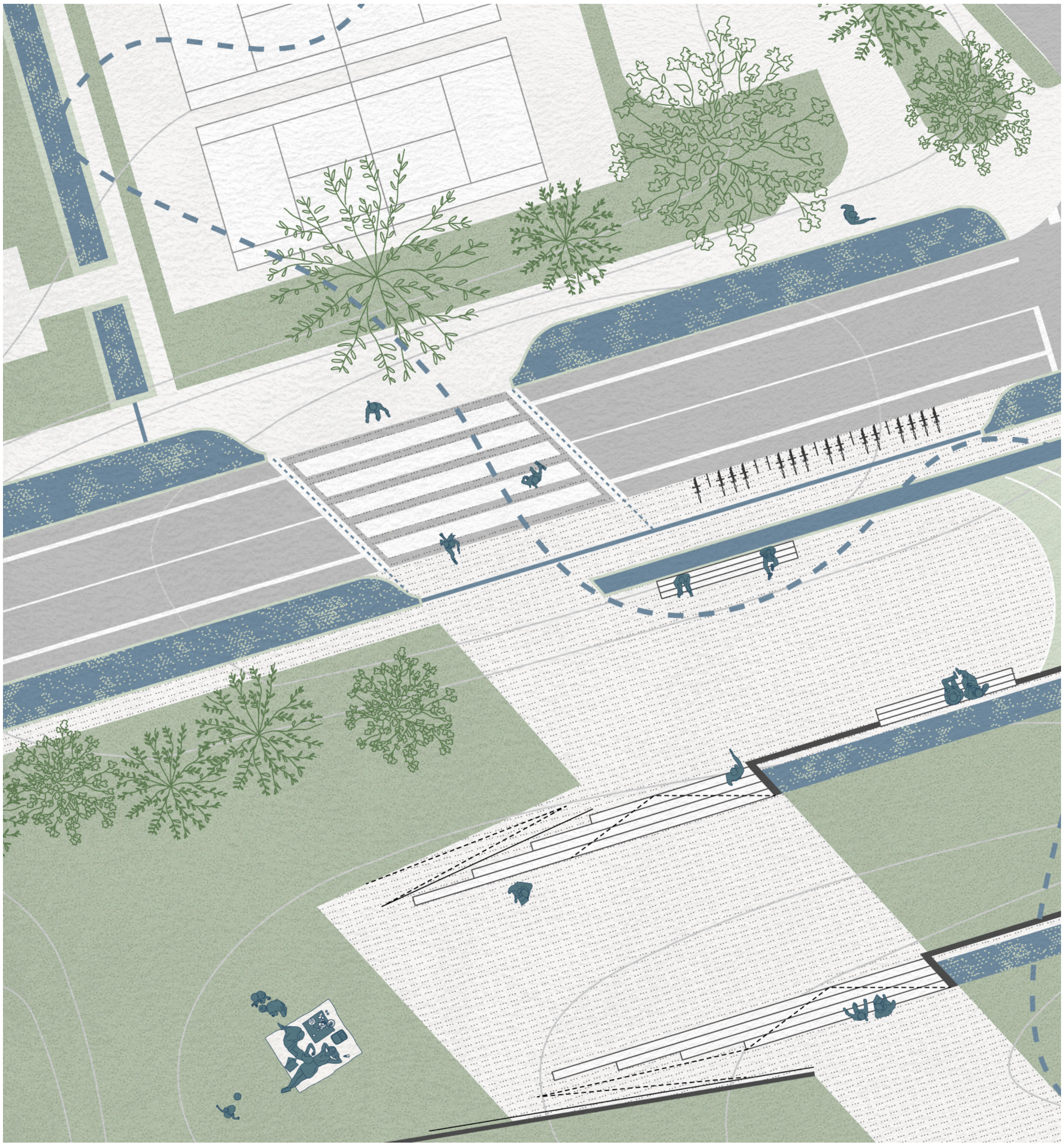
To the East of the heritage building, an extended permeable plaza provides moments for crossing over the bio-filtration swales. Visitors who are sitting down at nearby cafes as well as casual passersby all are exposed to the dynamic processes of stormwater filtration and movement. The dynamic changes in the level of water throughout rainfall patterns and seasons provides seasonal connection to the otherwise flat zone surrounding the retained smokestack. As the system continues to age, further intensification of stormwater planting divides each of the plaza areas into unique zones, creating further variety in the visitor experience.

5.56 _ Stormwater Curb Swale and Tree, Etobicoke

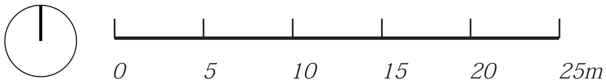
5.57 _ Freightyard Water Retention Plaza, Copenhagen

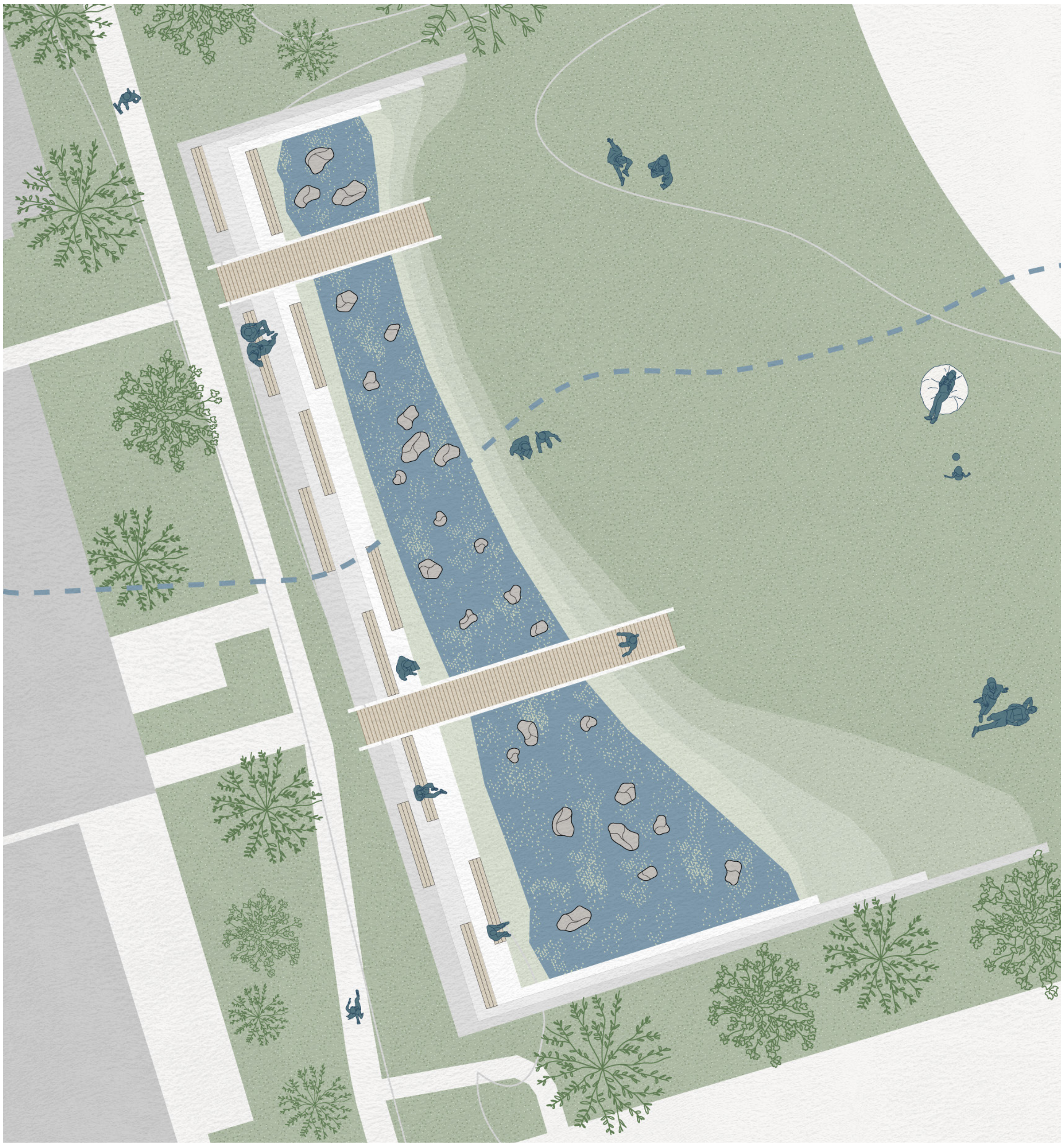
At the street level crossing at the lowest point of Wellington Street West, a new proposed pedestrian crossing links the new park system with the existing pedestrian paths. Additional bike share parking is provided and new stormwater speed bumps allow stormwater to be conveyed across the street system during peak rainfall events. Stormwater is then directed from the stormwater curb extensions and into the first level of the bio swale terrace filtration system. Adjacent to the sidewalk is an extended plaza as a space for meeting or for sitting. Heading directly South affords a direct visual connection the proposed water square plaza to the South,



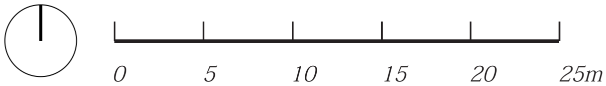


5.58 _ Plaza Crossing Along Wellington Street West



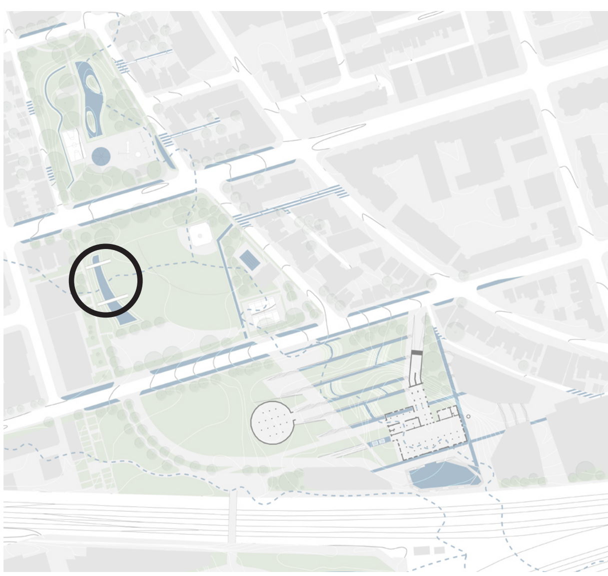


5.59 _ Stanley Park Baseball Diamond Infiltration Basin



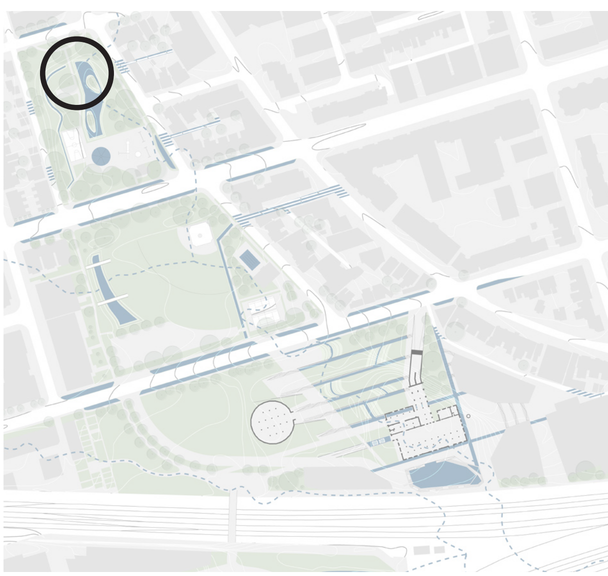
5.60 _ Salem State University Marsh Hall, Massachusetts

5.61 _ Tåsinge Square Infiltration Zone, Copenhagen



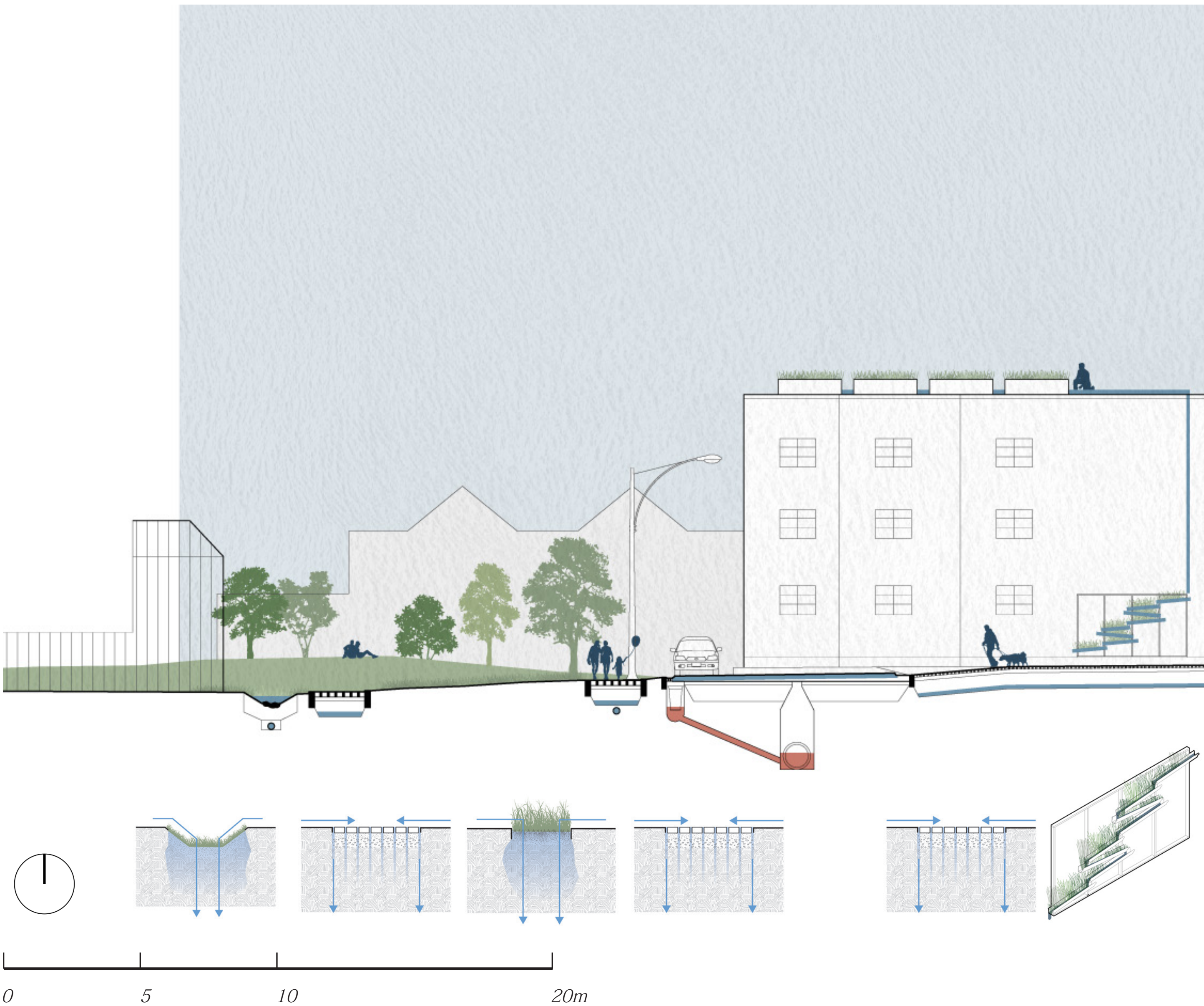
Further North is a proposed high rate infiltration basin which collects stormwater runoff from nearby rooftop mid rise developments as well as excess runoff from the baseball diamond and dog park to the South. Pedestrian bridges link the existing sidewalks over to the baseball diamond to maintain accessibility over the basin. This also provides space for seating towards the baseball diamond to watch the game. Extending the public space from the sidewalk incites further curiosity and awareness of the volumes that stormwater tends to occupy on larger rooftops such as these mid rise buildings.

Public awareness and community involvement can begin to occur once nearby homeowners and visitors incorporate their own applications of decentralized stormwater management through the previously outlined component systems. Connecting to existing park areas provides the potential for further growth and productivity of existing park uses. The park becomes a reflection of the users level of involvement and reflects its results back to the users who use them the most. Synergistic relationships are now able to be realized between the landscape and the complexity of the city fabric. This is capable with the help of the following interventions through laneways and rooftops.



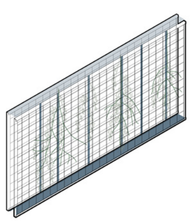
5.62 _ Stanley Park North Stormwater Retrofits to The Existing Undulated Landscape

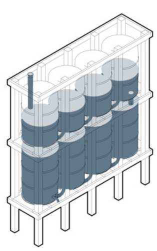
3_Laneways

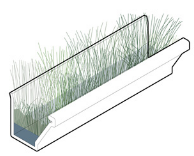


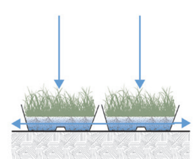
5.63 _ Laneway Conversion Example Showing Park Connection

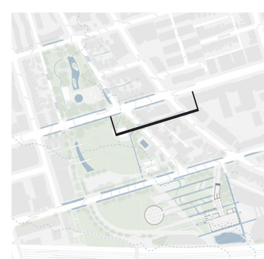
In one year about 1.5 billion liters of rain fall on Toronto laneways. More than 90% of it runs into the sewer system. Permeable laneways could save about .645 million cubic meters of water from spilling into overloaded sewers. Laneways provide a unique opportunity to integrate stormwater management through the surrounding roofs and driveways that









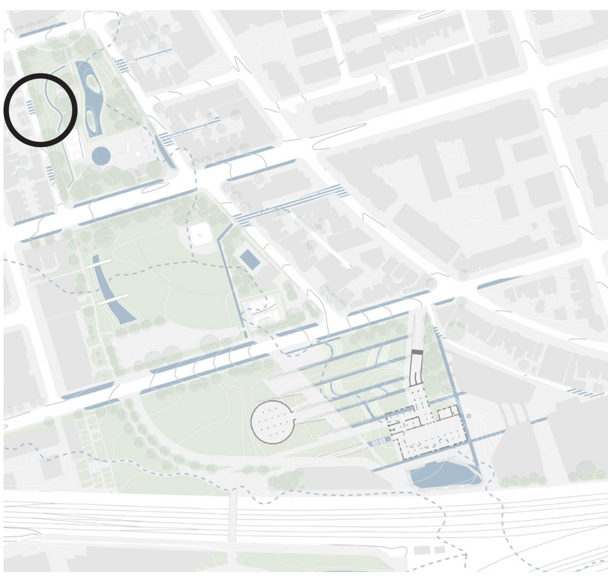


already exist with new community run systems. This can include irrigation for gardening and non-potable water storage for potentially new laneway development. This can be made possible through the abundant and bare vertical walls present in many of the spaces, which can potentially lead to an interconnected vertical filtration system from the roof. A modular downspout allows for individual units to tap into water supply for individual stormwater planting systems such as singular eaves trough planters or PVC hydroponics systems. The resulting additions further expand awareness and education of stormwater. In addition, rooftops can provide space for potential green roof additions.

4_Rooftops

Green roofs build on the three previous components through increasing the catchment capacity of roof runoff. Filtering this overall volume of stormwater through green roofs is the primary step in reducing polluted stormwater from entering sewers. Connected to these systems are previously outlined component systems that can be used to redirect stormwater back to the park across laneways through stormwater speed bumps and modified curb details, thus connecting to the proposed high rate infiltration basins to be further treated and gradually reintroduced back into the ground. All these pieces further grant agency and awareness for each of the homeowners. Within larger buildings, roofs become shared community spaces.

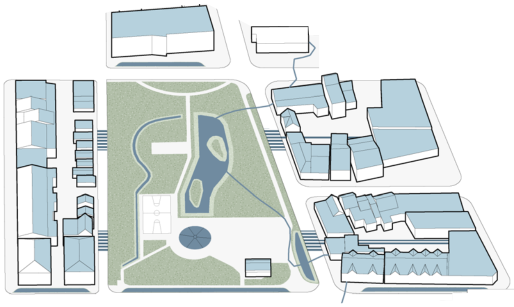
5.64 _ Angled Rooftop Soil Retention System



5.65 _ Repurposed Milk Crates Into Rooftop Planters

5.66 _ Laneway Conversion Example Showing Park Connection

Intervention Capacities

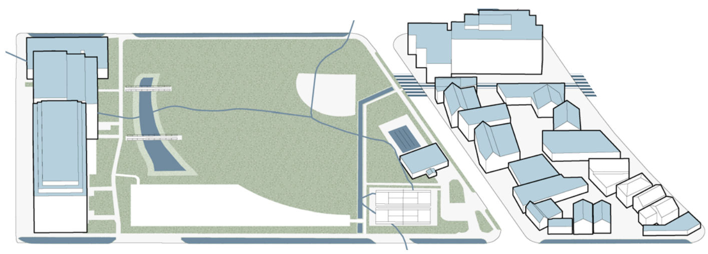


Stanley Park North

8578 sq.m Roof Area

242 m Laneways

2096 sq,m Basins

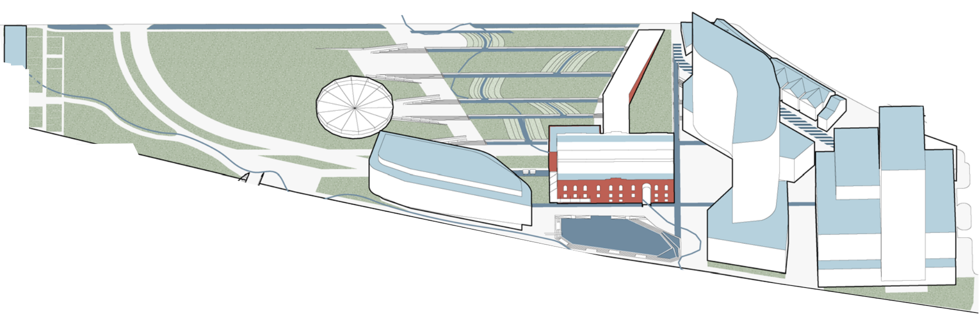


Stanley Park

8405 sq.m Roof Area

164 m Laneways

2427 sq,m Basins



Stanley Park South

14598 sq.m Roof Area

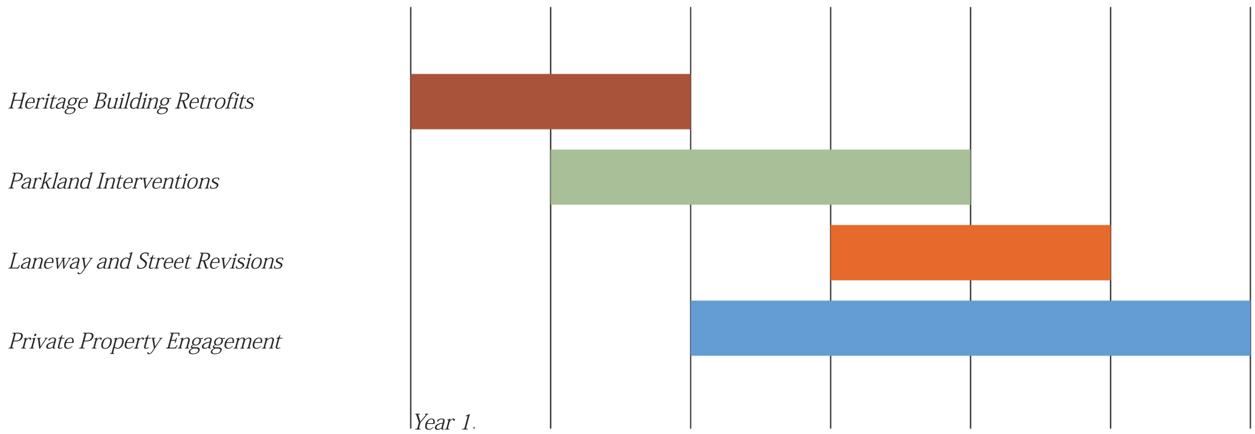
199 m Laneways

4636 sq,m Basins

5.67 _ Stanley Park System Stormwater Intervention Impact

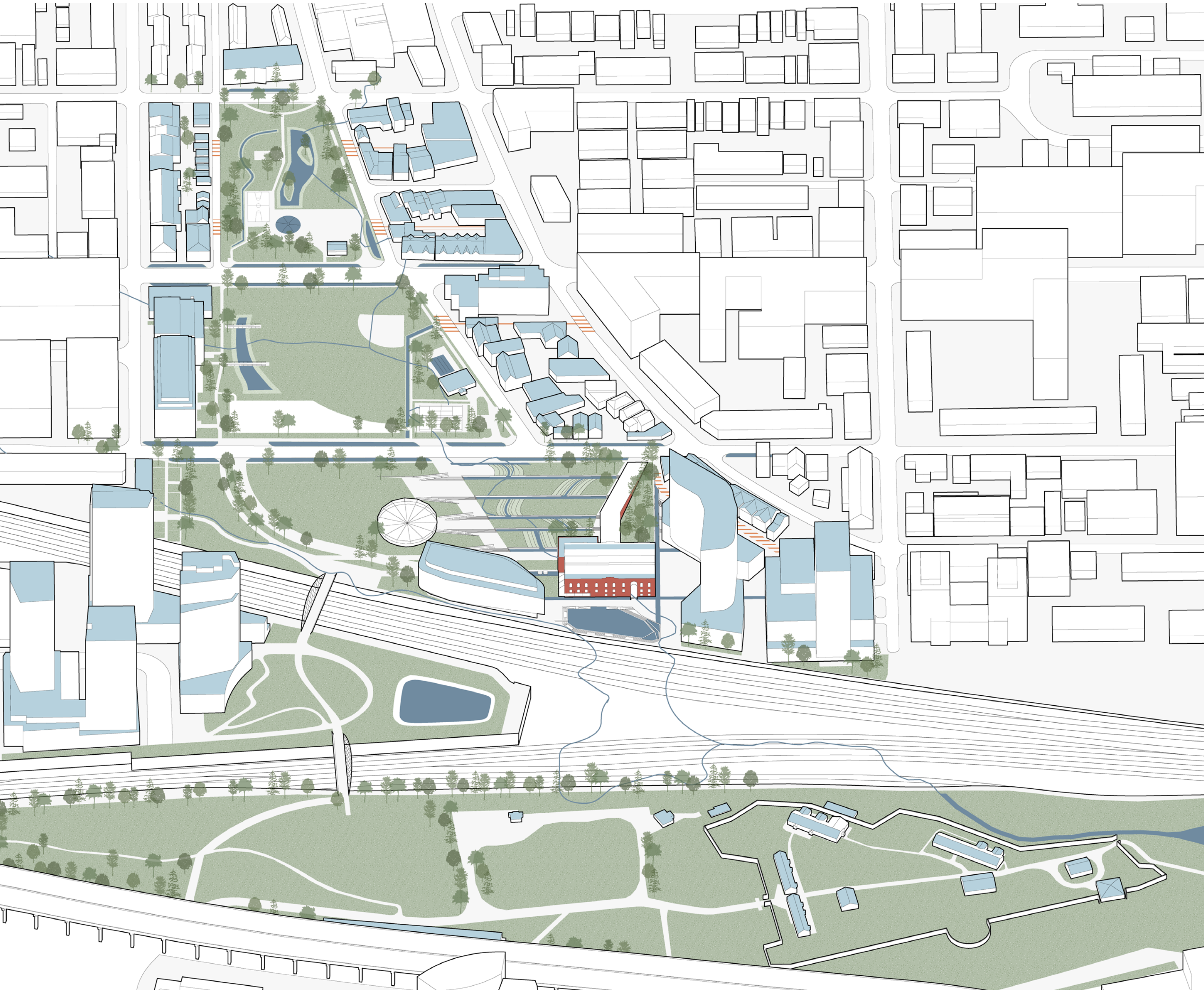
To predict the effectiveness of the intervention, each park has been broken down into three levels of designed stormwater capacity in reference to the 95th percentile rainfall of the 2 151 000 L combined for Stanley Parks. Depending on changing rainfall conditions, the system is adaptable for a variety of levels of stormwater mitigation. From these calculations, a range from 123% up to 492% in runoff reduction could be achieved with the following four frameworks incorporated in the intervention.

Rooftop Capacity +	Laneway Capacity +	Basin Capacity =	Total Capacity
Soil Water Holding Coefficient = 0.5 *1 Milk Crate = 15 L*	*1 Rainbarrel = 200L*	*1 m^2 of Basin x 1m depth = 1000L*	
1 Milk Crate/m^2 = 64 335 L *2 Milk Crates/m^2 = 128 670 L* *4 Milk Crates/m^2 = 257 340 L*	*1 Rainbarrel/m = 48 600 L* *2 Rainbarrels/m = 97 200 L* *4 Rainbarrels/m = 194 400 L*	*1/4 m Avg. Deep Basin = 524 000 L* *1/2 m Avg. Deep Basins = 1 048 000 L* *1 m Avg. Deep Basins = 2 096 000 L*	*Min Design Capacity = 636 935 L* *Med Design Capacity = 1 273 870 L* *Max Design Capacity = 2 547 740 L*
1 Milk Crate/m^2 = 63 038 L *2 Milk Crates/m^2 = 126 075 L* *4 Milk Crates/m^2 = 252 150 L*	*1 Rainbarrel/m = 32 800 L* *2 Rainbarrels/m = 65 600 L* *4 Rainbarrels/m = 131 200 L*	*1/4 m Avg. Deep Basin = 606 750 L* *1/2m Avg. Deep Basins = 1 213 500 L* *1m Avg. Deep Basins = 2 427 000 L*	*Min Design Capacity = 702 588 L* *Med Design Capacity = 1 405 176 L* *Max Design Capacity = 2 810 352 L*
1 Milk Crate/m^2 = 109 485 L *2 Milk Crates/m^2 = 218 970 L* *4 Milk Crates/m^2 = 437 940 L*	*1 Rainbarrel/m = 39 800 L* *2 Rainbarrels/m = 79 600 L* *4 Rainbarrels/m = 159 200 L*	*1/4m Avg. Deep Basin = 1 159 000 L* *1/2m Avg. Deep Basins = 2 318 000 L* *1m Avg. Deep Basins = 4 636 000 L*	*Min Design Capacity = 1 308 285 L* *Med Design Capacity = 2 616 570 L* *Max Design Capacity = 5 233 140 L*
Total Roof Area = 37 050 m^2	*Total Laneway Length = 580 m*	*Total Basin Area = 9159 m^2*	*Total Design Capacity /Total Target Capacity* *= 123 % Min Reduction* *= 246% Med Reduction* *= 492% Max Reduction*



5.68 _ Proposed Project Phasing Timeline

Incorporating the intervention on a timeline basis would allow multiple phases to be carried out , eventually connecting and reinforcing each of the existing systems placed on the site such as the infiltration basins located within the parks (Fig. 5.68). This would reinforce the notion of multiple short term interventions over a period of time rather than one large long-term system like that of the wastewater trunk sewers currently being proposed by the city. While the interventions aren't designed to completely replace the existing centralized sewage systems, they instead highlight the potential benefits of incorporating resilient decentralized stormwater infrastructures back into the city and its users. New relationships with stormwater and individual homeowners can begin to take place through self-constructed rainwater components, and this is further leveraged by proposed parks that can accommodate future growth of storm water volumes. Laneways provide arterial green spaces which further expands the boundary of the park edge, and a re-purposed heritage building continues to fuel the regenerative cycle of ecological infrastructures in the city.



5.69 _ Ecological Infrastructures In Toronto

Conclusion

Frequent extreme weather, rapid urban development, and an overwhelmed city sewage system, calls for action where numerous decentralized stormwater management systems in Toronto can make an impact to revitalize lost watershed landscapes surrounding Lake Ontario. This proposal sheds light on the potential of a new framework for developing both public amenity and community awareness for visitors to the proposed site as well as harness existing creek initiative groups. While the Garrison Creek is not restored to its natural former ecological state, through metaphor, interaction, and intervention, the experience of this creek is reinterpreted back into the city landscape, revealing once again the hidden layers of history to the urban experience.

The proposed four frameworks interconnect with existing leisurely park uses while responding to the need for new productive, resilient and educational decentralized stormwater management systems in the city. Public communication and education of stormwater systems not only can happen with the active participants of the heritage buildings and homeowner interventions, but also towards everyday visitors of the park. Functional park space design with the combination of accessible stormwater management components allows for both public and private properties to begin working cooperatively and efficiently with each other to reduce stormwater runoff and ultimately Lake Ontario water quality. This set of frameworks will not solve the issue of flooding completely, but is an initial step which can become a component of a larger potential overall strategy for fully eliminating combined sewer runoff.

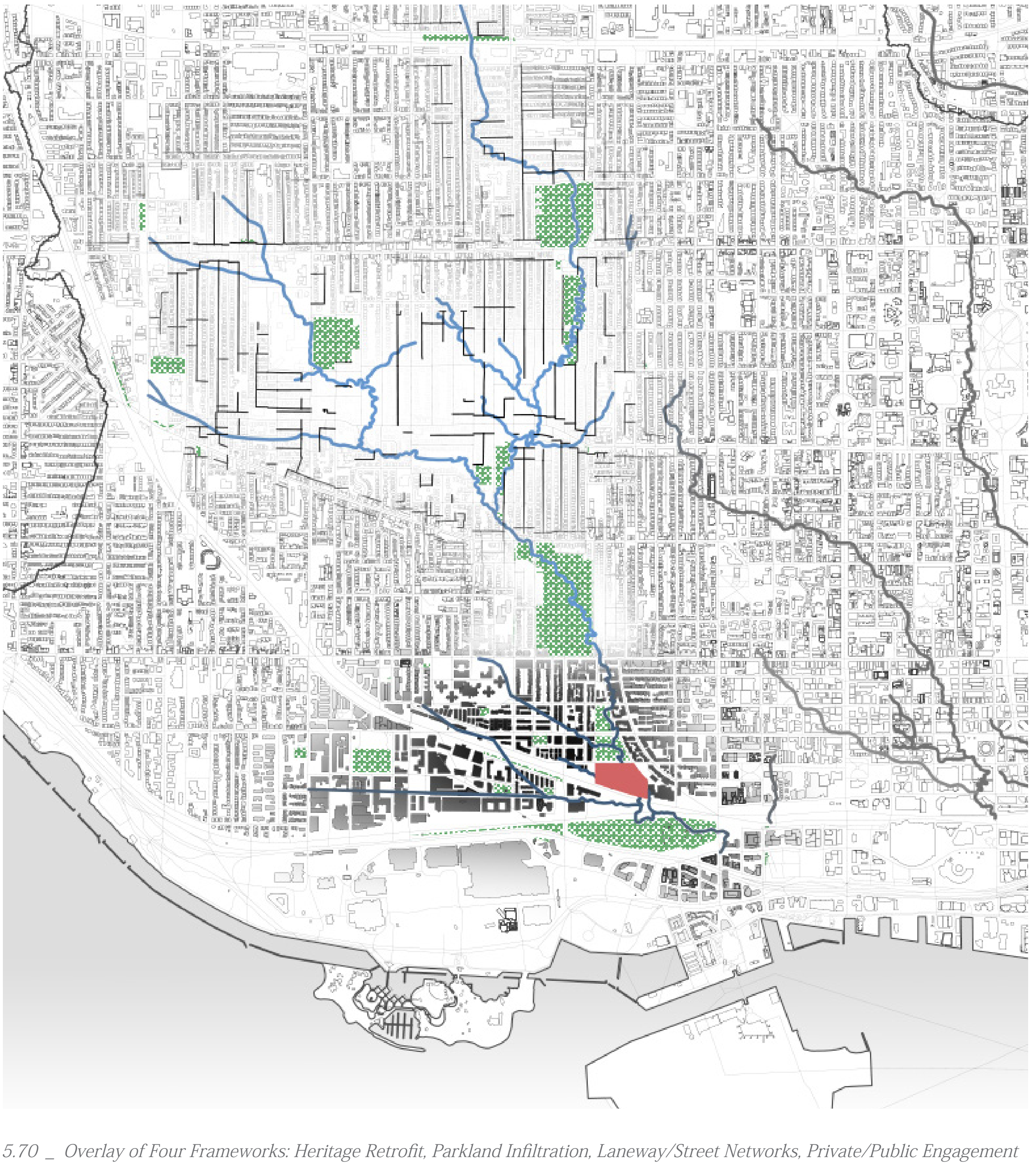
The scalability of the decentralized four frameworks can be applied to the remaining park systems along the Garrison Creek ravine network. The affordable examples illustrated for private property integration for stormwater management are only a select few types of the many various strategies for dealing with stormwater runoff. The 123% to 492% in runoff reduction also only applies to approximately 16% of the overall Garrison Creek watershed, consequently the remainder of the park system would require the same level of design capacity within each of the remaining parks. While this may be advantageous for individual flexibility of applications in each park, this also creates challenges for a consistent design criteria.

Challenges

Additional issues include the willingness for private homeowners to act upon and be involved with this proposed system, even with the inclusion of stormwater incentive fees which reimburse homeowners for participating.

Another potential issue is the requirement for funding larger scale interventions such as the large infiltration basins located within each of the parks and thus the political urge to fund more of these types of projects over sewage pipeline upgrades. Pilot projects such as the heritage building retrofit may be able to provide a better understanding of the advantages over centralized sewer system upgrades, which can further increase the chances of pursuing such an intervention.

Lastly, this thesis primarily focuses on the aspect of stormwater in the city, however flooding is just one of the many different types of issues that need to be addressed



5.70 _ Overlay of Four Frameworks: Heritage Retrofit, Parkland Infiltration, Laneway/Street Networks, Private/Public Engagement

5.71 _ Various Levels of City and Street Infrastructure Redesign within public park spaces along Garrison Creek. Constraints such as City Park budgetary limits as well as a complex and continuously changing landscape like the proposed mixed use development surrounding the incinerator building exemplify this rapid change.

Opportunities

The thesis outlines the use of both interim/temporary design interventions such as the laneway and rooftops of individual properties in combination with capital reconstruction projects within each of the major parks. The inherent flexibility and scalability of such temporary types of interventions may allow for rapid testing and redesigns according to changing rainfall patterns and surrounding homeowner runoff levels. Furthermore, this provides a quick way to test the feasibility of the system before capital reconstruction is planned and completed. Understanding the interim designs functionality can convince city officials to convert these intervention areas into more permanent capital construction projects which are more integrated with Parks, Sewer, and Transportation departments of the city. (Fig. 5.54)

> *"We continue to build into any intervention, but with appropriate adaptability that will allow us to compensate for our ignorance as we are confronted with surprises"* [1]

In light of the addition of communicative stormwater landscapes in the city, this thesis begins to illustrate the potential for park spaces in the city beyond leisurely use with an educational, resilient and responsive stormwater framework for parks in Toronto that can cater to the dynamic growth of the city with equally diverse uses.

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1 Wendell Berry, Home Economics (Toronto [u.a.]: New Whole Earth LLC, 1986), 2.

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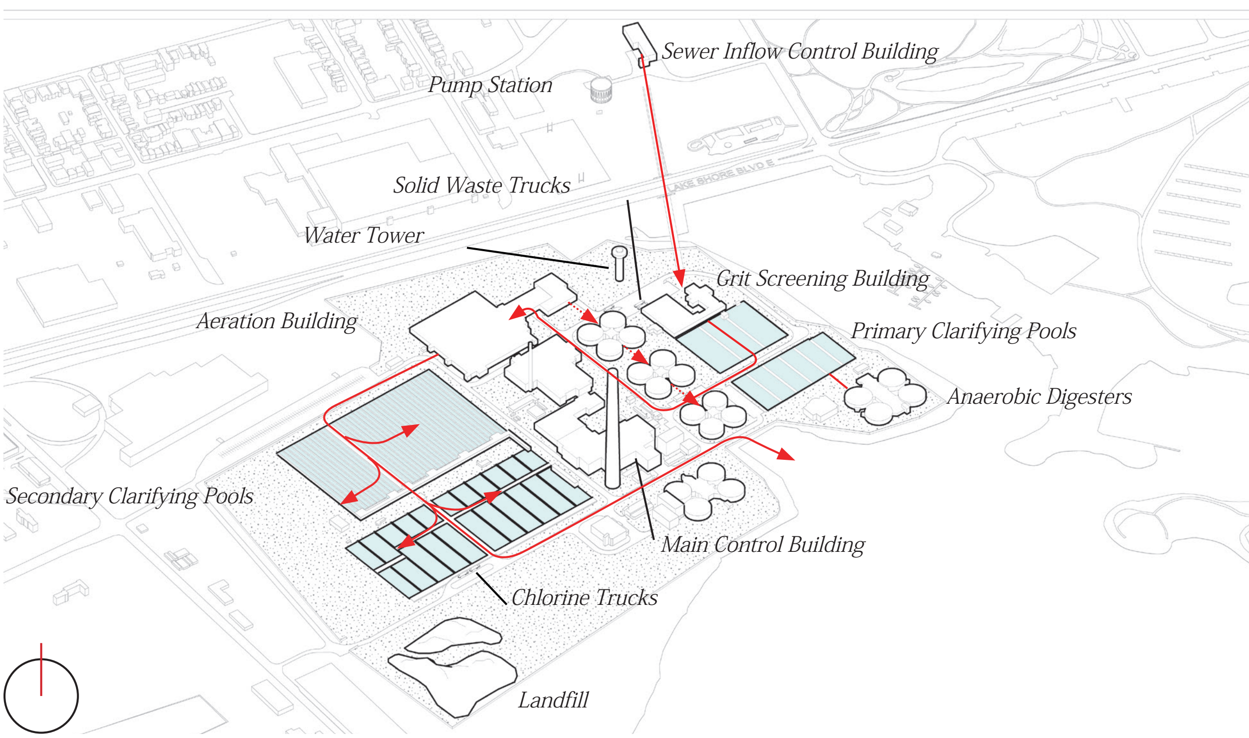
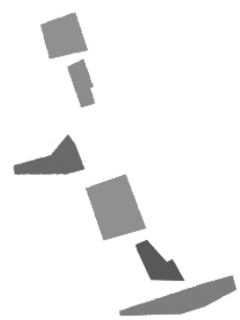
Appendix

Additional information regarding storm water treatment plants, site analysis and calculations for decentralized stormwater management methodologies found in the design proposal.



5.72 _ Ashbridges Bay Wastewater Treatment Flow Diagram
Image by Author. Data Source: City of Toronto

Christie Pits Park	*40 %*
Bickford Park	*41%*
George Ben Park	*56 %*
Trinity Bellwoods Park	*40%*
Stanley Park	*63 %*
Fort York Historic Site	*47 %*



5.73 _ Permeability Mapping of Downtown Toronto and Average Impermeability Surrounding Each Park Along Garrison Creek
Image by Author. Data Source: City of Toronto

TABLE 7–10 Runoff Coefficients for the Rational Method

Description of Area	Range of Runoff Coefficients	Recommended Value*
Business		
Downtown	0.70–0.95	0.85
Neighborhood	0.50–0.70	0.60
Residential		
Single-family	0.30–0.50	0.40
Multiunits, detached	0.40–0.60	0.50
Multiunits, attached	0.60–0.75	0.70
Residential (suburban)	0.25–0.40	0.35
Apartment	0.50–0.70	0.60
Industrial		
Light	0.50–0.80	0.65
Heavy	0.60–0.90	0.75
Parks, cemeteries	0.10–0.25	0.20
Playgrounds	0.20–0.35	0.30
Railroad yard	0.20–0.35	0.30
Unimproved	0.10–0.30	0.20

It is often desirable to develop a composite runoff coefficient based on the percentage of different types of surface in the drainage area. This procedure often is applied to typical "sample" block as a guide to selection of reasonable values of the coefficient for an entire area. Coefficients with respect to surface type currently in use are listed below.

Character of Surface	Range of Runoff Coefficients	Recommended Value*
Pavement		
Asphaltic and Concrete	0.70–0.95	0.85
Brick	0.75–0.85	0.80
Roofs	0.75–0.95	0.85
Lawns, sandy soil		
Flat, 2%	0.05–0.10	0.08
Average, 2 to 7%	0.10–0.15	0.13
Steep, 7%	0.15–0.20	0.18
Lawns, heavy soil		
Flat, 2%	0.13–0.17	0.15
Average, 2 to 7%	0.18–0.22	0.20
Steep, 7%	0.25–0.35	0.30

The coefficients in these two tabulations are applicable for storms of 5- to 10-year frequencies. Less frequent, higher intensity storms will require the use of higher coefficients because infiltration and other losses have a proportionally smaller effect on runoff. The coefficients are based on the assumption that the design storm does not occur when the ground surface is frozen.

*Recommended value not included in original source.

5.74 _ Runoff Coefficients for The Rational Method