

**Urban Waterscapes:
Water as Social Infrastructure in Vancouver, BC**

by

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ABSTRACT

Vancouver, BC is a rainy city surrounded by water. Climate change analysis predicts the city will begin to experience more frequent and intense rain as well as rising sea levels. If intensities increase, existing systems may lack the capacity to provide the necessary level of flood protection and drainage. Like most cities, infrastructure currently in place consists of embedded systems networked across a vast scale, which leave little room for interaction.

This increasing saturation is an opportunity to rethink Vancouver's relationship with water: instead of rain being an inconvenience, it could be possible for the city to celebrate water and come to life when it rains.

This thesis seeks to explore how a new water infrastructure could encompass the localized scale. To not only manage and distribute water, but to strengthen communities, connect urban conditions and create a stimulus that reflects the cultural and geographical identity of the city.

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Thank you to my parents, who have always worked so hard to offer me every opportunity: to you I owe every success.

Max, thank you.

CHAPTER 1: INTRODUCTION

Water and The World

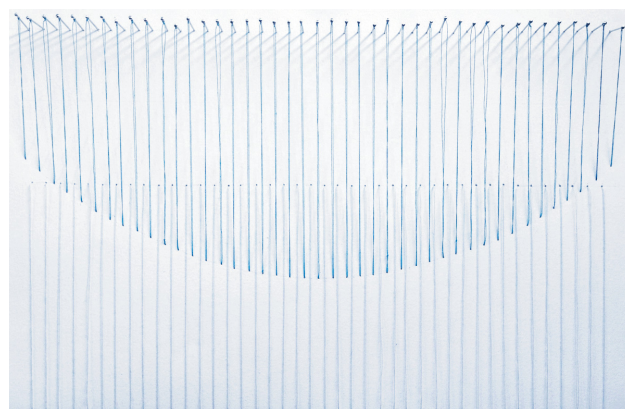
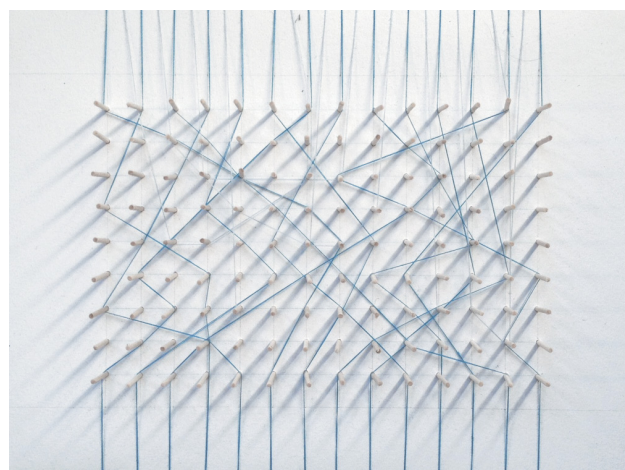
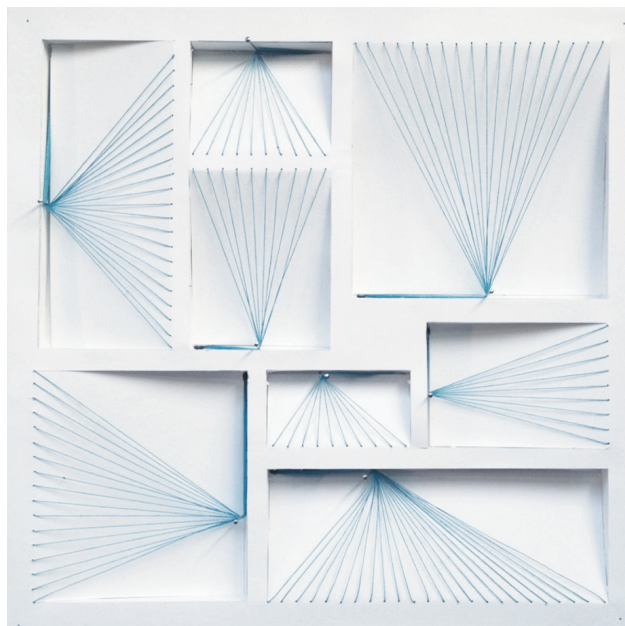
Due to a growing population, increasing urbanization, and industrial agriculture supplying much of the world's food, we are beginning to feel the effects of climate change, and the Earth is now left unable to replenish its water supplies as quickly as they are being used. As stated in the *Human Development Report of 2006*, "The symptoms of overuse are disturbingly clear: rivers are drying up, groundwater tables are falling and water-based ecosystems are being rapidly degraded."¹

Officially, freshwater is a renewable resource. Water evaporates from the surface of the oceans and land to feed the clouds, from clouds fall rain, rain feeds the rivers and streams, which enter lakes and estuaries before running back to the sea to begin the cycle again.² Today, however, this great cycle of water's transformations has been interrupted by the impermeable surfaces of the city, including transportation infrastructure, rooftops, and large scale manipulations, namely agri-



Edward Burtynsky, "Colorado River Delta #2," 2011; from Edward Burtynsky (website), documenting the Colorado River, which now dries up completely in the sands of its delta.

- 1 Kevin Watkins, "HDR 2006 Report Power Poverty and the World Water Crisis," (2006), vi, <http://hdr.undp.org/sites/default/files/reports/267/hdr06-complete.pdf>.
- 2 Richard Forman and Michel Godron, *Landscape Ecology* (New York: John Wiley & Sons, 1986), 45.



Study models of the water cycle: intake from city streets, wetlands, and brackish water

cultural uses that rely on non-sustainable methods of irrigation. In recent times, the concept of peak water has been presented to help understand the growing constraints on the availability, quality, and use of freshwater resources.³

However, climate change doesn't only mean too little water. For some areas, such as the coastal city of Vancouver, B.C., predictions include rising sea levels and increasing precipitation levels and intensities. In addition, over recent decades, urban landscapes have become increasingly susceptible to flooding and with the predicted future climatic extremes, this is likely to increase. Although we cannot reverse the effects of urban form, it is possible to imagine that this increasing saturation could offer an opportunity to rethink the relationship between cities and water. There are many examples of cultures and cities which embrace their watery nature and celebrate water as an essential, life-sustaining resource.



Urban flooding in Vancouver, BC; from VanCityBuzz, "Metro Vancouver Wind and Rain Storm Causes Havoc, Flooding," 2013.

3 Laura Allen and Mark Smout, "Augmented Landscapes and Delicate Machinery," *Architectural Design* 83, no. 5 (2013): 88.

Water and Community

The Greek philosopher Thales of Miletos taught, “Water is everything,”⁴ Water makes up about two thirds of our bodies; it is a primary biological necessity and without it we are unable to live. Three quarters of the planet we live in is also made up of water, in the form of rivers, lakes, oceans, creeks and streams.⁵ Probably because of our human need for water, it has a history of bringing people together. It is storied in spiritual traditions throughout the world, and has ritual significance in many religions. A great example of this is India’s holy river Ganges.

India: The Ganges River

The Ganges is a sacred river to Hindus along every inch of its course. They bathe along its length, and consider its water to be pure and purifying. Two major celebrations of its waters are the the Ganga Dashahara, which each years brings crowds of bathers to the banks of the river, and the Kumbh Mela, a mass Hindu pilgrimage of faith in which Hindus gather to bathe in a sacred river. This takes place



John Stanmeyer, “Sacred Water,” 2009, from Stanmeyer (website), showing the Ganga Dashahara.

4 John Knechtel, *Water: Alphabet City Magazine 14* (Cambridge: MIT Press, 2009), 25.

5 *Ibid.*, 85.



Manish Swarup, “Bridge Crossings,” 2013, from *National Geographic Daily News* (website), showing the Kumbh Mela on the Ganges.

every three years at one of four rivers, including the Ganges.

The significant connection between humans and water described suggests the potential for a more profound infrastructure in our cities, which takes this relationship into consideration and integrates both social and practical requirements.

Water and Urban Infrastructure

[The contemporary city has] a tendency to loosen the bonds that connect its inhabitants with nature and to transform, eliminate, or replace its earth-bound aspects, covering the natural site with an artificial environment that enhances the dominance of man and encourages an illusion of complete independence from nature.⁶

Infrastructure as we understand it today is a product of the industrial era. Prior to the 20th century, there were few cities that exceeded 50,000 inhabitants.⁷ This allowed cities to fit into their surrounding environments more easily. However,

6 Andrew Karvonen, *Politics of Urban Runoff: Nature, Technology, and the Sustainable City*, (Cambridge: MIT Press, 2011), 1.

7 Michael Neuman and Sheri Smith, “City Planning and Infrastructure: Once and Future Partners,” *Journal of Planning History* 9, no. 1 (2010): 23.

when the 19th century ‘organic city’ gave way to the ‘rational city’ of the 20th century, populations grew quickly, and vast numbers of people relocated to urban centres. Perhaps inevitably, this brought with it problems regarding public health and living conditions: housing was overcrowded and health was poor due to the lack of sanitation, ventilation and open space. Urban centres began to exceed the capacity of the natural ecosystems to support it.⁸

In this stems the foundation of large technical systems for water, sewage, transport, communication and electricity services.⁹ In terms of water and sewage, these systems were built to prevent cholera and other water-borne diseases and created sanitary conditions that improved the health of urban residents. Sewage and storm water were treated together, and the logic of their engineering was to get water away from roads and buildings as quickly as possible, which is why roofs and streets are made from impermeable material, directing surface runoff into drains and back to the nearest waterways. Arguably, this also caused a rift in our relationship with nature, which still exists today. Cities began to be understood as the antithesis of nature: something entirely human-created, rational, and permanent.

However, it is now coming to light that these highly engineered systems are not serving us that well anymore. From *Politics of Urban Runoff*:

Rain produces a particular mood in cities - shiny surfaces and spotted windows, puddles with oil rainbows, flowing water in gutters, rushing creeks- but it is also the cause of serious and confounding problems including flooding, erosion, landslides and water pollution.¹⁰

In a paved, impermeable city, there is nowhere for water to infiltrate the ground and when sewers and storm drains can’t manage the amount of water entering them, urban flooding occurs. Because of aging infrastructures and rising precipitation levels and intensities, this is becoming a more common occurrence. Impermeability also means water picks up the surface of our cities streets, including; agricultural chemicals, sewage, oil from cars, and trash and is put back into our oceans and lakes.

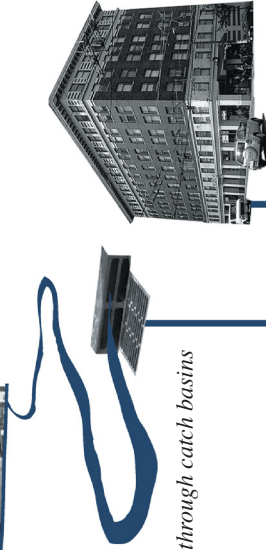
8 Ibid., 23.

9 Karvonen, *Politics of Urban Runoff: Nature, Technology, and the Sustainable City*, 1.

10 Ibid., vii.



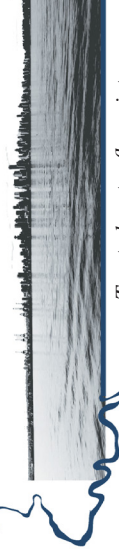
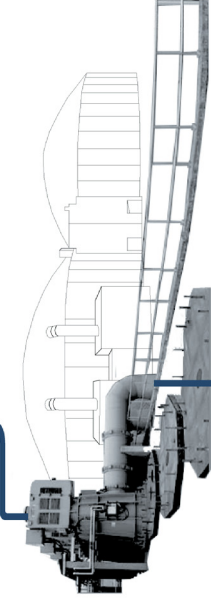
Rain falls on city streets



Rain is channeled through catch basins

Sewer pipes carry water and sewage

Water is treated outside the city at a sewage treatment plant



Treated water flows into ocean.

Urban water cycle: combined sewer system



Unfiltered oil and garbage running into storm drain.

There are, however, examples of cities and communities with more compelling water systems, both modern and historical. Three examples that I studied were canals and cisterns in Venice, Italy; the *bächle* of Freiburg, Germany and the Acadian dykelands of Nova Scotia, Canada.

Venice, Italy: Canals and Wells

Venice is an example of a city designed for water. It is changed almost hourly by the tides, which reveal and conceal the city. It is known for its canals: carefully planned urban environments that form a network of public spaces within the city. The surrounding architecture was designed to be seen from within and in relation to the water.¹¹

Historically, surrounded by the lagoon, Venice was always in need of fresh water for drinking. The solution was thousands of rainwater cisterns, also known as *pozzos*, below the pavement of public squares and courtyards. The cisterns were made possible by a combination of sand and clay.¹² Clay kept the salt water out,

11 Daniel Savoy, *Venice From the Water* (New Haven: Yale University Press, 2012), 112.

12 "Supply of Water to Cities.-The cisterns of Venice," *Journal of the Franklin Institute* 75, no. 6 (June 1863): 364.



Venice as a system: bird's eye view looking North with visible canals; from Bing Maps.

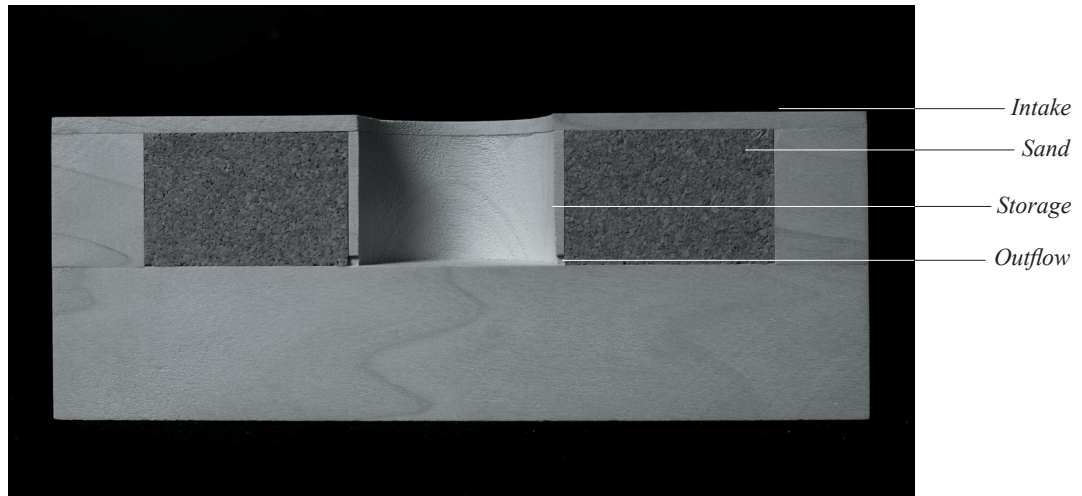


A Venetian *pozzo* and three visible drains; from Pries, “Drip | Dry: Systems that Seep.”

and sand filtered the rainwater and obviated the need for a structural system below. The surfaces encircling the cistern were sloping; when it rained, water from the surrounding ground and roofs would run towards one of the four drains which surrounded the cistern.¹³ The rainwater would then filter through the layers of sand and gravel and into the base of the well where it would be stored until it was pumped up by residents for use. The water was shared by residents and used as needed. The

¹³ Ibid., 365.

wells, as they are often called, are an example of simple adaptation that became an integral part of the city's fabric: "these cisterns present a remarkable example of the highest ingenuity, and skilful adaptation by the self-taught engineers of the middle ages, of materials the very simplest and cheapest, combined to attain with perfection the end desired."¹⁴ Essentially, Venice became a city of fresh water aquifers sitting in a salt water lagoon; a balance between city and water, both fresh and salt. Many *pozzos* still exist today.



Sectional study model of a pozzo.

Freiburg, Germany: Bächle

Bächle are small water filled runnels seen along most streets and alleyways in the old city of Freiburg. They bring water from the Dreisam river, and were once the city's water supply. The Bächle fed water to the city's fountains, similar to the system in Rome, and after running through the streets their water was used to irrigate fields. Today, although no longer the city's main water source, they are something unique to the city. The Bächle tell a story about the city's past and connect it back to its natural surroundings. They also function as a impromptu public space, to sit around and dip your feet in, play in and sometimes eat dinner over.

Nova Scotia, Canada: Acadian Dykelands

Dykelands are coastal salt marshes which have been drained and dyked to create productive agricultural land; Acadian settlers were the first to practice this

¹⁴ Ibid., 363.



Informal usage over Freiburg's Bächle for eating and play; from Loux, "The Bächle of Freiburg."

landforming in Nova Scotia. Before the arrival of the first Acadian settlers, the Bay of Fundy's low-lying, muddy, tidal flats flooded twice daily.¹⁵ Farmers built dykes, known as *aboiteaux*, to deal with the movement of the tides so they could make use of the fertile soil. It is often noted that most Acadian dyking projects were community undertakings, and guided collective work for the benefit of all.

Earthen dykes were first constructed to stop high tides from flooding marshlands.¹⁶ A sluice (a wooden waterway) was then built into the dyke with a hinged gate, which opened and closed with the ebb and flow of the tide.¹⁷ The gate allowed fresh water to drain from the farmland, but swung shut at high tide to prevent salt water from inundating the fields. The water pressure of high tides would hold the door closed.

The precedents above are examples of infrastructural elements and systems that were designed unique to a place. Each offers a lesson in water management that

15 J Sherman Bleakney, *Sods, Soil, and Spades: The Acadians at Grand Pré and Their Dykeland Legacy* (Montreal: McGill-Queen's University Press, 2004), 9.

16 *Ibid.*, 63.

17 *Ibid.*, 52.

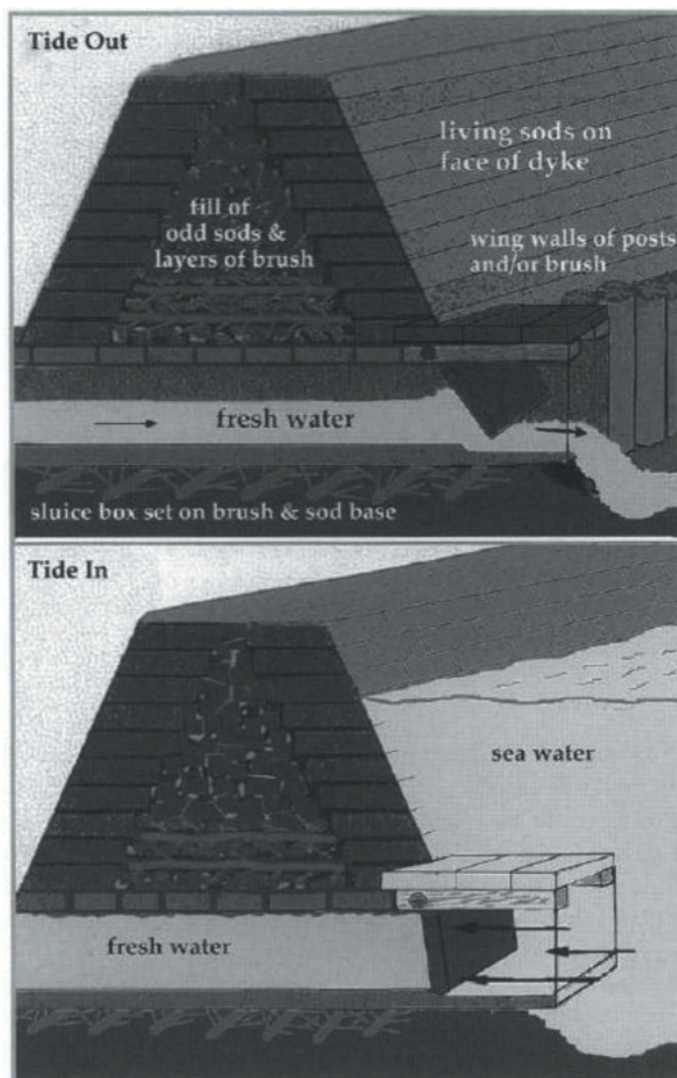


Diagram of a sluice-gate; from Bleakney, *Sods, Soil and Spades: The Acadians at Grand Pré and Their Dykeland Legacy*, 52.

was specific to the landscape it was for. This is in contrast to the systems existing in modern cities today, which, except for size, are unchanging from city to city regardless of landscape, culture or climate.

Infrastructural Landscapes

It is not sufficient to understand either the processes of the social system or the processes of the natural system alone. Both mold the city's physical environment, which forms the common ground between them.¹⁸

- Anne Whiston Spirn

Simply put, the infrastructure currently in place in Vancouver and other cities isn't serving us so well anymore. They are simply corridors for transit, whether it be storm lines, sewage lines or city streets; technical requirements are met, but the pieces are unchanging in section without any engagement with the surrounding environment. From "Landscapes of Infrastructure:"

These ubiquitous urban environments have been considered and evaluated solely on technical criteria and somehow exempted from having to function socially, aesthetically, or ecologically.¹⁹

As discussed earlier, due to age, climate change and increasing populations, updates will soon be inevitable. This, alongside the imperative nature of infrastructure, offers a unique opportunity. Instead of mundane, concealed backdrops, these urban frameworks could have a role as part of the inhabited city that take into account the importance of place and natural systems. They could become productive public space that function ecologically by engaging with the underlying landscapes of the city: the topography, climate, rivers and harbours, which once played the role of the city's 'infrastructure.' This could be especially interesting in a city like Vancouver, BC, a place that's natural surroundings are its key defining features.

An example of a city with an infrastructural element that acts as an ecological public space, is Seoul, South Korea.

Cheonggyecheon: Seoul, South Korea

Cheonggyecheon is a stream that flowed in Seoul, South Korea before being covered by transportation infrastructure during the rapid post-war economic

18 Karvonen, *Politics of Urban Runoff: Nature, Technology, and the Sustainable City*, 17.

19 Elizabeth Mossop, "Landscapes of Infrastructure," in *The Landscape Urbanism Reader*, ed. Charles Waldheim (Princeton: Princeton University Press, 2006), 171.



The Cheonggyecheon: Views down the stream and pedestrian paths; from Keun Lee, “Cheong Gye Cheon Restoration Project: a revolution in Seoul,” *ICLEI World Congress* (website.)

development.²⁰ In 2005 it was restored and opened as a public recreation space. It brought with it clean water and natural habitat to Seoul’s downtown. The stream has become a central hub, with many pedestrians visiting its banks on an average day. It also has substantially cut air pollution from cars and reduced air temperatures in the surrounding area.²¹ This project is a great example of how a civic infrastructure could incorporate the public realm by making its’ function visible and including pedestrian paths, moments of interaction (like the steps over Cheonggyecheon), green space, and room for improvisation. However, it isn’t a particularly great example of a productive infrastructure: almost all of the Cheonggyecheon’s water is pumped there through miles of pipes. At a time of when cities are redefining their relationships with infrastructure and nature, it would be a more beneficial study to design a system that would function within both realms.

20 Keun Lee, “Cheong Gye Cheon Restoration Project: a revolution in Seoul,” *ICLEI World Congress 2006: For Cities and Local Governments* (Cape Town, 2006), 8, http://worldcongress2006.iclei.org/uploads/media/K_LEEInKeun_Seoul_-_River_Project.pdf.

21 *Ibid.*, 52.

Critical Position

This project aims to provide a model for a visible storm water infrastructure within the city of Vancouver. The intention is to not only deal with increasing flows of water brought along by climate change, but to encourage water use along the system's path. At the human scale, this thesis takes the position that water infrastructure must be visible to the public in order to educate and strengthen their relationship with water, climate, and nature. At the built scale, this thesis seeks to integrate water flows, filtration, and use into part of the city's fabric. Finally, at the city/landscape scale, this thesis takes the position that landscape, infrastructure and urban processes are inseparable and, consequently, it is not sufficient to understand any of these systems alone. Infrastructure is the connection of elements to one another that is the foundation of urban life; we must consider what is both in and around our cities in order to successfully design it.

Thesis Question

How could a new storm water infrastructure in Vancouver, BC work to encompass the community scale while still existing as a functional piece of the larger city system?

Water and Vancouver

Vancouver, B.C. is a rainy city that is surrounded by water. It is part of the Pacific Northwest, a place whose regional identity is almost wholly linked to its natural setting, with water at its heart. As stated in *Politics of Urban Runoff* about this region, “water here is an abiding, if not always appreciated presence; fog and rain, glacier and waterfall, irrigation canal and tidal estuary, river and pacific ocean.”²² Vancouver itself is located near the mouth of the Fraser River, and on the waterways of the Strait of Georgia, Howe Sound, Burrard Inlet and their tributaries.

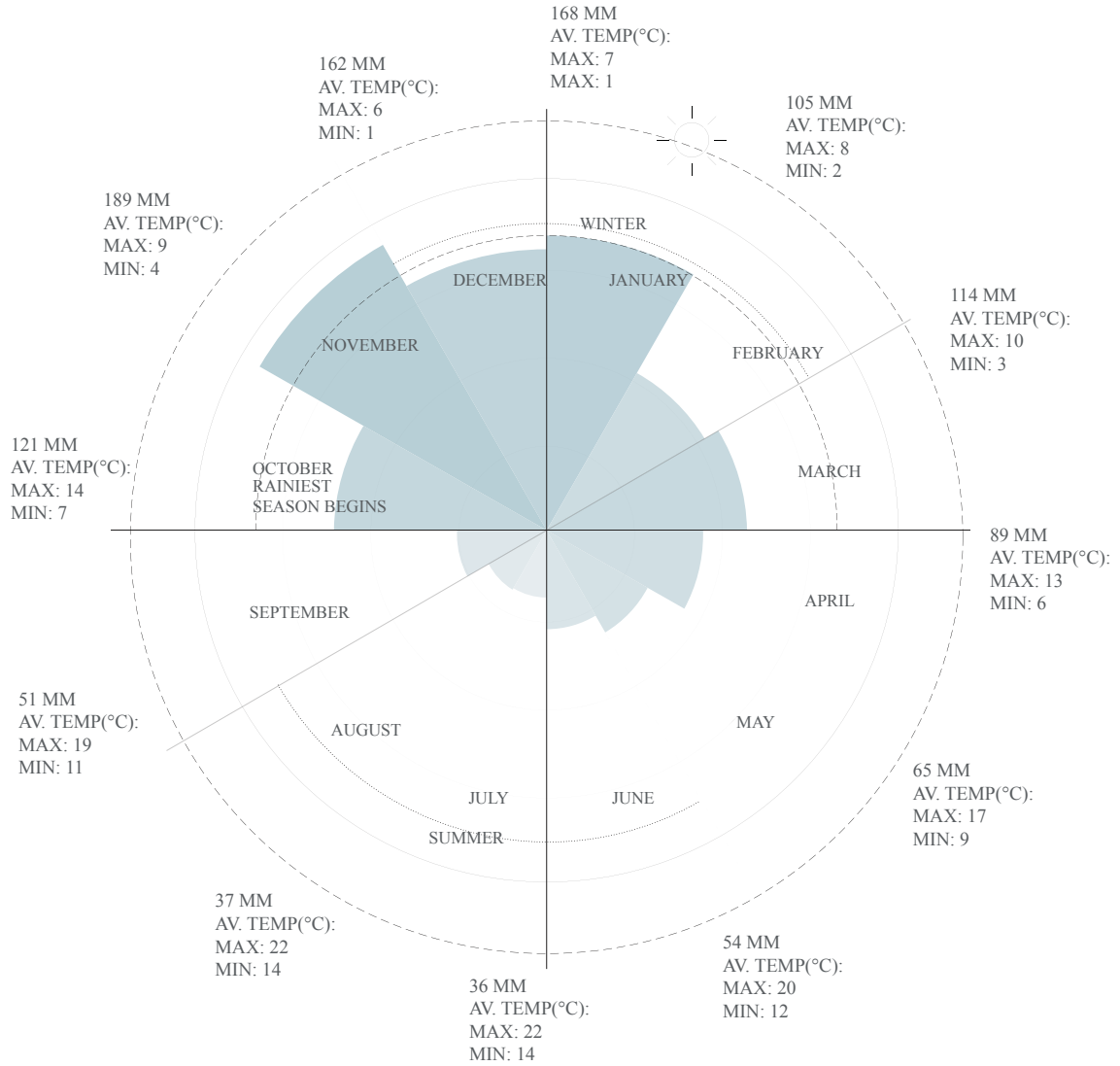
Climate change analysis predicts that the city will only begin to experience more frequent and intense rain as well as rising sea levels.²³ This may present a problem for water management of the city, as it is densely populated (5,249/km²) and like most cities, is made up almost entirely of hard surfaces.



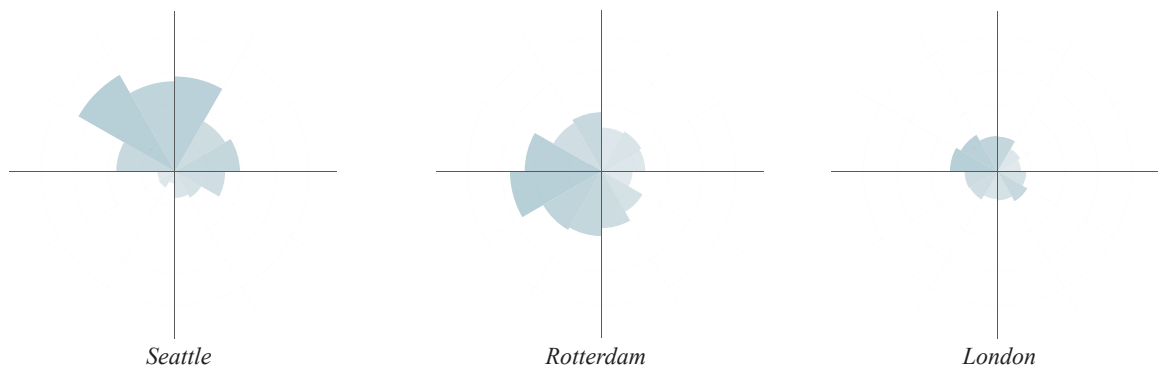
Vancouver, BC: Views West over False Creek with English Bay in the background.

²² Karvonen, *Politics of Urban Runoff: Nature, Technology, and the Sustainable City*, 93.

²³ Metro Vancouver, “Vulnerability of Vancouver Sewerage Area Infrastructure to Climate Change,” (March 2008), 2-1, http://www.metrovancouver.org/planning/ClimateChange/ClimateChangeDocs/Vulnerability_climate_change.pdf.



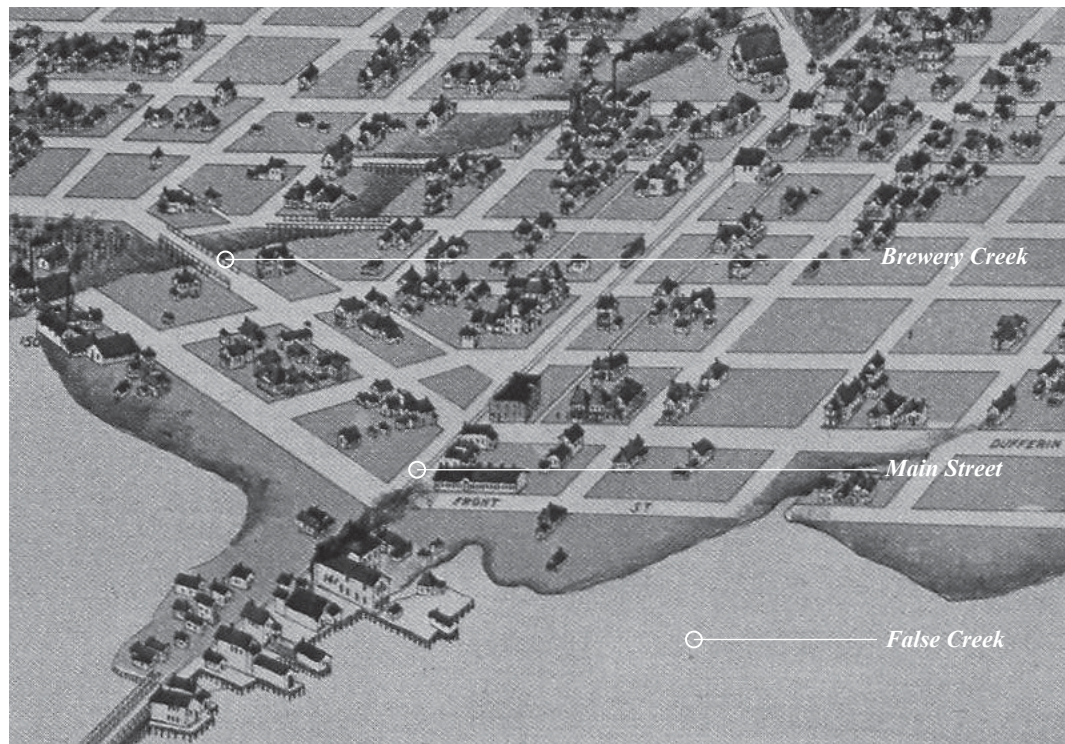
Vancouver’s average monthly precipitation and temperature; data from World Weather Online.



Average monthly precipitation of three rainy cities as comparison; data from World Weather Online.

History

There was a time when the land here was mediated through a network of freshwater creeks and marshes that bordered the city's waterfronts. Both were erased through the early development of Vancouver, but the creeks still exist as residual indentations in the landscape of the city, and as artifacts engineered into the infrastructure of the City. These ecologies provided important habitat for different animals and fish: including salmon, cormorants, ducks, herons, kingfishers, owls, geese, crows, and gulls, as well as harbour seals.²⁴






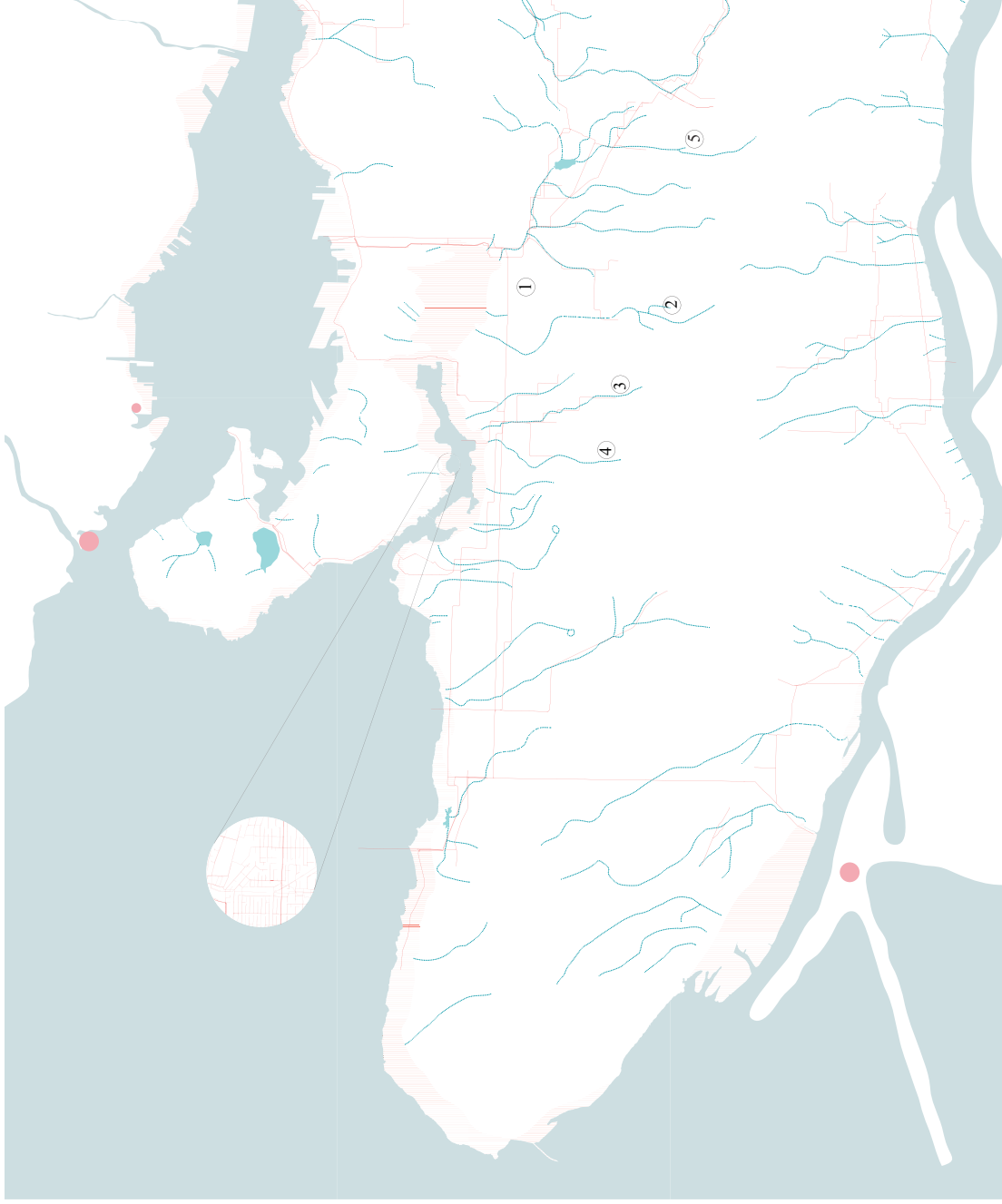
“Panoramic view of the City of Vancouver, British Columbia, 1898.”; from the City of Vancouver Archives, illustrating views south: False Creek was not yet filled in and Main Street was supplemented as a bridge. Brewery Creek is also visible; urban conditions adapted to it by crossing it with bridges.

Current Infrastructure

Modern infrastructure is a contrast to the natural landscape that used to exist and manage water here. These infrastructures are large, contiguous systems net-

²⁴ Bruce Macdonald, *Vancouver: A Visual History* (Vancouver: Talonbooks, 1992), 10.

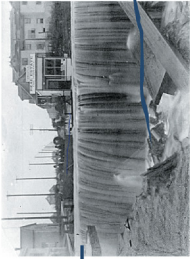
- 1 China Creek
 - 2 Ivian Creek
 - 3 Brewery Creek
 - 4 Bridge Street Creek
 - 5 Mackie Creek
-  Primary wastewater treatment
 -  Proposed secondary wastewater treatment
 -  Main sewer lines



City of Vancouver showing former marshland, creeks, and trunk sewer and storm water lines; data from VanMap 19



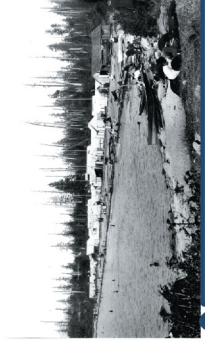
Rain falls on city streets



Water runs through a network of creeks



Creeks enter the False Creek Flats: a salt water marsh that is habitat to many birds, fish and other animals



Filtered water flows into ocean.

worked across a vast scale.²⁵ Currently, Vancouver is serviced, for the most part, by a separated storm and sewer system, except for a few remaining areas still using the antiquated combined systems. This means that rainwater enters a independent system, separate from sewage, lessening the chances of CSO's or combined sewer overflows.

However, in Vancouver, the overall annual number of high intensity rainfall days have increased since the mid 1970s.²⁶ Likely, this is an effect of urbanization and global climactic change. If these trends in precipitation intensities continue into the future, water related infrastructure will likely be effected. More specifically, it is expected that some of these systems may lack the capacity to provide the current level of flood protection and drainage by the second or third decade of the 21st century. Changes in precipitation intensity and recurrence would impact sewerage

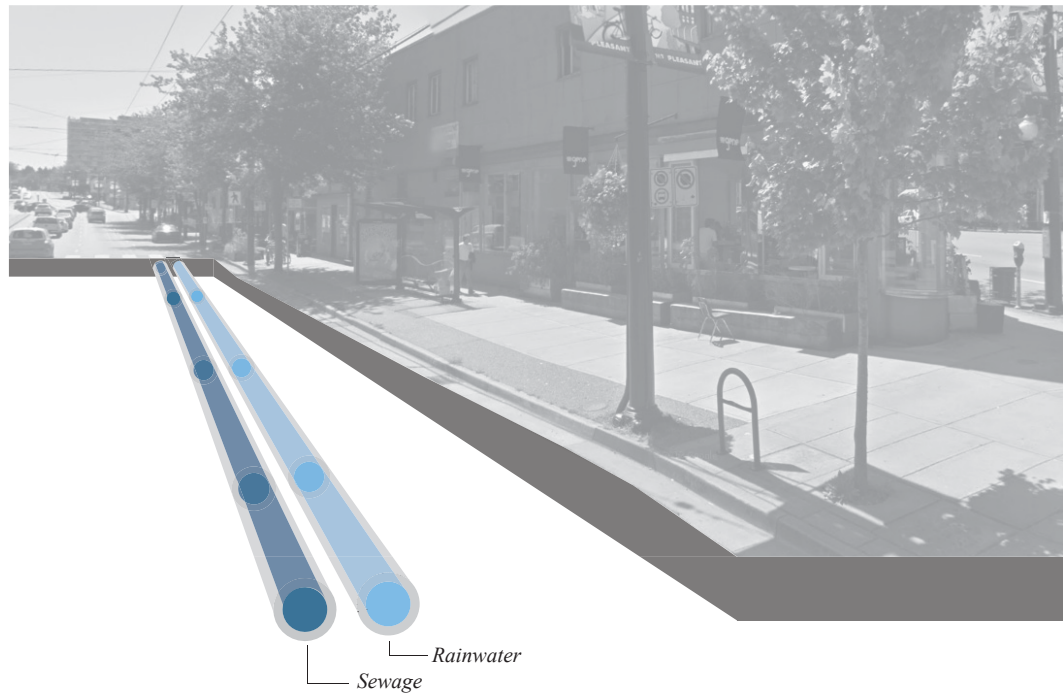
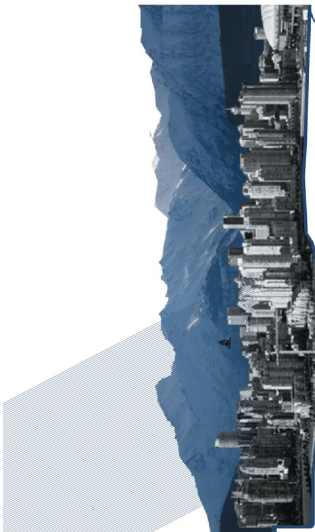


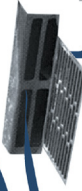
Diagram illustrating separate storm and sewer lines running below Main Street

25 Gerdo Aquino, "The Re-Representation of Urbanism," in *Landscape Urbanism* (Fall 2011), 1, <http://landscapeurbanism.com/article/gerdoaquino/>.

26 Greater Vancouver Regional District, "Development of GVRD Precipitation Scenarios," (October 2002), 1-1, <http://www.metrovancouver.org/about/publications/Publications/PrecipitationScenarios.pdf>.



Rain falls on city streets



Rain is channelled through storm drains



Storm sewer pipes carry water

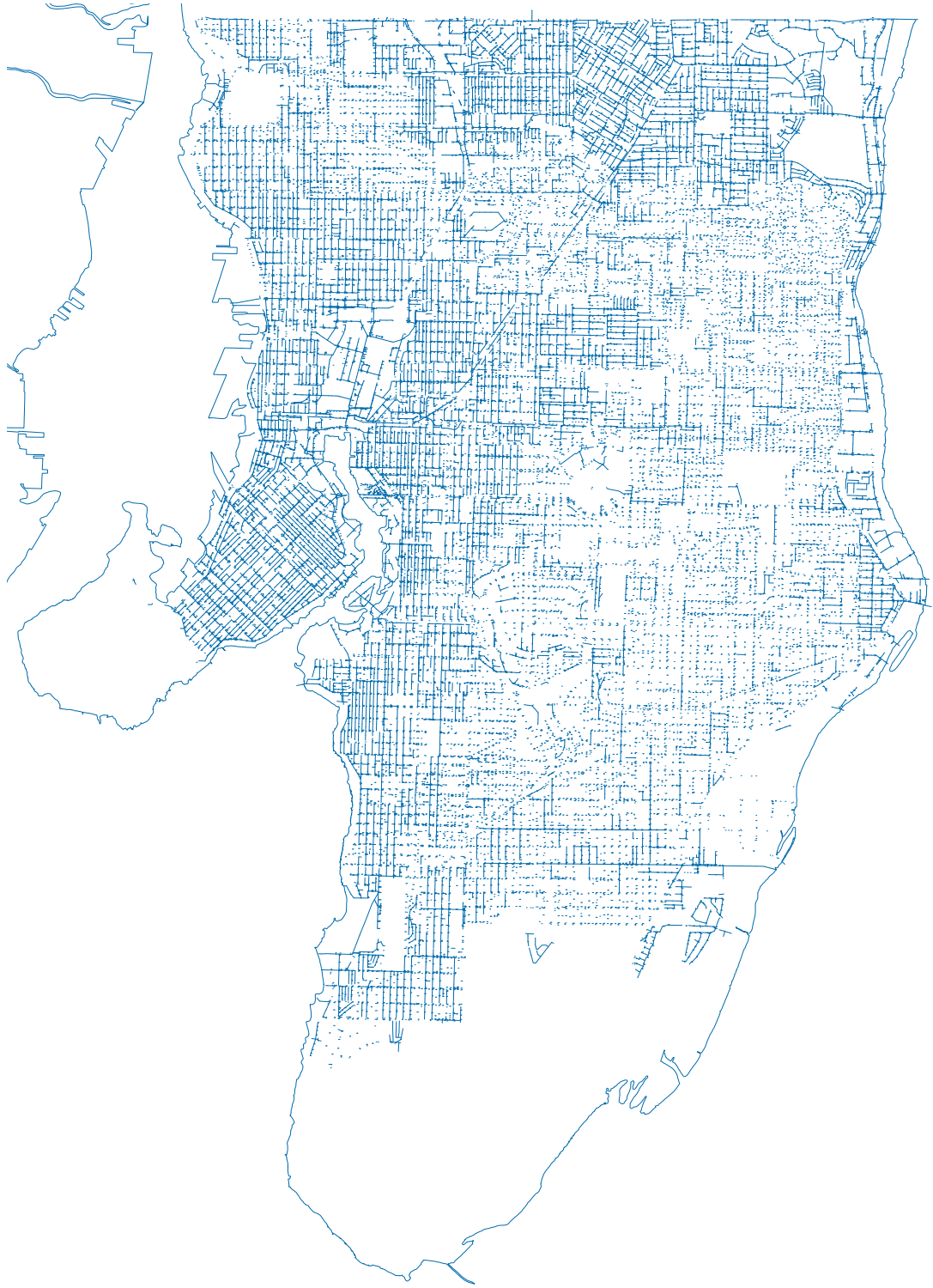


Unfiltered water flows out of outflow pipe



...and into the ocean.

Urban water cycle: separated system



Vancouver's current storm water system lines and man holes; data from VanMap.

and drainage infrastructure primarily. Sewerage and drainage infrastructure systems are designed for current climatic conditions and do not take into account long-term changes in precipitation and runoff pattern.²⁷ The life span of these systems is from 50 to 100 years, so an upgrade of the system may become necessary. This offers a unique opportunity for a new stormwater infrastructure within Vancouver, one which takes into account its natural surroundings, history and the unique communities that live there.

²⁷ Ibid., 1-1.

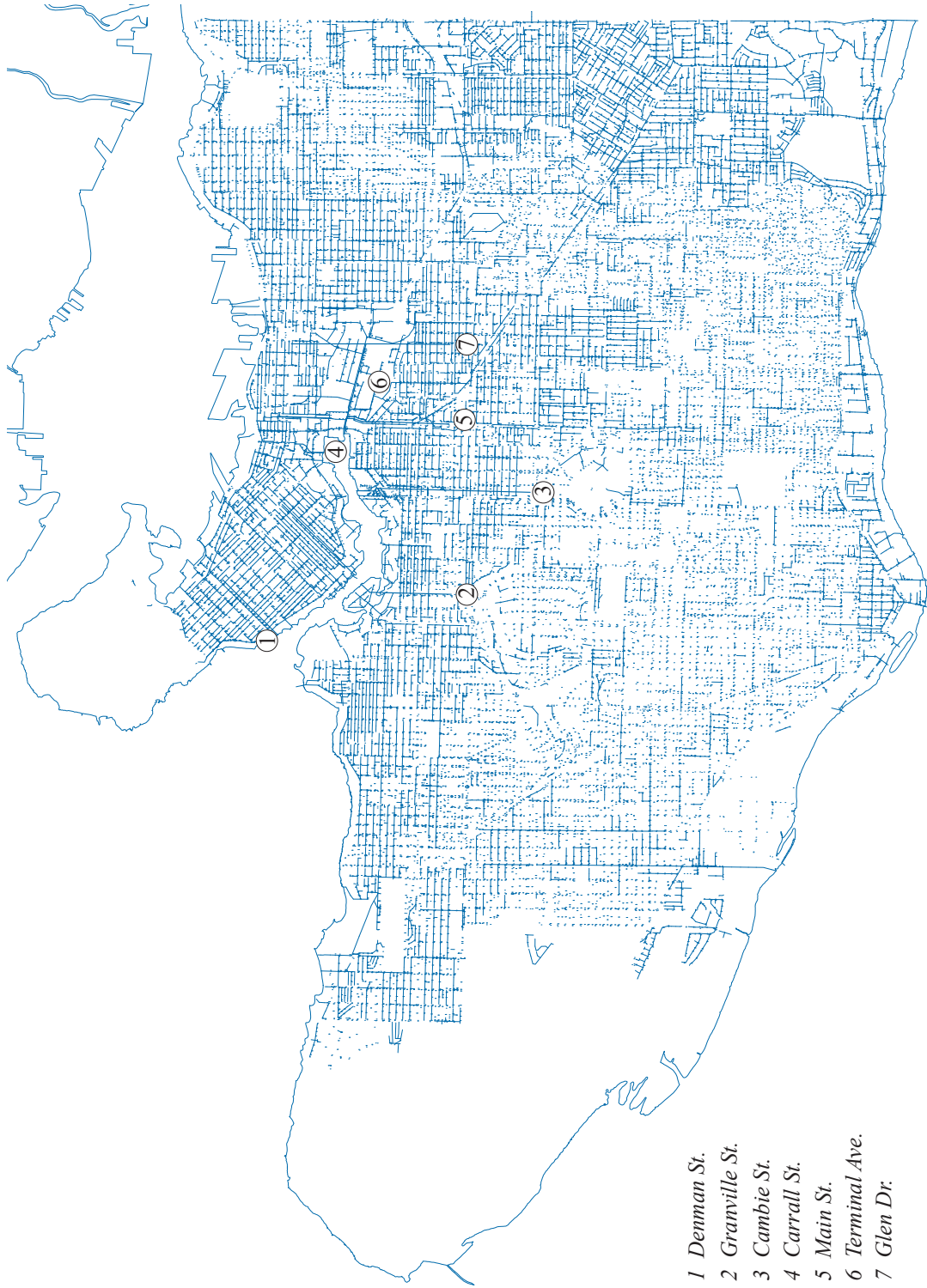
CHAPTER 2: DESIGN

Site Selection

To identify streets of interest within Vancouver, I focused solely on the False Creek watershed and screened for three criteria: (1) a sloping topography, (2) a close connection to the ocean and (3) a public street type. After this initial screening process, I had seven possible choices: Granville Street (both North and South), Terminal Avenue, Main Street (North and South), Denman Street, Carrall Street, Cambie Street, and Glen Drive. Each of these streets is public, with the exception of Glen Drive and Terminal Avenue; regardless, I chose to include these two because of their location within a declining industrial area. Almost all of these streets were formerly drained by a creek, which suggests the topography would be sufficient for drainage.

I selected Main Street as the study site primarily because of the three distinctive neighbourhoods it intersects: Mount Pleasant, Chinatown and the Downtown Eastside, but also because of its more complicated relationship with the ocean. After the infill of the False Creek tidal flats, Main Street was disconnected from the sea by approximately two blocks. The chosen site is bounded by two cross streets: East Hastings and 12th Avenue. East Hastings was selected because it is a high point, and I chose to end it at 12th Avenue to limit the scope of the waterway.

Each of the neighbourhoods encountered is historic. The city began its development around Hastings Street with Chinatown following closely behind, and later expanded into Mount Pleasant. The areas were always connected by Main Street; it was a bridge before the land was infilled. Today this infilled zone connects Chinatown to Mount Pleasant; an uninspired area that lacks the productive life it once had.

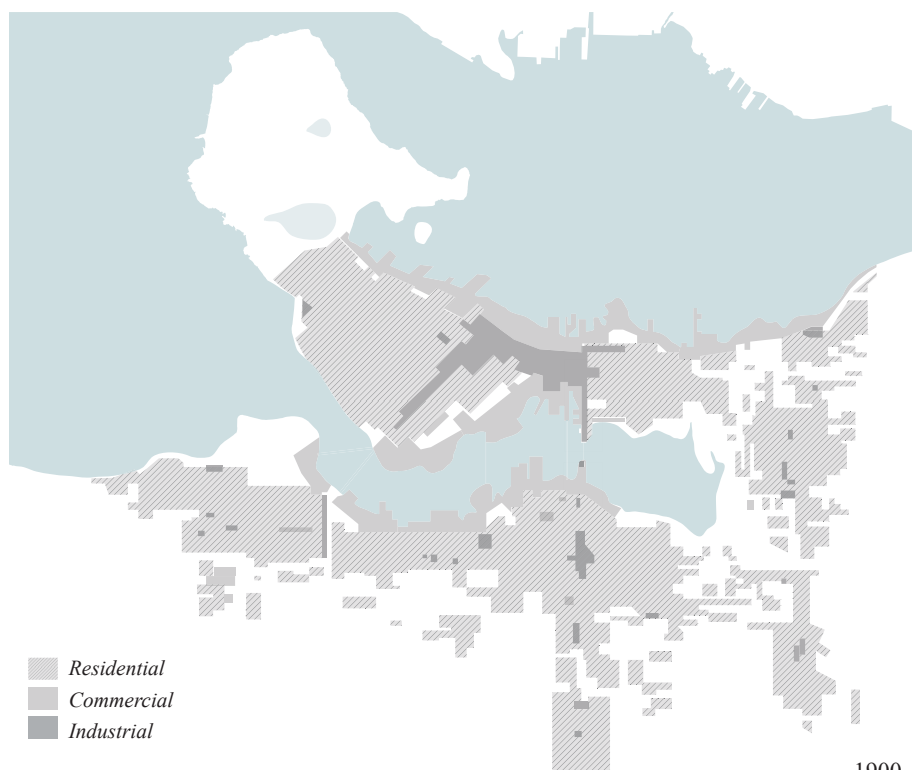


Vancouver's current storm water system, with identified streets overlaid; data from VanMap.



Residential
Commercial
Industrial

1880



Residential
Commercial
Industrial

1900

Maps illustrating Vancouver's development by 1880 and 1900; data from Bruce Macdonald, *Vancouver: A Visual History*.

Mount Pleasant

Mount Pleasant was built upon a creek, which supplied fresh water, fish and many plants and animals in the surrounding habitat.²⁸ In the 1880s, the Mount Pleasant area began to be cleared for development. The creek attracted many breweries that clustered in this area and became known as Brewery creek. The arrival of the street car along Main in 1891, brought with it many young couples in search of less expensive lots on the edge of town.²⁹

Today, above 7th Avenue, Mount Pleasant is a vibrant place: there are many shops and restaurants around Main Street, and many young people and families live in this area. The neighbourhood has another distinctive area, existing between 1st and 7th Avenues. In this area, Main St. is surrounded mostly by parking lots, car dealerships and auto repair shops. The city hopes to further develop the neighbourhood here along Main to better connect it to upper Mount Pleasant and the rest of the city. This plan includes widening sidewalks, more plazas, and a focus on public transportation rather than vehicles.³⁰

Mount Pleasant provides two sites for added programmatic elements. The first is located at the Rumpus Room restaurant at Main and 11th Avenue. The objective here is to provide a space on a commercial street for children living nearby. The second site is within a large parking lot at Main and 6th Avenue. The intention for this site is to bridge the gap between the two parts of Mount Pleasant and provide a space for families and residents within a zone used primarily for manufacture and auto repair.

Chinatown

Chinatown is a community with a long history. The first Chinese immigrants to British Columbia arrived in 1858 from California, following the stream of fortune seekers that came to BC searching for gold. The building of the Canadian

28 City of Vancouver, “Mount Pleasant Community Plan Implementation, Section 3: Lower Main Urban Design Framework,” (October 23, 2013), 29.

29 Ibid., 29.

30 Ibid., 33.



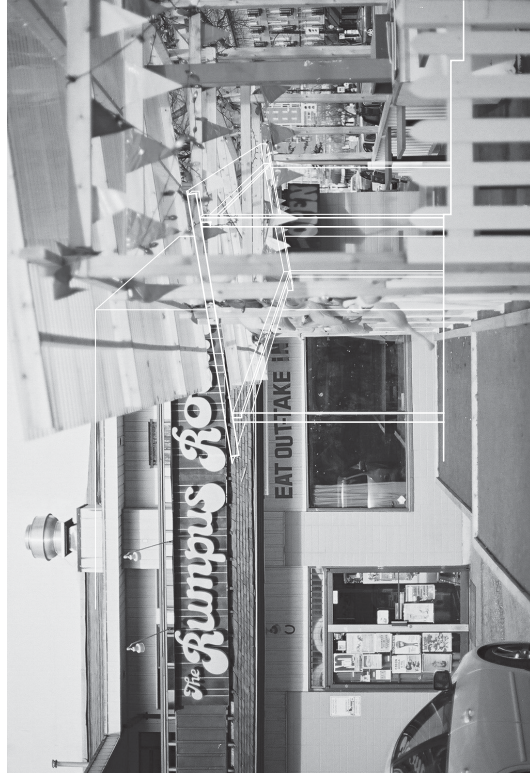
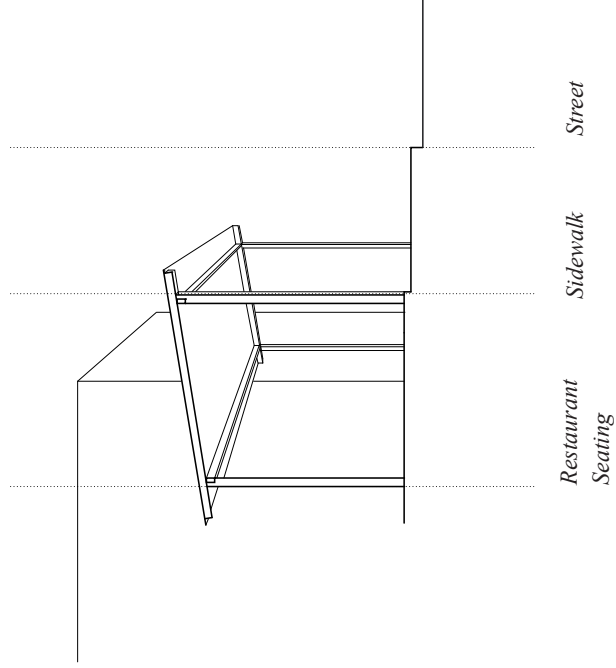
Main Street, proposed and prospective future sites; data from VanMap.



Main and 11th Ave.: Rumpus Room Restaurant's outdoor patio



Main and 6th Ave: parking lot; from Google Maps street view.



Mount Pleasant: user groups and street use



Diagrams illustrating parking lots (above) and parks (below) with-in surrounding neighbourhoods; data from VanMap.

Pacific Railway sparked another influx of immigrants between 1881 and 1885.³¹ Chinatown developed around two main areas: Shanghai Alley and Canton Alley. Today Chinatown is an interesting place, with over 60 buildings on the heritage register and many traditional markets.³² However, it is an evolving neighbourhood. Chinatown is currently being developed: permitted building heights have risen, and new condos and businesses are settling in. Some local traditions are at risk: including the 17 year old Chinatown Nightmarket, which runs during the summer months.

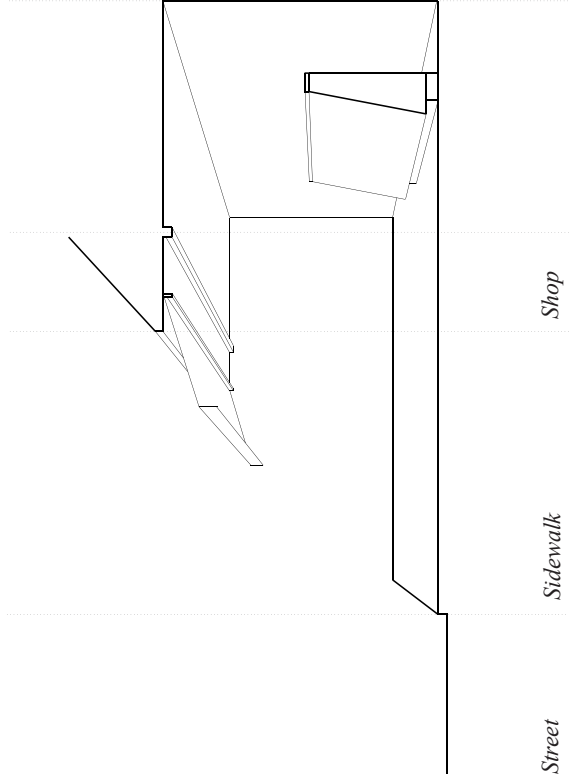


Main and Keefer Street: Chinatown Night Market; sourced from Chung, “From the Weekend: Vancouver Chinatown Night Market,” 2013.

Chinatown provides the site for another programmatic device, located at Main and E. Georgia Street, one block away from the Chinatown Night Market. The site is a dead end street, with a building to the north and south, and an alley to the west.

31 Vancouver Economic Development Commission. “2009 Chinatown Neighbourhood Profile,” (2009), 1, <http://www.vancouvereconomic.com/userfiles/chinatown-neighbourhood.pdf>.

32 Ibid., 2.



Chinatown: user groups and street use

Downtown Eastside

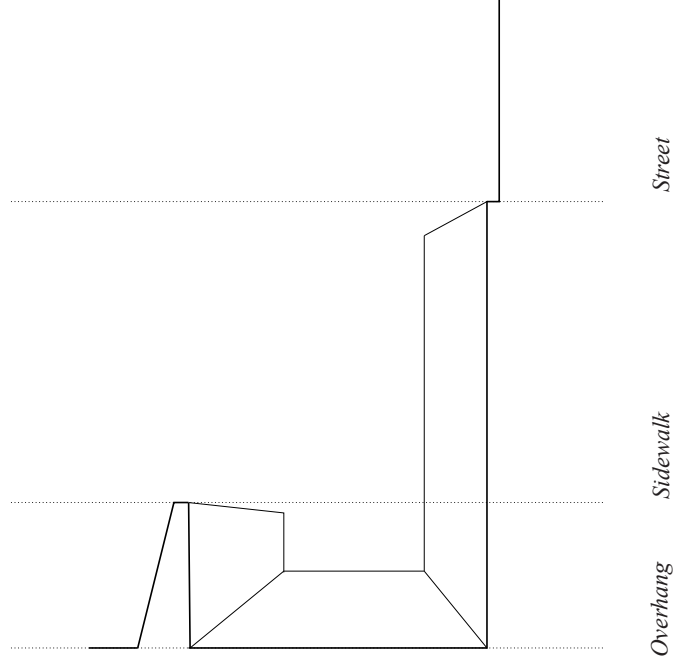
The Downtown Eastside is one of the oldest areas of Vancouver, the historic heart of the city, and has also been known as “Canada’s Poorest Postal Code.” In recent years, the Downtown Eastside has struggled with many complex challenges: including drug use, crime, homelessness, and housing issues. The area has also been victim of significant urban decay, but presently buildings are being renewed and many new businesses are operating in the community.³³



Main and East Hastings Street: Carnegie Community Centre

The vast amount of social services present in the community is notable. This includes community centers, churches, shelters, health clinics, and free kitch-

³³ City of Vancouver, “Downtown Eastside Local Area Plan,” (March 2014), 11, <http://vancouver.ca/files/cov/downtown-eastside-plan.pdf>.



Downtown Eastside: user groups and street use



Diagrams of existing social agencies (above) and community gardens and markets within surrounding neighbourhoods; data from VanMap.

ens. The historic Carnegie Centre on Hastings and Main provides food, library services, arts and recreational programs and one-on-one tutoring, amongst other services. A membership costs one dollar annually, and all the centre's programs are free to members. The centre is sometimes referred to as the living room of the Downtown Eastside.

The Downtown Eastside provides a site at the northern most tip of the waterway. Located directly in front of the Carnegie Center at Main and E. Hastings Street, this site provides an opportunity for a programmatic element that provides water for those most in need.

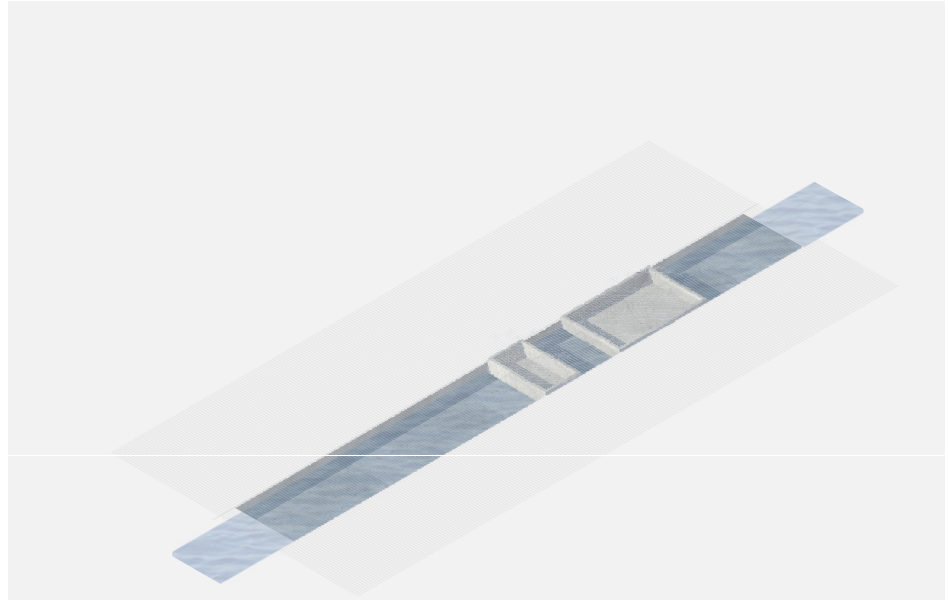
Unfortunately, as Vancouver rapidly expands, it is becoming increasingly homogenized. Some of its distinctive neighbourhoods, including those discussed, are at risk of losing their defining qualities. As a relatively young city with few historical neighbourhoods, these places tell an important story about the city's past. It is imperative that new additions to the neighbourhoods reflect the surrounding environment and tie into the needs of the people who live there.

Waterscape

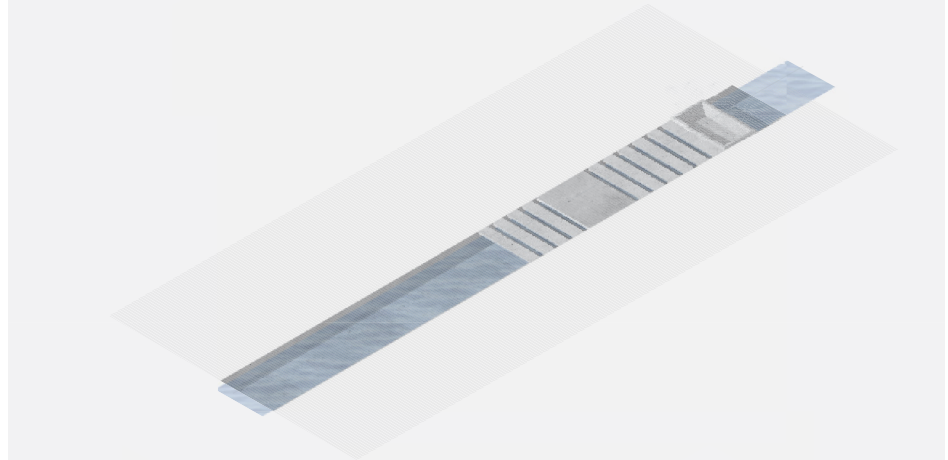
I propose a redesign of Main Street, between East Hastings and 12th Avenue. The street will function as a water boulevard that manages storm water in a visible and engaging way, as an alternative to the extensive water management systems currently in place. Water is the key ingredient; a connective channel will flow through the street, linking neighbourhoods and providing water for use at various points along its path.

The system is not autonomous; locals are physically active and engaged with the site. This includes programmatic pieces in each neighbourhood, as well as maintenance of filters throughout. The associated program is as follows: a vertical farm in Chinatown, water for drinking and laundry on East Hastings, a washing station and play fountains in Mount Pleasant) The waterway itself is also a programmatic element: it is covered with bridges, seating, squares, and plants.

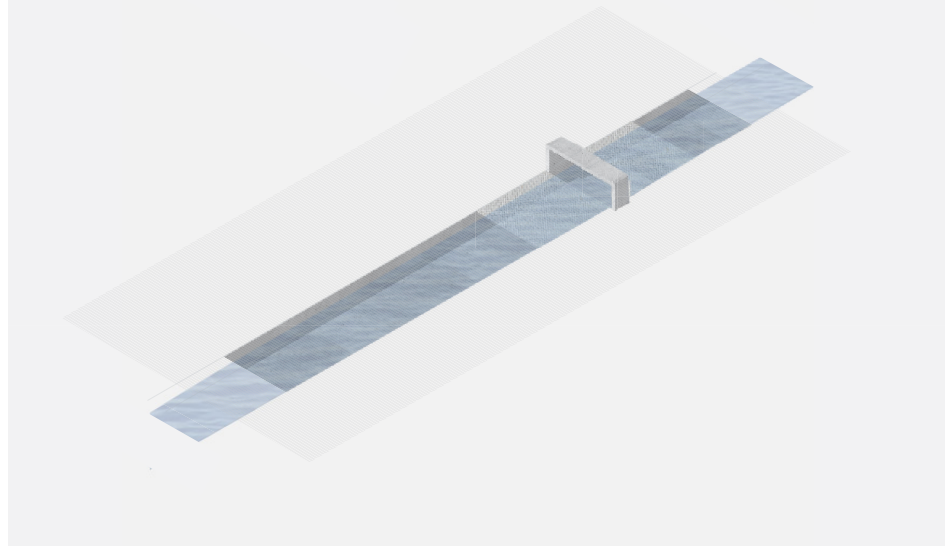
Plants



Steps

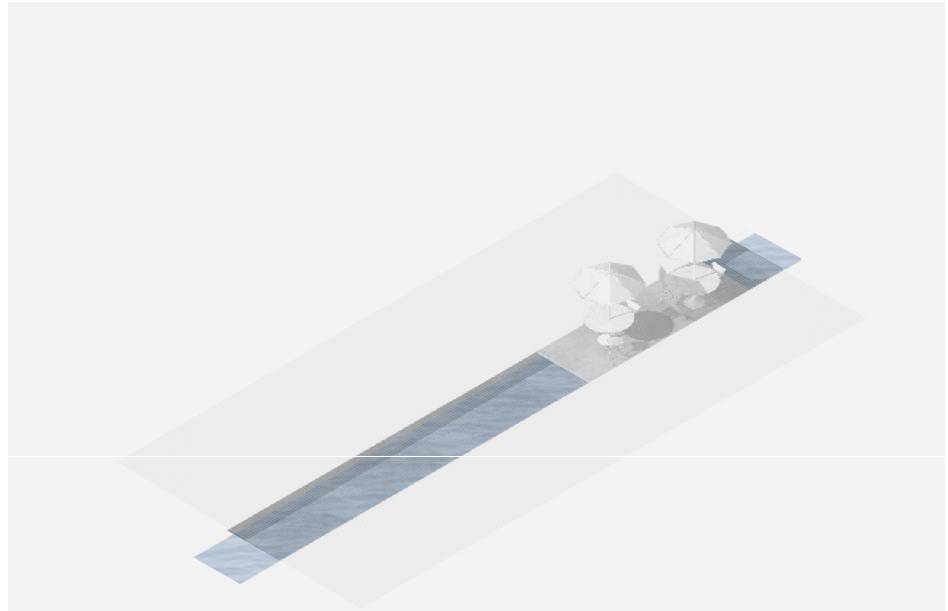


Benches

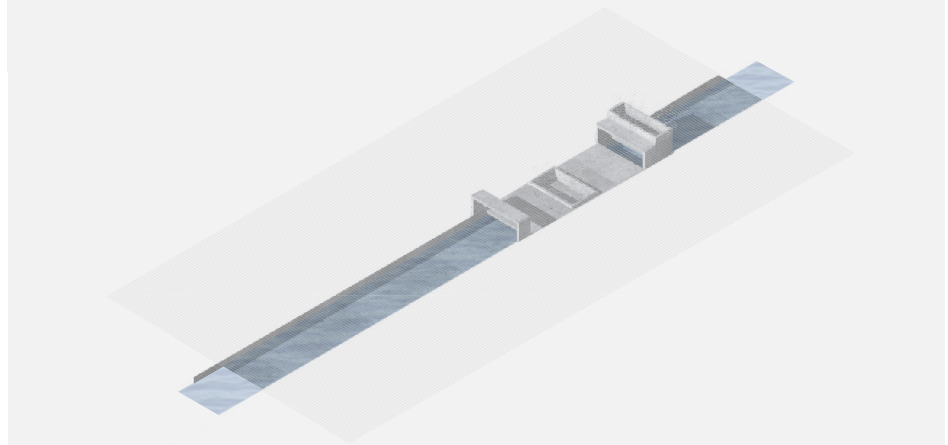


Waterway as a programmatic element.

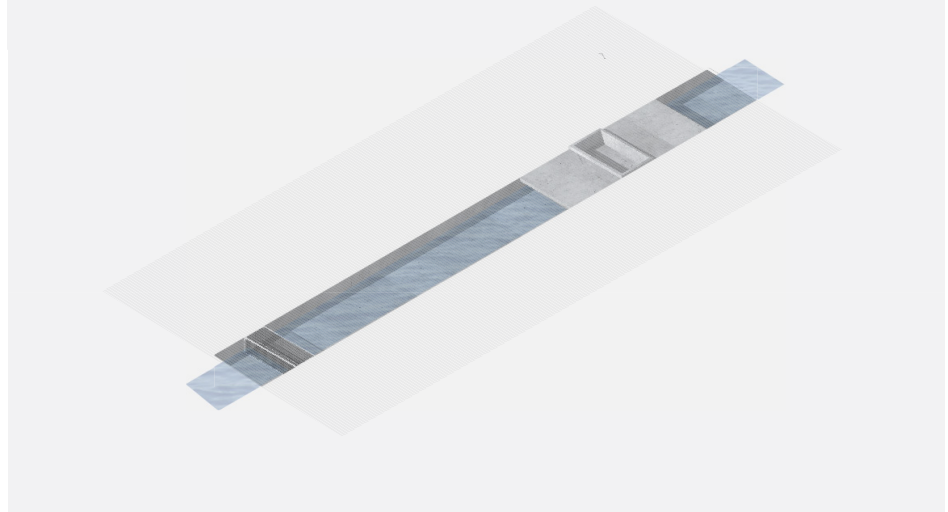
Restaurant seating



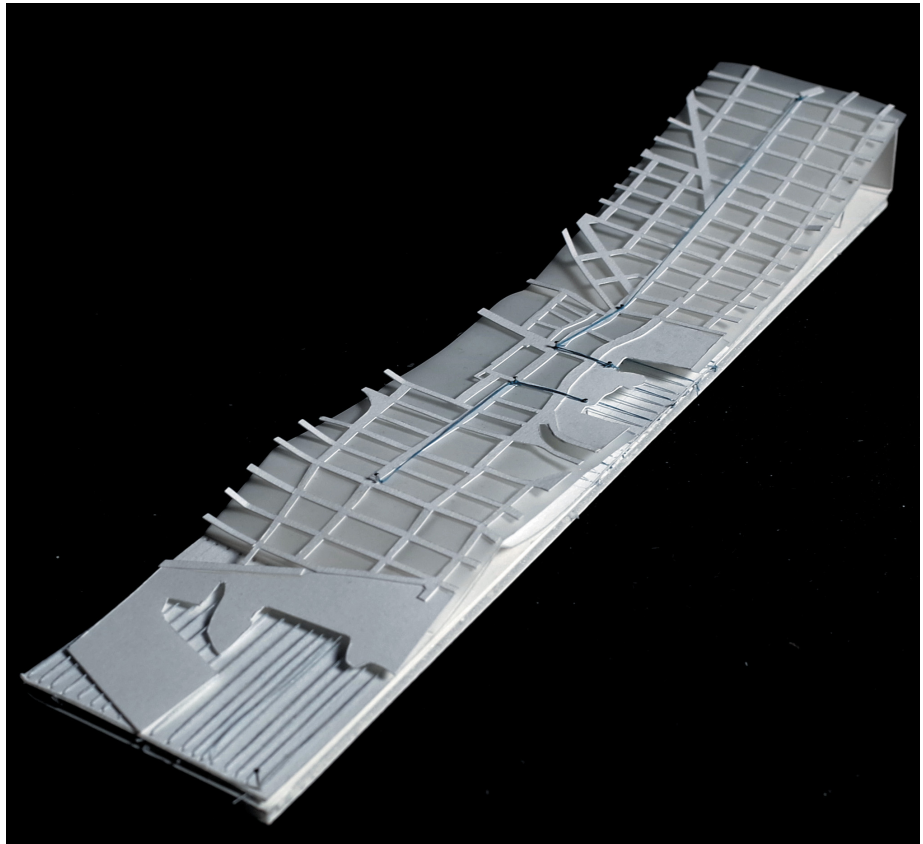
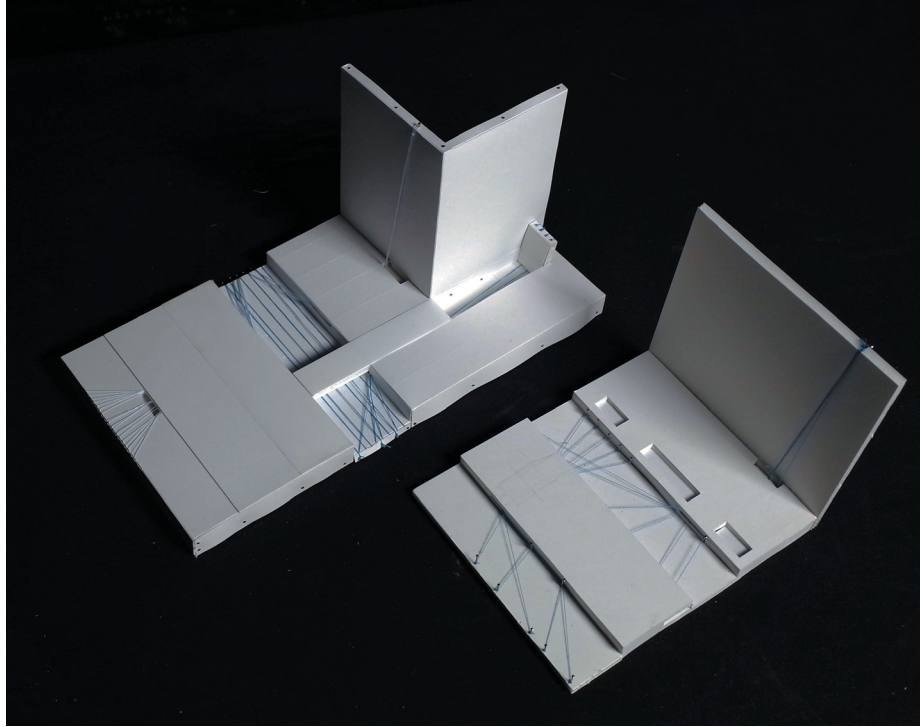
Square



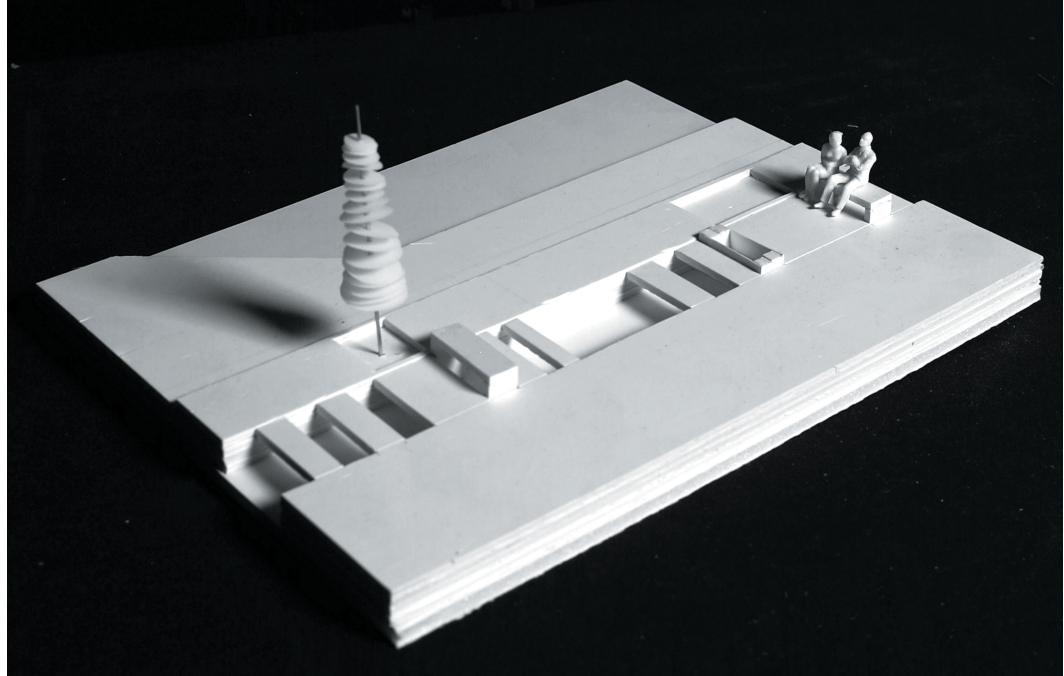
Filter and bridge



Waterway as a programmatic element.



System study models: the street scale (above) and the city scale (below).



Study model of waterway: seating, trees and parking spaces are visible.

Frameworks for Community Development

Sites of future development are included in the scheme as plug in points for water, which allow future programmatic elements to be added on. These points permit future growth of the street by local communities according to their changing needs and requirements.

Streetscape

Currently, Main Street is a six lane street (two are used for parking) and sidewalks are a standard 2.5 meter width. This is unchanging down the length of the site, regardless of surroundings. As is standard, the high point of the street is in the middle, which allows water to flow to either side and channel through storm drains. Main Street today is a car oriented street, with eighty-three percent dedicated to automobiles and sixteen percent dedicated to pedestrians.

The design begins by is slowing the street, using the Dutch concept of *Woonerf*. This includes widening sidewalks, curb bump outs for parking, and material chan-



Main St. at Pender St. (Chinatown) today looking North, 2014.

ges to the street, such as brick roads.

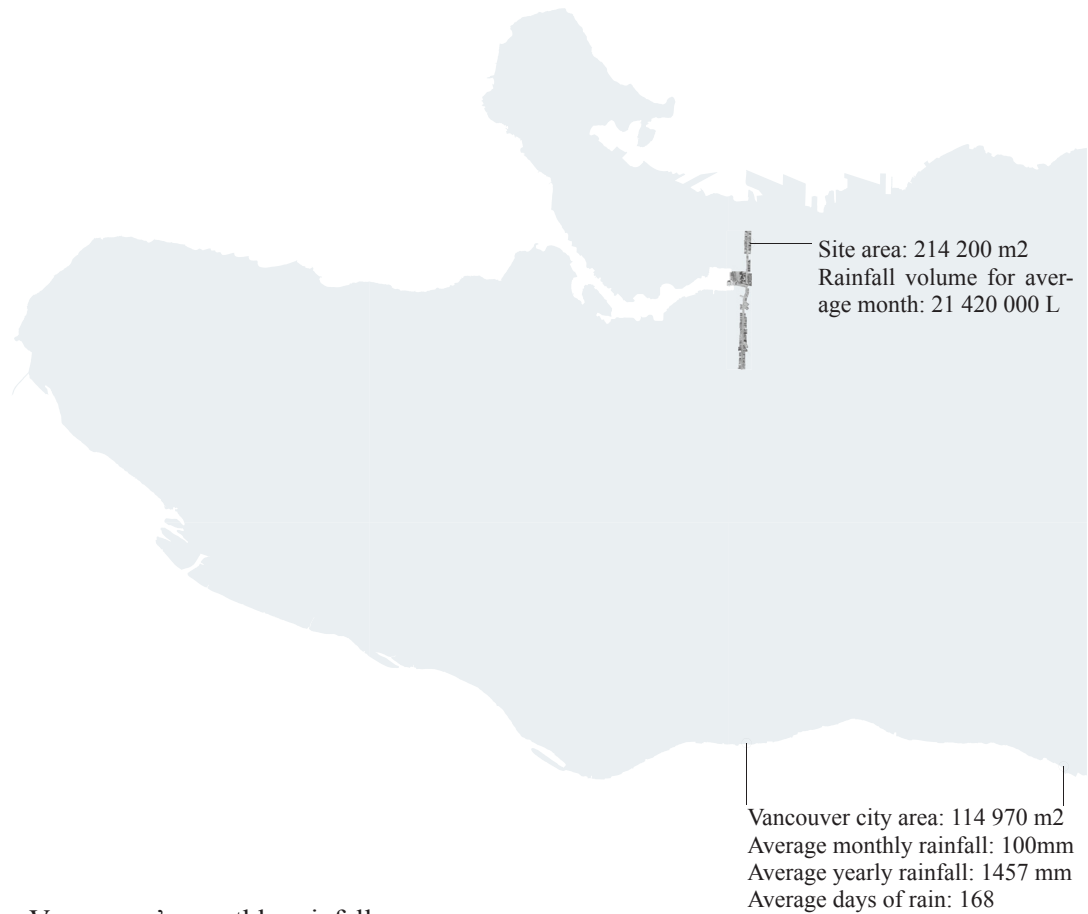
The first step in determining the required waterway size is to calculate the watershed area and find the peak 15 minute rainfall listed for the location in the National Building Code.³⁴ The peak 15 minute rainfall listed for Vancouver is 10mm/15 minutes, which equals 0.667 mm/min. For this project, the area consists of the street, the surrounding rooftops and the surface area of the building elevations on one side of the street. To find the flow rate, area is multiplied by rain fall:

$$Q = (214,200 \text{ m}^2 + 9,000/2 \text{ m}^2) \times 0.667 \text{ mm/min} \times 1/1000 \text{ m/mm}, \text{ which equals } 145.8 \text{ m}^3/\text{min} \text{ or } 85.75 \text{ ft}^3/\text{sec}.$$

Then, the Manning Method is used to find the required cross sectional area of the waterway, assuming a minimum velocity of 3ft/sec:

$$Q_{full} = V_{full}(\pi D^2/4) \rightarrow 85.75 = 3(\pi D^2/4) \rightarrow D = 6\text{ft}$$

³⁴ Curtis Enman, Email to Author, June 2014.



Vancouver's monthly rainfall

Therefore, the cross sectional area of the waterway needs to be the same as a 6ft pipe.

With the proposed design changes, including the 2m wide waterway, the street will be transformed to dedicate fifty-eight percent to pedestrians, which includes the waterway, widened sidewalks, planting and bike paths. Forty-two percent will be dedicated to automobiles. In the future, this could be decreased further if a transit system such as a trolley was introduced. An existing example of this is the Avenida Jimenez in Bogota, Columbia, re-designed by Rogelio Salmons as an environmental street, which includes a water feature. A transit system was implemented here, which increased its ability to act as a pedestrian street.



Section through Main Street, showing street materials, bioswales, reed beds, bike lanes and widened sidewalks.

Neighbourhood Water Use

Water ‘devices’ exist in each neighbourhood; they are designed to utilize community resources already in place and encourage further involvement with the water system. Each is designed for a particular site, but with the intent that they could be replicated at different sites if desired. The designs are modular, allowing them to be used in sites of varying space allocations.

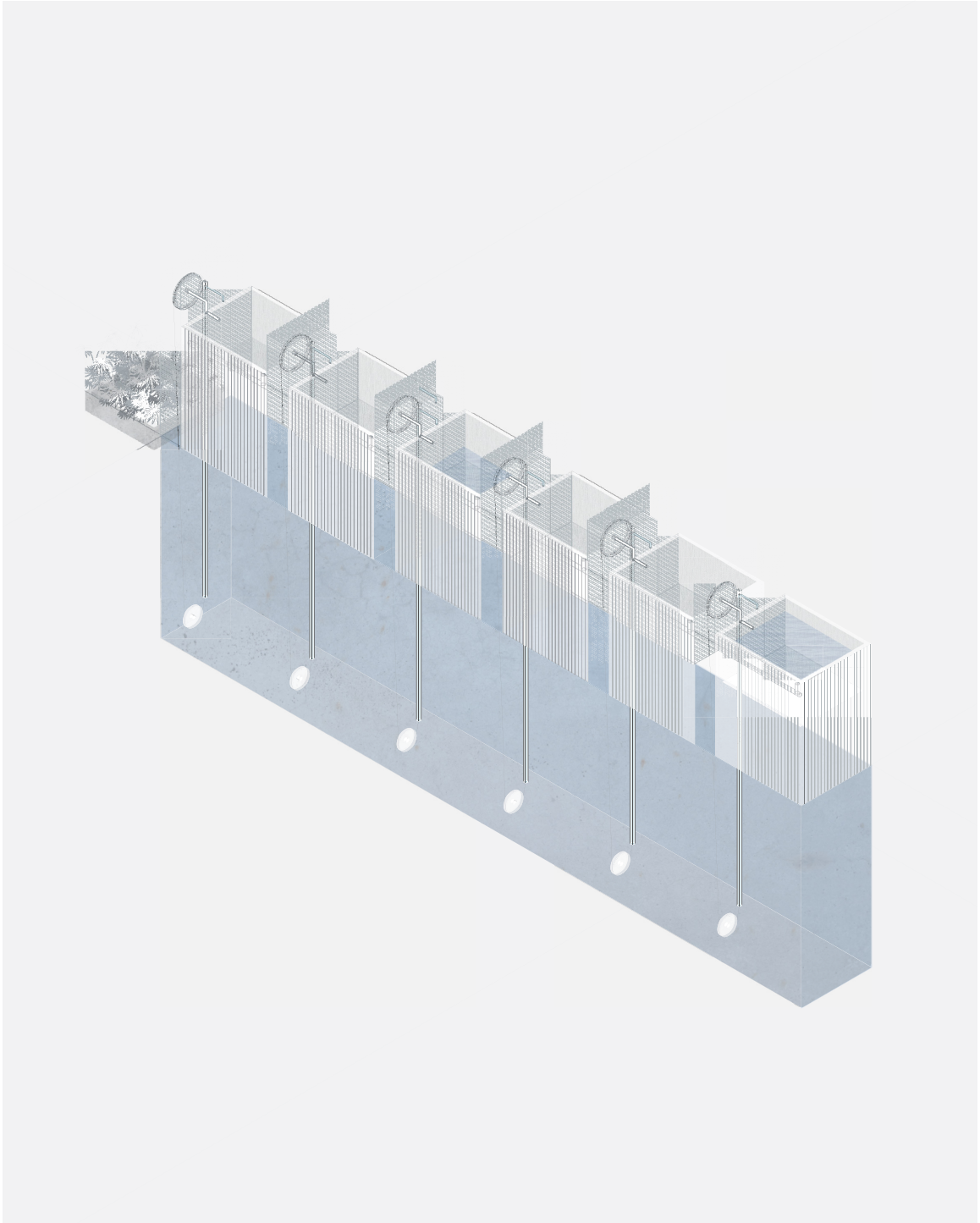
Each piece uses a derivative of a rope pump system. A rope pump is a simple pump system which utilizes a hanging rope to draw water up from a well through a pipe. Round disks or knots on the rope match the diameter of the pipe and pull the water up to the surface. There is a wheel at the top and the bottom of the system; the bottom wheel is submerged in water and directs the rope into the pipe. The top wheel has a handle, which is spun to pull the rope and draw water upwards. In each case, the half of the pump existing above ground is enclosed in perforated aluminum.

The pump system is varied to meet the size requirements of each design. For example, a vertical garden in Chinatown demands a taller pump in order for the water to flow out at the top of the wall: this is possible by adding an third wheel to carry the rope above. The handle remains within arms reach on the centre wheel.

Main and Hastings: Sinks for Washing

As stated earlier, the design objective for the site at Main and East Hastings was to tie into the program of the Carnegie Centre and create a place for those most in need. The centre has a large attendance and the sidewalk outside is generally crowded with people, often the homeless. The site for the feature in this neighbourhood is within the courtyard at the front of the building.

Water is a human necessity; it would be valuable for any city to create a dependable source that can provide water for drinking and washing for those who may not have access. In view of this, the design proposed here is a set of sinks. Each sink has its own pump so the user can gather water as required. The sinks are large enough to fulfill multiple uses, including washing clothing and filling water bottles.



Main and East Hastings: sinks with water for drinking and washing.

After use, the grey water filters through a bioswale at the side before re-entering the water way.

Main and East Georgia: Vertical Farm

The design intent for Main and East Georgia was to create a feature to be used by both the existing community and the new population infiltrating the neighbourhood of Chinatown. Currently, the site has historical buildings on either side but one will soon be replaced by a new condo building. The design could help to integrate the new, unfamiliar building into the neighbourhood.

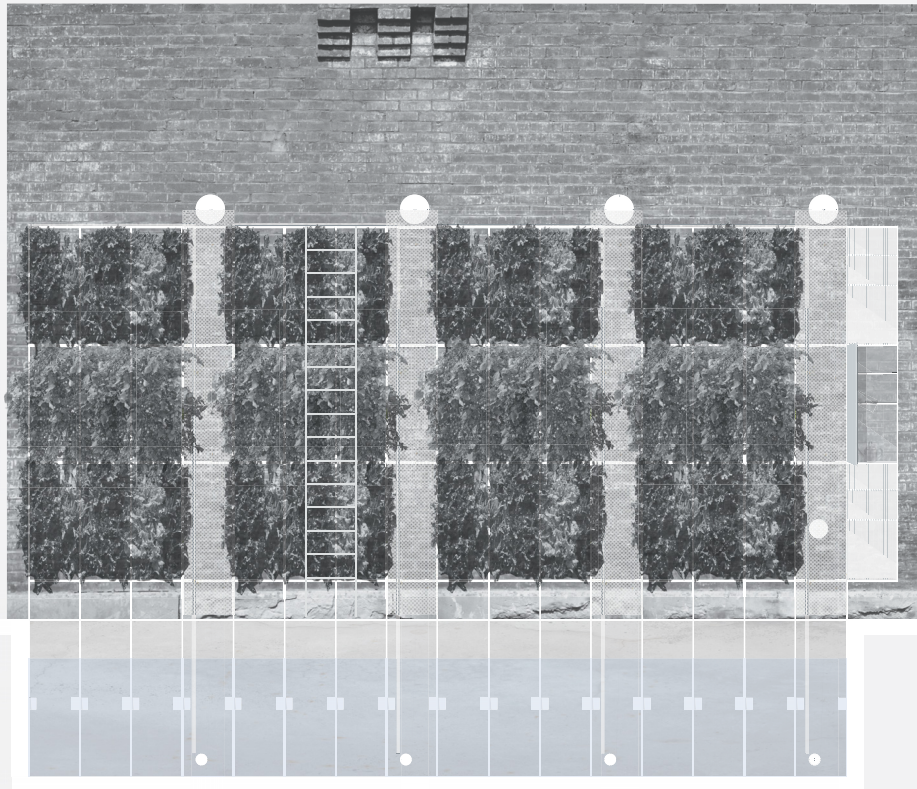
There are still many traditional markets within Chinatown and in the summer months the Chinatown Night Market is well attended. Both have been part of the neighbourhood for many years and the proposed vertical garden wall is inspired by these. Community gardens are already popular in the surrounding areas but they require open space, which is something not easily found here. A vertical system allows farming to exist on smaller, varied sites, but still yield produce that could be profitable for the surrounding markets.

The south-facing wall is made from a grid of thin aluminum bars. Small planting beds are created by filling the squares in with earth; these plots could be divided up per bed, column or row. In this scenario, every fourth column is used by a pump. At the far side, doors are applied and the column is used for storage. The garden could be planted as required but a potential planting sample is offered to demonstrate the gradient of water and sun requirements.

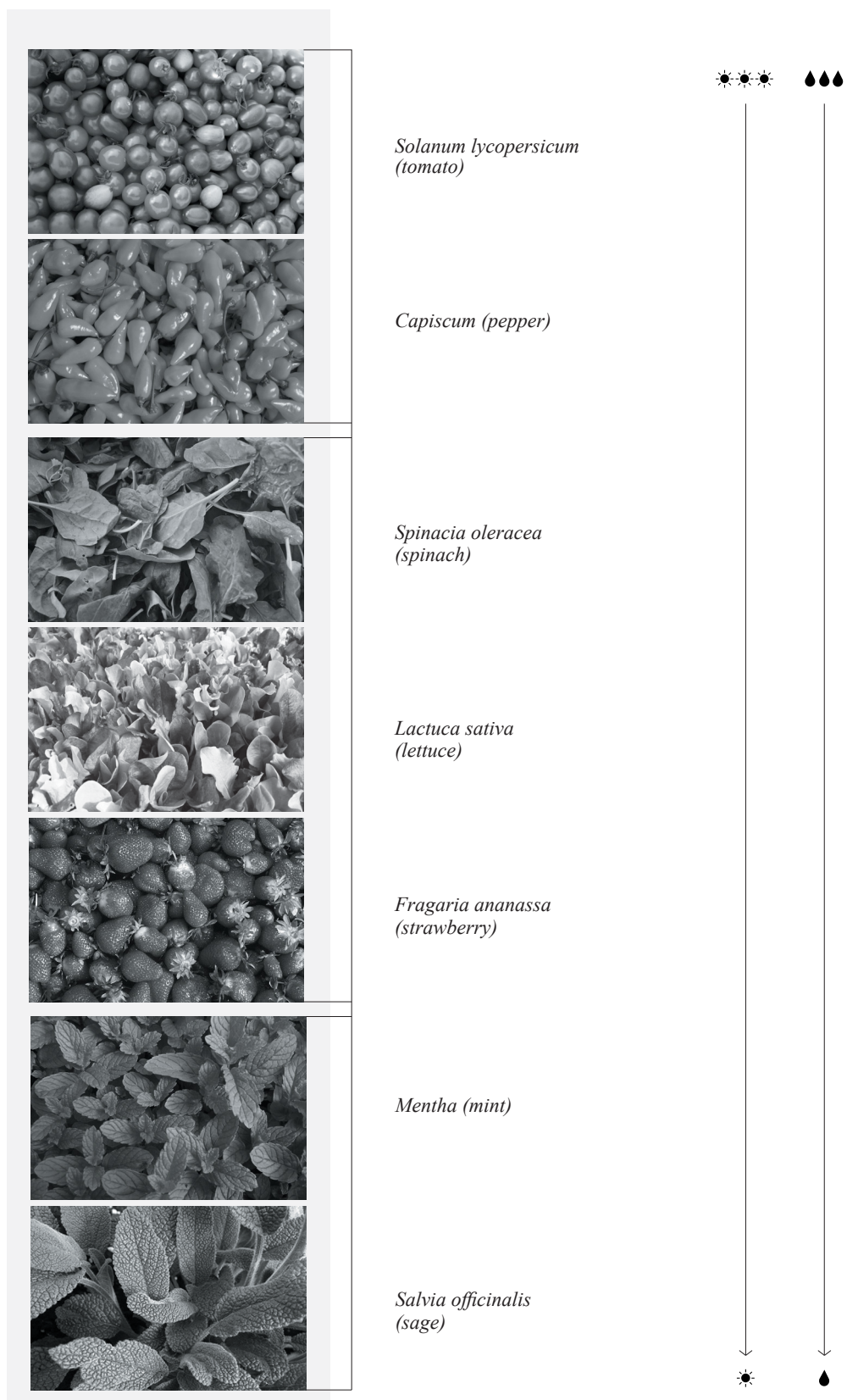
Main and 6th: Washing Station

The design intent of the first site in Mount Pleasant at Main and 6th Avenue was to create a space that could be used by families in this now light industrial/commercial area. This would help to bridge the two areas of Mount Pleasant together and draw families further along the waterway.

A washing station within an existing parking lot is proposed, to be used for cars, bikes or dogs. Three car and two bike/dog spaces are offered. Each space has

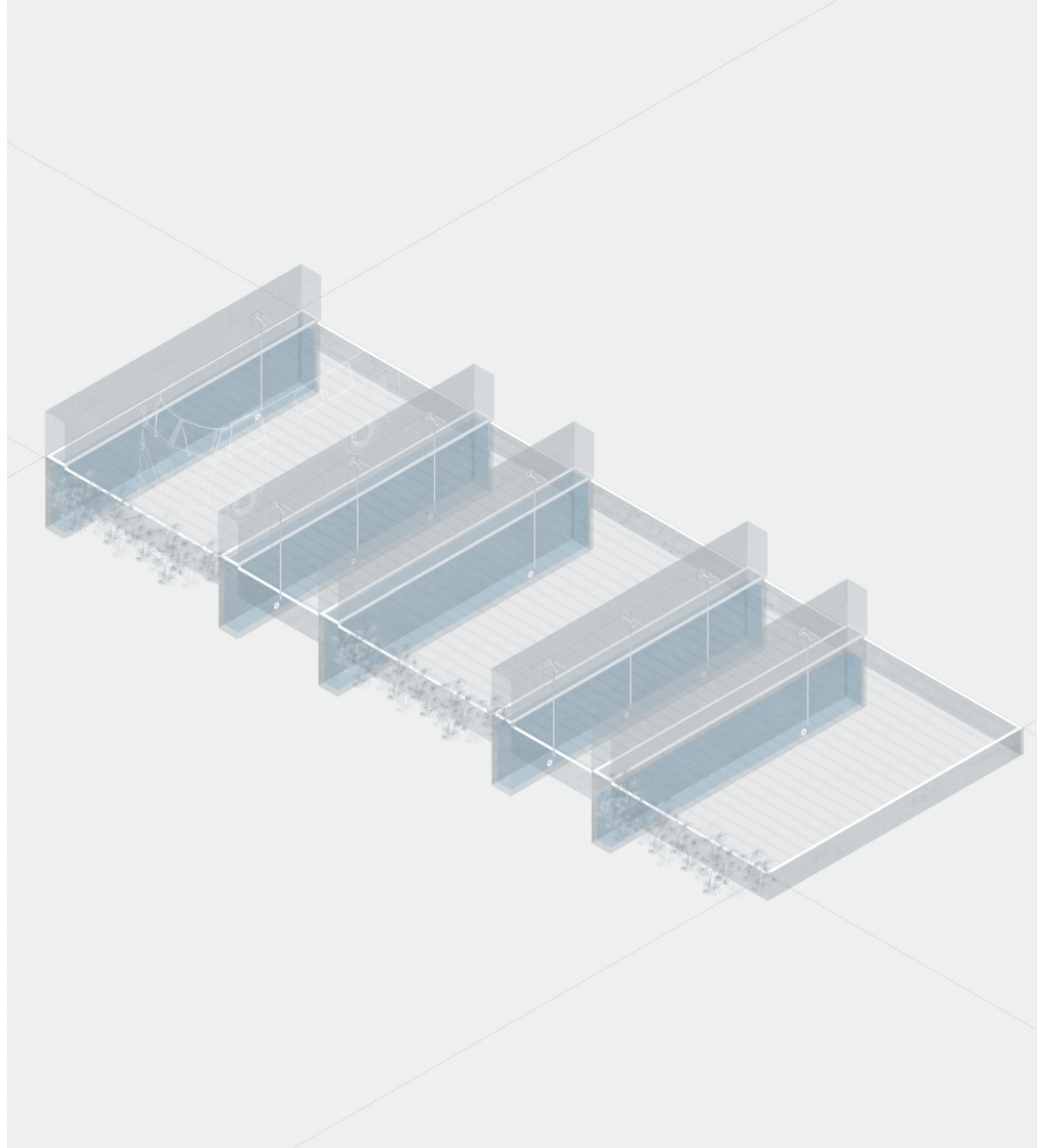


Main and E. Georgia: vertical garden.



Potential planting sample for vertical garden.

a water storage cistern beside it; car spaces have one pump and the bike spaces have three pumps, and thus can be used by three people at a time.

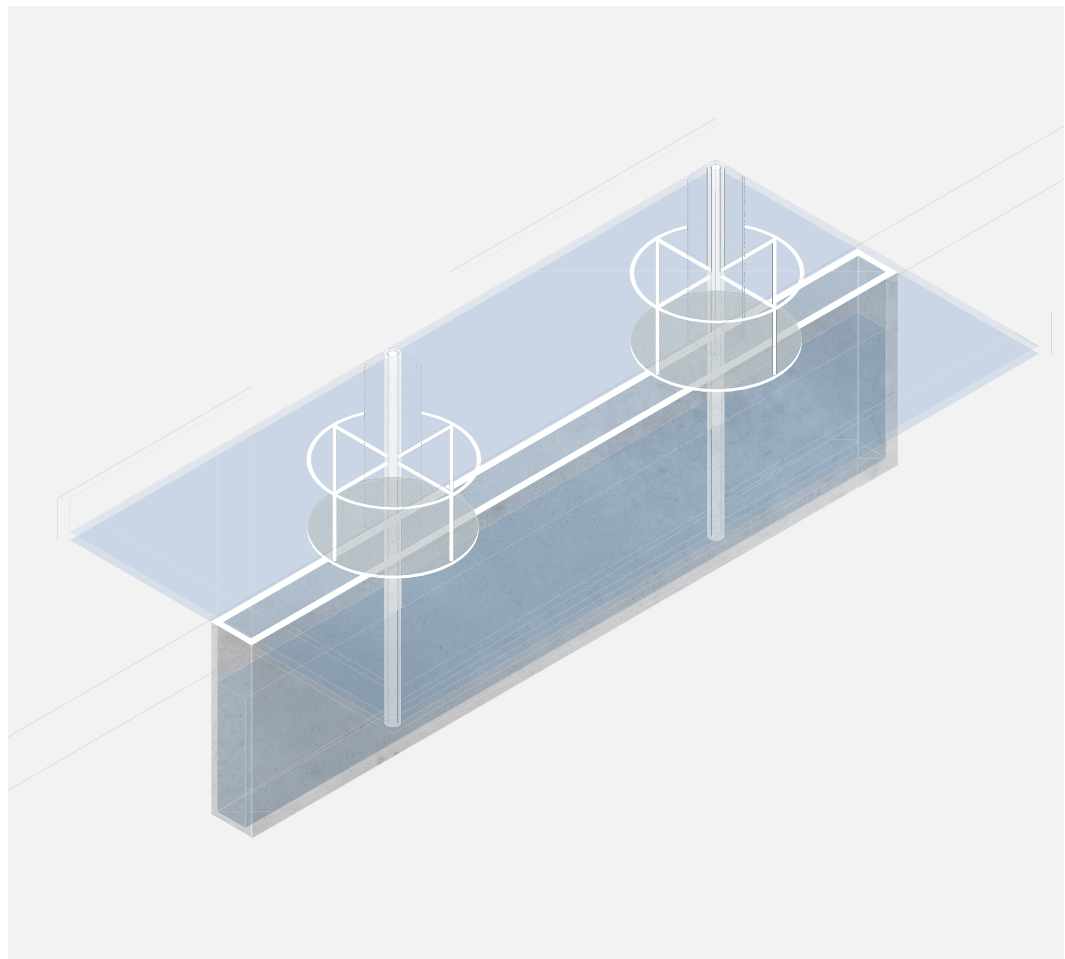


Main and 6th: washing station.

Main and 11th: Spray Fountains

Within cities, children are often limited to residential areas, schools and parks for play. The proposed feature of a spray fountain at Main and 11th Avenue aims to offer a small space for children to play in a commercial area of the city while they are with their families or friends. The design could easily be replicated at other locations.

The spray fountains move away from the rope pump system and use a rotating bore to pump water. Similar to the rope pump, water is manually drawn up a cylinder, but in this case the threads of a bore inside draw water up rather than the disks of a rope pump. As a child spins the apparatus from outside, water travels up the threads of the bore, until it reaches the spouts and is released above.



Main and 11th Avenue: spray fountains.

Filtration

Filtration is a major consideration for water use in an urban environment. Within the proposed system, four water filtration methods are used: *screening*, *sand*, *reeds* and *bioswales*.

Screening, in this sense, refers to using a woven mesh to separate solid matter from water.

A *sand filter* is a filter in which water flows through sand, gravel and other granular material using gravity. Often, the process of sedimentation precedes this and a disinfection treatment follows afterwards.

A *reed bed* (or a *constructed wetland*) refers to artificial swamps which use reed or other marshland plants to form part of a water treatment system. Water passing through the bed is cleaned by microorganisms living in the root system. There are two kinds: surface flow wetlands and subsurface flow wetlands.³⁵

A *bioswale* is a landscape element designed to remove silt and pollution from surface runoff.³⁶ They consist of a gently sloped drainage course, which is filled in with vegetation.

Each of these filtration methods address the requirements of a specific environment, including streets, sidewalks, rooftops and programmatic points.

Street and Sidewalk

From the street and sidewalk, the primary concern is automotive pollution, animal waste, and garbage. To address this, a continuous bioswale strip exists beside the waterway to filter incoming water from the street. Curb-side bump outs, which contain bus stops and create street parking spaces, are also functional bio-

35 Dennis Jurries, "BIOFILTERS (Bioswales, Vegetative Buffers, & Constructed Wetlands) For Storm Water Discharge Pollution Removal," *The State of Oregon Department of Environmental Quality Northwest Region Document* (2003), 39, <http://www.deq.state.or.us/wq/stormwater/docs/nwr/biofilters.pdf>.

36 *Ibid.*, 14.



Intake to waterway: sectional study with visible bioswale strip and reed bed.

swales and exist on both sides of the street. Water is able to flow in, filter through and into the waterway, as a result of periodic breaks in the concrete lips that border the swales.

In general, swale vegetation must meet criteria to maximize the bioswale's ability to filter pollutants from storm water. In particular, the vegetation must: tolerate periodic flooding and drought, provide a dense cover and a root structure that holds the soil in place to resist erosion, and stand upright to allow for maximum residence time and pollutant removal.³⁷ In the case of this thesis, plants were chosen with the best ability to filter hydrocarbons and heavy metals: two major vehicle emissions (see following page for a planting sample.)³⁸ In addition to the bioswales, screened collection filters exist within the waterway itself (as do periodic floating reed beds) to catch garbage and other solid waste. They are easily removable to allow for community involvement in the process.

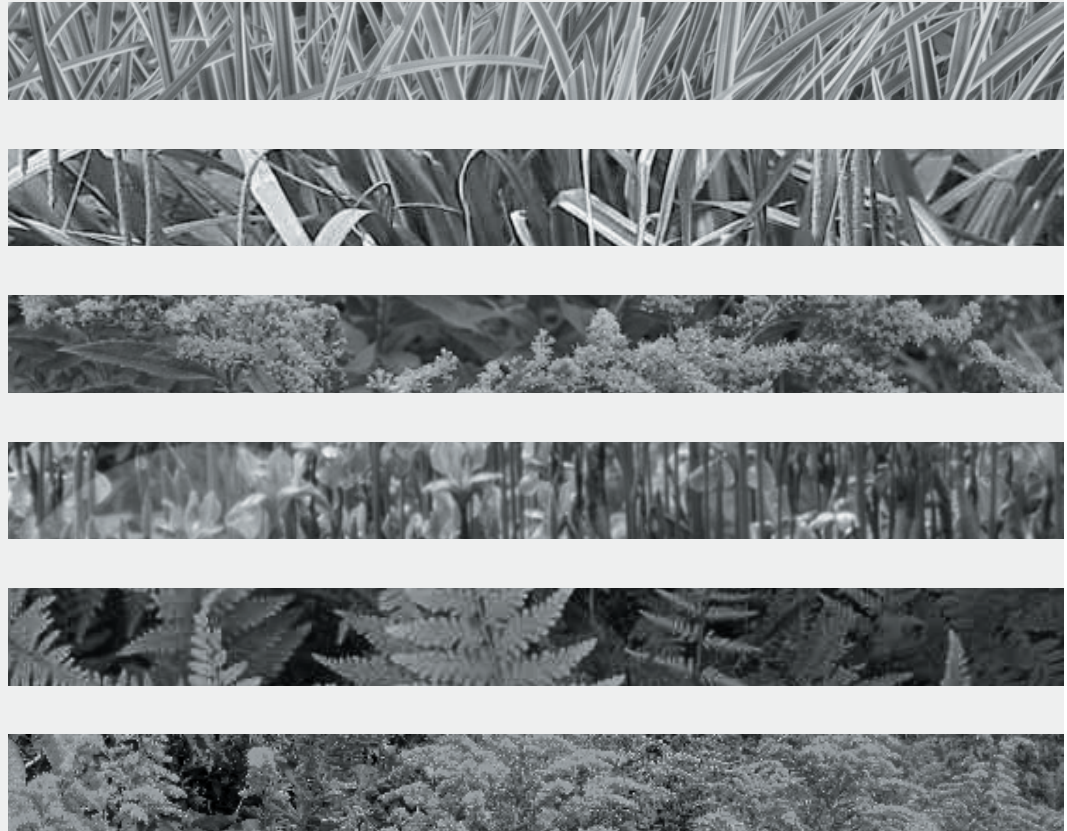
Rooftops

In regards to the water incoming from rooftops, the primary concern is accumulated pollution and bacteria from decomposed insects and animal droppings. To address this, pipe and gutter systems from buildings on the west side of the street plug directly into the system: water splashes out of copper downspouts and into reed beds that connect to the waterway. Every one or two buildings plug into one reed bed, depending on building size. The water from the east side rooftops is filtered by the bioswales bordering the waterway.

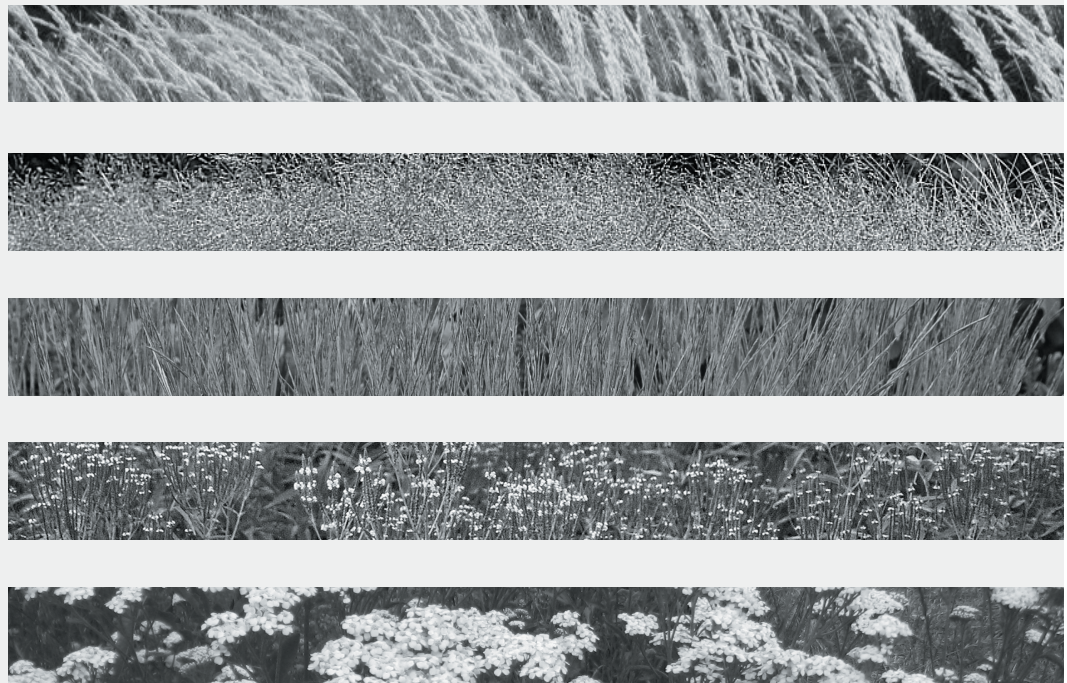
The reed beds used in this thesis are subsurface flow, which means the water level and clean water outflow is below the ground surface level. The vegetation is rooted below ground and emerges above the waters surface, and thus is visible from the street. Subsurface flow was chosen because it is more effective for smaller

37 Ibid., 17.

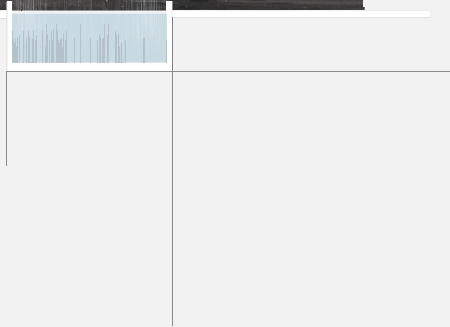
38 dlandstudio, "HOLD system: Flushing Bay," from *dlandstudio: architecture and landscape architecture pllc*, 2014, http://www.dlandstudio.com/projects_holds_flushing.html.



Bioswale planting sample (for heavy metal accumulation), from top: *Carex ice dance*, *Carex pendula*, *Solidago sempervirens*, *Iris*, *Athyrium filix-femina*, *Solidago hispida*.



Bioswale planting sample (for hydrocarbon accumulation), from top: *Calamagrostis x acutiflora*, *Panicum virgatum*, *Schizachyrium scoparium nash*, *Verbena hastata*, *Achillea millefolium*.



Rooftops to reedbeds: sectional study.

wetlands, and is thought to treat storm water faster than surface flow.³⁹ It is important to note that the water level within a reed bed must be maintained as water level fluctuations can kill the plants. In the case of this project, this is possible using a dyke system similar to that used in the acadian dykes discussed earlier, which allow water to remain within the small wetland and only flow out when the water level is high enough.

Usage

At the programmatic points along the waterway, water is filtered more intensively through a layered filtration system in order to be used by the public; this includes a preliminary screening, sand filtration and disinfection. The preliminary screening allows sediment and garbage to settle before the water enters the sand filter. Water is drawn through sand and gravel using gravity. Before entering the storage cistern, water is disinfected, and clean water enters the cistern through a check valve, the same as the one used in the reed beds, as long as it isn't at capacity.

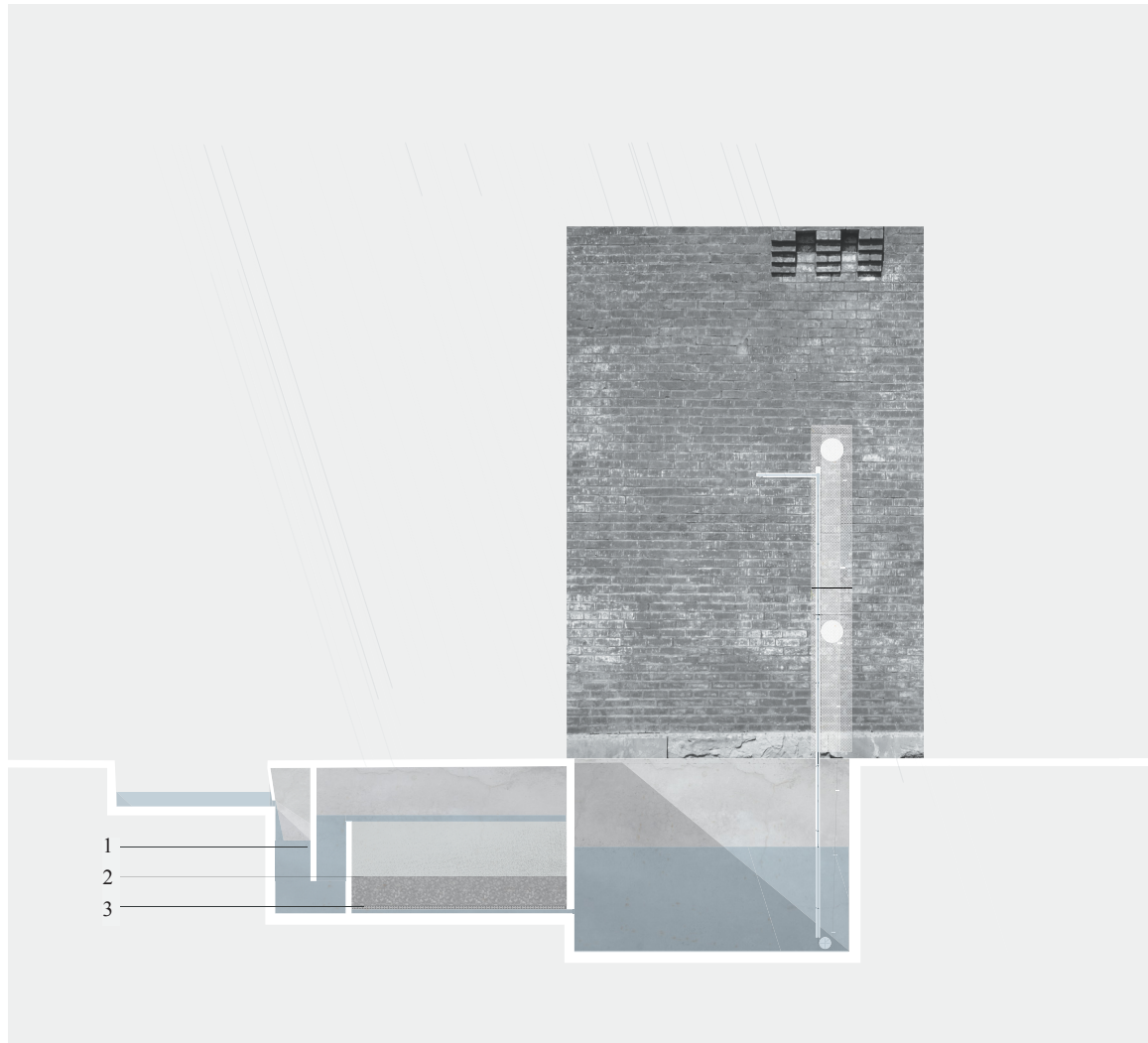
Sweet and Salt

The topography of the street slopes towards the middle, where Main St. met False Creek before the land was infilled. At this point, the system changes to reflect the productive landscape that once existed here, and to route the water towards the ocean.

Using the land's natural slope, the water enters the ocean from two points; the water coming from the North (Chinatown and Hastings) enters False Creek by way of National Ave., and the water coming from the South (Mount Pleasant) enters by way of Terminal Ave. These two streets straddle Vancouver's Science World, adding an educational element to the waterway, which tells the story of the city and of the water cycle itself.

As the final moment in the system, both Terminal and National Avenues are taken over for one block and become public squares that naturally integrate water

³⁹ Jurries, "BIOFILTERS (Bioswales, Vegetative Buffers, & Constructed Wetlands) For Storm Water Discharge Pollution Removal," 39.

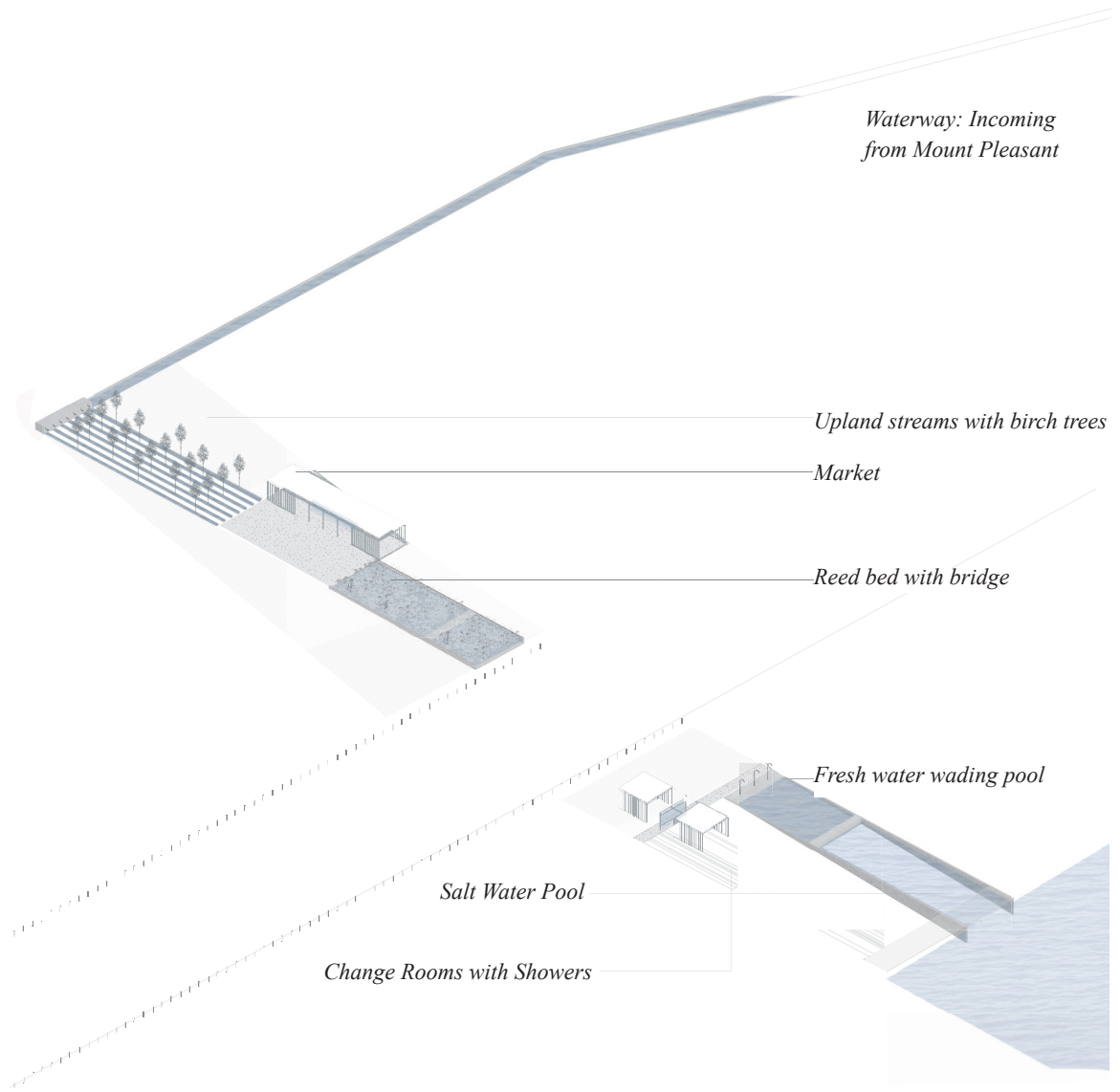


- 1. Screening and Sedimentation*
- 2. Sand and Gravel*
- 3. Disinfection*

Storage and use: sectional study through layered filtration system.

cycles, people and their activities. These two sites reflect one another, and each is divided into three areas: The first is an upland area, containing a dense grouping of small canals and a grove of birch trees. The second is a recreated fresh water marsh: a contained reed bed, traversed with bridges. Finally, a series of two wading pools allow the rain water to flow into the ocean again. The first is the shallowest: it fills with filtered rain water, which overflows into the second which is open to the sea. where fresh and salt water meet.

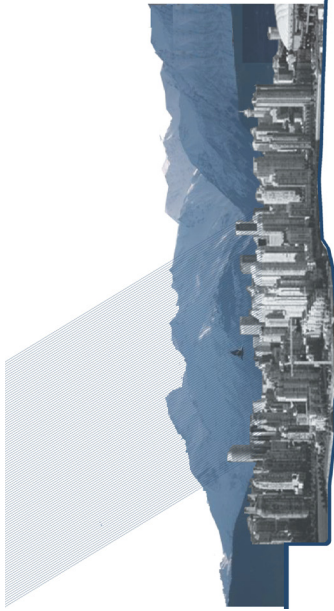
The site also contains two more programmatic water elements: a covered market and showers for the pools.



Waterway meeting False Creek: Terminal and Main.



Section through market: skytrain, birch trees and canals are visible in the background.

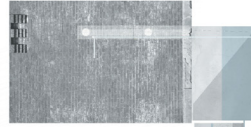


Rain falls on the city

Rain from rooftops is channeled into reed beds



Rain from the street is filtered and collects in the waterway

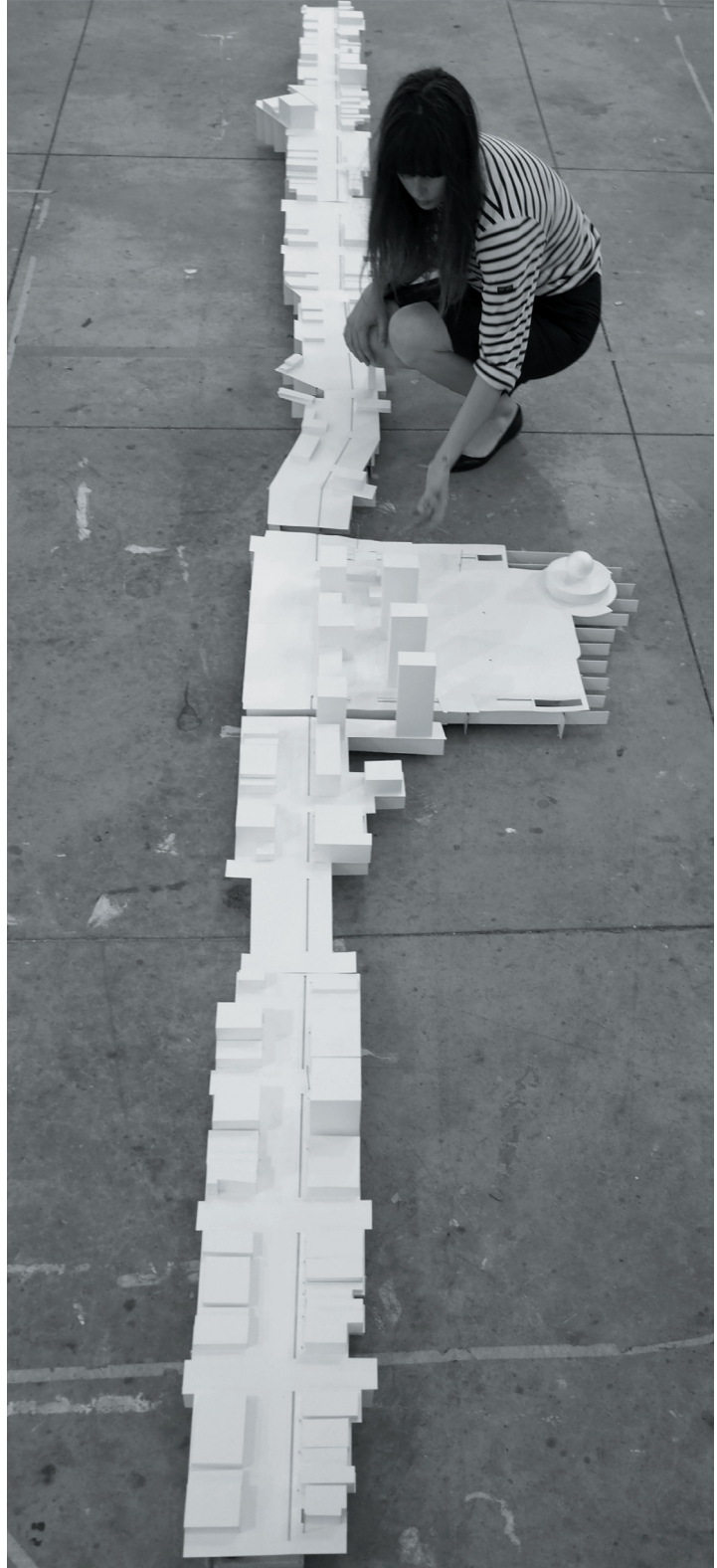


Clean water is stored for use

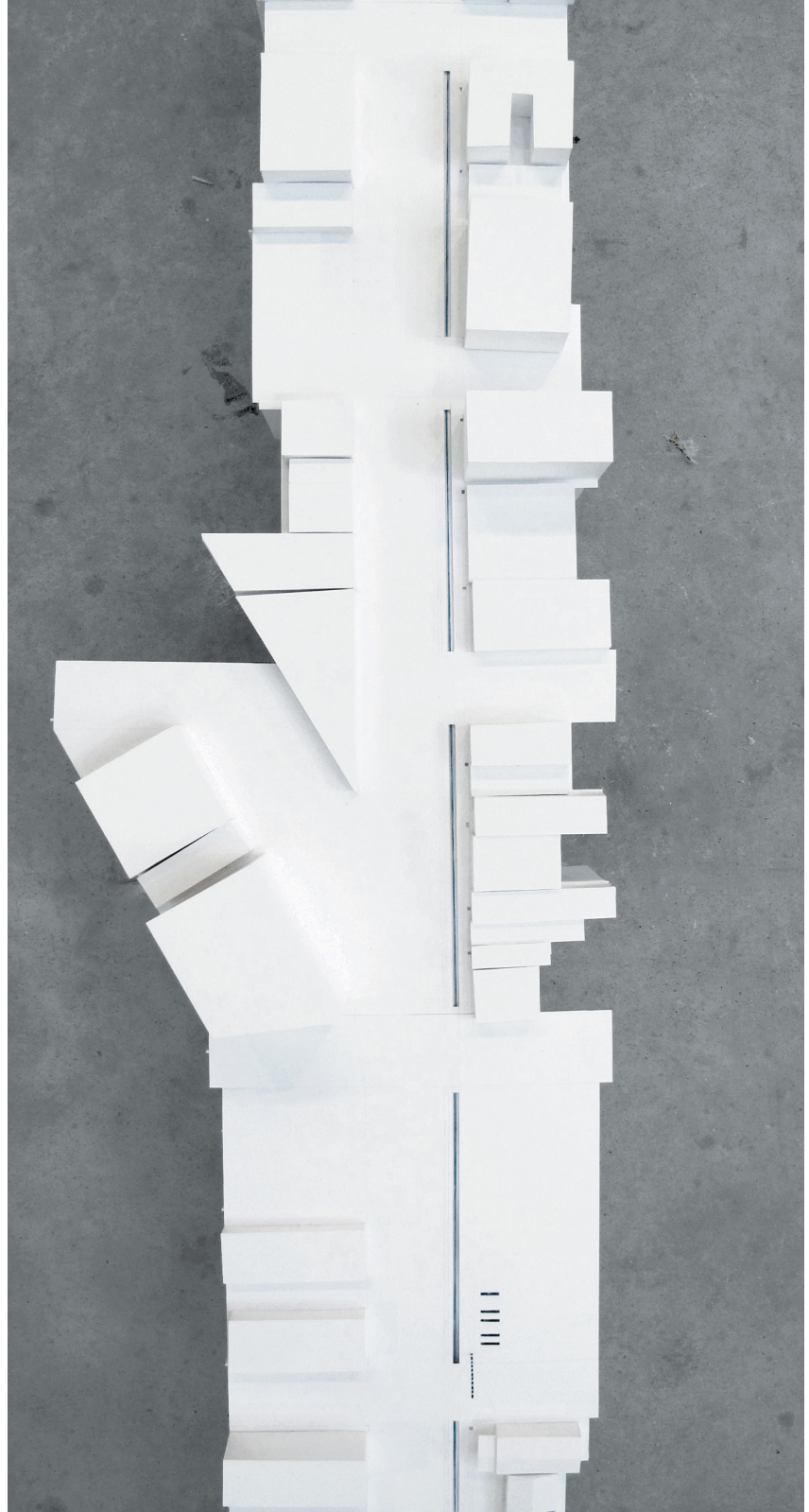


Unused, filtered water is returned to the ocean.

Proposed water cycle



Site model, 1:500, showing length of street, waterway and relationship between sites.



Detail of site model, 6th Ave. to 10th Ave., washing station is visible.

CHAPTER 3: CONCLUSION

This thesis provides a model for the integration of a new storm water infrastructure into the social fabric of the city. It incorporates strategies on various scales, including the greater city system (flows), the civic scale (public green spaces), and the community scale (individual use). Users are connected to water, landscape, climate, flows and surrounding neighbourhoods.

Water flows occur using natural topography and sloping street cross sections. Clean water is generated through various filtration techniques, including sand filters, reed beds and bioswales. Water use is made possible by water storage cisterns, programmatic devices, integrated public spaces, and community efforts.

The study represents an intersection between several broader issues, including (1) *cities and infrastructure*, (2) *climate change*, especially its effects on water supply and (3) *urban nature*, in regards to green spaces and porosity (4) *urban identity*, in regards to rapid development and historic neighbourhoods. The infrastructure not only deals with the increasing flows of water brought along by climate change, but allows for the use of and interaction with rainwater and provides a network of public spaces along its path. It responds to the issue of urban identity by within itself creating something that responds to the surrounding landscape and climate, as well as programmatic elements that vary depending on neighbourhood requirements. The matter of urban nature is addressed throughout the length of the waterway's course, in its performance as a green corridor.

Challenges and Future Implications

Although examples have been given within this thesis, built hybrid, infrastructural designs are uncommon, with most projects existing solely as proposals. Working outside the standard design boundaries within a realm currently considered as engineering, a lack of modern precedents, and complexity of program make it difficult to gain public acceptance and to insert new ideas into our existing urban fabrics.

Phasing is a response to some of these challenges. In the case of this thesis, site selection, which considered topography, connection to ocean and street type, left six site possibilities in addition to Main St.: Granville St., Carrall St., Terminal Ave., Denman St., Cambie St., and Glen Dr.. Main St. is offered as the first test for the city, but the aspiration is for it to be part of a greater system of ‘water boulevards.’ Other streets could apply the methods demonstrated in this thesis for flow, filtration and storage, but practice alternative water use according to neighbourhood demands. Main St. itself could be incrementally developed by beginning with the Hastings St. to National Avenue area and then Terminal to 12th Avenue.

In response to the challenges of working across the disciplines of architecture, landscape and engineering: the obvious solution is to work together and understand what each individual has to offer. In doing so, we will be able to build precedents that demonstrate a more integrated approach towards our cities’ infrastructure and landscapes. In the case of this thesis, speaking to engineers and individuals with knowledge of watersheds and GIS, helped me to gain critical knowledge I may not have been able to find myself.



Image of presentation for thesis defence, July 2014.

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