RR-2

CITY OF VANCOUVER

ADMINISTRATIVE REPORT

Report Date:	March 30, 2016
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Meeting Date:	April 19, 2016

TO: Vancouver City Council

FROM: General Manager of Engineering Services

SUBJECT: Rainwater Management Plan and Green Infrastructure Strategy

RECOMMENDATION

A. THAT Council adopt the long-term target to capture and treat 90% of Vancouver's average annual rainfall through the implementation of green infrastructure (GI) on public and private property throughout the City.

B. THAT Council support the Green Infrastructure tools of the City-Wide Integrated Rainwater Management Plan, included in Appendix A.

C. THAT Council support the creation of a Green Infrastructure Team to develop a Green Infrastructure Implementation Plan, including interim targets and milestones.

D. THAT Council approve a multi-year capital project budget up to $1.5 million; source of funding to be $0.75 million from City-Wide Emerging Priorities in the 2015-2018 Capital Plan and $0.75 million from Utilities borrowing authority, to be added to the 2015-18 Capital. The 2016 expenditures will be managed within the overall approved annual Capital Expenditure Budget.

E. THAT staff report back to Council with an implementation plan update by December 2017.

REPORT SUMMARY

The purpose of this report is to present the outcomes of the City-Wide Integrated Rainwater Management Plan (IRMP) (Appendix A), which is the culmination of over two-years of technical analysis, stakeholder workshops and best management practice review. The IRMP, which is a regulatory requirement of the Province, provides a long-term Green Infrastructure Strategy to protect and improve water quality in the waterbodies surrounding Vancouver. This report seeks Council endorsement of the IRMP target and the support of green infrastructure tools that will inform public and private property infrastructure requirements and design guidelines. The report also seeks Council support for the creation of a Green Infrastructure Team to develop an Implementation Plan with interim targets and milestones toward the long-term target. Implementation of green infrastructure will improve water quality to protect the environment, support recreational water use, and meet current and emerging regulatory requirements.

COUNCIL AUTHORITY/PREVIOUS DECISIONS

In 2010 the Province approved the Integrated Liquid Waste and Resource Management Plan (ILWRMP), for the protection of public health and the environment, which sets goals and actions for Metro Vancouver and its member municipalities. Integrated Stormwater Management Plans (also called Rainwater Management Plans) are a regulatory requirement of the ILWRMP.

In 2011 the Greenest City 2020 Action Plan (GCAP) set goals toward a healthy, prosperous and resilient future for the City. GCAP Goal 8 - Clean Water- strives to have the best water in the world, which applies to both drinking water and overall environmental water quality.

In 2012 the Climate Change Adaptation Strategy was adopted by Council to ensure that Vancouver remains livable and resilient in the face of climate change, including the increasing frequency and intensity of rain storms.

In 2014 the Healthy City Strategy was adopted by Council, providing a comprehensive and integrated plan for social sustainability that complements the environmental sustainability focus of the Greenest City Action Plan.

In 2016 the Park Board approved the Biodiversity Strategy to guide the Park Board’s ongoing work to protect, enhance and restore biodiversity throughout the park system, including the aquatic environment.

CITY MANAGER'S/GENERAL MANAGER'S COMMENTS

By investing in green infrastructure the City can proactively prepare for climate change impacts, improve resilience to storms, support biodiversity and ensure cleaner urban run-off to our surrounding water bodies. For years Vancouver has been a municipal pioneer in innovative green infrastructure, by using rain gardens and other natural features to capture and treat rainwater, thereby treating it as a resource rather than a nuisance. This innovation has often been through one-off pilots. By adopting an Integrated Rainwater Management Plan and developing a Green Infrastructure Implementation Plan, the City can use the lessons learned from pilot programs to ensure citywide adoption of green infrastructure best practices. The City Manager recommends adoption of the foregoing.

REPORT

Background/Context

In 2010 the Province adopted the Integrated Liquid Waste and Resource Management Plan (ILWRMP), which was prepared by Metro Vancouver and its member municipalities. Under the ILWRMP, municipalities are required to develop Integrated Stormwater (or Rainwater) Management Plans (ISMPs or IRMPs) for each watershed within their municipal boundaries, to protect the environment and public health from urban contaminant loading and rainfall impacts.

Vancouver has three watersheds subject to ISMPs. The Still Creek ISMP was completed in 2006 by Metro Vancouver, the City of Vancouver and the City of Burnaby, covering the Still Creek Watershed in Vancouver and Burnaby. The Musqueam Creek ISMP is underway in partnership with the Musqueam First Nation, covering the Musqueam Creek watershed in the southwest corner of Vancouver. The IRMP for the rest of the City is the subject of this report, which covers the City of Vancouver's built-out urban environment that drains directly to the ocean and the Fraser River. This City-wide IRMP report (contained in Appendix A) analyzes the issues and opportunities; defines the goals and target; and identifies programs, tools and adaptation actions customized to Vancouver's context and vision.

The underlying premise of rainwater management plans is that untreated urban runoff is a significant source of pollution that must be appropriately managed. Rainfall that lands on public and private urban spaces picks up pollutants including hydrocarbons, heavy metals, sediment, organics and fertilizers such as animal waste, and litter. Urban runoff conveys these pollutants through storm sewers to surrounding waterbodies such as Burrard Inlet, English Bay, False Creek and the Fraser River. Left untreated, these urban pollutants are detrimental to environmental health and reduce the recreational value of the marine environment.

Rainwater management plans lay out an overall strategy for utilizing green infrastructure to provide source-treatment of urban runoff, before it enters the traditional sewer system (which is often called "grey infrastructure"). Green infrastructure (GI) refers to a group of assets and devices on public and private property that capture rainwater and naturally treat or remove urban pollutants. Whenever possible, green infrastructure allows rainwater to infiltrate into the ground, restoring groundwater aquifers and reducing peak flows through sewer systems and urban creeks. Common examples of green infrastructure are rain gardens, permeable pavements, infiltration swales, and green roofs. The full suite of locally-applicable green infrastructure is outlined in the attached report.

"Green" and "Grey" Rainwater Infrastructure:

Green and grey infrastructure work together to provide a complete storm sewer system. Green infrastructure can capture and treat a significant portion of Vancouver's annual rainfall, but it is not practical to install large enough or adequate numbers of GI devices to handle the most intense rainstorms that constitute about 10% of our annual rainfall. These storms are handled by traditional grey infrastructure (catch-basins, pipes, curb-and-gutter systems, etc.), which is designed to safely convey these large flows and mitigate urban flooding. Conversely, grey infrastructure is very effective at flood prevention, but does not typically provide effective stormwater pollution prevention. Together, the two systems can provide a high level of environmental protection and flood prevention. As we experience climate change and changing rainfall patterns, green infrastructure working in conjunction with the piped storm network will provide better service levels across the rainfall spectrum now and into the future.

In Vancouver, green infrastructure will also help reduce combined sewer overflows (CSOs) and sanitary sewer backups in areas of the City where the sanitary and storm sewers have not yet been separated. The City was historically constructed with sewers that combine sanitary sewage and stormwater drainage, and send the combined flow to the treatment plant during dry weather or light rainfall. When the intensity of rainfall mixing with sewage in a combined sewer overcomes the capacity of the pipe, CSOs occur and diluted raw sewage is discharged to the environment. To meet our regulatory requirement to eliminate CSOs by 2050, the City has an established capital program to replace end-of-life combined sewers with a separated system of sanitary and storm sewers. The sewer separation program will eventually completely eliminate CSOs; until that time, the reduction in volume of stormwater reaching combined sewers will reduce the frequency, volume and impacts of CSOs.

<u>Existing Green Infrastructure Projects in Vancouver:</u>

For more than ten years, City staff have championed the implementation of public realm GI projects such as Country Lanes (2002-2004), the Crown Street sustainable street project (2006), Creekway Park (2013) and numerous rain gardens and infiltration bulges (2004+). Comprehensive green infrastructure plans were also developed at the neighbourhood scale for the Olympic Village in S.E. False Creek, and the River District (East Fraser Lands) development. Development of private property green infrastructure was stimulated by LEED Building requirements, and the Sustainable Large Development Policy which requires rainwater management plans for all development sites larger than 2 acres.

The above-noted projects, among others, have delivered world-class green infrastructure installations; however, without comprehensive policy, green infrastructure projects have mainly been staff-led pilot initiatives. Most GI projects in Vancouver were developed only when opportunities arose and resources were available, rather than an integral part of City capital programs or development requirements. The IRMP provides the basis to evolve from pilot projects to a performance-based City-wide GI strategy.

Rain Garden

Green Roof

Strategic Analysis

The IRMP sets forth the following vision, goals and targets:

Vision - Vancouver's abundant rainwater is celebrated as a resource:

- To maintain clean water from watersheds to receiving environments
- To reduce potable water demand
- To connect people to urban and natural ecosystem functions

The overall goal of the IRMP is that:

Goal - Vancouver is a city surrounded by Clean Water. This goal is achieved by:

- Reducing Combined Sewer Overflows (CSOs)
- Replacing combined sewers with separated storm and sanitary sewage systems
- Redirecting rainwater into natural pathways
- Allowing the piped drainage system to be resilient to climate change.
- Protecting water quality in our beaches, bays, rivers and groundwater
- Providing healthier landscapes and water conservation/drought tolerance
- Adding to biodiversity, environmental health and urban design diversity

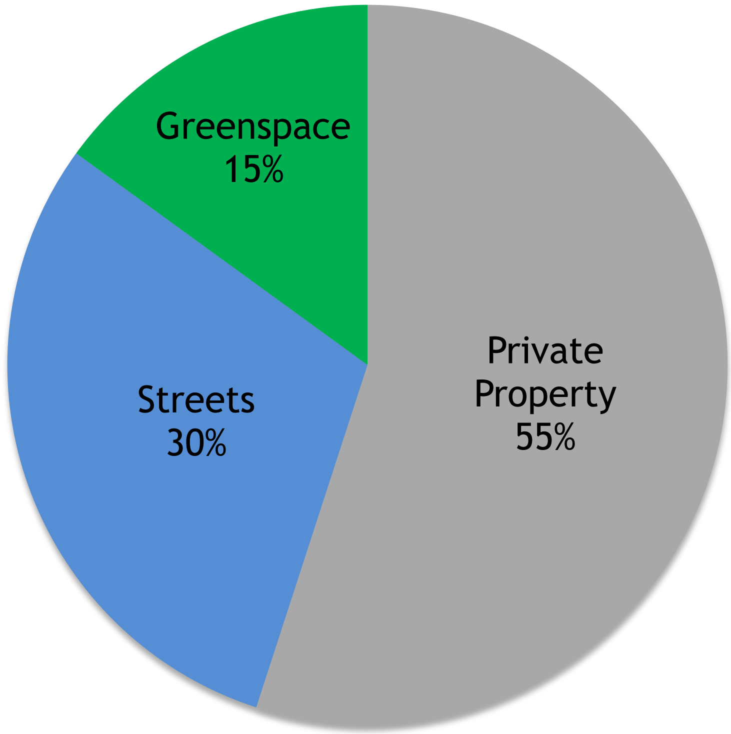
Through extensive analysis of Vancouver's current and projected rainfall patterns, soil types, land uses, and applicable GI tools, the IRMP has established the following long-term target:

Target - 90% of our annual average rainfall should be captured, infiltrated or treated, before discharge into our marine environment.

Only extreme storm events, which constitute approximately 10% of our annual rainfall, need to rely on direct conveyance in pipes, road-side gutters and overland flow paths to protect from flood damage, rather than first travelling through green infrastructure.

Application of Green Infrastructure to Various Land Uses Throughout the City:

The City of Vancouver is a fully urbanized environment in which historic streams were filled in and replaced with a piped sewer network and natural forests replaced with urban development and a road network. Approximately 55% of Vancouver's area is covered by development parcels subject to municipal regulations through by-laws, standards, and guidelines. These land uses vary from single family homes, to high rise condominiums, to industrial and commercial properties, all of which vary in permeability. Approximately 30% of the City's land mass is the municipal road network, which consists of local roads, lanes and arterial streets, all of which are highly impermeable. The remaining 15% are highly permeable greenspaces such as parks, golf courses and open spaces.



Breakdown of land uses in the City

The IRMP includes a best management practice toolkit to identify green infrastructure tools that can be applied to various land uses and ownership across the City. These tools include:

- Absorbent Landscapes
- Infiltration Swales
- Rains Gardens & Infiltration Bulges
- Pervious Paving
- Green Roofs
- Tree Well Structures
- Rainwater Harvesting
- Infiltration Trenches
- Water Quality Structures
- Detention Tanks
- Daylighted Streams
- Constructed Wetlands

Detailed information on each of these tools is included in the attached IRMP report.

Effective city-wide implementation of GI will require its application to all types of land uses and ownership. Green Infrastructure implementation will therefore require cross-departmental integration and coordination. Engineering, Planning & Development Services, Finance, Real Estate and Facilities Management, and Park Board staff will need to develop and implement collaborative processes to achieve the goal and meet the rainwater management target.

GI Strategy Implementation Planning:

To achieve the long-term goal and target of the Rainwater Management Plan, the Green Infrastructure Strategy will need to be planned through a focused and dedicated multi-departmental effort. A Green Infrastructure Team is required to develop the Implementation Plan. The Plan will detail how these tools and programs will be integrated into work programs; identify process changes and resource needs; evaluate capital and operating costs; and recommend implementation metrics.

Examples of new programs and revisions to existing policy are outlined below.

Private Property	Zoning & Development By-Law Amendments	Best Management Practices
	Vancouver Building By-Law Amendments	
	Urban Design Guidelines	
	Absorbent Sites Program	
Streets	Public Realm Design	
	Street Parking Treatment	
	Funding Strategy	
Greenspace	Parks & Open Space Design	
	Multi-Purpose Opportunities	

Funding strategies will be evaluated that take into account regulatory authority, capital investment needs, operating and maintenance requirements, and affordability. Among the options for review are growth-related capital funding sources, utilization of capital funding from relevant City programs, and the possibility of establishing drainage fees as a new funding source within the Sewer Utility. Financial analysis will also evaluate the potential cost savings achievable through GI, such as avoided flooding costs and deferred sewer separation.

As this is a cross-departmental initiative involving groups such as Engineering, Planning & Development Services, Finance and Park Board, the GI Team would include representatives from departments across the organization. The GI Team would report back to Council in 2017 with an Implementation Plan. While the implementation plan is developed, staff may bring forward components for Council consideration as was the case with the Urban Forest Strategy. The GI Team would also support the implementation of other plans such as the Biodiversity Strategy, Healthy City Strategy and Greenest City Action Plan.

Stakeholder Consultation

The Rainwater Management Plan was developed in consultation with over 20 local stakeholder representatives, environmental advocacy groups and an Intergovernmental Expert Panel (IEP) consisting of government agencies, First Nations and local jurisdictional authorities. Feedback and comments helped shape the vision, goal, target and tools contained within the IRMP.

IRMP information was provided to stakeholders through document packages, a City of Vancouver website and six topic specific workshops. Stakeholders that attended one or more of the workshops included the St. George Rainway Society, False Creek Watershed Society, Pacific Streamkeepers Foundation, Still Moon Arts Society, Evergreen, University of British Columbia, BCIT, Vancouver Coastal Health, Fraser Basin Council, Port Metro, Metro Vancouver, City of Burnaby and Tsleil-Watuth First Nation.

As part of the implementation plan, involvement with these stakeholders and the public through public engagement, advocacy and partnerships will continue as part of the implementation planning process.

Implications/Related Issues/Risk (if applicable)

Financial

Staff recommend a multi-year capital project budget up to $1.5 million to support the GI Team and the creation of the GI Implementation Plan.

The source of funding will be $0.75 million from City-Wide Emerging Priorities in the 2015-2018 Capital Plan and $0.75 million from Utilities borrowing authority, to be added to the 2015-18 Capital. Expenditures for 2016 are estimated to be $300,000 and will be managed within the overall approved annual Capital Expenditure Budget. The budget for the remaining expenditures will form part of the annual budget process for 2017.

The long term financial implications arising from the Green Infrastructure Strategy will be determined as part of the Implementation Plan and reported back to Council for consideration of ongoing funding options.

Environmental

One of the primary purposes of the Rainwater Management Plan is to improve and maintain water quality of receiving waterbodies surrounding the City, such as Coal Harbour, False Creek and the Fraser River. Urban pollutants carried by untreated rainwater runoff can cause environmental harm and limit recreational benefits. By adopting the long-term rainwater management target and implementing green infrastructure in the public and private realm, Vancouver can effectively manage rainwater pollutants in the urban environment.

Supporting salmon, aquatic ecosystems, waterfront enjoyment and beach swimming are all fundamental objectives of the IRMP, which are aligned with the GCAP Clean Water goal to have the best water in the world. Constructing green infrastructure in our urban environment also supports increased biodiversity and urban forest canopy coverage, which in turn will detain rainwater during extreme weather events. GI also mitigates the urban heat island effect as adding vegetation and green space can significantly cool surrounding areas.

Legal

Legal implications of the Green Infrastructure Strategy will be presented to Council when staff report back on the Green Infrastructure Implementation Strategy. These are anticipated to include various by-law changes, building code provisions, and funding tools.

Social

Some aspects of operations and maintenance associated with Green Infrastructure represent a new type of work currently not done by the City. Other North American jurisdictions have leveraged this new work to provide training and job opportunities for youth and other disadvantaged populations. These opportunities in Vancouver will be explored as part of the development of the GI Implementation Plan.

Other

Climate change has begun and is predicted to produce wetter winters, springs and autumns and drier summers in the Vancouver area. The piped stormwater system has been designed to handle peak flows from historical data that did not anticipate climate change. As we experience changing climate and rainfall patterns, green infrastructure working in conjunction with the piped storm network will provide better service levels across the rainfall spectrum now and into the future. Reduction in peak flows entering the piped stormwater system provides additional capacity to allow for climate-related changes in rainfall patterns.

CONCLUSION

The Rainwater Management Plan and Green Infrastructure Strategy identify that it is not only feasible to treat urban pollutants in rainwater runoff but in doing so, Vancouver can achieve long term environmental, recreational and social benefits. Green Infrastructure tools can not only achieve current and future water quality regulatory compliance and respond to the changing climate, but also support the goals and benefits in other City Strategies such as the Greenest City Action Plan, Climate Change Adaptation Strategy, Urban Forest Strategy and the Biodiversity Strategy.

As GI implementation will require long-term program changes to leverage redevelopment of the City’s public and private realms, the next step in the GI Strategy is to develop a holistic implementation plan that includes interim milestones and targets, phase-in strategies, and financial evaluation of proposed programs and funding models.

* * * * *



VOLUME I

Vision, Principles & Actions

FINAL DRAFT

Structure of the Citywide Integrated Rainwater Management Plan

The Citywide Integrated Rainwater Management Plan (IRMP) addresses areas of Vancouver where stormwater is piped directly to either combined sewer or ocean outfalls. Outside of the IRMP study area, two watersheds in Vancouver have remaining surface streams—Still Creek and Musqueam Creek—and are guided by their own integrated stormwater (rainwater) management plans, under separate cover. Stanley Park, which has surface streams, is also excluded from this study area.

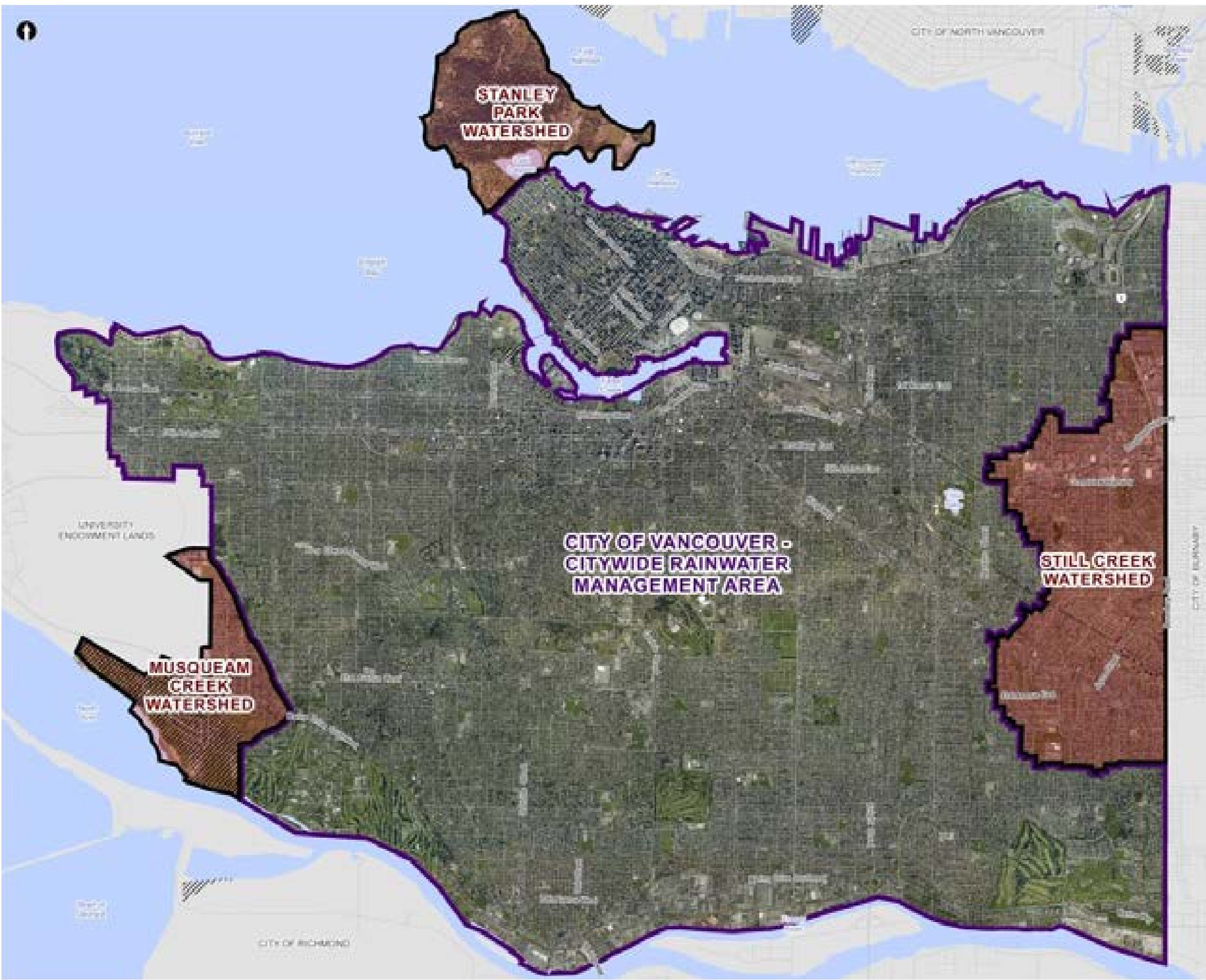
Credits

Prime Consultant/Author:
Golder Associates Ltd.

Subconsultants:
Kerr Wood Leidal Associates Ltd.
Lanarc 2015 Consultants Ltd.

March 2016

Figure I - 1: City of Vancouver - Citywide Rainwater Management Area



The Citywide Integrated Rainwater Management Plan is presented in three volumes:

I. **Vision, Principles and Actions** – a summary of why rainwater management is required, introduction to targets programs to address priorities. (this document)

II. **Best Practice Toolkit** – a guide to common tools to address rainwater management in Vancouver, highlighting their strengths and challenges.

III. **Technical Background Report** (internal) – a detailed record of process, stakeholder input, alternatives considered, technical and financial analysis, program details and action plan.

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VISION FOR THE CITYWIDE IRMP

Vancouver's abundant rainwater is celebrated as a resource:

- To maintain clean water from watersheds to receiving environments.
- To reduce potable water demand;
- To connect people to urban and natural ecosystem functions

1.0 WHY RAINWATER MANAGEMENT?

Links to the Greenest City Action Plan

The City of Vancouver is a leader in sustainability, with an enviable world reputation for innovation. Not resting on this success, the City has established the Greenest City Action Plan (GCAP), with the mission to become the greenest city on earth by the Year 2020.

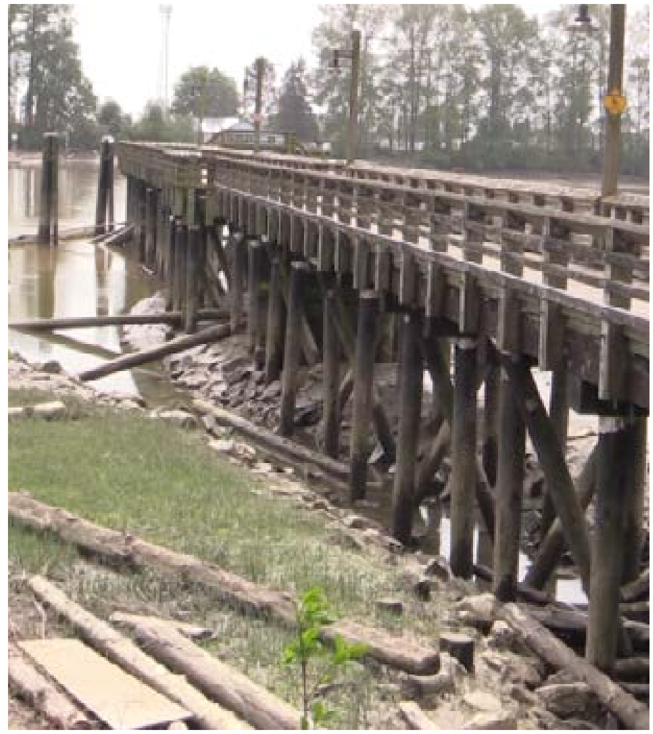
The three Integrated Stormwater (Rainwater) Management Plans Still, Musqueam and Citywide support the vision and goals of the Greenest City Action Plan. Rainwater management has a relationship with many aspects of GCAP, including:

- **Goal 1**: Green Economy
- **Goal 3**: Green Buildings
- **Goal 6:** Access to Nature
- **Goal 8**: Clean Water

The last Goal—Clean Water— could be refined in GCAP to include the quality of water being released to the environment, which is the primary target of the Citywide IRMP. The stormwater in City pipes flows to sensitive receiving waters including False Creek, Coal Harbour, beaches at English Bay, Kitsilano, Jericho and Spanish Banks, and to the sensitive fisheries of the Fraser River. Supporting salmon, aquatic ecosystems, waterfront enjoyment and beach swimming are all fundamental objectives of the Citywide IRMP.

Supporting Nature's Ecosystems

How the city is designed and operated has a direct effect on rainwater and runoff quality and quantity. Cumulatively, management of the city urban design determines the health of Vancouver's watersheds and receiving waters, including high habitat values along shorelines of the Fraser River, and recovering habitat in restored areas of the central city.



Urban Watershed Health is determined by Urban Design – example shown is Hinge Park and Fraser River in Vancouver.

Stormwater Source Controls, like these infiltration bulges in Vancouver streets, are part of Climate Change Adaptation green infrastructure.

Preparing for Climate Change and Severe Weather

Climate change is predicted to produce wetter winters, and dryer summers, in the Vancouver area. The city has also recently seen summer cloudbursts, which can lead to damage to buildings and utilities. Flooding occurs when intense rainfall overcome the piped system capacity, which has been designed to handle peak flows from historical data that did not anticipate climate change.

Rainwater Management should include actions that reduce impervious areas that create runoff, or redirect stormwater to areas where it can soak in or be stored. These 'stormwater source controls', as shown in the BMP Toolkit (IRMP Volume II), can play a significant role in maintaining water quality and reducing peak flows.

Reduction in peak flows in the piped stormwater system also provides additional capacity to allow for climate-related changes in rainfall patterns.

Rainwater Management should include actions that reduce impervious area, or redirect stormwater to areas where it can soak in or be stored.

Protecting Sensitive Waterbodies

MAINTAINING WATER QUALITY FOR BEACHES

A primary driver in rainwater management in Vancouver is to maintain the water quality of receiving waters. This is particularly important where receiving waters are sensitive, including areas with recreational use, such as beaches along Kitsilano, West End and Jericho, and in False Creek.

Urban stormwater includes many common pollutants: e.g. petroleum hydrocarbons and heavy metals from vehicles, sediment from construction sites, excess nutrients from fertilizer, and bacteria from organic waste. As untreated stormwater is redirected by pipe to the water bodies surrounding Vancouver, the quality of water in these receiving waters may decline compared to today, with potential for increased closures of swimming beaches.

Urban Runoff Carries Pollutants

Kitsilano Beach [cropped] by Christine Rondeau (CC BY 2.0)

MAINTAINING WATER QUALITY FOR RECREATION

Water quality is particularly important where receiving waters are confined, including areas with reduced dilution or dispersion of pollutants, such as False Creek or Coal Harbour.

> The IRMP and its action plan can help the people of Vancouver reconnect with the watersheds and ecosystems that support them, and connect socially, intellectually and spiritually with each other.

Reducing Combined Sewer Overflows

The volume of water that flows into City sewers is also an issue.

The City was constructed historically with sewers that combine sanitary sewage and stormwater drainage. Combined sewer overflows (CSOs) occur when the volume of rainfall mixing with sewage in the combined sewer overcomes the capacity of the pipe, with the overflow draining to receiving waters such as Burrard Inlet or English Bay.

The City has an established program to convert combined sewers into separated systems of sanitary sewers and storm drains. Already well underway, the program should be completed by Year 2050. When the sewer separation is complete, instead of stormwater currently piped to the regional wastewater treatment plants, there will be new flows of stormwater directly into tidal and estuarine receiving waters around the city.

Although the stormwater outflows will be significantly less polluting than existing combined sewer overflows, the water quality of stormwater remains a concern. Implementation of the best practices for stormwater source control treatment that are recommended in the Action Plan would reduce stormwater flows and improve stormwater quality to meet regional guidelines.

Until such time as separated sewers are completed, there will be continuing combined sewer overflows (CSOs) during periods of heavy rain. These CSOs have impacts on both beach swimming and ecosystems.

Reduction in the volume of stormwater reaching combined sewers in the interim period until sewer separation is complete will reduce the frequency, size and impacts of CSOs.

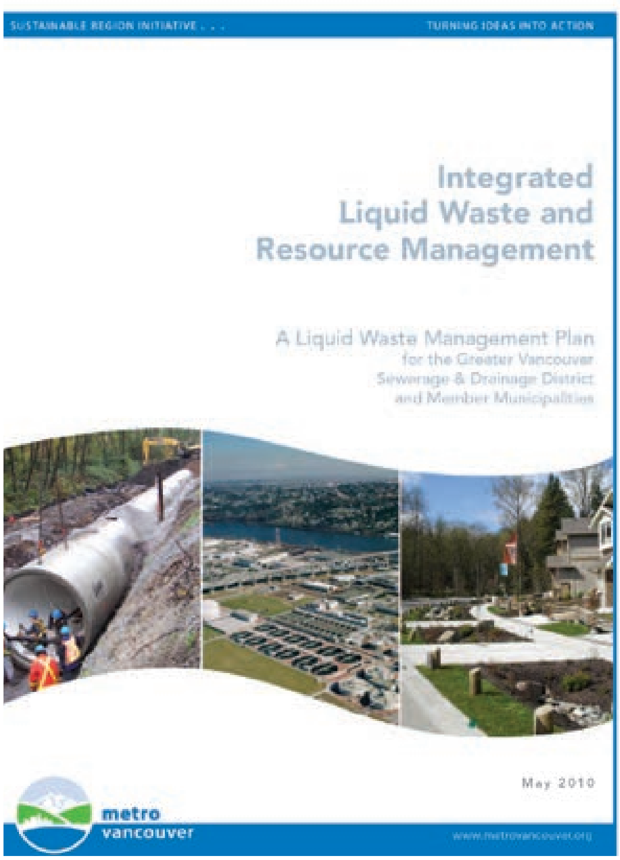
Fraser River and Marine Habitat is at Risk

Meeting Regulatory Requirements

The City needs to meet Water Quality Guidelines that are established under senior levels of government. Environment Canada establishes guidelines for water quality and urban runoff. Fisheries and Oceans Canada establishes requirements for protection of aquatic habitat. The Province of British Columbia, through BC Environment and the Ministry of Health, set and administer requirements for the protection of the environment and public health. These senior government requirements inform a region-specific implementation strategy through the Metro Vancouver Integrated Liquid Waste and Resource Management Plan (ILWRMP). The City of Vancouver and other members of Metro Vancouver are committed to creating and monitoring Integrated Stormwater Management Plans in response to these guidelines and regulations.

This Citywide Integrated Rainwater Management Plan (IRMP) is one of the City of Vancouver's responses to the ILWRMP requirements. The three volumes of the IRMP analyze the issues and opportunities, summarize stakeholder input, and identify programs, tools and adaptation actions customized to the Citywide context and vision.

These documents work together to also meet the needs of senior government regulators for certainty around Vancouver's commitment to sustainable development and redevelopment in its watersheds.



The Metro Vancouver Integrated Liquid Waste and Resource Management Plan provides a region-specific implementation strategy

Honouring Vancouver's Rainfall Resource

Vancouver's First Nations, and early European settlers, lived in economies that depended on the food and timber resources provided by the rainforest and shorelines. Over the 19th and early 20th centuries, Vancouver's development advanced with little regard for the watersheds and watercourses that dissected it. Most streams were culverted, and ravines were filled for development.

Today, only two watersheds remain with surface streams: Still Creek and Musqueam Creek. The City of Vancouver has already created an Integrated Stormwater Management Plan focused on restoration of Still Creek, and is seeing successful return of salmon to that system. The City and Musqueam First Nation are also starting a similar plan for the Musqueam Watershed, to steward and enhance its existing fish populations and biodiversity, as well as manage flooding risks.

The remainder of the city, where streams have been buried underground in pipes, is the subject of this **Citywide Integrated Rainwater Management Plan** (IRMP). The Citywide IRMP has similarities with the objectives and solutions in the Still and Musqueam watersheds, and other coastal BC IRMPs.

But the Citywide study area is also unique, in that all drainage within it is piped, and the entire area has fully developed urban conditions. Vancouver Citywide IRMP issues and solutions require a customized approach. Figure I - 1 on the inside cover illustrates the extent of the Citywide IRMP area.

Rain: Vancouver. The two seem inseparable. Vancouver's abundant rainfall is a key ingredient of its character—the foundation of its coastal forest ecosystems; a part of winter life living here.

Rain Umbrella 01 [cropped] by Al Safrata (CC BY-SA 3.0)

2.0 THE NATURE OF RAINFALL IN VANCOUVER

Rainfall Spectrum in Vancouver

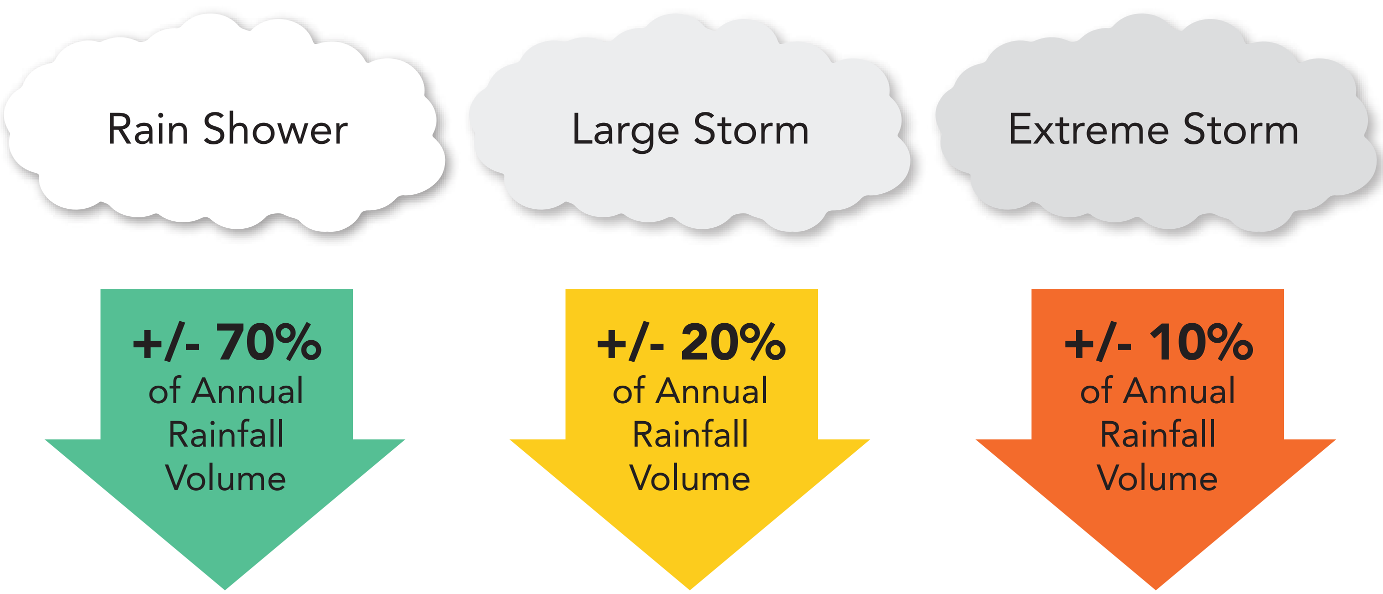
Rainwater Management requires an understanding of the rainfall spectrum.

In South Coast BC, including Vancouver, the great majority (+/-70%) of rainfall volume in an average year falls as light showers to small storms. A further +/-20% is large storms but within the average mean annual rainfall. Only +/-10% of the rainfall volume in an average year is extreme storms that might create widespread flooding. The rainfall distribution varies from year to year (+/-), but figure I - 2 represents averages.

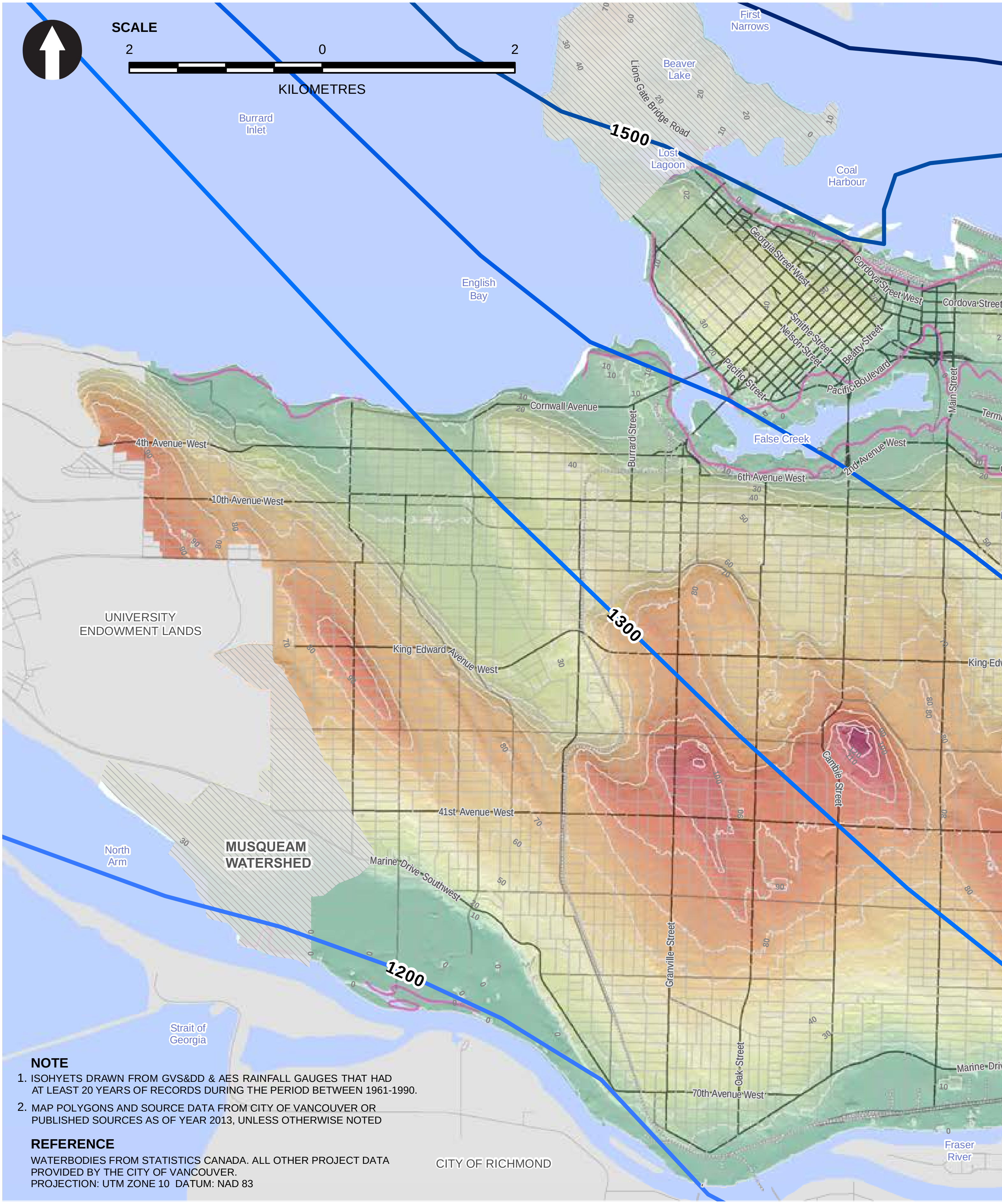
With this insight into rainfall characteristics, Rainwater Management in Vancouver can capture, through infiltration or reuse, the rainfall from drizzle and small storms. Both small and large storms—representing +/-90% of the average annual rainfall volume, can be treated using stormwater source controls (see Volume II) to improve water quality to Metro Vancouver's Monitoring and Adaptive Framework yellow or green standards.

For the rare extreme storm events, conveyance in roadside, gutters and other major overland flow paths is necessary to protect from flood damage.

Figure I - 2: Rainfall Spectrum



*adapted from BC Environment, Stormwater Planning: A Guidebook for British Columbia, 2002



NOTE

1. ISOHYETS DRAWN FROM GVS&DD & AES RAINFALL GAUGES THAT HAD AT LEAST 20 YEARS OF RECORDS DURING THE PERIOD BETWEEN 1961-1990.
2. MAP POLYGONS AND SOURCE DATA FROM CITY OF VANCOUVER OR PUBLISHED SOURCES AS OF YEAR 2013, UNLESS OTHERWISE NOTED

REFERENCE

WATERBODIES FROM STATISTICS CANADA. ALL OTHER PROJECT DATA PROVIDED BY THE CITY OF VANCOUVER.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

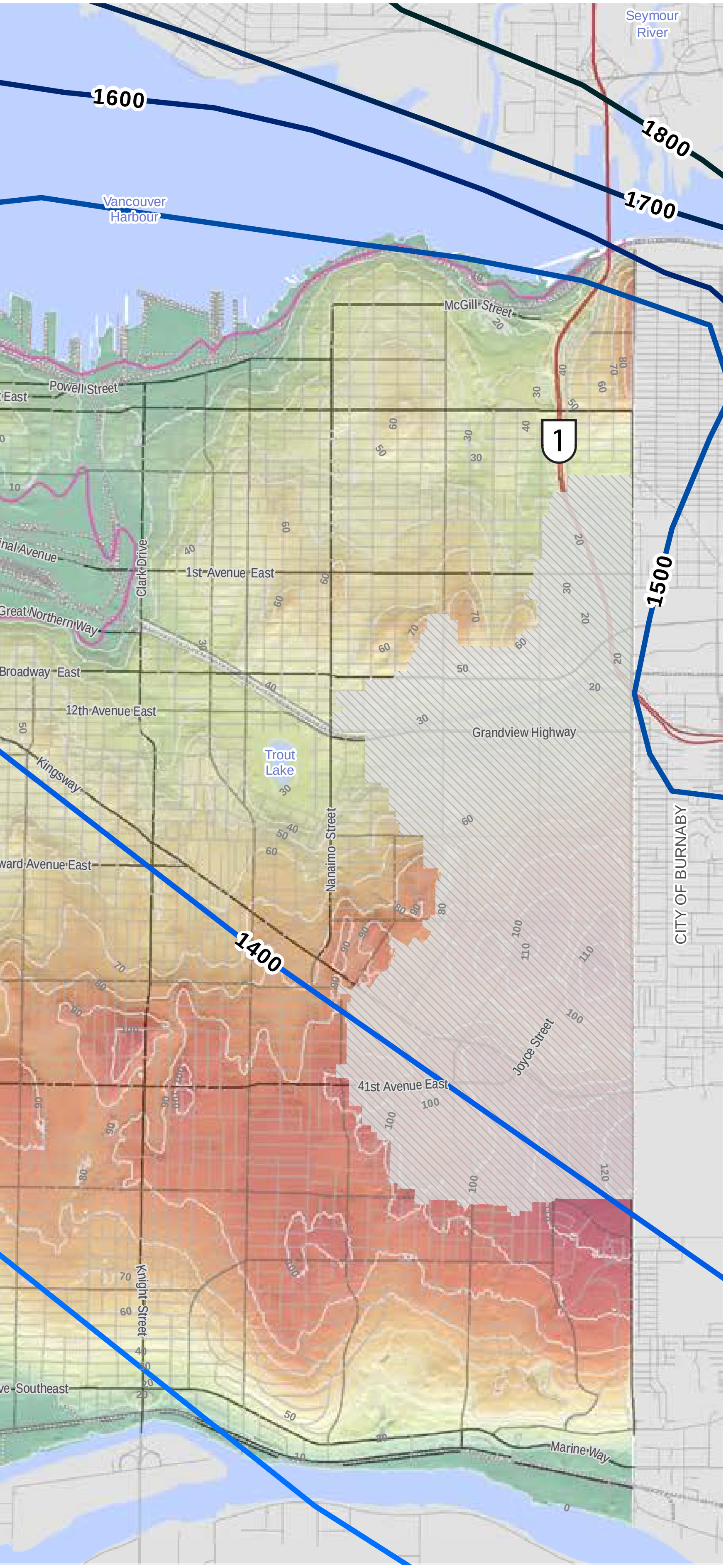


Figure I - 3:

Topography & Areas of Average Annual Precipitation

The pattern of rainfall in Vancouver is influenced by prevailing winds and the effect of the North Shore Mountains that force moisture-laden clouds to rise, cool, and therefore drop their rainfall.

Figure I - 3 shows the increase in average annual rainfall (AAR) from 1200mm AAR near the Fraser River up to 1500mm AAR at Burrard Inlet shoreline. The variation in rainfall and the pattern of drainage to receiving waters may influence sizing of stormwater infrastructure, and priorities for action.

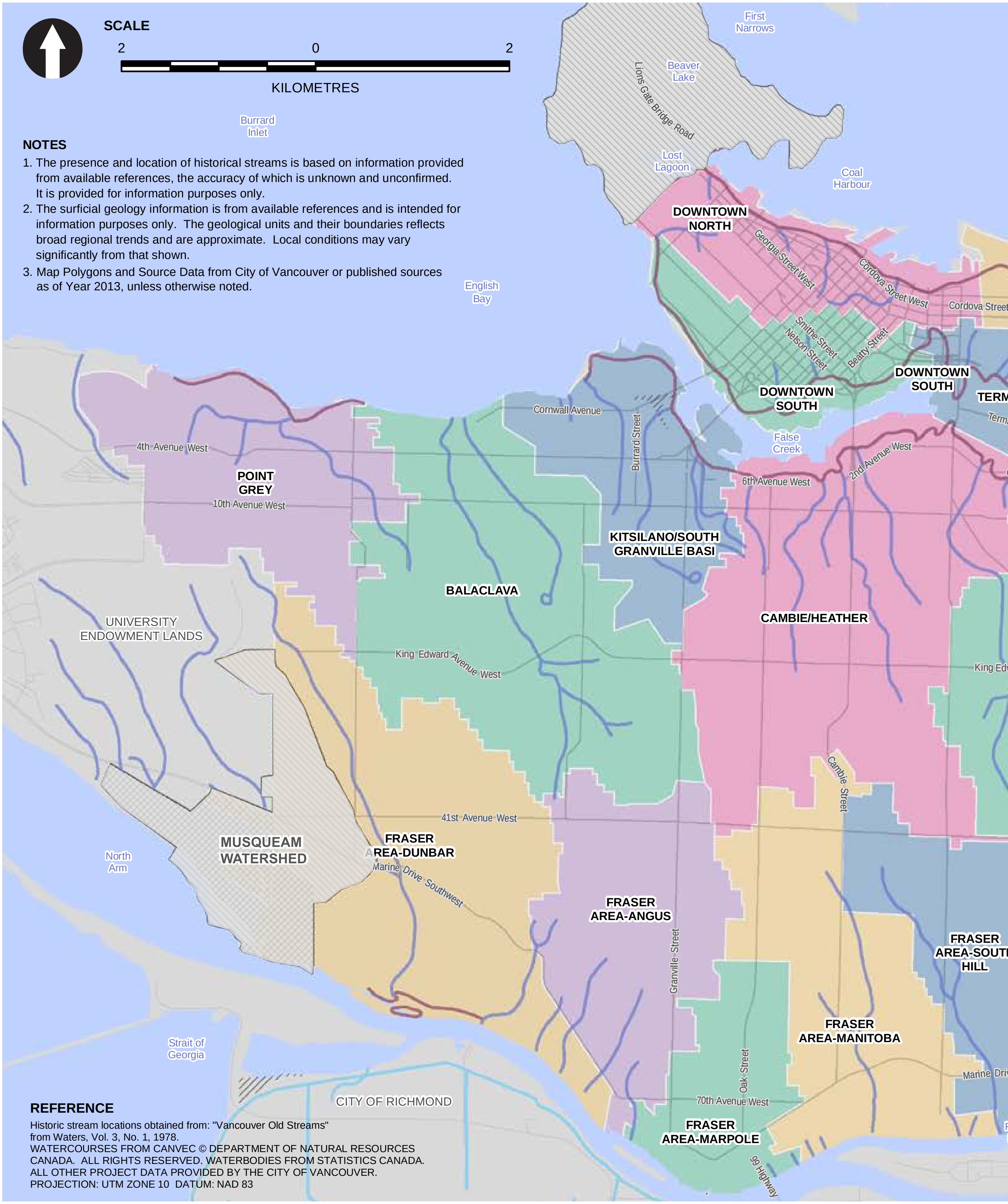
LEGEND

- AREA EXCLUDED FROM STUDY
- HISTORIC SHORELINE
- HIGHWAY
- ARTERIAL ROAD
- SECONDARY ARTERIAL AND COLLECTOR ROAD
- RESIDENTIAL, LEASED AND CLOSED STREET
- RAILWAY
- ELEVATION CONTOUR (10m)
- AVERAGE ANNUAL PRECIPITATION BANDS - ISOHYETS (mm)

ELEVATION (m)

125

0


SCALE
2
0
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KILOMETRES
NOTES
1. The presence and location of historical streams is based on information provided from available references, the accuracy of which is unknown and unconfirmed. It is provided for information purposes only.
2. The surficial geology information is from available references and is intended for information purposes only. The geological units and their boundaries reflects broad regional trends and are approximate. Local conditions may vary significantly from that shown.
3. Map Polygons and Source Data from City of Vancouver or published sources as of Year 2013, unless otherwise noted.
First Narrows
Beaver Lake
Lions Gate Bridge Road
Lost Lagoon
Coal Harbour
Burrard Inlet
English Bay
DOWNTOWN NORTH
Georgia Street West
Cordova Street West
Cordova Street
Smithe Street
Nelson Street
Beatty Street
DOWNTOWN SOUTH
DOWNTOWN SOUTH
TERM
Term
Cornwall Avenue
Burrard Street
False Creek
2nd Avenue West
6th Avenue West
4th Avenue West
POINT GREY
10th Avenue West
KITSILANO/SOUTH GRANVILLE BASI
BALACLAVA
CAMBIE/HEATHER
UNIVERSITY ENDOWMENT LANDS
King Edward Avenue West
King Edw
Cambie Street
41st Avenue West
MUSQUEAM WATERSHED
FRASER AREA-DUNBAR
Marine Drive Southwest
North Arm
FRASER AREA-ANGUS
Granville Street
FRASER AREA-SOUTH HILL
FRASER AREA-MANITOBA
Strait of Georgia
Oak Street
Marine Dri
CITY OF RICHMOND
70th Avenue West
FRASER AREA-MARPOLE
90 Highway
REFERENCE
Historic stream locations obtained from: "Vancouver Old Streams" from Waters, Vol. 3, No. 1, 1978.
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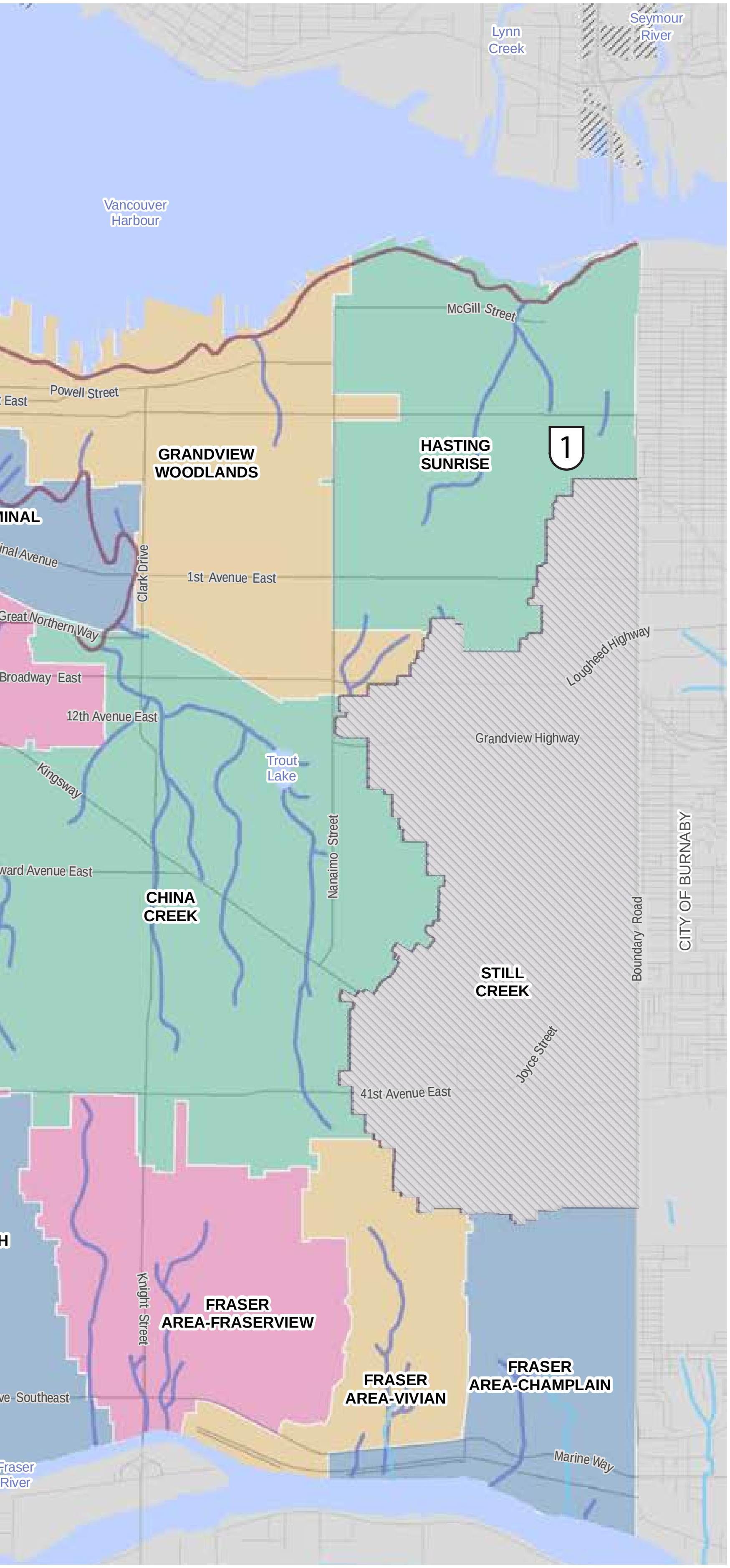
Figure I - 4:

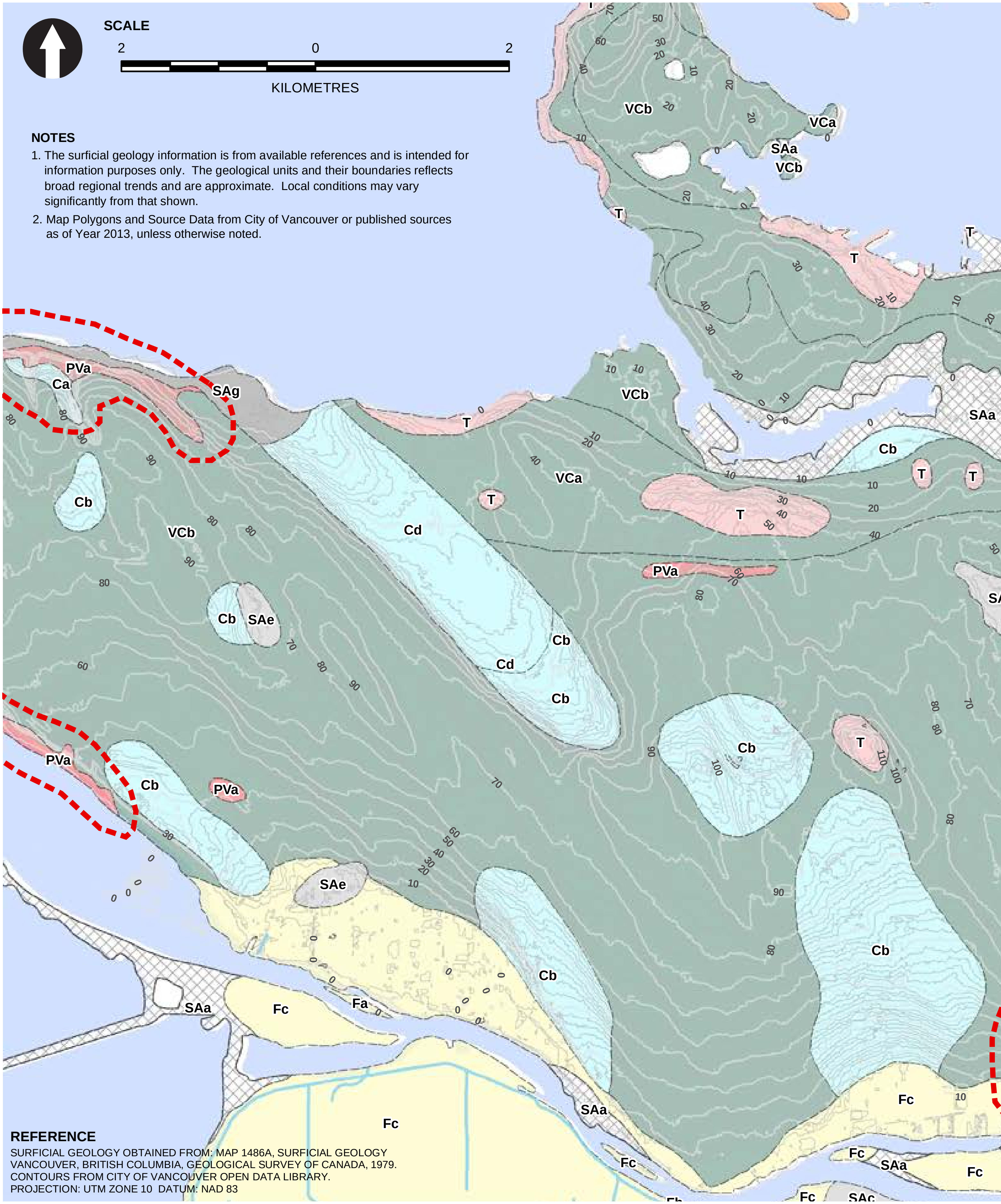
Historical Stream Locations

In the Citywide study area, all of the historical streams shown conceptually on Figure I-4 have been piped and filled. The remaining surface streams and their watersheds (Still and Musqueam) outside the Citywide Study Area are identified. Stanley Park also has surface watercourses, and is outside the study area.



LEGEND

- STORMWATER CATCHMENT AREA (NAME)
- AREA EXCLUDED FROM STUDY
- ROAD
- HISTORIC HIGH WATER MARK
- HISTORICAL STREAM



NOTES

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2. Map Polygons and Source Data from City of Vancouver or published sources as of Year 2013, unless otherwise noted.

REFERENCE

SURFICIAL GEOLOGY OBTAINED FROM: MAP 1486A, SURFICIAL GEOLOGY VANCOUVER, BRITISH COLUMBIA, GEOLOGICAL SURVEY OF CANADA, 1979.
CONTOURS FROM CITY OF VANCOUVER OPEN DATA LIBRARY.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

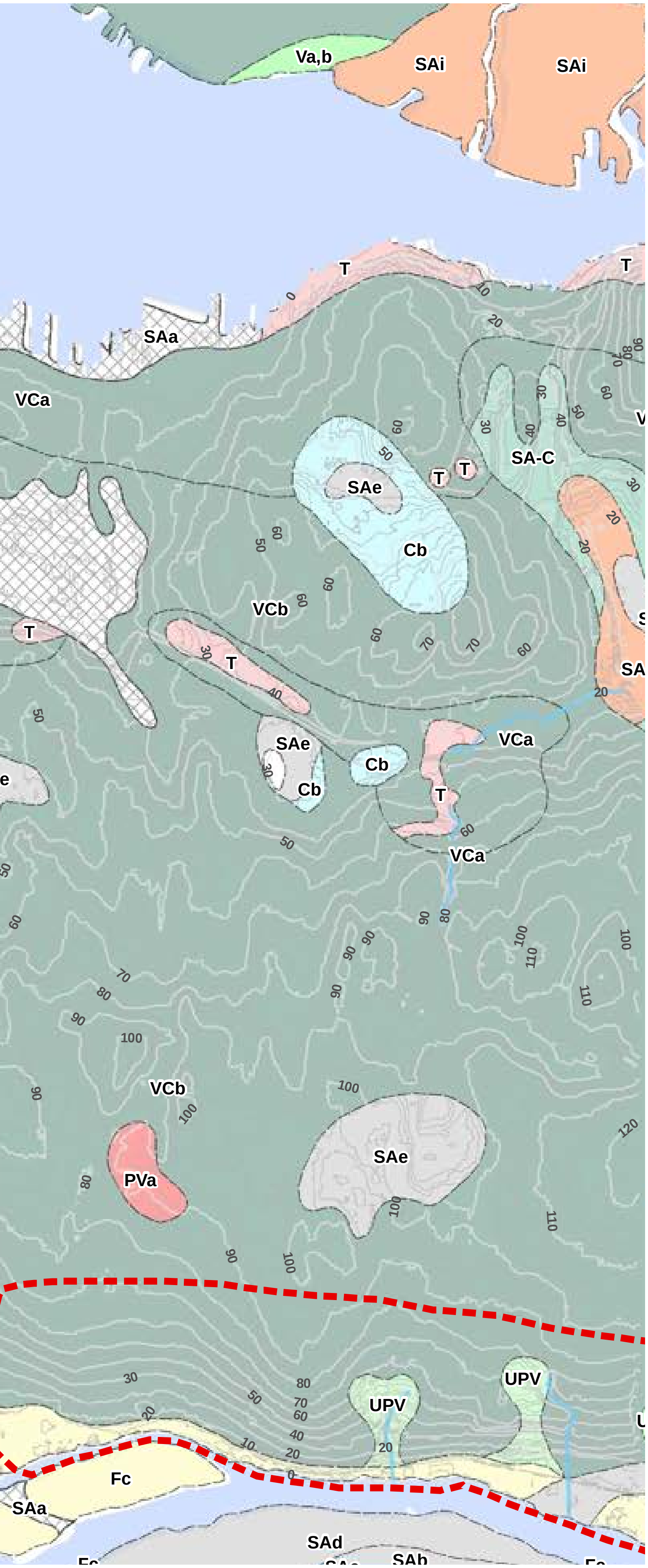


Figure I - 5:

Our Geology and Soils

Figure I - 5 provides general information on the ground conditions (surficial geology) that underlay the City. The City geology has been influenced by glaciers, leaving subsoils that are highly variable. See figure I - 6 for a summary of predominate infiltration potential.

Landfill has also been a significant part of the City history – including major fill areas along Burrard Inlet and at False Creek. Limited areas of the City have steep slopes which could be made less stable by increased groundwater.

LEGEND

SPECIAL INVESTIGATION AREAS - SLOPE STABILITY RISK

WATERCOURSE

ELEVATION CONTOUR (10m)

ELEVATION CONTOUR (2m)

QUATERNARY

POSTGLACIAL

SALISH SEDIMENTS

SAa — Landfill including sand, gravel, till, crushed stone, and refuse

SAb-e — Bog, swamp, and shallow lake deposits: SAb, lowland peat up to 8 m thick overlying Fb,c; SAc, lowland peat up to 1 m thick, underlying Fb (up to 2 m thick); SAd, organic-rich sandy loam to clay loam 15 to 45 cm thick overlying Fd; SAe, upland peat up to 8 m or more thick overlying VC units

SAf,g — Marine shore sediments (beach deposits): SAf, sand to sandy loam up to 2 m thick overlying Fe; SAg, sand to gravel up to 8 m thick

SAh-j — Lowland and mountain stream deltaic, channel fill, and overbank sediments: SAh, lowland stream channel fill and overbank sandy loam to clay loam, also organic sediments: up to 8 m thick; SAi, mountain stream marine deltaic medium to coarse gravel and minor sand up to 15 m or more thick. SAj, mountain stream channel fill sand to gravel up to 8 m thick

FRASER RIVER SEDIMENTS

Fa-e — Deltaic and distributary channel fill sediments overlying and cutting estuarine sediments and overlain in much of the area by overbank sediments: Fa, channel deposits, fine to medium sand and minor silt occurring along present day river channels; Fb, overbank sandy to silt loam normally less than 2 m thick overlying 15 m or more of Fd; Fc, overbank silty to silt clay loam normally less than 2 m thick overlying 15 m or more of Fd; Fd*, deltaic and distributary channel fill (includes tidal flat deposits), 10 to 25 m interbedded fine to medium sand and minor silt beds; may contain organic and fossiliferous material; Fe*, estuarine, fossiliferous, interbedded fine sand to clayey silt (sand content increases from bottom to top of sequence), 10 to 185 m thick

POSTGLACIAL AND PLEISTOCENE

SA-C — Marine shore and fluvial sand up to 8 m thick, Cb in part has been reworked and redeposited by lowland streams (SAh)

PLEISTOCENE

CAPILANO SEDIMENTS

Ca-d — Raised marine, deltaic, and fluvial deposits: Ca, raised marine beach, spit, bar, and lag veneer, poorly sorted sand to gravel (except in bar deposits) up to 10 m thick mantling older sediments and containing fossil marine shell casts up to 175 m above sea level; Cb, raised beach medium to coarse sand 1 to 5 m thick; Cc, raised deltaic and channel fill medium sand to cobble gravel up to 15 m thick deposited by proglacial streams and commonly underlain by silty to silty clay loam; Cd, marine and glaciomarine stony (including till-like deposits) to stoneless silt loam to clay loam with minor sand and silt, normally less than 3 m thick but up to 10 m thick in upland areas

VASHON DRIFT AND CAPILANO SEDIMENTS

VCa,b — Glacial drift including; lodgment and minor flow till, lenses and interbeds of substratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt; up to 25 m thick; in most places correlated with Va,b; overlain by glaciomarine and marine deposits similar to Cd, normally less than 3 m but in places up to 10 m thick. Marine derived (Ca) lag gravel normally less than 1 m thick containing marine shell casts has been found mantling till and glaciomarine deposits up to 175 m above sea level; above 175 m till is mantled by bouldery gravel that may be in part ablation till, in part colluvium, and in part marine. VCa, bedrock within 10 m or less of the surface; VCb, bedrock more than 10 m below surface

VASHON DRIFT

Va,b — Till, glaciofluvial, glaciolacustrine, and ice-contact deposits: Va, lodgment till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silts; Vb, glaciofluvial sandy gravel and gravelly sand outwash and ice-contact deposits

PRE-VASHON DEPOSITS

PVa,b,e-h — Pre-Vashon glacial, nonglacial, and glaciomarine sediments: PVa, Quadra fluvial channel fill and floodplain deposits, crossbedded sand containing minor silt and gravel lenses and interbeds; PVb, Quadra deltaic deposits and crossbedded sand and gravel; PVe, Cowichan Head organic sediments; PVf, Semiahmoo glaciomarine, glaciofluvial sediments and till; PVG, Highbury fluvial, marine, and bog and swamp deposits; PVh, Westlynn till and glaciomarine stony silty clay loam

UNDIVIDED PRE-VASHON DEPOSITS

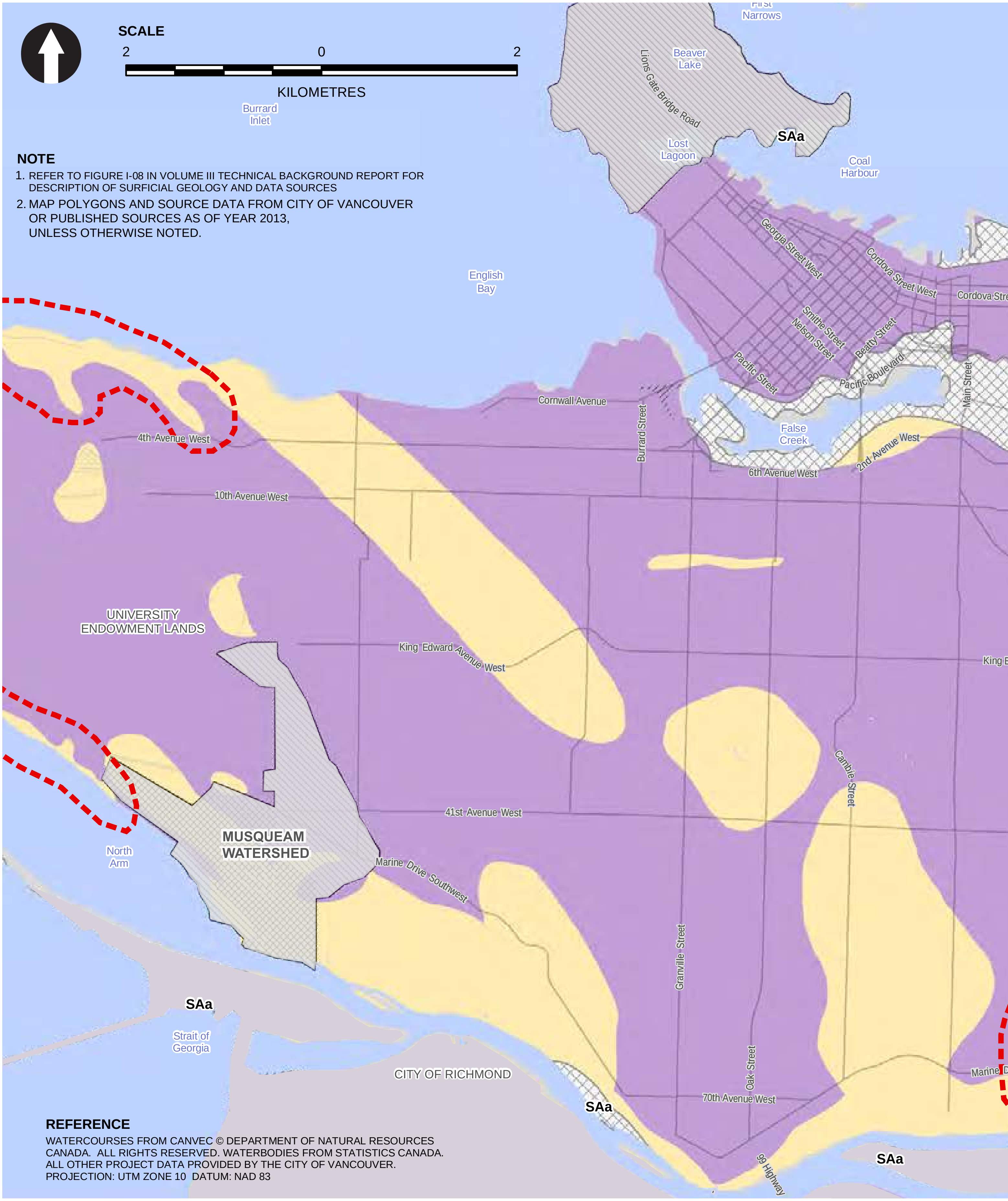
UPV — Till, glaciofluvial, glaciolacustrine, fluvial marine, and organic sediments

TERTIARY

T — Tertiary bedrock including sandstone, siltstone, shale, conglomerate, and minor volcanic rocks; where bedrock is not exposed it is covered by glacial deposits and colluvium

PRE-TERTIARY

PT — Mesozoic bedrock including granitic and associated rock types; where bedrock is not exposed it is covered by glacial deposits and colluvium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NOTE
1. REFER TO FIGURE I-08 IN VOLUME III TECHNICAL BACKGROUND REPORT FOR DESCRIPTION OF SURFICIAL GEOLOGY AND DATA SOURCES
2. MAP POLYGONS AND SOURCE DATA FROM CITY OF VANCOUVER OR PUBLISHED SOURCES AS OF YEAR 2013, UNLESS OTHERWISE NOTED.
Burrard Inlet
First Narrows
Beaver Lake
Lions Gate Bridge Road
Lost Lagoon
SAa
Coal Harbour
English Bay
Georgia Street West
Cordova Street West
Cordova Stree
Smithe Street
Nelson Street
Beatty Street
Pacific Street
Pacific Boulevard
Main Street
Cornwall Avenue
Burrard Street
False Creek
2nd Avenue West
6th Avenue West
4th Avenue West
10th Avenue West
UNIVERSITY ENDOWMENT LANDS
King Edward Avenue West
King Ed
Cambie Street
41st Avenue West
MUSQUEAM WATERSHED
North Arm
Marine Drive Southwest
Granville Street
SAa
Strait of Georgia
CITY OF RICHMOND
SAa
Oak Street
70th Avenue West
Marine Dri
99 Highway
SAa
REFERENCE
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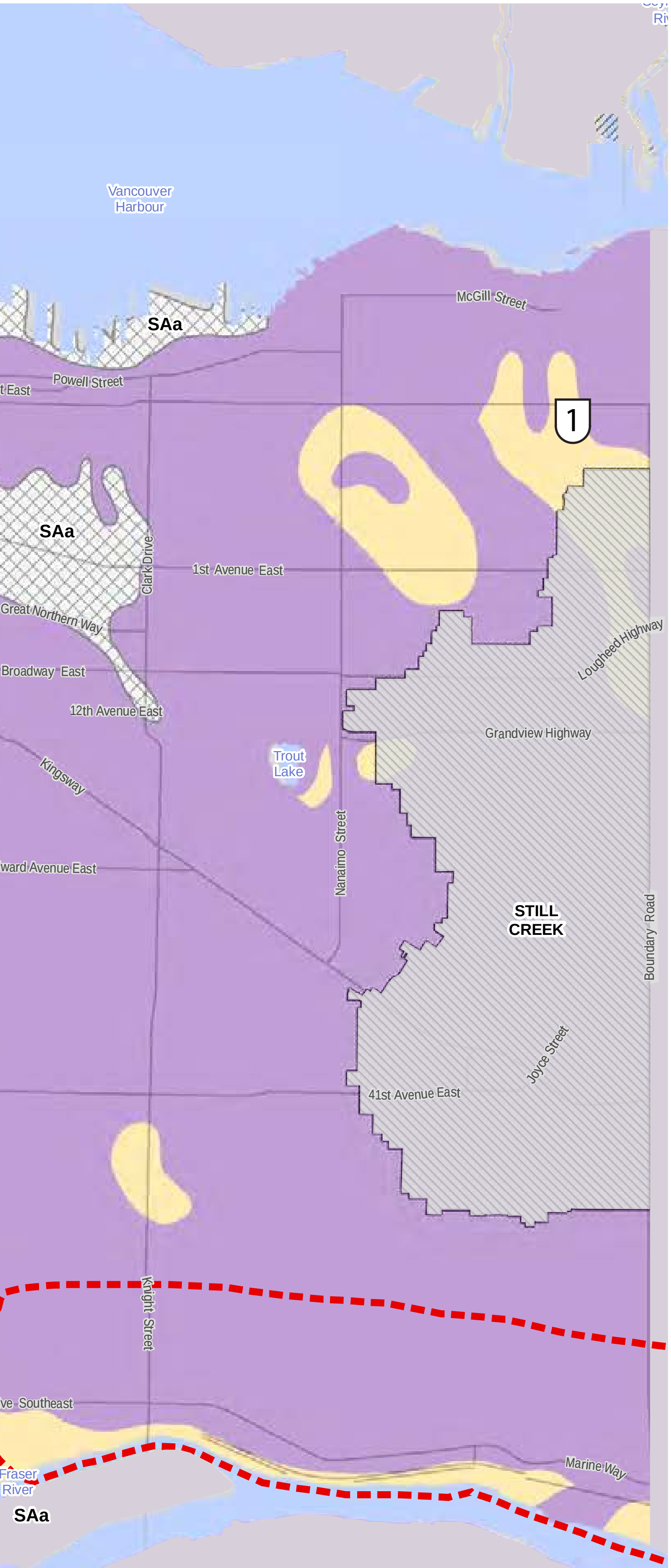


Figure I - 6:

Predominant Infiltration Potential

Most of the study area has predominantly low infiltration potential although some local areas may have moderate subsoil infiltration rates which should be confirmed by local testing. For this study the precautionary principle is used by assuming limited infiltration rates into subsoils (in the range of 1–2mm/hr (average 1.5mm/hr).

However, note that even these low rates of subsoil infiltration—not visible to the naked eye within a short time period – represent 24–48mm of infiltration over a 24 hour period. This slow infiltration is still very relevant to meeting the proposed targets for rainwater capture that are introduced in this report.

Areas planned for concentrated infiltration, and in particular areas of fill or steep slope, should have site-specific investigations of hydrogeology conditions and risks prior to implementing groundwater infiltration practices.

LEGEND

AREA EXCLUDED FROM STUDY

PREDOMINANT INFILTRATION POTENTIAL

PREDOMINANTLY LOW INFILTRATION POTENTIAL

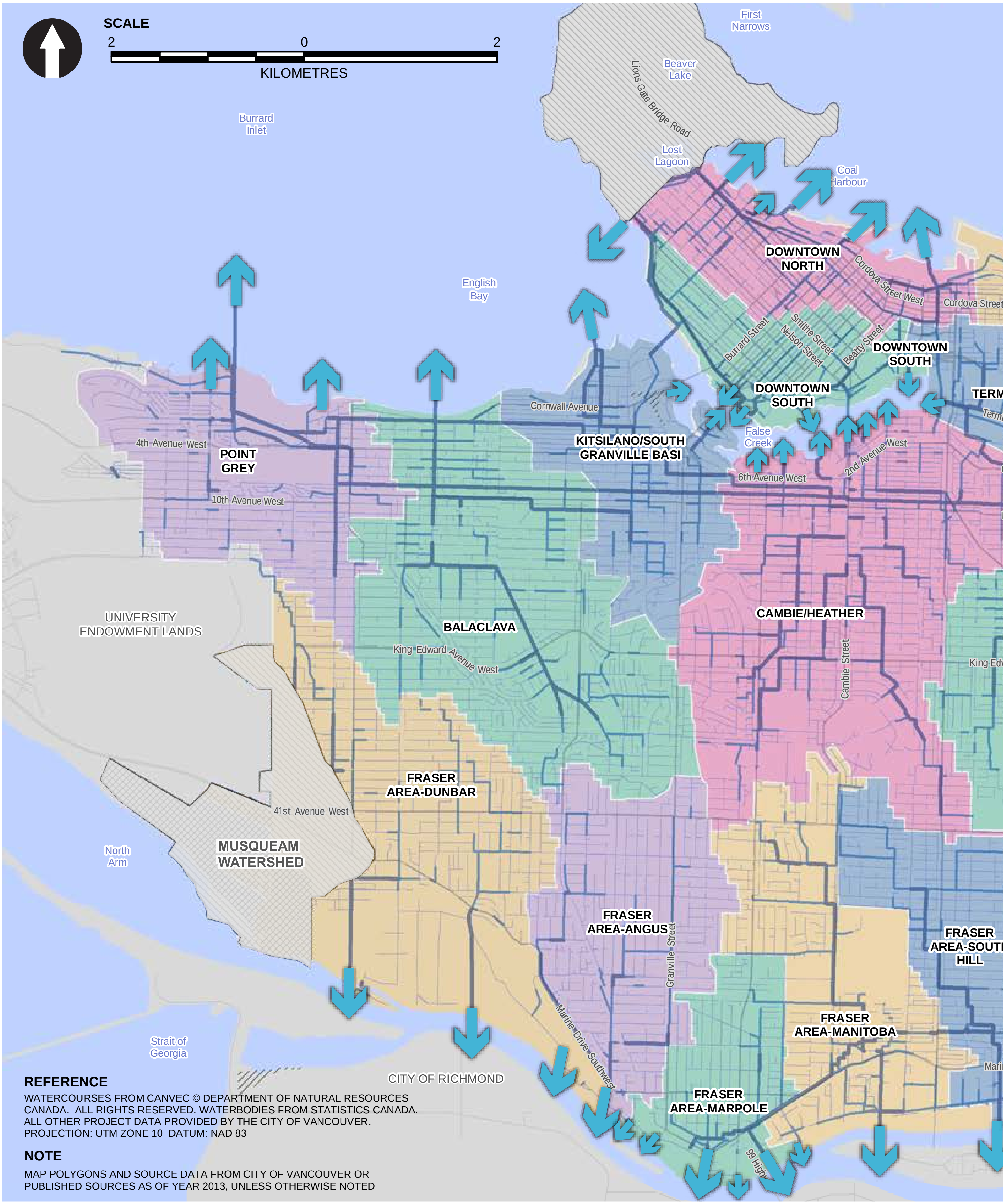
PREDOMINANTLY MODERATE INFILTRATION POTENTIAL

SPECIAL INVESTIGATION AREAS

LANDFILL INCLUDING SAND, GRAVEL, TILL, CRUSHED STONE AND REFUSE*

SLOPE STABILITY RISK

ARTERIAL ROAD



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Lions Gate Bridge Road
Lost Lagoon
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Cordova Street
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Cornwall Avenue
KITSILANO/SOUTH GRANVILLE BASI
False Creek
6th Avenue West
2nd Avenue West
4th Avenue West
POINT GREY
10th Avenue West
UNIVERSITY ENDOWMENT LANDS
BALACLAVA
King Edward Avenue West
CAMBIE/HEATHER
Cambie Street
King Edw
FRASER AREA-DUNBAR
41st Avenue West
North Arm
MUSQUEAM WATERSHED
FRASER AREA-ANGUS
Granville Street
FRASER AREA-SOUTH HILL
FRASER AREA-MANITOBA
Marine Drive Southwest
Mari
Strait of Georgia
CITY OF RICHMOND
FRASER AREA-MARPOLE
99 High
REFERENCE
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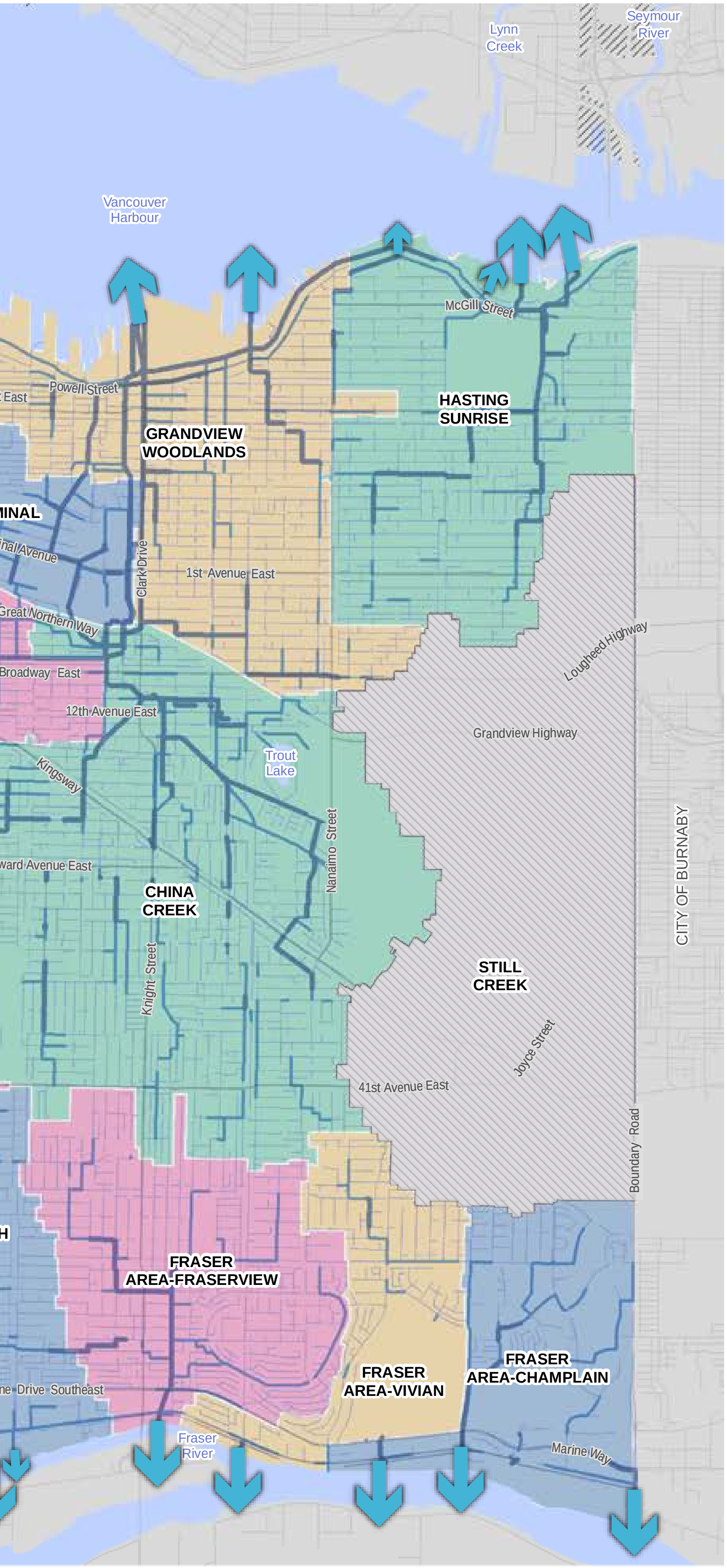
NOTE
MAP POLYGONS AND SOURCE DATA FROM CITY OF VANCOUVER OR PUBLISHED SOURCES AS OF YEAR 2013, UNLESS OTHERWISE NOTED

Figure I - 7:

Sewers and Combined Sewer Overflows - Today

Vancouver's piped sewers were developed in the first half of the last century, and at that time it was common to construct combined sewers that received both sanitary (toilet, dish, laundry water) and stormwater (roof, site and pavement drainage). Figure I - 7 shows drainage catchment areas and major sewer pipes, which drain under most weather conditions via Metro Vancouver sewer collectors to wastewater treatment plants and after treatment to the Strait of Georgia.

In extreme storm events, the capacity of existing pipes can be overcome by rainwater, and mixed sanitary and storm water can create combined sewer overflows (CSOs) to some of the existing outfalls shown in Figure I - 7. This brings high diluted, but polluted, water into Burrard Inlet, around English Bay, and to the Fraser River.



LEGEND

STORMWATER CATCHMENT AREA (NAME)

AREA EXCLUDED FROM STUDY

ROAD

SEWER MAIN SIZE (mm)

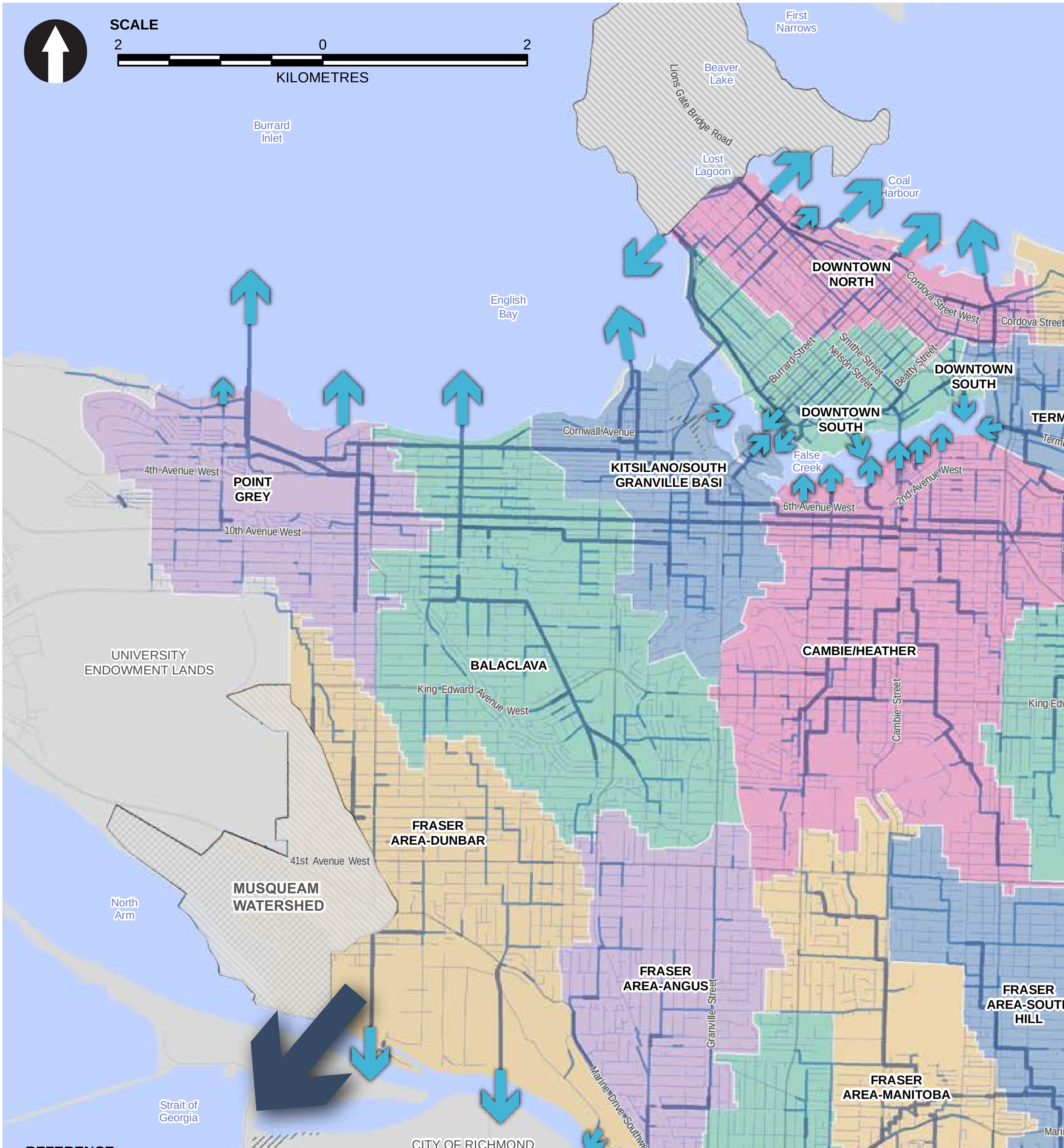
SMALL (0 - 499)

MEDIUM (500 - 999)

LARGE (1,000 - 4,975)

NOW:

COMBINED OR STORMWATER



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NOTE

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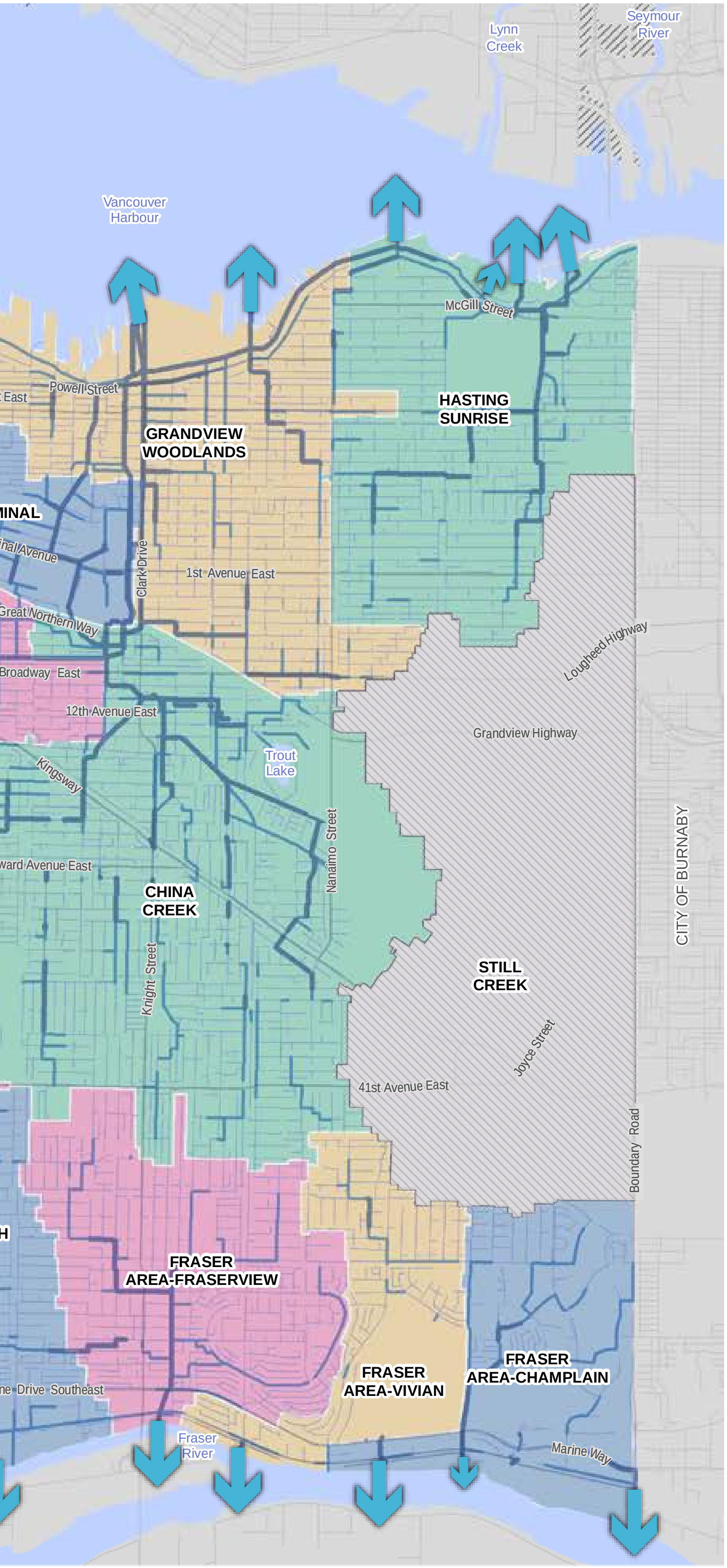


Figure I - 8:

Drainage Areas and Receiving Waters - Tomorrow

To eliminate CSOs and provide more sewer capacity, the City has an established program to separate combined sewers into separated systems of sanitary and storm sewers, with on-going implementation until Year 2050. However, until such time as the sewer separation is completed, there will be continuing combined sewer overflows (CSOs). Reductions in stormwater volume in this interim period will reduce the frequency and size of these CSO events.

Once completed, and with changes in the Metro Vancouver major sewer collectors, the new stormwater system will bring runoff from streets and land uses in the City direct to receiving waters – including False Creek, Coal Harbour and Burrard Inlet, beach areas in English Bay, and the Fraser River. Although the heavy organic pollution from sewage flows has been separated, the remaining stormwater, if untreated, can bring other pollutants such as petroleum hydrocarbons and heavy metals from parking areas to these sensitive receiving waters, with impacts on habitat as well as recreation and waterfront property values.

LEGEND

STORMWATER CATCHMENT AREA (NAME)

AREA EXCLUDED FROM STUDY

ROAD

SEWER MAIN SIZE (mm)

SMALL (0 - 499)

MEDIUM (500 - 999)

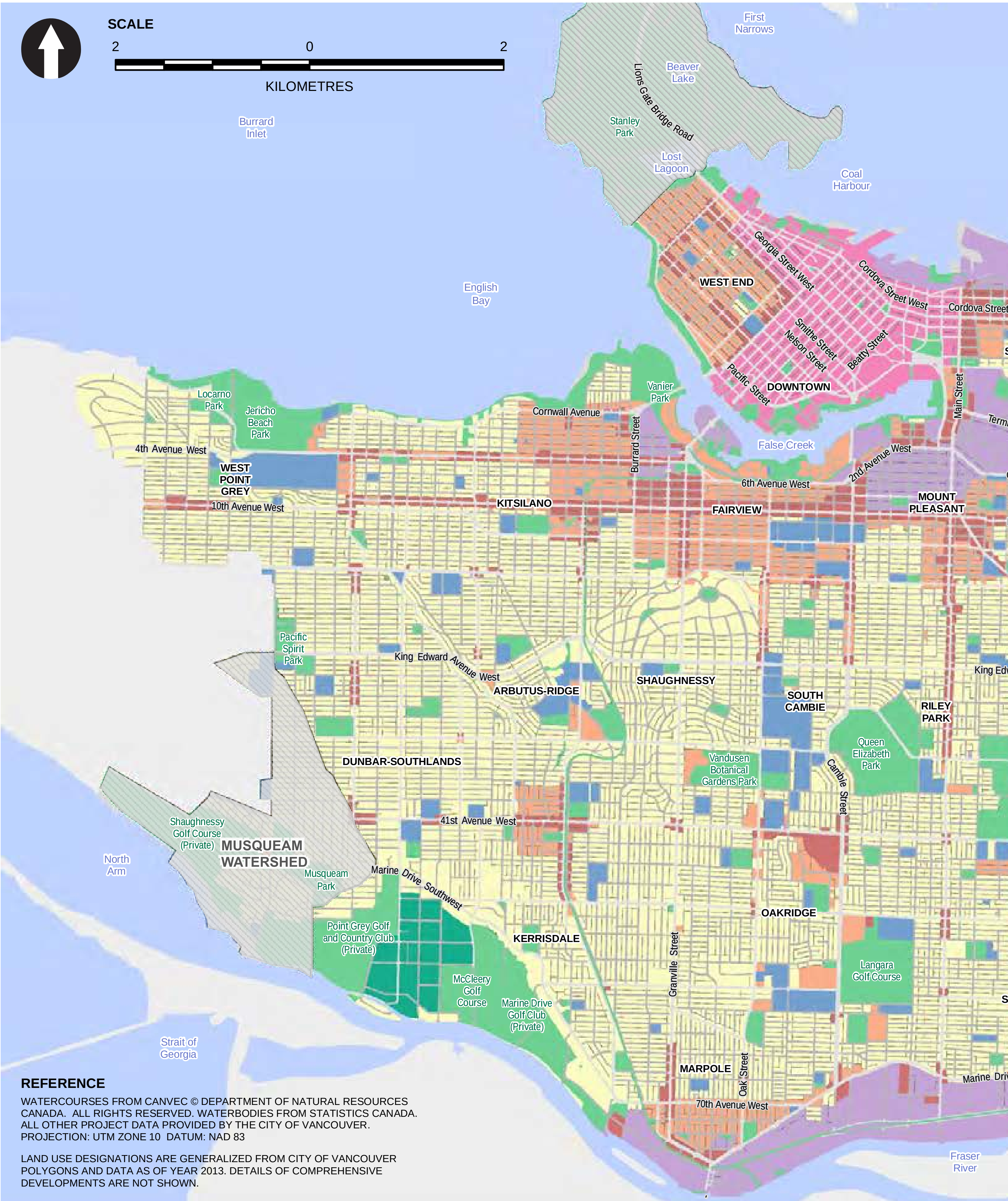
LARGE (1,000 - 4,975)

TOMORROW:

SANITARY ONLY TO TREATMENT PLANT

TOMORROW:

STORMWATER ONLY TO RECEIVING WATERS



REFERENCE

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LAND USE DESIGNATIONS ARE GENERALIZED FROM CITY OF VANCOUVER POLYGONS AND DATA AS OF YEAR 2013. DETAILS OF COMPREHENSIVE DEVELOPMENTS ARE NOT SHOWN.

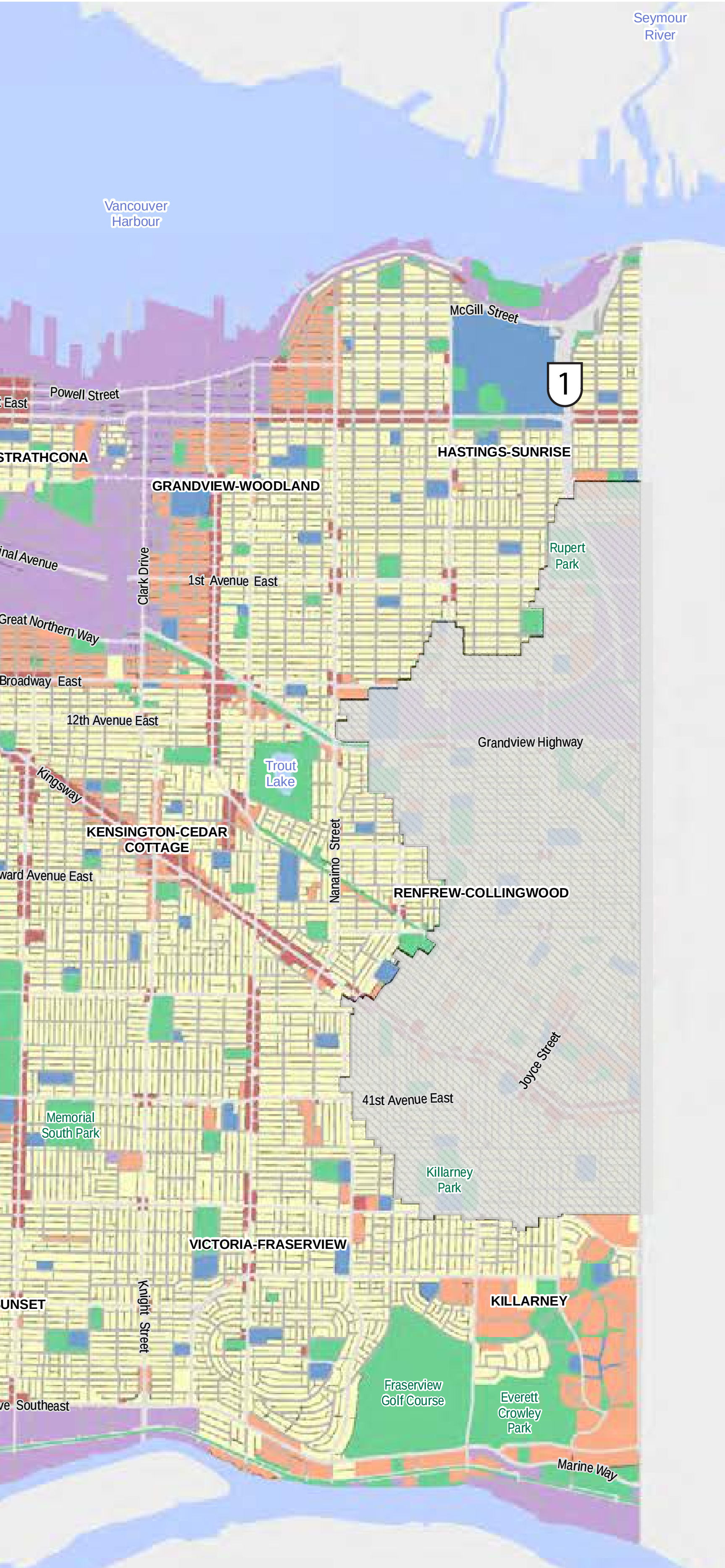


Figure I - 9:

Land Use

The amount of absorbent landscape that soaks up rainfall is directly related to land use designations and zoning, as well as the details of development urban design such as impervious area coverage, green roof or underground parking covered with absorbent landscape.

Although there is more potential runoff per hectare from higher density uses - arterial streets, industrial, commercial, and some institutional land uses - the cumulative area of these higher uses is small compared to the area of low density single family uses across the city.

LEGEND

AREA EXCLUDED FROM STUDY

LAND USE TYPOLOGY

ONE/TWO DWELLING RESIDENTIAL

MULTIPLE DWELLING RESIDENTIAL

COMMERCIAL / MIXED USE

DOWNTOWN MIXED USE

INDUSTRIAL

INSTITUTIONAL / AGRICULTURE

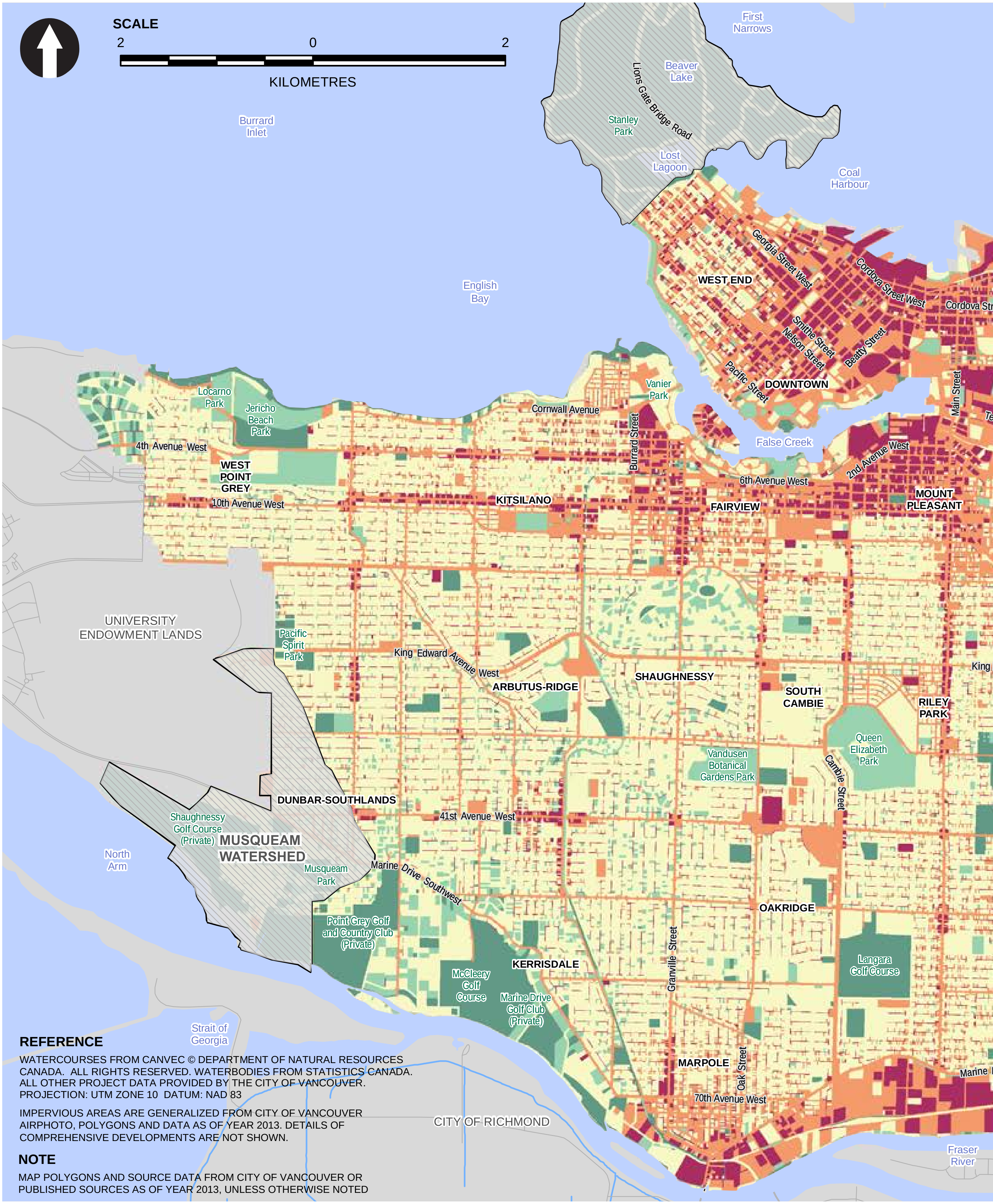
PARK / GREENSPACE

AGRICULTURE

ARTERIAL STREET

LOCAL STREET

LANEWAY



REFERENCE

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IMPERVIOUS AREAS ARE GENERALIZED FROM CITY OF VANCOUVER AIRPHOTO, POLYGONS AND DATA AS OF YEAR 2013. DETAILS OF COMPREHENSIVE DEVELOPMENTS ARE NOT SHOWN.

NOTE

MAP POLYGONS AND SOURCE DATA FROM CITY OF VANCOUVER OR PUBLISHED SOURCES AS OF YEAR 2013, UNLESS OTHERWISE NOTED

Figure I - 10:

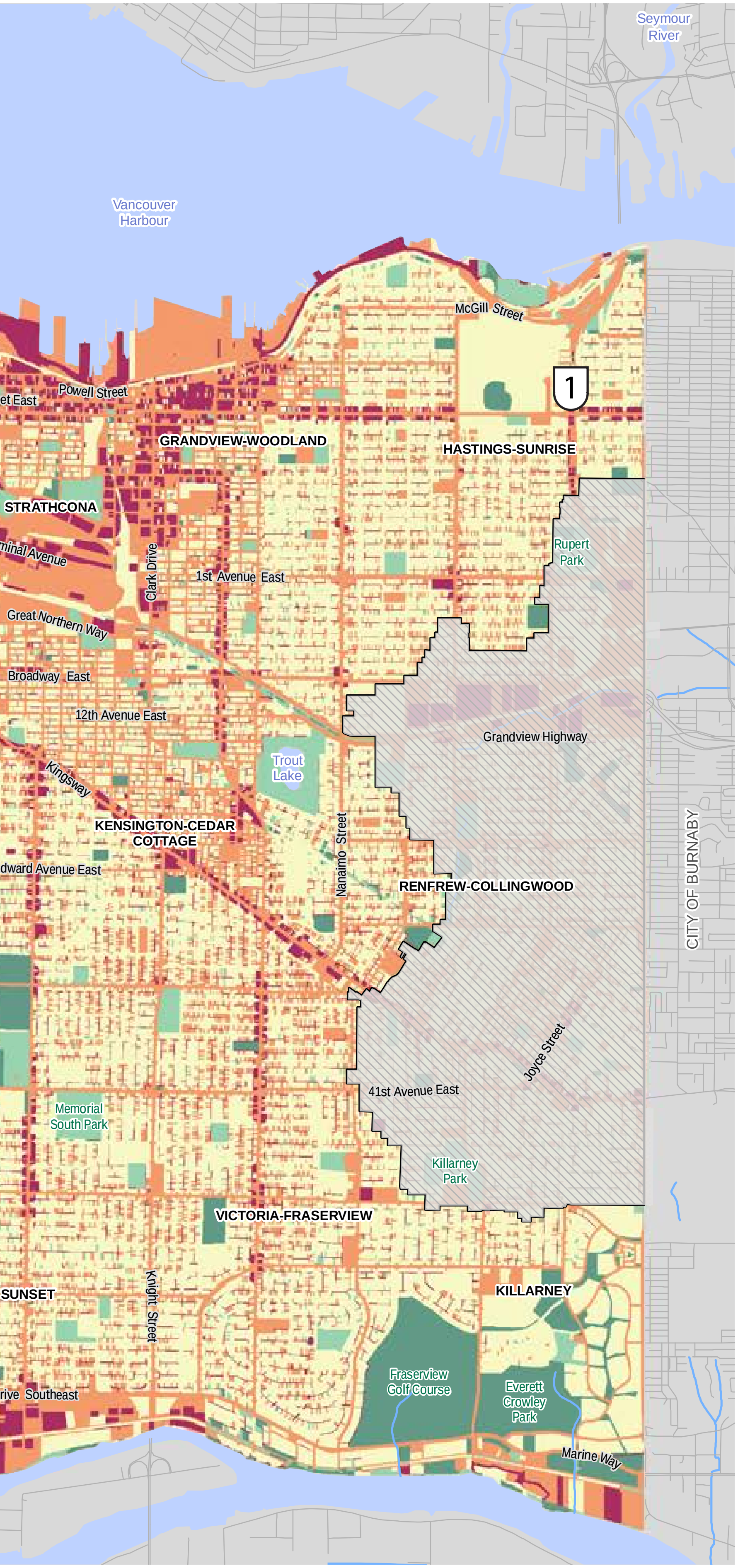
Impervious Areas

The Impervious Surface Area per parcel is the percent of each lot or street right of way that would create runoff – including roof, patios, driveways, parking areas and street travel lanes.

New high-density residential may reduce surface parking and replace it with underground parking with absorbent landscape above the garage, thereby in some cases reducing effective impervious area.

New single family residential in many cases involves greater building and paving coverage than older homes, resulting in an increase in effective impervious area.

Without use of rainwater best management practices or green infrastructure, the majority of rainfall falling in impervious surfaces creates runoff to the sewer system and from there to receiving waters in beaches, bays, rivers or ocean.



LEGEND

AREA EXCLUDED FROM STUDY

IMPERVIOUS SURFACE AREA PER PARCEL (%)

- 0 - 9
- 10 - 24
- 25 - 59
- 60 - 79
- 80 - 100

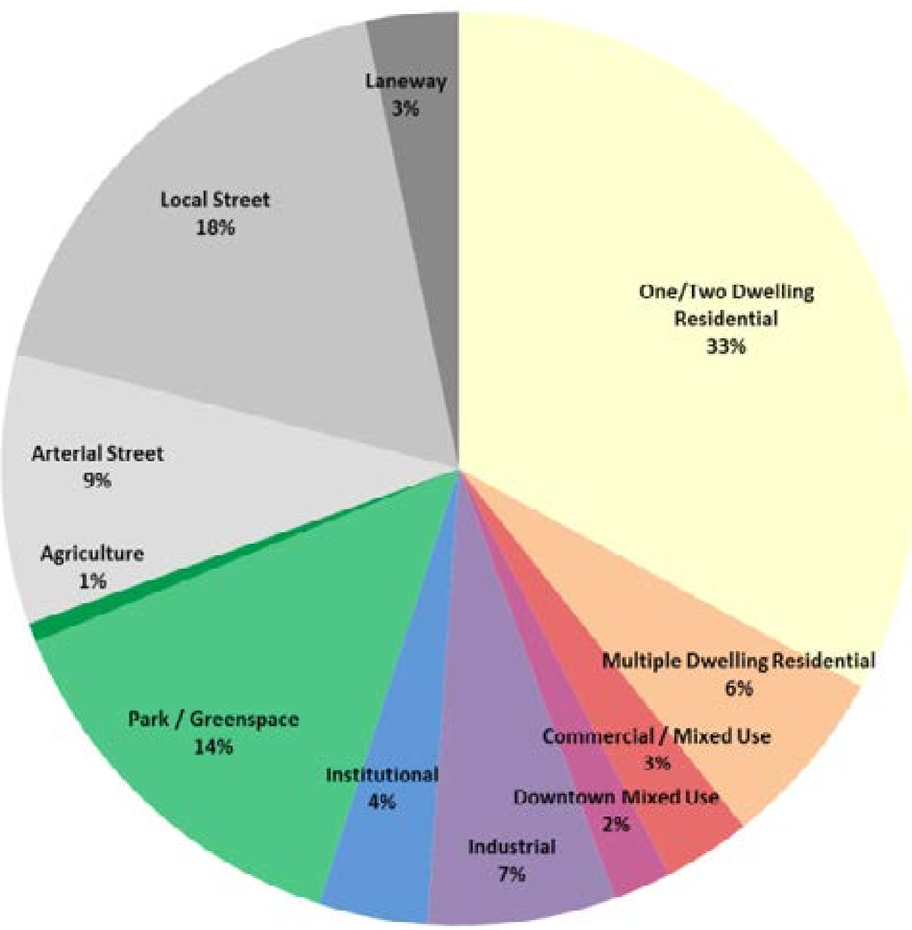
WATERCOURSE

Impervious Areas by Land Use Type

Although higher density areas like City Centre and Fairview show the highest percent impervious area per parcel, it is actually lower density areas (one and two family dwellings and local streets) that provide by far the greatest quantity of impervious area in the city. Figure I-11 illustrates that one/two dwelling residential and local streets and lanes make up more than 50% of the study area. Figure I - 12 shows how this translates into distribution of impervious road, building and site paving across land use typologies. Solutions need to be sought across all land uses in the city.

Figure I - 10 shows graphically the percent of impervious area across the city, as of 2013 (details of comprehensive developments are not shown).

Figure I - 11: Land use percentage of total study area

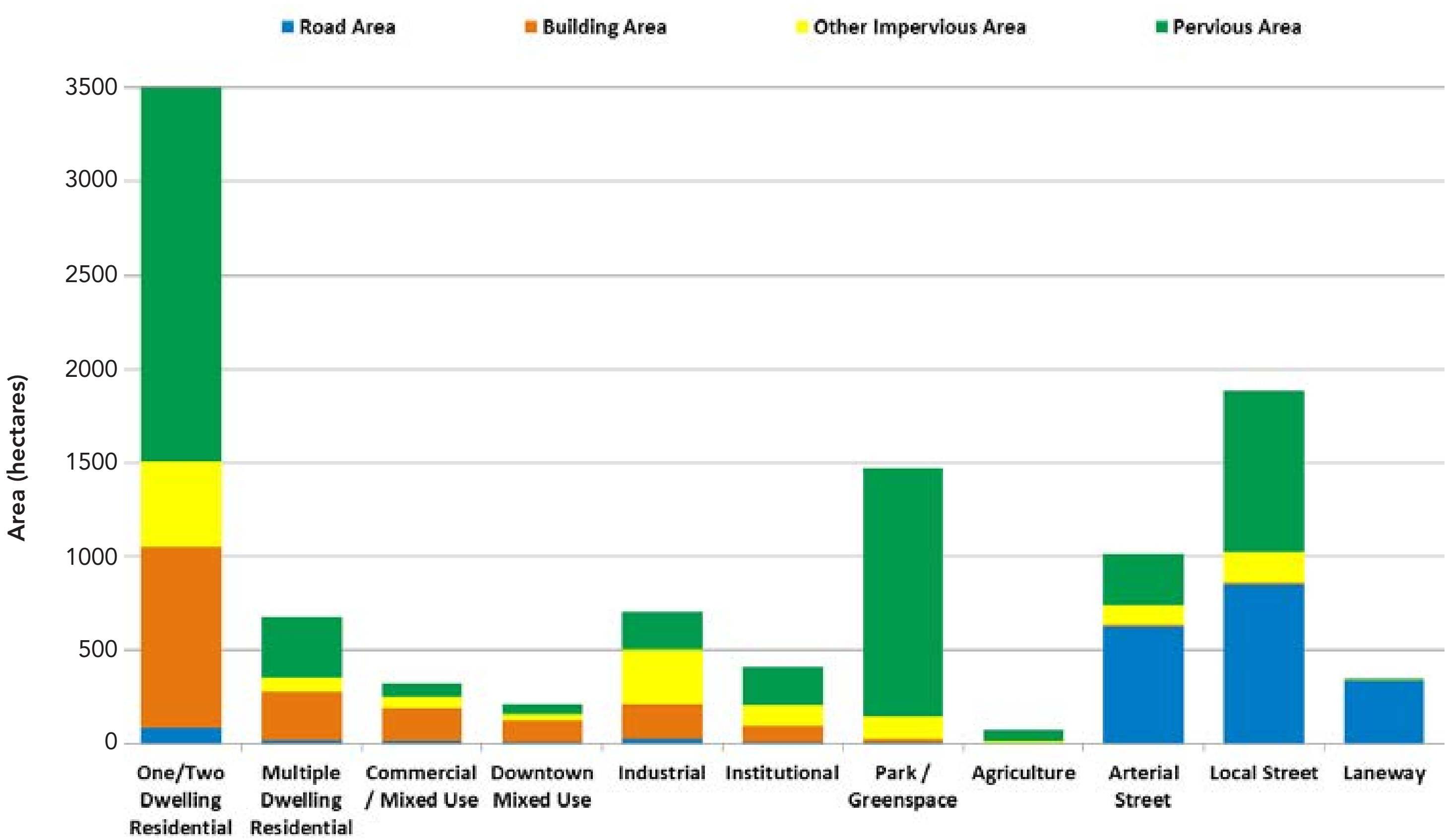


The percent of land use compared to the total Citywide study area is shown in the pie chart (Figure 1-11). About 54% of the study area is One/Two Family Dwellings, Local Streets, and Laneways. Arterial streets make up 9%. Parks and Agriculture represent 15%. Industrial areas represent 7%, with some of these converting to other uses through comprehensive development. The remainder, in high density, institutional and commercial uses make up only 15% of the total land area.

The bar graph in Figure 1-12 further breaks down each land use type into road and other impervious area, building area, and pervious area. Across the city, it is one/two family residential and streets/lanes that make up the highest total amount of impervious area.

For that reason it is important to include green infrastructure strategies for these low density areas and streets, in addition to high density sites, to reduce the cumulative impact of polluted stormwater on Vancouver's beaches, bays, rivers and other receiving waters.

Figure I - 12: Areas of Land Use Typologies



3.0 WHAT DO WE NEED TO DO DIFFERENTLY?

Treating Rainfall as a Resource

Rainwater in Vancouver should be treated as a resource, as articulated in the Vision for the Citywide IRMP that has been created through stakeholder engagement.

But, like any resource, there is a need for thoughtful management.

The Greening of Land Use and Streets

A long-term focus of this Integrated Rainwater Management Plan is both to minimize runoff volume and to reduce the risks and consequences of pollutants in stormwater runoff.

The focus on rainwater management starts where the rainfall hits the city—in its urban forest, its soils, its streets and land uses.

Without use of rainwater best management practices, the majority of rainfall landing on impervious surfaces—roof, streets, parking areas and other paved surfaces—creates runoff to the sewer system.

Vancouver's future as a Greenest City includes joining leading cities around the world that are mimicking natural ecological systems as the city is gradually reconstructed through building and infrastructure asset life cycles.

With better urban design as we redevelop our buildings and streets when they wear out, we can incorporate Green Infrastructure (GI) approaches to protect our rainwater and water resources.

There are also opportunities to store, treat or infiltrate rainwater and runoff in parks, playing field areas, skateboard bowls, surface parking areas and other civic facilities. Maintaining and increasing the tree canopy of the City also intercepts rainfall and increases evapotranspiration.

To meet objectives, Green Infrastructure will need to be implemented broadly across the City's drainage areas, streets and land uses.

Returning Rainfall to Natural Pathways

Part of Vancouver's Greenest City future is recognizing the role of the urban forest and soils in soaking up, cleaning and slowly releasing rainwater. Minor changes can increase the capacity of existing landscape areas to be more absorbent. New rain gardens and infiltration swales can slow down and treat runoff from streets and parking areas. Pervious paving can be used in select locations to reduce impervious area. Capture and local treatment of roof rainwater can provide water for irrigation, toilet and urinal flushing, and other non-potable uses, and reduce the city's reliance on potable water. These tools are introduced on the following page, and explored in Volume II: BMP Toolkit.

The City and private sector have piloted many of these tools – through the Green Streets program, at the Olympic Village, at new LEED Gold Certification developments, as well as in private residences and lane housing. Review of these pilots is providing insights for improved BMPs.

All of these actions together can help the city avoid water quality problems that have been problematic for many cities around the world. For example, the nutrients in stormwater runoff can cause elevated algae and vegetation growth that, in addition to adversely impacting the receiving environment and aquatic habitat, can result in foul odour due to decay. The results can be aesthetically unappealing – affecting recreation and land values. Further the costs of remediating the excess of nutrients, related excessive plant growth and low oxygen (eutrophication) can be extremely high. Excess bacteria concentration is a common problem in Vancouver's sheltered bays like False Creek, and can cause Health Authorities to impose extended beach closures in English Bay.

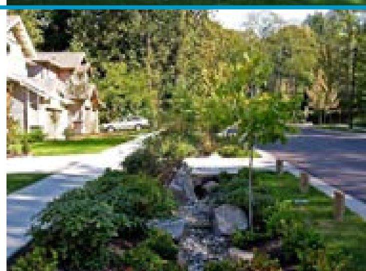
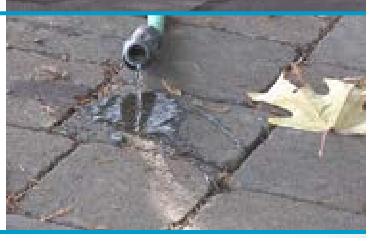
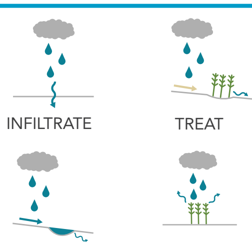
Rainwater management and Green Infrastructure approaches should reduce these risks proactively.

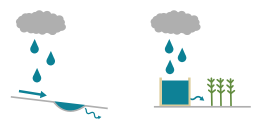
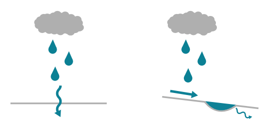
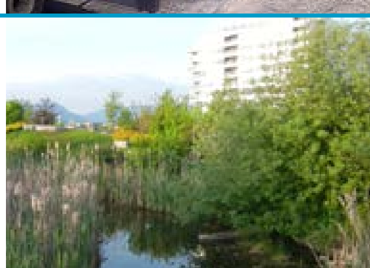
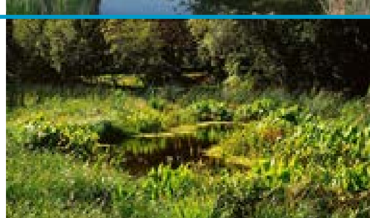
Urban forest (native and planted) as well as urban soils and rain gardens all mimic the evapotranspiration and infiltration that are natural flow pathways for rainwater.

Green Infrastructure Tools for Rainwater Management

The summary matrix below introduces a range of Green Infrastructure practices to improve rainwater management. These tools are in common use in other jurisdictions around Metro Vancouver, the Pacific Northwest, and in developed areas around the world.

For more information on Green Infrastructure, see the BMP Toolkit (IRMP Volume II)

TOOL		IMPACTS ON WATER	BENEFITS
Absorbent Landscapes			• intercept and clean rainwater through soil pores, allowing gradual infiltration into subsoils to recharge groundwater
Infiltration Swales			• reduce runoff volume and increase water quality by capturing, detaining, treating, and conveying stormwater
Rain Gardens & Infiltration Bulges			• reduce runoff volume and improve water quality by infiltrating, capturing, and filtering stormwater • an overflow conveys extreme rainfall volumes
Pervious Paving			• reduce runoff volume and improve water quality by infiltrating and treating stormwater while still providing a hard, drivable surface
Green Roofs			• reduce stormwater peak flows and volume, depending on depth of growing medium • benefit buildings by providing insulation and by reducing the heat island effect • provide urban habitat
Tree Well Structures			• adequate soil volume will retain excess stormwater and help to remove pollutants from stormwater runoff • support a healthy tree canopy which intercepts rainfall

TOOL		IMPACTS ON WATER	BENEFITS
Rainwater Harvesting		 DETAIN; CAPTURE & REUSE	• runoff from roof surfaces can be captured, stored and used for non-potable uses like landscape irrigation, laundry, and toilets, subject to approval of authorities having jurisdiction.
Infiltration Trenches		 INFILTRATE; DETAIN	• reduce the volume and rate of runoff by holding and infiltrating water into subsurface soils • water quality pre-treatment is advisable
Water Quality Structures		 TREAT	• capture petroleum hydrocarbons, coarse grit and coarse sediment • provide some water quality benefits except for soluble nutrients and pollutants
Detention Tanks		 DETAIN	• reduce flooding and in-stream erosion by collecting and storing stormwater runoff during a storm event, and releasing it at controlled rates to the downstream drainage system
Daylighted Streams & Channel Improvements		 DETAIN; HABITAT; TREAT	• may provide in-stream detention, water quality improvements, and essential habitat for aquatic life • contribute to the liveability of an area and establish a sense of place if properly designed
Constructed Wetlands		 DETAIN; HABITAT; TREAT	• provide detention, storage, habitat, and treat stormwater runoff through natural processes prior to discharging it into the downstream drainage system

CONSIDERATIONS IN EVALUATING PERFORMANCE

Vancouver's Citywide IRMP is different than many other watershed-based stormwater management plans, in that the Vancouver Citywide study area is entirely serviced with piped stormwater systems. Whereas most IRMPs would aim to protect the water quality and hydrological flow systems of surface streams, the Citywide IRMP is focused on managing piped systems that discharge to tidal or estuarine receiving waters.

In this context, there is a need for the Citywide IRMP to revisit common criteria for evaluating performance of stormwater best management practices (BMPs). Volume II also evaluates the performance of the tools in two sets of criteria: function and cost.

Functional Criteria

- Maximize Water Quality Treatment
- Maximize Volume Control (reduced CSOs)
- Maximize Aesthetic Benefits
- Maximize Biodiversity Benefits
- Maximize Public Education, Culture and Health Values

Cost Criteria

- Minimize Land or Space Cost
- Minimize Material and Construction Cost
- Minimize Maintenance Cost
- Maximize Property Value
- Maximize Longevity

As well as evaluating performance of the tools in isolation, it is also beneficial to know how the tools work together as a system at the City-wide and drainage basin scales (i.e., what is the optimum combination of tools for each land use type?). IRMP Volume III Technical Background Report (internal) provides a full analysis of alternative scenarios that combine tools.

4.0 WHAT DO WE WISH TO ACHIEVE?

It is essential to have a clear understanding of 'what are we trying to achieve?' with implementation of best practices. The following section introduces key principles and customized targets for the Citywide study area, to address both water quality and water volume issues in the watersheds.

Key Principles for Results

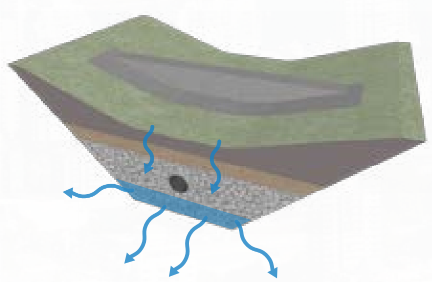
- Reduce Combined Sewer Overflows (CSOs) into Vancouver's tidal and river waters.
- Reduce the demands on capacity for sewage treatment through replacement of combined sewers with separated storm drainage systems and sanitary sewage systems.
- Redirect rainwater into natural pathways, including infiltration to subsoils and aquifers, evaporation, and evapotranspiration through the leaves of plants.
- Allow for reserve capacity in the City's piped drainage system, and constructed watercourses where applicable, to be resilient to changes in precipitation patterns related to climate change.
- Protect water quality in our beaches, bays, rivers and groundwater by using green infrastructure to provide pollution treatment by filtering surface water through soil and organic layers.
- Consider how green infrastructure and installed deep soil/organic compost layers could also provide healthier landscapes and water conservation benefits.
- Add to the biodiversity, environmental health and urban design diversity of Vancouver by integrating plantings, the urban forest, and constructed wetlands or rain gardens into both private landscapes and city parks, plazas and streets.

Targets: Soak it in! Clean it up! Convey it safely!

The graphic and summary on the following facing pages outline the objectives - expressed as quantitative targets – for the three levels of storm events: showers and small storms, large and extreme storms. The graphic and summary also explain the fundamentals of how green infrastructure can meet these targets.

Rainwater management targets
in Vancouver citywide area

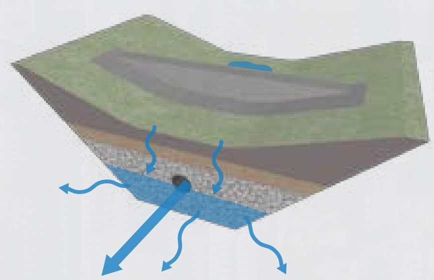
Rain Shower	Large Storm	Extreme Storm
+/- 70% of Annual Rainfall Volume	**+/- 20%** of Annual Rainfall Volume	**+/- 10%** of Annual Rainfall Volume



Soak it in!

First **24mm** per day

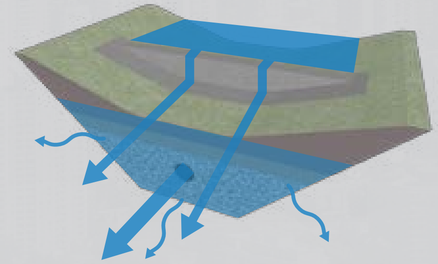
Capture (infiltrate) or reuse at source



Clean it up!

Second **24mm** per day

Treat, ideally through surface soils



Convey it safely!

Remainder

Provide runoff routes (pipes and/or overflow)

Water Quality Treatment Target

Water Volume Reduction Target

The Water Volume Reduction target is to return the first 24mm of rainfall per day into natural pathways of infiltration through subsoils or evapotranspiration to air - removing this volume from stormwater pipes. The Water Quality Treatment target includes both the first and second 24mm of rainfall a day - to a total of 48mm a day, equal to the 6 month return period. After flowing through treatment soils, some of the treated water quality flows may enter piped drainage through sub-surface perforated drains.

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NORMAL RAINFALL: SOAK IT IN!

- Soak up the first 24mm (1") in a day (24 hrs)
- Includes the common 'drizzle' up to small storms
- Objective is to infiltrate these rainfalls near where they land, providing benefits of water quality and reduced runoff.

HOW GREEN INFRASTRUCTURE WORKS

Even Vancouver's slow-draining subsoils will typically absorb 1mm an hour, or 24 mm over 24 hours.

Good quality topsoil and organic compost will absorb and hold about 10-20% of its volume in rainfall – a 450 mm soil layer would hold at least 45mm, where the moisture would either slowly evaporate or soak into the subsoils.

LARGE STORMS: CLEAN IT UP!

- Clean Up the next 24mm (1"), when combined with the small storms adding up to 48mm in a day (24 hrs).
- Includes large storms that occur once/year in a typical year.
- Objective is to treat for water quality in the runoff from these rainfalls near where they land, as well as to maximize the time available for rainfall to soak into the subsoils.

HOW GREEN INFRASTRUCTURE WORKS

A good topsoil/organic compost mix will typically absorb these volumes (rates of 12mm/hour infiltration into landscape soils are common) and will take out most storm runoff pollutants, including petroleum hydrocarbons, heavy metals from brake linings, sediment from erosion, excess nutrients and bacteria from fertilizers and pet/bird droppings.

A drain rock water reservoir under the topsoil layer would provide underground storage so that the water is given greater time to soak into the subsoils. A perforated underdrain at the top of the drain rock reservoir would take excess water to the City piped drainage system.

EXTREME STORMS: CONVEY IT SAFELY!

- Addresses storm events that are over 48 mm (2") in 24 hours, up to extreme events
- Extreme storms (1 in 10 year, 1 in 100 year return period) can occur at any time, but on average do not happen once/year.
- Objective is to safely convey to outlets the excess runoff through both pipes and in extreme cases by the 'major drainage' system of surface gutters along street edges, channels and overflows.

HOW GREEN INFRASTRUCTURE WORKS

In these larger and extreme storms, the first 48mm are still being treated by green infrastructure as described above.

The runoff from rainfall above 48mm in 24 hours will be carried in pipes, surface routes or channels that minimize the damage to buildings or property.

This type of 'flood conveyance' stormwater management is inherent in all drainage system design, including grey infrastructure systems.

Because these events are rare, water quality is not specifically addressed other than by dilution.

INFORMATION ABOUT VANCOUVER'S CITYWIDE AREA RAINFALL:

Annual Rainfall amounts in a typical year vary from 1200 mm in Southwest Vancouver to 1500mm in Northeast Vancouver. For targets, the larger rainfall amount is used.

For area of Vancouver with 1500mm of rainfall in an average year:

6 month return period storm in 24 hour period = 47.7 mm rainfall (water quality storm)

2 year return period storm in 24 hour period = 66.2 mm rainfall (mean annual rainfall)

Support for These Targets

Targets introduced above follow the intent of guidelines from the federal Department of Fisheries and Oceans, and are adapted from Metro Vancouver Stormwater Source Control guidelines and the MV Integrated Liquid Waste and Resource Management Plan. They also reflect 'aspirational targets' determined by stakeholder input.

The technical wording for targets are listed below, and described in more detail in Volume III: Technical Background (internal). These details include some nuances particular to the Citywide study area conditions.

Water Quality Target:
Treat 90% of the volume of runoff from effective impervious areas, other than roof in low density residential land uses, to the water quality standards - yellow or green - for piped drainage set out in Monitoring and Adaptive Management Framework for Stormwater, Metro Vancouver, 2014. A draft monitoring program is outlined in Volume III of the IRMP.

Water Volume Reduction Target:
Capture a minimum of 50% of the 6-month/24-hour post development volume from effective impervious areas, other than collector/arterial roads in all land uses and either infiltrate to ground, evapotranspirate, or reuse the captured rainfall.

Roof Drainage in Low Density Residential Land Use Areas:
Whereas existing roof drainage in low density residential land uses is required to be piped to the city sewer system, changes to regulations are encouraged to allow either harvest and reuse of this roof drainage, or 'disconnected roof leaders' which direct the roof drainage to on-site absorbent landscape areas. Disconnection of roof drainage should be subject to an approval process, and only in neighbourhoods with foundation drains at buildings. In cases where roof drainage is directed to the ground surface, the water quality target would apply to the roof drainage. This could be met by deep absorbent soils and/or properly sized rain gardens for infiltration of the small and large storm events from the roof and site, with provision for safe conveyance of extreme storm overflow from private property to the public major drainage flow path.

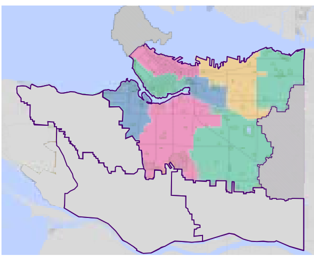
Detention or Rate Control Target:
For developments defined as 'large scale developments', reduce post-development rate and volume to at or below pre-development levels for the 2-year/24-hour precipitation events. Pre-development equals the site's immediate preceding use. Large scale developments should be defined using the same criteria as in the Rezoning Policy for Sustainable Large Developments, City of Vancouver, 2013 which currently has similar requirements.

Like all initiatives, the principle of 'what gets measured - gets done' applies within the Citywide study area. The implementation action plan includes a monitoring and adaptive management strategy, which should complete periodic review of meeting these targets, and allows for adjustment of strategies to ensure the targets are met in a practical and feasible manner.

Rainwater Management Areas and Biodiversity Demonstration Projects

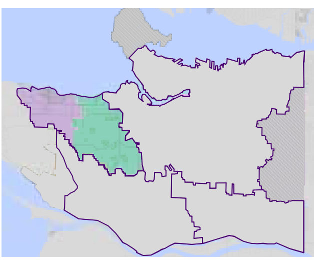
Across the Citywide study area, there are differences in average annual rainfall, in the destination of stormwater runoff to receiving waters, and in the average age of sewer infrastructure. These differences are summarized in the Rainwater Management Areas shown on Figure I-13.

The phasing of on-street green infrastructure should generally follow the pattern of combined sewer separation, with the oldest sewers and those that flow to confined water like False Creek being addressed first. The Rainwater Management areas are a coarse division that follow the principles of integrating green infrastructure at the end of life cycle of existing infrastructure. Individual projects may also respond to servicing issues, development plans and coordination with other infrastructure.



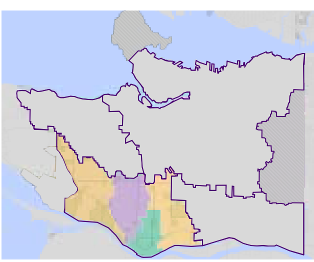
North-East RMA

- Drains to False Creek and Burrard Inlet, older sewers
- Relatively heavy rainfall (1300-1500 mm/yr average)
- Early application of sewer separation and green infrastructure



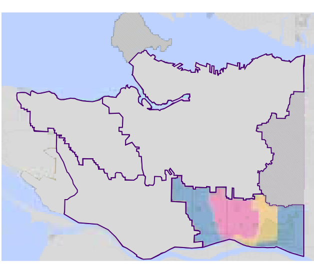
North-West RMA

- Drains to English Bay Beaches, older sewers
- Relatively low rainfall (1200-1300 mm / yr. average)
- Mid-priority application of sewer separation and green infrastructure



South-West RMA

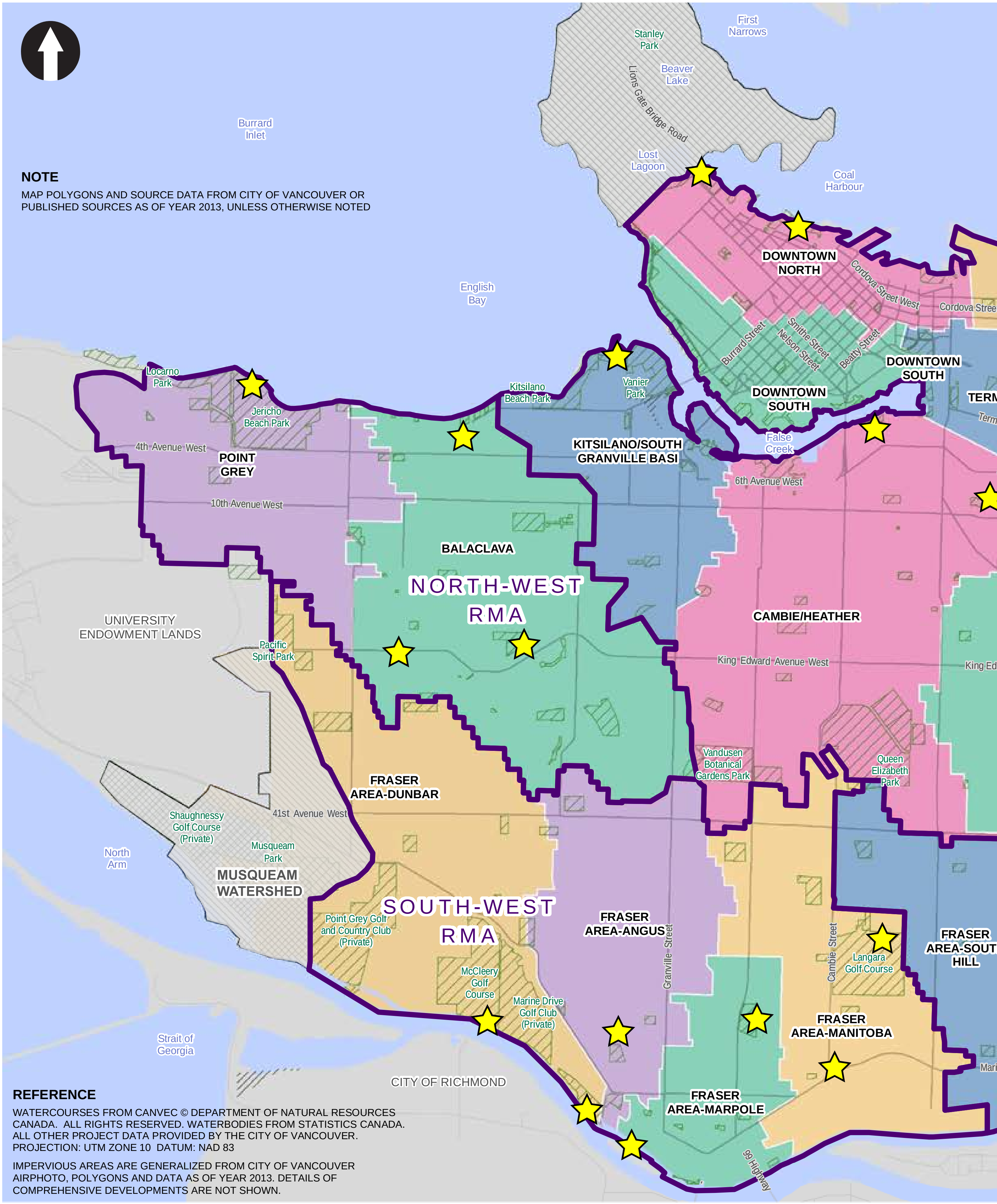
- Drains to Fraser River, newer sewers
- Relatively low rainfall (1200 – 1300 mm / yr. average)
- Later application of sewer separation and green infrastructure



South-East RMA

- Drains to Fraser River, newer sewers
- Relatively heavy rainfall (1300-1500 mm/yr average)
- Later application of sewer separation and green infrastructure

Volume III Technical Background Report (internal) recognizes that larger or custom developments may undertake custom engineering and sizing of green infrastructure to reflect local rainfall and infiltration conditions.



NOTE

MAP POLYGONS AND SOURCE DATA FROM CITY OF VANCOUVER OR PUBLISHED SOURCES AS OF YEAR 2013, UNLESS OTHERWISE NOTED

REFERENCE

WATERCOURSES FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. WATERBODIES FROM STATISTICS CANADA. ALL OTHER PROJECT DATA PROVIDED BY THE CITY OF VANCOUVER. PROJECTION: UTM ZONE 10 DATUM: NAD 83

IMPERVIOUS AREAS ARE GENERALIZED FROM CITY OF VANCOUVER AIRPHOTO, POLYGONS AND DATA AS OF YEAR 2013. DETAILS OF COMPREHENSIVE DEVELOPMENTS ARE NOT SHOWN.

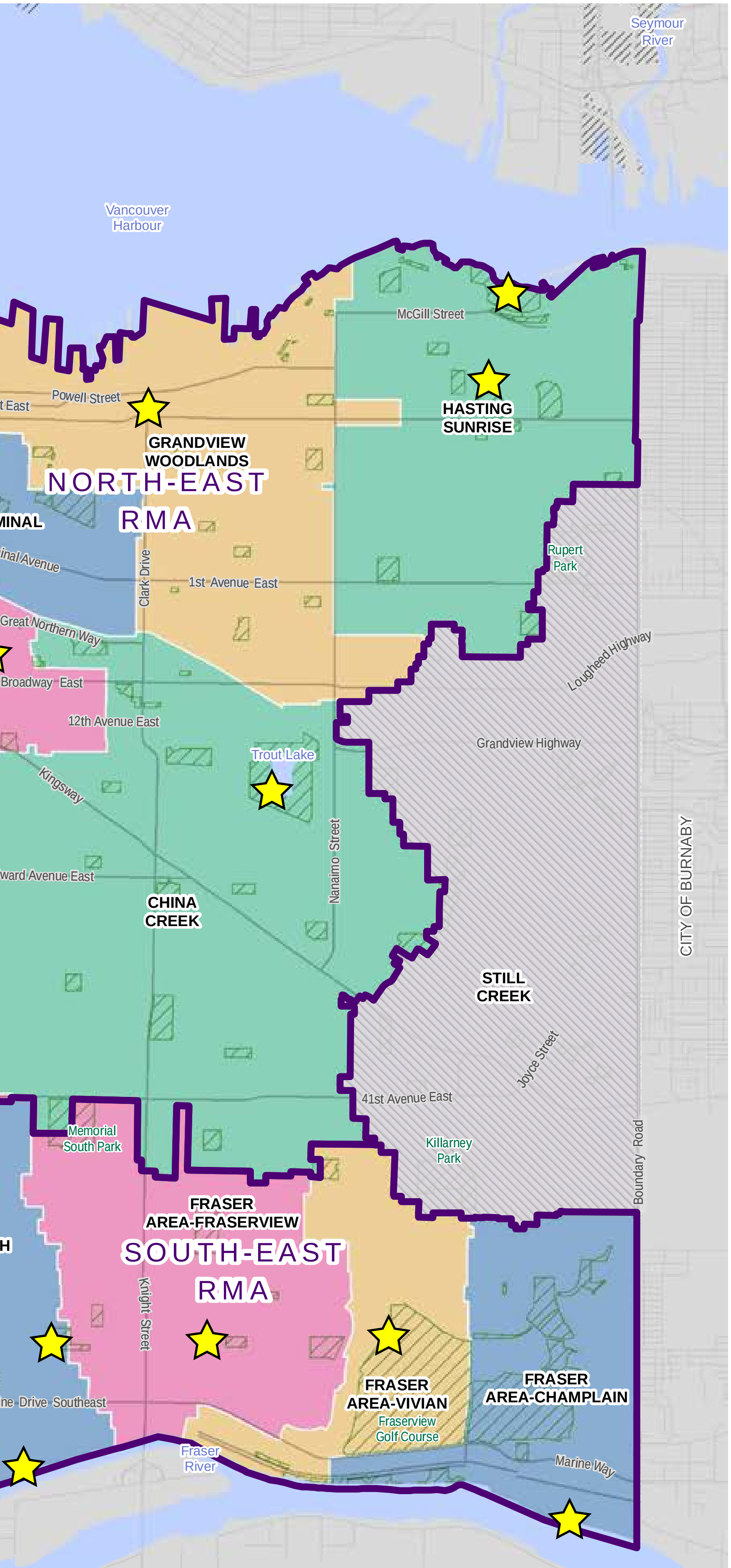


Figure I - 13:

Rainwater Management Areas and Biodiversity Demonstration Projects

An early priority in selected areas should be to create a visible 'water focal point' or biodiversity demonstrations in each watershed - a place where the quality and quantity of water, and the life it supports, can be seen (and monitored / improved).

New focal points are conceptual at this point. Schematic locations of potential Green Infrastructure and Biodiversity Demonstration Projects are shown in Figure I-13, with the intent that widespread BMP adoption would follow across the City.

LEGEND

RAINWATER MANAGEMENT AREAS (RMA)

STORMWATER CATCHMENT AREA

AREA EXCLUDED FROM STUDY

ARTERIAL ROAD

BIODIVERSITY DEMONSTRATION PROJECT

Potential new water focus projects / biodiversity demonstration projects

(Examples - subject to priority evaluation)

NORTHEAST RAINWATER MANAGEMENT AREA

Hastings Sunrise

- Playland redevelopment stormwater features, Broughton Park and Hastings Park Creek daylighting to complete Renfrew Creek system.

Grandview Woodlands

- Rain Garden and Pervious Paving Demonstration.

China Creek

- Trout Lake watershed reconnection, treatment wetlands, interpretation, St. George Rainway.

Cambie Heather

- Rainwater Interpretive Route at Olympic Village / Hinge Park (bioswale, pervious paving, green roof, stormwater stream, rainwater reuse, urban tree planting, habitat restoration). Rainwater BMP / biodiversity displays at Queen Elizabeth Park and Van Dusen Gardens. New median infiltration swales along King Edward Ave.

Terminal

- Creekside Park South (Science World) rainwater and climate change interpretive display (including sea level rise)

Downtown South

- Water quality treatment wetland. rainwater re-use features (Georgia Viaduct replacement or parks areas, in cooperation with adjacent developments)

Downtown North

- Coal Harbour rainwater and habitat interpretive display (at unfinished area at east end of Harbour Green Park) – convention centre green roof, rainwater and wastewater treatment and reuse, water edge habitat terraces, light for salmon on waterfront walkways, new visual water and biodiversity display using recycled water source. Pond / wetland stormwater improvements at Devonian Harbour Park. Interpretation of this plus of Lost Lagoon treatment wetland.

Kitsilano South Granville

- Hadden / Vanier Park (Maple and Ogden) treatment wetlands and beach water quality interpretive displays

NORTHWEST RAINWATER MANAGEMENT AREA

Balaclava

- Median infiltration swale demonstration at King Edward Ave., BMP and biodiversity displays at Quilchena Park, Prince of Wales Park, and Trafalgar Park. Tatlow Creek daylighting and park improvements.

Point Grey

- Biodiversity and rainwater enhancements at Jericho Beach Park. Cooperative rainwater and wastewater reuse demonstration and interpretation at future developments. On-going interpretation at Spanish Banks Creek.

SOUTHEAST RAINWATER MANAGEMENT AREA

Champlain

- Habitat biodiversity improvements and water quality interpretation along waterfront walks at East Fraserlands, Riverfront Park, connecting walks and open channel at foot of Boundary Road.

Vivian

- Rainwater BMP showcase near entrances to Fraserview Golf Course Riverfront biodiversity enhancements and interpretation at Gladstone Riverside Park, and at foot of Victoria Drive and Beatrice St. waterfront area.

Fraser View

- Rainwater BMP and biodiversity showcase at Victoria Drive Park / School areas, and at Memorial South Park.

South Hill

- Rainwater BMP showcase at Ross Park / Moberly Park / Schools. BMP Showcase at a volunteer industrial retrofit along the waterfront area.

SOUTHWEST RAINWATER MANAGEMENT AREA

Manitoba

- Biodiversity and rainwater management showcase at Langara Golf Course Biodiversity and rainwater management showcase at 64th and Yukon.

Marpole

- Rainwater BMP showcase at Oak Park, biodiversity and rainwater BMP interpretation at redevelopment of Bus Yard lands.

Angus

- Rainwater BMP and biodiversity displays at Kerrisdale Park and Riverview Park

Dunbar

- Biodiversity and rainwater enhancements and displays at McCleery Golf Course, and at Fraser River Park (joint with Angus watershed)

Everyone Plays a Role – Public and Private

Meeting the goals and targets to protect Vancouver's bays, beaches and biodiversity requires cooperation from all land uses and land managers in the city. Even single family and low density land uses, and local streets, need to play a role, as they represent over 80% of the land area in our watersheds.

Refer to the BMP Tookit (Volume II) for a listing of common practices and their suitability to various land use types. Strategies to meet targets in typical land uses include:

Low Density One/Two Family & Lane Housing

- Eliminate sanitary sewer cross connections into storm sewer.
- Design for zero runoff leaving the site for small or large storms in new homes. Convey runoff from extreme storms to the major drainage path (street or lane).
- Direct roof rainwater to infiltration (subject to an approval process) rather than to piped sewers.
- Provide incentive programs for roof rainwater harvesting and reuse (existing and new homes).

Medium / High Density: Multi-family, Industrial Commercial Institutional

- Meet water quality, volume reduction and detention targets. Allow flexibility to use all Green Infrastructure tools.

Lanes

- Design new homes for no runoff from private parcel to lane.
- Implement regular lane vacuum sweeping and catch basin cleaning in sewer-separated areas, .
- When resurfacing, meet water quality (but not necessarily water volume) targets by installing Green Infrastructure associated with resurfacing.

Local Streets

- Meet water quality and volume reduction targets, but not detention targets.
- Provide flexibility to use several Green Infrastructure tools or combinations.
- Undertake neighbourhood consultation and involvement in design, as well as in operations and maintenance.

Collector / Arterial Streets

- Meet water quality targets, but not water volume reduction or detention targets. Due to space constraints, it may be necessary to consider grey infrastructure for limited water quality treatment.

PRIORITIES AND BENEFITS

The priority in the above actions is reduction of water quality risks to receiving waters, by phasing-in conformance to the Metro Vancouver Monitoring and Adaptive Management Framework (yellow or green standards) that sets out water quality requirements that would apply to the piped drainage in the Citywide area.

The actions should also provide stormwater volume reduction at time of redevelopment through specified practices on local streets, reducing effective impervious area at the site level of one/two family & lane housing, and requiring volume reduction and detention at large High Density Multi Family and Industrial/Commercial/Institutional (MF/ICI) developments.

The volume reduction target should provide additional space (approximately 30%) in storm sewer pipes to accommodate flows that may increase due to more intense rainfall events and climate change.

Until sewer separation is completed, the increased available volume in existing combined sewers would mitigate the tendency towards more frequent or higher volume Combined Sewer Overflows (CSOs).

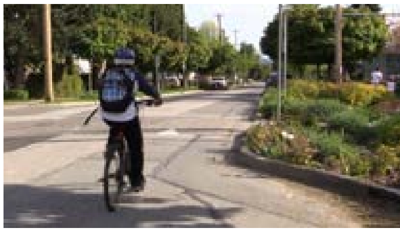
The Action Plan in Section 5.0 of this IRMP introduces the Actions and Priorities to get started on effective implementation.

Some Actions are ongoing, and can continue with renewed committment and focus of City staff. Other actions are new, and will benefit from on-going community engagement, including stewardship groups, the real estate and development community, homeowners and tenants.

Public awareness and outreach programs should be a perennial part of implementation of the IRMP.

Key Implementation Principles for Action

Working with Stakeholders, Key Principles have been noted to guide implementation of the Citywide IRMP.



MULTIPLE BENEFITS AND CONTINUOUS IMPROVEMENT

- Pursue rainwater management solutions that have multiple benefits—that meet many cross-discipline and cross departmental aspirations.
- Ensure that constructed rainwater management solutions are evaluated, and lessons-learned are shared, for continuous improvement.
- Reduce reliance on drinking water supplies to meet non-potable use demands by supporting roof water harvesting and water-conserving absorbent landscape.

CONTEXT SENSITIVE DESIGN

- Recognize that there may be variation in rainwater management solutions among different land use typologies.
- Identify areas of the city that have natural hazards or conditions that would restrict the type of rainwater management technique used (e.g. reduced reliance on infiltration in areas of slope instability, contaminated soils, high water table).
- Support, where possible, the objective of daylighting creeks is supported within the constraints of urban conditions.

SHARED RESPONSIBILITY

- Balance the responsibility to implement rainwater management solutions among private and public sectors, and support community stewardship.
- Continue to show leadership by example, with the City and private sector showcasing projects that demonstrate success in rainwater management.
- Ensure solutions balance capital, operations and maintenance considerations, and anticipate needs for maintenance funds and the role of private property owners in maintenance.

INCREMENTAL ADAPTATION

- Meet water quality and volume reduction targets, but not detention targets.
- Flexibility is provided to use several Green Infrastructure tools or combinations.
- Undertake neighbourhood and stewardship group consultation and involvement in design, as well as in operations and maintenance.
- Implement stormwater source controls into the long-term program of transitioning the combined sewer system into a separated system to reduce CSOs.
- Redevelopment of streets, parks or private lands provide opportunities for incremental rainwater management—leading to significant improvements over time.
- Provide on-going monitoring and periodic implementation refinement to support the Adaptive Management Framework and objectives of Metro Vancouver's Integrated Liquid Waste and Resource Management Plan.
- Adapt existing roles into clear and consistent regulations and requirements, rather than creating new programs or bylaws.

5.0 HOW DO WE START?

Implementing the Citywide IRMP will require a sustained effort among a wide variety of partners in City administration and among stakeholder and groups outside the City staff.

Actions will be incorporated into the City's budgeting processes for capital, operating/maintenance and staffing. Investment and priorities may change from year to year.

Overview of Action Programs

'Action Programs' are recommended to organize the implementation – these are presented as:

I. On-going Existing Actions

II. New Short Term Actions

III. New Sustained Actions

IV. New Longer Term Actions

On-Going Existing Actions

A fundamental issue in pollution abatement is on-going management of the amount of nutrients and bacteria that flow from the stormwater system to receiving waters - as well as sediment, oil and heavy metals that can flow with runoff from surface parking areas.

To minimize these risks, City programs for catch-basin / sump cleaning and sewer cross connection control would be combined to support:

STREET CLEANING

The ongoing program of street sweeping and sidewalk maintenance should continue and be enhanced, to remove sediments and litter such as gum and cigarettes from public spaces. A renewed focus should be placed on fall leaf and water quality cleanup, including citizen programs to encourage timely removal of leaf litter from boulevards, and avoiding the placement of tree or lawn leaf litter on street surfaces where it blocks catch basins and adds excess nutrients to runoff.

CATCH BASIN CLEANING

Catch basin sumps on streets function to remove coarse sediment from runoff before water enters the storm drain pipe. However, when leaves or organic debris and soil accumulate in the catch basins, bacteria can grow and can contribute to the closure of public swimming beaches.

The City should continue and increase regular catch basin cleaning by vacuum truck. It should also continue to remove sediment and oils from 'structural' best practices, like oil/water separators or detention tanks, and require this maintenance on private property.

Oils, sediment, and organics in CBs can generate beach-closing bacteria.

SEWER SEPARATION PROGRAM

The City is well advanced on a major capital investment to replace combined sewers with separate systems of sanitary sewer (human contact water) and storm water (roof and pavement drainage).

The sewer separation program is scheduled to be complete by Year 2015. As it is implemented the size and frequency of combined sewer overflows into Vancouver's bays, beaches and rivers should be reduced.

SEWER CROSS-CONNECTION ELIMINATION PROGRAM

Even after sewer separation in the public street, there are cases on private property where sanitary sewage is running undetected into storm sewers.

This is against City regulations and health best practice. The City should cooperate with private landowners on an on-going investigation and elimination of cross-connections between storm and sanitary systems within buildings or on private land.

MAJOR DEVELOPMENTS RAINWATER MANAGEMENT (SUSTAINABLE LARGE DEVELOPMENTS REZONING POLICY)

The City has an established policy where major rezoning applications are required to provide a Rainwater Management Plan that meets detention and water quality criteria established by the City. This policy should be maintained, and reviewed to ensure that it meets the requirements of the Citywide Integrated Rainwater Management Plan.

New Short Term Actions

WATERSHED PUBLIC AWARENESS OUTREACH PROGRAM (PHASED)

The Watershed Public Awareness and Outreach Program would recognize that urban design and green infrastructure implementation, in each of the city's watersheds, has a direct relationship to the health of the ecosystem of its receiving waters, and on the health of the watershed itself.

The quality of water that is delivered, and to a certain extent its quantity, influence the ability of the watershed and receiving waters to support life and ecosystems—benthic invertebrates (bugs) and insects that are food for aquatic species; clams, mollusks, oysters and other bivalves that are early indicators of pollution and desirable food species; support for the life ecosystems of salmon, herring, trout and other fishes, and for heron, eagles and other birds and mammals that prey on the bounty of the shorelines.

The purpose of the Watershed Public Awareness Outreach Program is to:

- Raise awareness among the public, business, agencies and city staff of the relationship of rainwater and watersheds to local ecosystems and life;
- Provide a vehicle for interested stakeholders within each watershed to focus their efforts;
- Support communication and training among watershed stakeholders, and sharing of green infrastructure and other best practices; Undertake communications and outreach, including multi-media and live training and awareness programs. The focus of these communications would be to help the public, landowners and stakeholders understand the relationship of their actions to watershed and salmon health;
- Provide a constituency in support of applications for outside funding for watershed improvements;
- Allow a role for 'citizen-science' in combination with City-funded science and testing, and a focus for monitoring and adaptive management of the watershed;
- Build a bridge between and support for both the Integrated Rainwater Management Plan and the City's Water Wise, Urban Forest and Biodiversity Program; and
- Share resources to implement adaptive management improvements to improve watershed health.

The City may phase in this 'Watersheds' Program gradually, and expand its depth and breadth in each phase of implementation.

An early priority in selected areas should be to create one or more visible 'water focal points' in each watershed – places where the quality and quantity of water, and the life it supports, can be seen (and monitored / improved). Existing and potential locations for water focal points will be determined on a balance of public land and resources available, potential private sector contributions, community / stakeholder interest, and the potential for the projects to increase community awareness and support.

As well as the environmental benefits, the Watersheds Program is also another means to community and social development in public, school and neighbourhood groups.

DEMONSTRATION PROJECTS AND CAPACITY–BUILDING

Implementation of the Citywide IRMP will require technical knowledge and confidence around design, construction and maintenance of new best practices and technologies. The Capacity-Building Program for Rainwater Management would support:

- Pilot and demonstration projects—these projects provide excellent opportunities to make training and results 'hands-on'. Pilot projects build comfort and confidence among staff and contractors and the skills to implement properly.
- Early projects and capacity building should also showcase 'quick wins' to solidify support.
- Capacity-building should include a review of implementation and enforcement of existing standards and regulations e.g. construction site erosion and sediment control.

Existing Infiltration Bulge in Vancouver

UPDATED ENGINEERING AND BUILDING STANDARDS

The City should bring regulations and procedures into alignment with the IRMP recommendations. Some older city regulations may require exclusive use of 'grey' infrastructure, and require update. The city should add green infrastructure 'city standards' for typical design, sizing and specifications that are well vetted and accepted. Results of pilot projects should inform these new standards.

UPDATED MAINTENANCE STANDARDS AND ROLES

All infrastructure – whether green or grey – requires on-going maintenance. Some parts of the street (notably landscape boulevards) have been maintained by adjacent landowners. Other programs such as the Green Streets program have provided guidance for citizen involvement beyond basic maintenance.

As green infrastructure is contemplated in city streets, plazas and parks, the City should review its maintenance standards and roles, including the role of adjacent properties and the private sector at larger developments. New standards for maintenance and roles should be developed, and funding allocated for the City portion of maintenance responsibilities.
A review of the potential 'social development' opportunities for green infrastructure maintenance should be a part of the review.

UPDATED DEVELOPMENT APPROVAL AND INSPECTION PROCESSES

Like all infrastructure, green infrastructure should function well if properly designed, installed and maintained, and may fail if poorly implemented. The City's approval and inspection processes should encourage proper design and installation of green infrastructure. Implementing requires a careful allocation of people and process to create an efficient and effective development and implementation approval system. The intent should be to fully incorporate green infrastructure reviews into existing review procedures, rather than inventing new administrative systems.

TECHNICAL TRAINING AND STAFF DEVELOPMENT

Both City staff and external contractors have ongoing needs for technical training on green infrastructure. Related training activities should include:

- Internal technical and training materials and staff development.
- External training materials—aimed at increasing the capacity for proper Green Infrastructure and other BMP design and installation on private lands, aimed at the consulting design community, and in contracting installation and maintenance firms, as well as small property owners and homeowners.
- Implementation should also include training of staff that review applications and that provide referrals or informal guidance to applicants.
- Training should also reinforce enforcement of sediment and erosion control during construction on public and private sites.

ORGANIZATIONAL DEVELOPMENT FOR FUNDING AND IMPLEMENTATION

Many aspects of implementing the IRMP should be accommodated as adjustments to existing budgeting, funding and staffing programs. There are, however, some key changes that would benefit from an organizational development approach, including:

- Creation of a Green Infrastructure Team as a focal point for the program;
- Identification of functions that may be accommodated in existing budgets;
- Identification of new service functions that should require allocations of budget and staffing for effective delivery;
- Clarity on roles of City and Park Board departments, staff and consultants/contractors in on-going implementation.

AWARDS AND INCENTIVE PROGRAM

The City should integrate Green Infrastructure recognition into Annual Awards programs to recognize noteworthy investments and awareness-building activities that meet the objectives of the IRMP.

New Sustained Actions

Three new programs should be phased in: Absorbent Sites Program; Surface Parking Treatment Program; and Monitoring and Adaptive Management Program.

ABSORBENT SITES PROGRAM

Over 50% of land area in the City of Vancouver is covered by residential land uses and the adjacent local streets. These residential neighbourhoods occur in two widespread types - low density one and two family homes, and high density or mixed use residential/commercial. The quality and volume of water entering the stormwater system and receiving waters is directly related to the design and maintenance of these places that we live.

Pet waste and over-fertilization of landscape areas can lead to bacteria, aquatic weed and algae problems in receiving waters. Proper depth and quality of absorbent landscape soils can mitigate these risks.

Erosion and sediment control during construction is of paramount importance to water quality in receiving waters

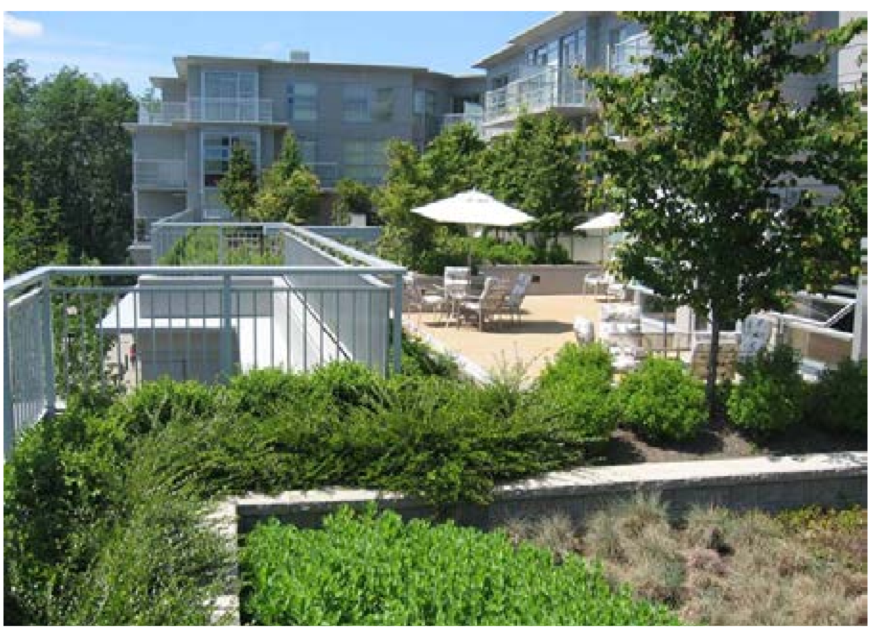
The Absorbent Sites Program provides guidance for rainwater-sensitive site development for private residential lands. The local streets and surface parking concerns are addressed below by the Surface Parking Treatment Program.

The issues with at-grade drainage from housing areas are excess nutrients from over-fertilization, nutrients and bacteria from pet waste, petroleum hydrocarbons and heavy metals from driveways or other surface parking areas, and potential erosion and sediment transport to stormwater from gardening activities, and in particular from construction sites.

The Absorbent Sites Program primary objective is that small storms that land on the at-grade portion of residential landscapes should be absorbed into the underlying subsoils, and large storms should be filtered through surface soils. It is recognized that extreme storms (above the water quality storm) may create some runoff to drain inlets or the fronting street, and provisions for positive drainage for these extreme events should still be made in site and utility planning.

Absorbent Sites can be readily achieved by use of the practices in the BMPs (Vol II). Requirements for Absorbent Sites would be established by design guideline policy or bylaw, and administered at the time of redevelopment through the development or building permit processes.

Single and two-family zones should be encouraged (subject to an approval process) to either harvest roof rainwater for re-use, or disconnect roof rainwater leaders and distribute the roof water to absorbent landscape areas, with an overflow from these absorbent areas for major storm events to the street or piped stormwater system. City exceptions to this requirement should be identified, including areas without foundation drains, or other areas at risk based on hydrogeological investigations. Where landowners otherwise wish an exception to the requirement, approval of the exception should be based on a detailed application form and established criteria.



Absorbent landscape and soils are often installed above parking garages in high density developments.

Medium and High Density residential and mixed-use developments are also required to meet the Absorbent Sites Program requirements. It is anticipated that most of these developments would use the performance application process, and that these requirements would be generally complementary to current best practices such as those encouraged by LEED certification. The Rezoning Policy for Sustainable Large Sites already provides a similar requirement. Refer to the following Roof Rainwater Harvesting and Reuse Program for guidance on roof rainwater reuse.

SURFACE PARKING TREATMENT PROGRAM

Surface Parking is one of the major contributors in urban environments to water quality pollution of receiving waters. The parking areas (even recently paved) show visible droppings of petroleum hydrocarbons, which flow with stormwater into pipes and show up as sheen on surface waters. What are not as visible are heavy metals from brake linings, sediments that are carried into the drains by stormwater, bacteria and other pollutants.

In the Citywide Area, there are two areas of surface parking: on-street, and off-street. All surface parking, whether public or private, contributes to urban water quality issues.

On-street parking is common across Vancouver

Off street surface parking remains a common land use outside the downtown core.

ON STREET SURFACE PARKING TREATMENT

On-street parking areas are perhaps the largest area of surface parking in the study area. Almost every local street is lined with surface parking, usually on both sides. Implementing treatment of water quality associated with on-street parking is a high priority.

The Surface Parking Treatment Program would support an inter-departmental focus to implement water quality treatment on all on-street parking areas. Priority would be given to streets where drainage is now or soon to be flowing into separated storm sewers and to receiving waters.

All BMP tools should be considered for treating water quality from surface parking. IRMP Volume III: Technical Background Report (internal), has compared the life cycle cost and functionality of combinations of tools in a typical Vancouver residential neighbourhood. Based on that analysis, the program envisions the general allocation of tools to be:

Local Streets:

- Four infiltration bulges per block (approximately 90% of locations – see Figure I - 13 Option LS1);
- Two infiltration bulges at the lower portion of a block, with treatment of the upper half of the block provided by pervious paving under parking (approximately 5% of locations);
- Two infiltration bulges, at the lower portion of a block, with treatment of the upper half of the block provided by pervious paving under parking isolated from travel lanes by a gutter that flows to the infiltration bulges (approximately 5% of locations).

Collector and Arterial Streets:

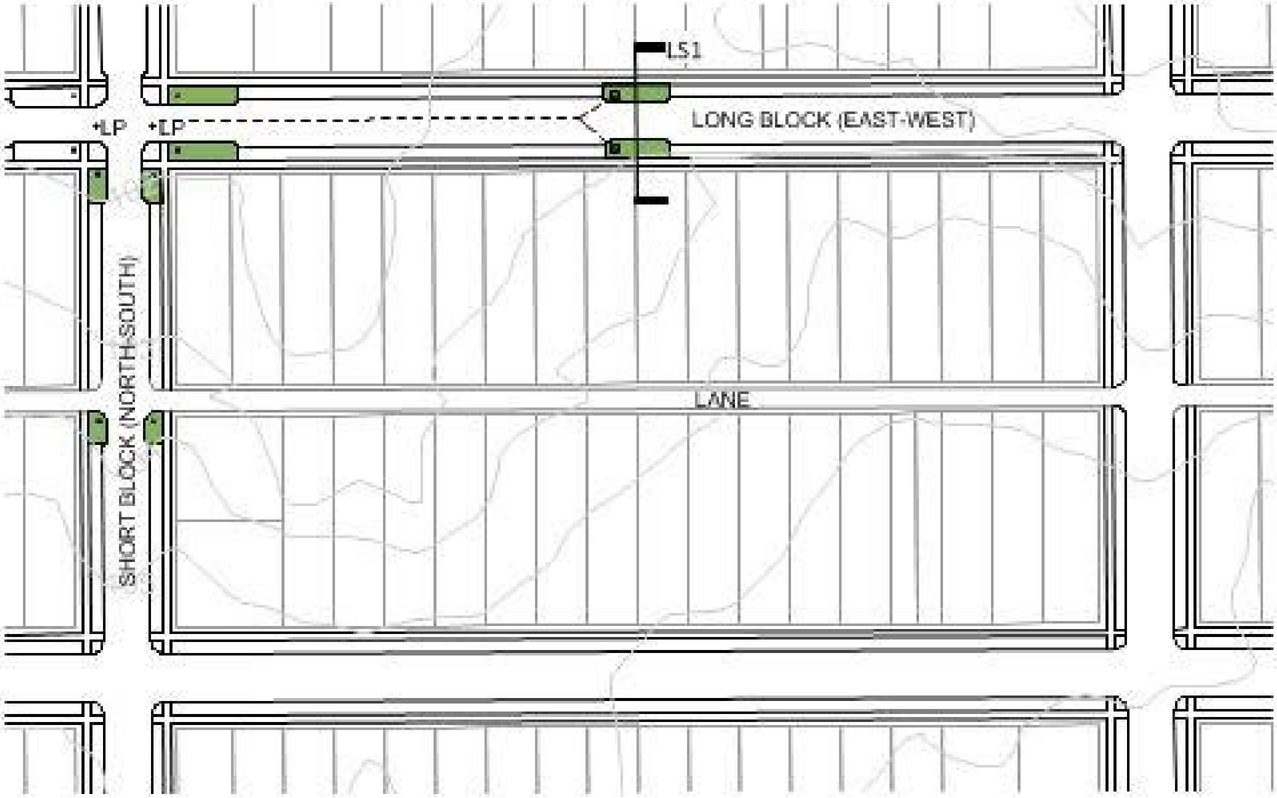
- Membrane-based Water Quality Structures (approximately 90% of locations);
- Localized infiltration bulges or Pervious Paving and Surface Parking (approximately 5% of locations);
- Localized Infiltration into Street Tree Wells (approximately 5% of locations)

Use of water quality structures to treat local streets is discouraged, but may be the only option in certain conditions.

Coordination of technical details with Coastal Health and utility agencies will be required. A review is anticipated of the interface with potable water supply utilities of both natural groundwater and infiltrated runoff.

Guidelines and analysis of these best practices are provided in IRMP Volume II: BMP Toolkit and Volume III: Technical Background Report (internal).

Figure I - 13: Local Street Surface Parking Treatment Option LS1

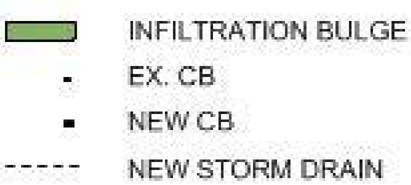


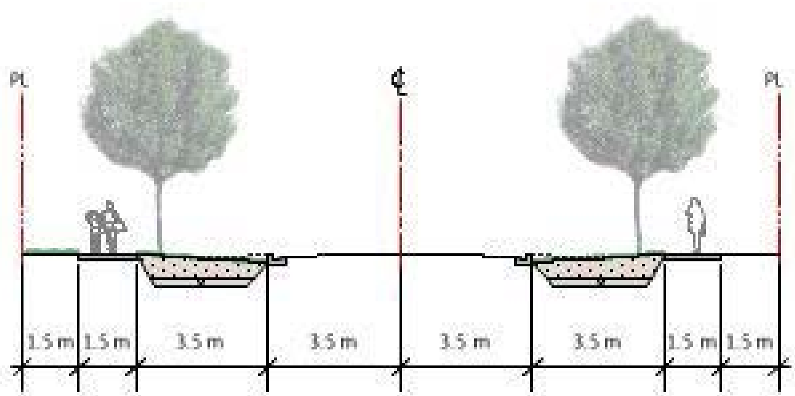
SHORT BLOCK (NORTH-SOUTH)

INFILTRATION BULGE AREA	92 sq.m
PARKING REDUCTION	4 stalls
TREE REMOVAL/REPLACE	4 trees

LONG BLOCK (EAST-WEST)

INFILTRATION BULGE AREA	180 sq.m
PARKING REDUCTION	8 stalls
TREE REMOVAL/REPLACE	4 trees





LOCAL STREET - INFILTRATION BULGES
Scale 1:200

OFF STREET SURFACE PARKING TREATMENT

Off-street parking areas still exist in the Citywide study area. Although their presence is dwindling in the downtown peninsula, they are still a common element along arterial and collector streets (behind or beside commercial buildings), at shopping centres or warehouse areas, at places of worship, and at schools and institutions.

Although this section is intended to address staff parking areas at heavy industrial sites, it should not be applied to industrial yards—which should have their own pollution abatement program.

The preference for treatments of off-street surface parking is similar to that for on-street, although the site plan configuration varies. All BMP tools should be considered for treating water quality from surface parking. However, the program envisions the general allocation of tools to be:

Off-Street Surface Parking:

- Infiltration Swales (Figure I - 14 Small Parking Option PS1)
- Pervious Paving to Parking Bays

Guidelines and analysis of these best practices are provided in IRMP Volume II: BMP Toolkit and Volume III: Technical Background Report (internal).

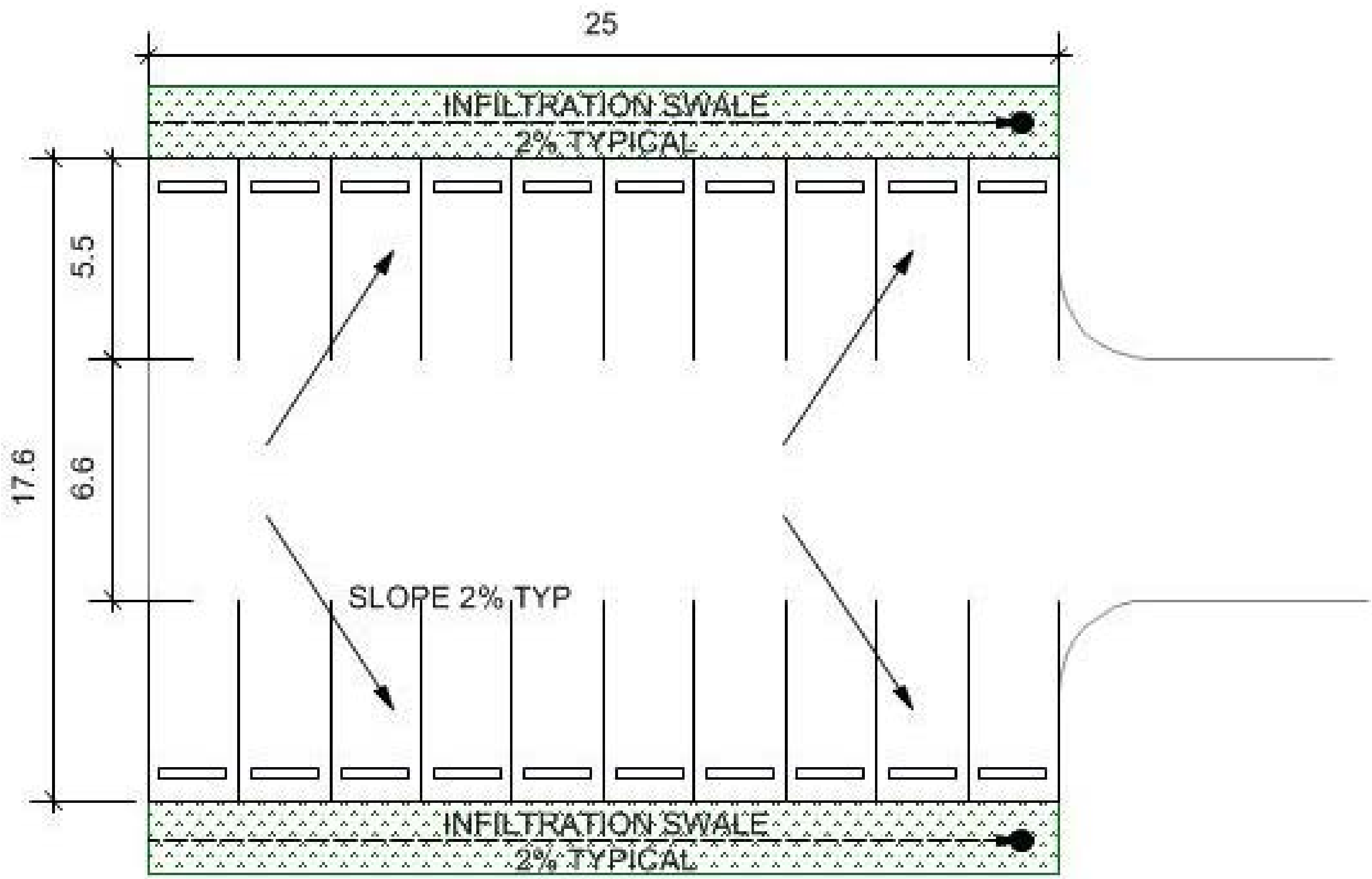
Which of these approaches are chosen for a given off-street parking area is to be determined at the time of development application, or if there is a rezoning application, at the rezoning stage. The development permit process may require landscaped area and tree cover for other purposes, and this requirement, as well as site configuration and space available, should lead to site specific choices.

Use of water quality structures to treat off-street surface parking is discouraged, but may be the only option in certain conditions. Water quality structures (e.g. pretreatment and membrane filtration system) may be appropriate in retrofit surface parking situations where no redevelopment is anticipated for some time, but there is a desire to provide basic water quality treatment.

Where surface parking is an open roof of a parking garage, treatment shall be to a similar performance standard to that provided by the above. Where space is limited, this might be by a water quality structure.

As storm sewer separation progresses, existing off-street parking areas may be connected to new storm sewers that will outfall to sensitive receiving waters. In addition to installed BMPs with new construction, it is therefore important to encourage water quality BMP retrofit of existing off-street surface parking areas prior to final sewer separation. A proposed Surface Parking Treatment Incentive Program could provide a charge on un-treated surface parking areas, with these charges reduced or eliminated as treatment BMPs are installed. A related grants program could provide incentives to early adopters.

Figure I - 14: Small Parking Area Treatment Option PS1



MONITORING AND ADAPTIVE MANAGEMENT PROGRAM

Metro Vancouver's approved Integrated Liquid Waste Resource Management Plan (ILWRMP) requires that municipalities monitor stormwater to assess and report on the effectiveness of ISMP implementation. Metro Vancouver, in consultation with member organizations, has developed a Monitoring and Adaptive Management Framework (MAMF) to monitor watershed health. It is recommended that the City of Vancouver create and maintain a Monitoring and Adaptive Management Program in accordance with the guidelines in the MAMF.

Under the MAMF, there are specific guidelines for piped systems, including monitoring of water quality parameters in every watershed once in every five years, for dissoved oxygen, pH, temperature, conductivity, turbidity, nutrients, E.coli and fecal oliforms, iron, copper, zinc, lead, and cadmium.

Early steps in the Vancouver Citywide Monitoring and Adaptive Management program implementation will include establishing monitoring sites and baseline data, and reviewing that baseline data in context with the water quality performance targets set out in the MAMF. Subject to baseline results, it is recommended that the City adopt the 'Yellow' MAMF ISMP Performance Targets as a minimum, while striving to meet the 'Green' water quality targets.

Additional detail of the proposed monitoring program are provided in IRMP Volume III (internal).

New Longer Term Actions

Two programs that are worthy, but potentially later in the implementation priorities: Absorbent Lanes and Rainwater Harvesting and Reuse.

ABSORBENT LANES PROGRAM

The City of Vancouver has been a leader in showcasing rainwater best practices in its Country Lanes Project.

The use of concrete wheel strips to support heavy waste vehicles, with surrounding absorbent landscape of pervious paving, is an exemplary design. This installation also represents a healthy relationship in involving the neighbourhood and adjacent landowners in pre-design engagement and in on-going maintenance.

However, lanes in Vancouver generally do not support much surface parking, and it is runoff from surface parking that is a priority for treatment to provide acceptable water quality for receiving waters. For this reason, investment in further Country Lanes projects would be a lower priority in the Citywide area than investing in solutions which treat water from surface parking areas (on-street or off-street).

The Country Lanes approach is important in reducing volume flows, and would reduce CSOs in the combined sewer system in the short term, and provide additional capacity in separate storm sewers in the long term. When other priority projects have been funded, attention could turn to investment in further Country Lane projects, with a determination of what parts of the Citywide system would be most beneficial at that time.

In the meantime, it is important that the amount and quality of runoff from lanes does not deteriorate. The Absorbent Sites program (above) should encourage no runoff during the design minor storm from private lands. Other than in major storms, there should therefore be no runoff from private lands to lanes or streets.

The City of Vancouver has been a leader in showcasing rainwater best practices in its Country Lanes Project.

Country Lanes

ROOF RAINWATER HARVESTING AND REUSE PROGRAM

Rooftop drainage from residential development, is less polluted than at-grade drainage, and should be treated as a resource for reuse where possible.

There are areas of BC (Gulf Islands, Vancouver Island) where use of roof rainwater harvesting and reuse technology is established and growing. There are also several examples of institutional and mixed use buildings in Vancouver that use rainwater harvesting and reuse technology, and in some cases wastewater treatment and reuse (Convention Centre, Olympic Village, UBC, private developments). For general introduction to Rainwater Capture and Reuse, refer to the IRMP Volume II: BMP Toolkit.

There are water conservation advantages in use of roof rainwater harvesting, both in reducing potable water consumption in summer outdoor water use and indoor toilet flushing. Use of the collected rainwater for toilet flushing is also important for a winter 'draw-down' of the water level in the tank in order to provide room for stormwater storage during periods of heavy rain.

Rainwater Harvesting system in a private residential home

Approvals systems for rainwater harvesting and reuse are evolving quickly in Canada and BC, with some concerns remaining in approval authorities about quality control in system installation and operations.

In this context, we recommend a program that encourages, but does not require, roof rainwater harvesting and reuse in the city. Elements would include:

- Motivational information to explain the benefits of rainwater harvesting (videos, pamphlets).
- Technical materials on the issues and guidelines for proper installation and maintenance.
- A focus on design, development and cost optimization for low-cost treatment techniques to reduce health risks and improve aesthetic acceptance of roof rainwater harvesting, in particular for toilet flushing but also as spray irrigation water where human contact may be possible.
- Work on expedited approval procedures between City Building and Plumbing Inspection, as well as with Coastal Health and BC Environment. These approval issues are common to many local governments, and therefore cooperative measures may be appropriate.
- Leadership on pilot installations and monitoring / public familiarization.
- Consideration of using Vancouver's custom building code powers to create a leading 'code' application to guide installation and quality control.

6.0 HOW DO WE ORGANIZE LONG-TERM FUNDING AND IMPLEMENTATION?

A Gradual and Sustained Effort

Meeting the targets for water quality long term, and reducing combined sewer overflows (CSOs) in the short term will take both community effort and financial effort.

The effort should be tied to infrastructure renewal. Although the City is built-out, it is constantly undergoing gradual re-construction as buildings, streets and infrastructure reach the end of their design-life.

At the current rate of redevelopment, a significant portion of Vancouver's single family buildings will be reconstructed by mid-century. The City's sewer separation program will also extend past mid-century before it is complete.
The timeline of implementing the Citywide IRMP is in the same scale – it will require a sustained effort in the range of 50 – 70 years before its recommendations are fully implemented in concert with building and infrastructure renewal.

Funding should vary by year and by the aggressiveness of the program. Based on analysis in IRMP Volume III Technical Background (internal), funding allocation over and above the existing sewer separation program will be required to:

- Support the Capacity-Building Program for staff and stakeholders that design, regulate, approve and deliver rainwater best practices.
- Support pilot projects – design, implementation and monitoring – to act as both training and proof of performance initiatives.
- Fund scientific monitoring as required by the Adaptive Management Framework.
- Provide pooled capital and operating/maintenance funds to allow detail design, construction and targeted maintenance of required stormwater retrofits and best practices on City streets and properties (see IRMP Volume III for maintenance assumptions).
- Fund the detail writing and adoption / phase-in of updated regulatory approaches to promote implementation of rainwater BMPs.
- Receive funds, and disburse grants or reductions in fees, related to stormwater incentive programs, both the Surface Parking Treatment program, and a potential Rainwater Reuse program.

Some of this budget might incorporate and enhance existing City funding e.g. catch-basin cleaning and cleaning of other structural best practices, as well as the sewer cross-connection program.

Short Term Organizational Development and Funding

The 'Phasing and Scheduling Strategy' in Figure I - 15 suggests that a 5 year effort may be necessary to 'start-up and phase-in' the implementation of proposed changes.

In reality, the City is already active in stormwater management. The proposed targets will bring new players, new roles, and a need for new understanding and training as a precedent to on-the-ground action. There are likely to be both education and awareness steps, as well as refined or new regulations and financing mechanisms that need to be put in place.

Figure I - 15: Phasing and Scheduling Strategy

Ongoing Stakeholder Consultation & Public Outreach

1 PHASE A: Immediate and On Going

- Complete detail design of programs, and related financial planning. Confirm Council support.
- Create and staff a new Green Infrastructure (GI) Team.
- Supplement existing street and catch basin cleaning & sewer cross connection programs. Continue rainwater management plans for large rezonings.
- Continue on-going sewer separation program.
- Increase the implementation of Green Infrastructure demonstration and learning in current projects.

2 PHASE B: Remove Barriers, Build Capacity

- Create green infrastructure capacity-building materials like video and web materials that explain, in plain english, the why, what and how of rainwater management.
- Identify priorities for GI demonstration projects, and start off-street implementation.
- Update the City's Engineering Standards to include typical details and design guidelines that ease implementation of best practices.
- Start and maintain a Water Quality Monitoring Adaptive Management program to meet senior agency requirements (all subsequent phases).

Ongoing Stakeholder Consultation & Public Outreach

3

i

PHASE C: Expand Green Infrastructure (GI) into New Non-SF Projects

- Review options for a stormwater utility and for financial incentive programs.
- Require BMP application in new non-single family projects on private land.
- Upscale the amount of GI installations in local streets.
- Continue with public awareness programs and demonstration / capacity building.

ii

PHASE D: Expand Green Infrastructure to New One/Two Family / Lane Housing

- expand GI application to new One/Two Family Housing and Lane Housing, with the familiarity and standards gained in the above three phases now used to expand application or best practices into new construction in low density residential redevelopment.
- Provide SF-specific demonstration and public awareness. programs.

iii

PHASE E: Expand Green Infrastructure to Retrofits

- expand application to retrofits, in recognition that implementing water quality improvements will need to address problems in existing surface parking and building sites.
- Incentive programs, financed by fees on untreated impervious area, are to be considered to speed adoption for retrofits.
- Expand public information and homeowner/small contractor training to facilitate implementation.

4

PHASE F: Long Term Aspirations

- Phase F would introduce incentives and programs for Rainwater Harvesting and Reuse, and for Absorbent Lanes.
- Public awareness programs, water quality monitoring and adaptive management programs would continue to allow fine-tuning.

Beyond Phase F, the programs would be fully active. Continuous improvement to the City's rainwater management is envisioned as a permanent objective, in recognition that full implementation will be achieved only over a building/street asset life cycle, which is in the range of 50 to 100 years (average 75 years).

The following Action Priorities table identifies tasks, roles, and implementation timetables, to be updated from time to time.

1.1 Vancouver IRMP Action Priorities

ACTION	FUNDING	PRIORITY	LEAD AGENCY	RESOURCES (City)
PHASE A: IMMEDIATE AND ONGOING (2016)				S=small M=medium L=large
Implement GI team	Operating	By 2016	Inter-departmental	M
Catch basin cleaning action / awareness	Operating	Ongoing	Eng.:Sewers	S
Cross connection control action / awareness	Operating	Ongoing	Eng.:Sewers	S
Require Green Infrastructure (GI) in large rezonings (cont'd)	Operating	Ongoing	Planning / Eng.	S
Integrate GI demonstration/learning in current projects	Capital & Development	Ongoing	Planning / Eng. / Real Estate / Facilities Management	M
PHASE B: REMOVE BARRIERS, BUILD CAPACITY (2017)				
Green Infrastructure (GI) public awareness (stage one)	Operating	By 2017	GI Team / Communications / Eng.	M
Identify priority areas for street GI implementation	Operating	By 2017	Eng.:Sewers / Streets / Transportation	S
Update Engineering standards to include GI	Operating	By 2017	Eng.:Sewers / Streets	S
Water Quality Monitoring / Adapt to meet regulations	Operating	By 2017	Eng.:Sewers	M
City Off-Street Property GI demo / monitoring projects	Capital / Development	Ongoing	Planning / Real Estate	S
PHASE C: EXPAND GREEN INFRASTRUCTURE INTO NEW NON-SF PROJECTS (2018)				
Review surface parking treatment fee / incentives options	Operating	By 2018	Eng.:Sewers / Planning / Finance	S
Study stormwater utility admin system - future option	Operating	By 2018	Eng.:Sewers / Planning / Finance	S
Street block GI demo / monitoring projects	Capital	Ongoing	Eng:.Sewers /Streets	S
Parks site GI and biodiversity demo / monitoring projects	Capital	Ongoing	Parks / Eng: Sewers	S
Green Infrastructure (GI) public awareness (stage two)	Operating	By 2018	Communications / GI Team	S
Require GI in new MF ICI projects (update regs)	Operating	By 2018	Planning / Dev. Services	M
On-street surface parking treatment integrated with sewer separation	Capital	Ongoing	Eng.:Sewers/streets	L

1.1 Vancouver IRMP Action Priorities (cont'd)

ACTION	FUNDING	PRIORITY	LEAD AGENCY	RESOURCES (City)
PHASE D: EXPAND GREEN INFRASTRUCTURE TO NEW ONE/TWO FAMILY / LANE HOUSING (2019)				S=small M=medium L=large
Green Infrastructure (GI) public awareness (stage three)	Operating	By 2019	GI Team / Communications	S
Private SF GI demo / monitoring projects	Capital / Development	Ongoing	Planning / Dev. Services	S
Require GI in new SF/Duplex projects (update regs.)	Operating	By 2019	Planning / Dev. Services	M
Water Quality Monitoring / Adapt to meet regulations	Operating	Ongoing	Eng.:Sewers	M
On-street surface parking treatment integrated with sewer separation	Capital	Ongoing	Eng.:Sewers/streets	L
PHASE E: EXPAND GREEN INFRASTRUCTURE TO RETROFITS (2020)				
Green Infrastructure (GI) public multimedia (stage four)	Operating	By 2020	GI Team / Communications	S
Private surface parking GI demo / monitoring projects	Capital / Development	Ongoing	Planning / Dev. Services	S
Launch charges/incentives for GI in ex private surface parking	Operating	By 2020	Planning / Dev. Services	M
Water Quality Monitoring / Adapt to meet regulations	Operating	Ongoing	Eng.:Sewers	M
On-street surface parking treatment integrated with sewer separation	Capital	Ongoing	Eng.:Sewers/streets	L
PHASE F: LONG-TERM ASPIRATIONS (beyond 2020)				
Green Infrastructure (GI) public multimedia (stage five)	Operating	By 2021	GI Team / Communications	S
Rainwater capture / reuse demo / monitoring projects	Capital	Ongoing	Eng: Sewers / Planning / Dev. Services	S
Launch incentives for rainwater capture/reuse	Operating	By 2022	Planning / Eng. / Dev. Services	M
Start Absorbent Lanes program	Operating	By 2023	Eng.:Sewers/streets	M
Water Quality Monitoring / Adapt to meet regulations	Operating	Ongoing	Eng.:Sewers	M
On-street surface parking treatment integrated with sewer separation	Capital	Ongoing	Eng.:Sewers/streets	L

Long-term Organizational Development and Funding

It is very important to get started on implementation of the Citywide IRMP Recommendations. Minor Supplements to existing funding can support that beginning.

For a sustained and long-term effort, it is recommended that the following funding strategies be investigated in more detail.

SHIFT TO POLLUTER PAY MODEL

The City is investing heavily in the sewer separation program, and that should support major reductions in the pollution associated with combined sewer overflows.

As stormwater is separated, and as it outfalls directly to the beaches, bays and receiving waters, there will be a reduced, but still signficant amount of pollution that is carried with the stormwater, if it is untreated.

The source of pollution in stormwater is widely spread – it is the surface parking areas, whether on-street or off-street, the manicured landscapes with excess nutrient runoff, the pet and wildlife feces, and sediment from construction operations.

To be fair to the city taxpayer, the costs of such pollution should be allocated to the source of the pollution. It is possible, with implementation of green infrastructure, to have a highly livable and high density city that has very low levels of pollution. The City should move to the principle of 'polluter pay', with both the public and private sector / homeowners contributing in measure to their pollution.

As a corollary, those who are not sources of pollution should pay significantly less than those who are polluting.

STORMWATER UTILITY

Other local governments (e.g. Halifax, Victoria) have implemented a distinct organization to administer stormwater management and funding – a stormwater utility. Similar to a water, energy, or communications utility, this administration would operate on a 'fee for service' basis. It would charge user fees based on a fair allocation of benefits and costs, with the total fees sufficient to make the utility self-sufficient with little or no subsidy from the property tax base.

In the City of Victoria, a primary reason for establishment of a stormwater utility was to provide a system of incentives for stormwater pollution control, financed by changes on untreated impervious area, similar to the parking area pollutions fees described below.

PARKING AREA POLLUTION FEES

An increasingly common approach by other local governments is to establish a fee that is calculated on the area of un-treated surface parking area on a parcel. The fee is calculated based on a combination of aerial imagery and building permit records. Areas of surface parking that have implemented green infrastructure water quality treatment would be exempt from the fee. Some parts of the revenue generated may be used for incentive funding to assist green infrastructure retrofits.

Taken together, this fee and incentive has the effect of encouraging retrofit of green infrastructure water quality treatment into existing surface parking areas. At the same time, it allows that some parcels may not wish to retrofit (e.g. being too small, or being slated for early redevelopment) and they would prefer to simply pay the fee, which in effect funds the implementation of water quality treatment in another location.

These types of fees utilize market forces to encourage change – and are often targeted at existing development, where the regulatory requirements associated with permitting for new development do not apply.

STORMWATER PARCEL TAX

A second approach to funding infrastructure separate from assessment-based property tax is to implement a function-specific parcel tax. These charge a fixed amount per year per parcel. The fee does not vary based on assessed value of the property. In effect, these fees do not penalize large or high value property owners – such as industry or larger commercial. Commonly a parcel tax is a small amount per property, which adds up to a substantial and sustainable fund for a specific purpose – like implementation of stormwater improvements – as opposed to general revenue. In that way the public is certain of the allocation of the tax. The parcel tax may also have a sunset arrangement – where it is set to expire after a stated time period.

As opposed to a stormwater utility or parking area pollution fees, a stormwater parcel tax does not follow the principle of polluter pay.

INTEGRATION WITH CLIMATE CHANGE AND RISK MANAGEMENT PROGRAMS

Climate Change and Risk Management Programs related to sea level rise, storm and flood risk, and drought risk will all require increasing attention and investment by all levels of government and the private sector.

The City of Vancouver's Citywide IRMP implementation should be watchful of how its funding could be integrated into larger risk management programs and senior government grants and incentives. There is much cross-over among objectives of the IRMP and actions that would make the city more resilient to climate change.

ADAPTIVE MANAGEMENT

Just as the water quality aspects of the IRMP should be subject to ongoing monitoring and adaptive management, we recommend that the funding and implementation action plan take a similar approach.

The lifespan of this program implementation should extend through the lifespan of a typical simple building – about 75 years. There will be much change – in technology, in precedents, in public attitudes, in climate – over those years. A review of priorities and programs is advised, at least once every five years.

7.0 WHAT CONSTITUTES SUCCESS?

Vancouver continues to be a world-class city, and it has created attention across the world for its Greenest City Action Plan (GCAP) and related progress. The Integrated Rainwater Management Plan is a key implementation tool for GCAP, and through its actions we expect Vancouver to become increasingly noteworthy for:

- Urban beaches, within walking distance, that support swimming and recreation;
- Urban waters that are alive with fish, amphibians, birds and marine mammals;
- Urban streets and developments that are resilient to climate change;
- A world leading example of livable and sustainable urban design.

To quantify success, this Integrated Rainwater Management Plan includes specific targets and action programs for water quality improvements and stormwater runoff volume reduction.

The proposed Monitoring and Adaptive Management Strategy should be used to measure results on a regular basis, and the associated data will inform IRMP implementation updates to achieve target performance. Reporting on this performance will be important to senior government agencies overseeing the Metro Vancouver Integrated Waste and Resource Management Plan, and to stakeholders and the public.

The IRMP sets out a long term strategy. It's success will require gradual and sustained effort by both City forces and the private sector. The most effective implementation will be through integration of the IRMP best practices into on-going infrastructure and development projects as assets reach the end of their life cycle.

One of the IRMP's greatest challenges, and its greatest success if achieved, will be an improved cross-discipline and public understanding of the design, construction and maintenance of green infrastructure throughout the city's parks, streets, institutions and private land holdings.

Success will be gained through the entire community taking up a role to protect Vancouver's water and watersheds and the quality of life and urban biodiversity that our abundant and valuable rainwater supports.

Assumptions and Limitations

The analysis and recommended actions in this document are based on review of currently available information, and are in accordance with current planning and engineering practice.

Readers should note the following limitations:

I. Maps and quantities shown are based on 'sample areas' that are representative of the pattern of conditions across the study area. Actual total quantities may vary.

II. Where unit costs or quantities are shown, these are approximate 2014 dollars CDN suitable for comparison of options, and based on little or no site information, and therefore only accurate within a range of plus or minus 30% (Class D). No warranty is implied or given on accuracy of quantities or unit costs for any given project.

III. Mapping is based on data and polygons from a variety of sources, and is schematic in nature. No warranty is made as to accuracy of map information.

IV. Infiltration rates discussed are theoretical based on typical rates in assumed soil conditions, sufficient for general option comparison and policy guidance. Users are advised to gain site-specific hydrotechnical advice as a basis for detail design.

V. Where design detail guidelines are provided, the information is intended as an introduction. Readers are guided to the technical reference documents listed as References in IRMP Volume III: Technical Background (internal) for more information. In all cases, it is required that professional site-specific design and construction management advice be sought to customize application of these best practices to a specific site and land use situation.

CITY OF VANCOUVER

GREENEST CITY

Golder Associates

Sustainable Communities

VOLUME II

Best Management Practice Toolkit

FINAL DRAFT

CITY OF VANCOUVER

GREENEST CITY

Structure of the Citywide Integrated Rainwater Management Plan

The Citywide Integrated Rainwater Management Plan (IRMP) addresses areas of Vancouver where stormwater is piped directly to either combined sewer or ocean outfalls. Outside of the IRMP study area, two watersheds in Vancouver have remaining surface streams—Still Creek and Musqueam Creek—and are guided by their own integrated stormwater (rainwater) management plans, under separate cover. Stanley Park, which has surface streams, is also excluded from this study area.

Credits

Prime Consultant/Author:
Golder Associates Ltd.

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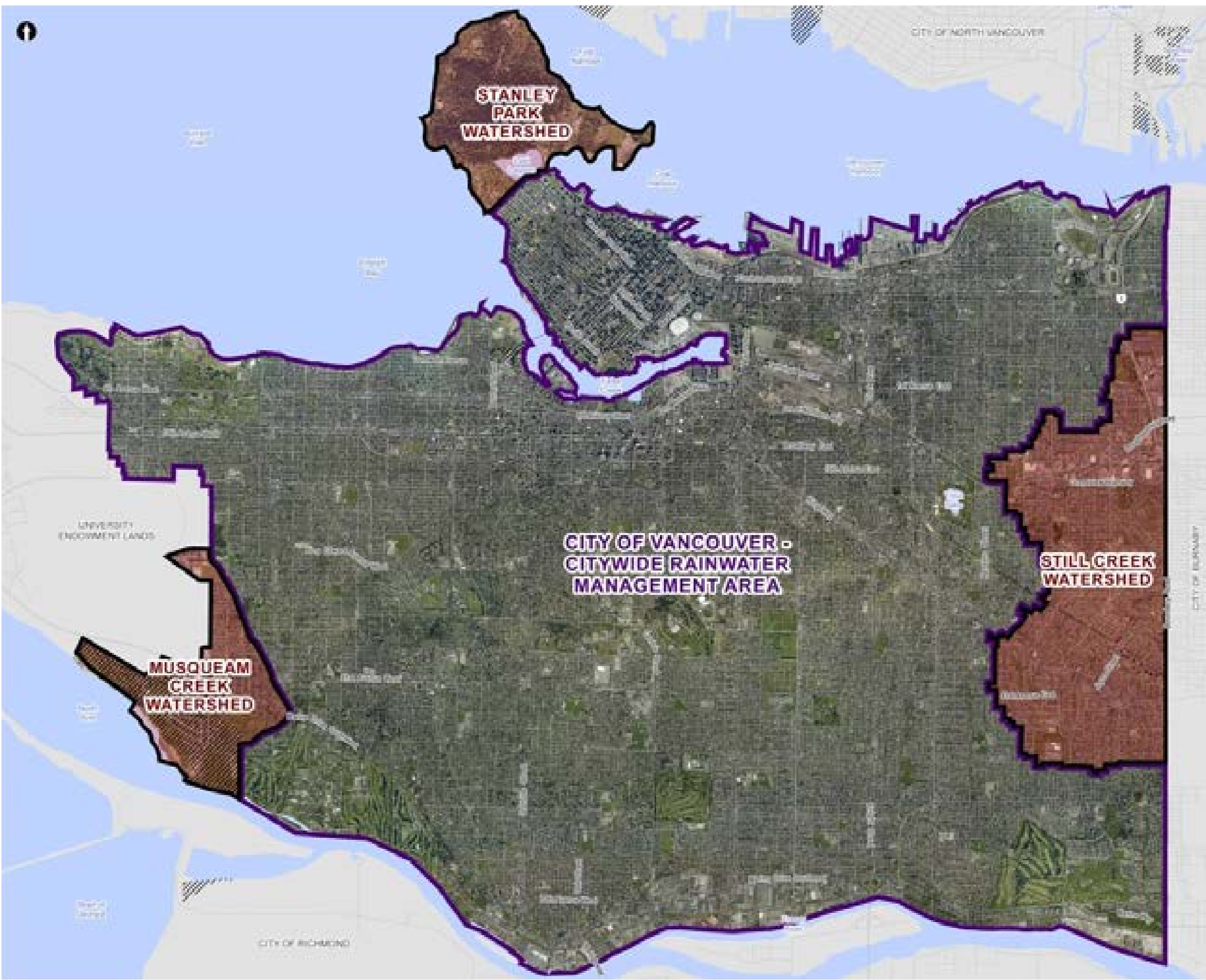
Lanarc 2015 Consultants Ltd.

March 2016

City of Vancouver - Citywide Rainwater Management Area



The Citywide Integrated Rainwater Management Plan is presented in three volumes:

I. **Vision, Principles and Actions** – a summary of why rainwater management is required, introduction to targets programs to address priorities.

II. **Best Practice Toolkit** – a guide to common tools to address rainwater management in Vancouver, highlighting their strengths and challenges. (this document)

III. **Technical Background Report** (internal) – a detailed record of process, stakeholder input, alternatives considered, technical and financial analysis, program details and action plan.

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facilitate double-sided booklet printing.

1.0 BEST MANAGEMENT PRACTICE TOOLKIT

The BMP Toolkit provides an introduction to a range of common best practices to improve rainwater management. These tools are in common use in other jurisdictions around Metro Vancouver, the Pacific Northwest, and in developed areas around the world.

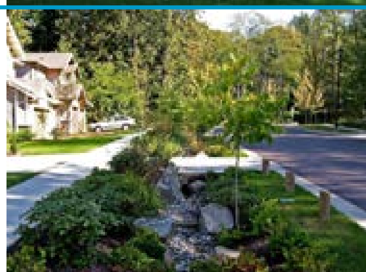
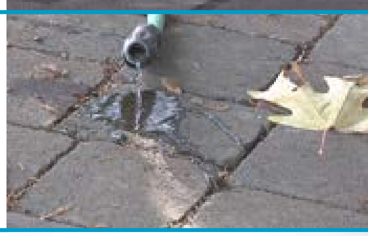
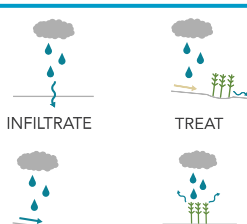
The Toolkit BMPs are:

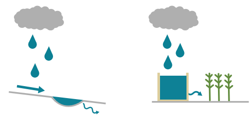
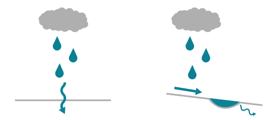
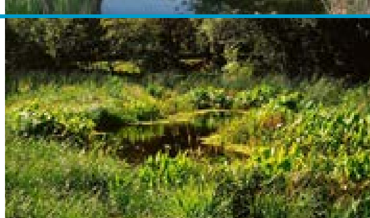
- Absorbent Landscapes
- Infiltration Swales
- Rain Gardens & Infiltration Bulges
- Pervious Paving
- Green Roof
- Tree Well Structure
- Rainwater
- Infiltration Trench
- Water Quality Structures
- Detention Tanks
- Daylighted Streams
- Constructed Wetlands

Table II - 1 summarizes the Toolkit BMPs. The Toolkit includes key description of purpose, graphics and diagrams to show scope and application, key design principles, limitations and sizing variables, and maintenance and operations considerations.

The Toolkit is introductory. Links to examples and manufacturer information is provided in the 'For More Information' Section. Readers should use the Toolkit in conjunction with more detailed technical guidance which is provided generally in the Metro Vancouver Stormwater Source Control Guidelines 2012.

Table II - 1: BMP Toolkit Summary Table

TOOL		IMPACTS ON WATER	BENEFITS
Absorbent Landscapes			• intercept and clean rainwater through soil pores, allowing gradual infiltration into subsoils to recharge groundwater
Infiltration Swales			• reduce runoff volume and increase water quality by capturing, detaining, treating, and conveying stormwater
Rain Gardens & Infiltration Bulges			• reduce runoff volume and improve water quality by infiltrating, capturing, and filtering stormwater • an overflow conveys extreme rainfall volumes
Pervious Paving			• reduce runoff volume and improve water quality by infiltrating and treating stormwater while still providing a hard, drivable surface
Green Roofs			• reduce stormwater peak flows and volume, depending on depth of growing medium • benefit buildings by providing insulation and by reducing the heat island effect • provide urban habitat
Tree Well Structures			• adequate soil volume will retain excess stormwater and help to remove pollutants from stormwater runoff • support a healthy tree canopy which intercepts rainfall

TOOL		IMPACTS ON WATER	BENEFITS
Rainwater Harvesting		 DETAIN; CAPTURE & REUSE	• runoff from roof surfaces can be captured, stored and used for non-potable uses like landscape irrigation, laundry, and toilets, subject to approval of authorities having jurisdiction.
Infiltration Trenches		 INFILTRATE; DETAIN	• reduce the volume and rate of runoff by holding and infiltrating water into subsurface soils • water quality pre-treatment is advisable
Water Quality Structures		 TREAT	• capture petroleum hydrocarbons, coarse grit and coarse sediment • provide some water quality benefits except for soluble nutrients and pollutants
Detention Tanks		 DETAIN	• reduce flooding and in-stream erosion by collecting and storing stormwater runoff during a storm event, and releasing it at controlled rates to the downstream drainage system
Daylighted Streams & Channel Improvements		 DETAIN; HABITAT; TREAT	• may provide in-stream detention, water quality improvements, and essential habitat for aquatic life • contribute to the liveability of an area and establish a sense of place if properly designed
Constructed Wetlands		 DETAIN; HABITAT; TREAT	• provide detention, storage, habitat, and treat stormwater runoff through natural processes prior to discharging it into the downstream drainage system

Absorbent Landscapes

In most natural wooded conditions in Metro Vancouver 90% of rainfall volume never become runoff, but it is either soaked into the soils or evaporates/transpirates. Trees, shrubs, grasses, surface organic matter, and soils all play a role.

Primary Purpose

- To reduce runoff from impermeable surfaces by creating more absorbent landscapes that intercept and retain rainwater.

Performance Rating

FUNCTIONAL CRITERIA

Best

- Water Quality Treatment
- Aesthetic Benefits
- Biodiversity Benefits

Good

- Volume Control (reduced CSO's)
- Public Education, Culture and Health Values

COST CRITERIA

Best

- Land Cost
- Property Value
- Longevity

Good

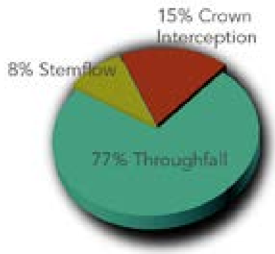
- Material and Construction Cost

Limited Benefit

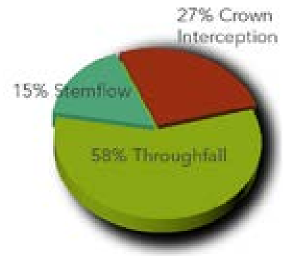
- Maintenance Cost

This tool is suitable for:

- Low Density
- Medium/High Density
- Commercial Mixed Use
- Industrial
- Institutional
- Parks & Greenspace
- Local Streets



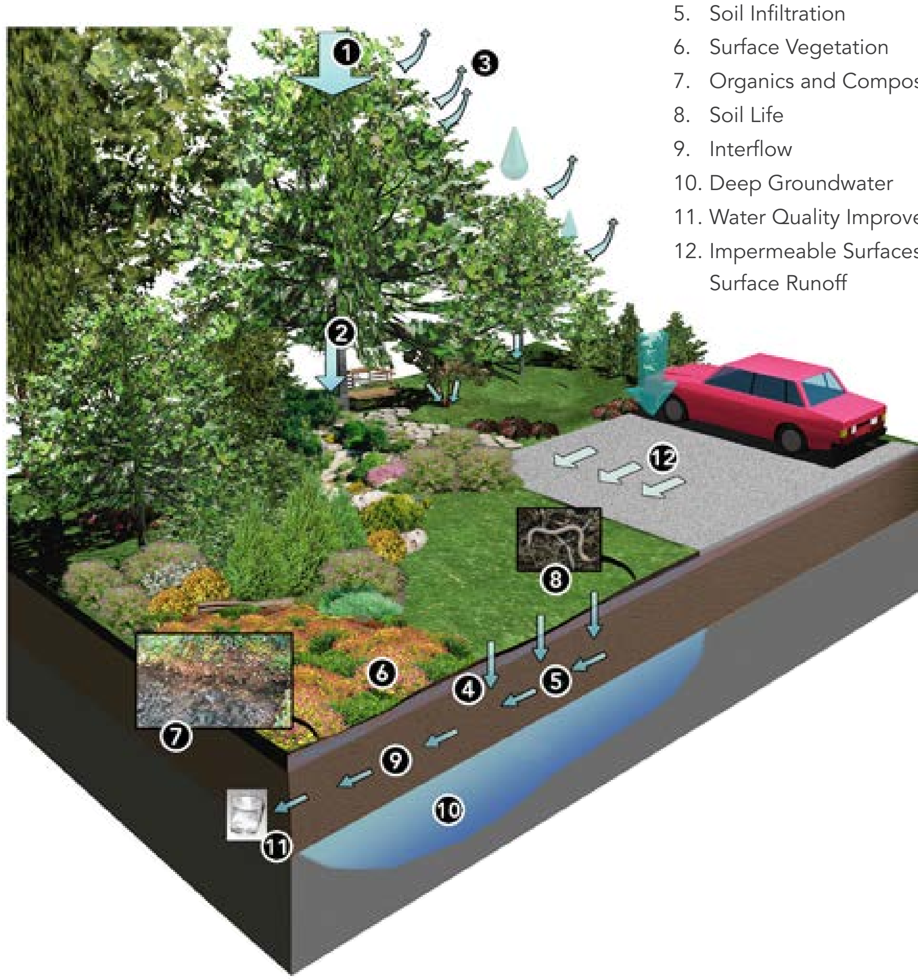
Pear Tree



Evergreen Oak Tree

Winter tree canopies intercept 15% to 27% of rainfall

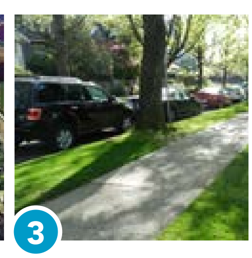
1. Crown Interception
2. Throughfall and Stemflow
3. Evapotranspiration
4. Soil Water Storage
5. Soil Infiltration
6. Surface Vegetation
7. Organics and Compost
8. Soil Life
9. Interflow
10. Deep Groundwater
11. Water Quality Improvement
12. Impermeable Surfaces and Surface Runoff



Absorbent Landscape Examples

1 Vancouver's Green Street Program

2 Private residential yard



3 Residential Street

4 Parks & Open Space

Design Principles, Limitations and Sizing Variables

- Maximize the area of absorbent landscape—either existing or constructed—on the site. Conserve as much existing vegetation and undisturbed soil as possible.
- Minimize impervious area by using multi-storey buildings, narrower roads, minimum parking, larger landscape areas, green roof, and pervious paving.
- Disconnect impervious areas from the storm sewer system, having them drain to absorbent landscape.
- Design absorbent landscape areas as dished areas that temporarily store stormwater and allow it to soak in, with overflow for large rain events to the storm drain system.
- Maximize the vegetation canopy cover over the site. Multi-layered evergreens are ideal, but deciduous cover is also beneficial for stormwater management.
- Ensure adequate growing medium depth for both horticultural and stormwater needs—a minimum depth of 300 mm for lawn is required to store 60 mm of rainfall.
- Cultivate compost into surface soils to create minimum 8% organic matter for lawns, and 15% for planting beds.
- To avoid surface crusting and maintain surface permeability, install vegetative (grass, groundcovers, shrubs, trees) or organic cover (mulch, straw, wood fibre) as early as possible in the construction process, and prior to winter storms.
- Provide effective erosion control during construction, including erosion control on upstream sites that may flow into absorbent landscape.

Optimizing Performance

DESIGN & CONSTRUCTION

- Ensure roughening (scarification) of subgrade to reduce crusting / impermeability of the excavation surface prior to placing topsoil.
- Enforce quality control of topsoil to be free of weed seeds, and to meet specs for texture and hydraulic properties. If suitable reuse existing topsoil.
- Include compost to increase percolation and reduce need for water and fertilizer inputs.
- Greater growing medium depth equals greater storage and treatment of rainfall.
- Include an organic mulch layer to surface.

MAINTENANCE

- In planting beds, aerate or till surface 25 mm deep between plants each spring to reduce crusting.
- In lawns, core-aerate areas of surface compaction each spring.
- Ensure regular spring weeding to avoid weeds going to seed.
- Remove and replace surface mulch in ponding areas once every three years

Did you know?

- Impermeable surfaces create 8 –10 times more runoff than absorbent landscapes.
- Organic matter and soil micro-organisms are vital to maintaining soil infiltration rates.
- Rainfall storage in soil is 7% to 18% of soil volume.

For more information:

www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/StormwaterSourceControlDesignGuidelines2012.pdf

Infiltration Swales

An Infiltration Swale is a shallow grassed or vegetated channel designed to capture, detain and treat stormwater and convey larger flows. It takes surface flows from adjacent paved surfaces, holds the water behind weirs, and allows it to infiltrate through a soil bed into underlying soils. The swale and weir structures provide conveyance for larger storm events to the storm drain system. Variations on designs include an underlying drain rock reservoir, with or without a perforated underdrain.

Primary Purpose

- Water quality treatment, reduction of runoff

Performance Rating

FUNCTIONAL CRITERIA

Best

- Water Quality Treatment

Good

- Volume Control (reduced CSO's)
- Public Education, Culture and Health Values
- Aesthetic Benefits
- Biodiversity Benefits

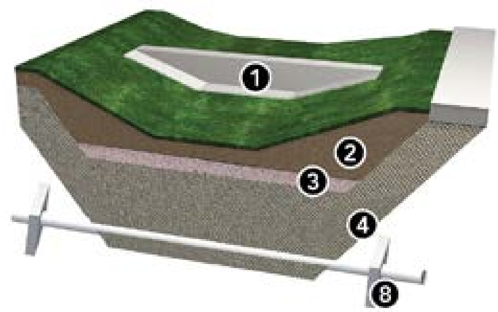
COST CRITERIA

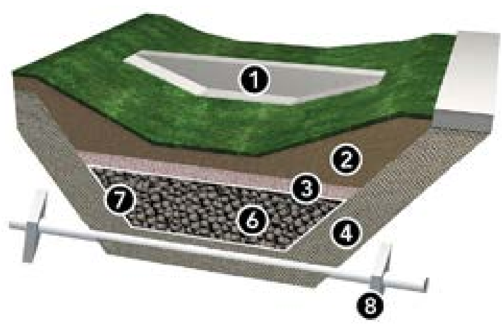
Best

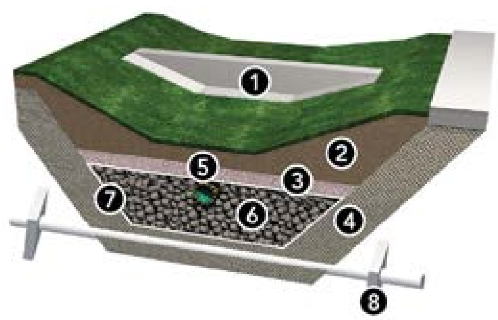
- Property Value

Good

- Longevity
- Land Cost
- Material and Construction Cost
- Maintenance Cost







1. Weir Keyed into Swale Side Slope
2. Growing Medium (300 mm Min.)
3. Sand
4. Existing Scarified Subsoil
5. Perforated Underdrain (150 mm Dia. Min.)
6. Drain Rock Reservoir (300mm Min.)
7. Geotextile Along All Sides of Reservoir
8. Trench Dams at All Utility Crossing

This tool is suitable for:

- Medium/High Density
- Commercial Mixed Use
- Industrial
- Institutional
- Parks & Greenspace
- Local Streets
- Collector/ Arterial Streets

FULL INFILTRATION

Where water entering the swale is filtered through a grass or groundcover layer, and then passes through sandy growing medium and a sand layer into underlying scarified subgrade. Suitable for sites with small catchments and subsoil permeability > 30 mm/hr.

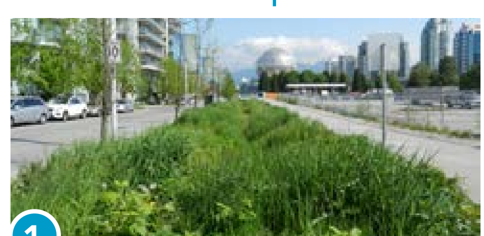
FULL INFILTRATION WITH RESERVOIR

Designed to reduce surface ponding by providing underground storage in a drain rock reservoir. Suitable for sites with small catchments and subsoil permeability > 15 mm/hr.

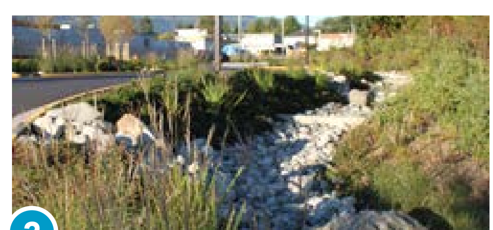
PARTIAL INFILTRATION WITH RESERVOIR & SUBDRAIN

Where a perforated drain pipe is installed at the top of the reservoir, providing an underground overflow that removes excess water before it backs up to the surface of the swale. Suitable for sites with larger catchments and low infiltration rates into subsoil permeability < 15 mm/hr. Provides water quality treatment even if infiltration into subsoils is limited.

Precedent examples



1 **Bioswale -** Olympic Village



2 **Infiltration Swale -** Nanaimo Regional General Hospital

Design Principles, Limitations and Sizing Variables

- See the reference document for sizing guidelines. Higher sediment load land uses require lower ratios of impervious area to swale area.
- Flow to the swale should be distributed sheet flow, traveling through a filter area at the swale verges. Provide pre-treatment and erosion control to avoid sedimentation in the swale.
- Provide a 50 mm drop at the edge of paving to the swale soil surface, to allow for positive drainage and buildup of road sanding/organic materials at this edge.
- Swale planting is typically sodded lawn. Low volume swales can be finished with a combination of grasses, shrub, groundcover and tree planting.
- Swale bottom - flat cross section, 600 to 2400 mm width, 1–2% longitudinal slope or dished between weirs.
- Swale side slopes—3(horizontal):1(vertical) maximum, 4:1 or less preferred for maintenance.
- Weirs to have level top to spread flows and avoid channelization, keyed in 100 mm minimum.
- Maximum ponding level - 150 mm for minimum hazard. Drawdown time for the maximum surface ponded volume - 48 hrs
- Treatment soil depth—300 mm desirable, minimum 150 mm if design professional calculates adequate pollutant removal - varies depending on planting design.
- Design stormwater conveyance using Manning's formula or weir equations whichever governs with attention to channel stability during maximum flows.
- Drain rock reservoir and underdrain may be avoided where infiltration tests by a qualified professional, taken at the depth of the proposed infiltration, show an infiltration rate that exceeds the rate required by the design.

Optimizing Performance

DESIGN & CONSTRUCTION

- Undertake site-specific infiltration testing and, based on results, design the system infiltration area, surface and underground storage volume, and overflow subdrain. Be careful to not exceed impervious / pervious (I/P) guidelines in design, exercising great caution in Vancouver if exceeding a 5:1 I/P ratio.
- Provide a minimum 50 mm drop in gutter profiles and further 50 mm drop into the infiltration surface to avoid runoff bypassing the facility.
- Enforce quality control of topsoil to be free of weed seeds, and to meet specs for texture and hydraulic properties. Use of non-angular sand (e.g. Fraser River pump sand) is encouraged for the sand component. Native topsoil will rarely be suitable, having too low an infiltration rate.
- Include compost to increase percolation and reduce need for water and fertilizer inputs. Greater growing medium depth equals greater storage and treatment of rainfall. Include an organic mulch layer to surface.

MAINTENANCE

- Inspect and clean the inlet twice per year minimum (spring and fall).
- In lawns, core-aerate areas of surface compaction each spring.
- In planting beds, cultivate surface 25 mm deep between plants each spring to reduce crusting. Ensure regular spring weeding to avoid weeds going to seed.
- Remove and replace surface mulch between plants in ponding areas once every three years.

For more information:

www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/04StormwaterSourceControlDesignGuidelinesInfiltrationSwales.pdf

Rain Gardens & Infiltration Bulges

An Infiltration Rain Garden is a form of bioretention facility designed to have aesthetic appeal as well as a stormwater function. Rain gardens are commonly a concave landscaped area where runoff from roofs or paving infiltrates into deep constructed soils and subsoils below. On subsoils with low infiltration rates, Rain Gardens often have a drain rock reservoir and perforated drain system to convey away excess water.

Primary Purpose

- Capture and filter runoff from adjacent impervious surfaces such as roads, roofs, parking lots and driveways.

Performance Rating

FUNCTIONAL CRITERIA

Best

- Water Quality Treatment
- Aesthetic Benefits
- Biodiversity Benefits

Good

- Volume Control (reduced CSO's)
- Public Education, Culture and Health Values

COST CRITERIA

Best

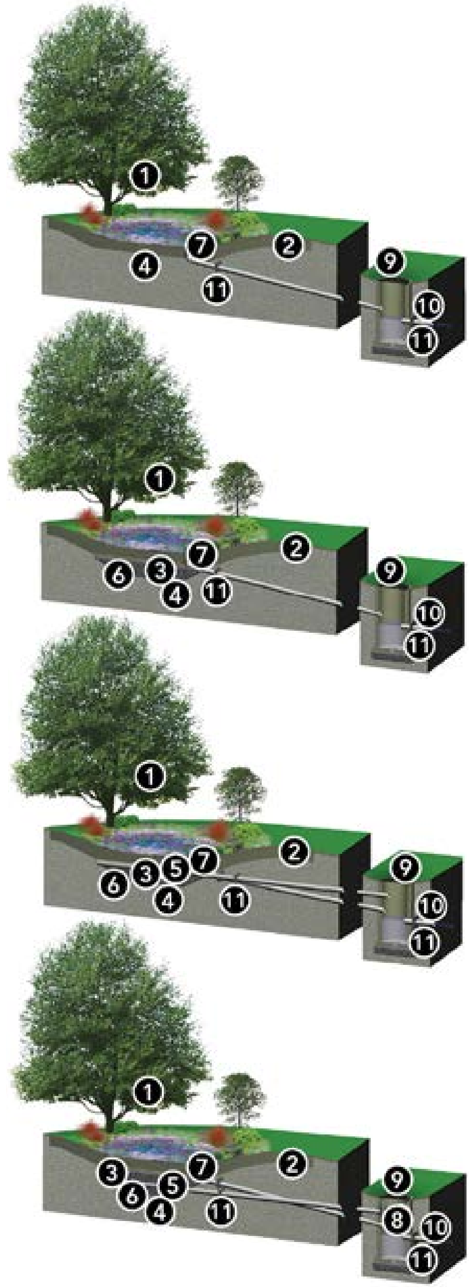
- Land Cost
- Property Value

Good

- Longevity
- Material and Construction Cost
- Maintenance Cost

This tool is suitable for:

- Low Density
- Medium/High Density
- Commercial Mixed Use
- Industrial
- Institutional
- Parks & Greenspace
- Local Streets



1. Tree, Shrub and Groundcover Plantings
2. Growing Medium Minimum 450 mm Depth
3. Drain Rock Reservoir
4. Flat Subsoil - scarified
5. Perforated Drain Pipe 150 mm Dia. Min.
6. Geotextile Along All Sides of Drain Rock Reservoir
7. Overflow (standpipe or swale)
8. Flow Restrictor Assembly
9. Secondary Overflow Inlet at Catch Basin
10. Outflow Pipe to Storm Drain or Swale System
11. Trench Dams at All Utility Crossings

FULL INFILTRATION

Where all inflow is intended to infiltrate into the underlying subsoil. Candidate in sites with subsoil permeability > 30 mm/hr. An overflow for large events is provided by pipe or swale to the storm drain system.

FULL INFILTRATION WITH RESERVOIR

Adding a drain rock reservoir so that surface water can move quickly through the installed growing medium and infiltrate slowly into subsoils from the reservoir below. Candidate in sites with subsoil permeability > 15 mm/hr.

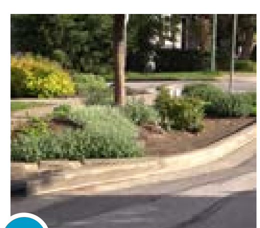
PARTIAL INFILTRATION

Designed so that most water may infiltrate into the underlying soil while the surplus overflow is drained by perforated pipes that are placed near the top of the drain rock reservoir. Suitable for sites with subsoil permeability > 1 and < 15 mm/hr.

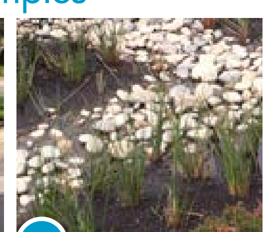
PARTIAL INFILTRATION WITH FLOW RESTRICTOR

For sites with subsoil permeability < 5 mm/hr, the addition of a flow restrictor assembly with a small orifice slowly decants the top portion of the reservoir and rain garden. Provides water quality treatment and some infiltration, while acting like a small detention facility.

Precedent examples



1 **Infiltration Bulge -** Ontario St.



2 **Rain garden infiltration area -** East Fraserlands

Design Principles, Limitations and Sizing Variables

- See the references for sizing guidelines. Higher sediment load land uses require lower ratios of impervious area to rain garden area.
- Smaller, distributed rain gardens are better than single large scale facilities.
- Locate rain gardens a minimum 30.5 m from wells, 3m downslope of building foundations, and only in areas where foundations have footing drains and are not above steep slopes.
- Provide pretreatment and erosion control i.e. grass filter strip to avoid introducing sediment into the garden.
- At point-source inlets, install non-erodable material, sediment cleanout basins, and weir flow spreaders.
- Bottom width - 600 mm (Min.) to 3000 mm and length-width ratio of 2:1 desirable.
- Side slopes – 2:1 maximum, 4:1 preferred for maintenance. Ponding depth - 150 – 300 mm.
- Draw-down time for maximum ponded volume - 72 hours.
- Treatment soil depth - 300 mm (Min.) to 1200 mm (desirable); use soils with minimum infiltration rate of 50 mm/hr.
- Surface planting should be primarily trees, shrubs, and groundcovers, with planting designs respecting the various soil moisture conditions in the garden. Plantings may include rushes, sedges and grasses as well as lawn areas for erosion control and multiple uses.
- Apply a 50–75 mm layer of organic mulch for both erosion control and to maintain infiltration capacity.
- Install a non-erodible outlet or spillway to discharge overflow.
- Avoid utility or other crossings of the rain garden. Where utility trenches must be constructed below the garden, install trench dams to avoid infiltration water following the utility trench.
- Drain rock reservoir and perforated drain pipe may be avoided where infiltration tests by a design professional show a subsoil infiltration rate that exceeds the inflow rate..

Optimizing Performance

DESIGN & CONSTRUCTION

- Undertake site-specific infiltration testing and, based on results, design the system infiltration area, surface and underground storage volume, and overflow subdrain. Be careful to not exceed impervious / pervious (I/P) guidelines in design, exercising great caution in Vancouver if exceeding a 5:1 I/P ratio.
- Provide a minimum 50 mm drop in gutter profiles and further 50 mm drop into the infiltration surface to avoid runoff bypassing the facility.
- Enforce quality control of topsoil to be free of weed seeds, and to meet specs for texture and hydraulic properties. Use of non-angular sand (e.g. Fraser River pump sand) is encouraged for the sand component. Native topsoil will rarely be suitable, having too low an infiltration rate.
- Include compost to increase percolation and reduce need for water and fertilizer inputs. Greater growing medium depth equals greater storage and treatment of rainfall. Include an organic mulch layer to surface.

MAINTENANCE

- Inspect and clean the inlet twice per year minimum (spring and fall).
- In planting beds, cultivate surface 25 mm deep between plants each spring to reduce crusting. Ensure regular spring weeding to avoid weeds going to seed.
- Remove and replace surface mulch between plants in ponding areas once every three years.

For more information:

www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/05StormwaterSourceControlDesignGuidelinesRainGarden.pdf

Pervious Paving

Pervious paving is a surface layer that allows rainfall to percolate into an underlying reservoir base where rainfall is either infiltrated to underlying soils or removed by a subsurface drain. The surface component of pervious paving can be:

- Porous asphalt or porous concrete.
- Concrete or plastic grid structures filled with unvegetated gravel or vegetated soil,
- Concrete modular pavers with gapped joints that allow water to percolate through.

Primary Purpose

- Infiltrate and treat stormwater while still providing a hard surface.

Performance Rating

FUNCTIONAL CRITERIA

Best

- Water Quality Treatment

Good

- Volume Control (reduced CSO's)
- Public Education, Culture and Health Values

Limited Benefit

- Aesthetic Benefits
- Biodiversity Benefits

COST CRITERIA

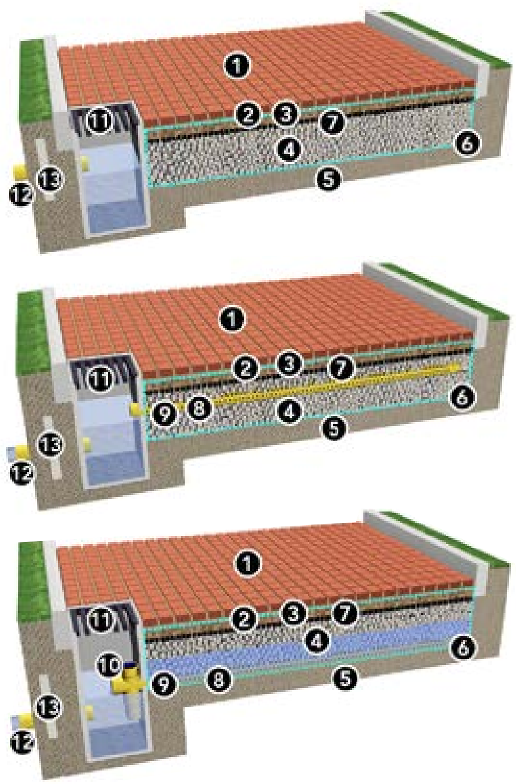
Best

- Land Cost

Good

- Property Value
- Material and Construction Cost
- Maintenance Cost
- Longevity

PERVIOUS PAVEMENT DESIGNS MAY BE ONE OF THREE TYPES:



1. Permeable Pavers (Min. 80 mm thickness)
2. Aggregate Bedding Course - not sand (50 mm depth)
3. Open Graded Base (depth varies by design application)
4. Open Graded Sub-base (depth varies by design application)
5. Subsoil - flat and scarified in infiltration designs
6. Geotextile on All Sides of Reservoir
7. Optional Reinforcing Grid for Heavy Loads
8. Perforated Drain Pipe 150 mm Dia. Min.
9. Geotextile Adhered to Drain at Opening
10. Flow Restrictor Assembly
11. Secondary Overflow Inlet at Catch Basin
12. Outlet Pipe to Storm Drain or Swale System. Locate Crown of Pipe Below Open Graded Base (no. 3) to Prevent Heaving During Freeze/Thaw Cycle
13. Trench Dams at All Utility Crossings

FULL INFILTRATION

Where rainfall is intended to infiltrate into the underlying subsoil. Candidate in sites with subsoil permeability > 15 mm/hr.

PARTIAL INFILTRATION

Designed so that most water may infiltrate into the underlying soil while the surplus overflow is drained by perforated pipes that are placed near the top of the drain rock reservoir. Suitable for subsoil permeability >1 and < 15 mm/hr.

PARTIAL INFILTRATION WITH FLOW RESTRICTOR

Where subsoil permeability is < 1 mm/hr, water is removed at a controlled rate through a bottom pipe system and flow restrictor assembly. Systems are essentially underground detention systems, used where the underlying soil has very low permeability or in areas with high water table. Also provides water quality benefits. However this should not be needed if I/P< 2.

This tool is suitable for:

- Low Density
- Medium/High Density
- Commercial Mixed Use
- Institutional
- Parks & Greenspace
- Local Streets

Precedent examples

1 Olympic Village

2 Reid Residence, Nanaimo, BC

Design Principles, Limitations and Sizing Variables

- Pervious paving is most suitable for low traffic areas—driveways, parking areas(maximum 1–2 vehicles per day per parking space), walkways, recreational vehicle pads, service roads, fire lanes.
- The ratio of impermeable surface area draining onto pervious pavement area should be ratio 2:1 maximum.
- To avoid surface plugging, it is critical to protect pervious paving from sedimentation during and after construction.
- Identify pollutant sources, particularly in industrial/ commercial hotspots, that require pre-treatment or source control upstream.
- For designs which rely entirely on infiltration into underlying soils, the infiltration rate should be 15 mm/hr minimum.
- Soil subgrade analysis should include soil texture class, moisture content, 96 hour soaked California Bearing Ratio (CBR) and on-site infiltration tests at the elevation of the base of the reservoir.
- Surface slope should be 1% minimum to avoid ponding and related sediment accumulation.
- Wrap paver bedding material with geotextile filter cloth on bottom and sides to maintain water quality performance and keep out intrusion of fines.
- Provide edge restraint to contain pavers, similar to standard unit paving.
- Design reservoir water levels using continuous flow modeling. Drawdown time—96 hrs max., 72 hrs desirable.
- Bottom of reservoir: flat in full infiltration designs, minimum 0.1% slope to drain in piped systems.
- Where utility trenches must be constructed below the reservoir, install trench dams at exits to avoid infiltration water following the utility trench.
- Pavers with wide joints should not be used for disabled persons parking or pedestrian ramps at street crossings.
- If being designed for heavy loads, optional reinforcing grids may be included in the pavement sub-base.

Optimizing Performance

DESIGN & CONSTRUCTION

- Undertake site-specific infiltration testing and, based on results, design the system infiltration area, underground storage volume, and overflow subdrain. Be careful to not exceed impervious / pervious (I/P) guidelines in design, exercising great caution if exceeding a 2:1 I/P ratio.
- Isolate the pervious pavement from sources of sediment – consider a gutter to separate traveled lane drainage from pervious pavement parking area. Although this would reduce the I/P area efficiency, it also reduces the risk of surface plugging. Install pervious paving after adjacent construction is complete.
- Enforce quality control of materials, in particular bedding and crack aggregate sizing and fractured face qualities. These pavements have no sands, no fines.
- Greater reservoir depth equals greater storage and treatment of rainfall. Hydrocarbons soaking into the aggregate undergo aerobic digestion.

MAINTENANCE

- Provide vacuum sweeping at least twice/year, spring, and fall after leaf drop.
- Surface weeding may be similar to that required of standard interlocking pavers (some weed/ moss growth). Ensure regular spring weeding to avoid weeds going to seed.
- In interlocking pervious pavements, remove and replace top one-third of crack aggregate once every three years. Localized plugged areas, if found, may be repaired by lifting the pavers, replacing bedding aggregate and upper filter cloth, and returning the pavers—a shallow repair.

For more information:

www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/06StormwaterSourceControlDesignGuidelinesPerviousPaving.pdf

www.pavingstones.com/document/pdfviewer/printer-friendly-brochure/160/aquapave_web.pdf

Green Roof

A Green Roof is a roof with a veneer of drainage and growing media that supports living vegetation.

Green roofs provide a wide range of benefits—from reduction in peak flows and volumes to building heat gain reductions.

Primary Purpose

- To reduce peak flows and stormwater volume;
- To provide additional benefits to the building, such as insulation, air filtration and reduced heat island effect.

Performance Rating

FUNCTIONAL CRITERIA

Best

- Aesthetic Benefits
- Biodiversity Benefits

Good

- Public Education, Culture and Health Values
- Volume Control (reduced CSO's)

Limited Benefit

- Water Quality Treatment

COST CRITERIA

Best

- Land Cost
- Property Value

Good

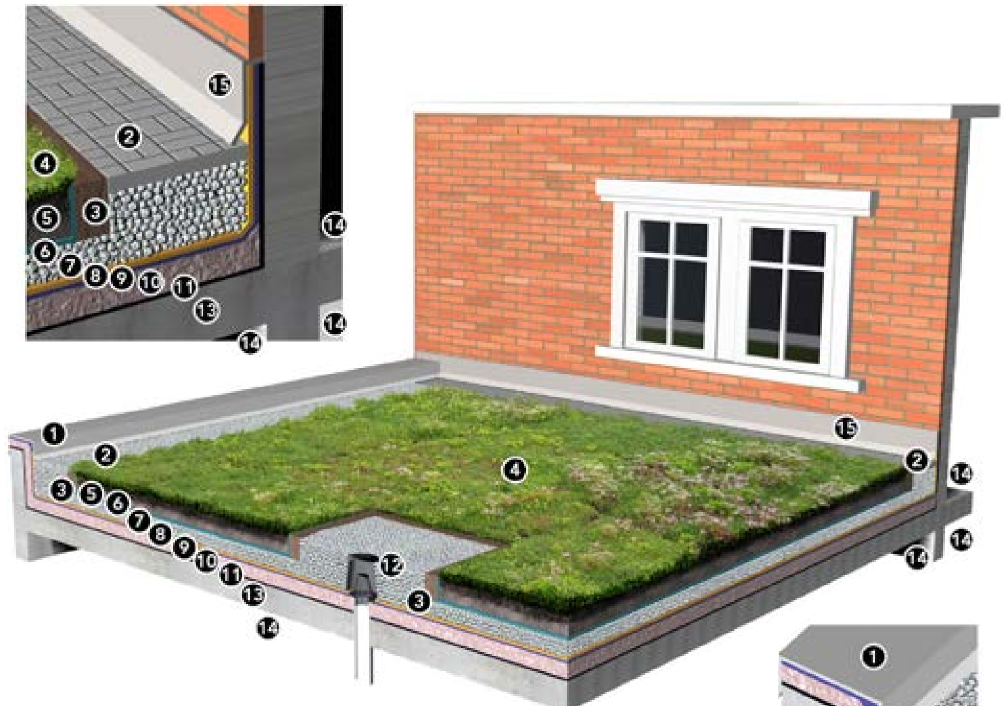
- Longevity

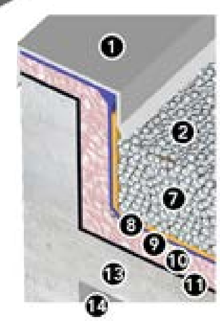
Limited Benefit

- Maintenance Cost
- Material and Construction Cost

This tool is suitable for:

- Commercial Mixed Use
- Institutional
- Parks & Greenspace





There are two basic types of Green Roofs:

Intensive **–** deeper growing medium to support larger plants and trees; designed for public use as well as stormwater and insulation functions.

Extensive **-** shallow, lightweight growing medium; designed for stormwater, insulation and environmental functions; vegetation is low and hardy; usually no public access.

Extensive Green Roof

1. Wall Cap Flashing, waterproof membrane extends to 100 mm above finished grade
2. Drain Rock, Paving Slab, or Other Buffer Equivalent
3. Wood, Steel or Concrete Curb/Edging (Optional)
4. Planting
5. Growing Medium
6. Filter Layer
7. Drainage Layer
8. Protection Layer and Root Barrier
9. Waterproof Membrane
10. Thermal Insulation
11. Vapour Barrier
12. Area Drain
13. Structural Slab
14. Building Interior
15. Wall Flashing, waterproof membrane extends to 150mm above finished grade

Precedent examples

1 Vancouver Convention Centre

2 Vancouver Central Library

3 Private Residence, Vancouver

4 Creekside Community Centre

Design Principles, Limitations and Sizing Variables

- Suitable for flat roofs and, with proper design, roofs of 20° (4:12 roof pitch) or less.
- Suitable for many rooftop situations—industrial, warehousing, commercial buildings, office complexes, hospitals, schools, institutional/ administrative buildings, residential and garages.
- Design a green roof at the same time as designing the building or retrofit, so that the structural load can be balanced with the design of the building.
- In calculating structural loads, always design for the saturated weight of each material.
- Provide construction and maintenance access to extensive green roofs. Access through a 'man door' is preferable to a roof hatch.
- Roofs with less than 2% slope require special drainage construction so that no part of the growing medium is continuously saturated.
- Avoid monocultures when planting a green roof; the success of establishing a self-maintaining plant community is increased when a mix of species is used.
- Provide intensive maintenance for the first 2 years after plant installation—irrigation in dry periods, weed removal, light fertilization with slow release complete fertilizers, and replacement of dead plants.
- To facilitate access and prevent moisture on exposed structural components, provide plant free zones along the perimeter, adjacent facades, expansion joints, and around each roof penetration.
- Fire breaks of non-combustible material, 50 cm wide, should be located every 40 m in all directions and at roof penetrations.
- Provide protection against root penetration of the waterproof membrane by either adding a root barrier or using a membrane that is itself resistant to root penetration.

Optimizing Performance

DESIGN & CONSTRUCTION

- Intensive green roof (>100 depth) provides greater rainwater storage and stormwater benefits than an Extensive Green Roof (<100 depth)
- Growing medium mixes for Extensive Green roof may be primarily fine aggregate with limited rainwater storage potential.
- Greater growing medium depth and higher fines/organic content of Intensive Green Roof equals greater storage and treatment of rainfall.

MAINTENANCE

- In planting beds, cultivate surface 25mm deep between plants each spring to reduce crusting.
- In Extensive Green Roof lawns, core-aerate areas of surface compaction each spring.
- Ensure regular spring weeding to avoid weeds going to seed.

Green Roof Benefits

- Reduced peak flows & stormwater volume
- Mitigation of urban heat island effect
- Insulation against heat loss and gain
- Extended roof membrane life
- Sound insulation & air filtration
- Urban habitat & biodiversity
- Aesthetics

For more information:

www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/07StormwaterSourceControlDesignGuidelinesGreenRoof.pdf

Tree Well Structures

Trees play a vital role in reducing stormwater runoff in urban settings. Trees within tree wells are generally healthier and reach mature height faster, which leads to more water being intercepted by the tree canopy. Tree wells contain a large volume of soil which retains excess stormwater and helps to remove pollutants from stormwater runoff.

Primary Purpose

- To optimize tree growth and manage stormwater from adjacent hard surfaces.

Performance Rating

FUNCTIONAL CRITERIA

Good

- Water Quality Treatment
- Volume Control (reduced CSO's)
- Aesthetic Benefits
- Public Education, Culture and Health Values

Limited Benefit

- Biodiversity Benefits

COST CRITERIA

Best

- Land Cost
- Longevity

Good

- Maintenance Cost
- Property Value

Limited Benefit

- Material and Construction Cost

This tool is suitable for:

- Medium/High Density
- Commercial Mixed Use
- Institutional
- Collector/Arterial Streets

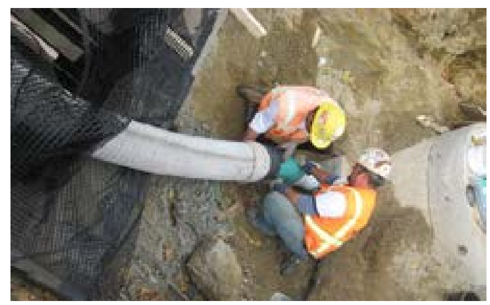
Tree wells (also called soil cells) are rigid frame structures which are typically installed under a hard surface such as a sidewalk, parking lot or road. Tree wells allow a large amount of soil to be installed under hard surfaces without compromising surface loading.

Street tree in Silva Cell - 2009

Street tree in Silva Cell - 2013

Winter tree canopies intercept 15% to 27% of rainfall. The bigger the canopy, the more water it intercepts.

Perforated drain line is installed at the bottom of the 1st layer of Silva Cells and connected to the catch basin.

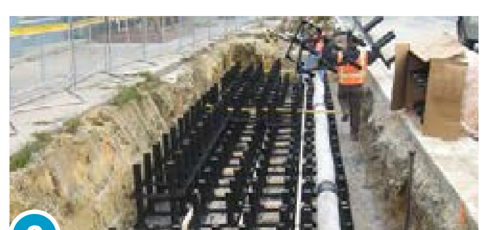


Did you know?

- Tree wells can be fed by curb grates, permeable pavement, natural surface infiltration and collected roof water.
- Tree wells can be used in a number of areas including streetscapes, plazas, and parking lots.

Tree Well Examples

1 **Installation of Strata Cell -** Rossland, BC



2 **Installation of Silva Cell -** Queensway, Toronto, ON

Design Principles, Limitations and Sizing Variables

- Verify location of all existing underground utilities and conditions prior to excavation.
- Excavate the trench according to the dimensions necessary to install the desired tree well system. Allow 12" (30 cm) additional space along all edges.
- Compact subgrade to 95% density or as recommended by the geotechnical engineer.
- Prepare the sub-base as per product specifications.
- Do not install when subgrades or planting soils are wet, muddy or frozen.
- Review installation layout and procedures with the general contractor, landscape architect and product representative prior to installation.
- Refer to product supplier specifications for information on sizing, material type, preparation and system installation.
- Refer to product specifications for installation instructions.

Optimizing Performance

DESIGN & CONSTRUCTION

- If including infiltration in the design, undertake site-specific infiltration testing and, based on results, design the system infiltration area, surface and underground storage volume, and overflow subdrain. Be careful to not exceed impervious/pervious (I/P) guidelines in design, exercising great caution in Vancouver if exceeding a 5:1 I/P ratio. If using a 'flow-through' design, do not exceed the infiltration capacity of the design soil.
- Ensure the design provides root barriers and/or air gap to separate tree roots from paving. Note that root barriers must break to the air surface – roots will grow over buried root barriers.
- Enforce quality control of topsoil to be free of weed seeds, and to meet specs for texture and hydraulic properties. Use of non-angular sand (e.g. Fraser River pump sand) is encouraged for the sand component. Native topsoil will rarely be suitable, having too low an infiltration rate.
- Include compost to increase percolation and reduce need for water and fertilizer inputs. Greater growing medium depth equals greater storage and treatment of rainfall.
- Include an organic mulch layer to surface.

MAINTENANCE

- Inspect and clean the inlet twice per year minimum (spring and fall).
- Surface areas exposed to air/ moisture will require weeding. Ensure regular spring weeding to avoid weeds going to seed.
- Adjust the tree well grate opening to allow for tree growth, and remove/replace organic mulch to exposed areas, as required but at least once every three years.

For more information:

www.deeproot.com/silvapdfs/resources/supporting/silva_cell_brochure.pdf
www.citygreen.com/products/structural-cells/stratacell/

Rainwater Harvesting

Rainwater harvesting involves collecting rainwater from roofs and storing it for non-potable uses.

Primary Purpose

- To reduce domestic water demands and runoff from impermeable surfaces.

Performance Rating

FUNCTIONAL CRITERIA

Good

- Volume Control (reduced CSO's)
- Aesthetic Benefits
- Public Education, Culture and Health Values

Limited Benefit

- Water Quality Treatment
- Biodiversity Benefits

COST CRITERIA

Best

- Land Cost
- Property Value

Good

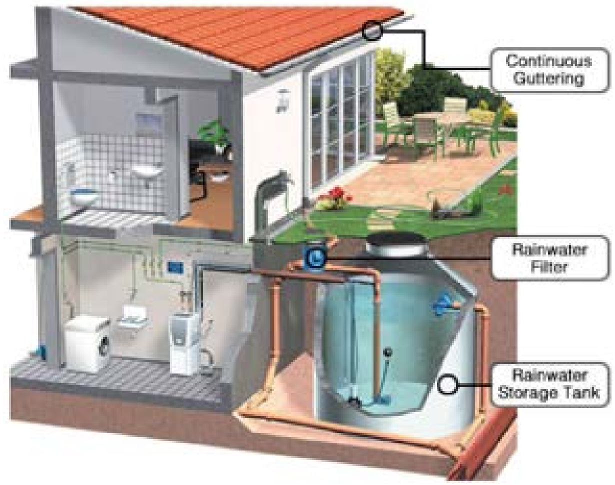
- Longevity

Limited Benefit

- Maintenance Cost
- Material and Construction Cost

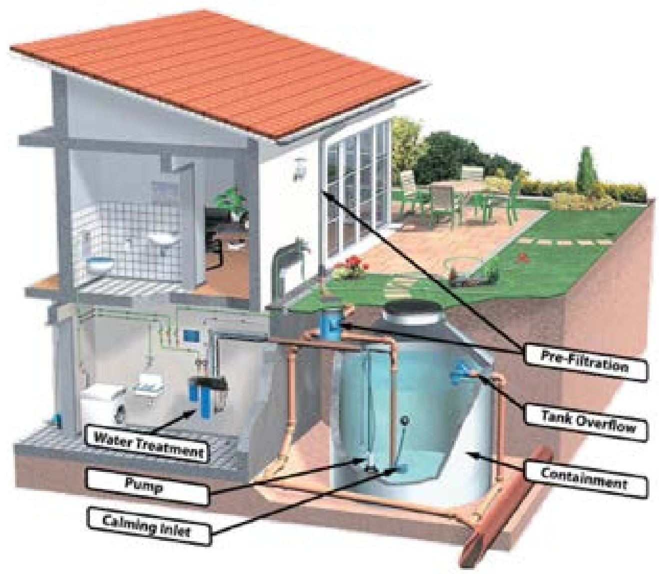
This tool is suitable for:

- Commercial Mixed Use
- Institutional



The primary components of a rainwater harvesting system for non-potable water applications include the following:

- Roofing materials;
- Gutters, gutter covers and downspouts;
- Leaf screens and roof washers;
- First-flush diverter;
- Storage Tank (Cistern);
- Pump and pressure tank.
- Filter; and
- Backflow preventer.



- The installed cost for an in-ground rainwater harvesting system capable of meeting two-thirds of residential water needs Is about $10,000
- Good practice involves diverting the initial portion of a rainfall event to prevent contaminants from entering the water storage

Rainwater Harvesting Example

1

Above Ground Rainwater Harvesting System (www.completeenergyuk.co.uk)

Design Principles, Limitations and Sizing Variables

- The amount of rainfall that can be potentially captured depends on the catchment area (area of the roof used to capture rainfall) and the precipitation.
- In Vancouver average precipitation is 1170–1600 mm per year depending on location.
- The total amount of rainfall in Litres that can be captured is calculated by multiplying the roof area (m^2) by a percent of average rainfall.
- In South Vancouver, a roof area of 100 m^2 would require a 19 m^3 of storage to maximize the amount of captured water
- To avoid contaminating the rainwater, careful selection of building materials is required as well as incorporating screens and making provision for diverting the first 0.5 mm of each rainfall event.
- A pumping and pressure control system needs to meet minimum pressure requirements under conditions of maximum demand and system head-losses.
- Backflow prevention, either air gap or reduced pressure principle, is required to avoid direct connection between the rainwater system and the municipal potable water system.
- The cost of a rainwater harvesting system is approximately $10,000 for 15 m^3 (4,000 gallon) capacity below ground tank, and less for above ground storage, and could supply about 2/3 of the domestic water demands for an average family.
- By diverting roof runoff from the storm sewer, rainwater capture and reuse that includes toilet flushing to draw down the tank year round provides stormwater benefits.
- Combined with toilet flushing, summer outdoor water use from rainwater tank provides major water conservation benefits.

Optimizing Performance

DESIGN & CONSTRUCTION

- To maximize stormwater benefits, a regular, slow decanting of the tank is desired year round. Toilets (and laundry) provide this regular demand. If they are not connected, the tank needs to have a winter 'seep' facility to slowly decant to absorbent landscape or infiltration trench.
- Roof surfaces that are not under trees, and of relatively clean materials (metal or asphalt) are preferred. Green roof is not a desirable source of rainwater harvesting.
- Careful plumbing installation/inspection to avoid cross connection between rainwater and potable water is warranted.
- Minor rainwater treatment to reduce colouration of rainwater will increase user acceptance, in particular for indoor non-potable uses.

Key Eight Rainwater Harvesting System Design Considerations (Exall, K., and T.D. Vassos, 2012)

MAINTENANCE

- Inspect and clean gutters, first flush diverter regularly (spring and fall or more often).
- Maintain non-light conditions in tanks and pipes—this will reduce algae growth.
- Drain and clean tanks and fixtures at least once every three years.

For more information:

www.rdn.bc.ca/cms/wpattachments/wpID2430atID5059.pdf

Infiltration Trench

An Infiltration Trench system is a sub-surface infiltration facility. These systems are often rock retention trenches or 'milk crate' type facilities that hold and infiltrate water into the subsurface soils. The system includes an inlet pipe or water source, catch basin sump, perforated distribution pipe, infiltration trench and overflow to the storm sewer.

Primary Purpose

- Volumetric Reduction and Rate Reduction

Performance Rating

FUNCTIONAL CRITERIA

Best

- Water Quality Treatment

Good

- Volume Control (reduced CSO's)
- Aesthetic Benefits
- Public Education, Culture and Health Values

Limited Benefit

- Biodiversity Benefits

COST CRITERIA

Best

- Land Cost

Good

- Material and Construction Cost
- Maintenance Cost
- Property Value
- Longevity

This tool is suitable for:

- Commercial Mixed Use
- Industrial
- Institutional
- Local Streets

A properly designed retention trench differs from a rock pit in a number of ways. To prevent the retention trench from clogging over time, the trench is encapsulated in filter fabric to prevent entry of any fine material around and on top of the trench and the stormwater entering the trench via perforated pipes is first treated to remove fines in a sump or through grass filter strips. No pavement/walkway runoff, which may contain pollutants and grit, is allowed to flow directly into the trench. Instead it is also first filtered by a grass area, a filter strip, or a planted swale. The retention trench is sized based on measured infiltration rates of the native soils below the trench and the trench depth is limited to allow it to fully drain between storm events. The retention trench is only used where the seasonal high water table and/or bedrock is well below the bottom of the trench. An overflow pipe is incorporated into the retention trench design to prevent the lawn overtop of the trench from becoming saturated and unusable.

Infiltration Chamber Installation, MEC North Vancouver

Rock Trench Installation with Perforated Pipe, MEC North Vancouver

Precedent examples

1 Whistler Athletes Village Drywell

2 Rock Pit Installation, Squamish Thunderbird Subdivision

3 Atlantis Style Infiltration Chamber, Turtle Mountain

Design Principles, Limitations and Sizing Variables

- Sized to drain completely between storms.
- Rock Trench depth vary from 0.3 m to 2 m deep depending on infiltration capacity of native soils
- Trench must be located 5 m from any building, 1.5 m from property lines and 6 m from adjacent infiltration systems
- Suitable for clean runoff from surfaces such as roofs
- Does not provide water quality, dirty runoff (parking, roads) must be treated prior to being directed to infiltration trench.
- Can be placed under pervious or impervious surfaces (lawns or parking lots)
- Conduct on an on-site infiltration test at the proposed infiltration depth and design the trench based on the design flow and infiltration rate.
- Separation between base of drain rock reservoir and water table should be a minimum of 600 mm
- Trench bottom width is not restricted but is generally between 600 mm and 2400 mm
- Install infiltration trench over native ground and avoid over compaction of the trench sides and bottom to protect the infiltration capacity.
- Scarify infiltration trench base to a depth of 150 mm prior to installation of the rock reservoir.
- Infiltration trench shall include a sump with lid to allow for inspection and cleanout.
- Install infiltration trench with overflow to storm sewer to allow flows in excess of the design flow to pass.
- Avoid utilities and other crossings of the trench. Where utilities cross the trench install trench dams to avid infiltration water following the utility trench.
- More detailed design information can be found at www.metrovancouver.org/about/publications/Publications/01StormwaterSourceControlDesignGuidelinesCover-Intro.pdf

Optimizing Performance

DESIGN & CONSTRUCTION

- Infiltration trenches used for vehicle or pedestrian traveled areas require a water quality pre-treatment system installed ahead of the trench to remove sediment and gross pollutants.
- Preform site-specific infiltration testing and design infiltration basin based on the results of such.
- Site the infiltration trench at least 5 meters from any building footings or foundations

MAINTENANCE

- Sump should be inspected annually and cleaned as required. Sediment should be removed from the tank bottom and floatables removed from the water surface.

For more information: (not to imply a recommendation on suppliers)

www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/08StormwaterSourceControlDesignGuidelinesInfiltrationTrenchSoakawayManhole.pdf

Infiltration Chambers

StormTrap: www.stormtrap.com

Brentwood Industries Storm Tank: www.BrentwoodProcess.com

Hancor LandMax system: www.hancor.com

Triton Stormwater: www.tritonsws.com

Stormtech: www.stormtech.com

Contech: www.conteches.com/products/applications/stormwater-infiltration.aspx

Water Quality Structures

Water quality structures are manufactured BMPs that treat for a variety of pollutants. There are several different kinds of water quality structures including: Oil separators, grit/sediment separators, and filter structures.

Primary Purpose

- Water Quality Treatment

Performance Rating

FUNCTIONAL CRITERIA

Good

- Water Quality Treatment
- Aesthetic Benefits
- Public Education, Culture and Health Values

Limited Benefit

- Volume Control (reduced CSO's)
- Biodiversity Benefits

COST CRITERIA

Best

- Land Cost

Good

- Material and Construction Cost
- Property Value
- Longevity

Limited Benefit

- Maintenance Cost

This tool is suitable for:

- Local Streets
- Collector/Arterial Streets

Oil separators are typically precast tanks with buffer walls or coalescing plates to encourage oil to float to the top of the structure and become trapped behind the buffer or plate. The oil remains floating on the top of the tank until removed by routine maintenance. Oil separators may also collect floating trash.

Grit / sediment separators can take several forms including precast cylindrical tanks which replace manholes in pipe systems or precast tanks. Most separators rely on gravity separation or hydrodynamic separation and settlement of particles. Several of the hydrodynamic separators also collect oil and floating trash. Particles are settled and collect until removed by routine maintenance.

Filter structures can be used to remove the most challenging pollutants from stormwater including nutrients such as phosphorus. Similar to sediment separators, filter structures come in either a precast cylindrical tank or a more traditional shaped precast tank. The filter structures require filter media that must be maintained or replaced regularly.

Installation of a Oil Water Separator - Coast Mountain Bus Company

Copper Valley Oil Interceptor installation (Photo Credit: Langley Concrete)

Precedent examples

1 Oil & Grit Separator, ICBC Salvage Facility, New Westminster

2 MEC Head Office Interceptor, Vancouver

3 Deltaport Multiple Unit Stormceptor

Design Principles, Limitations and Sizing Variables

- They are available in a variety of sizes and are sized based on maximum treatment flow.
- Any flow above the designed treatment flow is bypassed either by an upstream bypass or an in structure bypass.
- Work with product manufacture to ensure product is properly sized and selected for site and runoff composition.

Optimizing Performance

DESIGN & CONSTRUCTION

- Ensure proper design flow and move unit off line if peak flows are expected to exceed desired treatment flow to prevent wash though and other problems

MAINTENANCE

- Inspect annually and clean as required. Sediment should be removed from the structure bottom and floatables removed from the water surface. Vacuum truck should be used to dispose of any oil/hydro carbons within the unit.
- Change any filter media / cartridges as needed or as recommended by manufacture

For more information: (not to imply a recommendation on suppliers)

Proceptor by Green Turtle: www.greenturtletech.com/introduction-to-proceptor.php
Imbrium: Stormceptor, Jellyfish, Sorbtive media: www.imbriumsystems.com/
Contech: Vortech, Vortsentry, Jellyfish, VortClarex: www.conteches.com/products/stormwater-management/treatment.aspx
Armtec: www.armtec.com/products/stormwater-management/

Detention Tanks

Detention tanks collect and store stormwater runoff during a storm event, then release it at controlled rates to the downstream drainage system, thereby attenuating peak discharge rates from the site. With such systems in place, a drainage system can cater for high intensity rainfall events. Detention tanks may be located above or below ground. Detention systems can address a number of stormwater related issues such as: flood protection, erosion and aquatic habitat.

Primary Purpose

- Reduce the risk of flooding and erosion downstream of the detention tanks for major storm events

Performance Rating

FUNCTIONAL CRITERIA

Good

- Aesthetic Benefits

Limited Benefit

- Volume Control (reduced CSO's)
- Water Quality Treatment
- Biodiversity Benefits
- Public Education, Culture and Health Values

COST CRITERIA

Best

- Land Cost

Good

- Maintenance Cost
- Longevity

Limited Benefit

- Material and Construction Cost
- Property Value

Detention Tank Installation, MEC Head Office

This tool is suitable for:

- Commercial Mixed Use
- Industrial
- Institutional

Precedent examples

1 UBC Detention Tank Installation

2 StormTrap Detention Installation
(Photo credit: Sustainable Technologies Evaluation Program)

Design Principles, Limitations and Sizing Variables

- To determine if detention tank systems are required for a site by looking at municipal or LEED requirements.
- Determine the pre-development flow pattern and volume for the site.
- The tank should be designed based on the size of the development, degree of detention required and specific criteria for post development flows.
- Design tank to meet criteria for post-development flows.
- Typical Peak Discharge Criteria
  - » **Flood/Erosion Protection:** Control the post-development to pre-development levels for the 5-year return period.
  - » **Aquatic Habitat Protection (DFO) :** 6-MONTH Volume Reduction and Water Quality treatment and flow control 6-month, 2-year, and 5-year 24-hour post-development flows to pre-development levels.
- Detention requirements can be estimated by various methods including: the rational method, SCS (U.S. Soil Conservation Service) unit hydrograph and level pool routing as examples.
- The selection of the method of analysis depends on the size of the development and the intended application of the results.
- Most analysis should be done or reviewed by a Professional Engineer.
- Underground detention can be provided by tanks or pipes or culverts that are designed to be oversized.
- Discharge either by gravity or through pumping. In order to ensure that detention volume is available for the next storm event.
- A pre-treatment sump is required to remove sediments in the runoff.
- Provide an overflow to allow larger storms to overflow the tank.
- Tank should be designed to allow for access for maintenance or cleaning.
- All underground tanks should have an air space equal to 20% of the maximum depth, connected to the atmosphere by a vent.
- The maximum depth is a function of safety and convenience of users. A depth of over 2 meters is not recommended.
- Undertone tanks must have a minimum of 0.5 meters of cover and must be capable of handing the loads from the surface above.
- More detailed information can be found at: Metro Vancouver Best Management Practices Guide: www.metrovancouver.org/about/publications/Publications/BMPVol1a.pdf

Optimizing Performance

DESIGN & CONSTRUCTION

- To maximize stormwater benefits, detention to pre-development conditions is preferred.
- Many pre-cast concrete vaults exist that can be utilized for detention tanks.

MAINTENANCE

- Inspect manhole/tank annually and clean as required. Sediment should be removed from the tank bottom and floatables removed from the water surface.
- Maintain any sumps or upstream pre-treatment regularly to ensure proper operation.

For more information: (not to imply a recommendation on suppliers)

ZCL: www.zcl.com/products/water-products.html

Langley Concrete: www.langleyconcretegroup.com/

Barr: www.barrplastics.com

Armtech: www.armtec.com

StormTech: www.stormtech.com/

Cultech: www.cultec.com/stormwater-systems.html

Storm Chamber: https://www.layfieldgroup.com/Geosynthetics/Storm-Water-Control-Products/StormChamber-Arch-System.aspx

Contech: www.conteches.com

StormTrap: www.stormtrap.com

Hancor: www.hancor.com

Daylighted Streams

In the City of Vancouver, all but two of the historic streams flow through storm sewers before discharging into the Fraser River, Burrard inlet, False Creek or English Bay. Daylighting of historical streams creates essential habitat for aquatic life, contributes to the liveability of a neighbourhood and provides a sense of place.

Primary Purpose

- To contribute to the liveability, sense of place, and environmental education of residents and providing needed habitat for birds, small mammals, amphibians and other wildlife within the urban environment

Performance Rating

FUNCTIONAL CRITERIA

Best

- Habitat Creation
- Biodiversity Benefits
- Increased Liveability

Good

- Flood Control

Limited Benefit

- Water Quality Treatment

COST CRITERIA

Best

- Property Values
- Longevity

Good

- Material & Construction Costs

Limited Benefit

- Land Acquisition Cost
- Stream Maintenance

Daylighting of streams should be undertaken in areas where maximum benefit (i.e. maximized habitat creation) can be achieved.

This tool is suitable for:

- Parks and Green Space
- Commercial Mixed Use
- Industrial
- Institutional

Design Principles, Limitations and Sizing Variables

- Determine flow patterns.
- Design the channel to convey the 100 year event as well as maintaining adequate depths and flows for aquatic species during summer
- Create complexity within the channel (use large woody debris, boulder clusters, weirs and vegetation to mimic the natural environment)
- Provide a riparian margin planted with woody vegetation to provide shade to the stream as well as creating further habitat for birds and other wildlife
- Provide appropriate armouring at storm outfalls into the daylighted creek
- Have a geotechnical assessment done.
- Is there soil contaminant issues?
- Is stability an issue?
- Utilize catchment metrics to determine the suitability of daylighting
  » Total impervious area
  » Catchment flow characteristics
  » Available stream corridor width

Optimizing Performance

- Undertake public consultation to give a sense of ownership to the community and to understand what is driving the project
- Utilize landscape architecture and fish biology principles early. Determine the correct species to plant given design objectives, site conditions, and desired maintenance levels. Incorporate habitat features into the design and plantings
- Plan for follow-up and repair to stream features as the daylighted reach evolves throughout the first few seasons. Prepare an operation and maintenance manual to manage and maintain the stream and riparian buffers after construction.

For more information:

www.americanrivers.org/newsroom/resources/daylighting-streams-breathing-life-into-urban-streams-and-communities/

Constructed Wetlands

Engineered stormwater treatment wetlands are a series of shallow ponds connected by an engineered marsh system designed to treat contaminated stormwater through the biological processes associated with emergent aquatic plants and via sedimentation. Treatment wetlands typically are not designed to provide stormwater detention as the area required for both treatment and detention is usually in excess of what is available (approximately 3–5% of the catchment area).

Primary Purpose

- Treat stormwater runoff through natural processes prior to discharge into the receiving waters

Performance Rating

FUNCTIONAL CRITERIA

Best

- Water Quality Treatment
- Habitat Creation
- Biodiversity Benefits

Good

- Aesthetic Benefits
- Peak Flow Reduction for Frequent Events

Limited Benefit

- Volume Control (reduced CSO's)

COST CRITERIA

Best

- Longevity

Good

- Construction Costs

Limited Benefit

- Land Cost
- Maintenance Cost

Wetlands collect, detain and treat stormwater runoff during storm events and release it into the receiving environment. Properly constructed wetland systems provide a high level of contaminant removal through sedimentation and biological uptake. Wetlands can also benefit issues such as flood protection, stream erosion, habitat creation and protection.

This tool is suitable for:

- Parks & Greenspace
- Industrial
- Institutional

Design Principles, Limitations and Sizing Variables

- The wetland location should be chosen to provide continual flow throughout the year so as not to allow stagnation.
- Typical Design Criteria
  - » Water Quality Treatment Size forebay to allow sediment to settle out (~80% TSS removal) Size wetland to hold 90% of average annual rainfall runoff
- Wetlands can be land intensive because they are shallow facilities
  - » Minimum 65% of the pond should be less than 450 mm deep allowing for vegetation growth and contaminant uptake
  - » Depths should vary (25% > 1.2 m deep, 65% < 450 mm deep, 35% < 150 mm deep)
- A sediment forebay of 10% of the total wetland area

- Length to width ratio of 3:1 to 5:1
- Recommended side slopes 5:1 (H:V) or flatter
- Permanently wetted area should be approximately 72% of the runoff from a 2-year 24-hour rainfall event
- Analysis should be done or reviewed by a professional engineer
- Select plant species for survival rather than contaminant uptake
- Use a professional to determine the correct plants for each of the zones (wet to dry)

Optimizing Performance

- Location should be chosen to ensure a large enough catchment for continual flow though the dry season (June – September)
- Design wetland to mimic natural systems (varying depths, islands, high marsh peninsulas)
- Minimize flow velocities to minimize sediment re-entrainment and erosion
- Intersperse open water with marsh
- Limit extended detention depth (live storage) to 1m or less to protect plants

For more information:

www.saskatoon.ca/sites/default/files/wetlands_design_guidelines.pdf

www.env.gov.bc.ca/wld/documents/bmp/wetlandways2009/Wetland%20Ways%20Ch%2010%20Development.pdf

www.env.gov.bc.ca/wld/documents/bmp/wetlandways2009/Wetland%20Ways%20Ch%2011%20Enhancement.pdf

2.0 TOOL PERFORMANCE AND SUITABILITY

Performance Rating

A Performance Rating is provided as a summary of how each tool compares with others in the Toolkit.

The general Performance Rating is a summary of 10 criteria, which are organized in two groups: Function and Cost. The 'Considerations in Evaluating Performance' section provides a detailed description of how the criteria apply to the specific conditions of the City of Vancouver Citywide study area.

Considerations in Evaluating Performance

Vancouver's Citywide IRMP is different than many other watershed-based stormwater management plans, in that the Vancouver study area is entirely serviced with piped stormwater systems. Whereas most IRMPs would aim to protect the water quality and hydrological flow systems of streams, the Citywide IRMP is focused on managing piped systems that discharge to tidal or estrarine receiving waters.

In this context, there is a need for the Citywide IRMP to revisit common criteria for evaluating performance of stormwater best management practices (BMPs) or alternative combinations of BMPs.

The primary criteria relevant to the Citywide IRMP are discussed below in two groups: functional criteria and cost criteria.

Functional Criteria

- Maximize Water Quality Treatment
- Maximize Volume Control (reduced CSOs)
- Maximize Aesthetic Benefits
- Maximize Biodiversity Benefits
- Maximize Public Education, Culture, and Health Values

Cost Criteria

- Minimize Land or Space Cost
- Minimize Material and Construction Cost
- Minimize Maintenance Cost
- Maximize Property Value
- Maximize Longetivity

Functional Criteria

The functional Criteria compare how well the proposed Best Management Practice would provide a functional benefit. These objectives may be set out at the federal, provincial or local level, or be encouraged by non-government stakeholders and the general public in engagement events.

MAXIMIZE WATER QUALITY TREATMENT

A primary driver in rainwater management in Vancouver's Citywide area is to maintain the water quality of receiving waters. This is particularly important where receiving waters are sensitive, including:

- Areas with reduced dilution or dispersion of pollutants, such as False Creek
- Areas with high habitat values, such as shorelines of the Fraser River;
- Areas with sensitive recreational use, such as beaches along Kitsilano, West End and Jericho.

The City also needs to meet Water Quality Guidelines that are established under senior levels of government, and in particular under the Metro Vancouver Liquid Waste Management Plan. A Monitoring and Adaptive Management Framework under consideration between Metro Vancouver and the Province of BC will call for regular monitoring and corresponding

False Creek is the receiving body for several stormwater outfalls

action to meet prescribed targets for quality of water at outfalls to receiving waters. Specific water quality parameters of concern for piped stormwater include:

- Turbidity, which results from erosion of sediments, often from construction activities or materials tracked on to paved surfaces. These suspended solids impact the gills and food visibility for fish, and can settle in and smother the life on the bed receiving waters.
- Nitrate (Nitrogen), often from fertilizers or animal feces.
- Indicator bacteria (e.g. Enterococci and E. coli) that may indicate the stormwater is contaminated by sanitary waste (e.g. from cross-connections at houses) but can also be due to feces from animals (e.g. dogs, geese, and ducks) or bacteria growing on decaying vegetation (e.g. organic material accumulation in catch basins).
- Metals, including iron, copper, lead, zinc and cadmium, which commonly in urban are associated with metal corrosion, vehicle exhaust and brakes/rotors, as well as roof and drainage metal components.
- Hydrocarbons from oil drips in parking areas and atmospheric fall-out of exhaust and other emissions.
- Secondary concerns in tidal receiving waters are high pH (e.g. concrete wash water), elevated water temperature, and low dissolved oxygen concentrations.

In practical terms in the Citywide study area, these water quality objectives create a need to:

1. Provide full sediment and erosion control during construction, and control of wash water.
2. Avoid surface runoff from fertilized landscape areas into the storm sewer system.
3. Proceed with the separation of stormwater from combined sewers, eliminate combined sewer overflows, and find/repair sewer cross-connections.
4. Intercept rainwater that comes into contact with trafficked areas (vehicle parking in particular) and treat runoff from these areas to remove hydrocarbons and heavy metals.
5. Provide regular catch basin maintenance in sewer-separated areas to reduce downstream microbiological contamination.
6. Educate and enforce pollution control standards from point source pollution sources like industrial operations or fueling stations.
7. Give priority to water quality actions in areas where sewer separation is leading to outfalls to surface receiving waters (e.g. Trout Lake, recovered streams, or sensitive tidal waters).

MAXIMIZE VOLUME CONTROL (REDUCED CSOS)

In less urbanized watersheds outside the Citywide study area, Integrated Stormwater Management Plans would pay special attention to the volume of stormwater in order to reduce impacts on receiving streams, flood plains and wetlands. However, at present the Citywide study area, does not have these types of receiving waters that are sensitive to the rate and volume of runoff.

The City has an established program to separate combined sewers into separated systems of sanitary and storm sewers. As this program is implemented over the next 35-50 years, there will be new outfalls for stormwater that will fall directly into tidal and estuarine receiving waters around the City. When these stormwater outfalls become active, the Water Quality criteria listed above will become paramount in importance. The volume of stormwater entering tidal receiving waters is, however, not considered a criterion of concern among senior government agencies. However, until such time as separated sewers are completed, there will be continuing combined sewer overflows (CSOs). Reductions in stormwater volume in this interim period will reduce the frequency and size of these CSO events.

There is therefore a benefit to actions that reduce impervious area, or redirect stormwater to areas where it can soak in or be stored. Modelling (Effectiveness of Stormwater Source Control, GVSDD, CH2M Hill, December 2002) shows that these 'stormwater source controls' can play a significant role in reducing the peak flows from summer cloudbursts, and in reducing the load on the piped stormwater system - having the effect of providing additional capacity to allow for climate-related changes in rainfall patterns.

In summary for the Citywide study area, rainwater volume objectives are:

1. Continue with the separation of combined sewers into separate sanitary and stormwater sewer systems.
2. Although stormwater source controls may be driven ultimately by water quality considerations, recognize the benefits in reducing CSOs in the short term, and providing resilience against climate change in the long term.

MAXIMIZE AESTHETIC BENEFITS

The recognition of Vancouver as one of the most desirable places to live on earth is the result of many factors, but the aesthetics of the City is a major component.
Stormwater Best Management Practices that add to the beauty of the city provide an important function. Examples of aesthetic objectives include:

1. Maintaining or enhancing the urban forest and tree cover of the City.
2. Choosing other surface plantings that provide visual interest, including shrubs, groundcovers and flowers.
3. Providing lawn areas and open spaces.
4. Including attractive pavement texture, colour and articulation that provide a comfortable pedestrian or cycling environment.
5. Celebrating the presence of rainfall and surface water, and its reflective, movement and ephemeral qualities.
6. Preventing the eutrofication of streams and receiving waters.

MAXIMIZE BIODIVERSITY BENEFITS

Stormwater elements that support a variety of habitats also add to the value of the City. Examples of biodiversity objectives include:

1. Increasing the presence of surface water streams, wetlands, and sylvan or intermittent ponds and pools.
2. Providing a variety of water and riparian habitats for birds, bees, dragonflies, butterflies and other compatible urban wildlife.
3. Restoring, where possible, fish habitat in the City.

MAXIMIZE PUBLIC EDUCATION, CULTURE AND HEALTH VALUES

The citizens of Vancouver are highly educated and involved in their City. Many community groups and individuals are actively pursuing:

1. School and public education programs and events that reconnect Vancouver citizens with nature and natural systems. Often these programs include a public art component.
2. Cultural programs and events that bring people outdoors and build neighbourhood community. Green Streets is a good example of volunteer-based community involvement that often involves a stormwater component.
3. Additional amenity along Greenways and Streets to encourage active and healthy transportation like walking, running, cycling.

Cost Criteria

Cost considerations of a stormwater Best Management Practice is not limited to its capital and maintenance costs. With very high land values in the City of Vancouver, and the trend towards increasing density, BMPs need to be effective with minimal land area, and in locations (e.g. street edges or front/side yards) where transportation or building area is not impacted. BMPs also need to consider the potential impact on property value (positive or negative). Property and land value impacts of these BMPS may in many cases be the most significant financial consideration, in particular on private property.

MINIMIZE LAND OR SPACE COST

With extraordinarily high land values, anything in Vancouver that requires dedicated land that would displace economic uses is a significant cost. The space objectives for stormwater source controls in the Citywide area include:

1. Creating multiple benefits of a given space by layering other uses (e.g. parking, building, circulation or open space uses, traffic calming) under or over stormwater functions.

2. Incorporating stormwater into buildings, either on rooftops or in tanks, minimizing the structural costs of accommodating the stormwater.

3. Integrating stormwater functions into landscape setback and amenity areas, and biodiversity areas as much as possible, so that there is minimal reduction in 'buildable area' that is an essential measure of land value.

MINIMIZE MATERIAL AND CONSTRUCTION COST

The lowest cost BMP is not always the best performing BMP. Cost objectives include:

1. Giving priority to BMPs that provide efficient benefits for the cost.

2. Considering the 'incremental cost' of the stormwater benefit, as opposed to costs which may be incurred for other reasons. For example the costs of street tree wells may be largely driven by the need to provide adequate soil volumes for tree growth and to avoid root sidewalk damage, as opposed to being driven by stormwater objectives. Similarly, the cost of a green roof may be aesthetically driven, or for energy and heat island reasons, rather than purely for stormwater benefits.

3. Considering the waste management aspects of a practice – how much deconstruction is required and corresponding solid waste? Are there opportunities to reuse materials like topsoil, organics and compost?

MINIMIZE MAINTENANCE COST

The cost of maintenance and operations is of great concern. Objectives include:

1. Isolating the 'incremental cost of maintenance' related to stormwater functions. What maintenance would be required even without the stormwater aspects of the best management practice? How often is maintenance required?

2. Considering the traffic management impacts of maintenance. Is machine access needed?

3. Determining what maintenance activities could be combined with other routine maintenance to increase efficiency.

4. Determining if the City has the equipment needed to undertake the maintenance?

5. Determining if there is specialized expertise needed to provide maintenance, or is it well-known practices.

6. Determining the current role of volunteers, fronting property owners and/or contract labour. What is the future role?

Infiltration bulges throughout Vancouver enhance the aesthetic quality of city streets.

MAXIMIZE PROPERTY VALUE

Whereas taxes and fees are commonly a concern, in the case of Vancouver's Citywide area a minor percent effect on property value can be a very large sum. Objectives in considering the relationship of stormwater BMPs to property value include:

1. Maintaining the high visual and functional quality of streetscapes, street trees and visible areas

2. Avoiding urban decay, or areas of unsightly, weedy or unkempt areas where they front highly maintained private settings (naturalized areas are more acceptable when backed by natural settings).

3. Treating 'utilities' as part of the urban fabric, and integrating them into architecture, street furniture and public art

4. Avoid flooding outside infiltration areas, in vehicle and pedestrian traffic areas, and around buildings.

MAXIMIZE LONGEVITY

If a stormwater BMP has a long service life, it may be worth more initial investment than otherwise. Life-cycle considerations include:

1. Selecting BMPs that have a service life that matches or exceeds the street or development in which they are situated.

2. Considering the consequences of inadequate maintenance or operational errors – is the practice resilient?

Summary of Tool Advantages and Disadvantages

The 10 criteria above are shown on each Toolkit factsheet and are split into three categories based on how they perform in relation to the BMP:

- Best: The criterion provides a high functional benefit in meeting public objectives and/or reducing costs.

- Good: The criterion provides a moderate functional benefit in meeting public objectives and/or reducing cost.

- Limited Benefit: The criterion has limited benefit to the overall performance of the BMP.

The Performance Rating provides an overall summary of how each tool compares with other tools in isolation. Table II-2 summarizes how BMPs are suitable for land uses. Note that exceptions to these ratings will occur on specific site and land use situations.

Most important is how the tools work together as a system at the City-wide and drainage basin scales (i.e., what is the optimum combination of tools for each land use typology?). Refer to the Technical Background Report for related scenarios and analysis of tool combinations.

Table II - 2: Summary of BMP Suitability for Land Uses

LEGEND 🟢 BEST SUITABILITY 🟡 GOOD SUITABILITY, BUT WITH CONSTRAINTS 🔴 LIMITED BENEFIT, OR NOT APPLICABLE

TOOL	PERFORMANCE RATING (varies by site)	LOW DENSITY (one/two family & lane housing)	MEDIUM / HIGH DENSITY	COMMERCIAL MIXED USE	INDUSTRIAL
Absorbent Landscapes	4.4	🟢	🟢	🟢	🟢
Infiltration Swales	3.7	🟢 Infiltration swale along narrow linear strips (i.e. along the side of the house) to capture roof drainage, etc.	🟢 Infiltration swale along boulevards & along parking lots	🟢 Infiltration swale along boulevards & along parking lots	🟢 Infiltration swale along parking lots
Rain Gardens & Infiltration Bulges	4.3	🟢 Install rain gardens at natural low points of property in place of regular shrub beds	🟢 Install rain gardens at natural low points of property in place of regular shrub beds	🟢 Install rain gardens at natural low points of property in place of regular shrub beds	🟢 Install rain gardens at natural low points of property in place of regular shrub beds
Pervious Paving	3.3	🟢 Driveways, walkways, patios	🟢 Parking, walkways, patios	🟢 Parking, walkways, patios	🔴 Staff parking areas (away from sediment sources)
Green Roofs	3.6	🟡 Desirable, but cost of adequate soil depth for rainwater management may be prohibitive in many cases	🟢 Intensive Green Roof recommended for rainwater management over parking garages	🟢 Intensive Green Roof recommended for rainwater management over parking garages	🟢 Intensive Green Roof recommended for rainwater management over parking garages
Tree Well Structures	3.7	🔴 Not applicable	🟢 Along boulevard where space restrictions prevent adequate tree soil volume to be achieved	🟢 Along boulevard where space restrictions prevent adequate tree soil volume to be achieved	🟡 Cost and available space may promote tree planting without tree wells

	INSTITUTIONAL	PARKS & GREENSPACE	LANES	LOCAL STREETS	COLLECTOR / ARTERIAL STREETS
			Potential 'country lanes' approach		
	Infiltration swale along boulevards & along parking lots	Infiltration swale along parking edges	Not applicable	Infiltration swale along boulevards & medians at time of tree replacement	Infiltration swale along boulevards & medians at time of tree replacement
	Install rain gardens along buildings and/or in open space. Bulges within internal streets	Install rain gardens in open space at natural low points and within parking lots	Not applicable	Install rain gardens at natural low points of streets or above intersections	Likely limited by available space
	Parking, walkways, patios	Parking, walkways	Potential 'country lanes' approach	On-street parking bays	Not applicable
	Showcase green roofs on University campus buildings, hospitals, & other institutions	Community Centres, Interpretive Centres	Not applicable	Not applicable	Not applicable
	Along pedestrian corridors & internal roads where space restrictions / paving prevent adequate tree soil volume to be achieved	Cost and available space may promote tree planting without tree wells	Cost and space would prohibit using this tool in laneways	Generally the boulevard on a local street has adequate soil volume for tree planting	Along boulevards & paved medians where space restrictions / paving prevent adequate tree soil volume from being achieved

Table II - 2: Summary of BMP Suitability for Land Uses (continued)

LEGEND

- BEST SUITABILITY (green)
- GOOD SUITABILITY, BUT WITH CONSTRAINTS (yellow)
- LIMITED BENEFIT, OR NOT APPLICABLE (red)

TOOL	PERFORMANCE RATING (varies by site)	LOW DENSITY (one/two family & lane housing)	MEDIUM / HIGH DENSITY	COMMERCIAL MIXED USE	INDUSTRIAL
Detention Tanks	2.3	Limited benefit, or not applicable	Good suitability, but with constraints: Used when there is not adequate surface area for ponding infiltration	Best suitability: Used when there is not adequate surface area for ponding infiltration	Best suitability: Used when there is not adequate surface area for ponding infiltration
Water Quality Structure	2.8	Limited benefit, or not applicable	Limited benefit, or not applicable: Soil and plant-based BMPs are preferred. Use WQ structural only as last resort	Limited benefit, or not applicable: Soil and plant-based BMPs are preferred. Use WQ structural only as last resort	Limited benefit, or not applicable: Soil and plant-based BMPs are preferred. Use WQ structural only as last resort
Infiltration Trench Engineered underground structures suitable for large-scale developments	3.6	Good suitability, but with constraints: Use only for roof drainage or after pre-treatment of parking runoff	Good suitability, but with constraints: Use only for roof drainage or after pre-treatment of parking runoff	Good suitability, but with constraints: Use only for roof drainage or after pre-treatment of parking runoff	Good suitability, but with constraints: Use only for roof drainage or after pre-treatment of parking runoff
Rainwater Harvesting	3.0	Good suitability, but with constraints: Gain advice on plumbing and treatment for toilet aesthetic considerations	Good suitability, but with constraints: Gain advice on plumbing and treatment for toilet aesthetic considerations	Good suitability, but with constraints: Gain advice on plumbing and treatment for toilet aesthetic considerations	Good suitability, but with constraints: Gain advice on plumbing and treatment for toilet aesthetic considerations
Daylighted Watercourses / Constructed Wetlands	3.0	Limited benefit, or not applicable: Inadequate space	Good suitability, but with constraints: Ensure sufficient drainage area for summer base flow, or design to be seasonally dry	Good suitability, but with constraints: Ensure sufficient drainage area for summer base flow, or design to be seasonally dry	Good suitability, but with constraints: Ensure sufficient drainage area for summer base flow, or design to be seasonally dry

INSTITUTIONAL	PARKS & GREENSPACE	LANES	LOCAL STREETS	COLLECTOR / ARTERIAL STREETS
Used when there is not adequate surface area for ponding infiltration	Cost and available space may promote tree planting without tree wells	Cost and space would prohibit using this tool in laneways	Generally the boulevard on a local street has adequate soil volume for tree planting	Along boulevards & paved medians where space restrictions / paving prevent adequate tree soil volume from being achieved
Soil and plant-based BMPs are preferred. Use WQ structural only as last resort	Use soil and plant-based BMPs		Installed on local streets only where space for other treatments is not available	Installed on collector / arterial streets where space is an issue and / or parking cannot be compromised
Use only for roof drainage or after pre-treatment of parking runoff	Use only for roof drainage or after pre-treatment of parking runoff			
Gain advice on plumbing and treatment for toilet aesthetic considerations				
Ensure sufficient drainage area for summer base flow, or design to be seasonally dry	Ensure sufficient drainage area for summer base flow, or design to be seasonally dry	Cost and space would prohibit using this tool in laneways	May be considered on extemely low volume streets or unused rights of way	Cost and space would prohibit using this tool in collector/arterial streets, unless there are large medians or boulevards

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Assumptions and Limitations

The analysis and recommended actions in this document are based on review of currently available information, and are in accordance with current planning and engineering practice.

Readers should note the following limitations:

1. Maps and quantities shown are based on 'sample areas' that are representative of the pattern of conditions across the study area. Actual total quantities may vary.

2. Where unit costs or quantities are shown, these are approximate 2014 dollars CDN suitable for comparison of options, and based on little or no site information, and therefore only accurate within a range of plus or minus 30% (Class D). No warranty is implied or given on accuracy of quantities or unit costs for any given project.

3. Mapping is based on data and polygons from a variety of sources, and is schematic in nature. No warranty is made as to accuracy of map information.

4. Infiltration rates discussed are theoretical based on typical rates in assumed soil conditions, sufficient for general option comparison and policy guidance. Users are advised to gain site-specific hydrotechnical advice as a basis for detail design.

5. Where design detail guidelines are provided, the information is intended as an introduction. Readers are guided to the technical reference documents listed as References in IRMP Volume II and III for more information. In all cases, it is required that professional site-specific design and construction management advice should be sought to customize application of these best practices to a specific site and land use situation.

Notes:

Notes:

CITY OF VANCOUVER

GREENEST CITY

Golder Associates

Sustainable Communities