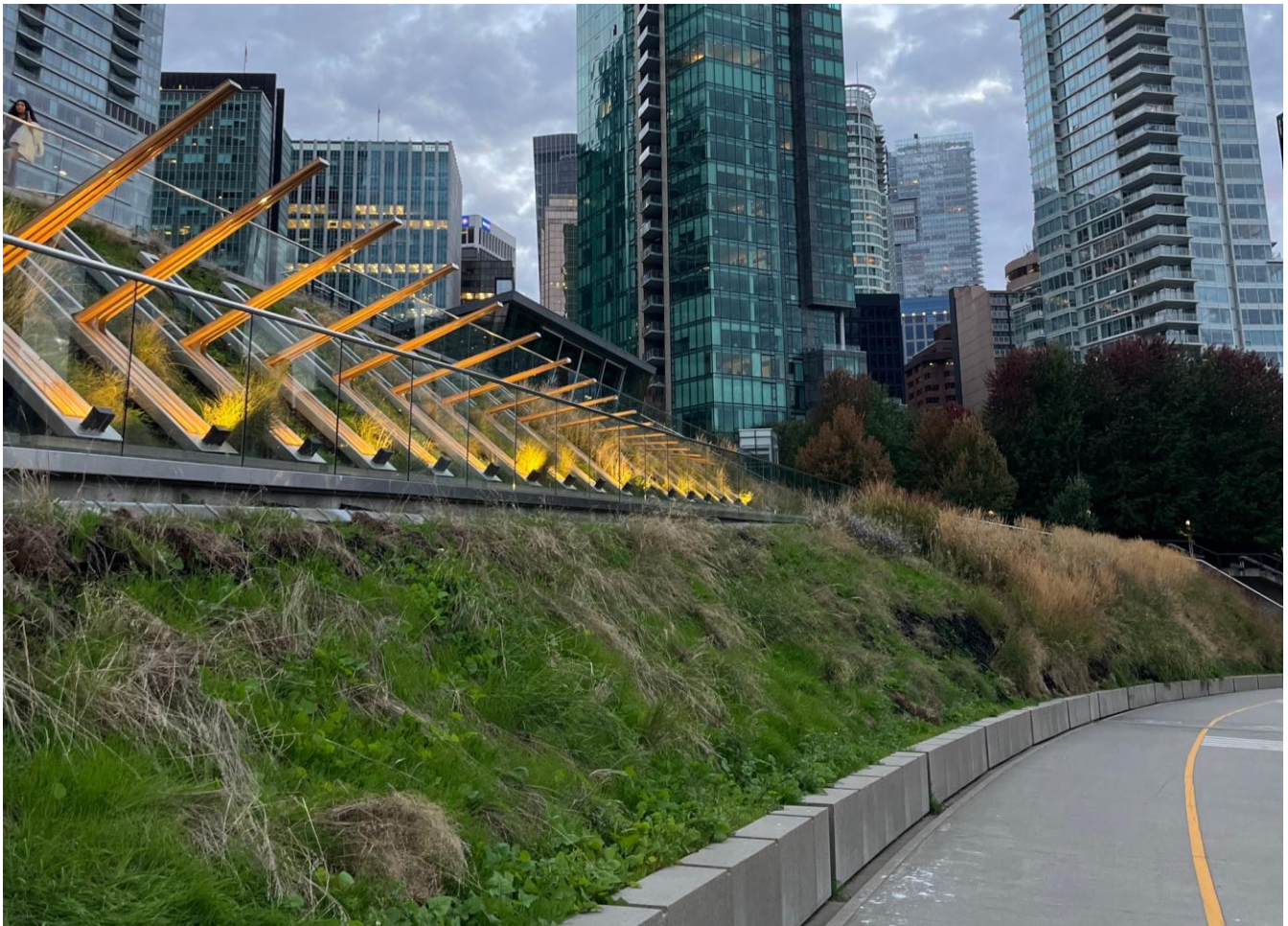




LOWER FRASER RIVER STORMWATER MANAGEMENT

IMPLEMENTATION METHODS, BARRIERS AND SOLUTIONS IN THE METRO VANCOUVER REGION

Prepared by: Xian Kerfoot and Nicole Christiansen

2025



**PACIFIC SALMON
FOUNDATION**

FORWARD

The idea for this report came from a proposal by John Roe of the Veins of Life Watershed Society who provided invaluable support and expertise in the development of this report.

The Veins of Life Watershed Society (VOLWS) is a community-based environmental conservation organization operating in the Salish Sea region, including parts of Vancouver Island, British Columbia. Founded in 1995, the society focuses on a watershed-based approach to environmental restoration and protection. Their work includes habitat restoration, garbage removal from shorelines and streams, and public education on environmental stewardship. VOLWS collaborates with government agencies, businesses, local environmental groups, and the public to foster sustainable ecosystems that support wildlife and recreational activities. Their efforts have directly benefitted Pacific salmon rearing habitats and the greater ecosystem. In this report VOLWS and the Pacific Salmon Foundation seek to improve general understanding of the impact of existing stormwater practices on salmon habitats and determine the main challenges impeding effective stormwater management by local governments. Ultimately, we would like to foster stormwater solutions that protect Pacific salmon and benefit ecosystems and our communities. While the focus of this report is on stormwater management for the Fraser River Watershed, lessons are applicable across other jurisdictions and the intended audience is local governments and qualified professionals, developers, and building contractors implementing stormwater infrastructure.

We, the Veins of Life Watershed Society, are pleased to participate in this report on stormwater management for the Fraser River Watershed in collaboration with the Pacific Salmon Foundation (PSF). The PSF's invaluable support and expertise have greatly contributed to the success of our efforts in addressing stormwater impacts on salmon habitats. As we move forward, we look forward to continuing our partnership in protecting and restoring the watershed for future generations.

Thank you once again for your commitment and dedication to this critical work.

Sincerely,

*John R Roe
A Founding Director
Veins of Life Watershed Society
www.salishsea.ca*

EXECUTIVE SUMMARY

Stormwater runoff is the leading cause of nonpoint source pollution and poses a significant threat to our precious waterways and aquatic ecosystems. As rainwater flows over urban areas, it picks up a range of toxic chemicals, which are then delivered into sensitive environments at high velocities. Metro Vancouver, a highly urbanized region, sits at the base of one of the world's most important salmon runs. Runoff into the Fraser River has severely impacted salmon habitats through high water velocity, the addition of harmful silts and toxins, and altered temperatures. This degradation has challenged the recovery of Pacific salmon populations.

The Pacific Salmon Foundation (PSF) has undertaken this report to better understand the impact of stormwater runoff on salmon habitats and to explore opportunities for more effective stormwater management in the Lower Fraser River. This effort aligns directly with PSF's mission to support the conservation and recovery of Pacific salmon populations across British Columbia and the Yukon. Over the past two decades, PSF has become a leader in both oceanic and freshwater salmon science, integrating research and innovative solutions to support sustainable ecosystems.

The objective of this report is to identify key barriers to effective stormwater management and provide municipalities with actionable recommendations to mitigate the harmful effects of runoff. The assessment of stormwater practices in municipalities across the Lower Fraser revealed key challenges, with the most significant being the limited resource capacity of municipalities and competing priorities of urban densification.

To support municipalities in overcoming these barriers, this report compiles insights from interviews with municipal representatives, supported by a literature review, and offers a series of recommendations. These suggestions cover both individual actions and tools that municipalities can undertake and broader regional policy adjustments to improve how stormwater management is governed and implemented in the Metro Vancouver region.

This report serves as a snapshot status of stormwater management presented by Metro Vancouver municipal participants. The findings underscore the need for collaboration, resource allocation, and policy reform to ensure the protection and restoration of salmon habitats in the Lower Fraser and beyond in the face of ongoing urban development pressures.

LAND ACKNOWLEDGMENT

The contents of this report encompass the traditional territories of the Skwxwú7mesh Úxwumixw (Squamish), xʷməθkʷəy̍əm (Musqueam), and səliwətaʔt (Tsleil-Waututh) First Nations (Vancouver, BC). We gratefully acknowledge that the authors live and work on these traditional territories, and we recognize the enduring connection and stewardship for these lands and waters by Indigenous Peoples since time immemorial.

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ACRONYMS

AMF.....	Monitoring and Adaptive Management Framework for Stormwater
BMP.....	Best Management Practices
CRD.....	Capital Regional District
CWA.....	EPA Clean
DFO.....	Department of Fisheries and Oceans
ECCC.....	Environment and Climate Change Canada
EMA.....	Environmental Act
EPA.....	United States Environmental Protection Agency
FBC.....	Fraser Basin Council
GI.....	Green Infrastructure
GSI.....	Green Stormwater Infrastructure
ILWRMP.....	Integrated Liquid Waste and Resource Management Plan
ISMP.....	Integrated Stormwater Management Plan
IWMP.....	Integrated Watershed Management Plan
LFW.....	Lower Fraser Watershed
LWMP.....	Liquid Waste Management Plan
MAR.....	Mean Annual Rainfall
NOAA.....	United States National Oceanic and Atmospheric Administration SILG
OCP.....	Official Community Plan
SILG.....	Stormwater Interagency Liaison Group
RAPA.....	Riparian Areas Protection Act
RMA.....	Rainwater Maintenance Amenities
WSA.....	Water Sustainability Act

INTRODUCTION

Aquatic and riparian ecosystems face increasing threats as natural landscapes are transformed into urban settings. In a natural system, rainwater and snowmelt travel across varied terrain and permeate into the ground where the impurities are filtered out by the vegetation and soil, recharging groundwater aquifers and replenishing waterways. With roads, buildings, and other impervious surfaces in urbanized landscapes, rainwater becomes runoff, collecting debris and contaminants as it moves rapidly through the system flowing directly into and polluting nearby water bodies. With no natural absorption and retention to slow down and capture the water, the volume of runoff can be extreme during storm events causing further damage from erosion and flash flooding. Urban runoff is one of the many human pressures that have led to the degradation of aquatic and riparian ecosystems.

At the southwest tip of British Columbia sits the Lower Fraser Watershed (LFW), which is home to more than half of the population of B.C. with 2.8 million residents and growing. It is the most urbanized, built-out region in the province. As the name implies, the Lower Fraser is also where the Fraser River, the longest and the most productive salmon river in British Columbia, empties out into the Strait of Georgia (Hall & Schreier 1996; McDonald 2021) (Fig. 1). The dense concentration of human activities and extensive impervious surfaces in such close proximity to sensitive and significant aquatic ecosystems highlights the critical challenge of managing urban drainage. Effective management and guidance are needed to preserve and safeguard this key salmonid migration corridor.

Successful implementation of stormwater management, or rainwater management, is often in competition with urban densification, political will, and the capacity of member municipalities. The overarching purpose of this report is to understand which hurdles impede Metro Vancouver municipalities in their stormwater management goals, and how these local communities can be better supported in their pursuit of more long-term positive changes for surrounding ecosystems including Pacific salmon habitats.



Figure 1. Map of the administrative boundaries and municipal populations in the Metro Vancouver Region. Source: [Metro Vancouver Governance Structure](#).

REPORT OBJECTIVES AND STRUCTURE

This report is divided into three sections. It begins with background information on the impacts of stormwater on salmon and mitigation approaches. Section II provides a summary of current stormwater management guidelines recommended to Metro Vancouver municipalities, a review of Guidance Documents, Best Management Practices, and relevant policies provided by federal, provincial, and regional levels of governance. Finally, in Section III we evaluate these guidance measures' effectiveness and highlight the challenges and barriers that impede more effective rainwater management based on interviews with municipal government staff. Our focus was placed on municipalities closest to the mouth of the Fraser due to the high population density of these communities and the resulting impact they would have on the mouth of the Fraser, the estuary, and the Strait of Georgia.

The report concludes with recommendations and resources that aim to support local governments in rainwater management practices and green infrastructure implementation.

In sum, the objectives of this project are:

1. **Review Guidance Documents** – Understand the current impact of stormwater management on natural systems by reviewing existing guidance documents for stormwater management.
2. **Summarize Implementation Methods** – Identify the practices currently being implemented by local governments based on available guidelines.
3. **Identify Gaps and Barriers** – Conduct interviews with local municipalities and document the main challenges faced when trying to implement stormwater management practices.
4. **Highlight Solutions** – Determine what stormwater practices are working for municipalities and what tools and information is needed by local governments to move past barriers and support stormwater management goals for healthier ecosystems.

SECTION I – AN INTRODUCTION TO STORMWATER MANAGEMENT

URBAN PRESSURES – WHAT IS STORMWATER?

Rainwater sustains the interconnected world. It nourishes the land, replenishes streams, lakes and aquifers, and provides drinking water for communities. However, as urban areas expand and the natural landscape gives way to buildings and pavement, pristine rainwater can easily transform into pollution. When rainwater or snowmelt flows over impervious surfaces like roofs, driveways, and commercial and industrial zones, it collects a range of contaminants, including fertilizers, heavy metals, oil, PCBs, pesticides, and road salts. Without natural absorption or filtration, the increased volume of untreated runoff is channelled into sensitive waterways, at high velocities during storms, leading to flooding, erosion, increased sediment and pollution loads, and elevated water temperatures. Runoff generated from impervious surfaces can be more than five times that of a woodland area of the same size (Fig. 2). Traditional, grey-piped drainage infrastructure, including gutters and pipes, only exacerbates the issue by concentrating the stormwater into smooth conduits that lead directly into the water bodies.

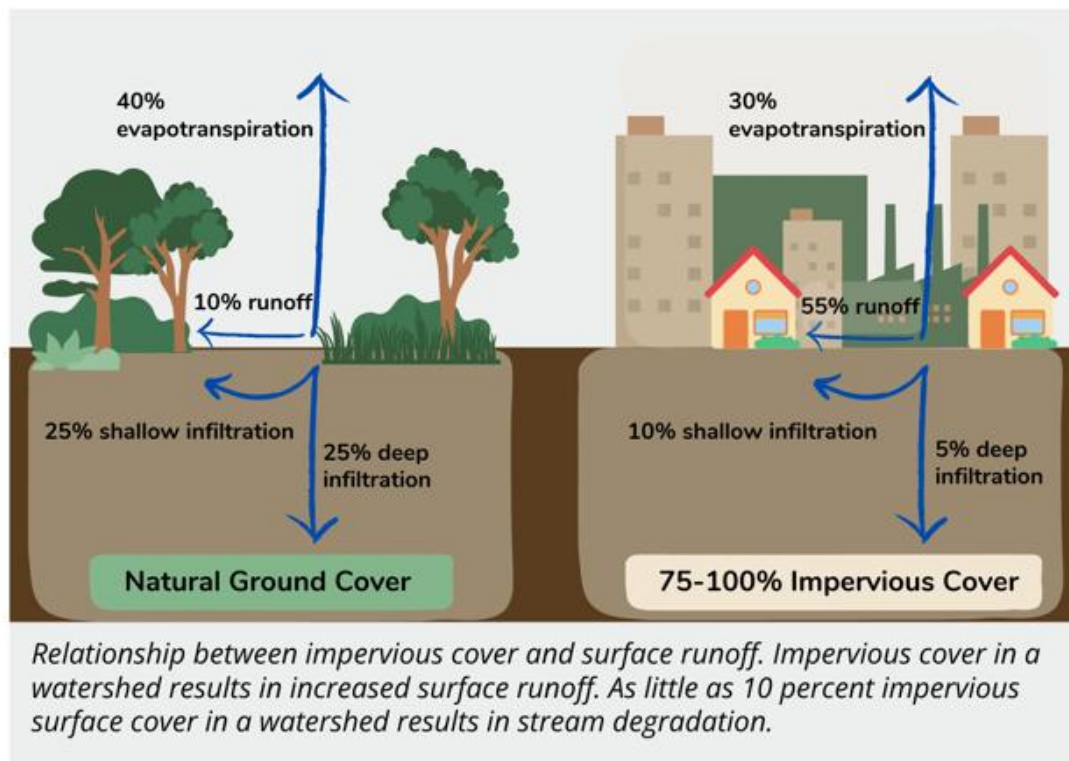


Figure 2. Infiltration comparison between natural ground cover and impervious surface cover (adapted from EPA 2003).

ENVIRONMENTAL IMPACTS OF STORMWATER RUNOFF

The increase of impervious surfaces has transformed how natural watersheds function. As the human population grows and the urban footprint expands, so do the number of pollutants across the landscape. Pollution comes from a variety of sources, including industry, agriculture, motor vehicles, and everyday practices such as washing your car. On the west coast, the proximity of human developments to freshwater, estuarine, and marine habitats can pose significant threats to a myriad of species. This includes the keystone species Pacific salmon, which are particularly vulnerable in nearshore areas where human expansion is prevalent, such as Puget Sound and the Strait of Georgia. Research in Canada and the US has found that runoff is a leading pollution threat to aquatic species and ecosystems (Metro Vancouver 2022).

There is a direct and positive correlation between the level of urbanization in a watershed and the concentration of pollutants found in local waterways (Walsh *et al.* 2005). Stormwater pollution originates from a variety of sources and follows a general pathway to receiving waters (Fig. 3). Point source pollution, such as untreated sewer discharges and overflows from older combined sewer systems, remains an issue in older cities with this outdated infrastructure. However, in cities with updated separated storm and sewer systems, non-point pollution is the leading cause of water quality degradation and contamination (Walsh *et al.* 2005; NOAA 2016). Pollutants leaching from urban impervious surfaces have been directly linked to the increased mortality of salmon migrating through urban landscapes (McDonald 2021). Stormwater runoff dominates non-point sources of contamination in urbanized areas and can contain levels of trace metals that exceed the safe threshold for the protection of aquatic life (Hall & Schreier 1996).

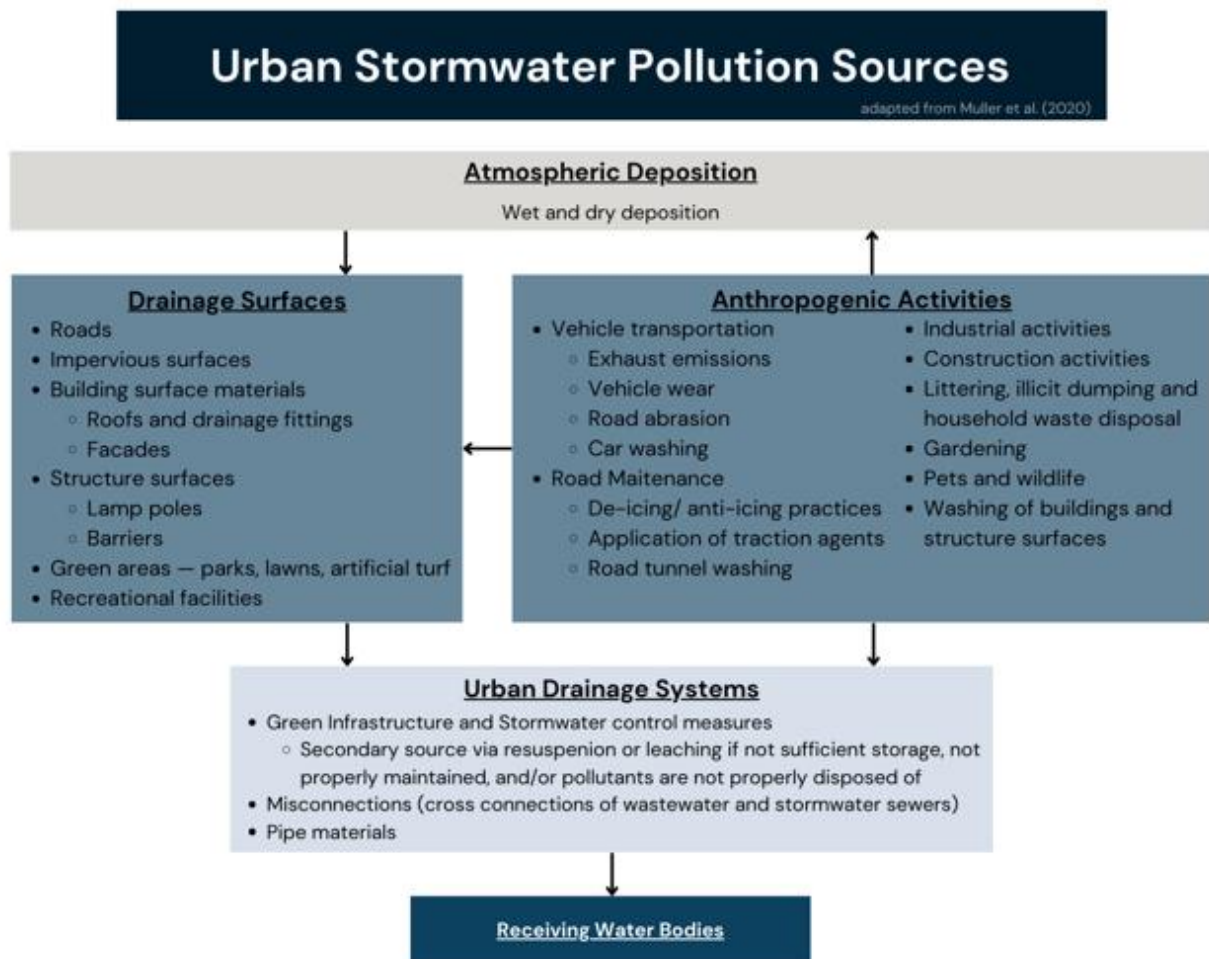


Figure 3. Urban stormwater pollution sources and transport pathways (adapted from Muller et al. 2020).

IMPACTS OF STORMWATER RUNOFF ON PACIFIC SALMON

Pacific salmon hold significant value in British Columbia. Ecologically, they are considered both an indicator and keystone species, linking aquatic and terrestrial environments. Their health and survival serve as a proxy for the overall state of their habitat. Additionally, salmon are culturally and economically foundational to the communities along the West Coast (Price 2013; McDonald 2021).

However, development, human activity, intensive land-use, land conversions, and the escalating threat of climate change have significantly altered aquatic salmonid habitat, contributing to the decline of salmon in the Pacific Northwest (McDonald 2021). The pollutants in urban runoff can negatively impact salmon in a variety of ways (Chow *et al.* 2019). Table 1 shows common pollutants found in stormwater, where they come from and how they impact salmon.

Table 1. Common pollutants found in urban stormwater, their sources, and their impact on salmon.

CONSTITUENT	ORIGIN	IMPACT ON SALMON
Copper (Cu) ^{1, 3, 4, 5}	• Break and exhaust emissions from automobiles • Building siding • Industrial discharges • Municipal Sewage • Agricultural pesticides and fertilizers	• Neurobehavioural toxicant – interferes with the ability of fish to detect and respond to chemical signals in aquatic environments • Toxic to sensory systems of fish – impairs ability to detect odours (olfactory impairment) ◦ Disrupts anti-predator response • Disrupts the downstream migration of juvenile salmonids and reduces survival in seawater • Induces stress and increases susceptibility to secondary stressors through reduced immune response
Nickel (Ni) ^{1, 3, 4, 5}	• Fossil fuel combustion • Mining, smelting, refining • Waste incineration	• Respiratory toxicity – alters gill morphology • Impairs swim performance and oxygen consumption patterns
Zinc (Zn) ^{1, 3, 4, 5}	• Brick walls • Tire wear • Metal roofs	• May induce avoidance of rearing habitat • Induces physiological stress and reduces immune response
Cadmium (Cd) ^{1, 3, 4, 5}	• Wet deposition • Building walls • Dry deposition • Smelter fumes and dust • Fertilizers • Municipal wastewater and sludge discharges	• Disruption of the olfactory system • Reduces growth
Petroleum-Derived Compounds (oils, grease, vehicle exhaust, soaps and detergents) ^{1, 5, 6}	• Industrial and domestic • Soaps • Car washing • Lawns • Roadways • Parking lots	• Suppresses the Immune System • Renders the organism more vulnerable to pathogens • Depresses the growth rate of juvenile salmon • Impacts the cardiovascular system causing heart failure or permanent heart defects

6PPD-quinone ^{9, 10, 11, 12, 13}	• Tire wear particles	• Lethal acute toxicity where the onset of symptoms includes: ◦ Disrupts vascular permeability ◦ Gasping at water's surface ◦ Fin splaying ◦ Loss of equilibrium • Blood-brain barrier compromised
Pesticides (insecticides, herbicides, fungicides) ^{1, 5, 6}	• Agricultural practices • Landscape maintenance	• Suppresses the Immune System • Renders the organism more vulnerable to pathogens • Toxic to the salmon nervous system – disrupting feeding and predator avoidance • Disrupts the food web by depleting aquatic and terrestrial species salmon rely on for food
Nutrient Rich Material ^{5, 6}	• Agricultural runoff • Landscape maintenance • Municipal wastewater • Pets and Wildlife	• Plant and algae blooms • Depletes oxygen levels below what can support salmon
Sediment ^{5, 6, 7}	• Soil Erosion	• Smothers stream habitat, alters stream flow • Increases nutrients to harmful levels • Suffocates spawning gravel where eggs could be laid • Impacts proper water flow, therefore reducing oxygen exchange to eggs • Reduces the amount of light penetration into the water column and increases turbidity
Thermal Pollution ^{5, 6, 8}	• Dark impervious surfaces such as streets and rooftops • Loss of streamside trees due to erosion of banks	• Energy loss and increase of non-aerobic fuelling resulting in oxygen debt and reduced capacity to recover • Energetic trade-offs impact migration • Production of less viable gametes

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Spotlight on 6PPD-Q

For the past two decades, researchers in the Pacific Northwest have been studying the phenomenon of urban runoff mortality syndrome in coho salmon, where exposure to road runoff was causing mortality of 40-90% of returning coho salmon prior to spawning (French *et al.* 2022; Rodgers *et al.* 2023). It is now understood that these stormwater-driven die-offs are caused by a compound derived from a preservative in tires called 6PPD. When this compound reacts with ozone in the air, it transforms into a highly toxic form called 6PPD-quinone (6PPD-Q) (*N*-(1,3-dimethylbutyl)-*N*-phenyl-*p*-phenylenediamine-quinone); both compounds surpass the threshold for *very high* acute aquatic toxicity in the Globally Harmonised System of Classification and Labeling of Chemicals (Tian *et al.* 2021; ITRC 2023).

Evolving research indicates that environmentally relevant concentrations of 6PPD-Q do not affect all closely related salmonid species equally. Studies have shown that coho and Chinook salmon, cutthroat, steelhead and rainbow trout, and white-spotted char are the salmonids most sensitive to the acutely lethal toxicity of 6PPD-Q, whereas species that do not experience acute toxicity include chum salmon, sockeye salmon, Arctic char, Atlantic salmon and brown trout (French *et al.* 2022; ITRC 2023). The onset of acute symptoms mimics respiratory distress, including gasping at the water's surface, fin splaying, and loss of equilibrium, where the progression from asymptomatic to death can occur within a span of a few hours (French *et al.* 2022; Greer *et al.* 2023; ITRC 2023). It has been shown that the blood-brain barrier is compromised when coho are exposed to roadway runoff, causing fluid to leak out of blood vessels in the gills and the brain (Blair *et al.* 2021).

Unfortunately, the problem is ubiquitous. Globally, it has been estimated that six million tonnes of tire wear particles (TWPs) are released into the environment annually (Innovation Science and Economic Development Canada 2022; EPA 2023). Stormwater is the primary transport

mechanism for 6PPD-Q to surface water, where the levels of 6PPD-Q are highest during or following rain or snowmelt runoff after an extended dry period (ITRC 2023). As we are learning about the devastating impacts of 6PPD-Q, researchers are also discovering how to mitigate the impacts with green infrastructure (see next section) as well as monitor where and when harmful spikes of 6PPD-Q occur to prioritize intervention (Fig. 4). To learn more, visit [this link](#), which includes talks given by the leading experts researching 6PPD-Q at a Tire Toin Workshop held by the [BC Conservation Foundation Aquatic Research & Restoration](#) and [Vancouver Island University's Applied Environmental Research Lab](#) and co-sponsored by the PSF.

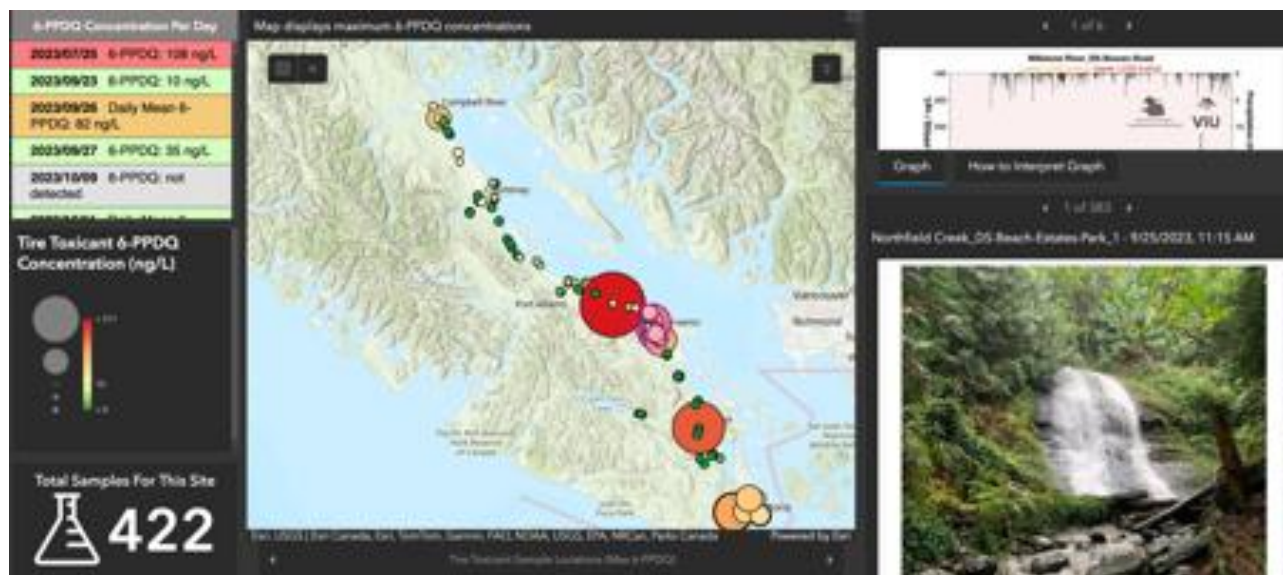


Figure 4. Screenshot (January 2025) of the [BC Conservation Foundation Tire Wear Toxin Load Map](#) detailing the 6PPD-Q load in Northfield Creek on Vancouver Island, British Columbia. The map includes maximum found 6PPD-Q concentration and daily concentrations.

CURRENT SOLUTIONS TO MANAGE STORMWATER

To mitigate the impact of urban runoff on salmon populations, several strategies have been employed to minimize runoff volumes and treat the stormwater. They include legislative source controls to remove a pollutant from circulation and building absorptive infrastructure that lowers the volume and speed of stormwater, subsequently reducing the pollutant load entering an aquatic system.

Legislative Source Control

Source controls are the most effective means for reducing or eliminating toxins in stormwater runoff. For example, legislation that phases out the use of copper and other metals in vehicle brake pads can significantly decrease these pollutants in runoff (view the [Better Brakes Law](#) in this link). Recently, the European Union adopted the Euro 7 regulation, which imposes stricter rules for exhaust emissions from road vehicles, as well as tire and brake wear particles (Council of EU 2024). This regulation includes specific limits for electric vehicles and the release of non-exhaust particulate matter.

Green Infrastructure

Green infrastructure (GI) is a key approach to reducing the volume of runoff by encouraging rain infiltration to help prevent water pollution, reduce flooding, and increase climate resiliency in urban areas (EPA 2024a). GI refers to low-impact, nature-based solutions that have the capacity to retain rainfall where it lands, with effective systems such as green roofs and permeable pavements retaining 50–70% of stormwater onsite (Mead-Fox 2022). *Natural* green infrastructure – forests, grasslands, wetlands – and *engineered* green infrastructure – human designed devices that mimic natural function such as bioswales, pervious pavement, and rain gardens, are two complementary strategies that can re-establish the natural water cycle that existed prior to urbanization (Fig. 5). Tree canopy alone is an important component of the water balance with rainfall interception, accounting for up to 35% of the gross annual precipitation (Asadian & Weiler 2009). In a dense city where natural GI has not been preserved, engineered GI can be a successful alternative (Rutherford 2007).

GI elements can be woven into a community at multiple scales, from individual rain barrels against a house, to a constructed wetland near residential housing (Fig. 5). These elements slow and reduce the volume of stormwater entering traditional grey-piped systems, capturing pollutants and improving the quality of water entering receiving watercourses (FBC 2016). Integrating existing grey infrastructure (e.g., pipes and concrete) and GI systems has provided the greatest resilience to urban flooding by providing relief to grey drainage systems overwhelmed by stronger rain events (Mead-Fox 2022). The benefits of GI, which extend beyond stormwater management, are outlined in the bullets below:

- **Water Management:** GI retains and filters rainwater at its source and increases evapotranspiration and infiltration, decreasing the risk of flooding and combined sewer overflows whilst protecting water quality.
- **Temperature Moderation:** Urban green spaces help moderate temperature and reduce heat-related deaths during extreme heat waves for humans and animals alike.
- **Erosion Control:** GI systems can capture sediment and reduce the volume and rate of runoff flow into nearby bodies of water.
- **Ecosystem Services:** GI can serve multiple functions, including filtration for improved air and water quality, enhanced water security, pollination, enhanced food security, health and wellness improvements, enhanced livability, and urban biodiversity.
- **Climate Change Resilience and Adaptation:** GI enables and supports community resiliency and promotes global water security by providing physical adaptation and mediating the extremes of climate change, such as drought and flooding events.

GI systems are increasingly being used to prioritize a specific performance outcome (Mead-Fox 2022) (Fig. 5). Green roofs take up and degrade contaminants before runoff enters surrounding water bodies. Plants with high evapotranspiration rates can be used when heat island reduction is a priority. To increase infiltration and maximize peak flow reduction, systems can be designed to maximize underground surface area to hold more rainfall on site or use sandy soils to encourage infiltration. GI systems aiming to improve water quality rely on bioretention or biofiltration to trap and degrade pollutants in the system's biomass (Mead-Fox 2022). It has been found that stormwater bioretention systems, or rain gardens designed with a bioretention soil mixture (compost and sand), can effectively mitigate >90% of 6PPD-quinone loadings to water bodies under typical storm conditions (Rodgers *et al.* 2023).

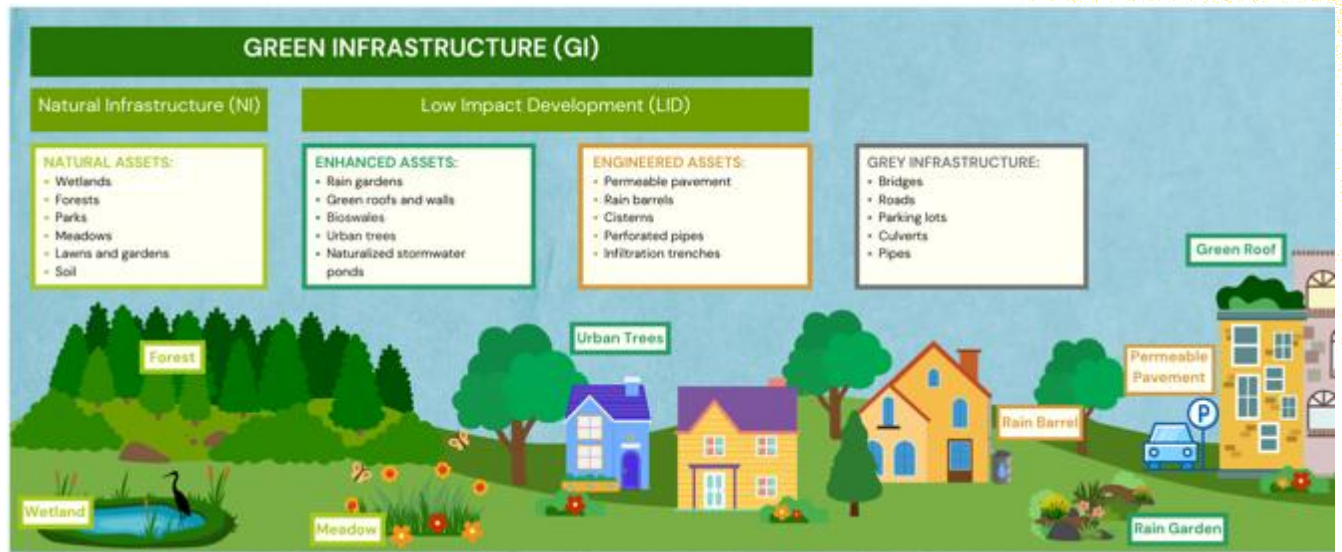


Figure 5. Distinguishing between different GI assets that can be implemented in an urban environment (adapted from [Green Infrastructure Ontario Coalition](#)).

SECTION II – STORMWATER MANAGEMENT GUIDANCE IN THE METRO VANCOUVER REGION

A BRIEF OVERVIEW OF THE VARYING GOVERNMENT ROLES AND RESPONSIBILITIES IN STORMWATER MANAGEMENT

Water policy and stormwater management involve coordination across all levels of government, with federal regulations setting broad standards and provincial and local authorities implementing specific practices and programs. An overview of the main governing bodies, guidance documents, and policies found at each level of governance can be seen in Figure 6. The Government of Canada, through the Department of Fisheries and Oceans (DFO) and Environment and Climate Change Canada (ECCC), is concerned with regulating pollutants and protecting fish habitats and populations in receiving waters and urban streams (Water Bucket 2007). Under the federal Fisheries Act, regional authorities and member municipalities are not allowed to discharge stormwater and rain runoff that would negatively impact fish and their habitat.

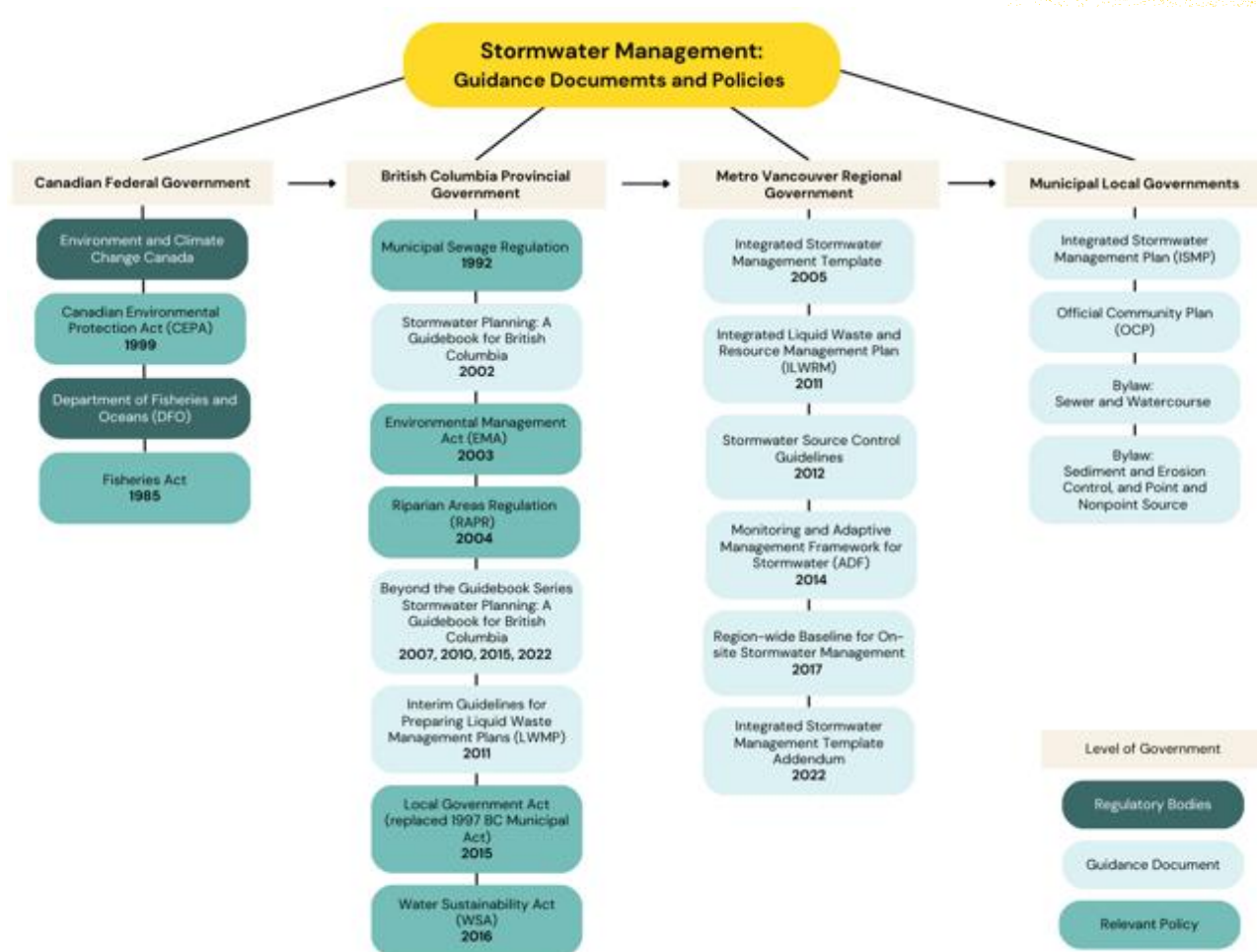


Figure 6. Overview of the key governing bodies, guidance documents, and policies at the federal, provincial, regional, and municipal scales that inform water and environmental policy and stormwater management for Metro Vancouver in British Columbia, Canada.

All water resources are “owned” by individual provinces. The Government of British Columbia regulates water resources under the *Water Sustainability Act* (WSA), and all impacts to the environment or riparian areas are under the *Environmental Management Act* (EMA) and *Riparian Areas Protection Act* (RAPA) (McDonald 2021). Responsibility carries through to regional governments via the *Local Government Act* in British Columbia, which vests the responsibility of drainage with municipalities. It provides the statutory framework that enables local governments to be proactive with stormwater management solutions and allows local governments to be held liable for downstream impacts resulting from upstream drainage patterns (Water Bucket 2007). Municipal authority includes regulating subdivision servicing requirements, which allow the establishment of location and construction standards regarding stormwater collection/disposal. In cooperation with the BC Minister of Environment, all regional governments were required to develop an approved *Liquid Waste*

Management Plan (LWMP) that includes a stormwater component (Metro Vancouver 2010). The subsequent purpose of a LWMP is to minimize the adverse environmental impact of land use planning found in an Official Community Plan (OCP) (Stephens *et al.* 2002). In the absence of an approved LWMP, the provincial *Municipal Sewage Regulation* (1992) governs.

Metro Vancouver's *Integrated Liquid Waste and Resource Management Plan* (ILWRMP) was approved in 2011 and outlines goals, strategies, and actions for Metro Vancouver and member jurisdictions to ensure the health of the environment and its inhabitants by managing sanitary sewage and stormwater at their sources. The ILWRMP designates Metro Vancouver with delivering liquid waste management, including documents on regulatory standards, such as established region-wide baseline criteria for on-site rainfall management, including variations for localized geology, rainfall, and watershed conditions (Metro Vancouver 2010). The region specifically oversees wastewater treatment, as well as any combined sewer outfalls still located within the older municipalities. The document sees stormwater as a liquid waste and places the responsibility of managing and regulating stormwater systems on the member municipalities (Stephens *et al.* 2002). In agreement with the ILWRMP, all Metro Vancouver municipalities were required to develop an Integrated Stormwater Management Plan (ISMP) and separate any historic combined sewer system. ISMPs bring the two disciplines of stormwater management and land use planning together to facilitate growth while protecting the environment (Metro Vancouver 2022). Due to the interdisciplinary nature and regional impact of stormwater management, the Stormwater Interagency Liaison Group (SILG) was formed in 2002. The group consists of representatives from Metro Vancouver, its member municipalities, and provincial and federal environmental agencies. This was done to facilitate the coordination and sharing of common research related to stormwater management.

HISTORICAL APPROACHES TO STORMWATER MANAGEMENT IN THE LOWER FRASER WATERSHED

Metro Vancouver is composed of 23 member jurisdictions: 21 municipalities, one electoral area, and one treaty First Nation. The organization is governed by a Board of Directors of elected officials from each member jurisdiction that act to deliver regional services, policy, and political leadership for the member municipalities. Development and urbanization of the Lower Fraser Valley (extending from the Strait of Georgia to the Coquihalla Watershed) has resulted in the loss of over 117 streams and endangered nearly 50% of recorded streams due to diversion, loss of riparian vegetation and water quality, or cumulative effects of urban development and land-use changes (McDonald 2021). Contributing to the decline and vulnerability of the health of the Fraser River are nonpoint and point source discharges from sewage treatment plants, infiltration ponds, septic tanks, and urban combined sewer overflows (Swain *et al.* 1998). The impact of wastewater treatment plants, combined sewer

outfalls, and sanitary sewer outfalls are monitored and reported on by Metro Vancouver through their environmental monitoring programs for adherence to their ILWRMP. However, there is an emphasis on sanitary contamination and no inclusion of stormwater outfalls in the monitoring program ([see here for reports produced by Metro Vancouver](#)).

Traditionally, stormwater management relied on “grey” infrastructure – human-engineered networks of curbs, gutters, and pipes designed to convey water away from urban properties as quickly as possible (FBC 2016). This approach altered the natural landscape of the watershed, creating impervious surfaces that disturbed the existing water balance and resulted in impacts such as water pollution, streambank erosion due to higher surface runoff volumes, and destruction of native vegetation and fish habitat (Stephens *et al.* 2002; Kokkonen *et al.* 2018; FBC 2016). In a 2020 study, almost half of Metro Vancouver municipalities’ total land area was 50% impervious surface, with the distribution of impervious surfaces dominated by private residential lots and roads (Metro Vancouver 2024).

In the 1990s, the degradation of the natural environment and salmon populations became a major concern after studies linked declining salmon populations with the urbanization of LFW (McDonald 2021). During this period, the Province of British Columbia recognized that stormwater management needed to evolve beyond mere drainage, acknowledging stormwater as a resource for aquatic species, groundwater recharge, and water supply (Stephens *et al.* 2002). Water volume, in particular, was recognized as a resource that local governments have control over through infrastructure policies, practices, and standards. To address the challenges of managing the volume of untreated urban rainwater runoff, a ‘design with nature’ approach was pushed, aiming to mimic or restore the natural hydrological patterns of the landscape (Stephens & Dumont 2010).

In 2002, the province released *Stormwater Planning: A Guidebook for British Columbia*, which sets out five guiding principles for the development and implementation of holistic stormwater management:

1. Agree that stormwater is a resource.
2. Design for the complete spectrum of rainfall events.
3. Act on a priority basis in at-risk drainage catchments.
4. Plan at four scales – regional, watershed, neighborhood, and site.
5. Test Solutions and reduce costs by adaptive management.

The term “Integrated Stormwater Management” is unique to British Columbia, and has gained widespread acceptance by local governments and environmental agencies to describe a comprehensive approach to stormwater management (Intergovernmental Partnership 2007). An Integrated Stormwater Management Plan (ISMP) is a planning tool used to accommodate population growth and community values while also protecting watershed health, and climate variability and change. Greater emphasis was placed on GI to

manage watershed hydrology more sustainably and mitigate the impact caused by the high volume and pollution of stormwater (Stephens *et al.* 2002). This approach was further advanced with the introduction of the *Beyond the Guidebook* series in 2007, 2015, 2020, and 2021, as referenced in Figure 6, which emphasized GI's role in fostering healthy watersheds in a runoff-based approach to urban drainage modeling. Many Metro Vancouver municipalities have included GI in the Best Management Practices (BMP) Toolkit for stormwater source control and treatment (Metro Vancouver 2022).

GUIDANCE DOCUMENT SUMMARY

Decisions on how rainwater is managed as a resource are a key pillar of sustainable development and an entry point for a local government wanting to implement a “green infrastructure” approach. Local governments are advised to use design techniques that prevent flooding while also preserving the health of aquatic and riparian ecosystems through design-with-nature elements that support natural processes and ecological assets.

Minimum Requirements for Metro Vancouver Member Municipalities

Underneath Metro Vancouver's ILWRM, each member municipality is expected to meet four broad requirements:

- Develop and implement ISMPs at the watershed scale.
- Integrate land use planning and rainwater management.
- Place emphasis on managing rainwater runoff at the site level, which reduces negative quality and quantity impacts.
- Prohibit the construction of new combined sewers and replace combined sewer systems with separate sanitary and storm.

The ISMP is designed to assess the baseline ecological health of urban watersheds and incorporate more natural processes into stormwater plans. The goal is to ensure no net loss to environmental quality and protect communities from localized flooding. While an ISMP is a helpful tool, committing to one is a large undertaking. The plan should address a wide range of management issues and require the integration of watershed, catchment, master drainage plans, and stormwater plans with relevant municipal planning processes such as Official Community or Neighbourhood Concept Plan, Recreation and Parks Master Plans, and Strategic Transportation Plans into a single document. The given ISMP templates (2005; 2022) apply to watersheds only within the Metro Vancouver area, where aggressive development has taken place.

Although senior levels of government provide guidance, the *Integrated Stormwater Management Template* (2005; 2022) underscores that stormwater management largely rests

on the discretion of the individual municipality. As such, a minimum standard for ISMP preparation was set, consisting of bylaws designed to safeguard human and aquatic health. If an ISMP has not been created, municipalities are expected to have one or more of the following bylaws:

- **Bylaw for Stormwater Source Controls:** Regulates new and redevelopment parcels.
- **Bylaw for Protecting Riparian Areas:** Includes riparian areas regulation or stream protection regulation.
- **Bylaw for Sediment and Erosion Control:** Addresses control measures for both point and nonpoint pollution control for water quality.

The BC Provincial page on [Local government stormwater infrastructure](#) outlines additional authority that local governments can implement for stormwater solutions:

- Bylaws that limit impervious surfaces and encourage infiltration.
- Alternative low-impact subdivision bylaw standards.
- Bylaws that prevent the release of contaminants into storm drains.
- Watercourse setback zoning bylaws.
- Development permit areas that protect watercourses and floodplains.

Practices for Managing the Rainfall Spectrum and Stormwater Discharge

An integrated strategy for managing rainfall across a typical year represents a proactive approach to controlling stormwater discharge. The proposed ISMP process for the Metro Vancouver region recommends the implementation of citywide stormwater criteria to manage and treat stormwater runoff from impervious areas for the entire rainfall spectrum (Stephens *et al.* 2002; DFO 2001; Metro Vancouver 2005; Intergovernmental Partnership 2007). GI is the most common source control method, designed to mitigate the potential environmental impacts of development and enhance community long-term sustainability by softening the environmental footprint (Rutherford 2007). For GI to perform as required, it must be designed to acceptable stormwater criteria, otherwise, it will not replicate natural hydrology. These performance targets assess the management of the complete rainfall spectrum through achievable runoff volume-based criteria (Intergovernmental Partnership 2007). The stormwater discharge criteria for BC are summarized in the table below.

Table 2. Summary of the criteria governing stormwater discharge in British Columbia.

	Target rainfall Amount	Integrated Management Strategy
Provincial Stormwater Guidebook (Stephens <i>et al.</i> 2002)		
Volumetric Reduction	0-50% Mean Annual Rain Event (MAR) – Tier A/B rainfall events	Capture 90% of annual rainfall in a typical year and infiltrate and/or evaporate it at the source (runoff volume reduction and water quality control).
Runoff Control for Large Storms	50-100% MAR – Tier C storms	Store runoff from infrequent large storms and release at a rate that approximates the natural forested condition or decreases erosion.
Flood Risk Management for Extreme Storms	Greater than MAR up to 100-year return period – Tier D storms	Reduce flooding by providing sufficient hydraulic capacity to contain and convey extreme storm events with only minimal damage to public and private property (peak flow conveyance).
Fisheries and Oceans Canada (DFO 2001)		
Water Quality	Treat 90% of annual rainfall	Provide treatment for 90% of rainfall events falling on impervious areas with suitable BMPs.
Volumetric Reduction	6-month	Infiltrate, evaporate, transpire, or reuse all rainfall up to the 6-month storm (only applicable to fish-bearing creeks).
Rate Control – Erosion	6-month, 2-year, and 5-year events	Control post-development flows to pre-development levels for 6-month, 2-year, and 5-year events.

Stormwater source control design and implementation strategies are one of the building blocks outlined in ISMPs. These ISMP controls should address volume reduction and water quality aspects for watersheds, or parts of watersheds, and can be designed based upon the discharge criteria shown in the above Table 2. More information regarding Best Management Practices for stormwater source controls, including design guidelines, applications, limitations, and maintenance, is explored in the Metro Vancouver *Stormwater Source Control Guidelines* (Metro Vancouver 2012). The following typologies were shown:

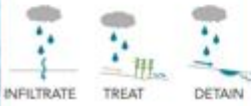
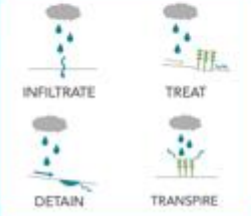
- **Absorbent landscapes**, including native soils and woods, compost-amended soils, planters, and other treatments to reduce runoff from landscape areas and mimic the hydrologic function of undeveloped land on a development site.
- **Bioretention facilities** include rain gardens, sunken landscape areas, and infiltration areas, with or without an underdrain.
- **Vegetated swales** include bioswales and associated vegetated filter strips.
- **Pervious paving**, including both vegetative and non-vegetated types.
- **Infiltration trenches, sumps, and drywells**, including various underground infiltration devices.
- **Extensive green roofs**, having less than 300 millimetres depth of growing medium.

The creation of source control designs in ISMPs requires the obtaining of data such as:

- Rainfall data to determine rainfall depth, sizing of source controls, and overflows.
- Surficial soils mapping and infiltration values.
- Identification of hazardous slopes and protected habitat.
- Overflow drainage paths.
- Infiltration constraints such as a high-water table.

This inventory of data will allow municipalities to implement the best stormwater source controls based on the situation. To evaluate source control options under a full range of operating conditions, continuous simulation of water balance modeling should be completed, see the *Water Balance Model for British Columbia*, powered by [QUALHYMO](#) (Intergovernmental Partnership 2007). See below for the BMP toolkit for stormwater source control recommendations to treat and retain, included in the City of Vancouver's ISMP (Vancouver 2016).

Table 3. BMP Toolkit summary table for stormwater source controls (Source: Vancouver 2019).

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

Adaptive Management and Ongoing Monitoring

Clear GI policy goals help incentivize implementation by creating measurable targets to work towards. Tracking GI progress towards those goals is essential to determining what changes need to be made. Performance tracking can also be used to optimize the performance of GI systems, which should be a consideration for any municipality seeking to achieve its goals with limited resources (Mead-Fox 2022). Condition 7 of the BC Minister of Environment's

approval of the ILWRMP requires that municipalities, with the coordination of Metro Vancouver, develop a monitoring and adaptive management framework for assessing watershed health and the effectiveness of ISMPs (Metro Vancouver 2014).

Metro Vancouver published the *Monitoring and Adaptive Management Framework for Stormwater* (AMF) in 2014 to provide a “weight of evidence approach” for monitoring watershed health (Metro Vancouver 2022). This was done for three types of systems: low-gradient streams, high-gradient streams, and piped systems (Fig. 7). In order to confirm the effectiveness of the ISMP in achieving good watershed health or a positive trend towards good watershed health, AMF criteria for flow and water quality should be monitored to establish trends of watershed health. Adaptive management is meant to optimize rainwater system design through confirming initial assumptions of performance monitoring (Intergovernmental Partnership 2007; Rutherford 2007). ISMPs are expected to include baseline data collection and monitoring recommendations in accordance with AMF, however the minimum level of effort may be zero if the municipality has determined a parameter does not apply for a watershed and its ISMP (Metro Vancouver 2022).

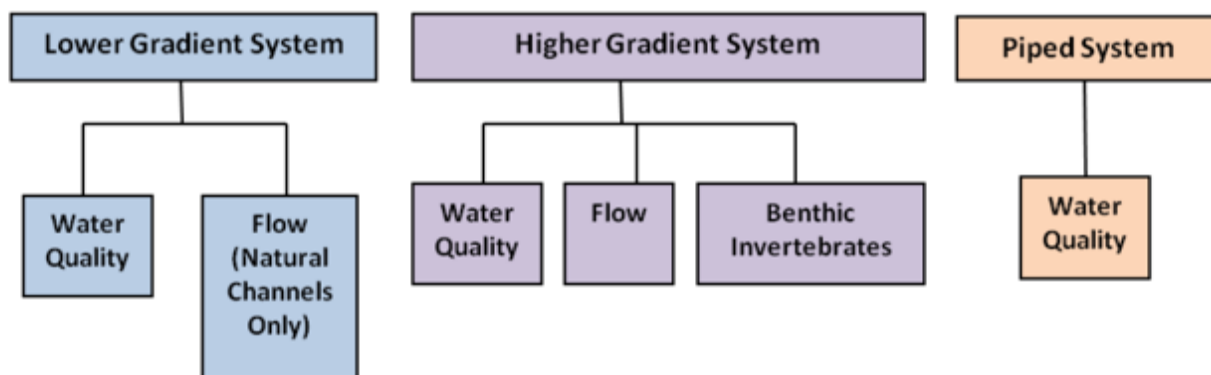


Figure 7. Monitoring programs based on system type (Source: Metro Vancouver 2014).

Metro Vancouver’s ILWRMP requires all member municipalities to review current ISMPs on a 12-year cycle or sooner. This includes ensuring source control requirements are up to date, health indicators based on collected AMF data are positive, and potential mitigation and adaptation measures based on new guidance and data on changing climate predictions are included (Metro Vancouver 2022). This provides opportunities for new legislation, research, techniques, and technology to be developed to expand upon the initial scope of existing ISMPs. Additional AMF monitoring is required every five years, establishing two sets of data of at least five samples within a 30 day period in the wet and dry season. Although AMF includes many water quality indices, the minimum standard of framework required for monitoring, reporting, and assessing trends in various watershed health metrics includes the following key components:

- **Flow Monitoring Methodology:** establish flow monitor gauge and develop a stage-discharge rating curve for one year of flow monitoring; if resources allow, a flow monitor should be installed in every drainage system.
- **Benthic Invertebrate Sampling:** to assess overall health of a stream or watershed; at a minimum, sampling should occur every five years, but more frequent collection is recommended for a better understanding in changes in stream health over time.
- **Recommended water quality parameters to measure are:** dissolved oxygen, temperature, turbidity, pH, conductivity, nitrate, E.coli, fecal coliforms, and total iron, copper, lead, zinc, and cadmium.

It is clearly stated that ISMPs may need additional metrics beyond the minimum standard to more accurately reflect specific priority issues in the watershed and changes over time based on the ISMP's objectives (Metro Vancouver 2022). These monitoring programs have focused on water quality sampling and evaluation of water quality parameters for the creeks within study watersheds in previous years. The link between water quality and protecting downstream water uses in creeks or in major receiving water bodies such as the Burrard Inlet, the Fraser River, and Boundary Bay are often not considered (Metro Vancouver 2022). Ongoing monitoring of areas such as the Fraser River suggests that human impacts continue to reduce the opportunities for water uses, such as First Nations' traditional harvesting and cultural practices (Metro Vancouver 2022).



SECTION III – CURRENT PRACTICES AND CHALLENGES TO STORMWATER MANAGEMENT IN THE METRO VANCOUVER REGION

CURRENT STORMWATER PRACTICES

The following summaries are based on the information shared by participating municipalities during an interview on current stormwater practices. For further details and the full set of questions, see Appendix A. Further contextual information was gleaned from links available on each municipal website.

In this section, we report on the action municipalities are taking regarding:

- Establishment of an ISMP.
- Source control bylaws and policies surrounding them.
- Stormwater management data and modeling.
- Case study GI projects.
- Monitoring and management programs for GI, grey infrastructure, and water quality.
- Community engagement and educational products.

Here, we highlight the current implementation by the participating municipalities and compare it with the guidance provided by the documents available for local governments in Metro Vancouver. A more comprehensive table of the stormwater management practices implemented by all interviewed municipalities can be found in Appendix B.

Minimum Level Requirements and ISMP Creation

Recall, the minimum broad requirements for all Metro Vancouver Municipalities are:

- **Prohibit the construction of new combined sewers and replace combined sewer systems with separate sanitary and storm.**

Currently, three municipalities still have sections of combined sewer systems – the City of Vancouver, the City of New Westminster, and the City of Burnaby – and are in various stages of separating the older combined system into sanitary and storm sewer systems. Separation on the public side of development must be completed by 2050 to meet the Province of BC’s environmental goal. The separation remains a priority to decrease the flooding and contamination caused by combined sewer overflows, especially as climate change and extreme weather overwhelm these outdated systems. The urgency in separation consumes a large portion of stormwater resources.

- **Develop and implement ISMPs at the watershed scale.**

Guidance provided by senior levels of government, such as the Integrated Stormwater Management Template (2005; 2022), emphasizes that stormwater management largely rests on the discretion of the individual municipality. Consequently, the extent to which local governments implement recommendations varies based on their capacity in terms of personnel, funding, and the specific goals and objectives of each municipality. The ISMP process allows municipalities to develop tailored solutions and criteria for their specific watersheds, as long as they adhere to the approved ISMP template and receive endorsement from the municipal council (Metro Vancouver 2005; Metro Vancouver 2022).

Most municipalities have completed or are in various stages of completing ISMPs for the watersheds in their municipal jurisdictions. However, updates to said ISMPs have been limited. To see the links for available municipal ISMPs, including updates, or guidelines, and bylaws that are in place that follow traditional ISMP requirements, see Appendix B. To see outlines of the two following requirements, see the following subsections.

- **Integrate land use planning and rainwater management.**
- **Place emphasis on managing rainwater runoff at the site level which reduces negative quality and quantity impacts.**

Source Control Bylaws and Policies Surrounding Stormwater

The two main bylaws that encompass source control measures enacted by municipalities are a *Sewer and Watercourse Bylaw*, which prohibits the fouling or contamination of storm sewers and water bodies, as well as an *Erosion and Sediment Control Bylaw* that outlines development controls during the construction phase. Cities such as Burnaby and Delta whose geography is characterized by streams enact a *Streamside Protection and Enhancement Area (SPEA) Bylaw*, which aims to restrict development from entering sensitive habitat.

Dictating source controls on private developments can be difficult, especially as new and re-developments often increase the impervious area. The District of North Vancouver encourages the maintenance of 20% tree canopy on private, single-family zoned lots by not requiring replacements when certain protected trees are removed through their [Tree Protection Bylaw 7671](#). In order to ensure the volume of runoff created by development does not pressure the storm sewer system, bylaws such as New Westminster's [Subdivision Design and Control Bylaw](#) require the management of runoff to be controlled to pre-development conditions through the use of source controls. This is echoed by the [SSMUH Zoning Bylaw Amendment](#) that was recently adopted by Burnaby, which addresses the need to require single-family housing lots to implement stormwater management, a process that was initially not required due to the lower levels of development historically seen on these lots.

Burnaby and Coquitlam both stipulate stormwater requirements during and post-construction. During construction, sites are required to have erosion and sediment control measures in place, and

all treatment systems must ensure discharge into stormwater drainage systems meets the quality criteria in municipal and Provincial legislation. This is done through a real-time third-party monitoring system that automatically recirculates the discharge to prevent contaminants from entering the storm system. Additionally, construction sites are required to follow best management practices that increase infiltration and on-site retention of stormwater. After construction, the cities require properties to follow the stormwater management design guidelines to meet discharge rate and quality requirements. See Burnaby's [Total Stormwater Approach Policy](#), and Coquitlam's [Stream and Drainage System Protection Bylaw](#) to learn more.

Burnaby also discussed an upcoming policy shift in building and plumbing, which would allow the disconnection of roof leaders from storm systems, creating opportunities for natural infiltration of the previously untreated roof runoff. This would require a rewrite of the plumbing bylaw and a change of building code to allow the proper treatment and capture of rainwater on single-family plots. If done correctly, overflow connections back into the system would also be provided. This is a collaboration between the private and public sectors of the city.

Stormwater Management Documents and Data Modelling

All member municipalities of Metro Vancouver are required to implement an Integrated Stormwater Management Plan that encompasses the prioritization of watershed health goals and urban growth and development. These comprehensive documents often reflected the discharge criteria as seen in Table 2, where the aim is to treat 90% of the annual rainfall runoff prior to it entering waterways. GI and natural hydrology are credited as key source control measures to increase absorption. Through the [Rain City Strategy](#), the City of Vancouver has been able to implement over 360 green infrastructure assets to control the volume of water. This includes permeable pavements, bioretention corner bulges that aid in filtration and increase the safety of traffic in urban areas, as well as rainwater tree trenches, which have the co-benefit of reducing heat island effects. All of these assets are publicly documented and can be found on the interactive web map [VanMap](#) (see Fig. 8 for an example of documented rainwater tree trenches along Richards Street). GI implementation varies slightly city to city, with each municipality relying on their own standardized design manuals, [click here to view Vancouver's design standards](#).

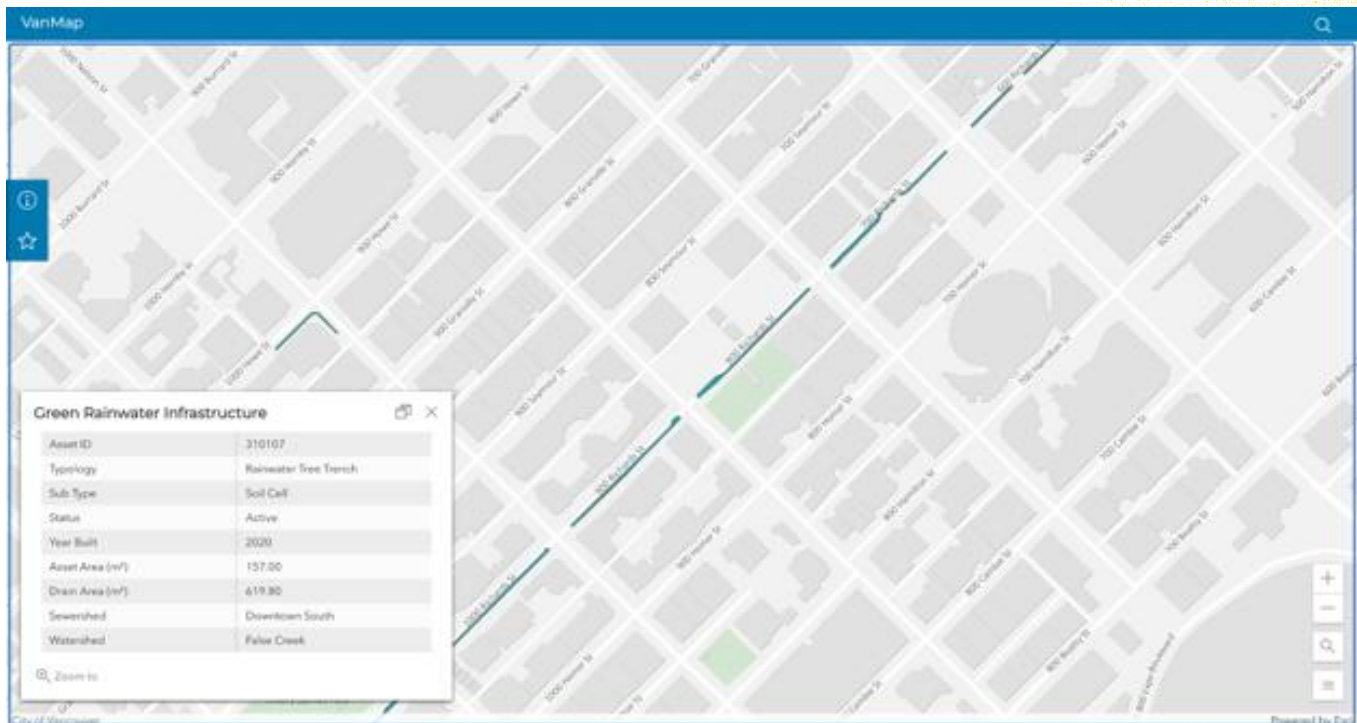


Figure 8. Screen grab of installed Rainwater Tree Trenches along Richards St. All green rainwater assets have an ID documenting the green rainwater asset typology, active status, year built, estimated asset area, and receiving watershed. This [Green Rainwater Infrastructure Data Set](#) was updated in June 2023.

Both the [District of North Vancouver](#) and the [City of Coquitlam](#) have created a water balance interactive tool that allows property homeowners, and private and public (re)developers to configure a site with various natural hydrology, green infrastructure, and impervious areas to understand the volume of runoff created through different design choices. This tool can be used to explore how developments on a property may better manage rainwater resources and restore the natural balance of the region's water. The express guide lets homeowners experiment with different actions, such as sizing rain gardens, cisterns, and landscaping.

These region-specific water balance tools follow in the footsteps of the *Water Balance Model for British Columbia*, powered by QUALHYMO, a hydrologic simulation tool created in 2003. This online decision support and scenario modelling tool demonstrated how to achieve a light hydrologic footprint and implement green solutions on the ground through calculating annual runoff volumes. It was done under different combinations of building coverage, rainfall, soil type and depth, tree canopy coverage, and source controls.

Case Study Green Infrastructure Projects

Burnaby Town Centre Standards

Burnaby has made a commitment to increase the livability and sustainability of their neighborhoods and streets, beginning with the four Town Centres – Brentwood, Edmonds, Lougheed, and Metrotown. Through new development and re-development, the complex streetscapes of the Town Centres have been transformed with rainwater management amenities (RMAs) to manage the rainwater runoff from the roads (Fig. 9). The bioretention practices have been designed to collect and treat runoff from 90% of the annual rainfall events, while working in harmony with every day public spaces such as pedestrian and cyclist zones. Additional assets include traffic calming bulges, greenways, and bikeways. Each RMA is designed with an overflow control structure, which is raised above the surface of the RMA to force rainwater to filter through the engineered soil mix and be collected by the subsurface underdrain, from which it is routed to a storm sewer outfall. In addition to the linear RMAs, urban street tree plantings with 28–34 cubic metres of growing medium, larger than the conventional tree planting, are used to ensure long-term healthy development of street trees. The unique opportunity the Town Centres provide is through lessening the financial and resource burden of maintaining RMAs. Developers are expected to undertake the cost of maintenance during the first two years after installation. Burnaby has built a maintenance schedule into the Town Centre Standards, where the City will ensure the developers are currently maintaining all infrastructure (Burnaby 2020).

“The number one challenge is always funding. The Town Centre Standards were a good way to find funding, as growth should be paying for development and growth and the effects of that.”

– David Lee, City of Burnaby

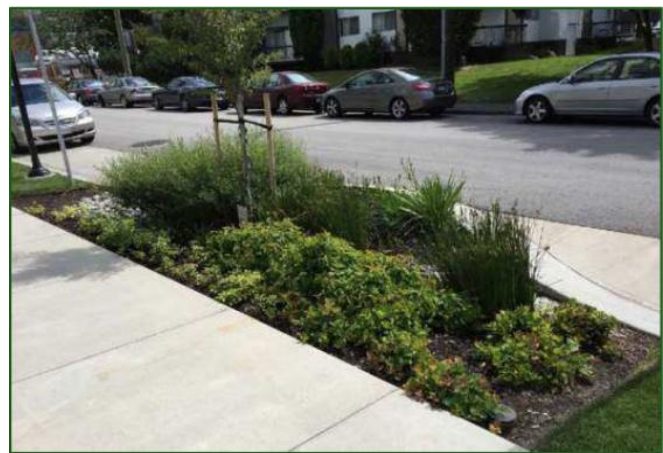


Figure 9. RMAs in Burnaby Town Centers. (Left) RMA at Lougheed Highway, Brentwood Town Centre. (Right) Silver Avenue, Metrotown Town Centre. (Source: Burnaby 2020)

sθəqəlxenəm ts'exwts'áxwi7 “Rainbow” Park

sθəqəlxenəm ts'exwts'áxwi7 Park, a name gifted by the Musqueam, Squamish, and Tsleil-Waututh Nations, is in the heart of downtown Vancouver, servicing over 10,000 residents and 17,000 employees who live and work within a 5-minute walk of the area. This site features dynamic play areas, art installations, multidimensional walkways, as well as green spaces and infiltration sites for rainfall (Fig. 10). It represents the intersectional need of third spaces and parks in dense urban landscapes create community connection, while also providing source control measures to mitigate the impacts of impervious surface area. The development of the park was funded through [Community Amenity Contributions](#) to help the City build and expand facilities such as parks and open spaces, community facilities, and arts and cultural spaces.



Figure 10. sθəqəlxenəm ts'exwts'áxwi7 Park, Smithe and Richards streets.

Robb Lukes noted the co-benefits of the addition of nature into a city via green infrastructure. *“The need for green infrastructure to reduce the urban heat island effect became prevalent in the 2021 heat dome. This was one of the most deadly disasters in Canadian history. Green spaces can mitigate the effects of urban heat island, such as shade trees, permeable spaces, cooler pavements that encourage air circulation and moisture. This infrastructure could have played a role in reducing the number of deaths that occurred.”*

To see more GI case studies in the Metro Vancouver Region and other parts of the world, infrastructure implemented in high and low urbanized spaces, as well as reports investigating the effectiveness of source control measures, click the links below.

- [Connecting the Dots: Regional Green Infrastructure Network Resource Guide](#) – *Explores opportunities for implementing GI projects across Metro Vancouver using case studies in various urbanized areas in British Columbia and around the world.*
- [Urban Stormwater Source Controls: Investigating the Effectiveness of Common and New Measures in Managing Stormwater Quality and Quantity](#) – *Recommends updates to Stormwater Source Control Design Guidelines (SSCDG) following the review of existing source controls in SSCDG, emerging source controls and new technologies, as well as implemented infrastructure and lessons learned.*
- [Green Rainwater Infrastructure Typologies](#) – *Provides illustrations and descriptions of various GRI typologies implemented throughout Vancouver and other parts of the world.*

Stormwater Monitoring and Management Programs

Green Infrastructure

GI is designed to perform to a specific standard to retain and infiltrate a certain percentage of runoff volume. In most municipalities, the installation of GI has been relatively new, and the budget is shared between implementation and maintenance. Due to this constraint, monitoring of GI structures has focused on performance through containing volume and limiting overflows. Occasional spot testing of water quality has been done on the water leaving a GI system, however, no formal routine testing has been implemented. The City of Vancouver has been able to establish a monitoring program for the widespread GI implemented throughout the City, and since 2022, has produced [biannual performance modeling reports](#) that include data on rainfall, water level monitoring, soil moisture monitoring, and synthetic runoff testing.

“There is a lot of research on green infrastructure performance. It has gotten to a point where if you design it to a certain standard, i.e. this deep, this much soil, you should expect this outcome for water quality. This is a presumptive approach, and therefore, assumptions are supported with the occasional spot testing to make sure it is performing to that standard.”

– Robb Lukes, City of Vancouver

Grey Infrastructure

The maintenance of grey infrastructure in most municipalities falls back on the operations teams. Storm sewers, alongside sanitary sewers, are inspected via CCTV scans, with a certain percentage of the system scanned each year according to a zoned schedule. The time required for a municipality to complete a full scan of piping lines depends on the total area that needs to be inspected as well as the capacity of the operations team. It can take anywhere from 5 to over 10 years to complete a full

scan of the city. Based on the results of the CCTV scan, lines are added to an asset management priority list, and flushed and repaired as needed. The cleaning and vacuuming of catch basins is often a reactive process, driven by high-priority locations or community flooding complaints.

Pollution and Water Quality Control

Through Metro Vancouver's ILWRMP and AMF program, member municipalities are required to report on water quality, which is subsequently submitted in cumulative reports to the Provincial Environment Minister. These water quality reports focus on wastewater treatment plants, sanitary sewer outfalls, as well as combined sewer outfalls, all of which are strictly regulated. The level of stormwater monitoring is up to the discretion of individual municipalities. There is no driving regulatory framework for water quality provided by senior levels of government outside of recreational water guidelines during the summer months and the AMF program, which is largely focused on local streams and creeks. Therefore, pollution and water quality issues are often dealt with reactively. There is no requirement for municipalities to put into place a consistent data monitoring system of receiving water bodies, as no water quality goals have been established. The lack of regulations increases with the size of the water body. Certain municipalities, such as the cities of Burnaby and Coquitlam, have taken it upon themselves to establish real-time data monitoring to measure indicators such as temperature, pH, conductivity, and turbidity at several storm sewer outfall locations, with the aim to install one in every creek. When the multi-parameter devices were not possible to install, the municipalities have used temperature and flow measurements as stand-ins.

A common sentiment expressed in the interviews was the desire for broader data modelling across water bodies to assess the effectiveness of upstream mitigation efforts. Participants noted that implementing these practices seemed unfeasible without the necessary regulations from senior levels of government or adequate funding and resources to support teams in managing this substantial task.

"AMF is honestly to be seen as a baseline minimum that municipalities should be doing, real-time monitoring is above and beyond AMF. Those who have established an AMF program can do more. That being said, smaller municipalities struggle when we try to push for more stringent requirements. But to be honest, without provincial regulation from the ministry of environment or DFO, there is no legal need for us to do more."

"It is hard to make decisions without data. [I] hope that as more people do it, the industry will recognize it and the cost will come down. [If we] work with the region, cost can come down with technology, innovation, and better practices. Hopefully this can be done regionwide or province wide."

- David Lee, City of Burnaby



Vancouver has made moves through their [Healthy Waters Plan](#) to create baseline water quality targets on receiving water bodies. In addition, Vancouver is currently advocating for a citywide pollutant load model that mimics the [Clean Water Act](#) (CWA) in the USA for the region. The pollutant loads for different land uses are known estimates, e.g. a residential street in a year produces this weight of zinc and copper sediments, creating an opportunity for a citywide model for sediment (an indicator pollutant) loading to be created. This model could be applied across the region and allow cities to identify pollution hot spots or areas of concern that require stormwater management action, for example, implementing a bioswale or increasing the rate of street sweeping (R. Lukes, personal communication, June 19, 2024). By utilizing BMPs in the most effective locations, the overall loading of pollutants in water bodies would decrease.

Community Engagement and Educational Products

Municipal staff saw great value in community engagement, and there was a consensus that the level of community understanding of an issue directly correlated with the level of appreciation shown for municipal preventative and mitigation efforts. Additionally, a greater community understanding encouraged individuals to take steps in reducing collective impact. However, the level of community engagement and educational products a municipality was able to produce heavily relied on the

resource capacity of the local government, including teams and funding, as well as the support received from council, different departments, and finally the interest of the communities themselves.

Municipalities with dedicated environmental teams were able to focus on educational products and partnerships. Some communities, such as Burnaby, Coquitlam, and the District of North Vancouver have a high level of engagement, data sharing partnerships, and established monitoring programs with streamkeeper groups, as well as First Nations. Delta has implemented rain gardens at several elementary schools and around roadways in partnership with participating volunteers, streamkeepers, and schools. Individuals are invited to [adopt-a-rain garden](#) where they will receive training to maintain it. In addition to the program, a rain garden curriculum has been developed for Grades 4 and 5 to raise awareness on how everyday actions impact watercourses. In a similar essence, adopt-a-catch basin programs have been established in other municipalities to lessen the maintenance load on operation crews, one example being the [catch basin program in Vancouver](#).

Multiple municipalities have collaborated with post-secondary institutions when it comes to projects, data monitoring, and studies. Burnaby has set up a [Civic Innovation Lab](#) with Simon Fraser University. This unique collaboration between the two entities allows for research to be tested *in situ*, conducted directly in the real-world using the City as a lab. The hope is to create solutions to achieve sustainable growth and address the impacts of climate change.



Photo Source: [Adopt-a-Rain-Garden Program, Delta](#)

CHALLENGES AND SOLUTIONS TO STORMWATER MANAGEMENT IN THE METRO VANCOUVER REGION

Barriers to Implementing Effective Stormwater Management

Although Metro Vancouver and its municipalities have made significant strides in establishing green stormwater management goals and planning documents, several barriers to implementing nature-based solutions persist. Stormwater practices largely exist within the context of a singular municipality, although some collaboration on ISMPs occurs between municipalities when watersheds cross boundaries.

Interviews with local government staff provided insight into the common barriers and challenges experienced by communities when addressing stormwater management (see Appendix A for the list of interview questions). The main challenges are summarized in Table 4 below.

Table 4. Summary of barriers to effective stormwater management

Type of Barrier	Identified Barrier
Funding	• Lack of funding for infrastructure implementation, operation, and maintenance. • Oversubscribed grants.
Political and Policy	• Competing priorities between housing demand and stormwater management. • More support and regulatory drivers from senior levels of government to manage issues such as water quality. • Need for stronger policies and enforcement of documents such as ISMPs. • Implementing source controls on private property.
Organization and Capacity	• Limited by local government staff and resource capacity. • Collaboration across disciplines and standardization of practices.
Knowledge and Education	• Increasing community engagement. • Climate change uncertainty.

The following bullet points aim to provide more detail on the aforementioned barriers to effective stormwater management.

- **Lack of funding:** Stormwater management and drainage are often funded through general tax or shared utility charges, both of which also support other projects such as community recreation. The absence of dedicated stormwater funding creates budget constraints for infrastructure implementation, operations, and maintenance. This includes funding to establish water quality management programs and community education products. In older cities with combined sewers, most capital funding dedicated to stormwater is consumed by

separation costs. Furthermore, grants are often oversubscribed, adding to funding challenges.

- **Competing priorities with urban densification and rapid development:** Federal and [Provincial pressures to densify urban spaces](#) and meet housing demands can conflict with the need to manage impervious surfaces and increase rainwater infiltration, especially in built-out cities where space is considered a luxury. Specifically, the National Building Code, which calls for a 5-metre setback, and the Provincial 3-metre setback requirement create challenges when attempting to manage rainwater where it falls. While ISMPs are designed with the intent to balance development with environmental considerations, housing policies often take precedence over stormwater management needs.
- **Staff capacity:** Local governments often face limitations in staff availability. This includes operation crews managing street and grey infrastructure maintenance, a lack of a team directly overseeing environment and climate change needs, and instances where flooding and drainage responsibilities fall on a single individual.
- **Implementing source controls on private property:** Local governments have been able to enact community source controls and rely on bylaws to enforce citizen management of stormwater. However, there has been hesitation to impose additional requirements for rainwater management source controls on private property when the cost to develop is already so great.
- **Support and regulatory drivers from senior levels of government:** Although guidance is provided to municipalities, the responsibility to enact stormwater management rests upon the individual municipality. This becomes complex with regional issues such as standardizing GI practices, creating water quality guidelines for cross-jurisdictional receiving water bodies, and addressing interdisciplinary concerns such as 6PPD-Q. Therefore, local municipalities look towards senior levels of government to implement guidance on such topics. A unified master municipal contract for standardized GI could help reduce the cost of GI implementation through contractors by enforcing consistency of implementation across the region. In addition, cost-effective solutions and management practices need to be highlighted.
- **Collaboration between disciplines:** Stormwater management involves multiple sectors, including engineering, city planning, operations and utilities, parks, and the environment. Education and training of all staff when implementing relatively new data and practices into policies and procedures can prove challenging. Problems conceptualizing or defining GI can make it hard to collaborate across departments and communicate the benefits of GI beyond stormwater management. The standardization of BMPs could improve coordination across sectors.
- **Community engagement:** There is a need for more educational products surrounding the impact of stormwater, watershed connectivity, the importance of natural systems, and

homeowner practices to reduce their impact. Increased community engagement through education could build support for stormwater practices, potentially facilitating the implementation of a stormwater and drainage levy tax or influencing political will for additional funding and bylaw creation. The need to share knowledge and gain acceptance from the public also hinders the implementation of GI.

- **Need for stronger policies and enforcement of documents:** Many municipalities have invested in the creation of an ISMP, which is relied upon for guidance in new development and redevelopment. However, the ISMP on its own does not carry much weight, and the integration of ISMP recommendations into policies and community plans remains low due to the perception of it being an “engineering” tool rather than integral to planning. This is especially true with British Columbia’s new housing and home legislation, raising questions about its implications for stormwater management.
- **Climate change uncertainty:** Increased extreme weather events due to climate change creates uncertainty surrounding the capacity of infrastructure to effectively handle higher water volumes. Long-term watershed health planning is challenging as new climate data consistently emerges. ISMPs must incorporate flexibility to adapt to evolving assumptions and data, which is an obstacle on its own.

Exploring Solutions

This section focuses on solutions that local governments can implement to increase the implementation of GI and overcome the challenge of funding for operation and maintenance. We also suggest policy changes that would create more support for environmental management. These recommendations are informed by literature reviews, examples from surrounding regions, as well as statements by interviewed Metro Vancouver municipality staff.

1. Shift stormwater management from being the sole responsibility of the individual municipality to a collaborative watershed approach.

Larger bodies of water, such as the Fraser River, span multiple municipalities, leading these jurisdictions to seek guidance from the regional governing body of Metro Vancouver on stormwater management. However, there is currently a lack of regulatory guidance concerning the water quality of receiving water bodies. Establishing regional basin-specific water quality objectives would offer municipalities clear direction on this common goal, as well as create an incentive to track stormwater water quality and require data-sharing. The establishment of region-specific water quality guidelines may initiate the establishment of an end-of-pipe monitoring program for stormwater outfalls. The Capital Regional District (CRD) has established a [Marine Monitoring Program](#) that collects and analyzes samples from storm drain pipes, creeks, harbours, and nearshore marine environments at over 500 locations to identify sources of contamination and direct clean-up efforts, infrastructure upgrades, and restoration activities.

An example of systematically regulated stormwater management can be seen in the US, where the federal CWA has been in place since the 1980s. Through this act, a public entity in an urban area that owns a stormwater system separate from the sewer system must apply to the US Environmental Protection Agency (EPA) to release stormwater into US waters. Stormwater systems must have a detailed stormwater management program and meet water quality standards for both stormwater systems and combined sewer systems. This is partially done through the development of total maximum daily pollutant loads, or surface water quality monitoring (EPA 2024b).

2. Establish a stormwater utility charge on property owners in the municipality.

Stormwater utilities are specialized public utilities responsible for managing and treating stormwater runoff, which are often funded through user fees. Their primary focus is on preventing pollution from entering natural water bodies like rivers, lakes, and oceans, which is particularly critical in urban areas. Stormwater utility charges create a long-term opportunity for municipalities. The utility can be used to finance and support:

- Maintenance and necessary stormwater infrastructure upgrades.
- Water quality monitoring and testing.
- Aggressive source control programs to prevent pollutants from entering stormwater systems.
 - This includes public education, stricter regulations on industries, and retrofitting urban areas with pollution control devices like oil/water separators in parking lots.
- Partnerships with industry and local communities to ensure coordinated efforts. See the Kitsap County [Pollution Identification and Correction \(PIC\)](#) program for an example.
- Implementation of comprehensive GI programs, including bioswales, rain gardens, and permeable pavements.

GI implementation programs work best with long-term funding commitments to support maintenance, research, and incremental system expansion (Mead-Fox 2022). The charge is often based on the “polluter pays” principle, where the impact the property has on the storm sewer system influences the fee, an example being the percentage of impervious surface area. Stormwater utilities can leverage federal, provincial, and regional grants to support large-scale infrastructure projects. Involving industries in involuntary cleanup for stormwater management programs can also alleviate the burden of public funding. To see key successes in the Puget Sound region, and how stormwater utilities have played a vital role in protecting water quality, recovering the shellfish industry, and improving marine ecosystems, see Appendix C.

CASE STUDY: [Rainwater Utility Charge in the City of Victoria, BC](#)

Victoria implemented a Stormwater Utility charge program in 2016. The program determines the charge based upon four factors: (1) The property’s impervious area; (2) the street type and length of the property’s street frontage (to account for street cleaning costs); (3) an intensity code (denotes the impact of the property on rainwater management system and is determined by the [BC Assessment based on property type](#)); and (4) whether

a property must have a code of practice (or a program that cleans stormwater prior to leaving their property) (Nadji 2018).

Built into the Rainwater Utility charge program is the [Rainwater Rewards Program](#), which awards rebates and credits for sustainable rainwater management practices on one's property. Credits can be applied to the Rainwater Utility bill, and rebates are available for GI installation, such as permeable sidewalks and plantings.

3. Standardize common practices including Green Stormwater Infrastructure.

Smaller municipalities often lack the resources or capacity to develop standards or data-monitoring programs independently and rely on the products produced by the region or larger municipalities. The standardization of GI in a similar fashion can help reduce the cost of GI implementation by familiarizing consultants and contractors with common guidelines, rather than varying standards imposed by different municipalities. This will mimic the Master and Municipal Contract Documents (MMCD), which provide the framework and foundation for municipal infrastructure projects for sanitary and water systems ([MMCD 2019](#)). It will also decrease the burden on public and private sector professionals of designing, reviewing, and approving unique GI systems. Financial and resource requirements can be built into the standards, such as Burnaby's Town Centre Standards, to create a budget for maintaining implemented GI ([Burnaby 2020](#)).

Greater Vancouver Municipalities have currently taken on the initiative to promote regional cooperation on GI standards, and established the Green Rainwater Infrastructure Municipal Exchange (GRIME) in 2021 (Mead-Fox 2022). This developed into an active community of GI practitioners in the region to facilitate discussions between municipalities about GI implementation challenges and successes. This was later expanded into a [Community of Practice through the BC Water and Wastewater Association](#) to hold bi-monthly meetings with non-municipal stakeholders and experts (Mead-Fox 2022).

4. Increase public engagement and outreach by collaborating with stewardship and community groups, developers, homeowners, and educational institutions.

Effective public outreach can provide municipalities with cost-saving opportunities. Citizens who are supportive and engaged can help municipalities with maintenance and monitoring programs. This begins with educating the public about the impact of stormwater and the benefits of GI systems, through initiatives such as demonstration sites and educational signage. GI systems are more accessible, visible, and visually appealing than traditional stormwater infrastructure. Engaging public participation and outreach can expand support for GI systems while reducing the likelihood of negative political pressure against GI expansion. The Pacific Salmon Foundation, through the [Resilient Coasts for Salmon project](#), has created resources on the benefits of nature-based solutions, which [can be viewed here](#). The City of Detroit has established a "[friendly fence](#)" initiative to create a pathway for homeowners to build their own basement rain gardens. Municipalities can also benefit

from collaboration with academic institutions that can offer support in a variety of ways, including conducting GI performance tests, studies, and providing technical data needed to inform local GI systems.

Successful examples of public engagement done in the Metro Vancouver region include the [rain garden program implemented in Delta](#) which partners with schools to bypass funding hurdles, and has established rain gardens and a curriculum to educate the younger generation about the importance of watershed protection. Through this program, Delta has over 40 rain gardens throughout the city. Metro Vancouver also provides watershed in-class programs facilitated by a watershed educator, schools can register for [this resource here](#).

The District of North Vancouver relies heavily on partnerships with streamkeeper groups to monitor stream health and collect data. To see a list of streamkeepers and other stewardship groups within Metro Vancouver, see Appendix D. BCWF offers [Fish Habitat Restoration and Education](#) workshops and initiatives to raise awareness of the importance of conserving freshwater fish and riparian habitats across BC through community engagement. A third party certification program, titled Salmon-Safe, is delivered by the Fraser Basin Council that encourages and certifies urban and agricultural sites committed to supporting ecosystem health through stormwater management, water use management, erosion and sediment control, water quality protection and enhancement of ecological function course through the adherence to [Salmon-Safe Standards, which can be viewed here](#).

5. Reform policies and legislation of all governments in the region to ensure implementation of green infrastructure across the landscape as well as ongoing maintenance.

The Green Infrastructure Guide, published in 2007 by West Coast Environmental Law, provides guidance on how local governments can use legal and policy strategies to encourage or require more sustainable infrastructure designs to soften the footprint of development ([Rutherford 2007](#)). It highlights case studies of local governments, and focuses on the implementation mechanisms, issues and barriers, and on what lessons have been learned from experiences to date.

Legal and policy tools suggested in the guide to seed greener approaches include:

- Establish a subdivision servicing bylaw that prescribes specific technology or performance standards to ensure the usage of low-impact development that mimics natural systems.
- Use development permit areas that stipulate and protect the natural environment, requiring development to acquire a permit and follow specific guidelines to build on the identified land.
- Regulatory bylaws: green infrastructure requirements in zoning, landscaping, runoff and sediment control, parking, and comprehensive rainwater management bylaws.
- Use of development cost charges to support neighborhood level management.
- Stormwater management policy.
- Pilot and demonstration projects of GI.

- Require civic and private development to monitor GI performance based on stipulated performance standards.

To read more on how to reduce stormwater costs through low-impact development strategies and practices, refer to the *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices* report created by the EPA. It outlines a cost comparison of GI projects across the US ([EPA 2007](#)).

6. Educate and collaborate with other departments of the city.

Due to the lack of space in a city, as well as the high cost of development, it is imperative that collaboration across all disciplines occurs to increase the implementation of GI. Combining GI with planned infrastructure improvements such as road reconstruction, utility restoration or roof replacements will lower the cost of implementation. Standardizing these practices will lessen the confusion of how to maintain the infrastructure, and also create clear roles and responsibilities for continued care.

Population growth can be seen as an opportunity for innovation, where funding for greener infrastructure can come from development. Existing landscapes can be made to be multifunctional, such as incorporating infiltration into corner bulges used for traffic safety (R. Lukes, personal communication, June 19, 2024)

The City Parks Alliance in the USA is an independent, nationwide membership organization solely dedicated to urban parks. In 2023, they [launched an initiative to help parks and water practitioners collaborate](#) on green stormwater infrastructure in park systems. This was meant to highlight successful examples of GI projects in urban parklands and multi-benefit projects. To read more examples see: *Designing Parks and Playgrounds as Green Infrastructure for Stormwater and Climate Resilience* ([Metropolitan Area Planning Council 2018](#)).

7. Ensure source controls on private property.

Residential areas are often not impacted by the community source controls implemented in urban areas, and due to the smaller size of development, it is uncommon for rainwater management on these properties to be required. This poses an issue as private property still represents a large portion of runoff. The City of North Vancouver has provided [a list of recommended stormwater tools](#) for residents to install source controls to capture and infiltrate on private property. In addition, Metro Vancouver has created a *Homeowner's Guide to Stormwater Management*, which details easy to implement GI for private landowners, as well as maintenance recommendations ([Metro Vancouver](#)).

More information on the minimum acceptable on-site stormwater practices for single-family residential lots can be seen in *Region-Wide Baseline for On-Site Stormwater Management* ([Metro Vancouver 2017](#)). It includes guidelines for the implementation of the baseline for municipalities, cost implications, and typical design drawings for BMPs. This tool is to assist municipalities in enacting stormwater management to mitigate the often-seen increase of impervious surface area for new and/or redevelopment of existing zoning of single-family residential lots.

8. Increase low-hanging fruit practices such as street sweeping.

In most urban areas, street sweeping is traditionally seen as an aesthetic practice aimed at removing trash, built-up sediment, and large debris that also mitigates potential flooding hazards and drainage blockages. However, it is increasingly recognized for its role in reducing stormwater pollutant loads. Impervious surfaces such as streets, roads, highways, and parking lots accumulate pollutants. Street sweeping can minimize these pollutants entering waterways, and remove up to 90% of pollutants, including copper, zinc, and petroleum hydrocarbons (e.g., motor oil) from roadways (NOAA 2016). An effective street sweeping program for municipalities requires collaboration across municipal environmental and operations teams, as well as third-party contractors hired to complete the work. Several considerations are:

- **Scheduling:** A successful program should be flexible to accommodate climate conditions and areas of concern. Factors such as traffic volume, land-use, sediment accumulation, and proximity to surface waters all impact how often an impervious area should be swept. The schedule should account for seasonal changes, such as the “first flush” of a rainstorm after a dry period when higher concentrations of pollutants will enter storm systems. Removal of sand, grit, and salts from roads after snow melts will also reduce the volume of pollutants mobilized in subsequent storms.
- **Street Sweeping Storage:** Collected materials from street sweeping contain pollutants and should be tested by the municipality before disposal or reuse to ensure proper handling and environmental protection. These remains must be properly disposed of through the correct treatment plants, or the efforts for pollution mitigation via street sweeping will be negated. It has been anecdotally reported that street sweeping waste has been disposed of into storm drains, which directly introduces high concentrations of pollutants into sensitive water bodies.
- **Street Sweeper Type:** Mechanical sweepers may not effectively remove finer particles and target pollutants (EPA 2016). In contrast, vacuum and regenerative air sweepers are generally more effective.

Practices such as street sweeping can be combined with supplementary GI to collect draining water off of impervious surfaces. High usage areas, such as parking lots, can be retrofitted with rain gardens and infiltration trenches to add another layer of stormwater pollution protection.



CONCLUSION AND SUMMARY OF RECOMMENDATIONS

Metro Vancouver and its municipalities are clearly committed to protecting the ecological integrity of aquatic and riparian habitats when implementing stormwater management and balancing the demands of urban growth and densification. Addressing the above barriers is not simple. Impact mitigation amidst the rapid pace of development poses real challenges. The interviews indicated that the optimal stormwater management approach would involve treating all stormwater with detention and gradual release to mimic natural hydrology and decrease the impacts to aquatic systems. However, achieving this would require dismantling much of the existing stormwater infrastructure and fundamentally rethinking land use and urban planning. Nonetheless, municipalities have focused on making continuous improvements in stormwater management during development to protect and improve riparian and instream habitat where possible through measures such as new technology, in-stream real-time monitoring units, and expanding water quality programs. Effective management requires a collaborative effort among all levels of government, industry, the private sector, the community, and across municipalities. Existing policies, including calls for housing densification, are sometimes in contradiction with practices that would benefit the management of rainwater. These policies must also be updated to account for climate change resilience, particularly when safeguarding sensitive habitats. An example of such a policy is the Provincial Level Riparian Protection Regulation. To address the challenges municipalities face, this paper's key recommendations are summarized in the following table.

Table 5. Summary of key recommendations.

Key Recommendation	Summarized Areas of Impact
Shift stormwater management from being the sole responsibility of the individual municipality to a collaborative watershed approach.	• Establish regional-specific stormwater water quality guidelines for receiving water bodies. • Create an end-of-pipe monitoring program.
Consider a stormwater utility charge on property owners in the municipality.	• Create long-term funding opportunities for municipalities to finance and support: ◦ Maintenance and infrastructure upgrades ◦ Water quality monitoring and testing ◦ Comprehensive GI programs ◦ Source control programs, including public education, stricter regulations on industry, retrofitting urban areas with pollution control devices
Standardize common practices including Green Stormwater Infrastructure.	• Creation of common GI guidelines to decrease the cost of contractors. • Decrease the burden on private and public sectors to design, review, and approve GI systems. • Build in budgets for maintaining GI.
Increase public engagement and outreach by collaborating with stewardship and community groups, developers, homeowners, and educational institutions.	• Engage citizens in maintenance and monitoring programs. • Increase education and awareness of stormwater impacts with younger generations and homeowners. • Increase data collection and sharing.
Reform policies and legislation of all governments in the region to ensure implementation of GI across the landscape as well as ongoing maintenance.	• Establish guidelines and performance requirements that increase low-impact development. • Use performance and demonstration sites to enhance public engagement and support for GI.
Educate and collaborate with other departments of the city.	• Partnerships with parks, community development, and transportation to increase space and the implementation of GI. • Parks and operation teams can aid in GI maintenance.
Ensure source controls on private property.	• Zoning can impose stormwater requirements on private properties and developments (See Burnaby SSMUH zoning district).
Increase low-hanging fruit practices such as street sweeping.	• Upscaling street sweeping and ensuring correct disposal can reduce the pollutant loads entering stormwater drains.

PSF TOOLS AND RESOURCES

The Pacific Salmon Foundation is dedicated to supporting all ventures that protect aquatic and riparian habitats. Here is a list of PSF resources that can support local communities:

- **Marine Data Centre**
 - [Marine Ecosystem Map](#) – an interactive map that visualizes more than 400 layers of data of BC's marine ecosystem.
 - [Contaminants Atlas](#) – a central metadata record of georeferenced environmental samples taken for contamination analysis throughout the Salish Sea to facilitate access to data. It includes contaminants from stormwater, municipal wastewater systems, and industrial and mining sources.
- **Resilient Coasts for Salmon**
 - [Tool Kit](#) – how-to guides on various topics such as nature-based solutions, stormwater runoff solutions, and eco-friendly gardens that enable individuals to reduce their environmental impact. Specific guides on stormwater runoff solutions include:
 - [Building a rain garden](#)
 - [Installing permeable pavers](#)
 - [Harvesting rainwater](#)
 - [A map that directs you to a variety of local NGOs and stewardship groups in the Lower Mainland and Vancouver Island](#). A comprehensive table of Metro Vancouver streamkeeper groups is also included in Appendix D.
- **[Community Salmon Program](#)**
 - Provides grants to streamkeepers, First Nations, schools, and conservation organizations across the province for projects hoping to save and restore Pacific salmon and their habitats.
- **Efforts to mitigate 6PPD-Q**
 - [Co-signed a letter to Climate Change Canada](#) calling for a deeper investigation into the ecological impact of 6PPD-Q.
 - Co-hosted the [first 6PPD-Q conference at Vancouver Island University \(VIU\) in April 2024](#) and a second meeting in 2025, bringing together experts to discuss and mitigate the growing concerns surrounding this contaminant.

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APPENDIX A – INTERVIEW QUESTIONS

Stormwater Management

1. Best Management Practices:

- What Best Management Practices are currently being implemented for stormwater management?
- Are there any recent or planned changes to enhance stormwater management? *(e.g. highlight updates to the municipality's ISMP)*

2. Source Control Program:

- Is there an active source control program in place for managing pollutants entering the storm sewer system? *(e.g. absorbent landscapes, rain gardens)*

3. Street Cleaning and Maintenance:

- How often do you perform street sweeping and cleaning?
- Are catchment basins, both private and public, regularly vacuumed and maintained?

4. Resources and Education:

- Are you developing any resources related to stormwater pollution, management, and impact? *(e.g. public educational materials/ programs, stormwater data/ modeling, infrastructure maps)*
- How do you engage with the community surrounding stormwater management? *(e.g. community meeting platforms, incentive programs for green infrastructure such as pervious pavements)*

Inspection, Reporting, and Improvement

5. Inspection and Reporting:

- What is the frequency and methodology of inspections for storm sewer systems? *(e.g. methods used to perform end-of-pipe sampling, and to test materials collected from storm sewers and catchment basins)*
- How is the data from these inspections reported and utilized?

6. Inter-Agency Collaboration

- Is there collaboration with other agencies, municipalities, or universities regarding managing stormwater and/or collecting data? *(examples of successful projects)*

7. Challenges and Barriers:

- What are your main challenges when addressing stormwater concerns and implementing best management practices?
- What information or resources are needed to move past these barriers and support greener stormwater management?

APPENDIX B – SUMMARY TABLES OF ALL STORMWATER PRACTICES IMPLEMENTED BY PARTICIPATING MUNICIPALITIES

The City of Vancouver

Current Stormwater Management Goals and Highlights	Through the <i>Rain City Strategy</i>, the goal is to manage 48mm rainfall per day, or 90% of generated runoff, with a removal of 80% of total suspended solids (TSS). By 2050, 40% of impervious surface areas will be treated with green infrastructure. Eventually, the hope is to restore the waters of Still Creek, Fraser River, and Burrard Inlet. The City has a large in-house stormwater management team of 25 people that are focused on the management of runoff in public spaces, as well as collaborating with parks. This large team enables in-house design detailing, construction and maintenance. Stormwater Management Focuses On: • Reducing the volume of stormwater entering the sewer system • Treating, holding, and encouraging infiltration via green infrastructure • Focused on the management of the volume of stormwater	
	Current Practices	Main Challenges and Barriers
Source Control Bylaws and Policies	• Sewer and Watercourse Bylaw 8093 – “No person shall cause or permit contaminated water or wastewater to be discharged into a storm sewer” • Erosion and Sediment Control Bylaw for the development of Small Lots and Big Lots	• Response to pollution spills is a reactive process based on immediate visual or telling environmental cues.
Stormwater Management Documents and Data Modelling	• ISMP Part 1, Part 2 • Still Creek ISMP: From pipe dreams to healthy streams • Rain City Strategy: A green rainwater infrastructure and rainwater management initiative • Healthy Waters Plan (2025) • VanCity Maps: Green Infrastructure • Biannual green infrastructure performance monitoring reports • Green Infrastructure Design Manual	
Implemented Green	At the time of the interview, Vancouver had over 360 green assets. Assets include,	• The National Building Code of Canada (2015) requires a 5 meter

Infrastructure	but are not limited to: • Bioretention – corner bulges • Subsurface infiltration – infiltration trenches and chambers • Permeable pavements • Rainwater tree trenches • Absorbent landscaping • Treatment Manholes	offset from all buildings and foundations from any infiltration. This hinders the implementation of green infrastructure, which is based on encouraging infiltration, especially in a built-out city where space is limited.
Monitoring and Management Program	Green Infrastructure • Performance monitoring completed for GI assets through drainage and water level loggers, occasional spot water quality testing done. • Operation and maintenance program continues for 3-4 years after initial installation. • Subsurface devices such as tree and infiltration trenches are cleaned out based on locations known for high sediment loading. Grey Infrastructure • The target is to vacuum all catchment basins annually for high priority arterial locations. • Other locations completed on a drainage complaint basis. • Storm sewer system inspected via CCTV scans and flushing when necessary. Pollution and Water Quality • Immediate spill response and clean up. • Five grab samples are done at randomized outfall locations throughout the year based on AMF parameters. • No current water quality objectives for stormwater in receiving water bodies (see Healthy Waters Plan).	• Regular maintenance of assets, specifically grey infrastructure such as catch basins distribution pipes, and sumps, constrained by funding and crew availability. • Green Infrastructure assets are fairly young, still establishing maintenance schedules. • Water quality guidelines created by Metro Vancouver and other senior levels of government. The focus has been placed on smaller streams, therefore creating a lack of regulatory drivers needed to enact stronger emphasis on protecting and testing water quality in waterways such as the Fraser.

	Automated-flow samples for monitoring industrial stations.	
Street Cleaning and Maintenance	- Arterial streets done daily-weekly - All streets done on an annual basis during leaf litter pick up	Constrained by crew availability
Community Engagement and Educational Products	Adopt-a-catch basin Green Streets Program - Informational signage around pilot projects VanMap holds all stormwater infrastructure mapped . - Collaborate with the University of British Columbia and Streamkeeper societies. - Attend community events to discuss neighborhood projects and green infrastructure project case studies in the area.	Need more educational products surrounding the impacts of stormwater pollution

The City of Burnaby

Current Stormwater Management Goals	Burnaby has preserved the ecological value of the city by protecting a network of more than 90 streams. This was done through an open water course policy implemented in the 1970s that prohibits the fouling, obstructing or impeding any creek, stream, waterway, watercourse, ditch, drain, or sewer. This has enabled the City to maintain more natural infiltration spaces, such as ditches, for stormwater. In order to maintain the health of the surrounding water courses, Burnaby: • Encourages green infrastructure implementation on public and private side. • Implemented bylaw to require construction sites to have an erosion and sediment control plan, where third party monitoring valves will recirculate the water back to treatment system if water quality standards are not met. • Installed real-time data monitoring devices at construction sites and several stormwater outfall locations that measure temperature, pH, conductivity, and turbidity.	
	Current Practices	Main Challenges and Barriers
Source Control Bylaws and Policies	• Watercourse Bylaw 1988 (9044) – prohibits fouling or obstruction of waterways • Streamside Protection and Enhancement Areas Bylaw – developments must be located outside of SPEA • Total Stormwater Approach Policy – required on-site retention, infiltration and treatment of stormwater for new development and redevelopment • Sediment and Erosion Control Plan must be submitted by developers; standards found with engineering design criteria • SSMUH Zoning Bylaw Amendment – consolidated all single-and two-family areas into one RI small-scale and multi-unit housing district (SMUH). Allows the City to require stormwater management for all family lots	• Although Bylaws protect the natural waterways of Burnaby, it is hard to justify keeping ditches in heavily urbanized areas where space is already at a premium.
Stormwater Management Documents and Data	• Stoney Creek ISMP • Brunette Basin ISMP	• Need to update detention requirements due to climate

Modelling	• Still Creek ISMP • Landscaping for New Single and Two Family Dwellings – guide to encourage rainwater infiltration as a minimum 30% of lot must be soft landscaping • Town Centre Standards for the Four Town Centres – establishment of a rainwater management strategy for the Town Centres; including treatment of 90% of runoff of annual rain events. • Waterway Open Data Map	change and the experience of more intense rainfall.
Implemented Green Infrastructure	Town Centre Standards for the Four Town Centres – Brentwood, Metrotown, Lougheed, Edmonds • Rain gardens – linear rain gardens to treat street, multi-use path or sidewalk • Corner bulges	• Trying to develop a community source control program to implement citywide boulevard rain gardens. • Hard to collaborate with other sectors of the City, which have their own agendas.
Monitoring and Management Program	Green Infrastructure • Pilot monitoring programs for soil moisture and rainfall gauges. • Track rainfall and correlate with storms to determine if an overflow should or should not have occurred. Grey Infrastructure • Scheduled maintenance – Hydrovacating of sumps, CCTV scans • Catch basins cleaned on a complaint/issue basis Pollution and Water Quality • Require construction sites to have erosion sediment control plans. This includes third party monitoring with shutoff valves to reroute poor quality water to ensure no illegal discharges. • AMF five-year monitoring cycle to track watershed health with grab samples • Implemented own water quality monitoring system using	• Funding and resource availability. They are a small team, therefore need to work collaboratively with Planning, Building, Transportation, and Parks.

	multiparameter sondes with real time data every 5 minutes. Placed at outfall locations, as well as downstream to understand dilution effects. Goal is to place at least one quality monitor in every creek. • Implemented flow and temperature measurements as stand ins where multi-parameter water quality stations cannot be implemented.	
Street Cleaning and Maintenance	• Scheduled maintenance – at least once a year for major arterial roadways. Try to sweep in the spring before the first flush.	• Restrained by capacity and crew availability
Community Engagement and Educational Products	• Civic Innovation Lab – collaboration with Simon Fraser University where the City of Burnaby becomes the “lab” for students	• Drainage, including educational products, are funded through general tax revenue. Competing with funding for community aspects such as recreation centers, pools, etc.

The City of New Westminster

Current Stormwater Management Goals	The City aims to separate sewers by 2075 to eliminate combined sewer overflows from entering the Fraser River, as is mandated by the Integrated Liquid Waste and Resource Management Plan (ILWRMP). Long term goals are to address the water quality of stormwater at the source prior to entering water bodies. This will be achieved through more green infrastructure projects, relying on gray infrastructure as a secondary method. Currently, the City's subdivision design and control bylaw captures climate change pre-existing conditions from developments by requiring the management of runoff. The new development must not add more to the system than what was previously seen, i.e. the runoff volume generated from a new development during a 10 year, two hour storm must not be more than the volume generated during a 10 year, two hour storm of the pre development.	
	Current Practices	Main Challenges and Barriers
Source Control Bylaws and Policies	• Sewer and Drainage Regulation Bylaw 7746 • Erosion and Sediment Control Bylaw 7754 • City of New Westminster Design Criteria	
Stormwater Management Documents and Data Modelling	• New Westminster ISMP Volume I and II • Model catchment basins, sewers, outfalls,	• City would like to have their own in-house modeling data to be able to do sanity checks on the Developer/Consultants proposed infrastructure upgrades/designs
Implemented Green Infrastructure	• 3 major rain gardens: ○ Queen's Park ○ City Hall ○ 5th St and 8th Ave	• City is very old and therefore competing with real estate in and above the ground for space. • Competing for capital funding. Separation of combined sewers takes precedence. • No standard of design for BMPs. Engineered GI versus infrastructure in Parks have an implementation discrepancy.
Monitoring and Management Program	Green Infrastructure • No monitoring of green infrastructure, current effort has been on	• Internal resources for maintenance is a struggle, very limited in staff

	implementation not performance. Grey Infrastructure - Public catch basins cleaned on a complaint style basis. - Storm sewers are inspected via CCTV on a 10 year-zone basis. Generally good due to newer utilities. Pollution and Water Quality - Monitoring has been done on a reactive basis	- Staff capacity - Maintenance and operation of new assets; unclear who will maintain the new GI features; restrained by time and knowledge of maintenance as unfamiliar with this infrastructure.
Street Cleaning and Maintenance	The City regularly performs street cleaning. The City is broken up into 4 zones, with street cleaning within each zone done weekly. The aim is to have each street cleaned at least once per month.	Staff capacity
Community Engagement and Educational Products	- Rely on Metro Vancouver and larger cities such as Vancouver and the stormwater resource and control guidelines they produce. - Some educational signage around GI Adopt-a-catch basin Rain barrel program	- Staff capacity - Lack of funding - Lack of resources

The City of Coquitlam

Current Stormwater Management Goals	The City aims to create an Integrated Watershed Management Plan (IWMP) for every watershed to be used as the key document to measure stormwater management performance. The City is split into two sections, in the south everything is mostly developed. There is not a lot of space, and therefore rely on new or re-developments to implement engineered GI in an opportunistic fashion. In the north, there is more natural area and so development has focused on retaining areas for retention ponds, wetlands, etc. The City has multiple teams dedicated to ensuring the safety of watershed health, including an environment team and water engineers. The ultimate goal is watershed health. This is done through monitoring adaptations, maintenance of assets and monitoring resilience of ecosystems in the face of climate change.	
	Current Practices	Main Challenges and Barriers
Source Control Bylaws and Policies	• Stream and Drainage Systems Protection Bylaw – new update in June 2024 required real-time monitoring for all large development sites throughout the entire City • Erosion and Sediment Control Bylaw	• Rapid pace of development and land use changes • Climate change uncertainty
Stormwater Management Documents and Data Modelling	• IWMPs for all watersheds • Data-sharing agreement with City of Coquitlam, City of Burnaby, Stoney Creek Environment Committee, other non-profit organizations for the monthly real-time creek monitors • City has own engineering standardized details available for developers during construction • Environmental Sustainability Plan	• IWMPs are comprehensive, but recommendations do not always get incorporated at the policy or into land use plans in a concrete way.
Implemented Green Infrastructure	• New stormwater treatment facility installed at Stoney Creek Summer 2024 • GI source control projects include: ○ Boulevard retention trench ○ Boulevard land basin with retention trench ○ Curb bulge rain garden ○ Permeable pavement ○ Green lane	• Resources (funding and staffing)

Monitoring and Management Program	Green Infrastructure • Infrastructure fairly new, no established monitoring program Grey Infrastructure • Catch basins schedule maintenance every 3 years; prioritized on a complaint style basis • Intakes and outfalls once every year; prioritized on a complaint style basis Pollution and Water Quality • Use AMF to monitor changes every 5 years in order to ensure IWMPs are working • Need to update IWMP as new climate news emerges; planned updates for current ISMPs coming in 2025 and 2026	• Competing priorities (e.g. housing targets vs. environmental goals)
Street Cleaning and Maintenance	• Active development sites required to complete daily site street sweeping • Scheduled maintenance where highways and arterial roads done at least monthly, every other road at least once a year	• Staff and resource capacity
Community Engagement and Educational Products	• Environmental education team has held numerous campaigns and created educational material • Coquitlam water balance tool • Rain Barrel Program • Adopt-a-catch basin program • Attend meetings with Streamkeepers and Neighborhood Associations ◦ Hoy/Scott Watershed Society ◦ Stoney Creek Environmental Working Group ◦ Oakdale Neighborhood Association • Coquitlam River Watershed Roundtable • Sustainability Environmental Advisory Committee • “Only rain down the drain” door hanger	• Need for more public engagement education in order to inform on the impacts.

The City of Delta

Current Stormwater Management Goals	The City's immediate priority is to minimize the volume of stormwater conveyance off of impervious surfaces that enter piping infrastructure. Practices such as increasing natural filtration, tracking how much runoff leaves property, and installing GI are all methods to decrease runoff volumes. The approaches for infiltration differ between highlands which are able to handle infiltrated water, versus the lowlands which have a high water table. Delta also is trying to rehabilitate salmon-bearing creeks throughout the city. The City has a very collaborative approach to stormwater management and environmental protection, with the utilities team, solid waste team, climate action and environment department all working together for events, education, and implementing projects.	
	Current Practices	Main Challenges and Barriers
Source Control Bylaws and Policies	• Pre/post development runoff control encouraged through GI such as bioswales, rain gardens, etc.	• Enforcement of source controls is difficult, no set bylaw. City relies on ISMP for guidance
Stormwater Management Documents and Data Modelling	• Mapped locations of rain gardens • Green infrastructure standards created by Delta	
Implemented Green Infrastructure	• Large rain garden program established in North Delta (highlands) • Curb cuts	• Need for unified master municipal contract for standardized green infrastructure to lower cost of implementing GI by contractors
Monitoring and Management Program	Green Infrastructure • Performance monitoring program for rain gardens twice in a year (wet and dry) by own gardeners. Focus placed on soil replacement and replanting when pollution loads get high. • Volunteer rain gardens typically attached to a school, education material is provided for the upkeep of those assets. • Assisted by local stream keeper groups. Grey Infrastructure • Flush critical catchments every couple years. Lowlands where the grade in	• Need supporting bylaws and regulations from directing city. • Need consistency with permitting by senior levels of government across all branches. • Need to standardize resources and create more funding opportunities.

	pipes is low are inspected regularly. • CCTV storm sewers as needed. Pollution and Water Quality • Environmental team can request end-of-pipe sampling. • AMF five year monitoring cycle to track watershed health with grab samples. • Rely on a reactive basis for spills.	
Street Cleaning and Maintenance	• Street sweeping program • Use of vacuum truck during the cold months when high loads of salts are on roads	
Community Engagement and Educational Products	• Rain garden program with schools • Adopt-a-rain garden • Partner with stream keepers, elementary schools • Defer to Metro Vancouver for highlighting homeowner tactics to managing stormwater. • Educational signage created for rain garden sites. • Host free sustainability workshops to inform residents on gardening techniques, etc. • Subsidized rain barrel program • Adopt a street program, including cleaning of catch basins • Delta Living Dike project	

The City of White Rock

Current Stormwater Management Goals	The City's main concern with stormwater management is the capacity of their systems and dealing with more extreme weather events. Flood protection is a consideration due to the lower geography of specific parts of the City. White Rock is a small team with no separate environmental department. The engineering & municipal operations department juggles many functions, including stormwater management. Stormwater management is often engulfed into other projects to address council strategic priority. The City works closely with First Nations groups, and has adopted an ISMP.	
	Current Practices	Main Challenges and Barriers
Source Control Bylaws and Policies	• Tree Protection Bylaw 2407 • Official Community Plan – addresses many environmental standards including protection of the ecological integrity of watercourses • Environmental Development Permit Areas required to submit an Erosion and Sediment Control Plan	
Stormwater Management Documents and Data Modelling	• ISMP Part 1, Part 2, Part 3	
Implemented Green Infrastructure	• Upcoming opportunities for green infrastructure due to recently awarded grant • Johnson Road tree cells	• Limited by capacity and funding
Monitoring and Management Program	Green Infrastructure • Rain gardens maintained by parks department. Grey Infrastructure • Flush and clean entire sewer system every five years (20% a year) • Immediate action in annual sewer rehab program if spot repairs come up on CCTV scans. • Catch basins inspected every two years and vacuumed when necessary. Pollution and Water Quality	• Limited by capacity to maintain GI long term. Need a dedicated team for environment and sustainability and/or stormwater and drainage

	• AMF as dictated by Metro Vancouver • Friends of Semiahmoo Bay complete their own testing	
Street Cleaning and Maintenance	• Street sweeping and cleaning done daily. • Side streets swept every once or two weeks.	
Community Engagement and Educational Products		• Rely on the products made by larger municipalities and Metro Vancouver. • Would support a joint municipality outreach. • Need more education and outreach for homeowners.

The District of North Vancouver

Current Stormwater Management Goals	The District of North Vancouver is unique due to the large number of fish bearing, steep streams that ribbon through the municipality. The municipality largely consists of private single family developments, where community based mitigation is difficult due the absence of available space. The District has a long history of partnering with other agencies, including stream keeper groups and post secondary institutions to undertake research on the effects of urbanization on small watersheds. For example current projects include monitoring streams to investigate the highly toxic tire chemical 6PPD-Q and the potential effects of using crumb rubber and other recyclable tire products in artificial turf fields.	
	Current Practices	Main Challenges and Barriers
Source Control Bylaws and Policies	• Environmental Protection and Preservation Bylaw 6515 – regulates the protection and preservation of natural environment including watercourse. • Tree Protection Bylaw 7671 – regulates the preservation of trees, protection of important species, replanting of trees and penalties for unauthorized tree work. • In accordance with Bylaw 6515 and 7671, Sediment and Erosion control is required for all construction projects that involve excavation or soil disturbance. • The Pesticide Use Control Bylaw 7686 controls the use of regulated pesticides and bans cosmetic use of the same. • Sewer Bylaw 6656 prevents the interception, collection and discharge of groundwater into DNV storm sewers to protect streamflow.	
Stormwater Management Documents and Data Modelling	• Have not officially adopted a comprehensive ISMP, however are following intended practices associated with traditional ISMP • Water Balance Model (free online tool) which allows the user to configure and modify a site with various green infrastructure and tree coverage to understand the volume of runoff created	• Due to the high percentage of land with single-family lots, and conflict with private ownership, there has been reluctance to outline additional requirements for rainwater management when the cost to develop is already so great.

	The District has a comprehensive real time streamflow and climate monitoring network.	
Implemented Green Infrastructure	Some wetlands and biofiltration areas	
Monitoring and Management Program	Grey Infrastructure - No scheduled routine maintenance for catch basins. Prioritized specific catch basins that will cause flooding issues Pollution and Water Quality - Community based monitoring network composed of stream keeper groups and community members that notify the District of potential hazards and spills. - Training and outreach in the environmental sector team work with different District departments to ensure everyone is comfortable and knowledgeable with responding to pollution calls – Staff team is trained and certified in Shoreline Cleanup and Methodology (SCAT)	
Street Cleaning and Maintenance	- Main arterial roads swept 10x a year. - Oil and Grit interceptor vaults are installed on many storm outfalls but maintenance is not as frequent as needed. - Built a source separation and disposal system for street sweeping waste.	
Community Engagement and Educational Products	- Established a citizen science creek water quality creek program where interested parties would be trained on a water-quality metering program. Urban Tree Canopy Project – giving free trees to homeowners and shrubs to those in apartments.	Uptake for the science creek water quality program has been slow or nonexistent.

APPENDIX C – SUCCESSFUL STORMWATER UTILITIES IN THE PUGET SOUND

Seattle Public Utilities (SPU) is a model example in the Puget Sound region. They have implemented the Green Stormwater Infrastructure (GSI) program, which uses natural systems to manage stormwater. This has resulted in significant improvements in water quality, benefiting shellfish recovery efforts in the Puget Sound.

Key Successes:

- Use of rain gardens, green roofs, and bioswales to naturally filter and reduce stormwater runoff.
- Extensive public engagement programs encouraging citizens to build rain gardens and other stormwater management systems on their property.
- Partnering with local and tribal governments to ensure clean water for shellfish harvesting areas.

Kitsap County has a dedicated stormwater utility that has helped improve water quality in Dyes Inlet, a key shellfish-growing area. They've also implemented aggressive source control programs and have successfully improved stormwater infrastructure with a focus on reducing pollutants.

Key Successes:

- Dyes Inlet, once closed to shellfish harvesting due to pollution, was reopened in 2011 after significant improvements in water quality.
- The utility uses a combination of stormwater treatment and habitat restoration to reduce the impact of runoff on local water bodies.
- Comprehensive watershed-scale stormwater management plans and targeted source control measures to mitigate pollutants like fecal coliform bacteria.

City of Olympia's stormwater utility focuses on reducing pollutants that affect local shellfish beds and aquatic life. The city's utility fee structure supports continuous water quality testing and improvements to infrastructure, like stormwater treatment facilities.

Key Successes:

- The LOTT Clean Water Alliance, a partnership between Olympia, Lacey, Tumwater, and Thurston County, manages wastewater and stormwater in a way that protects Puget Sound.
- Water quality improvements in Budd Inlet have been directly linked to stormwater management efforts, leading to healthier shellfish beds.

APPENDIX D – STREAM KEEPER AND STEWARDSHIP GROUPS IN METRO VANCOUVER

STEWARDSHIP GROUP	WEB ADDRESS	LOCATION	DESCRIPTION
Burnaby Lake Park Association	https://burnabylakepark.ca	Burnaby/New Westminster	The Burnaby Lake Park Association preserves, restores, and protects the ecological integrity of Burnaby Lake Regional Park.
Byrne Creek Streamkeepers	https://byrnecreekstreamkeepers.wixsite.com/bcss	Burnaby/New Westminster	Byrne Creek Streamkeepers volunteers monitor the health of this urban stream and conduct streamkeeping activities.
Capitol Hill Tree Keepers	https://capitolhilltreekeepers.ca/	Burnaby/New Westminster	Capital Hill Tree Keepers works in cooperation with the City of Burnaby and other entities in the wise management and preservation of the Capital Hill forest in Burnaby.
Cariboo Heights Forest Preservation Society	https://caribooheightsforestpreservation.org/	Burnaby/New Westminster	The Cariboo Heights Forest Preservation Society works for the preservation of a large second growth forest, located south of the Brunette River. Significant for its local history and diversity of native plants and wildlife, this forest is a sanctuary for both people and nature.
Eagle Creek Streamkeepers	https://www.facebook.com/eaglecreekstreamkeepers/	Burnaby/New Westminster	The members of the Eagle Creek Streamkeeper Society protect, preserve and enhance the Eagle Creek watershed habitat, through environmental education and volunteer involvement.
New West Environmental Partners	https://www.facebook.com/the.nwep/	Burnaby/New Westminster	Non-profit society for environmental education and advocacy on local and regional topics.
Stoney Creek Environment Committee	https://scec.ca/	Burnaby/New Westminster	Stoney Creek Environment Committee (SCEC) is a dedicated group of volunteers committed to protecting, preserving, and enhancing Burnaby's urban forest and salmon bearing stream through various stream-keeping activities.

Friends of Cypress Provincial Park Society	https://cypresspark.ca/	North Shore	Friends of Cypress Provincial Park dedicated to the protection of Cypress Park's natural environment.
City of North Vancouver Park Stewards	https://www.cnv.org/Community-Environment/Help-Environment/city-park-stewards	North Shore	The Park Stewardship Program started in 2001 and aims to restore the City's parks, natural areas, and biodiversity.
Lighthouse Park Preservation Society	http://www.lpps.ca/	North Shore	Lighthouse Park Preservation Society is a membership-based non-profit organization formed in 1998.
North Shore Streamkeepers	https://www.nssk.ca/	North Shore	Protecting & Preserving Waterways on Vancouver's North Shore.
Old Growth Conservancy Society	https://ogcs.ca/	North Shore	The Old Growth Conservancy Society (OGCS) is a registered society working in partnership with the District of West Vancouver, British Columbia in the management and stewardship of West Vancouver's Old Growth Conservancy.
West Vancouver Streamkeeper Society	https://www.westvancouverstreamkeepers.ca/about	North Shore	The West Vancouver Streamkeepers aims to protect and restore local fish and aquatic stocks in 22 creeks and tributaries in West Vancouver. They coordinate with environmental stewardship among public, corporate and private stakeholders, as well as manage a fish hatchery.
Alouette River Management Society	https://alouetteriver.org/	Pitt Meadows/Maple Ridge	The Alouette River Management Society sustains and enhances the integrity of the Alouette Watershed through advocacy, education, collaboration, and stewardship using science-based decision-making.
Kanaka Education & Environmental Partnership Society (KEEPS)	https://keeps.org/	Pitt Meadows/Maple Ridge	To maintain the health of Kanaka Creek watershed's natural ecosystems through education, community involvement, scientific research, land preservations and partnerships based on stewardship principles.

Burns Bog Conservation Society	https://burnsbog.org/	Richmond/Delta	The Burns Bog Conservation Society was officially formed in 1988 by a group of citizens concerned with the protection (or lack thereof) of Burns Bog. This group of dedicated individuals helped to save Burns Bog from various development proposals.
Cougar Creek Streamkeepers	https://cougarcreekstreamkeepers.ca/	North Delta	Cougar Creek Streamkeepers is an informal group of volunteers dedicated to restoring and maintaining the health of Cougar Creek, a salmon stream that rises in Surrey, British Columbia (Canada), flows through North Delta and empties into the Fraser River.
Delta Naturalists Society	https://dncb.wordpress.com/	Richmond/Delta	The Delta Naturalists Society fosters communal appreciation for nature, notably birds, and serves as a members conduit to a wide range of information on nature. Delta Nats is involved in community education about the environment and makes representations to all three levels of government on environmental issues.
Earthwise	https://www.earthwisesociety.bc.ca/	Richmond/Delta	Earthwise Society is devoted to promoting sustainability through education and Red Barn with Yellow and Blue Flowers Community initiatives. Based in South Delta's Boundary Bay, Earthwise Society operates the Earthwise Garden and Earthwise Farm.
Richmond Nature Park Society	https://www.richmond.ca/parks/parks/naturepark/about.htm	Richmond/Delta	The Richmond Nature Park consists of 200 acres of the raised peat bog habitat that once covered large portions of Lulu Island. Four walking trails totalling 5 kilometres provide visitors the chance to encounter plants and animals in bog, forest and pond habitats.
Cougar Creek Streamkeepers	https://cougarcreekstreamkeepers.ca/	Surrey/Langley/White Rock	Cougar Creek Streamkeepers is an informal group of volunteers dedicated to restoring and maintaining the health of Cougar Creek, a salmon stream that rises in Surrey, British Columbia (Canada), flows through North Delta and empties into the Fraser River.

Derby Reach Brae Island Parks Association (DRBIPA)	https://www.drbipa.org/	Surrey/Langley/ White Rock	Derby Reach Brae Island Parks Association (DRBIPA) is a nonprofit society providing the community with opportunities to preserve, protect and enhance the natural environment of Derby Reach and Brae Island Regional Parks in Fort Langley, BC.
Friends of Semiahmoo Bay Society	https://www.birdsonthebay.ca	Surrey/Langley/ White Rock	Friends of Semiahmoo Bay work to preserve, restore and raise knowledge of the ecological values of the Boundary Bay Ecosystem and its watershed.
Green Timbers Heritage Society	https://www.greentimbers.ca/	Surrey/Langley/ White Rock	A dedicated group of volunteers working to preserve and promote the rich heritage and natural areas of Green Timbers.
Langley Environmental Partners Society	https://www.leps.bc.ca/	Surrey/Langley/ White Rock	As a leading environmental organization in the Fraser Valley for over twenty two years, LEPS actively partners with local environmental stewardship groups to engage the public in a variety of initiatives that contribute to a healthy community.
Langley Field Naturalists	https://www.langleyfieldnaturalists.org/	Surrey/Langley/ White Rock	The Langley Field Naturalists Society is a non-profit organization that aims to promote enjoyment, understanding and conservation of the natural environment. Most of our members live in Langley City or Langley Township, British Columbia, but residents in other areas are also welcome to join.
Salmon River Enhancement Society	http://salmonriver.org/	Surrey/Langley/ White Rock	The Salmon River Enhancement Society is a citizens group that formed in 1995 to work with government agencies, increase public involvement, and lobby government agencies when appropriate.
Sunnyside Acres Heritage Society	https://www.sunnysideacres.ca/	Surrey/Langley/ White Rock	We work cooperatively with the City of Surrey to protect and manage the 130 hectares of mature second growth forest known today as Sunnyside Acres Urban Forest.
Surrey Environmental Partners	https://www.facebook.com/SEPBC2003/	Surrey/Langley/ White Rock	Surrey Environmental Partners is a citizen based group dedicated to conserving the natural environment
Surreys Natural Areas Partnership (SNAP)	https://www.surreysnaturalareaspartnership.com/	Surrey/Langley/ White Rock	Surrey's Natural Areas Partnership (SNAP) plays an important role in caring for Surrey's urban forest

White Rock & Surrey Naturalists	https://bcnature.org/white-rock-surrey-naturalists-society/	Surrey/Langley/White Rock	Whiterock & Surrey Naturalists promote education, conservation and stewardship activities, including gardening, walks, cleanups, surveys, field trips, presentations
Broombusters	https://www.broombusters.org/coquitlam/	Tri- Cities (Coquitlam, Port Coquitlam, Port Moody, Anmore, Belcarra)	The Coquitlam chapter started in 2022 with 29 enthusiastic volunteers and 187 hours of work. They work in partnership with the City of Coquitlam with support from the Hoy/Scott Watershed Society.
Burke Mountain Naturalists	https://www.burkemountainnaturalists.ca/	Tri-Cities	The Burke Mountain Naturalists (BMN) was formed in 1989 by local residents interested in enjoying nature and conserving local green spaces.
Burrard Inlet Marine Enhancement Society	http://www.mossomcreek.org/	Tri-Cities	Burrard Inlet Marine Enhancement Society is committed to providing environmental education and stewardship activities in the Burrard Inlet area, including managing the Mossom Creek Hatchery & Education Centre located in Port Moody, BC.
Colony Farm Park Association	https://colonyfarmpa.com/	Tri-Cities	Colony Farm Park Association is a community group with a Volunteer Board of Directors and Members. We offer free nature walks, birding events, stewardship activities and citizen science opportunities.
Friends of DeBoville Slough	https://www.burkemountainnaturalists.ca/fodbs/	Tri-Cities	In January 2022, the Friends of DeBoville Slough (FoDBS) teamed up with Burke Mountain Naturalists (BMN) to form a new BMN committee – the BMN/FODBS Committee.
Hyde Creek Watershed Society	http://www.hydecreek.org/	Tri-Cities	Our Society is comprised of volunteers of all ages, whose focus is on our incredible urban setting, our salmon hatchery, tours and public education.
Maple Creek Watershed Streamkeepers Society	https://maplecreekstreamkeepers.com/	Tri-Cities	Maple Creek Watershed Streamkeepers Society is a stewardship group dedicated to encourage all community members to protect, rehabilitate and restore the natural environment, including Maple Creek, and the services it provides us.

Minnehada Park Association	https://www.minnehada.ca/	Tri-Cities	To preserve, protect and enhance the natural environment of Minnehada Regional Park, while advocating respect, appreciation and enjoyment of the Park's natural and historic attributes as well as recreational resources.
Port Moody Ecological Society	https://www.noonscreek.org/	Tri-Cities	The Port Moody Ecological Society is a 100% volunteer based organization whose mandate is to operate a salmon hatchery and water quality laboratory located in the City of Port Moody.
Everett Crowley Park Committee	https://www.vcn.bc.ca/ecpc/index.html	Vancouver	The Everett Crowley Park Committee (ECPC) is a sub-committee of the Champlain Heights Community Association and is made up of park users and local residents who are working to see this green space protected and enhanced for the long term.
Free the Fern Stewardship Society	https://freethefern.ca/	Vancouver	The Fern Stewardship Society has the goal of reducing the spread of invasive plants and replanting native plants along the Champlain Heights Trail. In addition, Free the Fern has organized public events and created a native plant teaching garden for the public.
Hastings Park Conservancy	https://www.facebook.com/TheHastingsParkConservancy/	Vancouver	The Hastings Park Conservancy (HPC) advocates for public access, natural habitat, enhanced green space, and the sustainability of Hastings Park for the enjoyment of all. It is also involved in a variety of educational and environmental activities in Hastings Park, including a monthly nature walk.
Jericho Stewardship Group	http://jerichostewardship.ca/	Vancouver	The Jericho Stewardship Group is a registered non-profit organization comprising residents, students, naturalists and other non-profit groups, that works with the Vancouver Park Board to restore and encourage the natural habitat of Jericho Beach Park.
Musqueam Natural Resources Service Group	https://www.musqueam.bc.ca/departments/title-and-rights/enviro-stewardship/	Vancouver	Customary use and stewardship of our ancestral and traditional lands compels xʷməθkʷəy̍əm to take a lead role in planning for access, use, and management of these lands and waters for present and future generations.
Nature Vancouver	https://naturevancouver.ca/	Vancouver	Nature Vancouver is a not-for-profit charitable society dedicated to enjoyment, education, and conservation of nature.

Pacific Spirit Park Society	https://pacificspiritparksociety.org/	Vancouver	The Pacific Spirit Park Society is a non-profit society that works with Metro Vancouver, as part of the Regional Park Partners Program. We hold a vision of an urban forest and foreshore park that is protected and cared for in perpetuity, for the benefit of all.
Stanley Park Ecology Society	http://www.stanleyparkecolony.ca	Vancouver	Collaborative leadership in environmental education, research, and conservation in Stanley Park.
Still Creek Streamkeepers	https://stillmoonarts.ca/streamkeepers/	Vancouver	The Still Creek Streamkeepers are a group of neighbours and citizen scientists who help take care of Still Creek and Renfrew Ravine, with the support of Still Moon Arts Society.
Still Moon Arts Society	https://stillmoonarts.ca/	Vancouver	Still Moon Arts Society inspires vibrant and connected communities by creating artistic experiences and nurturing a passion for nature.
Vancouver Urban Food Forest Foundation	https://vufff.org/	Vancouver	Vancouver Urban Food Forest Foundation realized that a crucial way to help with the alienation and food shortages we saw in our neighbourhood was to establish a collective garden and food forest.
Catching the Spirit Youth Society	https://ctsyouthsociety.com/	Region-wide	For over 20 years, CTS Youth Society has been connecting Metro Vancouver youth with their natural environment, their community, and each other through life-changing outdoor experiences. Free and open to all participants, we are "for youth, by youth".
Colour the Trails	https://colourthetrails.com/	Region-wide	We advocate for inclusive representation in outdoor spaces, working with brand partners, businesses, and organizations to break barriers and create accessibility.
Environmental Youth Alliance	https://eya.ca/	Region-wide	The Environmental Youth Alliance is a registered charity supporting equity-seeking youth to connect with nature, community, and skills to become environmental stewards and community leaders. We provide free land-based education and paid employment-training programs in Vancouver's Downtown Eastside.

Invasive Species Council of BC – youth program	https://bcinvasives.ca/take-action/community-science/youth-team/	Region-wide	Get your hands dirty with fieldwork, engage in skill-building workshops, and gain community service experience.
Invasive Species Council of Metro Vancouver	https://iscmv.ca/	Region-wide	ISCMV offers a variety of educational, technical and support services for invasive species in Metro Vancouver.
Land Conservancy of BC, The	http://conservancy.bc.ca/	Region-wide	TLC protects important habitats for plants, animals and natural communities as well as properties with historical, cultural, scientific, scenic or compatible recreational value.
Lower Mainland Green Team	https://greenteamscanada.ca/our-green-teams/lower-mainland-green-team/	Region-wide	The Lower Mainland Green Team volunteers come from all over the Lower Mainland and work in provincial, regional and municipal parks tackling environmental issues that need cooperation and teamwork to get done.
Metro Vancouver Regional Parks Ecological Restoration Team	http://www.metrovancouver.org/services/parks/get-involved/volunteer/Pages/default.aspx	Region-wide	Volunteers lend nature a helping hand in fun and interesting ways – removing invasive plants, monitoring wildlife, planting native trees and shrubs, conducting bird surveys and more.
Metro Vancouver Regional Parks Foundation	https://mvrpfoundation.ca/	Region-wide	Led by an independent board of directors, Metro Vancouver Regional Parks Foundation (previously known as Pacific Parklands Foundation) is the only registered charity dedicated to supporting Metro Vancouver Regional Parks.
Nature Kids BC	https://naturekidsbc.ca/	Region-wide	To help BC children get outside with their families to explore, play, learn about and take action for nature.
Nature Trust of British Columbia	https://www.naturetrust.bc.ca/	Region-wide	The Nature Trust of British Columbia protects the natural riches of the province by building a treasury of wild natural areas that conserve iconic and important species at risk.
Northwest Wildlife Preservation Society	https://www.northwestwildlife.com/	Region-wide	Since 1987 NWPS focus has been on providing free wildlife education and stewardship programs to disadvantaged people throughout British Columbia.

Pacific Salmon Foundation	https://psf.ca/	Region-wide	The Pacific Salmon Foundation, founded in 1987, is a non-profit environmental organization dedicated to the conservation and restoration of wild Pacific salmon and their habitats in B.C. and the Yukon.
Stewardship Centre for British Columbia	https://stewardshipcentreb.c.ca/	Region-wide	Protecting the environment through the development of Science-based practices
Tree Canada	https://treecanada.ca/	Region-wide	Tree Canada is the only national non-profit organization dedicated to planting and nurturing trees in rural and urban environments, in every province across the country.
WILD Outside	https://cwf-fcf.org/en/explore/wild-outside/	Region-wide	Canadian Wildlife Federation (CWF), program for young people (age 15-18) who want to get involved and help the planet.
Adapted from ISCMV Metro Vancouver Stewardship Groups List and the Pacific Stream keepers Federation Stream keepers Database .			



**PACIFIC SALMON
FOUNDATION**