

GROUNDWATER STRATEGY

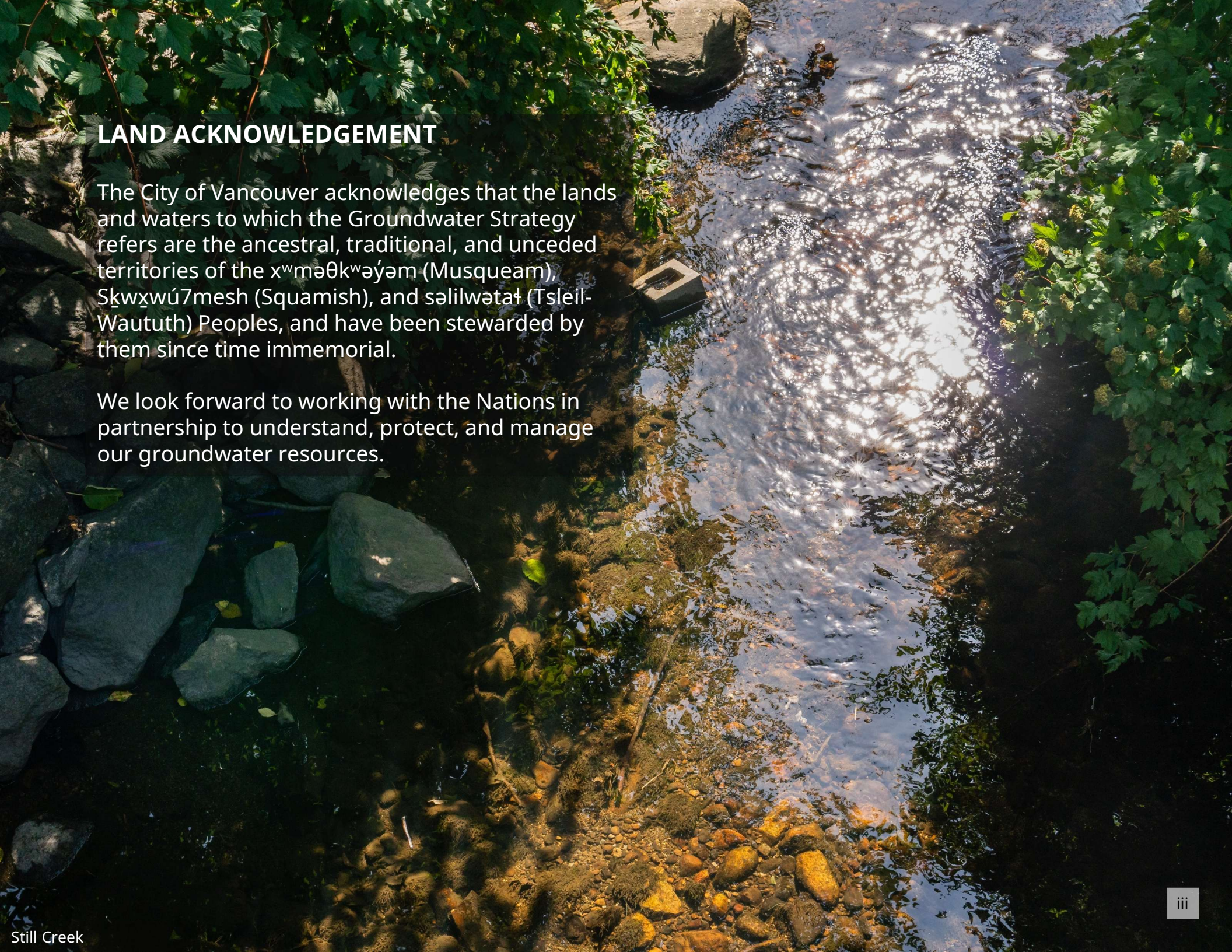
June 2026



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LAND ACKNOWLEDGEMENT

The City of Vancouver acknowledges that the lands and waters to which the Groundwater Strategy refers are the ancestral, traditional, and unceded territories of the xʷməθkʷə́yəm (Musqueam), Skwxwú7mesh (Squamish), and səliłwətał (Tseil-Waututh) Peoples, and have been stewarded by them since time immemorial.

We look forward to working with the Nations in partnership to understand, protect, and manage our groundwater resources.

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EXECUTIVE SUMMARY

The Groundwater Strategy was identified as key a deliverable under the *City's Climate Change Adaptation Strategy* and the *Healthy Waters Plan – Key Directions*. Water nourishes and sustains us; it is essential to all life and a defining element of Vancouver's identity as a city. Like many cities, however, Vancouver faces a growing set of water-related challenges. Groundwater in particular has significant implications for the City, presenting both issues that must be managed and opportunities that can be leveraged.

FRAMEWORK

Vision

Groundwater is recognized as an important resource and managed to mitigate risks, support ecosystems, and advance the City's adaptation to climate change.

Goals

- **Protect** people, infrastructure, and property from groundwater-related risks.
- **Preserve** groundwater to diversify water resources and maintain ecosystem services.
- **Adapt** to population growth, climate change, and emerging priorities with resilient groundwater management.

Objectives

- **Support Groundwater-Dependent Ecosystems** by preserving local resources and vital hydrological connections
- **Improve Water Security** and emergency preparedness through the sustainable use of groundwater
- **Reduce the impact of groundwater-related risks** by assessing vulnerabilities and developing mitigation strategies
- **Maintain groundwater levels** by enhancing infiltration and reducing waste
- **Safeguard groundwater quality** by implementing measures to prevent and mitigate aquifer contamination
- **Foster community awareness and support** for groundwater protection through education and engagement
- **Inform decision making** by increasing our understanding of local hydrogeology

Research and engagement with stakeholders and partners identified the issues and opportunities that would be addressed by the Strategy. These were subsequently organized into four key drivers: 1) Optimize liquid waste management; 2) Mitigate and adapt to risks; 3) Use groundwater strategically and sustainably; and 4) Protect ecosystems and environment.

Following additional engagement and an external assessment of costs and benefits, a consolidated list of 43 discrete actions was developed to address these drivers and achieve the Framework. This work recognized that critical knowledge gaps make a long-term plan infeasible at this time. The Groundwater Strategy therefore proposes a phased, adaptive approach, with 10 short-term actions in Phase 1. These actions will fill key knowledge gaps, reduce immediate risks, build organizational capacity, and position the City for future decision-making. They will also deliver financial savings by minimizing groundwater inflow and infiltration, avoiding land and infrastructure rehabilitation costs, and reducing purchased water costs through strategic groundwater use. After evaluating Phase 1 outcomes, a series of Phase 2 options will be considered to advance the Framework.

PHASE 1 ACTIONS (2026-2030)

1. Restrict the discharge of foundation drains into sewers
2. Develop a groundwater monitoring program
3. Assess aquifer recharge and infiltration potential
4. Quantify groundwater diversions
5. Identify groundwater-dependent ecosystems
6. Develop a groundwater data repository
7. Update the city-wide groundwater flow model
8. Assess the sustainable extraction potential of groundwater
9. Assess the potential extent and magnitude of groundwater rise
10. Engage external partners to advance objectives

INTRODUCTION: GROUNDWATER BASICS

WHAT IS GROUNDWATER?

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock, shown schematically in Figure 1. It supplies water to wells, springs, and many streams and wetlands. Groundwater is a major source of drinking water supply worldwide and supports agriculture and ecosystems. Although it is out of sight, groundwater plays a critical role in the water cycle and in sustaining life on Earth.

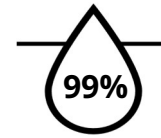
WHERE DOES GROUNDWATER COME FROM?

Groundwater typically comes from rainwater, snowmelt, or surface water bodies (e.g., rivers and lakes) where the water infiltrates into the ground. In more urbanized settings such as Vancouver, leakage from underground utilities (e.g., water pipes) can also be a source. This reliance on recharge from surface water means that groundwater can become depleted if rainfall is no longer able to infiltrate (e.g., where vegetated areas are paved over or built on).

The flow of groundwater is complex and variable; water that enters the ground as rainfall can quickly find its way back to the surface as baseflow to a watercourse, or it can move downward into deeper aquifers over thousands or even millions of years until it reaches the ocean or is extracted by a well (Figure 1).

WHAT IS AN AQUIFER?

An **aquifer** is classified as an area underground where there are significant amounts of saturated subsurface material that groundwater can move through easily (e.g., sand or gravel). The **water table** defines the water level in an aquifer, essentially a measure of how “full” the aquifer is. Where there is material that groundwater moves through much more slowly (e.g., silt, clay, or solid rock), that unit is called an **aquitard**. Underground there can be a layering of aquifers and aquitards. Where an aquitard is on top of an aquifer, it can act like a lid or cover, protecting the aquifer from contamination but also potentially causing it to become pressurized. This is referred to as a **confined aquifer**. Conversely, **unconfined aquifers** are not capped by an aquitard and are more likely to be found near the surface, are more easily contaminated from chemicals released near the surface, and often interact with and support surface water like creeks and wetlands.



Groundwater comprises 99% of all liquid fresh water on Earth^[1].



An estimated 2.5 billion people depend on groundwater for drinking, including almost 10 million Canadians^[2].



Groundwater plays a significant role in the production of food and in supporting ecosystems, such as providing base flow to streams between periods of rainfall.

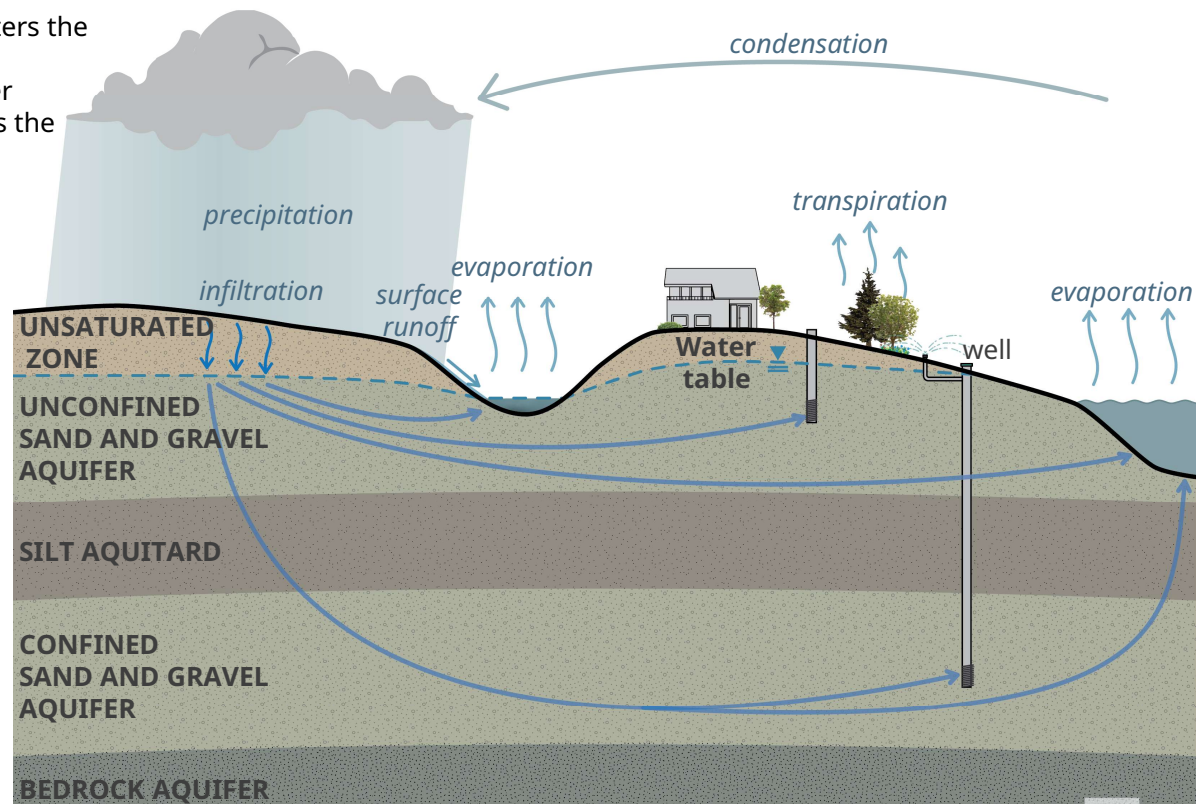


Figure 1. Groundwater cross-section.

GROUNDWATER IN VANCOUVER

AQUIFER MAPPING

Aquifers are mapped by the Province of BC^[3] to understand their extent and characteristics, using information that is available at the time. Aquifer mapping helps us understand where significant quantities of groundwater may be found, which can inform future planning initiatives. As additional studies and/or monitoring are carried out, aquifer maps may be updated, and additional aquifers may be identified. Aquifers mapped in Vancouver are shown in Map 1.

Quadra Sands Aquifer (Aquifer #49)^[4]

The Quadra Sands Aquifer is a partially confined aquifer that is understood to extend from the University of British Columbia to Port Moody and Coquitlam. The Quadra Sands Aquifer was deposited between periods of glaciation and has an age of approximately 18,000 to 26,000 years. The aquifer is known to extend farther south than is currently mapped, and is expected to underlie much of Aquifer #45 and extend south of the Fraser River. The portion of this aquifer that covers southern Vancouver, Burnaby, and New Westminster is subject to a well drilling advisory due to pressurized groundwater conditions (see Map 2 on page 15).

Fraser River Sediments Aquifer (Aquifer #45)^[5]

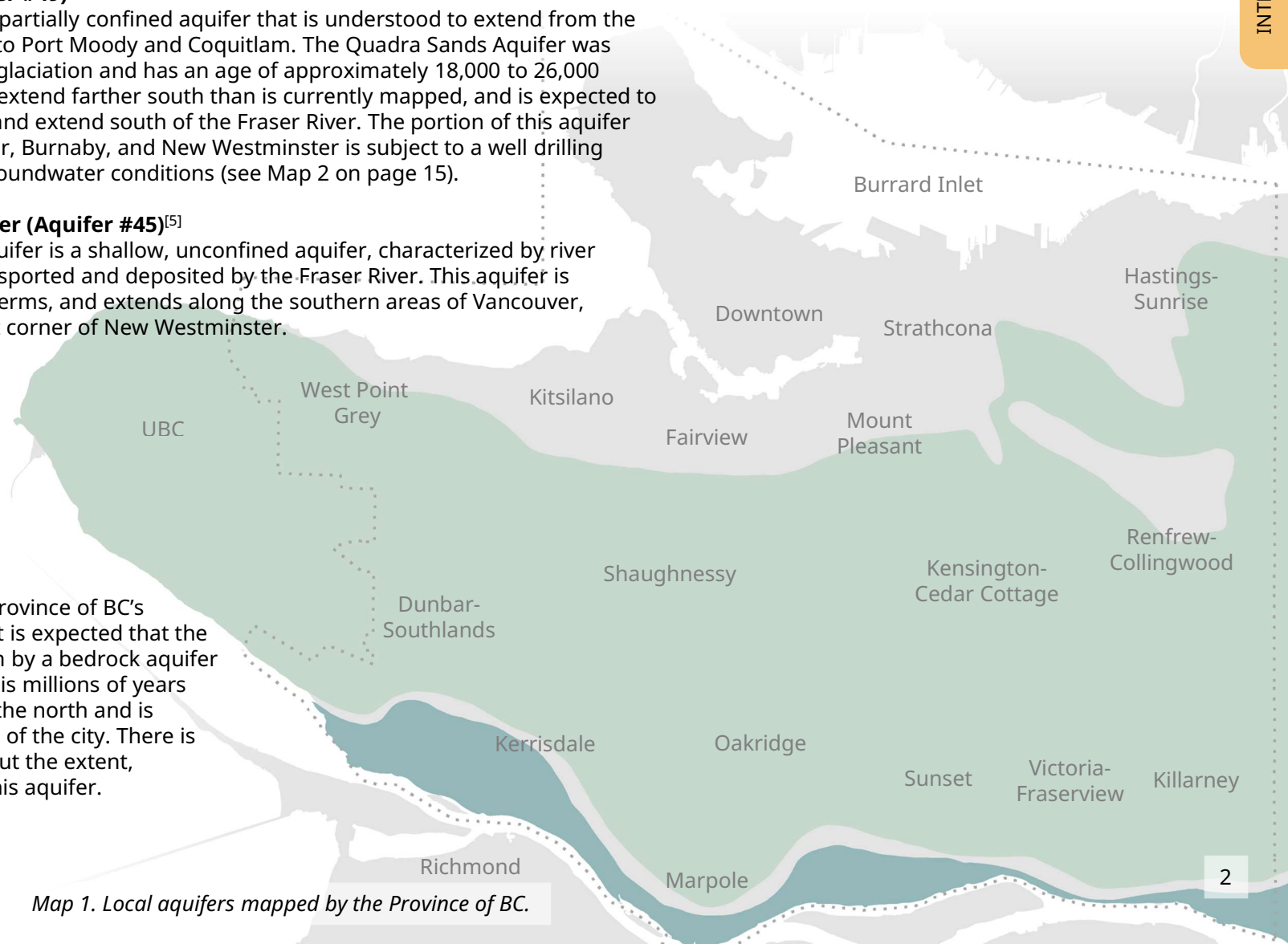
The Fraser River Sediments Aquifer is a shallow, unconfined aquifer, characterized by river sediments that have been transported and deposited by the Fraser River. This aquifer is relatively young in geological terms, and extends along the southern areas of Vancouver, Burnaby, and the westernmost corner of New Westminster.

Bedrock Aquifer (not shown)

Although not mapped by the Province of BC's Aquifer Classification System, it is expected that the majority of the City is underlain by a bedrock aquifer composed of sandstone which is millions of years old. This bedrock is shallow in the north and is deeper in the southern portion of the city. There is generally very little known about the extent, characteristics, or viability of this aquifer.

Legend

-  Aquifer #49 mapped extent
-  Aquifer #45 mapped extent
-  City of Vancouver boundary



Map 1. Local aquifers mapped by the Province of BC.

GROUNDWATER GOVERNANCE AND RATIONALE

PROVINCIAL AND LOCAL JURISDICTION

In British Columbia, the Province manages surface water and groundwater through legislation like the *Water Sustainability Act*^[6] and the *Environmental Management Act*^[7]. While this establishes the provincial framework for groundwater management, groundwater can affect local infrastructure and urban development. The Province is the primary regulator of groundwater; however, local governments also play an important influencing role through land use planning, infrastructure management, and environmental protection.

For example, the extraction and use of groundwater are regulated by the Province – yet municipal decisions related to development siting, form, or density and stormwater management largely determine the extent to which rainwater can infiltrate local aquifers. In this way, the Province manages groundwater outputs (i.e., extraction), whereas the local governments manage groundwater inputs (i.e., recharge).

In terms of water quality, the Province develops and enforces legislation to prevent and remediate groundwater contamination^[8]. Local governments also play an important role through zoning and development permitting, which often determine the likelihood of contamination occurring in a particular location.

Therefore, while groundwater jurisdiction primarily rests with the Province, local governments play a critical role in preserving both groundwater quantity and quality.

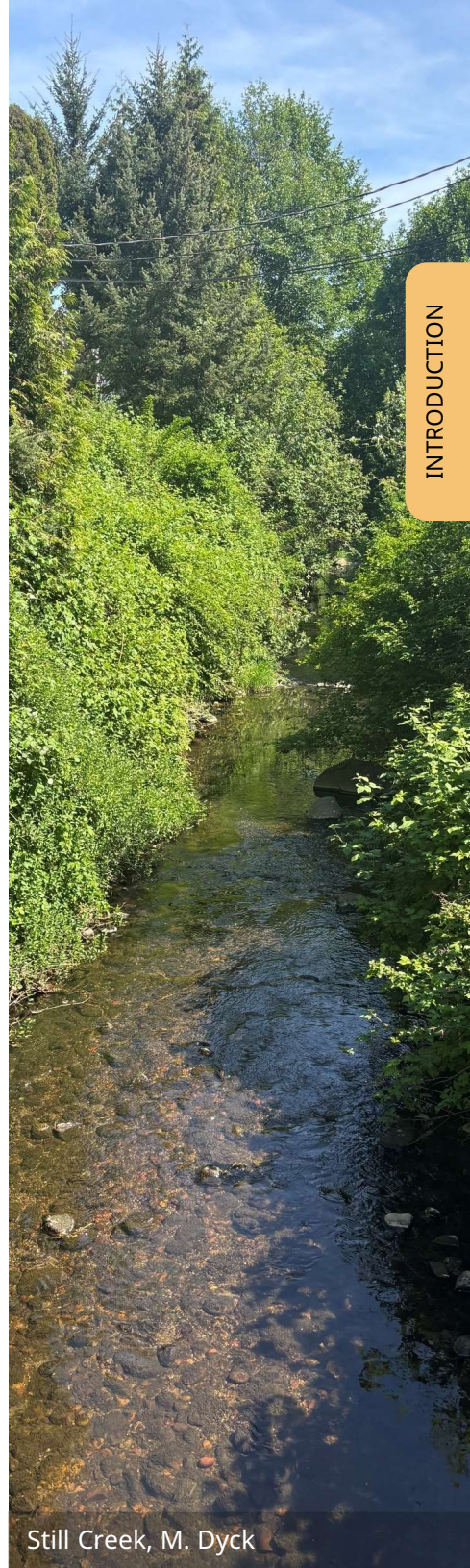
WHY WE NEED A GROUNDWATER STRATEGY

The City of Vancouver is affected by groundwater-related issues, particularly where groundwater is entering the sewer system. Vancouver has a legacy combined sewer system, where a single pipe carries both sewage and stormwater to treatment plants. Buildings constructed underground must manage groundwater both during and after construction, which often results in groundwater being diverted to sewers, with cost implications for the City on the order of tens of millions of dollars annually.

The City has responded through the development of policies/tools such as the *Groundwater Management Bulletin* to reduce the impacts of diverting groundwater to sewers, and the Groundwater Protection Area under the *Vancouver Building By-law* to maintain Still Creek groundwater baseflow. These initiatives have begun to address certain groundwater issues, but a coordinated approach is needed to understand and respond to the various ways that groundwater impacts the City, and to reduce the social, economic, and environmental costs over the long-term.

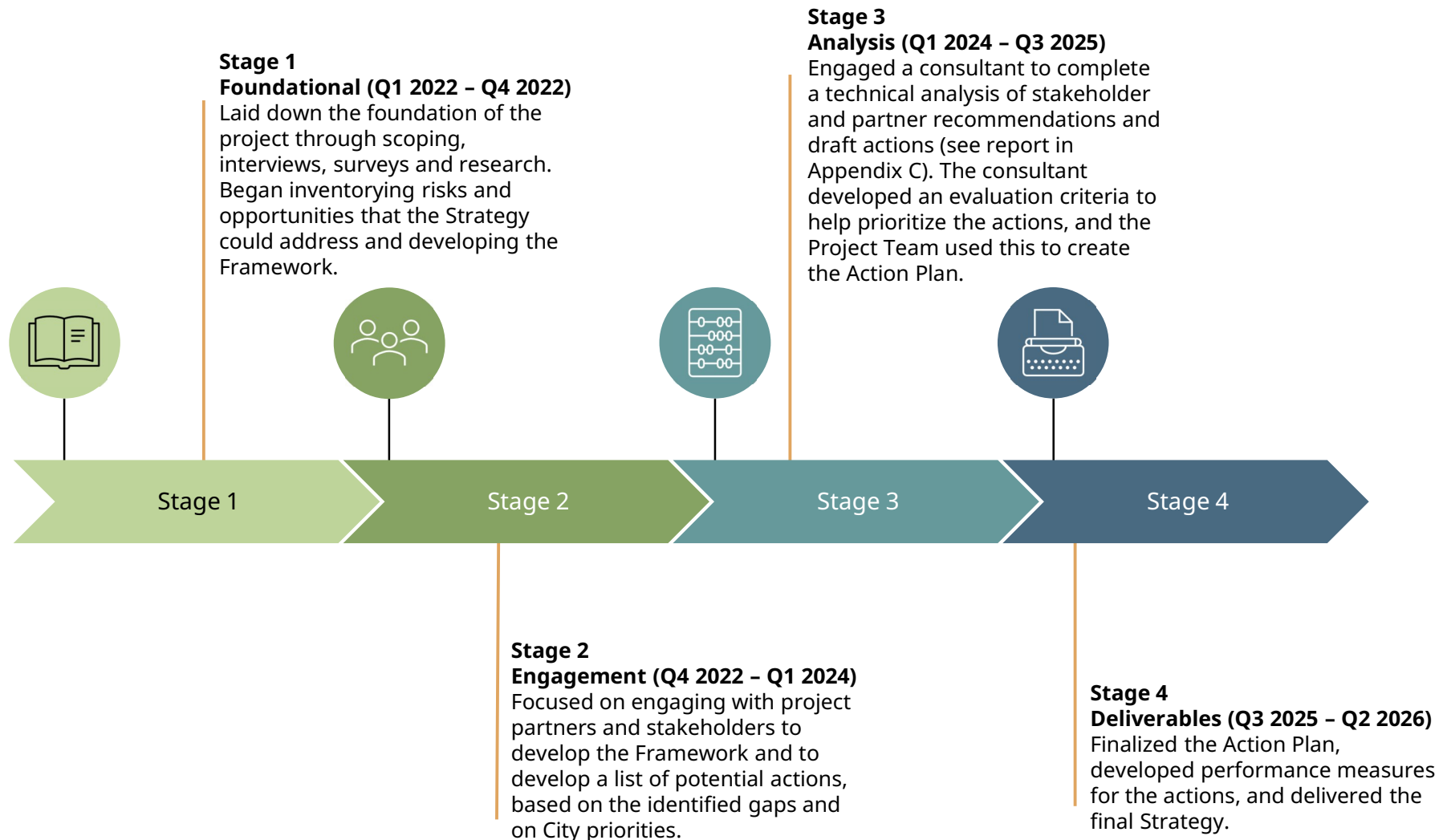
Mitigating and adapting to climate-driven threats—such as drought, sea-level rise, and extreme rainfall—presents a compelling case for action. Understanding groundwater is critical in this context, as it not only underpins effective climate adaptation but also represents a resource the City can leverage to strengthen climate resilience as it grows, supports an increasing population, and prepares for future emergencies, including droughts and earthquakes.

The Groundwater Strategy sets out a strategic, city-wide approach to characterizing and understanding Vancouver's groundwater system to provide a clearer understanding of groundwater conditions, risks, and interactions across the city. This will support more proactive planning, infrastructure management, environmental protection, and long-term decision-making, while helping the City better anticipate and respond to future pressures associated with urban growth, aging infrastructure, and climate change.



DEVELOPING THE STRATEGY: OVERVIEW

The Groundwater Strategy has been completed over four stages: completion of foundational research, engagement with stakeholders and partners, analysis of recommendations, and preparation of deliverables including an Action Plan and performance measures.



STAKEHOLDER AND PARTNER ENGAGEMENT

ENGAGEMENT OVERVIEW

The Groundwater Strategy was developed through a collaborative engagement process between City staff, local experts, and project stakeholders and partners.

STAKEHOLDERS AND PARTNERS

Staff Working Group and Expert Panel

A series of workshops were held with an internal Staff Working Group (SWG) and an Expert Panel (EP), with initial work defining the need for a groundwater strategy and identifying associated drivers. This foundational analysis informed the project's strategic direction, including the Framework (pages 12-13). Subsequent workshops produced a number of potential actions to respond to the drivers. These sessions facilitated broader engagement and helped identify insights and considerations from across the organization.

Steering Committee

Consultation with the project Steering Committee further refined and finalized the draft Framework. This helped ensure strategic alignment with other programs (i.e., One Water) and City priorities, and endorsement of the final Framework.

Local Nations

Throughout the process, the Project Team engaged with the xʷməθkʷə́yəm (Musqueam Indian Band), Skwxwú7mesh Úxwumixw (Squamish Nation), and səliłwətał (Tsleil-Waututh Nation) through a variety of mechanisms. These included regular updates through the Indigenous Referral Process, introductory and project update meetings with each of the Nations, and coordinated project and document review.

The Project Team also received learnings from the *Healthy Waters Plan* team from their ongoing engagement with the local Nations. Common themes were identified between the two projects, such as environmental protection and stewardship, cultural values and traditional knowledge, consultation and inclusion, and long-term planning. Of particular relevance to both the *Healthy Waters Plan* and the Groundwater Strategy is that each Nation linked the health of the ecosystem to their cultural identity and traditional practices. Engagement with local Nations will continue to build on these themes and they will be incorporated into the project as it moves into the implementation of Phase 1, as well as subsequent phases.

In addition, the Groundwater Strategy has considered ongoing work on the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) Action Plan 2024-2028, that was approved by Vancouver City Council on June 25, 2024^[9]. The Project Team has identified potential opportunities to support the UNDRIP Action Plan during implementation of the Groundwater Strategy, and will continue to explore these in collaboration with the Nations.



STAKEHOLDER AND PARTNER ENGAGEMENT

WHAT WE HEARD

Through extensive engagement, the City gained a clearer understanding of the complex role groundwater plays in Vancouver:

1. Groundwater risks are growing and interconnected. Stakeholders and partners identified concerns about sea level rise, saltwater intrusion, subsidence, contamination, and groundwater ingress into buildings and infrastructure. Without improved monitoring and policies, these risks will continue to escalate.
2. Knowledge of Vancouver's aquifers is limited. Across all groups, there was strong consensus that Vancouver lacks baseline information on groundwater levels, recharge areas, extraction potential, contamination pathways, and how local ecosystems depend on groundwater. This limited understanding constrains planning and risk management.
3. Groundwater is an underused resource. City teams, external experts, and the local Nations emphasized opportunities for non-potable uses, emergency supply, and supporting ecological systems. However, stakeholders and partners noted that clearer policies, updated by-laws and better data are needed to unlock these opportunities safely and sustainably.
4. Groundwater is being diverted to sewers and takes up valuable capacity in the system, increasing water treatment costs, speeding up the need for replacements, and contributing to combined sewer overflows. Stakeholders shared that minimizing capacity constraints on sewer infrastructure was an immediate priority to be addressed.
5. Policy alignment is fragmented. While multiple strategies, by-laws, and provincial regulations relate to groundwater, responsibilities and expectations are not always clear. Staff identified the need for integrated guidance that supports core service delivery, simplifies development requirements, and aligns with climate resiliency goals.
6. Staff guidance reflected that implementation of Strategy actions would need to consider financial pressures, other City priorities, and evolving risks, with a focus on delivering core services.
7. The preservation of the environment, supported by groundwater, is paramount to the well-being and resilience of the City and its residents. Local Nations also emphasized this work as being of critical importance.



FRAMEWORK

The Framework sets the overall direction of the Groundwater Strategy by articulating a clear **vision**, defining priority **goals**, and establishing **objectives** and **guiding principles**. It provides a foundation for decision-making by outlining what the City aims to achieve and how the work will be carried out. The guiding principles will help to ensure that implementation of the actions is strategic, evidence-based, collaborative, equitable, and sustainable, while aligning groundwater management with broader City priorities and responsibilities.

GUIDING PRINCIPLES

Efficient

The Groundwater Strategy will prioritize cost-effective actions that are expected to have the most impact, including by avoiding significant future expenses related to groundwater risks. Emphasis will also be given to actions that address a number of concerns, have synergies with other City strategies and programs, or that produce additional co-benefits.

Sustainable

The Groundwater Strategy will aim to protect local aquifers from contamination and depletion, support ecosystems that depend on groundwater, and enable ongoing sustainable development. Emphasis will be on restoring and enhancing ecosystems and the services they perform, rather than simply limiting negative impacts.

Leadership

Within its jurisdiction, the City of Vancouver endeavours to do its part to protect and manage groundwater, including by modelling best management practices for groundwater in its own operations (e.g., at City-owned facilities), as well as through its planning and other decision-making.

Equitable

The Groundwater Strategy will be developed through the lens of equity and endeavour to fairly balance the interests of all parties that depend on or are affected by groundwater. In particular, the Groundwater Strategy will consider the potential impacts of groundwater-related decisions on marginalized groups in the city.

Integrated

Because land use, ecological health, and various forms of water (e.g., groundwater, rainwater, surface water, drinking water, and wastewater) are inextricably linked, the Groundwater Strategy will consider them holistically. As well, whenever possible, City groundwater efforts will be coordinated with its other work and incorporated into its policies, planning, and operations.

Evidence-based

Groundwater management will be informed by the best available science and emerging practices, high quality data, and traditional ecological knowledge. As such, the Groundwater Strategy will facilitate an understanding of available groundwater resources, risks and opportunities to inform future decisions.

Strategic

Wherever possible, the Groundwater Strategy will align with existing City policies and emerging priorities. It will also aim to maximize co-benefits.

Reconciliatory

Vancouver has committed to implementing the *United Nations Declaration on the Rights of Indigenous People*. Indigenous Peoples have the right to maintain and strengthen their relationship with their traditional waters. The City will engage with the local Nations during the development and implementation of its Groundwater Strategy. Moreover, shifting the City's water management paradigm towards one that respects and values water as a critical resource for people and ecosystems presents an opportunity to advance reconciliation.

Collaborative

Stakeholder involvement is a key component of successful groundwater management. The Groundwater Strategy will encourage the development of effective networks, promote the sharing of data, and improve coordination with other governments including where an action is outside of the City's jurisdiction or spans multiple jurisdictions. The City will also endeavour to conduct outreach programs in the community for businesses and residents to advance groundwater protection.

FRAMEWORK

VISION

Groundwater is recognized as an **important resource** and managed to **mitigate risks, support ecosystems, and advance the City's adaptation to climate change.**

GOALS

How we set out to achieve our vision

PROTECT

Protect people, infrastructure and property from groundwater-related risks.

PRESERVE

Preserve groundwater to diversify water resources and maintain ecosystem services.

ADAPT

Adapt to population growth, climate change and emerging priorities with resilient groundwater management.

OBJECTIVES

How we set out to achieve our goals



SUPPORT GROUNDWATER-DEPENDENT ECOSYSTEMS

by preserving local resources and vital hydrological connections



IMPROVE WATER SECURITY

and emergency preparedness through the sustainable use of groundwater



REDUCE THE IMPACT OF GROUNDWATER-RELATED RISKS

by assessing vulnerabilities and developing mitigation strategies



MAINTAIN GROUNDWATER LEVELS

by enhancing infiltration and reducing waste



SAFEGUARD GROUNDWATER QUALITY

by implementing measures to prevent and mitigate aquifer contamination



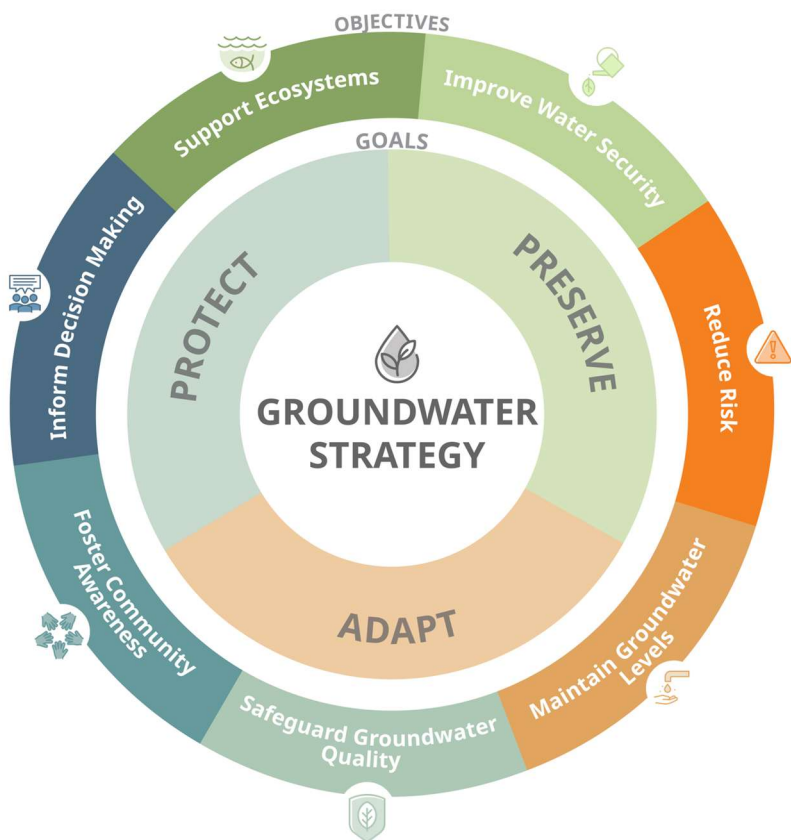
FOSTER COMMUNITY AWARENESS AND SUPPORT

for groundwater protection through education and engagement



INFORM DECISION MAKING

by increasing our understanding of local hydrogeology



Note: The Groundwater Strategy is intended as a planning and guidance document only. It does not intend to create or imply any directive, obligation or guarantee of performance by the City. The vision, goals, objectives, and actions described are aspirational and always subject to available budgetary and other resources, technical feasibility, and evolving environmental or regulatory conditions. The City may need to adjust priorities, timelines, or approaches under this Strategy, including deviating from or suspending actions, for instance, if these are not or no longer feasible or effective.

DRIVERS: OVERVIEW

Jurisdictional research, expert advice, and engagement with partners and stakeholders yielded a thorough inventory of the issues and opportunities to be addressed by the Framework. These topics are organized into four key Drivers, introduced below and discussed in more detail in the following pages.

1. OPTIMIZE LIQUID WASTE MANAGEMENT

Groundwater entering our sewers takes up valuable capacity in the system, which can increase wastewater treatment costs, contribute to combined sewer overflows, and require costly and otherwise unnecessary pipe upgrades. Some of this groundwater leaks into pipes through cracks or defects in the sewer system. Groundwater also enters the sewer via foundation drainage, which is installed to protect buildings from subsurface water. Alternatives to foundation drainage can add to the cost of new developments and impact housing delivery and affordability.

2. MITIGATE AND ADAPT TO RISKS

A number of groundwater-related hazards have been identified in Vancouver, including the potential for land subsidence due to groundwater pumping and dewatering activities, and potential flowing artesian conditions. Additional hazards are expected to be driven by climate change, including saltwater intrusion and groundwater rise. To limit the social, environmental, and financial impacts of these hazards, there is a need to better understand them, identify the City's vulnerabilities, and develop plans to proactively mitigate or adapt to them.

3. USE GROUNDWATER STRATEGICALLY AND SUSTAINABLY

A water supply gap has been predicted for the region as soon as 2030^[10], due to climate change and population growth. The use of alternative sources such as groundwater for non-potable purposes (e.g., irrigation) could provide a "potable offset," preserving potable water from the North Shore reservoirs for other uses. This practice may also have financial benefits, as locally sourced groundwater is often more cost-effective than making additional water purchases from Metro Vancouver. Diversifying the City's water resources would also make it less vulnerable to drought and may help the City respond to natural disasters like an earthquake.

4. PROTECT ECOSYSTEMS AND ENVIRONMENT

Groundwater sustains ecosystems by providing a steady source of water that supports wetlands, streams, and vegetation – especially during dry periods when surface water is scarce. The diversion of groundwater to sewer, or the reduction of rainfall infiltrating into the ground, disconnect natural systems and can limit the ability for groundwater to provide this support. Groundwater diversion to combined sewers also adds to combined sewer overflows, which can negatively impact ecosystems and deliver contaminants to receiving bodies.

DRIVER 1: OPTIMIZE LIQUID WASTE MANAGEMENT

INTRODUCTION

The City is committed to providing core services in an efficient and cost-effective manner. An opportunity to address the impacts of groundwater on the sewer system is by enhancing efforts to minimize **Inflow and Infiltration (I&I)**. **Inflow** refers to water entering sewers through direct connections (e.g., foundation drainage connections from underground parkades), while **Infiltration** refers to water that seeps into pipes through defects like cracks or leaky joints (Figure 2). I&I burdens the City's sewerage and drainage system capacity and adds to treatment costs. It also diverts groundwater baseflows away from streams and increases combined sewer overflows or introduces naturally occurring groundwater contaminants to the environment. The City addresses some groundwater inflow through development reviews; however, this can have various implications related to housing delivery timelines and costs.

KEY

1 Permanent Groundwater Inflow: Permanent discharge into sewers from foundation drains

2 Groundwater Infiltration: Leakage into sewers through cracks in pipe

3 Temporary Groundwater Inflow: Temporary discharge from construction site excavation

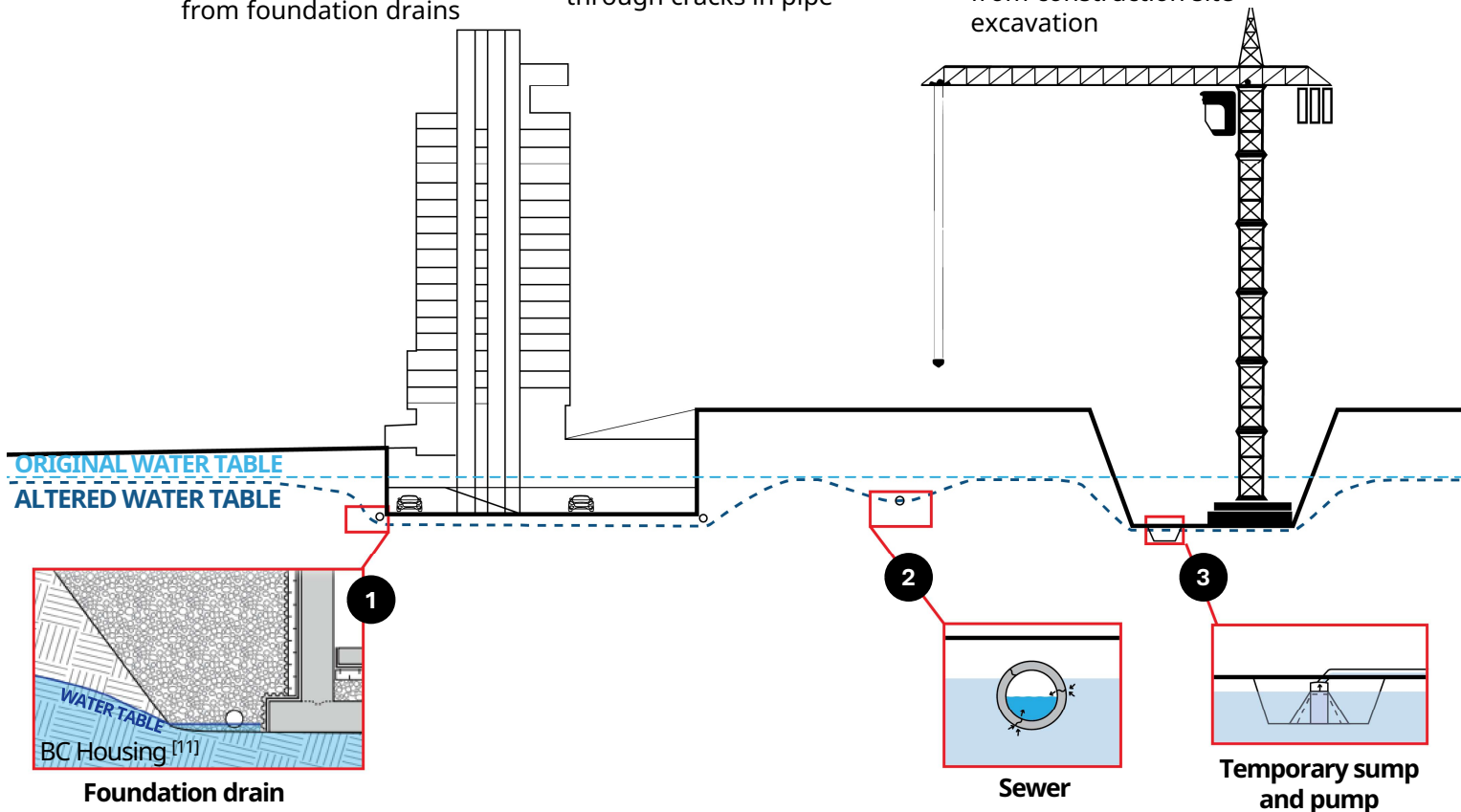


Figure 2. Groundwater inflow and infiltration.

POLICY ALIGNMENT

ENVIRONMENTAL
MANAGEMENT ACT

MUNICIPAL
WASTEWATER
REGULATION

LIQUID WASTE
MANAGEMENT PLAN

Sets requirements for the City of Vancouver to address inflow and infiltration, which Groundwater is suspected to contribute to significantly

EMERGENCY AND
DISASTER
MANAGEMENT ACT

2024 HAZARD, RISK
AND VULNERABILITY
ANALYSIS

EXTREME RAINFALL
RISK RATING: MEDIUM

By working towards reducing existing burdens on sewer system capacity, fewer upgrades may be required to manage the strain that extreme rainfall will add to the system.

INFLOW AND INFILTRATION



KEY ISSUE

Vancouver's combined sewage and drainage infrastructure was not designed to convey groundwater, however, it is often relied upon for this purpose. The intentional discharge of groundwater to sewer (i.e., inflow) stems from the construction of below ground levels, which requires foundation drainage to prevent moisture ingress into the building. Groundwater also leaks into the sewers (i.e., infiltration); however, it is often difficult to pinpoint where this is occurring, or likely to occur in the future.

Groundwater I&I increases the cost of delivering sewerage and drainage services by necessitating pre-emptive sewer pipe upgrades before they have reached the end of their expected service life. Further, the *Healthy Waters Plan* estimates that groundwater I&I contributes significantly to the volume of wastewater treated by regional treatment plants. These costs are borne by taxpayers; reducing groundwater I&I will reduce financial burden on taxpayers and extend the capacity of existing treatment plants.

Regulatory compliance

The Metro Vancouver *Liquid Waste Management Plan*^[12] prohibits groundwater discharge into sanitary sewers, and outlines requirements for the member local governments, including the City of Vancouver, to manage groundwater impacts to their sewage and drainage systems by addressing I&I management issues. Under the City's Zoning & Development by-law, a development project may be required to be designed to prevent groundwater discharge into the City collection system and to limit or reduce environmental impacts.



DESIRED FUTURE STATE

- Prioritization framework focusing efforts to limit the infiltration of groundwater to sewers, informed by relevant data on local soil and groundwater conditions and sewer infrastructure.
- A reduction in the discharge of groundwater to sewer from foundation drains (i.e., groundwater inflow).
- Compliance with regulatory obligations to not discharge groundwater into sanitary sewer systems.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Compilation of available hydrogeologic data (e.g., groundwater levels and permeability).
- ❑ Tools to cross-reference hydrogeologic data with sewer infrastructure data (e.g., pipe depth, age, material).
- ❑ A clear and transparent by-law, with requirements and incentives or penalties, that limit foundation drain discharge to the City's sewer system, developed in consultation with industry.



LEADING PRACTICE

Seattle, Washington, USA^[13]

The City of Seattle has implemented a utility fee specific to groundwater discharges to its sewer system. If estimated discharge rates are over a certain threshold, developments must install a flowmeter and pay the fee according to the measured discharge flow volumes.

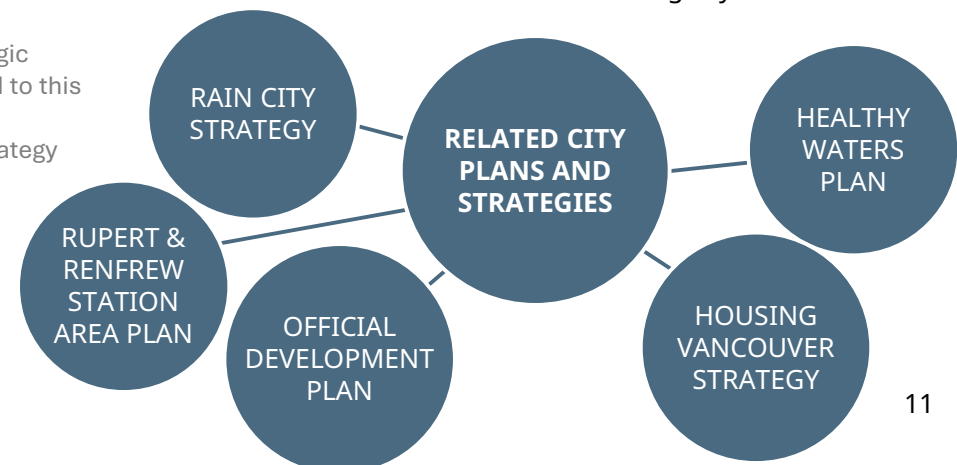


LEADING PRACTICE

San Francisco, California, USA^[14]

The City of San Francisco's public utility requires that large new developments construct an on-site water reuse system for toilet flushing and irrigation. The water sources for this system can include various stormwater sources as well as groundwater collected by foundation drainage systems.

Other City strategic initiatives related to this driver that the Groundwater Strategy builds upon:



2 UNDERGROUND PARKING



KEY ISSUE

The most cost-effective solution to reducing groundwater inflow to sewers is to reduce the depth of a building. This is most simply achieved by reducing the number of underground parking levels constructed. Although parking minimums in the City have been eliminated, the market demand for parking remains high, and there are few other incentives currently in place to reduce underground parking and associated groundwater discharge.



DESIRED FUTURE STATE

Groundwater diversions to the sewer system are minimized due to a reduction in the depth of underground parkades. Where appropriate, new developments reduce parking provisions. Above-grade parking is considered in high-risk areas where it also supports urban design objectives.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Exclude above-grade parking from floor space ratio calculations in high-risk areas where it supports groundwater objectives and achieves urban design outcomes.
- ❑ Targeted height relaxations are used, where appropriate, to enable above-grade parking solutions aligned with urban design outcomes

3 EXPEDITE AFFORDABLE HOUSING DELIVERY



KEY ISSUE

The City has the authority to limit the discharge of groundwater to sewer. However, methods to limit this discharge can add significant costs and negatively impact housing affordability (Figure 3). Reducing development review timelines has been identified as an opportunity to expedite housing supply; this can be supported by streamlining the City's groundwater requirements and clarifying groundwater management expectations.



DESIRED FUTURE STATE

- City priorities (e.g., housing) are balanced with regulatory obligations to not discharge groundwater into sanitary sewer systems.
- A reduction in development review timelines.



OPPORTUNITY FOR IMPROVEMENT

- ❑ By-law requirements that consider the cost implications of managing groundwater and are sufficiently clear and transparent that a detailed review of the project by the City is not required.

4 PROTECT AQUATIC ECOSYSTEMS



KEY ISSUE

Groundwater provides critical baseflow to aquatic ecosystems. When groundwater is diverted to the sewer, or when rain cannot infiltrate the ground, it reduces the amount of water in the ecosystem, impacting aquatic life. Groundwater may also impact habitat through alterations to water quality. For example, contaminants within groundwater may be collected and discharged to receiving bodies via I&I, and groundwater also contributes to combined sewer overflows.



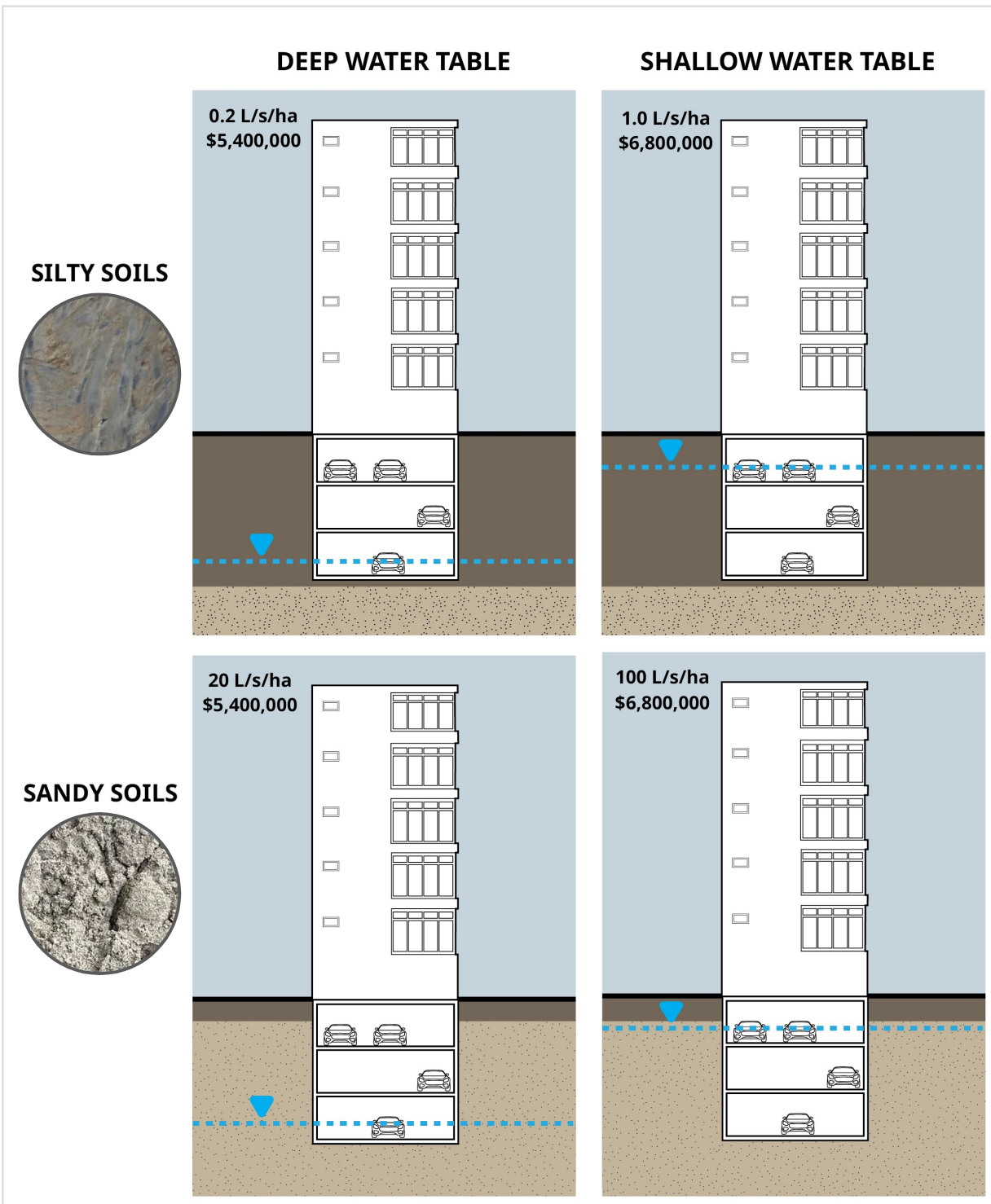
DESIRED FUTURE STATE

- Groundwater diversions to sewers are minimized, and water quality is monitored to limit impacts to receiving bodies.
- Stormwater is preferentially managed through infiltration into the ground to reduce the burden on City utilities and to enhance aquifer recharge.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Requirements or incentives for managing stormwater via infiltration.
- ❑ Requirements to monitor and report groundwater quality.



NO ONE-SIZE-FITS-ALL APPROACH

The volume of groundwater that may be collected by a building foundation drainage system can vary based on how deep the water table is, and the soil or material that surrounds the building.

Foundation "tanking" is a groundwater management solution that generally involves:

- waterproofing the underground portion of the building,
- designing the building foundation walls and slab to withstand hydrostatic pressure, and
- designing the building to resist uplift associated with buoyancy.

"Tanking" is one approach to groundwater management in areas with a high water table and relatively high estimated groundwater inflow rates (e.g., in sandy soils).

However, this approach can add millions of dollars to building construction costs. It can be difficult to justify the added expense of tanking a foundation for a new development in locations with a deeper/lower water table (left of Figure 3) or in areas where groundwater flows through the natural soil more slowly (top of Figure 3).

Estimated construction costs for a "tanked" foundation, and associated reduction in groundwater discharge to the sewer:

- Based on a 0.16 ha site area.
- Rates (L/s/ha) are groundwater discharges to sewer avoided by constructing a "tanked" foundation below the water table.
- Dollar values are estimated costs to "tank" the foundation below the water table.
- Costs are in addition to the "base case" for conventional underground construction (estimated to be \$14.9M for a 0.16 ha site).

Figure 3. Tanked foundations: construction costs and discharge reduction.

DRIVER 2: MITIGATE AND ADAPT TO RISKS

INTRODUCTION

A number of groundwater-related hazards currently exist within Vancouver, including the potential for land subsidence due to groundwater diversions and flowing artesian conditions (see case study, below). In the coming years, climate change is expected to introduce new groundwater-related hazards, including saltwater intrusion and groundwater rise, and may worsen the risks posed by existing hazards. To effectively mitigate and adapt to these hazards, additional work is needed to better understand groundwater, how it interacts with the local built environment, and how future stressors like climate change will affect this interaction.

CASE STUDY



Beechwood, J. Payne, Vancouver Sun

The Beechwood Street incident

In 2015, a private contractor drilled into the Quadra Sands Aquifer and encountered groundwater under pressure, which is known as flowing artesian conditions^[15] (see Figure 4 on page 17). Millions of litres of water were brought to the surface each day, requiring significant effort to contain and divert this water to sewers. Additionally, neighbouring homes had to be evacuated temporarily because of the risk of sinkhole formation. By the time the flow was brought under control several years later, significant costs were accrued by the property owner (over \$1 million) and the City (over \$12 million). Following this incident, the Province issued an advisory for portions of Vancouver, Burnaby, and New Westminster to educate others about this risk (see Map 2).

POLICY ALIGNMENT

EMERGENCY AND DISASTER MANAGEMENT ACT

2024 HAZARD, RISK AND VULNERABILITY ANALYSIS

SEA LEVEL RISE
RISK RATING: LOW

By characterizing the scale and extent of groundwater rise, the City can proactively manage risks associated with sea level rise

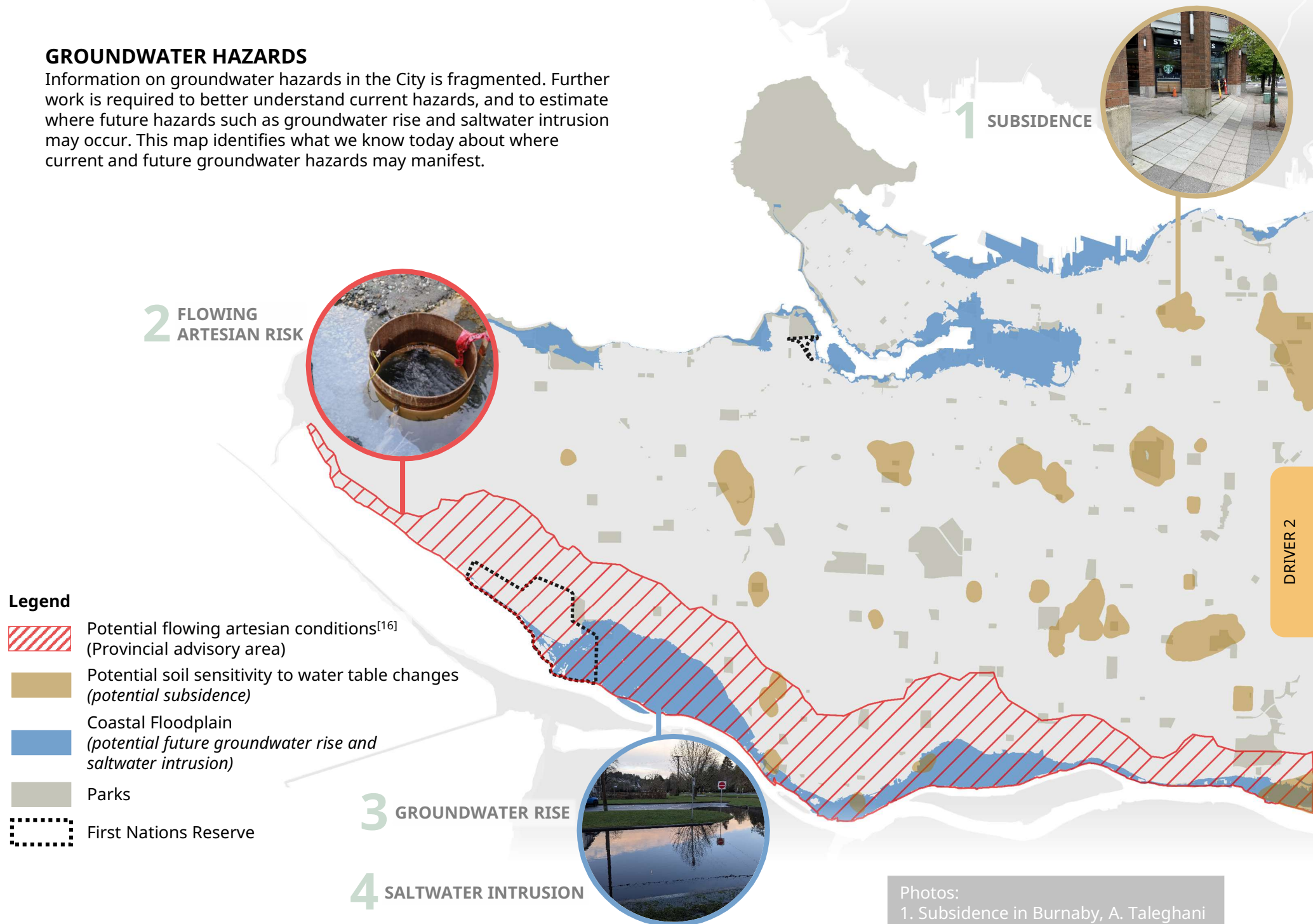
Other City strategic initiatives related to this driver that the Groundwater Strategy builds upon:



The *Climate Change Adaptation Strategy 2024-2025 Update and Action Plan* identified groundwater management as a potential means to address several risks identified by the *Hazard, Risk and Vulnerability Analysis*.

GROUNDWATER HAZARDS

Information on groundwater hazards in the City is fragmented. Further work is required to better understand current hazards, and to estimate where future hazards such as groundwater rise and saltwater intrusion may occur. This map identifies what we know today about where current and future groundwater hazards may manifest.



Map 2. Potential current and future groundwater-related hazards.

CURRENT AND FUTURE HAZARDS RELATED TO GROUNDWATER

The City is actively working to manage current groundwater-related hazards but must continue to learn about their scale and extent to proactively manage risks. As our interactions with groundwater change in the future, current hazards may evolve and risks levels change. Future hazards have also been identified by City staff as a potential threat to people, property, and/or infrastructure that should be understood and planned for.

CURRENT HAZARD: SUBSIDENCE



KEY ISSUE

Ground settlement may occur in certain areas of the city due to consolidation of certain soil types, decay of organic matter (including peat), or soil erosion (e.g., migration of soil into a void, potentially triggering sinkholes). Pumping of groundwater (i.e., dewatering) has the potential to negatively impact these mechanisms and increase the rate and amount of settlement. Where ground settlement occurs, neighbouring buildings and infrastructure may be vulnerable to damage and require costly repairs.



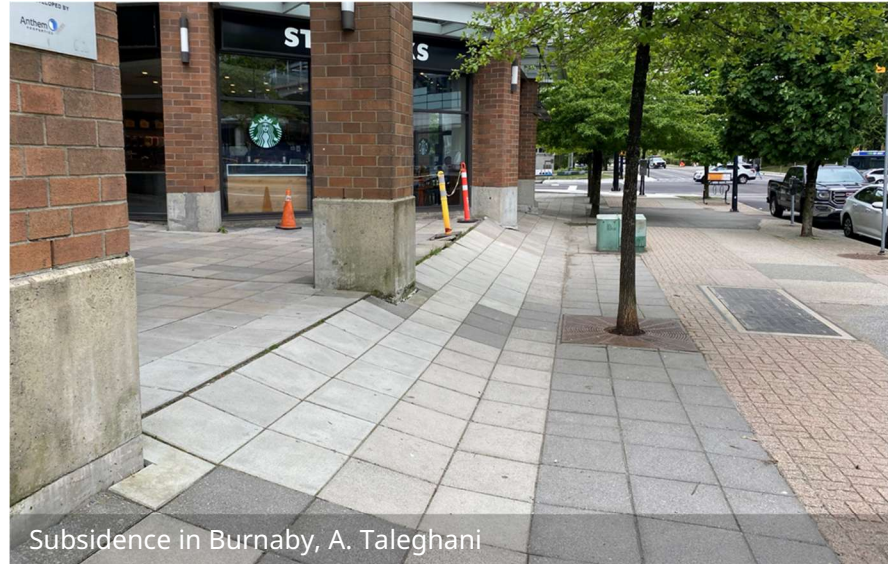
DESIRED FUTURE STATE

- The areas at risk of subsidence due to groundwater dewatering are known by the development community, and risks are managed according to best practices.
- Risks are considered during land use planning.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Increased awareness in the development community of the potential for subsidence induced by temporary and permanent groundwater diversions.
- ❑ Consideration of subsidence risk in area plan/policy documents.
- ❑ Allowance for additional above-grade density to offset loss of below-grade space, where risks exceed tolerances.

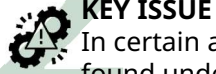


Subsidence in Burnaby, A. Taleghani



Subsidence in East Vancouver, P. Lingl

CURRENT HAZARD: FLOWING ARTESIAN GROUNDWATER



KEY ISSUE

In certain areas of the city, groundwater is naturally found under enough pressure to rise above the ground surface when disturbed by drilling or excavation. This is known as flowing artesian groundwater and can result in issues including flooding and sinkhole formation (such as occurred at Beechwood Street) and is shown schematically in Figure 4. Additional work is needed to better understand where this hazard may be present in the city and mitigate local risks.



DESIRED FUTURE STATE

➤ The extent of flowing artesian conditions is understood, and risks are communicated to relevant industries. If/where necessary, risk mitigation planning is carried out.



OPPORTUNITIES FOR IMPROVEMENT

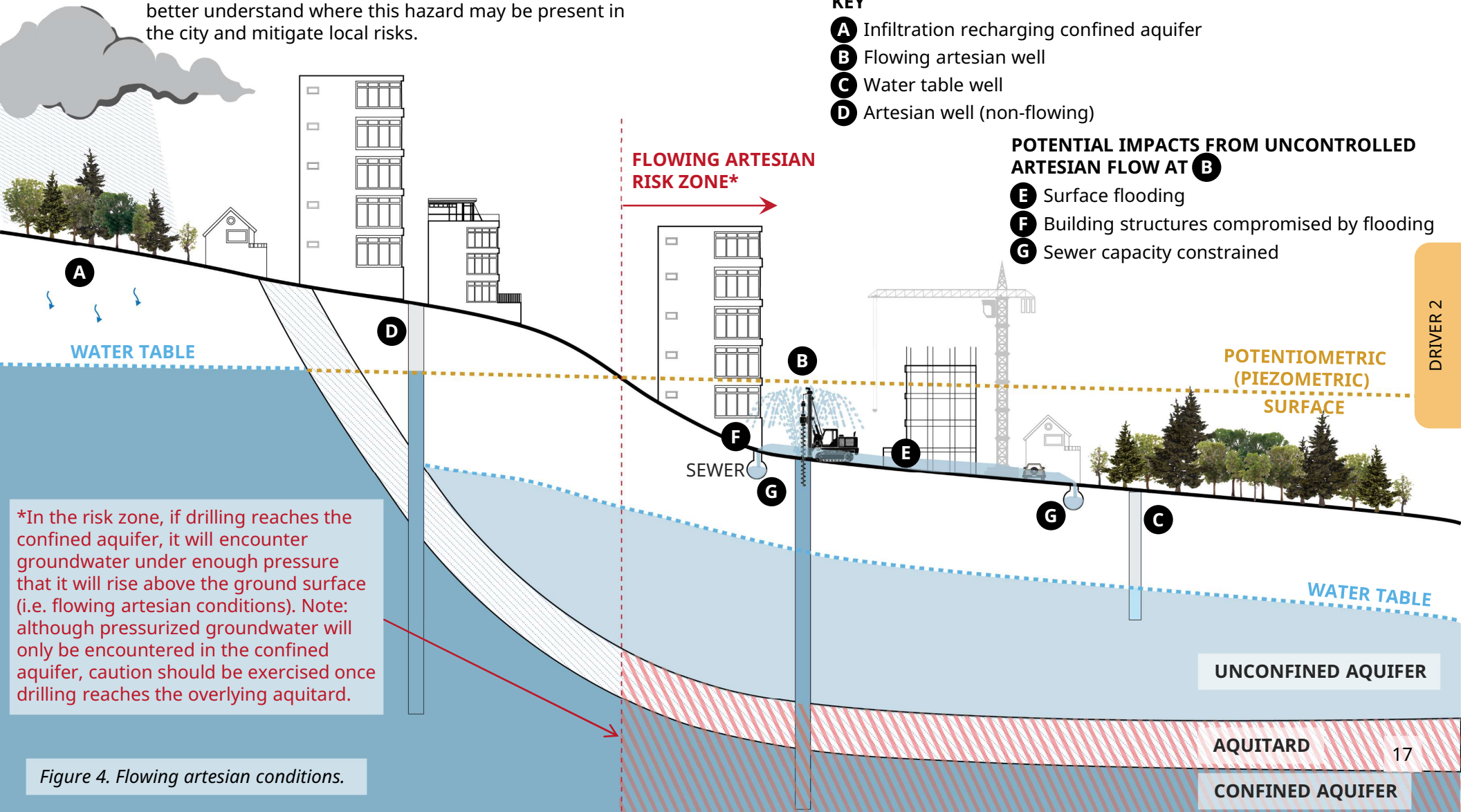
- ❑ Understanding of the aerial extent, depth, and pressure of the portions of the Quadra Sands Aquifer that exhibit flowing artesian conditions.
- ❑ Improve public, developer, and contractor awareness.

KEY

- A** Infiltration recharging confined aquifer
- B** Flowing artesian well
- C** Water table well
- D** Artesian well (non-flowing)

POTENTIAL IMPACTS FROM UNCONTROLLED ARTESIAN FLOW AT **B**

- E** Surface flooding
- F** Building structures compromised by flooding
- G** Sewer capacity constrained



DRIVER 2

*In the risk zone, if drilling reaches the confined aquifer, it will encounter groundwater under enough pressure that it will rise above the ground surface (i.e. flowing artesian conditions). Note: although pressurized groundwater will only be encountered in the confined aquifer, caution should be exercised once drilling reaches the overlying aquitard.

Figure 4. Flowing artesian conditions.

FUTURE HAZARD: GROUNDWATER RISE



KEY ISSUE

Vancouver is anticipating half a metre of sea level rise by 2050, and one metre by 2100^[17]. Groundwater levels in coastal areas are anticipated to rise as sea level rises, potentially resulting in deterioration of buried infrastructure leading to decreased service life, reduced sewer capacity, increased overland flood risk for low lying areas, below-grade flooding and moisture ingress, geotechnical impacts including increased earthquake liquefaction susceptibility, and potential contaminant mobilization/migration, shown in Figure 5.



DESIRED FUTURE STATE

➤ Buildings and infrastructure along Vancouver's coastline are protected from the impacts of groundwater rise induced by sea level rise.



LEADING PRACTICE

Oahu, Hawaii, USA^[18]

Groundwater rise induced by sea-level rise has been identified as a threat to people, property, and infrastructure throughout the island of Oahu. There are plans to map the most vulnerable areas, with mitigation strategies including raising street levels and the expansion of drainage canals.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Assessment of areas prone to groundwater rise induced by sea level rise.
- ❑ Mitigation/adaptation strategies for at-risk infrastructure.
- ❑ Policy related to new construction in high-risk areas.

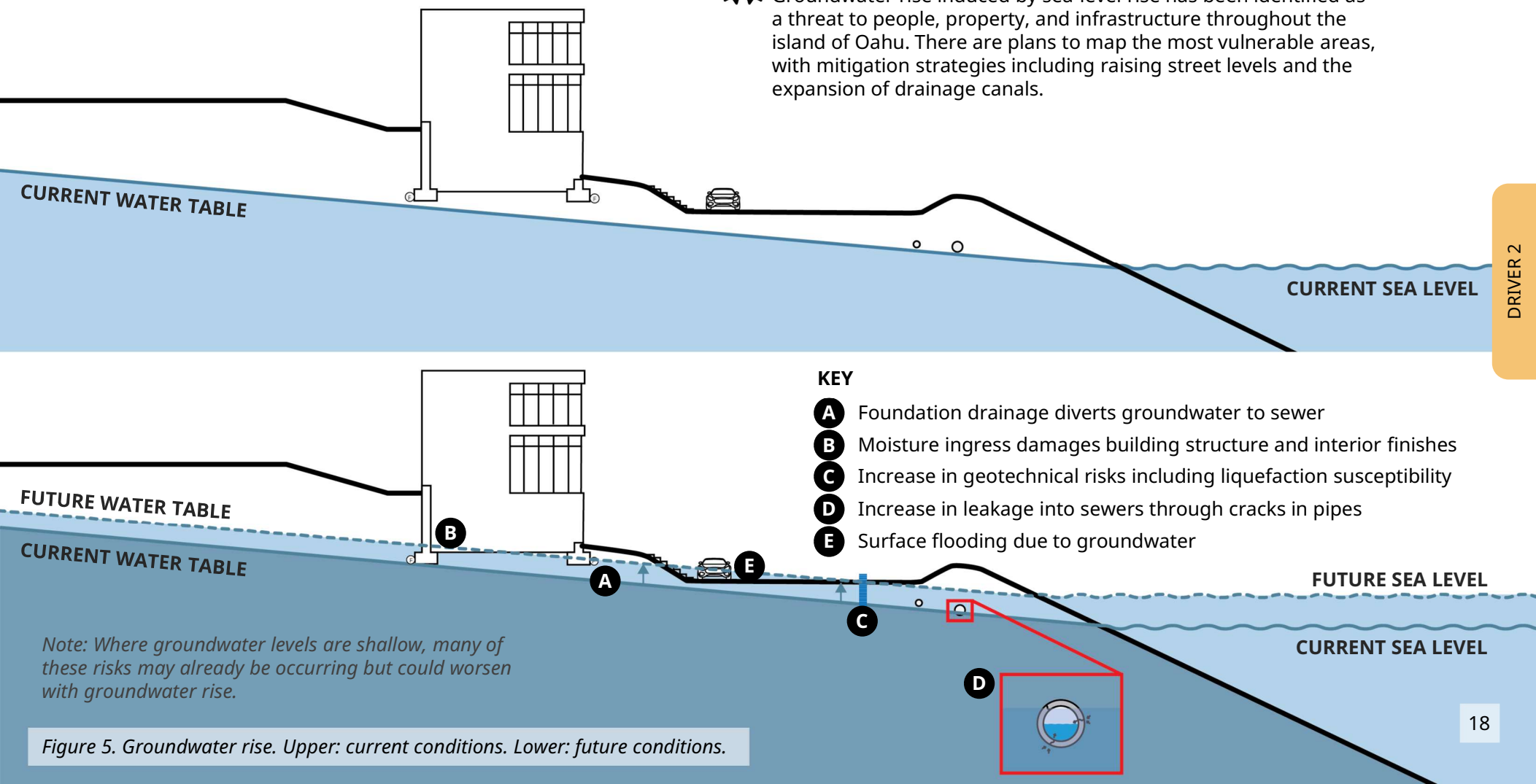
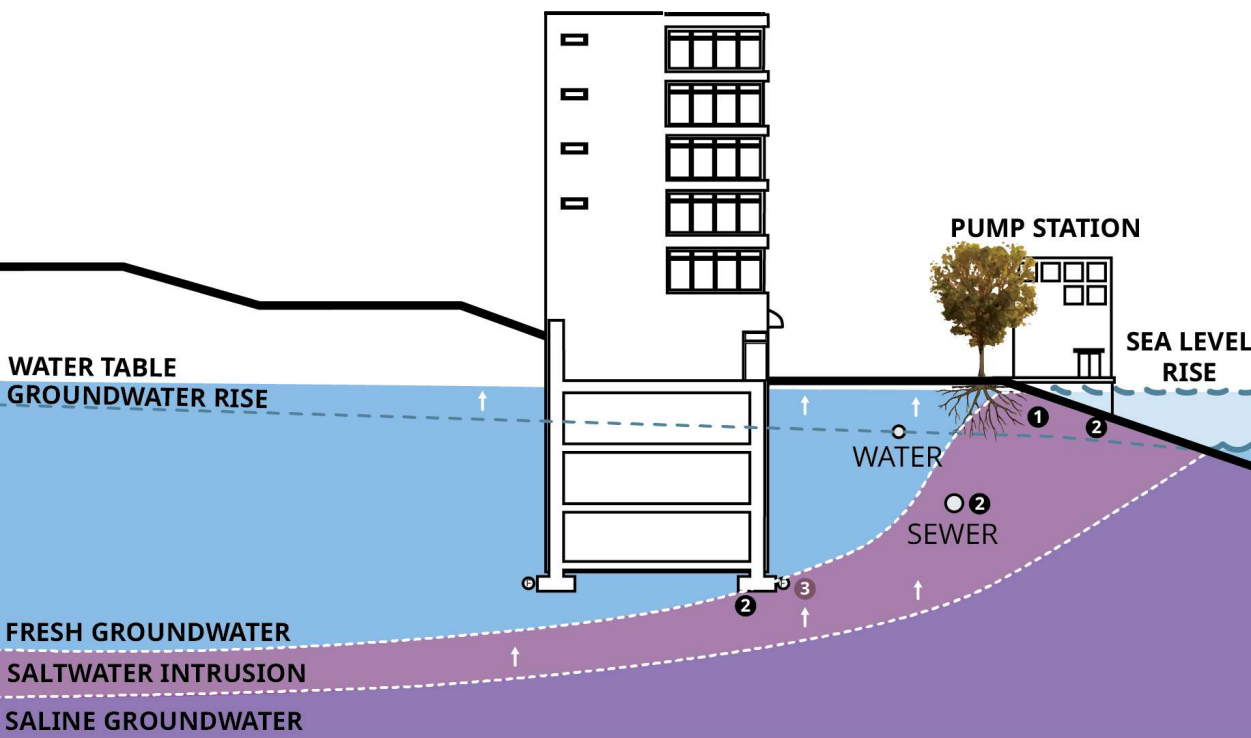
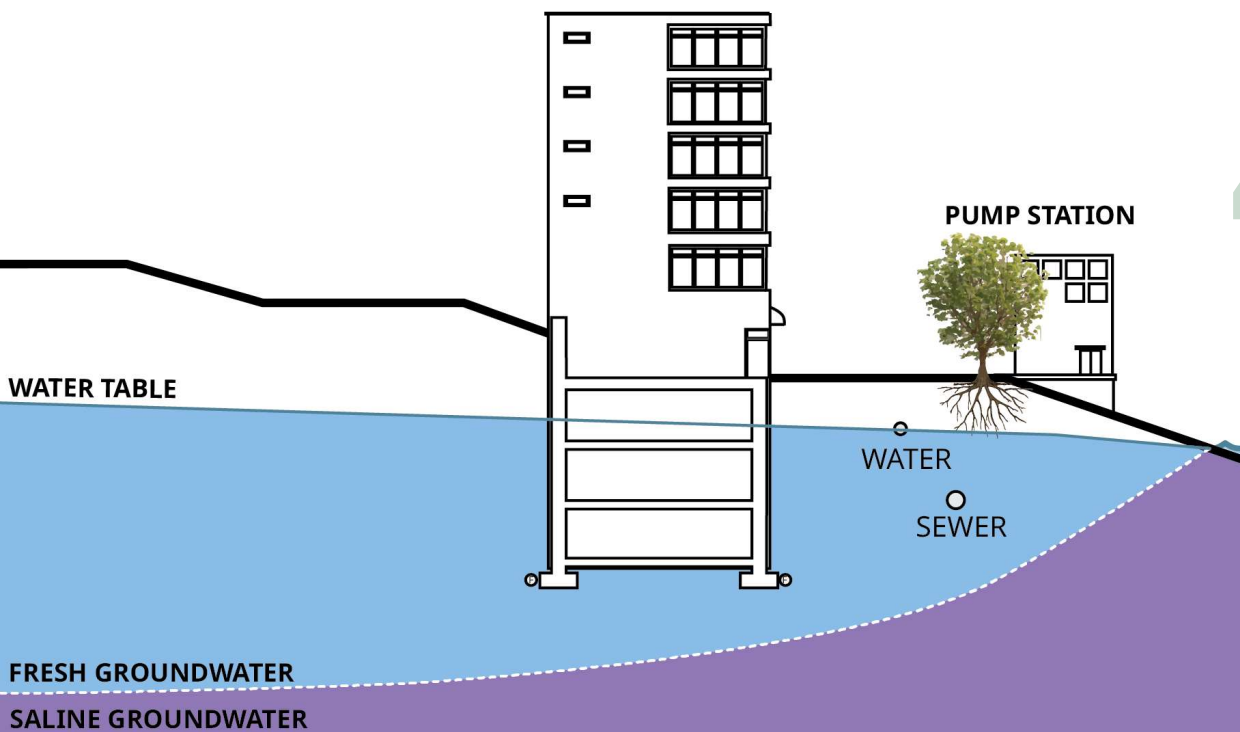


Figure 5. Groundwater rise. Upper: current conditions. Lower: future conditions.



4 FUTURE HAZARD: SALTWATER INTRUSION

KEY ISSUE

As sea level rises, or groundwater becomes depleted, salty groundwater that exists naturally beneath the coastline will move inland, shown in the lower portion of Figure 6. This issue, known as saltwater intrusion, poses a threat to critical infrastructure and buildings. Increased groundwater salinity can accelerate corrosion and deterioration of buried infrastructure and buildings, resulting in a reduced service life and costly remediation. A change in groundwater chemistry may also have negative impacts on nearby groundwater-dependent ecosystems, and will impact the potential for future groundwater use.

DESIRED FUTURE STATE

- At-risk buildings and infrastructure along Vancouver's coastline are protected from the impacts of saltwater intrusion.

OPPORTUNITIES FOR IMPROVEMENT

- ❑ Assessment of the areas prone to saltwater intrusion induced by sea level rise.
- ❑ Mitigation/adaptation strategies for at risk infrastructure.
- ❑ Policy related to new construction in high-risk areas.

KEY

- 1 Saline groundwater stresses plant health
- 2 Saline groundwater corrodes infrastructure and buildings
- 3 Foundation drainage pumps saline groundwater to sewers

Figure 6. Saltwater intrusion. Upper: current conditions. Lower: future conditions.

DRIVER 3: USE GROUNDWATER STRATEGICALLY AND SUSTAINABLY

INTRODUCTION

The City of Vancouver has piloted using groundwater for a handful of non-potable use applications such as irrigating golf courses and flushing toilets in some City facilities. As Vancouver densifies, population growth will add demand for potable water while climate change reduces the availability of drinking water sources. Exploring the potential for using groundwater for non-potable purposes to offset this growing demand, as well as a potential back-up potable water source for emergency use, may be beneficial to support water security and enhance future climate resilience. To use groundwater as an alternative water source, groundwater resources of suitable quality and quantity must be located, characterized, and protected.

CASE STUDY



Due to the volume of potable water saved, Oakridge Park is a great example of using alternative sources for non-potable purposes. The site will consume approximately 40% less potable water by using groundwater and rainwater for non-potable uses. It is estimated that the development may use 300 million litres of groundwater and 50 million litres of rainwater per year for the non-potable water system^[19], which will supply water for all of the on-site toilets and urinals, cooling towers, car wash, and irrigation, as well as limited use for residential laundry.

POLICY ALIGNMENT

EMERGENCY AND DISASTER
MANAGEMENT ACT

2024 HAZARD, RISK AND
VULNERABILITY ANALYSIS
DROUGHT
RISK RATING: MEDIUM

By working towards using groundwater strategically and sustainably as an alternative resource, the City can manage water demand more cost-effectively.

Other City strategic initiatives related to this driver that the Groundwater Strategy builds upon:



STRESSED WATER SUPPLY



KEY ISSUE

Metro Vancouver is expected to face significant water supply challenges as climate change reduces snowpack by an estimated 56% by 2050^[20]. At the same time, longer and drier summers are likely to increase the frequency and severity of droughts, leading to more frequent restrictions on potable water use (Figure 7). Population growth will further intensify demand, potentially requiring costly investments in new infrastructure. Together, these pressures are expected to both increase demand for potable water and decrease availability, prompting a need to explore alternative supplies. Regional and municipal strategies already emphasize diversifying water sources, particularly for non-potable uses. Groundwater presents a viable opportunity to offset potable water demand for activities that do not require treated drinking water. Currently, substantial volumes of potable water are used for non-potable purposes. Expanding the use of groundwater for purposes like irrigation, street cleaning, toilet flushing, and certain industrial applications, would help to conserve limited potable water resources for essential uses.



DESIRED FUTURE STATE

- The City has a comprehensive understanding of local groundwater resources, including the quantity of groundwater that could be sustainably extracted.
- Rainwater infiltration is increased throughout the City (e.g., through construction of green rainwater infrastructure and/or a reduction of impervious area) which supports replenishing local aquifers and connected natural areas.
- Key groundwater recharge areas are protected to ensure adequate replenishment of the resource.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ An expanded conceptual model of Vancouver geology, monitoring of groundwater levels, and an assessment of how extraction may impact local ecosystems.
- ❑ Updated City rainwater management requirements to incentivize infiltration solutions to manage stormwater.
- ❑ Comprehensive information about infiltration potential, to help encourage and plan green rainwater infrastructure.
- ❑ Reduced setbacks requirements for infiltration features, where feasible.
- ❑ An assessment of aquifer recharge across the city.
- ❑ Land-use and development policies that encourage the preservation of absorbent landscapes in areas of significant aquifer recharge.

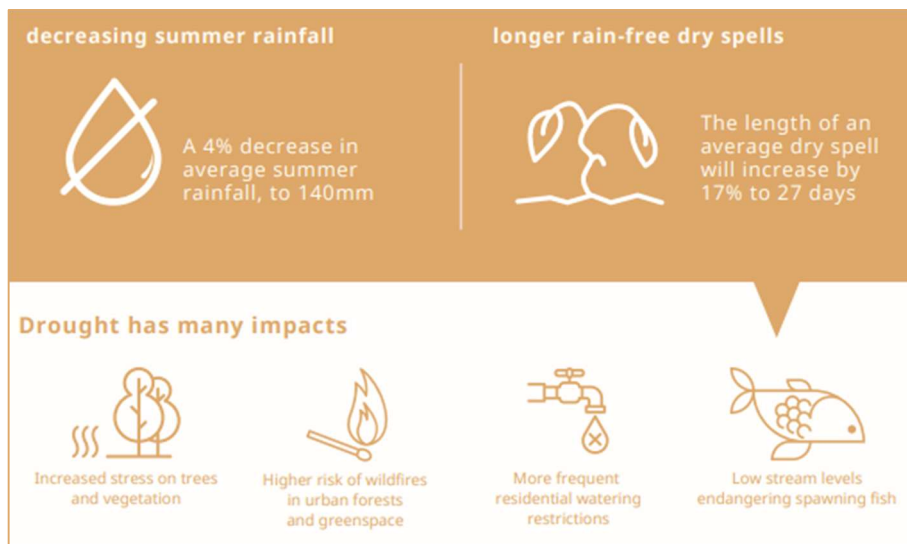


Figure 7. What to expect in Vancouver by the 2050s (Climate Change Adaptation Strategy 2024-2025 Update and Action Plan).



Capilano Lake reservoir (2015), CBC

EMERGENCY DRINKING WATER SUPPLY



KEY ISSUE

Groundwater has the potential to act as a back-up potable water source in the event of an emergency, such as an extended drought or earthquake. Local aquifers could be used to stretch our water supplies through the longer summers that are expected due to climate change (Figure 7). Emergency-use wells could access groundwater in aquifers beneath the city, which are less susceptible to damage during an earthquake. As they are local, there is a reduced need for infrastructure to convey groundwater to its destination. Several earthquake-prone jurisdictions that predominantly rely on surface water for their potable water source include groundwater as a backup supply for these reasons (e.g., Japan^[21] and California^[22]).



DESIRED FUTURE STATE

➤ Emergency supply wells are strategically located throughout the city, for use in an emergency. To ensure the wells are in good working order in the event they are needed, these wells would be used regularly in non-emergencies for non-potable purposes.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Groundwater resources are well characterized and protected (e.g., with groundwater protection zones).
- ❑ Specific facilities and/or locations that would be ideal candidates for emergency groundwater use are identified and cross-referenced with information about groundwater availability.
- ❑ Emergency supply wells are installed and equipped for emergency use and used regularly for non-potable purposes to ensure adequate maintenance and testing.



LEADING PRACTICE

San Francisco, California, USA^[23]

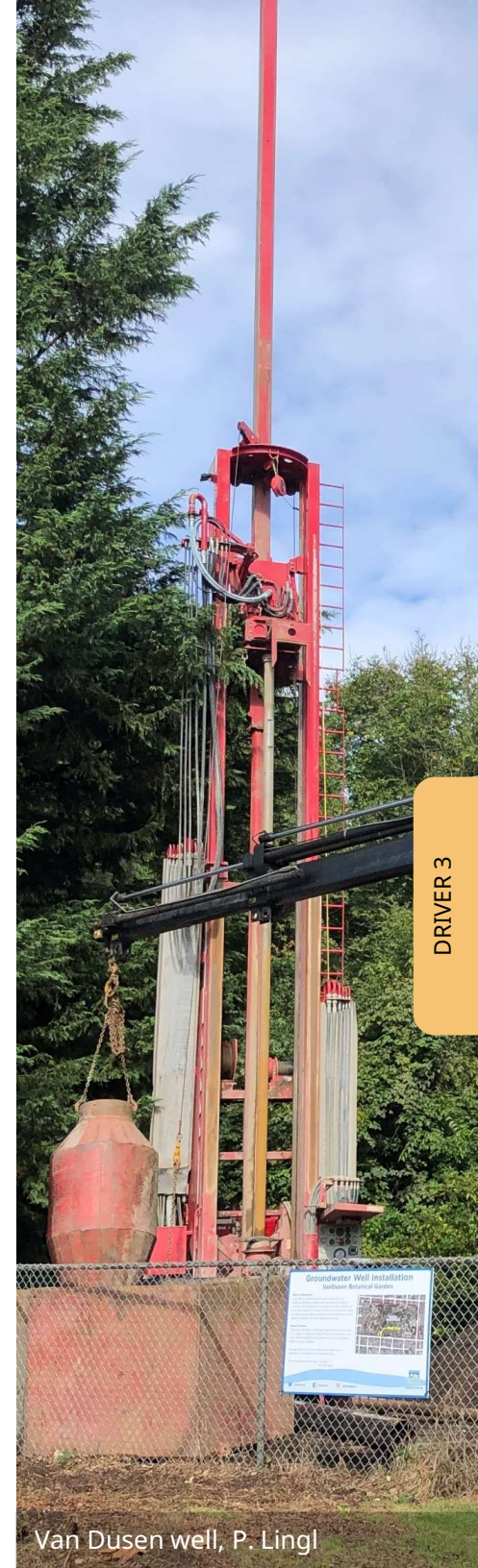
The San Francisco Public Utilities Commission has six wells where groundwater is extracted for use. One of the wells has onsite disinfection for use during an emergency. The utility intends to increase groundwater use to make their supply more diverse, and resilient to natural disasters. San Francisco is also one of the leading US cities in implementing non-potable water systems and has several district-scale projects that utilize water from foundation drainage. All new large developments must install a non-potable water system for toilet flushing and irrigation.



LEADING PRACTICE

Delta, British Columbia, Canada^{[24][25]}

The City of Delta has several wells to provide drinking water to residents and that can act as an emergency water source. These wells provide water at a lower cost than purchasing from Metro Vancouver. They are currently investigating additional areas for emergency supply.



CONTAMINATION



KEY ISSUE

Groundwater contamination can impact if and how groundwater can be used; it can also potentially migrate to sensitive habitats such as fish-bearing streams. In general, anthropogenic (human-induced) contamination in groundwater can come from point sources, such as improper management of chemicals/waste, or non-point sources, which are cumulative impacts from diffuse pollution that find their way to the aquifer. Examples of point sources of contamination are leachate from landfills, leaks of petroleum products at service stations, and legacy contamination at industrial sites. Examples of potential non-point source contamination includes urban run-off, which can contain hydrocarbons or tire compounds, or the repeated and prolonged use of fertilizers or chemical pesticides. Groundwater can also be unfit for use due to natural processes that result in elevated levels of elements such as arsenic, iron and manganese. Understanding where groundwater quality is currently not suitable, where groundwater may be more susceptible to new contamination, and how we can responsibly manage the use of potential contaminants or find alternatives, are key to protecting groundwater quality and for determining if and where groundwater may be used.

DESIRED FUTURE STATE

- Groundwater resources with adequate quality and quantity for use are protected from future contamination from widely-known and emerging contaminants.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Mapping of aquifer areas vulnerable to contamination.
- ❑ Public education on the impacts of contamination (e.g., to groundwater resources and ecosystems).
- ❑ City policies or procedures related to using the least toxic chemical available for a specific task.



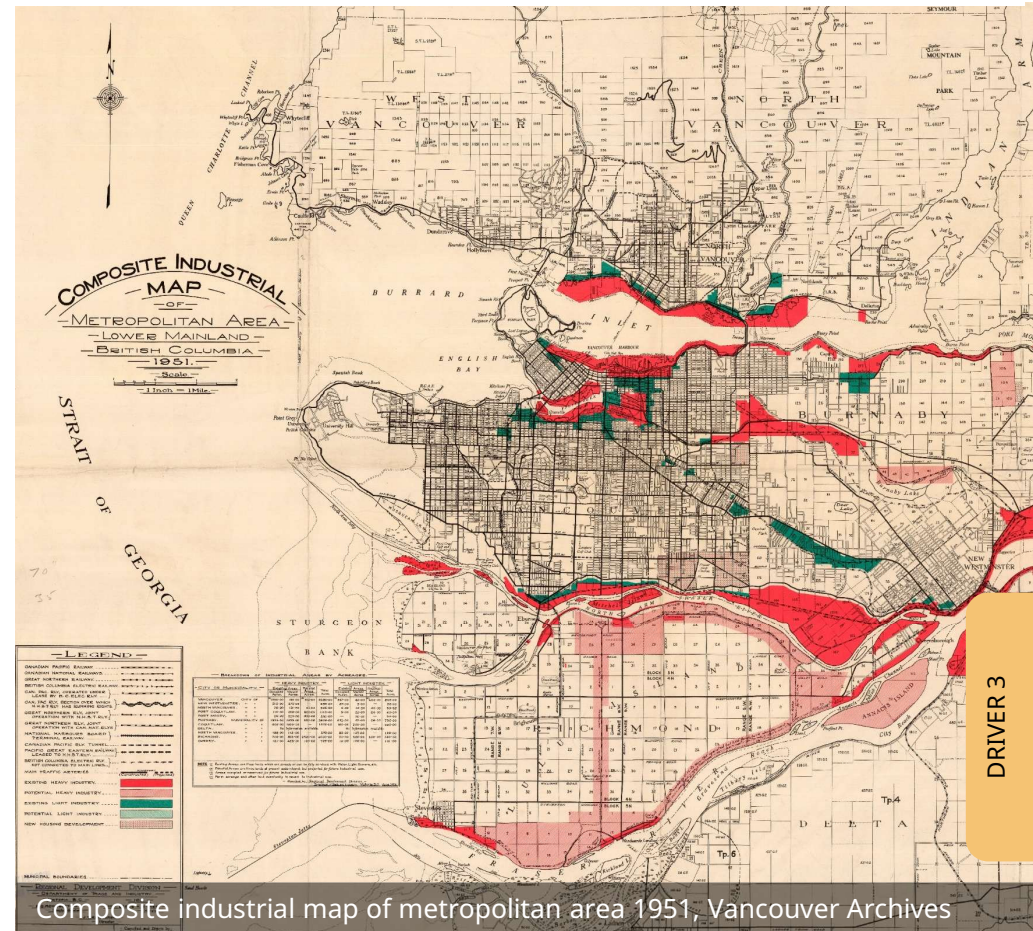
Legend



Heavy Industrial



Light Industrial



LEGACY CONTAMINATION

Chemical handling practices from historical industrial activities have left contamination in soil, sediment, and groundwater in some areas across the city. This legacy contamination limits how the land and groundwater can be used today. The protection of suitable groundwater resources is vital to ensuring they can be used, when needed, for years to come.

DRIVER 4: PROTECT ECOSYSTEMS AND ENVIRONMENT

INTRODUCTION

Historically a temperate rainforest, Vancouver was once shaped by a dense network of ravines, streams, and wetlands that were sustained by groundwater and performed critical ecological functions, including natural drainage, wildlife habitat provision, and fish spawning. Urbanization has filled in or buried most of these watercourses in pipes and has resulted in groundwater being diverted to the sewer, away from downstream ecosystems. This has disrupted natural groundwater–surface water connections and left very few streams intact. Still Creek, for example, is one of the City’s last salmon-bearing streams, and its health depends on groundwater inputs during dry periods to maintain flow and to regulate temperature. Groundwater plays a foundational role in the natural water cycle by linking surface water, soils, vegetation, and aquatic habitats, and by sustaining both terrestrial and aquatic ecosystems. Healthy ecosystems provide a suite of community benefits—including improved water quality, reduced flood and erosion risks, habitat for diverse species, access to nature and community well-being. In turn, these ecosystems help preserve groundwater by supporting infiltration and recharge processes (e.g., through vegetation, intact soils, and wetland function), which protect the long-term capacity of groundwater to support communities. Integrating ecosystem needs—including the preservation of groundwater recharge and discharge functions—into watershed-based land use planning can help protect and restore the health of ecosystems, and support mitigation and resilience to climate change.



Still Creek, C. Kimmel, Alpine Edge Photography

Other City strategic initiatives related to this driver that the Groundwater Strategy builds upon:



CLIMATE CHANGE AND GROUNDWATER-DEPENDENT ECOSYSTEMS



KEY ISSUE

Vancouver's natural assets are critical to supporting climate change mitigation and resilience. As climate projections indicate longer, hotter, and drier summers, local ecosystems such as wetlands, streams, riparian areas, are expected to experience increased reliance on groundwater to maintain ecological function. Groundwater provides a steady source of water during dry periods when surface flows decline (Map 3). Urban trees and vegetation similarly depend on shallow groundwater to support growth, health, and drought resilience. Protecting and managing groundwater resources and in turn, these natural areas is therefore essential to achieving urban forest canopy targets and maintaining ecosystem services and community benefits such as urban cooling, stormwater management, air and water quality improvements, recreational opportunities, and equitable access to nature.



DESIRED FUTURE STATE

- There is an understanding of which ecosystems across the city are reliant on groundwater, and groundwater preservation efforts are prioritized in these areas.



OPPORTUNITIES FOR IMPROVEMENT

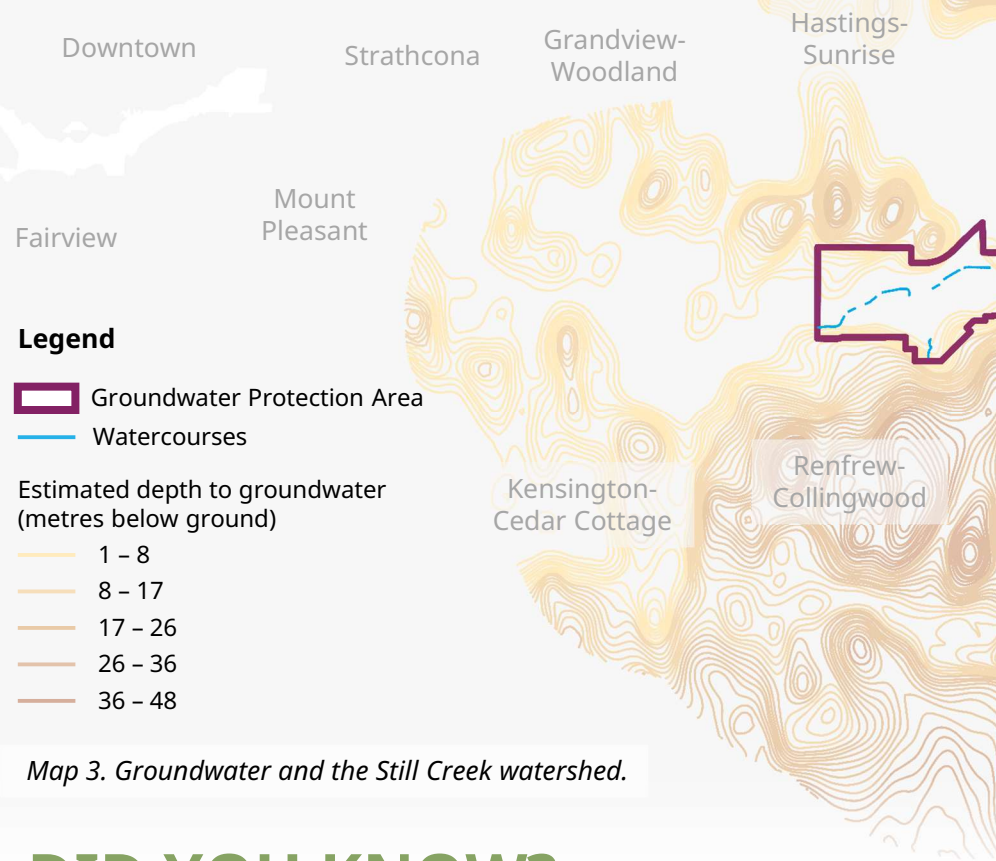
- ❑ A conceptual understanding of how groundwater interacts with specific ecosystems.
- ❑ Knowledge sharing (internally and externally) to improve the understanding of why groundwater is important to our natural systems.



LEADING PRACTICE

Vancouver Island, British Columbia, Canada^[26]

A groundwater curtailment model was developed for the Koksilah River watershed to protect aquatic life, including salmonid species. The model informed restrictions on groundwater use that had demonstrated positive impacts on streamflow.



Map 3. Groundwater and the Still Creek watershed.

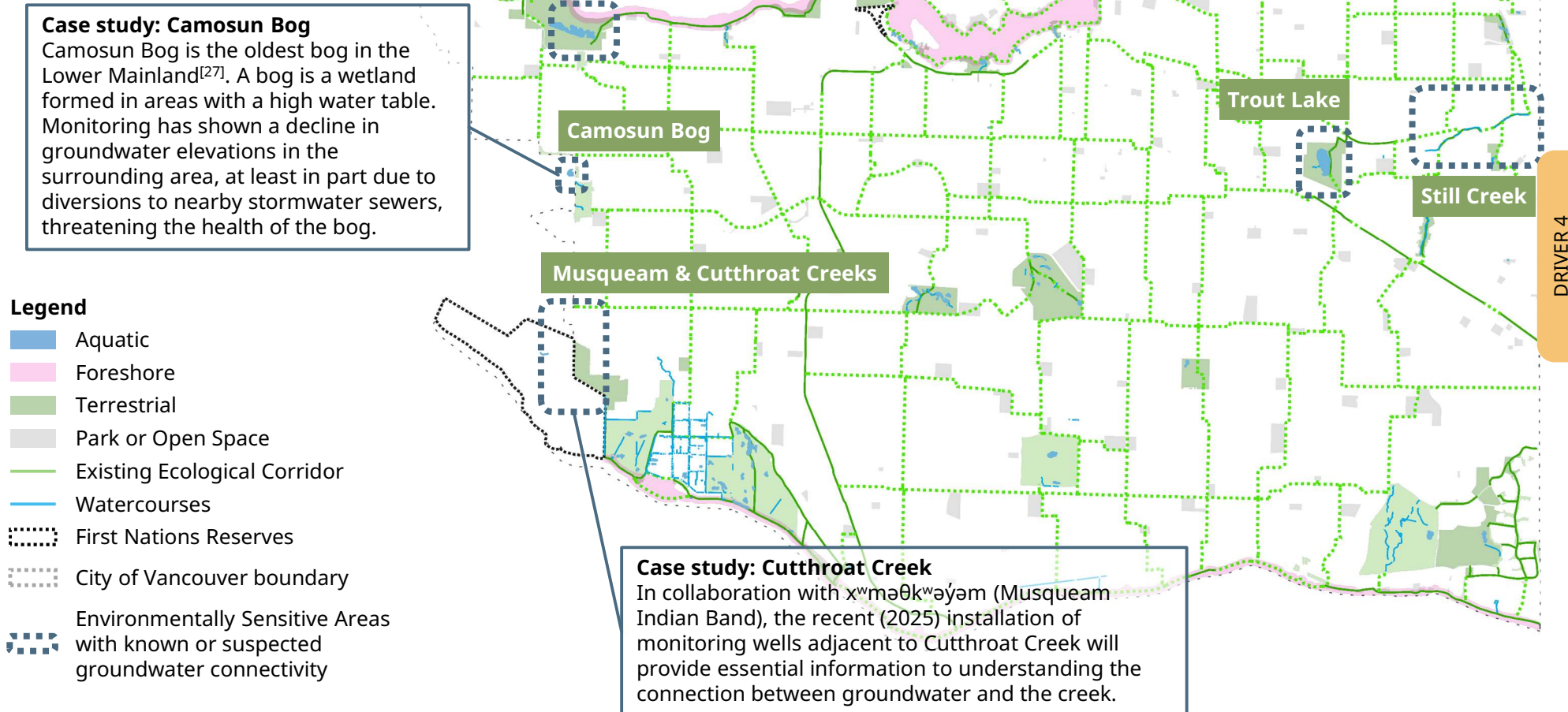
DID YOU KNOW?

Through the development of the Rupert and Renfrew Station Area Plan, the City's groundwater flow model was refined for the Still Creek watershed. The model was used to estimate groundwater depth and map critical groundwater flow paths, which led to establishment of the Groundwater Protection Area (GPA).

New developments within the GPA are subject to limits on development depth, below-grade setbacks from Still Creek, and prescriptive groundwater management requirements to protect groundwater baseflow to the watercourse. A similar process could be replicated for other ecosystems that are dependent on groundwater in the City.

ENVIRONMENTALLY SENSITIVE AREAS

The Official Development Plan (ODP) includes direction to develop a management approach for Environmentally Sensitive Areas (ESAs). Expanding the City's existing groundwater flow model could help characterize groundwater interactions with ESAs and adjacent sensitive areas, similar to what was done for Still Creek (Map 3). An increased understanding of this connectivity could support decision making and inform land use policy or planning tools to protect these ecosystems.



LAND USE PLANNING



KEY ISSUE

The early steps of embedding ecosystem management and protection into land-use planning have been achieved through prior planning efforts (e.g., Rupert & Renfrew Area Plan) as well as the more recent adoption of the City of Vancouver's first Official Development Plan (ODP). The ODP envisions an enhanced and connected Ecological Network that includes environmentally sensitive areas and other natural areas and features that may have a range of reliance on groundwater (Map 4). Not only do some natural areas rely on groundwater, but natural areas also play an important role in protecting groundwater resources. As the degree of connectivity between natural areas and groundwater becomes better understood, appropriate measures to protect groundwater contributions to natural landscapes could be implemented. For example, policies that limit the depth of below grade structures or require infiltration to maintain groundwater recharge can help ensure that the support provided by groundwater to aquatic and terrestrial ecosystems is maintained (see Figure 8).



DESIRED FUTURE STATE

- There is a clear approach across the city for land use planning that considers the impacts of development on interactions between natural areas and groundwater.



OPPORTUNITY FOR IMPROVEMENT

- ❑ Policies and programs to protect and preserve groundwater in ecological areas that are dependent on it, which may include limits on building depth to maintain groundwater flow paths, and infiltration targets to preserve groundwater recharge.



LEADING PRACTICE

Toronto, Ontario, Canada^[28]

The Toronto and Region Conservation Authority developed the Terrestrial Natural Heritage System to establish, protect, and restore a connected network of natural cover across its jurisdiction. Supporting datasets were created to identify terrestrial, aquatic, and hydrological priorities, including mapping ecologically significant groundwater recharge areas to highlight critical linkages between terrestrial and aquatic systems.

GROUNDWATER DIVERTED TO SEWERS



KEY ISSUE

When buildings are constructed below the water table, natural groundwater flow patterns are impacted. During construction, the excavation area must be kept dry, thus groundwater is pumped from the excavation and discharged on a temporary basis to the municipal sewer system. After construction, groundwater is often collected by the building's foundation drainage systems and discharged on a permanent basis to the municipal sewer system (Figure 2). Under both scenarios, "nuisance" groundwater ends up in sewers, which diverts water away from critical downstream ecosystems such as creeks. Groundwater also contains naturally occurring dissolved minerals and constituents that can affect freshwater chemistry when discharged to surface water bodies. Additionally, groundwater can carry contaminants introduced into the ground from human activities. Together, changes to groundwater flow regimes (i.e., volumes and quality) can adversely impact natural environments.



DESIRED FUTURE STATE

- Initiatives to protect groundwater-dependent ecosystems are supported and prioritized.



OPPORTUNITY FOR IMPROVEMENT

- ❑ A regulatory Framework that aims to preserve groundwater contributions to ecosystems, which may include restrictions on groundwater diversion to sewer.



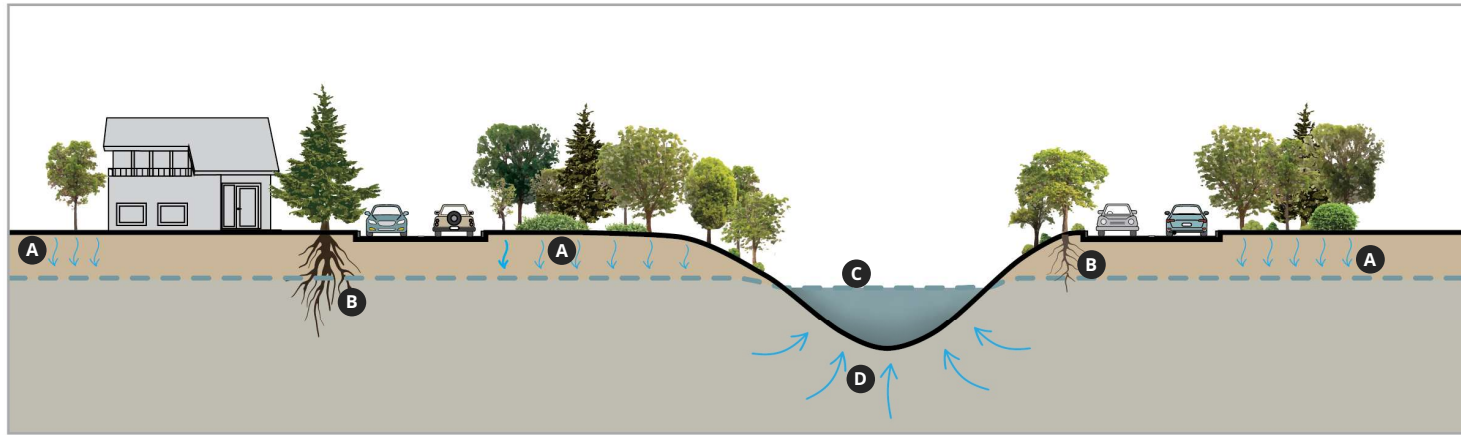
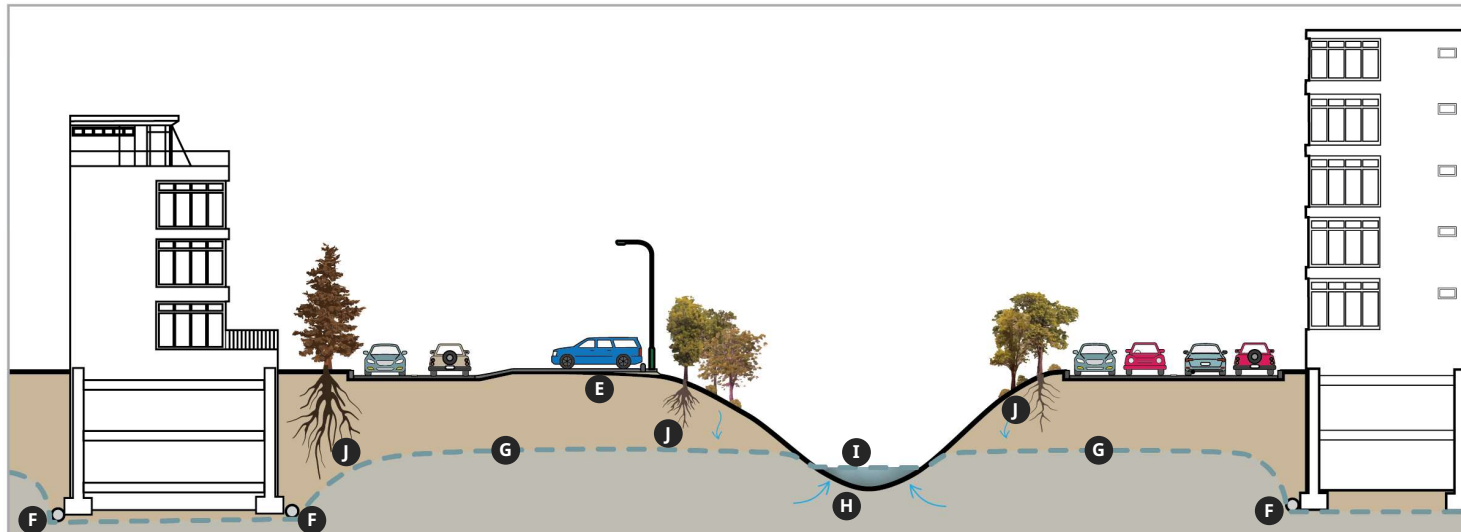
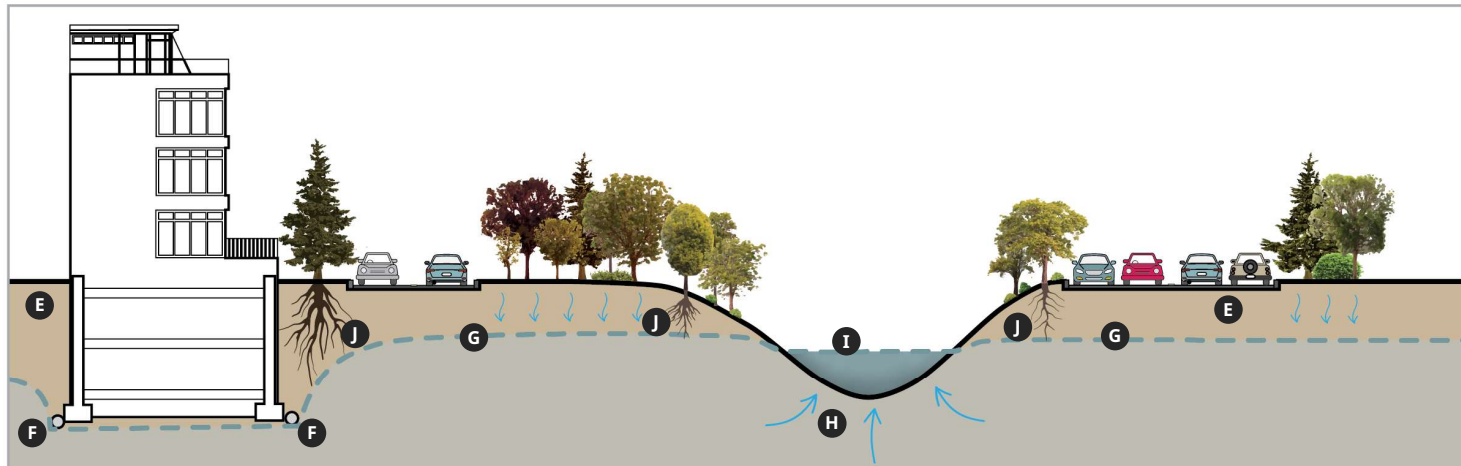


Figure 8. Reduced rainwater infiltration and increased groundwater diversions from increasing urbanization, resulting in lower water tables and various impacts to groundwater-dependent ecosystems – terrestrial and aquatic.



- A** Rainfall infiltration and groundwater recharge
- B** Uptake of groundwater by roots
- C** Gaining watercourse (receives water)
- D** Groundwater baseflow to watercourse
- E** Increased imperviousness and reduced infiltration and recharge
- F** Foundation drain diverting groundwater to sewer
- G** Lowered water table
- H** Reduced groundwater baseflow to watercourse
- I** Reduced water level in watercourse
- J** Reduced ability for roots to access groundwater

ACTION PLAN: DEVELOPING PHASE 1

DEVELOPING THE ACTION PLAN

To identify the specific steps the City will take to advance the Framework in response to the drivers, a multi-phase process was undertaken. This work integrated extensive research, broad stakeholder engagement, and technical analysis to produce a targeted, actionable, and realistic plan.

Generating a comprehensive set of actions

Engagement with the Staff Working Group (SWG) and Expert Panel (EP) resulted in significant discussion on the desired future state for a particular issue. The opportunities for improvement that were identified to reach that ideal future evolved into 300+ ideas for potential actions spanning topics from groundwater hazards, ecosystems, groundwater quality, preserving groundwater quantity, emergency use, general use (potable and non-potable applications), and sewer impacts.

Shortlisting priority actions

Refining 300+ ideas to a manageable number of actions required multiple rounds of evaluation by the Project Team, followed by additional review by the SWG and EP. To confirm the completeness and feasibility of the proposed actions and ensure that all viable options were considered, an external consultant was retained to complete jurisdictional research to explore groundwater management practices in other cities. The consultant identified redundant actions, and recommended additional actions where gaps were identified. Through this iterative process, the actions were consolidated into a set of 43 well-defined, discrete shortlisted actions that addressed the most significant and relevant risks and opportunities.

Technical analysis: deep dive on the shortlisted actions

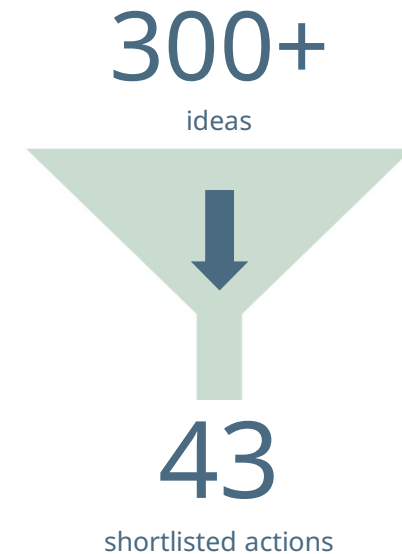
The consultant's subsequent scope of work included a cost-benefit analysis and development of high-level implementation considerations for the shortlisted actions (Appendix C).

➤ Cost-effectiveness prioritization

Benefits and indicative costs (Class D estimates) were evaluated across three categories: economic, social and environmental. Opportunities for financial savings were clearly identified in actions related to minimizing groundwater in the sewer system, avoiding rehabilitation costs for land and infrastructure, and reducing purchased water cost through strategic groundwater use. Opportunities for social and environmental benefits were highlighted in actions where limited or moderate capital investment was required and groundwater considerations could be integrated into existing City processes (e.g., engagement, partnerships, and enhancing infiltration).

➤ High-level implementation analysis

For each shortlisted action, the consultant assessed the recommended methodology or approach, expected duration and resource requirements (including costs), and key risks and dependencies in order to inform future implementation planning.



DEVELOPING PHASE 1

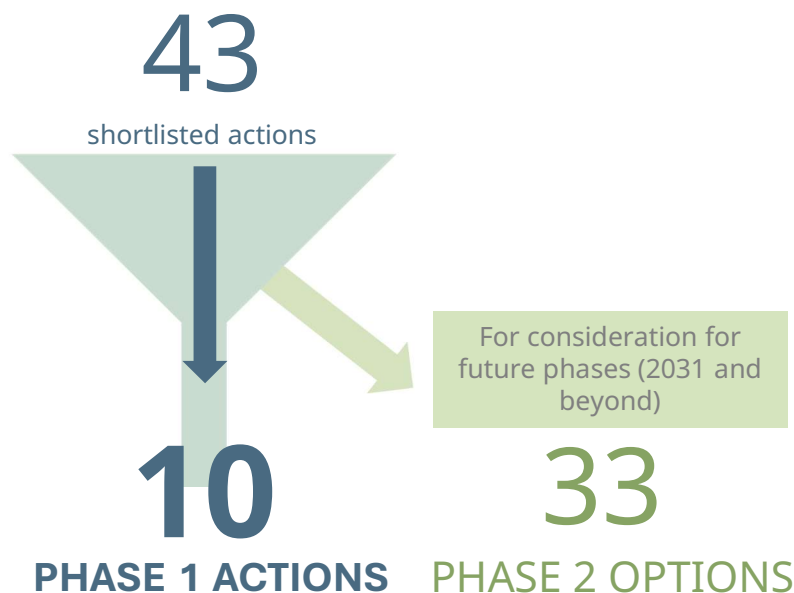
AN ADAPTIVE, PHASED APPROACH

The work to develop an extensive list of potential actions highlighted the need for work to initially focus on filling foundational gaps in our understanding about local groundwater resources. This lack of critical knowledge meant that the development of a long-term plan was not feasible or appropriate. Instead, the project transitioned to a more flexible and pragmatic planning model. The Groundwater Strategy proposes a phased, adaptive implementation approach with 10 actions prioritized for short-term implementation through 2030, which has been identified as Phase 1. These 10 actions are summarized in Tables 1 and 2 and are listed with additional context and rationale in Appendix A. The remaining 33 actions are considered options for Phase 2 and are listed in Appendix B and will be reevaluated for feasibility and suitability for implementation upon the completion of Phase 1.

PHASE 1: A FIVE-YEAR PLAN

Phase 1 brings forward a plan that:

- Spans a five-year planning horizon,
- Focuses on actions that are achievable with existing capacity,
- Establishes foundational knowledge to reduce uncertainty and support future decision-making, and
- Positions the City to reassess progress and recalibrate priorities prior to initiating subsequent phases.



2026-2030

PHASE 1

BEYOND
2030

CRITERIA FOR SELECTING PHASE 1 ACTIONS

Phase 1 actions were selected based on the following principles:

- **Foundational value**
Actions that fill critical knowledge gaps, clarify risks and opportunities, and enable future actions.
- **Support for core service delivery**
Actions that directly or indirectly support core City functions, ensuring alignment with operational priorities.
- **Cost effectiveness**
Actions identified as high-value and cost-effective.
- **Stakeholder support**
Actions that received broad support from the Staff Working Group and were informed by Expert Panel insights.

PHASE 1 ACTIONS & DELIVERABLES

 Support groundwater-dependent ecosystems	 Improve water security	 Reduce the impact of groundwater-related risks	 Maintain groundwater levels	 Safeguard groundwater quality	 Foster community awareness and support	 Inform decision making
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#	Action	Deliverable	Objectives Advanced						
									
IMMEDIATE PRIORITY									
01	Restrict the discharge of foundation drains into sewers Develop city-wide, performance-based requirements to limit the permanent diversion of groundwater into sewers from foundation drains (e.g., a maximum discharge rate).	A by-law requirement for the long-term discharge of groundwater to City sewers.							
FOUNDATIONAL KNOWLEDGE									
02	Develop a groundwater monitoring program Develop a monitoring well network throughout the city to determine seasonal and long-term groundwater elevations as well as groundwater chemistry.	Seasonal groundwater elevation data.							
		Groundwater quality data for locations with extraction potential.							
		Stratigraphy and hydraulic properties.							
03	Assess aquifer recharge and infiltration potential Undertake a city-wide assessment of infiltration potential to delineate areas where stormwater infiltration should be encouraged AND utilize this assessment to quantify aquifer recharge.	A city-wide map of infiltration potential, to inform stormwater management planning.							
		A city-wide map of groundwater recharge.							

Table 1 – Phase 1 actions, deliverables, and objectives advanced.

PHASE 1 ACTIONS & DELIVERABLES

 Support groundwater-dependent ecosystems	 Improve water security	 Reduce the impact of groundwater-related risks	 Maintain groundwater levels	 Safeguard groundwater quality	 Foster community awareness and support	 Inform decision making
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#	Action	Deliverable	Objectives Advanced					
								
FOUNDATIONAL KNOWLEDGE (CONT'D)								
04	Quantify groundwater diversions Inventory and estimate all known groundwater diversions to sewers (e.g., construction dewatering, foundation drains, wells) in order to manage risks to infrastructure and development.	An inventory of suspected locations, and estimated flow volumes, of long-term groundwater diversions to sewer via foundation drainage.						
		An inventory of suspected locations, and estimated flow volumes, of short-term groundwater diversions to sewer via construction dewatering.						
05	Identify groundwater-dependent ecosystems Identify ecosystems that are reliant on groundwater and develop a water budget to support decision-making regarding how these areas should be protected.	Classification of groundwater-dependent ecosystems within ESAs.						
		A high-level water budget for all ecosystems determined to be groundwater-dependent.						
DECISION SUPPORT								
06	Develop a groundwater data repository Composite data from external sources (permit applications) and internal geotechnical data into one repository to improve decision-making for groundwater management.	A geodatabase with hydrogeological and geotechnical information, accessible by all City staff, in a spatial format.						

PHASE 1 ACTIONS & DELIVERABLES



#	Action	Deliverable	Objectives Advanced						
									
DECISION SUPPORT (CONT'D)									
07	Update the city-wide groundwater flow model Refine and expand the existing city-wide hydrogeological model with data from the monitoring program, groundwater diversion estimates, and infiltration and recharge estimates to allow for its use as a decision-support tool for risk mitigation, Area plan development, ecosystem protection, and utility and city planning.	City-wide groundwater elevation contour map.							
		A conceptual model of the city's hydrogeology.							
		A predictive tool to understand the impacts of land use changes, development projects, or other planning decisions.							
		A predictive tool to understand the impacts of climate change, and related risks.							
		A predictive tool to understand where we have areas of high I&I potential.							
08	Assess the sustainable extraction potential of groundwater Explore the potential for the future use of groundwater by completing an assessment of sustainable extraction across the city.	A heatmap of areas with a high extraction potential.							
		An estimate of extraction potential for select City parcels.							
09	Assess the potential extent and magnitude of groundwater rise Reduce risks, including surface or subsurface flooding, by completing a predictive assessment of groundwater rise induced by sea-level rise (if warranted, this will be followed by the development of mitigation strategies).	A heatmap showing the extent and magnitude of groundwater rise.							

PHASE 1 ACTIONS & DELIVERABLES



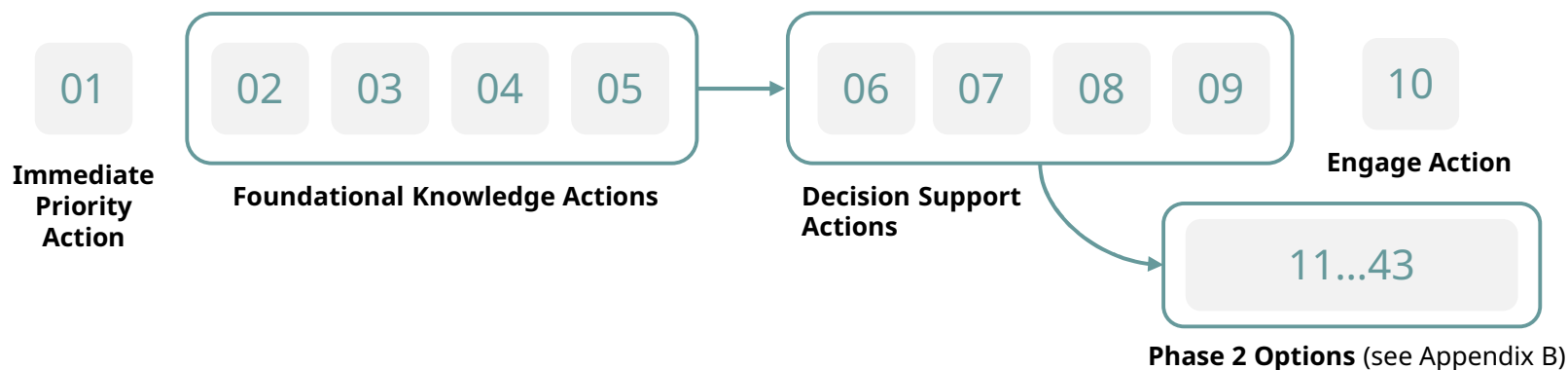
			Objectives Advanced						
#	Action	Deliverable							

OUTREACH

10	Engage external partners to advance objectives a) Work with the Province to increase the enforcement of well decommissioning requirements b) Work with the Province to apply conditions to groundwater licenses that require adherence to local water conservation by-laws c) Work with Engineers & Geoscientists BC (EGBC) to develop a Practice Advisory for the design and construction of groundwater management structures.	An inventory of abandoned wells to support a request to the Province to increase enforcement efforts. Research instances of groundwater use which circumvent local water conservation efforts, in support of a request to the Province to update licensing conditions. Baseline prevalence and issues associated with groundwater tanking and cutoff structures to support a request to EGBC.							

Table 1 continued – Phase 1 actions, deliverables, and objectives advanced.

ACTION PLAN SUMMARY



PHASE 1 ACTIONS PROPOSED TIMELINE & TARGETS

Action	Target	2026	2027	2028	2029	2030
IMMEDIATE PRIORITY						
01	Restrict the discharge of foundation drains to sewer	Enact city-wide by-law that restricts groundwater discharge via foundation drainage by 2027				
FOUNDATIONAL KNOWLEDGE						
02	Develop a groundwater monitoring program	Install 15 wells (10 with telemetry) by 2028				
03	Assess aquifer recharge and infiltration potential	Map infiltration potential for 100% of the city by 2028				
04	Quantify groundwater diversions	Estimate groundwater diversion rates across 100% of sewer catchments by 2027				
05	Identify groundwater-dependent ecosystems	1. Identify ecosystems that are dependent on groundwater within ESAs by 2028 2. Develop water budgets for identified ecosystems by 2029				
DECISION SUPPORT						
06	Develop a groundwater data repository	Complete geodatabase for groundwater-related data by 2027				
07	Update the city-wide groundwater flow model	Update the model with data collected in Phase 1 and calibrate to steady-state conditions (calibration target: Normalized Root Mean Square Error (NRMSE) < 10%) using water levels from Action 01 by 2029				
08	Assess the sustainable extraction potential of groundwater	Complete assessment to evaluate sustainable extraction potential across the city by 2030				
09	Assess the potential extent and magnitude of groundwater rise	Complete assessment to identify areas vulnerable to groundwater rise by 2030				
OUTREACH						
10	Engage external partners to advance objectives	Complete baseline and inventory for priority areas in the city by 2030				

Table 2 – Phase 1 actions, timelines, and targets.

PHASE 1 OUTCOMES

The actions proposed in Phase 1 of the Groundwater Strategy are anticipated to deliver financial savings for the City at an order of magnitude greater than the program's cost, based on preliminary analysis by the consultant (Appendix C). While further validation would be required to confirm the exact numbers, the primary opportunities for cost savings are clear:

➤ **Inflow and infiltration into the sewer system is minimized**

In 2025, Metro Vancouver charged the City of Vancouver \$173 million for treatment and disposal; a portion of this cost reflects treatment of groundwater entering the sewer system through inflow and infiltration. By keeping groundwater out of the sewer network, the City will ease demand on wastewater treatment plants, prevent or delay costly upgrades to infrastructure, and may reduce the volume of combined sewer overflows.

➤ **Rehabilitation costs for land and infrastructure is avoided**

Proactively identifying and planning for risks is significantly more cost-effective than reacting to them as they occur. An improved understanding of groundwater rise induced by sea level rise will help the City make informed decisions about infrastructure and land-use planning, avoiding costly remediation of buildings, utilities, and public land.

➤ **Purchased water costs is reduced through strategic groundwater use**

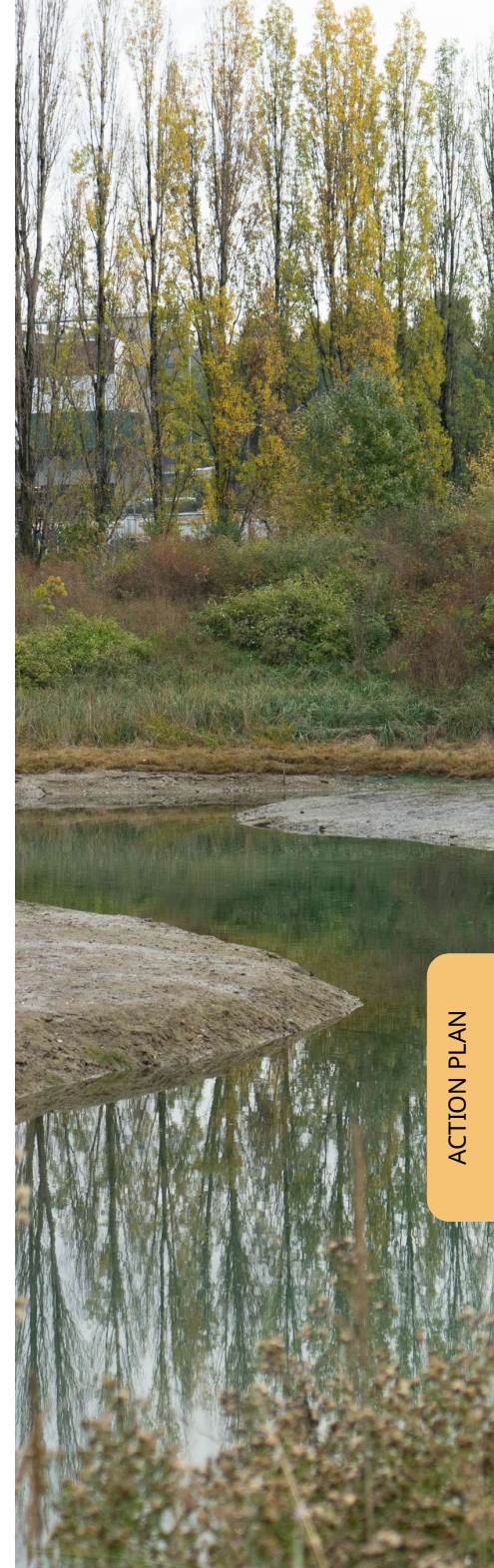
In 2025, Vancouver purchased \$107 million of drinking water from Metro Vancouver. Identifying opportunities to extract and use groundwater may lead to a decreased reliance on water purchased from Metro Vancouver, generating ongoing operational savings.

➤ **Expedited housing delivery through simplified development review processes**

As of 2024 and 2025, the Groundwater team reviewed 120 development applications per year on average. Through the development of a simplified, citywide by-law that sets clear requirements for foundation drainage, the development review processes can be accelerated for developers and will build capacity internally to focus more on value-added work.

➤ **Informed decision-making and unlocking Phase 2 Options**

20-25 monitoring wells will be added between 2026 and 2030 to help build foundational knowledge about groundwater-related risks and opportunities. Assessments on groundwater inputs and outputs will inform groundwater management as well as the cost-effective management of sewer and drainage infrastructure. This information will culminate in the refinement of the groundwater flow model, informing future decision-making related to various known and unknown risks as well as groundwater extraction potential and environmental protection. These outcomes will also help determine which Phase 2 Options should be prioritized for implementation to deliver the full value of the Strategy.



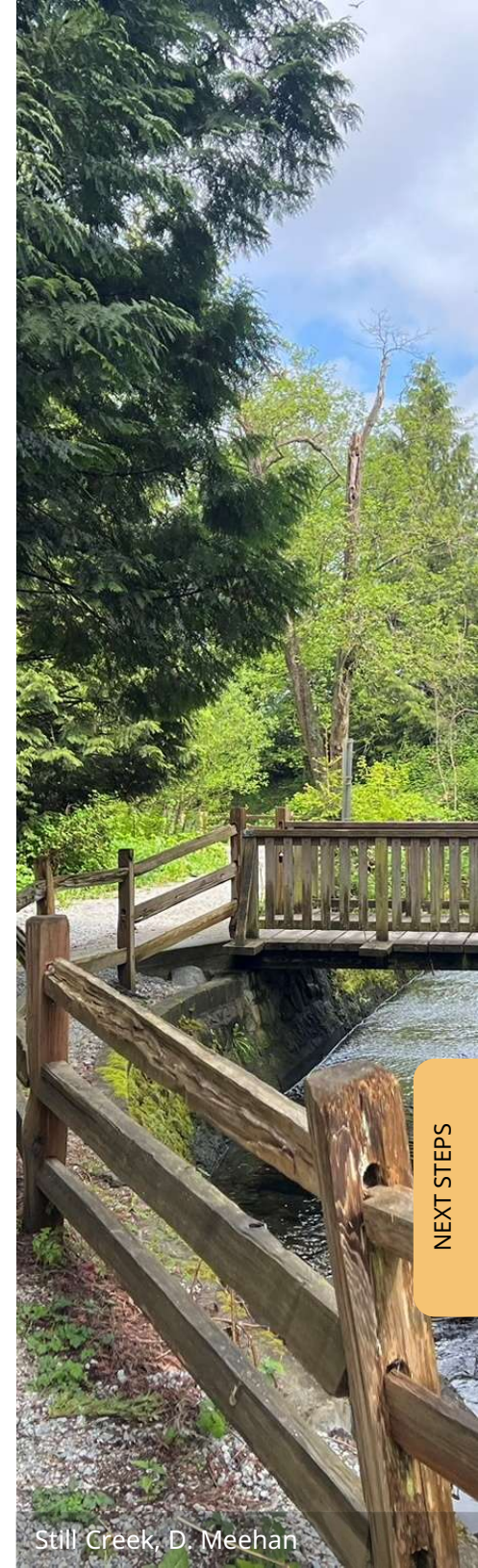
NEXT STEPS

BEYOND PHASE 1

The Groundwater Strategy sets out a vision for groundwater in Vancouver to be recognized as an important resource and managed in order to mitigate risks, support ecosystems, and advance the City's adaptation to climate change. The first phase of the Groundwater Strategy provides a strong foundation for building an understanding of the resource and sets out an Action Plan to be implemented between 2026 and 2030.

As the City moves forward with implementation of this first phase of actions, engagement with stakeholders on the details and timing of implementation will continue.

Upon completion of Phase 1, and following a review of environmental and regulatory considerations, current priorities and context, and available resources, the City will determine appropriate options for Phase 2 (see Appendix B). Financial and resource needs for this future work will be developed and brought forward through the appropriate budgeting and approval processes at that time.



GLOSSARY

Aquifer: a layer of permeable material below ground where groundwater can be transmitted and stored.

Aquitard: a layer of material that impedes the movement of groundwater (e.g., silt, clay, or solid rock).

Artesian aquifer: a permeable layer, sandwiched between two layers of impermeable material, that contains pressurized water.

Bog: A type of organic wetland whose development and persistence depends on climate, hydrology, geomorphology, and biology.

Combined sewers: a type of sewer system in which one set of pipes carries both sanitary sewage and urban rainwater runoff.

Combined sewer overflows (CSOs): events when a combined sewer is over capacity and releases a mixture of stormwater and sewage into receiving waterbodies.

Confined aquifer: an aquifer that is beneath an aquitard.

Flowing artesian well: a well that is drilled into an aquifer under enough pressure to force the water level in the well to rise above the ground surface and flow over the top of the well.

Gaining stream: a stream or river that receives water inputs from groundwater.

Green rainwater infrastructure (GRI): a suite of rainwater management tools that use both engineered and nature-based solutions to protect, restore, and mimic the natural water cycle.

Groundwater: the water found underground in the cracks and spaces in soil, sand and rock.

Groundwater recharge: the process of water entering the subsurface and reaching the water table, either as infiltration of rainfall, or losses from surface water such as rivers, creeks, ditches, lakes, ponds, and wetlands.

Groundwater rise: the upward movement of the water table due to increases in rainfall and/or nearby river, ocean or tidal levels.

Hydrologic cycle: the movement of water from precipitation, to surface water runoff, infiltration, evaporation, transpiration, and groundwater discharge. Also known as the “water cycle.”

Infiltration: the downward movement of rainwater into the soil.

Inflow and Infiltration (I&I): unwanted flows entering sewer pipes, which contribute to reduced sewer capacity, increased wastewater treatment costs, and increased combined sewer overflows. In this context:

- **I&I Inflow** refers to water entering sewers through direct connections (e.g., perimeter/foundation drainage connections), and
- **I&I Infiltration** refers to water that seeps into pipes through defects like cracks or leaky joints.

Monitoring well: a type of well used principally used for observing groundwater levels and flow conditions, obtaining samples for determining groundwater quality, and evaluating hydraulic properties of water-bearing strata.

Non-potable water: water that is not safe to drink but can still be used for other purposes including washing cars, flushing toilets, and watering plants.

Numerical model: a technique to tackle complex geological problems. Numerical modeling uses mathematical models to describe the physical conditions of geological scenarios using numbers and equations.

Potable offset: groundwater or other alternative water sources that offset or replace an equal quantity of potable water.

Potable water: water that is appropriate for drinking, cooking and bathing.

Potentiometric surface: an imaginary surface representing the total pressure of groundwater, indicating the level to which water will rise in wells drilled into a confined aquifer.

Saltwater intrusion: the movement of saline water into fresh groundwater regions in coastal aquifer settings due to pumping, reduced recharge, climate variations, or sea-level fluctuations.

Subsidence: the sinking of land. Groundwater-related subsidence occurs due to groundwater extraction.

Surface water: water bodies such as rivers, lakes, streams, and oceans which sit on the surface of the planet.

GLOSSARY

Transpiration: the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers.

Unconfined aquifer: an aquifer that is not beneath an aquitard, typically located at more shallow depths than a confined aquifer.

Water budget: an account of the water stored in a system, such as an aquifer, and the movement of water in and out of that system.

Watercourse: a river, stream, creek, waterway, lagoon, lake, spring, swamp, marsh or other natural bodies of fresh water; or a canal, ditch, reservoir or other man-made surface feature; whether it contains or conveys water continuously or intermittently

Watershed: a distinct hydrologically-defined geographic unit, within which all waterways such as creeks, streams and rivers drain to a common outlet.

Water table: the water level in an aquifer.

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- ❖ Page iv, Acknowledgements, Camosun Bog, Julie LeBlanc
- ❖ Page 3, Groundwater governance & rationale, Still Creek, Michaela Dyck
- ❖ Page 6, Stakeholder and partner engagement, Vanier Park, Diane Meehan
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- ❖ Page 15, Groundwater hazards, flowing artesian groundwater at Beechwood, Mike Simpson
- ❖ Page 15, Groundwater hazards, street flooding, Chris Duncan
- ❖ Page 16, Current and future hazards related to groundwater, subsidence in Burnaby, Amir Taleghani
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- ❖ Page 27, Driver 4: Protect ecology and environment, Vanier Park, Diane Meehan
- ❖ Page 36, Phase 1 outcomes, New Brighton Park, Julia Scott Lenz
- ❖ Page 37, Next steps, Still Creek, Diane Meehan

APPENDIX A

RATIONALE FOR PHASE 1 ACTIONS

RATIONALE FOR PHASE 1 ACTIONS

Action Name	Description	Rationale
01 Restrict the discharge of foundation drains into sewers	Develop city-wide, performance-based requirements to limit the permanent diversion of groundwater into sewers from foundation drains (e.g., a maximum discharge rate).	Underground structures, including parkades, require drainage systems to protect them from water ingress and hydrostatic pressures. The groundwater collected by these systems is usually discharged to the sewer system, which not only reduces sewer system capacity, increases treatment costs, and adds to combined sewer overflow events, but can also result in other impacts such as reduced baseflow to nearby streams and geotechnical risks (e.g., subsidence). There are currently no incentives in place for developers to limit groundwater discharge. Strategies for developers to limit groundwater discharge may include constructing groundwater cut-off walls, designing building foundations to be “tanked,” reducing below-grade parking, or by re-using onsite groundwater. Currently, the requirements to limit groundwater discharge are not well defined, resulting in unforeseen costs for developers, and additional permit review time. The development of clear by-law requirements will increase transparency, reduce costs, and expedite housing delivery.
02 Develop a groundwater monitoring program	Develop a monitoring well network throughout the city to determine seasonal and long-term groundwater elevations as well as groundwater chemistry.	Little is known about groundwater elevations or water quality across the city. The data from the monitoring well network will be critical for many other actions in the Strategy as the City needs to better understand local hydrogeology to effectively protect and manage it. Data from the monitoring well network (e.g., water levels) would be made publicly available. These data will be used for various purposes, including, for example, assessing extraction potential and infiltration capacities, better understanding groundwater-ecosystem interactions, calibrating models, predicting the impacts of land-use changes, monitoring groundwater-rise, etc.
03 Assess aquifer recharge and infiltration potential	Undertake a city-wide assessment of infiltration potential to delineate areas where stormwater infiltration should be encouraged AND utilize this assessment to quantify aquifer recharge.	Protecting and enhancing recharge areas is critical to preserving aquifer resources. This action will help the City better understand our ability to manage stormwater through infiltration and potentially identify specific target areas for infiltration projects. It will also help identify areas that currently provide significant recharge to local aquifers which may inform future planning work. Assessing recharge across the City will also assist with the development of a water budget and/or refinement of the city-wide numerical model.

RATIONALE FOR PHASE 1 ACTIONS

Action Name	Description	Rationale
04 Quantify groundwater diversions	Inventory and estimate all known groundwater diversions to sewers (e.g., construction dewatering, foundation drains, wells) in order to manage risks to infrastructure and development.	The City currently has limited information about the quantity of groundwater being diverted from local aquifers; via construction dewatering, foundation drainage, and leakage into sewers. This limits our ability to properly manage and potentially use the resource, due to a fundamental gap in our understanding of its water budget. As the majority of groundwater diversions occurring today are thought to be adding that groundwater to the City's sewer and drainage system, this gap also limits our ability to properly manage our infrastructure. By inventorying groundwater diversions, we can better understand the quantity and locations of groundwater inputs to our sewer and drainage system. This will allow Staff to better focus our efforts to limit these diversions in order to preserve capacity, and will also assist with related technical work such as sewer modeling and planning. This information will also enable the development of a more complete water budget for our aquifers, allowing the City to better understand the potential for groundwater use in the future and to better understand and protect groundwater-dependent ecosystems.
05 Identify groundwater-dependent ecosystems	Identify ecosystems that are reliant on groundwater and develop a water budget to support decision-making regarding how these ecosystems should be protected.	Many natural areas, including Still Creek and Camosun Bog, are dependent on groundwater to properly function. Several others are suspected to rely on groundwater, but a city-wide inventory of groundwater-dependent ecosystems (GDEs) has not been completed. In order to protect these ecosystems, we need to first identify them and then understand how they interact with groundwater. With this information, we can predict how different stressors (e.g., increased upgradient imperviousness, new drainage systems or wells, etc) may impact these ecosystems and take steps to reduce or mitigate these impacts.
06 Develop a groundwater data repository	Composite data from external sources (permit applications) and internal geotechnical data into one repository to improve decision-making for groundwater management.	The current state of data on groundwater is uncoordinated and a patchwork, creating challenges around baselining groundwater to manage it effectively. Internal data needs to be streamlined, and barriers exist around using external data to complete information gaps. The data repository will be the first step to developing a baseline characterization of groundwater so that it can be managed to help mitigate risks, support core services, and support the 100-year ecological vision.

RATIONALE FOR PHASE 1 ACTIONS

Action Name	Description	Rationale
07 Update the city-wide groundwater flow model	Refine and expand the existing city-wide hydrogeological model with data from the monitoring program, groundwater diversion estimates, and infiltration and recharge estimates to allow for its use as a decision-support tool for risk mitigation, Area-plan development, ecosystem protection, and utility and city planning.	The City has an existing numerical model that covers the municipality (and slightly beyond). If the model can be refined to improve accuracy, it can be a powerful tool in predicting the impacts of various stressors (e.g., a changing climate, rising sea levels, groundwater extraction, increased imperviousness, additional underground infrastructure, etc.) on groundwater, connected ecosystems, and/or infrastructure. This action will allow the City to compile all the various data it has on local geology and water levels and update the existing model such that it can be used to inform decision-making.
08 Assess the sustainable extraction potential of groundwater	Explore the potential for the future use of groundwater by completing an assessment of sustainable extraction across the city.	Jurisdictions with multiple water sources that includes groundwater (e.g., San Francisco) have redundancies in terms of their water supply in the event of emergencies (e.g., after earthquakes). Other jurisdictions, including some located with Metro Vancouver, have either considered or installed wells for non-potable and potable purposes, including for emergency purposes. There is growing interest in the City to use groundwater for non-potable purposes to reduce the burden on our potable water supply. This action would determine the sustainable yield (i.e., how much groundwater can be used without depleting the aquifers or causing other adverse impacts) to determine where and how much groundwater can be used. If sufficient potential exists, this action could be followed by a demand assessment and subsequently by evaluating the feasibility of adding emergency groundwater supply to Vancouver. This could include such options as installing wells at key facilities (e.g., hospitals), adding wells to our existing water supply system as a redundancy, or installing wells in specific areas for specific purposes (e.g., for firefighting).
09 Assess the potential extent and magnitude of groundwater rise	Reduce risks, including surface or subsurface flooding, by completing a predictive assessment of groundwater rise induced by sea-level rise (if warranted, this will be followed by the development of mitigation strategies).	As sea levels rise (i.e., due to climate change) groundwater, which is hydraulically connected to the sea, will also rise. This can lead to flooding of below ground structures, geotechnical impacts, increased capture of groundwater via drainage systems, surface flooding, and other impacts. There are a number of City-owned facilities (e.g., Kitsilano Pool) and other assets (e.g., roads, sewer pipes, etc.) that may be vulnerable to groundwater rise. This action would commission a study to determine the potential future extent and magnitude of groundwater rise. Based on study findings, this action would subsequently prompt development of mitigation plans for vulnerable areas, if warranted.

RATIONALE FOR PHASE 1 ACTIONS

Action Name	Description	Rationale
10 Engage external partners to advance objectives	a) Work with the Province to increase the enforcement of well decommissioning requirements. b) Work with the Province to apply conditions to groundwater licenses that require adherence to local water conservation by-laws. c) Work with Engineers & Geoscientists BC (EGBC) to develop a Practice Advisory for the design and construction of groundwater management structures.	Despite Provincial legislation, some unused wells are not decommissioned, leading to safety concerns and potential pathways for contaminants to enter local aquifers Well closure requirements are not actively enforced by the Province. As this impacts City resources, the intention is to engage with the Province to convey our concerns and seek a commitment for additional efforts to ensure compliance. There is currently little to no design guidance available for permanent groundwater management structures (which include tanked foundations and groundwater cut-off walls). These types of structures are becoming increasingly common in Vancouver and elsewhere, and there is a level of inconsistency in the designs submitted with development applications, and the performance of these features after construction. This action would lobby EGBC to develop a Practice Advisory related to these groundwater management structures, which would simplify the development review process, improve overall performance of these structures, and protect the City, future owners, and local groundwater resources from risks.

APPENDIX B

PHASE 2 OPTIONS

PHASE 2 OPTIONS

The 2026-2030 Phase 1 Action Plan will establish the baseline information required to enable full realization of Groundwater Strategy objectives. Future phases (2031 and beyond) will implement a targeted set of additional actions summarized below. These actions were also developed in collaboration with project partners and stakeholders.

 Support groundwater-dependent ecosystems

 Improve water security

 Reduce the impact of groundwater-related risks

 Maintain groundwater levels

 Safeguard groundwater quality

 Foster community awareness and support

 Inform decision making

#	Action Name	Objectives Advanced
11	Well drilling advisory	
12	Inform neighborhood planning initiatives	
13	Discharge during construction	
14	Stormwater infiltration incentives	
15	Aquifer valuation	
16	Map groundwater I&I risks	
17	Mitigate risk of potential impacts to groundwater quality from urban runoff	
18	Aquifer vulnerability assessment	
19	Remediation for future use	
20	Reduce setbacks for infiltration features	
21	Emergency response business continuity	

#	Action Name	Objectives Advanced
22	Leverage external partners to advance our objectives	
23	Partnerships to protect groundwater ecosystems	
24	Managed aquifer recharge	
25	Reduce parkade depths	
26	Requirements for injection systems	
27	Reduce contaminants from City operations	
28	Internal education	
29	Green rainwater infrastructure at City-owned buildings	
30	Water reservation application	
31	Groundwater partnerships plan	

#	Action Name	Objectives Advanced
32	Groundwater public outreach plan	
33	Geoexchange impacts	
34	Vancouver Landfill considerations	
35	Impacts of utility trenches	
36	VBBL regulations for non-potable use	
37	Replace PFAS in firefighting foams	
38	Mitigate artificial turf	
39	Well acquisition	
40	Academic partnerships	
41	Coordinate City groundwater use	
42	Saltwater intrusion assessment	
43	Increase infiltration through parks	

PHASE 2 OPTIONS

Action Name	Description	Rationale
11 Well drilling advisory	Reduce risks related to flowing artesian conditions: a) Work with the Province and other affected local governments to refine the Well Drilling Advisory Area for flowing artesian conditions. b) Develop a plan to mitigate the risks of encountering flowing artesian conditions within the Well Drilling Advisory Area.	Flowing artesian conditions are pressurized portions of aquifers, and wells drilled in these areas can cause serious problems. For example, in 2015 a geoexchange well for a home was drilled by an inexperienced contractor, and this pierced a pressurized (artesian) portion of the underlying aquifer. It took two years and cost the City almost \$12 million to control the flow, and an estimated 3 billion gallons of groundwater were discharged to the sewer system. These pressurized areas are delineated by a Provincial Well Drilling Advisory Area map to help alert developers to the risk. The current advisory area extends from the University Endowment Lands to just west of Coquitlam. The advisory area was defined using a limited amount of available information and could be drastically improved using additional tools (e.g., geophysics). Refinement of the advisory area would improve confidence in the area boundary and would ideally reduce the size of the area itself, potentially reducing costs related to risk mitigation for municipalities and developers. This action would also help identify other requirements the City could implement to reduce the risk from these flowing artesian conditions.
12 Inform neighbourhood planning initiatives	Undertake groundwater investigations to help inform neighbourhood planning initiatives (e.g., Area Plans), related building requirements, and integrated watershed management plans in order to preserve groundwater resources and protect buildings, infrastructure, and groundwater-dependent ecosystems such as Still Creek.	These investigations will help identify areas of concern for groundwater in future neighbourhood planning initiatives and allow the City to implement targeted building requirements there. Depending on the situation, these investigations could be simple desktop exercises, or more detailed investigations (e.g., monitoring well installations) with elaborate decision support tools (i.e., numerical models).
13 Discharge during construction	Mitigate risks associated with groundwater discharged to the sewer system during construction by ensuring capacity constraints are considered as well as requirements of the City's Sewer and Watercourse By-law. This may include expanding requirements and/or establishing a monitoring and enforcement program.	Groundwater discharges from a site during construction are not currently subject to fees if entering the City's storm system or combined system. The City is paying treatment costs for discharges to the combined system and there are few disincentives for high volume discharges. In addition, the City's Erosion and Sediment Control (ESC) requirements for large lot developments are limited with respect to water quality as only TSS and pH must be monitored and treated, creating a gap in monitoring other contaminants that may pose a potential risk to receiving bodies and exposes the City to liability.

PHASE 2 OPTIONS

Action Name	Description	Rationale
14 Stormwater infiltration incentives	In line with <i>Healthy Waters Plan</i> and <i>Rain City Strategy</i> , develop options and incentives for developers to infiltrate stormwater on private property to enhance groundwater recharge, and reduce burden on sewer system capacity.	The City requires rainwater management for rezoning applications that are subject to the City's Green Buildings Policy for Rezonings, or the Rezoning Policy for Sustainable Large Developments. As of 2024, the VBBL also requires developers to require rainwater detention into tanks at minimum. However, developers have little incentive to explore options for infiltrating rainwater. Stormwater infiltration provides two purposes: it reduces the burden on the City's sewer system by reducing rainwater entering the system, and it recharges groundwater. Providing developers with options and incentives to infiltrate rainwater will reduce infrastructure and treatment costs for the City and maintain groundwater levels to support environmental benefits. By providing more options and incentives for developers to infiltrate rainwater, the City enables developers to have greater autonomy to choose retention and/or detention practices where possible. These incentives can be developed in consultation with developers.
15 Aquifer valuation	Quantify the "natural asset" value of local aquifers in terms of water storage and supply, supporting ecosystems, and other municipal services, and incorporate this information into the City's asset management system.	Traditionally, civic asset management processes have only been applied to engineered infrastructure. However, there is growing evidence that by considering natural assets (e.g., aquifers) within asset management processes, local governments can decrease capital, operations, and maintenance costs, increase levels of service, enhance their ability to adapt to climate change, and reduce the community's unfunded liabilities – all while protecting or enhancing the multitude of other benefits that natural assets bring to communities. The functions that nature provides to communities beyond core services, such as recreation, climate regulation, clean air, habitat, and biodiversity, are invaluable to the overall health and well-being of a community. Therefore, including natural assets in asset management processes provides an integrated approach to maintaining or enhancing the natural assets in a community.
16 Map groundwater I&I risks	Develop a map of groundwater elevation and cross-reference with sewer and drainage infrastructure to highlight areas where infiltration is most likely, and should be prioritized for I&I monitoring, and pipe repairs as needed.	Inflow & Infiltration (I&I) occurs when water is erroneously or unnecessarily directed to sewer pipes. One source of I&I is due to leaking sewer pipes that allow the groundwater to enter the pipe through holes or cracks in the pipe network (referred to as infiltration). This not only reduces sewer system capacity and increases treatment costs and combined sewer overflow events, but also wastes groundwater resources. A city-wide, comprehensive I&I monitoring program is very costly. However, by mapping out where City infrastructure is below the water table, it may be possible to prioritize I&I flow monitoring locations. The effectiveness of this assessment may be increased by adding available data on sewer infrastructure that may indicate the likelihood of leaks (e.g., pipe type, age, etc.).

PHASE 2 OPTIONS

Action Name	Description	Rationale
17 Mitigate risk of potential impacts to groundwater quality from urban runoff	Reduce contaminants of concern entering groundwater through urban runoff: a) Monitor and baseline groundwater quality for contaminants that may originate from urban runoff b) Collaborate with the Green Rainwater Infrastructure (GRI) branch to address contaminants of concern through GRI projects.	Urban runoff can contain contaminants which could have an adverse effect on groundwater quality. There is limited understanding of if these contaminants are present and at what magnitude in groundwater across the city. By undertaking sampling studies on on-site infiltration practices, the City will be able to characterize whether any new contaminants of concern are infiltrating into groundwater, and how to best mitigate and/or remediate them. This may include working with the Green Rainwater Infrastructure branch to develop design guidelines to treat soluble contaminants from urban runoff.
18 Aquifer vulnerability assessment	Complete an aquifer vulnerability assessment to prioritize actions related to the protection of groundwater quality.	The purpose of this action is to develop aquifer vulnerability mapping (e.g., AVI, DRASTIC) to inform land use policy and decision making. It will be an invaluable tool to help the City protect local aquifers.
19 Remediation for future use	Work with the Province to strengthen remediation requirements in areas identified for future groundwater use with consideration of the Province's <i>Considering climate change in remediation</i> guidance^[31].	Following completion of an aquifer vulnerability assessment and groundwater use potential assessment, sites suitable for future groundwater use will be identified. These sites may include private properties or City-owned properties, and they may be known to have contamination. In many situations, these sites will be remediated based on a risk assessment which often prohibits use of an underlying viable groundwater aquifer as a potable water source. This action entails working with the Province in order to protect and preserve groundwater resources for future use, in line with the Province's guidance of <i>Considering climate change in remediation</i>^[31].
20 Reduce setbacks for infiltration features	Support other City teams to work towards reducing infiltration setback requirements to meet <i>Rain City Strategy</i> objectives and enhance aquifer recharge.	Given the development pressures in the City, every inch of developable space on a property is often used, leaving limited space for infiltration features. Additionally, known setback requirements exacerbate this issue by limiting infiltration within 5 metres of Part 9 building foundations per the Vancouver Building By-law 2025 and within 3 metres of potable water pipes per Design Guidelines for Drinking Water Systems in British Columbia). This action would seek to further support ongoing work that is looking at potential options for relaxing these setbacks, to increase onsite opportunities for infiltration.

PHASE 2 OPTIONS

	Action Name	Description	Rationale
21	Emergency response business continuity	Develop a clear governance structure specific to emergency response related to groundwater risks.	In the 2015 Beechwood incident, an inexperienced contractor pierced a pressurized (flowing artesian) portion of the aquifer, leading to several billion gallons of groundwater being discharged. At the time, it was initially unclear which City business units needed to be involved, and this might have led to delays in managing the issue. This action will integrate a clear governance structure for managing these and other types of groundwater emergencies in the existing Emergency Management Plan and Incident Response Guidelines, including channels for efficient communication and data sharing, for managing groundwater-related incidents.
22	Leverage external partners to advance our objectives	Establish a forum for the Province, Metro Vancouver, and neighbouring governments including the local Nations to coordinate and collaborate to assess and mitigate groundwater-related risks (e.g., saltwater intrusion).	The Province of BC has identified two aquifers beneath Vancouver, both of which extend across multiple other municipalities. As the management of these aquifers is shared by many levels of government (including the local Nations and the Province of BC), it makes sense to have a coordinated approach. Key groundwater issues that could be addressed include drought resilience, land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets, and establishing a notification or monitoring system for large (e.g., commercial or industrial) water users.
23	Partnerships to protect groundwater ecosystems	Explore partnership opportunities with the local Nations and stewardship groups to protect groundwater-dependent ecosystems, share data and lessons learned, and collaborate on regional biodiversity goals.	Several natural areas in the city are believed to be groundwater dependent ecosystems. Many stakeholders and other governments have considerable knowledge and expertise related to the historic and present-day health and well-being of these ecosystems. To better understand and preserve these assets, the City needs to work with these partners towards a shared goal. Regional biodiversity goals could include exploring land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets. To support the UNDRIP Action Plan and better understand and preserve ecosystems, the City needs to work with these partners towards a shared goal. This might include providing support to the local Nations to facilitate participation in partnerships and to develop stewardship monitoring capacity; additionally, Indigenous vendors/consultants should be prioritized for related work. To enhance equity, this work should consider the needs of multiple species and be rooted in moving away from City control of processes.

PHASE 2 OPTIONS

Action Name	Description	Rationale
24 Managed aquifer recharge	Complete an assessment of the potential for Managed Aquifer Recharge, including the potential for aquifer storage and recovery to be used in the City as a means of storing excess rainwater for use during times of water scarcity.	Currently, the city receives too much rainfall in the winter, and not enough in the summer. This situation is likely to worsen as climate change progresses. This action will assess the potential of using local aquifers to store excess rainwater in winter months for use during times of scarcity, much like reservoirs in the North Shore do.
25 Reduce parkade depths	Explore ways to discourage below-grade parking and/or reduce overall parkade depths where groundwater may be encountered.	Parking and storage are often located in below-grade areas of the development, and depths can be significant. The deeper a development goes below ground, the greater the chances that it will impact groundwater. Groundwater is typically collected in a perimeter drainage system and discharged to the sewer as waste. Above-grade parking levels may "count against" the overall FSR (floor space ratio) of a project, resulting in a reduced allowable area for residential or commercial space. This action will explore ways to limit adverse impacts from below-grade development on groundwater. This could be achieved through allowing/encouraging above-grade parking, providing height/density bonuses to developments to make up the loss of below-grade space, and/or setting maximum allowable parkade depths.
26 Requirements for injection systems	Develop requirements, including water quality objectives and maintenance requirements, for stormwater injection systems to ensure that groundwater quality is protected.	Although relatively rare in Vancouver presently, injection wells may be used to re-inject water (or other fluid) below ground into a porous geologic formation (e.g., groundwater collected via foundation drainage, or as part of an open-loop geothermal system). It may also be used in the future to manage stormwater, in areas with limited sewer capacity. Although the Province has developed Best Management Practices related to water quality, and the <i>Environmental Management Act</i> (EMA) prohibits "pollution," limited guidance exists to ensure groundwater quality is protected. To protect groundwater quality, this action will set water quality guidelines and other requirements for any injection systems implemented in Vancouver.

PHASE 2 OPTIONS

Action Name	Description	Rationale
27 Reduce contaminants from City operations	Reduce the risks of groundwater contamination from City operations: a) Work with the City's Source Control team to inventory and assess the City's use, storage, and handling of chemicals that may impact groundwater. b) Following the development of an inventory of contaminants used by City operations, research and acquire less toxic but equally effective alternatives wherever available.	The City uses several chemicals in its daily operations, some of which may eventually make their way into local aquifers. This action will identify all contaminants of concern used by the City and Park Board and consider opportunities for less toxic but equally effective alternatives to reduce potential groundwater pollution. It may also identify additional measures that may be taken to reduce risks.
28 Internal education	Conduct regular learning sessions with key City departments about the importance of groundwater and how staff can help protect it (e.g., through process changes).	While the profile of groundwater is gradually increasing within various City departments, there is still a long way to go in terms of raising internal groundwater literacy. This action will involve hosting regular learning sessions with different City business units, particularly those whose work touches on groundwater. The goal will be to foster greater awareness and interest in protecting groundwater (and minimizing groundwater-related risks) through their work. Education should also include awareness of the liability the City carries due to wastewater and groundwater in our sewer system.
29 Green Rainwater Infrastructure at City-owned buildings	To enhance aquifer recharge, explore ways to support <i>Rain City Strategy</i> "Building and Sites Action Plan," implementing innovative Green Rainwater Infrastructure (GRI) practices at City-owned buildings.	As part of the City's efforts to show leadership on water management, this action entails developing internal policy to build and/or renovate future city buildings to manage a certain amount (e.g., 90%) of stormwater through infiltration/Green Rainwater Infrastructure (GRI). This may also include building at least one civic facility to manage all (i.e., 100%) collected stormwater through infiltration. This would demonstrate to others that infiltration is a feasible and affordable means of managing stormwater, with additional co-benefits (e.g., supporting aquifer recharge, supporting ecosystems, etc.), and help generate support for these types of actions by the public who visit the facility.

PHASE 2 OPTIONS

	Action Name	Description	Rationale
30	Water reservation application	Following an assessment of extraction potential, apply for a "water reservation" under the Province's <i>Water Sustainability Act</i> to set aside water rights for future City use.	Because the Province's approach to groundwater use is "first in time, first in right" – meaning that during times of water scarcity, licensees with earlier authorization dates are prioritized and entitled to take their full allocation of water before more recent licensees – it is important for the City to engage with the Province to determine how best to secure future water rights. This may be in the form of a water license or a water reservation. This action may also include discussions around prohibiting commercial activities that are reliant on large quantities of groundwater, or that extract and sell groundwater (e.g., water or other beverage bottlers).
31	Groundwater partnerships plan	Create outreach programs for the development community and industry/businesses on groundwater-related risks (e.g., uncertain water levels, dependent ecosystems, flowing artesian conditions, etc.) as well as best management practices.	Vancouver has unique geotechnical conditions that can impact and be impacted by development. However, developers and industry members do not always know or understand what best practices exist to manage groundwater to minimize risks, impacts, and costs to the environment and their developments. By developing digital and development-focused engagement materials, the City can equip developers and industry with the tools they need to manage groundwater effectively so as to limit impacts, risks, and costs. Potential topics include groundwater-related risks (e.g., artificially lowered water levels, dewatering-induced subsidence, flowing artesian conditions, etc.), environmental impacts (e.g., to groundwater-dependent ecosystems), as well as best management practices (e.g., site and foundation drainage).

PHASE 2 OPTIONS

Action Name	Description	Rationale
32 Groundwater public outreach plan	Engage with residents and businesses to reduce the impact of groundwater-related risks.	One of the most cost-effective means of protecting groundwater is to educate the public. Some sites in the city (e.g., civic golf courses, Hillcrest community centre) already use some groundwater (e.g., for watering lawns, flushing toilets, etc.), but the public is largely unaware of these initiatives. Public installations including signs and artwork would raise awareness of the city's groundwater resources and create interest in what the City is doing to protect it. Several potential initiatives to leverage public awareness to support groundwater management include: A) Explore targeted outreach opportunities (e.g., in schools or at public events) including by partnering with NGOs, the local Nations, and/or academic institutions on the importance of groundwater and how to protect it. B) Educate residents and businesses about the safe handling, storage, use of common chemicals, and less toxic alternatives to mitigate potential impacts on groundwater (e.g., lawn chemicals, de-icing agents, oil, paint, etc.) C) Install signage in high-traffic areas to inform the public on the importance of groundwater, what the City is doing to protect it, and how everyone can play a part. D) Engage local artists to create groundwater-themed art for public spaces to educate and inspire residents to protect local aquifers. E) Install at least one pumping well in a high-profile location to showcase opportunities related to groundwater use.
33 Geoexchange impacts	Develop requirements for geoexchange systems to limit the impact on groundwater resources and groundwater-dependent ecosystems: A) Research known impacts of geoexchange systems, and provide recommendations for potential mitigation tools (e.g., by-law requirements). B) As needed, develop and implement tools (e.g., by-laws) to mitigate impacts. May also include cross-governmental collaboration to further mitigate impacts.	While geoexchange systems are currently not very common in the city, their use could expand as developers and homeowners seek opportunities to reduce energy use and greenhouse gas emissions. However, as these systems become more common, there is a risk of thermal pollution of aquifers, which could have negative impacts (e.g., on groundwater-dependent ecosystems). There is also some concern that geothermal systems could potentially degrade groundwater quality as a result of coolant fluid leaking underground from a closed-loop system, or as a result of the water injected back into the geological formations from an open-loop system. This action will research potential impacts and mitigation strategies.

PHASE 2 OPTIONS

	Action Name	Description	Rationale
34	Vancouver Landfill considerations	Work with Vancouver Landfill operations staff and their groundwater consultants to explore additional measures for the protection of the underlying aquifer and nearby ecosystems.	The Vancouver Landfill currently discharges approximately 2,000 m ³ of leachate and groundwater contaminated by leachate to the Annacis Island Wastewater Treatment Plant (WWTP) each day, resulting in significant water treatment costs. While the landfill is run exceptionally well and has engineered controls to manage leachate and groundwater that may be contaminated by leachate, there may be opportunities to strengthen groundwater protection measures. These measures could exceed Provincial requirements, but are important for the City to show leadership with all of its operations, regardless of their location. In addition, these measures can limit the cost of leachate and groundwater contaminated by leachate being sent to Annacis Island for treatment.
35	Impacts of utility trenches	Develop guidance to reduce the potential for utility trenches to act as preferential pathways that drain groundwater	Excavation backfill in utility trenches can become a preferential pathway for groundwater. In certain situations, these trenches may become unintended drainage systems that stretch over large distances. Where these trenches intercept aquifers, significant loss of groundwater may result. They could also lead to, or exacerbate, the diversion of groundwater to the sewer. This action would identify situations where additional measures may be necessary and propose solutions (e.g., require the installation of seepage collars).
36	VBBL regulations for non-potable use	Develop regulations in the Vancouver Building By-law to facilitate the sustainable use of groundwater for non-potable applications.	Groundwater in Vancouver could be used for non-potable purposes such as watering green spaces or even flushing toilets, assuming that it is used sustainably and does not deplete the aquifers. Currently, the Vancouver Building By-law (VBBL) does not include groundwater as an approved source of water, requiring that an exemption process (called an "Alternative Solution") be followed if someone wishes to use groundwater for non-potable purposes. If the VBBL could be amended to accommodate groundwater use, it may become more common. Currently, Vancouver Coastal Health and the City of Vancouver Development, Buildings & Licensing branch are exploring options, and this work could be supported by the Strategy prioritization.

PHASE 2 OPTIONS

Action Name	Description	Rationale
37 Replace PFAS in firefighting foams	Support Vancouver Fire Rescue Services in transitioning to firefighting foams that are equally effective, but do not contain toxic per- and polyfluoroalkyl substances (PFAS) or other harmful chemicals which may impact local aquifers and compromise the health of firefighters.	Many firefighting foams contain toxic per- and polyfluoroalkyl substances (PFAS). PFAS are carcinogenic and have many risks to human health. PFAS are known as “forever chemicals” and are becoming an urgent global public health issue because they do not degrade and may accumulate in groundwater. The cost of cleanup for known PFAS-contaminated sites is significant (e.g., Canadian Forces Base Comox) and can range to billions of dollars. In 2024, the Vancouver Fire Rescue Services spent \$2.8 million to purchase PFAS-free gear. The next step is to replace PFAS-containing firefighting foams. This action would reduce the potential for PFAS to impact local aquifers, protect firefighter health, and show City leadership on this important issue.
38 Mitigate artificial turf	Work with the Vancouver Park Board to explore key findings of the <i>Sport Field Strategy</i> and discuss specific applications of the synthetic turf mitigation strategies to protect groundwater as warranted.	While the use of artificial turf has expanded across the city, there are some concerns over its use. For example, runoff from artificial turf may contain microplastics and tire compounds (6PPD-quinone) that can migrate into surface waters or groundwater. This action will explore possibilities for reducing the use of artificial turf in City-owned facilities, parks, and sports fields, determining if the use of artificial turf is a threat to local groundwater quality, and developing mitigation strategies for managing potential contamination.
39 Well acquisition	Explore options for the City to acquire a well on City property once it is no longer needed by the well owner.	The City issues permits to private entities, for the use of our road right of ways, for the purpose of installing monitoring wells. These wells are often only needed temporarily and are decommissioned (ideally) when no longer needed. This action will allow the City to acquire a well when it is no longer needed by the well owner, and potentially initiate groundwater monitoring at the well.
40 Academic partnerships	Explore partnerships with academic institutions to advance the City's understanding of local aquifers and groundwater resources.	Build collaborative relationships with academic institutions to develop our understanding of local groundwater resources and groundwater quality. This may include research or studies as part of students' Capstone projects.
41 Coordinate City groundwater use	Develop a coordinated approach for City and Park Board groundwater extraction activities to ensure critical uses are prioritized, and over-extraction is avoided.	This action would facilitate a joint understanding of what activities may use groundwater in the future and establish a coordinated approach to prioritize City use and avoid over-extraction. Current consideration for uses include irrigation of park grounds, irrigation of green infrastructure assets, non-potable uses to offset drinking water uses, etc.

PHASE 2 OPTIONS

Action Name	Description	Rationale
42 Saltwater intrusion	Reduce risks related to saltwater intrusion: a) Complete an assessment of the potential extent and magnitude of saltwater intrusion, induced by sea-level rise and other factors. b) Complete an inventory of City-owned assets that may be vulnerable to saltwater intrusion and develop mitigation strategies for those assets.	Groundwater near the coast is naturally saline and the inland extent of saltwater can change over time. This process, known as saltwater intrusion, will occur in Vancouver due to a rising sea level, and may be worsened by reduced aquifer recharge and increased groundwater extraction, but the geographical extent and magnitude of this intrusion is unknown. Saltwater intrusion degrades potential groundwater resources and may impact groundwater-dependent ecosystems. It can also negatively impact infrastructure (e.g., through corrosion). There are a number of City-owned facilities (e.g., Kitsilano pool) and other assets (e.g., water and sewer pipes) that may be vulnerable to negative impacts. This action will further the City's understanding of where these types of impacts are most likely to occur. If suitable, at-risk infrastructure will be identified and mitigation strategies developed.
43 Increase infiltration through parks	Infiltrate stormwater into shallow aquifers through available large permeable spaces such as parks.	Parks currently drain excess stormwater into the sewer and drainage system, which adds burden to the sewer system and misses an opportunity for some of the City's largest permeable spaces to infiltrate and recharge groundwater. This action would explore opportunities for large permeable spaces such as turf fields and natural parks to infiltrate stormwater into the ground.

APPENDIX C

GROUNDWATER STRATEGY ACTIONS ANALYSIS REPORT