metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

METRO VANCOUVER REGIONAL DISTRICT
WATER COMMITTEEE

MEETING

Wednesday June 14, 2023
9:00 am
Meeting conducted electronically/in-person pursuant to the Procedure Bylaw
28th Floor Committee room, 4515 Central Boulevard, Burnaby, British Columbia

AGENDA[1]

1. ADOPTION OF THE AGENDA

1.1 June 14, 2023 Meeting Agenda
That the Water Committee adopt the agenda for its meeting scheduled for June 14, 2023 as circulated.

2. ADOPTION OF THE MINUTES

2.1 May 17, 2023 Meeting Minutes *3*
That the Water Committee adopt the minutes of its meeting held May 17, 2023 as circulated.

3. DELEGATIONS

4. INVITED PRESENTATIONS

5. REPORTS FROM COMMITTEE OR STAFF

5.1 Non-Potable Water Project *8*
That the Water Committee receive for information the report dated June 1, 2023, titled "Non-Potable Water Project".

5.2 2022 GVWD Dam Safety Program Annual Update
That the Water Committee receive for information the report dated May 16, 2023, titled "2022 GVWD Dam Safety Program Annual Update".

5.3 Capilano Main No. 4 Repairs and Upcoming Replacement Project *168*
That the Water Committee receive for information the report dated May 23, 2023, titled "Capilano Main No. 4 Repairs and Upcoming Replacement Project".

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[1] *Note: Recommendation is shown under each item, where applicable.*

5.4 Water Supply Tunnel Updates *74*

That the Water Committee receive for information the report dated May 25, 2023 titled "Water Supply Tunnel Projects Updates".

5.5 Award of Tender No. 23-100 for Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Backup Power *79*

That the GVWD Board:

a) Approve award of Tender No. 23-100 Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Back Up Power, in the amount of up to $10,899,738 (exclusive of taxes) to North America Construction (1993) Ltd., for a term of three years, subject to final review by the Commissioner; and
b) Authorize the Commissioner and the Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

5.6 Manager's Report *85*

That the Water Committee receive for information, the report dated May 30, 2023, titled "Manager's Report".

6. INFORMATION ITEMS

7. OTHER BUSINESS

8. BUSINESS ARISING FROM DELEGATIONS

9. RESOLUTION TO CLOSE MEETING

10. ADJOURNMENT/CONCLUSION

That the Water Committee adjourn/conclude its meeting of June 14, 2023.

Membership:

Brodie, Malcolm (C) – Richmond
Sager, Mark (VC) – West Vancouver
Albrecht, Paul – Langley City
Bell, Don – North Vancouver City
Bligh, Rebecca – Vancouver
Cassidy, Laura – Scəẃaθən məsteyəxʷ (Tsawwassen First Nation)
Guichon, Alicia – Delta
Hodge, Craig – Coquitlam
Keithley, Joe – Burnaby
Little, Mike – North Vancouver District
MacDonald, Nicole – Pitt Meadows
Stutt, Rob – Surrey
vanPopta, Misty – Langley Township

METRO VANCOUVER REGIONAL DISTRICT
WATER COMMITTEE

Minutes of the Regular Meeting of the Metro Vancouver Regional District (MVRD) Water Committee held at 9:00 am on Wednesday, May 17, 2023 in the 28th Floor Committee Room, 4515 Central Boulevard, Burnaby British Columbia.

MEMBERS PRESENT:
Chair, Mayor Malcolm Brodie, Richmond
Vice Chair, Mayor Mark Sager*, West Vancouver
Councillor Paul Albrecht, Langley
Councillor Don Bell*, North Vancouver City
Councillor Alicia Guichon*, Delta
Councillor Craig Hodge*, Coquitlam
Councillor Joe Keithley*, Burnaby
Councillor Rob Stutt, Surrey
Councillor Misty vanPopta*, Langley Township

MEMBERS ABSENT:
Councillor Rebecca Bligh, Vancouver
Chief Laura Cassidy, scəw̓aθən məsteyəxʷ (Tsawwassen First Nation)
Mayor Mike Little, North Vancouver District
Mayor Nicole MacDonald, Pitt Meadows

STAFF PRESENT:
Heather McNell, Deputy Chief Administrative Officer, Policy and Planning
Marilyn Towill, General Manager, Water Services
Rapinder Khaira, Legislative Services Coordinator, Board and Information Services

1. ADOPTION OF THE AGENDA

1.1 May 17, 2023 Meeting Agenda

It was MOVED and SECONDED
That the Water Committee adopt the agenda for its meeting scheduled for May 17, 2023 as circulated.

CARRIED

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*denotes electronic meeting participation as authorized by section 3.6.2 of the *Procedure Bylaw*

2. ADOPTION OF THE MINUTES

2.1 April 12, 2023 Meeting Minutes

It was MOVED and SECONDED
That the Water Committee adopt the minutes of its meeting held April 12, 2023 as circulated.

CARRIED

3. DELEGATIONS

No items presented.

4. INVITED PRESENTATIONS

No items presented.

5. REPORTS FROM COMMITTEE OR STAFF

5.1 Award of Contract for RFP 22-361, Construction Management of Coquitlam Main No. 4 South Section

Report dated May 3, 2023, from George Kavouras, Director, Procurement and Real Estate Services and Bob Cheng, Director, Major Projects, Project Delivery, seeking GVWD Board approval of the award of contract to Stantec Consulting Ltd., in the amount of $9,561,410 (exclusive of taxes).

It was MOVED and SECONDED
That the GVWD Board:

a) approve the award of a contract in the amount of $9,561,410 (exclusive of taxes) to Stantec Consulting Ltd. resulting from RFP No. 22-361: Construction Management of Coquitlam Main No. 4 South Section, subject to final review by the Commissioner; and
b) authorize the Commissioner and Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

CARRIED

5.2 Drinking Water Management Plan Update

Report dated May 3, 2023, from Linda Parkinson, Director, Policy, Planning and Analysis, Water Services and Vanessa Anthony, Community Engagement Program Manager, External Relations, seeking GVWD Board approval to begin public engagement in the fall of 2023 on the Drinking Water Management Plan.

It was MOVED and SECONDED
That the GVWD Board authorize staff to proceed with public engagement, as outlined in the Engagement Plan, to update the *Drinking Water Management Plan*, as outlined in the report dated May 3, 2023, titled "Drinking Water Management Plan Update".

CARRIED

5.3 Water Supply Update for Summer 2023

Report dated May 1, 2023, from Linda Parkinson, Director, Policy, Planning and Analysis and Paul Kohl, Director, Operations and Maintenance, Water Services, providing the Water Committee an update on the water supply situation and water consumption projections before the high demand period.

It was MOVED and SECONDED
That the Water Committee receive for information the report dated May 1, 2023, titled "Water Supply Update for Summer 2023".

CARRIED

5.4 Water Services Wildfire Preparedness Update

Report dated May 4, 2023, from Kevin Brown, Superintendent, Watershed Protection, Watersheds and Environment, Water Services, providing the Water Committee with an annual update on wildfire preparedness for the water supply areas in advance of the 2023 fire season.

Members were provided with an overview of the watershed protection history, Water Services Wildfire Protection program, British Columbia Wildfire Services Agreement, strategic partnerships through the Watershed Wildfire Working Group, Metro Vancouver wildfire support and response, and 2023 readiness.

Presentation material titled 'Water Services Wildfire Preparedness Update" is retained with the May 17, 2023 Water Committee agenda.

It was MOVED and SECONDED
That the Water Committee receive for information the report dated May 4, 2023, titled "Water Services Wildfire Preparedness Update".

CARRIED

5.5 Douglas Road Water Main No. 2 Still Creek Tunnel

Report dated May 3, 2023, from Dustin Erickson, Lead Senior Engineer, Engineering and Construction, Water Services, providing the Water Committee with information on the collaboration implementation process and successful completion of the Douglas Road Water Main No. 2 Still Creek Tunnel.

It was MOVED and SECONDED
That the Water Committee receive for information the report dated May 3, 2023, titled “Douglas Road Water Main No. 2 Still Creek Tunnel”.

CARRIED

5.6 Manager’s Report

Report May 3, 2023, from Marilyn Towill, General Manager, Water Services, providing the Water Committee with an update on the Bylaw Notice Authority for GVS&DD and GVWD, Dam Safety Awareness Campaign, a leak on the section of Capilano Main No. 4 within Stanley Park, and on the Water Committee 2023 Work Plan.

It was MOVED and SECONDED
That the Water Committee receive for information the report dated May 3, 2023, titled “Manager’s Report”.

CARRIED

6. INFORMATION ITEMS

No items presented.

7. OTHER BUSINESS

No items presented.

8. BUSINESS ARISING FROM DELEGATIONS

No items presented.

9. RESOLUTION TO CLOSE MEETING

It was MOVED and SECONDED
That the Water Committee close its meeting scheduled for May 17, 2023 pursuant to section 226 (1) (a) of the *Local Government Act* and the *Community Charter* provisions as follows:

“90 (1) A part of a council meeting may be closed to the public if the subject matter being considered relates to or is one or more of the following:
(e) the acquisition, disposition or expropriation of land or improvements, if the council considers that disclosure could reasonably be expected to harm the interests of the municipality;
(g) litigation or potential litigation affecting the municipality;
(i) the receipt of advice that is subject to solicitor-client privilege, including communications necessary for that purpose;
90 (2) A part of a meeting must be closed to the public if the subject matter being considered relates to one or more of the following:
(b) the consideration of information received and held in confidence relating to negotiations between the municipality and a provincial government or the federal government or both, or between a provincial government or the federal government or both and a third party.”

CARRIED

10. ADJOURNMENT/CONCLUSION

It was MOVED and SECONDED
That the Water Committee adjourn its meeting of May 17, 2023.

CARRIED
(Time: 9:25 am)

Rapinder Khaira, Legislative Services Coordinator	Malcolm Brodie, Chair

59920044 FINAL

To:	Water Committee
From:	Linda Parkinson, Director, Policy, Planning and Analysis, Water Services
Date:	June 1, 2023 Meeting Date: June 14, 2023
Subject:	**Non-Potable Water Project**

RECOMMENDATION

That the Water Committee receive for information the report dated June 1, 2023, titled "Non-Potable Water Project".

EXECUTIVE SUMMARY

Using onsite water sources to supply non-potable end uses, at the building level, presents an opportunity to use water resources more sustainably and prioritize drinking water for essential uses. To support regional water conservation the Non-Potable Water Project, funded by the Water Sustainability Innovation Fund, aims to promote water reuse and rainwater harvesting systems (non-potable water systems) by identifying and addressing barriers to the adoption of these systems.

Guiding documents were developed for stakeholders within building and water industries to support overcoming barriers associated with non-potable water systems:

1. Guidebook – leads stakeholders from planning to operations of building-scale non-potable water systems
2. Companion document – provides technical design and performance monitoring guidance
3. Key findings document – outlines recommendations to address identified barriers to non-potable water system uptake

After publishing these documents, engagement with stakeholders will continue in order to secure an appropriate group or agency to own and action the key findings document. This project, aimed at promoting non-potable water use, supports goals and objectives in both the Drinking Water Management Plan and Integrated Liquid Waste and Resource Management Plan.

PURPOSE

The purpose of this report is to provide an update on the Non-Potable Water Project (the Project) and to bring to the attention of the Water Committee the three guiding documents that have been developed, funded by the Water Sustainability Innovation Fund (WSIF), to support the uptake of non-potable water systems in the region.

BACKGROUND

With the WSIF funded Project recently completed, this information is being provided to the Water Committee to report the Project outcomes prior to making the resulting resources available to the public.

NON-POTABLE WATER PROJECT

The Project is intended to promote non-potable water systems as a way to support drinking water conservation in the Metro Vancouver region. With up to 75 per cent of drinking water in the summer being used for non-potable purposes, there is an opportunity to use water resources more sustainably by utilizing onsite sources for non-potable water uses.

Benefits of increased non-potable water use include:

- Reducing drinking water demand, as well as wastewater and stormwater collection
- Assisting in reducing water demand during the warm and dry high demand season when water supply and system operations are most challenging
- Assisting in meeting the challenges and uncertainty that climate change brings, thereby increasing resilience
- Supporting sustainable building certification

Non-potable water systems are not prevalent within the region for reasons that include regulatory hurdles, implementation and operational challenges, as well as potentially lengthy payback periods.

METHODOLOGY

The Project focused on identifying and investigating solutions to region-specific challenges associated with the uptake of non-potable water systems as informed by the Non-Potable Water Working Group (working group) convened by Metro Vancouver. The working group comprised stakeholder representatives from municipal and provincial governments, health authorities, building industry, post-secondary institutions, and other relevant agencies who are familiar with:

- Non-potable water use policies and regulations applicable to the Metro Vancouver region
- Review and approval processes of non-potable water systems, and/or
- Development and deployment of systems from an industry perspective, including design, implementation, and operations

Three half-day workshops and several small-group discussions were completed to:

- Identify policy, regulatory, and other barriers to non-potable water use
- Identify opportunities and develop responses to overcome barriers to system uptake, and
- Agree on the contents of the key findings document

This Project also incorporated lessons learned from local case studies, and from regions with greater technical expertise and industry best practices, to provide guidance to local industry stakeholders working within the current regional regulatory environment. Information and input were gathered from various relevant stakeholders ranging from building industry professionals to regulatory authorities, researchers, and water reuse professionals. The content of the guiding documents was also informed by a review of municipal policies and bylaws, published academic research, and guidelines sourced from a number of organizations ranging from the World Health Organization to provincial health services to professional and technical associations. A study of operational and decommissioned systems in the region was also completed.

GUIDING DOCUMENTS

This Project produced guiding documents to support planning through to operation and maintenance of non-potable water systems. The guiding documents include a guidebook, companion document, and a key findings document. These documents are not designed to be relied upon as technical documents, but rather to provide insight, guidance, and resources on non-potable water use, specific to the Metro Vancouver region.

Guidebook and Companion Document

The guidebook and companion document were created as resources for technical and non-technical industry stakeholders to use while planning, designing, and implementing non-potable water systems.

The guidebook includes topics such as industry drivers, regulation and policy, logistical and feasibility considerations, and design process recommendations. Case studies of existing systems in the region highlight some of the lessons learned to aid in future applications.

The companion document, which was created in tandem with the guidebook, caters more specifically to technical groups and provides additional technical information and guidance for various elements of the guidebook, including examples, tables, and additional references. For example, embedded in the companion document are an expanded fit-for-purpose matrix, checklists for plans during system design and implementation, and water balance model data sources and notes.

Key Findings of the Working Group

The key findings of the working group are outlined in a key findings document that identifies barriers to uptake of non-potable water systems and recommendations to address those barriers. The document provides regulatory context and aims to inform the next steps of local, regional, and provincial governments, local health authorities, and technical associations as they develop pertinent regulations, policies, codes, and standards associated with non-potable water systems. For example, to enhance public policy and improve the business case for these systems, the working group recommends that regional policies be developed and adopted, and municipal policies be reviewed and updated to support non-potable water use.

The findings and recommendations fall into six main categories: regulation and its application; management and oversight post-occupancy; public policy and business casing; institutional and industry capacity; monitoring and evaluation; and ongoing coordination.

NEXT STEPS

The guidebook and companion document will be published on the Metro Vancouver website with a target audience of technical and professional associations related to the non-potable water industry.

The recommendations of the working group cannot be actioned by Metro Vancouver alone, with several recommendations requiring provincial authority and/or province-wide resources and alignment. To continue working towards broader adoption of non-potable water use in the region, engagement will continue with the aim of identifying an appropriate agency or level of government to own and action the key findings document. If established, the future champion can continue this valuable initiative and support coordination across regulators, policy developers, and other key stakeholders in undertaking the strategies recommended in the key findings document.

ALTERNATIVES

This is an information report. No alternatives are presented.

FINANCIAL IMPLICATIONS

From the WSIF, $350,000 was allocated for this Project. To date, approximately $289K has been charged and $61K of the allocated budget remains. Funds totaling $30K have been set aside for continued engagement with stakeholders. There are no current plans to request additional funding.

CONCLUSION

Increasing non-potable water use by breaking down barriers to system implementation can support regional drinking water conservation and climate resilience. The Non-Potable Water Project produced a guidebook and companion document that will support the design and implementation of non-potable water systems, providing insight and guidance specific to the regulation and resources of non-potable water use in the region. These documents also highlight the lessons learned as they pertain to design processes, implementation, operations, and maintenance. To complement the guidebook, a working group of industry professionals contributed to the development of a key findings document that identifies barriers associated with the uptake of non-potable water systems and provides recommended approaches to addressing those barriers.

Attachments

1. Non-Potable Water Systems – A Guidebook for the Metro Vancouver Region *(58039106)*
2. Non-Potable Water Systems Companion Document *(54140672)*
3. Overcoming Barriers to Non-Potable Water Use in the Metro Vancouver Region: Key findings of the Non-Potable Water Working Group to support broader uptake of non-potable water systems (*60024895*)
4. Presentation re: Non-Potable Water Project *(59385797)*

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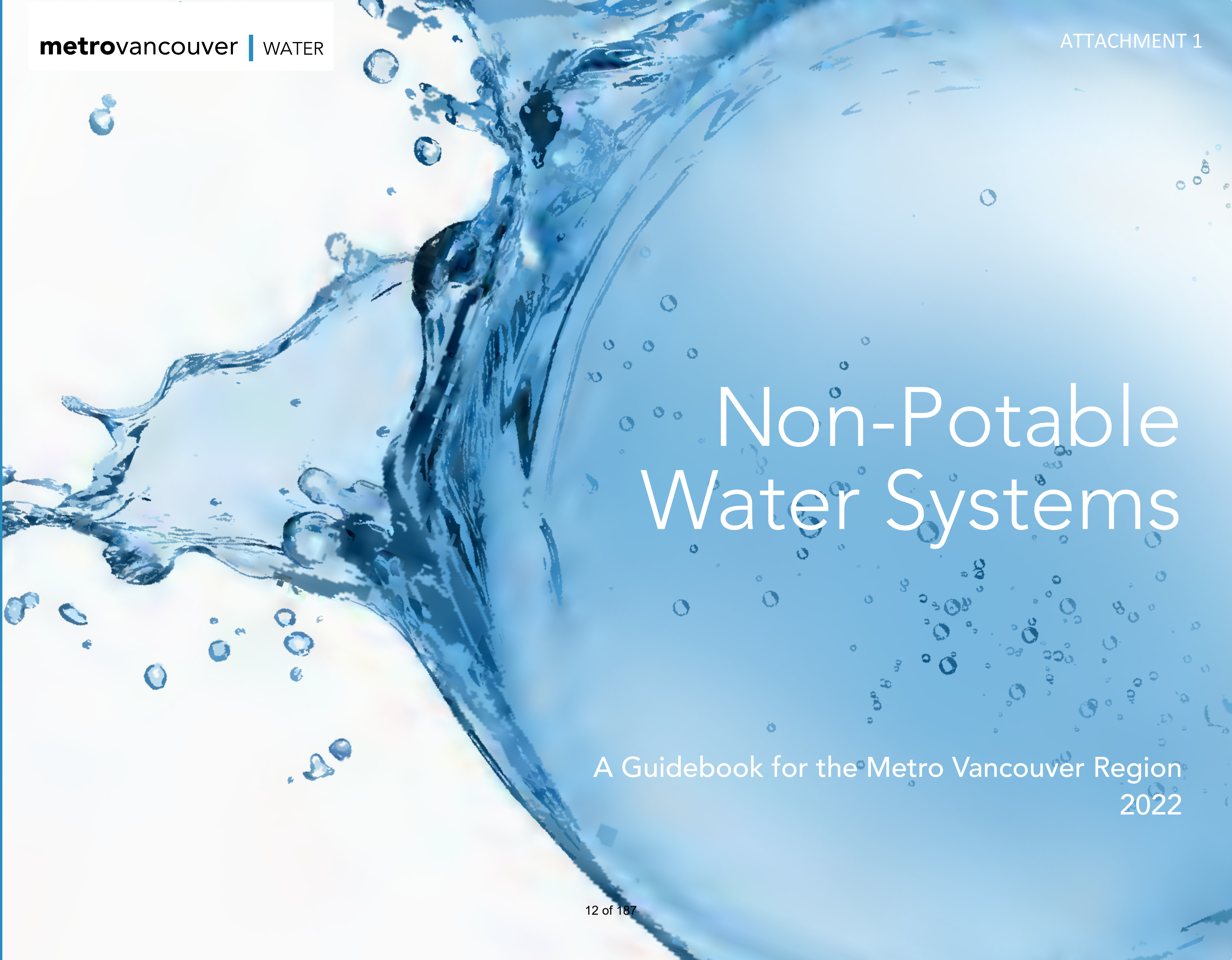
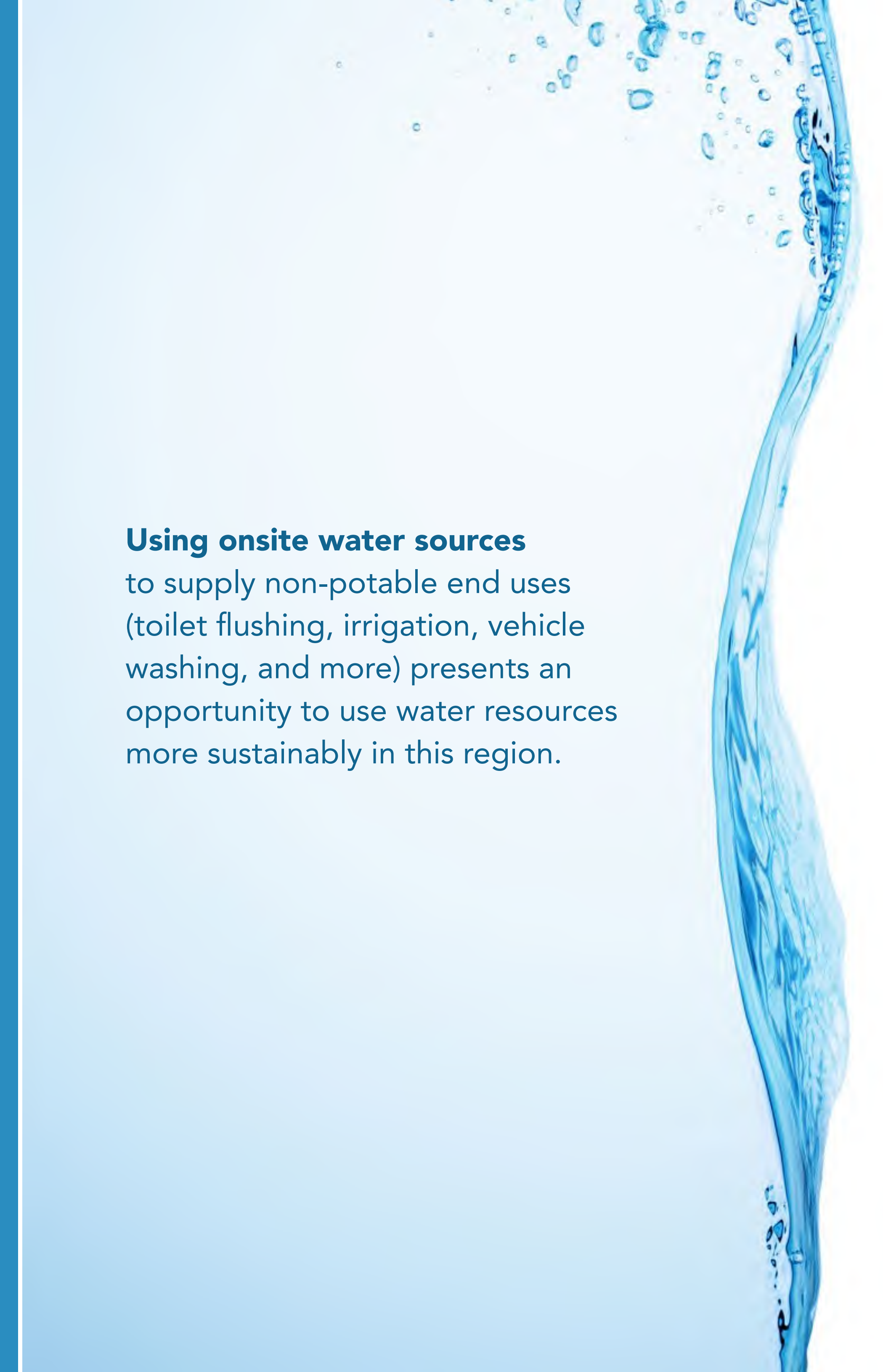
ATTACHMENT 1



Non-Potable Water Systems

A Guidebook for the Metro Vancouver Region

2022



Using onsite water sources to supply non-potable end uses (toilet flushing, irrigation, vehicle washing, and more) presents an opportunity to use water resources more sustainably in this region.

About Metro Vancouver

Metro Vancouver is a federation of 21 municipalities, one electoral area, and one treaty First Nation that collaboratively plans for and delivers regional-scale services. Its core services are drinking water, wastewater treatment, and solid waste management. Metro Vancouver also regulates air quality, plans for urban growth, manages a regional parks system, and provides affordable housing. The regional district is governed by a Board of Directors of elected officials from each local authority.

Metro Vancouver acknowledges that the region's residents live, work, and learn on the shared territories of many Indigenous Peoples, including 10 local First Nations: Katzie, Kwantlen, Kwikwetlem, Matsqui, Musqueam, Qayqayt, Semiahmoo, Squamish, Tsawwassen, and Tsleil-Waututh. Metro Vancouver respects the diverse and distinct histories, languages, and cultures of First Nations, Métis, and Inuit, which collectively enrich our lives and the region.

Using onsite water sources to supply non-potable end uses (toilet flushing, irrigation, vehicle washing, and more) presents an opportunity to use water resources more sustainably in this region. This guidebook describes best practices for adopting non-potable water systems in a manner that helps Metro Vancouver move toward more resilient and sustainable use of available water resources.

TABLE OF CONTENTS

Acknowledgements

Metro Vancouver acknowledges the contribution of several organizations who participated in discussions, provided valuable suggestions for the content, and shared lessons, data, and information to support the development of this guidebook. Contributing organizations included:

- BC Building and Safety Standards Branch
- BC Ministry of Health
- Canada Green Building Council
- City of Coquitlam
- City of North Vancouver
- City of Surrey
- City of Vancouver
- Concert Properties Ltd
- District of North Vancouver
- Engineers and Geoscientists of British Columbia
- Fraser Health Authority
- Integral Group
- University of British Columbia
- Vancouver Coastal Health

Metro Vancouver also thanks those who contributed their experiences of using non-potable water systems in buildings throughout Metro Vancouver, including:

- Clean Flo Water Technologies
- Colliers Canada
- ECOfluid Systems Inc
- Mountain Equipment Company
- IKEA Canada
- Simon Fraser University Community Trust
- University of British Columbia
- Wall Financial Corp
- Westbank Corporation
- Williams Engineering
- Van der Zalm & Associates

Metro Vancouver also thanks the team at Pinna Sustainability, including Eco-Sense, Trax Development, Mika Creative, The Kreative, and PUBLIC Architecture for their assistance in preparing the guidebook.

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The material provided in this publication is intended for educational and informational purposes only. This publication is not intended to endorse or recommend any particular product, material or service provider nor is it intended as a substitute for engineering, legal or other professional advice. Such advice should be sought from qualified professionals.

The Non-Potable Water Systems: A Guidebook for the Metro Vancouver Region is not a legal document and should not be considered a substitute for governing legislation and regulation. This guidebook is a living document and may be updated periodically.

Located in Surrey, City Centre 2 has incorporated simple stormwater reuse systems, implemented to meet City of Surrey standards and to assist with the achievement of LEED® certification.

Overview

We use water in many different ways in our daily lives — everything from drinking to washing ourselves and our clothes to flushing toilets to watering landscapes and more. In Metro Vancouver, almost all of the water we use is pristine drinking water. But the reality is that we do not need to use treated drinking water for a lot of these activities. When we are designing buildings, we can think about the types of water that are available onsite and how much treatment would be needed to make the water safe for non-potable (non-drinking) purposes.

Installing non-potable water systems helps us:

- Conserve treated drinking water that currently gets used for non-potable end uses (like flushing toilets and watering grass).
- Make better use of onsite water (like rain or stormwater) that is normally viewed as a nuisance to be captured and piped away — especially in denser urban areas.
- Become more resilient to a changing climate, for example, by reusing water for irrigation or car washing during drought periods.

Right now, there are a small number of non-potable water systems installed across Metro Vancouver, but they are far from typical. And in a number of cases, systems that were installed over the last decade have been decommissioned for various reasons (inadequate design, commissioning, maintenance, etc.). Many lessons have been learned since these systems were put into place. By applying best practices, there is potential for many more non-potable water systems to help us use water more sustainably, safely, and effectively over time.

WE USE WATER IN MANY DIFFERENT WAYS IN OUR DAILY LIVES - EVERYTHING FROM DRINKING TO WASHING OURSELVES AND OUR CLOTHES TO FLUSHING TOILETS TO WATERING LANDSCAPES AND MORE.

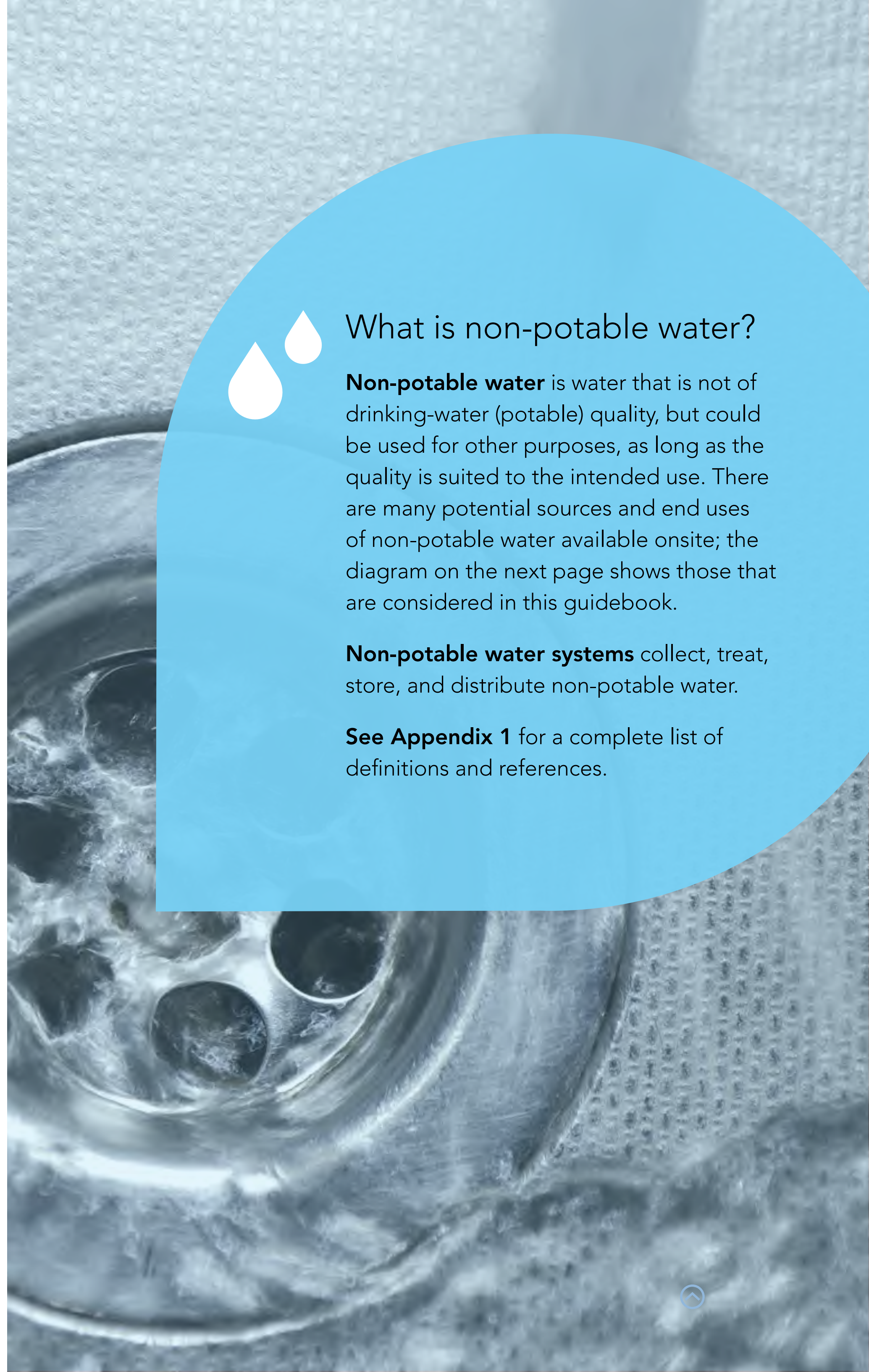
Purpose of this guidebook

This guidebook aims to support an increase in the number of non-potable water systems being installed, and the longevity of systems in place, by:

- Providing an outline of best practices and resources for owners, professionals, and regulators at each stage from planning and design through implementation to operations and maintenance.
- Clarifying the regulations involved with getting these systems approved and operating.
- Discussing the costs and benefits of these systems.
- Showing examples of non-potable water systems currently operating in the Metro Vancouver region.
- Highlighting common problems and ways to address them.

Who is this guidebook for? Everyone involved in planning, designing, installing, operating, and maintaining buildings with non-potable water systems. This includes owners, developers, architects, project managers, engineers, local government planners and building inspectors, health authority officers, and building maintenance and operations professionals.

What types of buildings are discussed? Although these systems can be integrated into almost any building, the focus of this guidebook is on multi-family, commercial, mixed-use buildings and institutional buildings, where the majority of growth of new construction is anticipated over the coming decades. This guidebook presents best practices for buildings that are connected to the municipal water and sewer systems.

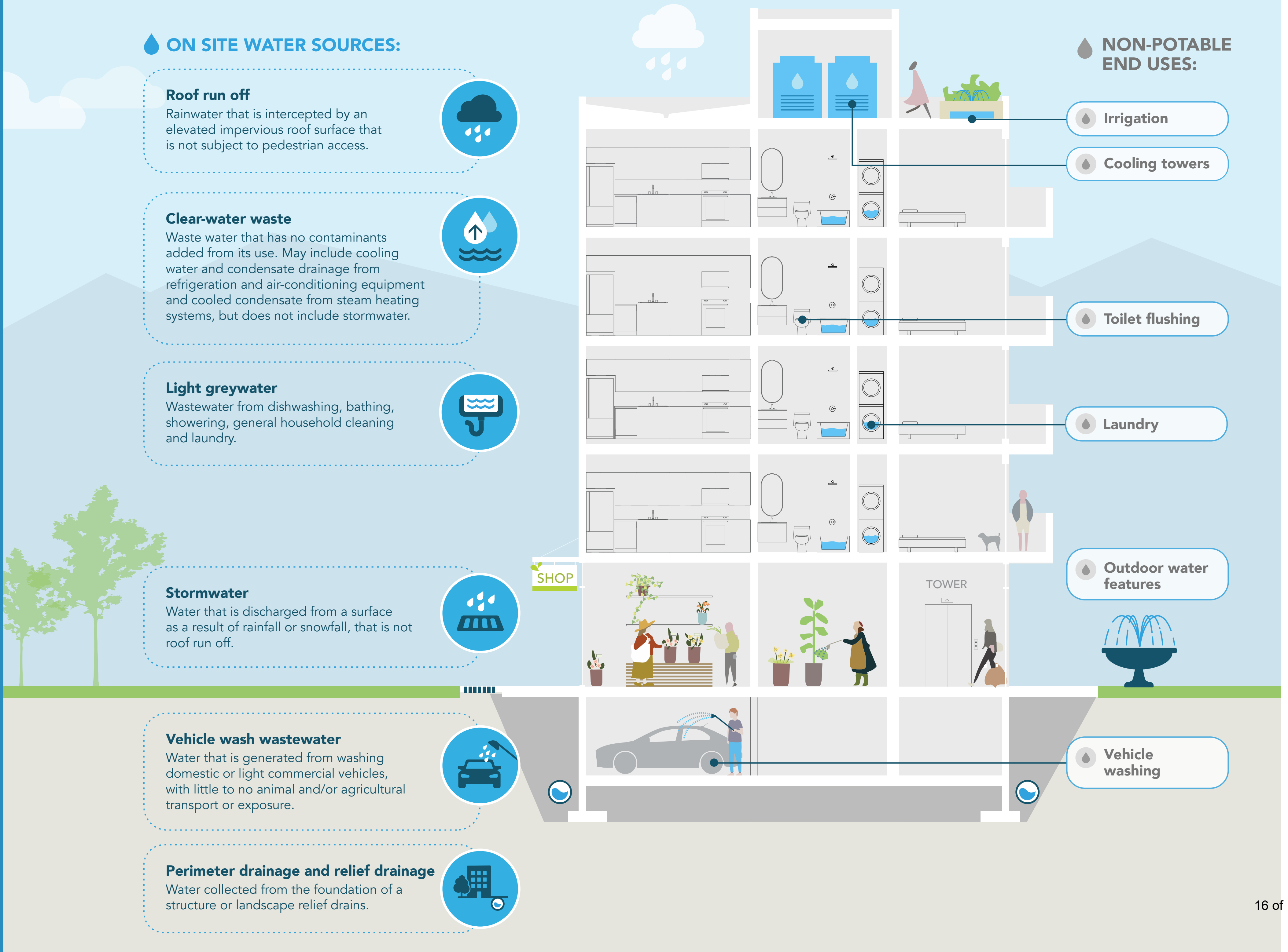


What is non-potable water?

Non-potable water is water that is not of drinking-water (potable) quality, but could be used for other purposes, as long as the quality is suited to the intended use. There are many potential sources and end uses of non-potable water available onsite; the diagram on the next page shows those that are considered in this guidebook.

Non-potable water systems collect, treat, store, and distribute non-potable water.

See Appendix 1 for a complete list of definitions and references.



ON SITE WATER SOURCES:

Roof run off
Rainwater that is intercepted by an elevated impervious roof surface that is not subject to pedestrian access.

Clear-water waste
Waste water that has no contaminants added from its use. May include cooling water and condensate drainage from refrigeration and air-conditioning equipment and cooled condensate from steam heating systems, but does not include stormwater.

Light greywater
Wastewater from dishwashing, bathing, showering, general household cleaning and laundry.

Stormwater
Water that is discharged from a surface as a result of rainfall or snowfall, that is not roof run off.

Vehicle wash wastewater
Water that is generated from washing domestic or light commercial vehicles, with little to no animal and/or agricultural transport or exposure.

Perimeter drainage and relief drainage
Water collected from the foundation of a structure or landscape relief drains.

NON-POTABLE END USES:

- Irrigation
- Cooling towers
- Toilet flushing
- Laundry
- Outdoor water features
- Vehicle washing

Fit-for-purpose water

An important concept for non-potable water systems is “fit-for-purpose water.” In this guidebook, this concept refers to the matching of an appropriate water source to an end use where the source is of adequate quantity and is treated only to the extent needed to meet the quality requirements of that end use. By finding a good match in terms of volume and quality, non-potable water systems can provide a sustainable alternative to using clean drinking water where it is not needed, while making best use of water already available onsite.

Why should we use non-potable water in Metro Vancouver?

In this region, we tend to think of water as plentiful, but we are starting to see that there are limits. These limits are particularly clear as we experience hotter summers with longer dry spells, compounded by less snowfall accumulation in our water supply area during warmer winters. To overcome these challenges, seasonal watering restrictions are implemented annually with more advanced restrictions activated on an as-needed basis. These types of conditions are expected to become more frequent as our climate continues to change.

Drinking water is a precious and limited resource. Managing this resource requires substantial ongoing effort to ensure the water sources are protected, the treatment is effective, and the transmission system brings clean water safely to all users throughout the region on a continuous basis. Using fit-for-purpose water for non-potable end uses can reduce the resource requirements to maintain the drinking-water system, and may help defer the need to expand the system – a very expensive undertaking.

As we continue to increase the density of our urban areas and experience more intense rain events, stormwater and sewer systems can become overwhelmed, leading to sewer overflows and flooding. There are three primary strategies that address the need to conserve water as well as to reduce the load on our sewer and stormwater systems:

1 **Use less water**: Install water-efficient fixtures, manage leaks, and modify water use behaviours.

2 **Release less water to the sewer system**: Capture and infiltrate water into the ground onsite (although there’s usually not enough surface area in an urban setting to handle storms) or temporarily store water from a storm to be slowly released later.

3 **Use fit-for-purpose water**: Make use of the water sources onsite, which can conserve drinking water, reduce or slow down the release of water into the sewer system, and make our water system more resilient to a changing climate. This is the focus of this guidebook.

SUSTAINABLE BUILDING CERTIFICATION CREDITS FOR NON-POTABLE WATER: LEED V4 BUILDING DESIGN AND CONSTRUCTION

Implementing non-potable water systems in new buildings can assist in achieving credits for sustainable building certification programs. For example, the current version of Leadership in Energy and Environmental Design (LEED v4) gives credits for non-potable water systems through the following:

Sustainable Sites - Rainwater Management:

This credit rewards projects that retain rainfall runoff onsite through low-impact development (LID) or green infrastructure (GI) practices. Collecting rainwater and reusing it is a key strategy to achieve the required thresholds.

Water Efficiency - Outdoor Water Use Reduction:

Projects may achieve additional thresholds in water savings by using non-potable water sources to offset their landscape water requirement, after first meeting a prerequisite level through plant species selection and irrigation system efficiency.

Water Efficiency - Indoor Water Use Reduction:

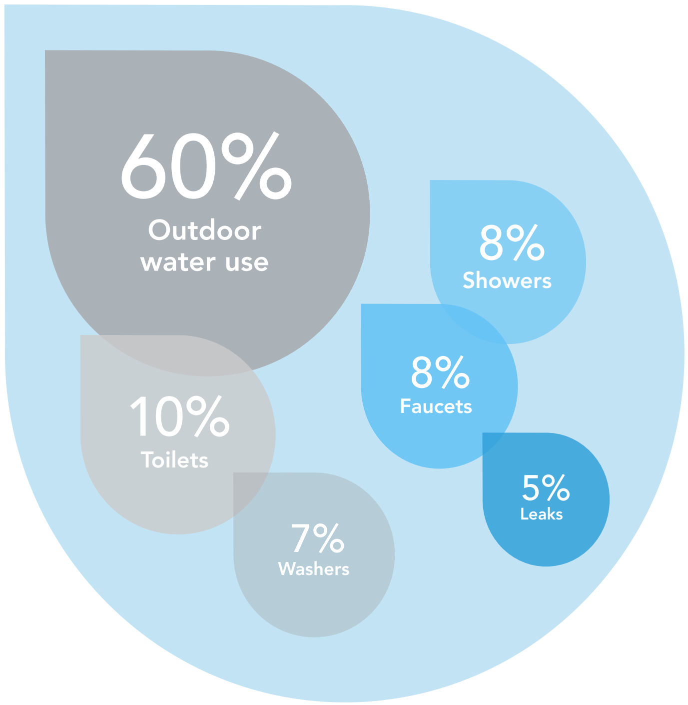
Non-potable water sources can be used to target additional savings in water used for indoor fixtures and fittings beyond a prerequisite efficient target.

Water Efficiency - Optimize Process Water:

(LEED v4.1 beta): Under this new credit, projects are rewarded for offsetting a portion of the building's process water use with non-potable sources. Eligible subsystems may include boilers, chillers, clothes washing, vehicle washing, etc.

How much potential is there to save drinking water?

A lot. If we consider that any water used for drinking, washing ourselves, and preparing food needs to be of drinking-water quality, nearly everything else could be provided by non-potable water where it is fit-for-purpose. In Metro Vancouver, over 75% of the water we use is estimated to be for non-potable end uses.



Currently, almost all of the water we use meets a clean drinking-water standard. But when we break down our water use, it turns out the majority of it could use non-potable water, including outdoor uses, toilets, and washers, shown in grey above (Metro Vancouver, accessed 2022).

Benefits of non-potable water systems

It is clear there is a big opportunity to conserve clean drinking water and to supply many of our water needs with non-potable sources of water. In addition to conserving treated drinking water, non-potable systems can make use of nuisance stormwater that needs to be captured and slowly released to the sewer system. Many municipalities in Metro Vancouver have stormwater management requirements for new developments that help ensure the sewers do not become overwhelmed during periods of heavy or frequent rainfall. Rain or stormwater that is already required to be captured can be an excellent source of non-potable water. Additional benefits include:

- **Increased resilience**: Creating alternative water supplies can increase our resilience to drought or supply disruptions. This is already apparent during Metro Vancouver's dry season, when annual water restrictions come into effect. Buildings with non-potable water systems may avoid restrictions for irrigation and vehicle washing.
- **Sustainable buildings**: Non-potable water systems can support sustainable building certification and demonstrate a commitment to sustainability.
- **Providing greener public spaces**: By using an onsite source of water that is available year-round for irrigation, such as light greywater (from showers and laundry), there may be additional opportunities for greening outdoor spaces that provide shade and cooling in urban areas.
- **Reducing utility costs**: Water and sewer charges have been rising recently and are forecasted to increase further. Using less drinking water and reducing sewer outflows can save operating costs.
- **Deferring regional investments**: If enough buildings make use of non-potable water, there may be potential to defer some aspects of regional water supply and infrastructure expansion, and associated rate increases.
- **Capturing nutrients**: In some systems there may be opportunities to capture nutrients in wastewater for beneficial use.
- **Demonstrating innovation**: These onsite systems align well with a movement towards more innovation in sustainable architecture and building engineering. The systems can also provide opportunities for education, engagement, and research.

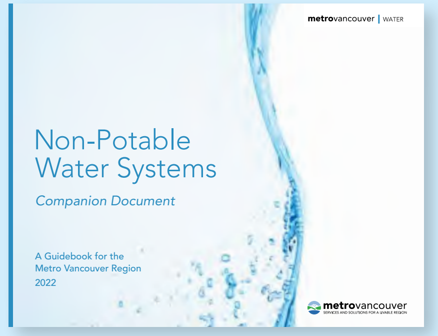
Common challenges for non-potable water systems

Despite the significant benefits of non-potable water systems for conserving drinking water, reducing the strain on sewer systems and stormwater systems, and increasing the sustainability of our buildings, there are also a number of challenges that hinder them from being installed, and cause some of them to be decommissioned well before their useful lifespan. Common challenges include:

- **Unclear regulatory approvals:** Although these systems are allowed by current regulations, there is a general lack of awareness and understanding of the regulatory requirements and who needs to be involved in approving these systems.
- **Lack of business case:** Installing these systems increases capital costs for building projects, and the savings in water and sewer discharge costs generally do not make up for the up-front investment cost due to relatively low rates in this region.
- **Budget for ongoing costs:** These systems require ongoing maintenance and monitoring, which may become cost prohibitive relative to the low cost of water and sewer discharge in this region.
- **Insufficient public policy support:** Although these systems support numerous sustainability goals that align with public policy, generally the policies in place may not sufficiently incentivize or offset the costs to warrant the investment.
- **Insufficient management:** If not properly conceived, designed, and reviewed during the approval process, and without an identified management strategy, the systems may be too complex for the owner/operator to properly operate, maintain, and monitor, which can lead to decommissioning systems.
- **Lack of local capacity:** Due to the general low uptake of these systems in the region, local industry capacity to design, build, operate, and maintain these systems is less mature than in other areas of building and development, though knowledge and experience is increasing.

This guidebook helps explain these challenges, and provides clarity on best practices and resources to improve outcomes and mitigate challenges.

This guidebook is accompanied by a document that provides additional context and links to references, and assembles relevant guidance from other sources into a convenient location. The Companion Document is referenced in various sections throughout this guidebook.



metrovancouver | WATER

Non-Potable Water Systems

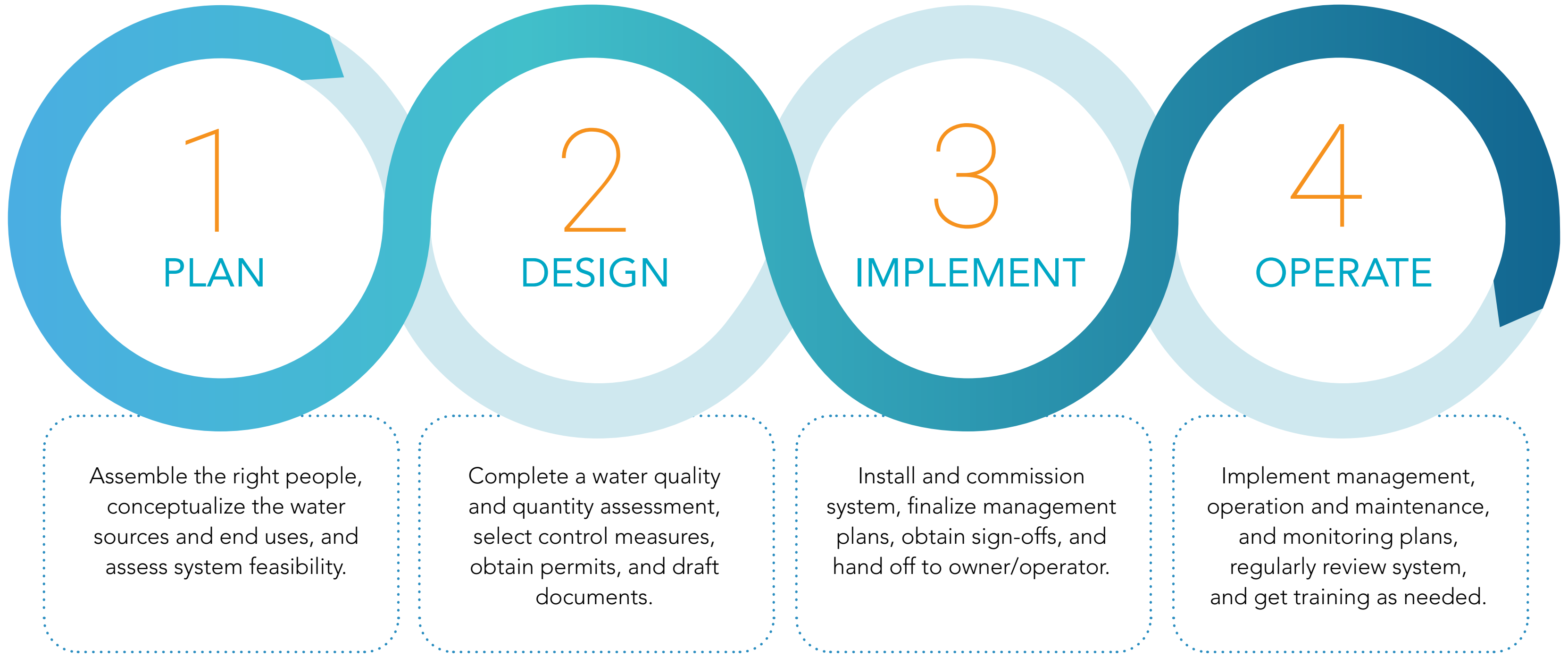
Companion Document

A Guidebook for the
Metro Vancouver Region
2022

metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

What is involved in these systems from planning through to operation?

Non-potable water systems come in many different forms and can be as simple as a small rain barrel that has no treatment and limited maintenance, to complex systems that need a qualified operator to monitor and manage on a daily basis. Understanding the lifecycle of the system, and in particular how it will be operated and maintained, is crucial to designing a system that has a good chance of success over the long term. This guidebook outlines best practices and considerations for each of the following stages in the lifecycle of the system.



1 PLAN

Assemble the right people, conceptualize the water sources and end uses, and assess system feasibility.

2 DESIGN

Complete a water quality and quantity assessment, select control measures, obtain permits, and draft documents.

3 IMPLEMENT

Install and commission system, finalize management plans, obtain sign-offs, and hand off to owner/operator.

4 OPERATE

Implement management, operation and maintenance, and monitoring plans, regularly review system, and get training as needed.

1. Planning non-potable water systems

1.1 Checklist and outcomes

The planning stage is an opportunity to identify the purpose, potential for, and initial feasibility of including a non-potable water system in a building project. If the system gets the go-ahead after planning, then the project moves into the design, implementation, and operation stages. The project management role will guide the project through these stages, and will be responsible for maintaining consistency with goals and desired outcomes identified during the planning stage.

Table 1.1 Planning stage checklist and outcomes

PLANNING STAGE: **CHECKLIST**	PLANNING STAGE: **OUTCOMES**
✓ Prepare project description, including goals, desired outcomes, constraints, and stakeholder requirements.	Project Description documented and confirmed.
✓ Identify applicable regulations and policies based on source and use combinations. ✓ Meet with the regulator to discuss preliminary concept, and to identify process and requirements.	Relevant regulatory framework and policies identified.
✓ Conduct initial fit-for-purpose assessment (characterize water quality and quantity). ✓ Select preferred combination of sources and uses.	Water sources and planned end uses identified and characterized.
✓ Develop initial management plan with organizational chart of roles and responsibilities. ✓ Consider system oversight options and responsible management entity.	Initial Management Plan documented and confirmed.
✓ Identify initial and lifecycle costs and benefits, at a planning level. ✓ Make preliminary assessment of capacity for construction, operation, and maintenance of systems. ✓ Assess project feasibility and adjust project description.	Preliminary feasibility assessment completed and documented in the Project Description. Proceed to design, if feasible.

1.2 Project goals and outcomes

Non-potable water systems can support a variety of social and environmental goals and desired outcomes. As highlighted in the overview chapter, the primary regional benefits of these systems are: using less drinking water for non-potable end uses, assisting with reducing peak sewer and stormwater flows, and increasing our resilience to droughts or supply disruptions. Beyond these benefits, these systems can also contribute to meeting specific building goals; broader social goals including enhanced aesthetics, reduced urban heat stress, enhanced park spaces, and improved resilience to system shocks; or other environmental goals, such as improved water quality for aquatic habitats and carbon footprint reduction. Other benefits are listed in the overview chapter.

As part of this process, consider the following questions to help document the goals for using onsite water sources for non-potable purposes in your project:

- What is the sustainability vision for the project?
- What social, cultural, corporate, and environmental goals are being pursued?
- What are the co-benefits of using non-potable water?
- Are there any regulatory obligations or local policies that may be met with non-potable water use?
- Who are the stakeholders and what are their requirements?
- Is the project targeting a sustainable building certification, and what are the opportunities for non-potable water to obtain the appropriate credits?
- What other project constraints need to be considered?
- How will success be measured?

Project goals and desired outcomes should be documented in a project description, together with pertinent information about the site and planned building size, occupancy, and use.

1.3 Roles and responsibilities during planning

There are a number of different people representing various roles that need to be involved for the successful implementation of a non-potable water system. Those directly engaged in designing, constructing, commissioning, and handing over the system are part of the project team. Those that can affect, be affected by, or perceive to be affected by the project are considered stakeholders. A common understanding of the roles of project team members and key stakeholders together with assignment and acceptance of responsibilities is critical for project success.

Integrated design process

A shift toward Integrated Design Processes (IDPs) in building design over recent decades has helped achieve a shift toward more sustainable buildings by using a more iterative, flexible process that allows optimal designs to emerge rather than following a predetermined path. IDPs are well matched to the design of non-potable water systems, which can overlap into multiple disciplines. These processes involve more time and effort during the planning stage. Through an IDP that allows for iterative design, the project goals and desired outcomes identified above can be balanced to achieve a successful project in a financially feasible manner, while managing project risks. Table 1.2 outlines the key principles of an IDP (BC Green Building Roundtable, 2007) and relates them to non-potable water use.

Table 1.2 Key principles of an IDP and how they relate to planning for non-potable water use

IDP PRINCIPLE	HOW THIS APPLIES TO NON-POTABLE WATER USE
Broad collaborative team from outset	Early involvement of non-potable water system designers can influence or inform the project goals and may increase the potential for learning and collaboration with experts in other areas.
Well-defined scope, vision, goals, and objectives	Integrating non-potable water considerations early will result in the best chance to realize water sustainability outcomes for the project, while meeting other goals and objectives.
Effective and open communication	Interaction between non-potable water system designers and other team members reduces potential for competing objectives when designing in silos, increases potential for optimal integrated solutions, and assists with proper transition to the ultimate owner.
Innovation and synthesis	Integrated visioning and design may result in innovative designs by synthesizing across disciplines.
Systematic decision-making	Incorporating non-potable water design tools and best practices can support strong and informed decision-making related to sustainability benefits and other analyses, such as lifecycle costs.
Iterative process with feedback cycles	Non-potable water systems are best designed using an iterative process with feedback as more is learned about the various potential sources and end uses — making them a good match for an IDP.

Example of overlap between civil and mechanical engineers on a non-potable water project: Commercial projects will involve both civil engineers and mechanical engineers, with the civil engineer responsible for ensuring the building can handle extreme weather events, and the mechanical engineer responsible for ensuring the potential source water is effectively captured and collected at volumes and flow rates manageable for the system. Through an IDP, these professionals will communicate to determine the point where handling of these source water flows transfers between professionals. A transfer point of responsibility might be designing the stormwater connection to allow the non-potable water system to collect source water under typical precipitation conditions for the region, but also to manage surge flows and shunt excesses that might come with an extreme event. Communication in the early project stage to identify and resolve these integrated systems will contribute to the project's success.

Organizational chart: establishing responsibilities

During the planning stage, it is important to create an organizational chart that identifies all of the roles and responsibilities from planning through design, implementation, and handover, into operation, monitoring, and maintenance. In addition, create a Gantt chart to map out the project schedule for all team activities. Identify all critical path tasks, processes, and dependencies. These charts will be updated throughout the project.

By clearly identifying roles early in the project, team members and stakeholders can be empowered to assume the appropriate level of responsibility during each phase and to communicate with each other through the phases. Table 1.3 outlines the general roles that may be involved, though these will be different for each project. It is important to get buy-in from all project team members and stakeholders on these roles and responsibilities.

For some systems, broader public input beyond the identified stakeholders may also be sought where the system may impact them or to build awareness for the sustainable benefits of the proposed system. This would be included in the project plan.

Table 1.3 Key roles and responsibilities during the system planning stage

ROLE	RESPONSIBILITY
Owner/developer	Articulate the goals for the project. Understand the costs and benefits of these systems.
Architect/engineer/ project manager	Assemble an interdisciplinary team to identify project goals and desired outcomes, ensuring appropriate project team and stakeholder participation. Drive the full project process and identify process and task dependencies.
Non-potable water system designer/design team	Conduct a thorough review and characterization of the available sources and potential end uses using a fit-for-purpose lens. Consider the options with a risk management framework. Articulate the costs, benefits, and considerations for each option and demonstrate how the options meet or do not meet the project goals and objectives.
Authority having jurisdiction (regulator)	Engage with the design team to understand the project goals and desired outcomes, and to identify regulatory requirements and approval process based on the system being conceptualized.
Builder/contractor	Construct the building and non-potable system as specified in design. During the planning stage the builder or contractor will be identified — it is important to consider contractor capacity and experience with onsite water systems during the selection process.
Future owner/operator of the system	Operate and maintain the system as specified in the Operation and Maintenance Plan provided at handover of the facility. Although the specific operator may not be known during planning, it is important to consider the potential capacity of the future owner/operator at this time to inform decisions regarding system complexity. For example, a smaller multi-family strata building may have limited capacity to maintain a system over time and will require a simpler, low-maintenance system.
Responsible management entity (RME)	Commit to long-term oversight of the system to ensure it continues to perform as designed to protect public health. Identify protocols and costs for re-inspection/certification. The RME is identified during the planning or design stage.

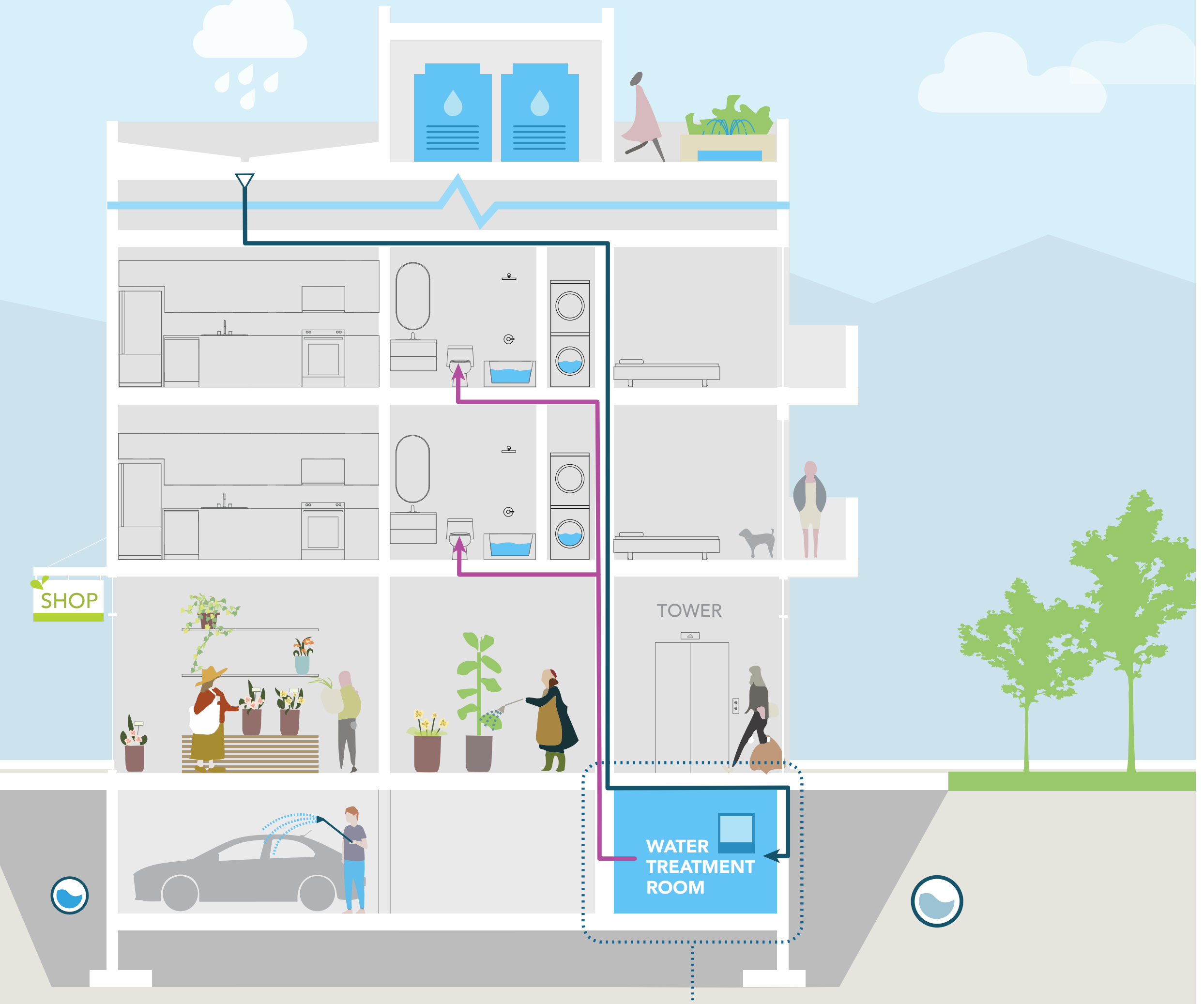
Responsible management entity (RME): A person, corporation, non-profit organization, or governmental body with ultimate legal responsibility for the performance of a non-potable water system.

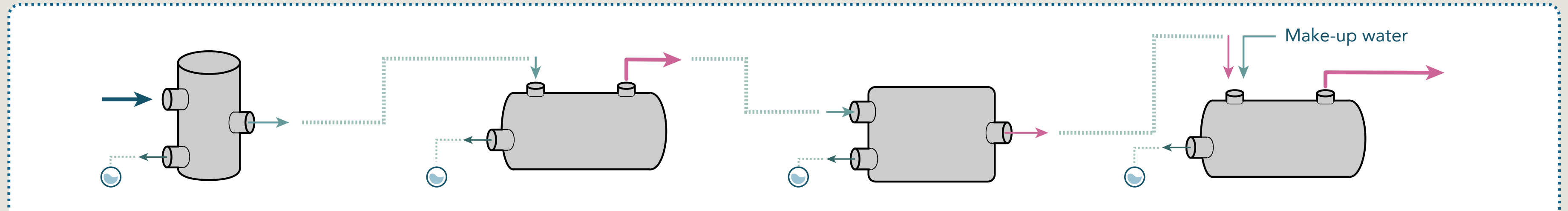
Authority having jurisdiction (regulator): An organization, office, or individual having statutory responsibility for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

1.4 Introduction to non-potable water systems

What is a non-potable water system?

Non-potable water systems collect, treat, store, and distribute non-potable water. The following figure shows an example system where roof runoff water is collected, treated, stored, and then distributed to be used for toilet flushing in the building. Most non-potable water systems will involve the key steps outlined in the figure, however, the sequence of steps may change and the storage and treatment needs will vary depending on how well-matched the sources and end uses are in terms of quantity and quality. During the planning phase, a variety of sources and end uses can be explored to identify optimal combinations to meet the project goals.





STEP 1: PRE-FILTRATION

screens course debris and fine particles, flushes them to the municipal sewer or stormwater system, and protects against entry of unwanted pests.

STEP 2: RAW WATER STORAGE

provides storage to meet end-use demand over extended periods and provides initial treatment through settling or possibly aeration.

STEP 3: TREATMENT

may involve a number of different technologies that reduce pathogens and treat for other contaminants to attain quality targets.

STEP 4: TREATED WATER STORAGE

is an option to meet variations in daily end-use demand, while providing time for additional disinfection (e.g., chlorine contact time), with residual disinfection to control opportunistic organisms in storage and distribution.

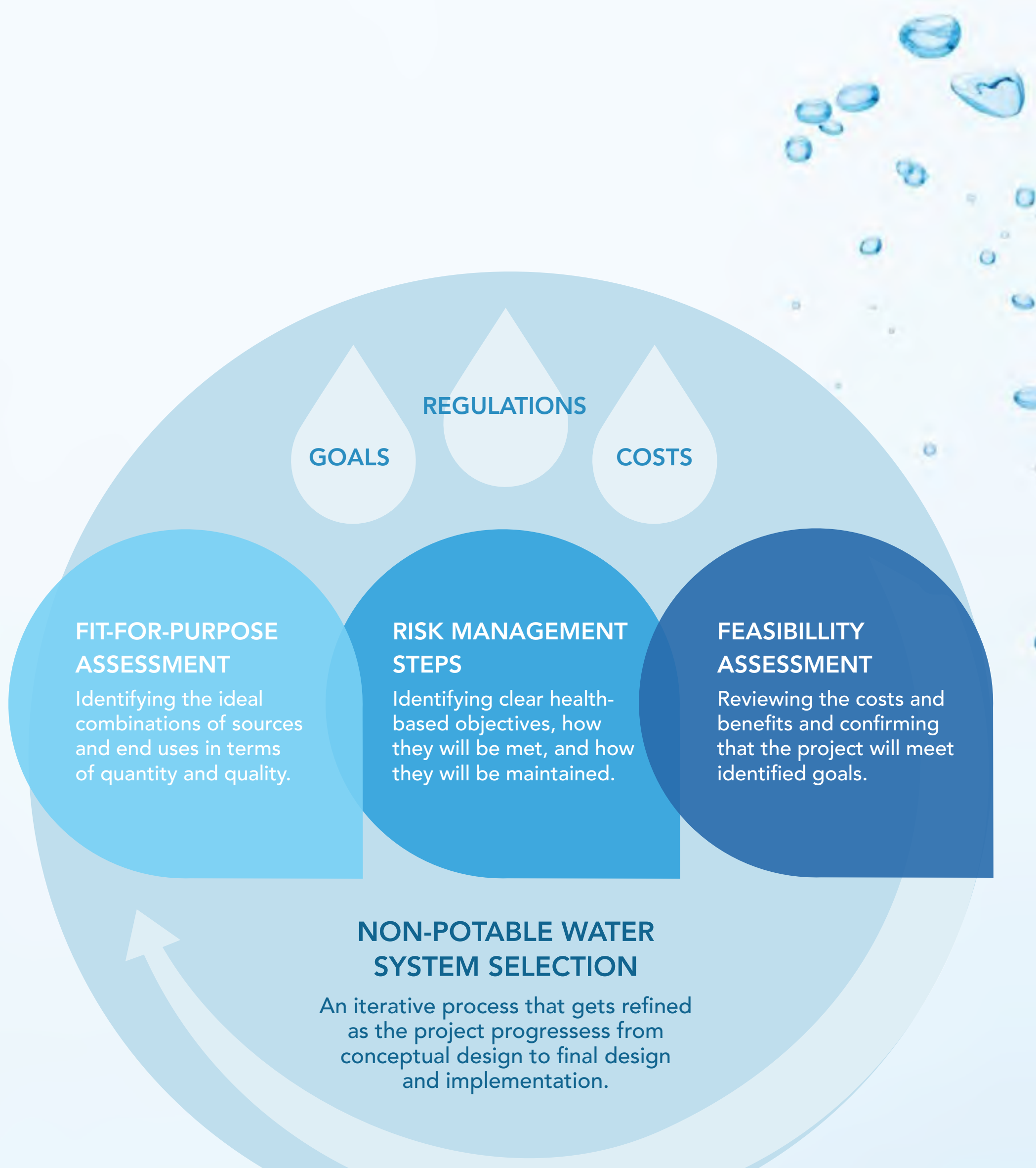
What is involved with selecting a non-potable water system?

The selection process is normally iterative, starting with understanding the regulatory requirements, then moving between considering fit-for-purpose source and end use combinations, identifying and considering how to manage risks, and determining the system feasibility. The iterative process is expected to continue from preliminary planning to conceptual design through to final design, in coordination with the full project's cost and benefit assessment.

1.5 What regulations and regulators are involved?

In this region, the design, installation, maintenance, and ongoing monitoring of non-potable water systems may be governed by a number of regulations; which ones depends on several factors, including the source, end use, type of building, size of system, and more. The regulations are supported by several standards and guidelines from international, national, provincial, and local organizations and authorities.

Involving the regulator early in the planning process is an important step to help identify the potential requirements for the various options being considered, to collectively discuss the appropriate management categories and responses, and to identify the responsible management entity. This also gives the opportunity to ask the regulator about the latest updates to regulation and policy, as well as the specific policy of the local office or official as applicable to the specific project.



FIT-FOR-PURPOSE ASSESSMENT
Identifying the ideal combinations of sources and end uses in terms of quantity and quality.

RISK MANAGEMENT STEPS
Identifying clear health-based objectives, how they will be met, and how they will be maintained.

FEASIBILLITY ASSESSMENT
Reviewing the costs and benefits and confirming that the project will meet identified goals.

NON-POTABLE WATER SYSTEM SELECTION
An iterative process that gets refined as the project progresses from conceptual design to final design and implementation.

Table 1.4 provides a general introduction to the regulations that may apply, but note that it is important to communicate with applicable regulators to clarify the regulations that are relevant and applicable to your project. Standards and guidelines that may be referenced for different system types are listed in Appendix 2.

Table 1.4 Existing regulations relevant to non-potable water in the Metro Vancouver region

AUTHORITY	DESCRIPTION	WHEN DOES IT APPLY?	CONSIDERATIONS FOR THE PLANNING STAGE
BC Public Health Act	*Sewerage System Regulation* (SSR) • Greywater falls within the definition of "domestic sewage," and the BC Sewerage System Standard Practice Manual (SPM) provides standards for sub-surface drip dispersal with a filing as a ground discharge system. • Additional guidance provided by the Manual of Composting Toilets and Greywater Practice. • Establishes a professional reliance model, defining Authorized Persons (APs).	• Sewerage systems that discharge less than 22,700 litres per day to ground. • All domestic sewage from a building must go into a public sewer or a sewerage system, unless it is authorized under the Building Code or bylaw (see local bylaws row below).	• Contact the local municipality to verify if a greywater discharge bylaw is in place. • Engage Authorized Person, as defined in the SSR. • Review the Manual of Composting Toilets and Greywater Practice and SPM.
BC Drinking Water Protection Act	*Drinking Water Protection Act* (DWPA) and *Regulation* (DWPR) • The DWPA outlines general requirements for water suppliers supplying water for potable water systems. • The DWPR sets out more specific requirements and has provisions and requirements for non-potable systems (section 3.1).	• DWPA applies to non-potable water systems except in a single-family residence, and equipment, works, or facilities prescribed by the DWPR as being excluded (see section 3 of the DWPR).	• Contact a regional health authority drinking water officer for information or to confirm whether the system would be subject to the DWPA and DWPR. • Compliance is separate from compliance with the BC Building Code or Vancouver Building Bylaw. • Additional guidance is provided in the Drinking Water Officers' Guide (e.g., guidance for treatment of rainwater harvested for potable use).
BC Building Code (or National Building Code, Part 7)	*BC Plumbing Code*, Division B, Section 2.7. "Non-potable water systems" (BCPC) • Permits non-potable water systems in buildings. • Design, fabrication, and installation to be in accordance with good engineering practice. • Example end uses include toilet and urinal flushing, laundry, cooling towers.	• Design, installation, alteration, renewal, or repair of a plumbing system in a building where the BC Building Code applies. • Applies in all Metro Vancouver electoral areas and member jurisdictions, except City of Vancouver.	• Engage the regulator to discuss preliminary options; regulator may also involve local health authority. • Identify potential risk management steps and quality assurance processes. • Identify verification and validation for approval and management requirements for operation.
BC Environmental Management Act	*Municipal Wastewater Regulation* (MWR) • Establishes prescriptive water quality requirements for reclaimed water applications.	• Discharge of domestic wastewater is greater than 22,700 litres per day to ground or discharges to water. • All uses of reclaimed water; except single-family dwelling or duplex, which are exempt.	• Contact the Ministry of Environment and Climate Change Strategy to determine applicability, process, and requirements. • Expect a complex process over longer timeframes. • If considering registration, refer to the Ministry's Reclaimed Water Guideline.
Vancouver Building Bylaw	*Vancouver Building By-law*, Book II, Division B, Section 2.7. "Non-potable water systems" (VBBL) • Acceptable solutions allow use of rainwater and clear-water waste; require capture for water closets, urinals, and trap primers; and require systems to obtain operating permits. Allows other end uses (non-food irrigation, clothes washing, vehicle washing, make-up water for hydronic systems and cooling towers, adiabatic cooling systems).	• Any building where VBBL applies, excluding single-family residence. • City plans to include stormwater as another source starting 2023. • Alternative solutions may be used for other systems similar to BC Plumbing Code.	• For rainwater and clear-water waste sources, familiarize the team with VBBL requirements and clarify with the regulator. • For all other systems, see suggestions for the BC Building Code above.
Local government bylaws	Local government bylaws may be in place for: • Cross-connection control requirements. • Stormwater management requirements to mitigate peak flows. • Greywater discharge bylaws.	• Only applicable where local bylaws are in place. • Local governments may create bylaws allowing surface discharge of greywater.	• Engage the local government to confirm which bylaws are applicable. • Identify associated requirements. • For cross-connection bylaws, identify verification/ commissioning steps for approval.

Supportive local government policies

Beyond regulatory requirements, local governments may support voluntary non-potable water systems in various ways, such as:

- Participating early in the design process to provide clear direction on the process and expectations.
- Providing floorspace exclusions to accommodate the non-potable system and storage.
- Offering credits on development charges for improved stormwater or wastewater management.
- Funding pilot or research projects that can be transferred to future projects.

Table 1.5 Finding well-matched source water and end ese, for annual use scenario

	TOILET FLUSHING/ LAUNDRY USE	COOLING TOWERS	VEHICLE WASHING	SUBSURFACE IRRIGATION	SURFACE IRRIGATION	OUTDOOR WATER FEATURES

Quantity: Using a water balance model

At the planning stage, it is necessary to consider whether each potential source water supply is sufficient for the proposed use(s) throughout the entire year, and what storage or make-up water would be needed to fill gaps. To perform this assessment, a water balance model is prepared that allows the characteristics of the source water to be compared to the characteristics of the end use. This will allow the professional to select the optimal matches of water before moving into detailed design, where the model will be confirmed, tested, and refined (see Design for details).

Professionals who specialize in design will use a "water calculator" to perform this task. The calculators are commonly custom built for the specific profession. Rainfall calculators will reference weather station data and BC Building Code intensity-duration-frequency (IDF) tables, estimate collection efficiencies, anticipate deductions from collections due to seasonal bypass or first-flush diversion, accommodate different usage and storage scenarios, and model overflows or required make-up water. Professionals are relied upon to use experience to estimate collection coefficients appropriate to the local context.

In addition to evaluating the source and end-use flow characteristics, determining whether the source water is sufficient for the proposed end use will also require answering other questions that relate to the project goals and desired outcomes previously defined, for example:

- Does the project require complete use of the source or complete supply of the use? (E.g., a net-zero water balance is required to meet Living Building Challenge certification).
- Is there a mandate that limits the proportion of make-up water to be used in non-potable water systems? (E.g., no more than 30% of a non-potable water system can be supplied by municipal water). Or, alternatively, requirements that mandate the provision of make-up water?
- Would storage or disposal of excess supply be acceptable, and if so, how?
- Is there sufficient space to allow storage to match end use patterns?
- What are the ballpark costs for anticipated storage?

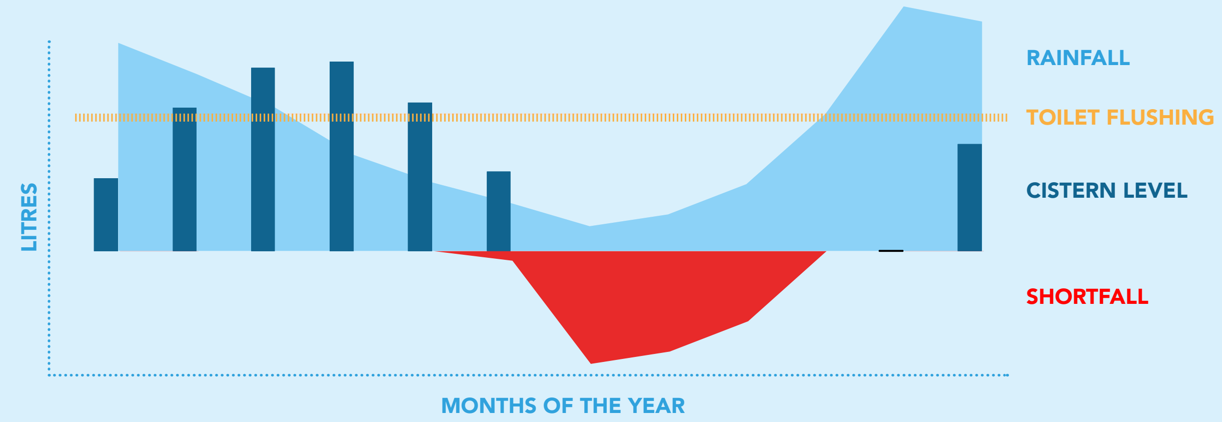
EXAMPLE OF WELL-MATCHED AND NOT-SO-WELL MATCHED SOURCE AND END USE

The following two graphs demonstrate the matching potential of different source water to the same end use, in this case, toilet flushing. This hypothetical example is for a commercial building with:

- 150 people working in offices, with 200 visitors per day.
- Roof collection surface of 650 square metres.
- Assuming an average quantity of flush-water use of 2,300 litres per day, Monday to Friday.

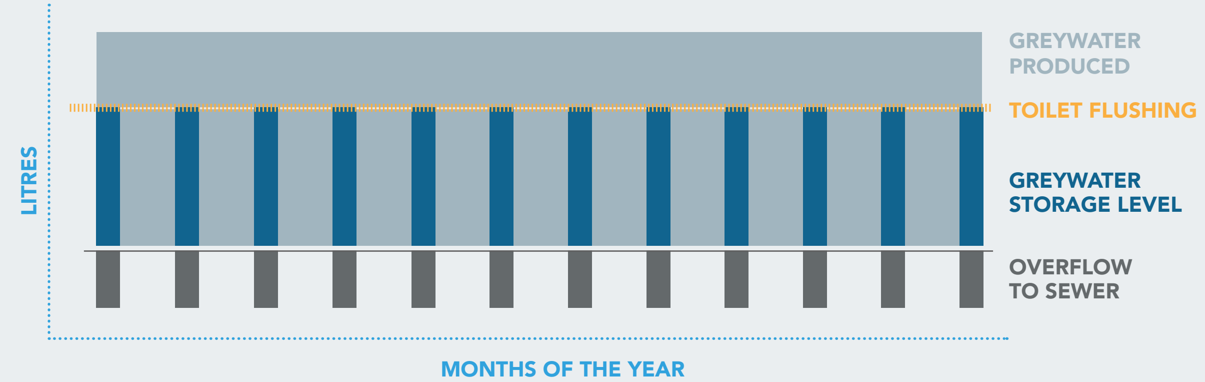
OPTION #1: RAINWATER SOURCE WITH 100,000 L STORAGE

- Considerable storage capacity is required along with additional make-up supply water to cover the periods where stored rainwater is lacking, which coincides with seasonal water restrictions.
- May provide benefits in lower treatment costs as the source is better matched in quality to the end use, but additional storage infrastructure may outweigh the cost benefit of a simpler treatment system.



OPTION #2: LIGHT GREYWATER SOURCE FROM SINKS WITH 10,000 L STORAGE

- Source is well matched to usage patterns requiring considerably less storage (saving cost and space), virtually no reliance on additional make-up supply water, and a minimal discharge of excess greywater to the municipal sewer system.
- Higher degree of treatment required to meet the end use.



Quality: Comparing the source to the end use needs

At the planning stage, the quality of each potential source water is characterized and compared to the quality needs of the end use(s). This process will help identify optimal combinations for a preliminary concept and includes the following considerations:

- What is the makeup of the source water? For example, is it roof runoff from roofs not accessible to people and domestic animals? Stormwater that is captured from a parking lot?
- Based on the makeup of the source water, what information is available on typical source quality from literature or guidance documents?
- For an existing source, what does a water test on an existing source tell us about the basic water quality, such as pathogens, chemistry, turbidity, suspended solids, nutrients, and other contaminants?
- For each source, what type of end use is proposed, what level of treatment, and what management and control processes are needed to manage risk for that use? Does the end use have any specific water quality needs other than reducing pathogen levels?

Pathogens and chemicals

The quality of water is described using biological, physical, or chemical parameters that are related to the end use application. The primary risk to human health from non-potable water is exposure to pathogens. Pathogens typically include enteric viruses, enteric bacteria, and parasitic protozoa.

Additional risk may arise from chemicals in the water, from the chemical by-products of disinfection, environmental contaminants, or from growth of opportunistic pathogens in a water storage and distribution system. Table 1.6 highlights considerations for different types of source water.

This guidebook focuses primarily on risk to human health from pathogens in water. However, an important part of fit-for-purpose evaluation is to identify any chemicals in the source water (or disinfection products) that would impact usability. Consider these examples:

- Greywater is expected to contain significant levels of complex organic compounds, such as personal care products, and these compounds may be metabolic disruptors. Therefore, even where subsurface irrigation is used, greywater may not be considered suitable for irrigation of soft-stemmed vegetables or fruit that will be consumed by humans.
- In some cases, stormwater or drainage water may be contaminated with toxic chemicals, such as heavy metals, organo-metal compounds, polychlorinated biphenyls (PCBs), or hydrocarbons. If the designer considers this to be a risk for the particular site then more extensive testing of the source water should be carried out prior to system design.

Table 1.6 Typical quality concerns by type of source water

● Significant ◍ Potential ○ Not Significant

SOURCE WATER	VIRAL PATHOGENS	BACTERIAL PATHOGENS	PROTOZOAN PATHOGENS	CHEMICAL CONTAMINATION	ORGANIC MATTER AND DUST	HYDROCARBONS
Roof runoff water or condensate	○	●	◍	○	◍	○
Light greywater	●	●	●	●	●	○
Vehicle wash wastewater	○	●	○	●	●	●
Stormwater	●	●	●	●	●	●
Foundation and relief drainage	●	●	●	●	●	●

Identifying the quality needs of the end use

The many types of non-potable water sources vary greatly in their composition. Sometimes the source water may already be safe enough for non-potable uses, such as irrigation, toilet flushing, car washing, street cleaning, or in cooling towers, and at other times it will require treatment or other management measures prior to use.

Not all intended uses require the same level of treatment – different uses have different potentials for harmful exposure (e.g., spray irrigation has potential for inhalation exposure while drip irrigation does not). Intended uses that will result in human contact and pose potential health risks require a higher standard of water quality. For each use under consideration, we need to answer the key question: for our proposed use, what quality do we need?

During initial analysis for planning, the quality objectives are normally based on guidance lookup tables, with detailed analysis required during the design stage for more complex systems (see Design for details).

ASSESS RISK TO HUMAN HEALTH

SELECT SYSTEM PERFORMANCE OBJECTIVES

IDENTIFY CONTROL MEASURES

DEFINE HOW THE SYSTEM WILL BE MANAGED, OPERATED, AND MAINTAINED

CONDUCT ONGOING MONITORING, EVALUATION, AND REPORTING

1.7 Risk management approach

Risk to human health encompasses the likelihood and consequence of exposure to a health hazard that may cause harm. Understanding the risk means understanding both how likely the exposure is and how harmful it can be. It is important to manage these risks by using a risk management approach to plan and implement the non-potable water system. Note that management of project risks, such as the potential impact of climate change, is a separate process (see Companion Document, section 3, for a summary of these risks).

What is risk management?

It is not always practical to eliminate risk; however, risk can be managed. Risk management involves identifying risks to human health, selecting system performance objectives, identifying control measures that reduce the risks to an acceptable risk level, identifying how the system will be managed and maintained, and monitoring the system to ensure it continues to perform as expected. A risk management approach affects how a non-potable water system is designed, implemented, and operated, - and is further described throughout this guidebook. The World Health Organization recommends using a risk-based approach for all water exposures (uses or unintentional exposures) (WHO, 2006). This approach has been widely adopted for both potable water systems and non-potable water systems and is considered best practice.

What does exposure mean?

Exposure means that there is human contact with the non-potable water or waterborne contaminants, typically by ingestion, inhalation, or skin contact. Sometimes the contact is intended or voluntary (going swimming in a lake), and sometimes it is unintended or involuntary (water used for toilet flushing gets accidentally ingested or inhaled). Gauging the potential type, quantity, and frequency of exposure to the non-potable water during operation of the system is an important part of assessing the potential risk and identifying appropriate measures to reduce the risk. See the Companion Document, section 4, for a table of exposure potential for different end uses.

NORTH VANCOUVER'S MOODYVILLE DEVELOPMENT GUIDELINES

The City of North Vancouver's Development Guidelines for Moodyville include landscaping guidelines that "seek to create attractive and productive gardens and boulevards and to implement progressive strategies to manage stormwater and to conserve water." This includes a guideline for rainwater retention (City of North Vancouver, 2016):

Guideline 4.2.1 In order to reduce peak stormwater runoff and to conserve water required for landscaping, roof drainage should be designed to:

(a) provide a minimum 500 litres (132.1 gallons) [storage] for every 350 square metres (3,767.4 square feet) roof area for rainwater storage in barrels or cisterns that allow water to be drawn for landscaping purposes; or

(b) collect and detain rainwater in accordance with LEED® Gold stormwater design provisions.

New developments in Moodyville demonstrate the implementation of this policy. The Trails Phase 1A development includes a rainwater cistern that reduces the peak stormwater runoff, and provides a supply of non-potable water for irrigation purposes.

1.8 Feasibility review

A key goal of the planning process is to gather the information needed to determine the feasibility of implementing a non-potable water system as part of the building project. Feasibility assessments include reviewing both the financial and non-financial implications on the operations, management, and oversight of the proposed system, and reflecting on whether the costs are balanced by the benefits or project objectives being met. At this time, project risks can also be identified and assessed (e.g., financial risks and contingencies, potential liabilities affecting insurance coverage, environmental).

During feasibility assessments the following points should be considered:

- Capacity of owner, responsible management entity, maintenance provider, and regulator to properly manage the system.
- Regulatory or policy requirements, barriers, or opportunities.
- Cost-benefit analysis including capital, operational and lifecycle costs, and tangible and intangible benefits.
- Capacity and availability of qualified trades to construct, operate, and maintain the system.
- Project risks (see a list in the Companion Document, section 3).

What are the benefits of these systems? As discussed in the overview section, there are substantial benefits of having these systems, both for the community or region as a whole and for the specific building. These range from significant opportunities to conserve water, align with stormwater management practices, increase resilience to drought, save on water and sewer costs, and more.

What are the costs associated with these systems? Although a small part of an overall building budget, the costs of including a non-potable water system are not negligible. The types of costs include:

- Design costs.
- Installation of a duplicate water system.
- Space for water storage and treatment systems (a significant cost where space is at a premium).
- Operation and maintenance of the system for its lifespan.
- Monitoring and oversight of the system for its lifespan.

Generally, in this region, a purely financial cost-benefit analysis will not be favourable for these systems because the savings in water or sewer charges will not make up for the added costs. However, when considering a triple bottom line or multiple criteria, these systems may demonstrate substantial positive returns. Where the financial case is weak, but the societal and environmental benefits are substantial, local government policies may be needed to support and incentivize both the installation and the ongoing operation of the systems over time.

Information developed in the fit-for-purpose, risk management, feasibility, and project risk evaluations is documented in the finalized Project Description. These results will inform the design stage, and may include preliminary assessment of storage and treatment needs. At the end of this assessment the decision is made whether to proceed with system design.

1.9 Common challenges and how to address them

Table 1.7 highlights some common planning-related challenges that can result in no or incomplete implementation, system malfunction, system abandonment, or the system not being used to its full potential.

Table 1.7 Common challenges and mitigation strategies for planning stage

POTENTIAL PLANNING-RELATED CHALLENGES	HOW TO MITIGATE THE CHALLENGES
Unclear regulatory approvals: The regulator is not engaged early, does not provide sufficient clarity on requirements, or does not have sufficient capacity.	Identify and meet with the regulator early to identify requirements and review the plan to ensure realistic timelines. Evaluate capacity constraints.
Business case: Lacking consideration of lifecycle costs, returns, and non-financial benefits for the system leads to a weak financial return on investment and decision not to proceed.	Clearly outline project sustainability goals together with project stakeholders, and demonstrate how the non-potable system supports these goals. Use tools that financially represent non-financial benefits.
Policy: Inadequate government policies to support non-potable water systems leads to weak business cases and less uptake of systems.	Local and provincial policy makers can adopt incentive, pricing, and regulatory policies that support uptake of these systems.
Management: No responsible management entity identified. Lack of ongoing commitment to the system or system purpose.	During planning, begin documenting the Organizational Chart and Management Plan, including consideration of who will be the responsible management entity and what their capacity will be.
Local capacity: Fit-for-purpose assessment approachdoes not adequately consider the optimal matching of available sources and end uses, including water balance and quality.	Follow the recommended process to assess a variety of sources and end uses, selecting appropriate data sources and modelling timeframes to find the best fit.

2. Designing non-potable water systems

2.2 Roles and responsibilities during design

Roles and responsibilities identified during planning are confirmed and assigned during the design phase by updating the organizational chart in the Management Plan and having project team members and stakeholders sign off on their responsibilities. As part of this, roles and responsibilities are identified for the construction and operation phases.

Table 2.2 Key roles and responsibilities during the system design stage

ROLE	RESPONSIBILITY
Owner/developer	Review project progress and confirm that it remains on track with goals and desired outcomes.
Architect/engineer/project manager	Confirm ongoing alignment with the project goals and desired outcomes. Work with the system designer to communicate with regulators, complete required regulatory and permitting applications, and adjust plans and design as needed. Determine communications and handover processes between responsible parties for the transition to the construction and operating phases.
Non-potable water system designer/design team	Perform conceptual and detailed design, complete with documented design rationale supporting protection of public health, system longevity, and system performance. Develop drawings, specifications, and plans for final approval. Document applicable regulations, permits, and processes, and confirm any prescriptive requirements. Reference applicable guidelines and standards used in the design.
Authority having jurisdiction (regulator)	Provide clear process and requirements for stakeholder involvement, system design, permitting, and approval. Review the system design and approve once the applicable regulations and standards have been demonstrably met. Clarify the role of the regulator in performance monitoring and oversight to inform draft plans.
Builder/contractor	Participate in the process and add practical input, assuming the contractor has been chosen. For larger projects, the contractor may not yet be selected and their responsibilities will be fulfilled in the implementation stage.
Future owner/operator of the system	May not know the future owner/operator at this stage, but the roles of the future owner and operator are established and assigned at this stage.
Responsible management entity (RME)	RME is identified in either the planning or design stage. Commitment to the long-term oversight of the system to ensure that it continues to perform as designed and protect public health.

2.3 Regulations, standards, and guidelines

Non-potable water systems in Metro Vancouver may be governed by or affected by:

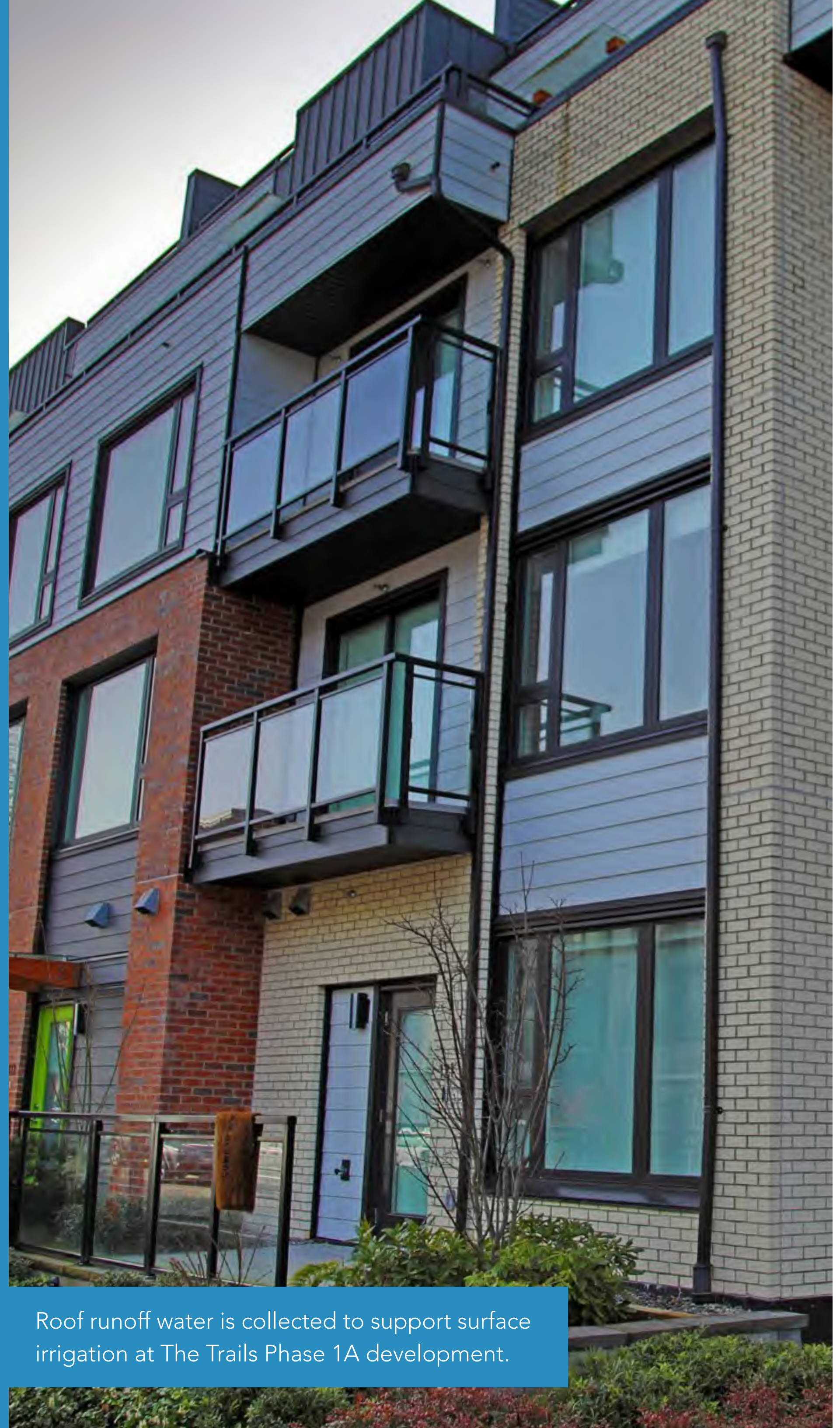
- **Regulations**, such as a provincial act or regulation, a local government zoning bylaw, or a building bylaw (see the Planning section for an overview of applicable regulations).
- **Standards**, which may be contained within regulation, referred to by regulation, or be contained within a policy adopted by a regulator.
- **Guidelines**, including those referred to in regulations and professional practice guidelines, are sources of standard practice and design guidance.

The field of non-potable water use is rapidly evolving, and therefore, it is important to check with the regulator to obtain the most recent information on regulations, bylaws, and policies applicable to the project. See Appendix 2 for a list of relevant standards and guidelines, current as of February 2022.

Determining which authority has jurisdiction

Determining who the regulator is and what regulations apply can be complicated. As outlined earlier, there are many different regulations and regulatory authorities that may apply depending on the sources, uses, size, location, and more. To confirm and document who needs to be involved in each project, contact regulators at the provincial and local level, obtain consensus and agreement on who needs to be involved and when, and confirm the regulations, bylaws, standards, or guidelines each regulator will require of the project. The following steps will help guide you through this process:

- Contact the local government (building, planning departments).
  - Enquire who would be the representative regulator for the local government.
  - Identify what policies or bylaws would apply.
  - Identify if they require other assurances (e.g., health authority, qualified professional).
- If needed, contact the local health authority (health protection and environmental services department).
  - Determine if the health authority has jurisdiction on the project and, if yes, identify who will be the representative regulator for the health authority.
  - Confirm regulations, policies, and guidelines that apply.
  - Confirm an acceptable process for communication between different regulators.
- If needed, contact a qualified professional.
  - Determine professional guidelines to influence design.
  - List design standards to rely on.
- If needed, contact the BC Ministry of Environment.
  - The Ministry must be involved for sewerage systems with flows of 22,700 litres per day or more, or for systems that will supply reclaimed water under the Municipal Wastewater Regulation.



Roof runoff water is collected to support surface irrigation at The Trails Phase 1A development.

- Determine other parties.
    - Determine if other parties have legal ties to the project (stratas, user groups, Trusts, etc.).
- Update the Organizational Chart.
    - List the regulators involved, their roles, where and when they are to be involved in the project, regulations or policies, standards or guidelines, and communication requirements.
    - Ensure and document that regulators and stakeholders understand and agree to their roles.
- During design, clarify exactly what prescriptive requirements may be in place affecting design and system monitoring. Where these are unclear, the regulator should be asked to confirm the requirements.

Local government bylaws and policies

There are several types of bylaws and local government policies that either directly or indirectly relate to non-potable water systems, covering topics such as cross connections, stormwater, rainwater, greywater, and water reuse.

Cross connections are regulated through bylaws to ensure that the potable water supply is not connected to a non-potable water source. These requirements are often embedded in a comprehensive bylaw for waterworks or water servicing (e.g., Delta Water Service Bylaw 7441), or they can be standalone bylaws (e.g., Surrey Waterworks Cross Connection Control Bylaw 17988). These regulations set out requirements for backflow protection, installation, commissioning, inspection frequency, and reporting.

Stormwater is regulated through bylaws and through integrated stormwater management plans (ISMPs). Generally, bylaws that govern stormwater design are embedded in comprehensive land use and development servicing bylaws. Some stormwater management requirements may align with non-potable water use, for example, where the local government requires stormwater to be captured and slowly released to the storm sewer (to avoid overloading the sewer system during heavy rain). ISMPs link stormwater management with strategic goals to conserve and enhance the environment, promote biodiversity, and increase natural capital. Some ISMPs include strategies for non-potable water.

For example, Richmond has an Integrated Rainwater Resource Management Strategy, which identifies a strategy for rainwater and stormwater harvesting to be used to decrease the demand for potable water. Further, the Richmond OCP Section 14 – Development Permit Guidelines has a specific reference to using rainwater for reuse (14.2.10.D), though no additional bylaw is associated. In Richmond, there are two projects that employ the intent of the strategy: Ikea Richmond that harvests rooftop rainwater and uses it for toilet flushing, and Water Sky Garden that collects rooftop rainwater and stormwater, treats it in a natural pond and reuses it for toilet flushing and irrigation.

Rainwater, in some areas, is managed through integrated rainwater management plans (IRMPs) that specifically focus on rainwater capture and use or infiltration of the rainwater onsite. The City of Vancouver's IRMP, named Rain City Strategy, targets capturing and cleaning 90% of rainwater, and includes an objective to harvest and reuse the water.

Greywater can be managed by local governments through bylaws that, for example, allow use for surface irrigation purposes. However, there are currently no bylaws in the Metro Vancouver region that explicitly address greywater discharge. Instead, greywater is managed through provincial regulations.

Design documentation

In some cases, regulations, standards, or guidelines may be prescriptive in nature, that is, they explicitly set out what level of treatment is required. In other cases, they may be performance-based in nature, where a set of criteria stipulate how the system should perform. Typically, a performance-based approach will be coupled with a professional reliance model that defines how the system performance will be managed and monitored over time.

The risk management design approach outlined in this guidebook provides a framework for safely deploying non-potable water systems regardless of the type of requirements that apply. It will be important to document the design in a manner that demonstrates both risk management steps and how prescriptive requirements will be met. This has a number of advantages, including the following:

- Results in a properly documented rationale, as recommended by Engineers and Geoscientists BC (2021).
- Clearly defines choice of system components and allows for future adaptation of the system.
- Provides confidence that risk will be managed, and that prescribed outcomes will be met.
- Supports a science-based approach to system monitoring and operation, informing the Monitoring Plan.
- Provides the underpinning for the risk management steps in the Management Plan.
- Is aligned with the ongoing development of global standard practice.

The following section outlines the steps for design using a risk-based approach. The designer will document the Design Rationale and will typically prepare summary design notes to include with final design documentation. Including these notes is good practice to ensure any professional reviewing system operations has the information needed to better understand the design intent.

NON-POTABLE WATER PROGRAM REQUIREMENTS IN THE CITY OF VANCOUVER

In 2018, the City of Vancouver initiated a non-potable water program as one response to city-wide goals to improve water efficiency and reuse stormwater. Updates in 2019 and 2022 introduced an oversight mechanism with operating permits issued by the Chief Building Official, and other requirements to support the long-term safety and resiliency of these systems. The program has been very successful, and since implementing these requirements, City staff have inspected over three dozen systems and have helped owners bring their systems into compliance, when necessary.

The requirements are provided in the Vancouver Building Bylaw Book II (Plumbing Systems), Division B, Section 2.7 - Non-Potable Water Systems, with basic requirements applying to any non-potable water system using rainwater and clear-water waste as non-potable water sources (see Subsections 2.7.1, 2.7.2 and 2.7.3). The City intends to include stormwater sources beginning in 2023.

Further requirements for "alternate water source systems" (which include the types of non-potable water systems discussed in this guidebook) include:

- New buildings must use non-potable water sources for these end uses: water closets (toilets), urinals, and trap primers.
- Optionally, buildings may use non-potable water sources to serve these end uses: irrigation (non-food), clothes washing, vehicle washing, make-up water (cooling towers, hydronic systems), adiabatic cooling systems, and tempering of discharge waters.
- Systems must obtain an operating permit, which requires compliance with water quality standards, testing, documentation, and reporting requirements. Water quality must be tested and reported to the City, demonstrating performance-based compliance for *Legionella pneumophila, Escherichia coli*, turbidity, and temperature. Visit the City's website for details on operating permits.
- As of January 1, 2022, all (new and existing) systems require an operator with Building Water Systems Operator certification from the Environmental Operators Certification Program.
- Additional requirements for systems installed after January 1, 2019:
    - Occupancy permit is dependent on formal system commissioning, which includes water quality testing, reporting, demonstration of operations, and cross-control connection test.
    - Design must be performed by a registered professional, use the International Association of Plumbing and Mechanical Officials Water Demand Calculator for pipe sizing, use purple-coloured pipes, be sub-metered, have a sampling port, have an alert system if temperature exceeds the standard, and other requirements.
    - Operating Manual must be supplied to the owner and operator, be sealed by a registered professional, and a maintenance log must be kept.

2.4 Fit-for-purpose: assessing and evaluating sources and end uses

Water quantity: finalizing the water balance model

In the planning stage, a preliminary water balance model was completed to provide enough information to select a good match of source and end-use water, and to inform a feasibility assessment using simple or generic regional data sources.

During design, the system water balance model is revisited with more scrutiny, incorporating more information and detailed data to further enhance and refine the model. At this stage, the information and data analyzed will move beyond confirming project goals and general sizing to informing the system design itself. Analysis may be more complex, with detailed modelling of supply and demand (e.g., using daily or weekly data for specific years instead of monthly data for a range of years). Assessment of supply capacity may now need to take into account changes to planned site development (e.g., proportion of hardscape for stormwater modelling) and to planned end uses (e.g., type of plantings to be irrigated).

Understanding source flow profiles, daily water demands, volumes of diverted waters, and quality and quantity of source water will directly inform:

- Rainfall leaders and piping configuration
- Stormwater infiltrators and rainfall pre-filter sizing
- Diversion to storm or sewer specifications
- Raw water storage options, including sizing, drainage, and in-tank treatment
- Management measures to ensure source control and safety
- Size of treated water tanks
- Size of irrigable area that can be serviced

The Companion Document, section 6, provides additional details on aspects to be considered, sources of information, and typical data requirements to develop a water balance model.

Photo: Westbank Corporation

410 WEST GEORGIA: WATER BALANCE MODEL FOR A LARGE STORMWATER SYSTEM

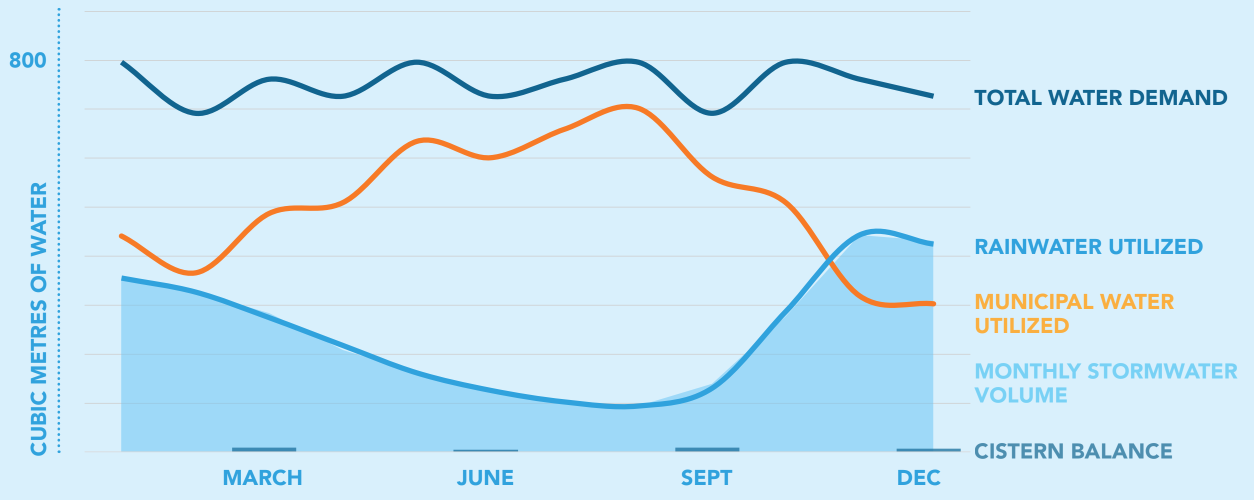
The Deloitte Summit Building, a 25-storey office tower, has a stormwater system designed to comply with the City of Vancouver's Building By-law and the City's on-site rainwater management requirements. The key objectives of the system are to use all rainfall onsite and to detain stormflow surges that could be experienced in a 2-year, 24-hour, 48-mm rain event (Duffey, 2018). Two scenarios demonstrate the building's water balance.

SITE FACTS:

- Storage size selected by designers: 230 m^3
- Average daily non-potable water demand: 36.4 m^3
- Average daily precipitation volume modelled: 17.7 m^3
- Weekend non-potable water demand estimated: 0 m^3

SCENARIO 1.

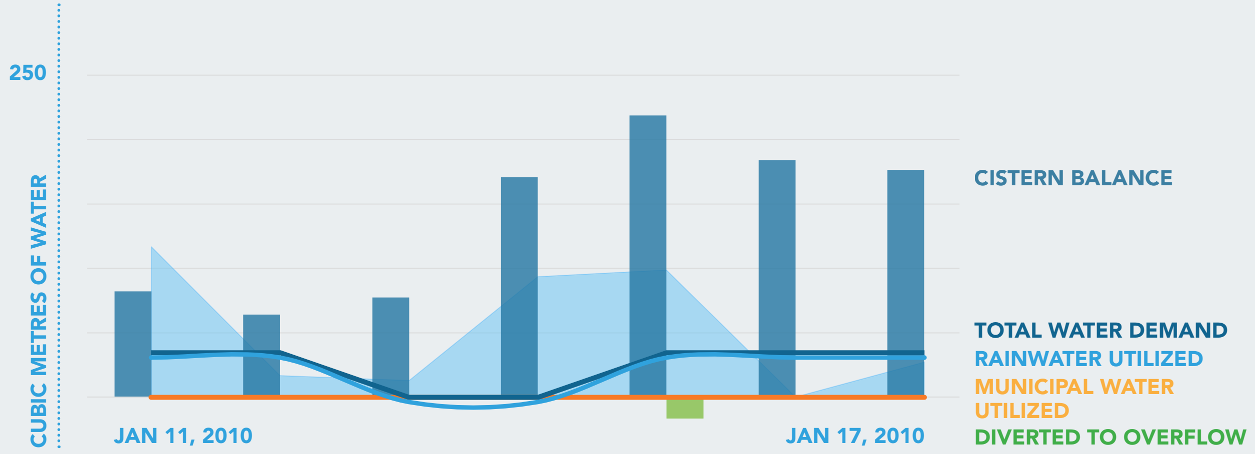
Annual water balance model:
This graph shows the results of modelling daily toilet flushing usage with daily average precipitation across 365 days. The model demonstrates that virtually all of the rainfall collection is used for toilet flushing, and that municipal water is needed to supplement between 50% and 80% of the total demand. The design objectives to maintain near-empty cistern storage and to avoid diverting rainwater to city storm sewers are being met in this model.



SCENARIO 2.

One-week historical storm event: This graph shows the result of modelling one of Vancouver's wettest weeks on record, an event with two days exceeding the design requirements for this system (2-year, 24-hour, 56-mm rain event). The model shows the design surpasses expectations, where there is no overflow on the first exceedance, and the overflow is limited to 13 m^3 during the second event.

Water Balance based on January 11–17, 2010



Water quality: assessing sources and defining objectives

In the planning stage, the quality of each potential source of water was characterized and compared to the quality needs of each potential end use to help identify optimal combinations for a preliminary concept, and to inform a feasibility assessment. This analysis is typically based on literature data sources or preliminary testing results and is relatively simple in nature.

During design, this is revisited in greater depth, starting with defining water quality and treatment objectives, then selecting risk management steps and control measures that will ensure the objectives are met. Data collection may include detailed ongoing testing of a specific source.

The Companion Document, section 6, provides additional details on aspects to be considered, sources of information, and typical data requirements to assess sources and establish objectives for end uses.

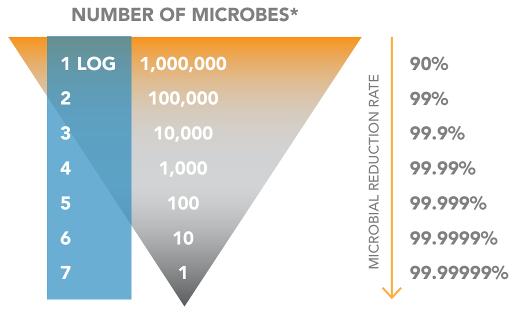
Source water quality and protection

Source water quality is identified through testing or from literature and guideline values. Once established, the source water quality is compared to the expected end-use quality objectives to determine the level of treatment or other controls needed. It is important that the source does not degrade in quality over time, which could result in the planned treatment system being inadequate to manage risk. To address this concern, the detailed design will identify control measures to protect the water source. This may include, for example, restricting access to a roof area used as a catchment. The system Operation and Maintenance Plan will include any measures specified for source protection and the Monitoring Plan will include monitoring of those measures, with linked actions where the source is not being adequately protected.

Water quality objectives and treatment objectives

To identify the best fit between source and end use, we must understand how much pathogen or contaminant concentrations need to be reduced to manage risk for the intended end use. This water quality objective is measured using $\log_{10}$ reduction. Two important terms for discussing water quality objectives are:

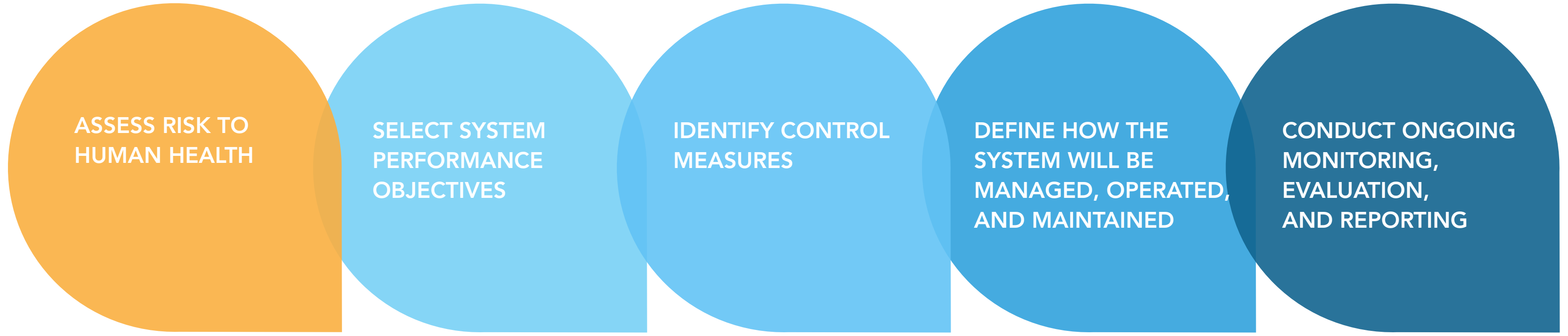
- **Log reduction target (LRT)** – The log reduction needed for the whole system to meet objectives.
- **Log reduction value (LRV)** – The log reduction that is expected to be achieved by each control measure or treatment step. Also termed "log reduction credit."



Different pathogen groups require different LRT values. The goal is to ensure that sufficient control measures are put in place where the combined LRVs allow us to reach the targeted LRTs for each pathogen group. These are described more in the risk management section that follows.

During design, the design professional will finalize and document their Design Rationale for how the source water is fit for the proposed use, following a risk management approach.

*Adapted from https://munglobal.com.au



2.5 Designing with a risk management approach

Under a risk management approach, the designer must identify the risk to human health before selecting control measures to manage the risk. The risk may be established using values from guidelines or scientific literature, where available, or through project-specific analysis.

Step 1: Assess human health risk

The essential first step for a risk management approach is to establish the acceptable level of risk to human health from the non-potable water system. This may also be termed a "health-based target." It is important to recognize that risk is unlikely to be reduced to zero, and to understand that acceptance of a suitable level of risk is necessary in order to manage system costs and complexity of system management, and to support sustainability goals.

Risk determination is made separately for potable use, non-potable use, and for voluntary and involuntary exposure. The acceptable level of risk may be specified by regulation or policy. Alternatively, the system designer (alone or in consultation with the regulator) may identify this on a project-specific basis. A good starting point is to refer to the World Health Organization's maximum tolerable risk levels and the US Environmental Protection Agency's recommended risk levels for non-potable water. See the Companion Document, section 7, for more information.

QUANTITATIVE MICROBIAL RISK ASSESSMENT

Risk is assessed by considering the specific sources and end uses together with the population being served or in potential contact with the water. This is carried out using a quantitative microbial risk assessment (QMRA). Risk is typically examined for one or more chosen representative pathogens for each of the pathogen classes (viruses, bacteria, and protozoa). Undertaking a QMRA is an in-depth process and may be important for large or complex systems. However, QMRA values for many sources and end uses are documented in literature, and these can be referenced in the design without the need for a project-specific assessment in many cases.

WHO definition of QMRA (2016): A formal, quantitative risk assessment approach that combines scientific knowledge about the presence and nature of pathogens, their potential fate and transport in the water cycle, the routes of exposure of humans, and the health effects that may result from this exposure, as well as the effect of natural and engineered barriers and hygiene measures. All this knowledge is combined into a single assessment that allows evidence-based, proportionate, transparent, and coherent management of the risk of waterborne infectious disease transmission. QMRA has developed as a scientific discipline over the last two decades and has been embedded in the WHO water-related guidelines (references WHO, 2003, 2006 a,b).

Step 2: Select system performance objectives

A key purpose of a non-potable water system is to remove pathogens (viruses, bacteria, protozoa) and other contaminants to the degree required for the intended non-potable use, and to deliver the water to the point of use without new contamination occurring. Risks of new contamination can come from several sources, including vectors (e.g., birds or pets), exposure to contaminated materials, ingress of untreated water or sewage, and growth of opportunistic pathogens (e.g., ***Legionella***).

The designer selects the system performance objectives needed to match the chosen source to the end use, and expresses the objectives as log reduction targets (LRTs) for each class of pathogens. LRTs are based on characterizing typical pathogen density and occurrence by source water type (e.g., roof runoff, stormwater, or greywater), together with QMRA results.

In their design, the professional may undertake their own QMRA, use LRT values from research, or may consider established water quality guidelines, such as BC's Water Quality Guidelines or Health Canada's Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing. Targets from research are summarized in the Companion Document, section 8.

Once selected, the LRTs, and the rationale for their selection, are documented in the Design Specifications.

Step 3: Identify control measures

Treatment systems are typically combined with other control measures to address contamination concerns, such as cross-connection, access to the water source, or other identified risks. Each system will normally include more than one control measure, forming part of a multi-barrier approach.

The designer specifies the control measures, including treatment and other risk management steps, to meet the established LRT for a given source and end use. Log_{10} reduction values (LRVs) for typical control measures have been developed through scientific research and can be looked up in reference material (see the Companion Document, section 10). Control measures reduce levels of contaminants in a number of ways:

- Reducing their entry into the water (e.g., source protection).
- Reducing their concentration once in the water (e.g., disinfection).
- Reducing their proliferation (e.g., residual chlorine in water).
- Reducing contact with the water (e.g., cross-connection control).

Detailed guidance related to control of risk with respect to opportunistic pathogens is available in Sharvelle, et.al., 2017.

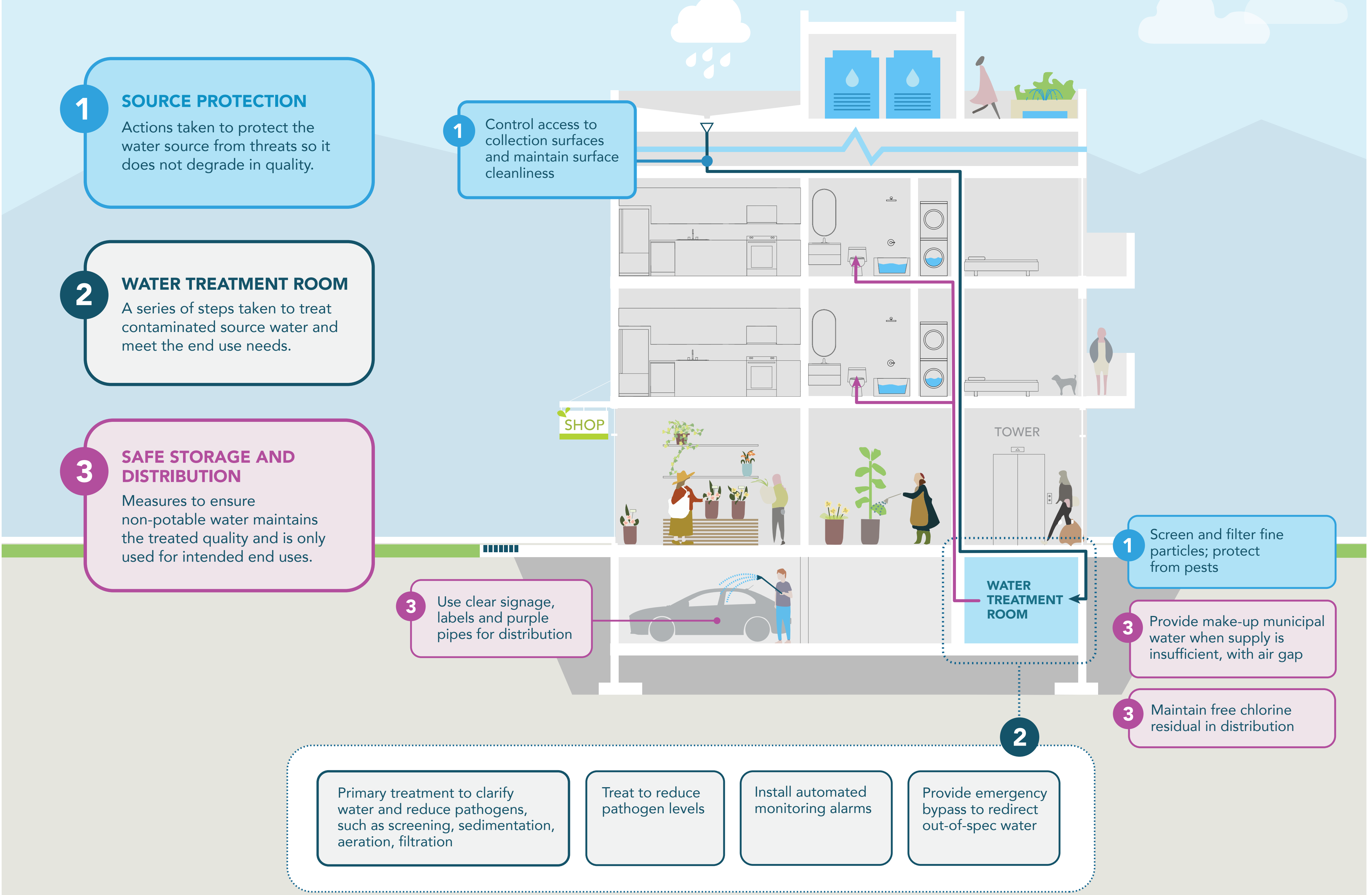
MULTI-BARRIER APPROACH

A multi-barrier approach is an integrated system of procedures, treatment processes, and management tools that collectively reduce the risk of human exposure to pathogens and harmful substances.

The multi-barrier approach can include many elements beyond the design or processes of a specific system, including identification of the appropriate responsible management entity, regulations with monitoring and reporting requirements, requirements for training, or certification of operators and others.

A multi-barrier approach to design includes identifying control measures that provide barriers beyond treatment. This improves reliability of the overall treatment and management system. Typically the LRV for a process or step is restricted to a maximum value, emphasizing the need for multiple barriers.

OVERVIEW OF TYPES OF CONTROL MEASURES



1 SOURCE PROTECTION
Actions taken to protect the water source from threats so it does not degrade in quality.

2 WATER TREATMENT ROOM
A series of steps taken to treat contaminated source water and meet the end use needs.

3 SAFE STORAGE AND DISTRIBUTION
Measures to ensure non-potable water maintains the treated quality and is only used for intended end uses.

1 Control access to collection surfaces and maintain surface cleanliness

3 Use clear signage, labels and purple pipes for distribution

1 Screen and filter fine particles; protect from pests

3 Provide make-up municipal water when supply is insufficient, with air gap

3 Maintain free chlorine residual in distribution

2

- Primary treatment to clarify water and reduce pathogens, such as screening, sedimentation, aeration, filtration
- Treat to reduce pathogen levels
- Install automated monitoring alarms
- Provide emergency bypass to redirect out-of-spec water

Types of control measures

A wide range of options for control measures are available to the designer. Several measures are depicted on page 48 in the Overview of Types of Control measures diagram. Some of these control measures may have individual LRVs that can be added to the treatment process LRVs to help meet the overall LRT. Storage and treatment needs will vary depending on how well matched the sources and end uses are (in terms of quantity and quality), and the sequence of steps may vary (e.g., filtration may occur after initial settling in some designs).

In addition to these control measures, implementing management requirements that improve system reliability and support proper system operation and maintenance is also critical to risk management.

Treatment systems

Water treatment systems are usually designed in process steps to perform a particular function. A UV light would be a separate process step from a sand filter, or a chlorinator – with each step serving a purpose to reduce pathogen concentrations. Each process step is associated with an LRV for specific pathogens, and typically there is a process control point where performance can be checked. A critical control point may also be defined, representing one or more steps of the process.

A series of process steps is called a treatment train. Common types of treatment technologies and treatment trains include natural and biological processes, filtration processes, and disinfection processes (e.g., microfiltration, membrane biological reactor, ultraviolet light disinfection, ozone disinfection, chlorination, etc.) (see the Companion Document, section 9, for an overview of each). The treatment train is chosen so that the combined LRVs meet the LRTs for the water source and intended use by one of the following:

- Demonstrating through validation (challenge testing) that the target will be achieved (see Implementation section).
- Accruing enough LRVs, based on guidance tables, to demonstrate that the LRTs are expected to be achieved (see Companion Document, section 10).
- Conducting a probabilistic assessment of the treatment train performance (see Companion Document, section 7).

Rationale for performance-based design and validation will be documented as part of the design. This documented rationale should be included or summarized in the design notes so that future adjustments to the system can be made, possibly by another professional, while taking the original rationale into account.

Identify system validation

The design will establish how the system performance will be validated. This may include field validation testing during construction or commissioning. For established technologies, validation may be based on literature studies, past experience, third-party testing, and monitoring data.

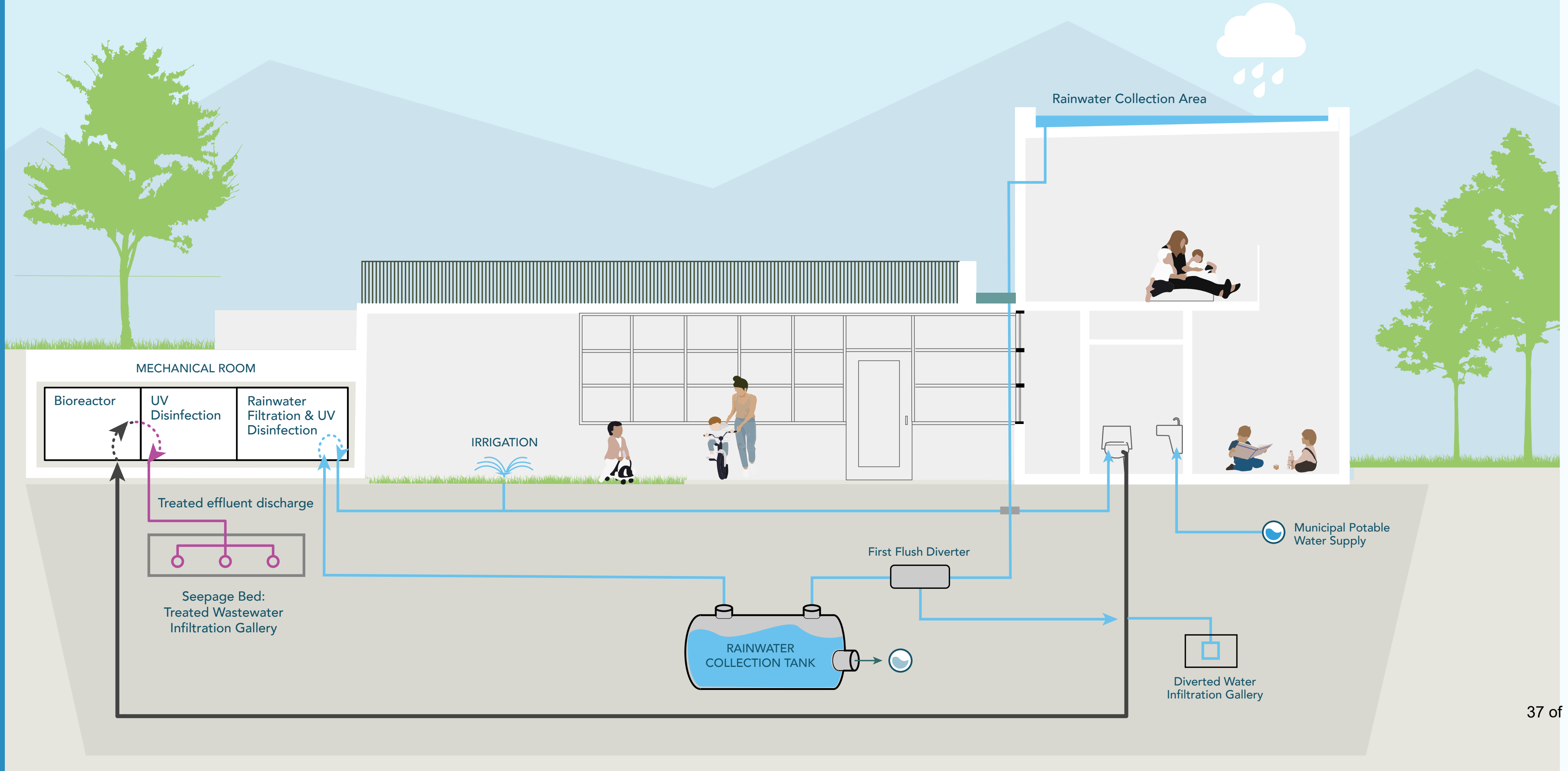
System validation refers to a practical step that measures and confirms a system meets the design requirements. This can be based on previous testing, or can involve building prototype systems (or parts of systems) and physically testing the outputs, or can test a completed system wherein the results are used to ensure its functionality at commissioning.

UNIVERCITY CHILDCARE CENTRE AT SIMON FRASER: A WATER-INDEPENDENT SITE

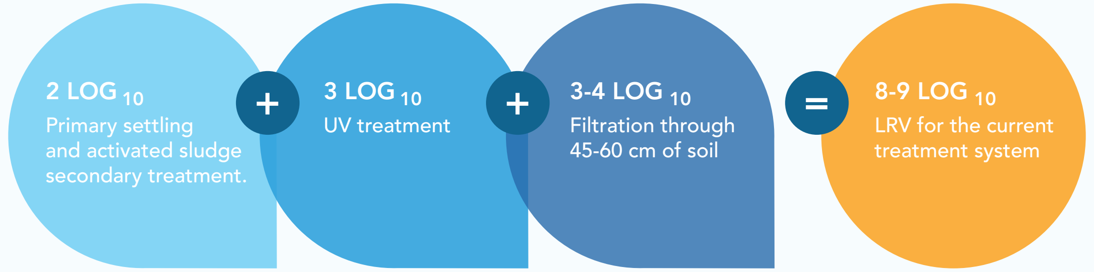
The UniverCity Childcare Centre, initiated in 2008, was an early adopter of the Living Building Challenge (LBC). The Water requirements of the LBC seek to create **water-independent sites, buildings, and communities**. To meet this challenge, the Childcare Centre was designed with:

- A rainwater capture system that serves toilet flushing, hose bibs, art sinks, and laundry.
- An onsite sewerage system with advanced treatment that recycles wastewater to ground.

Overview of the UniverCity Childcare rainwater capture and onsite sewerage systems in place



ESTIMATED LOG REDUCTION VALUES OF CURRENT SEWERAGE SYSTEM



A closer look at the onsite sewerage system

The childcare centre has a rainwater capture system that supplies toilets, hose bibs, laundry, and an art sink. In addition to rainwater capture and use, the initial concept was to treat all sewage (greywater and blackwater combined) onsite for irrigation and toilet flushing. Preliminary designs were prepared and the design team engaged with the local regulator and health authority representatives. However, it was deemed too challenging to obtain approval for reuse of combined sewage and an alternative plan was adopted to treat and discharge recreational grade water to a seepage bed for dispersal, returning the water to the natural water cycle, and providing below-grade irrigation and nutrient cycling.

The implemented system manages pathogen risk through multiple barriers, providing effective protection for aquifers or receptors downslope, and manages the risk of operational failures. In addition to the UV system, control measures include:

- Mandated maintenance procedures with professional oversight.
- Monitoring of UV intensity, with continuous monitoring and automatic switching to backup system.
- Backup UV system.
- Pathogen attenuation in treatment and in soil-based treatment, providing overall 8 to 9 $\log_{10}$ reduction (LRV) for viral or bacterial pathogens.

What if?

Given the quantity and quality of treated water available, there is potential to use it for higher purposes than the current discharge. What if there was demand for subsurface drip irrigation of turfgrass or landscape plantings near the childcare centre? Could this system safely supply that demand in terms of quantity and quality? Yes, there is potential for this end use given the following estimates:

- ✓ **QUANTITY:** During the dry season, an estimated 1,400 litres per day would be available and, with moderately sized storage tanks, this could irrigate an area of 400 to 500 square metres during that season without supplementary water.
- ✓ **QUALITY:** The source wastewater would typically exhibit a mean fecal coliform bacteria level of 6 $\log_{10}$, with risk of contamination from viruses, organic contaminants, nutrients, and other contaminants. The end use of subsurface irrigation assumes secondary (limited) contact. Based on this, the LRT selected could be 3.5 $\log_{10}$. The existing system meets this requirement.

- **Regulatory considerations**: This small system would meet the standards of the *Sewerage System Regulation*, and the current BC Standard Practice Manual standards supporting the use of subsurface drip dispersal. Therefore, the existing system has the potential to be expanded to provide for irrigation if there is demand.

Step 4: Defining system management

Management, operation and maintenance, and monitoring (verification and compliance monitoring) of non-potable water systems is an essential part of risk management. Non-potable water systems require varying degrees of operation, maintenance, monitoring, and oversight, depending on their complexity and the types of sources and end uses involved.

At the planning stage, system management was considered as a part of the initial feasibility assessment.

During the design stage and in consultation with the regulator where appropriate, the design team will develop a draft Management Plan to document the system management requirements and framework, including confirmation of the organizational chart that defines roles and responsibilities. A best practice is to assign a management category that represents the level of management needed, based on the level of risk presented by the system.

Management categories

Identifying a management category can be used to inform requirements for design, management, operation, monitoring, and reporting. Three levels of management categories are listed below (where 1 is low and 3 is high), as developed by Sharvelle et al. (2017). See the Companion Document, section 11 for more details on selecting a management category.

A management category is selected on a project-specific basis. The designer considers the combined risk factors for each paired source and end use, and documents the rationale for assigning a management category in the Management Plan. This may be completed by the system designer alone or in consultation with the regulator. The defined category will inform the level of regulatory oversight needed, the requirements for the responsible management entity, and the level of monitoring and validation required. In some cases, the regulator may have requirements related to qualifications or capacity for operators.

It is important to factor in responsible management entity and regulator capacity and the cost implications for operation and monitoring, as these may result in the need to adjust system selection and design to lower the category to a more appropriate level.

Table 2.3 Management categories

MANAGEMENT CATEGORIES	EXAMPLE TYPE OF SYSTEM	OVERSIGHT	RESPONSIBLE MANAGEMENT ENTITY
1 LOW	Moderately sized multi-family building has a subsurface drip irrigation system sourced from treated combined wastewater that uses a simple, reliable treatment system.	Reliance on system owner with support via education and potentially by maintenance bylaw.	System owner
2 MODERATE	Commercial office building with several hundred occupants has a combined stormwater and roof-runoff system that treats and reuses for toilet and urinal flushing.	Reliance on system owner, but increased involvement by regulator in review of monitoring.	System owner, with qualified operator
3 HIGH	Independent senior living residence has a rooftop rainwater system serving toilet and laundry needs.	Reliance on responsible management entity, with active oversight and ongoing inspections, compliance enforcement by regulator.	System owner or utility, with qualified operator

Identify system verification

The draft Commissioning, Operation and Maintenance, and Monitoring Plans developed during the design stage will establish how ongoing performance will be verified during system operation. Depending on regulatory requirements, the plans will also specify any compliance monitoring necessary.

What are system verification and compliance monitoring?

System **verification monitoring** refers to the use of surrogates to confirm that the system continues to operate as planned, or to control or prompt diversion of water, process adjustments, and other actions. A **surrogate** is "a continuous in-stream sensor measurement used to compute or estimate the concentration of a water-quality constituent of greater interest," with results available in real time (US Geological Survey, 2014).

Compliance monitoring is completed to satisfy requirements of the regulator. This may utilize the same surrogate data as verification, but may also include grab sampling for defined parameters.

Step 5: Prepare for ongoing monitoring, evaluation, and reporting

For a performance-based design to be effective, verification data must be analyzed and acted upon. Data (raw and analyzed) will need to be reported to the responsible management entity, and for more complex systems, to the qualified professional. Compliance monitoring data will need to be reported to the regulator or retained for their review.

The Management Plan will define what actions are to be taken in response to the monitored data. For example:

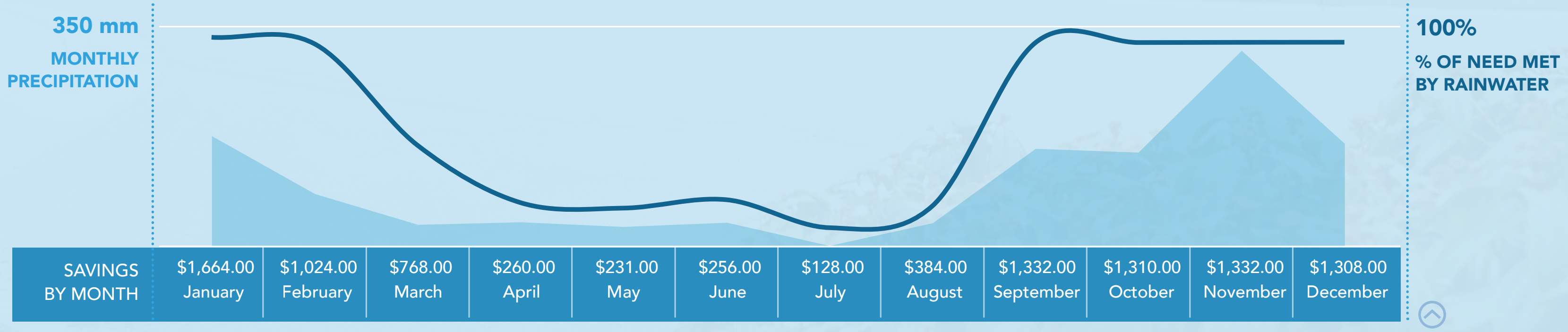
- Where performance verification is not meeting design objectives, actions may include process adjustment, improved source protection, or addition of process steps in order to improve performance.
- Where verification confirms performance is consistently being met, reduced frequency or range of monitoring may be specified.

Verification data summaries or compliance monitoring data may also be required by the regulator, and the regulator may respond to outcomes by requiring changes or periods of more intensive monitoring. If changes are made during the life of the system that are expected to affect performance, it may be necessary to carry out a further validation step as part of redesign or new commissioning.

IKEA stores across the globe are working to incorporate sustainability into the infrastructure and culture of their organization and stores. IKEA Richmond has a roof-runoff harvesting system that collects rainwater for toilet flushing. Water collected from the roof is stored in a cistern which is distributed to the toilets when water is available – the system uses municipal backup when the rainwater stores are low.

In 2021, with water and sewer utility rates at \$2.56 per m^3, the IKEA Richmond store was able to realize an approximate water savings of \$10,000. This does not include the beneficial savings to the municipality through IKEA reducing flows to the stormwater infrastructure, nor does it capture the social and environmental benefits of the system.

As demonstrated in the graph below, as precipitation in Richmond increases, so do the water savings at the IKEA Richmond store. In the months where the roof collected more than 80mm of precipitation, IKEA was able to serve more than 90% of their toilet flushing demand. This example highlights that local government policies that incentivize reduced flows to storm sewers can support further improvements to the return on investment for these systems.



2.6 Feasibility review and cost-benefit

Project risks, costs and benefits, and overall feasibility were initially evaluated during the planning stage, informing the decision to move into design. During design, the assessment continues to evaluate feasibility and whether the benefits outweigh the costs and potential risks, informing the decision to move into system implementation.

At this stage it is critical to consider not only the cost to install and commission the system, but what will be involved with ensuring its ongoing safe operation for years to come. Designs that do not consider the financial implications over time will fail even if the initial budget for construction is secured. There are two aspects of feasibility the designer needs to consider.

Annual costs are represented in the annual budget and include ongoing operational, maintenance and monitoring costs of equipment, consumables, and service providers. Over the years, variances in costs can be monitored and trends observed.

Lifecycle costs are represented in an asset management plan that amortizes costs across the expected lifespan of the system. The designer provides key information for the owner to perform a cost-benefit analysis. It is common to see this in a net-present-value format with information that may include:

- Lifespan of key components (estimated dates of replacement).
- Estimated present value of replacing those components.
- List of consumables for the operation and maintenance of the system.
- Estimated costs that could be expected to train a new operator.
- Estimated validation costs that could be incurred if/when source water changes, treatment processes change, or regulations change.
- Consideration of future repair and replacement of proprietary components in case of non-availability or changes to model specifications.

In considering these financial aspects, design choices can be made that align with the financial sustainability, and the owner can more fully recognize the financial management responsibilities beyond the construction phase.

The UBC Aquatic Centre demonstrates a multi-use facility that supplies non-potable water that meets toilet flushing and recreational water standards.

The *Non-Potable Environmental and Economic Water Reuse Calculator* (NEWR) was released in 2021 by the US EPA, providing a web-based tool to help assess cost-effective matches for source water and end uses. The tool considers environmental indicators (e.g., climate, geography, source water) and lifecycle cost assessments of operation and distribution to provide both an environmental and a lifecycle cost assessment to support decision-making.

2.7 Common challenges and how to address them

Table 2.4 highlights some common design-related challenges that can result in equipment or system malfunction, health risk, system abandonment, or the system not being used to its full potential.

Table 2.4 Common challenges and mitigation strategies for design stage

POTENTIAL DESIGN-RELATED CHALLENGES	HOW TO MITIGATE THE CHALLENGES
Business case: Lack of lifecycle feasibility analysis.	Complete lifecycle feasibility analysis. Consider risks related to proprietary technology and include plans to address possible future replacement of equipment.
Budget: Lack of lifecycle budget planning suited to the complexity of the design and system components.	Ensure budget and funding method is in place for operation, maintenance, monitoring, repair, and system adaptation or component replacement. Adjust design if needed.
Management: Lack of responsibility for monitoring or for taking action on outcomes of monitoring.	Clearly outline roles and responsibilities and obtain sign-off. Consider costs of monitoring the system and draft an initial Monitoring Plan that considers these factors. Plan for responsible management entity succession or replacement, with adequate oversight. Design for good, safe, maintenance and monitoring access.
Local capacity: System design is overly complex relative to the capacity of the operator.	Ensure that both the design and draft Operation and Maintenance Plan take into consideration the capacity of the probable owner, responsible management entity, and operator to operate, repair, and maintain the system.
Local capacity: Water source is exposed to unplanned contaminants or changes in quantity.	Include source protection in design. Consider future climate change impacts (e.g., drought) in the fit-for-purpose analysis, design for system flexibility, and allow for make-up water.

3.1 Checklist and outcomes

The implementation stage includes installing and commissioning the system, adapting the design as needed, and finalizing the plans for ongoing operation, maintenance, and monitoring. This stage concludes with handing over the system to the owner and the responsible management entity who will manage ongoing system operations.

Table 3.1 Implementation stage checklist and outcomes

IMPLEMENTATION STAGE: **CHECKLIST**	IMPLEMENTATION STAGE: **OUTCOMES**
✓ Set scope, define roles, and prepare submittals for contract Request for Proposal or tenders. ✓ Choose contractor and include in project team meetings. ✓ Conduct and document field review, updating drawings as needed. ✓ Conduct and document field validation, if necessary.	System installed, verified, and field validated (as necessary).
✓ Finalize Commissioning Plan and commission system, which may include field validation. ✓ Prepare Completion Report with record drawings, specifications, and description of how to access the system. ✓ Submit Commissioning Report to the regulator, together with any required details of the responsible management entity.	• System commissioned with regulator approval. • Finalized Operation and Maintenance Plan, including Completion Report. • May include Training Plan.
✓ Obtain sign-offs from the regulator, responsible management entity, operator, and any other stakeholders committing to roles. ✓ Ongoing management of project-related risks and impacts.	Finalized Management Plan, including organizational chart with sign-offs.
✓ Confirm ongoing verification and monitoring requirements to meet prescriptive standards with the regulator and update Monitoring Plan. ✓ Hand over system to owner and responsible management entity, with any necessary training.	Finalized Monitoring Plan, with actions and oversight requirements.

3.2 Roles and responsibilities during implementation

The organizational chart developed and refined during planning and design articulates the roles and responsibilities of project team members and other stakeholders during system construction and commissioning. At this stage, stakeholders and team members have committed to these roles and responsibilities.

Table 3.2 Key roles and responsibilities in the implementation stage

ROLE	RESPONSIBILITY
Owner/developer	Review and approve project to confirm completion to expected outcomes.
Architect/engineer/project manager	Ensure the organizational chart listing roles and responsibilities is kept active during construction and commissioning. Further develop and confirm the chart in relation to ongoing system operation, maintenance, monitoring, and adjustments to the design. Ensure field review of construction is completed. At the end of the implementation stage, arrange for preparation of final letter of assurance, as needed, and a complete record of the system as built.
Non-potable water system designer/design team	Undertake and document field review of construction. Oversee any necessary changes to the design specifications and document changes in record drawings and as-built specifications. Include records of any required validation testing in the final documentation and communicate the requirements to relevant stakeholders (e.g., the regulator).
Authority having jurisdiction (regulator)	Review and approve system when demonstrated to meet applicable regulations and standards. May also review and approve Commissioning Plan.
Builder/contractor	Participate in project team meetings and ensure familiarity with the design and intent of the system. Construct as per design, communicate and seek approval for needed (as-built) design changes from the designer and design team. Provide information for record drawings and as-installed specifications to the designer, with electrical schematics and information, product manuals, and other information for the Operation and Maintenance Plan.
Future owner/operator of the system	Engage in the system handover process. Learn about all aspects of the system, and associated plans (management, operation and monitoring). Undergo training as needed.
Responsible management entity	Engage in the system handover process. Sign off on system plans and take responsibility for long-term oversight of the system to ensure it continues to perform as designed and to protect public health.

3.3 Regulatory considerations during implementation

During implementation, there are several considerations to take into account to ensure the system is installed to the regulator's requirements, to ensure worker and public safety, and to ensure the system is set up for long-term safe operation. Considerations include:

- Reporting and inspections required by the regulator during construction.
- Cross-connection control plan.
- Emergency response plan.
- Signage and labelling.
- Environmental protection during construction.
- Physical barriers (e.g., fencing).
- Materials (e.g., purple pipe).
- Requirements related to the system Monitoring Plan.
- Requirements related to final record drawings and documentation.

Aligning risk management approach with prescriptive outcome requirements

Standards or policies for management of non-potable water systems may include a requirement to test water quality at a system boundary or end point, such as point of use, and have test results remain below a prescriptive value (compliance monitoring). This may, for example, focus on grab-sample testing for bacterial fecal indicator organisms (FIOs) such as E. coli or fecal coliforms. The regulator may have a policy requiring monitoring of control measures.

When developing the system Monitoring Plan, best practice is to focus on the goal of achieving risk management performance by including performance verification monitoring. This is compatible with supplemental or additional compliance monitoring. Reliance on compliance monitoring alone may not be effective in supporting risk management. See Companion Document, section 12, for discussion.

3.4 Risk management: performance validation and verification

Monitoring is a critical component of operations and maintenance that ensures the system is operating as intended by the design, and is meeting the risk management goals and objectives. Validation is intended to directly confirm system performance, while verification is intended to confirm that the system is continuing to perform as expected during operation on an ongoing basis.

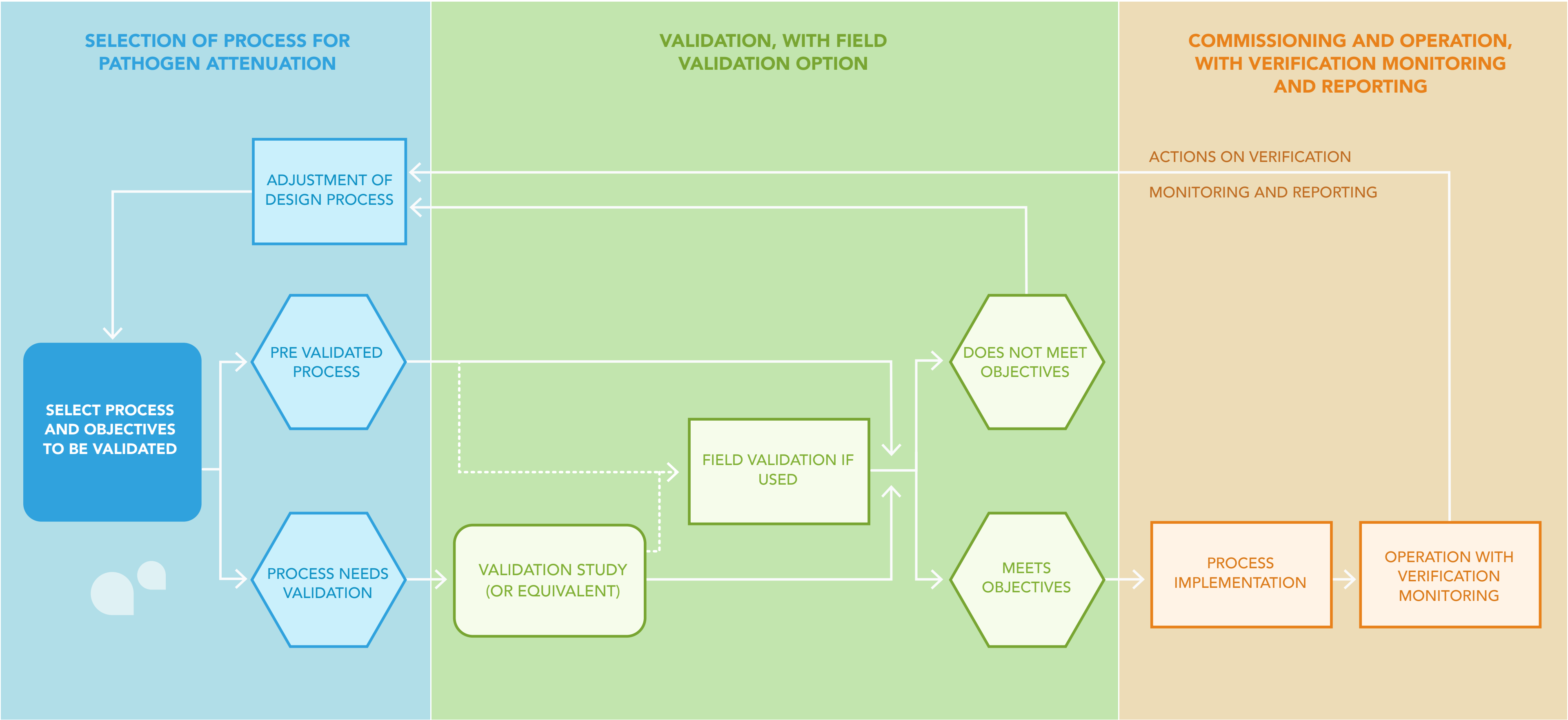
Validation of performance

As risk management is partly based on the projected process performance, it is necessary to validate those performance projections. Validation may be based on previous testing, or may be a specific testing program for the particular system.

- **Simpler systems**: These are likely to rely on **pre-validated technology** and control measures. Generally, the added cost for conservative measures is offset for smaller or simpler systems, by avoiding costs associated with full-scale validation. In these cases, validation will include review of testing by others, literature reports, test results from similar systems, and a documented rationale. Caution should be used in accepting the results of testing by bodies, such as NSF, because operating conditions may differ between testing and actual system operations. In addition, test results may not include challenge testing for the classes of pathogens of concern. Preferred practice is for the designer to base their rationale on a more detailed analysis or on field performance data in addition to standard testing results.
- **Larger systems** (or where innovative design is used): **Pilot-scale validation, full-scale validation, or field validation testing** will be documented as part of the design, installation, and commissioning processes. Validation in these cases will normally be by challenge-testing using target or surrogate pathogens over a defined range of operating conditions intended to reflect probable system operation. **Note that in some literature “field validation” is referred to as “field verification”.** If validation forms part of commissioning, this will be described in the Commissioning Plan and may lead to a more extended period for commissioning (BC Ministry of Health, 2022, provides an example of a validation process).

During operation of the system, changes may be made to the system configuration, operation, or usage, which may subsequently affect performance in relation to the original design assumptions. Or, the system may be found to be operating outside of the original validation envelope (e.g., with higher flow rate than originally validated). In these cases, the designer will develop new documented rationale or document new field validation testing and results.

OVERVIEW OF VALIDATION AND VERIFICATION PROCESS



Oversight of the validation stage and of verification monitoring may be by the regulator or responsible professional (not shown).

Verification of performance and system monitoring

Once the system is validated and operational, ongoing performance needs to be verified as part of system management to ensure the LRTs are met. Verification can be applied at each pathogen control point in the system treatment train, storage, and distribution network, or to an aggregate of steps at a critical control point. Surrogate monitoring is used to verify the system's performance.

Surrogate monitoring

Surrogate parameters are monitored performance indicators (often on an automated continuous basis) that are correlated with the design LRT for a particular control measure. Automated monitoring triggers automated actions when surrogate measurements are out of tolerance (e.g., divert water from use until it is meeting objectives).

For example, monitoring UV transmittance or intensity may be used as a surrogate to confirm ongoing efficacy of UV treatment, and monitoring residual chlorine can represent control of opportunistic pathogen risk in the storage and distribution subsystem. Best practice is to include continuous verification monitoring of one or more surrogates. See the Companion Document, section 12, for more background on surrogate monitoring.

Monitoring other control measures

Monitoring will also include recording parameters that indicate or confirm the efficacy of control measures, such as access control, or cross-connection control. This may be by documented testing, such as testing of double-check valve assemblies or observation of air gaps, or by review of documented observations, such as review of records of public access control.

Documentation of monitoring and actions

Monitoring without documentation, reporting, and actions in response to outcomes is of no value. The Monitoring Plan drafted during the design stage is confirmed after commissioning and considers the outcomes of validation testing, final system configuration, and final set-up of surrogate verification monitoring systems. The plan will include procedures for ongoing documentation of monitoring outcomes and will outline actions that are to be taken if and when monitoring indicates a threshold is exceeded. In order to facilitate this process, ongoing oversight is needed. This may be by a qualified professional and should include regular review of the outcomes and of the Monitoring Plan itself.

It may be necessary to include specifications for monitoring of specific parameters to meet regulatory or policy requirements, in addition to verification monitoring. For example:

- If regulations or policy require testing for certain surrogate parameters as part of compliance monitoring, these may be incorporated as a part of verification monitoring (e.g., turbidity monitoring).
- If grab-sample testing for parameters is required as part of compliance monitoring, this will be specified as a separate monitoring task (e.g., grab sampling and analysis for fecal indicator organisms).

The Companion Document, section 5, provides an example of a checklist for a system Monitoring Plan.

Validation and verification in relation to management categories

Table 3.3 relates the system management category established during design to the use of validation and verification as part of risk management.

Table 3.3 Management categories

MANAGEMENT CATEGORY	OVERSIGHT	RESPONSIBLE MANAGEMENT ENTITY	VALIDATION TESTING*	VERIFICATION MONITORING
1 LOW	Reliance on responsible management entity (RME) with support via education and potentially by maintenance bylaw. Occasional review by a professional recommended.	System owner	Not required, except as defined by the design.	Continuous monitoring is not required, except as defined by the design. No reporting to the regulator unless required by the regulator for the specific case.
2 MODERATE	Reliance on RME, but increased involvement by regulator and professional in review of monitoring.	System owner with qualified operator	Validation testing for innovative processes at design or commissioning, or as defined by the design.	Continuous process monitoring where practical, defined by the design. Regular reporting to the regulator.
3 HIGH	Reliance on RME, but with active oversight of ongoing inspections by a professional and compliance enforcement by the regulator.	System owner or utility with qualified operator	Validation testing at design or commissioning.	Continuous process monitoring required. Regular reporting at short intervals to the regulator.

** Validation may be used for any system, but normally is not necessary for simple systems using well-established techniques or control measures.*

3.5 System construction and commissioning practices

Key considerations for the design team during construction and commissioning include the following:

- Ensure appropriate documented field review of construction.
- Confirm that the system is adequately accessible for maintenance and monitoring.
- Document any changes to system design made during construction, together with any changes to the performance-based design rationale.
- Document any validation testing.
- Prepare a Commissioning Plan, which serves to guide commissioning of the system. The Companion Document, section 6, includes checklists to assist with completion of this plan.
- Participate in and document system commissioning, including checks on verification monitoring, in a Commissioning Report, which will form part of the Operation and Maintenance Plan.
- Prepare a Training Plan for operators who will be involved in operation, maintenance, and monitoring. Involve them in the system commissioning where possible.

3.6 Cost considerations and financial instruments

Cost considerations during the construction phase will likely be pre-budgeted in the planning phase, refined during design, and adjusted after successful contract negotiations tied to bid tenders and Requests for Proposals. The project Management Plan should include mechanisms to record and monitor actual costs as part of financial oversight, to capture design rationale and budgetary estimates for as-built changes, as well as outline an approval process to address project changes.

Cost considerations for validation and verification monitoring can vary from system to system as the monitoring results inform control process modifications and will require repeat testing until design requirements are met.

Training costs will be incurred during this phase and become an ongoing part of system operations. Training can potentially be part of the annual education credits required for many professions.

Financial instruments may be required by the Management Plan to ensure financial commitments are met by all parties at time of handover. Financial instruments could include bonds, reserve funds, an asset management plan that sets funding policy, or financial contracts between different stakeholders tied to scope and responsibilities.

METRO VANCOUVER METROTOWER III: BURNABY

In 2014, Metro Vancouver purchased Metrotower III, located in Metrotown Centre, from Ivanhoe Cambridge. This 29-storey office building is certified LEED® Platinum.

The building is home to a rainwater harvesting system, whereby rainwater is collected from the rooftops of Metrotowers II and III. This system, which stores the roof runoff in a cistern of 181,000 litres, is used for irrigation, make-up supply for the water feature, and supply to the toilets and urinals. When the cistern is full, roof runoff is diverted directly to the municipal storm system.

Operation and maintenance of the system are currently managed and run by Colliers Property Management, who oversee all aspects of the base building. The management company reports that the added expertise and time needed to operate and maintain the rainwater harvesting system is minimal. Currently, onsite staff ensure that day-to-day maintenance is complete. In total, the system requires less than 50 hours per year of maintenance and operational attention.

MOUNTAIN EQUIPMENT COMPANY PINNACLE STORE

In March 2020, Mountain Equipment Company (MEC) opened a new Pinnacle Store in Vancouver. The store was designed to achieve a minimum of LEED® Gold certification. One component of the sustainable store design was the installation of a rainwater harvesting system, which operates under the City of Vancouver's Operating Permit Program. The roof captures rainwater and funnels it to an underground cistern that provides up to 80% of the water used for flushing toilets.

3.7 Common challenges and how to address them

Table 3.4 highlights some common design-related challenges that can result in equipment or system malfunction, health risk, system abandonment, or the system not being used to its full potential.

Table 3.4 Common challenges and mitigation strategies for the implementation stage

POTENTIAL STAGE-RELATED CHALLENGES	HOW TO MITIGATE THE CHALLENGES
Regulatory: Regulator may require changes during installation or after review of commissioning results.	Effective communication between the regulator and team, with recognition of impact of changes, to meet regulator requirements. Align risk management approach with prescriptive outcome requirements at design stage and in preparation of the Monitoring Plan.
Budget: Unexpected construction costs and impacts, reallocation of budget.	Ensure budget and funding method is in place for system construction prior to commencement and for operation stage prior to commissioning.
Management: Lack of responsibility for monitoring or for taking action on outcomes of monitoring.	Complete the draft Operation and Maintenance Plan, Monitoring Plan, and Emergency Response Plan prior to commissioning. Involve responsible management entity in system commissioning, with training. Educate stakeholders. Install for safe operations, and good maintenance and monitoring access.
Local capacity: Inadequate maintenance and monitoring. Lack of skilled technicians.	Involve operator in system commissioning, with training. Finalize service contracts.
Local capacity: System installation defects.	Ensure both the design and the draft Operation and Maintenance Plan consider the probable owner, responsible management entity, and operator capacity to operate, repair, and maintain the system.

4. Operating and maintaining non-potable water systems

4.2 Roles and responsibilities during operation

Roles and responsibilities during system operation are outlined in the organizational chart in the Management Plan. This will include any specific roles and responsibilities defined by regulation or policy, as well as those developed as part of the design. As part of the annual review of the Management Plan, this organizational chart may be updated to reflect changing roles or new areas of responsibility identified during the year. See the risk management section that follows for more discussion about responsibilities in the context of different management categories.

Table 4.2 Key roles and responsibilities in the operation stage

ROLE	RESPONSIBILITY
Owner	Participate in annual review to confirm that ongoing operations meet expected outcomes. Engage trained and certified operator and qualified professional for system reviews, as defined by the Management Plan, in coordination with the responsible management entity. Ensure a procedure is in place for knowledge transfer to new staff, and that financial budgeting incorporates input from the responsible management entity
Operator	Obtain and maintain appropriate training and certification. Implement the Operation and Maintenance and Monitoring Plans. Maintain records. Conduct regular maintenance inspections.
Qualified professional	Review system at intervals stated in the Management Plan, update the Management, Operation and Maintenance, and Monitoring Plans as needed, in response to review.
Authority having jurisdiction (regulator)	Where applicable, review submitted reports to ensure ongoing system compliance. Take action where reporting or results do not demonstrate protection of public health.
Responsible management entity (may be the owner)	Take responsibility for long-term management of the system to ensure that it continues to perform to protect public health, that operators have adequate training and capacity to complete their work, that monitoring is completed and reviewed, and that the system receives the financial support requested and required.

Photo by Ema Peter, courtesy of Acton Ostry Architects.

UBC AQUATICS CENTRE

The UBC Aquatics Centre is located on the UBC-Vancouver Campus and houses several swimming pools, offices, and a small café, and has a rooftop rainwater collection system that services pool water top-up, toilet flushing, and irrigation. This building demonstrates a multi-use facility that supplies non-potable water that meets toilet flushing and recreational water standards.

The UBC Aquatics Centre provides a good example of continuous process monitoring and established operational controls so that system management is not cumbersome nor expensive. The rainwater harvesting system is operated almost entirely through automated sensors and systems to reduce staffing time that would otherwise be required. Ongoing operational duties are streamlined into a daily checklist that encompasses the whole of the facility operations by the onsite Level 2 Pool Operators. Daily observations and monitoring of water flows, alarm status, and pump performance ensure operators become familiar with small aberrations in performance, leading to quick responses when required. Clear service agreements ensure monthly inspections and servicing of the rainwater treatment system are conducted by the external water treatment contractor.

4.3 Regulatory considerations during operation

Regulations, policies, standards, or guidelines may include ongoing monitoring or maintenance requirements, such as compliance monitoring. The regulator may require verification data summaries and may respond to outcomes by requiring changes or periods of more intensive monitoring.

If required changes are made during the life of the system that are expected to affect performance, it may be necessary to carry out a further validation step as part of that redesign or new commissioning.

Continued engagement with the regulator, even if regular reporting is not required, enhances the relationship with the regulator, supports risk management objectives, and ensures a responsible and proactive approach to regulatory changes.

4.4 Risk management responsibilities

Responsibilities involved with ongoing operation, maintenance, and inspection will vary depending on the system management category. Table 4.3 highlights the types of responsibilities expected for different categories.

Table 4.3 Responsibilities for operation and maintenance and for inspection based on management category

MANAGEMENT CATEGORY	RESPONSIBILITIES FOR OPERATION AND MAINTENANCE	RESPONSIBILITIES FOR INSPECTION
1 LOW	Specific skills, training, or qualifications not required, and operator relies on a user manual for operation and maintenance. Actions performed by: • System owner • General contracted service provider • Unskilled staff • By, or under supervision of, an authorized professional for systems under the *Sewerage System Regulation*	Inspections and review may be required: • For systems involving greywater or combined wastewater, inspections are performed by an Authorized Person (typically annually). • For backflow protection devices; an inspection report must be submitted to the regulator, as required by cross-connection bylaws. Performed by certified individuals. Regular review of monitoring outcomes may be specified in the Monitoring or Operation and Maintenance Plans, or by the regulator. Recommendations should be followed to improve system function and performance.
2 MODERATE	Specific skills, training, and qualifications are required to oversee activities of others who perform maintenance. These systems may not require full-time involvement of skilled or qualified professionals, but professionals should review on a regular, defined, basis. General maintenance and operations performed by: • Trained staff, under supervision of a Qualified Professional (QP) • Contracted operator or service provider with specific skills and qualifications (e.g., EOCP, ROWP) • Contracted service provider under supervision of a QP	Inspections likely required for operations and include: • Review of monitoring outcomes • System function • Backflow prevention and cross-connection control • Requirements as stipulated in operating permits • Actions to be taken Performed by contracted QP. QP reports to the regulator (where required) and system owner.
3 HIGH	Specific skills training and qualifications are required for routine operations and maintenance. Maintenance is provided by or under the direct supervision of the onsite professional (EOCP, ROWP, Engineer, QP). All training would be under the supervision of the QP.	Responsibilities will most commonly be assigned to the QP overseeing and managing daily operations. The QP would be responsible for system documentation, and report submission to the regulator, covering: • Performance verification • System monitoring • System function • Cross-connection controls • Alerts and out of specification performance • Actions to be taken • Requirements (e.g., water quality monitoring) as stipulated in operating permits

Acronyms used in this table: QP means qualified professional. AP means Authorized Person under the ***Sewerage System Regulation***, either a Registered Onsite Wastewater Practitioner (ROWP) or professional. EOCP means an Operator certified under the Environmental Operators Certification Program, in the designated fields of building water systems, water treatment, wastewater treatment, water distribution, and wastewater collection. Note that EOCP certification is required for permitted non-potable water systems in the City of Vancouver.

4.5 Reporting and record keeping

Proper system management will include documentation of system maintenance and monitoring, and may include documentation of parameters, such as system flow. In order for this documentation to be useful in supporting proper operation of the system, actions must be identified to address concerning, out of specification, or unusual monitoring data and observations. These actions may include:

- Reporting of the monitoring findings by the operator and (if appropriate) designer to the responsible management entity, with recommendations for repairs, process adaptation, or changes to plans or management.
- External reporting to the regulator; for example, incident reporting or annual reporting if specified in the organizational chart and Management Plan.
- Enforcement actions provided by the regulator.
- Regular review by the designer or other professional to analyze records of monitoring, make process or management adjustments, and update the Operation and Maintenance and Monitoring Plans.
- Annual review of the Management Plan by the owner and responsible management entity to ensure that system goals and objectives are met, with adjustment to the Management Plan and desired goals and outcomes as required.

4.6 System operation and maintenance

The Operation and Maintenance Plan will include defined maintenance steps and will typically include templates for the operator's use to keep a simple record of maintenance at the defined intervals. Systems vary widely, but typical operation and maintenance tasks may include:

- Day-to-day operational activities, such as replenishing chlorine feed tanks and checks on residual chlorine levels.
- Inspections, such as testing of backflow prevention, checks on cross-connections, checks on physical barriers, checks on source protection, and visual system inspection.
- Physical maintenance of the treatment processes, storage tanks, etc., including actions, such as cleaning, and checks on the function of surrogate monitoring equipment, alarms, or automatic diversion systems.
- Routine equipment replacement or preventative repairs, such as UV bulb replacement.
- Repairs and re-stocking of spare parts.

Monitoring is separated in terms of planning, but for simpler systems will be implemented alongside regular maintenance. This will include verification monitoring, both automated and manual, as well as any grab sampling or other monitoring required by regulation. Documented operational inspections may form part of the Monitoring Plan to provide checks on non-treatment control measures. See the Companion Document, section 5, for checklists for these plans.

Prior to commissioning, a Training Plan will have been prepared, which will support learning and capacity building for the operators in key areas such as:

- System design and operational concepts, and principles of operation.
- Operation and Maintenance and Monitoring Plans.
- Regulatory responsibilities.
- Purpose of continuous and intermittent monitoring and verification.
- Actions attached to monitoring outcomes in the Operation and Maintenance Plan.
- Overview of the system Management Plan and roles and responsibilities.
- Specific procedures for installed technology.
- Emergency response.
- Safety considerations.

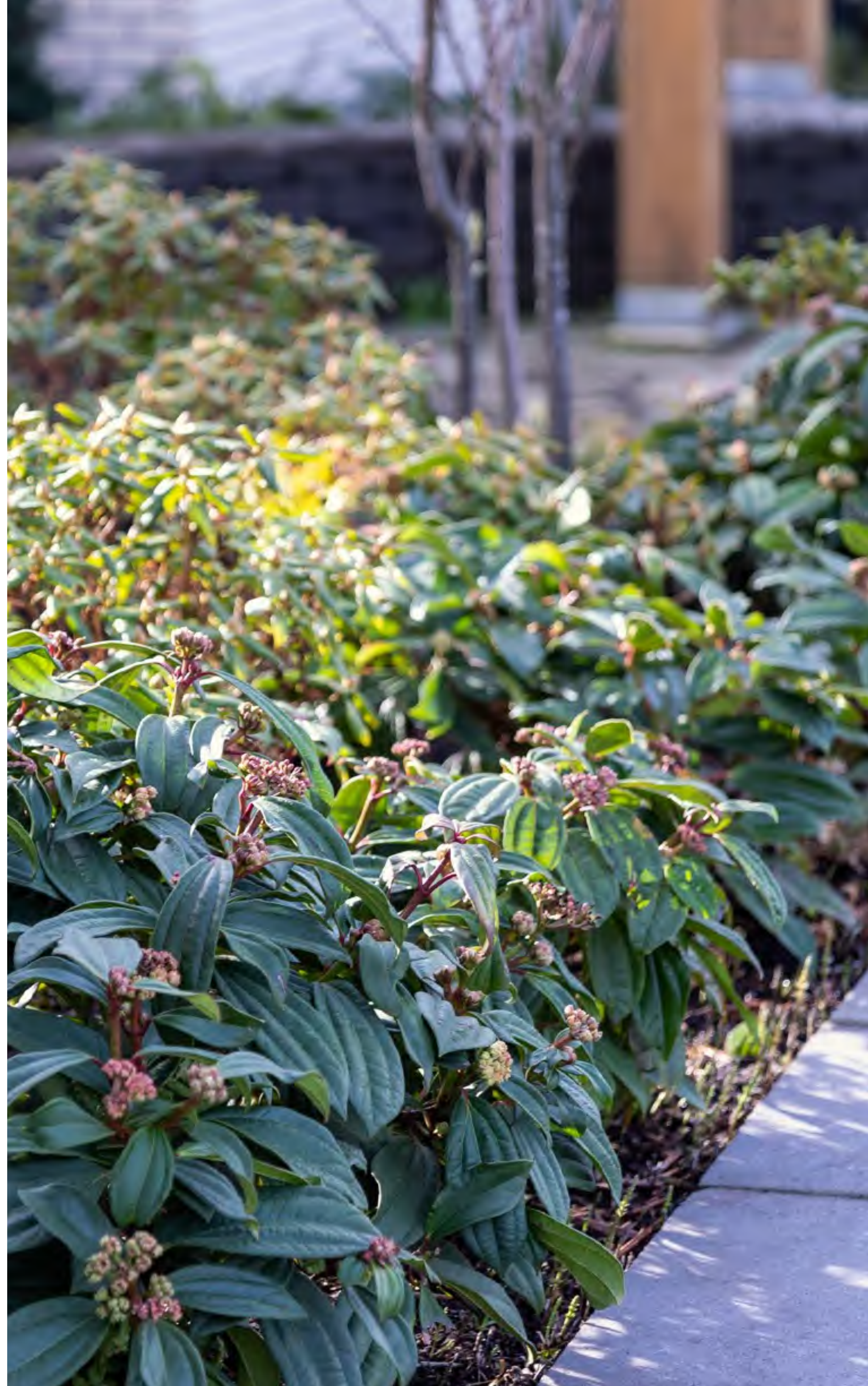
4.7 Cost considerations

Cost considerations during the operation phase will have been pre-budgeted during the design and implementation stages, and service contracts (if any) will be in place. Part of the Management Plan should include a mechanism to record and monitor actual costs, adjust budgets with time, receive budgetary estimates for adaptive changes that differ from the original design, and review and approve proposed changes.

Cost considerations for verification monitoring can vary as the results, and any control or process modifications, may necessitate changes to the Monitoring Plan to meet original design objectives.

Training costs will continue to be incurred during this phase. Training can potentially be part of the annual education credits required across most professions. Stakeholder involvement costs also need to be considered.

Financial instruments may need to be maintained and adjusted over time. These could include bonds, reserve funds, an asset management plan that sets funding policy, or financial contracts between different stakeholders tied to scope and responsibilities.



SURREY CITY CENTRE 2

Located in Surrey, City Centre Buildings have incorporated simple stormwater reuse systems, implemented to meet City of Surrey standards and to assist with the achievement of LEED® certification.

City Centre 2, certified LEED® Gold, collects stormwater and roof-runoff from the building and hardscapes and filters the water prior to it entering a 48,000-litre storage tank integrated with the building parkade. An external pump system lifts the stored water to provide drip irrigation for rooftop gardens. The irrigated area on the building roof top is approximately 1020 square metres. The system design utilized a LEED water savings calculator, which projected a total savings of up to 78,000 litres (51%) for the peak irrigation season month of July. The storage tank level is monitored and used to control bypass and flow to the municipal stormwater system. As a result, the storage tank serves double duty, providing a stormwater detention tank and reducing peak discharge flows to meet the City of Surrey requirements, while also supplying the non-potable system.

4.8 Common challenges and how to address them

Table 4.4 highlights some common operational challenges that can result in equipment or system malfunction, health risk, system abandonment, or the system not being used to its full potential.

Table 4.4 Common challenges and mitigation strategies for the operation stage

POTENTIAL STAGE-RELATED CHALLENGES	HOW TO MITIGATE THE CHALLENGES
Budget: Lack of ongoing lifecycle budget planning.	Maintain the Management Plan to ensure budget and funding method continues to be updated and kept in place for operation, maintenance, monitoring, repair, and system adaptation or component replacement.
Management: Lack of responsibility for operation, maintenance, and monitoring, or for taking action on outcomes of monitoring.	Ensure responsible management entity is in place with oversight and enforcement by the regulator, owner, or covenant holder where necessary. Support stakeholder and owner involvement and education through reporting.
Management: Inadequate maintenance or monitoring.	Ensure responsible management entity understands its responsibility to make certain the system is properly managed. Ensure regulator or professional oversight. Ensure contact information for the designer and other professionals or service providers is up to date.
Local capacity: Issues with proprietary technology or lack of operator capacity.	Responsible management entity and professionals to be ready to adapt the system if needed. Ongoing training for operators. Secure service contracts.
Unclear regulatory approvals: Changes to regulation or policy impacts system operation.	Include mechanisms for transition or grandparenting of existing systems in light of new policy.

Closing

Non-potable water systems have tremendous potential to support sustainability goals in the Metro Vancouver region, and to address the challenges arising from growth management, particularly in the context of a changing climate.

New growth and increasing density are occurring in the context of hotter summers with longer dry spells, lower winter snowfall accumulation with more rapid spring melt, and more intense rain events in the fall. All of these factors put pressure on the regional systems to sustainably provide water and wastewater services. Implementation of non-potable water systems supports water conservation, aligns with stormwater and sewer management objectives, supports environmental enhancement, and builds resiliency through distributed systems all while meeting the needs of citizens through various non-potable end uses.

This guidebook emphasizes the importance of considering the whole system and project lifecycle to safely and cost-effectively ensure the supply of water to non-potable end uses over the long term. The proper ongoing management, maintenance, and monitoring of systems are critical to system sustainability and performance. Further, this guidebook highlights that well-managed systems will be monitored, with results communicated to and acted upon as needed by appropriate stakeholders, in an adaptive and responsive process — raising awareness, as well as ensuring sustainability of the systems.

By applying these best practices, an increased level of comfort and proficiency can develop across all stakeholders, enabling many more people, businesses, and communities to value and effectively use water of all types safely in the way best suited to the sources and end uses.

Appendix 1: Glossary and definitions

The following glossary terms include a mixture of definitions directly quoted or adapted from other relevant sources, and, where necessary, original definitions are provided to most accurately represent the terminology in the context of Metro Vancouver.

Authority having jurisdiction (regulator): An organization, office, or individual having statutory responsibility for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. (Indigenous Services of Canada)

Control measures: Those steps between source and end use that directly affect water quality or exposure, and which, collectively, ensure that water consistently meets health-based targets as well as managing exposure to risk. They are actions, activities, and processes applied to prevent or minimize hazards occurring.

Commissioning: The activities associated with bringing a new process, such as a water system, into normal working condition (new or re-commissioning after alterations or an unplanned long non-operational period), ensuring the system components and overall process perform as designed and according to the owner's requirements. (Adapted from Sharvelle et al., 2017, to align with Vancouver Building By-Law)

Compliance monitoring: Monitoring mandated by regulation or by the authority having jurisdiction.

Condensate: Water vapour that is converted to a liquid and collected (the most common source in buildings being equipment for air-conditioning, refrigeration, and steam heating. (Sharvelle et al., 2017)

Contaminant: An undesirable organic or inorganic, soluble or insoluble substance in water, including microorganisms. (Adapted from CSA B805-18)

Exposure: Human contact with water or waterborne contaminants, typically by ingestion, inhalation, or skin contact.

"Fit-for-purpose" use: Water source(s) of adequate quantity is matched to an end use (or uses) and is treated only to the extent needed to meet end use quality requirements.

Greywater: Wastewater from the preparation of food and drink, dishwashing, bathing, showering, and general household cleaning and laundry. Greywater does not mean "reclaimed water". (BC Ministry of Health, 2016)

- Dark greywater: Greywater flowing from kitchen, dishwashing, and mop sink uses.
- Light greywater: Greywater flowing from uses other than kitchen, dishwashing, or mop sinks. Example, shower water or laundry greywater.
- Very light greywater: Wastewater from showers, baths, hand basins. Light greywater excluding laundry water.
- Laundry greywater: Greywater flowing from washing machines and laundry sinks.

Groundwater: Water naturally occurring below the surface of the ground. (BC Water Sustainability Act)

Log$_{10}$ reduction: The removal of pathogens or a surrogate in a unit process expressed in log$_{10}$ units. A 1-log$_{10}$ reduction equates to a 90% removal, 2-log$_{10}$ reduction to 99% removal, 3-log$_{10}$ reduction to a 99.9% removal, and so on. (Sharvelle et al., 2017)

Management category: A category defining the level of pathogen and process malfunction risk associated with a particular non-potable water system, leading to the establishment of management requirements for the system. This guidebook defines three categories, on a continuum of low to high risk.

Multiple barrier (multi-barrier) approach: An integrated system of procedures, treatment processes, and management tools that collectively reduce the risk of human exposure to pathogens and harmful substances.

Non-potable water: Water that is not of drinking water (potable) quality, but may be used for other purposes.

Non-potable water system: A system which collects, treats, stores, and distributes non-potable water.

Non-potable water sources: Typical non-potable water sources include: clear water waste, foundation drainage water, greywater, groundwater (in specific contexts only*), rainwater, stormwater, and vehicle wash wastewater. *Groundwater is considered a potential non-potable water source only in contexts where the building intersects with a source of groundwater and the groundwater would otherwise be considered a nuisance to be disposed of through the stormwater system.

Non-potable water use: Utilization of treated or untreated non-potable water in buildings or outside of buildings for purposes other than drinking water supply, providing the non-potable water meets applicable water quality standards. Examples include flushing toilets, irrigating lawns and gardens, washing vehicles and washing clothes. (Adapted from CSA B128.1-06/.2-06)

Performance objective: The outcomes that a system must attain in order to be acceptable. Also, the objective for a specific treatment step, e.g., log reduction of pathogen indicators in that step. (Engineering and Geoscientists BC, 2018)

Quantitative microbial risk assessment (QMRA): A statistical modelling approach used to estimate the potential risk of infection and illness when a population is exposed to pathogens in the environment.

Responsible management entity (RME): A person, corporation, NGO, or governmental body with ultimate legal responsibility for the performance of a non-potable water system. (Sharvelle et al., 2017)

Risks: The effect of uncertainty on objectives. In context to health risk from *non-potable water systems*, the potential that chemicals or micro-organisms will reach a person at harmful doses depending upon that person's actual means of exposure and level of exposure. (Adapted from Engineering and Geoscientists BC, 2018)

Roof runoff: Rainwater that is intercepted by an elevated impervious roof surface that is not subject to pedestrian access. (CSA B805-18)

Stormwater: Water that is discharged from a surface as a result of rainfall or snowfall that is not roof runoff. (Adapted from BC Building Code and CSA B805-18)

Validation: A practical step that measures and confirms a system meets the design requirements. This can be based on previous testing, or can involve building prototype systems (or parts of systems) and physically testing the outputs, or can test a completed system wherein the results are used to ensure its functionality at commissioning.

Vehicle wash wastewater: Water that is generated from washing domestic or light commercial vehicles, with little to no animal and/or agricultural transport or exposure. (Adapted from Alberta Health Services, 2021)

Verification: Monitoring of surrogates to confirm that the system continues to operate as planned, or to control or prompt diversion of water, process adjustments, and other actions.

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Standards and guidelines relevant in BC

The following short list of standards and guidelines are recommended for planners and designers working with non-potable water systems. When referring to these references, follow BC regulatory requirements where these differ from those used in the references. Also, consider the climatic conditions that the information is related to.

Organization/ Year	Standard/Guideline	Relevance to	Description
Alberta Health Services (2021)	Public health guidelines for water reuse and stormwater use	Non-potable water system design, risk management	Similar coverage to Sharvelle et al 2017, in the Canadian context.
BC Ministry of Health (2014)	Sewerage System Standard Practices Manual	Sewerage system design	Standard practices for the planning, installation, and maintenance of sewerage systems. Covers soil and site evaluation, planning, installation and maintenance.
BC Ministry of Health (2016)	Manual of Composting Toilets and Greywater Practice (SSR)	Greywater dispersal system design	Minimum standards and guidelines for planning, installation, monitoring, and maintenance of composting toilet and greywater systems, and performance criteria and objectives to meet health and safety needs.
BC Ministry of Health (2020)	Drinking Water Officers' Guide 2020 – Part B, Guidance for Treatment of Rainwater Harvested for Potable Use in British Columbia	Rainwater risk and treatment guidance	Intended for risk assessment and treatment protocols for rainwater for drinking water; risk and treatments are transferable to non-potable design excluding greywater.
BC Ministry of Health (2022)	Guidelines for Pathogen Log Reduction Credit Assignment Part B: section 15	Log Reduction Credits attributable for treatment processes	Intended for drinking water systems, but provides log reduction values for types of filtration, and UV and chemical disinfection that are transferable to non-potable water, excluding greywater.
BC Ministry of Health (2022)	Drinking Water Officers' Guide 2022 – Part B: Section 16, Guidelines for Ultraviolet Disinfection of Drinking Water, V1	UV validation, verification, calibration, certification, monitoring, and install reference	Comprehensive guidelines for UV disinfection for drinking water, but the procedures and processes described are transferable to the design and use of UV in all non-potable water systems.
BC Ministry of Environment and Climate Change Strategy (2019)	BC Water Quality Guidelines: Recreation	Waters used for recreation	Safe levels for chemical, physical, and biological attributes in waters that come into contact with recreational users of water sources.
BC Ministry of Environment and Climate Change Strategy (2021)	BC Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture (2019)	Waters in contact with wildlife, aquatic life, and agriculture	Safe levels for chemical, physical, and biological attributes in waters that come into contact with and in use with aquatic life, wildlife, and agriculture.
BC Ministry of Environment (2013)	BC Reclaimed Water Guidelines	Companion guidance document to the *Municipal Wastewater Regulation*	Provides guidance in complying with the *Municipal Wastewater Regulation*.
Canadian Onsite Technical Resource Association (2016)	Guidance for Composting Toilet and Greywater Systems in BC Version A	Greywater reuse and subirrigation	Greywater quality and quantity parameters and background to the Manual of Composting Toilets and Greywater Practice.
CSA Group (2017)	CSA B128.3-12 (R2017)	Performance of non-potable water systems	Applies to packaged systems or site assembled components designed to process under 10,000 L/day. Testing methods to demonstrate performance, required materials, and design, construction and instruction documentation. Covers Class A and Class B water treatment levels.

CSA Group (2018)	CSA B805-18	Rainwater and stormwater collection for potable and non-potable use	Design standard that addresses risk assessment of source water, required LRT for end uses, acceptable materials, documentation, and design requirements. Applicable to residential, commercial, and multi-residential systems.
CSA Group (2021)	CSA B128.1-06 (R2021)	Non-potable water systems Design and installation	Specifies design and installation of non-potable water systems (toilet/urinal flushing, irrigation, vehicle washing, showering, bathing, laundry, heating and cooling).
CSA Group (2021)	CSA B128.2-06 (R2021)	Non-potable water systems Maintenance and field testing	Specifies the requirements for maintenance and field testing of non-potable water systems.
Engineers and Geoscientists BC (2018)	Guidelines & Advisories	Professional practice guidance for registered members	Provides a reference for consistent use of terminology.
Engineers and Geoscientists BC (2021)	Professional Practice Guidelines, Onsite Sewerage Systems	Sewerage and greywater system design, operation, maintenance, and monitoring	Includes guidance on design approaches and performance-based design.
Health Canada (2010)	Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing	Domestic reclaimed water quality parameters Management elements of reclaimed water systems	Provides water quality parameters for domestic reclaimed water, and list management elements for successful reclaimed water systems.
Health Canada (2020)	Guidance on Monitoring the Biological Stability of Drinking Water in Distribution Systems	Distribution systems	Protection of distribution systems from risk of deterioration in water quality.
NSF International	NSF/ANSI Standard 350	Onsite residential and commercial water reuse treatment systems	Challenge-testing standards for non-potable water reuse systems that incorporate a testing period, dosing requirements (loading and stress events), influent characteristics for several water types (laundry, bath, greywater), recipe for the synthetic challenge water, and effluent criteria. Applies to three water classifications: typical bathing water, laundry water and combined greywater.
NSF International	The New NSF 350 and 350-1	Onsite residential and commercial treatment systems for subsurface discharge	Less rigorous effluent criteria than NSF 350. Challenge testing standards for non-potable water reuse systems that incorporate a testing period, dosing requirements (loading and stress events), influent characteristics for several water types (laundry, bath, greywater), recipe for the synthetic challenge water, and effluent criteria.
Province of British Columbia (2017)	BC Drinking Water Officers' Guide	Provincial health policy related to drinking water	Includes guidance on interpreting the *Drinking Water Protection Act* and the Drinking Water Protection Regulation. Specifies non-potable water system provisions and requirements are found in the DWPR section 3.1.
US Environmental Protection Agency (2006)	40 CFR Parts 9, 141 and 142. National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule; Final Rule	Treatment of protozoa and microbial contaminants in surface water	Primarily directed towards surface waters used for drinking water, the LT2ESWTR provides applicable procedures for monitoring and treatment of cryptosporidium and microbial contaminants.
US Environmental Protection Agency (2006)	Ultraviolet Disinfection Guidance Manual For the Final Long Term 2 Enhanced Surface Water Treatment Rule, p. 43	Ultraviolet disinfection intensities for disinfection of protozoa and microbial contaminants	Background information and guidance on UV light, microbial response to UV light, and UV reactors.

US Environmental Protection Agency (2012)	[Guidelines for Water Reuse](#)	Comprehensive coverage of all aspects	Covers planning and management considerations, reuse applications, treatment technologies, funding of systems, and general information on best practices.
US Environmental Protection Agency (2012)	[Recreational Water Quality Criteria Office of Water 820-F-12-058](#)	Water quality where recreation may occur	Water quality recommendations for pathogens and pathogen indicators, testing methods for water where recreation occurs.
US Environmental Protection Agency (2021)	[Non-Potable Environmental and Economic Water Reuse (NEWR) Calculator](#)	Environmental and lifecycle cost assessment tool	Online/web-based tool that allows environmental and lifecycle costs assessment across various non-potable source waters and matched end uses; geography, regional climate, and water pricing influence the assessment.
World Health Organization (2006)	[World Health Organization Guidelines For The Safe Use Of Wastewater, Excreta and Greywater](#)	Greywater, microbial risk abatement, health-based targets for irrigation	Series of 4 volumes that provide continual updates to health-based targets for end use in irrigation.
World Health Organization (2006)	[Quantitative Microbial Risk Assessment: Application for Water Safety Management](#)	Using risk-based water safety management	Provides a framework and guidance for undertaking QMRA for non-potable water.
World Health Organization (2021)	[Guidelines on Recreational Water Quality](#)	Recreational water	Guidelines for safe recreational water environments provide health-based guidance for setting national water quality standards and implementing preventive risk management at the local level. Risk management approaches are covered.

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ATTACHMENT 2

Non-Potable Water Systems

Companion Document

A Guidebook for the
Metro Vancouver Region

2022

metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

About Metro Vancouver
Metro Vancouver is a federation of 21 municipalities, one electoral area, and one treaty First Nation that collaboratively plans for and delivers regional-scale services. Its core services are drinking water, wastewater treatment, and solid waste management. Metro Vancouver also regulates air quality, plans for urban growth, manages a regional parks system, and provides affordable housing. The regional district is governed by a Board of Directors of elected officials from each local authority.

Metro Vancouver acknowledges that the region's residents live, work, and learn on the shared territories of many Indigenous Peoples, including 10 local First Nations: Katzie, Kwantlen, Kwikwetlem, Matsqui, Musqueam, Qayqayt, Semiahmoo, Squamish, Tsawwassen, and Tsleil-Waututh.

Metro Vancouver respects the diverse and distinct histories, languages, and cultures of First Nations, Métis, and Inuit, which collectively enrich our lives and the region.

Using onsite water sources to supply non-potable end uses (toilet flushing, irrigation, vehicle washing, and more) presents an opportunity to use water resources more sustainably in this region. This Companion Document accompanies the Non-Potable Water Systems Guidebook for the Metro Vancouver Region to provide additional context and links to references, and assemble relevant guidance from other sources into a convenient location.

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The Non-Potable Water Systems: A Guidebook for the Metro Vancouver Region Companion Document is not a legal document and should not be considered a substitute for governing legislation and regulation. This is a living document and may be updated periodically.

Table of contents

COMPANION DOCUMENT		**NON-POTABLE WATER SYSTEMS – A GUIDEBOOK FOR THE METRO VANCOUVER REGION**	
Section	Page #	Related Guidebook Sections	Page #
7. Acceptable risk: introduction to probabilistic assessment	22	Section 2 – Designing with a risk management approach, Assess human health risk Section 2 – Designing with a risk management approach, Identify control measures	45, 47
8. Typical log reduction targets (LRTs) by end use	25	Section 2 – Risk management, Select system performance objectives	46
9. Common process controls and treatment systems	30	Section 2 – Risk management, Identify control measures	47
10. Typical log reduction values (LRVs)	32	Section 2 – Risk management, Identify control measures	47
11. Management category guidance	38	Section 2 – Risk management, Defining system management	52
12. Monitoring with grab samples vs. continuous monitoring	44	Section 3 – Regulatory considerations during implementation	61
13. Surrogates for system performance verification monitoring	47	Section 3 – Risk management, Verification of performance and system monitoring	64

Acronyms

CSA: Canadian Standards Association

DALY: Disability Adjusted Life Year

FIOs: Fecal indicator organisms

IDF: Intensity Duration Frequency

LRT: Log reduction target

LRV: Log reduction value

MoH: Ministry of Health

O&M: Operations & Maintenance

PPY: Per persons per year

QMRA: Quantitative microbial risk assessment

RME: Responsible Management Entity

USEPA: U.S. Environmental Protection Agency

WHO: World Health Organization

1. Purpose of this document

This is a companion document to the Non-Potable Water Systems – A Guidebook for the Metro Vancouver Region (Guidebook). The purpose of this document is to provide further information and guidance to those involved in the non-potable water field, as well as background information for the general reader. Sections within this document will have varying degrees of relevance for the different professions; it is not intended to be a detailed design manual or educational or training text.

2. Fit-for-purpose: Matching sources and end uses

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 1 – Table 1.5 Finding Well-matched Source Water and End Use, for Annual Use Scenario**
- **Section 1– Table 1.6 Typical Quality Concerns by Type of Source Water**

2.1 Expanded fit-for-purpose matrix

This section illustrates typical considerations for the matching of sources and end uses in terms of quantity and quality. In all cases, custom analysis is important since considerations will vary for each specific project for both sources and end uses. This summary employs subjective wording such as “easy to treat” or “large storage”. Project-specific analysis will refine these subjective terms to suitable quantitative relationships as part of the design process.

Examples of variation between projects include: 1) A site may have seasonal peak usage during the season of water generation, which will improve the match to a seasonal source, but the opposite may also be the case. 2) An irrigated area that is poorly matched to available flow rates for a greywater source would result in the need for more storage, or the need for supplemental water since long-term storage of greywater may be problematic.

In Table 1, potential storage volume needed is illustrated as follows:

- “Large storage” means approximately four times monthly end use demand, with “very large” storage being a situation with large storage combined with high volume end use.
- “Small storage” means up to approximately one times daily or weekly end use demand.
- “Medium storage” means situations between large and small, or small storage requirement combined with high volume end uses.

The quality match between source and end use must consider the characteristics of the water (potential for contamination) together with exposure risk. It must also consider the probable management needs in relation to the source, use, and size of project (see Section 4 of this document for exposure risk tiers). In the case of irrigation, vehicle washing and outdoor water features the usage may fall into differing tiers of exposure potential depending on the nature of use. For example, vehicle washing may be Tier 1 if automatic drive through, but Tier 3 if pressure washing or wand washing. This means that the information on quality matching in the following table is illustrative only—each project must be individually assessed.

In Table 1, potential treatment requirements and associated system management requirements are illustrated as follows:

- “Easy to treat to necessary level”, simple and relatively low-cost treatment methods with simple operation, monitoring, and maintenance requirements and costs. "Very easy" indicates situations where treatment may be as simple as screening and filtration.
- “Complex”, a more complex treatment train with multiple processes, higher capital or operating costs, and more onerous operation, monitoring and maintenance requirements.
- “Medium”, situations in between, and may also apply to easy to treat combinations which have very high flows or larger potential exposed population.

In Table 1, typical levels of source contamination are indicated by NS (not significant), low, medium, or high. This is illustrative only and may vary widely by project. For example, stormwater contaminant risk is linked to risk of sewage contamination or a specific use may require consideration of chemical contamination beyond the norm. Likewise, size of population and sources included within collection will affect probable levels of contaminants in light greywater. Note that source protection or source control may be important in improving or maintaining quality prior to or during collection of the source water. See Section 2.2. below, for more detail on typical contaminant considerations for source waters.

Table 1 does not summarize risk posed by the source contamination. Table 1.6 in the guidebook summarizes contamination risks as “quality concerns”, grouping risk into “not significant” (typically NS or low levels in Table 1), “potential” (typically low and medium levels in Table 1), and “significant” (typically medium and high levels in Table 1).

Table 1. Considerations for the matching of sources and end uses by quantity and quality

SOURCE EXAMPLES		**END USE EXAMPLES**					
		TOILET FLUSHING/ LAUNDRY, Tier 3	COOLING TOWERS, Tier 2	VEHICLE WASHING, Tier 1 or 3	NON AGRI FOOD SUBSURFACE IRRIGATION, Tier 1	NON AGRI FOOD UNRESTRICED SURFACE IRRIGATION, Tier 3	OUTDOOR WATER FEATURES, Tier 1 to 3
Roof runoff water • Seasonal • Viral potential NS • Bacterial potential High • Protozoan potential Med • Chemical impurities* Low	QUANTITY	• Large storage needed to match seasonal source flows to continuous end use	• Very large storage needed • Peak demand coincides with lowest precipitation period	• Small storage needed • Peak demand coincides with wet season	• Very large storage needed If paired with a high demand end use • Peak irrigation demand coincides with dry season	• Very large storage needed If paired with high demand end use • Peak irrigation demand coincides with dry season	• Medium storage needed to meet seasonal evaporation if paired with low demand end use
	QUALITY	• Easy to treat to necessary level	• Easy to treat to necessary level	• Easy to treat to necessary level for Tier 1 or Tier 3	• Very easy to treat to necessary level	• Easy to treat to necessary level	• Moderate treatment needed to meet necessary level

SOURCE EXAMPLES		**END USE EXAMPLES**					
		TOILET FLUSHING/ LAUNDRY, Tier 3	COOLING TOWERS, Tier 2	VEHICLE WASHING, Tier 1 or 3	NON AGRI FOOD SUBSURFACE IRRIGATION, Tier 1	NON AGRI FOOD UNRESTRICED SURFACE IRRIGATION, Tier 3	OUTDOOR WATER FEATURES, Tier 1 to 3
Stormwater** • Seasonal • Variable quality • Viral potential High • Bacterial potential High • Protozoan potential High • Chemical impurities High • Physical impurities High	QUANTITY	• Large storage needed to match seasonal flows to continuous end use (similar profile to rainwater)	• Very large storage needed (similar profile to rainwater) • Peak demand coincides with lowest precipitation period	• Small to medium storage needed (similar profile to rainwater) • Peak demand coincides with wet season	• Very large storage needed (similar profile to rainwater) • Peak demand coincides with dry season	• Very large storage needed (similar profile to rainwater) • Peak demand coincides with dry season	• Medium storage needed to meet seasonal evaporation (similar profile to rainwater)
	QUALITY	• Complex to treat to necessary level	• Moderate treatment needed to reach necessary level	• Moderate treatment needed to meet necessary level for commercial use to meet workplace safety requirements	• Easy to treat to necessary level • Chemical contaminants may cause issues	• Complex to treat to necessary level • Chemical contaminants may cause issues	• Variable depending upon nature of feature • Chemical contaminants may cause issues

SOURCE EXAMPLES		END USE EXAMPLES					
		TOILET FLUSHING/ LAUNDRY, Tier 3	COOLING TOWERS, Tier 2	VEHICLE WASHING, Tier 1 or 3	NON AGRI FOOD SUBSURFACE IRRIGATION, Tier 1	NON AGRI FOOD UNRESTRICED SURFACE IRRIGATION, Tier 3	OUTDOOR WATER FEATURES, Tier 1 to 3
Foundation and relief drainage** • Seasonal or annual • Variable quality • Viral potential High • Bacterial potential High • Protozoan potential Med • Chemical impurities High • Physical impurities High	QUANTITY	• Small storage needed if available during dry season • If not, large storage needed to meet continuous use	• Small storage needed if available during dry season • If not, large storage needed to meet continuous use	• Small storage, if available during washing season	• Small storage if available during dry season • If not, large storage needed to meet peak demand during dry season	• Small storage needed if available during dry season • If not, large storage needed to meet peak demand during dry season	• Medium storage needed for seasonal evaporation if not available in dry season
	QUALITY	• Complex to treat to necessary level, depending on contamination level	• Moderate treatment needed to reach necessary level	• Moderate treatment needed to reach necessary level for commercial use to meet workplace safety requirements	• Easy to treat to necessary level • Chemical contaminants may cause issues	• Complex to treat to necessary level, depending on contamination level • Chemical contaminants may cause issues	• Variable depending upon nature of feature and level and type of contamination

SOURCE EXAMPLES		**END USE EXAMPLES**					
		TOILET FLUSHING/ LAUNDRY, Tier 3	COOLING TOWERS, Tier 2	VEHICLE WASHING, Tier 1 or 3	NON AGRI FOOD SUBSURFACE IRRIGATION, Tier 1	NON AGRI FOOD UNRESTRICED SURFACE IRRIGATION, Tier 3	OUTDOOR WATER FEATURES, Tier 1 to 3
Light greywater • Annual • Viral potential High • Bacterial potential High • Protozoan potential Med • Chemical impurities Med • Physical impurities Med	QUANTITY	• Small storage needed • Continuous supply matches continuous demand	• Small storage needed if source quantity adequate during cooling season	• Small storage needed	• Small storage needed, if irrigated area is sized to match volumes generated during peak dry season	**Use not supported under current regulation**	**Use not supported under current regulation**
	QUALITY	• Complex to treat to necessary level	• Moderate treatment needed to reach necessary level	• Moderate treatment needed to reach necessary level for commercial use to meet workplace safety requirements	• Moderate treatment needed to reach necessary level	**Use not supported under current regulation**	**Use not supported under current regulation**

SOURCE EXAMPLES		END USE EXAMPLES					
		TOILET FLUSHING/ LAUNDRY, Tier 3	COOLING TOWERS, Tier 2	VEHICLE WASHING, Tier 1 or 3	NON AGRI FOOD SUBSURFACE IRRIGATION, Tier 1	NON AGRI FOOD UNRESTRICED SURFACE IRRIGATION, Tier 3	OUTDOOR WATER FEATURES, Tier 1 to 3
Vehicle wash water • Seasonal peak • Based on vehicles not used for animal or septage transport • Viral potential NS • Bacterial potential High • Protozoan potential NS • Chemical impurities High • Physical impurities High	QUANTITY	• Medium to very large storage depending on seasonal peak supply, to match seasonal source flows to continuous end use	• Medium to very large storage depending on seasonal peak supply, to match seasonal source flows to continuous end use	• Small to no storage for closed loop recycling	• Medium to very large storage depending on seasonal peak supply, to meet peak demand during dry season	• Medium to very large storage depending on seasonal peak supply, to meet peak demand during dry season	• Small to medium storage needed for seasonal evaporation depending upon supply in dry season
	QUALITY	• Complex to treat to necessary level	• Moderate treatment needed to reach necessary level	• Moderate treatment needed to reach necessary level for commercial use to meet workplace safety requirements • Management of chemical contaminants is necessary	• Moderate treatment needed to reach necessary level • Chemical contaminants may cause issues • If contamination level is high then use is not recommended	• Complex to treat to necessary level • If contamination level is high then use is not recommended	• Variable depending upon nature of feature • Chemical and physical contaminants must be fully mitigated

SOURCE EXAMPLES		END USE EXAMPLES					
		TOILET FLUSHING/ LAUNDRY, Tier 3	COOLING TOWERS, Tier 2	VEHICLE WASHING, Tier 1 or 3	NON AGRI FOOD SUBSURFACE IRRIGATION, Tier 1	NON AGRI FOOD UNRESTRICED SURFACE IRRIGATION, Tier 3	OUTDOOR WATER FEATURES, Tier 1 to 3
Condensate*** • Seasonal peak/variable • Viral potential NS • Bacterial potential High • Protozoan potential Med • Chemical impurities Med • Physical impurities Med	QUANTITY	• Medium to very large storage may be needed depending on seasonal peak supply, to meet continuous end use • Better suited for lower demand commercial facilities	• Medium to very large storage may be needed depending on seasonal peak supply, to meet continuous end use • Similar production/end use conditions as for toilet flushing	• Large storage needed if peak supply coincides with dry season and vehicle washing coincides with the wet season • Small storage if peak generation coincides with dry season and acts as a supplement source for end use	• Small storage needed if peak supply coincides with dry season • May be better match to supplement another source for irrigation	• Small storage needed if peak supply coincides with dry season • May be better match to supplement another source for irrigation	• Small storage needed if peak supply coincides with dry season • May be better match to supplement another source for water feature top-up
	QUALITY	• Easy to treat to necessary level	• Easy to treat to necessary level	• Easy to moderate treatment to meet necessary level • Management of chemical contaminants is necessary	• Easy to treat to necessary level • Chemical contaminants may cause issues	• Variable treatment needed, depending on level of contamination • Chemical contaminants may cause issues	• Variable treatment needed, depends on level of contamination • Chemical and physical contaminants may cause issues

* Depends upon airshed quality, roof, and other material in contact with the water. Lower tier non-potable usage allows for collection from a wider range of roofing materials, whereas potable collection standards strictly limit allowable materials. See CSA B805-18.

** Contaminant levels and types are variable. Microbial contaminant levels in stormwater and drainage water are related to degree of contamination with sewage (see Section 9), as well as to other sources of microbial contaminants, such as animal wastes. Chemical risk will also vary, depending on the source characteristics (e.g., traffic areas vs. hardscape), and in the case of drainage water, the level of chemical contaminants in the site or shallow aquifer soils. Risks from potential hazardous chemical spills should be assessed and managed (e.g., by emergency bypass in the collection system). If contaminants of emerging concern must be controlled, chemical contamination will require more detailed analysis and may result in some waters being unsuitable for a proposed end use — for example, for a water feature which is intended to support an aquatic ecosystem.

*** Condensate production is highly variable and dependant on system, cooling demand, and relative humidity, and so the relationship of end use demands to condensate generation will also be highly variable both project-to-project, and potentially within the lifecycle of a single project.

2.2 Quality concerns for source water

The Table 2 summarizes typical quality concerns by type of source water. As noted In Section 2.1, above, project specific analysis Is necessary.

Table 2. Typical quality concerns by type of source water

SOURCE WATER	TYPICAL QUALITY CONCERNS
Roof runoff water or condensate	• Viral pathogens are not a significant risk where there is no access by humans or animals to the source. • Bacterial pathogens are a significant risk and come from a range of sources, e.g., fecal matter, aerosol deposition, tree litter. • Potential risk of protozoan parasites from bird or bat fecal matter. • Chemical contamination of varying potential due to varying airshed quality, varying physical parameters of water that could cause corrosion of surfaces, and type of material in contact with the water. • Seasonal suspended or entrained organic matter and dust. • Hydrocarbons are not as significant a risk as for stormwater due to limited access and activities in proximity to the source water. Remaining risk is primarily related to airshed quality.
Stormwater	• Viral, bacterial, and protozoan pathogens, risk of contamination with sewage and animal feces (depending on level of dilution probable or assessed). • Hydrocarbons and potential chemical contamination, including salts, dust control, and de-icing chemicals, linked to the site's historical and present use, and potential risks posed to the site — including spill risk. • Suspended or entrained organic matter and soil or grit particles.
Foundation and relief drainage	• Similar contamination risk to stormwater, with potentially higher risk of leaching chemicals from contaminated sites (subject sites and other sites affecting the shallow aquifer).
Light greywater	• Viral, bacterial, and protozoan pathogens. • Personal care products, soaps, and cleaning chemicals — some may be metabolic disruptors and may affect irrigated plants and ecosystem. • Dissolved organic matter and suspended solids. Significant biochemical oxygen demand and risk of biofilm and opportunistic pathogen growth in storage. • Differing risk and variability for single family vs. multi family or commercial greywater.
Vehicle wash wastewater	• Bacterial pathogens (viral and protozoan pathogens typically not significant where there is little animal, septage, or agricultural transport or exposure — to be assessed on a case-by-case basis). Similar risk to no-access roof runoff. • Chemical contamination. Soaps and surfactants, cleaning chemicals, hydrocarbons, salts, dust control, and de-icing chemicals.

3. Project risks

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- Section 1 – Risk management approach
- Section 1 – Feasibility review

When planning a non-potable water project, it is important to identify, consider, plan for, and manage risks that may impact project design, implementation, and ongoing operation. In addition to addressing human health risks, the design of the system and project planning should also consider and minimize several other project risks, including but not limited to:

- Property and infrastructure-related risks generated by the project
- Leakage or evaporation losses in storage and distribution
- Environmental impact
- Impact on the project infrastructure from outside sources (e.g., people/vandalism, wildlife, and domestic animals)
- Future changes in ownership
- Future regulatory changes
- Supply and demand change related to climate change
- Potential impact of climate change and or disasters on the system
- Construction-related risks (e.g., materials availability, trades availability, delays, safety)
- Financial risks and contingencies
- Potential liabilities affecting insurance rates or coverage, specific to non-potable water systems

4. Exposure potential for different end uses

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 1 – Risk management approach**

Table 3 is adapted from CSA B805-18/ICC 805-2018, Table 5.1 "End use tiers and the likelihood of exposure without mitigation measures". Table 3 in this document provides a link between the end use and a risk reduction target, which is not included in the CSA table.

Table 3. End use tiers and likelihood of exposure, adapted from CSA B805-18

TIER	RISK TARGET (PPY)	DESCRIPTION OF END USE	END USE EXAMPLES	LIKELIHOOD OF EXPOSURE			
				Ingestion	Inhalation	Skin Contact	Overall
1	10^{-2}	• Rare contact • Installation limits direct and indirect exposure • Mainly outdoor	• Trap primers • Non agri-food irrigation (spray with restricted access) • Non agri-food irrigation (subsurface and drip irrigation) • Dust control and street cleaning (night application) • Car and truck washing (automatic spray, drive through) • Fire protection • Ice rinks • Aesthetic water features (ponds with no direct contact or spray features)	Rare	Unlikely	Unlikely	Unlikely

TIER	RISK TARGET (PPY)	DESCRIPTION OF END USE	END USE EXAMPLES	LIKELIHOOD OF EXPOSURE			
				Ingestion	Inhalation	Skin Contact	Overall
2	10^{-2}	• Indirect exposures • Installation includes some level of exposure management	• HVAC evaporative cooling • Rooftop thermal cooling • Exposure to indoor plumbing leaks of non-potable water	Rare	Possible	Possible	Possible
2	10^{-4}	• Indirect exposures • Installation includes some level of exposure management	• Clothes washing • Indoor water features (incl. fountains and waterfalls)	Rare	Possible	Possible	Possible
3	10^{-2}	• Probable direct exposures • No exposure management	• Pressure washing • Car and truck washing (wand washing) • Outdoor recreational end uses (swimming, boating) • Non agri-food irrigation (spray with unrestricted access)	Possible	Likely	Likely	Likely
3	10^{-4}	• Probable direct exposures • No exposure management	• Toilet and urinal flushing • Indoor aesthetic water features • Agriculture-food irrigation	Possible	Likely	Likely	Likely
CC	10^{-4}	• Cross-connection risk*	• Indoor uses of water	Likely	Likely	Likely	Likely

*It is critical that cross-connection risk be managed through control measures other than treatment. If not managed, cross-connection becomes the controlling risk.

5. Checklist for plans during system design and implementation

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 2**
- **Section 3**
- **Section 4**

5.1 Management Plan checklist

The Management Plan checklist helps to ensure that a review of the operations of the system occurs annually, that the goals and objectives continue to be met, and that persons/departments are tasked with their roles and responsibilities.

Use the following checklist when writing the management plan, include at minimum:

☐ Description of the system, including objectives and goals defined in the planning process.
☐ Regulatory context and requirements.
☐ Operating Permit – or conditions set out by the authority having jurisdiction (regulator).
☐ Identification of and contact for the Responsible Management Entity (RME), with attached list of RME undertakings if in place.
☐ Emergency Response Plan including emergency contacts, service providers, equipment suppliers, designer/engineer team (updated annually).
☐ Schedule of daily, weekly, monthly and yearly tasks; include operation, maintenance, scheduled replacements, monitoring, and reporting tasks.
☐ Schedule of summary reports required (financial, operations, monitoring).
☐ Flowchart or list of persons/departments responsible for tasks and reports above.
☐ Ensure the current system design and drawings are current (checked annually).
☐ Asset Management Plan and capital replacement fund report (updated annually).
☐ Annual budget report (with subcategories for service provider costs, consumables, O&M expenses, amortization expenses, asset capitalization).
☐ Annual report covering summary of the prior year's operations, changes that have been made to design/drawings, expectations for the coming year, and reconfirmation that goals and objectives have been met (or adjusted).
☐ Planned funding methods to meet operating and capital budgets.
☐ Stakeholder engagement and reporting, related to objectives and goals.
☐ Procedures for routine external review or oversight, by the regulator or a professional.
☐ Project organizational chart (updated as needed).

5.2 Operation and Maintenance Plan checklist

The Operation and Maintenance (O&M) Plan should include tables that summarize the O&M schedule and allow for consistent recording of actions and data. Detailed operational instructions, training plans, and manufacturer equipment manuals should be included as appendices to shorten and enhance usability of the main document. Ensure plans meet the regulator requirements. Attach outcomes of commissioning and, if used, validation testing to the Plan. For further information on operating plans, refer to Chapter 5 of Pecson and Post, "Onsite Non-Potable Water System Guidance Manual." The Water Research Foundation, 2020.

Use the following checklist when writing the Operation and Maintenance Plan, include at minimum:

☐ Description of the system.
☐ Objectives of the system.
☐ Identify and implement source control/protection measures.
☐ Storage and flow equalization summary, if appropriate.
☐ System flow chart with summary of treatment processes, controls, and monitoring points. May include treatment objectives and description of redundancy.
☐ Operational parameters for treatment process steps and equipment, including raw water requirements, flow limits, and other factors related to the original validation envelope.
☐ Equipment component summary list, which may be included in flow chart for smaller, simpler systems. May include probable or planned replacement intervals.
☐ Spare parts inventory, if appropriate. Supplier contact information if needed.
☐ Regulatory and other oversight requirements related to system operation and monitoring.
☐ Monitoring Plan, including verification and compliance monitoring and required outcomes to meet design performance objectives (unless the monitoring plan is included in system objectives and maintenance and monitoring schedule, which is typical for smaller, simpler, systems).
☐ Operation Manual for the system, with a compendium of equipment manuals as appendix. Include start-up and shut-down procedures, any calibration or other equipment adjustment procedures. Procedures/requirements for testing of any cross-connection provisions.
☐ Schedule for regular maintenance and monitoring, including prescribed maintenance tasks as established by the designer or the manufacturer, verification monitoring, and, if appropriate, compliance monitoring.
☐ Monitoring reporting and actions (summarized from the Monitoring Plan for larger systems).
☐ Alarm response plan(s) and diversion methods as appropriate.
☐ Emergency procedures and, if appropriate, contingency plan.
☐ Safety related guidance for system and system consumables.
☐ Troubleshooting guide, if needed.
☐ Contact information and emergency contact information for the Responsible Management Entity, the designer, installer, service provider(s), equipment suppliers, regulator or other oversight provider, and the electrician, plumber and or mechanical contractor (updated annually).
☐ Procedure for regular review of the O&M Plan by the responsible professional, the RME and the regulator (if appropriate). Include triggers for review (e.g., process issues).
☐ Sign-off by owner and RME, confirming they have received and understood the plan requirements.

5.3 Commissioning Plan checklist

Attach a copy of the draft Operation and Maintenance and Monitoring Plans to the Commissioning Plan. Note that for some systems commissioning may take place over a period of weeks or even months, normally under the oversight of a professional. The commissioning report records the outcomes of commissioning, including measurements, settings, calibrations, etc., and is attached to the Operation and Maintenance Plan.

Use the following checklist together with regulatory standard requirements when writing the commissioning plan, include at minimum:

☐ Description of the system, summarized from Operation and Maintenance Plan draft.
☐ Expected or required surrogate verification monitoring outcomes and compliance monitoring outcomes, relating to design performance objectives and regulatory requirements.
☐ For the installed equipment, operational parameters used in validation testing to inform operational performance checks (ensure within validation envelope).
☐ System flow chart with summary of unit treatment processes, controls and monitoring points. Sourced from the Operation and Maintenance Plan draft.
☐ Procedures for equipment calibration, start-up and functional testing, including recording of initial verification (surrogate) monitoring and any performance testing.
☐ Procedures for testing back-up systems, including electrical back-up, redundant treatment processes, make-up water supply.
☐ Procedures and requirements for testing of any cross-connection provisions.
☐ If validation forms part of commissioning, a Validation Plan pre-approved by the regulator or other overseer (e.g., professional providing oversight) for the entire process or relevant unit process.
☐ Schedule for commissioning, including start-up, any time period needed for testing or evaluation prior to system being put into service, sequence of performance testing, and scheduling dependencies.
☐ Templates to record results of functional testing, initial verification monitoring, and performance testing. Organized to match the draft Operation and Maintenance Plan schedules. Where necessary, include confirmation that the systems are operating within equipment validation parameters.
☐ Templates to record electrical, sensor, and control system testing, calibration, and as-commissioned settings.
☐ Checklist or template forms to ensure all testing is completed and to simplify feedback to designer for any alterations needed.
☐ Procedure for safe discharge of water during commissioning, and where necessary, for adequate supply of source water with characteristics that match the raw water requirements for the design.
☐ Safety considerations for system and consumables, from draft Operation and Maintenance Plan with special considerations for commissioning.
☐ Training manual, matched to system requirements and operator/service provider capacity.

5.4 Monitoring Plan checklist

Attach the Monitoring Plan to the Operation and Maintenance Plan. For small, simple systems the Monitoring Plan may simply form part of the Operation and Maintenance Plan. The Monitoring Plan should be reviewed by the authority having jurisdiction (regulator) or by the professional who will be providing oversight.

Use the following checklist together with the regulator's requirements when writing the Monitoring Plan, include at minimum:

☐ Objectives (goals) of the Monitoring Plan, e.g.: to outline procedures for monitoring, reporting, providing information to the responsible management entity, and to provide data to inform design adaptation or process adaptation.
☐ Description of the system, summarized from the Operation and Maintenance Plan, including a flow chart with monitoring points. If necessary, a system drawing with monitoring points shown.
☐ Reference to reports, drawings, and original design rationale with performance objectives.
☐ Performance and surrogate objectives for the system and system components, including regulatory or permit requirements.
☐ Raw water requirements or process-step raw water requirements and surrogate objectives.
☐ Scope of verification and compliance monitoring.
☐ Continuous verification monitoring points and methods.
☐ Procedures and schedule for intermittent compliance monitoring, with sample collection, transport, and lab analysis methods meeting regulatory or provincial standards.
☐ Identification of any verification monitoring parameters that are to be reported as part of compliance monitoring.
☐ Calibration and testing methods for monitoring instruments, as necessary.
☐ Reporting forms and procedures.
☐ Procedure for regular review of the Plan by the responsible professional and regulator (if appropriate). May include triggers for review (e.g., process issues).

6. Water balance model data sources and notes

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 2 – Fit-for-purpose, Water quantity: finalizing the water balance model**

Table 4 provides additional information on aspects to be considered, sources of information, and typical data requirements for the development of a water balance model, organized by water source.

Table 4. Additional information and data sources to support water balance modeling

SOURCE WATER	INFORMATION NEEDED	DATA SOURCES AND NOTES

Rainwater	• Precipitation information
	  • Daily, weekly, or monthly averages
	  • Intensity Duration Frequency (IDF) data
	• Collection surface area
	  • Size of surfaces
	  • Size of adjacent walls
	• Collection efficiencies
	  • Roof material collection coefficient
	  • Pre-filter efficiency at anticipated flow and velocity
	• Seasonal airshed
	  • Determines if seasonal bypass is incorporated into design
		Precipitation:
		• Environment Canada
		• Pacific Climate Impacts Consortium
		• Climate BC
		Intensity/Duration/Frequency:
		• BC Building Code Division B, Appendix C: Climate and Seismic Information for Building Design in BC
		Coefficients:
		• Rainwater Harvest System Planning; Texas Agrilife Extension (2010); Table 7.2
		• Rainwater Harvesting Manual 1st Ed.; ARCSA (2015); Table 4.5

Greywater	• Generation volumes
	  • Types of fixtures and flow rates
	  • Number of users
	  • Number of uses/day/user/fixture
	  • Data from flow meters or other
	• Patterns of generation
	  • Peak periods
	  • Low-use periods
		Source:
		• Manufacturers specs
		• BC SPM and MCTGP
		• COTRA Guidance document
		• Data collection

SOURCE WATER	INFORMATION NEEDED	DATA SOURCES AND NOTES
Stormwater	● Precipitation information • Weekly or monthly averages • IDF data ● Collection surface area • Size of surfaces ● Collection efficiencies • Soil/surface runoff coefficient • Pre-filter efficiency at anticipated flow and velocity	Precipitation: ● Environment Canada ● Pacific Climate Impacts Consortium ● Climate BC Intensity/Duration/Frequency: ● Environment Canada ● BC Building Code Division B, Appendix C: Climate and Seismic Information for Building Design in BC Stormwater Calculators: ● BC Water Balance Tools (irrigation, Infrastructure, soil info finding tool, agriculture)
Clear water	● Manufacturer's specifications ● Volume produced (seasonal fluctuations and regional differences)	Clear water covers many sources, so rationale for the choice of estimated available quantity and seasonal availability needs to be clearly expressed.
Drainage water	● Site observation and testing ● Modeling results ● Historical data if available ● Aquifer data if appropriate	Drainage water yield and flow pattern is influenced by precipitation, surface water flows, water table, and soil or shallow aquifer characteristics. Site evaluation can include: ● Hydraulic conductivity tests ● Water table monitoring ● Yield tests ● Datalogging flows in drainage pipes and interceptors Drainage modelling or shallow groundwater modelling is then based on site information together with rainfall and runon (water from offsite) input data.
Toilet Flushing	● Flow volumes • Number of uses/fixture/day • Fixture flow rate or volume/use • Flush counters • Flow meter ● Usage patterns • Average • Peak and low period usage	● Manufacturer's specifications ● BC SPM and MCTGP ● COTRA Guidance document ● Literature review ● Data collection

SOURCE WATER	INFORMATION NEEDED	DATA SOURCES AND NOTES
Laundry	● Volume/load ● Loads/day ● Usage patterns (average, daily, peak)	● Manufacturer's specifications ● BC MCTGP ● COTRA Guidance document ● Literature review ● Data collection

Irrigation	● Precipitation information
	  ● Daily/Weekly averages
	  ● Effective Precipitation (EP) for region
	● Climatic information
	  ● Evapotranspiration
	● Soil type and characteristics
	● Vegetation type
	● Irrigation method efficiency
		● BC Agricultural Water Calculator
		● BC Landscape Water Calculator
		● BC Agricultural Scheduling Calculator
		● Data from Climate BC, FARMWEST, Environment Canada
		● Site and soil evaluation
		● Modelling by irrigation professional

Cooling/ Heating	● Manufacturer's specifications ● Seasonal demands	Consult mechanical engineer.
Water Features	● Evaporation for site ● Measured data	Consult with landscape architects, designer/Installer, equipment suppliers. ● Data from Climate BC, FARMWEST, Environment Canada

Onsite Water Reuse Calculators:

- Austin Texas Water Reuse Calculator is a downloadable Excel spreadsheet that provides a comprehensive evaluation of indoor and outdoor demand of potable and non-potable water (e.g., toilet, urinal, process water, car wash, laundry), the potential source supply (rain, stormwater, HVAC, greywater, regional supply) and provides a monthly summary of potable and non-potable demands and onsite alternative water sources to meet the demands. https://www.austintexas.gov/sites/default/files/files/Water/AW_Water_Balance_Calculator_v1.xls

Examples of regionally appropriate tools include those provided at waterbalance.ca that can be used as a screening or initial assessment, linked below. There are many others available online, and many professionals will develop their own spreadsheet-based assessment tools.

- Water Balance Model Desktop/Online (https://waterbalance.ca/tool/water-balance-desktop/)
- Water Balance Express (https://waterbalance.ca/tool/water-balance-express/)
- Drainage Infrastructure Screening Tool (https://waterbalance.ca/tool/drainage-infrastructure-screening/)

7. Introduction to acceptable level of risk

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 2 – Designing with a risk management approach, Assess human health risk**
- **Section 2 – Identify control measures**

7.1 Assess human health risk

The essential first step for a risk management approach is to establish the acceptable level of risk to human health from the non-potable water system. It is important to recognize that risk is unlikely to be reduced to zero, and to understand that acceptance of a suitable level of risk is necessary in order to manage system costs, complexity of system management, and to support sustainability goals.

Risk determination is made separately for potable use, non-potable use, and for voluntary and involuntary exposure in each case. The acceptable level of risk is normally provided in (or may be interpreted from) the regulator's regulation or policy. Alternatively, the system designer, sometimes in consultation with the regulator, may identify acceptable risk on a project-specific basis. A good starting point is to refer to the World Health Organization's maximum tolerable risk levels and the US Environmental Protection Agency's recommended risk levels for non-potable water (USEPA, 2005; WHO, 2006).

Acceptable risk levels are normally described in regulatory standards or government policies but can be developed on a project-specific basis. Acceptable risk levels are expressed as either:

- The Disability Adjusted Life Year (DALY), which is the sum of years of life lost and years lived with disability, weighted for the severity of disability, per person per year (ppy); or

- The tolerable risk of infection or illness risk per ppy. This may be for a specific reference pathogen based on the tolerable additional DALY, or may be simplified to an overall acceptable additional risk of enteric illness for all classes of enteric pathogens under consideration.

Risk from voluntary versus non-voluntary exposure is commonly differentiated and may be expressed, for example, as acceptable risk for potable use (involuntary) versus for recreational water exposure (voluntary). Essentially, voluntary exposure means that the user knows the water is non-potable and chooses to use or expose themselves to it, while involuntary exposure means the user is unaware that the water they have been exposed to is of non-potable quality.

The WHO adopted the DALY (maximum tolerable additional DALY of 10^{-6} and 10^{-4} ppy) which equates approximately to additional infection risk of 10^{-3} ppy for Cryptosporidium, 7.2×10^{-4} ppy for Campylobacter, and 10^{-4} ppy for Rotavirus.

The USEPA has developed recommended risk levels for non-potable water, which can be simplified to 10^{-4} involuntary and 10^{-2} voluntary maximum tolerable additional risk of enteric infection per ppy. The tabular values of Section 8 are based on these simplified risk values.

These recommended risk levels are likely to change with time for both potable and non-potable water (Sinclair, O'Toole, Gibney & Leder, 2015). The current state of understanding is that they may be excessively conservative for non-potable uses and so may be changed to reflect a more realistic risk level over time. The scientific basis for the objectives also changes with time, for example to reflect the understanding of long-term impacts of certain gastrointestinal illnesses or to reflect the results of a vaccination program that reduces risk related to a commonly used reference pathogen.

For a custom design, the designer may alternatively use the WHO adopted DALY values, with a maximum tolerable additional DALY of 10^{-6} ppy for potable water consumption, which has also been used widely for non-potable purposes, especially in relation to involuntary exposure. These equate approximately to additional infection risk of 10^{-3} ppy for Cryptosporidium, 7.2×10^{-4} ppy for Campylobacter, and 10^{-4} ppy for Rotavirus (Schoen et. al., 2017)]. The designer may also use a custom DALY level considered appropriate to the project setting.

Note that the WHO DALY objectives were utilized in the BC Manual of Composting Toilet and Greywater Practice and in the Health Canada toilet flushing guideline. More detailed analysis of appropriate risk levels may be suitable in cases where a greater level of effort is expected to result in a more economical or more sustainable system. This may require the designer undertaking new QMRA studies, where no literature is available with pre-prepared QMRA, to establish reduction targets related to differing objectives, differing sources and uses, etc.

7.2 Quantifying risk

Risk is quantified using QMRA, as described in the guidebook. A number of factors are considered to characterize the risk level using QMRA:

- **Hazard identification:** The parameters associated with a particular pathogen under consideration.
- **Exposure assessment:**
    - Expected concentration of the pathogen in the water at time of contact or ingestion, and probability that the pathogen may be present in the water over time.

        - How much exposure individuals have to the water and what type of exposure (e.g., aerosol, ingestion, skin contact). Exposure may be from the end use (e.g., from contact with water in a swimming pool), from incidental contact with the water (e.g., from an aerosol formed when flushing a toilet), or from accidental contact (e.g., through cross connection).

- **Dose-response:** The risk of a response (e.g., infection, illness, death, disability) in relation to the dose of pathogen received. This depends on the dose plus the infectivity of a particular pathogen and impact of disease on health in the short and long term.

- **Population:**

    - How many individuals are exposed to the water and how often (e.g., average 100 persons per day)?

    - Who are the users? Different segments of the population will have different susceptibility to infection (e.g., seniors care facility vs. commercial building).

References Section 7

Schoen, M.E., Ashbolt, N.J., Jahne, M.A., & Garland, J. (2017). Risk-based enteric pathogen reduction targets for non-potable and direct potable use of roof runoff, stormwater, and greywater. Microbial Risk Analysis, vol. 5, pp. 32–43.

Sinclair, M., O'Toole, J., Gibney, K., & Leder, K. (2015). Evolution of regulatory targets for drinking water quality. *Journal of Water and Health*, vol. 13, no. 2, pp. 413–426, doi: 10.2166/wh.2014.242.

USEPA, S. (2005). *Occurrence and exposure assessment for the final long term 2 enhanced surface water treatment rule*. EPA 815-R-06-002. United States Environmental Protection Agency, Office of Water, Washington, DC.

World Health Organization. (2006). *Guidelines for the Safe Use of Wastewater, Excreta and Greywater*; WHO: Geneva, Switzerland.

8. Typical log reduction targets (LRT) by end use

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 2 – Risk management, Select system performance objectives**

The guidebook focuses primarily on risk to human health from pathogens in water. See Section 2 (Fit-for purpose) for a table of typical source water concerns. In addition to pathogen risk, an important part of fit-for-purpose evaluation is to identify any contaminants in the source water (or disinfection products) that would impact usability. Consider these examples:

- Greywater is expected to contain significant levels of complex organic compounds, such as personal care products, and these compounds may be metabolic disruptors. Therefore, even where subsurface irrigation is used, greywater may not be considered suitable for irrigation of soft-stemmed vegetables or fruit that will be consumed by humans.

- In some cases, stormwater or drainage water may be contaminated with toxic chemicals, such as heavy metals, organo-metal compounds, polychlorinated biphenyls, or hydrocarbons. If the designer considers this to be a risk for the particular site, then more extensive testing of the source water should be carried out prior to system design.

Based on the outcome of QMRA analysis for particular sources, uses, and system scales, the designer will select the reduction levels needed to meet the risk of infection objectives. The QMRA process for development of LRT is applied to reference pathogens, typically enteric viruses, enteric bacteria, and parasitic protozoa in the case of water systems. Each of the three categories' reference pathogens will have differing tolerable additional infection risk, but for simplicity we follow Schoen et al. (2017) in selecting the most conservative infection risk limits for all categories. Some water sources may be unlikely to pose significant risk from one category (e.g., roof runoff is likely to have insignificant virus risk).

Table 5 provides LRT values based on risk analysis and QMRA developed by Schoen et al. (2017), as presented in Sharvelle et al. (2017) and in Alberta Health Services (2021), together with values found in the CSA B805-18 standard. These analyses were based on meeting the USEPA acceptable risk levels. These tables are provided for guidance only. It is recommended that, prior to utilizing the tabular values, a designer read the referenced research papers and develop an understanding of the basis of the values. It is likely that ongoing research will lead to refinement of these values.

Given the simplified approach, it is likely that in some cases system design may be more conservative than necessary. However, for simple systems the simplification of the design, treatment process selection, and implementation process is likely to offset any negative impact of conservative assumptions.

These LRTs are intended to result in the additional probability of infection meeting the EPA recommended objectives for 95% of years for the given input assumptions, and are properly stated as "LRT_{95}". The values are rounded to the nearest 0.5 Log_{10}. The objective values are considered to be highly conservative. Reference pathogens used in QMRA were reported to be *Norovirus* (viruses), *Campylobacter jejuni* (bacteria), and *Giardia lamblia* (protozoa).

It is important to note that these health outcomes are for typical source water. Source water quality may vary widely, and data on source water is limited, particularly for roof runoff. In some cases, the designer may need to undertake in situ testing of source water in order to determine appropriate LRTs.

The LRTs are suitable only for typical users of the systems, and do not apply to those with increased exposure (e.g., maintenance workers) or to those with increased susceptibility (e.g., immunocompromised individuals) where dose-response relationships are not available.

Table 5. Typical log reduction targets by source and end use

SOURCE WATER AND PROPOSED USE	INFECTION RISK TARGET (PPY)	ENTERIC VIRUSES	ENTERIC BACTERIA	PARASITIC PROTOZOA
Municipal Wastewater or Blackwater				
Indoor use (cross-connection risk)	1×10^{-4}	8.5	6	7
Indoor use, HVAC cooling	1×10^{-2}	4.5	4.5	4
Indoor use, clothes washing	1×10^{-4}	4.5	4.5	3.5
Indoor use, toilet flushing	1×10^{-4}	5.5	5.5	5
Indoor water features	1×10^{-4}	6	5.5	5
Outdoor recreational or water-feature use	1×10^{-2}	4	3.5	3
Vehicle washing	1×10^{-4}	5.5	5.5	4.5
Dust control, street cleaning (night)	1×10^{-2}	3.5	3.5	2.5
Agri-food irrigation, all	1×10^{-4}	7	7	6.5
Non agri-food irrigation, spray, restricted	1×10^{-2}	3.5	3.5	2.5
Non agri-food irrigation, spray, unrestricted	1×10^{-2}	6	4	5
Non agri-food irrigation, subsurface or drip	1×10^{-2}	3.5	3.5	2.5
Greywater (community or multi-unit building)				
Indoor use (cross connection risk)	1×10^{-4}	6	3.5	4.5
Indoor use, HVAC cooling	1×10^{-2}	4	2	2
Indoor use, clothes washing	1×10^{-4}	4	2	2
Indoor use, toilet flushing	1×10^{-4}	5	3.5	3
Indoor water features	1×10^{-4}	5	3	3

SOURCE WATER AND PROPOSED USE	INFECTION RISK TARGET (PPY)	ENTERIC VIRUSES	ENTERIC BACTERIA	PARASITIC PROTOZOA
Outdoor recreational or water-feature use	1 x 10^{-2}	3	1	1
Vehicle washing	1 x 10^{-4}	5	3	2.5
Dust control, street cleaning (night)	1 x 10^{-2}	3	0.5	0.5
Agri-food irrigation, all	1 x 10^{-4}	6.5	4.5	4.5
Non agri-food irrigation, spray, restricted	1 x 10^{-2}	3	0.5	0.5
Non agri-food irrigation, spray, unrestricted	1 x 10^{-2}	3.5	1.5	2.5
Non agri-food irrigation, subsurface or drip	1 x 10^{-2}	3	0.5	0.5
Stormwater, relief, and foundation drainage water (10^{-1} Dilution)				
Indoor use (cross-connection risk)	1 x 10^{-4}	5.5	5	5.5
Indoor use, HVAC cooling	1 x 10^{-2}	3.5	3.5	3
Indoor use, clothes washing	1 x 10^{-4}	3.5	3.5	2
Indoor use, toilet flushing	1 x 10^{-4}	4	4.5	4
Indoor water features	1 x 10^{-4}	5	4.5	4
Outdoor recreational or water-feature use	1 x 10^{-2}	3	2.5	2
Vehicle washing	1 x 10^{-4}	4.5	4.5	3
Dust control, street cleaning (night)	1 x 10^{-2}	2.5	2.5	1.5
Agri-food irrigation, all	1 x 10^{-4}	6	6	5.5
Non agri-food irrigation, spray, restricted	1 x 10^{-2}	2.5	2.5	1.5
Non agri-food irrigation, spray, unrestricted	1 x 10^{-2}	3	2	2.5
Non agri-food irrigation, subsurface or drip	1 x 10^{-2}	3	0.5	0.5
Stormwater, relief, and foundation drainage water (10^{-3} Dilution)				
Indoor use (cross-connection risk)	1 x 10^{-4}	3.5	3	3.5
Indoor use, HVAC cooling	1 x 10^{-2}	1.5	1.5	1
Indoor use, clothes washing	1 x 10^{-4}	1.5	1.5	0.5
Indoor use, toilet flushing	1 x 10^{-4}	2.5	2.5	2
Indoor water features	1 x 10^{-4}	2.5	2.5	2
Outdoor recreational or water-feature use	1 x 10^{-2}	0.5	0.5	0
Vehicle washing	1 x 10^{-4}	2.5	2.5	1.5
Dust control, street cleaning (night)	1 x 10^{-2}	0.5	0.5	0

SOURCE WATER AND PROPOSED USE	INFECTION RISK TARGET (PPY)	ENTERIC VIRUSES	ENTERIC BACTERIA	PARASITIC PROTOZOA
Agri-food irrigation, all	1 x 10^{-4}	4	4	3.5
Non agri-food irrigation, spray, restricted	1 x 10^{-2}	0.5	0.5	0
Non agri-food irrigation, spray, unrestricted	1 x 10^{-2}	1	0	0.5
Non agri-food irrigation, subsurface or drip	1 x 10^{-2}	0.5	0.5	0
Roof runoff water OR condensate				
Indoor use (cross-connection risk)	1 x 10^{-4}	NA	3.5	ND
Indoor use, HVAC cooling	1 x 10^{-2}	NA	2	ND
Indoor use, clothes washing	1 x 10^{-4}	NA	2	ND
Indoor use, toilet flushing	1 x 10^{-4}	NA	3	ND
Indoor water features	1 x 10^{-4}	NA	3	ND
Outdoor recreational or water-feature use	1 x 10^{-2}	NA	1	ND
Vehicle washing	1 x 10^{-4}	NA	3	ND
Dust control, street cleaning (night)	1 x 10^{-2}	NA	1	ND
Agri-food irrigation, all	1 x 10^{-4}	NA	4.5	ND
Non agri-food irrigation, spray, restricted	1 x 10^{-2}	NA	1	ND
Non agri-food irrigation, spray, unrestricted	1 x 10^{-2}	NA	1.5	ND
Non agri-food irrigation, subsurface or drip	1 x 10^{-2}	NA	1	ND

Notes to table:

- **Cross-connection risk is not included and must be addressed through specific management steps.** The tabular values are based on adequate control measures being in place to manage cross-connection risk.
- Risk from growth of opportunistic pathogens post treatment is managed by control measures related to the storage and distribution system, and is not addressed by these tables.
- NA indicates not applicable – for example, virus risk from roof runoff water or condensate is expected to be negligible.
- ND indicates no data – for example, while some risk from cryptosporidium has been identified from bird feces in roof runoff, the source reports indicate that data was not adequate for risk analysis.

- As this guideline is targeted at multi-family, commercial, or mixed-use buildings, single-family greywater system LRT values were not included.
- Agri-food irrigation risk may be partially managed by food processing steps.
- Stormwater is considered to be contaminated with sewage. Two dilution values were assessed based on the level of contamination expected and spanning the typical expected range of contamination in an urban setting. Low dilution, with 10% contribution from sewage (10^{-1} dilution), is recommended for preliminary assessment. Moderate dilution, 1% contribution from sewage (10^{-3} dilution), is suitable for special cases or where the source has been evaluated for human fecal contamination to confirm the higher dilution. See Alberta Health Services (2021) for guidance on assessment.
- Foundation and relief drain water QMRA is not available for typical uses. This water is best assessed as stormwater at 10^{-1} or 10^{-3} dilution (as appropriate based onsite specific assessment).

References Section 8

Alberta Health Services. (2021). Public health guidelines for water reuse and stormwater use. Government of Alberta. Available at: https://open.alberta.ca/dataset/6a57d29c-d437-4dd9-94e3-d96bedc01bb4/resource/d533afcb-2933-43da-9199-eea030148c00/download/health-public-health-guidelines-water-reuse-stormwater-use-2021.pdf.

CSA. (2018). CSA B805-18/ICC 805-2018, Rainwater Harvesting Systems.

Schoen, M.E., Ashbolt, N.J., Jahne, M.A., & Garland, J. (2017). Risk-based enteric pathogen reduction targets for non-potable and direct potable use of roof runoff, stormwater, and greywater. Microbial Risk Analysis, vol. 5, pp. 32–43.

Schoen, M.E., Jahne, M.A., & Garland, J. (2020) A risk-based evaluation of onsite, non-potable reuse systems developed in compliance with conventional water quality measures. *J Water Health* 18 (3): 331–344. doi: https://doi.org/10.2166/wh.2020.221.

Sharvelle, S., Ashbolt, N., Clerico, E., Holquist, R. Levernz, H., & Olivieri, A. (2017). Risk-Based Framework for the Development of Public Health Guidance for Decentralized Non-Potable Water Systems. Proceedings of the Water Environment Federation, vol. 8, pp. 3799-3809.

9. Common process controls and treatment systems

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 2 – Risk management, Identify control measures**

Table 6 provides a brief overview of the common types of process controls and treatment systems. A resource list is also provided for additional information.

Table 6. Common types of process controls and treatment systems

NATURAL/PHYSICAL & BIOLOGICAL PROCESSES	Natural and biological treatment processes rely on one or more processes to reduce pathogens and enhance physical water quality aspects. Processes include retention time, biological digestion of organic matter, biological competition, predation, die-off, pH adjustment, settling or flotation, and solar radiation. Some processes will include adsorption and/or uptake of contaminants.
	• Primary settling, screening, or filtration • Flotation or flocculation • Upflow anaerobic sludge blanket/filter or other anaerobic digestion • Packed filter bed • Trickling filter • Aerobic suspended or attached growth reactor, including activated sludge and membrane bioreactor systems • Retention (ponds/lagoons) and wetlands (vertical, horizontal, and hybrid)
FILTRATION PROCESSES	Filtration processes rely primarily on exclusion of particles of set sizes, though can also include biological digestion of retained sludge, biological competition, predation or die-off, absorption or adsorption, and ion exchange
	• Primary screening or filtration as part of primary settlement • Flotation or flocculation • Slow sand filter • Media filters • Diatomaceous earth filter • Micro/Ultra/Nano filtration (membrane filtration may form part of an aerobic reactor) • Reverse osmosis • Rapid sand

DISINFECTION PROCESSES	Disinfection processes can include the use of chemicals or radiation to neutralize pathogens. Oxidation works on proteins and cells and effectively “burns” their structures to neutralize/destroy them and may also treat some chemical contaminants. Ultraviolet (UV) radiation penetrates the cell wall and disrupts cell reproduction. Disinfection processes may result in chemical by-products.
	• Ozone • Peracetic acid • Hydrogen peroxide • Chlorination, including Chlorine, Chloramine, and Chlorine Dioxide • Advanced Oxidation (typically combining UV with an oxidation process) • Ultraviolet light

Additional resources

BC Ministry of Health (2020). Guidance for Treatment of Rainwater Harvested for Potable Use in British Columbia.

BC Ministry of Health (2022). Guidelines for Pathogen Log Reduction Credit Assignment, Part B, p. 67.

BC Ministry of Health (2022). Guidelines for Ultraviolet Disinfection of Drinking Water.

State of Washington Department of Ecology. (Accessed 2022). Emerging Stormwater Treatment Technologies. https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies. It is a database continuously reviewed and updated by Washington State Technology Assessment Protocol-Ecology (TAPE), providing a listing of state approved technologies for stormwater.

US EPA. (2006). Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, p. 436.

US EPA. Drinking Water Treatability Database. https://tdb.epa.gov/tdb/home. It is a tool that allows search for treatment technologies suitable for the pollutant of concern. It provides information on over 30 treatment processes for over 120 contaminants.

US EPA. Industrial Wastewater Treatment Technology Database. https://www.epa.gov/septic/wastewater-technology-fact-sheets. Provides a tool to search for technologies suitable to industrial activities, and filtered by treatment technology, pollutant or industry.

US EPA. “2017 Potable Reuse Compendium,” 2017, 203. https://www.epa.gov/sites/default/files/2018-01/documents/potablereusecompendium_3.pdf.

US EPA. “Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management,” 2013, https://www.epa.gov/sites/default/files/2019-02/documents/emerging-tech-wastewater-treatment-management.pdf.

US EPA. Wastewater Technology Fact Sheets.

10. Typical log reduction values (LRVs)

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 2 – Risk management, Identify control measures**

10.1 Log reduction values and assignment of credits

Where risk of infection posed by a particular use of a specific source is higher than the acceptable level established by regulation, policy, or on a project-specific basis, the treatment and other controls need to be adjusted such that the credits for pathogen reduction result in acceptable risk. This is carried out in an iterative process, matching Log Reduction Values (LRVs) to the required Log Reduction Target (LRT), until acceptable risk management is achieved. Note that LRV credits are also termed “log reduction credits.” See the BC Ministry of Health *Guidelines for Pathogen Log Reduction Credit Assignment* (MoH Guidelines).

The reduction of reference pathogen levels by control measures are specified as LRV, the Log_{10} reduction in the reference pathogen expected for a particular step in the treatment train (or other barrier), and a total LRV is calculated for the entire process from source to use (or source to exposure).

A limit may be placed on the LRV credits allocated to any one step of the overall treatment train and multi-barrier risk management strategy. This approach is recommended to avoid overreliance on any one barrier within a risk management strategy.

LRVs may be assigned based on literature values, standards and guidelines, third-party testing (with consideration of installed system performance), validation testing or pilot scale testing, or probabilistic assessment of treatment train performance (PATTP) and reliability. In all cases the designer must consider how LRVs will be validated.

Table 7 provides preliminary guidance for scoping and design based on values from literature and guidelines for typical control measures and processes. These tabular values may be suitable for direct use in the case of small, simple systems using well-established and pre-validated technology; but in all cases LRVs should be considered on a project-specific basis by the designer. This should include risk of performance malfunctions (reliability of processes or control measures) and mitigation strategies to address these risks (e.g., diversion of out of specification water, redundancy, caps on LRV credits, analysis of performance for other steps in case of malfunction of one step).

For more detailed analysis, it is recommended that the designer look at probabilistic risk and probabilistic assessment of treatment train performance and reliability in a linked process. For further information refer to Pecson et al. (2021), Sharvelle et al. (2017) and Regulating Direct Potable Reuse in California | California State Water Resources Control Board.

Table 7. Preliminary log reduction values for non-process control measures, based on literature

CONTROL MEASURE	REDUCTION IN PATHOGEN EXPOSURE
Controlling methods of application and application rates	
Drip irrigation of crops	2 log
Drip irrigation of crops with limited to no ground contact (e.g., tomatoes, capsicums)	3 log
Drip irrigation of raised crops with no ground contact (e.g., apples, apricots, grapes)	5 log
Subsurface irrigation of above-ground crops	4 log
Spray drift control (micro-sprinklers, anemometer systems, inward-throwing sprinklers, etc.)	1 log
Drip irrigation of plants/shrubs	4 log
Subsurface irrigation of plants/shrubs or grassed areas	5 log
Setting withholding periods	
Withholding periods: agri-food irrigation	0.5 log/day
Withholding periods: non-agri-food irrigation	0.4 log/4 hours viruses
	0.7 log/4 hours bacteria
Controlling public access and application times	
No public access during irrigation	2 log
No public access during irrigation and limited contact after (non-grassed areas) (e.g., food crop irrigation)	3 log
Buffer zones (25–30m)	1 log
Drive-through vehicle wash	3 log

Non-process control measure LRVs are for all pathogen types unless specified. For withholding periods, protozoan parasite risk reduction requires desiccation. Control of public access typically includes fencing and signage.

LRV CREDITS FOR COMMON PROCESS CONTROL MEASURES

For preliminary design or for simple systems, conservative typical values for common processes in Tables 8 to 11 are taken from Sharvelle et al. (2017) and Alberta Health Services (2021). For Table 8 these references were used together with the MoH Guidelines for Pathogen Log Reduction Credit Assignment for drinking water systems.

Refer to the above-mentioned references for background information and criteria, including required monitoring and source or raw water requirements. Note that the MoH Guidelines are intended for potable water and therefore may include more conservative safety factors and/or ceiling values in some cases.

Alberta Health Services (2021) includes some summary information in their Appendix D and E on key factors that may impact the LRV for particular processes, on the type of monitoring needed and on reliability of processes.

The MoH Guidelines (2022) provide recommended maximum LRV credits for reduction of *Cryptosporidium*, *Giardia,* and viruses for some treatment processes (for drinking water systems), affording guidance to issuing officials at Health Authorities. The MoH Guidelines also include information on factors that impact performance and raw water requirements and on surrogates for monitoring together with minimum monitoring requirements. Do not use these tabular values without reading and understanding the original sources, and do not apply them without also applying necessary raw water controls and performance verification monitoring. See Section 13 for typical surrogates for verification monitoring of system performance.

When assessing treatment performance, LRV_{50} values are recommended. Refer to Sharvelle et al. (2017) for a recommended assessment process, including probabilistic analysis. Refer to the MoH Guidelines for recommendations on validation, including third-party validation.

Table 8. Log reduction value credits for natural and biological treatment and filtration processes

CONTROL MEASURE	**EXAMPLE LRV AND RANGE**		
	VIRUS	BACTERIA	PROTOZOA
Primary settling/septic tank	0.8 (0.5 – 1)	0.5 (0.1 – 0.6)	0.5 (0.2 – 1)
Upflow anaerobic sludge blanket/anaerobic filter	0.8 (0.5 – 1)	0.5 (0.1 – 0.6)	0.5 (0.2 – 1)
Packed bed filter	1 (1 – 2)	1 (1 – 1.3)	2 (1 – 4)
Trickling filter	0.5 (0.3 – 1)	0.5 (0.2 – 1)	0.6 (0.4 – 1)
Suspended growth reactor/ activated sludge	0.5 (0.5 – 2)	1 (1 – 1.7)	0.5 (0.2 – 1)
Pond/lagoon	0.8 (0.5 – 1)	0.5 (0.1 – 0.6)	1 (0.7 – 2)
Treatment wetland	0.5 (0.2 – 1)	0.8 (0.5 – 1)	1.2 (1 – 2)
Slow sand filter	2 (2 – 3) 2*	2 (0.6 – 5)	4 (3.9 – 7.1) 3*

CONTROL MEASURE	EXAMPLE LRV AND RANGE		
	VIRUS	BACTERIA	PROTOZOA
Storage pond/reflection pool/water feature	1 (1 – 4)	1 (1 – 3.5)	1 (1 – 3.5)
Dual media filter with coagulant	1 (0.5 – 3)	1 (0.25 – 1)	2 (1.5 – 2.5)
Cartridge/bag filter (5 to 10 microns)	0	0	0
Cartridge/bag filter (3 microns or less)	0	0	3 (2.5 – >4)
Cartridge/bag filter (1-micron absolute)	0 0*	0	4 (2.5 – >4) 2, 2.5 for two in series*
Diatomaceous earth (DE) filter	1 (0.4 – 3) 1*	2 (0.1 – 3.3)	4 (3.5 – 7.7) 3*
Microfilter	1 (0 – >2) 0*	6 (3.5 – >6)	>6 (4 – >6) 4*
Ultrafilter	>6 (4 – >6) 0*	>6	>6 4*
Nanofilter	>6 0*	>6	>6 4*
Reverse osmosis	>6 0*	>6	>6 4*

* MoH values for potable water system maximum LRV credit (in relation to the MoH Guidelines LRT requirements). Note that the MoH Guidelines do not give credit to bag filters due to failure risks — see the MoH Guidelines for rationale. See MoH Guidelines for discussion of virus removal by membrane filtration. 4 Log_{10} is a ceiling for unit performance for all processes for drinking water treatment in the MoH Guidelines.

Table 9. LRV for common disinfection processes, for enteric viruses in filtered secondary effluent

DISINFECTION STEP	UNIT	DOSE FOR CORRESPONDING LOG$_{10}$ REDUCTION VALUE			
		1 Log$_{10}$	2 Log$_{10}$	3 Log$_{10}$	4 Log$_{10}$
Free chlorine	mg • min/L		1.5 – 1.8	2.2 – 2.6	3 – 3.5
Chloramine	mg • min/L		370 – 400	550 – 600	750 – 800
Peracetic acid	mg • min/L	NA	NA	NA	NA
Ozone	mg • min/L		0.25 – 0.3	0.35 – 0.45	0.5 – 0.6
Ultraviolet radiation	mJ/cm^2	50 – 60	90 – 110	140 – 150	180 – 200
Advanced oxidation[1]	mJ/cm^2	10 – 20	50 – 60	70 – 80	110 – 130
Pasteurization (60°C)	second	140	280	420	560

Table 10. LRV for common disinfection processes, for enteric bacteria in filtered secondary effluent

DISINFECTION STEP	UNIT	DOSE FOR CORRESPONDING LOG$_{10}$ REDUCTION VALUE			
		1 Log$_{10}$	2 Log$_{10}$	3 Log$_{10}$	4 Log$_{10}$
Free chlorine	mg • min/L	0.4 – 0.6	0.8 – 1.2	1.2 – 1.8	1.6 – 2.4
Chloramine	mg • min/L	50 – 70	95 – 150	140 – 220	200 – 300
Peracetic acid	mg • min/L	10 – 25	40 – 60	75 – 125	150 – 200
Ozone	mg • min/L	0.005 – 0.01	0.01 – 0.02	0.02 – 0.03	0.03 – 0.04
Ultraviolet radiation	mJ/cm^2	10 – 15	20 – 30	30 – 45	40 – 60
Advanced oxidation[1]	mJ/cm^2	4 – 6	6 – 8	8 – 10	10 – 12
Pasteurization (60°C)	second	50	100	150	200

Table 11. LRV for common disinfection processes, for parasitic protozoa in filtered secondary effluent

DISINFECTION STEP	UNIT	DOSE FOR CORRESPONDING LOG$_{10}$ REDUCTION VALUE			
		1 Log$_{10}$	2 Log$_{10}$	3 Log$_{10}$	4 Log$_{10}$
Free chlorine	mg • min/L	2000 – 2600	NA	NA	NA
Chloramine	mg • min/L	NA	NA	NA	NA
Peracetic acid	mg • min/L	NA	NA	NA	NA
Ozone	mg • min/L	4 – 4.5	8 – 8.5	12 – 13	NA
Ultraviolet radiation	mJ/cm^2	2 – 3	5 – 6	11 – 12	20 – 25
Advanced oxidation[1]	mJ/cm^2	2 – 3	5 – 6	10 – 12	20 – 25
Pasteurization (60°C)	second	30	60	90	120

Where treatment malfunctions are expected, management steps are needed to address this risk. This is not included in the guidance LRT values for treatment processes.

Overall treatment train performance may be assessed by adding LRV$_{50}$ values from these tables or other suitable literature sources.

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[1] “Advanced oxidation” includes a few combinations of two oxidation processes, either chemical or photochemical (i.e., UV/peroxide, UV/ozone, ozone/peroxide), and requires validation to determine the LRV. Examples shown are for UV combined with hydrogen peroxide with a dose rate of 10 mg/L hydrogen peroxide, for adenovirus. The values are for the UV part of the process step only.

10.2 Bacterial log reduction values

Crediting frameworks for assignment of bacterial LRV in relation to surrogates for performance or in relation to particular processes are not as strongly established as for protozoa and viruses. This is because, in the past, regulations and policy focused on grab-sample outcome testing of bacterial indicators because these are easily assayed. As design and monitoring of non-potable systems moves further toward risk management there will be a transition period during which it is likely that grab sampling (compliance monitoring) for bacterial indicators may still be required by the regulator alongside surrogate verification monitoring.

10.3 Probabilistic assessment of treatment performance

For more advanced design and for higher risk systems, a probabilistic approach that considers the range of performance values and the impact of reliability considerations may be warranted. Refer to Sharvelle et al. (2017) for discussion.

References Section 10

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11. Management category guidance

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 2 – Risk management, Defining system management**

11.1 Examples of methods to assign management category

The designer considers the combined risk factors for each paired source and end use proposed, and develops a rationale for assignment of a management category. Various approaches may be used, including a simple consideration of combined factors (only suitable for simple systems), a guided flow chart approach, or a weighted matrix.

These are illustrated by examples below. It is recommended that the designer use a consistent approach across projects in order to provide a rationale for selection. Discussion of assignment with the regulator may be helpful. See Sharvelle et al. (2017) for further discussion.

COMBINED FACTORS EXAMPLE

Table 12 provides examples of combined factors that may lead to selection of a particular management category. The factors considered include exposed population, risk characterization of the source/end use, pathogen risk, and process complexity/malfunction risk. Factors are likely to fall on a spectrum, and judgement is needed to determine the appropriate risk level when the factors are considered in combination (e.g., a moderate population served by a simple, reliable system with low LRT and low exposure may be considered low risk).

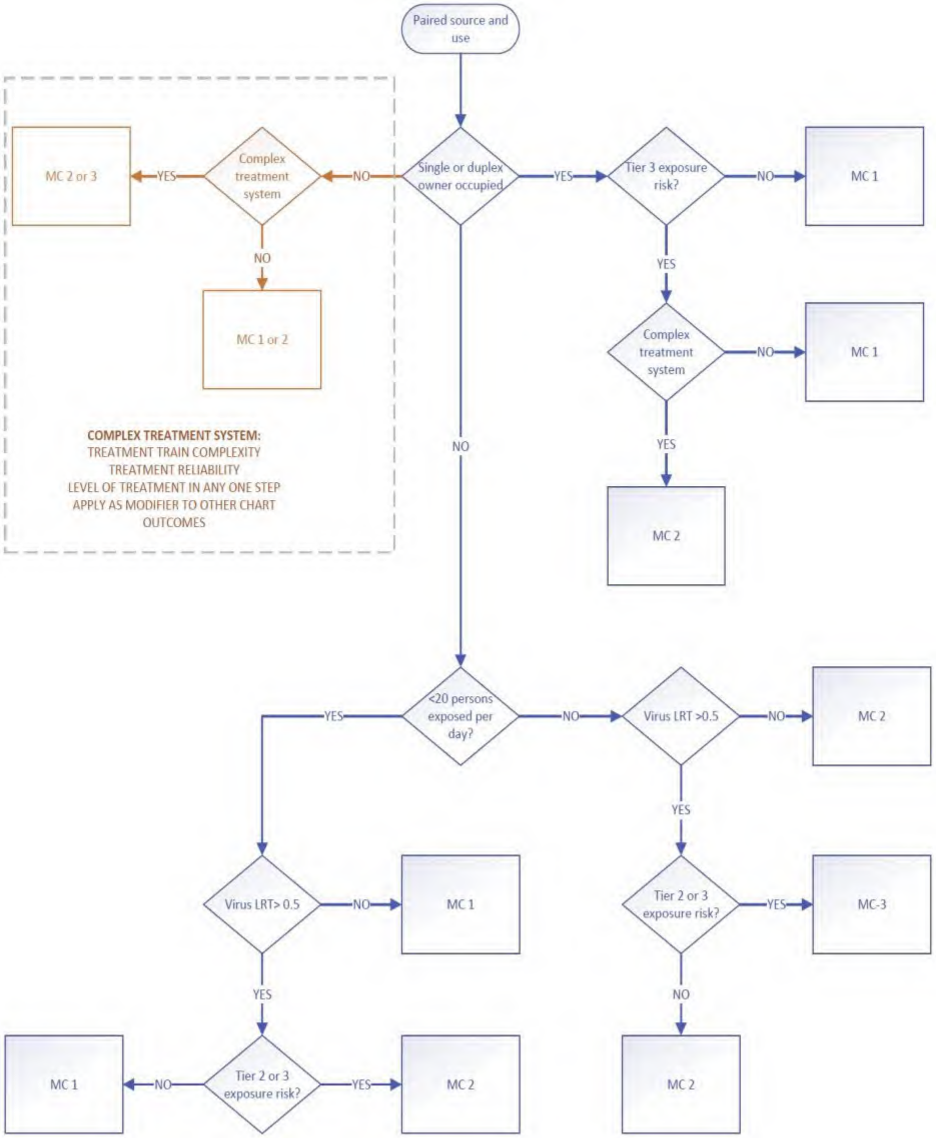
Table 12. Combined factors to consider in management category selection

MGMT CATEGORY	RISK LEVEL	EXAMPLE OF COMBINED FACTORS
1	Low	• Low population • Lower risk source • Lower exposure (e.g., Tier 1 or 2 end uses) • 10^{-2} ppy infection risk target • Low LRT (e.g., 3-0.5-0.5) • Simple, reliable treatment systems • Low LRT per unit process • Systems that can be maintained by uncertified or unskilled contractors or staff
2	Medium	• Moderate population • Lower risk source • Lower exposure (e.g., Tier 1, or 2 end uses) • 10^{-2} or 10^{-4} ppy infection risk target • Moderate LRT (e.g. 4-4-4) • Moderately complex, reliable treatment systems • Moderate LRT per unit process • Systems that require trained/certified contractors or staff
3	High	• Higher user population • Higher risk source • Higher exposure risk (e.g., Tier 3 end uses) • 10^{-4} ppy infection risk target • High LRT (e.g. 5.5-5.5-5) • Complex, less reliable treatment systems • High LRT per unit process • Systems that require trained/certified contractors or staff

FLOW CHART EXAMPLE

The flow chart on the right illustrates one potential decision tree used by a designer to assign a management category. The example considers population, source, and end use tier. The chart also considers treatment system complexity, reliability, and reliance on single-step pathogen attenuation as a modifier.

Example of Flow Chart for Selection of Management Category (MC)



WEIGHTED MATRIX EXAMPLE

A weighting matrix checklist is another approach to select a management category and to record rationale. Sharvelle et. al. (2017) provides further examples. The example on the right is a matrix which lists nine factors to be considered, with each factor having a series of simple options to choose from. The option chosen is then weighted (by the multiplier). Weighted scores are summed to arrive at a total score.

Scores:

Category 1	≤2;
Category 2	>2 ≤3;
Category 3	>3

	Risk Ranking	Weighted %	Weighted Score
Population Served 1-10 = 1 10-20=2 >20=3		15%	
End Use Tier (refer to Tier Table XXX to choose tier level) Tier 1=1 Tier 2=2 Tier 3=3		10%	
Water Source Roof runoff = 1 Condensate = 2 Ground/Drainage water (10-3) = 3 Storm/Grnd./Found. water (10-1) = 4 Greywater = 5		10%	
Treatment System Complexity - level of operations and maintenance (refer to Treatment System Complexity Matrix) Simple = 1 Medium = 2 Complex= 3		15%	
Technology validation requirements None = 1 Recommended=2 Required=3		15%	
Monitoring requirements None = 1 Recommended=2 Required=3		20%	
Estimated Log10 reduction target - Viruses (see LRT tables for water source & end use) LRT<2 = 1 LRT 2-4 = 2 LRT >4 = 3		5%	
Estimated Log10 reduction target - Protozoa (see LRT tables for water source & end use) LRT<2 = 1 LRT 2-3 = 2 LRT >3 = 3		5%	
Estimated Log10 reduction target - Bacteria (see LRT tables for water source & end use) LRT<2 = 1 LRT 2-3 = 2 LRT >3 = 3		5%	

SCORE

11.2 Treatment system complexity and reliability guidance

The reliability of treatment process steps and other control measures is an important consideration, and assignment of a management category can help to characterize the probability of risk from malfunction or failure. Complexity of treatment systems can also influence reliability and probable operational issues.

It is also important to consider impact of individual unit process malfunctions on the whole treatment train. As an example, a treatment train combining several complex steps in one proprietary unit may be very effective when operating as intended, but failure of one step may result in performance malfunction for the whole treatment train. Likewise, a typically reliable system may malfunction catastrophically if the responsible management entity does not obtain funding for system maintenance.

Table 13 shows levels of treatment system complexity and reliability for reference when selecting a management category. Factors to consider include: reliance on a single treatment step, total LRV for all treatment steps, risk of treatment malfunction, vulnerability of unit processes to malfunction, and level of skill and effort needed for operation, maintenance, and monitoring of system.

Table 13. Treatment system complexity and reliability characteristics

TREATMENT SYSTEM COMPLEXITY	TYPICAL CHARACTERISTICS OF TREATMENT SYSTEM OR UNIT PROCESS
Low	• Low LRV required from treatment system • Simple, reliable treatment systems • Low LRT per unit process • Treatment trains with unit processes that will function adequately even if upstream processes malfunction • Systems that can be maintained by uncertified or unskilled contractors or staff
Medium	• Moderate LRV required from treatment system • Moderately complex, reliable treatment systems • Moderate LRT per unit process • Treatment trains with some risk that unit processes may not function if upstream processes malfunction • Systems that require trained/certified contractors or staff
High	• Moderate LRV required from treatment system • Highly complex and/or less reliable, treatment systems • High LRT per unit process • Treatment trains with reliance on unit processes that may not function if upstream processes malfunction • Systems that require trained/certified contractors or staff

References Section 11

Sharvelle, S., Ashbolt, N., Clerico, E., Holquist, R., Levernz, H., & Olivieri, A. (2017). Risk-Based Framework for the Development of Public Health Guidance for Decentralized Non-Potable Water Systems," Proceedings of the Water Environment Federation, vol. 2017, no. 8, pp. 3799–3809, doi: 10.2175/193864717822158189.

12. Monitoring with grab samples vs. continuous monitoring

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 2 – Verification Monitoring**
- **Section 3 – Regulatory considerations during implementation**

12.1 Continuous monitoring and verification

Standards or guidelines for non-potable water systems and wastewater systems often rely upon assessment of water quality at a boundary or end point, for example at point of use. This may focus on testing for bacterial fecal indicator organisms (FIOs), such as E. coli or fecal coliforms. Testing standards (e.g., NSF) intended for treatment unit process testing have also generally been focused on testing outcomes of treatment, focusing on FIOs and parameters such as BOD and TSS to meet a defined standard for concentration in the produced water rather than on challenge-testing.

In some cases, these standards may have been developed using a risk-based management approach (e.g., Health Canada). In other cases, they may be based on adopted historical values that may not relate directly to an acceptable risk level.

Regardless of the source or validity of the values for water quality at point of use or exposure, the key problems with utilizing such standards as the sole basis for design and management of non-potable water systems include the following (Sinclair, O'Toole, Gibney, & Leder, 2015).

- The concentration of fecal indicator organisms (FIOs) does not necessarily correlate with the risk to health from differing source water. This is because the highest-risk pathogen group varies depending on the source of water and source of contamination.
- FIOs are not a reliable indicator of risk in treated water, since absence of FIOs does not necessarily mean absence of enteric pathogens, such as viruses or protozoa. Reliable, easy-to-test indicators for these pathogen groups have not been established.
- Grab-sample monitoring for testing for FIOs is not accurately representative of risk, and is impractical to achieve on a sufficiently frequent basis. Further, sample testing and analysis is slow and does not support the rapid adjustment of processes to avert risk.
- Even where the standards may be performance-based in terms of the development of the target concentration of FIOs, they are not based on the performance of each barrier within the system and do not consider barriers to risk beyond treatment itself.
- The approach is inflexible because the link between prescribed concentration of FIOs and risk is not clearly shown.
- Independent agency testing is costly and requires a "certified" product, which may stifle innovation. In addition, some of the parameters tested for do not necessarily relate to human health risk.

- Independent testing procedures and their results for proprietary treatment systems often do not represent performance observed in field-installed systems and seldom include a requirement for field monitoring (verification). They also do not place the treatment system in the context of a real-world installation.
- Management requirements are not necessarily included within the standards or guidelines, resulting in lack of proper management framework for the systems, as well as lack of commitment by stakeholders.

However, these issues do not mean that a risk management approach to design is incompatible with the achievement of outcomes.

12.2 Continuous process monitoring and log reduction value verification

Following the use of water quality objectives or required outcomes, it is common to attempt verification of the safety of water by frequent grab-sample measurement of fecal indicator organisms (FIOs). In some cases, weekly or even daily measurements are specified or required to improve detection of out of specification water.

An analysis of the frequency of monitoring needed to verify performance of a treatment unit process has established a relationship between the required frequency and the process design LRV for unit processes (LRV) (Smeets, Rietveld, van Dijk, & Medema, 2010). The analysis determined that increasing frequency of monitoring is needed to verify processes as design LRV increases. For example, a process intended to achieve 2-log reduction needs to be monitored daily, but for a 4-log reduction monitoring every 15 minutes would be necessary, and a 6-log reduction sampling would need to be at 10-second intervals.

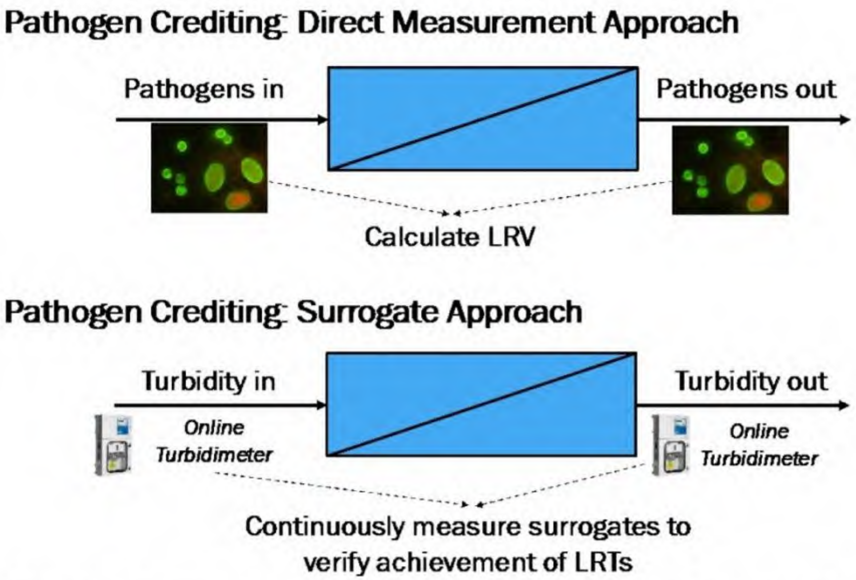
Therefore, for treatment systems that are at risk of failure events, verification cannot practically be achieved by manual sampling for FIOs. While this sampling may be required for compliance with regulation or code, best practice for verification of treatment processes is to specify continuous monitoring of a surrogate that represents performance of the unit process at a process control point. An example would be continuous monitoring of chlorine residual for a chlorination process.

Best practice for verification monitoring is, therefore, continuous process monitoring. This approach is valuable for all systems and is of critical importance for systems where risk is higher or that rely on risk management to achieve a high LRV in a particular unit process, especially one that is subject to failure events (those in higher management categories).

This verification monitoring may be combined with ongoing grab-sample monitoring where the latter is required to meet regulatory or policy standards of a regulator.

Continuous monitoring is often combined with automated diversion of water from the non-potable use when a surrogate does not meet the standard defined in design.

The following diagram from Pecson and Post (2020) illustrates the use of surrogates for performance verification.


Pathogen Crediting: Direct Measurement Approach

Pathogen Crediting: Surrogate Approach

Figure 8. Pathogen Crediting Through a Unit Process Typically Relies on Surrogate Monitoring. Surrogates often underestimate the actual level of pathogen reduction occurring but are selected for their real-time measurement capabilities over direct pathogen measurements.

References Section 12

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13. Surrogates for system performance verification monitoring

Relates to: Non-potable Water Systems – A Guidebook for the Metro Vancouver Region

- **Section 3 – Risk management, Verification of performance monitoring**

Table 14, adapted from Alberta Health Services (2021) and other sources, illustrates examples of verification and monitoring parameters and surrogates for performance for common treatment and disinfection processes.

These examples are not exhaustive and a wide range of potential parameters may be used to verify performance, depending upon the specific system design and operational regime. Some may be more suited to simpler systems, where acceptable verification costs and complexity will typically be lower, and where continuous monitoring may not be necessary for most parameters. In some cases, a parameter may be a direct measurement of performance, but in the majority of the examples the parameters are themselves surrogates for performance. For example, UV transmissivity may be a surrogate for pathogen attenuation in line with design LRV and validation for the UV treatment reactor.

Surrogate examples shown may not be adequate for systems in higher management categories, but are likely to form a useful or important part of verification monitoring and management of system operation, particularly where they extend or improve the quality of information gathered during monitoring for specific parameters. As an example, solids depth may be an indicator of retention time in a settling tank, but is not likely to be a reliable surrogate for flow rate through the system — so for improved performance monitoring (in a case where flow rate is an important surrogate for system performance) continuous records of flow rate will be more useful.

Refer to the MoH Log Reduction Credits Guideline (2022) for detailed recommendations on turbidity monitoring and raw water parameters. Refer to the MoH UV Treatment Guideline (2022) and the USEPA UV Manual (2012) for details related to UV systems.

For many processes the raw water must meet certain parameters, in which case monitoring of raw water (which may be from an earlier treatment step) will be necessary. These parameters should be clearly defined in the design and Operation and Maintenance Plan, as with all parameters that affect validation of treatment processes. It is important that monitoring includes confirmation that treatment processes are operated within the operating parameters of their original validation. A common source of malfunction of installed treatment systems that were originally third-party validated at a testing facility is operation outside of their validated parameters.

Table 14. Operational verification and monitoring parameters, surrogates

TREATMENT UNIT PROCESS	EXAMPLES OF PARAMETERS FOR VERIFICATION MONITORING	EXAMPLES OF SECONDARY SURROGATES FOR MONITORING PARAMETERS (INCLUDING CONTINUOUS MONITORING)
Influent/raw water	Flow rate, pH, temperature, conductivity, suspended solids, pathogen indicator count, TDS, ORP, dissolved O_2	Flow rate Turbidity, colour measurement pH, temperature, conductivity, dissolved O_2
Primary settling/septic tank	Flow rate through the system, suspended solids	Flow rate Solids depth, turbidity
Upflow anaerobic sludge blanket/anaerobic filter	Flow rate through system, suspended solids Biological oxygen demand (BOD)	Sludge blanket depth, turbidity
Suspended growth reactor/activated sludge Treatment wetland Storage pond	Retention time in treatment unit pH, temperature, conductivity, and other parameters in reactor Cyanobacteria levels and toxin concentrations	Flow rate Biomass concentrations and wastage rates from reactor Process-specific parameters Visual indicators
Membrane bioreactor	Membrane integrity Membrane flux Transmembrane pressure Permeate water quality Dissolved oxygen	Flow rate Turbidity (continuous monitoring required, with automatic control to address membrane integrity) Temperature Process pH Solids retention time Food-to-microorganism ratio Flow rate
Slow sand filter	Suspended solids Particle size distribution Flow rate through filter/total volume filtered Clogging Schmutzdecke depth and integrity	Flow rate and cumulative flow Turbidity (continuous monitoring recommended) Backwashing cycle counts Filter maintenance/cleaning
Cartridge/bag filter	Suspended solids Particle size distribution Flow rate through filter/total volume filtered Clogging	Flow rate and cumulative flow Turbidity (continuous monitoring required, automatic control may be necessary) Differential pressure/vacuum pressure Filter maintenance/cleaning
Dual media filter with coagulant Diatomaceous earth (DE) Packed bed filter Trickling filter	Particle size analysis/distribution Filtration rate Filter run time Backwash rate Headloss across system	Flow rate and cumulative flow Temperature, pH, alkalinity, TDS Turbidity (continuous monitoring required for media and DE filters, recommended for others) Coagulant type, dose, and blending system

TREATMENT UNIT PROCESS	EXAMPLES OF PARAMETERS FOR VERIFICATION MONITORING	EXAMPLES OF SECONDARY SURROGATES FOR MONITORING PARAMETERS (INCLUDING CONTINUOUS MONITORING)
Microfilter Ultrafilter Nanofilter Reverse osmosis	Membrane integrity (pressure decay testing) Membrane flux Transmembrane pressure Permeate water quality Process turbidity - pH	Turbidity (continuous monitoring required, with automatic control to address membrane integrity) Electrical conductivity Solids retention time / hydraulic retention time (flow rate) Dissolved oxygen Temperature Flow rate Head Loss across system Pressure decay test or bubble point test Cumulative volume of permeate
Activated carbon/ion exchange contactors	Effluent constituents Flow rate through contactor Total bed volumes processed Dissolved O_2	Flow rate and cumulative flow Pressure differential across contactor Bed regeneration/cleaning/backwashing cycles Dissolved O_2 monitoring
Free chlorine and chloramine	Chlorine residual (free or chloramine) pH Turbidity/particle size distribution in flow entering the contact tank CT value	Flow rate through contact tanks/contact time Amount of chlorine remaining in chlorine feed tank Temperature Oxidation reduction potential (ORP)
Peracetic acid	Concentration	Contact time
Ozone	Ozone residual UV absorbance (UVA) at 254 nanometers and UV transmissivity (UVT) ORP Turbidity/particle size distribution in flow entering the contact tank	Flow rate through venturi injector Oxygen generator output oxygen concentration and flow rate Inlet and outlet pressure at venturi, vacuum at venturi Power consumption by oxygen concentrator and ozone generator
Ultraviolet (UV) radiation	Flow rate through reactor, in range UV intensity/applied dose Turbidity/particle size distribution in flow entering UV contactor Colour (absorbance at wavelengths ranging from 420 to 460 nm depending on reactor type) UVA_{254} and UVT	Turbidity in flow entering reactor ORP Flow rate through UV reactor UV intensity in reactor UVA_{254} and UVT (typically primary) Temperature in reactor Lamp age and/or lamp output Ballast functionality Cleaning frequency and inspection of automatic cleaners

TREATMENT UNIT PROCESS	EXAMPLES OF PARAMETERS FOR VERIFICATION MONITORING	EXAMPLES OF SECONDARY SURROGATES FOR MONITORING PARAMETERS (INCLUDING CONTINUOUS MONITORING)
Advanced oxidation (UV and hydrogen peroxide)	Electrical conductivity Total organic carbon (TOC) ORP Colour	Turbidity in flow entering reactor Process flow rate Per UV systems, above.
Sensors	Power consumption Calibration schedule Maintenance schedule	
Distribution system*	Residual disinfectant (when used) Temperature (where opportunistic pathogen growth a concern) Leaks	Continuous residual and temperature monitoring Pressure in pressure tank/distribution system Flow rates and levels in non-potable water system process tanks, including product water, make-up water, source water, and discharged flow Automated leak detection Cumulative volume
Irrigation control	Soil moisture content Irrigation time	Soil moisture content
Accidental exposure control (spray irrigation example)	Timing of irrigation Direction of sprinkler throw before application Wind direction before application	Presence, currency, and comprehension of user agreements Presence, integrity and clarity of fittings Signage and other end-user controls Records of application

* Refer to Health Canada Guidance on Monitoring the Biological Stability of Drinking Water in Distribution Systems

References Section 13

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metrovancouver | WATER

Overcoming Barriers to Non-Potable Water Use in the Metro Vancouver Region

Key findings of the Non-Potable Water Working Group to support broader uptake of non-potable water systems

Executive Summary

THIS DOCUMENT HIGHLIGHTS THE PRIMARY BARRIERS TO THE BROADER UPTAKE AND SUSTAINABLE IMPLEMENTATION OF NON-POTABLE WATER SYSTEMS IN THE METRO VANCOUVER REGION, AND PROVIDES RECOMMENDATIONS TO ADDRESS THESE BARRIERS. THIS DOCUMENT WAS DEVELOPED WITH INPUT FROM REPRESENTATIVES OF VARIOUS ORGANIZATIONS, INCLUDING PROVINCIAL GOVERNMENTS AND MEMBER JURISDICTIONS, HEALTH AUTHORITIES, PROFESSIONAL ORGANIZATIONS, EDUCATIONAL INSTITUTIONS, AND INDUSTRY. TOGETHER, THESE REPRESENTATIVES FORM THE NON-POTABLE WATER WORKING GROUP[1].

The Metro Vancouver region is confronted with the reality of the climate emergency, facing hotter, drier summers, less snowfall accumulation, and more intense rainfall events in the fall and winter months. These changes in the climate put pressure on water and sewer infrastructure, with impacts that include a decline in water supply over the coming decades and rain events that risk overwhelming local and regional sewer systems. Water from these large storms, as well as regular rainfall, can be redirected and stored for future use in non-potable applications to reduce demands on both the drinking water and stormwater systems. In addition, the region's population is projected to increase by over 35,000 residents per year, from 2.7 million to 3.6 million by 2050 (Metro Vancouver, 2019), compounding the challenges of managing water and wastewater in a changing climate. Increasing the uptake of non-potable water systems can help the region to prepare for and adapt to the changing climate as well as to manage water resources more sustainably by conserving drinking water and reducing the load on storm and sewer systems.

In Metro Vancouver, over 75% of summer residential water demand is estimated to be for non-potable end uses (Metro Vancouver, 2022)[2]. Onsite water sources, such as rainwater, stormwater, or greywater, can be used instead of drinking-quality water to supply non-potable end uses, including irrigation and vehicle washing during the summer months, and indoor uses such as toilet flushing and laundering year-round. Furthermore, local governments are increasingly requiring new developments to capture and manage stormwater flows onsite to reduce strain on the storm and sewer systems. With appropriate non-potable water systems in place, these risks and challenges can become an opportunity for using onsite water more sustainably.

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[1] A complete list of organizations who formed the working group can be found in the Acknowledgements, page iv.

[2] Approximately 60% of summer residential water demand is used for outdoor purposes, 10% for toilets (24% of indoor use), and 7% for washers (17% of indoor use) – all potential non-potable end uses. Showers, baths, faucets and leaks account for remaining indoor water use.

Currently, there are dozens of non-potable water systems installed across the Metro Vancouver region, but they are quite rare among new developments, with very few installations occurring annually. The vast majority of new developments do not contemplate or advance non-potable water systems for various reasons, including regulatory uncertainty, insufficient business case, and shortage of local expertise. Where non-potable water systems have been installed, some are functioning as planned; however, there are several systems that have been decommissioned for various reasons, including inadequate design, inadequate commissioning, or insufficient maintenance, and other operations and maintenance challenges. This is slowly changing, but more support is needed to shift to a place where these systems are more commonly considered and integrated into new developments.

The Non-Potable Water Working Group (the "working group") discussed and identified barriers to non-potable water use in the Metro Vancouver region, with a focus on multi-family, commercial, mixed-use, and institutional buildings, where the majority of new construction is anticipated over the coming decades. The working group did not discuss blackwater or industrial process water in its consideration of non-potable water sources, and also excluded any potable-water end uses from its scope of work.

This document presents a path forward to supporting non-potable water systems through review and update of local and provincial policies and regulations, preparation and delivery of training and professional development, and ongoing research, monitoring, and evaluation. Table A summarizes the key findings and recommendations from this process with further detail provided in the document.

Table A. Summary of Working Group Findings and Recommendations

FINDINGS	RECOMMENDATIONS
Regulatory clarity and improved guidance	1. Develop province-wide guidelines for use of non-potable water. 2. Clarify and expand non-potable water systems requirements in the BC Plumbing Code.
Need for increased management and oversight post occupancy	3. Continue to explore and identify a regulatory mechanism in BC to provide oversight for the safe and ongoing operation of non-potable water systems.
Enhanced public policy support to improve business case	4. Develop and adopt regional policies that support non-potable water use. 5. Review and update municipal water policies that support non-potable water use.
Need for increased institutional and industry capacity	6. Develop training materials and roll-out strategy to accompany province-wide guidelines and/or regulatory changes for industry and regulators.
Opportunities for monitoring and evaluation	7. Continue/expand regional data and research on non-potable water use. 8. Investigate options to develop a regional tracking mechanism for non-potable water systems. 9. Investigate mechanisms for monitoring and reporting of non-potable water systems in operation.
Need for ongoing coordination across agencies	10. Establish a forum to host ongoing coordination across regulators, policy developers, and other key stakeholders.

At the time of publication, there is a continued and ongoing search for stakeholders and organizations to lead and guide this work. It is clear that some recommendations need to be led at a provincial or national scale, while others need to be led by Metro Vancouver, member jurisdictions, or other organizations in the region. As a next step, it will be important to establish an ongoing mechanism for continued collaboration across the multiple regulators, jurisdictions, and organizations involved in policy, regulation, capacity building, and research related to non-potable water systems (Recommendation #10). The Non-Potable Water Working Group acknowledge their shared interest in advocating for and supporting non-potable water systems, and participants support continued collaboration as a group. Doing so will better support the uptake of non-potable water systems in a safe and sustainable manner that helps the region use its water resources more sustainably.

Acknowledgements

Overcoming Barriers to Non-Potable Water Use in the Metro Vancouver Region includes input from representatives of several organizations that have regulatory and non-regulatory roles involved in the safe deployment of non-potable water systems within Metro Vancouver, and across the province of BC. Pinna Sustainability facilitated the stakeholder engagement process and report writing. Metro Vancouver would like to thank representatives from the following organizations for their participation and valuable input:

- BC Building and Safety Standards Branch
- BC Ministry of Health
- Canada Green Building Council
- City of Coquitlam
- City of North Vancouver
- City of Surrey
- City of Vancouver
- Concert Properties Ltd
- District of North Vancouver
- Engineers and Geoscientists British Columbia
- Fraser Health Authority
- Integral Group
- University of British Columbia
- Vancouver Coastal Health
- Convened by: Metro Vancouver
- Facilitated by: Pinna Sustainability

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Table of Contents

1. Background

Overcoming Barriers to Non-Potable Water Use in the Metro Vancouver Region highlights the primary barriers to the broader uptake and sustainable implementation of non-potable water systems and provides recommendations to address these barriers. This document was developed with input from representatives of several organizations, including provincial governments, member jurisdictions, health authorities, professional organizations, educational institutions, and industry.

1.1. Why Use Non-Potable Water?

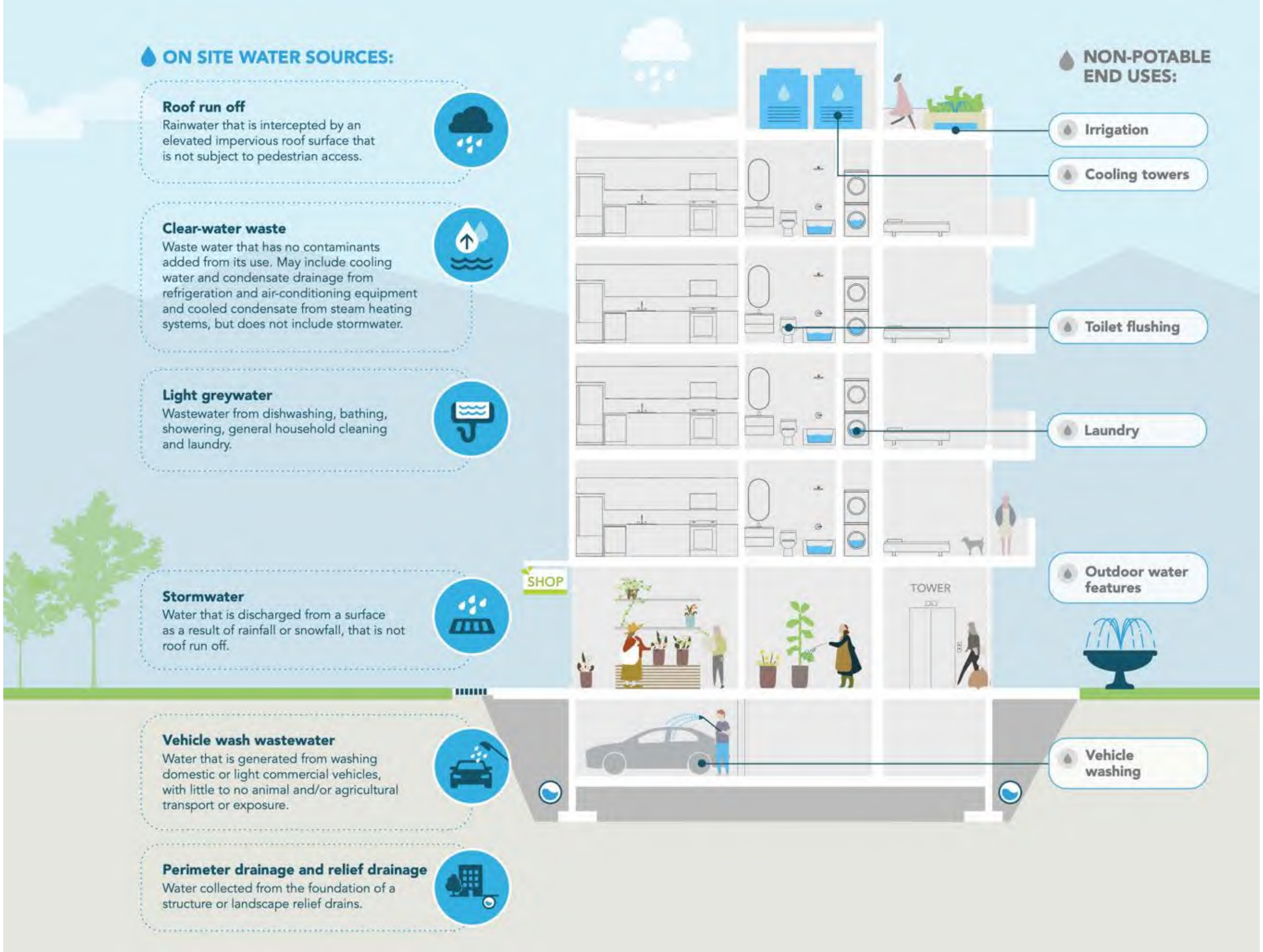
BC's preliminary strategic climate risk assessment (Province of BC, 2019) identifies seasonal water shortage and moderate flooding as two of BC's highest-risk scenarios based on projected climate changes and an assessment of the degree of impact of those changes. In Metro Vancouver, some of these climate change impacts are already presenting themselves, including hotter, drier summers with longer dry spells, less snowfall accumulation during warmer winters, more rapid snow melt, as well as more intense rainfall events in the fall and winter months. To increase resilience, jurisdictions across the region have recognized the need for climate change adaptation. They are preparing to adapt to impacts such as a decline in drinking-water source supply over the coming decades and more intense rain events that risk overwhelming local or regional storm and sewer systems.

One approach to increasing resilience in light of these impacts is to use water captured on building sites to serve non-potable end uses. Non-potable water is water that is not of drinking-water (potable) quality, but could be used for other purposes (such as flushing toilets, laundry, irrigation, and vehicle washing), as long as the quality and quantity is suited to the intended use. This is also termed "fit-for-purpose" water, where the water sources and end uses are strategically matched in terms of quantity and quality.

A non-potable water system collects, treats, stores, and distributes non-potable water. Common examples of non-potable water systems include rainwater harvesting, stormwater capture, and greywater reuse systems. By finding a good match, non-potable water systems can provide a sustainable alternative to using drinking water where it is not needed, while making best use of water already available onsite. Figure 1 summarizes the potential sources of onsite water, and the types of end uses that can use non-potable water.

The introduction and uptake of non-potable water systems across the Metro Vancouver region can support member jurisdictions in preparing for and adapting to the impacts of a changing climate, and to managing water and wastewater in a more integrated manner that values water as a resource in all of its forms.

Figure 1. Overview of Potential Sources and End Uses for Non-Potable Water Systems (Metro Vancouver, 2022)



1.2. Why is Metro Vancouver Interested in Non-Potable Water?

Metro Vancouver is a federation of 21 municipalities, one electoral area, and one treaty First Nation that collaboratively plans for and delivers regional-scale services. It provides clean, safe drinking water through its member jurisdictions to over 2.7 million residents in the Lower Mainland. This includes acquiring and maintaining supply, as well as treating, testing, and delivering water to the members. Currently, almost all of the water used by Metro Vancouver residents is treated drinking water; however, drinking water does not need to be used for many activities. Over 75% of the region's summer residential water use is estimated to be used for non-potable end uses (Metro Vancouver, 2022), demonstrating that there is substantial opportunity to reduce the use of drinking water and make better use of water captured onsite. Increasing use of onsite water supports reducing demand of treated drinking water and slowing down the release of water into the storm and sanitary sewer systems.

Metro Vancouver is committed to ensuring the sustainable use of water resources, as outlined in its *Drinking Water Management Plan* (2011), *Integrated Liquid Waste and Resource Management Plan* (2010), and *Board Strategic Plan* (2021). To alleviate climate change and growth-related pressures on the region's water and sewer systems and water resources, Metro Vancouver has identified an opportunity to support the uptake of non-potable water systems. In addition to increasing climate resilience, non-potable water systems can provide many other local and regional benefits, including providing more sustainable and vibrant public spaces using onsite water, reducing drinking water and sewer costs, supporting sustainable building credits, and innovation in building design. A substantial increase in adoption of these systems and the resulting reduction in water demand may also support increased operational efficiency of the regional water system and deferral of regional infrastructure investments.

There are several buildings in the Metro Vancouver region that have implemented non-potable water systems in recent years, with varying degrees of success. The limited adoption of these systems and their inconsistent outcomes indicates that there remain many barriers to the uptake of these systems and their long-term success as a substantive alternative water supply that increases local and regional resilience and improves sustainability outcomes.

1.3. Non-Potable Water Use Project

The Metro Vancouver Non-Potable Water Use Project presents an opportunity to advance non-potable water use through research, education, capacity building, and by convening relevant stakeholders into a process to identify and address barriers to the broader adoption of non-potable water systems.

The Metro Vancouver Non-Potable Water Use Project has two key project components to support broader adoption of non-potable water systems in the region:

1. To develop a guidebook for non-potable water systems that outlines best practices for planning, designing, implementing, and operating non-potable water systems in commercial and residential buildings, specific to this region.

2. To facilitate a non-potable water systems stakeholder engagement process and document that identifies barriers to planning, designing, implementing, and operating non-potable water systems and highlights opportunities to address these barriers.

Pinna Sustainability was retained to support Metro Vancouver in the management, facilitation, and development of these two components. This document represents the findings from facilitated discussions with the Non-Potable Water Working Group, supplemented by interviews and research with a variety of participants and other jurisdictions.

1.4. Non-Potable Water Working Group

The Non-Potable Water Working Group (the "working group") was convened and managed by Metro Vancouver, bringing together regulatory and non-regulatory actors involved in the safe deployment of non-potable water systems at individual buildings of all types across the region. Facilitated and supported by Pinna Sustainability, the working group comprised stakeholder representatives from member jurisdictions, health authorities, provincial government, industry, non-profit organizations, academia, and other relevant agencies. The representatives were varied with respect to their areas and levels of expertise, and included individuals familiar with:

- Non-potable water use policies and regulations applicable to the Metro Vancouver region;
- Review and approval processes of non-potable water systems; and/or
- Development and deployment of systems from an industry perspective, including design, implementation, and operations.

The stakeholder engagement process included three half-day stakeholder workshops, several small-group discussions to clarify issues between workshops, and the opportunity to provide input to and review both the guidebook and this document. The working group was guided by the following objectives:

- Identify policy, regulatory, and other barriers to non-potable water use.
- Identify opportunities and develop responses, strategies, and/or actions to overcome barriers to system uptake.
- Agree on the contents of this document.
- Determine and potentially assign responsibility for the next steps to address the barriers identified.

At the time of publication, there is a continued and ongoing search for stakeholders and organizations to continue leading and guiding this work.

1.5. Scope

The working group defined the following scope for the discussion and identification of barriers to non-potable water use in this region:

- **Building types and scale:** This document focuses on multi-family, commercial, mixed-use, and institutional buildings, where the majority of new construction is anticipated over the coming decades. Discussions concentrated on more complex buildings (i.e., BC Building Code Part 3 buildings) using onsite source(s) of water. Single-family residential, duplex residential and industrial applications were not included in discussions.
- **Non-potable end uses**: This document focuses exclusively on the use of water available onsite for non-potable end uses. Any potable-water end uses are excluded. Non-potable end uses discussed include cooling towers, irrigation, laundry, outdoor water features, toilet flushing, and vehicle washing. This is not an exhaustive list, but provides guidance on the intended scope of end uses.
- **Non-potable water sources:** The discussions with stakeholders covered many sources of non-potable water, including clear-water waste, light greywater, groundwater*, perimeter and relief drainage, roof runoff, stormwater, and vehicle-wash wastewater. Blackwater and industrial process water were not included in the discussions.

*Groundwater was considered a potential non-potable water source only in contexts where the building intersects with a source of groundwater and the groundwater would otherwise be considered a nuisance to be disposed of through the stormwater system.

Additional definitions (Appendix 1) were developed for this project to ensure that the most relevant terms are used consistently and within the context of the Metro Vancouver region. The initial list of terms was developed by conducting an environmental scan of current regulations, standards, guidelines, and other relevant documents. The Pinna team collated the definitions and identified those that were best aligned with the Metro Vancouver region — prioritizing alignment with existing definitions in regulation, while ensuring definitions are aligned with those used by other jurisdictions and leading research. Where necessary, the team adapted definitions or created original definitions to minimize ambiguity and prioritize alignment. The definitions were reviewed, refined, and confirmed with the working group.

2. Non-Potable Water Systems Overview

2.1. Established Approaches and Best Practices

Decentralized water systems that provide non-potable water for certain end uses are not new. Regions that have constraints on available water supply, such as Australia, the Middle East, and parts of the US, provide examples of advancement of these systems. They have developed and established best practices for the safe management and use of non-potable water in urban areas, over recent decades in particular.

For regions like Metro Vancouver that are earlier in the journey of adopting non-potable water systems, there are substantial resources available to guide the practices for onsite scale systems, as well as to guide the adoption of these systems on a broader (city-wide or regional) scale. Many resources reference the term "One Water," a term used to describe a more holistic approach to water management that is being adopted in some regions, particularly in North America (see "What is One Water?" inset below).

Key resources from the North American context that can support these practices and approaches in the Metro Vancouver region include:

- Onsite Water Recycling: An Innovative Approach to Solving an Old Problem (2022) published by San Francisco Water Power Sewer. This guidebook includes summary background information on the concept of "One Water" and onsite non-potable water use, and goes on to recount the experience of the San Francisco municipality in beginning to implement a One Water approach, as well as articulating future direction and opportunities for both local and national non-potable water use programs. Many case studies are included from the San Francisco area and worldwide.
- Onsite Non-Potable Water System Guidance Manual – Project #1732/4909 (2020) published by the Water Research Foundation. This manual is focused primarily on technical and management aspects of non-potable water systems, but includes information on typical interactions between professionals involved with system design, managers, and the authority having jurisdiction.
- Blueprint for One Water – Project #4660 (2017) published by the Water Research Foundation. This resource provides a blueprint for the practical application of One Water planning across water resource sectors.
- A Guidebook for Developing and Implementing Regulations for Onsite Non-potable Water Systems (2017) published by the National Blue Ribbon Commission for Onsite Non-potable Water Systems. This guidebook aims to advance the uses of onsite non-potable water systems as part of the One Water approach by sharing best practices and providing guidance on fostering a supportive policy and regulatory environment. Accompanying this guidebook are model regulations that are aimed at the US context, but which may assist in development of BC-specific model bylaws or regulatory amendments.
- 2012 Guidelines for Water Reuse (2012) published by the United States Environmental Protection Agency. These guidelines reflect the most recent updates to water reuse guidelines (at time of writing), covering topics of best practices, water treatment objectives, and monitoring.

What is “One Water”?

San Francisco Public Utilities Commission (SFPUC) recognized the need to modernize its perspective of water management in the face of water scarcity driven by climate change and population growth, health and equity issues, energy conservation, and infrastructure tied to traditional "water-in" and "wastewater-out" silos. In response, SFPUC developed OneWaterSF, a strategic approach to resource management. This involved *“a shift from thinking about one project at a time to thinking more holistically; thinking about the impact of one water source on another; thinking about the potential synergies between our water system operations.”* (SFPUC, 2016)

OneWaterSF Guiding Principles:

1. Match the right resource to the right use.
2. Look holistically at water, wastewater, and power systems to develop programs, policies, and projects that provide multiple benefits.
3. Plan for variable outcomes and build in flexibility to adapt to future changes.
4. Develop projects and programs that conserve resources and promote ecosystem health.
5. Work across traditional boundaries within the organization to foster collaboration that results in the efficient use of our water, wastewater, energy, and financial resources.
6. Engage our communities to foster awareness and collaboration around OneWaterSF.
7. Pursue partnerships with other agencies, the private sector, and other stakeholders to generate new and creative ideas.
8. Pilot state-of-the-art technologies, and test new approaches to develop new business practices.

SFPUC undertook a series of programs and strategic initiatives under these principles, including:

- Water Conservation Program – promotes efficiency through education.
- Recycled Water Program – uses reclaimed water to irrigate large parks and golf courses.
- Non-potable Water Program – supports the collection and treatment of water within buildings for non-potable reuse.
- Urban Watershed Management Program – uses green infrastructure to manage combined stormwater and sewer discharge.
- Residential Programs – facilitates residential irrigation needs through greywater and rainwater collection.
- Stormwater Ordinance – incorporates onsite use of stormwater, removal of impervious surfaces, rainwater harvesting and green infrastructure, and is supported through planning tools, grant programs and implementation of green infrastructure in capital projects.

SFPUC recognizes that the research, tools and technologies, and skills that have evolved over the past 20 years allow for new considerations around managing water in a holistic resilient approach.

Metro Vancouver and its member jurisdictions have been developing plans and strategies to increase non-potable water use in the region as a means to tackle similar challenges to those that San Francisco has faced. For example, the development of integrated stormwater and rainwater management plans, water conservation education strategies, and various independent policies have been undertaken to support the reduction of potable water use for non-potable water purposes and to reduce stormwater flows.

2.2. Overview of Non-Potable Water Systems in the Region

The Metro Vancouver region continues to grow and develop, with a projected 530,000 new dwellings to be added between 2017-2041, as well as millions of square metres of institutional and commercial floor space (Pinna Sustainability, 2018). Despite substantial new development, few buildings (on the order of dozens over the last decade) have implemented non-potable water systems. Nonetheless, uptake of these systems has increased in the last decade, driven by a combination of factors, including an increase in buildings achieving sustainable building certification that provides credit for these systems, as well as local government policies that support or require sustainable building and stormwater management (Pinna Sustainability, 2018).

As a result, there are examples of non-potable water systems in the region, including several that use roof runoff to serve toilet flushing or irrigation systems, and a select few that use stormwater or greywater. Owners and operators have experienced various challenges in system implementation — some managed to overcome those challenges and continue to operate their systems today, while other systems were decommissioned within a few years of installation, well before the end of their expected lifespan. Despite having established approaches and best practices, various constraints have prevented the full adoption of non-potable water systems in the region, including regulatory constraints, lack of effective system oversight or management, and local capacity constraints.

In recent years, substantial progress has been made in policy development at the City of Vancouver. Since 2019, developments (excluding laneway houses and buildings containing no more than four dwelling units and no other major occupancies) in Vancouver are required to include an alternate water system that uses rainwater and clear-water waste to serve toilet flushing. This program and the accompanying Vancouver Building Bylaw update are leading the way for improving how non-potable water systems are managed, with built-in requirements for monitoring, annual operating permits, operator training, and more. Although the City of Vancouver has made advances in this policy area, other municipalities in the region operate under a different regulatory authority with respect to municipal powers for buildings and development (as prescribed by the Community Charter and the BC Building Code), and these differences were explored as part of the process.

This document explores the region-specific challenges being faced in building and maintaining non-potable water systems and explores opportunities to address them through public policy, both at the provincial and municipal level. Supporting this document is the publication of the *Non-Potable Water Systems: A Guidebook for the Metro Vancouver Region*, which showcases best practices for planning, designing, implementing, and operating non-potable water systems applicable to this region in today's context.

3. Regulatory Context

Table 1, also included in the *Non-Potable Water Systems: A Guidebook for the Metro Vancouver Region*, provides an overview of the regulations currently in place for various non-potable water systems in the region. The information provided within was also provided to members of the Non-Potable Water Working Group, and serves as a foundation for the potential changes discussed in Section 4 to improve the current state of regulations for non-potable water systems. In addition to regulations, there are numerous standards and guidelines that serve as an important reference, either referenced directly in regulation, or by professionals involved in the design, implementation, and operation of non-potable water systems. Appendix 2 in the guidebook provides a summary of the standards and guidelines most relevant to the Metro Vancouver region at this time.

Table 1. Existing Regulations Relevant to Non-Potable Water in the Metro Vancouver Region (as provided in the guidebook)

AUTHORITY	DESCRIPTION	WHEN DOES IT APPLY?	CONSIDERATIONS FOR THE PLANNING STAGE
BC Public Health Act	Sewerage System Regulation (SSR) • Greywater falls within the definition of "domestic sewage," and the BC Sewerage System Standard Practice Manual (SPM) provides standards for sub-surface drip dispersal filed as a ground discharge system. • Additional guidance provided by the Manual of Composting Toilets and Greywater Practice. • Establishes a professional reliance model, defining Authorized Persons (APs).	• Domestic sewerage systems that discharge less than 22,700 litres per day to ground. • All domestic sewage from a building must go into a public sewer or a sewerage system, unless it is authorized under the Building Code or bylaw (see local bylaws row below).	• Contact the local municipality to verify if a greywater discharge bylaw is in place. • Contact the regional health authority to determine if and how the SSR applies. • Engage Authorized Person, as defined in the SSR. • Review the Manual of Composting Toilets and Greywater Practice and SPM.
BC Drinking Water	Drinking Water Protection Act (DWPA) and Regulation (DWPR)	• DWPA applies to non-potable water systems except in a	• Contact a regional health authority drinking water officer for information or

AUTHORITY	DESCRIPTION	WHEN DOES IT APPLY?	CONSIDERATIONS FOR THE PLANNING STAGE
Protection Act	• The DWPA outlines general requirements for water suppliers supplying water for potable water systems. • The DWPR sets out more specific requirements and has provisions and requirements for non-potable systems (section 3.1).	single-family residence, and equipment, works, or facilities prescribed by the DWPR as being excluded (see section 3 of the DWPR).	to confirm whether the system would be subject to the DWPA and DWPR. • Compliance is separate from compliance with the BC Building Code or Vancouver Building Bylaw. • Additional guidance is provided in the Drinking Water Officers' Guide (e.g., guidance for treatment of rainwater harvested for potable use).
BC Building Code (or National Building Code, Part 7)	BC Plumbing Code, Division B, Section 2.7. "Non-potable water systems" (BCPC) • Permits non-potable water systems in buildings. • Design, fabrication, and installation to be in accordance with good engineering practice. • Example end uses include toilet and urinal flushing, laundry, cooling towers.	• Design, installation, alteration, renewal, or repair of a plumbing system in a building where the BC Building Code applies. • Applies in all Metro Vancouver electoral areas and member jurisdictions, except City of Vancouver.	• Engage the regulator to discuss preliminary options; regulator may also involve local health authority. • Identify potential risk management steps and quality assurance processes. • Identify verification and validation for approval and management requirements for operation.
BC Environmental Management Act	Municipal Wastewater Regulation (MWR) • Defines "reclaimed water" as municipal wastewater treated by a wastewater facility and suitable for reuse in accordance with the regulation. • Establishes prescriptive water quality requirements for reclaimed water applications.	• Discharge of domestic wastewater is greater than 22,700 litres per day to ground or discharges to water. • All uses of reclaimed water; except single-family dwelling or duplex, which are exempt.	• Contact the Ministry of Environment and Climate Change Strategy to determine applicability, process, and requirements. • Expect a complex process over longer timeframes. • If considering registration, refer to the Ministry's Reclaimed Water Guideline.

AUTHORITY	DESCRIPTION	WHEN DOES IT APPLY?	CONSIDERATIONS FOR THE PLANNING STAGE
Vancouver Building Bylaw	Vancouver Building By-law, Book II, Division B, Section 2.7. "Non-potable water systems" (VBBL) • Acceptable solutions allow use of rainwater and clear-water waste; require capture for water closets, urinals, and trap primers; and require systems to obtain operating permits. Allows other end uses (non-food irrigation, clothes washing, vehicle washing, make-up water for hydronic systems and cooling towers, adiabatic cooling systems).	• Only applies in the City of Vancouver. • Any building where VBBL applies, excluding single-family residence. • City plans to include stormwater as another source starting 2023. • Alternative solutions may be used for other systems similar to BC Plumbing Code.	• For rainwater and clear-water waste sources, familiarize the team with VBBL requirements and clarify with the regulator. • For all other systems, see suggestions for the BC Building Code above.
Local government bylaws	Local government bylaws may be in place for: • Cross-connection control requirements. • Stormwater management requirements to mitigate peak flows. • Greywater discharge bylaws.	• Only applicable where local bylaws are in place. • Local governments may create bylaws allowing surface discharge of greywater.	• Engage the local government to confirm which bylaws are applicable. • Identify associated requirements. • For cross-connection bylaws, identify verification/commissioning steps for approval.

4. Findings and Recommendations

Throughout the stakeholder engagement process, the Non-Potable Water Working Group (the "working group") identified barriers to uptake of non-potable water systems and issues with implementation. In addition to highlighting the challenges, the working group also identified opportunities to navigate these barriers and recommendations for advancing non-potable water systems. In some cases, the findings are applicable across Metro Vancouver member jurisdictions (and even province-wide), except the City of Vancouver which has its own building bylaw. In the City of Vancouver, some of the barriers are addressed through the implementation of the non-potable water program in the *Vancouver Building Bylaw Book II* (Plumbing Systems) Division B, Section 2.7.

Key findings and recommendations fall into five main categories:

- Regulatory clarity and improved guidance
- Need for increased management and oversight post occupancy
- Enhanced public policy support to improve business case
- Need for increased institutional and industry capacity to design, build, operate and maintain systems
- Opportunities for monitoring and evaluation

The information provided in this section highlights the outcomes of the working group discussions and may not be an exhaustive list of barriers and solutions. However, the information can be used to navigate and prompt changes to existing policies and regulations that impact the uptake and implementation of non-potable water systems in the region.

4.1. Regulatory Clarity and Improved Guidance

4.1.1. Findings

Although non-potable water systems are allowed by current regulations, there is a general lack of awareness and understanding of the regulatory requirements and processes for approving non-potable water systems. This is in part due to poor coordination between regulations and policies from different regulatory authorities. The lack of regulatory clarity may inhibit the uptake of non-potable water systems due to the risks and uncertainties around the approvals process, or may affect whether best practices are incorporated into the design, implementation, and ongoing operation.

There are several areas that require greater clarity and consideration:

- Prior to publication of the *Manual of Composting Toilet and Greywater Practice* in 2016, regulations and policies were not developed to consider onsite sources of water as a resource, resulting in a poor fit for non-potable water use objectives, and the need to use regulations in ways that were not originally contemplated.
- Regulations are spread across multiple locations and jurisdictions. In some cases, it is not clear which organization(s) is the authority having jurisdiction.

- There is little provincial guidance on the acceptable risk levels for different circumstances, leaving this up to each project team to determine with the authority having jurisdiction.
- The current regulatory environment is not well aligned with established industry best practices. For example, a risk-based approach to non-potable water system design and management with performance monitoring is considered best practice, but is not consistently supported by regulation, policy, and guidelines.
- The BC Building Code is quite broad with respect to non-potable water systems and does not provide clear guidance or requirements for applicable systems. As a result, local building officials may impose requirements or conditions that are unclear at the outset, vary across jurisdictions, or even vary between officials within the same jurisdiction.
- There is uncertainty about when the local health authority needs to be involved in the approval of systems and the requirements that need to be met.
- Different definitions are used in different regulations and policies across the province (e.g., for stormwater, greywater), and these may differ from national or international standards and guidelines.

The lack of clear and consistent regulations is problematic for non-potable water system design professionals and for any authority having jurisdiction that provides approvals as it opens the door to liability concerns if the non-potable water systems are not designed, installed, or implemented in a manner that minimizes risks to public health and promotes the long-term sustainability of the systems.

4.1.2. Recommendations

Key opportunities to increase clarity and consistency of regulations were provided by the working group.

RECOMMENDATION 1: DEVELOP RISK-BASED PROVINCE-WIDE GUIDELINES FOR THE USE OF NON-POTABLE WATER.

Developing a set of guidelines for non-potable water use at the provincial level is an important step towards a more consistent application of regulations and implementation of non-potable water systems, building on the existing initiatives undertaken by the Ministry of Health. This would give an opportunity for the review and planning of regulations and policies to support an integrated approach that considers all sources of water to be a resource.

Other regions have developed similar guidelines that can be used as models. Practical guidance typically takes a risk-based approach to the assessment and management of non-potable water systems (e.g., Alberta Health Services, 2021, *Public Health Guidelines for Water Reuse and Stormwater Use*). These guidelines describe a public health risk-based assessment process and performance targets that can be used by applicants and regulators across the province.

As policy and regulatory pathways are further explored, employing a risk-based approach to regulating non-potable water systems provides an opportunity to reduce the burden of compliance for low-risk non-potable water systems. At the same time, this approach ensures that higher-risk systems are accompanied with greater requirements for verifying and validating their performance at the outset, and on an ongoing basis. This approach may need to include consensus across multiple jurisdictions/organizations on acceptable risk, pre-completed risk assessments, and other tools to support design in order to both improve practice and reduce the cost of design for smaller projects. For example, this could involve a multilateral group led by the provincial government or a university research institute.

The recommended guidelines can build on the guidebook for the Metro Vancouver region and could include:

- A standardized process to assess risk and determine the appropriate requirements and control measures that should be in place for different types of non-potable water systems and situations.
- Establishing province-wide acceptable risk levels for different types of source/end use combinations.
- Pre-developed support tools and tables on risk management design.
- A definition of and information on management categories and responsible management entities.
- Provincial policy on water and wastewater realigned to support One Water planning by local government.
- Clarity on definitions, seeking alignment between provincial regulations, and national or international standards where possible.
- Model bylaws and policies to support consistent requirements across jurisdictions, including those related to monitoring and oversight.

Following development of provincial-scale guidance, health authorities would need to review and adjust policies to align with the provincial guidance.

RECOMMENDATION 2: CLARIFY AND EXPAND NON-POTABLE WATER SYSTEMS REQUIREMENTS IN THE BC PLUMBING CODE.

There is currently limited clarity on requirements that should be met for non-potable systems that fall under the *BC Plumbing Code*. However, in the City of Vancouver, recent updates to the *Vancouver Building Bylaw* provide more guidance and enable select types of non-potable water systems without requiring an alternative solution. The City of Vancouver undertook substantial engagement with industry and has issued over 1,500 operating permits for non-potable water systems since bringing in the new bylaw.

There is opportunity to learn from the City of Vancouver updates to inform the provincial and national codes. The recently updated *National Plumbing Code*, which serves as a model for provincial and territorial codes, adopts some provisions similar to those in the *Vancouver Building Bylaw*, including explicitly stating requirements for rainwater harvesting system design without needing an alternative solution (which would still be required for other non-potable water systems).[3] However, the updated language is not consistent with a performance-based approach that manages risks.

During the next update of the *BC Plumbing Code*, the intent will be to harmonize the provisions[4] included in the *National Plumbing Code*, unless there is a compelling reason not to do so. Discussions in the stakeholder engagement process highlighted some compelling reasons to consider varying from this

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[3] https://nrc-publications.canada.ca/eng/view/ft/?id=6e7cabf5-d83e-4efd-9a1c-6515fc7cdc71

[4] https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/bc-codes/construction-codes-reconciliation-agreement

approach, and these should be considered during the next code update cycle. An important consideration will be seeking consistency with other BC regulations, in particular the *Sewerage System Regulation* and the *Municipal Wastewater Regulation*. For example, the *Sewerage System Regulation* allows for the use of treated wastewater effluent for sub-surface application, and further, Ministry of Health guidance suggests local governments may enact bylaws allowing the use of light greywater for surface irrigation. The recent *National Plumbing Code* appears to potentially conflict with the Ministry of Health's guidance by specifying that non-potable water may only be used in specific applications, with one of those applications being the direct connection to underground irrigation systems, which are not the subject of standards within the plumbing code. It will be important to hold discussions between the Building and Safety Standards Branch (Ministry of Attorney General), the Ministry of Health, non-potable water system experts, and other relevant stakeholders in order to determine the optimal approach for the next code update. The province-wide guidelines on treatment objectives and risk that are recommended above (Recommendation 1) can also serve to support updates to the BC Plumbing Code.

The need for regulatory change to support non-potable water use in BC: District of Sechelt

The District of Sechelt is facing increased pressure on the water supply system due to extended periods of hotter, drier summer weather in recent years. In the summer of 2021, the regional water supply provided by the Sunshine Coast Regional District approached its limits, raising concerns about the sustainability of the water system, particularly in the context of projected climate change for hotter, drier summers and planned future growth in the region.

As a result, District staff and Council investigated various options to reduce the strain on the water system. The use of site-based sources of water to serve non-potable end uses emerged as a key opportunity to pursue. In particular, requiring the use of greywater to serve toilet flushing was identified as the primary opportunity. Although these systems are allowed under the BC Building Code, at time of writing, the *Building Act* does not allow municipalities to require non-potable water systems for in-building systems. As a result, the District is currently preparing to request a Local Authority Variation to the *Building Act* that would allow the District to require these systems. This represents one example of the need for strengthened province-wide policies and regulations enabling non-potable water systems.

4.2. Need for Increased Management and Oversight Post Occupancy

4.2.1. Findings

Inconsistent management and oversight post occupancy was highlighted as an area of risk for both the long-term safe operations of non-potable water systems and for the longevity of the systems. The planning, design, and management strategy must clearly identify a responsible management entity (RME) and must take into consideration the ability and resources of the owner/operator to properly operate, maintain, and monitor the system. Oversight is necessary to ensure that non-potable water systems continue to be maintained to meet risk management objectives throughout their lifespan. A lack of oversight could lead to issues with both the non-potable water systems and public health. For example, if water sits for an extended period without proper treatment, it may result in an increased risk of Legionella.

With the exception of the *Vancouver Building Bylaw* and a few other local government maintenance bylaws for non-potable water systems constructed as a sewerage system under the *Sewerage System Regulation*, there are currently no enforced or mandated mechanisms for oversight of installed non-potable water systems during operation.

The working group highlighted that adding requirements, such as operating permits, may also add to the existing barriers to uptake — emphasizing the importance of public policy support to incentivize and improve the business case for non-potable water systems (see section 4.3), and the need to expand both institutional and industry capacity (see section 4.4).

4.2.2. Recommendations

Several ideas for increasing oversight post occupancy were brought forward by the working group, including updating existing regulatory mechanisms for oversight and/or introducing new approaches to regulations and oversight. Each of these options could require substantive regulatory change and increased resources to implement.

> See also Section 4.1 recommendations related to standards and guidance for system management, and Section 4.5 recommendations related to monitoring, which are important aspects of system management.

RECOMMENDATION 3: CONTINUE TO EXPLORE AND IDENTIFY A REGULATORY MECHANISM IN BC TO PROVIDE OVERSIGHT FOR THE SAFE AND ONGOING OPERATION OF NON-POTABLE WATER SYSTEMS.

Oversight of operational non-potable water systems is currently limited to non-potable water systems that fall under the *Sewerage System Regulation* in municipalities that have enacted a maintenance bylaw (e.g., the Capital Regional District), and to the City of Vancouver, which has adopted a program of operating permits for non-potable systems. All other non-potable water systems generally operate without regulatory oversight.

Continued technology advancement enables smarter monitoring capabilities, and policies and regulations should be updated to reflect this. For example, in-line monitoring of non-potable water systems enables automatic continuous monitoring for various surrogate parameters, as well as automated response when water is out of specification – an ultraviolet (UV) disinfection system may continuously monitor UV intensity and can alarm and/or automatically shut off the supply of water if it falls below a set point. Real-time verification monitoring using surrogates is preferred under a risk-based management approach for non-potable water systems. These advancements are important to consider when exploring policy options to improve system oversight. An online system to manage documentation at the local government level would be an important aspect of any new regulatory oversight system as well.

There are many potential paths forward to increasing the oversight of non-potable water systems, but initial discussions have identified that there are significant barriers to overcome. It is not yet clear which path is most appropriate or achievable. Opportunities to investigate further include:

- **Update the *Local Government Act*** to enable local governments to issue permits post occupancy. An example is the use of backflow preventers, where a licence is issued to use and verify an installed backflow preventer on an ongoing basis, as a means to protect the public drinking water supply (enabled under *Local Government Act* section 304 and Community Charter section 23, allowing operation of a drinking water system). A similar avenue could be created in the *Local Government Act* for non-potable water systems. Following this, the *BC Building Act* would also need to be updated to allow for these permits in existing buildings (e.g., this could in future be part of the *Alterations Code for Existing Buildings*, currently in development at the national and provincial levels to address energy efficiency in existing buildings, or other new regulations). This would be a substantive effort and may have far-reaching implications with regards to the involvement of local governments in monitoring/regulating buildings once occupied. Other considerations for enabling local governments to permit and oversee non-potable water systems during operation include:
    - Local governments already employ a similar approach for cross-connection control systems.
    - Jurisdictional authority can also be provided to a municipality to manage the oversight of aspects of provincial regulation, allowing an integrated approach to several regulations. For example, the Ministry of Environment has permitting for discharge, which may be an opportunity to co-manage these systems.
    - If given authority, the local government can also contract the health authority to enforce local bylaws. This approach has been taken with respect to noise bylaws and smoking bylaws.
- **Explore a future role for Technical Safety BC** to issue permits and provide inspections for non-potable water systems. Technical Safety BC already provides operating permits in other areas, including elevators, electrical, and gas systems. There is currently no mandate for ensuring the safety of non-potable water systems, but this may be an area to explore further. In conjunction with this approach, the following should be considered:
    - Develop a professional reliance model with ongoing audit and review, expanding the existing approach used in the *Sewerage System Regulation* to apply to other systems, but with the addition of mechanisms for external inspections and other checks to improve oversight. This approach requires an authority having jurisdiction to establish a central registry or record-keeping and audit role.

Although feasible, the opportunities above are not without challenges. A key challenge may be in identifying an organization/jurisdiction/champion to foster the process. Federal and provincial initiatives to support climate adaptation and resilience work may provide an additional avenue to advance this work in support of a more integrated approach to managing our valuable water resources.

4.3. Enhanced Public Policy Support to Improve Business Case

4.3.1. Findings

Although non-potable water systems support numerous sustainability goals that align with public benefits and goals, generally, the policies in place may not sufficiently incentivize or offset the costs to warrant the investment. For example, the savings in drinking water, stormwater, and sewer utility fees generally do not make up for the up-front investment cost or ongoing operational costs due to relatively low utility rates in this region. Where installation and ongoing maintenance and operation of non-potable water systems cannot be justified as a strong business case, additional public policy support may be warranted. Several key barriers were highlighted by members of the working group.

- **Cost of water, stormwater, and sewer utilities:** Although starting to shift, the current utility costs are too low to justify the cost of installing and maintaining non-potable water systems. In some cases, water supply charges may not include metering, and charges for stormwater and sewer do not normally include pricing that would allow incentivizing reductions in peak or total discharge.
- **Cost of installation and operations:** Cost of design, approvals, and installation may prevent non-potable water systems from being installed, particularly where permitting requirements are unclear and may cause additional unexpected costs or time. Cost of ongoing maintenance and operations (when done properly) may be too high and may not be upheld to the degree needed. This can lead to system malfunction, typically followed by system abandonment or decommissioning.
- **Cost of insurance:** Water damage is currently the highest insurance cost in Canada. With limited experience/outcomes from non-potable water systems in the region, insurance premiums may be affected.

4.3.2. Recommendations

In addition to the need for province-wide policy support and guidance (addressed in section 4.1 above), there are also opportunities to provide further policy support at the regional and local scales.

RECOMMENDATION 4: DEVELOP AND ADOPT REGIONAL POLICIES THAT SUPPORT NON-POTABLE WATER USE.

At a local level, Metro Vancouver, its member jurisdictions, and other municipalities in the province can play a role in reducing barriers to non-potable water systems, including:

- Review options for regional water, sewer, and stormwater peak flow disposal pricing that improves the business case for using non-potable water and identify how these will be adopted in the Drinking Water Management Plan and the Liquid Waste Management Plan. Ensure that appropriate requirements for metering are identified to support pricing.
- Shift toward a One Water approach that supports more integrated management of water and wastewater and supports the use of non-potable water sources. The process can follow the blueprint recommended by the Water Research Foundation. This is a substantial undertaking and will require considerable consultation, long-range planning, and major organizational changes. A One Water

approach will also benefit from a supporting policy at the provincial level. The authority to make such changes are governed by legislation and bylaws that would need to be reviewed and possibly amended in order to better support this shift. (See also "What is One Water?" inset in section 2).

- Introduce and familiarize policy makers (elected officials) to concepts of One Water and non-potable water use, and reference these as options in staff reports.
- Investigate the option to have centralized management of decentralized water systems, wherein monitoring/verification information is reported to and monitored by the member jurisdiction, and notification provided when a system deviates from the allowances in the operating permit. (See also 4.2)
- Assess policies that incentivize reduced water, stormwater, and sewer use.
- Engage the Intergovernmental Partnership on Regional Emergency Management (IPREM), a partnership between the province and Metro Vancouver, in a discussion of the risks and benefits of decentralized water systems in the context of emergency management. Research in other regions indicates that decentralized water systems can play an important role in increasing a region's resilience to shocks or extreme events.

RECOMMENDATION 5: REVIEW AND UPDATE MUNICIPAL WATER POLICIES THAT SUPPORT NON-POTABLE WATER USE.

A number of the opportunities discussed relate to municipal policies that can reduce barriers and support non-potable water systems, including:

- Adopting universal metering.
- Implementing water, sewer, and stormwater peak flow disposal pricing option(s) identified in the regional policies noted in Recommendation 4.
- Reviewing and adopting policies that encourage, incentivize, or require non-potable water systems in new developments, and their maintenance and monitoring.
- Exploring the development of bylaws and policies that enable the application of light greywater outdoors (e.g., for surface irrigation), outside of the *Public Health Act* Sewerage System Regulation or the *Environmental Management Act* Municipal Wastewater Regulation.[5]
- Adopting policies that support risk-based performance design and management of systems.

This may require one or more municipalities to take a lead role in piloting and demonstrating new approaches. It could also involve regional coordination and development of model policies, bylaws, or other supporting materials.

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[5] The *Sewerage System Regulation* allows for the use of greywater for sub-surface irrigation, but excludes surface irrigation. However, guidance from the Ministry of Health states that local governments may enact a bylaw that allows the application of greywater for surface irrigation. To date no local governments in BC have enacted such a bylaw. Treated greywater application by surface irrigation may also be authorized under the *Municipal Wastewater Regulation* as reused under that regulation.

4.4. Need for Increased Institutional and Industry Capacity

4.4.1. Findings

The working group identified a gap in experience and knowledge among authorities having jurisdiction, qualified professionals, builders, and operators (among others) when it comes to best practices in the design and operation of non-potable water systems. Due to the low uptake of these systems in the region, local industry capacity to design, build, operate, and maintain non-potable water systems is less mature than in other areas of building and development, though knowledge and experience are increasing.

Industry may seek guidance from the authority having jurisdiction on acceptable practices for non-potable water systems; however, building officials typically have limited resources, training, or experience in the non-potable water field and are not in a position to provide guidance. Without appropriate guidance, municipal building officials may be less willing to issue permits, reinforcing the low uptake of non-potable water systems. In addition, professionals involved in design may not fully consider system longevity and ongoing operations, maintenance, and monitoring in management plans, leading to higher rates of system decommissioning after a short period of operation.

Capacity is also limited in terms of available regulator time for oversight (constrained by funding and available skilled regulators) and available qualified professionals, operators, and service providers.

Training is needed in order to fill the identified gap in experience and knowledge, but it is not widely available in the region at this time. The capacity of educational institutions and industry associations to provide good quality training and support services (e.g., tools, information, advice) with respect to non-potable water systems is limited and often fragmented.

In some cases, it is not clear which professional jurisdictions non-potable water systems fall into, how professionals can be trained, or how the work can be outsourced to specialists. While some tools and resources have been put in place, such as the recent Environmental Operators Certification Program (EOCP) Building Systems certification program, there is a need for upgraded standardized training in other areas (e.g., plumbing, mechanical, and wastewater programs). Training would provide:

- Clarity on best practices (e.g., commissioning, validation, and verification practices)
- An understanding of risk-based design and management
- A baseline understanding of what systems exist
- A consistent framework (e.g., design/approval process, documentation, and reference tools as per recommendation #1)

In addition to the barriers named above, the working group commented on the negative public perception of the use of non-potable water — given the current norm of using potable water for almost everything — and that this may result in resistance to adoption, particularly for multi-unit residential buildings or stratas. Finally, the working group suggested that alleviating these barriers may be a monumental task, and that knowing where to begin in terms of resource development will be difficult.

Lessons learned: An example of system decommissioning

A commercial office building in Metro Vancouver incorporated a rainwater and stormwater collection system that was designed for two end uses: irrigation and toilet flushing. The irrigation end use treatment consisted of particle filtration and recirculation, with municipal water top-up as required. The toilet flushing treatment had finer sediment filtration and a chlorination system, also with a bypass that allowed municipal water to flush toilets in event of the treatment system being down.

When visited, the chlorination system had been deactivated for a year. Inspection found a leaking connection between the chlorine feed tube and a fitting; as a result, the chlorine residual was unable to attain the desired concentration for the chlorine meter to shut off the chlorine injection system.

In this case, the facility operator did not have a good understanding of the system and had not realized there was a leak. Additionally, the contracted engineer focused on the chlorine pump and sensor, but failed to inspect the piping. This issue, which resulted in the system being decommissioned, could have been resolved by implementing a weekly checklist that requires visual inspection of the chlorine feed tubing for leaks and the replacement of a $7 fitting.

This provides an example of inadequate system documentation, training, and management that could be improved with broader industry capacity improvement.

4.4.2. Recommendations

The working group highlighted several opportunities to increase knowledge and awareness of non-potable water system best practices and approaches among both institutional and industry partners.

RECOMMENDATION 6: DEVELOP TRAINING MATERIALS AND A ROLL-OUT STRATEGY TO ACCOMPANY PROVINCE-WIDE STANDARDS, GUIDELINES, AND/OR REGULATORY CHANGES FOR INDUSTRY AND AUTHORITIES HAVING JURISDICTION.

This may include:

- Promote and expand the Environmental Operators Certification Program (EOCP) – Building Water Systems, which is a requirement under the *Vancouver Building Bylaw Book II* (Plumbing Code) Division B, Section 2.7, through professional associations (e.g., Engineers and Geoscientists BC, Applied Science Technologists and Technicians of BC, and Architectural Institute of BC) and other avenues.
- Expand resources and capacity-building through professional associations (e.g., Engineers and Geoscientists BC, Applied Science Technologists and Technicians of BC, Architectural Institute of BC, Building Officials Association of BC) and industry groups (e.g., Canadian Green Building Council, BC Water and Wastewater Association).
- Incorporate mandatory non-potable water training into the Continuing Professional Development Program credits through the Building Officials Association of BC.

- Incorporate mandatory non-potable water training into the Continuing Professional Development Program at both Engineers and Geoscientists BC and the Architectural Institute of BC.
- Identify other training opportunities to serve property managers and others (e.g., with BCIT/trade-technical colleges).
- Develop province-wide communication materials to encourage water conservation and use of non-potable water, see City of Vancouver example.
- Build capacity through regional Building Officials Association of BC wherein a resource team specializing in non-potable water systems is created and trained to support building officials within the region in their understanding and assessment of applications, regulations and standards. Opportunities for monitoring and evaluation

4.4.3. Findings

Monitoring and evaluation is central to the success of any program. While there is continuous monitoring technology with online capabilities, with the exception of the City of Vancouver, non-potable water systems in the region are not currently connected to centralized oversight or other evaluation systems. Additionally, members of the working group indicated that there is little local and regional data about the potential benefits of non-potable water systems as they expand, which can inform and support policy change. For example, such data would support the quantification and qualification of benefits associated with non-potable water systems, including water savings and reduced peak flows. Data would also support better understanding of different source qualities to inform risk management practices. The following opportunities support ongoing monitoring and evaluation, which could inform future policy development and aid in the continued adoption of non-potable water systems across Metro Vancouver and the province.

4.4.4. Recommendations

RECOMMENDATION 7: CONTINUE/EXPAND REGIONAL DATA AND RESEARCH ON NON-POTABLE WATER USE.

There is a growing body of research about the expected quality of different sources of water, and potential variations in that quality under different circumstances, that could inform risk assessment processes, selection of appropriate control measures, management categories, and level of oversight. This body of research will continue to grow as an increasing number of non-potable water systems are put into place, operated, monitored, and evaluated. There will be a need to monitor and regularly review new research and consider these in light of any risk assessment procedures in use.

There is an opportunity to continue research at the local level by engaging with research projects embedded within local academic institutions (e.g., University of British Columbia, Simon Fraser University, University of Victoria) and participating in programs such as the UBC sustainability scholar internship program and others.

RECOMMENDATION 8: INVESTIGATE OPTIONS TO DEVELOP A REGIONAL TRACKING MECHANISM FOR NON-POTABLE WATER SYSTEMS.

Although non-potable water systems are currently allowed by regulation, there is no tracking mechanism in place to monitor how many systems are installed, or their current state of operation. For example, through the recent updates to the City of Vancouver program, Vancouver has created an online portal that tracks all non-potable water systems in the city and provides a central place to upload monitoring results. Although operating permits are not yet on the table for other municipalities in the region, tracking the location and operational status of all new and existing non-potable water systems would be a strong starting point for future management and regulation of these systems. It could also provide insight into the benefits for improving regional resilience.

- Note that a nation-wide system is being developed in the US that could serve as a model or possibly be extended to include this region.

RECOMMENDATION 9: INVESTIGATE MECHANISMS TO ENCOURAGE MONITORING AND REPORTING OF NON-POTABLE WATER SYSTEMS IN OPERATION.

Voluntary monitoring and reporting may be explored through established green building rating systems. These systems often do not include provisions for ongoing monitoring and reporting to maintain certification during operation, thus, this may be a new approach for these programs. As a voluntary approach, there is no way to ensure ongoing participation.

LEED provides some examples of credits that extend into commissioning (e.g., LEED v4 BD+C Fundamental commissioning and verification prerequisite, and Enhanced Commissioning credit) and operation (e.g., LEED v4 BD+C Water Metering credit). This approach would require concerted effort and time.

Alternatively, provisions for monitoring and reporting can be explored through local government policies, in a similar manner as is currently being explored for tracking energy use and greenhouse gas emissions from buildings as part of climate action policies.

Lessons learned: An example of identifying errors in commissioning and transfer that caused a system to be non-functional system for over a year

A recreation centre uses rainwater for toilet and urinal flushing and as a top-up for the pool water. Despite being a complex building, the system design was fairly simple, and employed sensors to allow for clear tracking of issues. Upon construction, the operations transitions team was engaged to act as the knowledge transfer conduit to the facility operations staff.

After transfer, the facility operators recognized that the system was non-functional because a depth sounder continually read an empty tank. On investigation it was found that the plumbing contractor had installed valves incorrectly, which led to waters entering the tank being automatically released to storm sewers, and left the non-potable water system non-functional for approximately a year.

A more fulsome commissioning that required mimicking rainfall collection with outside water inputs would have demonstrated the defect while the plumbing contractor was still engaged in the construction, and would have avoided the troubleshooting required after the fact. Proper commissioning as part of conditions of sign-off for contractors is indispensable.

4.5. Need for Ongoing Coordination Across Agencies

4.5.1. Findings

Non-potable water systems sit in a complex regulatory and policy realm where multiple organizations are involved. As a result, there is no comprehensive approach to support the broader uptake of non-potable water systems. Through this process, multiple agencies were identified to actively participate in the working group, however, there is no ongoing forum for this coordination.

4.5.2. Recommendations

RECOMMENDATION 10: ESTABLISH A FORUM TO HOST ONGOING COORDINATION ACROSS REGULATORS, POLICY DEVELOPERS, AND OTHER KEY STAKEHOLDERS.

Metro Vancouver took a first step by convening the working group to conduct this initial assessment of barriers to and opportunities for advancing the installation and ongoing operation of non-potable water systems in the region. However, the Non-Potable Water Use Project had a distinct set of deliverables, including the guidebook and this document.

Many of the barriers and opportunities identified necessitate continued work and would benefit from a broader province-wide process. The working group acknowledge their shared interest in advocating for and supporting non-potable water systems, and participants support continued collaboration as a group. Participants noted the need for an ongoing forum or working group to continue advancing this work.

Establishing a forum to continue the work started through this process is important to support the continued and broader uptake of non-potable water systems in a manner that ensures they are implemented safely and with longevity. Through the exploration, evolution, and implementation of these recommendations, non-potable water systems can play an important role in increasing the resilience of our built environment to the current and future changes to our climate.

5. Conclusion

Improving the use of on-site sources of non-potable water in this region can support local and regional sustainability, water conservation, and climate adaptation goals. The working group identified ten recommendations to support the advancement of these systems, ranging from local and regional policy changes, to enhanced data, monitoring and evaluation, to significant longer-term changes to the provincial regulatory framework. Continuing to advance this work will require ongoing collaboration of a broad cross-section of regulatory and non-regulatory organizations.

The working group identified immediate next steps that will support the continuation of this work, including:

- Working group members bring this document and the identified barriers and opportunities back to their organizations for review and inclusion in future policy, regulatory, and programmatic developments.
- Working group members, assisted by project consultants Pinna Sustainability, identify and reach out to additional organizations to gauge interest and ability to continue or establish a new multi-lateral group to advance the opportunities identified in this document. For example:
    - Engage the Ministry of Municipal Affairs and Housing, alongside the Union of BC Municipalities, who spearhead climate action and building resilient communities.
    - Investigate the alignment or potential integration with the existing federal-provincial Climate-Resilient Buildings and Core Public Infrastructure Initiative.
- Engage with Natural Resources Canada to learn more about the work being conducted to compile a report on the state of Disaster Risk Reduction (DRR) in BC.
- Metro Vancouver, facilitated by Pinna Sustainability, will reconvene the working group to provide updates, report back, and learn from the outcomes of this document, the guidebook and companion document. This process will also include ongoing engagement and outreach to support the continued evolution of this initiative and the working group.

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Additional references used to inform this work can be found in *Non-Potable Water Systems: A Guidebook for the Metro Vancouver Region*.

Appendix 1: Glossary

The following terms include a mixture of definitions directly quoted or adapted from other relevant sources, and, where necessary, original definitions are provided to most accurately represent the terminology in the context of Metro Vancouver.

Authority having jurisdiction (AHJ): An organization, office, or individual having statutory responsibility for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. (Indigenous Services of Canada)

"Fit-for-purpose" use: Water source(s) of adequate quantity is matched to an end use (or uses) and is treated only to the extent needed to meet end use quality requirements.

Greywater: Wastewater from the preparation of food and drink, dishwashing, bathing, showering, and general household cleaning and laundry. Greywater does not mean "reclaimed water". (BC Ministry of Health, 2016)

- **Dark greywater:** Greywater flowing from kitchen, dishwashing, and mop sink uses.
- **Light greywater:** Greywater flowing from uses other than kitchen, dishwashing, or mop sinks. Example, shower water or laundry greywater.
- **Very light greywater:** Wastewater from showers, baths, hand basins. Light greywater excluding laundry water.
- **Laundry greywater:** Greywater flowing from washing machines and laundry sinks.

Groundwater: Water naturally occurring below the surface of the ground. (BC *Water Sustainability Act*)

Management category: A category defining the level of pathogen and process malfunction risk associated with a particular non-potable water system, leading to the establishment of management requirements for the system.

Non-potable water: Water that is not of drinking water (potable) quality, but may be used for other purposes.

Non-potable water system: A system which collects, treats, stores, and distributes non-potable water.

Non-potable water sources: Typical non-potable water sources include: clear water waste, foundation drainage water, greywater, groundwater (in specific contexts only*), rainwater, stormwater, and vehicle wash wastewater. *Groundwater is considered a potential non-potable water source only in contexts where the building intersects with a source of groundwater and the groundwater would otherwise be considered a nuisance to be disposed of through the stormwater system.

Non-potable water use: Utilization of treated or untreated non-potable water in buildings or outside of buildings for purposes other than drinking water supply, providing the non-potable water meets applicable water quality standards. Examples include flushing toilets, irrigating lawns and gardens, washing vehicles, and washing clothes. (Adapted from CSA B128.1-06/.2-06)

Responsible management entity (RME): A person, corporation, NGO, or governmental body with ultimate legal responsibility for the performance of a non-potable water system. (Sharvelle et al., 2017)

Risks: The effect of uncertainty on objectives. In context to health risk from *non-potable water systems*, the potential that chemicals or micro-organisms will reach a person at harmful doses depending upon that person's actual means of exposure and level of exposure. (Adapted from Engineering and Geoscientists BC, 2018)

Roof run off: Rainwater that is intercepted by an elevated impervious roof surface that is not subject to pedestrian access. (CSA B805-18)

Stormwater: Water that is discharged from a surface as a result of rainfall or snowfall that is not roof run off. (Adapted from BC Building Code and CSA B805-18)

Surrogate (for verification monitoring): A biological, chemical or physical marker of the efficacy of a process step (Sharvelle et al., 2017).

Uptake: The action of taking up, adopting, or implementing something that is available – in this scenario, non-potable water systems.

Vehicle wash wastewater: Water that is generated from washing domestic or light commercial vehicles, with little to no animal and/or agricultural transport or exposure. (Adapted from Alberta Health Services, 2021)

Verification: Monitoring of surrogates to confirm that the system continues to operate as planned, or to control or prompt diversion of water, process adjustments, and other actions.

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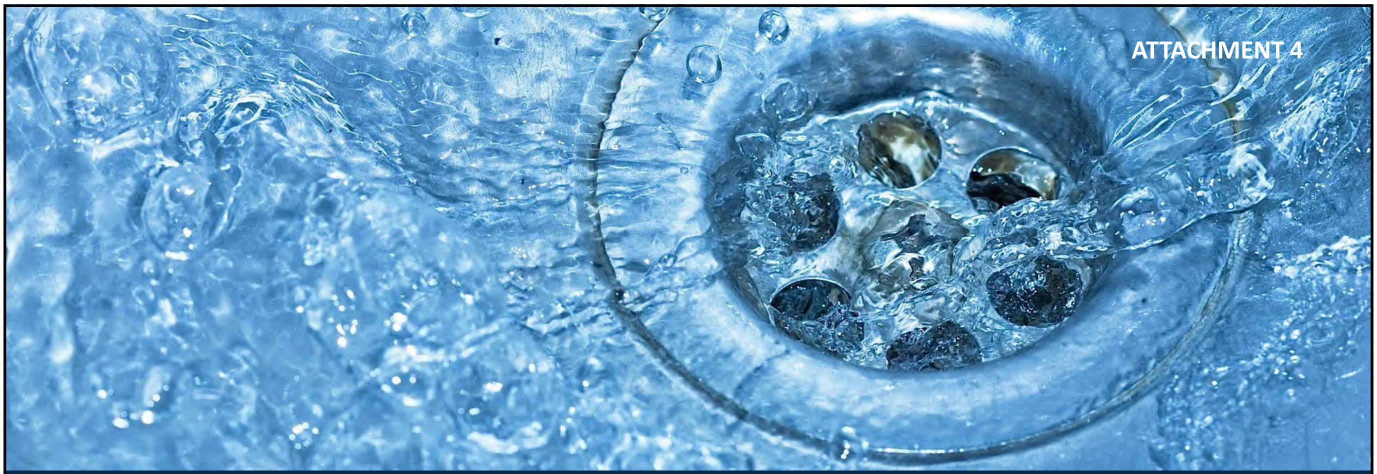
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

ATTACHMENT 4



Draining Water

Non-Potable Water Project

UPDATE

Linda Parkinson

Director, Policy, Planning, and Analysis, Water Services

Water Committee - June 14, 2023

59385797

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BACKGROUND

- Pressures on the water system
  - A changing climate
  - Population growth
- Summer residential water demand for non-potable end uses can reach up to 75% of demand
- Water Sustainability Innovation Fund project

PROJECT OBJECTIVE

This Sustainability Innovation Fund project aims to support the uptake of on-site non-potable water systems (water reuse and rainwater harvesting) in the region to reduce the use of drinking water for non-potable uses.

BENEFITS OF NON-POTABLE WATER USE

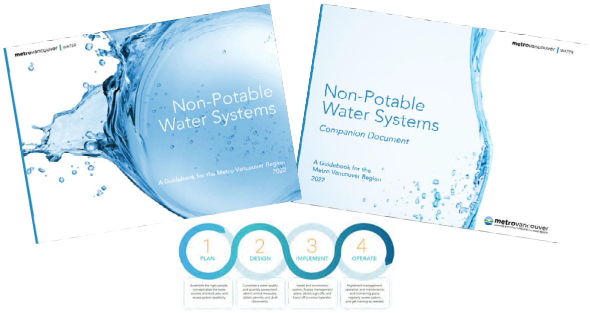
- Assist in reducing drinking water demand, and wastewater and stormwater collection
- Increase climate resilience
- Support sustainable building certification

Capilano Reservoir during the warm, dry fall of 2022

METHODOLOGY

- Convened the Non-Potable Water Working Group to:
  - Identify barriers to non-potable water use
  - Identify opportunities and strategies to overcome barriers to system uptake
- Conducted research to inform the guidebook, companion document, and key findings document
- Developed Case studies

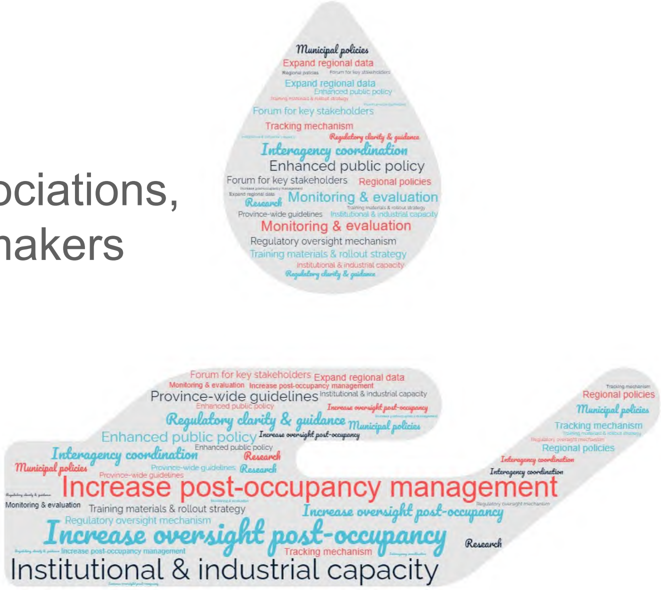
GUIDEBOOK & COMPANION DOCUMENT



- Audience – building owners, developers, architects, and other industry professionals
- Outlines best practices and resources at each stage from planning and design through implementation to operations and maintenance

KEY FINDINGS DOCUMENT

- For regulatory agencies, governments, technical associations, and other potential changemakers
- Identifies barriers to uptake of non-potable water systems and recommends strategies and actions to overcome barriers



NEXT STEPS

- Distribute the guidebook, companion document, and key findings document
- Continue engagement and collaboration with industry stakeholders to work towards increased non-potable water use in the region
- Identify an appropriate agency or level of government to own and action the key findings document

Water Droplets

TOGETHER
WE MAKE OUR REGION
STRONG

Questions?

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SERVICES AND SOLUTIONS FOR A LIVABLE REGION

To: Water Committee

From: Ian Manning, Director, Dam Safety, Water Services

Date: May 16, 2023 Meeting Date: June 14, 2023

Subject: **2022 GVWD Dam Safety Program Annual Update**

RECOMMENDATION

That the Water Committee receive for information the report dated May 16, 2023, titled "2022 GVWD Dam Safety Program Annual Update".

EXECUTIVE SUMMARY

The GVWD owns and operates seven dams that are regulated by the Ministry of Forests – Dam Safety Branch, five of which are regional drinking water supply dams and two of which store water for ecological and recreational purposes. The GVWD Dam Safety Program is compliant with the requirements outlined in the provincial Dam Safety Regulation (BC Reg. 11/2021) for the water supply dams, as required for all dam owners in British Columbia. There were no significant concerns identified from the 2022 routine surveillance, monitoring, or formal dam inspections.

PURPOSE

To provide the Water Committee with an annual update on dam safety activities associated with the Cleveland, Seymour Falls, Palisade, Burwell, Loch Lomond, Rice Lake North, and Rice Lake South dams.

BACKGROUND

The GVWD dam safety team monitors and reviews the performance of seven dams to ensure they remain safe and to ensure the five GVWD water supply dams continue to provide reliable sources of drinking water. A dam surveillance consultant is retained to carry out third party review and report on dam monitoring and inspection activities. The dam safety team supports the goals and initiatives of the Board Strategic Plan and Drinking Water Management Plan through contribution to the provision of clean, safe, drinking water and ensuring the long-term financial and functional resilience of the dams.

GVWD DAMS

Cleveland Dam and Seymour Falls Dam

Cleveland Dam is a 92-metre-high concrete gravity dam that impounds Capilano Reservoir. Seymour Falls Dam is a 30 m high composite concrete and earth fill dam that impounds Seymour Reservoir. Both dams include discharge outlets to release water downstream to their respective rivers, as well as water supply intakes to convey water for treatment at the Seymour Capilano Filtration Plant. The reservoir areas upstream of the dams are kept clear of debris with a series of booms that float on the reservoir surface preventing the passage of debris towards the dams and associated intakes.

Alpine Lake Dams

The three alpine lake dams (Palisade, Burwell, and Loch Lomond dams) are located within the Capilano and Seymour watersheds and range in height from 5.8 m to 8.2 m. Palisade and Burwell Dams are rock fill dams with concrete slabs on their upstream faces, while Loch Lomond Dam is a vertical-face concrete dam. All three alpine lake dams include spillways and discharge outlets that allow for the release of water to their respective downstream reservoirs. Palisade Lake discharges to the Capilano Reservoir. Burwell and Loch Lomond Lakes discharge to the Seymour Reservoir. The alpine lakes are primarily used to augment the summertime storage capacity of the two downstream water supply reservoirs.

Rice Lake Dams

The two Rice Lake dams are located at the north and south ends of Rice Lake within the Lower Seymour Conservation Reserve (LSCR) in North Vancouver. Metro Vancouver operates and maintains the LSCR for future water supply purposes as well as its ecological and recreational values. The Rice Lake North Dam is a 5.5 m high earth fill dam and includes an overflow spillway. The Rice Lake South Dam is 7.5 m high earth fill dam. The Rice Lake dams were constructed in the late 1950s to provide a supplemental drinking water supply for the City of North Vancouver. The function of Rice Lake as a drinking water supply source ceased in the 1980s and it has since been used for recreational purposes (e.g.: public walking trails, floating dock, and fishing).

DAM SAFETY COMPLIANCE

Cleveland Dam and Seymour Falls Dam fall under the “extreme consequence” classification of the provincial Dam Safety Regulation. The three alpine lake dams fall under the “significant consequence” classification, and the two Rice Lake dams have been assigned a provisional “very high consequence” classification. The following work was completed in 2022 to ensure continued compliance with the Dam Safety Regulation:

- Weekly site surveillance, at a minimum, was carried out at Cleveland and Seymour Falls Dams.

- Weekly site surveillance was carried out at the Rice Lake dams.

- Monthly site surveillance is typically required at significant consequence dams, unless otherwise specified in the *Operation, Maintenance, and Surveillance* (OMS) Manual. Given their remote locations and winter helicopter access restrictions, the alpine lake dams were periodically inspected by staff in accordance with the OMS Manual between July and October.

- Semi-annual formal inspections were completed for Cleveland Dam and Seymour Falls Dam. Annual formal inspections were completed for the alpine lake dams and Rice Lake dams.

- Annual test operation of mechanical, electrical, and communications components was completed for all five water supply dams. There are currently no mechanical, electrical, or communications components at the Rice Lake dams.

- Cleveland Dam and Seymour Falls Dam instrumentation readings were collected at various intervals, ranging from daily to annual. Data from instrumentation at the Rice Lake dams was collected weekly. The data from instrumentation at the alpine lake dams was reviewed daily.

- Annual review of contact information in the *Emergency Response Plan* (ERP) / *Ancillary Response Plan* (ARP) is required, and if necessary, revision and submission to the Provincial Dam Safety Officer. The internal and external contact information for Cleveland Dam, Seymour Falls Dam, and the alpine lake dams was reviewed in the winter of 2022, and re-submitted to the Dam Safety Officer as part of ERP revisions in February 2023. An ARP for the Rice Lake dams will be issued in 2023.

- At a minimum, the OMS Manual and ERP for extreme and very high consequence dams must be reviewed every seven years and revised and reported to the Dam Safety Officer, if necessary. A revised Cleveland Dam OMS manual was issued in June 2022. Revisions to the Seymour Falls Dam OMS manual and to the Cleveland Dam and Seymour Falls Dam ERP documents were ongoing in 2022 and revised versions will be issued in 2023. Various engagement activities were on-going throughout 2022 to improve emergency coordination with all Cleveland Dam and Seymour Falls Dam external ERP plan holders. An OMS Manual and ARP for the Rice Lake dams will be issued in 2023.

- At a minimum, the OMS Manual and ARP for significant consequence dams must be reviewed and revised every ten years and reported to the Dam Safety Officer, if necessary. Information pertaining to the alpine lake dams was last revised and reported in July 2016.

- A formal dam safety review must be carried out, with the report submitted to the Dam Safety Officer every seven years for extreme consequence dams, and every ten years for very high consequence dams. The last dam safety review for Cleveland Dam was completed in 2016, and no unsafe or unacceptable conditions in relation to the design, construction, or operation were identified. The next review will commence in 2023. The last dam safety review for Seymour Falls Dam commenced in 2021, with a final report to be issued in 2023. The draft report concluded that Seymour Falls Dam is reasonably safe, operated safely, maintained in a safe condition, and that surveillance is adequate to detect any developing safety problems. Detailed hydrotechnical and geotechnical engineering assessments for the Rice Lake dams were carried out in 2022, and a formal dam safety review for the Rice Lake dams will be conducted in 2025.

- A formal dam safety review is not required for significant consequence dams. To be proactive, a dam safety review was carried out for the alpine lake dams in 2012, with results indicating the dams are being operated and maintained in a satisfactory manner. Another dam safety review is planned for 2026.

- Formal dam audits are carried out every five years by the provincial Dam Safety Officers at Cleveland and Seymour Falls Dams. The last formal dam audit was carried out in 2020. The audits noted the safety incident that occurred at Cleveland Dam on October 1, 2020. No other significant concerns or comments were provided.

RICE LAKE DAMS ACTIVITIES

In a recent review of the regulatory and maintenance requirements for the Rice Lake dams, staff identified the need for hydrotechnical and geotechnical engineering assessments, as well as a need to update their consequence classifications under the BC Dam Safety Regulation. This work commenced in spring 2022 and will be completed in 2023.

The review also identified the need for a new provincial water licence that better reflects Rice Lake's function as a water storage facility for ecological and recreational purposes. In support of the water licence application, and general asset management, staff also identified a need for an archaeological impact assessment which commenced in 2022. Tree removal in the areas around the dams was completed in early 2023. Other maintenance activities and restoration work will commence in 2023. Staff actively engaged with the public in 2022 to create awareness about the dams, discuss required tree removal, and seek input into options for restoring the area for recreational purposes.

CLEVELAND DAM SAFETY ENHANCEMENTS

The Cleveland Dam Safety Enhancements program was initiated in 2021 and involves the identification and management of various initiatives to improve the safety and reliability of the dam. The safety enhancements program includes:

- Dam Safety Advisory Panel meetings with external technical experts to discuss improvements to the operations and maintenance of Cleveland Dam and the dam spillway gate, as well as issues involving public safety around dams.

- The Cleveland Dam Drum Gate Return to Service project was completed in June 2021. A follow-up project commenced in late 2021 and continued through spring 2022 to address other enhancements. Notable enhancements completed include spillway gate emergency raise function, improvements to backup power sources, and improved monitoring of the spillway gate while in operation.

- The Cleveland Dam Interim Public Warning System project started in 2021, with six of seven public warning systems installed along the Capilano River. The Cleveland Dam Public Warning System and Enhancements project started in 2022 to install comprehensive public safety enhancements, including a public education campaign, additional signage and the permanent public warning system.

- Public engagement started in 2021 on the public warning system, and in summer 2022 staff and consultants collected additional input from river users and the general public to help inform the design of the permanent safety enhancements.

- The Cleveland Dam Safety Enhancements Program will be carried out from 2022 to 2024, with activities including a river users study, river hydraulic and hazard modelling, updated public safety risk assessment, and the design and construction of site specific safety features including the permanent public warning system.

INTERIM CORPORATE DAM SAFETY POLICY

The Metro Vancouver Corporate Planning Committee directed Water Services Dam Safety staff to lead the development of a formal dam safety policy, and to propose a framework for a centralized approach for dam safety activities. On December 9, 2022, the new Interim Corporate policy on Dam Safety was approved. The purpose of this policy is to outline the principles and responsibilities for dam safety and public safety for all dams owned by Metro Vancouver, and to ensure the consistency in corporate approach to manage risks associated with the dams.

Work commenced in 2023 to secure the required financial and staffing resources for a centralized dam safety team. This will be followed by training and a phased transition of dam safety activities for all dams owned by Water Services, Liquid Waste Services, Solid Waste Services, and Regional Parks to the centralized dam safety team in 2024.

DAM ASSET CONDITION

The five drinking water supply dams and two Rice Lake dams are regularly maintained and upgraded to ensure they remain in good operating condition and to extend their service life. Issues are identified through surveillance, inspections, assessments, and independent expert reviews. Improvement projects are prioritized and incorporated into GVWD's operating and capital financial planning process.

ALTERNATIVES

This is an information report. No alternatives are presented.

FINANCIAL IMPLICATIONS

There are no financial implications arising from this report. The cost of routine surveillance, monitoring, and inspection activities form part of the Water Services annual operating budget.

CONCLUSION

The GVWD Dam Safety Program is compliant with the requirements of the provincial Dam Safety Regulation for the water supply dams. No significant concerns were identified by the GVWD dam safety team or dam surveillance consultant from the 2022 routine surveillance, monitoring, and formal dam inspections. A review of the regulatory and maintenance requirements for the Rice Lake dams identified the need for new engineering assessments and a new provincial water licence that better reflects Rice Lake's function as a water storage facility for ecological and recreational purposes. This work commenced in spring 2022 and will be completed in 2023.

Attachments:

1. Photos of the GVWD Water Supply Dams and Other GVWD Dams
2. Presentation re: 2022 GVWD Dam Safety Program Annual Update (Orbit No. 59919721)

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GVWD Water Supply Dams:
Cleveland Dam

Seymour Falls Dam

Palisade Dam

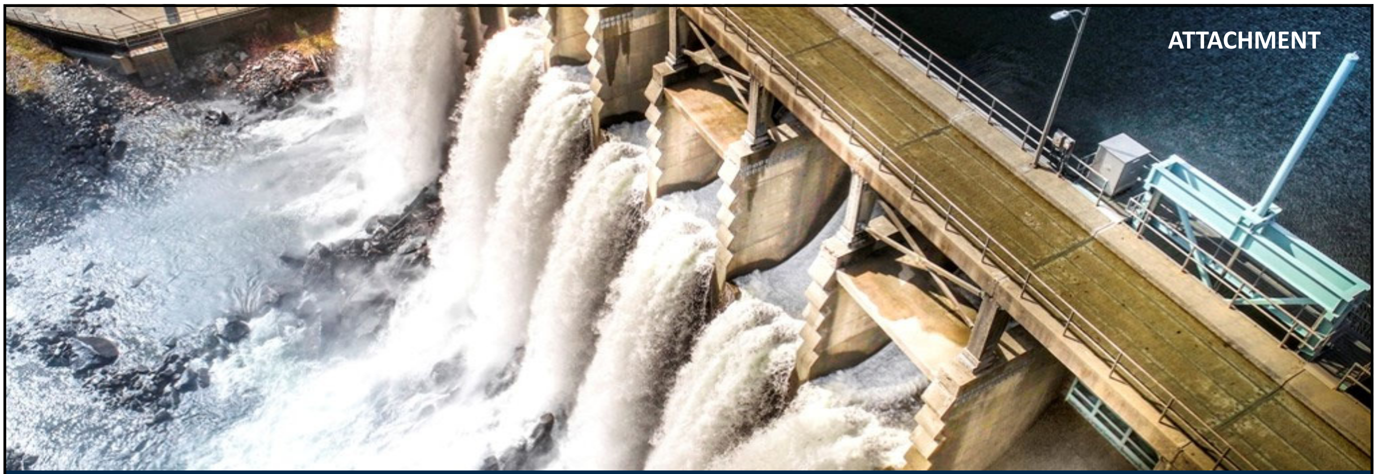
Burwell Dam

Loch Lomond Dam

Other GVWD Dams:

Rice Lake North Dam

Rice Lake South Dam



ATTACHMENT

Seymour Falls Dam Spillway

2022 GVWD Dam Safety Program Annual Update

Ian Manning

Director Dam Safety, Water Services

Water Committee – June 14, 2023

59919721

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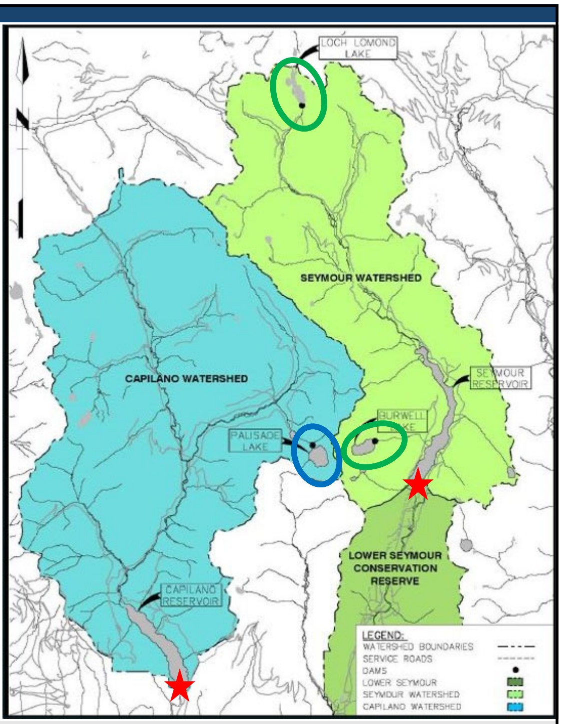
EXECUTIVE SUMMARY

- GVWD owns Seven Regulated Dams
- Ministry of Forests - Dam Safety Regulation
- No significant concerns identified in 2022

Seymour Falls Dam

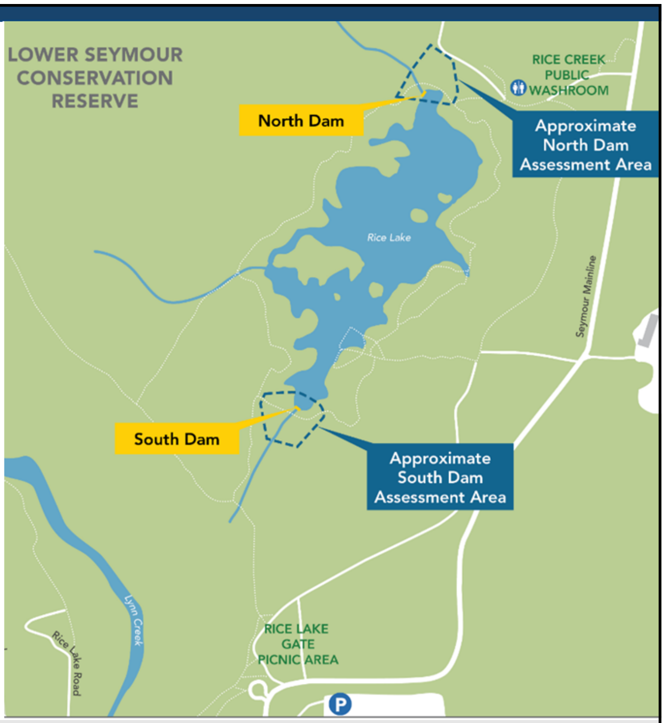
WATER SUPPLY DAMS

- Primary Water Supply Dams
  - Cleveland Dam
  - Seymour Falls Dam
- Alpine Lake Dams
  - Palisade Dam
  - Burwell Dam
  - Loch Lomond Dam



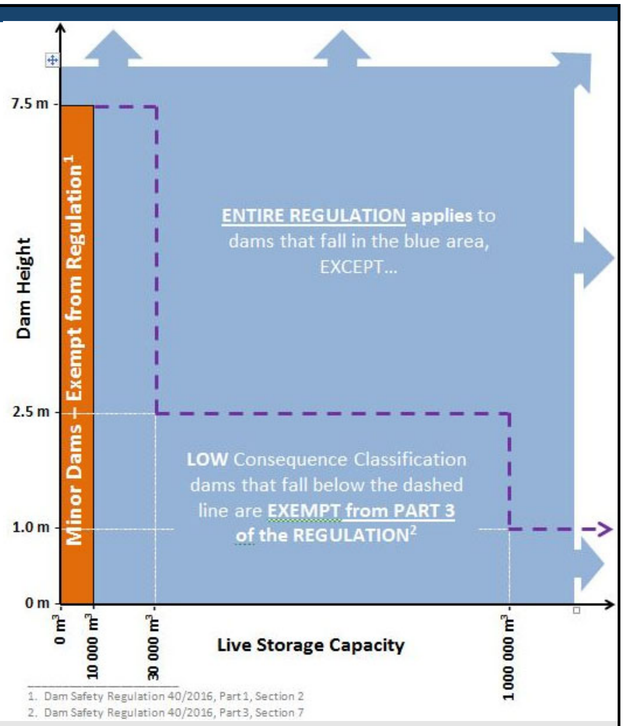
RECREATIONAL PURPOSE DAMS

- Rice Lake Dams
  - North Dam
  - South Dam



PROVINCIAL DAM SAFETY REGULATION

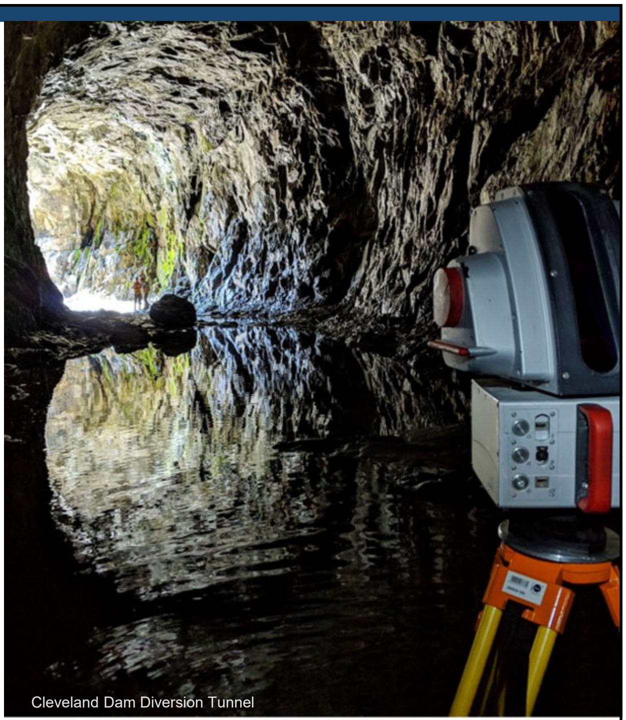
- Site Surveillance
- Formal Inspections
- Operational Testing
- Instrumentation Readings
- Regulatory Documents
- Formal Dam Safety Reviews



1. Dam Safety Regulation 40/2016, Part 1, Section 2
2. Dam Safety Regulation 40/2016, Part 3, Section 7

SITE SURVEILLANCE AND FORMAL INSPECTIONS

- Site Surveillance
  - Weekly to monthly
- Formal Inspections
  - Semi-Annual or Annual
- No significant concerns identified in 2022


Cleveland Dam Diversion Tunnel

TEST OPERATION AND INSTRUMENT READINGS

- Test Operation
  - Annual
- Instrument Readings
  - Annual
- No significant concerns identified in 2022

Cleveland Dam East Abutment Instrument Readings

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REGULATORY DOCUMENTS AND DAM SAFETY REVIEWS

- Regulatory Document Review
  - Seven to Ten Years
- Annual Review of Contact Information
- Formal Dam Safety Reviews
  - Seven to Ten Years

Burwell Dam

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CLEVELAND DAM SAFETY ENHANCEMENTS

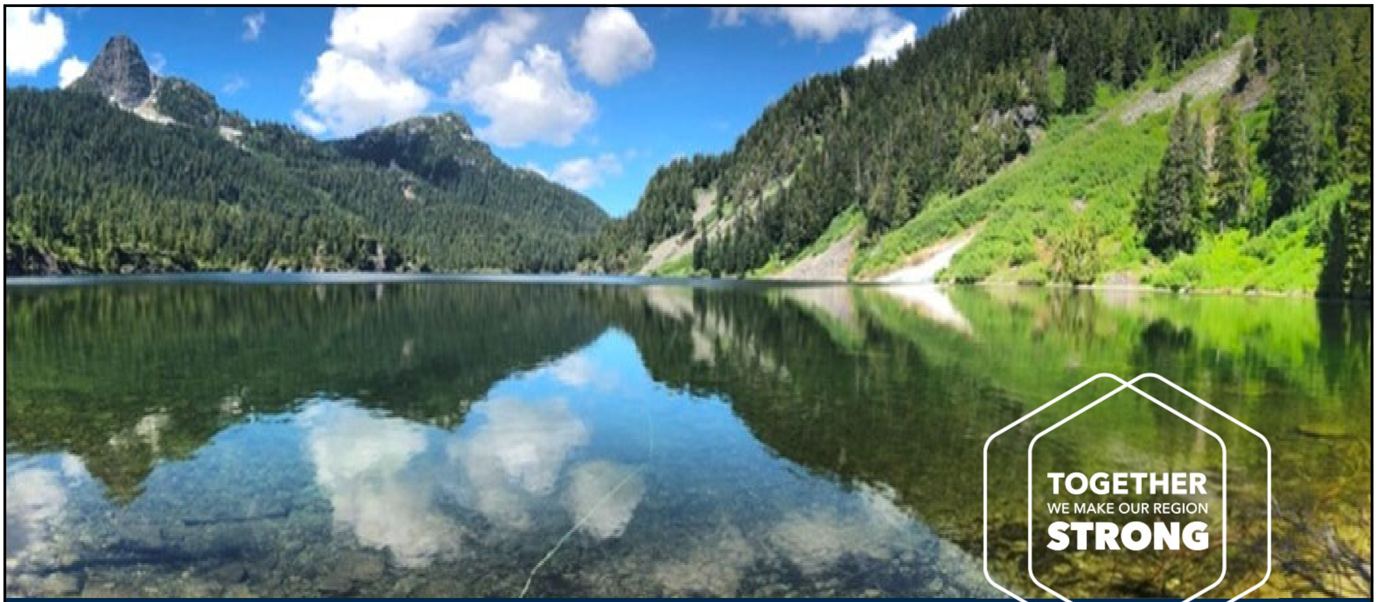
- Dam Safety Advisory Panel
- Drum Gate Return to Service
- Interim Public Warning System
- Public Engagement
- Cleveland Dam Safety Enhancements Program

Cleveland Dam Spillway

INTERIM DAM SAFETY POLICY AND CENTRALIZED MODEL

- Interim Corporate Dam Safety Policy
- Effective December 9, 2022
- Transition to Centralized Dam Safety Model in 2024

Seymour Reservoir



Loch Lomond Lake

Thank You

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To: Water Committee

From: Daniel Roberge, Deputy GM Operations, Water Services

Date: May 23, 2023 Meeting Date: June 14, 2023

Subject: **Capilano Main No. 4 Repairs and Upcoming Replacement Project**

RECOMMENDATION

That the Water Committee receive for information the report dated May 23, 2023, titled "Capilano Main No. 4 Repairs and Upcoming Replacement Project".

EXECUTIVE SUMMARY

Metro Vancouver's Capilano Main No. 4 is an aging water main that supplies approximately one third of the region under normal operating conditions. A 1.4 kilometre section of Capilano Main No. 4 runs through Stanley Park and was installed in 1932. Recent leak history, including a leak discovered on May 10, 2023, has highlighted the importance of the construction of the Stanley Park Water Supply Tunnel which will replace this section of Capilano Main No.4 and provide additional capacity and seismic resiliency.

PURPOSE

To inform the Water Committee of the on-going maintenance required for aging linear assets such as the Capilano Main No. 4 and, in turn, the importance of the Stanley Park Water Supply Tunnel capital project.

BACKGROUND

A leak was discovered on the Capilano Main No. 4 in Stanley Park on May 10, 2023. The leak proved to be a challenging repair and highlights the importance of the upcoming Stanley Park Water Supply Tunnel project.

CONTEXT

Metro Vancouver's Capilano Main No. 4 runs from a line valve chamber at Edgemont Boulevard and Capilano Road on the North Shore to the Little Mountain Reservoir in Vancouver and is a critical component of the regional water supply system. Under normal operating conditions, it conveys drinking water from north to south and supplies the west side of Vancouver, as well as parts of Richmond, Delta, Tsawwassen First Nation, and Point Roberts (USA). The steel water main was constructed in 1932 and is currently 91 years old.

The section of Capilano Main No.4 running through Stanley Park is of critical importance as it is a single supply main with no redundancy and its existing alignment is through an environmentally sensitive area. This section of the water main is 1.4 km in length and 1.8 m in diameter with peak daily flows of up to 500 million liters at 180 PSI (pounds per square inch). Capilano Main No. 4 has seen approximately seven leaks since 2000 along the Stanley Park section. Due to its criticality, age, and leak history, this section of water main is nearing the end of its service life. Using our Asset Management methodology, the condition of the main is assessed to be poor indicating it is prioritized for replacement.

A major leak occurred in August 2016 adjacent to Lost Lagoon and during the subsequent repair, corrosion of the pipe was identified together with the presence of conductive soil indicating salt water contamination. Following this leak, Metro Vancouver began planning for the replacement of this section of water main with a new water supply tunnel which will be bored under Stanley Park.

RECENT LEAK REPAIR

On May 10, 2023, Metro Vancouver confirmed a leak on Capilano Main No. 4 in Stanley Park close to the intersection of Pipeline Road and Rose Garden Lane. Metro Vancouver staff responded quickly to mitigate the environmental impacts of the leaking drinking water and began planning for the repairs. A three-meter deep excavation on Pipeline Road was required to safely access and repair the leak.

The water leaking from the water main was dechlorinated, tested, and monitored for the duration of the leak repair to ensure no chlorinated water was discharged to the environment. Due to the high demand for water and unseasonably hot weather in mid-May 2023, any isolation of the Stanley Park section of the Capilano Main No.4 during this period would affect water supply to the City of Vancouver’s second largest pressure zone, which services the West End, Downtown Vancouver and Kitsilano. To minimize impacts to drinking water supply in the City of Vancouver, the main remained in service during the repair. Contingency and isolation plans were developed in the event that a shutdown of the water main became necessary.

Metro Vancouver worked closely with the City of Vancouver Engineering and Park Board staff to coordinate the water main repair, minimize impacts on vehicle traffic, parks users, and communicate possible work related impacts.

STANLEY PARK WATER SUPPLY TUNNEL

To safeguard supply, meet growing demand for drinking water in the region and improve the system’s overall seismic resiliency, Metro Vancouver is planning to construct the Stanley Park Water Supply Tunnel below the surface of Stanley Park from the First Narrows crossing south shaft to the intersection of Chilco and Alberni Streets. The project is currently in the long-range plan and is at the detailed design stage. The new tunnel will replace the aging Capilano Main No.4 within Stanley Park and is planned to be in service by 2029. Any schedule delays in implementation of the Stanley Park Water Supply Tunnel project will result in additional risk to the water supply in the region and should be avoided where possible.

ALTERNATIVES

This is an information report. No alternatives are presented.

FINANCIAL IMPLICATIONS

This is an information report. No financial implications are presented.

CONCLUSION

The Capilano Main No. 4 is near end of its operational service life and is critical for drinking water supply to the western areas of the region. Metro Vancouver is actively maintaining this piece of aging infrastructure to ensure uninterrupted drinking water supply to the region as seen with the most recent leak repair. The Stanley Park Water Supply Tunnel project planned to be in service by 2029, will provide increased capacity and seismic resiliency. Any schedule delays in implementation of the Stanley Park Water Supply Tunnel project will result in additional risk to the water supply in the region and should be avoided where possible.

Attachment:
Presentation re: Capilano Main No. 4 Repairs and Upcoming Replacement Project (*60210963*)

60099619

ATTACHMENT

View of Burrard Inlet and Stanley Park

Capilano Main No. 4 – Stanley Park Leak

Daniel Roberge

Deputy GM of Operations, Water Services

Water Committee - June 14, 2023

60210963

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CAPILANO MAIN NO. 4 – STANLEY PARK SECTION

- Built in 1932 (91 years old)
- Services one third of the region
- 1.8 m diameter welded steel pipe
- 180 psi operating pressure
- 500 MLD peak daily flows
- No redundancy in this section
- 7 leaks since 2000
- Condition of main is assessed to be ‘poor’ – prioritized for replacement

1932 Construction

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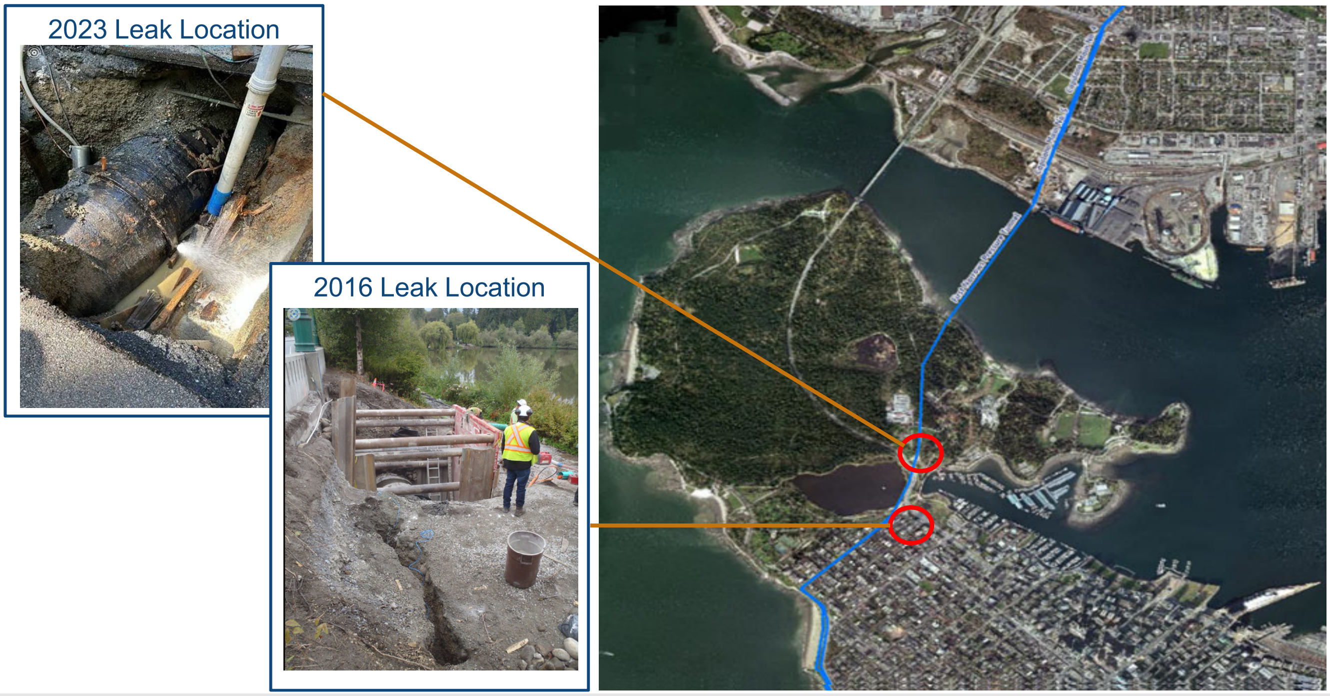


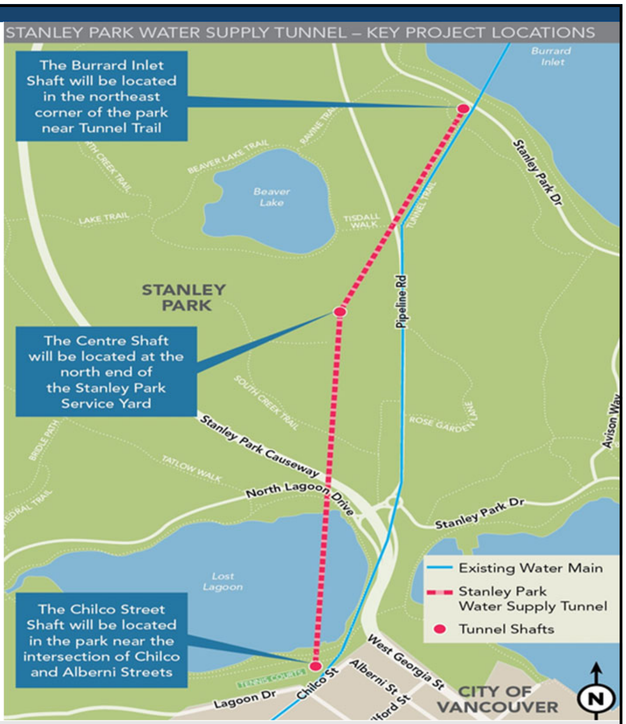
CAPILANO MAIN NO. 4 – 2023 LEAK REPAIR

- Leak confirmed on May 10, 2023
- Metro Vancouver crews responded quickly to minimize environmental impacts
- Three meter deep excavation
- Cause of leak was corrosion
- Isolation was not possible so repair was done on pressurized pipe
- Worked closely with the City of Vancouver and Park Board staff


Stanley Park Leak Repairs Sites

STANLEY PARK WATER SUPPLY TUNNEL

- To replace aging Capilano Main No 4
- 2.6 m diameter steel pipe to be installed within a tunnel 30 – 50 m below ground
- Schedule:
- 2022 – Start of detailed design
- 2024 – Start of construction
- 2029 – Planned to be in service


STANLEY PARK WATER SUPPLY TUNNEL – KEY PROJECT LOCATIONS

The Burrard Inlet Shaft will be located in the northeast corner of the park near Tunnel Trail

The Centre Shaft will be located at the north end of the Stanley Park Service Yard

The Chilco Street Shaft will be located in the park near the intersection of Chilco and Alberni Streets

Capilano Main No.4 2023 Leak Repair – Welding of Permanent Repair

Questions?

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SERVICES AND SOLUTIONS FOR A LIVABLE REGION

5.4

To: Water Committee

From: Murray Gant, Director, Major Projects, Project Delivery

Date: May 25, 2023 Meeting Date: June 14, 2023

Subject: **Water Supply Tunnel Projects Updates**

RECOMMENDATION

That the Water Committee receive for information the report dated May 25, 2023 titled "Water Supply Tunnel Projects Updates".

EXECUTIVE SUMMARY

Over the next 30 years, one million people will join the region's existing 2.8 million residents and Metro Vancouver's long-term plans ensure there will be enough water for future generations by promoting conservation, improving transmission, and expanding supply.

Metro Vancouver has a total of six major water supply tunnels in various stages of design and construction which are being managed and delivered by the Project Delivery department. These high risk, high value, complex tunnel projects are critical components of the water transmission system and are being designed and constructed to withstand a major earthquake, to protect against scour and other marine activities, and to meet projected future drinking water demands in the region.

Once complete, these projects will significantly contribute to Metro Vancouver's goals to ensure that the transmission components of the drinking water system are expanded and strengthened to allow the continued supply of safe, clean drinking water to the region's residents and businesses.

PURPOSE

The purpose of this report is to provide an update on the status and progress of the water supply tunnel projects.

BACKGROUND

In accordance with the Water Committee 2023 Work Plan, updates for the water supply tunnel projects are being brought forward to the Water Committee.

PROJECT UPDATES

The water supply tunnel projects are in various stages of planning, design and construction. The following is a summary of the status of each project. A map showing the locations of the projects is included in the Attachment.

Second Narrows Water Supply Tunnel (Construction) – Project 1

The Second Narrows Water Supply Tunnel is a 1.1 kilometre long, 6.5 metre diameter tunnel crossing of Burrard Inlet from North Vancouver to Burnaby. It is under construction, and is one of five marine crossings in the water transmission system that is required to support the delivery of water to the region following a major earthquake.

This new water supply tunnel includes three steel water mains that will replace three existing mains which were constructed in shallow trenches at the bottom of the Burrard Inlet between the 1940s through 1970s. The existing mains are near the end of their service lives and do not meet current seismic standards.

The project also consists of vertical shafts constructed on each side of Burrard Inlet, and large underground valve chambers to regulate the water flow through the newly installed steel water mains.

Construction of this new tunnel infrastructure commenced in 2019 and is scheduled to be completed in 2024. Connections of the new water mains into the existing system will take two winter seasons to complete, resulting in a final anticipated in-service date of 2026. The total budget for construction is $445 million.

Annacis Water Supply Tunnel (Construction) – Project 2

The Annacis Water Supply Tunnel is a 2.3 km long, 4.5 m diameter crossing of the Fraser River from New Westminster to Surrey. It is also under construction, and is one of the five marine crossings in the regional water transmission system being designed and constructed to withstand a major earthquake.

The project consists of a tunnel and deep vertical shafts located on each side of the river which will accommodate the installation of a 2.6 m diameter welded steel water main. Large underground valve chambers will be constructed adjacent to each shaft to regulate flow and facilitate connection of the water main into the existing water transmission system.

Construction commenced in early 2022 and the new tunnel is scheduled to be completed and in-service by 2028. The total budget for construction is $450 million.

Stanley Park Water Supply Tunnel (Detailed Design) – Project 3

To meet the growing demand for drinking water, Metro Vancouver is planning to construct a new water supply tunnel deep under Stanley Park. The new water supply tunnel will replace an existing water main that was built in the 1930s, has experienced leaks in 2016 and 2023, and has reached the end of its service life. The new Stanley Park Water Supply Tunnel is urgently needed to reduce the likelihood of additional leaks from the water main. This project is part of Metro Vancouver's regional plan to upgrade the existing drinking water system to meet the needs of the growing region.

The project involves the construction of a new water supply tunnel, designed to provide increased capacity to meet future water demand as well as to meet current seismic standards. The new tunnel will be 1.4 km long, approximately 4.5 m in diameter and include a 2.65 m diameter steel water main, and will connect to two new underground valve chambers.

To facilitate construction, three shafts will be constructed within Stanley Park. The tunnel will be constructed from an intermediary central shaft located in the existing Stanley Park Service Yard, with two exit shafts, one at the north side of park at the First Narrows Crossing of Burrard Inlet, and one at the south side of the park near the intersection of Chilco and Alberni streets. The project has been designed to minimize construction footprint, minimize impacts to the park, and reduce construction impacts to park users and residents.

The detailed design phase is essentially complete and project staff are finalizing permitting and approvals prior to proceeding to procurement for construction later this year. The total budget for construction is $315 million and is expected to be substantially complete by 2029.

Cambie-Richmond Water Supply Tunnel (Preliminary Design) – Project 4

The Cambie-Richmond Water Supply Tunnel is a 1.1 km long, 4.5 m diameter crossing under the Fraser River from Vancouver to Richmond. The tunnel is also one of the five new marine crossings in the regional water transmission system being designed and constructed to withstand a major earthquake.

The project consists of a tunnel and deep vertical shafts located on each side of the river to facilitate the installation of a 2.1 m diameter welded steel water main. Each shaft site will also include the construction of underground valve chambers and tie-in connections to facilitate water control functions.

The conceptual design phase of the project was completed in 2021. Metro Vancouver subsequently acquired property in Vancouver and Richmond to facilitate construction of the shafts and valve chambers, and to launch and retrieve the tunnel boring machine.

The preliminary design phase of the project is scheduled to commence later this year, with construction scheduled to commence in 2027. Construction is anticipated to take approximately five years to complete. The preliminary design budget including the funds for the property acquisition is $60 million.

Lulu Delta Water Supply Tunnel (Initiation) – Project 5

The Lulu Delta Water Supply Tunnel is a 1 to 2 km long marine crossing deep under the Fraser River from Richmond to Delta, and is located near the George Massey Tunnel. The new water supply tunnel will replace the existing Lulu Delta crossing which is near the end of its service life.

The project is currently in the initiation or planning phase and consists of a new welded steel water main crossing constructed using a trenchless method such as tunneling, micro-tunneling or horizontal directional drilling, to be confirmed during conceptual design which is scheduled to commence later this year. Construction is anticipated to commence in 2029. The conceptual design budget is $5 million.

This project is located in close proximity to the new George Massey Tunnel Replacement project, which will require close coordination with Ministry of Transportation and Infrastructure staff on logistics, schedule and workspace requirements. These discussions have commenced.

Pitt River Water Supply Tunnel (Definition/Conceptual Design) – Project 6

The Pitt River (Haney) Water Supply Tunnel is a 1 km long tunnel crossing of the Pitt River from Port Coquitlam to Pitt Meadows and Maple Ridge. The new water supply tunnel will replace the existing Haney Mains No. 2 and No. 3, and is another one of five marine crossings in the regional water transmission system being designed and constructed to withstand a major earthquake.

The project consists of constructing a shaft on each side of the Pitt River connected deep underground by a tunnel, which will facilitate the installation of a welded steel water main. Each shaft site will also include the construction of valve chambers and tie-in connections to facilitate water control functions. The final alignment of the tunnel, including the length and size of the water main will be determined during conceptual and preliminary design.

The definition/conceptual design phase is currently underway. As a part of conceptual design, it is anticipated that Metro Vancouver will purchase properties required for the Port Coquitlam and Pitt Meadows shafts to launch and receive the tunnel boring machine. Construction is anticipated to commence in 2029 and will take approximately five years to complete. The conceptual design budget including the funds for the property acquisition is $25 million.

ALTERNATIVES

This is an information report. No alternatives are presented.

FINANCIAL IMPLICATIONS

The budgets noted in this report have been previously approved by the Board. At this time, the total expenditures projected for each noted phase are not anticipated to exceed the budget amounts. The Water Committee will be advised of any changes required as the projects progress through design and construction.

CONCLUSION

Making sure the regional infrastructure is resilient to earthquakes is a high priority with upgrades to drinking water transmission system constantly underway. A major resilience initiative is to strengthen the water supply system by building large-diameter water mains in tunnels deep under the Burrard Inlet, the Fraser River, and in Stanley Park. These water supply tunnel projects are critical components of Metro Vancouver’s drinking water transmission system and are being designed to withstand a major earthquake, river scour and marine activities, and to meet projected future drinking water demands for the region’s growing population.

Attachment

Water Supply Tunnel Projects Map

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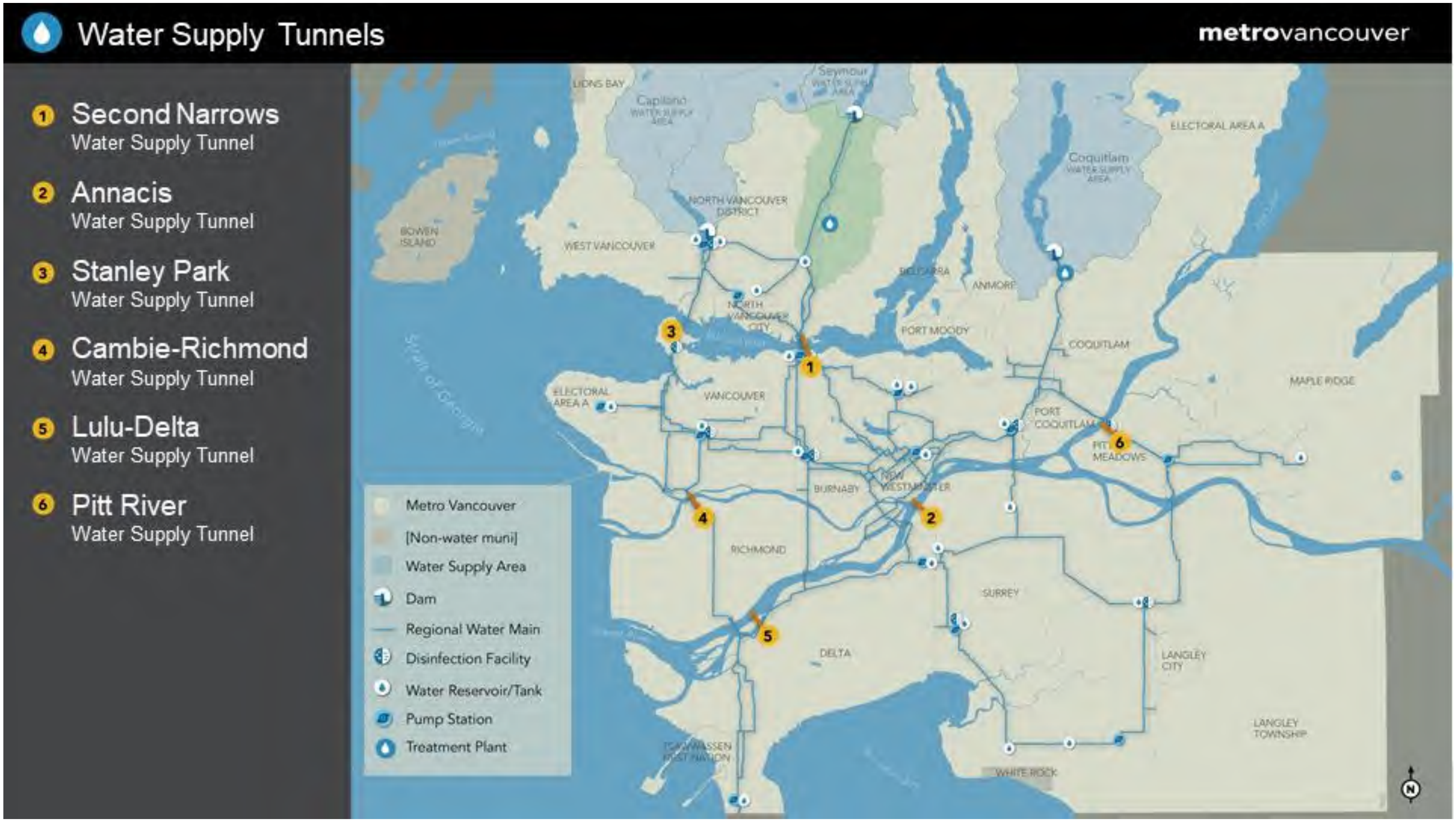
ATTACHMENT

Water Supply Tunnel Projects Map



To: Water Committee

From: George Kavouras, Director, Procurement and Real Estate Services
Bob Cheng, Director, Major Projects, Project Delivery

Date: May 31, 2023 Meeting Date: June 14, 2023

Subject: **Award of Tender No. 23-100 Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Backup Power**

RECOMMENDATION

That the GVWD Board:

a) Approve award of Tender No. 23-100 Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Back Up Power, in the amount of up to $10,899,738 (exclusive of taxes) to North America Construction (1993) Ltd., for a term of three years, subject to final review by the Commissioner; and
b) Authorize the Commissioner and the Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

EXECUTIVE SUMMARY

North American Construction (1993) Ltd. was identified as the lowest compliant bid, and on that basis it is recommended that the GVWD Board award Tender No. 23-100 to North American Construction (1993) Ltd.

To ensure the continuous supply of drinking water in the event one of the existing Coquitlam Mains No. 2 or No. 3 is damaged during construction of Coquitlam Main No. 4 and at the same time a power outage occurs at the Capilano Raw Water Pump Station and/or Westburnco Pump Station, temporary backup power at these two pump station sites is required to allow the Seymour-Capilano source to back-feed the eastern portion of Greater Vancouver Regional District's transmission system.

Greater Vancouver Water District issued Tender No. 23-100 Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Back Up Power on April 18, 2023 and the tender closed on May 18, 2023. This tender was issued by invitation to three vendors shortlisted as a result of Request for Qualifications No. 22-532 Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Back Up Power. All three firms submitted bids which were deemed compliant and independently reviewed by staff from Metro Vancouver's Procurement Division and Project Delivery Department.

PURPOSE

Pursuant to the *GVWD Officers and Delegation Bylaw No. 247, 2014 (Bylaw)* and the *Procurement and Real Property Contracting Authority Policy (Policy)*, procurement contracts which exceed a value of $5 million require the approval of the GVWD Board of Directors.

BACKGROUND

Greater Vancouver Water District will obtain its next increment of drinking water supply from the Coquitlam Reservoir as part of its long-range planning for growth in the region. Installation of Coquitlam Main No. 4 is required to address a current shortfall in transmission capacity in the Coquitlam source supply system, and provide additional capacity for the eventual Coquitlam Lake Water Supply Project.

Installation of Coquitlam Main No. 4 South Section, is proximal to existing critical Greater Vancouver Water District water mains in the City of Coquitlam along Pipeline Road, namely Coquitlam Mains No. 2 and No. 3. The alignment of Coquitlam Main No. 4 adjacent to the existing Coquitlam mains was determined to be the most beneficial through a triple-bottom-line assessment that looked at the technical, financial, and social impacts.

However, should any of the two existing Coquitlam Mains be impacted during construction, the eastern region of Greater Vancouver Water District’s transmission system supply from the Seymour Capilano Filtration Plant would need to be supported by the Capilano Raw Water Pump Station in the District of North Vancouver and the Westburnco Pump Station in the City of New Westminster (see Attachments 1 and 2 for location maps). In the event of BC Hydro power outages at either of these two pump stations, temporary backup power is required to ensure uninterrupted flow of drinking water (see Attachment 3).

Furthermore, temporary backup power at Westburnco Pump Station is also required for TransLink’s Operations and Maintenance Centre 4 project, which requires the relocation of Greater Vancouver Water District’s Sapperton Main No. 2. The relocation works are slated to begin this fall and are considered critical to ensure TransLink’s project stays on schedule.

The scope of work of the temporary backup power generally consists of four gensets at the Capilano Raw Water Pump Station, two gensets at Westburnco Pump Station, hook up of the genset, and associated fuel tanks at both sites. Gensets will be located at the two facilities until all critical project work is completed, which is currently expected to be in approximately three years.

Upon completion of Coquitlam Main No. 4 construction, the gensets will be redeployed to other Metro Vancouver pump station sites needing similar temporary backup power.

PROCUREMENT SUMMARY

RFQ No. 22-532 was issued on January 25, 2023 to prequalify proponents to participate in Tender No. 23-100. Three vendors responded to RFQ No. 23-532, of those all were shortlisted and invited to respond to Tender No. 23-100.

Tenderer	Price (excluding taxes)
North America Construction (1993) Ltd.	$10,899,738.00
Tritech Group Ltd.	$11,076,453.45
Bennet Mechanical Installations (2001) Ltd.	$12,637,000.00

Metro Vancouver received three tenders. All tenders submitted by the tenderers were in compliance with the submission requirements. The compliant tenders were evaluated against each other based on the total tender prices submitted. After a comprehensive and detailed evaluation of the tenders the evaluation team concluded that the proposal submitted by North America Construction (1993) Ltd. is the lowest compliant bid.

ALTERNATIVES

1. That the GVWD Board:
    a) Approve award of Tender No. 23-100 Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Back Up Power, in the amount of up to $10,899,738 (exclusive of taxes) to North America Construction (1993) Ltd., for a term of three years, subject to final review by the Commissioner; and
    b) Authorize the Commissioner and the Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

2. That the GVWD Board not approve award of Tender No. 23-100 Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Back Up Power, and direct staff to report back to the GVWD Board with options for an alternate course of action.

FINANCIAL IMPLICATIONS

Finance has reviewed and confirmed that approved funding is available from the Coquitlam Water Main Program. There are sufficient funds to award this construction contract to North America Construction (1993) Ltd. in the amount of $10,899,738.

CONCLUSION

It is recommended that GVWD Board authorize the Commissioner and the Corporate Officer to approve the award of Tender No. 23-100 Capilano Raw Water Pump Station and Westburnco Pump Station Temporary Back Up Power, in the amount of up to $10,899,738 (exclusive of taxes) to North America Construction (1993) Ltd., for a term of three years.

Attachments

1. Capilano Raw Water Pump Station – Location Map
2. Westburnco Pump Station – Location Map
3. Temporary Backup Power – Overall System Map

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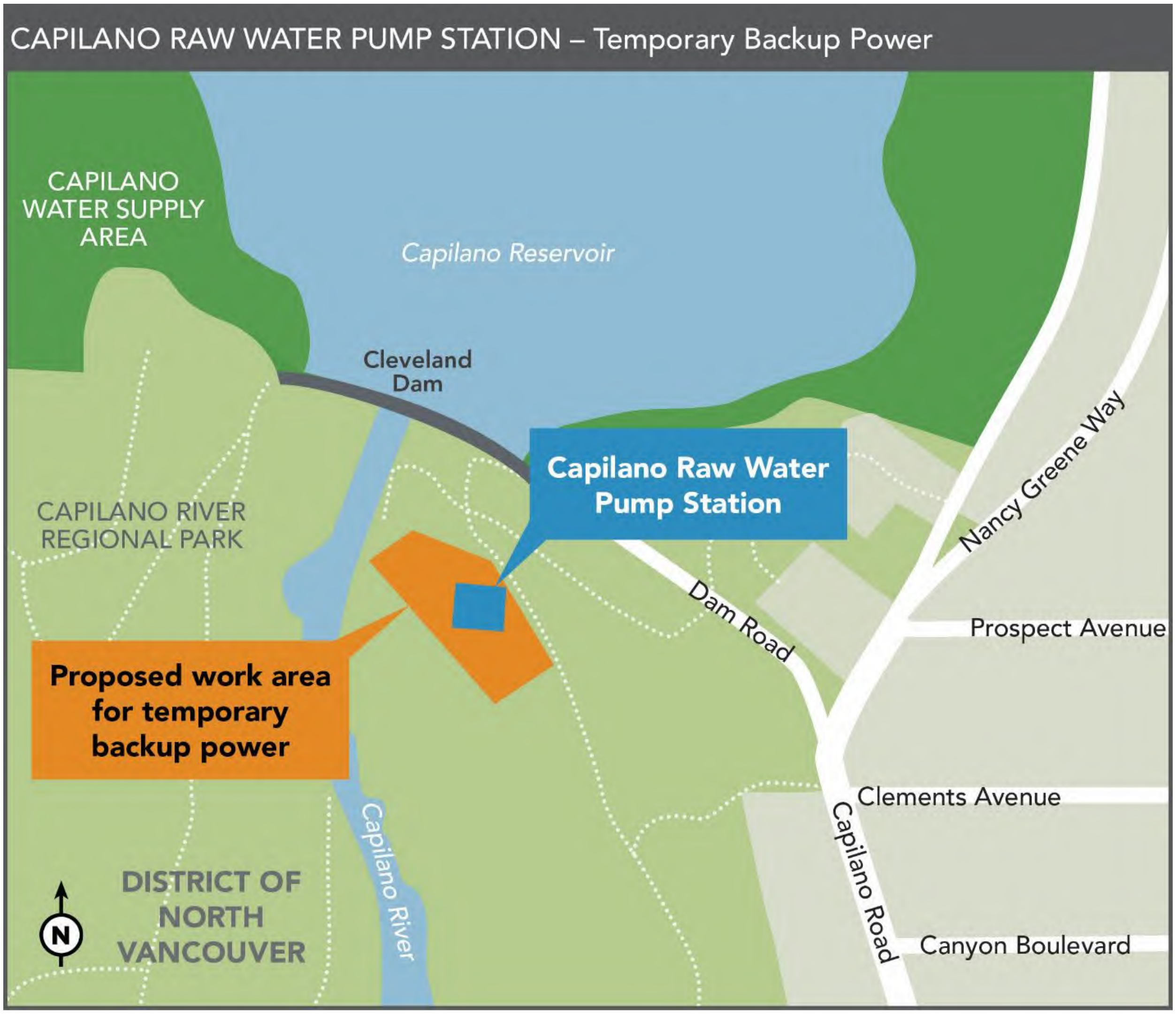
ATTACHMENT 1

Capilano Raw Water Pump Station – Location Map

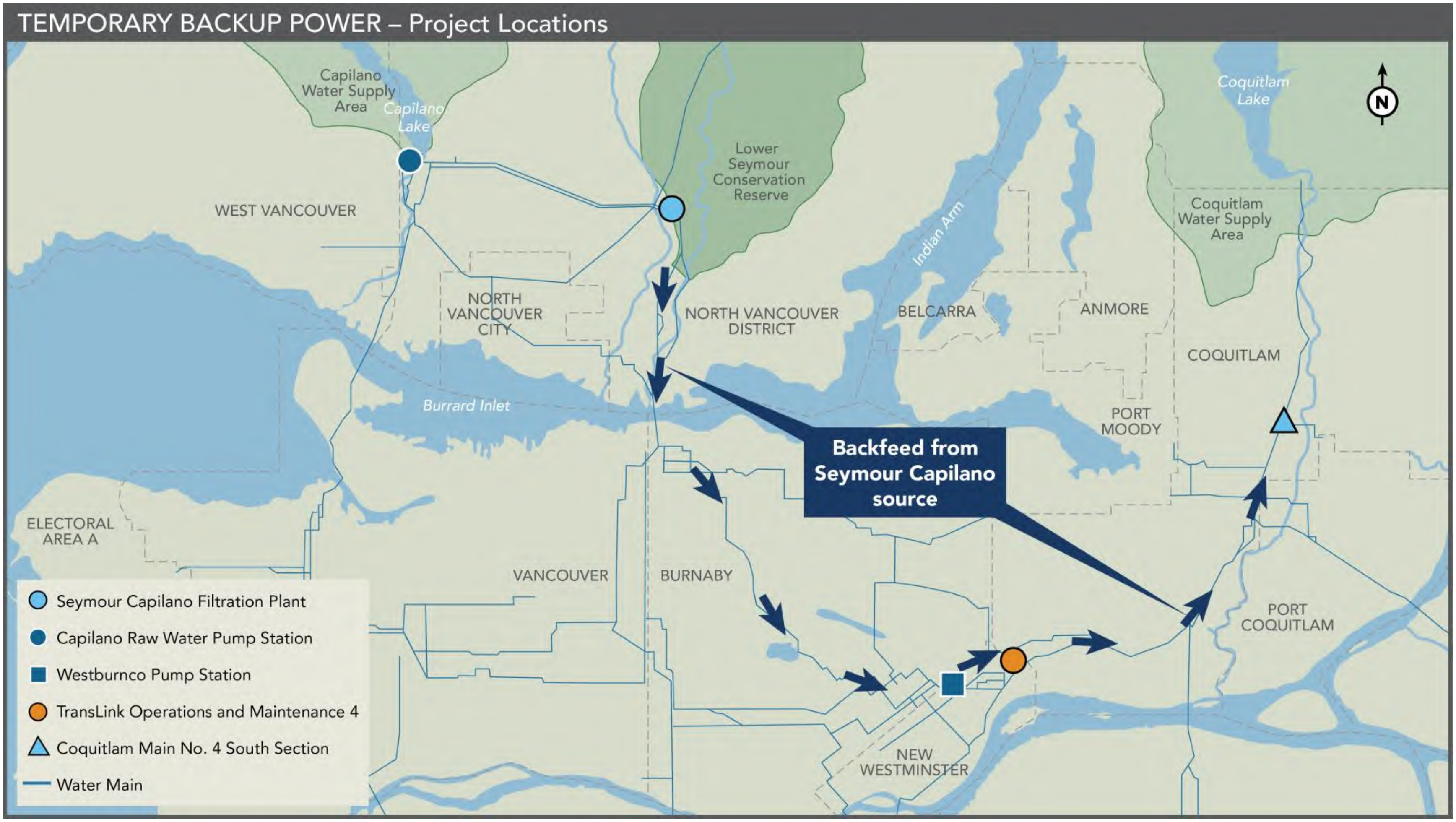


ATTACHMENT 2

Westburnco Pump Station – Location Map

ATTACHMENT 3

Temporary Backup Power – Overall System Map



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SERVICES AND SOLUTIONS FOR A LIVABLE REGION

5.6

To: Water Committee

From: Marilyn Towill, General Manager, Water Services

Date: May 30, 2023 Meeting Date: June 14, 2023

Subject: **Manager's Report**

RECOMMENDATION

That the Water Committee receive for information, the report dated May 30, 2023 titled "Manager's Report".

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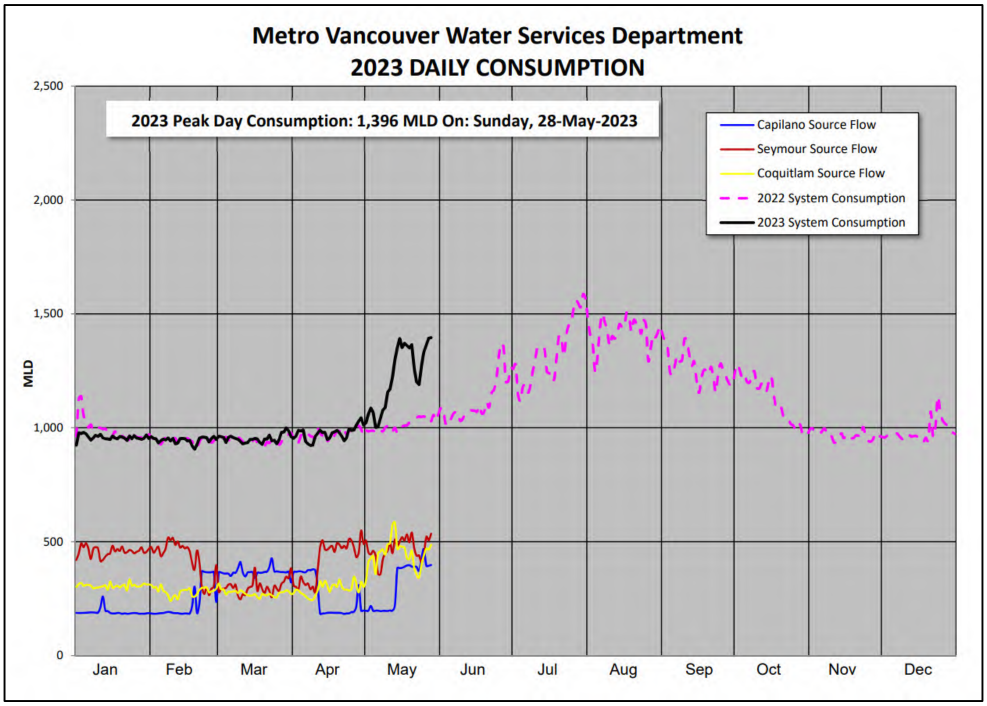
1. Water Storage and Demands

As of the end of May, the total source storage is 95% of maximum and is within the normal range for this time of year. The latest snow survey indicates that we are at 63% average historical snow depth and 62% average historical snow water equivalent (SWE). As the snow melts, it will be captured to provide additional water storage into early June. Capilano Reservoir is being refilled to its maximum storage level. Seymour Reservoir is at full storage level and spilling. Palisade Lake and Burwell Lake are full and available to supplement Capilano and Seymour Reservoirs if required. Loch Lomond is on schedule to be available for summer use.

The average temperature in May was 3.7 degrees Celsius warmer than historical past. The hot weather contributed to high consumption of drinking water across the Region. A new daily consumption record was set for the month of May - 1.4 BL/D on Sunday May 28. Staff were able to manage the water transmission systems to meet the higher demands.



2. Water Committee Work Plan

Attachment

Water Committee 2023 Work Plan

ATTACHMENT

Water Committee 2023
Work Plan

Priorities

1st Quarter	**Status**
Drinking Water Conservation Plan 2022 Summer Support Program Update	Complete
GVWD Electrical Energy Use, Generation and Management	Complete
Non-Potable Water Re-Use Project	In Progress
Project Delivery Update: Coquitlam Main No. 4	Complete
Watershed Fisheries Initiatives Annual Update	Complete
New 2023 Water Sustainability Innovation Fund Projects	Complete
Contract Approvals as per Procurement and Real Property Contracting Authority Policy	Complete
Water Policies (as applicable)	Complete
2nd Quarter	
2022 Contribution Agreement Annual Reports - Seymour Salmonid Society and Coquitlam River Watershed Roundtable	Complete
Drinking Water Management Plan Update	Complete
GVWD 2022 Water Quality Annual Report	Complete
GVWD Capital Program Expenditure Update to December 31, 2022	Complete
GVWD Water Supply System 2022 Annual Update	Complete
Project Delivery Update: Water Tunneling Projects	In Progress
Water Communications and Public Outreach Update	Complete
Wildfire Preparedness Update	Complete
Water Supply Update for Summer 2023	Complete
Contract Approvals as per Procurement and Real Property Contracting Authority Policy	In Progress
Water Policies (as applicable)	In Progress
3rd Quarter	
Annual Update on Water Sustainability Innovation Fund Projects	Pending
Corrosion Control Program Monitoring Update	Pending
GVWD 2022 Dam Safety Program Annual Update	In Progress
GVWD Capital Program Expenditure Update to April 30 2023	Pending
In-System Reservoir Upgrades Update	Pending
Project Delivery Update: Coquitlam Lake Water Supply Project	Pending
Contract Approvals as per Procurement and Real Property Contracting Authority Policy	Pending
Water Policies (as applicable)	Pending
4th Quarter	
Annual Budget and 5-year Financial Plan	Pending
GVWD Capital Program Expenditure Update to August 31, 2023	Pending
GVWD Development Cost Charges – Update	Pending
Quality Management System for Drinking Water Update	Pending
Summer 2023 Water Supply Performance	Pending
Water Communications and Public Outreach Results	Pending
Contract Approvals as per Procurement and Real Property Contracting Authority Policy	Pending
Water Policies (as applicable)	Pending