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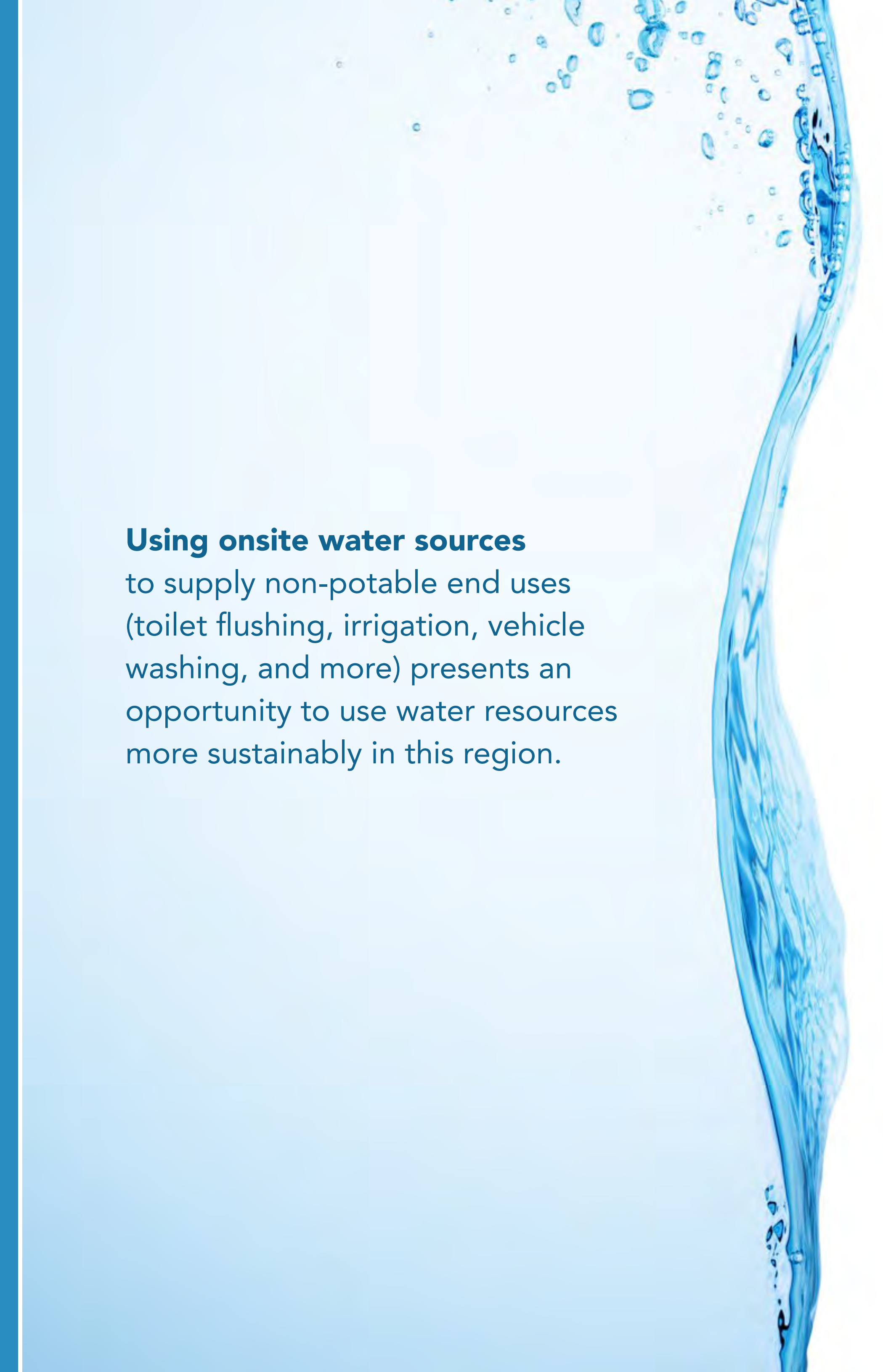
Non-Potable Water Systems

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.

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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.

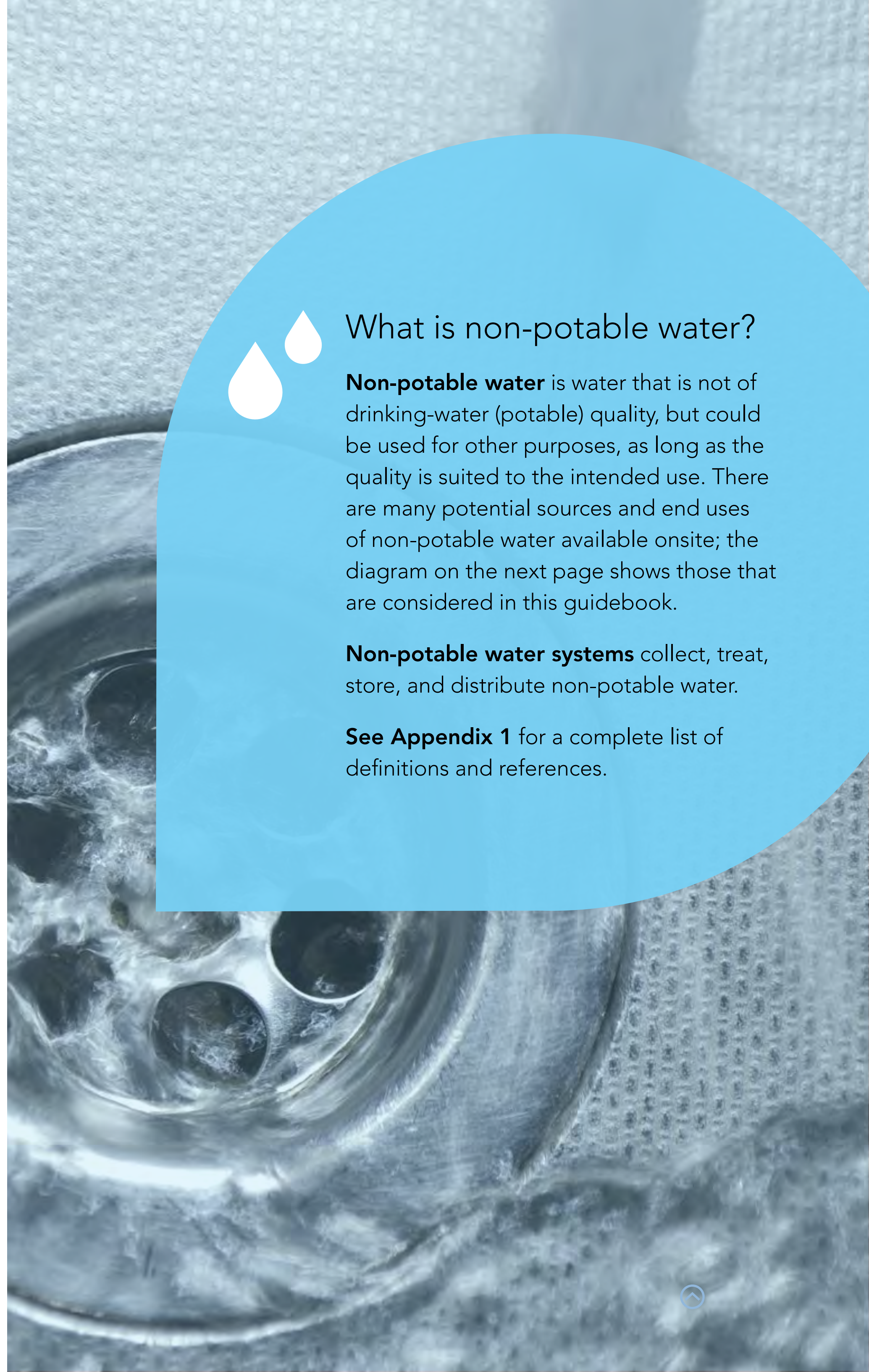
Purpose of this guidebook

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:

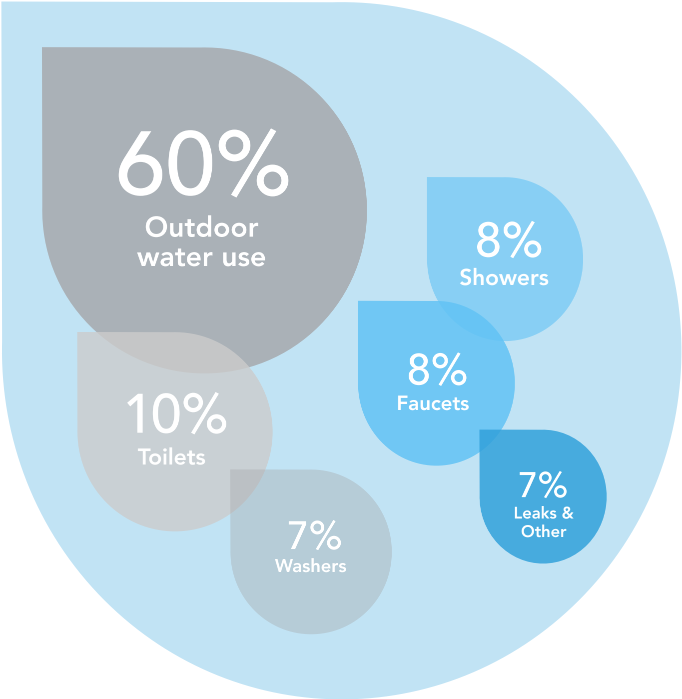
Non-potable water sources can be used to target additional savings in water used for indoor fixtures and fittings beyond a prerequisite efficient target.

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.

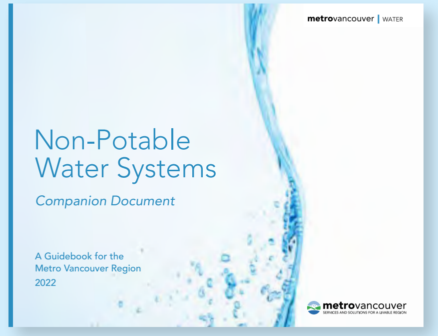
Common challenges for non-potable water systems

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.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Non-Potable Water Systems

Companion Document

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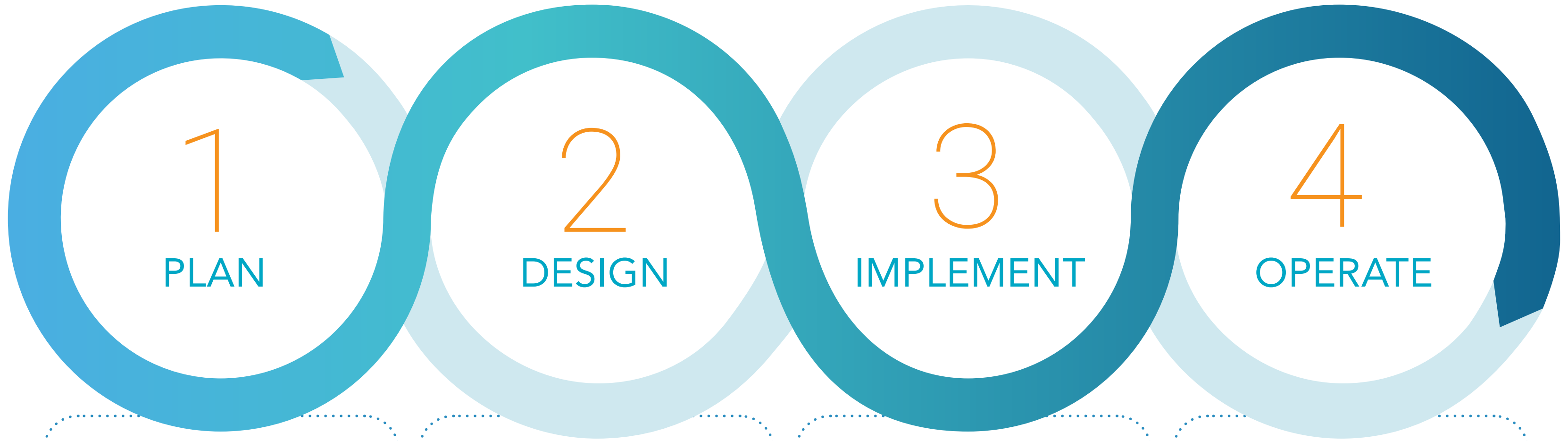
What is involved in these systems from planning through to operation?

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

PLAN

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.

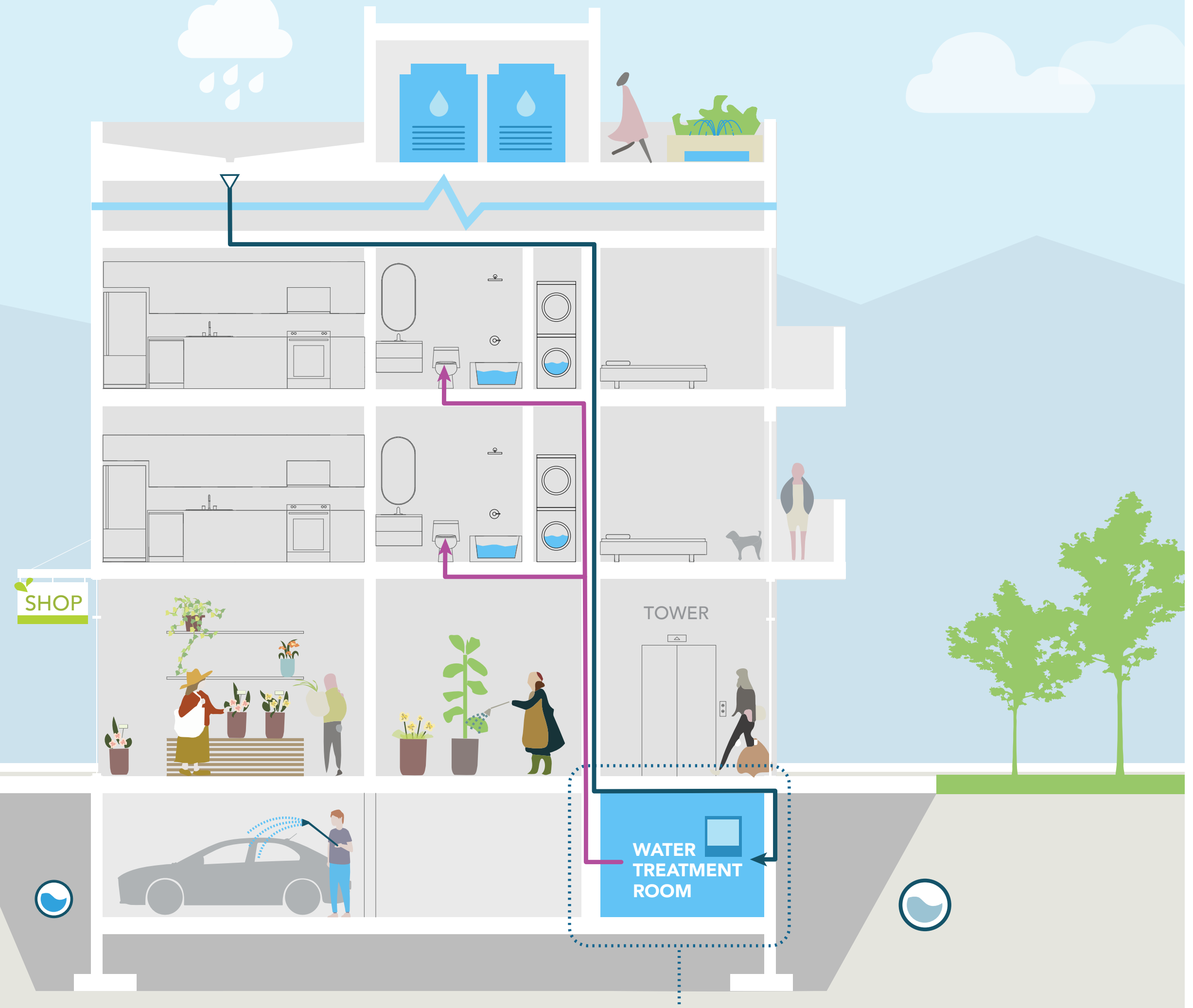
Responsible management entity (RME): A person, corporation, non-profit organization, or governmental body with ultimate legal responsibility for the performance of a non-potable water system.

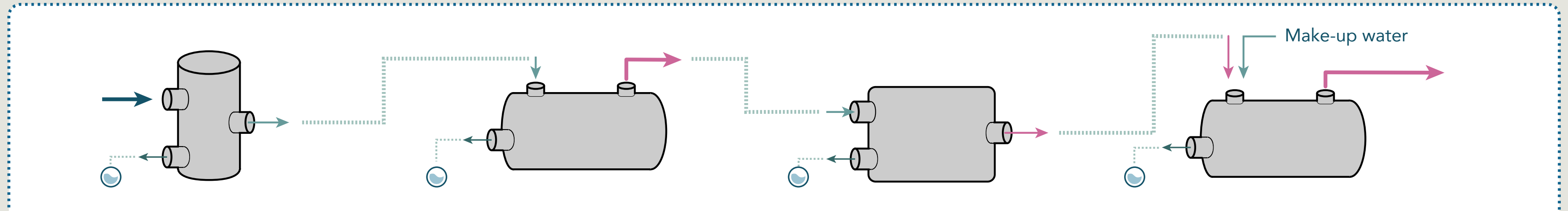
Authority having jurisdiction (regulator): An organization, office, or individual having statutory responsibility for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

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.

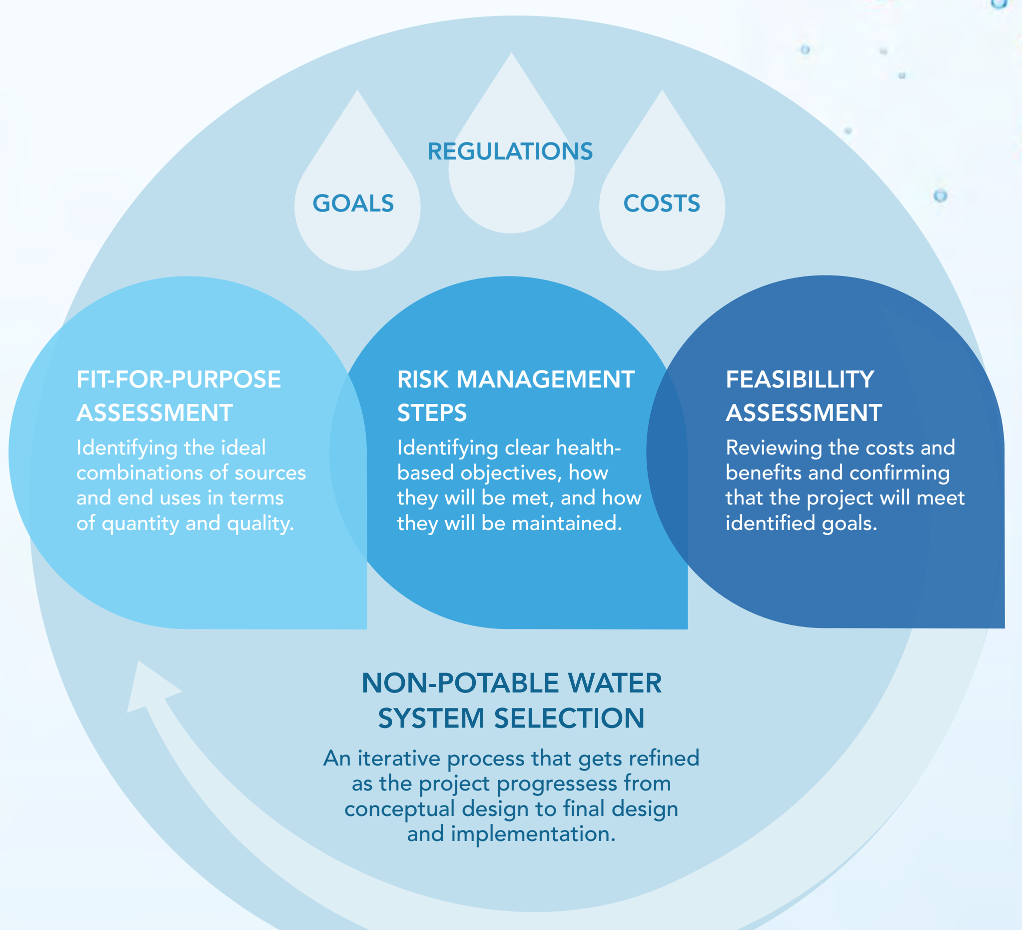
What is involved with selecting a non-potable water system?

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.

Gardens at The Trails Phase 1A development receive roof runoff water for surface irrigation.

1.6 Fit-for-purpose assessment: characterizing water sources and end uses

The term "fit-for-purpose" water means that the water sources are of adequate quantity to match to an end use and the water is treated only to the extent needed to meet end-use quality requirements. Using a fit-for-purpose lens to select appropriate sources and end uses will maximize the water sustainability benefits of the project, while also helping to minimize costs. This is important for assessing feasibility of including a non-potable water system in the project, and also provides the starting point for the design stage. For example, more closely matching quantities of sources and end uses can minimize storage requirements, and more closely matching the qualities of the sources and end uses can reduce treatment or management requirements.

Selecting the optimal combination of sources and end uses is iterative, starting with a high-level assessment to prioritize options, then refining those options as more is learned through the planning and design process. Preliminary, planning-level data is gathered at this stage. This initial fit-for-purpose assessment will provide:

- An understanding of the potential sources, with characterization of quantities, flow patterns, and quality.
- A comparison to the needs of potential end uses for non-potable water in the project.

Table 1.5 provides general guidance on the typical opportunities and challenges for matching sources and end uses, specific to the Metro Vancouver region. The table highlights suitability based on annual use, but each application may vary and may have better or worse suitability depending on seasonality of use, variations in source quality, or other factors. See the Companion Document, section 2, for a more detailed version and a list of common data sources used during this stage.

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
Roof runoff water	🟢 🟦	🟢 🟦	🟢 🔹	🟢 🟦	🟢 🟦	🟡 🔹
Stormwater	🔴 🟦	🟡 🟦	🟡 🔹	🟢 🟦	🔴 🟦	🟡 🔹
Foundation and relief drainage	🔴 🔹	🟡 🔹	🟡 🔹	🟢 🔹	🔴 🔹	🟡 🔹
Light greywater	🔴 🔹	🟡 🔹	🟡 🔹	🟡 🔹	╱	╱
Vehicle wash water	🔴 🟦	🟡 🟦	🟡 🔹	🟡 🟦	🔴 🟦	🟡 🔹
Condensate	🟢 🟦	🟢 🟦	🟡 🟦	🟢 🔹	🟡 🔹	🟡 🔹

🔴 Complex treatment required
🟡 Moderate treatment required
🟢 Easy to treat to required standard
🟦 Large/very large storage
🔹 Med/small storage

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?

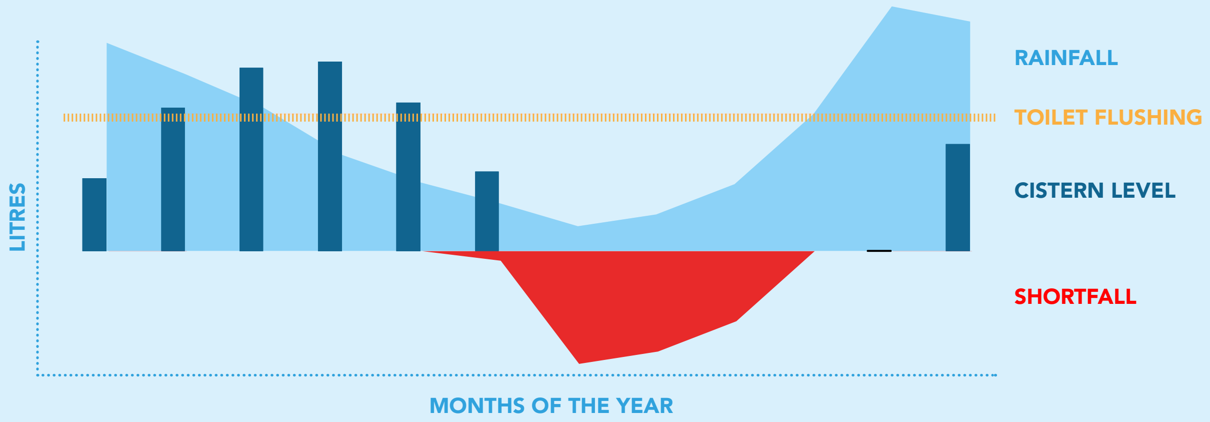
EXAMPLE OF WELL-MATCHED AND NOT-SO-WELL MATCHED SOURCE AND END USE

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.

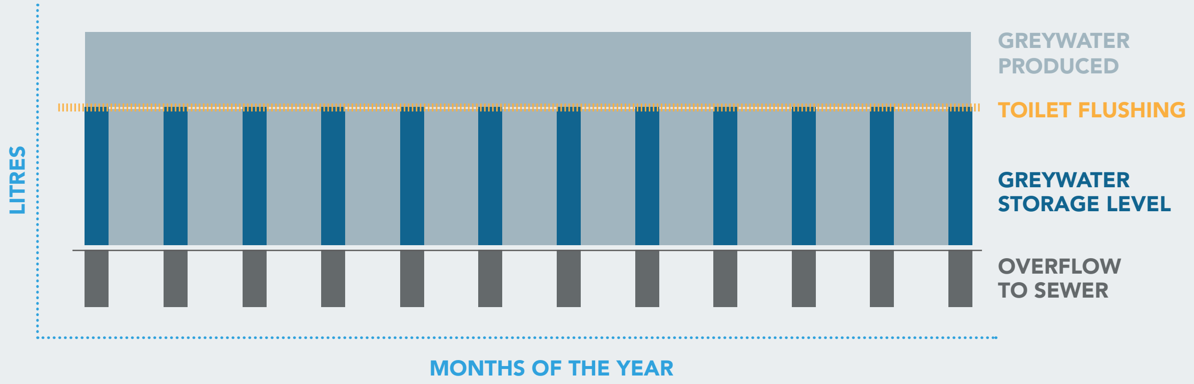
OPTION #1: RAINWATER SOURCE WITH 100,000 L STORAGE

- 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

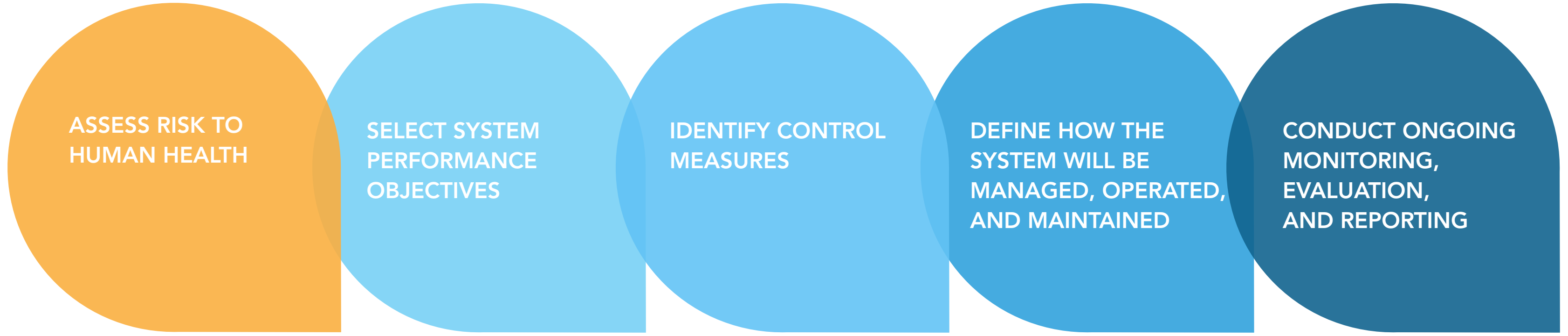
SOURCE WATER	VIRAL PATHOGENS	BACTERIAL PATHOGENS	PROTOZOAN PATHOGENS	CHEMICAL CONTAMINATION	ORGANIC MATTER AND DUST	HYDROCARBONS
Roof runoff water or condensate	○	●	◍	○	◍	○
Light greywater	●	●	●	●	●	○
Vehicle wash wastewater	○	●	○	●	●	●
Stormwater	●	●	●	●	●	●
Foundation and relief drainage	●	●	●	●	●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

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).



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 DESIGN

2. Designing non-potable water systems

2.1 Checklist and outcomes

The design stage builds upon the planning stage, starting with a conceptual design followed by a detailed design. In very simple, small projects, conceptual design may not be a separate step and may be completed as part of initial project planning; but for larger, more complex projects, the conceptual design would likely go through an approval process with the client and preliminary approval with the authority having jurisdiction (regulator) before moving into detailed design.

Table 2.1 Design stage checklist and outcomes

DESIGN STAGE: **CHECKLIST**	DESIGN STAGE: **OUTCOMES**
✓ Update and confirm roles and responsibilities in the organizational chart. ✓ Establish management category and ensure design matches the capacity of the responsible management entity and regulator.	Draft Management Plan,* including updated organizational chart.
✓ Identify regulatory permitting, approval, and prescriptive requirements. ✓ Obtain approval of the conceptual design. ✓ Submit required documentation to the regulator to obtain permits or acceptance to move forward.	Necessary permits obtained.
✓ Demonstrate and document the fit-for-purpose assessment. ✓ Assess the human health risk and select appropriate performance objectives. ✓ Select control measures to meet the objectives. ✓ Document the system design rationale and validation. ✓ Prepare design notes, drawings, and specifications. ✓ Revisit goals and desired outcomes from the planning phase and adjust as needed.	Design drawings and specifications completed and approved, including the design rationale.
✓ Ascertain any required validation steps and document in the draft Commissioning Plan. ✓ Prepare a process schematic with control points and document in the draft Operation and Maintenance Plan. ✓ Identify ongoing verification and compliance monitoring required, and document in the draft Monitoring Plan.	Draft plans completed: • Commissioning Plan* • Operation and Maintenance Plan* • Monitoring Plan* • Validation Plan (if necessary)

* Companion Document, section 5, provides checklists to assist with preparation of these plans.

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:

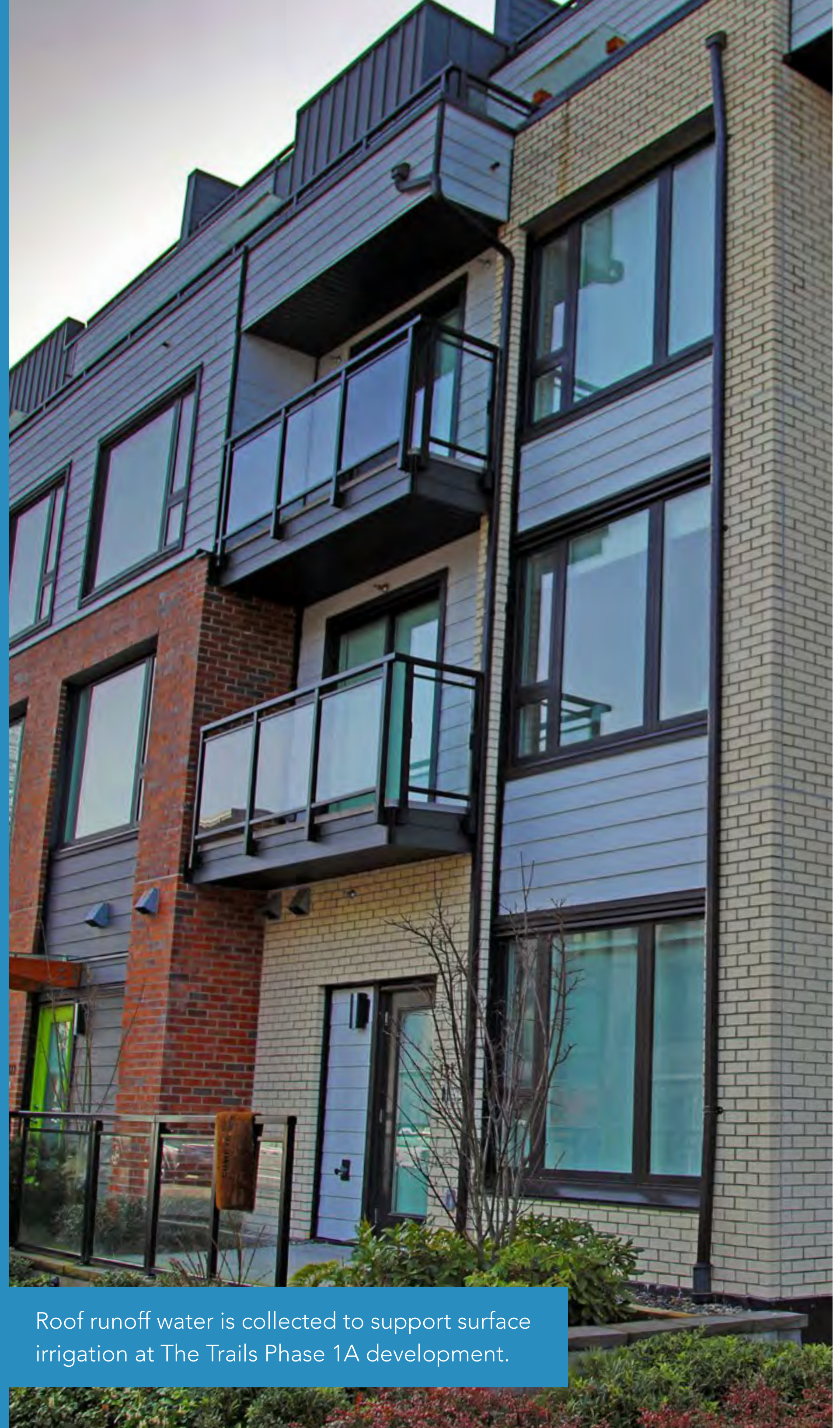
- **Regulations**, such as a provincial act or regulation, a local government zoning bylaw, or a building bylaw (see the Planning section for an overview of applicable regulations).
- **Standards**, which may be contained within regulation, referred to by regulation, or be contained within a policy adopted 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

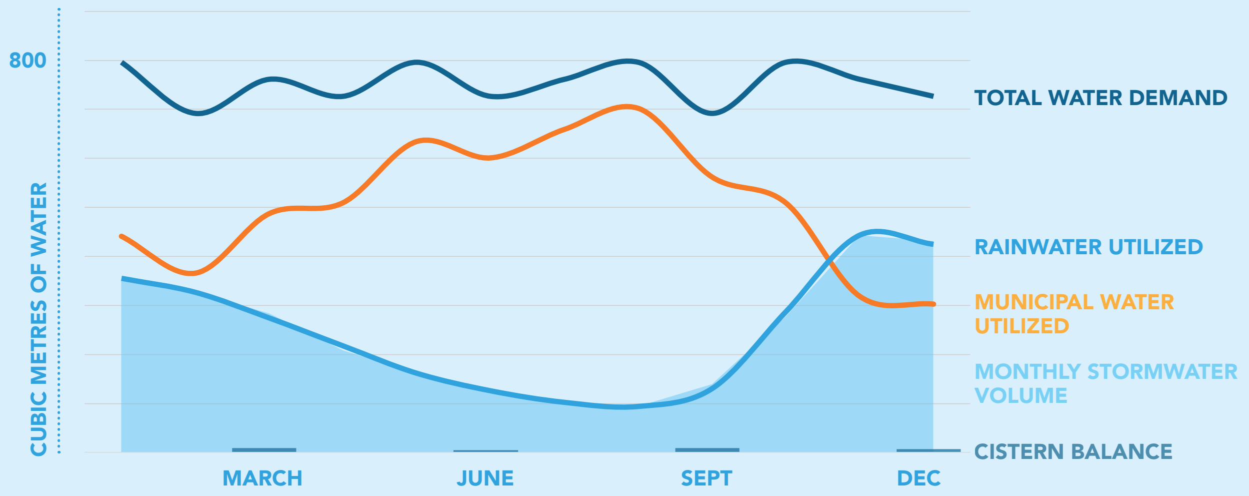
The Deloitte Summit Building, a 25-storey office tower, has a stormwater system designed to comply with the City of Vancouver's Building By-law and the City's on-site rainwater management requirements. The key objectives of the system are to use all rainfall onsite and to detain stormflow surges that 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.

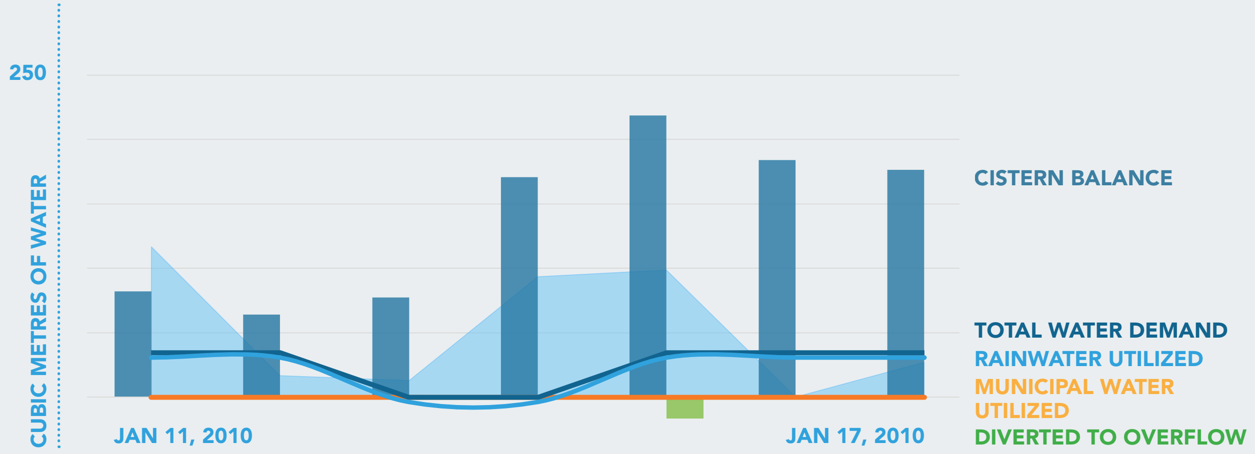
Annual water balance model:
This graph shows the results of modelling daily toilet flushing usage with daily average precipitation across 365 days. The model demonstrates that virtually all of the rainfall collection is used for toilet flushing, and that municipal water is needed to supplement between 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.

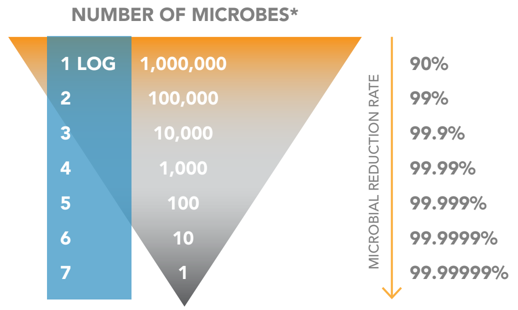
Source water quality and protection

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:

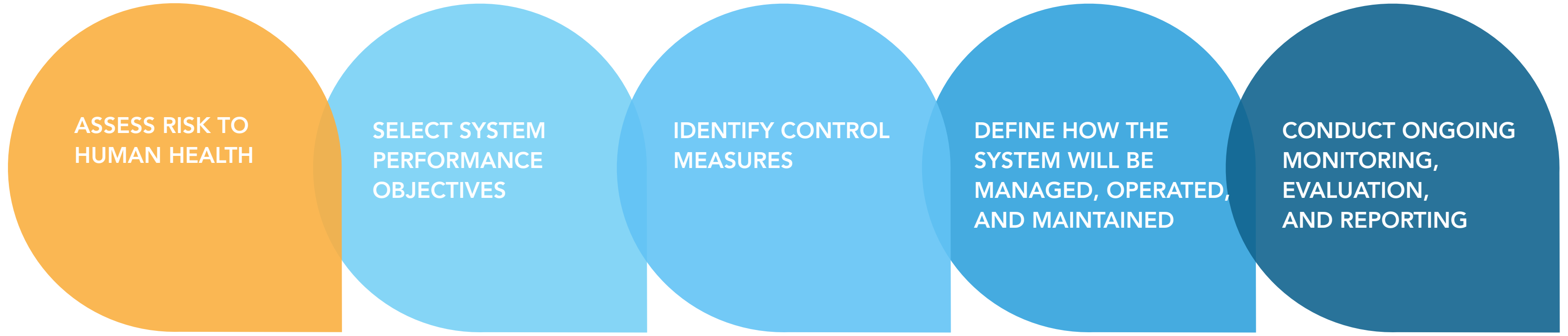
- **Log reduction target (LRT)** – The log reduction needed for the whole system to meet objectives.
- **Log reduction value (LRV)** – The log reduction that is expected to be achieved by each control measure or treatment step. Also termed "log reduction credit."



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

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.



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.

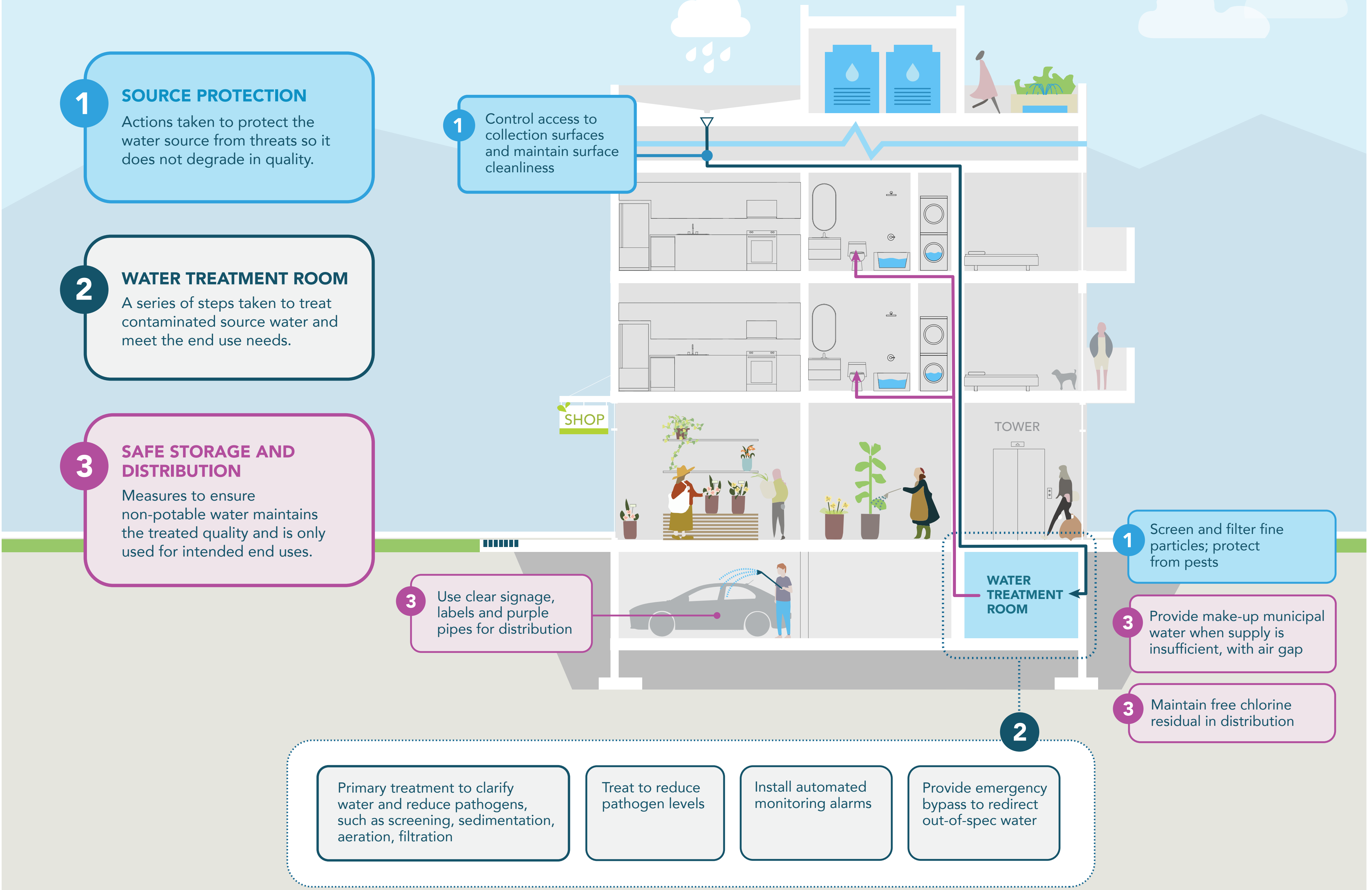
MULTI-BARRIER APPROACH

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

1 Screen and filter fine particles; protect from pests

3 Use clear signage, labels and purple pipes for distribution

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.

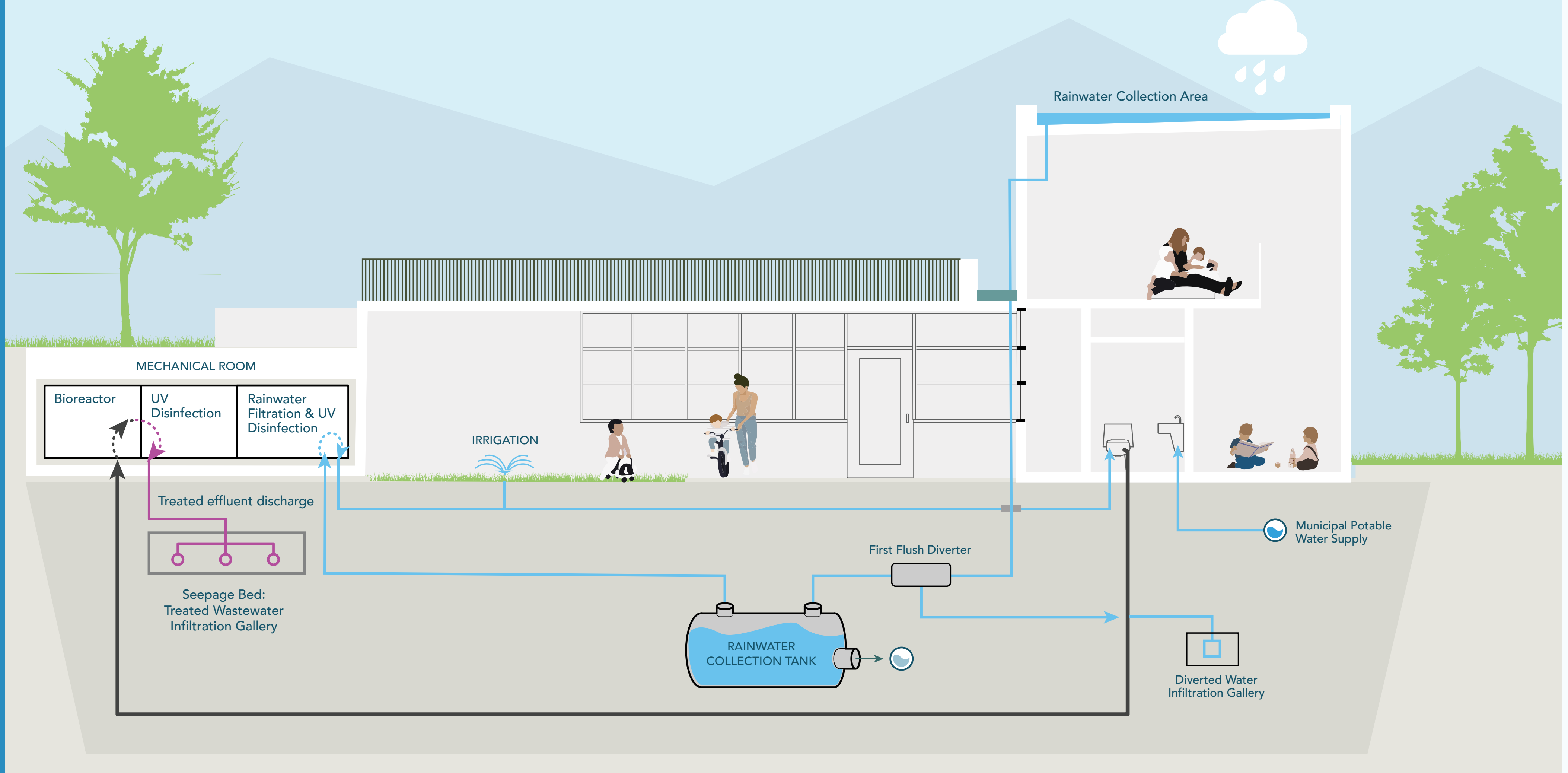
System validation refers to a practical step that measures and confirms a system meets the design requirements. This can be based on previous testing, or can involve building prototype systems (or parts of systems) and physically testing the outputs, or can test a completed system wherein the results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

2 LOG $_{10}$
Primary settling and activated sludge secondary treatment.

+

3 LOG $_{10}$
UV treatment

+

3-4 LOG $_{10}$
Filtration through 45-60 cm of soil

=

8-9 LOG $_{10}$
LRV for the current treatment 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:

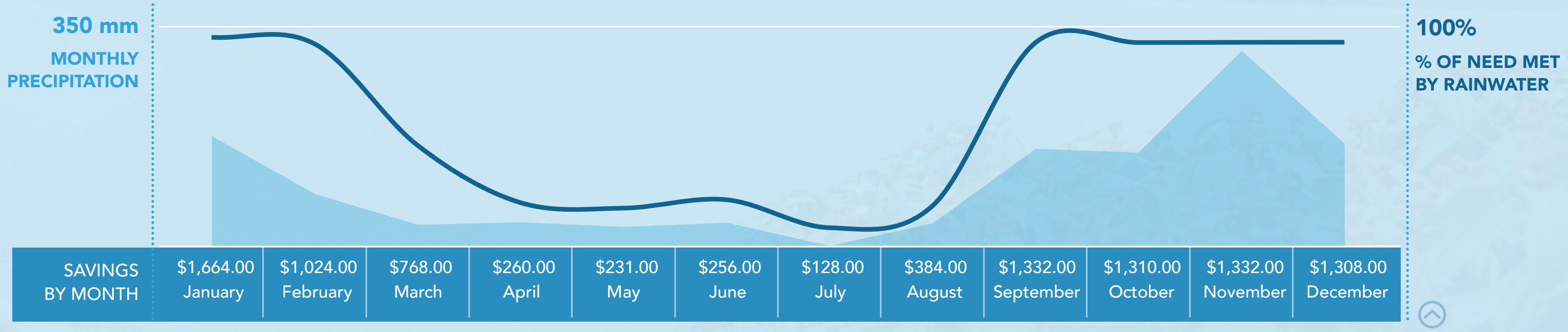
- Where performance verification is not meeting design objectives, actions may include process adjustment, improved source protection, or addition of process steps in order to improve performance.
- Where verification confirms performance is consistently being met, reduced frequency or range of monitoring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

IMPLEMENT

3. Implementing non-potable water systems

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.

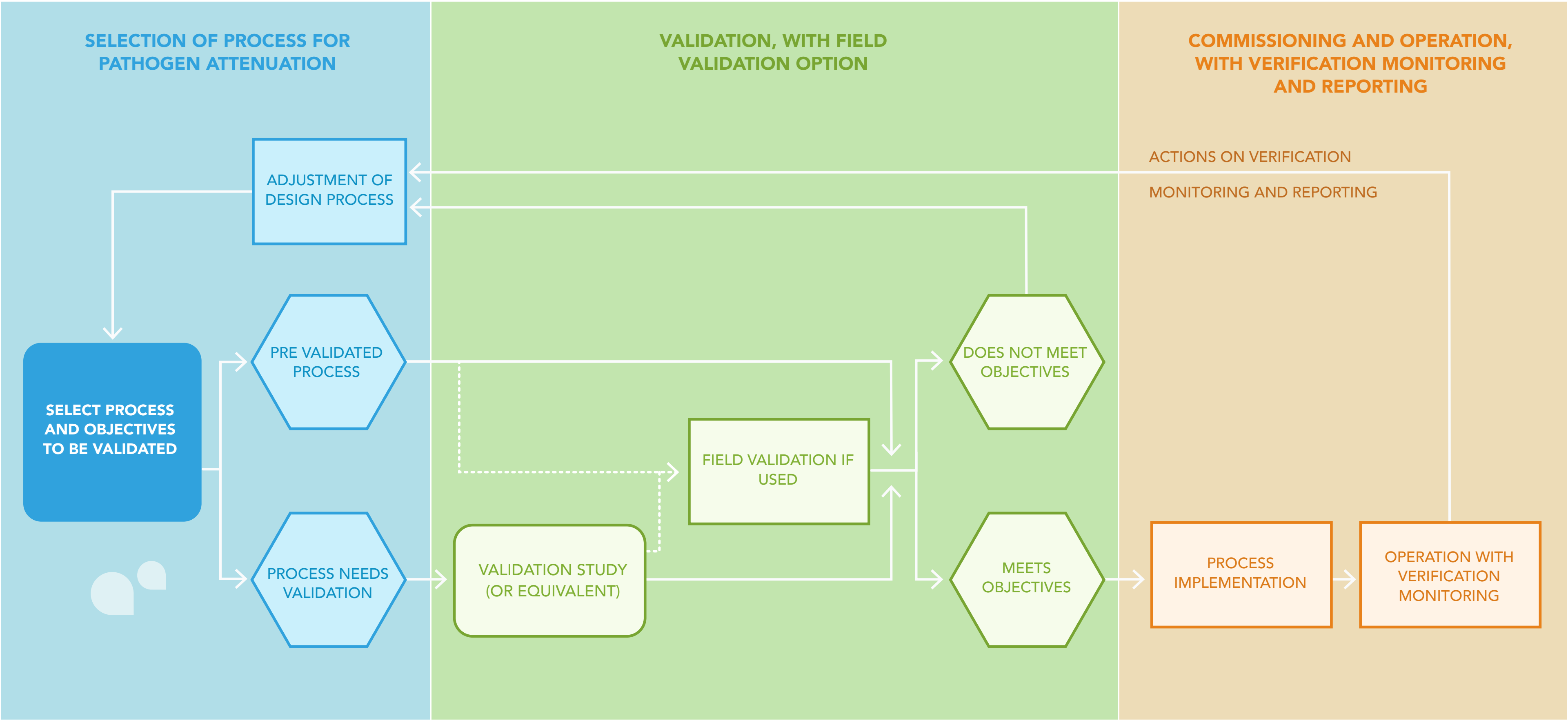
Validation of performance

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

OPERATE

4. Operating and maintaining non-potable water systems

4.1 Checklist and outcomes

The operation stage includes ongoing operation, maintenance, and monitoring by the owner and the responsible management entity. The system implementation stage concludes with completion of the Management, Operation and Maintenance, and Monitoring Plans, which guide the operation and management of the system over time to ensure that it continues to protect public health. For all but the simplest systems, some form of external oversight is likely to be required, and this may include reporting to and enforcement by the regulator.

During system operation, monitoring data is used to inform changes to operation and maintenance, improvements to system management, and in some situations, changes to system design. The management and operation of the system is not static, but rather adapts to changing needs and in response to the measured outcomes of ongoing performance verification.

Table 4.1 Operation stage checklist and outcomes

OPERATION STAGE: **CHECKLIST**	OPERATION STAGE: **OUTCOMES**
✓ Ongoing inspections, operation, maintenance, and repairs. ✓ Ongoing monitoring and verification monitoring as specified in the Monitoring Plan. ✓ Ensure diversion of out of specification water. ✓ Update controls as necessary to address monitoring results.	• Management, Operation and Maintenance, and Monitoring Plans are implemented and revised as needed. • Training Plan may be developed or updated.
✓ Ongoing system management and record keeping. ✓ Reporting as specified in the Management Plan and assigned in the organizational chart (e.g., incident reporting, annual reporting, regulatory or responsible management entity reporting).	Record keeping and reporting meet all risk management objectives and regulatory requirements.
✓ Current operator obtains and maintains appropriate training and certification. ✓ Transition to new operator includes appropriate training.	Operator is appropriately trained.
✓ Conduct annual review to ensure goals from planning are met, or adjust as needed. ✓ Regular review by a qualified professional, with updates to Plans as needed.	Annual system reviews are conducted to ensure outcomes meet system objectives and protect public health.

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.

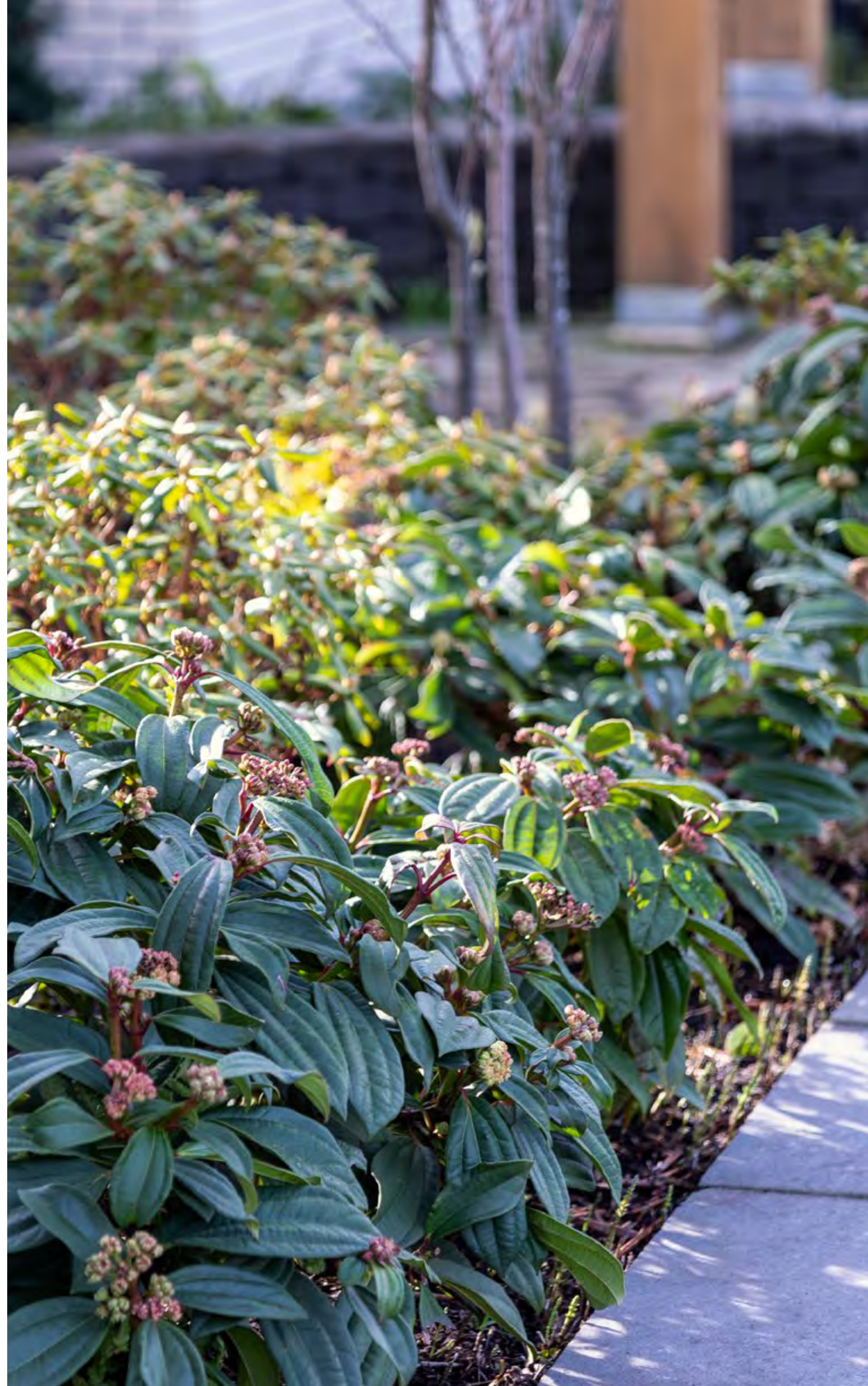
4.7 Cost considerations

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.

Appendix 2: Bibliography and recommended reading

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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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