Decentralised Drinking Water and Wastewater Expert Report:

Technical issues, community-level risk identification, and management recommendations

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The views and opinions expressed in this report are those of the authors. The authors collaborated with, engaged with, and were guided by a project team, expert panel, and First Nations participants. While Indigenous Services Canada (ISC financed this report to be prepared through the Centre of Water Resources Studies and participated in discussions during the information-gathering stage of this report, ISC did not participate in the development of this report. As with any third-party report prepared for the department, the content, findings, or conclusions contained therein are those of the authors. The report should not be interpreted as representing the official policy, position, or views of the Government of Canada.

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Jamie Saunders, Nishnawbe Aski Nation

Adam McCue, Ontario First Nations Technical Services Corporation

James MacKinnon, Atlantic First Nations Water Authority

The Project Team – Our positionality to this work

Dr. Graham Gagnon (Cdn settler) Dr. Gagnon has spent his career at Dalhousie University located in Halifax (Kjipuktuk, the Great Harbour), Nova Scotia located in Mi'kma'ki. Graham is the Director and Professor in the Centre for Water Resources Studies (CWRS) at Dalhousie University. His research has supported of First Nations-led co-generation of safe water solutions and innovation with First Nation and Inuit communities. Graham has worked with the Atlantic Policy Congress of First Nation Chiefs since 2008 on a series of activities, which ultimately helped to form the Atlantic First Nation Water Authority (AFNWA). His team is now guided by AFNWA priorities, where they work on projects that support safe water for the Nations and their environment. Graham's work has extended to serve other First Nation and Inuit community priorities.

Dr. Sheri Longboat is Mohawk and Six Nations of the Grand River member with mixed Ukrainian ancestry. She is an Associate Professor at Wilfrid Laurier University, Faculty of Science, Geography and Environmental Studies, and Associate Graduate Faculty at the University of Guelph, Rural Planning and Development. Her community-engaged multidisciplinary scholarship centres on First Nations water security, policy and governance; climate change and Indigenous Peoples wellbeing; and planning for self-determined sustainable communities. Her academic background includes environment and resource studies, physical geography, education, and environment and resource management. Dr. Longboat has more than 25 years lived experience working with and within First Nations communities as a member, employee, consultant and researcher. She's worked with First Nations throughout Ontario and Canada, including traditional leadership and elected band councils. She has also contributed to federal programs through two terms on Natural Resources Canada's GeoConnections Management Board—a federal partnership program to enable and make available Canada's geospatial databases and tools (CGDI). Working within transdisciplinary collaborative teams, Dr. Longboat has co-authored over 40 academic and community papers and reports. Most recently, *Indigenous Peoples' health and wellbeing: A systematic umbrella review (2024)* for the World Health Organization; *Indigenous and Western Knowledge: Bringing Diverse Understandings of Water Together in Practice (2023) a* commissioned report for the Global Commission on the Economics of Water; and *Local Communities and the Mining Industry: Economic Potential and Social and Environmental Responsibilities (2023)* a co-edited book with funding from Social Sciences and Humanities Research Council.

Dr. Megan Fuller is of mixed European ancestry born in the United States and a recent citizen of Canada. She grew up in Virginia near the Native American "Great Warriors' Path" where shifting tribes of Soiux, Cherokee, and Shawnee existed for millennia. Dr. Fuller moved to Halifax (Kjipuktuk, the Great Harbour), Nova Scotia in 2019 and joined Dr. Gagnon's team at the CWRS in 2020. Her current role is Director of Research for the AFNWA at Dalhousie University, where she advances research, governance, and First Nations education initiatives, as guided by the AFNWA's Elders Advisory Lodge, Board of Directors, and CEO. Dr. Fuller recently co-published an article in the Facets Journal co-written by the Elders Advisory Lodge entitled *The Atlantic First Nations Water Authority: An Indigenous Water Utility Guided by Etuaptmumk or Two-Eyed Seeing*, to share the importance of the spiritual and cultural significance of water in a First Nations-led water utility.

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List of Acronyms

AANDC	Aboriginal Affairs and Northern Development Canada, now ISC
AE	Associated Engineering
AFN	Assembly of First Nations
AFNWA	Atlantic First Nations Water Authority
ALARA	As low as reasonably achievable
AMP	Asset Management Planning
AO	Aesthetic Objective
APC	Atlantic Policy Congress of First Nations Chiefs Secretariat
AWWAO	Aboriginal Water and Wastewater Association of Ontario
BOD	Biological Oxygen Demand
CBWM	Community-based Water Monitoring
CMHC	Canada Mortgage Housing Corporation
CFMP	Capital Facilities Management Program
CRTP	Circuit Rider Training Program
DBP	Disinfection byproducts
DOC	Dissolved Organic Content
DWPNAR	Drinking Water Program National Annual Report
E-ACRS	Extended Asset Condition Reporting System
EPHO	Environmental Public Health Officer
FIO	Fecal indicator organisms
FNCIAS	First Nations Capital and Infrastructure Agency of Saskatchewan
FNESL	First Nations Engineering Services, Ltd.
FNFNES	First Nations Food, Nutrition, and Environment Study
FNHA	First Nations Health Authority
FNHIC	First Nations Housing and Infrastructure Council
FNIHB	First Nations & Inuit Health Branch
FNIIP	First Nations Infrastructure Investment Plan
FSIN	Federation of Sovereign Indigenous Nations
FTA	Financial Transfer Agreement
GCDWQ	Guidelines for Canadian Drinking Water Quality
GIS	Geographic Information Systems
HAA	Haloacetic Acids
HAB	Harmful Algal Blooms
HACCP	Hazard Analysis and Critical Control Points
ICMS	Integrated Capital Management System
IRP	Integrated Resource Planning
ISC	Indigenous Services Canada
ISC-RO	Indigenous Services – Regional Office Engineering
LoSS	Level of Service Standard
MAC	Maximum Acceptable Concentration
MC	Microcystins
MPN	Most Probable Number
MTSA	Municipal Transfer Service Agreement
NCCEH	National Collaborating Centre for Environmental Health
NDMA	N-Nitro dimethylamine
NOM	Natural Organic Matter
NSECC	Nova Scotia Department of Environment and Climate Change
O&M	Operations and Maintenance
OFNTSC	Ontario First Nations Technical Services Corporation
OSTS	Onsite Sewage Treatment Systems

PFAS	Per- and polyfluoroalkyl substances
POE	Point-of-entry
POU	Point-of-use
QMRA	Qualitative Microbial Risk Assessment
RME	Responsible Management Entity
RO	Reverse Osmosis
SCADA	Supervisory Control and Data Acquisition
SFNWA	Saskatchewan First Nations Water Association
TDS	Total Dissolved Solids
THM	Trihalomethanes
TSAG	Technical Services Advisory Group
TSS	Total Suspended Solids
US EPA	United States' Environmental Protection Agency
WSP	Water Safety Plans
WTP	Water Treatment Plants
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plants

Glossary of Terms

There are common terms and phrases used throughout this report that may mean different things to different readers. To clarify any ambiguity of terms, the expert review panel and authors have provided definitions below.

ALACTA – As low as current technology allows. This term appears in Appendix J and is an important concept when considering drinking water quality and human health. Currently, the Canadian Drinking Water Quality Guidelines establishes some parameters should be "ALARA" – as low as reasonably achievable – however, the question of what qualifies as reasonable and who holds the power to make that decision is imbalanced in a First Nations context. FSIN's Healthy Water Working Group's Drinkable Water Regulations refer to ALACTA rather than ALARA.

Adequate – Throughout this report the word adequate, or inadequate, appears over 100 times. The determination of adequate services, funding, maintenance, monitoring, etc. should be determined by First Nations. For the purpose of this report *adequate* means satisfactory or acceptable to the individual First Nation seeking funding, infrastructure, and capacity for safe and clean drinking water and wastewater services.

Centrally managed decentralised systems – The definition of a centrally managed decentralised system is critical to clarifying what systems are eligible for funding from ISC. The Protocol for Decentralised Water and Wastewater Systems in First Nations Communities sets "minimum standards and codes that must be followed for the design, construction, operation, and maintenance of onsite water and wastewater systems that are to be funded in whole or in part by AANDC. The term decentralised system refers to a group or groups of band-managed (as opposed to individually managed) onsite water or wastewater systems." This report highlights the disconnect between policy and practice regarding the operationalization of this definition to reflect current management approaches on First Nations.

Consult/consultation – Here, the term consult, or the act of consultation, is interchangeable with collaboration and implies the continuous and on-going discussion, knowledge exchange, co-development of questions, processes, and solution-building with First Nations as equal partners, although ideally, First Nations would co-lead the consultation process.

Economic leakage – This term refers to capital or income that escapes a First Nations economy because the funding flows directly from the Federal Government to outside entities, be it engineering firms, consultants, or other service providers. This process short-circuits First Nations capacity building and results in industry and professionals being the direct beneficiary of First Nations funding.

First Nations and Indigenous – Both terms are used throughout this report. The authors used the term Indigenous when referring to bodies of research that may include Métis, Inuit, or other Indigenous peoples around the world. Indigenous is also used in quotes or references to UN texts, including the Reports of the Special Rapporteur. The term First Nations is used to refer to the over 630 First Nations located across Canada.

Reasonable – The use of the term reasonable, when in reference to the Federal Court and the Court of the Queen's Bench of Manitoba settlement agreement refers to "all reasonable efforts" to ensure Individual Class Members living on Reserves have regular access to safe drinking water in their homes, whether from a public water system or a private water system, as established in the agreement. If used in other contexts throughout the report, reasonable means rational, appropriate, ordinary, or usual in the circumstances. It is implied that reasonable references the appropriate, ordinary, or usual circumstances experienced in municipal or provincial contexts. It should be noted that it is not the objective of this report to define "reasonable" effort, but rather to provide a summary of the state of the science in decentralised system risks, a preliminary survey of current practices in participating First Nations, and an outline of recommendations for improvements to these current practices.

Shoot-outs - shoot-outs result from modifications of failed onsite wastewater systems that direct untreated wastewater directly to the ground - often in close proximity to the home or well. After the infiltration field fails, the septic tank can back up into the house and as a temporary (which may become permanent) measure operators install piping going directly out of the tank to the ground service to by-pass the field. These systems are different than an open discharge system, which is regulated in some provinces and provide a minimal level of treatment with adequate set-back distances to key infrastructure, etc.

Source to tap and tap to source – Source to tap is a common phrase referring to water being extracted from either surface water or groundwater, treated and distributed to homes and buildings, and consumed via a sink tap. Tap to source refers to waters transition to wastewater, as it moves from the tap to the drain, collected in the house and transported to treatment, either in an onsite system or through the collection system to a wastewater treatment plant.

Well-being – Holistic and multidimensional, wellbeing refers to the overall quality of life in First Nations communities. It reflects collective prosperity and resilience, shaped by equitable access to resources and opportunities. Wellbeing encompasses, for example, social connections, health, economic stability, education, environmental sustainability, cultural identity and relationship with land; those dimensions essential for First Nations self-determination and sustainable and responsible development.

Executive Summary

Currently, decentralised water and wastewater systems, including individual wells, truck-to-cistern systems, onsite septic systems, and wastewater holding tanks, represent a significant risk to public and environmental health in First Nations due to the lack of funding, insufficient monitoring, and absence of effective policy to guide the management of these systems. These conditions have resulted in:

- significant knowledge gaps regarding asset inventory, system performance, and safety
- insufficient action to address acute and long-term risks associated with lack of treatment, monitoring, and maintenance in these systems
- lack of policy and planning to ensure a level of servicing for new and existing homes and buildings that meets or exceeds provincial standards.

These gaps have contributed to the overreliance of these potentially high-risk decentralised systems with insufficient monitoring and maintenance, to the detriment of First Nations well-being. Secure and sustainable access to adequate clean and safe drinking water and wastewater services is a critical social determinant of health, a basic human right, and essential for sustainable development. The fragmented policy addressing centralised and decentralised water and wastewater systems has created a two-tiered structure with the lack of funding and management challenges contributing to the potential for decreased levels of service and increased levels of risk for people reliant on decentralised systems.

This report provides initial recommendations to improve asset management approaches, characterize and mitigate health risks, and practice due diligence in the holistic design and management of drinking water and wastewater services in First Nations that integrates centralised and decentralised system components in ways that best serve each First Nation.

The United Nations recognizes that equitable access to safe and clean drinking water and sanitation is an integral component of the realization of all human rights and calls on States to provide financial resources, support capacity-building, and facilitate technology transfer to provide safe, clean, accessible, and affordable drinking water and sanitation to all (64/292, 2010). The United Nations also recognizes, through the Declaration of the Rights of Indigenous Peoples (61/295, 2007), an urgent need to respect and promote the rights of Indigenous peoples affirmed in treaties and their right to self-determination.

The Federal Government of Canada's current focus on removing long-term drinking water advisories on centralised systems fails to acknowledge and address the substantial risks that exist in decentralised drinking water systems and neglects to consider the impacts of failing onsite septic and wastewater holding tanks on Nation well-being. It is estimated that in First Nations, over 30,000 homes rely on decentralised drinking water systems (individual wells or truck-to-cistern systems) and over 40,000 homes rely on decentralised wastewater systems (onsite septic fields or truck-hauled holding tanks), accounting for nearly a third of all homes on First Nations reserves. It is estimated that over half of all First Nations have some level of decentralised services in their communities. However, because there is no formal inventory system in place, the actual number of homes reliant on these systems is unknown. Further, because of fragmented housing, infrastructure, and health policies and practices, these critical services are disconnected, resulting in significant gaps that contribute to the housing and infrastructure crises in many First Nations.

Despite the *Decentralised Protocols for Drinking Water and Wastewater Systems in First Nations* and the Federal Government's *Water and Wastewater Policy and Level of Service Standard*, which define funding availability for centrally managed decentralised systems in First Nations, these systems have been historically un-, or underfunded. These funding and policy gaps impact system design, installation, performance, monitoring, and maintenance of decentralised systems, which result in a serious, but largely unquantified, risk to public and environmental health, and more broadly, First Nations well-being. Current funding mechanisms fail to allow long-term planning and asset management practices and bias the installation of decentralised systems, creating a substantial burden on First Nations.

As an initial fact-finding effort to better understand the technical risks and management challenges associated with these systems, Indigenous Services Canada (ISC) commissioned the production of this report, led by Dr. Graham Gagnon, Dr. Sheri Longboat, and Dr. Megan Fuller to provide preliminary information on three main objectives:

Objective 1: Assess the state of the science on private wells, cisterns, trucked water, and onsite wastewater systems.
Objective 2: Gather and summarize current First Nations practices regarding the installation, operation, maintenance, monitoring, and management of decentralised systems.
Objective 3: Offer First Nations- led recommendations and best practices for the installation, operation, maintenance, and management of decentralised systems, as well as the planning, capacity building, funding, and decision-making processes necessary to support adequate systems that ensure sustainable, safe, and reliable service to protect public and environmental health. This report aims to understand the role of asset design, maintenance and management within the broader physical, management, policy, funding, and governance paradigms that currently exist in First Nations, as depicted in Figure 1.

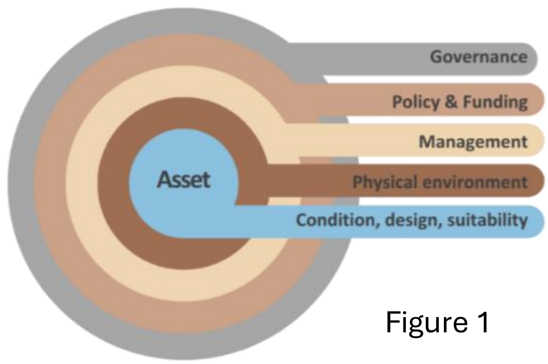


Figure 1

PART 1 – STATE OF THE SCIENCE FOR DECENTRALISED DRINKING WATER AND WASTEWATER SYSTEMS provides an in-depth assessment of the state of the science for decentralised water and wastewater systems recognized by the federal government in the Water and Wastewater Policy and Level of Service Standards (individual wells, truck-to-cistern systems, onsite septic, and wastewater holding tanks) based on a literature review, jurisdictional scan, and conversations with water and wastewater industry experts. Risks inherent to each system type are summarized from source to tap (drinking water) and tap to source (wastewater), with a focus on asset management, system performance, and safety. Common health risks due to natural and human-caused sources are described and the importance of system design, installation, maintenance, and monitoring to protect human and environmental health are summarized.

PART 2 – CURRENT PRACTICES AND CRITICAL GAPS presents a summary of current practices related to decentralised system management in First Nations. Content and voices shared in Part 2 come directly from First Nations staff, Tribal Council staff, industry technical experts and engineers with knowledge of these systems in a First Nations context, researchers, and regional and national First Nations experts. Critical gaps are organized into three key categories to inform where current policy and practices are failing to protect public and environmental health and Nation well-being:

- Inadequate funding
- Management barriers and obstacles
- Lack of knowledge, sharing, and action

A key finding from the gap analysis is the increased risk to public and environmental health due to the fragmented treatment of centralised systems and decentralised systems. The current two-tiered approach to water and wastewater in First Nations has created a significant level of service gap, underserves homes reliant on decentralised systems, and exacerbates housing and lot servicing challenges present in First Nations.

PART 3 – A PATH FORWARD summarizes recommendations gathered from the over 70 interviews and discussions with contributors to specifically address the current gaps and challenges present in decentralised drinking water and wastewater systems, and infrastructure more broadly, in First Nations. Part 3 also provides guiding principles shared by contributors to ensure policy change and progress in drinking water and wastewater service provision are grounded in the fundamental reform of the current First Nations – Federal government relationship. Change is needed to address persistent problematic elements of the status quo. The recommendations are organized as immediate, intermediate, and reform actions to move toward long-term sustainable funding for a holistic drinking water and wastewater service framework led by First Nations. Many contributors agreed that decentralised services play an important role in supporting First Nation growth and development while allowing culturally preferred housing arrangements. However, all contributors noted that current funding, management, and monitoring practices for decentralised services are insufficient and have resulted in serious threats to public and environmental health. An imperative first step is identifying funding and capacity building mechanisms to facilitate First Nations to generate comprehensive asset inventories and asset condition assessment data to understand the number, location, and condition of decentralised water and wastewater assets in all First Nations. Immediate knowledge gathering and data generating activities should inform intermediate changes to funding approaches to allow for appropriate system design, installation, monitoring, and maintenance of decentralised assets. Ultimately, long-term reform is needed to support First Nations to manage water and wastewater services in an integrated way that prioritizes public and environmental health, supports community growth, and ensures First Nations well-being.

This report does not represent, and should not be taken as, formal consultation with First Nations and does not reflect the diverse perspectives, thoughts, experiences, or guidance of First Nations. Rather, this report is a curated culmination of conversations and knowledge exchanges with participating First Nations staff, First Nations technical organizations, Tribal Councils, researchers, technical experts, and Indigenous and non-Indigenous water and wastewater experts. The report is meant to provide a first step in initial fact-finding to provide context for future work to address these significant risks. The report summarizes preliminary information, thematic evaluation, and First Nations-led recommendations toward self-determined management of decentralised water and wastewater system.

The aim of this report is not to make policy, and it does not represent or replace First Nations-led policy development grounded in free, prior, and informed consent.

Recommendation matrix summarizing what was shared by contributors to improve collaborative structures, invest in Nation-led initiatives, and establish long-term funding to support Nation well-being.

	Immediate	Intermediate	Reform
Fund the True Cost of Water and Wastewater Systems +	Invest in comprehensive knowledge of decentralised systems to determine capacity and costs	Develop pilots to identify funding mechanisms for the design, monitoring, and management of decentralised systems	Shift to long-term funding cycles to facilitate Nation-led growth & Standards and requirements for water and wastewater systems to ensure Nation well-being
Structures and Processes to Enable First Nations Self-Determination +	Improve knowledge and data sharing with First Nations to support asset management	Align RFP and procurement practices to Nation capacity building & Build knowledge sharing around water and wastewater systems	Develop First Nation-informed feasibility study process to align with capital and asset management planning
Responsive Integrated Management of Water and Wastewater Systems to Support Nation Well-being	Collaborative water and wastewater working groups within the Regions to prioritize and address risks holistically	Pilot inspection and monitoring programs to address under-investments in decentralised systems and find sustainable solutions	Integrated water and wastewater policies that prioritize public health and Nation well-being
	Knowledge gathering and collaboration before policy development	First Nations-led piloting to build sustainable solutions	Funding, policy, and management reform based on evidence and First Nations collaboration

Expert Review Process

This report was compiled by the project team, but represents the collective voices, experiences, and ideas of dozens of contributors. To ensure that the report is technically sound and reflective of First Nations realities regarding decentralised systems on reserves, the report was reviewed through multiple rounds of both in-person and online workshops.

Expert Panel

An initial review of the draft report occurred at an in-person two-day panel held in Calgary, AB on October 17 – 18, 2024. Invitations were extended to eight First Nations organizations and water advisors with technical, governance, and/or health expertise. Seven panelists, representing four regions, northern Nations, and a national perspective, joined the project team for an in-depth review of the report. The panelists included:

Rob Fleming, First Nations Health Authority

Irving LeBlanc, Community Circle; True North Aid; Former Director of Infrastructure, AFN

Tim Vogel, First Nations Capital and Infrastructure Agency of Saskatchewan

Rebecca Zagozewski, The Saskatchewan First Nations Water Association

Jamie Saunders, Nishnawbe Aski Nation

Adam McCue, Ontario First Nations Technical Services Corporation

James MacKinnon, Atlantic First Nations Water Authority

The expert panel provided revision and refinement of the framing of the report, technical details of risks of decentralised systems, and the organization and presentation of recommendations. All experts in attendance stressed that while they reviewed the report on behalf of the First Nations they represent and serve through their organizations and professional capacity, their opinions and comments did not represent, nor replace, the need for direct First Nations engagement and collaboration.

Expert Review Summits: Tribal Council, First Nation Organizations, Service Providers

A second draft of the report was prepared following the expert panel review and circulated to more than 40 people for feedback and comments. Tribal councils, First Nations organizations, engineering firms and service providers, and other individuals who contributed to the report were invited to join one of three online expert review summits held between November 13th and 18th. Thirty attendees joined the online summits to provide feedback and recommendations for the report. Written comments were also accepted.

First Nations Review Process

The second draft of the report was sent directly to all First Nations representatives who contributed to the report. The report was shared via email on November 15th to allow Nations staff time to review the report and provide feedback, either through written edits or via online meetings, whatever was preferred by the Nation.

PART 1: State of the Science for Decentralised Water and Wastewater Systems

1. Introduction

1.1. Water is Life

On the surface, this literature review focuses on technical and managerial aspects of decentralised drinking water and wastewater systems, but at the core of this work is the recognition that these topics are important to us because water is life. Clean water nurtures and sustains us and all our relations. It is our responsibility to take care of the water and make sure it is protected for future generations.

1.2. Context

The Class Action Settlement Agreement commits Canada to making all reasonable efforts to ensure individual class members living on reserve have safe drinking water in their homes, whether from a public or private including on-site systems, that meets the stricter of the federal requirements or provincial standards governing water quality. The settlement agreement includes specific guidance on prospective relief, to ensure the future “never again resembles the past.” To this end, Canada committed to spend at least $6 billion by March 31, 2030, to implement this commitment by funding the actual costs of construction, upgrades, operations, and maintenance for water infrastructure on reserve in First Nations communities. Additionally, at the time of drafting this report, the government had tabled Bill C-61, the First Nations Clean Water Act which would have provided a path toward regulations and funding frameworks for all water services on reserves (note, at the time of finalization of this report, the Bill had not passed third reading as a result of prorogation of Parliament. To ensure decentralised water and wastewater systems are considered in these efforts to support adequate infrastructure on reserves, Indigenous Services Canada (ISC) seeks to better understand these systems.

This Expert Report aims to gather and consider information about decentralised systems, as they have been historically un- or underfunded and less well understood than centralised systems in First Nations. This report summarizes key technical risks inherent in decentralised systems, provides details on management challenges specific to a First Nations context, and presents feedback from practitioners knowledgeable about decentralised systems in First Nations. To adequately enable First Nations to manage their decentralised water and wastewater systems, and to ensure any future legislation and/or funding mechanisms adequately address risks inherent in decentralised systems, there is a need to work with First Nations to identify current challenges and best practices related to the installation, operation and maintenance, monitoring, and management of these systems to reduce risk to public health and improve well-being for all people on reserves.

1.3. Project Objectives

This Expert Report provides a summary of the state of the science of decentralised drinking water and wastewater systems, as defined by federal policy, and presents a summary of current practices from the 20 First Nations that contributed to this report and the collective knowledge of over 70 practitioners with knowledge of decentralised systems in First Nations. Part 1 of this report addresses Objective 1. Part 2 addresses Objectives 2 and 3.

Objective 1: Assess the state of the science on private wells, cisterns, trucked water, and onsite wastewater systems. A review of the impacts of installation, maintenance, operation, and management practices were conducted to understand significant threats to safe drinking water and properly treated wastewater effluent in decentralised systems. Research literature, industry standards, regulatory requirements and best practices were reviewed to identify risks accumulation from source to tap (for drinking water) and tap to source (for wastewater). Research characterizing technical solutions for risk mitigation strategies were summarized to highlight best practices that protect public and environmental health. Key factors such as hydrogeological conditions, aquifer type, system design and construction, and site geography were considered. When possible and appropriate, the impacts of climate change threats and challenges were also examined. This objective resulted in both provincial jurisdictional scans (Appendices B - D) and a risk assessment literature review (Part 1).

Objective 2: Gather and summarize current First Nations practices regarding the installation, operation, maintenance, monitoring, and management of decentralised systems. Through dozens of discussions, exchanges, visits, and review of available asset condition assessment reports, processes and activities related to decentralised system planning, funding, installation, operation and maintenance, and monitoring were gathered and summarized. Details on crucial gaps, challenges, and obstacles present in First Nation communities were investigated. Emerging best practices and exemplary cases of effective and successful models and practices were identified and shared in the report to inform paths toward more effective and adequate decentralised drinking water and wastewater system planning, funding, design, and delivery. This objective resulted in summaries of practices related to funding, system design, and planning, as well as lifecycle narratives for individual wells, truck-to-cistern systems, onsite septic systems, and holding tanks. This objective also highlighted crucial governance and management gaps and emerging First Nations solutions which are discussed in Part 2.

Objective 3: Offer recommendations and best practices for the installation, operation, maintenance, and management of decentralised systems, as well as the planning, capacity building, funding, and decision-making processes necessary to support adequate systems that ensure sustainable, safe, and reliable service to protect public and environmental health. These recommendations have been co-developed with First Nations contributors, First Nations organizations, service providers, Tribal Councils, researchers, and technical experts and are reflective of identified challenges and successes shared by the contributors included in this report. This objective resulted in the identification of key Guiding Principles that underpin a paradigm shift needed in decentralised drinking water and wastewater systems used in First Nations (Section 11.1). The recommendations are framed as immediate, intermediate, and reform actions with detailed discussion of recommendations for a path forward to reshape all drinking water and wastewater services in First Nations in an integrated way to strengthen Nation well-being (Section 11.2).

This report does not represent, and should not be taken as, formal consultation with First Nations and does not reflect the diverse perspectives, thoughts, experiences, or guidance of First Nations.

Rather, this report is a curated culmination of conversations and exchanges with participating First Nations staff, First Nations technical organizations, Tribal Councils, researchers, technical experts, and non-Indigenous water and wastewater experts meant to provide preliminary information and recommendations toward First Nations-led management decentralised water and wastewater system.

2. Approach & Methodology

Part 1 was prepared to summarize the state of the science of decentralised drinking water and wastewater systems, with a particular focus on understanding the i) key risks and ii) best practices in installing, operating, maintaining, monitoring, and managing individual wells, truck-to-cistern systems, holding tanks, and onsite septic systems. Given the breadth of these topics and the interplay of geologic, technical, and managerial elements in risk manifestation in these water and wastewater systems, it is important to define key terminology and describe the framework used to organize and describe hazards and risks in this literature review.

2.1. Terminology

Risk management terminology varies across sectors, with aviation, construction, cyber security, and pharmaceutical industries developing a range of models and methods for understanding and mitigating risks. Likewise, many jurisdictions have developed drinking water risk management systems for centralised systems to protect public health. These approaches have been adapted from the food safety industry (HACCP), quality management paradigms (ISO 31000, etc.), and the World Health Organization's Water Safety Plans (WSPs). Decentralised drinking water and wastewater systems, because they are often the responsibility of individual residents or property owners, have less well-established risk management frameworks.

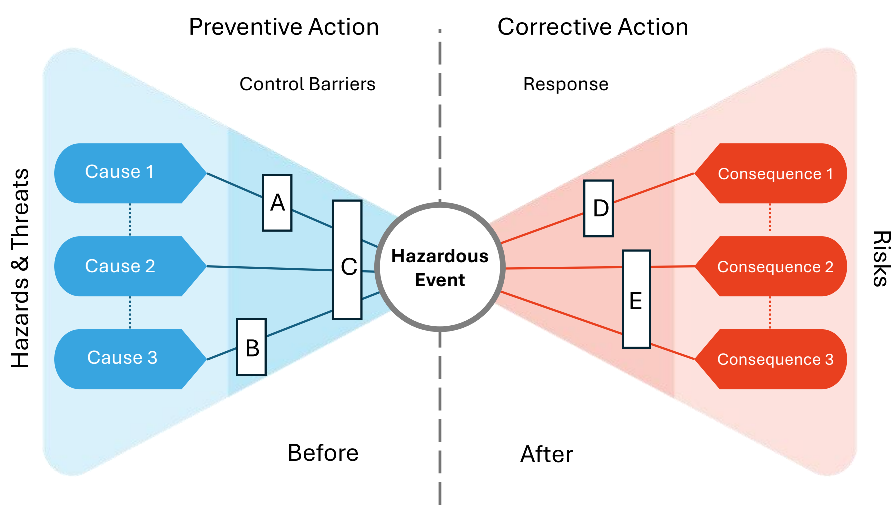


Figure 2-1. Bowtie risk model showing the relationships of hazards, causal pathways, and control barriers with outcomes, corrective actions, consequences, and risks.

For the purpose of this literature review the bowtie risk model shown in Figure 2-1 will be used throughout to discuss the risk pathways for decentralised drinking water and wastewater systems. Table 2-1 contains the definitions of key terms relevant to hazard identification and risk assessment practices (Nadebaum, 2004; Røstum & Eikebrokk, 2009).

Table 2-1. Definition of key terms related to risk assessments and response.

Term	**Definition**
Hazard or Threat	Any biological, chemical, physical, or radiological agents that have the potential to cause harm to water quality or quantity.
Hazardous Event	An event or incident that can cause harm, i.e. how a specific hazard or threat can occur.
Cause	The origin of the hazardous event, i.e. design-related, operation-related, external-related (i.e. weather or climate) occurrence that resulted in a hazardous event.
Preventive Action	Planned actions, activities, or processes used to prevent hazards from occurring, or reduce the likelihood to an acceptable level
Control Barrier	Specific preventive actions or processes along the multibarrier pathway from source to tap (drinking water) or tap to source (wastewater) to protect human and environmental health.
Consequence	The negative outcome of a hazardous event occurring
Corrective Action	Risk mitigation activities, actions, or processes that occur after a hazardous event; are intended to mitigate consequences and reduce the negative outcomes or risks of the event.
Response	Specific corrective actions or processes along the multibarrier pathway from source to tap or drain to effluent release in drinking water or wastewater systems
Risk	The likelihood of an identified hazard causing harm, including the severity of the consequence if a hazardous event were to occur.

Hazardous events in drinking water and wastewater systems are precipitated by any number of causal pathways, depending on the number and nature of control barriers along the water/wastewater system. The outcomes, or risks, associated with hazardous events depend on the efficacy of corrective actions and the vulnerability of the populations impacted by the consequences of the event. As shown through the dotted lines between both the causes and the

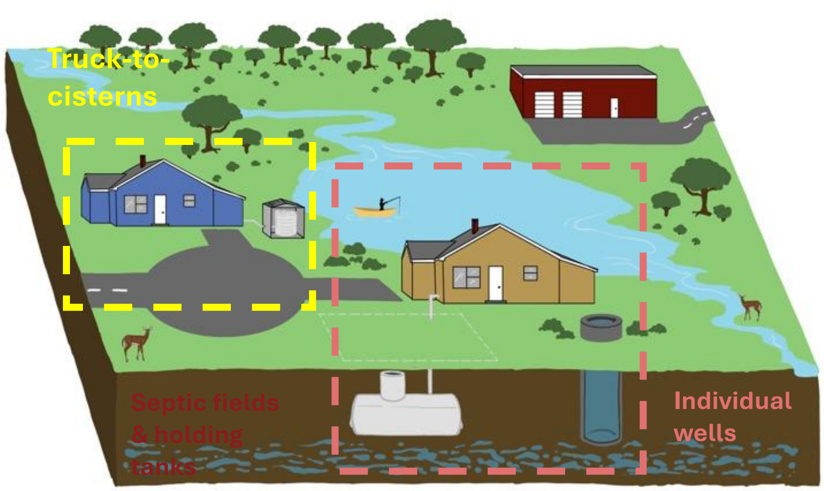


Figure 2-2. Spatial relationships of the decentralised services, key infrastructure, and natural elements that interact to determine water and wastewater safety.

consequences, individual or chains of interdependent causes can result in cascading risks. This is particularly true in decentralised drinking water and wastewater systems, in which drinking water and wastewater infrastructure are often located near each other, and both are susceptible to infiltration and contamination. See Figure 2-2 for a representation of the spatial relationships between decentralised system components and other key infrastructure and features, i.e. roads and surface water. Throughout this report, these terms and concepts will be used to discuss the potential for individual, compound, and cascading risks that may exist due to natural and anthropogenic hazards, faulty or missing control barriers, and limited corrective actions. Where evidence exists, best practices for risk mitigation will be highlighted and recommendations for improved water safety will be shared.

2.2. Hazard and Risk Identification in a Multibarrier Asset Management Framework

Hazard occurrence and risk manifestation are characterized as products of complex relationships between technical problems, system problems, and people problems (Hrudey et al., 2006). Work by Hrudey et al. (2006) discussed recurring themes found in modern waterborne disease outbreaks in centralised drinking water systems and found common failures occurred in these three key areas. There is far less research available to understand risk pathways in decentralised systems, and even less that focuses on First Nations' decentralised systems. However, it is reasonable to assume that the technical, systemic, and people problems multiply as the number of individual onsite systems increases. In general, the management of decentralised systems requires the coordination of more people to manage a greater number of pieces of infrastructure to ensure safe drinking water and properly treated wastewater. This literature review includes research and information from both Indigenous and non-Indigenous contexts but aims to apply non-Indigenous results to a First Nations context when possible. To capture and characterize these diverse components of risk in decentralised drinking water and wastewater systems in a meaningful way for First Nations, the model in Figure 2-3 was used to frame the discussions presented in this report.

As discussed in Section 2.1, hazardous events occur if control barriers and preventive processes fail. Control barriers exist in various forms along the drinking water and wastewater pathways and can include physical infrastructure, maintenance programs, inspection processes, monitoring programs, and educational outreach. Because control barriers are diverse, they can be supported, or degraded, by physical phenomena (i.e. soil conditions, flooding), management systems (i.e. record keeping, communication practices), and adequate and sustained funding. Drinking water and wastewater asset suitability and condition is the first line of defense against hazardous events. Figure 2-3 shows the assets as the centre of the asset management framework. Implicit in the "asset" circle are the numerous individual asset components that combine to produce safe drinking water and properly treated wastewater. The expanded view of the "asset" circle shows a *One Water* approach to understanding the water cycle from source to tap, and back again to the receiving body as wastewater effluent (Tuser, 2021). Assets, throughout their lifecycle from installation to repair/replacement, are impacted by their physical environment (geology and site conditions), management practices, funding support, and broader governance structures.

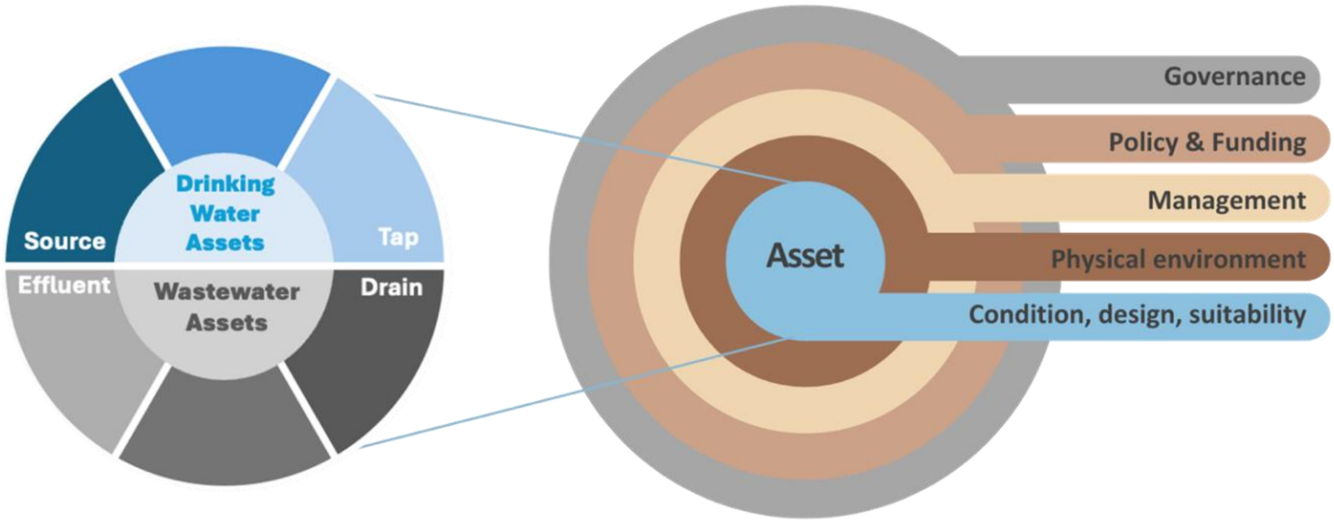


Figure 2-3. The multibarrier asset management framework that illustrates the source-to-tap and drain-to-effluent asset as the central components to the broader asset management environment.

This multibarrier asset management framework will be used throughout the report to provide a comprehensive review of hazard and risk identification in decentralised drinking water and wastewater systems.

2.3. Literature Review

Adapting a methodology detailed in Whittemore & Knafl (2005), an integrative literature review was completed to understand the state of the science of decentralised drinking water and wastewater systems. As defined by Whittemore & Knafl (2005, pg. 547), an integrative review is the broadest type of research review "allowing for the simultaneous inclusion of experimental and non-experimental research to more fully understand a phenomenon of concern." Appendix A provides a summary of the results from the literature search for groundwater quality and risk identification in individual wells. Similar methodologies were employed for truck-to-cistern systems, onsite septic systems, and sewage holding tanks. In brief, keyword searches were conducted using Google Scholar to identify articles that contained useful results related to "groundwater quality" and "microbial risks" for "individual wells" and "private wells" located in "confined aquifers", "bedrock aquifers", "unconfined aquifers" and located near "septic systems", "filtration fields", etc. Article abstracts were reviewed and relevant articles with potentially important information were stored in Zotero and catalogued in an Excel spreadsheet. Each article was read, and key observations and findings were recorded in an Excel table for inclusion in the literature review. Similar keyword searches were completed to identify articles that included water quality risks present in truck-to-cistern systems and ecological and health risks associated with onsite septic systems and holding tanks. For all articles selected for the literature review, forward and backward chaining of articles was used to identify additional references.

An integrated review allowed the inclusion of documents and information other than scholarly publications. Provincial best management practices and guidance documents, federal reports and guidance documents, and public health information were included, when appropriate, in the literature review. Where possible, First Nations and Tribal Council annual reports, news articles, and relevant publications were also incorporated. This report is a synthesis of diverse sources of information that aims to provide a summary of the state of the science of decentralised systems and understand that science in a First Nations context.

2.4. Expert Consultation

To support and augment the findings of the literature review, numerous experts were interviewed to gather their thoughts on the challenges and risks inherent in these systems. Nine researchers, two policy analysts, three engineering groups, and twelve provincial regulators were interviewed for this literature review. These experts' contributions will be anonymous and were primarily used to direct the literature review and ensure that high-priority hazards, hazardous events, causal pathways, preventive actions, and corrective actions were considered in the literature review process.

3. Drinking Water

ISC defines levels of drinking water services suitable for First Nations in the Water and Wastewater Policy and Level of Services Standard (Corporate Manual System), Volume 1 (LoSS). This document states that ISC is "prepared to financially support [to assist] First Nations in providing community services comparable to the levels of service that would generally be available in off-reserve communities of similar size and circumstances" and outlines resourcing guidelines. The policy defines key elements that determine water and wastewater service decision-making, including life cycle-costing details, feasibility study requirements, and requirements for the extension of existing piped systems. These policies inform system selection in First Nations and establish the inextricable relationship between housing availability and density (i.e. serviced lots) with funding expenditures for water and wastewater infrastructure systems.

The primary decision when servicing residences for drinking water systems is whether a centralised or decentralised solution is more practical and affordable. Inherent in the Water and Wastewater Policy and LoSS is the understanding that practicality and affordability are both functions of source water quality, the level of treatment needed to produce safe and sustainable drinking water, and the level of operational and maintenance support required over the life cycle of the drinking water system. Beyond water quality and quantity, remoteness, accessibility, as well as the practicality of burying lateral assets, affect what level of service can reasonably be provided. However, it is worth noting that the metrics for determining "practical and affordable" are defined by the federal government and rely on, and prefer, non-Indigenous housing paradigms, i.e. subdivisions. There is abundant evidence of significant gaps in providing safe drinking water and properly treated wastewater in First Nations, so an evaluation of the content and application of the policy and LoSS, particularly for decentralised systems, is warranted. In the sections that follow, hazard and risk identification will be discussed from source to tap for decentralised drinking water systems, with source water quality, remoteness, and construction limitations considered from coast to coast to coast.

3.1. Level of Service

The LoSS provides criteria for funding the four levels of drinking water system services present across First Nations. Table 3-1 defines these four levels of service.

Table 3-1. Level of Services definitions for drinking water systems from ISC's LoSS.

Level of Service	Description
W1	Centrally managed onsite systems, such as wells, water storage tanks, and drinking water units, designed, installed, and continuously operated, maintained, and monitored as per the *Protocol for Decentralised Water and Wastewater Systems in First Nations Communities*.
W2	One or more watering points, which should be no greater than 100 meters from a residence and should serve at least 10 homes where practical.
W3	Trucked water delivery where treated water is delivered by vehicle to residences in limited quantity. The source is either treated surface or groundwater or both.
W4A	Piped water distribution, system consists of water supply, treatment, storage facility, and piped distribution system to each residence.
W4B	Piped water supply with fire protection capacity.

This report is tasked with summarizing the risks and management challenges of decentralised drinking water systems, so Level W4 (including W4A and W4B) will not be addressed here. Additionally, Section 2.3 of the LoSS identifies watering points (Level W2) as only appropriate as interim measures. Given that ISC does not recognize watering points as an adequate and sustainable level of service, they will not be considered in this report. Level W1 – centrally managed onsite systems, including wells, and Level W3 – Trucked Water Delivery will be the focus of this report.

Data from ISC's 2022-2023 from the Integrated Capital Management System (ICMS) is summarized in Figure 3-1. Of the 120,935 reported First Nations housing units across the country, roughly 29% were reported to be serviced by decentralised drinking water systems.

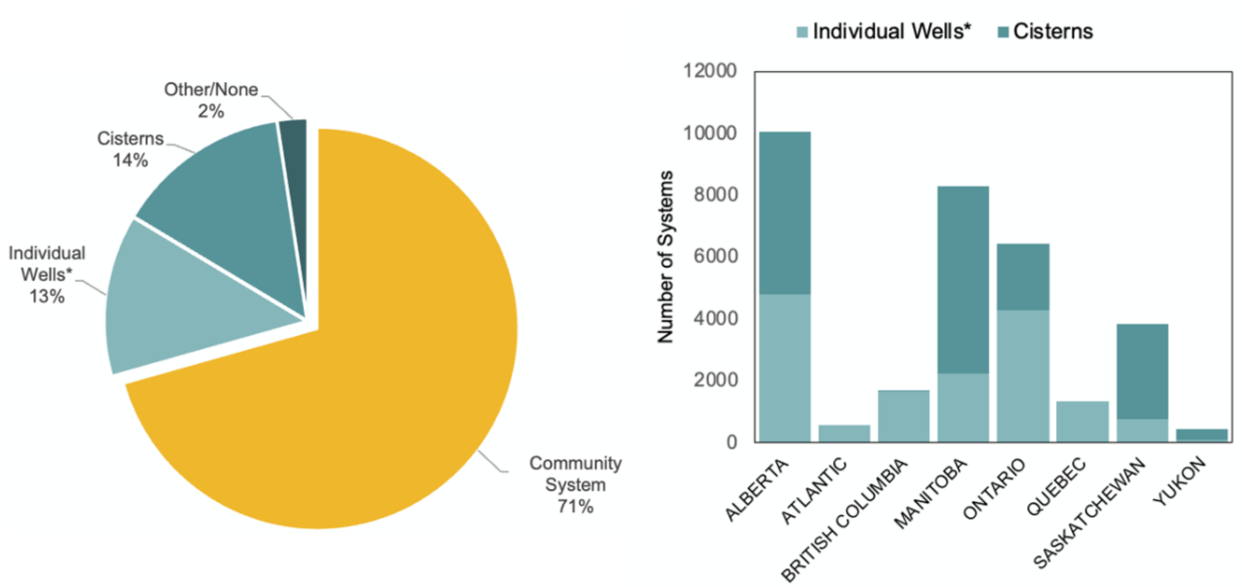


*Figure 3-1. The proportion of decentralised drinking water systems by type (left) and within each region (right), summarized from data in the 2022 - 2023 ICMS housing survey. *Also includes surface water intakes with full or partial treatment.*

It should be noted that while decentralised drinking water systems are evenly split between individual well systems and truck-to-cistern systems according to the housing data available for First Nations, this is not the case in non-Indigenous communities. The majority of rural decentralised water systems in non-Indigenous contexts are individual wells, though cisterns and truck-hauled water systems are used to a lesser extent in several provinces and territories (Baird et al., 2013; O'Keeffe, 2024). Because of the significant reliance on groundwater in Canada in municipal centralised systems and individual wells, there is an abundance of research and information available on wells and drinking water. There is a lack of research and information available for truck-to-cistern systems. What limited information is available on the threats and risks present in truck-to-cistern systems has been summarized here, but there is an imbalance in Sections 3.2 (Individual Wells) and 3.3 (Truck-to-Cistern Systems). This discrepancy does not reflect the relative risks of each system, but rather the lack of data and research available on the vulnerability and risk pathways in truck-to-cistern systems.

3.2. Level W1 - Individual Wells

An estimated 4 million non-Indigenous peoples in Canada rely on individual wells to provide domestic water to their homes (Government of Canada, 2017). The use of individual wells is highest in rural settings, with New Brunswick and Nova Scotia having the highest proportion (~40%) of their populations reliant on individual wells. Ontario, as the most populated province, has the highest total number of people, 1.6M, that use private wells (Latchmore et al., 2023). Provincial and territorial oversight of individual wells varies across jurisdictions, but most require well drillers to be certified through a provincial program and many have regulations outlining well construction requirements. The results of a jurisdictional scan are provided in Appendix B. In all provinces and Yukon, well operation, maintenance, repair, monitoring, water treatment, and decommissioning are the responsibilities of the homeowner. Researchers have noted that people who rely on individual wells for their domestic water supply own the well and the land, but do not control the source, movement, or quality of the water they have access to (Burch et al., 2021). People reliant on individual wells are left to manage this highly variable and uncontrolled resource the best they can. Provinces and territories recognize that individual wells represent a significant public health burden because homeowners are often unaware of health threats posed by contaminated drinking water, or are not able to afford the expense of installing and maintaining a safe drinking water system (Charrois, 2010; Fitzgerald et al., 2001; Kennedy & Drage, 2016; Lee & Murphy, 2020; Ochoo et al., 2017). Provincial practices and resources are often the default practices and resources in First Nations for well installation and maintenance, given the reliance on provincial well drillers and services and the common geographical and hydrogeological contexts. Additionally, there are no regulated well installation standards for First Nations on federal land. Many challenges associated with individual wells in a municipal-provincial context are shared by First Nations, however, the legal and jurisdictional contexts of First Nations create unique challenges and opportunities for individual well management.

As shown in Figure 3.1, every region has at least a small population of First Nations homes that rely on individual wells, with Alberta, Manitoba, Ontario, British Columbia, and Quebec having thousands of homes that use groundwater for their domestic water needs. While there is limited published research related to First Nations groundwater quality, well condition, well maintenance, and treatment practices, there is significant research available on domestic wells in a municipal-provincial context. The literature presented here offers examples and general findings regarding individual wells and drinking water safety that can be applied or extended to a First Nations context to evaluate water quality risks and provide guidance on asset management to protect human health. Where possible, literature and research done with and by First Nations is included. It should be noted that much of the water quality monitoring and public health guidance for First Nations is supported by First Nations and Inuit Health Branch (FNIHB) or other devolved entities, e.g. First Nations Health Authority for Nations located in British Columbia or individual tribal councils for First Nations in Saskatchewan. FNIHB developed a tool kit for individual wells for First Nations, which is a collection of public awareness and educational materials, including advice on wells monitoring, inspection, maintenance for First Nation residents who are served by wells with fewer than five connections. FNIHB, through Environmental Public Health Officers (EPHOs) and community based water monitors (CBWMs), assists with individual well inspection and microbiological monitoring upon request. Details about these programs will be discussed further in Sections 8 and 9.

3.2.1. Risk Identification from Source to Tap

There are several well-established categories of hazards that threaten the safety of drinking water, and while these hazards are well known, disease outbreaks still happen, even in advanced countries with robust centralised drinking water systems (Hrudey & Hrudey, 2007). From source to tap, environmental conditions, system changes, and human error can create the potential for unsafe drinking water in both centralised and individual systems. The aim of any drinking water system is to implement the necessary control barriers to reduce the risk of these hazards, primarily biological, chemical, physical, or radiological, in nature. The discussion in Section 3.2.1 will review key threats, hazardous events, causes, control barriers, corrective actions, and risks common in individual wells, from source aquifers to building plumbing and treatment units.

Figure 3-2 provides a high-level overview of common causal elements of hazardous events from source to tap in individual drinking water wells. The bullet point lists are non-exhaustive, and other location-specific and management-specific challenges can threaten individual drinking wells.

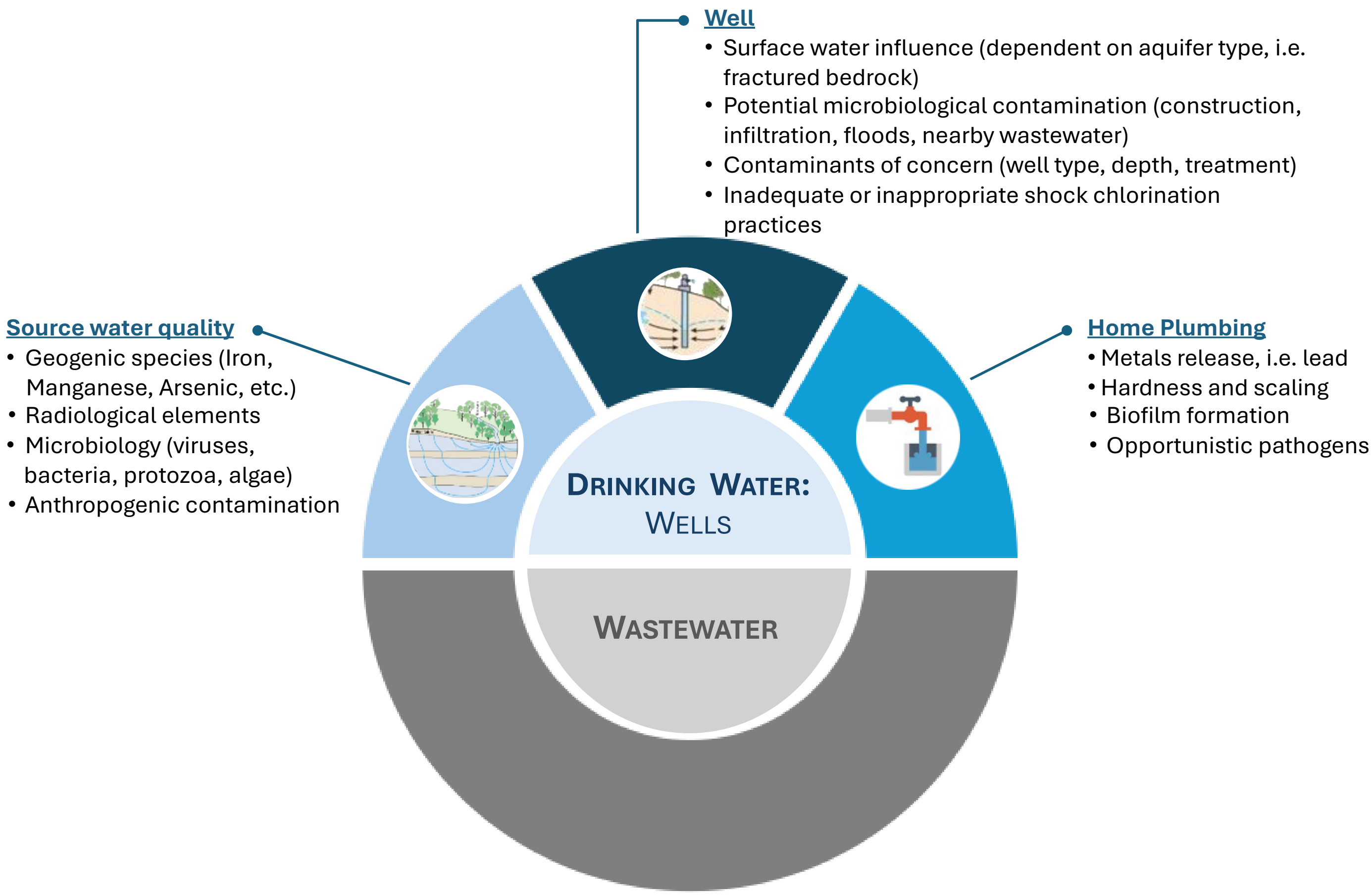


Figure 3-2. Source-to-tap assets in individual wells that provide potential risk to drinking water quality and identify locations for necessary barriers in the multibarrier approach.

3.2.1.1. *Source Water – Quality and Quantity*

Groundwater is a complex mixture of naturally occurring geological (geogenic), microbiological, and human-sourced (anthropogenic) contaminants and chemical species. Both biological and chemical components of water can impact human health. It is well understood that microbiological pathogens in drinking water, including bacteria, viruses, and protozoa, are the most significant threat to human health and are the primary cause of outbreaks of waterborne illnesses across the world (Hrudey & Hrudey, 2019). Pathogens originate in humans or other animals can travel into groundwater through surface water recharge and/or infiltration from poorly installed onsite septic systems and wells. Geogenic compounds, e.g. arsenic and manganese, also pose a significant threat to human health and require monitoring and treatment to ensure water safety.

Understanding hydrogeologic conditions of aquifer resources, robust well installation and construction practices, routine monitoring and maintenance, and effective treatment allow most groundwater sources to be used for potable domestic supply. To better understand the key risks of individual drinking wells, this section will discuss common geogenic and anthropogenic threats to safe groundwater and briefly discuss the importance of reliable water quantity.

There are common water quality parameters that present health and aesthetic risks in water derived from groundwater aquifers. Many of these species can have both geogenic and anthropogenic sources. Table 3-2 provides an abbreviated list of some of the most common water quality parameters that pose a threat to human health, as established by Health Canada's Guidelines for Canadian Drinking Water Quality.

Table 3-2. Summary table of Canadian Drinking Water Guidelines for key water quality parameters.

Parameter	Year Published	MAC (mg/L)	AO (mg/L)
Aluminium	2021	2.9	None
Arsenic	2006	0.010 (ALARA*)	None
Chloride	2005	None	≤ 250
Fluoride	2010	1.5	None
Lead**	2019	0.005 (ALARA)	None
Manganese	2019	0.12	≤ 0.02
Uranium	2019	0.02	None
Methane***	2003	10 – 28 mg/L	2 mg/L
Dichloromethane	2011	0.05	None
Trihalomethanes	2006	0.1	
Nitrate	2013	45 (NO_3) 10 (N)	None

*ALARA = as low as reasonably possible.
**Lead contamination is rarely from geogenic sources and usually comes from plumbing sources in buildings or lead services lines.
*** There is no Canadian Drinking Water Guideline for methane, but the US Department of the Interior recommends an action limit of 10 mg/L to 28 mg/L for homeowners to remove potential ignition sources. If levels exceed 28 mg/L, immediate action should be taken to reduce methane levels. Ontario Ministry of Environment (2006) set an aesthetic objective of 2 mg/L to limit gas bubbles and spurting from taps.

It should be noted that First Nations have long engaged in both traditional source water protection and western-based approaches to source water protection (Collins et al., 2017; McGregor, 2012; Roy, 2010). However, a comprehensive review of source water protection practices is beyond the scope of this work.

Regional Geogenic Groundwater Quality

Canada has vast groundwater resources distributed throughout consolidated and unconsolidated aquifers that vary regionally depending on the mineralogy and morphology of subsurface geologic units. Recharge rates, storage volumes, and water quality are highly influenced by the granular material and bedrock present in the aquifers. An extensive review of groundwater in Canada is provided in Canada's Groundwater Resources (2014), compiled and edited by Alfonso Rivera, former Chief Hydrogeologist of the Geological Survey of Canada. A summary of key elements of the hydrogeology of Canada will be included here, when possible, to contextualize the geogenic groundwater quality and quantity available to First Nations to help inform common threats to safe drinking water. Groundwater is found in most geologic formations in pores and fractures present in igneous, sedimentary, and metamorphic rocks and in unconsolidated sand and gravel aquifers. One-third of Canada is located on the Precambrian Shield, a large plutonic section of igneous rock. Aquifers in the Canadian Shield are highly variable due to the heterogeneity of the hydrogeological units, but many areas are characterized by restrictive flow and low well yield (Rivera, 2014). However, some highly fractured areas provide important water resources to rural communities. Many other Canadian aquifers are unconsolidated sand and gravel formations caused by the last glaciation, such as the Waterloo Moraine in Ontario, the Fredericton area in New Brunswick, the Carberry Aquifer in Manitoba, and the Fraser Valley aquifer in British Columbia (Rivera, 2014). Regional fractured-bedrock aquifers also supply water, such as the sandstone aquifer located under Prince Edward Island, the carbonate and shale aquifer under the Winnipeg Region, and the carbonate and dolostone aquifer under the Montreal region. Each of these aquifer types controls the yield and chemical quality of the water they produce. Populations across the country also rely on the significant number of shallow aquifers for their drinking water resources, which are easier to access and wells are less expensive to install when compared to the installation of wells in deeper, confined aquifers. Consolidated or unconsolidated, confined or unconfined, water quantity and quality in aquifers can vary significantly within relatively short distances.

Chemical *species* in water that come from the minerals and rocks directly are referred to as geogenic compounds. These naturally occurring groundwater components may be present at undetectable or low concentrations and pose no health threat, however, when present at concentrations above the Maximum Acceptable Concentration (MAC) (see Table 3-2), these species are not safe for consumption. The only way to know what geogenic compounds are in the groundwater is to conduct sampling of test wells or drinking water wells to establish a baseline for water quality in a particular area. Significant research has been conducted on the geogenic risks of groundwater across Canada.

- Arsenic

Arsenic is a widely occurring trace metal present in mineral sediments in aquifers across Canada (CWN, 2015, McGuigan et al., 2010; Moncur et al., 2015; Wang & Mulligan, 2006). Arsenic is released into the water through geochemical leaching and weathering of minerals. Nearly all provinces and territories have reported localized areas with groundwater that contains arsenic concentrations above Health Canada's MAC. The MAC for arsenic in drinking water is 0.010 mg/L based on treatment achievability, however, it is recommended to reduce arsenic concentrations to as low as reasonably achievable (ALARA) (Health Canada, 2014a). Following the acute health threat of microbiological pathogens, arsenic is cited as the second most significant contaminant in drinking water (Drage, 2022; Hu et al., 2020). The presence of arsenic in groundwater wells has been a longstanding public health concern in Nova Scotia and is considered to be the most significant naturally occurring risk to drinking water derived from groundwater in the province

(Kennedy & Drage, 2016). Arsenic is a known Class I human carcinogen with established causal links to skin, bladder, kidney, and lung cancer (International Agency for Research on Cancer, 2012). Research by Yu et al. (2014) found that arsenic from drinking water is the most important contributor to the total arsenic body burden of Nova Scotians. Dummer et al. (2015) found that arsenic levels in the toenail trimmings of Nova Scotians who relied on individual groundwater wells as their domestic water supplies were significantly higher than levels found in people who received water from municipal distribution systems. Drilled bedrock wells were found to be more likely to have elevated arsenic concentrations, however, dug wells near mine tailings also have an increased likelihood of elevated arsenic levels (Kennedy & Drage, 2016; Wang & Mulligan, 2006).

Wells present in highly fractured areas of the Canadian Shield underlying parts of Quebec were studied by Bondu et al. (2017) and over half of the wells sampled were found to have arsenic concentrations in exceedance of the MAC. Bondu et al. report that water quality with weak alkaline conditions (pH > 7.4), low Ca/Na ratios, and elevated dissolved iron and manganese concentrations were found to have higher arsenic levels. In general, arsenic presence and redox state are dependent on biogeochemical conditions at the water-mineral interface, with microbes and pH controlling the dissolution of iron and arsenic sulphide minerals (Kennedy & Drage, 2016). Other provinces have completed groundwater analyses to better understand arsenic occurrence. Alberta Health and Wellness published a report in 2000 evaluating groundwater arsenic levels in three regions and found that annual average arsenic concentration exceeded 0.025mg/L in 22%, 4%, and 20% of the samples collected from the three regions. (Note, the MAC for Arsenic was decreased to 0.010 mg/L in 2006). The study also found that the occurrence of elevated arsenic concentrations increased with wells greater than 50 feet in depth. Arsenic concentrations in exceedance of the MAC are also widely reported across Saskatchewan and Manitoba, often associated with confined sand and gravel aquifers formed by glacial till (Rivera, 2014) (and references therein). While the occurrence of arsenic is both widespread and localized depending on the mineral composition of aquifers, Health Canada (2006) and many provinces recommend that individual well users monitor for arsenic concentrations in their drinking water to evaluate whether point-of-use (POU) or point-of-entry (POE) treatment is required to remediate arsenic concentrations. Bondu et al. (2017), found that of homeowners who had wells with elevated arsenic concentrations, 38% were unaware of the exceedance, 50% were aware and had taken some level of mitigation (bottled water or treatment), and 12% were aware and took no mitigation efforts, possibly due to low-risk perception and high treatment costs. Residential reverse osmosis units have been shown as effective treatment options for decreasing total arsenic, though most technology cannot remove trivalent arsenic (Health Canada, 2006a).

KEY RISK: *Many geologic units in Canada are sources of arsenic in groundwater.*
KEY BARRIER: *Monitoring of chemical water quality must be done during the installation of a well to characterize the risks and inform treatment requirements for the well water.*

There is very little publicly available information on arsenic concentrations in First Nations drinking water and no clear understanding of exposure through individual wells. Health Canada (2009, 2019b) describes the number and nature of long-term (> 12 months) drinking water advisories in centralised systems in First Nations and notes that 5% of the 166 persistent advisories were due to elevated arsenic or uranium levels (Health Canada, 2009a). Lane et al. (2020) evaluated aggregated water quality data available through WaterTrax for 47 community drinking water systems from 33 First Nations in the Atlantic region. This analysis considered both centralised and decentralised drinking water systems with no delineation between system types and included both treated and raw water analyses. The study found that several First Nations in the Atlantic region have a history of elevated arsenic levels in drinking water, some with over ten years of data demonstrating long-term exposure (Lane et al., 2020). While there is some information available regarding elevated arsenic levels in centralised systems (McCue, 2015; Schwartz et al., 2021), information on individual wells is scarce.

- Manganese

Manganese (Mn) can be present in groundwater and surface water through leaching and weathering of minerals. In groundwater, high spatial variability is possible, so all wells in a well field need to be characterized individually to understand the presence and concentration of manganese if used for drinking water production (Health Canada, 2016). Health Canada recently revised the guidance on Mn in drinking water and recommended a MAC of 0.120 mg/L in addition to a reduction of the aesthetic objective (AO) to 0.020 mg/L. This change was precipitated by the recognition of the deleterious health effects of Mn, including neurotoxicity, and set at a level to be protective of neurological effects in infants, the most sensitive population (Health Canada, 2019b).

A 2008 report by the water management branch of the Manitoba provincial government reported that deeper wells with higher dissolved solids (TDS) content were found to have elevated Iron and Mn levels, with an average Mn concentration of 0.6 mg/L, well in exceedance of the MAC. Of the 319 samples analyzed for the study, groundwater samples from sand and gravel aquifers across Manitoba exceeded the AO (0.05mg/L prior to 2019), with 72% exceeding the historical AO. Mn presence in groundwater is controlled by mineralogy, redox chemistry, and residence time of water in contact with Mn-rich material. Kennedy (2021) reported that of bedrock and surficial aquifers in Nova Scotia, 22.5% of wells exceeded the MAC and 45% exceeded the AO for Mn. 33.4% of metamorphic bedrock and related surficial aquifers exceeded the MAC, and some surficial aquifers in sedimentary basins also exceeded the MAC. likely due to the increased alkalinity of these groundwaters (Kennedy, 2021). Surficial aquifers in sedimentary basins were also found to have elevated exceedance rates, likely due to the increased alkalinity of these groundwaters (Kennedy, 2021). In waters with pH > 8, Mn concentrations were generally lower, due to the formation of oxide and carbon precipitates. Work by Saby et al. (2016), found that groundwater quality is linked to residence time and regional geology present in southern Quebec. Maximum Mn concentrations in groundwater collected in the study reached 5.9 mg/L. A study of 8 communities in southeastern Quebec by Barbeau et al. (2011), reported a maximum value of Mn at 2.7 mg/L and notes the region as having a high spatial variability of Mn concentrations but limited temporal variability. Despite the low seasonal variation of Mn in groundwater sources, Health Canada's guidance recommends semi-annual monitoring (Health Canada, 2019b). Much like arsenic, manganese is both widespread and localized depending on the mineral composition of aquifers. The treatment systems most used in Nova Scotia for the removal of Mn include cation exchange and POU or POE reverse osmosis (Kennedy & Drage, 2020a). Barbeau et al. (2011), and Di Battista et al. (2024), both report that POE greensand filtration operated by residences to treat individual well water resulted in treated water with higher Mn concentrations than raw water.

Barbeau et al. found 29% to 199% increases in Mn concentrations in treated water due to poor operation and maintenance practices. Reverse osmosis treatment showed high removal of Mn from source water (Barbeau et al., 2011).

KEY RISK: *Some POU/POE commercially available treatment devices fail to remediate elevated manganese levels if operation, maintenance, and monitoring are not conducted properly.*
KEY BARRIER: *Pre- and post-treatment water quality should be monitored regularly to ensure appropriate treatment technology is installed and is operated and maintained properly.*

While there is very little publicly available data for individual wells in First Nations, work by Lane et al. (2020) and Schwartz et al. (2021) report significantly elevated Mn concentrations in some First Nations. Lane et al.'s analysis of Atlantic region First Nation WaterTrax data revealed years of repeated elevated Mn concentrations in several First Nations. The First Nations Food, Nutrition, and Environment Study (FNFNES), a national study on the benefits and risks of food and water in First Nations monitored Mn in hundreds of homes across 91 First Nations coast to coast and found 55 households that exceeded the MAC. The study found a maximum Mn level of 1.530 mg/L in Saskatchewan. The study also found that 96 household samples exceeded AO for Mn (Schwartz et al., 2021). The samples included in the published analysis only contain data from centralised drinking water systems.

- Uranium

Naturally occurring deposits of uranium-rich minerals can result in groundwater with elevated levels of the heavy metal. Health Canada's MAC for uranium is 0.02 mg/L. The health effects of consuming uranium via drinking water are not definitively linked to cancer, but there are known harmful effects on kidneys (Health Canada, 2019c). Uranium presence in groundwater supplies is directly related to mineral geochemistry and is found in its highest concentrations in plutonic and sedimentary bedrock groundwater regions. A 1986 study of metals and health in the general population in Nova Scotia revealed elevated uranium in one subject's hair (Grantham, 1986). This result led to a regional well survey that determined a portion of domestic drinking water wells in Nova Scotia had elevated uranium concentrations (Drage, 2022). A study of uranium levels in groundwater in Nova Scotia found samples from plutonic and sedimentary bedrock regions found that 30.3% and 6.3% exceeded the MAC, respectively (Kennedy & Drage, 2020b). Long-term consumption of groundwater with elevated levels of uranium found in high-risk areas of Nova Scotia could lead to kidney disease. Analysis of water quality from across Nova Scotia found that pH and total alkalinity (as $CaCO_3$) were key controls for the occurrence and mobility of uranium in groundwater. Based on risk maps generated by the Department of Energy and Mines, it is estimated that 26,445 private wells are in high-risk areas (> 15% exceedance rate) (Kennedy & Drage, 2020b). In general, uranium-rich minerals are associated with more felsic and silica-rich rocks, formed at the later stages of igneous magma differentiation (Kennedy & Drage, 2020b). The Government of Alberta published a report in 2011 detailing uranium sources in a shallow aquifer near Bonnyville, Alberta (Moncur et al., 2011). The glacial till is composed of igneous and metamorphic rocks derived from the Canada Shield (Andriashek, 2000). Uranium in groundwater samples was found to range from 0.0045 mg/L to 0.151 mg/L, with 12 of the 16 monitoring wells having uranium levels exceeding the MAC. Because uranium deposits are highly localized and dependent on geological factors, it is not a common variable included in individual drinking well monitoring practices. Health Canada recommends the use of an alternative water source or the installation of a treatment unit. While there are no certified residential treatment units to remove uranium from drinking water, there are treatment devices that could be effective at removing uranium, including reverse osmosis units, depending on general water quality conditions such as hardness and sulfide concentrations (Health Canada, 2019c).

KEY RISK: *There is no certified residential treatment unit for uranium removal from drinking water.*
KEY BARRIER: *The best available treatment technology should be installed and monitored routinely to ensure effective treatment and proper operation and maintenance.*
KEY BARRIER: *Alternative drinking water sources, such as centralised drinking water from a surface water source, may need to be implemented if water quality cannot be improved with available treatment technology.*

In First Nations, it is unlikely that uranium concentrations are measured routinely in individual drinking water wells. The FNFNES national study monitored uranium levels in 91 First Nations and sampled several decentralised water sources, though the decentralised water quality findings were not included in the published results (Schwartz et al., 2021). The centralised, or community, water supplies analyzed found 1.6% of sample locations had uranium concentrations in exceedance of MAC. By region, Ontario and Saskatchewan First Nations had the highest maximum recorded uranium concentration, 0.037 mg/L and 0.046 mg/L respectively with a total of 24 households across three First Nations found to have uranium levels above the MAC (Schwartz et al., 2021).

- Fluoride

Fluoride in drinking water is beneficial at low concentrations, with optimal health effects at 0.7 mg/L. However, too much fluoride exposure becomes harmful at concentrations above the MAC of 1.5 mg/L, with both acute and chronic toxicity concerns, including dental and skeletal fluorosis, though these conditions are rarely reported in Canada (Nawrin et al., 2024). Natural groundwater can contain fluoride derived from minerals associated with sedimentary, volcanic, and crystalline bedrock aquifers with the potential for harmful levels of fluoride in some locations. Communities in Quebec, Saskatchewan, and Alberta have recorded concentrations upwards of 2.5 to 4.3 mg/L (Health Canada, 2010), while 3% of rural wells sampled near Okanagan Falls and the east coast of Vancouver Island in BC have been shown to have fluoride concentrations above the MAC (Earle & Krogh, 2006). As noted in the discussion of manganese levels in groundwater, residence time is a significant factor in controlling dissolved ions. Work by Saby et. al (2016) found that elevated fluoride concentrations in southern Quebec were linked to the redox state of the water, pH, mineralogy, and residence time of the water in the aquifer, with a maximum fluoride concentration of 2 mg/L. In Manitoba, large aquifers located in Paleozoic sedimentary rocks around Lake Saint Martin are rich in carbonates and evaporite minerals, causing domestic wells to have elevated TDS, salinity, sulfates, and fluoride concentrations upwards of 15.2 mg/L. Leybourne et al.'s (2008) report that fluoride concentration in aquifers underlying this area of Manitoba is highly spatially correlated with the presence of impact melt rock and evaporite/red bed lithologies associated with a large meteorite impact during the Paleozoic era. A study evaluating drinking water quality in private wells on farms in Alberta sampled over 800 wells between 1995 and 1996 and fluoride was found to be the most frequent water quality parameter to exceed the MAC (Fitzgerald et al., 2001). Approximately 13% of the water samples collected from kitchen taps were found in exceedance, with 71 samples having concentrations between 1.5 and 2.5 mg/L, 34 samples having between 2.5 and 4 mg/L, and one sample having 6.4 mg/L of fluoride (Fitzgerald et al., 2001). While the occurrence of elevated fluoride is highly spatially heterogeneous, it has been noted as a groundwater challenge in discussions with First Nations. However, no water quality data for fluoride is publicly available for First Nations.

KEY RISK: *Fluoride exceedances are highly spatially varied and present significant treatment challenges in individual wells.*
KEY BARRIER: *Monitoring of chemical water quality must be done during the installation of a well to characterize risks and should include fluoride as a parameter to inform well placement. Ongoing monitoring is required to ensure changes do not occur over time and aquifer changes.*

- Methane

Methane is a naturally occurring gas that is largely formed by thermogenic processes when organic matter trapped in sediments is buried and heated over geologic time scales (Drage & Kennedy, 2014). Methane is colourless, odourless, tasteless, and nontoxic. However, at high enough concentrations in groundwater, the gas can cause flammable and explosive conditions. There is no Health Canada guidance on methane in groundwater, but in 2003 the (then) Ontario Ministry of the Environment established an aesthetic objective for methane of 2 mg/L (Drage & Kennedy, 2014). Further guidance on the management of methane in groundwater is provided by the US Department of the Interior, setting an action limit of greater than 10 mg/L for the removal of potential ignition sources in the vicinity of the water source, and an action limit of greater than 28 mg/L to immediately reduce the methane levels (Eltschlager et al., 2001).

Western Canada, known for its oil and gas resources, has nearly ubiquitous methane detection in groundwaters across Alberta. Humez et al. (2016) studied 186 groundwater wells throughout Alberta and found methane present in 179 of the wells with free gas found in 112 of these samples. A total of 28 samples collected from 21 wells exceeded the US Interior's 10 mg/L safety threshold for methane in groundwater and 14 samples exceeded 31 mg/L. The study found that methane concentrations increased with increasing well depth and were correlated with the nearby presence of coal seams or shale units in aquifers (Humez et al., 2016, p.20). Eastern Canada also has detectable levels of methane in groundwater with Nova Scotia and New Brunswick reporting maximum methane concentrations of 6.0 mg/L and 15.7 mg/L, respectively (Drage & Kennedy, 2014; Loomer et al., 2018). A study by Taylor et al. (2021) sampled for methane in 45 domestic wells in the coal-bearing Stellarton Basin in Nova Scotia and found 94% of the wells to have detectable levels of methane, with six wells exceeding the 28 mg/L immediate action threshold and one well with a maximum concentration of 73 mg/L. Likewise, Bordeleau et al. (2018) found methane in groundwater in 46 of 48 samples taken over a 500 km^2 area in the Utica Shale in southern Quebec with concentrations ranging from < 0.006 mg/L to 82 mg/L. While methane is not a direct threat to human health through digestion in drinking water, the presence of elevated methane gas poses possible explosion and fire risks and other aesthetic concerns.

<u>Key Risk</u>: *Methane monitoring is rarely done in drinking water wells, and while not directly harmful through consumption, does present a safety risk at elevated levels.*
<u>Key Barrier</u>: *Monitoring of chemical water quality should be done during the installation of a well to characterize the risks, and should include methane as a key parameter, to inform well placement. If methane is detected, ongoing monitoring is required to ensure water quality changes do not occur over time and aquifer changes.*

Anthropogenic and Surface Water Influence on Groundwater Quality

Groundwater is a more protected water source than surface water, however, it is still susceptible to infiltration from surface contaminants associated with both natural and human activities. Some groundwater sources are more vulnerable to surface water and contaminant infiltration depending on the interconnection of surface water and recharge characteristics of the aquifer itself, which are controlled by sediment and hydrogeology conditions. However, well construction and infrastructure conditions can also affect well water vulnerability. Discussion of well construction and infrastructure conditions' role in protecting groundwater quality is covered in Section 3.2.1.2. Here, the role of surface water influence and anthropogenic activities will be discussed in relation to groundwater quality.

While it is impossible to catalogue all potential contaminants that may threaten drinking water, dozens of high-priority industrial and agricultural chemicals are included in the Health Canada's Guidelines for Drinking Water Quality (Health Canada, 2024). Most global and Canadian jurisdictions recommend a risk-based assessment to identify threats and hazardous events and activities that may pose system-specific source risks (Simpson, 2004). These risk-based approaches identify potential contaminants by land use activity including septic and wastewater treatment, agriculture, industrial and extractive industry, and fuel storage or transport. Sources of contamination can be point source, i.e. septic tank or fuel tank, or non-point source, i.e. road salt, agriculture, or wildlife excrement. Ritter et al. (2002), offers a robust evaluation of sources, pathways, and relative risks of key anthropogenic contaminants. Initially prepared in response to the Walkerton Inquiry, it offers a useful framework to consider the myriad of human activities that should be included when assessing risks to water sources (Ritter et al., 2002). Because these surface activities impact groundwater through infiltration and recharge, it is critical to consider the relationship between precipitation events and aquifer vulnerability. Below is a discussion on key risks to groundwater quality due to anthropogenic contaminants and the role of weather events and climate change in compounding these risks.

- Pathogens

Historically, groundwater was considered to be protected from microbiological contamination, however significant research now exists that shows groundwater to be susceptible to pathogen contamination and transport (Murphy et al., 2017). Waterborne disease surveillance in the US in 2001 to 2002 found that approximately 74% (23/31) of confirmed waterborne disease outbreaks were attributed to groundwater sources (Blackburn et al., 2004). Most individual wells used for drinking water receive no treatment or disinfection, leaving the consumer susceptible to bacteria and viruses that may be present in the water (Pang et al., 2021). A review of 649 articles reviewing global acute gastrointestinal illnesses between 1948 and 2013 found an increased risk of illness from drinking untreated groundwater, with norovirus, *Campylobacter*, *Shigella*, Hepatitis A, and

Giardia being found responsible for the majority of outbreaks (Murphy et al., 2017). Aquifers, while significantly more protected than surface water sources, still experience differential vulnerability to microbial contamination. It is well established that aquifer type (confined or unconfined) and geological material (unconsolidated or consolidated) influence the vulnerability of groundwater to microbiological contamination (Conboy & Goss, 2000; Owusu et al., 2021; Petculescu et al., 2022; Procopio et al., 2017). Because of the acute seriousness of consuming pathogen contaminated water, bacteriological monitoring of individual wells is the most common type of water monitoring recommended by all Canadian jurisdictions. Current best practices across North America use total coliform and E. coli monitoring as fecal indicator organisms (FIOs). Total coliforms are present in fecal and non-fecal environments, so are not singularly conclusive of fecal contamination. However, Health Canada's guidance on total coliform in drinking water states that groundwater should be free of total coliforms, so the presence of total coliform in well water is indicative of groundwater contamination and warrants further investigation (Health Canada, 2020c). E. coli is a bacteria associated with human and animal feces. Drinking water with detectable E. coli is likely contaminated with feces, and may contain fecal pathogens (Health Canada, 2020b). E. coli is used as an indicator of fecal contamination and may or may not be pathogenic in and of itself. The presence of E. coli provides evidence that broader and more substantial microbial threats may be present, and crucial barriers and controls to safe drinking water are missing or have failed.

Septic Systems

While pathogens have many sources, the most common source of groundwater microbiological contamination is from nearby septic systems. Often homes that rely on individual wells are also serviced by onsite septic systems which tend to include soil infiltration fields as a key treatment component. Soil infiltration can be an effective method for removing and deactivating pathogens. Mechanisms that promote the removal of bacteria in aquifers include physical straining, adhesion, and electrostatic adsorption by the unconsolidated material, and adhesion to sand may be bactericidal (Gamazo et al., 2018; Gerba & Bitton, 1984; Scholl & Harvey, 1992). However, aging, poorly installed, and/or poorly sited septic systems act as sources of pathogens that threaten groundwater safety. Additionally, some First Nations have a relatively high number of open discharge, or 'shoot-out' systems, where effluent from a septic tank is discharged directly to the ground surface (Lauret, 2023). These systems pose a significant threat to public health, both through direct disease transmission and contamination of nearby surface waters and groundwater. Whatever the pathway, once present in the groundwater aquifer system, fecal contamination moves through consolidated, unconsolidated, and fractured bedrock aquifers differently, with preferential flow paths influencing the distance pathogens can travel. In general, aquifer type and geologic strata combined with well construction and well integrity provide barriers to groundwater contamination.

KEY RISK: *Fractured bedrock aquifers have higher detections of microbial contamination.*
KEY BARRIER: *The thickness of overlying sediment layers helps attenuate bacterial transport.*

The aquifer type and geologic strata together determine the fate and transport of microbes through the subsurface, with hydraulic permeability and bacterial attenuation capacity being the main factors influencing bacterial contamination of groundwater aquifers (Somaratne & Hallas, 2015). Fractured bedrock aquifers have been found to have higher levels of contamination than consolidated or unconsolidated aquifers, with karst (or highly fractured carbonate bedrock) aquifers shown to be the most vulnerable to pathogen contamination (Burch et al., 2021; Johnson et al., 2011; Petculescu et al., 2022). The thickness of sediment layers above the fractured bedrock offers an important control barrier for pathogen transport (Burch et al., 2021; Conboy & Goss, 2000; Latchmore et al., 2023). A study of domestic wells in a fractured dolomite aquifer in Wisconsin found that wells contaminated with human fecal material were most influenced by the depth to groundwater and the total number of septic systems in a 229 m radius of the wells (Burch et al., 2021). Wells located in the shallowest depth-to-bedrock categories (< 1.5m and 1.5 to 6.1m of overlying sediment) had statistically higher positive detections of fecal contamination than wells in areas with > 6.1m of overlying surficial sediments. Recharge flow through thicker sediments likely removed pathogens before the water entered the highly fractured bedrock, reducing the contamination of the bedrock aquifer itself (Burch et al., 2021). In total, 79 of the 131 wells tested in this study were found to have fecal contamination with markers for pathogens that could infect humans. Seventy of the wells were contaminated with two or more markers.

Similar findings suggesting unconsolidated overlying material offers improved pathogen mitigation were reported in a comprehensive study of over 200,000 private wells across Ontario. The study evaluated E. coli contamination as a function of well depth, aquifer type (consolidated or unconsolidated), bedrock type, and sampling frequency. Consolidated aquifers had higher detection rates of E. coli than unconsolidated aquifers, and limestone material had higher detection rates than granite, shale, or sandstone material. In fact, sandstone aquifers were found to have significantly lower bacterial contamination rates (Latchmore et al., 2020). A compelling finding of this study was that increased sampling frequencies were associated with increased detections, indicating that once or twice per year sampling is likely not reflective of typical water quality conditions in individual wells (Latchmore et al., 2020). The timing between preceding rain events and sample collection has a significant impact on the likelihood of detection (Ahmed et al., 2019; Hynds et al., 2014; Latchmore et al., 2020) Further discussion on the role of precipitation and groundwater quality can be found below

Total coliforms and E. coli as FIOs are useful to detect fecal bacterial contamination of a water source and there is general agreement in bacterial transport behaviours in a range of aquifer conditions. However, these FIOs are known to be poor proxies for virus prevalence and transport in groundwater sources (Cyterski et al., 2022, Fout et al., 2017). Soil-pathogen mechanisms that control bacterial transport in sediments and aquifers may not be attributable to viral transport (Nicosia et al., 2001). While significant research exists on E. coli and total coliform prevalence in a range of aquifer types, virus transport and occurrence in groundwater sources is less understood, but no less important to understanding public health protection. A recent study by Stallard et al. (2021) evaluated 122 untreated domestic wells at homes also serviced by onsite septic systems for human virus contamination. While total coliform and E. coli detections were generally low, virus proxies, male-specific and somatic coliphages, were detectable in 66% and 54% of the samples, respectively. The study concluded that traditional FIOs do not accurately represent the presence or persistence of viral pathogens in groundwater sources (Stallard et al., 2021). A study of enteric viruses in private wells in Alberta found that virus presence was generally low, with only 6.3% of the samples analyzed containing viral genomic material. However, at least one sample from 22 of 49 wells tested had detectable levels of viruses, including adenovirus, rotavirus, reovirus, JC virus, and norovirus (Pang et al., 2021). So, while the occurrence was infrequent, the presence of viruses was widespread. The study found virus detections were slightly higher in wells located in areas with gravel sediment than those with sand or shale sediments, but in general, there was no significant relationship between lithologies and virus occurrence (Pang et al., 2021). An in-depth study of pathogen transport mechanics in bedrock aquifers was conducted in three locations across Canada and found the primary pathway from bedrock aquifers to domestic wells to be vertical fractures (Kozuskanich et al., 2014). This study found a widespread presence of viral pathogens in bedrock aquifers and suggests onsite waste treatment systems as the source of the enteric viruses. The study also evaluated the transport mechanisms of a bacteriophage through bedrock aquifers and found pore-exclusion to be a key parameter controlling the rate of transport. Additionally, water chemistry was found to control transport rates, with waters of higher ionic strength showing slower bacteriophage transport times. Kozuskanich et al. (2014) attributed the slower travel times to increased electrostatic forces between the bacteriophage and mineralogic surfaces on the fracture walls.

KEY RISK: *Wells located in confined aquifers, thought to be invulnerable to surface contamination, were found to have presence of viral contamination.*
KEY BARRIER: *Wells in confined aquifers are vulnerable to fecal contamination, through either the aquifer or well vulnerability and may require the same treatment and monitoring practices as wells in unconfined aquifers.*

A study from France found human adenovirus present in groundwater from a confined aquifer where no FIOs were detected (Ogorzaly et al., 2010). This research reports adenoviral degradation at low temperatures (4 ºC) was significantly slower than other phages, suggesting adenovirus can retain genomic integrity over long time periods, and therefore long transport distances. Likewise, work by Borchardt et al. (2007) also found enterovirus-positive samples from a deep confined sandstone aquifer overlaid by a regionally extensive shale aquitard, or area of low permeability. The wells evaluated in this study were for public water supplies, but the detection of pathogenic viruses in a well-protected sandstone aquifer indicates that virus transport is possible through preferential pathways in low permeability confining layers. However, it is also possible that degraded well conditions could be a contributing cause. Regardless of the exact pathways, deep confined aquifer wells are not invulnerable to viral contamination, as has historically been the assumption (Borchardt et al., 2007). Viral detection does not necessarily translate directly to human health risk but does indicate some level of fecal contamination (Ogorzaly et al., 2010). From a public health perspective, it should be assumed that confined aquifers are vulnerable to virus contamination and may require a similar level of disinfection and monitoring as unconfined aquifers (Borchardt et al., 2007). Gitter et al. (2023) applied a qualitative microbial risk assessment (QMRA) approach to evaluate microbial safety of individual wells in Texas and found that the reference pathogens norovirus and Cryptosporidium represent the greatest health risks. The authors concluded that QMRA for individual wells, especially following regional or local flooding is a useful tool to guide decision-making regarding water safety (Gitter et al., 2023).

KEY RISK: FIOs do not accurately reflect virus contamination, as viruses are small and stable and can be transported greater distances.
KEY BARRIER: Utilization of a risk-based approach, such as QMRA, would provide a more holistic assessment of water safety from untreated groundwater wells and inform treatment and monitoring practices to ensure safe drinking water.

Agricultural Sources

In addition to domestic onsite septic sources for microbial contamination, agricultural operations with livestock and high manure applications are also key threats to groundwater safety (M. J. Goss et al., 1998). Most notably, the outbreak in 2000 in Walkerton, ON was caused, in part, by livestock waste runoff from a nearby farm (Clark et al., 2003). The threat of animal manure containing pathogenic organisms is a well-known risk to both surface water and groundwater sources. Significant research has been done to understand the manifestation of these risks in agricultural settings. A monitoring program of over 1000 domestic wells on farms in Ontario conducted in 1992 and 1993 found that 34% of wells tested exceeded the MAC for total coliform concentrations and that detection rates decreased with increasing distance from feed lots or holding areas (M. J. Goss et al., 1998). A similar province-wide sampling initiative was undertaken in Alberta. The five-year Farmstead Water Quality Study evaluated well water quality at 824 farm sites between 1995 and 1996. Microbiological analysis found that 7.6% of wells tested exceeded the MAC for total coliforms and 3.1% of the wells tested positive for fecal coliforms, with shallow dug wells (< 30m) having higher detection rates (Fitzgerald et al., 2001). However, this study found a negative relationship between coliform detection rates and the presence of livestock. A study of private wells across Canada found that groundwater near poultry farms had a higher risk of contamination with antimicrobial resistant E. coli than wells located in areas with no poultry farms (Coleman et al., 2013). Similar patterns of contamination were seen by Burch et al. (2021) who found manure-related contamination was controlled by the size of the agriculture land use area and the distance between the well and manure source.

Regardless of the source of microbial contamination, the fate and transport of the contamination in groundwater aquifers are the same, with highly fractured bedrock aquifers presenting the greatest risk to drinking water wells and the depth of overlying unconfined material offering the same potential protective barriers (Burch et al., 2021).

- Nitrates

Nitrate (NO_3-N) can occur naturally in groundwater, typically at concentrations below 3 mg/L. Concentrations above this level may be attributable to waste contamination, either from onsite septic systems and/or manure storage or runoff from agricultural operations (Kohn et al., 2016; US Geological Survey, 1985). Health Canada's 2013 MAC for nitrate in drinking water is 10 mg/L as nitrate-nitrogen (45mg.L as nitrate), established because of the relationship with methemoglobinemia in infants and possible carcinogenic effects in adults from prolonged exposure (Bonton et al., 2010; Lee & Murphy, 2020). Burch et al. (2021) found that nitrate contamination in domestic wells in agricultural settings in Wisconsin was associated with agricultural land use, dairy manure lagoons, and swine manure lagoons. This is consistent with the agricultural water quality studies conducted in the 1990's in Alberta and Ontario that both found a small percentage of wells with nitrate concentrations above the MAC, 6% and 14% respectively, due to nearby manure sources and infiltration of the groundwater (Fitzgerald et al., 2001; M. J. Goss et al., 1998). The Abbotsford-Sumas Aquifer case study is a primary example of the temporal and spatial variation of agricultural nitrate inputs threatening an extensive, highly permeable, sand and gravel aquifer (Zebarth et al., 2015). Fertilizer application to crops, and manure runoff from poultry have created long-standing nitrogen exceedances in a highly extracted groundwater resource.

Recently, the increase in housing density in rural settings, e.g. subdivisions, that rely on onsite septic systems have been associated with increased groundwater nitrate levels. A study in Cape Cod, Massachusetts, USA by Schaider et al. (2016), measured 20 domestic drinking water wells located near onsite septic systems to monitor for groundwater quality impacts. Half of the wells tested were found to be highly impacted by nitrate, with concentrations above 2.5 mg N/L and one well in exceedance of the MAC. These wells were also found to have detectable levels of acesulfame, an artificial sweetener that acts as a *de facto* conserved tracer in wastewater – groundwater systems (Schaider et al., 2016). Because of these known communication pathways between adjacent onsite septic systems and individual drinking water wells and the impact of cumulative effects of multiple septic systems in close proximity (Kozuskanich et al., 2014), some jurisdictions have developed regulations and practices aimed at improving subdivision wastewater system installation protocols. Both Ontario and Saskatchewan have requirements for hydrogeological studies in subdivisions after a number of subdivisions with domestic wells were found to have groundwater quality problems, including high nitrate levels from onsite septic systems (Ontario Ministry of Environment and Energy, 1996; SHA, 2023). Septic systems are discussed in more detail in Section 4.

KEY RISK: *Multiple close-proximity onsite septic systems can have cumulative impacts, resulting in nitrate plumes that impact drinking water wells.*
KEY BARRIER: *Beneficial design practices include robust hydrogeological site analyses to inform septic system design optimization. Routine monitoring also provides ongoing verification of drinking water safety.*

- Metals

While geogenic trace metals have been discussed extensively above, it is important to note that some human activities and land uses introduce or exacerbate metal contamination and release in groundwater. Mining operations, forestry, and oil and gas exploration & extraction all pose significant risks to groundwater quality. Globally, anthropogenic arsenic sources are associated with mining, smelting, pesticides, and fertilizers (Nriagu et al., 2007; Webster et al., 2015). There is limited published research on the impacts of industrial activities on individual drinking water wells in Canada. One study of 515 dug and drilled wells in Ontario found that 2% of the dug wells and 4% of the drilled wells had arsenic levels exceeding the MAC (Narwin et al., 2024). The authors attributed the drilled well exceedances to the mineralogy of the Paleozoic bedrock and suggested the dug well exceedances were likely due to localized fertilizer application in crop-based agricultural settings (Nawrin et al., 2024). Forestry practices are also known to change fundamental water-soil-groundwater relationships (Webster et al., 2015). Research has found that clear cutting can slow groundwater recharge, increase flooding risks, and alter transportation mechanisms in groundwater (Khatri & Tyagi, 2015).

KEY RISK: *Limited published information on the impact of industries on individual drinking water wells.*
KEY BARRIER: *Source water protection planning, and routine monitoring can help identify contaminants and compounds of importance.*

Industrial activities and their impact on groundwater resources are of particular concern First Nations, as Nations often have limited jurisdictional power to engage in or influence industries off-reserve and are left to deal with the impacts of decisions made upstream (Muir, 2022; Patrick, 2011; Tollefson & Wipond, 1998).

- Heavy rainfall and overland flooding

Precipitation is a critical component of the water cycle and an important factor in aquifer recharge and the overall regional water budgets (Wang et al., 2014). While precipitation is vital to freshwater reservoirs, climate change is intensifying precipitation event frequency and intensity heterogeneously across Canada (Vincent et al., 2018). Increases in precipitation events, particularly rain events that deliver significant volumes of water quickly, control the resuspension, transport, and fate of microbial and chemical species (Ahmed et al., 2019). A scoping review by Andrade et al. (2018) evaluated fourteen studies that focused on the relationship between groundwater susceptibility and flooding events, and all publications included in the review found high groundwater susceptibility to contaminations due to surface water flooding. The authors noted that climate-exacerbated rain events and overland flooding pose significant threats to groundwater quality. It is estimated that the current 100-year flood probability will occur more frequently across at least 40% of the world (Gosling & Arnell, 2016), and these events have the potential to mobilize enteric pathogens and anthropogenic contaminants in the environment, inundate septic fields and agricultural settings, and enhance groundwater infiltration (Andrade et al., 2018; Burch et al., 2021).

KEY RISK: *Overland flooding intensifies the rate of groundwater recharge and is related to increases in microbial contamination.*
KEY BARRIER: *Increased water quality monitoring following intense rain events and the use of microbial treatment units offer protection from consuming pathogen-contaminated water.*

(Latchmore et al., 2023) evaluated over 200,000 individual drinking water wells in Ontario from 2010 to 2017 across differing aquifer types, well depths, and seasons, and found that the year with the highest rainfall totals, 2016, had more positive detections of E. coli and total coliform than 2013, the dryest year included in the study. The authors suggest that increased precipitation resuspended and transported bacteria into the groundwater, resulting in more positive detections. Likewise, Eccles et al. (2017) evaluated individual drinking water wells in Calgary following the 2013 flood in southern Alberta and found that E. coli and total coliform results from private well sampling were higher than nearly every year included in the study, (excluding 2005). A comprehensive 12-month study of five drinking water wells adjacent to septic systems in Pennsylvania found that human viruses were most detectable in drinking water samples 8 to 14 days following a significant rainfall event, indicating that preferential flow paths between the septic infiltration fields and the groundwater well intake were susceptible to precipitation-driven recharge flows (Murphy, 2022). Work by Ahmed et al. in 2019 reviewed FIO and microbial source tracking marker genes in urban stormwater and found that storm events can resuspend sediment-bound FIOs to create concentrations upwards of 30x higher than base flow concentrations. Importantly, this review concluded that FIOs are not adequate proxies for pathogenic viruses in stormwater, indicating a need for improved viral source tracking in stormwaters (Ahmed et al., 2019).

KEY RISK: *Confined aquifers are susceptible to contamination through flooding events.*
KEY BARRIER: *Water quality monitoring and treatment practices used for higher-risk unconfined aquifers should be employed for confined aquifers.*

Rudd et al. (2023) studied wells in confined and unconfined aquifers and compared the amount of "modern water", as determined by isotopic tritium-hydrogen ratios, in wells that had reportedly been flooded and wells that had no history of flooding. Wells that are in areas that have experienced a flood had increased "modern water" and anthropogenic chemicals, indicative of surface water infiltration. This was true in both confined and unconfined aquifers, up to a depth of 206m (Rudd et al., 2023). Flooding events that overwhelm the tops of well caps/liners pose a threat to groundwater quality, both in unconfined and confined aquifers, as they cause episodic pulses of "modern water" input to preferential flow pathways, such as macropores and high conductivity flow paths present in drinking water wells and aquifers (Li & Tsai, 2020; Stumpp & Kammerer, 2022; Rudd et al., 2023)

- Emerging Contaminants

Advances in analytical techniques have allowed for the detection and quantification of anthropogenic compounds related to a wide variety of industrial applications. The flood study by Rudd et al. (2023) evaluated groundwater from wells that have experienced floods and wells that have no history of flooding for the presence of anthropogenic organic compounds included in the United States Environmental Protection Agency (US EPA) ToxCast chemicals. Groundwater samples contained on average 19 tentatively identified chemicals, including diethyltoluamide, triphenyl phosphate, diethyl phthalate, benzothiazole, octanoic acid, benzoic acid, and butylated hydroxytoluene. These compounds are used as plasticizers, additives in personal care and pharmaceutical compounds, and hydrocarbon products. The study also detected atrazine, a common pesticide. While these compounds were not present in significant amounts to impact human health, it does indicate that human activities have far-reaching effects in the broader ecosystem.

Per- and polyfluoroalkyl substances (PFAS) are also being detected in drinking water sources. As part of the US EPA's Unregulated Contaminant Monitoring Rule, public water utilities must monitor a set of unregulated contaminants in their water sources (Lee & Murphy, 2020). In a recent sampling exercise, several PFAS compounds were found in public drinking water systems that rely on groundwater. The systems with detectable levels of PFAS were near military fire training sites and industrial sites known to manufacture or use these compounds (Guelfo & Adamson, 2018; Kotlarz et al., 2024). In Canada, a study of 463 domestic taps serviced by community water systems in Quebec found that 99.3% of the water sampled tested positive for the detection of at least one PFAS compound (Munoz et al., 2023). While there is limited information on PFAS in individual wells in Canada (Lee & Murphy, 2020), there are studies that indicate PFAS contamination has been detected in numerous private wells near manufacturing plants in the US with a maximum total concentration of 0.348 µg/L (Smalling et al., 2023) and some homes not located near manufacturing plants (Schaider et al., 2016).

KEY RISK: *Emerging contaminants are ever evolving and require dynamic management and monitoring.*

KEY BARRIER: *Risk assessment practices, such as the World Health Organization's Water Safety Planning, provide a systematic approach to identifying risks relevant to drinking water sources and the development of risk-based monitoring to better understand high-priority health risks present in drinking water.*

Emerging contaminants are important to consider in the context of individual drinking water wells, because often the source, transport mechanisms, accumulation in groundwater, and potential health effects are poorly understood. As is the case with PFAS, the understanding of the prevalence and risk of these compounds is rapidly developing. Risk-based, routine water quality sampling programs are essential to monitor for emerging contaminants.

Water Quantity

No jurisdiction in Canada monitors water withdrawal from individual domestic wells, though Nova Scotia did implement protocols for groundwater assessments required when developing wells in proximity within subdivisions due to issues with well interference and draw down (Drage, 2022; Nova Scotia Environment, 2011). Nova Scotia, much like all other provinces, has experienced significant and prolonged regional droughts, with the most recent 2016 drought impacting thousands of individual well users, particularly those with shallow-dug wells (Kennedy & Drage, 2016). Western Canada's extensive history of drought has provided key lessons regarding proactive drought planning and adaptation measures. Research by Wittrock et al. (2011) evaluates community-level vulnerability and adaptation capacity developed as a result of the 2001 – 2002 prairie drought and highlights the importance of economic stability, community demographics, and diversity of water supplies as significant factors that determine drought resiliency. In the case of Nova Scotia's 2016 drought, subsidy programs were developed to allow homeowners to invest in drilled wells, and emergency management infrastructure was enhanced to support truck-hauled water and watering points within regional municipalities (Kennedy & Drage, 2016). To better predict and respond to drought risks the province has developed predictive drought indices to communicate water conservation needs earlier in a potential drought (Kennedy & Drage, 2016).

KEY RISK: *Individual wells are susceptible to drought conditions which can cause water security challenges.*

KEY BARRIER: *Proactive contingency planning, including early warning, water conservation practices, and development of alternative water supplies can help prepare families to respond to drought.*

While drought adaptation strategies are beyond the scope of this report, it is important to note that water quantity is a key determinant of public health, ensuring proper hydration, good hygiene, and general well-being. In the case of First Nations, access to water is also a vital part of ceremony and spiritual well-being. Unreliable water access is a serious threat, and appropriate preventive barriers and corrective actions need to be developed to reduce the risk of inadequate water. Alternative water sources and contingency plans need to be created and supported to respond to any threat to water quantity.

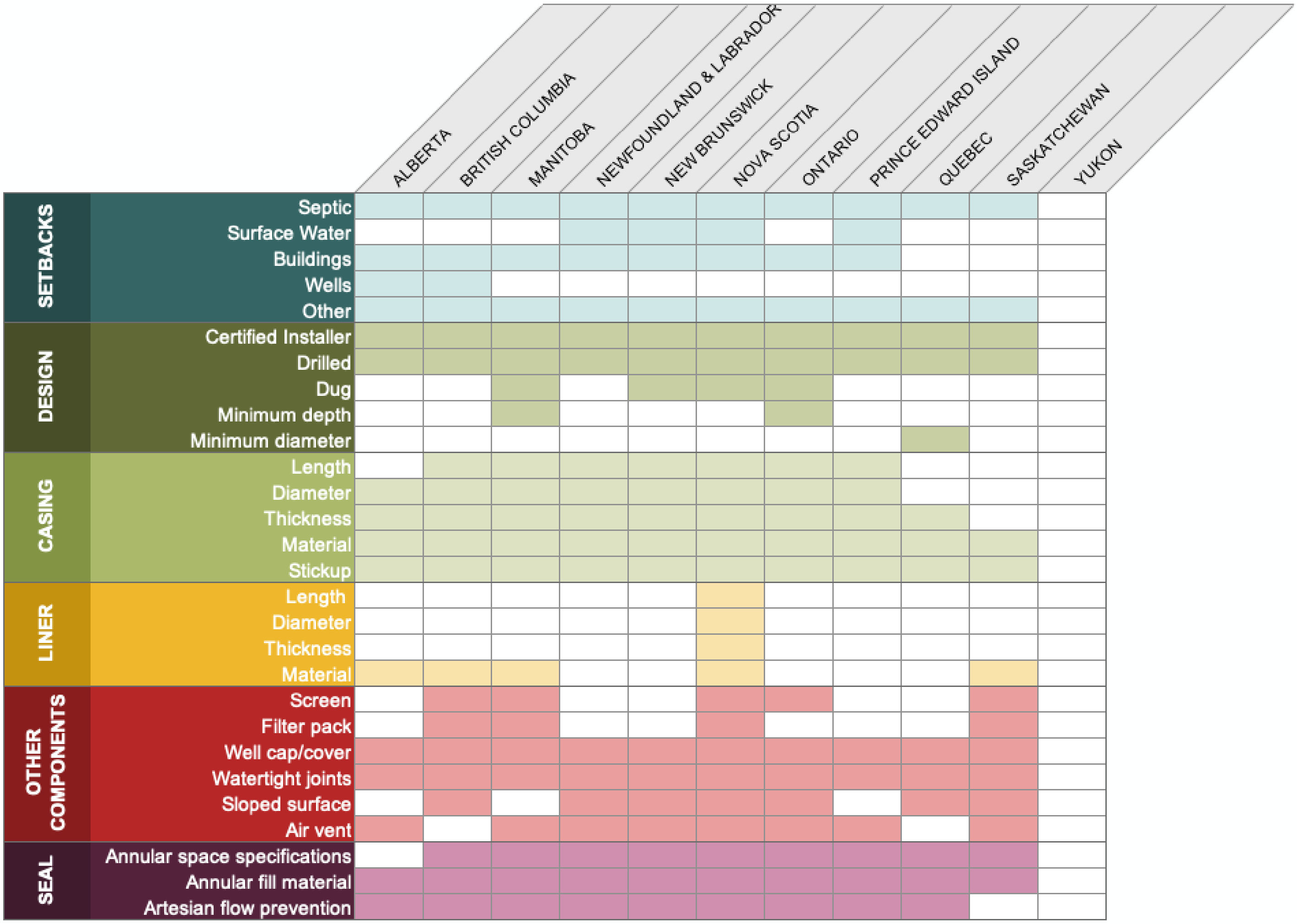
3.2.1.2. *Well*

Construction

The siting and installation of a well is regulated to varying extents in all provinces. There are no regulated standards for individual drinking water well installation in Yukon. It should also be noted that these provincial regulations do not apply to federal land, including First Nations reserves. There is no readily available information on if/how provincial well drillers apply provincial standards to wells developed in First Nations. Appendix B has the summary of a jurisdictional scan that details the legislative and administrative aspects of well installation in each province. Table 3-3 provides a summary of key components of well installation required in each province.

Siting a well with appropriate setbacks from other infrastructure, waterways, utilities, and potential sources of contamination is controlled, at least in part, through regulations in each province and the responsibility of a certified well driller, also required in each province. The construction of a well, including all aspects detailed in the table, from depth, diameter, casing material/thickness/height, liner material, well covers/caps, annual spacing, sealant, and depth, are all important components to prevent the infiltration of surface water and contaminants necessary to protect aquifers and groundwater quality. Despite the increase in provincial regulations addressing well installation, older wells and/or poorly sited and installed wells are a significant transport mechanism for anthropogenic and surface contamination (Borchardt et al., 2007a; Burch et al., 2021; P. D. Hynds et al., 2013; Latchmore et al., 2020a, 2023; Lee & Murphy, 2020).

Table 3-3. Summary of jurisdictional well construction components regulated in each province and Yukon.



- Well Depth

Well depth is a complex design feature that is a primary factor in drinking water quality. Geogenic risks, particularly arsenic and manganese concentrations can increase with increasing aquifer depth, as water residence times and chemistry promote leaching of trace metals (Alberta Health and Wellness, 2000; Saby et al., 2016). However, microbial and anthropogenic risks have the inverse trend, with risks greatest in shallow aquifers (Collins et al., 2017; P. D. Hynds et al., 2013; Petculescu et al., 2022). A study of drinking water wells in Ireland found significantly higher levels of total coliform in hand-dug wells, with shallower wells with simpler design specifications being more susceptible to microbial infiltration than borehole or drilled wells (P. D. Hynds et al., 2013). This was also reported in Latchmore et al.'s 2020 evaluation of private wells across Ontario that found shallow to moderate well depths had greater detection rates of E. coli and total coliform. In general, the risk of anthropogenic and surface contaminants, such as nitrate from agricultural sources, are less likely in deeper drilled wells. Burch et al. (2021) found that wells with longer casing depth into the aquifer reduced nitrate contamination.

KEY RISK: *Shallow wells are susceptible to surface influence, including microbial contamination and anthropogenic compound infiltration.*
KEY BARRIER: *Where geogenic risks are low or treatable, well-designed wells should be installed at greater depths to reduce surface influences.*

- Casing and annual seal condition – age and integrity

Regardless of well depth, the research is clear, degraded or inferior casing conditions and inadequate or damaged annular seals are possible pathways to aquifer contamination. Simpson (2004), at the time , who was a staff at the Ontario Ministry of Agriculture and Food at the time and is now a principal investigator at Morwick G360 Groundwater Research Institute, cited the most common threat to the quality of private well water to be surface water moving into the casing, or along the outside of the well due to poor construction (Simpson, 2004). A study of well construction, geological settings, setback distances, and antecedent precipitation was conducted in 262 individual wells in Ireland. Of all these potential threats, poor well construction accounted for the greatest hazard source. All wellheads were inspected and visual inspection elements, including visible cracking in the well chamber, visibly open liner annulus at the surface, and visibly wet liner were included in the development of a risk model for total coliform contamination susceptibility. The study found well liner clearance was a significant factor in all wells contaminated with total coliforms. Uncontaminated wells were found to have an average liner clearance above ground of 98 mm, while wells with a positive total coliform detection had an average liner clearance of 62 mm (Hynds et al., 2013). Significant work by Borchardt et al. (2003; 2007), Burch et al. (2021), and Rudd et al. (2023) found deep and confined aquifers contaminated by fecal material and anthropogenic chemical compounds. The authors conclude that faulty annular seals in wells with deteriorating grout or casing material may cross-connect upper and confined aquifers and cannot be ruled out as a possible contamination pathway.

3.2.1.3. Building Plumbing & Point of Entry and Point of Use Treatment

- Corrosion and Lead

Groundwater is not generally a source of lead, however water quality and premise plumbing components inside of homes may interact and pose a risk of lead release. Lead in drinking water is highly regulated in public water systems, with annual sampling guidelines established by Health Canada to monitor for lead levels across distribution systems to understand community level lead exposure from drinking water (Health Canada, 2019a). Utilities in many jurisdictions are also required to establish corrosion control programs to minimize the corrosivity of water entering buildings. These regulated standards are in place because Health Canada recognizes that there is no safe level of lead exposure and lead is clearly linked to significant health risks, including developmental and cognitive effects in children and cardiovascular dysfunction and cancer in adults (Health Canada, 2019a). Health Canada has recently reduced the MAC for lead to 0.005 mg/L. While significant barriers and controls are implemented in public water supplies, individual drinking water supplies are unregulated, with the voluntary monitoring and treatment left to homeowners. Homes built before 1986 are more likely to contain plumbing components with higher percentages of lead, which pose a risk for leaching into stagnate water (Lee & Murphy, 2020). Groundwater in certain regions have a higher likelihood to be corrosive and are characterized by low pH and alkalinity, though this is an oversimplification of the complex water chemistry that controls lead solubility in water (Kennedy, 2019). A full discussion on lead chemistry is beyond the scope of this review. Jurgens et al. (2019) applied a geochemical model to evaluate lead solubility potential (LSP) in over 8300 untreated groundwater samples collected between 2000 and 2016. The model identified 30% of the water samples where lead solubility potentials exceeded the US EPA's maximum concentration levels of 0.015 mg/L (Jurgens et al., 2019). The model demonstrated that certain water quality, if present in homes with plumbing that contain sources of lead, could result in lead concentrations in domestic water that are associated with significant health threats. The study found that most of these corrosive groundwater samples were in the eastern and southeastern US (Jurgens et al., 2019). This work aligns with research conducted by Nova Scotia Environment and Climate Change (NSECC), that studied untreated groundwater across the province (Kennedy, 2019).

KEY RISK: *Untreated groundwater has the potential to be corrosive and promote the leaching of lead from building plumbing.*
KEY BARRIER: *Routine monitoring and point-of-use or point-of-entry treatment has been found to mitigate lead exposure through drinking water.*

Using a composite measure of the Langelier Saturation Index and the Potential to Promote Galvanic Corrosion indicator, the risk of corrosive water was geospatially determined across Nova Scotia's five dominant aquifer types. The study found carbonate and evaporite aquifers to have the lowest corrosion risk and metamorphic and surficial aquifers to have the highest corrosion risk. Nearly 46% of Nova Scotians rely on individual groundwater wells for their domestic water supply, so understanding the implications of essentially unregulated drinking water on public health is a key objective of the Nova Scotia government (Kennedy, 2019; Sweeney et al., 2017). The NSECC study found that 56% (n = 111,100) of private wells are located in aquifers that are associated with corrosive groundwater. These groundwater conditions, if present in older homes with lead sources, could be causing unknown health problems for the residents. The Atlantic Partnership for Tomorrow's Health study collected water samples from over 2,500 homes in Nova Scotia to assess for the presence of lead in drinking water (Sweeney et al., 2017). Household water samples from 709 homes serviced by municipal supplies, 1,454 drilled wells, and 503 dug wells were analyzed for lead and 2.2% of the samples (59 samples) were found to exceed the MAC for lead (at the time of the study, 0.010 mg/L). The majority of the exceedances were from individual wells, with dug wells having the highest exceedance frequency (Sweeney et al., 2017). It should be noted that the sampling protocol at the time employed a 10-minute flush period before collecting the samples, so these values likely are far lower than a sample collected randomly. Also, since the publication of this study, Health Canada has reduced the MAC of lead from 0.010 mg/L to 0.005 mg/L, so there is no way of knowing how many of these samples would exceed the present-day health limits.

- Common treatment technologies

POU treatment units are control barriers installed directly to a tap or fixture to treat water at the point of use. POE treatment units are control barriers installed where the water enters the house/building, so all water travelling to any tap in the house/building has been treated. While these technologies are paramount for mitigating water quality issues and limiting health risks, they must be operated, maintained, and monitored to ensure optimal performance. The literature available on the implementation and efficacy of POU and POE systems in homes that rely on individual wells, while plentiful, offers very limited temporal and spatial lessons on treatment technologies. For instance, a four-week study in West Virginia and southwestern Virginia evaluated 21 homes and measured the efficacy of a faucet mounted commercially available filter to remove trace metals and microbial contamination. Pre- and post-filtered water was analyzed at two time periods (two weeks and four weeks after filter installation) to evaluate filter performance (Patton et al., 2024). The study found that the filters reduced total coliform, barium, cadmium, chromium, uranium, copper, lead, aluminum, manganese, zinc, and strontium from pre-filtered concentrations, but source waters with high initial levels of contamination still had exceedances post-filter. Small study sizes over short durations offer a snapshot of treatment efficacy but do not offer a robust understanding of treatment behaviours or efficacies over the scale necessary to protect human health.

KEY RISK: *Filtration treatment to remove trace metals may act as a source for microbial colonization and increased microbial risks.*
KEY BARRIER: *A multibarrier approach of groundwater is needed to address microbial risks prior to filtration to mitigate trace metals, or a barrier capable of both microbial and chemical treatment is needed, depending on drinking water source quality.*

There is some concern that filters, while aiming to remove metals, may serve as a colonization surface for attached microbes, particularly in untreated groundwater susceptible to bacterial contamination. Mulhern et al. (2022) measured pre- and post-filtered water for 5 months in 17 homes in North Carolina from sinks that were fitted with inline activated carbon filters. Of the 66 post-filtered samples analyzed in the study, five were positive for total coliform ranging from 1 to 2,203 MPN/100mL. None of these five samples were paired with unfiltered influent with known total coliform contamination. Of the 66 initial pre-filter water samples analyzed, six were found to have detectable total coliform ranging from 1 to 101 MPN/100mL. The paired post-filtered samples associated with these influent detections were found to have no measurable total coliform after filtration (Mulhern et al., 2022). These results indicate that while filters can successfully remove influent total coliform, there is also a risk that they can introduce total coliform through external contamination. In this particular study, the total coliform contamination was in the first few weeks of filter use, and total coliform contamination did decrease with continued usage. Filter installation and initial usage periods may need to be coupled with additional barriers and routine monitoring. The same study found that viral coliphages, measured as a proxy for virus removal efficacy, showed no reduction as a result of filtration, indicating that activated carbon filtration is not a reliable virus mitigation barrier for untreated groundwater (Mulhern et al., 2022).

Reverse osmosis (RO) is a widely employed treatment technology that removes dissolved contaminants from drinking water but require operation and maintenance practices to ensure treatment efficacy. It is also a popular POE device to treat elevated arsenic levels. However, improper operation and maintenance of these devices have been associated with incomplete or inadequate arsenic removal. George et al. (2006) evaluated arsenic in 102 homes in an area of Nevada with known elevated groundwater concentrations and found that of the 19 homes that used RO units, arsenic levels remained above the 0.010 mg/L health limit in 10 homes and above 0.10 mg/L in four homes. These findings align with broader research that reports that the effectiveness of RO filters depends on filter and membrane replacement per manufacturer’s guidance, but that efficacy can also be negatively impacted by water feed pressure, total gallons of water treated, hardness, and pH (Fox & Sorg, 1987; Lin et al., 2002; Torii et al., 2019). Water treatment technology limitations must be considered in the design phase and routine monitoring must be used to evaluate effectiveness.

Similar treatment challenges have been reported regarding Mn removal by POE greensand filters. A study by Barbeau et al. (2011) measured pre- and post-treatment Mn concentration in 49 residences with POU/POE devices installed. Four homes used POE greensand filters, which have a high maintenance requirement, including backwashing and media regeneration. All four locations were found to have higher Mn in the treated water (29 to 199% increase) due to improper system operation and maintenance. The study found RO treatment units were very effective at removing Mn, even when the influent concentrations were extremely elevated (Barbeau et al., 2011).

The installation of, and reliance on, treatment devices must be done with effective and continuous operation and maintenance practices, which require engagement from the resident, education and support from knowledgeable third parties, and the capacity to employ a routine monitoring program.

3.2.2. Asset Management

Municipal-provincial regulations and policies for individual wells may provide some guidance that could be beneficial to First Nations, particularly related to design, installation, well tagging and data management practices. However, beyond installation, all responsibilities of operation, maintenance, monitoring, and repair fall to individual homeowners. The devolvement of drinking water system management to individual well owners makes drinking water quality and operations largely unregulated across Canada. There is a wealth of research investigating individual well owners' behaviours in this unregulated space, mostly related to the implementation of monitoring and treatment activities and the varied and significant challenges that exist (Kreutzwiser et al., 2011; McDowell et al., 2021; Munene et al., 2019; Ochoo et al., 2017; Zheng & Ayotte, 2015). While there are certainly lessons to be learned from this literature, it is not directly relevant to, or reflective of, First Nations attitudes, actions, and perceptions of safe drinking water. There is limited published material on current First Nations management strategies for decentralised systems. Part 2 of this report provides specific information on common practices and challenges in managing decentralised systems in First Nations.

While there is limited literature regarding the management of individual wells that is relevant to a First Nations context, there is value in discussing best practices related to asset management more broadly. Asset management is generally understood to be an integrated approach to managing existing and new assets to deliver the desired level of service at the best appropriate cost (US EPA, 2015). In the water sector, asset management is exclusively applied to centralised systems, because they are centrally managed and management routinely engages in large-scale and long-term planning (Beuken et al., 2020). However, First Nations are uniquely positioned to be leaders in applying asset management practices to decentralised water systems and indeed have decades of experience, some perhaps informal or ad hoc, in centrally managing decentralised water assets (Indigenous Services Canada, 2011; Ontario First Nations Technical Services Corporation, 2018).

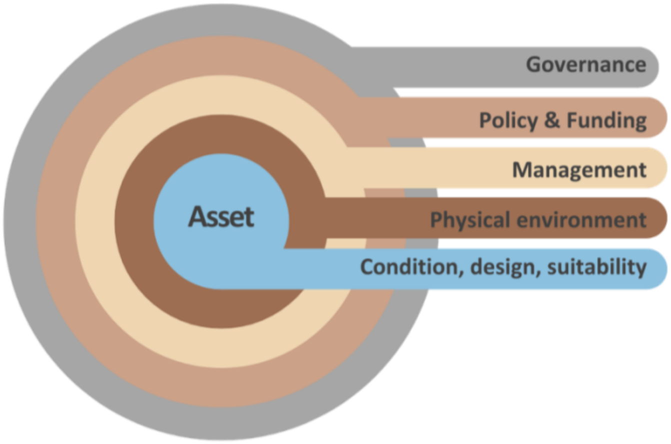


Figure 3-3. Asset management framework where asset condition, design, and suitability are central to asset performance, which are supported by several contextual conditions.

While formal asset management practices are relatively new in First Nations, there is a growing recognition that an asset management approach can provide a holistic strategy for service provision, as outlined in the Assembly of First Nations (AFN) Resolution no. 82/2019 (Assembly of First Nations, 2019). Asset Management Program funding is available through ISC's Capital Facilities and Maintenance Program (CFMP), but this funding does not apply specifically to decentralised assets and does not include identified funding for asset condition assessment activities, which is a vital part of asset management planning (AMP). AMPs integrate infrastructure design, capacity, condition, and performance into broader community planning, as shown in Figure 3-3, and link asset function to the key services the asset provides – in the case of water, supporting individual and public health as well as economic development. Asset management promotes investments in inspections, preventative maintenance, and regular repairs which prolong asset service life, and ensure optimal asset performance (Ontario First Nations Technical Services Corporation, 2018). In a municipal-provincial context, AMPs are subject to a number of drivers, including external forces (i.e., regulatory compliance requirements and community growth), asset age and condition (deterioration rates which are dependent on operation and maintenance (O&M) capacity), service level (i.e. expected reliability, prevention of catastrophic failure, resiliency to climate change), and cost efficiency (i.e. cost-optimized decision making). In a First Nations context, the specific drivers differ, but the broad categories apply.

To conceive of a decentralised asset management strategy for First Nations the key drivers need to be considered, with the understanding that each First Nation will have a unique set of conditions influencing its capacity to manage decentralised drinking water assets. A variety of planning processes exist for First Nations, i.e. Comprehensive Community Plan, First Nations Infrastructure Investment Plan, etc., so tools are available to advance asset management approaches to include decentralised water systems.

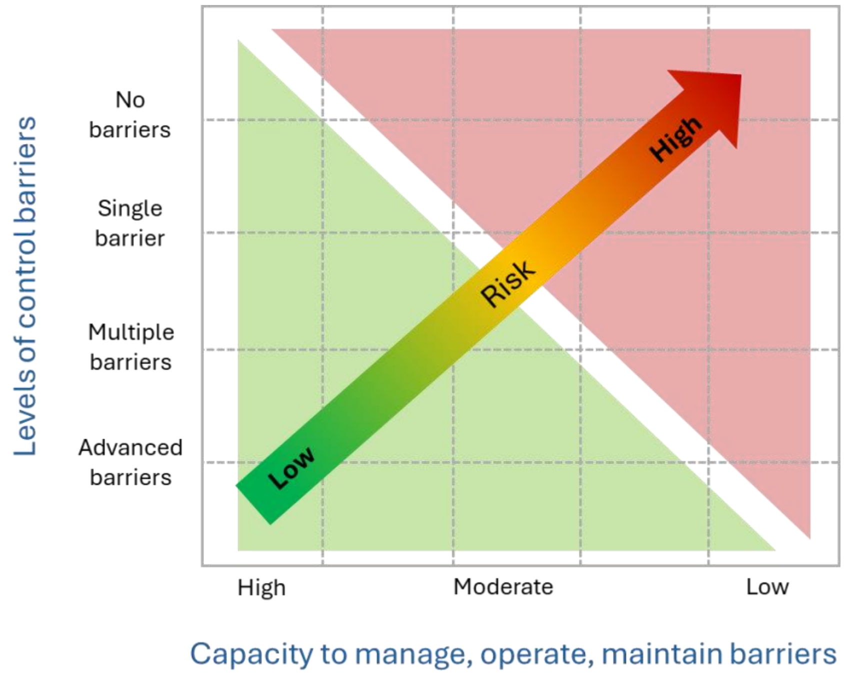


Figure 3-4. The relationship of control barriers and management capacity as risk mitigation mechanisms, adapted from Huck et al., 2001.

Figure 3-4, adapted from Huck et al. (2001), demonstrates the importance of both control barriers and management capacity to ensure effective risk mitigation and the production of safe drinking water. Management must be responsive to asset conditions (i.e. condition, design, and suitability) and physical and environmental conditions, which is only possible if broader policies, funding, and governance frameworks support proactive asset management.

In the case of individual wells, the threats to drinking water quality and quantity accumulate from source to tap and require multiple barriers, including source water protection actions, conservative well siting and setbacks, high standards of construction quality, routine and risk-based monitoring, and well-managed treatment systems. Asset management of individual wells should include (US EPA, 2015):

- Building an inventory of assets, including condition and expected lifespan.
- Scheduling and tracking maintenance (preventive and corrective) to inform future investments and O&M budgets and evaluate current practices for continual improvement.
- Managing budgeted and actual annual expenses to optimize investments through preventive asset maintenance.

Benefits of an AMP approach include developing a documented understanding of the assets that require maintenance, the expected life span of assets, costs of repair and replacement, and financial projects associated with supplying safe and sustainable drinking water. Examples and precedents of asset management practices for decentralised water systems are largely undocumented, but some First Nations have developed de facto policies and procedures to care for decentralised assets.

3.3. Level W3 - Truck-to-Cistern

Reliance on truck-hauled potable water for domestic supply is highest in the prairie provinces and the north and is most prevalent in rural or remote locations where installation of piped distribution systems is prohibitively expensive or logistically infeasible, or where groundwater quality is significantly impaired. Provinces and municipalities do not have readily available information on the number of homes that use cisterns to store truck-hauled water, as ‘cistern system’ is not a reporting category in the Canadian census (Baird et al., 2013). The safety of stored water in Canada has recently been reported on by the National Collaborating Centre for Environmental Health (NCCEH) and water quality degradation, inadequate inspections, and significant research gaps in understanding how stored water impacts human health were noted as key challenges in water cistern usage (O’Keeffe, 2024). The report also noted that living in a water-stressed and water-constrained environment has important health impacts due to lack of hygiene, reduced hydration, and psychosocial implications.

While truck-to-cistern usage is largely unknown in a municipal-provincial context, it is estimated that over 15,000 First Nations homes, nearly 13% of homes on reserves, rely on truck-hauled water for domestic supply. Manitoba, Alberta, Saskatchewan, and Ontario account for the majority of these homes, with 33%, 28%, 19%, and 16% of the First Nations homes in these provinces, respectively, using cisterns for their domestic water supplies. However, asset inventories may not reflect the total number of truck-to-cistern homes present in First Nations. Additionally, while Yukon has fewer than 400 homes that rely on truck-to-cistern systems, this accounts for upwards of 70% of all First Nations homes in the territory. Again, this inventory number may not be entirely accurate. It is important to note that truck-to-cistern systems are sometimes thought of as a ‘prairie problem’, but in Ontario, while only 16% of homes are on cistern systems, this represents over 4,000 individual residences, the third highest number of cistern-supplied homes by region.

Unlike individual wells where First Nations rely on provincial expertise, regulations, and best practices, truck-to-cistern systems are not prominent in municipalities and are largely unregulated by provinces. A jurisdictional scan summary for truck-hauled water and cistern usage regulations and guidance is provided in Appendix C. Cistern design and installation practices are not regulated in Canada, but several provinces provide guidance to homeowners regarding setbacks and cistern standards, often citing CSA’s Cistern Standard B126-series 13 (Canadian Standards Association, 2013). Health Canada published the *Guidance on Trucked Drinking Water Delivery in First Nations South of 60°* (Health Canada, 2012a) and the Guidance for Designing, Installing, Maintaining and Decommissioning Drinking Water Cisterns *First Nations South of 60°* (Health Canada, 2012b) to provide guidance on how to best protect public health in trucked water systems. Manitoba, Saskatchewan, and Alberta require some level of approval and permitting for water truck haulers, with Public Health Departments holding oversight responsibility for truck inspection and water quality monitoring. In a First Nations context, trucked water is often supplied by band staff from the Nation’s drinking water treatment facility, however, some rely in part or in whole on a third-party provider for delivery service.

There are multiple causal pathways for risk manifestation in truck-to-cistern systems due to the significant number of control barriers that must be maintained to prevent compounding and cascading risk accumulation. The maintenance, operation, and monitoring required to ensure effective control barriers from source to tap also make these systems expensive to manage effectively. Baijius & Patrick (2019) studied political and governance processes and practices that impact water safety in six First Nations in the prairies and found that one Nation spent $1M annually to fund water delivery and the members of this Nation reported not drinking the cistern water due to fears of contamination. Significant investments in high-risk water systems will be insufficient if individual control barriers cannot be maintained.

3.3.1. Risk Identification from Source to Tap

Truck-hauled water is generally considered to be more vulnerable to risk accumulation from source to tap than pipe distributed water because of the higher number of transfer points during delivery (Amarawansha et al., 2021; Baird et al., 2013; Bradford et al., 2018; Duncan & Bowden, 2009). Figure 3-5 shows the multiple locations where threats to safe water can manifest from source to tap, including the source water, treatment processes, truck hauling, cistern contact, and the home plumbing and fixtures. Because of the increased number of potential contamination sites, each site requires multiple control barriers, and the management and maintenance of those control barriers, to protect against the accumulation and compounding of risks. Further, the threats that exist to the delivery of water represent significant water quantity risks. Deteriorated road conditions, unreliable or insufficient truck services, and the impassability of gravel or dirt roads during rain and snowstorms, etc. represent water security challenges in truck hauled services. Because cistern use is more commonplace in First Nations than a municipal-provincial context, the body of literature on drinking water quality and risks in truck-to-cistern systems is predominantly conducted with First Nations. Research teams and First Nations in Manitoba and Saskatchewan have published several water quality studies detailing some of the significant risks associated with truck-to-cistern systems, and rural First Nations water treatment challenges in general.

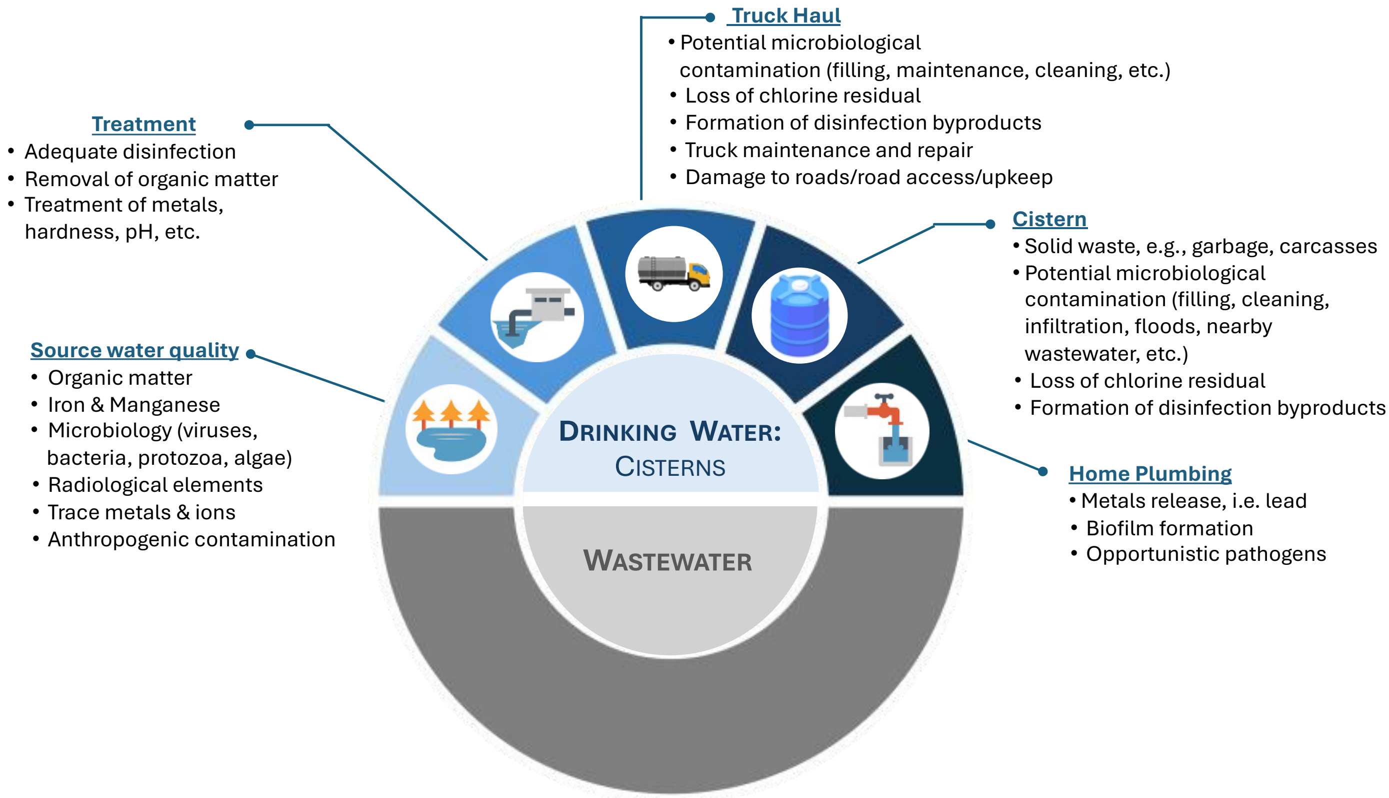


Figure 3-5. Source-to-tap assets in truck-to-cistern systems that provide potential risk to drinking water quality and identify locations for necessary barriers in the multibarrier approach.

3.3.1.1. *Source Water*

Most First Nations that rely on truck-to-cistern systems operate drinking water treatment plants (WTP) that service a small distribution system and provide trucked water to homes that are plumbed with cisterns. The source water of these WTPs could be surface water or groundwater and the level of treatment should correspond to the quality of the source water. Key threats to groundwater quality have been discussed above. Many of these threats also apply to surface water, particularly microbial and anthropogenic contamination. An in-depth review of the wide variety of contaminants that pose a threat to surface water is beyond the scope of this review. However, a comprehensive body of literature exists on this topic (Davies & Mazumder, 2003; Van Winckel et al., 2021; World Health Organization, 2016).

To fully understand specific threats to surface water sources, water quality must be well characterized across all seasons and during dry and wet conditions to ensure appropriate treatment processes are present in the WTP to produce drinking water that meets or exceeds the GCDWQ established by Health Canada. Two threats to surface waters that warrant mention in this review are toxic algal blooms and natural organic matter (NOM), which can lead to the formation of disinfection byproducts (DBP). Toxic algal blooms, also called harmful algal blooms (HAB) and DBPs are challenging to treat and have significant human health impacts if consumed in drinking water.

- Harmful algal blooms

HABs are naturally occurring cyanobacteria that are found in surface waters. The occurrence and intensification of HABs is increasing in recent years due to warming water temperatures and the influx of nutrients, such as phosphorus, into surface waters (Goucher & Maas, 2014). HABs are caused by accumulations of cyanobacteria with the ability to release secondary metabolites that are toxic compounds to humans. The chemicals are known to act as hepatotoxins, neurotoxins, and endotoxins in humans (Weirich & Miller, 2014). HABs are occurring in surface drinking water sources more frequently due to a combination of climate change and anthropogenic changes, including development and land use changes, sewage and septic system contamination, agricultural activities, and warming temperatures (Brophy et al., 2019). HABs present significant water monitoring and treatment challenges, due to their transient nature and complex toxicity (He et al., 2016; Treuer et al., 2021). Although there are numerous toxic compounds produced by cyanobacteria, the Health Canada drinking water guidelines set a MAC for only one group – microcystins (MC), a family of cyanotoxins, at 0.0015mg/L (Health Canada, 2021). Guidelines are not established for other cyanotoxins, including anatoxin-a and cylindrospermopsin, as health and exposure data on these toxins are limited (Health Canada, 2021). Detection of algal toxins in surface waters is challenging, as grab samples may miss bloom events by hours or days and composite sampling is time-consuming and expensive (Redden et al., 2023). HAB events are notoriously hard to treat in drinking water sources, requiring rapid implementation of treatment processes to remove cyanobacteria cells while minimizing the release of intracellular toxins and reducing total toxin concentrations (He et al., 2016). Truck-hauled water is not an an elevated risk of HAB contamination, however any cyanobacteria or related toxins that are present in treated water leaving the WTP will be transported to cisterns and present potential health problems. Farenhorst et al. (2017) analyzed lake source water in a fly-in First Nation in Manitoba using 16sRNA sequencing. The lake samples showed significant viable cells (32.8% of all cells sequenced) to be associated with cyanobacteria, indicating the source water is susceptible for bloom formation and toxin release. In general, many communities obtain their source water from lakes or reservoirs that could be susceptible to HAB formation at certain times of year, which could pose a risk of cyanobacteria or toxin breakthrough into treated water. There is little research on the persistence of cyanobacteria in trucked water systems and no data available on toxins present in cisterns. The singular study available for review by Gora et al. (2020) analyzed bacteria present in truck-to-cistern systems in Pond Inlet, Nunavut and found cyanobacteria cells present in the pumphouse, truck, and several community building taps in low abundances. This is an area in need of improved management and monitoring processes for First Nations, particularly in a warming and changing climate.

- Natural Organic Matter (NOM)

NOM has no direct impact on health, but the presence of NOM, derived from vegetation, microbial biomass, and root exudates, in drinking water can interfere with treatment and disinfection processes, lead to the formation of disinfection byproducts (DBPs) and play an important role in distribution system water quality, including biofilm production (Ndiongue et al., 2005) and metals transport (Trueman et al., 2019). Distribution system issues will be discussed in more detail in Section 3.3.1.5. DBPs are halogenated compounds that form from the reaction of chlorine-based disinfectants and NOM found predominantly in surface water sources. DBPs are carcinogens and are a significant public health concern. The presence of NOM and the risk of DBPs is not just a surface water issue. Groundwater in the Prairies can have elevated levels of dissolved organic carbon and without proper treatment there is a risk of DBP formation. Further, elevated bromine is also a risk factor for DPB formation. Groundwater high in bromine, if not treated for removal prior to chlorination, the water leaving the plant would have unacceptable THMs as the formation is almost instantaneous (T. Bonish, personal communication, November 14, 2024). There are numerous unwanted chemical byproducts that can be formed depending on the source and nature of the organic matter undergoing the reaction (Kimura & Ortega-Hernandez, 2019). The most important control barrier for the prevention of DBP formation is the effective treatment of source water NOM and bromine. Health Canada published its guidance document on NOM in drinking water to assist water utilities in managing NOM to improve water treatment processes and address DBP formation risks (Health Canada, 2020a). Health Canada recommends source-specific treatability studies to assess the best treatment process to remove NOM, as NOM's chemical and physical characteristics can vary significantly based on its source, form, and hydrophilicity. WTPs that fail to reduce NOM prior to disinfection will require increased disinfection doses and risk forming significant DBPs (Sohn et al., 2004).

KEY RISK: *Inadequately treated surface water sources may contain elevated levels of NOM that could drive DBP formation as water ages in trucks and cisterns.*
KEY BARRIER: *Appropriate water treatment processes consistently remove NOM across all seasons. This can be accomplished through site-specific treatability studies, routine monitoring, and effective WTP design and operation.*

3.3.1.2. Treatment

WTP design and treatment standards are highly regulated in most provinces, and yet water quality issues still occur as source waters change and control barriers degrade or become ineffective (Anderson et al., 2017, 2023). First Nations face the same water quality changes and water treatment challenges, but these challenges are compounded by the lack of drinking water standards and commensurate funding. It is well established that some centralised drinking water systems in First Nations have significant gaps in design standards, operational requirements, and sustainable long-term funding when compared to non-Indigenous water utilities (Neegan Burnside Ltd., 2011; Office of the Auditor General of Canada, 2021). The lack of regulated treatment standards and insufficient funding are two key risks that influence First Nations WTPs vulnerability to inadequate treatment processes. A full consideration of the risks of inadequately treated ground and surface water in centralised systems is beyond the scope of this review. However, given the relationship between DPBs and microbial disinfection and the significance of DBPs in truck-to-cisterns systems on First Nations, additional detail will be provided here for reference. Since the discovery of DBPs and the identification of health impacts caused by the ingestion of these compounds, DBP formation has been a significant area of research to understand the formation potential and reaction mechanisms that result in harmful DBPs. Health Canada's GCDWQ provides MAC values for six DBPs (Health Canada, 2024).

- Bromate (0.01 mg/L) is predominately caused by ozonation disinfection and is associated with reproductive effects in males and general developmental health effects.
- Chromate (1 mg/L) formed during disinfection with chlorine dioxide and can also be formed by contaminants found in aged hypochlorite solution; health effects impact thyroid function.

- Chlorite (1 mg/L) is predominantly caused by chlorine dioxide disinfection and is associated with neurobehavioural health effects.
- Haloacetic acids (HAAs) (0.08 mg/L, ALARA) are formed by chlorine-based disinfection reactions and are associated with liver cancer; multiple HAAs can form depending on the nature of NOM and compounds are probable carcinogens.
- N-Nitroso dimethylamine (NDMA) (0.00004 mg/L) is predominantly formed by chloramine disinfection or surface water disinfection with any chlorine-based disinfection; the compound is a probable carcinogen associated with liver cancer.
- Trihalomethanes (THMs) (0.10 mg/L) formed by chlorine-based disinfection reactions and associated with liver effects.

There is a separate MAC for bromodichloromethane (BDCM for drinking water (0.016 mg/L), as it is known to be a carcinogenic compound. In general, trihalomethanes that contain bromine may be more toxic than chlorinated trihalomethanes (Health Canada, 2006b).

KEY RISK: *DPBs can form during chlorination of source water with elevated NOM and/or bromine.*
KEY BARRIER: *Source water characterization and effective water treatment can reduce NOM, bromine, and DBP formation potential. Additionally, routine monitoring of NOM and bromine will ensure treatment is working.*

The occurrence of DBPs in surface WTPs that supply both piped distribution systems and truck-to-cistern systems has been reported in three First Nations by Amarawansha et al. (2023). All three First Nations have conventional WTPs with coagulation, flocculation, sedimentation, filtration, and disinfection using sodium hypochlorite solution. Single or duplicate sampling events occurred in 2015 where samples were collected from source water, treated water in the WTP, truck water from the filling hose, and kitchen taps. Ten homes on the piped distribution system and ten homes plumbed with cisterns were sampled in each Nation. Two of the three systems were found to have higher dissolved organic carbon (DOC) in the treated water than the raw water, and the third system showed only a 13% reduction in DOC. These results indicate significant issues with the treatment trains that prevented the removal of DOC and acts as a source for recontamination. The persistent organic content increased DBP potential in the treated water and resulted in DBP formation as water aged in both the piped distribution system and trucks/cisterns. Amarawansha et al. found that water samples from kitchen taps had THM concentrations in exceedance of the MAC 75% of the time in piped distribution system homes and 70% of the time in cistern homes. Trichloromethane was found to be the dominant THM. The authors note that the elevated DOC is a known surface water quality challenge in the prairies, as well as elevated hardness, which interferes with water treatment processes (C. D. Goss & Gorczyca, 2013; M. J. Goss et al., 1998). These complex treatment conditions require advanced operational water quality monitoring, accessible water quality lab equipment, and training and support for operators. These are common practices and activities in municipal utilities where DBP monitoring and reporting are regulated. FNIHB policy requires the monitoring of DBP concentrations quarterly per its Drinking Water Program Manual (Health Canada, 2014b), with THMs being monitored at the most distant points of the distribution system and HAAs being monitored at both the mid-point and most distant points of the distribution system. However, there is no guidance on best practices regarding measuring DBPs in cistern systems, where formation is predicated on site-specific conditions and water age. It is unclear if FNIHB monitors the chemical water quality of cisterns through either the Environmental Public Health program or Community-Based Water Monitoring (CBWM).

There is First Nations research that shows treated water quality leaving the surface water plant in a fly-in community had adequate chlorine residual and no detectable E. coli, indicating that as the water left the plant, there was likely minimal bacterial and viral risks (Farenhorst et al., 2017). There was no data published on protozoa and no details on the treatment processes present in the WTP, so it is unknown if protozoa risks were well mitigated. However, once the water left the plant and was transferred into the single water hauling truck in the First Nation, microbiological quality was found to degrade. This was also seen in Bradford et al.'s (2018) study in a First Nation in Saskatchewan. Water leaving the WTP had acceptable chlorine residual and no total coliform, but water in the truck, cisterns, and kitchen taps were found to be positive for total coliform. Safe water at the WTP is not a guarantee of safe water being delivered to the home (Bradford et al., 2018; Farenhorst et al., 2017).

3.3.1.3. *Truck*

Significant investments in WTPs, while necessary for safe drinking water, provide little protection to water quality once the water is transferred into a delivery truck. Water hauled by a truck is susceptible to a range of potential contamination sources. Hauler lids and hoses are two vulnerable pathways for microbial contamination. Bradford et al. (2018) interviewed First Nations members about their perception of truck-hauled water and participants noted their concern over the trucks, including lack of oversight and poorly maintained hoses lying on the ground. Farenhorst et al. (2017) found that water sampled in a hauler truck immediately after it was filled experienced rapid depletion of chlorine residual, with the influent water's residual falling from 0.67 mg/L to 0.07 mg/L. The truck water had a distinctly different bacterial abundance than the water leaving the WTP, with significant Betaproteobacteria that are commonly found in soil, indicating ubiquitous soil contamination in the truck. Further, if trucks are not routinely cleaned, biofilms can form and build microbial communities over time. However, a study by the same research group analyzed samples collected from three First Nations in 2016, including a treated groundwater system, a treated surface water system, and an untreated groundwater system and found no detectable E. coli or total coliform in any of the trucks used for water delivery (Mi et al., 2019). Bradford et al. (2018) sampled trucks in a Saskatchewan First Nation and found 25% of the 81 samples collected over the study period had detectable levels of total coliform, but no measurable EC. Most truck samples had chlorine residuals with the recommended range of 0.20 to 4.0 mg/L (Bradford et al., 2018). Gora et al. (2020) analyzed water samples along the WTP – truck – cistern path in Pond Inlet, Nunavut and found that of the 72 samples collected from source to tap, only 7 had detectable total coliform and these were raw water samples prior to disinfection. Gora et al. found the chlorine residuals in the trucks to be less than 0.15 mg/L in all samples, below the recommended residual for disinfection. However, the cellular ATP measurements, an indicator of viable cells in a water sample, were lowest in the hauler trucks compared to the pumphouse, cisterns, and taps sampled (Gora et al., 2020).

While these few studies indicate variable results, it is clear that trucks introduce a significant risk of microbial contamination which can manifest differently depending on chlorine residual. However, it should be noted that chlorine-based disinfection processes could exacerbate DBP formation in trucks with elevated levels of NOM. The only study on DBPs in truck-to-cistern systems found that THM concentrations were similar between the WTP, trucks, and cisterns for the three communities studied (Amarawansha et al., 2023), though trucks still pose a theoretical risk for DBP formation.

KEY RISK: *Trucks pose a significant contamination pathway for well-treated water.*
KEY BARRIER: *Having redundant trucks allows for routine cleaning and disinfection of truck tanks.*

Health Canada published *Guidance on Trucked Drinking Water Delivery in First Nations South of 60°* that outlines key actions for operating and maintaining a water delivery truck. The guidance document details safety precautions, i.e. air gap distances in top-filled drinking water tanks, backflow preventers on bottom-filled tanks, NSF/ANSI Standard 61 for materials that contact drinking water, and appropriate hose handling and storage practices, specifically that hoses must be kept off the ground (Health Canada, 2012). The guidance also recommends that all water truck components that come in contact with drinking water should be cleaned and disinfected when a chlorine residual of less than 0.2 mg/L is detected in the tank water and every three months. The cleaning protocol requires a truck to sit with highly chlorinated water for 24 hours before being rinsed. It is unclear from the published literature if these practices are being followed in First Nations, though Farenhorst et al. (2017) noted that the Nation involved in the study had 150 cisterns to fill each week and one operational water truck that had to run "non-stop." The water truck was found to have chlorine residuals near 0.07 mg/L and there was no mention of following the 24-hour cleaning protocol recommended by Health Canada (2012).

Truck-hauled water also presents potential water quantity concerns. Trucks can typically fill two to four cisterns per trip, depending on the capacity of the truck and the cisterns to be filled. This results in continuous use of the trucks to return and refill several times per day. If a truck is out of service and there is no redundancy of assets, homes may have to wait longer than normal periods for water delivery. Weather events and road conditions also represent significant risks to drinking water delivery and causes collateral impacts to broader infrastructure. Parts 2 and 3 of this report will discuss the fragility of the delivery system and the necessity of redundancy of key control barriers from source to tap.

3.3.1.4. Cisterns

Once the truck delivers the water to a cistern, storage in the cistern causes significant water quality changes and degradation. Cistern design, installation, material, condition, and maintenance all influence the safety of the stored water. Table 3-4 shows a summary of key elements of cistern installation, design, and maintenance guidance provided by provincial, national, and First Nations documents. A more comprehensive provincial jurisdictional scan of cistern best practices is included in Appendix C. It should be noted that Ontario devolves cistern oversight to regional health authorities, and the authors did not locate and summarize guidance documents from individual regions. Likewise, oversight of water haulers is also devolved to regional health authorities in BC and were not considered here. CSA Standard B126 – series 13 is a national technical standard establishing industry best practices for testing, installing, commissioning, inspecting, operating, and maintaining cisterns (CSA, 2023). Some provinces reference CSA 126 in their guidance documents, however, the Health Canada First Nations guidance document predates the CSA standard (Health Canada, 2012). The CSA document is extensive, however, cistern usage for potable water is not directly regulated in any jurisdiction, so there is little evidence of oversight or implementation of the standard available in the literature.

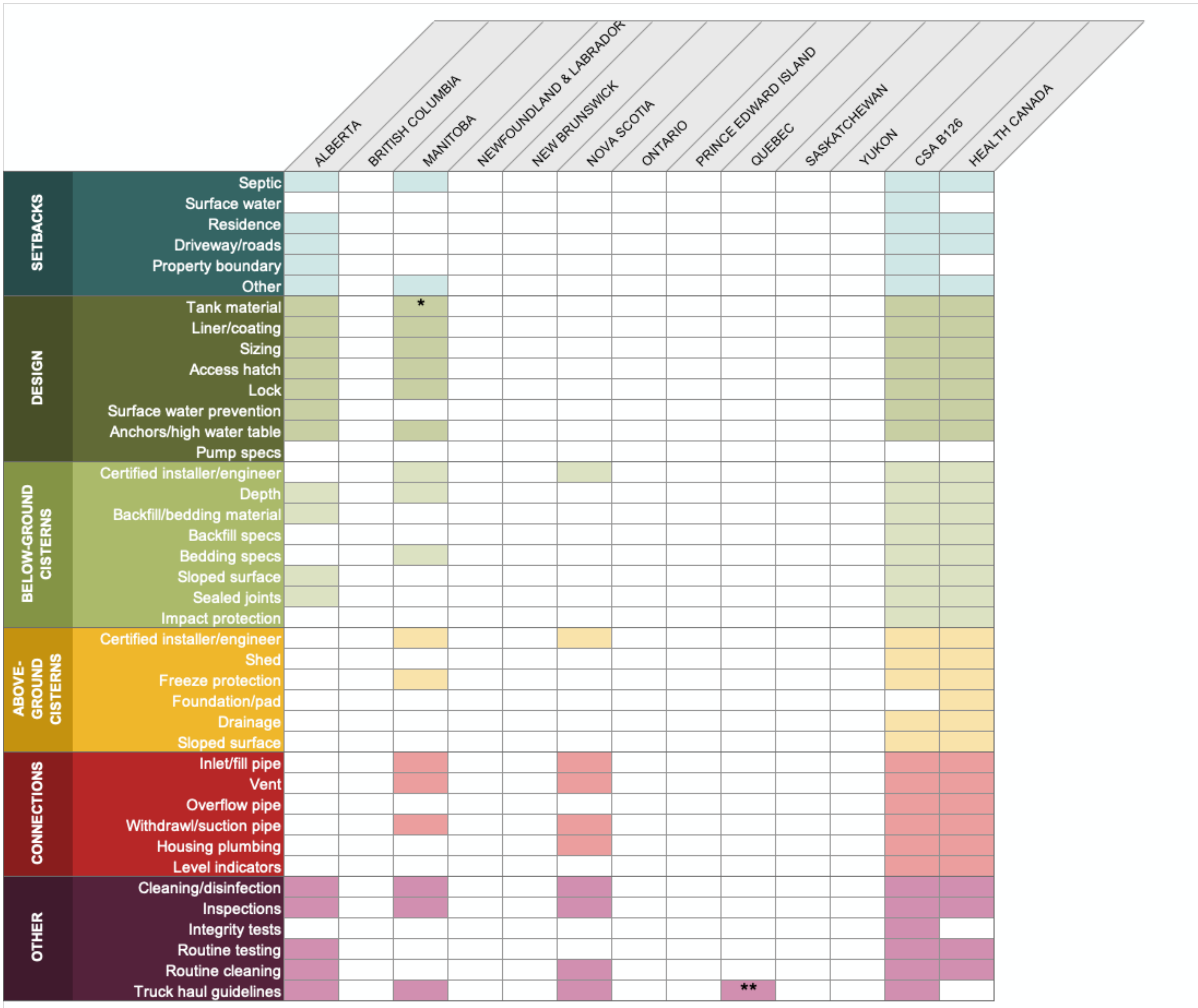
A global review of drinking water quality stored in tanks reports that microbial growth due to the decay, or inadequacy, of disinfectant is the greatest risk from drinking stored water (Slavik et al., 2020). Disinfectant decay can be caused by oversized tanks and/or poor mixing dynamics, i.e. short circuit flow paths from inlet to outlet, as well as ingress of water with microbial contamination through poor seals and structural defaults. Insufficient cistern cleaning is also associated with increased biofilm growth which can consume free chlorine and promote microbial regrowth (Slavik et al., 2020). The review identified the most common pathogens of concern to include Acanthamoeba keratitis, Aeromonas spp., E. coli and Enterococcus sp., Legionella sp., Pseudomonas sp., and Salmonella spp. (Slavik et al., 2020 and reference therein). A study of cisterns in three First Nations found that regardless of cistern material and location, cistern water had higher rates of microbial contamination than piped water, with both cement and polyethylene cisterns located above and below ground being susceptible to microbial ingress (Amarawashna et al., 2020). The study found that a below-ground cement cistern included in the study experienced microbial contamination throughout the year, indicating this cistern had a serious structural fault allowing persistent ingress of contaminated water. Other below-ground cisterns, including polyethylene cisterns experienced microbial contamination during spring melt events and following extreme rain events (Amarawashna et al., 2020). A study of cisterns, individual wells, and piped distribution system water in three First Nations was conducted and sampling revealed two of the three communities had no detectable total coliform or E. coli in the cisterns sampled, however in the third community six of the seven cisterns tested had both total coliform and E. coli (Mi et al., 2019).

KEY RISK: *The storage of water provides significant pathways for contamination.*
KEY BARRIER: *Routine cleaning and inspection should be coupled with POE disinfection and routine monitoring of water quality to provide multiple control barriers to ensure safe drinking water.*

The cisterns that were found to be most protected against microbial contamination were above-ground polyethylene cisterns stored in insulated sheds next to the homes. The community with contamination in the cisterns had no total coliform or E. coli in the WTP or truck samples, indicating that the contamination occurred once the water was transferred into the cisterns. These cisterns were all installed underground. While total coliform and E. coli are often used as proxies for fecal contamination, there are numerous pathogens that may be present in contaminated wastewater regardless of the presence or absence of total coliform and/or EC. Khan et al. (2022) evaluated two First Nations water supply systems for *Campylobacter ssp*. from source to tap and found that a home serviced by a fibreglass cistern was contaminated in 100% of the samples collected between 2016 and 2018. The study found that *Campylobacter* was prevalent in the source water, standpipe, and throughout the piped and truck-haul systems (Khan et al., 2022). The cisterns sampled in this study had chronically low chlorine residual, below Health Canada’s recommended > 0.20 mg/L. However, the WTP, trucks, and piped water all had compliant chlorine residuals, so the persistence of *Campylobacter* in these locations suggests possible fecal contamination through unknown routes (Khan et al., 2022). A study of homes in Coral Harbour, Pond Inlet, and Pangnirtung, Nunavut also found that homes serviced by cisterns had tap water with less than 0.20 mg/L of residual chlorine, while homes serviced by piped distribution systems had residual chlorine levels within Health Canada's guidelines (Daley et al., 2018). Increasing chlorine residual levels may help reduce microbial growth, but leaky cisterns that experience persistent infiltration of groundwater will continue to consume chlorine, resulting in increased formation of DBPs (Mi et al., 2019).

System design and installation are crucial to maintaining safe and secure drinking water supplies. Research published by Yee (2007) on housing infrastructure in Alberta First Nations evaluated 402 cisterns and found that 75% of the cisterns were not vented. CSA B126 requires cisterns to have a downward-facing vent to maintain equilibrated air pressure during filling and draw-down (US EPA, 2016). Approximately 35% of the cisterns did not have a childproof lid, which presents a range of health and safety concerns. The study also found that 21% of the cisterns were installed in areas where the land sloped towards the cistern, which increases the likelihood of runoff water entering the cistern and 28% of the cisterns had manhole opening covers that were cracked, damaged, or missing. Of the 402 cisterns evaluated, all of them failed at least one significant health and safety condition (Yee, 2007).

Table 3-4. Summary of jurisdictional cistern components recommended or regulated in each province and Yukon, as well as Health Canada's Guidance for Designing, Installing, Maintaining and Decommissioning Drinking Water Cisterns in First Nations South of 60°. Any guidelines or regulatory activities devolved to regional health authorities were not included in this review, i.e. cistern guidelines in Ontario and truck hauler requirements in BC, etc.
** Refers to CSA standard for all construction guidance. ** Truck haul guidelines only apply to trucks providing water to 20 or more people.*



Careful installation, commissioning, inspection, monitoring, and maintenance are crucial for mitigating risks associated with stored water. While the few studies cited here illustrate the vulnerability of cisterns to infiltration, degradation, and contamination, there is very limited information available about effective maintenance and operation practices to maintain the control barriers necessary for safe stored water.

It should also be noted that while the installation of cisterns can occur relatively quickly to meet housing needs, each cistern installed has multiplicative impacts on the source-to-tap water delivery system. This includes additional trips per truck, increased deterioration of roads and supporting infrastructure, increased O&M for inspection and cleaning of cisterns, increased monitoring needs, and an increased demand on WTP production.

3.3.1.5. Building Plumbing & Point of Entry and Point of Use Treatment

The risks to drinking water quality from building plumbing and POE/POU devices are similar in truck-to-cistern systems as those found in individual well systems. However, depending on the source water, there may be fewer geogenic risks in cistern water and increased microbial risks. There is limited research on the impact of cistern water on building plumbing, but the few publications that are available point to increased biofilm growth in premise plumbing, including opportunistic pathogens. Gora et al. (2020) collected water samples and biofilm swabs from homes serviced by cisterns in Pond Inlet, Nunavut and found pathogenic species including Mycobacterium and Legionella which can cause tuberculosis and Legionnaire's disease, respectively. The study did not analyze to the species level, so it was unknown if the bacteria present were the pathogenic strains.

Beyond microbial risks, premise plumbing can also serve as a source for metals release, with lead being a particular health risk. Gora et al. (2020) studied hundreds of water samples collected from 24 buildings in Pond Inlet, Nunavut and found that three buildings had repeated water samples that exceeded Health Canada's MAC, often by over 100 times. The study found that source water quality combined with low pH and lead-bearing plumbing components produced drinking water with excessive lead concentrations. The source water in Pond Inlet, the trucked water, and the cistern water all had nondetectable to very low levels of lead, indicating that the source of the lead was located between the cistern and the tap. Colloidal analysis showed that lead was most often associated with, and therefore likely co-transported by, NOM particles, iron, and manganese particles from the source water. Because the surface water is not filtered or otherwise treated, these water quality parameters facilitate lead leaching from premise plumbing present in some buildings (Gora et al., 2020). Similar frequencies of metals release were seen by Daley et al. (2017), where lead, copper, and manganese exceedances were found in select buildings in Coral Harbour, Iqaluit, Pangnirtung, and Pond Inlet, Nunavut.

KEY RISK: *Premise plumbing in homes serviced by cisterns may exhibit corrosion and release lead in drinking water.*
KEY BARRIER: *Cistern water quality monitoring should include pH and alkalinity, as well as annual lead monitoring, at the kitchen tap, to inform mitigation measures.*

As noted in Section 3.2.1.3, routine monitoring of residential lead concentrations in drinking water should be monitored following Health Canada's guidelines and appropriate treatment technology should be employed to mitigate lead ingestion. However, the use of activated carbon filtration is only recommended in adequately disinfected water, so while filtration can be effective at lead removal, the filtration media may serve as a source of bacterial regrowth and contamination in poorly disinfected water, if not adequately maintained.

3.3.2. Asset Management

Similar to the discussion and recommendations in Section 3.2.2, asset management practices for decentralised systems could support a centrally managed decentralised system. This is particularly important in a truck-to-cistern system where there are multiple transfer points that require good operational practices, preventive maintenance, inspections, and monitoring to ensure effective control barriers are in place to limit contamination. ISC has implemented a triannual extended asset condition reporting system (E-ACRS) program that assesses the performance, condition, and lifecycle needs of ISC-funded assets. This asset management approach to infrastructure could be extended to include centrally managed decentralised assets that should be, and in some regional cases, are eligible for ISC O&M funding. The First Nations Technical Services Advisory Group (TSAG) developed an Asset Management Tool Kit funded by ISC to assist First Nations in developing functional AMPs. The Tool Kit highlights the benefits of an AMP approach, including enhanced service delivery, improved prioritization of projects, improved management of risks, and an advocacy tool for seeking funding (TSAG, 2019). The Tool Kit emphasizes the foundational work already underway in many First Nations through ACRS, capital planning work, and First Nations Infrastructure Investment planning. While the Tool Kit is focused on ISC-funded infrastructure, which includes water hauling trucks, storage buildings for the trucks, the WTP, roads used to deliver water, etc. this process can also be extended to include all decentralised assets including the cisterns, insulation sheds, and any POU/POE treatment that might be installed in homes.

Recent work by Lauret et al. (2023) presents the planning and management practices of an Alberta First Nation to develop an internal assessment framework to develop inventories of failed or failing systems, document attributes contributing to the failure of system assets, and conduct site assessments to prioritize remediation actions. Based on the assessment findings, a number of risk mitigation options were considered to improve drinking water safety and remove Drinking Water Advisories on decentralised systems, including replacing all water systems older than 25 years, addressing specific contamination pathways, i.e. replace/repair septic systems, regrade site to improve drainage, and conduct comprehensive water quality testing to better characterize treatment options (Lauret et al., 2023).

Significant work has been done by Vogel (2018) to compare the capital costs associated with decentralised and centralised systems in First Nations and evaluate the costing formulas used by the federal government to budget for centralised systems. Vogel et al. (2018) suggests that decisions regarding centralised and decentralised systems need to consider numerous other costs to community health and well-being associated with water insecurity typical in decentralised systems, particularly in truck-to-cistern systems. However, there is no federal funding formula for decentralised systems beyond the costs associated with trucks, including O&M and staffing costs for drivers (ISC, 2025). Currently, life cycle costing for decentralised systems are handled through feasibility studies conducted by engineering consultants. Vogel et al. (2018) also highlighted the use of remoteness factors and other costing assumptions that render the funding formula less than ideal for reflecting actual costs incurred by First Nations, but these limitations influence both piped and trucked system costs similarly. There is a clear need for improved asset management practices to better capture the costs of operating, maintaining, and monitoring truck-to-cistern systems so that these systems can be priced appropriately. On paper, truck-haul systems may appear more economical, but as Baijius & Patrick noted, spending money to operate an unsafe system produces water that a Nation often does not drink, due to the lack of confidence in the water quality in cistern systems (Baijius & Patrick, 2019).

4. Wastewater

4.1. Level of Service

The Level of Service Standard (LoSS) defines three wastewater systems that are eligible for funding from ISC, as shown in Table 4-1.

Table 3-5. Level of service definitions for wastewater systems from ISC's LoSS.

Level of Service	Description
S1	Centrally managed onsite systems, including septic tanks and disposal fields, designed, installed, and continuously operated, maintained, and monitored as per the *Protocol for Decentralised Water and Wastewater Systems in First Nations Communities.*
S2	Truck-hauled sewage, where holding tanks collect and store all wastewater from the home, to be collected and transported to a central treatment plant or other disposal facility.
S3A	Communal septic system, where full or partial plumbing transports the wastewater from several residences to a common septic tank and disposal field nearby.
S3B	Fully piped sewer system with a piped collection system and central sewage treatment plant.

The objective of this report is to summarize the risks and management challenges of decentralised wastewater systems, so the focus will be on service levels S1 and S2. However, some communities use their own lagoons or other centralised wastewater treatment plants (WWTP) to receive and treat solid and liquid waste pumped from septic and holding tanks, so service level S3B will be discussed to some extent to understand certain risks associated with WWTP capacity.

Data from ISC’s 2022-2023 ICMS is summarized in Figure 4-1 and shows that of the 120,935 reported housing units across the country, approximately 22% were serviced by decentralised wastewater systems, either septic tanks with a disposal field or a sewage holding tank. It should be noted that the ICMS data is likely highly skewed because “truck hauled” holding tanks are often confused with septic tanks, which also require a truck to vacuum out sludge build-up. In addition, it is known that some First Nations have a number of ‘shoot-out’ systems, where wastewater effluent is discharged directly from the septic tank to the ground surface. The number of shoot-out systems is not reflected in the ICMS data. While the delineation between septic systems, holding tanks, and shoot-outs are unclear in the housing data, it does show that Ontario, Alberta, Saskatchewan, and Manitoba have the highest number of homes serviced by decentralised waste systems of some kind. By percentage of homes serviced by a decentralised system, Alberta has the highest relative proportion at 62% of homes using septic fields or holdings tanks. Ontario, Manitoba, and Saskatchewan follow with 50%, 43%, and 29% respectively. Similar to decentralised drinking water system patterns, homes in the Yukon are nearly entirely serviced by decentralised waste systems, with either septic systems or holding tanks associated with 95% of homes in First Nations. The remaining regions, Atlantic, Quebec, and British Columbia range from 8 to 18% reliance on decentralised wastewater systems. The significant regional differences in the prevalence of decentralised wastewater systems may be reflective of the rural and remote nature of Nations, however, these regional differentials are not as drastic in decentralised drinking water systems, indicating that the differing approaches to wastewater treatment may be more administrative than geographical.

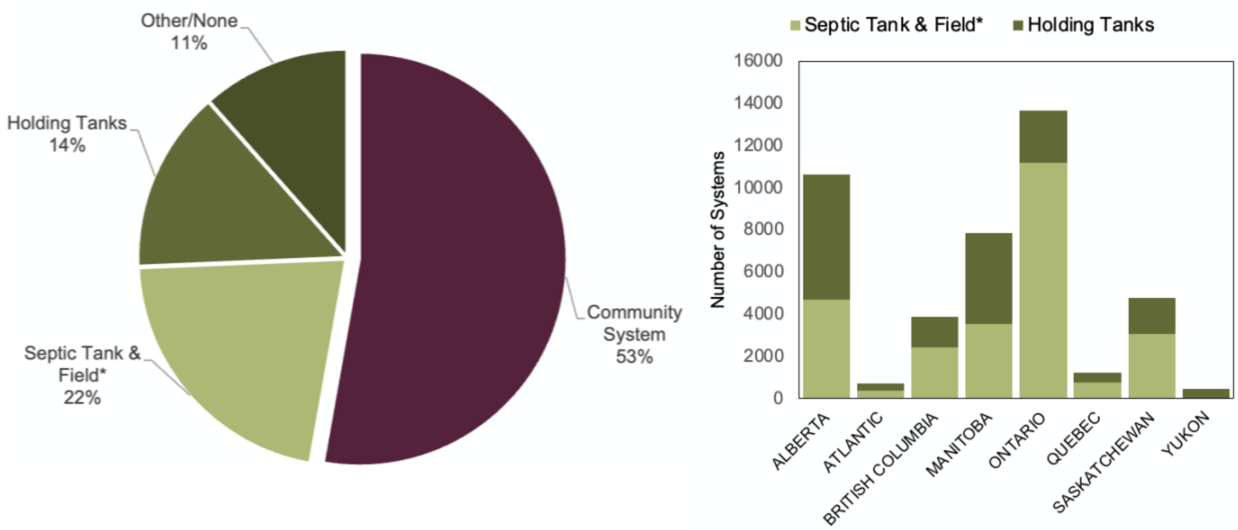


Figure 3-6. The proportion of decentralised wastewater systems by type (left) and within each region (right), summarized from data in the 2022 - 2023 ICMS housing survey.

4.2. Onsite Sewage Treatment Systems (Septic)

Globally, onsite sewage treatment systems (OSTS), also referred to as septic systems, are widely used to treat domestic wastewater. OSTSs utilize a settling tank and a soil dispersion or infiltration field to return wastewater safely back to the environment, ideally removing total suspended solids (TSS) and reducing biological oxygen demand (BOD), nutrient loads, and microbial contaminants in the wastewater effluent. Because wastewater is biologically and chemically complex, OSTS design, location, soil characteristics, hydraulic loading, and residence times must be optimized to allow for adequate and sustainable treatment of domestic waste. Given the technical nature of these treatment systems, most provinces and/or municipalities regulate OSTS installation and repair through application, design, approval, installation, and inspection requirements, often including certification of both designers and installers of OSTSs. Appendix D contains details of a jurisdictional scan of regulations and practices in each province and Yukon. Even with this highly regulated approach, poorly performing OSTSs are known to be a significant cause of environmental contamination. Internationally, many jurisdictions have employed a range of interventions and technical requirements to improve the functionality of decentralised wastewater systems (Ireland Environmental Protection Agency, 2021; O'Keeffe et al., 2015; US EPA, 2003; US EPA, 2002). In Canada, CSA *B65:12, Installation Code for Decentralized Wastewater Systems*, was first published in 2012 and updated in 2021 to establish national standards for the proper installation of both septic systems and holding tanks (Canadian Standards Association, 2012). These standards have not been formally adopted in provinces but do inform best practices in some jurisdictions.

In a provincial context, once an OSTS is installed, the operation, maintenance, and repair of OSTSs in municipalities fall to the homeowner, with some jurisdictions requiring service and tank pumping to be carried out by a certified contractor or waste hauler. Regulatory agencies only become involved in inspection and repairs if *nuisance* or complaints are made against failing OSTSs. First Nations have a range of management practices in place for OSTS installation, but many regions rely on provincial best practices to broadly guide the installation, operation, and maintenance of OSTSs. However, research indicates that across North America, OSTS are a significant contributor to environmental contamination. The US EPA published the Onsite Wastewater Treatment Systems Manual in 2002 in recognition of the need for enhanced technical guidance for OSTS planning, design, installation, operation, and maintenance standards (US EPA, 2002). The manual acknowledges that while OSTSs could be potentially viable, low-cost, long-term wastewater treatment systems, poor planning, operations, and maintenance of the systems have caused widespread environmental and public health risks (US EPA, 2002). The authors of the manual cite lack of coordination across land use planning, zoning, development, water resources protection, and public health initiatives as leading causes of inappropriate and inadequate OSTS implementation (US EPA, 2002). These challenges also exist across Canadian jurisdictions and are particularly significant in First Nations, where they are compounded by the lack of regulations, an absence of a formal oversight framework, and often inadequate funding.

4.2.1. Risk Identification from Drain to Effluent

As soon as domestic water is collected in a drain, it becomes wastewater and begins the journey back to source water. The ability of OSTSs to adequately treat wastewater is a crucial component of the water cycle, particularly in areas where individual wells, underground cisterns, and surface waters are in close proximity to an infiltration field(s). Because OSTSs are known to have high failure rates, understanding the relationship of percolated wastewater back into groundwater and surface water sources is paramount for protecting public health. Figure 4-2 shows the wastewater half of the one water cycle, with in-home collection leading to septic tank treatment and release of wastewater effluent into an infiltration field. As with drinking water, there are multiple barriers in an OSTS, and these barriers can be optimized or compromised throughout the life cycle of the assets. Depending on the soil environment, lot size, slope conditions, and setback distances to other features, the septic tank unit and infiltration field may have a variety of engineered features. This report will not provide an exhaustive discussion of the numerous septic system types but will generalize common risks of inadequate OSTS performance. There are common causes of failure that can be categorized into design failures, technical failures, and management failures (Prince, 2017). These will be discussed below across the multiple components of an OSTS with a focus on key risks and necessary control barriers to mitigate these risks.

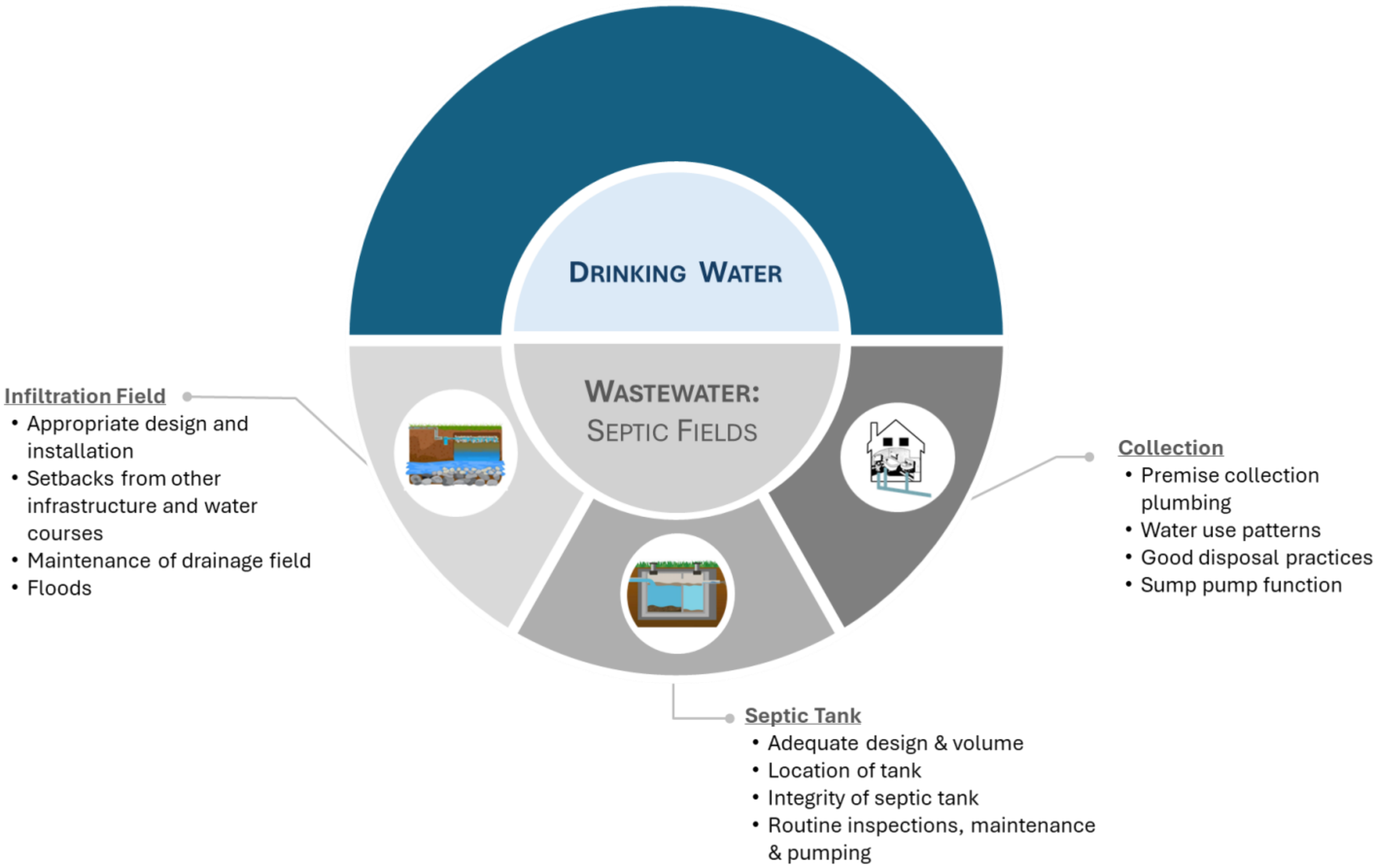


Figure 3-7. Drain-to-effluent assets in onsite septic treatment systems (OSTS) that provide potential risk to wastewater effluent quality and identify locations for necessary barriers in the multibarrier approach.

4.2.1.1. *Collection*

The efficacy of an OSTS is dependent on both the volume and the composition of the wastewater that needs to be treated. Volume is determined by the number of occupants in the home and the water consumption patterns and behaviours of the occupants. Composition is determined largely by the products used and collected in the home, including detergents, oils and fats, harsh cleaning chemicals, and solid materials that enter the drains. In general, the purpose of an OSTS is to improve wastewater quality to a level that it is safe to return to the environment without causing harm. Most domestic wastewater requires the reduction of biochemical oxygen demand (BOD), the removal of TSS and nutrients (nitrogen and phosphorous compounds), and the removal or inactivation of microorganisms (US EPA, 2002). The degree of treatment needed is dependent on the initial character of the wastewater, which is a function of how many people are in the home and what chemicals are released into the household drains. Septic tank functionality is largely driven by bacterial digestion of organics and sequestration of nutrients. Fluctuations in water chemistry, through harsh chemicals, changes in pH, increased temperatures, etc. can kill bacterial communities and reduce the digestion of organic matter in the septic tank digestion (Prince, 2017). A study of aerobic onsite wastewater treatment systems in South Australia found that the nutrient load of domestic wastewater was positively correlated to the number of occupants in the house (Levett et al., 2010). A comparative field experiment found that wastewater with elevated concentrations of bleach and detergent caused decreased treatment performance, as measured by BOD removal, in conventional septic tanks (Ip & Jowett, 2004) and a laboratory study by Gross (1987) found that bleach, Lysol, and Drano all killed the bacterial population in septic tanks. Both studies found that bacterial populations recovered within 48 hours of die-off, however frequent use of these chemicals can decrease treatment efficacy. Baths and high volumes of laundering release warm, detergent-rich water, are also known to decrease septic tank treatment efficacy (Patterson, 2003; Prince, 2017).

KEY RISK: *Water use behaviours and patterns in the home impact the efficacy and performance of the OSTS.*
KEY BARRIER: *Education and awareness are necessary control barriers that have to be supported with outreach and engagement.*

Because human behaviour is the key driver of wastewater quality and quantity and can alter the efficacy of OSTSs, many provincial agencies provide manuals and guidebooks for homeowners to educate them on how to maintain their OSTS through good wastewater practices (Environment, Labour and Justice Inspection Services Prince Edward Island, 2013; HealthLink BC, 2021; Nova Scotia Department of the Environment, 2009). Scotland's Centre of Expertise for Waters published a review aimed at identifying practical measures for reducing phosphorus and fecal microorganism release from OSTS and recommended home occupants use phosphorus-free detergents, reducing food waste entering drains, and enhancing their awareness and education regarding OSTS (O'Keeffe et al., 2015).

The US EPA recognized that devolving maintenance and operation responsibilities to individuals in a fragmented regulatory environment was a key contributor to the high rate of OSTS failure in the US (US EPA, 2003). The EPA developed voluntary national guidelines for the management of onsite wastewater treatment systems to support OSTS performance through a watershed management approach. The guidelines highlight the importance of cumulative effects of all OSTSs within a watershed and a central management element in the model was the advancement of public education and engagement to build an understanding of the importance of system operation and maintenance (US EPA, 2002; US EPA, 2003). First Nations are particularly well positioned to be leaders in developing a comprehensive framework for centrally managed decentralised systems, where lot size, housing density, soil characteristics, and funding allow.

4.2.1.2. *Septic Tanks (conventional system)*

Wastewater from the home is transported by gravity or pump into a septic tank for initial treatment. Modern septic tanks tend to have two chambers, in which the first acts as a settling tank and the second provides storage for the resulting wastewater effluent from the first tank prior to being released to the infiltration field. Septic tanks perform three main functions in the treatment of domestic wastewater 1) separate solids and fats through settling and flotation, 2) facilitate anaerobic digestion of solids and dissolved organic material and 3) provide storage for remaining solids until removal (Viraraghavan, 1976). The design and total volume of the tank are critical to achieving these three processes. Provinces with OSTS regulations set estimated minimum working capacity for tanks based on the number of bedrooms in the home, usually with the assumption that each bedroom represents 1.5 to 2 people in a home with each person generating an average daily flow of ~ 360 L/d (CSA, 2021; US EPA, 2002), though this varies by jurisdiction. The assumption of these housing conditions is entirely cultural and does not reflect occupancy practices in First Nations, particularly given the housing crisis in most First Nations (Indigenous Services Canada & Assembly of First Nations, 2023). While there is no available published literature on OSTSs in First Nations, it is fair to reason that septic tanks may be under-designed for many homes because they follow non-Indigenous design criteria for determining minimum total volume. Likewise, daily water use surveys that inform industry standards were conducted across North America, in part by the American Water Works Association, and focused on large urban centres serviced by centralised drinking water systems (Mayer et al., 1999). These usage values may or may not be representative of average daily usage on First Nations. There is general knowledge that First Nations homes serviced by truck-to-cistern systems use significantly less water than a home serviced by centralised drinking water systems in an effort to conserve cistern water between truck deliveries (Sayers, personal communication). Given the lack of information on First Nations water usage patterns, it is unknown if provincial standards are appropriate when designing septic systems.

KEY RISK: *Provincial design standards may be inadequate to inform First Nations OSTS.*
KEY BARRIER: *First Nations housing and water usage practices and patterns should be evaluated to create relevant policies.*

Septic tank design is crucial, as volume, geometry, baffle configuration, and number of compartments facilitate stagnant conditions for solids to settle (sludge) and low-density material to float (scum), producing an anaerobic environment that facilitates treatment. Many jurisdictions apply CSA B66 standard for tank design (Ralston & Payne, 2014; SMH, 2018) to ensure optimal conditions for the development of anaerobic conditions required for the digestion of organic materials, i.e. carbohydrates and proteins (Penn et al., 2006; Prince, 2017). The anaerobic conditions in the tank also facilitate the conversion of organic nitrogen into ammonium nitrogen (NH_4^+), which is an important step in the nitrification process (Prince, 2017). The sludge/scum formation is only possible when wastewater effluent residence time in the tank is sufficiently long, and the water quality supports the growth of necessary bacteria (US EPA, 2002). As discussed above, water usage practices in the home directly affect septic tank performance, additionally, system maintenance activities are also necessary to maintain an operational OSTS. Septic tanks must be emptied of scum and sludge on a routine basis, depending on manufacturer’s recommendations and system performance to prevent the over-accumulation of solids, which can lead to reduced treatment volumes and hydraulic overloading. In First Nations, some bands own a vacuum truck(s) and provide this service to community members, either transporting the waste to the Nation’s WWTP or hauling it to an off-site location. If septic tank contents are delivered to the Nation’s WWTP, it must be able to accommodate this concentrated waste product. OSTS design, operation, and maintenance are important in maintaining a functional wastewater treatment system. A comprehensive review of OSTSs in Western Australia from 1997 to 2011 found that improperly installed systems, undersized systems, and unauthorized materials, i.e. fats and oils, were among the most frequent causes of system failures (Gunady et al., 2015).

Causes of septic tank failures and resulting risks

- Poorly designed or damaged tanks

When flow rates into a septic tank exceed the hydraulic loading capacity of the tank, necessary residence times are not achieved, and optimal settling cannot occur. Possible causes of insufficient residence time include undersized tanks, changes in the number of occupants in a home, significant changes in water usage, or tanks that lack appropriate baffling geometry (CSA, 2021; US EPA, 2002). Tank geometry and inlet/outlet placement also affect possible hydraulic short-circuiting that can occur and cause reduced residence time and sediment resuspension (O'Keeffe et al., 2015). Hydraulic overloading can also be caused by infiltration into cracked or damaged tanks. Hydraulic overloading can lead to inefficient anaerobic digestion and incomplete treatment of effluent. Decreased treatment efficacy results in the release of wastewater with high biological oxygen demand and high concentrations of nutrients and microorganisms (Holt, 2011; Prince, 2017). Untreated, or undertreated, wastewater effluent entering the infiltration field poses a risk to environmental and public health. Incomplete settling and scum formation can also lead solid discharge, or carryover, from the tank to the septic field. If the septic field becomes blocked, wastewater can back up into homes or cause ponding of wastewater around the infiltration field (Butler & Payne, 1995; Gunady et al., 2015). Both pose significant public health threats, as untreated effluent can lead to disease transmission of gastroenteritis from bacteria, viruses, or protozoa, bacterial dysentery, infections hepatitis, or skin infections from a variety of pathogens (Gunady et al., 2015). Tank design should also account for influent wastewater characteristics. In homes where food grinders are used and/or oil and grease concentration are expected to be significant, tanks should be fitted with a grease interceptor to protect the sludge and scum layers in the tank or be designed with 20% additional working volume (CSA, 2021; NS DECC, 2009).

- Inadequate tank maintenance

Septic tank maintenance is crucial for the sustained and efficient treatment of wastewater. Over time, scum and sludge will build up, which reduces the volume and effective residence time in the tank. This can lead to untreated effluent reaching the infiltration field and/or carryover which could result in infiltration field failure. Routine maintenance is needed to remove, by vacuum truck, the sludge and scum that accumulate in the septic tank. Significant research has evaluated sludge accumulation rates in multi-compartment septic tanks to understand how these systems perform over time. Gray (1995) found that sludge accumulation rates decrease rapidly over the first 12 months of operation, dropping from 0.254 L/person/day during the first 6 months to 0.178 L/person/day after 60 months. As systems age, they may require desludging less often, as longer sludge ages were found to be associated with more stable sludge volumes. Depending on the age of the system desludging may need to be done every two years, though Gray (2010) suggests every five years for older systems. This finding was supported by Mac Mahon et al. ((Mac Mahon et al., 2022) who studied sludge accumulation rates in septic tanks in a northern maritime temperate climate and found that sludge accumulation decreases with system age and desludging should be done every three to five years. The US EPA manual recommends tanks should be emptied when more than 30% of the working volume is filled with sludge (US EPA, 2002). Technical standards, including CSA B65:12, recommend septic tanks that utilize effluent pumps should be installed with liquid-level sensors and high-liquid-level alarms to notify the home occupant of system malfunction (CSA, 2021). In the US, the National Water Quality Inventory: 1996 report to Congress cited failing septic systems as the second leading cause of groundwater contamination and reported that improperly constructed and poorly maintained septic systems are the dominant cause of “substantial and widespread nutrient and microbial contamination to groundwater” (US EPA, 2003, pg. 10).

4.2.1.3. *Infiltration Fields*

Infiltration, or dispersal, fields provide significant treatment of wastewater effluent leaving the septic tank. As water percolates through the soil bed, organic compounds, nutrients, and microorganisms undergo attenuation through biotic and abiotic processes, including filtration, soil adsorption, biodegradation, and microbe inactivation (Prince, 2017; Withers et al., 2012). Significant research exists that describes treatment mechanisms within biomats that form in soil infiltration fields and the importance of hydraulic properties and soil structure of fields to allow the dispersal of effluent evenly across the treatment area (Beal et al., 2006; Lowe & Siegrist, 2008; Rutledge et al., 1993). When designed, installed, and maintained properly, contaminant attenuation can approach 70 to 90% for lifetime phosphorus removal and upwards of 80% for nitrogen removal (Withers et al., 2014 and references within). Nearly every province has regulations that establish technical standards that must be considered during the design of an infiltration field to ensure that the hydraulic loading rates and soil permeability allow for optimal treatment. Site characterizations, including soil analyses, are a required part of all provincial application and/or approval processes (see Appendix D for more detail) because lot size and required setbacks, both horizontal and vertical, must be able to accommodate the filtration field dimensions. Field dimensions are often determined by soil texture and structure, permeability, and depth to groundwater table or impervious layer, but methods vary across jurisdictions (Nova Scotia Department of Environment and Climate Change, 2013; Ralston & Payne, 2014; Safety Codes Council, 2021). Soil treatment only works if 1) the hydraulic loading rate does not exceed the infiltrative capacity of the field and 2) the permeability of the soil is low enough to allow for adequate treatment, e.g. soils with permeabilities > 0.0005 m/sec are unacceptable for infiltration fields in Nova Scotia.

KEY RISK: *Poorly designed infiltration fields will fail if effluent is not able to travel through adequate soil depth to allow for the treatment of microbiological components. Low or high permeability will prevent effective treatment.*
KEY BARRIER: *Best practices for soil characterization using test pits and in situ permeability tests should be conducted to inform field design.*

Depending on lot size, topography, and soil characteristics, *in situ* soil may not be suitable for an OSTS infiltration field. Most provinces provide technical guidance on alternative field designs for conventional onsite septic systems, including raised mound systems, trench systems, and sand filters (New Brunswick Department of Public Safety, 2020; Saskatchewan Ministry of Health, 2018). Whatever field type is installed it must adhere to the following general principles to ensure optimal treatment (SMH, 2018):

- Aerobic conditions are present beneath the infiltrative surface.
- Unsaturated flow is maintained beneath the infiltrative surface.
- Bypass flows and short-circuiting through soil are not allowed.
- Sufficient vertical separation between a restrictive layer and the infiltrative surface is maintained to avoid saturated flow paths. A retention time of at least 7 days is ideal.

- Uniform distribution of the effluent over the soil infiltration surface is required.

If an infiltration field can maintain these key treatment conditions, it is likely to provide adequate treatment of domestic wastewater.

However, it is well established in the literature that OSTSs frequently fail for a variety of reasons, and in the US are considered to be a leading cause of environmental contamination (US EPA, 2002). Likewise, Australia, Scotland, and Ireland have well-documented issues with underperforming OSTSs that have led to environmental and public health concerns (Gunady et al., 2015; Hynds et al., 2012; O'Keeffe et al., 2015). Improperly designed and/or installed systems, the devolution of operation and maintenance responsibilities to homeowners, and the lack of system performance monitoring all contribute to the frequent failures of OSTSs across jurisdictions. These systems are likely to face similar challenges in First Nations, compounded by the fragmented funding and management frameworks for these decentralised systems.

Causes of infiltration field failure and resulting risks

- Improper design and soil characteristics

The goal of a functional infiltration field is to maintain an unsaturated zone below the infiltration surface and above the groundwater table to allow the oxidation of nitrogen to nitrate, convert organic matter (BOD) to carbon dioxide, and facilitate the inactivation of microbial contaminants (Gardner et al., 2006). Wastewater effluent needs to percolate through soil at a rate that allows filtration, adsorption, and biodegradation. Insufficient residence time and loss of an oxic zone both result in soil treatment failure. A number of design issues can interrupt this key treatment mechanism, including 1) the formation of impervious biomats at the infiltration surface, 2) high permeability soils or preferential flow paths that prevent necessary residence times, and 3) loss of the unsaturated zone due to insufficient soil thickness relative to groundwater level or poor surface drainage of the infiltration field. Benchtop studies of long-term acceptance rates of domestic wastewater to various soil columns found that increased organic loading and hydraulic loading rates accelerated the formation of low permeability biomats, resulting in decreased wastewater infiltration and treatment (Beach et al., 2005; Beal et al., 2006). OSTS may have an appropriate design based on the original design of the home, however, additions to the home (i.e. added bathroom, more inhabitants, garbage disposal addition) can substantially increase hydraulic and/or organic loading rates which can overwhelm the treatment capacity of the soil (Capps et al., 2020).

While low permeability conditions threaten the functionality of OSTSs, high permeability soils are also associated with system failures. Geary & Lucas (2019) conducted a field study of OSTSs in NSW, Australia to understand the importance of hydraulic and organic loading of infiltration fields. The authors found wastewater distribution rates from a home to an infiltration field to average 55 L/m^2/day, which exceeded the receiving capacity of the 9 m tunnel trench dispersal field. The coarse, highly-permeable soil caused wastewater effluent to pass quickly through the field, causing nutrients (nitrogen and phosphorus) and fecal contaminants to be transported through the subsurface with little attenuation (Geary & Lucas, 2019). Infiltration fields with insufficient soil depth can lead to rapid transportation of contaminated wastewater to enter groundwater, either directly into the water table or through preferential flow paths. This is of particular concern when infiltration fields overlay fractured bedrock (Marshall et al., 2022). A study of a single-family home in a First Nation in Ontario used tracer experiments to determine the residence time of wastewater in the infiltration bed of the OSTS. A tracer was introduced to the infiltration field through piezometers installed for this purpose and the tracer was detected at nearby monitoring locations 3 hours after injection. Wastewater effluent residence times should be on the order of 7 days, a recovery of tracer compounds within 3 hours indicates significant short-circuiting of the infiltration field. The authors concluded that the septic field, located above fractured bedrock, was releasing effluent through fracture networks allowing the tracer to move long distances in very short time periods (Marshall et al., 2022). Work by Capps et al. (2020) stresses that poorly designed systems can fail relatively soon after installation. Younger OSTSs often fail due to under-sizing with respect to hydraulic load or improperly assessed soil capacity.

The literature referenced here offers limited examples of how soil characteristics and system design can lead to system failure if improperly considered, but there is a large body of research detailing the numerous technical challenges associated with infiltration field performance. Inadequate lot sizes, insufficient vertical and horizontal setbacks, and poor soil characteristics all contribute to contaminated wastewater effluent entering the environment. Large and/or complex infiltration fields are expensive to design and install and while most jurisdictions have some sort of application or approval process, many do not complete a technical review of the system design, but rather trust certified designers and installers to follow the technical guidelines and regulations. Some provinces require inspections of every septic system installation before they are backfilled, however many do not. In First Nations, there are no regulations or standards that are legally enforceable and the installation of these critical pieces of infrastructure occurs through highly variable practices.

- Poorly maintained or old fields

Properly designed and well-functioning systems can fail due to age or lack of necessary maintenance. Studies of US systems have reported that upwards of 50% of homeowners do not maintain their OSTSs according to recommended guidelines (Withers et al., 2014). Capps et al. (2020) developed a framework to guide OSTS maintenance and management decisions in northeast Georgia. Over 9,000 septic systems were evaluated using GIS and OSTS database information. The study found that only 8% of the OSTS were considered high risk due to their location, i.e. setback distance to key water sources, poor soil, or steep slopes. However, nearly 70% of the OSTS were found to be high risk because of their age (26 to 45 years). Research and best practices suggest most infiltration fields remain hydraulically operational for 11 to 30 years (Connelly et al., 2023; Siegrist et al., 2000). Younger systems are also at risk of failing if the infiltration field is damaged. Physical damage is most often caused by soil compaction, freeze/thaw damage, broken distribution pipes, and infiltration of roots (PEI ELJIS, 2013). Paving, building, or driving over infiltration fields can compact soil and damage distribution piping. Most homeowners' manuals provide guidance on what to look for during a field inspection and what preventive activities help keep a field safe (Rideau Valley Conservation Authority & Government of Ontario, 2022; SMH, 2018). OSTS failures often go unnoticed by homeowners, unless ponding and odours occur at the site of the infiltration field (Withers et al., 2014). So, because many systems can fail to adequately treat wastewater without a homeowner knowing, the environmental and public health risks silently permeate through subsoil and manifest in a variety of ways in both groundwater and surface water sources (Withers et al., 2014; Connelly et al., 2023). Also, because individual system failure generally goes unnoticed and responsibility falls to homeowners, there is very little research on failure mechanisms of individual systems, but there is a wealth of research at the watershed scale (Borchardt et al., 2003; Oliver et al., 2014; Withers et al., 2012) and a focus on fecal contamination of drinking water wells caused by failing septic systems (Conboy & Goss, 2000; Latchmore et al., 2020; Owusu et al., 2021; Petculescu et al., 2022; Procopio et al., 2017).

In some areas, where fields are impractical, or prone to rapid failure due to poor soil characteristics, some jurisdictions allow direct-to-land discharge through the use of ejector systems, though they are highly regulated and require very large lot sizes to ensure all waste remains within the property boundaries (SCC, 2021; SMH, 2018). In some First Nations, where septic fields have failed, "shoot-outs" release untreated or undertreated wastewater effluent directly from a septic tank to the ground surface (Baijius & Patrick, 2019; Lauret, 2023). The study by Yee (2007) of First Nations housing and public health found that homes with higher numbers of occupants were positively correlated with increased occurrence of sewage back-up in the home and the use of open discharge systems. Yee concluded that increased wastewater production in the home overwhelmed under-designed septic systems resulting in more frequent failure. The study included 48 homes that openly discharged effluent directly from the septic tank to the ground surface and found that 82% of the homes did not have a fence around the discharge point and half of the systems were not fitted with frost protection (Yee, 2007), further increasing public health risks from these inadequate systems.

- Risk of failure - contamination of drinking water wells and underground cisterns

The risk of septic system failure to groundwater quality cannot be overstated. The hydraulic connection between septic systems and drinking water wells provides a direct path for fecal contamination to transmit disease. This is discussed in detail in Section 3.2.1.1. There is a large body of research that investigates the role of hydrogeology, well construction, septic system locations, and the transport of viral and bacterial pathogens in subsurface aquifers. There are critical barriers, both in decentralised drinking water systems and wastewater systems aimed at mitigating the risk of fecal contamination of aquifers. These barriers are well understood, if not well implemented, maintained, and monitored in drinking well systems. However, there is little research available to evaluate the risk of failed septic systems on underground cisterns. Mi et al. (2019) found that six of the seven cisterns studied for total coliform and E. coli were contaminated and that these cisterns were all installed underground. The same study found that the most protected cisterns were polyethylene cisterns installed above ground. See Section 3.3.1.4 for additional discussion. There is a scarcity of systematic research evaluating the likelihood and consequence of hydraulic connection between septic infiltration fields and underground cisterns, an infrastructure arrangement that is common in some First Nations.

- Risk of failure - cumulative impacts

Over the last several decades, housing densification and reliance on decentralised wastewater treatment methods have resulted in a high number of OSTS within watersheds (Withers et al., 2014). There are several case studies in the US, Ireland, and Scotland that demonstrate the cumulative impacts of high-density OSTS. Iverson et al. (2018) evaluated 11 watersheds in the Piedmont region of North Carolina with varying densities of OSTS and found that watersheds with high-density OSTS exported more than double the median masses of total dissolved nitrogen and phosphorus (as PO_4-P) than low-density OSTS watersheds. The impacts of failed septic systems affect groundwater and surface water alike. Excess nutrients in surface waters can lead to eutrophication (Herren et al., 2021) and the formation of harmful algal blooms (Lapointe et al., 2017; Rakhimbekova et al., 2021). Excess nutrient release in groundwater can pose a health risk if the contamination reaches drinking water wells. Elevated nitrate concentrations can occur if untreated septic effluent enters oxic aquifers (McQuillan, 2004). Nitrate plumes have been associated with drinking water contamination that can result in serious health conditions (Health Canada, 2013; Humphrey et al., 2013).

Cumulative impacts of failed septic systems also include fecal contamination and microbiological pathogens in both groundwater and surface water sources. A study of 115 surface water sites in Georgia monitored the presence of antibiotic-resistance genes and found that 48% of samples tested positive for fecal contamination from humans (Damashek et al., 2022). The authors expected the positive samples to be located near centralised wastewater effluent fallouts, however, the positive samples were associated with areas of high OSTS usage, as well as areas with high occurrence of sewage collection pipes, leading the authors to conclude that aging septic systems were one of the primary drivers for non-point fecal contamination in surface waters. While it can be hard to trace individual failed septic systems to watershed-scale water quality concerns, Ahmed et al. (2005) developed a biochemical fingerprint method to compare enterococci and E. coli strains to those found in nearby creek water. The study linked 98 biochemical phenotypes from 33 septic tanks to the bacteria found in the creeks. Historically, OSTS were thought to be small-scale and discrete units that effectively treated domestic wastewater and posed no large-scale threat to the broader watershed. However, it is now understood that the cumulative impacts of poorly functioning OSTS are a significant source of nutrients and microbiological contaminants to both groundwater and surface water sources (Macintosh et al., 2011; Withers et al., 2014).

Some jurisdictions are now taking additional regulatory precautions to mitigate the cumulative impacts of high-density OSTS. In these jurisdictions, rural subdivisions have more stringent requirements for septic system site assessments, as the nearby lots and adjacent septic fields can have a significant effect on groundwater quality. Many rural subdivisions also rely on well water for domestic supply, so the effective control of septic treatment is critical to keep drinking water safe (NS DECC, 2013; Saskatchewan Health Authority, 2023). The Saskatchewan Health Authority oversees the assessment and reporting criteria for the creation of subdivisions, which include a site suitability assessment that characterizes vadose zone conditions, aquifer isolation, preliminary fate of effluent, and other general water quality impact assessment requirements (SKHA, 2023).

- Risk of failure - climate change and increased precipitation

As discussed in Section 3.2.1.1, climate change will result in precipitation changes, both in the form of increased storm frequency and intensity. These conditions could lead to septic tank inundation in damaged or leaky tanks and will impact the performance of infiltration fields. The presence of an unsaturated zone beneath the biomat layer in an infiltration field is a critical component of effective biotic and abiotic treatment mechanisms. Heavy precipitation not only saturates the infiltration field but can also cause the elevation of the water table, which can short-circuit the available treatment area (Arnade, 2005; Vorhees et al., 2022). Work by Cooper et al. (2016) found that warmer, wetter soils had decreased capacity for treating onsite septic wastewater effluent, due to decreased phosphorous removal and reduction in fecal coliform retention than the same soil profiles at cooler and drier conditions. Increased precipitation events are known to exacerbate drinking water well contamination, likely due to the increased release of untreated wastewater effluent from adjacent septic systems (Latchmore et al., 2020). Likewise, in coastal areas, the effects of rising sea levels and groundwater tables have been found to decrease OSTS performance (Cooper et al., 2016; Cox, Dowling, et al., 2020; Cox, Surabian, et al., 2020; Vorhees et al., 2022). Similar impacts are likely in and around other water bodies, particularly the Great Lakes (Nelson et al., 2011).

4.2.1.4. Packaged Treatment Systems

Onsite domestic wastewater treatment technology is ever evolving. Many jurisdictions allow the installation of non-conventional OSTS and have a variety of processes to evaluate and approve advanced treatment systems, often referred to as 'package treatment systems' or 'advanced treatment units. In some jurisdictions, advanced systems with secondary or higher levels of treatment are required in certain circumstances, particularly in small lots, or areas with shallow groundwater tables, or lands adjacent to surface waters. Ontario building code requires that advanced septic systems are used for new installations in vulnerable areas, such as subsurface-connected karst features (Marshall et al., 2022). Research conducted by Marshall et al., 2022 in two Ontario First Nations recommended that in instances where communities have the capacity to replace aging OSTS, advanced treatment technologies should be considered - particularly those located in areas with rapid recharge rates (Marshall et al., 2022). Many packaged treatment systems rely on aeration, through mechanical mixing or an air compressor to promote aerobic digestion. These units tend to be more expensive to install and require routine maintenance and monitoring, often by a third-party contractor or manufacturer-trained certified installer (Manitoba Conservation, 2011). These units require an engineer to design the system (NS DECC 2013; Ralston & Payne, 2014; NB DPS, 2020). It is unknown how many packaged treatment systems are installed in First Nations or how the design, installation, operation, monitoring, and maintenance of these systems are managed in a First Nations context.

4.2.2. Asset Management

OSTS require ongoing regular maintenance and inspection to ensure optimal performance of the systems. The final report for this project will outline how First Nations approach the centralised management of these O&M requirements. Because of the serious groundwater and surface water contamination threats associated with failing OSTS, a holistic approach to O&M is needed to avoid cumulative impacts and protect drinking water sources. The US EPA recognized that the devolution of O&M of OSTS to individual homeowners had resulted in improperly managed and poorly performing systems that were "a national issue of great concern" (US EPA, 2003, pg. 3). The US EPA published the *Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems* to provide guidance to state, tribal, and local authorities on how best to manage these crucial assets through a comprehensive watershed approach (US EPA, 2003). The Guidelines outlined five possible management models:

- *Homeowner Awareness* – OSTS are owned and operated by individual property owners, where the regulatory authority mails maintenance reminders to the system owners

- *Maintenance Contracts* – complex OSTS designs are employed to enhance the treatment capacity and improve wastewater effluent quality, requiring owners to hold contracts with qualified technicians for timely maintenance.
- *Operating Permits* – limited-term operating permits are issued to owners and are renewable upon demonstration of compliance with terms and conditions of the permit.
- *Responsible Management Entity (RME) Operation and Maintenance* – applicable where highly reliable operation of OSTS is required to ensure water resource protection in sensitive environments. The operating permit is issued to the RME
- Responsible Management Entity Ownership – treatment systems are owned, operated, and maintained by the RME, removing the homeowner from the responsibility for the system.

The Guidelines recommended the inventorying of existing systems and their level of performance as a minimum standard for any management model. Further, the Guidelines acknowledge that any management model must be informed by an evaluation of risk, definitions of all roles and responsibilities, and an understanding of costs to all stakeholders (US EPA, 2003). This management model approach aligns well with a centrally managed, multibarrier asset management framework, but requires adaptation to a First Nations context. How these management models could be organized, implemented, and funded in First Nations are key areas for collaborative co-designing. The final report will present challenges, opportunities, and recommendations to address the lack of risk assessment and asset management currently present in decentralised wastewater systems in First Nations.

4.3. Holding Tanks

The ICMS data reports an estimated 14% of decentralised wastewater systems are holding tanks that store domestic wastewater without treatment and require pumping and transportation of wastewater to a treatment facility. Discussions with FNIHB Environmental Public Health Officers (EPHOs) and ISC Engineers suggest that this percentage may be an overestimation, but no alternative data source exists. Preliminary discussions with First Nations and Tribal Councils indicate that northern and remote locations, where septic infiltration fields are impractical or ineffective, do rely on holding tanks for domestic wastewater collection. Several provincial jurisdictions also allow holding tanks to be used, though the application and approval process for holding tanks is highly regulated and in some jurisdictions restricted. In Nova Scotia, installation of a holding tank is only permitted if the application includes a sewage management plan and holding tanks must be fitted with audible and visible high-level alarms (NS DECC, 2013). In Manitoba, holding tanks are the only sewage system type allowed in areas designated as sensitive and they must be registered with the local Manitoba Conservation office per the *Environment Act* (Manitoba Conservation, 2007). The storage, transportation, and treatment of hauled wastewater pose a range of possible risks that differ in some key ways from an underground OSTS. Several provinces require sewage waste to be hauled by a certified or licensed waste hauler to ensure the waste is transported safely to an appropriate treatment facility, including PE, NS, NL, MB, and SK. Because the total number of holding tanks are unknown, the magnitude of their risk is unknown. A brief discussion of drain-to-effluent risks will be discussed, particularly in a northern context.

4.3.1. Risk Identification from Drain to Effluent

Any storage chamber for domestic wastewater, whether underground or above ground is a potential risk to public health and ground and surface water quality. As with other wastewater systems, all components from drain to effluent require control barriers to mitigate risks and protect public and environmental health. Figure 4-3 shows a summary of key design, management, and treatment elements that are central to the optimal performance of holding systems as wastewater management options.

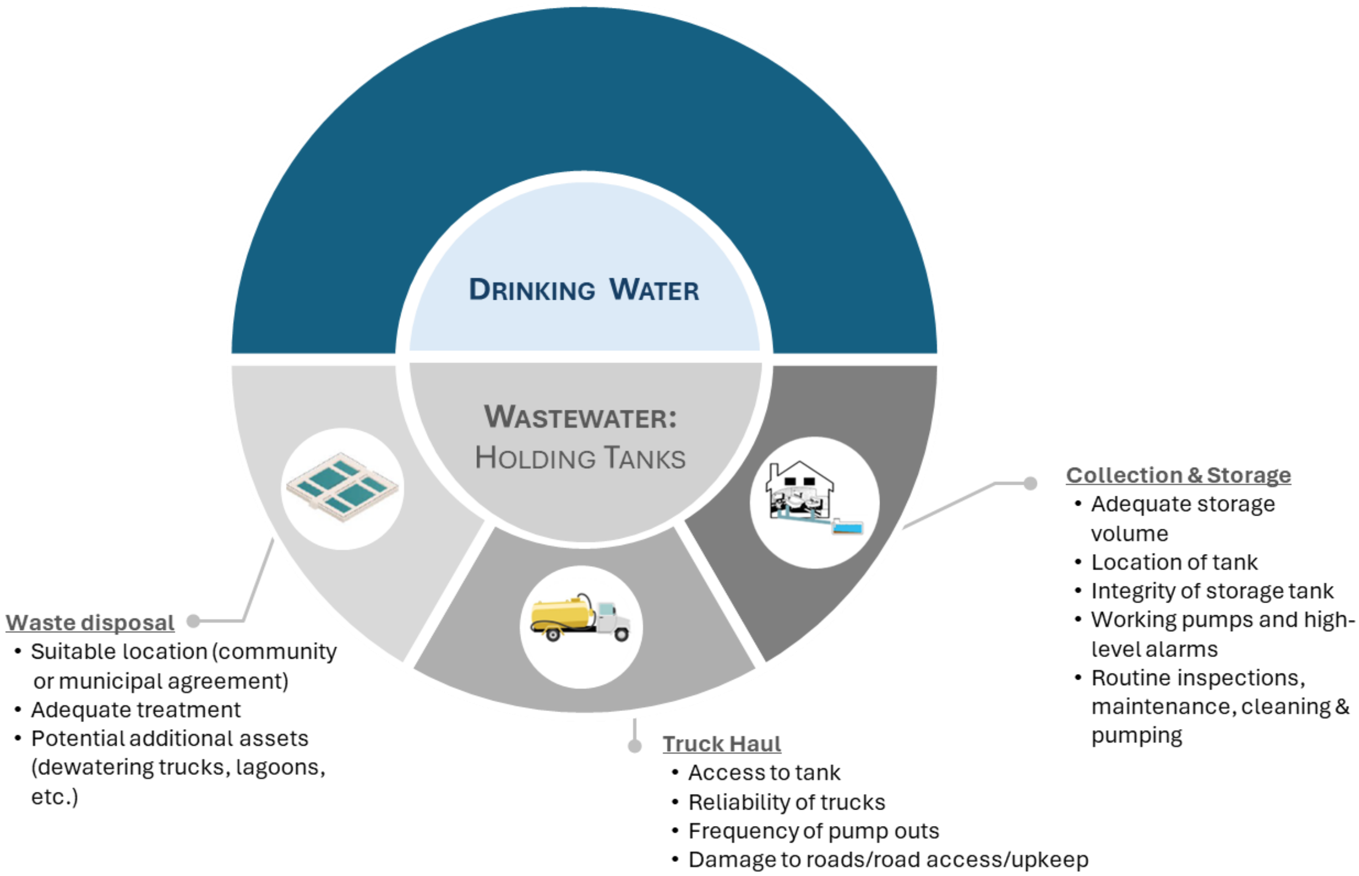


Figure 3-8. Drain-to-effluent assets in wastewater holding tank systems that provide potential risk to wastewater effluent quality and identify locations for necessary barriers in the multibarrier approach.

4.3.1.1. *Collection & Holding Tank*

Because holding tanks have a finite volume for wastewater storage, the planning, design, and installation of tanks are crucial to ensuring they do not overflow or become damaged. CSA Standard B66:21 *Design, Material, and Manufacturing Requirements for Prefabricated Septic Tanks and Holding Tanks*, is often referenced in provincial technical guidelines, as well as in the Protocols for Decentralised Water and Wastewater Systems in First Nation, to establish holding tank requirements (Canadian Standards Association, 2021). Many provinces require a minimum tank volume of 4,500L for a single-family home. The Protocols for Decentralised Systems in First Nations do not include a minimum storage volume. It is important that holding tanks are watertight, as environmental flows of water both into and out of the tank are associated with elevated health risks. Untreated wastewater released from holding tanks, either due to overflow or a leaky tank has similar associated risks as poorly functioning OSTS discussed above in Section 4.2.1.3. There is little research available investigating the contamination impacts of leaky holding tanks, as they are not a primary method of domestic waste management.

4.3.1.2. Truck Haul

Holding tanks need to be emptied regularly, the frequency of which is dependent on the size of the tank, number of occupants in the home, and quantity of water available in the home. Reliable trucks with skilled operators are needed to ensure that a holding tank is not at risk of overflowing. In most provincial jurisdictions, waste haulers are certified or licensed by the province, with some requiring annual logs to document the volume of waste hauled and confirmation of transport to an approved treatment location (PEI ELJIS, 2013). There are no such regulations relevant to First Nations, who rely on either band-operated truck-haul or third-party service providers to empty holding tanks. Similar to truck-to-cistern systems, the reliability and maintenance of the trucks are paramount for sustainable service provision. Having skilled drivers, working vehicles, adequate fuel, and passable roads are necessary supports to ensure holding tanks are emptied regularly. Without regular servicing, holding tanks could overflow and/or or sewage could back up into homes, causing a significant public health threat (Yee, 2007).

4.3.1.3. Treatment

Holding tank waste must be transported to an appropriate facility, often a WWTP either on reserve or in a nearby municipality. In northern and remote communities, often the waste is delivered to the Nation’s WWTP. It has been noted that the reliance on OSTS in general, and holding tanks specifically, requires the management of a significant amount of waste hauling and treatment for First Nations (Kotak et al., 2011). As new residential developments occur in First Nations to address the housing crisis, this additional infrastructure puts a strain on existing WWTPs, which may not have the necessary capacity to treat additional waste. A housing study published by Kotak et al. (2011) highlights that for a Nation to be eligible for CMHC and other federal funding for housing development, the community must be able to prove capacity in the wastewater system for treatment of estimated additional waste collected from holding tanks and septic tanks.

Centralised WWTP performance and capacity are beyond the scope of this project, but it is important to consider the relationship between centralised and decentralised water and wastewater components. Many WWTPs in northern and remote locations rely on lagoons, which have limited treatment efficacy during the cold months (Ragush et al., 2015; Smyth et al., 2018), unless there are supplemental treatment processes.

5. Building on this Knowledge

Using this risk-based framework grounded in the multibarrier approach developed in Part 1, Part 2 of this report will present current practices gathered from the First Nation contributors and align the technical risks highlighted here with the gaps and challenges shared by First Nations. The goal of this report is to provide actionable recommendations to mitigate risks present in decentralised water and wastewater systems in First Nations. The manifestation of risks, as shown in Part 1, are the result of complex relationships between the natural environment and inadequate or inappropriate system installation, operation, management, and monitoring, as well as inadequate policies and procedures. The recommendations are holistic and focus on the need for integrated and responsive management of the built – natural environment interface.

PART 2: Current Practices and Critical Gap

6. Introduction

The inequitable and inadequate drinking water and wastewater conditions experienced by some First Nations has been a topic of an Expert Report (INAC, 2006), Auditor General Reports (OAG, 2005, 2011, 2021), Parliamentary Budget report (Parliamentary Budget Office, 2021), and UN Human Rights of Indigenous Peoples visitations and reports (OHCHR, 2013 & 2024). Recently, drinking water services were subject to a class action lawsuit, which was resolved via a Court approved Settlement Agreement. The Settlement Agreement commits Canada to make “all reasonable efforts” to ensure Individual Class Members living on reserves have regular access to safe drinking water in their homes, whether from a public or private water system (First Nations Drinking Water Settlement Agreement, 2021).

The Settlement Agreement also committed Canada to take reasonable effort to repeal and replacement of the Safe Drinking Water for First Nations Act with legislation developed in consultation with First Nations. At the time of the drafting of this report (December 2024) the tabled replacement legislation, Bill C-61 (First Nations Clean Water Act), defined water services as the public or private collection, storage, treatment and distribution of water intended for drinking or for sanitation and hygiene purposes and the collection, treatment and disposal of wastewater. This definition is inclusive of decentralised water and wastewater systems, though levels of services for private water systems are not discussed explicitly. There is a need to better understand the current state of, and challenges associated with, decentralised drinking water and wastewater services, to inform improvements of planning, design, installation, operation and monitoring practices, maintenance (both preventive and corrective) and asset lifecycle management to ensure safe and reliable drinking water and wastewater services for First Nations. This report is one part of a what must be a broader collective effort to inform a new paradigm for decentralised system design and implementation.

7. Participation and Contributions

The project team worked to ensure that as many First Nations as possible were aware of this work. Initial outreach and announcement of this project was made to all First Nations, regardless of water and wastewater system types. The project team emailed 747 Chiefs, Councillors, executive officers, executive directors, general managers and Regional Chiefs to introduce this work and invite their participation. Email communication was also sent to Tribal Councils in each region. This initial outreach resulted in dozens of emails and phone call responses from both First Nations and Tribal Council staff to determine if they were able to contribute to the report. Beyond a blanket email introduction, regional outreach was conducted via further emails and phone calls, particularly to First Nations that were known to have reliance upon decentralised drinking water and/or wastewater system. According to housing and infrastructure data provided by ISC's Strategic Water Management team, approximately 360 First Nations of 601 Nations (60%) included in the data set rely to some degree on decentralised drinking water systems, and 337 (56%) of those First Nations rely to some degree on decentralised wastewater systems. Directed outreach to these First Nations was guided by recommendations from ISC and snowball sampling from discussions with First Nations. Figure 7-1 shows a summary of our outreach initiative, including presentations made at national and regional conferences and summits. More detail regarding decentralised system usage across the ISC regions is provided throughout Part 1.

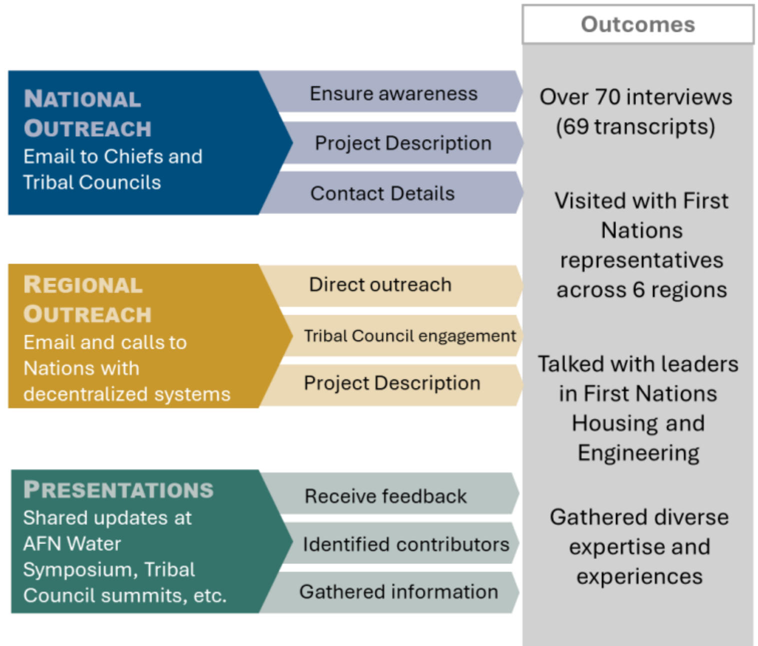


Figure 7-1. Summary of outreach mechanisms to share this project with First Nations.

7.1. Outreach

Water and wastewater services are central to a Nation's public health, housing strategy, and economic development goals, and are interconnected to individuals' quality of life and lived experience. To understand the far-reaching and complex relationships that manifest in drinking water and wastewater system design, monitoring, and management, a range of knowledge holders and experts were included in the outreach strategy for this report. The roles, responsibilities, and realities of First Nations staff, service providers and engineers, ISC-RO and ISC-FNIHB staff and managers, and in some instances CRTP and Tribal Councils all play a role in the performance of drinking water and wastewater services on reserves. Below is a summary of the outreach activities associated with different knowledge holders and stakeholders.

7.1.1. First Nations

Decentralised water and wastewater services are managed by First Nations and their members differently based on housing type, ownership status, regional practices, governance structures, and a variety of other factors. To better understand how various positions and departments interact with, and support, decentralised water and wastewater services, a range of First Nations staff were invited to participate in the discussions and information gathering activities. Our team spoke with housing managers, public works staff, capital managers, water and wastewater operators, land managers, health directors, councillors, and Chiefs. While the majority of our conversations were conducted through online video calls, several discussions took place at conferences and in-person meetings. Six in-person visits were made to First Nations across four different regions to understand the physical realities and contexts of decentralised systems. It should be noted that several First Nations indicated an interest in participating in this project, but either limited capacity or complications with receiving Chief and Council approval resulted in the staff not contributing to the report. The project team fully understands that requests to First Nations staff to participate in the production of a report is a burden and engagement in the process does not provide immediate or direct benefit to the Nation.

First Nations outreach focused on hearing from Nations across all regions with representation from a range of community sizes and populations, remoteness, system type, and governance structures. Assistance was provided by ISC to identify Nations with experience in managing decentralised systems.

7.1.2. Tribal Councils

Some Tribal Councils provide drinking water and wastewater technical advisory services to participating First Nations. The types of services vary by region and council and often are focused on centralised drinking water and wastewater services. In Ontario, Tribal Councils may act as water and wastewater hubs, which provide a range of services to First Nations, i.e. overall responsible operator services, O&M assistance, training, and procurement. To understand how Tribal Councils support decentralised drinking water and wastewater systems in First Nations, councils were invited to meet with the project team to provide their insights and experiences regarding decentralised services. Tribal Councils from across five regions contributed to the report.

7.1.3. First Nations Organizations

In response to the persistent infrastructure and services needs experienced by First Nations, Indigenous-owned and operated organizations and engineering firms have formed to help fill these critical gaps. Ontario First Nations Technical Services Corporation (OFNTSC), First Nations Technical Services Advisory Group, First Nations Engineering Services Limited (FNESL), Atlantic First Nations Water Authority (AFNWA), The Saskatchewan First Nations Water Association (SFNWA), First Nations Capital and Infrastructure Agency of Saskatchewan (FNCIAS), and First Nations Housing and Infrastructure Council (FNHIC) are just a few examples of the various types of organizations that provide a range of technical, professional, and training services to First Nations and often liaise between ISC and First Nations to mediate service provision, provide technical guidance, and assist in accessing funding. To understand how First Nations organizations fill crucial gaps and address water and wastewater challenges, particularly related to decentralised systems, over a dozen organizations were invited to contribute to this project and inform the production of this report.

7.1.4. Engineers and service providers

Consultants, engineers, contractors, and other service providers are vital resources for First Nations and profit significantly from First Nations contracts. The quality of these professionals' work directly influences the success of infrastructure projects on reserves. Both First Nations and ISC representatives commented on the significant role engineers and service providers play in the development of feasibility studies and the design and execution of decentralised water and wastewater projects. To ensure the expertise and experiences of technical service providers were included in this report, First Nations representatives were asked about the firms that they rely on and provided contact information for engineering firm staff who may be interested in participating in this project. Our team reached out to firms from four regions and conducted both online and in-person meetings with five technical services providers from three different regions. The information and insights shared by these staff are included throughout the report.

7.1.5. Scholars and experts

Researchers, scholars, and technical experts with experience in decentralised water and wastewater systems were invited to contribute their knowledge to this report. Several researchers with specific expertise in groundwater quality, system design, septic system installation, and water safety were interviewed to clarify best practices and the current state of knowledge in decentralised systems. Additionally, some researchers were invited to contribute to the report because of their extensive relationships with First Nations and their specific knowledge about decentralised drinking water and wastewater services in First Nations. The work of these researchers is included in the technical literature review in Part 1 and their insights and recommendations were integrated throughout Part 2 of this report.

7.2. Who we talked with

7.2.1. Regions and Voices

A total of 70 discussions were held that included over 100 individuals (not including provincial regulators), with the majority being documented through digital transcript recordings which were used for thematic analysis and evaluation. Some conversations conducted by the project team were not captured in transcript form, but handwritten notes were used to inform and guide the broader analysis process. Figure 7-2 shows the number and type of participants we talked with and/or visited across the eight ISC service regions.

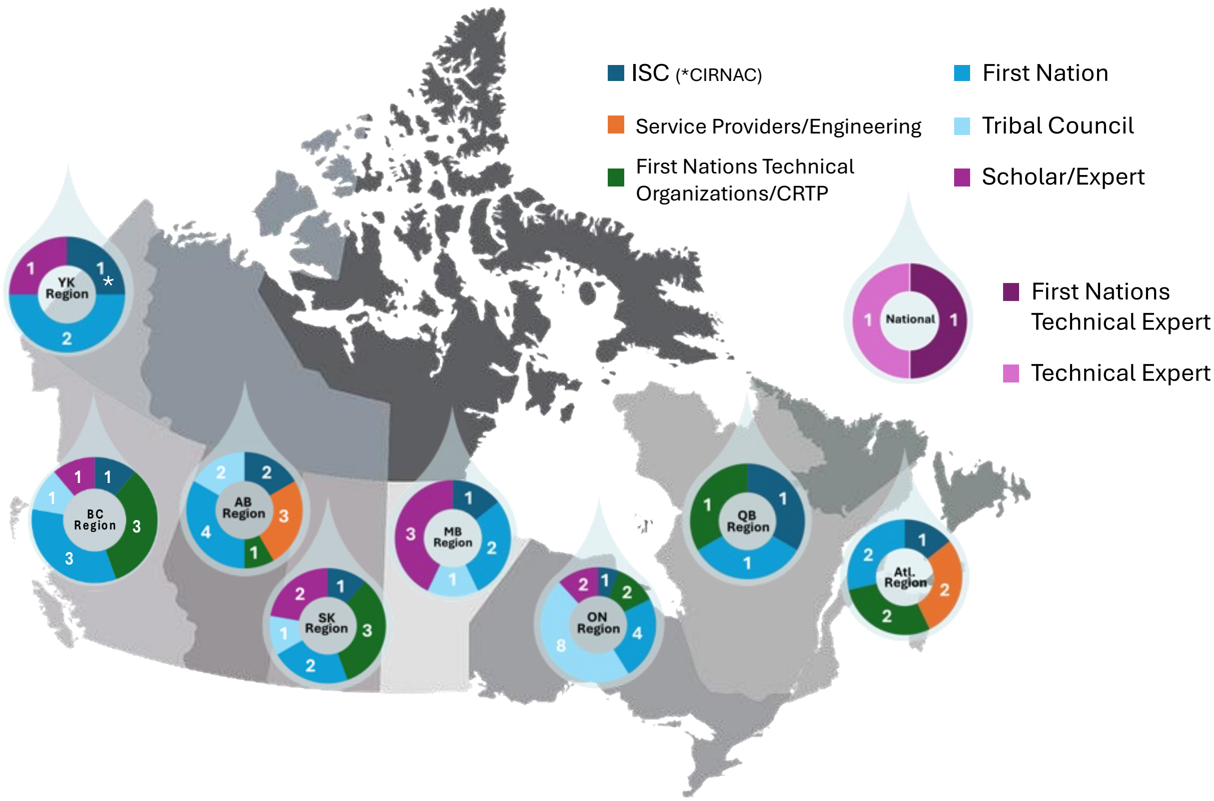


Figure 7-2. Number of regional and national contributions from all stakeholders involved in the production of this report.

Our engagement and contribution goals were to hear from First Nations from each of the eight regions, with representation reflecting the number of homes reliant on decentralised systems within each region. Our goal was to have 25 to 30 First Nations contribute to the report. By region, Alberta, Manitoba, Ontario, and Saskatchewan have both the greatest absolute number of decentralised systems and the highest proportion of houses on reserves serviced by decentralised systems. Yukon is the exception, with greater than 90% of First Nations homes serviced by decentralised systems. Our team talked with representatives from 20 First Nations that represented a range of populations, system types, geographies, and governance structures. One area where direct engagement with First Nations was difficult was in northern Nations. To compensate for this, our team talked with several northern Tribal Councils, met with council representatives at conferences and housing summits, and had discussions with northern First Nations organizations to include this crucial perspective in this report. Additional details regarding the limitations and constraints of this work are provided in Section 7.4.

Only the contributions from First Nations representatives who provided verbal or written consent to participate in this work are included here. Dozens of casual and informal conversations took place throughout the outreach process, but information and ideas shared during these discussions are not included here. Our project team sought free, prior, and informed consent and notified all contributors that they could withdraw their participation at any time.

7.2.2. Anonymity

To ensure that all participating contributors, particularly First Nations representatives, were able to share experiences, challenges, and recommendations freely without concern for repercussions or perceived or unperceived consequences, the project team ensured confidentiality of all contributors. It has been shown in qualitative research across disciplines that providing anonymity through the redaction of names and identifying characteristics helps establish trust and rapport between project staff and participants, upholds ethical research standards, and strengthens the credibility of the research process (Kang & Hwang, 2023). Anonymity is imperative to protect those that shared their experiences and removes the potential for unintended bias or judgement of First Nations contributions.

7.3. Transcript Review & Thematic Analysis

The transcript review and analysis prioritized contributors and representatives from First Nations. Discussions with First Nations contributors were recorded using Otter AI and/or Microsoft Teams and reviewed following the method presented in Figure 7-3. A member of the project team verified the accuracy of the transcription by listening to the audio recording of the discussion and confirming the transcript content. Using NVivo qualitative research software the transcripts were

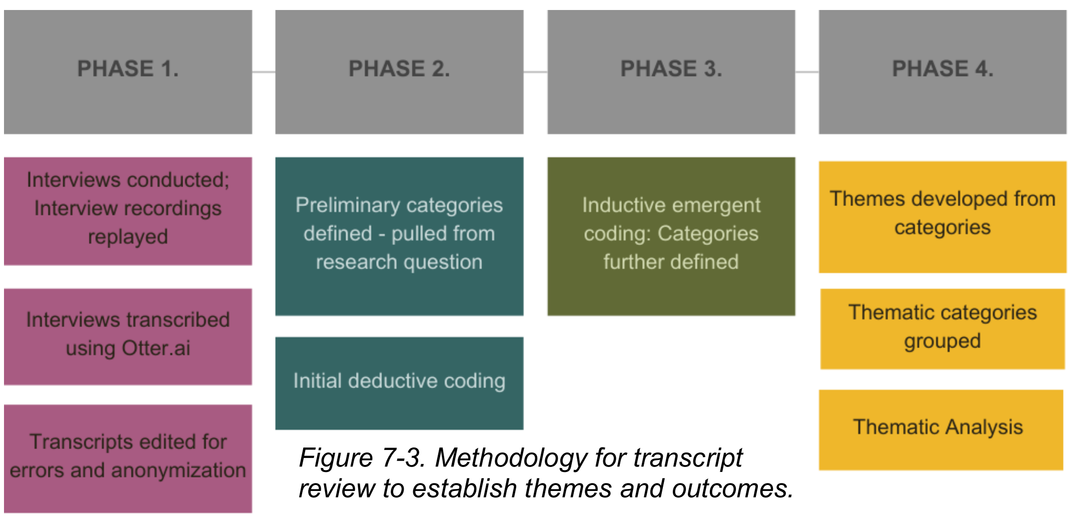


Figure 7-3. Methodology for transcript review to establish themes and outcomes.

then coded (categorized) first deductively according to the research questions. A second level of inductive (emergent) coding allowed further categorization and organization of transcript information from which overarching themes were identified, grouped and analyzed according to the coding framework provided in Appendix F.

The codes and themes that were found through the analysis of First Nations transcripts were then used to evaluate transcripts and notes from Tribal Councils, First Nations technical organizations, engineers and service providers, technical experts, and researchers. These transcripts were used to triangulate and contextualize the findings from First Nations analysis. Together, the primary themes from the First Nations discussion and the supporting context from the other contributors' transcripts were synthesized to produce Section 8 – Current Practices, Section 9 – Gaps and Risks, Section 10 – Best Practices in Addressing the Gaps, and Part 3 - A Path Forward.

7.4. Project Limitations and Constraints

There are several critical limitations and constraints that need to be understood before reading and interpreting the information and knowledge shared in the following sections. Key methodological limitations include:

- **Conceptual framing:** The Statement of Work was provided by ISC to address knowledge gaps

The nature of this report was largely framed by ISC's Statement of Work to meet specific needs related to technical risk identification, current practices, and First Nations recommendations. This framing was not intended to capture First Nations socio-cultural or spiritual relationship with water. This report is largely silent on First Nations relationality with water beyond a western approach to water and wastewater service delivery. The report also does not capture the human and social impacts of water and sanitation insecurity. The lived experience of having poor quality and/or limited amounts of water and the implications of having insufficient wastewater treatment could not be considered fully or carefully in the limited time and engagement of this work.

- **Selection bias:** These types of conversation-based knowledge gathering efforts bias data collection from high-capacity Nations with adequate staff to engage with the project team. There is no way of estimating the number of Nations that would have contributed and shared information if they were adequately staffed and had the capacity to participate. This creates a selection bias that could influence the information shared in this report.

- **Population sample size:** A limited number of First Nations contributed to this report

Initial outreach activities revealed a significant number of First Nations who identified decentralised water and wastewater services to be an area of significant concern, however not all of these respondents contributed to the report. Several Chiefs and other leaders reached out to contribute to the report, but ultimately did not respond to subsequent emails or phone calls, likely because they are very busy have other pressing issues to attend to. Several First Nation staff, including health directors, public works managers, and capital managers responded via email or phone call and acknowledged they would need to seek Band Council approval, many of these potential contributors did not reach back out, likely because approval took too much time, or was not received. Some First Nations responders inquired about direct benefit to their Nations as a result of their contribution. Our team was transparent that there would be no direct, short-term benefits from participation and in fact, there may not be any indirect, long-term benefits from this report. Our team recognizes that contributing to a report of this nature is a burden for First Nations and there is no promise of improvement of current conditions.

There were also three instances of First Nations contributors becoming ill or changing positions during the project time period, and subsequently they could not participate in the project.

- **Project timelines:** Limited time for relationship building and in-depth analysis

The project team met with several First Nations, technical experts, and First Nations organization multiple times throughout the project. These repeated meetings allowed for iterative discussions and deeper levels of knowledge sharing and context building. However, many First Nations and Tribal Councils met with the team only once. While the information they provided was critical to this report, the nature of this high-level summary report does not allow for detailed and specific reporting on asset-specific performance, data collection, or water quality analyses.

- **Number and types of contributors:** Contributors often had a singular lens for the complex issues

Many meetings with First Nations included a group of representatives, often including an operator, health director, housing manager, public works manager, capital manager, and/or the Chief or a councillor. In these cases, a breadth of information could be collected from multiple view-points. However, the majority of the meetings were with one or two First Nations staff and these meetings, while in-depth and helpful, lacked the multifaceted details necessary to understand the broader context of drinking water and wastewater services present in First Nations. In many cases contributors would mention poor water quality but were not able to readily access water quality results to share specifics. Contributors would also note ongoing projects to assess decentralised systems, but would not know if or how these projects related to the FNIIHP or determination of O&M funding, etc.

- **Representing diversity and heterogeneity:** This report cannot be used to infer the of frequency of certain practices or gaps due to the heterogeneity of discussions, variable knowledge bases of contributors, and limited number of participating First Nations

This report cannot provide details on the frequency of specific experiences by First Nations. Each region, and indeed each Nation, has particular political, cultural, environmental, management, funding, and housing conditions that impact the delivery of decentralised services. Individual transcripts were used to evaluate general themes, identify common and shared challenges, to provide a first step in understanding and addressing the historical and long-standing inadequate for support for, and use of, decentralised water and wastewater systems in First Nations. This report summarizes these themes and provides recommendations for a path forward.

8. Current Practices – what we heard

8.1. From First Nations and Supporting Stakeholders

8.1.1. Asset Lifecycle and System Management – processes and gaps

All First Nations representatives were asked questions about their decentralised drinking water and/or wastewater systems and asset lifecycles, from planning and design to installation, operations and maintenance, repair and replacement, and decommissioning. This question framework (shown in Appendix G) allowed for discussions to touch on policy and funding considerations for new installations, including lot servicing, system selection, and siting of new infrastructure. The questions also allowed for the discussion of current practices, including water quality monitoring, asset management, funding of routine operations and maintenance, responsibility of repairs and replacements (of parts or whole systems), and what, if any, decommissioning processes were followed for decentralised drinking water and wastewater systems. The comments, stories, and experiences shared by First Nations representatives ranged from very specific asset and system operations activities and challenges to broad and wide-reaching planning and management practices and gaps. As shown in Figure 8-1, the relationships between asset condition, design, and suitability influence, and are influenced by, complex physical, social, financial, and governance conditions. The following sections provide a summary of the current practices and experiences of First Nations contributors in managing, and responding to challenges, in their decentralised systems, and illustrate the intricate connection between governance, planning, funding, housing, management capacity, the physical environment and the assets and systems themselves.

8.1.2. Existing Systems and Planning for Growth

All First Nations participants were asked to describe their current decentralised water and wastewater systems and to discuss how system planning and design was managed. These questions led to very specific installation, O&M, repair, and replacement discussions that are summarized in Sections 4.1.2 (drinking water) and 4.1.3 (wastewater). However, many contributors also shared important information about the complexities and challenges integral to addressing inadequate levels of service and/or improving drinking water and wastewater systems on reserve. Figure 8-1 shows the connections between discrete water and wastewater assets and the broader context for the management and governance of these assets. These broader themes and current practices are discussed here in Section 4.1.1.

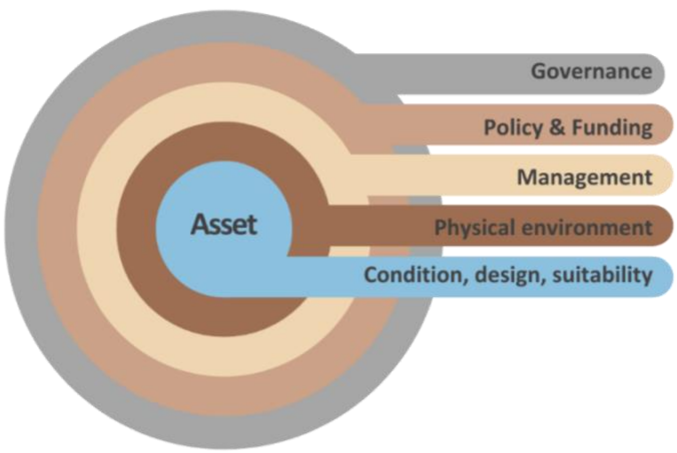


Figure 8-1. Representation of the mutual relationships between asset performance, the natural environment, and socio-administrative and governance drivers.

It should be noted that several technical experts and service providers commented that the very existence of this project and resulting report was a symptom of the broader problem regarding the fragmented approach to water and wastewater services in First Nations. The separation of centralised and decentralised systems, and the very disparate funding and management paradigms present in First Nations, as predicated by ISC's policies, are inherently problematic and result in a two-tiered service structure with differential health threats and risks.

8.1.2.1. Level of Service and System Design

Feasibility Studies

Most First Nations who contributed to this report have hybrid centralised/decentralised drinking water and wastewater systems with the centralised system servicing the 'urban' or 'core' area of the reserve, with a minority of Nations having fully decentralised water and wastewater. Nearly all First Nations we spoke with that rely on truck-to-cistern systems treat their own water before transporting it to homes and community buildings via water hauling trucks. Likewise, many First

Nations that rely on individual drinking water wells often, but not always, have a centralised system serving part of the community. Wastewater systems in participating Nations were highly variable, ranging from predominantly holding tanks with routine pump outs, to direct-to-surface discharge, or more traditional onsite treatment fields. When asked how the level of service is determined for homes in their Nations, most representatives talked about feasibility reports and pre-feasibility reports and the pattern of making repeated funding attempts through ISC to receive funding for feasibility reports as a first step to either improving the current decentralised systems or evaluating the possibility of moving from decentralised to centralised systems.

One Nation discussed trying to extend the centralised drinking water system to incorporate more homes that currently rely on individual wells.

> *" … so what happens is the water dead ends… so it gets stale, it doesn't circulate back. If we were to extend … and put a water system in and loop it back, the water would be flowing the entire time. So we get a hold of [ISC Rep] and give him an idea, you know, we need this. He does a pre-feasibility study and sends it to ISC and says this is what the community is thinking. Either they fund it or don't fund it and we go through this. If we don't fund it we go through the same process next year. We change the date, make some changes, submit to ISC… and they say ok, we'll fund the feasibility study and that just takes years."*

One contributor explained the ongoing process to move towards a drinking water distribution system to replace cisterns and said their Nation has done a lot of work to seek a higher level of service.

> *"So we've done a feasibility study for it, in fact we're at a 95% design state, so it's ready to go. We know the costs, it's been sitting on somebody's desk at ISC for three or four years now. So the costs have gone up."*

Most First Nations indicated that the process required for feasibility studies moved slowly or failed to address the risks of decentralised services, despite the Nation's express desire to move toward centralised services. Even in cases where relationships were noted as good, the slowness of the process was seen as problematic.

> *"In general capital and investment feels like little band aid fixes with no real solution. The last feasibility study found that the houses were too far apart for piped water."*
> *"I did three water feasibility studies for them, it has been going on for decades. Finally got the project approved. You know, it's, it went from an $X million dollar job a decade ago to it's a $5X million job today. And every time we looked at those wells, the water quality got worse. We had I don't know 10% of wells became radioactive, naturally occurring uranium."*

> *"And I'm not saying that ISC isn't supporting the infrastructure part. It's just lagging behind. We have a very good regional relationship with the engineer and team at ISC for capital infrastructure. Like I'm not throwing them under the bus at all. They're working on our side on it."*

KEY GAP: The mechanism for submitting a feasibility study is a noted bottleneck that contributes to the years long process of capital improvements.

A common theme across regions and stakeholders regarding feasibility studies and lifecycle costing in general, is the challenge of meaningfully capturing the direct and indirect costs of different levels of service. Current funding formulas and the Cost Reference Manuals attempt to quantify factors such as location, remoteness, and some elements of O&M, but these formulas do not extend to decentralised systems, other than trucks for water and wastewater hauling. There is no comprehensive approach for comparing centralised and decentralised system feasibility, so this work is left to case-by-case evaluation and regional discretion.

> *"Now I've just kind of gone a bit broader just looking at how we as engineers, and technical people can fit in social values, community vision, cultural connections, community connections, and prioritize those within our technical frameworks of lifecycle costing. So, we always quantify and monetize everything as much as we can. That's not always appropriate. You know, so you can't say connecting to the land the way I want to and being close to my grandmother and having her be able to watch my children and work, can't say that it's worth $30 a day or whatever it is that you can align to some of the funding frameworks to justify different types of levels of service."*

> *"In these kind of feasibility, or pre-feasibility, asset decisions or design alternative decisions are our Class C Class D, so like very kind of order of magnitude, but we pretend like they are a lot more certain than they are. So we're using money to quantify an impact, but it's not a precise quantification."*

Several Nations that participated in this report have received recent support to assess improving level of service for wastewater treatment systems, citing current investment in feasibility studies for either improved decentralised wastewater solutions, i.e. shootouts to holding tanks, or moving towards a centralised collection system. This influx of spending for wastewater system replacements or upgrades seemed to be in response to decades of inadequate or nonexistent funding for decentralised wastewater systems.

> *"Seems like a lot of money was spent the last couple of years, because I think they've been ignored for so many years. So we actually also did a feasibility study example to look at putting in a wastewater treatment facility…"*

KEY GAP: Feasibility studies are often pursued as a reactionary response that does not facilitate an integrated and collaborative approach of designing feasible and sustainable solutions through consensus building.

One thing that was clear from the discussions with First Nations across the 8 ISC regions was the remarkable regional differences Nations reported with ISC processes, with one First Nation representative sharing

“We do have a good project manager from ISC. I worked with him for a few years now. … I asked them if I could get a project started and how do I start it? They said it was feasibility and design first. So they allocated $100,000 for us to kickstart that and I did engage [Engineering Firm] to get the work started. So we’re just waiting for the design to come back now and then we can move forward with that.”

KEY GAP: Differences in ISC regional practices result in differential outcomes for First Nations.

Non-Indigenous Comparisons

In the case of First Nations located very near municipalities, the differences and discrepancies between systems were noted, with First Nations often having much poorer drinking water and/or wastewater systems than their non-Indigenous neighbors. Excerpts from three different discussions:

“On the municipal side of things with drinking water in those tanks- they're only meant to be temporary. And if they weren't cleaned on a regular basis, then those individual homes are actually on a mandatory boil water advisory. Whereas we don't have that within the First Nation. We don't have that and you know, and I often think of that because it would sure change ISCs outlook on using these tank systems.”

“And so you know, in our neighboring communities they all have clean drinking water, they could walk up to any tap. Right? They walk up to any tap and you can drink that water and one hour away … we can't even do that. So here's the issue. Why is that? Why do we have to play these games? We've been working with ISC for six to seven years now. Trying to fix this issue.”

One service provider discussed how rural municipalities manage drinking water solutions in areas of poor groundwater quality, noting that the solution is not truck-to-cistern systems.

“If I go outside southwestern Ontario rural, municipal areas outside of London, they're running into the same problem we've got with our First Nation territories, the groundwater will not sustain itself, the groundwater isn't safe. And they're doing these low density watermain extensions and to start providing potable water to communities around let's see, Moravian town. All around them have gone to communal water that's coming off wells because of the same issues”

There were similar comparisons made about onsite wastewater systems, with one Nation noting that their municipal counterpart was receiving piped collection, while they would be left to haul their waste further away for treatment.

“They are telling us at this point that they're going to be like piping sewer. So when this new lagoon is built, the municipal is going to get the pipe sewer, but the First Nation will not.”

In general, there was concern that decentralised drinking water systems and wastewater systems do not offer an adequate level of service for First Nations and that processes for upgrading levels of service relied too heavily on receiving funding for a feasibility study, were considered unlikely to be funded in most regions, and led to a general perception that services on First Nations have inequitable levels of services comparable to non-Indigenous communities.

KEY GAP: Current water and wastewater policies and practices can result in inadequate decentralised drinking water and wastewater services in First Nations with no efficient path to addressing system improvement.

8.1.2.2. Funding

For context regarding funding of infrastructure in First Nations, McClearn (2017) notes that the federal government (through AANDC, INAC and ISC) has typically provided the majority of capital funding for new centralised water and wastewater infrastructure, however this funding has been insufficient. From the mid-1990s until 2016, the Government of Canada restricted the growth of funding for First Nations – including for water and wastewater infrastructure capital and operation and maintenance funds – to less than 2% per year. Given that the rate of inflation was on average 2% over this period, and most First Nations had population growth rates higher than 2%, this period was characterized by declining real per capita funding for water and wastewater systems on reserve. Despite increases in funding in recent years, the Parliamentary Budget Office 2017 report notes that total government spending since 2011 only covered 54% of the total investment needs (PBO, 2017, page 7). ISC pledged to spend an additional $1.8 billion from 2016-21 (McClearn, 2016) however that alone would have just covered maintenance costs for 2016-21 assuming they had not increased since the Neegan Burnside (2011) estimate.

In general, federal funding for centralised water and wastewater systems on reserve has been insufficient and erratic for decades. Until such funding is stable and sufficient, and include decentralised water and wastewater systems, deficiencies in water and wastewater systems will remain pervasive.

Because of these persistent and substantive gaps in funding, particularly for decentralised systems, First Nations participants were asked about funding at several points throughout the lifecycle assessment questions, specifically regarding the installation, maintenance, and repair of decentralised systems. Responses varied by region and were dependent on the availability of own-source revenue of the First Nation and the nature of the governance structure.

ISC, through it's Water and Wastewater Policy and LoSS, indicates that subject to availability of funds new construction of "centrally managed onsite systems" are eligible for capital funding assistance. There has been recent changes to the funding support for O&M of existing decentralised systems, but these changes are not publicly available and did not seem to be well known by contributors to this report. First Nations participants all noted a lack of funding for decentralised drinking water and wastewater systems across the lifecycle, from installation to repair and replacement. There remains a significant disconnect, perhaps due to policy and/or communication gaps, regarding if and how First Nations can access funding for decentralised systems and how the concept of "centrally managed" decentralised systems can be operationalized by First Nations in the absence of funding. An engineer with years of experience working with First Nations noted the impact this gap has had on First Nations.

"Coming back again, to the decentralised protocol, I think one of the biggest fundamental things that the Nations uncovered through this process is ISC has kind of categorically defined all of these decentralised systems as private or individual systems under their protocol, which I think really is being felt across the country without Nations consent or understanding because as a consultant, I work with lots of Nations …and I'd say in 100% of the cases, every nation that we've worked with, centrally manages the systems. So the way that the decentralised protocol really is like if it's private, it's the homeowner or home occupants responsibility. ISC doesn't care about it. It's not really the nation's responsibility either. But in reality, it is the Nation's responsibility. They're trying to do their best and there is zero funding going towards paying for them or building the right system to begin with."

A FNIHB staff person expressed similar concerns about the Protocols for Decentralised Water and Wastewater Systems in First Nations, commenting "*What good is a policy with no money attached?"* An engineering staff person stressed that if the federal government is responsible to provide clean drinking water through Treaty and other legal obligations, why does it become the responsibility of the home occupant for people reliant on individual systems.

KEY GAP: An unfunded policy that fails to capture the reality of decentralised system management in First Nations has created significant infrastructure and public health risks and placed Nations in an untenable situation regarding addressing these risks.

In Ontario, First Nations, Tribal Councils, and a First Nation technical organization all understood decentralised systems to be fully the responsibility of the resident or the band, and not eligible for ISC funding, for either installation or O&M.

"They've always said that cisterns, septic field, holding tanks, wells are the responsibility of the homeowner. They made it very clear. They are not funding the capital project to install wells. They're not funding the capital project to install fields. That is part of building a house just like they don't fund the service connection to the main line to the house."

"Well, I think a lot of it has to do with like, most of these cisterns are [managed] by private homeowners, right. So usually we'll do the install and once the install is done it's up to the homeowner to do the maintenance and stuff on it, usually."

"I have not come across one of our clients yet that's getting funded for a decentralised system. Because I've been asking the same thing…Hey, where are you guys' funding decentralised system for Ontario First Nations? Any of them say, I don't know of anything."

Many First Nations noted both unseen and unintended costs associated with decentralised systems, especially truck-to-cistern systems.

“There's not a lot of people in the community that can go round shoveling the snow to enable the water to get delivered. And so the driver doesn't have time to do that. If you've got 108 deliveries, it's coordinated mind you. But if you have a high, large volume and that's something that you have, it's part of your operation and maintenance plan. And no money to pay them.”

“The holding tanks themselves we just don't have the staff to go and test. Ideally, we would like them done at least once or twice per year. And we get funding from ISC for the community-based water monitor, which is only 25k. So, in order to hire somebody that gives us a short time frame where we're able to hire somebody full time to go and sample in these locations. So, it's definitely not done enough.”

“And to be able to provide those reports on those wells. I just don't have the time to be able to do that, stretched thin as well. So funding is our biggest thing and then also money to maintain as we discussed with the cleaning, the UV light and the filters, making sure that’s done, that's what I would want them to hear. I know that that's probably what they always hear that, you know funding is short, but I guess we can't stress it enough”

“On the social support side, there's very, very few options for the people, other than take out a loan they can't afford or pay for, then it ends up as a delinquent account. Then the auditors say well the council is not doing enough to follow up on the debts that are collected to the, owed to the band, but the people couldn't afford the loan in the first place.”

KEY GAP: Lack of funding for decentralised systems prevents appropriate system design and selection, limits routine O&M for most residents, results in inadequate monitoring and sampling, and makes the installation and maintenance of appropriate treatment units very unlikely. These conditions put a serious financial burden on band administration and/or community members.

In Saskatchewan, participants noted that if there were demonstrable health concerns related to decentralised systems, funding could be found from ISC to assist in the installation of POU/POE treatment systems.

“So to get it done quickly, the community paid the largest portion themselves. And then they basically … got reimbursed. And I think that's the other challenge when we talk about the funding aspect of it is it's not completely funded. It's a cost share, both on the engineering and I mean, the split varies between the engineering and the installation. But even with what they pay per connection … it's not enough money. [ISC] haven't increased their values, or costs.”

Likewise, participating First Nations located in the Alberta region reported success with accessing funding for repairing and replacing decentralised systems based on adverse health impacts. In response to the persistent public health risks associated with shoot-outs, or direct-to-surface discharge wastewater systems, a First Nation recently received funding to pilot a septic field system.

> *"So that's why more recently they went with the combined treatment disposal model. But that was largely because it also came with funding of like, hey, let's do a three-year pilot program to actually provide operational and maintenance funding for the first time ever."*

However, these anecdotal stories and small pilot projects are the exception when it comes to available funding for decentralised drinking water and wastewater systems. In general, the cost of maintaining, repairing, and ensuring safety of these systems falls to individual community members, who often cannot afford the growing costs of maintaining the systems. Several Nations reported that the Band Administrations try to pay for decentralised system maintenance and repair, when possible, because it is an issue of public health.

> *"…we're just now we're in the in the mode of getting [Drilling Company] to come back out to take a look and scope out where a new well would go and give us an approximate cost. For that, we are going to have to figure out where the funding comes from… Short answer, if it's if it's private owned, it's up to the private owner. That's the short answer. …but we've always tried to take care of our own. So if someone runs into a situation where they don't have the funding for this, and especially when it comes to a septic system, I mean, this is a vital health issue. We will step in and we will assist. … We are a little bit different than then a lot of other [First Nations], we are in a better situation when it comes to finances."*

Another Nation noted that many First Nations members do not have the disposable income to deal with emergencies when they arise.

> *"The septics I guess get pumped out, you know, when they need pumping, I guess that happens. But when they need replacement, usually it's a crisis where there's a money issue. Then they come, go to the programs and services. We only get $24,000 for transitional support, housing, that's got to help people get first and last month's rent, maybe get a septic system, maybe the roof is leaking. That doesn't go very far in a large First Nations community. That doesn't go very far anywhere. When you've got 100 families they, like a septic system alone can be you know, it can be $25,000 to replace the septic system."*

There are some elements of decentralised drinking water and wastewater systems do receive O&M funding, namely for pump truck and vacuum truck upkeep and repair. Several Nations that contributed to the report cited block funding as a challenge, because it obscures how much money is being provided for specific purposes. While the 2020 shift to 100% O&M for centralised systems has been beneficial in some Nations, others have not noticed substantial improvements.

> *"I know with our funding, like I think we're one of the communities that are blocked funding. And our public works department is actually one of the ones that are that are underfunded due to the fact that you know, you have in a purchase all these*

trucks, you know, our road conditions and it takes a toll on these trucks. There's always those replacement costs, the fuel costs and then you know, since COVID everything you can jump right up. And we always talk about with ISC closing this infrastructure gap, that big announcement that was made and we haven't seen that yet, so in 2030 you know, it's not that far."

"They will balk at putting out that kind of money to put in a water distribution system, but yet, they continue to have to repair roads because of the heavy wear and tear of the water trucks running over them and damaging roads and they continually have to repair pay for that cost."

The lack of funding for decentralised systems has caused significant disrepair in aging systems, with no clear path towards the maintenance, repair, and replacement of wells, cisterns, septic systems, holding tanks, and shoot outs.

"A lot of issues we're having now is they're either old or they're failing apart, or. A lot of the problems we're having right now - is that we're looking at the wastewater system, is that the fissure rock is leeching, right? It's going to be a health issue. So yeah, doing that, but so one of the biggest struggles we're going to have probably, you know, identifying the money going through the funding source or like ISC or that. And one of the things like, even like, uh one of the early numbers we looked at, putting our wastewater system here is probably about $50 million. That's just for infrastructure, because it's all bedrock here."

"[Underfunding] is driving infrastructure off the cliff, like you're not only ruining any progression, you're ruining what's in the ground and will pay the consequences of that right now."

"It's been kind of scoping that lifecycle costs to you know, tertiary assets, tangential assets, social capacity, like everything has a cost that we can in some way, not always quantify, but at least qualify. In terms of impact. So just looking at the number of assets that you're having to maintain and the burden that that becomes, and the costs associated with that burden, I think, in that way can justify greater levels of service within the existing decision-making tool that they use"

KEY GAP: Unfunded, or underfunded, decentralised systems have unintended costs and consequences, such as deterioration of road conditions due to water deliveries and waste hauling, contamination of groundwater resources from poorly maintained septic fields, etc.. These impacts are poorly documented because they are poorly monitored.

First Nations funding and governance structures were also noted as key drivers of funding access. The annual funding cycle prevents long-term planning, complicated multi-year projects, and actively limits a Nation's ability to build infrastructure investment momentum. In the one instance where a contributing Nation had access to multi-year funding through the new fiscal relationship agreement, the representative reported that having flexibility in spending and knowing what long-term funding is available has allowed for the Nation to prioritize spending needs.

> *"Last year, okay. We knew by summertime we're going to need a new water truck. So what we said was okay well, we got this much left in our new formula funding on March 31. Let's roll it over into when we get our new funding on April first and then we'll buy a new water truck. We did, instead of buying old water trucks, you know, used water trucks, we actually were able to afford to buy a brand-new water truck."*

KEY ENABLER: Multiyear funding models offer First Nations flexibility in investment and decision-making, if budgets are sufficient.

While multi-year budgeting can help secure small investments like a water truck, a First Nation with a self-governance agreement shared that their budget is inadequate for implementing any substantial improvements to their decentralised drinking water systems. The Financial Transfer Agreement (FTA) is renegotiated based on expenditure need to ensure the Nation has sufficient fiscal resources to provide public services, however this Nation has not had success in acquiring the necessary funding for a centralised drinking water system.

> *"But in order to connect that with piping to go under the river or to go that far, we're just not considered feasible... We have too high of an expense, and our FTA wouldn't cover it. And then we're not eligible to Canada."*

8.1.2.3. Housing, Infrastructure, and Community Planning Needs

Housing conditions and shortages were identified as a key risk by nearly all First Nations participants. The intersection of aging housing stock, insufficient number of houses, and growing populations were recognized as significant strains on water and wastewater systems, particularly in the case of decentralised systems, where holding tank sizes, delivery and pumping schedules, and treatment capacity of septic fields all have a fixed capacity. In these Nations, an increase in houses relying on trucked services result in investments in unsustainable solutions.

> *"Well, it has to be studied number one. We have to determine what's the best, again we're looking at options for the community to consider, right? So we have to take a period and study the problem and determine what's the best recommendation for the community. There's a lot of time to get from where you are, like the gap is huge, right? So to get from where we are to where we need to be sometimes can take 5, 6, 7 years. In the meantime, the communities are languishing in a situation where they don't have enough homes. They're growing obviously, infrastructure is limited, so they're kind of forced into putting homes with truck haul capacity because they can buy a truck, right… And the longer we wait, the more expensive it gets."*

> *"Our experience has been, well we've outgrown our infrastructure number one. Most of it was installed in the late 90s. The communities have grown beyond what was originally designed. So they are really out of options now. So if they're going*

to build a new subdivision, with our current way of doing things would be 100% truck haul. There is an expense to that, obviously, and a risk because the trucks are our weak link."

When this contributor was asked what, if anything, could help move the processes along faster, they responded *"…you can accumulate a group of butt kickers to the regional office to get people moving. Other than that, I don't know. The process is designed to be slow."*

KEY GAP: Truck-to-cistern systems and wastewater holding tanks are unsustainable short-term solutions that are installed too often as convenient stopgaps in lieu of substantive growth planning.

Several First Nations participants commented on the relationship between overcrowded housing and the negative quality of life implications for residents that depend on trucked water services.

"We have several members that have their own trucks. I'm one of those people my wife is one of those people. My wife goes through a lot of water. And when there was 11 of us in our home, I had to come to get the water every 4 days."

Tribal Council staff noted serious concerns around cistern and holding tank sizes in northern remote Nations.

"So we're expecting households with children, elderly, people on dialysis, all of these things to be inconvenienced, because we won't create enough space for one cistern or sewage holding tank. It's like a two to one ratio usually by you know, people who I would say are the best conservation people around water in the household - First Nations. It's crazy, I can go in a house and they say don't flush the toilet because we only have five gallons left. Wow. You know that I think that's a huge aspect that needs to be conveyed. We're not able to make coffee for several days. Yeah, there's no water they have no water."

"Then there's the other side, the health aspect to it, which is what we've always pushed is that people limit their water usage. They're, they're not cleaning as often as they start doing dishes or when they're hand washing. They don't hand wash as long as they're supposed to because they're always in water conservation mode."

While much work has been done to characterize long-term drinking water advisories in centralised drinking water systems, there is no information available on the water quantity crisis that exists in some First Nations.

KEY GAP: The limited capacities of truck-to-cistern systems result in water scarcity issues and force water conservation that does not support public health and hygiene and broader Nation well-being.

Similarly, decentralised wastewater systems pose significant health risks and untenable financial burdens for many First Nations who participated in this report. Onsite wastewater asset lifecycles are intricately linked to design capacity and usage conditions, with poor system design resulting in a decreased life span and ultimately increased costs for system repair or replacement.

> *"And they've run into so many challenges in the past with fields or mounds failing because of like inadequate housing conditions, where you build a field or a mound for a house that should only have a maximum six people in it and then you have 12 people living in it for a year. Because someone else's house became uninhabitable, or whatever and then that mound fails and then that's a $70,000 repair that they don't have budget for so the open discharge systems we're having most flexibility to have different amount of people in each house but they are also the worst from like a public health perspective."*

The connection between housing and water and wastewater services is often lacking. As housing funding becomes available, there may not be adequate services to meet the increased needs, particularly in the case of truck-to-cistern drinking water systems and wastewater holding tanks.

> *"… we do have projects on the go with new subdivisions because the First Nation is also working on their own. They have mandated themselves to build 400 homes within the next 10 years. That's separate from CMHC. So now we have to develop all these new subdivisions right? But the issue we're having right now, with all this development, is the water treatment facilities that we have in place right now are insufficient to handle that capacity."*

> *"We spent the last three months trying to figure out how we're going to service homes that have been approved that have to be built by March, end of March, and there's no serviced lots."*

> *"And I didn't realize how bad it was until I was working with the federal closing the infrastructure gap. And I had to explain to them what construction sequencing means. You put the water and sewer in first before you build a house."*

One First Nation noted the tension between wanting to install high-quality water and wastewater services in rural homes, but also recognizing the need to stretch the insufficient funding as far as possible.

> *"The model was just updated a couple of years ago to go from $25,000 to $30,000 for servicing of a home in the country. So something that's not connected to a centralized system and $25,000, now increased to $30,000, is supposed to cover water, sewer, power, gas, driveway, and the Internet and a water well in [First Nation] because they're all drilled deep. Like they're all drilled into a safe aquifer that is generally considered not under the influence of surface water. Those average about $30,000 for a well and then the septic system for an open discharge system average about $25,000 to $30,000. But if it's an Elgin system, that provide higher quality treatment, to address the public health concern that's in the $70,000 to $90,000 range. So right out of the gate the nation's having to make choices that limit the investment they can put in."*

A Tribal Council noted the challenge of responding to the rapid housing initiative with insufficient infrastructure planning and funding.

> *"We're actually in a kind of a crunch because of CMHC with rapid housing initiatives and things like that in most of our communities, that there's two government organizations dealing with housing, but the infrastructure is lagging behind. We're not ready, but we're getting influx of houses and we're really struggling through it."*

KEY GAP: The lack of funding for servicing homes is complicating housing initiative implementation and resulting in the installation of inadequate decentralised systems that will lead to poor water and wastewater services.

When asked about finding solutions to community planning challenges a Tribal Council representative responded *"It's not designed to be expedient at all. Although if there's an emergency then the government seems to be able to react to that quite quickly. I would think they would be, if you look at it, why can't you react just as quickly to prevent the emergency from happening?"* An engineer had a similar response and noted that they spent more time and budget *"jumping through hoops"* than making designs, a process they termed "*death by a thousand papercuts*." It was also noted that ISC seemed to be able to "*throw the binders away*" when there was an emergency, leaving the engineer to ask "*how do we get them to throw the binders away*" for routine work of First Nations development.

8.1.2.4. Human Resources Capacity and Training

In nearly all discussions across all stakeholder groups, administrative limitations were noted as barriers that prevented successful management of current systems and delayed progress in areas needing improvement. These limitations involved management challenges, communication breakdowns, and insufficient capacity to accomplish key tasks related to drinking water and wastewater services and were cited within ISC, First Nations, and engineering firms and service providers.

It was noted in every Nation that relies on truck-to-cistern water that there was remarkably limited capacity to inspect, maintain, clean, and monitor water quality in the cisterns. These Nations also highlighted that trucks and cisterns are just a different kind of centralised system, in that the water treatment plant operators produce all of the water for the community.

> *"But we have to go back to centralized as well, that it is the water treatment plant operator that ultimately is producing the water that goes into these, and most of our operators aren't being paid. Some of them aren't even being paid minimum wage."*
> *"So you know, operators are overrun and burnt out and don't get vacation and don't get sick time and, and so they need you know, proper, qualified, trained, properly trained personnel, enough of them. You need to have salaries that people want, that they'll stay, that they'll actually attract good people. And then you got Circuit Riders, they're overrun. It's just it's just a huge nasty cycle."*

"I was just going to add a little more to the funding issue. What I've seen over the years is that First Nations are put in a really tough spot as funding or programs devolve to them. And they were very often these devolution or if this transfer of authority and funding comes with the promise that you can now control the program. Well, nearly all their programs are underfunded. So they're putting out where they're told - well, if you've got any savings in this program over here, you can use it to cover other things that you want to do. And we've often seen that things like a cistern which is out-of-sight-out-of-mind is not going to get the funding that it needs."

KEY GAP: In many cases decentralised and centralised systems are intimately connected and the current funding and policy environment creates siloes and does not allow for integrated planning, management, and funding solutions.

Often, First Nations commented on the lack of internal capacity to design, install, and maintain decentralised systems and explained that relying on outside services created a flow of funding away from the Nation, rather than building skills and positions in the community.

"And not just the lack of contractors but also, you know, community members can't afford to pay so, if they can get a contractor, they're looking from anywhere from you know, $300 to $1,000, just to get that clean, so people can't afford to do that."

"You know, when it's Nation business it should be Nation led and things like that. So that the money comes back. So that it's socioeconomically responsible. You know, that's what I'm afraid of, is that somebody's going to take that package and run with it, and then just flip the Nation the bills and is ISC going to pay them, but we need to know these things."

"And I think it gives them something like $75 and that cistern should be cleaned say twice a year even more if it's a big family and so the $75 can't cut out it therefore, it doesn't get cleaned at all. So that's the kind of thing if they had, you know, the training incorporated into the annual funding and then the person that's supposed to go clean it their full cost was incorporated."

A researcher who has worked with First Nations for years shared a similar concern that too often money flows from ISC to external entities without careful consideration of how to empower First Nations to build capacity.

"Many First Nations rely on external people to come in, many engineers come in that are very well paid. So lots of money goes to these big engineering firms that do not live in the community. I think traditionally, a lot of engineering firms went in, got lots of money, didn't really do an investigation about the system, they didn't talk very much with the people who were living there and installed things in a certain way that, you know, we now all know it wasn't the right way. And so I strongly believe to fix this problem we need to focus on empowering communities, whatever that looks like. Then the money doesn't go out of community, the money stays in the

community. If you would have an engineer in the community who has a business and does that work and maybe for the neighboring First Nations as well. The money stays in the community, and then people can profit from that and do good things with that."

A First Nation Health Director noted that there is a lot of good work that does not get done because there is not funding to invest in new positions. She offered an example related to public awareness and education about water safety.

"We have World Water Day coming up, just looking at doing a walk. This is very short notice for us to be able to work together to pull something together from that. So having somebody to be able to look after those things and to do workshops and try and, like even though, even if we got three people, that's three people who know a little bit more than they did, you know than not, going into it. So not just about getting a sampler. It's about getting an outreach worker as well."

KEY GAP: Investment in drinking water and wastewater services flows out to external service providers with limited investment in human capacity development in First Nations.

First Nations contributors also highlighted the significantly limited funding available for routine water quality testing. Many First Nations quoted a budget line of around $25K - $30K including salary for the community-based water monitor. One First Nation contributor explained that "they're only allotted so many dollars and that block funding is for the position and supplies." Nearly all Nations we spoke with said the funding for water quality sampling was insufficient and largely used to sample centralised drinking water systems. Many FNIHB staff we spoke with across the regions shared that routine monitoring of wells and cisterns presented significant logistical difficulties, with some Nations having dozens to hundreds of individual onsite drinking water systems. Many Nations indicated that cistern and well sampling was done if requested by the resident or homeowner. Some participants noted that there is the intention of sampling more frequently, but the lack of trained staff and/or available funding presents challenges.

"Our health services used to sample once a year, their mandate had changed to do it twice a year. I don't know if they had the manpower to keep up but they were doing it and then, depending on the test results, they would recommend cleaning the well - that would mean adding chlorine and then flushing it out. They had a certain process that they had offered… They think they do the bacteriological twice a year. They do a physical chemical once a year. I don't know if they always keep up with it because I've called and asked for certain ones like okay, yeah, we'll get out there that one's due."

"Its usually on request, I do believe, yeah… Now we're actually trying to change that up where we're actually trying to get community-based water quality monitors to actually go around and test these cisterns on a regular basis and try to basically try to get these people, homeowners, to be community-based water quality monitors."

"The public health authorities mandate testing. So when we started working with the Nation, a couple years ago, they had a list of about 120 homes in the country out of the 900 or so that exist there are on active drinking water advisories. Almost all of those were boil water advisories because the core mandate of the Public Health Authority is to do bacteriological testing of every home once a year and when we were working alongside them this year, they weren't able to make it to every home once a year. So there's some concern about trust or access or even just capacity within the public health authorities to do that work."

KEY GAP: Water quality sampling in decentralised systems is a much more time intensive and resource intensive task than sampling in a centralised system because each home represents a separate system that needs to be sampled.

The value of adequate water quality testing was very apparent, with the data being one of the main drivers of action and system improvement. There were examples of successful partnerships between First Nations and ISC staff that resulted in addressing the persistent risks present in decentralised services. The importance of collaborative engagement in problem-solving was evident and resulted in effective co-management and decision making.

"I would say it came from [FNIHB staff] and in services from the health side we've got a very proactive relationship in all three communities, the Health Canada field officer, if you call them that, are proactive in the communities and really take a close look at making sure the sampling is done and looking at the water quality reports that are coming back."

While collaborative relationships may not result in direct funding or system improvement, FNIHB staff were reported as providing important support services that informed Nations in how they pursued improvements and solutions to decentralised water and wastewater challenges.

"Our First Nation health officer is very much involved in some of that kind of stuff. If we have other issues with septics, I often, at least in our housing department, we will call him out often, especially if we have fields that are failing. He's come out for me several times just to come and have a conversation with the member to say listen, you know this field is failing, really you need to replace it and then I get a report that if, if ever funding comes available through ISC or CMHC, to replace those septics or wells, then we can go that direction, right? So that there's something official from a health officer that says, yes, it's backing up into the house."

KEY ENABLER: Collaborative relationships with FNIHB staff allowed for the collection and recording of important data and system information that were used for system improvements.

One key area where ISC support was noted as highly effective was in an example of securing and coordinating training opportunities for First Nations staff. One participant recalled that years of investment in training, supported by both ISC-FNIHB and First Nations leadership has transformed the siting and installation practices for onsite septic systems.

"[First Nations Manager] said, well, look, he says I need to train some of our newer people there because they haven't been trained on septic systems. And, you know, maybe because they're doing the water testing all the time, but also to be aware of septic systems and make sure I guess, for safety. I think so he says a lot of my other guys are retiring. I have younger people come in, they haven't had this training and their background, so it'd be a good chance to do that for them plus, we could put your guys in to do the installations and the maintenance. So from [our Nation] I think we must have had about probably seven or eight people, Public Works, Capital and also our Environment office too."

"Yeah, [Trainer] did it. He did it last year. We met in July and August and I think we need to do a few more days of training to continue this year. But [FNIHB staff] was the one who secured this funding. He kept pushing. So he made it possible to get this funding in this training for us. So now that we know about this, that's when we said okay, we have to start actually using this training because now I think I had seen it about three times the training. That comes back to when I got the visit from the three chiefs and like okay, we need to change what we're doing here. Something, whatever we're doing, is not fixing the problem. So that's why I had to get consultants and actual resources not just well, it is what it is."

KEY ENABLER: Training opportunities provided to First Nations staff can result in improved service delivery and system performance.

In general, the project team found that regional contexts within ISC, combined with exceptional ISC staff, produced positive, collaborative, and progressive change in decentralised systems. However, it was clear that these conditions for success were not present universally, and in general, were the exception not the rule.

One First Nation participant, when asked if the Nation had worked with ISC to address failing septic fields that were over 30 years old, replied *"They've never had a conversation with ISC about any of this sort of stuff. No. Yeah, basically. I just handle it. You know, it's got to be handled. We handle it the best way we can do it. Never gonna have too many conversations with ISC."*

Both best practices and challenges were used by the project team to inform recommendations presented in Section 11.

8.1.2.5. Public Health Impacts

The gaps and challenges noted in the previous sections interact through complex relationships to produce significant public health risks for First Nations members – feasibility studies fail to assign a value to public health and broader Nation well-being, funding gaps fail to provide adequate monitoring and sustainable O&M, an overreliance on decentralised systems with no funded management strategy results in lack of treatment (both for drinking water and wastewater), and forces water conservation measures in many homes.

An engineer with years of experience assisting with addressing challenges in decentralised systems on First Nations shared this example of the manifestation of decades of unquantified health impacts for First Nations members.

> *"And what we're finding is all these systems that have been replaced and have been taken off the boil water advisory at least 50% of them are now being put back on do not consume orders because there's fluoride or arsenic that exceeds the max. Like they're drilling in the same aquifer that they've been getting water from for, you know, generations. So now we're finding so [fluoride and arsenic] has always been there, but it hasn't been tested [for], right? So now the Nation is undertaking the installation of treatment systems within the homes to address those but how long have the Nation members been exposed to some of these contaminants that exceed those guidelines."*

Several Nations shared that many people who have decentralised drinking water systems simply do not drink the water because there is no way of knowing if it is safe.

> *"The other thing to make mention to is because the well systems that are currently on the south side have not connected to the water plant, all the south side residents are on bottled water. They all have to buy bottled water there. They don't think, even with treatment they recommend that the well waters on the south side are not consumable for drinking."*

> *"I don't know any home that drinks their tap water anymore. So we've got about 450 homes, I would say 400 of those they get their water bottles brought in."*

> *"We do have a blanket boil water advisories out for … all cisterns. The precautionary advisory is because we can't guarantee the safety, even if we test it and say it's negative, there's no bacteria there, five minutes later, it can be contaminated. So we just know there's no way of guaranteeing that especially with trucks."*

While there has been significant attention paid to the drinking water advisories in centralised systems, there is no formalized monitoring of advisories in place in decentralised systems. In the Alberta region FNIHB has expanded its mandate to track advisories for decentralised systems and has found that these systems are under-sampled compared to centralised systems but have significantly higher occurrences of total coliform and *E. Coli* present. Table 8-1 shows sampling data by system type reported by Alberta Regional FNIHB from the 2022 First Nations Health Protection Report. The second column of data are the estimated number of homes serviced by each system type, as reported in the Integrated Capital Management System.

Table 8-1. Table of sampling data by system type from the Alberta Regional 2022 First Nations Health Protection Report.

Water Supply Type	Estimated number of houses served by system type	Total number of samples tested	Samples that tested positive for total coliforms	Samples that tested positive for *E. coli*
Public	6,763	15,242	137 (0.9%)	6 (0.04%)
Semi-Public	\	1,966	78 (3.9%)	4 (0.20%)
Private - Well	4,795	1,753	469 (26.2%)	20 (1.14%)
Private - Cistern	5,272	2,216	469 (21.2%)	36 (1.62%)

This data shows that approximately 60% of homes are serviced by individual drinking water systems and receive 20% of the sampling effort. The minority of the homes serviced by centralised systems receive 80% of the sampling effort. Moreover, the results indicate that individual systems are one to three orders of magnitude more likely to have total coliforms and/or E. coli present.

KEY GAP: There is insufficient monitoring data on the performance of decentralised systems in First Nations, and what data does exist demonstrates the increased likelihood and consequences of risks in these systems.

When First Nations advocate for centralised drinking water services it is because they are aware that these systems receive improved funding and support and are often associated with better water quality.

8.1.3. Decentralised Drinking Water Systems

Through discussions with contributing First Nations and information collected from Tribal Councils, First Nations organizations, engineers and service providers, and researchers familiar with First Nations decentralised systems, lifecycle narratives were compiled to understand current practices in how systems are designed, installed, operated, maintained, repaired, replaced, and decommissioned for both individual well and truck-to-cistern systems. As noted earlier in Section 7.4 Constraints and Limitations, the examples provided here are not exhaustive and present a very limited picture of the diverse practices in First Nations. However, the details contributed here are a vital first-step to listening to First Nations and learning from the extensive tacit knowledge they have to offer.

8.1.3.1. Individual Wells Lifecycle Narratives

System design and installation

For individual wells, all First Nations that contributed to the report indicated well drilling contractors were used to install drinking water wells. Where existent, provincially certified well drillers were routinely used. A summary of provincial regulations regarding well installation is included in Appendix B. Most provincially certified well drillers are required to ensure a well passes a yield test and can produce adequate water. However, despite this requirement one First Nation representative reported wells with low yield that result in poor service for the residents.

“There are some cases where there are some wells with a low yield, which requires these residents to have retention tanks. We have no maintenance system put in place quite yet.”

Water quality analysis at the time of well installation is not required in most jurisdictions. One First Nation contributor noted that health staff conduct water quality sampling of new wells after the home is built and well is plumbed.

“We asked them to build their well and drill a well and then we pay them for that and that's that. We do our own water testing. We have a couple officers at the health center, so [they] would test the water once the house is in, the well it's plumbed in, homeowners ready to move in, he’s going to go in and check the water first and let him know - your water’s not too great. So you know, go get your water at the plant kind of thing.”

“So there's a process for that, our individual homeowners, or the band if we were to build our own new houses, where we have septic or well then we will, the process is the same, be that a band house that's being built or be at a private home. We all follow the same rules. So you have to have a certified installer. We're very fortunate in our area we do have a company that digs wells and then we have another one that does the connections to the house.”

“[The contractor] will do all of the water. Deciding where it's gonna go, how it goes there. And then once they do the actual work, a water report comes back to us and to our lands department. It's part of the building permitting process, and then the well gets registered.”

This Nation quoted above is building a database of existing wells and maintains records of well reports provided by the installer.

KEY GAP: The lack of water quality analysis prior to home construction results in homes existing in areas with poor groundwater quality.

In general, there is a lack of decentralised asset inventories and a significant lack of data regarding well and septic set back distances. As noted in Section 4, the single greatest risk to groundwater quality from an individual well is contamination from a poorly installed or poorly sited septic system. The paucity of information about well and septic proximity is a significant knowledge gap that represents potential risk. The project team did receive one decentralised asset survey that evaluated the number of septic system assets in the buffer zone of dug well, drilled wells, or water courses. Of the 260 wells included in the report there were 87 septic system components (i.e. fields, septic tanks) within the regulated buffer zones of the wells or water courses.

There was a trend of individual wells being used in areas with known water quality issues, however in some regions when groundwater quality concerns were too high, either because of geogenic or anthropogenic risks, truck-to-cistern systems are installed.

> *"There are about 95 individual wells in service on the settled land. A small number of homes receive truck hauled water. The homes with cisterns are in close proximity to the dump, so wells may not be safe."*

KEY GAP: The lack of data on well siting, particularly relative to septic systems, is a critical knowledge gap that presents a significant risk to human health.

Some First Nations are beginning to receive funding for decentralised asset surveys that include inventory and asset condition data. One asset inventory report shared with the project team indicated general observations that the majority of the wells surveyed were drilled, though some dug wells were found. A small percentage of wells were physically damaged, though some wells were reported as being buried or located inside a building or house and could not be visually inspected. The report highlighted the importance of asset identification and condition assessment as a crucial first step to prioritizing risk mitigation actions and preventive management practices.

Operation & Maintenance

Generally, individual wells operate until reactive maintenance is needed. There was little to no preventive maintenance performed on the wells, such as annual inspection or well head protection activities. Because of this, many wells are known to be very old and many First Nations that contributed to this work reported many homes on individual wells do not drink the well water.

> *"A lot of well are just aged out, and some of them are sinking. A lot of them don't have well surface seals because they've been drilled 30 plus years ago so a lot of these houses are close by cattle… these are some of the situations here with the lack of funding."*

> *"And as the Chief said in the beginning, people who are on well systems, they shouldn't be drinking their water anyways because we are on a precautionary boil water advisory in this community for all well water due to the fractured bedrock that the community is predominantly situated on. So people shouldn't be drinking their well water anyways."*

> *"The other thing is 99% of our wells are GUDI wells, which means groundwater under the direct influence of surface water. The drinkable aquifer we use used to be around about 30-35 feet deep, maybe shallower in some places, but again, it's very easily impacted by surface water. And if the streams dry up, then usually the groundwater table gets very low. And then the water is not good."*

KEY GAP: Unfunded or underfunded operations and maintenance programs for individual wells result in deteriorated systems that are prone to contamination.

Many First Nations contributors also noted the negative impacts poor water quality has on the housing infrastructure and appliances. These unintended consequences are costly to the Nations, but are not considered when evaluating water system level of service and overall lifecycle costing. Replacing washing machines, dish washers, toilets, and fixtures due to scaling and staining is an increased expense caused by the poor water quality. On Nation explained that even after replacing the well and installing POE treatment, the water quality sampling was coming back with bacteria due to the build-up of scale and biofilm in the home from years of poor water quality.

> *"We will replace the well and septic within the house but with all those lines, those old copper lines with dead ends, as much as you can shock chlorinate the lines you are not doing the job of cleaning it out properly."*

> *"The hard water is bad for the appliances. Do you want to see our pile of junked washing machines?"*

KEY GAP: The unintended and undocumented impacts of poor water quality on housing infrastructure places an increased burden on First Nations administration and members living in homes serviced by individual wells with untreated water quality issues.

Regardless of governance structure and housing ownership, many First Nations contributors said that the band offered as much maintenance and operations support as possible for residents, despite the lack of funding for decentralised systems.

> *"And they the public works teams is, they're rock stars, they provide support as they can, when they can, where they can. And they for the most part, I mean they have regular working hours but in emergency cases, we have a team set up to our emergency operation centers but they are part of that team as well."*

> *"I usually get a call either to myself or the office and they notify me that they have water issues. And so I'm going to call my plumber, and he's going to go in, go take a peek and see what's the issue and then he'll kind of let me know if he needs machines and all that sort of stuff. So, kind of coordinate and you know, if it needs to be dug up and redone the public works and the operators kind of go hand in hand with the plumbing division."*

Maintenance practices were found to differ in come cases regarding how band owned and CP houses are managed. When asked if the band assists with maintenance of decentralised systems, one Nation shared "*on band owned land they do, on certificate of possession it's normally up to the individual*."

Some Nations shared details about how they use ISC funding and resources to support the operation and maintenance for decentralised systems.

> *"I get funding for my operations and maintenance for the year. So that's what it comes out of. We have or our O & M budget from ISC, and that's how I pay my plumber and the machine operator."*

> *"Our Public Works has been involved in community for probably 40 years so they're very familiar with the system that we have. He uses his best judgment so he may call a local contractor and do it out of own source revenue and then talking to ISC after the fact. But at the same time, keeping in mind a lot of these problems are reoccurring problems for those properties. So ISC has a following on it. So when he picks up the phone and said hey, I had to pull a well pump out of houses number XX, they can look at their system and say okay yeah, you guys have been talking to us about this for some time."*

It was clear that there are regional differences in how ISC and First Nations coordinate and action intervention and support for decentralised systems.

Monitoring & Treatment

Most First Nations contributors indicated that individual wells were tested, at most, once a year, but acknowledged that often it likely does not get done or is only done in response to water quality concerns. FNIHB EPHOs and/or CBWMs, or other devolved public health entities, assist with microbial water quality sampling on an as needed, or by request, basis (Health Canada, 2014b). Many reported that band staff, in combination with a variety of contractors, were the ones to respond to adverse water quality results.

> *"Our health services had used to be once a year, their mandate had changed to do it twice a year. I don't know if they had the manpower to keep up but they were doing it and then, depending on the test results, they would recommend cleaning the well that would mean adding chlorine and then flushing it out. They had a certain process that they had offered."*

> *"I think they do the bacteriological twice a year. They do a physical chemical once a year. I don't know if they always keep up with it because I've called and asked for certain ones like okay, yeah, we'll get out there that one's due."*

> *"So on my well, they picked up some E. coli and some bacteria. So the band village maintenance person came up, did further tests and found okay, there's issues there and they went through a manual chlorination system when they pump stuff down the well and, and then retested again to see what happens. Similar things happen on the band side of things. They do some, they come up, do the tests, get recommendations what to do and then kind of monitored as we as they go forward."*

KEY GAP: Insufficient water quality testing and lack of access to water quality data may create an increased risk level for families living in homes serviced by an individual well as compared to families serviced by a centralised system.

There were regional differences noted due to the devolution of public health services managed by different entities from coast to coast. Also, First Nations in Yukon Territory highlighted the important role of the Yukon Government in providing laboratory services at no cost.

“But in terms of the private owners, I'm not sure if it's just situational based or if there's a regular schedule. I do know at least once a year [FNHA] have them all tested because at some point I get a report from that, but if there's anything more consistent than that, I don't know. Often, we find when there's either high water in the river or it's low, the amount of turbidity often will determine when the families call and say, oh my goodness, this is what I'm finding and then we have to send them out just for peace of mind. Right? So that they know and this is a yearly thing that happens and it's the same families generally that phone.”

“There is no budget for individual well water testing, so no human resources to support sample collection. However, Yukon Govt provides analyses at no cost. The Nation gets complaints about the well water all the time.”

First Nations, engineers, scholars, and FNIHB staff all noted the importance of routine and robust water quality sampling programs to evaluate system performance and protect public health.

“You guys need to start testing regularly so that we can get some data and even baseline data right now. Like at least it'll help you determine health risks in the long run. So we just have to keep on top of that, like in the wells, especially with climate change and infrastructure, which the North is experiencing rapidly. Yeah, we do have some data collection, but where we're at with that I'm not quite sure. But with capacity, sometimes that becomes an issue as well.”

“Most of the homes that are on well water systems have high manganese and high sulfur. So there is a that smell that comes with it. And we always have to regulate what's happening in the wells. Because of the floods as well and because of the depth of the sewers. Yes, there's potential for cross contamination. And so with climate change, and the flooding is happening more often, sampling is very important.”

In one First Nation, robust sampling was used to inform improvement strategies and guide infrastructure work. There is currently a gap in decentralised drinking water monitoring, as there is a lack of ISC program/policy that covers annual chemical or radiological analysis for individual wells, although some regions are conducting monitoring on request. The paucity of data represents a significant unknown risk for residents reliant on these systems.

“We tried, I guess you could say identifying issues and prioritizing which houses need replacement or repairs and in order for us to get some of these houses off a do not consume or boil water advisory we have to replace the wells and septics. I don't have the number right in front of me quite yet but we have lifted a number of homes off the advisories.”

A FNIHB Regional Manger stressed the importance of water quality sampling and system monitoring "*My last parting comment is we have to use data, we have to use the evidence, and in areas we don't have it, we need to get it*."

KEY GAP: There is a lack of data regarding individual well performance and water quality. This gap in knowledge results in an unknown and unacceptable level of risk for these systems.

Most of the First Nations that contributed to this work did not have POU or POE treatment systems installed on decentralised systems. In the few that did have treatment technologies, some relied on contractors and companies for treatment design and installation. Others managed the treatment.

> *"Usually, the most that we deal with is adding potassium. And I believe that recently, probably in the last six months, I'm not sure is that they're switching over from that. They're not they're using less and less for some reason. I'm not sure. We haven't had an answer back from the company that we deal with. Of all the systems that I believe are installed, we only have one that is it's like a mini water treatment plant and the rest are basic sand filters. And where we don't have too many problems, some have chlorine added to them."*
>
> *"For homes with filters, Capital department maintains the filters. They often have to be replaced frequently"*

One Tribal Council raised a concern about the need for additional maintenance capacity in First Nation with decentralised treatment systems. As mentioned in Part 1, unmaintained or poorly maintained POE/POU treatment systems can make water quality worse.

> *"Yes, I mean, there's certainly great technologies out there that you can put on private wells, for instance. You know, treat just about anything if you wanted to monitor what's going on in the groundwater, but there's the concern with that is the maintenance aspect. Are things going to get changed on a proper basis? If you're looking at a filtration system, whatever it is, there's a maintenance aspect to that and you could have a problem occur without even knowing it and causing health problems."*

KEY GAP: The lack of funding for individual well treatment systems and lack of human resource capacity of maintenance of treatment systems may prevent the production of safe drinking water.

Perceptions and Water Usage

As noted above, several First Nations with members relying on individual wells shared that many people do not drink the well water either because they choose not to, or they are told not to by band/Nation management.

> *"I don't know any home that drinks their tap water anymore. So we've got about X homes, I would say [90%] of those are they get their water bottles brought in. The other*

[10%]are homes, for example, there's a stretch down with a band office here that's about 30 something homes served by a water treatment plant."

"All the south side residents are on bottled water. They all have to buy bottled water there. They don't think, even with treatment they recommend that the well waters on the south side are not consumable for drinking."

"So, it was widespread like the flood. I was here for the flood years actually. How should I put it, it affected, we were lucky if I can say that. We are probably affected maybe in 30% or 40% of the homes. Considering [neighboring location] was wiped off the map, I'll say we were lucky with those 40% of the homes. The other 60% they're not going to drink their water because they know your next-door neighbor's water isn't good and you're across the road and might not be touching mine but I'm not going to drink it. So once one house is affected, everyone is affected. Right, so they're not going to drink their water."

"Because of the water, right, Like the babies are bathing in this stuff, and there's no way around it and it's affecting our skin and like I've never seen so much in the last few years of I don't know what you would call it because they have psoriasis. I wouldn't want my children to have that sort of stuff. I'll put it that way."

"Well, if you're Indigenous Services, and I'm speaking to you right now, I'm going to ask you a simple question. Its 2024, why can't I have clean drinking water like everyone else? That's all I'm going to ask you."

KEY GAP: The current policies regarding installation, operation, maintenance, and monitoring of individual wells in First Nations has resulted in the lack of trust in these systems in some First Nations.

Decommissioning

No First Nation that contributed had a formal well decommissioning process. Many said that there were few to no abandoned wells because wells are expensive and would be saved for possible future use. Others noted that they were aware of abandoned wells and the risks associated with them and were working on addressing the issue.

"No, we don't have any abandoned wells. The reason for that is the housing shortage is so dire out here so somebody moves out, someone else moves in. Someone else is moving right back in. We don't have it, the only time we would have that issue is if we have a burnout and so the well, it wouldn't be decommissioned, but like the pump would be shut off, but the well is still there for future use, we'll call it. You know, don't get me wrong, because it cost me $5,000 to $6,000 to drill that well. I'm not going to drill it again. So if a homeowner picks hey, that's a nice block. We're certainly going to give them that spot with the well in it already intact."

“We have several wells that are abandoned and have never been properly dealt with. And so I know that our lands department is working on a process or a protocol. Generally, when we have this issue, or we find something or as we're doing some exploratory work on a particular lot, I'll call the lands department and say, hey, my understanding is there is a well, that's been decommissioned or not decommissioned, that's been abandoned here.”

KEY GAP: Abandoned wells represent a key threat to groundwater aquifers, as they act as direct conduits to the groundwater. The lack of a federal well log system similar to those in provincial jurisdictions creates a significant inventory gap. The scope of the problem is unknown.

8.1.3.2. Truck-to-Cisterns Lifecycle Narratives

Water Treatment Plants

Most First Nations included in this work that rely on truck-to-cistern systems produced their own drinking water at a community water treatment plant. These Nations had very limited centralised distribution systems and the majority of homes were serviced by truck hauled water. Many of these Nations, generally located in central and southern locations, shared that they were pleased with the quality of water being produced by the plants and noted recent advancement of their plants, with little to no investment in extending the distribution system.

“You know, we've been having this long-term co-management with ISC trying to figure out solutions for our water issues, but it came down to the point where we were able to get a biological system within our community where it was able to use less chemicals you don't know, you use less everything just to make some clear, clean water right. So after that was done we're pretty happy.”

“It's a lot of help to have that O&M funding ... So, you know, today I can tell you, it is adequate funding to clean the cisterns. I hired two people, to drive the trucks, hired those two people to keep an eye out on the water treatment plant. “

“I contribute a lot of that to our water plant operators we have here at the water plant, Our water plant, I think was built 2011 and I swear to god, everyone that comes walking out of there, you'd think it was just built yesterday. Seriously, you could eat off the floor in there. That's how clean they keep it.”

First Nations in northern and remote locations were faced with challenges in the management of the WTPs, including recruiting and retaining water operators. A First Nations organization representative shared details of the experiences in some northern Nations.

“Typically, there'll be a water plant and operators in the community at varying levels of training competence. Very, very few of our operators are qualified to the level of the plant that they're trying to operate. You can go and look at the list of communities and I think, you know, I'd have to go back but I think we're still hovering around a dozen communities on long term Drinking Water Advisory with another eight or nine on short term.”

"Certainly, there are several of the communities that are on the long term Drinking Water Advisory lists still that their plants are capable of producing perfectly good water and potentially they are producing perfectly good water, but the sampling regime and the oversight is not in a place where the Chief and Council are willing to assume the risk for the quality of the of the drinking water. So a lot of it really depends on the appetite for risk that Chief and Council has and also the degree of faith that they put on the water plant operation."

KEY GAP: Remote and northern First Nations face challenges in service provision due to training and capacity issues.

In most regions there were general concerns around adequate pay, training, and capacity building for First Nation water operators. Inadequate pay for operators and reports of unpaid Operator-in-Training positions were voiced by First Nations contributors.

"We don't get funding to pay our training operators so the band's got to find money through their O&M money or somewhere to find an operator that they want to train to become an operator because you don't get any funding from ISC until they're certified. So, if we can get some operator and training dollars over and above our O&M dollars, just so we can bring people in the plant and actually pay them while they're training to become an operator. I think it's important."

"One thing I wanted to mention was the need for longer training periods for operators, either testing or exams to become certified. It's a thorn in my side. You bring in an operator, he goes to take the exams, he passes on both and he gets put into a water treatment plant that's a $4 million asset for the band. And he has one week of training. He passed the exams he did the one week of training and now they put him in a position like that."

"I would say the specific challenges I mean, I can have a laundry list of challenges, but the main ones that I see facing First Nations is from an operational perspective, because we get hung up on this capital investment of like new water plants and new facilities, operationally, it would be capacity and understanding at the community level, the importance of positions. We always talk about capacity building, but I don't think we're at a position now at least in my communities, where there's just not enough people that fulfill roles."

KEY GAP: Operational solutions are needed alongside capital solutions to ensure systems are operated, managed, and maintained to provide sustainable and safe services.

System Design and Installation

Cistern material type, installation method, and set back distances were highly variable across, and even within, regions. There were reports of cement, polyethylene, and fiberglass cisterns ranging from less than a year old to greater than 30 years old. A cistern asset condition report shared by a First Nation found that 64% of cisterns present in the Nation were more than 30 years old, half of all cisterns assessed had cracked foundations or walls, and a significant portion of the cisterns failed to comply with the required setback distances to septic system components. Cistern placement was also highly variable, some were installed partially or fully below ground, others in crawl spaces under the home, and some in the home or in an insulated building near the home.

> *"Some of them are below ground. There's nothing that's really like above ground, and maybe about half is showing because we have a lot of bedrock here. Okay, so we get them as deep as we can when we install. They are cement, just less of a hassle for us. And what we do is we insulate it with blue board and plastic blue board plastic that we cover, just to keep filtration out."*
>
> *"Another problem is that some of these tanks are concrete tanks. So eventually they're going to break down, like water is naturally corrosive. We recommend all new tanks being installed are NSF, so they meet the standards for potable water. They are a plastic poly and they do last a bit longer. But again, when the driver is opening and closing the lids, they have a tendency to wear the rim down around the edge so there's potential for leaks to get in from the top. Those are just some of the maintenance things. And if somebody were driving over, like a lot of times there's been situations where the propane truck has backed overtop of a tank, and it's caused problems to the actual structure of the tank. So we don't recommend anything other than a riding lawnmower weight go over top of the tank. So there's another potential problem that could happen with them."*

As noted in Section 3.3, there is very little research on the safety and performance of different cistern materials or installation locations. What research does exist indicates that below ground cement cisterns have a higher likelihood of infiltration and contamination, however it may be because the cisterns studied were very old and in poor condition. There is no definitive guidance on cistern safety. A cistern asset condition report noted that risers and lids made of concrete showed deterioration, cracking, and deformation that allowed for infiltration from surface water. The asset report also highlighted that the likelihood of a septic tank being installed as a cistern was "almost certain" and associated with severe consequences, resulting in high risk.

KEY GAP: The lack of research, monitoring, and piloting of truck-to cistern systems results in a significant knowledge gap and insufficient guidance on cistern asset management best practices to mitigate risks in these systems.

Placement of cisterns is critically important because the fill port must be accessible at all times. Many First Nations contributor noted that snow fall, poor driveway conditions, and lack of cistern protection presented serious challenges to water delivery programs and made truck-to-cistern systems high-risk.

“One of the issues is we have winter here and I don't know if you've noticed but we have snow. And somebody's got to shovel the pathway to the, from the delivery truck to this, to the holding tank to keep it clear because the driver doesn't have time to deliver water and shovel snow. Oftentimes, if the pathway has too much snow or it’s drifted in, they will not deliver water. And so the homeowners, and Indian Affairs knows that, Indigenous Services Canada knows that many First Nations have a lot of comorbidity. And even though the person may be at home, they may be elderly with a walker. They are certainly beyond their snow shoveling years and then the other is because we have a mortgage program and I'm sure most families are working.”

“The [band staff] will often hit them when they're cleaning out the yard, or the water truck backs into it. They get a little too close. They don't have bollards around them.”

“You know, you got the fill pipe sticking up dogs come by there. You want to make sure it's protected. They pee anywhere.”

Many First Nations recognized the practicality of cistern systems in home that were very rural, but all First Nations with truck-to-cistern expressed the preference for extending the distribution system and removing cisterns where possible. Despite this, most First Nations that contributed to this project noted that they are still building homes that will be serviced by cisterns, because it was the only way to make use of rapid housing initiative funding.

“There are four more houses coming on this year. And they will have septic tanks and .... So you know, I don't like putting cisterns in when we have a project that's due… We were encouraged to put them on old homesteads, where the infrastructure is already in place like a driveway, gas and power. We're encouraged to try to do that first. So we've selected where houses that burned down in the past or maybe an old yard site where houses demolished.”

“But no, it’d be good to get everyone off cisterns but like I said, the infrastructure is not there to do it. It's just the communities are so spread out.”

In general, in the Nations that we visited and the assessment reports that were shared, cistern installation practices are not in conformance with CSA B126 standards and there are numerous issues that were identified, including risers at ground level, lack of access for cleaning, lack of vent screens to prevent ingress of rodents and insects, poor grading and drainage, lack of dedicated truck fill port, and unsecured lids, etc.

KEY GAP: The absence of oversight and monitoring of cistern systems throughout the asset lifecycle produces serious and complex health risks.

Operation & Maintenance

Nearly all First Nations contributors that have experience with truck-to-cistern systems shared that most O&M activities are the responsibility of the resident and were prohibitively expensive.

In the rare case where the Nation assisted with the cleaning and maintenance of cisterns, there was still a lack of routine maintenance due to the difficulty of finding and/or paying contractors.

> *"But there's no funding for that right because ISC has put that burden on the homeowner. So the homeowner is responsible for maintaining their holding tanks and their systems"*

> *"Most of these cisterns are [managed] by private homeowners, right. So usually we'll do the install and once the install is done it's up to the homeowner to do the maintenance and stuff on it, usually."*

> *"Its at the homeowner's cost like to clean your tank. A lot of times it's a replacement of their tanks, because they are cracked and there's infiltration from water coming in and the quality of water is not good. So it's usually up to the homeowner that actually does all the work."*

> *"It's considered a confined space, right. So you have to have somebody with those proper qualifications and then they also need to be aware of the disinfection procedures. So the AWWO recommends a certain amount of chlorine and then has to be set for so long. And so there's lots of steps to it. It's unfortunately not just get in there and shop VAC and that's done. Like there's other steps. So I think just making sure that people who are willing to do it are qualified to do it and they're doing it properly."*

> *"And they did after lots of discussions they increased [O&M budget] to $1,100. That extra $100 was supposed to cover cleaning."*

> *"That's what our contractor charges. In the spring here, that was our fee $1,200. Confined space and stuff like that. And you would need a pump and a back-up truck, things like that, to do an actual good cleaning of it. We did do a couple cleanings. This would have been about eight years ago when we did a couple of cistern cleaning on our own. But we kind of went away from that and it's better to have a contractor to do it because then we have some paper trail right to say that the cistern got cleaned on this day by the company or whatever. It seems a lot more than just saying only our guys went in and cleaned it. Yeah, I appreciate that part that there's a paper trail. It's proof that that work actually done."*

The cleaning and maintenance of a cistern requires the home residence to have an alternative water source while the cistern is being cleaned and the chlorinated cleaning water and all rinse waters must be drained or pumped out of the cistern with a submersible pump. The water is often discharged directly to the ground, which can cause ponding and runoff. In the Saskatchewan Region, the File Hills Qu'Appelle Tribal Council has published a guidance document to help First Nations safely complete routine cleaning of cisterns (Appendix H).

Some First Nations have received funding to conduct cistern condition assessments because there is a growing awareness of the high risks associated with these aging and deteriorating systems. However, many Nations have either not pursued or not been approved for such assessment activities.

> *"We haven't done that in a long, long time. Yeah, not since the early 2000s. Last time it was done I think something like that."*

> *"There are cisterns that were put in before us, like older cisterns where you know, they're probably like 30-year-old tanks or even older. So what you find is that you dig them up, and then you open them up, and it's a whole different world inside of them. We've seen some footage from an engineer that did a lot of assessments and they stick the camera down and you're just like, uh-oh, where you see like boots and toys. Well, a whole lot of stuff."*

KEY GAP: Unfunded or underfunded O&M results in unmaintained systems that are left in service well beyond the life span of the asset.

A Tribal Council with a technical advisor for water and wastewater systems indicated that reactive maintenance of cistern systems is made easier by carefully managing inventory and being ready to respond to issues.

> *"When it comes to cisterns and the homes, the pressure pumps that are attached to the holding tanks are the weak link. So they would require changing annually. And we kind of plan for that, to expect annually the pumps will fail, keep spares, for that volume of changeover."*

Trucks and Roads

All First Nations contributors that rely on trucks to fill cisterns noted the risks that trucks present in drinking water's journey from source to tap. As noted in Section 3.3, every transfer point of water in the distribution system represents a potential contamination risk and requires barriers and practices to mitigate these risks.

> *"Surely shouldn't we receive beautiful water, but after the top technology cleans the water, once we put it into that truck, put that beautiful water in the truck, drive it down the road, drop it into the cistern and how many contaminants does it get, you know contaminated water by the time it comes through your to your tap. ISC knows the issue right?"*

> *"You can have a drinking water system that is not on your long-term drinking water or boil water advisory and be dumping the water into a truck. Like most of these systems are like one truck right? So they don't get a chance to go offline to be to be cleaned a lot of the time, right. We see the water truck just bouncing around in that dusty summer with it with the top unlocked."*

All First Nations contributors that utilized truck haul services indicated there was a negative feedback loop between road conditions and truck performance. The more wear and tear and on the roads from truck runs, the worse the roads become. The worse the roads become, the more deleterious the road conditions became for the trucks.

> *"The truck hauling causes significant deterioration of the road. Roads are not safe during rain events. With 260 cisterns to fill, if a truck can fill one cistern and the trucks have to go there and back, that's over 500 trips a week. Homes with high occupancy may need two trips a week. So the number of truck trips can climb towards 1000 quickly."*

> *"Then there is repairs of trucks, the roads are often not paved, these are the our gravel roads, sandy roads. And so things do go wrong. We were driving somewhere and the whole wheel fell off. So that happens. And, and so there are those issues that that sometimes the trucks are not operational, and there are not enough trucks. So the guy driving around with a water truck, he works all the time, from what I've seen, when I'm in the community, eats lunch in the truck. You know, he barely had time to stop for us to sample the truck. That's how busy they are. And so sometimes there's not even enough time to serve all the homes. So that's another that's another issue. So not enough trucks. Too many homes."*

> *"The running gear of the truck like the engine, transmission, everything that makes the truck move is usually the first thing that will fail on the trucks. The system for delivering water is pretty robust. So if it can, we can often just buy the chasse of a truck, transfer the tank over to it. But yeah, the roads are not paved. So the roads are quite rough. The frequency of travel of these vehicles is, well it's daily, so they do wear out pretty quickly. So, typically you would expect a truck like that to maybe last five years, but our experience is two to three years with the truck."*

A First Nations contributor noted that good maintenance practices and proactive engagement with ISC can help prevent delays in replacing trucks.

> *"It's just like a preventative maintenance program, right. There's a life expectancy and you know, you have to start your succession planning for that piece of equipment."*

Remote and northern First Nations face significant financial and resource challenges when addressing truck and maintenance issues.

> *Because we don't have the capacity of heavy equipment or heavy-duty mechanics essentially, if something breaks down, it's usually about $10,000. Just it's the going rate $10,000 to have someone respond. It's a challenge so from a maintenance perspective, it becomes very difficult because we don't have that. We have quote-unquote, mechanics, in the communities but we don't really have that capacity and in at least my communities that's not being done appropriately. And then there's the road conditions for maintenance, we kept trying to manage grading roads without having a grader. You know, everybody gets stuck in driveways and driveways aren't plowed and it's just like this huge, huge, massive challenge trying to deliver water to the community members, right?*

In addition to the truck and road maintenance, some First Nations and Tribal Councils noted the important role truck drivers play in the delivery of safe water. There was a general concern for the lack of training and education of drivers.

> *"Yeah. Then the other part is having trained drivers. In all reality, those people should probably take distribution courses, but truck drivers, it's all they want to do is drive. I don't think there's a level of understanding of the importance there."*

> *"We do provide them with information on how to clean their truck. It's been talked about and I think it's in the in the decentralised water protocols, about the testing of the trucks and monitoring. So I'm working on a training for water truck drivers and it doesn't exist right now. [We've] talked about getting a training in place because we do have a training for the water technicians. It hasn't happened yet, but it's been talked about."*

KEY GAP: Water truck drivers provide an essential service and play a critical role in mitigating the health risks in cistern systems but often do not fully realize their importance in the distribution of safe drinking water.

Monitoring & Treatment

Water quality monitoring in truck-to-cistern systems must happen from source to tap - at the WTP, the truck, the cisterns, and individual taps to fully track the changes in water quality before the point of consumption and use. First Nations contributors generally felt confident in the water quality sampling occurring in the WTP, but sampling in the truck and individual cisterns were reported to be more heterogenous and less robust.

There is a diversity in delivery systems, with some Bands owning and operating the delivery trucks, while other Nations rely on contractors or a mixture of individual members, contractors, and First Nations owned trucks that complicates the clarity of water quality sampling in the trucks themselves.

> *"We have two or three band trucks. Okay. Plus, we have a backup. We have several members who have their own trucks."*

> *"Our water truck is sampled every week for bacteriological and we try and do a chemical analysis on it once a year."*

> *"We do test the truck. It's when I was at work, we will do a weekly which is down to about every two weeks or sometimes once a month to take a sample from the water truck. So, it does get done but not as, I guess as timely as I would appreciate it to be done every week."*

A First Nation contributor shared that bacteriological contamination on the trucks in their Nation are very rare, but that if one were to occur, there is a process in place that should be followed.

“You have a good driver on there. Ya know if there was a positive hit, I think that we would immediately inform the council first and then the Health Canada and then we would shock chlorinate the truck, of course to make sure that would all have to be sampled at that time as well.”

KEY GAP: Monitoring of water quality in trucks presents a challenge in some First Nations and represents a critical breakdown in the multibarrier approach to safe drinking water.

Sampling programs for individual cisterns ranged from on an as-needed basis to routine monthly sampling initiatives. Some cisterns in First Nations have not been sampled in years while others may be sampled monthly, quarterly, or annually. One contributor noted that cisterns are filled at least weekly and every fill is an opportunity for contamination. Any sampling that is done is a single moment in time that does not accurately reflect the intrinsic risk in cistern systems. Because of the difficulty in sampling and the recognition that the truck-to-cistern distribution system is prone to contamination through a variety of pathways, the File Hills Qu'Appelle Tribal Council recommends a blanket boil water advisory for all homes that receive drinking water from a cistern system. See Appendix I for an informational document the tribal council shares with its First Nations.

“You know, my cistern hasn't been repaired and it's been broken for five or six years or you know, it hasn't been cleaned in years. So those are the other challenges. So when we take a sample, it's just at that moment in time that it may be safe, but or not safe.”

One Nation reported that 68% of their cistern systems are on a boil water advisory due to maintenance or condition concerns and 32% of the cistern systems have tested positive for either total coliform or EC. In many Nations, the water quality data was not readily available and exact sampling programs were not known. This may be a function of who we talked with for this report rather than an actual lack of data. However, water quality data availability and transparency across all roles and staff that work with water is crucial for risk mitigation.

KEY GAP: Monitoring of water quality in individual cisterns presents a challenge in all First Nations contributing to this work and represents a critical breakdown in the multibarrier approach to safe drinking water.

General comments around water quality sampling in cisterns suggested highly variable practices.

“So we promote that they, at least one of the tanks is sampled weekly for bacteriological contamination”

“What we try to do here is that we try to do monthly bacteria testing on the systems you know, just to monitor for the turbidity, the bac-t reading, the chlorine residual in there. That way it kind of gives us, it's almost like kind of going above and beyond because you want to provide safe water to community … Then once we find the water is getting more turbid, or chlorine is low or too low we actually pump them out … and … refill.

Usually, it should be a cost towards the community member but I think we just absorbed that through the water plant and it's just a thing that we do."

"The challenge is, is that we don't always get into houses we do try several times, but sometimes people are never home. The risk though, is that that's one snapshot in time."

One contributor provided details and actions that were taken in response to a contamination event, indicating that rigorous cleaning and sampling was undertaken to ensure drinking water was safe for the community. They noted that in emergencies, sampling can be completed, but that routine sampling is problematic because of driver behaviour.

"Last year we had a sewage contamination of the water system, which led to complete cleaning of all of the cisterns and we tested everything in the community from cistern to distribution. And during that time, yeah, it was every water truck was tested multiple times. So they were told they had to be at the plant at the specific time and they were being tested that day. So it was very much a force issue, but it was in relation to that event. We don't have that that success on a routine basis because they sometimes try to avoid us. They see you and they drive away."

Very few First Nations had any formal data on POU/POE treatment systems installed on cisterns. One Nation explained that any treatment would be the responsibility of the residents and noted the additional burden this would cause for community members.

"And they also recommend that they install UV lights in their house and a filter. So that's a secondary protection against bacteria, every time the holding tank is open when we're filling it gets exposed to the elements. So having that UV light provides that secondary disinfection, but again, who is ensuring that the maintenance is being done on those lights and who can afford to keep you know- it used to be years ago $100 for another light but then you need to pay, so if you don't know, if you're not comfortable doing it yourself, you've got to hire somebody to come in and do it. So there's all those extra costs."

KEY GAP: Lack of evidence-based use of treatment devices in individual drinking water systems is a critical gap in the multibarrier approach to safe drinking water.

Perceptions and Water Usage

Many First Nations contributors expressed frustration with the persistence and growth of truck hauled water distribution but were managing the systems as best as they could to ensure their members had water. Some noted that cistern water is used for non potable purposes only, with drinking water coming from bottled water delivery or jug filling stations.

"So we have130 cisterns, but you know a lot of them come to the water plant for the actual drinking water right. Well, everybody on the cisterns have to fill up these jugs whether they go to town or they come to our plant."

“Yeah, if you can't get the bottled water, if you’re a senior, we accommodate and deliver the water. We do that once a week. We do it on Tuesdays. We have about 60 I think it was about 60 homes that we delivered bottles of water to once a week. We want them to drink good water.”

First Nations contributors and Tribal Councils understand the fiscal challenges facing the Federal Government, but shared concerns about the path forward.

“Our problem that we're having with our water here is going unnoticed. We wrote several letters to apply for the water claim. You know we're just not quite clear as to how the federal government are doing all this infrastructure. We're at a point where we definitely need some help or they need some definite answers from the federal government as to how they're going to fix a lot of these issues on Nations.”

“It's not going to be a cheap fix, right? Everybody knows that here, we understand it's going to cost us $10 million, even more. By the time it is done, the construction is done, we understand that, however, we still have an understanding of that the federal government is responsible for providing us with health and safety of our Nation.”

One First Nation contributor explained that increases in O&M and improvements in the water plant were welcomed and appreciated, but that the persistence of truck hauled water was not acceptable. They stated on behalf of their Nation “*We're just not healthy. That's the thing, right*?”

Decommissioning

Not all interviews and discussion with First Nations included questions about decommissioning. When the question was asked, some contributors said there was no decommissioning process. Only one First Nation reported decommissioning underground cisterns through backfilling with sand.

8.1.4. Decentralised Wastewater Systems

Through discussions with contributing First Nations and information collected from Tribal Councils, First Nations organizations, engineers and service providers, and researchers familiar with First Nations decentralised systems, lifecycle narratives were compiled to understand current practices in how systems are designed, installed, operated, maintained, repaired, replaced, and decommissioned for both septic field and holding tank systems. Importantly, discussion on shoot outs, or jet systems, where wastewater effluent is released directly to the ground service, were also included here. This is not a level of service discussed in ISC’s Water and Wastewater Policy, but it was included here due to the impacts and implications for public health. As noted earlier in Section 7.4 Constraints and Limitations, the examples provided here are not exhaustive and present a very limited picture of the diverse practices in First Nations. However, the details contributed here are a vital first-step to listening to First Nations and learning from the extensive tacit knowledge they have to offer.

8.1.4.1. Septic Systems Lifecycle Narratives

System Design and Installation

Onsite septic system designs varied from simple infiltration fields to engineered advanced treatment units. Many contributors mentioned engaging certified installers and engineers who followed provincial standards. In some regions FNIHB EPHO staff provided direct inspection assistance with onsite septic installation. Two First Nations contributors shared details about the permitting and approval systems they developed to ensure septic system installations conformed to Nation by-laws and provincial standards.

> *“It's usually designed, and we install it by the contractors that are built into homes and stuff or, or how they tie into the water system, but it's designed by an engineering firm that's been working with our community for a number of years.”*

> *“The house will depend on the lot size. So if we’re anticipating bigger than 1200 sq ft footprint they’ll have to build up. They’re already limited to the footprint of the building depending on the lot test. We’re tying to keep distances from each house to a minimum distance of 3 meters on each side. So 6 metres between houses.”*

> *“We use licensed contractors. There are several here on the territory that do install, and we go out with [our EPHO] to inspect them. Prior to being installed they have to have approval and then after they're installed, to go out and do another final inspection, and then again to make sure that it's seeded and grass is properly growing. So all of those inspections are done by [our EPHO] from ISC.”*

KEY ENABLER: The use of certified designers and installers, following provincial standards, and EPHO inspections help to ensure appropriate onsite septic systems are installed.

Two First Nations shared that there has been significant advancement in the design, planning, and installation of onsite septic system in the recent past. In general, all First Nations contributors understood the serious public health impacts of poorly installed systems, but few Nations had the necessary management structures in place to ensure proper system design and implementation.

> *“Because we have an inspector, we can do that. Our First Nation holds the governing body so we work closely with them to make sure all the contractors are getting the details and they're doing the correct work. Using the proper material, proper piping, you know all that stuff. It's not like it was 15-20 years ago.”*

> *“The septic system installation, which now, lately, we do install them to [Provincial] standards. That's only when I say recently, I mean that's only in the last year because we were installing - I don't know what you want to call them, "illegal systems," "not approved systems," "dirty systems," whatever. And we were getting, I guess, depending on how they were maintained, complaints that they smell, the backyard is getting kind of saturated, but it took us a while to get around to get in a consultant now. So, yeah, in the last say five, six months, we've installed 10 systems. These are new systems, like 9 out of 10 are a new construction, new home construction and then one of them was*

a problem system, really a lot of problems. So we've done 10 of those up till this week. Those are done by an outside consultant because we said well, what do we need to have it designed to that law regulation, we needed to have a civil engineering technologist [approved] in the province"

One Nation noted that internal organizational silos complicated the installation and maintenance of onsite septic systems between the Capital department and Public Works. Recent staffing changes have resulted in improvements of the design, installation, and operation and maintenance of the systems.

"So pretty much what happens is if there's any new infrastructure that goes on, or replacement, Capital, does the installation, construction, and it gets turned over to Public Works to operate and maintain for the next so many years until it's time to replace it or redesign it, study it whatever, to figure out what's going to be needed. In this case, we knew we had a pretty good idea what needed to be done, but we weren't getting too much cooperation on changing the design. And the outlook wasn't good for us because we didn't know if we were dealing with inadequate systems. Great. Now we got more complaints and calls added to the list of the other 400+."

Not all systems are installed by certified or qualified contractors, with some Nations noting that individuals can install their own systems and that preventing this practice is challenging. This was particularly true in the case of CP land.

"But we do have some people who will try and install their own, on their own, especially if like, there's a lot of people around here who have money, people with the pot shops and whatnot. So they're able to just go ahead and do whatever they want, it's their property and we have no control or say whether they do or they don't. Which could potentially lead to issues of well contamination and then we get the neighbors calling and there's nothing we can do about it because there's no bylaws here to enforce anything."

The sentiment of concern for aquifer protection was mentioned by several contributors, particularly when asked about general risks in decentralised systems. A Tribal Council contributor noted that the engagement of engineering firms to evaluate the condition and safety of decentralised systems has begin to shed new light on these vulnerable systems.

"And then the same when we're talking about some source water protection. We do have communities that have a community well, and they have five or six homes right in that area. With septics you know, it's a risk. We don't see any E. coli… but there is still that chance that you can contaminate the wells especially if they're dilapidated."

"I think just in terms of identifying these individual systems, to me over the last six years, in my position, I don't see the government really focused on wastewater, or groundwater water. That's the challenge here, but then I think we kind of opened some eyes when we work with consultants."

Key Gap: Poorly installed or poorly performing septic systems present a serious risk to groundwater quality. Insufficient setbacks between septic systems and wells increase the risk of contamination.

Several First Nations were either engaged in, or recently completed, onsite wastewater system surveys or condition assessment activities. A First Nation that recently completed an onsite septic asset condition assessment project and developed an onsite septic wastewater management plan with a regional engineering firm shared the findings with the project team. The asset condition assessment found that most onsite systems in the Nation were conventional systems including pipe and trench, mounded pipe and trench, and plastic infiltration systems. The system servicing the Health Centre was an engineered system. Of the 65 residential systems located, 39 of them were determined to be greater than 20 years old. Eleven systems were found to have non-critical issues and 15 systems had critical issues. The assessment also revealed four systems located in lots that were too small to accommodate a drainage field and were thought to have direct discharge in ditches.

Shoot-out Systems

The Water and Wastewater Policy and Level of Service Standard does not include shoot-outs or direct discharge of wastewater to the ground surface, although some provinces allow direct discharge in certain rural contexts. While FNIHB does not officially approve of these systems, they are commonplace in Nations across the prairies due to a confluence of environmental, maintenance, and funding realities. Installing adequate treatment systems in poorly suited soil is prohibitively expensive, with sand mounds requiring significant material to be hauled in. Likewise, advanced treatment units are expensive and require continued maintenance and operational care. Many prairie First Nations choose the reliability of a direct “shoot out” or “jet” system despite the aesthetic and public health concerns.

> *“The majority of them are jet systems. Yes. And I'm going to say only about six mounds out here”*

> *“We're finding that a lot of our infrastructure is just failing and aging out. And sometimes with the lack of funding or just the amount of emergencies, our plumbers would have to do emergency repairs by installing a temporary shoot out redirecting away from their house, but sometimes your shoot out becomes permanent because of funding and it's just yeah, there's a lot going on not only just outside, but even as well as it could be from the inside [of the house].”*

> *“Because right now [our] Nation is still on many shootouts, my [relative’s] house is one and the line is cracked in the back end. Sewage is just pooled in the back of her house and that's been going on for over 20 years. So these new builds even with the rapid housing initiative, the bare minimum conditions and standards that have to be met they will put it in the proposal.”*

> *“And generally the preferred options in rural [Province] would be you know a buried septic field or if you don't have the right soil conditions or high groundwater table you*

put in a septic mound, which is essentially a septic field but above grade and through talking with that and the housing department and the team it was actually decided that the Nation would proceed with open discharge systems, which are not going to shootout in the way that it was before, they're still allowed under the [provincial standard]. But it would get it at least a safe distance away from the house and part of the reason the Nation felt that was their only option really that they could go it was there was no mention of any sort of long-term funding for operation and maintenance."

KEY GAP: The lack of funding for proper system design, installation, O&M, and repair of septic systems result in the utilization of direct discharge of wastewater, which has serious environmental and public health risks.

Operation & Maintenance

The maintenance and operation of onsite septic systems, much like decentralised drinking water systems, vary by region and Nation. First Nations public works and water and wastewater operators who contributed to the study shared that Nation staff do provide support, when possible, for failing or problematic systems. However, many Nations noted that the majority of onsite septic systems were considered failed or failing with no budget for comprehensive rehabilitation or replacement of the systems. When asked what the biggest risks and challenges were with onsite septic systems were for the Nations, the responses varied based on First Nations governance models, whether the home was owned by the band or an individual, and what the nature of the problem was.

"It changes but a lot of them are septic systems failures, over overflow leach fields. The emptying of them. That's really the most calls we get."

"So basically, if again, if it has to do with the collection system infrastructure, then yeah, then they would call us and then we would address it. As it stands for these field beds, they're kind of more or less on their own. So then the idea is like if there is any remediation, then it would have to go through a different program basically, like a housing program there where we would say, okay, well, we can get that fixed for you. But you're gonna have you know, just get a loan and we'll consult."

First Nations contributors, Tribal Council representatives, and engineering service providers noted the value of decentralised asset condition assessment activities to begin to get a sense of the scope and severity of the problem of failed onsite septic fields.

"Yeah, so we just did a couple of years ago, we actually did a survey with one of the engineers who came in assessing septic systems here in the community. So last year, I switched out two complete ones to field bed. So this year, I got 13 and I'm doing this spring switching over. A lot of issues we're having now is they're either old or they're falling apart."

"The community solely relies on individual septic systems. They do not do anything in order to maintain them, there's no maintenance. I recall, years ago when I first started

saying 'you guys got to cut your fields.' No one cut them. We offered to get every community a summer student program that would go around and weed whack and cut grass and we told them to you know, cut the fields. Everyone's fields have to be cut. Now it's getting to be a challenge, right? Because now you got all these major roots getting deep down in there and they compromised the whole septic field. I had this conversation yesterday with the housing manager. And I said we're going to have to get a study done. And address how many [systems] are failing just because of lack of maintenance. It's hard because I think the biggest challenge here is, you see a lot of turnover in your operations and maintenance in the housing people. You know, you can tell one person three months later, they're gone. Six months later, they're gone. It's a never ending, vicious circle. You can train somebody you can tell somebody and then you find yourself repeating. Repeat. Repeat. Repeat."

KEY GAP: Poor maintenance of onsite septic systems and the lack of asset management results in aging and failing systems.

One onsite septic assessment report noted that septic field breakthrough often led to odours and nutrient loading to nearby surface waters. A common cause of field failure was undersized or poorly sited fields, significant overgrowth and root damage, and damaged fields caused by vehicle traffic and compression. Many tanks were also found to be unsuitable for purpose, damaged, clogged, and/or inaccessible for pumping. Approximately 20% of all systems in the Nation need immediate replacement and another 28% of the systems are over 20 years old and will likely need replacement in the next 10 years. The same engineering firm was hired to evaluate the feasibility of a centralised wastewater system, as well as possible onsite system upgrades and improvements to ensure proper wastewater treatment. The estimated cost of replacing and repairing systems was upwards of $1M over the next twenty-years in 2022 dollars.

While a small number of First Nations operated their own vacuum truck for septic tank emptying, most First Nations relied on contractors to empty septic tanks and waste is delivered to an off-reserve waste treatment facility. Old and deteriorated tanks pose risks to the vacuum trucks.

"The septic system, these tanks, they're 30 plus years old, when you lift the concrete to suck out the waste some of those chips and rocks get in there and then it messes up the pump."

First Nations in British Columbia noted that disposing of septic waste has become harder in recent years due to regulatory changes in septic sludge acceptance.

Perceptions of Safety and Risk

Both First Nations and Tribal Councils noted the importance of safe onsite wastewater treatment systems to protect both public and environmental health. The lack of adequate and sustainable funding for both installation and O&M prevented Nations from choosing the types of systems they preferred. In most Nations that contributed to the report, the most affordable – not the most technically appropriate – systems were installed in homes, resulting in failed or insufficient treatment.

“ISC introduced us to Elgin [an advanced treatment unit with dispersal field] and we currently have [X] and these units installed. They're $70,000 per unit. But these septic systems are like a geotextile filtration model that treats the water, it's just another step to make sure there's no contamination of our lands, our watersheds or even our water sources.”

“When it comes septic tanks, basically every single home now only has a septic tank with it. We used to have these old septic field systems. But after 20 or 30 years they break down into we just end up closing that field and we started pumping like it becomes a daily or weekly pump out tank.”

KEY GAP: Current policies and practices prevent necessary investments in suitable onsite septic systems and result in an abundance failing and high-risk systems.

Decommissioning

There were no Nations that discussed a formal decommissioning procedure for onsite septic systems. This may be because one did not exist or because the line of discussion did not fully cover the topic.

8.1.4.2. Holding Tanks Lifecycle Narratives

System Design and Installation

The ICMS data indicates just over 17,000 homes across the nation rely on truck collected wastewater systems, however these systems are self-reported and ISC staff noted this number seemed to over represent holding tank systems. In discussions with First Nation contributors the term “septic tank” was sometimes used to refer to holding tanks and vacuum pumping of septic tanks was occasionally conflated with “truck hauled” systems. These systems require significant operational effort with weekly pump outs, so accurately inventorying these systems is paramount. Current available data indicates Alberta, Manitoba, and Ontario have the highest number of holding tank systems. In First Nations that confirmed reliance on holding tanks for wastewater storage prior to truck haul to a treatment facility, the reason for these high maintenance systems included geologic and soil conditions that precluded infiltration fields, failed septic beds with no funding to replace them, because of the proximity of the house to water courses, and because of small lot sizes that can not accommodate a drainage field.

“One of the reasons why these systems exist is because the ground condition in the communities isn't the best. So they'll be shallow bedrock. Our preference is to put them (holding tanks) out on the surface in an insulated building, or a lien-to on the building or whatever makes sense for the site. That building itself may vary, but the infrastructure within it would be the same for every home as far as how, how the wastewater gets into it and how it's removed from it. So yeah, they, but they are separate from the, obviously you don't want a wastewater tank in the same space as your cistern. So there's a physical separation there.”

“And so that's why when it comes to the septic fields that are failing and there's not too many anymore, there's maybe about 20 to 30 off the top my head, but once the field goes and it becomes a holding tank we just end up pumping it but we don't make any more fields anymore. We're not allowed to do that. Not only that when it comes to like our reserve, we're running out of space and you know, fields take up quite a bit of space, right? We don't want to use up any more than we already have.”

“When you start getting four or five buildings round in the same area, the setback is impossible to follow, right? Yep. The only way around that is to put in a closed tank and have it pumped out on a schedule. The only way to know that really is to just run the building and see how long it takes for it to fill up. Somebody needs to go out there and pull the cover and say you know what, we're getting kind of full. We should probably call in a drop. Yep. That's one of the biggest things right there.”

KEY GAP: Holding tanks have low installation costs but high operational costs over the asset’s lifecycle. They are generally not used for sustainable long-term wastewater management solutions.

Much like in truck-to-cistern drinking water cisterns, the vacuum trucks used to empty the holding tanks and transport the waste to a treatment facility require significant maintenance and repair and cause significant deterioration to the roads. One First Nation contributor also noted the importance of planning the placement of a holding tank to allow access for pumping.

“The wastewater collection is fairly straightforward. It's all by gravity. There's no mechanical components other than the piping. It's not a septic tank. It's just a holding tank. So there's no internal components for separation of scum and settling of the solids. That's all done elsewhere. So the limiting factor is the truck. And the wastewater truck is little more, well, it's a lot more technological than a water truck. Because it's a vacuum system and vacuum pumps and water removal from a vacuum and everything else, has to be taken care of. But that is fairly robust as well. The running gear on the truck is what challenges us. The engines, the transmissions, suspension, and everything like that.”

“Like we try and coordinate with housing more with my septic tanks and with my trucks. Before, the contractor would come in and he would put a septic tank where the driveway was right and so like I think it's easy to plow it over. So now we're kind of redesigning our homes to where the septic tank has its own kind of little driveway and then the homeowner can park in different areas. Kind of eliminating the operator accidentally hitting the well or the tank and but also, when you got small driveways and people are parked in front of the tanks, they're not going to get pumped out and then some more problems come up right. Access.”* * the contributor was discussing holding tanks and pumping schedules, but referred to the tanks as septic tanks.

Operation & Maintenance
As noted above, holding tanks themselves do not require significant operational or maintenance effort, particularly if the collection system from the house is gravity fed. Most First Nations who contributed did not have high level alarms, as required in many provincial jurisdictions. The main O&M component of a truck hauled waste system for all First Nations contributing to this work were the vacuum trucks and the impact of these trucks on the roads.

> *"The issue is they tell you the truck is good and it lasts. But the factors that come into play are the roads. We have gravel roads, so when it rains there's more pot holes and not only that but when you're adding 2000 liters of gray water into a tank you're putting a lot of weight and load on the trucks and you're going to wear it down like a truck when they tell you like it'll last five years. It certainly will if it's empty and you're driving on paved roads, sure. If you're putting all that stuff on the gravel road it's not going to last five years, going to last three maybe four."*

> *"The bulk of my budget comes from septic trucks because they are on the road so much like they're pumping, like I pumped out tanks on Christmas Eve even though the guys are busy, right? So yeah, the trucks are my main source of funding, like O& M funding, like repairs, because they're on the road 24/7."*

> *"Actually, I had to drive a truck for quite a few years. There are times scheduled, but there's a lot of factors that come into play, a lot of factors holidays, right? Mom and Dad are home for the weekend with the kids and your water usage doubles. People are sick. Water usage is going to double. So there's a new baby in the home, water usage is going to double. For whatever reason, the size of the tank also like you're basically being pumped out once a week. Some of them are twice a week. I mean, I got a woman there she's got her daughter and she's keeping three younger females okay, so these five or six females are in the home and so their water usage is high. I have them being pumped out three times a week. You know, naturally they go through a lot of water. And so that's compared to a grandmother who like I get pumped out once a week and her tank isn't always full. So it all depends on your own usage also. So yeah, like some people conserve water more than others. And like I said, they're on a schedule and they're pumped two, three times a week, 7 days a week, and it's 365 days a year."*

KEY GAP: Holding tanks cause broad collateral impacts on other infrastructure and require significant operational effort.

Similar to what was heard about truck hauled water systems, the winter, and other seasonal, conditions present serious challenges to holding tank operation and maintenance due to the difficulties of accessing the holding tanks and the risk of shifting or collapsing a tank if trucks drive over them.

> *"There's times especially in the wintertime with big snowstorms, basically if I have a snow storm then it's all hands on deck. I'm going to call extra guys to help because when there's a snowstorm, everyone's a priority right, so we need to clear roads for 450*

homes in eight hours. That's impossible. So I am hiring guys who can run the machines here or renting plows with like on ATVs and those come with problems sometimes the guy doesn't know the home he's going to plow over the septic tank, and so he cracks the lid or whatever. There are times where I got to repair tanks or because of locations and all that but the design of these things, this was all contractors and how they designed before I got in."

We do have to change a lot of tanks arising from collapsed tanks because these tanks are bigger and the trucks are going over them during the winter. They've moved that ground and these tanks do end up getting brittle and they do collapse. So that's another added costs. And then also, because we're in a in a very swampy area, a lot of groundwater, so it actually a lot of times those will actually pop the tanks right out of the ground."

One First Nation contributor shared that they are replacing smaller holding tanks to allow for longer collection periods between pump outs.

"We pull it out and put in a new one. That's the thing to like when we come into these fields. And a lot of the older units they got these small little tanks in them, so we just pulled them out and replace them. In some of the areas of their reserve, we got a lot of bedrock. And so at the time, we weren't equipped to dig tanks. We are now obviously, with our machines and the equipment we have now but last winter I had to jackhammer with a bunch of rock and put in bigger tanks for people because they've only got the 500 gallon and we were pumping it every two days. Just like I said, if it needs to be replaced, we rip it out and put another one in there."

Wastewater Treatment Facility
All First Nations that reported a significant number of truck-hauled wastewater systems have community wastewater treatment facilities where they empty the vacuum trucks and treat the wastewater, generally in a lagoon. As housing with holding tanks increase, the capacity of the lagoon(s) must be considered to ensure wastewater can be treated safely.

"We have two different treatment processes. So we have a sewage treatment plant in the south end of the community. And that's where the majority of our trucks go and dump their sewage from the holding tanks in the north end and in the south end the community has the lagoon."

"And then maybe there is a few that just pump out and pump with a vacuum truck. So more of a holding cell tank, and that's taken to a quote-unquote sludge drying bed at the landfill, and in my opinion, it's not an adequate piece of infrastructure for that."

"On south side what we do is, if there is an existing lagoon and we try to tap into that we would base it on the capacity that's there, how much it's been used. The engineers do a calculation and then we try to find a way to tap into it to make use of an existing to the lagoon, so we're not making any more."

Decommissioning

No First Nations contributors discussed decommissioning procedures for holding tanks.

8.1.5. Climate Change

Many contributors, from First Nations staff to technical experts and practitioners, noted the varied and significant impacts of climate change on the installation, operation, and safety of decentralised systems. There was general consensus that climate change impacts will exacerbate current decentralised system risks, for example the aging and deteriorating well casing and well head conditions will act as a critical pathway for pathogen contamination in a flooding event. Warming temperatures, extreme precipitation events, droughts, wildfires, and shortened and warmer winters impact water and wastewater services in complex and compounding ways. A non-exhaustive list of key climate change risks highlighted by contributors include:

- **Reduction of ice roads** – many tribal councils of northern First Nations noted that ice roads are present for shorter periods of time, which limits the window for construction planning and staging, complicates the delivery of goods, and increases the costs of services and deliveries. One tribal council technical advisor noted that shipping costs have increased significantly because ice road trucking companies have had large increases in insurance premiums due to lost or damaged trucks on the unstable ice roads. These additional costs and condensed service windows present significant challenges for remote Nations.
- **Melting of permafrost** – warmer temperatures throughout the year have also causes melting of permafrost, which has caused soil slippage and loss of land in northern First Nations. These changes can have impacts on infrastructure and result in the loss of land through significant erosion along riverbanks, etc.
- **Overland flooding** – extreme precipitation events that exceed infiltration rates can result in overland flooding which inundate onsite septic fields, mobilize pathogens and other contaminants and can lead to ponding and flooding of wellheads. These extreme events are known to increase contamination of individual wells and impact treatment efficiencies of onsite septic systems. Overland flooding can also lead to increased groundwater infiltration and result in contamination of buried cisterns.
- **Wildfires** – wildfires can cause direct damage to infrastructure, including melting plastic wellheads and damaging cisterns, however there are also significant impacts to surface water sources that may be used to provide drinking water in truck-hauled systems. Wildfires drive increases in NOM and DOC in impacted watersheds which can alter source water quality and challenge treatment processes. The absence or inadequacy of fire flow in many Nations was mentioned as an area of significant concern.

8.2. From Indigenous Services Canada

Through this work, several discussions were had with ISC staff primarily to identify prevalent system types within each region, discuss possible First Nations to reach out to, and to characterize areas of concern in decentralised systems. Through these fact-finding discussions more than 25 ISC staff provided valuable information and context for this report which included identifying gaps and identifying areas for improvement. Direct quotes will not be presented here, as not all conversations were recorded. Rather, the project team has synthesized what was heard from staff, combined with our own observations collected during the completion of this project, to construct the themes provided below. Additionally, available FNIHB drinking water reports and ISC funding documents, both National and Regional, were reviewed and used to inform this section.

FNIHB – RO internal communications and process integration

The Strategic Water Management team, RO engineers, the Environmental Public Health Division, regional Environmental Public Health Mangers, and regional EPHO staff have contributed to, and informed, this project. Through this process staff have acknowledged that the transition of FNIHB from Health Canada to ISC represented a substantial organizational change that is still in the process of maturing. It was shared with the project team that FNIHB is considered, functionally, to be a service organization while RO acts more as a funding agency. The cultural and practical implications of these different guiding philosophies and roles were apparent to the project team and explicitly stated by ISC staff. These differences impact mission and scope of the two divisions.

FNIHB's Drinking Water Program includes annual, or as needed, microbiological sampling of decentralised drinking water systems in First Nations as well as visual inspection of well heads and cisterns, though limited resourcing makes adequate sampling a challenge in many regions. There exist no specified requirements for chemical or radiological analyses of decentralised systems. FNIHB also provides decentralised wastewater system support, as requested by First Nations, including advice and recommendations on the siting, design, inspection, and decommissioning of onsite septic systems. These support services are outlined in FNIHB's National Framework for the Environmental Public Health Program in First Nations Communities South of 60°, which also include responding to complaints associated with failing onsite systems (Health Canada, 2009b). In contrast, RO engineering staff have limited engagement with decentralised systems in most regions, because, while there is a funding mechanism for these systems through CFMP, there has historically been insufficient funding for decentralised systems. There has been a recent increase in RO funding for decentralised asset condition assessment activities, repair and replacement programs, and funding for feasibility studies to extend distribution and collection systems in some regions. The value and benefit of strong synergies between public health and engineering services can be seen in some regions. This will be discussed further in Section 11.

Data-sharing and evidence-based actions

There was a noted disconnect between water quality monitoring results and a coordinated response to address underlying decentralised system risk. In regions where FNIHB tracked (formally or informally) drinking water advisories on decentralised drinking water systems, these advisories did not seem to directly result in broader ISC action. Both RO and FNIHB staff have a level of awareness of the risks inherent in these systems, but no framework exists to translate this knowledge into improvement. Moreover, the level of awareness differs greatly between regions and can differ greatly between RO and FNIHB counterparts, depending on regional practices. Data on the number of decentralised drinking water systems shared by ISC with our project team had significant discrepancy depending on the source of the data. ICMS housing information, self-reported by First Nations differed widely from WaterTrax data used by FNIHB in its Drinking Water Program National Annual Report (DWPNAR) in some regions by as much as 200%. FNIHB reports, both annual and national, acknowledge that cistern and well numbers are always changing in First Nations and are not comprehensively tracked, so data presented in the reports only reflect the decentralised drinking water systems that have been sampled in the past.

Relationship between water and wastewater service providers and Chief and Council
There was anecdotal evidence that some First Nations operators are limited in their abilities to manage and maintain their centralised systems (which in the case of truck-hauled services are critical components of decentralised systems) because of obstacles, communication issues, or ineffective relationships with First Nations leadership. This was also noted in discussions with First Nations water operators, First Nations organizations, and Tribal Councils. It was suggested that separation of water and wastewater services from political cycles could be beneficial in some circumstances.

Saskatchewan's transparent funding process
RO in Saskatchewan releases the capital plan for all First Nations communities to show where money is being committed, including all submissions for funding requests, both for funded and unfunded projects. This process is favourably viewed across stakeholders, as it provides transparency in spending and provides useful examples and context for other First Nations as they identify and prioritize their budget needs.

Need for integrated water service framework
Decentralised system components are generally considered to be a function of housing projects. RO Engineering staff report they are not consulted on cisterns, individual wells, septic system design, or holding tank installation. ISC staff note an internal disconnect regarding where decentralised systems responsibility should lie.

FNIHB staff shared that having separate centralised and decentralised protocols creates unnecessary and problematic segregation in service provision and results in a fragmented policy landscape. This landscape is conducive to costs savings for the federal government because it is structured to be prohibitive for connecting a new or existing home to a centralised distribution or collection system. FNIHB staff suggested that an integrated water and wastewater policy for all service levels would allow for a holistic approach to designing and funding continuous improvement in services and facilitate a phased transition away from high-risk systems toward low-risk systems.

9. Gaps and Risks

Transcripts and notes from First Nations meetings and visits were coded to identify key gaps and key enablers in decentralised water and wastewater service provision using both an asset lifecycle framework, i.e. installation through decommissioning and a multibarrier approach framework. This analysis was aligned with the findings from the literature review presented in Part 1 of this report to categorize gaps and risks into overarching themes. Figure 9-1 shows the three organizing categories of key gaps identified in decentralised drinking water and wastewater systems in First Nations. The base, or foundational gaps i) inadequate funding and ii) management barriers and obstacles underlie the pinnacle gap of iii) lack of knowledge, sharing, and action. Within these broad categories, specific gaps and related risks for drinking water and wastewater systems will be discussed below.

Figure 9-1. The three over-arching categories of gaps existent in decentralised water and wastewater systems.

9.1. Inadequate Funding

Decentralised asset costs largely fall directly to the First Nation, and in some regions and Nations directly to the residents, because current ISC policy does not adequately address these system types. Because there is no comprehensive funding approach for decentralised systems, Nations rely on a mixture of own source revenue, A-base funding for housing, and/or reallocation of other budget areas to supplement the cost of decentralised system spending. However, in many cases, decentralised system assets are unmaintained, uninspected, and unmonitored until there is a crisis. However, sometimes poor water quality and failing onsite septic systems are not prioritized for decades, due to lack of monitoring. **A common theme across all stakeholder groups was the recognition that capital, particularly related to decentralised systems, is dealt with through a reactive, triage basis of addressing only the most pressing issues**.

As articulated in Figure 9-2, the current gaps in funding for decentralised systems extend beyond the cost of asset installation, management, and monitoring to a broader collection of unintended consequences. Not only are the systems themselves un-or underfunded, but they result in collateral costs that are unquantified, and in some cases unquantifiable.

> *"But what it fails to take into account is I can build a new home. I put in a cistern under the auspices of creating that house or creating that additional residence. But what hasn't*

gone into it is what is the impact on the road? How many trucks do I need? What's the maintenance on the truck in ongoing operational cost? What is the cost of the person driving that truck? So, all those pieces haven't been incorporated into the overall life cycle cost; that piece doesn't exist anywhere. They're often looked at as a short-term cost effectiveness, right? Oh yeah, we can build this house for $100,000. Get in a cistern and we're good to go. But none of that's built in, but what's also missing is the public health consequence cost. Nobody ever factors that in. What is the cost of maintaining that cistern? What's the cost of shock chlorination when that home goes on a boil water advisory or do not consume advisory because the cistern is old and is now cracked? What's the cost of bottled water? What's the cost of treating a person with illness in that home? What's the cost of ongoing testing of that system? Even if it's once a year. And then what's the cost of paying that person to go test that once a year for the lifetime of that house, all those costs are not factored in."

While there is a funding formula for the number of trucks, driver salaries, and O&M on trucks, as these elements are considered parts of a distribution system, there was a general sentiment from contributors that the current funding paradigm creates significant gaps, some of which are hard to put a price on.

Cascading and Compounding Impacts of Inadequate Funding

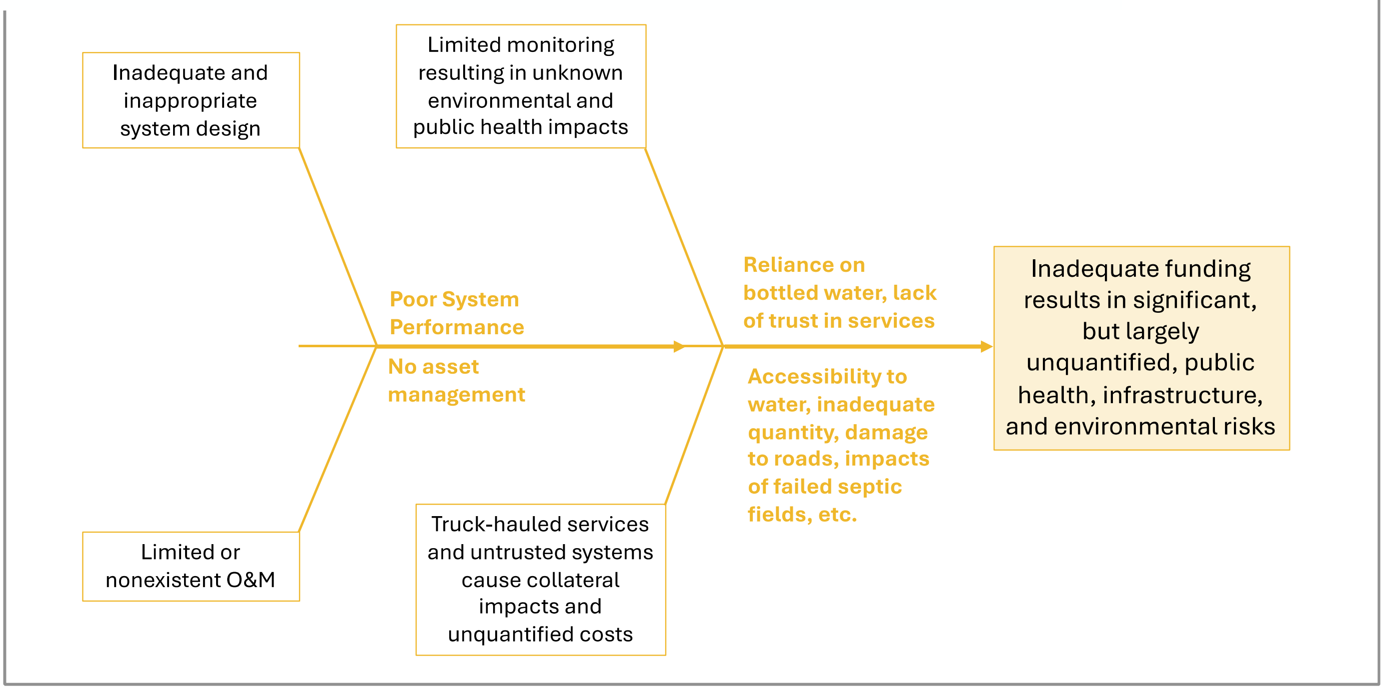


Figure 9-2. Examples of key funding gaps and associated risks that exist due to these gaps.

The limited funding scope of the FNIIP was also highlighted as an obstacle for financing decentralised systems in a realistic and operationally robust way. Because FNIIP is a function of the Capital and Management Program, the process is highly biased toward capital investments. Funding is limited to the designing, building, and operation of a federally funded asset. This fails to consider all aspects of the management and realities of infrastructure. As infrastructure assets grow in number and complexity, both organizational infrastructure and asset management processes need to be funded sustainably. Some Nations noted the need for asset managers and additional public works staff, as well as other capacity building positions such as a project communication specialist to keep the Nation informed about the progress of projects and training managers to ensure First Nations members are able to train for these positions. The FNIIP process does not explicitly address these broader funding limitations in First Nations.

The findings regarding funding short falls and the implications for system design and operation are not new. Other First Nations experts and organizations have documented the importance of appropriately capturing the real cost of water and wastewater services in First Nations. OFNTSC and researchers such as Tim Vogel and Melanie O'Goreman have presented and published on ISC's problematic funding formulas for assessing lifecycle costs of centralised systems, which are critical when comparing centralised and decentralised system options. This will be discussed further in Section 11.

9.2. Management Barriers and Obstacles

Inadequate funding and the current policy environment both contribute to, and are exacerbated by, broader management barriers and policy obstacles. Because decentralised water and wastewater assets are integral to housing strategies, decisions around the construction of new homes have long-lasting impacts on a Nation's ability to manage drinking water and wastewater services.

As shown in Figure 9-3, insufficient investment in services for new homes can result in the overuse of low upfront cost decentralised systems. Policies and practices prevent the maintenance and

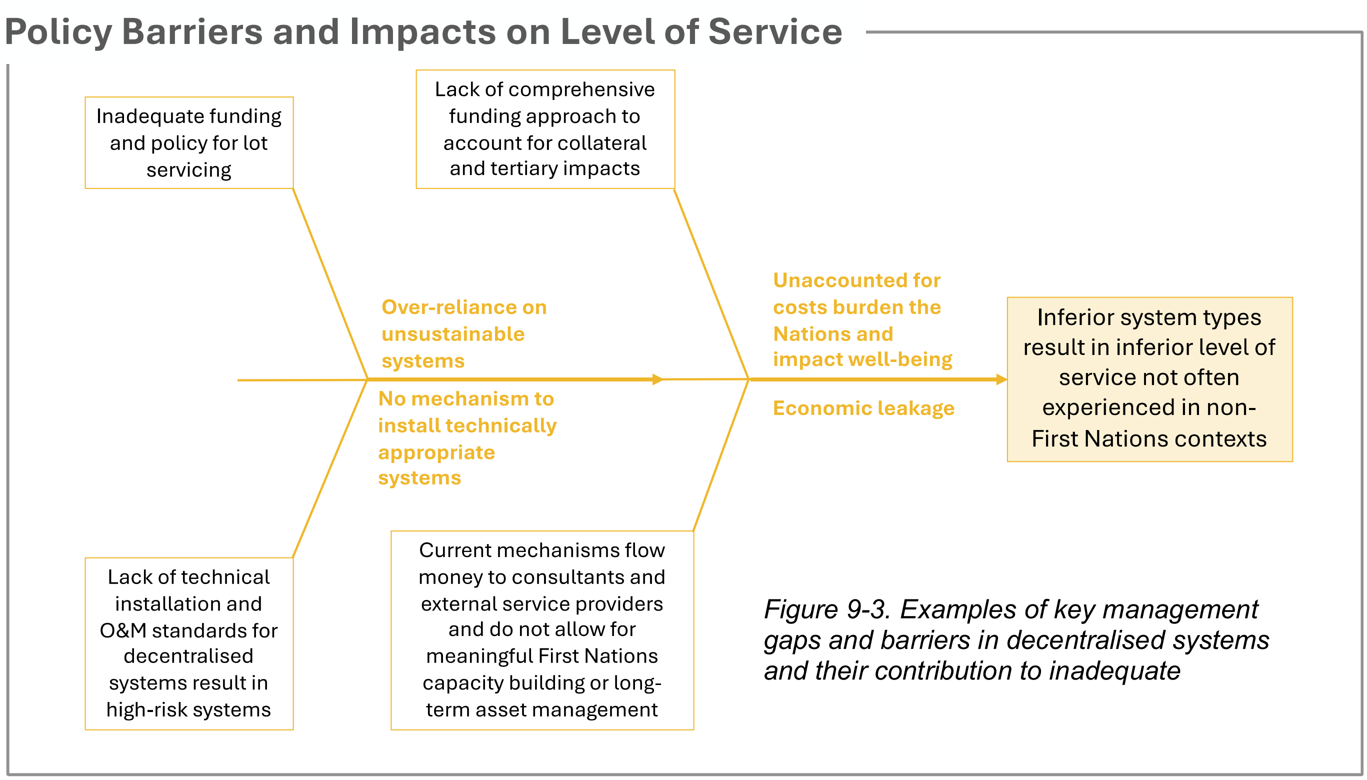


Figure 9-3. Examples of key management gaps and barriers in decentralised systems and their contribution to inadequate

monitoring of these systems and can result in poor system performance. If the Nation seeks to address these failing systems, feasibility studies for asset condition surveys or the transition to centralised systems have been identified as critical obstacles for First Nations. Many First Nations contributors shared that they must resubmit the same feasibility study year after year and watch the cost of the project climb as the years pass.

> *"Yeah, and we did this we did this thing in 2010. We engaged an engineering company to come and do the drawings. And design and all of that. And at that time, the project would have cost $X million. And we were expected to come up with I think it was they wanted a 60/40 split so they would pay I believe it was the 40 and we would pay the 60. Since then, it's changed around now. I heard a while back that it was 50/50. But when I got the numbers redone again, now it's coming in at $3X million. Yeah, the same amount as knowing that was from 2010 to 2024. So 14 years it's gone up 3 times the amount. So that's why I think that it's paramount that we do it now because five years is going to be $5X million… think we would like to take out a loan or something like that. We're going to try and get ISC to pay for as much as we can on the system because it should have been done 10 years ago, 15 years ago, right."*

First Nations contributors also shared that many policies and processes for housing and decentralised systems are fragmented and siloed, causing many inefficiencies for the Nations. These inefficiencies impact both O&M for existing decentralised systems, as well as investments in major capital projects.

> *"So basically, if it has to do with the collection system infrastructure, then they would call us and we would address it. As it stands for these field beds, they're kind of more or less on their own. But if there is any remediation, then it would have to go through a different program basically, like a housing program maybe, where we would say we can get that fixed for you. But you're going to have you know, just get a loan and we'll consult."*
> *"Yeah, [the new system] will be probably about 90% centralized for water. And, again, like we discussed, ISC is not providing funding for [wastewater] collection. So even though we have a trench going down the road, they're not getting sewer. It sounds goofy, but we're okay. I'm taking it where we can get it right."*

The project team heard from all stakeholders – First Nations administrators, engineering firms, First Nations technical organizations, and ISC staff – that processes for minor and major capital and housing management were overly complicated and a significant barrier to progress. A common theme in the discussions was the impact of the siloed approach to asset management, particularly between the point of transfer between ISC departments, i.e. water and wastewater systems and housing. Water quality is impacted by all parts of the distribution system, including premise plumbing, and the fragmented approach to management was noted as a serious barrier. All contributors noted that a significant part of their work was filling out reports and "jumping through hoops" rather than doing the work itself. Most organizations and Nations we spoke with reported working on projects for multiple years or decades in order to make progress. This was highlighted as an exponential challenge because of frequent turn overs in key positions over these long project periods, both in First Nations administration and ISC, cause serious disruptions.

One contributor from an engineering firm with decades of experience facilitating capital projects in First Nations summarized the problem:

> ***"****The question ISC has to ask themselves is:* ***are we in this in service to Nations or are we agents of policy?"***

9.3. Lack of Knowledge, Sharing, and Action

Due to under funding, policy barriers, lack of capacity building, and a general lack of a comprehensive management strategy for decentralised water and wastewater services, there is a significant knowledge gap about these systems in First Nations. This gap is, in large part, due to the decentralised system protocol and the interpretation of the definition of a decentralised system. During a visit with a First Nation and the engineering consulting firm, it was expressed that there remains a disconnect between the understanding of what a centrally managed decentralised system means to First Nations and ISC.

> *"I think one of the biggest fundamental things that the Nation uncovered through this process is ISC has categorically defined all of these decentralised systems as private or individual systems under their protocol … <u>without a Nation's consent or understanding</u>. As a consultant, I work with lots of Nations … and I'd say in 100% of the cases, every Nation that we've worked with centrally manages the system. So, the way that the decentralised protocol defines a system as private, it's the homeowner or home occupant's responsibility. ISC doesn't care about it. It's not really the Nation's responsibility either. But in reality, it is the Nation's responsibility. They're trying to do their best and there was zero funding going towards the systems or building the right system to begin with."*

Nations are grappling with how best to manage these unfunded systems without the necessary staff and resources, leading to a circular issue of not being able to centrally manage the systems and then not being eligible for funding because the systems are not centrally managed. This is what one ISC representative called the "one-to-many problem", where limited individuals are tasked with managing sometimes hundreds of decentralised systems. This policy gap has been noted by ISC staff and is highlighted in Alberta Region's First Nations Health Protection Report of 2022, where the proper installation and routine maintenance of cisterns is cited as a critical factor in ensuring safe drinking water in First Nations in Alberta. Figure 9-4 is taken from the 2022 Report, which shows that of all drinking water advisories tracked in public, semi-public, and private (individual wells and truck-to-cistern) systems, 83% of them occur in private systems. It should be noted that ISC's definition of decentralised system is an individual system that serves less than 5 homes, while centralised public systems generally serve dozens to hundreds of homes, so the impact to total number of homes is unknown. However, this data indicates that there is a significant burden to residents serviced by decentralised systems.

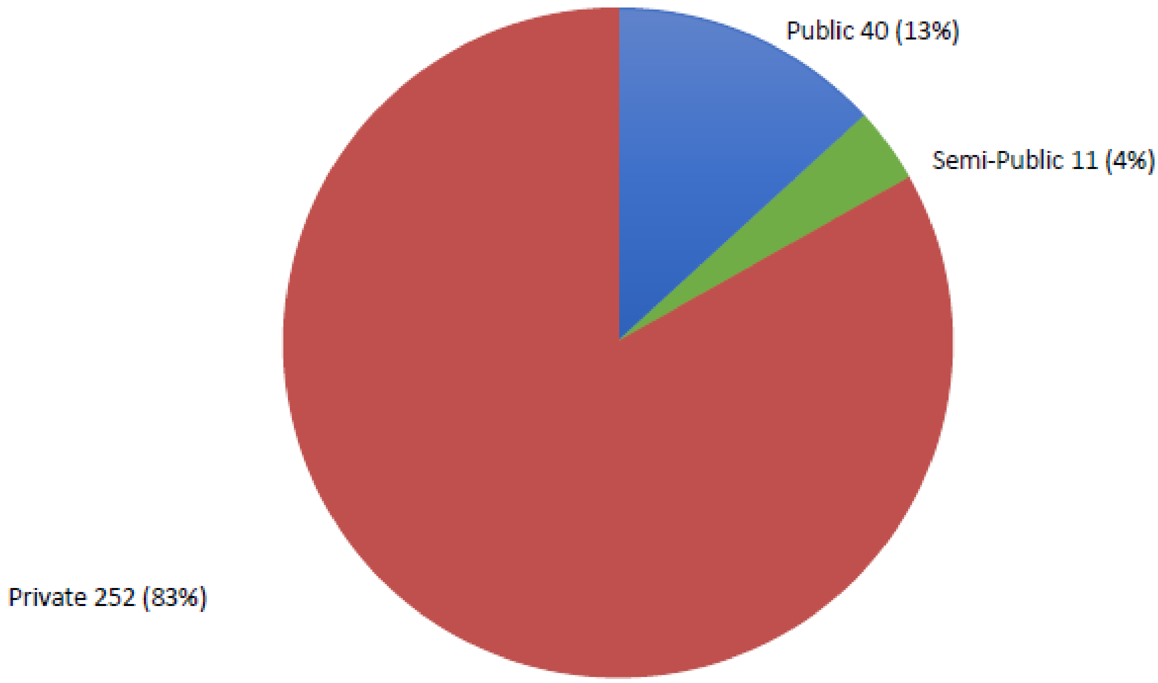


Figure 9-4. Number of drinking water advisories in the Alberta region by system type.

Figure 9-5 summarizes how lack of evidence regarding system performance and water quality manifests in unknown levels of risk in decentralised systems. There is inadequate information about onsite wastewater system siting practices, impacts to source water quality, and the evolution of water quality from source to tap for both wells and truck-to-cistern systems. With no clear path forward toward decentralised water and wastewater solutions, other than feasibility studies and stretching community-based water monitors and EPHO efforts across numerous decentralised systems, many Nations expressed frustration. One First Nations contributor commented "*Why do we have to keep playing these games?*" in response to a discussion about inaction to address drinking water quality concerns in the Nation's cisterns.

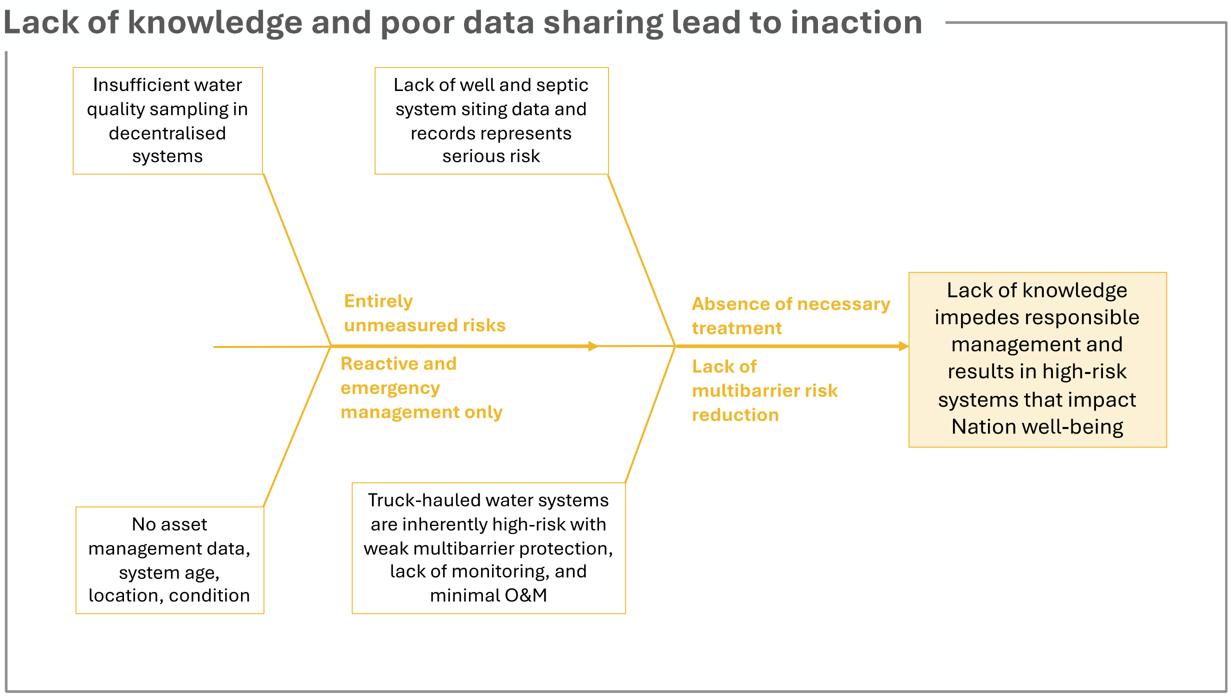


Figure 9-5. Examples of lack of knowledge for decentralised systems and how these knowledge gaps result in significant risk to public and environmental health.

Those First Nations, Tribal Councils, and First Nations organizations, as well as engineers and service providers who contributed to this report expressed an interest in finding ways of closing these gaps through policy development and funding initiatives. They recognized this Expert Report as an opportunity to take a comprehensive look at the fragmented policy and funding landscape and move toward a more holistic approach to water and wastewater management.

> *"I don't think there's been a consolidation of something like what you guys are doing to get information from everywhere and say, 'Okay, what's working, what's not working, what needs to be done, what are these people doing?' We're, we're being divided and siloed and all those other buzzwords. But I think truly, to make a difference in the operations of water plants and sewage treatment, it has to be really appropriately resourced. Let's throw a ton of people at the issue. Keeping in mind, we always want to build capacity in the communities."*

There is a recognition that there is a need for data and information about decentralised systems to better understand the risks and chart a path toward sustainable, adequate, and safe systems. While sampling is a reactive measure, it is necessary to identify where the risks lie and what sort of actions are needed.

> *"The problem is we're doing a very limited amount of screening on our highest risk systems and the interventions are even lower."*

First Nations-led work by Community Circle acknowledges that centralising or decentralising is a complex and challenging decision. While the effort of ISC has been to invest in colonial housing paradigms, i.e. subdivisions with decades spent focusing on centralisation, Community Circle suggests it's time to invest and innovate in decentralised solutions to solve water health challenges that are unique to individual First Nation's location, history, culture, language, and population. Indeed, Community Circle notes that an unmet need exists to generate and capture contextual data and translate it into insights augmented by communities' principles and decisions to inform the innovation cycle for Indigenous communities. This innovation gap is also an opportunity to support First Nations to build their own knowledge and develop their own innovation to find sustainable solutions.

10. Best Practices in Addressing the Gaps

Through engagement with a variety of knowledge holders, this project has identified numerous best practices currently arising from coast-to-coast. First Nations and First Nations organizations are experts on their own systems, the challenges of water and wastewater services in First Nations, and the federal policies and First Nations contexts that perpetuate these challenges. In response to these long-standing challenges there are several successful examples of First Nations addressing the funding, management, and knowledge gaps that exist, particularly in decentralised systems in First Nations. This section presents four brief cases studies of First Nations-led best practices that have recently emerged to address the gaps and risks associated with decentralised water and wastewater services on First Nations. Before describing the case studies, it is important to reflect on the significant water governance vacuum that exists in First Nations compared to non-Indigenous communities to more fully understand the inequitable governance environment First Nations must navigate.

Figure 10-1, adapted from Longboat (2012), draws crucial parallels between the Federal-Provincial-Municipal shared responsibility for the production of safe drinking water for non-First Nations communities and the Federal-First Nations shared responsibility for the production for safe drinking water for First Nations. Because the responsibility and authority to provide drinking water and wastewater services to Canadians is devolved to the provinces and territories, the federal government does not directly regulate drinking water or wastewater standards (beyond the national minimal wastewater effluent standards established by the Fisheries Act). The provinces hold authority for source water management, land use planning, water allocation, and regulation of drinking water standards, including treatment, monitoring, inspection, and enforcement standards. Through legislative action, provinces also have the ability to establish certification and training requirements for water and wastewater operators, engineers, onsite septic installers, well drillers, septage haulers, and water truck drivers. Provinces can also enable municipalities to establish utilities, utility review boards, water and wastewater rate by-laws, and local land use planning by-laws. Through these multiple legal instruments, provinces and municipalities create critical support structures to ensure the delivery of safe drinking water and adequate treatment of wastewater to their populations. First Nations, as it has been well documented, lack this jurisdictional autonomy and do not benefit from enabling legislative and regulatory frameworks.

In this governance vacuum, First Nations are left to directly negotiate funding and services with the federal government without clear standards or regulations. Moreover, ISC is the funder, inspector, and arbiter of policy, leaving First Nations with few formal mechanisms to make change or influence decision making. There are limited mechanisms for broader oversight of federal actions, i.e. reports by the Auditor General's Office, which is tasked with evaluating the performance of federal agencies; legal actions, as seen in the class action settlement agreement in 2021; and recent UN Reports from the Special Rapporteurs on the rights of Indigenous Peoples. This leaves First Nations to fill critical gaps without robust institutional arrangements and similar tools that are available to non-Indigenous jurisdictions, often having to self-organize and advocate for structures and processes that are all too common in non-Indigenous contexts.

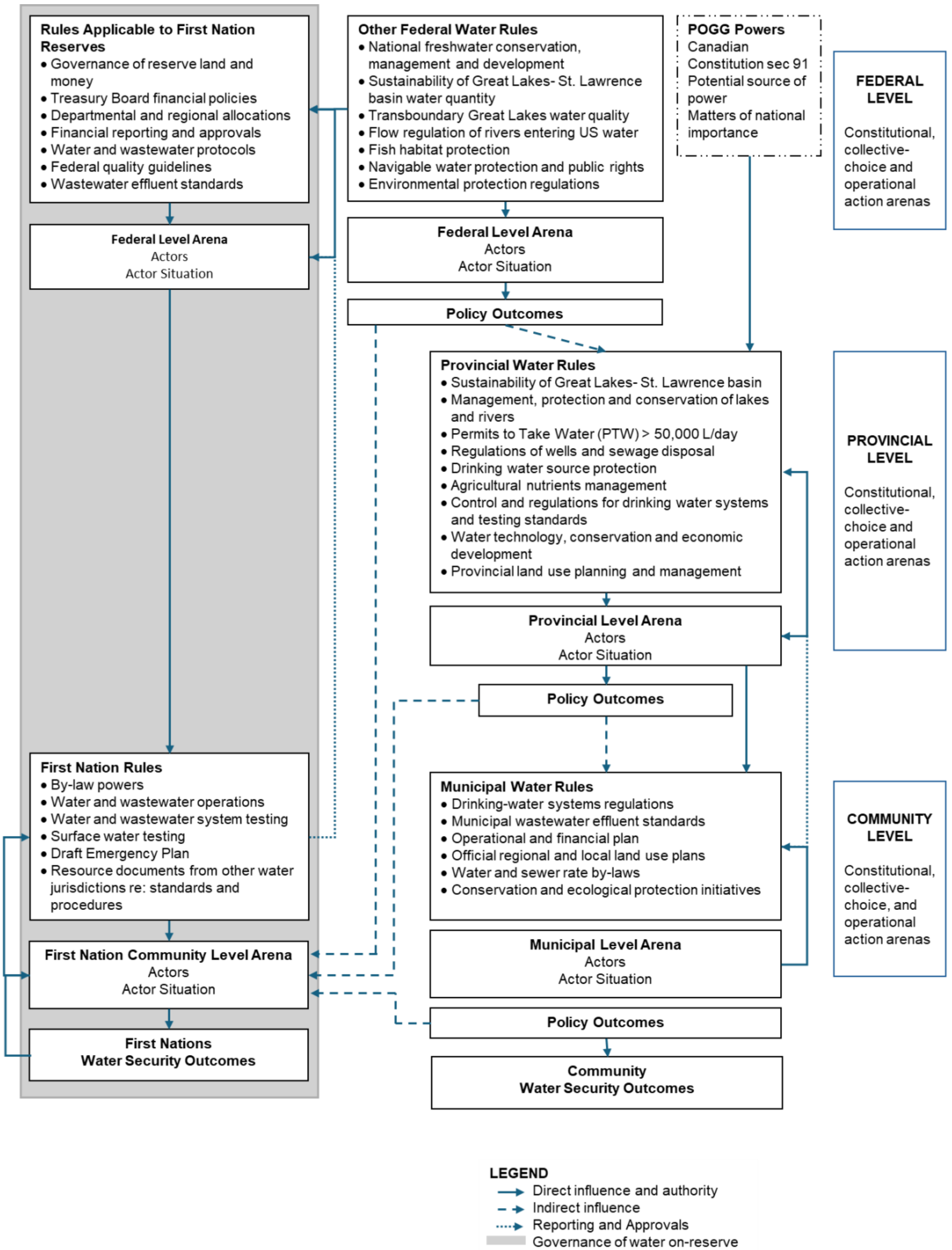


Figure 10-1. Institutional analysis and development (IAD) framework comparison of First Nations and provincial-municipal water governance structures, replicated from Longboat, 2012.

10.1. Filling the gap – First Nations Solutions

In response to the lack of enabling structures, legally enforced standards, and oversight that exists in the federal government – First Nation paradigm, particularly regarding decentralised systems, some Nations have established their own practices to improve service and protect public health. Many Nations contributed to this report and shared a range of procedures and actions that promote good system design, installation practices, record keeping, and maintenance management. These best practices have directly informed the guiding principles and recommendations presented in Sections 11. However, two First Nations that agreed to contribute to this report have made significant and systemic advances in decentralised water and wastewater service management. Whitefish Lake First Nation and Samson Cree Nation, both located in Treaty 6 Territory in Alberta, have been working for over a decade to address the longstanding public health concerns related to decentralised drinking water and wastewater systems in their communities. The Nations kindly allowed the project team to share parts of their stories in this report. Their progress and experiences provide insight into mechanisms, structures, and processes that have helped address the many gaps and risks associated with inadequate funding, management barriers, and lack of knowledge sharing and action described in Section 4 and 5.

10.1.1. Whitefish Lake First Nation – Capacity Building

Whitefish Lake First Nation #128, located in Treaty 6 Territory, has been on a more than decade-long journey to assert its right to safe drinking water and properly treated wastewater through self-determination and economic renewal. The Nation has experienced years of unsafe drinking water due to complex surface water quality issues resulting in elevated levels of disinfection byproducts, compounded by the reliance on truck-to-cistern systems in 262 homes and community buildings. The Nation has worked with Associated Engineering (AE) for more than a decade to characterize the water quality challenges and identify feasible solutions. Through an arrangement between ISC and the province of Alberta, drinking water is now delivered to the Nation's boundary through a regional system, and is delivered to the majority of homes through truck haul.

The chronic underfunding of decentralised systems left the cisterns in aged and failing states. Whitefish Lake First Nation understood the significant health risks posed by the cisterns and pursued improved drinking water conditions for its community, while also addressing the longstanding issue of economic leakage associated with traditional major capital project delivery that is commonplace in First Nations.

Sustained Relationships and Trust
Whitefish Lake First Nation understood that ISC RO would need compelling evidence to prioritize funding for mitigative action to improve decentralised drinking water system safety. The Nation, through a collaborative and sustained working relationship with their FNIHB EPHO, conducted bacteriological water sampling on a majority of the cisterns in the community. The analyses found that 149 homes tested positive for bacteriological contamination and 101 homes were on active boil water advisories. The Nation used this data to secure funding to retain AE to initiate a comprehensive cistern inspection program. In addition to the crucial support from FNIHB, AE staff

have been working alongside Whitefish Lake First Nation to support the Nation in their goal of achieving sufficient, high-quality potable water for all members in the community.

> *"We finally were able to test all of the cisterns. That made all the difference in starting the cistern program. We had the right EHO with the right connections to advocate for us."*

> *"It took years of the Nation and AE fostering relationships built on trust to do this."*

The working relationship between AE and the Nation, supported by an engaged Chief and Council, and led by Marvin Steinhauer, the Program Manager for Water and Wastewater Operations in Whitefish Lake First Nation provided a crucial foundation for innovative and progressive decentralised system improvement strategies. Nation staff noted that this type of progress should not take over a decade of perseverance and that ISC procedures can be challenging to work through. Changes in leadership in the Nation, staff turnover at ISC, and staff changes at engineering firms present challenges to building momentum within these protracted timelines. Whitefish Lake First Nation staff explained that it is largely due to their continued diligence over many years and AE's consistent support that progress has been made.

Investing in Capacity and Self-reliance

The ultimate goal in Whitefish Lake First Nation is to work towards centralised services for all community members, but this reality will take years to achieve. In the meantime, immediate action was needed to protect public health, improve water quality, and remove boil water advisories. The Nation retained AE to conduct a cistern condition assessment study that included visual inspections, siting locations, and evaluating physical condition of the assets. Initially, the inspection program developed by AE was staffed with 4 AE employees and 2 Whitefish Lake First Nations community members. Over the course of the program, with appropriate training and SOP development, the inspection team shifted to 1 AE staff and 4 Whitefish Lake First Nations members. AE was dedicated to building internal Nation capacity through training and skill-building.

> *"It's so important to teach people here how to inspect their own systems. We quickly achieved 1000 hours of community labour."*

The assessment study led to an $8M cistern replacement program funded by ISC. Rather than hiring outside contractors to complete the project, the Nation knew it had all of the resources necessary to complete the work. With assistance from AE, Whitefish Lake First Nation hired and trained over 40 of its own members to replace the cisterns, including a project manager and community engagement coordinator to help administer the program. This investment in members returned millions of dollars back to the Nation and has created an economy for the Whitefish Lake First Nation. The Nation now has dozens of members with technical skills needed to maintain, clean, and inspect cisterns, and these skills will be needed within the community as it continues to advocate for centralised services. While hiring and training community members is a slower process, it is a substantive approach to meaningful capacity building in a First Nation.

AE has since completed a septic inspection program and is currently in the process of completing a feasibility study to address the abundant direct discharge systems present in the community and expects that if an onsite septic installation program is funded, it will provide years of work for the Whitefish Lake First Nation crews.

Establishing and Complying with Technical Standards

The cistern assessment and replacement programs were completed following the national CSA-B126 Water Cisterns standard to evaluate the materials, structural integrity, and installation requirements established by the standard. Because First Nations do not fall within provincial jurisdictions, the Public Health Guidelines for Non-municipal Drinking Water that exist to support Alberta's Public Health Act do not apply to First Nations. In the absence of a regulator, e.g. Alberta Health Services, AE and Whitefish Lake First Nation had to identify other suitable and rigorous standards for the cistern assessment and replacement programs. CSA-B126 was created by the CSA Group and approved by the Standards Council of Canada. The Standard consists of six sections including general requirements and methods of testing for water cisterns, installation of water cisterns, commissioning and field inspection of water cisterns, and operation and maintenance requirements for water cisterns. Through the application of this standard, clear installation, operation, and maintenance issues were identified, including poor riser conditions, deteriorated cistern conditions, and improperly cited cisterns.

Using CSA-B126 as an operation and maintenance guide allowed AE to develop an estimated budget for a maintenance and inspection program, including annual cleaning, visual inspection, leakage testing, and water quality sampling. AE estimated an annual O&M budget of $200,000 to $400,000 for just the cistern components. Truck and road maintenance was not included in the cistern assessment project but do represent significant issues of considerable cost and concern for Whitefish Lake First Nation.

Whitefish Lake First Nation has demonstrated that capacity building, economic investment in the community, and adherence to technical standards are crucial elements to advancing Nation well-being and exercising self-determination in pursuit of clean drinking water and safe wastewater systems. The Nation has also demonstrated how immediate investments in short-term solutions must be balanced with long-term multi-phased investments to achieve centralised services for all Nation members.

10.1.2. Samson Cree Nation – The Nipiy Department

Samson Cree Nation is located in Treaty 6 Territory in Maskwacis, Alberta. The Nation is the one of the largest in the region and has a hybrid drinking water and wastewater system, with approximately 300 homes serviced by centralised drinking water and wastewater systems in the town core. There are an estimated 900 homes located in the rural areas of the 156 km^2 reserve that are serviced by individual wells and decentralised onsite wastewater systems. Samson Cree Nation has been advocating for improved water and wastewater services for over a decade and have partnered with a number of researchers, watershed groups, and community leaders to make substantive changes. Our project group was invited to Maskwacis to visit Samson Cree Nation and hear about the long journey that led to the formation of the Nipiy (Water) Department. Through our conversations with leadership, Nipiy Department staff, and ISC regional staff, several important lessons have been shared. The discussion below is not meant to be an exhaustive retelling of the history of the formation of the Nipiy Department, but rather a highlight of key enablers and guiding principles that serve as the foundation of Samson Cree Nation's progress in self-determination in water and wastewater management.

Collaboration and Partnership

The Nipiy Department was officially formed in 2024, but was made possible by the Nipiy Committee, a working group that came about more than a decade before. Led by Mario Swampy, the committee aimed to find workable solutions for safe drinking water in Samson Cree. This committee began around the time of the introduction of Bill S8, a Bill in which First Nation leadership would be held legally responsible for failing water systems that were forced upon them, leaving them to manage the fallout from previous failed policies. The Nipiy Committee was centered on the assertion of Treaty rights and the understanding that in a treaty there are partners that stand shoulder to shoulder in relationship, not as adversaries who are trying to establish winners and losers. The committee adopted a four quadrant, medicine wheel approach, to make sure the right people were at the table – political/legal, historical, spiritual, and technical knowledge were all needed to find balanced solutions.

To address the need for a holistic approach, the Nipiy Committee worked with engineering masters students from University of Alberta and University of Calgary and established a sustained working relationship with professional engineers at Urban Systems. Through these relationships, the committee generated their own data and leveraged the research to better identify the problems and generate solutions to reduce the risks of unsafe drinking water and wastewater systems.

Equipped with their own data and information, and guided by Treaty principles, the Nipiy Committee had continual meetings with federal (INAC at the time, now ISC) staff to address the over 900 individual wells and onsite sewage systems that were known to be in deteriorated and unsafe conditions. Serious and dedicated relationship building and listening had to occur in the beginning to overcome old patterns of behaviour and find new ways to work together.

> *"Because it's difficult when we do this, of course, there're no unlimited resources. There's no unlimited capacity. When we get into these challenges, just having honest conversations helped us. I think there was a lot of reluctance on both sides to trust each other. The tone I tried to set on the committee was 'we're all partners.' We have to look at each other like partners, we have to look at each other as being on the same team. So, what I told them was you guys are on this committee as well. You've got to help us accomplish the goals. We need to accomplish the goals together, because we're not going to do it separate from each other. And I think setting that tone really kind of shifted the conversation and there was more of a willingness for allyship."*

Samson Cree Nation contributors noted that everyone around the table needed to be committed to finding achievable solutions.

> *"I appreciate Adam [Manager of Water and Wastewater Engineering, Alberta Region, ISC]. … I think when Adam came on board, it was simple enough to look at what we were doing, and to recognize that we were inviting him to be part of this team. And that kind of changed the narrative for us, to start looking at it from a true partnership approach."*

The committee brought together people with a common cause, to find long-term solutions that would be good for Samson Cree Nation. The committee created a place for process development and idea generation with multiple perspectives and skill sets.

> *"I understood enough to know that this is not something that can be driven by one individual, especially politically. More people have to have buy-in. And you have to value and appreciate the people around the table, whether you agree with them or not. And so that was kind of the Nipiy model. I think it really opened the door for us to have honest conversations and robust conversations."*

The formative relationships that were built between Samson Cree Nation, ISC, and Urban Systems were grounded in critical thinking and courage to be self-reflective.

> *"We have to be willing to be critical on both sides of the table. Critical thinkers, because oftentimes we go in these things already anticipating an adversarial approach, and it becomes a finger pointing exercise at each other. We're pointing out what each other is doing wrong. I think sometimes, on both sides of the table, we need to point that finger back to ourselves and say, 'Okay, this is a problem, how are we contributing either to the problem or to the solution?' There has to be courage to be able to do that on both sides. If there's a willingness to do that, then I think we're going to start seeing some real traction moving forward in terms of a true partnership and a true relationship that's going to be beneficial."*

Sustainable and Holistic Solutions

The Nipiy Committee acknowledged that the status quo for water and wastewater services, and broader water rights, was unacceptable for Samson Cree Nation and a new way forward was paramount for protecting public health and supporting Nation well-being. The committee understood that the historical pattern of the federal government providing inadequately funded technical solutions without addressing the political, spiritual, and historical contexts would result in more failed efforts.

> *"Oftentimes what has been presented to First Nations are temporary band aid solutions, stopgap measures, that really don't offer sustainable long-term solutions."*

> *"You know you could do a water feasibility study for example. If we're going to do a water feasibility, then darn it, show us how we're going to get the sustainability from that feasibility because a sustainable future is what Canada committed to through reconciliation."*

The Nipiy Committee provided a mechanism to identify a phased, holistic approach to both assessing and prioritising the current risks in the decentralised systems to develop near-term and long-term actions for immediate and sustainable solutions.

> *"There're certain things that we can accomplish now. And let's build on that versus thinking that everything is going to happen right now. I think that's the pressure in this*

experience, oftentimes, is that the problems are big. The resources are limited. But the demand is to get it done now. So it's like where is easy, let's push the easy button, but there is no easy button."

Through the partnerships formed by the Nipiy committee members with researchers, Urban Systems, and ISC staff, a risk assessment process was developed to characterize drinking water safety in Samson Cree Nation. Of the 900 individual wells, at least 120 of them were on boil water advisories due to bacteriological exceedances that were measured by the public health authority. The Nipiy Committee worked to secure funding to replace these assets and complete comprehensive water testing. This work revealed that many of the new wells were contaminated with fluoride and/or arsenic.

"So as the nation's gone and replaced these systems, and part of the funding of that project has included comprehensive water testing at the end. And what we're finding is all these systems that have been replaced and have been taken off the boil water advisory at least 50% of them are now being put back on do not consume orders because there's fluoride or arsenic that exceeds the max. Like they're drilling in the same aquifer that they've been getting water from for generations. Now we're finding this has maybe always been there, but it hasn't been tested right so now Samson Cree is undertaking the installation of treatment systems within the homes to address those exceedances. But how long have the nation members been exposed to some of these contaminants that exceed those guidelines."

First Nations Empowerment and Self-Determination

The Nipiy Committee provided the table to engage with ISC staff in an open and transparent way to find sustainable solutions to these serious and persistent water quality risks. It was clear that sustained and well-funded efforts would be needed to continue the water quality monitoring, POU/POE treatment systems, and manage the future capital projects that would be necessary to move toward long-term drinking water and wastewater services, particularly related to the phased extension of centralized services. The Committee worked to become a permanent Department of Samson Cree's governance structure.

"What we understood is water itself is going to require a lot of resources. We talked about the amount of work that's going to be needed to update our infrastructure to build a structure that is not just politically driven. Because politics is going to be very fleeting and temporary."

"Having a department prevented a complete upheaval or overturn, having that structure. We recognize that because this can't be politically driven, the politicians don't have all the technical expertise. We needed a department where this can be housed. The conversation was always about how something needs to be established so that it can withstand the political cycles that happen, because it's going to it's going to require a long-term vision and long-term solutions. You can't keep trying to reinvent the wheel every three years on all facets because that's just not possible."

The creation of the Nipiy Department is a significant Nation-building step that has, and will continue to, increase capacity and advance Samson Cree Nation's expertise in water and wastewater management.

> *"I believe the solution moving forward, with ISC's involvement, is that funding has to go towards Nations to develop capacity, because we're Nations in this Nation-to-Nation, government-to-government relationship. That's how we approach things, we want to build up our Nations. We want to move away from this dependency model, a dependency model that keeps people reliant. The focus for us, our motivation for doing what we're doing, was always about empowerment. How do we empower people to achieve solutions and to accomplish what needs to be accomplished?"*

10.2. Filling the gap – Emerging First Nations Organizations

While many First Nations are working to address drinking water and wastewater challenges within their communities, they are also engaging with other First Nations to build organizations, associations, and corporations to provide systemic solutions. Ontario First Nations Technical Services Corp (OFNTSC), Aboriginal Water and Wastewater Association of Ontario (AWWAO), First Nations Technical Services Advisory Group (TSAG), First Nations Engineering Services, Ltd. (FNESL), and other First Nations owned and operated technical organizations provide vital services to First Nations, by First Nations. In recent years, two First Nations organizations have formed to specifically address water and wastewater challenges within their respective regions. The mission and objectives of The Saskatchewan First Nations Water Association (SFNWA) and the Atlantic First Nations Water Authority (AFNWA) are very different, as are their origins, but both organizations prioritize First Nations-led capacity building. The SFNWA was called to be formed by operators in the region during an operator conference hosted by the Federation of Sovereign Indigenous Nations (FSIN), while the AFNWA was formed through leadership and direction by the Chiefs in the Atlantic region. Despite the disparate missions, functions, and origins, both organizations emerged to address the challenges First Nations face to deliver safe and clean drinking water and wastewater. The SFNWA and AFWNA serve as examples of organizational structures that can directly fill key gaps created by the problematic federal government – First Nations jurisdictional paradigm.

10.2.1. SFNWA

The SFNWA is a not-for-profit, charitable First Nations organization with a Board of Directors composed primarily of First Nations water operators, formed to i) provide operators access to professional development tools and resources, ii) serve as a research and information-sharing organization for water operators, iii) provide a networking environment for its members, iv) affiliate and liaise with other professional organizations regarding certification and classification, and v) establish First Nations-led water and wastewater certification programs. The organization has over 300 members representing 64 First Nations and Tribal Councils in Saskatchewan. The organization is in its development stages and continues to increase its membership and programming, with its reach extending beyond Saskatchewan, as shown in Figure 10-2.

Figure 10-2. Map of SFNWA members.

Networking and Knowledge Sharing

The SFNWA brings operators together so they can learn from each other, share knowledge about system design, operation and maintenance practices, and identify areas for growth and development.

> *"I wanted to network with other operators, wanted to hear what their concerns were, what are the good treatment systems. You know, when we were doing our upgrade, it's good to go visit other water treatment plant operators just to see and talk to the operators to see any challenges. Learn about any successes they're having with their system. When First Nations apply to get a system upgrade, Council doesn't [always] have the expertise so they rely heavily on the engineers to design them a water treatment plant that fits their community. And sometimes it isn't always good. We have had a microfiltration plant and there was nothing but problems there. So we went to [First Nation] to see their system and it was much better, much better. Now we're on a bio system as well. So they're constantly upgrading as they learn bad from good systems. But I think it should be on the portfolio holder on council or the water treatment plant operator to go out and look at other systems in the area and see how they're operating before they select a system and say this is what we want in our water treatment plant. I mean it goes hand in hand with the chemical analysis your source water of course, but it's like the bio filtration system or RO system. You need to know those before you go ahead and select one for your First Nation."*

In nearly all other provincial and territorial jurisdictions multiple professional organizations exist to serve water and wastewater operators and guide industry advancement. In a First Nations context, the SFNWA is a unique organization filling this significant gap by providing a parallel, culturally relevant organization for First Nations operators and other water staff on reserve. In the absence of a robust regulatory environment with significant resources for water and wastewater utilities and staff, the SFNWA provides valuable support mechanisms for First Nations operators, from technical training to salary and benefits information.

> *"The operators need support in developing a standard operating procedure and maintenance plan for their water systems. I know that ISC requires that, but not a lot of the plants have them and I think the operators sometimes don't know how to start a standard operating procedure or maintenance plan. … but I think it should be done to ensure that at least those two documents, the management plans and standard operating procedures, are there for plants."*

Training and Skill Development

SFNWA Executive Director, Rebecca Zagozewski, noted the need for community-level capacity building and training opportunities for operators. Free, low-barrier, culturally appropriate training options are lacking for First Nations, particularly in remote or rural locations where operators do not have the funding or time-off to attend in-person training events. The SFNWA provides free online training courses, in-person workshops, examination preparation, exam writing sessions, and CEU opportunities for its members to help fill this significant gap for First Nations operators. The SFNWA has developed numerous relevant training modules that they provide for free to First Nations operators. These modules are designed to align with the operators' realities within their nations, with real-life examples, and delivered in a setting amongst their fellow First Nations colleagues. In addition, the SFNWA is developing operator certification programs that also align with the unique reality of First Nations operators in their communities. Vetted by a Circuit Rider Trainer Working Group, the program has many aspects that target certification goals, training First Nations instructors, and provide information and support to leadership on how to promote and encourage operators in their nations.

Currently, there are no standards, or guidance, regarding salaries for First Nations operators in the Saskatchewan region, with years of service and certification level having little to no impact on operator pay scales. The SFNWA is working with members to characterize First Nations operators' salaries in the region and provide recommendations to better align training, certification, years of experience, and context-specific workload with operator pay scales. The SFNWA provides water operators a platform to guide change in First Nations water and wastewater systems, inform policy, and creates the opportunity for a collective voice that is missing in many other regions. The operators, while generally employed to run the centralised plants, often fulfill de facto roles to care for decentralised water and wastewater assets as well. This is particularly vital work in Nations with truck hauled water, where operators may have additional responsibilities in liaising with truck drivers and health officers.

One of the main events of the SFNWA is the Annual Conference, General Meeting, and Trade Show. It is an opportunity for operators to write certification exams, attain continuing education units, learn from each other through discussion sessions, but also to engage in their cultural practices. Unique to this conference is the inclusion of ceremonies, cultural teachings from Elders and Knowledge Holders, and being engaged with each other while on the land.

Research and Advancement
Having a regional organization to identify and pursue research and advancement opportunities on behalf of operators has resulted in marked benefit to SFNWA members and their Nations. The SFNWA provides the capacity for operators to speak with a collective voice to address challenges and promote change. Through the capacity and expertise present in the SFNWA, operators have access to conferences, research opportunities, and other information at a level that is not possible for a single operator. Through the SFNWA, operators and allies have been able to help inform the development of the Federation of Sovereign Indigenous FSIN's Healthy Water Working Group's Drinkable Water Regulations (see Appendix H), Drinkable Water Standards, Wastewater Regulations, and Wastewater Standards for their voluntary application to water systems in Saskatchewan communities. The SFNWA has also assisted Dr. Robert Partick from the University of Saskatchewan to establish source water protection plans for Saskatchewan First Nations. Through this partnership Saskatchewan First Nations have made marked progress in source water protection, with nearly a dozen Nations in the region having plans.

These are just a small number of examples of how the SFNWA is identifying and addressing gaps in drinking water and wastewater systems in First Nations and providing support to operators to advance their skills and increase their capacity to manage and govern their own water and wastewater systems.

10.2.2. AFNWA

The Atlantic First Nations Water Authority (AFNWA) is the only First Nations-owned and operated water and wastewater utility in Canada. The AFNWA was incorporated in 2018 as a non-profit organization after more than a decade of collective action and negotiation led by the Chiefs in the Atlantic Region through the Atlantic Policy Congress of the First Nations Chiefs Secretariat (APC). In 2021, the AFNWA negotiated a transfer framework that resulted in the transfer agreement of responsibility, liability, and funding in 2022. The mandate of the AFNWA is to provide safe drinking water and properly treated wastewater to its participating First Nations, but currently the funding transfer from the federal government only addresses centralised systems and municipal transfer service agreements (MTSAs). The Board of Directors, comprised of Chiefs and technical experts, and the Elders Advisory Lodge recognize the significant gap presented by unfunded decentralised services and have testified publicly to the Standing Committee on Indigenous and Northern Affairs regarding Bill C-61 and the need for comprehensive funding for all water and wastewater services. The AFNWA has been able to reallocate fixed funding to provide O&M for decentralised services at the direction of the Board and has recently completed a decentralised asset survey and GIS asset map for all participating communities. This responsive and adaptive management approach is possible because the AFNWA is guided by self-determination, has access to adequate and long-term funding and is committed to integrated resource planning for the AFNWA First Nations.

Self-determination
Central to the AFNWA's transfer agreement and devolution of responsibility of service provision was a 10-year business plan that outlined how the utility would manage governance, human resources, financial programs, economic oversight, drinking water and wastewater regulations, level of service, asset management, and procurement to ensure continuous improvement of services. This comprehensive management of water and wastewater services is grounded in self-

determination and guided by the Elders Advisory Lodge, an *ex officio* advisory committee to the Board of Directors. Rarely does a First Nation, or a collection of Nations, have access to the tools, structures, and resources to fully embody self-determination in governance and service provision. The AFNWA provides both technical and administrative capacity to participating Nations to ensure water and wastewater services are elevated to levels of service experienced by non-Indigenous communities across Canada. Through this enhanced capacity, the AFNWA aims to support Nations in servicing housing and economic development initiatives, providing a range of employment opportunities to Nation members, and serving as an example and resource for other First Nations as they exercise self-determination in service provision.

Because the AFNWA is operated by a Board of Directors composed of largely First Nations Chiefs and guided by the Elders Advisory Lodge, First Nations culture, values, and ways of knowing are central to the organization. Ceremony, powwows, and Etuaptmumk (Two-Eyed Seeing) shape how decisions are made, how information is shared, and how relationships are built. The AFNWA understands that replicating a purely western model of a water utility will not serve First Nations well and will not honour their millennia-long relationship as stewards of Mother Earth.

Adequate and Long-term Funding

The foundation of the business plan for the AFNWA was a series of asset condition assessment initiatives in interested in First Nations to identify key service and infrastructure gaps. The AFNWA required the federal government to provide a ten-year operating budget, to be reviewed and renewed every five years, with sufficient capital investment and O&M funding to address established asset gaps and mitigate existing risks in the centralised water and wastewater systems. Adequate and long-term funding allows the AFNWA to build new assets, or repair or replace aging and inadequate assets, to comply with its drinking water and wastewater interim regulations. Adequate funding also allows the AFNWA to manage its investments to best meet emerging needs in participating communities, i.e. establishing O&M budgets for existing, but unfunded decentralised systems in some First Nations. The 10-year budgeting timeline aids the AFNWA in taking a long term, 25-year, view on investments for asset renewal and regulation compliance.

The first initiatives of the AFNWA were to complete detailed Asset Management Plans and develop a SCADA Master Plan for all systems. Decades of under-funding had resulted in aging and obsolete infrastructure and significantly inadequate or absent SCADA systems. These projects were paramount for determining water treatment efficacy and monitoring.

Integrated Resource Planning

The AFNWA is undertaking Integrated Resource Planning (IRP) to identify growth initiatives in participating First Nations and prepare water and wastewater servicing plans to support this growth. All too often, First Nation are forced to be reactive and focused on closing gaps and addressing shortfalls rather than forward looking and proactive. Through the IRP lens, the AFNWA will assist Nations in anticipating future needs, preparing for future regulatory requirements, and planning climate change adaptation investments to address vulnerabilities. Through this initiative, the AFNWA will also evaluate both decentralised and centralised assets to look for opportunities to service lots on centralised services, extend lateral assets, and minimize unnecessary reliance on decentralised systems. The IRP process provides a mechanism for integrating all AFNWA initiatives and programs into an enhanced single capital program that identifies long-term resource needs and financial expenditures. Currently, most First Nations do not have the ability to engage in this long-term planning due to the annual budgeting cycles established by ISC. No municipal utility exists on an annual planning cycle.

PART 3: A Path Forward

11. Partnership and First Nations-led Processes

The Settlement Agreement acknowledges that the status quo for safe drinking water in First Nations is unacceptable, and prospective relief must be achieved. New outcomes require new relationships and mechanisms which must be supported by new frameworks and ways of working together. The 2013 and 2023 UN Special Rapporteur visits and subsequent reports recommend the continued transfer of governance responsibilities to First Nations, supported by adequate funding, to move towards a nation-to-nation relationship (OHCHR, 2013 & 2024). To accomplish this long-term goal of transfer of governance for key services, a collaborative and transparent partnership is needed between the federal government and First Nations governments. Incremental movement toward First Nations-led processes and long-range planning and funding are needed to ready Nations for transfer. Through our conversations with First Nations, Tribal Councils, and First Nations organizations, key themes and guiding principles emerged that are central to fundamental change that will support Nations. New policies, frameworks, funding mechanisms, and investment practices should be informed by these principles.

11.1. Guiding Principles

11.1.1. First Nations-led decision-making with the right people around the table

While many First Nations engage with ISC processes and procedures to solicit funds and prioritize projects, very few Nations lead these processes or guide decision making. A First Nations housing expert explained

> *"When [ISC] divested in the 90's, they said 'it's all yours now,' but there is no funding. It's yours, but you have no control over your funding or the processes."*

This concept of responsibility without control has been cited by other First Nations researchers and policy makers. Goddard (1997), writing about education, describes the "oxymoron of band control."

> *"To talk of Band control, however, is inaccurate, for control implies the means to determine resources rather than simply manage resources allocated by others. In order to acquire operating funds the First Nations are required to petition the federal government, through INAC, on an annual basis."*

In the creation of Samson Cree's Nipyi committee, the central element of success was bringing ISC staff and Nation staff together to have honest, reflective conversations in which Samson Cree articulated their concerns and had their challenges, ideas, and needs listened to and actioned. We can see this model echoed in the 2013 Final Report of the UN Special Rapporteur report on Indigenous People's Rights (OHCHR, 2013):

> *"Indigenous people' concerns merit a higher priority at all levels and within all branches of government and across all departments. Concerted measures, based on mutual understanding and real partnership with Aboriginal peoples, through their own*

> *representative institutions, are vital to establishing long-term solutions. To that end, it is necessary for Canada to arrive at a common understanding with Indigenous peoples of objectives and goals that are based on full respect for their constitutional, treaty, and internationally recognized rights."*

The status quo in water and wastewater services, in many ways, is one of oxymoronic "band control." The new path forward must be built on First Nations-led decision making to establish solutions based on the full respect of their rights.

11.1.2. Prioritizing well-being over lowest infrastructure lifecycle cost

Everyone that contributed to this report cited the estimated lifecycle costing to be an inexact, narrow, and problematic practice that can result in affordable systems but in many cases not sustainable or healthy systems that support Nation well-being. While cistern systems are sometimes the most suitable solution due to remoteness and poor groundwater quality, these systems require significant investment and management to protect public health. Contributors to this report raised concerns about the ongoing challenges of funding, monitoring, and maintaining these systems.

> *"They aim to find the most conservative solution, not the most sustainable solution."*

There are consequences that are not, and cannot, be captured in a lifecycle cost estimate that have very real implications for the well-being of First Nations people on reserve. This report identified some of these consequences, but there is much more work to be done to listen to First Nations and trust their vast tacit expertise.

11.1.3. Building organizational infrastructure commensurate with physical infrastructure to minimize economic leakage and build Nation capacity

In Nations that reported making progress on managing decentralised systems, they all cited the consistent and talented Nation staff who championed the progress for years, sometimes decades. The safe and effective management of decentralised systems require an exponential number of staff when compared to a centralised system. A FNIHB staff called it a "one-to-many" problem, because every system functions independently from the other and represents its own risk profiles. Lack of human resources was identified as a significant challenge, as was the substantial leakage of money from Nations to contractors and consultants. Safe and well-managed decentralised systems require adequate and comprehensive administrative supports. While some First Nations have made strides in augmenting their staff to include project manager and project engagement positions, these are just the first steps toward reimagining what Nation administration needs to include to properly plan for, install, maintain, operate, and monitor decentralised systems.

> *"So the demand for housing has increased. At the same time, we're trying to develop an economy in the community. We're trying to get more people that can work, hiring those people."*

11.1.4. Structures and process that withstand the political cycles and have established evaluation and oversight

Annual block funding, and other current policy realities, cause a reactionary, resource constrained management style in Nations that contributes to the politicization of spending decisions. Water and wastewater systems need stable, adequate, and sustainable levels of funding and a long-term planning and management process that extends far beyond the election cycle in First Nations. In the case studies in Section 10, there were examples of how Nations have developed either internal water departments or external water solutions to separate water and wastewater systems and supports outside of Chief and Council elections.

> *"Our governance models sometimes impact us because we get a rotation of leadership and we're going to redo and reinvent and re-introduce [our work] make it meaningful to our own leadership. [The leadership] has to have these relationships as well, that are open and accountable, and transparent. Adequate funding provides that transparency."*

> *"But 35 years ago, I was a professional engineer. I said you've got to get them off [cisterns] and it took this long. The only reason it's happening is because the former band manager is on council now and is still around. I'm still around. The current chief is still around. We were the commonality in all this, like our tune never changed. But it's taken this long to get us to this point."*

This need for stable staff and leadership at ISC was also noted as a serious issue, with one First Nation sharing they called the ISC RO staff member "Engineer" rather than remembering their name, because they knew that by next year, there would be someone else in the position. Lack of staffing continuity, in some cases, resulted in Nations spending more time bring new staff up to speed than in making progress in their projects.

11.1.5. Federal policies that prioritize adaptive management that supports regional and cultural innovation

Across all contributors, the common theme of policy inflexibility was discussed as a significant barrier to progress. The administrative burden of engaging with the federal government, on all things, not just water and wastewater services, is immense. This is particularly challenging in small, remote, and northern Nations.

> *"The federal government uses federal tools to accomplish municipal affairs."*

Additionally, the cultural divide between how First Nations have traditionally governed themselves and how the federal government engages with First Nations is enormous. It is beyond the scope of this report to comment on the differences in the ways First Nations and the federal government validate knowledge, share ideas, and practice reciprocity and responsibility, but it is vital to note that the differences are substantial and central to the continued challenges of meaningfully addressing service failures in First Nations. A First Nations housing expert explained that First

Nations value relationships and grow trust through shared stories. They recommended ISC find a way to take a relational approach to services, rather than a hierarchical, control-based approach.

11.1.6. Integrative water and wastewater investment and management is necessary to address the housing crisis and support community growth

The segregation of centralised and decentralised water and wastewater protocols contributes to a fragmented management environment that can result in siloed decision making around housing and Nation growth. Housing initiatives seem to exist outside of broader infrastructure planning, which has caused growth to too easily default to the use of decentralised water and wastewater system installation. A commitment is needed to establish integrated planning and funding of centralised assets. A FNIHB staff member noted that all too often trucked services are used as the solution to difficult servicing issues, despite their well-established health concerns. Nations are forced to accept these decentralised systems because they need housing for their members.

An integrated approach to safe water and wastewater, that considers the management of all systems imperative for Nation well-being.

11.2. Recommendations

These recommendations are a product of thematic analysis of over 70 conversations with First Nations staff, Tribal Councils, First Nations technical experts, scholars, researchers, practitioners, and ISC staff, and are presented in direct response to the gaps identified in Section 10.

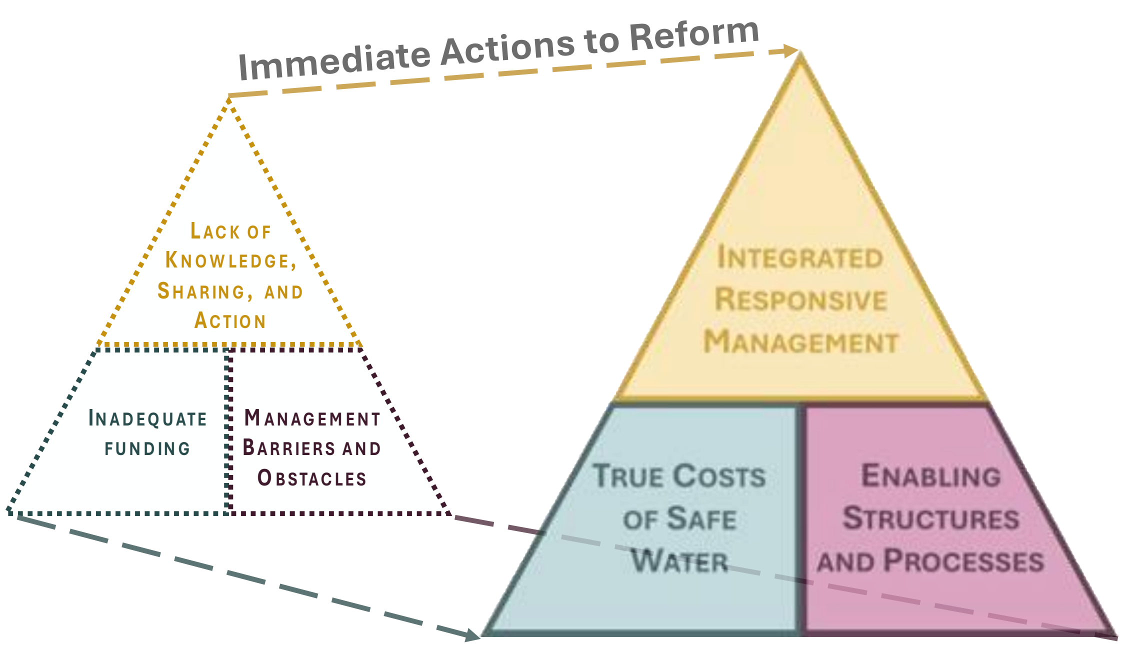


Figure 11-1. Summary of key themes for recommendations to address the current gaps and challenges.

Figure 11-1 shows the three categories of recommendations, with i) the need to fund the true costs of safe water and wastewater services and ii) the importance of developing enabling structures and processes situated as the foundational elements necessary to support the pinnacle recommendation of iii) establishing integrative and responsive management of water and wastewater systems in First Nations. In the following subsections, each of these broad areas are discussed further, with examples and details provided to illustrate specific recommendations.

11.2.1. Fund the True Cost of Water and Wastewater Systems to Protect Public and Environmental Health and Nation Well-being

- **IMMEDIATE: Improve comprehensive knowledge of decentralised systems, including types, performance, environmental and health impacts of these systems, and key risks**

Understanding comprehensive asset details of decentralised drinking water and wastewater systems through accurate inventories and asset condition assessments is a necessary first step in addressing the significant gaps present in decentralised system management. Comprehensive water quality assessments are needed to characterize system performance and inform treatment requirements for achieving the CDWQG, as a minimum, for drinking water assets. The evaluation of direct and collateral risks of both decentralised water and wastewater systems is needed to understand the burdens associated with these system types. This is particularly true onsite septic fields and holding tanks where the lack of monitoring, maintenance, and inspection have resulted in failing systems with unknown environmental impacts, including potential risks to groundwater aquifers. This knowledge gathering will require funding, resources, and training and should be led by First Nations to develop appropriate capacity building processes.

> *"So, the idea is we will talk to the homeowners. We ultimately want to run our own property management system. So again, we would look at those assets and determine which ones are in most need of repaired or replacement. Just like in the ACRS, but instead of just looking at the water treatment plant system and other large capital systems it would be more tailored towards decentralised assets."*

A better understanding of the numbers, types, and conditions of decentralised systems will be instrumental in informing the development of a management approach for these systems. There is a need to bring decentralised systems in line with management practices already in place for centralised system asset management, i.e., E-ACRS or similar routine evaluation of individual systems. This foundational information will be necessary to assess the true cost of water and wastewater services and can be used to prepare for long-term management, maintenance, and monitoring frameworks. This comprehensive evaluation will help to scope the human capacity needs to maintain and monitor decentralised systems, which will be a crucial consideration when comparing funding requirements for centralised and decentralised systems.

Lastly, understanding asset locations, conditions, and performance will aid in the identification of high-risk systems and prepare for a phased approach for improving the level of service, which may include a transition to centralised systems, or investment in well-designed onsite systems that meet installation, operation, maintenance, and monitoring standards through sustained adequate funding.

- **INTERMEDIATE: Develop pilots to identify interim funding mechanisms for the design, installation, operation, monitoring, and management of decentralised systems**

Both new and existing decentralised systems must be adequately funded, with funding mechanisms being co-developed with Nations, or First Nations governing bodies. Installation and lot servicing funding must be sufficient to provide sustainable and appropriate levels of service to ensure well-designed systems are installed in a way to protect public and environmental health throughout the assets lifecycle. Funding must also be adequate to support appropriate treatment to ensure safe water quality, with CDWQG as the minimum, and properly treated wastewater. Preliminary work led by Community Circle has found that Nations prefer a range, and combination, of viable management mechanisms including band management, private businesses, and individual homeowner solutions. Increased community capacity may come in the form of increases in Nation staff or through economic development of business opportunities for Nation members. Funding frameworks will need to be flexible to allow Nations to identify feasible structures and processes for decentralised system management.

> *"We're looking at some of that budget to do some inspections of these systems and provide training. What we want to do is provide training to local members, get the water quality management training, and then they can start their own business to actually do this type of work."*

The interim framework for funding should address training, human resource capacity building for Nations to support the management of systems, and must be reflective of the number, types, and conditions of the decentralised assets. There is a linear relationship between the number of assets and the number of staff needed to maintain and monitor the systems.

The interim funding mechanisms will likely mature over time as Nations and First Nations organizations identify best practices and develop new service models, i.e. the AFNWA. Additionally, these interim mechanisms may ultimately be replaced by regulated practices and the funding framework outlined per Bill C-61 (at the time of the drafting of this report, December 2024), or other forthcoming legislation (at the time of the finalization of this report Bill C-61 died on the Order paper as a result of prorogation of Parliament).

Importantly, work from Community Circle also highlights the need for federal funding to better align with the ministerial mandates of the over 30 ministries and agencies. Many of the past mandates highlight the advancement and prioritization of Indigenous issues and specifically direct every Minister to implement the United Nations Declaration on the rights of Indigenous Peoples. This acute focus on improving conditions for Indigenous peoples must come with financial investments

– Ministers of Transportation, Environment and Climate Change, Rural Economic Development, Natural Resources, Innovation, Science and Industry all have reason to invest in First Nations water and wastewater systems to ensure public and environmental health, advance innovation water and wastewater technology, and improve conditions for all rural and remote populations.

- **REFORM: Standards and Requirements for water and wastewater systems are needed to ensure Nation well-being and allow for growth and development.**

First Nations and First Nations governing bodies must lead the development of appropriate standards for decentralised system design, installation, monitoring, maintenance, inspection, and decommissioning. Figure 11-2 demonstrates the role standards have on controlling ultimate funding needs. Standards articulate requirements for site characterization, including water and soil testing, which inform system design, including required treatment processes. The complexity of the assets needed to provide safe services establish the level of O&M and necessary levels of staffing and required training and skills. Standards also determine public health protective measures, including specifying monitoring requirements and corrective actions in cases of system failure. Without clear and comprehensive standards guiding system design, systemic underinvestment is likely to occur.

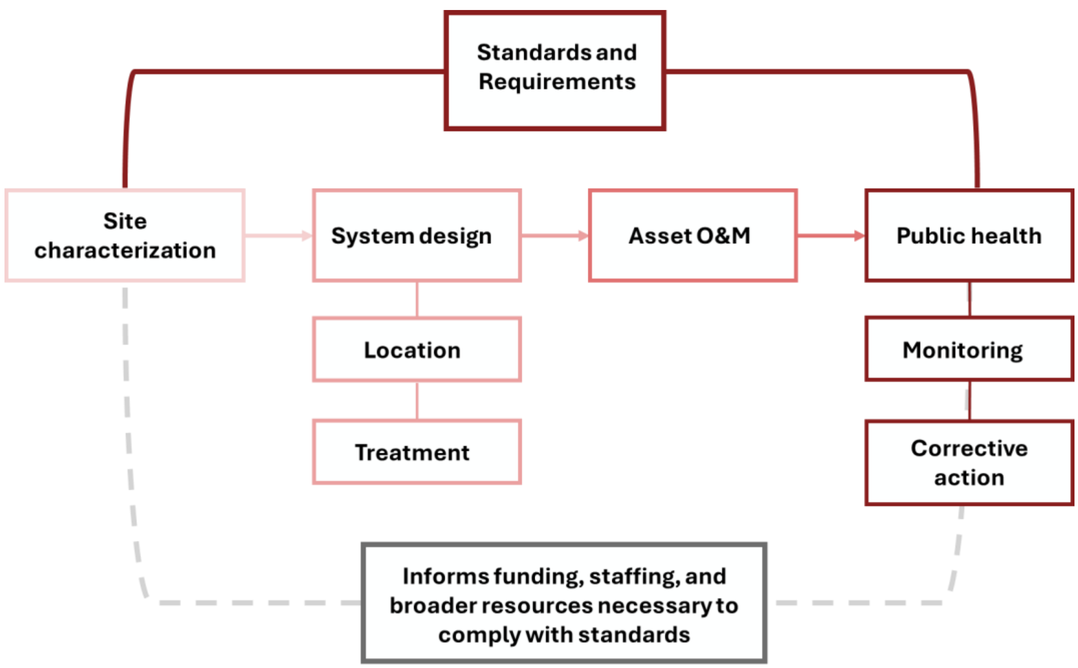


Figure 11-2. Diagram showing the relationships between standards, technical requirements for systems, and necessary funding to support public health.

Having drinking water standards that include acceptable source water quality, minimum setbacks for decentralised infrastructure, required treatment processes, and mandatory monitoring activities would help inform the choice between centralised and decentralised system type. Likewise for wastewater treatment, soil type, setbacks, and required treatment processes would provide established standards to inform system design and guide the selection of decentralised or centralised system approach. While standards and requirements should be determined by First Nations themselves, the CDWQG, CSA B126 Series 13 (cisterns), CSA B66:21 (materials for septic and holding tanks), and CSA B65:12 (decentralised wastewater systems with soil adsorption fields), in combination with provincial regulations and standards can provide industry best practices and technical guidance.

Having established First Nations' defined standards will provide clear requirements for lot sizes, acceptable system types, installation practices, monitoring requirements, and record keeping. These standards are necessary to ensure Nation well-being and inform community development.

In addition to standards, adequate and appropriate oversight is necessary to ensure that water and wastewater systems are properly designed, installed, monitored, and maintained. Because of the jurisdictional singularity of First Nations, oversight mechanisms are not readily available, but organizations like the AFNWA are trying to develop technically and culturally sound oversight relationships.

- **REFORM: Shift to long-term funding cycles**

Ultimately, there is a need for predictable, sustainable, and adequate long-term funding cycles, based on a comprehensive asset management plan, to identify, prioritize, and operationalize long-term planning objectives. First Nations do not have the ability to engage in long-range planning because of the lack of sustainable, predictable, and adequate funding. It is worth noting, that the conditions that allow for predictable, sustainable, and adequate funding must be defined by First Nations. In a provincial – municipal context, some jurisdictions have regulated infrastructure planning requirements, such as those outlined in Ontario's Infrastructure for Jobs and Prosperity Act, 2015, which establishes mechanism to support principled, evidence-based and strategic long-term planning to support job creation, training opportunities, economic growth, and protection of the environment when conducting infrastructure planning.

Our work found that the new fiscal relationship has had positive outcomes in one contributing First Nation.

> *"We have opportunities to expand our human resources. I was the housing manager for the last five years. My job is two jobs now. We're splitting the housing manager into two more jobs. So we're able to hire more people."*

Predictable, adequate, long-term funding allows Nations to identify areas for growth and develop strategies for strengthening governance and management initiatives. Water and wastewater system assets have lifecycles upwards of 10 to 20 years, which allow for and should encourage planning and investment timelines of equal length. In a provincial context, long-term funding cycles have allowed alternative structures for water delivery, including the Manitoba Rural Water Development Program (MRWDP). The program is a co-op venture between the Manitoba Water Services Board and Federal Agriculture and Agri-Food. These types of long-range water systems should be viable solutions for rural First Nations; however, the current planning and funding cycles do not support this innovation. The MRWDP shared technical and funding information with the project team.

"The [MRWDP] go will hold public information meetings with the municipality to gather their interest, present some costs, and see what the interest is and then a municipality may look at it and do it in phases. If you apply, you get government funding assistance. They'll do through taxation. They'll do a borrowing bylaw, so that allows them to issue a debenture, and residences can either pay an upfront fee of X amount to pay or they can pay it off over 20 years type of agreement."

Autonomy over budgeting and spending would allow First Nations to pursue novel water solutions and exercise self-determination in system design and management.

11.2.2. Structures and Processes to Enable First Nations Self-Determination

- **IMMEDIATE: Improve knowledge and data sharing with First Nations**

Because First Nations rely on FNIHB or other health authorities to conduct distribution system and decentralised system water quality sampling, this data is separate from any operational monitoring that may be done in a drinking water treatment plant. Drinking water quality should be readily available from source to tap to inform water treatment and ensure protection of public health. There is a significant gap in data management, access, and sharing that leads to lack of knowledge regarding system performance. This is particularly true for decentralised systems. In preparing this report, it was discovered the ICMS housing data and WaterTrax water quality sampling records complied by FNIHB reported significantly different counts for the number of individual wells in Ontario.

There is an opportunity to engage First Nations and have them lead the way on data management and knowledge sharing practices. First Nations may choose to create a data management administration position or may choose to hire a First Nation owned business to help curate and manage data sets. There is a need for decentralised asset inventories and GIS mapping exercises. These also present opportunities for new roles and economies in First Nations. Many Nations and Tribal Councils have already begun this work and can serve as examples of ways forward. Some Nations that contributed to this report indicated an interest in providing these types of services to other neighboring First Nations. There are numerous opportunities for innovative solutions.

- **INTERMEDIATE: Align RFP and procurement practices to Nation capacity building**

The FNIIP informs ISC's Capital Facilities and Maintenance Program funding, and as such is a tool for planning infrastructure investments in First Nations. The FNIIP does not directly capture broader resourcing needs, particularly the human and organizational capacity required to manage the physical infrastructure. Project management, community engagement and education, sustained asset management, and operations and maintenance of infrastructure all require human capacity. The current funding formulas for large, federally funded assets sometimes include the cost of specific positions, i.e. truck driver for hauled water. However, there is no mechanism to meaningfully augment Nations' management staff, specifically regarding the management of decentralised water and wastewater assets.

Our visits and conversations with Whitefish Lake First Nation and Samson Cree Nation highlighted their success at procuring funding to recruit, hire, and train Nation members for both administrative and technical positions within their large, decentralised asset projects. Both Urban Systems Engineering and Associated Engineering shared that they use capital infrastructure projects to allocate direct funding back to the Nation to support human resource capacity building. UA shared that they earmark a percentage of all capital project budgets to provide Nation administration, i.e. First Nation project manager. These practices provide experience and training opportunities for Nation staff and create funding to augment administrative staff to manage the physical infrastructure.

Ultimately, funding for these types of organizational and management roles should be funded on a permanent basis, to ensure the recruitment and retainment of talented staff and allow for organizational succession planning. There is a general trend of an aging staff and a need for intentional training programs to transfer knowledge and prepare future generations to care for First Nations infrastructure.

- **INTERMEDIATE: Develop First Nations-led capacity building focused on communication and knowledge sharing around water and wastewater systems**

First Nations have a collective lived experience of inadequate water and wastewater services, either through direct exposure to unsafe systems or indirectly through shared stories. First Nations public health staff and First Nations organizations' technical staff noted the importance of increasing First Nation members' internal capacity to communicate and share knowledge of water and wastewater systems through education and outreach. Interpreting water quality results, understanding groundwater aquifers and potential contaminants, communicating details about treatment processes, and building residents' awareness of onsite septic operation and maintenance are all key components to strengthening a Nation's ability to act in its own best interest and share the responsibilities of water and wastewater stewardship.

This outreach, engagement, and education could be managed through the health centre, or via a communication/education position. Funding for this additional capacity could be provided through water and wastewater initiatives, community-based water monitors, or other approaches, to meet individual First Nations' needs.

- **REFORM: Develop First Nation-informed feasibility study process to align with capital planning and asset management planning to support Nation Well**

Feasibility studies were characterized as "choke points", "band aids", or "delay tactics" with one contributor noting that feasibility studies often failed to identify what a Nation really needs, because they only focus on physical infrastructure and not broader systemic strategies and solutions for providing critical services in a sustainable and safe way. Because of the general lack of knowledge regarding decentralised drinking water and wastewater systems, often Nations do not know where to begin or what to ask for to address the unknown risks. Engineers with significant experience who work for First Nations shared that before a feasibility study can be considered, the scope of the risks must first be determined, and there has historically been limited funding available for such work. Evidence and information are needed to make a meaningful funding request through the FNIIP.

Our conversations with First Nations and engineering firms highlighted that feasibility studies can result in an incomplete or insufficient options analysis which may provide an imperfect solution because of the lack of data and knowledge about the underlying problems and challenges. The ultimate goal of many First Nations is to move toward centralised systems whenever possible, however this is often prohibitively expensive in the short-term. In the case studies provided here, both Whitefish Lake First Nation and Samson Cree Nation are following a phased approach of addressing immediate public health threats posed by failed or failing decentralised systems while also pursuing long-term implementation of centralisation. This long-term phased planning provides near-term relief for high-risk systems and provides a concrete process for extending centralised systems.

Rather than rely solely on traditional feasibility studies, often based on assumptions and class D estimates, it is recommended to collaborate with First Nations to develop a First Nation-informed feasibility study that considers the holistic well-being of the Nation and aligns with a well-staffed asset management-based approach to infrastructure investment. Urban Associates conceptualizes phased planning to include a preliminary phase focused on defining the problem from the Nation’s perspective. The second phase collects evidence and information to inform and scope the work, with the third phase initiating the solution design. In the case of Whitefish Lake First Nation, it is expected that the extension of centralised systems will take five or six phases over several years to slowly invest in system improvement.

11.2.3. Responsive Integrated Management of Water and Wastewater Systems to Support Nation Well-being

- **IMMEDIATE: Collaborative water and wastewater working groups within the Regions to address risks holistically**

The Alberta region has established a collaborative Regional Water Team for assessing and mitigating risks in both centralised and decentralised systems. Representatives from RO, FNIHB, and CRTP meet weekly to share information about all water and wastewater systems, taking a holistic view of these critical services. Through this collaboration, progress has been made to work with Nations to identify their challenges and needs and find ways to address priority risks. It is no coincidence that the two First Nations highlighted in this report are located in Treaty 6 in the Alberta region. Although the two Nations took very different paths, the Regional Water Team was the common factor that facilitated each Nation’s progress. Similar models could be operationalized in each region in appropriate ways, i.e. include transferred health authorities, Tribal Councils, water hubs, etc. The Whitefish Lake First Nation staff who participated in this report noted specifically that it was the public health component that was critical for obtaining funding to move forward with decentralised asset condition assessment. FNIHB's drinking water program mandate, as outlined in the National Framework, includes maintaining quality assurance and quality control in drinking water through sampling and testing activities in water cisterns and community wells.

It is recommended that this regional team approach be used to bring engineering and health staff together to collaborate with First Nations to understand the needs, priorities, and risks present in decentralised systems. This group can facilitate the development of decentralised asset inventories and assessments described in 11.2.1. ISC-RO, in collaboration with FNHIB or other appropriate health agencies, should initiate and organize these collaborative meetings, to provide a mechanism to jointly evaluate decentralised systems, which currently fall outside the purview of ISC-RO (in most regions). This work can only be done effectively with FNIHB (or other public health bodies) and RO working together with other First Nations organizations, i.e. tribal councils, and the Nations themselves. As noted in Section 10.1, relational approaches to service provision, more specifically enabling relationships, have proved effective and productive in the Alberta region. Both Whitefish Lake First Nation and Samson Cree Nation noted that RO adopted a First Nations-led approach to solution building.

- **INTERMEDIATE: Restructure inspection and monitoring programs to address under-investment in decentralised systems**

The current model of drinking water quality sampling is not sufficient to provide adequate monitoring of decentralised systems. There is a need to reconsider this model and work with Nations to identify other options that could include the addition of Nation staff, Tribal Council support, or business development within the Nation to provide these key services. Likewise, additional capacity is needed to provide inspection and maintenance for onsite wastewater systems. One contributing First Nation collaborated with FNIHB to receive substantial onsite septic system installation and management training and now has significant capacity to site, design (or collaborate with a professional for designs), install, inspect, and maintain onsite septic systems.

Enhanced inspection and monitoring programs will facilitate knowledge collection to inform asset management plans, document system performance, prioritize maintenance, and identify funding needs. This restructuring will only be possible if funding mechanisms are also restructured to provide adequate resources and training. The current funding levels for drinking water sampling is inadequate and undervalues the important work done by the Community Based Water Monitors. One contributing health director noted that a full-time staff member is needed to advance community education, share water quality information, and assist with sample collection and data management. Significant investment is needed to address these long-standing monitoring gaps that persist in all decentralised drinking water systems. Augmentation of monitoring positions to include additional technical training and responsibilities will build capacity and provide full time employment to First Nations members, or provide an opportunity for private business development, depending on how First Nations choose to organize monitoring and inspection programs.

- **REFORM: Integrated water and wastewater policies that prioritize public and environmental health and Nation well-being**

The Regional Water Team approach employed in the Alberta region has proven effective at providing an integrated and holistic view of water and wastewater services in First Nations. First Nations from other regions also noted that an integrated approach with a range of knowledge holders at the table is needed to identify feasible, sustainable, and functional solutions to water and wastewater challenges.

> *"I think the water treatment plant operators, they must be part of the [project management team (PMT)] that are started when there's a major capital project going on a First Nation, like the building of a water treatment plant. The operator has to sit at that PMT table and provide their input on the construction or renovation, because it's a lot of money being spent and they want to spend it the right way. I think the more heads at that table, the better because an engineer will come in, they will build you a water treatment plan, but they're not the ones operating it. So, the operator may have some good ideas from networking or historical experience. They could bring it to the table."*

Similarly, housing managers, public works managers, and public health directors are all vital voices in developing a holistic management strategy for decentralised systems on First Nations. An integrated water and wastewater approach is necessary to inform broader community planning and housing strategies. Our work found that decentralised systems are sometimes used as fast, low-cost (in the short-term) solutions for rapid housing initiatives, particularly truck-hauled services, which are known to create significant public health risks due to the current state of inadequate funding and management practices.

An integrated water and wastewater management approach must be based on mitigating risks from source to tap and tap to source to protect public health, replace high-risk systems, and prioritize Nation well-being in the long-term.

11.3. Holistic View of Recommendations

Figure 11-3 shows the summary of the immediate, intermediate, and reform recommendations across the three thematic areas. Immediate recommendations highlight the need for collaborative structures that support knowledge building and sharing. Decentralised systems require innovative funding and management strategies, led by First Nations and supported by both public health agencies and RO engineer staff, in collaboration with First Nations technical organizations and Tribal Councils, who are well-situated to provide guidance, training, and service.

Immediate progress will facilitate the formation of funding mechanisms, procurement and capacity building practices, and inspection and monitoring programs that will direct funding to First Nations, grow Nation capacity, and support self-determination and water governance development. Reform recommendations are aimed at advancing transfer of services and governance to First Nations or First Nations organizations through enforceable standards, long-term funding, holistic planning, and integrated water and wastewater management policies that prioritize First Nation well-being.

	Immediate	Intermediate	Reform
Fund the True Cost of Water and Wastewater Systems +	Invest in comprehensive knowledge of decentralised systems to determine capacity and costs	Develop pilots to identify funding mechanisms for the design, monitoring, and management of decentralised systems	Shift to long-term funding cycles to facilitate Nation-led growth & Standards and requirements for water and wastewater systems to ensure Nation well-being
Structures and Processes to Enable First Nations Self-Determination +	Improve knowledge and data sharing with First Nations to support asset management	Align RFP and procurement practices to Nation capacity building & Build knowledge sharing around water and wastewater systems	Develop First Nation-informed feasibility study process to align with capital and asset management planning
Responsive Integrated Management of Water and Wastewater Systems to Support Nation Well-being	Collaborative water and wastewater working groups within the Regions to prioritize and address risks holistically	Pilot inspection and monitoring programs to address under-investments in decentralised systems and find sustainable solutions	Integrated water and wastewater policies that prioritize public health and Nation well-being
	Knowledge gathering and collaboration before policy development	First Nations-led piloting to build sustainable solutions	Funding, policy, and management reform based on evidence and First Nations collaboration

Figure 11-3. Summary of short-, mid-, and long-term recommendations across the three thematic areas.

Appendix A Literature Review Results

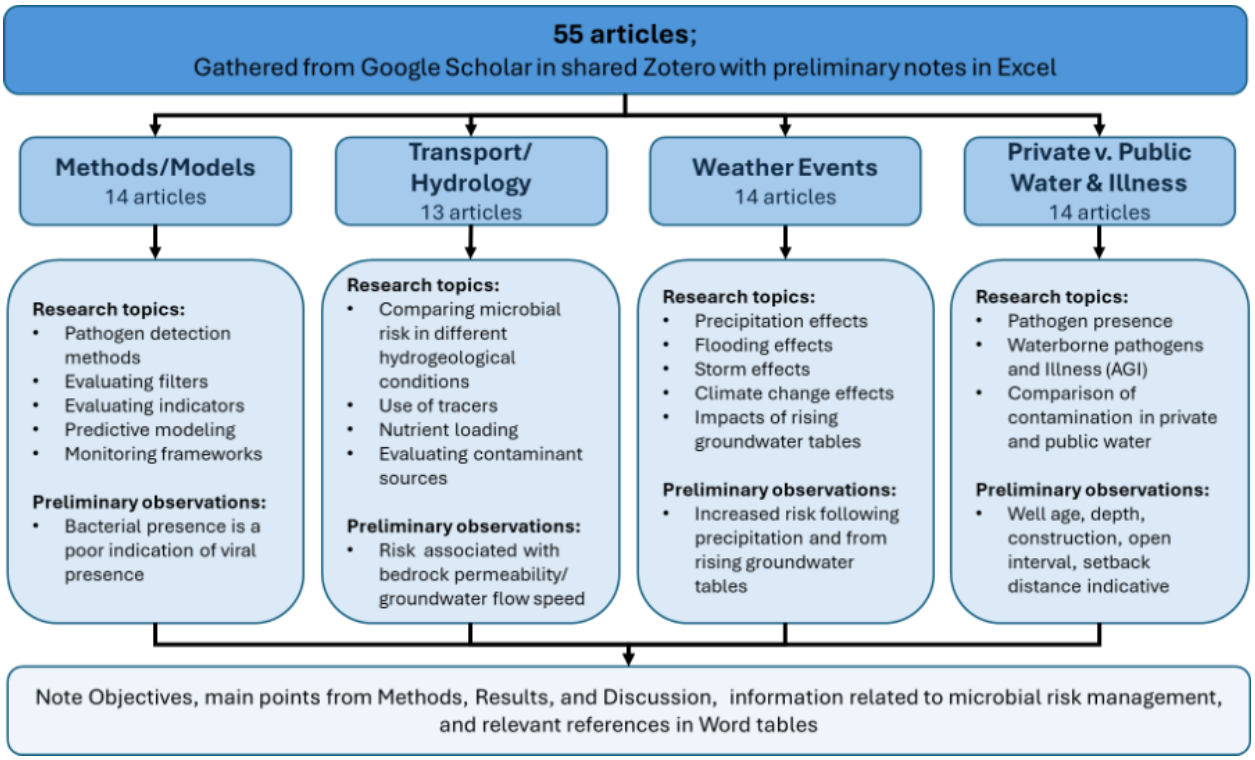


Figure A- 1. Methodology summary of how the literature review component of the integrative review process was performed. This process was used to collect relevant literature for drinking water and wastewater systems, but only the groundwater example is shown for demonstrative purposes.

Appendix B – Individual Wells Jurisdictional Scan

To better understand the regional and jurisdictional variations in the planning, installation, operation, maintenance, repair, and decommissioning of decentralised drinking water systems a jurisdictional scan was conducted for each province and the Yukon. The scan included consideration of i) relevant legislation, including Acts and regulations, ii) policy and guidance documents, including standards of practice, technical guidelines, and protocols published by the principal authority or professional organization, iii) publicly available documentation, i.e. websites, homeowner's manuals, information brochures, etc. and iv) video and/or phone calls with regulatory administrators and/or professional organization staff.

A full understanding of provincial and territorial standards and requirements, as well as management and enforcement tools, will provide a useful backdrop for the processes and activities currently being employed in First Nations communities. Subsection 1.1 contains brief summaries of the activities, stakeholders, documentation, and regulations central to the planning, installation, operation, maintenance, repair, and decommissioning of individual drinking wells in the provinces and the Yukon.

Prince Edward Island

Regulatory Context

Private wells are regulated under Prince Edward Island's (PEI) Water Act through The Well Regulations. The drilling, construction, or reconstruction of a well must be done by a licenced well driller who is employed by a company that holds a well contractor's licence. Licences are issued through the Drinking Water and Wastewater Management Section of the Department of Environment, Energy and Climate Action (EEC). The regulations cite various standards (American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), National Sanitation Foundation (NSF), etc.) that must be followed for well installation. The decommissioning of a well must be completed by a licenced well driller, contractor, or plumber. Figure B-1 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	PEI Department of Environment, Energy and Climate Action Certified Well Driller Certified Well Contractor	Application to and approval by the Department for certificates Application to and approval by the Department for permits (for construction outside the regulatory requirements) Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements, outside restricted areas)	Well Driller's License Well Contractor's License Well Permit	Prince Edward Island Well Construction Regulations. ASTM Standard A589 (type IV, grade B), A53 (type E, grade B), and/or F480. NSF/ANSI Standard 60. NSF Standard 61. Department of Environment, Energy and Climate Action – Testing of Drinking Water
Installation	PEI Department of Environment, Energy and Climate Action Certified Well Driller Certified Well Contractor	Drill well (no specified depth) Log stratigraphy of well Install casing (L >=12m, ID >=127mm) Install well cap Fill annular space and seal well Perform yield test Install pump and disinfect well	Well Construction Report	
Operation & Monitoring	Certified Well Driller Homeowner	Driller must install a sampling port Test water quality annually Cap and seal if well becomes flowing		
Maintenance & Repairs	Certified Well Driller Certified Well Contractor Homeowner	Repair wells as necessary		
Decommission	PEI Department of Environment, Energy and Climate Action Certified Well Driller Certified Well Contractor Plumber Homeowner	Decommission order by the Minister Seal well and stop vertical movement of water		

Figure B-1. Individual well lifecycle in PEI.

Planning and Approvals

If a well driller is planning to drill, construct or reconstruct a well in a restricted area or in a manner that does not follow the restrictions, regulations, or standards, they must apply to the Department (EEC) for a well permit. Before a well is drilled, the licenced well driller must site the location of a well so that it is accessible, adapts to the existing geologic and groundwater conditions of the area, maintains existing natural protection from contaminants, prevents surface water contamination and meets setback distances. A well must be 1.5 meters from any property boundary and underground electrical cables and the specified distances from potential sources of contamination listed in Table B-1.

Table B-1. Setback distances for individual wells in PEI.

Potential Source of Contamination	Setback Distance (m)
Building	3
Sewer line	3
Sewer collection main	6
Wastewater treatment system	100
Septic tank, sewage disposal field, or rock pit	15
Manure storage facility	90
Solid waste disposal site	150
Petroleum storage tank system =< 1,200 L	5
Petroleum storage tank system > 1,200 L	15
Commercial chemical storage facility	45

Existing or abandoned well	6

Installation

Well installation must be overseen by a licenced well contractor and completed by a licenced well driller. A notice of installation to the Department (EEC) is not required before installation. The regulations list specific requirements for well and pump installation and well completion.

Well Construction

The regulations include requirements for well casing length, casing height above the ground, grout and well caps. Upon completion of the well, the well driller must remove all debris and conduct a pumping test for at least 30 minutes. The static water level, pumping rate and pumping water level must all be recorded on a well construction report, along with recommended pump specifications and other construction details. If a well becomes flowing, it must be capped and sealed immediately to prevent vertical movement of water.

Pump Installation & Well Completion

Pumps must be installed in accordance with the recommendations in the well construction report and the *Electrical Inspections Act*. The pump must meet clearance and connection requirements and cannot be installed without a sampling port or tap between the pump and any water treatment device. After completion, the well must be disinfected following a method outlined in Schedule C of the regulations. Well drillers are responsible for submitting a Well Construction Report to the department (EEC).

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. PEI provides free bacterial and general water chemistry testing to all private well owners. The province encourages homeowners to test their water at least once a year for bacteria and every two years for general chemistry.

Maintenance and Repairs

All maintenance, repair, and replacement of the well is the responsibility of the property owner. Any reconstruction (i.e. significant repairs or replacement) to a well must be completed by a licenced well driller and overseen by a licenced well contractor. If a pump is to be repaired, the well must be disinfected immediately after. The province has an online resource on How to Disinfect Your Well that homeowners should follow.

Decommissioning

The Minister (EEC) may declare a well to be unused and notify the owner of the land. The regulations state that the person responsible for the unused well must ensure it is decommissioned by a well contractor, well driller or plumber. The decommissioning of a well must follow a method that is applicable to the type of well listed in Schedule D of the regulations.

Challenges and gaps

Through discussion with a representative from the Water and Wastewater Management Section (EEC), challenges with saltwater intrusion were highlighted. To avoid saltwater intrusion, wells can be dug shallower (with special permission) to pump freshwater that sits above saltwater or drilled deeper to drill past saltwater. Both methods have limitations as shallow wells have a higher risk for contamination and water yield issues, and deeper wells can be much more costly.

Nova Scotia

Regulatory Context

Private wells are regulated under Nova Scotia's (NS) Environment Act through the Well Construction Regulations. The drilling, construction, repair, and modification of a drilled well must be done by a certified well driller. The digging, construction, repair, and modification of a dug well must be done by a certified well digger. An exception to this regulation is if an individual plans to dig or drill a well on the property they own, however, the construction and installation of casing, lining, and screening must still meet the regulations. The installation of a pump must be completed by a certified pump installer, unless the individual installing the pump is the owner of land the well resides on. Along with the regulations, a certified pump installer must also follow the National Plumbing Code of Canada, 2003, and CSA Standard, Canadian Electrical Code (Part I) when installing a pump. Licences are issued through the Department of Environment and Climate Change (ECC). The regulations cite various ASTM standards that must be followed for well installation. The decommissioning of a drilled or dug well must be completed by a certified well driller or digger, respectively and in accordance with the Water Well Decommissioning Guidelines. Figure B-2 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	NS Department of Environment and Climate Change Certified Well Driller/Digger Certified Pump Installer (Class I or II)	Application to and approval by the Department for certificates Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements)	Certificate of Qualification	Nova Scotia Well Construction Regulations ASTM Standard A589 (type IV, grade B), A53 (type E, grade B), and/or F480. Nova Scotia Environment and Climate Change – The Drop on Water Nova Scotia Department of Environment and Labour – Before You Construct a Water Well: Facts a Homeowner Should Know
Installation	NS Department of Environment and Climate Change Certified Well Driller/Digger Certified Pump Installer (Class I or II)	Drill or dig well (no specified depth) Log stratigraphy of well Install casing (L >=6.1m, ID >=152mm) Install liner (ID >= 102mm) Install screen, filter and well cap Fill annular space and seal well Slope surface away from wellhead Perform yield test and disinfect well Install pump Characterize water quality	Well Completion Report	
Operation & Monitoring	Certified Well Driller/Digger Homeowner	Driller must install a sampling port Test water quality annually and after floods Ensure flow of water is controlled or stopped		
Maintenance & Repairs	NS Department of Environment and Climate Change Certified Well Driller/Digger Certified Pump Installer (Class I or II) Homeowner	Well inspections may lead to well modifications Maintain well & prevent adverse effect Maintain area around well Repair and modify wells as necessary	Notice to Well Driller Pump Installation Report	
Decommission	NS Department of Environment and Climate Change Certified Well Driller/Digger Homeowner	Decommission order by the Minister Seal well and stop vertical movement of water	Well Decommissioning Record	

Figure B-2. Lifecycle of Private Wells in NS.

Planning and Approvals

The certified well driller or digger must give at least 24-hour notice to the Department (ECC) before the drilling or digging, construction, repair, or modification of a well if requested by an inspector of the Department (ECC). Before a well is drilled or dug, a certified person must site the location of a well so that it is accessible, not located in a basement, prevents surface water contamination, and meets setback distances. A well must not be constructed within the distances from potential contamination sources listed in Table B-2. The Minister (ECC) may approve alternative well locations if the location ensures no adverse effects will occur to the groundwater. Additionally, the Minister (ECC) may approve a request to install an innovative well or innovative pumping equipment that does not meet the regulations.

Table B-2. Setback distances for private wells in NS.

Potential Source of Contamination	Well Type	Setback Distance (m)
Cesspool	Drilled / Dug	61
Onsite sewage disposal system	Drilled Dug	15.2 30.5
Sewer with tightly joined connections/sewer connected foundation or floor drain/water treatment discharge point	Drilled Dug	15.2 30.5
Secondary containment sewer / non-sewer connection	Drilled / Dug	3
Pumphouse floor drain	Drilled / Dug	0.61
Above ground petroleum storage tank system =< 1,200L	Drilled Dug	5 15.2

Above ground petroleum storage tank system > 1,200L	Drilled / Dug	15.3
Underground petroleum storage system	Drilled / Dug	15.2
Outer boundary of public road or highway	Drilled / Dug	6.1
Solid waste facility, dump, or other significant source	Drilled / Dug	61

Installation

Well installation must be completed by a certified well driller or digger, and pump installation must be completed by a certified pump installer. The regulations list specific requirements for well and pump installation and well completion.

Well Construction

The regulations include minimum size and material requirements for well casing and liners or screens for drilled and dug wells. Furthermore, wells must be installed so that they meet the minimum requirements for casing height above ground, annular space, annular fill, grout, filter packs, and well caps. Upon completion of a drilled or dug well, the well driller/digger must remove all debris and conduct a basic yield test. The static water level, subsequent yield rate, and water level recovery measurements must all be recorded on a well construction report. If a well becomes flowing, it must be capped and sealed immediately to prevent vertical movement of water.

Pump Installation & Well Completion

The pump selected by a certified pump installer must meet minimum specifications based on casing measurements and yield test requirements. After completion, the well must be disinfected and sealed following the regulations. Well drillers and diggers are responsible for submitting a Well Construction Record to the Department (ECC).

Operation & Monitoring

The operation and monitoring of the system is the responsibility of the property owner. Nova Scotia recommends that homeowners test their water every six months for bacteria and every two years for chemical contaminants.

Maintenance and Repairs

All maintenance of the well is the responsibility of the property owner and must be done to prevent any adverse effect. A homeowner must make sure that no lubricants, hydraulic fluids, or other harmful materials that may harm groundwater are placed in a well or to spill into a well. The repair and modification of a well is the responsibility of a certified well driller or digger. Likewise, the repair or replacement of a pump is the responsibility of a certified pump installer. An inspector may require a certified well driller or digger to make modifications to a well if its construction does not meet the regulations. If repairs are made to a well or pump, the well must be disinfected immediately after. If a well is modified or repaired by methods that may change the yield of the well, the certified well driller, digger and/or pump installer must conduct a basic yield test.

Decommissioning

The decommissioning of a well may be required by the Minister (EEC) if it is causing, or has the potential to cause, an adverse effect. The regulations state that it is the responsibility of the person who owns a well that is required to be decommissioned or is no longer being maintained for future use to immediately decommission the well. A certified well driller or digger must seal in accordance with the Water Well Decommissioning Guidelines to ensure that vertical movement of water in the well is prevented. A Well Decommissioning Record must be completed by the certified well driller or digger and submitted to the department (ECC).

Challenges and gaps

A few key challenges and gaps were identified in terms of well installation, operation, and monitoring through discussion with a representative from the Department (ECC). The department no longer funds positions for well inspectors. Thus, most compliance issues are only discovered on a complaint basis from homeowners. It is the responsibility of the well driller to submit their well construction report, but there is no confirmation from the Department, highlighting a gap in compliance and record keeping. The operation of wells, specifically dug wells in the Southwestern region of the province, can be challenging during the summer and fall months. The warm and dry weather causes many of these wells to dry up, causing water shortages and forcing many homeowners to rely on cistern systems or modify their wells. Additionally, there is an accessibility issue when it comes to water quality monitoring. Many homeowners face barriers to water testing such as location (rural), lab accessibility, cost, etc., creating higher risks for unsafe water consumption.

Newfoundland and Labrador

Regulatory Context

Private wells are regulated under Newfoundland and Labrador's (NFL) Water Resources Act through the Well Drilling Regulations. The drilling, construction, or reconstruction of a well must be done by a well driller who is licenced through the Department of Environment and Climate Change (ECC). The regulations outline construction standards (including ASTM) that must be followed for any new installation. Figure B.3 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	NL Department of Environment and Climate Change Certified Well Driller	Application to and approval by the Minister for licences Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements)	Well Driller Licence	Newfoundland and Labrador Well Drilling Regulations Government of Newfoundland and Labrador – Guidelines for Sealing Groundwater Wells Government of Newfoundland and Labrador – Groundwater Wells: What You Need to Know, Monitoring, Maintenance, and Retrofitting ASTM and CSTM Standards for Well Casing
Installation	NL Department of Environment and Climate Change Certified Well Driller	Drill well (no specified depth) Install casing Install well cap Fill annular space and seal well Slope surface away from wellhead Perform yield test and disinfect well Install pump	Well Construction Record	
Operation & Monitoring	Homeowner	Test water quality annually Ensure flow of water is controlled or stopped		
Maintenance & Repairs	NL Department of Environment and Climate Change Certified Well Driller Homeowner	Maintain well & prevent adverse affect Maintain area around well Repair and modify wells as necessary		
Decommission	NL Department of Environment and Climate Change Certified Well Driller Homeowner	Decommission order by the Minister Seal well and stop vertical movement of water	Well Sealing Report	

Figure B-3. Lifecycle of Private Wells in NFL.

Planning and Approvals

Before a well is drilled, the licenced well driller must site the location of a well so that it is accessible, prevents surface water contamination and meets setback distances. Furthermore, the well driller must investigate whether the area of the province in which they propose to drill has a history of flowing wells. Except where permeability tests indicate a great distance should be maintained, a well must not be constructed within the distances from potential contamination sources listed in Table B.3. A well driller must receive approval from the Minister (ECC) if a well is to be installed near a sanitary landfill, garbage dump, or other massive source of contamination.

Table B-3. Setback distances for private wells in NFL.

Potential Source of Contamination	Setback Distance (m)
Building	2
Cesspool (receiving raw sewage)	30
Cesspool > 4m deep	60
Seepage (leaching) pit, filter bed, soil absorption field, earth pit privy, or similar disposal unit	16
Septic tank, concrete vault privy, sewer of tightly jointed tile or equivalent material, or sewer connected foundation drain	16
Sewer of cast iron with leaded or approved mechanical joints, independent clean water drain, or cistern	3

Pumphouse floor drain, cast iron with leaded joints, draining to ground surface	1

Installation

Well installation must be completed by a licenced well driller. The regulations list specific requirements for well and pump installation and well completion.

Well Construction

The regulations include requirements for well casing length, material, grout and well caps. Upon completion of the well, the well driller must remove all debris and conduct a water yield test. The minimum well yield required is approximately 340 L per day per person. The well driller is responsible for taking the necessary precautions to prevent a well from flowing out of control.

Pump Installation & Well Completion

Immediately after construction, wells must be disinfected following a method approved by the Minister (ECC). Pumps must be installed in accordance with the regulations and must be disinfected prior to installation. Well drillers are responsible for submitting a Well Construction Record to the department (ECC). Wells are not inspected after construction unless a problem is reported.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. Homeowners must ensure that nothing gets into their well that could contaminate groundwater resources. The province provides free bacterial testing and recommends homeowners test their water at least twice per year. The provinces recommends that homeowners test general water chemistry parameters at least every two years.

Maintenance and Repairs

All maintenance, repair, and replacement of the well is the responsibility of the property owner. The province has an online manual, 'Well Aware', that homeowners can consult for maintenance guidance surrounding access, well caps, annular seal, well casing, and backflow prevention. Any reconstruction (i.e. significant repairs or replacement) to a well must be completed by a licenced well driller.

Decommissioning

The regulations state that the owner of an abandoned well must cap the well with a commercially manufactured device that prevents the entry of anything that may contaminate the water. If an abandoned well becomes dry or its continued existence may result in groundwater contamination, the owner must fill and seal the well following a method approved by the Minister (ECC) to prevent any vertical movement of water.

New Brunswick

Regulatory Context

Private wells are regulated under New Brunswick's (NB) Clean Water Act through the Water Well Construction Regulation. The drilling, altering, repair or decommissioning of a well must be done by a certified well driller who holds a well driller's permit and is employed by a company that holds a well contractor's licence. Permits are issued through the Department of Environment and Local Government (ELG) and must be renewed on an annual basis. The regulations cite ASTM standards that must also be followed for well installation. Figure B.4 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	NB Department of Environment and Local Government Certified Well Driller/Contractor	Application to and approval by the Minister for permits Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements)	Well Contractor's Permit Well Driller's Permit	New Brunswick Well Drilling Regulations New Brunswick Potable Water Regulation ASTM standard A589-84
Installation	NB Department of Environment and Local Government Certified Well Driller/Contractor	Drill or dig well (no specified depth) Install casing (L >=6 m, ID >=127mm) Install well cap Fill annular space and seal well Slope surface away from wellhead Perform yield test and disinfect well Install pump Test water quality	Water Well Driller's Report	
Operation & Monitoring	Homeowner	Ensure flow of water is controlled or stopped		
Maintenance & Repairs	Certified Well Driller	Repair and modify wells as necessary	Well Driller's Permit	
Decommission	NB Department of Environment and Local Government Homeowner	Decommission order by the Minister Seal well and stop vertical movement of water	Minister Approval	

Table B-4. Lifecycle of Private Wells in NB

Planning and Approvals

Before a well is drilled or dug, a certified person must site the location of a well so that it is accessible, outside of a building, prevents surface water contamination, and meets setback distances. A well must not be constructed within the distances from potential contamination sources listed in Table B.4. A well driller must receive approval from the Minister (ELG) and Minister of Health if a well is to be installed within any of the specified distances or near a sanitary landfill, garbage dump, or other massive source of contamination.

Table B-4. Setback distances for private wells in NB

Potential Source of Contamination	Well Type	Setback Distance (m)
Building	Drilled / Dug	2
Right-of-way of any highway or public road	Drilled / Dug	10
Cesspool	Drilled / Dug	30
Cesspool >= 3.5m deep	Drilled / Dug	60
Seepage pit, filter bed, soil adsorption field, earth pit privy or similar disposal unit	Drilled Dug	25 30
Septic tank, concrete vault privy, sewer of tightly joined tile or equivalent, or sewer connected foundation drain	Drilled Dug	15 30
Cast iron sewer, clean water drain, or cistern	Drilled / Dug	3
Pumphouse floor drain or draining to ground surface	Drilled / Dug	0.60

Installation

Well installation must be overseen by a licenced well contractor and completed by a licenced well driller. The regulations list specific requirements for well and pump installation and well completion for drilled and dug wells.

Well Construction

The regulations include requirements for well casing length, diameter, casing height above the ground, grout and well caps. Upon completion of the well, the well driller must remove all debris and conduct a pumping test for at least one hour. The water level before, during and after the pumping test must be recorded on a well driller's report, along with other construction details. A well tag must be obtained from the department (ELG) and attached to the well.

Pump Installation & Well Completion

Pumps must be installed in accordance with the regulations. The person installing the pump is responsible for disinfecting the well and pump using a method approved by the Minister (ELG). The pump installer is also responsible for installing a well cap and an air vent that meets minimum size requirements. The pump must meet clearance and connection requirements and cannot be installed without a sampling port or tap between the pump and any water treatment device. After completion, the well must be disinfected following a method outlined in Schedule C of the regulations. Well drillers are responsible for submitting a Well Driller's Report to the department (ELG) and homeowner.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. NB's Water Well Protection Program requires every homeowner to pay for water quality testing (chemistry and microbiology) as a part of their well installation cost. The well contractor is responsible for providing the homeowner with a voucher after the well is installed, but it is the responsibility of the homeowner to redeem their voucher and have their water tested at the department's laboratory. The province encourages homeowners to test their water at least twice per year for bacteria, once every two to three years for inorganic compounds, and after an incident (oil spill, etc.) for organic compounds. The owner of a flowing well must ensure the well is always fitted with a control device to prevent or minimize the flow of water to waste.

Maintenance and Repairs
The homeowner is responsible for ensuring the well is maintained. Any altering or repair to the well must be completed by a certified well driller with a well drilling permit. If a pump is to be repaired, the well must be disinfected immediately after. The province has an online resource, 'Well Water: A Safety Checklist for homeowners to follow for proper well maintenance'. It includes activities such as inspecting your wellhead for cracks, corrosion, or other damage, maintaining the area around the well, and guidance on what substances to keep away from your well.

Decommissioning
The Minister (ELG) may declare a well to be abandoned. The regulations state that, unless the person sealing the well is the homeowner, they must have a well driller's permit. If a well is not in use, and its existence may create a safety hazard to the aquifer, the well must be sealed to prevent any vertical movement of water using an approved method by the Minister (ELG).

Quebec

Regulatory Context
Private wells are regulated under Quebec's Environment Quality Act through the Water Withdrawal and Protection Regulation. The drilling, construction, repair, replacement and decommissioning of a well must be done by a certified well driller/installer. Certifications are issued through the Régie du bâtiment du Québec. Figure B.5 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs Régie du bâtiment du Québec Municipality Certified Driller/Installer	Selection of location of well (accessible, prevents surface water contamination, minimizes lakeshore & riverbank erosion, outside a high velocity flood zone)	Approval from Municipality Certification	Environment Quality Act Water Withdrawal and Protection Regulation (Q-2 r. 35.2) "The Quality of my Well Water" Ministère de l'Environnement
Installation	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs Professional (Supervision) Certified Driller/Installer	New materials Drill well (>= 5m) Install casing Install well cap Casing stickup Fill annular space and seal well Slope surface away from wellhead Perform yield test and disinfect well Flow control system for artesian wells	Well Construction Report	
Operation & Monitoring	Homeowner	Test water quality annually		
Maintenance & Repairs	Homeowner Certified Driller/Installer	Maintain well & prevent adverse effect		
Decommission	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs Certified Driller/Installer	Plugged with material not likely to degrade the quality of the groundwater May be inspected		

Figure B-5. Lifecycle of individual wells in QB.

Planning and Approvals

Before a well is installed, a certified person must site the location of a well so that it is accessible, prevents surface water contamination, minimizes lakeshore and riverbank erosion, and meets setback distances. A well must not be constructed in a high-velocity flood zone or within distances from potential contamination sources listed in Table B.5.

Table B-5. Setback distances for wells in Quebec

Potential Source of Contamination	Setback Distance (m)
Watertight wastewater treatment system	15
Non-watertight wastewater treatment system	30
Land for animal waste, pasture, composting facility, or cemetery	30

Installation

Drilled wells must be installed by a certified well driller and other types of wells must be installed by the corresponding certified persons. If the well is installed in a flood zone, it must be constructed under the supervision of a professional. The

Well Construction

The regulations include requirements for well depth, casing thickness, casing material, casing stickup, annular space, sealing, and well caps. All materials used must be new and for potable water, and casing joints must be watertight. The soil around the well must be graded to prevent water pooling and runoff toward the well. Drilled wells must be assessed by the person who constructed it to ensure it meets water quantity needs. The person who performed the construction work must record the construction details in a report and certify that the well complies with the regulations.

Pump Installation & Well Completion

After installation, the person constructing the well is responsible for disinfecting the well and any accessory equipment installed. Certified well drillers/installers are responsible for submitting a well construction record to the Minister and homeowner.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. The property owner must ensure that the well is visibly locatable and resistant to the weather, contaminants, and vermin at all times. If the well is flowing, it must include a flow control system, so it does not damage the neighbouring properties. Homeowners are not required to monitor the quality of their well water, but the Ministère de l'Environnement provides monitoring guidance through their website, "The Quality of my Well Water. It is suggested that homeowners sample their wells for microbiological parameters at least twice a year, in the spring of fall and at least once for physio-chemical parameters during a well's usage period.

Maintenance and Repairs

The homeowner is responsible for ensuring the well is maintained. Any altering or major repair to the well must be completed by a certified well driller/installer.

Decommissioning

The decommissioning of a well must be completed by a certified well driller/installer. A well must be plugged using a material that is not likely to degrade, and the portion of the casing open to the aquifer must be filled with clean sand. Specific excavation and filling requirements must be met, however, there is no obligation to report the decommissioning.

Challenges and gaps

Through discussion with provincial regulators, it was noted that there is a lack of clarification of professionals who install wells. Systems are not always inspected, so it is important that installers have the right qualifications in order for homeowners to trust the work is being done properly. Furthermore, the department already has too much on their plate and would be unable to inspect individual wells. It may be beneficial for municipalities to implement regulations and conduct these inspections.

Ontario

Regulatory Context

Private wells are regulated under Ontario's (ON) Water Resources Act through Regulation 903: Wells. The drilling, digging, major altering, repair or decommissioning of a well must be done by a certified well technician that is employed by a company that holds a well contractor's licence. Licences are issued through the Ministry of the Environment, Conservation & Parks (ECP) and must be specific to the type of technical services being provided (drilling, digging, other well construction, pump installation and monitoring/sampling/testing). The regulations cite ASTM and ANSI/American Water Works Association (AWWA) standards that must also be followed for well installation. Figure B.6 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	Ministry of the Environment, Conservation & Parks Certified Well Contractor Certified Well Technician	Application to and approval by the Ministry for certificates Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements)	Well Contractor Licence Well Technician Licence	Ontario Water Resources Act – Regulation 903: Wells. Ontario Building Code Act – Regulation 332/12: Building Code. Water Supply Wells: Requirements and Best Practices Ontario Environment and Energy – Wells on your property NSF International ASTM Standard A252, A500, A139, A606, A778, A589 (type IV, grade B), A53 (type E, grade B), and/or F480. ANSI/AWWA Standard C200.
Installation	Ministry of the Environment, Conservation & Parks Certified Well Contractor Certified Well Technician	Drill or dig well (>=6m) Log stratigraphy of well Install casing (material dependent) Install screen and well cap Fill annular space and seal well Slope surface away from wellhead Perform yield test and disinfect well Install pump	Well Record	
Operation & Monitoring	Certified Well Technician Homeowner	Driller must complete visual inspection of water sample with homeowner Test water quality on a regular basis Ensure flow of water is controlled or stopped		
Maintenance & Repairs	Ministry of the Environment, Conservation & Parks Certified Well Technician Homeowner	Maintain well & prevent adverse effect Maintain area around well Repair and modify wells as necessary		
Decommission	Ministry of the Environment, Conservation & Parks Certified Well Technician Homeowner	Seal well and stop vertical movement of water	Well Record	

Figure B-6. Lifecycle of individual wells in Ontario

Planning and Approvals

Before a well is drilled or dug, a certified person must site the location of a well so that it is accessible, outside of a well pit, prevents surface water contamination, and meets setback distances. A well must not be constructed within the distances from potential contamination sources listed in Table B.6. Setback distances are regulated under Ontario's Building Code Act through Regulation 332: Building Code.

Table B-6. Setback distances for private wells in Ontario

Potential Source of Contamination	Setback Distance (m)
Cesspool	30
Earth pit privy, privy vault, pail privy, greywater system or similar disposal unit	15
Treatment unit, distribution pipe, or holding tank	15
Other source of contamination not outlined (drilled wells)	15
Other source of contamination not outlined (dug wells)	30

Installation

Well installation must be overseen by a licenced well contractor and completed by a licenced well driller or digger. Pumps must be installed by certified pump installers. The regulations list specific requirements for well and pump installation and well completion for drilled and dug wells. Furthermore, the province has an online resource, 'Water Supply Wells: Requirements and Best Practices', which outlines the regulatory requirements and best practices for well installation.

Well Construction

The regulations include requirements for well depth, casing length, casing diameter, casing stickup, annular fill, screens and well caps. Upon completion of the well, the well driller must remove all debris and conduct a pumping test for at least one hour. The water level before, during and after the pumping test must be recorded on a well record, along with other construction details. A well tag must be obtained from the Ministry (ECP) and permanently affixed to the well.

Pump Installation & Well Completion

Pumps must be installed in accordance with the regulations by a licenced pump installer. After installation, the person constructing the well is responsible for disinfecting the well using dosing methods outlined in the regulations. Well technicians are responsible for submitting a well construction record to the Department (ECP) and homeowner.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. The requirements and best practices recommend homeowners to test their water at least three times per year for bacteria. It is suggested to take three samples, each a week apart, every time testing occurs as bacteria may not always show up from just one sample. If there is no concern for other organic and inorganic contaminants, routine testing should be done once every five years. The owner of a flowing well must ensure the well is always fitted with a control device to prevent or minimize the flow of water to waste.

Maintenance and Repairs

The homeowner is responsible for ensuring the well is maintained. The province provides homeowners with examples of common well problems, probable causes, and rehabilitation techniques in their requirements and best practices online resource. Any minor alteration or repair to the well can be completed by the homeowner, but major alterations and repairs must be completed by a certified well technician. If a well undergoing repair does not have a well tag, one must be obtained from the Ministry (ECP) and permanently affixed to the well. All alterations and repairs must be reported to the Ministry using a well construction record and associated with a well tag number. If a pump is to be repaired, the well must be disinfected immediately after, and the certified well technician must submit a well construction record to the Department (ECP).

Decommissioning

The owner of a dry or unused well must abandon it immediately if it is not being maintained for future use as a well. The abandonment of a well must be completed by a licenced will technician who is certified to install the type of well that is being abandoned. Well abandonment must be completed in accordance with the regulations, where a well technician is to remove the well tag, plug the well to prevent any movement of water, and seal it at the ground surface. A well abandonment record must be completed and submitted to the Ministry (ECP).

Challenges and gaps

Through discussion with a representative from the Department (ECP), challenges with regards to groundwater quality and northern communities were highlighted. The province has highly mineralized groundwater, with some areas having high concentrations of hydrogen sulfide, gas, and chloride, creating barriers to well installation. Additionally, northern communities have a harder time getting licenced well drillers to install wells as most of them are located in the southern regions of the province. Some homeowners may wait 6-12 months for a well to be installed, which could potentially be prevented if there were more training opportunities available for northern technicians.

Manitoba

Regulatory Context

Private wells are regulated under Manitoba's Groundwater and Water Well Act through the Groundwater and Water Well (General Matters) Regulation and the Well Standard

Regulation. The drilling, construction, repair, and modification of a drilled or dug well must be done by a licenced well contractor. Licences are issued through the Ground Water Management Branch of the Department of Environment and Climate Change (ECC) and are specific to the type of technical services being provided (drilling, digging, other well construction). A homeowner may install a well on the property they own, however, they must follow the regulations. The regulations cite various CSA, ASTM, AWWA and NSF standards that must be followed for well installation. Figure B.7 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	MB Department of Environment and Climate Change Certified Well Drilling Contractor	Application to and approval by the Department for certificates Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements)	Well Drilling Contractor Licence (Class 1, 2, 3, or 4)	Manitoba Groundwater and Water Well (General Matters) Regulation Manitoba Well Standards Regulation CSA, ASTM, AWWA and NSF Standards
Installation	MB Department of Environment and Climate Change Certified Well Drilling Contractor	Drill or dig well (>=6m) Log stratigraphy of well Install casing Install liner Install screen, filter and well cap Fill annular space and seal well Perform yield test and disinfect well Install pump	Well Construction Report	
Operation & Monitoring	Certified Well Drilling Contractor Homeowner	Director or well driller officer may inspect well at any time Ensure flow of water is controlled or stopped		
Maintenance & Repairs	MB Department of Environment and Climate Change Certified Well Drilling Contractor Homeowner	Well inspections may lead to well modifications Maintain well & prevent adverse effect Maintain area around well Repair and modify wells as necessary		
Decommission	MB Department of Environment and Climate Change Certified Well Drilling Contractor Homeowner	Decommission order by the Minister Seal well and stop vertical movement of water	Well Sealing Record	

Figure B-7. Lifecycle of Private Wells in Manitoba

Planning and Approvals

Before a well is drilled or dug, a licenced well contractor must site the location of a well so that it is accessible, prevents surface water contamination, and meets setback distances. A well must not be constructed within 1.5 meters of any property boundary or within the distances from potential contamination sources listed in Table B.7. A well cannot be constructed in a designated sensitive groundwater area. Furthermore, if a well is to be constructed in a flood zone, the landowner must ensure it meets additional requirements.

Table B-7. Setback distances for private wells in Manitoba

Potential Source of Contamination	Well Type	Setback Distance (m)
Human grave/mausoleum, disposal field, greywater pit, pit privy	With casing >= 6m below	15
	All other types	30
Septic tank, vault privy or pail privy	All	8
Manure storage facility or confined livestock are with 10 or more animal units	All	100
Underground and above-ground fuel storage tanks, pesticide storage area, fertilizer storage area	With casing >= 6m below	15
	All other types	30

Installation

Well installation must be completed by the appropriate licenced well contractor. The regulations list specific requirements for well and pump installation and well completion.

Well Construction

A well cannot be constructed in a manner that will contaminate the well or the surrounding groundwater. If there is suspected contamination during drilling, construction should stop, and emergency response should be notified. The regulations include material requirements for well casings, screens, and annular fill. Furthermore, wells must be installed so that they meet the minimum requirements for depth, casing stickup and well caps. Upon completion of a well, the well contractor must remove all debris and conduct a basic yield test for at least one hour. The method of testing, static water level before testing, rate of water discharge, water level after testing, and the duration of the test must all be recorded on a well construction report. If a well becomes flowing, it must be kept under control for the rest of construction.

Pump Installation & Well Completion

The person performing the test is responsible for recommending a pump-setting depth and pumping rate. Once the installation is complete, the well must be disinfected so that a certain dose is maintained throughout the well. Well contractors are responsible for ensuring a well identification tag is affixed to the well and submitting a Well Construction Record to the Department (ECC). All records are reviewed, and wells may be inspected by the Director or a well driller officer at any time to ensure the installation is in accordance with the regulations.

Operation & Monitoring

The operation and monitoring of the system is the responsibility of the property owner. Manitoba recommends that homeowners test their water immediately after well construction and at least once per year for bacteria. The province provides a guidance manual, 'Well Aware', that outlines further information on water quality testing for homeowners.

Maintenance and Repairs

All maintenance of the well is the responsibility of the property owner and must be done to prevent any adverse effect. The guidance manual, 'Well Aware', provides homeowners with information on how to inspect their wells for possible maintenance or repairs. This includes keeping contaminants away from the well, maintaining the area around the well, and inspecting the wellhead and cap. The repair and modification of a well is the responsibility of a certified well contractor. If repairs are made to a well or pump, the well must be disinfected immediately after. If a well is modified or repaired by methods that may change the yield of the well, the licenced well contractor must conduct a basic yield test.

Decommissioning

The property owner is responsible for the decommissioning of an unused well. The sealing of a well should be completed by a licenced well contractor to ensure that vertical movement of water in the well is prevented. Sealing material, slurry grout and ground surface sealer must meet the specifications listed in the regulation. A well sealing record must be completed by the well contractor and submitted to the Department (ECC).

Saskatchewan

Regulatory Context

The Water Security Agency (WSA) is a provincial Crown corporation that was established to manage, administer, develop, control, and protect the water in Saskatchewan. The WSA is responsible for administering the approval process for well construction and operation and the right to use groundwater. The WSA is granted this authority through The Water Security Agency Act and the Ground Water Regulations which are administered under the Act. The WSA requires that a Water Rights Licence and an Approval to Construct and Operate Works are obtained to use groundwater. However, wells for domestic use (< 5000 cubic meters per year) are exempt from obtaining a licence and approval but must still be installed by a registered well driller and follow the regulations. Figure B.8 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	Water Security Agency Registered Well Driller	Application to and approval by the Department for certificates Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements)		The Ground Water Regulations A Landowners Guide to Water Well Management The Plumbing and Drainage Regulations
Installation	Water Security Agency Registered Well Driller Homeowner	Drill a test hole Log stratigraphy of well Install casing Install Liner Install screen, filter and well cap Fill annular space and seal well Slope surface away from wellhead Perform yield test and disinfect well Install pump Characterize water quality	Well Completion Record	
Operation & Monitoring	Registered Well Driller Homeowner	Test water quality after maintenance, floods, and if changes occur		
Maintenance & Repairs	Water Security Agency Registered Well Driller Homeowner	Well inspections may lead to well modifications Maintain well & prevent adverse effect Repair and modify wells as necessary		
Decommission	Water Security Agency Registered Well Driller Homeowner	Seal abandoned wells to stop vertical movement of water	Well Decommissioning Record	

Figure B-8. Lifecycle of Private Wells in Saskatchewan

Planning and Approvals

Before a well is drilled, a registered well driller must site the location of a well so that it is accessible, outside of a building, prevents surface water contamination, and meets setback distances. A well must not be constructed within the distances from potential contamination sources listed in Table B.8.

Table B-8. Setback distances for private wells in Saskatchewan

Potential Source of Contamination	Setback Distance (m)
Septic tanks, package sewage treatment plants, or holding tanks	9
Absorption fields, chamber systems, and mounds	15
Open discharge systems and jet-type disposals	45
Private sewage lagoons	90

Installation

Private well installation must be completed by a registered well driller, but no notice to the WSA is required before construction. The regulations list specific requirements for well and pump installation and well completion.

Well Construction

The province has a guidance document, A Landowner's Guide to Water Well Management, which details the installation requirements for private wells. Well depth, casing material, casing size, intake design, annulus seal, and screen should all be considered in the well design. It is the registered well driller's responsibility to ensure the well's design adheres to the regulations. Upon completion of a well, the well driller must remove all debris and conduct a basic yield test. The driller must include the construction specifications and yield test results on the well record. If a well becomes flowing, the driller must set and cement in sufficient surface casing to control the flow of water.

Pump Installation & Well Completion

The person performing the yield test is responsible for selecting a pump suited for the measured pumping rate. Once the installation is complete, the well must be disinfected. Registered well drillers are responsible for submitting a Well Completion Record to the WSA. Private wells are not inspected by the WSA.

Operation & Monitoring

The operation and monitoring of the system is the responsibility of the property owner. The landowner's guide includes actions for adequate water management, including how to measure the water level of a well and how often to check the water quality. The guide recommends that homeowners test their water for bacteria immediately after well construction, after a heavy rainfall event, after any changes in color or odor in the water, if a newborn is in the house, and at least routinely once per year. Chemical analysis should be done less frequently.

Maintenance and Repairs

All maintenance of the well is the responsibility of the property owner and must be done to prevent any adverse effect. The guide details common well problems to look out for such as improper well design/construction, incomplete well development, borehole instability, screen plugging, corrosion and more. The major repair and modification of a well should be carried out by a registered well driller. If repairs are made to a well, the well should be disinfected immediately after.

Decommissioning

The property owner is responsible for the decommissioning of an abandoned well. The sealing of a well should be completed by a registered well driller to ensure that vertical movement of water in the well is prevented. For wells with a casing diameter of 18 inches or less, the well casing, liner, screen, and similar materials should be removed and filled with cement or approved heavy drilling mud, or the casing should be cut of at least two feet below the surface, secured with a cap and backfilled with compacted earth. For shallow wells or wells with a diameter greater than 18 inches, the well should be filled with compacted earth up to the natural ground elevation. The driller is responsible for submitting a Well Decommissioning Record to the WSA.

Alberta

Private wells are regulated under Alberta's Water Act through the Water (Ministerial) Regulation (the Regulation) and the Directive for Water Wells and Ground Source Heat Exchange Systems (the Directive). The drilling, construction, repair, and modification of a drilled well must be done by a certified journeyman water well driller with a Class A approval from the Ministry of Environment and Protected Areas (EPA). Well drilling contractors must also receive Class A Approval from the Ministry (EPA). Shallow, large diameter wells must be constructed by contractors with Class B approval from the Ministry (EPA). The regulations cite various CSA and ASTM standards that must be followed for well installation. Figure B.9 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	Ministry of Environment and Protected Areas Certified Journeyman Driller Qualified Driller	Application to and approval by the Department for approvals Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements)	Class A or C Approval? Water Well Driller Certificate	Alberta Water Act Water (Ministerial) Regulation Directive for Water Wells and Ground Source Heat Exchange Systems CSA and ASTM Standards
Installation	Ministry of Environment and Protected Areas Certified Journeyman Driller Qualified Diller	Drill or dig well (no specified depth) Log stratigraphy of well Install casing (60cm above highest flood) Install liner Install screen, filter and well cap Fill annular space and seal well Perform yield test and disinfect well Install pump	Drilling Report	
Operation & Monitoring	Certified Journeyman Driller Qualified Diller Homeowner	Ensure flow of water is controlled or stopped		
Maintenance & Repairs	Ministry of Environment and Protected Areas Homeowner	Maintain well & prevent adverse effect Maintain area around well		
Decommission	Ministry of Environment and Protected Areas Certified Journeyman Driller Qualified Driller Homeowner	Flush, clean and disinfect well Seal well and stop vertical movement of water	Drilling Report	

Figure B-9.. Lifecycle of Private Wells in Alberta

Planning and Approvals

Before a well is drilled, a certified well driller must site the location of the well so that it is accessible, prevents surface water contamination, outside of a pit and meets setback distances. A well must not be constructed within the distances from potential contamination sources listed in Table B.9.

Table B-9. Setback distances for private wells in Alberta

Potential Source of Contamination	Setback Distance (m)
Adjacent building	3.25
Another well	15
Spring	30
Watertight septic tank or sewage holding tanks	10
Sub-surface weeping tile effluent disposal field or an evaporation mound	15
Above ground storage tanks containing petroleum substances	50
Sewage effluent discharge to the ground surface	50
Sewage lagoon	100
Unpressurized (gravity flow) sewer lateral into a building	3
Pressurized (pumped) sewer lateral into a building	6

Installation

Well installation must be completed by a certified well driller. The Directive lists specific requirements for well and pump installation and well completion.

Well Construction

All materials used for well casing, lining, screen, and caps must meet specific standards described in the Directive. Furthermore, wells must be installed so that they meet the minimum requirements for casing sizing, casing stickup and annulus fill. Upon completion of a well, the well driller must remove all debris and conduct a basic yield test for at least two hours using either a pumping or bailing method. The method of testing, rate of pumping, and static water levels before, during and after testing must all be recorded on a well drilling report. If a well becomes flowing, the driller must prevent out of control water flow.

Pump Installation & Well Completion

The person installing the pump must make sure it will remain sanitary, not exceed the recommended pumping rate, and remain supported. Once the installation is complete, the well and pump must be disinfected at a constant chlorine concentration for 12 hours. Well drillers are responsible for submitting a Well Drilling Report to the Ministry (EPA). Wells are not inspected by the Ministry upon completion, they are only inspected if they receive a complaint from a property owner.

Operation & Monitoring

The operation and monitoring of the system is the responsibility of the property owner. Alberta's homeowner's guide, Water Wells That Last, explains how homeowners should conduct visual inspections to ensure their wells are operating properly. Alberta also has a Working Well Program which provides resources and workshops to property owners to help them operate and take care of their well. The province recommends that homeowners monitor the taste, odor, and appearance of their water routinely. Additionally, it is recommended that homeowners test shallow wells (less than 15 meters) quarterly and deeper wells semi-annually for bacteria. Chemical analyses should be conducted every two to five years.

Maintenance and Repairs

All maintenance of the well and the area around it is the responsibility of the property owner and must be done to prevent any adverse effect. The guide describes how to measure the water level of your well to ensure it is adequately maintained. It also provides recommendations on how to effectively monitor a well for repairs. The repair and modification of a well is the responsibility of a certified well driller.

Decommissioning

The property owner is responsible for the decommissioning of an unused well. The sealing of a well should be completed by a licenced well driller to ensure that the well is properly cleaned, disinfected, and filled to prevent vertical movement of water using a material that isn't harmful to the aquifer. A Well Reclamation Report must be completed by the well driller and submitted to the Ministry (EPA).

British Columbia

Regulatory Context

Private wells are regulated under British Columbia's (BC) Water Sustainability Act through the Groundwater Protection Regulation. The drilling, construction, repair, and alteration of a drilled well must be done by a certified water well driller registered with the Ministry of Water, Land and Resource Stewardship (WLRS). Similarly, pump installation must be completed by a certified pump installer registered with the Ministry (WLRS). The regulations cite various CSA, ASTM and NSF standards that must be followed during well installation. Figure B.10

provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	Ministry of Water, Land and Resource Stewardship Registered Water Well Driller Registered Pump Installer	Application to and approval by the comptroller for registration Selection of location of well (accessible, prevents surface water contamination, meets contamination setback requirements)	Certificate of Qualification Registration Acceptance Letter	British Columbia Groundwater Protection Regulation BC Regulations – Groundwater Protection Guidance Manual CSA, ASTM, NSF Standards
Installation	Ministry of Water, Land and Resource Stewardship Registered Water Well Driller Registered Pump Installer	Drill or dig well (no specified depth) Log stratigraphy of well Install casing Install liner Install screen, filter and well cap Fill annular space and seal well Slope surface away from wellhead Perform yield test and disinfect well Install pump	Well Construction Report	
Operation & Monitoring	Certified Well Driller/Digger Homeowner	Ensure flow of water is controlled or stopped		
Maintenance & Repairs	Ministry of Water, Land and Resource Stewardship Registered Water Well Driller Registered Pump Installer Homeowner	Maintain well & prevent adverse effect Maintain area around well Repair and modify wells as necessary	Well Alteration Report	
Decommission	Ministry of Water, Land and Resource Stewardship Registered Water Well Driller Registered Pump Installer Homeowner	Seal well and stop vertical movement of water	Well Decommissioning Report	

Figure B-10. Lifecycle of Private Wells in BC

Planning and Approvals

Before a well is drilled, a registered well driller must site the location of the well so that it is accessible, prevents surface water contamination and meets setback distances. A well must not be constructed within the distances from potential contamination sources listed in Table B.10.

Table B-10. Setback distances for private wells in BC

Potential Source of Contamination	Setback Distance (m)
Private dwelling	6
Another well	15
Any probable source of contamination	30
Cemetery or dumping ground	120

Installation

Well installation must be completed by a registered well driller. The regulation lists specific requirements for well and pump installation and well completion.

Well Construction

All materials used for well casing and lining must be new or like-new and meet certain strength requirements and well screens must be durable. Furthermore, the well casing stick-up must meet a specified height before being capped. The annular fill and surface sealant must meet material and fill method requirements. Upon completion of a well, the well driller must remove all debris and conduct a well yield test and record the results on a well construction report. If a well becomes flowing, it the driller must prevent or minimize the flow.

Pump Installation & Well Completion

The person installing the pump must disinfect the well immediately after installation. The pump installer must make sure the pump does not cause any damage to the well, prevents entry of foreign material, and allows the well and pump to be properly disinfection. Once the installation is complete, the well and pump must be disinfected. Well drillers are responsible for attaching a well plate to the wellhead and submitting a Well Construction Report to the Minister (WLRS). If a well plate is added, the owner of the well must submit a Well Identification Report to the Minister (WLRS).

Operation & Monitoring

The operation and monitoring of the system is the responsibility of the property owner. The province has various online resources to assist homeowners in monitoring their wells. BC recommends that homeowners test their well water for bacteria at least once per year. Additionally, chemical testing should be done immediately after well installation and annually. The province also provides brochures on how to disinfect a well.

Maintenance and Repairs

The maintenance and minor repairs of a well are the responsibility of the property owner and must be done to prevent any adverse effect. The homeowner is responsible for maintaining the area around the well and ensuring that any repairs required are promptly undertaken to maintain good working operation of the well. BC's Best Practices for Dug Wells outlines how to inspect a dug well and what repairs may be necessary based on findings. The major repair and alteration of wells is the responsibility of a registered well driller. A well must be disinfected immediately after any alterations or major repairs to prevent contamination. In the case of a flowing artesian well, the owner must make sure the device used to control the flow is properly maintained and repaired when necessary. A Well Construction Report must be submitted to the Minister (WLRS) for any alterations made.

Decommissioning

The property owner is responsible for the decommissioning of an unused well. A registered well driller should be hired to remove the pump and any other equipment, if possible. The well must be filled to prevent the vertical movement of water in the well, annular space, and between casings before being sealed at the surface. The sealing of a well should be completed by a registered well driller to ensure that the well is properly cleaned, disinfected, and filled to prevent vertical movement of water using a material that isn't harmful to the aquifer. A Well Decommissioning Report must be completed by the well driller and submitted to the Minister (WLRS).

Yukon

Regulatory Context

The Yukon government undertakes groundwater protection through the Waters Act. Currently, there is no legislation in place pertaining specifically to water well drilling and private wells in the Yukon, but the Public Health and Safety Act contains some regulations. The Act states that groundwater drinking sources must come from a drilled well that is constructed in accordance with the Guidelines for Well Water Construction and certified by an independent professional engineer. However, to our knowledge, these guidelines no longer exist. Figure B.11 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the private well's lifecycle, which in this case is very limited.

Lifecycle Phase	Stakeholders	Actions	Documentation	Regulations
Planning & Approval	Yukon Water Professional Engineer	Potential GUDI assessment Hydrogeological study to determine minimum separation from pollution sources		Public Health and Safety Act Yukon Waters Act
Installation		Drill well		
Operation & Monitoring				
Maintenance & Repairs	Homeowner	Protect wellhead		
Decommission				

Figure B-11. Lifecycle of Private Wells in the Yukon.

Planning and Approvals

Before a well is drilled, a Health Officer may require the owner to conduct or cause to conduct a hydrogeological study to determine whether a groundwater source is under the influence of surface water (GUDI) and the minimum separation distances to pollution sources (if it is a bedrock aquifer). Unless otherwise determined by the results of a comprehensive hydrogeological study, a well must not be constructed within the distances from potential contamination sources listed in Table B.11. Additionally, the Yukon Water Well Registry is a publicly accessible groundwater database containing groundwater level information from wells installed throughout the territory, which can aid in the siting of a new well.

Table B-11. Setback distances for private wells in the Yukon

Potential Source of Contamination	Setback Distance (m)
a sewage disposal system, or other potential sources of pollution that may pose a health and safety risk	60
solid waste site or dump, and cemetery	120
sewage lagoon or pit	300

Installation

There are no requirements listed in the regulations for well installation other than the well must be drilled.

Operation & Monitoring

The operation and monitoring of the system is the responsibility of the property owner. The Yukon Government website recommends that homeowners test their well water for bacteria after a well is installed and at least once per year after that. Chemical testing should be conducted once per year for the 2 consecutive years and if no significant changes in chemistry are observed, once every five years.

Maintenance and Repairs

The maintenance and minor repairs of a well are the responsibility of the property owner and must be done to prevent any adverse effect. The homeowner must ensure that the wellhead is maintained. If a water well is being maintained for future use, the property owner must ensure that the well is capped in a manner that prevents the entry of any substance that may adversely affect the quality of water in the well.

Decommissioning

The Act states that the property owner must ensure that the decommissioning or abandonment of a drinking water well is done in accordance with criteria outlined in the Guidelines for Water Well Construction. As mentioned above, these guidelines no longer exist.

Challenges and gaps

A major challenge for the Yukon is that there are currently no regulations for well drilling and no licencing programs for well drillers. Reporting for well construction is voluntary and comes from the drillers, or from the Yukon's Rural Domestic Well Program applications, resulting in a huge gap in record keeping.

Appendix C – Truck-to-Cistern Jurisdictional Scan

Prince Edward Island

Prince Edward Island does not have any regulations or guidelines for cisterns or bulk water vehicles.

Nova Scotia

Regulatory Context

Currently, there is no legislation in place pertaining specifically to trucked drinking water and cisterns in Nova Scotia. The Department of Environment and Climate Change (ECC) has a guidance document, The Drop on Water, which outlines best practices for cistern installation, operation, monitoring, and maintenance. The document specifies that water haulers may use public drinking water supplies registered with the Department (ECC) that are monitored and tested in accordance with the 'Guidelines for Monitoring Public Drinking Water Supplies'. Water that is hauled from any other acceptable sources must also be monitored and sampled in accordance with the Water and Wastewater Facility Regulations. It is suggested that best practices be followed for the collection, transport, and discharge of water.

Planning and Approvals

Proposed cisterns for a new or existing building or home should be indicated on the design drawing. It should be brought to the attention of the municipality on any permit application required for construction. Before construction, the size of the proposed cistern should be calculated considering if it is the only potable water source, the household size, and the water-use habits of each resident. If a cistern is a household's only source of water, the minimum recommended capacity for a storage reservoir is 27,000L.

Installation

Cisterns should be installed by a person who is equipped to do so. Depending on the design, a screened vent may be installed to prevent surface contaminants from entering the water supply and to ensure the interior of the cistern is not under pressure. If a vent is installed, the opening should be facing downward to prevent airborne contaminants from entering the water supply. An access hatch should be installed so the cistern is accessible for cleaning, maintenance, and repairs. Cisterns should include adequate piping and the withdrawal pipe should be screened and 10-15 cm above the bottom of the tank to avoid the intake of sediment.

Operation & Monitoring

The guidance document states that hauler trucks should be made of stainless steel or another material that meets NSF standards for potable water. Trucks are usually filled using a municipal supply, where municipalities are responsible for making sure the water is properly managed, protected, and safe to drink. It is the responsibility of the water hauler to make sure the water stays safe during transport. Furthermore, trucks should never be filled using water from an untreated water supply as it can make consumers sick. Each utility may have different requirements for access to their filling stations. Halifax Water requires trucks to be inspected annually to ensure the system is compatible and the vehicle meets specific requirements. For Halifax Water, trucks must have a cam-lock adapter, rigid piping permanently attached to the vehicle, air gap twice the size of the diameter of pipe, shut off valve, and must be designed for potable water hauling only. Any water that is stored in a cistern for longer than 14 days should have chlorine bleach added to it to minimize bacteria and algae growth. The guidance document states how much bleach should be added based on the amount of water in the cistern. Water should be regularly tested for bacterial and chemical analyses.

Maintenance and Repairs

It is the responsibility of the homeowner to keep the cistern cleaned and maintained to ensure the water quality is adequate. For a system to work properly, it must be inspected, cleaned, and maintained regularly. The guidance document recommends that cisterns be maintained according to the manufacturer's instructions and that any maintenance performed should be done by a person who is qualified to work in confined spaces and has the appropriate safety equipment. Sludge and/or slime can accumulate at the bottom of the cistern will impact the quality of the water. Cisterns should be cleaned before sludge/slime buildup exceeds 2.5 cm in thickness. Because a cistern must be drained for cleaning and maintenance, this work should be completed when the water level is low to reduce the amount of water removed and wasted. The guidance document outlines how to clean and disinfect a cistern and its piping system.

Decommissioning

The province has no guidelines pertaining to the decommissioning of a cistern.

New Brunswick

New Brunswick does not have any regulations or guidelines for cisterns or bulk water vehicles. The only mention of cisterns is in Regulation 90-97 under the Clean Water Act, where it states that a well must be located 3 m from a cistern.

Newfoundland & Labrador

Newfoundland and Labrador does not have any regulations or guidelines for cisterns or bulk water vehicles.

Quebec

There is no legislation in place pertaining to cisterns in Quebec, however, trucked water that is supplied to more than 20 persons is regulated by the Regulation respecting the quality of drinking water under the Environment Quality Act (Q-2, r. 40). Under this act, all responsibility is incumbent on the certified person in charge of the tank truck, unless stated otherwise. The person in charge must make sure the water used to fill the tank is tested at the outlet of the reservoir, meets the standards in Schedule 1, has a chlorine residual greater than or equal to 0.2 mg/L, and is tested at least once per day when it's in the truck tank. All transfer operations must be performed under sanitary conditions and equipment must be maintained and cleaned to prevent any contamination. A hauling truck must have been designed for the transportation of potable water and can only be filled with potable water. Equipment must be cleaned and disinfected if anything other than potable water comes in contact with it. Analysis reports from an accredited laboratory must be kept for 2 years and made available to the Minister. The truck hauler must notify the Minister and regional health director of any non-compliant results to remedy the situation, create a sampling plane and protect the users. In the case of fecal contamination, all users must be notified. It should be noted that these regulations do not apply to trucked water systems that serve less than 20 persons.

Ontario

Ontario does not have any regulations for cisterns or bulk water vehicles for residential users. The province only provides guidelines for small or large non-municipal, non-residential systems and small or large municipal, non-residential systems. There are guidelines for cistern systems published by regional health authorities, but these were not summarized for this work.

Manitoba

Regulatory Context

There is no legislation in place pertaining specifically to cisterns in Manitoba. However, there is a factsheet: Water Storage Tanks (Cisterns) written by Manitoba Conservation and Water Stewardship that serves as a general reference guide for cistern users. The factsheet refers owners to the Canadian Standards Association (CSA) B126 Series-13 on water cisterns for detailed information on cistern construction. The Public Health Act regulations require bulk water haulers to obtain a permit to sell or convey water for sale for domestic purposes. Additionally, Manitoba Health Protection Unit has created Bulk Water Hauling Guidelines for bulk water haulers. It is suggested that these guidance documents be followed for the construction, maintenance, and monitoring of cisterns and water hauling trucks to ensure the public health is protected.

Planning and Approvals

The size of a cistern should be dependent on the amount of water to be used and the frequency of delivery. The factsheet suggests that cisterns typically hold volumes between 5,500 and 7,500 litres and should be sized to be filled once per week. There is no regulation for the location of cisterns, however, the Onsite Wastewater Management System Regulation under the Environment Act requires septic tanks and aerobic treatment units to be at least 3 m from cisterns. It is recommended to have cisterns installed in areas that allow easy access for water haulers, maintenance, and cleaning and are at least 15 m from septic fields and 30 m from chemical storage areas, trees, animal corrals and pens.

Installation

Cisterns should be installed by a person who is equipped to do so by following the Canadian Standards Association (CSA) B126 Series-13. Cisterns are usually prefabricated but larger systems may be custom or cast in place. In any case, cisterns must be constructed using material and any internal coating must be certified to NSF/ANSI Standard 61 and suitable for drinking water use. An air vent should be located at least 0.6 meters above ground level, screened and opening facing downward to prevent any contamination. An access hatch should be installed so the cistern is accessible for cleaning, maintenance, and repairs and must be lockable to prevent surface water, insect, and vermin entry. A fill port should be installed to prevent the entry of hoses, debris, and other materials from entering the cistern during refiling and should have cam locks. Cisterns should include a screened withdrawal pipe that is installed 10-15 cm above the bottom of the tank to avoid the intake of sediment into the plumbing system. Underground cisterns should be located below the frost line (often 2.4 m) or properly insulated, and adequate bedding should be provided during placement. Above ground cisterns should also be insulated.

Operation & Monitoring

The guidance document states that cistern owners should hire services of an approved bulk water hauler that holds a valid permit to operate. Water hauling vehicles and equipment must be designed, operated, and maintained in a sanitary manner to ensure water does not become contaminated. Hauler trucks must meet NSF/ANSI Standard 61 or equivalent for food or water grade containers and be designed in a manner that allows easy access for cleaning. Hoses, nozzles, and all other equipment must be kept in a sanitary condition and moveable equipment should be disinfected using bleach. Truck tanks should only be filled with water obtained from an approved source and clearly labelled for potable water only. be Trucks must also be sampled 4 times per year for e. coli and HPC. Drivers are responsible for keeping an activity log in the water hauling vehicle that includes date, location of each fill, delivery, emergency disinfection, etc. Furthermore, visual inspections must be conducted daily to ensure access/fill hatch seals are in good condition. If homeowners are concerned about chlorine residuals in the truck tank, they can request that the hauler test the water prior to filling. Cisterns should be inspected regularly and tested for bacteria at least once per year. If results are concerning, the water quality of the trucks should be compared to the cistern to determine where contamination is coming from.

Maintenance and Repairs

The factsheet recommends that cisterns should be cleaned and disinfected periodically, but at least once per year and following construction, maintenance, repair, flooding in the area, period of non-use, or sampling that indicates presence of bacteria. It is recommended that cleaning is scheduled at the end of a water use period, just prior to a refill. According to the guidelines, water tanks must be sanitized at least three times per year (spring, summer, fall), and immediately after any contamination incident or failed bacteriological test.

Decommissioning

The province has no guidelines pertaining to the decommissioning of a cistern.

Saskatchewan

Currently, there is no legislation in place pertaining specifically to cisterns and bulk water hauling in Saskatchewan. The Saskatchewan Health Authority (SKHA) has two guidance documents, the Disinfection Guideline for Bulk Water Haulers and the Cleaning and Disinfection Guideline for Private Cisterns after a Drinking Water Advisory. Any persons operating a business of hauling water for domestic use must first contact the SKHA. There is no guidance on the planning, approval, installation, operation, or monitoring of cisterns, however, homeowners can follow the SKHA guidance for cleaning and disinfecting cisterns.

As cistern is a confined space and should only be entered by a trained person with the right equipment; homeowners should only undertake activities that do not require entry into the cistern. When cleaning a cistern, the seals, surfaces, and floors should be inspected for any signs of cracks or leaks. The person disinfecting the system should follow the outlined protocol and ensure the safe disposal of the chlorinated water.

The water hauler is responsible for obtaining water from a municipal water supply approved by the local regional health authority and protecting it from contamination during filling, storage, transportation, and delivery. Chlorine should be added to the water tank following the chlorination protocol outlined by SKHA to achieve a free chlorine residual of 1.0 mg/L at the time of filling. To ensure the water is still potable upon delivery, it should have a chlorine residual of 0.1 mg/L and confirmed by testing. Truck equipment must be cleaned and disinfected regularly, and haulers should shock chlorinate their tanks periodically following the SKHA protocol.

Alberta

Regulatory Context

The *Public health guidelines for non-municipal drinking water* is a guidance document made by Alberta Health intended to support the *Public Health Act*. These guidelines should be followed to ensure the safe planning, installation, operation, and maintenance of cisterns. Cisterns should be connected to plumbing by a licensed plumber. Water hauling trucks must be inspected and approved by Alberta Health Services (AHS) and have an appropriate decal fixed onto the hauling vehicle. Public health inspectors inspect water-hauling vehicles on a regular basis under the authority of the *Public Health Act*. Bulk water must be obtained from a water supply that is regulated by Alberta Environment and Parks or Alberta Health as a potable water source. The Nuisance and General Sanitation Regulation states that tanks can only be used for the transport of potable water. Transporting any other material will void the water tank approval.

Planning and Approvals

The size of a cistern should be at least three times the expected daily water use and no less than a 24 hour supply. It should be filled at least once per month or frequent enough to prevent stagnated water and maintain chlorine residual. A cistern should be accessible for cleaning, servicing, and filling. Additionally, it should meet the setback requirements listed in Table C.1 and not be downgradient from an open discharge, sewage lagoon, or other contamination.

Table C-1. Setback distances for cisterns in Alberta

Potential Source of Contamination	Setback Distance (m)
Property line	1
Drains, foundation walls, and roadways	1.5
Septic tank	10
Sewage treatment field	15
Other sources	15

Installation

The installation of a cistern should follow the manufacturers specifications for burial depth, bedding/cover materials, placement in high groundwater tables, protection from permafrost, and sealant. Cisterns should be built using a material that won't easily decay, deform, corrode, or diffuse any contaminants into the water. All flanges, gaskets, housing, and other components of the cistern should be stamped to indicate they conform with NSF/ANSI 61-2016. Any coatings of the interior should be certified with NSF/ANSI Standard 61 and if liners are used, they should be in good condition and have an NSF of USFDA approval/certification. To ensure water is protected, the cistern must be watertight, vermin and insect proof, prevent infiltration, and have a free draining top. An access hatch should be installed so the cistern is accessible for cleaning, maintenance, and repairs and should be lockable in some cases to prevent vandalism. The lid and collar should be elevated, and the area around should be maintained to prevent infiltration from rain, snow, and floods. The cistern should be disinfected before first use and commissioning.

Operation & Monitoring

The guidelines state that bulk water should be delivered by an AHS approved hauler. All water hauling tanks must be made of food-grade material that is approved by AHS. Equipment must be food-grade, protected, and clearly labelled for drinking water use only. Tight fitting covers and caps should be used when contamination may occur during storage and transport. The water hauler should routinely assess the tanks for damage that may affect the integrity of the tank. Hatches and seals must be watertight and in good repair and any nozzles/hoses should be cleaned and disinfected at least daily. The water hauler is responsible for preventing the contamination of bulk water during cistern filling. Chlorine should be added to water that has been stored for more than 14 days to minimize algal and bacterial growth in the cistern. Maintaining a chlorine residual of 0.1 mg/L is recommended. The cistern site should be visually inspected for flaws and damages at least twice per year. The cistern should be tested for e. coli and coliforms at least quarterly and for seasonal systems, prior to opening a system again.

Maintenance and Repairs

The guidelines recommend that cisterns should be inspected regularly. Cleaning and disinfecting procedures must be followed training and should be reviewed with AHS public health inspector. Cisterns should be cleaned and disinfected on annual basis and after plumbing maintenance, when the source water is deemed unsafe, if there is microbial contamination, if the source is changed, and when recommended by a public health inspector. All internal servicing must be completed by someone with confined space training.

Decommissioning

The province has no guidelines pertaining to the decommissioning of a cistern.

British Columbia

British Columbia does not have any provincial regulations or guidelines for cisterns or bulk water vehicles. However, there are guidelines provided by regional health authorities. The bulk water hauling guidelines that are available through health authorities, many of which are not be publicly available, apply to suppliers that want to be licenced as water haulers.

Yukon

Currently, there is no legislation in place pertaining specifically to cisterns in the Yukon. Water hauling for municipalities and health districts under the Public Health and Safety Act and trucked distribution systems that deliver to five or more sites is regulated in Part 2 of the Public Health and Safety Act: Bulk Delivery of Drinking Water. The owner of a truck hauling vehicle must apply for a permit to operate a trucked system through the Environmental Health Services and obtain a written permit from a health officer before the truck is operated. Operators must hold a valid operator certificate for bulk delivery of water. The owner of a truck hauling vehicle is responsible for obtaining water from drinking water systems permitted under Part 1 and 2 of the regulations only and for the safe delivery to consumers. Unless the owner obtains written approval from a health officer, the hauling trucks must not be used for any other purpose other than hauling potable water and must be labelled accordingly. Tanks must meet proper design specification for tank material, coating, and equipment and have a sealed engineering assessment. Tanks must have vents and watertight, lockable access ports to prevent contamination. The owner is responsible for the maintenance and upgrade of hauling vehicle and maintaining construction, inspection, maintenance, sampling, and testing records. Equipment must be clean and in sanitary condition, and hoses and nozzles must be disinfected each day. Tanks must be sampled for bacteria bi-weekly or if they have not been used for 30 days. Additionally, tanks must be cleaned and disinfected at least every six months following disinfection protocols. To ensure the chlorine residual is 0.4 mg/L at the time of filling the truck and 0.2 mg/L when delivering, the operator must measure the chlorine residual at the time of filling, first delivery and last delivery.

Appendix D – Onsite Wastewater Treatment Systems Jurisdictional Scan

To better understand the regional and jurisdictional variations in the planning, installation, operation, maintenance, repair, and decommissioning of decentralised wastewater systems a jurisdictional scan was conducted for each province and the Yukon. The scan included consideration of i) relevant legislation, including Acts and regulations, ii) policy and guidance documents, including standards of practice, technical guidelines, and protocols published by the principal authority or professional organization, iii) publicly available documentation, i.e. websites, homeowner's manuals, information brochures, etc. and iv) video and/or phone calls with regulatory administrators and/or professional organization staff.

A full understanding of provincial and territorial standards and requirements, as well as management and enforcement tools, will provide a useful backdrop for the processes and activities currently being employed in First Nations communities. Subsection 2.1 contains brief summaries of the activities, stakeholders, documentation, and regulations central to the planning, installation, operation, maintenance, repair, and decommissioning of onsite septic systems, including holding tanks, in the provinces and the Yukon.

Prince Edward Island

Regulatory Context

Onsite septic systems are regulated under Prince Edward Island's (PEI) Water Act through the Sewage Disposal Systems Regulations. The Regulations empower licensed site assessors, licensed septic contractors, professional engineers, and licensed pumpers to engage in activities to support onsite septic systems in PEI. The installation, reconstruction, modification, or decommissioning of a sewage disposal system must be done by a licenced septic contractor or professional engineer. Licences are issued through the Minster of Housing, Land, and Communities (HLC)/Environment, Energy and Climate Action (EEC). Licensed site assessors undertake site suitability assessments to evaluate the soil and land conditions. The regulations cite the Onsite Sewage Systems Construction Standards (Construction Standards) for determining technical guidelines for site assessment, soil characterization, system selection, installation, and management. The cleaning and disposal of onsite septic systems must be completed by a person with a valid pumper's licence issued by the Minster of EEC. Figure D.1 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Licensed Septic Contractor Licensed Site Assessor Engineer Environmental Officer (Housing, Land and Communities) Person responsible for property	Site assessment – soil characterization, test pits, soil permeability, System design and selection, sizing and sighting requirements	Site Suitability Assessment Registration form Sewage Disposal System Registration form Form A (test pit record) Site Plan	Sewage Disposal Systems Regulation On-Site Sewage Disposal Systems Construction Standards On-Site Sewage Disposal Systems – A homeowners Guide
Installation	Licensed Septic Contractor	Install following acceptable construction practices Give notice of installation to the Minister	Certificate of Compliance Sewage Disposal System Installation & Assessment (Audit Report)	
Operation & Monitoring	Licensed Plumber Person responsible for the property	Routine pumping, effluent filter cleaning following manufacturer's guidance If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field	Pumping Records Annual Report (by pumpers)	
Maintenance & Repairs	Licensed Septic Contractor Person responsible for the property	Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden If malfunction/failure occurs system can be repaired, replaced by QP or Engineer		
Decommission	Person responsible for property	Remove contents of septic tank, disinfect, fill tank OR remove septic tank, disinfect excavation, fill with clean soil	Notification of decommissioning	

Figure D-1. Lifecycle of Onsite Sewage Systems in PEI.

Planning and Approvals

Several steps must be taken by the licenced septic contractor to complete the registration form for the installation of a new onsite septic system. Systems with a flow less than 6,810 L/d have a less rigorous planning process than systems with a flow that exceeds this volume. The process below summarizes the process for systems < 6,810 L/d.

Site Suitability Assessment

In accordance with the Construction Standards, a site suitability assessment must be completed, including a soil assessment with a test pit (to 1.2m depth), soil characterization, soil permeability analysis (minimum of two tests), and determination of soil drainage class. A site plan must also be submitted, detailing the location of all required clearances and setbacks from property boundaries, buildings, watercourses, wells, beaches, and water lines. The site drawing should also confirm minimum lot size, as determined by types of services to be installed.

System Design and Selection

A Sewage Disposal System Registration Form must be submitted to the Environmental Officer at HLC for approval. The size of the dwelling, number of bedrooms, and estimated design flows, as well as key system details must be provided in the registration form, including septic tank material type, tank size, pump or dosing chamber capacity, disposal field configuration, and imported fill type.

Installation

A licensed septic contractor will ensure that a contractor or installer is on site during the installation process. A 24-hour notice of installation must be given to the Minister (HLC). Following installation, the septic contractor must submit a completed Certificate of Compliance form certifying that the sewage disposal system has been installed in accordance with the sewage disposal system registration form and the Construction Standards. An Onsite Sewage Disposal System Audit Report may be conducted by a Safety Standards Office to verify the Site Suitability Assessment details and the Septic System details. Construction Standards (Section 4) states: *A Licensed Septic Contractor, not licensed as a site assessor, and utilizing the permit process must also follow these standards. Under the permit process, licensed contractors are required to make application for a permit, receive a closing time and have an inspection carried out, prior to covering the sewage disposal system.*

Operation and Monitoring

Operation and monitoring of the system is the responsibility of the property owner. PEI provides an Onsite Sewage Disposal System Homeowners Guide to provide support to individuals operating and maintaining an onsite septic system. The guide encourages record keeping and best practices to ensure the optimal operation of the system. Monitoring and conservation of water use, restriction of the use/disposal of certain materials, and the monitoring of the septic field (i.e. tree roots, overburden, etc.) are recommended to support the operation of the septic system. Routine pumping is recommended, with the schedule being dependent on system size, usage patterns, and types of materials routinely put into the system. PEI requires pumpers to be licensed and requires pumpers to maintain a record of all septage removed from systems and submit an annual report to the Minster detailing all septage pumping completed in the calendar year.

Maintenance and Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The Homeowner's guide provides information about common causes for system failures, including system overloading (due to poor initial sizing, or changes in occupancy load), poor design/installation, physical damage, and lack of maintenance. Signs of failure are provided to assist the homeowner in detecting septic issues. Per the Sewage Disposal Systems Regulations, any reconstruction or modification of a septic system (i.e. significant repairs or replacement) requires notification of the Minister.

Decommissioning

Abandoned septic tanks must be decommissioned by a septic contractor. It is the responsibility of the property owner to ensure the system is decommissioned following the Sewage Disposal System Regulations. The septic contractor must notify the minister within 60 days of decommissioning. The tank must be pumped, disinfected, and filled with clean soil, or, the tank can be removed, the excavation site disinfected, and filled with clean soil.

Holding Tanks

The Sewage Disposal System Regulations provide specifications for the design, installation, and use of a holding tank, but clarify that a holding tank is not considered an onsite sewage disposal system. The minimum tank volume is 4,540 L for residential use. The tank must be equipped with audible and visible high-level alarms, be readily accessible for a pump truck, and the proposal for a holding tank must include the costs for ongoing pumping services. The regulations state that the maintenance and operating costs of a holding tank are substantially higher than a traditional sewage disposal system and caution that holding tanks should be installed as a "last resort" for onsite sewage management.

Nova Scotia

Regulatory Context

Under the Activities Designation Regulations, onsite sewage system installation requires notification or approval to install. The specifications for system design and installation are detailed in the Onsite Sewage Disposal System Regulations under the Environment Act. The installation of a sewage disposal system must only be done after notification to, or approval from, Nova Scotia Environment and Climate Change (NSECC) administrators. NSECC provides the Onsite Sewage Disposal System: Technical Guidelines (Guidelines) to establish planning and installation requirements. Systems must be selected by either qualified persons certified by the NSECC or professional engineers. Only professional engineers can design systems. Certified installers and certified septic tank cleaners are required to install and pump systems, respectively. All certifications are issued and managed by NSECC. Figure D.2 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	NSECC regulator Qualified person and/or Engineer Resident/owner	Notification (or Approval) process Site assessment: soil assessment (pit test & hydraulic conductivity), horizontal & vertical clearance distances, slope System selection (CSA B66) based on capacity and site conditions	Notification/Approval Site Plan/Drawing Construction Alert form	-On-site Sewage Disposal (OSSD) Regulations -Designated Activities Regulations -Approvals & Notifications Procedures Regulations - OSSD Standard - OSSD Technical Guidance
Installation	Qualified person and/or Engineer Installer	Excavation Importation of soil (if necessary) Installation of tanks, plumbing, electricity (if necessary) Inspection by Qualified Person	Completion of Work form Certification of Installation	
Operation & Monitoring	Residents Contractors (waste haulers/pumpers)	Routine pumping, effluent filter cleaning following manufacturer's guidance If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field	Sewage management plan (if holding tank is included in system)	
Maintenance & Repairs	Residents Contractors *In case of malfunction:* Qualified person and/or Engineer NSECC regulator	Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden If malfunction/failure occurs system can be repaired, replaced by QP or Engineer	Certificate of Installation Record of inspection Service report Malfunction Inspection form	
Decommission	Residents Contractors	Pump out tank completely If structurally sound, septic tanks can be filled in with soil If not structurally sound, tanks can be broken in place and backfilled with soil or removed and backfilled	Procedures for abandoning septic tanks (Appendix to Technical Guidelines)	

Figure D-2. Lifecycle of Onsite Sewage Systems in Nova Scotia.

Planning and Approvals

The qualified person, on behalf of the property owner, must either notify NSECC of an onsite system installation, or apply for approval of a designed system. If the system is selected from the Guidelines (i.e. does not require any alteration or engineering), the qualified person must notify the administrator. If the system has designed elements, the professional engineer must apply for approval of the system. In either case, a site assessment including lot dimensions, layout, setbacks, surface slope, test pit findings, and soil assessment are required. Additionally, system components and selection of disposal field properties must be reported. Either a Receipt of Notification or issuance of system approval from NSECC administrator is needed prior to installation.

Installation

Only a qualified person, including a certified installer, can install a selected or designed system. Once a system is installed, the qualified person who selected the system or the professional engineer who designed the system must inspect the system prior to the system being back filled. Following a successful inspection, a Completion of Work form must be completed by the qualified person and a Certification of Installation must be issued to the Minister, the local building official appointed under the Building Code Act, and the owner of the lot.

Operation and Monitoring

Operation and monitoring of the system is the responsibility of the property owner. Routine pumping of septic tanks must be done by a certified septage hauler and follow the Guidelines for the Handling, Treatment, and Disposal of Septage. The Wastewater Nova Scotia Society, in partnership with NSECC, published a Homeowner's Guide to Septic Systems that provides basic information about septic systems, general maintenance instructions, causes of system failure, signs of failure, and general guidance on how to choose an installation team. The Guide recommends system assessment at least every three years and routine pumping every three to five years. Water usage efficiency and proper disposal practices are stressed as key elements of optimal operation.

Maintenance and Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The Onsite Sewage Disposal System Regulations specify that the owner of the lot must advise NSECC no later than 15 das after the date the owner becomes aware of any malfunction of the system or release of untreated sewage into the environment. Any substantive repairs or replacement of a system must be reported to NSECC, and the record of inspection and Malfunction Inspection Form must be submitted. This work must be caried out by a qualified person or professional engineer.

Decommissioning

Recommended procedures for system decommissioning are provided in the Guidelines. The tank is to be pumped out and filled with soil or rock, or the tank is to be removed and the site back filled. Organic material is not to be used as fill, as it could produce toxic or explosive gases.

Holding Tanks

Holding tanks are permissible per the Onsite Sewage Disposal System Regulations only if the lot is unsuitable for installing another system. Installation of a holding tank must include a prepared sewage management program. All manufacturer details on tank clean out must be followed in the management plan. Audible and visible alarm systems indicating 25% storage remaining must be included in the system design. The capacity of the holding tank for a single residential unit shall not be less than 4500L. If installed above ground, the tank must be adequately anchored and have secondary containment (dykes, berms, etc.). Holding tanks must be watertight and corrosion resistant. Tanks must be pumped, and waste should be disposed of at an approved dumping site/station.

Newfoundland and Labrador

Regulatory Context

Onsite septic systems with flows less than 4,564 L/d are regulated under Newfoundland and Labrador's (NFL) Public Health Act through the Sanitation Regulations. The installation of a sewage disposal system must only be done after obtaining a certificate of approval from a Public Health Officer. Approvals are issued through the NFL Government Services Centre. The regulations cite the Private Sewage Disposal and Water Supply Standards (Standards) for determining technical guidelines for site evaluation, system selection, installation, and management. The Standards cite the Approved Designer policy of the Department of Government Services, which require the evaluation of a site for onsite sewage systems to be performed by an Approved Designer. Approved Designers are designated and managed through the Government Service Centre. NFL also has a licensure program for septic waste haulers managed by Environmental Protection. Figure D.3 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Approved Designer Environmental Public Health Officer Government Service Centre Residents/owner	*< or > 4546 L/Day (allows for medium to large commercial establishments) Building site evaluation – percolation test, location plan Percolation test and soil strata details (test pits), vertical & horizontal distances, profile of land System selection – floor plan of dwelling, construction drawings, design calcs	Application to Install Application for Sewage Disposal Plan/Approval Certificate Municipal Approval (if applicable)	Private Sewage Disposal and Water Supply Standards Sanitation Regulations Maintenance Assurance Manual
Installation	Approved Designer Contractors Environmental Public Health Officer	Excavation Importation of soil (if necessary) Installation of tanks, plumbing, electricity (if necessary) Inspection by Environmental Public Health Officer	Certificate of Approval	
Operation & Monitoring	Residents Sewage waste hauler Contractors	Routine pumping, effluent filter cleaning following manufacturer's guidance or every 3-4 years If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field		
Maintenance & Repairs	Residents Contractors	Maintenance Assurance Manual includes Septic Tank Inspection, service, and maintenance record forms Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components every two years Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden	Septic Tank Inspection Report Septic Tank Service Report Septic Tank Maintenance Record	
Decommission	Contractors	Tanks and distribution boxes are to be pumped out and removed OR pumped out and filled with gravel or similar Absorption fields (trenches) may be left in ground		

Figure D-3. Lifecycle of Onsite Sewage Systems in NFL

Planning and Approvals

The Approved Designer must submit the applications for approval of a septic system installation including an application to Install a Private Water and Sewage System and an application for Sewage Disposal Plans. The components of these submissions include i) application to Develop Land (if land is located in a protected area or located on a provincially serviced road), ii) detailed lot diagram including property lines, location of adjacent wells and sewage systems, separation distances, ditching, natural water courses, driveways, and livestock operations, iii) floor plan of the proposed dwelling, iv) municipal approval (if applicable), v) results of a percolation test, vi) soil strata data from test pits, vii) depth of groundwater table, viii) design calculations for the design of the septic system, ix) detailed construction drawings of the septic system, x) profile of land with grade where septic system is to be installed, xi) description of ground condition and surface drainage (photograph), xii) details of the imported fill to be used (if applicable). Certificates of Approval will be issued after an Environmental Health Officer reviews the submission. The Sanitation Regulations allow for the design of an “alternate system” to provide secondary or tertiary treatment if deemed necessary by an Inspector. These systems must be designed by a professional engineer.

Installation

Installation may only proceed after receiving a Certificate of Approval from Government and Service NL. Installations can be carried out by a homeowner, contractor, or approved designer. Once a system is installed, a final inspection must be conducted by an Environmental Health Officer to ensure the system is compliant with the Standards and Sanitation Regulations prior to the system being backfilled. The Officer will evaluate the site slope, tank compliance with CSA-B66, sizing of crushed stone in trenches, piping dimensions, sealant quality for watertight components, configuration and length of adsorption field piping, depth and width of trenches, and confirmation of setback distances. Following a successful inspection, a Final Approval Certificate will be issued to the municipal authority and the Approved Designer.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. The Standards provide a brief overview of practices that can ensure the optimal operation of the system. Monitoring and conservation of water use to manage hydraulic loading of the system, restriction of the use/disposal of certain materials, the monitoring of the septic field (i.e. tree roots, overburden, etc.), and the management of stormwater runoff away from the septic field are recommended to support the operation of the septic system. Routine inspections every two years and routine pumping every three years are recommended, with annual inspections suggested as a preventive practice to avoid system malfunction. Pumping services must be provided by a licensed septic waste hauler.

Maintenance and Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The province provides a Maintenance Assurance Manual that includes Septic Tank Inspection, service, and maintenance record forms to guide homeowners on the types of maintenance and repairs that are most common in septic systems. These templates also provide a process for keeping records to inform contractors of the work that has been done to the system over its lifetime. The Manual recommends routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components every two years. Maintenance practices for greywater sources in houses are also outlined in the manual to prevent/address leaks as they occur to reduce septic system burden.

Decommissioning

Abandoned septic systems must be decommissioned following the Standards. Tank and distribution boxes must be pumped out and removed or pumped out and filled with gravel. If any spillage of tank contents occurs, the area must be treated with lime. A licenced sewage waste hauler must be contracted to provide pumping services for decommissioning to be considered by the Government Service Centre.

Holding Tanks

Holding tanks are permissible per the Sanitation Regulations if the daily sewage flow is less than 4,564 L/d, but they must be sized to receive the amount of sewage produced between removals with an additional reserve volume. If installed above ground, the tank must be adequately anchored. Holding tanks must be watertight and corrosion resistant. Tanks must be pumped, and waste should be disposed of at an approved dumping site/station.

New Brunswick

Regulatory Context

Onsite septic systems are regulated under New Brunswick's (NB) Public Health Act through the Onsite Sewage Disposal System Regulations. The Regulations empower licensed installers and professional engineers to engage in activities to install onsite septic systems in NB. The installation, construction, repair, or replacement of a sewage disposal system must be done by a licenced installer or professional engineer. There are two categories of installer licenses: conventional sewage disposal system licence and non-conventional sewage disposal systems license. Non-conventional installers are licensed on specific types of non-conventional systems. The regulations cite the New Brunswick Technical Guidelines for Onsite Sewage Disposal Systems (Guidelines) for determining technical specifications for lot evaluation, soil conditions, system design, installation, and management. Figure D.4 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Licensed Septic Contractor Licensed Site Assessor Engineer Environmental Officer (Housing, Land and Communities) Person responsible for property	Site assessment – soil characterization, test pits, soil permeability, System design and selection, sizing and sighting requirements	Site Suitability Assessment Registration form Sewage Disposal System Registration form Form A (test pit record) Site Plan	Sewage Disposal Systems Regulation On-Site Sewage Disposal Systems Construction Standards On-Site Sewage Disposal Systems – A homeowners Guide
Installation	Licensed Septic Contractor	Install following acceptable construction practices Give notice of installation to the Minister	Certificate of Compliance Sewage Disposal System Installation & Assessment (Audit Report)	
Operation & Monitoring	Licensed Plumber Person responsible for the property	Routine pumping, effluent filter cleaning following manufacturer's guidance If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field	Pumping Records Annual Report (by pumpers)	
Maintenance & Repairs	Licensed Septic Contractor Person responsible for the property	Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden If malfunction/failure occurs system can be repaired, replaced by QP or Engineer		
Decommission	Person responsible for property	Remove contents of septic tank, disinfect, fill tank OR remove septic tank, disinfect excavation, fill with clean soil	Notification of decommissioning	

Figure D-4. Lifecycle of Onsite Sewage Systems in NB

Planning and Approvals

Several steps must be taken by the licenced septic installer to complete the application to install an onsite sewage disposal system with a flow less than 5,460 L/d. Any system with a flow exceeding this volume must be designed by a professional engineer. An application to install must include i) a site plan with lot size, separation distances and slope, ii) type of system and design details, estimated wastewater flows, distance to restrictive layer (bedrock, impermeable layer, or water table), iii) soil characterization based on test pit, soil assessment (percolation test, hydraulic conductivity test, soil sieve analysis), and iv) system materials specifications. The disposal field must be sized based on the soil with the slowest permeability withing 1.2m below the distribution pipe. The Guidelines provide detailed information on system design requirements and administrative steps for receiving approval to install.

Regulation 2009-137 allows for the installation of a non-conventional system, including contour systems, sloping sand filters, aerobic/anaerobic package plants, pressure-dosed infiltrative chamber systems, peat or other sand-type filters, constructed wetlands, large diameter matted pipe, or other systems with a daily sewage flow > 5460 L/d. These systems must be installed by an installer with the appropriate non-conventional license or a professional Engineer. The application and approval processes are managed through the Department of Public Safety.

Installation

Installation may only proceed after receiving approval from the Department of Public Safety. Once a system is installed, a final inspection may be conducted by a Public Safety Inspector to ensure the system is compliant with the Guidelines and Onsite Sewage Disposal System Regulations prior to the system being backfilled. The first installation made by a licenced installer each year will be inspected, with ~20% of subsequent installations being audited each year, as resources and time permit. Within 60 days of a successful installation, the licenced installer will submit to the property owner a Certificate of Compliance for the system, a copy of the plan of the installation, and operating instructions for the system. A copy of the Certificate of Compliance must also be submitted to the Department of Public Safety.

Operation and Monitoring

Operation and monitoring of the system is the responsibility of the property owner. Installers or Engineers are required to provide property owners operating instructions for the system. NB provides a brochure for homeowners that includes basic septic system details to provide support to individuals operating and maintaining an onsite septic system. The guide provides basic tips for optimal system performance, including monitoring and conservation of water use, restriction of the use/disposal of certain materials, and the monitoring of the septic field (i.e. tree roots, overburden, etc.) to support the operation of the septic system. System pumping every two to three years by a licensed septic pumper is recommended.

Maintenance and Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The Homeowner's guide provides information about common causes for system failures, including system overloading (due to poor initial sizing, or changes in occupancy load), poor design/installation, physical damage, and lack of maintenance. Signs of failure are provided to assist the homeowner in detecting septic issues. Per the Onsite Sewage Disposal System Regulations, any replacement or repairs of a septic system requires an application to be reviewed by Technical Inspection Services. Some repairs may be waived, but all activities require that notice be given to the Department of Public Safety.

Decommissioning

The regulations and technical guidelines are silent regarding the requirements for decommissioning of onsite systems.

Holding Tanks

Holding tanks are included in the definition of 'conventional sewage disposal system' in Regulation 2009-137, however these systems are only allowed in limited circumstances, such as when conventional or non-conventional onsite sewage disposal systems cannot be installed due to insufficient setback distances, for temporary waste management solutions, or for non-residential uses with flows < 90 L/d. Ultimately, the Chief Plumbing Inspector reserves the right to use discretion to approve holding tanks. Holding tanks must be equipped with visible and audible alarm systems and the licensee must have an inspection of electrical components.

Challenges and gaps

Through discussions with a representative from the Department of Public Safety, challenges and gaps in the regulatory structure were identified. Limited resources have reduced the frequency of inspections, though additional inspectors are set to be hired soon. Enforcement staff often have to follow-up with installers to obtain the appropriate post-installation documentation, namely the Certificate of Compliance.

Quebec

Regulatory Context

The installation of onsite sewage systems with a flow less than 3,240 L/d is regulated under the Environment Quality Act, per the Regulation respecting the evacuation and treatment of wastewater from isolated residences. The administration of these systems is devolved to

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	MRC staff Property owner Installer Engineer	Submit application through MRC Permit submission and approval Characterization study of the site and natural terrain Scale location plan	Permit Application	Environment Quality Act Regulation respecting the evacuation and treatment of wastewater from isolated residences Technical guide for wastewater treatment for isolated dwellings Best practice sheet – selective emptying Best practice sheet – contents of a maintenance report
Installation	Installer	Excavation Importation of soil (if necessary) Installation of tanks, plumbing, electricity (if necessary) Inspection (depends on MRC practices)	Notice of completion	
Operation & Monitoring	Property Owner	The owner is responsible for the operation and monitoring of the system Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field Some regions have mandatory septic inspections	Best Practice Guide for system owners	
Maintenance & Repairs	Certified Installer Property Owner	Construction, renovation, modification, reconstruction, moving, or enlarging a system requires an application for permit The owner is responsible for all maintenance, which includes seeing to repair or replacement of parts. "Other Primary", secondary, and tertiary treatment systems must have a maintenance contract with a third party (standard NQ 3680-910 of the Bureau de normalization du Québec)	Permit Application Maintenance contract	
			No notification, though work	

Figure D.5. Lifecycle of Onsite Sewage Systems in QB.

municipalities or Regional County Municipalities (MRC) and are managed by municipal staff. Systems that exceed this daily treatment flow are regulated by the Ministry of the Sustainable Development, Environment, and Climate Change. For systems with flow less than 3,240 L/d, the regulation allows for the use of technologies that produce different effluent quality levels dependent on site conditions and the use of additional treatment, including advanced secondary treatment or tertiary treatment systems. Figure D.5 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Planning and Approvals

All onsite sewage systems must receive a permit from the municipality or MRC before construction can begin. Permit applications include a characterization study of the site and natural terrain carried out by a member of a professional order competent in the matter. There is no regulated certification process for septic installers. Treatment system design must consider the local characteristics of the soil, available surface area, and slope of the land. The system must be designed to provide sufficient hydraulic capacity for the size of the building, permeability of the soil, and thickness of the soil later above the water table or impermeable layer.

Installation

Prior to the installation, a system permit must be granted by the municipality, confirming the system to be installed conforms to the Regulations. Inspection practices depend on the individual municipalities and MRCs. There is no regulated requirement for an inspection prior to backfilling the system. The Bureau de normalization du Québec (BNQ) has the exclusive mandate to ensure standardization and conformity certification activities for industrial products. The installation of any prefabricated onsite sewage system must be installed in a way to achieve the treatment efficacy of the product, as defined by BNQ.

Operation & Monitoring

The Regulations require that sewage systems are operated in accordance with manufacturers' requirements and in keeping with the approval of the system. Different system types require specific operating conditions and all responsibilities for optimal system operation, both from inside the residence (water use patterns, restriction of damaging chemicals and liquids, etc.) and outside the residence (monitoring the drainage field for ponding or overgrowth, etc.) are the responsibility of the system owner. The Ministry does provide a Best Practices Guide for system owners and provides other resources through its website.

Maintenance and Repairs

All maintenance, repair, and replacement of the system are the responsibility of the property owner. Any construction, augmentation, relocation, or repair of a system requires a permit and associated application. Systems authorized under section 95 of the Regulation require owners to maintain the system in accordance with manufacturers guidance, be bound by a contract with the manufacturer or third part for all required maintenance activities and retain copies of all maintenance reports for the system.

Decommissioning

There is no regulated requirement to notify in the case of system decommissioning. Some municipalities or MRCs may have policies and practices in place regarding decommissioning, but these are best practices and not requirements of the legislation.

Holding Tanks

Holding tanks are permissible in certain locations but are subject to routine municipal inspection to verify watertightness. Holding tanks must meet the design and installation specification outlined in the Regulations.

Challenges and gaps

Through conversations with provincial representatives, it was noted that onsite sewage system treatment that relies on a soil drainage and filtration field is highly dependent on effective installation. The lack of an installer certification program was noted as a gap, as training and oversight of these key contractors would improve the quality of system design and installation.

Ontario

Regulatory Context

The installation of onsite sewage systems with a flow less than 10,000 L/d is regulated under the Ontario Building Code Act, per the Ontario Building Code (Part 8). The Code provides guidance on design standards, including site evaluation requirements and system design. Principal Authorities responsible for the Building Code vary regionally, with Health Units, Conservation Authorities, and Municipalities overseeing onsite sewage systems in different locations. The application process varies regionally depending on the Principal Authority. Ontario requires onsite sewage systems to be installed by a licensed sewage system installer. Systems must be designed by qualified designers and sewage must be hauled by licensed sewage haulers. System inspections are conducted by qualified and registered sewage system inspectors. These professionals are qualified and registered by the Ministry of Municipal Affairs and Housing (MMAH). Figure D.6 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Public Health Inspector Principal Authority Property owner Installer Qualified and registered designer	Find Principal Authority (Health Units, Conservation Authorities, Municipalities) Pre-permit approval, preliminary site inspection Complete Municipal forms, and Schedules 1&2 Provide Site Plan System capacity (per rooms and fixtures) Percolation test (or lab submission)	Sewage system application Sewage System Permit Municipal forms Schedule 1 & 2 Site Plan	Ontario Building Code OOWA's Homeowner's Guide to a Healthy Sewage System Septic Smart Brochure
Installation	Qualified Septic system installer Sewage System Inspector	Excavation Importation of soil (if necessary) Installation of tanks, plumbing, electricity (if necessary) Post-permit, substantial inspection Final grading inspection	Notice of completion	
Operation & Monitoring	Municipal or Conservation Authority Inspector (if required) Licensed technician Property Owner	Operate the system per the requirements of the manufacturer Routine pumping, effluent filter cleaning following manufacturer's guidance If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field Some regions have mandatory septic inspections	Manufacturer's literature (printed), complete instructions for operation, servicing, maintenance	
Maintenance & Repairs	Licensed technician Property Owner	Maintain the system in accordance with the system approval, including grease interceptors		
Decommission		Different processes per region – pump tank, crush or fill, inspection, and receive approved decommissioning	Septic System Decommissioning form (in some areas)	

Figure D-6. Lifecycle of Onsite Sewage Systems in Ontario

Planning and Approvals

The qualified and certified system designer, in coordination with the property owner, completes the sewage system application, including appropriate municipal forms in Schedule 1 and 2. The pre-permit approval is issued based on a preliminary site inspection. All systems are classified as Class 1, 2, 3, 4, or 5. With Class 4 being a leaching bed system and Class 5 being a septic holding tank. Applications include site evaluation information, including setback distances, soil percolation time, and test pit analysis, as well as system design flows based on residential occupancies. Once an application is approved, a Sewage System Permit will be issued by the Principal Authority.

Installation

Systems must be installed by a certified installer in accordance with the requirements in Building Code Act, Section 8. Following installation, there is a post-permit, substantial inspection conducted by a qualified and registered sewage system inspector prior to backfilling a system. After the system is backfilled, there is a final grading inspection. Following successful inspections, a Notice of Completion is submitted by the Principal Authority.

Operation & Monitoring
The Building Code requires that sewage systems are operated in accordance with manufacturers' requirements and in keeping with the approval of the system. Shallow buried trenches must be monitored every 36 months to ensure compliance of the pressure head at the furthest point in the distribution pipes. Some regions have a mandatory septic inspection every five years. Ontario Onsite Wastewater Association publishes a Homeowner’s Guide to a Health Sewage (septic) System to educate property owners on the operation and maintenance of their systems.

Maintenance and Repairs
All maintenance, repair, and replacement of the system is the responsibility of the property owner and must be done by a licensed technician or qualified septic system installer. The Building Code requires that the land in the vicinity of the sewage system shall be maintained in a condition that will not cause damage to, or impair the functioning of, the sewage system. Septic tanks and other Class 4 treatment units must be cleaned whenever the sludge and scum occupy a third of the working capacity of the tank.

Decommissioning
Ontario Onsite Wastewater Association provides a technical guidance document ‘How to Decommission an Existing Onsite Sewage System’. This document recommends the contents of the tank be pumped out by a licensed hauler and the inlet and outlet be disconnected. The tank should be backfilled with clean sand or granular material, or the tank can be removed or crushed in place and backfilled with native or imported material. If any electrical components are present, these should be removed and disposed of according to local regulations.

Holding Tanks
Holding tanks are permissible per the Building Code Act only if the proposed use is temporary or an interim measure until municipal sewers are available. Holding tanks may be allowed if they provide a remedy to an unsafe sewage system where the installation of a Class 4 system is impracticable or if they are used as an upgrade to an existing building where upgrading with a Class 4 system is not possible due to lot size and clearance limitations.

Manitoba

Regulatory Context
The installation of onsite sewage systems with flows less than 10,000 L/d is administered under the Onsite Wastewater Management Systems (OWMS) Regulations established under

the Environment Act. The Environmental Compliance and Enforcement Branch of Manitoba Environment and Climate Change oversees system proposals and certification of installers. The Nutrient Management Regulation and Red River Corridor Designated Area provide additional directives for sewage installation. Soil and Site Evaluation Guidelines (Guidelines) and Supplementary Information for Onsite Wastewater Management System Installations (SI) are provided by the Branch to clarify technical specifications of system design and installation. Figure D.7 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Approved Soil Testing Labs Property owner Manitoba ECC Environmental Officer Certified Installer	Submit a proposal for registration Soil test pits and soil analysis System selection (daily flow estimates, system design) and disposal field characterization Vertical and horizontal clearances Site plan	Application to register Sand Mound Worksheet ASTM C33 Sand Analysis Report	Onsite Wastewater Management Systems Regulations (OWMS) Nutrient Management Regulation & Red River Corridor Designated Area Supplementary Information Manual Soil and Site Evaluation Guidelines Sewage Ejector Decommissioning guideline Homeowner Manual and other supporting documents ASTM C33 Sand Media Specs
Installation	Certified Installers	Excavation Importation of soil (if necessary) Installation of tanks, plumbing, electricity (if necessary) Installation notification Inspection and authorization to cover		
Operation & Monitoring	Registered Sewage Haulers Property owner	Routine pumping, effluent filter cleaning following manufacturer's guidance If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field	Recording form for sewage collection and disposal	
Maintenance & Repairs	Certified Installer	Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden If malfunction/failure occurs system can be repaired, watch for slow drains, ponding, etc.	Application to register a replacement	
Decommission		Pump contents, backfill, dismantle disposal field (if needed)	Decommissioning form	

Figure D-7. Lifecycle of Onsite Sewage Systems in Manitoba

Planning and Approvals

Onsite sewage systems require the submission of a proposal for registration, which must include soil test pit analysis (conducted by an accredited soil lab), depth to restrictive layer, depth to normal high-water table, details of system selection, estimated daily flow, disposal field characteristics, and a site plan that includes vertical and horizontal clearances. Additional information must be submitted if material, i.e. sand fill, is to be imported and used. All applications are reviewed by an Environmental Officer to evaluate the system design and location with respect to soil characteristics, site slope, and clearance distances. Following successful review, a system registration will be issued, and the system can be installed. It should be noted that Manitoba is in the process of phasing out sewage ejectors, which deliver sewage directly to the ground surface. To retain an ejector, the lot must be 10 acres and have a 200 ft setback from any feature. If a lot is sold or subdivided, an application must be submitted to retain the ejector system, otherwise, it must be replaced with an underground septic system.

Installation

Systems must be installed by a certified installer, an employee under direct supervision of a certified installer, or the owner of the installation site. The OWMS Regulations require a property lot size of at least 0.8 ha and have 60 ft. frontage to be suitable for an onsite sewage system. Once a system has been installed, the property owner or certified installer must give 48-hour notice prior to covering the system to allow time for an inspection by an Environmental Officer. Following a successful inspection, authorization to cover will be given and a copy of the application to register will be given to the property owner for their records.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. Manitoba Environment and Climate Change publishes ‘A Homeowner’s Manual for Onsite Wastewater Management Systems’, that provides information on the installation, operation, and care of onsite systems. The Manual recommends routine tank pumping every one to three years depending on system use and performance. Septic haulers must be registered, per the OWMS regulations and maintain daily records of septage collected.

Maintenance and Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The Homeowner's guide provides information about common causes for system failures, including system overloading (due to poor initial sizing or high flows), poor design/installation, physical damage, and lack of maintenance. Signs of failure are provided to assist the homeowner in detecting septic issues. Per the OWMS Regulations, any reconstruction or modification of a septic system (i.e. significant repairs or replacement) requires an application to register the alteration and the work must be done by either a certified installer or the property owner. The Homeowner’s Guide includes a template for System Maintenance Records that should be kept by the property owner to ensure timely maintenance practices.

Decommissioning

The decommissioning of septic or holding tanks must be done in accordance with the OWMS Regulations and reported to Manitoba Environment and Climate Change per the Out-of-Service Wastewater Management System Decommissioning Form. The tank must be pumped by a certified septage hauler and backfilled with appropriate gravel.

Holding Tanks

Holding tanks are permissible per the OWMS Regulations as long as they meet the specifications noted in the Regulations, including a minimum total capacity of 4,500 L and it meets CSA Standard B66-00. In areas designated as sensitive, holding tanks are the only system type allowed. Manitoba Environment and Climate Change provides literature describing the benefits of holding tanks for cottages and other seasonal applications.

Challenges and Gaps

Currently, the only training program for certifying installers has ceased operation and no new installers are able to pursue certification. The workload of inspecting every septic installation is not sustainable, so the Enforcement and Compliance branch is in the process of developing a risk-based prioritization system for managing the inspection process. This will ensure that high-risk systems are inspected thoroughly to ensure compliance with the OWMS Regulations. The jurisdictional discrepancies between First Nations communities on federal land and systems installed on provincial land have led to conversations between the Manitoba Regional Office and FNIHB staff and the provincial regulators. There is an interest in collaboration, particularly on training and education. Given Manitoba's lack of a certification program, there is a notable gap regarding training and education.

Saskatchewan

Regulatory Context

The installation of private sewage works is administered by the Private Sewage Works Regulations established under the Public Health Act. The Ministry of Health is responsible for ensuring site-appropriate design and installation of onsite sewage systems. The Shoreland Pollution Control Regulations provide additional requirements for sewage disposal systems in shoreland development areas. The Saskatchewan Onsite Wastewater Disposal Guide (Guide) and additional guidance documents are provided by the Government of Saskatchewan to provide technical support to installers and developers. The Onsite Wastewater Treatment Systems in Planned Developments: A guide for developers establishes best practices for understanding and mitigating cumulative risks from multiple septic systems. Figure D.8 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Saskatchewan Health Authority Public Health Inspection Office System Owner Designer – qualified person Recognized laboratory (soil analysis)	Check with Shoreland Pollution Control Regulations (457m from high water mark level of lake, river, stream, etc.) and Municipal bylaws Site Evaluation, soil investigation (required for soil treatment fields), site plan and setbacks Construction drawing of select system (CSA B66 standard) Influent quality estimation, design flows, maximum capacity	Permit application form including: site assessment, soil investigation, and system design worksheet	The Private Sewage Works Regulations The Shoreland Pollution Control Regulations Onsite Wastewater Treatment Systems in Planned Developments: A guide for developers Guidance for Installers: Designing an Onsite Wastewater Treatment and Disposal System Onsite Wastewater Treatment and Disposal – System Maintenance
Installation	Installer/Contractor Public Health Inspector	Excavation and installation following manufacturer's guidance Installation notification Inspection and authorization to cover Certificate of Approval		
Operation & Monitoring	Contractor Property Owner	Routine pumping, effluent filter cleaning following manufacturer's guidance Recommended audio/visual warning for high liquid levels in tank If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field	Operation and Maintenance Manual (required for permit approval)	
Maintenance & Repairs	Contractor	Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden If malfunction/failure occurs system can be repaired, watch for slow drains, ponding, etc.		
Decommission				

Figure D-8. Lifecycle of Onsite Sewage Systems in Saskatchewan.

Planning and Approvals

Onsite sewage systems require a permit application form. All applications require a site evaluation. A soil investigation is recommended in all cases but only required when a soil treatment field is installed. Property owners and other individuals deemed "qualified" by the local authority can apply for the permit, conduct the site evaluation and soil investigation, and plan and design systems. A site evaluation must include lot boundaries, distance to water courses and wells, location of proposed septic tank, slope of the land surface, and an inventory of all pertinent features on the site (i.e. trees, rock outcrops, swales, etc.). A soil investigation must include test pits from a minimum of two representative locations, description of soil profile, and a laboratory analysis of the limiting layer of soil. In addition to these components, construction drawings and an operation and maintenance manual for the proposed system must be included in the application package. There is currently no system to train and certify installers. It is the responsibility of the local Health Authority to determine if an applicant is "qualified". All applications are reviewed by a public health inspector to evaluate the system design and location with respect to soil characteristics, site slope, and clearance distances. Once an application has been accepted, a permit for installation will be issued.

Installation

Systems can be installed by the property owner, or a person deemed “qualified” by the local health authority. The system design and installation must comply with the Regulations and the details of the permit. Once installation has begun, multiple site visits and inspections by a public health inspector are likely to occur. Before a system can be covered, a final inspection must be completed prior to backfilling. Following a successful final inspection, the system can be made operational, and a Certificate of Approval will be issued to the owner or permit holder.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. To receive a permit for a system, an Operations and Maintenance manual based on manufacturer’s specification, must be given to the property owner. This manual provides system-specific instructions for optimal operation and preventive maintenance, including principles of operation, construction details, pump capacity requirements, control settings, float elevations, and instructions on managing alarm conditions. Saskatchewan Public Health publishes a pamphlet for homeowners ‘Onsite Wastewater Treatment & Disposal-System Maintenance’ that provides general information on how to operate and maintain onsite systems. Routine cleaning and pumping are recommended either on a two-year schedule or when half of the initial liquid capacity is occupied by solids. Physical care instruction, including restriction of vehicle traffic on the field, prevention of freezing, and other landscaping care is provided in the manual.

Maintenance and Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The homeowner's ‘Onsite Wastewater Treatment & Disposal-System Maintenance’ document provides information about common causes for system failures and signs of system malfunction. It is recommended that a professional contractor perform a system investigation at the first signs of malfunction. If substantive repairs or system replacement is needed, the installer or property owner must apply for a permit to undertake sewage works, per the Private Sewage Works Regulations.

Decommissioning

The Regulations and the Guide are silent on decommissioning procedures.

Holding Tanks

Holding tanks are permissible per the Regulations, however, the Guidelines recommend that holding tanks are only used on properties where no other alternative methods of wastewater disposal are feasible or allowed by regulation. Proposals for the installation of holding tanks are reviewed on the basis of public health requirements and must include scheduled and approved pumping services.

Challenges and Gaps

Currently, there is no certification requirement for installers or system designers. Because of this gap, the Local Health Authorities engage in site and installation inspections to ensure systems comply with the Regulations. The Private Sewage Works Regulations are currently undergoing amendment to include installer certification requirements.

Alberta

Regulatory Context

The installation of private sewage works handling less than 25 m^3/d is administered by the Private Sewage Disposal Systems Regulations established under the Safety Code Act. Alberta Municipal Affairs Administrators provide technical guidance in the execution of the Alberta Private Sewage Systems Standard of Practice (SoP). Accredited municipalities are responsible for administering the Safety Codes Act, including the management of private sewage permits and inspections. Unaccredited municipalities rely on the Alberta Safety Codes Authority for the administration of private sewage permits and inspections. Regardless of the administering body, private sewage works must comply with the SoP. Complex onsite wastewater treatment systems designed to receive more than 5.7m^3/d must be designed for specific sites by a professional engineer, or a person who has qualifications acceptable to the Administrator. Figure D.9 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Professional Engineer or qualified person (certified contractor) Soil Laboratory Property Owner	Check with Municipality for specific bylaws and restrictions Obtain private sewage permit prior to installation (from Municipality) Property evaluation – site plan, soil profile, soil classification, design worksheet Engage with safety codes officer to comply with SOP	PSTS Permit application PSTS Permit	Safety Codes Act Private Sewage Disposal Systems Regulation Alberta Private Sewage Systems Standard of Practice (SOP) Separation distances for sewage treatment systems Safety Code Councils Private Sewage Treatment Systems – Safety Tips
Installation	Contractor	Excavation and installation Test and commission the system to comply with SOP Inspection report	Inspection report	
Operation & Monitoring	Property owner Licensed vacuum truck	Routine pumping, effluent filter cleaning following manufacturer's guidance If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field	Operations and Maintenance Manual	
Maintenance & Repairs	Contractor	Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden If malfunction/failure occurs system can be repaired, watch for slow drains, ponding, etc.		
Decommission				

Figure D-9. Lifecycle of Onsite Sewage Systems in Alberta

Planning and Approvals

Onsite sewage systems require a private sewage disposal permit application form. Certified private sewage installers can apply for permits for all system types. Certified restricted private sewage installers can apply for holding tank projects only. Homeowners who reside on the property intended for system installation, who will be doing the work themselves, can apply for permits for soil-based disposal systems. Applications must include the i) application form, ii) site plan showing property dimensions, natural features, water courses, wetlands, wells, easements, etc., iii) soil profile information using the Canadian System of Soil Classification, iv) lab reports on soil classification, and v) calculation worksheet showing the determination of appropriate treatment components. Accredited and non-accredited municipalities have different review and permitting processes.

Installation

Systems can be installed by the property owner who intends to reside on the property, or a certified private sewage installer. The system design and installation must comply with the Regulations and the details of the permit. Once a system has been installed, it is the responsibility of the system designer and/or installer to test and commission the system to confirm it operates safely, as intended and meets the objectives of the SoP. Processes for final inspections and issuance of final inspection reports differ between accredited and non-accredited municipalities.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. Prior to installation of an onsite wastewater treatment system, an operations and maintenance manual must be made available to the owner. The manual must include i) the capacity of the system design, ii) the principles of operation, iii) construction details, including a site plan, iv) pump capacity requirements, control settings, float elevations, etc., v) all operating and maintenance requirements, and vi) instructions on managing an alarm condition. Systems designed to treat more than 5.7m^3/d have additional requirements, including the installation of at least three groundwater monitoring wells to measure impact to groundwater. In addition to the operations and maintenance manual, the Alberta Onsite Wastewater Management Association offers several resources for homeowners to understand and operate their onsite systems. *Septic Sense* is a program of webinars and public meetings that are presented by regional districts and homeowners associations to provide education to homeowners.

Maintenance & Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The operations and maintenance manual provided to the property owner details key preventive maintenance requirements, including effluent filter cleaning and servicing of pumps and valves.

Decommissioning

The Regulations and the SoP are silent on decommissioning procedures.

Holding Tanks

Holding tanks are permissible per the Regulations and must have a storage capacity of at least 4,500L for a single-family dwelling. Where the groundwater table is known to be high, the tank must be fitted with anti-floatation measures. All required setbacks, per the SoP, must be met and the tanks must be located in such a way to allow for vacuum truck access.

Challenges and Gaps

Open discharge systems are allowed in Alberta as long as i) the soil test pit results indicate the soil conditions are adequate, ii) the setbacks specified in the SoP are met and iii) the effluent discharge meets the quality of primary treated effluent Level 1. Open discharge is prohibited if the setbacks cannot be met, the effluent quality is greater than primary treatment Level 1, or if the discharge exceeds $3m^3/d$. If multiple discharge points are used to achieve rates less than $3m^3/d$, the discharge points must be separated by at least 30m.

British Columbia

Regulatory Context

The installation of private sewage works receiving less than 22,700 L/d is administered by the Sewerage System Regulations established under the Public Health Act. Regional Health Authorities accept system filings and letters of certification submitted by registered onsite wastewater practitioners (ROWPs) or professional engineers and geoscientists (PEGs). The Ministry of Health oversees the development of guidelines and policies related to onsite sewage system design and installation. ROWPs and PEGs are the two authorized groups recognized as onsite sewage system installers. ROWPs are trained and certified by Applied Science Technologists and Technicians of BC (ASTTBC). Professional engineers and geoscientists are members of Engineers and Geoscientists BC (EGBC). ROWPs must follow the design requirements established in the Sewerage System Standard Practice Manual (SPM). PEGs must refer to the Professional Practice Guidelines: Onsite Sewerage Systems (PPG) published by EGBC when designing and installing a system. Figure D.10 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Ministry of Health and Regional Health Authorities Registered onsite wastewater practitioners Prof Engineers Property Owner	Access forms from Regional Health Authority Site evaluation – soil evaluation, test pits, soil permeability System selection, system plans	Site and Soil Evaluation Report (including climate or soil factors) Health Author Filing Form Record of Design Daily Design Flow & HLR	Sewerage System Regulation (Public Health Act) Sewerage System Standard Practice Manual Health Hazard Interpretation Guideline Sewerage System Policy for Setback from Wells Based on Repairs or Alterations Sewerage Systems and Flooding
Installation	ROWP (or authorized person)	Excavation and installation Commission and maintenance plan Letter of Certification and Record Drawing	Letter of Certification	
Operation & Monitoring	Property Owner ROWP or AP	Routine pumping, effluent filter cleaning following manufacturer's guidance If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field	Operation Manual with contact information of installer, maintenance provider, and electrician	
Maintenance & Repairs	ROWP or AP	Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden If malfunction/failure occurs system can be repaired, watch for slow drains, ponding, etc.	Maintenance Plan Records of Maintenance Amendments to Maintenance plan following repair/alteration Site Investigations (complaint driven)	
Decommission	ROWP or AP	Pump contents, backfill, dismantle disposal field (if needed)		

Figure D-10. Lifecycle of Onsite Sewage Systems in BC

Planning and Approvals

Onsite sewage systems require a i) sewage source characterization, ii) site and soil evaluation report, and iii) health authority filing form. There is no application review or approval process. The sewage source characterization must provide daily design flow, sewage type evaluation, and pattern of water usage for the property. The site and soil evaluation must detail lot boundaries, horizontal separations for specified features, investigation of soil profile, test pit findings, and soil permeability in a minimum of four locations. All work should be carried out to comply with the SPM or PPG. An authorized sewage installer must submit all forms on behalf of the property owner. The Regulations describe three types of sewage systems: Type 1 – treatment by a septic tank and dispersal field only, Type 2 – treatment that produces an effluent consistently containing < 45 mg/L total suspended solids (TSS) and five-day biochemical oxygen demand (BOD_5) < 45 mg/L, Type 3 – treatment that produces < 10 mg/L TSS, < 10 mg/L BOD_5 , and median fecal coliform < 400 colony forming units per 100 mL. Only PEGs can construct or maintain a sewer system classified as Type 3 or designed for a minimum daily domestic sewage flow more than 9,100 L.

Installation

Onsite systems must be installed by an authorized person, or an owner installing a system on their own land under the supervision of an authorized person. The system is considered complete when the authorized person has completed a final inspection and is satisfied that the system is complete and ready to operate. Within 30 days of completing the installation of a system, the authorized person must provide the owner with a copy of the system plans, a maintenance plan for the system consistent with standard practice, and a copy of the letter of certification provided to the health authority. Included in the maintenance plan should be the details from the system commissioning and would include panel records at commissioning (cycle count, pump run time, number of alarm events, etc.), dispersal field residual head, pump draw down per minute, float settings for each event, etc.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. Following the completion of an onsite sewage system, a maintenance manual must be made available to the owner. The manual will establish monitoring frequencies for the first year of system operation, including effluent collection and monitoring for Type 2 and Type 3 systems to ensure effluent complies with standards in the Sewerage System Regulations. Following the first year of system operation, based on monitoring results, the owner and authorized person should establish the maintenance and monitoring frequency for the next 5 to 10 years of operation and file an amended maintenance plan with the health authority. The Ministry of Health provides additional resources to assist homeowners with the optimal operation of onsite sewage systems, including a pamphlet 'Maintenance and Operation of Onsite Sewage Systems' which details daily and seasonal actions to prolong the life of the system.

Maintenance & Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The maintenance manual provided to the property owner details key preventive maintenance requirements for the system. The Sewerage System Regulations require property owners to maintain systems in accordance with the maintenance plan provided and require that the owner keep records of maintenance. The SPM provides information on the reporting requirements for system malfunctions that may pose a risk to public health. All system repairs and replacements must be done by an authorized person and require a health authority filing form.

Decommissioning

The SPM provides details on the procedures for decommissioning a system. The tank components should be pumped of all contents, with sewage disposed of at an approved facility. The tanks may be removed and disposed of at an approved facility or abandoned in situ. Tanks should be broken to avoid pooling of groundwater and backfilled to minimize risk of settling.

Holding Tanks

Holding tanks are permissible per the Regulations but do not require planning or installation by an authorized person. Holding tanks are not covered by the SPM.

Yukon

Regulatory Context

Environmental Health Services is responsible for the issuance of sewage disposal permits under the Sewage Disposal Systems Regulations established under the Public Health and Safety Act. A permit is required prior to construction, installation, or substantial repair of a sewage system. Figure D.11 provides a graphic detailing the stakeholders, activities, and documentation required for each phase of the onsite system's lifecycle.

Lifecycle Phase	Stakeholders	Activities	Documentation	Regulations
Planning & Approval	Health Officer Environmental Health Services Property Owner	Obtain permit for installation Soil investigation and percolation test Site drawing with setbacks	Permit application Permit and approval CSA B-66 compliance	Public Health and Safety Act Sewage Disposal Systems Regulations Design Specifications for Sewage Disposal Systems *Application for Permission to Retain a Sewage Disposal System Application for Approval to Use a Sewage Disposal System
Installation		Excavation and installation 72-hour notification prior to backfill	Photographic evidence of installation process Notification of installation Undertaking to Maintain a Sewage Holding Tank (in necessary)	
Operation & Monitoring		Routine pumping, effluent filter cleaning following manufacturer's guidance If pressurized - pumps, floats and alarms should be checked Water use pattern adherence (laundry cycles, etc.), water conservation, prevention of fats/grease down drains Grounds maintenance – lawn care, root maintenance, etc. to protect drain field, prevent flooding of drain field		
Maintenance & Repairs		Routine inspections to look for back-ups, leaks, scum/sludge build up, and inspecting mechanical components Maintain greywater sources in house – prevent/address leaks as they occur to reduce septic system burden If malfunction/failure occurs system can be repaired, watch for slow drains, ponding, etc.		
Decommission	Health Officer	Pump contents, backfill, dismantle disposal field (if needed)	Notification of health officer	

Figure D-11. Lifecycle of Onsite Sewage Systems in the Yukon

Planning and Approvals

Onsite sewage systems require the submission of the Application for Approval to Use a Sewage Disposal System form, approval of the application, and the issuance of the permit before installation can begin. System design and installation must be in accordance with the Septic Systems in Yukon, Design Specifications for the Septic Tank and Soil Absorption System (Design Specifications). The application form requires soil investigation and percolation test findings from at least two locations, system design details, soil adsorption dimensions and features, and a site plan with all clearances and setbacks noted. The designs for septic systems can be completed by the homeowner, contractor, or an engineering consultant. Once the application is accepted and a permit is issued, construction may begin.

Installation

Onsite systems may be installed by the property owner or contractor. Installation must comply with the Design Specifications and a photographic record of the stages of installation must be prepared. The full list of photographs needed is detailed in the Design Specifications. Written approval from Environmental Health Services is required prior to the use of a sewage disposal system and 72-hour notice must be given prior to backfilling a system. An inspection may be scheduled by a health officer. Permission from a health officer is required to cover the system. Once the system is covered and operational, the property owner has 30 days to submit to Environmental Health Services i) the photographic record of installation, ii) septic tank and sewage holding tank installation declaration form, iii) notification of installation and undertaking to maintain a sewage disposal system/holding tank form, iv) electrical assurance forms completed by a certified electrician, and v) other documentation as requested by the health officer.

Operation & Monitoring

Operation and monitoring of the system is the responsibility of the property owner. The Sewage Disposal Systems Regulations require the owner of the sewage disposal system to periodically inspect and monitor the system for integrity and operation. The regulations require the owner to pump the septic tank often enough to ensure that the depth of sewage does not rise above one-third of the depth of liquid in the tank. Waste that is removed from tanks should be transported to a final disposal site as approved by the health officer. The Design Specifications detail proper operation conditions to ensure system functionality, including management of surface water drainage, water use conservation, and waste management practices.

Maintenance & Repairs

All maintenance, repair, and replacement of the system is the responsibility of the property owner. The Regulations require that owners of the system protect the system from vehicle traffic and heat loss and that the tanks be maintained in a leak-proof condition. The regulations require permitting to enlarge, replace, or substantially repair a sewage system.

Decommissioning

The Regulations require notification of a health officer when a sewage system is to be abandoned. With the permission of Environmental Health Services, a septic or holding tank may be removed and backfilled, filled with soil or sand, collapsed and filled in, or otherwise reclaimed.

Holding Tanks
Holding tanks are permissible per the Regulations, as allowed by a health officer, if soil adsorption conditions make the lot unsuitable for a ground adsorption system or if the location of the field cannot comply with the clearances and setbacks required by the Regulations. Holdings tanks must meet the design criteria outlined in "Sewage Holding Tank Standards".

Appendix E – Provincial Regulations and Resources

Regulations and Guidelines for Private Wells	
Prince Edward Island	Prince Edward Island Well Construction Regulations, ASTM Standard A589 (type IV, grade B), A53 (type E, grade B), and/or F480 NSF/ANSI Standard 60 NSF Standard 61 Dep't of Environment, Energy and Climate Action – Testing of Drinking Water
Nova Scotia	Nova Scotia Well Construction Regulations ASTM Standard A589 (type IV, grade B), A53 (type E, grade B), and/or F480 Nova Scotia Environment and Climate Change – The Drop on Water Nova Scotia Department of Environment and Labour – Before You Construct a Water Well: Facts and Homeowner should know
Newfoundland and Labrador	Newfoundland and Labrador Well Drilling Regulations Gov't of Newfoundland and Labrador – Guidelines for Sealing Groundwater Wells Gov't of Newfoundland and Labrador – Groundwater Wells: What You Need to Know, Monitoring, Maintenance, and Retrofitting ASTM and CSTM Standards for Well Casing
New Brunswick	New Brunswick Well Drilling Regulations New Brunswick Potable Water Regulation ASTM standard A589-84
Quebec	Environment Quality Act Water Withdrawal and Protection Regulation (Q-2 r. 35.2) 'The Quality of my Well Water': Ministère de l'Environnement
Ontario	Ontario Water Resources Act – Regulation 903: Wells Ontario Building Code Act – Regulation 332/12: Building Code Water Supply Wells: Requirements and Best Practices Ontario Environment and Energy – Wells on your property NSF International ASTM Standard A252, A500, A139, A606, A778, A589 (type IV, grade B), A53 (type E, grade B), and/or F480 ANSI/AWWA Standard C200

Manitoba	Manitoba Groundwater and Water Well (General Matters Regulation) Manitoba Well Standards Regulation CSA, ASTM, AWWA, and NSF Standards
Saskatchewan	The Ground Water Regulations A Landowners Guide to Water Well Management The Plumbing and Drainage Regulations
Alberta	Alberta Water Act Water (Ministerial) Regulation Directive for Water Wells and Ground Source Heat Exchange Sytems CSA and ASTM Standards
British Columbia	British Columbia Groundwater Protection Regulation BC Regulations – Groundwater Protection Guidance Manual CSA, ASTM, NSF Standards
Yukon	Public Health and Safety Act Yukon Waters Act

Regulations and Guidelines for Onsite Sewage Systems	
Prince Edward Island	Sewage Disposal Systems Regulation Onsite Sewage Disposal Systems Construction Standards Onsite Sewage Disposal Systems – A homeowner's guide
Nova Scotia	Onsite Sewage Disposal (OSSD) Regulations Designated Activities Regulations Approvals & Notifications Procedures Regulations OSSD Standard Homeowners guide
Newfoundland and Labrador	Private Sewage Disposal and Water Supply Standards Sanitation Regulations Maintenance Assurance Manual
New Brunswick	Sewage Disposal Systems Regulation Onsite Sewage Disposal Systems Construction Standards Onsite Sewage Disposal Systems – A homeowners' guide
Quebec	Environment Quality Act Regulation respecting the evacuation and treatment of wastewater from isolated residences Technical guide for wastewater treatment for isolated dwellings Best practice sheet – selective emptying Best practice sheet – contents of a maintenance report
Ontario	Ontario Building Code OOWA's Homeowner's Guide to a Healthy Sewage System Septic Smart Brochure
Manitoba	Onsite Wastewater Management Systems Regulations (OWMS) Nutrient Management Regulation & Red River Corridor Designated Area Supplementary Information Manual Soil and Site Evaluation Guidelines

	Sewage Ejector Decommissioning guideline Homeowner manual ASTM C33 Sand Media Specs
Saskatchewan	The Private Sewage Works Regulations The Shoreland Pollution Control Regulations Onsite Wastewater Treatment Systems in Planned Developments: A guide for developers Guidance for Installers: Designing an Onsite Wastewater Treatment and Disposal System Onsite Wastewater treatment and Disposal – System Maintenance
Alberta	Private Sewage Disposal Systems Regulation Safety Code Safety Code Act Alberta Private Sewer System Standard of Practice Septic System Setback distances Treatment System Safety Tips
British Columbia	Sewerage System Regulation (Public Health Act) Sewerage System Standard Practice Manual Health Hazard Interpretation Guideline Sewerage System Policy for Setback from Wells Based on Repairs or Alterations Sewerage Systems and Flooding
Yukon	Public Health and Safety Act Sewerage Disposal Systems Regulations Design Specification for Sewage Disposal Systems Application for Permission to Retain a Sewage Disposal System Application for Approval to Use a Sewage Disposal System

Regulations and Guidelines for Truck to Cistern	
Prince Edward Island	Non-existent
Nova Scotia	"The Drop on Water" Guidance Sheet Water and Wastewater Facility Regulations
Newfoundland and Labrador	Non-existent
New Brunswick	Clean Water Act: Regulation 90-97
Quebec	Environment Quality Act (Q-2, r.40) *applies water supplied to more than 20 persons
Ontario	Based on regional Health Authority administration
Manitoba	"Water Storage Tanks" Factsheet CSA B126 Series-13 NSF/ANSI Standard 61 The Public Health Act Bulk Water Hauling Guidelines Onsite Wastewater Management System Regulation

Saskatchewan	Disinfection Guideline for Bulk Haulers Disinfection Guideline for Private Cisterns after a Drinking Water Advisory
Alberta	Public Health Guidelines for Non-Municipal Drinking Water Public Health Act NSF/ANSI 16-2016
British Columbia	Non-existent
Yukon	Public Health and Safety Act Part 2

Appendix F – Code Book

CONSTRAINTS and RISKS

Capacity:	Constraints affecting the ability of First Nations to sufficiently manage utilities.
Communication:	Areas where understanding breaks down between parties.
Environmental:	Constraints related to environmental concerns or risks.
Funding:	Cases where limited access to funding is identified as a constraint to developing effective water systems.
Health & Safety:	Situations where residents' health and safety are affected by the quality of their water services.
Land Use Planning:	Challenges where inadequate planning leads to insufficient systems and obstacles to utility setup.
Maintenance:	Issues impeding the sufficient maintenance of water systems, including water testing, pump trucks, roads, and infrastructure.
Policy:	Constraints arising from policy decisions.
System Design Limits:	Flaws in the design of the system that result in reduced productivity and efficiency.
Time:	Constraints related to time delays, time limitations, and time pressures.
Trust:	Instances where First Nations have communicated a lack of trust in the systems providing their water services.

CURRENT PRACTICES

Bottled Water:	Current state of bottled water use in First Nations.
Cisterns:	Current practices for cisterns within First Nations.
Holding Tanks:	Current practices for holding tanks within First Nations.
Septics:	Current practices for septic systems within First Nations
Treatment Plants:	Current state of treatment plants in First Nations.
Trucks:	Current practices with water delivery trucks and vacuum trucks in First Nations.
Wells:	Current practices for wells within First Nations, including the state of source water.

RECOMMENDATIONS

Recommendations:	Suggestions from First Nations on how to improve water and wastewater systems
Opportunities:	Factors identified as enhancing productivity in First Nations' water and wastewater systems
Progress & Adaptiveness:	Achievements and the ability of First Nations to adapt to challenges in water and wastewater systems
Enablers:	Successful factors and practices in First Nations' water and wastewater systems
Quotes:	Significant excerpts from interviews

Appendix G – Questionnaire for First Nations Contributors

Part A – Background Questions

Q1. INTERVIEWEE – Tell us about your job title and how it relates to DECENTRALISED system?

Q2. COMMUNITY DETAILS – Tell us about your community's population, number of homes, and number or parcels?

Probes:
- Population and number of residences?
- Number of parcels
- Geographic location? (proximity to water courses, remoteness, etc.)

Nodes:
- ○

Q3. SYSTEM DESCRIPTION – Tell us about your DECENTRALISED systems?

Probes:
- Type of DW systems and number?
- Type of WW systems and number?
- Age of systems (are most older systems? What is the oldest system?)
- Other key infrastructure or assets that help maintain/operate these systems? (i.e., pump trucks, water trucks, plows for winter access, drill rigs, etc.)

Nodes:
- ○

Part B – Institutional Context Questions

Q4. GOVERNANCE – We are trying to understand the relationship between governance, housing, and decentralised systems in your community?

Probes:
- Are you self-governed? FNLMA?
- Is it mostly Band land, or is there CP land?
- By-laws (housing or other related to individual)?

Nodes:
- ○

Q5. SERVICE & SUPPORT – What administrative offices/roles interact with/support decentralised systems? Are there any service arrangements?

Probes:
- Programs or services departments within the community?
- Tribal Council support?
- External support?

Nodes:
- ○

Part C – Water Systems

WELLS

Q6. PLANNING & DESIGN – Can you walk us through how you would choose to install a new well in a new home?

Probes:

- Who makes this decision?
- Do you do any siting to keep it away from water courses, septic systems, or potential sources of contamination?
- Is there agriculture nearby? Other possible sources of contamination?
- Do you do any testing on the plot of land?
- How do you choose between dug or drilled wells?

Nodes:

- *Actions (management, RFPs, Coordination)*
- *Documentation*
- *Hazards, risk, gaps in practice (limitations to practice?)*
- *Other (emergent during transcript review)*

CISTERNS

Q6. PLANNING & APPROVALS (DESIGN) – Can you walk us through how you choose to install cisterns or how that occurs?

Probes:

- How do you decide between installing a cistern vs a well?
- Do you do any siting to keep it away from water courses, septic systems, or potential sources of contamination?
- Is there agriculture nearby? Other possible sources of contamination?
- How do you choose cistern design?
- How are cisterns sized?

Nodes:

- *Actions (management, RFPs, Coordination)*
- *Documentation*
- *Hazards, risk, gaps in practice (limitations to practice?)*
- *Other (emergent during transcript review)*

WELLS

Q7. INSTALLATION – Help us understand how you go about installing wells?

Probes:

- Do you have a driller you rely on? Are they certified in the province?
- What do you do with the well driller report?
- Have you ever had a plot of land where you couldn't find a suitable well location? What happens in this case?
- Do any wells have treatment units installed? If so, who decides on this?
- Does anyone inspect the wells after installation? Any testing done?

Nodes:

- *Setback*
- *Construction*
- *Documentation*
- *Inspection*
- *Yield and quality testing*
- *Reporting*
- *Hazards, risk, gaps in practice*

CISTERNS

Q7. INSTALLATION – Help us understand how you go about installing cisterns?

Probes:

- Do you have an engineer you use, or an installer you rely on?
- Are the cisterns above or below ground?
- Does anyone inspect the cisterns during/after installation?
- Is there any testing (i.e. microbial) done before use?

Nodes:

- *Setback*
- *Construction*
- *Documentation*
- *Inspection*
- *Commissioning*
- *Hazards, risk, gaps in practice*

WELLS

Q8. OPERATION & MONITORING – Help us understand water wells operationally and how/when they are monitored?

Probes:

- Do actions and testing differ between band-owned or private residents?
- When do you test the wells? Who is responsible for testing them?
- What happens if test results are concerning?
- Have you had any floods or droughts that have presented challenges?

Nodes:

- *Actions*
- *Responsibilities (band asset vs other)*
- *Testing / inspection*
- *Source water protection*
- *Band/PW Support*
- *ISC Support*
- *Hazards, risk, gaps in practice*
- *Boil water advisories*

CISTERNS

Q8. OPERATION & MONITORING – Help us understand cisterns operationally and how/when they are monitored?

Probes:

- How often are cisterns filled?
- What is the process for getting cisterns filled? Have there been times when water isn't available? Are the cisterns accessible to the trucks?
- Where does the water supply come from?
- Are there times when water sits for a long period of time (i.e. family travelling)?
- Do you monitor water from the cistern or the house tap? How often?
- What happens if test results are concerning?
- Are the cisterns protected from infiltration, dirt, debris, etc.?
- Are secondary storage containers used in the homes (jugs, etc.)?

Nodes:

- *Actions*
- *Responsibilities (band asset vs other)*
- *Testing / inspection*
- *Source water protection*
- *Band/PW Support*
- *ISC Support*
- *Hazards, risk, gaps in practice*
- *Boil water advisories*

WELLS

Q9. MAINTENANCE & REPAIRS – Help us understand water well maintenance and repairs?

Probes:

- If a pump needs to be replaced, well head needs repair, etc. who will coordinate that work? Funds?
- Is there a routine inspection/ maintenance schedule? Who is responsible?
- What are the most common maintenance/repair activities?
- Are there challenges with getting repairs done?
- Have there been issues following floods or snow events?

Nodes:

- *Who maintains/ repairs (homeowner, operator, PW, etc.)*
- *Modifications, repairs, replacements, documentation*
- *Band/PW Support*
- *ISC Support*
- *Other Support*
- *Hazards, risk, gaps in practice*
- *Other (emergent during transcript review)*

CISTERNS

Q9. MAINTENANCE & REPAIRS – Help us understand cistern maintenance and repairs?

Probes:

- If a cistern needs a part replaced, routine cleaning, disinfection, etc. who will coordinate that work? Funds?
- Is there a routine inspection/ maintenance schedule? Who is responsible?
- What are the most common maintenance/repair activities?
- Are there challenges with getting repairs done?

Nodes:

- *Who maintains/ repairs (homeowner, operator, PW, etc.)*
- *Modifications, repairs, replacements, documentation*
- *Band/PW Support*
- *ISC Support*
- *Other Support*
- *Hazards, risk, gaps in practice*
- *Other (emergent during transcript review)*

WELLS

Q10. DECOMMISSIONING – Help us understand the state of decommissioning for wells?

Probes:

- Who decides when a well should be decommissioned?
- Do you have an engineer you use or a driller you rely on?
- Do you submit any documentation or keep any records?
- If you don't have a decommissioning plan, why not?

Nodes:

- *Responsibilities*
- *Documentation*
- *Yield and quality testing*
- *Reporting*
- *Hazards, risk, gaps in practice*

CISTERNS

Q10. DECOMMISSIONING – How are cisterns replaced or removed? Or how should they be removed?

Probes:

- Who decides when a cistern should be replaced/removed?
- Do you have an engineer or a contractor you rely on?
- Do you keep any records?
- If you don't have a decommissioning plan, why not?

Nodes:

- *Documentation*
- *Actual practices*
- *Funding (by who?)*
- *Hazards, risk, gaps in practice*

Part D – Wastewater Systems

ONSITE SEPTIC

Q11. PLANNING & DESIGN – Can you walk us through how you would choose to install a septic system at a new home?

Probes:

- Is a soil analysis done? Site characterization?
- Do you do any siting to keep it away from water courses, wells/cisterns, or other limiting features?
- Who designs and selects the type of system?
- How is the capacity of the systems determined?
- What is the best type of system for your soil type, land conditions, and plot sizes?

Nodes:

- *Actions*
- *Documentation*
- *Hazards, risk, gaps in practice*
- *Other (emergent during transcript review)*

HOLDING TANK / OTHER

Q11. PLANNING & DESIGN – Can you walk us through how you decide to rely on a holding tank at a new home?

Probes:

- Are there specific conditions that warrant a holding tank?
- Do you work with an engineer or contractor to review holding tank design/size/location?
- Do you do any siting to keep it away from water courses, wells/cisterns, or other limiting features?
- How are holding tanks sized?
- Are there protections in place in case of flooding?

Nodes:

- *Actions*
- *Documentation*
- *Hazards, risk, gaps in practice*
- *Other (emergent during transcript review)*

ONSITE SEPTIC

Q12. INSTALLATION – Help us understand how you go about installing onsite septic systems?

Probes:

- Do you have an installer you rely on? Are they certified in the province?
- What is the greatest challenge to installing a septic system?
- Do the systems require electric work (i.e. alarms, pumps)? If so, who does this work?

Nodes:

- *Setback*
- *Construction*
- *Documentation*
- *Inspection*
- *Reporting*
- *Hazards, risk, gaps in practice*

HOLDING TANK / OTHER

Q12. INSTALLATION – Help us understand how you go about installing a holding tank or other?

Probes:

- Do you have a contractor or installer that you rely on?
- Does anyone inspect the holding tanks during/after installation?
- Do the systems require electric work (i.e. alarms, pumps)? If so, who does this work?

Nodes:

- *Setback*
- *Construction*
- *Documentation*
- *Inspection*
- *Hazards, risk, gaps in practice*

ONSITE SEPTIC

Q13. OPERATION & MONITORING – Help us understand onsite septic systems operationally and how/when monitoring occurs?

Probes:

- Do actions differ between different band owned or private residents?
- Are routine inspections done? Routine pumping? Are there access issues?
- Where does the pump waste go?
- Are residents aware of good septic care (i.e. careful about what goes down the drain, maintaining the field, etc.)
- Are there flooding issues?

Nodes:

- *Actions*
- *Responsibilities (band asset vs other)*
- *Testing / inspection*
- *Band/PW Support*
- *ISC Support*
- *Hazards, risk, gaps in practice*

HOLDING TANK / OTHER

Q13. OPERATION & MONITORING – Help us understand onsite septic systems operationally and how/when monitoring occurs?

Probes:

- Are there issues with accessing the tank for inspection?
- Are the tanks fit with level monitors?
- Are routine inspections done? Routine pumping?
- How often are tanks pumped?
- Where does the pumped waste go?

Nodes:

- *Actions*
- *Responsibilities (band asset vs other)*
- *Testing / inspection*
- *Band/PW Support*
- *ISC Support*
- *Hazards, risk, gaps in practice*

ONSITE SEPTIC

Q14. MAINTENANCE & REPAIRS – Help us understand onsite septic system maintenance and repairs?

Probes:

- Do you have a contractor, engineer, or hauler that you use?
- Is there a maintenance schedule?
- What is the most common maintenance issue? Repair needed?
- What actions are taken when a septic system fails?
- What are the greatest risks/challenges with septic systems?

Nodes:

- *Who maintains/ repairs (homeowner, operator, PW, etc.)*
- *Modifications, repairs, replacements, documentation*
- *Band/PW Support*
- *ISC Support*
- *Other Support*
- *Hazards, risk, gaps in practice*
- *Other (emergent during transcript review)*

HOLDING TANK / OTHER

Q14. MAINTENANCE & REPAIRS – Help us understand how you go about maintaining and repairing holding tanks (or other)?

Probes:

- Do you have a contractor or hauler you use?
- What is the most common maintenance issue? Repair needed?
- What are the greatest risks/challenges with septic systems?
- Where does the pumped waste go?

Nodes:

- *Who maintains/ repairs (homeowner, operator, PW, etc.)*
- *Modifications, repairs, replacements, documentation*
- *Band/PW Support*
- *ISC Support*
- *Other Support*
- *Hazards, risk, gaps in practice*
- *Other (emergent during transcript review)*

ONSITE SEPTIC

Q15. DECOMMISSIONING – Help us understand the state of decommissioning onsite septic systems?

Probes:

- Who decides when a system should be decommissioned?
- Do you have a contractor or engineer you rely on?
- Do you know of abandoned septic systems that were not removed/destroyed?
- Do you submit any documentation or keep any records?
- What challenges prevent you from decommissioning these systems?

Nodes:

- *Responsibilities*
- *Actual Practices*
- *Documentation*
- *Disinfection, Backfill*
- *Reporting*
- *Hazards, risk, gaps in practice*

HOLDING TANK / OTHER

Q15. DECOMMISSIONING – How are holding tanks replaced or removed? Or how should they be removed?

Probes:

- Who decides when a holding tank should be replaced/removed?
- Do you have an engineer or a contractor you rely on?
- Do you know of abandoned holding tanks that were not removed/destroyed?
- Do you keep any records?
- What challenges prevent you from decommissioning these systems?

Nodes:

- *Responsibilities*
- *Actual Practices*
- *Documentation*
- *Disinfection, Backfill*
- *Reporting*
- *Hazards, risk, gaps in practice*

Part E – Closing Questions

Q16. RECOMMENDATIONS – What do you want ISC to hear about your experiences or policies and procedures that are controlling or influencing your ability to manage these systems?

Probes:

- Access to funding support? (centrally managed decentralised systems)
- **Biggest risks**/concerns?
- Most **challenging obstacle**?
- **Biggest support** that allows these systems to function?
- What is **working well in managing** these systems?

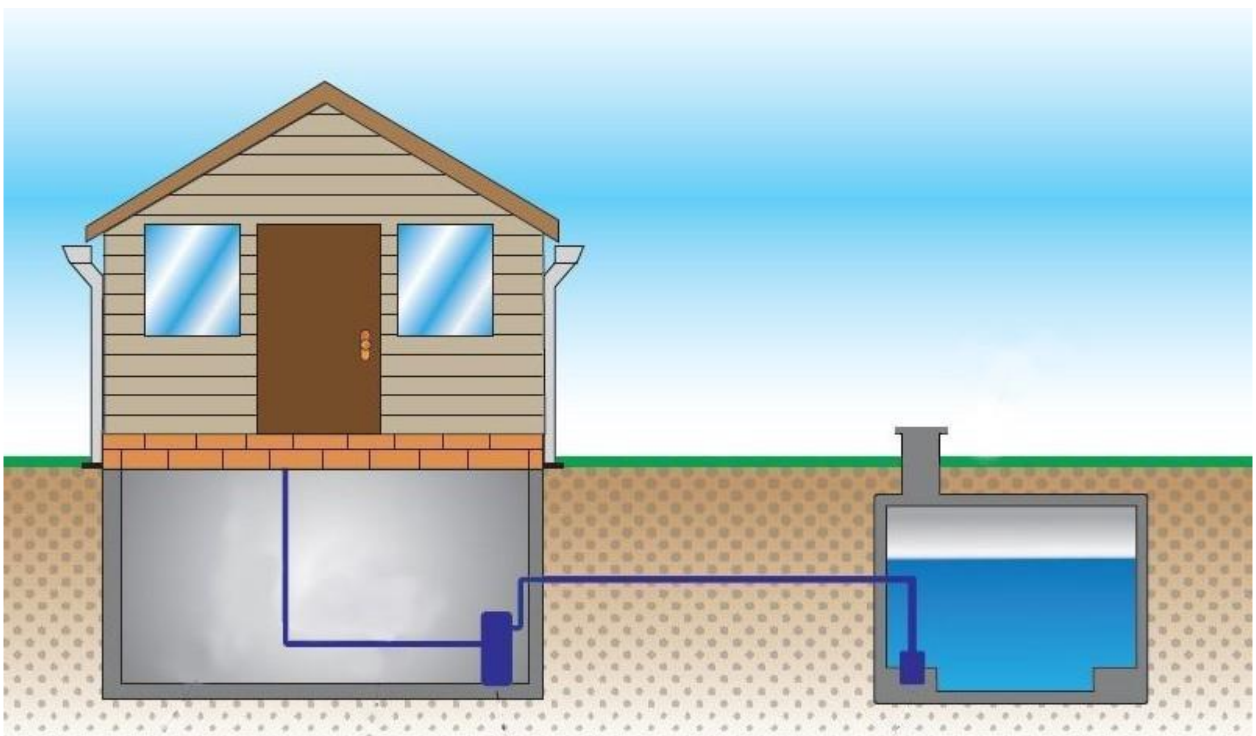
Q3. ADDITIONAL – Anything we're missing or anyone we should talk to?

Other Possible Nodes:

- *Policy – what policies, guidelines, others are mentioned.*
- *Finance – discussion on the financial aspect.*
- *HR – discussion on people, human power.*
- *Training – any specific mentioned.*
- *Actors/Roles – people/roles mentioned.*
- *Organizations/Support – organizations and support provided.*
- *Relationships – critical and enablers where they exist.*
- *Recommendations – specific that come from the interviewee.*
- *Opportunities/What works – if they make note, not to emphasize but to identify what works*

Appendix H – Cistern Cleaning and Disinfection Guidelines from File Hills Qu'Appelle Tribal Council

Cistern Cleaning & Disinfection Guideline



(Image source: Government of Ontario)

Environmental Public Health Services FHQ Health Services

November 4, 2025

Cisterns should be periodically cleaned and disinfected. Over time:

- Bacteria can start to regrow, resulting in slime forming on the inside surfaces;
- Sediments/sludge can build up on the bottom of the cistern;
- Groundwater and surface runoff can contaminate it; and
- animals or insects or debris can fall in.

Cleaning and disinfection of a cistern should be done at least once every two years, and after:

- construction, repair or maintenance work on it;
- flooding of the cistern (or flooding next to it);
- an extended period of non-use;
- testing finds coliforms or E. coli in the tap water: or,
- after a Boil Water Advisory on the delivery truck or the source water (but only if the possibly contaminated water was delivered to the cistern).

⚠CAUTION

- **All cisterns or tanks should be considered a "confined space," which can be dangerous.**
    - **The possible presence of hazardous gases or the lack of oxygen in a cistern could cause injury or death.**
- **No one should enter a cistern unless they are properly trained in confined space entry and are equipped with air testing, ventilation and rescue equipment.**
- **Proper confined space entry procedures should always be used.**
- **No matter how clean the cistern or tank may appear, these dangers are not able to be detected by human sight or smell.**
- **Only use clean water and a chlorine solution when cleaning a cistern. Recommended chlorine solutions are unscented household bleach (5 to 6% chlorine) or a commercial sodium hypochlorite solution (12% chlorine) which is what is used in most water treatment plants.**
    - **Other cleaning products, such as ones with ammonia, may react with chlorine to form toxic gases and compounds.**
- **People working with chlorine solutions should wear personal protective clothing to protect them from splashes.**

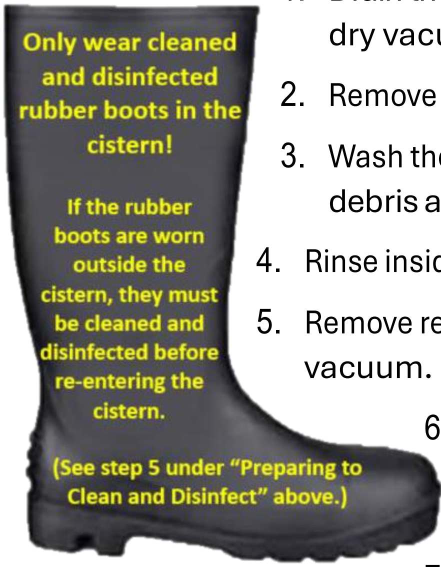
Preparing to Clean & Disinfect the Cistern

The best time to schedule a cleaning is just prior to a refill. It is important to do the following prior to beginning the cleaning and disinfection process:

1. Arrange water deliveries for the cleaning and disinfection.
2. Advise occupants that the cistern is being cleaned and disinfected and not to use the water.
   - Occupants should store enough water for up to 24 hours. Use a safe source of bottled water for drinking, brushing teeth and food prep during the disinfection process or fill clean water containers with a safe source of drinking water. The bathtub can be used to store water for other household purposes, such as flushing the toilet.
   - During the cleaning and disinfection work, occupants should not bathe, shower, or do laundry.
   - They also should not flush the toilet—unless they have stored water (such as in the bathtub) and can fill the toilet's tank with water before flushing.
3. Buy new containers of regular, unscented, detergent- free chlorine bleach as bleach can lose its strength over time.
4. Gather the tools and footwear you will be using to clean the tank, such as:
   - a mop or long-handled stiff brush, shovels, pails, rubber boots, pressure washer, wet-dry vacuum, submersible pump (and hose), etcetera
5. Clean, rinse and disinfect any tools (such as mops, vacuum nozzles, brushes, shovels, pails, and rubber boots) that will touch the cistern's interior surfaces.
   - Use 10 millilitres (or 2 teaspoonfuls) of unscented, household bleach mixed with 4 litres (about 1 gallon) of water from a safe source. Let the mixture stand for at least 10 minutes before using it to disinfect tools.
   - Mops and brushes should be soaked in solution for 2 minutes.
   - Solution may be sprayed on to boots and other tools, let stand for 1 minute.
6. Disconnect or bypass any water treatment devices such as filters and reverse osmosis (RO) systems. Check the owners' manuals for instructions on cleaning or disinfecting the treatment equipment.

REMEMBER: coordinate with the Water Treatment Plant Operator and Water Truck Hauler as you will need clean water during this process.

Cleaning the Cistern



1. Drain the cistern of water using submersible pump and/or wet dry vacuum.
2. Remove any sludge buildup at the bottom of the cistern.
3. Wash the cistern with a pressure washer or a stiff brush to clean debris and sediment from all interior surfaces.
4. Rinse inside surfaces with a pressure washer or mop.
5. Remove remaining water and sediment using a mop or wet-dry vacuum.
6. Inspect the tank, access collars, lid, fill port cap and all seals for damage or signs of leaks. (Report any damage or suspected leaks to Band administration.)
7. Follow the disinfection procedures below.

Disinfecting the Cistern

1. Fill the cistern ½ full of clean water.
2. Add chlorine to the cistern to make a 50 milligram/L (mg/L) chlorine solution strength in the water.

How Much Chlorine Should You Add to Make a 50 mg/L Solution?

If using Unscented Household Bleach:

- Add 1 litre (4 cups) of unscented household bleach to the cistern for every 1000 L (220 imp gal.) of water it can hold.

If using a commercial sodium hypochlorite solution:

- add 440m ml (1.5 cups) of sodium hypochlorite into the water cistern for each 1000 L (220 imp gal.) of water it can hold.

3. Add more clean water to the cistern until it is just above the normal fill level.

4. Open each water tap, one by one, until you smell the chlorine odour, then turn it off. If the tub has water stored in it, do not run its tap.
5. Leave the super chlorinated water in the cistern and piping for at least six (6) hours.
6. Drain the cistern using an outside tap connected to a garden hose.

- Direct the chlorinated water to an area away from vegetation to avoid damage.
- Because chlorine can kill fish and aquatic organisms, make certain that it doesn't drain into a lake, river, or other surface water body.
- Do not direct the chlorinated water to a septic tank or field as it may kill the bacteria the septic system needs to work.

7. Have the cistern refilled and flush the plumbing system by running each faucet (including inside, outside, cold and hot water faucets, baths and showers) until you can no longer smell chlorine. Flush all toilets one at a time.

Remember: do not run this super chlorinated water through certain types of water treatment equipment (e.g., softeners, carbon filters, reverse osmosis systems). For specific information, contact your equipment dealer or the manufacturer.

The household must not turn on taps, shower or do laundry while super chlorinated water is in the pipes.

If the water supply line to toilet has been turned off, the toilet can be flushed and the tank refilled manually with water that was stored in the tub earlier.

Something to Consider: As water had to be run to clear the chlorine solution out of the piping, the household may require a partial water delivery before the next scheduled cistern fill.

⚠CAUTION

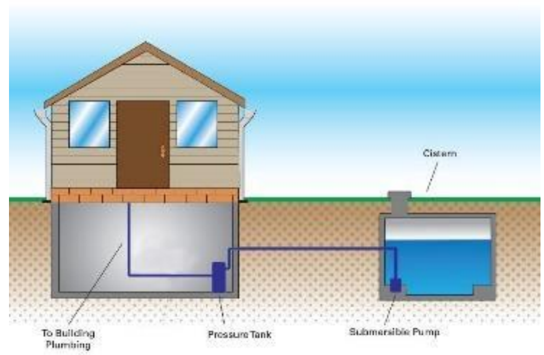
If the occupants decide to clean and disinfect their own cistern, they should not enter it. For example, after emptying, the walls may be washed down with a garden hose, wand or a pressure washer, while working from outside the tank. The wash water can be removed using a submersible pump and discharged into an open outside area. This may have to be done more than once to adequately remove settled material.

Appendix I – Q&A Boil Water Advisory on Cisterns from File Hills Qu'Appelle Tribal Council

FHQ Tribal Council

Questions & Answers: Boil Water Advisory on Cisterns

Does the water in your house come from a cistern?



If it does, then all water for

- drinking,
- food preparation (including washing fruits and vegetables)
- making baby formula, and,
- brushing teeth

should be heated until it's at full boil for at least one minute and then cooled before use. Once cooled, this boiled water can be stored in a clean, covered container.

Why does cistern water need to be boiled before being consumed?

There are several reasons why we recommended a Boil Water Advisory (BWA) on all cisterns:

- The water is 'handled' many times before it comes out of your home's taps.
  - The tank is filled at the Water Treatment Plant,
  - Transported by truck,
  - Hose dragged over to the cistern, and then,
  - Pumped into your cistern.

All this 'handling' just increases the possibility of contamination.

- Most cisterns are constructed from concrete and are buried underground in clay soil. Clay soil can shift, contract and/or expand, which can crack the concrete and break seals leaving the cistern open to contamination by groundwater or surface runoff.
- With repeated water deliveries, weathering and wear & tear over time, cistern lids and access ports can be damaged which will allow rainwater, surface runoff, insects and animals into the cistern.

If there is BWA on my cistern, why does a Tribal Council Water Quality Technician collect water samples for bacteriological testing?

We continue to sample cisterns for the following reasons.

1. Cisterns still need to be cleaned to prevent the water from developing tastes and odors or becoming cloudy.
    - Our sampling program helps your First Nation plan the cleaning and disinfection of cisterns.
2. The analysis report on a sample from a cistern can be used by the household to make an informed decision on following the BWA.
    - We know that not everyone follows the BWA on cisterns.

Are the risks of drinking contaminated water the same for everyone?

Anyone can develop a stomach illness drinking contaminated water. However, the very young, pregnant women, the elderly and people with weakened immune systems are at greater risk of

having a severe illness.

How can I keep my family safe?

Boil all water used for:

- Drinking,
- Food preparation (including washing fruits and vegetables)
- Making baby formula, and,
- Brushing teeth.

Once the water has boiled for a minute the water can be cooled and stored in clean covered containers in your fridge.

Do we have to boil the water for other uses?

No. You can use cistern water without boiling for washing dishes, handwashing, laundry, and household cleaning.

You can also use the water directly from your cistern for showering or bathing, but remember to:

- avoid swallowing water,
- sponge bath infants, and,
- supervise younger children when they bathe.

For more information: call FHQ Health Services at 306-332-8241

(2024-08-13)

Appendix J – FSIN Healthy Water Working Group's Drinkable Water Quality Standards

Drinkable Water Quality Standards

(DWQS)

Drinking Water Standards for

Saskatchewan First Nations Water Treatment

and Distribution

Published by:

Federation of Sovereign Indigenous

Nations 134 Kahkewistahaw Crescent

#10 Saskatoon, SK S7L 7E1

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Please obtain the latest update of this document, available at: www.fsin.ca

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Introduction

The right to safe drinking water was expressed by the World Health Organization (WHO): "All people, whatever their stage of development and their social and economic conditions, have the right to have access to an adequate supply of safe drinking water." The United Nations Declaration on the Rights of Indigenous Peoples (2008) states in Article 23 that:

> Indigenous peoples have the right to determine and develop priorities and strategies for exercising their right to development. In particular, indigenous peoples have the right to be actively involved in developing and determining health, housing, and other economic and social programmes affecting them and, as far as possible, to administer such programmes through their own institutions[1].

The Federation of Sovereign Indigenous Nations resolved that SK First Nations require a Water Management Strategy[2] that includes the creation of clearly defined water quality standards and appropriate infrastructure, among other priorities. This follows from the knowledge that:

- First Nations have the inherent human right to safe living conditions, and the treaty right to health that includes access to a safe water supply; and
- Provincial regulations and water quality standards do not apply on-reserve; and
- Federal guidelines do not address adequate water quality standards to ensure a sufficient supply of safe drinking water.

The Indigenous Nations in Saskatchewan believe that water quality standards should be universal and not vary by the location of the water system. The water quality standards for a drinking water system in a Saskatchewan Nation should be the same as the standards for a water system in a Nation elsewhere in Canada. We also believe the standards for each parameter should be as low as current technology allows.[3]

The development of guidelines globally follows technical information and, typically, commentary and votes of those who consider political ramifications of the proposed guidelines. These limits are based on community-health priorities and science-based results of water quality and associated risk and are, therefore, more stringent than previous guidelines for several parameters.

It must also be noted that laboratories running routine water quality analyses are able to detect the parameters suggested in this document at levels that are 10 times lower than our suggestions for standards. Several newer water treatment technologies routinely meet all of the standards proposed here and are now available in Saskatchewan. Our standards frequently resemble what

[1] United Nations. 2008. United Nations Declaration on the Rights of Indigenous Peoples. Published by the United Nations.
[2] Federation of Saskatchewan Indian Nations. May 31, 2006. Procedural Resolution: Saskatchewan First Nations' Water Management Strategy. Legislative Assembly Resolution, Reference number: 1458.
[3] The term "as low as current technology allows (ALACTA)" is used rather than "as low as reasonably achievable (ALARA)" because what is considered reasonable is open to interpretation.

was hoped for under the federal government's enabling legislation Bill S-8 without the abrogation of Treaty Rights and the protection from liability that the government of the day wanted.

This document suggests the adoption of approximately 90% of the Guidelines for Canadian Drinking Water Quality (GCDWQ). Focus is aimed at water quality standards that water treatment plant operators can implement with ease with proper treatment systems and that will result in an improvement in drinking water quality. These standards may be used by agencies not tied to existing guidelines and regulations to provide a framework for high quality tap water in their communities.

Objectives

The purpose of this report is to provide a framework for how distributed treated water can protect health and provide an aesthetically-pleasing supply of tap water. This requires:

1) Assessment of the raw water source via detailed chemical analysis. The Authority Having Jurisdiction would require and pay for this for maximum objectivity. The Authority Having Jurisdiction will also assess physical attributes (such as depth of water intake, temperature, pH, redox potential, etc.) of the water.
2) The production of safe drinking water with the least amount of treatment process chemicals.
3) Selection of treatment technologies by the Authority Having Jurisdiction that will produce water to the standards described herein.
4) Engineering Consultants: Development of a database that can be used to evaluate previous experience with engineering consultants working in member communities. The Authority Having Jurisdiction shall maintain this.
5) Manufacturers: Development of a database evaluating previous experiences with water treatment manufacturers and suppliers working in member communities. The Authority Having Jurisdiction shall maintain this.
6) Distributed Water Quality Standards: Any water treatment process needs to consistently meet established water quality standards. A water treatment plant is

typically built for a 20-30 year useful lifespan. A water treatment process needs to be sustainable with minimum use of chemicals and costs during that time-period, yet maintain the regulated water quality standards. Some of these costs are borne by the First Nation out of general revenue. For a community of 1,000 members, some technologies may require
$100,000/year in operational costs while other technologies will require less than

$10,000/year. This needs to be documented and considered. Often, a shortsighted, sole-economic bottom line is to blame for poor quality treated water.

7) Pilot Studies: The period of piloting a water treatment technology for a new or upgraded water treatment process will depend on whether or not the treatment technology has been demonstrated to produce water meeting standards set herein on a consistent basis utilizing data from one or more water treatment plant systems with similar source waters and climatic conditions.

8) Tender Process: Although this process has shown improvement over time, the federal government favored lowest cost bids from engineering companies. This forced manufacturers to source cheap parts and take as many short-cuts as possible in their goals to reach the bottom line. This often results/resulted in the construction of a sub-optimal water treatment process and the likely failure to consistently produce acceptable quality water to First Nations. A water treatment process MUST NOT be judged on initial cost alone, but also include regular chemical costs, maintenance costs, life-cycle of the plant, as well as health and social implications of the treated water.

9) Irrespective of the chemical or biological process used by a manufacturer, the process needs to be explained in the project proposal. A process described as biological cannot be based on chemical removal.

Water Quality Parameters

Turbidity

Turbidity measurements are commonly required for surface water sources and groundwater under the influence of surface water (GUDI) with no real turbidity requirements for true groundwater. Surface waters are often teeming with pathogenic microbes such as

Cryptosporidium and Giardia (protozoan parasites) with turbidity measurements and adjustments as a means of protecting consumers from such microbes. However, the fact is that most turbidity requirements do not provide protection from *Cryptosporidium*.

The Saskatchewan standards and objectives for turbidity are similar to that of the Guidelines for Canadian Drinking Water Quality (GCDWQ) and it is not always certain that these provincial and federal standards and guidelines were created in the sole interest of human health. GCDWQ range from 0.10 to 3.0 Nephelometric Turbidity Units (NTUs). It is uncertain why a single number is not recommended, particularly in the interest of health. Water treatment plants that are only capable of meeting 3.0 NTU seem to be at a disadvantage. (See discussion on total dissolved solids [TDS]).

Of most concern is the potential presence of disease-causing organisms, particularly human parasites such as *Giardia* (as it can cause Giardiasis) and *Cryptosporidium* (as it can cause Cryptosporidiosis). However, both Canada and Saskatchewan have accommodated various treatment processes when setting their guidelines, rather than basing decisions on human health.

In 1979, the GCDWQ for turbidity was 5 NTUs. The GCDWQ for turbidity was strengthened in 2004, but is conditional on the filtration method.

The former guideline decreased to 0.30 NTU for granular filtration water treatment processes as measured at the point of discharge from the filter vessels and it remains at this level currently. It cannot guarantee the absence of parasites in the treated water. However, guidelines also include a provision for membrane technologies, which is set at 0.10 NTUs. At this low turbidity level it is unlikely that parasites will slip through to the treated water.

Membrane integrity should be monitored and recorded daily when membrane technology is used to filter ground and surface waters. Conductivity (and TDS) tests will determine the quality of reserve osmosis (RO) filters. For ultrafiltration, refer to the United States Environmental Protection Agency's (U.S EPA) *Membrane Filtration Guidance Manual.*[4]

A distinction exists in terms of turbidity levels after filtration, prior to distribution, and in the distribution system itself. Filter level turbidities are strictly operational and, if human health is the main concern, water for distribution and water in the distribution system would be prioritized. Turbidity will be tested on a weekly basis in piped distribution to detect contaminated lines, line breaks, backflow, and cross connection contamination.

Recommendation

We recommend a maximum distributed turbidity level be set at 0.10 NTU, which is measured for water leaving the plant. We need, however, to remember that it is ONLY membrane technologies that can consistently meet this regulation: micro-, ultra-, nano- and RO-membranes. Granular filtration can barely manage to get below 0.30 NTU. Occasionally, a good operator can achieve

0.20 NTU.

Surface water and GUDI treatment systems require inline meters on the discharge from each filter and manual testing of the mixed filter effluent. Groundwater treatment plants require weekly tests of raw water and daily tests of the treated water at the plant. Manual turbidity tests will be carried out daily as part of the operator's routine testing. Inline turbidity meters and other inline analysers are helpful but require frequent cleaning. Further, inline meters will not eliminate the requirement for manual turbidity measurements.

Turbidity levels in the distribution system, regardless of treatment system, must also be measured regularly. Weekly testing will indicate the presence or absence of harmful bacteria and viruses, or severe local corrosion of the water pipes. The ideal turbidity level in piped distribution is 0.1 NTU, however, we recommend 0.20 NTU with an added ALACTA statement.

[4] https://hero.epa.gov/hero/index.cfm/reference/details/reference_id/2826618

Total Dissolved Solids (TDS)

TDS is a measurement of how many ions or how many inorganic salts are present in the water. TDS is calculated from conductivity measurements. On average, multiplying the conductivity measurement in microsiemens with 0.7 will equate to TDS reflected as mg/L. Lake water is often around 200 mg/L. Groundwater in Saskatchewan can be greater than 2,000 mg/L.

Canada has set an upper acceptable level of TDS at 500 mg/L. The current Saskatchewan limit of 1,500 mg/L is characterized by a distinctly salty taste.

Recommendation

It is recommended that SK First Nations adopt the world standard of a 500 mg/L limit for TDS (it should be a standard rather than a guideline).

Iron

At present, iron has an aesthetic objective of 0.3 mg/L. Higher levels will stain clothes, showers, bathtubs, toilets, toilet tanks, and dishes. It can also give the water an unpleasant metallic taste and offensive odour. Washing with water that is high in iron can damage healthy skin cells, which can lead to wrinkles.

In addition, water with high levels of iron does not blend well with soap. This can lead to a soap scum residue not only being left in your bathtub, but on your skin as well (which can clog pores and lead to skin problems such as acne or eczema). When water with high levels of iron flows through pipes, iron residue will build. This can lead to clogged and stained toilets and sinks, as well as overall reduced water pressure in homes. It can also be linked to excessive bacterial activity. Iron will foul nano- and RO membranes. Feed waters to such membrane-systems must be limited to iron levels below 0.05 mg/L. Iron, manganese and high hardness (calcium and magnesium) levels cause hot water heaters, washing machines and other appliances using water to prematurely fail. Better quality distributed water will eliminate these problems.

Recommendation

We recommend that a level of 0.05 mg/L is used.

Manganese

The most recent guideline for total manganese in drinking water in the GCDWQ is set at an aesthetic objective of 0.02 mg/L and a maximum acceptable concentration (MAC) of 0.12mg/L.[5] At a level of 0.3 mg/L manganese becomes a health concern as it can affect brain health.[6] At a level above 0.12 mg/L manganese becomes a health concern for infant brain health.[7] Manganese above 0.05 mg/L can stain plumbing and laundry as well as impart taste and odour to the water. Manganese-containing water can react with coffee, tea, and even alcoholic beverages, producing a black sludge affecting both taste and appearance. In addition, commonly occurring dissolved manganese can be oxidized by bacteria, encouraging microbial slime formation in both distribution and household pipes. Some communities do not chlorinate properly and no free chlorine residual is present, which allows high levels of manganese to remain in the solution (around 2-3 mg/L).

Recommendation

The new GCDWQ have a MAC of 0.12 mg/L and an AO of 0.02 mg/L. Our recommendation is to decrease allowable manganese levels to 0.02 mg/L as per the potential GCDWQ for both the MAC and aesthetic objectives.

Lead

Lead is typically not present in raw water sources, but may be leached out of distribution and home plumbing—especially if lead solders have been used. To avoid having lead leach out of lead solder and other lead-containing fixtures the distributed water needs to be non-corrosive (See discussion under pH). Health Canada has lowered the current lead guideline to 0.005 mg/L from 0.01 mg/L. We concur with this most recent guideline as this will protect First Nations from the ill effects of lead. Refer to the Lead Fact Sheet from the Safe Drinking Water Foundation, part of which has been reproduced below.

(https://www.safewater.org/fact-sheets-1/2017/1/23/lead):

Potential effects of lead include premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in young children. Lead exposure is most serious for young children because they absorb lead more easily than adults and are more susceptible to its harmful effects. Even low-level exposure may harm the intellectual development, behaviour, size, and hearing of infants. There is a future risk of osteoporosis in exposed children. Symptoms of adverse effects to the nervous system, the primary target organ for lead, include forgetfulness, tiredness, headaches, changes in mood and behaviour, lower IQ, decreased hand dexterity and weakness of arms, legs, wrists, fingers or ankles. Even though adults do not absorb lead as easily as children, there are also health effects in adults who drink water with high levels of lead over many years. These health problems include kidney problems, anemia, reduced sperm count and fertility problems, and high blood pressure. In addition to these health effects, people who are exposed to moderate levels of lead for an extended period of time may be at a greater risk of experiencing changes in hearing ability, digestive issues (abdominal pain, cramps, nausea, vomiting, etc.), altered immune systems and changes in levels of certain hormones. Exposure to lead over a lifetime may also increase the risk of developing cancer. The International Agency for Research on Cancer (IARC) has recently re-classified lead as a probable carcinogenic to humans (Group 2A), based on sufficient evidence of carcinogenicity in experimental animals and some limited evidence of carcinogenicity in human studies.

[5] The consultation document can be found at https://www.canada.ca/en/health-canada/programs/consultation-manganese-drinking-water/manganese-drinking-wat er.html

[6] https://www.epa.gov/sites/default/files/2014-09/documents/support_cc1_magnese_dwreport_0.pdf

[7] https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-qu ality-guideline-technical-document-manganese.html

Recommendation

Accept the current 0.005 mg/L Health Canada guideline.

Arsenic

Arsenic in tap water has been regulated for a long time and has been classified as a human carcinogen by regulatory agencies. In a literature review of the human health effects of arsenic, Kapaj et al. (2006) recommended that a community distributing water with an arsenic level higher than 0.005 mg/L should test its community members for symptoms of arsenic poisoning. The arsenic guideline in Canada was first set to 0.05 mg/L, but this was followed by decreases to 0.025 mg/L and then to 0.01 mg/L. However, even 0.01 mg/L has been contested. Currently, the “no-effect level” of arsenic is in the sub-microgram range (around 0.0003 mg/L).

The current 0.01 mg/L arsenic guideline in the Guidelines for Canadian Drinking Water Quality, is the same as the WHO Guideline for Drinking-Water Quality, European Union Drinking Water Directive, and the United States Environmental Protection Agency National Primary Drinking Water Regulation.[8] Health Canada, in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water (CDW), and other federal departments (those who establish the GCDWQ) have added an ALARA statement (as low as reasonably achievable) to the arsenic guideline.

Recommendation

After reviewing the literature, we believe that an acceptable upper limit for arsenic in distributed water is 0.0003 mg/L. The detection limit for arsenic at the University of Saskatchewan is currently around 0.00004 mg/L for multi-element runs and is predicted to be 0.00003 mg/L or lower for single-element runs (determination of arsenic alone), so there is no analytical barrier to this tighter guideline.

[8] United States Environmental Protection Agency. 2009. *National Primary Drinking Water Regulations*. https://www.google.com/url?q=https://www.epa.gov/sites/default/files/2016-06/documents/npwdr_complete_table.pdf&sa=D&source=docs&ust=1674581703933999&usg=AOvVaw1w4b3Lzv_2PySq2YEVr9W

Taste and Odour

Despite the lack of regulations surrounding taste and odour quality of treated and distributed water, larger water treatment plants ensure that their treatment processes, and end product, meet the desires of the consumer; that is, that the water tastes and smells good. Some larger water treatment plants employ "taste panels" whose job it is to test, via smell and taste, distributed water. If the water is not satisfactory, action is taken immediately to ensure that the consumer appreciates their water, despite the lack of regulations. Currently, processes to ensure the acceptable aesthetics of treated water are not often considered in First Nations communities.

Recommendation

The distributed water in First Nations communities needs to have a pleasant smell and taste, which includes a lack of offensive odours and taste from chlorine. This could be determined via a "taste panel" of 10-20 community members of various ages during the piloting process for the treatment plant. The Project Management Team can ensure that the tasting panel is created and that their recommendations are followed.

Surface water treatment plants' raw water is more susceptible to quality, quantity and temperature fluctuations. Significant parameter fluctuations may necessitate the formation of subsequent taste panels to ensure that the water meets aesthetic requirements.

Chlorine

The most basic of all requirements that a water operator needs to meet, the addition of chlorine to the treated water, is shrouded in mystery. Operators require clear regulations to follow regarding

1) the maximum level of chlorine to add to treated water; and 2) the minimum acceptable level of free chlorine throughout the distribution system. Regulations for sampling requirements need to be established to ensure the presence of chlorine residual levels. It is important to note that the majority of this discussion pertains to water that is distributed through a piped distribution system. However, recommendations regarding decentralised distribution via the trucked delivery of water to cisterns are included.[9]

Most regulatory agencies require that chemicals used in the production of water meet requirements of NSF/ANSI 60 which limits the use of 12.5% sodium hypochlorite to 84 mg/L. This is roughly 10 mg/L of available chlorine. The reason for the Maximum Use Limits (MULs) is based on the fact that sodium hypochlorite can have contaminants, including bromate, chlorate and perchlorate, which are by-products from the manufacturing process. As sodium hypochlorite

[9] The recommendations only provide guidance on the free chlorine residual to be present in the water delivery truck. More research needs to be conducted on how to best ensure chlorine residuals in cistern systems.

ages, so does the concentration of chlorate and perchlorate increase. Sodium hypochlorite also loses strength with age.[10]

Disinfection Requirements

In general, the water systems must meet the Disinfection requirements found in the *Procedure for Disinfection of Drinking Water in Ontario*. In Saskatchewan, most First Nations use sodium hypochlorite to disinfect. The chlorine solution used for disinfection (sodium hypochlorite)

should be used within 3 months of purchase as the disinfecting power of the solution lessens over time. Other forms of disinfection are available as outlined in the Ontario Ministry of the Environment, Conservation and Parks' Procedure for Disinfection of Drinking Water in Ontario (https://www.ontario.ca/page/procedure-disinfection-drinking-water-ontario).

To meet the disinfection requirements set out in the Saskatchewan First Nations Drinkable Water Quality Standards (DWQS) with the least amount of chlorine, some rules apply and are listed below.

1) All community water systems must provide primary disinfection to reduce or eliminate microbial risks. Also, primary disinfection must meet the Contact Time (CT) requirements outlined in Ontario's Procedure for Disinfection of Drinking Water in Ontario. In addition, there is a requirement for secondary disinfection to prevent microbiological regrowth and act as a measure of system integrity.

2) The maximum amount of chlorine that can be added during water treatment is 3 mg/L. In order to not exceed this maximum use level, the water to be disinfected must have:

   a. A low chlorine demand. To achieve a low chlorine demand, the water needs to have low levels of ammonia, iron, manganese and other compounds, which will keep the amount of chlorine required to meet disinfection requirements to a minimum; and,

   b. Low levels of Dissolved Organic Carbon (DOC), less than 1.5 mg/L, to decrease the production of disinfection by-products and the possible regrowth of microbes in the distribution system.

Chlorine use

The minimum level of free chlorine residual required at the plant and throughout the distribution system is 0.2 mg/L (or 1.0 mg/L combined chlorine for disinfection processes that employ chloramination).

[10] More research is necessary to determine the exact time period for maximum effectiveness, however three months is a general guideline recommended to water treatment plant operators.

Measuring both Free Chlorine Residual and Total Chlorine Residual

You must always measure total chlorine residual whenever free chlorine residual is measured. Comparing the level of free chlorine residual to the total chlorine residual will tell you how much of the chlorine is combining (reacting with) organic and inorganic compounds (such as DOCs, manganese, iron and ammonia). This information is important in assessing whether or not primary disinfection has been achieved and will also help identify problems in the distribution system. To compare the two residuals:

$$(\text{Free} \div \text{Total}) \times 100$$

The above calculation will tell you what percentage of the total chlorine residual is free chlorine residual. Breakpoint chlorination occurs when, after chlorination, there is free chlorine in the water.

The following are examples of how this information can be used.

- If, at the water plant, the free chlorine residual is less than 80% of the total chlorine residual, you likely have not met primary disinfection requirements. The *Procedure for Disinfection of Drinking Water in Ontario*[11] states that, at the end of the primary disinfection process, where ammonia is present, the free chlorine residual should be 80% of the total chlorine residual. If this cannot be achieved, the primary compounds reacting with chlorine need to be removed from the water.
    - For example, if the free chlorine residual at the water plant is 0.2 mg/L, while the total chlorine is 0.6 mg/L, you have likely not met primary disinfection requirements as the free chlorine residual is only 33% of the total chlorine residual (0.2 ÷ 0.6 × 100 = 33%).
    - If the free chlorine residual at the plant is 0.5 mg/L and the total chlorine

residual is 0.6 mg/L, you have likely achieved breakpoint chlorination and met primary disinfection requirements as the free chlorine residual is 83% of the total chlorine residual (0.5 ÷ 0.6 x 100 = 83%)

- In the distribution system, you may have problems if you notice a significant drop in the free chlorine residual as a percentage of total chlorine residual as compared to the percentage found at the water treatment plant. If your free chlorine residual as a percentage of the total chlorine residual at the water treatment plant is 83% but out in the distribution system the percentage is only 50%, then there is something in the distribution system that is combining with or using up the free chlorine. It will be time to swab and flush the distribution system.

[11] Ministry of the Environment and Climate Change. 2016. *Procedure for Disinfection of Drinking Water in Ontario,*
July 29, 2016 at: https://www.ontario.ca/page/procedure-disinfection-drinking-water-ontario.

For water treatment plants that require chloramination after primary disinfection has been achieved, please follow the advice given in the GCDWQ. For use of chlorine dioxide or UV, please follow the GCDWQ.

Recommendation

We recommend that the highest level of available chlorine additions in a water treatment plant be kept below 3 mg/L. Breakpoint chlorination plus required contact time must be achieved.

It is also recommended that each water system determine the chlorine breakpoint curve for the filtered water for each season. This can be done with assistance of a circuit rider, if needed, by a jar test, or through a lab.

In contrast to Health Canada, we will only use total chlorine to confirm that the treated water is beyond breakpoint. It will strictly be used to ensure that free chlorine is always, at a minimum, 80% of total chlorine.

NOTE: If ammonium is present in the raw water, we recommend its level to be kept below 0.15 mg/L so as not to conflict with the disinfection process.

Sodium

There is no health-based GCDWQ for sodium, but Health Canada warns consumers to not drink sodium-softened water as the sodium levels are not safe for consumption. The province of Saskatchewan has a 300 mg/L objective for sodium and Health Canada has issued an aesthetic (i.e., taste) guidance number of 200 mg/L. The U.S. EPA has a stricter, albeit not federally enforceable, guideline for aesthetic effects set to between 30 mg/L to 60 mg/L of sodium.[12] When a direct RO uses sodium hydroxide to adjust the water's pH, it is estimated that an additional 50 mg/L of sodium is added.

The U.S. EPA has also issued a 20 mg/L guideline for those individuals restricted to a total sodium intake of 500 mg/day. Typically, it is also assumed that a person will drink at least 2 L of water per day. If using the Saskatchewan Guideline of 300 mg/L, a level that exceeds the sodium restricted diet can be consumed by simply drinking water. This is not good, as water is supposed to only supply 5%-10% of the daily sodium load.

Water that is high in sodium not only affects aesthetic appeal, and those individuals prone to hypertension, but also increases corrosion rates in both large and small appliances. These appliances (i.e., hot water heaters, washing machines, toilets, sinks, kettles) need continued maintenance and replacement, which is a waste of financial resources.

[12] Adherence to this guideline is dependent on local conditions (i.e., the ability to acquire alternate source waters), as long as public health is not affected negatively.

Recommendation

We will adopt the U.S. EPA guidance limit of 30 mg/L to 60 mg/L of sodium in treated water. However, the final guideline will be determined by the tasting panel upon piloting of the upgraded or new treatment system.

Chlorination By-Products

Trihalomethanes

When chlorine reacts with DOC and Bromide, a string of chlorination by-products are formed. Some, like the trihalomethanes group (THMs) and haloacetic acids (HAAs) are included among a myriad of organic chlorination by-products. Little is known about many of these by-products, so a prudent goal would be to decrease the DOC as much as possible, as without DOC there would be no organic chlorination by-products. Several of these chlorination by-products are carcinogens or suspected carcinogens.

Efforts should, therefore, be centered on the removal of DOC and decreasing the amount of chlorine that is added to the water, bearing in mind that the 0.2 mg/L free chlorine regulation anywhere in the piped distribution system must still be achieved. This will mean that a higher than 0.2 mg/L free chlorine residual needs to be maintained at the water treatment plant. Free chlorine residuals will decrease and THMs will increase as the water travels through the distribution system. Measurements of free residual chlorine and THMs should be taken at the point with the maximum retention time in the piped distribution system. One sample will be taken at the most remote point in the system, and one sample will be taken from the middle of the piped distribution system.

Health Canada attempted to decrease the guidelines for THMs to 0.02 mg/L several years ago, but the provincial and territorial representatives resisted the change and Health Canada put the THM guideline back to 0.1 mg/L. Health Canada, at that time, stated that there was no measurable health benefit to lowering the guideline to 0.05 mg/L. Going to THM levels below

0.05 mg/L will require the abandonment of filtration technologies as stand-alone processes, including manganese greensand and any other form of granular (sand, etc.) filtration. For most situations in which poor quality raw water sources are treated, there would be an additional requirement for membrane treatment.

The United States Environmental Protection Agency (U.S. EPA) maintains a 0.08 mg/L THM regulation, but stated more than a decade ago that it will decrease it to 0.03 mg/L. The U.S. EPA, most likely, also recognized the need for membranes when poor quality water sources are treated and opposed the lowering of the THM regulation.

Analyses of THMs and THM-surrogates

Routine determinations of the level of precursors, the DOC acting as a surrogate for THMs, could be determined at a fraction of the cost to determine THM levels, and more reliably. The level of DOC required to meet a 0.02 mg/L THM guideline will be less than 1.5 mg/L of DOC. This requirement, however, needs further study. There are technologies that can decrease DOC to below detection, which also means that the detection of THMs is below current analytical determinations. The lowering of THMs, HAAs, and the realization of the presence of many other chlorination by-products have forced water suppliers of large urban centers to start considering the use of nano- and RO membrane treatment technologies. This is likely the future for water treatment in general, but the costs for large cities are prohibitive. These cities also typically have high quality source waters giving them a “grace” period to implement better water treatment technologies. For communities treating poor quality source waters the application of better water treatment processes is imperative.

Recommendation

We recommend that the THM guideline be lowered to 0.02 mg/L. THMs need to only be measured once per year in September. However, precursors to THMs, the DOCs, should be routinely measured. Treated water from a groundwater source should be tested for DOCs every nine months, or as needed, and for a surface/GUDI water source every 3 months. We are adopting a maximum DOC level of 1.5 mg/L.

Adjustment of pH

The GCDWQ state that the pH level of distributed water should be between 7.0 and 10.5. Typically, most raw water sources fit within those pH levels. Granular filtration technologies (manganese greensand, sand filtration, etc.) do not alter the pH levels much through their filtration processes. Even membrane processes, such as micro-filtration and ultra-filtration have minimal impact on pH. However, when using nano- and RO membranes the pH levels will change. These two processes remove ions, including hydroxide and carbonate ions, leading to lowered pH levels. In addition, the inorganic carbon in carbonate ions is split into carbon dioxide (a gas) and water, further decreasing the pH as carbon dioxide drives pH lower. The nano-membranes may only marginally change the pH levels, but an RO membrane will drop the pH levels to between 5 and 6.

The two most desirable ions found in finished drinking water are calcium and magnesium, as they are the two hardness ions most beneficial to human health. Both nano- and RO membranes remove these hardness ions. Nano-membranes may create TDS levels between 200 mg/L and 400 mg/L, while RO membranes typically produce TDS levels below 30 mg/L (around ten times lower). The nano-membranes will also yield a pH level typically between 6 and 7 while the RO-membranes produce pH levels between 5 and 6. As a result, the pH adjustment requirement is lower for nano-membrane treated water. However, nano-membranes are not preferred as they yield a higher TDS level that is composed of ions detrimental to human health (i.e., sodium, chloride, etc.).

The WHO suggests a calcium level for nano or RO treated water of 30 mg/L and a magnesium level of 10 mg/L. With both nano- and RO membranes, it is necessary to add calcium and magnesium to the treated water to produce a healthy water.

Corrosion Control Concerns

The level of pH is intimately associated with control of the release of copper and lead from distribution and household plumbing. The GCDWQ guideline for copper is 1 mg/L. Copper levels would rarely reach this high level, even with water that may be slightly corrosive (leaching copper from pipes). However, lead is different. The current GCDWQ for lead is 0.01 mg/L and Health Canada is proposing that it should be dropped to 0.005 mg/L.

There are two ways corrosion control can be achieved in the water treatment plant: pH adjustment with sodium hydroxide (NaOH) plus a corrosion control inhibitor, or pH adjustment using calcium (and magnesium, although it is not necessary for corrosion control). Water that is pH adjusted with NaOH still needs to meet the sodium limits outlined in these standards.

Regulatory Concerns

Indigenous Services Canada (ISC) has previously approved pH adjustment of RO treated water strictly with NaOH and this has not changed. A better way to adjust pH may be to use calcium. The WHO has stated that it would like to see minimum levels of both calcium and magnesium for water produced by RO treatment plants. The target levels suggested by the WHO are 30 mg/L for calcium and 10 mg/L for magnesium. One way to achieve this is for the water to extract calcium and magnesium from a mineral bed. This approach does have a higher capital cost compared to NaOH. Under ISC's tender process, pH adjustment with calcium and magnesium will not likely happen (due to the low-cost bidding process) unless specifically stated in engineering specifications. Some engineering companies are not aware of the above.

Recommendation

To adjust pH, we recommend the use of a mineral contactor in which treated water can run through a calcium (and magnesium) bed. When considering human and infrastructure health, an ideal pH level would be 8.0.

Coagulation

In traditional, and even advanced, surface water treatment processes, coagulation is used to make the water suitable for further treatment. This consists of adding chemicals to the raw water that combine with particulate and dissolved organic compounds to form new, larger agglomerations of particles that can be filtered out either using conventional gravity (typically sand) filters or membrane technologies (micro- or ultra-filtration). The goal, when granular filtration is used, is to form a large, heavy floc, and this requires a longer time frame than forming a smaller "pin" floc. Membranes can remove pin flocs, but granular filters may have problems doing so. There have been many attempts to improve flocculation processes. The most successful improvement may have been when Veolia invented "ballasted" flocs (flocs that cling to sand grains and drop out of solution faster than traditional flocs). Veolia calls this process Actiflo.

There are some basic flaws with coagulation as a water treatment process. When trying to achieve low levels of DOC (1.0 mg/L-2.0 mg/L) and THMs (< 0.02 mg/L), as proposed in this document, coagulation will fail in most cases. Dissolved organics are defined here as DOC. DOC is composed of two types of organics, lipophilic (fat-loving) compounds and hydrophilic (water-loving) compounds. That means that one set of organics will dissolve in fats and one set will dissolve in water. The distribution of lipo- and hydro-philic compounds is typically equal. Coagulation chemicals can only react with and remove lipophilic compounds. Therefore, the most coagulation can achieve is a 50% removal of DOC. When

Saskatchewan municipal surface water reservoirs were studied, the average DOC level was above 10.0 mg/L. Coagulation of this water can only achieve a reduction to 5.0 mg/L of DOC. At that level, the current THM limit of 0.1 mg/L can barely be met.

Another coagulant problem is the generation of soluble dissolved inorganic residuals from the coagulant. The most common coagulant used in Saskatchewan is alum, which is an aluminum (Al) based compound.

Coagulants used in Saskatchewan

The most commonly used coagulants include aluminum and iron salts with some popular trade-chemicals including inorganic salts and polymers. A survey of operators indicated that alum is the number 1 coagulant used. Clearpac plus and Clearpac are the second- and third-most used coagulants. Communities with high levels of DOCs will require larger amounts of alum than communities with low levels of DOCs in their raw water.

One troubling chemical used in Saskatchewan is an organic polymer, polyacrylamide. It is always contaminated with acrylamide. The acrylamide monomer is said to only compose 0.05% of the weight of the polyacrylamide, but the science behind this assumption is not solid.

Acrylamide is a probable brain toxin and carcinogen and, while the concentration can be decreased by ozone, if the acrylamide is not there, it does not need to be decreased. Acrylamide is only allowed at 1 mg/L, but we believe it should simply not be used in First Nation water treatment.

Recommendation

1) It is recommended that the use of coagulation chemicals to address raw water challenges be limited to pre-treatment ahead of membranes. When aluminum-based

coagulants are used, the water needs to be tested for aluminium residuals; they need to be lower than 0.10 mg/L.

2) An organic polymer, polyacrylamide, used in coagulation treatment, should be banned outright as it is contaminated with a potential carcinogen, acrylamide.

Antiscalants

Antiscalants are chemicals used in nanofiltration systems and in reverse osmosis systems to inhibit the formation of crystallized mineral salts that build to form scale. Products in the antiscalant family are usually made of human-made polymers (e.g., carboxylic acids, polyacrylic acids, organophosphates, polymaleic acids, phosphonates, polyphosphates, anionic polymers, etc.).

Antiscalant products must be used with caution.

Recommendation

Dosage rates are calculated from feed water analysis and flow rate. The least amount of antiscalant necessary to reduce scaling should be used. The treatment systems manufacturers' instructions should be used when using antiscalant products. If there is no National Sanitation Foundation (NSF) value stated, operators should set antiscalant maximums to 5 mg/L, otherwise most NSF values are about 6 mg/L.

Pesticides

Pesticides in drinking water are good examples of how lobby groups can influence regulators, for better or worse. In Europe, environmental groups are much stronger than they are in North America. This has resulted in Europe not accepting drinking water tainted by pesticides. In contrast, North American regulators are heavily influenced by large chemical companies with clout in Washington and in Ottawa. This leads regulators to invent quasi-scientific excuses to allow large amounts of pesticides in drinking water. *(Note – one of the authors of this document was hired by the United States Office of Pesticides, Washington D.C. to help them sort out problems with pesticides and generate solid data that both environmental groups and the pesticide industry could not pick apart)*.

Canadian Guidelines

In Canada, in 1987, 42 pesticides were selected for the development of guidelines for drinking water. The 42 pesticides represented about 80% of all agricultural pesticides used in Canada, based on active ingredient weight sold. The Government of Canada has used one approach to derive health-based guidelines or MAC of pesticides in drinking water, that of the threshold approach. This approach assumes that there is a dose below which no adverse effect will occur.

This threshold level is closely related to the experimentally determined "no observed adverse effect level" and, when divided by an appropriate uncertainty or safety factor, forms the basis for the establishment of the MAC.

There is another approach, the non-threshold or risk assessment approach, which assumes that there is some probability of harm at any level of exposure.[13] This latter approach is generally used for chemicals believed to be capable of causing cancer. But this approach has not yet been used for any of the existing 11 pesticide-related drinking water guidelines developed in Canada[14].

Another key problem with Health Canada's approach is that they look at one pesticide at a time and never consider the presence of several pesticides at the same time. Synergy between pesticides invalidates Health Canada's approach. This approach is also overly reliant on the ability to determine no-effect levels.

In February 2020, Health Canada initially proposed the removal of 14 pesticides from the GCDWQ.[15] Subsequently, by January 2022, 13 of these pesticides were removed.[16] In the most recent edition of the GCDWQ, published in September 2022, Health Canada indicates that it has introduced a science-based approach for reviewing older guidelines. Within this edition, they include a table that lists all the chemical substances, including 33 pesticides, that have been removed from the GCDWQ because they are "no longer found in Canadian drinking water supplies at levels that could pose a risk to human health."[14] However, as we pointed out in the previous paragraph, Health Canada's approach is unreliable, as it involves individual testing of these pesticides rather than assessing their collective effects. Further, the chemical industry is constantly changing and Health Canada will always play "catch-up" to determine which pesticides are detrimental to human health.

European Union Regulations (EU)

The EU does not establish specific guidelines for individual pesticides, but instead, uses a generic guideline of 0.0001 mg/L MAC for an individual pesticide, ten times or more below all of the GCDWQ for acceptable concentrations of pesticides in drinking water. The EU also sets an overall limit of 0.0005 mg/L for the total amount of all pesticides that can be in drinking water. This approach recognizes that cumulative exposure to a number of different pesticides, each of which is below the individual level of concern,

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[13] Ritter, L. & Wood, G. 2009. *Evaluation and regulation of pesticides in drinking water: A Canadian approach*. https://www.tandfonline.com/doi/abs/10.1080/02652038909373762?journalCode=tfac19&

[14] Health Canada. (2023, February 8). *Guidelines for Canadian Drinking Water Quality - Summary Tables*. Canada.ca. https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality /guidelines-canadian-drinking-water-quality-summary-table.html

15 Health Canada. (2020, February 21). *Withdrawal of select guidelines for Canadian drinking water quality*. Canada.ca. https://www.canada.ca/en/health-canada/programs/consultation-withdrawl-guidelines-drinking-water/document.html

[16] Health Canada. (2022, January 28). *Withdrawal of select guidelines for Canadian drinking water quality*. Canada.ca. https://www.canada.ca/en/health-canada/services/publications/healthy-living/withdrawal-select-guidelines-canadian- drinking-water-quality.html

may cause negative health effects.[17] Canada does not have any comparable limit, meaning that Canadians can be exposed to combinations of various pesticides in drinking water at levels that would be unlawful in Europe. In the past, Canada established a guideline for the MAC of total pesticides in drinking water, but it was discontinued.[18] If one were to add up the 24 current guidelines for pesticides in the Guidelines for Canadian Drinking Water Quality, the sum would be 1.754 mg/L, or 3,000 times higher than that allowed in Europe.

It is not only Europe that is ahead of Canada in establishing more conservative MACs for chemical contaminants. For example, for the pesticide 2,4-D, Canada's guideline is 1,000 times higher than Australia's guideline. In other words, Canadians may be exposed to up to 1,000 times the concentration of 2,4-D in their drinking water without raising alarm bells with the relevant authorities. For glyphosate, the most heavily applied pesticide in Ontario (and the world), Australia's guideline is 28 times as strict as the corresponding Canadian guideline.[19]

Seasonal presence of pesticides in raw water sources is hard to determine, as are sampling requirements. We need knowledge of the risk factors involved in any farm drainage that might reach a source of drinking water, including which pesticides are used in a particular drainage basin and when they are used. Testing for pesticides that are not used in the drainage basin is not helpful in protecting communities from pesticide exposure. As with many other contaminants, the best approach may be to use a water treatment technology that will remove whatever contaminants may be present.

Recommendation

We recommend that the European regulations be followed. Therefore, the highest acceptable level of an individual pesticide in tap water is 0.0001 mg/L and the highest acceptable level of combinations of pesticides is 0.0005 mg/L.

Pharmaceuticals

Pharmaceuticals are natural or synthetic chemicals found in veterinary drugs, over-the-counter therapeutic drugs, and prescription drugs. A recent study carried out in Saskatchewan First Nations[20] on surface water bodies indicate the presence of multiple pharmaceuticals including:

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[17] David Suzuki Foundation. 2006. *The Water We Drink: An International Comparison of Drinking Water Standards and Guidelines*. https://davidsuzuki.org/science-learning-centre-article/the-water-we-drink-an-international-comparison-of-drinking- water-standards-and-guidelines/

[18] Government of Canada. 2023. *Guidelines for Canadian Drinking Water Quality: Summary Tables*. https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality /guidelines-canadian-drinking-water-quality-summary-table.html

[19] Ontario Ministry of Agriculture and Food. 2004. Survey of Pesticide Use in Ontario, 2003.
[20] Chan, L., Receveur, O., Batal, M., Sadik, T., Schwartz, H., Ing, A., Fediuk, K., and Tikhonoz, C. (2018). *First Nations Food, Nutrition and Environment Study (FNFNES): Results from Saskatchewan (2015)*. Ottawa: University of Ottawa.

- Analgesic/Anti-inflammatory: Acetaminophen, Ketoprofen
- Antibiotic: Clarithromycin, Sulfamethoxazole, Trimethoprim
- Antacid: Cimetidine
- Antidiabetic: Metformin
- Antihypertensive (Beta-blocker): Atenolol, Metoprolol
- Anticonvulsant: Carbamazepine
- Analgesic: Codeine
- Lipid Regulator: Clofibric Acid, Gemifibrozil
- Stimulant: Caffeine
- Metabolite of nicotine: Cotinine
- Other: Naproxen, Bezafibrate

The levels of these pharmaceuticals do not exceed, and are far below, the Australian Guidelines for Water Recycling[21] and the California Monitoring Trigger Level[22]. Adverse impacts to human health related to acute exposure are very unlikely, as exposure is limited to trace amounts.[23] However, the cumulative effects of long-term consumption of trace amounts are not known at this time. The human health effects of the combination of various pharmaceuticals are also not known. Further, it is very difficult to predict the seasonal behaviour of pharmaceuticals in water sources. Dependence on pharmaceuticals, particularly for populations experiencing a disproportionate level of ill-health compared to that of the typical Canadian population, will not likely decrease in the near future and, therefore, levels of pharmaceuticals in surface water will likely increase over time, as they have in more populated areas of Canada and the world.[24]

Currently, pharmaceuticals and hormone-disrupting agents are not tested for in drinking water in Canada. A preventative approach will be more effective (i.e., proper disposal so pharmaceuticals do not make it into the water system) than subsequent treatment. Further study on source waters in First Nations needs to be carried out, particularly for those First Nations that draw raw water for treatment from surface water sources.

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[21] Australian guidelines for Water Recycling. (2008). *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Augmentation of Drinking Water Supplies*. Canberra: Environment Protection and Heritage Council, the National Health and Medical Research Council and the Natural Resource Management Ministerial Council.
[22] Drewes, J.E., Anderson, P., Denslow, N., Jakubowski, W., Olivieri, A., Schlenk, D., and Snyder, S. 2018. *Monitoring Strategies for Constituents of Emerging Concern (CECs) in Recycled Water. Recommendations of a Science Advisory Panel Convened by the State Water Resources Control Board*. Southern California Coastal Water Research Project (SCCWRP) Technical Report 1032.

https://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1032_CECMonitoringInRecycledWater.pdf [23] World Health Organization. (2011). *Pharmaceuticals in Drinking-Water: Public Health and Environment, Water, Sanitation, Hygiene and Health*. WHO Press: Geneva 27, Switzerland.
[24] Ibid.

Recommendation

Further research is necessary to determine harmful levels of exposure through drinking water sources. Sampling from both raw and treated waters on the aforementioned pharmaceuticals, and potentially more, is recommended.

The sampling results will be used to determine treatment options for new and upgraded treatment plants. Those treatment plants that target the removal of pesticides will have an increased likelihood of also removing pharmaceuticals.

Radon

Radon is not currently included in water quality testing. Further research is required to determine harmful levels of exposure through drinking water sources.

Recommendation

Radon will be added to baseline water quality tests for monitoring purposes.

Water Treatment Technologies

Background and Rationale

In this report, we have outlined what we feel is necessary to produce water that is safe, healthy, and that tastes and smells good, from ground and surface water sources that can be of extremely poor quality. We do not know all of the particular inorganic and organic compounds present in poor quality source waters as the testing is limited to a suite of commonly accepted parameters. When the goal is to achieve high quality tap water, meeting standards or regulations is only one step within the approach to treating poor quality source water. All of the potential contaminants within source waters, and their potential health impacts, are not known and, therefore, it is best to adopt a precautionary approach to treatment (i.e., limiting DOCs, limiting pesticides) within a multi-system approach.[25] Similarly, when chlorine is added to water many chlorinated organic compounds are formed; many of these compounds have not been evaluated for possible health impacts. We do not believe any of the above is acceptable and have set out regulations to limit both known and unknown compounds in the provision of tap water to Saskatchewan First Nation communities.

Our stance has implications for how water needs to be treated. Granular filtration technologies have been used in the treatment of raw water sources for more than 100 years and are still being used on high quality water treated by Canada's cities. These technologies, however, will not produce acceptable quality treated water if used as stand-alone processes on poor quality source waters. Granular filtration technologies can be refined using various

[25] Source water protection is a key component of a multi-system approach to healthy drinking water.

techniques as long as no toxic or carcinogenic compound (like acrylamide) is added to the filters. No bacteria or other microbes must be added to the filters even if this is for purposes of "seeding." Performance enhancements must not have harmful effects on either the water consumers or the operators.

It is necessary to add membrane technologies to the aforementioned granular filtration technologies or use alternative strategies that do not rely on granular filtration. To be acceptable, the water quality must meet these new standards, as well as operational considerations. We also need an extended warranty period of four years from the engineering companies. The agreement will also include all chemicals required for the treatment process for this 4-year warranty period. These chemical costs will be included in the initial calculations for the project.

The company will also have to present reliable annual operating costs of the proposed system, including all power, chemicals, labour, membrane and filter replacements, etc. The company needs to explain what the daily, weekly, monthly and yearly tasks of the operators look like. If the operator needs to troubleshoot his plant does the company provide support for the operator? Is this support onsite or remote? What are the expected costs for an hour of remote support and one onsite visit (2 hours onsite)? Remote monitoring needs to be included in the water treatment package and enhanced remote monitoring such as supervisory control and data acquisition (SCADA) is encouraged.

Operational Considerations

It is possible to utilize a tight RO membrane for treatment of the poorest quality water source imaginable and produce water that meets our standards. This, however, is not sustainable, as the membranes will not be protected. ISC has recorded many 'catastrophic' membrane failures and have come to the conclusion that pre-treatment ahead of membranes is essential. The RO membrane can be considered to have holes that are 30,000 times smaller than the width of a human hair and plugging and fouling are major challenges that may, over time, compromise the treated water quality and the rate of pure water production. It is, therefore, essential that an engineering company or manufacturer explain how their suggested treatment process works and then prove that this can be shown at real water treatment plants over the course of time. Piloting periods will be determined on a case by case basis, however it is strongly encouraged that water treatment plants with groundwater as their source have a pilot period of at least six months, and that water treatment plants with surface water/GUDI as their source have a pilot period of at least 12 months (all seasons throughout the year). A pilot period of three months is insufficient. As a result, more emphasis will be placed on information from existing treatment plants that are using the suggested technology.

Two examples of pre-treatment technologies utilized ahead of membranes that are often applied to First Nations water are coagulation followed by granular filtration and ultra-filtration or gravity filtration ahead of nano- or RO membranes; and the use of biological filtration prior to membranes. The requested determinations must be carried out by the Authority Having Jurisdiction. Apart from operational data outlined below, final treated water quality data is also required. The name and contact information of water systems operators at treatment plants that are using the suggested technology is also required.

Coagulation

The objective of using this technology is to decrease the number of particles (turbidity measured with NTUs) and the level of DOC. After coagulation, some form of filtration is required ahead of nano- or RO membranes. A minimum requirement will be to report on raw water NTUs and treated water NTUs, raw water DOC, treated water DOC, and the concentration of coagulation residuals in the treated water.

Biological Filtration

The objective with biological filtration is to decrease nutrient and energy sources that can support microbial growth. Minimum reporting requirements include raw water and treated water determinations of iron and ammonium.

Other Technologies

Protocols will be developed by the Authority Having Jurisdiction for other technologies. Proposals for the use of such technologies, with explanations of how the technologies work, should be made to the Authority Having Jurisdiction for approval. ISC has determined that nano- and RO membranes need to be preceded by appropriate pre-treatment, making direct RO unacceptable for use in First Nations communities.

Complete Tables of Standards for use in SK First Nations

Acronyms	Meaning
A	acceptability
ALACTA	as low as current technology allows
ALARA	as low as reasonably achievable
AO	aesthetic objective
D	disinfectant
DBP	disinfectant by-product
HPC	heterotrophic plate count
I	inorganic chemical
MAC	maximum acceptable concentration
NTU	nephelometric turbidity units
O	organic chemical
OG	operational guidance value
T	treatment-related
TCU	true colour units

Chemical Parameters	Type[1]	DWQS (mg/L unless stated otherwise)	GCDWQ (mg/L unless stated otherwise) [Values are MAC unless otherwise stated]
Aluminum	T		MAC: 2.9; OG: 0.1
Ammonium	I	less than 0.15	None
Antimony	I		0.006
Arsenic	I	0.0003 or less	0.01 ALARA
Asbestos	I		None
Atrazine	P		0.005
Barium	I		2.0
Benzene	O		0.005

Benzo[*a*]pyrene	O		0.00004
Boron	I		5
Bromate	DBP		0.01
Bromoxynil	P		0.03
Cadmium	I		0.007
Calcium	I		None required - no evidence of adverse health effects; calcium contributes to hardness
Carbon tetrachloride	O		0.002
Chloramines	D	Use is discouraged	None (3 in the Protocol for Centralised Drinking Water Systems in First Nations Communities)
Chlorate	DBP		1
Chloride	I		AO: ≤ 250
Chlorine - free chlorine minimum (for distribution)	D	0.2 (0.2 in the Protocol for Centralised Drinking Water Systems in First Nations Communities)	(0.2 in the Protocol for Centralised Drinking Water Systems in First Nations Communities)
Chlorine - maximum added	D	3.0 or less	
Chlorine dioxide	D		None required - a maximum feed dose of 1.2 should not be exceeded to control the formation of chlorite and chlorate.
Chlorite	DBP		1
Chlorpyrifos	P		0.09
Chromium	I		0.05
Coagulants	T	Limited to pre-treatment prior to membrane filtration; aluminum residuals lower than 0.1; no use of polyacrylamides	
Colour	T		AO: ≤ 15 TCU
Copper	I	1.0 (see Taste and Odour)	AO: 1
Cyanide	I		0.2
Cyanobacterial toxins - Microcystin-LR	O		0.0015

Dicamba	P		0.11
1,4-Dichlorobenzene[2]	O	see Taste and Odour	0.005; AO: ≤ 0.001
1,2-Dichloroethane	O		0.005
1,1-Dichloroethylene	O		0.014
Dichloromethane	O		0.05
2,4-Dichlorophenoxy acetic acid (2,4-D)	P		0.1
Dimethoate and omethoate	P		0.02
1,4-Dioxane	I		0.05
Diquat	P		0.05
Dissolved Organic Carbon (DOC)	T	less than 1.5	
Ethylbenzene	O		0.14; AO: 0.0016
Fluoride	I		1.5
Formaldehyde	DBP		None required - levels in drinking water are below the level at which adverse health effects may occur.
Glyphosate	P		0.28
Haloacetic acids - Total (HAAs)	DBP	see Dissolved Organic Carbon (DOC)	0.08 ALARA
Hardness	T		None required - levels between 80 and 100 mg/L (as $CaCO_3$) provide acceptable balance between corrosion and incrustation
Iron	I	0.05 or less	AO: ≤ 0.3
Lead	I	0.005 or less	0.005 ALARA
Magnesium	I		None required - no evidence of adverse health effects from magnesium in drinking water.
Malathion	P		0.19
Manganese	I	0.02 or less	0.12; AO: ≤ 0.02
Mercury	I		0.001
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	P		0.35
Methyl tertiary-butyl ether (MTBE)	O		AO: ≤ 0.015

Metribuzin	P		0.08
Nitrate	I		45 as nitrate; 10 as nitrate-nitrogen
Nitrilotriacetic acid (NTA)	I		0.4
Nitrite	I		3 as nitrite; 1 as nitrite-nitrogen
N-Nitroso dimethylamine (NDMA)	DBP		0.00004
Odour	A	Taste Panel approval for all aesthetic objectives (AO)	AO: Inoffensive
Pentachlorophenol	O		0.06; AO: ≤ 0.03
Perfluorooctane Sulfonate (PFOS)	O		0.0006
Perfluorooactanoic Acid (PFOA)	O		0.0002
Pesticides[3]	O		
Combination		0.0005	
Individual		0.0001	
pH[4]	T	7.0-9.0	7.0-10.5
Pharmaceuticals	O	TBD	
Selenium	I		0.05
Silver	I		None required - drinking water contributes negligibly to an individual's daily intake.
Sodium	I	30 to 60 - final level determined by Taste Panel	AO: ≤ 200
Strontium	I		7.0
Sulphate	I		AO: ≤ 500
Sulphide	I		AO: ≤ 0.05
Taste		Taste Panel approval for all aesthetic objectives (AO)	AO: Inoffensive
Tetrachloroethylene	O		0.01
Toluene	O		0.06; AO: ≤ 0.024
Total Dissolved Solids (TDS)	A	500 or less	AO: ≤ 500
Trichloroethylene	O		0.005
2,4,6-Trichlorophenol	O		0.005; AO: ≤ 0.002

Trihalomethanes (THMs)	DBP	0.02	0.1
Turbidity		0.1 NTU or 0.2 NTU ALACTA	Treatment limits for individual filters or units: • Conventional and direct filtration: ≤ 0.3 NTU (in at least 95% of measurements either per filter cycle or per month; never to exceed 1.0 NTU) • slow sand and diatomaceous earth filtration: ≤ 1.0 NTU (in at least 95% of measurements either per filter cycle or per month; never to exceed 3.0 NTU) • membrane filtration: ≤ 0.1 NTU (in at least 99% of measurements per operational filter period or per month. Measurements greater than 0.1 NTU for a period greater than 15 minutes from an individual membrane unit should immediately trigger an investigation of the membrane unit integrity.)
Uranium	I		0.02
Vinyl chloride	O		0.002 ALARA
Xylenes (total)	O		0.09; AO: 0.02
Zinc	I		AO: ≤ 5.0

[1] The DWQSs do not differentiate between Aesthetic Objectives (AO) and Maximum Acceptable Concentrations (MACs) as they are both related to, and therefore impact, health.

[2] In cases where total dichlorobenzenes are measured and concentrations exceed the most stringent value (0.005 mg/L), the concentrations of the individual isomers should be established.

[3] This category includes ALL pesticides used in the Saskatchewan region including those listed in the Canadian Drinking Water Quality Guidelines (Atrazine, Azinphos-methyl, Bromoxynil, Carbaryl, Carbofuran, Chlorpyrifos, Diazinon, Dicamba, 2,4-Dichlorophenoxy, Diclofop-methyl, Dimethoate, Diquat, Diuron, Glyphosate, Malathion, 2-Methyl-4-chlorophenoxyacetic acid (MCPA), Metolachlor, Metribuzin, Paraquat, Phorate, Picloram, Simazine, Terbufos, Trifluralin)

[4] No units

Radiological Parameters	DWQS	GCDWQ (Bq/L)
Cesium-137		10
Iodine-131		6
Lead-210		0.2
Radium-226		0.5
Radon	added to baseline for monitoring	None
Strontium-90		5
Tritium		7000
Uranium		N/A (MAC based on chemical properties)

Guidance Documents	GCDWQ Comments
Chloral hydrate in drinking water (2008)	Exposure levels in Canada far below concentration that would cause health effects; levels above 0.2 mg/L may indicate a concern for health effects and should be investigated.
Controlling corrosion in drinking water distribution systems (2009)	Addresses strategies to deal with leaching of lead from materials in the distribution system; sampling protocols can be used to assess corrosion and the effectiveness of remediation/control measures to reduce lead levels in drinking water; corrective measures are outlined to address lead sources.
Heterotrophic plate count (HPC) (2013)	A useful operational tool for monitoring general bacteriological water quality through the treatment process and in the distribution system. HPC results are not an indicator of water safety and should not be used as an indicator of potential adverse human health effects.
Issuing and rescinding boil water advisories in Canadian drinking water supplies (2015)	Summarizes factors for consideration when responsible authorities issue or rescind boil water advisories. Provides trend information on reasons boil water advisories are issued in Canada.
Issuing and rescinding drinking water avoidance advisories in emergency situations (2009)	Summarizes factors for consideration when responsible authorities issue or rescind drinking water avoidance advisories in emergency situations.
Potassium from water softeners (2008)	Not a concern for the general population; those with kidney disease or other conditions, such as heart disease, coronary artery disease, hypertension or diabetes, and those who are taking medications that interfere with normal body potassium handling should avoid the consumption of water treated by water softeners using potassium chloride.

Use of the microbiological drinking water guidelines (2013)	Provides an overview of the microbiological considerations to ensure drinking water quality, integrating key content of the relevant guideline technical documents and guidance documents to illustrate how they fit into the multi-barrier approach.
Waterborne bacterial pathogens (2013)	Originate from human or animal feces or may be naturally occurring in the environment. Commonly associated with gastrointestinal upset (nausea, vomiting, diarrhea); some pathogens may infect wounds, lungs, skin, eyes, central nervous system or the liver. Document provides information on these pathogens and treatment options, and recommends using the multi-barrier approach to reduce their levels.

Groundwater

WSO:

• Bacteriological: at least one raw water sample per week per well

• Turbidity: 1 raw sample per

month EHO:

• Chemical analysis: every 9 months on each well

• DOCs: every 9 months or as

needed Other:

• Baseline: For new water sources, every six months until a trend is established and then every 5 years, or as needed if concerns

o Pesticide testing included in baseline or as needed, if concerns.

o Radon has been added to baseline testing for monitoring purposes and consideration in treatment

options Surface Water or GUDI

WSO:

• Bacteriological: at least 1 raw sample per week
• Turbidity: 1 raw water sample per

month EHO:

• Chemical analysis: every 9 months

• DOCs: every 3

months Other:

• Baseline: For new water sources, every six months until a trend is established and then every 5 years, or as needed if concerns

o Pesticide testing included in baseline or as needed, if concerns

o Radon has been added to baseline testing for monitoring purposes and consideration in treatment options.

Appendix E: Comprehensive Monitoring Schedule

KEY:

WTP: Water Treatment Plant

GUDI: Groundwater Under Direct Influence (of surface water)
DOCs: Dissolved Organic Carbons

OAN: Or As Needed
THMs: Trihalomethanes

	Raw Groundwater	Raw Surface/GUDI Water	WTP Treated Groundwater	WTP Treated Surface/GUDI Water	Piped Distribution	Trucked Water Delivery	Cistern	Decentralized Well	Decentralized Surface/GUDI source
Water System Operator (WSO)	Bacteriological: at least 1/week/well Turbidity: 1/mo	Bacteriological: at least 1/week Turbidity: 1/mo	Total chlorine: 1/day Free chlorine: cont online OR at least 1/day Bacteriological: 1/wk Turbidity: Online AND 1/day	Total chlorine: 1/day Free chlorine: cont online OR at least 1/day Bacteriological: 1/wk Turbidity: Online AND 1/day	2 representative samples (middle and remote locations)/wk for bacteriological, chlorine residuals, and turbidity.				
Community-Based Water Monitor (CBWM)/ Water Quality Technician (WQT)					<75 homes: 3 representative samples (WTP, mid point, end point)/wk >75 homes: 5 representative samples (WTP, 2 mid point, 2 end point)/wk		Bacteriological: 1 every 3 months (by WQT/CBWM or EHO)	Bacteriological: 1 every 6 mos OAN Chemical analysis: every 2 yrs in fall OAN (by WQT/CBWM or EHO)	Bacteriological: 1 every 6 mos OAN Chemical analysis: every 2 yrs in fall OAN (by WQT/CBWM or EHO)
Environmental Health Officer (EHO)	Chemical analysis: every 9 mos/well DOCs: 1 every 9 mos OAN	Chemical analysis: every 9 mos DOCs: 1 every 3 mos	Chemical analysis: every 9 mos DOCs: 1 every 9 mos OAN THMs: 1/yr in Sept	Chemical analysis: every yr DOCs: 1 every 3 mos THMs: 1 every 3 mos			Bacteriological: 1 every 3 months (by WQT/CBWM or EHO)	Bacteriological: 1 every 6 mos OAN Chemical analysis: every 2 yrs in fall OAN (by WQT/CBWM or EHO)	Bacteriological: 1 every 6 mos OAN Chemical analysis: every 2 yrs in fall OAN (by WQT/CBWM or EHO)
Water Delivery Driver						Free chlorine: 1 every delivery day at time of first delivery Bacteriological: 1 every month from tank fill and delivery hoses			
Other	Baseline: every 5 yrs OAN *New water source: every 6 mos/well until trend established	Baseline: every 5 yrs OAN *New water source: every 6 mos/well until trend established	Baseline: every 5 yrs OAN *New water source: every 6 mos/well until trend established	Baseline: every 5 yrs OAN *New water source: every 6 mos/well until trend established				Baseline: 1 every 5 yrs OAN *New water source: every 6 mos/well until trend established	Baseline: 1 every 5 yrs OAN *New water source: every 6 mos/well until trend established

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