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Research Article

Investigating Standards for Small Water and Wastewater Systems in Northern Canada

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Abstract: Research investigating the potential of standards for the build, operation, and maintenance phases of small water and wastewater systems in the Canadian North was conducted to identify opportunities for standards to help ensure safe, accessible, and high-quality drinking water and sanitation for all northerners. This involved a review of literature, a survey of northern water system users and practitioners, and key informant interviews. The study highlights a general trend of low adaptation to local conditions for standardization documents on many technical topics in northern Canada. A number of major themes and corresponding recommendations are subsequently drawn with respect to potential for standardization efforts. Of these, training and certification/classification were identified as a key area that has many gaps, challenges, and potential opportunities with respect to the use of standardized procedures for small-scale water and wastewater systems. Subsequently, this is also identified as the area where standardization efforts may have the broadest social benefit, urgency, as well as potential feasibility.

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1. Introduction

1.1 General

This article builds upon a comprehensive review of opportunities for standards to contribute to health, safety, resilience, and environmental protection in northern Canada (Steenhof 2018) by focusing on access to clean and safe drinking water and sanitation, and also considering the complementary roles of training and certification for this topic area.

While significant investments have been made in water and wastewater infrastructure in the North, water systems across the region[1] have received poor grades in recent years and are generally still below the Canadian average—especially in Indigenous communities and for systems servicing smaller communities and population centres (Ecojustice 2011; Government of Canada 2011; Human Rights Watch 2016). As communicated to the authors in this research, northerners also expressed concerns about the quality of wastewater treatment effluents and the risk of leakage from failing infrastructure.

As such, in this article we focus on needs specific to small-scale water and wastewater systems servicing 500 people or fewer. Based on a review of publicly available information, there are about 500 such systems in Canada's North (and thus an upper limit of 25,000 people in terms of the potentially affected population). This includes publicly owned small systems as well as systems serving the general public that are owned and operated by private interests.

1.2 Objectives and Intended Audience

Three broad objectives motivated the research:

- to provide an assessment of the situation regarding standardization of small water/wastewater systems in Canada's North, with an overview of standardization documents and their usage;
- to examine gaps and challenges with these systems, and;
- to provide recommendations on where standardization efforts would best be invested and in what form, particularly in terms of how standardization documents can be effectively used.

This article should be of interest to regulators, educators, operators, and related service providers involved with small-scale water and wastewater systems not only in northern Canada, but more broadly.

2. Methodology

2.1 Literature Review

Preliminary information was gathered through a literature review, with an emphasis on identifying gaps and challenges as well as which standardization documents are used or of relevance. The main sources of information were public authorities' websites, which were thoroughly examined and cross-referenced.

2.2 Engagement Exercise

Following the literature review, an engagement exercise was conducted to survey and then interview water/wastewater stakeholders active throughout Canada's North. This first involved building a contact list of such stakeholders. A survey was sent to the entire contact list and then key informants were interviewed. A special effort was made to reach out to and engage with small-scale water and wastewater operators and stakeholders who self-declared Indigenous identity.

2.2.1 Survey

The survey developed and employed for this project was meant to:

- reveal current practices related to small water/wastewater systems in Canada's North;
- generate feedback on gaps and challenges that had already been identified in order to determine their relative importance;
- identify any standardization document that would not have been rendered by the literature review, with a broader objective of helping identify the typical usage of such documents, and;
- identify where/how standardization could further play a role.

The specific questions in the survey were informed by the literature review process. The survey was disseminated through email, and fifty-three recipients responded. Approximately half of the respondents (twenty-five individuals) declared that they represented or belonged to a small community in northern Canada (with an average population size of 388 people). The Yukon was most represented, with 66% of the respondents (thirty-five individuals). Twelve respondents came from the Northwest Territories (NWT), leaving approximately 12% to the other jurisdictions, including three individuals from Northern British Columbia. Twelve respondents declared an Indigenous identity. It is important to note that the respondents provided significant supplemental information via general comments through this survey.

2.2.2 Key Informant Interviews

Targeted key informant interviews were then conducted to drill down in the information obtained from the survey and to further inform the recommendations. Specifically, these interviews were meant to help further inform how standardization documents are used in the interviewees' respective territorial/provincial jurisdictions and communities, and to collect their perspective on gaps and challenges with small water/wastewater systems in the North. The interviewees were asked to share any success stories and point out any specific concerns about any aspects of the water/wastewater system. The interviews provided quality feedback and information, complemented by generous supplementary comments from the survey.

3. Current Situation with Small-Scale Water and Wastewater Systems in the Canadian North

The following provides an overview of the current situation regarding small-scale water/wastewater systems in northern Canada, as informed by the review of literature, the survey, and key informant interviews. Specific details are provided for the various components of the water/wastewater system (e.g., from water sourcing to distribution, to water and wastewater testing, certification, and so on).

The material in section 3 provides the basis for understanding and identifying possible needs and opportunities for standardization of water/wastewater systems, as detailed in sections 4 and 5.

3.1 Water Sourcing

Water sourcing varies with the availability and quality of source water. For example, the Yukon generally has favourable geological characteristics that provide an abundance of groundwater that can be easily treated. These conditions consistently produce quality drinking water. Other northern regions need to rely on surface water bodies (e.g., lakes and rivers) and groundwater that, generally, have higher organic content. This poses a specific challenge for disinfection and chlorination. These sources are also prone to seasonal fluctuation, such as high turbidity in the spring.

Where groundwater is suspected of potentially being under the direct influence of surface water, legislation typically prescribes the use of a specific standardized assessment method. For instance, the Yukon requires the use of an in-house method (Yukon Government 2006), while Nunavik (Government of Quebec 2001) prescribes another method (i.e., the DRASTIC method; United States Environmental Protection Agency 1985).

It is also important to note that collecting water from the land, rather than using treated tap water, is preferred by many people across northern Canada. For example, Martin et al. (2007) found that 29% of Nunavik residents drank untreated raw water from the land. A number of reasons contributed to this, such as a dislike for the taste of chlorinated water or that "harvest water" is often viewed as an ancestral practice by many. Moreover, as heard through this research, many have built a distrust for drinking delivered water—with this sometimes associated with the perceived risk of gastrointestinal issues.

3.2 Water Distribution and Wastewater Collection

Small water systems in northern Canada often involve trucks delivering drinking water to residences (i.e., bulk water delivery). The same is true for wastewater collection. While the operating costs of bulk systems are high due to higher human resource requirements and truck operation costs, there is also a lower investment in construction and maintenance, often making it the most economical solution in the local conditions.

When there is piping, it is sometimes buried (e.g., Rankin Inlet/Kangiqtiniq), but above-ground conduits ("utilidors") also exist. Such utilidor systems are typically restricted to larger communities (e.g., Inuvik, Norman Wells/Tłegǫ̀hłı, Iqaluit, Kuujuarapik, Whapmagoostui), but a notable exception to this is Resolute Bay/Qausuittuq.

3.3 Water and Wastewater Treatment

Small water systems across the Canadian North use a variety of treatment processes. The design of each system and related treatment approach is based on such criteria as raw water quality, location, required water volume, preference of consumers, and legal requirements. Many small systems use a treatment train, starting with basic particle filtration, possibly followed by a variety of techniques targeting specific water constituents (e.g., ion exchange, activated carbon, ultraviolet/chlorination/ozone).

Where a regulation applies, one common requirement for small water systems in the North is that supplied water must undergo a continuous filtration and disinfection treatment if it comes from surface water, or from groundwater the microbiological quality of which is likely to be affected by surface water. The requirement sometimes extends to all types of raw water. Such primary disinfection is required before and during the distribution, and secondary chlorination treatment is also typically required to keep a minimum chlorine residual throughout the distribution system.[2] In exceptional circumstances, regulations will allow disinfection at point-of-use, foregoing primary and secondary chlorine treatment.

A few communities in the Northwest Territories and Nunavik use fluoridation. No water system serving the general public in the Yukon uses fluoridation.

The majority of small communities in northern Canada rely on passive systems for wastewater treatment, such as stabilization ponds, lagoons, and treatment wetlands, and, for the smallest of systems, sometimes a septic field. It is interesting to note that treatment wetlands, and especially wetland treatment areas, seem to be popular in certain regions of the North, especially NWT and Nunavut. Possible reasons include fewer operational requirements, they are easier to implement, and they have proven to be effective in the local conditions.

3.4 Operation and Servicing, Maintenance, and Repair

While the jurisdictions in the Canadian North have strict enforceable legislation that establishes requirements for the operation and maintenance (O&M) of water and wastewater systems, these largely apply to larger systems. Legal O&M requirements for small systems, rather, tend to be case specific (e.g., through water licensing), and in some cases, nil. For example, not all small systems have legal reporting requirements. The legal requirements are supplemented by case-specific operational and maintenance manuals such as Standard Operating Procedures (SOPs). Where standards and best practices exist for O&M, the manuals often refer to them in the same way legislation does. While there are a multitude of best practices, guidance documents, and similar standardization documents for this subject, few technical standards that would be specifically applicable to operation, servicing/maintenance, and repair of components of water and wastewater systems in the conditions of northern Canada exist (for example, see CSA Group 2017).

Proactive maintenance of each water and wastewater system component is especially important with respect to the conditions of the North, particularly the limited expertise to repair them and logistical challenges to deliver replacement parts due to climate, remoteness, and isolation. The O&M requirements for the components of water and wastewater systems typically are those of the private suppliers. Sometimes there is also a legal provision to keep maintenance records in the form of a maintenance log (e.g., replacement of media or filters, replacement of lamps, performance testing, troubleshooting, and professional service events). Where a regulation applies for on-site water holding tanks, maintenance, cleaning, and disinfection is typically required at a minimum set frequency (e.g., once per year).

3.5 Testing and Monitoring

3.5.1 Water Sampling, Analysis, and Reporting

All three territories and Nunavik base their water quality requirements on the "Guidelines for Canadian Drinking Water Quality" issued by the federal government (Health Canada 2020). These standards define the biological, chemical, physical, and radiological criteria for drinking water to be considered safe in terms of the presence/absence or concentration of water constituents (e.g., absence of total coliforms; ≤ 0.1 mg/L trihalomethanes). Water quality is monitored to manage the risk from hazards that may compromise public health and safety, and also to ensure it is within guideline values.

Applicable regulations also establish requirements for water sampling and analysis, including the manner of collecting samples, transport, as well as testing methods and the type of instruments and laboratories to be used. For instance, there is typically a provision that sampling results, other than spot readings (e.g., chlorine, turbidity), can only be accepted if the laboratory is accredited. These requirements are typically based on the "Standard Methods for Examination of Water and Wastewater" (American Public Health Association 2017). A variety of other well-established technical standards and standardization documents exist for specific aspects of testing and monitoring, which are sometimes referred to in legislation.

Water licences and other regulatory instruments also often establish the frequency and sampling location requirements for each parameter of the water sample, as well as recording and reporting requirements. The requirements are as diverse as there are pieces of legislation, types and sizes of facilities, and parameters. Although case-specific best practices and guidance documents exist for such aspects, technical standards barely exist for frequency and location of sampling, or for recording and reporting results.

3.5.2 Wastewater Monitoring

Across the North, wastewater quality criteria developed by the federal government currently apply only in the Yukon and only on systems producing at least 100 m^3 of wastewater per day (Environment Canada 2015). This volume requirement excludes most small systems. Where applicable, wastewater quality requirements are otherwise dictated by the individual water licence, which is case specific. These often refer to best practices and other related standardization documents (American Public Health Association 2017). No technical standard, however, exists for wastewater quality requirements. Where legislation (including water licence) applies, sampling must typically be carried out at designated Surveillance Network Program (SNP) sites throughout the wastewater treatment system. The

SNP sites are specific to each wastewater treatment system and are determined as part of the water licence.

A limited number of accredited laboratories exist in Canada's North. For instance, public authorities operate laboratories that can analyze the presence of bacteriological content of drinking water in Whitehorse (Environmental Health Services), Yellowknife (Taiga), and Kuujjuak (Ungava Tulattavik Health Centre). Taiga Environmental Laboratory is also accredited for a wide range of organic and inorganic chemical analyses on water. No accredited laboratory currently operates in Nunavut. In Nunavik, accredited labs exist in the northern villages that can perform bacteriological analysis (Government of Quebec 2001). For all other analyses, samples must be shipped to private accredited laboratories located in southern Canada.

3.6 Certification of Water and Wastewater System Practitioners

3.6.1 General

The territorial and provincial governments across northern Canada are responsible for establishing and enforcing operator certification requirements. They are also responsible for recognizing certification and classification agencies. In turn, a certifying agency may require classification of facilities where certified operators are currently or will be working. Certification exam prerequisites (e.g., formal education, work experience, training) and requirements to maintain a certification (e.g., periodic re-examination, continuing education, periodic dues) are determined by the certifying agency and are specific to each certification level.

3.6.2 Requirements for Operators to be Certified and Facilities to be Classified

Where provincial and territorial legislation exists, operators are typically required to hold a valid certification for regulated facilities. Although encouraged, certification is voluntary for operators working at any other water/wastewater facility, including all wastewater facilities and most small water facilities across Canada's North. This also reflects that where there is no wastewater legislation, there are no requirements for operators.

3.6.3 Certification and Classification

Unless stated otherwise in legislation, any certifying agency signatory to Canadian Water and Wastewater Operator Certification Committee's (CWWOCC) Best Practices can be recognized (CWWOCC 2014). For instance, the Environmental Operators Certification Program (EOCP) (EOCP 2018) is active and recognized for certification of water and wastewater operators and classification of their facilities in the Yukon. In the NWT, it is the NWT government, through its Municipal and Community Affairs Department (MACA), that fulfills this role (GNWT 2018). No certifying/classification agency currently is active or recognized in Nunavut. Similar to the NWT, a governmental agency fulfills the role in Nunavik—Government of Quebec's Ministry of Work, Employment and Social Solidarity (Emploi-Québec 2019). It is worth noting that in Nunavut, as much as in Nunavik, local public authorities are currently developing certification abd classification programs that would apply to their specific jurisdictions.

The type of training activities that are necessary to prepare for a certification exam, as well as continuing education activities required to fulfill continuing education requirements, are typically offered by institutions other than the legislator, certifying agency, or water/wastewater facility owner. In Canada's North, such opportunities are offered by post-secondary academic institutions, professional associations, private companies, and sometimes by governments. Some activities are offered in small rural centres or small communities, and online and web-conferencing options exist. As a mobile complement, private companies contracted through the Circuit Rider Training Program of Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) do provide on-the-job continuing education activities in First Nation communities (CIRNAC 2020).

4. Identified Gaps, Challenges, and Potential Needs for Standardization

The following summarizes feedback received from the survey and key informant interviews on the gaps, challenges, and potential needs for standardization as related to small drinking water and wastewater systems in northern Canada. This is organized around six key themes that emerged from the research.

4.1 Engagement and Involvement of Indigenous Peoples and Indigenous Perspectives

One consistent message heard throughout the surveys and interviews was that there are opportunities to improve the engagement and involvement of Indigenous Peoples into each phase of the water/wastewater system life cycle. This could help ensure that the management, design, and types of systems, as well as related procedures, better reflect both the population being serviced and those likely to be involved in the O&M of these assets.

For example, concerns over the federal Safe Drinking Water for First Nations Act have been widespread and consistent since its proposal and adoption, including that it is inconsistent with a reconciliation approach (Behn 2019; Thornton 2018). While recent international declarations and efforts from the federal government have recognized human rights to water and sanitation, "It is not just the violation of rights that is the problem, it is also the removal of the ability to fulfill First

Nations responsibilities as stewards of the land and water that are at issue as well" (Behn 2019, 10; see also United Nations Declaration on the Rights of Indigenous Peoples 2007).

An example of where respondents indicated that perspectives can be important is with the basic concept of what "water" and "wastewater" are. As Caleb Behn explains, "The Assembly of First Nations (AFN), instructed by Chiefs who are informed on the state of First Nations water and wastewater infrastructures, operates with the view that water is more than a commodity or a 'resource to be managed.' Rather, water is a sacred relation and a transcendent gift." (Behn 2019, 10).

An example of cultural specificities that respondents underscored is languages. For example, courses and certification exams are, in most cases, only available in English, doing little to recognize the languages of the Indigenous Peoples living in northern Canada. More specifically, one sentiment heard through the research was that a significant proportion of the Indigenous community does not like chlorinated water and questioned its potential impact on health as defined from an Indigenous perspective. Removal of chlorine or ultraviolet (UV) disinfection in place of chlorination at point of use might be preferred options. Over and above the development and use of technical standards for these innovations, adoption of these might require accommodation of current regulations, which in some cases prescribes blanket chlorination in all instances.

4.2 Ensuring Consistent Use and Accessibility to Best Practices

This study highlighted that numerous guidance documents exist for small water and wastewater systems across northern Canada. However, users noted some difficulties in accessing these, as well as possible inconsistencies among existing guidance documents—for example regarding aspects of tank cleaning, sampling frequency, and record-keeping and reporting. Also, there are different approaches to important aspects of managing small water/wastewater systems and projects (e.g., planning, engagement, risk assessment, decision making). Respondents also told us that, in some cases, there had been ineffective adaptation or design of drinking and wastewater systems to respond to local realities. Mohseni illustrated this with the following example: "many water plants fail because they're over-designed for local needs or require complicated technology to operate" (UBC 2018; also see Mohseni 2016).

The use and referencing of standards has been found to be well advanced in northern Canada for the design and build phase. Nonetheless, whereas there might be guidance available for design and build, it was identified that additional guidance may be needed for the management and operation of small water/wastewater systems (as defined before, this refers to those systems servicing 500 people or fewer). While many participants observed a general trend of low adaptation to local conditions for existing technical standards, as discussed in Section 4.1, they were clear that solutions for the North must be based on northern circumstances and encapsulate northerners' perspectives and knowledge.

4.3 Managing Challenging Environmental Conditions

There are a number of challenges with respect to dealing with the impacts of extreme and changing climate on water/wastewater systems. For instance, passive wastewater systems can be highly impacted by the quantity of sunlight received by photosynthetic organisms during long summer days. Moreover, shipping and handling of water samples can be challenging due to both geographical and environmental factors. Notably, given the distances and transportation logistics involved, there are difficulties in accessing laboratory services in a timely manner for testing time sensitive water samples across northern Canada. This situation is compounded by extreme cold temperatures, where samples can be compromised if exposed to freezing temperatures. This is especially true for bacteriological analysis (e.g., coliforms), which is sensitive to freezing. Similarly, there are unique cold-related health and safety considerations for water/wastewater practitioners that need to be accounted for since their work can often involve a significant amount of time in very cold temperatures while performing maintenance or other detailed tasks. Although not entirely universal, much of the soil is locked in permafrost (permanently frozen ground), posing major challenges to construct and build, especially for underground infrastructures such as water wells, water supply piping, and sewers.

Science and Indigenous Knowledge both attest to major climatic changes happening in northern Canada, with these changes happening at a faster rate than southern regions. Changes include higher temperatures, alteration of precipitation patterns, an increase in occurrence of extreme climatic events, and permafrost degradation—with the latter contributing to instances of structural failures in water and wastewater system components (CSA Group 2017). For example, Norman Wells, NWT, had to replace its water reservoir in 2008 due to structural cracks caused by ground settlement (Ripley 2009). The risk is especially high with components that have been designed to rely on permafrost to maintain their structure. Recent examples are in Old Crow, Yukon, and Umiujaq, Nunavik, where permafrost degradation and changes in precipitation patterns contributed to the failure of wastewater treatment infrastructures, in turn leading to an increased risk for contamination from wastewater effluents. Permafrost melt may also alter the composition of source water. For example, surface water might see an increase in humic acids and turbidity levels, which subsequently can escalate maintenance costs and require more chlorine to adequately disinfect water (Ripley 2009).

4.4 Capacity Building, Training, and Continuing Education

Capacity building, training, and continuing education are key to ensuring a workforce that is adequate and capable of designing, building, operating, and maintaining and servicing water and wastewater systems and infrastructure. While the feedback received indicated that the level of knowledge and information contained in the courses currently offered throughout the North is appropriate, a number of challenges and opportunities for advancement, including costs, a general lack of local opportunities, and some inconsistency in the capacity building methods being used, were also noted. For example, respondents felt that in-class and live virtual training courses can sometimes be "too intense," with a lot of theoretical concepts covered while sitting for four to five days consecutively. Much like what was identified by ECO Canada (Environmental Labour Market Research 2010), respondents were clear that hands-on and on-the-job training and continuing education were the optimal methods; unfortunately, however, such opportunities are not always available in the North and are expensive. The interest to develop cross-training between roles, communities, and systems that was identified by the Yukon Government (Yukon Government 2017) was also confirmed in this research.

The study participants also expressed that local capacity building opportunities were generally insufficient for the workers to acquire and maintain their certification, with limited ability to travel long distances or for long periods of time to attend classes where they were offered. In particular, these are typically only offered in the largest centres that often are at a great distance and sometimes require air travel. Online and virtual options are only good in so far as the attendee already has the necessary skills (e.g., computer proficiency).

Another key consideration raised was the lack of redundancy and replacement opportunities when a team member must leave for a few days to attend training or continuing education. This was identified as critical in smaller teams, especially when alternative workers lacked certification and operation of the facility legally required valid certification. It was suggested that certification of a higher proportion of the team members could contribute to alleviating this issue, as well as access to temporary, mobile certified workers. While praising the efforts already imparted (e.g., CIRNAC support for Yukon Water and Wastewater Operator Program), it was felt that support by public agencies for capacity building of small water and wastewater operators was uneven and could be improved across northern Canada.

As discussed in section 4.1, there may also be language barriers given that training and continuing education courses are only available in English, whereas many more languages have official status (e.g., eleven languages in NWT, four languages in Nunavut, and French and Inuktitut in Nunavik), and even more Indigenous languages spoken.

4.5 Certification of Water and Wastewater Practitioners

Participants acknowledged that certification was often challenging to obtain. Some of the challenges included costs and insufficient opportunities, especially at the local level, for the same reasons as mentioned for capacity building in the previous section. Although online options exist in some cases, an invigilator must typically be present, and it was found that personnel to fulfill that role were not always available.

While participants noted that the three certifying agencies active in the North strived to follow the Canadian Water and Wastewater Operator Certification Committee (CWWOCC)'s Best Practices (CWWOCC 2014), their programs vary considerably, with no inter-jurisdiction transferability. For instance, although most signatories to CWWOCC's Best Practices have reciprocity agreements, there are no reciprocity agreements between certifying agencies active in Canada's North. Moreover, although standardized exams seem to be an avenue of choice for some certifying and classification agencies for systems servicing more than 500 people, there are currently no standardized exams for small water or small wastewater operator certification, no more than for bulk water delivery. This situation is similar to what once prevailed across North America and which led to the creation of the Association of Boards of Certification (ABC) (Association of Boards of Certification 2013) and, later, the CWWOCC (CWWOCC 2014) and the Certification Commission for Environmental Professionals (C_2EP) (Certification Commission for Environmental Professionals 2018).

Respondents also reported that a lack of legal requirements for certification effectively posed a barrier to training and continuing education of operators in that efforts and costs related to certification are not as evidently justifiable and warrantable financially. For instance, although encouraged, certification is voluntary for most small water and wastewater operators working in Canada's North. This, in turn, is seen as contributing to the risk imparted to small water and wastewater systems. By comparison, the legislation in all of Canada's southern provinces has a mandatory operator certification requirement, albeit not always applicable to small operators.

Certification programs are the result of decades of hard work and consensus-building efforts. Recognizing the challenges inherent to building and maintaining a personnel certification program, especially for a sparse population scattered over a large region, respondents pointed out that not all certifying agencies active in the North respected the independence criteria as set out by the industry. Independence is seen as an important tool in ensuring autonomy and impartiality and in warding against inappropriate influence, potential conflict of interest, and unintentional self-serving bias, as well as for controlling the risk imparted to

small water and wastewater systems (Association of Boards of Certification 2013; CWWOCC 2014).

Similar to training and continuing education, mixed comments were heard regarding the cultural adaptation of certification schemes, as discussed in section 4.1. In contrast, participants noted that the certifying agency active and recognized in Nunavik was somewhat culturally and linguistically flexible, with documents and communication being available in first languages such as Inuktitut, and usage languages such as English, over and above the official French language.

4.6 Recruitment, Retention, and Advancement of Operators

As previously noted by ECO Canada (Environmental Labour Market Research 2010) for Canada, by CSA Group (CSA Group 2017) for Canada's North, and by the Yukon Government for the Yukon specifically (Yukon Government 2017), respondents reinforced that the recruitment and retention of the workforce necessary to help operate and maintain water and wastewater systems can be a major challenge in northern Canada.

It was particularly emphasized that the region's remoteness and the smaller labour supply pool to draw from can limit the availability and attraction of potential operators. This is often exacerbated by competition for employees from other economic sectors such as mining. Smaller communities also often lose talent to larger municipalities that offer greater career growth and better pay.

Respondents indicated that challenges inherent to capacity building and certification/classification heavily impacted recruitment, retention, and advancement. The fact that small-system operators often must cover more tasks than larger system operators, increases the training, certification, and continuing education development requirements of each individual. In addition to these factors, respondents expressed that requirement for hands-on work experience at a water and wastewater facility before being hired as an operator can be a challenge in cases where opportunities for hands-on work experience are limited.

The compartmentalization and limited harmonization of the three operator certifying programs active across the Canadian North (see section 4.5 above) was a major challenge to recruitment, retention, and advancement of the operators in that it effectively hampered the mobility of skilled trades and the sharing of knowledge and best practices within northern Canada and beyond. Respondents also mentioned that many small water and wastewater practitioners lacked the training in leadership, communication, and computer skills to enable them to advance in the workforce, much like that identified by the Yukon Government (Yukon Government 2017).

Respondents also communicated that, due to formal education levels in the North not always being on par with the southern reality, community-based recruitment, retention, and advancement of operators is negatively affected. It was heard that this education disparity was most critical in small communities. Identified challenges and barriers to formal education included incompatibilities of education systems with the lifestyles and living conditions of northerners, lack of coordination among relevant stakeholders, and other systemic issues. Similar to what was identified by the Yukon Government (Yukon Government 2017), participants were insistent that such social challenges as lack of opportunity for adults to pursue Grade 12 equivalency in the North, and unconventional limitations to what was recognized as Grade 12 equivalency were major compounding factors.

Respondents identified that it would be beneficial to have more mentoring, improved training and continuing education for junior staff, better formal education systems, greater clarity over what constitutes high school equivalency, as well as better succession planning generally, all of which represent standardization opportunities.

5. Recommendations

The following recommendations are based on an analysis of the survey responses and the feedback from the interviewees, particularly with respect to the identified gaps, challenges, and potential needs for standardization as detailed above. Some recommendations call for harmonizing, streamlining, and improving the usage of existing standardization documents, while others call for the development of new standards. Where possible, recommendations address the content in standards and related documents so that these can be effectively used in small communities.

Nonetheless, it is emphasized that while this is presented for the North overall, the situation regarding water and wastewater systems differs significantly from jurisdiction to jurisdiction.

5.1 Engagement of Indigenous Nations and Peoples

CSA Group northern Canada report (CSA Group 2017) identified a number of fundamental elements of success and best practices for the engagement of Indigenous and non-Indigenous northerners. Paramount is the need to both acknowledge and include the variety of perspectives, conceptions, and cultural and societal specificities of Indigenous Nations and Peoples, as well as to recognize the value and contribution of Indigenous Knowledge and the related importance and role of Elders. A number of key aspects concerning how standards and related instruments (such as guidance) for various phases of the water and wastewater lifecycle could help support this were also gathered through the literature review and heard through the engagement process of this research.

For instance, promotion of well-established and successful engagement models such as RÉS'EAU/WaterNET's "Community Circle" approach (RÉS'EAU/WaterNET 2018) could do much in advancing engagement processes. This model has a strong track record in small Indigenous communities by conducting research and testing on promising new solutions under real-world conditions, and integrating community feedback into the refinement process. Such success stories involved, for example, the implementation of point-of-entry (POE) treatment systems to meet site-specific needs and the installation of a mobile water treatment unit.

Respondents also emphasized and reinforced that it is critical to formally recognize the value of Indigenous Knowledge, as well as cultural and societal specificities, in any document involving the topic of Indigenous engagement, such as incorporation of world view, language, history, customs, values, traditional economic roles, infrastructure, governance, and differences across Indigenous communities and Peoples. Any effort to develop guidance on this topic area should also consider the ethics of the decolonization of science as well as the Truth and Reconciliation Commission of Canada Final Report (Truth and Reconciliation Commission of Canada 2015), with meaningful consultation and building respectful relationships in conformity with relevant international legal frameworks and related documents, such as:

- the United Nations Declaration on the Rights of Indigenous Peoples (United Nations 2007);
- the United Nation Declaration on the Rights to Water (United Nations 2010), and;
- the Garma International Indigenous Water Declaration (United Nations University – Institute of Advanced Studies Traditional Knowledge Institute 2008).

5.2 Promote and Facilitate the Use of Existing Standardization Documents

As identified through the literature review as well as the stakeholder consultation process, there are many relevant and existing standardization documents that could be utilized for the purpose of small-scale water and wastewater systems.

Where relevant for small systems and with due consideration for local conditions, efforts should be made to have these referenced within operations and maintenance manuals (e.g., Standard Operating Procedures) and referenced or required as part of tendering documents. For instance, there are opportunities to reference well-established standards in product specifications, procurement documents, and sourcing requirements to help improve asset management and accessibility to the parts and equipment used and needed by small water and wastewater system practitioners in the North.

Efforts should be made to have these referenced in relevant legislation. One general attribute of standards is that these can be much more easily updated than compared to legislation, and also can be used to complement regulations through the process of "regulation through reference." Opportunities exist for First Nation governments to reference such technical standards as they (re)build their own governance structures and institutions, such as their unique sets of regulations governing the design, build, operation, and maintenance of their water and wastewater systems.

Special efforts should also be made to see that well-established standards are used and referenced with technical topics for which referencing is not as well-advanced, such as management (e.g., emergency plans); operations, maintenance and servicing, and repair (e.g., tank cleaning); and testing and monitoring (e.g., reporting and record keeping).

Referencing standards in tendering documents, legislation, and so on, could help facilitate accountability and could be used to enforce circumstances where procedures are not followed. This would require, and benefit from, the involvement of key stakeholders, notably regulatory authorities that could raise the profile of any related standard and heighten their potential use and applicability. There is also the opportunity for standards to provide requirements or recommendations for record drawings post construction so that designs are installed to specifications. Some examples of existing standards are provided in Table 1.

Table 1. Examples of existing standards relevant to small-scale water and wastewater systems

Category	Name of Standard/Program	Standards Development Organization	Year
Certification & Classification	General Requirements for Bodies Operating Certification of Persons	International Organization for Standardization	2012
	Conformity assessment — Requirements for bodies certifying products, processes, and services	International Organization for Standardization	2012
Design & Build	Ultraviolet Disinfection Systems for Drinking Water	American Water Works Association	2016
	Water Wells	American Water Works Association	2015
	Wastewater Treatment in Northern Communities Using Lagoon and Wetland Systems	Canadian Standards Association	2018
	Drinking Water Treatment Systems	Canadian Standards Association	2017
Lab Conformity	General requirements for the competence of testing and calibration of laboratories	International Organization for Standardization	2017
	Conformity assessment — Requirements for accreditation bodies accrediting conformity assessment bodies	International Organization for Standardization	2017
Management	Risk and Resilience Management of Water and Wastewater Systems	American Water Works Association	2013
	Climate change adaptation for wastewater treatment plants	Canadian Standards Association	2018
	Activities relating to drinking water and wastewater services — Guidelines for the management of drinking water utilities and for the assessment of drinking water services (Adopted)	Canadian Standards Association	2014
	Technical guide: Performance improvement for small & medium sized water utilities	Canadian Standards Association	2009
Operations, Maintenance/ Servicing & Repair	Sodium Chloride	American Water Works Association	2017
	Disinfecting Water Mains	American Water Works Association	2014
	Wastewater Treatment Plant Operations and Management	American Water Works Association	2013
	Disinfection of Wells	American Water Works Association	2013
Testing & Monitoring	Online Turbidimeter Operation and Maintenance	American Water Works Association	2016
	Online Chlorine Analyzer Operation and Maintenance	American Water Works Association	2015
	Water Quality Standards (standards development program)	International Organization for Standardization	2019

5.3 Mainstreaming Existing Best Practices and Developing New Standards

There is an opportunity to mainstream existing guidance documents, procedures, and best practices into new technical standards. A wide variety of best practices and guidance documents exist as related to water and wastewater systems generally. These could form the basis for more widely useable and referable standards specific to small-scale water and wastewater systems in northern Canada. These could allow for the broader application of best practices, encourage consistency in approach across these regions, and allow for the use of standards for reference in tendering documents and in regulation more broadly. Existing technical standards developed based on southern realities could also be adapted so that these are more applicable to the North and northern stakeholders.

Nonetheless, there are important topics where best practices or similar standardization documents are limited and could benefit from the development of technical standards. These include, for example, issuing and rescinding boil water advisories, assessing groundwater that is under the direct influence of surface water, freeze prevention in water distribution lines, pharmaceuticals treatment, point-of-use dechlorination, POE UV treatment, ozone treatment (pre-distribution

and POE), stabilized hydrogen peroxide treatment (pre-distribution and POE), or remote sensing/monitoring and process control. Other broader topics include issues related to water delivery truck technical specifications and O&M more generally.

5.4 Analysis of Water and Wastewater across Canada's North

Recognizing that the presence of laboratories is mostly market-driven, there appears to be a need to help bolster the analysis of water across the North as per the quality of both drinking water and wastewater effluents and the operational integrity of water and wastewater infrastructures. As possible, given things like financial or staffing constraints, this should be done in collaboration with public authorities (governments). For instance, there might be an opportunity for the establishment and support of laboratories accredited for proficiency, quality assurance, quality control, and accountability according to already existing laboratory conformity assessment standards or other standards developed specifically for the topic. This could include the training of local health practitioners (e.g., at local nursing stations) to perform such standardized analysis as Colilert™ for bacteriological content.

5.5 Training, Certification, and Continuing Education of the Operators

Northerners involved in this project were clear that there are opportunities to standardize certification schemes inter-jurisdictionally, making staff transferability possible, for example, through reciprocity agreements. As mentioned by ABC (Association of Boards of Certification 2013), "this call for standardization and collaboration between operator certification programs is not merely for the sake of uniformity, but also to provide the opportunity for greater assurances of public health and environmental protection." Standardization of certification schemes can also foster synergies between jurisdictions sharing similarities in terms of governance, culture, geography, and environment. For instance, standardization of certifying models can bring savings through economies of scale and by removing redundancy. Most importantly, standardization of models across the North could give rise to a better representation of the societal/cultural, environmental, and geographical specificities of the region in terms of capacity building and certification and classification. Harmonization could also help recruitment and stimulate recognition and transferability of operators outside the region.

Standards exist that can help certifying and classification agencies harmonize their practices. Basic standards include ABC (Association of Boards of Certification 2013) and CWWOCC (CWWOCC 2014). For instance, the collaborative development and adoption of standard exams for small water, wastewater, and bulk water delivery operators could do much for inter-jurisdiction transferability as well as recruitment, retention, and career advancement. The adoption of a common, standard, and consistent definition of what constitutes Grade 12 equivalency could also have a significant impact. The adoption of a standardized requirement for bulk water delivery operators to attend subject-specific training and commit to continuing education like other certified water and wastewater operators could enhance safety and reliability of the systems while fostering public health. A further elaborated alternative could be for Canada's northern stakeholders to call on a common certifying agency active and recognized in multiple jurisdictions such as EOCP (EOCP 2018) and C_2EP (Certification Commission for Environmental Professionals 2018).

Another option could be for northerners to develop a cross-jurisdiction certifying agency specific to the Canadian North. This would require broad stakeholder representation and a significant commitment. As with other topic areas, this could be specific to small water and wastewater systems or broader, and while it could be limited to the typical definition of water and wastewater operators, it could also be applicable to other legislated and related professions involved with each lifecycle component of the water and wastewater systems, and which currently are governed under their own set of certifying agencies (e.g., laboratory analyst, well driller, and so on). Such a certification program could also be designed to serve all of northern Canada or only specific jurisdictions. This could be an opportunity to better align the qualification process to that of traditional trades such as Red Seal.

A better alignment of certification programs with conformity assessment (e.g., independence criteria) and quality assurance standards (e.g., continuous improvement) could do much to alleviate unnecessary systemic risks imparted to small water and wastewater systems across the North.

Diversity in capacity-building approaches and topics is essential to fulfill the purpose of exposing operators to new and rapidly evolving water treatment technologies, legislation, and health risks. The adoption of common requirements that would address the specificities of small systems across Canada's North would, however, support standardization efforts in certification/classification, while keeping and respecting the independence of each training and continuing education institution and the people they cater to. This could also be an opportunity to better represent the cultural/societal specificities of the populations living in northern Canada, for instance through licensing under ECO Canada's Building Environmental Aboriginal Human Resources program (ECO Canada 2020) or another technical standard developed specifically for the situation.

Other key factors that should be considered for the success of such potential standardization projects for training, certification, and continuing education include:

- accessibility with respect to cost;
- consideration of the fact that acquisition of hands-on working hours can take much longer with small systems as the work shifts are short and often sporadic;
- use of a common, standard, and consistent definition of what constitutes Grade 12 equivalent;
- provide for the integration of new operators (e.g., internship) and encourage mentoring/hands-on training;
- consider current typical level of formal education (e.g., Grade 12) in the application area;
- reflect the current and prospective physical environment realities in the application area;
- utilize the Multi-Barrier Approach (source to tap), with emphasis on source water protection; and
- other factors for the success of engaging Indigenous Peoples (see section 5.1).

6. Conclusions

Research investigating the potential of standards for the build, operation, and maintenance phases of small water and wastewater systems in northern Canada was conducted to identify opportunities for standards to help ensure safe, accessible, and high-quality drinking water and sanitation for all northerners. A literature review was conducted, followed by an engagement exercise through a survey and targeted interviews to gather northerners' perspectives.

Water governance in the Canadian North is inherently complex. The situation is rapidly evolving and important pieces of legislation have been put in place in recent years where high requirements have been established, especially for larger systems.

Small water and wastewater systems in northern Canada also differ in many ways from their southern Canada counterparts. For instance, bulk delivery and collection systems are more common than in southern Canada, and wastewater is mainly treated through passive systems including constructed and tundra wetlands. This study highlights that many existing technical documents do not adequately reflect the unique climatic and environmental conditions in northern Canada. It is worth noting that in the North, standardization seems to be more advanced with drinking water systems compared to wastewater treatment systems, and with the "design & build" phase of these systems, compared to other lifecycle phases.

A number of major themes and corresponding recommendations have been drawn from this research project with respect to the potential for standardization efforts. This includes the engagement and involvement of Indigenous Peoples and perspectives; ensuring consistent use and accessibility to best practices; managing challenging environmental conditions; capacity building and training and continuing education; certification of water and wastewater practitioners; and the recruitment, retention, and advancement of operators.

Of the themes identified, training and certification/classification were identified as a key area that has many gaps, challenges, and potential opportunities with respect to the use of standardized procedures for small-scale water and wastewater systems. For instance, the lack of harmonization seems to undermine inter-jurisdiction transferability of skills and knowledge. Subsequently, this is also identified as the area where standardization efforts may have the broadest social benefit and urgency, as well as potential feasibility.

Notes

1. For the purposes of this article, the Canadian North is defined as all Canadian geographical areas above the 60th degree of latitude. Reference is also made in some sections to the Arctic, particularly when speaking of specific geographical features such as Arctic waters or where existing regulations or associated government departments use the word Arctic. The research methodology included engaging both stakeholders physically located in the North as well as others not necessarily located there but still with significant experience and knowledge of northern issues.
2. Primary disinfection kills or inactivates bacteria, viruses, and other potentially harmful organisms in drinking water, while secondary disinfection provides longer-lasting water treatment as the water moves through pipes to consumers (Environmental Protection Agency 2009).

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Research Article

The Gahcho Kué Diamond Mine: A Case Study in Intergovernmental Environmental Management

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Abstract: The Gahcho Kué Diamond Mine is an operating mine in the Northwest Territories, Canada. Due to requirements defined in law, the mine required several authorizations for construction and operation, including both federal and territorial authorizations. Throughout the construction and operation of the diamond mine, instances occurred when the proponent, De Beers Canada Inc., raised objections about applying conditions in the water licence to areas that were authorized by Fisheries and Oceans Canada. As well, there have been ongoing discussions between various parties, including those with regulatory mandates, regarding requirements and jurisdiction related to site closure planning. This article outlines the discussions that have occurred to date, detailing the areas of ambiguity regarding projects that are authorized under multiple pieces of legislation. Lessons learned, as well as recommendations to address some of these issues, are provided.

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