Drinking Water in Interior Health

An Assessment of Drinking Water Systems, Risks to Public Health, and Recommendations for Improvement

Office of the Medical Health Officer

January, 2017

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This Report has been compiled for and is brought to the Interior Health Authority Board under Order in Council by a Medical Health Officer, pursuant to Section 73 of the *Public Health Act* of British Columbia. It describes a significant and/or time sensitive risk to the health of persons residing in BC's interior region, and provides recommendations for which the health authority is responsible.

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Message from the Chief Medical Health Officer

I am excited to present this report on the status of Drinking Water in Interior Health. The provision of clean drinking water to our residents and visitors is an extremely important service, and one that is supported by legislation to ensure that the risk to public health is minimized. We currently oversee more than 1,900 individual drinking water systems in the Interior Health region, and we must work collaboratively with our First Nations partners with respect to hundreds more. Our team within Population Health, and specifically the Drinking Water Program, works hard to understand the challenges and opportunities of each water system.

Delegated Drinking Water Officers work with water system owners to ensure the delivery of safe drinking water. This approach of education and communication with water operators and local governments has been successful in many communities as a pathway to system improvement. We look forward to building upon these successes to ensure access to safe drinking water in all communities in the interior of British Columbia. Creating a plan is the first step in the journey to clean water. While we in British Columbia are fortunate to have some of the cleanest source waters in Canada, the risk of contamination exists, particularly for those drawing from surface water sources.

We will continue to work with our water system owners, operators, local governments, and First Nations partners to chart a course toward sustainable achievement of the Drinking Water Treatment Objectives using a multiple barrier approach, with the goal of providing clean, safe, and reliable drinking water to our entire population.

Dr. Trevor Corneil, BA MD MHSc FCFP FRCPC
VP Population Health & Chief Medical Health Officer
Interior Health Authority

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From left to right, the core team: Roger Parsonage, Corporate Director Population Health; Tara Gostelow, Communications Officer; Dr. Kamran Golmohammadi, Medical Health Officer; J. Ivor Norlin, Manager of Infrastructure Programs; and Brent Harris, Epidemiologist.
Not pictured is Laurie Bourdin, Administrative Support.

Additional thanks go out the team members that provided valuable feedback and advice throughout:

Robert Birtles, Small Water Systems Team Leader
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The entire Office of the Medical Health Officer

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Executive Summary

Access to clean, safe, reliable tap water for all people at all times is the ultimate goal of the drinking water program at Interior Health (IH). Assessing the safety of drinking water requires a multi-level view of risk. The first lens is that of water-borne diseases. Is there demonstrable evidence of outbreaks, clusters, and baseline illness? Within IH, the most drastic reductions in waterborne diseases occurred in the wake of large outbreaks in the late 1990's. Since then the truly deficient systems have made changes, such as chlorination of surface water sources. As a result, outbreaks and disease clusters are no longer common occurrences. Further to some of these changes, the usage of public notifications and advisories for potentially unsafe water helped prevent large instances of disease. Unfortunately, the reduction of disease led to a degree of complacency within many water systems, where the reliance on advisories and notifications to keep people safe has in some cases impacted the planning for necessary infrastructure improvements which could ensure the delivery of safe drinking water at all times. Fortunately, there exist standards, guidelines, and legislation to help water purveyors to achieve this goal in a sustainable way.

Best practice is recognized as meeting the multiple barrier approach (MBA) to safe drinking water. This is supported by documents such as the Guidelines for Canadian Drinking Water Quality (GCDWQ) (Health Canada, 2014) and the British Columbia Drinking Water Protection Act (DWPA) (Province of British Columbia, 2001). The central idea of the MBA is that safe, reliable drinking water is a collaborative process. This process involves not only the treatment of water using physical and chemical barriers, but also emphasizes that an understanding of the entire process by all stakeholders, such as communities, local governments, water operators and regulators, will maintain and improve the quality of water on its journey from source to tap. This information needs to be captured appropriately to determine a holistic view of risk.

The DWPA is the legislation that requires IH to oversee the provision of potable water to consumers. It gives water suppliers responsibility for ensuring that they provide safe water and compels them to act to protect users if there is an actual or potential risk to their drinking water. The legislation provides planning tools, and monitoring and enforcement powers to drinking water officers to oversee the work of water suppliers and take action if there is a risk to public health.

Data collection methods in IH are in a constant state of quality improvement. However, there are challenges associated with accessing and analyzing the information needed to report on the state of our systems. In spite of this, a great deal of information was retrieved for this report. There are currently more than 1,900 individual drinking water systems regulated by IH, plus an additional 107 or more in First Nations communities. That is near half of all drinking water systems in BC. More than 90% of drinking water systems in the IH region are serving fewer than 500 people per day, and about 60% serve fewer than 100. This report focuses on the 1,454 small water systems and 133 large water systems managed by our Drinking Water program, as well as those in First Nations communities. There remaining 300+ systems in IH are not part of the drinking water program. The 133 large water systems provide water to approximately 85% of the people in IH and are predominantly owned and operated by local governments (municipalities and regional districts).

This report focuses on pathogenic microorganisms, which are the viruses, bacteria, and protozoa that cause infectious diseases such as Cryptosporidiosis, Giardiasis, and Campylobacteriosis. Physical contamination is also addressed, as turbidity can shield microorganisms from certain types of treatment. To do this, a composite indicator was developed based on water quality advisories (WQA) and boil water notices (BWN). Water systems were then assessed in terms of historical and current days on advisory, geographic distribution, and population affected.

For the risk of pathogenic microorganisms, the total number of days each active system has spent on advisory and notification over the past five years was counted. Among small systems, 80% had an average of just less than 100 days on advisory over the five year period. In contrast, the top 20% of systems averaged more than 1,766 days on advisory out of a possible 1,826, including 241 systems that were on advisory every day of the five year period. Among large water systems, 80% of them averaged approximately 37 days on advisory, compared to the top 20% of systems, which averaged 1,122 days out of a possible 1,826. There were six large systems on advisory each day of the five years. While the number of days on advisory and notification was not available for water systems in First Nations communities, an assessment in 2011 (Neegan Burnside) found that approximately 73% of First Nations water systems in IH were considered to be at high risk of providing poor quality water.

Drinking water advisories and notifications are meant to be a temporary means of protecting the health of water consumers by providing them with information about how they can reduce their risk of negative health impacts. It is an interim measure and does not take the place of any of the barriers contained in the MBA. The MBA provides guidance for the management and protection of water sources, treatment process, and distribution systems that can reduce the need for public advisories and notifications.

From the beginning of 2006 to the end of 2015 there have been 307 WQAs issued on small systems, and 279 issued on large systems. Another 803 BWNs were issued on small systems and 249 on large systems. While most BWNs in place at any point in time affect small water systems serving fewer than 500 people per day, large water systems can also be affected. The population health risk grows exponentially when large systems are affected by a BWN due to the larger populations that are served.

There have been many good news stories though, with the successful construction of state-of-the-art treatment facilities in communities of all sizes, improved source protection in many watersheds, and the creation of emergency response plans to help protect public health during unexpected situations. While each community has taken a slightly different path to improvement, success has been earned by making clean water a priority for current and future populations. The consistent theme is that the MBA encourages water systems to mitigate risk using a variety of approaches. This report outlines the path forward for change in the remaining systems that do not currently meet the best practice guidelines.

Based on the findings of this report, the following six recommendations are noted:

1. IH Medical Health Officers (MHOs), delegated Drinking Water Officers (DWOs) and Communications Officers should develop and implement a community engagement strategy with water suppliers, municipalities and regional districts that encourages in-depth local dialogue over the next 12-18 months.
    a) The strategy should follow a logical order that includes all water systems prioritized by risk and population size.
    b) IH program staff should collaborate with the Ministry of Health in developing and implementing this strategy based on community readiness for change.
2. Delegated DWOs should work with all large water systems using a surface source to achieve provincial treatment objectives by 2025. This may serve as a goal upon which water suppliers, local governments, MHOs and delegated DWOs develop local improvement plans that take into consideration community needs, value engineering, construction, provincial and federal grant opportunities, and cost.
3. Delegated DWOs should report annually to the Chief MHO on water systems at highest risk and which are unable to implement the multiple barrier approach to safe drinking water. Reporting may include barriers that are preventing water suppliers from meaningful progress, and the consideration and use of progressive compliance measures available under the *Drinking Water Protection Act*.
4. IH program staff should enhance information management to support reporting on multiple barriers for drinking water safety that aligns with provincial reporting.
5. IH program staff should collaborate with and empower First Nations communities and the First Nations Health Authority to achieve safe drinking water for First Nations people. Opportunities may include aligned reporting of waterborne disease rates, public advisories and use of the multiple barrier approach to ensure clean, safe and reliable drinking water.
6. IH program staff should work with the Ministry of Health and local and provincial partners to explore an area-based management approach to drinking water systems, similar to that used for liquid-waste management. This approach would need to include methods to engage communities in planning for sustainable small water systems and to identify funding mechanisms to support.

1. Introduction

Access to safe, clean drinking water in Canada is regarded as a fundamental right, and taken for granted by many. In large and established cities, it is often used and consumed without much thought to the processes in place that bring water to the tap. Drinking water in Canada is jointly managed by provincial/territorial governments and the federal government, with day to day operations managed by individual water system owners, such as municipalities, First Nations, regional districts, improvement districts, and private corporations, among others. These water system owners must comply with regulations administered by the Drinking Water Officer (DWO) of the health authority, with the exception of those in First Nations communities. Through BC Statute and Regulation, Medical Health Officers are by definition DWOs. The statutory powers and responsibilities of a DWO are delegated to health authority Environmental Health Officers (EHOs) within the drinking water program in Interior Health (IH).

"…the needs and challenges presented in IH are different than in other health authorities."

The requirements of drinking water systems are governed by the Drinking Water Protection Act (DWPA) and the Drinking Water Protection Regulation (DWPR), both of which were developed to be consistent with federal guidelines for drinking water quality in Canada. While the legislated requirements of drinking water systems in IH are exactly the same as those in other BC jurisdictions, the needs and challenges presented in IH are different than in other health authorities. Specifically, we are challenged by the number of systems under our jurisdiction, the mix of residential consumers and agricultural producers, and the geographic spread of the health authority.

The population in IH is estimated to be 737,000 (BC Stats, 2015) spread across an area roughly the size of the state of Idaho, which has a population of 1.6 million. By area IH represents nearly 23% of British Columbia's (BC) land mass, but contains less than 16% of the provincial population. There are 59 municipalities across IH, which contain 75% of the total IH population. The remainder is spread across the region in small rural and remote communities under the jurisdiction of the 10 regional districts that operate within IH's borders. In addition, there are 54 First Nations communities representing 7.7% of the IH population with which IH has service agreements in place, and whose water systems are governed by the federal government along with First Nations Health Authority (FNHA). The map in Figure 1 shows the distribution of population across the health authority using local populations from the 2011 Census. The darkest brown demonstrates the most densely populated areas while the lightest beige shows the sparsely populated areas. Gray shows the areas where people do not live. This highlights the relatively low population density in most of IH. The thick gray borders show administrative health service areas of IH East/West/Central.

British Columbia has nearly 5,000 individual water systems (Office of the Provincial Health Officer, 2015), and close to 40% of them, or 1,900 systems fall within IH boundaries. Interior Health also contains nearly two million hectares of Agricultural Land Reserve (ALR), which is 42% of the BC total, where irrigation need is high during the hot and dry summers of the southern interior. The competing requirements of residential and agricultural water use have resulted in issues of both treatment and capacity in areas where the two share a distribution system.

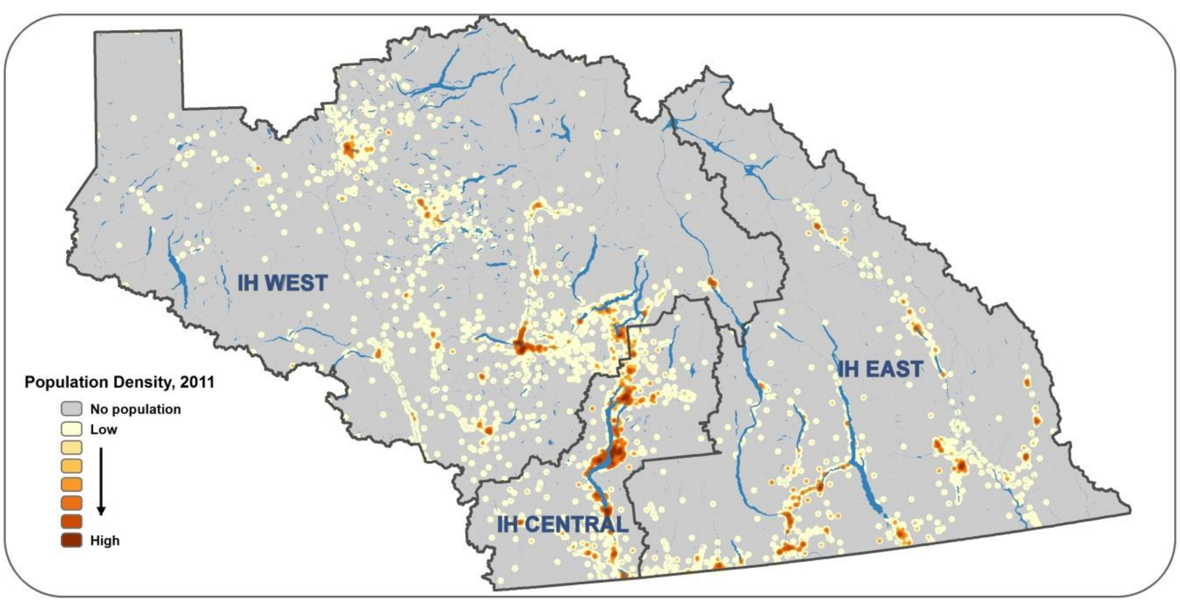


Figure 1: Population Distribution in Interior Health, 2011

1.1. Purpose

This report sets out to provide an overview of the drinking water systems that serve the residents of IH, passed through three lenses: impacts to health and disease burden, public advisories, and the multiple barrier approach (MBA). The value of clean drinking water should be understood not just by those regulating and providing it, but by the public at large. This report will hopefully illuminate the issues being faced and provide a platform to engage consumers in the provision of water to their homes, schools, workplaces, and civic facilities. Ultimately, people should understand where their water comes from, the type of treatment it receives, and the risks to their health should those protective measures fail. Ensuring safe drinking water is a complex undertaking that requires careful planning, detailed engineering, and significant capital costs. These costs are necessary for stable, healthy, and sustainable communities.

The analysis begins with a look at the current and recent levels of disease for which water is a leading risk factor. Following this is the history of water systems under the jurisdiction of IH's drinking water program, along with an assessment of public advisories warning about potential health hazards. Lastly, application of the MBA will be explored. This is a holistic view of water systems that represents current best practice. Within each of these lenses and assessments, water systems will be examined separately as Large, Small, and First Nations, representing distinct governance structures and operational challenges. This report will conclude with some success stories, highlighting communities that have recently made drinking water a priority and followed through to ensure the safety of their residents for decades to come.

2. Health Impacts and Waterborne Diseases

Contamination of drinking water can occur at multiple points along the journey from source to tap. Contamination can be microbiological, coming from viruses, bacteria or protozoa that can cause human illness. Contamination can also be chemical, such as heavy metals that occur naturally in source water, or nitrates in ground water as a result of agricultural activity. Chemical contamination can result in wide-ranging effects, can be difficult to mitigate and is dependent on the chemical in question. The third type of contamination is physical, such as suspended sediment, known as turbidity, in surface water during spring runoff. This report will focus largely on microbiological contamination, though turbidity plays a significant role. Sediment found in turbid water can shield the tiny viruses, bacteria, and protozoa from treatment if chlorination is the only barrier.

"Ultimately, people should understand where their water comes from, the type of treatment it receives, and the risks to their health should those protective measures fail."

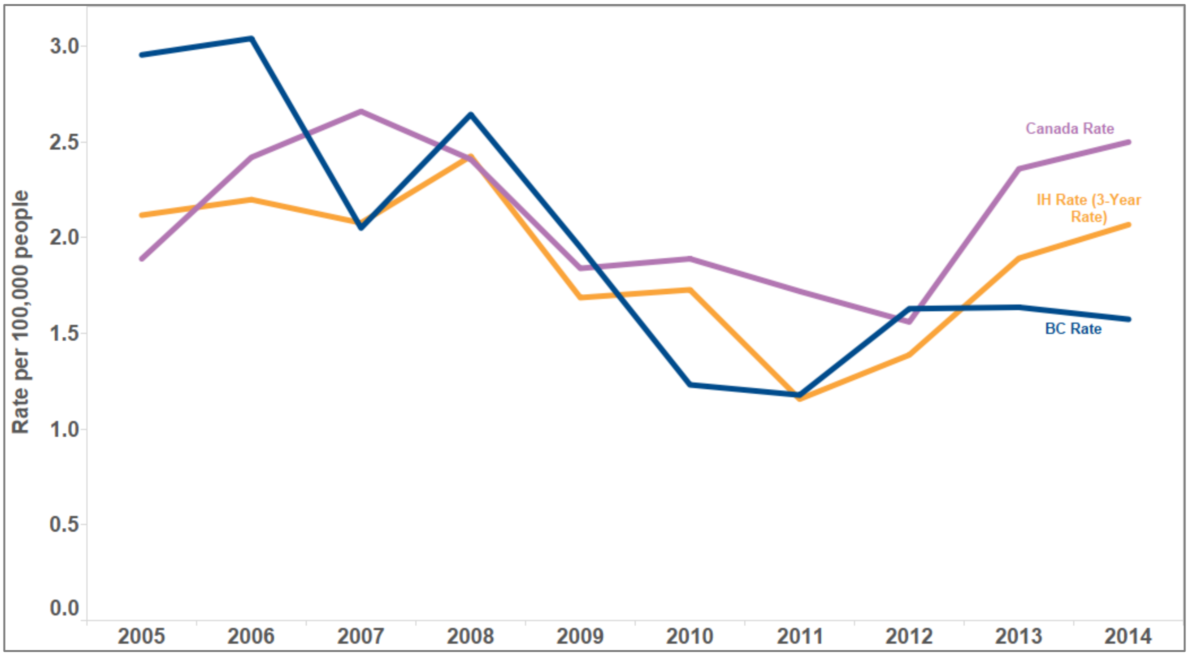
Typical symptoms of mild waterborne diseases due to viral, bacterial and protozoan pathogens include minor abdominal discomfort, and gastrointestinal (GI) illnesses like diarrhea and nausea. Waterborne diseases can also be serious, leading to hospitalization and even death. These types of illnesses are often contagious, and can be easily transmitted between humans. Known as

communicable diseases, these must be reported to the Medical Health Officer (MHO) for the region, as well as to the Province of BC. They are monitored in IH by the Communicable Disease Unit and tracked to detect clusters, outbreaks, and common sources of contamination.

Waterborne diseases are generally difficult to trace to a specific water source unless there is a large outbreak of illness. This is due to the multiple potential sources for infection which include water, food, and person-to-person transmission. The last large outbreaks of waterborne disease in IH were in 1996 and 1997, when there were two separate outbreaks of Cryptosporidiosis and one outbreak of Norovirus. The first Cryptosporidiosis outbreak in 1996 was in Cranbrook, and was estimated to have affected more than 2,000 people. The second, in Kelowna, caused an estimated 10,000 illnesses. There were likely many more people exposed to the parasite that causes this disease, as it is estimated that only 10.5% of people who are exposed actually contract Cryptosporidiosis (Newman, Hooper, Powell, & Njenga, 2003). The 1997 Norovirus outbreak in Princeton impacted an estimated 88% of the population. These large outbreaks were the direct result of contaminated water supplies due to inadequate disinfection of source waters.

The following figures highlight the incidence rates of three common waterborne GI illnesses as a rolling three-year average per 100,000 people. A rolling three-year average is used to account for the fluctuations of small case numbers in IH. The orange line represents the IH three-year rate, while the blue and purple lines represent the single-year rate for BC and Canada, respectively. It is important to note that these diseases are not exclusively waterborne, and could be the result of contaminated food, travel, or other transmission pathways. Figure 2 shows the IH rate per 100,000 people for Cryptosporidiosis. Between 2005 and 2014 the rate was essentially flat, though with slight variation over the 10-year period. In 2014 there were approximately 2 lab-confirmed cases per 100,000 people. In comparison, BC saw slightly fewer cases per 100,000 in 2014 (1.5), while Canada experienced slightly more (2.5). Chlorination of water is often not enough on its own to destroy the *Cryptosporidium* protozoa.

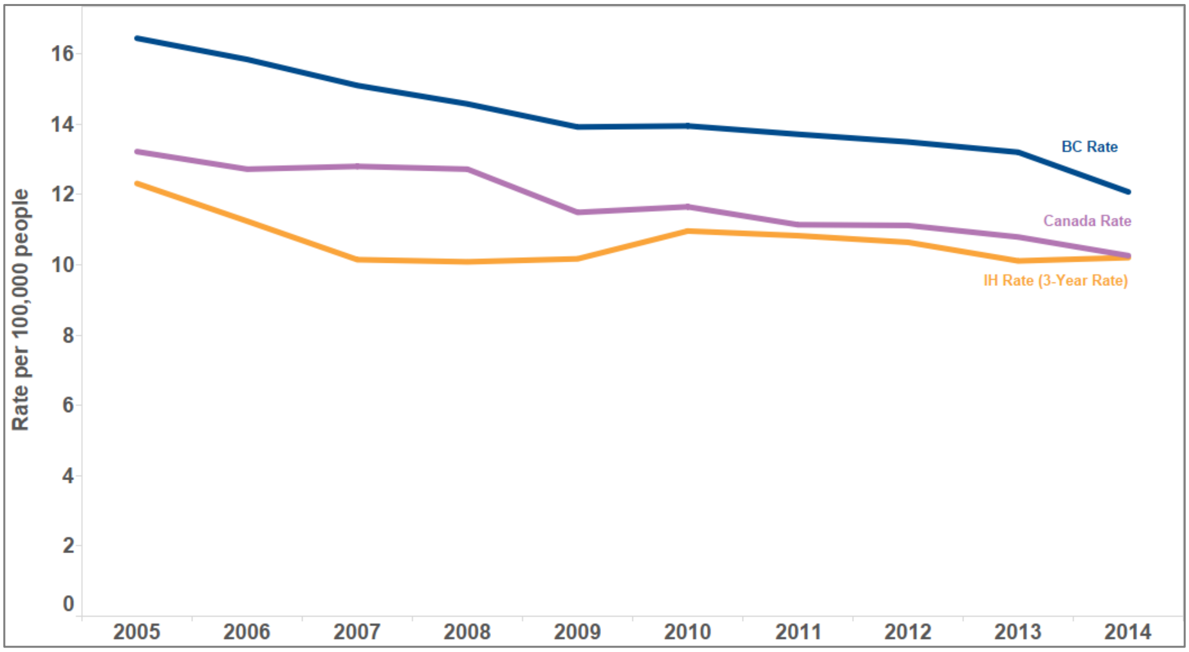
"Waterborne diseases are generally difficult to trace to a specific water source unless there is a large outbreak of illness."



Sources: Panorama (IH Rate); BCCDC/Panorama (BC Rate); Canada Notifiable Disease Charts (Canada Rate)

Figure 2: 3-Year Incidence Rate per 100,000 Population of Lab-Confirmed Cryptosporidiosis Infection, Interior Health 2005 – 2015

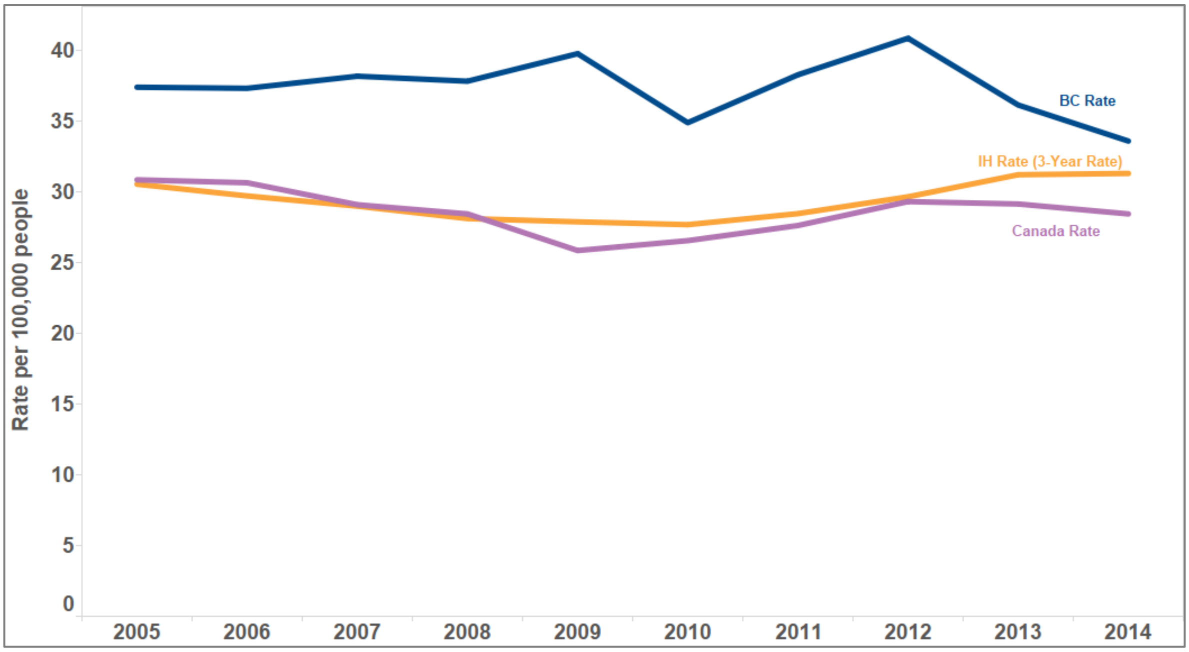
Giardiasis rates for IH, BC, and Canada are shown in Figure 3. All three geographies show a very slight downward trend over the study period. In 2014, there were approximately 10 cases per 100,000 people in IH, which was the same as the Canada rate. BC had a slightly higher rate. Similar to *Cryptosporidium*, *Giardia*, also known as "beaver fever", can cause long lasting effects in people with compromised immune systems, and is of particular concern for water systems drawing from surface water sources. *Giardia* is also difficult to destroy with chlorination alone, and typically requires a second form of disinfection.



Sources: Panorama (IH Rate); BCCDC/Panorama (BC Rate); Canada Notifiable Disease Charts (Canada Rate)

Figure 3: 3-Year Incidence Rate per 100,000 Population of Lab-Confirmed Giardiasis Infection, 2005 - 2015

Lastly, the most common waterborne disease of concern is Campylobacteriosis. The infection rates for IH are highlighted in Figure 4. Similar to *Cryptosporidium* and *Giardia*, the IH rate is quite flat, and falls between the Canada rate which is lower, and the BC rate which is higher. There are far more *Campylobacteriosis* cases each year than the other two illnesses. *Campylobacter* bacteria is predominantly foodborne, but can also be transmitted in water. It causes GI illness that is typically minor, but can become severe in some cases.



Sources: Panorama (IH Rate); BCCDC/Panorama (BC Rate); Canada Notifiable Disease Charts (Canada Rate)

Figure 4: 3-Year Incidence Rate per 100,000 Population of Lab-Confirmed Campylobacteriosis Infection, Interior Health 2005 - 2015

The epidemiologic review undertaken for this report suggests that the burden of waterborne diseases in IH is not at epidemic levels. There are not regular outbreaks where thousands of people get sick from drinking water from their tap. However, the low current level of disease does not mean that improvements to drinking water systems are not necessary. People are still at risk of getting sick, and in fact do get sick every year. It does not take more than a few individual microorganisms to make a person sick. Systems drawing from surface water sources are the most likely to carry pathogenic microorganisms due to their exposure to plant, animal, and human activities. Ground water sources are less likely to become contaminated because they are recharged by water that passes through natural filtration systems in the ground. Across IH, roughly one-third of small water systems, two-thirds of large water systems, and one quarter of First Nations systems use a surface water source, or a groundwater source that is under the direct influence of surface water, such as a shallow well.

“Disease levels are kept low, despite the abundance of surface water sources treated only with chlorination, by a dangerous overreliance on public advisories.”

Disease levels are kept low, despite the abundance of surface water sources treated only with chlorination, by a dangerous overreliance on public advisories. The risk of this overreliance can be attributed to consumers suffering from information fatigue and potentially ignoring advisories, and the significant IH resources needed to closely monitor so many deficient systems.

3. Advisories and Notifications

As per the DWPA, water system operators and delegated DWOs have a duty to protect the public from health hazards that exist or are likely to exist within a drinking water system. As with other environmental health hazards, a principal tool for operators and delegated DWOs is to inform the public of risks and what they can do to protect themselves. This is done by placing an advisory on the system, and ensuring that a corresponding notification is communicated to users that a hazard or risk exists. There are three levels of notifications that can be issued depending on the type of hazard. A Water Quality Advisory (WQA) is used when there is some level of risk associated with drinking the water from a specific system, but insufficient evidence or risk exists to warrant the issuance of a more intrusive Boil Water or Do Not Use Notice. A WQA could be issued in the event of a long term health risk such as an exposure over long periods of time that could result in illness, as opposed to something that would cause more acute health impacts; or it could represent a potential threat to the safety of the water, such as lower-level turbidity potentially shielding microorganisms from chlorination. Examples of some recent WQAs are for unapproved construction of a water supply system; construction/repairs/maintenance within the supply system; and turbidity above the threshold level. WQAs are the most common advisory among large water systems.

The next type of notification is the Boil Water Notice (BWN). This is used when there is a health hazard present in the water supply system that can be mitigated by bringing the water to a rolling boil for one minute. During a BWN it is recommended that any water used for drinking, cooking, brushing teeth, washing dishes, and washing fruits and vegetables to be eaten raw, be treated this way. Examples of some recent BWNs include inadequate treatment of a surface water source and having a positive *E. coli* test result. Boil water notices are the most common notifications issued among small water systems.

The most severe and least common notification is the Do Not Use (DNU) notice. This is administered only when there is an imminent risk of a negative health impact due to drinking water that cannot be mitigated by boiling the water, or the full nature of the risk is not understood. An example that could result in a DNU is a chemical contamination of a water supply system or intentional break-in and tampering at a reservoir.

The primary source of data about our drinking water systems and the advisories placed thereon is a database used by the Health Protection branch of the Population Health Portfolio. This information system is updated by EHOs for multiple program areas, such as Food Safety, Licensing, Recreational Water, and Drinking Water, and includes information about each entity monitored by staff. For drinking water systems, a single record is maintained for each water system, along with related tables that store additional information such as advisories and complaints from members of the public. However, the data are not perfect, and there remain some gaps in the information collected by the health authority. The data presented herein should be interpreted with that in mind.

3.1. Information System Current State

Each water system record includes information about the name of the water system, the physical location, ownership details and contact information, along with additional descriptive and administrative fields. This system is constantly being updated and improved, with data quality checks and audits performed regularly. There is always room for improvement, and we are aware that this system is not immune to the issues of data quality. As such, a concerted effort is underway to revise or develop new data collection policies, and to ensure that staff are trained and engaged appropriately to input data at a high standard of quality on an ongoing basis.

The entire database system was updated in the fall of 2015 to a new platform. With this transition came the resolution of a number of issues, but also the introduction of others. Having strong policies in place and an appropriately trained workforce will result in better recording of water system information. This in turn will lead to a more accurate reflection of the state of drinking water quality across the region for internal reporting. It will also result in enriched communication with water purveyors, local governments, and the public. Internal policies and planning will benefit from data that is accurate, standardized and repeatable. For example, improving the accuracy of geographical coordinates for all systems will improve our ability to plan for emergency situations and hazard mitigation.

An area of recent improvement is the standardization of reasons for the issuance of a BWN or WQA. This enhancement will make classifying and categorizing notifications and advisories more efficient, thus streamlining analysis of current issues among water systems. New data elements and categories should align, where possible, with other provincial objectives/requirements to ensure interoperability with other health authorities and the Ministry of Health. In June 2016 the Ministry of Health selected IH to implement a pilot project to enhance the Provincial Health

Officer's Report on Drinking Water. By September 2016 more than 3,000 pieces of additional information were configured into the information system. With the cooperation of delegated DWOs entering the appropriate data, this enhancement will increase the level of detail for each water system, allowing for more robust analysis.

3.2. Information System Future State

In addition to some specific elements that need to be refined in the database, there remains a gap in the collection of information related to the holistic view of the MBA, as well as operational planning information for the water systems. During routine meetings with water purveyors, delegated DWOs discuss and collaborate on a multitude of areas including acquisition planning, drought and water supply/demand issues, financial planning for system improvements, and the timelines for meeting the conditions on permit and the Drinking Water Treatment Objectives (DWTO). This information is not always captured, and when it is, can often be written down and kept in paper files. Opportunities for better record keeping of enforcement activities and system improvement monitoring should be explored.

Furthermore, there is a need to develop a robust risk assessment protocol against which all systems can be assessed. This will help delegated DWOs prioritize planning opportunities with water purveyors and use standardized information when looking at opportunities for growth. It will also help the office of the MHO to prioritize systems and communities that require additional assistance in meeting the DWTOs within the time frame set out in the recommendations of this report.

3.3. Drinking Water Systems in Interior Health

Drinking water systems within the IH area are classified in four administrative categories based primarily on the number of connections each system provides. A connection is simply where the distribution system branches off to a consumer. For example, a house, a school, and a restaurant are all typically served by one connection each. The systems presented in this section are those that were active at December 31, 2015. Figure 5 provides an overview of the number of active water systems in each administrative group. There were 1,923 permitted systems providing water to consumers at the end of 2015.

Water systems managed by our Small Water Team (n=1,454) are those with fewer than 300 connections, or typically serving fewer than 500 people per day. The majority of these systems have fewer than 15 connections, and are serving fewer than 100 people per day. The Large Water Team looks after systems (n=133) with more than 300 connections, some systems with between 15 and 300 connections, and a few other systems of particular interest. These large systems typically provide water to more than 500 people per day. A small number of these large (n=1) and small (n=9) water systems are only active during the winter.

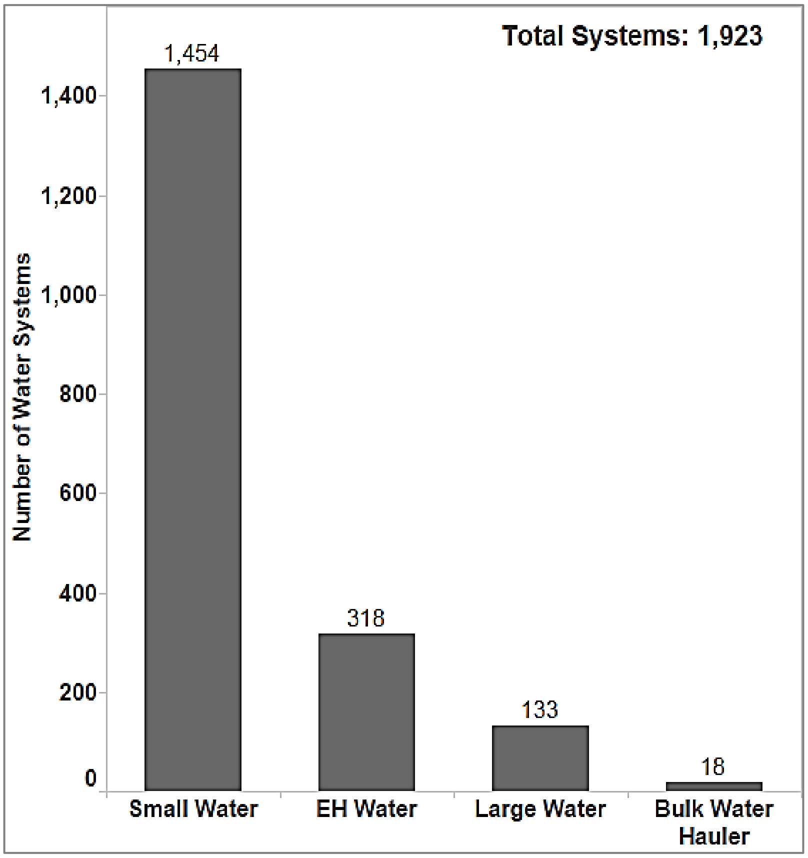


Figure 5: Number of Water Systems by Administrative Group, Interior Health Dec. 31, 2015

Environmental Health (EH) Water systems (n=318) are those that are only in place to serve a licensed or permitted facility, for example a restaurant, daycare or seniors home. If the facility were to close, the water system would no longer meet the definition of a water supply system. Lastly, Bulk Water Haulers (n=18) are vehicles with tanks designed to carry large volumes of potable water to fill cisterns for example.

First Nations communities in IH have 107 systems (Neegan Burnside, 2011), including two that serve more than 300 connections. See Table 4 for the full breakdown. To put the number of drinking water systems in IH in perspective, Island Health, which serves a population that is similar in size to that in IH, stated that they had approximately 900 total active water systems at the time their drinking water report was published in 2014 (Island Health, 2014).

The number of systems serving the population in IH has been rising over the years, far outpacing the growth in population. Between 2006 and 2015, the IH population grew by approximately 7% (BC Stats, 2016), whereas the number of water systems almost doubled from approximately 1,000 in 2006 to the current total at more than 1,900 (see Figure 7). The increased number of water systems is driven by an increase in small water systems. This can be due to the identification of previously unregulated systems, or new small water systems that have been constructed. New strata developments, mobile home parks, and campgrounds are just some examples of development activity that could result in a new small system. Table 1 shows the ownership breakdown of Small Water Systems.

"Between 2006 and 2015, the IH population grew by approximately 7%, whereas the number of water systems almost doubled…"

Table 1: Small Water Systems by Ownership Type, Interior Health Dec. 31, 2015

Ownership	# of Systems
Corporation	505
Sole Proprietorship	217
Partnership	134
Society	126
Provincial Government	109
Other (11 Types)	363
Total	1,454

Large water systems on the other hand have been quite stable in numbers. These are the systems that are primarily owned and operated by local municipal and regional governments and improvement districts. There are 133 large water systems serving approximately 85% of the IH population on a daily basis. This leaves only 15% of the population, or approximately 100,000 people, that are served by the nearly 1,500 small water systems. This can be a serious problem when large capital improvements are required to work towards compliance with the GCDWQ because there are so few ratepayers to fund expensive upgrades. Within large water systems there are exponentially more ratepayers within each system, but this is often offset by the size, complexity, and subsequently higher cost to fund capital improvements.

Table 2 shows the population served by large water systems based on ownership as of the end of 2015. We do not currently collect population estimates in our information system for small water systems.

Table 2: Population Served by Ownership Type of Large Water Systems, Interior Health Dec. 31, 2015

Ownership	# of Systems	Avg. Population	Max. Population	Total Population
Local Gov. (Municipality)	71	5,618	87,000	393,245
Local Gov. (Regional District)	20	3,836	55,000	76,713
Improvement District	18	4,209	22,550	75,768
Corporation	11	4,858	33,160	53,438
Private Utility	9	2,674	10,001	24,067
Other	4	1,032	1,800	4,126
Total	133	4,753	87,000	627,357

The average population served by each system is close to 5,000 people, though the largest system serves nearly 90,000. Municipalities own the majority of large water systems. This is a benefit to planning for long term upgrades because they have councils in place to prioritize community needs. Organized municipalities also benefit from dedicated staff and are better suited to applying for grants from higher levels of government to help offset costs. However, because municipalities also serve the greatest concentration of people in IH, they also have the greatest responsibility to maintain clean, safe drinking water systems.

3.4. Population Health Risk

For the purposes of this report, health risks associated with drinking water at the tap were grouped by risk of contamination with: 1) pathogenic microorganisms, 2) physical contaminants, and 3) chemical contaminants. This report focuses on pathogenic microorganisms, which are the viruses, bacteria, and protozoa that cause infectious diseases such as Cryptosporidiosis, Giardiasis, and Campylobacteriosis. Physical contamination is also addressed, as turbidity can shield microorganisms from certain types of treatment. Chemical contamination on the other hand is indicative of a different type of risk and must be addressed using a different set of tools. From this point forward, unless otherwise indicated, only those WQAs identified as related to the risk of pathogenic microorganisms are included.

To do this, a composite indicator was developed based on water quality advisories (WQA) and boil water notices (BWN). Water systems were then assessed in terms of historical and current days on advisory, geographic distribution, and population affected. The population health risk is exponentially higher as the population increases. For example, a BWN in place on a small water system serving five houses or

"…because municipalities also serve the greatest concentration of people in IH, they also have the greatest responsibility to maintain clean, safe drinking water systems."

10-15 people would have to be in place for many years to accumulate the person-days of risk equal to a large water system serving 25,000 people having a BWN in place for just one day (Table 3).

Table 3: Example of Person-Days at Risk

Population Served	Days on Advisory	Person Days at Risk (Pop x Days)
50	730 (two years)	36,500
300	60 (two months)	18,000
10,000	14 (two weeks)	140,000
60,000	2 days	120,000

Regional districts and improvement districts also provide water to large numbers of people, and sometimes over large geographic areas. These systems operate within and outside of municipal boundaries, and often have responsibility for agricultural operations like farms in addition to residential consumers. This creates additional challenges where water destined for irrigation does not necessarily require the same treatment as water destined for domestic use. These challenges become magnified as new residential development occurs in these areas.

It is vitally important for systems of all sizes and governance structures to bring all stakeholders together and to work collaboratively using the MBA to reduce the risk of contamination as much as possible. In cases where the current system is not adequate to meet the guidelines, stakeholders must work together to create a plan for compliance in a reasonable time frame. See the section on success stories for examples of communities of all sizes that have prioritized their drinking water and realized the benefits.

The primary source of water for small water systems is ground water, with close to two-thirds of systems using wells to extract their water. However, the opposite is true of large water systems with approximately two-thirds drawing directly from surface sources. Surface sources, as explained previously, are more susceptible to contamination, and generally require a higher level of treatment to mitigate risks than ground water sources.

"In cases where the current system is not adequate to meet the guidelines, stakeholders must work together to create a plan for compliance in a reasonable time frame."

Since the beginning of 2006 there have been approximately 1,653 total advisories issued on small and large water systems. Figure 6 shows that of these, roughly 72% of small water advisories were BWNs, whereas only 47% of large water advisories were BWNs. Less than 1% of all advisories were DNUs. It is important to note that advisories should not be interpreted as a measure of health outcomes, as not all people who drink contaminated water will become ill. Rather, in the absence of clusters and disease outbreaks, advisories should be considered as one measure of risk in a system.

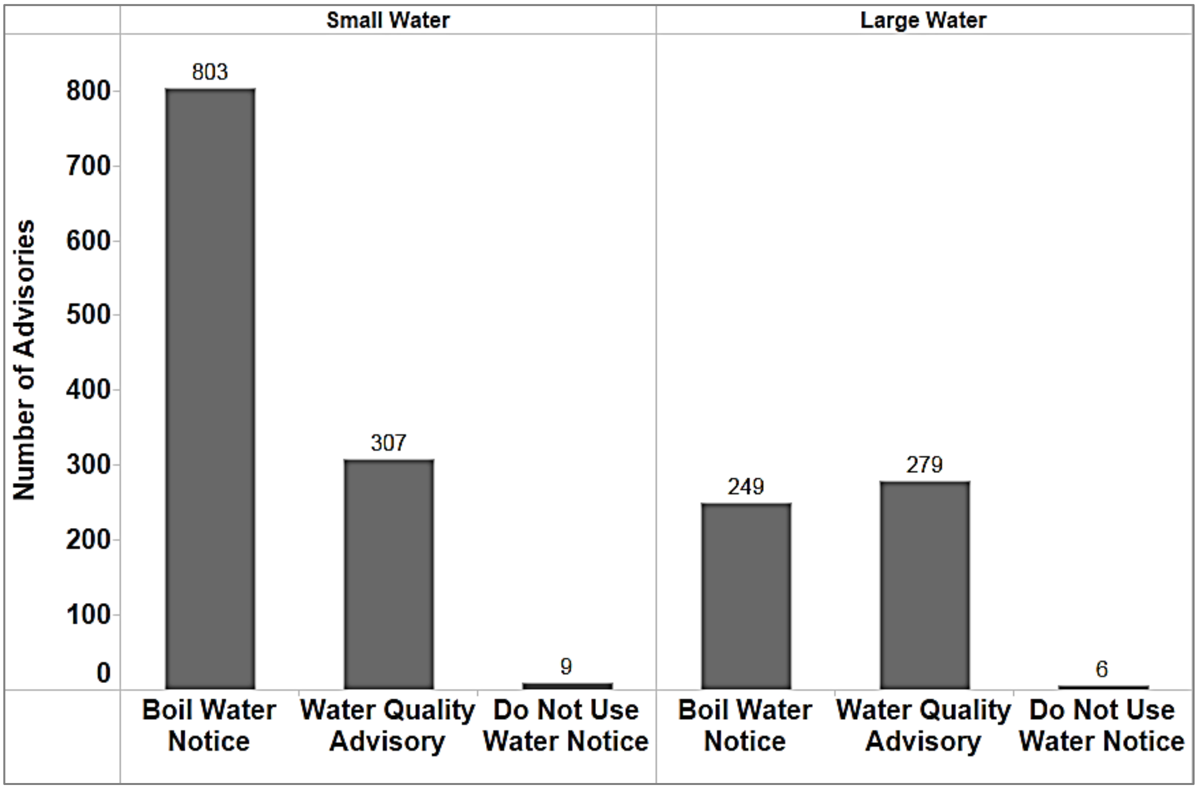


Figure 6: Number of Advisories Issued by Type and Water System Size, Interior Health, 2006 - 2015

The nature of a WQA is such that the risk to public health may be minimal for the average user, but potentially higher for those with compromised immune systems, the very young, and the elderly. While the reasons for a WQA can be quite varied, more than 90% of those issued in IH were due to a risk of pathogenic microorganisms in the water. For example, a rise in turbidity above the lower threshold results in a WQA, whereas turbidity above the higher threshold would result in a BWN. Though potentially minimal, these WQAs are indicative of a risk to the health of consumers and have been included along with BWNs to assess the performance of water systems in IH.

The number of BWNs and WQAs in place at any point in time has grown slowly over the past 10 years, with an absolute growth of approximately 44% across all systems. However, this growth occurred primarily in small water systems between 2006 and 2010. The number of small water advisories has been relatively stable over the last five or six years, whereas the number of systems has grown substantially. Figure 7 shows the number of active WQAs and BWNs in relation to the number of active water systems over the past 10 years for both small and large water systems. In large water systems, a cyclical pattern of advisories is evident. This is likely the result of seasonal turbidity issues each spring.

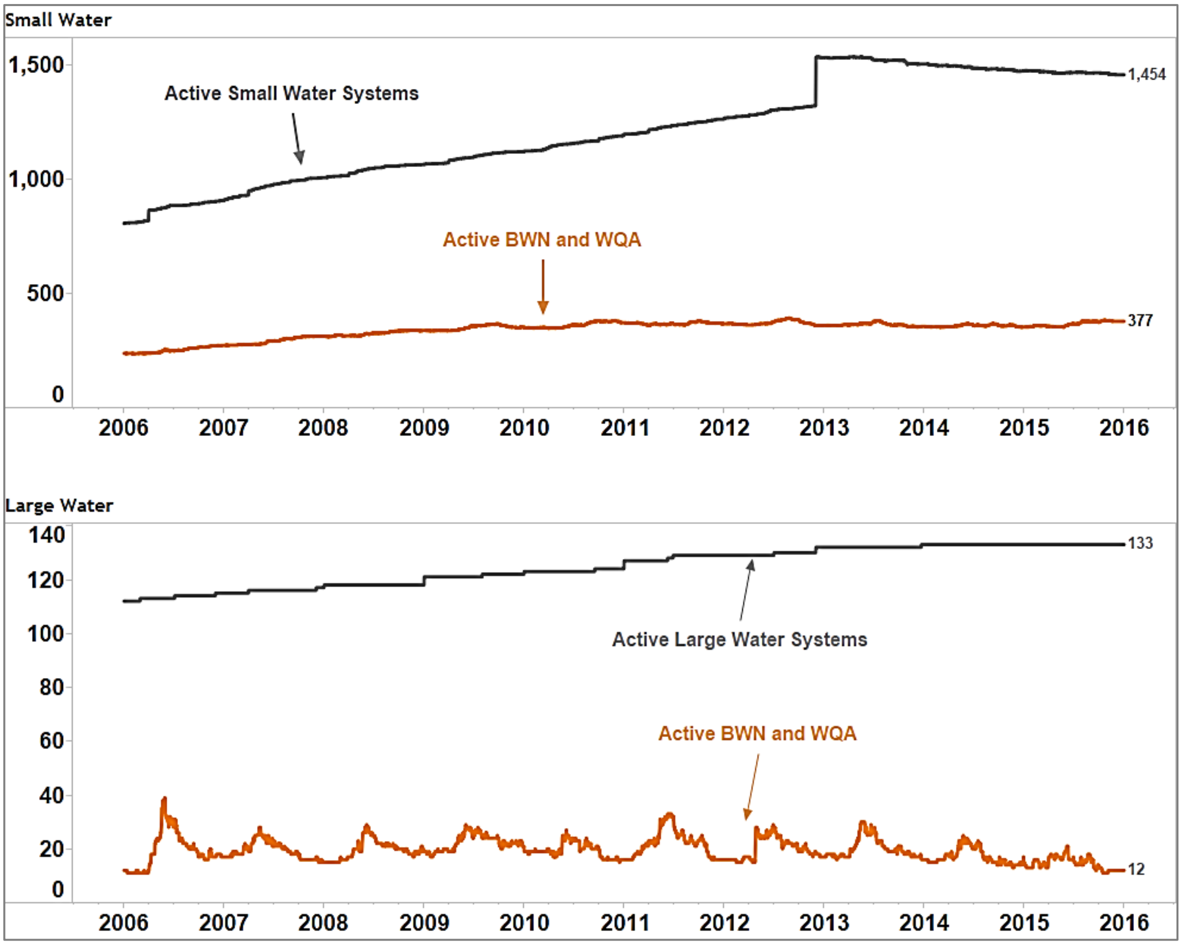


Figure 7: Number of Active Water Systems[1] and Advisories over Time, Interior Health, 2006 - 2015

"…approximately 10% of large systems and approximately 25% of small systems are not making the necessary improvements to reach the goal of safe, clean, and reliable tap water."

While the number of advisories is generally not growing, it is also important to understand that more work is required to reduce the number of and time spent on BWNs and WQAs. The stability of these measures suggests that the same approximately 10% of large systems and approximately 25% of small systems are not making the necessary improvements to reach the goal of safe, clean, and reliable tap water.

[1] The jump in small water systems at the end of 2012 was a period of administrative catch-up in the database system.

The key to this is for water systems using a surface source to improve treatment from chlorination only. Additional efforts need to be made to increase public awareness of their water source, the type(s) of treatment being employed, and the risk of illness and harm if that water is not being treated appropriately. By engaging the public in this process, people will want to hold their water suppliers accountable for providing clean, safe drinking water, and will hopefully be willing to make it a priority for their community.

Water systems in First Nations communities in IH are predominantly small water systems, although some do serve larger populations. In 2011, at the time of a Canada-wide inventory of First Nations water systems (Neegan Burnside, 2011), there were approximately 107 water systems in First Nations communities in IH, serving fewer than 22,000 people (Table 4). At the time of that report, 26% were on some form of drinking water advisory, which is roughly equal to the small water systems in IH as of December 31, 2015. According to the First Nations Health Authority Advisory Status Report for the Interior Region on December 29, 2015, there were 18 active advisories out of 232 water systems. This helps highlight the need for better communication and collaboration between IH and FNHA. In some cases, water systems on reserve supply water to non-First Nations consumers both on and off reserve.

Table 4: First Nations Water Systems by Connections and Population Served, Jan. 2011

Connections	# of Systems	Advisory in Place	Avg. Population	Max. Population	Population Served
0	1		5	5	5
1	1		450	450	450
2 - 14	35	8	25	72	872
15 - 300	68	20	162	785	11,025
301 - 10,000	2		4,700	7,800	9,400
Total	107	28	203	7,800	21,752

Source: Neegan Burnside, 2011

The Provincial Health Officer Discussion Paper (Office of the Provincial Health Officer, 2014) on drinking water program indicators suggests that BWNs are a reasonable indicator for the overall function of a water system as a means of monitoring public health protection and risk. However, reporting a straight count of BWNs and WQAs does not provide a robust measure of risk. There are different reasons for BWNs and WQAs to be issued, some of which cannot be avoided regardless of the treatment system in place.

As such, a new composite indicator was developed. The total number of days on BWN and WQA over the last 10 years has been calculated for each water system. Small and large systems are addressed separately to control for the differences in person days at risk presented in Table 3. This allows us to measure distinct counts of new advisories as well as cumulative risk to the public, and can take into account those systems that jump back and forth between a BWN and WQA, for example during spring freshet when turbidity can be a problem. Figure 8 highlights a randomly selected and de-identified assortment of water systems and their time on advisory between 2006 and 2015. The brown bars represent time spent on BWNs, while the orange represents time on WQAs. The solid bars across the entire chart indicate that a particular system had an advisory in place for the entire 10 year period. The narrow bars that are spaced across time indicate shorter, intermittent advisories, while those with regularly occurring brown and orange bars are likely indicative of spring freshet type events.

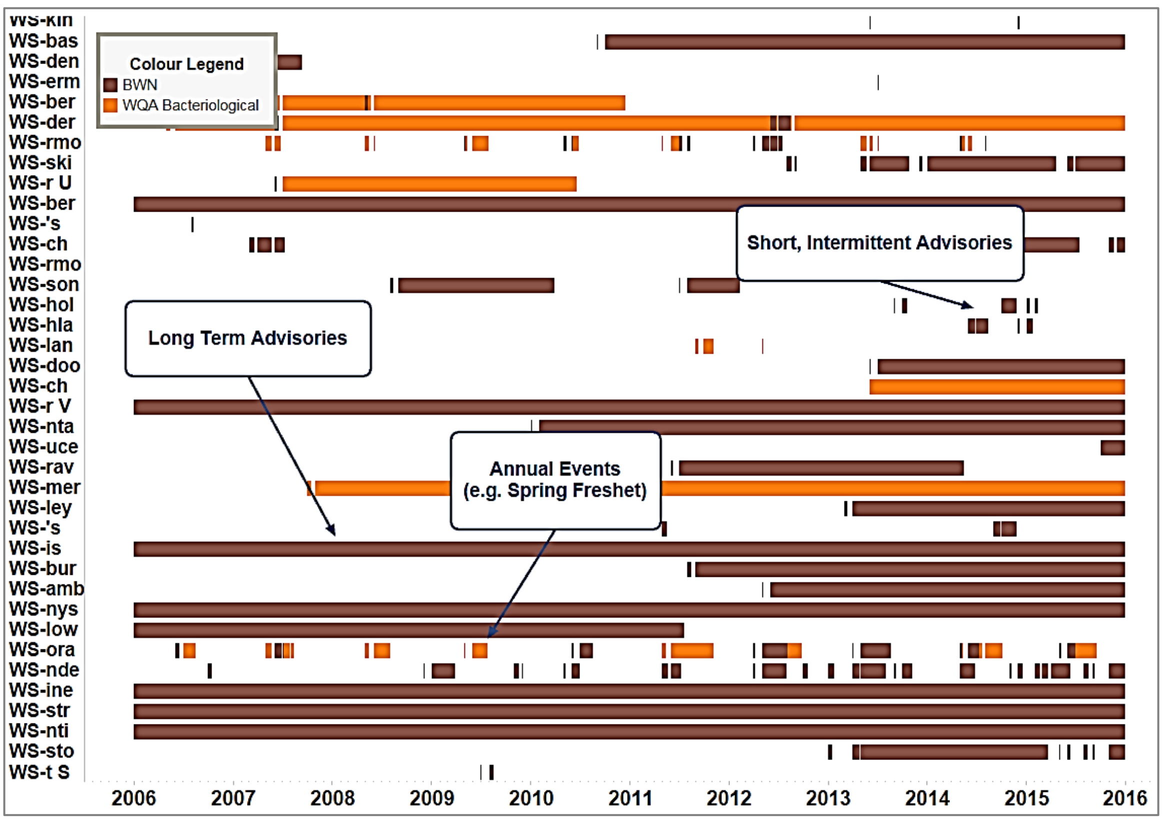


Figure 8: Duration of Boil Water Notices and Water Quality Advisories Related to the Risk of Pathogenic Microorganisms

The short, intermittent advisories are not of primary concern. These could be due to a maintenance issue or a temporary but significant weather event. Systems that are affected by cyclical/annual events are a concern because it means they are not equipped to handle typical fluctuations in water entering the treatment system. Water systems that use chlorination as their sole treatment method and use a flowing surface source are particularly susceptible to this pattern. Systems with advisories in effect for longer than 18 months, known as a long term advisory, along with those that are regularly on a BWN for long periods of time less than 18 months, are of greatest concern. These can be indicative of a systemic deficiency such as inadequate treatment. It is likely that these systems face additional challenges related to the MBA like inadequate source protection.

Table 5 shows the number of BWNs and WQAs that have been issued and resolved since 2006 across IH and the length of time it took to resolve them. This table does not include advisories that have not yet been resolved. In this case, 15% of advisories issued since 2006 are ongoing. Small and large water systems differ in the typical amount of time it takes to resolve an advisory. Over the 10 year period, 60% of large water system advisories were resolved within 1 month, compared to only 39% of small water systems. Furthermore, 15% of small water advisories took longer than 18 months to resolve, whereas only 3% of large water advisories were resolved after 18 months.

Table 5: Boil Water Notices and Pathogenic Microorganism-Related Water Quality Advisories Time to Resolution, Interior Health 2006 - 2015

		1 Month		18 Months		> 18 Months		Total	
		N	%	N	%	N	%	N	%
Small Water	2006	33	42%	19	24%	27	34%	79	100%
	2007	20	28%	31	44%	20	28%	71	100%
	2008	25	34%	25	34%	24	32%	74	100%
	2009	31	38%	36	44%	14	17%	81	100%
	2010	32	33%	50	52%	15	15%	97	100%
	2011	23	25%	51	55%	19	20%	93	100%
	2012	31	36%	51	59%	4	5%	86	100%
	2013	40	39%	55	54%	7	7%	102	100%
	2014	37	45%	46	55%			83	100%
	2015	56	67%	28	33%			84	100%
	Total	328	39%	392	46%	130	15%	850	100%
Large Water	2006	53	64%	26	31%	4	5%	83	100%
	2007	33	67%	14	29%	2	4%	49	100%
	2008	22	50%	20	45%	2	5%	44	100%
	2009	32	60%	20	38%	1	2%	53	100%
	2010	25	58%	17	40%	1	2%	43	100%
	2011	27	50%	22	41%	5	9%	54	100%
	2012	29	57%	21	41%	1	2%	51	100%
	2013	28	64%	16	36%			44	100%
	2014	32	67%	16	33%			48	100%
	2015	23	66%	12	34%			35	100%
	Total	304	60%	184	37%	16	3%	504	100%
Total		632	47%	576	43%	146	11%	1,354	100%

This could suggest that as time goes on, many older systems are able to make the required adjustments to remove the advisory and any immediate public health risk in the short term only. This does not mean that they necessarily meet current guidelines. Table 6 shows that the percentage of unresolved advisories has increased from 9% in 2011 to 19% in 2014.

Table 6: Resolved vs. Ongoing Boil Water Notices and Pathogenic Microorganism-Related Water Quality Advisories, Interior Health 2006 - 2015

		Resolved		Ongoing		Total	
		N	%	N	%	N	%
Large Water	2006	83	100%			83	100%
	2007	49	100%			49	100%
	2008	44	100%			44	100%
	2009	53	98%	1	2%	54	100%
	2010	43	98%	1	2%	44	100%
	2011	54	100%			54	100%
	2012	51	100%			51	100%
	2013	44	96%	2	4%	46	100%
	2014	48	92%	4	8%	52	100%
	2015	35	92%	3	8%	38	100%
	Total	504	98%	11	2%	515	100%
Small Water	2006	79	91%	8	9%	87	100%
	2007	71	76%	22	24%	93	100%
	2008	74	84%	14	16%	88	100%
	2009	81	84%	15	16%	96	100%
	2010	97	84%	18	16%	115	100%
	2011	93	86%	15	14%	108	100%
	2012	86	83%	18	17%	104	100%
	2013	102	84%	20	16%	122	100%
	2014	83	78%	24	22%	107	100%
	2015	84	56%	66	44%	150	100%
	Total	850	79%	220	21%	1,070	100%
Total		1,354	85%	231	15%	1,585	100%

*Percentages for 2015 should be interpreted with caution as they may have been resolved since the data were extracted. Data is current to Dec. 31, 2015

It is important to note that not all systems are equal performers. There are systems that never issue BWNs or WQAs. There are those that are consistently on BWNs and WQAs, and there are many that occasionally issue a BWN or WQA during an extreme weather event or maintenance project. While these advisories do indicate elevated risk in the system, the issuance of an advisory

does not necessarily indicate a problem. The most serious concern is with systems in which BWNs and WQAs are the norm, with no reasonable plan for improvement.

More than 50% of all systems have not issued a BWN or WQA at all in the previous five years. This means quite simply that more than half of all water systems are consistently providing water that remained below the risk threshold for a public notification. In the absence of a fully implemented MBA, this does not necessarily mean there is no risk of illness.

For those that have issued advisories, it is not meaningful to simply count the number of BWNs and WQAs issued. While person-days on advisory would be an even more robust measure, it was determined that splitting small and large water systems would be sufficient to capture the population differences for this exercise. In an attempt to distinguish the systems that spend the most time on advisory, and therefore represent a public health risk, the total number of days on BWN and WQA was calculated for each water system. After summing the days over the five year period 2011-2015 and ranking the systems, the top fifth or top 20% were identified as the top quintile of days at risk for both small and large water systems.

For small water systems, this group had at least 1,242 days on advisory, equal to 68% of the time, and an average of 1,766 days, or 97% of the time. There were 241 small systems that were on advisory every single day of the five year period. Large water system performance was better, with the top quintile having greater than 409 days on advisory, equal to 22% of the time, and an average of 1,122 days or 61% of the time. Comparatively, 80% of small systems, known as the bottom quintiles, averaged less than 100 days on advisory, and 80% of large systems averaged just 37 days on advisory.

"The most serious concern is with systems in which BWNs and WQAs are the norm, with no reasonable plan for improvement."

Maps showing the locations of systems in the top quintile, as well as the bottom quintiles are presented in Appendix 1 for IH Central, IH West, and IH East. The second map in each set represents water systems that improved substantially between the five year period of 2006-2010 and 2011-2015. A system is included if it was in the top quintile between 2006 and 2010, but no longer in the top quintile between 2011-2015, and it reduced the total number of days on advisory by at least 10%. This shows that the system improved in relation to its own performance history and outperformed other systems around them during the same time period.

We will be monitoring water systems based on their days at risk and person-days at risk each year, with the results being presented to MHOs and the IH Board on an annual basis. Our goal is to reduce these numbers, particularly in those systems which continually have the greatest number of days on advisory.

3.5. Geographic Considerations

IH Central

IH Central, which represents the Okanagan region, has the fewest total number of water systems of the three health service areas in IH. However, these water systems serve the largest population of the three; more people than the other two regions combined. Nine of these large systems are in the top quintile of days at risk between 2011 and 2015 (Appendix Figure 1), along with 55 small water systems. However, there were also seven other large water and 12 small water systems that improved substantially from the previous five year period (Appendix Figure 2).

IH West

IH West, generally representing the Thompson and Cariboo regions, has the greatest number of individual systems of all the health service areas, with more than 800 active water systems. There were seven large water systems and 131 small water systems in IH West in the top quintile of days at risk. There is only one large water system in this region that improved substantially between 2006-2010 and 2011-2015. However, one of the systems that is in the top quintile, owned and operated by the District of Sicamous, is featured in the success stories section toward the end of this report. The District has recently opened a brand new water treatment plant, ending a years-long advisory due to a flood event in 2012. An additional 39 small water systems improved substantially in the most recent five years (Appendix Figure 4).

IH East

IH East, representing the Kootenay Boundary and East Kootenay regions, has the greatest number of large water systems, though only three of them serve more than 10,000 people. In the top quintile of days at risk (Appendix Figure 5), 11 large water systems and 104 small water systems are in IH East. Substantial improvement between study periods was noted in three large water and 21 small water systems (Appendix Figure 6).

These maps help to visualize the geographic challenges that IH faces, and provide some context around the distribution of water systems and populations. There have been great improvements over the years in systems of all sizes, and there is much to learn from these successes as other systems work to remove the risk of contamination and ultimately try to meet current guidelines. Two-thirds of the systems in the top quintile of risk draw from surface water sources. While this is consistent with the proportion of large water systems on surface sources across the region, only one-third of all small water systems are served from surface sources. There appears to be an opportunity for additional education and improvement in surface-based small water systems.

First Nations

A 2011 report commissioned by the Department of Indian Affairs and Northern Development, now called Indigenous and Northern Affairs Canada, and prepared by consultants from Neegan Burnside, created an inventory of water systems within First Nations communities across Canada. That data showed nearly 300 water systems across BC, approximately one third of which, or 107, were in IH.

As of December 29, 2015, FNHA indicated that 16 BWNs were in place, along with two DNUs. Maps showing water systems in First Nations communities can be found in Appendix 2. Similar to the non-First Nations water systems in IH, First Nations water systems are primarily small, but with some large systems that serve many thousands of people that are both First Nations and not.

Interior Health has committed to working with local First Nations and FNHA to collaborate on drinking water issues, regardless of jurisdictional or statutory oversight, and to overcome barriers to potable drinking water. This includes working with those purveyors who supply water solely to populations on reserve, and those purveyors who supply water across jurisdictional lines.

"Interior Health has committed to working with local First Nations and FNHA to collaborate on drinking water issues, regardless of jurisdictional or statutory oversight, and to overcome barriers to potable drinking water."

The use of advisory days or population-based person-days on advisory may not be a holistic measure of public health risk in First Nations communities. Other necessary considerations may include the spectrum of severity, source of data, jurisdictional oversight, environmental sustainability, and cultural safety. A collaborative, empowering, and flexible approach to local risk assessments, interventions, and planning requires further development with multiple stakeholders, including individual First Nations, FNHA, and the Partnership Accord Leadership Table (PALT).

4. The Multi-Barrier Approach

Environmental health hazards are the threats to human health that arise from interaction with our physical environment. With drinking water, the threat is that it can become contaminated at any point along its journey from source to tap. The absence of disease or a water quality issue today does not preclude a drinking water disaster tomorrow. Even a water system that is well operated still faces some chance of a failure or contamination event disrupting service or, worse, harming users. Reflecting on the inherent risks in our environment, Hrudey & Krewski (1995) provide the following working definition for the concept of 'safe':

> "… risk so small that a reasonable, well-informed individual need not be concerned nor have a rational reason to change behavior to avoid."

A reasonably informed individual should take action to protect themselves and their family when there is an outbreak of drinking water disease in their community. They should also take action when there is a public health advisory in place with explicit instructions on how to protect themselves. However, it is difficult to know if or when one should alter behavior to avoid drinking water hazards when there isn't an outbreak or active public advisory. A safety plan approach is needed to ensure water users are protected. The BC Action Plan for Safe Drinking Water (2002) established the MBA to safe drinking water, demonstrated in Figure 9, as the standard for all British Columbians. The DWPA and DWPR are key tools guiding all community water supply systems to adopt the MBA.

"The MBA represents the aspects of a drinking water system that need to be in place to ensure the delivery of clean, safe, and reliable tap water."

The MBA represents the aspects of a drinking water system that need to be in place to ensure the delivery of clean, safe, and reliable tap water. Along the outermost rings are the high-level requirements of the DWPA and the GCDWQ. There is also a need for the public to be aware of their water system to understand the value of clean water, and their shared responsibility for stewardship. Research, science and technology support safe drinking water by establishing and evaluating best practices, identifying emerging threats to water safety, and creating new options for hazard mitigation. This is often led by federal agencies and university researchers with results informing provincial and regional policy.

The next ring inward reflects the responsibilities of the health authority and the water purveyors to manage, operate, monitor, and report. This includes having a plan in place for emergencies that threaten water quality and public health. Water system operators need to be well trained to monitor the system and report regularly on results generated from testing.

The core of the MBA represents the three stages in the journey of water destined for drinking. First, the water comes from its source in nature, whether it is an underground aquifer, a flowing stream, or a natural reservoir like a lake. The journey begins with an assessment of the threats to a clean source. For example, land used for livestock adjacent to a source stream may result in pathogens introduced by the animals as they pass through or drink from the source. The next stage involves extracting water from its source and subjecting it to treatment, with the type of treatment depending upon water source and potential threats. Lastly the storage and distribution system transports treated water to the tap. This system must be monitored and managed properly to maintain the quality of the treated water in this final leg of the journey.

"Integrating multiple barriers to water system operations requires the cooperation and collaboration of a whole range of stakeholders."

Integrating multiple barriers to water system operations requires the cooperation and collaboration of a whole range of stakeholders. This includes, but is not limited to, residents, communities, First Nations, health authorities, purveyors, government, and industry. This comprehensive approach to managing water from source to tap is the best way to ensure safe tap water. While it is still possible for contamination to occur where these barriers of protection exist, a reasonably informed individual should not feel compelled to take special action to avoid a drinking water health hazard. They can be reassured that all reasonable steps are being taken to protect their health, and in the event of a system failure they will be immediately informed and able to protect themselves accordingly.

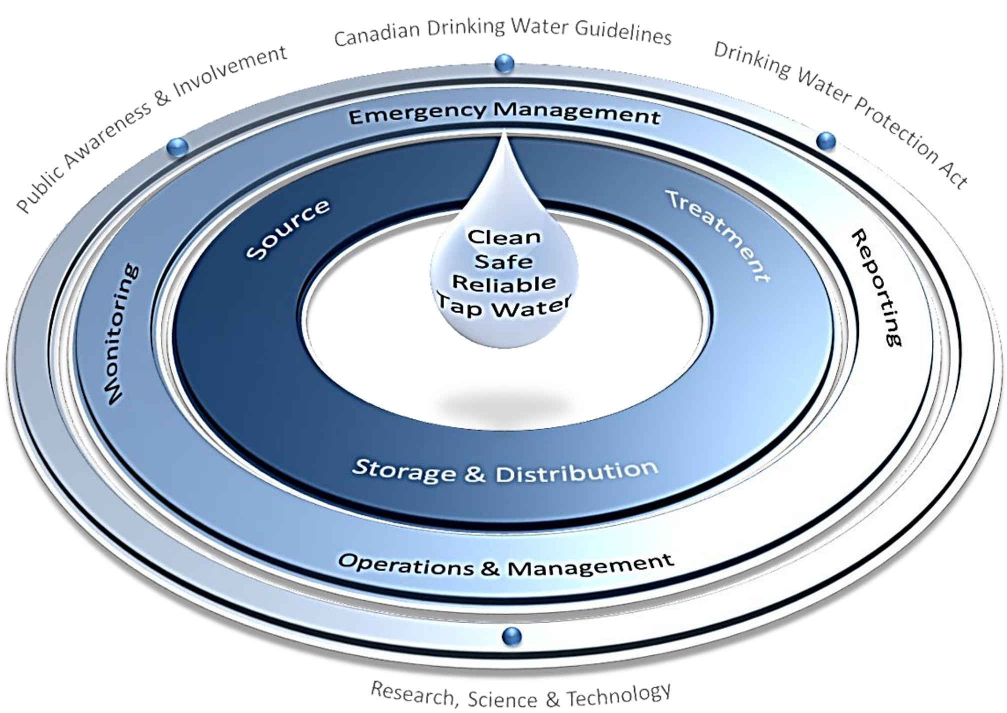


Figure 9: The Multi-Barrier Approach to Safe Drinking Water

4.1. Drinking Water Treatment Objectives – Surface Water

Drinking water systems that pull their water from surface sources such as flowing creeks and lakes, have a much higher chance of contamination than those extracting from ground water sources, which are regenerated as water passes through natural ground filtration.

"…surface sources such as flowing creeks and lakes, have a much higher chance of contamination than those extracting from ground water sources,"

There are three main types of pathogens that can be present in water and are a hazard to human health: viruses, bacteria, and protozoa. In 2012, the Province of BC released a framework under which delegated DWOs can work to ensure that water from surface sources is provided to consumers free from contamination. This framework, as mentioned previously, is known as the DWTO and is sometimes referred to as the 4-3-2-1-0 approach within the Treatment segment of the MBA. These treatment objectives can be described as follows:

- 4-log (99.99%) reduction or inactivation of viruses
  - Common treatments for this objective include filtration, chemical inactivation like chlorination, and ultra-violet (UV)
- 3-log (99.9%) reduction or inactivation of *Giardia* and *Cryptosporidium* protozoa
  - Common treatments for this objective include chlorine, UV, and certain types of filtration
- 2 methods of treatment (dual treatment)
  - The best methods are to pair filtration and one form of disinfection such as chlorine or UV, though two forms of disinfection may be used if the source water meets certain criteria
- ≤ 1 Nephelometric Turbidity Unit (NTU) of turbidity, which is cloudiness caused by suspended sediment
  - Filtration is the recommended treatment for high turbidity
- 0 detectable *E. coli*, fecal coliform and total coliform
  - The best methods to remove *E. coli*, fecal coliform and total coliform is disinfection using chlorine or UV, though filtration will also reduce these bacteria

Table 7: 4.3.2.1.0 Treatment Objectives for Microbiological Contamination

4 refers to the inactivation of viruses
3 refers to the removal or inactivation of parasites
2 refers to two treatment processes for all surface water or unprotected groundwater
1 refers to maintaining a turbidity of less than 1 NTU.
0 refers to indicators of bacterial contamination either Fecal Coliform or *E. coli* bacteria

Delegated DWOs work with water system operators to assess the risk of each individual water system using the MBA. They can then determine the best course of action within the DWTO. IH expects all water systems to move toward and eventually achieve compliance with these objectives. Water systems using ground water sources may be required to comply with surface water objectives if the source is deemed to be under the direct influence of a surface water source, for example a shallow well. Otherwise, they will be expected to comply with the DWTO for Ground Water Supplies.

4.2. Drinking Water Treatment Objectives – Ground Water

Ground water sources must be assessed for their risk of contamination before determining treatment requirements. This is done using the Ground Water at Risk of Containing Pathogens (GARP) assessment tool. There are three possible outcomes:

- At risk of containing pathogens
  - Treatment must match that of surface sources, the 4-3-2-1-0 objective described above
- At risk of containing viruses
  - Treatment must provide 4-log (99.99%) removal or inactivation of viruses, typically done using chlorination or UV treatment
- Low risk of containing pathogens
  - No disinfection is required

These descriptions are meant as an overview of these treatment objectives. The documents themselves provide great detail about the process, and much work is done by delegated DWOs to apply the many pathways provided for safe drinking water. Please refer to the reference documents for more in-depth information.

"IH expects all water systems to move toward and eventually achieve compliance with these objectives."

Currently in IH, the Health Protection Operations team regularly discusses MBA components with water purveyors. However, this qualitative information is not yet stored in an information system that allows for ongoing analysis. Attempts have been made to capture some of this information, such as the creation of spreadsheets to outline the ability of large surface water systems to meet the DWTOs, but more work is needed, and much of it is already underway.

First Nations systems underwent a comprehensive risk assessment during the aforementioned 2011 inventory by Neegan Burnside. That report evaluated the risk of water systems with respect to the MBA parameters of source, design, operation and maintenance, reporting, and qualified operators. Of the 107 First Nations water systems in IH, which represent 37% of the provincial First Nations total, 78 were categorized as High Risk. This represents 73% of all the First Nations systems in IH, and approximately 51% of all High Risk First Nations systems across the province.

4.3. Risk Assessment

Risk is a measure of the probability of something happening, for example a system failure or contamination event; and the consequences that are likely to result, such as someone getting ill or a system going on advisory. Assessing risk is a core practice of environmental public health, and is a responsibility of the delegated DWOs within the IH drinking water program. The provincial Drinking Water Officer's Guide (see Part A, Section 4.5) (BC Ministry of Health, 2014) instructs regional health authorities on how to assess the inherent risk associated with drinking water systems, to rank systems, and to prioritize inspection activities. Examples of risk assessment criteria include the size of population served, the water source type, and the type(s) of treatment. The current version of the Drinking Water Officer's Guide (BC Ministry of Health, 2014) includes tools for conducting screening level and comprehensive assessment for potential drinking water health hazards. IH delegated DWOs use all of these tools in their work and in determining status and priority of drinking water systems.

Whatever the tool or approach, there remains a certain degree of subjectivity and professional opinion in determining the probability and likely consequence of any specific hazard or system deficiency. Standardized administrative tools and processes can help support consistent, defensible assessment of risk and effective communication of results with key stakeholders. Recognized better practice suggests semi-quantitative matrix-based methods are best suited for supporting risk assessment activities of regional health authorities like IH. Module 7 of the BC Comprehensive Drinking Water Source to Tap Assessment Guideline (BC Ministry of Healthy Living and Sport, 2010) provides a risk matrix. This tool is not currently integrated into the IH drinking water program administrative information system, nor is it integrated in the supporting policies such as the Mandate Continuum, though work is underway to determine the best approach for implementation. Formal adoption and integration of standardized risk assessment criteria and tools would likely support improved consistency and transparency for the program.

"Risk is a measure of the probability of something happening…and the consequences that are likely to result…"

5. Consultation with Drinking Water Operators

Consultation with drinking water operators and community suppliers began while this report was being developed. External stakeholder consultations took place between July and September, 2016 in 10 communities. Care was taken to select a mix of geographic locations, with representation in each of the three health service areas, as well as a mix of large and small drinking water systems. Consultations were conducted with two municipalities, four regional districts, and four irrigation districts responsible for approximately 60 individual drinking water systems serving more than 200,000 people; that is, greater than 25% of IH's population. The focus of the meetings was to explore the form and function of a drinking water report, and to gain insight in to the most pressing issues and challenges associated with their respective drinking water system(s). The draft recommendations of the report were also shared. A qualitative analysis of the feedback from these consultations identified the following four main themes.

Theme 1: Goals, objectives, and expectations need to be clear and achievable

This was the most common theme expressed by the water operators and suppliers that were consulted. Achieving safe, clean, and reliable drinking water is a shared goal among all suppliers. The desire is for flexibility in the approach, understanding that every system will have different challenges, and will require different levels of engagement to achieve those goals. Strong, consistent communication from IH with a focus on education and advocacy was expressed as the primary need for some communities. There was a concern from some purveyors about over-regulation, and forcing a blanket timeline on everyone. However, most saw value in consistent timelines and expectations as an additional layer of support for the work they are already doing.

Theme 2: Residents of our region need to be informed about the significant efforts and investments required to ensure clean, safe, and reliable water at their taps so they can lend their support for the necessary infrastructure improvements

The next most common theme centred on the idea that water treatment is expensive, and often requires the support of ratepayers to approve infrastructure investments and/or loans. In order to get the support of the ratepayers and politicians, there needs to be a better understanding of the needs and why treatment upgrades are important. Water treatment is just one part of this, and the value of watershed land-use planning, source protection, and operator training also need to be communicated. The general public misperception that water is naturally clean, abundant, and cheap was expressed as a significant barrier to drinking water systems receiving appropriate support and investment. It was indicated that MHOs can, as medical doctors, lend their voice to water suppliers to help communicate health risks to the public. Despite best efforts, sometimes referenda to borrow money can fail, challenging local governments to navigate conflicting legal requirements between the public health legislation and the local government legislation.

Theme 3: Extra attention is required for tailoring information and communications and making the information relevant for community leaders and users

This theme is a derivative of Theme 2, where appropriate communication can help people understand and value their water system. For community members to really embrace their water service they need to be engaged in the way funding is used, how their system performs, and what deficiencies mean for the risk to public health. This theme speaks to the importance of knowledge translation as a tool to engage the public in their water system, but also to support the supplier as they work to improve the system using the MBA. Local leaders require information on risk and the needs of their water systems, as well as information on their roles and responsibilities as water system owners. This theme ties in to one of the recommendations of this report, which states the need for a broad communication plan to be developed.

Theme 4: Small water systems face greater challenges in accessing and maintaining necessary technical skills and resources, including regularly and effectively engaging with users

This theme is specific to small water purveyors because their challenges can be different than those of larger systems, and may require a different level of support. There is the feeling among some small water system operators that they have been forgotten in previous initiatives because their relative risk to public health is much smaller. This can be difficult to reconcile. Owners and operators are often challenged in speaking with consumers to clarify issues, leading to a perception that the only time small system users are engaged is when they are asked for money to improve or fix the system. Furthermore, it is sometimes difficult with small water system owners to recruit, train and maintain operators. That speaks to an important area of need particularly in small water systems that is developing and maintaining competency in safely and effectively operating a small drinking water system.

6. Success Stories

Over the years there have been many examples of communities that have made clean water a priority. They put together strong plans, working with IH delegated DWOs, and secured funding from multiple levels of government. Each situation is unique to the issues faced in the community. Here are some pathways to improvement.

Each situation is unique to the issues faced in the community.

The City of Kamloops

The City of Kamloops is the second largest municipality in IH, with a population of approximately 90,000 people. The municipal water system draws from the North Thompson River, and serves the entire city. As a water source, the North Thompson is reliable and, compared with many other parts of Canada and the world, a high quality source. However, it is also known to have significant concentrations of pathogens including Giardia and Cryptosporidium, and spring turbidity levels approximately 100 times higher than the level at which a WQA is issued. Historically, this water was treated solely with chlorination, meaning that a public health risk existed. In 1998 the IH MHO concluded that the risk to public health needed to be addressed through additional treatment. An order was issued that required the City of Kamloops to upgrade the system, including the addition of filtration, by 2003. The City had been exploring opportunities for improvement but had struggled with the cost required for the additional treatment needed to meet the GCDWQ. Following a legal review, extensive debate and consultation for a borrowing bylaw, the City was ultimately successful in securing $50 million, or two-thirds of the cost through provincial and federal government funding to build their new treatment facility. The Kamloops Centre for Water Quality opened in 2005, and is now a world class facility highlighted by innovative pre-treatment strategies and membrane filtration. It also acts as a hub for learning and excellence in drinking water system operations for our region.

The District of Sicamous

The District of Sicamous is a small municipality of approximately 2,500 people at the junction of Mara Lake and Shuswap Lake. The water system draws directly from Mara Lake, which had typically been a very high quality and reliable source. However, as a single-disinfection treatment system with chlorine only, the District was vulnerable to contamination including protozoan pathogens like Giardia and Cryptosporidium. A long term plan was in place to improve the system by adding UV disinfection as a second treatment option. This would keep costs down in comparison to adding filtration. Unfortunately in June 2012 a debris flow was triggered by an extreme rain event, and millions of tons of debris were deposited near the water intake in Mara Lake. A DNU was immediately issued due to potential chemical contamination from vehicles and industrial materials involved in the flow. After this immediate risk passed, the long term changes to turbidity in the lake meant that a BWN had to remain in place. It also meant that the long term plan to add UV to the existing chlorination disinfection would no longer be an effective upgrade. The community worked with provincial staff and was successful in acquiring $3 million in emergency relief funding. The District then came together to pass a borrowing bylaw through referendum for the additional $5.7 million needed to upgrade the system to include filtration. In December 2015 the new ultrafiltration treatment plant was opened, and the long-term BWN was finally lifted. This new system fully meets the GCDWQ, and will be an asset to the community for decades to come.

The Village of Clinton

The Village of Clinton has an estimated population of just over 600 people. This small population size presents many resource and capacity challenges that are common among smaller water systems. Water is pulled from nearby Clinton Creek, which is susceptible to periods of high turbidity during spring runoff. Their sole treatment was chlorine disinfection, and was inadequate to address the issues and health risks that come along with high turbidity. The result was that local residents and visitors were met with frequent and lengthy advisories and notifications due to potentially unsafe tap water. Adding to the issues that are present with a single treatment system, the watershed contains significant dissolved organic compounds that get released by trees and other vegetation. On their own, these compounds do not pose a health risk. However, when chlorinated, by-products like trihalomethanes are created, and these can become harmful over time. Additionally, it is possible that these compounds can interfere with the disinfection process, resulting in additional risk. The Village was aware of these factors, and worked with their delegated DWO to explore a number of options for water system improvement. They examined a number of different treatment technologies, as well as a separate groundwater source. Ultimately, it was decided that a full filtration plant was the best option. A staged approach was developed, and the Village began to prepare submissions for provincial and federal government funding support. Following an unsuccessful funding campaign in 2011, Clinton used feedback from the Union of BC Municipalities and the Ministry of Health for an improved application for Gas Tax Funding in 2012. They were successful, and secured $2.45 million. In December 2014 the new micro-membrane plant and associated reservoir was opened, with tap water in the Village fully meeting the CGDWQ.

Lytton First Nation

Lytton First Nation is made up of 56 reserves totaling more than 14,000 acres of land (Lytton First Nation, 2016). One of the reserves, Nickeyeah 25, was the site of a collaborative and innovative project in partnership with RES’EAU-WaterNET, Aboriginal Affairs and Northern Development Canada, BI Pure Water, KWL and Lillooet Contracting (RES'EAU-WaterNET, 2016). This project showcased the benefits of strong engagement, while also highlighting where improvements could be made. Additionally, it provides an example of some emerging technology that allows small communities to test a range of solutions on their source water before making an expensive decision. One of the main challenges was surging turbidity of the source water at certain times of the year. This is a fairly common issue in many drinking water systems using surface water as a source. The source water for Nickeyeah is the Stein River system, which is subject to seasonal fluctuations in quality due to snowpack melt and weather (RES'EAU-WaterNET, 2016). A mobile test lab was set up on site to measure the variability, and to see how different potential solutions perform under different conditions. An appropriate technology was selected that included UV, filtration and chlorination, and the new water treatment plant was constructed, along with upgrades to the intake and storage reservoir in 2015 (Visser Sales Corp., 2015). This is an example of the type of innovation and collaboration that can happen when it originates in the community and is supported by its members. There is opportunity for IH and FNHA to collaborate and empower First Nations communities to find solutions that meet their needs.

7. Conclusions and Recommendations

While there remain many challenges in addressing the potential for unsafe drinking water in IH, there is plenty to celebrate. In early 2016, the Province of BC released the list of infrastructure projects to be funded under the Government of Canada Gas Tax Fund. Communities in IH received more than $30M towards improvements of drinking water systems. This kind of success would not be possible without the strong collaborative relationships built between delegated DWOs, local governments, and water suppliers. The improvements stemming from these grants will help ensure access to clean, safe drinking water for generations to come in communities of all sizes.

There is still plenty of work to do. The barriers faced by many small systems remain. The challenges faced by irrigation districts to meet the needs of both residential and agricultural consumers remain. The difficulty of developing plans and securing funding will continue. However, every year we are made aware of new success stories and creative ways that suppliers have been able to use the MBA to appropriately protect consumers from health hazards. This report has shown that drinking water needs to remain a priority for IH.

In order to keep moving toward the goal of 100% compliance with the GCDWQ, improvements still need to be made. The following six recommendations will help us get there:

1. IH Medical Health Officers (MHOs), delegated Drinking Water Officers (DWOs) and Communications Officers should develop and implement a community engagement strategy with water suppliers, municipalities and regional districts that encourages in-depth local dialogue over the next 12-18 months.
    a) The strategy should follow a logical order that includes all water systems prioritized by risk and population size.
    b) IH program staff should collaborate with the Ministry of Health in developing and implementing this strategy based on community readiness for change.
2. Delegated DWOs should work with all large water systems using a surface source to achieve provincial treatment objectives by 2025. This may serve as a goal upon which water suppliers, local governments, MHOs and delegated DWOs develop local improvement plans that take into consideration community needs, value engineering, construction, provincial and federal grant opportunities, and cost.
3. Delegated DWOs should report annually to the Chief MHO on water systems at highest risk and which are unable to implement the multiple barrier approach to safe drinking water. Reporting may include barriers that are preventing water suppliers from meaningful progress, and the consideration and use of progressive compliance measures available under the *Drinking Water Protection Act*.
4. IH program staff should enhance information management to support reporting on multiple barriers for drinking water safety that aligns with provincial reporting.

5. IH program staff should collaborate with and empower First Nations communities and the First Nations Health Authority to achieve safe drinking water for First Nations people. Opportunities may include aligned reporting of waterborne disease rates, public advisories and use of the multiple barrier approach to ensure clean, safe and reliable drinking water.
6. IH program staff should work with the Ministry of Health and local and provincial partners to explore an area-based management approach to drinking water systems, similar to that used for liquid-waste management. This approach would need to include methods to engage communities in planning for sustainable small water systems and to identify funding mechanisms to support.

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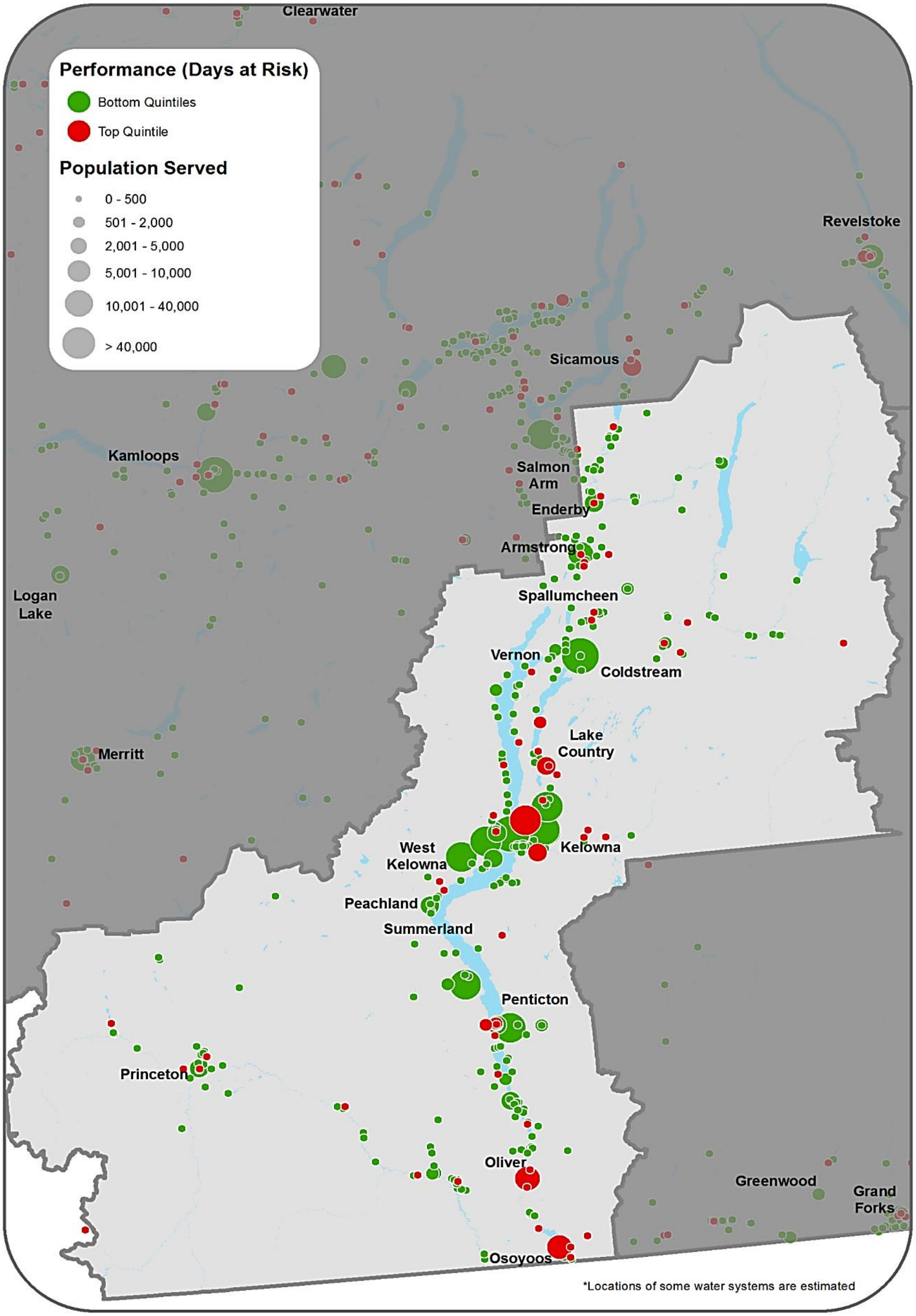
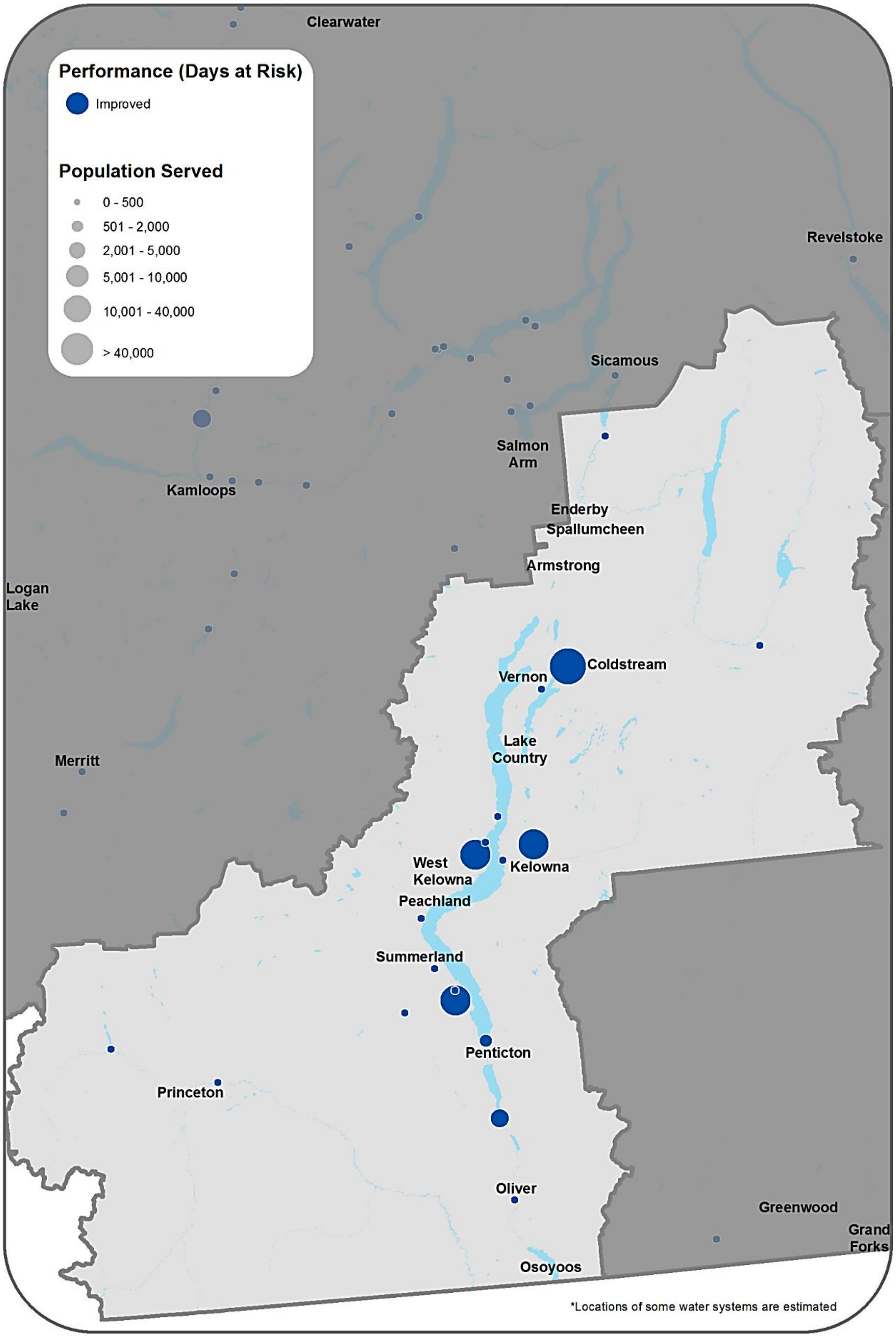
Appendix 1

The following six maps are presented as pairs, based on IH health service areas. The first map in each pair shows the locations of individual water systems, represented by a circle. The red colour represents the top quintile, or top 20% of systems for days at risk, while the green represents the bottom quintiles, or 80% of systems. Each circle is sized by the population served by the water system. The largest circles represent the largest water systems. Days at risk are not the only measure of risk in a system. Similarly, systems with very few days at risk are not necessarily safe, as was discussed toward the beginning of this report.

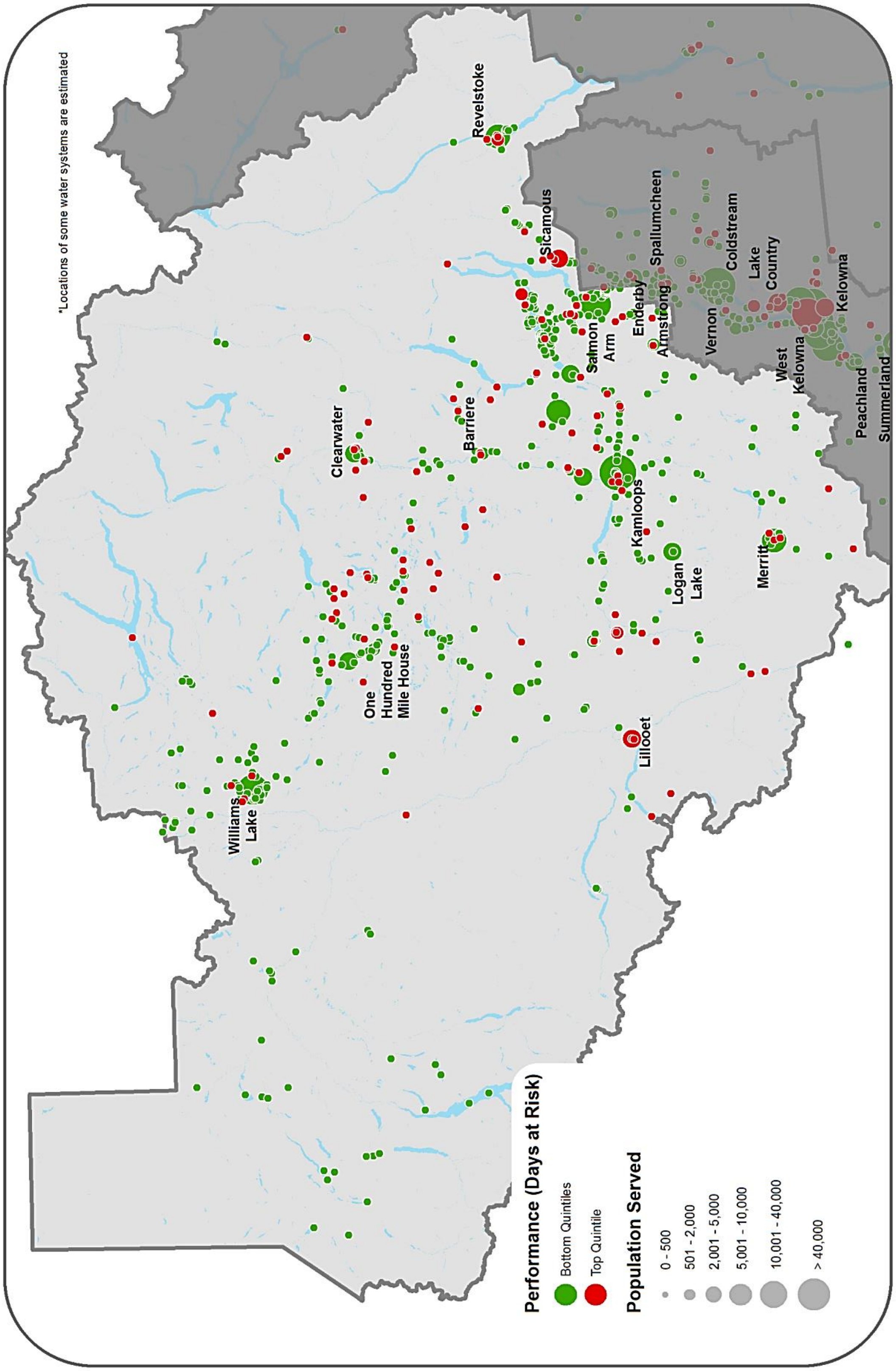
The second map in each pair shows the water systems that improved their days at risk substantially from one five-year period, 2006-2010, to the next, 2011-2015. Each blue circle represents a water system that was in the top quintile for the period 2006-2010, but NOT in the top quintile for the period 2011-2015. Additionally, they reduced their days at risk by at least 10%. The size of the circle again represents the population served by the water system.



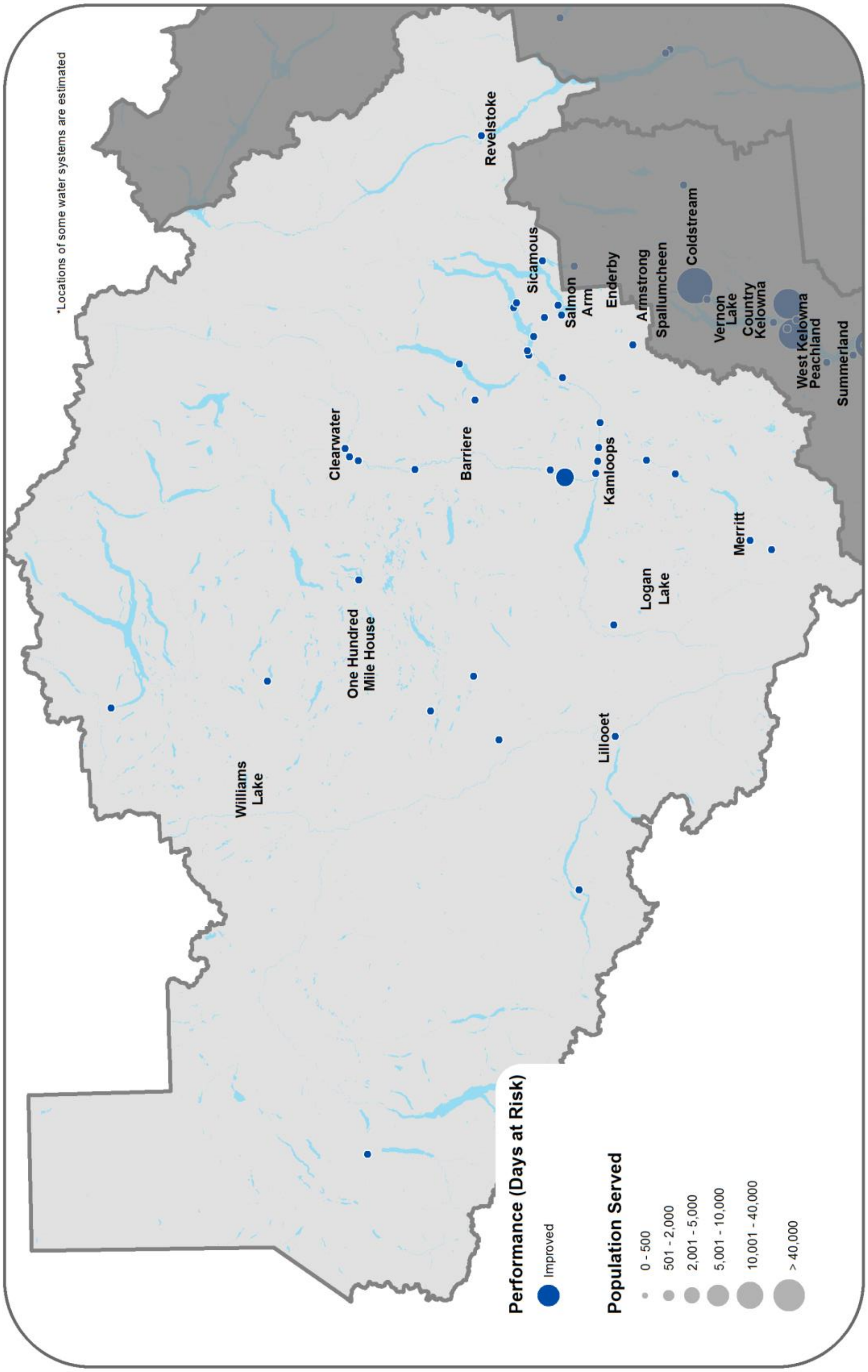
Appendix Figure 1: IH Central Water System Days at Risk



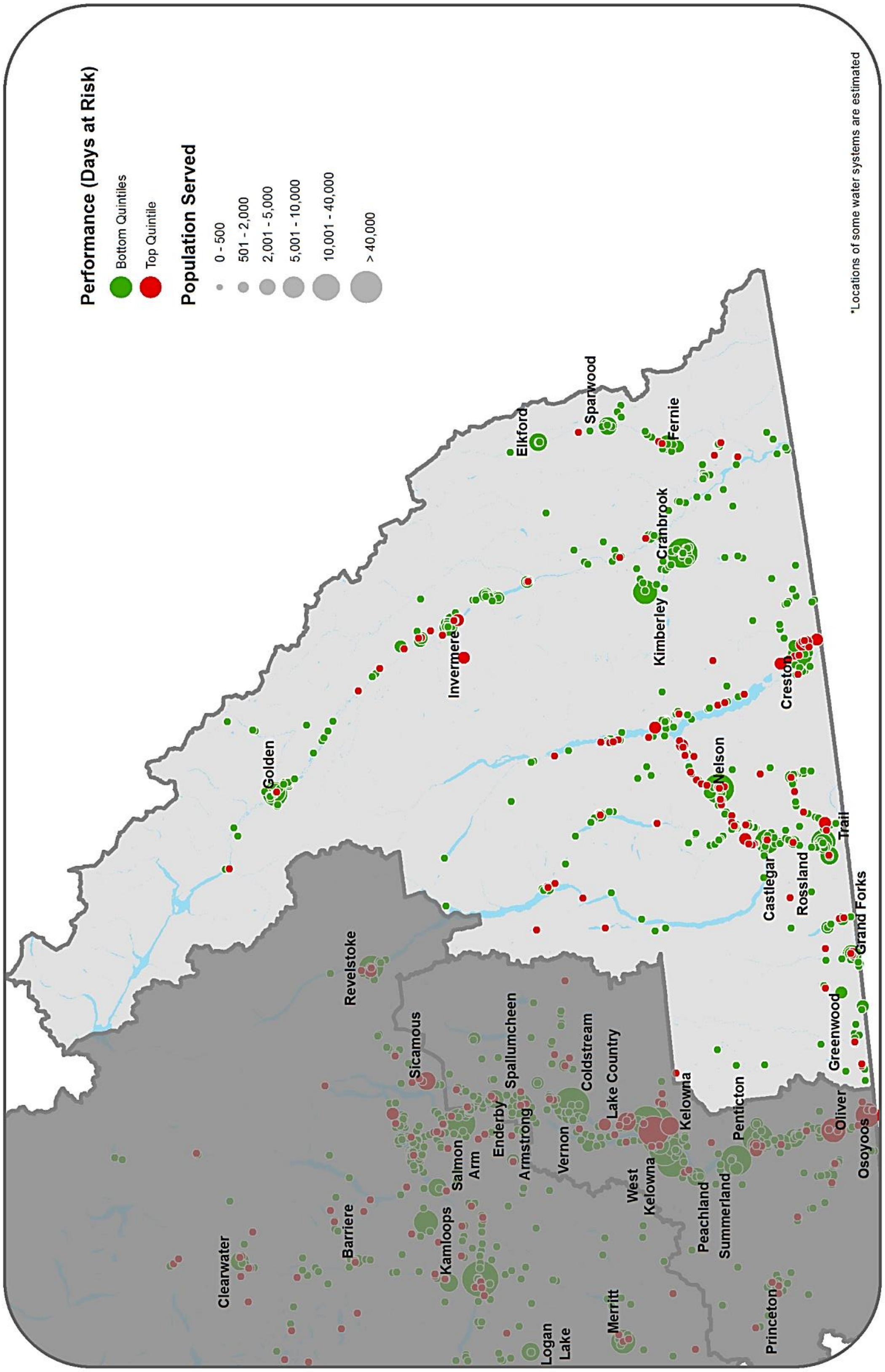
Appendix Figure 2: IH Central Improved Water Systems 2006-2010 to 2011-2015



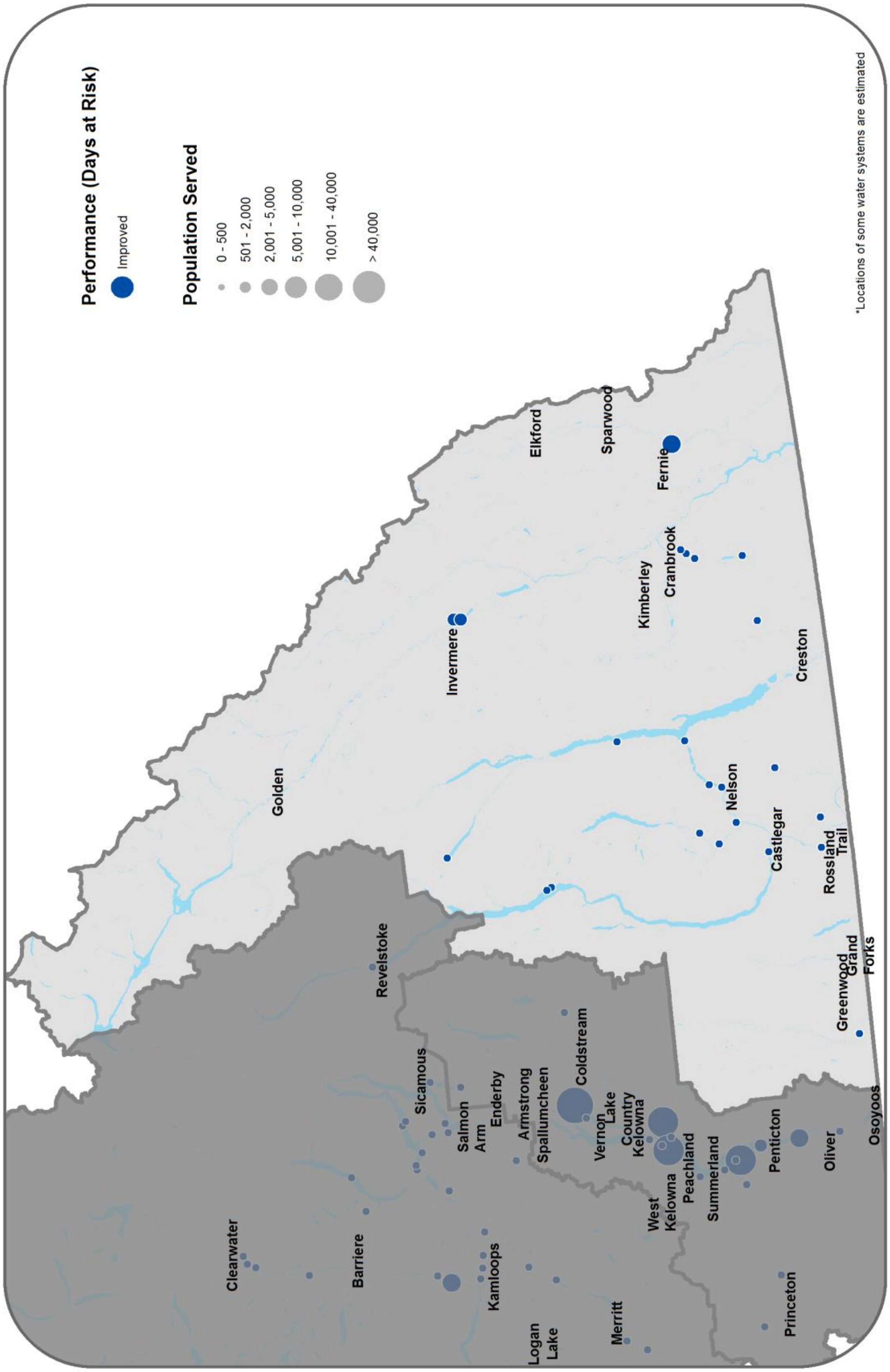
Appendix Figure 3: IH West Water System Days at Risk



Appendix Figure 4: IH West Improved Water Systems 2006-2010 to 2011-2015



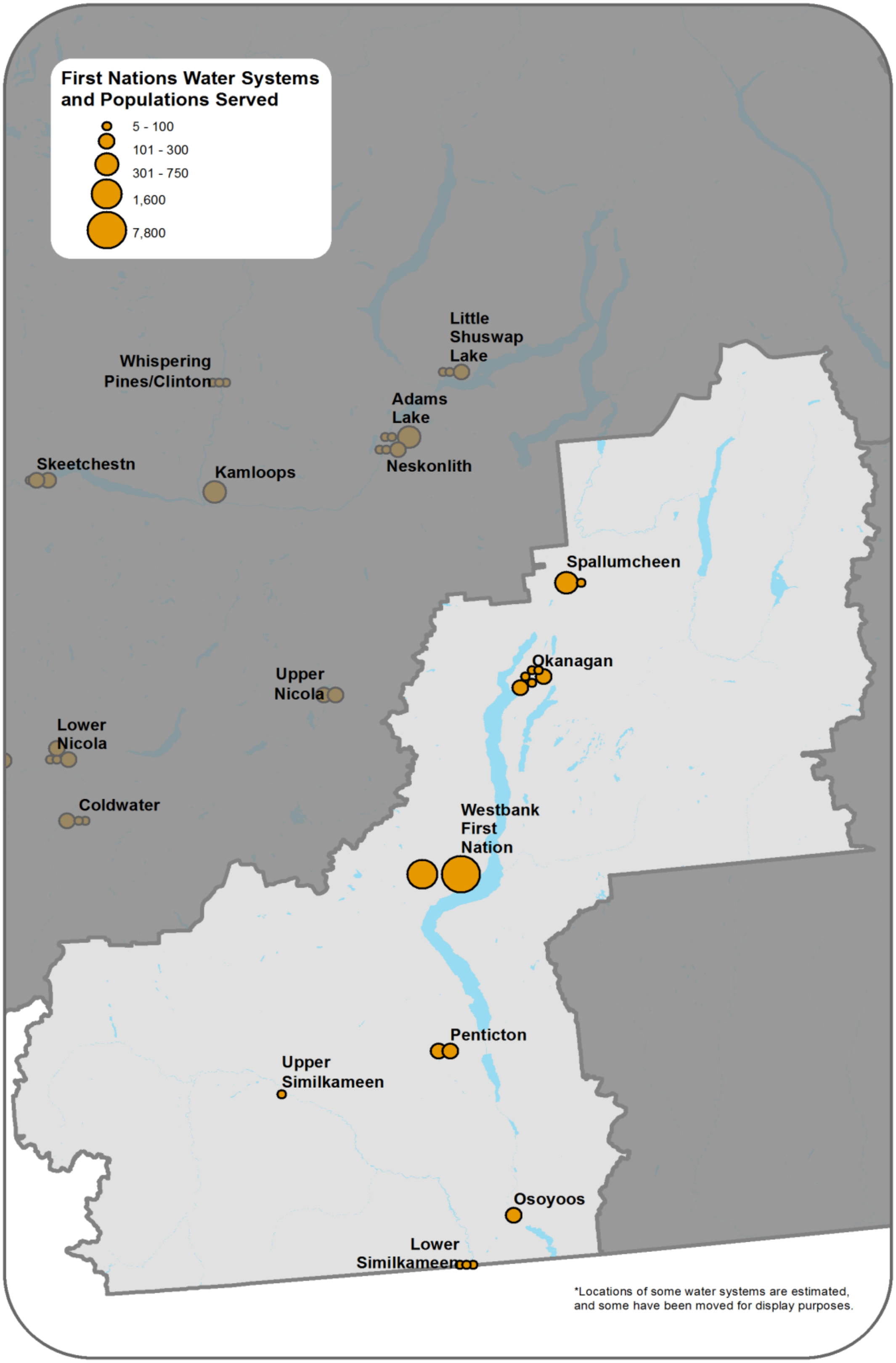
Appendix Figure 5: IH East Water System Days at Risk



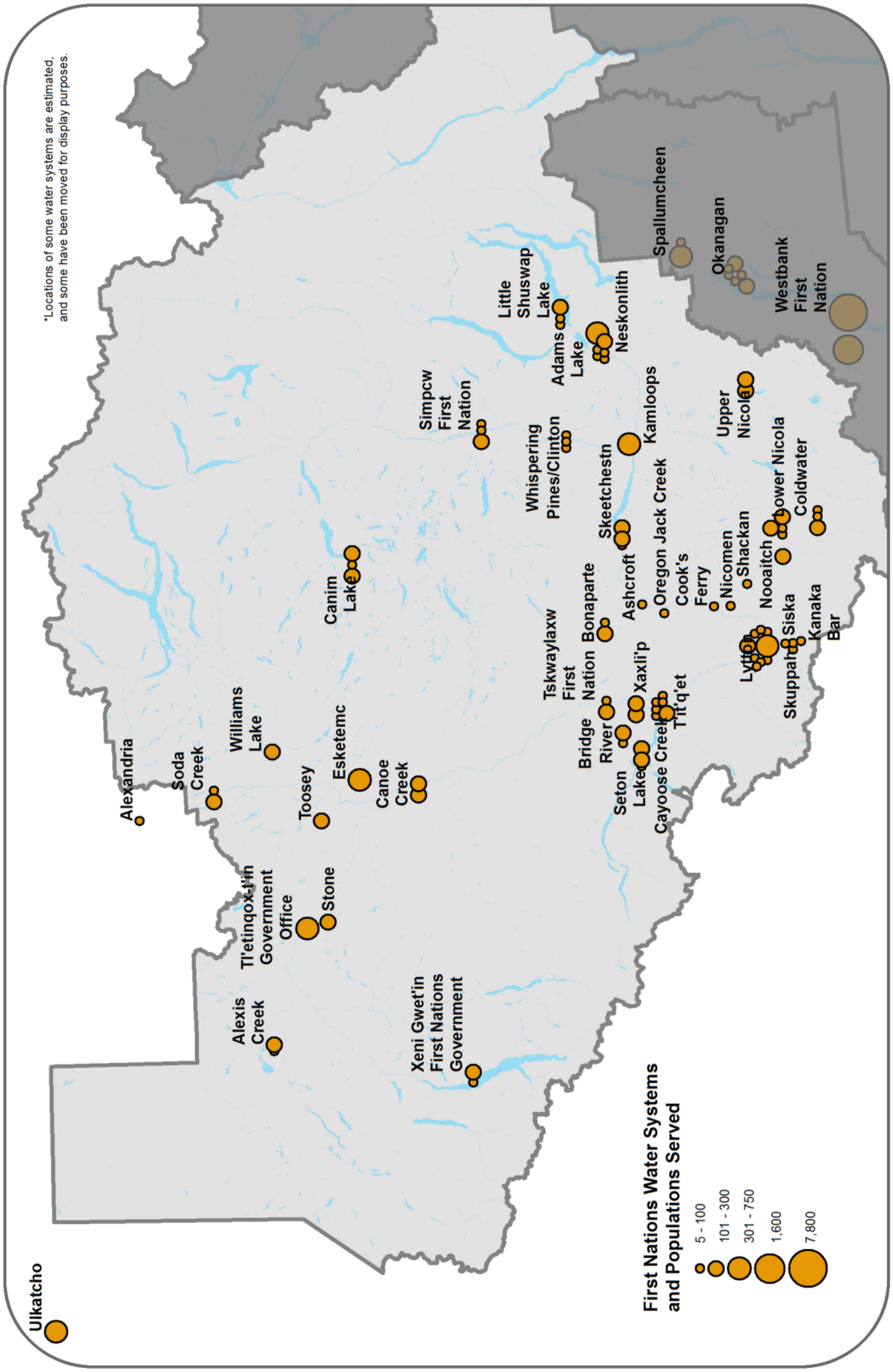
Appendix Figure 6: IH East Improved Water Systems 2006-2010 to 2011-2015

Appendix 2

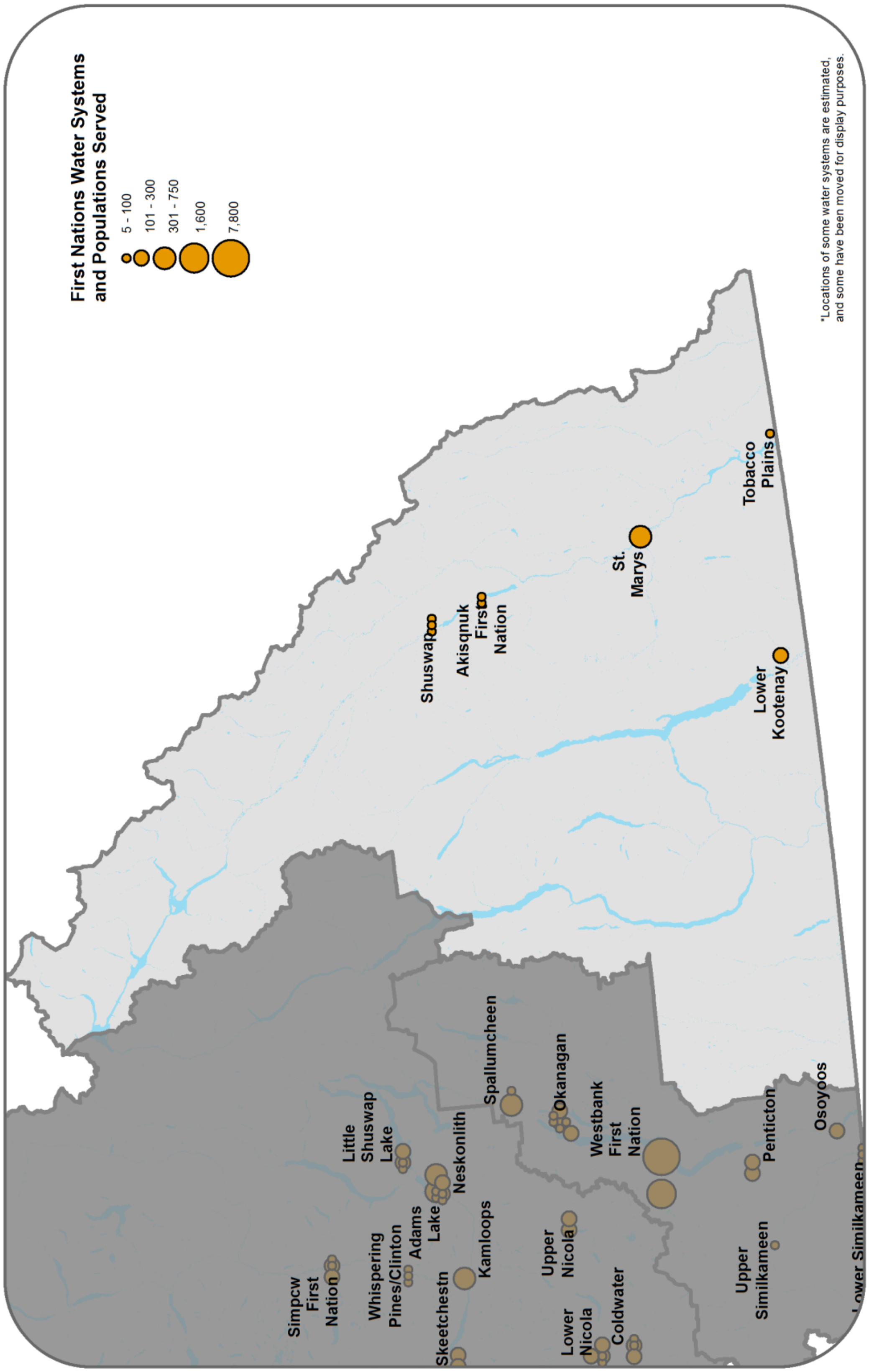
The following three maps show the inventory of First Nations water systems, as captured by Neegan Burnside (2011) and transcribed for the purposes of this report. The locations of individual water systems are represented by an orange circle which is sized by the population served. The largest circles represent the largest water systems.



Appendix Figure 7: First Nations Water Systems in IH Central



Appendix Figure 8: First Nations Water Systems in IH West



Appendix Figure 9: First Nations Water Systems in IH East