Framework for Safe Drinking Water

In Canada, municipalities own and are responsible for drinking water treatment facilities and must supply the public with safe drinking water. This task is often more difficult in rural communities due to the fact that they typically only have access to poorer quality source water than that to which cities have access. First Nations communities face similar challenges. However, in their case, they are under federal government jurisdiction and the federal government pays for the construction of their water treatment plants. The First Nations communities do, however, pay for operational and chemical costs.

First Nations communities may want to sign Band Council Resolutions to reject responsibility for their own drinking water quality until such a time that they have the necessary equipment to consistently produce sufficient safe drinking water for the members of their communities. Furthermore, some provinces have provincial standards for drinking water quality but federally there are only the Guidelines for Canadian Drinking Water Quality, and these guidelines are not legally enforceable. Smaller communities (such as rural and First Nations communities) general have less expertise, fewer resources, and poorer quality source water than larger cities. Another problem is that most existing water treatment technologies are optimized for larger centres and may not work as well when scaled down or applied to poorer quality raw water sources. This framework is meant to counter these challenges and streamline the daunting task of building new or updating older drinking water treatment facilities. By looking at it from both the legal and health perspectives we can help communities get the safest drinking water possible.

Diligence in Building Drinking Water Treatment Facilities

A very helpful document called Safe Drinking Water for Public Water Systems: an Overview of a Diligent Approach has been published by the Nova Scotia government. This document summarizes the responsibilities of public water system owners in that province, but much of it is relevant to owners and operators across the country.

Due diligence is a topic of great importance. It means taking all reasonable steps, within your ability and authority, to identify and eliminate risks to the safety of your drinking water. This is important to protecting yourself legally and financially. Outbreaks of waterborne illnesses in communities that failed to take proper precautions have resulted in multi-million dollar lawsuits.

The big question is what steps need to be taken and what requirements you should be seeking to meet. There is a range of how thorough you can be in your strategy in identifying and eliminating risks; lower upfront cost and higher risk of drinking water contamination on one end and higher upfront cost and lower risk of drinking water contamination on the other end. Proper due diligence is about finding the right spot on this scale for your community by staying within your means and providing the safest possible public drinking water. This concept is discussed in more detail in this cost-benefit analysis of treating drinking water versus treating the illnesses caused by poor quality water. For more information you can also view the Introduction to Risk Assessment and Management webinar and the Introduction to Risk Assessment and Management II webinar.

In the case of rural communities, at the absolute minimum, you are responsible for meeting the requirements laid out in your province's drinking water treatment policy. Each province regulates drinking water in different ways and has different standards for treatment methods, testing procedures, and allowable levels of contamination.

Information on the water policies of each province and territory has been compiled and is available on this Environment Canada website; you should be familiar with your province's policy.

In the case of First Nations communities, the Guidelines for Canadian Drinking Water Quality apply, but they are not legally enforceable.

A detailed comparison and critique of these differing policies can be found in the report Waterproof 2, which was written by the Sierra Legal Defence Fund. Beginning on page 48 of this document you will find a table laying out the water treatment requirements, drinking water quality standards, water quality testing requirements, regulation of water system design and construction, and accredited labs and operator certification requirements for each province and territory as they were in 2001 and as they were in 2006. Two things to notice about these tables are that there is a lot of variance between provinces in each category and there were many changes made in each province over that five-year span. Useful reports, written more recently (by ecojustice), are Waterproof 3 and Waterproof: Standards.

The variations between provinces are due to political differences. The medical and scientific communities are constantly lobbying for the kinds of policies and regulations that would bring safe drinking water to all public systems but they have always had to compromise with the minimal requirements that the provincial governments seem to want. Each province is slowly giving way to these pressures as they realize the positive effects stronger regulations will have on the health of their citizens.

We are now in a time where the amounts of specific contaminants allowed in drinking water (guideline values) are rethought and lowered on a schedule of years, not decades. Stricter guidelines are conducive to the goal of safer drinking water but they make it difficult for existing treatment plants which are sometimes unable to meet the more stringent standards. Soon, even the smallest communities will have to make additions to their treatment methods to meet more stringent guidelines regarding the inactivation or removal of microbes and chemicals.

Any community faced with the task of updating or replacing their water infrastructure must think about where they would like to be 10 to 20 years from now. It is no longer enough to build a facility that can meet today's standards; it must be able to meet the strictest proposed standards because, otherwise, it will need to be updated again when those new standards are mandated.

It should never be your goal to simply meet the minimum standards in your province as this in no way guarantees that the water is safe to drink. Take another look at the report card on page 48 of the report Waterproof 2. Any municipality should seriously consider going beyond the requirements in their province in any category that has received a grade of lacking or needing improvement. One place to look for guidance on this matter are the Drinking Water Quality Standards in Ontario, which were found to be the best in Canada.

Identifying Risks

A major aspect of your due diligence is your responsibility to identify risks. This process begins with testing the raw source water so that you know exactly what you are working with. Too often, source water is tested for only a small number of possible contaminants. This can result in your being unaware of the presence of contaminants that can disrupt the treatment process or cause serious health problems. There have been instances of communities building water treatment facilities that were simply incapable of producing potable water from the available source water because the condition of that source water was not completely understood. The source water must be tested very carefully for a wide range of contaminants including some, like ammonia and total organic carbon, which are not even included in the Guidelines for Canadian Drinking Water Quality.

The contaminants for which tests should be conducted should include but not be limited to: E. coli, coliforms, protozoa, total organic carbon, ammonia, nitrate, sulfate, aluminum, arsenic, iron, barium, boron, copper, lead, selenium, zinc, chromium, and cadmium. If the raw water smells then you have reduced gases in the water; they can impact your treatment or cause problems in your treated water reservoirs and distribution system. Detailed information on these and many other water contaminants can be found on the Health Canada website.

The first step is to find a laboratory to do the testing. Always look for an accredited laboratory and never get your water tested by someone who is also trying to sell you something. In Canada, there are two accreditation bodies recognized by the Ministry of the Environment and Climate Change to accredit drinking water testing labs:

- Standards Council of Canada (SCC)
- Canadian Association for Laboratory Accreditation (CALA)

Check the results of your source water tests against this chart of drinking water standards. Your source water may already meet many of these standards before it is treated but if some contaminants are present in much higher concentrations than would be allowed then you know that this is something your treatment facility will need to be able to correct. The goal should be for the treated water to not only meet all of the Guidelines for Canadian Drinking Water Quality, but all of the other standards listed on the chart as well.

For each contaminant that is present in your source water in quantities that exceed any of the standards, you should make sure that the engineering company that will build your facility has a plan to address it. One way to do this is to have them complete a series of statements using the following format:

(Name of contaminant)'s concentration will be reduced by (treatment method) to a level no greater than (value with units).

Considerations When Choosing Treatment Methods

You may not have much knowledge of different water treatment technologies and it might seem reasonable to assume that the science and engineering side of things can be left to the professionals. Unfortunately, this assumption has failed communities in the past. The more you understand about water treatment processes and possible complications the better you will be able to ask the right questions of the engineers and get the best system for your community. Some basic information about different water treatment methods is available from The Centers for Disease Control and Prevention website. Additionally, you can learn more about the Integrated Biological Reverse Osmosis Membrane (IBROM) treatment system on the SDWT website. The following is a set of four sample contaminants, the problems they can cause, and some possible solutions:

Organic Carbon and Disinfection Byproducts

Chlorine can be very useful in water treatment processes but there are a number of ways in which it can be misused. Chlorine should only be added to water in the final stages of treatment for the purpose of disinfection after all other contaminants have been removed. The problem is that chlorine is a powerful oxidant, so it reacts with almost everything. When there are other substances in the water, more chemical reactions will occur, and more unwanted byproducts will end up in the water.

The most dangerous of these byproducts are the ones that are created through reactions between chlorine and natural organic matter. This organic matter is microscopic pieces of broken down plant and animal material and is found in nearly all ground and surface source waters. In source water it is referred to as total organic carbon (TOC) and the portion that remains in filtered water is called dissolved organic carbon (DOC). The reaction between chlorine and organic material results in two different kinds of chemicals, trihalomethanes (THMs) and haloacetic acids (HAAs). THMs and HAAs are known to cause cancer and have other toxic effects so it is important to reduce their presence in treated water.

The best way to keep THMs and HAAs out of drinking water is to minimize the amount of DOC present in the water before chlorine is added; this can be achieved with a granular activated carbon (GAC) filter or reverse osmosis (RO) system. If THMs or HAAs are found in the treated water another stage of filtration may be required; GAC and RO systems are also effective in removing the THMs and HAAs themselves.

Ammonia

It is common for ground and surface water sources to contain ammonia because ammonia can come from so many sources. It can be added to soil by nitrogen-fixing bacteria as part of the nitrogen cycle, decay of plants and animals, or agricultural and industrial processes. Ammonia is highly soluble so it gets dissolved and transported by surrounding groundwater.

Ammonia is very problematic to the water treatment process but usually goes undetected. In Canada there is no guideline for ammonia so source waters are rarely tested for its presence and many communities that have ammonia in their water do not know that it is there. Ammonia is a problem primarily because of the way it disrupts the disinfection process. When chlorine is added to water it will react with, and get used up by, the ammonia much faster than it can kill bacteria. This reaction produces other chemicals called chloramines and leaves any harmful bacteria intact. To make matters worse, chloramines can be picked up by some chlorine tests so it can appear that you have residual chlorine (which indicates the absence of disease causing organisms) when there really is none and the water has not been disinfected at all.

The most common method of dealing with ammonia in drinking water is simply to continue adding more chlorine until the ammonia is used up. This process can be dangerous because if there is more than about 0.3 mg/L ammonia in the water then too much chlorine would have to be added to get rid of it. A safer chemical-free method of removing ammonia is through biological filtration. This method uses a controlled population of nitrifying bacteria that can remove ammonia and nitrite from water as part of the natural nitrogen cycle.

Cryptosporidium

Cryptosporidium is a parasite that originates in the fecal matter of humans or livestock and is often found in surface water and can be found in groundwater under the influence of surface water. Infection with cryptosporidium causes diarrhea, abdominal cramps, nausea, vomiting, fever, headache, and can be fatal.

There are tests that can detect cryptosporidium in water but they are difficult to perform and very expensive. Cryptosporidium is usually not tested for directly - instead tests are done for indicator bacteria. When indicator bacteria are detected in a water sample it indicates that there is a risk of cryptosporidium also being in that water. The two kinds of bacteria used as indicators of cryptosporidium are E. coli and coliforms; cryptosporidium is usually only considered a threat if these bacteria are found in treated drinking water.

Although widely used, this method of using indicators has proven to be unreliable. The disinfection processes used during drinking water treatment are much more effective against the indicator bacteria than the more resilient cryptosporidium. This means that if your source water had E. coli, coliforms, and cryptosporidium in it and you chlorinated it you would kill the indicator bacteria but leave the cryptosporidium parasites. Testing the treated water for the indicators would not turn up anything in this example and you would not know that your water was still contaminated with cryptosporidium.

It is vital that a municipal drinking water treatment facility not rely on testing and reaction to prevent a cryptosporidium outbreak. The treatment methods employed must be capable of removing these parasites as a part of everyday operation. Two of the most reliable methods of removing these parasites from water are ultraviolet disinfection systems and membrane filtration systems such as ultrafiltration or reverse osmosis.

Iron

Iron is a common element found in well water. The guideline for iron in the Guidelines for Canadian Drinking Water Quality is 0.3 mg/L. This guideline is in place primarily for aesthetic reasons since iron discolours water and promotes bacterial growth. It is not a health-based guideline because iron, and the kinds of bacteria that grow around iron, are not usually harmful to human health. However, these iron bacteria do cause many other problems. When iron is present in water, bacteria that use iron as their energy source will grow and build up anywhere that water flows. These bacteria form thick layers called biofilms in reservoirs and pipes, causing much damage to distribution systems that is difficult and expensive to repair. Excessive bacterial activity also results in water with an unpleasant taste and smell which makes it bad for both cooking and washing. These bacteria can still grow in water that has less iron than the 0.3 mg/L guideline. If there is any iron at all that these bacteria can use for energy then they will grow and spread. To keep iron bacteria out of drinking water all of the iron must be removed, not just enough to meet the guideline.

To remove iron from water it must first be oxidized. There are a few different ways that this is commonly done. The iron can be oxidized through aeration and be allowed to settle out in a reservoir, the iron can be oxidized with potassium permanganate and removed with a manganese greensand filter, or the iron can be oxidized and removed with a biological filter using a controlled population of iron bacteria. This third option is an emerging technology that has been proven to be more effective and efficient than the two traditional methods.

You Can't Test Your Way to Better Water

Another big part of identifying risks is understanding what challenges your drinking water treatment facility would fail to meet. It is a mistake to assume that the results of source water tests will give a permanent picture of the quality of your source water. A facility should not be designed to treat only what is first found in the source water because conditions can always change. Source water protection measures can be put in place to minimize this possibility but new contaminants can appear without warning. It is vital that the treatment facility be able to handle changes that might occur in the incoming water - it will always be the last barrier between possibly dangerous contaminants and the population.

Two examples are the cryptosporidium outbreaks in Milwaukee, Wisconsin in 1993 and North Battleford, Saskatchewan in 2001. The water treatment facilities in these cities were not equipped to remove dangerous protozoa such as cryptosporidium, so when it appeared in the source water there was no barrier in place keeping it from sickening, and in some cases killing, people who drank the public tap water.

New industrial operations in the area or infrastructure changes can have large impacts on the quality of your source water. When new chemical or microbial contaminants appear in your source water will your treatment facility remove them or let them pass through? The answer will be different for each type of contaminant and each kind of water treatment method. You should get a list of contaminants that your facility would not be able to remove from the engineering company that designed and built it and familiarize yourself with the risks associated with each.

Municipalities that are not prepared or unable to do everything that is required to provide safe public drinking water should inform the public of the risks. It is important that people know what treatment techniques are in use and what contaminants are still a danger in their drinking water.

Guarantee from Engineers

Upon completion of a water treatment facility the engineering company that has designed and constructed it can usually not be held accountable if that facility fails to produce safe drinking water. They often have clauses in their contracts stating that they cannot guarantee that the water produced will meet any given set of standards or even be safe to drink. The facility gets turned over to the municipality before the treated water is even tested and the municipality/First Nation is fully responsible for it from that point forward.

This is something that you should seek to change during contract negotiations. You can insist on commitments from the engineers that the treated water will pass a set of agreed-upon tests and continue to pass those tests months and years down the road. If the municipality has a qualified operator on site and is following proper maintenance procedures this should not be a problem. This deal could include withholding part of the payment for the project until the facility is shown to be working properly or the promise of a refund if the facility fails to meet expectations.

Some manufacturing companies, such as Sapphire Water, are willing to make these kinds of guarantees regarding the quality of the water their facilities produce. You do not want to work with any company that will be unwilling to work with you in the future to resolve any problem with the facility which they designed and constructed.

Operation

Once operation of the facility is turned over to you, with or without guarantees from the engineers, you must do everything in your power to ensure that it is run properly. Many details of the day-to-day operation of a water treatment facility depend on, and vary with, the type of facility. What they all have in common is the need for qualified operators, regularly scheduled maintenance, and diligent record keeping.

The Operator

Just like everything else to do with drinking water treatment, the certification process for operators is different in each province. Finding someone with the right education and certifications to be your operator is often more difficult in rural areas. Smaller communities might have to find someone willing to acquire the certifications and help them do so. Some extra effort and expense will be well-rewarded when you have a qualified professional overseeing your facility.

Maintenance

A water treatment facility needs continued care if it is going to produce safe drinking water in the long-term. A detailed set of operating manuals should be either provided by, or developed in cooperation with, the engineers. It should be clear what maintenance the facility will require, exactly how these procedures are to be carried out, and on what schedule. It is also important that you know who to contact if there are any questions or problems.

Testing

Periodic testing of the treated water will give an indication of how the facility is performing. As mentioned earlier, relying too heavily on testing can be dangerous as the results can be misleading, but continued monitoring of a subset of contaminants can provide a warning that the quality of the treated water is declining. Many contaminants can be tested on-site by the operator using simple equipment. For the results of these tests to be useful they must be included in a logbook so any trends can be noticed.

Record Keeping

Detailed record books serve multiple purposes. Keeping a record of maintenance done can serve as proof that procedures are being followed and that you are staying on top of things. This will be to your benefit if the quality of the water is called into question. A log of all changes made to a facility can also help identify the source of problems. For example, if there is a problem with the treated water the log might show that it started around the time that some component was replaced and you might find that it was installed incorrectly. To maximize the effectiveness of the record keeping process the operators should be encouraged to include daily notes of observations pertaining to the performance of the facility. A simple note that a piece of equipment is making a different noise than usual can be very useful when attempting to identify when and where problems are occurring.

Links and Resources

List of links appearing in the body of this document in the order that they appear

Safe Drinking Water Team – Band Council Resolution

- https://static1.squarespace.com/static/58f044a429687fbef7b2c576/t/590107a086e6c042bf118f37/1493239714946/BandCouncilResolution.pdf

Nova Scotia Environment and Labour: Environmental and Natural Areas Management – Safe Drinking Water for Public Water Systems: An Overview of a Diligent Approach

- http://www.novascotia.ca/nse/water/docs/DrinkingWaterDueDiligenceOverview.pdf

Safe Drinking Water Foundation – Cost-Benefit Analysis: Treat the Illness or Treat the Water?

- https://www.safewater.org/fact-sheets-1/2017/1/23/cost-benefit-analysis

Safe Drinking Water Foundation – An Introduction to Risk Assessment and Management Webinar

- https://www.youtube.com/watch?v=ohkrD9Md0M8

Safe Drinking Water Foundation – An Introduction to Risk Assessment and Management II Webinar

- https://www.youtube.com/watch?v=vwn-8gSu-Y4

Environment and Climate Change Canada – Water Governance & Legislation: Provincial/Territorial

- https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=24C5BD18-1

Sierra Legal Defence Fund – Waterproof 2: Canada's Drinking Water Report Card

- https://www.ecojustice.ca/wp-content/uploads/2015/02/Waterproof-2.pdf

Ecojustice – Waterproof 3: Canada's Drinking Water Report Card

- https://www.ecojustice.ca/wp-content/uploads/2014/11/Waterproof_Essentials_web_corrected_Dec_8.pdf

Ecojustice – Waterproof: Standards

- https://www.ecojustice.ca/wp-content/uploads/2014/09/Ecojustice-Waterproof_Standards-report-2014.pdf

Health Canada – Guidelines for Canadian Drinking Water Quality: Summary Table

- http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php

Health Canada – Water Quality: Reports and Publications

- http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php

Safe Drinking Water Foundation – Comparison Chart of Drinking Water Standards from around the World

- https://static1.squarespace.com/static/583ca2f2d482e9bbbef7dad9/t/58a38a1415d5dbb6a1a01d0d/1487112727550/Colour+Comparison+Chart.pdf

Centers for Disease Control and Prevention – Water Treatment: Community Water Treatment

- http://www.cdc.gov/healthywater/drinking/public/water_treatment.html

Safe Drinking Water Team – IBROM

- http://www.safedrinkingwaterteam.org/ibrom

Government of Canada – Guidelines for Canadian Drinking Water Quality: Guideline Technical Document: Trihalomethanes

- http://healthycanadians.gc.ca/publications/healthy-living-vie-saine/water-trihalomethanes-eau/index-eng.php

Government of Canada – Guidelines for Canadian Drinking Water Quality: Guideline Technical Document: Haloacetic Acids

- http://healthycanadians.gc.ca/publications/healthy-living-vie-saine/water-haloacetic-haloacetique-eau/index-eng.php

Safe Drinking Water Foundation – Detailed Information for Cryptosporidium

- https://www.safewater.org/fact-sheets-1/2017/1/23/cryptosporidium

Safe Drinking Water Foundation – Source Water Protection

- https://www.safewater.org/fact-sheets-1/2017/1/23/source-water-protection

Sapphire Water

- http://www.sapphire-water.ca/