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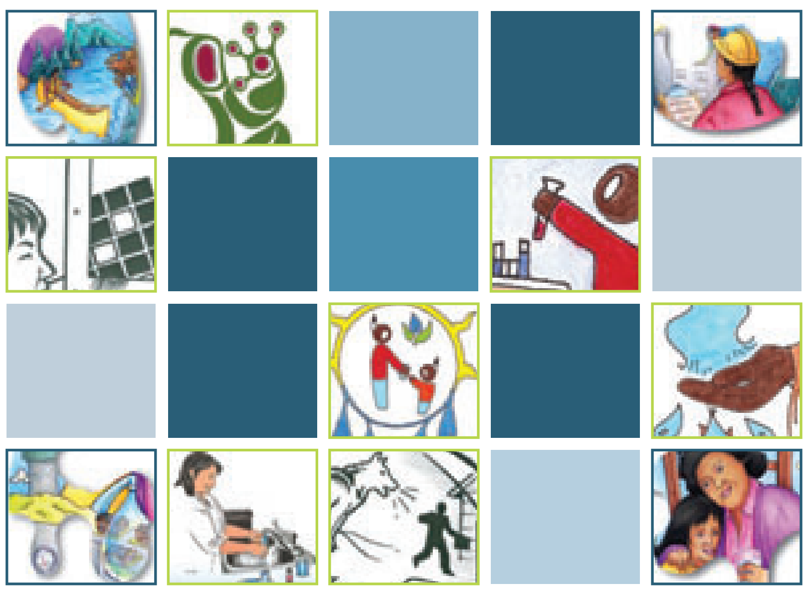
# COMMUNITY-BASED DRINKING WATER QUALITY MONITORS

## REFERENCE MANUAL



Centre de Santé Odanak

UNIVERSITÉ de GUELPH CAMPUS d'ALFRED

Canada

Please note that this document distributed by Health Canada's Environmental Public Health Program is not final and is part of the pilot project stage which will take place from April 2011 to March 2013.

The final document will be distributed after the pilot project stage and could include content and design changes.

# ACRONYMS

| | |
|---|---|
| **CBWM** | Community-Based Drinking Water Quality Monitor |
| **CHN** | Community Health Nurse |
| **CHR** | Community Health Representative |
| ***E. coli*** | *Escherichia coli* |
| **EHO** | Environmental Health Officer |
| **ERP** | Emergency Response Plan |
| **GCDWQ** | *Guidelines for Canadian Drinking Water Quality* |
| **GUDI** | Groundwater Under the Direct Influence of Surface Water |
| **HAA** | Haloacetic acids |
| **HC** | Health Canada |
| **INAC** | Indian and Northern Affairs Canada |
| **L** | Litre |
| **MAC** | Maximum Acceptable Concentration |
| **mg** | Milligram |
| **mg/L** | Milligram/Litre |
| **MOH** | Medical Officer of Health |
| **MPN** | Most Probable Number |
| **MSDS** | Material Safety Data Sheet |
| **P/A** | Presence/Absence |
| **QA** | Quality Assurance |
| **TC** | Total Coliform |
| **THM** | Trihalomethanes |
| **UV** | Ultraviolet |
| **WTPO** | Water Treatment Plant Operator |
| **WHMIS** | Workplace Hazardous Materials Information System |

# GLOSSARY OF TERMS

**Alkali** – Any strongly basic substance of hydroxide and carbonate, such as soda, potash, etc., that is soluble in water and increases the pH of a solution.

**alkalinity** – A measure of water's acid neutralizing capacity, primarily a function of the amount of carbonate, bicarbonate, and hydroxide found in the water.

**aquifer** – An underground formation or group of formations in rocks and soils containing enough groundwater to supply wells and springs.

**bacteria** – Simple, unicellular organisms with an average size of 1/1,000 mm diameter.

**biofilm** – A protective organic film created by a community of microorganisms living on a surface. Biofilms often are the result of interactions between existing piping systems which have some deposits or growth, and which experience some form of contamination through disinfection breakdown or through the entrance of organisms into the system.

**chloramines** – Disinfectants used to treat drinking water. Chloramines are most commonly formed when ammonia is added to chlorine to treat drinking water.

**Chlorination** – The process of adding chlorine to drinking water to reduce or eliminate microorganisms, such as bacteria and viruses, which can be present in water supplies. Chlorination of drinking water has greatly reduced the risk ofwaterborne diseases.

**coagulation** – Clumping of particles in raw water to settle out impurities, often induced by chemicals such as lime, alum, and iron salts.

**cross-connection** – Any connection (actual or potential) between a drinking water supply and a contamination source.

***Cryptosporidium parvum*** – A widespread intestinal protozoan parasite commonly found in lakes and rivers, which is highly resistant to disinfection. May cause gastrointestinal illness.

**disinfectant** – A chemical or physical process that kills or inactivates microorganisms such as bacteria, viruses, and protozoa.

**disinfection** – Cleaning something (surfaces,drinking water) so as to inhibit or destroy disease-causing microorganisms and prevent infection. Generally involves the use of a chemical.

**disinfection by-product** – A chemical compound formed by the reaction of a water disinfectant (e.g. chlorine) with a precursor (e.g. natural organic matter) found in a water supply.

**filtration** – A treatment process, for removing solid (particulate) matter from water by means of porous media such as sand or a man-made filter; often used to remove particles that contain pathogens.

**floc** – A clump of solids formed in sewage by biological or chemical action.

**flocculation** – Process by which clumps of solids in water or sewage aggregate through biological or chemical action so they can be separated from water or sewage.

***Giardia lamblia*** – Protozoan parasites found in a variety of vertebrates including mammals, birds, and reptiles, and frequently found in rivers and lakes, which, if not treated properly, may cause gastrointestinal illness (Giardiasis).

**groundwater under direct influence of surface water (GUDI)** – Any water beneath the surface of the ground that is located near enough to surface waters to receive direct surface water recharge.

**hard water** – water containing dissolved minerals such as calcium, iron, and magnesium.

**inorganic matter** – Matter of mineral origin such as sand, salt, iron, calcium salts, or other mineral materials.

**maximum acceptable concentration (MAC)** – A concentration established by the Federal-Provincial-Territorial Committee on Drinking Water for specific water contaminants that are known or suspected to cause adverse health effects at levels that may be found in Canadian drinking water supplies.

**Nephelometric Turbidity Unit (NTU)** – A unit of measure for the amount of turbidity (or cloudiness) in water.

**non-point source pollution** – pollution discharged over a wide land area, not from one specific location.

**organic** – Referring to or derived from living organisms (plants or animals); in chemistry, any compound containing carbon.

**ozonation** – Application of ozone to water for disinfection or for taste and odour control.

**pathogenic microorganisms** – Microorganisms that can cause disease in other organisms including humans, animals, and plants.

**pH** – An expression of both acidity and alkalinity on a scale of 0 to 14, with 7 representing neutrality; numbers less than 7 indicate increasing acidity and numbers greater than 7 indicate increasing alkalinity.

**point source pollution** – any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, or factory smokestack.

**potable** – Drinkable; a drinkable substance. Potable water implies safe water.

**protozoa** – Single-celled organisms, more complex physiology than viruses and bacteria; average size of 1/100 mm diameter.

**raw water** – Water in its natural state, prior to any treatment for drinking, also known as source water.

**reverse osmosis –** A treatment process used in water systems by adding pressure to force water through a semi-permeable membrane. Reverse osmosis removes most drinking water contaminants.

**saturated zone** – The area below the water table where all open spaces are filled with water under pressure equal to or greater than that of the atmosphere.

**sedimentation** – Letting solids settle out of raw water by gravity during treatment.

**source water** – Water in its natural state (source), prior to any treatment for drinking; also known as raw water.

**toxicity** – The quality or degree of being poisonous or harmful to plant, animal or human life.

**turbidity** – Cloudiness caused by the presence of suspended matter in water

**unsaturated zone** – The area above the ground water level or water table where soil pores are not fully saturated, although some water may be present.

**Ultraviolet(UV) Disinfection** – A physical process of drinking water treatment that uses light energy to inactivate waterborne pathogens. As a result of UV disinfection, the pathogen cannot infect its host. UV disinfection does not leave any disinfectant residual in the water, therefore a secondary chemical disinfectant like chlorine is added to maintain a residual in the distribution system.

**virus** – An extremely small microorganism that can infect other organisms. It can only reproduce inside the cell of a host organism. Common waterborne viruses are *Norovirus* and *Hepatitis A*.

**watershed** – The land area from which water drains into a stream, river, or reservoir.

**water table** – The upper level of the saturated zone of water found below the earth's surface. This level varies greatly in different parts of the country and also varies seasonally depending on the amount of rain and snowmelt.

**wellhead protection area** – The area surrounding a drinking water well or well field which is protected to prevent contamination of the well(s)

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# ACKNOWLEDGEMENTS

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# FORWARD

Providing safe drinking water to First Nations Communities is a shared responsibility. Among the various people involved, the Community-Based Drinking Water Quality Monitor (CBWM) plays a critical role in monitoring drinking water quality. The role of a CBWM and others in maintaining safe drinking water is discussed in Chapter 1.

The principal objective of this reference manual is to provide the CBWM with a guide to best practices in collecting and analysing drinking water samples. The methodologies are presented in Chapter 6 as well as in the Training DVD ***Tasks of a CBWM***.

However, the reference manual is more than just a guide to best practices. The multi-barrier approach to drinking water protection is used around the world to safeguard drinking water systems and is presented in Chapter 2. The DVD ***Multi-barrier Approach to Drinking Water Protection*** illustrates this methodology. This DVD is meant to be used by CBWMs as a training tool for community awareness activities.

The theory of microbiology and chlorination are presented in Chapters 3 and 4, respectively. The information presented in these chapters reinforces the important role a CBWM plays.

Chapter 5 presents some potential risks a CBWM can be exposed to while carrying out his/her tasks along with the appropriate health and safety measures to mitigate these risks.

Finally, the CBWM has a critical role in communicating water quality results. Chapter 7 discusses the tasks and responsibilities of a CBWM in communicating information necessary to protect public health and to maintain public confidence in a community's drinking water system.

# INTRODUCTION

Aboriginal people have always given an importance to water and its preservation. According to First Nation beliefs, Water – along with Earth, Air and Fire – is one of four sacred elements.

Beyond their strong connections with these sacred elements is a deep spiritual interaction. Sacred elements, such as water, have a major role in First Nations traditions and customs. Water is the source of life, and the special relationship that North American aboriginal peoples have with water is characterized by the continuation today of modes of subsistence which go back thousands of years.

> *"You can't live without water; your body is over two-thirds fluid. And how can you survive without water – everything needs water. That's the biggest belief that our people had. Water is something they really wanted to protect because that's where they get their food, their daily living, like the fish, all kinds of fish. Without the water we can't survive. Water is powerful and yet it can be so gentle. You can see that when there's a big washout, the water can bring down boulders and big huge trees. It can move anything – a whole mountainside. And yet if you sit by a little brook, I can feel that – I experience all what my Elders taught me – I personally experience it. And you think of that water, you wonder where is it coming from – will it ever empty? Where is it going – will it ever fill up?" (Mary Thomas, 2001)*

During a public session of the 1999 Quebec Commission on Water Management, Nicole O'Bomsawin, from the Abenaki Nation, discussed the strong bond that aboriginal people maintain with water.

> *"[. . .] women were the drinking-water guardians while men were the fire guardians. The powers were shared; each gender with one of the great powers of life. Waterways represented paths of identity; paths that enabled people to recognize and identify themselves [...] people lived near the rivers. There were also meeting points for bartering and trading [...] but beyond that, beyond the trade, what did water signify, what did water represent? For us, water is life, water is sacred. When there are ceremonies, we always give thanks for water. In some First Nations, people will often describe water as the blood of the earth." (Nicole O'Bomsawin, 1999)*[ii]

Nicole O'Bomsawin – Première Odanak nation, Québec

To the present day, water remains an important concern for First Nations peoples. As a result of population growth, increasing consumerism, and new sources of contamination, such as from industrial activities, First Nations now strive to maintain and improve water quality. Modern society has brought about important changes to the way of life in aboriginal communities, resulting in new stresses on water quality.

Water is an important health and safety issue in First Nations communities. The need to maintain a safe, sustainable drinking water supply is paramount. The lessons learned from tragic events of contaminated drinking water in the past show the serious consequences that can occur if water supplies are not properly managed

# REFERENCES

[i] Mary Thomas, Secwepemc (Shuswap) First Nation, British Columbia (2001).

[ii] Nicole O'Bomsawin (1999).

Jeremy Francis, Eel Ground First Nation, 2010

# CHAPTER 1

# ROLE OF A COMMUNITY-BASED DRINKING WATER QUALITY MONITOR

## INTRODUCTION

Many people work to provide safe drinking water and to protect public health in First Nations communities. Access to safe drinking water is essential for health. That makes it vital that we work together, individually and as a community, to protect our drinking water quality.

When you have finished this chapter, you should be able to:

- Describe your roles and responsibilities as a Community-Based Drinking Water Quality Monitor (CBWM) in providing safe drinking water in First Nations communities
- Understand the roles of others involved in drinking-water safety.

# 1.1 ROLES AND RESPONSIBILITIES OF A CBWM

As the Community-Based Drinking Water Quality Monitor you are responsible for regularly monitoring community drinking water quality in:

- The distribution network
- Public buildings
- Cisterns

In some communities, you may also test private drinking water supplies upon request and collect samples at drinking water treatment plants.

Your main responsibilities include, but are not limited to[1,2]:

- Sampling and testing
- Recording and documentation
- Notification and reporting
- Quality assurance
- Public Awareness
- Emergency Planning and Response
- Participation in training

Laurent Paul, Community of Mashteuiatsh, Lac-Saint-Jean, Quebec (Photo: Claude Verville)

## SAMPLING AND TESTING

Your prime duties are drinking water quality sampling and analysis. Keep in mind that the result of any test is only as good as the sample you collect. Thus you must collect representative drinking water samples and ensure they do not become contaminated before they are analyzed or delivered to an accredited external laboratory.

NOTE

> Sampling frequencies will vary by region and by the type of distribution system in your community. Your Environmental Health Officer (EHO) will help you develop a sampling plan.

Sampling and testing involves[3]:

1. Maintaining a community water testing facility (lab) with sampling supplies
2. Collecting weekly samples in the distribution system and at public buildings:
   - › testing for bacteriological quality
   - › testing for residual chlorine where appropriate
3. Collecting a minimum of quarterly samples from community wells that serve public facilities, such as schools or health centres.

## RECORDING AND DOCUMENTATION

As a CBWM, you must maintain a log book with test results and notes about your daily activities. In some regions, you also must keep an up-to-date database of sampling information and test results. This includes records of unsatisfactory test results. Ask your EHO about your region's reporting requirements.

There is a template for recording sampling information in Appendix A.

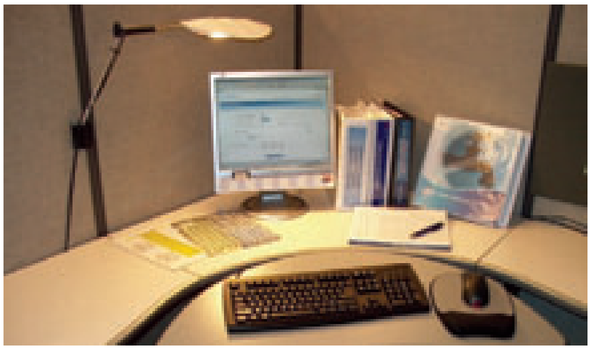


Photo: C. Wakelin

## NOTIFICATION AND REPORTING

Immediately contact your EHO when your testing finds:

- Positive bacteria results ( total coliforms and/or *E. coli* ) in a drinking water sample
- Chlorine residuals outside recommended limits. For example, if the chlorine residual is below the guideline value.

Your EHO will:

- Give you advice and interpret the results
- Advise what to do

In some regions, weekly, monthly, or quarterly reports must be sent to various partners including the EHOs, Chief and Council, the Health Director or the Water Treatment Plant Operator (WTPO). Ask your EHO about your reporting requirements.

## QUALITY ASSURANCE

An effective Quality Assurance (QA) program ensures the reliability of drinking water quality samples and test results.

At a minimum you should:

- Check the shelf life of test materials (i.e. chlorine powder pillows, Colilert chemicals) to ensure that they have not expired or spoiled.
- Maintain equipment – such as incubators, sealers and chlorine analyzers – according to the manufacturers' instructions.
- Store, ship, and track samples properly using the chain of custody form.

NOTE

For more information, refer to *Procedure Manual for Drinking Water in First Nations Communities South of 60°* - See Chapter 7.

## PUBLIC AWARENESS

Depending on your region, you also may be asked to participate in public education about protecting drinking water.

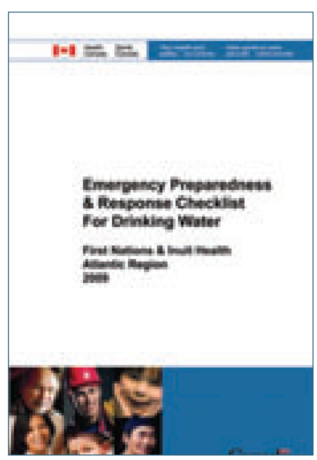
You can increase the awareness of drinking water quality issues and instill confidence in First Nations drinking water by:

- Participating in drinking water workshops or health fairs and informing the public about drinking water quality and pollution prevention.
- Making drinking water monitoring results or summaries public.
- Informing owners of private drinking water systems about the steps to take if their water becomes contaminated.

Unconfined Landfill

## EMERGENCY PLANNING AND RESPONSE

You are responsible jointly with your Water Treatment Plant Operator (WTPO), your EHO and other health professionals and community leaders for responding to waterborne disease outbreaks and any other drinking-water-related incidents.



For example, if there is a Boil Water Advisory, you may be asked to conduct increased sampling, distribute the advisory to residents and put up posters in public buildings.

You also may be asked to help develop an Emergency Response Plan (ERP) or an All-Hazard Plan.

NOTE

> Be your community's eyes and ears. Discuss any issues raised by a community member with your EHO.

## PARTICIPATION IN TRAINING

You should take the training offered or recommended by the Environmental Public Health Services in your region. Training is an important component of the drinking water safety program.

Photo: C. Wakelin

# 1.2 TEAM-BASED APPROACH TO DRINKING WATER PROTECTION

Making sure drinking water in First Nations communities is safe takes a team approach involving:

- Drinking water treatment
- Drinking water quality monitoring

The Chief and Council (or Tribal Councils) generally are responsible for planning and developing water treatment systems and their day-to-day operation.

Government departments provide technical and financial support.

Along with Chief and Council and community residents, you may work with the:

- Environmental Health Officer (EHO)
- Water Treatment Plant Operator (WTPO)
- Health Director
- Community Health Nurse (CHN)
- Community Health Representative (CHR) and other Community Health Workers

NOTE

> In some cases, community health representatives (CHRS) or water treatment plant operators (WTPOs) may play dual roles as CBWMs.

## ENVIRONMENTAL HEALTH OFFICERS

Your EHO provides training, supports you and helps to plan and develop your community's drinking water quality program.

Your EHO also:

- Reviews and interprets your drinking water sample results
- Advises the Band Council (and possibly Tribal Council) of any drinking water quality problems
- Implements a Quality Assurance (QA) program for your drinking water sampling and analyses
- Provides emergency planning and response when a community or private drinking water supply becomes contaminated
- Investigates waterborne disease outbreaks
- Conducts routine drinking water sampling when necessary; such as annual chemical sampling
- Writes reports to Chief and Council about the community's drinking water quality
- Conducts training and education sessions on drinking-water-related topics
- Reviews plans to build or upgrade drinking water treatment systems

NOTE

> When you are absent, your EHO may assist with drinking wter sampling if you do not have a back-up sampler available.

## WATER TREATMENT PLANT OPERATORS

Water Treatment Plant Operators (WTPOs) are responsible for the operation and maintenance of the water treatment plant and the distribution system, including maintaining a chlorine residual in the distribution network.

Water Treatment Plant Operator Floyd Naziel, Moricetown, BC (2009)

The plant operator also is responsible for operational water quality monitoring. This may include testing raw, treated, and distribution water for bacteria, chlorine and turbidity

## COMMUNITY HEALTH NURSES AND COMMUNITY HEALTH REPRESENTATIVES

Community Health Nurses (CHNs) help identify an outbreak of waterborne disease. They are often the first persons contacted when someone becomes ill.

Community Health Nurse Janice Millette
Chippewas of Nawash First Nation, ON (2010)

They are supported by a regional team of public health professionals and are responsible for[4]:

- Health promotion and disease prevention
- Identifying trends that may suggest a potential waterborne disease outbreak
- Supporting communities during outbreaks or other drinking-water-related emergencies

In consultation with the CHN and/or the EHO, Community Health Representatives (CHRs) and other Community Health Workers may[5]:

- Educate your community about source water protection, health promotion and disease prevention
- Provide information to the public about drinking water quality issues in your community
- Report observations that may indicate the potential for waterborne disease outbreaks
- Support your community during a waterborne disease outbreak or other drinking-water-related emergency.

In some communities, one person could be both the CHR and the CBWM.

Colleen Polson, CHR, Timiskaming First Nation, Québec

# REFERENCES


[1] Health Canada, First Nations and Inuit Health Branch. 2009. National Framework for the Environmental Public Health Program in First Nations Communities South of 60° (s. 3.2.1.2 a).

[2] Health Canada, First Nations and Inuit Health Branch Environmental Health Division. 2007. Procedure Manual for Safe Drinking Water in First Nations Communities South of 60° (s. 3.8).

[3] Health Canada, First Nations and Inuit Health Branch Environmental Health Division. 2007. Procedure Manual for Safe Drinking Water in First Nations Communities South of 60° (s. 5.1).

[4] Health Canada, First Nations and Inuit Health Branch Environmental Health Division. 2007. Procedure Manual for Safe Drinking Water in First Nations Communities South of 60° ( s. 3.6).

[5] Health Canada, First Nations and Inuit Health Branch Environmental Health Division. 2007. Procedure Manual for Safe Drinking Water in First Nations Communities South of 60° (s. 3.7) .

Jeremy Francis, Eel Ground First Nation, 2010

# CHAPTER 2

# MULTI-BARRIER APPROACH TO SAFE DRINKING WATER



## INTRODUCTION

Putting in place multiple barriers that keep contaminants out of drinking water and detect any harmful contaminants that may be present is the best way to ensure a safe public drinking water supply.

When you finish this chapter, you should be able to:

- Understand the multi-barrier approach to safe drinking water
- Describe sources of drinking water
- Identify potential sources of water contamination
- Understand how drinking water is treated
- Describe the importance of monitoring drinking water, the barrier in which you are most involved

# 2.1 THE MULTI-BARRIER APPROACH

The multi-barrier approach has four elements:

- Barrier 1: Source water protection
- Barrier 2: Drinking water treatment
- Barrier 3: Water distribution system cleanliness and maintenance of a chlorine residual
- Barrier 4: Drinking water monitoring

Multi-barrier Approach to Drinking Water Protection

Before discussing the barriers we will describe basic concepts in hydrology.

## BASIC CONCEPTS IN HYDROLOGY

Hydrology is the study of the movement, distribution, and quality of water throughout the Earth.

Here are some basic hydrology concepts on:

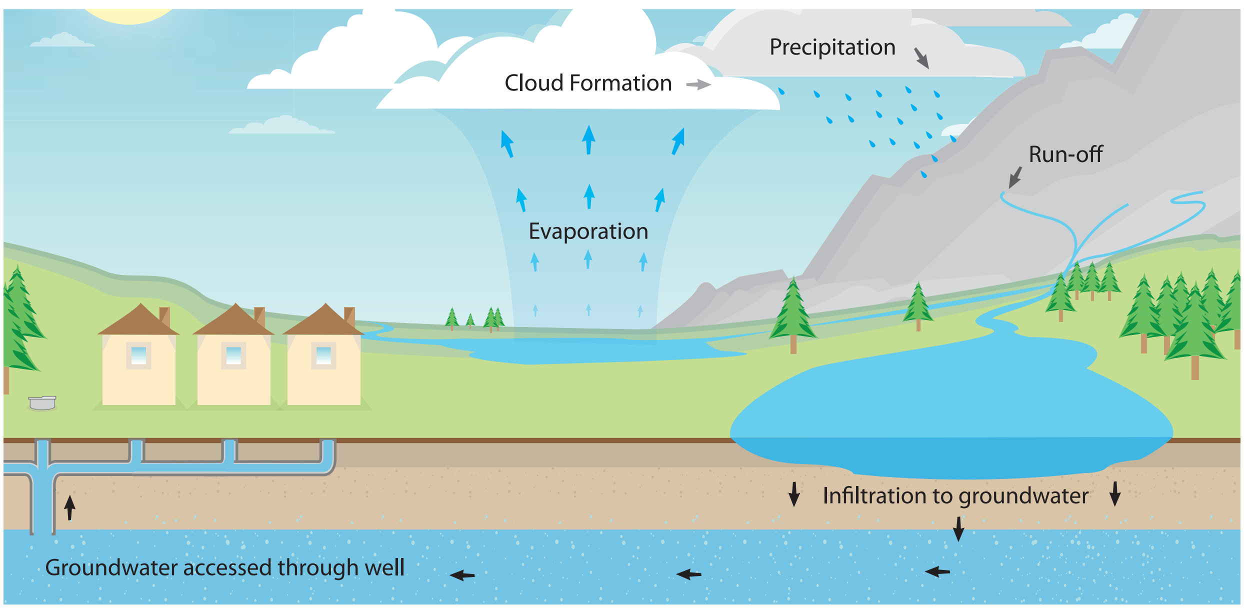
- The Water Cycle
- Watersheds
- Groundwater

## THE WATER CYCLE

The total amount of water on Earth is constant. It is continuously moving in what is called the water cycle – which is the storage and movement of water between land, water and air (see figure).

The cycle starts when sunlight evaporates water creating water vapour that rises in the air, cools, and condenses back to a liquid.

This water then falls as rain or snow (precipitation) to replenish streams, lakes, and rivers or to seep into the ground, creating groundwater. Much of the water eventually returns to the oceans — the largest water reservoirs on Earth.




Water Cycle



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EVERYTHING IS INTER-CONNECTED

The water cycle shows that both types of source water – surface water and groundwater – are interconnected. Surface water is simply the surface extension of groundwater – where the water table intersects the surface of the Earth.

Surface waters often are fed by groundwater. They can contribute significantly to surface water flows and often prevent streams and rivers from drying up during droughts.

Some groundwater reserves are recharged by water seeping underground from surface streams and rivers. Groundwater Under the Direct Influence of surface water (GUDI) refers to a groundwater source that is recharged directly by a surface water source.

## WATERSHEDS

A watershed is the area that catches rain and snow and drains this water into a stream, river, lake or the groundwater. It is also called the river's valley or drainage basin. Watersheds come in all shapes and sizes, and cut across towns, provinces, and even countries.

To protect drinking water, we must control sources of pollution that are close to the drinking water supplies (i.e. well head or water intake).

We must also manage sources of pollution throughout a watershed. Dispersed sources of pollution can include mining, forestry, farming operations and the like. These operations may generate pollutants that can affect water quality.

This is why water quality should be managed at the watershed level.

NOTE

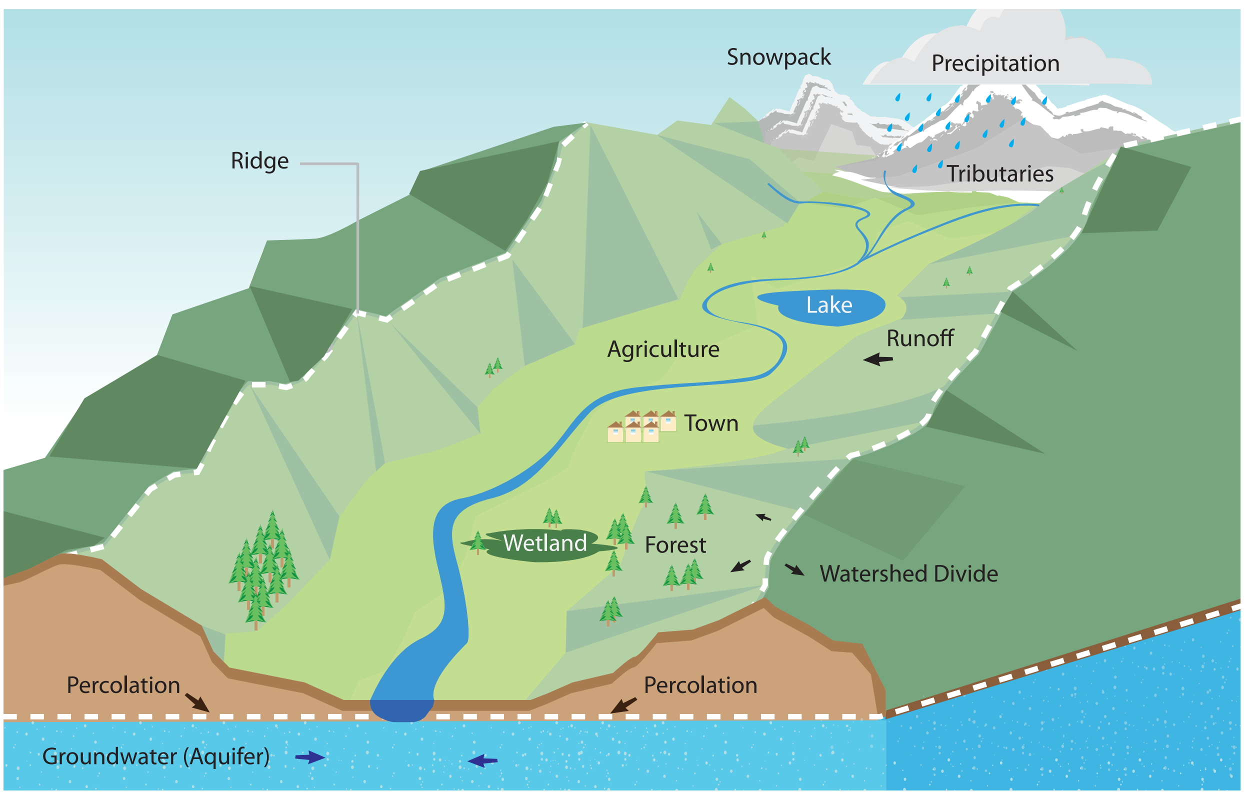
> Many provincial environmental agencies have watershed maps available.

## GROUNDWATER FUNDAMENTALS

WATER TABLE

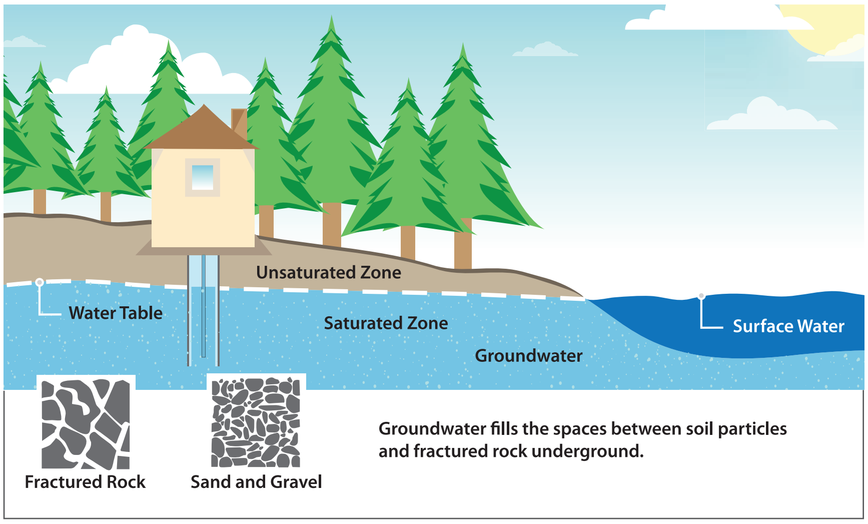
Water that seeps into the ground travels down until it hits an impermeable (sealed) layer, such as rock or clay. Water then saturates all of the cracks above this layer. The top of this saturated zone is called the water table.

It rises and falls depending on the season, the temperature and the amount of rain or snow. Above the water table is the unsaturated zone where the soil contains both air and water.




Watershed

## AQUIFERS

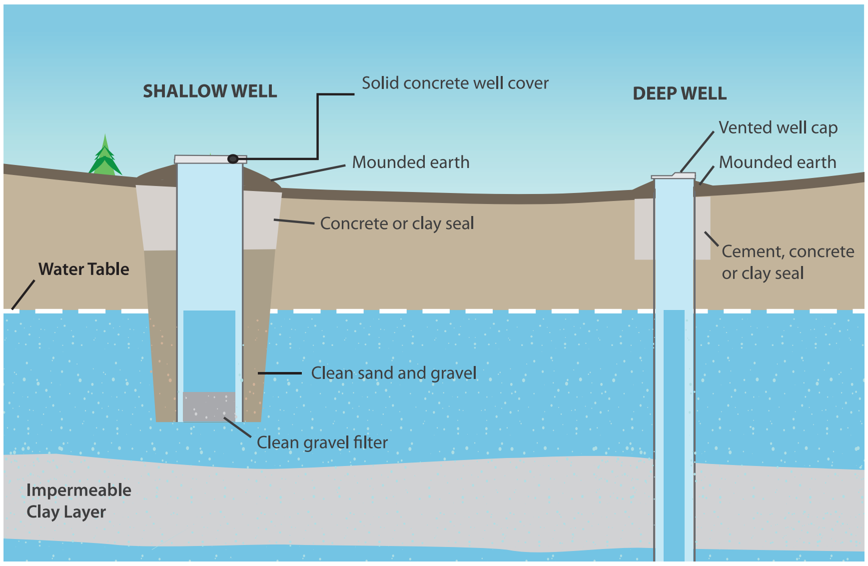



Saturated and Unsaturated Zones

An aquifer is an underground zone that holds enough easily pumped out water to supply a well.

The flow of water into an aquifer is called aquifer recharge. Most recharge occurs in spring from melting snow and from rain. The area where the rain or snow seeps into the ground is called a recharge area. Typically, recharge area soils absorb water quickly.

## GROUNDWATER WELLS




Shallow and Deep Wells

Groundwater is often considered a safer source of drinking water than surface water. This is because the ground acts as a natural filter to remove many contaminants, including some microorganisms. However, if polluted, groundwater sources are difficult and expensive to clean up.

Your community may have many individual wells. These should be maintained to avoid surface water infiltration, which could contaminate the wells.

There are two common types of wells – shallow and deep.

**Shallow wells** (also known as dug wells / bore wells / sand point wells) are close to the surface. These are more at risk from surface contamination.

**Deep wells** (also known as drilled wells), are drilled deep into the ground. These are generally protected from surface contamination. There are often layers of impermeable soil or rock above a deep aquifer that provide additional protection.

NOTE

Health Canada has two useful references:

- *Tool Kit For Individual Wells: For First Nations.*
- *What's In Your Well? - A Guide to Well Water Treatment and Maintenance* (Fact Sheet).

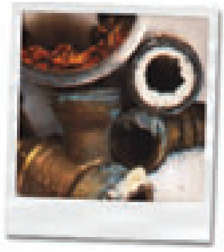
SPRINGS

A spring is where groundwater emerges naturally from the ground. Its source usually is rainfall that seeps into the ground uphill from the spring.

Springs can be contaminated easily since the water feeding them often flows only a short distance through the ground. This limits the amount of natural filtering that happens when water passes through soil. If your community uses a spring as a drinking water supply, you must treat the water the same way you treat a surface water source.

MINERALS IN GROUNDWATER

Unlike surface water, groundwater usually contains high concentrations of minerals, such as iron, magnesium and calcium. They dissolve into the water as it passes through rock. Magnesium and calcium make the water 'hard'. Hard water is not dangerous to drink, but it makes it difficult to lather soap and causes scale in pipes, kettles, and pots.



# 2.2 BARRIER 1: SOURCE WATER PROTECTION

Source protection – preventing contaminants from getting into water sources – is the first line of defense in a multi-barrier approach to safe drinking water.

A source protection plan focuses on preventing, minimizing, and controlling any contamination in or near a community's drinking water source(s).

Each community must develop and implement a source protection plan for its region. Note, however, that most watersheds and aquifers stretch across community boundaries, so coordination with local governments will be necessary. Many local governments already may be developing a source water protection plan. It is important that your community is involved in the process.

As a CBWM, you may be asked to sit on a Source Protection Planning Committee for your community.

Here are five general steps for developing a source water protection plan:

STEP 1: Identify team members (your partners)

STEP 2: Decide on the source protection area surrounding your community's drinking water supply

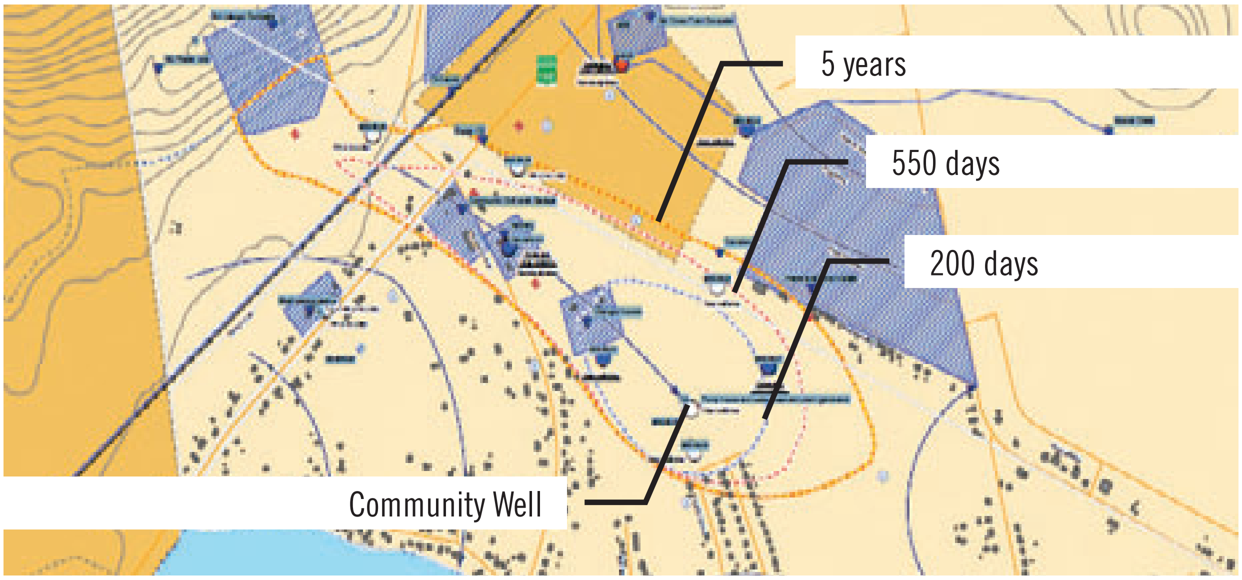
STEP 3: Identify potential contaminants and assess the risk they pose.

STEP 4: Develop your source water protection plan

STEP 5: Develop a monitoring program

Your plan and its objectives can be expanded and modified over time.

An example of a source protection area for the Listuguj First Nation drinking water well is presented in the following figure.




Source Water Protection Area for Listiguj First Nation, QC

Legend

- - - - - - Bacteriological protection area (200 days)
- - - - - - Virological protection area (550 days)
- - - - - - Environmental protection area (5 years)
- - - - - - Well capture zone

## DRINKING WATER SOURCES

Drinking water comes from either surface water or groundwater sources. Lakes and rivers are the main surface water sources. Groundwater is the source for wells and springs. All these sources are linked in a watershed through the water cycle.


Surface and Groundwater Sources

## POTENTIAL SOURCES OF CONTAMINATION

Microbiological, chemical, physical, and even radioactive contaminants can pollute drinking water supplies.

This makes it important to select a good quality drinking water source with a low risk of contamination. If a source does become contaminated, the best solution is to identify and then eliminate or control the pollution source.

Water can become contaminated by either a point source pollutant or a non-point source pollutant.

Point source pollution enters the environment at a specific place. Its source usually is easy to spot

Sewage Outfall

EXAMPLES OF POINT SOURCE POLLUTION

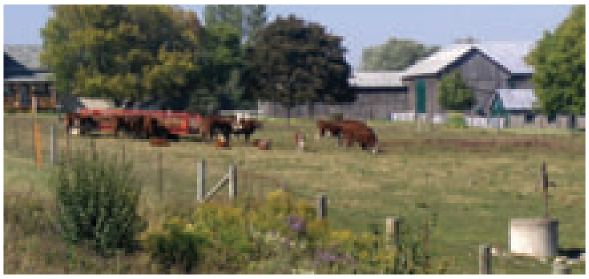
- Industrial waste discharges, spills and leaks
- Municipal wastewater discharges
- Landfill sites – toxic liquid from landfill garbage
- Wastes from existing and abandoned mining sites

Failed septic field

Non-point source pollution comes from multiple sources when water runs over land, picking up natural and man-made pollutants. These then find their way into surface and groundwater.

EXAMPLES OF NON- POINT SOURCE POLLUTION

- Agricultural runoff, which can contain fertilizers, pesticides, bacteria and nutrients from livestock and manure
- Runoff from buildings and streets that carry sediment, nutrients, bacteria, oil, metals, chemicals, road salt and pet droppings
- Acid rain and other forms of air pollution that fall on surface waters and land



Cattle grazing near a well in Ontario. Cattle may tend to loiter near the water supply (Photo: G. Korzeniecki)

# 2.3 BARRIER 2: DRINKING WATER TREATMENT

Treatment is the second barrier in drinking water protection. Treatment makes water potable – that is fit to drink.

Different levels of treatment are required depending on the drinking water source.

## REASONS FOR TREATING DRINKING WATER

We treat drinking water for two reasons.

REASON 1- SAFETY

Drinking water treatment is designed to remove harmful microorganisms (organisms too small to be seen with the unaided eye) from water. These pathogenic (disease-causing) microorganisms are found in fecal matter. Some illnesses from fecal contaminated water include:

- Cholera
- Shigellosis
- Typhoid Fever
- Hepatitis A
- Giardiasis (sometimes called beaver fever)

Although harmful chemicals, such as arsenic or uranium are less common than microbial contaminants, they also have to be removed if they are present in the drinking water source.

REASON 2- ACCEPTANCE

Drinking water should be clear, have a pleasing taste, and be free of colour and odour. If the drinking water is safe, but does not look, taste, or smell, right, users may drink from other sources such as springs, streams, or lakes that may be unsafe.

Noticeable Problems include:

TASTE

- Salty taste – high sodium content in water
- Soapy taste – calcium and magnesium
- Metallic taste – acidity or high iron content

ODOUR

- Rotten egg smell – dissolved hydrogen sulfide gas
- Musty / earthy smell – decaying organic matter

COLOUR

- Unclear / turbid water – dirt, clay or silt
- Red-brown scum – magnesium
- Green stains in sinks or faucets – acidity in copper pipes
- Brown stains in sinks, dishwashers, on clothes – iron
- Black stains in sinks, in dishwashers, or on clothes – manganese

## TREATMENT REQUIREMENTS FOR WATER SOURCES

GROUNDWATER

Groundwater does not usually contain harmful microorganisms. However, groundwater can be contaminated through surface infiltration depending on the source and type of well.

NOTE

> The minimum recommended treatment for community groundwater systems is disinfection (usually chlorination).

SURFACE WATER

Surface water is less reliable than groundwater because it is more susceptible to contamination. Therefore, it must be treated to make it safe for drinking.

NOTE

> The minimum recommended treatment for community surface systems is filtration followed by disinfection (usually chlorination).

GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER (GUDI)

GUDI often refers to a groundwater source near enough to surface waters to receive direct surface water recharge.

Groundwater wells under the direct influence of surface water have water quality issues similar to a surface water source. Therefore, the water must be treated to make it safe to drink.

NOTE

> The minimum recommended treatment for community GUDI systems is filtration followed by disinfection (usually chlorination).



Health Canada Santé Canada

## DRINKING WATER TREATMENT

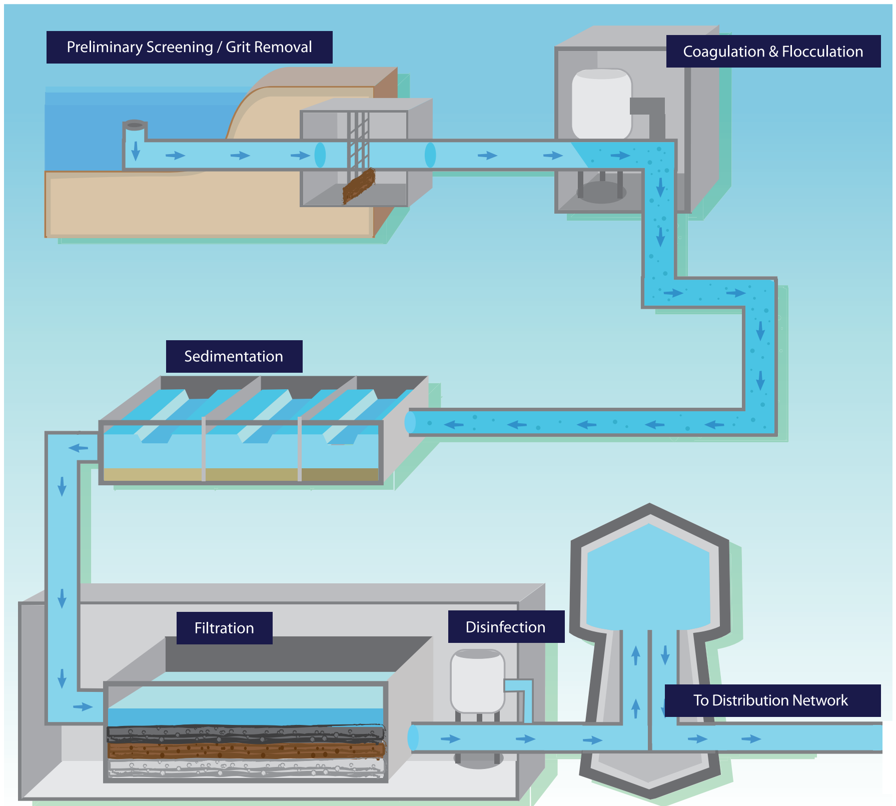
Surface water and GUDI supplies normally receive complete drinking water treatment. This may include:

1. Preliminary Screening / Grit Removal
2. Coagulation and Flocculation
3. Sedimentation
4. Filtration
5. Disinfection

Each Water Treatment Plant (WTP) is different and may not include all the treatment steps shown below.

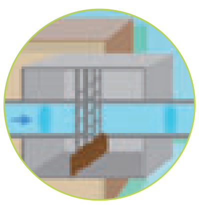
TIP

> If you can, visit your local water treatment plant to see how it works



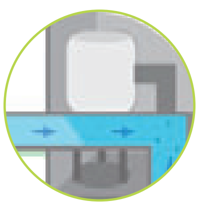

Water Treatment

### PRELIMINARY SCREENING / GRIT REMOVAL



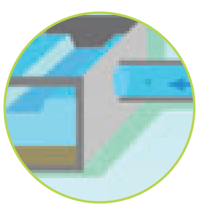
Water is first screened to remove large solids that could affect treatment plant machinery.

### COAGULATION AND FLOCCULATION



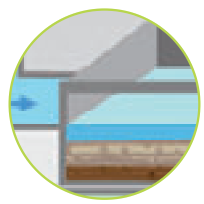
Next, coagulation followed by flocculation. Coagulants and flocculants are chemicals that when added to water cause the smaller particles to clump together to form flocs.

### SEDIMENTATION



The flocs settle by gravity. This is a process – known as sedimentation – that removes solids from the water. Coagulants and flocculants work together with sedimentation to eliminate the small particles in water that sedimentation alone cannot remove.

### FILTRATION

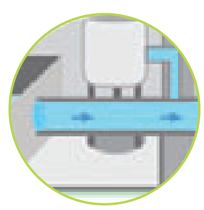


The next step is filtration – passing water through a medium such as sand or anthracite (a type of coal). This strains, or filters, the water.

The filter media allows the clean water to flow through but holds back the fine particles. The filter has to be cleaned from time to time by forcing clean water back through it – called backwashing – to remove the buildup of particles.

Water can also be filtered with membranes in a pressure-driven process. Water is pushed through a permeable membrane (one that allows the water to pass through) leaving the solid particles behind.

### DISINFECTION



Before the drinking water enters the distribution system, we must destroy all potentially pathogenic microorganisms. Chlorination is the most common method of disinfection. Chlorination is discussed in Chapter 4. Ozone and using ultraviolet light are two other methods of disinfection.

## HOUSEHOLD WATER TREATMENT SYSTEMS

Some households also use treatment systems to improve their drinking water quality.

The following table shows some of the treatment options available based on the drinking water quality issue.

Contact your EHO if you have questions about sampling water in a household with one of these units.

NOTE

Household treatment systems must be certified for treatment and use by the National Sanitation Foundation (NSF).

### Household Drinking Water Treatment Options

| Drinking Water Quality Issue - Health Related | Treatment Options |
|---|---|
| *E. coli* bacteria | UV, chlorination |
| Nitrate | Reverse osmosis |
| Sodium | Reverse osmosis |
| Arsenic | Reverse osmosis |
| **Drinking Water Quality Issue - Taste, Colour and Odour** | **Treatment Options** |
| Hardness (calcium, magnesium) | Water softener |
| Iron bacteria (red-brown slime, unpleasant taste and odour) | Chlorination/filtration |
| Iron and/or manganese (rusty black stains on fixtures, laundry) | Filtration, greensand filters, water softeners, chlorination/filtration |
| Hydrogen sulphide (rotten egg smell) | Chlorination/filtration, green sand filter, aeration |
| Chloride (salty taste) | Reverse osmosis |
| Turbidity (cloudy water) | Filters, alum treatment |

# 2.4 BARRIER 3: WATER DISTRIBUTION SYSTEM CLEANLINESS AND MAINTENANCE OF A CHLORINE RESIDUAL

Water distribution system cleanliness and its proper maintenance – including the maintenance of a chlorine residual – is the third barrier to protect drinking water.

There are four different drinking water distribution and storage systems:

1. Community system
2. Trucked system
3. Public system
4. Private system

For definitions and further details, see Chapter 6.

## DISTRIBUTION SYSTEM CLEANLINESS

To keep water safe, the water distribution system must be maintained in good condition.

This includes:

- Regular maintenance
- Cleaning and flushing of lines
- Repairing breaks
- Preventing access by wildlife and unauthorized personnel
- Cross-connection controls

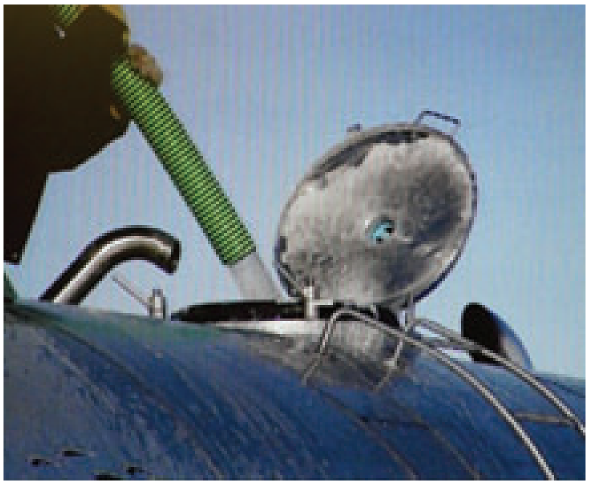
## CHLORINE RESIDUAL IN THE WATER DISTRIBUTION SYSTEM.

Chlorine must be present in the drinking water distribution system in order to reduce the risk of contamination or microbial re-growth in the system. For more information on this subject, see Chapter 4.

## TRUCKED SYSTEMS

Trucked systems use trucks for filling drinking water reservoirs (cisterns) that serve households or public facilities/buildings.

Trucked drinking water must meet the Guidelines for Canadian Drinking Water Quality (GCDWQ). Its original source should be a water system whose treatment provides a disinfection residual before the water is delivered to the truck.



Filling a water truck

The trucked water-cistern combination has a higher risk of contamination because it goes through multiple transfers –from the treatment plant to the truck, from the truck to the cistern, and from the cistern to the home – and can become contaminated at each step. This is why it is vital the transportation equipment be kept very clean. The potable water tank / container and the pumps, hoses, and other equipment must be maintained and operated in a clean and sanitary condition.

The tank / container must not be used to transport other liquids – such as sewage – that could contaminate the water, and must not have been used previously for hazardous or toxic substances.

For more information on cisterns, see the Health Canada Fact Sheet *Tips for Home Owners with Water Cisterns* in Appendix B.

# 2.5 BARRIER 4: DRINKING WATER MONITORING

The fourth and final barrier to effectively protecting drinking water is adequate monitoring. To be safe, drinking water must meet the quality criteria set out in the latest edition of Health Canada's Guidelines for Canadian Drinking Water Quality.

You, as a CBWM, have a very important job and are responsible for testing the community drinking water for microbial parameters, total coliforms and *E. coli*, and for chlorine residual.

The EHO or another designated person will perform regular sampling for chemical parameters.

# 2.6 CASE STUDIES OF DRINKING WATER CONTAMINATION

The waterborne disease outbreaks in Walkerton, ON and North Battleford, SK brought drinking water supply and pollution control to the forefront in recent years. They made it clear how easily drinking water can become contaminated and how damaging the consequences can be.


## WALKERTON

Seven people died and 2,300 people became sick in May 2000 after ingesting *E. coli* bacteria that had entered Walkerton, ON's drinking water distribution system.

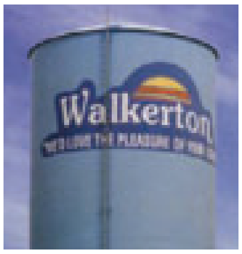
*E. coli* are usually harmless bacteria found in human and animal fecal matter. However, a pathogenic strain of *E. coli* that often originates in cows (0157:H7) can cause permanent kidney damage or death in people if it is ingested.

The Walkerton disaster provides a good example of multiple failures in the barriers designed to ensure safe drinking water.

Unusually heavy rain caused run-off from cattle manure to contaminate a nearby communal well (**failure of Barrier 1- Protecting Water at its Source**).

Next, the water treatment plant operators were not chlorinating one of the community wells (**failure of Barrier 2 – Proper Water Treatment**).

The operators also had not been following proper operating practices. They failed to:




- Use adequate doses of chlorine
- Monitor chlorine residuals daily

They also made false entries about residuals in daily operating records, and misstated the locations at which microbiological samples were taken[1] (**failure of *Barrier 4 – Drinking Water Monitoring***)."

After the outbreak an inspection of the distribution system found four separate breaks that needed to be fixed[2] (**failure of Barrier 3 – *Water Distribution System Cleanliness and Maintenance of a Chlorine Residual***).

In hindsight, if any of the proper barriers been in place – such as protecting the source, proper chlorination, or adequate monitoring – the disaster likely could have been avoided.

For more information about the incident in Walkerton and the susequent inquiry, please visit the website of the Attourney General of Ontario at: http://www.attorneygeneral.jus.gov.on.ca and search keyword "Walkerton".

## NORTH BATTLEFORD

In the spring of 2001, residents of the city of North Battleford, SK were ordered to boil their drinking water after the parasite

Cryptosporidium parvum was detected in the water system and 6,000-7,000 people became ill.

The city had two drinking water sources: groundwater from a number of wells along the Saskatchewan River, and surface water from the river itself. The well water was treated with chlorine and filtered to remove metals at a groundwater treatment plant and the surface water underwent complete treatment (flocculation, sedimentation, sand filtration, and chlorination) at the town's surface water treatment plant. Both plants fed into a common distribution system.

After the outbreak an investigation found that the surface water filter was not functioning properly and the turbidity of the treated water was higher than the recommended level (**failure of *Barrier 2- Proper Water Treatment***). While chlorine residuals were present, Cryptosporidium parvum is resistant to chlorination and must be removed through filtration. The faulty filter likely contributed to the outbreak[3].

In addition, untreated sewage was periodically discharged from an upstream sewage treatment plant. This may have been the source of the parasite. (**failure of *Barrier 1 – Protecting Source Water***).

Again, applying the multi-barrier approach likely would have avoided the outbreak.

# REFERENCES

[1] O'Connor, Dennis R. 2002. Report of the Walkerton Inquiry: The Events of May 2000 and Related Issues, Part One. Ontario Ministry of the Attorney General, Toronto. Available at: http://www.attorneygeneral.jus.gov.on.ca.

[2] O'Connor, Dennis R. 2002. Report of the Walkerton Inquiry: The Events of May 2000 and Related Issues, Part One. Ontario Ministry of the Attorney General, Toronto. Available at: http://www.attorneygeneral.jus.gov.on.ca.

[3] Public Health Agency of Canada. 2001. The Waterborne Cryptosporidiosis Outbreak, North Battleford, Saskatchewan. Canada Communicable Disease Report (CCDR) 27-22. Available at: http://www.phac-aspc.gc.ca.

Todd Baker, Coast Salish, Squamish Nation, 2010

# CHAPTER 3
# MICROBIOLOGY



## INTRODUCTION

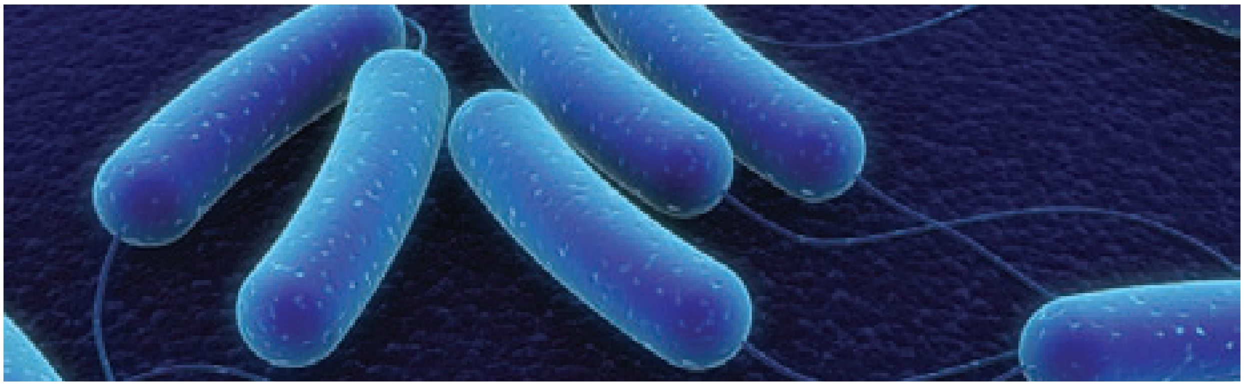
Fresh water is home to many microorganisms that can affect human health. This is why contaminated drinking water continues to be a major source of illness throughout the world.

By learning these basic microbiological concepts you will better understand how and why drinking water is treated to make it safe to drink.

When you complete this chapter, you should be able to:

- Recognize the different types of microorganisms that may be present in fresh water
- Understand what a pathogen is and recognize common waterborne diseases
- Describe an indicator organism and how it is used in drinking water testing
- Know the recommended microbiological levels for total coliforms and *E. coli* numbers in drinking water.

# 3.1 THEORY OF MICROBIOLOGY



Microorganisms, or microbes, are living organisms so small they can only be seen through a microscope. They exist everywhere, in the air, in and on people and animals, in soil, and in the food we eat.

Many of these microorganisms benefit humans. They help us digest food and protect us from environmental pathogens (germs). Some are essential in the production of food, like cheese and yogurt. Others decompose dead plants and pollutants found in sewage.

Three main types of microorganisms can be found in drinking water: bacteria, viruses, and protozoa. Some of these are pathogens.

## MICROORGANISMS: BACTERIA, PROTOZOA AND VIRUSES

### BACTERIA

Bacteria are single-celled microorganisms that in the right conditions can reproduce in less than a half-hour. In a single day, millions of new bacteria can be produced.

They are found in all living creatures and all environments. Many bacteria are usually found in water sources, and some of these can cause disease. Some bacteria live in your body and are good for you. For example, *Lactobacillus acidophilus*, which lives in your intestines, helps you digest food.

However, some bacteria are pathogenic (cause infectious diseases). You can get them if you drink contaminated water or eat contaminated food.

*Escherichia coli* (National Institutes of Health)

| Examples of Pathogenic Bacteria |
|---|
| *Escherichia coli O157:H7* |
| *Shigella* |
| *Salmonella* |
| *Vibrio cholerae* |

### PROTOZOA

Protozoa – the simplest of animal species – can be found in water and range in size from the diameter of a human hair to as much as 1 millimetre in length. They are easily seen under a microscope.

*Giardia lamblia* (Centres for Disease Control, Janice Carr)

Some protozoa cause human disease, such as *Cryptosporidium parvum* (causing Cryptosporidiosis) and *Giardia lamblia* (causing Giardiasis, sometimes called beaver fever). These are the two most difficult pathogenic microorganisms to eliminate through drinking water treatment because they are resistant to disinfection. However, they can be easily removed by filtration.

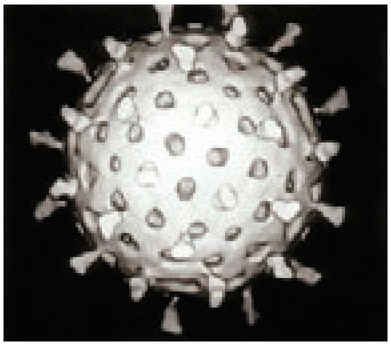
| Examples of Pathogenic Protozoa |
|---|
| *Cryptosporidium parvum* |
| *Entamoeba histolytica* |
| *Giardia lamblia* |

VIRUSES

Viruses are extremely small microorganisms. They are smaller than bacteria and can only be seen through a high-power microscope. For comparison, if you enlarged an average virus to the size of a baseball, the average bacterium would be about the size of the pitcher's mound.

Viruses can only reproduce inside the cell of a host organism such as humans. They can be present in human or animal feces and can spread through contaminated water.

Polio and the common cold are viral illnesses.



*Rotavirus* (Graham Colm, 2008)

| Examples of Pathogenic Viruses |
|---|
| *Enteroviruses* |
| *Hepatitis A* |
| *Norovirus* |
| *Rotavirus* |

## PATHOGENS AND COMMON WATERBORNE DISEASES

Some microorganisms can cause serious illness – and even death – in humans. These are pathogenic microorganisms, or simply pathogens. You find them in the intestines of humans and animals and can contaminate water through their feces.

Calves grazing near a well

Infectious diseases caused by water-borne pathogens result from consuming contaminated water. Water can be colourless, taste good, and smell normal and still be contaminated. Symptoms include stomach illness, diarrhoea, fever and/or vomiting.

These effects can be more serious, chronic or even deadly if more fragile persons – such as infants, the elderly or people with compromised immune systems – are infected.

Even though water-related diseases in North America are well under control, the protozoa *Cryptosporidium parvum* and *Giardia lamblia* are of special concern because they cannot be eliminated through simple disinfection. Protozoa often are found in surface waters. As a result, surface water supplies, shallow wells, or Groundwater Under the Direct Influence of surface water (GUDI wells) require filtration in addition to disinfection.

The following table describes some common waterborne pathogens and their associated diseases.

**Waterborne Pathogens of Concern to Human Health and their Associated Diseases[1]**

| ORGANISM | SOURCE | DISEASE | SYMPTOMS | INCUBATION PERIOD |
|---|---|---|---|---|
| **BACTERIA** | | | | |
| *Campylobacter* | Domestic, wild animal feces | Campylobac-teriosis | Diarrhoea | 1-7 days |
| *Escherichia coli 0157:H7* (enteropathogenic) | Feces of animals and infected people | Gastroenteritis | Vomiting, diarrhoea | 3-4 days |
| *Salmonella* | Domestic and wild animal, human feces | Salmonellosis | Diarrhoea | 8-48 hours |
| *Shigella* | Infected humans | Shigellosis (bacillary dysentery) | Inflammation of the intestine, fever | 1-7 days |
| *Vibrio cholerae* | Feces, human carriers | Cholera | Heavy diarrhoea | 9-72 hours |
| **PROTOZOA** | | | | |
| *Cryptosporidium* | Human, animal and bird feces | Cryptosporidiosis | Diarrhoea, death in some cases | 1-2 weeks |
| *Entamoeba histolytica* | Human feces | Amebiasis (Amebic dysentery) | Prolonged diarrhoea with bleeding | 2-4 weeks |
| *Giardia lamblia* | Human, animal and bird feces | Giardiasis | Mild to severe diarrhoea, nausea | 5-25 days |
| **VIRUSES** | | | | |
| *Enteroviruses* | Humans | Gastroenteritis, heart anomalies, meningitis | Respiratory illness, common cold | 3-14 days (usually 5-10 days) |
| *Hepatitis A* | Feces from infected persons | Infectious hepatitis | Jaundice, fever | 15-50 days (usually 25-30 days) |
| *Norovirus* | Humans | Gastroenteritis | Vomiting | 1-2 days |
| *Rotavirus* | Humans | Gastroenteritis | Vomiting, diarrhoea | 1-3 days |

## MICROBIOLOGICAL INDICATORS OF DRINKING WATER QUALITY

You can detect pathogen-contaminated water using microbiological indicators. Since testing for specific pathogens is very time-consuming and expensive and requires special techniques and equipment, it is more practical to use indicator organisms to determine water quality.

There are two specific groups of indicator organisms we test for: total coliforms and *Escherichia coli* (*E. coli*) bacteria.

These are found throughout the environment and are not necessarily harmful. However, their appearance in drinking water may indicate the presence of pathogens.

AN IDEAL INDICATOR OF MICROBIOLOGICAL PATHOGENS IN DRINKING WATER[2]:

- Is always present when the pathogen is present
- Has a life span similar to that of the pathogen
- Is present in large numbers and easy to detect by simple and inexpensive methods
- Does not multiply in the environment

### TOTAL COLIFORMS

Total coliforms are found naturally in animal and human feces, in surface waters, soil, and on vegetation. The total coliforms group includes *E. coli* as well as other types of coliform bacteria that are naturally found in the environment.

PRESENCE OF TOTAL COLIFORMS MAY INDICATE:

- Contamination in the drinking water supply
- Inadequate disinfection
- Leaks or cracks in the drinking water system
- Poor drinking water system maintenance

ABSENCE OF TOTAL COLIFORMS MAY INDICATE:

- Evidence of safe drinking water
- Drinking water likely free of pathogens and having a low risk of waterborne disease

The presence of total coliforms in drinking water does not always mean the water poses a health risk. However, it does require that you review all facilities and operations to determine why these organisms are in the system.

Testing for total coliforms determines how adequate the drinking water treatment is and the reliability of the distribution system. The absence of total coliforms in the distribution system means there is a low risk of pathogens being present.

NOTE

> An improper sampling technique can often lead to the sample testing positive (false positive) for total coliforms.

*ESCHERICHIA COLI* (*E. coli*)

*E. coli* are members of the coliforms group. They normally are harmless bacteria found in the human and animal intestines. However, some strains, such as 0157:H7, are harmful to humans. Typically water becomes contaminated with *E. coli* through contact with human or animal feces. Thus, *E. coli* is used as an indicator of fecal contamination of water.

*E. coli*'s survival time in the environment is dependent on many factors, including: temperature, its exposure to sunlight, and presence of other types of microbes. Generally, *E. coli* can survive for 4-12 weeks in water[3].

The inability of *E. coli* to reproduce in the environment and its relatively short survival time in water, means that if you detect *E. coli* in a drinking water system it is a good indicator of recent fecal contamination.

PRESENCE OF *E. coli*

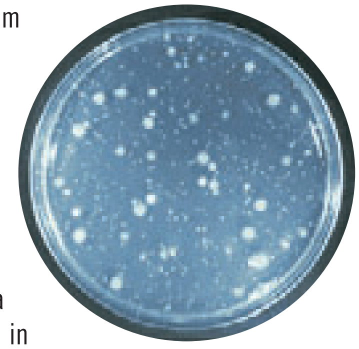
- Indicator of fecal pollution that poses a direct threat to human health
- May indicate recent fecal contamination

ABSENCE OF *E. coli*

- Evidence of safe drinking water
- Water likely free of pathogens; water has a low risk of waterborne infectious disease

## HETEROTROPHIC PLATE COUNT (HPC)

Heterotroph microorganisms are very common in drinking water systems. Most bacteria, including many of the bacteria associated with drinking water systems are heterotrophic microorganisms. We use the Heterotrophic Plate Count (HPC) method to estimate the amount of bacteria in a drinking water sample.



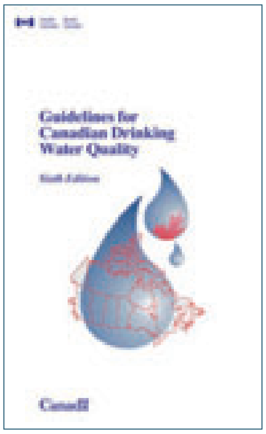
Heterotrophs on a petri dish

There is no maximum acceptable concentration (MAC) for HPC in drinking water; however, an increase in HPC above background levels is undesirable and can indicate a re-growth of bacteria in the distribution system. There is no association between heterotrophic bacteria and illness[4].

NOTE

> You are not expected to conduct HPC tests.

## MICROBIOLOGICAL GUIDELINES




The number, frequency, and location of samples for microbiological testing will vary depending on your community's size and type of drinking water system.

According to the Guidelines for Canadian Drinking Water Quality (GCDWQ), the Maximum Acceptable Concentration (MAC) of *Escherichia coli* in public, semi-public, and private drinking water systems is zero – none detectable per 100 ml.

The MAC of total coliforms in water leaving a treatment plant in a public system and throughout semi-public and private supply systems is zero – none detectable per 100 ml.

NOTE

> If you get a positive result, you must contact your EHO immediately for further instructions.

In public distribution systems in which fewer than 10 samples are collected in a given period, no sample should contain total coliform bacteria. In distribution systems where more than 10 samples are collected in a given period, no consecutive samples from the same site – or not more than 10% of samples – should have total coliform bacteria present.

NOTE

A microbiological test is a snapshot of the water quality at a distribution network location at a point in time.

**Guidelines for Microbiological Parameters (GCDWQ – Summary Table, 2008)**

| | |
|---|---|
| **TOTAL COLIFORMS** | Zero – Non-detectable (0) per 100 mL |
| ***E. coli*** | Zero – Non-detectable (0) per 100 mL |

## TURBIDITY

Turbidity is the muddy or cloudy appearance of water caused by suspended particles. These particles can come from a variety of sources including runoff, the weathering of rock and soil, and industrial effluents (liquid waste).

Water that is too turbid may taste or smell bad.

Turbid water can harbour bacteria and protozoa or accumulate heavy metals. The GCDWQ suggest that it is good practice to make sure water entering the distribution system has a turbidity of less than 0.1-1.0 Nephelometric Turbidity Units (NTU) depending on the type of filtration[5].

Turbidity levels can be monitored over time at different locations in the distribution network to establish typical levels. Then, a change in turbidity can indicate an issue such as microbial growth in the system. There is no established guideline value for turbidity in the distribution network.

If you notice any change in turbidity levels, notify your WTPO and your EHO.

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Jeremy Francis, Eel Ground First Nation, 2010

# CHAPTER 4
# CHLORINATION



## INTRODUCTION

Chlorine is a disinfectant that is added to drinking water to destroy any pathogenic microorganisms present. The introduction of chlorine to the drinking water treatment process greatly reduced the risks of illness associated with waterborne diseases.

When you finish this chapter, you should be able to:

- Understand why most drinking water supplies are chlorinated
- Identify minimum chlorine residual levels

# 4.1 THEORY OF CHLORINATION

## HISTORY OF CHLORINE USE

Historically, waterborne disease has been a major cause of human death. That's not the case today in developed countries, but the lack of clean drinking water in developing countries still is a major cause of disease and death.

The goal of drinking water treatment and disinfection is to destroy waterborne pathogens found in a drinking water supply.

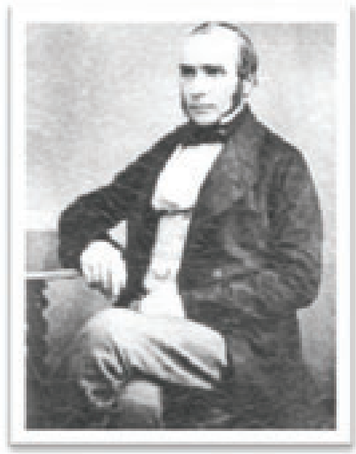
Common waterborne diseases include:

- Amoebic dysentery
- Bacillary dysentery (Shigellosis)
- Cryptosporidiosis
- Giardiasis
- Hepatitis
- Pathogenic *E. coli*
- Salmonellosis
- Typhoid
- Cholera

In 1854, a sudden influx of people into London's Soho district and a lack of proper sanitation resulted in a waste disposal problem. The result was a major outbreak of cholera in Soho that killed 616 people.

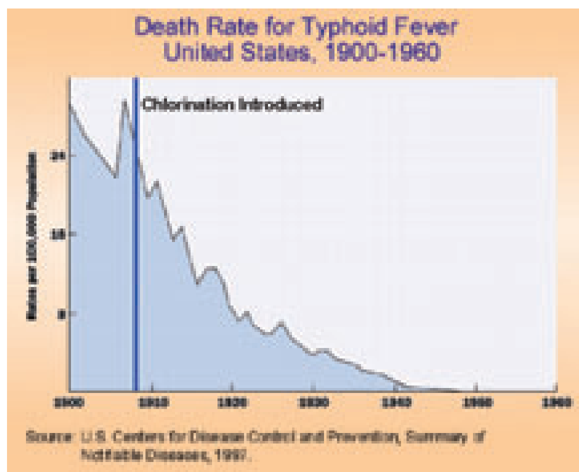
Broad Street Pump
Source of the 1854 Soho cholera outbreak

Doctor John Snow traced the cholera outbreak to a public well contaminated by diaper washings from an infected infant draining into the well. When the well was closed the illness rates dropped[1].



Dr. John Snow (1813-1858)[2]

The outbreak established the link between waterborne microorganisms and disease and methods to disinfect drinking water quickly developed. By the early 1900's, drinking water supply companies had started using disinfection to prevent disease (see figure).




Typhoid death rate compared to access to treated water in the USA[3]

## ADVANTAGES OF CHLORINE

Chlorine is the most widely used disinfectant in the world. It is inexpensive, simple to use, effective, and leaves a residual which protects against re-contamination. Chlorine also removes tastes, odours, iron, and controls slime-producing bacteria.

While new methods of disinfection – such as reverse osmosis, ultraviolet light, and ozonation – have been developed in recent years, the use of chlorine is still one of the best options for disinfecting drinking water.

## FORMS OF CHLORINE USED IN DISINFECTION

Various forms of chlorine can be used for disinfection. The most common are sodium or calcium hypochlorite, chlorine gas, and chlorine dioxide.

### CHLORAMINES

Chloramines are produced in water by the reaction between free chlorine and ammonia. The ammonia occurs naturally in the raw water or is added by the WTPO using chemical feed pumps or ammonia gas injection.

### HYPOCHLORITE

Hypochlorite – sodium hypochlorite or calcium hypochlorite – forms hypochlorous acid when dissolved in water.

- Calcium hypochlorite contains about 70% available chlorine.
- Sodium hypochlorite typically contains 5.25-15% available chlorine (household bleach is 5.25%).

In-line chlorinator
(S. Schurman, 2006)

Sodium hypochlorite is the most common type of chlorine used in First Nations drinking water treatment plants.

### PURE CHLORINE

Pure chlorine is available as a gas or as a liquid under pressure.


### CHLORINE DIOXIDE

Chlorine Dioxide is sometimes used as a disinfectant. It is typically produced on site and stored as a liquid. However, the liquid cannot be stored for long since it breaks down into chlorine and oxygen.

Chloramines are weaker disinfectants than free chlorine, but they remain in the water much longer than free chlorine and prevent the formation of *Trihalomethanes* (THMs) (see Section 4.2.5).

## FACTORS AFFECTING CHLORINATION

Chlorination effectiveness depends primarily on four factors:

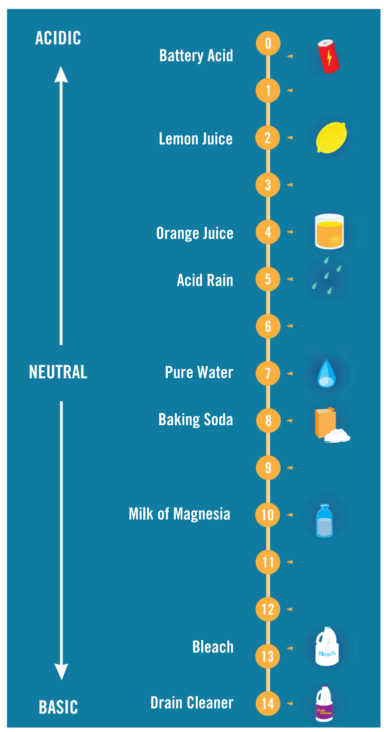
- Contact Time
- Concentration
- Temperature
- pH

Once chlorine has been added to water, it needs a certain amount of time – the Contact Time – to kill any pathogens present. The chlorinated water must be held for the contact time at the drinking water treatment plant before being released to the distribution system.

The length of the contact time required for the chlorine to be fully effective depends upon many factors. The most important is the chlorine concentration: the higher the concentration, the lower the contact time required.

The temperature of the water to be disinfected also affects the efficiency of chlorination – the colder the water, the longer the contact time required.

The pH of the water also affects chlorination. Optimal drinking water pH levels should range from 6.5 to 8.5[4].



## PRIMARY AND SECONDARY DISINFECTION

Overall, the use of chlorine has practically eliminated the threat of waterborne disease from drinking water.

We can speak of primary and secondary disinfection. Primary disinfection kills any disease causing microorganisms (pathogens) in the raw water.

The chlorine residual in the distribution system (secondary disinfection) protects drinking water from microbiological re-contamination, bacterial re-growth, and biofilm formation.


In-line chlorinator and concentrated bleach

## CHLORINE RESIDUAL

Chlorine is easy to incorporate into the treatment process, and small amounts remain in the distribution system to provide a chlorine residual. The chlorine residual can be measured as either total chlorine residual or as free chlorine residual using a colorimeter.

### TOTAL CHLORINE RESIDUAL

The total chlorine residual is the total amount of chlorine residual present regardless of its type.

### FREE CHLORINE RESIDUAL

The free chlorine residual is the remaining amount of chlorine that has not combined with ammonia or other compounds in the water and is readily available to react with (and destroy) pathogens.

Free chlorine residual is measured in the distribution system unless the water treatment plant uses chloramination. If chloramination is used, we measure the combined chlorine in the distribution system.

### COMBINED CHLORINE RESIDUAL

The combined chlorine residual is the difference between the total and free chlorine residuals. The combined chlorine residual is not as powerful as free chlorine but lasts longer.

COMBINED CHLORINE (CHLORAMINES) RESIDUAL = TOTAL CHLORINE RESIDUAL – FREE CHLORINE RESIDUAL

## HEALTH EFFECTS FROM CONSUMING CHLORINATED DRINKING WATER

### CHLORINE

Chlorine has no significant health effects at the concentrations normally found in drinking water[5].

However, there may be a very small health risk from consuming drinking water that contains high concentrations of disinfection by-products.

### DISINFECTION BY-PRODUCTS

In the treatment process, chlorine reacts with both organic (eg. decaying leaves) and inorganic matter in the water. When chlorine reacts with organic matter the resulting chemical reaction forms disinfection by-products. The two most common are Trihalomethanes (THMs) and haloacetic acids (HAAs).

The maximum acceptable concentration (MAC) for THMs in drinking water is 0.1 mg/L[6]. The MAC for total HAAs in drinking water is 0.08 mg/L[7]. Both are based on an annual average of quarterly samples.

NOTE

> "The health risks from disinfection by-products, including THMs, are much less than the risks from consuming water that has not been disinfected."[1]

All the evidence shows that the concentrations of THMs and HAAs in Canadian drinking water are so low as to usually pose a negligible risk to human health.

Yet, it is still important to keep the concentrations of these by-products as low as possible while ensuring that the level of disinfection itself is not compromised. Your EHO – or another designated person – will collect drinking water samples quarterly to test THM and HAA levels.

The concentrations of chlorinated disinfection by-products can be reduced at the water treatment plant by:

- Removing the organic matter from the water before chlorine is added
- Optimizing the disinfection process
- Using alternative disinfection strategies
- Using a different water source

## CHLORINE LIMITS

The lower limits for free and total chlorine in the drinking water distribution system are 0.2 mg/L and 1.0 mg/L, respectively.[8]

A minimum level of 0.2 mg/L free chlorine residual is considered necessary to stop bacterial re-growth in the distribution system.[9,10]

In Ontario, the free chlorine residual should never be less than 0.05 mg/L in the distribution network for a system that provides chlorination. The combined chlorine residual should never be less than 0.25 mg/L for a system that uses chloramination with an optimum concentration of 1.0 mg/L.[11]

The recommended maximum acceptable concentration (MAC) for total chloramines in drinking water is 3.0 mg/L.[12]

In Newfoundland the minimum chlorine level in a distribution system is simply specified as "a measurable level", while in Manitoba, a minimum level of 0.5 mg/L is specified.[13]

Most provinces have not established a maximum chlorine level. Those that have, define or recommend a maximum level of 4 mg/L.[14]

NOTE

> Some regions may adopt provincial standards or guidelines which may be different from the national guidelines. Talk to your EHO about the limits in your region.

Water treatment plant operators follow operational guidelines depending on the type of treatment system.

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Dean Ottawa, Community of Kitigan Zibi Anishinabeg, 2010

# CHAPTER 5

# HEALTH AND SAFETY

## INTRODUCTION

Occupational health and safety focuses on protecting the safety, health and well-being of workers.

Employees have the right to know what hazardous materials, equipment or processes they are working with or could be exposed to, and what they can do to avoid injury or illness.

You should use a health and safety perspective to assess activities that could be part of your job as a CBWM.

Everyone – employers, supervisors and workers – has responsibilities in protecting the health and safety of themselves and co-workers.

The Canada Labour Code describes the general requirements for a safe and healthy workplace. These requirements also can help reduce the number of injuries in the workplace.

The code applies to all employees working under federal jurisdiction, including workers on First Nations reserves.

OCCUPATIONAL HEALTH AND SAFETY
IS EVERYONE'S RESPONSIBILITY

You can find more information on the code at: www.labour.gc.ca. You should also refer to your employer's health and safety policies. Note: any on the job injuries **must be reported** to your employer.

When you finish this chapter, you should be able to:

- Recognize common occupational hazards
- Perform your duties in a safe manner
- Identify confined spaces
- Be aware of the Workplace Hazardous Materials Information System (WHMIS)
- Identify personal protective equipment necessary in your role as a CBWM

# 5.1 SAFETY WHILE COLLECTING DRINKING WATER SAMPLES

Important: You must first identify any potential job hazards you may face when sampling and analyzing drinking water.

## HAZARDS: SAMPLE COLLECTION

You should identify and document hazards or risks when you first visit a sampling site.

Common hazards may include:

- Bad weather conditions
- Slips and falls on uneven surfaces or ice
- Aggressive animals
- Uncooperative/threatening people
- Chlorine bleach spills on skin or in eyes
- Working around confined spaces such as a cistern or reservoir
- Driving in off-road or remote locations

Any on the job injuries **must be reported** to your employer.

## WEATHER HAZARDS

Check the weather conditions before you head out to sample and wear/bring appropriate clothing such as a raincoat, warm clothes, and footwear with a good grip to avoid slipping and falling.

If a sampling location is inaccessible due to ice or freezing rain, choose an alternate site or return another day to collect the sample.

## ANIMALS

Aggressive animals may be a problem when you are trying to collect a sample. For example, if there is an aggressive dog at a particular home, go to a different residence for sampling.

Do not approach an aggressive animal. Select a different sampling site. If you are bitten or attacked, get medical help as soon as you can. Animals can carry diseases – such as rabies – which are fatal to humans if not quickly treated.

Training on dog behaviors may be available to you as a CBWM. Contact your EHO to find out if this training is available in your region.

## UNCOOPERATIVE PEOPLE

Avoid sampling at the homes of uncooperative / threatening people. Choose an alternate sampling location and inform your employer and your EHO of the issue.

## HANDLING BLEACH

You will often use a dilute solution of chlorine bleach to disinfect sink faucets before you collect a sample.

Handle bleach carefully. It can stain clothing and irritate skin and your eyes. If you get bleach on your clothes or skin, immediately rinse with clean water. If you get bleach in your eyes, flush with clean water for 15 minutes and get medical help immediately.

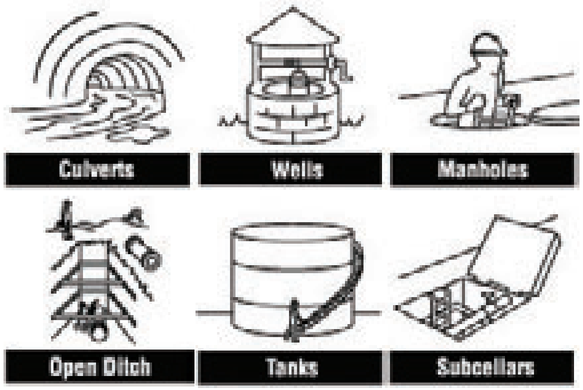
## CONFINED SPACES

A confined space is an enclosed area with conditions and limited access that make it dangerous.


As a CBWM, you will **never** need to enter a confined space. However it is important to be aware of them (cisterns and reservoirs are good examples) and the risks.

Many workers are injured or killed each year while working in confined spaces. This makes it important to follow safe practices when working near or in confined spaces.

NEVER ENTER CONFINED SPACES




Examples of Confined Spaces1

## COMMUNICATIONS

Always let someone in your office know your sampling schedule and when you plan on returning. If possible, carry a communication device to keep in contact.



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# 5.2 SAFETY WHILE PERFORMING ANALYSES

There are three main safety concerns in community testing facilities (laboratories):

1. The handling of biohazardous material, such as positive *E. coli* samples that can cause disease.
2. Eye damage resulting from improper use of ultraviolet (UV) light for identifying *E. coli*.
3. Eye irritation from exposure to chemicals such as the powder pillows for chlorine analyses.

## SAFETY CONCERN 1: BIOLOGICAL HAZARDS

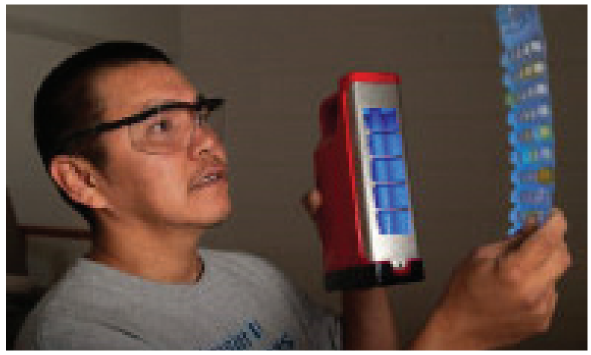
Water samples which test positive for *E. coli* may contain pathogens.

Protect yourself by:


- Washing your hands thoroughly after handling samples.
- Cleaning up any spills that occur with a disinfecting solution of 1 tablespoon (15 mL) of household bleach in half a cup of water (125mL). This gives you approximately a 1 in 10 solution.
- Disposing of positive samples in a safe manner. Discuss your options with your EHO.

NEVER EAT OR DRINK WHILE CONDUCTING ANALYSES.

## SAFETY CONCERN 2: UV LIGHT



Clayton Michell, WTPO, Moricetown, B.C. (Photo: Bedell)

UV lights are used alone, in biological safety cabinets, or in light boxes. Most UV lights come with a protective window.

Ultraviolet rays can damage your eyes. Wear protective eyewear if the UV light is not enclosed in a protective box and never look directly into the light.

UV viewing cabinet and UV lamp

## SAFETY CONCERN 3: CHEMICAL HAZARDS

Always wash your hands thoroughly after handling any chemicals.

Review the Material Safety Data Sheet (MSDS) for each chemical product you are handling, such as powder pouches for chlorine analysis, and Colilert® /Colisure® reagent packages (see next Section).

If you get any chemical in your eyes, flush with plenty of water. If you get any powder on your skin, wash it off with soap and water[2,3].

# 5.3 WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)

Workplace Hazardous Materials Information System (WHMIS) gives employers and workers consistent information about hazardous materials used in the workplace. WHMIS information should be readily available to all workers on site.

Workplace Hazardous Materials Information System
Système d'information sur les matières dangereuses utilisées au travail

WHMIS ensures you can find information on the hazardous materials in:

- Labels on the containers of hazardous materials
- Material Safety Data Sheets (MSDS) that supplement the label with detailed hazard and precautionary information
- Worker education programs

The hazardous material supplier provides the labels and material safety data sheets to the employer. The employer must ensure information on material safety is provided to workers and that education programs are provided. MSDS sheets must be updated at least every three years.

The Canadian Centre for Occupational Health and Safety provides a web-based databank of Material Safety Data Sheets (MSDS) at: http://www.ccohs.ca.

There is a description of the WHMIS classification system in Appendix C, including WHMIS label hazard symbols and MSDS sheets.

## PERSONAL PROTECTIVE EQUIPMENT

Every workplace has hazards. Controlling a hazard at its source is the first step in protecting workers. When a hazard cannot be removed or adequately controlled, personal protective equipment must be used to minimize exposure. Protective equipment can include: special clothing, helmets, goggles, or other garments designed to protect your body from injury.

As a CBWM, you may use protective gloves, UV protective glasses, and sturdy shoes.

Material Safety Data Sheets (MSDS) are useful. They tell you the proper protective equipment to use when working with a specific chemical.

Examples of personal protective equipment: latex gloves, UV viewing cabinet and protective glasses

# 5.4 COMMUNICATING SAFETY ISSUES

If you have any safety concerns you must inform your supervisor, a Health and Safety Committee Member or the Health and Safety Officer for your Band Council or Health Centre. You should also discuss safety issues with your EHO.

Sheryl St. Pierre, WTPO for Moose Deer Point First Nation, Ontario

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Dean Ottawa, Community of Kitigan Zibi Anishinabeg, 2010

# CHAPTER 6

# DRINKING WATER SAMPLING AND ANALYSIS

## INTRODUCTION

Your primary duties as a CBWM are drinking water quality sampling and analysis. You must collect a representative water sample and ensure it does not become contaminated before it is analysed or delivered to an external laboratory. Important: the result of any test is only as good as the sample you collect.

This chapter details how to properly collect water samples and analyse them.

When you finish this chapter, you should be able to:

- Recognize the various types of drinking water distribution systems
- Develop a sampling program with your EHO
- Collect representative samples from community and private drinking water systems
- Store and prepare water samples for transport to an external laboratory
- Conduct chlorine residual analyses
- Conduct total coliform (TC) and *E. coli* analyses

# 6.1 DRINKING WATER QUALITY MONITORING

The latest Guidelines for *Canadian Drinking Water Quality* (GCDWQ) sets out the basic parameters all drinking water distribution systems should strive for in order to deliver clean, safe and reliable drinking water to residents. These guidelines apply to drinking water and incorporate select physical, chemical, microbiological, and radiological parameters.

Microbiological parameters are among the most important health parameters (i.e. *E. coli* and total coliform). Monitoring them minimizes the risk of exposure to disease-causing organisms in drinking water.

The guidelines also address aesthetic parameters such as taste, odour and colour that can affect residents' acceptance of the water. Aesthetic values are set far below the levels which result in health effects.

The GCDWQ typically are used to evaluate drinking water quality in First Nations communities. The most recent summary of the GCDWQ is on the Health Canada website.

## SAMPLING PARAMETERS

You are responsible for testing for microbiological parameters, such as total coliform, *E. coli*, as well as chlorine residual to ensure the safety of the community's drinking water. The EHO typically is responsible for performing regular sampling for chemical parameters.

Common sampling parameters include: microbiological quality, chlorine residuals, and turbidity.

Chapters 3 and 4 have information on the theory behind bacteria indicators and chlorine residuals.

1- MICROBIOLOGICAL QUALITY

The number, frequency, and location of microbiological testing samples will vary depending on the size and type of drinking water distribution system in your community.

The maximum acceptable concentrations (MACs) below are from the GCDWQ and the *Procedure Manual for Safe Drinking Water in First Nations Communities South of 60º.*

The two microbiological water quality indicators are:

### Total Coliforms

No consecutive sample from the same site – or no more than 10% of samples within a given sampling period – should have total coliforms present. If fewer than 10 samples are collected, no sample should show the presence of total coliforms.[1]

### *E. coli*

MAC for *E. coli* is none detectable (0) *E. coli* per 100 mL.[2]

2- CHLORINE RESIDUALS

The proper disinfection of drinking water protects people from waterborne illnesses. Therefore, it is important to accurately monitor chlorine residual levels.

You monitor chlorine levels in the drinking water distribution system and possibly at the water treatment plant according to the sampling program. Chlorine sampling is done at the same time as microbiological sampling.

Minimum chlorine levels are specified in the *Protocol for Safe Drinking Water in First Nations Communities*. However, some regions follow Provincial guidelines. These could be different from the guidelines below. Your EHO will tell you the chlorine limits in your region.

There are two types of chlorine residuals: free chlorine residuals, and total chlorine residuals.

Free chlorine residual should be greater than 0.2 mg/L at the end of the drinking water distribution system. Total chlorine residuals should be greater than 1.0 mg/L.



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### 3- TURBIDITY

Turbidity refers to how muddy or cloudy the water looks. Turbidity is caused by suspended particles in the water. Water that is too turbid may taste or smell bad.

Turbid water also can harbour bacteria and protozoa or accumulate heavy metals.

Turbid water

Turbidity levels can be monitored over time at different locations in the distribution network to establish typical levels. With an established turbidity pattern, any sudden change can indicate an issue such as microbiological growth in the system. There are no established guideline values for turbidity in a distribution network.

Your EHO will tell you if you should monitor turbidity in your drinking water distribution system. The Water Treatment Plant Operator (WTPO) is responsible for monitoring turbidity at the plant and may also measure turbidity in the drinking water distribution system.

# 6.2 SELECTION OF SAMPLING SITES

You are responsible for sampling water in your community's drinking water distribution system.

Before sample collection can begin, you and your EHO – possibly in consultation with the WTPO – must ensure that the sample sites selected will be representative of your drinking water distribution system. You will meet with your EHO, to select the sites in your community where you will collect samples.

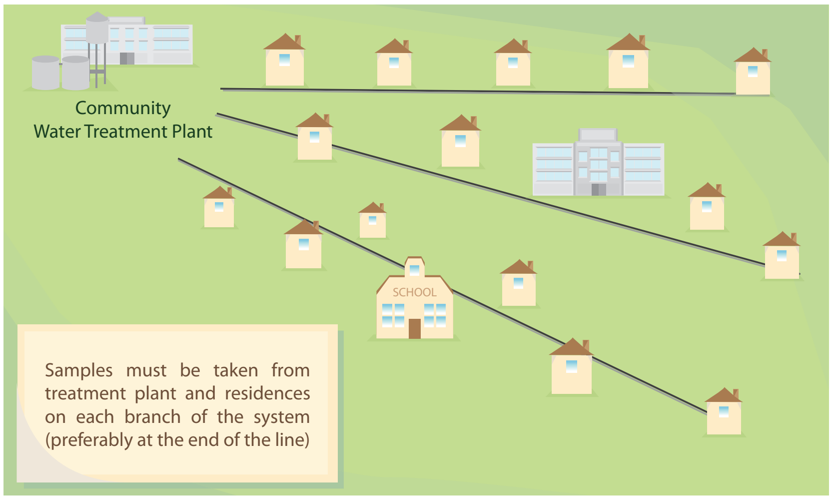
Since the location and distribution of sampling sites can affect the quality and importance of the data you obtain, developing a good sampling plan will ensure the drinking water monitoring is as effective as possible. The following two figures illustrate branched and looped distribution systems. Samples should be collected at the end of each line in a branched distribution system and at the middle and farthest points in a looped system.

You should monitor:

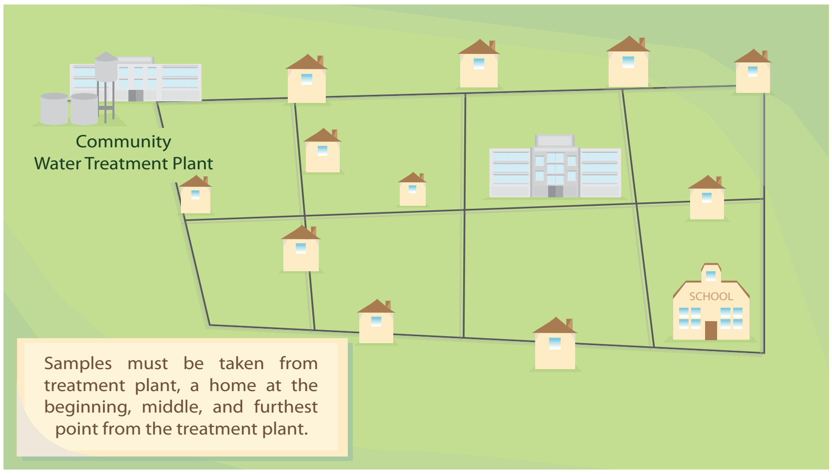
- High-risk areas, such as health centers, schools
- High- and low-flow areas
- Locations near reservoirs and pump stations
- Dead ends and end of distribution lines

In general, these locations should be representative of the entire distribution system.

Once you have the sampling sites chosen, your EHO will make sure you have a unique code for each. The codes identify each sampling location and help maintain accurate records when you enter data in your region's water database.




Branched Distribution System




Looped Distribution System



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# 6.3 DRINKING WATER DISTRIBUTION SYSTEMS AND SAMPLING FREQUENCIES

Here are the different types of water distribution systems you may be required to sample and their sampling frequencies.

## TYPES OF DRINKING WATER DISTRIBUTION SYSTEMS

There are four types:

1- COMMUNITY SYSTEM

**Community Systems** have at least five connections that serve households, public facilities/buildings, or both.

2-TRUCKED SYSTEM

**Trucked Systems** use trucks for filling drinking wtaer reservoirs (cisterns) that serve households or public facilities/buildings.

3-PUBLIC SYSTEM

**Public Systems** have less than five connections and serve at least one public facility/building (examples: school, health clinic, daycare, restaurant, arena, etc.).

4-PRIVATE SYSTEM

**Private Systems** have less than five connections and serve only households.

NOTE

> The Drinking Water System definitions are currently under review by a national working group and may be modified.

## SAMPLING FREQUENCY ACCORDING TO DRINKING WATER DISTRIBUTION SYSTEM

The frequency of the samples required will vary according to your community's drinking water distribution system. Here are the sampling frequencies for each type of system.

1-COMMUNITY SYSTEM

**Frequency:** For communities of up to 5,000, you should sample once per week. It is recommended to take a minimum of two samples from different locations in the distribution system.

For communities of 5,000 to 90,000 people, you should conduct evenly spaced weekly sampling at a recommended rate of one sample per 1,000 people per month. In a community of 7,000 people, this means a recommended seven samples per month.

You sample for E. coli and total coliforms at the same time you sample for chlorine residual.

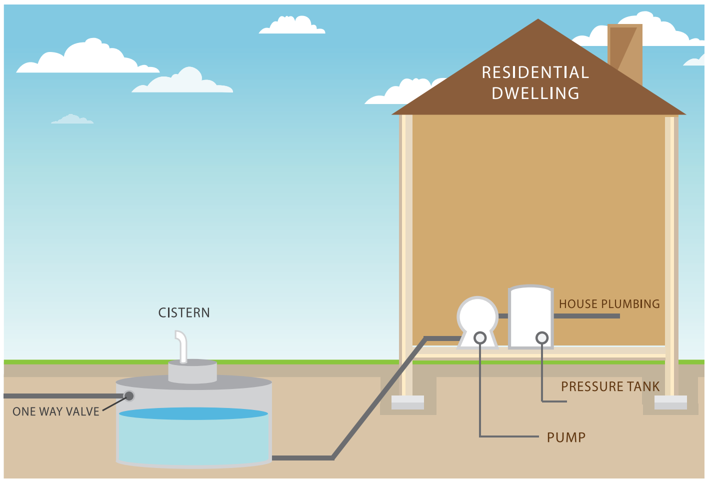
2-TRUCKED SYSTEM

**Frequency:** A recommended quarterly sampling frequency for cisterns.

It is not recommended to sample cisterns that are known to be contaminated due to their poor conditions until the repairs required to protect the stored water have been made and the cistern has been disinfected.

## RURAL WATER LINES

In some communities, potable water is delivered to homes a long distance from the community distribution network through low-pressure lines. In these systems, water trickles into the house or building cistern through a one-way valve. The cistern acts as a reservoir to provide enough water during times of heavy use. A pump inside the house or building pressurizes the water for use throughout the home or building




Rural Water Line

3-PUBLIC SYSTEM

**Frequency:** A recommended quarterly sampling frequency.

4-PRIVATE SYSTEM

**Frequency:** On-request sampling and testing services are available for First Nations residents served by Private Systems (individual wells) with fewer than five connections to ensure the quality and safety of their drinking water. For more information see Health Canada's *Tool Kit for Individual Wells for First Nations*.

# 6.4 PROCEDURE FOR SAMPLE COLLECTION AND HANDLING

Here's how to properly collect, store, and ship drinking water samples.

## SAMPLING KIT AND SUPPLIES

First, prepare your sampling kit.

It could include:

- A cooler with ice packs to store the samples
- Appropriate sample bottles
- Permanent marker for labelling
- Pen and logbook/log sheet to record the details of samples taken (sample site, location of sample, date and time of sample, free chlorine level, total chlorine level)
- Chlorine field kit
- Lint-free cloths
- Field turbidity meter (if required)
- Bleach solution[3] or alcohol swabs[4]

DISINFECTING FAUCETS WITH A BLEACH SOLUTION

Prepare a 1:10 solution of household bleach (approx. 1 tablespoon (15 ml) of bleach in 125 ml of water).

Take the bleach solution with you in a sample bottle.

Make up a new bleach solution every week.

After disinfecting the faucet with the bleach solution, let the water run for 2 to 3 minutes before taking your sample.

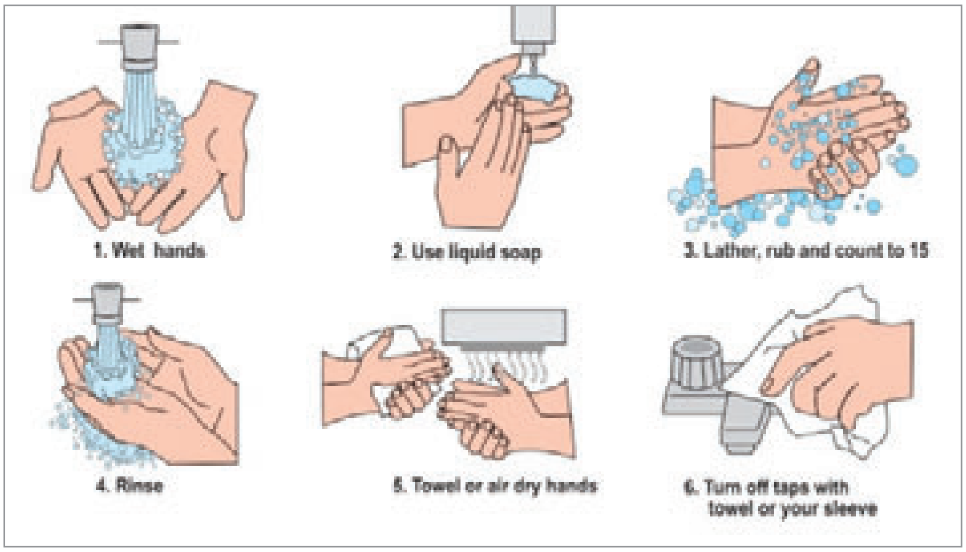
## HAND WASHING

Wash your hands before you take water samples. However, if hand washing is not possible, use hand sanitizer or an alcohol swab to disinfect your hands.

Your hands must be clean. If they are dirty, you may contaminate the water sample even though the water in the distribution system may be perfectly safe.

There is a Health Canada hand washing factsheet in Appendix D.

Wash your hands thoroughly using the following method:




Proper hand washing technique[5]

## SAMPLE LABELLING

You must label samples accurately so the data can be tracked and interpreted.

Labelling sample bottle

Record this information either on the sample label or on the bottle:

1. The unique site identifier such as name or street address
2. The date and time of sample collection (critical for bacteria tests)
3. Your initials

NOTE

> Record field measurements (i.e. chlorine residual, turbidity, and pH) in your field logbook or on a sample sheet. You also can record field measurements directly on the sample bottle if there is room.

When you send samples to an external laboratory, you must use the lab's appropriate chain of custody form. There is an example of a chain of custody form in Appendix E.

Example bottle label for external laboratory

## SAMPLE COLLECTION

The proper collection and handling of drinking water samples is critical for obtaining valid results. You must always collect your samples directly into a sterile sample bottle. Generally, you will collect your drinking water samples from taps located at pre-determined sampling points.

You must always take your samples from a cold water tap. Hot water has been sitting in a hot water tank and is not representative of the quality of the water in the drinking water distribution system.

Collecting a water sample, Tara Miller, Six Nations ON

NEVER TAKE YOUR SAMPLES FROM:

- Visibly dirty faucets
- Garden hoses, faucets in workshops, garages or other unclean areas
- Faucets connected to water softeners or other treatment devices (unless you are testing the effectiveness of the treatment unit)

AVOID TAKING YOUR SAMPLES FROM:

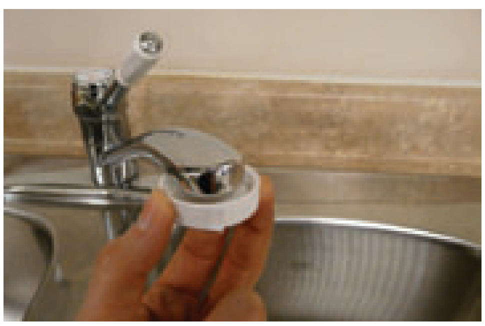
- Outdoor faucets
- Dripping faucets or faucets that leak around the seal
- Faucets that cannot deliver a smooth stream of water
- Faucets with a threaded end or hose end
- Metal fixtures with external plastic or rubber inserts
- Faucets where you cannot remove the aerator/filter

SAMPLE COLLECTION PROCEDURE[6]

Make sure your hands are clean. If possible, wash your hands before you collect the sample. Use an alcohol wipe, or hand sanitizer if you can't wash your hands with soap and water.

1. Use only approved sample bottles. For microbiological samples, use only sterile sampling bottles containing sodium thiosulphate (which neutralizes chlorine).
2. Make sure sampling bottles are kept clean and free of contamination before and after you collect the sample.
3. Remove any attachments on the faucet (aeration devices, water purification devices, or screens).

4. Disinfect the tap with your 10% household bleach solution or with an alcohol swab.



Disinfecting with bleach solution

TIP

> Carry the chlorine bleach solution in a bottle. Fill the cap of the bottle with the bleach solution and stick the end of the tap in it

Disinfecting with an alcohol swab

5. Let the cold water run in a steady stream for 2-5 minutes. As a general rule, you should keep the water running until it reaches a constant temperature.
   - If the faucet is at the end of a dead-end line, allow the water to run longer. This is necessary as water at the end of dead-end lines may have become stagnant[7].

6. Make sure you fill out all applicable information on the sample bottle label before you collect the sample.

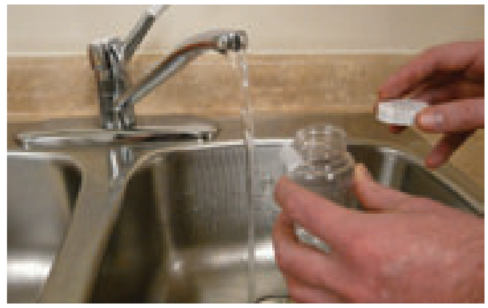
7. Reduce the water flow before you take your sample. The flow should be slow enough to ensure that none splashes while you are filling the sample bottle. (the water flow should be the width of a pencil).

8. Hold the base of the sample bottle and remove the plastic seal around the cap (not all sample bottles have seals).

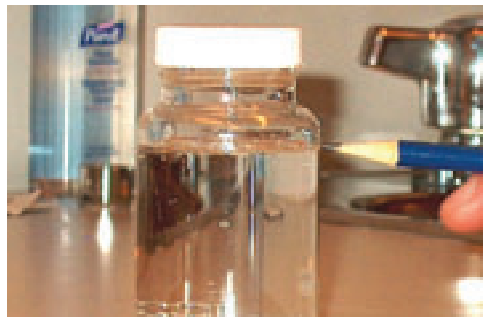
9. Remove the cap with your free hand and hold the cap between your fingers pointed down to avoid contamination.

   - Make sure you do not touch the inside of the cap or bottle with your fingers.
   - Do not use a sample bottle if: the cap is loose or cracked, the seal has been broken, the bottle appears dirty, or there are any other conditions that make you doubt the quality of the bottle.

10. Place the bottle under the stream of water and fill it to the fill line.



   - Do not dump or rinse the bottle before filling it. The white powder is sodium thiosulphate, which neutralizes the chlorine in the sample.
   - Do not allow the water to overflow the sample bottle.



11. You should replace the cap on the bottle as soon as it is filled.

NOTE

> If you drop the cap or the bottle, or contaminate the sample bottle in any way, start the process over with a new bottle.

12. Turn off the water and replace any attachments you removed.
13. Fill out any required forms.

Properly dispose of any waste (plastic seal, etc.) before you leave the sampling location.

## SAMPLE HANDLING AND TRANSPORTATION

Bring water samples to your onsite drinking water testing facility (laboratory) as soon as possible after sampling. Keep samples cool (refrigerated) before analysis or before shipment to an external laboratory. You should perform your analyses within 24 hours of collecting the samples.

EXTERNAL LABORATORY

You should pack samples being sent to an external laboratory with ice packs and ship them in insulated boxes/coolers. Do not use loose ice. Loose ice has a greater chance of contaminating the sample and will make a mess when it melts.

Sample bottles with ice packs for shipping to external laboratory

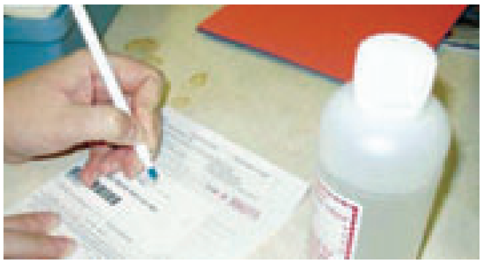
You must ship samples in time to arrive at the laboratory before the samples' holding time has expired. Generally this is between 24 and 48 hours after you take the sample. Check with your external laboratory for transit time limits.

When you send samples to an external laboratory, you must include a filled out chain-of-custody form. Chain-of-custody forms ensure that a sample is traceable from the time it was collected until it is analysed. The form validates the reliability of the sample and the data retrieved from it. Each person who has handled the sample must sign the custody form when they receive the sample and again when they hand over the sample to the next person.

Include this information in your chain-of-custody form:

1. The site code or sample location (i.e., occupant's name, house number, building name, and location within building, e.g., kitchen tap)
2. The date and time the sample was collected
3. The name of the person who collected the sample
4. The type of sample (i.e. drinking water)
5. Any other requested information on the chain-of-custody form

There is a chain of custody example form in Appendix E.



Filling out a chain of custody form

# 6.5 CONDUCTING CHLORINE ANALYSES

You measure chlorine levels to ensure that an appropriate level remains in the drinking water distribution system to protect against microbial recontamination.

## USING A COLORIMETER TO MEASURE CHLORINE RESIDUAL

Familiarize yourself with the equipment and reagents used in the analysis before you test for chlorine levels. Read all product labels and the Material Safety Data Sheets (MSDS) before using them.

The Hach Pocket Colorimeter (blue) and the Hach Pocket Colorimeter II (black) are common colorimeters used by CBWMs.

Hach Pocket Colorimeter and Hach Pocket Colorimeter II

Each colorimeter comes with an instruction manual which describes how to use it and how to troubleshoot problems.

Here's how to measure free chlorine residual and total chlorine residual:

A typical pocket colorimeter has two ranges — high and low. Before using the colorimeter, you must select the proper range. The low setting reads measurements from 0.02 to 2.00 mg/L of chlorine; the high setting reads measurements between 0.0 and 4.5 mg/L (Hach Pocket Colorimeter) and between 0.1 and 8.0 mg/L (Hach Pocket Colorimeter II).

To measure free chlorine residual set your meter in the Low Range (LR). To measure total chlorine, your meter can be in either Low Range (LR) LR or High Range (HR). Chloramines are usually measured as combined chlorine residual. You find this by subtracting the free chlorine residual from the total chlorine residual.

[Combined Cl (Chloramines) = Total Cl – Free Cl]

Both Hach Colorimeters come with a troubleshooting guide. You can verify the colorimeter's performance by following the manufacturer's instructions. There is an example of a chlorine test kit consistency check in Appendix F.

## LOW RANGE CHLORINE RESIDUAL TEST

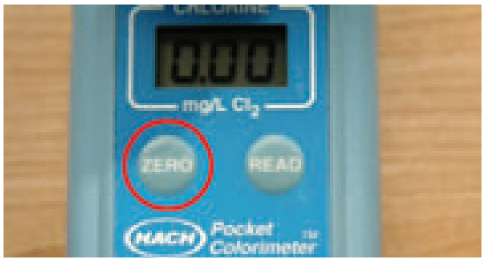
1. Wash your hands, or use an alcohol wipe/hand sanitizer if you can't wash with soap and water.
2. Run the tap for about 2-5 minutes, then fill the sample cell to the 10 ml mark and put on the cap.

3. Carefully dry the outside of the sample cell with a lint free cloth to remove fingerprints and any traces of liquid.

4. Turn on the meter.
5. Remove the cover from the Pocket Colorimeter. Place the sample cell in the measuring chamber. Make sure the diamond-shape marker is facing towards the screen.

6. Replace the cover.

7. Press the zero button (blue model) or the “0” (black model). The counter should read “0.00”.




8. Remove the sample cell from the measuring chamber. You have now completed meter zeroing.

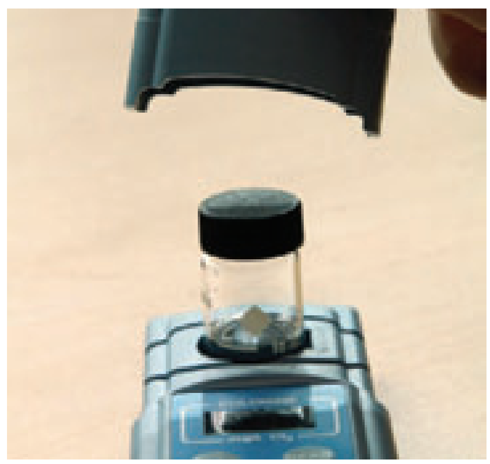
9. Fill a different sample cell with water from the tap to the 10 ml line.


10. For a low range sample of free chlorine take ONE packet of DPD free chlorine reagent. For a low range sample of total chlorine take ONE packet of DPD total chlorine reagent.

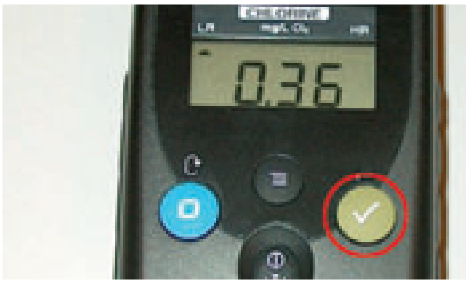
11. Add the contents of the reagent packets to the water sample, replace cap, and shake gently to dissolve the DPD reagent. NOTE: Accuracy is not affected by undissolved powder.

12. Carefully dry the outside of the sample cell with a lint free cloth to remove fingerprints and any traces of liquid.

13. Place the prepared sample cell in the measuring chamber. Make sure the diamond-shaped marker is facing the screen and replace the instrument cover.



14. With the Pocket Colorimeter on a flat surface, press the READ button (blue model) or the check mark symbol button (black model). **For free chlorine this needs to be done within 1 minute of adding DPD to the sample water. For total chlorine you need to wait 3 to 6 minutes after adding DPD to the sample water**. The instrument now displays the chlorine residual in mg/L. Record the number on your data sheet




15. When finished, thoroughly rinse the sample cells.

## HIGH RANGE CHLORINE RESIDUAL TEST

1. Wash your hands or use an alcohol wipe/hand sanitizer if you can't wash with soap and water.
2. Run the tap for 2-5 minutes, then fill the sample cell to the 10 ml mark and put on the cap.

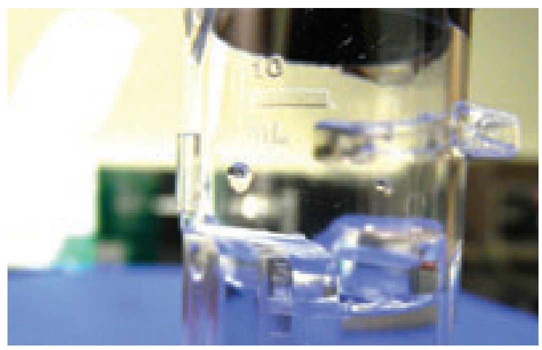
3. Carefully dry the outside of the sample cell with a lint free cloth to remove fingerprints and any traces of liquid.

4. Turn on the meter.
5. Remove the cover from the Pocket Colorimeter. Place the sample cell
6. In the measuring chamber. Make sure the traingle-shaped marker is facing away from the screen .


7. Replace the cover.


8. Press the zero button (blue model) or the "0" button (black model). The counter should read "0.0".
9. Remove the sample cell from the measuring chamber. You now have completed meter zeroing.


10. Fill a different sample bottle only to the 5ml line.



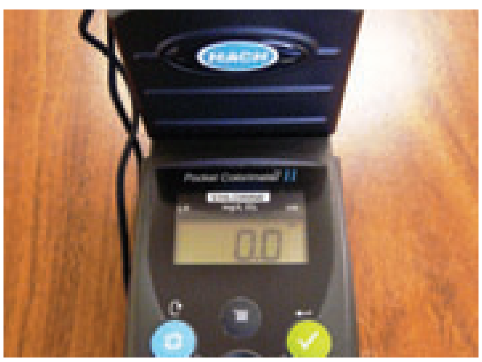
11. For a high range sample of free chlorine take TWO packets of DPD free chlorine reagent. For a high range sample of total chlorine take TWO packets of DPD total chlorine reagent.

12. Add the contents of the reagent packets to the water sample, replace cap and shake gently to dissolve the DPD reagent.

13. Carefully dry the outside of the sample cell with a lint free cloth to remove fingerprints and any traces of liquid.

14. Place the sample cell in the measuring chamber. Make sure the traingle-shaped marker is facing away from the screen .


15. Replace the cover.




16. With the Pocket Colorimeter on a flat surface, press READ button (blue model) or the check symbol button (black model). **For free chlorine this needs to be done within 1 minute of adding DPD to the sample water. For total chlorine you need to wait 3 to 6 minutes after adding DPD to the sample water**. The instrument now displays the chlorine residual in mg/L. Record the number on your data sheet


17. When finished, thoroughly rinse the sample cells.

## INTERPRETATION OF RESULTS

The lower limit for free chlorine in the drinking water distribution system is 0.2 mg/L (the ideal concentration). The upper limit for total chlorine in the drinking water distribution system is 1.0 mg/L[8].

However, some regions follow provincial standards, which may be different.

Your EHO will tell you the appropriate chlorine levels for your region.

If the free chlorine or the total chlorine residual is outside appropriate levels, retest and if the results are still outside the limits, notify your WTPO and EHO.

If the free chlorine residual at a sampling location is greater than 4.0 mg/L[9] or the combined chlorine residual is greater than 3.0 mg/L[10], you should retest and if the results remain high, immediately notify the WTPO and your EHO.

# 6.6 CONDUCTING MICROBIOLOGICAL ANALYSES

One of your most important tasks is conducting microbiological analyses. You must follow good sampling practices because it is very easy to contaminate a microbiological sample with bacteria from dirty hands or surfaces.

Four tests are detailed below: The Colilert® and Colisure® Presence/Absence tests, and the Colilert® and Colisure® Most Probable Number Tests.

The major difference between the Colilert® and Colisure® methods is the colour of the positive and negative samples.

COLILERT®:

- Colorless = **negative** for total coliforms and *E. coli*
- Yellow = **positive** for total coliforms
- Bluish fluorescence under UV light = **positive** for *E. coli*

COLISURE®:

- Yellow = **negative** for total coliforms and *E. coli*
- Magenta = **positive** for total coliforms
- Magenta/Bluish fluorescence under UV light = **positive** for *E. coli*

A negative sample will be colourless while a positive sample will be yellow. However, when using Colisure®, a negative will be yellow, while a positive test will turn mag

## MATERIALS AND SUPPLIES

You need an appropriate laboratory environment to carry out correct sampling and testing procedures. EHOs will work collaboratively with you and Chief and Council to ensure there is a suitable laboratory environment to conduct drinking water sampling and testing.

A suitable laboratory environment must have:

SAMPLING AND STORAGE

- Water sample bottles
- Cooler
- Ice packs
- Refrigerator
- Freezer
- Logbook or sampling sheet
- Permanent marker
- Portable Chlorine Testing Kit and DPD reagent

BACTERIA ANALYSES

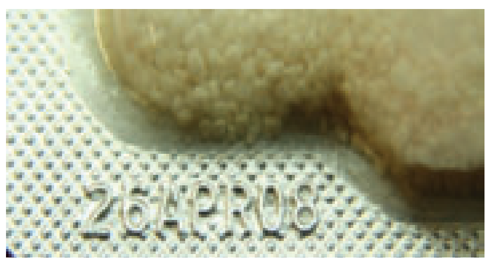
- Incubator with thermometer
- Colilert® reagent and comparator **or** Colisure® reagent
- UV light and protective glasses **or** UV light box
- Quanti-Trays and Quanti-Tray sealer

Please follow the manufacturer's instructions and procedures included with the equipment and supplies.

ADDITIONAL NOTES

You should:

- Maintain an inventory of laboratory contents
- Store sterile sample bottles in a dry location where they will be protected from contamination
- Check the expiry date on the the reagents package before using them
- Discard expired reagent. Results of analyses using expired reagents cannot be considered valid
- Contact your EHO or designated person for new supplies




Expired reagent

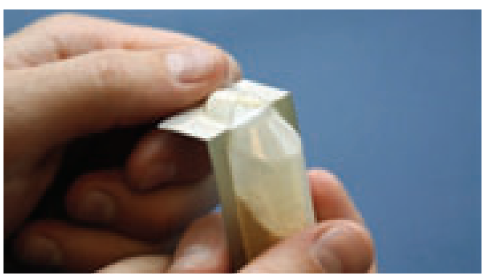
## COLILERT® PRESENCE/ABSENCE

The Colilert® reagent detects the presence or absence of both total coliforms and *E. coli*.

The reagent turns yellow in the presence of total coliforms If *E. coli* is present the sample emits a visible bluish fluorescence (glow) when illuminated by an ultraviolet lamp in a dark place. This test indicates whether total coliforms or *E. coli* are present in the drinking water sample. However, it does not tell us the actual quantities of total coliforms or *E. coli* in the sample.

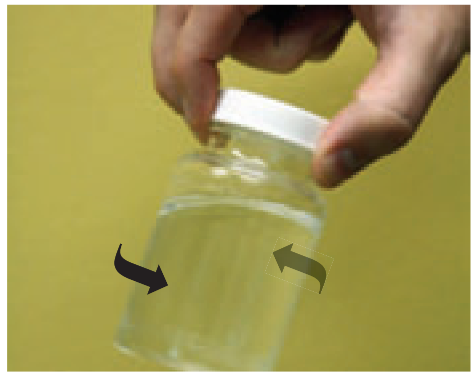
1. Verify the incubator is at 35 35°C ± 0.5°C. Adjust accordingly.
2. Before starting, clean your work surface and wash your hands.
3. Loosen the lid of the sample bottle.
4. Check the expiry date of the Colilert® reagent. If it has expired, dispose of it.
5. Carefully separate a Colilert® snap pack from the strip.
6. Tap the Colilert® reagent snap pack to ensure that all the powder falls to the bottom.

7. Open one pack by snapping back the top at the score line. Point the package away from your face when opening the snap pack and make sure you do not touch the score line with your fingers.



8. Remove the cap from the sample bottle (100 ml Colilert® bottle) and hold the cap facing down in one hand to avoid contamination. Add the contents of the pack to the sample. Replace cap and tighten.

9. Shake gently until the reagent dissolves. Some particles may remain in suspension, but this is normal. They will dissolve during incubation.



10. Incubate the sample at 35°C ± 0.5°C for 24 hours. Record the incubator temperature and the in-and-out time of the sample in your logbook or log sheet.

11. After 24 hours, compare each incubated sample against the colour comparator. If no yellow is observed, the test result is negative for total coliforms and *E. coli*. If the sample has a yellow colour stronger than or equivalent to that of the comparator, the sample is positive for total coliforms.

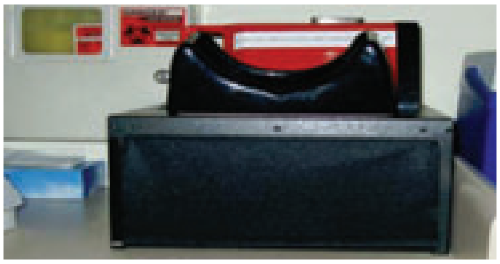
12. If a sample is yellow after 24 hours of incubation, but slightly less so than the comparator, it may be incubated for up to 4 hours more (but no more than 28 hours in total).
    - If the sample is positive for total coliform, the colour will intensify. If the sample remains less yellow than the comparator, it is negative.

NOTE

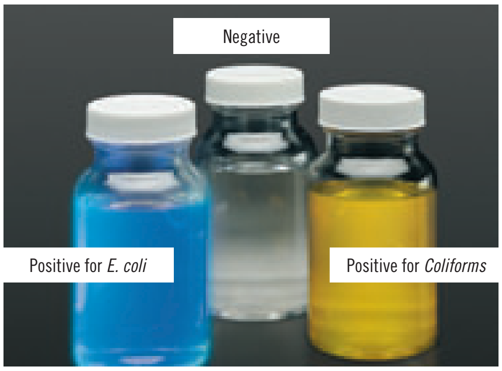
> If a sample accidentally is incubated for more than 28 hours:
> - No yellow colour is considered a valid negative test
> - Any yellow colour should be considered inconclusive and the site should be re-sampled.

13. If the sample is positive for total coliforms, check for *E. coli* by using a UV light. Wear protective eye wear or use a UV viewing cabinet. Place positive samples 3-5 inches (about 8-13 cm) in front of the ultraviolet light. Make sure the light faces away from you and toward the sample container. Look for a blue fluorescence in a dark environment. If the fluorescence is greater than or equal to that of the comparator, the sample is positive for *E. coli*.

    Remember to check the comparator expiry date.



UV viewing cabinet




Colilert® Results Summary (IDEXX)

14. Record data in your logbook/log sheets. If you get any positive results, immediately contact your EHO.

## COLILERT® MOST PROBABLE NUMBER (MPN)

The Quanti-Tray® test gives the Most Probable Number (MPN) of bacteria colonies in a sample.

QUANTI-TRAY® PROCEDURE

1. Before starting the test:
    - Verify the incubator is at 35 35°C ± 0.5°C. Adjust accordingly.
    - Clean your work surface
    - Wash your hands and
    - Turn on the Quanti-Tray® sealer to give it time to warm up (the light will turn green when the sealer is ready)
2. Loosen the lid on the sample bottle.
3. Check the expiry date of the Colilert® reagent before using it. If it has expired, dispose of it.
4. Carefully separate a Colilert® Snap Pack from the strip.

5. Tap the packet to ensure that all the powder falls to the bottom before opening.
6. Open one pack by snapping back the top at the score line. Point the package away from your face when opening.
7. Remove the cap from the sample bottle (100 ml Colilert® bottle). Hold the bottle cap between your fingers facing down and add the contents of the pack to the sample. Replace the cap and tighten.
8. Shake gently until the reagent is completely dissolved (note: the reagent must be competently dissolved for the MPN test).
9. Pour the sample into a Quanti-Tray®, making sure not to touch the opening of the Quanti-Tray® with your hand or the sample bottle.

10. Place the Quanti-tray® onto the rubber tray carrier of the Quanti-Tray® Sealer with the sample cells facing down. Push the rubber tray carrier into the sealer.

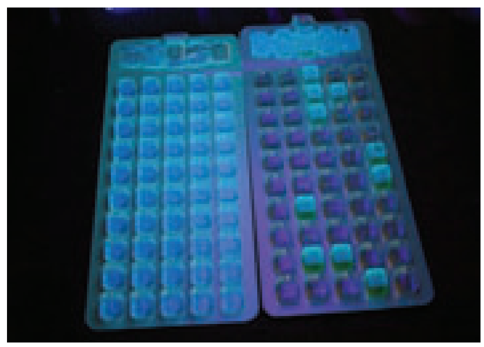
11. Incubate the sample mixture at 35°C±0.5°C for 24 hours. Record the incubator temperature and in-and-out time of the sample in your logbook/log sheet.

12. After 24 hours, compare each incubated sample against the colour comparator. No yellow visible means the test result is negative for total coliforms and *E. coli*. If the sample has a yellow colour stronger than – or equal to – that of the comparator, the sample is positive for total coliforms.

    Remember to check the comparator expiry date.

13. Record the MPN of total coliforms using the MPN table. To use the table: 1. Count the number of positive wells. 2. Refer to the MPN chart to see the corresponding number of total coliforms.
14. If a sample is yellow after 24 hours of incubation, but slightly less so than the comparator, it may be incubated for up to 4 hours more (but no more than 28 hours total). If the sample is positive for total coliform, the colour will intensify. If the sample remains the same, it is negative.
15. If the sample is positive for total coliforms, check for *E. coli* by using a UV light. Wear protective eye wear or use a UV viewing cabinet and place positive samples 3-5 inches (about 8-13 cm) in front of the ultraviolet light. Make sure the light faces away from you and toward the sample container.

    Look for a blue fluorescence (glow) in a dark environment. If the fluorescence is greater than or equal to that of the comparator, the sample is positive for *E. coli*.
16. Count the number of wells that fluoresce blue and record the MPN of *E. coli* using the MPN table (See Table 1 IDEXX Most Probably Number Chart).



NOTE

If you were unable to check the results within 28 hours:

- No yellow colour is considered a valid negative test
- Yellow colour is not considered to be a valid positive test. Resample the site and re-run the analysis.

## Most Probable Number (MPN) Table

| No. of wells giving positive reaction | MPN per 100ml sample |
|---|---|
| 0 | <1.0 |
| 1 | 1.0 |
| 2 | 2.0 |
| 3 | 3.1 |
| 4 | 4.2 |
| 5 | 5.3 |
| 6 | 6.4 |
| 7 | 7.5 |
| 8 | 8.7 |
| 9 | 9.9 |
| 10 | 11.1 |
| 11 | 12.4 |
| 12 | 13.7 |
| 13 | 15.0 |
| 14 | 16.4 |
| 15 | 17.8 |
| 16 | 19.2 |
| 17 | 20.7 |
| 18 | 22.2 |
| 19 | 23.8 |
| 20 | 25.4 |
| 21 | 27.1 |
| 22 | 28.8 |
| 23 | 30.6 |
| 24 | 32.4 |
| 25 | 34.4 |
| 26 | 36.4 |
| 27 | 38.4 |
| 28 | 40.6 |
| 29 | 42.9 |
| 30 | 45.3 |
| 31 | 47.8 |
| 32 | 50.4 |
| 33 | 53.1 |
| 34 | 56.0 |
| 35 | 59.1 |
| 36 | 62.4 |
| 37 | 65.9 |
| 38 | 69.7 |
| 39 | 73.8 |
| 40 | 78.2 |
| 41 | 83.1 |
| 42 | 88.5 |
| 43 | 94.5 |
| 44 | 101.3 |
| 45 | 109.1 |
| 46 | 118.4 |
| 47 | 129.8 |
| 48 | 144.5 |
| 49 | 165.2 |
| 50 | 200.5 |
| 51 | >200.5 |

## COLISURE® PRESENCE/ABSENCE

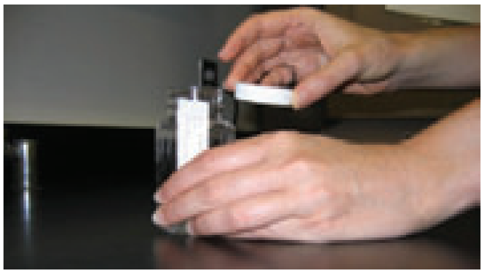
Instead of using the Colilert® reagent to detect total coliforms and *E. coli* in water, you can use a similar product, called Colisure®. The procedure is carried out in the same way as Colilert®. However, if a water sample contains total coliforms, it will turn magenta, a purplish-pink colour. This makes positive results easier to detect and you don't need to use a comparator.

PROCEDURE

1. Verify the incubator is at 35 35°C ± 0.5°C. Adjust accordingly.
2. Before starting the test, make sure to clean your work surface and wash your hands.
3. Loosen the cap of the sample bottle.
4. Check the expiry date of the Colisure® reagent before using it. If it has expired, dispose of it.
5. Carefully separate a Colisure® snap pack from the strip.
6. Tap the reagent snap pack to ensure that all the powder falls to the bottom.

7. Open one pack by snapping back the top at the score line. Point the package away from your face while opening the snap pack and be careful not to touch the score line with your fingers.

8. Remove the cap from a 100 ml Colisure® sample bottle. Hold the bottle cap between your fingers and point it down to avoid contamination.



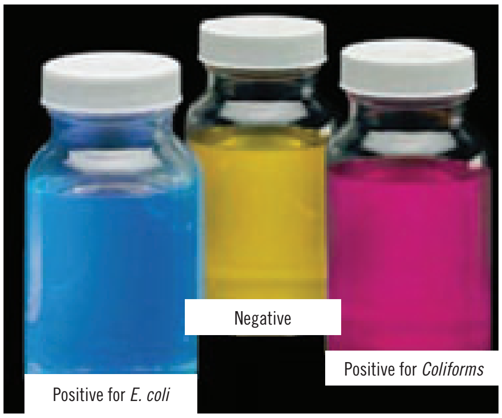
Add the contents of the pack to the sample. The sample will turn yellow. Replace the cap tightly.

9. Shake gently until the reagent dissolves. Some particles may remain in suspension, but this is normal. They will dissolve during incubation.

10. Incubate the sample mixture at 35°C ± 0.5°C for 24 hours. Record the incubator temperature and the in-and-out time of the sample in your logbook/log sheet.

11. If you don't see a magenta colour after 24 hours and the sample remains a yellow/gold colour, then the test result is negative for total coliform and *E. coli*. If the sample has a red/magenta colour then the sample is positive for total coliforms.

12. If a sample is pink or orange after 24 hours of incubation, it may be incubated for up to 24 hours more (but no more than 48 hours in total). If the sample is positive for total coliform, the colour will intensify. If the sample remains the same, it should be considered invalid, and the site should be re-sampled.
13. Red/magenta or red/magenta with fluorescence first observed after 48 hours is not a valid positive.
14. If the sample is positive for total coliform, check for *E. coli* using a UV light. Wear protective eye wear or use a UV viewing cabinet. Place positive samples 3-5 inches (about 8-13 cm) in front of the ultraviolet light. Make sure the light faces away from you and toward the sample container.
15. Observe for a blue fluorescence in a dark environment. If there is fluorescence, the sample is positive for *E. coli*.




Colisure® Results Summary (IDEXX)

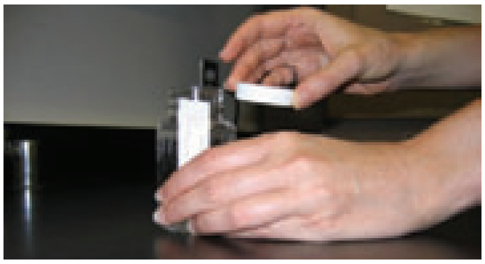
16. Record the data in a logbook/log sheet. Contact your EHO immediately if you get any positive results.

## COLISURE® MOST PROBABLE NUMBER (MPN)

The Quanti-Tray® test gives the Most Probable Number (MPN) of bacteria colonies in a water sample.

QUANTI-TRAY® PROCEDURE

1. Before starting the test:
   - Verify the incubator is at 35 35°C ± 0.5°C. Adjust accordingly.
   - Clean your work surface;
   - Wash your hands; and
   - Turn on the Quanti-Tray® Sealer to give it time to warm up (the light will turn green when the sealer is ready).
2. Loosen the cap of the sample bottle.
3. Check the expiry date of the Colisure® reagent before using it. If it has expired, dispose of it.
4. Carefully separate a Colisure® snap pack from the strip.
5. Tap the packet to ensure that all the powder falls to the bottom before opening.
6. Open one pack by snapping back the top at the score line. Point the package away from your face when opening.
7. Next, remove the cap from a 100 ml water sample collected in a Colisure® bottle. Hold the bottle cap between your fingers and point it down to avoid contamination.

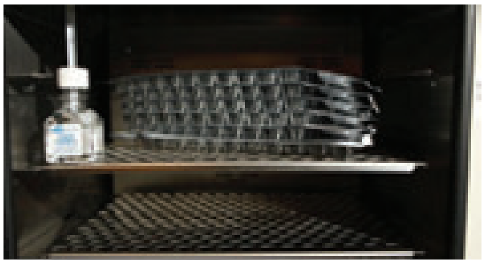


8. Add the contents of the pack to the sample.
9. Next add 5 drops of IDEXX Antifoam solution. Replace the cap.
10. Shake gently until the reagent is dissolved. (note: the reagent must be competently dissolved for the MPN test).

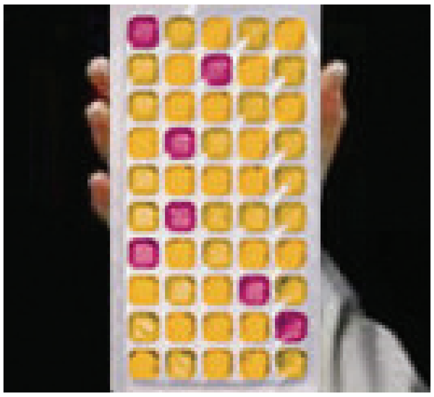
11. Pour the sample into a Quanti-Tray®.

12. Place the Quanti-tray® onto the rubber tray carrier of the Quanti-Tray® Sealer with the sample cells facing down. Push the rubber tray carrier into the sealer.

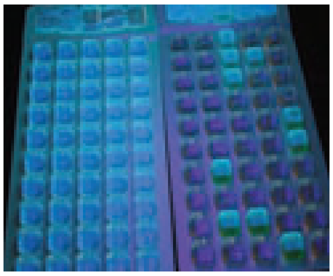
13. Incubate the sample mixture at 35°C ± 0.5°C for 24 hours. Record the incubator temperature and in-and-out time of the sample in your logbook/log sheet.



14. If you don't see magenta wells after 24 hours, the test result is negative for total coliforms and *E. coli*. If the sample has red/magenta coloured wells then the sample is positive for total coliforms.



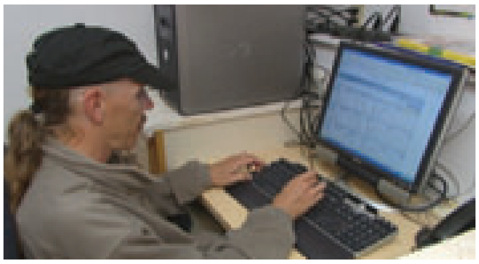
15. Record the MPN of total coliforms using the MPN table. To use the table: 1. Count the number of positive wells. 2. Refer to the MPN chart to see the corresponding number of total coliforms.
16. If a sample is pink/orange after 24 hours of incubation, it may be incubated for up to 24 hours more (but no more than 48 hours in total). If the sample is total coliform positive, the colour will intensify. If the sample remains the same, it should be considered invalid, and the site should be re-sampled.
17. If a sample accidentally is incubated for more than 48 hours, and you see red/magenta or red/magenta with fluorescence after the 48 hours this indicates the sample is not a valid positive.
18. If the sample is positive for total coliforms, check for *E. coli* by using a UV light. Wear protective eye wear or use a UV viewing cabinet Place positive samples 3-5 inches (about 8-13 cm) in front of the ultraviolet light. Make sure the light faces away from you and toward the sample container.
19. Look for a blue fluorescence in a dark environment. If there is fluorescence, the sample is positive for *E. coli*.
20. Count the number of wells that fluoresce blue, and then record the MPN of *E. coli* using the MPN table (see Table 1).



21. If you encounter any positive results, immediately contact your EHO.

# 6.7 REPORTING DRINKING WATER QUALITY DATA

There are several steps in reporting drinking water quality data. You must establish a clear reporting procedure with your EHO and Chief and Council.



Steve Peter-Paul, CBWM, NB

Generally, reporting drinking water quality data involves:

- Reporting adverse drinking water quality to your EHO
- Maintaining a logbook or log sheets
- Submitting data or entering data into a water quality database (depending on the region)
- Reporting to various partners (depending on the region)
- Reporting unusual occurrences

## MAINTAINING A LOGBOOK OR LOG SHEETS

Your logbook or log sheets should contain all of the information related to the sampling and analysis to be performed. You should include the following information:

- Sample location
- Type of sample
- Sample date and time
- Residual chlorine concentration
- Microbiological drinking water quality results

If you notice anything out of the ordinary (for instance, sample discoloration), record it in your logbook. If you have any equipment problems record them, too.

The more information you record the better. Your logbooks should have a permanent binding to help you keep all your information together. Use a pen instead of a pencil when recording information. Never remove pages from your logbook. Make sure to number all logbook pages. Always sign and date your work.

There are templates for logbooks/log sheets from different regions in Appendix A.

## RECORDING TEST RESULTS

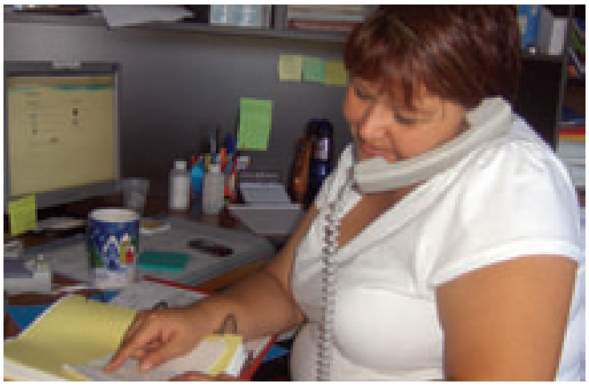
You must record results of drinking water quality tests. Enter the results into a database (if applicable) as soon as they are obtained. This information will include microbiological, chlorine residual and possibly turbidity test results.

Reports produced from the database can be used by the EHO or the Band Council to monitor the community drinking water quality and to ensure that the scheduled sampling has taken place.

If you can't enter the results immediately into a database, you must regularly report the drinking water quality data to your EHO. The frequency of reporting will depend on your region.

## REPORTING ADVERSE DRINKING WATER QUALITY

If you get an adverse drinking water quality result, **you must immediately advise your EHO** and inform the WTPO as well as any other responsible persons (Chief and Council, Health Director, etc.).



Sheryl St. Pierre, WTPO, Moose Deer Point ON

Adverse drinking water quality results may include:

- The presence of total coliforms or *E. coli*
- Low or high levels of chlorine residual
- Elevated turbidity levels

Your EHO will recommend next steps.

## REPORTING UNUSUAL CONDITIONS OR OCCURRENCES

Document any unusual occurrences or conditions in your logbook and report them to your EHO and WTPO.

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[10] Health Canada. 2008. Guidelines for Canadian Drinking Water Quality - Summary Table. Available at: http://www.hc-sc.gc.ca/.


Dean Ottawa, Community of Kitigan Zibi Anishinabeg, 2010

# CHAPTER 7

# COMMUNICATION AND PUBLIC AWARENESS

## INTRODUCTION

Effective communication is an essential part of your job as a CBWM. You often will be the first to discover adverse drinking water quality conditions in your community and will have to communicate this information quickly to help prevent a potential outbreak of waterborne disease. As detailed insection 6.7, you must establish a clear reporting procedure with your EHO and your Chief and Council.

You also will often play an important role in public awareness initiatives around drinking water quality and environmental protection.

When you finish this chapter you should be able to:

- Understand various Drinking Water Advisories
- Understand the importance of an Emergency Response Plan
- Describe potential public awareness activities in which you could participate

# 7.1 DRINKING WATER ADVISORIES – AN OVERVIEW

Drinking Water Advisories/Orders are preventative measures. They are designed to protect the public from waterborne contaminants that could be, or are known to be, present in drinking water. There are two types[1]:

- Boil Water Advisory/Order
- Do Not Drink Advisory

NOTE

> For more information refer to Health Canada's *Water Advisory Toolkit For First Nations*. The Tool Kit provides examples of print ads, posters, door hangers and electronic files for print and radio to use if a water advisory is issued.

## BOIL WATER ADVISORIES / ORDERS

A Boil Water Advisory or a Boil Water Order is effectively the same thing. Advisories are issued and lifted by the Chief and Council while Orders are issued and lifted by a Medical Officer of Health (MOH), who is authorized to do so under provincial *Public Health Acts*.

The EHO recommends to Chief and Council to issue – and when safe – lift a Boil Water Advisory.

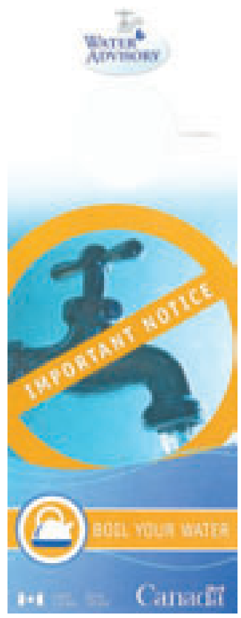
Factors that may prompt further investigation – or form the basis for issuing a Boil Water Advisory – include[2]:

- Operational conditions such as:
  - › Local maintenance or emergency repairs to the drinking water distribution system where there is a concern that microbiological contamination may exist.
  - › Equipment malfunction during water treatment or distribution.
  - › Inadequate disinfection or disinfectant residuals in the water.
  - › Situations in which continued operation of the system would compromise public health.
- Water quality conditions such as:
  - › Significant deterioration in the microbiological quality or turbidity of the raw water (i.e. levels that cannot be treated effectively at the plant).
  - › Sudden unexpected changes in water quality.
  - › Treated water that still is of unacceptable microbiological quality.
  - › When epidemiological evidence indicates that the drinking water is – or may be – responsible for an illness outbreak.

These conditions can occur for many reasons, including inadequate filtration and/or disinfection during treatment, or re-contamination in the drinking water distribution system.

DURING A BOIL WATER ADVISORY / ORDER

- Tap water must be brought to a rolling boil for at least one minute and then allowed to cool before it is used for:
  - › Drinking
  - › Brushing teeth or soaking false teeth
  - › Washing fruits and vegetables
  - › Preparing anything to eat or drink (such as soup, tea, juice, or infant formula)
  - › Making ice cubes
  - › Cooking and food preparation




- Water from drinking fountains is not safe and must not be used.
- Do not bathe infants or small children in tap water – they may swallow the contaminated water. Instead, bathe or sponge bathe using an alternate safe water supply or water that has been brought to a rolling boil for at least one minute and allowed to cool down to prevent burning.

NOTE

> Bringing water to a rolling boil for at least one minute will destroy any pathogenic microorganisms that may be present, making the water safe to drink.

Tap water for other household purposes does not usually need to be boiled. Adults, teenagers, and other children may shower, bathe, and wash in it but should avoid swallowing any water.

Dishes and laundry may be washed in tap water.

Talk to your EHO if you have any questions.


## DO NOT DRINK ADVISORY

A Do Not Drink Advisory is issued and lifted by the Chief and Council based on the recommendation of the EHO.


It should be emphasized that a Do Not Drink Advisory rarely requires stopping the supply of water, since it will most likely be suitable for flushing toilets and for essential services such as firefighting[3].

A Do Not Drink Advisory means the community drinking water supply is unsafe. It is issued when the water system contains a contaminant that poses a health risk and may not be removed by boiling.

The water should not be used in any way that results in it being swallowed or coming in contact with the mouth. It must not be used for drinking, cooking, making drinks, soups, or ice cubes or for bathing infants or toddlers.

NOTE

| |
|---|
| BOILING THE WATER WILL NOT MAKE IT SAFE |

An alternate safe water source, such as bottled water must be used for:

- Drinking
- Cooking
- Making juice, tea, coffee, soup, and infant formula
- Making ice cubes
- Washing fruit and vegetables
- Brushing teeth or soaking false teeth
- Bathing infants or toddlers

Water from public drinking fountains is not safe and must not be used

## LIFTING OF THE DRINKING WATER ADVISORIES

When a Drinking Water Advisory is lifted, it must be clearly communicated to all drinking water system users.


The EHO or MOH will advise the Chief and Council when the drinking water is safe and the Drinking Water Advisory can be lifted.

The Chief and Council are responsible for notifying community members that the Drinking Water Advisory has been lifted. At this point, you should distribute instructions on how to clean out building water lines before they are used again.

Before the community water supply can be used for drinking, residents should:

- Run all the cold water faucets for one full minute
- Remove all screens on faucets and clean them in soap and water, then rinse
- Run all drinking water fountains for one full minute.

Those residents with water softeners must run their softeners through a regeneration cycle and should check their owner's manual for additional instructions.

The Chief and Council also are responsible for notifying the following – both orally and in writing – that the Drinking Water Advisory has been lifted:

- Government health officials
- Elected officials
- Media

NOTE

> Individual wells may have additional requirements that must be met before they can be placed back into service. Talk to your EHO for more information.

# 7.2 EMERGENCY RESPONSE PLAN (ERP)


An Emergency Response Plan (ERP) is a plan of action that is followed in an emergency.

The Chief and Council are responsible for ensuring their community has an ERP in place. Part of the ERP will discuss the drinking water system and describe how to implement drinking water advisories.

The ERP is an essential part of the multi-barrier approach to ensure safe drinking water and should cover a number of possible emergency situations.

When an emergency situation does present itself, immediate action should be taken to resolve the problem. A well-developed ERP will detail the exact steps to follow and whom to call so that a response is carried out quickly and efficiently.

To develop an ERP, first identify the possible issues that could adversely impact drinking water quality or quantity. Then, develop specific solutions if any of the problems occur. Planning for emergencies is the first step in helping to prevent them. If you are aware of potential hazards in your drinking water system, you can prevent them from happening in the first place.

As the CBWM, you also may be asked to participate in developing and putting into action the ERP.

| THE EMERGENCY RESPONSE PLAN SHOULD INCLUDE: |
| --- |
| **A LIST OF CONTACTS**: The people and organizations that should be contacted if an emergency arises. This list should include: government contacts, media, alternate water suppliers, and repair technicians. The list should be updated regularly. |
| **A LIST OF POTENTIAL EMERGENCY SITUATIONS**: An emergency could include any situation that may make drinking water unsafe, prevent the flow of water, or otherwise pose a health risk. This can include: adverse water quality, distribution line breaks, flooding, and power failures. |
| **COMMUNICATIONS**: In the event of an emergency, all your system users must be contacted as soon as possible. Your communications plan will help. Your plan will greatly depend on the types of customers your drinking-water system serves. Common ways for communicating include: public notices, phone trees, media, and signs. |

# 7.3 PUBLIC AWARENESS ACTIVITIES

Depending on your region, you may also be asked to participate in public education on drinking-water protection. Community health fairs provide an opportunity for you to provide information to the general public about community drinking water quality issues. You also may provide information to community members on ways of reducing the risk of waterborne diseases.

You can raise awareness of drinking water quality issues and instill confidence in First Nations drinking water by:

- Participating in drinking water workshops or health fairs and informing the public about drinking water quality and pollution prevention.
- Making drinking water monitoring results or summaries available to the public and providing information about how risks are addressed.

**Be the eyes and ears of your community. Discuss any issues being brought up by community members with your EHO**

Environmental contaminants public presentation, Timiskaming First Nation, Québec.

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# REVIEW QUESTIONS

## Chapter 1 – Role of a Community-Based Drinking Water Monitor

1. As a CBWM, you are responsible for sample collection and lab analysis:
   a. True
   b. False

2. As a CBWM, you are responsible for record keeping and reporting of results:
   a. True
   b. False

3. The CBWM advises the EHO of unsatisfactory test results:
   a. True
   b. False

4. A CBWM will test private drinking water supplies as part of their regular monitoring schedule
   a. True
   b. False

5. Which of the following people could you be working with in your role as a CBWM?
   a. EHO
   b. Water Treatment Plant Operator
   c. Public Health Nurse
   d. Chief and Council
   e. All of the above

6. Which of the following public awareness activities may be done by a CBWM:
   a. Participate at a health fare
   b. Answer questions about water quality from residents
   c. Give a presentation at the local school
   d. Distribute information during a water advisory
   e. All of the above

7. Quality Assurance is an important CBWM task to ensure valid drinking water quality results:
   a. True
   b. False

8. During a Boil Water Advisory, a CBWM's responsibilities will include:
   a. Collecting and analyzing extra samples
   b. Distributing advisory information to residents and put posters in public buildings
   c. A and B
   d. Working overtime in the water treatment plant

9. Ensuring safe drinking water in communities requires:
   a. Drinking water quality monitoring
   b. Drinking water treatment
   c. Public health and primary health care services
   d. All of the above

10. Which of the following is NOT one of the responsibilities of a CBWM:
   a. Identifying trends that may suggest a potential waterborne disease outbreak
   b. Storing, shipping and tracking water samples
   c. Keeping up to date on training offered by the Environmental Public Health Services in your region
   d. Helping owners of private drinking water systems by providing information and collecting water samples on demand

11. Which of the following is NOT one of the responsibilities of your EHO:
   a. Advising the Band Council (and possibly Tribal Council) of any drinking water quality problems
   b. Maintaining operations at the water treatment plant
   c. Reviewing and interpreting your water sample results
   d. Conducting routine water sampling Investigating waterborne disease outbreaks

## Chapter 2 – Multi-Barrier Approach to Safe Drinking Water

1. Which barrier is the CBWM involved with while collecting and analyzing drinking water samples?
   a. Barrier 1 – Source Water Protection
   b. Barrier 2 – Drinking Water Treatment
   c. Barrier 3 – Distribution System Cleanliness and Maintenance of a Chlorine Residual
   d. Barrier 4 – Drinking Water Monitoring

2. It is not important to protect the drinking water source if there a good treatment system:
   a. True
   b. False

3. The minimum recommended treatment required for a community surface water source is:
   a. Disinfection
   b. Filtration and disinfection
   c. No treatment
   d. None of the above

4. The minimum recommended treatment required for a community shallow well is:
   a. Disinfection
   b. Filtration and disinfection
   c. No treatment
   d. None of the above

5. The minimum recommended treatment required for a community deep well is:
   a. Disinfection
   b. Filtration and disinfection
   c. No treatment
   d. None of the above

6. Identify the barriers that were not respected when the Walkerton incident occurred.
   a. Barrier 1 – Source Water Protection
   b. Barrier 2 – Drinking Water Treatment
   c. Barrier 3 – Distribution System Cleanliness and Maintenance of a Chlorine Residual
   d. Barrier 4 – Drinking Water Monitoring
   e. All of the above

7. Surface waters can flow into groundwater and groundwater can also flow into surface waters:
   a. True
   b. False

8. GUDI is a groundwater source that can be directly recharged and also directly contaminated by a surface water source:
   a. True
   b. False

9. A watershed can also be called:
   a. River valley
   b. Collection zone
   c. Drainage basin
   d. A and C

10. Many contaminants (including some microorganisms) can be removed naturally as water filters through the ground into groundwater sources
    a. True
    b. False

11. An area where groundwater emerges naturally from the ground is called a(n):
    a. Aquifer
    b. Pond
    c. Spring
    d. Shallow well

12. What is one of the main problems with using spring water as a drinking water source?
    a. It may stop flowing at any time
    b. It can be contaminated more easily than deeper groundwater sources
    c. It must be trucked to water users
    d. None of the above

13. Non-point source pollution that contaminates your drinking water source may have come from:
    a. Acid rain or air pollution particles falling onto surface waters and land
    b. Agricultural land in your area
    c. Streets and buildings in your area
    d. All of the above

14. It is very important that drinking water be treated so that it has a pleasing taste and appearance AND to remove harmful contaminants:
    a. True
    b. False

15. Complete drinking water treatment includes five steps in the following order:

    a. Sedimentation → Coagulation/Flocculation → Preliminary screening → Filtration → Disinfection
    b. Coagulation/Flocculation → Filtration → Disinfection → Preliminary screening → Sedimentation
    c. Preliminary screening → Coagulation/Flocculation → Sedimentation → Filtration → Disinfection
    d. None of the above

## Chapter 3 – Microbiology

1. We do bacterial tests on water:
    a. To ensure that the water is safe to drink
    b. To help support the economy
    c. Because it looks important
    d. None of the above

2. The Canadian Drinking Water Guideline for *E. coli* is:
    a. 100 detectable per 100ml
    b. 10 detectable per 100 ml
    c. 1 detectable per 100 ml
    d. None detectable per 100 ml

3. *Cryptosporidium parvum* and *Giardia lamblia* are difficult to eliminate in drinking water treatment because they are resistant to disinfection:
    a. True
    b. False

4. Viruses are smaller than bacteria and protozoa:
    a. True
    b. False

5. *E. coli* is a member of the total coliforms group of bacteria:
    a. True
    b. False

6. The absence of total coliforms in the drinking water distribution system indicates:
    a. Nothing
    b. Improper sampling technique
    c. Low risk that pathogens are present
    d. None of the above

7. The presence of *E. coli* in the drinking water distribution system directly indicates:
    a. The presence of *Giardia lamblia* in the water
    b. Fecal pollution of the water that may pose a threat to human health
    c. A broken water pipe somewhere in the distribution system
    d. None of the above

8. *Cryptosporidium parvum* and *Giardia lamblia* may only be confidently removed in drinking water treatment through filtration
    a. True
    b. False

9. An indicator organism allows us to assume the presence of a pathogen in the water system we have sampled from:
    a. True
    b. False

10. Characteristics of an indicator organism:
    a. It multiplies naturally in the environment
    b. It is always present when the pathogen is present
    c. It is easy to detect through simple and inexpensive methods
    d. All of the above
    e. B and C

11. A pathogen is:
    a. A type of bacteria
    b. A type of virus
    c. A microorganism that causes disease
    d. None of the above

12. Diseases caused by waterborne pathogens:
    a. Can have symptoms such as vomiting, diarrhea and fever
    b. Are more serious in infants, the elderly and persons with compromised immune systems (cancer or HIV/AIDS patients, for example)
    c. Can lead to death
    d. All of the above

13. If you have taken more than 10 samples in a public drinking water distribution system:
    a. No more than 10% of samples are allowed to have total coliform bacteria present
    b. Up to two consecutive samples are allowed to have total coliform bacteria present
    c. No consecutive samples are allowed to have total coliforms bacteria present
    d. A and C

14. If you get a positive result for total coliforms or *E. coli* you must:
    a. Repeat the tests before you call your EHO
    b. Call your EHO immediately
    c. Begin informing the public immediately that the water is unsafe to drink
    d. Wait until the next scheduled sampling date and see if you get another positive result

15. There is one prescribed maximum allowable turbidity level for all drinking water distribution systems:
    a. True
    b. False

## Chapter 4 – Chlorination

1. Drinking water that contains chlorine will make you ill:
   a. True
   b. False

2. Most drinking water systems use chlorine as the primary disinfectant:
   a. True
   b. False

3. Contaminated water is unsafe for human consumption:
   a. True
   b. False

4. Secondary disinfection is designed to kill disease causing micro-organisms that may be present in the raw water.
   a. True
   b. False

5. Killing of pathogenic organisms in water treatment is called disinfection:
   a. True
   b. False

6. What factor(s) influence chlorine disinfection
   a. concentration
   b. contact time
   c. pH
   d. temperature
   e. all of the above

7. Disinfection contact time must take place:
   a. In the pipes of the distribution system
   b. In the home or building being served by the drinking water system
   c. In the drinking water treatment plant
   d. None of the above

8. Which of the following is NOT a common waterborne disease?
   a. Dysentery (Amoebic and Bacillary)
   b. Salmonellosis
   c. Typhoid
   d. The common cold
   e. Hepatitis

9. The cholera outbreak of 1854 resulted from:
   a. Overpopulation
   b. Lack of proper sanitation
   c. Lack of drinking water disinfection
   d. All of the above

10. Chlorine is an ideal drinking water disinfectant because:
    a. It is relatively cheap
    b. It leaves behind a residual to protect the drinking water from re-contamination
    c. It adds a pleasant taste to the water
    d. A and B

11. Hypochlorites, ozone and chlorine dioxide are ALL common forms of chlorine used for disinfection:
    a. True
    b. False

12. Sodium hypochlorite is also known as household bleach:
    a. True
    b. False

13. Optimal drinking water pH for chlorination is:
    a. 2.6 – 4
    b. 6.5 – 8.5
    c. 7 – 8.5
    d. 4.5 – 5.2

14. Free chlorine residual:
    a. Is the total amount of chlorine available to react with pathogens
    b. Has combined with compounds in the water
    c. Poses a significant health risk in the drinking water
    d. All of the above

15. Chloramines:
    a. Are a product of the reaction between chlorine and ammonia
    b. Are stronger disinfectants than free chlorine
    c. Remain in the water much longer than free chlorine
    d. A and C

16. Disinfection by-products (Trihalomethanes and haloacetic acids):
    a. Pose a significantly smaller health risk than consuming drinking water that has not been disinfected
    b. Are formed when chlorine reacts with organic matter in water
    c. Have a maximum acceptable limit of zero mg/L in drinking water
    d. A and B

17. Concentrations of disinfection by-products can be reduced at the water treatment plant by:
    a. Removing organic matter from the source water before disinfection
    b. Using disinfection methods such as ozone and UV instead of chlorine
    c. Finding a different water source which naturally has less organic matter
    d. All of the above

18. Most provinces have established a maximum chlorine level for drinking water in a distribution system:
    a. True
    b. False

19. Generally, the free chlorine residual in the distribution network should be:
    a. 0.05 mg/L
    b. 0.1 mg/L
    c. 0.2 mg/L
    d. 0.5 mg/L
    e. 1.0 mg/L

## Chapter 5 – Health and Safety

1. Hazardous materials include:
    a. materials which are toxic, corrosive or dangerously reactive
    b. materials which are flammable or combustible
    c. compressed gasses
    d. all of the above

2. WHMIS stands for:
    a. Worker Hazardous Materials Information System
    b. Workplace Hazardous Materials Information System
    c. Workplace Hazardous Machine Information System
    d. Worker Hazardous Materials Information Standard

3. The purpose of WHMIS is to provide information on:
    a. use and storage of workplace hazardous materials
    b. mixing chemical compounds
    c. shipment of hazardous materials
    d. catalogue of dangerous goods

4. MSDS must be updated at least every three years:
    a. True
    b. False

5. CBWMs must enter confined spaces as part of their job:
    a. True
    b. False

6. If you spill bleach in your eye, you should:
   a. Rinse with water for 15 minutes
   b. Seek medical assistance
   c. Finish your task before rinsing your eyes
   d. A and B
   e. none of the above

7. Using a UV light does not require any protective measures
   a. True
   b. False

8. Which of the following are considered as confined spaces:
   a. Cistern
   b. Well
   c. Tank
   d. Manhole
   e. All of the above

9. The Canada Labour Code:
   a. Describes the general requirements for a safe and healthy workplace
   b. Applies to all workers on First Nations reserves
   c. Can help reduce the number of injuries in the workplace
   d. All of the above

10. Hazards on the job of a CBWM include:
    a. Slipping or falling on an uneven surface
    b. Uncooperative or aggressive people at sampling sites
    c. Bad weather conditions
    d. Bleach spills on skin or clothing
    e. All of the above

11. Only serious on the job injuries must be reported to your employer:
    a. True
    b. False

12. Ways to protect yourself while conducting analyses on water samples that test positive for *E. coli*:
    a. Never eat or drink while conducting analyses
    b. Wash your hands immediately after handling samples
    c. A and B
    d. Clean up any sample spills with soap and water

13. If you get any chemical powder on your skin, you should:
    a. Seek medical assistance
    b. Wash it off with soap and water
    c. Wipe it off with a dry towel
    d. Finish your task before doing anything

14. If the MSDS sheets are missing from your workplace, you should:
    a. Speak to your employer
    b. Go the Canadian Centre for Occupational Health and Safety webpage to access the online database of sheets (if possible)
    c. A and B
    d. Wait until the next update of the sheets to get new copies
    e. Call the hazardous material supplier directly

15. WHMIS provides information on hazardous materials through:
    a. MSDS
    b. Labels on the containers of hazardous materials
    c. Worker education programs
    d. All of the above

16. If a hazard in the workplace cannot be removed or controlled:
    a. The workplace is permanently unsafe
    b. You should not work there
    c. Personal protective equipment (gloves, goggles, etc.) should be used
    d. You can continue to work if you aren't worried about it

17. All workplace safety concerns should be discussed with:
    a. Your EHO
    b. A Health and Safety Committee Member
    c. The Health and Safety Officer for your Band Council or Health Centre

    Any of the above

## Chapter 6 – Drinking Water Sampling and Analysis

1. A water sample that is positive for *E. coli* will look dirty:
   a. True
   b. False

2. A water sample that is positive for *E. coli* will be fluorescent:
   a. True
   b. False

3. The Colilert®/Colisure® testing reagent has an expiry date:
   a. True
   b. False

4. A water sample that is positive for *E. coli* must always be positive for total coliform:
   a. True
   b. False

5. The result of a test is still valid even though the temperature of the incubator dropped to 25°C.
   a. True
   b. False

6. The CBWM advises their EHO of unsatisfactory total coliform results:
   a. True
   b. False

7. An incubator temperature reading of 33.5°C is within the acceptable range:
   a. True
   b. False

8. A Quanti-Tray® is used for free chlorine testing:
   a. True
   b. False

9. Total coliforms indicate the presence of bacteria:
   a. True
   b. False

10. Chlorine Bleach solution to disinfect faucets loses strength with time:
    a. True
    b. False

11. When taking a drinking water sample for bacteria you should always rinse the sample container:
    a. True
    b. False

12. When transporting samples to the laboratory it is critical to keep the samples cold:
    a. True
    b. False

13. For the 0 to 2.00 mg/L free and low range chlorine tests, the colorimeter should be in the high (HI) range mode:
    a. True
    b. False

14. It is not important to fill the bacteria sample bottle to the 100mL fill line.
    a. True
    b. False

15. A drinking water sample that is positive for total coliforms using the Colilert® test will be:
    a. Yellow
    b. Red
    c. Black
    d. Colourless

16. A Colilert® Quanti-Tray® has 10 yellow wells and 8 are fluorescing blue. Using the MPN table determine the number of total coliforms and E. coli:
    a. 19.8 total coliforms and 0 E. coli
    b. 11.1 total coliforms and 8.7 E. coli
    c. 2.0 total coliforms and 8.7 E. coli
    d. 22.2 total coliforms and 7.5 E. coli

17. A Colisure® Quanti-Tray® has 15 magenta wells and 0 are fluorescing blue. Using the MPN table determine the number of total coliforms and E. coli:
    a. 17.8 total coliforms and > 1 E. coli
    b. 11.1 total coliforms and < 1 E. coli
    c. 17.8 total coliforms and < 1 E. coli
    d. 17.8 total coliforms and 0 E. coli

18. A Colilert® Quanti-Tray® has 10 yellow wells. Using the MPN table the most probable number of bacteria in the sample is:

   a. 25.4
   b. 0
   c. 13.7
   d. 11.1

19. The best way to preserve the sample during transport to the laboratory is:

   a. to hold it in your hand
   b. in a cooler with a ice pack
   c. in a carry bag with a heat pack
   d. none of the above

20. It is not necessary to let water run before collecting a water sample:

   a. True
   b. False

21. It is necessary to remove the faucet grit screen before taking a sample:

   a. True
   b. False

22. The location of drinking water sampling sites:

   a. Will not affect the quality of the data you have received from the samples
   b. Are chosen by you and your EHO
   c. Must be changed before each sampling date
   d. Should be clustered near the end of your distribution system

23. Taking a minimum of two samples once per week is the appropriate sampling frequency for:

   a. A community water system serving up to 5,000 people
   b. A community water system serving 5,000 to 90,000 people
   c. An individual water system
   d. Cisterns in a trucked system

24. The chlorine bleach disinfecting solution mixture is:

   a. Half bleach, half water
   b. 1 tablespoon (15 ml) bleach to ½ cup (125 ml) water
   c. 1 teaspoon (5 ml) bleach to ½ cup (125 ml) water
   d. 1 splash of bleach into a 1 litre (1,000 ml) jug of water

25. After disinfecting the faucet:

   a. You should let the water run for at least 10 minutes before taking your sample
   b. You should collect your sample immediately
   c. You should leave the water off for 5 minutes
   d. You should let the water run for 2 or 3 minutes before taking your sample

26. You should never take your samples from:

   a. Garden hoses or faucets in garages and workshops
   b. Faucets connected to water softeners or other treatment devices
   c. Faucets where you cannot remove the aerator/grit screen
   d. Faucets that drip or leak around the seal
   e. All of the above

27. If you have added DPD reagent and waited 3 to 6 minutes, you are analyzing a sample for:

   a. Free chlorine residual
   b. Total chlorine residual
   c. E. coli
   d. Total coliforms

28. A Colilert® total coliforms test would be considered invalid and must be repeated when:

   a. The sample colour is less yellow than the comparator after 28 hours in the incubator
   b. The sample has a yellow colour but was incubated for more than 28 hours
   c. The incubator temperature went outside 35°C ± 0.5°C

   B and C

## Chapter 7 – Communication and Public Awareness

1. When test results are positive, who recommends corrective action to the Chief and Council?

   a. The EHO
   b. The CBWM
   c. The Community Health Representative
   d. The Community Engineer

2. If a sample is positive for total coliforms and negative for E. coli, the first thing you should do is:

   a. Collect and analyze another sample
   b. Inform your EHO
   c. Inform Indian and Northern Affairs Canada (INAC)
   d. Inform Environment Canada

3. If a Boil Water advisory is in effect you can still use the water to wash clothes and dishes.
   a. True
   b. False

4. If a Do Not Drink advisory is in effect you can still use the water to wash clothes and dishes.
   a. True
   b. False

5. If a Do Not Drink advisory is in effect you cannot use the water to:
   a. Wash dishes
   b. Bath infants and toddlers
   c. Bath older children, teenagers and adults
   d. Flush toilets

6. If a Boil Water advisory is in effect boiling the water makes it safe to drink.
   a. True
   b. False

7. If a Do Not Drink advisory is in effect boiling the water makes it safe to drink.
   a. True
   b. False

8. A contaminant in the drinking water supply that cannot be removed by boiling, but will not cause irritation to skin or eyes (arsenic for example) would form the basis for:
   a. A Boil Water Advisory
   b. A Do Not Use Advisory
   c. A Do Not Drink Advisory
   d. Further investigation before action is taken to fix the problem

9. Which of the following is NOT a situation that would form the basis for issuing a Boil Water Advisory:
   a. Inadequate disinfectant residuals are found in the water
   b. There is an unknown contaminant in the drinking water
   c. Emergency repairs to the drinking water distribution system cause concern that microbiological contamination may exist
   d. There is a sudden and significant increase in turbidity of the source water

10. After a Drinking Water Advisory is lifted, community members should:
   a. Run all cold water faucets for 1 minute
   b. Remove all screens from faucets, wash with soap and water and replace
   c. Run all drinking water fountains for 1 full minute
   All of the above

# ANSWER KEY

## Chapter 1 – Role of a Community-Based Drinking Water Monitor

1 a. True
2 a. True
3 a. True
4 b. False
5 e. All of the above
6 e. All of the above
7 a. True
8 c. A and B
9 d. All of the above
10 a. Identifying trends that may suggest a potential waterborne disease outbreak
11 b. Maintaining operations at the water treatment plant

## Chapter 2 – Multi-Barrier Approach to Safe Drinking Water

1 d. Barrier 4 – Drinking Water Monitoring
2 b. False
3 b. Filtration and disinfection
4 b. Filtration and disinfection
5 a. Disinfection
6 e. All of the above
7 a. True
8 a. True
9 d. A and C
10 a. True
11 c. Spring
12 b. It can be contaminated more easily than deeper groundwater sources
13 d. All of the above
14 a. True
15 c. Preliminary screening → Coagulation/Flocculation → Sedimentation → Filtration → Disinfection

## Chapter 3 – Microbiology

1 a. To ensure that the water is safe to drink
2 d. None detectable per 100 ml
3 a. True
4 a. True
5 a. True
6 c. Low risk that pathogens are present
7 b. Fecal pollution of the water that may pose a threat to human health
8 a. True
9 a. True
10 e. B and C
11 c. A microorganism that causes disease
12 d. All of the above
13 d. A and C
14 b. Call your EHO immediately
15 b. False

## Chapter 4 – Chlorination

1 b. False
2 a. True
3 a. True
4 b. False
5 a. True
6 e. all of the above
7 c. In the drinking water treatment plant
8 d. The common cold
9 d. All of the above
10 d. A and B
11 b. False
12 a. True
13 b. 6.5 – 8.5
14 a. Is the total amount of chlorine available to react with pathogens
15 d. A and C
16 d. A and B
17 d. All of the above
18 b. False
19 c. 0.2 mg/L

## Chapter 5 – Health and Safety

1 d. all of the above
2 b. Workplace Hazardous Materials Information System
3 a. use and storage of workplace hazardous materials
4 a. True
5 b. False
6 d. A and B
7 b. False
8 e. All of the above
9 d. All of the above
10 e. All of the above
11 b. False
12 c. A and B
13 b. Wash it off with soap and water
14 c. A and B
15 d. All of the above
16 c. Personal protective equipment (gloves, goggle, etc.) should be used
17 d. Any of the above

## Chapter 6 – Drinking Water Sampling and Analysis

1 b. False
2 a. True
3 a. True
4 a. True
5 b. False
6 a. True
7 b. False
8 b. False
9 a. True
10 a. True
11 b. False
12 a. True
13 b. False
14 b. False
15 a. Yellow
16 b. 11.1 total coliforms and 8.7 E. coli
17 c. 17.8 total coliforms and < 1 E. coli
18 d. 11.1
19 b. In a cooler with a ice pack
20 b. False
21 a. True
22 b. Are chosen by you and your EHO
23 a. A community water system serving up to 5,000 people
24 b. 1 tablespoon (15 ml) bleach to ½ cup (125 ml) water
25 d. You should let the water run for 2 or 3 minutes before taking your sample
26 e. All of the above
27 b. Total chlorine residual
28 d. B and C

## Chapter 7 – Communication and Public Awareness

1 a. The EHO
2 b. Inform your EHO
3 a. True
4 a. True
5 b. Bath infants and toddlers
6 a. True
7 b. False
8 c. A Do Not Drink Advisory
9 b. There is an unknown contaminant in the drinking water
10 d. All of the above

# APPENDIX A

# LOG SHEETS FOR RECORDING SAMPLE INFORMATION

# Bacteriological Water Quality Summary Report

Water Quality Testing for (Community Name): ______________________

Submitted by: ______________________ Date (Month/Year): __________

| Home Owner or Facility | Sample Collection Site | Date & Time of Sample | Incubation (from __ to __) | | Colilert Lab Results | | Source of Water: (distribution system, cistern, etc.) | Water Treatment | | Satisfactory (yes/no) to be completed by EHO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Date/ Time (from) | Date/ Time (to) | Total coliform MPN/100ml or P/A | E. coli MPN/100ml or P/A | | YES | NO | |
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## *EXAMPLES OF REPORTING TESTING RESULTS*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Health Centre | Staff Lunch room sink | 3/4/01, 11:00 am | 3/4/01, 2:00 pm | 4/4/01, 2:00 pm | 0 | 0 | Piped | | | none |
| Bob Willingdon's House | Kitchen Sink | 3/4/01, 11:45 am | 3/4/01, 2:00 pm | 4/4/01, 2:00 pm | 2 | 0 | Piped | | | none |
| Water Delivery Truck | Fill Hose | 3/4/01, 1:00pm | 3/4/01, 2:00 pm | 4/4/01, 2:00 pm | 4 | 1 | WTP | | | Fill Hose dirty |
| Rose Jones' Trailer | Washroom Sink | 3/4/01, 1:30 pm | 3/4/01, 2:00 pm | 4/4/01, 2:00 pm | 10 | 3 | Cistern | | | Cover Broken |

## 6.2 Water Quality Monitoring Forms and Reports

Community name: ______________________

Sampled by: ______________________

| Date and Time | Sample Number | Sample (include site code, house and building number) | Result | | Satisfactory (yes/no) to be completed by EHO |
|---|---|---|---|---|---|
| | | | Total coliforms (MPN or P/A) | *E. coli* (MPN or P/A) | |
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**First Nation:**
**Presence/Absence Testing** : Using Quanti-Tray
**Temperature of Incubator 35$^{0}$C - 24 Hour Incubation Time Period**
**Date Samples Taken:**
**Time Samples Put In:**
**Time Samples Taken Out:**

**<u>Source of Sample*</u>:**
*Drinking*........................................Treated ☐
Non-Treated ☐
Single Household ☐
*Non-Drinking*..................................Shore ☐
Other ☐
* - specific for each sample taken

**Performed By:**
Community Health Representative ☐
Environmental Health Officer (EHO) ☐
Water Treatment Plant Operator ☐
Circuit Rider Personnel ☐
Community Based Water Monitor ☐
OTHER ____________________ ☐

| WaterTrax SPL No.<br><br>(min 4 Digits mandatory) | Sample Location<br><br>(if chlorinated record free $Cl_2$ level)<br><br>(if chloramination mark Combined) | Chlorine Readings mg/l | | | Turbidity NTU | Bacterialogical Count Most Possible Number(MPN) | | | | pH | Action Taken if Required and/or Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Free<br>min >0.05<br>max 4.0<br>opt - 0.2 | Combined<br>min >0.25<br>max 3.0<br>opt - 1.0 | <1 (leaving plant)<br><5 in distribution line | No. of (+) Cells<br><br>(yellow) | MP-No. from Table<br><br>Total Coliforms | No. of (+) Cells<br><br>(Fluor-Blue) | MP-No. from Table<br><br>E.coli | <8.5 | |
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**Note: If samples show presence of E.coli advise consumers of that water to discontinue usage unless properly disinfected prior to use and contact the EHO as soon as possible.**

**Additional Comments:**

Log Sheet for Recording Sample Information - Ontario - Example of water quality log sheet used in Ontario

## CBWM LOG SHEET

**First Nations Environmental Public Health - Atlantic Region**
**Report Positive Results to Your EHO Immediately!**

**Watertrax 1-866-812-2233**
**www.watertrax.com**

FIRST NATION: COMMUNITY: Colisure Lot #: Expiry Date:

| SAMPLING POINT | | | | COLIFORM & CHLORINE SAMPLING INFORMATION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Site Location** | CWS PWS IWS | ID SPL # | Date/ Time Collected | Free Chlorine (mg/L) | **In Incubator** | | **Out Incubator** | | **P/A** | | **Quanti-Tray** | | | | **Recording** | |
| | | | | | **Temp °C** | | **Temp °C** | | | | | | | | | |
| | | | | | Date | Time | Date | Time | Total coliform | E. coli | # of Positive Wells | Total Coliform (MPN) | # of Positive Wells | E.coli (MPN) | WTX (entry date) | CBWM/ EHO initials |
| | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Negative (blank) Control | n/a | | | n/a | | | | | | | | | | | | |
| Positive Control | n/a | | | n/a | | | | | | | | | | | | |
| Sampling & Result Comment | | | | | | | | | | | | | | | | |
| **Sample Site Location** | CWS PWS IWS | ID SPL # | Date/ Time Collected | Free Chlorine (mg/L) | **In Incubator** | | **Out Incubator** | | **P/A** | | **Quanti-Tray** | | | | **Recording** | |
| | | | | | **Temp °C** | | **Temp °C** | | | | | | | | | |
| | | | | | Date | Time | Date | Time | Total coliform | E. coli | # of Positive Wells | Total Coliform (MPN) | # of Positive Wells | E.coli (MPN) | WTX (entry date) | CBWM/ EHO initials |
| | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | |
| Negative (blank) Control | n/a | | | n/a | | | | | | | | | | | | |
| Positive Control | n/a | | | n/a | | | | | | | | | | | | |

CBWM Log Sheet - Example of water quality log sheet used in the Atlantic Region

Health Canada / Santé Canada

BACTERIOLOGICAL ANALYSIS REQUEST - DRINKING WATER

Sampled at : ________________________________

Sampled by : ________________________________

Sampling date: 20__ __ / __ __ / __ __
Y Y M M D D

Page ___ of ___

**Analysis requested:**

☐ Total coliform ☐ E. Coli

☐ HPC ☐ ________________

| No | Sampling site | Lab |
|---|---|---|
| 1 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 2 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 3 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 4 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 5 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 6 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 7 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 8 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 9 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |
| 10 | Code: ______ ______ ______<br>Name: ____________ Free $Cl_2$: ______<br>____________ turbidity: ______ Total $Cl_2$: ______ | |

Canada

# APPENDIX B

# TIPS FOR HOME OWNERS WITH WATER CISTERNS

## Fact Sheet 6.6 Tips For Home Owners With Water Cisterns

**To ensure your cistern water is always safe for human consumption, the following should be considered:**

1. Get your water tested annually. Contact the Health Centre staff.
2. Teach your children not to throw objects into the cistern to protect water against contamination. DO NOT ALLOW YOUR CHILDREN TO PLAY AROUND THE CISTERN.
3. Do not allow animals around your cistern. Clean up pets' wastes as soon as you can.
4. Visually inspect your cistern on a regular basis. Check the following:
   - Your cistern should be properly landscaped (sloped) to allow the drainage of melting snow and rainwater away from the cistern.
   - Ensure cistern inlet pipe and a vent pipe are not damaged. The vent pipe should have a screen to prevent entry of insects or small animals. When they are damaged or missing, contact the Public Works Department for information to replace them.
   - The manhole cover should be in place at all times. If cracked or chipped, the cover should be replaced.
   - Ensure that all joins are sealed watertight.
5. Make sure your water delivery person uses the inlet (fill) pipe to fill the cistern and keeps the truck at least 10 feet away from the cistern.
6. The cistern should be cleaned and disinfected (shock chlorinated) when there is evidence of contamination, by a person certified in confined space entry as designated by Band leadership.
   *See Fact Sheet 6.7: Cistern Cleaning and Disinfection Procedure – For Trained Persons in Confined Space Entry*
7. The cistern should be periodically disinfected without entry, to ensure the safety of water. Entry into a cistern for the purpose of disinfection will not normally be required.
8. If you suspect anything in the water, call the Health Centre/Nursing Station Staff immediately.
9. Occupants who have cisterns must practice water conservation as water is delivered to the house only as scheduled by the Band.

FOR MORE INFORMATION, PLEASE CONTACT
THE HEALTH CENTRE/NURSING STATION STAFF OR ENVIRONMENTAL HEALTH OFFICER

# APPENDIX C

# WHMIS AND MSDS

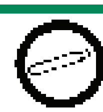
Health Canada Santé Canada

Canada

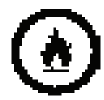
# Workplace Hazardous Materials Information System

## Classes of WHMIS Controlled Products

### CLASS A – Compressed Gas

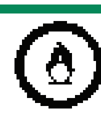


### CLASS B – Flammable and Combustible Material



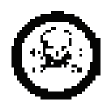
*Division 1*: Flammable Gases
*Division 2*: Flammable Liquids
*Division 3*: Combustible Liquids
*Division 4*: Flammable Solids
*Division 5*: Flammable Aerosols
*Division 6*: Reactive Flammable Materials

### CLASS C – Oxidizing Material



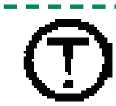
### CLASS D – Poisonous and Infectious Material

*Division 1*: Materials Causing Immediate and Serious Toxic Effects



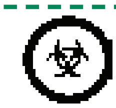
Subdivision A : Very Toxic Material
Subdivision B : Toxic Material

*Division 2*: Materials Causing Other Toxic Effects

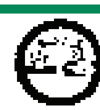


Subdivision A : Very Toxic Material
Subdivision B : Toxic Material

*Division 3*: Biohazardous Infectious Material



### CLASS E – Corrosive Material



### CLASS F – Dangerously Reactive Material

Workplace Hazardous Materials Information System

**For more information, please visit the National WHMIS Web site: www.hc-sc.gc.ca/whmis**

Health Canada Santé Canada

Canada

# Do You Know These Vital Signs?

## The Hazard Symbols of WHMIS

**CLASS A**
**Compressed Gas**

**CLASS D-2**
**Poisonous and Infectious Material (material causing other toxic effects)**

**CLASS B**
**Flammable and Combustible Material**

**CLASS D-3**
**Poisonous and Infectious Material (Biohazardous Infectious Material)**

**CLASS C**
**Oxidizing Material**

**CLASS E**
**Corrosive Material**

**CLASS D-1**
**Poisonous and Infectious Material (material causing immediate and serious effects)**

**CLASS F**
**Dangerously Reactive Material**

WHMIS provides you with information on the safe use, storage, handling and disposal ofh azardous materials at Canadian workplaces.

Workplace Hazardous Materials Information System

For more information, consult the MSDS, and visit the Health Canada WHMIS Web site: http://www.hc-sc.gc.ca/whmis

**The Clorox Company**
1221 Broadway
Oakland, CA 94612
Tel. (510) 271-7000

# Material Safety Data Sheet

| | |
|---|---|
| **I Product:** | CLOROX REGULAR-BLEACH |
| **Description:** | CLEAR, LIGHT YELLOW LIQUID WITH A CHARACTERISTIC CHLORINE ODOR |

| Other Designations | Distributor | Emergency Telephone Nos. |
|---|---|---|
| Clorox Bleach<br>EPA Reg. No. 5813-50 | Clorox Sales Company<br>1221 Broadway<br>Oakland, CA 94612 | For Medical Emergencies call:<br>(800) 446-1014<br>For Transportation Emergencies Chemtrec<br>(800) 424-9300 |

## II Health Hazard Data

DANGER: CORROSIVE. May cause severe irritation or damage to eyes and skin. Vapor or mist may irritate. Harmful if swallowed. Keep out of reach of children.

Some clinical reports suggest a low potential for sensitization upon exaggerated exposure to sodium hypochlorite if skin damage (e.g., irritation) occurs during exposure. Under normal consumer use conditions the likelihood of any adverse health effects are low.

Medical conditions that may be aggravated by exposure to high concentrations of vapor or mist: heart conditions or chronic respiratory problems such as asthma, emphysema, chronic bronchitis or obstructive lung disease.

FIRST AID:

Eye Contact: Hold eye open and rinse with water for 15-20 minutes. Remove contact lenses, after first 5 minutes. Continue rinsing eye. Call a physician.

Skin Contact: Wash skin with water for 15-20 minutes. If irritation develops, call a physician.

Ingestion: Do not induce vomiting. Drink a glassful of water. If irritation develops, call a physician. Do not give anything by mouth to an unconscious person.

Inhalation: Remove to fresh air. If breathing is affected, call a physician.

## III Hazardous Ingredients

| Ingredient | Concentration | Exposure Limit |
|---|---|---|
| Sodium hypochlorite<br>CAS# 7681-52-9 | 5 - 10% | Not established |
| Sodium hydroxide<br>CAS# 1310-73-2 | <1% | $2\ mg/m^1$<br>$2\ mg/m^2$ |

[1]ACGIH Threshold Limit Value (TLV) - Ceiling

[2]OHSA Permissible Exposure Limit (PEL) – Time Weighted Average (TWA)

None of the ingredients in this product are on the IARC, NTP or OSHA carcinogen lists.

## IV Special Protection and Precautions

No special protection or precautions have been identified for using this product under directed consumer use conditions. The following recommendations are given for production facilities and for other conditions and situations where there is increased potential for accidental, large-scale or prolonged exposure.

Hygienic Practices: Avoid contact with eyes, skin and clothing. Wash hands after direct contact. Do not wear product-contaminated clothing for prolonged periods.

Engineering Controls: Use general ventilation to minimize exposure to vapor or mist.

Personal Protective Equipment: Wear safety goggles. Use rubber or nitrile gloves if in contact liquid, especially for prolonged periods.

KEEP OUT OF REACH OF CHILDREN

## V Transportation and Regulatory Data

DOT/IMDG/IATA - Not restricted.

EPA - SARA TITLE III/CERCLA: Bottled product is not reportable under Sections 311/312 and contains no chemicals reportable under Section 313. This product does contain chemicals (sodium hydroxide <0.2% and sodium hypochlorite <7.35% ) that are regulated under Section 304/CERCLA.

TSCA/DSL STATUS: All components of this product are on the U.S. TSCA Inventory and Canadian DSL.

## VI Spill Procedures/Waste Disposal

Spill Procedures: Control spill. Containerize liquid and use absorbents on residual liquid; dispose appropriately. Wash area and let dry. For spills of multiple products, responders should evaluate the MSDS's of the products for incompatibility with sodium hypochlorite. Breathing protection should be worn in enclosed, and/or poorly ventilated areas until hazard assessment is complete.

Waste Disposal: Dispose of in accordance with all applicable federal, state, and local regulations.

## VII Reactivity Data

Stable under normal use and storage conditions. Strong oxidizing agent. Reacts with other household chemicals such as toilet bowl cleaners, rust removers, vinegar, acids or ammonia containing products to produce hazardous gases, such as chlorine and other chlorinated species. Prolonged contact with metal may cause pitting or discoloration.

## VIII Fire and Explosion Data

Flash Point: None

Special Firefighting Procedures: None

Unusual Fire/Explosion Hazards: None. Not flammable or explosive. Product does not ignite when exposed to open flame.

## IX Physical Data

Boiling point.......................................................................approx. 212°F/100°C
Specific Gravity ($H_20$=1) ................................................................ ~ 1.1 at 70°F
Solubility in Water ................................................................................ complete
pH ............................................................................................................~11.9



DATA SUPPLIED IS FOR USE ONLY IN CONNECTION WITH OCCUPATIONAL SAFETY AND HEALTH DATE PREPARED 08/09

*World Headquarters*
*Hach Company*
*P.O.Box 389*
*Loveland, CO USA 80539*
*(970) 669-3050*



# MATERIAL SAFETY DATA SHEET

## 1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

***Product Name:*** DPD Total Chlorine Reagent
***Catalog Number:*** 2105669

Hach Company
P.O.Box 389
Loveland, CO USA 80539
(970) 669-3050

Emergency Telephone Numbers:
(Medical and Transportation)
(303) 623-5716 24 Hour Service
(515)232-2533 8am - 4pm CST

***MSDS Number:*** M00110
***Chemical Name:*** Not applicable
***CAS No.:*** Not applicable
***Chemical Formula:*** Not applicable
***Chemical Family:*** Not applicable
***PIN:*** NA
***Intended Use:*** Indicator for total chlorine
***Date of MSDS Preparation:***
***Day:*** 15
***Month:*** October
***Year:*** 2009
***MSDS Prepared:*** MSDS prepared by Product Compliance Department extension 3350
HMIRC Registry Number: 6250 Granted 08/01/31

## 2. COMPOSITION / INFORMATION ON INGREDIENTS

**Potassium Iodide**
***Percent Range:*** 20.0 - 30.0
***Percent Range Units:*** weight / weight
***CAS No.:*** 7681-11-0
***LD50:*** Oral Mouse LD50 = 1862 mg/kg
***LC50:*** None reported
***TLV:*** Not established
***PEL:*** Not established
***Ingredient WHMIS Symbol:*** Other Toxic Effects

**Salt of N,N-Diethyl-p-Phenylenediamine**
***Percent Range:*** 1.0 - 5.0
***Percent Range Units:*** weight / weight
***CAS No.:*** Confidential
***LD50:*** Oral rat $LD_{50}$ = 970 mg/kg.
***LC50:*** None reported
***TLV:*** Not established
***PEL:*** Not established
***Ingredient WHMIS Symbol:*** Other Toxic Effects
HMIRC Registry Number: 6250 Granted 08/01/31

**Sodium Phosphate, Dibasic**
***Percent Range:*** 20.0 - 30.0
***Percent Range Units:*** weight / weight
***CAS No.:*** 7558-79-4
***LD50:*** Oral rat LD50 = 17 g/kg.
***LC50:*** None reported

***TLV:*** Not established
***PEL:*** Not established
***Ingredient WHMIS Symbol:*** Not applicable

**Other component**
***Percent Range:*** 0.1 - 1.0
***Percent Range Units:*** weight / weight
***CAS No.:*** Not applicable
***LD50:*** Not applicable
***LC50:*** Not applicable
***TLV:*** Not established
***PEL:*** Not established
***Ingredient WHMIS Symbol:*** Not applicable

**Carboxylate Salt**
***Percent Range:*** 40.0 - 50.0
***Percent Range Units:*** weight / weight
***CAS No.:*** Confidential
***LD50:*** None reported
***LC50:*** None reported
***TLV:*** Not established
***PEL:*** Not established
***Ingredient WHMIS Symbol:*** Other Toxic Effects
HMIRC Registry Number: 6250 Granted 08/01/31

## 3. HAZARDS IDENTIFICATION

***Emergency Overview:***
***Appearance:*** White or light pink powder
***Physical State:*** Solid
***Odor:*** None
MAY CAUSE EYE AND RESPIRATORY TRACT IRRITATION
MAY CAUSE ALLERGIC SKIN REACTION

***HMIS:***
***Health:*** 2
***Flammability:*** 1
***Reactivity:*** 0
***Protective Equipment:*** X - See protective equipment, Section 8.
***Potential Health Effects:***
***Eye Contact:*** May cause irritiation
***Skin Contact:*** May cause irritiation May cause allergic reaction
***Skin Absorption:*** No effects anticipated
***Target Organs:*** Not applicable
***Ingestion:*** Causes: lethargy loss of strength loss of coordination difficult breathing diarrhea May cause iodism, which symptoms include skin rash, conjunctivitis, runny nose, sneezing, bronchitis, headache, fever and irritation of mucous membranes. DPD Oral rat LD50 studies revealed decreased locomotor activity, depressed respiration, muscle spasms, loss of righting reflex and death. Autopsies revealed ulcerated stomach, enteritis, gas and congested lungs.
***Target Organs:*** Liver
***Inhalation:*** May cause: respiratory tract irritation Effects similar to those of ingestion.
***Target Organs:*** Liver
***Medical Conditions Aggravated:*** Allergy or sensitivity to salts of N,N-Diethyl-p-phenylenediamine Pre-existing: Eye conditions Skin conditions Respiratory conditions Persons with pre-existing respiratory conditions may be more susceptible to the effects of Potassium Iodide exposure.
***Chronic Effects:*** Chronic overexposure may cause allergic skin reactions hypothyroidism liver damage DPD may cause allergic skin reactions in some people causing severe skin rashes and itching. Iodines overdose, 'iodism', may cause skin rash, runny nose, headaches, fever and bronchitis.
***Cancer / Reproductive Toxicity Information:***

This product does NOT contain any IARC listed chemicals.

This product does NOT contain any NTP listed chemicals.

***Additional Cancer / Reproductive Toxicity Information:*** Maternal ingestion of potassium iodide during pregnancy may cause congenital goiter and hyperthyroidism in the newborn infant.

***Toxicologically Synergistic Products:*** None reported
***WHMIS Hazard Classification:*** Class D, Division 2, Subdivision A - Very toxic materials (other toxic effects) Class D, Division 2, Subdivision B - Toxic material (other toxic effects)
***WHMIS Symbols:*** Other Toxic Effects

## 4. FIRST AID

***Eye Contact:*** Immediately flush eyes with water for 15 minutes. Call physician.
***Skin Contact (First Aid):*** Wash skin with soap and plenty of water. Call physician if irritation develops.
***Ingestion (First Aid):*** Call physician immediately. Give 1-2 glasses of water under medical supervision. Never give anything by mouth to an unconscious person.
***Inhalation:*** Remove to fresh air.

## 5. FIRE FIGHTING MEASURES

***Flammable Properties:*** During a fire, this product decomposes to form toxic gases.
***Flash Point:*** Not applicable
***Method:*** Not applicable
***Flammability Limits:***
***Lower Explosion Limits:*** Not applicable
***Upper Explosion Limits:*** Not applicable
***Autoignition Temperature:*** Not determined
***Hazardous Combustion Products:*** Toxic fumes of: carbon monoxide, carbon dioxide. iodine compounds phosphorus oxides potassium oxides sodium monoxide nitrogen oxides.
***Fire / Explosion Hazards:*** None reported
***Static Discharge:*** None reported.
***Mechanical Impact:*** None reported
***Extinguishing Media:*** Use media appropriate to surrounding fire conditions
***Fire Fighting Instruction:*** As in any fire, wear self-contained breathing apparatus pressure-demand and full protective gear.

## 6. ACCIDENTAL RELEASE MEASURES

***Spill Response Notice:***
Only persons properly qualified to respond to an emergency involving hazardous substances should respond to a spill involving chemicals. See Section 13, Special Instructions for disposal assistance.
***Containment Technique:*** Stop spilled material from being released to the environment.
***Clean-up Technique:*** Scoop up spilled material into a large beaker and dissolve with water. Flush reacted material to the drain with a large excess of water. Decontaminate the area of the spill with a soap solution.
***Evacuation Procedure:*** Evacuate as needed to perform spill clean-up. If conditions warrant, increase the size of the evacuation.
***D.O.T. Emergency Response Guide Number:*** Not applicable

## 7. HANDLING / STORAGE

***Handling:*** Avoid contact with eyes skin clothing Do not breathe dust. Wash thoroughly after handling. Maintain general industrial hygiene practices when using this product.
***Storage:*** Store between 10° and 25°C. Protect from: light heat moisture

## 8. EXPOSURE CONTROLS / PROTECTIVE EQUIPMENT

***Engineering Controls:*** Have an eyewash station nearby. Use general ventilation to minimize exposure to mist, vapor or dust.
***Personal Protective Equipment:***

***Eye Protection:*** safety glasses with top and side shields
***Skin Protection:*** disposable latex gloves lab coat
***Inhalation Protection:*** adequate ventilation
***Precautionary Measures:*** Avoid contact with: eyes skin clothing Do not breathe: dust Wash thoroughly after handling. Protect from: light heat moisture
***TLV:*** Not established
***PEL:*** Not established

## 9. PHYSICAL / CHEMICAL PROPERTIES

***Appearance:*** White or light pink powder
***Physical State:*** Solid
***Molecular Weight:*** Not applicable
***Odor:*** None
***pH:*** of 1% soln = 6.35 @ 20°C
***Vapor Pressure:*** Not applicable
***Vapor Density (air = 1):*** Not applicable
***Boiling Point:*** Not applicable
***Melting Point:*** 145° C
***Specific Gravity (water = 1):*** 1.79
***Evaporation Rate (water = 1):*** Not applicable
***Volatile Organic Compounds Content:*** Not applicable
***Coefficient of Water / Oil:*** Not determined
***Solubility:***
***Water:*** Soluble
***Acid:*** Soluble
***Other:*** Not determined
***Metal Corrosivity:***
***Steel:*** 0.038 in/yr
***Aluminum:*** 0.006 in/yr

## 10. STABILITY / REACTIVITY

***Chemical Stability:*** Stable when stored under proper conditions.
***Conditions to Avoid:*** Exposure to light. Excess moisture Extreme temperatures
***Reactivity / Incompatibility:*** Incompatible with: oxidizers
***Hazardous Decomposition:*** Heating to decomposition releases toxic and/or corrosive fumes of: carbon dioxide carbon monoxide iodine compounds phosphorus oxides potassium oxide nitrogen oxides
***Hazardous Polymerization:*** Will not occur.

## 11. TOXICOLOGICAL INFORMATION

***Product Toxicological Data:***
***LD50:*** Oral rat (female) $LD_{50}$ = 4700 mg/kg; Oral rat (male) $LD_{50}$ = 7000 mg/kg.
***LC50:*** None reported
***Dermal Toxicity Data:*** None reported
***Skin and Eye Irritation Data:*** None reported
***Mutation Data:*** None reported
***Reproductive Effects Data:*** None reported
--
***Ingredient Toxicological Data:*** DPD Oral rat LD50 = 970 mg/kg; Potassium Iodide Oral mouse LDLo = 1862 mg/kg; Sodium Phosphate, Dibasic Oral rat LD50 = 17 g/kg

## 12. ECOLOGICAL INFORMATION

***Product Ecological Information:*** --
No ecological data available for this product.
***Ingredient Ecological Information:*** --
No ecological data available for the ingredients of this product.

## 13. DISPOSAL CONSIDERATIONS

***Special Instructions (Disposal):*** Dilute to 3 to 5 times the volume with cold water. Open cold water tap completely, slowly pour the material to the drain. Allow cold water to run for 5 minutes to completely flush the system.
***Empty Containers:*** Rinse three times with an appropriate solvent. Dispose of empty container as normal trash.
***NOTICE (Disposal):*** These disposal guidelines are based on federal regulations and may be superseded by more stringent state or local requirements. Please consult your local environmental regulators for more information.

## 14. TRANSPORT INFORMATION

***T.D.G.:***
***Proper Shipping Name:*** Not Currently Regulated
--
***Hazard Class:*** NA
***PIN:*** NA
***Group:*** NA
***Subsidiary Risk:*** NA
***Additional Information:*** There is a possibility that this product could be contained in a reagent set or kit composed of various compatible dangerous goods. If the item is NOT in a set or kit, the classification given above applies. If the item IS part of a set or kit, the classification would change to the following: UN3316 Chemical Kit, Class 9, PG II or III. If the item is not regulated, the Chemical Kit classification does not apply.

## 15. REGULATORY INFORMATION

***National Inventories:***
***Canadian Inventory Status:*** DSL Listed: Yes
This product has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR.

## 16. OTHER INFORMATION

***References:*** CCINFO MSDS/FTSS. Canadian Centre for Occupational Health and Safety. Hamilton, Ontario Canada: 30 June 1993. The Merck Index, 11th Ed. Rahway, New Jersey: Merck and Co., Inc., 1989. Outside Testing. Technical Judgment. In-house information. TLV's Threshold Limit Values and Biological Exposure Indices for 1992-1993. American Conference of Governmental Industrial Hygienists, 1992. Air Contaminants, Federal Register, Vol. 54, No. 12. Thursday, January 19, 1989. pp. 2332-2983.

**Legend:**

| | |
|---|---|
| NA - Not Applicable | w/w - weight/weight |
| ND - Not Determined | w/v - weight/volume |
| NV - Not Available | v/v - volume/volume |

**USER RESPONSIBILITY:** Each user should read and understand this information and incorporate it in individual site safety programs in accordance with applicable hazard communication standards and regulations.

**THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED TO BE ACCURATE. HOWEVER, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF.**

# APPENDIX D
## HAND WASHING

The Benefits of Hand Washing
Updated
April 2010

# IT'S YOUR HEALTH

***This article was produced in collaboration with the Public Health Agency of Canada.***

# The Benefits of Hand Washing

## The Issue

Washing your hands correctly (or using an alcohol-based hand rub) is the most effective thing you can do to protect yourself against a number of infectious diseases, such as influenza (the "flu") and the common cold. Not only will it help keep you healthy, it will help prevent the spread of infectious diseases to others.

## Background

Even if your hands appear to be clean, they may carry germs. Hands pick up micro-organisms (germs) in a number of ways.

When people who are sick sneeze or cough, the germs that are making them sick are expelled into the air in tiny droplets. If these droplets get onto your hands, and then you touch your mouth, eyes or nose without washing away the germs, you carry the infection. You can also get sick if you don't wash your hands before and after preparing food, after handling raw meat, and after using the toilet.

Washing your hands not only prevents you from getting sick, but it also reduces the risk of infecting others. If you don't wash your hands properly before coming into contact with others, you can infect them with the germs on your hands. Other people can also get sick from the germs unwashed hands leave on shared objects like doorknobs, keyboards, and other equipment in the home or workplace.

## How Hand Washing Reduces Health Risks

Hand-to-hand contact can spread mild conditions, such as the common cold, but also more severe or life-threatening diseases. Infectious diseases are a particular risk to the very young, the elderly, those with a pre-existing disease, and people with a compromised immune system, such as those with HIV or AIDS.

## Proper Methods of Hand Washing

Although hand washing might seem like a simple task, you should follow these steps to thoroughly rid your hands of germs.

**Using Soap**

- Use regular soap to wash your hands. Anti-bacterial soaps are not recommended because they destroy good bacteria as well as bad and can add to the problem of antibiotic resistance.
- Remove any hand or arm jewellery you may be wearing and wet your hands with warm water.
- Add regular soap and rub your hands together, ensuring you have lathered all surfaces for at least 15 seconds. How long is 15 seconds? The length of time it takes to sing Happy Birthday.
- Wash the front and back of your hands, as well as between your fingers and under your nails.

- Rinse your hands well under warm running water, using a rubbing motion.
- Wipe and dry your hands gently with a paper towel or a clean towel. Drying them vigorously can damage the skin.
- Turn off the tap using the paper towel so that you do not re-contaminate your hands. When using a public bathroom, use the same paper towel to open the door when you leave.
- If skin dryness is a problem, use a moisturizing lotion.

If you have sensitive skin or are in a position where you must wash your hands constantly (as a healthcare worker must), you might want to use an alcohol-based hand rub instead.

**Using Alcohol-based Hand Rubs**

- An alcohol-based hand rub can be used if soap and water are not available.
- If your hands are visibly soiled, it is best to use soap and water. If it's not possible to wash with soap and water, use towelettes to remove the soil, then use an alcohol-based hand rub.
- Use hand rubs according to the manufacturer's instructions. Make sure your hands are dry, as wet hands will dilute the product.
- Use enough product to cover all the surfaces of your hands and fingers.
- Rub your hands together until the product has evaporated. If dry skin is a problem, use a moisturizing lotion.

## Minimizing Your Risk

Here are further steps you can take to protect yourself and your family.

- Wash your hands often, especially after coughing, sneezing or using tissues, before and after eating, before preparing food, after handling raw meat, after petting an animal, and after using the bathroom.
- When you cough or sneeze, use a tissue or raise your arm up to your face and aim for your sleeve. Do not sneeze into your hand. Throw away tissues as soon as you use them
- Keep the surface areas in your home and office free of germs by cleaning them. Doorknobs, light switches, telephones, and keyboards are especially important to keep clean.
- If you have children, teach them good hygiene and how to wash their hands properly. Young children should be supervised while washing their hands.
- If you use bar soap, keep it in a self-draining holder that can be cleaned thoroughly before a new bar is added.
- Don't use a single damp cloth to wash a group of children's hands.
- Don't use a standing basin of water to rinse your hands.
- Don't use a common hand towel.
- Don't use sponges or non-disposable cleaning cloths unless you change them daily and launder them using detergent. Germs thrive on moist surfaces.

## Government of Canada's Role

The Public Health Agency of Canada (PHAC) publishes infection control guidelines for use by the provinces, territories, and healthcare organizations.

Working with the provinces and territorial governments, non-governmental organizations and health care providers, PHAC develops evidence-based national standards and policies, promotes the exchange of information, and engages in disease prevention and promotion activities.

## Need More Info?

For more information visit the following Web sites:

- Public Health Agency of Canada, ***Get the Dirt on clean hands***: www.phac-aspc.gc.ca/im/iif-vcg/wh-lm-eng.php
- Health Canada, ***Proper Handwashing***: www.hc-sc.gc.ca/ewh-semt/pubs/occup-travail/handwashing-lavage-eng.php
- **Community and Hospital Infection Control Association Canada** (CHICA-Canada) www.chica.org/links_handhygiene.html
- **Canadian Patient Safety Institute** www.handhygiene.ca/
- World Health Organization, **Global Hand Washing Day**: www.who.int/gpsc/events/2008/15_10_08/en/index.html
- **Handwashing for parents and kids** www.caringforkids.cps.ca/healthybodies/Handwashing.htm
- For additional articles on health and safety issues go to the ***It's Your Health*** Web section at: www.healthcanada.gc.ca/iyh
You can also call toll free at 1-866-225-0709
or TTY at 1-800-267-1245*

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# APPENDIX E

## CHAIN OF CUSTODY FORM

# 5.10 Sample of a Chain of Custody Form – Bacteriological Quality Analysis

| Water samples to be analyzed for bacteriological quality | |
|---|---|
| To:<br><br>Telephone:<br>Fax: | From: ______________________ First Nation<br><br>Telephone:<br>Fax: |
| Date and Time of sample collection (mm/dd/yy): | Samples collected by |
| Analyses required<br>❑ General Bacteria (HPC), Total Coliform and Fecal Coliform<br>❑ Pseudomonas<br>❑ Aeromonas<br>❑ Heterotrophic Plate Count<br>❑ *E. Coli*<br>❑ Shigella<br>❑ Salmonella<br>❑ Other: ______________________ | Sample location:<br>(e.g., home, school, store, clinic, pumphouse, beach, before or after filter, site code)<br><br>Type of System<br>❑ Distribution systems (more than five (5) connections)<br>❑ Cistern<br><br>Type of disinfection<br>(e.g., chlorine, ultraviolet, ozone, or none) |
| Sample Received by: ______________________________ | |
| Dated: ______________________ | Time: ______________________ |

# APPENDIX F

# CHLORINE TEST KIT CONSISTENCY CHECK

## Example of a chlorine test kit consistency check

| | | |
|---|---|---|
| Location: | | Using the SpecV Standards<br>1. Place the colorless SpecV blank into the cell holder with the alignment mark facing the keypad. Tightly cover the cell with the instrument cap.<br>2. Press ZERO. The display will show A0.00_.<br>3. Place ASTD 1_ Cell into the cell holder. Tightly cover the cell with the instrument cap.<br>4. Press READ/ENTER. Record the measurement on the log below.<br>5. Repeat steps 3 and 4 with the cells labeled ASTD 2_ and STD 3_.<br>6. Compare measurements and notify the EHO, should the measurements fall outside of the tolerance. |
| Colorimeter Model#: | Colorimeter S/N: | |
| | | |
| Lot #: | Expiry Date: | |

**Standard Values and Allowable Tolerances** (transfer information from the ACertificate of Analysis@ for the above model of colorimeter; staple the certificate to back of this page.)

| STD 1 | | STD 2 | | STD 3 | |
|---|---|---|---|---|---|
| Value | Tolerance +/- | Value | Tolerance +/- | Value | Tolerance +/- |

**Monthly Consistency Check (Check off AWithin Tolerance@ box if the Aresult@ is within the tolerance listed above)**

| Date (YY/MM/DD) | STD 1 | | STD 2 | | STD 3 | | Monitor's Initials | EHO Initials (Review) |
|---|---|---|---|---|---|---|---|---|
| | Result | Within Tolerance | Result | Within Tolerance | Result | Within Tolerance | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |