Alberta Domestic Well Water Quality Monitoring and Assessment Program

Domestic Well Water Quality in Alberta

Fact Sheets

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Alberta Government

ACFT
Alberta Centre For Toxicology

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Natural Groundwater Quality

What is natural groundwater quality?	Groundwater mainly comes from rainfall or snowmelt input. Water travels through soil, sediment and rocks contacting natural substances such as minerals from the surface of the earth. Water is a good solvent to dissolve these natural substances. Groundwater quality means that groundwater has good physical, chemical, and biological quality, and is suitable for a particular purpose such as human drinking or irrigation.
What is physical quality?	Temperature, turbidity, colour, taste and odour make up the physical quality of groundwater. Most natural groundwater is colourless, odourless and has no specific taste.
What is chemical quality?	Mineral chemicals influence the chemical quality of groundwater. Most chemicals are inorganic chemicals like major ions, minor ions, nutrients and trace elements. Occasionally, natural organic matter from topsoil enters groundwater.
What are major ions and minor ions?	Chemicals dissolved in groundwater are electrically charged particles. We call these chemicals “ions”. Major or minor ions comprise 99 per cent of the ions found in groundwater. These ions can provide important information about natural groundwater quality. Common major ions are calcium, magnesium, sodium, potassium, chloride, sulfate and bicarbonate. The most common minor ions are fluoride and nitrate. Nitrate is a nutrient.
What are trace elements?	If ions comprise less than 1 per cent of total ions found in groundwater, we call them trace elements. They are usually present in groundwater at low levels (less than 1 mg/L).
What is biological quality?	Microorganisms, invisible to the naked eye such as bacteria and viruses, determine the biological quality of groundwater. Most natural microorganisms in groundwater do not cause harm to humans.
What are natural contaminants?	Natural contaminants are any physical, chemical or biological substances that naturally occur in groundwater. Whether these natural contaminants affect the aesthetic

quality of groundwater or cause potential health problems depends on the quantity of a substance present in groundwater.

Are natural contaminants good for human health?

The presence of a natural contaminant in groundwater does not necessarily mean that there is a human health risk. For example, calcium, sodium, iron and selenium are essential for human health, and can be beneficial for human and/or animal health when taken in small amounts.

How can groundwater be polluted?

Groundwater is vulnerable to pollution from human activities such as agricultural activities, septic system for household wastewater, leaking of underground tanks, and surface spills of industrial waste.

Domestic Well Water Quality

What is domestic well water quality?

Domestic wells are private wells used for household drinking water. Domestic well water is a major water source for drinking, cooking, bathing or cleaning in rural areas. Water quality of a domestic well is influenced by groundwater quality.

Good domestic well water should:

- be free from harmful microorganisms that may cause infectious diseases;
- be suitable for drinking in terms of colour, taste, and smell; and
- have only acceptable or safe levels of natural or anthropogenic contaminants to avoid posing a health risk to humans.

How many domestic wells are in Alberta?

Since the mid-1970s, reports of new well drilling in Alberta had to be submitted to Alberta Environment. Alberta Environment and Sustainable Resource Development (AESRD) stores the well drilling reports in the database of the Groundwater Information Center. About 500,000 well drilling records plus an additional 5,000 – 7,000 new well drilling records are found annually in the database.

The lowest density of domestic wells is in the northern Alberta region. The highest density of domestic wells is in central and southern Alberta, where there is a good supply of groundwater for human drinking and agricultural use.

Who uses domestic well water for human drinking?

Nineteen per cent of the provincial population (about 600,000 people) resides in rural Alberta. In rural Alberta, many people rely on domestic well water as the primary source water for household use and agricultural use.

Who is responsible for monitoring domestic well water quality?

Individually owned water systems such as private wells are not regulated by either the provincial or federal governments. It is the responsibility of individual owners to ensure the quality and safety of their own water supply.

The Government of Alberta along with Alberta Health Services can provide information, advice, treatment options and interpretation of water quality analyses, but ultimately the final selection and cost associated with water treatment

devices, including maintenance and follow-up sampling, are the responsibility of the individual owners.

Why do you need to test domestic well water?

Inspection for possible contamination, monitoring and testing the water from your domestic well water helps to ensure that:

- the water is suitable for drinking;
- the water source used is being properly protected from potential contamination;
- the drinking water is safe, and
- the water treatment system used is effective.

Are there any human health concerns?

The most common cause of human illness from drinking water is microbial pathogens that cause infectious diseases. These pathogens come from human and animal fecal wastes.

Whether or not a pathogen or a particular chemical in well water is potentially harmful to human health depends on its toxicity, its levels in the well water, the amount of water you drink every day, your health condition and specific age and gender groups in your household. Some chemicals may cause human health concern if high levels of chemicals are present in the well water and a large amount of well water is consumed by people over a long time period.

Some chemicals affect the water's aesthetic quality such as taste, odour, colour, or hardness. Hardness can cause scaling problems in a house supply system (e.g. appliances, plumbing fixtures and pipes).

Who sets up the guidelines for drinking water quality?

Health agencies around the world have established guidelines for drinking water to ensure safe, clean drinking water for all people. In Canada, *the Guidelines for Canadian Drinking Water Quality* are set by Health Canada for many physical, chemical and biological agents.

Testing Domestic Well Water

How can you determine domestic well water quality?

In order to determine domestic well water quality, private well owners send the water samples to a certified laboratory for routine physical/chemical testing, trace element testing, organic compound testing or microbiological testing.

What is routine physical/chemical testing?

Routine testing measures the levels of physical properties and major and minor ions in the well water samples.

What is trace element testing?

Testing for trace elements is appropriate when specific elements may be present due to specific land formations (e.g. arsenic or uranium) or specific contamination sources (e.g. lead or cadmium in old plumbing system).

What is organic contaminant testing?

Organic contaminants are not usually naturally-occurring chemicals in well water. They can enter well water from a variety of human activity sources. Presence of elevated levels of volatile organic compounds (VOCs) in well water may indicate environmental contamination (e.g., leaking underground fuel storage). Some VOCs may cause human health concerns.

What is microbiological testing?

Microbiological testing includes:

- bacteriological testing (fecal bacteria); and
- other microbiological testing (e.g. protozoa, enteric viruses).

What to test?

The physical and chemical properties tested by Alberta Centre for Toxicology are shown in Table 1.

Microbiological tests are performed at the Alberta Public Health Laboratory for Microbiology.

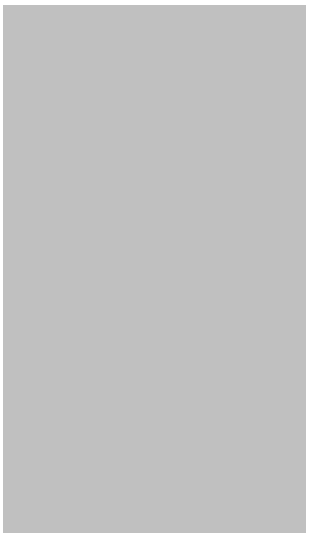
How to select tests?

Examples are shown in Table 2.

When to test?

Well owners should test their well water according to the following circumstances:

- test regularly for bacteria and routine physical/chemical substances (consult with your local public health officers for frequency



of regular testing);

- retest if the previous test results do not meet the guidelines;
- test if changes occur in taste, smell, or colour;
- test after heavy rains, flooding, spring floods, or extended drought;
- test when a well has not been used for a long period;
- test immediately after drilling a new well; or
- test when well owners have suspicion of contamination from local human activities such as septic systems, waste disposal, farming, or underground oil/gas tanks.

Table 1 Physical Property and Chemicals Tested in Alberta Centre for Toxicology

Chemical and its Physical Property	Type of Property	Aesthetic Objective	Essential for Human Health	Health Concern
pH	physical	taste, hardness, scaling		
Alkalinity as $CaCO_3$	physical			
Electrical Conductivity (EC)	physical			
Total Dissolved Solid (TDS)	major ion	taste, hardness, scaling		
Hardness	major ion	taste, hardness, scaling		
Calcium (Ca)	major ion	taste, hardness, scaling	yes	
Magnesium (Mg)	major ion	taste, hardness, scaling	yes	
Potassium (K)	major ion		yes	
Bicarbonate (HCO_3^-)	major ion			
Carbonate (CO_3^{2-})	major ion			
Chloride (Cl)	major ion	taste, colour	yes	
Sodium (Na)	major ion	taste	yes	
Sulfate (SO_4^-)	major ion	taste, scaling	yes	
Iron (Fe)	minor ion	taste, colour	yes	
Fluoride (F)	minor ion		yes	chronic
Nitrate (NO_3^-)	minor ion			acute
Nitrite (NO_2^-)	minor ion			acute
Aluminum (Al)	trace	colour		
Antimony (Sb)	trace			chronic
Arsenic (As)	trace			chronic
Barium (Ba)	trace		yes	chronic
Beryllium (Be)	trace			
Boron (B)	trace		yes	chronic
Cadmium (Cd)	trace			chronic
Chromium (Cr)	trace		yes	chronic
Cobalt (Co)	trace		yes	
Copper (Cu)	trace	taste, colour	yes	
Lead (Pb)	trace			chronic
Manganese (Mn)	trace	taste, colour	yes	
Mercury (Hg)	trace			chronic
Molybdenum (Mo)	trace		yes	chronic
Nickel (Ni)	trace		yes	chronic
Selenium (Se)	trace		yes	chronic
Silver (Ag)	trace			
Thallium (Tl)	trace			
Titanium (Ti)	trace			
Vanadium (V)	trace			
Zinc (Zn)	trace	taste, colour	yes	

Table 2 The Examples for Selecting Tests

Concern/Problem	Test for
Colour, Smell, Taste	
Colour: rusty, red, brown, black	iron, manganese
Colour: white flakes	hardness, calcium, magnesium
Smell: gasoline or solvent	VOCs
Smell: foul	hydrogen sulfide
Taste: metallic	lead, copper
Taste: salty	Sodium, chloride, TDS
Plumbing Fixture	
Stains: red, brown, black	iron, manganese
Stains: blue or green	pH, copper
Corrosion:	pH, lead, copper
Scale build-up, soap does not lather	alkalinity, bicarbonate, carbonate, hardness, calcium, magnesium
Activities nearby	
Radon in indoor air or regionional soil is radon rich	radon
Intensive agriculture	nitrate/nitrite, pesticides
Mining operation	pH, various trace elements
Gas / oil drilling operation	chloride, sodium, barium, strontium
Landfills, gas station	pH, TDS, chloride, sodium, various trace elements, VOCs
Septic system, animal waste	*E. coli*, heterotrophic plate count

Interpreting Test Results

What are indicators of physical water quality?	The most commonly used indicators for measuring physical properties are water temperature, pH, alkalinity, specific conductance and dissolved oxygen.
What are indicators of chemical water quality?	The most commonly used indicators for providing basic information on the suitability of drinking water are major ions and minor ions. Testing specific trace elements can provide information on specific contamination sources, land formations and water aquifers. Testing for VOCs is appropriate when contamination of a nearby well is suspected.
What are indicators of biological water quality?	Other microorganisms in groundwater, that can cause human illness, can come from contamination by human or animal wastes. The most commonly used indicators are *E. coli*. The presence of fecal such as E. Coli indicators may suggest the presence of other microbial contamination, but the absence of fecal indicators may not guarantee that enteric viruses and protozoa are absent. Well water must be tested for chemical quality. Well owners need to be certain they have not allowed the well to be vulnerable to contamination from human or animal wastes. Well owners should send the water samples for bacteriological testing on a regular basis.
Explanation of technical terms in the guidelines?	*Maximum Acceptable Concentration* (MAC) is a level that has been established for substances that are known or suspected to be harmful to humans. *Aesthetic Objective* (AO) is established for physical properties or substances that may cause water to have an unpleasant taste, smell or colour, or that may not be suitable for drinking due to aesthetic reasons. *Units*: mg/L is milligrams per litre equivalent to about one part per million.

How to interpret the results of well water testing?

The most common way to interpret your test results is to compare your test values *to the Guidelines of Canadian Drinking Water Quality*.

When seeking to interpret testing results that approach or exceed guideline values, it is important to know that these values are set with considerable precaution in mind. For example, humans should be able to drink water containing guideline levels of contaminants every day for a lifetime without developing illness. Thus, water quality values that are above guideline levels should be a cause for action, but they do not provide grounds to expect that an illness will occur.

How to protect the wells?

Contamination of well water often comes from surface contamination sources. The well head must be protected from any potential ponding of surface water or inflow of overland runoff that may carry surface contamination. Shallow wells are often susceptible to surface contamination, which might be difficult to see on inspection. If well water quality fluctuates, such as periodic turbidity, particularly after storm events, it is possible that the well is vulnerable to surface contamination. Guidance can be drawn from the information provided for municipal wells by visiting AESRD's website at http://environment.alberta.ca/2910.html

What information is present in tables and Q&A sheets in this document?

The tables in this document provide information on the guidelines of drinking water quality, impact of aesthetic quality or health effects, solutions and treatment options. The Q & A sheets in this document provide detailed information for substances found in Alberta that may cause public concern.

Who is able to assist you?

When you receive well-water testing results, you can consult with the local public health officers for assistance in interpreting the test results and receive advice about water treatment options and well maintenance.

How to contact public health officers?

For assistance in selecting the appropriate test, interpreting test results or obtaining advice on water treatment options, contact your local public health centre and speak with a public health inspector.

What actions are needed?

If your water exceeds a MAC or an AC, you should take action to find a cause or source of the problem, eliminate the problem, or select suitable treatment options.

If you have health concerns with the elevated levels of chemicals that may pose a health risk, you should discuss your concern with a physician.

More information

For *the Guidelines for Canadian Drinking Water Quality*, visit Health Canada website:
http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php

For *the Guidelines for Drinking Water Quality – World Health Organization*, visit World Health Organization website:
http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/

For the routine testing for private water supply system, refer to the Alberta Environmental Public Health Manual for Safe Drinking Water.

For interpreting the testing results of private well water for agricultural use, visit Alberta Agriculture and Rural Development (the Rural Water Quality tool) website: http://www.agric.gov.ab.ca/app84/rwqit

Questions and Answers

Arsenic

1. What is arsenic?

Arsenic, with the chemical formula symbol “As”, is widely distributed in the earth’s crust. It is tasteless and odourless. Inorganic arsenic, which is combined with oxygen, chlorine or sulfur, is usually found in water, soil and air. Organic arsenic, which is combined with carbon and hydrogen, is usually found in plants, animals and most food.

2. How does arsenic enter groundwater?

Groundwater normally contains higher concentrations of inorganic arsenic than are found in surface water. Most Canadian groundwater contains arsenic at levels less than 5 micrograms per litre (ppb), but some range up to 1,000 micrograms per litre (ppb).

Localized high levels of inorganic arsenic have been found in well water from some regions in Alberta. Arsenic levels can vary from one well to the next, even within a very small area.

These elevated arsenic levels are often associated with arsenic-containing bedrock formations. Inorganic arsenic occurs naturally in many kinds of rock. Groundwater flowing through underground rock and soil can dissolve arsenic from the bedrock. Once in the water, arsenic does not evaporate or decompose.

Arsenic may also get into water through man-made activities. In Canada, these activities include mining such as gold and base metal mining and agricultural use such as pesticides and feed additives.

3. How does arsenic get into and leave the body?

People ingest a small amount of arsenic (about 50 micrograms) every day. The sources of arsenic mainly come from the food you eat, particularly shellfish, and the water you drink. Sometimes, people may take in arsenic by breathing in smoke from burning arsenic-contaminated materials like treated wood.

The amount of inorganic arsenic taken in from drinking water alone by an average Canadian is probably about 7 to 35 micrograms each day. Consuming 2 litres per day of drinking water at the guideline level of 10 micrograms per litre would provide 20 micrograms of arsenic. Some people may take in the higher levels of arsenic from some groundwater supplies.

Once arsenic is in the body, the liver changes some of this chemical to a less harmful form. Within seven days, most of the arsenic leaves the body via urine while some will remain in the body for several months or longer.

4. How could arsenic affect your health?

Organic arsenic is generally less harmful than inorganic arsenic. Swallowing a large amount of inorganic arsenic from food or water (above 60,000 micrograms per kilogram or micrograms per litre) can cause death, but this would be considered poisoning, not incidental arsenic consumption. At low exposure levels (300 to 30,000 micrograms per kilogram or micrograms per litre in food or water). A person may experience nausea, vomiting, diarrhea, decreased production of red and white cells, abnormal heart rhythm and a “pins and needles” sensation in hands and feet. Long-term exposure to inorganic arsenic can cause thickening and darkening of the skin.

Some studies indicate an increased risk of tumors of the skin, liver, bladder and lungs, which can result from long-term exposure to relatively high levels of arsenic in water. Scientists continue to investigate the long-term health effects due to exposure to levels of arsenic less than 300 micrograms per litre. A few studies found no harmful health effects in persons in the Unites States, who drank water containing arsenic at levels of 50 to 100 micrograms per litre throughout their life time.

5. Does arsenic have any beneficial effects?

Arsenic is thought to be essential in trace amounts, but the benefits are not well understood. It is used in homeopathic treatments for some digestive problems including burning pain and symptoms of dehydration, and in cancer treatment as chemotherapy for acute promyelocytic leukemia. Most people receive enough arsenic from their diet to meet any normal beneficial needs.

6. What is the *Guideline for Canadian Drinking Water Quality* for arsenic?

In order to protect public health, a standard of 10 micrograms per litre (ppb) for the amount of arsenic in drinking water has been set, as a maximum acceptable concentration (MAC). This guideline provides a convenient yardstick against which water quality can be measured, so problems can be quickly identified and corrected.

7. How to interpret the result?

If you receive a result of less than 10 micrograms per litre (ppb) for arsenic in the well water, *it means that your health would not be directly affected by drinking water containing this level of arsenic. The guideline level is set at a level that is not expected to cause adverse health effects*. It is difficult to

predict whether or not arsenic in your drinking well water can affect you, or what the effects will be.

Most health problems from long-term exposure to arsenic through drinking water are health conditions that can have other possible causes and factors beside arsenic. Most common factors are diet, genes, lifestyle and current health conditions. How likely people are to experience these health problems from exposure to arsenic in well water depends on:

- how much arsenic is in the well water;
- how much tap water you drink every day;
- how long you have been drinking the well water (this arsenic guideline level is setting up for drinking arsenic-containing water for 70 years); and
- how sensitive an individual is to arsenic.

More exposure to arsenic increases the chance that health problems may occur. If arsenic in the well water is over 10 micrograms per litre and you mainly use the well water for drinking, cooking and preparing food and beverages, it is recommended that the levels of arsenic be reduced or an alternative water source be used.

8. What do the results of arsenic species mean to you?

There are two main arsenic species in groundwater: +3 (arsenite) and +5 (arsenate). These species are the most harmful forms of arsenic to the human body. Arsenite is difficult to remove from water; and arsenate is easier to remove from water. Therefore, arsenite must be converted to arsenate before arsenic can be removed. Testing arsenic species allows you to know how much arsenite and arsenate are in the well water. This helps you choose the proper methods to convert arsenite to arsenate to assure removal.

9. Can you use arsenic-rich well water for non-drinking activities?

Arsenic-rich well water may be used safely for laundry, bathing, showering, hand washing, dishwashing and watering a garden. Watch children during bathing in order to keep them from swallowing too much water.

10. What should you do if arsenic is high in the well water?

If the arsenic level is over the guideline level, you have to balance the potential health risk against cost and convenience in order to make a decision as to whether or not to continue to use the well water for drinking or cooking. If you have concerns about your health risk from drinking arsenic-rich well water, consult your family physician for advice.

The following recommendations will help you to make your own decisions:

- re-test well water once or twice per year;
- look for other types of water like bottled water, rain water, or treated surface water for drinking;
- look for an opportunity to connect to the public water supply if available and convenient;
- do not boil water because arsenic can be concentrated in boiled water;
- install an in-home treatment device to reduce arsenic levels in well water based on cost and difficulty;
- consult local public health officers for advice on water testing and well maintenance in order to select better options to reduce exposure to arsenic; and
- check your exposure levels of arsenic by having your urine tested.

11. What are treatment options?

If you choose to reduce the arsenic level in drinking well water, there are some short-term and long-term solutions. Well owners should work with local public health officers to find the best choices available because each method has its advantages and disadvantages. Well water treatment options are listed as follows:

Treatment Option	Advantages	Disadvantages
Use Another Source of Water: bottled water, treated surface water, rain water	-arsenic-free water.	-inconvenient.
Pre-oxidization: liquid chloride (bleach), hydrogen peroxide and ozone and chlorine	-efficiently converts inorganic arsenic As+3 to As+5.	-arsenic not removed from water; must be combined with other treatment devices.
Point of Use:** Install a point of use treatment system at the kitchen tap using any of the following:	- affordable; and - removes arsenic to levels below 10 ppb.	- treats water at a single kitchen tap; - produces a small quantity of water; - requires regular maintenance and testing - does not remove arsenic completely if As is > 300 ppb.
a. Reverse osmosis (RO)Treatment with pre-oxidation	- removes most minerals; - removes 98% of arsenic; and - is easy to service.	- must replace cartridge and membrane as scheduled; - uses copper/lead-free faucet; - mineral deficiency may be a health

		concern.
b. adsorptive Media: activated alumina, granular ferric adsorption system, Iron oxide filter	- simplicity; - easy operation and handling; - has regeneration capacity; and - removes a limited number of minerals.	- must replace cartridge and membrane as scheduled.
c. distillation	- removes most minerals.	- more complex than RO; - mineral deficiency may be a health concern.
****** Pitcher style water treatment filters are not approved to remove arsenic.		
Point of Entry Treatment System	- permanent solution; - produces large quantity of water; - treats water at every tap in whole house; and - efficiently removes arsenic.	- regular maintenance and testing; and - larger capacity comes with higher cost.
a. reverse osmosis (RO) with pre-oxidation	- removes most minerals; - removes 98% of arsenic; - easy to service.	- must replace cartridges and membranes as scheduled; - uses copper/lead-free faucets; - uses large quantity of water; - mineral deficiency may be a health concern.
b. anion exchange	- removes As+5.	- removes alkalinity to increase water corrosiveness.
c. adsorptive Media: activated alumina, granular ferric adsorption system,	- simplicity; - easy of operation and handling; - regeneration capacity; and - removes a limited number of minerals.	- replaces cartridge and membrane on schedules
d. iron oxide filter	- inconsistently removes As^{+3}, $As^{+5,}$ iron	- requires routine testing to confirm removal of arsenic - arsenic levels have been found to increase in wells that are not maintained.
New Well	- permanent solution if arsenic levels are low.	- high cost - no guarantee of locating arsenic-free well water
Connect to Public Water Supply or Community Well	- permanent solution	- not always possible to access a public water supply; - need cooperation between neighbors/municipality;

Fluoride

1. What is Fluoride?

Fluoride, with the chemical formula symbol “F”, is present naturally in air, water and soil. It can be found in various chemical compounds like sodium fluoride and calcium fluoride. Sodium fluoride dissolves easily in water, but calcium fluoride does not. Fluoride in drinking water has no taste, smell, or colour. Fluoride can be found in most foods as well.

2. How does fluoride enter groundwater?

Fluoride is found within many rock types, particularly in areas underlain by shale, sandstones and some fractured zones of granite bedrock. Fluoride enters groundwater via weathering and breakdown of rocks.

Fluoride can also come from sources of man-made activities such as:

- fertilizers;
- septic and sewage system; and
- industrial wastes.

3. How does fluoride get into and leave the body?

Fluoride can get into the human body by drinking water, eating food, or breathing the air. About 99 per cent of absorbed fluoride may be localized in calcified tissues such as bone and teeth. In adults, approximately 50-75 per cent of fluoride leaves the body within 24 hours via the urine.

4. How could fluoride affect your health?

Low levels of fluoride, such as 0.8-1.0 mg/L from drinking water, are good for preventing dental cavities in young children during the period of their tooth formation. Fluoride is added to many municipal drinking water supplies and dental products such as toothpastes and mouthwashes in order to help to prevent tooth decay.

In children, dental fluorosis is an irreversible condition caused by excessive ingestion of fluoride during the teeth forming years. If the child ingests fluoride at levels substantially above 1.5 mg/L, tooth enamel will develop white areas or brown stains, with increasing severity should fluoride exposure increase. In order to protect children’s teeth, Health Canada established a

maximum guideline of 1.5 mg/L for fluoride in drinking water, with 0.8 to 1.0 mg/L considered the optimum level.

Fluoride can damage bone, called skeletal fluorosis if adults are exposed to extremely high levels of fluoride in the drinking water over a long period of time. Adults may experience chronic joint pain, restriction of mobility or an increased risk of bone fractures. However, extremely high levels of fluoride are rarely found in groundwater in Alberta.

5. What are the *Guideline for Canadian Drinking Water Quality* and the Alberta standard?

In order to protect public health, a standard of 1.5 milligrams per litre (ppm) for fluoride in drinking water has been set by Health Canada in the *Guidelines for Canadian Drinking Water Quality*. This is the maximum acceptable concentration (MAC) for fluoride in drinking water to prevent dental fluorosis in young children.

Alberta Environment sets a standard (MAC) of 2.4 mg/L for fluoride in municipal drinking water for adults to prevent musculoskeletal effects.

6. **How to interpret the result?**

If you receive a result of greater than 1.5 milligrams per litre (ppm) for fluoride in the well water, *it means that your health would not be directly affected by drinking water containing this level of fluoride. The guideline level is set at a level that is not expected to cause adverse health effects*. It is difficult to predict whether or not fluoride in your drinking well water will affect you, or what the effects will be.

7. What should you do if fluoride levels are too high or too low in the well?

The optimum fluoride level in drinking water for good dental health is between 0.8 to 1.0 mg/L. It is not feasible to add fluoride to an individual's well. If fluoride levels are less than 0.8 mg/L in the well water and you have children under six years old at home, you should:

- retest the well water to confirm the original results; and
- visit your child's dentist or pediatrician. They should evaluate whether or not your child can benefit from daily fluoride supplements. The recommendation will depend on your child's risk of developing tooth decay as well as exposure to other sources of fluoride (e.g., drinking water at school or daycare, toothpaste).

If fluoride levels are greater than 1.5 mg/L and less than 2.4 mg/L in the well water, you should:

- retest the well water to confirm the original results;
- do not use water to prepare infant formula;
- do not give water to children under six years old for drinking; and
- adults and children older than six years of age can safely drink the water at this level.

If fluoride levels are greater than 2.4 mg/L in the well water, you should:

- use an alternate source of water for drinking, cooking, and brushing teeth;
- use water for bathing, dishwashing, laundry or gardening because fluoride does not pass through your skin; and
- treat your water to reduce fluoride levels.

8. What are treatment options?

Removal of fluoride from water is difficult. Most home point-of-use treatment systems that are installed at single faucets use activated carbon filtration which does not remove the fluoride.

Treatment options such as reverse osmosis, distillation or an ion exchange system can be used to remove fluoride, but not always remove it fully.

- **reverse osmosis** forces water under pressure through a membrane that filters out minerals. One-half to two-thirds of the water remains behind the membrane as rejected water. Higher-yield systems use water pressures of 150 psi.
- **distillation** boils the water, catches the resulting steam, and condenses the steam on a cold surface (a condenser). Fluoride remains behind in the boiling tank.
- **anion-exchange** removes certain fluoride in well water. The resin in the anion exchange unit may need to be regenerated more frequently to reduce the fluoride levels to a satisfactory level.

Hardness

1. What is hardness?

Hardness is water with high levels of minerals such as calcium and magnesium, sometimes bicarbonate and sulfate. Hard water makes soap less effective (reduced or no lather) compared with soft water, and you need to use more detergent and soap for your laundry and dishwashing.

2. Do you have hard water?

The degree of hard water is grouped based on the laboratory testing "hardness" as below:

- soft water at a level less than 60 mg/L;
- medium hard water at levels between 60 – 120 mg/L;
- hard water at levels between 120 – 180 mg/L; and
- very hard water at a level greater than 180 mg/L.

Hardness is made up in two parts: temporary (carbonate) and permanent (non carbonate) hardness. Temporary hardness occurs when water is boiled and a white scale deposits on a kettle. Scum floats to the surface and does not stick to the kettle. Permanent hardness occurs when calcium and magnesium sulfate are not removed by boiling and they form a scale deposit.

3. How does water become hard?

Hard water is mainly caused by a compound called calcium bicarbonate. This compound is formed when water reacts with calcium carbonate in some types of rocks such as limestone or chalk. Hard water can be caused by human activities such as mining activities and agricultural uses.

4. Does hard water affect your health?

Hard water itself does not affect your health and is safe to drink. Hard water will form scale deposits on kettles and water heaters.

Calcium and magnesium are good for health and are needed in a healthy diet. People do not always get enough calcium from a regular diet. It is helpful to get calcium from drinking water. There is some evidence that medium hard water and hard water may be good for heart and circulation health.

5. Does soft water affect your health?

Soft water contains less calcium and magnesium, and more sodium. When well owners use sodium-containing softener or potassium-containing softener

to treat hard water, sodium or potassium replaces calcium and magnesium to make water soft. In this case, the higher levels of sodium or potassium can be found in water. Consuming too much sodium or potassium from drinking water is not good for circulatory and kidney health, particularly for people who have heart diseases, high blood pressure, or kidney disease. People who have underlying health conditions or need sodium-restricted diets or potassium-restricted diets should consult a physician.

Soft water can lead to corrosion of household pipes. When corrosion occurs, some heavy metals such as lead, cadmium, copper and zinc will dissolve in the water. The presence of high levels of heavy metals in water can pose a health concern.

6. Is there the *Guideline for Canadian Drinking Water Quality*?

No, there are no guidelines for drinking water for hardness, calcium, magnesium, and bicarbonate. These chemicals do not pose a direct health risk to humans. Hard water can change taste if too much calcium is present in the water. Hard water mainly causes scale build-up problems in pipes and household appliances. People usually accept different hardness levels. Thus, an acceptable hardness level cannot be set up.

When hardness is over 200 mg/L, the water quality is considered to be poor, but many people can tolerate this level of hardness. If hardness exceeds 500 mg/L, the water cannot be used for drinking and other uses.

7. How to interpret the result?

If the hardness level is between 80 and 100 mg/L, it is good for drinking, preventing corrosion and avoiding scale problems.

8. What should you do if hardness levels are too high in the well?

The optimum hardness levels in drinking water are between 80 to 100 mg/L.

If hardness levels are greater than 200 to 500 mg/L, depending on your tolerance, you can use:

- a water softener*, or
- filters.

* Important note: If you install an ion exchange water softener, a separate non-softened water supply should be retained for drinking because softened water may have a high level of sodium or potassium.

Lead

1. What is lead?

Lead, with the chemical formula symbol “Pb”, is a naturally occurring bluish-gray, heavy metal found in small amounts in bedrock ore. Lead does not break down. Lead compounds are changed by sunlight, air, and water. Atmospheric lead, which is deposited onto soil, usually adheres to soil particles. Movement of lead from soil into groundwater will depend on the type of lead compound and the characteristics of the soil. Lead is rarely found in source water. Lead pipes are more resistant to corrosion than iron pipes, but corrosive water can dissolve some lead. Lead has been used in the pipe industry and has become widely distributed throughout the environment.

2. How does lead enter groundwater?

Lead is present in tap water, as a result of dissolution from natural sources or from household plumbing systems. The main source of lead in drinking water is through corrosion of plumbing materials with lead components such as pipes, lead-based solder, faucets, fittings and old galvanized well liners. The amount of lead dissolved in drinking water depends on many factors such as pH, alkalinity, water temperature, water hardness, length of piping and the amount of time that water has been sitting or left in pipes.

The highest levels of lead usually occur when very corrosive (low pH, low alkalinity) water stands motionless in lead or lead solder copper pipe for a long time. If corrosion occurs in the well water, you may find a greenish colour and unpleasant taste of tap water, but you may not have any visible indication. Corrosivity varies with water quality, but hard water is usually less corrosive than soft water. Hard water alone does not always guarantee that there will be no elevated lead levels.

3. How does lead get into and leave the body?

The greatest exposure to lead is through swallowing or breathing in lead paint chips and dust. People can be exposed to lead by eating food or drinking water if lead leaches out into the water from the plumbing system, especially in old houses. Lead also can get into the body by breathing air and through skin contact.

Once lead is absorbed, it enters the blood and then goes to soft tissues, liver, lung, spleen, kidney, bones, bone marrow and teeth. About 90 per cent of the total body lead in adults, and about 70 per cent in children is stored in the

bones and teeth for a long period of time. In Adults, about 99 per cent of the amount of lead leaves the body within a few weeks via urine and feces. In children, about 30 per cent of the lead leaves the body via urine and feces.

4. How could lead affect your health?

Lead ingested through drinking water can affect almost every system in the human body. Adverse health effects may include increased blood pressure, kidney damage, anemia, gastrointestinal problems, nerve disorders, memory loss, and muscle and joint pain.

Children under the age of six, infants and unborn children are at the greatest health risk because their body easily absorbs lead as compared to adults. Children's brain and nervous systems are also more sensitive to the effects of lead. Pregnant women and nursing mothers should avoid exposure to lead as it can result in behaviour and learning disabilities, physical and mental developmental delays, and hearing problems in children.

5. What is the *Guideline for Canadian Drinking Water Quality*?

In order to protect public health, a standard of 0.01 milligrams per litre (ppm) for lead in drinking water has been set as the maximum acceptable concentration (MAC).

6. How to interpret the result?

If you receive a result of greater than 0.01 milligrams per litre (ppm) for lead in the well water, *it means that your health would not be directly affected by drinking water containing this level of lead. The guideline level is set at a level that is not expected to cause adverse health effects*. It is difficult to predict with certainty whether or not lead in your drinking well water will affect you, or what the effects will be.

7. What should you do if lead levels are high in the well?

If lead levels are high in the well water, you should:

- test the well water by taking a sample of water from the well before it enters the buildings to determine whether or not the lead is present in the groundwater, or it is leaching from plumbing materials;
- use bottled water for drinking and cooking, and limit well water usage to bathing and showering while waiting for your second test results;
- remove the source of lead by replacing the plumbing system;

- flush faucets until the water runs as cold as possible before using the water for drinking and cooking;
- avoid drinking tap water during pregnancy if the levels of lead are close to or above the guideline level;
- not use water to prepare infant formula if the levels of lead are close to or above the guideline level;
- not boil water to remove lead because boiling water will increase the level of lead; and
- use a treatment system to reduce lead levels.

8. What are treatment options?

Treatment options such as reverse osmosis, distillation, and an ion exchange system or water filters can be used to remove lead.

- **reverse osmosis** forces water under pressure through a membrane that filters out minerals. One-half to two-thirds of the water remains behind the membrane as rejected water. Higher-yield systems use water pressures of 150 psi.
- **distillation** boils the water, catches the resulting steam, and condenses the steam on a cold surface (a condenser). Lead and other minerals remain behind in the boiling tank.
- **cation-exchange** generally removes lead if the pH of water is below seven. If the pH of water is above seven, lead may be in a form that cannot be readily removed using cation exchange.
- **water filters** with certification of NSF Standard No. 53 for reduction of lead.

Nitrate/Nitrite

1. What are nitrate and nitrite?

Nitrate, with the chemical formula symbol "NO_3^-", and its chemical cousin Nitrite "NO_2^-" are the most common form of nitrogen in groundwater. They naturally occur in soil, water and plants. They are nutrients for plants because plants need nitrogen to make amino acids and proteins for essential growth.

Microorganisms in the soil convert the nitrogen locked up in crop residues, human and animal wastes or compost to ammonium. A specific group of microorganisms convert ammonium to nitrate. Nitrate is also found in biotic materials that decompose such as animal waste and septic system absorption fields.

Nitrate and nitrite are water-soluble, stable and do not evaporate. They have a high potential to migrate to groundwater under oxidizing conditions, and are likely to remain in water.

2. How do nitrate and nitrite enter groundwater?

Naturally occurring nitrate and nitrite in groundwater comes from precipitation, leaching of organic debris, or dissolving/eroding of nitrate bedrock. The levels of naturally occurring nitrate and nitrite in well water are usually low.

They also can come from human activities through surface water runoff, rainwater and melting snow as they percolate through the soil and bedrock into the underlying aquifer. Some human activities for the sources of nitrate and nitrite are:

- fertilizer application;
- animal production (feedlots and livestock waste); and
- wastewater disposal (human sewage, industrial waste and food processing waste).

If levels of nitrate and nitrite are high in the well water, it may also indicate the occurrence of organic chemical contamination. To determine whether or not the well is vulnerable to nitrate contamination, check the following:

- well location: well is located downhill from farm field, feedlots, septic tank and waste treatment site;
- well casing depth and construction: shallow or damaged casing could allow the infiltration of run-off into the well; and
- geology: highly porous, sandy soils, fractured bedrock, natural caves and sinkholes are vulnerable to nitrate contamination.

3. How do nitrate and nitrite get into and leave the body?

Ingested nitrate is readily absorbed and distributed rapidly throughout the body. If the pH of the stomach is elevated (e.g. in bottle-fed infants), the growth of nitrate-reducing bacteria is allowed, and nitrate is converted to nitrite. Under normal conditions, 80 to 100 per cent of nitrate ingested by infants and 60 to 65 per cent of nitrate ingested by adults leaves the body via the urine. Nitrite is not normally found in the urine.

4. How could nitrate and nitrite affect your health?

Nitrate is the only nutrient in groundwater that cause health concerns. It causes the hemoglobin in the human bloodstream to change to methemoglobin, which reduces the amount of oxygen-carrying capacity available in the blood stream. This condition is called methemoglobinemia in adults or “blue baby syndrome” in infants. The lack of oxygen causes the baby’s skin to turn a bluish colour, particularly around the eyes and mouth. Infants under six months of age are the most at risk of developing serious health problems from drinking water that contains elevated levels of nitrate. High methemoglobin levels can lead to digestive and respiratory problems, anoxia, brain damage or even death.

It is common for methemoglobin levels of a pregnant woman to increase from normal to a maximum of 10 per cent in the 30^{th} week of pregnancy. Pregnant women are particularly susceptible to metheoglobinemia and should ensure the nitrate and nitrite in the well water are at safe levels for drinking.

Once diagnosed, methemoglobinemia can be readily reversed, although with anoxia permanent damage may have occurred. Methemoglobinemia can be prevented by restricting consumption of nitrite and nitrate.

Nitrate contamination may be associated with other contaminants. Health effects resulting from bacteria and pesticide contaminations should be watched.

5. What is the *Guideline for Canadian Drinking Water Quality*?

In order to protect public health, a standard of 45 milligrams per litre (ppm) for *nitrate* (NO_3^-) has been set in drinking water as the maximum acceptable concentration (MAC) for nitrate. If the laboratory measures nitrate and nitrite separately as a nitrogen-nitrate equivalent, standards are 10 mg/L for nitrate-N and 3.2 mg/L for nitrite-N.

6. How to interpret the results?

If you receive a result of greater than 45 milligrams per litre (ppm) for nitrate as NO_3, *it means that your health would not be directly affected by drinking water containing this level of nitrate/nitrite. The guideline level is set at a level that is not expected to cause adverse health effects*. The guideline value for nitrate should not be ignored, although it is difficult to predict whether or not nitrate and nitrite in your drinking well water will affect you, or what the effects will be. Sometimes results may be reported as nitrogen, so the guideline levels would be 10 mg/L of nitrate as nitrogen and 1.0 mg/L of nitrite as nitrogen.

7. What should you do if nitrate and nitrite levels are high in the well?

If nitrate and nitrite levels are greater than 45 mg/L (as NO_3) or 10 mg/L nitrate (as nitrogen) in the well water,

For infants and pregnant women at home, you should:

- test well water more frequently per year if you have an infant, or somebody who is planning to become pregnant in your house;
- avoid drinking tap water during pregnancy;
- not give water to infants under six months of age;
- not use water to prepare infant formula; and
- seek medical help immediately if the skin of colour of an infant appears bluish or gray.

For adults at home, you should:

- use bottled water for drinking and cooking, and limit well water usage to bathing and showering until contamination sources are removed and nitrates and nitrites are reduced to safe levels;
- not boil water to remove nitrate and nitrite because boiling water will increase the levels of nitrate and nitrite; and
- limit daily intake of well water if you have chronic health conditions.

Recommendations include:

- test the well water regularly after you drill a new well;
- test the well water for bacteria regularly;
- test the well water as soon as possible if there are changes in the taste, odour or colour of the water;
- identify and remove the sources of nitrate and nitrite contamination;
- use a treatment system.

8. What are treatment options?

Treatment option such as reverse osmosis, distillation or an ion exchange system can be used to remove nitrate and nitrite.

- **reverse osmosis** forces water under pressure through a membrane that filters out nitrate and minerals. One-half to two-thirds of the water remains behind the membrane as rejected water. Higher-yield systems use water pressures of 150 psi.
- **distillation** boils the water, catches the resulting steam, and condenses the steam on a cold surface (a condenser). Nitrate/nitrite and other minerals remain behind in the boiling tank.
- **anion-exchange** nitrate and nitrite are negative ions (anion) in solution. An ion exchange unit is filled with special resin beads that are charged with chloride. As water passes over the beads, the resin takes up nitrate and nitrite in exchange of chloride. The resin is recharged by backwashing with sodium chloride solution. The backwash solution, which is high in nitrate and nitrite, must be removed. When you use anion exchange treatment, the resin in the unit will remove certain anions (e.g. arsenic, sulfate, nitrate, nitrite and fluoride) more readily than others. The resin in the unit may need to be regenerated more frequently.

Uranium

1. What is uranium?

Uranium, with the chemical formula symbol “U”, is a common naturally occurring and radioactive element. Uranium in its pure metal form is silver-coloured with a gray surface and it is the heaviest naturally occurring metal nearly as strong as steel. It exists at low concentrations in rocks, soil, air, and water. High levels of uranium in well water are often related to the land formations with granite, sandstone and shale bedrock.

Natural uranium is a mixture of three types or isotopes called U-234 (^{234}U), U-235 (^{235}U), and U-238 (^{238}U). All three are the same chemical, but they have different radioactive properties. Uranium decays very slowly by emitting an alpha particle.

2. How does uranium enter groundwater?

Naturally occurring uranium in well water comes from dissolving or eroding of soils and rocks that contain uranium. Elevated levels of uranium are more likely to be found in drilled wells where the water flows from cracks and fractures in bedrock than in dug wells.

Some human activities are sources of uranium such as:

- milling tailings;
- emission from the nuclear industry;
- combustion of coal and other fuels; and
- use of phosphate fertilizers.

3. How does uranium get into and leave the body?

People may be exposed to uranium by breathing air, drinking water or eating local food in places that have high background levels of uranium. After ingestion and inhalation, uranium rapidly enters the blood stream and always accumulates in the kidneys and bone. Uranium ion can replace calcium in the bone. Uranium leaves the body very slowly via urine.

4. How could uranium affect your health?

The main health concern of exposure to uranium is kidney damage. The radiation damage from exposure to high levels of natural or depleted uranium is not known to cause cancer.

5. What is the *Guideline for Canadian Drinking Water Quality*?

In order to protect public health, a standard of 0.02 milligrams per litre (ppm) has been set as the maximum acceptable concentration (MAC) for uranium in drinking water.

6. How to interpret the result?

If you receive the result of greater than 0.02 milligrams per litre (ppm) for uranium in the well water, *it means that your health would not be directly affected by drinking water containing this level of uranium. The guideline level is set at a level that is not expected to cause adverse health effects*. It is difficult to predict whether or not uranium in your drinking well water will affect you, or what the effects will be.

7. What should you do if uranium levels are high in the well?

If uranium levels are high in the well water, you should:

- test the well water again to confirm the levels of uranium;
- use bottled water or a dug well for drinking and cooking, and limit well water usage to bathing and showering if levels of uranium are above the guideline; and
- use a treatment system to reduce uranium levels.

8. What are treatment options?

Treatment options such as reverse osmosis, distillation or an anion-exchange system can be used to remove uranium.

- **reverse osmosis** forces water under pressure through a membrane that filters out minerals. One-half to two-thirds of the water remains behind the membrane as rejected water. Higher-yield systems use water pressures of 150 psi.
- **distillation** boils the water, catches the resulting steam, and condenses the steam on a cold surface (a condenser). Uranium and other minerals remain behind in the boiling tank.
- **anion-exchange** uranium is a negative ion (anion) in solution. When you use anion exchange treatment, the resin in unit will remove certain anions (e.g. arsenic, sulfate, nitrate, nitrite and fluoride) more readily than others. The resin in the unit may need to be regenerated more frequently.

Information Tables

Table A Bacteriological Testing

	Health-based Guideline	Remarks	Health concern
Escherichia coli (E. coli)	0 per 100 ml	*E. coli* is • a member of the coliform bacteria; • a bacteria only found in the feces of humans and animals; • an organism which plays a symbiotic role in aiding digestion for the animal or human host; • an indicator for recent fecal contamination, • an indicator of possible presence of other pathogenic bacteria, enteric viruses and protozoa; and • *E. coli* O157:H7 is a rare pathogenic strain of the otherwise harmless *E. coli,* which is an emerging cause of waterborne illness and produces a powerful toxin and can cause severe illness. POTENTIAL CONTAMINATION SOURCES • effluent from septic system or sewage discharge; • agricultural runoff; • infiltration of domestic or animal fecal matter; • poorly constructed or maintained wells (e.g. shallow dug well). HEALTH CONCERN (only for the pathogenic strains like *E. coli* O157:H7) • common effects: bloody diarrhea, cramps, nausea, headaches, or other symptoms; and • severe effects: kidney damage, or may be fatal to infants, young children, elderly and people with immune deficiencies. SOLUTIONS • boil water before drinking, preparing food, and brushing teeth; • treat the well with shock chlorination; • use alternate water or other water systems; • remove the source of contamination; • repair the well as needed; • retest until the problem is fixed ; and • test other microbes if necessary. TREATMENT OPTIONS • disinfection (shock chlorination, ozone, UV)	Yes

Total Coliform	0 per 100 ml	Total coliforms are: • a group of several types of bacteria from the same family which are found in the environment and originates from both fecal or non-fecal sources; • a broad spectrum indicator for possible bacterial contamination in the well water or water supply system; • an indicator for effective disinfection treatment; • a very non-specific indicator for other possible pathogens. POTENTIAL CONTAMINATION SOURCES • effluent from septic system or sewage discharge; • agricultural runoff; • infiltration of domestic or animal fecal matter; • poorly constructed or maintained wells (e.g. shallow dug well). SOLUTIONS • retest the well water to confirm the original results; • test *E. coli* immediately; • test other pathogens if necessary; • boil water before drinking, preparing food and brushing teeth; • use alternative water or other water systems; • remove the source of contamination; • repair the wells as needed; and • retest until the problem is fixed. TREATMENT OPTIONS • disinfection (shock chlorination, ozone, UV) * Total coliforms are not harmful to humans, but may indicate that other pathogens have contaminated the water that could cause human illness. Total coliforms only serve as an indicator of disinfection efficiency for enteric bacteria.	No (See note*)
Heterotrophic Plate Count (HPC)		HPC is: • an indicator of the overall bacteriological quality in the well water; • not an indicator for water safety and causing human illness; and • a measure for changes in water treatment system.	No

Table B Routine Physical/Chemical Testing

	HG mg/L	AO/OG mg/L	Remarks	Health Concern
AESTHETIC QUALITY				
pH		6.5 -8.5	A measure of how acidic or alkaline water is. IMPACT < 6.5 • bitter taste; • softness; and • corrosion effect. > 8.5 • soda taste; • hardness; • scaling problem and incrustation; and • decreasing in the efficiency of chlorine disinfection processes. TREATMENT OPTIONS • acid neutralizing filters; • ion exchange unit; and • chemical feed pump with a neutralizing solution. *pH below 6.5 may increase the levels of some metals like lead, copper, cadmium and zinc as they dissolve in the water easily and increase health risk.	No (See note*)
conductivity			A measure of the degree to which water will carry an electrical current (usually under 200 µS/cm). An indicator for water purity because dissolved ions increase the ability to carry current. IMPACT • associated with the total dissolved solids in water; and • changes in conductivity may signal other changes of water quality.	No
total dissolved solids (TDS)		≤500	A measure of the total amount of salt, minerals or metals dissolved in the water. An indicator for the overall suitability of water for drinking and other uses. IMPACT > 500 mg/L • murky water;	No (See note*)

			• salty taste; • hardness; • scaling problem; • staining; and • corrosion effect. TREATMENT OPTIONS • softener: if calcium, magnesium and iron levels are high; and • reverse osmosis or distiller: if sodium and potassium levels are high. * > 1000 mg/L may cause digestive upset in some consumers.	
iron		≤0.03	An aesthetic indicator for changes in colour, stains or deposits. IMPACT > 0.03 mg/L • rusty/black/brown colour; • metallic taste; • rusty/black/brown staining; • sediment; • nuisance organisms; and • clogs in pipe. TREATMENT OPTIONS • softener; • aeration; • chlorination; • catalytic filter; • manganese greensand; • ozonation; • distiller; and • reverse osmosis.	No
chloride		≤250	An indicator of contamination by septic system, road salt, fertilizer, animal waste or other waste because chloride is a very soluble ion, not absorbed by soils, and readily travels in groundwater without attenuation. IMPACT > 250 mg/L • salty taste; • black staining; and • corrosion effect. TREATMENT OPTIONS • reverse osmosis; and	No

			• distiller.	
sodium		≤200	An aesthetic indicator for changes in taste. IMPACT > 200 mg/L • salty taste. TREATMENT OPTIONS • reverse osmosis; and • distiller. * Individuals with sodium-hypersensitive hypertension should consult with physicians if there are high level of sodium in the drinking water.	No (See note*)
sulfate		≤500	An aesthetic indicator for changes in taste. IMPACT > 500 mg/L • salty taste or bitter taste; • corrosion effect; and • scaling problem. TREATMENT OPTIONS • reverse osmosis; and • distiller. * Sulfate can cause a laxative effect (gastrointestinal irritation) on humans if sulfate level is over 1000 mg/L in drinking water. It is also recommended that local public health officers be notified of sources of drinking water that contain sulfate level in excess of 500 mg/L.	No (See note*)
fluoride	1.5		A major ion with health concern. HEALTH CONCERN • tooth discolouration; and • bone problem.	Yes (See Q & A)
SUPPLY USER CONVENIENCE				
hardness			A measure of high calcium, magnesium and similar minerals dissolved in water. CLASSIFICATION (as equivalent to calcium carbonate) • soft: 0-60 mg/L;	No

			• medium hard: 60 and 120 mg/L; • hard: 121-180 mg/L; and • very hard: >180 mg/L. OPTIMUM RANGE 80 and 100 mg/L IMPACT > 500 mg/L • scaling problem and incrustation; and • excessive soap consumption. < 100 mg/L • corrosion effect. TREATMENT OPTIONS • ion exchange (water softener); • oxidizing filter; • reverse osmosis; and • boiling water for presence of high levels of carbonate and bicarbonate.	
calcium			A major contributor to water hardness. IMPACT Excessive Level • scaling problem and incrustation; and • bitter taste. TREATMENT OPTIONS • ion exchange (water softener); • oxidizing filter; and • reverse osmosis.	No
magnesium			A major contributor to water hardness. IMPACT Excessive Level • scaling problem and incrustation; and • bitter taste. TREATMENT OPTIONS • ion exchange (water softener); • oxidizing filter; and • reverse osmosis.	No
alkalinity			A measure of the buffering capacity of water or its ability to resist sudden changes in pH. IMPACT > 150 mg/L: • soda taste; and	No

			• scaling problem. TREATMENT OPTIONS • reverse osmosis.	
bicarbonate			A common, natural major form of alkalinity. IMPACT Excessive Level • scaling problem. TREATMENT OPTIONS • boiling water.	No
carbonate			A common, natural major form of alkalinity IMPACT Excessive Level • scaling problem. TREATMENT OPTIONS • boiling water.	No
potassium			A natural, major ion. IMPACT Use of potassium-chloride-based softeners • high level of potassium in drinking water. * For individuals with kidney and heart conditions and diabetes, the high levels of potassium in drinking water may cause health condition called hyperkalemia. Individuals at-risk should consult with physicians if a high level of potassium occurs in drinking water.	No (See note*)
NUTRIENT				
Nitrate Nitrite	45 as NO_3 or NO_2		A natural nutrient. An indicator of organic chemical contamination in groundwater. POTENTIAL CONTAMINATION SOURCES • Fertilizers; • human sewage; and • livestock manure. The guideline value is equivalent to 10 mg/L as nitrate-N. When nitrate and nitrite are determined separately, levels of nitrite should not exceed 3.2 mg/L as nitrite-N.	Yes (See Q&A)

			It is recommended that any water sample with nitrate levels above 2 mg/L nitrate-nitrogen be tested immediately for microbial contamination. HEALTH CONCERN • methaemoglobinaemia or blue baby syndrome.	

HG means health-based guidelines listed as maximum acceptable concentrations (MAC).

AO means aesthetic objectives.

OG means operational guidance values for operational considerations.

Remarks include any health concern, meaning of the parameter, and treatment options if available.

Aesthetic Quality means that poor water clarity, high colour, odour and taste affect the general acceptability of drinking water.

Supply Amenity (user convenience) means that hardness of water increase the use of soap, detergents and cause deposits in pipes and plumbing fixtures, and reduce the life of household appliances and water heaters and boilers.

Health Concern "No" means "Not of health concern at level found in drinking water in Canada".

Table C Trace Element Testing

	HG mg/L	AO/OG mg/L	Remarks	Health Concern
Aluminum		0.1/ 0.2	Operational guidance values for water treatment plants using aluminum-based coagulants, based on a 12-month running average of monthly samples. IMPACT • coloured water. TREATMENT OPTIONS • reverse osmosis; and • distiller.	No
Antimony	0.006		A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • plumbing materials; • mining waste; • manufacturing effluent; • leaching of fertilizers; • leaching of landfills; and • fossil fuel combustion products. HEALTH CONCERN • short-term exposure to >30 mg/L: nausea, vomiting and diarrhea. SOLUTIONS • retest the well water at well head to determine whether or not the sources of antimony come from plumbing materials; • remove the source of antimony; • flushing the water before using for drinking; • avoid hot tap water for drinking; • adjust pH to make water less corrosive; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • reverse osmosis; and • distiller.	Yes
Arsenic	0.010		PRIMARY SOURCES • naturally occurring; and • common in the land formations in Alberta: La Biche, Lea Park and Smoky Group. POTENTIAL CONTAMINATION SOURCES • industrial effluent (not common); and	Yes (See Q&A)

			• pesticide runoff. HEALTH CONCERN • short-term exposure to high levels: nausea, vomiting, diarrhea, and abnormal heart rhythm; • long-term exposure to high levels: skin lesion; • long-term exposure to low levels: potentially increased risk of bladder, lung and skin cancer.	
Barium	1.0		PRIMARY SOURCES • naturally occurring; and • common in the land formation: sedimentary or carbonate rocks. POTENTIAL CONTAMINATION SOURCES • oil and gas well drilling operation; and • industrial effluent. HEALTH CONCERN • short-term exposure: nausea, vomiting, diarrhea, and muscular weakness; and • long-term exposure: high blood pressure. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • lime softening; • electrodialysis; • ion exchange; • reverse osmosis; and • distiller.	Yes
Boron	5.0		PRIMARY SOURCES • naturally occurring; and • common in the land formation: sedimentary or granitic rocks or pegmatites. POTENTIAL CONTAMINATION SOURCES • coal combustion products; • municipal sewage; • leaching from landfills; • fertilizers; and • pesticides. HEALTH CONCERN • short-term exposure to high levels: irritation of the nose, throat, eyes and gastrointestinal	Yes

			system; and • long-term exposure: increasing risk of reproductive and developmental effects. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • ion exchange; • reverse osmosis; and • distiller.	
Cadmium	0.005		A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • plumbing materials; • mining and smelting operation; • burning of fossil fuels; • leaching from landfills; and • fertilizers. HEALTH CONCERN • short-term exposure to high levels: nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and kidney failure; and • long-term exposure: liver, bone and blood damage. SOLUTIONS • retest the well water at well head to determine whether or not the sources of cadmium come from plumbing materials; • test the well water for lead and copper; • remove the sources of cadmium; • flushing the water before using for drinking; • avoid hot tap water for drinking; • adjust pH to make water less corrosive; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • lime softening; • ion exchange; • reverse osmosis; and • distiller.	Yes

Chromium	0.05		A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • mining and smelting operation; • burning of fossil fuels; and • industrial effluent. HEALTH CONCERN • short-term exposure to high levels: skin irritation or ulceration; and • long-term exposure: damage to liver, kidney circulatory and nerve tissues. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • lime softening; • ion exchange; • reverse osmosis; and • distiller.	Yes
Cobalt			A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • burning of fossil fuels; and • industrial effluent. HEALTH CONCERN • short-term exposure to high levels: skin irritation; and • long-term exposure: damage to lung and heart. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • reverse osmosis; and • distiller. * no guideline because the general population is rarely exposed to cobalt in drinking well water.	Yes (See note*)

Copper		≤1.0	An aesthetic objective. POTENTIAL CONTAMINATION SOURCES • plumbing materials; • septic system; • feedlots; • food processing waste; and • industrial waste. IMPACT > 1.0 mg/L • astringent taste; • blue-green staining; and • corrosion effect. SOLUTIONS • retest the well water at well head to determine whether or not the sources of copper come from plumbing materials; • test the well water for lead and cadmium; • remove the sources of copper; • flushing the water before using for drinking; • avoid hot tap water for drinking; • adjust pH to make water less corrosive; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • ion exchange; • reverse osmosis; and • distiller. * This level is below the taste threshold for copper in water, is protective of health, and contributes to minimum nutritional requirements.	No (See note*)
Lead	0.01		A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • plumbing materials. HEALTH CONCERN *Children* • damage to brain and nervous system; • behaviour and learning impairment; and • hearing disorders. *Adults* • increased blood pressure; • damage to kidney;	Yes (See Q&A)

			• anemia; and • gastrointestinal problems. TREATMENT OPTIONS • reverse osmosis; and • distiller.	
Manganese		≤0.05	An aesthetic objective. IMPACT > 0.05 mg/L • black or brown colour; • bitter taste; and • black staining. TREATMENT OPTIONS • softener; • aeration; • chlorination ; • catalytic filter; • manganese greensand ; • ozonation; • distiller; and • reverse osmosis.	No
Mercury	0.001		A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • mining and smelting operation; • burning of fossil fuels; • industrial effluent; • sewage; and • leaching from landfills. HEALTH CONCERN • damage to kidney. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • lime softening; and • reverse osmosis.	Yes
Molybdenum	0.07[+]		A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES	Yes

			• mining operation; • burning of fossil fuels; • industrial effluent; • fertilizers; and • intensive livestock operation. HEALTH CONCERN • joint pain; and • metabolism problems. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • reverse osmosis; and • distiller.	
Nickel (Ni)	0.07+		A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • food processing waste; and • fungicides. HEALTH CONCERN • skin irritation; • damage to heart and liver; and • decreased body weight. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • lime softening; • ion exchange; • reverse osmosis; and • distiller.	Yes
Selenium	0.01		A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • copper and lead refinery effluent; • municipal wastewater; and • industrial waste.	Yes

			HEALTH CONCERN • short-term exposure to high levels: nausea, vomiting, diarrhea; and • long-term exposure: damage to hair, fingernails and liver. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • reverse osmosis; and • distiller.	
Silver			A rare contaminant in groundwater. An aesthetic objective. POTENTIAL CONTAMINATION SOURCES • mining operations; and • fungicides. IMPACT Excessive Level • skin and eye discolouration (blue-grey). TREATMENT OPTIONS • lime softening.	No
Thallium			A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • burning of fossil fuel; and • smelting operation. HEALTH CONCERN • short-term exposure to high levels: gastrointestinal irritation and never damage; and • long-term exposure: changes in blood chemistry; damage to liver, kidney, intestinal and testicular tissues; hair loss. SOLUTIONS • retest the well water to confirm the original results; • use alternative water sources; and • use a treatment system. TREATMENT OPTIONS • activated alumina; and • ion exchange.	Yes (See note*)

			* no guideline because the general population is rarely exposed to thallium in drinking well water.	
Titanium			A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • mining operation. HEALTH CONCERN • short-term exposure to high levels: skin and eye irritation; and • long-term exposure: lung irritation (coughing). SOLUTIONS • retest the well water to confirm the original results; and • use alternative water sources. * no guideline because the general population is rarely exposed to titanium in drinking well water.	Yes (See note*)
Uranium	0.02		A rare contaminant in groundwater. PRIMARY SOURCES • a common naturally occurring and radioactive substance; and • common in the land formation: granite; and sandstone, and shale bedrocks. POTENTIAL CONTAMINATION SOURCES • mill tailings; • emission from the nuclear industry; and • combustion of fossil fuels. HEALTH CONCERN • damage to kidney. TREATMENT OPTIONS • reverse osmosis; and • distiller.	Yes (See Q&A)
Vanadium			A rare contaminant in groundwater. POTENTIAL CONTAMINATION SOURCES • industrial waste. SOLUTIONS • retest the well water to confirm the original results; and • use alternative water sources.	Yes (See note*)

			TREATMENT OPTIONS • reverse osmosis; and • distiller. * no guideline because we do not know the health effect from vanadium-contaminated drinking water.	
Zinc		≤5.0	An aesthetic objective. IMPACT > 5.0 mg/L • astringent taste; • a greasy film when boiled; and • milky appearance. TREATMENT OPTIONS • reverse osmosis; and • distiller.	No

HG means health-based guidelines listed as maximum acceptable concentrations (MAC).

AO means aesthetic objectives.

OG means operational guidance values for operational considerations.

Remarks include any health concern, meaning of the parameter, and treatment options if available
Health Concern "No" means "Not of health concern at level found in drinking water in Canada".

+ The guidelines proposed by World Health Organization.

Table D Volatile Organic Compound Testing

Chemical	HG mg/L	Source	Health Concern	Solution
Disinfection By-Products				
Trihalomethance (THMs) bromodichloromethane bromoform chloroform dibromochloromethane	0.1	• use of chlorine disinfection for well water.	• reproductive and development effects; and • potentially, increased risk of bladder cancer. * the health concerns for THMs are based on very precautionary assumptions and should not be used as a reason to stop chlorination of a well that requires disinfection because of potential microbial contamination.	• avoid drinking water from well for pregnant women; • boil water before drinking; and • use of certified water filters.
Chlorinated Solvents				
carbon tetrachloride	0.005	• industrial effluent; and • evaporates quickly from water.	• damage to liver, kidney and nervous system.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
chlorobenzene				
chloroethane				
1,2-dichlorobenzene	0.2	• industrial effluent.	• damage to liver.	• retest the well water to confirm the original results; • use alternative water

				sources; and • use of granular activated carbon plus packed tower aeration.
1,2-dichloroethane	0.005	• industrial effluent; and • evaporates quickly from water.	• damage to liver, kidney, lung and nervous system.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
1,4-dichlorobenzene	0.005	• industrial effluent.	• damage to liver.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
1,1-dichloroethylene	0.014	• industrial effluent; and • evaporates quickly from water.	• damage to liver, kidney and nervous system	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
dichloromethane	0.05	• industrial effluent; and • evaporates quickly from water.	• damage to liver.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
tetrachloroethylene	0.03	• industrial effluent.	• damage to liver and kidney.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
trichloroethylene	0.005	• industrial effluent.	• damage to liver and heart.	• retest the well water to confirm the original results;

				• use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
Fuel Components				
benzene	0.005	• gasoline underground storage tank; • industrial effluent; and • evaporates quickly from water.	• temporary nervous system disorders; • immune system depression; • anemia; and • increased risk of leukemia.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
ethylbenzene	≤0.0024[+]	• gasoline underground storage tank; • industrial effluent; and • evaporates quickly from water.	• causes odour, but not a direct threat to health.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
Toluene p-isopropyl toluene	≤0.024[+]	• gasoline underground storage tank; • industrial effluent; and • evaporates quickly from water.	• causes odour, but not a direct threat to health.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.
xylene m,p – xylene o – xylene	≤0.3[+]	• gasoline underground storage tank; • industrial effluent; and • evaporates quickly from water.	• causes odour, but not a direct threat to health.	• retest the well water to confirm the original results; • use alternative water sources; and • use of granular activated carbon plus packed tower aeration.

HG means health-based guidelines listed as maximum acceptable concentrations (MAC)
[+] *:* aesthetic objectives (AO) for toluene, ethylbenzene and the xylenes.