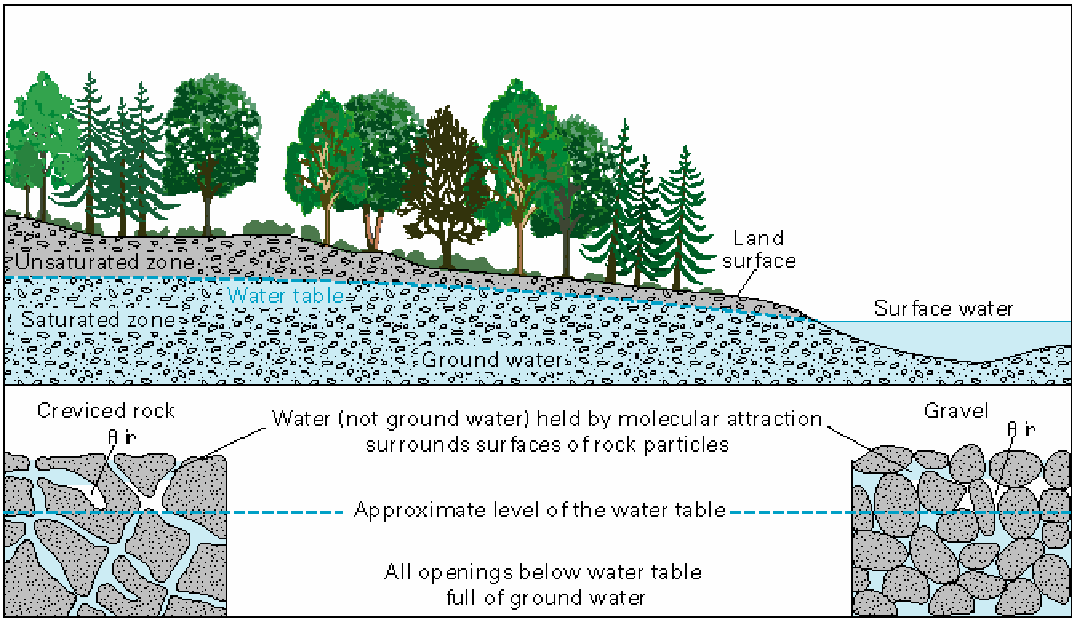
GROUNDWATER

When many people think of a water source, they think of lakes, rivers and streams; in other words, surface water. However, of all of the usable freshwater in the world, approximately 97 percent of it is groundwater. According to the United Nations, 10 million cubic kilometres of water are stored underground. The United States Geological Survey states that there is about 4.2 million cubic kilometres of water within 0.8 kilometre of the earth's surface. Environment Canada cites a study that estimates that all of the groundwater in the world would cover the surface of the earth to a depth of 120 metres, while all of the surface freshwater would only cover the earth to a depth of 0.25 metre! While groundwater estimates can vary, scientists agree that there is a lot of water under the earth's surface!

What is groundwater and where is it found?

Groundwater is water that accumulates underground. It can exist in spaces between loose particles of dirt and rock, or in cracks and crevices in rocks. Different types of rocks and dirt can contain different amounts of water. The saturation zone is the portion of the soil and rock that is saturated with water, while the unsaturated zone is the portion of the soil and rock that is not saturated. The top of the saturated zone is called the water table. The diagram below illustrates these terms.

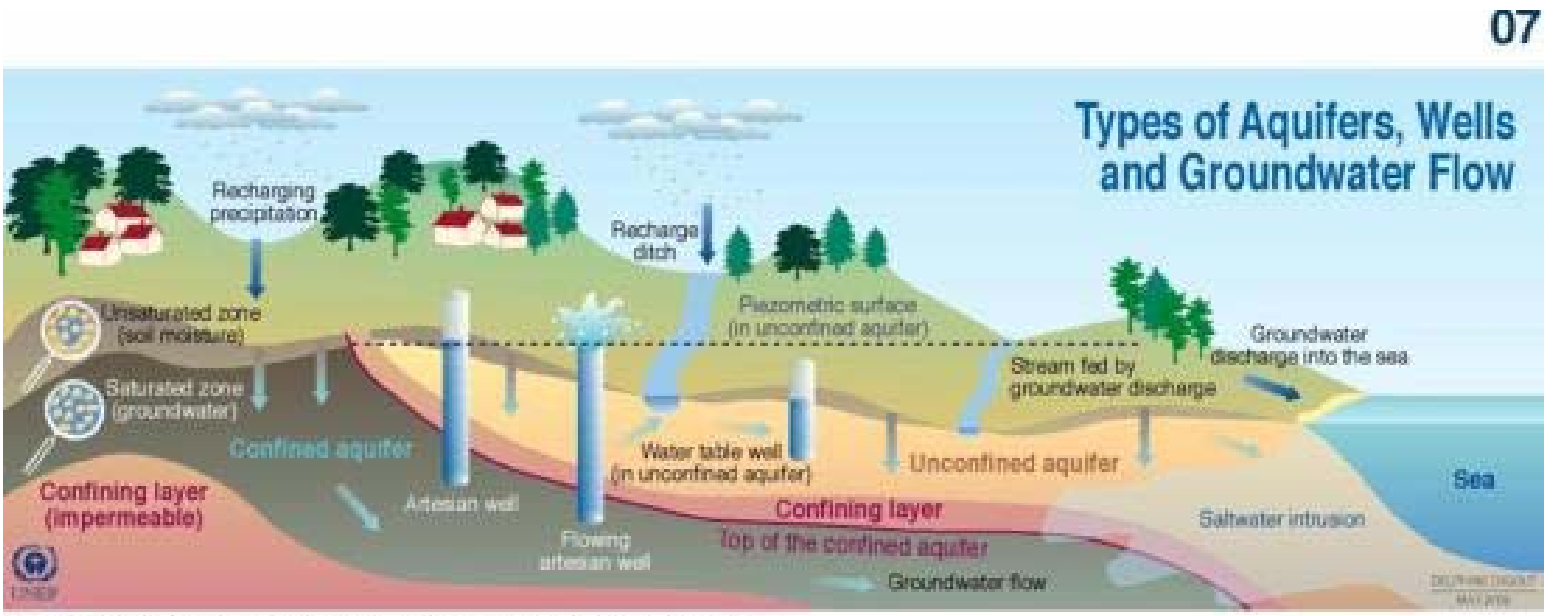


Water in the Ground;
http://capp.water.usgs.gov/GIP/gw_gip/how_occurs.html

When it rains, the water infiltrates the soil and percolates downwards until it reaches the water table. Some types of soils allow more water to infiltrate than others. Permeable surfaces, such as sand and gravel, allow up to 50 percent of precipitation to enter the soil. Rainwater can take years or even decades to reach the water table. Due to the immense volume of groundwater, once rainwater reaches the water table, it often remains there for an extremely long period of time. Some water that is currently stored in the ground may be rain that fell hundreds or thousands of years ago.

Aquifers are underground layers of permeable rock, gravel, sand or clay that water can be extracted from. From the above diagram, you can see that different types of rocks and soils can hold different amounts of water, depending on the porous areas (or spaces). When the spaces are large enough to contain usable quantities of water, it is called an aquifer. Large particles, such as coarse sand and gravel, can hold more water than fine sand and clay, because the spaces between gravel particles are larger than the spaces between fine sand particles. So, we can say that gravel has a greater porosity, or ability to hold water, than clay.

There are two types of aquifers; confined and unconfined. All aquifers sit on an impermeable layer of clay or bedrock. A confined aquifer has a layer of impermeable clay or bedrock above it, as well, and an unconfined aquifer does not. The following diagram illustrates the two types of aquifers, as well as the way in which the groundwater is connected to the surface. Artesian wells can be drilled into confined aquifers, because the great amount of pressure on the water (from the overlying ground) forces the water upwards. Unconfined aquifers can recharge nearby streams, during times of drought. Aquifers can range from a few hectares in area to thousands of square kilometres.



Source: Environment Canada, 2001 (Adapted from: http://www.ec.ca/water/index.htm).

Types of Aquifers, Wells and Groundwater Flows;
http://maps.grida.no/go/graphic/groundwater_aquifers_wells_and_circulation

Which is better: groundwater or surface water?

Generally, both groundwater and surface water can provide safe drinking water, as long as the sources are not polluted and the water is sufficiently treated. Groundwater is preferable over surface water for a number of reasons. First of all, groundwater is reliable during droughts, while surface water can be quickly depleted. Groundwater is, in general, easier and cheaper to treat than surface water, because it tends to be less polluted. Through wells, groundwater can be tapped where it is need, whereas surface waters are concentrated in lakes and streams.

For example, a large underground water source was recently found in Sudan's Darfur region. The ancient lake is 30,750 square kilometres, which is the same size as Lake Erie, and will be able to provide much needed freshwater resources to people in the country. The conflict between Arab nomads and African farmers has, since 2003, caused more than 200,000 deaths and forced two million people to flee their homes. The conflict began when drought and desertification forced the Arab nomads to move to South Darfur, where the African farmers were.

As the war began over competition for resources, there is speculation that the discovery of the water source will assist in ending the ongoing conflict. For more information, you can read the BBC news article, "Water find 'may end Darfur war.'" For more information about how the situation in Darfur, as well as many other countries, violates the human right to water, see the Human Rights fact sheet.

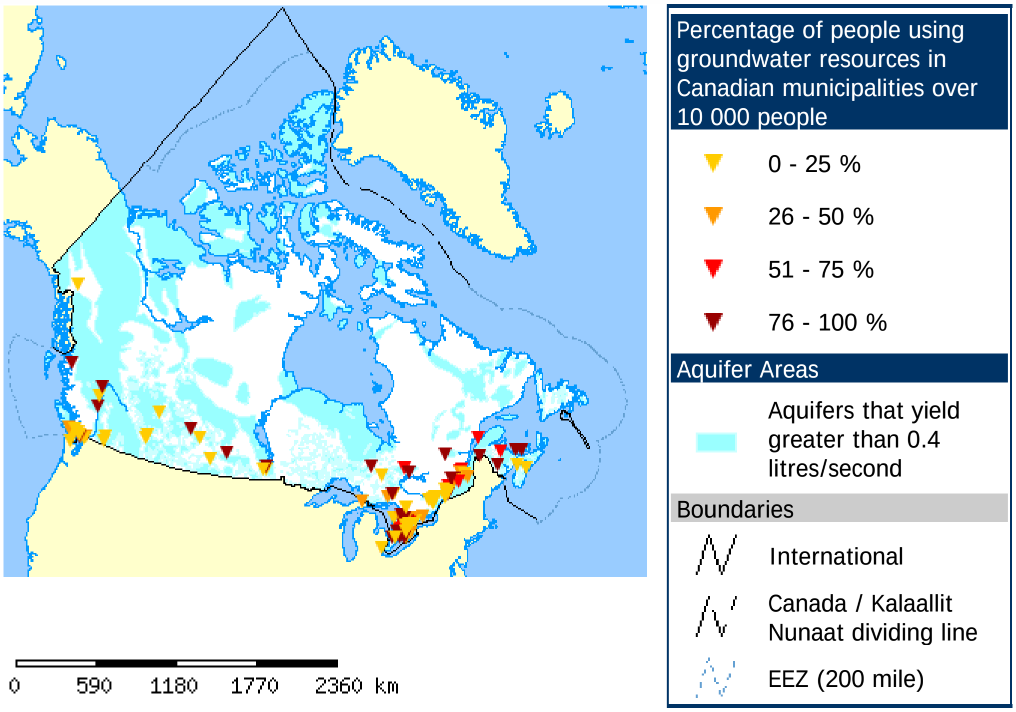
Groundwater has several other purposes, besides providing drinking water. Geothermal energy uses groundwater to produce energy-efficient heating and cooling systems. A swimming pool and recreational facility in Moose Jaw, Saskatchewan, a health centre complex in Sussex, New Brunswick, and Carleton University in Ottawa, Ontario are examples of large facilities that are using groundwater to heat and cool buildings.

However, there are a few concerns about groundwater. As population and pollution increases, there becomes more pressure on groundwater. While groundwater sources are more plentiful than surface water sources, aquifers take longer to recharge because of the length of time that it takes for rainwater to reach the aquifer. For this reason, aquifers can run dry. Surface water can also be depleted, but when groundwater sources are depleted, the overlying ground can compact and subside, causing damage to buildings on the surface. As well, when the groundwater level decreases in coastal regions and on small islands, saline water can enter the water supply.

But Canada must have more surface water than groundwater, right? How much do we rely on groundwater?

Canada has a lot of surface water, but even more groundwater. Approximately eight million Canadians rely on groundwater, two-thirds of whom are people in rural areas. Groundwater in Canada is also used for agricultural (including irrigation and livestock watering) and industrial operations. Half of the United States population relies on groundwater sources to provide drinking water.

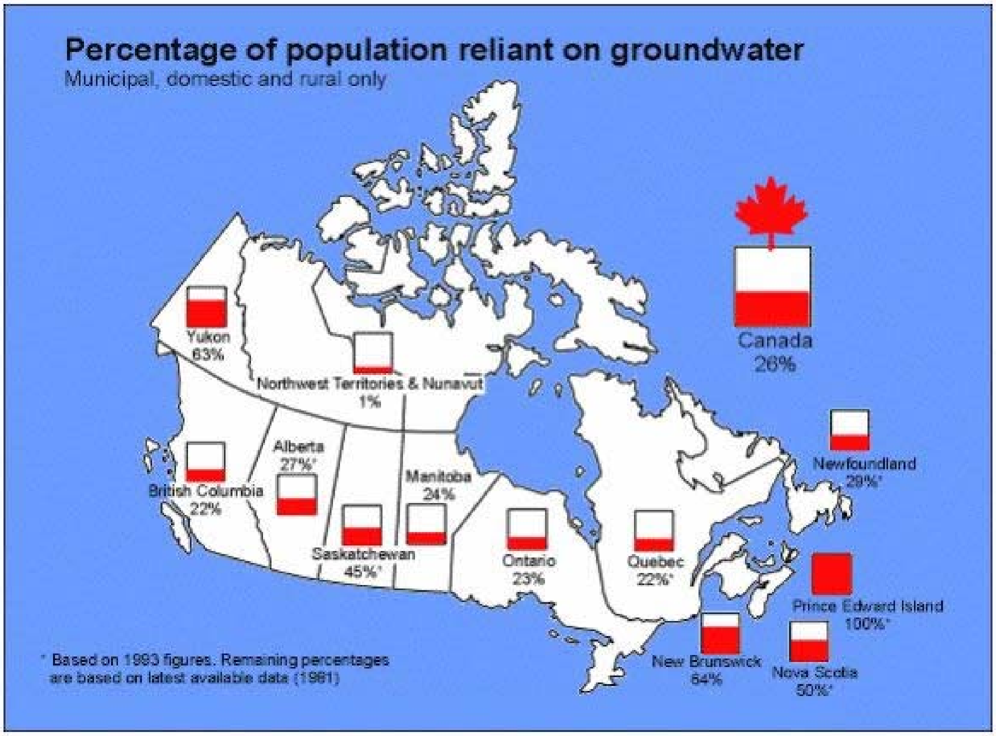
The map below shows the distribution of aquifers across Canada. There are several large aquifers and many more small ones. While, individually, small aquifers may not seem significant, they total a very large and important source of water.



Location of Aquifers in Canada and Proportions of People Relying on Groundwater;
http://atlas.nrcan.gc.ca/site/english/maps/freshwater/distribution/groundwater

The Canadian Shield regions do not have as many aquifers, because the rocks that make up the Canadian Shield do not store water well. In Prince Edward Island, New Brunswick, Ontario and the Yukon, groundwater is predominantly used for municipal purposes; in fact, 100 percent of Prince Edward Island's water and 60 percent of New Brunswick's water is extracted from groundwater sources. Alberta, Saskatchewan and Manitoba use groundwater mainly for livestock watering. British Columbia, Quebec and the Northwest Territories use groundwater mainly for industrial purposes, and Newfoundland and Nova Scotia use groundwater to provide drinking water for people living in rural areas.

The map to the right shows the proportion of the population in each province and territory that is reliant on groundwater for domestic use. While only 26 percent of the Canadian population relies on groundwater, more than half of the population in the Yukon, New Brunswick, Nova Scotia and Prince Edward Island use groundwater for domestic purposes. Nearly half of Saskatchewan residents are also reliant upon groundwater.



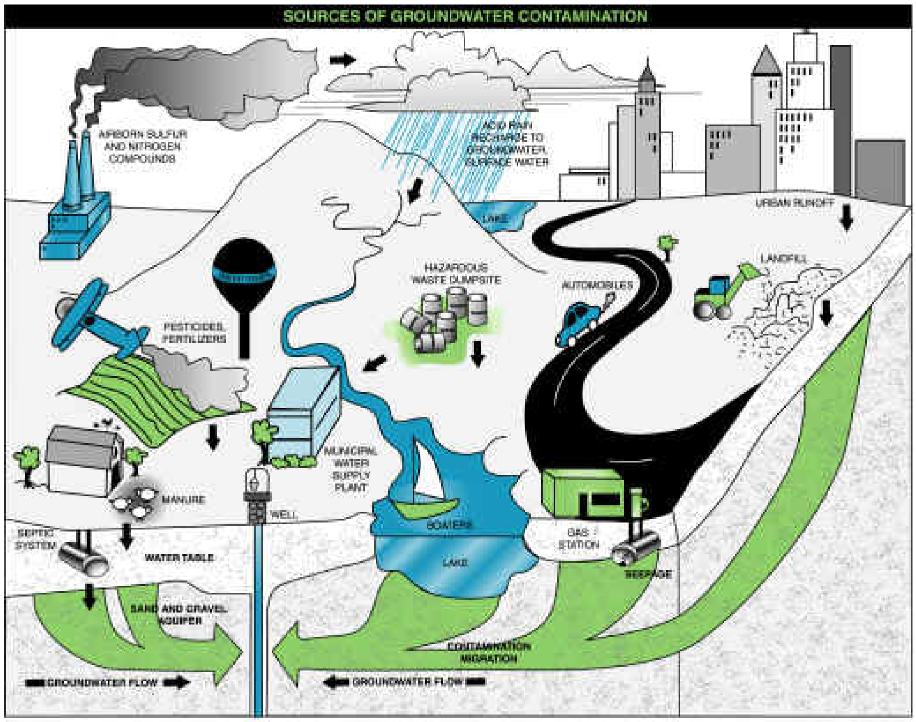
Percentage of People Reliant on Groundwater;
http://atlas.nrcan.gc.ca/site/english/maps/freshwater/distribution/groundwater/1

Can groundwater become contaminated?

Groundwater can become contaminated, by many of the same pollutants that contaminate surface water. For more information about water contamination, including the sources of pollution, see the fact sheet about Water Pollution. Pollution of groundwater occurs when contaminants are discharged to, deposited on, or leached from the land surface above the groundwater.

Even if there are no industrial and domestic pollution sources in the area, it is important to realize that the water may not be free from contaminants, and should be tested before human consumption. Arsenic, for example, is found in high concentrations in different parts of the country, and other contaminants, such as dissolved organic material, iron, manganese, ammonium and high salt levels are prominent in groundwater sources, especially on the Canadian prairies.

Pollution can come from two types of sources; point and non-point. Point sources are identifiable and localized sources of pollution. Point sources that can contaminate groundwater include landfills, buried gasoline or oil storage tanks, septic systems, industrial sources and accidental spills. Non-point sources tend to be in the form of pesticides and nutrients that enter the soil as a result of intense agricultural operations or the widespread use of road salts and chemicals. The diagram below illustrates some of the many ways in which groundwater can become contaminated.



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Sources of Pollution;
http://www.groundwater.org/gi/sourcesofgwcontam.html

Landfills can contaminate groundwater when harmful chemicals leach downwards. Landfills should have protective bottom layers to prevent leaching, but there are some landfills that do not have this protective layer, or it is old and cracked, and this allows chemicals to leak through.

In the United States, there is estimated to be more than ten million buried storage tanks, holding fluids such as gasoline, oil and chemicals. In the 1950s and 1960s, there were a large number of underground steel storage tanks that were installed in Canada. Without adequate protection, up to half of steel tanks will corrode and develop cracks by the time they are 15 years old.

Improperly designed, located, or constructed septic systems can allow harmful bacteria, viruses and chemicals to enter water sources. For more information about septic systems, see the Wastewater Treatment fact sheet. In the United States, there are more than 20,000 known abandoned and uncontrolled hazardous waste sites. Hazardous waste can contaminate water with chemicals that many cities and municipalities do not regularly test water for. Accidental spills can also contaminate groundwater supplies. A group of chemicals called dense non-aqueous phase liquids (DNAPLs) are used in dry-cleaning, wood preservation, asphalt operations and vehicle production and repair, and can also be released in accidents. DNAPL spills are more difficult to clean up than oil spills, because DNAPLs are heavier than water and quickly sink to the bottom. Other than in large cities, water is not tested for DNAPLs.

But I thought that soil can remove pollutants from the water before it reaches the aquifer?

In many cases, the soil can remove bacteria, viruses and chemicals from water that percolates downward. After all, that is one way in which nature cleans water. But not all soils remove contaminants as effectively as others, and domestic and industrial waste can also exceed the soil's ability to remove chemicals and contaminants. Some soils allow water to quickly percolate down to the aquifer. This generally means that less of the contaminants will be removed. As well, when the pollutants originate from an underground source, such as a storage tank or septic system, they may be very close to the groundwater and the soil does not have enough time to remove all harmful substances. The quality of the groundwater depends on the temperature, the pressure (which depends on how deep the groundwater is), the type of rock and soil and the residence time of the water.

Groundwater moves very slowly, generally between a few millimetres and a few metres each day. This means that contamination tends to be concentrated and localized, close to the pollution source. However, contamination can spread within the aquifer, or to nearby lakes and streams. Often, groundwater pollution is not noticed until the water is already contaminated and an expensive remediation process is required. It is extremely expensive and difficult to reverse groundwater contamination, and it may take decades before the water is usable again. In Ville Mercier, Quebec, disposal of industrial wastes into the lagoons of an old gravel pit occurred over many years. This eventually rendered the groundwater unusable, and water had to be pumped from ten kilometres away to supply thousands of people with water. For information about cleaning up after pollution has contaminated water sources, including groundwater, see the fact sheet about Cleaning Up After Pollution.

For more information about aquifers, including how they can become contaminated, see the "What is an aquifer anyway?" lesson plan in the Operation Water Flow program.

The Safe Drinking Water Foundation has educational programs that can supplement the information found in this fact sheet. Operation Water Drop looks at the chemical contaminants that are found in water; it is designed for a science class. Operation Water Flow looks at how water is used, where it comes from and how much it costs; it has lessons that are designed for Social Studies, Math, Biology, Chemistry and Science classes. Operation Water Spirit presents a First Nations perspective of water and the surrounding issues; it is designed for Native Studies or Social Studies classes. Operation Water Health looks at common health issues surrounding drinking water in Canada and around the world and is designed for a Health, Science and Social Studies collaboration. Operation Water Pollution focuses on how water pollution occurs and how it is cleaned up and has been designed for a Science and Social Studies collaboration. To access more information on these and other educational activities, as well as additional fact sheets, visit the Safe Drinking Water Foundation website at www.safewater.org.

Resources:

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