Groundwater Contamination

In this Section:

How we Contaminate Groundwater

Any addition of undesirable substances to groundwater caused by human activities is considered to be **contamination**. It has often been assumed that contaminants left on or under the ground will stay there. This has been shown to be wishful thinking. Groundwater often spreads the effects of dumps and spills far beyond the site of the original contamination. Groundwater contamination is extremely difficult, and sometimes impossible, to clean up.

Groundwater contaminants come from two categories of sources: point sources and distributed, or non-point sources. Landfills, leaking gasoline storage tanks, leaking septic tanks, and

accidental spills are examples of point sources. Infiltration from farm land treated with pesticides and fertilizers is an example of a non-point source.

Among the more significant point sources are municipal landfills and industrial waste disposal sites. When either of these occur in or near sand and gravel aquifers, the potential for widespread contamination is the greatest.

Other point sources are individually less significant, but they occur in large numbers all across the country. Some of these dangerous and widespread sources of contamination are septic tanks, leaks and spills of petroleum products and of dense industrial organic liquids.

Septic systems are designed so that some of the sewage is degraded in the tank and some is degraded and absorbed by the surrounding sand and subsoil. Contaminants that may enter groundwater from septic systems include bacteria, viruses, detergents, and household cleaners. These can create serious contamination problems. Despite the fact that septic tanks and cesspools are known sources of contaminants, they are poorly monitored and very little studied.

Contamination can render groundwater unsuitable for use. Although the overall extent of the problem across Canada is unknown, many individual cases of contamination have been investigated such as Ville Mercier in Quebec; the highway de-icing salt problem in Nova Scotia; industrial effluents in Elmira, Ontario; various pesticides in the Prairie provinces; industrial contamination in Vancouver, British Columbia; and so on. In many cases, contamination is recognized only after groundwater users have been exposed to potential health risks. The cost of cleaning up contaminated water supplies is usually extremely high.

Contamination problems are increasing in Canada primarily because of the large and growing number of toxic compounds used in industry and agriculture. In rural Canada, scientists suspect that many household wells are contaminated by substances from such common sources as septic systems, underground tanks, used motor oil, road salt, fertilizer, pesticides, and livestock wastes. Scientists also predict that in the next few decades more contaminated aquifers will be discovered, new contaminants will be identified, and more contaminated groundwater will be discharged into wetlands, streams and lakes.

Once an aquifer is contaminated, it may be unusable for decades. The residence time, as noted earlier, can be anywhere from two weeks or 10 000 years.

Furthermore, the effects of groundwater contamination do not end with the loss of well-water supplies. Several studies have documented the migration of contaminants from disposal or spill sites to nearby lakes and rivers as this groundwater passes through the hydrologic cycle, but the processes are not as yet well understood. In Canada, pollution of surface water by groundwater is probably at least as serious as the contamination of groundwater supplies. Preventing contamination in the first place is by far the most practical solution to the problem. This can be accomplished by the adoption of effective groundwater management practices by governments, industries and all Canadians. Although progress is being made in this direction, efforts are hampered by a serious shortage of groundwater experts and a general lack of knowledge about how groundwater behaves.

Sources of groundwater contamination

There are many different sources of groundwater contamination. Groundwater becomes contaminated when anthropogenic, or people-created, substances are dissolved or mixed in waters recharging the aquifer. Examples of this are road salt, petroleum products leaking from underground storage tanks, nitrates from the overuse of chemical fertilizers or manure on farmland, excessive applications of chemical pesticides, leaching of fluids from landfills and dumpsites, and accidental spills.

Contamination also results from an overabundance of naturally occurring iron, sulphides, manganese, and substances such as arsenic. Excess iron and manganese are the most common natural contaminants. Another form of contamination results from the radioactive decay of uranium in bedrock, which creates the radioactive gas radon. Methane and other gases sometimes cause problems. Seawater can also seep into groundwater and is a common problem in coastal areas. It is referred to as "saltwater intrusion".

These contaminants can originate from a “point source” or “non-point source” – meaning they can come from a single source (or point) or, that they don’t have one specific source and come instead from the cumulative effect of any number of factors or activities.

Below are some of the many point- and non-point sources of groundwater pollution, as well as more detailed explanations of four of these contaminants: septic disposal systems, saltwater intrusion, leaking underground storage tanks and DNAPLs.

Point sources

- On-site septic systems
- Leaky tanks or pipelines containing petroleum products
- Leaks or spills of industrial chemicals at manufacturing facilities
- Underground injection wells (industrial waste)
- Municipal landfills
- Livestock wastes
- Leaky sewer lines
- Chemicals used at wood preservation facilities
- Mill tailings in mining areas
- Fly ash from coal-fired power plants
- Sludge disposal areas at petroleum refineries
- Land spreading of sewage or sewage sludge
- Graveyards
- Road salt storage areas
- Wells for disposal of liquid wastes
- Runoff of salt and other chemicals from roads and highways
- Spills related to highway or railway accidents
- Coal tar at old coal gasification sites
- Asphalt production and equipment cleaning sites

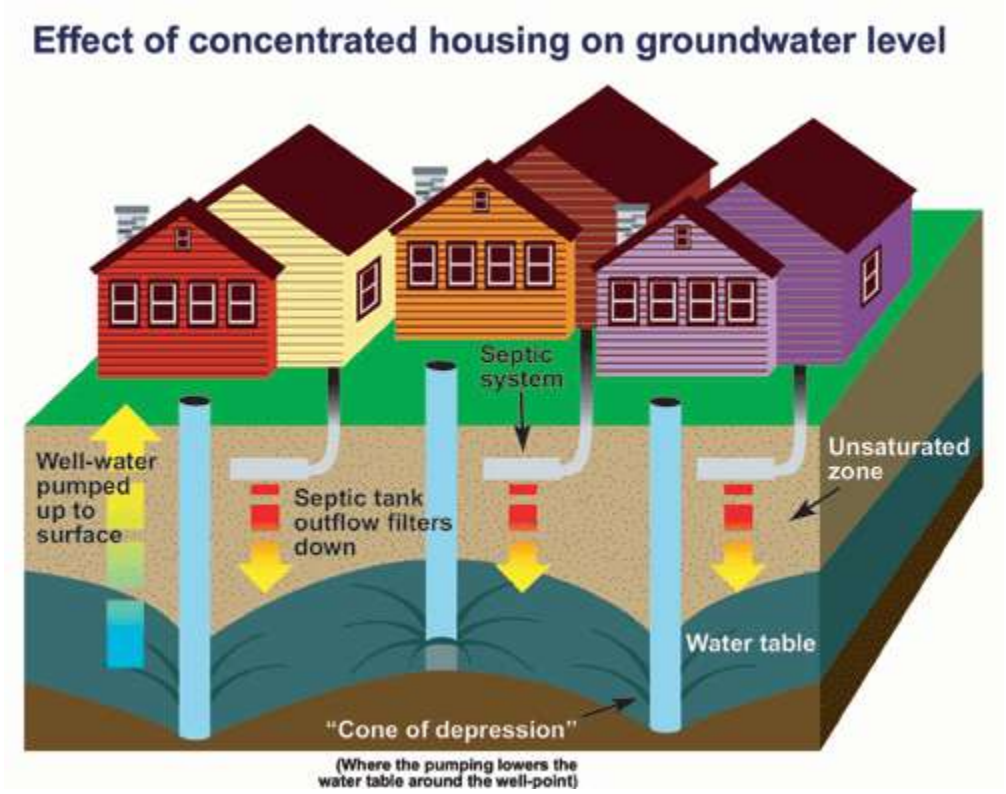
Non-point (distributed) sources

- Fertilizers on agricultural land
- Pesticides on agricultural land and forests
- Contaminants in rain, snow, and dry atmospheric fallout

Source: Adapted from: Cherry, John A. "Groundwater Occurrence and Contamination in Canada." In M.C. Healey and R.R. Wallace, *Canadian Aquatic Resources*, eds., Canadian Bulletin of Fisheries and Aquatic Sciences 215: 395. Department of Fisheries and Oceans: Ottawa, 1987.

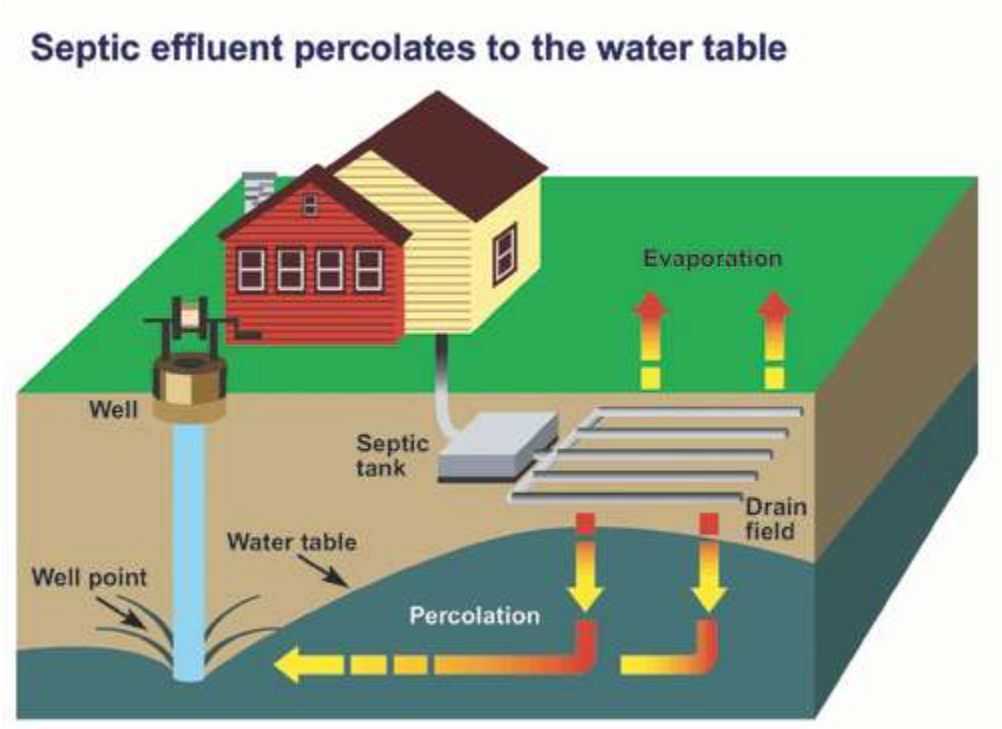
Septic disposal systems

Roughly 10 percent of the Canadian population is served by private wells and septic disposal systems. These systems were originally designed for houses that were widely separated from their nearest neighbour, such as farmhouses and the occasional rural residence. Yet, today, in many parts of the country, individual private wells are being installed in subdivisions at suburban densities. The primary danger here is that too many wells may pump too much water for the aquifer to sustain itself.



Septic treatment systems associated with these developments can stress the environment in a number of other ways. They are often allowed in less than satisfactory soil conditions and are seldom maintained properly. They are also unable to treat many household cleaners and chemicals which, when flushed down the drain or toilet, often impair or kill the bacterium needed to make the system work (The same applies in urban systems). The end results are

improper treatment of wastewater -- if not outright failure of the system -- and the contamination of adjacent wells with septic effluent containing bacterium, nitrates and other pollutants.



See also **Wastewater** section

Saltwater intrusion

Saltwater intrusion can be a problem in coastal areas where rates of groundwater pumping are high enough to cause sea water to invade freshwater aquifers. The problem can be avoided by appropriate well field design and by drilling relief wells to keep the salt water away from the fresh groundwater source. Some wells pumping saltwater in Prince Edward Island, are used as convenient water supplies for shellfish farms.

Leaking underground storage tanks and piping

Leaks of petroleum products have been increasing over the last two decades because underground steel tanks installed in large numbers in the 1950s and 1960s have become corroded. Before 1980, most underground tanks were made of steel. Without adequate corrosion protection, up to half of them leak by the time they are 15 years old.

Groundwater dissolves many different compounds, and most of these substances have the potential to contaminate large quantities of water. For example, one litre of gasoline can contaminate 1 000 000 litres of groundwater. This problem is particularly severe in the Atlantic provinces where there is a high usage of groundwater. In many cases, the problem is noticed long after the aquifer is contaminated, for example, when consumers start tasting or smelling gasoline.

Dense non-aqueous phase liquids (DNAPLs)

A type of contaminant that is especially troublesome is the group of chemicals known as **dense non-aqueous phase liquids**, or **DNAPLs**. These include chemicals used in dry cleaning, wood preservation, asphalt operations, machining, and in the production and repair of automobiles, aviation equipment, munitions, and electrical equipment. They can also be generated and released in accidents, e.g., the Hagersville, Ontario "tire fire." These substances are heavier than water and they sink quickly into the ground. This makes spills of DNAPLs more difficult to handle than spills of petroleum products. As with petroleum products, the problems are caused by groundwater dissolving some of the compounds in these volatile substances. These compounds can then move with the groundwater flow. Except in large cities, drinking water is rarely tested for these contaminants.

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Safeguarding our Groundwater Supply

Groundwater is an essential resource. It exists everywhere under the Canadian landscape and is vitally connected to our rich surface water resources. Contamination of groundwater is a serious problem in Canada. Industrial and agricultural activities are major sources of contaminants, but Canadian households are equally important sources.

Groundwater moves so slowly that problems take a long time to appear. Because of this, and because it is so expensive to clean up a contaminated aquifer (if it can be done at all), it is preferable by far to prevent contamination from happening in the first place. For example, leaking underground storage tanks can be replaced by tanks that will not corrode; landfills can be sited in locations where leachates will not contaminate underlying groundwater; and the impacts of spills of hazardous materials reduced by restricting access to recharge areas.

Once these contaminants are in the groundwater, they eventually reach rivers and lakes. In other words, once we have a **pollution** problem, we may be only a step away from a **water supply** problem.

All levels of government in Canada are starting to take some of the actions necessary to protect our groundwater supplies, but there is a long way to go before these measures are fully effective. At the same time, universities and government research institutes are investigating what happens to water underground and what can be done to preserve it and even improve its availability to us. Both as a society and as individuals, we must keep in mind groundwater's susceptibility to contamination.