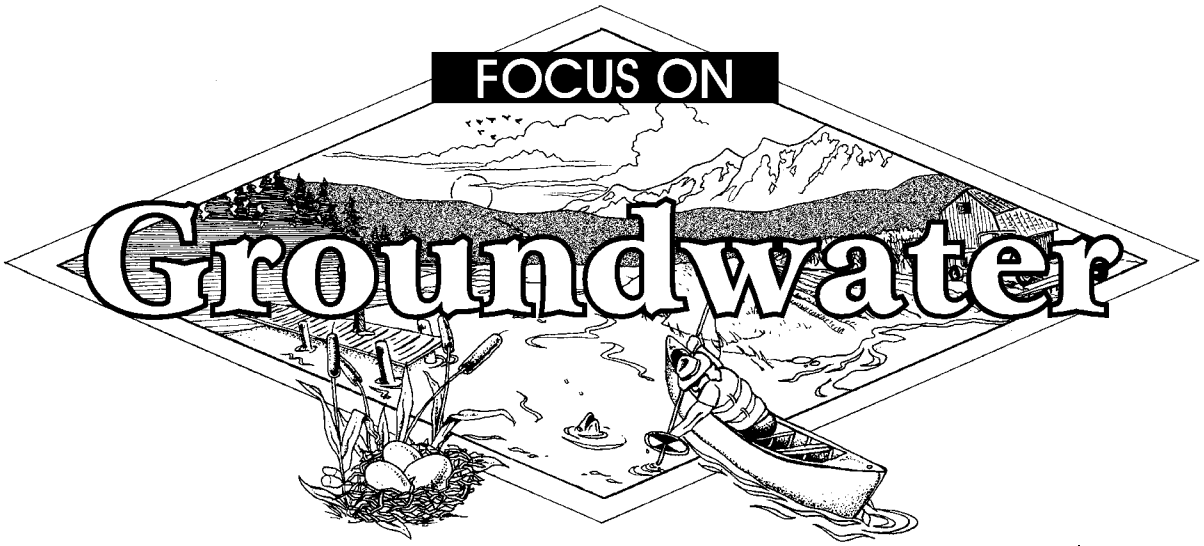
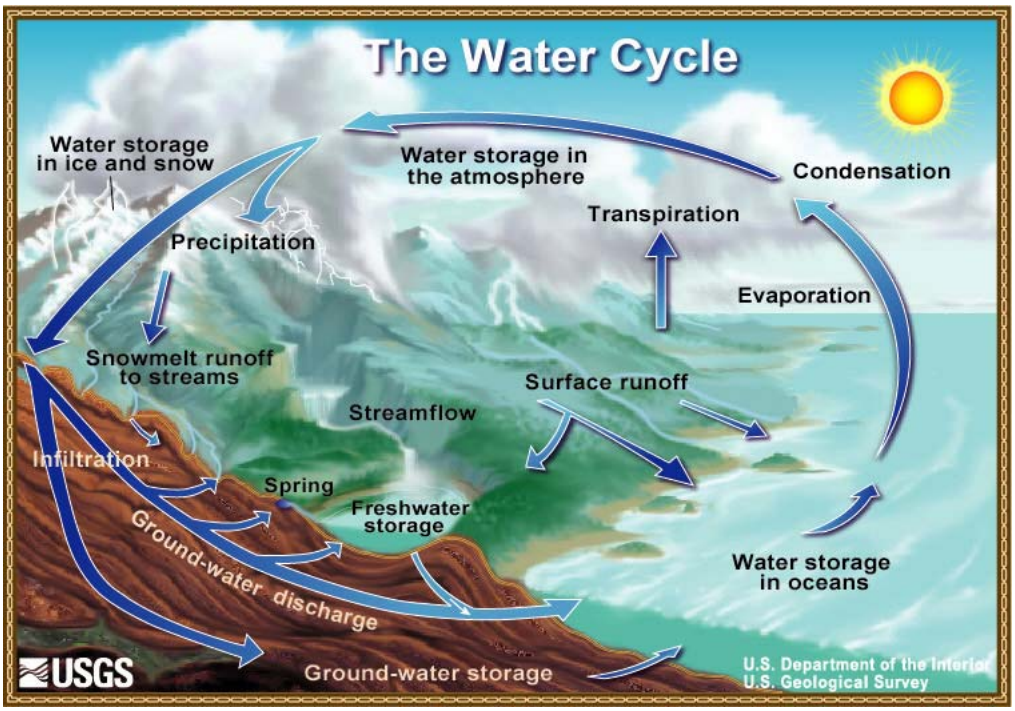


Introduction

The expression “out of sight - out of mind” is often accurate when considering Alberta’s ***groundwater***. Even though groundwater is an important part of our freshwater system, we rarely think about it. Hidden beneath the earth's surface, water moves slowly between rocks and grains of sand.

Groundwater
All water under the surface of the ground whether in liquid or solid state.

The underground movement of water is part of a larger cycle - the hydrologic cycle, commonly called the water cycle. Water falls to the earth as rain or snow. It flows into lakes and rivers, and seeps down into the soil becoming groundwater. When we use water, we borrow it from the water cycle. Eventually, water evaporates and returns to the earth as precipitation to continue the endless cycle.



http://ga.water.usgs.gov/edu/watercyclehi.html

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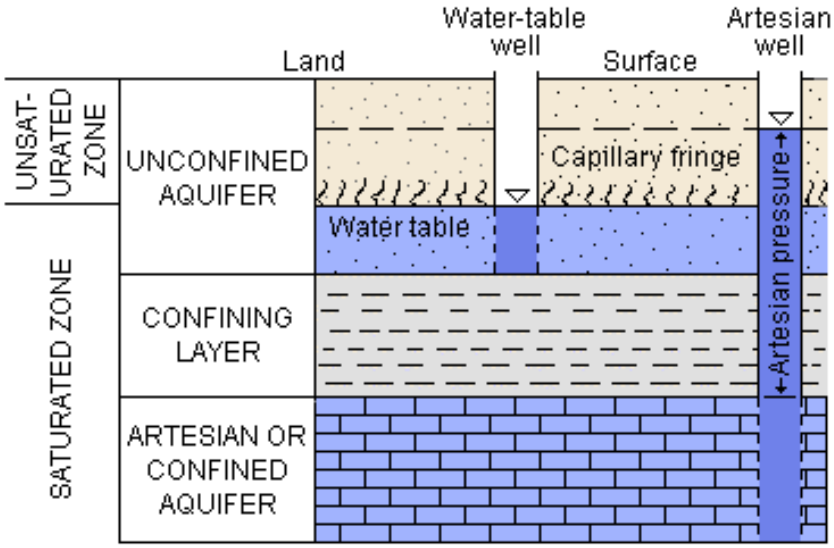
Aquifers

Groundwater begins as precipitation - rainfall or snowmelt. Precipitation soaks into the layers of soil just below the surface. In this unsaturated zone, water and air share the spaces between grains of soil. This creates moist soil conditions for plants.

Some water continues to filter downward to a depth where all the spaces in the soil and rock are filled with water. This is the saturation zone. The upper surface of this zone is called the water table.



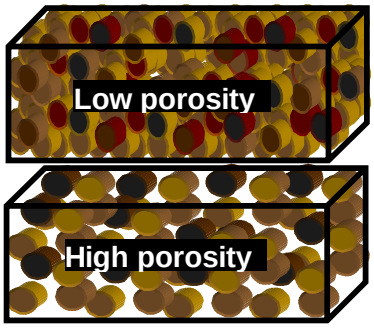
For groundwater to be a recoverable resource, it must exist in an ***aquifer***. An aquifer is a geological formation that can provide sufficient water to support a specific use such as a household well. Some aquifers can supply enough water to meet the needs of a single household, others can meet the needs of a city.

Aquifer
An underground water-bearing formation that is capable of yielding water.

Aquifers can be unconfined or confined. Imagine a sandy beach. Water is not visible on the surface; however, once you dig a hole water seeps in and eventually fills the hole. This is an unconfined aquifer. The top of an unconfined aquifer is referred to as the water table. The depth of the water table changes as the water level rises or falls. Aquifers are recharged with water from surface precipitation and infiltration. They discharge water into water bodies such as lakes, rivers, wetlands and springs. If a well is drilled into an unconfined aquifer, a pump is needed to push water to the surface.

To reach a confined aquifer, you usually need to drill a well since the water is trapped beneath materials like clay or shale. These materials do not transmit water rapidly. Since the water is contained, it may be pressurized. When a well is drilled, the natural pressure can push the water level above the top of the aquifer resulting in an artesian well. If the water level rises above the ground surface, it called a flowing artesian well.

The ability of an aquifer to store and transmit water is determined by its ***porosity*** and ***permeability***. Usually, the more porous a material, the more water it can hold. The more permeable an aquifer, the easier it is for water to move through the material because the areas where water collects are connected. For example, sand and gravel are very porous and permeable so they make excellent aquifers. Fine clay is porous and can store groundwater, but it is not permeable. Therefore, the free movement of water through clay is more difficult.



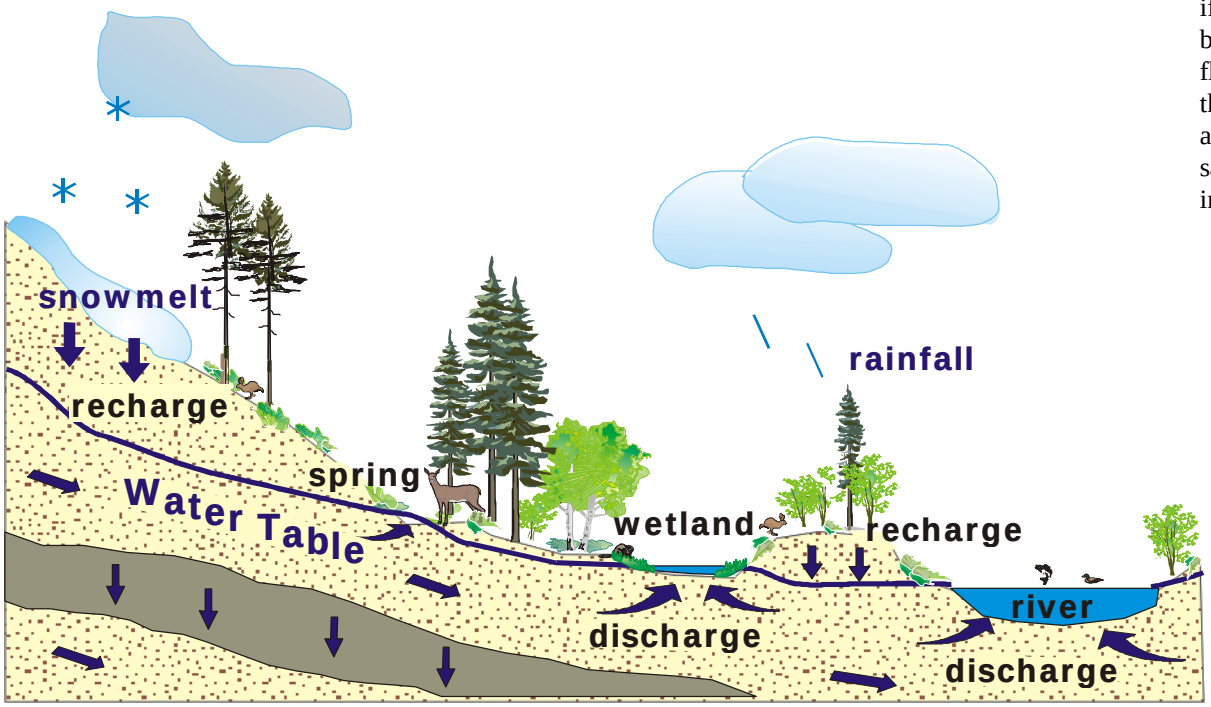
Groundwater Recharge & Discharge

Groundwater flows through an aquifer from an area of recharge to an area of discharge. In a recharge area, precipitation or runoff infiltrates the soil to the saturation zone or aquifer. Only a small percentage of rainfall and snowmelt reaches the water table. Most precipitation evaporates from the soil surface, transpires to the atmosphere from plants, or flows over the surface as runoff. On average, about six percent of annual precipitation becomes groundwater. Areas with coarse, gravely soils and shallow fractured bedrock collect the greatest amounts of rainfall becoming groundwater.

Discharge areas are located where the water table intersects the land surface. Groundwater becomes surface water when it discharges into springs, streams, lakes or wetlands. Often groundwater feeds directly into streams below the waterline and goes unnoticed. The length of time it takes groundwater to naturally reach the surface varies. Water may spend days or weeks underground; sometimes 10,000 years or more.

Porosity
Open spaces within a rock that contain fluids such as water, oil or natural gas.

Permeability
The measure of how easily a fluid can pass through soil or a section of rock. If fluid can pass relatively easily through a given layer, then the permeability is said to be high. However, if a layer effectively blocks fluids, or no fluids can flow through the layer at all, then the layer is said to be impermeable.

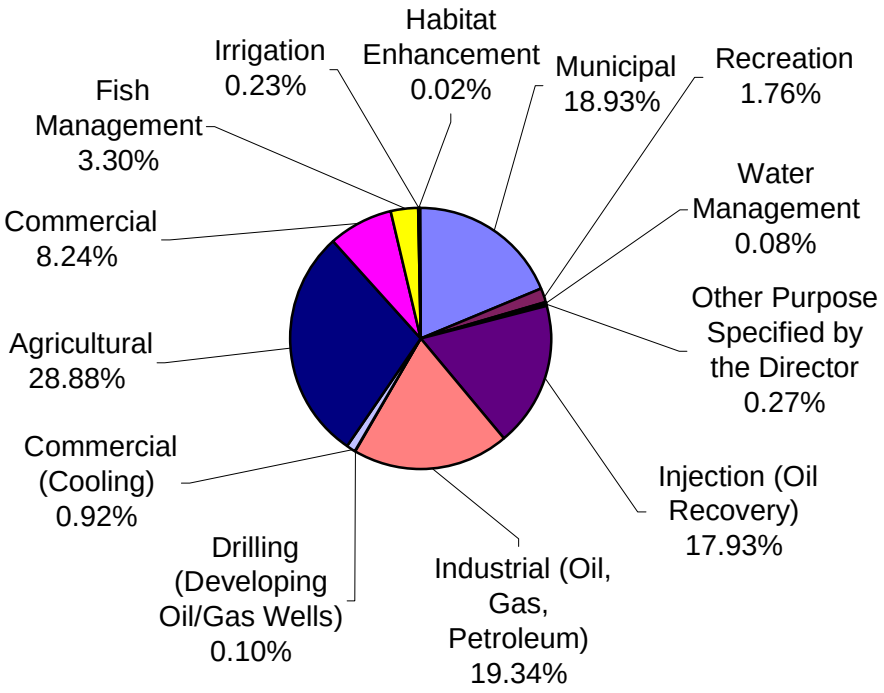


Groundwater Uses

There is approximately 40,000 km³ of groundwater in Alberta. This amount of water would cover the province to a depth of about 60 meters. Only a tiny fraction of this water is recoverable by conventional means – such as pumping through wells. If spread over the province, the "usable" portion of groundwater, would only be about six millimeters thick. Fortunately, groundwater resources can be replenished over time as rainfall and snowmelt soak into the ground.

In Alberta, users of large amounts of surface and groundwater must obtain a license from Alberta Environment. The license states the amount of water they can use each year. As of 2004, the total amount of surface and ground water licensed for use in Alberta was 9,725,841,409 m^3. Of this total amount, 283,134,064 m^3 or about 3 per cent was groundwater. The users of this groundwater are outlined below.

2004 Groundwater Allocations in Alberta by Specified Purpose (Representing 3% of Overall Water Allocations in Alberta)



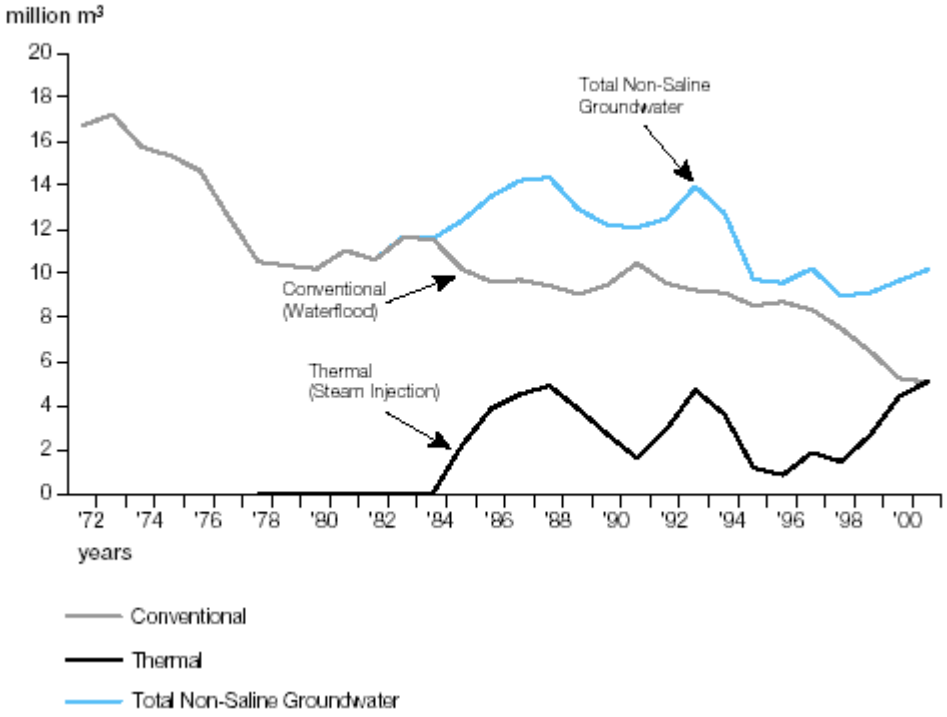
Groundwater Allocations
The diagram to the left presents how water is allocated for specified uses. The allocations **do not** represent the actual usage as the majority of users do not use all of the water they are licensed to use.

In addition to the above users, many Albertans depend on groundwater from domestic water wells. These wells do not require a license. There are approximately 500,000 domestic wells in the province and about 7,000 are added each year.

Companies that inject water into the ground for oil recovery are one of the largest groundwater users. Water is used for oil field injection to increase the amount of oil produced from an oil well. In most cases, water is injected into a well to increase pressure and force out some of the remaining oil (conventional oil recovery). Water is also used to recover oil from oilsands through the injection of steam to liquefy the crude bitumen (thermal oil recovery). While most of the water used for this purpose is recycled water (water recovered with oil that was previously extracted from oil reservoirs) some water is diverted from surface and groundwater sources. Groundwater sources can be ***saline*** or non-saline**.**
In 2001, water for oilfield injection accounted for 26.4 per cent of the groundwater allocation. The actual use of non-saline groundwater for oilfield injection in 2001 was 5.5 per cent (10,157,000 m^3 of the allocated total volume of groundwater).

Since the mid 1970's, the overall use of non-saline groundwater and surface water for conventional oilfield injection has declined in Alberta. The use of water for thermal oil recovery may increase due to the rapid expansion of the oil sands and heavy oil sectors.

Enhanced Oil Recovery – Non-Saline Groundwater Use 1972-2001



While the amount of water used for oil recovery is a small portion of the available and allocated provincial water supply, Albertans are concerned that enhanced oil recovery and injection removes water from the active water cycle.

Saline Groundwater
Groundwater that has more than 4,000 mg/L of total dissolved solids (TDS). Without treatment this water is not suitable for human use, but may have industrial uses. Industry does not need to obtain a water license to use saline groundwater.

For this reason, site-specific water use licenses are only issued by Alberta Environment after a complete review of the potential local impacts of a proposed water diversion. Licence conditions also protect existing users.

Although groundwater is a valuable resource, it is not always the most desirable source of water. If an aquifer is very deep, it may be too costly to recover the water. Without treatment, some water is not fit for human consumption. Typically, when concentration of ***total dissolved solids*** (TDS) exceeds 4,000 mg/L, the water is considered to be saline (or brackish) and not suitable for irrigation, livestock watering, or household use. This water may still have industrial applications.

Total Dissolved Solids
A measure in parts per million of the amount of dissolved inorganic chemicals in water. Common examples of dissolved solids include calcium, sodium and magnesium.

To date, Albertans have not drawn heavily on groundwater because surface water has been readily available. As the demand for water increases, the demand for groundwater will also increase. If managed and pumped at sustainable rates, groundwater can be an important and reliable renewable resource.

Groundwater Quality

Natural Qualities

The quality of groundwater depends on the concentration of ions present. Ions are electrically charged particles. Atoms or molecules, especially salts and acids, become ions in water. As water moves down through the soil, it dissolves various minerals. These minerals increase the water's ion concentration.

Variations in ion concentration determine water quality. Water containing iron may stain plumbing fixtures and laundry. People often compare the taste of water to iron and the smell of water to rotten eggs. These characteristics are determined by the amount of iron and sulfur ions. Water can also be described as "hard" or soft". Hard water has high concentrations of calcium and magnesium ions. Excessive hardness will leave solid deposits in water pipes and prevent soap from lathering. Soft water usually has high concentrations of sodium ions and allows soap to lather easily.

The concentration of ions can also be affected by ***cation*** exchange. This process naturally softens water by exchanging calcium and magnesium ions in the water for sodium ions often found on clay materials.

Cation
A positively charged ion.

In Alberta, groundwater quality can be linked to the type of aquifer that water originates in. Unconfined aquifers are primarily composed of sand and /or gravel, creating hard water with higher iron concentrations. Confined aquifers are often found in bedrock material such as sandstones, shales, and coalbeds, creating softer water with limited iron concentrations and higher levels of total dissolved solids.

Human Influences

As water use and human impacts from urban and rural development increase, there is an increase in the potential for groundwater contamination. Fortunately, the contamination of groundwater in Alberta is isolated because groundwater is often protected by the geological structure of our province. Most of Alberta is covered with a layer of clay deposits. Clay does not allow for rapid movement of water into aquifers. As water moves through this material, many contaminants are removed. As well, aquifers in Alberta tend to be smaller in size, which isolates contamination within an affected aquifer. If aquifers were very large, contamination in one area could spread to the entire aquifer, affecting a larger quantity of water.

When contamination does occur, it is described as point source or non-point source. Contamination that arises from a single, defined location or facility is referred to as point-source. Examples include leaking gasoline storage tanks, contamination from septic tanks or feedlots, accidental spills, and leakage from landfills. Contamination that arises from small amounts of particles collected over a large land area by run-off is referred to as non-point source. As rainwater, snowmelt, and irrigation water wash over plowed fields, city streets, or suburban yards, soil particles and pollutants, such as fertilizers, pesticides and oil are picked up and carried into lakes, rivers, or groundwater supplies as the contaminated water soaks into the ground.

Groundwater Quality Concerns

For Albertans who depend on groundwater supplies, the quality of water is as important as quantity. Groundwater can be unfit for human consumption or for other uses because of contamination. As population, land development, and resource development increases in Alberta, the risk of impacts to water quality also increase.

Some commercial and industrial activities can contaminate groundwater. Most of these potential sources are point source pollution. Regulations are in place to reduce the possibility of groundwater contamination occurring. Regulations protect groundwater quality from contamination such as:

- Leaking or malfunctioning septic tanks or cesspools. Faulty sewer systems can add ***organic compounds***, synthetic detergent and ***chlorides*** to groundwater. More important, ***nitrates*** and bacteria that affect human health can be introduced.
- Landfills can leak or leach harmful materials into the water supply. Organic compounds, chlorides, ***sulphates***, and a variety of metal salts could seep from a landfill.
- Underground gasoline storage tanks at gas stations can corrode and leak. Half of the tanks installed in the 1950's and 1960's were found to leak after 15 years. The Government of Alberta has taken steps to improve the underground storage of fuels.
- Oil extraction and oil sand production processes require the use of water. This water must be treated after use to ensure water supplies are not contaminated.

Organic Compounds
Compounds that have carbon and usually hydrogen and oxygen as the main elemental components in their structural framework. Most of the dissolved organic matter in groundwater is fulvic and humic acid.

Chlorides
A compound in which chlorine is combined with another element.

Nitrates
Used as fertilizers. When entering the human bloodstream, they compete with hemoglobin for oxygen.

Sulphates
A salt from sulphuric acid.

Non-point source contamination is more difficult to monitor than point source pollution. Some examples of non-point source contamination are outlined below.

- During irrigation or heavy rainfall, large quantities of water may be discharged onto the ground over a short period of time. The water soaks into the soil quickly carrying pesticides and herbicides with it. If the water continues to travel down into an aquifer, groundwater contamination may occur.
- Fertilizers add nitrates and phosphates to the water system. Fertilizers can move with groundwater and reach surface water. Eventually, their presence could show up as algae blooms in lakes.

Once groundwater is contaminated, it can be difficult and costly to clean up. Water that is contaminated in an aquifer may become surface water at some point and those supplies can also be affected. Preventing contamination is the most practical solution.

Groundwater Quantity

Water is an important renewable natural resource in Alberta. In the future, greater demands will be placed on our water supplies. Groundwater may be used in larger quantities. We need to protect and conserve our groundwater to ensure a continued supply.

If groundwater is removed from an aquifer faster than nature can replenish it, the water level will drop and the source is said to be ***mined***. A reduced flow of groundwater in discharge areas can result in a wetland drying up, a spring no longer flowing, or the water level in a lake decreasing. If mining continues, the water reserves will eventually be depleted, resulting in a water shortage.

Groundwater Mining
Withdrawing water from an aquifer faster than it can be replenished.

Mining of aquifers is not common in Alberta because there are rules and regulations that prevent this practice. However, in some areas there is high demand on groundwater resources. When demands are high and precipitation is low, there are greater pressures placed on our groundwater. Extensive use of groundwater can put supplies in jeopardy.

Groundwater supplies vary depending on locations; however, some generalizations can be made. Central Alberta has a good supply of groundwater for municipal and agricultural needs. The Peace River area has less useable groundwater because there are few aquifers and the groundwater quality is poor. North and east from Peace River to the Saskatchewan and the North West Territories borders, the quantity and quality of groundwater is relatively unknown.

Groundwater in the Future

During the last several decades, exploration and development of petroleum resources in Alberta was very active. Responsible industry practices and careful management are important to ensure the protection of groundwater resources in the future. Some considerations for the future are outlined below:

- After oil sands extraction and production processes are completed, tailings remain. This material consists of water and other substances that are removed from the oil or used to help process the oil. Tailings are stored in very large ponds where the suspended substances separate and settle. Tailings can include potentially harmful substances like metals and hydrocarbons.
- A newer method of extracting natural gas in coal is being developed. While it is not yet well established in Alberta, CBM development sometimes requires water to be removed from a coal seem to reduce pressure and allow methane gas to seep out of coal deposits. The removed water can contain a variety of substances and be of varying quality. Currently, much of this water is disposed of in deep underground formations.
- As development in the oil sands and heavy oil sector increase, the demand for water will likely increase as water is required to develop these resources.

Proper management of groundwater resources by all users is important to ensure future supplies. Examples of other current activities that may affect future groundwater are outlined below:

- Unused, abandoned water wells pose a threat to groundwater quality because they provide a direct path for surface contamination to enter aquifers, either down the inside of uncapped well casings or through the annular space around the outside of the well casing. By properly plugging abandoned wells, property owners reduce the risk of groundwater being contaminated.
- Large-scale urban and rural development has led to increasing effects on the natural environment. Although practices related to farming and urban development aim to reduce risks to groundwater quality and quantity, there is limited information to determine the combined effects of different activities that affect groundwater.
- There is an increasing concern about the impacts of global climate change and potential effects on groundwater resources due to uncertainties in natural water supply.

Managing Current & Future Groundwater Issues

Proper management of groundwater resources by all users is important to ensure future supplies. There are rules and policies in place to protect Alberta's groundwater. The *Water Act* and the *Environmental Protection and Enhancement Act* protect groundwater from overuse and contamination. This legislation regulates many areas including the following:

Well-drilling: In Alberta, water wells must be drilled by certified water well drillers. This ensures that proper drilling and construction methods are used to access groundwater in order to prevent contamination of the aquifer. Drillers also submit water well driller reports to assist the government in collecting information on groundwater resources.

Water demand: Water usage is regulated to prevent undue demands. For example, users such as oil companies, industrial plants, feedlot operators, irrigators or municipalities must obtain a licence from Alberta Environment to use a specified amount of water. Licences are granted only after certain requirements are met. Approvals issued for industrial operations very often include compulsory groundwater monitoring. Licences are normally issued for a period from 2 years to 25 years depending on the purpose of the licence and on the current regulation.

Oil and gas industry: Water use is limited. Users must obtain a licence to use fresh water. The licence identifies how much water can be used on a yearly basis, and how many years access is granted. In agricultural areas, the process for obtaining a licence to use non-saline groundwater for oilfield injection includes demonstrating that use of alternatives, such as saline groundwater, have been investigated.

Alberta Environment also promotes groundwater conservation and monitors the quality and quantity of the resource. For example, Alberta Environment and Alberta Energy and Utilities Board (AEUB) have developed water-recycling guidelines for "In Situ Oil Sands Facilities in Alberta". In addition, Alberta Environment is working with the oil and gas industry to share information which reduces the risk of oil and gas activities contaminating groundwater.

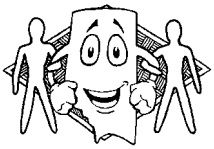
Find out more.
Water and oil: an overview of the use of water for enhanced oil recovery in Alberta is available online at www.waterforlife.gov.ab.ca

Alberta's *Water for Life* Strategy

In addition to current legislation and activities, Alberta has a long-term plan for managing water in Alberta. After extensive public consultation, *Water for Life: Alberta's Strategy for Sustainability* outlines the Government of Alberta's plan to ensure: reliable, quality water supplies; safe, secure drinking water; and healthy aquatic ecosystems. By assisting a wide range of Albertans to understand and care for every aspect of our water, our groundwater will be protected.

The need to increase understanding of the quality and quantity of Alberta's groundwater supply is one of the key actions of the water strategy. The use of water for underground injection was identified as an important public issue during the development of *Water for Life.* While there are several regulations and policies that oil and gas companies must follow when diverting and using water in their operations, *Water for Life* identified the need to improve the use and conservation of all water resources. The Minister of Environment responded to this concern by appointing an advisory committee to provide advice and make recommendations on water use related to oil field injection. To see more information on the committees' recommendations go to www.waterforlife.gov.ab.ca/

What can you do?



Water is necessary for our health and well-being. Every Albertan has a role to play and a responsibility towards maintaining water quality and preventing pollution to ensure a useable supply for future generations. Groundwater and surface water are linked, impacting one affects the other. Below you will find ideas on how you can help protect water quality and quantity in Alberta.

Reduce phosphorus and nitrogen pollution from your home.

- Re-assess your fertilizer needs. Use only as much fertilizer as lawn requires. Excess fertilizers can run-off into water bodies causing algae blooms in nearby lakes.
- Self-fertilize your lawn through grass-cycling. Grass-cycling requires the use of a mulching mower and requires that the grass be left on the lawn. The lawn will naturally reincorporate the trimmings in a few days. Grass-cycling is far less work for the average homeowner. Grass-cycled lawns have been shown to be healthier and require less water.
- Do not over water your lawn. Fertilizer can run off and pollute nearby water bodies.
- Dispose of pet wastes properly. Left on the ground, this waste will be washed away with run-off and enter our water supplies.

Reduce your water use.

Most people use and dispose of more water than they need. Consider the following water reduction ideas.

- Showers use less water than baths. Keep showers short – 5 minutes or less.
- Install low flow water fixtures (e.g. low flow shower heads).
- Repair leaky taps and toilets.
- Use dishwashers and washing machines for full loads only.
- Sweep off driveways with a broom instead of washing with a hose.
- Keep a jug of water in the fridge. Don't run the tap until the water is cold.

Did you know?
A tap dripping just one drop per second can result in a loss of 25 litres a day.

Reduce toxic substances from your home.

- Minimize or avoid using pesticides in your yard. Pesticides can enter groundwater and surface water. Humans can be exposed over long periods of time and can result in impacts on human health.
- Properly dispose of pharmaceutical products. Improper disposal of excess medications (flushing down the toilet or landfilling expired medications) can cause these pollutants to enter the water system.

Did you know?
Most pharmacies in Alberta will collect dead drugs for free and dispose of them properly.

- Properly dispose of household hazardous waste. Solvents, paints, or oil-based compounds that are poured down the sink can enter the water system, even if they go through a sewage treatment process. Heavy metals can end up in rivers and lakes.
- Properly dispose of products which contain heavy metals such as mercury or lead (e.g. end-of-life electronics, fluorescent bulbs, lead acid batteries). Heavy metals can leach into the ground or water, and even in small amounts cause concern for human health.
- Wash your vehicles at a car wash that collects and treats the wash water instead of washing your vehicle in the driveway. Soap, dirt, oils, greases, and other pollutants from washing vehicles in driveways end up directly in the storm water system. Storm water is generally not treated and contaminants can affect the quality of local water bodies.

Did you know?
One computer screen can contain 5lbs (approx. 2.3 kg) of lead.

For more information on groundwater in Alberta see the websites listed below or contact the Alberta Environment Education and Information Centre.

Water for Life: Alberta's Strategy for Sustainability
www.waterforlife.gov.ab.ca/
Learn About Alberta's Water
www.gov.ab.ca/env/water

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ISBN: 0-7785-4264-5