Water is Life

Agriculture in the Classroom

Agriculture in the Classroom **2001 Study Series**

Agriculture In The Classroom (Sask) Inc. is a non-profit organization funded by the agri-food industry with assistance from Saskatchewan Agriculture and Food. AITC is mandated to assist Saskatchewan learners and educators in increasing their awareness and understanding of the complexities and importance of agriculture through partnerships with educators, agri-business, and agriculture organizations. AITC's efforts enable more people to make informed choices and decisions related to food, the environment, lifestyles, and agriculture practices.

The agriculture and agri-food industry in Saskatchewan makes a significant contribution to the provincial economy, to the well-being of both rural and urban communities, and to the environment. This industry is constantly evolving within the traditional family farm and the large international agri-businesses. It is important to provide the general public with a greater awareness and understanding of industry changes and the impact they have on Saskatchewan people.

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Plant Biotechnology Institute

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Introduction

Water is the essence of life as we know it. Protecting and managing this resource responsibly is in everybody's interest.

As the global population increases, our environment is changing. Increased industrialization and more intensive agriculture have impacts on climate. Global warming has affected the distribution of water on the planet. As a result, water resources are scarce in many places, and water quality issues have become more important in peoples' perceptions.

Water's chemical properties allow the environment around us to exist. In many ways, Saskatchewan is defined by water. Living in a semi-arid region gives Saskatchewan residents an appreciation for water and all of the ways in which we use it - from drinking to recreation to power generation to agriculture. Dry land farming is still the predominant mode of agriculture, although we have an extensive and growing network of irrigation canals and pipelines. This network and reservoir system is made possible by the Gardiner Dam - the largest earth-filled dam in Canada, and still ranked in the top ten globally. Many of those involved in its construction in the 1960s have become international consultants in the construction of this type of dam, taking Saskatchewan-made expertise to the world.

Water is everyone's concern. In a global society we must work together to preserve water, or risk the consequences.

Photo: Nasa

There is only one body of water, and we...should be vitally interested in its purity.

A Prairie-wide Perspective of Non-point Agricultural Effects on Water Quality, Harper, 1998

Did You Know?

About 70% of the human body is water.

Life on earth probably originated in water.

The Earth is known as the "blue planet" because water reflects the blue tones of the sky.

The Chemistry of Water

Did You Know?

Raindrops are not tear-shaped. Scientists, using high-speed cameras, have discovered that raindrops resemble the shape of a small hamburger bun.

More than half of the world's animal and plant species live in the water.

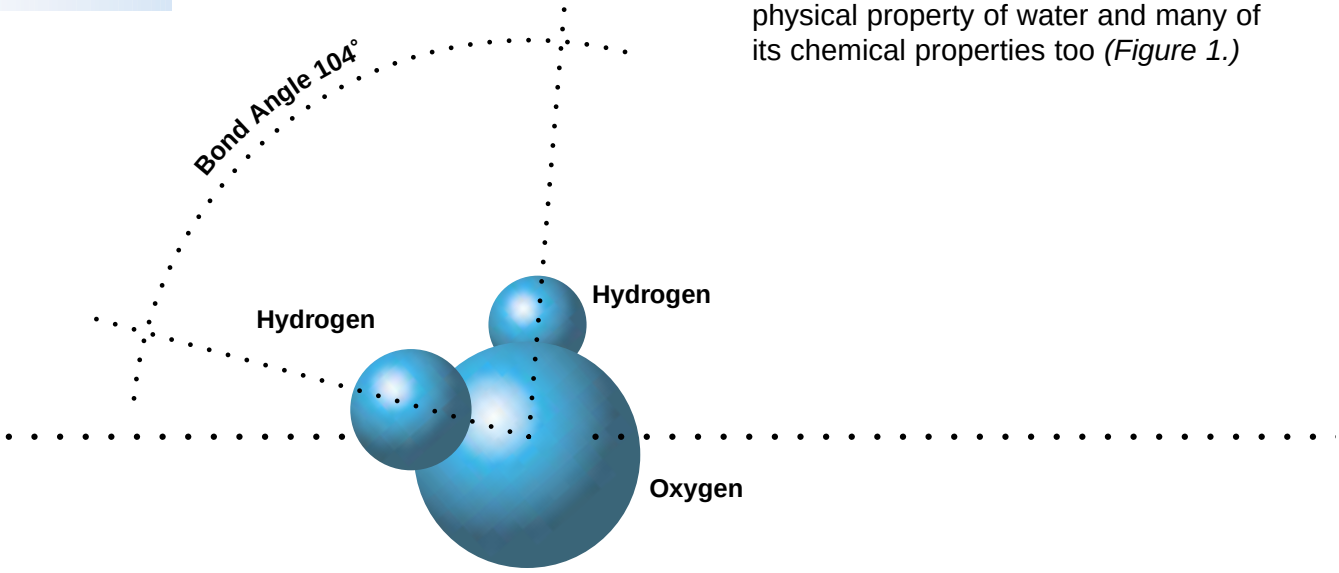
The human body needs 2.4 litres of water a day.

(Water – Nature's Magician, Environment Canada, 1992)

Water is the solvent, the medium and the participant in most of the chemical reactions occurring in our environment. A water molecule itself is simple, made up of three atoms: two hydrogen and one oxygen, H_20. The configuration of these building blocks produces a molecule with almost magical properties!

On earth, water is found as a liquid, as a solid (ice) or as a gas (water vapour). Canada has about 9% of the world's renewable freshwater supply, compared with 18% for Brazil, 9% for China, and 8% for the United States.

Figure 1 Water Molecule



The two hydrogen molecules are separated by a bond angle of 104° Two of the oxygen orbitals are full, and don't form bonds with other elements.)

The ice we skate on in winter is water in its solid form. Unlike most substances that are most dense in their solid state, ice is less dense than water and thus floats. If this were not the case, lakes and rivers would freeze from the bottom up. Fish could not survive, and it is unlikely that rivers and lakes in northern countries would ever completely thaw.

Water vapour forms a kind of global "blanket" that helps to keep the earth warm. Heat radiated from the sun-warmed surface of the earth is absorbed and held by the vapour.

Water's magical properties

Water molecules are attracted to each other, creating hydrogen bonds. These strong bonds determine almost every physical property of water and many of its chemical properties too *(Figure 1.)*

Boiling and Freezing

Pure water at sea level boils at 100°C and freezes at 0°C. At higher elevations (lower atmospheric pressures) water's boiling temperature decreases. This is why it takes longer to boil an egg at higher altitudes. The temperature does not get high enough to cook the egg properly. If a substance is dissolved in water, then the freezing point is lowered. That is why we spread salt on streets in winter to prevent ice formation.

Thermal Properties

Water absorbs and releases more heat than many substances for each degree of temperature increase or decrease. Because of this, it is widely used for cooling and for transferring heat in thermal and chemical processes. Differences in temperature between lakes and rivers and the surrounding air may have a variety of effects. For example, local fog or mist is likely to occur if a lake cools the surrounding air enough to cause saturation; consequently small water droplets are suspended in the air. Large bodies of water, such as the oceans or the Great Lakes, are the world's great heat reservoirs and heat exchangers… and the source of much of the moisture that falls as rain and snow over adjacent land masses. When water is colder than the air, precipitation is curbed, winds are reduced, and fog banks are formed.

Surface Tension

Surface tension is a measure of the strength of the water's surface film. The attraction between the water molecules creates a strong film, which among other common liquids is only surpassed by that of mercury. This surface tension permits water to hold up substances heavier and denser than itself. A steel needle carefully placed on the surface of a glass of water will float. Some aquatic insects such as the water strider rely on surface tension to walk on water. Surface tension is essential for the transfer of energy from wind to water to create waves. Waves are necessary for rapid oxygen diffusion in lakes and seas.

Molecules in Motion

Water molecules as well as binding to each other, bind to many other substances such as glass, cotton, plant tissues, and soils. This is called adhesion. For example, in a thin glass tube, when the molecules at the edge reach for and adhere to the molecules of glass just above them, they tow other water molecules along with them. The water surface, in turn, pulls the entire body of water to a new level until the downward force of gravity is too great to be overcome. This process is called capillary action. Thus water readily wets many materials. Capillary action allows a paper towel or a sponge to be used to soak up spilled water. Without this property, the nutrients needed by plants and trees would remain in the soil.

The Universal Solvent

An extraordinary property of water is its ability to dissolve other substances. There is hardly a substance known that has not been identified in solution in the earth's waters. Were it not for the solvent property of water, life could not exist because water transfers nutrients vital to life in animals and plants. A drop of rain water falling through the air dissolves atmospheric gases. When rain reaches the earth, it affects the quality of the land, lakes and rivers.

The Hydrologic Cycle

Did You Know?

Glacier ice over 100 000 years old is found at the base of Arctic ice caps.

30% of the Earth's freshwater exists as ice in glaciers and ice caps.

Canada's rivers and lakes contain enough water to flood the entire country to a depth of more than two meters.

The age of water in shallow wells (less than 50 m) may be days to months old, while in deep wells, the water may be thousands of years old. This is why deep well water is often saltier, as the water has dissolved salts into solution from its long stay in the ground.

(Water - Nature's Magician, Environment Canada, 1992)

The endless circulation of water from the atmosphere to the earth and its return to the atmosphere through condensation, precipitation, evaporation and transpiration is called the hydrologic cycle. Heating of the ocean water by the sun is the key process that keeps the hydrologic cycle in motion. Water evaporates, then falls as precipitation in the form of rain, hail, snow, sleet, drizzle or fog. On its way to earth some precipitation may evaporate or, when it falls over land, be intercepted by vegetation before reaching the ground. The cycle continues in three different ways:

1 **Evaporation/Transpiration**
On average, as much as 40% of precipitation in Canada is evaporated or transpired. In southern Saskatchewan, this number can reach 80%.

2 **Percolation into the Ground**
Water moves downward through cracks and pores in soil and rocks to the water table. Water can move back up by capillary action or it can move vertically or horizontally under the earth's surface until it re-enters a surface water system.

3 **Surface Runoff**
Water runs overland into nearby streams and lakes; the steeper the land and the less porous the soil, the greater the runoff. Overland flow is particularly visible in urban areas. Rivers join each other and eventually form one major river that carries all of the sub-basins' runoff into the ocean.

Although the hydrologic cycle *(Figure 2)* balances what goes up with what comes down, one phase of the cycle is "frozen" in the colder regions during the winter season. During the Canadian winter, for example, most of the precipitation is simply stored as snow or ice on the ground. Later, during the spring melt, huge quantities of water are released quickly, which results in heavy spring runoff and flooding.

Evaporation

As water is heated by the sun, its surface molecules become sufficiently energized to break free of the attractive force binding them together, and then evaporate and rise as invisible vapour in the atmosphere.

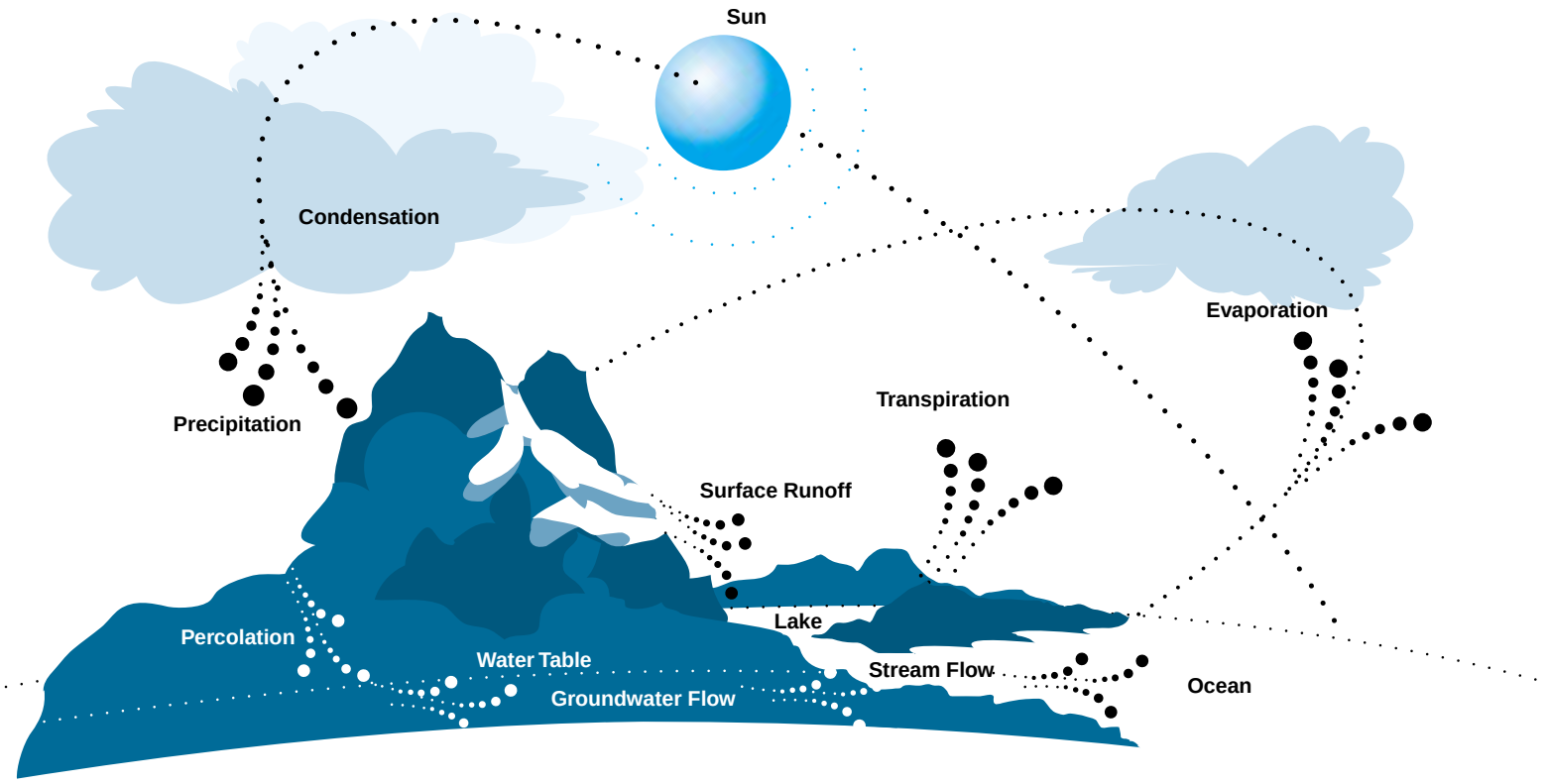
Transpiration

Water vapour is also emitted from plant leaves by a process called transpiration. Every day an actively growing plant transpires 5 to 10 times as much water as it can hold at any one time.

Condensation

As water vapour rises, it cools and eventually condenses, usually on tiny particles of dust in the air. When it condenses it becomes a liquid again or turns directly into a solid (ice, hail or snow). These water particles then collect and form clouds.

Figure 2 The Hydrologic Cycle



Precipitation

Precipitation in the form of rain, snow and hail comes from clouds. Clouds move around the world, propelled by air currents. For instance, when they rise over mountain ranges, they cool, becoming so saturated with water that water begins to fall as rain, snow or hail, depending on the temperature of the surrounding air.

Runoff

Excessive rain or snowmelt can produce overland flow to creeks and ditches. Runoff is visible flow of water in rivers, creeks and lakes as the water stored in the basin drains out.

Percolation

Some of the precipitation and snow melt moves downwards, percolates or infiltrates through cracks, joints and pores in soil and rocks until it reaches the water table where it becomes groundwater.

Groundwater

Subterranean water is held in cracks and pore spaces. Depending on the geology, the groundwater can flow to support above-ground streams. It can also be tapped by wells. Some ground-water is very old and may have been there for thousands of years.

Water Table

The water table is the level to which water will rise in an open well.

Groundwater, Aquifers, Surface Water, & Wells

Did You Know?

The available global water supply is distributed as follows

- 97.2% is saline water in oceans. This water is unsuitable for drinking or agricultural uses.
- 2.14% is in ice caps and glaciers
- 0.61% is groundwater. Much of this water is too deep for extraction.
- 0.009% is found in surface water. This is where most drinking water comes from.
- 0.005% makes up soil moisture.
- 0.001% of water is found in the atmosphere.

(Applied Hydrogeology, Fetter, 1994, p.4.)

Groundwater

(Groundwater - Nature's Hidden Treasure, Environment Canada, 1992)

It is sometimes thought that water flows through underground rivers or that it collects in underground lakes. Groundwater is not confined to only a few channels or depressions in the same way that surface water is concentrated in streams and lakes. Rather, it exists almost everywhere underground. It is found in the spaces between particles of rock and soil, or in crevices and cracks in rock. The water filling these openings is usually within 100 meters of the surface. Much of the earth's fresh water is found in these spaces. At greater depths, because of the weight of overlying rock, these opening are much smaller, and therefore hold considerably smaller quantities of water. The level below which all the spaces are filled with water is called the **water table**. Above the water table lies an unsaturated zone, where spaces are filled with water and air. Water in this zone is called **soil moisture**. The water in the saturated zone is called **groundwater**.

Aquifers

(Groundwater - Nature's Hidden Treasure, Environment Canada, 1992)

Although groundwater exists everywhere under the ground, some parts of the

Figure 3.1. Main Types of Porosity

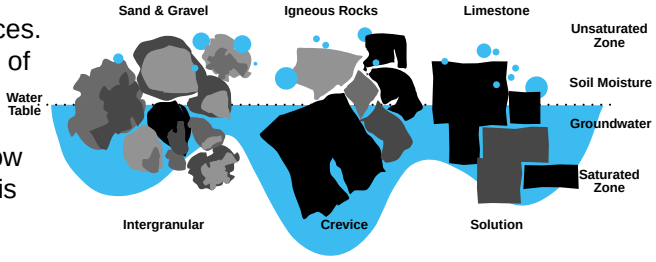
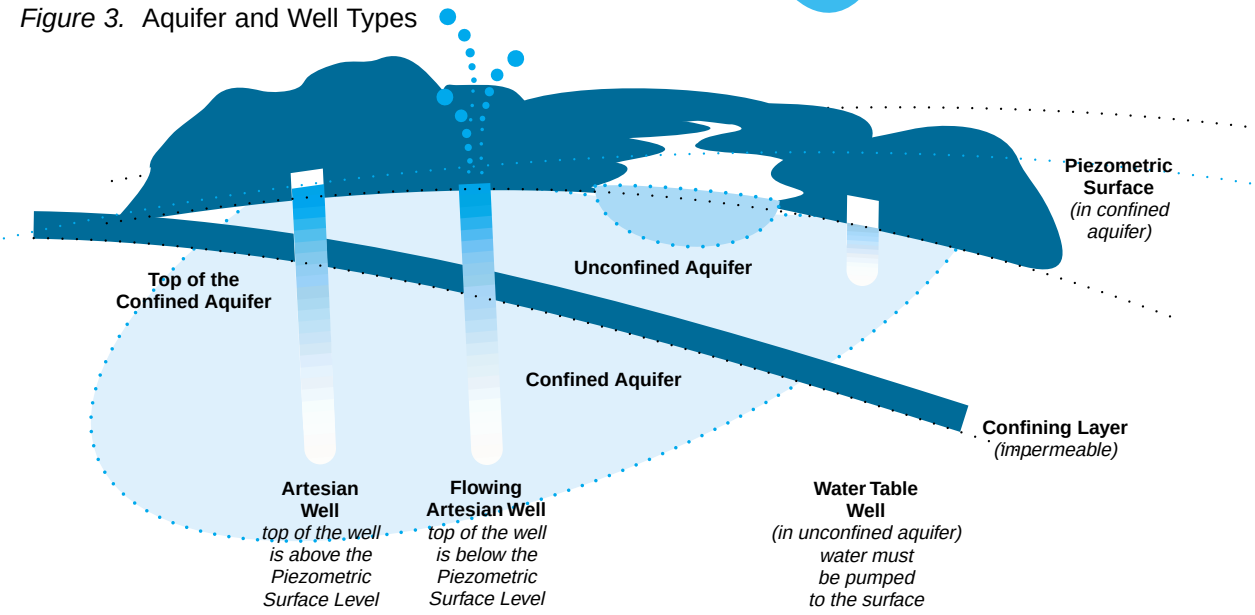


Figure 3. Aquifer and Well Types



saturated zone contain more water than others. An aquifer is an underground formation of permeable rock or loose material that can produce useful quantities of water when tapped by a well. Aquifers come in all sizes. They may be small, only a few hectares in area, or very large, underlying thousands of square kilometers. They may be only a few meters thick, or they may measure hundreds of meters from top to bottom.

Aquifers can be confined or unconfined *(Figure 3)*. A confined (or artesian) aquifer exists beneath a layer of impermeable materials – separating it from the water table. Unconfined aquifers, by comparison, can be a source of surface water areas.

Surface Water

Any water that is naturally open to the atmosphere is considered to be surface water. Surface water includes rivers, lakes, reservoirs, streams, seas, etc. Surface water can also include springs and wells.

Wells

A well is a "pit, hole, or shaft sunk into the earth to tap an underground source of water" *(A Primer on Fresh Water, Environment Canada, 1990)*. Wells are named according to the aquifer type from which the water comes *(Figure 3).*

Water Tells You Where it has Been

All water contains substances that it has picked up in its journey through the hydrologic cycle. Examples of these substances include bicarbonates, iron, arsenic, sulphates, sodium chlorides, calcium, magnesium, potassium, and uranium, etc. These compounds enter the surface and groundwater via:

- Soil, geologic formations and terrain in the catchment area (river basin)
- Surrounding vegetation and wildlife
- Precipitation and runoff from adjacent land
- Biological, physical and chemical processes in the water
- Human activities in the region

(Clean Water - Life Depends on It, Environment Canada, 1992)

Measuring the conductivity and hardness of water can tell a lot about what is in the water - in effect, where it has been.

- Conductivity is measured using a conductivity meter in units called Siemens (S) or microSiemens (µS). Conductivity measures the amount of salt in the water by measuring electrical conductance. The higher the conductance, the saltier the water. Measurements below 2000 µS are preferred - those above 8000 µS are unacceptable for many uses.
- Hardness is measured (using a test kit) in grains/US gallon, grains/Imperial gallon, or in mg/L. Drinking water with a hardness measurement of >20 grains/gallon is con sidered "hard". The hardness measure ment assesses the amount of calcium and magnesium present in the sample.

The different types of aquifers in Saskatchewan result in water that has characteristic combinations of conductivity and hardness *(Table 1)*. Surficial (or sandpoint) aquifers are sandy, unconfined, surface aquifers. Glacial aquifers are composed of rock that was deposited during the glacial retreat. The Empress Group of aquifers is made of buried valleys that existed before the glacial aquifers were created. Bedrock aquifers are deep, confined aquifers, resting on pre-glacial bedrock. Water that has been treated has different conductivity and hardness readings. *(Water Works!, Environment Canada, 1992)*

Table 1 Conductivity and Hardness Readings from Various Types of Aquifers.

Aquifer Type	Conductivity (µS)	Hardness (grains/gallon)
Surficial	700-1000	15-20
Glacial	2000-3000	50-100
Empress Group	1500-4000	20-50
Bedrock	2000-3000	2-3

Basic conductivity meters are available for ~$250 from scientific chemical companies. Hardness kits (Hach kits) are available from chemical or water treatment companies and cost ~$50.

How we use Water

Did You Know?

Globally, 8% of withdrawal water is used for domestic purposes, 23% in industry, and 69% for agriculture.

In North America, 9% is used domestically, 42% industrially, and 49% for agriculture. *(Water Quality: Management of a Natural Resource, Perry and Vanderklein, 1996, p.71)*

Saskatchewan uses 8% of its withdrawal water for domestic purposes, 17% for industrial uses, and 75% for agricultural uses! *(Water for All, Saskatchewan Water Corporation, 2001)*

Photos: D. Corkal, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration

Withdrawal Uses

The greatest number and variety of water uses occur on the land. These are called withdrawal uses. This term is appropriate because the water is withdrawn from its source (a reservoir, river, lake, or groundwater supply), piped or channelled to many different locations and users, and then is collected again for return to a lake, river or into the ground. Household and industrial uses, thermal and nuclear power generation, irrigation and livestock watering all fall into this category.

Most withdrawal uses "consume" some of the water, meaning less is returned to the source than was taken. Furthermore, the water that is put back into its natural setting is often degraded. For example, water leaving our houses contains human and household wastes. The same is true of water used in many industrial processes. Often this liquid waste is only partially treated, if at all, before it is returned to nature.

Thermal Power Generation

Next to fuels, water is the most important resource used in large-scale thermal power production. Production of one kilowatt-hour of electricity requires 140 litres of water for fossil fuel plants and 205 litres for nuclear power plants. Some of the water is converted to steam that drives the generator producing the electricity. Most of the water, however, is used for condenser cooling.

Manufacturing

Water is used as a raw material, a coolant, a solvent, a transport agent, and as a source of energy. An automobile coming off the assembly line, for example, will have used at least 120 000 litres of water - 80 000 to produce its tonne of steel and 40 000 more for the actual fabrication process. Many thousands more litres of water are involved in the manufacture of its plastic, glass, and fabric components. Paper and allied products, chemicals, and primary metals are the three main industrial users.

Municipal Use

Can you imagine a city without water? We use it for drinking, cooking, and for other household needs. Water is also needed to clean our streets, fight fires, fill public swimming pools, and water lawns and gardens.

Agriculture

Farmers depend on water for livestock and crop production. Water is withdrawn mainly for irrigation (85%) and livestock watering (15%). Irrigation is needed mainly in the drier parts of Canada, such as the southern regions of Alberta, British Columbia, Saskatchewan, and Manitoba. Because so much of the water intake evaporates, only a small fraction is returned to its source. This is a highly consumptive use.

Mining

This category includes metal mining, non-metal mining, and the extraction of coal. Water is used by the mining industry to separate ore from the rock, to cool drills, to wash the ore during production, and to carry away unwanted material. Mining recirculates its water intake to a greater extent than any other sector.

Photos: D. Corkal, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration

Instream Uses

Instream water uses are those that make use of water in its natural setting. Fish live in it, as do some birds and animals, at least part of the time. Hydroelectric power generation, shipping, and water-based recreation are other examples of human instream uses.

Instream uses are not always harmless. For example, oil leaking from outboard motors and freighters can cause pollution. Large reservoirs needed for hydroelectric power generation remove water by evaporation and completely change the river regime for downstream users.

The main instream uses are:

Hydroelectric Power Generation

This is the principal source of electricity in Canada today. Billions of dollars have been invested in its development. The Gardiner Dam is one of many dams in the province that is used to generate hydroelectric power. Twenty-five percent of Saskatchewan's electricity is generated by water. Three hydroelectrical generating stations are on the Saskatchewan River: Coteau Creek, E.B. Campbell, and Francois Finlay.

Water Transport

Historically, inland waterways in Canada have played a major role in getting Canadian goods and raw materials to market. Some traditional uses, such as log driving, have now disappeared. However, water transport is still the most economical means of moving the bulky raw materials that are our main exports: grain, pulp, lumber, and minerals. The main transportation waterways are the St. Lawrence River, the Mackenzie River, and the lower Fraser River on the Pacific Coast.

Freshwater Fisheries

Blessed with hundreds of thousands of freshwater lakes and rivers, Canada provides some of the most spectacular sport fishing in the world. Inland commercial fisheries employ some 10 000 Canadians, mostly in Ontario and the Prairie provinces. Coastal rivers provide spawning grounds for salmon and other fish populations that support major saltwater fisheries.

Wildlife

Many wildlife species live in, on, or near the water and require access to it throughout their lives. Other species may not use water as their primary habitat, but it is nonetheless essential to their well-being. Water is critical for all ecosystems. Wetlands - nature's natural water purifiers - are destroyed when drainage is improved. Increasing water drainage can cause future problems for water quality and loss of wildlife habitats.

Recreation

Activities such as swimming, boating, canoeing, fishing, and camping allow us to experience the beauty of our lakes and rivers. While not all outdoor recreation requires water, the presence of water tends to enhance the experience.

Waste Disposal

It has long been convenient to use lakes, rivers, and oceans as receiving bodies for human and industrial wastes. While water is capable of diluting and "digesting" society's wastes to some degree, there are limits to what even the largest body of water can absorb. The extent to which instream processes can absorb contaminants depends on factors such as the nature of the contaminant, how much of it there is compared to the volume of water, how long the contaminant stays in the water, the temperature of the water, and the rate of flow. Many of our waterways are now overloaded with wastes. This problem can best be resolved by increased regulation and/or monitoring.

Water Quality

Did You Know?

One litre of oil can contaminate up to two million litres of water.

During the summer, half of all treated water is sprayed onto lawns.

Many homes lose more water from leaky taps than they need for cooking and drinking.

Water quality depends upon the protection of all water supplies and understanding how the ways we use water affect the watershed. Surface water and groundwater are affected by natural events and the actions of humans.

Regardless of the intended use, there are four basic steps in maintaining water quality:

- Protection of surface and ground water,
- Practising effective water source management,
- Treating water appropriately for its intended use according to specific problems encountered, and
- Continually testing water for safety.

Protection of Surface and Ground Water

All water - both surface water and groundwater - is subject to contamination (Figure 4). Examples of contaminants include agricultural and industrial chemicals, nutrient inflow (phosphates, sediment) and human and animal wastes. The protection of surface water supplies involves minimizing the potential for run-off to enter a body of water. Wastewater treatment, too, is critical to reduce the impact on rivers and lakes. Direct watering of livestock in a water body should be avoided to reduce impacts on the water and to ensure that the animals get the best quality drinking water.

Rivers and lakes generally have plants, bushes, shrubs, and trees along a wet zone near the water. These are called "Riparian" zones. Riparian zones provide a buffer that is critical in the protection of the water supply.

Practising Effective Water Source Management

(Groundwater - Nature's Hidden Treasure, Environment Canada, 1992)

All levels of government in Canada are starting to take some of the actions necessary to protect groundwater supplies, but there is a long way to go before these management 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.

Figure 4. Groundwater Contamination from a waste disposal site.

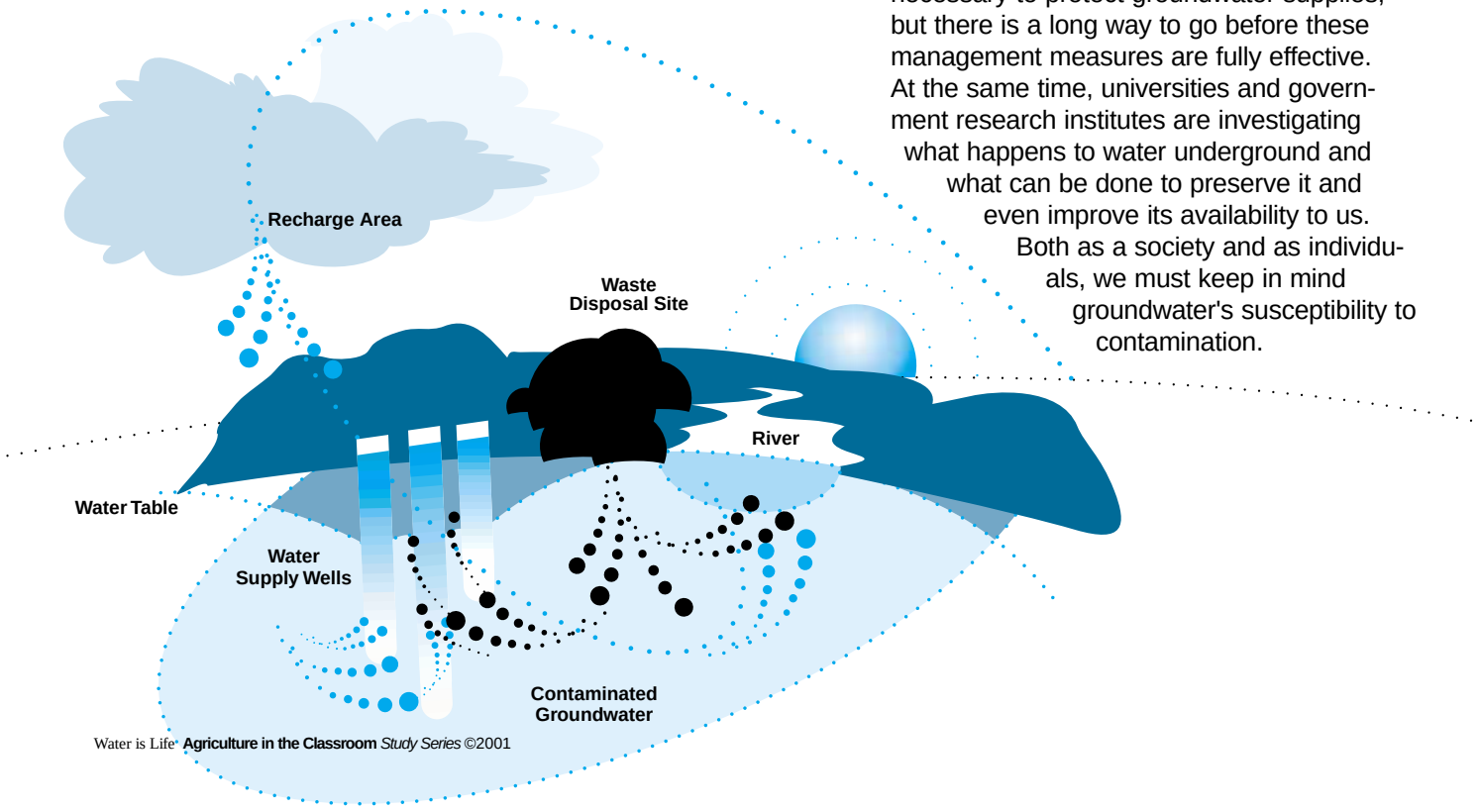


Table 2 Potential contaminants in water and their sources.

Potential Contaminant	Potential Source
Algae	Surface water rich in nutrients
Bacteria, Viruses, Parasites	Runoff, direct source contamination from fecal waste (human or animal)
Inorganic minerals (examples: S, Fe, Mn, As, Ca, Cu, Na)	Erosion of natural deposits,corrosion of pipes, industrial wastes, sewage, landfill
Nitrates, Nitrites	Runoff, direct source contamination from fecal waste and fertilizers, natural soils rich in nitrates
Radionuclides	Erosion of natural deposits, man-made structures
Reaction products of disinfection (bromates, chlorite, trihalomethanes)	Reaction of organic material in water with chlorine and/or bromine

Treating Water Appropriately

Appropriate water treatment depends both on where the water has been (its "incoming" quality), and its intended use. Water is almost always treated for domestic uses. Domestic water is used for bathing, laundry, dishwashing, toilets, drinking, and watering lawns and gardens.

Drinking water should not contain disease-causing microorganisms or harmful chemicals. It should be clear, colourless, and odourless. The steps in the treatment process are determined by which of these "contaminants" are present in the source waters *(Table 2).*

Common surface water problems include microorganisms, dissolved organic materials, dissolved nutrients and algae. Contaminants of groundwater include inorganic materials (iron, manganese, hardness factors, sodium, arsenic, and sulphates). Shallow wells can also have elevated nitrate levels.

Water Treatment Processes

Step 1. Coagulation.
Aluminum sulphate or ferric chloride is mixed with water. These chemicals react with solid particles - making them clump together and precipitate out of the water. The clumps are called "floc."

Step 2. Sedimentation.
The water is allowed to sit for long periods of time to allow the remaining floc and other solid materials to settle out of the water.

Step 3. Filtration.
Sand filter beds remove particulate matter from the water. Activated carbon beds further filter the water, removing some organic matter and other compounds that affect taste.

Step 4. Disinfection.
Chlorine and ozone are oxidizing compounds that result in disinfection. This process is effective only on good quality water. Using disinfecting agents on water that contains colloids of sand or organic material is ineffective because the colloids protect bacteria and other microorganisms. In addition, the reaction of oxidizing compounds with organic matter can result in the production of toxic by-products.

Step 5. Storage.
Treated water is stored until required. Storage helps even out the supply during peak demand times.

Step 6. Polishing Treatments.
Reverse osmosis membranes or water distillation units are used by many people in their homes. Polishing devices remove any remaining impurities (including chlorine) and result in "ultra-pure" water that is very low in essential elements.

Continual Testing for Safety

Testing water is critical - it is the only way to determine the safety of water. How often a water supply is tested depends on a number of factors:

- Quality of the water source
- The number of sources that are used. Is there one source, or many?
- The past frequency of unacceptable test results
- The adequacy of the treatment plan
- The methods of disinfection
- Population size

Testing frequency can vary from twice per year to 90 times per month. The kinds of components or potential contaminants that are tested for also depend upon these factors.

Did You Know?

Of the water we use in our homes, 40% is used by toilets, 35% for bathing, 20% for dishes and laundry, and 5% for drinking and cooking.

It can be difficult for rural Canadians to treat their own water effectively. Water can be high in salt, iron, arsenic, organic matter, etc. Purification processes can be adapted for smaller-scale water treatment - such as slow sand filters, biological carbon filters, coagulation treatments, and the use of membranes for filtration.

Issues of Water Quality in the News.

There are many examples of health-related water quality issues. Nitrates are an issue, but many other contaminants exist; bacteria and parasites are also found in water supplies. Health-related water quality issues result from both natural and human-related causes. As with any health-related water issue, the problem must be identified by water testing and addressed through proper watershed management.

Elevated Nitrate Levels in Water Cause Methaemoglobanemia – Blue Baby Syndrome

Elevated nitrate levels in drinking water are most commonly seen in well water that has been contaminated by human or animal waste, although elevated levels can occur naturally. High nitrate levels can cause serious health problems, and sometimes death, in infants who consume the water. Blue Baby Syndrome occurs when nitrites combine with the hemoglobin in the blood - greatly diminishing its oxygen carrying capacity. The pH of the upper digestive tract in infants is different from that in adults - and in infants nitrates in the water (or other food) can be converted into nitrites. In adults, methaemoglobin is also produced, but the adult body has enzymes that reverse the binding of nitrates with hemoglobin *(Skipton, 1998).*

Elevated nitrate levels in drinking water are most often associated with contamination of groundwater wells by livestock or fertilizers - or they can be naturally occurring. Cases of Blue Baby Syndrome have been documented in North America since the mid 1800s - and although the incidence of this illness has decreased with a better understanding of water-related illnesses, and better water-treatment methods, Blue Baby Syndrome is still documented today.

Regulation and Commercialization of Bottled Water
(Questions and Answers on Bottled Water, Health Canada, 2000)

In Canada, bottled water is considered to be a food and is regulated by the *Food and Drug Act*. Bottled water is defined as follows:

Bottled water labelled mineral or spring water is a water suitable for drinking that comes from an underground source. It cannot come from a public water supply. Mineral water is spring water with a larger amount of dissolved mineral salts, usually above 500 milligrams per litre of total dissolved solids.

Bottled water not represented as mineral or spring water, is water from any source (municipal water, well water, etc) that can be treated to make it fit for human consumption. These bottled waters can be distilled or passed through different deionization processes to remove their minerals, or they are simply municipal tap waters bottled for sale. The label on these water containers must show how they have been treated; for example "carbonated", "demineralized", "distilled", etc.

Water bottling in Quebec-*a case of competition.*

The water-bottling industry is booming in Quebec, directly and indirectly employing 5000 people and generating sales of $75 million each year. But the rapid expansion of this industry has some citizens concerned that there won't be enough water to go around. They worry that the lack of regulatory controls on groundwater use will allow the bottling industry to take more than its fair share, using up water also needed for domestic use, agriculture, and other activities.

In the Quebec municipality of Franklin, a citizens' committee has formed to oppose a new water-bottling project. They argue that a similar project near Mirabel has affected the quantity and quality of water used by 85% of the people living within 8 kilometres of the commercial well. Many Franklin farmers depend on groundwater to irrigate their fruit crops. The aquifer also serves the domestic needs of two municipalities, two agri-food industries, and two campsites receiving 10 000 visitors each summer. With good reason, Franklin's citizens are asking if their groundwater resource is going to last. The problem is, no one knows for sure how much groundwater is there, how it is renewed, or how extraction activities like water bottling affect the resource.

In the face of public and media pressure, the government of Quebec imposed a moratorium on the water-bottling industry in December 1997, freezing all new requests for permits until a new policy was created to define water rights and management in Quebec. Members of the industry protest this action, saying that they bottle only a fraction (half a million cubic meters) of the total amount of groundwater used in Quebec each year, while the aquaculture industry uses 40% (100 million cubic meters). They also decry the polluting effect of agriculture and are asking for exclusive and protected zones for their industry so the quality of their product can be protected.

Which water use should have priority? Who should have the power to decide this? All parties concerned agree that legislation is needed to provide precise and fair rules that will protect both the quantity and quality of the groundwater resource.
(The Health of Our Water, Nolin, 2000)

How Water is Managed

Sask Water is the lead agency responsible for managing surface water and groundwater in Saskatchewan. *The Water Corporation Act,* passed in 1984, provides an organized and systematic manner for allocating water. Sask Water grants approvals to construct and operate works for a person, business, community, or other group to secure a specified amount of water for a project if it is available. People only receive permission to use the water; they do not own the water.

Water management is shared with a variety of government agencies that have a specific interest in water related resource management. The hydrologic cycle demonstrates that there is really only one water supply - and how water is managed in one situation can have an impact on the amount and quality that is available for use in another situation. There are times when water use and quality issues can be in conflict. As a result, communication among various agencies and the different water users is required. Issues can be resolved by all stakeholders working together cooperatively.

Water Management

Major Flood in Vanguard

A major rain storm July 3, 2000 over the Vanguard area in southwest Saskatchewan marked the highest rainfall event ever recorded in the province. More than 300 millimeters (mm) of rain fell during a period of approximately 10 hours; the highest single point rainfall amount recorded was 375 mm. The resulting peak flows in the Notukeu Creek near Vanguard were the highest ever recorded, exceeding the previous flood of record which was the spring runoff event of 1952. Areas of the Notukeu Creek valley and adjacent farm land experienced extensive flooding.

Sask Water played a major role in forecasting and monitoring streamflows and assisting local residents. Following the July flood, Sask Water, in cooperation with Saskatchewan Health, the Swift Current Health District and the Prairie Farm Rehabilitation Administration (PFRA), contacted all rural residents who may have been impacted by the flood. The agencies, through a coordinated effort, sampled and tested all potentially affected groundwater supplies for contamination. Residents were also advised on various measures necessary to ensure their water supplies were safe to drink.
Our Water, Our Future. Sask Water Annual Report, 2000.

Who is Responsible for What?

Federal Organizations

Health Canada
Sets guidelines for drinking water.

Prairie Farm Rehabilitation Administration (Agriculture and Agri-Food Canada)
Advises the agri-food sector and rural residents on the sustainable use of the Prairie's soil and water resources.

Department of Foreign Affairs and International Trade
Regulates bulk water exports.

Environment Canada
Enforces environmental protection, regulations and monitors trans-boundary flows of water.

Department of Fisheries and Oceans
Oversees the protection of fisheries - including monitoring of polluters.

Provincial Organizations

Saskatchewan Environment and Resource Management
Management, enhancement, and protection of Saskatchewan's natural and environmental resources - fish, wildlife, lands, forests, parks and protected areas, air, water and soil.

Sask Health
Tests water for all municipalities at a provincial laboratory.

Saskatchewan Water Corporation
Manages, protects and develops the province's water and related land resources for economic, social, and environmental benefits.

Saskatchewan Agriculture and Food
Farm and agricultural uses of water.

Individuals

Responsible use of water resources domestically and recreationally. Understanding of local water issues and treatment.

Municipalities

Treatment of water and sewage according to provincial guidelines.

Public Health Officers
Advise on water safety of private water supplies in rural Saskatchewan.

Irrigation in Saskatchewan
A developing technology for sustainable agriculture

Did You Know?

Most of our food is water: tomatoes (95%), spinach (91%), milk (90%), apples (85%), potatoes (80%), beef (61%), hot dogs (56%).

1000 kg of water is required to grow 1 kg of potatoes.

The South Saskatchewan River system supplies water to over 450 growers who use irrigation.

Photos: D. Corkal, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration

Sask Water is responsible for the development and operation of irrigation in Saskatchewan under The Irrigation Act, 1996. Under this act, anyone who irrigates must have an Irrigation Certificate. This certificate is issued when Sask Water had assessed that the land to be irrigated, and the irrigation water source, are suitable for irrigation - to avoid negative effects on the land and water.

Assessment includes collecting information about the land - soil data, rural land assessment, and water quality.

- **Soil Salinity** is measured across the area to be irrigated. Results from all samples taken across the field are mapped to determine high and low spots. Improper irrigation can concentrate salts in the soil, limiting plant growth. Proper irrigation can improve high salt problems by leaching the salt downward.
- **Soil Texture** is analyzed. The relative amounts of sand, silt, and clay in the soil determine how much moisture a soil can hold and its fertility. Very sandy soil won't retain water. Soil that is sandy at greater depths will result in greater impacts to neighbouring land. Similarly, soil too high in clay will not drain.
- **Infiltration Rate and Moisture Holding Capacity** are considered. Infiltration rate is a measure of how quickly water is taken into the soil. Moisture holding capacity is a measure of how much water remains in the soil that can be used by plants. Soil that is highly sandy will have a high infiltration rate - and will not flood as easily. But its moisture holding capacity is low too - water drains away and is not available for crop use. These measurements influence the type of irrigation that is appropriate.
- **Drainage, Topography, and Depth to the Water Table** are important factors. Topography, soil composition and texture determine drainage. Artesian pressures that raise the water table can bring salt to the surface by capillary pressure.

- **Irrigation Water Quality** must be compatible with the land to be irrigated. Water high in salt will have to be applied at higher rates than the crop requires to avoid salt build up. Water with high sodium levels will break down the soil structure and result in surface sealing and crusting - making crop establishment difficult. The presence of other compounds (boron, bicarbonate) can be problematic. Fortunately, most water from the major waterways in Saskatchewan is suitable for irrigation.

These factors are looked at in combination. Poor characteristics of one or more factors may be overcome by management practices. When all of these factors are taken into account, the land and its water source will be rated as suitable, suitable with precautions, or unsuitable for irrigation.

Photos: D. Corkal, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration

Types of Irrigation

The Canada-Saskatchewan Irrigation Diversification Centre (CSIDC) is a joint federal and provincial government research and demonstration site for irrigation practices. In cooperation with university, government, and other researchers, this agency tests crops and management practices related to irrigation. Centre pivot, wheel line, flood and drip irrigation technologies are used and tested. CSIDC researches and provides demonstration work on pulse, vegetable, potato, turfgrass seed and herb crops. On-farm diversification and processing techniques are demonstrated. Farmers can get advice, ideas and help on all aspects of irrigated agriculture.

Saskatchewan has an extensive network of irrigation canals and pipelines that support the irrigated areas. Irrigation districts exist around Lake Diefenbaker and in south west Saskatchewan.

Photos: D. Corkal, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration

Elite Stock Farms - Irrigation Innovation

Elite Stock Farms is an intensive livestock operation (ILO) near Macrorie. All of the manure produced in the barns is separated into its liquid and solid components. The solid components are composted for sale to gardeners and landscapers. The liquid fraction is mixed with irrigation water instead of using fertilizer, and the diluted liquid is used to irrigate adjacent land using centre pivot irrigation systems. Cattle are grazed on this land, and the drinking water well is located here too.

This project was set up in cooperation with University of Saskatchewan researchers, and is certified through Sask Water. Monitoring of 16 wells that were originally set up during the initial research phase is still ongoing. Groundwater quality has not been negatively affected by the practice.

The Gardiner Dam

Did You Know?

More water evaporates from Lake Diefenbaker than is used by any other use. The lake loses 345 000 cubic decameters of water per year - equivalent to 90 000 Olympic-size swimming pools.

Construction of the Gardiner and Qu'Appelle dams cost $120 million. Their replacement cost is estimated at $1 billion.

The Gardiner Dam is 5 kilometres long, 64 meters high, and required 65, 000, 000 cubic meters of earthfill. (A Look at Lake Diefenbaker, Sask Water, 1998.)

Photos: D. Corkal, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration

The Gardiner Dam is located on the South Saskatchewan River. Construction was completed in 1967, and the dam remains one of the world's largest earthfill dams. The Gardiner Dam provides about 10 percent of Saskatchewan's power supply through Sask Power's Coteau Creek Generating Station. In addition to the dam's use in flood control, Lake Diefenbaker provides recreational facilities, industrial and agricultural water, and drinking water for about 45 percent of the province's population. Water levels are controlled from the spillway - which is more than a kilometer long, and can allow 7, 500 cubic meters of water to pass through it per second!

Flood Control & Water Level Regulation

Sask Water is responsible for the operation and maintenance of the Gardiner Dam. A big part of this responsibility is to monitor and forecast water levels at every place along the rivers that are affected by the Gardiner Dam. Water levels are affected not just by significant rainfall, but to a large extent by snow melt during the spring from the Rocky Mountains in Alberta. This water can take 9 days to travel to the Gardiner Dam. This is fortunate, because while the spillway can allow 7, 500 cubic meters of water to pass through it per second, this volume of water can cause damage downstream. Having accurate information in advance allows the operators to smooth out the impact during times when flooding could be a serious concern.

The Gardiner Dam is used also to mitigate the effects of drought. Because of the volume of Lake Diefenbaker, excess water can be stored and released evenly during years when spring snow melt and/or rainfall is below normal.

Coteau Creek Power Generation

Lake Diefenbaker is the reservoir for the water at the Coteau Creek power generating station. Water from the reservoir travels through a sluiceway to turbines that generate electricity *(Figure 5)*. The greater the difference in elevation between the water intake area and the turbine, the greater the energy the water has to turn the turbine.

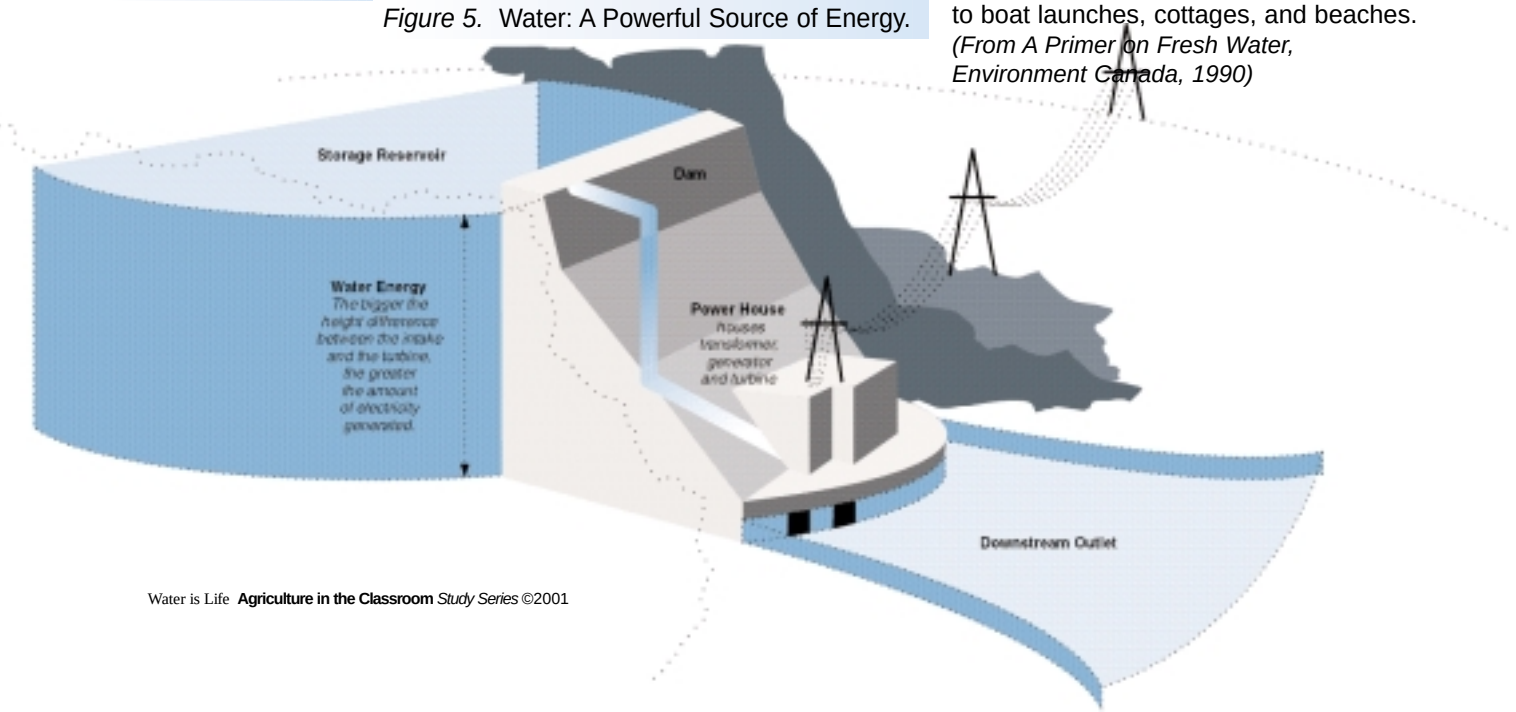
Wildlife - The Piping Plover

In addition to providing a habitat for a number of bird and game species, Lake Diefenbaker is home to the piping plover. This is one of the few places in North America where the plover lives. The piping plover was listed as an endangered species in 1985.

Recreation

Three Provincial Parks lie along the banks of Lake Diefenbaker - Danielson Provincial Park, Douglas Provincial Park, and Saskatchewan Landing Provincial Park - as do three regional parks. As a result, Lake Diefenbaker is home to boat launches, cottages, and beaches.
(From A Primer on Fresh Water, Environment Canada, 1990)

Figure 5. Water: A Powerful Source of Energy.



Water Dos & Don'ts

Everywhere

- Turn off taps tightly so they don't drip.
- Repair leaky faucets promptly.
- Use an aerator and/or a water-flow reducer in your sink faucets.

In the Kitchen

- Don't run water continuously when washing dishes or fruits and vegetables.
- Use dishwasher only on full loads.
- Boil vegetables in just enough water to cover them. Use a tightly fitting lid.
- Keep drinking water in your fridge to avoid running water until it's cold. Renew water every 2-3 days.

In the Bathroom

- Don't run water continuously when shaving or brushing teeth.
- Use low-flow or adjustable flow-reducer shower heads.
- Take short showers. Turn water off while you are soaping and shampooing.
- Showers take less water than baths, but when you bath avoid over-filling the tub.
- Use toilet-tank inserts to reduce the amount of water in the tank.
- Flush the toilet only when necessary. Don't use the toilet as a garbage can for disposing of cigarettes, paper tissues, etc.
- Check regularly for toilet tank leaks by putting a small amount of food colouring into the tank to see if it spreads to the bowl. Repair leaks promptly.
- Never flush garbage down the toilet. Cleaners, paint, solvents, pesticides, and other chemicals can harm the environment.
- Periodically record the water meter reading late at night and first thing in the morning to check for leakage. If there is, track it down and repair it promptly.

In the Laundry Room

- Only wash full loads.
- Use the shortest cycle possible. Use the suds saver feature if the machine has one.
- Use the water level that is most appropriate for your load.
- If you have a septic system, spread out the washing to avoid overloading the system.
- Use only cleaning products that won't harm the environment. Look for "environmentally friendly" products.
- Promptly repair leaks around taps, hoses, or fittings on your washer or laundry sink.

In the Yard

- Lawns and gardens require only 5 millimeters (mm) of water per day during warm weather. They require less during spring, fall, or cool weather.
- Water lawns every 3 to 5 days. Apply 5 mm for each day since the last watering (in warm weather).
- Measure the amount by placing a can in the area being sprinkled.
- Green grass does not need water. Water is required when the grass starts to develop a black tinge along the top.
- Do not over-water in anticipation of a shortage. Soil does not store extra water.
- Do not turn on sprinklers and leave for the day.
- Water during the cool part of the day - in the morning or evening. Do not water on windy days.
- Keep lawns at a height of 6.5 cm. Taller grass holds water better and chokes out weeds.
- Young or freshly transplanted garden plants need small quantities of water more frequently until established.
- Shrubs and young trees need water only once per week - even in warm weather.
- Wash your vehicle only when necessary.
- Clean sidewalks and driveways with a broom - not the hose.

Water Activities

The Chemistry of Water

The Tyndall Effect Demonstration - Why is Water Blue? When light passes through a clear fluid with suspended particles (like milk or dish soap), blue wavelengths are scattered more than red. From the side, light looks blue. Try this in your class and have the students try to explain the effect.

Subject	Level
Science	Middle and Secondary

Explore the unique chemical qualities of water. How do these qualities impact life on Earth?

Subject	Level
Science	Middle and Secondary

The Hydrologic Cycle

Make a diorama with moving parts to show the water cycle.

Subject	Level
Science	Elementary
Art	Elementary

Research the effect of acid rain on soil pH, and discuss methods of reducing the amount of acid rain. Refer to as many components of the hydrologic cycle as you can.

Subject	Level
Science	Middle and Secondary

Groundwater, Aquifers, Surface Water, & Wells

You are building a hog barn - a 150 sow operation! Write a proposal that includes where you will get your water, where you will dispose of the wastes, and what will be the environmental impact.

Subject	Level
Science	Middle and Secondary

You are a farmer who, for economic reasons, wants to drain 5 acres of wetland on your land. What steps will you take to accomplish this? Draw up an action plan. What rules and regulations must you follow? What government agencies do you need to contact?

Subject	Level
Science	Middle and Secondary
Social Studies	Middle and Secondary

Have the class bring in water samples from as many different sources as they can find. What are the conductivity and hardness measurements? Was the water treated? If not, where was it from? How do these readings correspond with hydrological maps of the province?

Subject	Level
Science	Middle and Secondary

How We Use Water

Brainstorm "The Uses of Water"

Subject	Level
Science	All Levels
Social Studies	All Levels

Water Quality

Using the Canadian Water Guidelines pamphlet, determine what components are important factors in your water source. What is being done at your treatment plant to treat the water? Which of the six treatment methods are being used? Which are not? Why?

Subject	Level
Science	Secondary

Discuss in small groups the following: Given three different sources of water (water from a mountain stream, tap water, or bottled water) which would you purchase? Give reasons for your selection.

Subject	Level
Science	Middle and Secondary

Research the topic: "How important is "safe" water for growing and washing fruits and vegetables?" What is "safe" in these circumstances?

Subject	Level
Science	Middle and Secondary
Food Studies	Middle and Secondary

Research the topic: "How important is "safe" water for raising livestock? What is "safe" in this circumstance? Does "unsafe" water affect the quality of meat, eggs, and dairy products?"

Subject	Level
Science	Middle and Secondary
Food Studies	Middle and Secondary

Research the effects of allowing livestock to drink directly from surface water sources.

Subject	Level
Science	Middle and Secondary
Food Studies	Middle and Secondary

Research the cost/process of various bottled waters. Decide on and perform tests that will be likely to show differences among the bottled waters, and from tap water.

Subject	Level
Science	Middle

Tour your local water treatment plant and your local sewage treatment plant. How is the water processed? What steps are taken to ensure that the drinking water is safe for consumption or waste water is acceptable for release back into the environment? Use a creative presentation format (posters, essays, interpretive dance, songs…)

Subject	Level
Science	All Levels

Create a chart comparing and contrasting the Buffalo Pound-Regina Water Treatment Plant, the Saskatoon Water Treatment Plant and a private in-house water treatment system for a farm.

Subject	Level
Science	Middle and Secondary

Using a jig-saw activity, investigate water-borne diseases. What are the symptoms? Where could the diseases have been contracted? What is/are the treatment(s)? What health precautions can be taken to avoid these infections? Have there been any outbreaks in your area?

Subject	Level
Science	Middle and Secondary

Compare and contrast the Canadian and American drinking water standards, and your municipal drinking water objectives.

Subject	Level
Science	Secondary

Operation Waterdrop is a hands-on water sampling lab from the Foundation for Safe Drinking Water. Operation Waterdrop comes complete with reagents and instructions for performing a number of water quality tests.

Subject	Level
Science	Middle and Secondary

How Water is Managed

Role play being ministers of the environment. Your task is to assess the current regulatory structure of water and suggest improvements/ changes to the current system.

Subject	Level
Science	Middle and Secondary

From Keepers of the Earth, Chapter 10,"Koluscap and the Water Monster", do the noise activity - Rain Noise. Read the story. Discuss the implications of good neighbours and water policy.

Subject	Level
Social Studies	All Levels
Science	All Levels
Native Studies	All Levels

Bottled Water Debate Topic: The government of Quebec should impose a moratorium on the water bottling industry. Students will research and prepare their debate according to the rules and regulations of the Saskatchewan Elocution and Debate Society. Hand out the article: "Water Bottling in Quebec - A case of competition" as background information to all students.
(From Health of Water, chapter 3. http://res2.agr.ca/research-recherche/science/healthy_water/epdf.html.)

Subject	Level
Science	Middle and Secondary
Social Studies	Middle and Secondary

Bottled Water Debate Topic: Should bottled water be regulated under the *Food and Drug Act*? As a class, brainstorm arguments for and against.

Subject	Level
Science	Middle and Secondary
Social Studies	Middle and Secondary

Trace your drinking water supply from source to end. Investigate possible sources of contamination along the way. What steps are taken to purify and decontaminate this water? Why?

Subject	Level
Science	Middle and Secondary

Debate Topic: Should Canada export its water?

Subject	Level
English Language Arts	Secondary
Social Studies	Secondary

Irrigation in Saskatchewan - A developing technology for sustainable agriculture

Investigate the different types of irrigation systems. Compare and contrast their advantages and disadvantages in chart format.

Subject	Level
Science	Middle and Secondary
Agriculture	Middle and Secondary

Research the topic: "Does using "unsafe" water for irrigation have an effect on the quality of food produced from crops that are irrigated?"

Subject	Level
Science	Middle and Secondary
Food Studies	Middle and Secondary

Contact a local area farmer or golf course, or anyone who irrigates for commercial reasons. Describe their irrigation practice. Include the purpose of the irrigation, results, water source, quality/characteristics of post-irrigation groundwater, and any other interesting facts about their irrigation. What are the advantages and disadvantages?

Subject	Level
Science	Secondary

On a Saskatchewan map, locate sites where irrigation is feasible. Explain how location and financial considerations influence feasibility.

Subject	Level
Science	Secondary
Geography	Secondary

Water Dos and Don’ts

Using "Water Do’s and Don’ts", construct and conduct a survey to find out how your community is doing in this area. Construct a graph to show your results. Example: When running the dishwasher, do you wash only full loads? Always, Sometimes, Rarely, Never?

Subject	Level
Math	Elementary and Middle

Resources

Environment Canada Publications may be copied freely with appropriate credit. These publications are available through the EC website
www2.ec.gc.ca/water/en/info/pubs/e_teach.htm
or by contacting the National Hydrology Research Institute publications coordinator in Saskatoon 306.975.4022

Books

Caduto, M.J. and J. Bruchac. (1988). ***Keepers of the Earth: Native American Stories and Environmental Activities for Children***. Goldon, CO: Fulcrum Press.

Department of National Health and Welfare Canada (now Health Canada). (1992). ***Guidelines for Canadian Recreational Water Quality***. Ottawa: Minister of Supply Services.

Environment Canada (1995). ***Canadian Water Quality Guidelines: Summary of Guidelines for Water Quality in Canada***. Ottawa: Minister of Supply and Services.

Environment Canada (1992). ***From the Mountains to the Sea: A Journey in Environmental Citizenship***. Ottawa: Minister of Supply and Services.

Health Canada. (1996) ***Guidelines for Canadian Drinking Water Quality***. Ottawa: Minister of Supply Services.

Websites - Information and Activities

City of Regina Water Treatment Information
www.cityregina.com/content/info_services/water_sewer/index.shtml
Includes information on water supply, FAQs, the sewer system, water conservation, and water quality data.

City of Saskatoon Water Treatment Information
www.city.saskatoon.sk.ca/org/water_treatment/index.asp
Includes information on current issues, water quality, FAQs, process and policy, and water facts.

Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration
www.agr.gc.ca/pfra/water/wqualite.htm
Rural water quality information, flash pages, fact sheets, and agricultural water quality references.

Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration - Effects of Aeration on a Dugout
www.agr.gc.ca/pfra/water/aerate/dugout.htm
A flash page and accompanying text that explains the effects of aeration on water quality – specifically in a dugout.

Ducks Unlimited Canada
www.ducks.org
Greenwings (www.ducks.org/puddler/greenwings/home3.htm)
is the kids' activity section of the website. There is also a teacher's resource page (www.ducks.org/ puddler/greenwings/activity/teachersdirectory.htm)
you need to register in order to download PDF files of prepared units.

Environmental Protection Agency (USA) - Activities for Kids
www.epa.gov/safewater/kids/games.html
The US Environmental Protection Agency site for kids! Topics include water filtration, the water cycle, water myths and realities, FAQ, water facts of life, and the decision-making process for drinking water.

Environmental Protection Agency (USA) - Educational Publications on Water
www.epa.gov/safewater/Pubs/kids.html
The US Environmental Protection Agency site for kids & teachers! Documents are available for order, through ERIC, or for downloading. Topics include drinking water activities, build your own aquifer or water shed, non-point source pollution, demo projects, activity sheets, posters.

Environmental Protection Agency (USA) - Publication Index
www.epa.gov/safewater/pubs/index.html
The US Environmental Protection Agency site for publications! Publications on/for: general drinking water information, kids & teachers, drinking water standards, protection of drinking water sources. More background information on water issues can be found here.

Environment Canada - Fresh Water Site
www.ec.gc.ca/water
This site has a lot of background information on many aspects of water. Topics include: The Nature of Water, Water Policy & Legislation, The Management of Water, Water & Culture, and Informational Resources & Services. The Teachers' Corner includes resources and activities pertaining to water issues. Free booklets, posters, and activities!

Environment Canada - Explore Water Activity Book
www2.ec.gc.ca/water/en/info/pubs/e_teach.htm
The Explore Water Activity book is available on-line at the Teacher's corner of Environment Canada's water site as a PDF. Recommended Elementary activities: Water is our best friend, The water cycle at work, Simple water science, Red celery, I can save water, Why is Holly Heron sad, Colour the 8 ways we use treated water, and Clean water for life outline aspects of the hydrologic cycle and water uses.

Environment Canada - From the Mountains to the Sea
www2.ec.gc.ca/water/en/info/pubs/e_teach.htm
This is a resource from which selected activities could be used.

Environment Canada - Getting Environmental Results on Clean Water
www.ec.gc.ca/envpriorities/cleanwater_e.htm
A summary of water and pollutants from the environment. Links provide more i nformation.

Foundation for Safe Drinking Water - Operation Waterdrop
www.safewater.org/waterdrop/waterdrop.html*Test your water using the Foundation for Safe Drinking Water's Operation Water Drop. All inclusive kit is available. A donation is required.*

Health Canada - Canadian Drinking Water Quality Guidelines
www.hc-sc.gc.ca/ehp/ehd/bch/water_quality/dwguide.htm
A summary of the Canadian Drinking Water Quality Guidelines can be down loaded from this site.

Health Canada - Bottled Water Questions and Answers
www.hc-sc.gc.ca/food-aliment/english/organization/microbial_hazards/faqs_bottle_water_eng.html#A5
Questions about bottled water regulations and safety issues.

Health Canada - Information on Giardia and Cryptosporidium
www.hc-sc.gc.ca/ehp/ehd/catalogue/general/iyh/giardia.htm
What are Giardia and Cryptosporidium? How do these parasites cause illness? What are the symptoms? How can drinking water become contaminated with these parasites? Have these parasites been found in Canadian drinking water supplies? How can these waterborne illnesses be prevented? How are these infections treated? What extra precautions can immunocompromised people take? What should you tell your physician? What is Health Canada doing to ensure the safety of our drinking water? This site last updated in 1996!

Partners FOR the Saskatchewan River Basin - Water Watchdog
www.saskriverbasin.ca
The Water Watchdog program is run by this organization. The program is geared for those between the ages of 7 and 14. The website has information on the program (attached) as well as an area to post your results, a Fun Stuff area, and water facts. Kids (and adults!) can calcu late their water "footprint" as well as deter mine whether their home is leak-free.

Prairie Water News
www.quantumlynx.com/water
Prairie Water News is a semi-annual publication of articles relevant to water quality on the Canadian Prairies. Excellent reference for many current topics on water!

Project WET
www.projectwet.org and www.saskwater.com/htdocs/educatn/wet.htm
The Kids' Activity section has an animated Water Festival game that covers the water cycle, % water of living organisms, ground water, water detective game for finding water wasting activities, matching animals with their habitats, a story, and some activities to do at home. In Saskatchewan, Project WET is delivered by Sask Water.

Saskatchewan Environment and Resource Management – Municipal Drinking Water Objectives
www.serm.gov.sk.ca/environment/protection/MDWQO.htm
A summary of the various levels of components allowed in the water, along with explanations of terms.

Saskatchewan Water Corporation
www.saskwater.com
Information about water levels and flows, Sask Water program descriptions, and an educational section on treatment plants, Lake Diefenbaker (Gardiner Dam), conservation and more.

University of Minnesota
www1.umn.edu/bellmuse/mnideals/watershed/watershed2.html
An educational site sponsored by the University of Minnesota. By playing the Watershed Game, students will learn how to manage watersheds and see what their impact will be. Good resource for Elementary and Middle Years.

Water and Me - New Orleans Elementary Science Program
www.monroe2boces.org/shared/esp/waterresource.htm
This page has information on: water treatment, making a model of a water filter, the importance of waste water treatment, and links to stuff on water and water conservation. Good resource for Elementary and Middle Years.

Water Water Everywhere - Singapore Think Quest Junior
http://thinkquestjr.moe.edu.sg/~tqj2156/
Think Quest Junior sponsors 9-11 year olds to produce websites for learning. This site was developed through this program. For a good introduction to the water cycle and water properties, uses, treatment problems, puzzles, quizzes, and experiments, this animated site entertains the students as they learn. Good resource for Elementary and Middle Years.

References

A Look at…Lake Diefenbaker. (1998) Sask Water.

Environment Canada (1992). *Clean Water - Life Depends on It.* Ottawa: Minister of Supply and Services.

Environment Canada (1992). *Groundwater - Nature's Hidden Treasure*. Ottawa: Minister of Supply and Services.

Environment Canada (1992). *Water - Nature's Magician*. Ottawa: Minister of Supply and Services.

Environment Canada (1993). *Water Works!* Ottawa: Minister of Supply and Services.

Environment Canada (1990). *A Primer on Fresh Water*. Ottawa: Minister of Supply and Services.

Fetter, C.W. (1994). *Applied Hydrogeology, 3rd Edition.* Upper Saddle River, NJ: Prentice Hall.

Harper, D.B. (1998). *A Prairie-wide Perspective of Non-point Agricultural Effects on Water Quality*. Regina: Prairie Farm Rehabilitation Administration.

Nolin, M.C. (2000). *Water Bottling in Quebec – a case of competition*. Ottawa, ON: The Health of our Water, Chapter 3. Retrieved July 21, 2001 from the World Wide Web: res2.agr.ca/research-recherche/science/Healthy_Water/e03d.html

Perry, J. and E. Vanderklein. (1996). *Water Quality: Management of a Natural Resource.* J. Lemons, Editor. Cambridge, MA: Blackwell Science.

Skipton, S. and D. Hay. (1998) *Drinking Water: Nitrate and Methemoglobinemia ("Blue Baby" Syndrome)*. Lincoln NB: University of Nebraska Extension Division. Retrieved July 21, 2001 from the World Wide Web: http://www.ianr.unl.edu/PUBS/water/g1369.htm

Questions and Answers on Bottled Water. (2000). Ottawa, ON: Health Canada. Retrieved July 21, 2001 from the World Wide Web: http://www.hc-sc.gc.ca/food-aliment/english/organization/microbial_hazards/faqs_bottle_water_eng.html#A5

Water For All. (2001). Regina, SK: Saskatchewan Water Corporation. Retrieved August 1, 2001 from the World Wide Web: http://www.saskwater.com/htdocs/educatn/waterall.htm

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