INTRODUCTION

Groundwater accounts for the majority of the world's useable freshwater. It is an important source of water for many municipalities and industries, and for irrigation, suburban homes, and farms. Saskatchewan has about 60,000 water wells, providing water for municipalities, agriculture, industry and domestic needs.

As with any natural resource, groundwater supplies are not unlimited. They must be wisely managed and protected against undue exploitation and influence by contaminants. This guide is intended to provide domestic water well owners with a brief overview of groundwater, well construction, well management, and well decommissioning.

CHAPTER 1

Groundwater

What is Groundwater?

Groundwater is an important part of the earth's water cycle. Water continuously circulates between land, air and ocean in the form of rain, snow, water vapour, surface water and groundwater. Groundwater starts off as surface water or precipitation and enters the ground through areas generally referred to as **recharge areas**.

Groundwater is water that occurs beneath the ground surface in the cracks and void spaces in soil, sand and rock. The area where water completely fills the pore spaces is called the **saturated zone**. The top of the saturated zone is the **water table**. Between the water table and the ground surface, some of the pore spaces are not completely filled with water, and this gives rise to the term **unsaturated zone**.

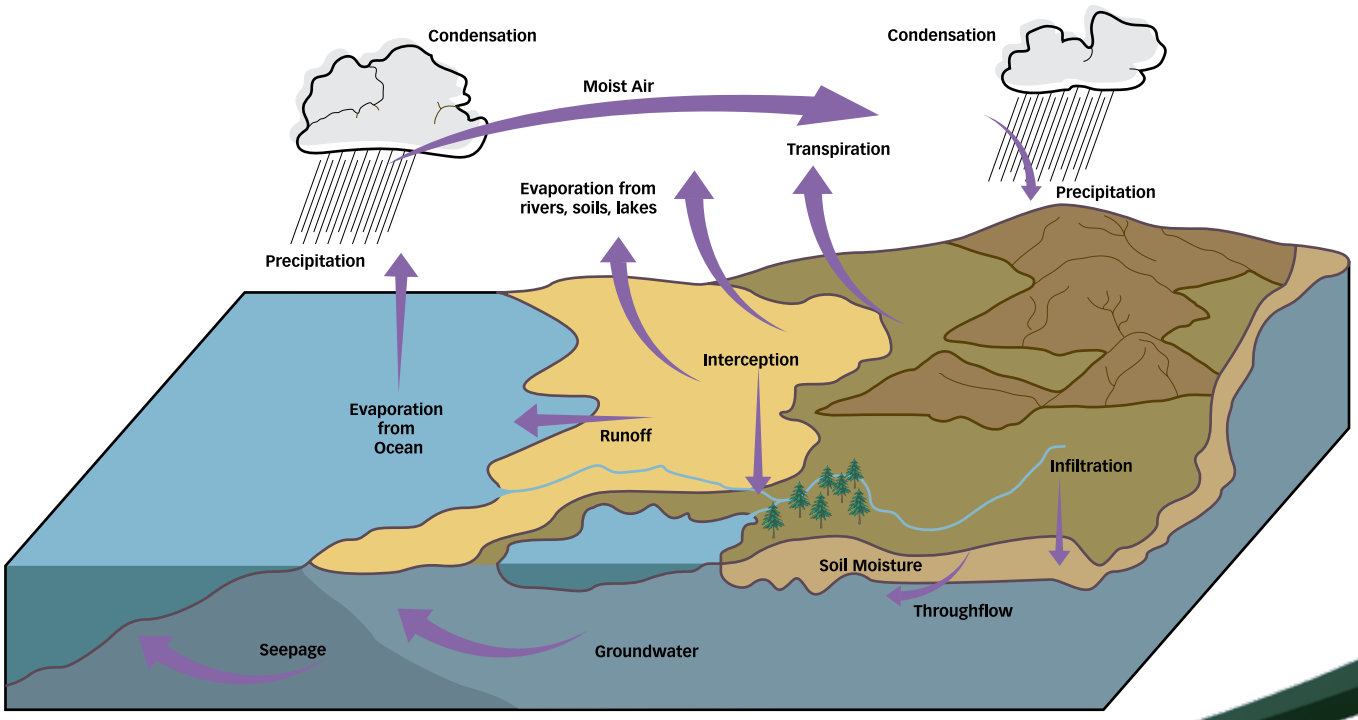

Figure 1: The Hydrological Cycle

Aquifers and Aquitards

Rock or soil that is completely saturated with water can be classified into two categories:

- Aquifers
- Aquitards

Aquifers are formations from which water can be removed economically. Although water moves through an aquifer, it is not an underground river. Typically, aquifers are made up of sediments with relatively large and connected pore spaces that permit water movement. Aquifers are most commonly composed of sands and gravels, but in some areas may be formed by cracked or fractured coal or shale.

Aquifers can be overlain or underlain by confining layers (**aquitards**), which are soil and rock formations like clays and silts that permit slower movement of groundwater. Although these materials can be saturated with groundwater, they are not able to yield sufficient water to a well. Flow within aquitards is limited within small areas, but regionally they may transmit significant volumes of water. Aquitards can therefore significantly affect the flow and quality of groundwater because they influence recharge and the flow between aquifers.

Confined and Unconfined Aquifers

Unconfined aquifers are often called water table aquifers, as their upper boundary is the water table. An unconfined aquifer does not have a confining layer (an aquitard) between it and the surface, so groundwater levels are free to rise or fall with changes in recharge and discharge, as well as barometric pressure. The volume of water in an unconfined aquifer is mainly dependent on recharge, and tends to vary seasonally. Typically, groundwater levels will be at their highest following spring snowmelt.

Confined aquifers occur when groundwater is restricted under pressure by an overlying confining layer. If a well penetrates a confined aquifer, the water level in the well will rise above the top of the aquifer. Confined aquifers are also known as **artesian aquifers**. If the pressure in the aquifer causes the water level in the well to reach the ground surface, it is called a **flowing artesian well**.

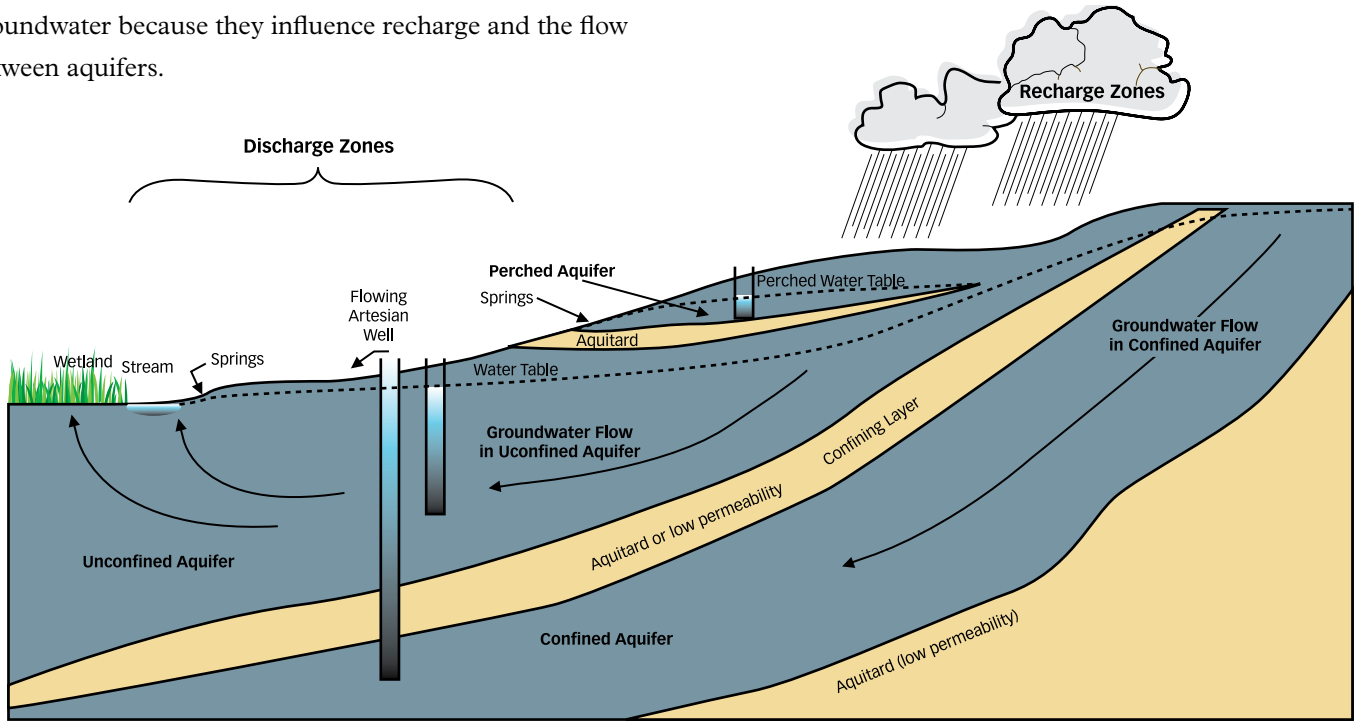

Figure 2: Aquifers and Aquitards

Groundwater Recharge

Recharge is the process by which groundwater is replenished. Groundwater can be recharged both by precipitation moving down through the soil and rock layers of the ground and by infiltration from surface water sources such as rivers and lakes. Springs and seeps are **discharge areas** where groundwater leaves the aquifer and flows to the surface. This discharge can represent a significant portion of the input water to a surface water source and can affect its quality. Therefore, groundwater's natural recharge and quality, and consequently surface water's quality, can be affected by human activities on the surface.

Aquifers of Saskatchewan

There are two main types of aquifers in Saskatchewan:

- Bedrock Aquifers
- Quaternary Aquifers

Bedrock aquifers in Saskatchewan are usually composed of sandstone, but in some limited areas they may also be formed by fractured shale or coal. They tend to be found at depths in excess of 100 metres, but in some areas may be encountered at much more shallow depths. They are usually overlain by thick, low permeability aquitards. For this reason, groundwater levels in bedrock aquifers tend not to fluctuate significantly with short-term variations in surface moisture conditions. Major bedrock aquifers in Saskatchewan include the Judith River formation and the Eastend to Ravenscrag formations.

Quaternary aquifers are defined as the aquifers occurring between the bedrock surface and the ground surface. In Saskatchewan, they are composed of gravels, sands and silts. These aquifers vary greatly in size, in some cases being adequate only for limited domestic use, while in other cases being able to provide sufficient supplies for large-scale industrial and municipal use. Quaternary aquifers are the most common groundwater source in Saskatchewan.

Types of Quaternary Aquifers

Buried valley aquifers are preglacial valleys cut into bedrock sediments that contain extensive thicknesses of coarse sand and gravel deposits. Major buried valley aquifers in Saskatchewan include the Hatfield Valley and Tyner Valley aquifers. These types of aquifers are capable of supporting high-yielding wells.

Blanket aquifers are usually quite large and consist of gravels, silts and tills. The main blanket aquifers in Saskatchewan include the Pathlow, Meacham and Wynyard-Melville aquifers.

Intertill aquifers are composed of glacial gravels, sands, and silts positioned between layers of till. These aquifers are extremely variable in size and productive capacity. They are found throughout southern Saskatchewan, with some of the major ones located around Regina and Saskatoon. These aquifers are probably the most common groundwater source in the province, providing the supply for many domestic, municipal and industrial users.

Surficial aquifers are composed of stratified deposits of sand, gravel, silt and clay, and occur at, or very near, the surface. They are located throughout southern Saskatchewan and vary greatly in size. These aquifers are generally low-yielding and only provide enough water for domestic supplies. Moreover, when these shallow aquifers are not insulated from the ground surface by an appreciable thickness of aquitard, they can show seasonal changes in water level and can be sensitive to drought.

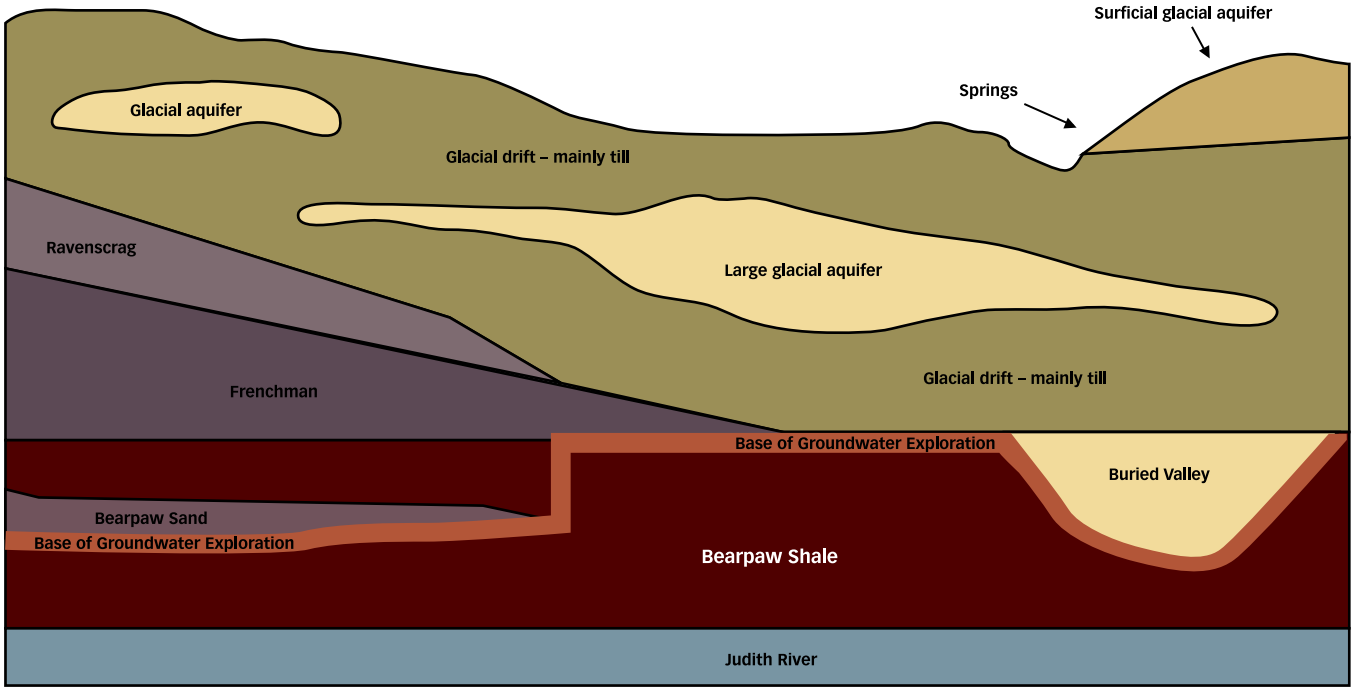

Figure 3: A sample cross-section of Quaternary Formations in southern Saskatchewan

Well Yields in Saskatchewan

For domestic uses, wells should ideally produce water at a rate of 0.375-0.75 litres per second (5-10 gallons per minute). If wells produce less than 0.375 L/s (5 gpm) for a one-hour peak use period, then additional storage in the form of a tank or cistern might be necessary. It should be noted, however, that with proper design, many farms can obtain an adequate supply from a well capable of producing only 0.075 L/s or 0.15 L/s (1 or 2 gpm). In the case of farms where a higher quantity of water is required, a well should be capable of providing a minimum of 0.75 L/s (10 gpm) for at least two continuous hours.

Well yields in Saskatchewan are highly variable. Buried valley aquifers and some of the large intertill aquifers may have yields of several hundred gallons per minute. Bedrock aquifers and small quaternary aquifers will have relatively low yields, often sufficient only for domestic purposes. Bedrock aquifers rarely yield more than ten gallons per minute. Well yields depend on a number of factors, but in general aquifer thickness and the characteristics of the aquifer material are the main influences on well yields. For example, a well completed in an aquifer formed by well-sorted gravel will have a higher yield than a well completed in an aquifer formed by very fine silty sand of similar thickness.

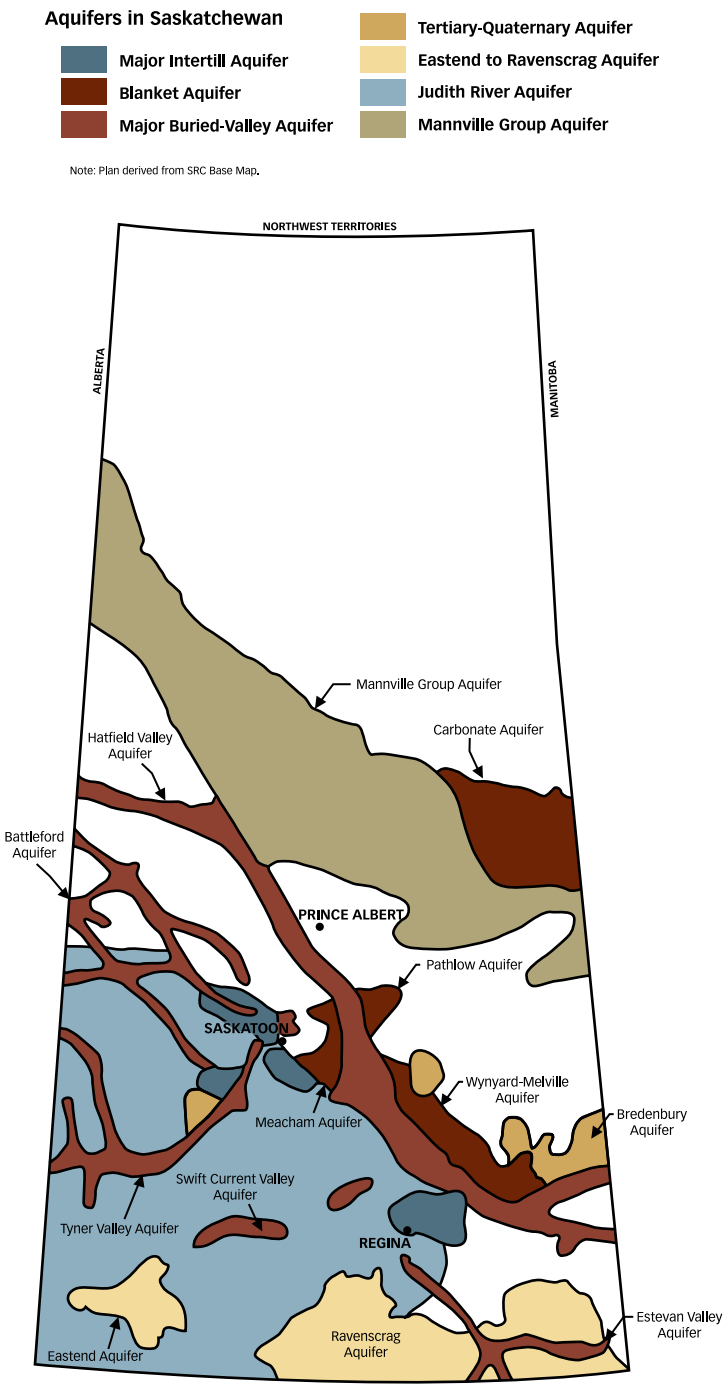

Figure 4: Aquifers of Saskatchewan

Groundwater Quality in Saskatchewan

Groundwater is an important source of domestic and drinking water in rural Saskatchewan. Groundwater supplies in Saskatchewan are highly mineralized, and can include sulphate, sodium, chloride, calcium, magnesium, bicarbonate and carbonate. The quantity of dissolved minerals and the type of ions dissolved in the water are primarily dependent on the type of rock and soil that the water comes into contact with as it infiltrates the soil. Groundwater quality in Saskatchewan is quite variable, but in general, deep aquifers tend to have higher total dissolved solid levels than shallow aquifers. However, shallow aquifers are more susceptible to contamination from local land use activities, and can be vulnerable to nitrate and microbial contamination.

Three trace elements (arsenic, selenium, and uranium) have also been found at above maximum acceptable concentrations for drinking water in a significant number of groundwater supplies throughout the province. While these elements are believed to be naturally occurring, they should be incorporated into the regular testing of groundwater supplies.

Unfortunately, most groundwater supplies in Saskatchewan do not meet Canadian Drinking Water Quality Guidelines. Most commonly, they exceed guidelines for aesthetic parameters such as total dissolved solids, hardness, and levels of iron and manganese. Of greater concern is the frequency in which the water from domestic wells exceeds health-related parameters such as bacteria, nitrate, arsenic, selenium and uranium. Some studies have shown that up to 99% of domestic wells sampled exceeded a health or aesthetic parameter, and 35% or more exceeded one or more health parameters. Despite the relatively poor quality of groundwater, in most cases the water can be treated to meet a satisfactory quality level. For this reason, it is very important that well owners regularly test their water supplies to identify any quality issues, and either take appropriate treatment actions to make it safe for its intended use or locate an alternate water source for consumption.

Natural Factors Affecting Groundwater Quality

By understanding the factors that affect groundwater quality, landowners can manage their farms and wells in order to avoid water contamination. There are several factors that affect groundwater quality:

- Depth from surface
- Permeability of sediments
- Climatic variations

Depth from Surface

Water is the world's most abundant natural solvent. Therefore, as it moves through the ground it dissolves minerals. These minerals are known as the Total Dissolved Solids (TDS) present in the water. In a shallow aquifer the water has a shorter distance to travel through the ground, and therefore tends to have a lower level of mineralization. Conversely, deeper aquifers tend to contain more dissolved solids. Shallow aquifers, however, are more susceptible to contamination from local land use activities, and can be vulnerable to nitrate and microbial contamination.

Permeability of Sediments

The amount of water that moves through the unsaturated zone is an important determinant of the extent of groundwater mineralization. Groundwater moves slowly through sediments with a low permeability, such as clay and silt. This slow movement allows more time for minerals to dissolve. Sediments with high permeability such as sand and gravel, on the other hand, allow groundwater to move through them more quickly. This results in a lower level of dissolved minerals.

Climatic Variations

Climatic variations such as rainfall and evaporation can affect groundwater quality. In semi-arid regions where discharging groundwater evaporates, precipitation infiltrating through the soil can re-dissolve salts and carry them back to the groundwater. In areas with higher precipitation and lower evaporation, precipitation reaching the groundwater is less mineralized.