A Landowner's Guide to

Water Well Management

Saskatchewan Watershed Authority

Saskatchewan Ministry of Agriculture

Saskatchewan Ground Water Association

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Landowner Review

We are extremely grateful to those landowners who provided us with their comments and feedback on this document. Your input was vital to ensuring that this guide provides the information landowners need to manage their water wells and be good stewards of our groundwater resources.

Sources of Information

We acknowledge the following sources of information which were used extensively in the preparation of this guide: B. Buchanan et al.'s *Water Wells… That Last for Generations*; F.G. Driscoll's *Groundwater and Wells*; and the Saskatchewan Ministry of Agriculture's *The Saskatchewan Environmental Farm Plan*.

We also acknowledge the following sources for the use of pictures and/or diagrams: Alberta Agriculture and Food, Centre for Ecology and Hydrology; the Natural Environment Research Council; F.G. Driscoll's *Groundwater and Wells*; Environment Canada; GlobalSecurity.org; the Idaho Museum of Natural History; Agriculture and Agri-Food Canada - Agri-Environment Services Branch; quantumlynx.com; the United States Department of Agriculture: Natural Resources Conservation Service; and the US Environmental Protection Agency.

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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**.

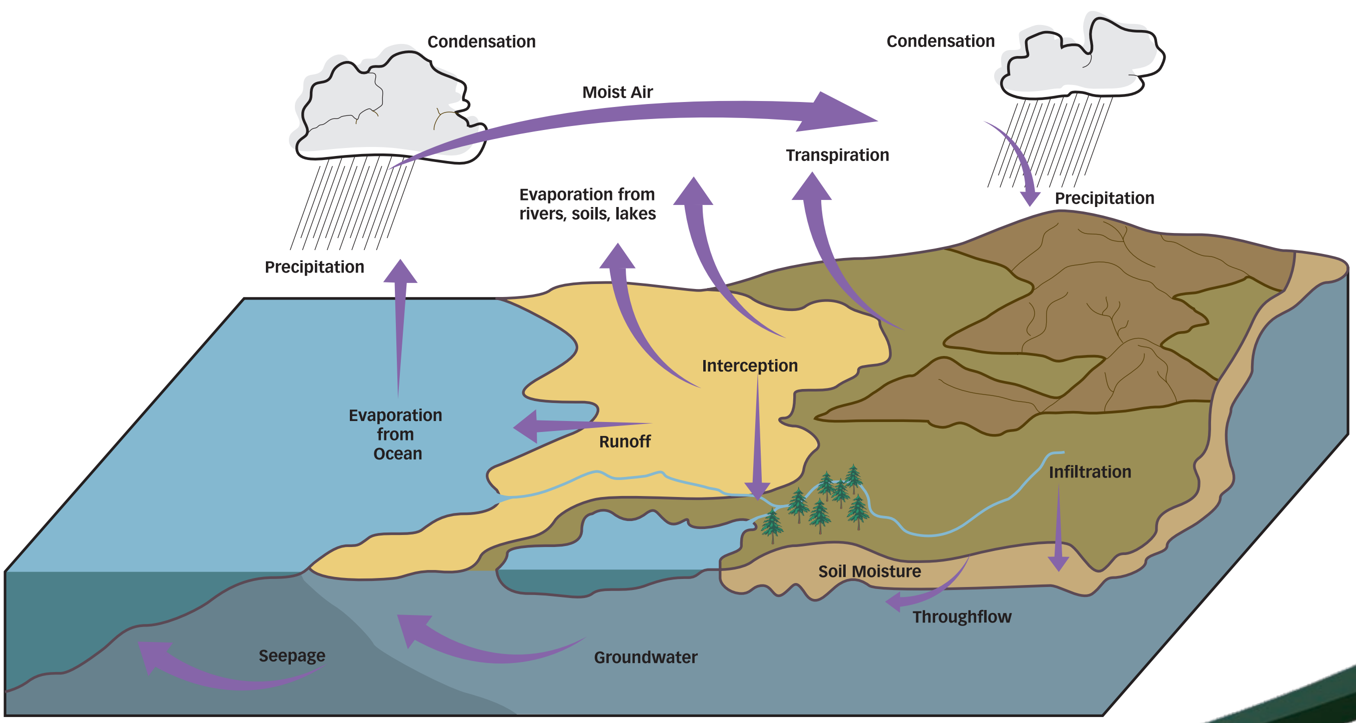

Figure 1: The Hydrological Cycle

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**.

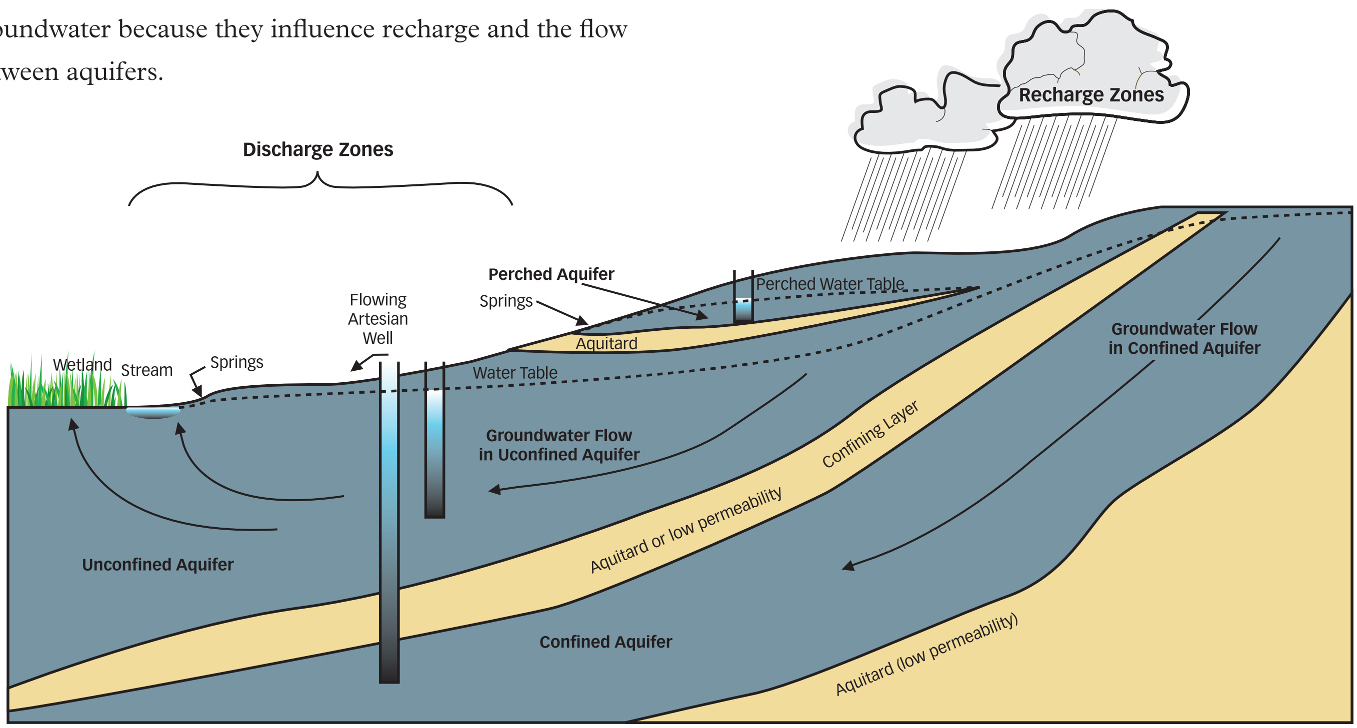

Figure 2: Aquifers and Aquitards

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.

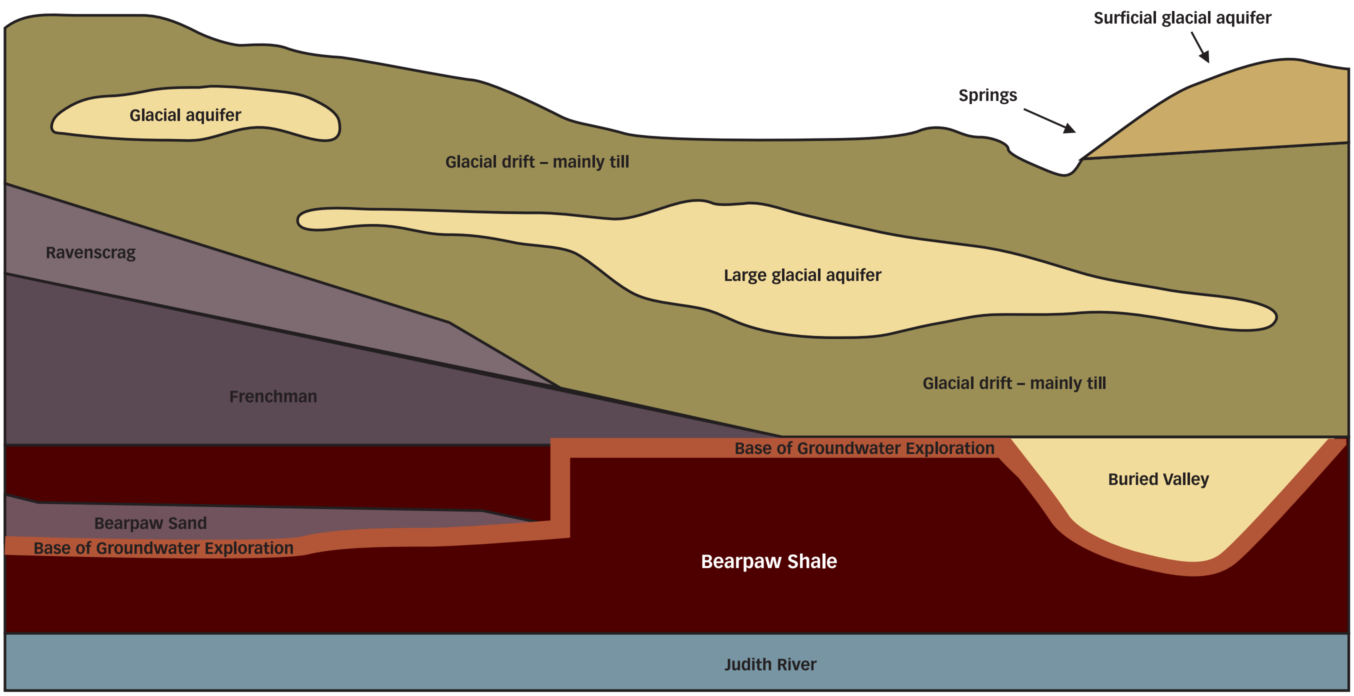

Figure 3: A sample cross-section of Quaternary Formations in southern Saskatchewan

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.

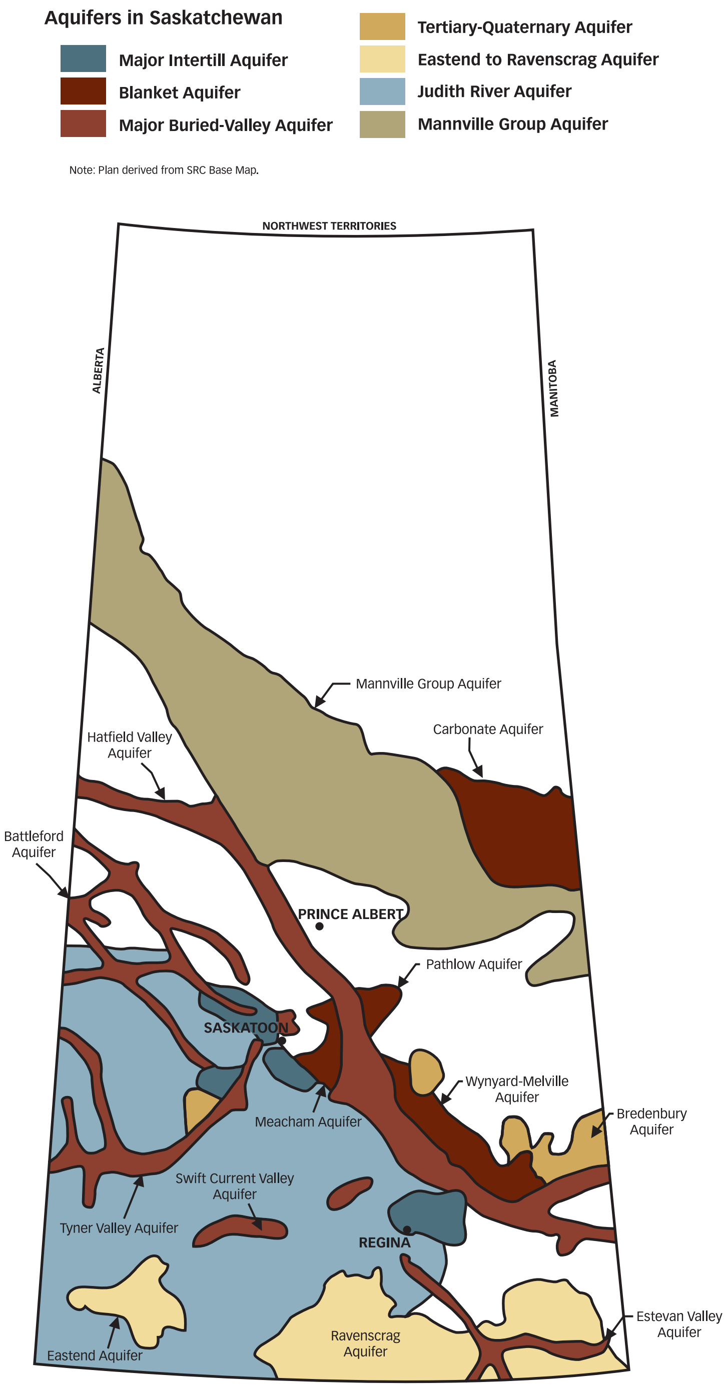

Figure 4: Aquifers of Saskatchewan

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 with 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.

Water Well Development

Proper well development is an important part of groundwater protection, as water wells can provide a direct path for contaminants to reach groundwater. It is important to properly plan and maintain water well systems in order to avoid contamination, protect aquifers from depletion, and ensure supply.

Planning Water Systems

A water system includes:

- Water sources
- Pumps
- Distribution systems including pipelines, automatic waterers, hydrants and home plumbing
- Water treatment equipment

Before beginning well construction, it is important to determine the amount of water available from current on-farm water sources, the potential available groundwater if a new well is drilled, the water quality of all sources, and all of the potential uses of the water. Water requirements should be established and provisions should be made for any changes that might occur in the near future.

Water Sources

The Saskatchewan Watershed Authority can be consulted for information on aquifers in the province (please refer to page 55 for contact information). This information can help people determine the potential groundwater supply at a given site. Information can also be gained from discussions with nearby well owners and certified well drillers.

After the completion of a test hole, a water well driller may use an electric logging device to E-log the test hole. An E-log can only be run in an uncased hole filled with drilling fluid. The E-log assists the driller in interpreting the formation characteristics of the test hole. It provides information on the depth, character of material, and relative quality of water in the formation.

Sizing the Water Supply

Water Requirements

It is important to determine the amount of water required before beginning to drill a well. An inventory must be taken of all current and future water needs, as well as all water sources available.

The following table provides average daily water requirements for both household and livestock use. These values can be added to other water uses, such as lawn watering, to determine total water need. It must be noted, however, that the quantity of water that livestock will consume depends on a number of physiological and environmental factors, such as:

- Type and size of animal
- Physiological state of animal (lactating, pregnant or growing)
- Activity level (more active animals require more water)
- Type of diet and amount consumed (dry hay, silage or lush pasture)
- Temperature (hot days will increase water consumption)
- Water quality (palatability and salt content)
- Ease of access (livestock will consume less if access to the water source is difficult)

Average Daily Water Requirements (LPD = litres per day , GPD = gallons per day)			
The following values can be compared to the average household use of 270 LPD/person and 60 GPD/person.			
Type of Animal	**Description**	**LPD**	**GPD**
Beef			
Cow with calf *	590 kg (1,300 lb)	54	12
Dry cow/mature cow *	590 kg (1,300 lb)	45	10
Calf *	115 kg (250 lb)	9-13.5	2-3
Feeder – growing **	180 – 360 kg (400 – 800 lb)	18-45	4-10
Feeder – finishing **	270 – 540 kg (600 – 1,200 lb)	45-81	10-18
Bull		36-54	8-12
Dairy			
Milking * (with wash water)	Holstein	135-162	30-36
Dry cow/replacement	Holstein	45-54	10-12
Calf	To 250 kg (To 550 lb)	13.5-16	3-3.5
Sheep and Goats			
Ewe/doe		9-11	2-2.5
Milking ewe/doe		9-16	2-3.5
Feeder lamb/kid		7-9	1.5-2
Bison, Horse, Mule		36-54	8-12
Swine (with wash water)			
Farrow – finish		91-108 / sow	20-24 / sow
Farrow – late wean	23 kg (50 lb)	29-36 / sow	6.5-8 / sow
Farrow – early wean	7 kg (15 lb)	25-29 / sow	5.5-6.5 / sow
Feeder	23 – 115 kg (50 –250 lb)	7-9 / pig	1.5-2 / pig
Weaner	7 – 23 kg (15 – 50 lb)	2-3 / pig	0.5-0.6 / pig
Poultry			
Broiler	Per 100	16-19	3.5-4.2
Roaster/pullet	Per 100	18-21.6	4-4.8
Layer	Per 100	25-29	5.5-6.5
Breeder	Per 100	31.5-38	7-8.5
Turkey – grower	Per 100	58.5-70	13-15.5
Turkey – heavy	Per 100	72-85.5	16-19
Ostrich		4.5-5.4	1-1.2
Deer, llama, alpaca		9-11	2-2.5
Elk, donkey		22.5-27	5-6

* For peak water use on days above 25°C multiply lpd/gdp by 1.5

** For peak water use on days above 25°C multiply lpd/gdp by 2

Peak Use Rates of Water System Fixtures	
Water System Fixtures	**Peak Use Rates**
Automatic cattle waterers (100-head size)	0.15 L/s (2 gpm)
Hog nipple waterer	0.075 L/s (1 gpm)
Poultry Fountain	0.075 L/s (1 gpm)
Yard hydrants	0.375 L/s (5 gpm)
Household	0.375-0.75 L/s (5-10 gpm)

Water Sources

It is important to determine whether the available water sources are sufficient to meet both the average water requirements as well as peak demand days throughout the year. The production rates, storage volumes, and water quality and quantity should be examined for each source. This will determine whether there will be sufficient water available to meet all requirements.

When determining the design flow rate of the system, one should consider the number and type of plumbing fixtures and the probable water demand for any facilities serviced by the system. This process will always result in a flow rate that exceeds the peak use rate of the fixture that uses the largest amount of water. If a well does not provide sufficient water to meet peak water demand needs, a storage facility such as a cistern will have to be installed.

Well Siting

The location of a well can greatly affect its quality and performance. The contractor and well owner should choose a well site that will minimize the risk of contamination. Any future land use developments for the site should also be taken into consideration. The following criteria should also be considered:

- A well should be accessible for testing, monitoring, maintenance and repair.
- The well location should adhere to provincial regulations in respect to setback distances from road allowances, municipal roads, highways, overhead power lines and underground utilities.
- The well should be located away from potential sources of contamination, including homes, equipment sheds, barns, livestock shelters and yards, manure lagoons, compost sites, surface water impoundments, runoff ditches, and pesticide, petroleum and fertilizer storage facilities.
- A well should be upslope from potential contamination sources, particularly when it is in close proximity to stressors such as sewage drainage fields, gasoline stations, farm feedlots, or landfill sites.
- A well should not be located in the basement of any building or in a pit.
- A well located in a building should be properly vented to the outside. A vent will allow air pressure between the inside of the casing and the atmosphere to equalize, and allows the release of unpleasant or dangerous gases. Vents must be screened or protected to prevent undesirable materials, insects and small animals from entering the well.

It is important to remember that locating a well the minimum distances from possible sources of contamination will not necessarily provide the protection that is needed. This is due to numerous factors that vary from site to site. These factors can include the nature and source of contamination, the topography, the nature of the aquifer, the thickness of overlying impermeable beds, the nature of the groundwater flow system, the potential for dilution of the contaminant, and other geologic and hydrologic factors. For example, in sandy environments where there is a high risk of contamination, the well should be located upslope and as far away as possible from contaminants. Therefore, wells should be located up-gradient of contamination sources, and the distances between wells and these sources should be maximized.

Saskatchewan Onsite Wastewater Disposal Guide Set Back Requirements*
• Septic tanks, package sewage treatment plants, or holding tanks should be located no less than **9 m** from a water source.
• Absorption fields, chamber systems, and mounds should be located no less than **15 m** from a water source.
• Open discharge systems and jet-type disposals should be located no less than **45 m** from a water source.
• Private sewage lagoons should be located no less than **90 m** from a water source.

* These guidelines apply only to private sewage works that are regulated by *The Plumbing and Drainage Regulations*. Municipal sewage works and industrial effluent works that have a design flow of effluent that is greater than 18 cubic metres per 24-hour period are regulated under *The Water Regulations, 2002*.

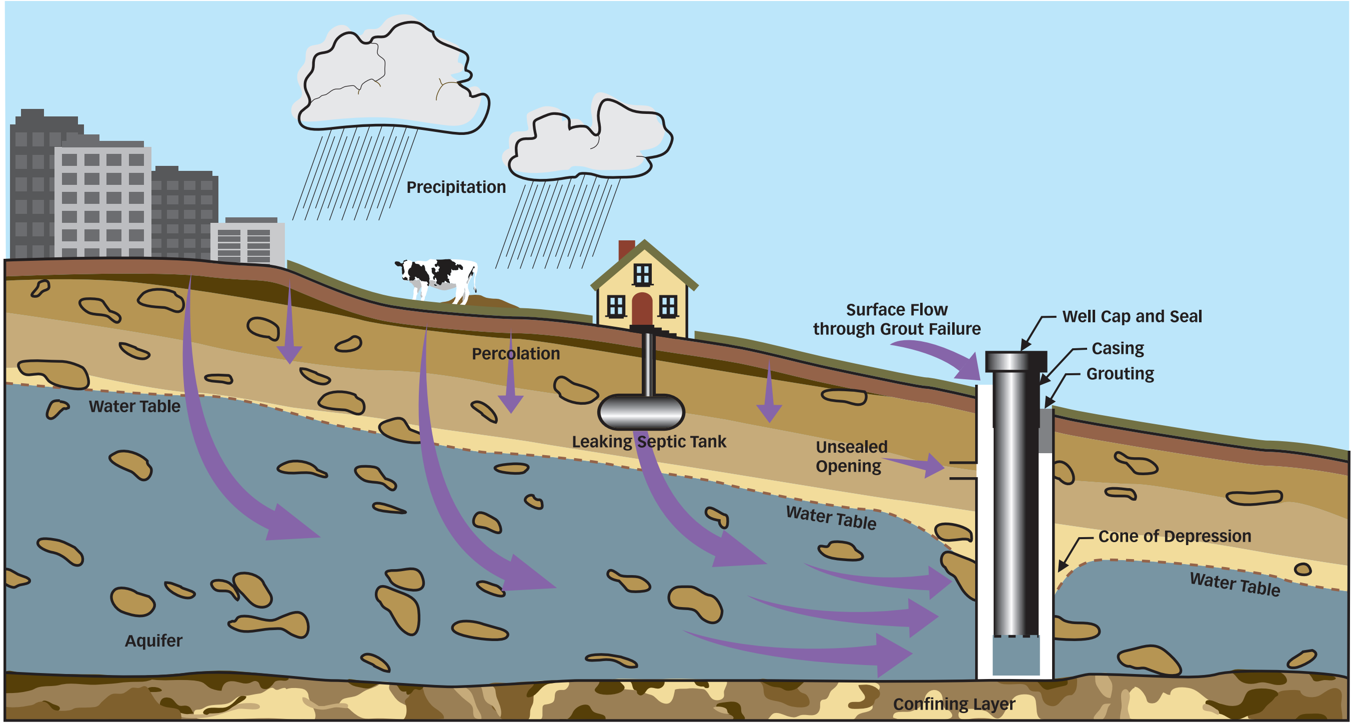

Figure 5: Groundwater Contamination Sources

Design and Construction of Water Wells

Well Design

Well design and construction details are determined after a test hole has been completed and the subsurface zones have been logged. A well driller will then be able to decide on the following design details:

- Well depth
- Type of well
- Casing size and type
- Intake design
- Annulus seal

Figure 6: Testhole Logging

Well Depth

The quality and quantity of water from a well depends on the geology and the hydrogeology of the area. Previous test holes and water wells may provide information on the groundwater potential in an area. The drilling contractor will drill a test hole and take soil and rock samples at various depths. Some contractors will also run an electric or gamma-ray log in the test hole to provide additional information on the geology of the site. This allows for the identification of the aquifers with the best potential for water supply. Wells are usually completed to the part of the aquifer that will yield the greatest quantity of water.

Figure 7: Well Drilling *(Courtesy of Agriculture and Agri-Food Canada – Agri-Environment Services Branch)*

Types of Wells

The two common well types in Saskatchewan are rotary drilled and bored wells. Other wells, such as sandpoints and hand-dug wells, are very susceptible to contamination and are not recommended.

Rotary Drilled Wells

Rotary drilling consists of advancing the borehole by means of a rotating bit and circulating drilling fluid or air to remove the cuttings from the borehole. The rotary drilling method was developed to increase drilling speeds and to reach greater depths in most formations. Therefore, drilled wells are usually smaller in diameter (10 – 20 cm, 4 – 8 inches), and completed to greater depths than bored wells.

Rotary drilling has many advantages. The rigs are considered rapid, and penetration rates are relatively high in most types of materials. Also, well screens can be set easily as part of the casing installation. Wells installed by rotary drilling will generally use stainless steel screens and PVC casing.

Bored Wells

Bored wells, or large diameter wells, are constructed using rotary bucket augers, turned from the surface by means of a drive shaft. This produces a cylindrical hole, inside of which a well screen and casing can be installed. Bored wells are usually used in shallower, low-yielding formations for more storage capacity to better meet peak demand use periods. This method is widely used for well construction in Saskatchewan, especially for domestic water sources.

Bored wells are usually 46 cm to 122 cm (18 – 48 inches) in diameter, with the most common size being 76 cm (30 inches). Generally in Saskatchewan they are limited to depths of approximately 30.5 m (100 ft). Because bored wells generally use shallow groundwater, they are more susceptible to seasonal water level fluctuations.

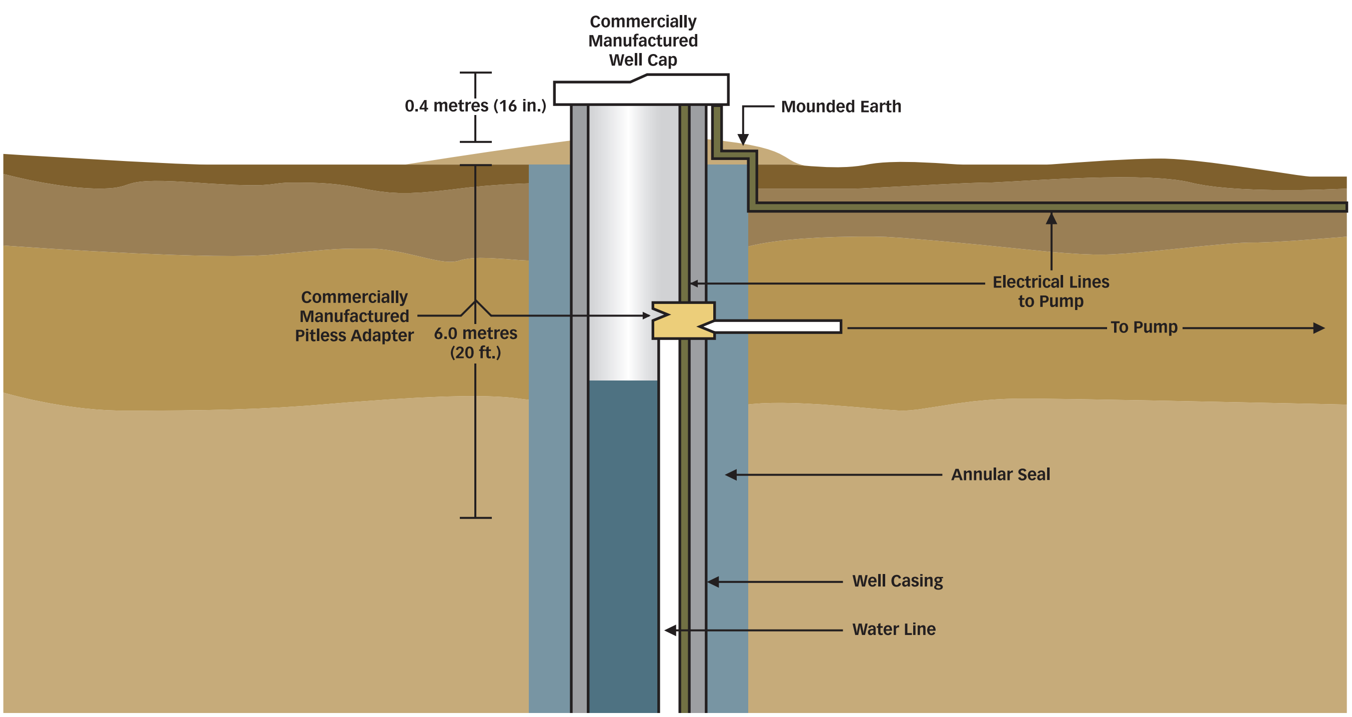

Figure 8: Drilled Well

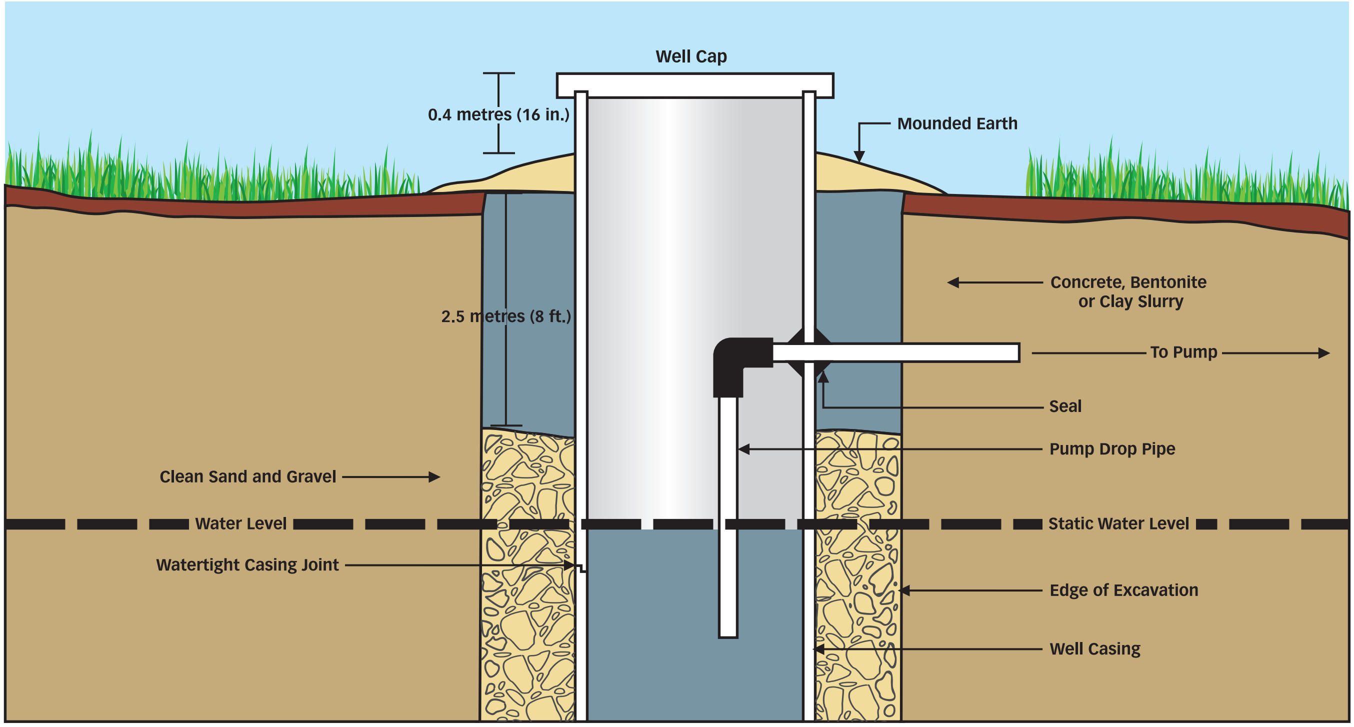

Figure 9: Bored Well

Casing Size and Type

Casing is a pipe that is used to protect the borehole from collapsing. The selection of the casing material and size is based on the following:

- Water quality
- Anticipated well yield
- Well depth
- Cost
- Borehole diameter
- Drilling procedure
- Regulations

The diameter of the casing should be chosen to accommodate the pumping equipment, with enough clearance for installation and efficient operation. Casings can be made from steel, plastic or fibreglass, although plastic is now more widely used because it is inexpensive and corrosion free. Bored wells usually use galvanized steel or fibreglass. All materials must be new and uncontaminated; therefore, no recycled material should be used.

Figure 10: Casing Installation

Figure 11: Lowering well screens

Intake Design

Groundwater enters the well through either a manufactured screen or a mechanically slotted or perforated liner. The screen is placed adjacent to part or all of the aquifer formation. Screens are engineered to allow the maximum amount of water in with minimal entry of formation sediments.

The casing or liner versions are made by creating openings using either a cutting tool or drill to create the slotted or perforated finish. Pre-slotted plastic and steel are available. These slot openings are placed further apart than the openings in a manufactured screen, providing a smaller open area for water to enter the well. This causes an increase in the velocity of flow entering the well, and could encourage mineral incrustation buildup on the liner. Slotted casings are generally only used for large diameter bored wells, as the much more efficient stainless steel screens would be cost prohibitive in this case. There are hundreds of different types, sizes, thicknesses, diameters and grades of casing.

Stainless steel screens are widely used in drilled wells because they have many advantages over slotted casings. They facilitate better well development, and result in much more efficient water wells. They are also strong, relatively well-suited to withstand corrosive waters, and are much more conducive to well treatment. The screens are manufactured with various regularly shaped and sized slots to match the characteristics of the aquifer.

In most cases, drilled wells should be completed with stainless steel screens, while slotted casings are predominantly used in bored wells due to cost.

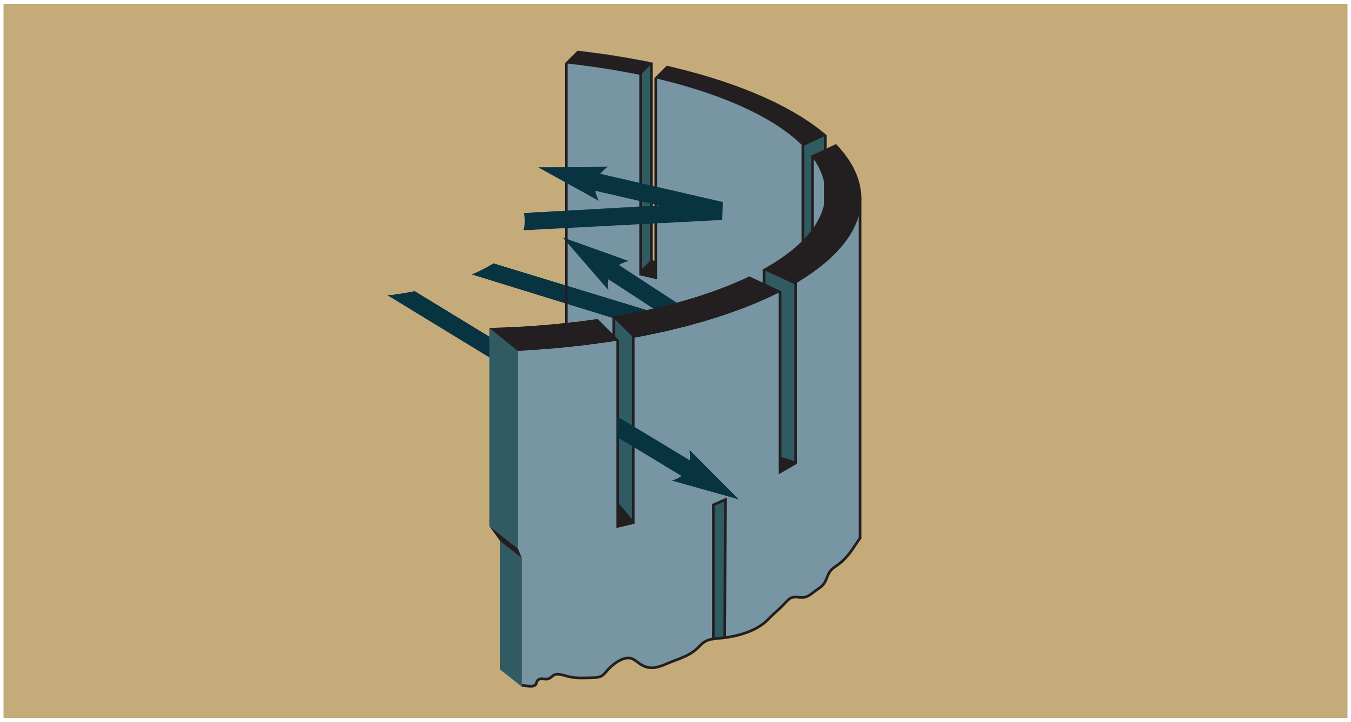

Figure 12: Slotted Pipe

Slot Size Opening

The width of slot openings should be chosen to match the grain size of the aquifer. The slot openings should be small enough to permit easy entry of water into the well while keeping sediment out.

The width of openings needed can differ between wells in the same formation depending on whether the well is naturally developed or filter packed. Aquifers with coarse-grained materials can be developed naturally, whereas those featuring fine-grained homogeneous materials are best developed using a gravel pack.

In naturally developed wells, the screen slot is selected so that approximately 60% of the aquifer material will pass through during development. The remaining 40%, comprising the coarsest materials, will form a natural filter pack around the perforations or screen.

In filter packed wells, a gravel pack is placed between the walls of the hole and the screen to provide artificial filtering. The grain size of the gravel is selected as a function of the grain size of the surrounding formation.

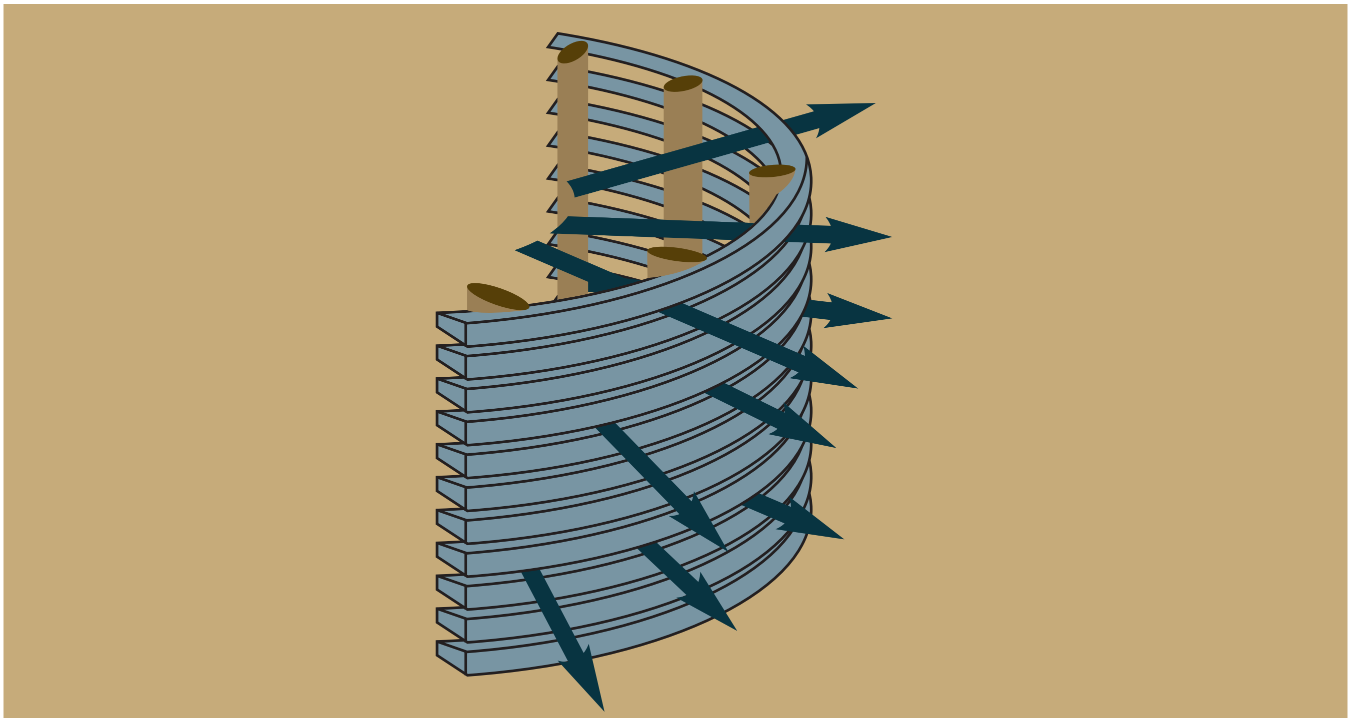

Figure 13: Slot Size

Total Open Area of Screen

The total open area of the screen is determined by the screen length and diameter. The length of the screen is based on the thickness of the aquifer, available drawdown, and the nature of the stratification of the aquifer. The screen diameter is dependent on the diameter of the well casing.

The open area of the screen should be chosen so that water does not enter the well too quickly. The driller will do this by balancing the length and slot sizes of the screen with the desired well yield. If the speed at which water enters the well is too high there are a number of undesirable impacts, such as the increased occurrence of incrustation.

Placement of Intake

In virtually every aquifer, certain zones will transmit more water than others. Thus, the intake part of the well must be placed in the zones that will yield the greatest quantity of water.

Annulus Seal

When constructing a well, the diameter of the borehole is usually slightly larger than the casing being installed. The resulting space (the annulus of the well) must be filled with a watertight sealant such as bentonite or cement for the entire length of the casing above the screened portion or the sand-packed portion of the annulus. This maintains water quality by preventing the migration of contaminants between aquifers or from the surface.

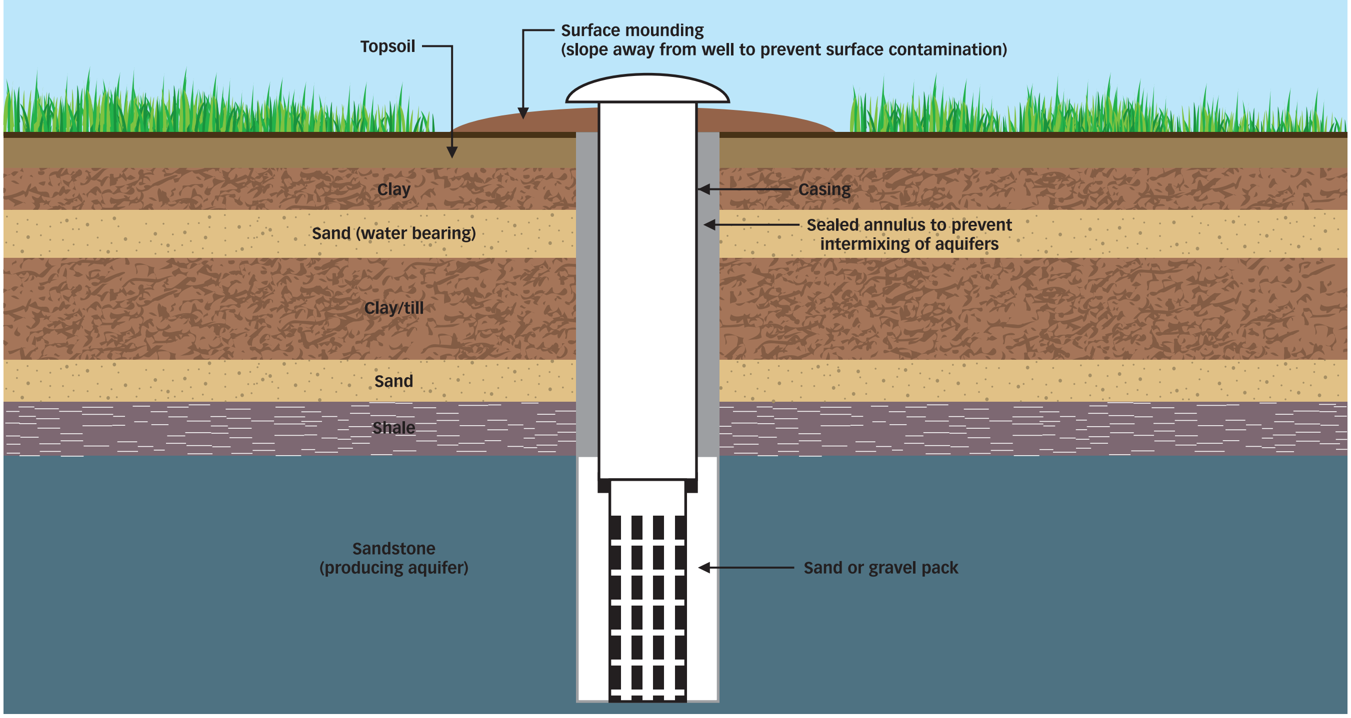

Figure 14: Annulus Seal

Well Completion

After the well has been drilled and the casing is in place, there are several procedures that the drilling contractor must complete before the well can be used. Well completion involves the following three processes:

- Well development
- Yield test
- Disinfection of the well

Well Development

Well development is the process where the aquifer material around the well screen is rearranged and fine particles are removed in order to produce a filter. This mainly concerns the region directly adjacent to the well where aquifer materials have been affected by the drilling fluid or disturbed by well construction procedures. Well development increases the movement of water from the aquifer into the well and increases the quantity of water that the well produces. Stainless steel screens will have significant advantages over slotted casing during well development.

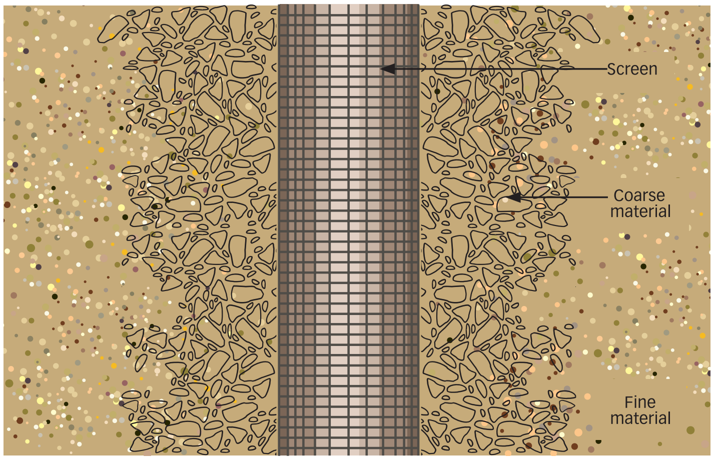

Figure 15: Developed well screen

There are several methods used to develop a well, including jetting, surging, backwashing, and overpumping. Water or air is surged back and forth through the perforations, and fine materials in the immediate formation are either pumped or bailed from the well. This procedure is continued until the water is clear and no suspended particles remain. Coarser materials are left behind to form a natural filter pack around the screen, slot openings and/or perforations.

If the aquifer formation does not have any coarse material to form a filter pack, an artificial one must be installed. A filter pack is placed between the walls of the hole and the screen to provide artificial filtering. The grain size of the filter material is selected in relation to the size of the slot openings of the screen in order to obtain a maximum yield from the well.

Yield Test

Well yield is the volume of water that can be pumped during a specific period of time. The yield test provides information that will allow the drilling contractor to decide the rate of pumping that a well can sustain without lowering the water level below the top boundary of the aquifer, below the top perforations of the well or below the pump intake.

Pumps are installed in water wells to lift the water to the ground surface. The yield test will help the drilling contractor select suitable pumping equipment that will maintain a safe pumping rate for the well. It will also help determine the depth at which to place the pump within the well.

Disinfecting the Well

The final step in well completion is thoroughly cleaning all foreign substances from the well. Usually, disinfection is accomplished with a chlorine solution, as it is cheap, simple and an effective agent for this purpose. The concentration of chlorine to be used is calculated based on the volume of water in the well. Chlorination of the well is also recommended after any maintenance work on the well, or if any water quality issues require it.

For more information on well disinfection procedures, please refer to page 45.

Well Management

It is important to monitor and maintain a water well in order to ensure adequate water supply and water quality. If a water source is not developed or maintained properly, it may become subject to water quality deterioration or contamination that could ultimately yield the water unfit for human or farm use. Taking water level measurements and water quality measurements are important steps in well management.

Water Level Measurements

The condition of a well can be monitored through the changes in the water level or discharge rate. A continuous drop in the water level could indicate a deterioration of the well structure, or a depletion of the aquifer itself.

Taking water level measurements on a regular basis will show whether water levels have changed significantly. Measurements should be taken with the pump both on and off. Readings taken with the pump in operation will alert the well owner to any problems related to the well itself, such as a plugged intake screen. Readings taken with the pump turned off will alert the owner to problems with the aquifer and the quantity of water available for pumping.

Water Level Measurement Methods

There are several methods available for measuring water levels, including:

- Dip tube
- Weighted line/measuring tape
- Water well sounder
- Air line method

Dip Tube

A dip tube can be constructed using a minimum 18 mm (3/4 inch) plastic pipe or hose, which will be lowered into the well to below the pumping water level. It should be secured to the pump line with electrical tape and should have a capped bottom with two 6 mm (1/4 inch) holes perforated on the bottom to let water in and out, allowing it to fluctuate identically to the water inside the well. A measuring device, such as a weighted line or a well sounder tape, can then be lowered inside the dip tube to measure the water level, with no threat of getting entangled in the pumping equipment.

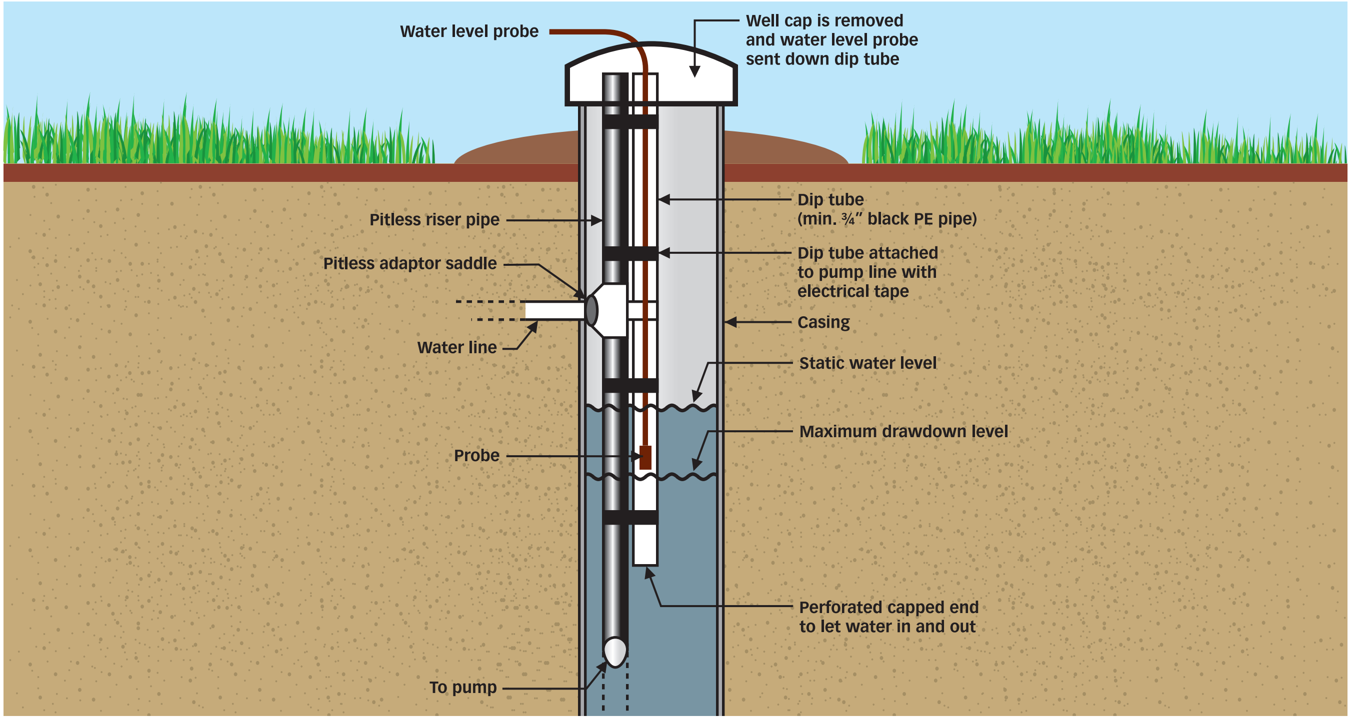

Figure 16: Dip Tube

Weighted Line/Measuring Tape

The weighted line/measuring tape device is commonly used for measuring water levels in large diameter or shallow wells. A weight is attached to the end of a 30.5 m (100 ft) measuring tape or line. The last 2.5 to 3 m (8 to 10 ft) of the tape is dried and coated with chalk before each measurement. The tape is then lowered down the well until a part of the chalked section is below water. A note is made on the tape exactly at the top of the casing. The tape can then be pulled up, and the actual depth from the top of the casing to the water level can be determined by subtracting the wetted mark from the mark made at the top of the casing.

Water Well Sounder

Water well sounders, or water tapes, are convenient and accurate tools for measuring water levels. Water well sounders can be purchased from various suppliers in the province. Electric water well sounders can be purchased with measurements to the closest millimetre.

Air Line Method

The air line method is convenient for measuring water levels regularly, as it is a permanent installation. It is simple and relatively low cost, with setup costs averaging approximately $60. The system is comprised of the following components:

- A small-diameter 6 mm (1/4 inch) plastic pipe or tube permanently attached to the water pipe above the pipe intake
- A pressure gauge and tire valve attached to the plastic pipe at the top of the well
- An air pump

The plastic pipe should be lowered down the well until the bottom of the pipe is about 0.6 m (2 feet) above the pump intake. If possible, the plastic pipe should be taped to the pump drop line. A measurement should be taken of the exact length of the plastic pipe when placed in the well. A pressure gauge and a tire valve should then be attached to the plastic pipe at the top of the well.

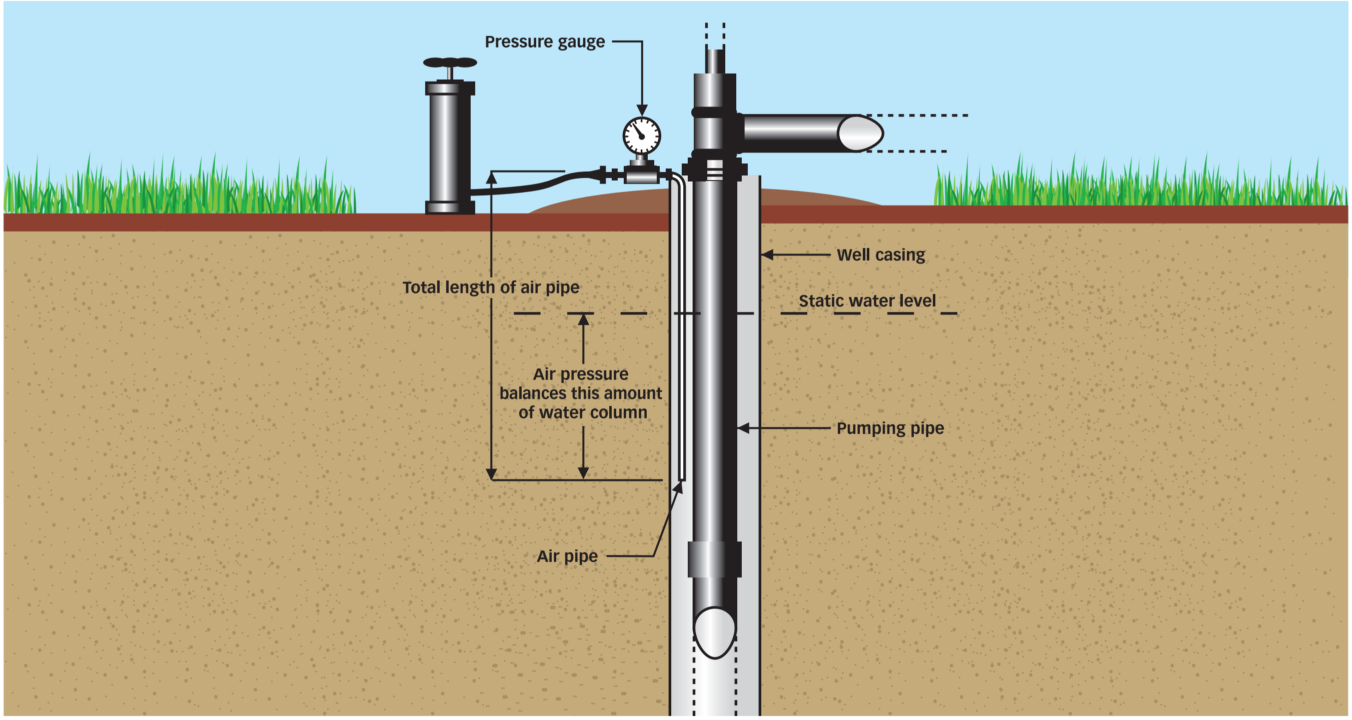

Figure 17: Air Line Method

A measurement should be taken of the height of water above the lower end of the air line. This can be calculated using the air pump and pressure gauge as follows:

1. All joints and connections should be airtight. Air should then be pumped into the air line until the pressure shown by the gauge levels off at a constant maximum, indicating that all water has been forced out of the line.
2. The reading of the gauge can then be converted to a height:
   a. If the gauge measures lb/sq inch (psi), then the reading should be multiplied by 2.31 in order to calculate the height in feet.
   b. If the gauge measures kilopascals (kPa), then the reading should be divided by 9.8 in order to calculate the height in metres.
3. Deduct this pressure from the known length of the air line to determine the water level.

The air line method is based on the principle that the air pressure required to push all of the water out of the submerged portion of the air line will equal the water pressure of a column of water of that same height. When all of the water has been forced out of the line, the pressure gauge stabilizes and indicates the original water column length.

Interpreting Water Levels

Once water level measurements have been taken, it is important to know how to interpret both non-pumping (static) and pumping water levels.

Non-pumping Water Levels

The non-pumping (static) water level is the level of water in a well that is not being affected by the withdrawal of groundwater. In other words, it is recorded after the pump has been shut off for an extended period of time and the water level in the well has fully recovered.

Monitoring the non-pumping water level allows the owner to assess whether the aquifer is sustainable at a specific pumping rate. A continually dropping water level could be caused by the overpumping of the well. In this case, the amount of water being taken from the well should be reduced. Further water level measurements should then be taken to see if the water level recovers.

Changes in water level could also be caused by seasonal fluctuations. For example, in shallower wells water levels are usually highest in June or July and gradually decline throughout the fall and winter.

If there is no significant change in the static water level, then full recharge of the aquifer is occurring at the same rate as water is being pumped from the well and sustainable water use is taking place.

Pumping Water Level

The pumping water level is the level at which water stands when the pump is in operation. Measurements should be taken when the pump has been in operation for a consistent period of time and there has been significant water use. For example, readings should always be taken when the pump has been in operation for two hours. This will allow for the comparison of results.

A drop in the pumping water level of a well, when there is no drop in the non-pumping level, indicates a problem with the well structure. This could include plugging of the screen (or slotted casing), bacterial growth, or incrustation that is diminishing the efficiency of the well. Conversely, a lowered discharge rate of the pump with an increase in the pumping water level would suggest a problem with the pump.

Even when the pumping water level remains relatively stable, regular maintenance procedures, such as shock chlorination, should be performed in order to maintain well efficiency.

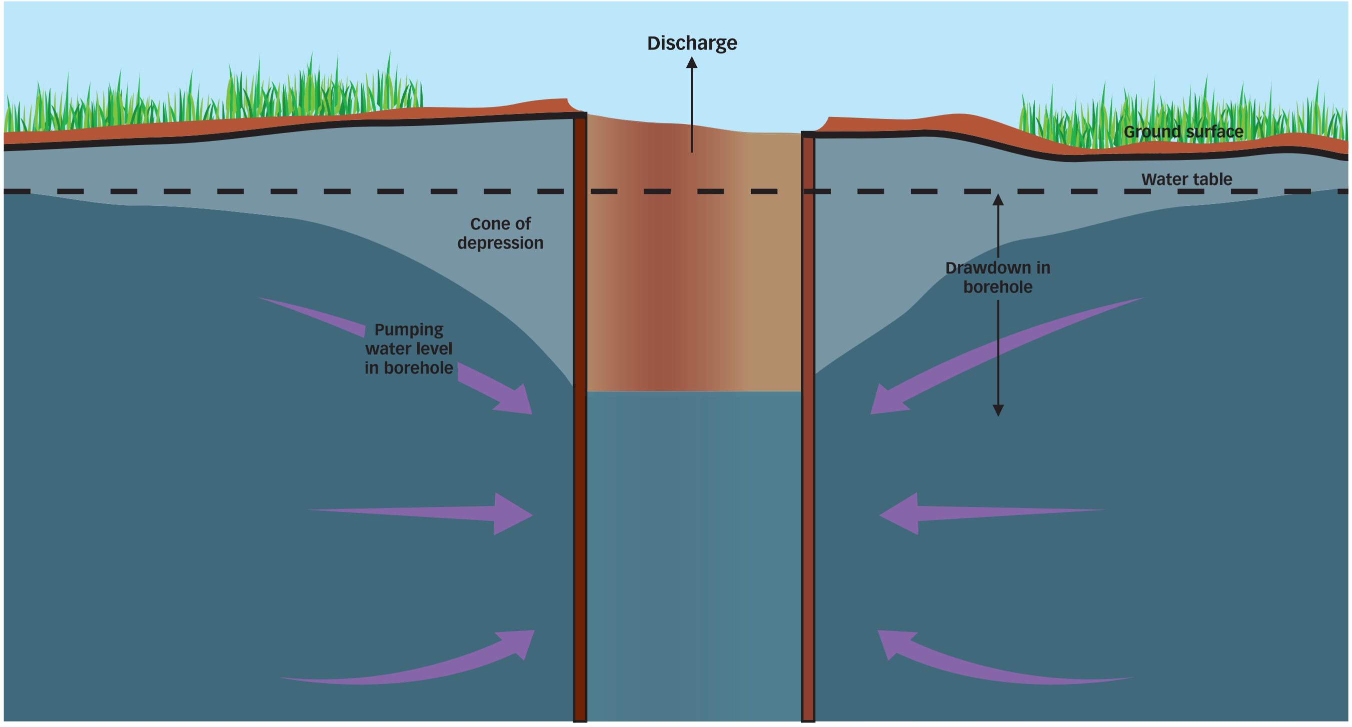

Figure 18: Pumping Water Level

Water Quality Measurements

The Saskatchewan Ministry of Environment sets quality objectives and monitors testing programs for municipal water supplies based on Health Canada guidelines, but there are no legal testing requirements for private wells. It is therefore up to the well owner to monitor the quality of their water. Well water should be tested for water quality initially after well construction and prior to being used, as well as on an at least yearly basis. For a list of provincial water quality guidelines and objectives please refer to page 48.

In addition to regular water quality testing, there are certain times when it is prudent or advisable to perform extra tests. These include:

- During runoff or after a heavy rain where water may affect the well.
- After work has been done on the well.
- After changes in nearby land use, such as landfill activity, road salting, installation or repair of septic systems, or road construction.
- After changes are detected in the colour, smell or appearance of the water.
- When there is a newborn in the house.

Ground and surface water supplies in Saskatchewan are often of poor quality and require some form of treatment to make them safe and aesthetically acceptable. Although some water quality characteristics can be determined by the way the water looks, tastes or smells, other properties that cannot be detected by these methods should also be considered. Even if water looks and tastes fine, it still might not be safe for consumption. For this reason, analysis, including bacterial, nitrate and trace metals testing, should be performed by an accredited water analysis laboratory. Tests for bacteria and nitrate should be done routinely (at least annually), while tests for trace metals can be done less frequently. Please refer to page 56 for contact information for accredited water analysis laboratories in Saskatchewan.

Method of Collection

In order to ensure a representative water sample, proper collection procedures must be followed. It is recommended that the well owner contact the laboratory that will examine the sample for information on collection and delivery procedures. The well owner should also consider:

- The length of time the well is pumped prior to sampling.
- How the sample is stored.
- The length of time it will take for the sample to be delivered to the laboratory.

The sample should also be collected as close to the wellhead as possible to avoid any effect the water treatment or distribution systems may have on the water quality results.

Bacterial and Nitrate Analysis

It is important to determine if bacterial or nitrate contamination is present in a well, as these are the most commonly encountered forms of contamination. The standard bacteriological tests for private wells are called the Total Coliform (TC) test and the E.Coli (EC) test. When running bacteriological tests, the Saskatchewan Ministry of Health's Disease Control Laboratory can also test for nitrate level in the water, if requested. If another lab is performing the test, it is prudent to ensure that nitrate is also included in the test.

Chemical Analysis

A chemical analysis tests for the most common ions and trace metals found in water, such as sodium and sulfates.

Questions relating to human health should be directed to the local Health Region. Please refer to page 54 for contact information.

Well Maintenance

Iron and sulfate-reducing bacteria are a widespread problem for many water wells in Saskatchewan. As they are not detrimental to human health, water quality guidelines for iron and sulfate-reducing bacteria are set on the basis of taste and appearance.

Shock chlorination is a cheap, simple and effective procedure used to control bacteria in water well systems. Shock chlorination is recommended as part of semi-annual maintenance to control iron and sulfate-reducing bacteria.

Identifying Iron and Sulfate-Reducing Bacteria

Bacteria Growth

Bacteria growth will coat the inside of the well casing, water piping and pumping equipment, causing a decrease in well yield or restricted water flow in distribution lines. An easy way to verify that a well or water system is being affected by iron bacteria is to examine the inside surface of the toilet flush tank. If a greasy, slimy substance can be observed, then iron bacteria are most likely present.

Staining Problems

Discolorations of water are often caused by the presence of iron. When the level of iron within the water exceeds the water quality guideline, red, brown, or yellow staining of laundry, dishes or fixtures are often observed.

Taste and Odour

The presence of bacteria can cause the water to have an offensive taste or odour. For example, the presence of sulfate-reducing bacteria can cause a rotten egg or sulfur odour in water.

Regular Disinfection

General maintenance of a groundwater supply should include semi-annual chlorine disinfection. For information on well disinfection procedures, please refer to page 45.

Common Well Problems

Problems with a well can result from many causes, including improper well design and completion, equipment failure, incrustation, corrosion and depletion of the aquifer. These problems could lead to decreases in well yield and water quality. By properly identifying a specific well problem, appropriate treatment or maintenance procedures can be carried out and more costly solutions, such as drilling a new well, can be avoided.

Improper Well Design and Construction

When designing or constructing a new water well, a drilling contractor must make decisions that will ultimately affect the quality and yield of water from the well. These decisions include the location and depth of the well, the type and size of casing and screen, the use of a gravel pack, and the location of the pump in the well. Poor choices could result in problems with contamination, sediment in the water or with well yield. If it is suspected that the well is of poor design or construction, a drilling contractor should be contacted.

Incomplete Well Development

Proper well development will insure that all drilling fluid and borehole cuttings are removed, allowing water to freely enter the well. If this procedure is not properly carried out, problems with sediment in the water or low well yield may occur. Therefore, the driller must ensure that the well is properly developed.

Borehole Instability

Borehole stability problems can result from damaged casings and screens, borehole wall collapse, corrosion, or excessive water velocities in the well. To avoid this type of problem, it is necessary to select appropriate materials during the well design and construction stage. A drilling contractor should be contacted to determine whether repair of the well is economically feasible. If it is not, the well should be properly decommissioned and a new well should be drilled.

Sand Pumping

In older wells, sand pumping can be caused by corrosion slowly eating away at the surface metal of the well casing. Other possible reasons for sand pumping include improper slot size, improper well level, overpumping, or casing separation. A drilling contractor should be consulted to determine the reason for the sand pumping.

Incrustation

When water is pumped from a well, changes in pressure and temperature occur. This provides ideal conditions for minerals to be deposited within the gravel pack around the screen or upon surfaces of the screen, casing, or pump. These deposits can reduce water passage and decrease the yield of the well.

There are three major forms of incrustation:

- Incrustation from calcium and magnesium carbonates.
- Incrustation from iron and manganese.
- Incrustation caused by slime-producing iron bacteria (biofouling).

Well owners can take preventative measures to help prevent incrustation. Regular shock chlorination can help control biofouling, and reducing pumping rates can help control mineral incrustation.

Carbonate

Incrustations can result from the precipitation of carbonates, principally calcium, from groundwater near the well screen. Other substances, such as aluminum silicates and iron compounds, can also add to the deposits and reduce the flow of water.

Iron and Manganese

Discolorations of water are often caused by the presence of iron and/or manganese. When there is an excess of iron, red, brown, or yellow staining of laundry, dishes and fixtures can be found. Manganese acts in a similar fashion, but causes a brown-black stain.

Biofouling

Biofouling is the accumulation of slime-producing bacteria. This accumulation can prevent water from moving into the well at the desired rate. Common effects of biofouling include clogging, corrosion, an undesirable odour and taste, bioaccumulation, and biodegradation activities. With biofouling, a slime growth can normally be observed on surfaces that are in contact with the water, such as the inside of the toilet flush tank.

Plugging of Screen and Surrounding Formation

The clogging of well screen openings with aquifer particles is a relatively common well problem, and can result in a lowered yield from the well. It can often be observed in wells that have been improperly developed or have poorly designed filter packs or screens. It can also be due to pumping at rates greater than those for which the well was designed. For this reason, the driller's recommended pumping rate should not be exceeded. This plugging of the screen and surrounding formation can also be observed in older, regularly used wells. Fine particles slowly move into the area around the screen and can decrease the specific capacity of the well. For a plugged screen and surrounding formation, have a drilling contractor redevelop the well.

Corrosion

Corrosion can cause the enlargement of the screen slots or the development of holes in the well casing. This can result in sand pumping. To eliminate corrosion, contractors may use materials such as plastic and fibreglass casings or stainless steel screens that are resistive to corrosion in the construction of new wells. Plastic liners may be installed in old steel wells to prolong the life of the well.

Failures Linked to the Resource

A decrease in a well's yield might not be due to a problem with the well structure itself, but might be linked to external factors. For example, in a period of drought the groundwater levels will lower, and will therefore bring about a drop in the pumping water level. Taking regular measurements of static water levels will help to identify possible problems related to the aquifer and will help avoid the possibility of overpumping.

Protecting Wells from Contamination

There are numerous preventative measures that a well owner can take to help protect their well from possible contamination. If water becomes contaminated, it can affect the health of people and livestock. It may also affect the quality of the water in nearby lakes, streams, dugouts, or other wells, impacting neighbouring water users. It is much easier and less expensive to prevent contamination than to clean it up. Treating contaminated water, drilling a new well, or getting water from another source are all inconvenient and expensive options.

Wellhead protection against contamination is important for all well owners. Wells can provide a direct route for contaminants to reach groundwater. It is therefore imperative that wells be constructed in a way that protects the water resource and inhibits the downward movement of contaminants.

Well owners should pay especially close attention to protecting the aquifer from contamination if it is naturally vulnerable. Where water can infiltrate below the root zone, there is a risk of pollution from dissolved chemicals in the water. The risk is increased when the aquifer is shallow, and where there are coarse textured soils such as sands and loamy soils that have large pore spaces which allow water to percolate through quickly.

Well Head Protection

Proper Well Siting

There is a greater risk of water contamination if the well is drilled in close proximity to potential contamination sources such as livestock yards, septic systems, and manure storage facilities.

Proper Well Construction

The following design considerations can help prevent the contamination of a well:

- A proper casing and annulus seal maintains water quality by preventing the movement of contaminants between aquifers and from the ground surface.
- The top of the well casing should be approximately 0.6-0.9 m (2-3 ft) above ground level, and the area around the well should be built up with good clay soil and sloped away from the well so that surface water will drain away from the well in all directions.
- A vented watertight well lid should be installed to prevent water and bugs or other creatures from entering the well.

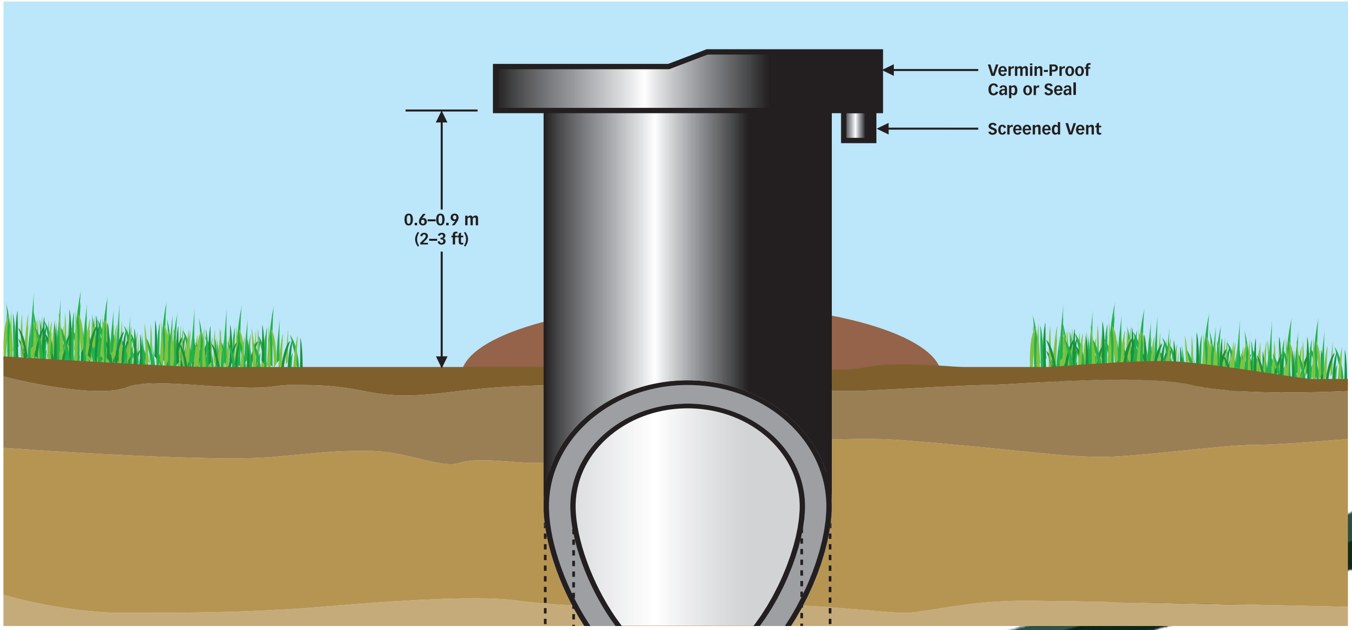

Figure 19: Well Cap

Well Contamination During Maintenance

Water can become contaminated when equipment is placed in the well without being properly disinfected. This can occur during the construction of a new well or during maintenance when piping or equipment is laid on the ground.

Improperly Decommissioned Wells

There are several ways that abandoned wells and improperly decommissioned wells may allow for the contamination of aquifers. They can act as a pathway for surface runoff to directly enter the aquifer. They can also permit cross-contamination of different aquifers along the length of the borehole. Nearby wells that are completed in the same aquifer may also eventually become contaminated.

Figure 20: An abandoned well in a cattle yard can contaminate the aquifer

Abandoned wells may also be a physical safety threat. Many unsealed, abandoned wells are not marked or covered, and they can pose a hazard to people or animals that might fall into them.

For the proper decommissioning procedure for abandoned wells, please refer to the following chapter.

Well Pits

In the past, water wells were sometimes constructed with the well casing ending 2.5 to three metres (8 to 10 feet) below ground level, with a larger surface casing installed around the well. These well pits would often contain the pressure system for the farm.

Well pits provide a place for contaminated surface water or shallow groundwater to collect. This water can directly enter the well or seep down around the well casing and eventually contaminate the aquifer. Well pits can also cause contamination by housing rodents or insects.

Well pits are also confined spaces, and may contain dangerous gases such as hydrogen sulfide gas or low levels of oxygen. The unsafe entry into well pits has resulted in asphyxiation and poisoning deaths. Entry into a well pit should never be conducted without special training, ventilation, and air monitoring equipment.

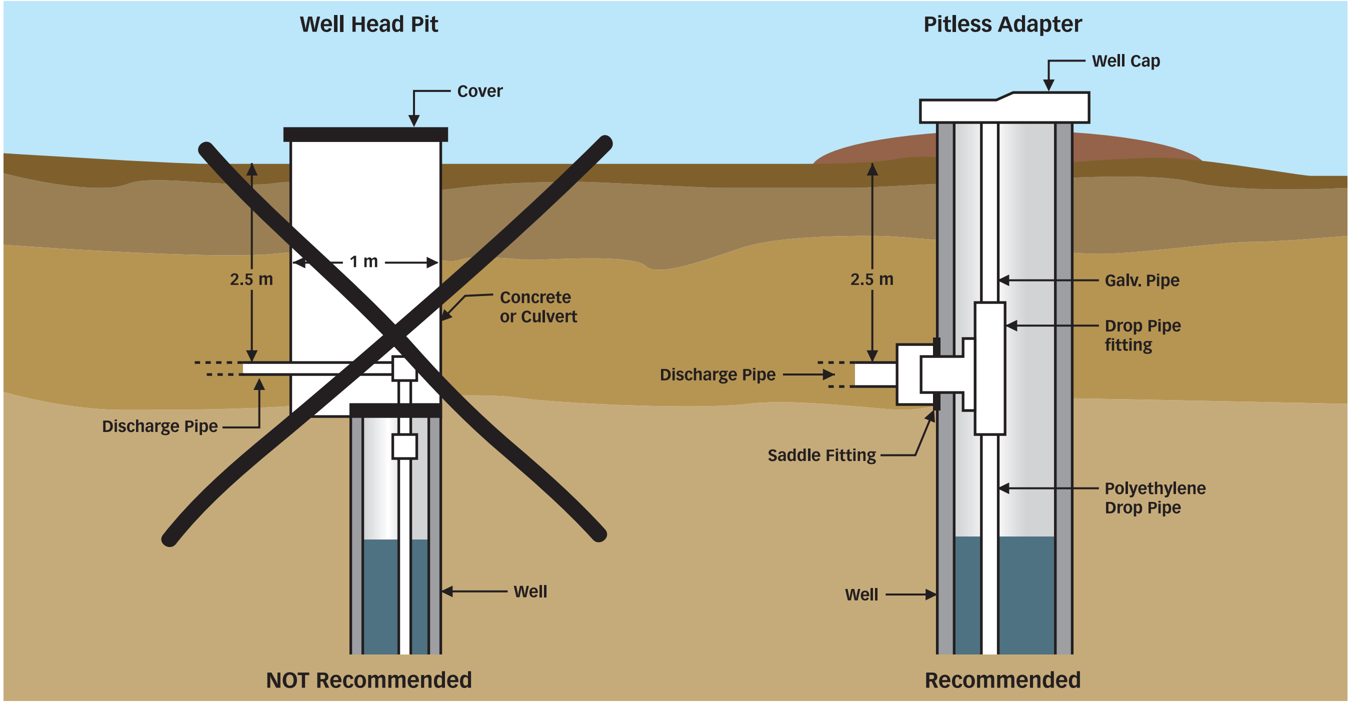

Figure 21: Well Pit and Pitless Adaptor

Because of the unacceptable risks presented by well pits, they should never be used. A pitless adaptor provides a sanitary connection between the well and the pressure system, and avoids the hazards and contamination issues of a well pit. Where well pits are currently used, the well casing should be extended above ground and the well should be connected to the distribution system with a pitless adaptor, allowing the well pit to be decommissioned.

Water Hydrants Installed in a Well or Well Pit

Water hydrants prevent freezing by draining water back down the well whenever they are shut off. In other words, the contents of the standpipe and hose are siphoned back into the well. Water hydrants can cause back siphoning that can draw contaminated water back down the well. For this reason, hydrants should never be completed in, or immediately adjacent to, a well.

Figure 22: Water Hydrant

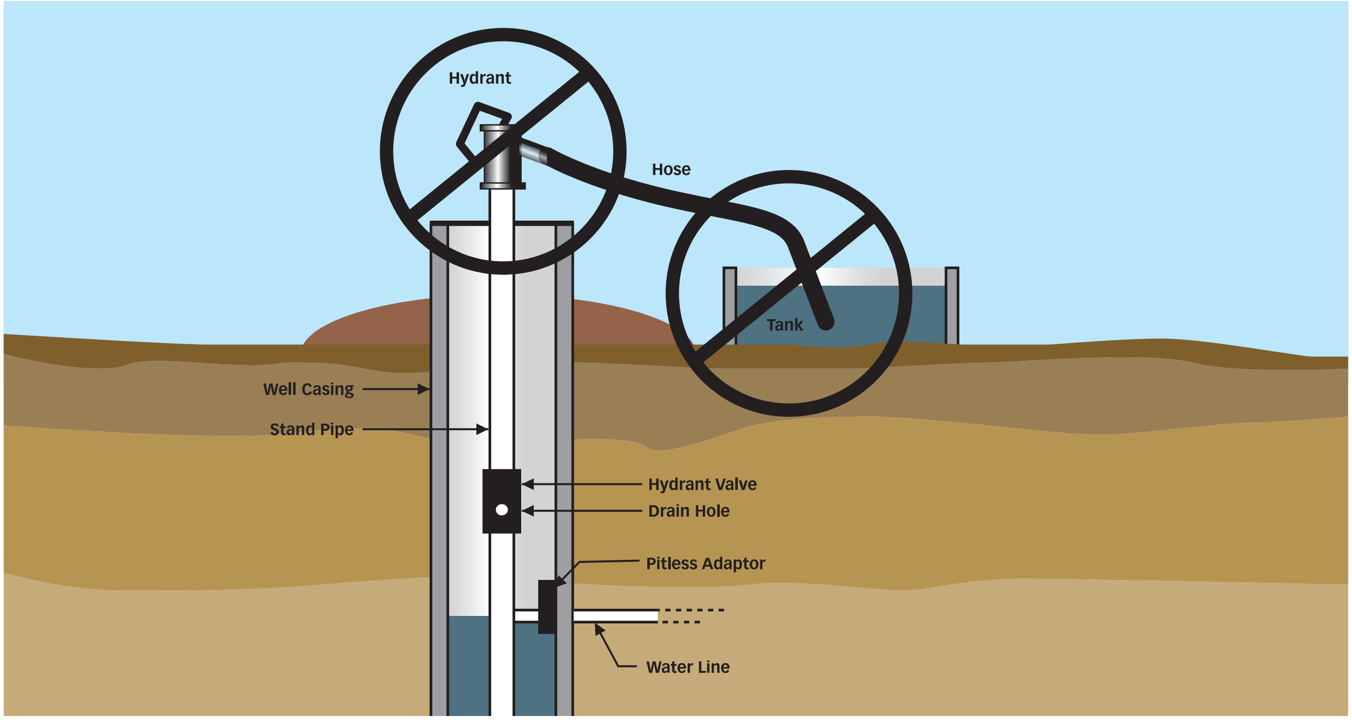

Figure 23: Water Hydrant

Aquifer Protection

Some aquifers are more susceptible to contamination than others, especially those located at shallow depths and overlaid by coarse textured soils. Although the susceptibility to contamination for each well can only be judged on an individual basis, general attempts should always be made to maximize the distance between contamination sources and the well. The well should also be upslope from these sources, and in a well-drained location.

Onsite Wastewater Systems

Onsite sewage systems can include holding tanks and septic tanks (which by themselves are a very low risk to groundwater supplies), chamber systems, absorption fields, mounds, jet type disposals, lagoons and package treatment systems. The Province of Saskatchewan has regulations to control the proper construction of onsite wastewater systems. All such systems (septic tanks and sewage disposal options) require a permit from the Health Region for a private sewage works under *The Plumbing and Drainage Regulations* and to be designed and installed according to The Saskatchewan Onsite Wastewater Disposal Guide. The system should also be maintained and operated within the design parameters, and the treated sewage should be disposed of properly. For an average household with a properly sized septic tank, the septic tank should be inspected for required cleaning at intervals of no more than two years to determine scum and sludge accumulation. It should also be ensured that the tank is not cracked or broken, and that the pump is functioning properly.

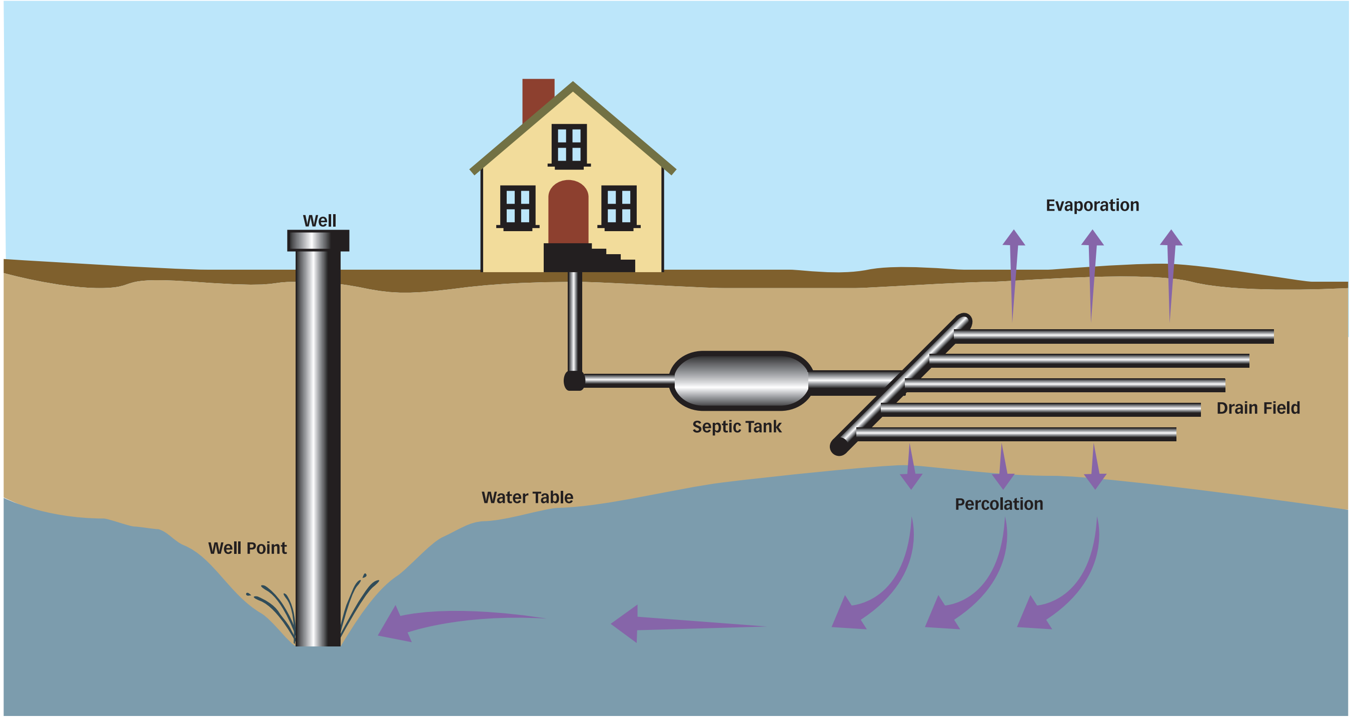

Figure 24: Septic System Contamination

Fuel Storage Tanks

Contamination of groundwater by hydrocarbons from fuel storage tanks is a significant problem. To avoid a spill or leak, it is important to have a properly installed, approved tank that will resist corrosion. Fuel storage tank dispensers are required to meet legislated requirements and avoid accidental spills due to overfilling or siphoning. Only approved dispensers [e.g. by the Underwriters' Laboratory of Canada (ULC) or the Canadian Standards Association (CSA)] are acceptable. All fuel must be pumped in such a manner as to meet legislated requirements and to avoid unwanted dispensing of fuel.

Tanks should be monitored for leakage by keeping measurements of the amount of fuel used and comparing this to the amount purchased. A spill or leak can occur in large quantities due to a tank rupture, or in small quantities due to pinhole leaks. If not contained, leaks can cause serious damage to groundwater quality. A dike can capture any spills or leaks from above-ground tanks. These spills should be cleaned up immediately. Above-ground fuel storage tanks are considered more desirable than underground tanks, as they are easier to monitor for leaks.

Pesticide Contamination

Pesticide is a broad term that refers to substances such as insecticides, rodenticides, fungicides, and herbicides used to control insects, rodents, fungal disease, and weeds. Pesticide contamination usually occurs when pesticides are mishandled in the area surrounding the well. Therefore, pesticides should be handled carefully, and should not be mixed or stored near a well. A safe storage area should be used, and pesticide containers should be emptied and the rinsate disposed of safely.

Manure and Fertilizer Contamination

Fertilizer or manure that is applied to agricultural land in excess of the crops' nutrient requirements can lead to nitrates being leached into groundwater. Regularly testing soil and manure can help maintain a balance between the nutrient requirements of the crops and the nutrient content of the manure or fertilizer.

Fertilizers should be handled carefully and stored in areas that meet all safety requirements. Storage facilities for manure should be large enough to safely hold all of the manure that is produced and should be checked regularly for leaks and damage.

Improper Storage of Silage

Silage is an important source of feed for livestock, but if it is improperly handled or stored, liquid or seepage may escape from the storage site. This seepage can contain high concentrations of nutrients and acid and can negatively affect groundwater quality. Therefore, silage should be stored at an appropriate moisture level to minimize seepage, and all parts of the silage storage, including the lining, should be in good condition.

Livestock Yards

Livestock yards include feedlots, cow-calf facilities, livestock handling facilities, stockyards, and assembly stations. Manure contains nutrients and microorganisms that could be a danger to groundwater quality. The livestock yard should be located a significant distance from nearby wells, and manure and all runoff from the facility should be collected and stored to avoid groundwater contamination. Under *The Agricultural Operations Act*, certain types of intensive livestock operations are required to obtain provincial approval of waste storage, manure management and dead animal disposal plans to ensure water protection.

Figure 25: Intensive Livestock Operation

Disposal of Farm Wastes

Farm wastes include dead livestock, animal health care products, packaging, old farm buildings, and worn-out equipment or machinery. Farm wastes may adversely affect groundwater quality if they are stored or disposed of in the wrong way. Whenever possible, all material or equipment should be recycled. Organic material, including leaves and dead animals or portions of dead animals, should be composted. Intensive livestock operations should have a dead animal disposal plan which has been approved by the Saskatchewan Ministry of Agriculture. All other material should be taken to a licensed landfill site.

Abandoned Wells

Abandoned wells are wells that are no longer in use. Over the years, many wells and test holes around homes and farms throughout the province have been abandoned without being properly sealed and decommissioned. Abandoned wells or improperly decommissioned wells can pose a serious threat to groundwater quality and can also be a safety hazard. Therefore, all abandoned wells should be properly plugged to prevent contamination and to eliminate any safety hazards. When a replacement water well is drilled, the old well should be plugged.

Abandoned wells:

- Can allow surface runoff to directly enter an aquifer, contaminating the aquifer and potentially contaminating nearby wells.
- Can permit cross-contamination of different aquifers encountered by the well bore.
- Can be a physical safety threat, as they are often not marked or covered, and can pose a hazard to people or animals that might fall into them.
- Can be a liability problem if the well contaminates neighbouring wells, or if the abandoned well still exists at the time of property resale.

Figure 26: Bull in Well

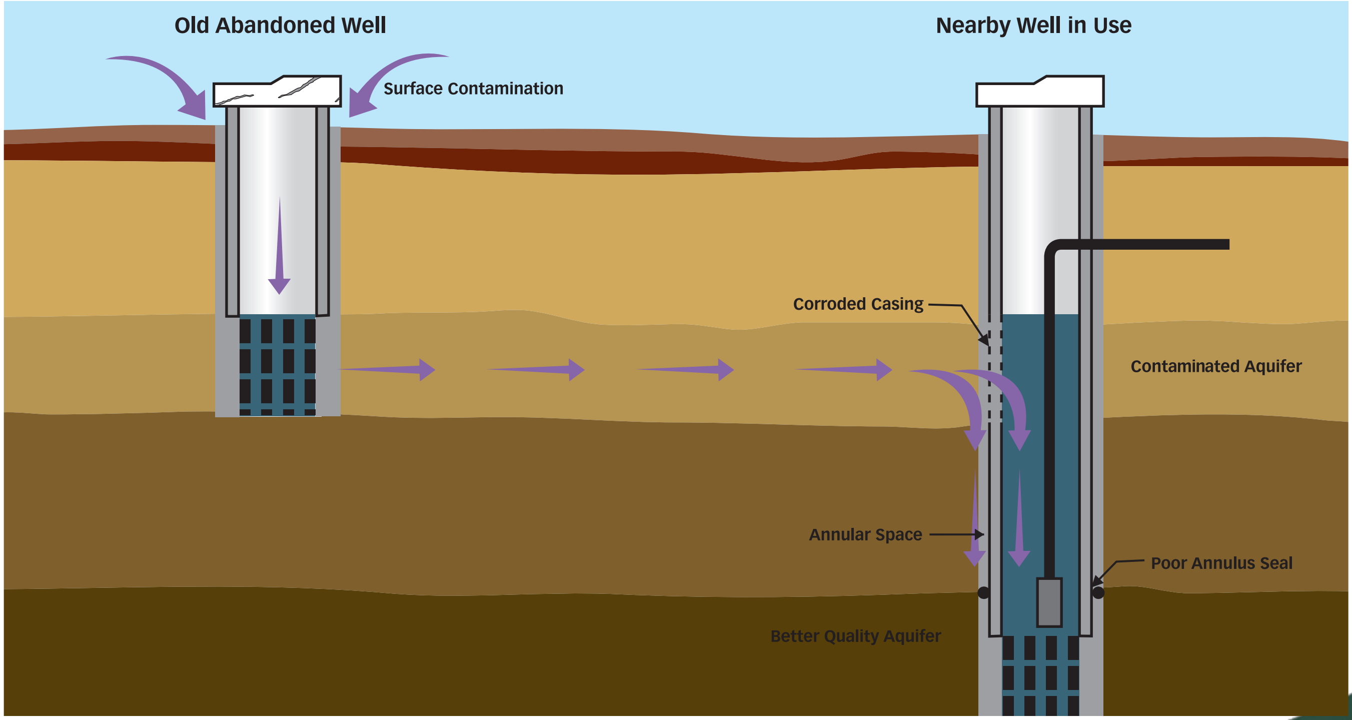

Figure 27: Contamination from an Abandoned Well

The same negative impacts can occur from test holes. For this reason, proper abandonment of test holes is also critical to the protection of groundwater quality.

When a well is abandoned after the date of completion, the owner is immediately responsible for filling and sealing the well with suitable uncontaminated material in a manner as to prevent the vertical movement of water in the well. It is recommended that a well owner hire a registered drilling contractor to ensure that the well is properly decommissioned. A well contractor will have access to the necessary equipment, as well as an understanding of correct abandonment materials and procedures. Unless the right materials are used and are properly placed in the well, the well will be poorly sealed and may continue to allow contaminants to reach the groundwater.

Decommissioning Abandoned Wells

Procedures

Well decommissioning procedures vary, depending primarily on well construction, hydrogeology and the geology of the site. One set of well decommissioning procedures is not suitable for all wells. The following decommissioning procedures should only be used as general guidelines. Site-specific conditions will dictate the exact procedures that should be followed to properly decommission the well.

Figure 28: Abandoned well

Decommissioning procedures:

- **Removal of well equipment** (pumps, drop pipe, wiring, etc.)
- **Well Characterization –** the depth, diameter and non-pumping (static) water level of the well should be recorded. This information is used to calculate the amount of materials required to decommission the well. It can also be used to compare the original depth to the current depth of the well and determine if a portion of the well has collapsed or if an obstruction exists within the well column. If an obstruction does occur within the well, it should be removed prior to sealing the well whenever possible.
- **Disinfection –** enough chlorine should be added to bring the standing water in the well to a chlorine concentration of 250 mg/L. The amount of chlorine to be added will depend on the casing size and the amount of water in the well. The table on the following page will help determine the quantity of chlorine that should be added to achieve a concentration of 250 mg/L when using either 12% sodium hypochlorite, 70% granular calcium hypochlorite, or 5.25% household bleach. This chlorinated water is to be left in the well.
- **Remove casing –** the casing should be removed prior to plugging the well whenever possible, but only if the integrity of the borehole will not be affected. Removing the casing in domestic wells that have been in place for a substantial period of time is often very difficult. Any casing that is left in place should be cut off three meters (9.85 ft) below ground surface after the well is sealed.
- **Filling and sealing –** the most preferred materials for sealing wells are low permeability materials that prevent the vertical movement of water. Generally the best product for this purpose is a manufactured bentonite product (chips, pellets or grout). However, in some cases it may be acceptable to use a combination of bentonite, clay and granular material. The effectiveness of well decommissioning in maintaining the quality of groundwater is determined by the placement of these low permeable materials in key portions of the well. The table on page 33 provides volume calculations for filling the well.

Amount of Chlorine Required to Obtain a Chlorine Concentration of 250 mg/L					
Casing diameter		Volume per 1 foot (30 cm) of casing	* 5.25% Domestic Chlorine Bleach	12% Industrial Sodium Hypochlorite	** 70 % Granular Calcium Hypochlorite
			Litres needed per 1 foot (30 cm) of water in casing	Litres needed per 1 foot (30 cm) of water in casing	Grams dry weight needed per 1 foot (30 cm) of water in casing
inches	meters	Litres	Litres	Litres	Grams
4	0.100	2.47	0.012	0.005	0.9
5	0.125	3.86	0.018	0.008	1.4
6	0.150	5.55	0.026	0.012	2.0
7	0.175	7.57	0.036	0.016	2.7
8	0.200	9.89	0.047	0.020	3.5
24	0.600	89.00	0.424	0.185	31.7
30	0.750	140.00	0.667	0.292	50.0
36	0.900	200.00	0.952	0.417	71.3

* Domestic bleach has a relatively low concentration of 5.25%, and after sitting on store shelves, this concentration may decrease further. For this reason, its effectiveness for disinfection may be limited.
** If the dry chemical is used, it should be mixed with water to form a chlorine solution prior to placing it in the well.

For example, if the well is 30 inches in diameter and 12% Industrial Sodium Hypochlorite is to be used, 0.292 L of the chemical will need to be added per foot of water in the casing in order to obtain a chlorine concentration of 250 mg/L. If there is 20 feet of water in the casing, a total of 5.84 L of 12% Industrial Sodium Hypochlorite will be required (0.292 L/ft. x 20 feet = 5.84 L).

Volume Calculation for Well Decommissioning						
Casing diameter	Casing radius	Casing radius	Volume per meter casing	Volume per foot casing	Volume per foot casing	Volume per foot casing
inches	inches	meters	Litres	gallons	cubic feet	cubic yards
4	2	0.0508	8.1	0.544	0.087	0.0032
5	2.5	0.0635	12.7	0.851	0.136	0.0050
6	3	0.0762	18.2	1.225	0.196	0.0073
7	3.5	0.0889	24.8	1.667	0.267	0.0099
8	4	0.1016	32.4	2.178	0.348	0.0129
24	12	0.3048	291.9	19.600	3.136	0.1161
30	15	0.381	456.0	30.625	4.900	0.1815
36	18	0.4572	656.7	44.099	7.056	0.2613

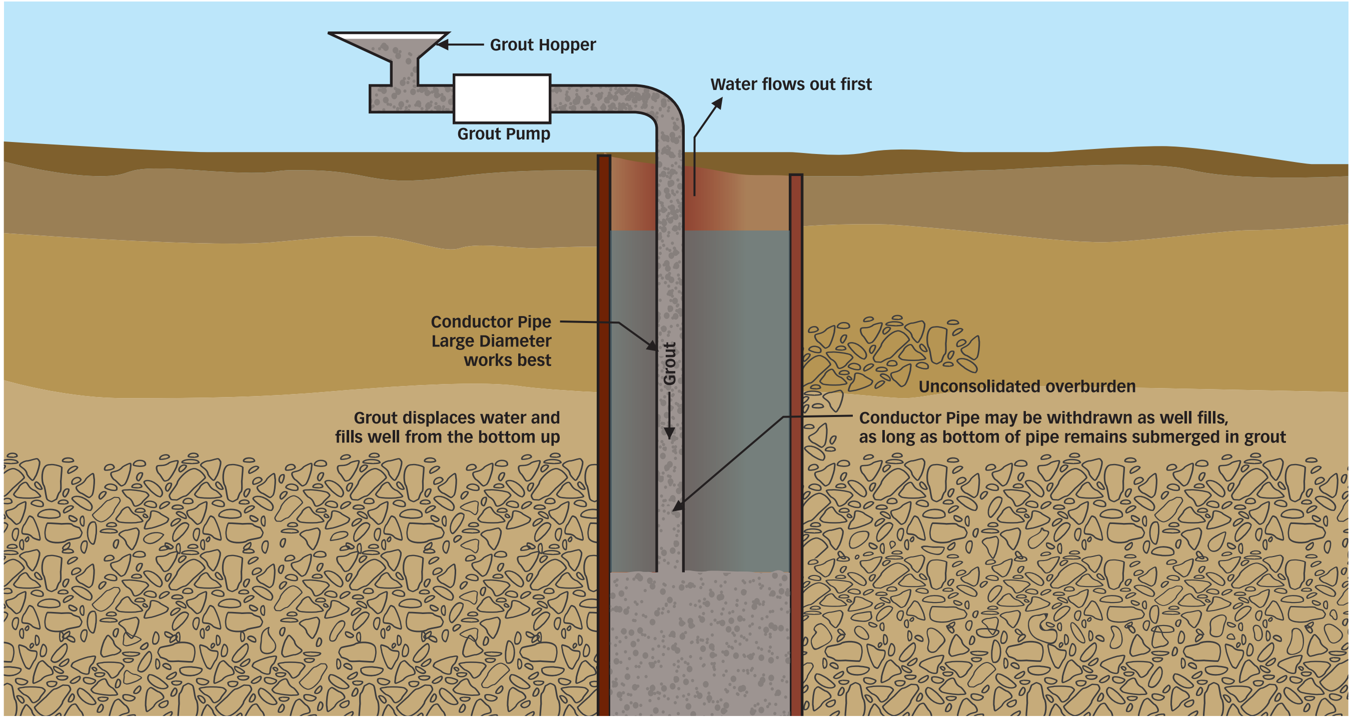

Figure 29: Pumped Method for Well Abandonment

Small Diameter Wells (drilled)

Small diameter wells should be decommissioned with a grout seal. The grout must be introduced at the bottom of the well and placed progressively upwards to ground surface. The use of a grout pump and tremie pipe is the preferred method for placing the grout. This will ensure the positive displacement of water in the well and minimize dilution or separation of the grout. The tremie pipe should be removed after the well has been grouted.

Figure 30: Filling the well with uncontaminated coarse sand or gravel

Large Diameter Wells (bored)

These wells are usually 0.3 meters (12 in.) to 1.2 meters (48 in.) in diameter and less than 30 meters deep.

A 0.3-meter (12 in.) layer of bentonite chips/pellets should be placed at the bottom of the well. The remainder of the well should be backfilled to a depth 3 meters (120 in.) below the ground surface with layers of uncontaminated coarse sand/gravel not more than 3 meters (120 in.) thick, with a 0.15 meter (6 in.) layer of bentonite chips between backfill layers.

- **Remove casing and capping –** casing that was left in place before sealing the well should be removed to a depth 3 meters (120 in.) below ground surface. The excavation should be backfilled with local uncontaminated clay, compacted and mounded to prevent water from ponding near the abandoned well site.


Figure 31: Removal of well casing

Flowing wells have unique characteristics and should only be decommissioned by an experienced water well contractor.

The effectiveness of the well decommissioning procedures in protecting groundwater from surface contamination is primarily determined by the method used to decommission the well and the materials used to seal the well. Exact procedures may differ for each circumstance, which is why it is important that the person responsible for performing the well decommissioning be knowledgeable about well construction practices and good groundwater protection principles.

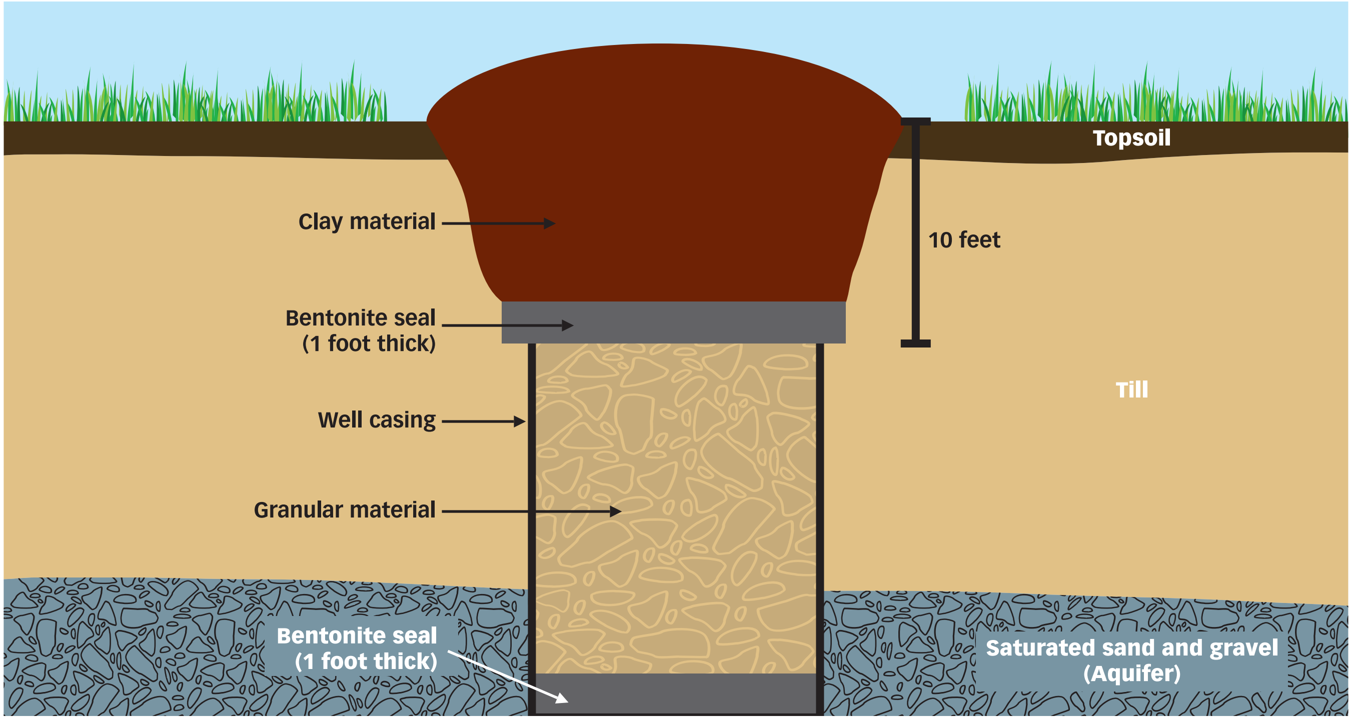

Figure 32: Well decommissioning for large diameter wells

CONCLUSION

We hope that this guide has provided you with useful information about groundwater and water well management. For assistance with any questions or concerns that were not addressed in this document, please see the contact information on page 52 for experts on groundwater resources, well siting and management, water quality, and well decommissioning.

Drilling Contractors

Choosing a Drilling Contractor

All drilling contractors in Saskatchewan are required to register their drilling rigs before they operate a machine for the purpose of obtaining groundwater or scientific data on groundwater. The Saskatchewan Watershed Authority can be contacted for an updated list of registered contractors and drilling rigs (please refer to page 55 for contact information). It is beneficial to contact numerous drillers in order to get a comparison of quotes. It is also advisable to hire a contractor who is familiar with the drilling conditions in the area.

Water Well Drilling Agreements

Water well drilling is a costly investment, and therefore a water well drilling agreement should be drawn up prior to the well being drilled. This will prevent any misunderstandings between the well owner and the drilling contractor and will clearly define the services, materials and costs involved in the drilling process. Agreements should cover:

- All costs of drilling/well construction.
- Starting date and completion date.
- Logging of test hole and submission of driller's report.
- Maximum depth of well construction.
- Type of well connection desired (ie. pitless adaptor).
- Desired well yield and acceptable water quality.
- Control of flowing well, if encountered.
- Details about well construction materials such as:
  - type and diameter of well casing.
  - type and diameter of well screen.
  - type of annulus or casing seal.
- Development of well.
- Yield test.
- Disinfection.
- Installation of pump.
- Equipping the well with a sanitary well cap.
- Guarantees.

The following pages provide an example of a water well drilling agreement form.

Water Well Drilling Agreement Form

Identification

1.	Well owner
	Address
2.	Drilling contractor
	Address
3.	Proposed starting date
	Proposed completion date

Planning of Water System

Water Sources

4.	Groundwater supply options based on existing records*

* A drilling contractor and well owner should research groundwater information on local wells to determine possible groundwater supply options. Information is available from the Saskatchewan Watershed Authority.

Water Quality Requirements

5.	Proposed well use:	Household	Livestock	Irrigation
6.	Desired water quality*	On-site tests:		
	Total dissolved solids mg/L		Iron mg/L	
	Hardness mg/L		pH	

* Water quality is a very important consideration for all potential water uses. Drilling contractors can determine rough estimates for some parameters, such as total dissolved solids, iron, hardness and pH. However, only accredited water analysis laboratories can provide reliable results. These results will establish whether water treatment equipment may be needed.

Water Quantity Requirements

7. Desired yield* L/s (gpm)	Min. acceptable yield L/s (gpm)

* The desired yield is the flow rate of water, either in litres per second (L/s) or gallons per minute (gpm), from a well. The desired yield can be determined by referring to the Sizing the Water Supply section in Chapter 2 of this publication. In some areas, aquifers are slow yielding, and the desired minimum yield might not be available. In this case, the desired yield should be stated as the normal yield for the area. It is important to establish a minimum yield of water desired so that the well is considered an economically feasible investment.

Well Site

8. Location of well:	Qtr	Sec	Twp	Rge
	W of Meridian	Lot	Block	Plan

Design and Construction of Water Well

Well Design

9. Maximum desired depth* m (ft.)
10. Type of drilling
11. Diameter of hole**
12. Flowing well control***
13. Well connection
14. Formation logging procedure****
15. Annulus or casing seal
16. Artificial filter pack*****

* A maximum desired depth should be established prior to drilling the well. This will depend on the known depths of productive aquifers and their respective water qualities. Personal finances are also a factor when determining the maximum desired well depth.
** The type of well that is drilled will help determine the diameter of the hole. Drilled wells are usually 10 –20 cm (4 – 8 inches) in diameter, and bored wells are usually 46 – 122 cm (18 – 48 inches) in diameter
*** If a flowing well is anticipated, sufficient surface casing should be set and cemented, and a control device that will allow the flow to be controlled and shut off should be added.
**** Well drillers will perform various logging procedures to identify the aquifers with the best potential for water supply. These can include descriptive logging, electric logging, or gamma-ray logging.
***** In the case where the aquifer has a relatively uniform grain size, an artificial filter pack may be used.

Material

17. Casing material		
Inside diameter	Weight per m (ft.)	Wall thickness
18. Well cover	Distance from top of casing to ground surface	
19. Liner material		
Insider diameter	Weight per m (ft.)	Wall thickness

20. Screen	
Manufacturer	Material
Length	Nominal diameter

Well Completion

Well Development

21. Well development method:	Backwashing	Jetting	Surging
	Bailing	Heavy pumping	

Yield Testing

22. Yield testing duration* (hours)

* A drilling contractor will perform a yield test in order to determine the most suitable pumping equipment for the well. The test should also provide the following information that can be used to monitor future well performance:

i. Non-pumping (static) water level.
ii. Water removal rate in L/s (gpm).
iii. Depth to the pumping water level at one or more constant pumping rates (drawdown).
iv. The length of time the well is pumped at each rate.
v. The recovery of the water level over a two-hour period or until 90% recovery of the non-pumping water level is reached.

Disinfection

23. Disinfection*

* The well and pumping equipment should be disinfected. The concentration of chlorine to be used is calculated based on the volume of water that is in the well. The concentration must be left in the well for at least 12 hours to ensure any bacteria present are destroyed.

Well Completion

24. Well head finishing*

* Well head finishing includes the clean up and removal of any mud, aquifer debris, and material scraps.

Costs

25. Test holes per metre (ft.)
26. Reaming per metre (ft.)
27. Drilling/boring per metre (ft.)
28. Casing per metre (ft.)
29. Liner per metre (ft.)
30. Screen
31. Filter pack
32. Development
33. Labour per hour
34. Water testing
35. Reclamation of unused well

36. Total costs
37. Payment schedule

38. Guarantee

Water Well Drilling Reports

Driller's Report

Within 30 days following the completion of the drilling of the well, the drilling contractor must submit a driller's report to the Saskatchewan Watershed Authority.

Electric and Other Logs

If the drilling contractor runs an electric log or other log on a test hole or well, the driller must submit a copy to the Saskatchewan Watershed Authority within 30 days following the completion of the logging.

Chlorine Disinfection Procedures

Disinfection is routinely used to control bacteria in wells and is applied as part of a start-up procedure for newly constructed wells and should be used as semi-annual maintenance for existing wells. Disinfection should also be performed in the event of contamination (e.g. flooding or unacceptable levels of bacterial growth).

Well disinfection can be performed by two methods: low or high level chlorine disinfection. High level chlorine disinfection is the preferred option. However, if the proper equipment (e.g. a 1,360 litre tank) is not available then low level disinfection may be adequate.

Until the disinfection procedure has eliminated the bacterial contamination, an alternate source of safe water should be used or the water should be boiled for one minute, at a rolling boil, before use. In addition, if possible identify and eliminate the source of contamination.

High Level Chlorine Well Disinfection (Shock Disinfection)

Materials Required

- A clean water tank with a holding capacity of at least 1,360 litres (300 gallons).
- Garden hose.
- 20 litres of industrial strength chlorine (12% sodium hypochlorite) – available from any chemical dealer, water treatment supplier, or dairy supply retailer.

Procedure

1. Follow chlorine manufacturer's instructions for use. Chlorine concentrations at this level are dangerous. Avoid contact with skin or inhaling the fumes, and wear protective clothing/eye wear. If the well is located in a pit, make sure there is proper ventilation during the chlorination procedure. It is recommended that the services of a licensed well driller who has the proper equipment and experience to do the job safely be contracted.
2. Ventilate confined spaces (e.g. well pit, crawl space, and all other confined spaces) where potentially dangerous levels of vapours may accumulate.
3. Do not run chlorinated water through certain types of water treatment equipment (e.g. softeners, carbon filters, reverse osmosis systems). For specific information, contact the equipment dealer or the Saskatchewan Watershed Authority.
4. The disinfection treatment will require the well to be taken out of service. Therefore, store enough water to meet all necessary requirements for a minimum 12 hour period.
5. Fill the water tank to a minimum of 1,360 litres (300 gallons) with water from the well.
6. After drawing the water from the well, allow the well to recover to its static (non-pumping) level.
7. Add 10 litres of the chlorine solution (12% sodium hypochlorite) to the well through the garden hose extended as far down the well as possible. If a well is slow yielding or tends to pump any sediment, be careful when chlorinating. Slowly siphon the solution down the well and pump it out very slowly. Over-pumping the well may worsen the sediment problem.
8. Add the remaining 10 litres of the 12% sodium hypochlorite to the tank of water.
9. Slowly add the water with chlorine from the tank to the well. Do not exceed the well pumping rate.
10. Start the pump and bleed air from the pressure tank. Open each tap and allow the water to run through all taps until a smell of chlorine is detected, then turn off the taps.
11. Turn the entire system off for at least 12 hours. Chlorine can be very corrosive if left in the water distribution system for an extended period of time.
12. After at least 12 hours, flush the system by running water through an outside hose away from grass, shrubs, trees and other sensitive plants until the strong smell of chlorine disappears. Make certain that the water does not enter any watercourse. Finally, open the indoor taps until the system is completely flushed. Return the system to normal operation.
13. If high level disinfection is being used to eliminate a bacterial problem, verify that the procedure has removed the bacteria.

Low Level Chlorine Well Disinfection

Materials Required

- Disinfection can be conducted using unscented household bleach. Check the product label to ensure that the chlorine is in the form of sodium hypochlorite or calcium hypochlorite. Some "all purpose bleaches" (such as Javex 2) contain no chlorine and should not be used for disinfecting wells.
- The table below outlines the quantity of bleach required to properly disinfect a well.

Procedure

1. Follow chlorine manufacturer's instructions for use. Chlorine concentrations at this level are dangerous. Avoid contact with skin, inhaling the fumes and wear protective clothing/eye wear. If the well is located in a pit, make sure there is proper ventilation during the chlorination procedure. It is recommended that the services of a licensed well driller who has the proper equipment and experience to do the job safely be contracted.
2. Ventilate confined spaces (e.g., well pit, crawl space, and all other confined spaces) where potentially dangerous levels of vapours may accumulate.
3. Do not run chlorinated water through certain types of water treatment equipment (e.g., softeners, carbon filters, reverse osmosis systems). For specific information, contact the equipment dealer or the Saskatchewan Watershed Authority.
4. If a well is slow yielding or tends to pump any sediment, be careful when chlorinating. Slowly siphon the solution down the well and pump it out very slowly. Over-pumping the well may worsen the sediment problem.
5. The disinfection treatment will require the well to be taken out of service. Therefore, store sufficient water to meet all necessary requirements for a minimum 12 to 24 hour period.
6. Add the amount of unscented bleach indicated in the table below directly into the well. Connect a garden hose to a nearby tap and wash down the inside wall of the well. This will ensure thorough mixing of the chlorine and the water throughout the well.
7. Start the pump and bleed air from the pressure tank. Open each tap and allow the water to run through all taps until a smell of chlorine is detected, then turn off the taps. If a strong smell is not detected, add more bleach to the well and repeat step 7.
8. Allow the water to sit in the system for 12 to 24 hours.
9. Start the pump and run water through an outside hose away from grass, shrubs, trees and other sensitive plants until the strong smell of chlorine disappears. Make certain that the water does not enter any watercourse. Finally, open the indoor taps until the system is completely flushed. Return the system to normal operation.
10. If low level disinfection is being used to eliminate a bacterial problem, verify that the procedure has removed the bacteria.

Low Level Chlorine Disinfection

Depth of Water in Well (m)	Volume of Bleach Added (5.25% chlorine)	
	Casing Diameter = 15 cm (Drilled Well)	Casing Diameter = 90 cm (Bored Well)
1	100 mL	3.2 L
3	300 mL	9.8 L
5	500 mL	16.5 L
10	1,000 mL	32.0 L
30	3,000 mL	96.0 L

Disinfection Verification

- Until water testing indicates that the water is safe to use, find another source of water, or boil the water for one minute, at a rolling boil, before consuming. This precaution is particularly important for persons who are immunocompromised and also if the water is being used for infant feeding (preparing formula, etc.).
- For **private water supplies**, it is recommended that a sample be taken five days after treatment and another at least one week after constant use. Two consecutive 'safe' test results are required to ensure that the treatment was effective.
- For **Health regulated public water supplies**:
  - wells not receiving continuous treatment require a sample taken five days after treatment and another at least one week after constant use,
  - wells receiving continuous disinfection treatment require at least two consecutive sets of samples. The samples should be taken at least one day after the treatment and one day apart. Health Region officials will be advising the owner/operator of the supply on number of samples, sampling locations and when the water supply can be used again for human consumption.
- In general, all private systems should be analysed at least once a year or whenever there is reason to believe that the water supply may have become contaminated (e.g. flooding).
- Health regulated public water supplies must sample as required by the Health Region.

Alternatives

Private Water Supply

If high level disinfection fails to correct the problem in a private water supply, contact the local offices of Agriculture and Agri-Food Canada – Agri-Environment Services Branch, the Saskatchewan Watershed Authority, the Saskatchewan Ground Water Association, or a Professional Engineer or Geoscientist for further assistance.

Health Regulated Public Water Supply

If high level disinfection fails to correct the problem in a Health regulated public water supply, contact the local Health Region Public Health Inspector for further assistance.

Drinking Water Quality Standards and Objectives

Saskatchewan Environment sets drinking water quality standards and objectives for municipal and other large drinking water systems based on limit values published by Health Canada. The following table provides the objectives for the most common parameters that are tested for when conducting water analysis on private rural wells.

Drinking Water Quality Standards and Objectives			
Analyte	**Units**	**Objective[1]**	**Objective Type**
Bicarbonate	mg/L	ng	
Calcium	mg/L	ng	
Carbonate	mg/L	ng	
Chlorides	mg/L	250	Aesthetic Objective
Hydroxide	mg/L	ng	
Magnesium	mg/L	200	Aesthetic Objective
pH	pH units	6.5 to 9.0	Aesthetic Objective
Potassium	mg/L	ng	
Sodium	mg/L	200	Aesthetic Objective
Specific Conductivity	µS/cm	ng	
Sulphate	mg/L	500	Aesthetic Objective
Sum of Ions	mg/L	1,500	Aesthetic Objective
Total Alkalinity	mg/L	500	Aesthetic Objective
Total Hardness	mg/L	800	Aesthetic Objective
Nitrate	mg/L	45	Maximum Acceptable Concentration
Organic Carbon, Dissolved	mg/L	ng	
Arsenic	µg/L	10	Interim Maximum Acceptable Concentration[2]
Barium	mg/L	1.0	Maximum Acceptable Concentration
Boron	mg/L	5	Interim Maximum Acceptable Concentration[2]
Cadmium	mg/L	0.005	Maximum Acceptable Concentration
Chromium	mg/L	0.05	Maximum Acceptable Concentration
Copper	mg/L	1.0	Aesthetic Objective
Fluoride	mg/L	1.5	Maximum Acceptable Concentration
Iron	mg/L	0.3	Aesthetic Objective
Lead	mg/L	0.01	Maximum Acceptable Concentration
Manganese	mg/L	0.05	Aesthetic Objective
Selenium	mg/L	0.01	Maximum Acceptable Concentration
Zinc	mg/L	5.0	Aesthetic Objective
Fecal Coliform Bacteria	ct/100 mL	0	Maximum Acceptable Concentration
Total Coliform Bacteria	ct/100 mL	0	Maximum Acceptable Concentration
Uranium	µg/L	20	Maximum Acceptable Concentration

1 Based on Saskatchewan's Drinking Water Quality Standards and Objectives
2 Interim Maximum Acceptable Concentrations have been set by Health Canada

mg/L = milligrams per litre
µg/L = micrograms per litre
µS/cm = microsiemens per centimetre
ct/100 mL = count per 100 milliliters
ng = no guideline set

There are three objective types used when referencing drinking water quality guidelines and objectives:

1. **Maximum Acceptable Concentration (MAC)**
   Maximum acceptable concentrations have been established for substances that are known or suspected to cause adverse effects on health. Objectives are set at levels that will not cause hazardous health effects when consumed at that concentration over a lifetime.
2. **Interim Maximum Acceptable Concentration (IMAC)**
   In some cases, there is insufficient toxicological data to establish MACs with reasonable certainty. For these substances, interim values are recommended, taking into account the available health-related data, while at the same time employing a safety factor to compensate for the uncertainties involved.
3. **Aesthetic Objective (AO)**
   Aesthetic objectives apply to substances or characteristics of drinking water that can affect its acceptability to consumers or interfere with practices for supplying good quality water. In some cases, both AO and health-related guidelines (MACs or IMACs) have been derived. Where only aesthetic objectives are specified, these values are below those considered to constitute a health hazard.

Questions relating to human health should be directed to the local Health Region. Please refer to page 54 for contact information.

Groundwater Management and Legal Requirements

Inventory of Groundwater Resources in Saskatchewan

The Saskatchewan Watershed Authority maintains a groundwater database that comprises an inventory of wells and test holes throughout the province. This information provides guidance to the public in determining the potential water supply at a given site. The information for a given area determines the base of groundwater exploration, well depth, yield, and water chemistry. Information can also be obtained on different exploration methods, well design considerations, possible water treatment requirements, well maintenance and groundwater protection practices.

All inquiries and requests for assistance regarding groundwater availability should be directed to the Saskatchewan Watershed Authority's Head Office in Moose Jaw or to the nearest Saskatchewan Watershed Authority Regional Office.

Allocation and Licensing

The Saskatchewan Watershed Authority is responsible for administrating the regulatory approval process for construction and operation of wells and other groundwater works. *The Saskatchewan Watershed Authority Act, 2005* and The Ground Water Regulations provide details for the requirements and processes in obtaining an approval.

Approvals are required to ensure proposed projects are sustainable and do not cause adverse impacts to the environment or other users. An approval is required for all groundwater use except for domestic purposes. Domestic purposes include water used for watering of stock (non-intensive) and non-commercial lawns and gardens, as well as household and sanitary purposes. Examples of works requiring approval include municipal, industrial (including groundwater dewatering), intensive livestock operations, and irrigation.

Development of a Groundwater Source

The Saskatchewan Watershed Authority's regulatory approval process for the development of a non-domestic groundwater source project has two parts. The developer of a proposed groundwater development is required to obtain:

1. a Ground Water Investigation Permit; and
2. an Approval to Construct and Operate Works and Water Rights Licence to Use Ground Water.

Ground Water Investigation Permit

The purpose of a groundwater investigation is to ensure that the groundwater source can sustain the proposed development without any adverse impacts on the source, or existing groundwater users.

Approval to Construct and Operate Works and Water Rights Licence to Use Ground Water

If the groundwater investigation was successful, the project developer is required to file an Approval to Construct and Operate Works and Water Rights Licence to Use Ground Water under *The Saskatchewan Watershed Authority Act, 2005*.

Groundwater Regulations and Legislation

Water Resources Legislation

The Saskatchewan Watershed Authority Act, 2005

The Saskatchewan Watershed Authority was established to manage, administer, develop, control, and protect the water, watersheds, and related land resources of Saskatchewan. Included in this mandate, the Saskatchewan Watershed Authority has the responsibility for administering the approval process for the construction and operation of water wells and other groundwater works, and the right to use groundwater.

The Irrigation Act, 1996

The Irrigation Act is an act that aims to promote, develop and sustain irrigation in Saskatchewan.

Water Quality Legislation

The Environmental Management and Protection Act, 2002

The Act gives the Minister of the Environment powers to issue orders to investigate any activities that may pollute the environment, to monitor for effects, to halt such activities, and to restore the affected environment.

The Environmental Assessment Act

The Environmental Assessment Act authorizes the Saskatchewan Ministry of Environment to review the potential environmental effects of a proposed development. Any project defined as a "development" must be approved by the Minister of Environment before it is allowed to proceed.

The Public Health Act, 1994

The Public Health Act, 1994 gives authority to the Local Authorities (i.e. Health Regions) for the administration and enforcement of the Act. The Act also provides responsibilities to municipalities to ensure that sewer systems and supply of potable water systems are available to inhabitants of cities, towns, villages and hamlets. The Local Authority can order the abatement of any condition that is or may become a health hazard.

The Pest Control Products (Saskatchewan) Act

The Pest Control Products (Saskatchewan) Act puts forth rules for the handling, storage and use of pesticides.

The Boiler and Pressure Vessel Act, 1999

The Boiler and Pressure Vessel Act, 1999 is an act respecting boilers and pressure vessels, as well as steam, refrigeration and compressed gas plants.

The Agricultural Operations Act

The Agricultural Operations Act is an act respecting agricultural operations, including intensive livestock operations.

Regulations

The Ground Water Regulations

The Ground Water Regulations put forth rules for the registration of drilling machines, drilling and evaluation, the abandonment of test holes and wells, and the use of groundwater.

The Water Regulations, 2002

The Water Regulations, 2002 set forth permit requirements for municipal sewage works, certain pipeline systems, and privately-owned water systems and that have a design flow of effluent that is greater than 18 cubic metres per 24-hour period. The regulations outline the requirements for the construction and operation of these systems, and also state the provincial drinking water quality standards.

The Hazardous Substances and Waste Dangerous Goods Regulations

The Hazardous Substances and Waste Dangerous Goods Regulations discuss the requirements to store or transfer hazardous substances.

The Environmental Spill Control Regulations

The Environmental Spill Control Regulations discuss the content and the method for submitting a spill report, as well as regulations concerning the disposal of the spilled pollutant.

The Health Hazard Regulations

The Health Hazard Regulations require specific actions to be taken by owners and operators of regulated water systems. In addition, the regulations include requirements for bulk water haulers, sanitary facilities at public places and the disposal of dead animals.

The Plumbing and Drainage Regulations

The Plumbing and Drainage Regulations adopt with amendments the Canadian Plumbing Code and require plumbing permits to be applied for. It is also this regulation that requires a permit for a private sewage works to be applied for and lays out requirements for water and sewer services within Mobile Home Parks.

The Shoreland Pollution Regulations

The Shoreland Pollution Control Regulations restrict land uses within a shoreland development area (eg. within 1,500 ft of a water body). Included in these regulations are restrictions on solid waste and sewage disposal works.

Contacts and Other Sources of Information

Agriculture and Agri-Food Canada – Agri-Environment Services Branch

North Saskatchewan

North Battleford District Office
Room 121 – 9800 Territorial Place
North Battleford, SK S9A 3N6

Ph: (306) 446-4050
Fax: (306) 446-4060
Website: www.agr.gc.ca

Melfort District Office
Box 1748
Bay 3 – 102 McKendry Avenue West
Melfort, SK S0E 1A0

Ph: (306) 752-4442
Fax: (306) 752-1991
Website: www.agr.gc.ca

Watrous District Office
Box 1150
107E 3rd Avenue East
Watrous, SK S0K 4T0

Ph: (306) 946-8720
Fax: (306) 946-3318
Website: www.agr.gc.ca

Rosetown District Office
Box 1420
219 Main Street
Rosetown, SK S0L 2V0

Ph: (306) 882-4272
Fax: (306) 882-4055
Website: www.agr.gc.ca

South Saskatchewan

Weyburn District Office
#21 110 Souris Avenue
Weyburn, SK S4H 2Z8

Ph: (306) 848-4488
Fax: (306) 848-4499
Website: www.agr.gc.ca

Gravelbourg District Office
Box 155
314 Main Street
Gravelbourg, SK S0H 1X0

Ph: (306) 648-2214
Fax: (306) 648-3402
Website: www.agr.gc.ca

Swift Current District Office
Box 1088
L.B. Thomson Place
Gate #2, SPARC, Airport Road
Swift Current, SK S9H 3X3

Ph: (306) 778-5000
Fax: (306) 778-5020
Website: www.agr.gc.ca

Maple Creek District Office
Box 430
Highway 21 and 2nd Avenue
Maple Creek, SK S0N 1N0

Ph: (306) 662-5520
Fax: (306) 662-3166
Website: www.agr.gc.ca

Moose Jaw District Office
1410A Caribou Street West
Moose Jaw, SK S6H 7S9

Ph: (306) 691-3370
Fax: (306) 693-3103
Website: www.agr.gc.ca

Melville District Office
Box 130
109 – 290 Prince William Drive
Melville, SK S0A 2P0

Ph: (306) 728-5790
Fax: (306) 728-6558
Website: www.agr.gc.ca

Canadian Ground Water Association

Main Office
1600 Bedford Highway
Suite 100 – 409
Bedford, NS B4A 1E8

Ph: (902) 845-1885
Fax: (902) 845-1886
E-mail: info@cgwa.org
Website: www.cgwa.org

Saskatchewan Ground Water Association
P.O. Box 9434
Saskatoon, SK S7K 7E9

Ph: (306) 244-7551
Fax: (306) 343-0002

SaskH_2O

Toll Free: 1-866 SASK H2O (727-5420)
Website: www.saskh2o.ca

Saskatchewan Ministry of Agriculture

Agriculture Knowledge Centre

Ph: 1-866-45-SAFRR (1-866-457-2377)
Email: aginfo@agr.gov.sk.ca
Website: www.agriculture.gov.sk.ca

Regional Offices

Kindersley Regional Office
409 Main Street
Kindersley, SK S0L 1S0

Phone: (306) 463-5513

North Battleford Regional Office
1192-102nd Street
North Battleford, SK S9A 1E9

Ph: (306) 446-7964

Outlook Regional Office
Box 9
420 Saskatchewan Avenue West
Outlook, SK S0L 2N0

Phone: (306) 867-5575

Prince Albert Regional Office
Box 3003
800 Central Avenue
Prince Albert, SK S6G 6G1

Phone: (306) 953-2363

Swift Current Regional Office
Box 5000
350 Cheadle Street West
Swift Current, SK S9H 4G3

Phone: (306) 778-8218

Tisdale Regional Office
Box 1480
1105-99th Street
Tisdale, SK S0E 1T0

Phone: (306) 878-8842

Watrous Regional Office
Box 520
403 Main Street
Watrous, SK S0K 4T0

Phone: (306) 946-3220

Weyburn Regional Office
Box 2003
110 Souris Avenue
Weyburn, SK S4H 2Z9

Phone: (306) 848-2857

Yorkton Regional Office
38-5th Avenue North
Yorkton, SK S3N 0Y8

Phone: (306) 786-1531

Saskatchewan Ministry of Environment

3211 Albert Street
Regina, SK S4S 5W6

Ph: (306) 787-2314
Website: www.environment.gov.sk.ca/

Spill Control Centre

Ph: 1-800-667-7525

Saskatchewan Health

Regional Health Authority Offices

Athabasca Health Authority
Box 124
Black Lake, SK S0J 0H0

Ph: (306) 439-2200
Website: www.athabascahealth.ca

Cypress Health Region
429 – 4th Avenue NE
Swift Current, SK S9H 2J9
Swift Current, SK

Ph: (306) 778-5100
Website: www.cypresshealth.ca

Five Hills Health Region
455 Fairford Street East
Moose Jaw, SK S6H 1H3

Ph: (306) 694-0296
Website: www.fhhr.ca

Heartland Health Region
Box 2110
110 Highway #4 South
Rosetown, SK S0L 2V0

Ph: (306) 882-4111
Website: www.hrha.sk.ca

Keewatin Yatthe Health Region
Box 40
Buffalo Narrows, SK S0M 0J0

Ph: (306) 235-2220
Website: www.kyrha.ca

Kelsey Trail Health Region
Box 1780
Tisdale, SK S0E 1T0

Ph: (306) 873-6600
Website: www.kelseytrailhealth.ca

Mamawetan Churchill River Health Region
Box 6000
La Ronge, SK S0J 1L0

Ph: (306) 425-2422
Website: www.mcrrha.sk.ca

Prairie North Health Region
1092 – 107th Street
North Battleford, SK S9A 1Z1

Ph: (306) 446-6606
Website: www.pnrha.ca

Prince Albert Parkland Health Region
2nd Floor
1521 - 6 Avenue West
Prince Albert, SK S6V 7V6

Ph: (306) 765-6400
Website: www.paphr.sk.ca

Regina Qu'Appelle Health Region
2180 – 23rd Avenue
Regina, SK S4S 0A5

Ph: (306) 766-7755
Website: www.rqhealth.ca

Saskatoon Health Region
3rd Floor, Saskatoon Square
410 - 22nd Street East
Saskatoon, SK S7K 5T6

Ph: (306) 655-4605
Website: www.saskatoonhealthregion.ca

Sun Country Health Region
Box 2003
Weyburn, SK S4H 2Z9

Ph: (306) 842-8618
Website: www.suncountry.sk.ca

Sunrise Health Region
270 Bradbrooke Drive
Yorkton, SK S3N 2K6

Ph: (306) 786-0600
Website: www.sunrisehealthregion.sk.ca

Saskatchewan Watershed Authority Offices

Head Office

Victoria Place
111 Fairford Street East
Moose Jaw, SK S6H 7X9

Ph: (306) 694-3900
Fax: (306) 694-3465
E-mail: comm@swa.ca
Website: www.swa.ca

Regional Offices

Southeast - Weyburn Regional Office
Box 2003
3rd Floor, City Centre Mall
110 Souris Avenue
Weyburn, SK S4H 2Z9

Ph: (306) 848-2345
Fax: (306) 848-2356
E-mail: comm@swa.ca
Website: www.swa.ca

Southwest - Swift Current Regional Office
Box 5000
3rd Floor, E.I. Wood Building
350 Cheadle Street West
Swift Current, SK S9H 4G3

Ph: (306) 778-8257
Fax: (306) 778-8271
E-mail: comm@swa.ca
Website: www.swa.ca

Northeast - Nipawin Regional Office
Box 2133
201 – 1st Avenue East
Nipawin, SK S0E 1E0

Ph: (306) 862-1750
Fax: (306) 862-1771
E-mail: comm@swa.ca
Website: www.swa.ca

East Central - Yorkton Regional Office
2nd Floor, 120 Smith Street East
Yorkton, SK S3N 3V3

Ph: (306) 786-1490
Fax: (306) 786-1495
E-mail: comm@swa.ca
Website: www.swa.ca

Northwest – North Battleford Regional Office
402 Royal Bank Tower
1101 – 101st Street
North Battleford, SK S9A 0Z5

Ph: (306) 446-7450
Fax: (306) 446-7461
E-mail: comm@swa.ca
Website: www.swa.ca

Other Offices

Regina Office
Park Plaza
Suite 420 – 2365 Albert Street
Regina, SK S4P 4K1

Ph: (306) 787-0726
Fax: (306) 787-0780
E-mail: comm@swa.ca
Website: www.swa.ca

Saskatoon Office
330 – 350 Third Avenue North
Saskatoon, SK S7K 2H6

Ph: (306) 933-7442
Fax: (306) 933-6820
E-mail: comm@swa.ca
Website: www.swa.ca

SaskWater

Head Office

111 Fairford Street East
Moose Jaw, SK   S6H 7X9

Ph: (306) 694-3098
Toll Free: 1-888-230-1111
Fax: (306) 694-3207

Other Offices

Watrous Office
Box 310
403 Main Street
Watrous, SK   S0K 4T0

Ph: (306) 946-3200
Fax: (306) 946-3533

Prince Albert Office
McIntosh Mall
800 Central Avenue
Prince Albert, SK   S6V 6G1

Ph: (306) 953-2250
Fax: (306) 953-225

24 Hour Emergency Number

1-800-667-5799

Water Quality

Saskatchewan Watershed Authority
Rural Water Quality Office
Ph: 1-866-TEST-H20 (1-866-837-8420)

Accredited Water Analysis Laboratories in Saskatchewan

BDS Laboratories
13 Qu'Appelle Street
Box 363
Qu'Appelle, SK   S0G 4A0

Ph: (306) 699-2679
Toll Free: 1-888-BDS-Labs (1-888-237-5227)
Fax: (306) 699-7190
Website: www.bdslabs.com

Buffalo Pound Water Treatment Plant
Box 1790
Regina, SK   S4P 3C8

Ph: (306) 694-1377
Fax: (306) 694-6050

ALS Laboratory Group
124 Veterinary Road
Saskatoon, SK   S7N 5E3

Ph: (306) 668-8370
Toll Free: 1-800-668-9878
Fax: (306) 668-8383

Saskatchewan Ministry of Health
Disease Control Laboratory
3211 Albert Street
Regina, SK   S4S 5W6

Ph: (306) 787-3131
Toll Free: 1-866-450-0000
Fax: (306) 798-0046

Saskatchewan Research Council
SRC Analytical Laboratories
422 Downey Road
Saskatoon, SK   S7N 4N1

Ph: (306) 933-6932
Toll Free: 1-800-240-8808
Fax: (306) 933-7922

References

The following is a list of useful publications related to groundwater.

Groundwater

A Primer on Fresh Water – Questions and Answers. 2000.
Environment Canada.

Groundwater – Nature's Hidden Treasure. 1999.
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Groundwater Protection

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Canadian Fertilizer Industry Storage and Handling Guidelines. 2001.
Canadian Fertilizer Institute.

Clean Water – Life Depends on It! 1992.
Environment Canada.

Developing a Manure and Dead Animal Management Plan. 2000.
Saskatchewan Agriculture and Food.

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Saskatchewan Agriculture and Food.

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Saskatchewan Agriculture and Food.

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Saskatchewan Environment.

Guide to Crop Protection. 2006.
Saskatchewan Agriculture and Food.

Holding Pond Site Selection and Design. 1999.
Saskatchewan Agriculture and Food.

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Saskatchewan Agriculture and Food.

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Manure Handling from Barn to Storage for Poultry.
Canada Plan Service Leaflet.

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National Research Council of Canada.

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Saskatchewan Agriculture and Food.

Protecting Your Ground Water. 2006.
Saskatchewan Watershed Authority.

Silage Storage Techniques.
Saskatchewan Agriculture and Food.

The Saskatchewan Onsite Wastewater Disposal Guide. 2007.
Saskatchewan Health.

Groundwater Quality

Guidelines for Drinking Water Quality.
Health Canada.

Groundwater Use

Ground Water Approval Process. 2006.
Saskatchewan Watershed Authority.

Domestic Water Use. 2006.
Saskatchewan Watershed Authority.

Water Quality Testing

Rural Water Quality Collection and Testing. 2006.
Saskatchewan Watershed Authority.

Water Treatment

Shock Chlorination for Ground Water Wells. 2006.
Saskatchewan Watershed Authority.

Well Abandonment

Abandonment – Test Holes and Wells. 2006.
Saskatchewan Watershed Authority.