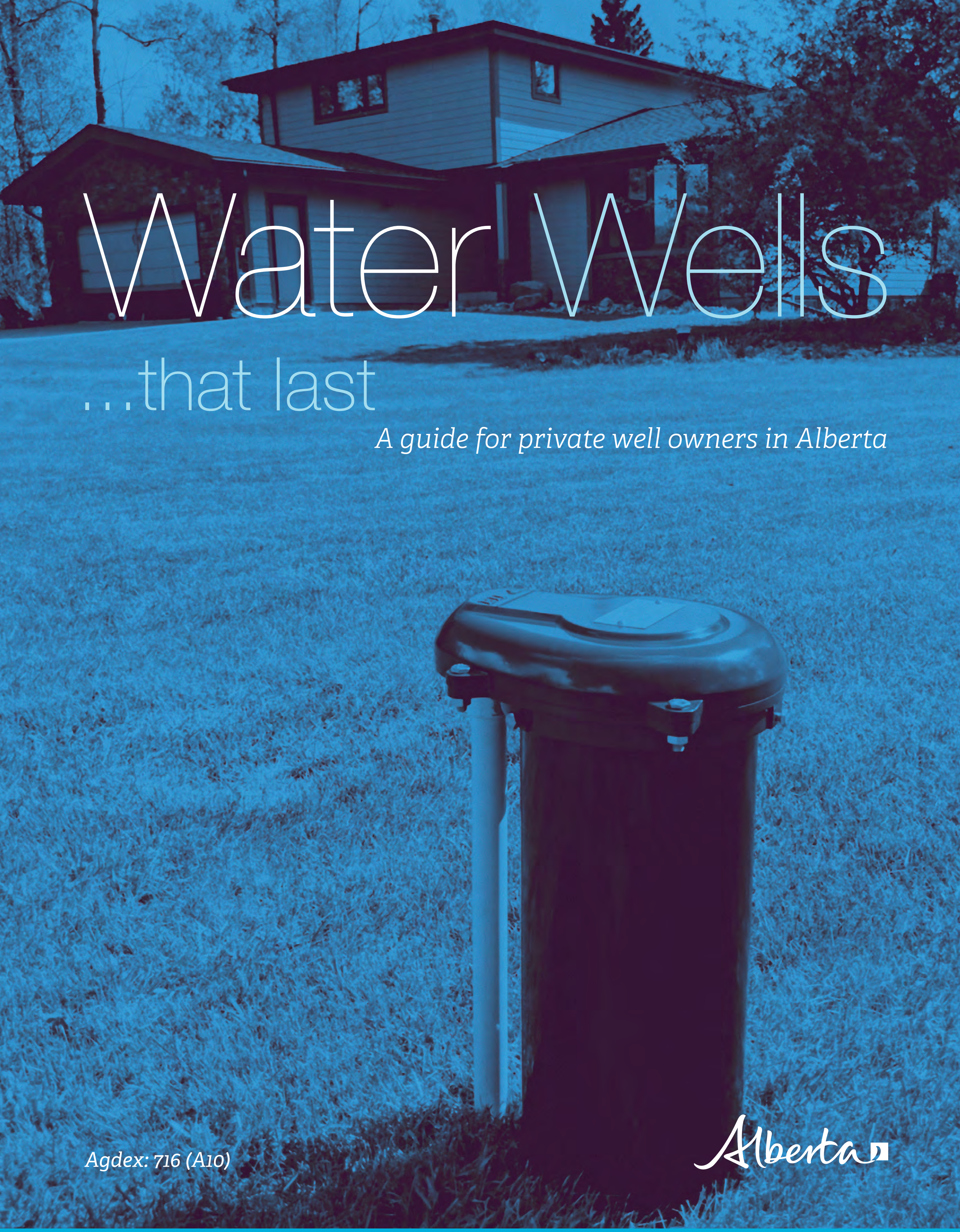
Water Wells

...that last

A guide for private well owners in Alberta



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Introduction

Groundwater is a priceless resource lying beneath most of Alberta's land surface. About 90 percent of rural Albertans rely on groundwater for a household water supply. Reliance on groundwater continues to increase in Alberta because of the steady rise in population and additional requirements for agricultural, industrial, municipal and domestic uses. Because it is a "hidden" resource, groundwater is vulnerable to overuse and water quality degradation.

Private water well owners are responsible for managing and maintaining their water wells. This publication provides information about how to properly manage private water wells which is key to protecting groundwater supplies.

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Photographs used in this publication were provided by Government of Alberta staff unless otherwise noted.

Chapter 01

Understanding Groundwater

01

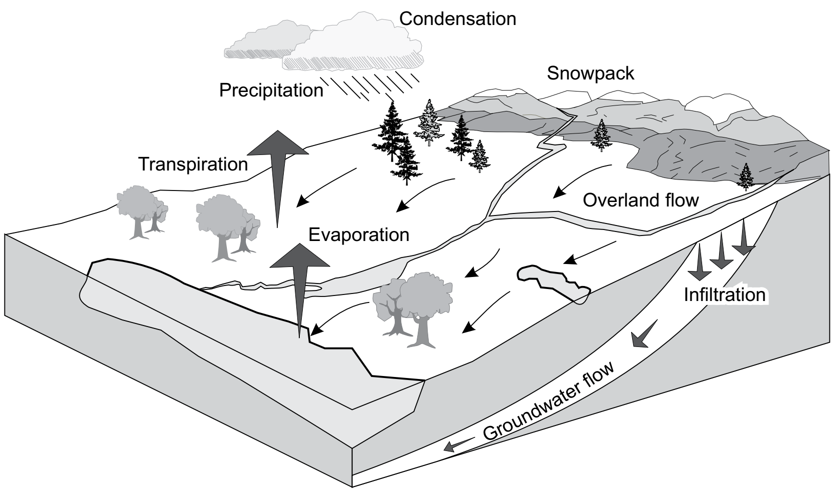
Understanding Groundwater

What is Groundwater?

All references to volumes or flow rates are in Metric (or Imperial) measurements unless otherwise specified.

Groundwater is one component of the earth's water cycle. The water cycle, called the hydrologic cycle, involves the movement of water as water vapour, rain, snow, surface water and groundwater. The earth's water is constantly circulating from the earth's surface up into the atmosphere and back down again as precipitation (see Figure 1-1, Hydrologic Cycle).

Figure 1-1, Hydrologic Cycle



Some precipitation that falls to the ground surface infiltrates the ground and becomes groundwater. Groundwater is defined as sub-surface water that fills openings and pore spaces in soil and rock layers. Below the ground surface is an unsaturated zone, which water travels through, to reach lower zones. The water table is the point at which the ground is completely saturated. Below this level the pore spaces between every grain of soil and rock crevice completely fill with water.

Aquifers, Aquitards and Aquicludes

Aquifers are water bearing layers (or formations) that can store and yield water to wells in usable amounts. Typical aquifers are made of sand, gravel or sandstone. These materials have large enough pore spaces between grains to allow water to move freely. Coal and shale are more tightly compacted formations but may also be a suitable aquifer if they are fractured enough to allow water to move through them.

Aquitards are formations of low permeability that restrict groundwater movement; they separate aquifers and can disconnect the flow of groundwater. They limit and direct seepage of infiltrating water that replenishes aquifers.

Aquicludes are formations that cannot yield adequate water for wells. Examples of these are clay and unfractured shale or coal. The pore spaces between grains of these materials may be saturated but are so small and poorly inter-connected that water does not moves through them.

Types of Aquifers in Alberta

Unconsolidated aquifers are typically surficial deposits of sand and gravel that occur between 10-50 m (33-164 ft). They are important sources of water in many parts of Alberta even though they are often susceptible to short-term, seasonal or long-term, climatic fluctuations and contamination from land-use activities.

Alberta also has a vast network of inter-connected buried valleys located beneath the land surface that were created by old river systems and glacial melt waters that carved valleys into the ground surface and left large sand and gravel deposits. Over time, these valleys were then buried by additional layers of sediment. Buried valleys range in depth from 15-90 m (50-300 ft) and in width from under 0.4 km (1/4 miles), to over 16 km (10 miles).

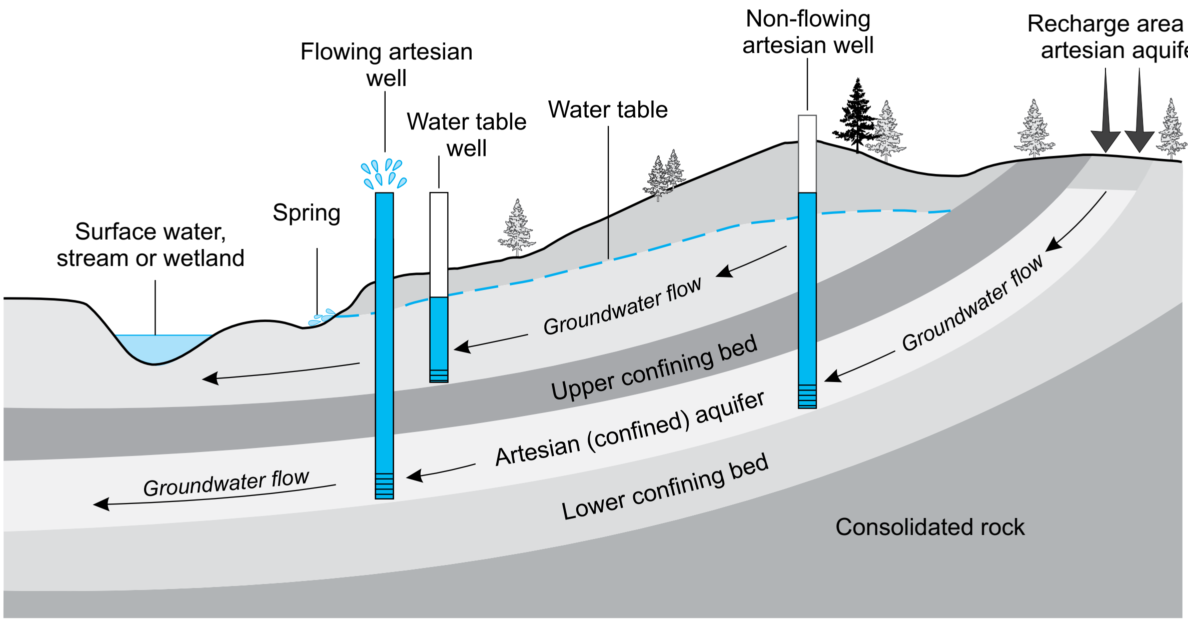
Water wells completed in such buried valley aquifers can often produce high yields, sometimes up to 300+ gallons per minute (gpm). Consequently, there has been considerable effort by hydrogeologists and licensed water well contactors to identify the locations of these high yielding aquifers. Tapping into these aquifers could help to ensure long-term, sustainable water supplies.

Consolidated aquifers in Alberta are usually composed of bedrock (sandstones, fractured shales and coal). Fractured shales and coals are generally much lower yielding (<1 to 30 gpm) than sandstones (1 to 300+ gpm). Higher yielding sandstones are often tapped for municipal use.

Unconfined aquifers are exposed directly to the atmosphere through openings in the soil. The volume of water within them is mainly dependent on seasonal cycles of precipitation that refills the aquifer. These aquifers are called water table aquifers because their upper boundary is the water table (see Figure 1-2, Types of Aquifers). When a well is drilled into an unconfined aquifer, the non-pumping (static) water level in the well will be at the same level as the water in the aquifer. Where the water table meets the ground surface you will see springs, wetlands, rivers and lakes.

Confined aquifers are aquifers that are "trapped" below an upper confining layer (an aquitard) of clay, till or shale. Confined aquifers are also called artesian aquifers. When a well is drilled into a confined aquifer, the water level in the well rises to above the upper boundary of the aquifer. Aquifers that are completely saturated with water and under pressure are called artesian aquifers. If the pressure in the aquifer raises the water level in the well to above the ground surface it is called a flowing artesian well (see Figure 1-2, Types of Aquifers).

Figure 1-2, Types of Aquifers



Well Yields in Alberta

Well yields from Alberta aquifers are quite variable. The Paskapoo Formation contains some of the largest bedrock aquifers in the province. Roughly one third of the wells in the province take groundwater from aquifers in the Paskapoo Formation. Yields can vary from 5 to 100 gpm.

Buried valley aquifers, such as the Beverly Channel Aquifer, the Calgary Buried Valley Aquifer and the Edson Valley Aquifer can provide yields from 10 to 300+ gpm.

Shallow, unconsolidated sand and gravel aquifers located near ground surface, although more susceptible to seasonal fluctuations and contamination from land-use activities can provide yields from 10 to 300 gpm.

Groundwater Movement

Groundwater is continually moving, but typically very slowly. Gravity is the major driving force and thus groundwater is always moving from areas of higher elevation to lower elevation. Notice the water table is not level in Figure 1-2, Types of Aquifers. It slopes toward the stream and thus moves in that direction. The water in the confined sandstone aquifer is also moving away from the area of higher elevation as this is where the pressure is coming from.

Knowing the direction of groundwater movement is increasingly important because of the danger of contaminating groundwater supplies. Shallow water table aquifers are especially susceptible to surface contaminants such as sewage, manure, pesticides and petroleum products when they enter the ground at higher elevations, or upslope from the well. Proper well location and separation distances from potential contaminants reduce this risk.

Groundwater Recharge

Aquifers can be recharged directly by precipitation moving down through the soil and rock layers. They can also be recharged by infiltration from surface water sources such as lakes, rivers, creeks and sloughs. Conversely, groundwater may discharge to surface water sources. The quantity of groundwater discharge may be a significant portion of input into the surface water source and can affect water quality accordingly.

Natural groundwater recharge can be affected by human activities on the ground surface. For example, drainage of a wetland removes water that would have infiltrated to eventually become groundwater. A reduction in groundwater recharge can seriously reduce the water level in nearby shallow wells. This groundwater/surface water interaction must be carefully considered as the development of one may seriously impact affect the quantity and quality of the other.

Groundwater Quality

An understanding of the factors that affect groundwater quality can help you make decisions on well depth and the best water quality for a particular application. Factors that affect groundwater quality include:

- Depth below ground surface
- Permeability of sediments
- Chemical makeup of sediments
- Climatic variations.

Depth from Ground Surface

Water is the world's greatest and most abundant solvent. It attempts to dissolve everything it comes in contact with. As a result, the longer groundwater takes to move through sediments, the more mineralized it becomes. Consequently, shallow groundwater aquifers have a lower level of mineralization, or total dissolved solids (TDS), than deeper aquifers. Groundwater from deeper aquifers typically travels much longer distances for longer periods of time and thus it usually becomes more mineralized.

Total dissolved solids (TDS) means the quantity of dissolved minerals in the water.

While shallow wells have lower levels of TDS, they generally do have higher levels of calcium, magnesium and iron than deeper wells. High levels of these minerals make the water "hard." Deeper aquifers often have higher levels of sodium and lower levels of hardness, making the water "soft"; as water moves downward through the sediment and rock formations, a natural ion exchange process occurs. Calcium, magnesium and iron in the groundwater are exchanged for sodium in the sediment and rock formations. The result is groundwater with higher levels of sodium and little or no hardness. The process is identical to what occurs in an automatic water softener, except in this case, it is a natural phenomenon.

Permeability of Sediments

Groundwater is stored in the small spaces between particles that make up the sediment and rock formations. These pore spaces are inter-connected and groundwater moves slowly through them. Permeability is a measure of the ease with which groundwater travels through the pore spaces. Groundwater moves very slowly through sediments with low permeability. This allows more time for minerals to dissolve. In contrast, sediments with high permeability, such as sand or gravel, allow groundwater to move more quickly. There is less time for minerals to dissolve and thus the groundwater usually contains lower levels of dissolved minerals.

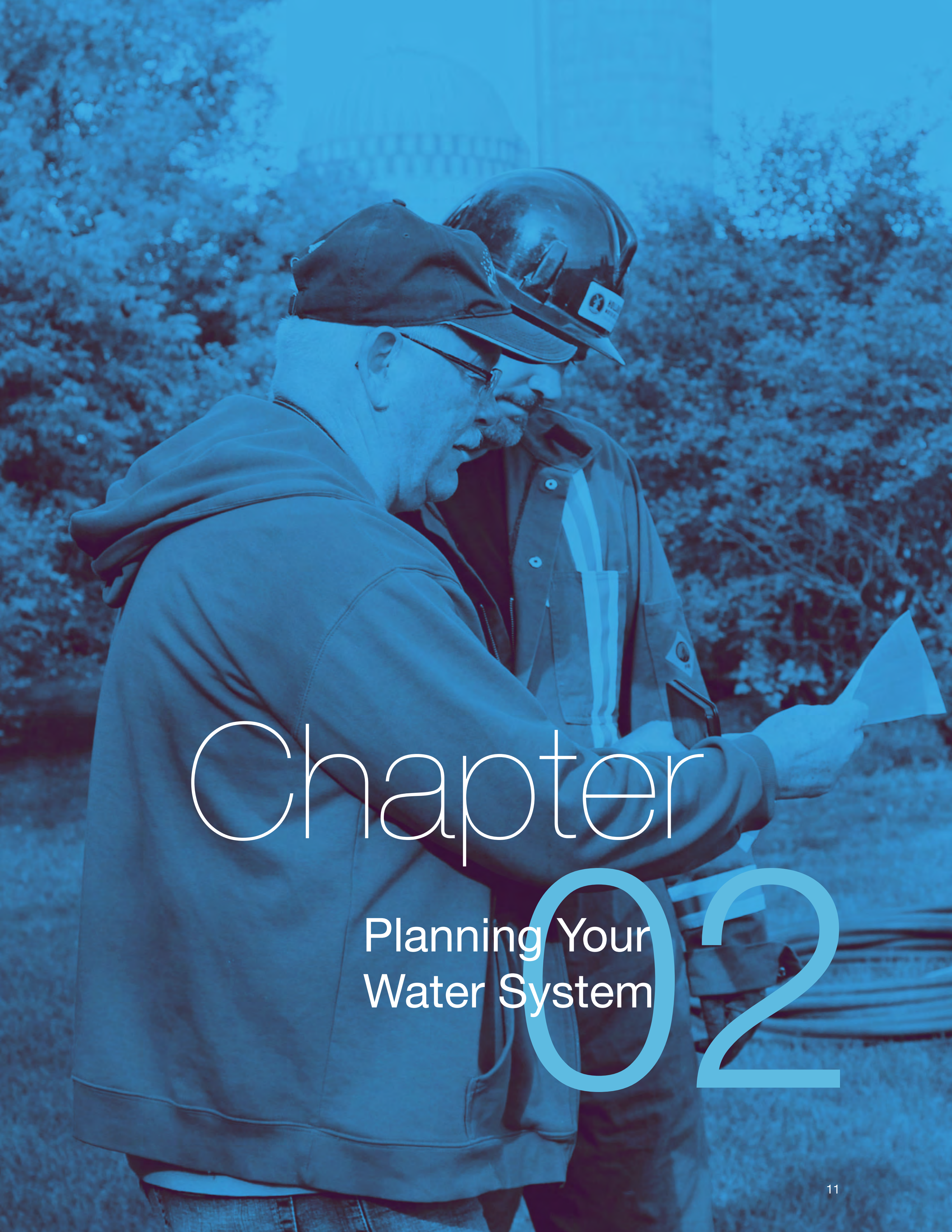
There is also a difference in the dissolved minerals content of groundwater found in recharge zones versus discharge zones. Recharge zones tend to be located in upland areas where precipitation readily infiltrates the ground surface. Groundwater in recharge zones tends to have a low level of mineralization. Discharge zones, found in lower lying areas where groundwater flow eventually makes its way back to (or near) the ground tends to have groundwater that is more highly mineralized.

Chemical Makeup of Sediments

Many factors influence the mineralization of groundwater, including the types of minerals contained in the aquifer, and the location of groundwater within the flow system. Different minerals show different degrees of solubility in water. Some minerals dissolve much more readily than others. For example, water dissolves calcite more readily than it does quartz. Groundwater in a calcite-rich aquifer will tend to be more mineralized than groundwater from a quartz-rich aquifer. The mineralization of groundwater is assessed in terms of the total dissolved solids (TDS) content.

Climatic Variations

Climatic variations such as annual rainfall and evaporation rates also play an important role in groundwater quality. In semi-arid regions, discharging groundwater often evaporates as it approaches the surface. The minerals from the water are deposited in the soil, creating a salt buildup. Precipitation infiltrating through the soil can redisslove the salts, carrying them back into the groundwater. For example, in east central and southern Alberta where annual precipitation is from 25-40 cm (10-16 in.) and the evaporation rate is high, TDS are about 2500 parts per million (ppm). In areas with higher precipitation and lower evaporation rates, precipitation that reaches groundwater is less mineralized. For example, in western Alberta, where annual precipitation is more than 45 cm (18 in.), groundwater in surficial deposits contains less than 800 ppm of TDS.



Chapter 02

Planning Your Water System

02

Planning Your Water System

Planning Considerations

All references to volumes or flow rates are in Metric (or Imperial) measurements unless otherwise specified.

Your property is worth little without an adequate supply of good quality water to meet your water needs. Often little thought and foresight are given to planning a farm or home water system. On the surface, a water system seems no more than an automatic pump and storage tank that delivers water under pressure to the household. However, there are other important aspects, such as how much water is available, the pressure requirements, water quality and provisions for watering a garden and fire fighting.

When planning your water system, consider all the uses (current and potential) of water in your home and business, such as:

- Household need
- Livestock watering
- Cleaning barn floors and equipment
- Irrigation of gardens and greenhouses
- Egg and milk production
- Fire protection

You should determine water quality and availability before you buy a new property. If there is an existing well, have it tested to establish its performance. You should also have the water quality tested.

A well planned and designed water system costs more initially but saves money in the end. Costly changes to correct errors are reduced and you have a convenient and reliable water supply, provided you monitor and maintain the system.

A water system may include:

- Water source
- Pumps
- Pressure system and additional storage, if required
- Distribution system, including pipelines, automatic waterers, hydrants and home plumbing
- Water treatment equipment

Steps to Planning Your Water System

In order to plan your water system you need to:

- Determine water requirements
- Complete an inventory of water sources

Determine Water Requirements

To calculate your daily, annual and peak use requirements, see worksheet in Appendix A-1, Calculating Average Daily and Annual Water Requirements, and Appendix A-2, Sizing of Water Systems.

The first step to planning is to determine your water requirements. Look beyond your current requirements and consider any changes you may be making in the next few years. You need to be sure you will have sufficient water (quantity and quality) for:

- Everyday use for drinking, cooking and household plumbing, accommodating for daily periods of peak demand
- Seasonal use, including lawn and garden watering, washing vehicles or farm equipment
- Livestock watering, crop irrigation, market garden irrigation
- Agricultural processors
- Fire protection

Complete an Inventory of Water Sources

To assess if there is adequate water supply to meet your needs year round, see worksheet in Appendix A-3, Farm Water Supply Inventory.

Peak demand is your water needs concentrated into a period of one to two hours, often in different areas of your home and property at the same time.

The next step to planning is to complete an inventory of all existing well and surface water sources accessible to you. Record production rates, storage volumes and any previous problems with water quantity or quality for each water source.

A well-planned water system should also have a back-up or second water source in case of pump or water source failure. Water sources that can easily be connected using underground piping provide the flexibility required for emergencies.

If you have doubt about the adequacy of your existing water sources, take time to check all the options before choosing to drill a new well. There may be ways of increasing existing well yields or water storage to meet your needs. In some situations, a well can comfortably keep up to daily water requirements but not periods of peak demand. The addition of a storage tank with one-half to one day storage capacity may be all that is required. (see Figure 2-1, Storage Tank).

Figure 2-1, Storage Tank

Water Source Options

Wells

Water wells are generally the first choice of Albertans wherever there is an adequate supply of good quality groundwater. In areas of marginal groundwater supply, livestock operations often use a combination of wells and dugouts. The better quality water from the well usually supplies the household and may supplement the livestock's requirements.

A well that produces as little as 0.5 gpm can still meet average household needs for most families if water from the well is pumped into a storage tank or cistern and stored for peak demand periods.

For most household situations, wells with a production rate of less than 5 gallons per minute (gpm) for a one hour (peak use) period do not supply enough water so it is usually necessary to create additional water storage using a tank or cistern. Wells that produce at a 5 to 10 gpm rate usually do not require additional storage.

When a lot of demand is placed on the well at any given time it should be capable of providing a minimum of 10 gpm for at least 2 continuous hours. If the flow rate of the well falls short of this amount, a cistern is usually the best option for providing water storage, to overcome the water shortage. For livestock operations, a well should be capable of providing all the water requirements in an 8 to 12 hour period.

Dugouts

In areas where there is either poor groundwater supply or quality, dugouts may be used exclusively, or in combination with a well. If you need to rely solely on a dugout for your water, size the dugout for a 2 to 5 year supply, ensuring you are covered in times of water shortage. When you plan the dugout, be sure to:

- Locate the dugout upstream of any livestock areas or other sources of contamination
- Fence the dugout
- Install a pumping system with a floating intake
- Install an aeration system to maintain/improve water quality

If you have a well and a dugout, it is often recommended you use the well water for household use because it will typically afford you better quality water. Dugout water quality should be monitored for suitability but typically can provide a good quality water source for livestock and irrigation purposes.

For more information on dugout design, maintenance and management, see "Quality Farm Dugouts" publication, Chapter 11, Contacts and Other Resources.

Cisterns

In some situations, it is more economical to install a cistern and haul water. This is particularly the case when water quality from available sources is unsuitable due to taste, odour or undesirable mineral characteristics. Installing a cistern and connecting to a water pipeline or hauling water from a municipally treated source is often more cost effective compared to the costs of installing and operating a water well and water treatment equipment. This is particularly the case when the only water needs are for household purpose.

Other Planning Considerations

Regardless of your water source, you should do the following to protect your water supply:

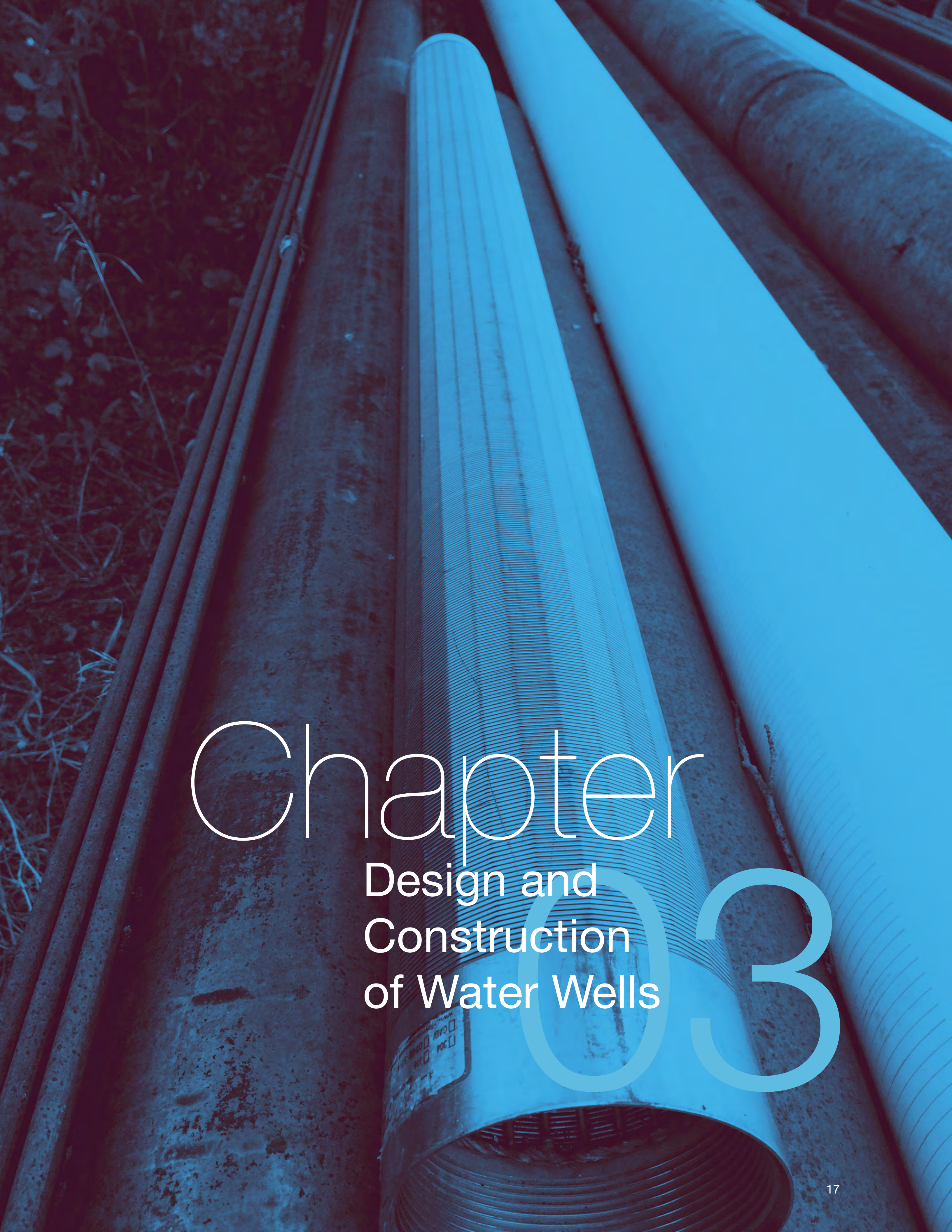
- Test the water quality regularly
  - All farm water sources should be tested when the supply is first connected and continually tested on a regular basis. Test more often if you notice a significant change in water quality, if a toxic spill occurs nearby, or if a change occurs in land use activity. A thorough bacteriological and chemical analysis of water for household use can be done through you local Community Health Centre (Public Health Unit). Water samples for agricultural use can be taken to private laboratories for testing. Proper sample bottles and correct procedures for sampling will be provided by the laboratory.
- Treat the water if necessary
  - Water quality test results will point out any problems that need to be corrected.
- Monitor the water supply and water level
  - Regular monitoring of your water source is an important step to ensuring a lasting supply. It can be compared to checking the oil in a vehicle; you will have advance notice of changes to the water supply and a chance to make changes before the problem becomes serious, repairs become costly or the well yield is substantially reduced.
- Maintain the water source and distribution system
  - Preventative maintenance, such as shock chlorination, will extend the life of your water well by keeping nuisance bacteria in check.
- Protect the water source from contamination
  - Both water wells and dugouts are susceptible to contamination from various sources. Practices to prevent contamination include proper location, proper design and construction, decommissioning abandoned wells, fencing, runoff controls and grass cover around dugouts.

Be sure to keep all records for future reference. Track your well's performance by keeping copies of your drilling reports, well inspections, water test results and treatments. Give this information to the new owners if you sell your property.

For more information on water testing, see Chapter 12, Contacts and Other Resources.

For information on water treatment, see Chapter 9, Water Treatment.

For information on how to check, record and interpret water level measurements, see Chapter 5, Monitoring and Preventative Maintenance.



Chapter 03

Design and Construction of Water Wells

03

Design and Construction of Water Wells

All references to volumes or flow rates are in Metric (or Imperial) measurements unless other-wise specified.

The initial investment for a properly designed and constructed water well pays off by ensuring:

- A reliable and sustainable water supply consistent with your needs and the capability of the aquifer
- Good quality water that is free of sediments and contaminants
- Increased life expectancy of the well
- Reduced operating and maintenance costs
- Ease of monitoring well performance

A water well is far more than a deep wet hole in the ground. It is an important and significant investment for any household or farm. Money spent on high quality well design and construction materials is money well invested. A low cost well may not deliver the quality, quantity or reliability you need. The least expensive "low-bid" approach to initial design and construction typically results in higher operation and maintenance costs over the lifespan of the well.

Choosing a Licensed Water Well Contractor

A list of licensed water well contractors is available through the Alberta Water Well Drilling Association at www.awwda.ca.

You need to hire a licensed water well contractor to design, drill and construct your well. In Alberta, well drillers must hold a current Approval to Drill Water Wells issued under the *Water Act.* To qualify for this approval, a driller must be a certified journeyman water well driller. It is important to choose an experienced contractor who has a good reputation, is reliable, competent and has the equipment to do the job right.

Water Well Drilling Agreement

For a template, see Appendix B-1, Water Well Drilling Agreement. However, water well drillers may have their own version of a Water Well Drilling Agreement.

There are things you and your contractor should discuss and agree to before starting any drilling. A clear understanding between both parties is crucial to eliminate misunderstandings or false expectations. Disagreements can arise after a well is completed because time was not taken beforehand to ensure all aspects of the drilling operations were clearly understood.

A written contract can establish:

- What your water requirement is
- How your well will be designed
- What materials will be used in well construction
- What kind of yield test will be performed
- An itemized estimate of costs
- A guarantee on workmanship and materials for a specified period of time

You should discuss the purpose of any new well being drilled with your driller. If it is going to be used for non-household purpose it must be constructed in a manner that will support licensing for diversion and use of groundwater. Also, you should get a cost estimate for the decommissioning of any old or abandoned wells on your property, to eliminate any potential safety hazard they may pose and to protect the water quality in your new well. The cost to have them plugged will be significantly reduced when your driller is already on-site.

A water well driller cannot always determine in advance the depth at which an adequate water supply will be found. Neighbouring wells offer some guidance but not a definite assurance.

Before drilling begins your driller should complete a survey of existing wells in your area. That will provide important information about typical yields, water quality and trends in well design and construction. The Groundwater Information Centre at Alberta Environment and Parks manages the Alberta Water Well Information Database that has records of water wells in the province. Also check with neighbours about their experiences with well performance, well maintenance and water quality changes. All of this information provides your driller with guidance but not a definite assurance regarding the depth at which an adequate water supply will be found.

Other things to consider when choosing a licensed water well contractor are:

- Are they approachable? Can you talk comfortably with them about the local geology, their proposed well design and construction and the pumping equipment they recommend?
- Do they have a good reputation? Ask for references and check whether previous clients are happy with their work.
- Are they insured?
- Are their prices competitive? Remember, the cheapest estimate may not translate into the best well. Be sure to compare cost estimates carefully. Some drillers will provide an estimate as a unit cost per foot that includes all well drilling, construction, pumping components and plumbing. At first glance this may appear to be more costly than another driller's estimate that only provides a unit cost per foot just for drilling of the well. It does not include additional costs for the required components to complete the well. It is important to ask for a full estimate so that you are not surprised by the end cost.
- Will they use a written contract?
- Will they provide a guarantee on workmanship and materials?
- Will they be responsible for sizing and placement of the pump? If not, the pumping equipment should be installed according to the driller's recommended pumping rate and pump depth provided on the drilling report.
- Are they knowledgeable and willing to discuss the regulations that govern water well drilling and construction in Alberta?

Well owners should take the time to ensure they fully understand what they are purchasing. A Water Well Drilling Agreement is designed to prevent misunderstandings between the well owner and the driller. It benefits both parties and can establish costs for materials and services.

A Water Well Drilling Agreement should cover the topics you should discuss with your driller before any work begins, including:

1. Identification

- Location of the well, including:
  - GPS coordinates
  - Legal land description
  - Lot, Block and Plan (if well is to be located within a subdivision)

2. Water Requirements

For water well drilling reports, contact the Groundwater Information Centre, Alberta Environment and Parks, at 780-427-2770.

- Proposed well use, specified as being for a particular use, such as household, livestock, irrigation, municipal, commercial or industrial purpose
- Desired water quality
- Desired well yield – the flow rate of water, in gallons per minute (gpm) the well will produce
- Groundwater supply options based on an assessment of existing well records
  - Your driller should review information on existing local wells to determine potential target aquifers and appropriate well design considerations. Well records are contained in the Alberta Water Well Information Database, available for public use (see Chapter 11, Contacts and Other Resources).

3. Drilling and Construction

Drillers are required to conduct a descriptive recording of the earth materials (lithology) encountered during drilling. Electric logging (E logging) is a useful tools that can verify and supplement the lithology description.

- Maximum desired depth
- Drilling method – type of drilling rig being used
- Diameter of hole – drilled wells are typically 100 – 305 mm (4 – 12 in.) in diameter; bored wells range from 60 – 90 cm (24 – 36 in.) in diameter
- Formation logging procedure
- Well design considerations to accommodate site-specific geological conditions (e.g. artesian flowing zones must be controlled)
- Well development method – there are various methods a driller can use for development which should be done prior to conducting the yield test

4. Materials

- Casing and liner casing material – type, inside diameter and wall thickness
- Annular seal and formation packers
- Screen – manufacturer, length, material and nominal diameter
- Artificial filter pack
- Flowing well control – where a flowing well is anticipated, provision must be made to equip the well with a flow control device that allows the flow to be completely shut off while preventing freezing
- Well connection – installation of a pitless adapter for below ground connection of well to pumping equipment and water distribution line
- Well cap – it should be removable, vented and vermin-proof

5. Well Connection and Yield Test

Using a pump to remove water during the yield test (instead of a bailer or air compressor) makes the test repeatable and serves as a benchmark for monitoring future well performance.

- Pump/pressure system wiring
  - Pump type, make, model and size
  - Drop pipe material
  - Pump cable wire sizing
- Yield test duration
    - The yield test should include the following information:
    - Non-pumping (static) water level
    - Water removal rate in L/s (gpm) – be aware, most manufacturers calibrate their pumps to produce in US gallons per minute
    - Depth to the pumping water level over a 2 hour period at a constant pumping rate (draw-down)
    - Recovery of the water level over a 2 hour period or until the water level returns to within 90 percent of its original static level
    - Calculation of specific capacity of the well
    - Collection of water samples for bacteriological and chemical analyses
- Well connection (tie-in) to pressure system
  - Pitless adapter
  - Wiring
  - Excavating
  - Trenching or directional drilling

6. Disinfection

- Disinfection – after well completion and installation of the pump.
- Well head finishing – including site clean-up.

7. Costs

While the licensed water well contractor is on-site, you may want to get an estimate to plug any unused or abandoned wells on your property to protect the water quality in your new well. For information on well decommissioning, see Chapter 8, Decommissioning Water Wells.

8. Guarantee

See Appendix B-1, Water Well Drilling Agreement for a template but recognize that water well drillers may have their own version.

Figure 3-1, Water Well Drilling Agreement Example

Water Well Drilling Agreement			
IDENTIFICATION			
Well Owner Name: John Doe			
Address: Anywhere, Alberta			
Location: ¼ or LSD: NE; SEC: 36; TWP: 17; RGE: 10; W of MER: 4	Lot: 15	Block: 3	Plan: 1732NF
Latitude: **Longitude:** in Decimal Degrees (GPS unit must be +/- 5-10m accuracy)		Additional Descriptor:	
Proposed Start Date: YYYY 2018 MM 11 DD 20		**Proposed Complete Date:** YYYY 2018 MM 11 DD 21	
WATER REQUIREMENTS			
Proposed Well Use: ☑ Household ❑ Stock ❑ Irrigation ❑ Commercial			
Desired Water Quality On-Site Test Results: ❑ TDS parts/million ❑ Iron parts/million ❑ Hardness parts/million ❑ pH parts/million			
Desired Yield: 0.4 (5) L/s (igpm)		**Minimal Acceptable Yield:** 0.1 (1) L/s (igpm)	
Groundwater supply options based on existing records: Consolidated bedrock, Paskapoo Formation, sandstone units – 30 to 60 m (100 to 200 ft)			
WELL CONSTRUCTION			
Maximum desired depth 65 (210) m (ft)		Type of drilling Rotary	
Diameter of hole 158 mm (6-1/4 in.) and 114 mm (4-1/2 in.)		Flowing well control N/A	
Well connection: ☑ Pitless adapter ❑ Other: (Describe)		Formation logging: ❑ Lithology ❑ E-logging	
Annular or casing seal bentonite slurry		Artificial sand pack 10-20 sand pack	
Well development method: ❑ Backwashing ☑ Jetting ❑ Surging ❑ Heavy pumping ❑ Bailing			
MATERIALS			
Surface casing material PVC, Sched 80	Inside diameter 127 (5) mm (in.)		Wall thickness 9.53 (0.375)
Casing stick-up from ground surface 45 (18) cm (in.)		Type of well cap Vermin-proof	
Liner casing material PVC, Sched 40	Inside diameter 102 (4) mm (in.)		Wall thickness 6.02 (0.237)
Screen material st. steel	Manufacturer ABC Co.	Length	Nominal diameter
YIELD TESTING			
Yield testing duration (hours) 2 hr drawdown/2 hr recovery		Pump type submersible	Size 0.5 HP
DISINFECTION			
Disinfection after pump installation		Well head finishing Driller to remove all surplus materials and equipment from site after well completion	
COSTS			
Test holes per metre (foot)		Sand pack	
Reaming per metre (foot)		Development	
Drilling/Boring per metre (foot)		Labour per hour	
Casing per metre (foot)		Water testing	
Liner per metre (foot)		Decommissioning of unused well	
Screen		Perforated casing	
TOTAL			
Total Costs:		**Payment Schedule:**	
GUARANTEE			

Choosing a Well Site

The adoption of pitless adapters has eliminated the need to locate wells in pits.

Your choice of well site will affect the safety and performance of your well. As you examine various sites, remember to consider any future development plans for your property such as barns, storage sheds and bulk fuel tanks. You must also consider provincial regulations that dictate well location.

Most contaminants enter a well either through the top or around the outside of the well casing. Contaminants may also percolate down through the upper layers of the ground surface to reach the aquifer. The following criteria should be considered, to prevent possible contamination of your well and aquifer. It is both your and your driller's responsibility to ensure that:

- The well is accessible for cleaning, testing, monitoring, maintenance and repair
- The ground surrounding the well is sloped away from the well to prevent any surface run-off from collecting or ponding around the well casing
- The well is up-slope and as far as possible from potential contamination sources such as septic systems, barnyards or surface water bodies
- The well is not located in a well pit or inside any building other than a pumphouse that houses only the well and pumping equipment
- All regulated setback distances are met

Water Well Setback Requirements

**Installation of a leaching cesspool is prohibited in Alberta. However, it is recommended that any newly constructed water well be located at least 30 m (100 ft) from any existing leaching cesspool.*

For requirements for Alberta Private Sewage Systems, see Chapter 11, Contacts and Other Resources.

Various provincial regulations define minimum setback requirements for water wells; these minimum setback distances are summarized in Table 1. Equivalent imperial distances in feet are rounded up. Greater setback distances or other protection may be required if your well is going to be completed in a shallow aquifer or if there are shallow sand or gravel deposits on your property.

Table 1, Water Well Setback Requirements

A water well must be:	
2 m (7 ft)	From overhead power lines if the line conductors are insulated or weather proofed and the line is 750 volts or less
3.25 m (11 ft)	From a building
6 m (20 ft)	From overhead power lines if the well has a PVC or non-conducting pipe pumping system, or as well casing sections no greater than 7 m (23 ft) in length
6.1 m (20 ft)	From the outer boundary of any road or public highway
10 m (33 ft)	From a watertight septic tank
12 m (40 ft)	From overhead power lines for all other well constructions
15 m (50 ft)	From a sub-surface weeping tile effluent disposal field or evaporation mound or an outdoor pit privy
30 m (100 ft)	From a leaching cesspool*
30 m (100 ft)	From pesticide or fertilizer storage
30 m (100 ft)	From manure or composting materials application
50 m (165 ft)	From sewage effluent discharge to the ground surface
50 m (165 ft)	From above-ground fuel storage tanks
100 m (330 ft)	From a sewage lagoon
100 m (330 ft)	From a manure storage facility or manure collection area or livestock yard
100 m (330 ft)	From a dead animal burial or composting site
450 m (1477 ft)	From any area where waste is or may be disposed of at a landfill

Well Design Considerations

The design of your well will be determined by the geology encountered during drilling, the type of drilling machine your contractor uses and the contractor's level of experience in drilling and constructing water wells. Money spent on high quality well design and construction materials is money well invested. Remember, a low cost well may not deliver the quality, quantity or reliability you need.

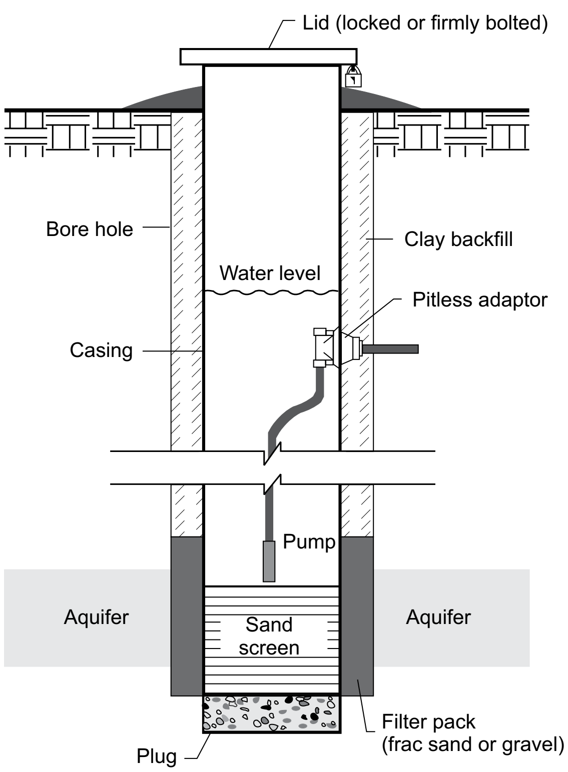
Well Depth

During drilling of the borehole, your driller will complete a lithologic or formation log describing the characteristics of the earth material encountered at various depths. This allows them to identify zones with the best potential for water supply. Some drillers will run a geophysical (electric) log in the hole to further define the geology and more clearly define aquifer boundaries.

Types of Wells

Bored wells are constructed when shallow aquifers (within less than 30 m (100 ft) below ground surface) are low-yielding. Bored wells are constructed using a rotary bucket auger and usually completed by perforating the casing (also called cribbing) or using a sand screen with continuous slot openings (see Figure 3-2, Bored Well).

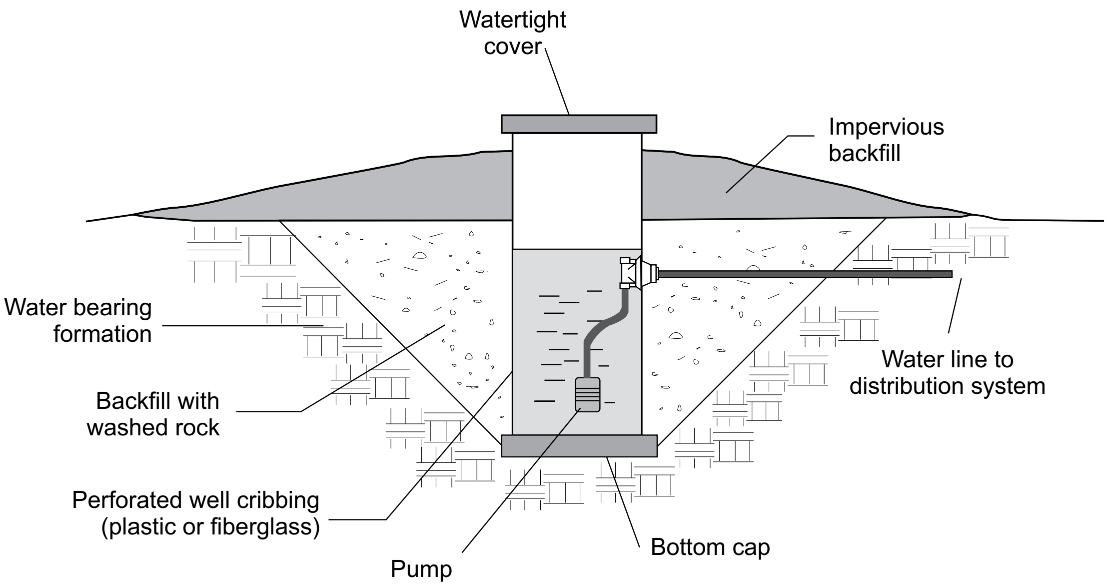
Figure 3-2, Bored Well



Even though the aquifer may be low-yielding, the large diameter of the casing, from 45-90 cm (18-36 in.), provides a water storage reservoir for use during peak demand periods. However, a disadvantage of utilizing a shallow aquifer is that it generally relies on annual precipitation for recharge so you may experience water shortages following long dry periods in summer and extended freeze-up during the winter months. It can also be more susceptible to contamination from surface land-use activities.

Dug wells and low area spring developments rely on shallow groundwater usually less than 6 m (20 ft) below ground surface and are constructed using excavation equipment. These wells must be constructed in accordance with provincial regulation, meeting the requirements for casing/cribbing, filter pack, annular seal and yield test (see Figure 3-3, Dug Well). Also, they must be constructed by a licensed water well contractor (Class A or Class B).

Figure 3-3, Dug Well

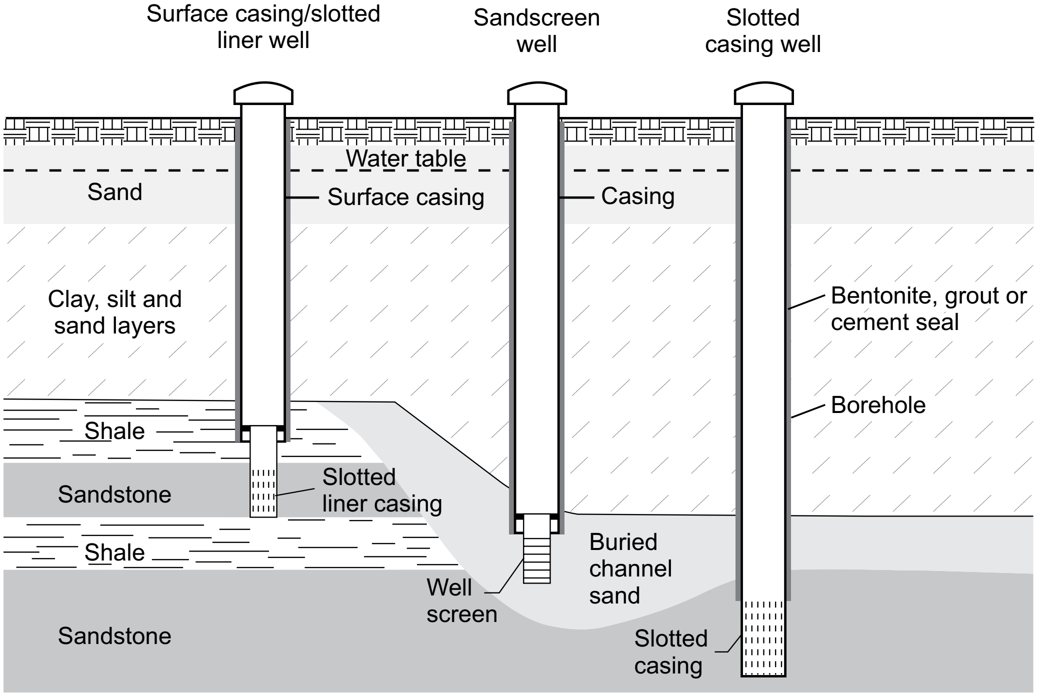


Drilled wells are smaller in diameter, usually ranging from 10-20 cm (4-8 in) and are completed at much greater depths than bored wells. The producing aquifer is typically much less susceptible to contamination from surface sources because of the depth and the water supply tends to be more reliable since it is less impacted by seasonal weather patterns. Drilled wells are constructed by various rotary or percussion drilling methods and well completions vary (see Figure 3-4, Well Completions).

In Alberta, typical completion for household wells are:

- Surface casing/slotted liner wells
  - Solid surface casing is used to keep out unconsolidated sediments when the targeted aquifer lies beneath caving formations (sand or gravel); also used to keep out undesirable water from upper aquifers.
  - Surface casing serves as a housing for the pumping equipment.
  - Slotted liner casing is placed adjacent the aquifer when it is a consolidated bedrock formation (sandstone or fractured shale); perforations allow water to flow into the well when pumped.
- Sand screen wells
  - Screens are used to control sediment pumping when the aquifer is an unconsolidated or semi-consolidated formation (gravel, sand or soft sandstone).
- Slotted casing wells
  - When the aquifer lies beneath formations that do not cave in during drilling, a single-string casing completion method can be used; the perforated casing or screen is attached to solid casing.

Figure 3-4, Well Completions



Casing Size and Type

Provincial regulation provides detailed specifications for casing diameters and wall thicknesses. All casing must meet or exceed standards set by the Canadian Standards Association or the American Society of Testing and Materials.

Materials used in the drilling and construction of water wells must be new and uncontaminated.

Decisions about the diameter and type of well casing are made after considering the following:

- Lithology
- Pump size
- Drilling method
- Well completion depth
- Cost (in discussion with the well owner)

The casing must be large enough to house the pumping equipment, allowing sufficient clearance for installation and efficient operation. Top of well casing (casing "stick-up") must be at least 20 cm (8 in.) above ground surface but best practise would be to have it at least 45 cm (18 in.). As well, top of casing must be at least 60 cm (24 in.) above the highest flood record in the area if the well is not equipped with a flood-proof cap.

All casing must be new and uncontaminated. Well casing can be made of either steel or plastic. Steel casing is stronger but susceptible to corrosion. Plastic casing is more popular because of its resistance to corrosion, must be made of virgin resin, not recycled material and must be protected at ground surface by steel casing that is firmly anchored in the ground. Large diameter casing is also available in fiberglass that is CSA approved for potable water use.

Intake Design

Water moves from the aquifer into the well through either a screen or slotted casing. Screens are manufactured with regularly shaped and sized openings that are engineered to allow the maximum amount of water in with minimal entry of sediments. Stainless steel screens are the most widely used because they are strong and relatively able to withstand corrosive water. Screens are manufactured with various slot sizes and shapes to match the characteristics of the aquifer. When the aquifer is composed of loose material such as fine sand, gravel or soft sandstone, a screen may be necessary.

Mill-slotted plastic casing is also available or drillers can create openings in plastic casing using a cutting tool or drill. The slot size and spacing of these perforations reduces the amount of open area available for water to flow into the well. They are less uniform and may have rough edges depending on how they were made which impedes the flow of water into the well and may not be effective in holding back sediments. Perforated casing can be used when the aquifer formation material is consolidated, such as coal, hard sandstone or fractured shale.

Sometimes a sieve analysis is performed to help in selection of screen slot size and filter pack.

The licensed water well contractor will make a judgement whether to use a screen or slotted casing based on examination of the cuttings from the borehole. Once that choice is made, decisions will be made regarding:

- Size of slot openings
- Total area of screen or perforations that is exposed to the aquifer
- Placement of the screen or casing perforations within the aquifer

Slot Size Openings

The slot openings must be small enough to permit easy entry of groundwater into the well while keeping out sediment. The slot size chosen will depend on the particle size of the aquifer formation material. Typically a licensed water well contractor will select a slot size that allows 60 percent of the aquifer formation material to pass through during the development phase of drilling. The remaining 40 percent, comprising the coarsest materials, will form a natural filter pack around the screen or casing perforations.

Total open Area of Screen

The amount of open area in the screen or perforated casing will affect the velocity of the groundwater entering into the well. A larger amount of open area allows the water to enter at a slower rate, causing a lower drop in pressure as the water moves into the well. If the water flows in too quickly, dissolved minerals in the groundwater will precipitate out of solution and create an incrustation build-up on the slot openings, restricting further flow of groundwater into the well. The pore spaces in the aquifer formation immediately adjacent to the slot openings may also get plugged, restricting the flow even more.

Placement in the Aquifer

The screen or perforated casing must be placed adjacent to the aquifer, to allow maximum well efficiency and avoid pulling in fine sediment which will plug plumbing fixtures and cause excessive wear on the pump. Sometimes wells are completed across two or more aquifers to provide a higher total well yield. This is called a multiple-aquifer completion. However, this type of completion should only be done in locations where the potential yield from each water-bearing zone is extremely minimal so that pumping the well will have only local impact on the aquifers and minimal impact on any neighbouring water wells.

There should be no "sump" below the screen or perforated casing, or "dead space" designed to be a collection zones for any sediment that may enter the well during pumping. Furthermore, a pump should never be placed within a sump to remedy a low non-pumping (static) water level situation. In reality these are collection zones for organic debris generated by bacterial growth that happens in the upper part of the well. The sump zone becomes anoxic and creates an ideal environment for the growth of anaerobic bacteria, such as sulfate-reducing bacteria (SRBs). As these bacteria metabolise they produce hydrogen sulfide gas, an acidic gas which, when dissolved in groundwater is corrosive to the well casing and pumping equipment.

Filter Pack

Some drillers refer to "artificial pack" as "gravel pack" or "sand pack".

If the aquifer formation material does not naturally have any relatively coarse particles to form a filter, it may be necessary for the driller to install an artificial filter pack in the annulus around the screen so the well can be developed. For example, this might be necessary when the aquifer formation material is a fine sand and the individual sand grains are uniform in size.

Filter pack material should be uniformly graded, well-rounded and have high permeability and porosity. It should consist of siliceous material and be sized based on the size of the slot openings of the well screen. The screen should typically retain about 85 to 90% of the artificial pack material after well development.

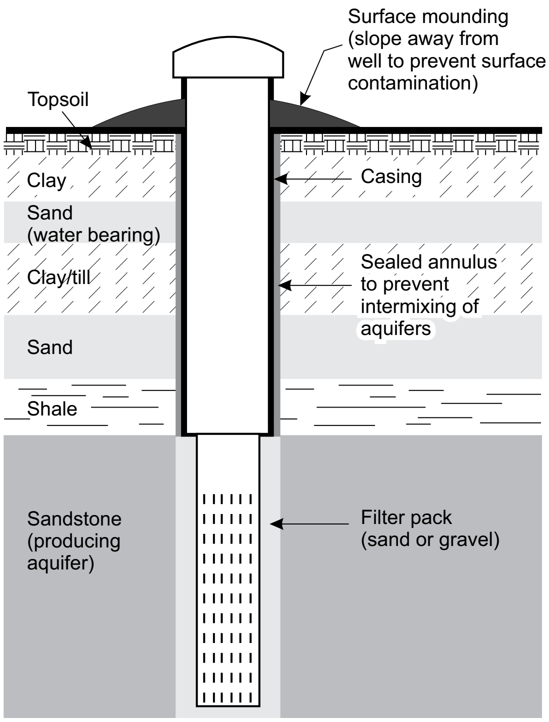
Sometimes the geological characteristics of the aquifer allow for development of a natural pack, without the need for an artificial pack. Development removes the formation particles smaller than the screen slot openings, leaving the coarser materials surrounding the screen to act as a filter. With distance away from the slot openings the aquifer particles grade back to their original grain size. Development should continue until movement of finer particles through the screen is minimal.

Annular Seal

The space between the borehole and the outside of the casing is called the annulus of the well (see Figure 3-5, Annular Seal). If not sealed, the annulus could provide a direct pathway, from ground surface to the aquifer, for surface contaminants to migrate downward at a significantly fast pace compared to infiltration through undisturbed soil. A properly sealed annulus also prevents any mixing of poorer quality water from upper aquifers with the water from the well's producing aquifer.

When a single-string completion method is used (one size diameter of casing installed inside a larger diameter borehole) the annulus must be completely filled, from immediately above the targeted aquifer to ground surface with impervious material. When a well is completed with multiple strings of casings of different diameters, the annulus of the first casing (surface casing) must be filled with impervious material, to create an annular seal to protect the well from surface contamination. The annulus of any other casing (liner casing) should be sealed using formation packers, placed immediately above the targeted aquifer, immediately above any other unwanted water-bearing zones and at the top of each liner casing.

Figure 3-5, Annular Seal



The annular seal will be disturbed during installation of the pitless adapter. It is the responsibility of the person completing this intallation to re-establish the annular seal back up to ground surface.

Well Completion

After the well has been drilled and constructed, there are other procedures the licenced water well contractor must complete before the well is ready to use, including:

- Developing the well
- Conducting a yield test
- Disinfecting the well

Well Development

Provincial regulation requires a water well be completed to ensure no damage will be incurred to the pumping system, plumbing or fixtures due to sediment in the water.

Well development is the process of removing fine sediment and drilling fluid from the area immediately surrounding the screen or perforated casing. This helps to repair any damage done to the aquifer formation from the drilling process, restore the hydraulic properties of the aquifer and alter the physical characteristics of the aquifer formation materials surrounding the screen or perforated casing, so groundwater can flow more freely into the well.

Every method of drilling alters, to some extent, the physical and hydraulic characteristics of the aquifer formation. Also, the presence of any clay sediments in the formation materials, or the addition of bentonite from drilling fluids, may create a filter cake that produces a plugging effect and will slow down a well's ability to produce unless it is removed. These finer materials are removed by developing the well and the development process should continue until the amount of fines being produced becomes negligible.

Well development selectively removes the finer particles from the aquifer formation and creates a more permeable zone immediately surrounding the screen or perforated casing enabling groundwater to flow more freely into the well and prevents the movement of sediment during puming. Proper development results in a water well that operates more efficiently.

Yield Test

The yield test provides a benchmark of your well's performance. Repeating this test at a later date can be used to assess any changing conditions in well performance and indicate when maintenance is required.

A yield test is important because the information gathered during the test assists the driller in determining the:

- Rate at which to pump the well – be aware, most manufacturers calibrate their pumps to produce in US gallons per minute
- Depth at which to place the pump.

Provincial regulation outlines the requirement for a minimum yield test to be performed on all new wells, after drilling and development have been completed. The driller must remove water from the well for at least 2 hours. If a pump is used to remove the water, water will be removed at a constant pumping rate and water level measurements can be recorded as the water level draws down during pumping. If the yield test is performed using a bailer or air compressor to remove the water, water level measurements cannot be taken during the water removal portion of the test and there will be no evidence to confirm the rate or length of time water was removed from the well.

The value of using a pump to perform the yield test is that it makes the test repeatable. You should periodically conduct a similar yield test to collect new data that can be compared to previous tests. If you notice a decline in well performance you can have your licensed water well contractor back to rehabilitate or repair your well. Keeping a watchful eye on your well will enable you to recognize the symptoms of declining performance before it is too late to economically repair your well (see Chapter 5, Monitoring and Preventative Maintenance).

After 2 hours, water removal must be stopped and the recovery of the water level then monitored and recorded. Measurements must be taken at specific time intervals for a 2 hour period or until the water level returns to within 90 percent of its original non-pumping (static) water level.

Once the yield test is completed, your driller will review the data obtained from the test to decide the rate at which the well should be pumped and the appropriate well intake depth. The pump should have a capacity equal to, or less than, the recommended rate at which the well can supply water for an extended period of time without lowering the water level below the pump intake. That pumping rate is considered the long-term, safe and sustainable pumping rate for the well.

Pumps

Not all licensed water well contractors include pump installation as part of their business. Be sure to select your pump contractor carefully and provide them with the drilling report from your driller so they can review the yield test data, the recommended pumping rate and the recommended pump intake depth.

Regardless of the type of pump chosen, it is important the pump be sized appropriately for your well. Many factors must be considered, including:

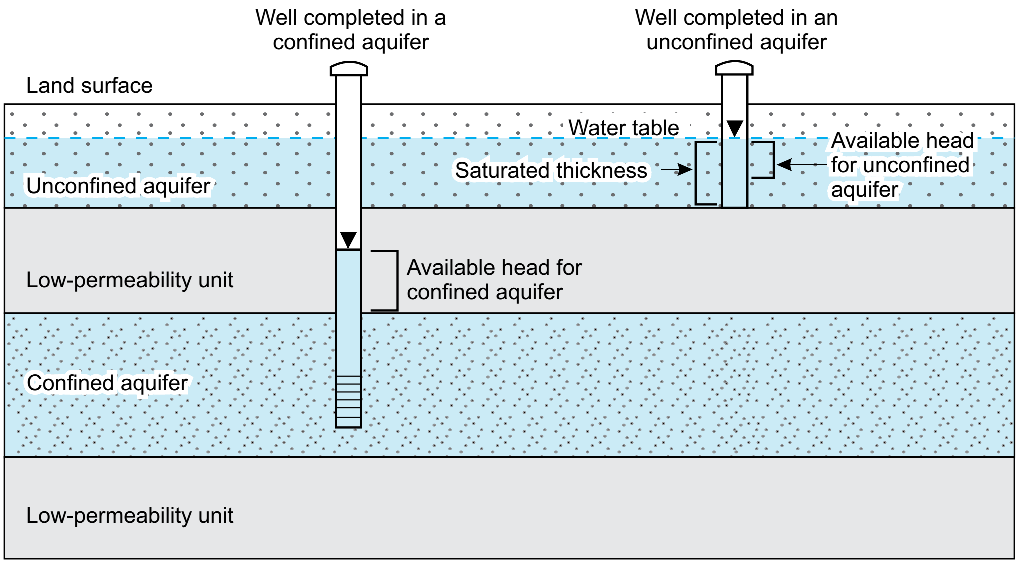
- Aquifer yield
- Well depth
- Casing diameter
- Distance from the pumping water level in the well to the final tap outlet
- Your water needs

The pump intake should ideally be above the screen or casing perforations, to reduce the likelihood of pulling in sediment and damaging the pump. Proper pump placement will extend the life of your well, prevent over-pumping and protect the aquifer.

When a well is completed in a confined aquifer, the available head is equal to the distance between the non-pumping (static) water level and the top of the aquifer. The pump intake depth should be such that the pumping water level does not draw down below the top of the aquifer. Otherwise, with continued use of the well you will eventually "mine" the aquifer.

When a well is completed in an unconfined aquifer, the available head is equal to two-thirds of the saturated thickness of the aquifer whose determination is based on a reliable non-pumping (static) water level measurement (see Figure 3-6, Available Head). The pump intake depth should be such that the pumping water level does not draw down below that depth to avoid aquifer depletion.

Figure 3-6, Available Head



"Mining" an aquifer means removing the groundwater at a faster rate than it can be recharged. This is also called aquifer depletion.

Available head is the portion of water column in a well available for drawdown by pumping.

Pressure Systems and Storage Tanks

A pressure tank is required to maintain pressure in the system when the pump is not in operation. There are several variations of pressure tanks that have been developed over time. Older style, galvanized pressure tanks are not often installed because they can become water logged when the pressurized air is absorbed by the water and require recharging. However, this type of tank is useful when gas is present in the well.

Pre-charged pressure tanks are most commonly used today. Early versions of these pre-charged tanks used a rigid float to separate the water from air but still needed to be recharged annually. Todays pre-charged tanks contain a sealed diaphragm so there is absolutely no water to air contact. If this type of tank needs recharging it is likely because the diaphragm has ruptured and needs replacement.

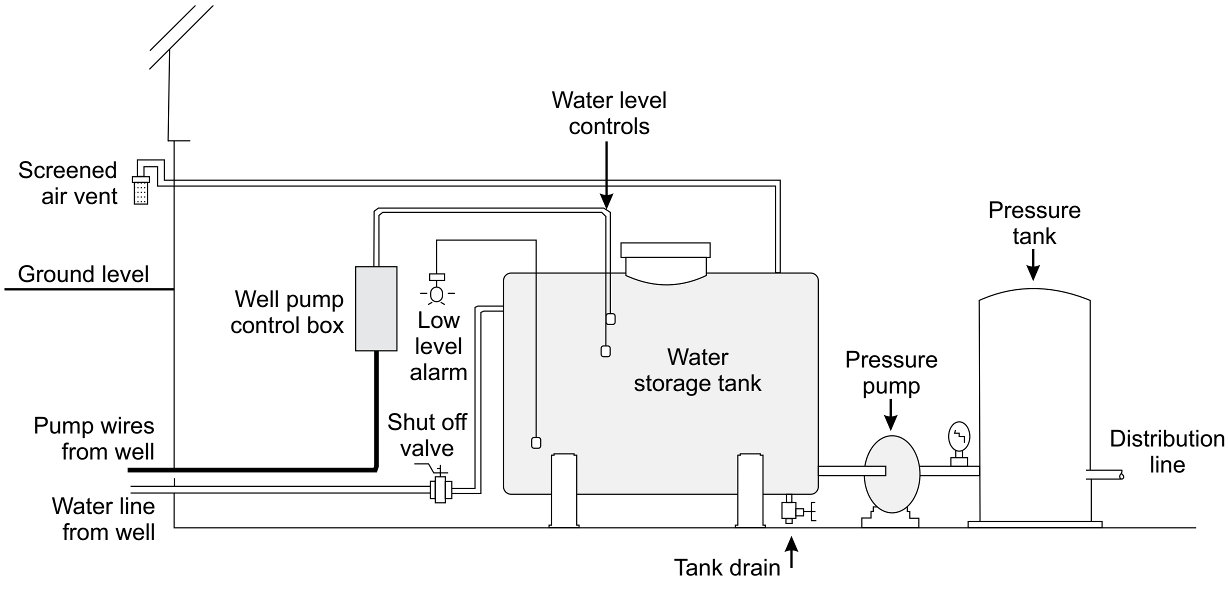
Draw off is the amount of water that can be taken from a pressure system between pump cycles.

Installing a disinfection system is recommended if you are using additional storage tanks to protect against potential build-up of bacteria and biofouling.

Pressure tanks should be sized so that your pump will not cycle more than 25 times per hour so as to create a draw off of no more than 1 gallon for every 100 gallon per hour pump capacity. For example, if a pump produces 300 gallons per hour (5 gpm) then the pressure tank should have a draw off of at least 3 gallons. The specification charts provided with the pressure tank will give the draw off capacities at different pressures. The size of the pressure tank is determined by the output capacity of the pump.

Alternatively, additional storage tanks can be used to provide additional water (see Figure 3-7, Components of a Water System using Additional Storage). Sizing of storage tanks should be based on the amount of water required during peak demand periods, which for a typical household would occur once in the morning and once at night. For example, a household of four people requiring roughly 1100 litres (240 gallons) per day should install a storage tank that holds at least 550 litres (120 gallons). This set up requires two pumps, a pressure tank and a storage tank. The primary pump (inside the well) moves water into the storage tank; a float switch inside the storage tank activates this pump. A pressure switch signals a secondary pump, at or in the storage tank, to transfer water from the storage tank to the pressure tank to supply water to the distribution system.

Figure 3-7, Components of an Additional Water Storage System



Constant pressure systems use smaller, lighter pressure tanks.

Constant pressure systems use variable frequency drive (VFD) technology to eliminate pressure fluctuations. The speed of the pump changes to meet the demand for water while maintaining a constant pressure within the system. A sensor detects water pressure, sending a signal to regulate the speed of the pump. Instead of turning the pump on and off (as in traditional pressure systems) the pump speed increases with water demand (see Figure 3-8, VFD System). To maintain pressure in the system, the pump only runs as much as is necessary to meet water demand. Caution should be taken to ensure the rate of pumping never exceeds the driller's recommended pumping rate so it is best to consult with a licensed water well contractor before installing a constant pressure system.

Figure 3-8, VFD System

Photo courtesy of M. Holland

Well Pits and Pitless Adaptors

In Alberta, people have died from asphyxiation after entering oxygen-depleted well pits.

Well pits for new wells were banned in Alberta in 1993. Well pits can allow surface water, small animals, insects and debris to collect around your well increasing the risk of contamination. Pits can also be a deadly safety hazard as they are confined spaces. The air in a well pit can become oxygen deficient or may contain dangerous gasses that can come from the groundwater through the well.

In the past, it was common practice to locate water wells in pits as they provided a frost-free location for the pressure system and easy access to the underground water distribution lines. The well casing was cut off below ground level and the well was enclosed in a pit made of wood, concrete or steel cribbing. Well pits are not necessary today because a pitless adaptor can be used to provide a water-tight, frost-free connection to the well casing while still allowing the casing to extend upward above the ground surface. The pitless assembly is installed 2 – 3 m (6 – 10 ft) below ground level. The pressure tank and fittings can then be located, offset from the well, in a basement, pump house or any other frost free location.

The pitless adaptor is a two piece unit; a removable part seals on a part that is permanently affixed to the well casing and directs the flow of water into a connected water discharge line (see Figure 3-9, Pitless Adapter). When the removable part is lifted vertically out of the well it allows for removal of the pump through the top of the well casing and full diameter access to the well for cleaning or repair when necessary.

Figure 3-9, Pitless Adapter

Photo courtesy of Merril Manufacturing Ltd.

In some instances a well pit may still be used to contain the pressure tank and electrical controls but they should have proper venting, frost-protection and adequate drainage so water cannot enter or collect on the pit floor. The actual well must be located outside the pit and the water distribution lines connected to the well through a pitless adaptor.

Well Cap

A commercially manufactured, “vermin-proof” well cap provides an extra level of protection than standard well caps that have been in use for decades. Vermin-proof well caps are equipped with a rubber gasket (O-ring) and a screened vent to ensure vermin stay out of the well and air can circulate through the well.

Standard well caps for drilled wells restrict the entry of large vermin such as mice, birds and snakes but “vermin-proof” caps prevent entry of even smaller creatures such as ants, beetles and spiders (see Figure 3-10, Installed Vermin-Proof Well Cap). Coverings for bored wells, because of their large diameter, will need to be custom made to make them “vermin-proof” (see Figure 3-11, Bored Well Cover).

Figure 3-10, Installed Vermin-Proof Well Cap

Figure 3-11, Bored Well Cover

Well Disinfection

Provincial regulation requires the licensed water well contractor to disinfect a new well with chlorine after it is drilled. The concentration is calculated based on the volume of water that is standing in the well. The concentration must be at least 200 milligrams of chlorine per litre of water (200 ppm) in the well and must be left in place for at least 12 hours, to ensure any bacteria present are destroyed. If the pumping equipment is installed in a new well by someone other than the well driller, regulation requires them to also disinfect the well after pump installation and before the well is put into production.

Water Well Drilling Report

Upon completion of a well, the licensed water well contractor must provide the well owner and Alberta Environment and Parks with a Water Well Drilling Report. This 2-page report contains important details on your well's location, well design and construction, materials used and yield test information (see Figure 3-12, Water Well Drilling Report Example). You should keep your copy of this report in a safe place for future reference. If you don't have a copy of your report, contact your licensed water well contractor or the Groundwater Information Centre, Alberta Environment and Parks at 780-427-2770 to search the Alberta Water Well Information Database.

Figure 3-12, Water Well Drilling Report Example

Alberta

Water Well Drilling Report

The driller supplies the data contained in this report. The Province disclaims responsibility for its accuracy. The information on this report will be retained in a public database.

GOWN ID

View in Metric

GIC Well ID 2096782
GoA Well Tag No.
Drilling Company Well ID
Date Report Received 2013/01/20

Well Identification and Location — Measurement in Imperial

Owner Name	Address	Town	Province	Country	Postal Code
JOHN DOE	1234 MAIN STREET	EDMONTON	ALBERTA	CANADA	T8A 0H1

Location	1/4 or LSD	SEC	TWP	RGE	W of MER	Lot	Block	Plan	Additional Description
	NW	20	20	5	5				

Measured from Boundary of
ft from
ft from

GPS Coordinates in Decimal Degrees (NAD 83)
Latitude 50.713778 Longitude -114.664938
How Location Obtained
Not Verified

Elevation ft
How Elevation Obtained
Not Obtained

Drilling Information

Method of Drilling
Rotary - Mud

Type of Work
New Well

Proposed Well Use
Domestic

Formation Log — Measurement in Imperial

Depth from ground level (ft)	Water Bearing	Lithology Description
1.00		Topsoil
23.00		Brown Clay & Rocks
77.00		Gray Clay
83.00		Gray Sandstone
97.00	Yes	Brown Sandstone

Yield Test Summary — Measurement in Imperial

Recommended Pump Rate 6.00 igpm

Test Date	Water Removal Rate (igpm)	Static Water Level (ft)
2013/01/09	8.60	25.52

Well Completion — Measurement in Imperial

Total Depth Drilled	Finished Well Depth	Start Date	End Date
97.00 ft	97.00 ft	2013/01/08	2013/01/09

Borehole

Diameter (in)	From (ft)	To (ft)
6.00	0.00	80.00
5.00	80.00	97.00

Surface Casing (if applicable)
Steel
Size OD : 5.63 in
Wall Thickness : 0.188 in
Bottom at : 80.00 ft

Well Casing/Liner
Plastic
Size OD : 4.50 in
Wall Thickness : 0.237 in
Top at : 77.00 ft
Bottom at : 97.00 ft

Perforations

From (ft)	To (ft)	Diameter or Slot Width(in)	Slot Length (in)	Hole or Slot Interval(in)
78.00	96.00	0.375		4.00

Perforated by Drill

Annular Seal Bentonite Chips
Placed from 0.00 ft to 79.00 ft
Amount 4.00 Bags

Other Seals

Type	At (ft)
Drive Shoe	80.00

Screen Type
Size OD : in

From (ft)	To (ft)	Slot Size (in)

Attachment
Top Fittings Bottom Fittings

Pack
Type Grain Size
Amount

Contractor Certification

Name of Journeyman responsible for drilling/construction of well
UNKNOWN DRILLER11

Certification No
11

Company Name
UNKNOWNDRILLINGCOMP11

Copy of Well report provided to owner
Yes

Date approval holder signed
2013/01/10

Printed on 2/12/2019 9:17:51 AM

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Alberta

Water Well Drilling Report

View in Metric

The driller supplies the data contained in this report. The Province disclaims responsibility for its accuracy. The information on this report will be retained in a public database.

GOWN ID

GIC Well ID 2096782
GoA Well Tag No.
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Measurement in Imperial

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Measured from Boundary of
ft from
ft from

GPS Coordinates in Decimal Degrees (NAD 83)
Latitude 50.713778 Longitude -114.664938
How Location Obtained
Not Verified

Elevation ft
How Elevation Obtained
Not Obtained

Additional Information

Measurement in Imperial

Distance From Top of Casing to Ground Level 30.00 in
Is Artesian Flow
Rate igpm
Is Flow Control Installed
Describe

Recommended Pump Rate 6.00 igpm
Recommended Pump Intake Depth (From TOC) 75.00 ft
Pump Installed Yes
Depth 75.00 ft
Type Submersible
Make GRUNDFOS
H.P. 0.5
Model (Output Rating)

Did you Encounter Saline Water (>4000 ppm TDS)
Depth ft
Gas
Depth ft
Well Disinfected Upon Completion Yes
Geophysical Log Taken
Submitted to ESRD
Sample Collected for Potability
Submitted to ESRD

Additional Comments on Well
TDS IS 1500 PPM

Yield Test

Taken From Top of Casing — Measurement in Imperial

Test Date	Start Time	Static Water Level
2013/01/09	2:30 PM	25.52 ft

Method of Water Removal
Type PUMP
Removal Rate 8.60 igpm
Depth Withdrawn From 75.00 ft

If water removal period was < 2 hours, explain why

Depth to water level

Pumping (ft)	Elapsed Time Minutes:Sec	Recovery (ft)
25.52	0:00	51.87
27.95	1:00	
29.07	2:00	48.72
29.59	3:00	48.10
30.22	4:00	47.60
30.81	5:00	47.18
31.30	6:00	46.75
31.79	7:00	46.29
32.22	8:00	46.06
32.64	9:00	45.73
33.10	10:00	45.44
33.86	12:00	44.95
34.55	14:00	44.49
35.20	16:00	44.03
36.38	18:00	43.31
37.73	20:00	42.91
38.88	25:00	42.62
39.90	30:00	42.22
41.01	35:00	41.34
42.68	40:00	40.68
44.29	50:00	39.70
46.49	60:00	39.30
48.52	75:00	36.25
50.26	90:00	35.73
51.35	105:00	33.96
51.87	120:00	32.45

Water Diverted for Drilling

Water Source	Amount Taken	Diversion Date & Time
CITY OF EDMONTON WATER SUPPLY	1500.00 ig	2013/01/08 7:15 AM

Contractor Certification

Name of Journeyman responsible for drilling/construction of well
UNKNOWN DRILLER11

Certification No
11

Company Name
UNKNOWNDRILLINGCOMP11

Copy of Well report provided to owner
Yes

Date approval holder signed
2013/01/10

Printed on 2/12/2019 9:17:51 AM

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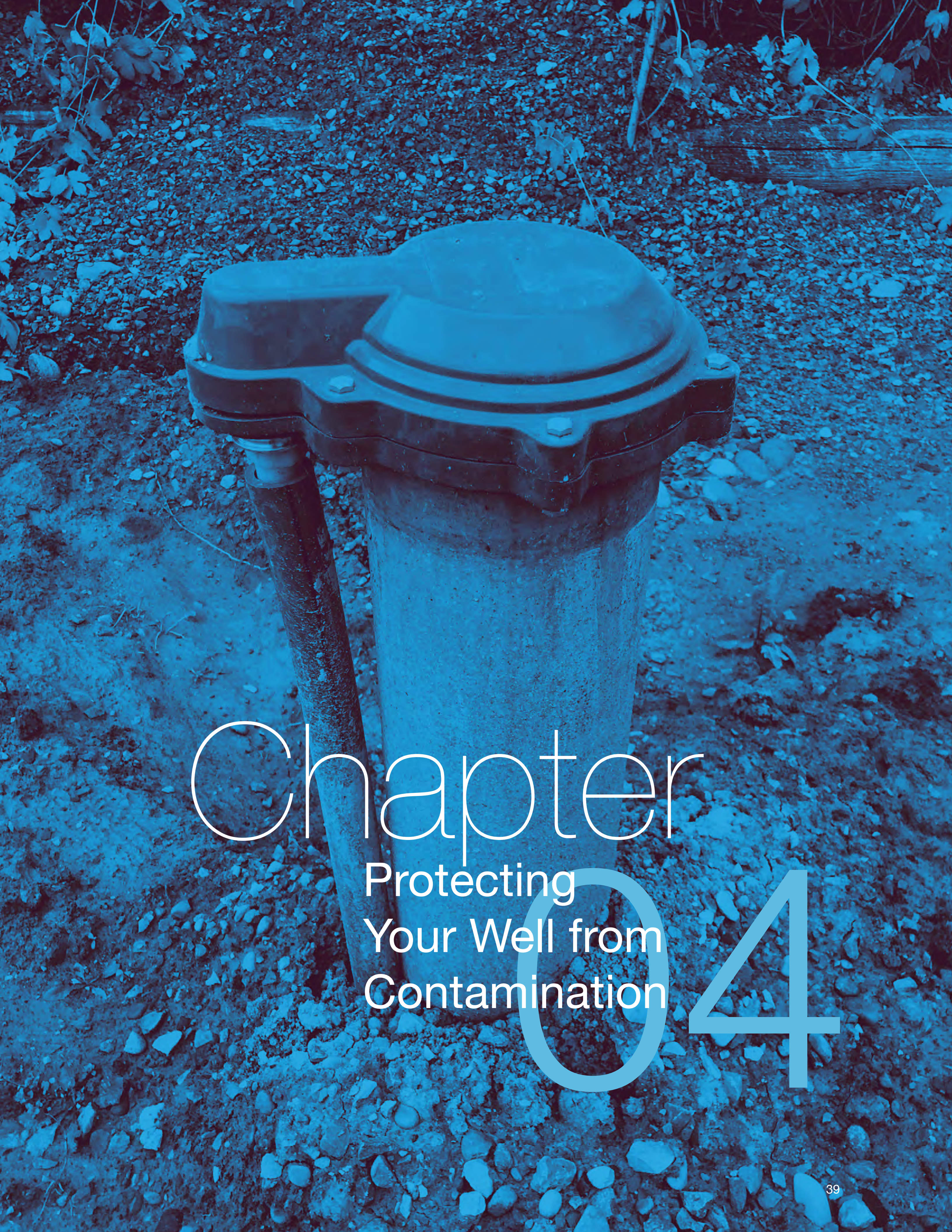


Chapter 04

Protecting Your Well from Contamination

04

Protecting Your Well from Contamination

Contamination of groundwater is hard to detect in the early stages. By the time the problem becomes obvious, it can be difficult to remove a contaminant from the aquifer. Protecting your well from contamination is imperative to avoid costly clean-up.

Wellhead protection is vital; your water well can provide a direct route for contaminants to reach groundwater. The land-use activities on your property can have an impact on groundwater quality, particularly on shallow aquifers. The most common contamination threats are often close to home.

Wellhead Protection

Old or Abandoned Wells

Old or abandoned wells can be a contamination risk and a safety hazard. They often have corroded or collapsed casing, missing well caps or are located in close proximity to contamination sources, such as barnyards or septic systems. If not properly plugged, these wells can allow contamination to reach groundwater. Nearby wells, completed in the same aquifer, may eventually become contaminated. Abandoned wells (particularly larger diameter wells) pose a safety threat when they are not covered or marked as people or animals can fall in.

Action: *All old or abandoned wells must be properly decommissioned (see Chapter 8, Decommissioning Water Wells).*

Well Pits

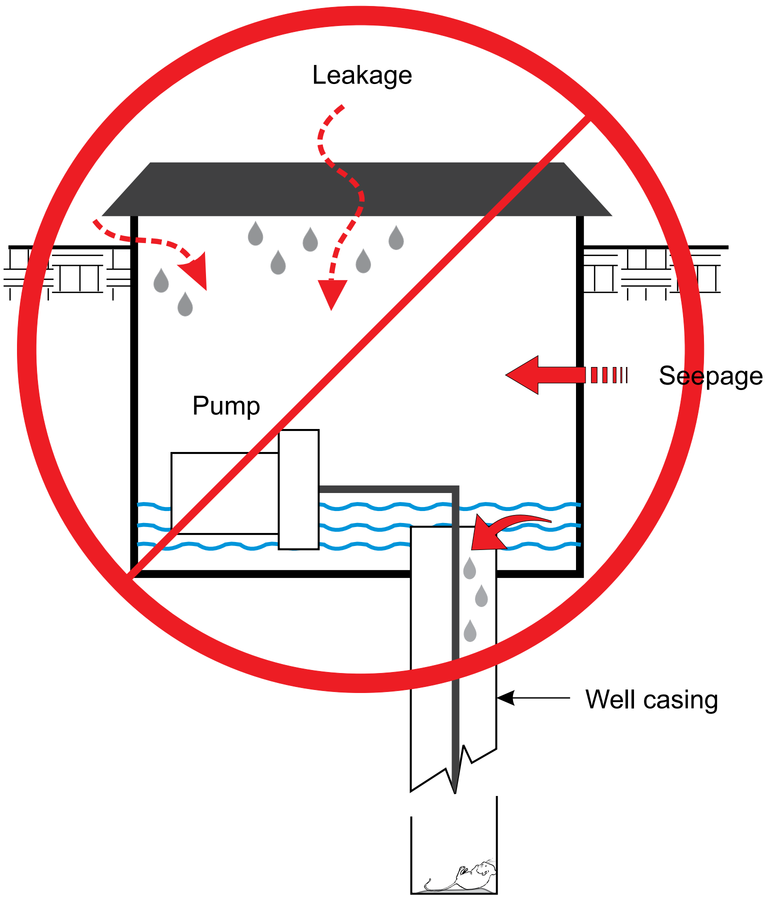
Do not enter a well pit without proper training on confined space entry and the appropriate safety equipment.

Locating a well inside any building, including a pumphouse, is not recommended.

In the past, it was common practise to locate water wells in pits (see Figure 4-1, Well Pit) as they provided a frost-free location for the pressure system and easy access to the water distribution lines. The well casing was cut off below ground level and enclosed in a pit. Regulation now prohibits the construction of well pits as they increase contamination risk to groundwater and have proven to be a deadly safety hazard.

Contaminated surface water can collect in the pit and either seep around the well casing or enter through the top of the well. Decaying carcasses and fecal matter from small animals and insects that have found their way into the pit can cause bacteriological contamination.

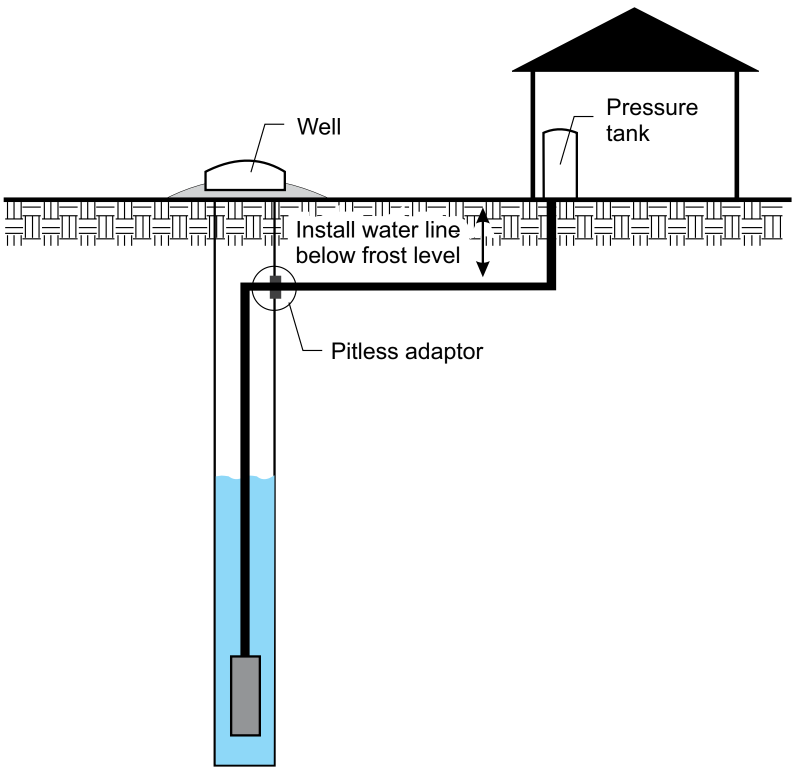
Figure 4-1, Well Pit



Well pits are "confined spaces" that can be a safety hazard to anyone who enters the pit. The air in the pit can become oxygen deficient or may contain dangerous gases that can come up from groundwater through the well. In Alberta, well pits have exploded due to the build-up of methane gas and people have died from asphyxiation after entering oxygen-depleted well pits.

> ***Action:*** *Upgrade any well located in a pit. Use a pitless adapter that provides a safe, sanitary and frost-free connection from the pumping system to the well (see Figure 4-2, Pitless Adapter).*

Figure 4-2, Pitless Adapter



Wells in Basements and Pumphouses

Water wells located in basements are susceptible to contamination from flooding or sewage back-up. Wells located in pumphouses can also be at risk when landowners store non-water system related materials and substances (chemicals, paints, lubricants, tools) beside the well.

Wells located in basements and pumphouses are not readily accessible for maintenance or repair and they pose a safety risk if dissolved gases are present in the groundwater or the well exhibits the "breathing well phenomenon".

> ***Action:*** *As a short-term measure, install a sanitary well seal with a vent line to open atmosphere (see Figure 4-3, Sanitary Well Seal). As a permanent solution, any well located in a basement should be decommissioned and replaced with a new well located outside. Pumphouses should only contain pumping equipment and the well. The well should be equipped with a screened vent to the outside atmosphere. Best practice would be to not locate a well inside the pumphouse.*

Figure 4-3, Sanitary Well Seal

For more information on dissolved gases in groundwater and the "Breathing Well Phenomenon", see Chapter 7, Common Well Problem.

Poor Well Construction

Water well contractors need approval authorizing them to drill water wells in Alberta. To obtain approval, they must be certified journeymen water well drillers.

The fastest way to contaminate groundwater is through a well as it provides a direct path for contamination to travel from the ground surface to the aquifer. The following features of well design and construction will help protect your water supply:

- Well casing stick-up should ideally be at least 45 cm (18 in.) above ground surface
- Any PVC well casing exposed above ground surface should be protected with a steel protector casing
- Annular space should be sealed to prevent downward movement of surface water or contaminants along the outside of the casing

Action: *Hire a licensed water well contractor to construct your well in accordance with the Water (Ministerial) Regulation of the Water Act and follow best management practices for water well design and construction.*

Inadequate Well Cap

"Vermin-proof" well caps prevent the smallest creatures from entering a well, such as ants, beetles and spiders.

Unsecure, missing or old-style well caps can provide a direct path for vermin, insects and other organisms to enter a well. A vermin-proof well cap (see Figure 4-4, Vermin-Proof Well Cap) is a modern design that provides an extra level of protection with the following features:

- A rubber gasket (O ring) seal around the well casing
- Two-piece construction (allows for easy access to the well without compromising the gasket seal)
- Screened vent(s)
- Threaded conduit for pump wiring
- Security lock

Figure 4-4, Vermin-Proof Well Cap

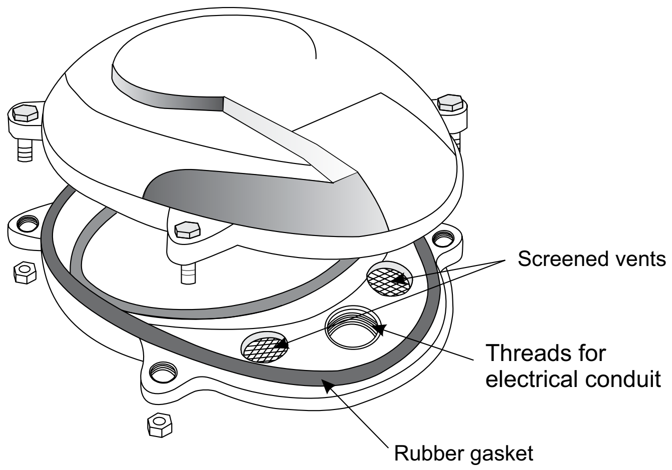


Figure 4-5, Examples of Standard Well Caps

> ***Action:*** *Replace all old-style, standard well caps with vermin-proof well caps.*

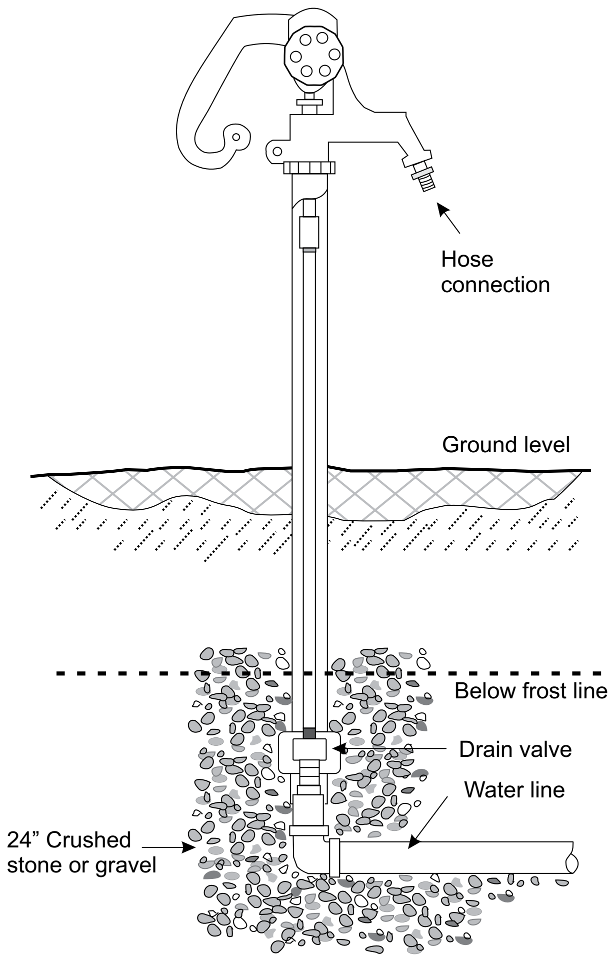
Standard well caps are no longer considered vermin-proof (see Figure 4-5, Examples of Standard Well Caps).

Cross-Connections (Backflow Risks)

In some water systems, potable water sources may be connected to other water sources that are not potable. If there is a failure in the system (i.e. a faulty check valve, power failure, misuse, lack of understanding) backflow can occur. Backflow is the unwanted reversal of flow in a water distribution system due to changes in the hydraulic pressure. While sometimes a cross-connection has been intentionally installed, such as plumbing in a back up water supply, other times it is unintentional.

Frost-free hydrants are designed to provide water all year long (see Figure 4-6, Frost Free Hydrant). When in use, the stop-and-drain valve is open and water flows from the well supply line and out the head of the hydrant, often with a garden hose attached. When the valve is closed, the flow of water stops and a drain hole in the valve opens (located at a depth below frost). All water contained within the hydrant (and garden hose if attached) drains out that hole into a gravel bed, preventing freezing of the hydrant.

Figure 4-6, Frost-Free Hydrant



If used correctly, a hydrant is a useful appliance. If installed and used incorrectly, it can cause serious contamination of your well and water supply. When a hydrant is installed on top of a well, the draining of the water from within the hydrant can cause serious biofouling and corrosion issues. The cascading water draining back into the well aerates the water, creating ideal conditions for the growth of slime-forming bacteria that causes biofouling. In addition, using a garden hose on a hydrant can create a cross-connection. If the hydrant is used to fill a livestock water trough, or chemical sprayer or other non-potable container, there is a significant risk of backflow. When the hydrant is shut off, any water connected to the hydrant via the garden hose will drain back through the system and directly into the well.

> ***Action:*** *Do not install a frost-free hydrant directly on top of a well.*
>
> ***Action:*** *Use an anti-backflow device such as a vacuum breaker on your hydrants and faucets, a dual check valve or other backflow preventer in your plumbing system.*

Poor Siting and Landscaping

To avoid contamination of your water supply, your well should be located on high ground that is not subject to flooding and is upslope from any potential or known contaminant sources such as livestock corrals, manure storage, household sewage systems, etc. Some setback distances are required by regulation and some are recommended as best management practices when locating your well (see Chapter 3, Design and Construction of Water Wells).

After a well is drilled, the well owner is responsible for ensuring the well is protected and maintained. Over time, the ground around the well may settle and need to be mounded to ensure no surface water collects around the well casing. Additionally, the well head should never be buried below ground surface.

> ***Action:*** *Maintain mounding around the casing of the well.*
>
> ***Action:*** *Never cut well casing off below ground surface or bury the well.*
>
> ***Action:*** *If a well is located in a flood prone area, install a flood-proof cap with an automatic sealing vent that will prevent floodwater from entering into the well.*

Contamination during Maintenance

When performing maintenance or repair on your well or water system (i.e. replacement or repair of your pump, pressure system, water lines, etc.), you need to take extra care to avoid contaminating your well. Before anything is put back down the well, it should be cleaned with a chlorine solution so that you don't inadvertently introduce coliform or nuisance bacteria.

> ***Action:*** *Immediately after any repair or service work is completed, disinfect the well and water system (see Appendix, Chlorination Procedure for Drilled Wells and Chlorination Procedure for Large Diameter Wells).*

Contamination Risks on Your Property

A cesspool is an underground container or pit built for the temporary storage of liquid waste and sewage. A cesspool allows liquid waste to seep, without treatment, into the surrounding soil and shallow groundwater. These are no longer permitted in Alberta.Septic system installers must be certified by the Alberta Onsite Wastewater Management Association.

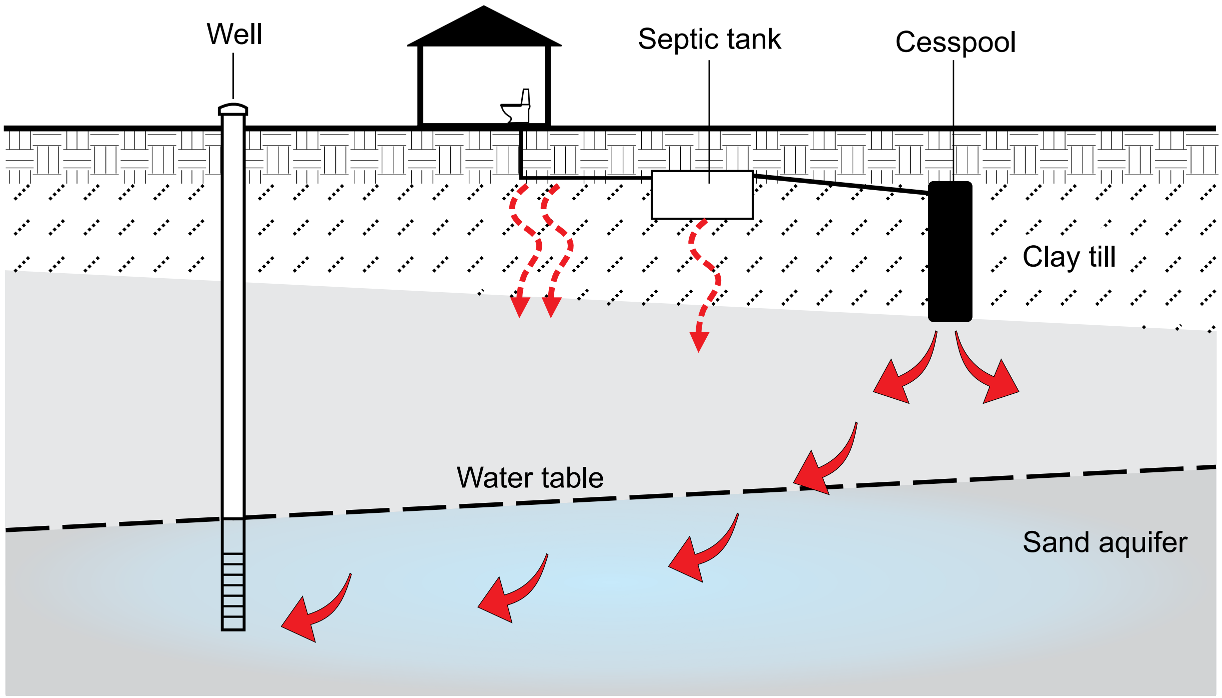
Poor Septic Systems

Shallow groundwater can be contaminated by:

- Septic systems that are not properly designed, installed or operated (see Figure 4-7, Poor Sewage Systems),
- Leaking septic tanks, or
- Systems that do not meet the Private Sewage Disposal Systems Regulation.

If your household water supply is contaminated it poses a serious risk to your health if consumed.

Figure 4-7, Poor Sewage Systems



Action: *When installing a new septic system, hire a certified contractor who holds a current Private Sewage Disposal System (PSDS) Ticket from the Province of Alberta. For more information, see Chapter 11, Contacts and Other Resources.*

Action: *To prevent system failure and groundwater contamination, hire a certified contractor to do a yearly inspection of your septic tank.*

Action: *Hire a certified contractor to pump out your septic tank every 1-3 years.*

Manure, Compost, and Fertilizer

The Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM) and the Manure Management Planner (MMP) are nutrient management tools that provide guidance to producers making fertilizer and manure nutrient decisions for their farm (see Chapter 11, Contacts and Other Resources).

Applying manure, compost or fertilizer to crops in excessive rates can result in nitrate leaching into groundwater. Storage of these products can also be a threat to groundwater quality; it concentrates the nutrients in one location. Improper storage of silage can also contribute to this problem.

Action: *Balance the nutrient requirements of your crops with the nutrient content of the manure or fertilizer.*

Action: *Conduct regular soil and manure tests and maintain accurate records of application.*

Action: *Manure, composting materials and compost facilities should be designed and constructed in accordance with the Agricultural Operation Practices Act (AOPA).*

Livestock Yards

The Agricultural Operation Practices Act sets out manure management standards for all agricultural operations in the province.

Livestock yards, including feedlots, cow-calf facilities, stock yards and livestock handling facilities, if not properly designed and managed, can pose a significant contamination risk to groundwater.

Action: *Manure collection and storage sites (e.g. feedlot pens) must be constructed no closer than 100 m (330 ft) from an existing water well. All manure and runoff must be collected and stored according to regulation under the AOPA.*

Pesticide and Chemical Storage, Handling and Application

The most common reason pesticide contamination of wells occurs is poor pesticide handling in the area around the well. Spills, improper storage and over application of pesticides and chemicals can also lead to contamination of groundwater.

Action: *Never fill a sprayer tank near a well or directly from a well. Always use a clean water storage tank (sometimes called a nurse tank) to haul water to the field for chemical mixing.*

Action: Store minimal amounts of pesticides and chemicals; purchase products with the intention of using them fully within the growing season.

Action: Properly store all chemicals and pesticides, in a secure location, with secondary containment and proper setbacks.

Fuel Storage and Handling

Fuel tanks must be located at least 50 m (165 ft) from a water well.

For more information see "Farm Fuel Storage and Handling" publication, Chapter 11, Contacts and Other Resources.

Leaking fuel can contaminate your water supply with hydrocarbons by penetrating water distribution lines or seeping directly into your aquifer.

Action: *Remove out-of-date, underground fuel storage tanks or gravity-fed fuel storage tanks with properly designed, up-to-code, on-ground fuel storage systems. Features of a properly designed system include secondary containment, collision protection and proper setbacks.*

Action: *Regularly monitor your fuel tanks for leakage, prepare an emergency plan and have an emergency spill kit on-site.*

Farmstead Waste and Hazardous Materials

Farm waste items and hazardous materials, if not stored or disposed of properly, pose significant threat to groundwater. Examples include:

- Old vehicles and farm equipment or machinery
- Restricted building materials (treated lumber, insulation, asbestos, composite products, lead pipe)
- Chemical and pesticide containers
- Dead livestock, animal health care products, medical waste
- Electronic waste, batteries
- Lubricants, antifreeze, paints, adhesives, cleaners
- Refrigerators, freezers

> ***Action:*** *Reduce your waste, reuse items where possible, recycle materials and dispose waste at a licensed landfill.*

Seismic Shot Holes

Improperly plugged shot holes can be a direct path for contamination to groundwater. Shot holes are typically 15 to 18 m (50 to 60 ft) deep and are plugged by installing a plastic plug (with identification) into the hole, at a depth of not less than 1 m (3 ft) below ground level, followed with bentonite pellets and firmly tamped borehole cuttings placed progressively upwards to the ground surface.

> ***Action:*** *Negotiate beforehand, with the seismic company, for a more effective method of plugging shot holes. Suggest they install the plastic plug closer to the bottom of each hole and fill the entire length of the hole, from the plug up to ground surface, with bentonite pellets.*

Groundwater-Fed Dugouts and Springs

For information on spring development, or approvals and licenses, see Chapter 11, Contacts and Other Resources.

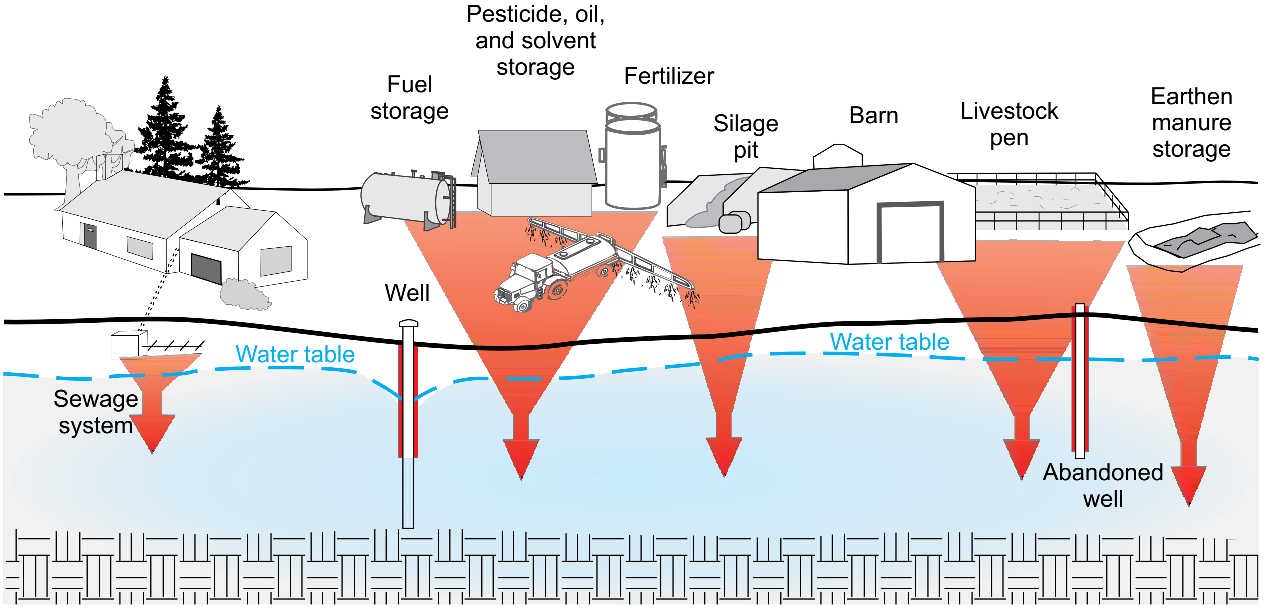
Shallow sand and gravel aquifers are potential sources for groundwater-fed dugouts, shallow wells and springs. They are directly linked to surface water sources so their water quality is also directly influenced by contamination to surface water sources. Examples include:

- Backfilling a wetland with contaminated materials, such as manure and bedding pack or farm waste
- Direct livestock watering in a groundwater-fed dugout
- Unprotected shallow wells or springs (natural or developed)

Action: *If you are digging a dugout and you encounter groundwater, stop construction. Contact Alberta Environment and Parks to make application, under the Water Act, for an approval.*

Action: *Application for approval is also required, prior to construction, for spring development.*

Figure 4-8, Potential Rural Contamination Sources



Chapter 05
Monitoring and Preventative Maintenance

05

Monitoring and Preventative Maintenance

All references to volumes or flow rates are in Metric (or Imperial) measurements unless otherwise specified.

An effective monitoring and preventative maintenance program for your water well is important to ensure a secure water supply, protect water quality and protect your investment. Water is key to our quality of life.

Monitoring will identify changes in water levels, water quality and well yield before they become a serious problem. Just like a vehicle needs regular oil changes, tune ups and inflated tires to run properly, your water well needs to be properly maintained to keep it operating smoothly for many years to come. Preventative maintenance reduces the onset of well problems, the need for costly, time-intensive rehabilitation treatments and even premature well failure.

In some areas of Alberta, up to one-third of wells are considered marginal or poor for either water quantity or quality. Regular monitoring and preventative maintenance will maximize the lifespan and use of these wells.

Visual Inspection of the Well

Your licensed water well contractor can investigate remedial action for any issues you discover.

You should regularly examine your well and the ground surface immediately surrounding it. Ask yourself the following questions:

- Is the casing in good condition (no corrosion, cracks, or holes) and does it extend at least 45 cm (18 in.) above ground level?
- Is the well cap securely attached? Is it vermin-proof? If your well is located in a low-lying area prone to flooding, is the well cap flood-proof?
- Are the electrical wires secure and protected from the elements?
- Are there any potential contamination sources or physical dangers nearby?
- Is the ground surrounding the wellhead sloping away to divert surface runoff?
- Can any vegetation with root systems cause harm?
- Is there any ground settling around the outside of the well casing? Could the annular seal be compromised allowing surface water to seep into the well?
- If your well is located in a high-traffic area, is it properly marked to avoid being damaged or lost in deep snow cover?

Monitoring Water Quality

Noting changes in water quality is an effective way to monitor the health of your well. The following checklist is a starting point to determine if a problem exists:

- Unpleasant odour or taste
- Cloudy, dirty water
- Red discolouration on plumbing fixtures and fabric
- Soap curd on dishes and fabrics
- Scale in pipes and water heater
- Salty alkali taste

However, some changes in water quality are not detected by changes in taste, smell or appearance so it is important to sample and analyze your well water regularly. Testing ensures you know your water remains safe to drink.

Bacteriological Analysis

Shallow wells less than 15 m (50 ft) are at higher risk for contamination and should be sampled quarterly for bacteriological analysis. Deeper wells should be sampled semi-annually.

A bacteriological analysis determines the microbiological quality of the water by looking for the presence of coliform bacteria that are indicative of fecal (sewage or manure) contamination. Coliform bacteria occur naturally in soil and in the gut of humans and animals; most types of coliform bacteria are harmless to humans but some, including fecal coliform (particularly Escherichia coli or E. coli), can cause serious gastrointestinal illness.

A standard bacteriological analysis for private wells includes a test for total coliforms and E.coli. When coliform bacteria are present in water it means a contamination event may have occurred but it does not confirm if the contamination is from a fecal or non-fecal source. Contaminated surface water may be getting into your well through an ill-fitted well cap, a cracked casing, poor sealing around the outside of the casing or a leak in your water distribution system. Bacteria can also be introduced when work is done on a well, including pump replacement or repair. The presence of coliform bacteria could also be due to improper sampling technique or poor choice of sample collection point. Re-sampling is recommended when a test result shows coliform bacteria are present. If a test result shows any amount of E. coli present, the water is not safe to consume; it means the groundwater has been contaminated with human or animal feces. You'll need to determine the source of contamination, fix the problem, disinfect the well (and distribution system) and then re-sample to confirm there is no longer any E. coli present before resuming consumption of the water.

Standard bacteriological tests do not confirm the presence of nuisance bacteria (iron bacteria or sulphate-reducing) which can commonly be found in water wells in Alberta. Nuisance bacteria are not detrimental to human health but cause biofouling in the well that may lead to plugging or irreparable damage to pumping equipment. Check the inside surface of your toilet tank for a greasy, slimy substance; if it is present, then iron bacteria are most likely thriving in your well. The presence of sulphate-reducing bacteria typically causes your water to have an offensive, rotten-egg odour.

Chemical Analysis

All wells should be sampled for routine chemical analysis every two to five years.

A routine chemical analysis determines the concentration of naturally occurring chemical parameters commonly found in water such as iron, sodium, sulphates, nitrates and nitrites. In some instances, you may need to request testing for additional parameters when a regional health concern is identified, such as arsenic or fluoride.

Non-routine Testing

Water from private drinking water wells is analyzed for bacteria at the Alberta Provincial Laboratory for Public Health. Chemical composition is analyzed at the Alberta Centre for Toxicology.

Non-routine testing is needed when unusual situations occur, such as unexplained illnesses or when obvious contamination situations happen like flooding or hydrocarbon spills. Occurrences on neighbouring properties may also provide reason for non-routine testing. Since specialized testing is expensive, get advice on which parameters are worth testing.

How to Take Water Samples

The accuracy of your test result is dependent on you properly collecting the water sample. Contact your local Community Health Centre (Public Health Unit) for a drinking water sample collection kit and follow the instructions provided on how to collect the sample and transport it. Only use the sampling bottle provided in collection kit. Some Health Centres may charge a small fee to offset the cost of shipping your sample to the laboratory.

For a list of Community Health Centres visit: https://myhealth.alberta.ca

Check ahead of time with your local Community Health Centre or private laboratory for proper sampling procedures and drop-off times.

When collecting your sample, be sure to let the water run for at least five minutes at a controlled, steady flow, before filling the sample bottle. This will help to ensure you are getting a sample that is representative of the water from your well.

For bacteriological analysis, the water sample should be collected from the kitchen faucet. You should remove any aerator, screen or other attachments from the faucet before collecting the sample. If that isn't possible, take the sample from another inside faucet with no aerator such as the bathtub. Swab the end of the faucet with an alcohol prep pad or diluted bleach solution (1 part household bleach to 10 parts water) to remove debris or bacteria.

For chemical analysis, collect the sample as close to the well head as possible to avoid the effect any water treatment equipment or the distribution system may have on the sample.

After you collect the water sample you will need to fill out a requisition form and attach the identification label from the front page of the form to the sample bottle. If you do not do this correctly your sample will not be accepted. You must return the sample to the Health Centre the same day it is collected. Make sure to confirm required drop-off times before you collect your sample.

Interpreting Water Test Results

The "Rural Water Quality Information Tool" provides information on interpreting water quality analysis results (see Chapter 11, Contacts and Other Resources).

All test results are sent from the laboratory directly to the Community Health Centres and then mailed to the person identified on the requisition form. An interpretation sheet will be included to assist you in understanding your results. A Public health Inspector at the Community Health Centre can also interpret results and provide advice on water treatment options, if needed.

Bacteriological test results are mailed within 7 -10 business days. If any amount of E. coli is found in your sample it is not safe to drink your water. This means the groundwater has been recently contaminated with human or animal feces. You need to determine the source of contamination, fix the problem and re-sample the water to show there is no E. coli present before resuming consumption of your water. If total coliform are present and E. coli are absent this is often due to improper sampling technique or poor choice of sample collection point. Re-sampling is recommended.

Chemical test results are mailed within 8 – 10 weeks. Changes over time in water chemistry may indicate problems with your well or aquifer. The Canadian Drinking Water Quality Guidelines, published by Health Canada are used to establish when parameters exceed maximum acceptable concentrations. Having a chemical analysis done regularly will provide you with the data you need to recognize when changes occur.

Annual Chlorination (“Shock Chlorination”)

A well creates a direct path for oxygen to travel into the ground where it would not normally exist, accelerating the growth of bacteria that require oxygen. When a well is pumped, water flowing in will bring nutrients that enhance bacterial growth.

Biofouling in water wells is caused by the presence of iron-related bacteria (IRB) or sulfate-reducing bacteria (SRB), two common nuisance bacteria found naturally-occurring in groundwater. These bacteria are not a health concern but cause biofouling, which may lead to well plugging or permanent damage of your pumping equipment.

Signs of Nuisance Bacteria

Signs that indicate the presence nuisance bacteria, include:

- Slime growth on the inside surface of your toilet flush tank
- Increased red staining on plumbing fixtures and laundry
- Sulphur or “rotten egg” odour in the water
- Corrosion of pumping equipment or well casing
- Reduced well yield
- Restricted water flow

Water wells provide ideal conditions for IRBs, to thrive; they require 0.5 – 4 mg/L of dissolved oxygen, as little as 0.01 mg/L dissolved iron and a temperature range of 5 to 15°C. Some IRBs use dissolved iron in the water as a food source.

Effectiveness of Chlorination

When done on a regular basis, as part of a well maintenance program, chlorination will control the growth of nuisance bacteria; it does not completely eradicate it from your water system but it will hold it in check. When done correctly, chlorination disinfects the entire well, the distribution lines, the pressure system, some water treatment equipment and into the aquifer. Chlorination will also effectively eliminate coliform bacteria, but remember, if your well is contaminated with E.coli, the source of contamination must be identified and removed before you chlorinate, otherwise the contamination will continue and the water will remain unsafe to consume.

If a well is low yielding or tends to pump any sediment, be extremely careful during the chlorination procedure to avoid over-pumping and damage to the well.

You can chlorinate your own well or hire a licensed water well contractor to do the procedure (see Appendix D-1, Chlorination Procedure for Drilled Wells). You will need to store enough water for 8 – 48 hours of farm and family use. You will also need to determine the diameter, depth and non-pumping water level of your well to make an accurate calculation of how much chlorine and water will be needed to create a chlorine solution that will effectively clean your well. If you have water treatment equipment (iron filter, water softener, etc.) ask your supplier if it needs to be disconnected or bypassed before chlorination.

The chlorine solution should be prepared outside or in a well ventilated space. Proper protective equipment should be used, including safety goggles, gloves, coveralls and waterproof footwear. Chlorine can be corrosive to submersible pump motors, metal casings and piping; never put chlorine into your well unless it is mixed in solution with water. Also, chlorine is a powerful oxidant that can induce dangerous chemical reactions (explosion or ignition); never mix chlorine with other chemicals, including ammonia.

pH is a numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases). Most well water ranges in pH from 6.5 to 8.5.

Adding chlorine to water increases the pH, which reduces the effectiveness of the chlorine to kill bacteria and makes the water more corrosive. There are manufactured products available today, formulated to adjust the pH of the disinfecting solution, to optimize biocidal efficiency. These products are used by most licensed water well contractors.

Hydrogen peroxide, although a strong oxidizing agent, is not recommended for disinfection of wells. The concentration of hydrogen peroxide required to disinfect a well is dangerous to handle and, unlike chlorine, it is odourless and undetectable without proper testing equipment. This makes it difficult to ensure it is completely flushed out of the well and distribution system at the end of the disinfection procedure.

Chlorination may not be effective on older wells or wells that have seldom or never been treated. Those poorly maintained wells will likely need to be inspected by a licensed water well contractor who has the necessary equipment and products to effectively and safely clean the well. Sometimes it is possible to restore such wells to near their original water quality and production capacity.

It should also be noted that shock chlorination is an effective preventative maintenance tool that kills nuisance bacteria and limits its ability to create biofilm. However, shock chlorination is not effective at penetrating biofilm. If biofilm build-up is suspected, the introduction of appropriate chemicals and physical agitation will be necessary to remove the biological plugging material before chlorination can be effective at removing the bacteria (see Chapter 6, Water Well Rehabilitation).

If your well is located in a pit, proper safety precautions need to be taken during the chlorination procedure. It is best to hire a licensed water well contractor who has the proper equipment and experience to get the job done safely.

Well pits are no longer legal to construct in Alberta.

Modified Procedure for Large Diameter Wells

The large volume of stored water in bored wells hinders the effectiveness of the regular chlorination procedure. A more practical way to chlorinate a large diameter well is to mix the recommended amount of chlorine right in the well. An extra volume of chlorinated water is then used to force some of the chlorine into the formation surrounding the well (see Appendix D-2, Chlorination Procedure for Large Diameter Wells).

Large cisterns should be bypassed and treated separately. If the water must travel through a long or large diameter pipeline, or large pressure tanks, an extra volume of chlorine solution should be used.

Be aware that chlorinating old, unmaintained wells may uncover existing holes in steel casing and speed up inevitable well failure.

Keeping Records

Keeping records of the monitoring and preventative maintenance performed on your wells builds history that is invaluable when problems arise. Changes in water levels, well performance and water quality all signal the onset of either well or aquifer problems. The information you gather will come in handy for your licensed water well contractor when diagnosing the cause of any well problems when they do arise and choosing which rehabilitation procedures to apply.

To keep a record of your well history, use the worksheets in Appendix C-1, Water Level Measurements Log Sheet, C-2, Water Testing Log Sheet and C-3, Water Well Maintenance Log Sheet.

Annual Inspection by a Licensed Water Well Contractor

As a well owner, you will benefit from a proactive approach to water well monitoring and preventive maintenance. It is much less expensive to actively schedule routine monitoring and maintenance, to keep your well operating efficiently, than it is to operate your well without, until failure occurs making expensive well rehabilitation (or worse yet, well replacement) necessary. Routine monitoring also protects your health by identifying contamination issues that may cause health risk.

If you do not have the time to conduct the monitoring steps outlined in this chapter, consider hiring a licensed water well contractor to conduct an annual inspection of your well. Be sure to ask for a detailed report to keep for your records. Remember, an annual inspection should include:

- Visual inspection and repair of any deficiencies
  - Integrity of well casing, well cap, electrical conduit
  - Setback distances from contamination sources
  - Sloping of ground surface away from well, to prevent pooling of water
- Collection of water samples for bacteriological and chemical analysis
- Measuring water levels
- Chlorination (disinfection)
- Assessment of pumping equipment and related wiring
- Assessment of storage tanks, water treatment equipment

When regular monitoring and preventative maintenance is started early in the life of a well, any build-up in the well is usually thin and relatively soft, and can usually be removed without pulling the pump or experiencing any down time. When left unaddressed, soft and slimy deposits turn into hard, scaly compositions that require intensive rehabilitation methods for successful removal.

Monitoring Water Levels

If you are a licensed water user, you will be required to monitor the effects of your water withdrawal as a condition of your diversion licence. Measuring and recording water level readings on a regular basis provides you with enough data to catch any water shortages long before irreparable damage is done to the well. Monitoring water levels also helps to determine the cause of any decline in water production.

The non-pumping (static) water level in your well may move up and down on a seasonal basis, rising in winter and spring when precipitation is higher and dropping in summer and fall when precipitation is lower and your water use is usually higher. The non-pumping water level should always be measured in the early morning, before the pump has turned so it will have fully recovered from the previous day's use.

The pumping water level is the level the water lowers to when pumping is in progress. It should be measured at the same time of the day, when the pump is operating and there has been significant water use. For example, you might take the measurement around the noon hour. Being consistent ensures you have comparable data.

Taking regular water level measurements is something you can do on a monthly or quarterly basis as shown in the example below. The more data points you have the more likely you are to be alerted to any changes. Being consistent when you take water level measurements ensures you have reliable, comparable data.

For a template to record the water level measurements for your well, see Appendix C-1, Water Level Measurements Log Sheet.

Table 1, Water Level Measurements Example

Month	Water	Time	Non-pumping	Pumping	Comments
01/10/2016	3.28 m	6:00 am	√		
01/10/2016	4.29 m	12:00 pm		√	
09/20/2016	3.23 m	6:30 am	√		
09/20/2016	4.35 m	1:30 pm		√	
04/30/2017	3.20 m	1:30 pm	√		
04/30/2017	4.5 m	11:45 pm		√	
10/03/2017	3.25 m	6:30 am	√		
10/03/2017	4.78 m	12:00 pm		√	
03/03/2018	3.23 m	6:15 am	√		
03/03/2018	4.96 m	12:20 pm		√	
12/15/2018	3.26 m	6:00 am	√		SWL appears to be stable, similar to previous SWL readings
12/15/2018	5.12 m	12:15 pm		√	PWL going down significantly, need to consult driller

How to Measure Water Levels

Tape sounders should always be sanitized before and after each use.

There are several devices you can use to measure water levels. A sonic water level sounder is a non-intrusive, user-friendly device that allows for quick and accurate measurements. It does not need to be lowered down the well. This instrument sends a pulse of sound down the well and records the time required for the sound to echo back from the water surface, using time to calculate the distance to the water level.

A water tape sounder, similar in price to the sonic water level sounder, is effective but the probe should be lowered inside an access tube (sometimes called a dip tube) to avoid entanglement with pumping equipment. An access tube can be constructed using a minimum 16 mm (3/4 in.) potable-grade plastic pipe or hose that extends down into the well to 1.5 m (5 ft) above the top of the pump. It should be taped to the pump line with electrical tape and have a capped bottom with two 6 mm (1/4 in.) holes perforated on the bottom to let water in and out, allowing it to fluctuate with the water inside the well. The measuring probe should always be disinfected prior to lowering it into the access tube.

A data logger is an electronic device capable of simultaneously recording multiple parameters within the well such as water level, temperature, conductivity and barometric pressure. This data can be downloaded on-site to a laptop computer or wirelessly through a cloud application.

Specific Capacity

Drawdown in a water well is the water level response to pumping.

The specific capacity of a well is an expression of the discharge rate (in L/s or gpm) divided by the water level drawdown (in metres or feet). Monitoring specific capacity is a simple method to determine significant change in well performance. An annual calculation provides useful data for comparison over time.

If your well is capable of producing more water than you require, you may not notice a decrease in well yield unless you are routinely monitoring your water levels.

For example, a well with an original pumping rate of 10 gpm and 5 feet of drawdown after 30 minutes of pumping has a specific capacity of 2 gpm/ft of drawdown. Tracking the specific capacity of the well over time can help to identify well performance problems. For example, 10 years later, the same well still pumping at 10 gpm but with 10 feet of drawdown after 30 minutes of pumping now has a specific capacity of only 1 gpm/ft of drawdown. When calculating the specific capacity you must always use the same pumping rate and length of time for an accurate comparison.

By keeping track of the specific capacity over time you can monitor the health of your well by comparing data. Wells lose specific capacity as a result of plugging and scaling. A 5 to 10 percent loss in the specific capacity should be considered significant and the well should be evaluated for maintenance servicing to recover the lost capacity. A 15 to 20 percent loss in specific capacity of a well will require more intense rehabilitation treatment to bring back production and the chances for successful rehabilitation on a well with an even greater loss of specific capacity is greatly reduced.

How to Interpret Water Level Measurements

If the well yield declines, yet the non-pumping (static) water level remains constant, the well likely needs to be serviced.

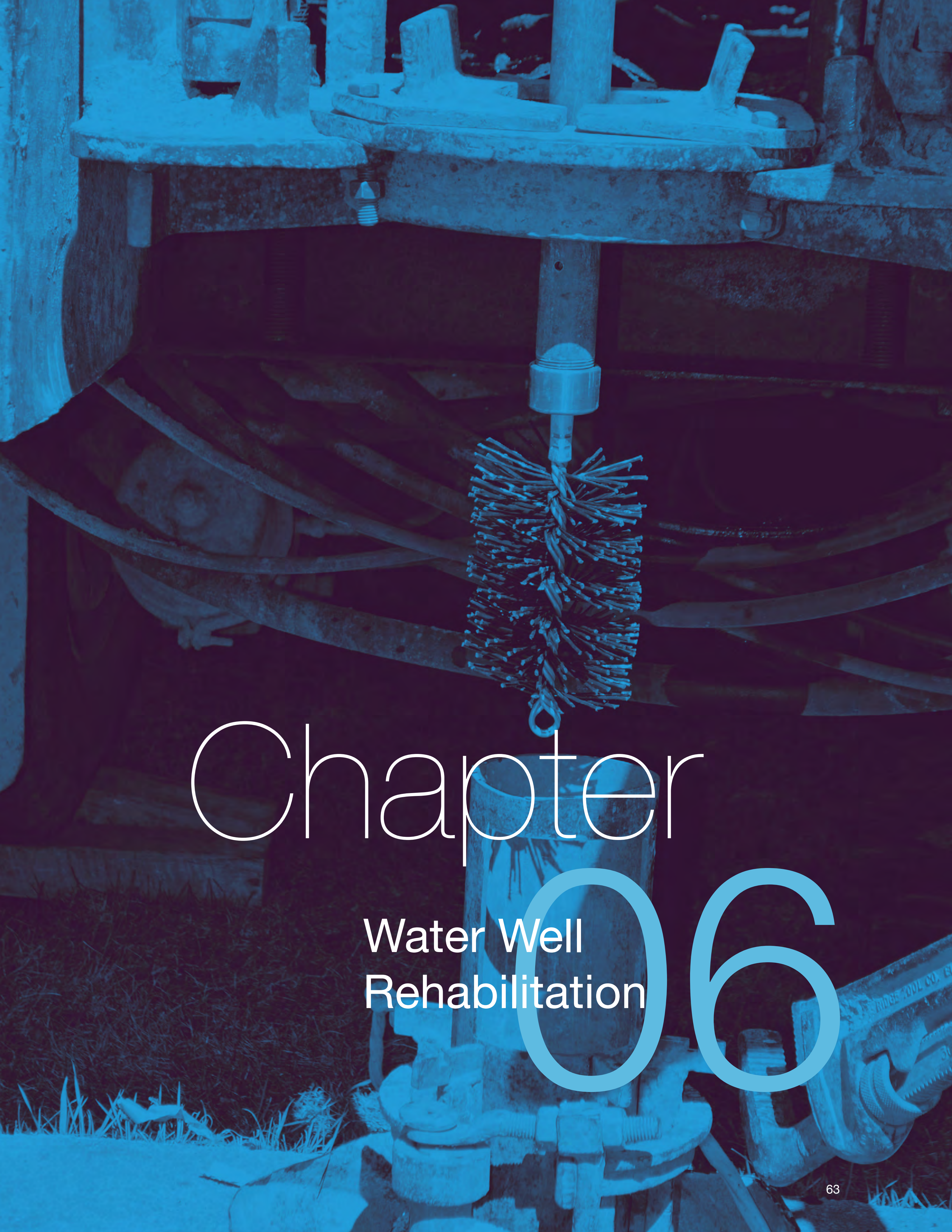
A steady decline of the non-pumping (static) water level is cause for concern because it means the aquifer is not able to supply water to the well at the rate you have been pumping. This can be caused when:

- Groundwater recharge is reduced naturally because of drought or is affected by land clearing, construction of sewers, drainage ditches or road cuts. Deeper aquifers, 60 m (200 ft) or more below ground surface, are less likely to experience seasonal fluctuations.
- You are pumping your well at a faster rate than it was designed to be pumped (you are stressing the well by over-pumping it)
- The volume of water being pumped from your well exceeds the rate at which the aquifer is capable of replenishing itself or you are experiencing the cumulative affect of too many landowners tapping into the same aquifer (depleting the aquifer)
- The aquifer has been disturbed from construction of sewers, drainage ditches or road cuts

Changes in the pumping water level indicate a decline in well efficiency as a result of something blocking the screened or perforated section of the well, preventing water from entering. This plugging can be caused by build-up of biological slimes and nuisance bacteria, mineral incrustation or sediment. You will need to hire a licensed water well contractor to assess what is causing the reduced efficiency and how to rehabilitate the well. They will likely require you to shut off the well for 24 to 48 hours to confirm if the non-pumping water level returns or gets near to the original level and if so, rehabilitation will likely make it possible to restore your well's water flow.

The pumping water level should never go below the top of the screen or perforations in the well casing, to prevent oxygen exposure to the aquifer which will enhance bacterial growth and result in reduced well yield. And, even when the pumping water level remains relatively steady, you still need to do regular preventative maintenance, including chlorination, to control bacteria build-up. If you allow a well to deteriorate for too long, it may not be possible to restore its original capacity.

Photo on page 63 courtesy of R. Arts.



Chapter 06

Water Well Rehabilitation

06

Water Well Rehabilitation

When you commit to a monitoring and preventative maintenance routine you will be able to recognize when changes in the performance of your well need to be addressed. All water wells lose their operating efficiency (capacity to produce water) over time. Well rehabilitation is generally needed once a well has deteriorated to the point where preventative maintenance can no longer resolve well performance issues.

When well capacity declines by 15 percent, you will likely need to hire a licensed water well contractor, with specialized equipment and trained personnel, to take measures to restore your well yield to its pre-deterioration capacity, or at least to a capacity that justifies keeping the well in production, avoiding well replacement. Delaying rehabilitation procedures can significantly increase operation costs and, in some cases, may make rehabilitation too costly.

Contractors must follow all health and safety requirements, including obtaining and following the guidelines set out in the Material Safety Data Sheet (MSDS) for any chemical products that are used. Products must also be safe for use in potable water well systems and meet NSF Standard 60.

An MSDS includes:

- *Properties of the material*
- *Hazards associated with the material*
- *Personal protective equipment required when using the material*
- *First aid and medical attention information*

Treatment methods will be custom-tailored to your well and many factors will need to be considered, including well construction details, aquifer characteristics and the nature of the plugging conditions.

Blockages can be created by:

- Bacteria build-up (iron bacteria, sulphate-reducing bacteria, and slime accumulations)
- Chemical build-up (mineral incrustation and scale)
- Physical blockages (fine sand or silt infiltration)

Typically, you will not be able to use your well for 2 – 3 days and the pump will need to be removed during treatment.

Pre-treatment Diagnostics

Your driller needs to understand the problem before deciding on a path to solving it. That is why keeping records is such an important part of a regular monitoring and preventative maintenance program. Otherwise your driller will need to collect information by conducting numerous tests, including a pump test, collecting water samples, removing and inspecting the pump or conducting a downhole video inspection of your well. Rehabilitation treatment will depend on the nature of the plugging conditions, so the more information gathered to make a determination the better.

Rehabilitation Treatment Methods

Well rehabilitation involves either mechanical or chemical treatment methods. Often a combination of both is the most effective strategy.

Mechanical Treatment

Mechanical processes are used to loosen and remove mineral incrustation, bacteria biofouling or sediment inside the well casing and screen. Mechanical processes include wire brushing, surging, swabbing and high-pressure jetting. Wire brushing consists of running a wire brush up and down the length of the well screen to dislodge build-up. Surging consists of repeatedly pushing and pulling the water in the well to dislodge build-up so it can be removed. Swabbing is similar to surging but often induces a much more forceful agitation. Jetting uses high-pressure spraying of water or air across the screen slots to remove build-up.

Removing as much build-up as possible prior to chemical treatment may reduce the amount of chemical required and allow more effective placement of the chemical within the well. Debris should be airlifted or bailed from the bottom of the well prior to any chemical treatment.

Chemical Treatment

Chemical treatment involves applying a chemical solution to the well that is designed to dissolve a specific type of plugging material. Acids are commonly used to dissolve mineral scale build-up and different scales react differently to the various acids marketed for well rehabilitation. Plugging due to mineral incrustation alone is relatively uncommon; it is usually accompanied by some form of bacterial or biofilm growth. If scale is present with bacteria slime, acid accompanied with an appropriate biocide will be needed for effective cleaning. Acid will dissolve the scale but will not kill the bacteria. Chlorine will kill bacteria present in the upper layer of the slime mass but cannot penetrate beneath any scale build-up.

Various acids on the market have advantages and disadvantages in use and application. An experienced water well contractor will choose the appropriate chemical after a thorough assessment of the well problem, well construction details, aquifer characteristics and groundwater chemistry.

Chemicals used in the well rehabilitation process may pose a health risk if consumed. Be sure you are fully informed of the chemicals being used by your licensed water well contractor and your well is thoroughly developed and flushed before consuming the water.

Acids are dangerous and corrosive products so the experience of your driller is paramount. Vapours generated during mixing and preparation of a chemical solution is potentially hazardous to health and will cause breathing problems in an unventilated or enclosed space.

Development

Developing the well immediately after mechanical and/or chemical treatment will loosen, break down and remove scale, biofilm and sediments. Developing the well will also redistribute the natural or artificial filter pack material surround the well and improve groundwater flow throughout the screen or perforated casing.

Loss of well performance can often be caused by the slow migration of fine particles in the aquifer towards the well screen or perforations causing plugging over time. Improper well design or insufficient well development following initial well construction often leads to sediment plugging. Excessive sediment in a water well can also cause pump damage.

Disinfection

After any rehabilitation treatment has been applied, and the pump is reinstalled, the well should be disinfected before it is put back into production. Provincial regulation requires the person installing pumping equipment in a well to disinfect the well with a chlorine concentration of at least 200 milligrams of chlorine per litre of water (200 ppm) in the well and it must be left in place for at least 12 hours, to ensure any bacteria present are destroyed.

A Typical Rehabilitation Procedure

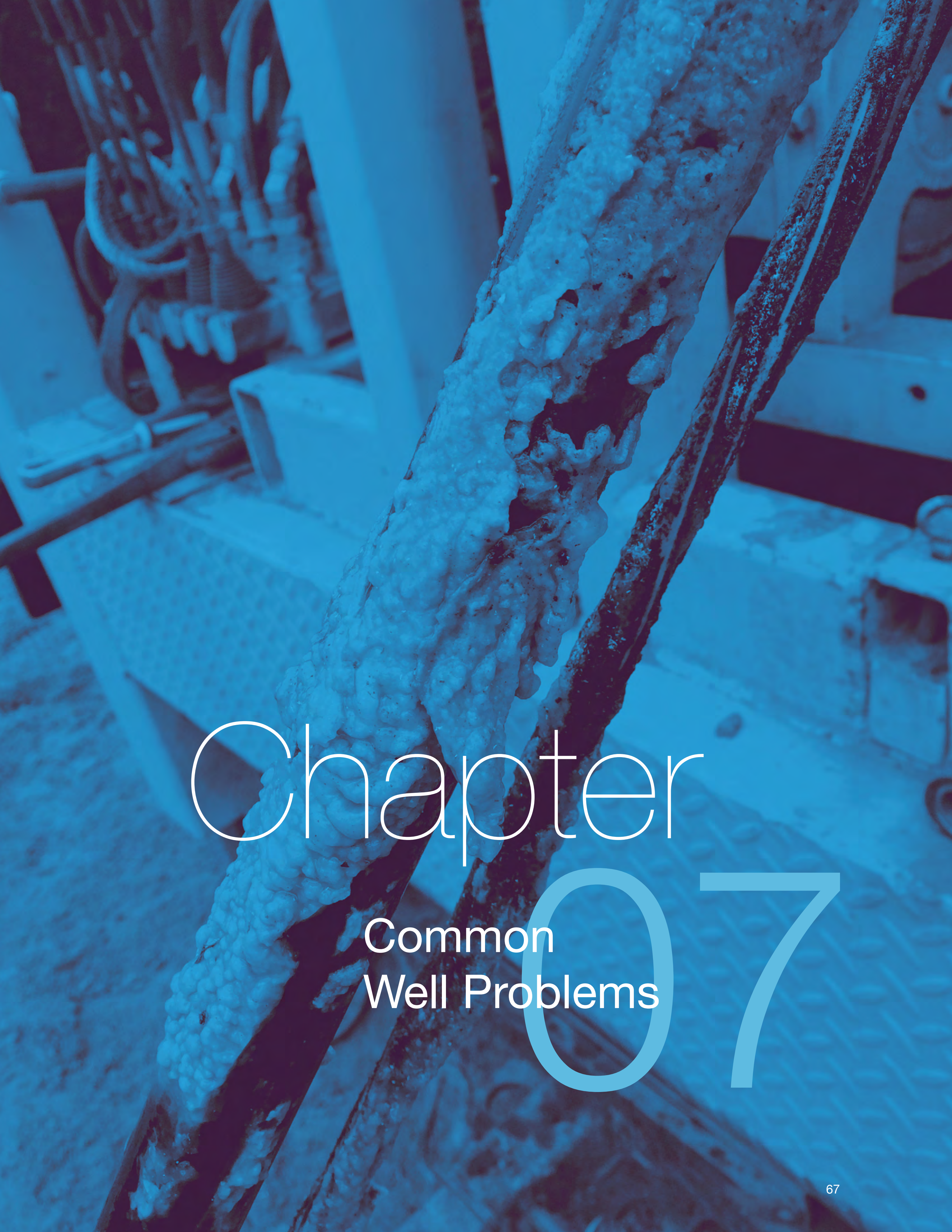
The rehabilitation procedure is dictated by the experience of the driller, the design of the well and a determination of the required steps, which might include the following:

- Pulling the pump
- Video inspecting the well
- Pre-cleaning the well using a mechanical method
- Removing the loosened material
- Applying chemical into the screened (perforated) area of the well
- Agitating the water in the well by mechanical methods to force the chemical into the filter pack or aquifer formation
- Monitoring the pH of the water to maintain a level below 3.0 for the treatment period
- Removing the chemical from the well
- Redeveloping the well to remove all dislodged materials
- Video inspecting the well to confirm successful removal of plugging materials
- Reinstalling the pump
- Disinfecting the well

When you do not adopt to a regular monitoring and preventative maintenance program for your well, you may not notice the accumulation of water-clogging build-up until it becomes excessive, and then it will be more difficult to remove. The age of a well will also determines which rehabilitation methods should be used. Aggressive cleaning of an old well may not be effective and could even pose a risk of exposing holes in the casing originally caused by corrosion.

A well that needs cleaning can be more costly to operate. If water cannot flow freely into the well through the screen or perforated casing, the pump will need to work harder; that results in higher electrical costs and excessive wear and tear on the pump.

Photo on page 67 courtesy of M. Holland.



Chapter 07

Common Well Problems

07

Common Well Problems

For assistance in identifying the cause of a well problem and what you can do to mitigate it, see Appendix E-1, Troubleshooting Water Well Problems. Be aware the problem might be the result of a combination of causes so correction may require a combination of actions.

The most common water well problems in Alberta include:

- Reduced yield
- Change in water quality
- Sediment in water
- Gas in water

There are several underlying causes for these problems. Correctly identifying the cause enables you to select appropriate treatment or maintenance to address the problem and prolong the life of your well. This troubleshooting chapter is designed to help you recognize the symptoms of your well problem, identify the cause and select the appropriate course of action. Technical assistance from licensed water well contractors or groundwater consultants is recommended.

Causes of Well Problems

Monitoring changes in the pumping water level over time will help you identify when your well intake is plugged with biofilm, scale build-up or sediment.

Common causes of well problems include:

- Biofouling
- Mineral incrustation
- Sediment plugging
- Over-pumping
- Well failure
- Aquifer depletion
- Natural dissolved gases in groundwater
- Contamination
- Breathing well phenomenon

Biofouling

Installing and pumping a well increases the level of oxygen and nutrients in the well and in the surrounding aquifer. Nuisance bacteria such as iron bacteria and sulphate-reducing bacteria can thrive under these conditions. While nuisance bacteria are not harmful, they can proliferate and form a gel-like slime or biofilm that coats the inside of the well casing, pumping equipment, distribution piping, water tanks and fixtures (see Figure 7-1, Slime Build-up in Toilet Tank). Biofouling can also lead to increased corrosion of steel and iron components of your well.

When biofouling occurs, you may notice the following symptoms:

- Slime build-up on plumbing fixtures (toilet tanks, livestock waterers)
- Staining on sinks, washing machines and laundry
- Bad taste and odour
- Discolouration of water
- Reduced well yield

Figure 7-1, Slime Build-up in Toilet Tank

Mineral Incrustation

Some shallow aquifers have an abundance of dissolved minerals such as calcium, magnesium and iron. When water is pumped from a well, changes in pressure and temperature occur. This facilitates the precipitation of dissolved minerals causing them to settle out and accumulate as scale on the casing, liner, screen, filter pack and pump intake. It can also accumulate within the formation immediately surrounding the well. Scale accumulation restricts the flow of water into the well.

Good management practices that reduce water pumping rates can minimize the effect of mineral incrustation. A strategy of reduced pumping rate with longer pumping intervals helps prevent incrustation of screens and perforated liners.

When mineral incrustation occurs, you may notice the following symptoms:

- Gradual decrease in yield
- Scale build-up on plumbing fixtures (faucets, hoses and fittings, livestock waterers)

Sediment Plugging

Well development is the process of removing fine sediment, drilling mud and borehole cuttings created during drilling operations.

If a well has been poorly designed and constructed, fine grained sediment from the aquifer can be drawn into the well. When designing a well, the licensed water well contractor must match well design and the type of well construction with the characteristics of the producing aquifer. Decisions must be made about:

- Slot size of the well screen or perforations
- Placement of well screen or perforated liner
- Size and amount of filter pack around the well screen (if needed)
- Duration of well development
- Pump intake depth.

When sediment plugging occurs you may notice the following symptoms:

- Sediment in the water
- Decreased yield

Provincial regulations require that a well must be completed to ensure no damage will be incurred to the pumping system, plumbing or fixtures due to sediment in the water. For more information on well design and construction, see Chapter 3, Design and Construction of Water Wells.

Over-pumping

When you pump water from your well at a higher rate than the aquifer can naturally replenish itself, "dewatering" occurs. Continuous lowering of the non-pumping (static) water level is a sign the aquifer is being dewatered.

A well is over-pumped if water is withdrawn at a faster rate than the well was designed for or the aquifer is able to produce. Over-pumping is the most common cause of premature well failure. Over-pumping not only depletes the aquifer, but rapidly increases the rate of corrosion, mineral incrustation, bacterial growth and biofouling.

When the pump is located within the screen of perforated casing and the pumping water level drops below the top of the producing aquifier, water cascades into the well, becomes oxygenated and is a real gourment treat for aerobic bacteria.

Over-pumping also increases the rate of sediment particles moving toward the well, causing plugging of the perforations and damage to the pump. It can also cause the aquifer to settle and compact which further restricts water flow to the well. Over-pumping wells completed in aquifers where gas is naturally present can, over time, reduce the pressure within the aquifer and release the gas.

When over-pumping occurs, you may notice the following symptoms:

- Sediment in the water
- Lowering of the non-pumping (static) water level
- Appearance of gas in water
- Development of the "breathing well phenomenon" (see Figure 7-3, Breathing Well Phenomenon)

Well Failure

Groundwater containing high concentrations of carbon dioxide, oxygen or hydrogen sulphide gas is corrosive and can cause holes in metal well casing, resulting in well failure.

Well failure can result from poor well design (casing selection, improper selection and placement of well intake or filter pack, inadequate annular seal), damaged casing and screens, corrosion or over-pumping. It is important to discuss the design of your well with your driller before construction begins. For example, licensed water well contractors usually select plastic casing and stainless steel well screens when dealing with corrosive water. A well that is properly designed and constructed will cost more up front but is money well spent, as it will deliver the quality, quantity and reliability you need.

When well failure occurs, you may notice the following symptoms:

- Sudden appearance of sediment in the water
- Changes in water quality

Figure 7-2, Holes in Well Casing

Photo courtesy of R. Arts.

Aquifer Depletion

Water withdrawal from multiple wells has a cumulative impact on the aquifer. When pumping collectively exceeds the natural recharge rate of the aquifer, each well owner may experience symptoms.

Reduced aquifer yield is caused by lack of recharge or over-use. Sometimes the decline is seasonal; typically water levels in shallow aquifers are higher in spring and lower in the fall. Extended dry periods can also have an impact. Over-pumping and unauthorized use of groundwater can lead to aquifer depletion.

When aquifer depletion occurs, you may notice the following symptoms:

- Decline in well yield
- Drop in non-pumping (static) water level

Natural Dissolved Gases in Groundwater

Sometimes the natural characteristics of groundwater can lead to undesirable affects. Oxygen, carbon dioxide, nitrogen, methane and hydrogen sulphide gases may naturally occur in groundwater from coal seams, fractured shales and sandstones. When gas is present, it is held in the groundwater under pressure. Pumping water wells completed in such aquifers can reduce the pressure, releasing the gas. Sometimes gas in groundwater can affect the operation of a well. However, even if gas is present, it may still be possible to use the well in a safe manner.

When gas occurs, you may notice the following symptoms:

- Spurting water taps
- Gas locking of pump
- Rotten egg odour (only when hydrogen sulphide is present)

Contamination

The fastest way to contaminate groundwater is through a water well because it provides a direct path for contaminants to travel from the surface to the aquifer.

The land-use activities that occur on your property can have a direct impact on your well, so it is important to manage potential contamination risks and routinely test your water quality. For example, test results showing the presence of E. Coli or nitrates could indicate contamination has occurred.

When contamination occurs, you may notice the following symptoms:

- Changes in water colour, odour or taste
- Increased biofouling
- Unexplained illnesses

Breathing Well Phenomenon

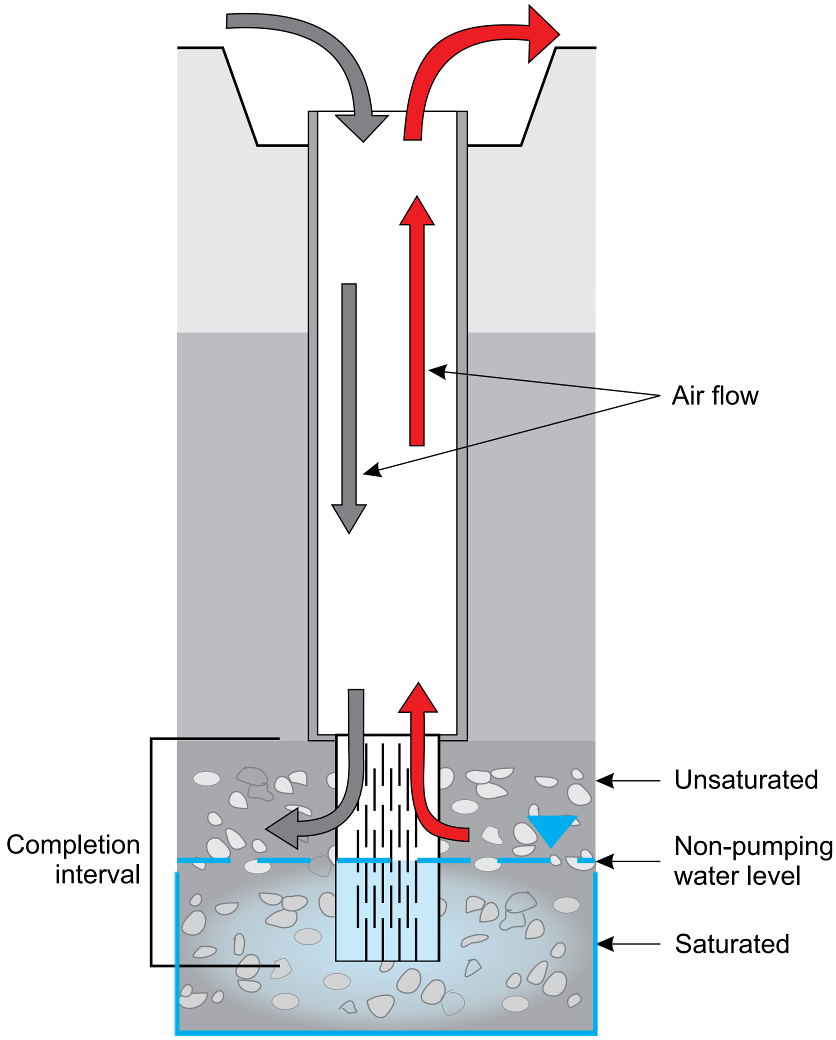
Breathing wells located in buildings or well pits pose a serious health risk. Depletion of oxygen in the air can result in asphyxiation causing death. Several cases have been documented in Alberta.

The “breathing well phenomenon” is another problem occasionally found in water wells in Alberta. Also referred to as “suckers and blowers”, these wells can be a safety concern if not appropriately managed. Sometimes the design of a well causes a specific, problematic condition, where unsaturated permeable formation is exposed to the well intake (perforations or screen). This allows air to move into or out of the formation depending on atmospheric conditions (see Figure 7-3, Breathing Well Phenomenon).

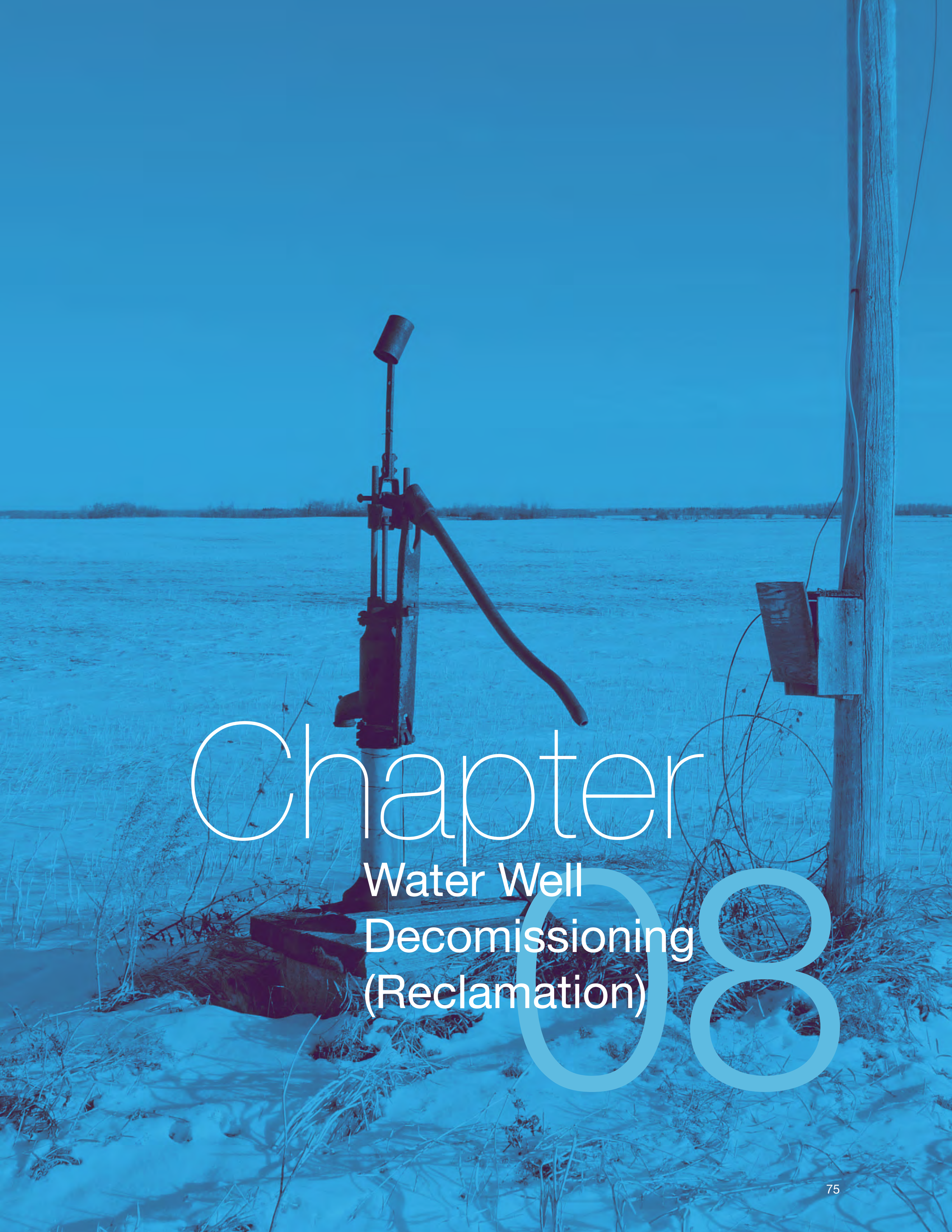
When atmospheric pressure rises, air flows into the well and the unsaturated formation. When this occurs, the well is described as “sucking” and causes symptoms like frozen water lines and pitless adapters in winter. When atmospheric pressure drops, air flows out of the well and is described as “blowing”. This becomes a real concern when the well is located in a confined space such as a building or a well pit. The air blowing out fills the confined space, depleting it of oxygen and can result in asphyxiation.

Over-pumping a well can also trigger this phenomenon. When the non-pumping (static) water level is drawn down below the top of the aquifer from excessive pumping, the previously saturated formation can become exposed to the well intake, allowing air to move in and out.

Figure 7-3, Breathing Well Phenomenon



Adapted from Water Wells That Breathe, Hydrogeological Consultants Ltd.



Chapter 08

Water Well Decomissioning (Reclamation)

Well Decommissioning (Reclamation)

All references to volumes or flow rates are in Metric (or Imperial) measurements unless otherwise specified.

Abandoned wells pose a threat to the preservation of groundwater quality and quantity and are a serious risk to public safety, especially young children and animals.

There are approximately 40,000 farmsteads in Alberta and most of these have at least one well. In addition, there are an increasing number of non-farming rural residents that rely on water wells. The exact number of abandoned wells in Alberta is unknown but is estimated to be in the tens of thousands.

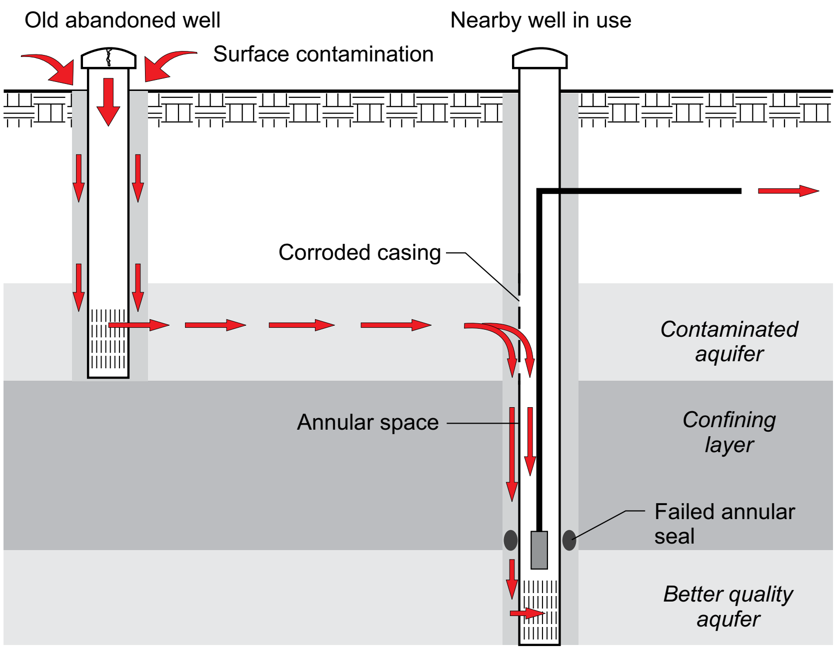
A water well is considered “abandoned” if it is:

- No longer in use and not intended to be used in the future for water supply,
- In a poor state of repair and the pumping equipment has been removed or cannot be repaired or replaced,
- Producing water that is unsuitable for drinking or other licensed uses, or
- Unproductive and no longer an asset to the property

A well is considered “inactive” if it is not being used but is being maintained for future use. This means the well owner actively conducts annual visual inspection of the well cap and casing, shock chlorination and water testing for coliform bacteria. Unlike an abandoned well, an inactive well can be placed back into production at short notice, ready to be used.

Wells that are no longer being used are a potential risk to groundwater and should be decommissioned. They are a serious environmental and public safety hazard.

Figure 8-1, Well Contamination



Abandoned water wells are a threat to groundwater because they provide a direct conduit for surface contaminants to reach groundwater. Contaminants can enter directly through the well casing, if the well cap is loose, cracked or missing, or through unsealed spaces along the outside of the well casing (see Figure 8-1, Well Contamination). When older wells lose their structural integrity (for example, steel casing starts to corrode and develop holes), intermixing can occur between aquifers with differing groundwater quality.

Who is Responsible?

In Alberta, a licensed water well contractor is legally responsible for immediately decommissioning any well they drill if it cannot be completed due to a construction problem or inadequate yield to meet their client's needs. Before you sign a contract with your driller, ask questions about the costs for decommissioning in case it may be required.

It is the landowner's legal responsibility to have any abandoned water wells on their property decommissioned.

Are there Abandoned Wells on My Property?

If you are new to your property, you should look for evidence of abandoned wells. Examples of evidence could include:

- An old power pole or an electrical panel that has been disconnected
- Pipes sticking out of the ground or basement floor
- A pit in the yard or basement, or a basement offset
- A waterline or patched hole through the basement floor or wall
- A basement offset (small room)
- A ring of concrete or bricks surrounding a hole in the ground surface
- Windmills, wishing wells, hand pumps or hydrants
- A dip or circular depression (diameter of 1.2 m (4 ft) or less) in the land surface
- Small outside buildings, sheds, windmills, wishing wells or hand pumps
- An old piece of plywood or metal laying on the ground, possibly with rocks piled on top

Who Should Decommission your Well?

It is vital the person performing well decommissioning is knowledgeable about well construction practices and good groundwater protection principles. Site specific conditions, such as well construction details, local geology and hydrogeological characteristics will dictate the best plugging method to use.

A licensed water well contractor is the most qualified person; they will have the expertise and proper equipment to get the job done right. Unless you use the appropriate plugging material and have it properly placed in the well, you will end up with an improperly sealed well that may continue to be a risk to groundwater. Properly plugging a well can be a complex procedure, especially with: flowing wells; wells that are contaminated or contain obstructions; deeper, smaller diameter wells located in high risk areas like barnyards or near septic fields; or deep wells containing large volumes of water.

When a replacement well is drilled, plugging your old well at the same time is not just economical but the most efficient use of time and resources. Frequently, landowners plan to do the decommissioning at a later date but often, for various reasons, don't follow through and the old well never gets decommissioned.

Process of Plugging a Well

There are several steps to take before your well actually gets plugged. Some steps you will be able to do yourself and others you will want to hire a licensed water well contractor to complete. Decommissioning procedures vary depending on well construction and site-specific hydrogeologic and geologic conditions.

For information on how to take a non-pumping (static) water level measurement, see Chapter 5, Monitoring and Preventative Maintenance.

Preparation

All pumping equipment (pump, drop pipe, wiring) should be removed from the well.

The total depth and diameter of the well must be measured, plus the non-pumping (static) water level. If possible, these measurements should be compared to the information on the drilling report from when the well was originally constructed. This information is needed to calculate the amount of material required to fully seal the well its entire length, from the bottom right up to ground surface. If a portion of the well has collapsed, or if an obstruction exists inside the well casing, effort should always be made to open the well to its original depth before filling.

When possible, the casing should be removed from the well before the plugging process begins but only if the integrity of the borehole will not be affected. Often only the screen or liner casing gets removed and the surface casing is left intact because it is more difficult to remove and it could separate down hole. The older the well, the more difficult it will be to successfully remove the casing. If left in place, casing should ideally be perforated, particularly if there is evidence of water movement in the annulus of the well.

Any standing water in the well must be disinfected by adding enough chlorine to bring the chlorine concentration up to 200 mg/L. The amount of chlorine needed will depend on the casing size and the volume of water in the well. For every 450 litres (100 gallons) of water in the well, add 2 litres (0.4 gallons) of household bleach (5.25% chlorine).

Materials

Materials used to plug a water well must be uncontaminated, low permeability materials that will prevent movement of water.

The best product for this is a manufactured, high yield bentonite because it is a special type of clay that swells when wet to about eight times its original size and provides a very effective, water-tight seal. It comes in a powder that can be mixed into slurry and pumped into the well or as chips, tablets or coated pellets that are designed and manufactured to be poured into the well. It is important to know bentonite cannot be used as a plugging material in some situations. When the chloride level in the water is greater than 4000 mg/L, or the calcium level is greater than 700 mg/L, bentonite will not swell properly so then it is best to use cement slurry to fill the well.

By regulation, a well must be filled full length with impervious material. That material must be introduced into the well at the bottom and be placed progressively upward to ground surface (unless it is designed and manufactured to be poured into the well.

Placement of Materials

Equally as important as the type of material chosen is the method of placing that material into the well.

If the plugging material of choice is bentonite or cement slurry, special equipment will be needed. A grout pump and tremie pipe must be used to ensure positive displacement of water in the well, and no dilution or separation of the slurry material as it is placed within the well, from bottom up to ground surface.

Bentonite chips, tablets and pellets require special attention to ensure they actually reach the bottom before they begin to swell up. If you are not careful, they will bridge off down hole and the well will only get partially sealed (see Figure 8-2, Bridging of Fill Material). It is advisable to run them over a fine mesh screen before they fall into the well to remove any fine dust that may have formed in the product bag during shipping (see Figure 8-3, Pouring Bentonite Chips).

Figure 8-2, Bridging of Fill Material

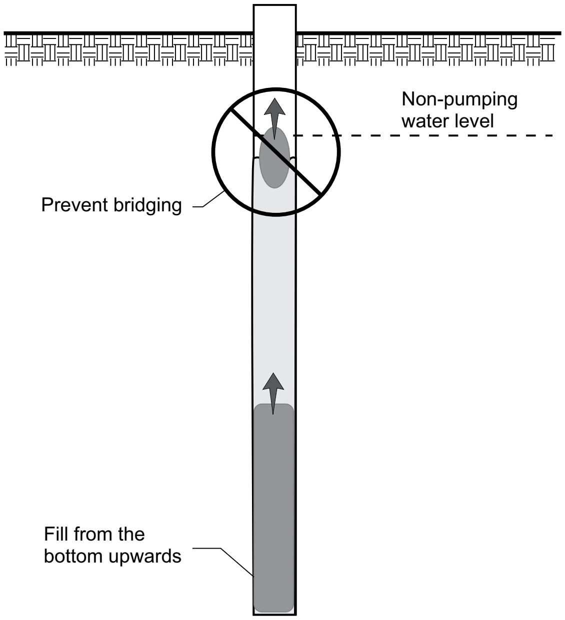


Figure 8-3, Pouring Bentonite Chips

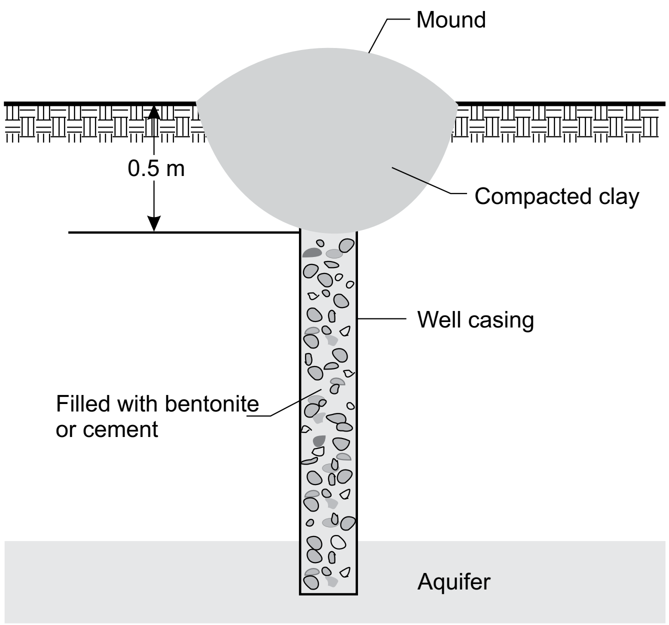
For steps to properly plug a water well, see Appendix D-3, Procedure for Water Well Decommissioning (Reclamation).

The person who completes the decommissioning process must report the details to Alberta Environment and Parks (see Appendix B-2, Water Well Decommissioning (Reclamation) Report).

Prior to pouring in the bentonite, a calculation should be done to determine how many feet of well casing can be filled with the size of chips, tablets or pellets chosen for the fill material. As the well is being filled, the depth to the top of the plugging material should be measured frequently so it will be obvious if the plug is rising faster than anticipated, indicating a bridge has formed. If this happens, the plug must be broken up before placing more fill material into the well.

Any well casing left in place must be cut off at least 0.5 m (20 in.) below ground surface after the well is plugged (see Figure 8-4, Cutting Off Casing and Mounding Clay).

Figure 8-4, Cutting Off Casing and Mounding Clay



Special Problems

Large Diameter Wells

Bored wells, with a diameter greater than 60 cm (24 in.) pose special problems during decommissioning because of their size and the sheer volume of material required to fill them. A lower cost alternative for the plugging material is clean, uncontaminated clay that can be shovelled into the well until it is filled. This must be done carefully, however, to ensure the clay reaches the bottom of the well and seals all empty space. The cribbing must be cut off at least 0.5 m (20 in.) below ground surface and the well topped up with high yield bentonite, to make a water-tight seal.

Flowing Wells

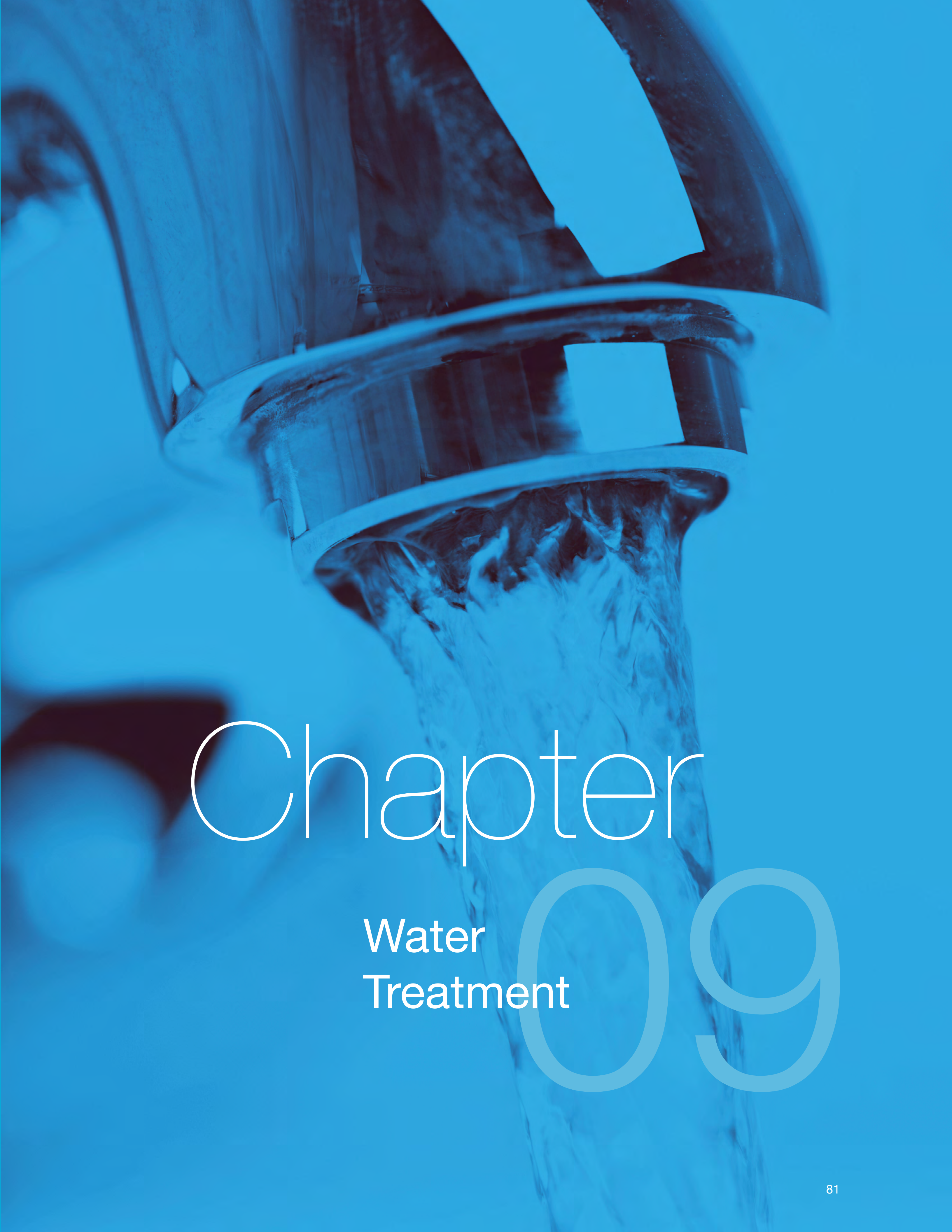
Any well that is flowing necessitates a more complex procedure for successful decommissioning. All flowing wells require the expertise and equipment of a licensed water well contractor who has experience decommissioning flowing wells. They will need to control the flow of water before the well can be plugged.

Unknown Well Construction

When you have little or no knowledge of the construction of an old well, you should have it assessed by a licensed water well contractor to determine the best procedure for effective decommissioning. The exact materials and placement method will be different for each circumstance.

Well Pits

If an abandoned well is located in a pit, extreme caution must be taken if it is necessary to enter the pit during the decommissioning process. The air in the pit can become oxygen deficient or it may contain dangerous gases that can come up from the groundwater through the well. Only someone who is trained and equipped for confined space entry should enter the pit.



Chapter 09

Water Treatment

09

Water Treatment

All references to volumes or flow rates are in Metric (or Imperial) measurements unless otherwise specified.

What you intend to use the water from your well for, and the quality of the groundwater your well produces, will determine whether or not you need water treatment equipment. It is important to identify which health-related or aesthetic parameters you want to remove before you invest in expensive treatment equipment. No single piece of equipment is capable of resolving all water quality problems, and sometimes, more than one device may be needed.

You should have your water tested, for both bacteriological and chemical analyses, and a Public Health Inspector can assist you in interpreting the results, identifying health related parameters of concern and discussing treatment options, if needed. Chemical analyses may also identify aesthetic parameters of concern that can be treated.

Water treatment equipment is available for:

- improving taste, odour and appearance of water
- removing chemical parameters of concern (health related or aesthetic)
- disinfecting water contaminated by microorganisms

For more information on collecting water samples and interpreting results, see Chapter 11, Contacts and Other Resources.

Standards and Certification

For information about the certification of devices, see:

- *CSA International: www.csa-international.org*
- *NSF International: www.nsf.org*
- *Underwriters Laboratories: www.ul.com*
- *www.cwqa.com*

There are currently six health-based performance standards that have been developed by the American National Standards Institute (ANSI) and the National Sanitation Foundation International (NSF International) for drinking water treatment devices. Manufacturers can apply and pay for their products to be certified against these standards.

The current ANSI/NSF health-based performance standards for drinking water treatment devices include:

- ANSI/NSF standard 42-Drinking Water Treatment Units-Aesthetic Effects
- ANSI/NSF standard 44-Cation Exchange Water Softeners
- ANSI/NSF standard 53-Drinking Water Treatment Units-Health Effects
- ANSI/NSF standard 55-Ultraviolet Microbiological Water Treatment Systems
- ANSI/NSF standard 58-Reverse Osmosis Drinking Water Treatment Systems
- ANSI/NSF standard 62-Drinking Water Distillation Systems

The Standards Council of Canada has authorized NSF International and Underwriters Laboratories of Canada (ULC) to certify devices against all six of these standards and the Canadian Standards Association (CSA) to certify against standards 42 and 53 only. When equipment meets certification you can be sure that its performance has been validated against these ANSI/NSF standards. However, be aware that some performance claims made by manufacturers fall outside of these standards and there is no current standard available to certify that performance claim against. As a consumer you must be careful to identify whether or not performance claims being made by a manufacturer have actually been verified by a certification body.

Be wary of water treatment installers who may try to sell you more equipment than you actually need; do your homework before you purchase any equipment. Accessing unbiased information is important. You will want to be certain you are buying a product that will actually address the parameter(s) of concern in your water and you should always verify the terms of warranty claims on both equipment and installation. Also, be sure any water treatment equipment you purchase is sized appropriately to match the flow rate of water in your distribution system.

Finding a reputable installer is vital to the success and performance of any treatment equipment. Check with the Better Business Bureau, ask for references and follow up with them and carefully compare quotes and estimates.

Point-of-Entry (POE) Systems

For guidance on water treatment systems, see Appendix E-2, Water Treatment Options.

Point-of-Entry (POE) Systems treat water before it is distributed throughout the household. System options commonly used for household water supplies include:

- Ion exchange systems (Water softeners)
- Filtration systems
  - Iron filters (Manganese greensand)
  - Sediment filters
  - Activated carbon filters
  - Membrane filtration
- Disinfection systems
- Aeration systems
- Air injection systems

Hard water contains a high level of calcium, magnesium and other minerals. It is expressed as a mg/L equivalent of calcium carbonate. Hard water causes mineral scale build-up or incrustation on the well screen or perforated well casing.

Ion-exchange systems use a process whereby undesirable ions are replaced by other ions of the same electrical charge. Some systems exchange positively charged ions called cations while others exchange negatively charged ions called anions. This process exchanges undesirable ions with ions that are less offensive.

- Water softeners are the most common ion exchange systems used by homeowners. They reduce water hardness by exchanging hardness mineral cations (calcium or magnesium) with softer mineral cations (sodium or potassium). Most softeners use sodium, however systems that use potassium are a good alternative for anyone concerned about their sodium intake. Softeners require routine backwashing to restore the exchange capability of the equipment. They can be set to regenerate at preset times or based on water volume usage. It is necessary to purchase and add water-softening salts on a regular basis and maintain the equipment according to the manufacturer's specifications.

Care should be taken to avoid overloading your septic system with backwash water from your water softener.

Filtration systems use a filtration media or membrane to remove parameters of concern. There are different types of filters that are typically used to treat water for household use, depending what parameter you want to remove.

- Manganese greensand filters (iron filters) are effective at removing iron and manganese. A coating on the surface of the filter media (manganese greensand) oxidizes the unwanted substance allowing it to be physically filtered out of the water. The greensand filter media must be regenerated periodically with potassium permanganate to replenish the oxidant on the surface of the media. A minimum available flow of 20 L/min (5 gpm) is required in order for proper backwash and regular regeneration.
- Sediment filters remove suspended particles such as rust caused by iron that is oxidized and sediments. Depending on the size of particles being removed, these filters are made of pleated polyester, cellulose fibre or porous ceramic materials. These filters can remove particles sized from 0.5 microns up to 25 microns.
- Activated carbon is charcoal that has been cleansed by a slow heating process in the absence of oxygen and "activated" using temperatures up to 800ºC. Activated carbon works by adsorbing residual chlorine and organic substances that cause undesirable taste, odour and colour of the water. These filters do not remove hardness, dissolved iron, fluoride, sodium, asbestos fibres or other inorganic materials. Large, point-of-entry systems need regular maintenance (media replacement or regeneration and backwashing) to maintain effectiveness.
- Membrane filtration are systems capable of filtering sediments of less than 0.1 microns and can also remove protozoa, such as Giardia and Cryptosporidium. Reverse osmosis is one type of membrane filtration but is not really economical to use in applications where large volumes of water (whole household) need to be treated. Other types of membrane filtration include micro filtration, ultra filtration and nano filtration.

Disinfection systems use an oxidizing agent (chlorine, hydrogen peroxide or ozone) that is continuously mixed with the water and allowed sufficient contact time to kill bacteria and viruses. A chemical feed pump and storage tank are integral parts of this type of system. Routine monitoring using test strips or home test kits to maintain chemical residual is required to ensure system effectiveness.

Pellet chlorinators, placed directly over the well head are not considered appropriate disinfection systems as they do not ensure disinfection and can cause irreparable damage to the well and pumping equipment.

Aeration systems are used to dissipate gas or precipitate iron. They involve water being sprayed or aerated into a storage tank. If gas is present, the system will require venting to the open atmosphere. If iron is precipitated it will be settle to the bottom of the tank and will need to be periodically removed.

Air injection systems uses a small venturi-type air injector, installed between the pump and pressure tank, to draw air into the water. Iron present in the water oxidizes to form rust particles that can be strained out using a filter.

Point-of-Use (POU) Systems

Point-of-Use (POU) Systems treat water at a single tap, providing a final barrier at the point of consumption. These systems can remove disinfection by-products, corrosion products (lead), disease-causing microbes (bacteria, viruses) and trace levels of other substances and chemicals. However, the other water distribution points in the house remain untreated. System options include:

- Cartridge filters
- Reverse osmosis units
- Ultraviolet (UV) technologies
- Distillers

Cartridge filters intended for use at single water outlets (taps, refrigerator water dispensers, etc.) are relatively inexpensive and remove sediments, precipitated iron (rust) and residual chlorine and organic substances that cause undesirable taste, odour and colour of the water. These disposable, cartridge-type filters are typically made of activated carbon and work by adsorbing residual chlorine and organic substances that cause undesirable taste, odour and colour of the water. These filters do not remove hardness, dissolved iron, fluoride, sodium, asbestos fibres or other inorganic materials. Cartridges need replacement every 3 to 6 months as the carbon adsorption effectiveness declines and to avoid contamination from bacterial growth.

Small RO systems used in household applications typically flush from 3 to 20 litres of water to waste for every litre of treated water.

Reverse Osmosis (RO) units remove dissolved minerals such as nitrates, sodium and arsenic by forcing pressurized water through an extremely fine, semi-permeable membrane. Water is purified as it passes through the membrane and collects in a storage container while the unwanted minerals are left behind. Pre-treatment may be required to remove sediment, iron, hardness and chlorine. These units are particularly useful because they can be mounted into tight spaces.

Ultraviolet (UV) light technology does not involve chemicals; rather it exposes water to light at the wavelength required to kill disease-causing bacteria and viruses and are particularly effective at killing protozoa (Cryptosporidium and Giardia). They are relatively low maintenance systems but do require routine monitoring and cleaning so the light source can continue to effectively penetrate the organism cell walls. Many systems have automatic cleaning options, warnings or alarms to make maintenance easier. Pre-treatment may be required to improve effectiveness of the system. Careful attention is needed when selecting a UV system, to ensure the system is properly sized to match the flow rate of your distribution system.

Distillation systems can remove over 95 percent of minerals in water, including sodium, sulfate, nitrate and arsenic. They can also remove most metals, organic chemicals (pesticides, petroleum compounds) and microorganisms. However, they are typically only used for treating small volumes of water for drinking and cooking purposes due to the cost of operation (high power usage), maintenance, scaling issues and the length of time it takes to produce distilled water.

Distillation systems require periodic cleaning and descaling to remove mineral build-up.

Photo on page 87 courtesy of J. Larson.

Chapter 10
Groundwater Management

10

Groundwater Management

Both groundwater and surface water are found in relative abundance in many areas of Alberta. Careful use and protection will safeguard this most important natural resource for future generations. The ownership of all groundwater and surface water is vested in the Crown. Two primary pieces of legislation provide a framework for water management and protection.

In designing legislation and policies, groundwater and surface water are considered as two forms of the same resource because they are often connected. Although the interactions between them are not always easy to see or measure, both can be affected by human activities.

The *Water Act* regulates the diversion and use of water through licences and manages all activities that could have potential impact on water through approvals.

The *Environmental Protection and Enhancement Act* provides control and prevention of the release of substances that may cause adverse effect on the environment, including water resources. It also requires proper reclamation or remediation of contaminated groundwater sites and environmental impact assessments, to determine the effects that any major developments will have on water resources.

Groundwater supplies in Alberta are currently managed through:

- Inventory
- Authorizations for licenses and approvals
- Protection and conservation

Inventory

Alberta Environment and Parks maintains a comprehensive inventory of groundwater resources through administration of the following databases:

- Alberta Water Well Information Database (AWWID)
- Groundwater Observation Well Network (GOWN)
- Provincial Groundwater Inventory Program (PGIP)

To contact the Groundwater Information Centre call: 780-427-2770.

The Alberta Water Well Information Database contains over 500,000 records of individual water well drilling reports, baseline water well testing reports, chemical analysis results (up until 1986), springs, flowing shot holes, structural test holes and federal well surveys. This database is administered by the Groundwater Information Centre and is accessible to the public at: groundwater.alberta.ca/WaterWells .

The Groundwater Observation Well Network has over 280 active monitoring wells ranging in depth from 5-400 m (16-1312 ft). Over 50 wells are equipped to enable near real-time reporting of water level data. Ambient groundwater level fluctuations and groundwater quality data provides information on the characteristics of various aquifers throughout the province.

The Provincial Groundwater Inventory Program was launched in 2008 to map an inventory of groundwater resources in Alberta. Airborne geophysical surveys were conducted to map various rock formations. Thousands of existing water well and oil and gas drilling records were used in conjunction with the airborne data and supported by the drilling of boreholes, groundwater sampling and other field-based activities. To date, the Edmonton-Calgary corridor, Calgary-Lethbridge corridor, Cold Lake, Sylvan Lake and Fox Creek areas have been mapped. Regional groundwater flow models are being developed using this data. Enhanced understanding of groundwater supplies enables better management of this valuable, "hidden", resource.

See Chapter 11, Contacts and Other Resources for more information on:

- *AWWID*
- *GOWN*
- *PGIP*
- *Regional groundwater reports*

A series of regional groundwater reports have been produced for counties and municipal districts in Alberta. These reports provide an overview of groundwater resources and characteristics. Shallow and deep aquifers are identified along with potential yield and water quality. These reports may be available at county offices or the Alberta Government Library (see Module 11, Contacts and Other Resources).

Allocation, Licences and Approvals

Licensing is required for all uses except household purposes.

Under the *Water Act,* a licence authorizes a user to divert and use water under specified conditions (the maximum volume that may be diverted annually, the maximum pumping rate, the point of diversion, point of use, time period and purpose). The terms and conditions of the licence are intended to protect the source of water, the rights of the licensee and the rights of other water users who are already using the water source. The priority date on the licence determines the licensee's priority of right. A temporary diversion licence (TDL) authorizes the diversion and use of water for a period of one year or less. No priority is assigned to a TDL and public notice may be required during the application process.

A user who was licensed first has priority right to use the water source before those licensed at a later date. That right is valid as long as the specified use continues but can be cancelled for:

- Non-use; not exercising the right to use the water
- Non-performance of a term or condition of the licence.

The Water Act defines:

- *Household purpose*
- *Traditional agriculture user*
- *Exempted agriculture user*
- *Licensee*

During emergency situations, a water licence can be cancelled or suspended, and the water can be re-designated for other uses.

The legislation clearly defines "household purpose" as the use of up to a maximum of 1,250 cubic metres (m^3) of water per year per household (750 imperial gallons per day), for the purposes of human consumption, sanitation, fire prevention and watering animals, gardens, lawns and trees. A "household" is further defined as one or more individuals living in a single, private and detached dwelling place.

Legislation further provides that water for household purposes has priority over all other water uses, and has no priority in relation to other household users. This means that during times of shortage, household users are entitled to their statutory right before other users of water and all household users have equal priority.

"Traditional agriculture user" applies to water historically used for watering livestock and pesticide application to crops. Users were given a one-time opportunity to register up to 6,250 cubic metres of water per year (3,767 imperial gallons per day) for "traditional agricultural use". The registration protects their right to use water at a specified land location by assigning priority "grandfathered" back to the date when the water was first put to use. That priority (the right to use the water) transfers with the sale of the land but cannot be diverted (piped or ditched) to another land location. Registration was voluntary, so if the landowner decided not to register, they could continue to use the water as an "exempted agriculture user". However, such use is not protected or transferable with the sale of the land and does not have assigned priority.

Registration does not guarantee that a water source will always be capable of supplying the amount of water you require. In addition, water required in excess of the registered amount, or for any other purpose (agricultural or otherwise), does require formal licensing.

An approval is issued to regulate any activity that could have potential impact on a water source, even if no use of water is intended. Examples of activities that would require an approval include a spring development, dugout construction over 2,500 cubic metres (550,000 imperial gallons) and extraction of gravel. Approvals do not assign priority in time relative to others but rather define the terms and conditions under which the activity can take place. All approvals have an expiry date.

Obtaining a Licence or Approval

To obtain a licence for the diversion and use of groundwater, you must submit an application form which may be downloaded from the Alberta Environment and Parks website. To apply for a license or approval, contact a regional office of Alberta Environment and Parks (see Chapter 11, Contacts and Other Resources).

If a well is going to be used for a non-household purpose it must be constructed in a manner that will allow it to be licensed. Wells that require licensing for diversion and use of groundwater cannot be constructed with a multi-aquifer completion. For more information, see "Alberta Environment Guide to Groundwater Authorization", Chapter 11, Contacts and Other Resources.

Supporting information will be required with the application depending on the scale and purpose of your proposed groundwater diversion. You will be required to publish public notice of your project, to give local water users an opportunity to express any concerns except in very specific circumstances where it is deemed your project will have minimal or no adverse effect on the environment, household users, licencees or traditional agriculture users.

After all required information is received, all concerns are addressed and the Department is satisfied your well is capable of providing adequate water for your project (without causing unreasonable interference with other water users or adverse effect on the aquifer or the environment), a decision will be made on the licence application.

A licence will include conditions requiring you to submit monitoring data including water level measurements, quantities of water used and water quality test results. It may also include investigating any complaints from nearby water users, monitoring the impact of your diversion and use on existing water wells and the responsibility of decommissioning your water well when it is no longer needed.

Your licence will have an expiry date based on the nature of your project or an estimation of how long you will need the water.

To obtain an approval for any activity that could have potential impact on an aquifer, you must submit an application form and a decision will be made on the approval application after all the required information is received, all concerns are addressed and the Department is satisfied your proposed activity will have minimal impact on the water source.

Protection and Conservation

Fertilizers, pesticides, fuel storage tanks, landfills, animal waste and septic systems are all examples of potential contamination sources. Always observe the regulated minimum setback distances from contamination sources. For regulated setback distances, see Chapter 3, Design and Construction of Water Wells.

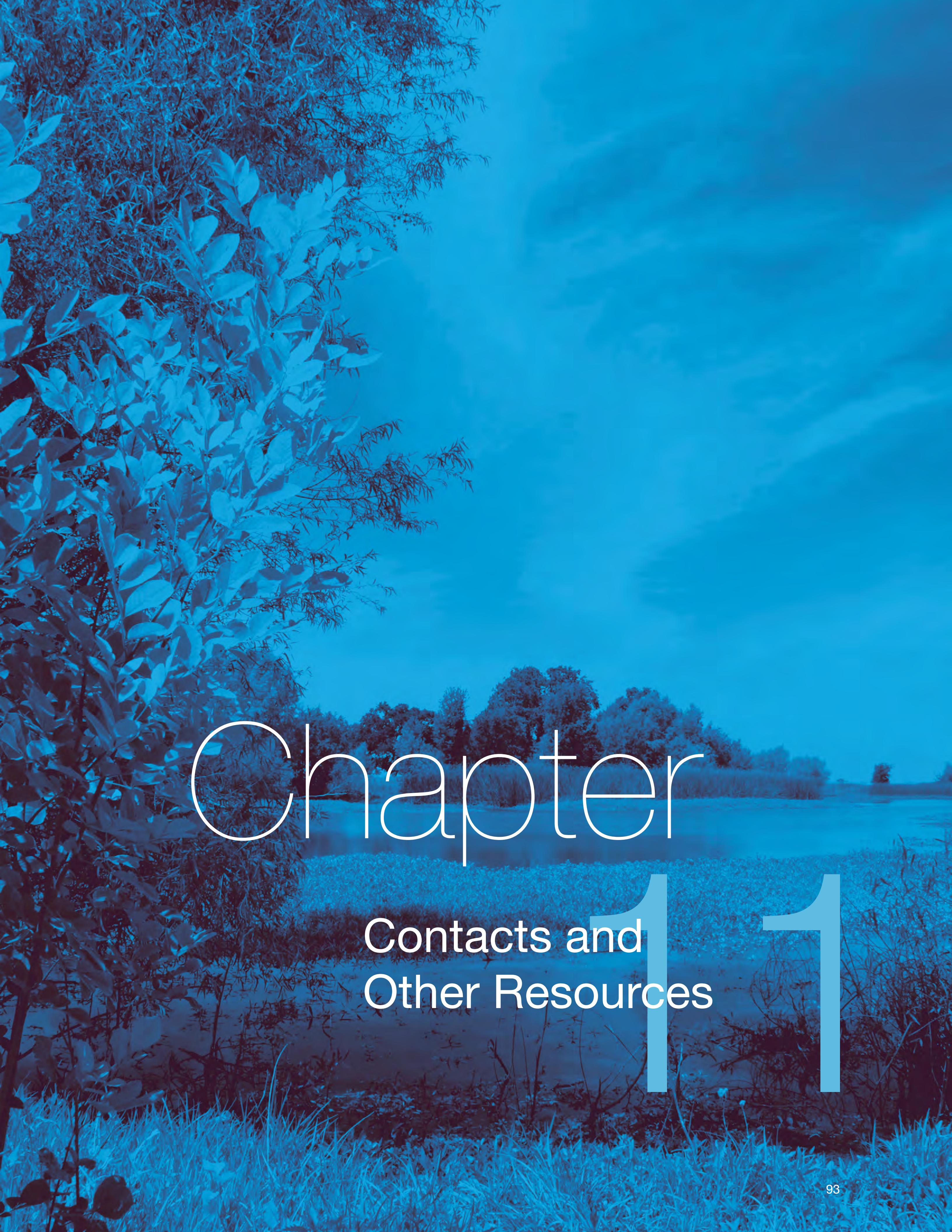
Protecting groundwater resources against overuse and pollution is an integral part of Alberta's water management strategy. Both the *Water Act* and the *Environmental Protection and Enhancement Act* provide protection for our water resources.

The *Water Act* requires all water well drilling contractors to obtain an approval that authorizes them to drill water wells in the province. The approval is issued only if the company has certified journeyman water well drillers available to operate each of their drilling machines. The standards for drilling, constructing, and decommissioning water wells are outline in the Water (Ministerial) Regulation of the *Water Act* and apply to all water wells, whether installed for temporary water supply or long-term use.

The *Environmental Protection and Enhancement Act* requires any release of a substance into the environment (including aquifers), that could cause an adverse effect, to be reported. Prompt reporting helps to ensure impacts are promptly addressed, minimized if possible, and ensures directly affected parties are notified.

While legislation and regulations go a long way to protect our water resources, it is the users who have the greatest impact on water protection. Land use activities can have significant impact on groundwater quality and cumulative usage can affect groundwater quantity. We all share the responsibility of ensuring a healthy, secure and sustainable water supply for future generations.

For information on how to properly plug a water well, see Chapter 8, Water Well Decommissioning.



Chapter 11

Contacts and Other Resources

11

Contacts and Other Resources

The purpose of this chapter is to provide Albertans with a list of agency contacts and resources that can help them with their water needs and problems.

To access provincial government numbers toll free, call 310-0000.

Contacts:

For information on farm water systems, water treatment, water quality, on-farm water management and grant programs.
Alberta Agriculture and Forestry
Agricultural Water Specialists at 310-FARM (3276)

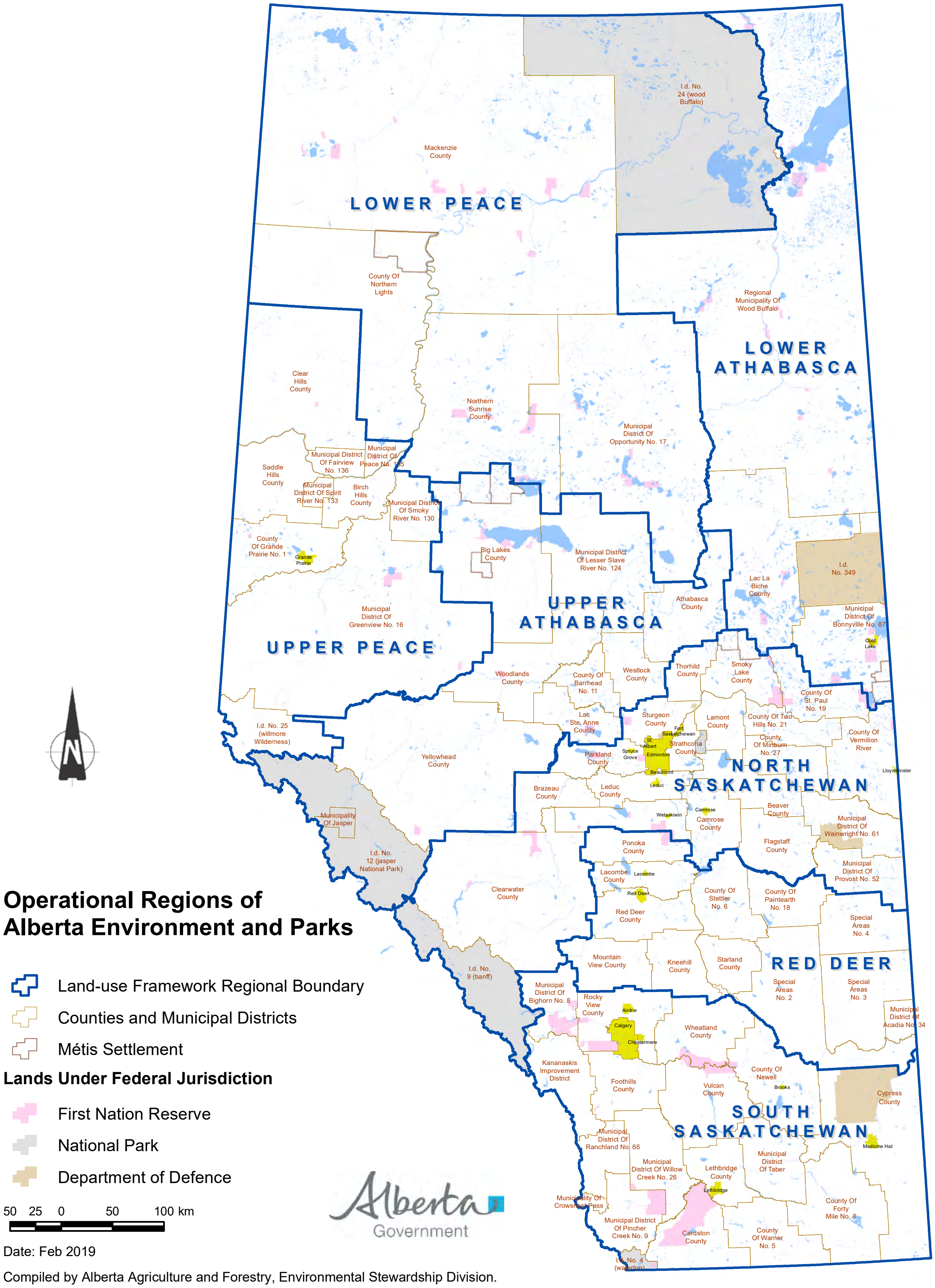
For information on provincial groundwater supplies, water well records, baseline water well testing reports.
Alberta Environment and Parks | Groundwater Information Centre
Phone: 780-427-2770
Email: gwinfo@gov.ab.ca

For information on approvals and licences under the Water Act.
Alberta Environment and Parks | Regional Offices:
Peace Region, Phone: 780-624-6167
Upper Athabasca, Phone: 780-960-8603
Lower Athabasca, Phone: 780-427-5296
North Saskatchewan, Phone: 780-427-7617
Red Deer, Phone 403-340-7052
South Saskatchewan, Calgary, Phone: 403-297-7602
South Saskatchewan, Lethbridge, Phone: 403-381-5322

To report:

- *complaints about licensed water well contractors and water well construction*
- *complaints about water wells affected by oilfield activities (including coalbed methane)*
- *complaints about seismic activity, water wells affected by seismic activity, seismic trespass and damage on private or public land*
- *contamination events, spills*

Alberta Environment and Parks
24-hour Environmental Hotline: 1-800-222-6514


LOWER PEACE
LOWER ATHABASCA
UPPER PEACE
UPPER ATHABASCA
NORTH SASKATCHEWAN
RED DEER
SOUTH SASKATCHEWAN
Mackenzie County
I.d. No. 24 (wood Buffalo)
County Of Northern Lights
Regional Municipality Of Wood Buffalo
Clear Hills County
Northern Sunrise County
Municipal District Of Opportunity No. 17
Saddle Hills County
Birch Hills County
County Of Grande Prairie No. 1
Big Lakes County
Municipal District Of Lesser Slave River No. 124
Lac La Biche County
I.d. No. 349
Athabasca County
Municipal District Of Greenview No. 16
Woodlands County
Westlock County
Thorhild County
Smoky Lake County
I.d. No. 25 (willmore Wilderness)
Yellowhead County
Sturgeon County
Lamont County
Parkland County
Strathcona County
Brazeau County
Leduc County
Beaver County
Camrose County
Municipality Of Jasper
I.d. No. 12 (jasper National Park)
Ponoka County
Flagstaff County
Clearwater County
Lacombe County
Red Deer County
Special Areas No. 4
Mountain View County
Kneehill County
Starland County
Special Areas No. 2
Special Areas No. 3
I.d. No. 9 (banff)
Rocky View County
Wheatland County
Kananaskis Improvement District
Foothills County
Vulcan County
County Of Newell
Cypress County
Lethbridge County
Municipal District Of Taber
Cardston County
County Of Forty Mile No. 8
County Of Warner No. 5
Operational Regions of Alberta Environment and Parks
Land-use Framework Regional Boundary
Counties and Municipal Districts
Métis Settlement
Lands Under Federal Jurisdiction
First Nation Reserve
National Park
Department of Defence
50 25 0 50 100 km
Alberta Government
Date: Feb 2019
Compiled by Alberta Agriculture and Forestry, Environmental Stewardship Division.

For information about the "Water Well Restoration and Replacement Program" that provides rural landowners with potential funding for repair or replacement of water sources affected by energy-related activity.

Farmer's Advocate Office, Alberta Agriculture and Forestry
Phone: 310-FARM (3276)
Email: farmers.advocate@gov.ab.ca
https://www.alberta.ca/farmers-advocate-office.aspx

For information on:

- *water testing and interpreting test results for drinking water supplies*
- *water sample pick up and drop off locations.*

Alberta Health Services, Environmental Public Health
https://albertahealthservices.ca/eph/Page15233.aspx

For information on procedures to follow after flooding events and during boil advisories.

Alberta Health Services, Environmental Public Health
https://albertahealthservices.ca/eph/Page15235.aspx

When water testing is for mortgage approvals, livestock use and other non-health related purposes, use an accredited, environmental laboratory.

For information on private sewage systems requirements.

Alberta Onsite Wastewater Management Association
Phone: 877-489-7471
www.aowma.com

Alberta Municipal Affairs, Safety Services
Phone: 866-421-6929
https://www.alberta.ca/private-sewage-codes.aspx

For a list of licensed water well contractors in Alberta.

Alberta Water Well Drilling Association
Phone: 780-386-2335
www.awwda.ca

Resources:

Alberta Environment and Parks

Groundwater Observation Well Network (GOWN)

GOWN is an Alberta Government owned network of groundwater monitoring wells located in various aquifers throughout the province. Most wells are fitted with data loggers and sensors that continuously record groundwater levels. In addition, many of these wells are periodically pumped and sampled for water quality analysis.
https://www.alberta.ca/groundwater-observation-well-network.aspx

Provincial Groundwater Inventory Program (PIGP)

PGIP is a joint partnership program between Alberta Environment and Parks and the Alberta Geological Survey to map and inventory groundwater resources in Alberta.
https://www.alberta.ca/provincial-groundwater-inventory-program.aspx

Alberta Water Well Information Database (AWWID)

AWWID contains approximately 500,000 water well records with nearly 5,000 records added annually. The website provides an interactive mapping tool for access to water well drilling reports, chemical analysis reports (up to the end of 1986), water well decommissioning reports, baseline water well testing reports, flowing shot holes and springs.
http://groundwater.alberta.ca/WaterWells/d/

Alberta Environment Guide to Groundwater Authorization

This guide clarifies the process applicants must follow when applying for a licence to divert and use groundwater.
https://open.alberta.ca/publications/5612701

Alberta Agriculture and Forestry

Visit https://www.alberta.ca/farm-water-resources.aspx for the following publications related to rural water sources, systems, analysis and treatment:

- Alternatives for Iron Removal
- Chemical Analysis Interpretation of Rural Household Farm Water Supplies
- Removing Hydrogen Sulphide Gas from Water
- Reverse Osmosis Water Treatment
- Shock Chlorination and Control of Iron Bacteria
- Water Distillers
- Water Softening
- Drought Proofing Farm Water Supplies
- Water Analysis Interpretation for Livestock
- Farm Water Supply Requirements
- Monitoring Well Construction, Installation and Development
- Choosing a Water Pump
- Deep Well Jet Pumps
- Frost-Free Yard Hydrants
- Pitless Adapters
- Pressure Tanks
- Pump Houses
- Shallow Well Jet Pumps
- Small Water Filters for Taste, Odour and Sediment Removal
- Submersible Pumps
- Dissolved Gases in Water
- Methane Gas in Well Water
- Spring Development
- Quality Farm Dugouts
- Farm Fuel Storage and Handling

Rural Water Quality Information Tool (RWQIT)

This on-line tool assesses the quality and suitability of rural water sources from privately owned and operated water supplies.
https://www.agric.gov.ab.ca/app84/rwqit

Dugout/Lagoon Volume Calculator

This on-line tool allows the user to calculate the volume of a dugout or lagoon.
https://www.agriculture.alberta.ca/app19/calc/volume/dugout.jsp

Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM)

This interactive software is designed to assist farm management decision makers in the selection of optimum fertilizer rates.
https://www1.agric.gov.ab.ca/$department/softdown.nsf/main?openform&type=AFFIRM&page=information

Manure Management Planner (MMP)

This tool enables the user to determine whether their current operation has sufficient crop acreage, land availability, manure storage capacity and application equipment to manage manure in an environmentally responsible manner.
https://www1.agric.gov.ab.ca/$department/softdown.nsf/main?openform&type=MMP&page=information

Other Resources

Working Well Program

The Working Well Program provides private well owners, who are responsible for managing their water supplies, with the information and tools they need to protect and maintain their water wells. The program offers free workshops in communities around the province and a variety of fact sheets, videos and interactive eLearning tools.
https://www.alberta.ca/working-well.aspx

Agriculture and Agri-Food Canada

For general information on aquifers, groundwater quality and water wells.
http://www.agr.gc.ca/eng/science-and-innovation/agricultural-practices/water/wells-and-groundwater/?id=1371245022134

Green Acreages Guide

For information on implementing stewardship practices for acreage owners that conserve and protect water, air, land and wildlife.
http://www.landstewardship.org/green-acreages-guide/

Canadian Water Quality Association

For information on certification of water treatment equipment.
http://www.cwqa.com

Regional Groundwater Assessments

For information on groundwater availability for various municipal districts and counties in Alberta.
https://www.hcl.ca/services/regional-groundwater-assessments

Appendix A

Worksheets

A1

Calculating Average Daily and Annual Water Requirements

All references to volumes or flow rates are in Metric (or Imperial) measurements unless otherwise specified.

The average daily and annual water requirement numbers can be used for estimating the amount of water used on your property. The average daily water requirements are based on typical average outside or in-barn temperatures that occur throughout the year. These numbers, however, cannot be used for designing the water supplies and pumping capacity of a farm water system. For example, consider a beef feedlot on a hot summer day. Feeder cattle will drink approximately twice the amounts shown in the table below. For this reason, the water supply and pumping systems need to be designed to meet peak demands.

Total Daily Water Requirements:						
Household use:		**No. of People**		**Volume per day per person (gpd)**		**Volume per day (gpd)**
People			x	60.0	=	
Beef:	**Animal Size**	**No. of Animals**		**Volume per day per animal (gpd)**		**Volume per day (gpd)**
Feeders[1]	550 lbs		x	4.0	=	
	900 lbs		x	7.0	=	
	1250 lbs		x	10.0	=	
Cows with calves[2]	1300 lbs		x	12.0	=	
Dry Cows[2]	1300 lbs		x	10.0	=	
Calves[2]	250 lbs		x	2.0	=	
				Beef Sub Total	=	
Swine:	**Animal Size**	**No. of Animals**		**Volume per day (gpd)**		**Volume per day (gpd)**
Farrow-Finish[4]			x	20.0	=	
Farrow-Light Wean[4]	50 lbs		x	6.5	=	
Farrow-Early Wean[4]	15 lbs		x	5.5	=	
Feeder	50-250 lbs		x	1.5	=	
Weaner	15-50 lbs		x	0.5	=	
				Swine Sub Total	=	
Dairy:	**Animal Size**	**No. of Animals**		**Volume per day per animal (gpd)**		**Volume per day (gpd)**
Milking Cow[5]			x	30.0	=	
Dry Cows/Replacement Heifers			x	10.0	=	
Calves	550 lbs		x	3.0	=	
				Dairy Sub Total	=	

Poultry:	No. of Birds[6]		Volume per day per animal (gpd)		Volume per day (gpd)
Broilers		x	0.035	=	
Roasters/Pullets		x	0.040	=	
Layers		x	0.055	=	
Breeders		x	0.070	=	
Turkey Growers		x	0.130	=	
Turkey Heavies		x	0.160	=	
			Poultry Sub Total	=	
Sheep/Goats:	**No. of Animals**		**Volume per day per animal (gpd)**		**Volume per day (gpd)**
Ewes/Does		x	2.0	=	
Milking Ewes/Does		x	3.0	=	
			Sheep/Goats Sub Total	=	
Other:	**No. of Animals**		**Volume per day per animal (gpd)**		**Volume per day (gpd)**
Horses, Bison, Mules		x	10.0	=	
Elk, Donkeys		x	5.0	=	
Deer, Llamas, Alpacas		x	2.0		
Ostrich		x	1.0	=	
			Other Sub Total	=	
			Total Daily Household and Livestock Water Requirements	=	

[1] For peak demand on hot summer days above 25°C, multiply by 2. Assuming on silage.
[2] For peak demand on hot summer days above 25°C, multiply by 1.5. Assuming on pasture or hay.
[3] Includes wash water for all types of swine operations.
[4] No. of animals = No. of breeding sows.
[5] Includes 3 gpd/cow for wash water.
[6] No. of Birds = No. of Birds per cycle x No. of cycles.

Total Annual Water Requirements:

				Volume per year (gal)
Irrigation of garden and yard[7]			=	
Chemical Spraying[8]			=	
Greenhouse			=	
Fire[9]			=	
Other uses			=	
Total Daily Livestock Water Requirements (from above)	x	365 days	=	
		Total Annual Water Requirements	=	

[7] Volume per year = Area in ft^2 x 3 gal/ft^2. Assume 15 cm (6 in.) application.
[8] Volume per year = No. of acres x Gal per acre x No. of applications.
[9] Min. 1200 gal/2 hour period.

Note: These livestock and poultry water requirement numbers have been compiled with input from Alberta Agriculture and Forestry staff. If you have questions or comments, please call an Agricultural Water Specialist at 310-FARM (3267).

A2

Sizing of Water Systems

All references to flow rates are Imperial measurements.

Be aware, most manufacturers calibrate their devices to produce in US gallons per minute. Verify this before you make your calculations.

Sizing of Water Systems

Water System Fixtures	No. of fixtures (or households)		Peak Use Rate per fixture (gpm)		Total Peak Use Rate (gpm)
Automatic livestock waterers		x	2	=	
Hog nipple waterers		X	1	=	
Poultry fountains		X	1	=	
Yard hydrants		X	5	=	
Households		X	5-10	=	
Fire hydrants		X	10	=	
Others		x		=	

Note: The minimum design flow rate of the system must exceed the peak use rate of the fixture that uses the largest amount of water.

Note: If the well is not solely capable of providing enough water for your peak use demand, you will need to install additional water storage. The well can be operated without over-pumping and the added water storage provided will ensure water for all your activities during peak demands.

A3

Farm Water Supply Inventory

All references to volumes or flow rates are in Imperial measurements.

Wells							
Purpose/Location	In Use? (Y or N)	Well ID (if known)	Date Constructed	Depth (ft)	Casing Diameter (in.)	Production Rate (gpm)	Comments/Concerns (Water quality, dry holes, gas in water, flowing artesian, etc.)
Eg. House well	Y	2096782	23/01/2013	97 ft	5.63 in.	6 gpm	Soft water
A.							
B.							
C.							
D.							

Dugouts					
Purpose/Location	Date Constructed	Size (L x W x D)	Slopes (run:rise)	Volume[1] (gal)	Comments/Concerns (Seepage, quality, inadequate runoff, etc.)
Eg. West dugout	21/08/1998	140'x60'x16'	4:1 ends, 1.5:1 sides	325,000 gal	Fills every spring
A.					
B.					
C.					
D.					

Other Sources	
Purpose/Location	Volume supplied, Limitations, Concerns
Eg. Spring	3 gpm flow rate, Summer use only, difficult access
A.	
B.	
C.	
D.	

[1]To determine the size of a dugout, see Alberta Agriculture and Forestry's "Dugout/Lagoon Volume Calculator", Chapter 11, Contacts and Other Resources.

Appendix B

Templates

B1

Water Well Drilling Agreement

Use this template to assist you in creating a water well drilling agreement with your licensed water well drilling contractor. Recognize that some drillers may have their own version of an agreement.

Water Well Drilling Agreement

IDENTIFICATION								
Well Owner Name:								
Address:								
Location	¼ or LSD	SEC:	TWP:	RGE:	W of MER:	Lot:	Block:	Plan:
Latitude: **Longitude**: in Decimal Degrees (GPS unit must be +/- 5-10m accuracy)						Additional Descriptor:		
Proposed Start Date: YYYY MM DD						**Proposed Complete Date:** YYYY MM DD		

WATER REQUIREMENTS	
Proposed Well Use: ❑ Household ❑ Stock ❑ Irrigation ❑ Commercial	
Desired Water Quality On-Site Test Results: ❑ TDS parts/million ❑ Iron parts/million ❑ Hardness parts/million ❑ pH parts/million	
Desired Yield: L/s (igpm)	**Minimal Acceptable Yield:** L/s (igpm)
Groundwater supply options based on existing records:	
WELL CONSTRUCTION	
Maximum desired depth m (ft)	Type of drilling
Diameter of hole	Flowing well control
Well connection: ❑ Pitless adapter ❑ Other: (Describe)	Formation logging: ❑ Lithology ❑ E-logging
Annular or casing seal	Artificial sand pack
Well development method: ❑ Backwashing ❑ Jetting ❑ Surging ❑ Heavy pumping ❑ Bailing	

MATERIALS			
Surface casing material		Inside diameter mm (in.)	Wall thickness
Casing stick-up from ground surface cm (in.)		Type of well cap	
Liner casing material		Inside diameter mm (in.)	Wall thickness
Screen material	Manufacturer	Length	Nominal diameter
YIELD TESTING			
Yield testing duration (hours)		Pump type	Size

DISINFECTION	
Disinfection	Well head finishing
COSTS	
Test holes per metre (foot)	Sand pack
Reaming per metre (foot)	Development
Drilling/Boring per metre (foot)	Labour per hour
Casing per metre (foot)	Water testing
Liner per metre (foot)	Decommissioning of unused well
Screen	Perforated casing
TOTAL	
Total Costs:	**Payment Schedule:**
GUARANTEE	

(January 2019)

B2

Water Well Decommissioning (Reclamation) Report

Use this report to record the details of the decommissioning of your water well.

Mail a copy of the report to:

Groundwater Information Centre
Alberta Environment and Parks
11th floor, 9820 106 Street
Edmonton, AB
T5K 2J6

Alberta Government

Water Well Decommissioning (Reclamation) Report

The Province disclaims responsibility for the accuracy of information provided in this report. The information on this report will be retained in a public database.

SUBMIT ONE REPORT PER WELL

Date Report Received: YYYY MM DD

WELL IDENTIFICATION AND LOCATION

Current Landowner Name:	**Address:**	**Town:**	**Postal Code:**

Location:	¼ or LSD	SEC:	TWP:	RGE:	W of MER:	Lot:	Block:	Plan:

Latitude: **Longitude:** in Decimal Degrees (GPS unit must be +/- 5-10m accuracy)

Additional Descriptor:

WELL DECOMMISSIONING DETAILS

Drilling report available?
- ❑ **YES** **GIC WELL ID:** ___________________
- ❑ **NO**

GoA Well Tag attached to casing?
- ❑ **YES** **GOA WELL TAG NO:** _____________
- ❑ **NO**

DATE WORK COMPLETED: YYYY MM DD

CURRENT WELL DEPTH (BGL): ❑ M ❑ Ft

CURRENT STATIC WATER LEVEL (BGL): ❑ M ❑ Ft

REASON FOR WELL DECOMMISSIONING:
- ❑ Structural failure
- ❑ Abandoned/Not being maintained
- ❑ Inadequate water quality
- ❑ Inadequate water quantity
- ❑ Municipal supply available
- ❑ No longer needed
- ❑ OTHER: (Describe)

CASING REMOVAL LOG: (to the best of your knowledge)

From	To	Diameter ❑ cm ❑ in	Screen	Liner Casing	Surface Casing	STATUS (Check one per line)
	❑ M ❑ Ft		❑	❑	❑	❑ Removed ❑ Perforated ❑ Left in place
	❑ M ❑ Ft		❑	❑	❑	❑ Removed ❑ Perforated ❑ Left in place
	❑ M ❑ Ft		❑	❑	❑	❑ Removed ❑ Perforated ❑ Left in place

❑ Well disinfected prior to decommissioning

Pump removed:
❑ YES ❑ NO (provide explanation):

Casing cut off below ground level:
❑ YES __________ ❑ M ❑ Ft
❑ NO (provide explanation):

FILL MATERIAL LOG:

Report depths as below ground level (BGL)		Material Options:								Placement Method		Unit Options:						
Depth From:	To:	Bentonite Slurry	Bentonite Chips	Bentonite Granular	Bentonite Pellets	Bentonite Tablets	Cement/Bentonite Slurry	Cement Slurry	Clean Clay	Poured	Pumped	Amount:	Bags	Gallons	Kilograms	Pounds	Tonnes	Yards
	❑ M ❑ Ft																	
	❑ M ❑ Ft																	
	❑ M ❑ Ft																	

Additional Comments on Decommissioning:

VALIDATION OF INFORMATION

❑ *I certify that the well described herein has been decommissioned (reclaimed) in accordance with the Water (Ministerial) Regulation of the Water Act.*

Decommissioned by Landowner ❑ YES ❑ NO

Name of Person Responsible for Decommissioning: Certification No. (if applicable):

Company Name: (if applicable):

❑ Copy of Water Well Decommissioning Report given to owner

(October 2018)

Appendix C

Log Sheets

Water Level Measurements Log Sheet

Use this log sheet to record your monthly or quarterly water level measurements. Keep track of whether the water level measurement is a non-pumping (static) water level or a pumping water level. Be consistent when you take water level measurements to ensure you have reliable, comparable data. Use a separate log sheet for each well on your property.

Well Name (Well ID):

Date Month / Day / Year	Time am / pm	Non-pumping (Static) Water Level	Pumping Water Level	Comment

Water Testing Log Sheet

Use this log sheet to track your water testing history. Use a separate log sheet for each well on your property.

Well Name (Well ID):

Date Month / Day / Year	Parameters of Concern (Microbial, Chemical)	Results (e.g. Normal)	Recommended Treatment (e.g. Shock Chlorination)

Water Well Maintenance Log Sheet

Use this log sheet to track history of well maintenance. Use a separate log sheet for each well on your property.

Well Name (Well ID):

Date Month / Day / Year	Time	Water Level Metres / Feet Non-pumping	Water Level Metres / Feet Pumping	Comments Quality (colour, taste, odour), presence of sediment, yield problems, etc.	Recommended Treatment (e.g. Shock Chlorination, repairs, etc.)

Appendix D

Procedures

D1

Chlorination Procedure for Drilled Wells

All references to volumes or flow rates are in Metric (or Imperial) measurements unless otherwise specified.

Chlorine can be corrosive to submersible pump motors, metal casings and piping. Do not put chlorine into your well unless it is mixed in solution with water. Do not exceed the recommended chlorine concentrations, and use extreme caution when chlorinating older wells and distribution systems or wells that have not received regular preventative maintenance.

A modified procedure is available for large diameter wells.

> ***Do not over-pump your well.*** *If the well is low-yielding or tends to pump sediment, be extremely careful using this chlorination procedure. Over-pumping may damage the well. When pumping out the chlorine solution, monitor the water discharge for sediment and if any appears, reduce the pumping rate.*

Step 1

Store sufficient water to meet farm and family needs for 8 to 48 hours.

Step 2

Calculate the feet of water in your well by subtracting the non-pumping water level from the total well depth.

Total well depth (ft) – *Non-pumping water level (ft)* = *Feet of water in your well (ft)*

Step 3

Use Table 1 to calculate the amount of water you'll need (based on casing diameter). Pump the required amount of water into clean storage. A clean tank used only for storing potable or chlorinated water should be used. The required amount of water to use is twice the volume of water present in the well casing.

Feet of water in your well (from Step 2) x *Water needed per foot (Table 1) (gal or L)* = *Volume of water from procedure (gal or L)*

Large cisterns should be bypassed and treated separately. If the water must travel through a long or large diameter pipeline, or large pressure tanks, and extra volume of chlorinated solution should be used. Consult with a licensed water well contractor or a Water Specialist with Alberta Agriculture and Forestry (see Chapter 11, Contacts and Other Resources).

Step 4

Use Table 1 to calculate the amount of chlorine you'll need (based on casing diameter). Add chlorine to the water in the storage tank. Use only the right amount. More is not better and might corrode your equipment.

[ ]	x	[ ]	=	[ ]
Feet of water in your well (from Step 2)		*Chlorine needed per foot (Table 1) (L)*		*Volume of chlorine for procedure (L)*

Table 1. Amount of Chlorine Required for a Chlorine Concentration of 200mg/L (ppm)

Casing Diameter		Volume of Water Needed		5 ¼% Domestic Chlorine Bleach [1]	12% Industrial Sodium Hypochlorite	70% High Test Hypochlorite [2]
		Water needed per 30 cm (1 ft) of water in the casing		L needed per 30 cm (1 ft) of water	L needed per 30 cm (1 ft) of water	Dry weight[2] per 30 cm (1ft) of water
(in.)	(mm)	(gal)	(L)	(L)	(L)	(g)
4	100	1.1	5.0	.019	.008	1.44
6	150	2.4	10.9	.042	.018	3.12
8	200	4.2	19.1	.072	.032	5.46
24	600 [3]	extra 200 gal	extra 1000 L	.340	.148	25.40
36	900 [3]	extra 200 gal	extra 1000 L	.46	.34	57.20

[1] Domestic chlorine bleach should not have additives or perfumes

[2] Since a dry chemical is being used, it should be mixed with water to form a chlorine solution before placing it in the well

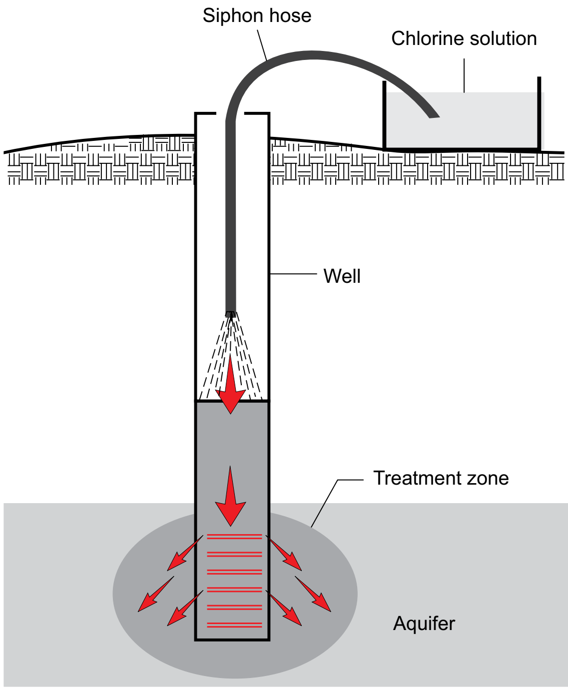
[3] See Chlorination Procedure for Large Diameter Wells

Sodium Hypochlorite (5-1/4% and 12%) has a shelf life. Purchase new stock and check the expiry date. Only purchase as much as you'll need for the procedure.

Step 5

Siphon the chlorine solution into your well using a clean garden hose (see diagram below).

Figure D-1 Siphoning Chlorine Solution



Step 6

Open all hydrants and faucets, including washing machines, dishwashers and taps. Flush all toilets and re-fill the hot water tank. Run water until you can smell chlorine at each outlet, or until there is a slippery feel to the water.

Step 7

Shut off the taps and leave the chlorine solution in the well and distribution system for 8 to 48 hours. The longer the contact time the better the results.

Step 8

To avoid damaging your septic system, open an outside faucet and run water until the chlorine smell disappears. Make sure to direct the water away from sensitive plants or landscaping.

Step 9

Run hot and cold taps inside the house to flush the hot water tank and distribution system. The trace of chlorine remaining in the system will not harm your septic tank.

Step 10

Backwash and regenerate any water treatment equipment according to supplier recommendations.

Dangerous vapours can accumulate in well pits, pump houses and crawl spaces making the chlorination procedure hazardous. Consider hiring a licensed water well contractor who has the right equipment and experience to do the job safely.

D2

Chlorination Procedure for Large Diameter Wells

All references to volumes or flow rates are in Metric (or Imperial) measurements unless otherwise specified.

The chlorination procedure is modified for large diameter wells due to the large volume of water with the casing. The more practical way to chlorinate is to mix the recommended amount of chlorine right in the well casing. An extra volume of chlorinated water is used to force some of the chlorine solution into the formation surrounding the well.

Do not over-pump your well. *If the well is low-yielding or tends to pump sediment, be extremely careful using this chlorination procedure. Over-pumping may damage the well. When pumping out the chlorine solution, monitor the water discharge for sediment and if any appears, reduce the pumping rate.*

Step 1

Store sufficient water to meet farm and family needs for 8 to 48 hours.

Step 2

Pump 1,000 L (200 gal) of water into a clean storage tank at the well head. A clean tank used only for storing potable or chlorinated water should be used. Mix 4.0 L of 5-1/4% domestic chlorine bleach that does not have additives or perfumes (or 1.5 L of 12% bleach or 0.26 kg of 70% calcium hypochlorite) into the 1,000 L (200 gal) of stored water. This mixture will be used later in Step 5.

Step 3

Calculate the feet of water in your well by subtracting the non-pumping water level from the total well depth.

	–		=	
Total well depth (ft)		*Non-pumping water level (ft)*		*Feet of water in your well (ft)*

Step 4

Use Table 1 to calculate the amount of chlorine you require per foot of water in the casing and add directly into the well. (Note that the 70% calcium hypochlorite should be completely dissolved in a small container of water to form a solution before placing in the well).

	x		=	
Feet of water in your well (from Step 3)		*Chlorine needed per foot (Table 1) (L)*		*Volume of chlorine for procedure (L)*

Table 1. Amount of Chlorine Required for a Chlorine Concentration of 200mg/L (ppm)

Casing Diameter		**Volume of Water Needed**		**5 ¼% Domestic Chlorine Bleach [1]**	**12% Industrial Sodium Hypochlorite**	**70% High Test Hypochlorite [2]**
		Water needed per 30 cm (1 ft) of water in the casing		L needed per 30 cm (1 ft) of water	L needed per 30 cm (1 ft) of water	Dry weight[2] per 30 cm (1ft) of water
(in.)	(mm)	(gal)	(L)	(L)	(L)	(g)
4	100	1.1	5.0	.019	.008	1.44
6	150	2.4	10.9	.042	.018	3.12
8	200	4.2	19.1	.072	.032	5.46
24	600 [3]	extra 200 gal	extra 1000 L	.340	.148	25.40
36	900 [3]	extra 200 gal	extra 1000 L	.46	.34	57.20

[1] Domestic chlorine bleach should not have additives or perfumes

[2] Since a dry chemical is being used, it should be mixed with water to form a chlorine solution before placing it in the well

[3] See Chlorination Procedure for Large Diameter Wells

Sodium Hypochlorite (5-1/4% and 12%) has a shelf life. Purchase new stock and check the expiry date. Only purchase as much as you'll need for the procedure.

Step 5

Circulate the chlorinated water in the well by hooking a clean garden house up to an outside faucet and placing the other end back down the well. This circulates the chlorinated water through the pressure system and back down the well. Continue for at least 15 minutes.

Step 6

Siphon or drain the 1,000 L (200 gal) bleach and water solution prepared in Steps 2 and 3 slowly into the well.

Step 7

Open all hydrants and faucets, including washing machines, dishwashers and taps. Flush all toilets and re-fill the hot water tank. Run water until you can smell chlorine at each outlet, or until there is a slippery feel to the water.

Caution: *Due to the large volume of water within a bored well, it may take significant time (days) to flush the chlorine from the well. Also, the water needs to be disposed of in an appropriate manner to avoid problems with flooding (or freezing in winter) or damage to the environment.*

Step 8

Shut off the taps and leave the chlorine solution in the well and distribution system for 8 to 48 hours. The longer the contact time the better the results.

Step 9

To avoid damaging your septic system, open an outside faucet and run water until the chlorine smell disappears. Make sure to direct the water away from sensitive plants or landscaping.

Step 10

Run hot and cold taps inside the house to flush the hot water tank and distribution system. The trace of chlorine remaining in the system will not harm your septic tank.

Step 11

Backwash and regenerate any water treatment equipment according to supplier recommendations.

Dangerous vapours can accumulate in well pits, pump houses and crawl spaces making the chlorination procedure hazardous. Consider hiring a licensed water well contractor who has the right equipment and experience to do the job safely.

D3

Procedure for Water Well Decommissioning (Reclamation)

All references to volumes are in Metric (or Imperial) measurements unless otherwise specified.

Abandoned water wells can be a serious safety hazard and threat to groundwater resources. Decommissioning these wells reduces the landowner's environmental liability and risk.

Decommissioning a well can be a complicated procedure. Landowners are strongly advised to contact a licensed water well drilling contractor to decommission their wells because they have the expertise and equipment to do a proper job.

Step 1

Clean out debris or remnants of pumping equipment.

Step 2

Measure the dimensions of the well (diameter, total depth and depth to the non-pumping (static) water level). Compare these figures with the information on the original drilling report. Confirm whether the well is open to its original depth. If it is not, consult with a licensed water well drilling contractor before proceeding.

Step 3

Decide which plugging material is appropriate. A licensed water well drilling contractor can help you decide; fill material must be impervious to prevent movement of water. Use Table 1 to calculate how much fill material will be required.

Table 1. Volume Calculation for Well Decommissioning

Volume Calculation for Well Decommissioning					
Casing Diameter		Volume per metre casing	Volume per foot casing	Volume per foot casing	Volume per foot casing
(in.)	(mm)	(L)	(gal)	Cubic feet	Cubic yards
4	100	8.1	0.544	0.87	0.0032
5	127	12.7	0.851	0.136	0.0050
6	150	18.2	1.225	0.196	0.0073
7	178	24.8	1.667	0.267	0.0099
8	200	32.4	2.178	0.348	0.0129
24	600	291.9	19.600	3.136	0.1161
30	762	456.0	30.625	4.900	0.1815
36	900	656.7	44.099	7.056	0.2613

Step 4

Disinfect any standing water in the well. Add enough chlorine to bring the water to a chlorine concentration of 200 mg/L (ppm). For every 450 L (100 gal) of water in the well, add 2 L (0.4 gal) of household bleach (5.25% chlorine). Table 1, Volume Calculation for Well Decommissioning can also be used to determine the volume of standing water in the well, based on the non-pumping (static) water level measurement.

Step 5

If possible, remove the well casing.

Step 6

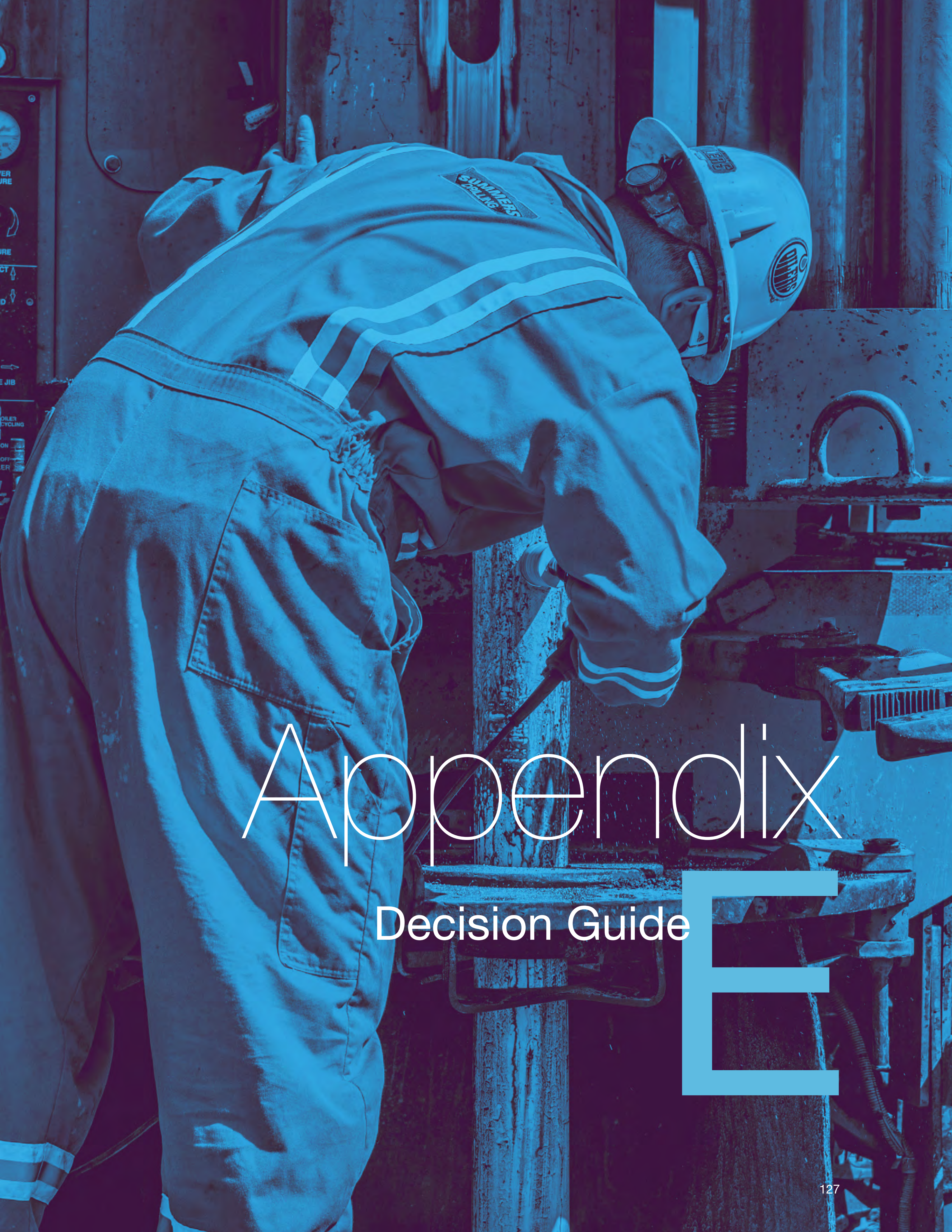
Place the fill material in the well so the well gets filled full length with no bridging or gaps. Slurry bentonite or cement must be introduced at the bottom of the well using a tremie pipe and placed progressively upwards to ground surface. Non-slurry bentonite (chips or pellets) is manufactured for pouring into the well from ground surface. Clean, uncontaminated clay used to plug a large diameter well should be placed into the well from surface with care taken to ensure complete filling of the well.

Step 7

If the casing is not removed, dig around it and cut it off a minimum of 0.5 m (20 in) below the ground surface. Backfill and mound to ground surface with material appropriate for the intended use of the land (e.g. clean, uncontaminated clay).

Step 8

Use the template found in Appendix B-2, Water Well Decommissioning (Reclamation) Report to record the details of your well decommissioning. Send a copy of this report to Alberta Environment and Parks.



Appendix E

Decision Guide

E1

Troubleshooting Water Well Problems

Use this guide to assist in determining the cause of your well problem. Be aware that often a well problem can be the result of a combination of causes and therefore correction may also need to be a combination of actions.

Well Problem	What causes the problem:	Signs to look for:	What accelerates the problem:	What you can do about it:
REDUCED YIELD	Pumping equipment issues	Low pump production but no change in SWL	Leak in system; Worn pump impellers	Check pump and pressure system; Replace non-working parts
REDUCED YIELD	Biofouling	Change in water colour, odour (rotten egg) or taste; Slime build-up in toilet tank, water storage tank or livestock waterers	Lack of well maintenance	Routine disinfection (shock chlorination) to keep bacteria in check
REDUCED YIELD	Mineral incrustation	Scale build-up on plumbing fixtures; Calculate the Ryznar Stability Index* to determine the water's incrusting (scaling) potential	Over-pumping; Groundwater quality with high levels of calcium and magnesium (i.e. hard water)	Inspect pump for scale build-up; Hire driller to conduct down-hole camera video inspection to confirm incrustation and conduct mechanical and/or chemical rehabilitation treatment
REDUCED YIELD	Sediment plugging	Sediment in water followed by decline in well yield	Over-pumping of well; Poor well design	Hire driller to redevelop the well
REDUCED YIELD	Structural failure (collapse or compromise of well casing)	Sediment in water; Current depth of well is less than original record	Age of well; Casing type; Physical damage to well; Groundwater quality	Hire driller to recondition well; If repair is not economical, have well decommissioned and drill a replacement well
REDUCED YIELD	Neighbouring well interference	Significant drop in Pumping water levels; possible decline in static water level over time	Over-allocation and use of groundwater in the area	Reduce pumping rate; Consider discussion with neighbouring groundwater users to establish conservation practices
REDUCED YIELD	Aquifer depletion	Static water level decline over time	Drought; Climate change; Over-allocation and use of groundwater in the area	Reduce water use; Install additional storage to meet peak water demands; Drill a deeper well

CHANGE IN WATER QUALITY	Biofouling	Change in water colour, odour (rotten egg) or taste; Slime build-up in toilet tank, water storage tank or livestock waterers	Lack of well maintenance	Routine disinfection (shock chlorination) to keep bacteria in check
	Structural failure (corrosion)	Change in water quality, coupled with sudden appearance of sediment in water	Over-pumping; Groundwater quality with high levels of calcium and magnesium (i.e. hard water)	Hire driller to recondition well; If repair is not possible or economical, have well decommissioned and drill a replacement well
	Structural failure (failure of annular seal)	Sudden appearance of sediment in water; May notice change in water quality	Over-pumping; Improper well design and construction	Hire driller to re-establish seal; If repair not possible or economical, have well decommissioned and drill a replacement well
	Contamination sources	Change in water colour, odour or taste; Water quality test results indicate possible contamination	Improper well design and construction; Not maintaining appropriate setbacks between well and contamination sources	Identify and remove contamination source(s); Monitor changes through routine water quality testing; Hire driller to clean and disinfect well

Well Problem	What causes the problem:	Signs to look for:	What accelerates the problem:	What you can do about it:
GAS IN WATER	Biofouling	Spurting water taps; Milky colour to water that settles out after a few seconds; Change in water colour, odour (rotten egg) or taste; Slime build-up in toilet tank, water storage tank or livestock waterers	Lack of well maintenance	Routine disinfection (shock chlorination) to keep bacteria in check
	Over-pumping	Spurting water taps; Milky colour to water that settles out after a few seconds; Gas-locking pump; May notice sediment in water	Aquifers with potential to produce gas (e.g. coal seams)	Hire driller to assess; Ensure current pumping rate does not exceed recommended pumping rate on drilling report; Install a flow restrictor on the pump to reduce pumping rate if necessary; Install additional storage to meet peak water requirements if well yield is not sufficient
	Natural dissolved gases in water (e.g. methane, hydrogen sulphide)	Spurting water taps; Milky colour to water that settles out after a few seconds; Gas-locking pump; Rotten-egg odour (if hydrogen sulphide is present; methane is odourless); In extreme cases pumphouse explosion	Over-pumping wells completed in aquifers with dissolved gases	Hire driller to assess; Avoid over-pumping (see above) For low concentrations of gas: • install an air volume release valve on the pressure tank if tank does not have an air bladder and ensure the tank is properly vented to open atmosphere • spray water from the well into a sealed storage tank that is properly vented to open atmosphere and use a secondary pump to distribute degassed water For high concentrations of gas: • determine depth gas is likely entering the well and, if possible, lower the pump intake to below that depth • install a gas sleeve over the pump intake to force the gas out of the water as it enters the intake and vent the well head to open atmosphere Caution: Water wells located inside pump houses or pits pose high risk to human safety.

SEDIMENT IN WATER	Structural failure (improper well design and construction)	Sediment in water shortly after well completion; Well yield does not improve with continued pumping	Improper pump sizing and placement; Over-pumping	Contact driller to return to assess and repair (correct pump size and placement, screen or perforation selection, filter pack)
SEDIMENT IN WATER	Improper well design and construction (poor well development)	Sediment in water shortly after well completion; Well yield may improve with continued pumping		Contact driller to return and redevelop well
SEDIMENT IN WATER	Over-pumping	Sediment in water		Hire driller to assess: Ensure current pumping rate does not exceed recommended pumping rate on drilling report; Install a flow restrictor on the pump to reduce pumping rate if necessary; Install additional storage to meet peak water requirements if well yield is not sufficient
SEDIMENT IN WATER	Structural failure (corrosion)	Change in water quality, coupled with sudden appearance of sediment in water	Over-pumping; Improper well design and construction	Hire driller to recondition well; If repair is not possible or economical, have well decommissioned and drill a replacement well
SEDIMENT IN WATER	Borehole stability problems (failure of annular seal)	Sudden appearance of sediment in water; may notice change in water quality	Over-pumping; Improper well design and construction	Hire driller to re-establish seal; If repair not possible or economical, have well decommissioned and drill a replacement well
BREATHING WELL PHENOMENON (SUCKER AND BLOWER WELLS)	Improper well design and construction (top of the well's intake portion (perforations) is above the static water level, exposing unsaturated, porous formation)	Freezing pitless adapter; people who enter enclosed spaces containing a well (i.e. pumphouse or well pit) may experience light-headedness, loss of consciousness, or in extreme cases, asphyxiation	Changing barometric pressure; Over-pumping resulting in dropping static water level	Hire driller to asses; If well is located in a pump house, vent to open atmosphere; If well is located in well pit install pitless adapter and remove pit; If well is located outside, use heat tape to avoid freezing of pitless adapter; Avoid over-pumping to keep water level above top of perforations; If problem persists, have well decommissioned and drill a replacement well Caution: Water wells located inside pump houses or pits pose high risk to human safety.

E2

Water Treatment Options

Use this chart to determine the type of water treatment equipment that would best remove your parameter(s) of concern.

Parameter of Concern to Remove	Point of Entry (Large, whole house treatment system)	Point of Use (Small, single tap system)
Bacteria (coliform, E. coli, enterococcus)	Disinfection	Ultraviolet (UV) Distillation
Nuisance bacteria (IRBs, SRBs)	Synthetic fiber micro-filter Disinfection	
Protozoa (Giardia, Cryptosporidium)	Synthetic fiber micro-filter	Distillation Ultraviolet (UV)
Hardness (calcium, magnesium)	Ion-exchange (water softener)	
Iron	Ion-exchange (water softener) – will remove up to 3.0 mg/L (ppm) iron Filtration (manganese greensand/iron filter) – will remove up to 6 mg/L (ppm) iron Aeration – with Filtration (sediment filter) Air injection – with Filtration (sediment filter) Disinfection – with Filtration (sediment filter)	
Sodium		Reverse Osmosis (RO) Distillation
Fluoride		Reverse Osmosis (RO) Distillation
Nitrate		Reverse Osmosis (RO) Distillation
Trace metals (manganese, arsenic, lead)		Reverse Osmosis (RO) Distillation
Chemicals (pesticides, petroleum products)		Reverse Osmosis (RO) Distillation
Taste, odour (chlorine, earthy smell) and colour		Filtration (activated carbon)
Turbidity, sediment		Filtration (sediment filter)
Gas (methane, hydrogen sulphide)	Aeration