BEST MANAGEMENT PRACTICES

Water Wells

REVISED EDITION, 2003

Agriculture and Agri-Food Canada

Ontario

What is a Best Management Practice (BMP)?

- a practical, affordable approach to conserving soil, water and other natural resources in rural areas
- an applied technology to enhance farm production without sacrificing soil and water resources

Who decides what qualifies as a BMP?

- a team of farmers, researchers, natural resource managers, extension staff and agribusiness professionals

What is the BMP Series?

- innovative, award-winning, full-colour books from 36 to 150 pages
- each book presents a range of circumstances and options to address a particular environmental concern – use the information to assess what's appropriate for your property
- the titles are:

Buffer Strips (2003)
Farm Forestry and Habitat Management
Field Crop Production
Fish and Wildlife Habitat Management
Horticultural Crops
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Irrigation Management
Livestock and Poultry Waste Management
No-Till: Making It Work
Nutrient Management
Nutrient Management Planning
Pesticide Storage, Handling and Application
Soil Management
Water Management
Water Wells

How do I obtain a BMP book?

- if you're an Ontario farmer, single copies of each title are available at no cost at your local Ontario Ministry of Agriculture and Food office – some titles may also be available at select Conservation Authorities and district offices of the Ontario Ministry of Natural Resources
- if you're an Ontario resident, single copies of the BMP *Water Wells* book are available at no cost from your local public health unit, and local offices of the Ontario Ministry of the Environment, Ontario Ministry of Agriculture and Food, and conservation authorities
- to purchase single copies or bulk orders of all other BMP titles, and to order complete sets of BMP books and related materials, contact: Ontario Federation of Agriculture, Attn: Manager, BMP, 40 Eglinton Ave. E., 5th flr., Toronto, Ontario, M4P 3B1. Phone: 416 485-3333.

For an order form, go to http://www.gov.on.ca/OMAFRA/english/products/best.html

Prices vary per title and with quantity ordered.

Table of Contents

A word about measurement...

In this book, most metric units are presented with approximate imperial equivalents immediately following in parentheses. Occasionally, where common usage or common sense dictates, only one of metric and imperial appears.

INTRODUCTION

GROUNDWATER: YOUR HEALTH AND YOUR BUSINESS

Think about the importance of having enough clean water. Your family's health depends on it, and so does your rural-based business. Every living thing – humans, plants and animals – needs water to survive. Good well stewardship goes a long way toward ensuring safe and reliable water supplies for you, your neighbours and future generations.

In eastern North America, rural residents and farming operations rely primarily on groundwater to meet their needs. In many areas, groundwater is the only water source.

Groundwater accumulates from precipitation (rain, snow or sleet) and is stored beneath the surface of the earth. It fills cracks, pores and crevices of underground materials.

The alternative is surface water, which is stored on the earth's surface in oceans, lakes, ponds, rivers, streams, ditches, ice-caps and wetlands.

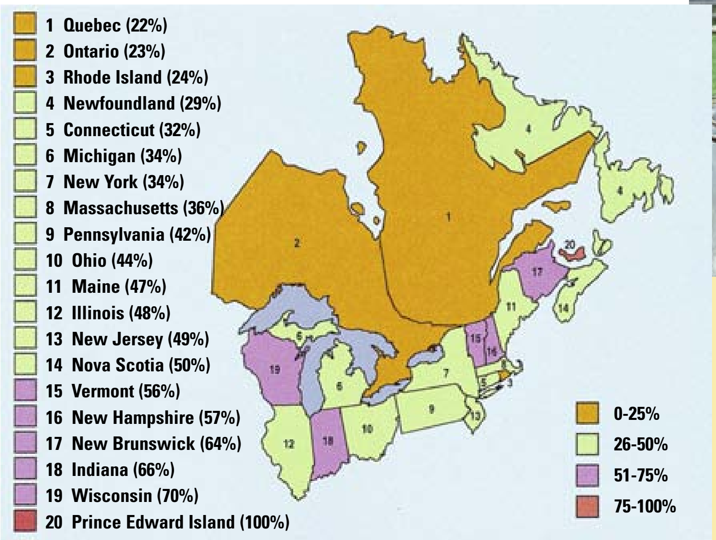
As a water source, groundwater is preferred. It requires minimum treatment, the need for costly pipelines is eliminated, temperature and quality are usually uniform, and when properly managed, the supply is dependable.

No one "owns" groundwater: it's a shared resource that we all enjoy and have a duty to protect.

The average Canadian uses 350 litres (80 gal.) of household water every day.

IS THERE ANY GOOD GROUNDWATER LEFT?

Groundwater is a renewable resource. In eastern North America, we have an abundant supply of good groundwater. Rainfall and melting snow replenish the water we draw from wells. The earth stores and protects an immense underground supply of groundwater.

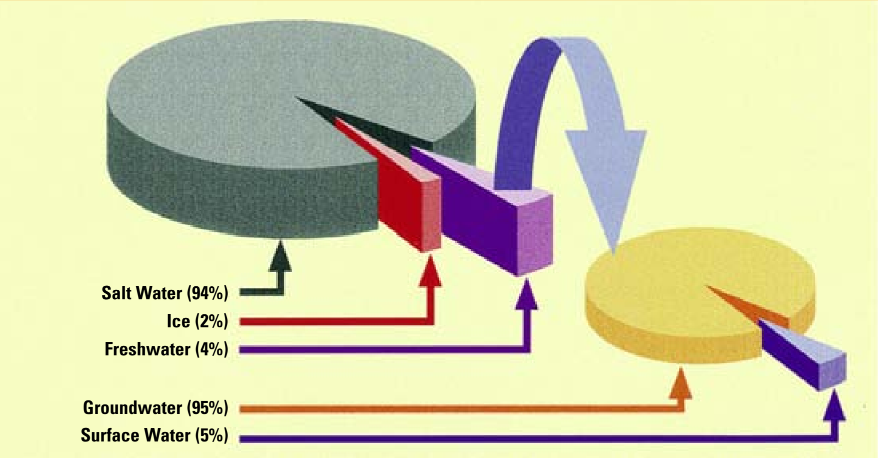


This shows the percentage of water use from groundwater sources in eastern North America.

Farming operations need a fresh, daily, dependable supply of drinking water for many purposes.

INTRODUCTION

GROUNDWATER: A FRESHWATER RESOURCE



About 94 percent of all the water on Earth is salt water in oceans and seas, two percent is frozen in glaciers, and four percent is fresh water – mostly groundwater.

Groundwater makes up about 95 percent of usable freshwater. The remaining five percent is in lakes, rivers, and wetlands.

OLD WELLS AND NEW WELLS

Early farm water supplies were drawn from streams, springs and hand-dug wells. Since then, the needs of rural businesses and residents, and the well technology to meet those needs, have evolved. Our awareness of the importance of clean groundwater has also grown. Regulations that govern the construction, maintenance and abandonment of wells have been put in place to protect water resources.

Like machines, well components wear out and sometimes have to be repaired or replaced. By looking after your well, you protect your investment and the reliability of your water supply. Currently, Regulation 903 of the Water Resources Act governs private water systems in Ontario.

Components such as pumps, screens, casings and caps wear out, and well production can drop. Well systems require routine inspection and maintenance to stay at peak production.

INTRODUCTION

WHAT'S IN THIS BOOK

You'll find practical information and advice on your well and the water supply it taps, including:

- where groundwater is found and how it moves
- what you should know about groundwater quality
- what you must do to protect each well on your property
- how to properly plug and seal unused water wells
- what you need to know about constructing new wells and upgrading old ones
- when and how to monitor water quality and correct problems
- the regulations and legislation that govern minimum construction, maintenance and abandonment requirements of water wells
- when to call the experts
- resources for more information.

If you need help with terminology, see the glossary on the final pages of this book.

Private wells are the primary source of safe and reliable water for farmers.

INTRODUCTION

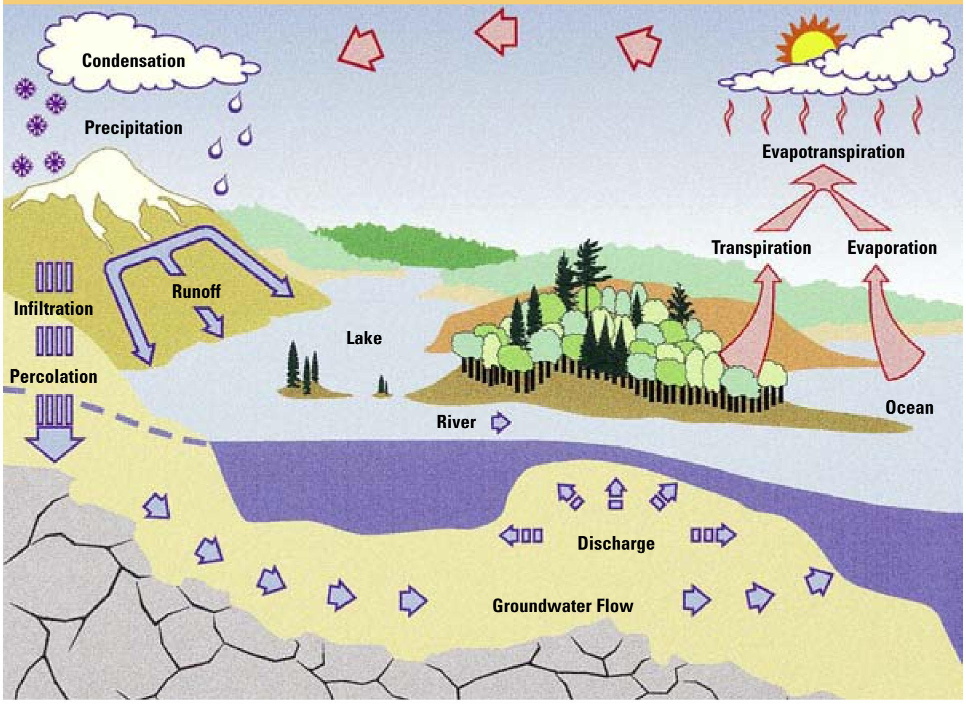
Proper construction and regular maintenance to protect your well from contamination are far less expensive and time-consuming than cleaning up your water supply once it has been polluted.

Modern drilling equipment operated by qualified and knowledgeable contractors can be very effective and efficient. Nonetheless, critical construction and maintenance practices must be followed to protect family health and the future of the water supply.

GROUNDWATER BASICS

WATER IN THE EARTH

THE WATER CYCLE



All water on and beneath Earth's surface and in the air is part of the water cycle. As rain hits Earth's surface, it can take several paths. (This is also true for melting snow.) It can run off into streams, lakes or rivers. It can seep into (infiltrate) the ground to be used directly by plants or to recharge groundwater. It can evaporate and return to the atmosphere. The cycle is complete when water in the atmosphere returns to Earth as rain or snow.

In this section, we look at:

- **where water occurs and how it moves in the earth**
- **the quantity of groundwater in aquifers and wells**
- **the quality of groundwater, and the importance of preventing its contamination**
- **types of water wells and pumps.**

Water is in constant motion, continually recycling through the environment in a series of pathways called the water cycle. Understanding the cycle is key to responsible water management. Every drop of water used on your farm – whether for drinking, livestock, laundry, or mixing with pesticides – has been used by other people, plants and wildlife before you. Likewise, when it leaves your operation – through evaporation, infiltration to groundwater, or runoff to surface water – it will be reused. We all have a role in keeping this shared resource as clean and abundant as possible.

Groundwater can move up or down or laterally. When groundwater flows naturally to surface water, it is called baseflow.

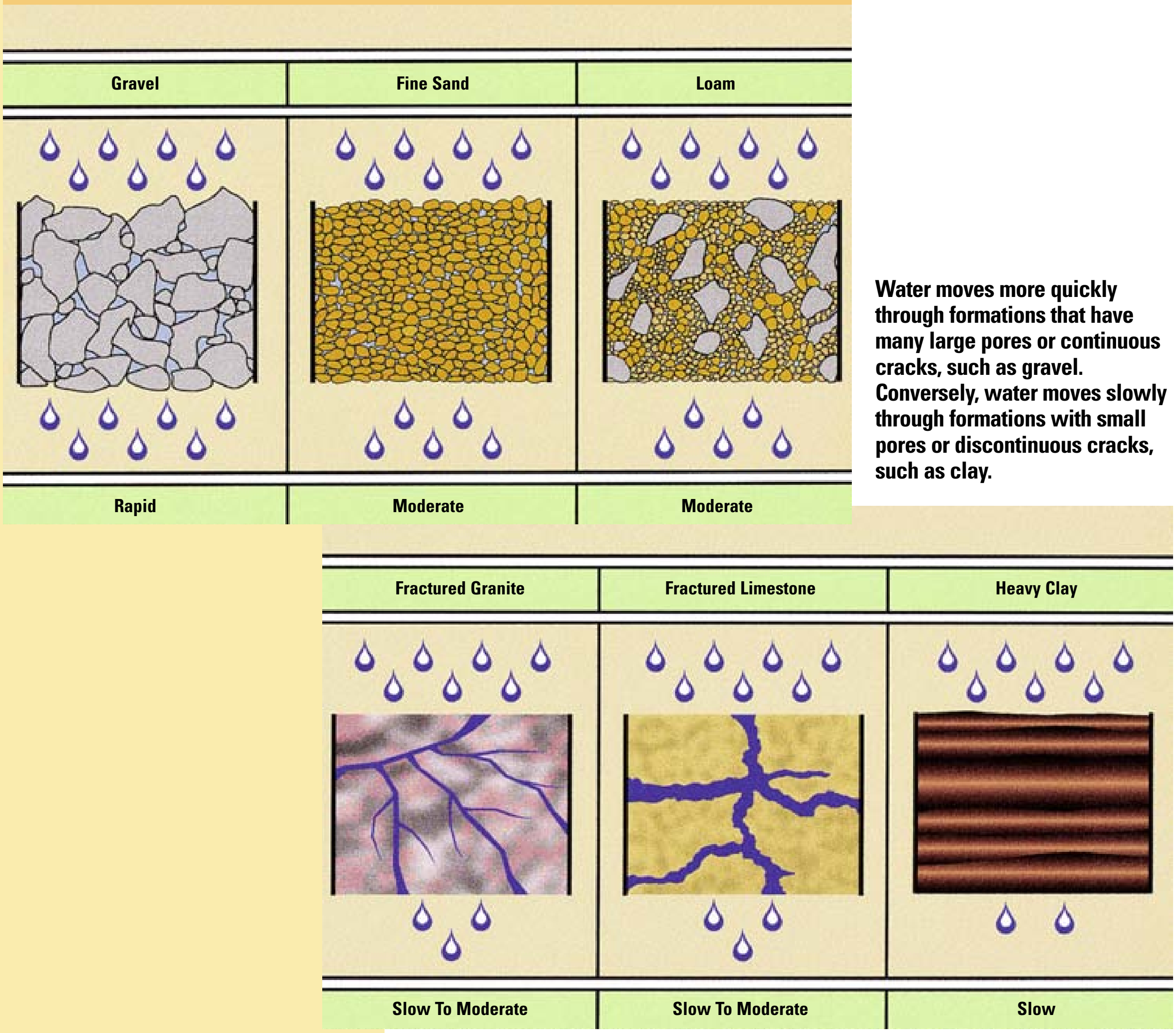
GROUNDWATER BASICS

WATER IN OVERBURDEN AND BEDROCK

Granite, sandstone, limestone, shale and other types of rock make up the hard crust of the earth, known as bedrock. In many areas, the bedrock is covered with deposits of clay, silt, sand or gravel. These overburden deposits were laid down by the action of glacial ice, water and wind. Well contractors and geologists call the earth's bedrock and overburden deposits "formations".

All formations contain pores or small openings filled with air or water. In some bedrock formations, oil or natural gas fills the pores. The percentage of pore space in a formation is its porosity.

HOW WATER MOVES THROUGH FORMATIONS



Water moves more quickly through formations that have many large pores or continuous cracks, such as gravel. Conversely, water moves slowly through formations with small pores or discontinuous cracks, such as clay.

GROUNDWATER BASICS

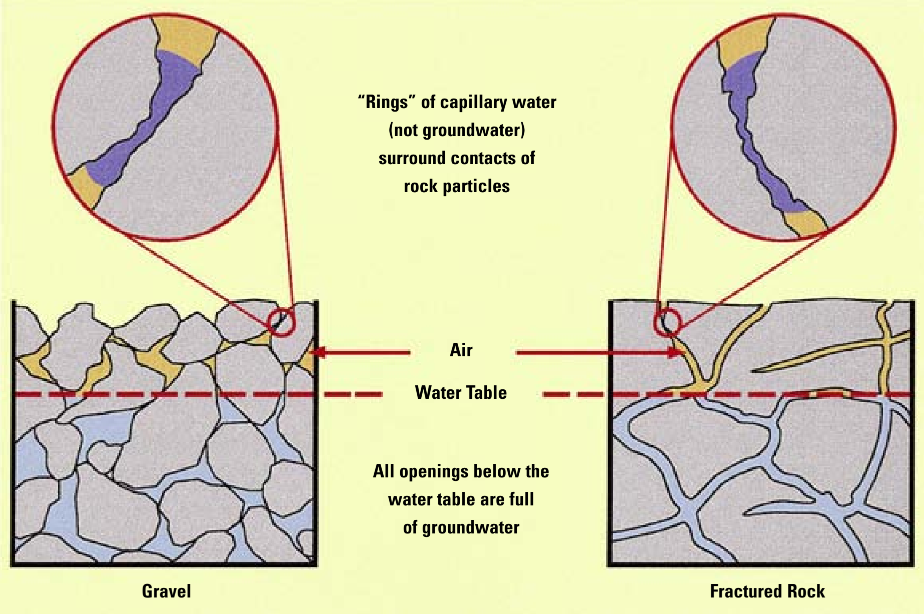
Sand can contain 25 to 50 percent pore space between the soil grains. Mixed sand and gravel formations can be 10 to 30 percent porous. These pores are large and connected to each other, so water moves easily through sand and gravel.

Clay contains 40 to 70 percent pore space, but water doesn't move easily through clay because the pores are small and poorly connected.

Pores containing air or a mixture of air and water are unsaturated. Pores filled with water are saturated. The depth at which all the pores are saturated, i.e., where the pressure is equal to atmospheric pressure, is the water table. In sand, groundwater will quickly fill a hole dug below the water table. In a tight clay deposit, however, groundwater seepage could take hours or days.

Above the water table, groundwater is drawn upward into the capillary zone, where fine soil pores act like a wick. In clay, for example, the soil may be saturated up to 1.5 metres (5 ft.) above the true water table because of capillary action. Water in this zone cannot be removed by pumping, so it cannot be used for drinking or irrigation. It represents, however, a significant pathway for contaminants to migrate down to drinking water supplies below.

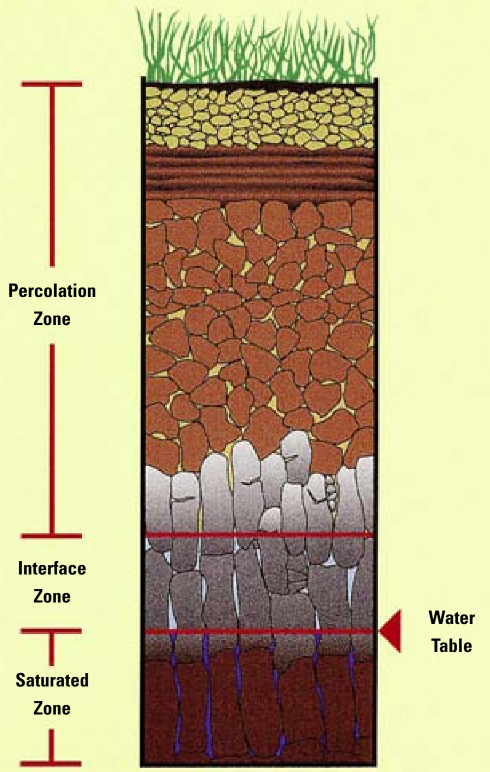
CAPILLARY WATER



Above the water table, water is held in pore spaces or cracks by capillary forces. The pressure in this water is negative, or less than atmospheric pressure.

GROUNDWATER BASICS

SURFACE WATER TABLE ZONES



In a typical loamy soil profile, water moves downward through the percolation zone to the saturated zone. Water is held by suction in the capillary zone.

Bedding planes are breaks or discontinuities between relatively homogeneous layers of sediment. Sediments are laid down by wind or water and a bedding plane results when a major climatic change occurs.

Formations that allow the rapid movement of water are called highly permeable. Sand and gravel deposits are highly permeable. Water flows easily and quickly through these materials.

Clay and silt are much less permeable. Some clay deposits may be fractured, which increases their permeability.

The permeability of bedrock depends on the number and size of fractures, bedding planes and solution channels, and how well they are connected.

In some areas, water moving through fractures in limestone has dissolved the rock, enlarging fractures and creating caverns. These are known as Karst formations. At the ground surface, this can result in sinkholes and "disappearing streams". Some places in the southern United States (Florida) and Europe have significant Karst areas. The large fractures and caverns associated with Karst formations can result in very rapid groundwater movement. In Ontario, this type of geology occurs in areas of Grey and Bruce counties along the top of the Niagara Escarpment, and in the Kingston area.

The number and size of cracks in the bedrock, and how well they are connected, help determine how fast groundwater will move.

GROUNDWATER BASICS

Although deep aquitards and thick aquitards (see sidebar) help to protect groundwater quality, all geological materials are permeable to some extent. That's why best management practices that protect groundwater from contamination are so important.

Most groundwater occurs in pores or fractures spread through the formation. What we look for when exploring for groundwater is a medium to highly permeable, saturated formation that would yield water easily to wells.

An aquifer is a saturated, permeable formation that can yield useful amounts of water for water supplies.

Common examples include saturated sand and gravel deposits.

An aquitard is a geological formation that prevents the significant flow of water. Common examples include clay layers or tight deposits of shale.

AQUIFERS: GROUNDWATER YOU CAN USE

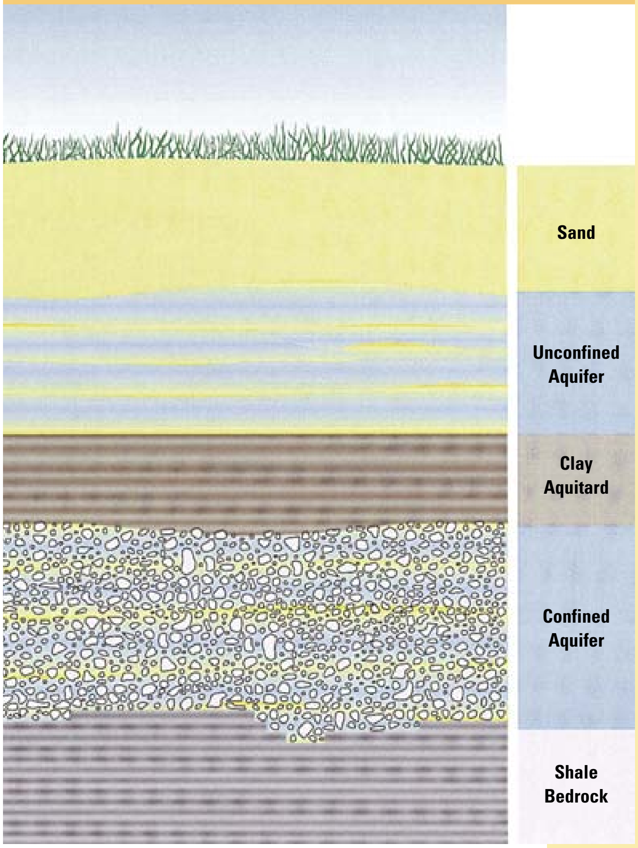
There are three kinds of aquifers.

Unconfined or **water table aquifers** are usually the most shallow. The top of an unconfined aquifer is the water table. In eastern North America, water table aquifers are often encountered between 2.5 and 14 metres (5 and 50 feet).

Confined or **artesian aquifers** are covered by an aquitard, a confining layer of lower permeability soil such as clay. Pressure in a confined aquifer can cause the water level in a well to rise above the top of the aquifer. If the pressure is high enough, the water can rise above the ground surface and flow out of the well. Special steps have to be taken when constructing wells in areas where flowing artesian wells occur. ***Caution:*** some contractors have not properly stopped the flow of water from some flowing wells. Be clear about who is responsible for stopping a flowing water well. In Ontario, a flowing well must be constructed so that all flow can be stopped.

When an aquitard is sufficiently permeable to allow some water to leak downward into the underlying aquifer, that aquifer is described as **leaky** or **semi-confined.** Drilling through an aquitard to the underlying groundwater is another common cause of "leakiness". This is one of the many reasons that water well contractors are licensed.

TYPES OF AQUIFERS



Most unconfined aquifers are shallow. Confined aquifers are usually found at greater depths beneath an aquitard. The pressure from the weight of the aquitard and other overburden materials may cause the water to rise to ground level.

Pressure in a confined aquifer can cause the water level in a well to flow out with force at ground surface.

GROUNDWATER BASICS

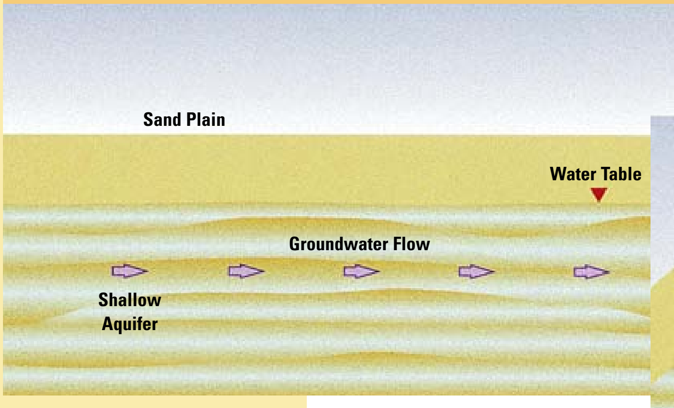
HOW DOES GROUNDWATER MOVE?

Groundwater moves (or flows) from areas of higher energy potential (higher elevation and/or pressure) to areas of lower energy potential (lower elevation and/or pressure). The diagram below shows that groundwater can flow horizontally or vertically upward or downward. Within an aquifer, groundwater naturally flows in one predominant direction, i.e., mainly horizontal or vertical, up or down. Locally, this natural flow direction can be affected or changed by pumping a well.

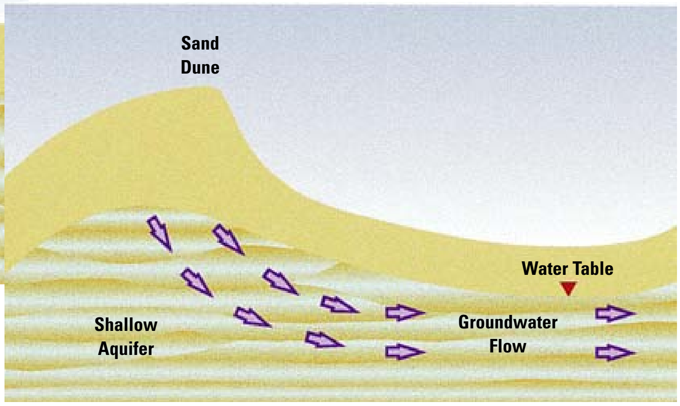
How fast groundwater moves depends on permeability and on the slope or gradient of the groundwater surface. Groundwater moves quickly through very permeable bedrock or overburden, and slowly through clay or silt. There is a great range in groundwater velocities.

Quick water movement is about 30 centimetres (1 ft.) per day, except in Karst topography. In some clay formations, it moves as slowly as a few centimetres a year. Groundwater drawn from a deep well may have been in the ground for hundreds or thousands of years. In a shallow aquifer, the age of the water may be only a few weeks or years.

GROUNDWATER MOVEMENT



LOW GRADIENT. In a shallow, sandy aquifer, where there is very little change in elevation, water moves slowly in a lateral direction from high pressure areas to low pressure ones.



HIGH GRADIENT. Water in hilly, sandy aquifers will move quickly from high elevation areas to areas of low elevation (or pressure). Note: the shape of the water table generally follows surface features.

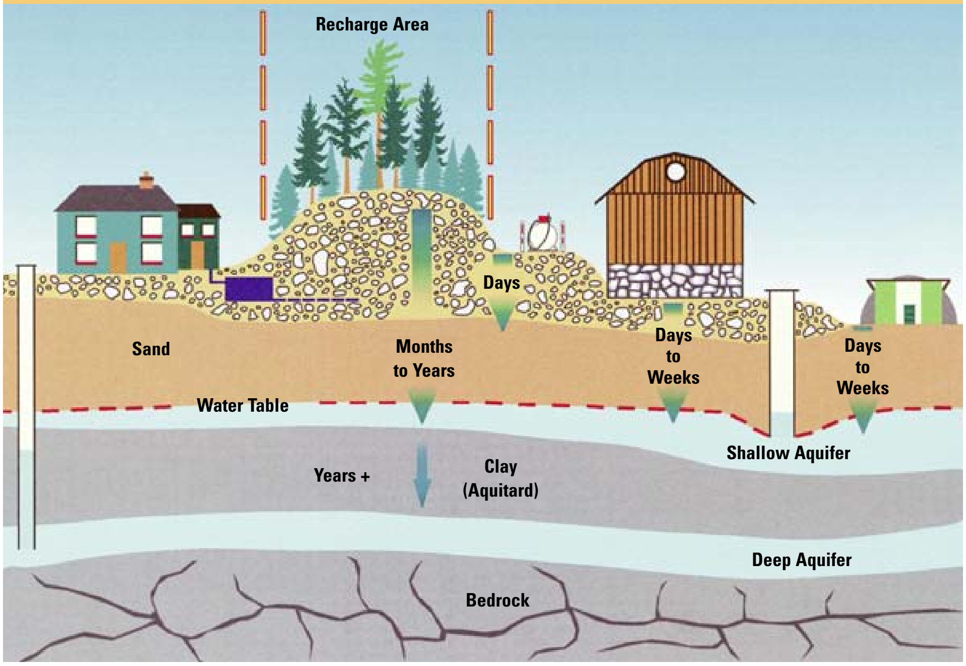
GROUNDWATER BASICS

GETTING WATER OUT OF THE GROUND: WELLS AND SPRINGS

For thousands of years, people have used wells to tap the abundant supply of fresh water in the earth. A water well is a hole drilled, dug or bored into an aquifer from which groundwater can be drawn.

Groundwater can flow to the surface naturally. When the water reappears above the ground surface, the water can discharge as a spring. Sometimes springs are used for water supplies. Groundwater discharge also feeds lakes, rivers and wetlands.

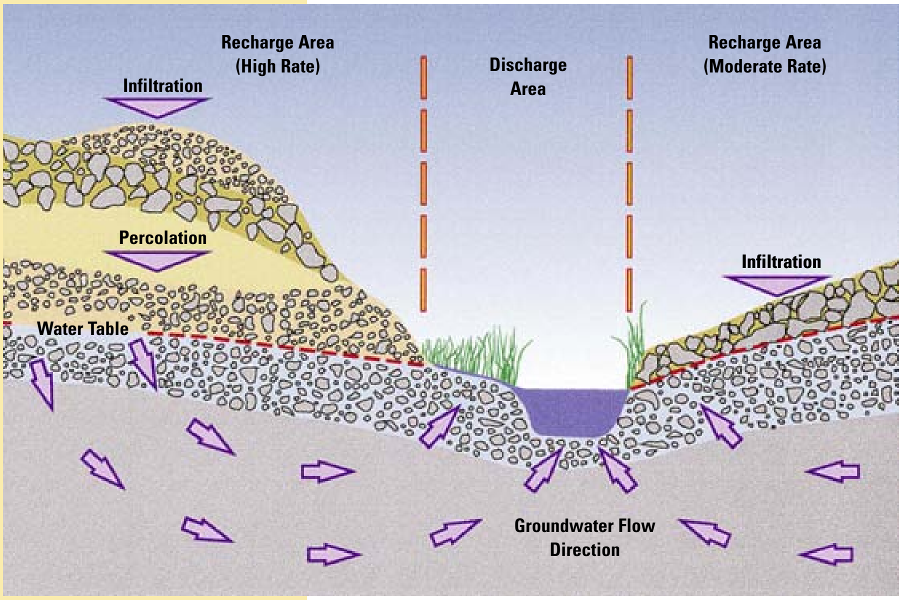
TYPES OF AQUIFERS AND PATHWAYS OF RECHARGE



Shallow aquifers are recharged rapidly when surface materials are highly permeable, as sand and gravel are. Recharge may take days to weeks. Less permeable materials like clays will act as aquitards. Deeper, confined aquifers can be found between aquitards and some permeable materials such as fractured limestone bedrock. Recharge through aquitards to deep aquifers can take decades. Recharge to deep aquifers may be more rapid, however, where the aquifer sediments intersect a shallower aquifer or the ground surface, usually at considerably higher elevation.

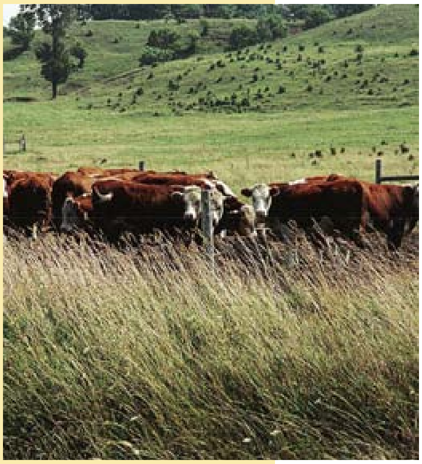
GROUNDWATER BASICS

RECHARGE: HOW AQUIFERS ARE REPLENISHED



In the water cycle, the portion of infiltrating water that isn't taken up by plants will move downward through the unsaturated zone. When infiltrating water reaches the water table, it becomes groundwater recharge. Recharge replenishes water in aquifers, or is discharged in springs, streams, lakes or wetlands.

On a larger, regional scale, recharge from shallow to deeper aquifers also takes place. It's possible to take the path of recharge to a deeper aquifer back up to the geographic areas of entry in the surface landscape. These are known as recharge areas. They are defined by a measurable downward driving force beneath the water table, or a vertically downward gradient. Spills anywhere within a recharge area can contaminate aquifers. Some recharge areas, such as hilly land with coarse-textured soils, are of particular importance because of their high permeability. The Oak Ridges Moraine in southern Ontario is a prime example of a large and important recharge area.



End moraines are good examples of important groundwater recharge areas.

How much recharge gets to the aquifer? In Ontario, the amount of recharge in an area of only one square kilometre (0.4 sq. mi.) ranges from 150,000 to 800,000 litres (30,000 to 180,000 gal.) a day, or 7 to 40 percent of the total precipitation. That's enough water to supply from 400 to 2,300 people daily. The lowest recharge rates occur in areas of fine-grained, low permeability soils, such as clay plains. More permeable soils such as sand and gravel allow higher recharge rates. The recharge rate is also influenced by climate, topography and vegetation cover.

The total groundwater pumped from all wells in an aquifer should be less than the amount of recharge to that aquifer. If not, the water level in the aquifer is gradually lowered, depleting the reserve of groundwater. This is called groundwater mining.

GROUNDWATER BASICS

Before purchasing rural property, it's a good idea to check Water Well Records and ask for water quality results.

FINDING GROUNDWATER

There are good sources of information on groundwater in your area and for wells on your property, including:

- Water Well Records on file with provincial agencies – there is more about Water Well Records throughout this book
- maps and reports on groundwater published by provincial agencies and in some cases municipalities have information on groundwater availability and quality, depth to aquifers, and susceptibility of aquifers to contamination
- local licensed water well contractors who understand local groundwater conditions
- hydrogeologists, scientists and engineers who study groundwater.

Find out if a record exists for wells on your property. Call 1-888-396-9355 (WELL).

TYPICAL INFORMATION IN A WATER WELL RECORD

- date completed
- location
  - lot, concession, municipality
  - mailing address
  - location map
- the original well owner's name
- geologic log listing type of overburden and bedrock
- depths and kind of water found
- casing(s): material, diameters and depths
- annular space, sealing/grouting details
- screen type, slot size, diameter, length, depth in well
- pumping test conducted upon completion
  - static water level
  - pumping level or recovery level(s)
  - pumping rate
  - length of time pumped
  - pump intake depth
  - recommended pump type, depth, rate
- final status of well
- type of water use
- construction method
- well plugging and sealing details
- contractor
  - name, address, license number
  - technician name, license number

GROUNDWATER BASICS

For generations, dowsers have claimed to be able to find groundwater by using a forked branch, rod or pendulum.

PHOTO CREDIT: Burnett, W. and T. Besterman. *The Divining Rod: An Experimental and Psychological Investigation* (London: Methuen & Co., 1926).

Some people claim to find groundwater by water witching or dowsing, using a forked stick, rod or pendulum. Although water witching has some popular appeal, there is no scientific evidence that it works better than chance alone. We know that groundwater occurs mainly in pores in geologic formations. An aquifer has to extend under a large area to provide enough groundwater to wells. In much of Ontario, because there is enough rainfall and the right geologic conditions, it is hard not to find groundwater.

GROUNDWATER QUANTITY

HOW MUCH WATER DO YOU NEED?

The amount of water you use depends on:

- family size
- family lifestyle (water-using appliances)
- type of farm (livestock, cash crop, greenhouse)
- number and type of livestock
- irrigation requirements
- lawn or garden watering
- water conservation practices.

All water use can be reduced by practising water conservation.

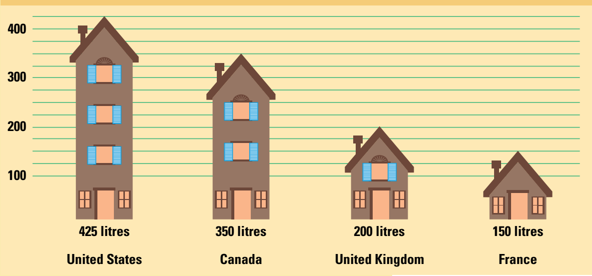
HUMAN WATER REQUIREMENTS

The average Canadian person uses 350 litres (about 80 gal.) a day, but this can vary from 270 to 450 litres (60 to 100 gal.) a day. To ensure an adequate supply, well contractors may base their calculations on 450 litres a day per person.

LIVESTOCK WATERING

Use the chart on the following page to estimate your livestock watering needs.

AVERAGE DAILY HOUSEHOLD WATER USE (PER CAPITA)



The average Canadian uses over twice as much household water per day as a European.

GROUNDWATER BASICS

ANIMAL	QUANTITY – litres (gallons) a day
Milking cow	90 to 135 (20 to 30)
Dry cow, beef cow, horse	40 to 45 (9 to 10)
Steers and heifers	30 (7)
Sow	21 (5)
Boar, dry sow	13 (3)
Feeder hogs	9 (2)
Sheep	7 (2)
Chicken	0.36 (0.08)
Turkey	0.45 (0.1)

PEAK WATER DEMAND

The amount of water a farm uses varies over the day. For example, the peak demand for a dairy operation that milks and feeds two times a day could occur for one hour in the morning and one hour in the evening. If equipment washing, feeding, and major household uses coincide, up to two-thirds of the daily water would be used during these peak hours.

Let's say that the total daily requirement (daily demand) of a family of five with a 50-cow dairy herd pipeline operation is 8,000 to 9,000 litres (1,750 to 1,800 gal.). If used evenly over the 24-hour period, the rate of use would be 6 litres (1.3 gal.) per minute. The rate of water use during the two hours of peak demand is 50 litres (11 gal.) a minute. If the water well can't supply the peak demand, water-using activities have to be changed or storage tanks added to provide water during high use periods. A water meter can be used to determine your daily and peak water demand.

On a dairy farm, the peak demand for groundwater often occurs for one-hour periods in mornings and evenings.

GROUNDWATER BASICS

HOW MUCH WATER CAN YOU GET?

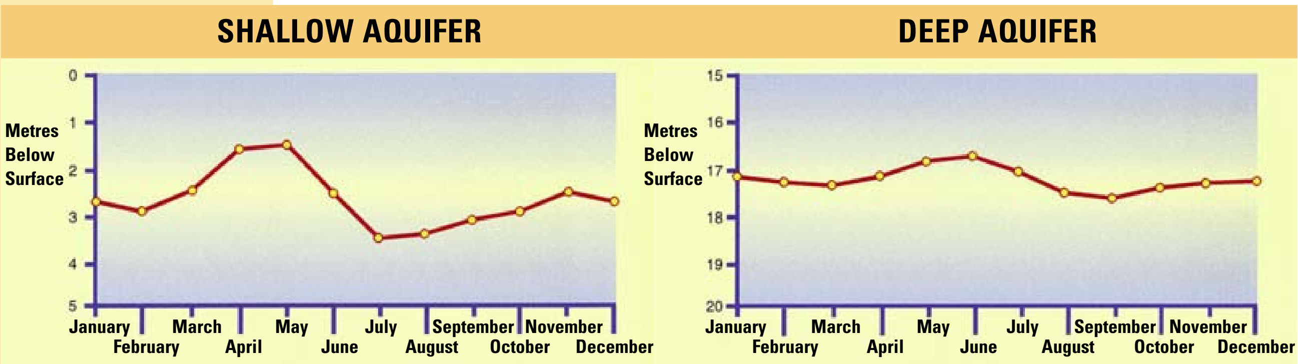
Groundwater yield from aquifers is affected by the characteristics of the aquifer and the amount of recharge getting to the aquifer. For example:

- thick sand and gravel or permeable bedrock formations extending over a large area can support high-capacity wells, with yields of millions of litres a day
- thin formations extending over only a small area may yield only a few hundred or thousand litres a day to wells – similarly, fine-textured deposits or bedrock aquifers with poorly developed fractures may supply only limited quantities of groundwater
- most aquifers in Ontario yield enough water for domestic or agricultural purposes
- major aquifers can support large-capacity municipal or irrigation supplies.

SHALLOW VERSUS DEEP WELLS

Generally, deeper wells have more available draw-down than shallow wells and are less affected by seasonal changes in water levels. (The illustration on page 70 shows what is meant by drawdown.)

There is no standard definition of shallow or deep wells. The three characteristics that might be used to classify a well as shallow or deep are: depth of intake (e.g., screen depth), depth of static water level, and depth of pump. A 6-metre (20-ft.) dug well with a shallow lift pump would universally be called a shallow well. A 75-metre (250-ft.) deep drilled well with a submersible pump at the 30-metre (100-ft.) level would be called deep. Is a 75-metre (250-ft.) drilled well with a 2-metre (5-ft.) water level and a shallow lift pump a deep or shallow well? For the purpose of this book, we assign the definition according to the bottom depth of the well, and use a cutoff point of 7 metres (25 ft.) – the maximum depth to which a shallow lift pump is effective.



Water levels in aquifers generally follow yearly precipitation patterns, with peaks in the spring and drops in late summer. This is more pronounced in shallow aquifers, and explains why some shallow wells run dry in the summer.

GROUNDWATER BASICS

Groundwater yields from wells are affected by the design of the well.

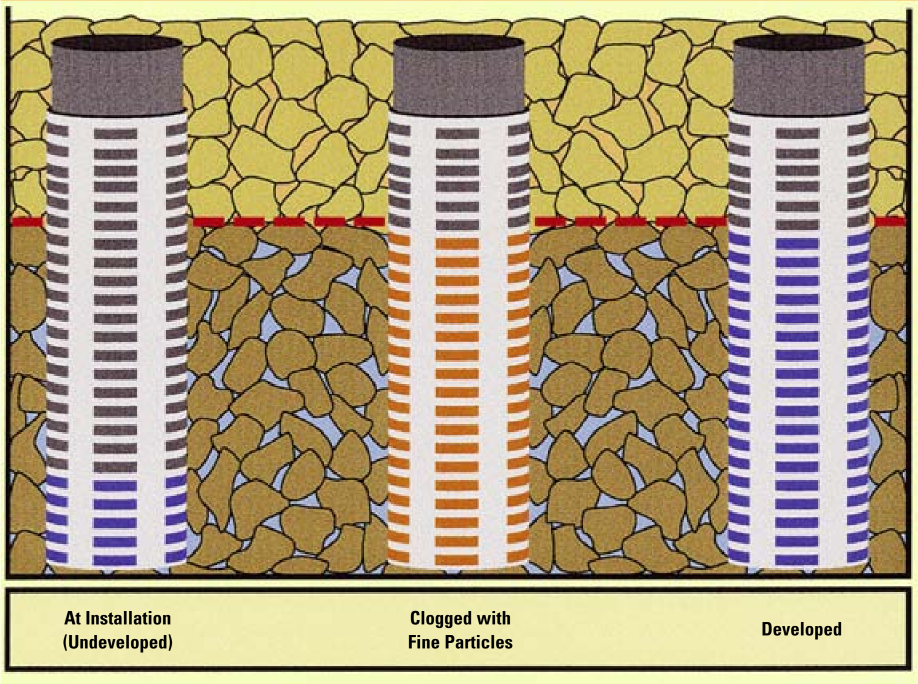
Seasonal changes in the level of the water table can affect the yield from shallow wells. Usually, the water table is highest in spring and fall, and lowest in summer and winter.

Proper selection of well screens and well development increase the efficiency and yield of wells in overburden aquifers. These construction methods are explained later in this book, starting on page 33.

A well owner's perception of how good a well is depends on the water demand. A well that only produces 5 litres (1 gal.) a minute will be a good well if little water is needed, or if extra water storage is provided to meet peak demands. An owner with a very high water demand will regard a 50-litre- (10-gal.-) a-minute well as poor.

Rule of thumb: a large-diameter well is usually shallow and a small-diameter well is deep.

DEVELOPING A WELL



All wells need to be developed at time of installation – or have the well screen flushed to maximize efficiency and yield. Some older drilled wells may also need to be developed to flush accumulated fine particles out of the well screen.

GROUNDWATER BASICS

GROUNDWATER QUALITY

Both natural processes and human activity can impact groundwater. The difference is that natural processes can either improve groundwater quality or degrade its aesthetic qualities. Human activity, for the most part, contaminates groundwater. With care, the impact of human activities can be reduced.

Not all bacteria found in groundwater are disease-causing. Nuisance organisms clog wells and pipes, and cause well yield to decline.

As groundwater percolates downward through formations above the aquifer, water quality may be affected in the following ways:

- the water dissolves minerals from the geologic materials it passes through, e.g., calcium carbonate in limestone can make recharge water hard
- organisms such as bacteria or protozoa may die off or be filtered out
- some substances in the recharge water, e.g., metals and phosphorus, may be removed by charged soil particles – thus improving the groundwater.

The following characteristics refer most often to shallow aquifers:

- the age of the groundwater determines its contact time with geologic materials, which affects its mineral content, e.g., the longer groundwater is in contact with limestone, the higher its calcium level
- bacteria may chemically alter nitrate or sulphur – this process will change the quality of groundwater, for better or worse
- groundwater temperature is affected by the depth of the aquifer
- bacteria may die off or be filtered out or remain dormant.

Water well quality may change due to the seasonal effects of snowmelt and rainfall, or if the depth of the well's aquifer changes.

GROUNDWATER BASICS

NATURAL INFLUENCES ON GROUNDWATER QUALITY

MATERIAL	SOURCE	IMPACT

CALCIUM AND MAGNESIUM	• areas where calcium-rich bedrock is found close to the surface
	• glaciated regions of Ontario near limestone bedrock formations
		• water becomes hard:
		  ○ lime scale becomes attached to fixtures and dishes and can clog plumbing, water heaters and dishwashers
		  ○ soap scum, excess soap consumption
		• dirty and stained laundry

IRON AND MANGANESE	• most bedrock and soil materials • most acute in areas with iron-rich crystalline (igneous and metamorphic) rocks and reddish shale rocks • acidic groundwater (as pH lowers, levels increase)	• stains plumbing fixtures, cooking utensils and clothing • red and black particles in water • unpleasant tastes and colours • reduced well yield • nuisance organisms
ARSENIC	• some limestone bedrock formations	• long-term health hazard, including increased risk of cancer
URANIUM	• very rare and localized in Canadian Shield	• toxic
CHLORIDE	• salt bedrock (halite) • marine environments	• salty taste • corroded plumbing
SULPHATE	• sulphur-rich bedrocks • gypsum	• water has laxative effects, may taste bitter • combines with calcium to form an adherent scale
SULPHIDE	• sulphur-rich geological material • aquifers with buried organic deposits (swamps)	• hydrogen sulphide or “rotten egg” smell • tarnished copper • corroded plumbing • nuisance organisms
PETROLIFEROUS	• oil-rich deposits	• some fossil-fuel chemical components (e.g., benzene, toluene) are known carcinogens
BACTERIA, PROTOZOA, VIRUSES	• wildlife: populations, waste materials and mortality	• gastrointestinal diseases and parasites

GROUNDWATER BASICS

THE ONTARIO FARM GROUNDWATER QUALITY SURVEY

About 1,300 domestic farm wells located throughout the province were tested in 1992 for nitrate, faecal coliform bacteria, and several common herbicides. The findings may or may not reflect the quality of the aquifer. These are a few of the findings:

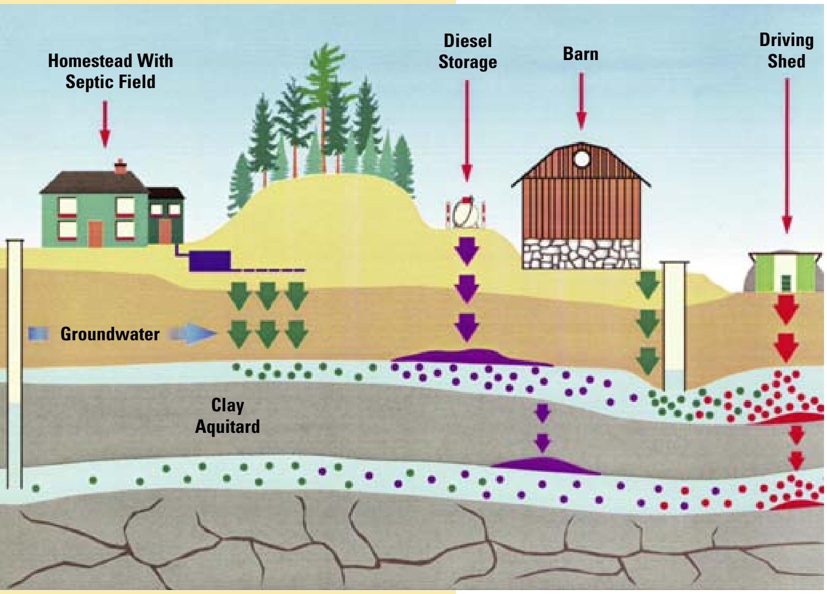
- 40 percent of wells tested contained levels of one or more of the target contaminants above the provincial drinking water objectives
- dug or bored wells and driven sandpoints were the most frequently contaminated well types, regardless of depth
- the frequency of contamination was higher in older wells and in shallower wells
- wells contaminated with nitrate tended to be in areas classified by Ontario Ministry of the Environment as having a high susceptibility to groundwater contamination.

GROUNDWATER CONTAMINATION

PATHWAYS OF CONTAMINATION

Groundwater can become contaminated in several ways:

- spills on the ground, e.g., fuel and pesticide spills
- injection into the ground, e.g., septic leaching beds, disposal of waste in wells, contaminated surface water running into poorly constructed wells, poorly maintained wells, improperly plugged wells and back-siphoning from spray tanks into wells
- improper handling of industrial solvents and chemicals, e.g., varsol and wood preservatives
- leakage from wastes, e.g., manure storages, wastewater, septic tanks and landfills
- leaking underground and aboveground fuel storage tanks
- movement of groundwater between contaminated and clean aquifers
- overapplication of soil amendments such as manure, commercial fertilizers or pesticides.



In aquifers, contaminants and recharge waters can follow similar pathways. This is the case for nitrates from household septic systems, livestock wastes and excess fertilizer application. Some contaminants, like diesel fuel, are less dense than water and will stay mostly near the top of the aquifer. Other contaminants that are more dense than water and do not dissolve readily will tend to accumulate at the bottom of an aquifer. Such contaminants are referred to as dense, non-aqueous phase liquids or D-NAPLs.

GROUNDWATER BASICS

Geologic formations may remove some contaminants. For example, metals like lead and mercury can become attached to soil particles. Nitrate levels can be reduced in the aquifer through denitrification. The likelihood that groundwater could become contaminated depends on:

- the size or strength of the contamination source
- the ease with which the contaminant can move into or travel through the soil.

Contaminants move most easily through coarse-textured soils (sand and gravel) and fractured bedrock. But even clay soils can have fractures that allow the movement of contaminants. Once contaminants have reached an aquifer, they are difficult and expensive to remove. High levels of a contaminant in an aquifer can make the water unfit and unsafe to use.

Septic systems must be located a safe distance from drinking-water wells. They should be maintained regularly to reduce the risk of bacteria and nitrate contamination.

To learn more about where to locate and how to construct a well to reduce the chance of contaminating wells and aquifers, see the section that starts on page 33. The illustration on page 33 shows some of the potential sources of groundwater contamination commonly found on a farm.

TYPES OF CONTAMINANTS

CONTAMINANTS THAT DISSOLVE

Some substances, like common table salt, dissolve easily in water. Examples of substances that can affect groundwater quality include:

- nitrate from septic systems, manure, synthetic and mineral fertilizer, and legume plowdown crops
- water-soluble pesticides
- road salt.

Nitrate is a more common contaminant than pesticides in rural groundwater supplies.

Once contaminants of this type reach an aquifer, they move in the direction of groundwater flow. The zone occupied by the contaminant in the aquifer is often called a plume. The size and shape of a plume depends on the strength and type of the contaminant source and the chemical and physical properties of the aquifer. The strength or level of the contaminant generally decreases the farther it gets from its source. Plumes may exist, however, over several kilometres.

Researchers have found that plowing down nitrogen-fixing forages can result in a "pulse" of nitrogen leaching into the groundwater.

GROUNDWATER BASICS

Some contaminants do not dissolve or flow with groundwater, making them difficult to clean up. These are sometimes known as NAPLs, which stands for non-aqueous phase liquids. Light-NAPLs or L-NAPLs such as gasoline are lighter than water and, for the most part, will remain at or near the surface of a contaminated aquifer. D-NAPLs or dense non-aqueous phase liquids such as perchloroethylene (a common degreasing agent) are heavier than water and will gravitate to the bottom of an aquifer.

CONTAMINANTS THAT DON'T DISSOLVE

Substances like oil don't mix with water, although small amounts may dissolve in water. Even the small amounts that do dissolve may exceed safe drinking water levels. Some liquids like diesel fuel, gasoline, and paint thinner are lighter than water and float on the water table surface. Others, including some common degreasers, are heavier than water and sink to the bottom of an aquifer.

If gasoline, for example, is spilled on the ground, it can travel down through the soil until it reaches the water table. Most of the gasoline floats on the water table where it can get into nearby shallow wells. A small amount dissolves and moves with the groundwater flow where it can affect deeper wells farther away. It only takes a litre of gasoline to make a million litres of water undrinkable because of the toxic chemicals contained in gasoline.

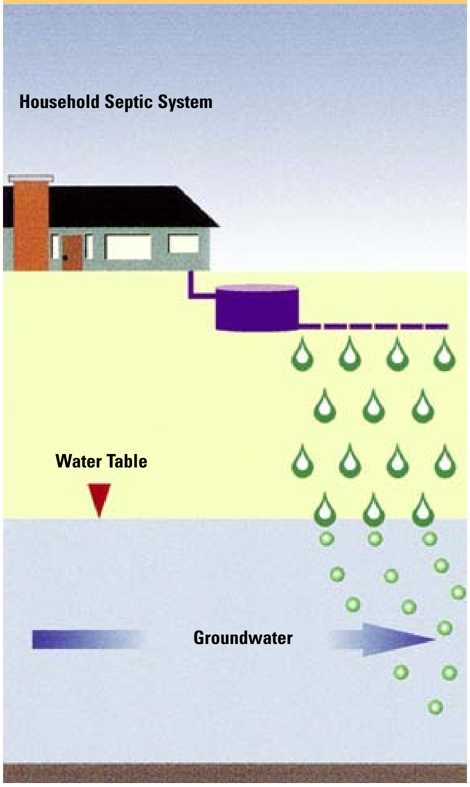
THE COST OF CLEANING UP

Near one small rural community, gasoline leaked from a fuel storage tank into the bedrock aquifer. The water in about 20 wells was contaminated and no longer fit to use. These wells had supplied water for farms, rural residences and livestock. Some wells that weren't too badly contaminated had expensive treatment systems installed to make the water drinkable. Other users had to be supplied with water piped in from a town about 10 kilometres (6 miles) away. The contamination had spread so far in the fractured bedrock that the aquifer could not be cleaned up. Several million dollars was spent in supplying water and cleanup efforts.

With recent changes to fuel regulations, many older installations are no longer acceptable. The 300-gallon fuel tank shown here has been placed in a rectangular containment to offer protection in case of a spill.

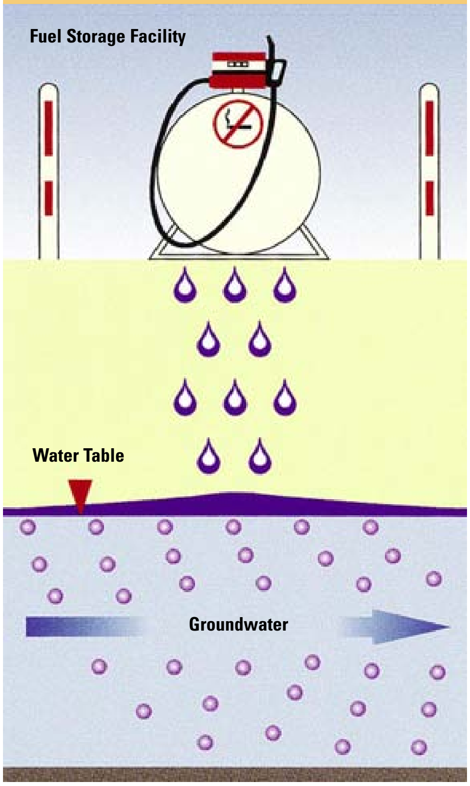
GROUNDWATER BASICS

HOUSEHOLD SEPTIC SYSTEM



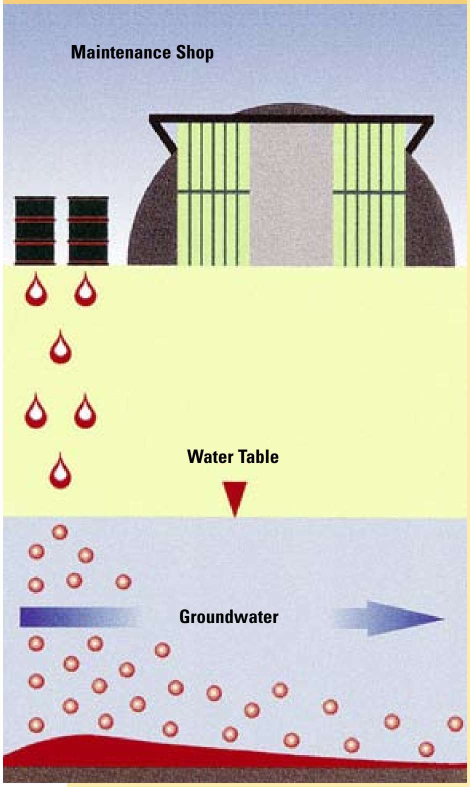
Septic systems are designed to treat human wastes, not hazardous household materials such as solvents and oil products. Substances that dissolve in groundwater such as fertilizers, road salts, water soluble pesticides and septic-based nitrates will move with recharge water to the aquifer. Once they reach the aquifer, they move in the direction of groundwater flow.

FUEL STORAGE FACILITY



Generally, oil products and water don't mix, although some of this material does "dissolve" in the water. If spills or leaks occur, small amounts may make an entire aquifer unfit to drink. Such materials are lighter than water and will remain near the top of the aquifer.

MAINTENANCE SHOP



Perchloroethylene, a common degreaser, is heavier than water. If spills or leaks occur, most of this material will gravitate and remain at the bottom of the aquifer. This characteristic makes it nearly impossible to clean up.

GROUNDWATER BASICS

Do not assume your well water is biologically safe. Have it tested regularly. See the sidebar on page 77 for more information on interpreting results.

BIOLOGICAL CONTAMINANTS

Bacteria, viruses, protozoa, and other disease-causing organisms can also contaminate groundwater. Faecal coliform bacteria found in the excrement of humans and warm-blooded animals can survive a long time in groundwater. Water samples are often taken to test for bacteria, but viruses are very difficult to detect. They are not likely to be transported from the ground surface to the water table and through the aquifer by natural flow. Rather, they are usually conveyed directly to groundwater down improperly sealed wells, via unused wells, and through other direct means such as septic systems.

The survival of disease-causing organisms decreases with: extremely hot temperatures; sunlight exposure; predation; pH extremes; depth to groundwater; lower moisture content and organic matter content in the soil; and smaller grain size.

There are microorganisms that are much more hazardous to humans than common faecal bacteria. Examples are *cryptosporidium,* a parasitic protozoa, and verotoxigenic bacteria, such as *E. coli* O157:H7*,* also known as the hamburger disease. Such organisms are common in animal and human waste, and can inflict serious illness in people.

It is increasingly important that groundwater supplies (aquifers) be protected from surface water by ensuring proper construction and maintenance of active wells and proper plugging and sealing of unused wells. The existence of these contaminants in water results from poor sanitation, improper handling of human and animal wastes, and poor well construction or maintenance.

It's important to assess the potential risk of management practices on the land and in the home to ensure the quality of surface water and groundwater.

Illustrations used with permission of Regional Municipality of Waterloo, Rural Groundwater Awareness Program, Waterloo, Ontario. From original watercolours prepared by Irene Shelton, Belwood, Ontario.

WELL BASICS

TYPES OF WELLS

There are three main types of water wells:

- drilled
- bored/dug
- sand point.

The following components are common to all wells:

- the **inlet,** which allows groundwater to enter the well – this may be a commercially manufactured well screen in overburden aquifers or an open hole in bedrock
- the **hole stabilizer,** which prevents the formation from collapsing into the well, may be a steel casing, a concrete tile, or an open hole in solid bedrock
- **sanitary protection,** including grout in the annular space around the casing, seals between concrete tiles or at the point of entry of water and electrical lines, sanitary well caps and well seals
- the **pumping system,** including the pump itself, along with electrical lines.

Best management practices for well construction and maintenance are described in the section that begins on page 33.

WELL BASICS

COMPARISON OF WELL TYPES

	WELL TYPE			
	DRILLED WELLS	**LARGE-DIAMETER WELLS** Dug	**LARGE-DIAMETER WELLS** Bored	**WELL POINTS (SAND POINTS)**
DESCRIPTION	• drilled with rotary or cable-tool water well drill • shallow or deep	• dug by backhoe or by hand • shallow (usually)	• constructed with boring machine • shallow or deep	• driven in or jetted with water • shallow
	• small-diameter casing, 10 to 20 cm (4 to 8 in.)	• large-diameter casing, 60 to 120 cm (24 to 48 in.)		• small-diameter casing, 2½ to 5 cm (1 to 2 in.)
ADVANTAGES	• can reach deeper aquifers • can drill into bedrock	• easy to construct • inexpensive initial cost	• more controlled hole than dug well	• generally simple and inexpensive to install
	• less subject to contamination, especially if deep • easier to seal • more constant temperature	• large casing provides storage • may be used in poor-yielding aquifer		
DISADVANTAGES	• vulnerable to deep aquifer contaminants • poorer natural water quality from some deep aquifers may occur, e.g., from salt	• if shallow, water shortages are possible in dry periods • easy to seal properly, but requires large volumes of material • vulnerable to near-surface contamination • water temperature may change seasonally		• limited to permeable materials • shallow water table • limited yield and possible shortages in dry periods • vulnerable to near-surface contamination

This drilled well casing has had a frost-free hydrant added with a backflow preventer.

Large-diameter wells typically use concrete casing. Older installations may have been cased with brick, stone, timber or corrugated steel.

WELL BASICS

For information on regulations in Ontario, see the Appendices, which start on page 82.

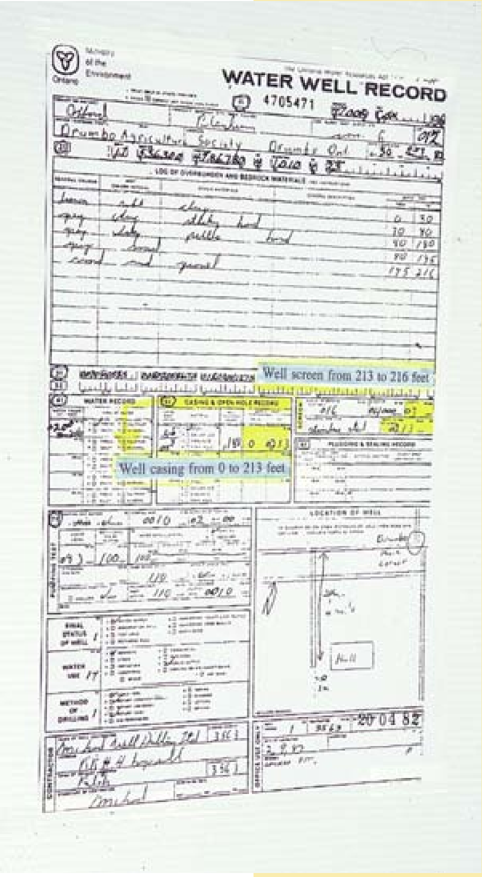
THINGS TO KNOW ABOUT REGULATIONS

Most jurisdictions have regulations governing the construction of water wells. Such regulations set out minimum construction standards for all types. The main purpose of the standards is to keep surface water and foreign matter out of wells and aquifers. Regulations cover:

- who is qualified to construct wells and install pumps – the Ontario Ministry of the Environment issues licenses to qualified water well contractors
- where a well can be located
- how the well is to be constructed, and what materials can be used
- well owner's responsibilities
- when a well must be properly plugged and sealed.

WATER WELL RECORDS

On completing a new well, the water well contractor provides information in the Water Well Record. See page 13 for a description of what's included in a typical water well record.



Upon completion of a well, Ontario regulations require all well contractors to submit a copy of the Water Well Record to the owner of the new well and to Ontario Ministry of the Environment. The record gives information on the location, owner's name, date of construction, contractor's name, geologic log, water quality record, well construction details, yield, and more.

WELL BASICS

WELL OWNER RIGHTS AND RESPONSIBILITIES

All rights come with responsibilities. As the owner of a property with wells, you are required to maintain each well to keep out surface water and other foreign materials. If you are not going to maintain your well properly, it should be plugged and sealed.

Proper well construction costs money, and proper maintenance may cost money. Don't cut corners. After a few years, shortcuts can end up costing a lot in repairs, or even cause well collapse and aquifer contamination.

It is very important to look after your well. A properly maintained well ensures a reliable supply of good quality water, and protects the aquifer and other water resources from contamination.

This is an unused well in very poor condition. Until it is properly plugged, it poses a threat to groundwater quality, and the safety of humans, livestock and wildlife.

PLUGGING AND SEALING UNUSED WELLS

Even a well you're not using now, but might use in the future, must be maintained like a working well. Some tips on maintaining your well are found in the section beginning on page 65.

A well that won't be used again must be plugged to:

- protect the aquifer from surface contamination
- prevent vertical movement of water between aquifers, or between an aquifer and the ground surface
- eliminate a safety hazard to humans, livestock and wildlife.

Deep or flowing wells, or wells in fractured bedrock, must be properly plugged by a licensed water well contractor.

Never add water to or dispose of wastes in unused wells.

A new well must be properly plugged and sealed if it is dry or if the water is not suitable for drinking.

The right way to plug a well depends on the well's construction. Methods of plugging unused wells are described in the Best Management Practices chapter. Consulting a licensed well contractor is usually recommended.

Abandoned wells should never be used as disposal sites for roof water, septic wastes or any other organic debris.

WELL BASICS

TYPES OF PUMPS

The common types of pumps fall into one of two categories: shallow well or deep well.

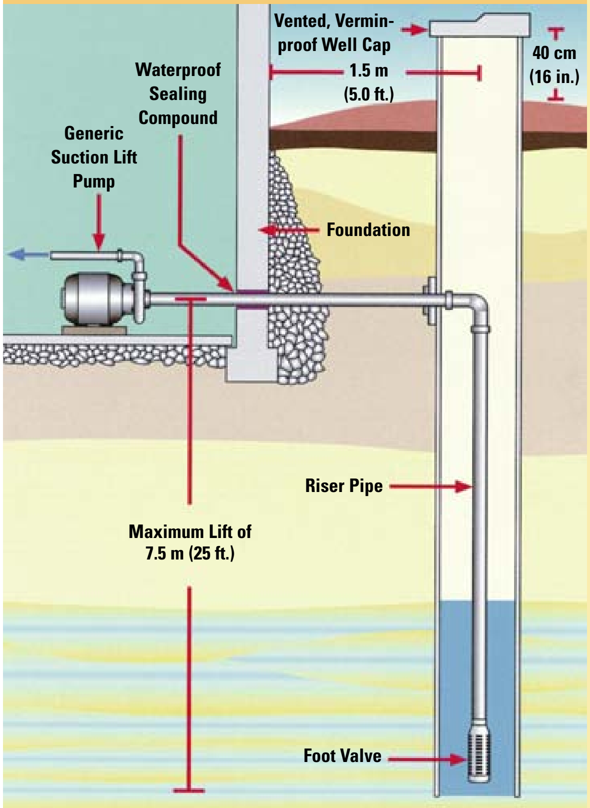
SHALLOW-WELL PUMPS

Shallow-well pumps work by suction lift, but the lift is limited to about 7 metres (25 ft.). These pumps sit at the ground surface adjacent to the well. They work by creating a vacuum in the pipe, and atmospheric pressure forces water up the pipe. A foot valve on the bottom of the drop pipe keeps the pipe and the pump full of water or primed.

Common shallow-well pumps include:

- ▶ reciprocating (piston) pump
- ▶ centrifugal pump
- ▶ centrifugal-jet pump.

TYPICAL SHALLOW-WELL PUMP INSTALLATION



Centrifugal pumps require little maintenance and can handle some soil particles in the water.

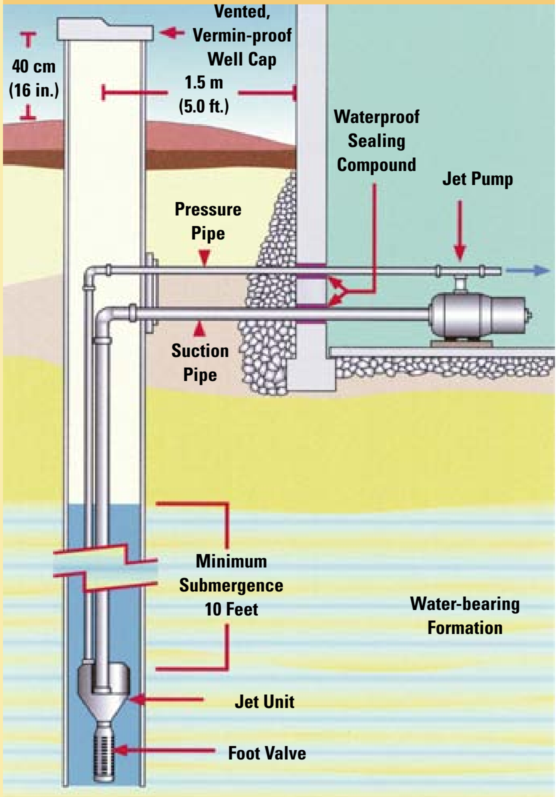
WELL BASICS

DEEP-WELL PUMPS

Deep-well pumps work in several ways.

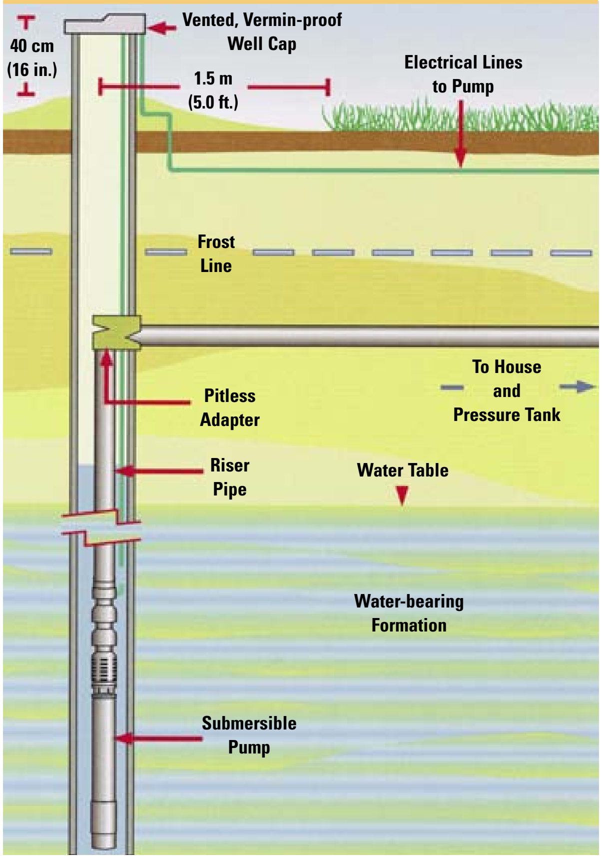
Reciprocating (piston) pumps work the same way as a hand pump. A motor sitting above the well moves a piston up and down inside a pipe in the well casing. On the upstroke, water is pulled into the pipe. A foot valve at the foot of the pipe prevents water from flowing out of the pipe on the downstroke.

CENTRIFUGAL PUMP



Centrifugal deep-well jet pumps work with two lines into the well. As water is moved at the surface by an impeller, some of the water is returned to the ejector assembly above the intake. This return water creates a "venturi" effect in the ejector, sucking well water through the check valve.

SUBMERSIBLE PUMP



Submersible pumps are long, narrow pumps that fit into the well and sit below the water level. They are connected to the surface by a plastic or steel pipe and a waterproof electrical cable. The water flow in the well provides cooling for the motor. This type of pump lasts longer in water that is sand- and gas-free.

WELL BASICS

SIZING THE PUMP

The size of the pump required depends on:

- the capacity of the well
- the demand rate for water, and
- the height of lift.

Your Water Well Record contains information pertinent to pump selection.

A well owner can check the yield of an existing well for which no well record exists. See the section on well yield on page 71.

The procedure for estimating daily and peak water demand, which will help you estimate water needs, is described on page 15.

If the pressure tank is too small, the pump has to come on frequently to maintain pressure in the water distribution system. Therefore, the size of the pressure tank is selected to provide enough storage to prevent excessive on/off cycling of the pump.

If the well yield is less than the estimated demand, additional storage capacity may have to be provided. This storage could be in reservoirs, water towers, cisterns or tanks. The pump capacity is not the same thing as the well yield.

GENERAL CONSIDERATIONS FOR PUMP INSTALLATION

Pump installations must be done in accordance with Ontario regulations. If you are in doubt, consult a licensed pump installer or the nearest office of your local agency responsible for regulating groundwater. In general:

- all connections between the pump and the well must be watertight to avoid well contamination and preserve water pressure – standard connections are shown in the construction diagrams later in this book
- the pump intake will pull sand and silt into the pump if it is too close to the bottom of the well, thus damaging the pump
- keep the intake securely positioned off the bottom of the well – this is especially important with dug wells
- low-producing wells (those that produce barely enough to meet demand) should have a control system to shut off the pump if the water level drops too far – this protects the pump from burnout if the water level drops below the intake

WELL BASICS

A pumphouse should be clean, insulated and weatherproof – and never used for any other purpose.

When working on a well, ensure that the components aren't contaminated with soil or other debris. Well components should be decontaminated after any work – inspection, maintenance or repair – is done on a well.

- all pumps, except submersible ones, need dry frost-proof housing
- if the pump motor is in a well pit or near the well, make sure that oil from the pump can't get into the well
- NEVER ENTER A WELL PIT without taking all the appropriate safety precautions
  - a well pit is a confined space – the absence of oxygen can cause accidents and death from suffocation
  - the presence of naturally occurring gases such as methane may cause an explosion, resulting in injury or death
- pumps must meet standards of the National Sanitation Foundation (NSF)/Canadian Standards Association (CSA)
- pump installations must meet plumbing and electrical codes
- pump capacity should never exceed well yield and available storage in the well
- if your submersible pump was purchased before 1981, check with the Ontario Groundwater Association – some pumps from this era contain PCBs, which should be properly removed and disposed.

BEST MANAGEMENT PRACTICES

NEW WELL CONSTRUCTION: LOCATION

Location plays an important role when planning a new well or upgrading an existing one. Well locations need to meet the minimum separation distances specified by your local provincial regulations. Greater separation distances should be allowed wherever possible. Current regulations (Regulation 903 – Water Wells) in Ontario require a minimum separation distance between wells and potential contamination sources.

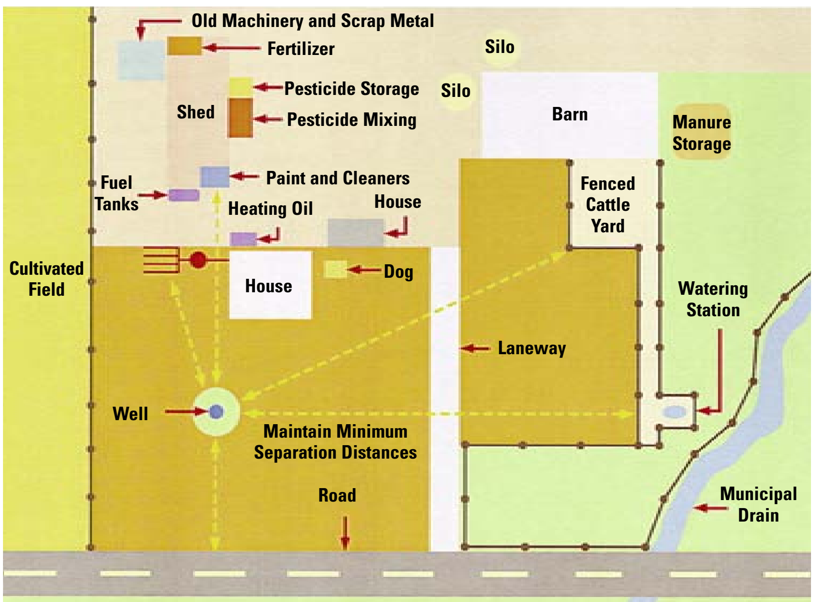
A well with a watertight casing to a depth of 6 metres (20 ft.) below ground must be at least 15 metres (50 ft.) from all potential contaminant sources. This requirement usually applies to drilled wells with steel casings with a minimum 6 metres of watertight casing.

Contact the nearest Ontario Ministry of the Environment office for updates to regulations.

A well with less than 6 metres of watertight casing must be at least 30 metres (100 ft.) from all potential contaminant sources. This requirement usually applies to dug or bored wells, even those deeper than 6 metres if the casing is not watertight to that depth.

The minimum separation distances alone don't ensure that the well will be safe from contamination.

Consider that effluent from a septic tile bed moves in the direction of groundwater flow, forming a long, narrow plume. A shallow well in sand directly in the path of the plume can become contaminated, even if it is 30 metres (100 ft.) away from the septic bed. Greater separation distances should be considered wherever possible.



Remember to take into account any contamination sources on nearby neighbouring properties.

This section describes:

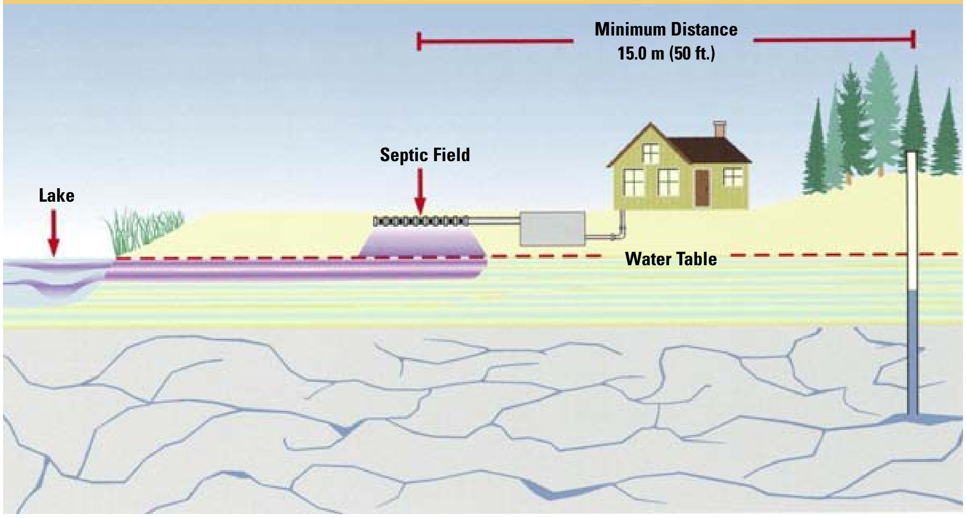
- **how to choose the best location for your well**
- **methods of constructing, upgrading and plugging drilled wells and large-diameter (dug or bored) wells**
- **well points and springs**
- **how to maintain and disinfect your well**
- **how to measure water levels and well yield**
- **how to monitor your well's performance**
- **groundwater treatment systems for domestic and agricultural uses.**

Proximity of the barn and house had a lot to do with the positioning of many older wells. Unfortunately, this sometimes heightened the risk of contaminating drinking water.

BEST MANAGEMENT PRACTICES

Generally, the direction of groundwater flow remains the same throughout the year. But where the ground surface is very flat, the water table may be similarly flat. In such cases, the direction of groundwater flow can actually change seasonally depending on the amount of recharge. For example, groundwater flowing northward most of the year may shift to north-west or northeast in the spring if there is a lot of recharge from melting snow and spring rains. A normally uncontaminated shallow well can therefore become contaminated for part of the year.

SEPTIC BEDS AND GROUNDWATER FLOW



Shallow groundwater aquifers tend to flow toward surface water bodies. Septic beds near coarse-textured aquifers can facilitate the transfer of contaminants to nearby lakes, rivers and streams.

To know with certainty the direction of groundwater flow, especially at greater depths, several test wells usually have to be installed and monitored. However, you can estimate the direction of shallow groundwater flow by making a few observations:

- look at how the ground surface slopes and the direction of bedrock bedding planes – shallow groundwater tends to follow the slope, flowing from high areas to low
- note the location of surface water features such as ponds, streams and drains – shallow groundwater tends to flow toward surface water bodies
- locate any tile drains – these also affect shallow groundwater flow direction.

BEST MANAGEMENT PRACTICES

A recommended practice is to locate a new well on ground higher than potential contamination sources (e.g., septic system), and not between streams and contamination sources. However, if the farmstead or rural home is situated on relatively flat ground with no surface water features, the direction of groundwater flow can't be easily determined. This is a special concern with shallow, dug or bored wells.

When the direction of groundwater flow is unknown, leave greater than the minimum separation distance between the well and potential contamination sources.

The Ontario Environmental Farm Plan Worksheets suggest a greater distance (90 metres or 300 feet) whenever possible. If an existing well is too close to contaminant sources, consider moving the source or consider another water source. It is easier to relocate a fuel tank now than to replace the well if an accidental spill occurs due to a leaking tank.

OTHER CONSIDERATIONS

To prevent surface water from ponding around the top of the well, locate it away from low areas or depressions. Slope the ground surface away from an existing well, and mound the earth around it, so that any surface water quickly flows away from the casing.

To allow easy access to the well for maintenance, repairs and inspection, the water well must be:

- away from overhead power lines and trees
- outside of buildings, basements and sheds
- not buried below ground surface but rather extended to the surface.

It is required that the well be accessible for cleaning, treatment, repair, testing and inspection at all times after completion.

For a poorly constructed well, there is no safe distance from sources of contaminants.

BEST MANAGEMENT PRACTICES

Wells positioned too close to roadways may be threatened with road salt and other contaminants.

The water quality in this well could be threatened by bacteria and nitrates originating from livestock manure. It's best to have a wider separation distance from such contaminant sources.

Parking areas can often pose problems with spills of motor oil, anti-freeze, and other compounds that can seep into the groundwater or enter directly through poorly constructed wells.

A tight-fitting cap should be installed and a permanent grass buffer zone maintained around this well to prevent entry of sediments, surface runoff, and possible pesticide drift.

BEST MANAGEMENT PRACTICES

DRILLED WELLS: CONSTRUCTION, UPGRADING, PLUGGING AND SEALING

CONSTRUCTION

Wells can be drilled into overburden or bedrock aquifers. The most common well drilling rigs are cable-tool drills and rotary drills.

Well casings installed in the drill hole keep the hole open and help to protect the well from contamination. For farm and house wells, the well casing:

- must be new for all wells
- may be made of steel, with a minimum wall thickness of 4.78 millimetres (0.188 in.), or fibreglass that conforms to the applicable standards
- have watertight joints, either solid welds or sealed with a waterproof material, then coupled
- is usually 12 to 15 centimetres (5 to 6 in.) in diameter, but can vary from 10 to 20 centimetres (4 to 8 in.).

Well drilling methods leave a gap **(annular space)** between the drill hole and the outside of the well casing. This gap must be sealed to at least 6 metres (20 ft.) below ground level with a material that will seal the space such as bentonite slurry, cement grout, or concrete. Without this seal, the outside of the casing acts as a path for surface water and contaminants to enter the aquifer.

► **Upgrading – see page 44**

► **Plugging and Sealing – see page 48**

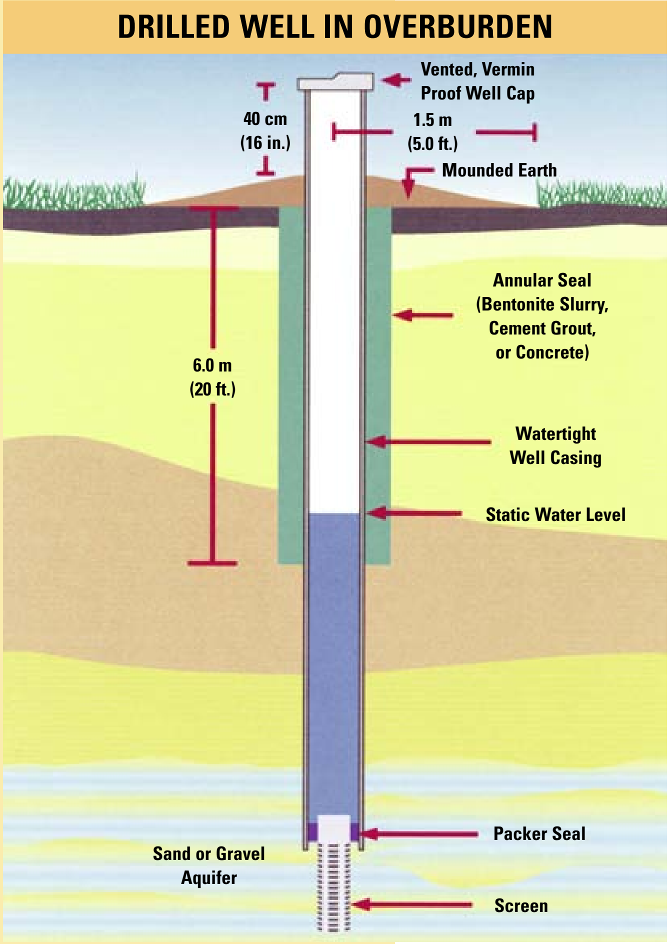
Contractors grout the annular space around the outside of the casing of a newly constructed well.

This is a problem situation: there is no watertight cap, and settling around the casing suggests a poor annular seal.

Joints between sections of steel casing are welded as they are lowered into the well.

If not sealed, the annular space around this drilled casing could convey contaminated surface water directly into the aquifer.

BEST MANAGEMENT PRACTICES



Wells drilled in overburden material will require a properly sized well screen.

Shown here is a stainless-steel well screen. The screen holds back sediments in the aquifer, while allowing the water to flow into the well casing.

The materials used for the annular seal are bentonite slurry, cement grout, or concrete (see page 59). The best way to ensure the annular space is properly filled is to use a tremmie pipe and fill the cavity from the bottom up.

The diagrams show recommended well construction standards for different drilled well types.

WELLS DRILLED IN OVERBURDEN

A well drilled into unconsolidated overburden such as clay, sand or gravel will not seal itself. The well contractor must grout/seal the area between the outside of the casing and the soil.

Here are some of the things to look for if your new well is drilled in overburden.

Well screens are needed in wells in overburden aquifers. A stainless-steel well screen at the bottom of the casing holds back the sediments in the aquifer, while allowing the water to flow into the well casing. Well screens are sized to maximize the efficiency and yield of the well. The well contractor selects the slot-size and length of the screen based on the grain-size of the aquifer material, the thickness of the aquifer, and the desired well yield. In some installations, specially graded sand or gravel is placed around the outside of the screen.

For all wells, after installing the screen, the driller must **develop** the well. This removes fine soil particles from around the screen and helps the well reach its maximum efficiency. (See page 17.) The well should be disinfected prior to use.

Some poorly constructed wells have no screens or have slots cut in the bottom of the well casing. Wells without screens, and those that are undeveloped, are inefficient. It costs more money to pump from them. Also, wells without screens may fail when pumping causes sand and gravel to heave up into the well casing. Overpumping makes this problem worse.

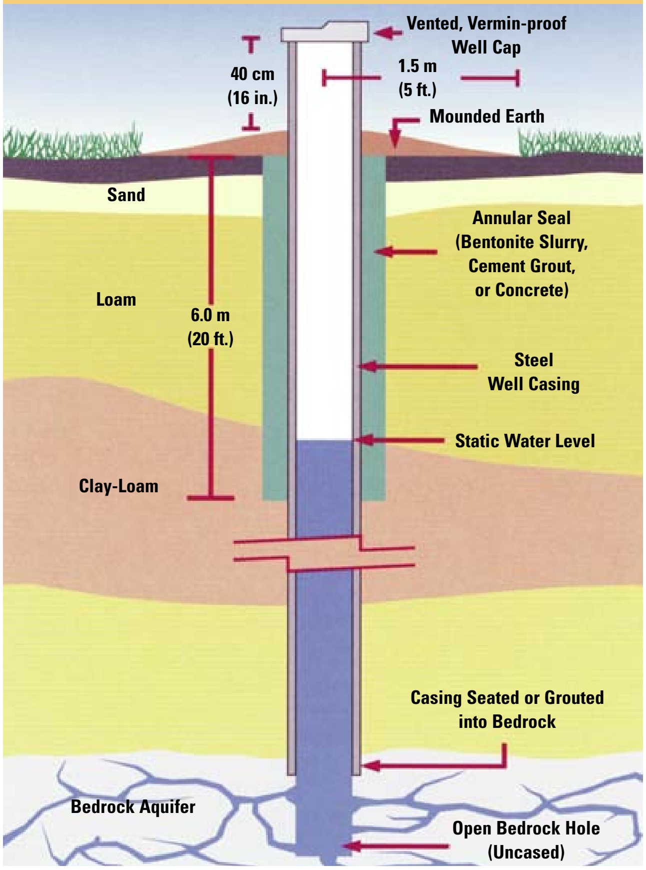
BEST MANAGEMENT PRACTICES

WELLS DRILLED IN BEDROCK

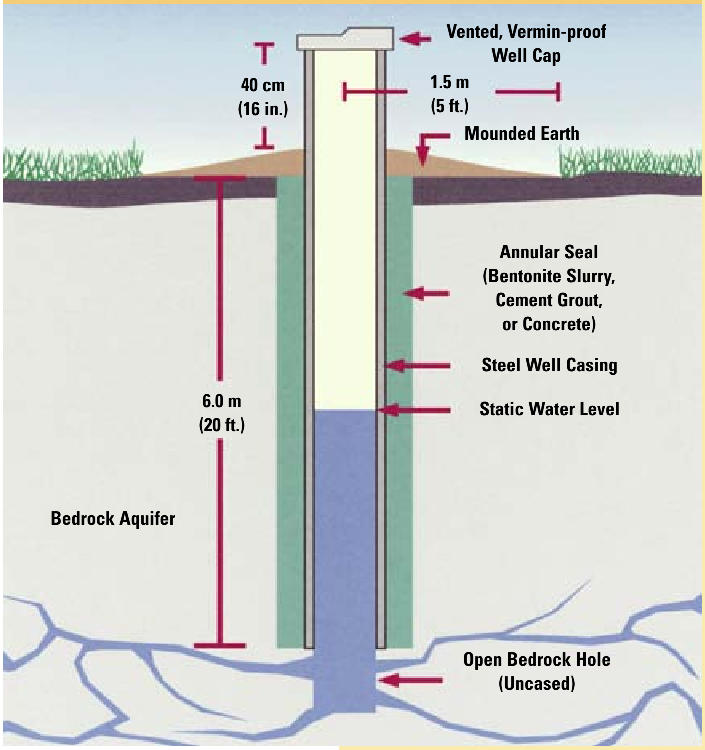
Bedrock wells are encased to at least 6 metres (20 ft.) below the ground surface. The casing is driven into solid bedrock or cemented at the bottom to keep sediment and foreign material out of the uncased open hole.

Where the bedrock in the aquifer is sound enough, no well screen is needed. Sometimes a slotted or louvered screen may be used to stabilize the hole where the bedrock is highly fractured or unstable.

DEEP-DRILLED WELL INTO BEDROCK



VERY SHALLOW-TO-BEDROCK WELL



Drilled wells into bedrock do not usually require well screens. However, note that the annular seal in the shallow-to-bedrock drilled wells should be at least 6 metres (20 ft.) in depth.

As with overburden wells, the bedrock well is developed to remove fine sediment from the fractures in the open hole. This improves the clarity of the water and the efficiency of the well. Following development, the well is disinfected with chlorine. (See page 73.)

BEST MANAGEMENT PRACTICES

FLOWING WELLS

Flowing wells occur when water pressure in the aquifer makes the water level rise above the top of the well. Improper well construction can result in uncontrolled flow of water from the well and sometimes around the outside of the casing.

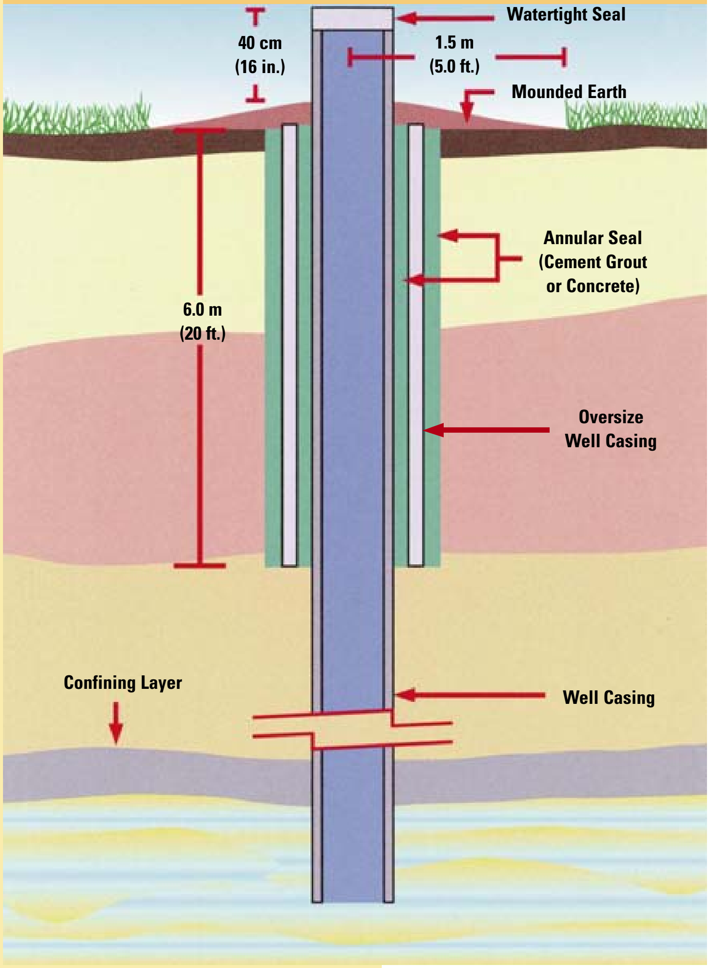
Flowing wells must be controlled. The risks of not doing so include:

- reduced artesian pressure and well yield
- waste of groundwater and interference with other groundwater users
- erosion and destabilizing of the ground around the well and neighbouring properties
- contamination of surface water.

To control this flow, a well contractor working in an area where flowing wells occur must use special construction methods:

- cement a second oversized casing around the well – this prevents uncontrolled flow around the outside of the well casing
- use a commercially manufactured well cap that allows for entry of pump lines and venting of the well, but controls flow out of the well.

SPECIAL CONSTRUCTION CONSIDERATIONS FOR A FLOWING WELL



To control a flowing well, a well contractor must create an oversized well casing. This prevents upward flow around the casing. Special well caps control flow out of the well.

BEST MANAGEMENT PRACTICES

If the water flow from the well or around the casing cannot be controlled, regulations require proper plugging and abandonment of the well. Plugging of flowing wells should be done by a licensed water well contractor. Some well contractors have walked away from flowing water wells. Be clear about who is responsible for the cost of controlling a flowing well. **The well contractor is responsible for stopping all flows *before* the well is put into use.**

Some flowing wells have been fitted with an overflow pipe for pressure relief. **This is not an acceptable construction practice.** Water in the overflow pipe or on the ground around the well can be sucked back into the well during pumping, causing well and aquifer contamination.

No flow-control device was included in the installation of this artesian well. The pressure has resulted in water flowing up the outside of the casing to the surface. This is poor workmanship.

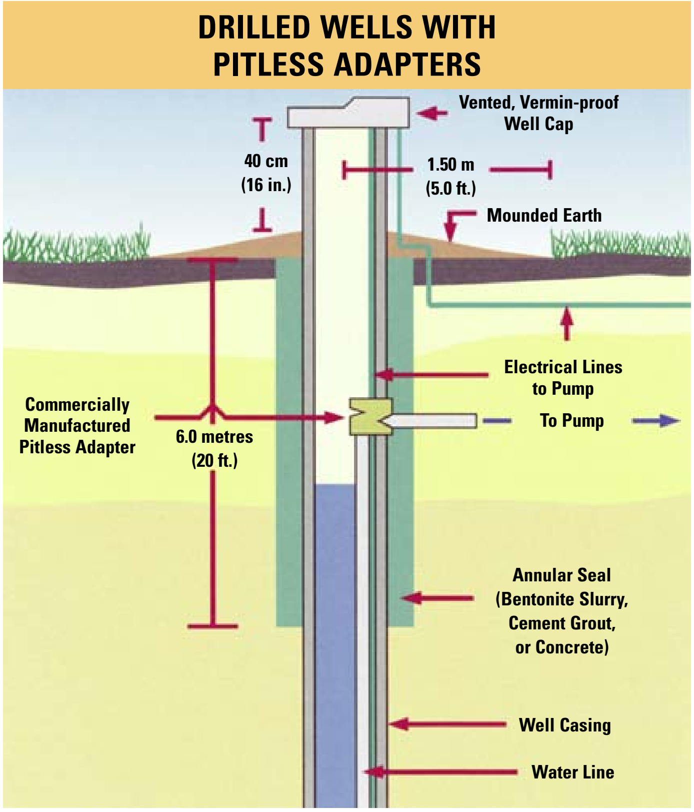
The relief valve on the casing offers some control of this flowing well. However, by itself it's not considered an acceptable construction practice.

BEST MANAGEMENT PRACTICES

Pitless adapters installed in the well casing below the frost line connect the water lines through the casing. The water line from the submersible pump is fixed to the component on the right, which slides into the sleeve of the component on the left, which extends through the casing.

DRILLED WELLS WITH PITLESS ADAPTERS

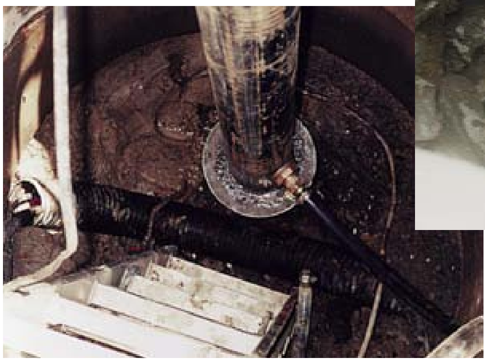
A commercially manufactured **pitless adapter** installed in the well casing below the frost line connects the water lines through the casing. The well casing extends above ground, making maintenance and pump servicing easier and ensuring that no surface water gets into the top of the well.



"A sanitary underground discharge assembly, called a pitless adapter, provides the most practical solution to the sanitary completion of the upper part of the well.... It provides a watertight surface connection for buried pump discharge or suction lines.... Until the development of the pitless adapter, installing pumps in pits below ground was common.... Pump pits are always unsanitary, and the pitless adapter provides a practical means of eliminating them."

Fletcher Driscoll, *Groundwater and Wells* (St. Paul: Johnson Division, 1986), pg. 627

These photos show pitless adapters installed during upgrade procedures. On the left is a drilled well in a pit, and on the right is a drilled well in an old dug well. (Both the pit and the dug well were later filled with clay material.)



BEST MANAGEMENT PRACTICES

DRILLED WELLS IN WELL PITS

Sometimes the top of the well is not finished above normal ground level, but instead is finished in a pit constructed below the frost line. This type of construction can lead to contaminated wells if the pit is not kept absolutely dry all year round. The well can become a drain for water and debris that collect on the pit floor.

Well pits can pose other serious health and safety risks. **A well pit is an enclosed space. Therefore anyone entering a well pit must take safety precautions.** Hazards such as natural gases that displace normal oxygen may collect in a well pit. Entering may result in suffocation. Explosions may also occur. A well pit is **not** considered a best management practice because it is considered dated technology. However, where there is an existing well pit, it should:

- be finished above ground level
- have solid walls and a cover
- keep precipitation and surface water out
- be vented
- be drained by gravity through tile if possible – otherwise, use an automatic sump pump
- have the top of the well casing at least 40 centimetres (16 in.) above the pit floor and have a sanitary seal over the opening to keep it clean.

To reduce the risk of surface water entry and the risk of explosion, it is better to use a pitless adapter, extend the drilled well casing above ground level and fill the pit in.

For further information about safety precautions when entering a confined space, see the Occupational Health and Safety Act.

The well cap is submerged in this pit. A faulty seal could lead to contamination of the well.

The abandoned drilled well in this pit has not been properly plugged. The situation invites serious contamination.

DRILLED WELLS INSIDE OLD DUG OR BORED WELLS

At one time a common practice was to drill a new well through the bottom of an old dug or bored well. The old well becomes a well pit.

The risk is that this construction allows surface water and shallow groundwater to enter the old well, and then drain into the new well. The result is contamination of the new well and of the aquifer. This method is seldom necessary and is **not** a good management practice. Extending the drilled well casing above ground and properly filling in the old well, after removal of a few metres of the old casing, is the preferred method.

Shown here is a drilled well inside an old dug well. Surface water and shallow groundwater can collect in the old well and drain into the new one, causing contamination problems.

BEST MANAGEMENT PRACTICES

BURIED WELLS AND WELLS INSIDE BARNS

Another practice was to cut off the well casing and to bury the wellhead below ground. The problems with this type of construction include:

- soil and vermin getting into well
- possibility of a contaminant (such as fertilizer, manure, chemicals) or a contaminant source (such as a septic system, feedlot, silo) being placed near or above the well
- lack of proper vents
- in the event of repair, inability to find the well when pump or other repairs are needed; also higher costs to access well
- possible gas buildup in well
- damage to the well during other excavation or construction.

This construction is highly susceptible to contamination and should never be used.

Wells inside barns and other buildings are susceptible to contamination from stored materials (chemicals, fuels and lubricants, cleaning materials, etc.) as well as from manure-handling operations, and roof and gutter drains. Moreover, a well inside a building may be inaccessible for repairs to the well or pump.

Wooden planks covering well pits are not watertight and can rot, presenting a safety hazard.

UPGRADING AN EXISTING DRILLED WELL

UPGRADE CHECKLIST

Check your well for the following:

✔ adequate distance between well and potential contamination sources

✔ a watertight well casing extending to a depth of at least 6 metres (20 ft.)

✔ the top of the casing covered with a commercially manufactured vented, vermin-proof well cap (for aboveground installations) or with a commercially manufactured sanitary well seal (when the well is in a pit or pumphouse)

✔ the ground sloping away from the top of the well or well pit

✔ well casing extending 0.4 metres (16 in.) above ground

✔ no holes or depressions around the top of well indicating the annular seal is settling

✔ the well cap or sanitary seal vented to equalize the pressure between the inside and outside of the well and to vent any natural gases

✔ screening of the vent.

If your well doesn't meet these standards, improvements should be made.

When upgrading an existing well, make sure the well casing extends 0.4 metres (16 in.) above finished ground level.

BEST MANAGEMENT PRACTICES

EXTENDING DRILLED WELL CASING

A drilled well casing should be extended above ground level in the case of:

- a well drilled through an old well lined with wood, stone, brick or cracked concrete tile
- a well finished in a wet, poorly constructed well pit
- a well buried below ground level or
- a well that is less than 0.4 metre (16 in.) above ground level or located in a depression.

Each situation will differ, but the procedure usually involves the following steps.

1. A backhoe opens a hole around the well, removing the old large-diameter casing or pit.
2. The condition of the steel drilled well casing is checked – if the casing is corroded or has other holes, the excavation is deepened to expose solid steel pipe and to remove the corroded section.

3. New steel casing is added to the top of the existing casing: the joint is either threaded, if a thread joint exists on the original casing, or welded using a collar between the two-pipe section. This joint must be watertight.
4. Any holes observed around the exposed well casing must be filled with proper sealing material.

5. A pitless adapter is installed through the new casing to allow the water lines to pass into the well through a sealed hole.
6. The excavation hole is backfilled and mounded with proper sealing material.

7. Further mounding of earth around the well will likely be necessary as the backfill settles.
8. A commercially manufactured well cap is secured on top of the steel casing.
9. The well is disinfected prior to use.
10. Planting a grass buffer around the top of the well, cutting the grass, and keeping vermin away from the well are recommended.
11. A revised Water Well Record is required from the well contractor or person doing the work.

BEST MANAGEMENT PRACTICES

Redeveloping wells involves clearing encrustation from the well screen, or removing plugs in the formation around the screen.

Because of the problems that may be encountered with corroded pipe, and the need to get a tight fit on the pitless adapter to create a watertight connection, this work is best done by a licensed well contractor.

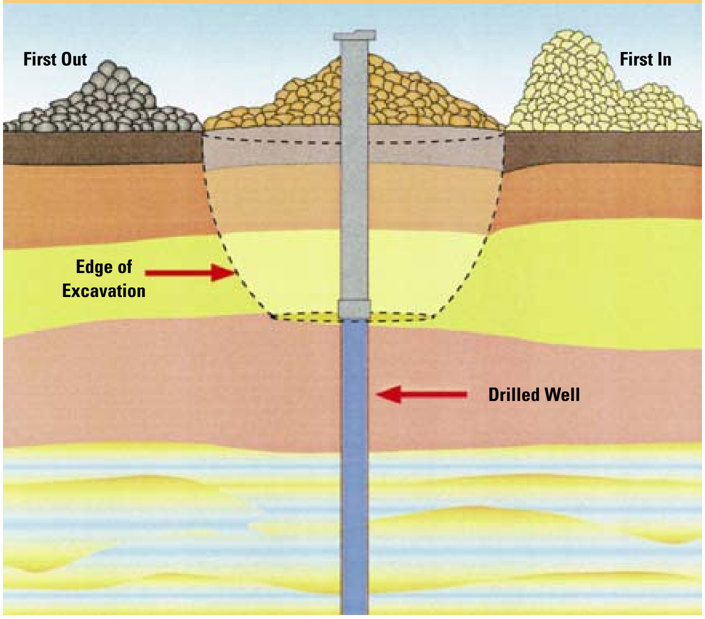
IMPROVING WELL YIELD

If no well screen was installed when the well was drilled, adding one may increase water flow and provide sediment-free water. Over time, wells with screens can experience reduced yields because of encrustation of the screen or plugging of the formation around the screen. Redeveloping the well may improve the yield in this case. Hire a licensed well contractor to select and install a well screen or to redevelop the well. Replacing or adding may be an expensive procedure. Be sure to get an estimate first.

RUSTED CASING OR SCREEN

Nothing lasts forever. After several decades, the well casing and screen may rust and develop holes or even collapse. A rusted casing will let surface water and soil into the well, impairing water quality and reducing well yield. You should get expert advice in repairing this condition. It may be possible to install a sleeve (a smaller-diameter well casing) inside the old casing. If the casing is badly corroded, the well should be plugged and replaced with a new one.

SOIL EXCAVATION



When excavating wells, or around wells, keep each soil layer separate and in sequence. When re-placing the soil, begin with the last (lowest) layer you removed, and re-place in reverse sequence.

BEST MANAGEMENT PRACTICES

CASE STUDY: WELLINGTON COUNTY, 1995

Prior condition: water and debris collected in pit, with risk of moving down drilled well casing.

A submersible pump was removed from well.

A backhoe removed well tile that served as the pit, and opened up hole around steel casing.

Steel casing was trimmed down and an adapter plate welded on to accept casing extension.

Hole was drilled through wall of casing below frost level to accept pitless adapter. Submersible pump was reinstalled with electrical service.

Hole was backfilled and mounded to direct all surface flows away. Electrical service was hooked up, and a tight-fitting vented cap secured. Total cost of materials and labour provided by a licensed well contractor was approximately $900. (The scope and cost of each job will of course vary. Always get an estimate.)

BEST MANAGEMENT PRACTICES

PLUGGING AND SEALING AN UNUSED DRILLED WELL

An open well no longer in use is a potential threat to groundwater quality in the aquifer and a physical risk to people and animals. It is the owner's responsibility to ensure that each unused well is properly plugged and sealed.

Because of the information needed and the equipment required to plug deep drilled wells, this is normally done by licensed water well contractors.

ESSENTIAL INFORMATION

The first step is to find out how the well was originally constructed.
Key factors include:

- total well depth
- depth of casing
- casing diameter and changes in diameter with depth
- presence of a well screen or open hole in bedrock
- static water level
- soil type or types the well passes through
- type of aquifer
- type of original sealing material, if any.

If no Water Well Record exists, the contractors must rely on measurements or their personal knowledge of local wells and groundwater conditions.

GENERAL PROCEDURE

Every well is different, and plugging and sealing procedures may be modified for each well. Your contractor should do the following:

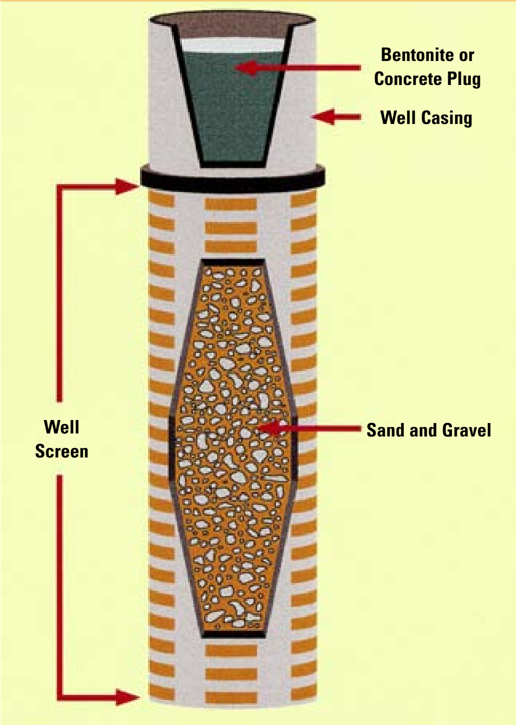
- remove the pumping equipment
- remove the entire length of casing from the hole, or, if the casing is old or corroded, leave it in place, puncturing if possible – ideally, the plugging material will seep through the casing to seal between the casing and the side of the hole (the annular space)
- disinfect the well
- fill the well screen or bedrock fractures with sand or gravel so that grout will not penetrate the aquifer and plug fractures or pores

BEST MANAGEMENT PRACTICES

- pump a carefully prepared plugging mixture, such as bentonite slurry and cement grout from the bottom to the top of the well through a pipe
  - as the grout or slurry fills the well, water in the well is forced out the top
  - if bentonite is used, it should be the type formulated specifically for plugging and sealing water wells
- do not pour dry bentonite into the top of the well because it can stick or bridge in the casing before reaching the well bottom — this leaves gaps in the seal, which can allow the entry of water and contaminants
- if the casing is left in the ground, cut the pipe off below ground level (at least 3 metres [10 ft.], if possible), and fill the bottom of the excavation and the space around the casing with the plugging mixture
- ensure the casing is deep enough so that future activities do not disturb the plugging mixture over the casing
  - the depth to which the casing is removed depends on the future use of the site, such as lawn, cultivated field or building foundation
- backfill the remaining hole with clean soil that is less permeable than the native soil (that is, containing more silt and clay **– remember the "last out, first in" principle when excavating and backfilling the hole**)
- mound the fill to allow for settlement
- prepare a Water Well Record showing the exact location of the plugged well and the material used
- keep the Water Well Record on file and give a copy to Ontario Ministry of the Environment if required.

Pouring dry bentonite down an unused drilled well casing may not form an effective plug. The material can stick or form a bridge in the casing, leaving gaps in the seal.

FILLING A WELL SCREEN



When a well is to be plugged and the screen left in place, the screen is first filled with sand and gravel to prevent the plugging material from moving into the aquifer. Nearby wells may be plugged or clouded by the travel of these materials. The same procedure applies in the case of wells with slotted casing instead of well screens.

BEST MANAGEMENT PRACTICES

CASE STUDY: OXFORD COUNTY, 1996

Prior condition: drilled well no longer used, 72 metres (216 ft.) deep into overburden, and located within a well pit. Surface water collects in pit and moves through cap into drilled well.

Landowner seeks professional advice and discusses options and costs.

The concrete cap is removed to reveal the pit. Plumbing and pressure tank were removed and discarded.

A slurry of bentonite clay and water was thoroughly mixed and pumped via a pipe to the bottom of the well. Filling from the bottom ensured a proper plug with no risk of the material bridging within the casing.

Water in the casing was displaced with the bentonite slurry. When the slurry reached the surface, it meant the entire casing was filled.

The concrete tile that served as the pit was removed, and the remaining hole back-filled with clean clay soil. The site was slightly mounded to direct surface flows away, and seeded to grass. Total material and labour costs were approximately $670. A Water Well Record describing the procedure was then filed with Ministry of the Environment.

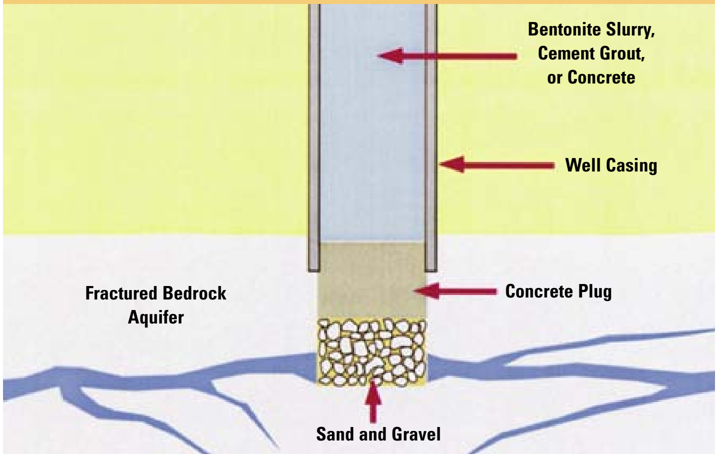
BEST MANAGEMENT PRACTICES

PLUGGING AND SEALING DRILLED WELLS IN BEDROCK

Before plugging a drilled well in a bedrock aquifer, the uncased part of the hole must be filled. Variations in the size and location of fractures in bedrock can make these holes difficult to plug. Groundwater flowing through large fractures can displace sand or cement grout. The recommended procedure is to place layers of gravel opposite the fractures and place grout between the gravel layers. This cuts off the vertical movement of water.

The locations of fractures may have been recorded in the Water Well Record. Otherwise, the contractor may have to use a special tool (called a hole caliper) or pump the well down to find the fractures.

PLUGGING AND SEALING DRILLED WELLS IN BEDROCK



Sand and gravel allow for the movement of water in the fractured bedrock. The concrete plug prevents any downward movement of water or contaminants.

Specialized video cameras can be lowered into well casings to enable specialists to view actual conditions at various depths. Inspections can be made of the casing and screen, and flow rate can be determined.

PLUGGING AND SEALING FLOWING WELLS

To plug and seal a flowing well properly, you must first stop the flow of water. Where the water level above the top of the casing is low, installing plugs, packers and heavy drilling mud, or extending the casing, may be enough to contain the flow inside the casing. Other cases may require drilling and pumping a second well to lower the water pressure in the aquifer. **These can be difficult wells to plug and always require the assistance of an experienced, licensed, water well contractor.**

Materials used for the annular seal include bentonite slurry, cement grout, or concrete.

BEST MANAGEMENT PRACTICES

LARGE-DIAMETER WELLS — CONSTRUCTION, UPGRADING, PLUGGING AND SEALING

CONSTRUCTION

▸ **Upgrading – see page 55**
▸ **Plugging and Sealing – see page 60**

Large-diameter wells are usually dug with a backhoe or bored with a well boring rig. Casings for constructing these wells may be:

- concrete tile, at least 60 centimetres (24 in.) in diameter and 5 centimetres (2 in.) thick, or made of 18-gauge corrugated, galvanized steel, or approved fibreglass
- made of new material with the concrete tile fully cured (up to 28 days).

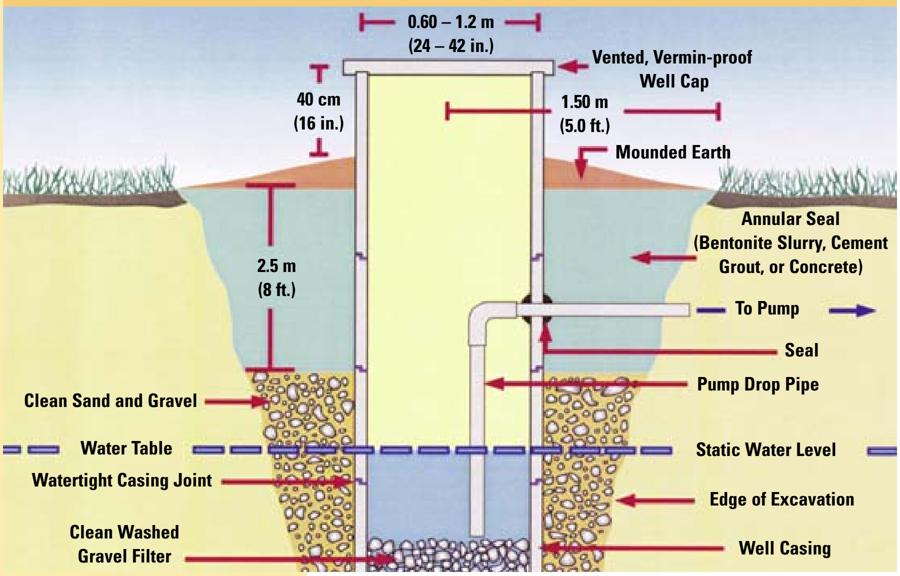
The upcoming diagrams show recommended well construction methods.

DUG WELLS

In the past, these wells were often dug by hand. Today, backhoes and power shovels are more common. The wells are shallow, seldom more than 9 metres (30 ft.) deep. They don't penetrate very far into the water table and can dry up if the water table drops during dry weather.

In dug wells, the annular space between the outside of the well casing and the edge of the hole is not always properly sealed because of the large hole dug to install the tiles. Shallow depths and poor seals make these wells susceptible to surface and subsurface contamination. Rubber rings are now frequently put in the joints between concrete tiles used as casings. It's extremely difficult to grout a large-diameter dug well properly. Make sure you watch the contractor grout between the tiles and annular space. Submit a Water Well Record on completion of a dug well.

BEST MANAGEMENT PRACTICES FOR CONSTRUCTING A LARGE-DIAMETER WELL



BEST MANAGEMENT PRACTICES

BORED WELLS

Boring machines make the hole for this type of well. The result is a much more controlled hole than the dug well. Properly constructed, bored wells can achieve a better seal.

Bored wells can be as much as 30 metres (100 ft.) deep, but average 15 metres (50 ft.). Some bored wells may go dry if not installed far enough below the water table, as a result of seasonal fluctuations in the water table.

WELLS LESS THAN 6 METRES (20 FT.) DEEP

Locating such wells far from potential contamination sources is very important. Use these wells as a last resort, where the shallow aquifer is the only source of water. Do not use a well less than 3 metres deep.

A proper bored well has a casing that extends at least 40 cm (16 in) above ground and a solid concrete lid that's vented and vermin-proof.

BEST MANAGEMENT PRACTICES

UPGRADING AN EXISTING LARGE-DIAMETER WELL

Check your well for the following:

✔ watertight casing to 6 metres (20 ft.) and no potential contamination sources within a minimum of 30 metres (100 ft.) – use casing without joints

✔ joints sealed with materials suitable for potable water supply – use a non-toxic, expandable material

✔ top of casing at least 0.4 metre (16 in.) above ground

✔ top of casing covered by a manufactured vented vermin-proof solid concrete or fibreglass lid to match casing (see illustration on page 52)

✔ ground sloping away from the well casing

✔ holes or depressions around the well, which indicate a malfunctioning annular seal.

Well casings in older wells came in all shapes and sizes – from 60 to 120 cm (24 to 48 in.) – and could be square, rectangular or round. Casings have been made of fieldstone, brick, concrete tile and even wood. Some exist that are combinations of two materials, possibly put in at different times.

With or without a proper cover, the brick lining on this old well can present problems.

These poorly maintained wells will not prevent surface water from entering. Water samples from these wells would have high counts for Total Coliform and possibly high counts for *E. coli.*

BEST MANAGEMENT PRACTICES

The tops of older well casings are seldom watertight. They rarely have an annular seal, and allow surface water to run freely into the well. In fact, some very poor wells are little more than collectors of rainwater and surface runoff.

Older wells were often finished at ground level, and if they had covers these decayed over the years. Today, many of these wells exist with only wood plank or scrap metal covers, or no cover at all – resulting in safety hazards.

IMPROVING WELL CONSTRUCTION

If your well doesn't meet minimum standards, but the casing is in good condition and located properly, it can be upgraded to improve the safety of the supply. Ensure that your licensed contractor uses the following procedures:

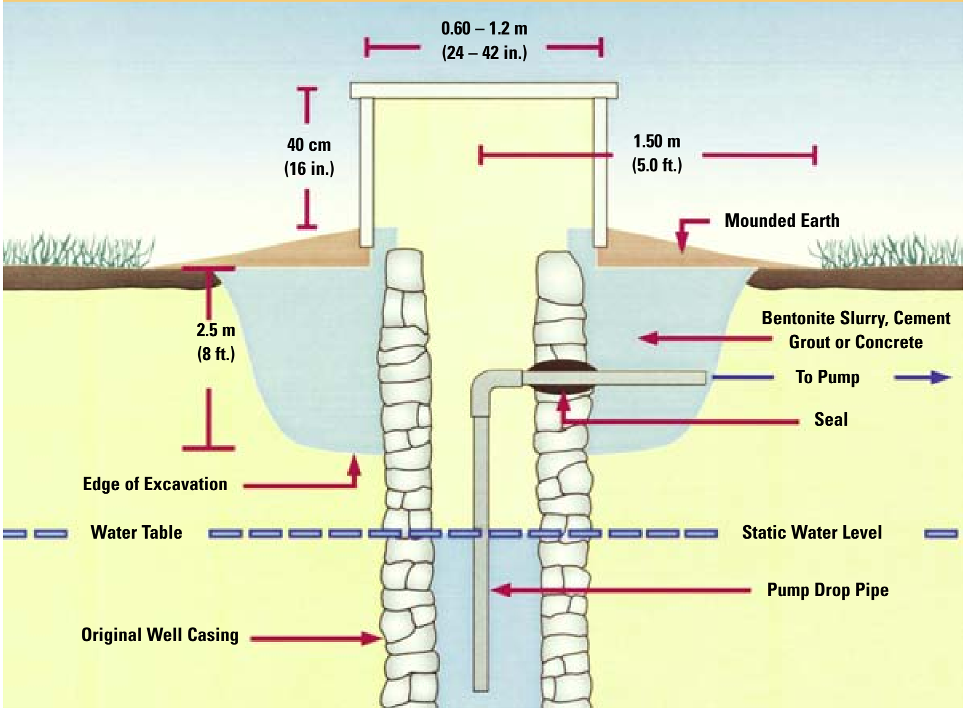
1. Excavate around the casing to a minimum depth of 2.5 metres (8 ft.) below ground:
   - deeper is better if the water table is low or the well is deep
   - try to keep the excavation narrow as it will later need to be sealed.
2. Add enough new concrete tile to the old casing to extend the top of the well at least 0.4 metre (16 in.) above the finished ground level.
3. Seal casing joints properly with materials suitable for potable water supplies (grout or non-toxic expandable seals).
4. If the new tile is a larger diameter than the old casing, overlap the casing joints and fill the space with proper sealant – using the same diameter avoids potential problems with frost heaving.
5. Seal the hole where the water lines enter the well from the pump.
6. Place a solid concrete cover over the top:
   - covers with cut-out sections in the middle make access to the well easier, but also allow easier access for contaminants, surface water and curious children
   - the top should be sufficiently heavy or secured so that it cannot be accidentally dislodged.
7. Fill the excavation around the well with bentonite slurry, cement grout, or concrete.

Beware: the sides of an excavated hole are prone to collapsing, so take appropriate precautions.

The finished casing height on this well satisfies the 0.4-metre (16 in.) minimum. A concrete lid is secure, and the surrounding lawn provides added protection – assuming fertilizer and pesticide use is kept back a recommended minimum of 3 metres (10 ft.).

BEST MANAGEMENT PRACTICES

IMPROVING WELL CONSTRUCTION FOR A LARGE-DIAMETER WELL



Poor covers and poorly sealed casing pose the greatest risks for contamination in a large-diameter well. The well can be improved by sealing the annular space outside the well, by replacing the cover, and by mounding earth to divert surface flow away from the top of the well.

8. Mound up the ground around the outside of the casing with a clean clay to direct runoff away from the well. Place a thin layer of topsoil on added material to establish sod and provide safer footing.

9. Plant a grass buffer at least 3 metres (10 ft.) around the well.

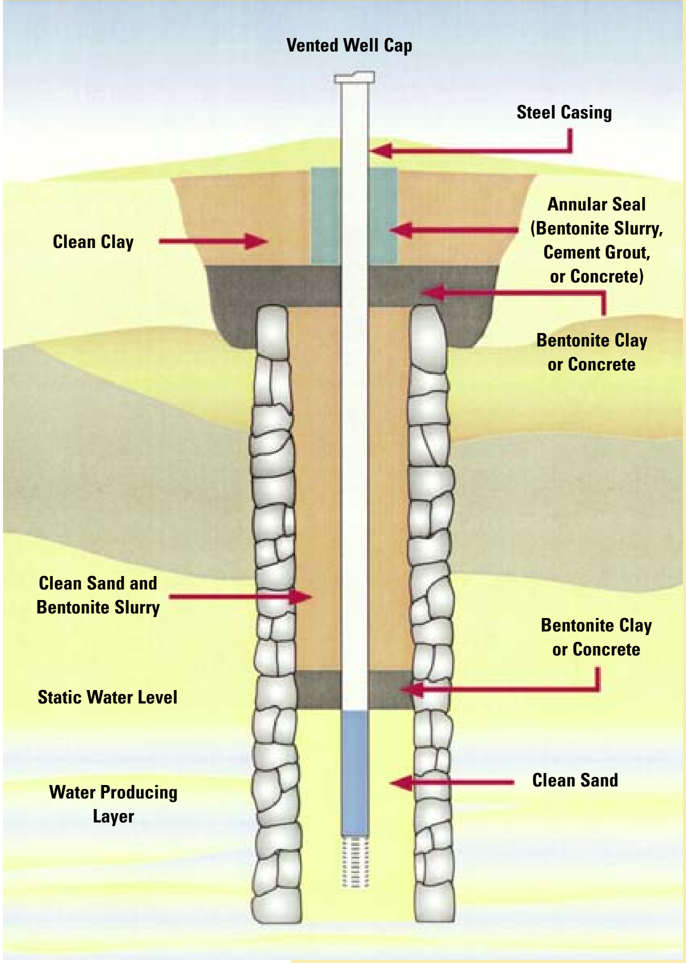
BEST MANAGEMENT PRACTICES

ONE OPTION FOR IMPROVING A LARGE-DIAMETER WELL

If the large-diameter well is constructed of cribbed stone, brick, or tile of questionable quality or condition, the following procedure is an option to consider to improve the safety of the supply. Because of the nature of the improvement and the equipment required to complete the steps, this procedure should be done by a licensed water well contractor. The best option may be to properly plug and seal the old well and replace with a new well.

1. Remove all piping and equipment from the water well.
2. Position a steel casing equipped with a screen into the well.
3. Fill the large-diameter well with clean sand up to the static water level of the well.
4. Place a 20-centimetre (8-in.) layer of bentonite or concrete on top of the clean sand.
5. Remove approximately 3 metres (10 ft.) of the old casing wall.
6. Fill the old well hole with clean sand and bentonite slurry. Maintain 0.3 m (12 in.) of bentonite slurry on top of sand as it is being added to the 3-metre (10-ft.) mark. Remember to install the pitless adapter at the appropriate depth.
7. Place another 20-centimetre (8-in.) layer of concrete for further protection.
8. Fill the remainder of the hole with clean clay material. Grout the annular space.
9. Mound the ground around the casing and establish a 3-metre (10-ft.) grass buffer strip around the well.
10. Finished casing height should be a minimum of .4 metre (16 in.) above the final ground level.
11. Install a proper well cap.
12. A revised Water Well Record is required from the well contractor or person doing the work.

ONE OPTION FOR IMPROVING A LARGE-DIAMETER WELL



BEST MANAGEMENT PRACTICES

CASE STUDY: ELGIN COUNTY, 1995

Prior condition: the hand pump was no longer used, surface water and debris were allowed to enter through wooden lid and cracked concrete casing, and field crops were planted right up to wellhead. This unused well posed a risk to groundwater from pesticide and fertilizer application on adjacent cropland.

A new concrete well tile was fitted over and around existing tile. The outer seal was provided by bentonite clay.

The inside space between the old and new tile was grouted with a concrete mixture to prevent entry of surface water.

A tight-fitting concrete lid was secured, and ground sloped away to prevent surface water ponding. Total cost for materials and labour provided by a licensed well contractor was approximately $400. (The scope and cost of each job will vary. Seek estimates first.)

A permanent grass buffer (3 metre [10 ft.] minimum) will be established around the wellhead to keep cropping activity at a safe distance.

BEST MANAGEMENT PRACTICES

You should replace a large-diameter dug or bored well when:

- ► the location is vulnerable to contamination
- ► the yield or quality of water is too poor to meet your needs
- ► the casing is in bad condition (cracked, leaking, rusted, etc.)
- ► the casing is made of wood or stone cribbing.

IMPROVING WELL YIELD

It's difficult to improve yields of dug or bored wells. Deepening the well may be an option if the water table has dropped. A deepened dug or bored well must meet well construction regulations.

USING A LARGE-DIAMETER WELL AS A CISTERN

Adding water to a well is a high-risk procedure. Materials attached to the casing above the water level and any source of contamination (e.g., organic debris) may become dislodged and contaminate the water in the well.

If you're adding water, **know what you're adding**. Test the water to be added prior to adding it, and then test the well water after the water's been added, before you use it. Consider using a holding tank instead.

Also:

- ► never run an eavestrough into a well – the water picks up bacteria and other substances that collect on the roof
- ► collect rainwater in a separate tank installed away from the well
- ► never use rainwater for drinking.

Many years ago, farmers in drier regions ran tile drains into wells to store water for later use, especially for livestock watering. Efforts to eliminate these high-risk structures have been largely successful. However, if you find an abandoned well on your property in this condition, you must eliminate the tile drain connection, and plug and seal the well.

Bentonite, a type of clay that comes from the erosion of volcanic rocks, is mined in western Canada and the United States. Its uses are varied and include paints, plastic filler, drilling mud, and even food additives.

Because of its great ability to absorb water and swell when wet, it has become a standard product in the well drilling industry as a drilling mud additive or alone for sealing annular spaces and plugging and sealing unused wells.

It's available from most well contractors and industry suppliers in 25-kilogram or 50-pound bags, in granular form. If you purchase bentonite, be aware that it is processed for different uses. Specify bentonite for plugging. The powdered bentonite is designed to be mixed with water to form a slurry that can be used as a drilling mud or as a sealing grout pumped in place with a tremmie pipe. Bentonite for animal feed should never be used to fill a well.

The granular plug is available in two formats. The preformed pellets are designed to swell more rapidly, and are perhaps delivered down holes with less bridging. Contractors may use these during plugging and sealing to seal tight spaces such as the annular ring around a casing or down a casing that cannot be removed. The other form of bentonite for plugging is an irregular granular material that resembles gravel.

BEST MANAGEMENT PRACTICES

Because it swells when wet, bentonite is put to a number of uses in well construction and maintenance.

Bentonite for plugging is available in pellet and granular form.

PLUGGING AND SEALING AN UNUSED LARGE-DIAMETER WELL

A well no longer being used is a threat to the quality of water in the aquifer and a physical danger to people and animals. It is the owner's responsibility to properly plug and seal these wells.

The main goal in plugging and sealing a well is to stop the direct movement of water from the ground surface down the inside or outside of the well casing to the aquifer. This means removing the casing or making sure both the inside and outside of the casing are sealed. You must also ensure that the annular space is properly sealed by removing the water well casing or at least the upper few tiles.

Other reasons to properly plug and seal unused wells are to maintain water levels in aquifers and to prevent mixing of different quality waters from different aquifers.

ESSENTIAL INFORMATION BEFORE YOU START

The first step is to find out how the well was originally constructed, i.e.,

- total well depth
- depth of casing
- casing diameter and changes in diameter with depth
- static water level
- type of aquifer
- annular space seals, if present.

A Water Well Record may contain this information, but may not be available for some dug wells, especially those constructed before 1950. If the well is shallow, much of this information can be observed directly or measured. See the section on Measuring Your Well on page 67. For most wells, it may be necessary to have the well contractor do the work.

HOW BENTONITE SWELLS WITH WATER

Water added to bentonite.

Swelling starts.

Swelling complete.

BEST MANAGEMENT PRACTICES

GENERAL PROCEDURE FOR PLUGGING AND SEALING A LARGE-DIAMETER WELL

No two wells are the same and there are many variations in well construction. It is impossible to provide detailed summaries for every situation. The following is a general method suitable for shallow wells in a water table aquifer.

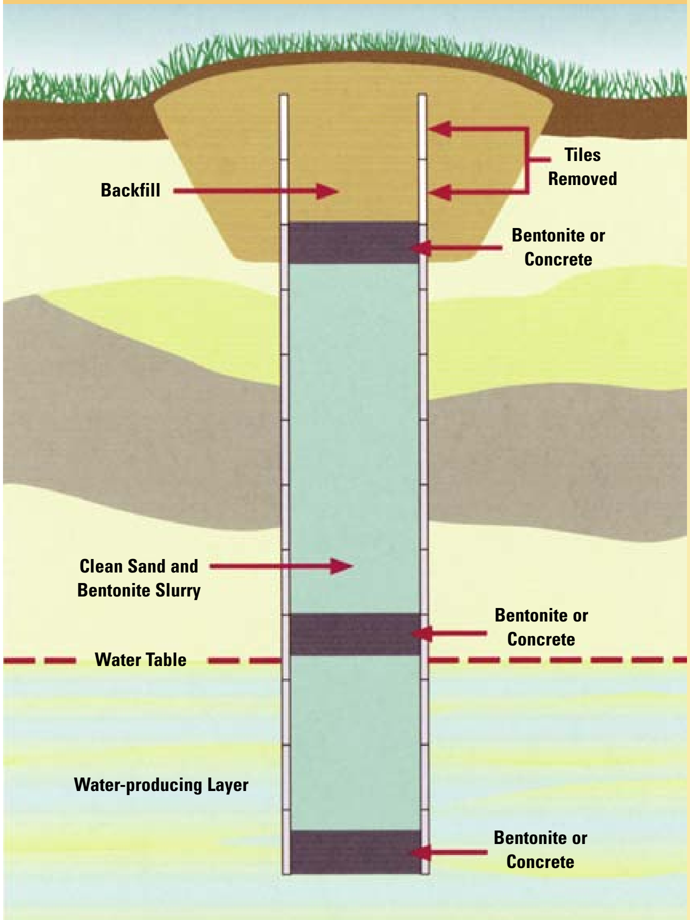
For a 9-metre (30-ft.) well with water at 6 metres (20 ft.) from the soil surface, use the following procedure.

1. Remove all pumping equipment, debris, and piping from well.
2. Disinfect with chlorine for 12 or more hours, then pump all water out of the well.
3. Fill bottom 0.3 metre (1 ft.) with granular bentonite, add water and wait 30 minutes.
4. Pour clean sand and bentonite slurry up to 3 metres (10 ft.) from the soil surface. Maintain 0.3 metre (12 in.) of bentonite slurry on top of sand as it is being added.
5. Remove top two or three tiles 2.5 metres (8 ft.), plugging any holes or cavities found on the outside of the well tiles.
6. Pour 0.3 metres (1 ft.) of granular bentonite 3.0 to 2.5-metre (10 to 8-ft. depth) both inside and outside the remaining tile to form a blanket.
7. Backfill with impervious subsoil and topsoil materials. Use the last out, first in method.

Recent demonstration projects showed that this work can generally be done in less than a day at a cost of between $400 and $1000. If you have a unique situation or you don't have clear answers to all the necessary questions, contact a local well contractor experienced in well plugging and sealing.

This method can only be used in lower yielding wells where the water can be pumped out faster than it recharges.

PLUGGING AND SEALING A LARGE-DIAMETER WELL



BEST MANAGEMENT PRACTICES

CASE STUDY: WELLINGTON COUNTY, 1996

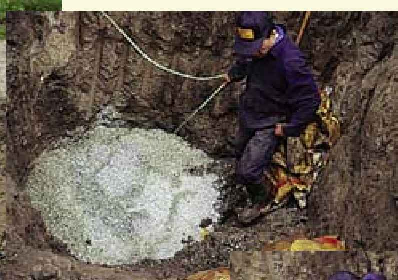
Prior condition: old dug well had been replaced with a drilled well nearby, and old well presented a risk to groundwater quality and personal safety.

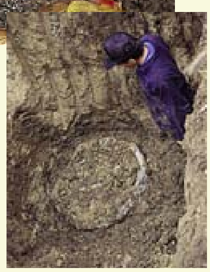
Consultation was made with a licensed professional to discuss options and cost.

Standing water was removed with a submersible pump.

Bentonite clay was added to form a plug at the water-bearing layer.

Clean clay fill was added to within 3 metres (10 ft.) of the ground surface.





Top few concrete well tiles were removed. A second plug of bentonite was placed over the remaining tiles to prevent any downward movement of liquids into the old well.

Hole was filled in with clay soil, mounded to direct away surface flows, and seeded. Total cost for materials and labour provided by a licensed contractor was approximately $600*. A Water Well Record describing the procedure was then filed with the proper authorities.

* The scope and cost of each job will vary. Seek estimates first. Also, check for any regulatory updates.

BEST MANAGEMENT PRACTICES

CASE STUDY: WELLINGTON COUNTY, 1995

Prior condition: bored well had not been used for decades, and the only protection was a steel mesh grate. The situation presented a risk to groundwater quality and personal safety.

Licensed contractors were hired to plug the well. Pea gravel was added to the well to provide a solid base over some rock and other debris that had been pitched into the well over the years. In some cases, debris removal would be required.

A plug of bentonite clay was formed at the water-bearing layer.

Water was added to activate the bentonite clay. Clean clay soil was added above the bentonite plug to within 3 metres (10 ft.) of the ground surface.

The upper concrete well tiles were removed to expose the clay soil fill.

A final plug of bentonite was created to prevent any movement of liquid down the old casing.

The hole was filled with clean clay soil, mounded to direct surface flows away, and seeded. A Water Well Record describing the procedure was completed and filed with the authorities. Total material and labour costs were $695.*

BEST MANAGEMENT PRACTICES

WELL POINTS AND SPRINGS

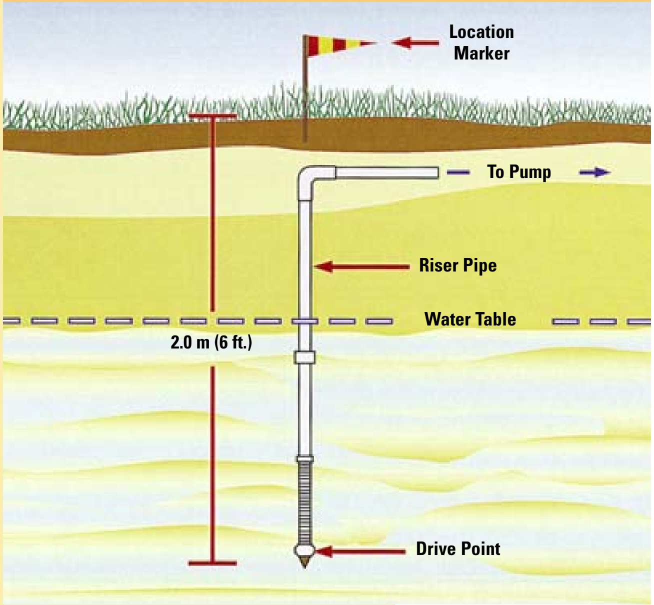
WELL POINTS

These wells are used in shallow, uniform, sand aquifers and for this reason are often called sand points.

They are used where:

- ▸ the water table is very shallow
- ▸ the aquifer is within about 5 metres (16 ft.) of surface
- ▸ the aquifer is loose sand and gravel, and free of stones.

WELL POINT INSTALLATION



This illustration shows a typical installation. It is better, and in some cases required, that a riser pipe be extended to the surface.

Since well points are located in materials with high infiltration rates and a shallow depth to the aquifer, they are **high-risk water supplies.**

Well points are usually 2.5 to 5 centimetres (1 to 2 in.) in diameter and made of stainless steel, forged steel, or brass. They may be driven or jetted into the ground. Jetting requires a high-capacity pump and a jetting tool (or a jetting shoe attached to the end of the well point). A stream of water is pumped through the tool into the ground. The erosive action of the water creates a hole for the well point.

Connecting several well points to one pump increases the water yield. The points should be spaced apart to avoid interference between them. The proper spacing depends on the thickness and permeability of the aquifer and on the expected pumping rate.

Removal of well points can be accomplished by pulling (e.g., with a winch) or jetting. However, this leaves a cavity, which, because it tends to collapse easily, is difficult to properly plug and seal. An alternative is to plug the well point with cement slurry or cement slurry with bentonite (5%).

IMPROVED SPRINGS

Water yields from springs are unreliable. They are subject to seasonal fluctuations according to changes in water table depth, which in turn is affected by precipitation patterns.

Groundwater springs often occur on hillsides where the ground surface crosses the water table. They are easily accessible as a water supply but must be collected or captured in a sanitary fashion to prevent surface contaminants from entering the water supply.

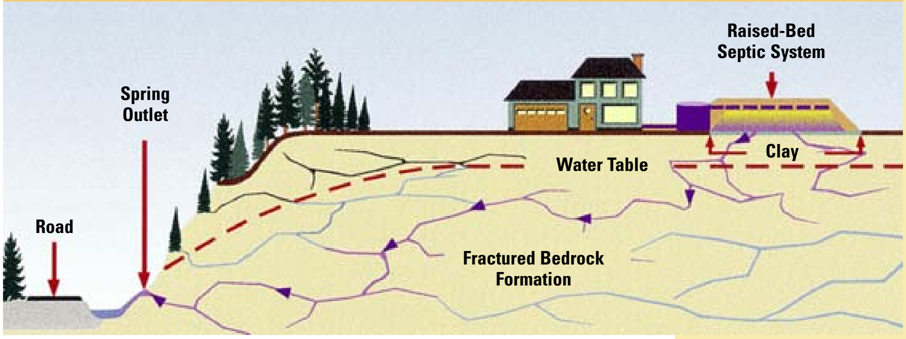
The groundwater discharging at a spring may have been in the ground for only a short time. Contaminants from human activities uphill from the spring can reach it in a very short time.

BEST MANAGEMENT PRACTICES

There is also difficulty keeping surface water out of the collection system. Water from improved springs may not be fit for human consumption. Spring water should be tested frequently before any use as a drinking supply. Spring water is best used for livestock water only.

SPRINGS: DISCHARGING GROUNDWATER

Spring water should be tested prior to consumption. Some spring water – like that in shallow, bedrock aquifers – may have been in the ground for only a short period of time.



WELL MAINTENANCE

The water well, like any piece of equipment, has a limited lifespan, and needs preventative maintenance to keep it working properly. We forget our dependence on our wells until they break down. The following checklist will help keep your well in top condition.

When it comes to maintenance, your well is your responsibility.

Install anti-backflow devices on all outdoor faucets. The devices cost only a few dollars and are available in brass or plastic.

Using clean clay, mound the ground around the outside of the well casing.

BEST MANAGEMENT PRACTICES WELL MAINTENANCE

Visible cracks in the casing should be sealed promptly.

Well Maintenance Checklist

✔ Know where your well is located. Extend the casing above grade, if buried.

✔ Watch for changes in the taste, odour and colour of the water.

✔ Have a sample tested for bacteria at least 3 times a year or every 3 to 4 months – more often if problems are suspected or if the well is very shallow. (See the section on monitoring your well.)

✔ Sample for other chemicals if you have concerns (e.g., fuel spills).

✔ Test for nitrate-nitrogen every year. Note: test for sodium plus nitrate-nitrogen to verify contaminant source from septic system.

✔ Disinfect the well with chlorine after doing any work on the inside of the well or after maintaining pumping equipment.

✔ Inspect the inside of the well at least once a year. Early spring just after the snow has melted is a good time. Also,

- ► check the seal around the plumbing inlets into the well casing (dug or bored) or well pit, and replace sealing material if water is seeping in from outside the well
- ► look for seepage through cracks or stains on the inside of the casing; look for signs of surface water seeping or running freely into the well; then ensure all cracks or joints in the well casing are properly sealed
- ► remove any debris floating in the well and prevent further debris from entering the well
- ► compare your well construction to the diagrams that show proper techniques.

✔ Inspect the cover or sanitary seal for cracks and holes. Ensure the cover or seal is securely in place and watertight.

✔ Check the condition of well vents to ensure they are unobstructed and the vent is screened to prevent the entry of vermin into the well.

✔ Watch for settling of the ground around the outside of the well casing.

✔ Mound up the ground around the outside of the well or well pit with clean earth to direct surface water drainage away from the well.

✔ Keep all potential contamination sources (e.g., septic systems, land fills) away from the top of the well.

✔ Maintain a permanent grassed buffer at least 3 metres (10 ft.) around your well.

✔ When a well is no longer in use, plug and seal it properly.

✔ If you have lightning rod protection, do not ground system to your drilled well casing. Use a separate grounding rod.

BEST MANAGEMENT PRACTICES WELL MAINTENANCE

MEASURING YOUR WELL

Before you start repairs on your well, you need to find out more about the well. A Water Well Record contains all of the measurements, or you can ask the contractor who constructed the well. A copy of your record may be on file with the Ontario Ministry of the Environment. Since well records are not always available, especially for older wells, you may need up-to-date measurements. This section describes the measurements you can make yourself.

WELL CASING MAINTENANCE AND WELL CAP DESIGN

Well casings can be constructed with cement, stone, steel, PVC or fibreglass. By determining your well casing material, you can better identify the risks associated with your type of well construction. For example, a stone casing may indicate a high-risk dug well. Cement casings may have joints between casing sections that need to be inspected for leaks and may need sealing. Steel casings are subject to corrosion, which will limit the well's lifespan.

The inside diameter of the casing can easily be measured by the landowner.

CASING DIAMETER

Well casings keep the well hole open and are supposed to keep surface water and contaminants out of the well. Casings come in different sizes and types. For most purposes the diameter can be measured at the top of the well, where it extends above the ground or into a well pit.

A Water Well Record will show if the same casing has been used for the full depth of the well. Some wells have been constructed with more than one casing size or type. This becomes important to know when repairing or plugging and sealing an old well.

In very shallow large-diameter wells, where you can actually see the inside of the casing, changes in size and type will be obvious. For deep wells and smaller-diameter drilled wells, special equipment is used by well contractors to measure the full length of the casing.

BEST MANAGEMENT PRACTICES WELL MAINTENANCE

WELL DEPTH AND CASING DEPTH

Well depth can be measured by lowering a clean rope or long measuring tape to the bottom of the well. For consistency's sake, follow these steps.

1. Remove the well cap, cover or seal. Make sure this can be done without dropping soil or other material into the well. If the well is finished in a well pit with a sanitary seal, the pump or intake lines may be held in place by the seal. In this case it may be possible to use the vent hole instead. Talk to a local well driller to ensure that your well is not in an area of flowing wells before removing seal. See the caution on page 43 regarding entering well pits.
2. Attach a weight to the end of the rope or tape measure to pull the line down through the water and help detect the bottom. The deeper the water in the well, the heavier the weight will need to be.
3. If you have a submersible pump installed inside the well, care must be taken when trying to measure the depth past the pump. The measuring tape could get stuck in the pump intake or among the electrical cables leading to the submersible pump. You may first want to talk to your pump installer, who may know the depth of the well.
4. Record the depth measurement from ground level or the top of the well casing. Use the same measuring point for all other measurements.
5. Replace well cap, cover or seal to original position.

Remember that you will eventually be drinking the water that the weight, rope or tape measure passes through, so it must be clean. Disinfect it, if possible.
Add 10 millilitres of liquid chlorine laundry bleach to 10 litres of clean water and soak for 12 hours.

Depth measurement tells you the current total depth of the well. It cannot tell you if the bottom of the well is the bottom of the casing. Beyond the end of the casing, there may be a well screen or a section of uncased hole in bedrock. Alternatively, the bottom of the well may have filled in or caved in. Water Well Records contain this information, but if a record is not available or is incomplete, a well contractor with experience in your area may be able to fill in these details.

Look and listen for water actually running into the upper portion of the well through casing joints, cracks or holes.

BEST MANAGEMENT PRACTICES WELL MAINTENANCE

ANNULAR SEAL

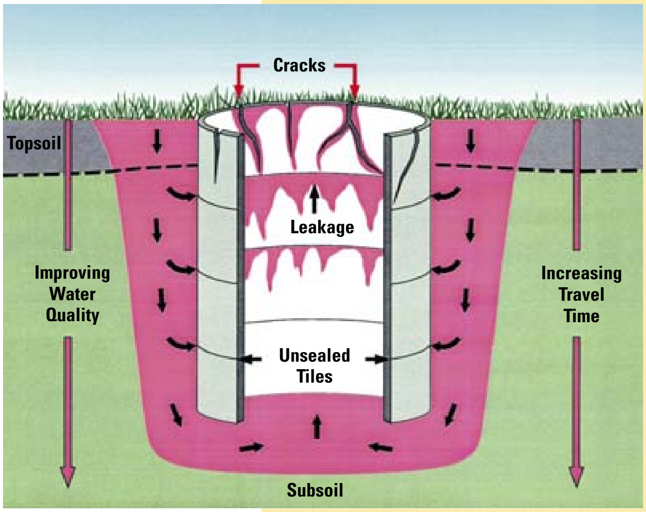
The annular seal is bentonite slurry, cement grout, or concrete placed between the outside of a well casing and the side of the hole. The construction diagrams in this book show the proper locations for this seal (see pages 38-40). Your Water Well Record may report if and where this seal was placed during well construction.

Groundwater should enter the well at the bottom, below the water level in the well. Water seeping through the casing just below ground level is probably surface water. This indicates that the casing is not watertight and that the seal is defective or missing.

Checking for the presence and condition of the seal may require careful digging around the outside of the casing. There are clues that can be used to detect a missing or leaking seal without digging. These do not work if the water level in the well is very high. Here's what to look for:

- water seepage or staining on the inside of the casing – this is difficult for drilled wells that have smaller diameter casings, but with a light it may be possible to see the upper part of the casing
- look and listen for water actually running into the well (see well upgrades for remedial actions)
- look for green, black or orange stains running down from casing joints, cracks or holes above the water level in the well – these indicate that surface water has been seeping into the well

If you detect a missing or improperly functioning annular seal, contact your local well driller.



The best time to check for seepage is in the spring when the water table is high or after a heavy rain. The best time to check for staining may be in the late summer or early fall when water levels are lower.

WATER LEVEL

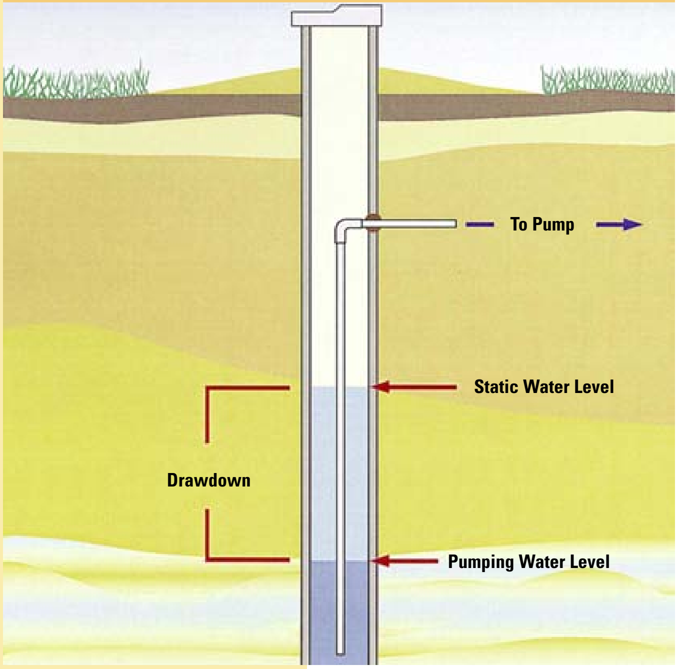
The water level measurements that you may need to know, or may want to measure yourself, are static water level and pumping water level. Mark water-level locations on the top of the casing.

A water well contractor takes these same measurements upon completing a well and notes them on the Water Well Record.

The static water level is the "at rest" level in the well (when the pump is not running). When the pump comes on and water is removed, the water level drops. How far and how fast it drops depends on the pumping rate, the permeability of the aquifer and the efficiency of the well.

BEST MANAGEMENT PRACTICES WELL MAINTENANCE

WATER LEVEL MEASUREMENTS



Periodic water level checks can help you identify if and when the water level has changed.

DRAWDOWN

The distance between the static water level and the pumping level is called the drawdown. If the static level is 2.5 metres (8 ft.) below the measuring point and the pumping level is 6.5 metres (21 ft.), the drawdown is 4 metres (13 ft.).

Measuring drawdown is an important step to ensure that the source water is adequate and not slowly being depleted. Drawdown data can be combined with well yield to evaluate the efficiency and performance of a well. Drawdown should be measured annually.

When the pump starts, the water level drops quickly at first, and then more slowly as the amount of water entering the well approaches the amount being pumped. This marks the pumping water level. A low-yielding well can be overpumped with the result that the pumping level drops down to the pump intake.

To measure water levels, you will need a way of detecting the surface of the water. Here are two different methods.

Subtracting the static level from the pumping level gives the draw-down due to pumping.

SOUNDING

A weight on the end of a rope or measuring tape makes a plunking sound when hitting the water surface. By raising and lowering the weight a few times and listening for the "plunk", a reasonably accurate water level measurement can usually be obtained. The measuring tape will give you a direct reading. The rope will have to be marked and the length measured as it is lifted from the well. Disinfect the well following this procedure.

Remember to turn off the power at the fuse-box or circuit breaker.

ELECTRICAL

It may be easier to measure levels using a light two-wire electrical line (speaker wire or lamp cord) and an ohmmeter or multimeter. Bare the ends of the wire that go into the well, but make sure the ends don't touch. Fixing a weight to the end helps keep the line straight. Attach the ohmmeter to the other ends of the wire. (Don't plug the wire into an electrical outlet.) When the bared ends contact the water surface, current travels through the water and the meter will indicate a complete circuit. The circuit is broken as soon as the wire is lifted free of the water. Measure the length of wire, or fasten a measuring tape to the wire for direct readings.

BEST MANAGEMENT PRACTICES WELL MAINTENANCE

Make a mark on the top of the well casing and measure to this mark every time. This allows all measurements to be compared. Remember that anything that goes into the well will be mixing with your drinking water, so it must be clean. Anyone who does this procedure should also disinfect the well.

MEASURING STATIC WATER LEVEL

1. Turn off the pump or stop all water uses – the pump must remain off until you finish the initial measurement.
2. If the pump has been running, wait 10 to 15 minutes for the water level to recover, then measure depth to water. Note that for tight formations such as clay, this may take several hours.
3. Wait another 10 to 15 minutes and measure again:
   - if the water level has risen, it is still recovering from pumping
   - repeat as necessary until the water level is stable – this is the static water level.

MEASURING PUMPING WATER LEVEL

1. Start the pump by using water or running an outside hose – the pump must remain on until your measurements are finished.
2. After 10 minutes, measure the depth to water.
3. Wait 10 minutes and measure again: you may have to repeat this several times until the water level starts to stabilize.
4. If the water level stabilizes, record this level and the time you measured it as the pumping water level for the size of pump in use.
5. If the water level does not stabilize, run the test for a fixed length of time, say 30 or 60 minutes, and record the level and time.

WELL YIELD

Take the following steps to test yield:

1. Stop all water uses for several hours or a day and measure the water level to the nearest inch. Measure it again in a half hour, and if it has not changed, this is the static level.
2. Run water from one source, such as an outside tap.
3. Run the water into a large pail (say, 20 litres) and time how long it takes to fill.

RULE OF THUMB

- **Disinfect any instruments you use for well maintenance.**
- **Test your well after maintenance procedures.**
- **Disinfect your well after any maintenance procedure.**

Pumping rate can be easily determined.

BEST MANAGEMENT PRACTICES WELL MAINTENANCE

By raising and lowering the weight on the end of the string a few times, and listening for the "plunk", a reasonably accurate water level measurement can be obtained.

4. Calculate the pumping rate by dividing the volume by the time, e.g., if a 20-litre pail fills in 1.25 minutes (75 seconds), the pumping rate is: 20 ÷ 1.25 = 16 litres per minute.
5. Continue pumping and measure the pumping level (see above); record the length of time the pump ran and the final pumping level.
6. Turn off the water.
7. If the drawdown is small compared to the depth of water in the well, then the well can produce more than the pumping rate.
8. If the well draws down quickly and the pumping level is close to the pump intake, the pumping rate exceeds the well's capacity.

Dividing the pumping rate by the drawdown will give you the specific capacity of the well. For example:

- the pumping rate = 16 litres per minute
- the static water level = 2.5 metres below the measuring point
- the pumping level = 6.5 metres below the measuring point.

The specific capacity is:

16 ÷ (6.5 – 2.5) = 16/4 = 4 litres per minute/metre of drawdown

3.5 gallons per minute ÷ (21 feet – 8 feet) = 0.3 gallons per minute/foot.

This number becomes useful if the yield test is repeated every couple of years. If the specific capacity declines, the amount of water the well can produce drops. Factors that contribute to a loss in specific capacity include plugging of the well screen or bedrock fractures around the well. Note: the maximum safe yield must not be exceeded. More than one test may be required to determine well yield.

An inefficient well uses more energy to pump water. There may be steps that a well contractor or pump installer can take to improve the performance of the well and return it to its original yield.

BEST MANAGEMENT PRACTICES

CHLORINATION

Handling of the pump or water lines can introduce bacteria into the well. Anytime a well or water system has been opened for repairs, it must be disinfected. Chlorine is used to kill bacteria in a well, pump and distribution system. Generally speaking, the goal is to attain three consecutive "negative" results. A negative result is 0 for *E. coli* and 0 for Total Coliform (T.C.).

Your well should be chlorinated:

- **immediately** following construction, maintenance, repair, inspection or upgrading – chlorination should be done by the contractor.
- if results from water well sampling and testing show **0 for *E. coli* but >5 for Total Coliform (T.C.)**. (Note: the water should be tested following chlorination.)
- if results from the first sample show **>0 for *E. coli.*** (Note: stop drinking the water, boil it or get a new supply. Re-test. Shock chlorinate.)
- if results from the second sample show **>0 for *E. coli*** or **>5 for Total Coliform (T.C.).** (Note: stop drinking the water, boil it or get a new supply. Re-test. **Shock chlorinate.**)
  - The owner should inspect the well or hire a licensed well contractor to inspect the well. This should be followed with shock chlorination.
  - Re-test. If you get two positive (undesirable) test results, hire a licensed well contractor to inspect the well for construction deficiencies and to investigate the source of contamination. If there's a problem, repair or upgrade. Shock chlorinate following inspection and repair work.
  - Re-test twice. If you get negative (desirable) results, test again. If you get positive test results, repeat the procedure.

There are two main methods of chlorination. **Shock chlorination** involves adding a large amount of chlorine to the water in the well and pumping it through the system. The chlorinated water is left in the system long enough to ensure complete disinfection. **Continuous chlorination** involves the continuous addition of low levels of chlorine to a water supply. Most municipal water supplies have continuous chlorination systems.

For shock chlorination, unscented liquid laundry bleach is the most common source of chlorine. Most brands contain 5 to 5.25 percent sodium hypochlorite. If you need to chlorinate a well, buy unscented fresh bleach to make sure it's effective. The chlorine in this solution is not stable and evaporates over time. Even if properly stored, the solution can lose half its strength in six months. If you use any chlorine compound with a hypochlorite concentration of greater than 5.25 percent (e.g., 40 percent muriatic acid), consult your local public health unit for recommended rates.

Continuous chlorination usually involves the use of an electric hypochlorite dosing pump that adds a small amount of chlorine whenever the well pump runs. This provides good protection from nuisance organisms that sometimes can make water undrinkable. If you do use such a system, remember to take water samples upstream

Some private well systems require continuous chlorination. Your local health unit or reputable water conditioning company can advise on appropriate treatments for your specific problem.

Chlorine can provide protection against most bacteria, but some dangerous microbes are resistant or immune to chlorine. A safe water source and properly functioning well are your best protection. Chlorine provides extra insurance.

BEST MANAGEMENT PRACTICES

Liquid bleach can be carefully administered to a well to control bacteria problems.

of where the chlorine is added. Otherwise, you're in danger of getting false-negative results. Use a swimming pool chlorine tester or colour wheel meter to set the chlorine level at about 1 ppm free chlorine. Check the level at least once every two weeks.

Water well contractors may use granular calcium hypochlorite to disinfect a well. This product, marketed under trade names such as Pit-Tabs and HTH Tablets, contains about 65 percent available chlorine.

CHLORINATION INSTRUCTIONS (USING LIQUID BLEACH FOR NEW WELLS)

As noted, well contractors must chlorinate new wells, and after well or pump repairs and upgrades. The following steps must be taken for proper chlorination:

1. Measure the diameter of the well.
2. Measure the well depth and the static water level, then calculate the height of water in the well.
3. Pour the required amount of liquid laundry bleach into the well. The table on page 75 gives the volume of bleach needed for different sizes of wells. With continued exposure, your nose loses its ability to detect chlorine.
4. If possible, agitate or mix the water in the well by using a clean hose to pump the chlorinated water back into the well, and flushing down the well casing and water lines above the water level.
5. Let the chlorinated water stand in the well for 12 hours.
6. Clear the chlorine from the well by pumping out the water through an outside hose – not down drains into septic systems.

If you have an existing well with repeated positive bacteria tests of your drinking water, you must chlorinate the well and the whole distribution system. Follow the steps just described, plus the following:

CHLORINATION INSTRUCTIONS FOR WELLS WITH REPEATED POSITIVE TESTS

DAY 1. SHOCK CHLORINATION

1. After adding chlorine to the well, remove or bypass any carbon filters that are in the system for water treatment. These filters will remove the chlorine from the water, and any pipes beyond the filter will not be disinfected.
2. Put in a new filter after chlorination to avoid reintroducing bacteria into the system.
3. Run water at every faucet in the house and barn until a strong chlorine odour is detected. Be aware that your nose may lose its ability to detect chlorine.
4. If there is no chlorine smell or it's very weak, add more bleach to the well.

BEST MANAGEMENT PRACTICES

5. Drain the water heater and fill with chlorinated water.
6. Backflush the water softener and all water filters (except carbon filters).
7. Let the chlorinated water stand in the system for 12 hours.
8. Clear the chlorine from the well by running an outside hose to the ground surface, then run clear water through the faucets. Avoid running water over the septic system.
9. Avoid putting too much chlorine into the septic system as the bacteria needed for septic decomposition will be killed.
10. Don't drink the water without boiling until test results show the water is safe to drink.

DAYS 3–4. RETEST TO CONFIRM WATER IS SAFE TO DRINK

1. Take a water sample for bacteria testing 3–4 days after chlorination.
2. If the test is clear, wait one week and retest. Two consecutive safe tests indicate that the treatment was effective.
3. If bacteria are still present, repeat chlorination and retest.

If the bacteria tests continue to be positive, it may be that the aquifer, not the well, is contaminated. The source of contamination needs to be identified and removed. If that's not possible, a new well must be constructed and the old one plugged, or continuous water treatment must be added to the system.

VOLUME OF UNSCENTED BLEACH ADDED FOR EVERY 3 METRES (10 FT.) OF WATER IN THE WELL

CASING DIAMETER		BLEACH VOLUME (5.0–5.25%)
mm	inches	mL
50	2	6
100	4	30
150	6	60
200	8	100
250	10	200
300	12	250
400	16	400
500	20	650
600	24	900
900	36	2000 (2 litres)
1200	48	3600 (3.6 litres)

If inspection and modification are unsuccessful, you may need to use continuous chlorination.

BEST MANAGEMENT PRACTICES

Deep wells with no history of bacterial contamination should be tested at least three times a year.

Sample bottles for bacteria can be obtained from your local public health unit. Home sampling kits may also be purchased commercially, and offer the homeowner a very quick indication of whether bacteria are present in the drinking water supply.

If you suspect pesticide contamination, secure the services of a commercial laboratory to help you decide what to test for, and how to collect the sample.

MONITORING

TESTING WATER QUALITY

The quality of groundwater in deep aquifers doesn't normally change from one season to the next, unless poor well construction lets surface water into the well. Seasonal changes in water quality in shallow wells can be quite noticeable. You owe it to yourself and your family to know what your water quality is and to monitor its changes.

If you're testing for more than indicator bacteria, water testing can get expensive, but there are several ways you can monitor water quality that don't require much time or expense.

1. Use your eyes and nose, but remember: water that looks, smells and tastes good may not be good.

- regularly inspect your well water and make notes on its general appearance (colour, cloudiness, presence of fine sand or sediment); also note the taste and odour of the water
- make special note of any sudden changes, and keep an ongoing record of your observations. Store these records where they can be easily retrieved.

2. Test the water for bacteria.

- have the water tested for the presence of indicator bacteria, i.e., Total Coliform and *E. coli* (this does not include the other biological contaminants described on page 24) – see sidebar on following page for more information
- all wells should be tested at least three times a year – you should sample at least every three to four months
- you may wish to test for bacteria more frequently if you've had a history of water quality problems or have a high-risk well (e.g., shallow to bedrock)
- check with local public health unit; in most cases, the test is provided free of charge.

3. Get a chemical test of your well water.

- many commercial laboratories offer a special test for drinking water (not for badly contaminated water) – this test measures most of the substances commonly found in natural waters, and gives you a benchmark for monitoring changes in water quality over time
- if nitrate is a problem in your area, you may have to ask for a test specifically for nitrate – some public health units or municipalities offer this service for a nominal fee
- test after weather events such as snowmelt, prolonged rain, or flooding; after the well has been out of use for a prolonged period; and after any maintenance work.

BEST MANAGEMENT PRACTICES

- test for petroleum compounds and manmade chemicals such as pesticides if your own observations suggest possible contamination
- call a commercial laboratory in your area to find out more about what you should test for and how to collect the sample: careful sample collection and storage prior to delivery to the laboratory are critical to ensure accurate results
- you can also get advice on water testing from your public health unit.

MONITORING WATER LEVELS

If you have access to the inside of your well, it's fairly easy to measure the water level. Doing this periodically will tell you how much the water level changes with the seasons. Regular water level monitoring in a shallow well can help alert you to potential water shortages during dry periods of the year. Keep a record of your water level measurements (see Measuring Your Well on page 67). See also the new publication available through Ontario Ministry of Agriculture and Food: *Private Water Well Owners – Dealing with Water Shortages.*

KEEPING TRACK OF MONITORING RESULTS

A simple record of your observations and test results will be very important in identifying changes in quality and possible sources of contaminants. Examples of recordkeeping sheets that you may find useful are included in the Appendices. It may be helpful to compare your monitoring results with the following chart. Keep all information pertaining to your well (Well Record, water quality, water quantity, test results, problems) in one location to provide solid historical documentation for future reference.

TEST RESULT OUTCOMES

Total Coliform per 100 mL *E. coli* per 100 mL	5 or less 0	No significant evidence of bacterial contamination	Three consecutive samples taken 1 to 3 weeks apart, with this designation are needed to determine the stability of the water supply.
Total Coliform per 100 mL *E. coli* per 100 mL	more than 5 0	Significant evidence of bacterial contamination	May be unsafe to drink. Consult your local public health unit for information as soon as possible.
E. coli per 100 mL	more than 0	Unsafe to drink. Animal or human waste contamination	Unsafe to drink. Evidence of animal or human waste contamination. Consult your local public health unit for information immediately.

When you test for biological contamination, the bacteria that are tested for in drinking water are called indicator organisms. The presence of indicator organisms acts as an early warning signal of health risks related to consuming your well water. Two common forms of indicator bacteria include:

- **Total Coliform**
  - **a general family of bacteria that are found in animal wastes, surface soils and vegetation**
  - **their presence is an early warning signal that there may be a problem with your water supply, possibly through surface water contamination**
- ***E. coli***
  - **a group of bacteria that live in the intestines of warm-blooded animals,**
  - **their presence indicates recent fecal contamination such as sewage, and that there is a problem with your water supply**

BEST MANAGEMENT PRACTICES

WELL TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSES
BACTERIA IN WELL (health-related)	• too close to contamination source (septic field, manure storage, etc.) • well casing not watertight or properly sealed • well cover old or cracked • well or pumping equipment not chlorinated after handling • aquifer has become contaminated
NITRATE IN WELL	• too close to contamination source (septic, manure, cultivated field) • top of casing not watertight or properly sealed • aquifer has become contaminated
GROUND SINKING AROUND WELL	• sealing or grouting material not properly compacted around well at time of construction • well casing not watertight; rain and snow runoff washing soil into the well
CLOUDY OR GRITTY WATER (may be constant or intermittent)	• sediment in the water • new well not properly developed after construction • pump intake too close to bottom of well or pumping rate too high • poor aquifer with too much clay, silt or fine sand • rusted casing or screen • no screen in a drilled overburden well • casing not properly seated into bedrock in a drilled bedrock well • well casing not watertight, surface water washing soil into well, especially after heavy rain or snowmelt • screen slot opening too large • sediment from bedrock aquifer
DECREASED YIELD	• collapse of well casing or screen • buildup of minerals or bacteria on the well screen • pump or pumping equipment malfunction • seasonal decline in water levels • long-term decline in water levels from over-pumping aquifer • interference from other pumping wells • yield actually unchanged, but owner has increased demand
NO WATER	• shallow well or poor yielding well pumped out: will recover with time • pump malfunction (electrical, mechanical) • distribution system malfunction (pressure tank, water lines) • interference from other large users; decline in static water level
CHANGE IN ODOUR, TASTE OR COLOUR	• change in water quality: have water tested • nuisance organisms
CHANGES IN WATER IN SPRING OR AFTER HEAVY RAINS	• surface water running into well through cracks in casing or cover, surface seal improper or inadequate

BEST MANAGEMENT PRACTICES

WATER TREATMENT

COMMON WATER QUALITY PROBLEMS

This chart lists common water quality problems that can be treated. Some of the substances occur naturally, but only become a problem because of poor waste management or well construction (e.g., bacteria, nitrate and chloride).

PROBLEM	CONCERN	SIGNS THAT INDICATE PROBLEM
HARDNESS	• aesthetic	• scale buildup on appliances, plumbing fixtures and pipes • soap scum, excess soap use
BACTERIA & VIRUSES	• health	• only detected by testing and may cause human health problems (fever, stomach cramps, diarrhea)
IRON	• aesthetic • clogs pipes	• rusty/black stains on plumbing fixtures, rusty/black water, metallic taste
NUISANCE BACTERIA	• aesthetic	• red/brown slime in plumbing fixtures, red filament-like particles in water, unpleasant taste and odour • decreasing well yield due to screen plugging
MANGANESE	• aesthetic	• black stains on fixtures and laundry, metallic taste
ACIDITY (low pH)	• aesthetic • health (from increased dissolution of metals)	• green stains on copper pipe, corrosion of pump
SODIUM	• health	• salty taste
CHLORIDE	• aesthetic	• salty taste, blackening and pitting of stainless-steel sinks
NITRATE	• health	• no signs, requires water test
SULPHATE	• health	• water has laxative effect
FLUORIDE	• aesthetic and health concerns	• mottled teeth at low doses, but at high concentrations can cause problems with bone development
ARSENIC	• health	• no indicator; must consult local public health unit

BEST MANAGEMENT PRACTICES

PROBLEM	CONCERN	SIGNS THAT INDICATE PROBLEM
HYDROGEN SULPHIDE & SULPHATE-REDUCING BACTERIA	• health	• "rotten-egg" smell, scale and black stains on pipes
METHANE GAS	• aesthetic • safety	• no odour by itself, but offensive odour if present with sulphide gases; gas bubbles in water; explosion/fire risk if not properly vented
DECAYING NATURAL ORGANIC MATTER	• aesthetic	• musty, earthy or wood smell
SEDIMENT	• aesthetic	• water cloudy or gritty

See the Appendices for local water quality guidelines for these and other substances.

MANMADE WATER QUALITY PROBLEMS

Other water quality problems are caused solely by human activities. It is possible to treat low levels of some manmade chemicals such as gasoline and pesticides.

Try to find the source of the contaminant. First, look for sources close to the well, such as a leaky fuel tank or an accidental spill of pesticide near the well. Fixing the leak or cleaning up the spill is necessary for water treatment to be effective.

BEST MANAGEMENT PRACTICES

STEPS FOR EFFICIENT WATER TREATMENT

1. Know what problems are common in your area and which specific problems you have in your own well: use your own observations and lab tests to decide if treatment is necessary.
2. Look for improvements in well construction that will improve water quality.
3. Consult your local health unit or a reputable water conditioning company about the type of treatment for your specific problem.

If treatment is necessary, keep the following points in mind.

No one treatment type solves all problems. There are more than 20 different treatment types for home use, including filters, chlorine pumps, permeable membrane systems and ultraviolet irradiation. Each has a specific purpose.

Some common problems can be treated easily and inexpensively. Others require treatment systems that are expensive to install and operate. Or, it may be necessary to find an alternative water supply, such as treated surface water, a deeper well, or a well at another location.

In most cases, it's worth the cost of paying extra to a reputable company for water treatment equipment and for certified products under the NSF trademark. Also, you can usually expect guarantees of effectiveness and expected useful lifetime from good suppliers.

All treatment systems need monitoring and routine maintenance. A charcoal filter on the kitchen tap may help to eliminate objectionable tastes. But if it's not changed frequently, the filter can actually provide a fertile place for harmful bacteria to grow.

Effective systems for treating surface water from lakes and rivers are particularly expensive to purchase, complex to operate, difficult to maintain, and complicated to monitor properly. They are not considered best management practices.

It's far better to get your water from a reliable source or use boiling distillation methods.

HOW CHEMICAL CONCENTRATIONS (LEVELS) ARE REPORTED

mg/L – milligrams of substance per litre of water, which in fresh dilute water is the same as parts per million (ppm)

– water treatment firms sometimes measure hardness in grains per gallon (1 grain per gallon = 17.1 mg/L)

µg/L – micrograms per litre or parts per billion (ppb)

– this unit is often used for reporting smaller amounts of substances such as organic chemicals and pesticides

Many types of water treatment systems are available on the market. Know and understand your problem before investing in a selected unit. Peroxide should not be used in place of chlorine – it's unsuitable for proper water disinfection.

APPENDICES

LEGISLATION

ACTS

Ontario Water Resources Act	Ontario Ministry of the Environment	• protects the quality and quantity of Ontario's surface water and groundwater
Environmental Protection Act	Ontario Ministry of the Environment	• protects Ontario's land, water, and air resources from pollution
Safe Drinking Water Act	Ontario Ministry of the Environment	• regulations concerning the sampling and testing, treatment, and reporting of water quality results for identified water systems
Technical Standards and Safety Act	Ontario Ministry of Consumer and Business Services, administered by Technical Standards and Safety Authority	• protects land and water resources from damage by petroleum products
Pesticide Act	Ontario Ministry of the Environment	• protects land and water resources from damage by improper pesticide use

REGULATIONS AND GUIDELINES

OWRA Regulation 903: Water Wells	Ontario Ministry of the Environment	• regulations for the construction, maintenance and abandonment of water wells
Canadian Water Quality Guidelines	Canadian Council of Ministers of the Environment/ Environment Canada	• water quality recommendations for drinking water, livestock watering, irrigation, recreation and aquatic life
Water Management Policies, Guidelines, Provincial Water Quality Objectives	Ontario Ministry of the Environment	• provides direction for the management of quality and quantity of surface and groundwater
Ontario Drinking Water Standards	Ontario Ministry of the Environment	• protects public interest by providing drinking water quality standards
Ontario Building Code, Reg. 403–97: Septic Systems	Ontario Ministry of Municipal Affairs and Housing Act	• code that stipulates minimum separation distances between wells and septic systems

APPENDICES

METRIC – IMPERIAL UNIT CONVERSIONS

LENGTH	
1 kilometre (km) = 0.621 mile	1 mile = 1.609 km
1 metre (m) = 3.28 feet	1 foot = 0.305 m
1 centimetre (cm) = 0.393 inch	1 inch = 2.54 cm
1 millimetre (mm) = 0.0393 inch	1 inch = 25.4 mm

VOLUME	
1 cubic metre (m^3) = 35.3 cubic feet	1 cubic foot = 0.0283 m^3
1 m^3 = 220 imperial gallons (imp.gal.)	
1 litre (l) = 0.220 imp.gal.	1 imp. gal. = 4.55 L

DISCHARGE RATE	
1 m^3/day = 0.0116 litres per second (L/s)	1 L/s = 86.4 m^3/d
1 m^3/d = 0.153 imp. gal. per min. (igpm)	1 igpm = 6.55 m^3/d
1 L/s = 13.2 igpm	1 igpm = 0.076 L/s
1 L/min = 0.22 imp. gal. per min. (igpm)	1 igpm = 4.55 L/min

PRESSURE	
1 kilopascal (kPa) = 0.102 m water	1 m water = 9.8 kPa
1 kPa = 0.145 psi	1 psi = 6.895 kPa

TRANSMISSIVITY	
1 m^3/s = 5.794 x 10^6 imp. gpd/ft	1 imp. gpd/ft = 1.726 x 10^{-7} m^3/s
1 m^3/s = 86,400 m^2/d	1 m^3/d = 1.157 x 10^{-5} m^3/s

APPENDICES

WATER QUALITY STANDARDS IN ONTARIO AND CANADA

WATER QUALITY STANDARDS – HOW CLEAN IS CLEAN?

In Ontario, the Ontario Ministry of the Environment sets water quality standards for human use based on federal guidelines. The Ontario Drinking Water Standards set tolerance limits on how much of certain substances can be in drinking water.

The Standards list over 100 substances that have had allowable and recommended limits put in place. Copies are available from ministry offices.

Water quality standards for livestock watering and irrigation are set by the federal government and listed in the Canadian Water Quality Guidelines. These are available from Environment Canada.

WATER QUALITY NEEDS ON THE FARM

Your water quality needs depend on what the water is used for.

HUMANS

Human water uses include not only drinking and cooking, but also the handling of farm products like fruit, vegetables and milk. These uses require water that meets the Ontario Drinking Water Standards. When you test your well water, the results can be compared to the Standards, which are divided into health-related and aesthetic standards.

Health-related standards are set for bacteria and for substances such as metals, pesticides and different forms of nitrogen. Some examples are:

► lead	0.01 mg/L	► malathion	0.19 mg/L
► mercury	0.001 mg/L	► nitrate	10 mg/L (as N)
► 2,4-D	0.1 mg/L	► Total Coliform	5 colonies/100mL
		► *E. coli*	0 colonies/100mL.

If test results show a contaminant exceeding the health-related standards, stop drinking the water and have it retested immediately. If the results remain elevated, steps must be taken to eliminate the contaminant source, upgrade the condition of the well, treat the water supply, or properly plug and seal the well.

The standard for nitrate-N in drinking water has been set at 10 mg/L because nitrate-N in drinking water above that level may cause infantile methaemoglobinaemia (the "blue baby" syndrome). In such cases, the nitrate ion is changed to nitrite by intestinal bacteria. The nitrite ion reacts with iron in the haemoglobin and reduces its ability to transfer oxygen. The tissue then becomes oxygen-starved. The effects are seen in infants.

Aesthetic standards are set for substances such as iron, hardness, sulfate, colour and taste. These substances are not harmful to your health but can be objectionable if present at high levels. Several of these substances are discussed under the section on water treatment.

Aesthetic limits, such as high levels of iron or hardness, may be exceeded without causing health concerns. Some aesthetic limits, such as sediment or colour, may indicate problems with the well construction.

LIVESTOCK

The quality of water needed for livestock watering depends on the species, age, and physical condition of the animal. Most livestock have a higher tolerance to bacteria and nitrate than humans, but only if they are accustomed to it. Water for livestock should not have an objectionable taste or smell.

Many of the limited substances listed in the Canadian Water Quality Guidelines are for metals and pesticides. These can be toxic to the animal itself and can be transferred to humans through meat, milk and eggs.

The limits placed on substances for livestock can be higher than those for humans. For example:

► lead	0.1 mg/L
► mercury	0.003 mg/L
► atrazine	0.06 mg/L.

Some guidelines are the same as for humans. For example:

► 2,4-D	0.1 mg/L
► glyphosate	0.28 mg/L.

And some guidelines for livestock have no corresponding limits for humans. For example:

► calcium	1000 mg/L
► MCPA (methyl chloro-phenoxy acetic acid) (amines, esters and salts)	0.025 mg/L.

APPENDICES

CROPS

The quality of water needed for irrigation and fruit and vegetable washing depends on the type of crop as well as soils, climate and method. The Canadian Water Quality Guidelines for pesticides gives different limits for (a) hay and cereals, (b) legumes and (c) other crops such as lettuce, tomatoes and sunflowers.

Again, most of the substances are metals and pesticides. One exception is bacteria, which is set at:

- *E. coli* 100/100 mL
- Total Coliform 1000/100 mL.

For pesticide mixing, the water must be clean with no sediment. Foam markers, because they are like soap, require soft water to work best.

ONTARIO WELL CONSTRUCTION REGULATIONS

The Ontario Ministry of the Environment regulations set minimum construction standards for all types of wells. The regulations cover:

- who is qualified to construct wells and install pumps
- where a well can be located
- what materials can be used
- how the well is to be constructed
- when a well must be properly abandoned.

Water well contractors are required to maintain a minimum performance standard and their employees are required to be licensed well technicians. They must abide by the water well regulations, which include minimum construction standards. Well technicians must have at least two years of experience. There are four classes of well technician.

Regulations and legislation are revised continuously. Contact the appropriate ministry or agency to confirm current requirements and standards.

WHO IS QUALIFIED TO CONSTRUCT WATER WELLS AND INSTALL PUMPS?

Anyone in the business of constructing wells must have a well contractor's license. The Ontario Ministry of the Environment licenses water well contractors and well technicians for drilling, boring, digging and pump installation.

A well contractor license pertains to anyone engaged in a well construction business (including well drilling and pump installation). The license means that the holder is required to know the regulations, employ licensed well technicians, and hold comprehensive liability insurance. You may wish to ask for evidence of this. You may also wish to check the reliability of the contractor by asking previous customers.

Anyone can construct a water well for his or her own use, but the well must meet ministry regulations, including minimum construction standards.

APPENDICES

WATER WELL RECORDS

Within two weeks of completing a new well, the person who constructed the well must give the owner a copy of the Water Well Record.

The person constructing the well must also send a copy to the Ontario Ministry of the Environment.

To obtain a copy of your Water Well Record, contact the Environmental Monitoring and Reporting Branch of the ministry. Call 1-888-396-9355.

WELL OWNER RIGHTS AND RESPONSIBILITIES

The provincial regulations protect water wells from interference by large users who move into an area. If a new larger user creates problems for a domestic or livestock water supply, the supply must be restored.

The legislation controls large water users with Permits to Take Water. Anyone planning to pump more than 50,000 litres (10,000 gal.) a day must contact the Ontario Ministry of the Environment to obtain a Permit to Take Water. Water-taking for livestock and poultry, domestic gardens, and domestic use is exempted from this requirement. (See Best Management Practices, *Irrigation Management,* for more information on Permits to Take Water).

All rights come with responsibilities. As the well owner, you are required to maintain your well so as to keep out surface water and other foreign materials.

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WELL INFORMATION AND MONITORING RECORD SHEETS

WELL INFORMATION SHEET

Type of well: *drilled / dug or bored / well point*

Type of aquifer: *overburden / bedrock* ________

Year constructed: ____________________

Contractor: ____________________

Well depth: ____________________

Casing depth: ____________________

Casing type: ____________________

Casing diameter: ____________________

Well Screen

Length: ____________________

Slot size: ____________________

Water Levels

Date: ____________________

Static water level: ____________________

Pumping water level: ____________________

LOCATION **North**

measure to closest permanent structure

Pump Information

Pump type: ____________________

Pumping rate: ____________________

Capacity: ____________________

Date installed: ____________________

Manufacturer: ____________________

Depth to intake: ____________________

Well Improvements

DATE	DESCRIPTION

Well owners may want to copy and affix this well information sheet to their water storage tank for recordkeeping.

APPENDICES

MONITORING RECORD SHEET

INSPECTION REPORT

Date: ______________

	CONDITION	ACTION NEEDED
Distance from potential pollution sources		
Ground condition around well		
Well cap/cover/sanitary seal and vent		
Casing condition – cracks/holes seepage/staining		

WATER LEVEL MONITORING

DATE	PUMPING RATE	STATIC WATER LEVEL	PUMPING WATER LEVEL

below top of casing

WATER QUALITY TEST RESULTS

	SAMPLE #1	SAMPLE #2	SAMPLE #3
DATE TESTED			
TOTAL COLIFORM			
E. COLI			
NITRATE			

APPENDICES

GLOSSARY

annular space – open space between the casing and the side of a well

aquifer – a waterbearing formation that is capable of transmitting water in sufficient quantities to serve as a source of water supply

aquitard – a geological formation that prevents the significant flow of water, e.g., clay layers or tight deposits of shale

baseflow – when groundwater flows to surface water

bedding plane – in sedimentary or stratified rocks, the division planes that separate the individual layers, beds or strata

bentonite – a colloidal clay, largely made up of the mineral sodium montmorillonite, a hydrated aluminum silicate; bentonite commonly has the ability to absorb water and to swell accordingly

capillary zone – area above the water table where groundwater is drawn upward and held in tension in the pore spaces

coliform – a general family of bacteria found in animal wastes, surface soils and vegetation whose presence in well water can indicate organic contamination and possible surface water contamination

continuous chlorination – involves the continuous addition of low levels of chlorine to a water supply

denitrification – the loss of nitrogen in soils by either biological or chemical mechanisms: this is a gaseous loss that isn't related to loss by physical processes such as leaching

discharge – when the water reappears above the ground surface

evaporation – part of the water cycle where water (liquid) from the earth's surface is transformed to vapor and is added to the atmosphere

evapotranspiration – the transformation of water (liquid) from both the earth's surface (evaporation) and from the surfaces of plants (transpiration) to the atmosphere

flowing well – a well that has a static water level above the surface of the adjacent ground, causing the well to flow

formation – bedrock (e.g., granite) or overburden deposits (e.g., sands and gravels) with pores containing water and air

fracture – breaks in rocks or soil due to folding or faulting

grout – material such as bentonite (1 part bentonite mixed with 4 parts clean water) or other materials capable of forming a watertight barrier, used to fill and seal the annular space

hole stabilizer – may be a steel casing, a concrete tile, or an open hole in solid bedrock

indicator bacteria – their presence in drinking-water test results suggest possible health risks related to the well water, and are often an indication of surface water contamination

infiltration – movement of water from the earth's surface into formations

inlet – allows groundwater to enter the well, and may be a slotted well screen in overburden aquifers or an open hole in bedrock

jetting – propulsion of water under high pressure into sandy aquifers to create a hole for a well point

Karst topography – water moving through fractures in limestone has dissolved the rock, enlarging fractures and creating caverns

overburden – the loose soil, clay, silt, sand, gravel or other unconsolidated material overlying the bedrock, whether transported or formed in place

peak water demand – highest rate of water use each day: well capacities or storage facilities must be able to meet this demand

permeability – the property of porous rock, sediment, or soil for transmitting a fluid: it is a measure of the relative ease of fluid flow under an energy gradient

pitless adapter – device designed to replace the need for well pits and pump-houses – usually a metallic (brass) fitting that is attached to the casing below the frost line to connect the in-well water line to the buried water line leading to point of use

plugging and sealing – corrective actions recommended for the proper abandonment of unused wells, including: the removal of the pump, piping, water, well casing, etc. and the filling of bore hole with proper materials to prevent the downward movement of water – this procedure is normally done by a licensed water well contractor

plume – a trail of dissolved contaminants in groundwater issuing from a contaminant source and spreading out as the trail travels in the direction of groundwater flow

pore – small openings filled with air or water

porosity – the amount of pore space in a formation

pumping water level – the water level in a well being pumped

recharge – replacement of moving aquifer water with water infiltrating from the surface and percolating through unsaturated formations to the water table

recharge area – area of land beneath which there is a measurable downward driving force below the water table: rolling or steep landforms with coarse-textured deposits (e.g., sand plains, end moraines) are particularly important recharge areas because of their high vertical flow rates

saturated – pores filled with water

shock chlorination – involves adding a large amount of chlorine to the water in the well and pumping it through the system: the chlorinated water is left in the system long enough to ensure complete disinfection

solution channel – cavities formed in soluble rocks (such as limestone) by the dissolving action of moving water

specific capacity – result of dividing the pumping rate by the drawdown

spring – discharge area where groundwater moves from a shallow aquifer to the surface or surface waters: wetlands, ponds, lakes, streams and rivers can be wholly, or in part, spring-fed

static water level – the level in a well attained by water at equilibrium in a well when no water is being taken from the well

unsaturated – pores containing air or a mixture of air and water

water cycle – continuous movement of water from the atmosphere to the earth's surface (precipitation), through (infiltration, percolation) formations to aquifers (recharge), back to the earth's surface (discharge, capillary rise, plant uptake) and to the atmosphere (evaporation, transpiration, evapotranspiration)

water table – depth at which all the pores are saturated

well – a hole made in the ground to locate or to obtain groundwater from an aquifer, and includes a spring around or in which works are made or equipment is installed for collation of water and that is or is likely to be used as a source of water for human consumption

well casing – pipe, tubing or other material installed in a well to support its sides

well screen – slotted or perforated cylinder that is attached to the bottom of the solid casing of a drilled well to keep formation particles out and let water in

Agencies and Offices

Ontario Ministry of the Environment
www.ene.gov.on.ca

Regional Offices of MOE

Southwestern Region
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Fax: 416-325-6345

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Kingston, Ontario K7L 4X6
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1-800-267-0974
Fax: 613-548-6908

Northern Region
435 James Street South
Suite 331, 3rd Floor
Thunder Bay, Ontario P7E 6S7
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Fax: 807-475-1754

Water Well Records Ministry of the Environment
Environmental Monitoring and Reporting Branch
125 Resources Road
Toronto, Ontario M9P 3V0
Tel: 1-888-396-9355
Fax: 416-235-5960

Environment Canada
Canadian Water Quality Guidelines; Ecosystems Conservation Directorate; Evaluation and Interpretation Branch; Guidelines Division
Ottawa, Ontario K1A 0H3
Tel: 819-953-0602
Fax: 819-953-0461
http://www.ec.gc.ca

Ontario Ministry of Health and Long-Term Care
Contact your local health unit.

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Publications

Assessing the Potential for Ground Water Contamination on Your Farm, AGDEX 751, Ontario Ministry of Agriculture and Food, 1997.

Best Management Practices: Water Management, Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, 1994.

Canadian Water Quality Guidelines, Health Canada, 2002.

Cryptosporidium: Could It Be In Your Water? AGDEX 716, Ontario Ministry of Agriculture and Food, 2000.

Farm Water Supply: Water Supply and Distribution Systems, Publication 476, Ontario Ministry of Agriculture and Food, 1988.

Farm Water Supply: Water Treatment Systems, Publication 85, Ontario Ministry of Agriculture and Food, 1993.

Groundwater, R.A. Freeze and J.A. Cherry, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1979.

Groundwater and Wells, F.G. Driscoll, Johnson Division, St. Paul, Minnesota, 2nd ed., 1986.

"How Well is Your Well?": A Sampling and Information Package for Owners of Private Wells, Ontario Ground Water Association, 2002.

Important Facts About Water Well Construction, Publication 3788e, Ontario Ministry of the Environment, 2000.

Installation of Well Pumps, Publication 3789e, Ontario Ministry of the Environment, 2000.

Managing Your Water Well in Times of Water Shortage, Publication 3784e, Ontario Ministry of the Environment, 1999.

Ontario Drinking Water Standards, Publication 3978, Ontario Ministry of the Environment, August 2000.

Ontario Environmental Farm Plan, 2nd ed., Ontario Farm Environmental Coalition,1996.

Pesticide Contamination of Farm Water Supplies: Recommendations on Avoidance, Cleanup and Responsibilities, AGDEX 607, Ontario Ministry of Agriculture and Food, 2000.

Private Water Well Owners – Dealing with Water Shortages, AGDEX 716/77, Ontario Ministry of Agriculture and Food, 1999.

The Protection of Water Quality in Bored and Dug Wells, Publication 3962, Ontario Ministry of the Environment, 2000.

The Protection of Water Quality in Drilled Wells, Publication 3961, Ontario Ministry of the Environment, 2000.

Water Wells and Groundwater Supplies: Recommended Methods for Plugging Abandoned Water Wells, Publication 3702e, Ontario Ministry of the Environment, 1999.

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