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Ground Water and the Rural Homeowner

Cover photograph: Rural dug well.

Ground Water and the Rural Homeowner

by Roger M. Waller

Preface

As the salesmen sang in the musical *The Music Man*, "You gotta know the territory." This saying is also true when planning to buy or build a house. Learn as much as possible about the land, the water supply, and the septic system of the house before buying or building. Do not just look at the construction aspects or the beauty of the home and surroundings. Be sure to consider the environmental conditions around and beneath the site as well. Try to visit the site under adverse conditions, such as during heavy rain or meltwater runoff, to observe the drainage characteristics, particularly the condition of the basement.

Many of the conditions discussed in this book, such as lowered well-water levels, flooded basements, and contamination from septic systems, are so common that rural families often have to deal with one or more of them. The purpose of this book is to awaken an interest in ground water and an awareness of where it is available, how it moves, how people can adjust to its patterns to avoid problems, and how it can be protected and used wisely.

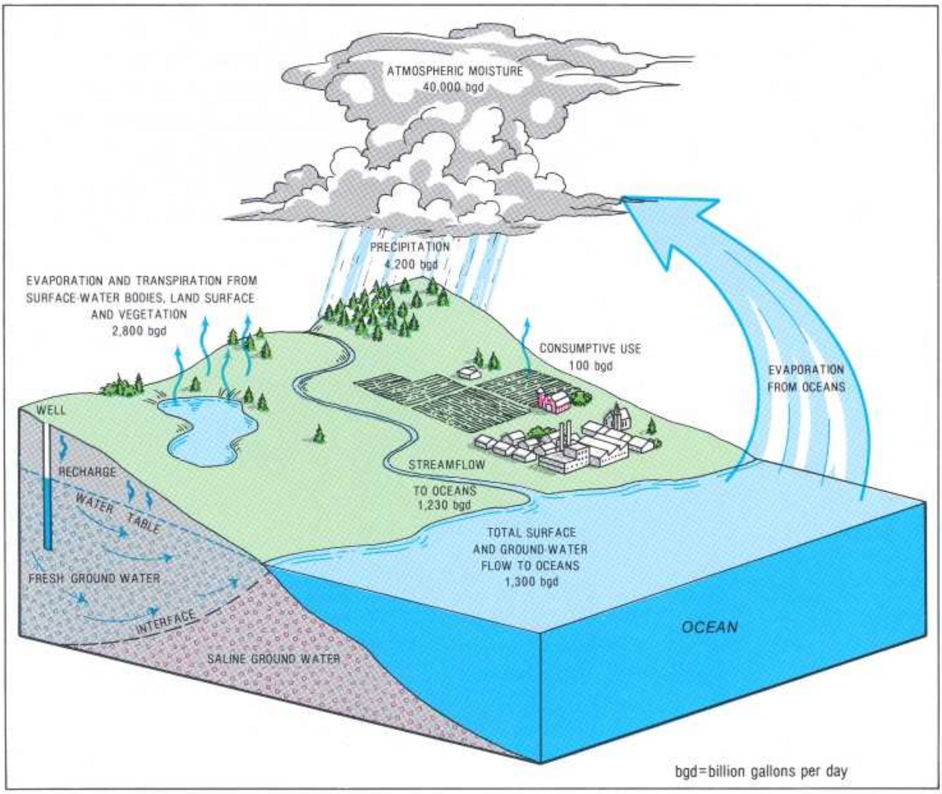
This booklet provides both present and prospective rural homeowners, particularly those in the glaciated northern parts of the United States, with a basic but comprehensive description of ground water. It also presents problems one may expect to encounter with ground water and some solutions or suggestions for help with these problems.

Introduction

When buying a home in the country, people need to consider certain factors that usually do not confront the urban homebuyer, such as whether or not the water supply is adequate and if the means of disposing of wastewater is safe. Disappointed rural homeowners have sometimes found out too late that the well drilled on their new land does not yield enough water or that the water is of poor chemical quality. Also, foundations can become unstable from excess surface runoff or from high ground-water levels. Septic systems, if not located properly or if soil conditions are not properly considered, can fail. Wells can be contaminated by septic systems or barnyard wastes. Shallow or dug wells on farms or near older homes that served adequately in earlier years are often inadequate for modern uses.

Preventing water problems or coping with them when buying or building a rural home can be either complex or relatively simple. Prospective homeowners need to know about the terrain, the proximity of the house to other structures, and the condition of the existing well and septic system. If building in an unpopulated area, drill a well first—or if buying an old house, find out if the water supply is adequate. This booklet describes the most common well problems encountered by rural homeowners, how to recognize them, solve them, or get help. But first, the characteristics and behavior of ground water and the relationship between ground water and the surrounding land are discussed briefly.

The Hydrologic Cycle

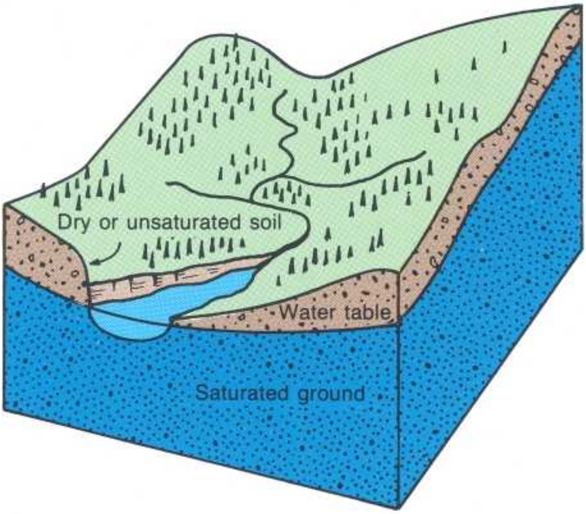


The continuous hydrologic cycle.

The hydrologic cycle is the continuous circulation of water from land and sea to the atmosphere and back again: water evaporates from oceans, lakes, and rivers into the atmosphere. This water later precipitates as rain or snow onto the land where it evaporates or runs off into streams and rivers; or it infiltrates (seeps) into the soil and rock from which some is transpired back into the atmosphere by plants. The remainder becomes ground water, which eventually seeps into streams or lakes from which it evaporates or flows to the oceans.

Ground Water

Ground water is that part of precipitation that infiltrates through the soil to the *water table*. The unsaturated material above the water table contains air and water in the spaces between the rock particles and supports vegetation. In the saturated zone below the water table, ground water fills in the spaces between rock particles and within bedrock fractures.



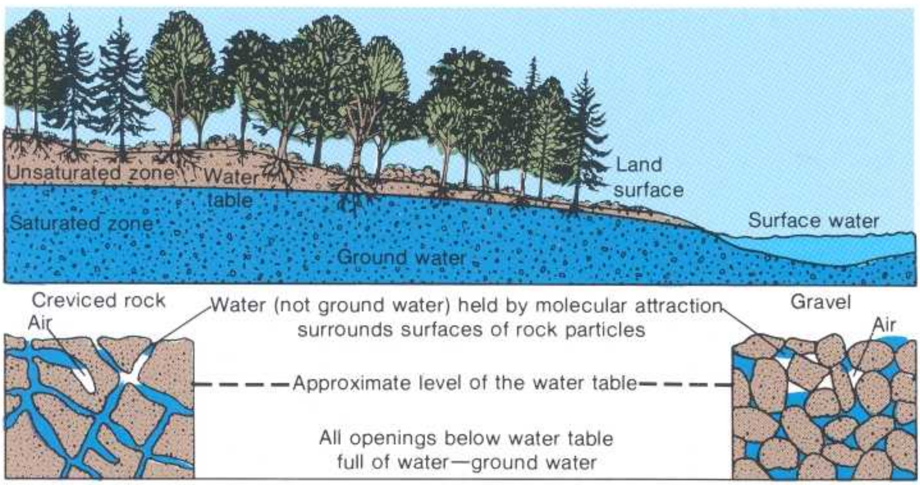
Occurrence of ground water.

Where ground water occurs

Rock materials may be classified as consolidated rock (often called bedrock) and may consist of sandstone, limestone, granite, and other rock, and as unconsolidated rock that consists of granular material such as sand, gravel, and clay. Two characteristics of all rocks that affect the presence and movement of ground water are *porosity* (size and amount of void spaces) and *permeability* (the relative ease with which water can move through spaces in the rock).

Consolidated rock may contain fractures, small cracks, pore spaces, spaces between layers, and solution openings, all of which are usually connected and can hold water. Bedded sedimentary rock contains spaces between layers that can transmit water great distances. Most bedrock contains vertical fractures that may intersect other fractures, enabling water to move from one layer to another. Water can dissolve carbonate rocks, such as limestone and dolomite, forming solution channels through which water can move both vertically and horizontally. Limestone caves are a good example of solution channels. Consolidated rock may be buried below many hundred feet of unconsolidated rock or may crop out at the land surface. Depending upon the size and number of connected openings, this bedrock may yield plentiful water to individual wells or be a poor water-bearing system.

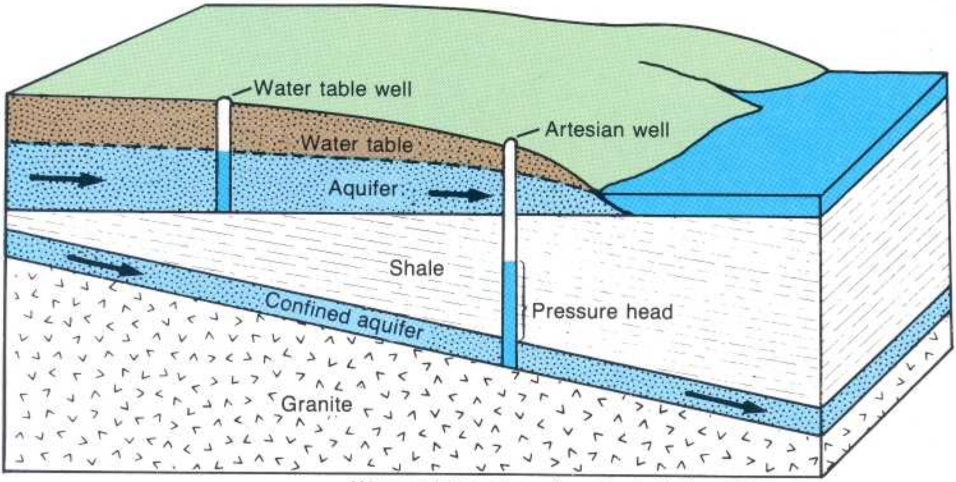
Unconsolidated material overlies bedrock and may consist of rock debris transported by glaciers or deposited by streams or deposited in lakes. It also may consist of weathered bedrock particles that form a loose granular or clay soil. Well-sorted unconsolidated material can store large quantites of ground water; the coarser materials—sand and gravel—readily yield water to wells.



How ground water occurs in rocks.

A close look at the rocks exposed in road cuts and along streams will show the types of openings in which ground water can occur. Especially noticeable in bedrock exposures are spaces between layers that can extend for miles—the void spaces between rock particles contain water that percolates into these spaces between the layers. In most sand and gravel deposits, water occupies and moves freely within granular material.

Road cuts reveal fractures, joints, and bedding planes.



Water-table and confined (artesian) aquifers.

Aquifers

Most of the void spaces in the rocks below the water table are filled with water. Wherever these water-bearing rocks readily transmit water to wells or springs, they are called *aquifers*.

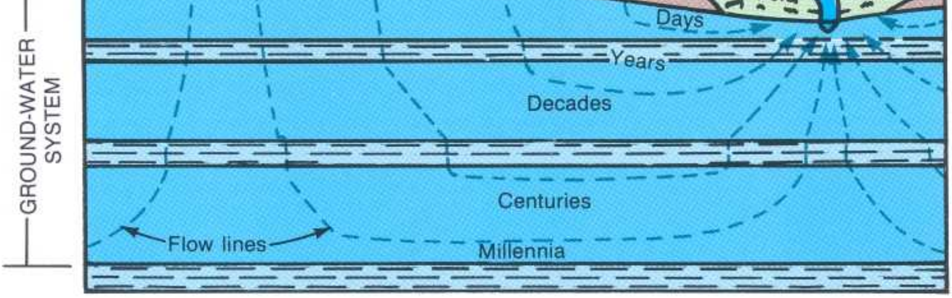
Although ground water can move from one aquifer into another, it generally follows the more permeable pathways within the individual aquifers from the point of recharge (areas where materials above the aquifer are permeable enough to permit infiltration of precipitation to the aquifer) to the point of discharge (areas at which the water table intersects the land surface and water leaves an aquifer by way of springs, streams, or lakes and wetlands). Where water moves beneath a layer of clay or other dense, low-permeability material, it is effectively confined, often under pressure. The pressure in most confined aquifers causes the water level in a well tapping the aquifer to rise above the top of the aquifer. Where the pressure is sufficient, the water may flow from a well.

Ground water is constantly moving

Ground water is always moving by the force of gravity from recharge areas to discharge areas. Ground-water movement in most areas is slow—a few feet per year. But, in more permeable zones, such as solution channels in limestone, movement can be as much as several feet per day. Evidence of the movement of ground water through rock and soil can be seen in road cuts, especially in winter, when the water freezes upon emerging from the rock. In some bedrock exposures, the water emerges along partings between rock layers; in others, along vertical fractures.

Seasonal patterns of ground-water recharge and storage

In latitudes where freezing is common, there is less recharge from rain or snowmelt during winter, which causes the water table to fall. Sporadic or differential freezing of the soil in the fall and winter inhibits recharge to the saturated zone, and the complete freezing of the soil in winter prevents all recharge until the soil thaws in the spring.



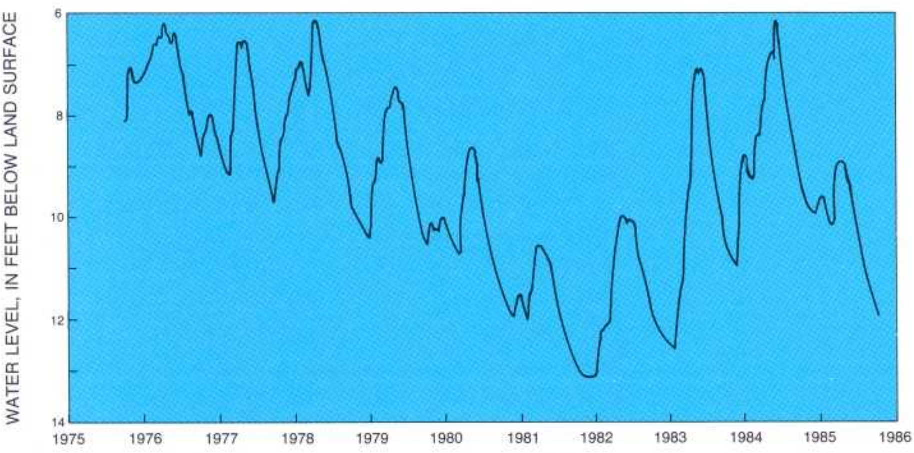
Direction and rate of ground-water movement.

Ground water, emerging from bedding planes, has created spectacular frozen waterfalls along a road cut.

The saturated zone beneath the water table is recharged by the excess water that is not discharged to streams. The resulting rise in the water table increases ground-water *storage* (the volume of ground water stored within an aquifer system). In late spring, summer, and early fall, evaporation and transpiration by plants capture most of the water that would otherwise recharge the aquifer, while discharge to streams continues. A seasonal decrease in ground-water storage results, as indicated by declining water levels in wells. In winter, freezing of the soil prevents recharge, which again causes a decline in storage. In early spring, frequent precipitation coupled with water from snowmelt causes a rapid increase in storage and a rise in the water table.

Effects of long-term climatic trends on ground-water storage

In addition to seasonal fluctuations in ground-water storage, long-term trends result from the variations in precipitation. Several years of below-normal precipitation causes a progressive decline in ground-water levels, and several years of above-normal precipitation causes a corresponding rise. These long-term climatic trends cause changes in ground-water storage. During periods of long-term, above-average precipitation, the water table may rise close to the land surface and interfere with home construction and waste disposal. For example, if a home had been built with a basement 8 feet below land surface during 1980-82 at the site of the well whose hydrograph is shown below, the basement would have been flooded in 1983 and 1984.

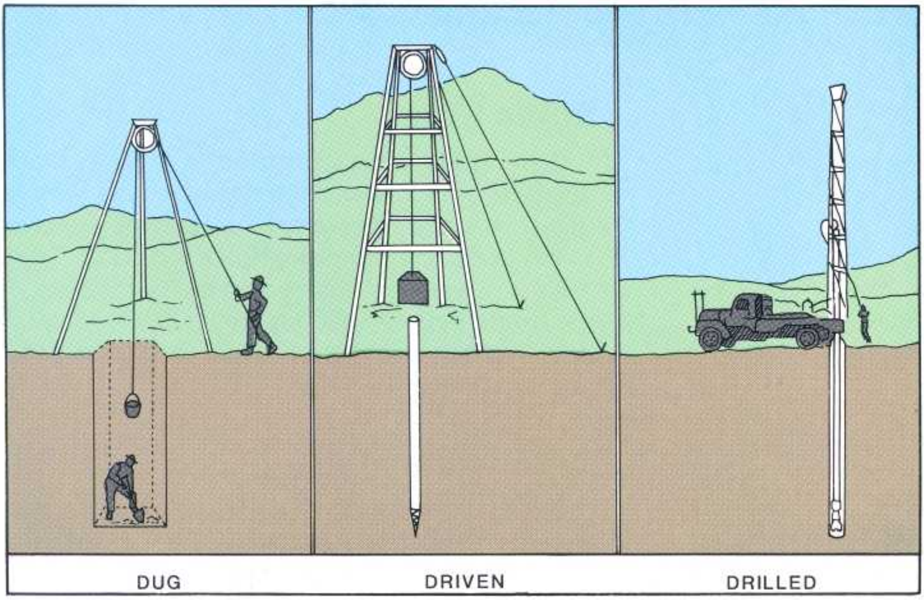


A 10-year well hydrograph showing climatic effects on ground-water level.

Types of Wells

Most modern wells are drilled by truck-mounted percussion (cable-tool) or rotary (air or hydraulic) drill rigs. Dug wells are still constructed in some areas, either by power equipment or by hand, but most hand-dug wells are the "relics" of older homes and were dug before drilling equipment was readily available or because drilling was considered too expensive. Driven wells, installed by hand or with power equipment, are still common and widely used where geologic conditions permit. Jetted and bored (augered) wells are less common types.

Types of wells.



Dug wells

Historically, dug wells were excavated by hand shovel to below the water table until incoming water exceeded the digger's bailing rate. The well was lined with stones, brick, tile, or other material to prevent collapse, and was covered with a cap of wood, stone, or concrete. Modern large-diameter dug wells are dug or bored by power equipment and typically are lined with concrete tile. Because of the type of construction, bored wells can go deeper beneath the water table than can hand-dug wells.

Dug and bored wells have a large diameter and expose a large area to the aquifer. These wells are able to obtain water from less-permeable materials such as very fine sand, silt, or clay. Some disadvantages of this type of well are that they are shallow and lack continuous casing, making them subject to contamination from nearby surface sources, and they go dry during periods of drought if the water table drops below the well bottom.

Driven wells

Driven wells are constructed by driving small-diameter pipe into shallow water-bearing sand or gravel. Usually a screened well point is attached to the bottom of the casing before driving. These wells are relatively simple and economical to construct, but they can tap only shallow water and, like dug wells, are easily contaminated from nearby surface sources.

Modern truck-mounted drill rig.

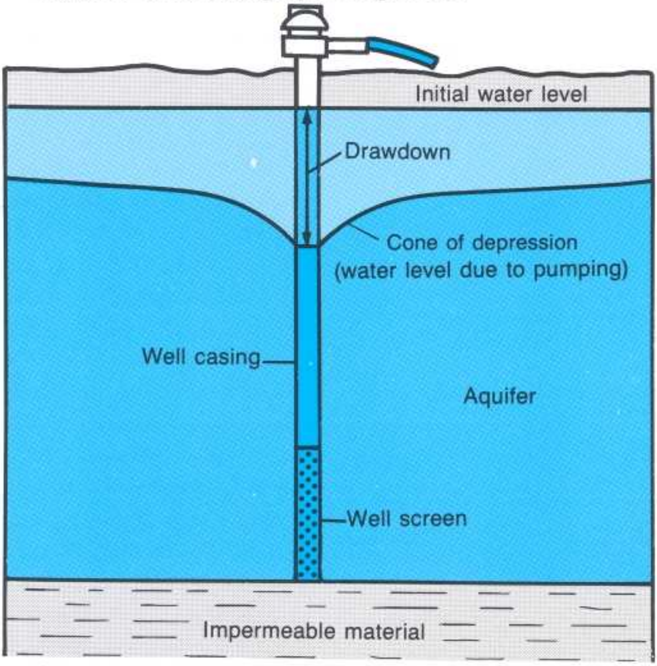
Drilled wells

Drilled wells are constructed by either percussion or rotary-drilling machines. Drilled wells that penetrate unconsolidated material require installation of casing and a screen to prevent inflow of sediment and collapse. They can be drilled more than 1,000 feet deep. To prevent contamination by water draining from the surface downward around the outside of the casing, the space around the casing must be sealed.

Wells and Pumpage

Even though water is present at some depth at almost any location, the success of obtaining an adequate domestic supply (usually 5 gallons per minute) of water from a well depends upon the permeability of the rock. Where permeable materials are near land surface, a shallow well may be adequate. Elsewhere, such as where clayey material directly overlies bedrock, a deep well extending into bedrock may be needed.

Pumping a well lowers the water level around the well to form a cone of depression in the water table. If the cone of depression extends to other nearby wells, the water level in those wells will be lowered. The cone develops in both shallow water-table and deeper confined-aquifer systems. In the deeper confined-aquifer system, the cone of depression is indicated by a decline in the pressure and the cone spreads over a much larger area than in a water-table system. For a given rate of withdrawal, the cone of depression extends deeper in low-yielding aquifers than in high-yielding ones.



Cone of depression caused by pumping.

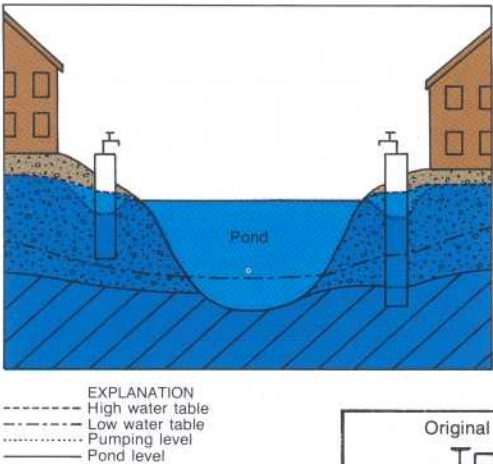
Water-Level Declines

The old saying that you "never miss the water until the well runs dry" remains true; however, *few drilled wells ever actually go dry*. Rather, what occurs most often is that the water table has dropped to near or below the pump intake because the pump intake is not set deep enough to allow for a potential decline in water levels. Alternatively, the small strainer that covers the end of the pump intake could be partly clogged so that it takes longer to pump the same amount of water. In either case, when the pumping rate exceeds inflow to the well, air is pumped and no more water is produced until the pump is shut off and the well recovers.

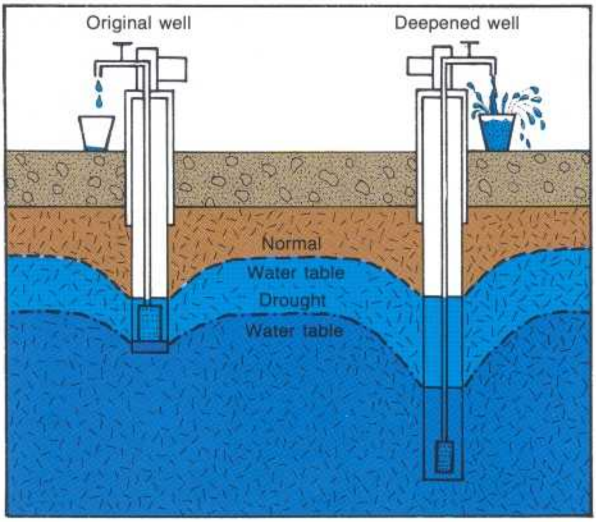
Shallow wells

The most common "dry well" problem has been with dug wells. Most dug wells are shallow and excavated in poorly permeable material; consequently they are readily affected by drought or by seasonal declines in the water table. The following figure shows the effect of declining water levels on two adjacent wells that are drilled to different depths on either side of a water-table pond. If the depth to water in the well on the left were, say, 10 feet during spring, it might decline to 15 feet during late summer or during a severe drought. If the pump normally causes the water level in the well to decline 5 feet or more during a pumping cycle, pumping during the drought would cause the water to decline to or below the pump intake. Excavating this well deeper to match the well on the right would solve this problem. Dug wells should be constructed during seasonal or climatically low-water-level periods.

Many dug wells extend only to the bedrock surface and tap the perched water (unconfined ground water separated from an underlying main body of ground water (aquifer) by an unsaturated (impermeable) zone) on top of the bedrock. These wells cannot be easily deepened. In such cases a new drilled well is the only long-term solution.



How does a well go dry?

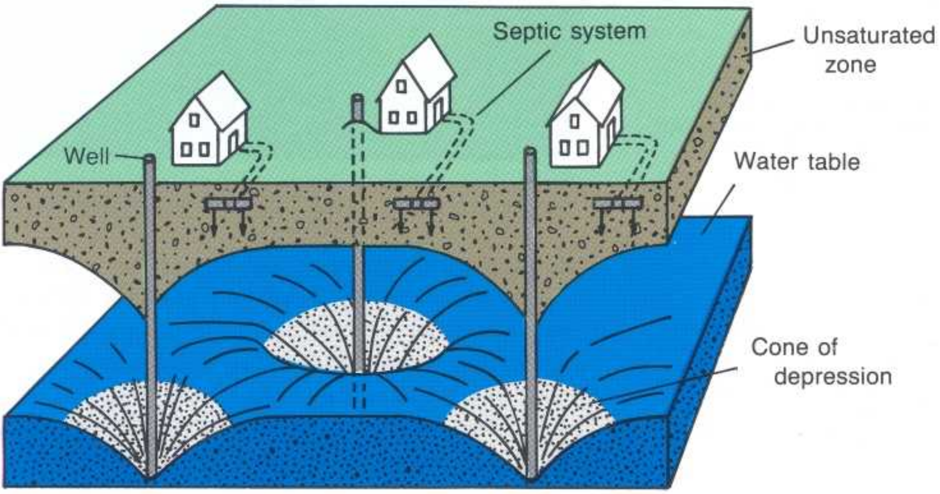


Solving a drought-related water shortage by deepening the well.

Some drilled wells that tap shallow bedrock will yield only 1 or 2 gallons of water per minute. These wells are not deep enough to provide adequate storage of water for short-term pumping cycles. Such a well may contain only 50 feet of water above the pump intake. As an example, when the water table declines 10 feet because of drought conditions, only 40 feet of water is available in the well for one pumping cycle, and the well seems to "go dry." In that situation, deepening the well may solve the problem as long as the deeper water is of good quality. If usable water is not available at a greater depth, the pumping rate must be reduced so that less water is pumped during each cycle.

Increased pumping in the immediate area

Another reason that wells "go dry" is the lowering of the water table by increased pumpage in the immediate area. Housing developments with small lots and individual wells have been built in many rural areas. If the aquifer is low yielding so that pumping causes a large drawdown, a cone of depression will develop around each well. Thus, several domestic wells close together can create a steady lowering of the water table if pumpage exceeds the natural recharge to the system (unless the withdrawn water is returned to the aquifer through septic systems). A third major reason that rural wells "go dry" is the installation of larger capacity wells for municipal, industrial, or agricultural purposes adjacent to residental areas. The increased withdrawals may cause large widespread cones of depression that intersect one another and cause general water-level declines that affect nearby domestic wells.



Effect of concentrated housing on ground-water level.