Water Treatment

NOTES

Cornell Cooperative Extension, College of Human Ecology

Private Household Water Supplies

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Approximately 50 percent of the population in the United States relies on groundwater sources for drinking water. in rural areas, this can be as high as 90 percent. Research in the past decade has shown that groundwater can be contaminated with microorganisms and chemicals that may be hazardous to drinking It is important that the individual household protect its water source and assure a good quality supply. This fact sheet describes techniques for proper construction and protection of a private well, various types of wells and springs, and how to maintain the quality of a water supply.

Developing drinking water sources

The water we consume comes from one of two sources. *Groundwater* is rain or snow melt that seeps into the earth until reaching a depth where all soil/rock pores are filled *(saturated zone).* The top of the saturated zone is the *water table.* Wells tap *aquifers*, those areas within the earth composed of gravel, sand, sandstone, limestone, shale, or other geologic formations that store significant quantities of groundwater.

Water that does not move into the soil or evaporate into the atmosphere runs over the surface and collects in streams, rivers, and lakes. This is called *surface water.* A sanitary surface-water supply is difficult to achieve because it is more vulnerable to contamination than a deep, groundwater source.

Either source of household water can be contaminated by a variety of microorganisms and chemicals. A properly designed drinking water supply protects the water and ensures that it will be appealing in taste with no odor or color, and not hazardous to drink.

There are several approaches to assessing potential problems with new water supplies. Talking to neighbors can provide information about common problems with local water supplies, if a groundwater source is used, drilling a pilot hole or test well (4-inch diameter) provides another means of testing the water without the expense of an entire well. The local health department should also be consulted for any known aesthetic problems associated with groundwater in a particular area, or if contamination of the aquifer has occurred.

Types of wells

The most common types of wells are named by the method used to construct them; i.e., drilled, jetted, driven, dug, or bored. Since constructing a well exposes the groundwater source to surface as well as subsurface contaminants, installation must be carefully done.

Considerations when choosing the type of well to construct are: soil characteristics, depth to bedrock, desired yield (a typical household requires a minimum flow of 3-5 gallons per minute to meet daily needs), depth to water table, characteristics of the aquifer, and construction costs. Local regulations vary regarding the type of well permitted, driller licensing, and construction standards. Most desirable is a deep, drilled well (recommended minimum is 70 feet); the driller should be chosen on the basis of experience and workmanship-not price alone

Drilled wells (fig. 1) are constructed with special equipment that drills through soil and rock formations to reach groundwater sources as deep as 1,000 feet. These wells are usually 6 inches in diameter and constructed by either *the percussion (cable tool)* method, using a falling weight to break through rock and soil (which is then removed by bailing), or a *hydraulic rotary* method (similar to a large drill bit). Geologic characteristics of the site, well diameter, and desired well depth determine the method chosen. As the hole is drilled, the well casing is inserted into the ground. The casing of a drilled well usually extends 12-18 inches above ground surface and should include a tight fitting well cap and seal. These wells are usually grouted (see section on Well Construction), and the ground around the casing is sloped away from the well.

Jetted wells (fig. 2), similar to drilled wells, are more common in sandy soils than in clay formations. A high velocity stream of water is forced into the soil, then a jetting tool (point) is pushed into the loosened material to provide access for the well casing that follows. The casing of a jetted well often does not extend above the ground surface, a factor that both allows contaminants to enter the well and makes it difficult to later locate and inspect the well.

Driven wells (fig. 3) tap water down to 50 feet below the surface and are usually 1-2 inches in diameter. The casing is comprised of coupled pipe sections tipped with a well point and screen. This well point is driven into the ground until water is reached, but does not usually go through bedrock. As with jetted wells, the casing of a driven well is often cut off below the ground surface, and likewise maybe easily contaminated and more difficult to locate for inspection than when the casing extends above ground.

Dug wells (fig. 4) are not considered by most health departments to be appropriate drinking water sources. Dug wells, constructed with hand or power tools, are usually 3-4 feet in diameter and less than 50 feet deep, which may result in an inadequate supply of water during dry periods. If sand mixed with clay and silt surrounds the well, a larger storage area can be provided to avoid water shortages. Newer dug wells use concrete well rings (3-foot diameter x 2-foot length) to encase the hole, but it is difficult to protect a dug well from contamination. Old dug wells often have a fieldstone casing and an ill-fitting wood lid or cap. This type of well construction and their shallow depth make them vulnerable to surface contamination. Constructing a shallow dug well to avoid iron or hydrogen sulfide in deeper wells may incur potential health problems instead.

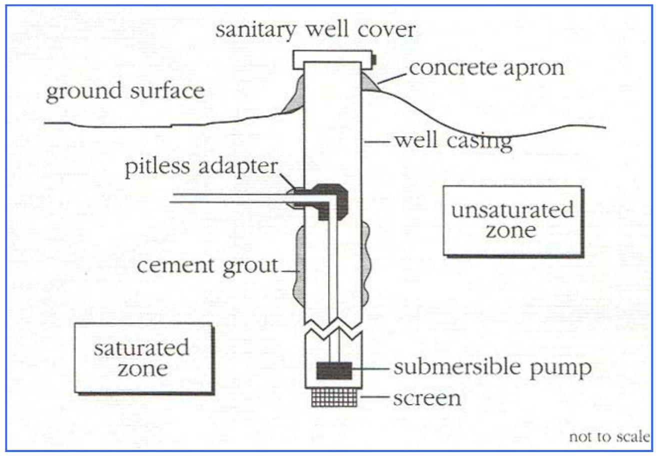

Figure 1. Drilled well

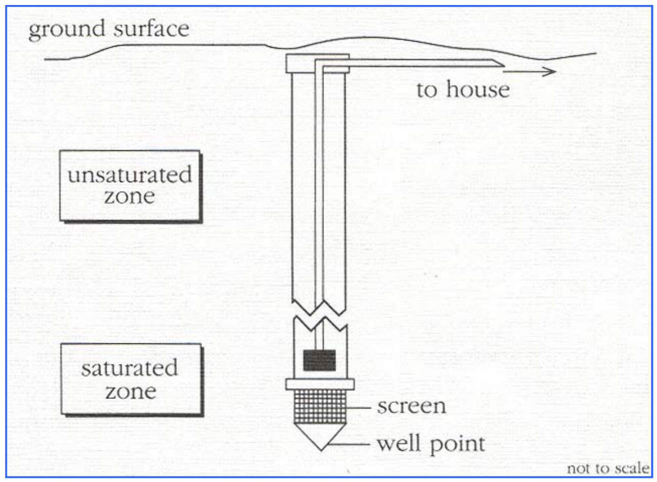

Figure 2. Jetted well

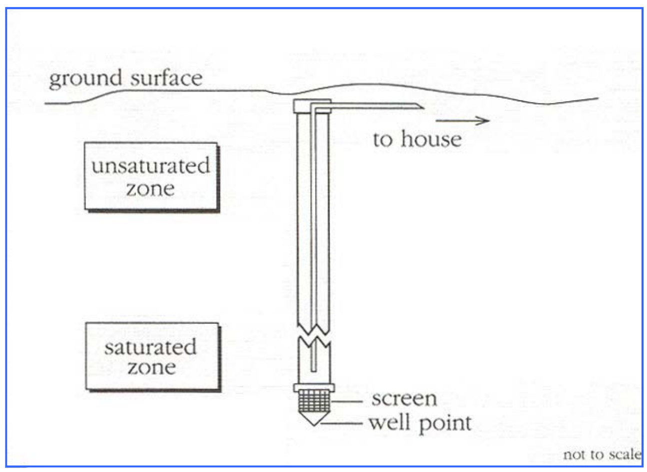

Figure 3. Driven well

Bored wells (fig. 5) are similar to dug wells but are usually smaller in diameter and tap a deeper water source.
They can be constructed with either a hand auger, for an 8-inch diameter well, or power auger, resulting in a well up to 3 feet in diameter. A bored well is usually cased, and the bottom may be screened.

Springs

Many health departments do not consider springs (fig. 6) to be appropriate sources for potable water. Typically, springs tap a shallow groundwater source with a variable flow rate. To be used as a drinking water source, two criteria must be met. First, the spring must provide adequate, good-quality water to meet household needs throughout the year. The origin of a spring is difficult to determine but ideally, better springs are those emerging from rock formations. It is desirable to ask the local health department to do a sanitary survey of the area before developing a spring. This inspection should detect any present and future health hazards in the vicinity of the spring.

Protection is the second requirement for proper spring development. Since the spring's source is at a higher elevation than its outflow, protecting this source is vital. Surface water runoff should be diverted by constructing a curtain drain or berm upstream of the spring. The area should be fenced to prevent animals from contaminating the spring source. Yearly water testing for coliform bacteria is necessary to monitor the sanitary condition of the spring.

The encasement surrounding a spring should be watertight, open at the bottom, and have a heavy, overlapping lid to prevent surface contamination of the reservoir. There should be an entry point to facilitate inspection, cleaning, and emptying the spring box. In addition, the spring box should be equipped with a down-facing, screened overflow pipe and be surrounded by a concrete apron on ground sloping away from it.

Siting a well

A well should provide adequate water for family needs and be protected from contamination. Most health departments determine the proper location for an on-site sewage treatment system, but they do not usually have jurisdiction over siting a drinking water supply. Many states that do not regulate the siting of a well do, however, give recommendations for its location. These guidelines specify the minimum distance between a drinking water supply and such obvious

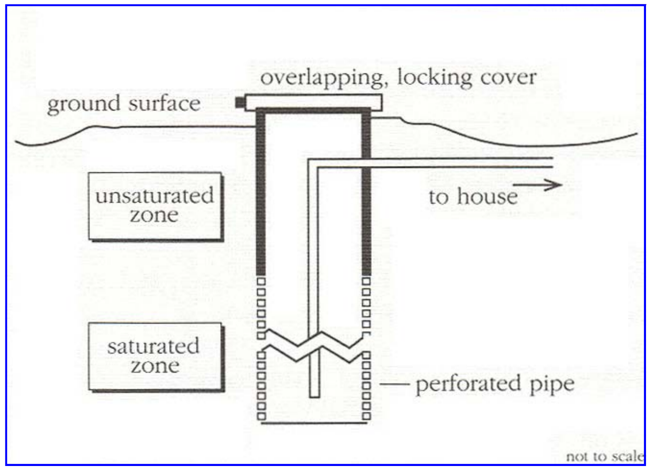

Figure 4. Dug well.

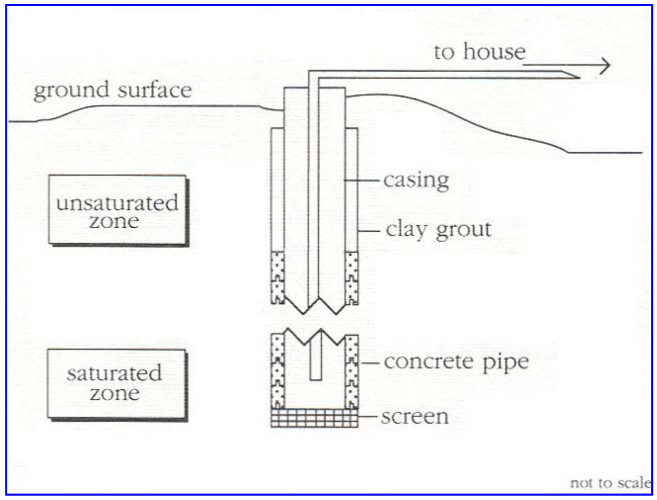

Figure 5. Bored well

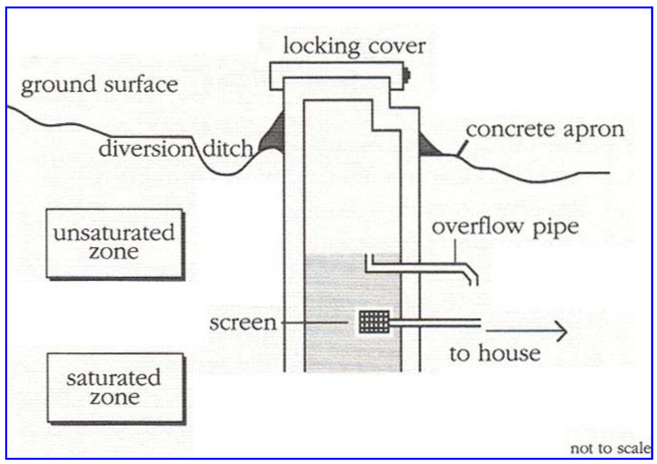

Figure 6. Spring

sources of contamination as wastewater systems, road salt storage piles, underground gasoline storage tanks, fertilizer or pesticide storage areas, or landfills. In general, a well should be located in an area higher than, and 200 feet from any potential source of pollution.

In New York State, a septic tank must be 50 feet from the well, and a sewage treatment and disposal system must be 100 feet from the well. These distances assume that the well is not down slope from the wastewater system, and that the soil or underlying material filters out microorganisms or other harmful contaminants. This filtering action is very dependent on the type of material through which the water moves; little filtration occurs in limestone or fractured rock. In certain types of soil, therefore, the distances between the drinking water supply and the wastewater treatment system should be more than the state's minimum recommendation.

Well construction

A properly designed and constructed well accounts for characteristics of the aquifer, the required water yield, state or local regulations, and water rights. Consideration also must be given to the drilling procedure, the type of casing to be used, the physical structure of the water intake, water source protection, water testing, and disinfection of the system. This information is often kept in a well record or log (fig. 7), a document that the driller provides and the owner maintains to give a history of the well, work done on the system, and water quality monitoring. Hiring a competent, experienced driller is essential; in states that do not license well drillers, recommendations from satisfied customers may be the only basis for determining which driller to use.

A drilled well in unconsolidated sand and gravel is divided into the *cased section* and the *intake section.* The cased or upper part maintains the borehole, increases water storage, and includes pumping equipment, whereas the intake section, or lower part of the well extends into the aquifer and allows water to enter the well but screens out surrounding sand and other particles. The casing should extend at least 20 feet below grade and at least 5 feet below the pumping level. Drilled wells that extend into consolidated or fractured bedrock may not require casing or screening below certain depths. The steel casing should be new, although plastic casing is appropriate in some shallow wells. The casing wall thickness is critical and should be at least 0.25 (1/4) inch.

contaminants from entering. Cement grout is used for this purpose and should be 2 inches thick around the casing. This *formation seal* also protects the casing from corrosion and possible cave-ins. in most cases, grouting is needed only around that portion of a well casing that is in unconsolidated soil.

To protect the well from surface contamination, the casing should extend 12-18 inches above ground level and be surrounded by a concrete slab that slopes away from the well. The top of the casing should have a sanitary seal and a screened, down-facing vent to close off potential pathways of contamination. The well should be protected by a shelter or pump house. (Household chemicals should never be stored in or used near this structure.)

The process of *well development* clears sand and mud from the area below grade around the well intake to prevent clogging and increase water yield. A common method moves a plunger up and down inside the well to dislodge small particles near the intake, followed by sustained pumping or bailing to remove any material before the well pump is installed.

Well
Name of driller:
Phone number:
Type of well:
Location:
Capacity (gal/min):
Depth of well casing above/below grade:
Depth of bedrock:
Date drilled:
Well permit number (if applicable):

Pump
Name of pump installer:
Phone number:
Type of pump:
Pump capacity:
Brand name:
Serial number and model:
Depth to pump or intake line:
Date purchased:

Water quality

When tested	What tested	Results

Well repairs

When	What

Shock chlorination?

Figure 7. Sample well record.

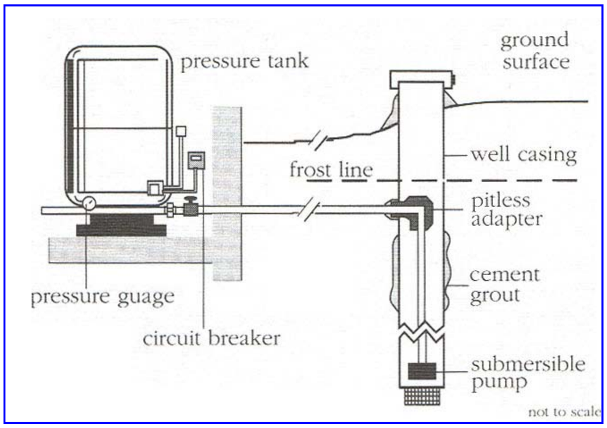

Figure 8. Private well water supply system.

This process has important implications for both the quantity and quality of water pumped from the well. The intake section of the well must allow adequate quantities of water into the casing without permitting surrounding soil and rock to enter. This is usually accomplished with a *well screen.* The screen specifications are especially important if the intake section is located in sand or loose material. It may be supplemented by a "gravel pack" that surrounds the screen and assists in filtering soil and rock from the well. Perforated pipe is not a suitable substitute for a well screen.

Once the well is installed, the space surrounding the casing *(annular space)* must be filled to prevent contamination of the water supply and can hasten deterioration of pumping equipment.

Submersible pump and pitless device

A submersible pump is most frequently used to lift water from the well into the pressurized distribution system of the house. Selecting the appropriate pump depends on well diameter, household needs, the distance water must be pumped, well depth, and overall water quality (sediment and corrosiveness can lower pump efficiency). Submersible pumps are commonly used in residential applications. They are designed to be immersed in water and are usually lowered to within 10 feet of the bottom of the well. The pump must be grounded, and the motor and electrical equipment must be protected from lightning.

The pitless device is a watertight connection to the well, attached either below the frost line (pitless adapter or pitless unit) or above ground level (above-ground discharge adapter). This device provides better protection of the well and the water supply and allows access to the well for maintenance and repair while not opening a contamination pathway. The pitless device replaces the earlier well pit (an area dug below the frost line) that housed the pump and protected the lines from frost. Well pits are prohibited by most state well codes because they allow

contamination of the water supply and can hasten deterioration of pumping equipment.

Of the three basic types of pitless devices, that selected depends on local code regulations. The pitless adapter and the pitless unit are commonly used with submersible, deep-well jet, shallow-well jet, and reciprocating pumps.

- The *pitless adapter* is attached to the well below the frost line, diverting water horizontally into the dwelling.
- The *pitless unit* is a fabricated item similar to the pitless adapter; it replaces the upper part of the well casing, which is cut off just below the frost line.
- The *above-ground discharge adapter* sits above ground level over the top of the well casing. Freezing is avoided by a heated pump house or enclosure.

Well abandonment

Unsealed, abandoned wells are hazardous to children and pets who may fall into them. An abandoned well also is a potential pathway for groundwater contamination. Abandoned wells should be filled with concrete, cement grout, or clay material. A dug or bored well should have as much of the lining removed as possible to prevent surface water from reaching the underlying aquifer through cracks or openings in the lining material. If the well cannot be filled in this manner, it should at least be tightly capped. Abandoned wells should never be used for waste disposal.

Maintenance

The area around a well should be protected from animals, chemicals, and any activity that might contaminate groundwater. Before it is first used, and anytime following work on it, the well should be disinfected. This is usually done by *shock chlorination* (described in *Water Treatment Notes 5:* Chlorination of Drinking Water). If subsequent water tests indicate recurring bacterial contamination of the water, disinfection by continuous chlorination, ultraviolet radiation, or ozone treatment may be appropriate. Contact the local health department before purchasing and installing such equipment.

Well water should be tested annually for coliform bacteria and nitrate and any other potential contaminants determined by activity near the well or more distant activities occurring in the aquifer recharge area. Iron, manganese, hydrogen sulfide, and hardness are frequently associated with groundwater supplies.

These contaminants are not considered to be health hazards, but they can make the water unpleasant to use or consume. Treatment for these problems is available, and the local Cooperative Extension office or health department can usually provide information about treatment options. (See other fact sheets in this series.)

A well may fail to provide an adequate supply of water due to a faulty pump, decline in water level, plugged or deteriorated screens, or an accumulation of sand or sediments in the well. A well driller or Cooperative Extension agent can help determine the cause of failure and provide information concerning possible remedies.

More information about wells can be found at http://www.watersystemscouncil.org/ a national not for profit organization. They provide a number of publications about wells and also have a free hotline to call with problems.

Summary

A properly constructed, developed, and protected well should provide adequate quantities of safe drinking water for many years (fig. 8). A deep, drilled well is the best way to tap groundwater for drinking although other methods may be satisfactory. This fact sheet outlines the types of wells available and precautions for using groundwater as a drinking water source.

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