Private Wells — Safe Location

Water supply to rural residences and agricultural operations without rural or public water systems is usually obtained from a private well or surface water supply. In Kansas, more than 73,000 individuals rely on private wells for a water supply.[1] When public and rural water systems that use well water are added to the private well numbers, 34.6% of the Kansas population relies on groundwater for their water supply. Surveys of private well water quality indicate that some rural wells may contain coliform bacteria, nitrate, or other elements and do not meet the safe drinking water standards used for public systems. Following the guidelines for recommended separation distance and direction from potential contamination sources when locating a well can help protect the quality of private well water.

Aquifers and Water Quality

When water from atmospheric events falls to the ground and fills the open spaces in sand, gravel, soil, and rock formations, it is called groundwater. When an underground formation contains enough water that can be removed at useful rates by a pump, it is called an aquifer. Aquifers contain fractured rock, porous rock, sand, and gravel to allow water storage and movement. Aquifers may be a single mass, a layer, or a series of layers. Water flows through aquifers as a result of the driving force (head) and permeability of the flow area. Figure 1 gives a cross section view of two underground aquifers and resulting water sources from wells and springs.

An aquifer that receives recharge water directly from the surface is called an unconfined aquifer. Since an unconfined aquifer is recharged locally, activities near a well pose a higher risk for contamination. Most water wells in western and south central Kansas and major stream valleys are located in unconfined aquifers.

Confined aquifers are located under a low-permeability layer or zone that minimizes direct water recharge from the surface. Confined aquifers are normally recharged at much greater horizontal distances from the well. Surface activities near a properly constructed well in a confined aquifer are less likely to contaminate the well. Many wells in north central and eastern Kansas are located in confined aquifers.

[1] *2023 Safe Drinking Water Information System Numbers, Kansas Department of Health and Environment Bureau of Water*

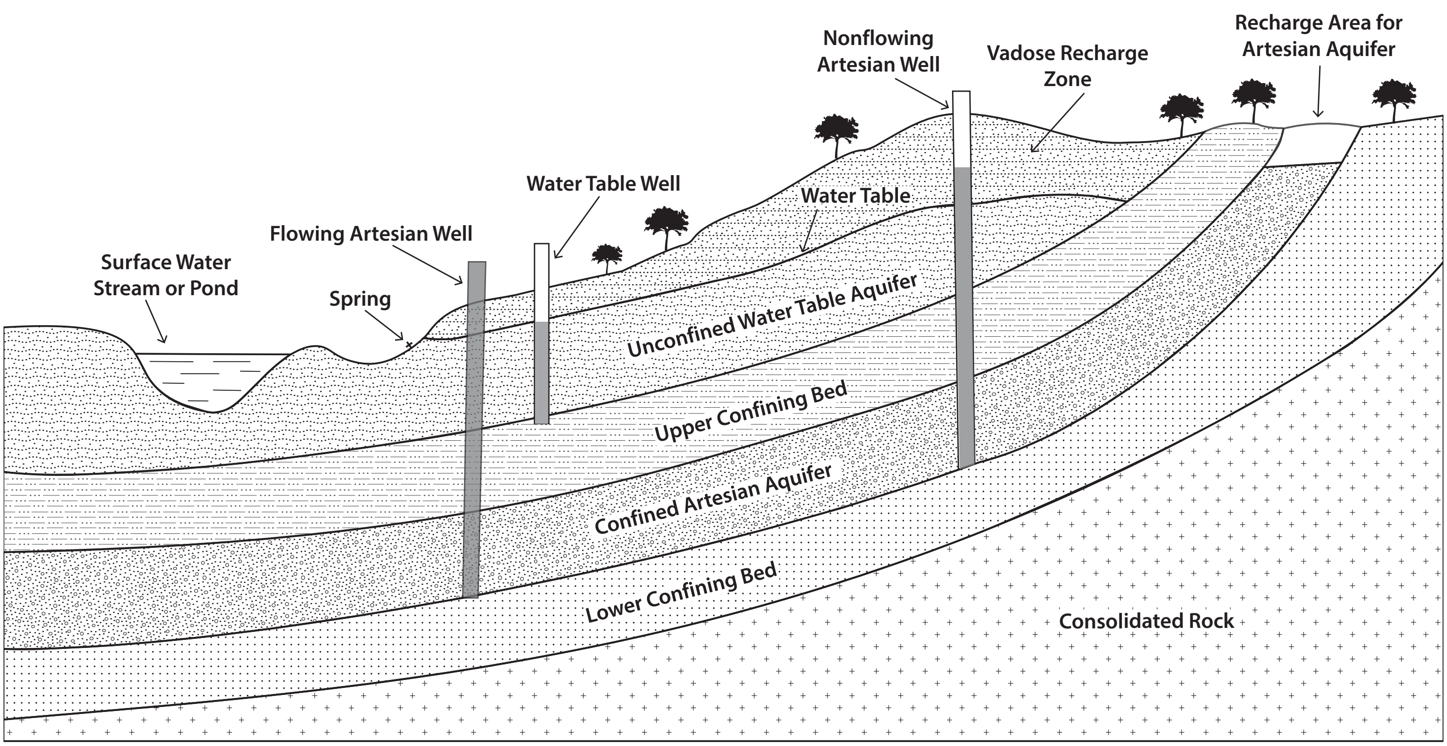

Figure 1. *Cross section of underground aquifers and water sources for wells. (Adapted with permission from Private Water System Handbook, Midwest Plan Service.)*

Other factors affecting potential contamination include depth to the water table, soil and geologic materials, permeability in the recharge zone, and, to a lesser extent, type and condition of surface vegetation. Recharge water passes through an unsaturated layer called the vadose zone or zone of aeration above the water table. The top portion of the vadose zone contains roots and most of the microbial activity.

Soil organisms break down many of the dissolved compounds in water, and plant roots remove nutrients and trace elements. As water passes through the vadose zone, suspended particles and most organisms are filtered and removed. Compounds dissolved in the water may be absorbed in soil particles, precipitated, or chemically combined to form new compounds. Healthy perennial vegetation with deep root zones and thick vadose zones of moderate permeability are ideal to ensure high-quality groundwater recharge.

Water quality is affected by the rate of recharge, the volume of storage, and the rate of flow through the aquifer. Low water-recharge rates allow greater root uptake and more time for soil organisms to break down dissolved and suspended materials in the water. Slow recharge rates also allow more time for other reactions between contaminants, soil, and rock. Minerals in the soil and rock may be dissolved into the water as it moves through these layers. Large storage volumes in an aquifer help dilute contaminants and enable a well to produce water during long, dry periods. Rapid flow through the aquifer may cause a water shortage during dry periods.

The water quality of an aquifer is normally variable. Water quality from deep aquifers tends to vary less. However, groundwater quality is not uniformly good or poor, even over relatively short distances.

Two aquifer types found in Kansas, detailed in the following paragraphs, deserve special attention when considering a private well. Hiring a knowledgeable, experienced, and licensed well driller is important when choosing to use or to avoid the aquifers.

Sand and Gravel Aquifers with similar deposits that extend to the surface are particularly difficult to protect from contamination. In many cases, material in the unsaturated zone is the same as the aquifer, and permeability can be high. Excess nitrate and other soluble compounds in the surface soil are easily transmitted to the groundwater. Plant growth is often limited by the low water-holding capacity of sandy soil. Adsorption of water and microbial activity are also less in sandy soils.

Limestone Aquifers require special attention in two situations. The first is where sink holes are common, called Karst topography. The second is where the rock is exposed or covered only by a shallow layer of soil. Sinkholes and exposed bedrock provide direct connections for contaminants to enter the groundwater and contaminate wells. Shallow soil layers provide little protection. These two situations pose a serious risk for groundwater contamination.

Water in limestone aquifers is held primarily in cracks, joints, and solution channels. These water flow spaces tend to be large compared to pore spaces in other types of aquifers. As a consequence, the water flow in limestone aquifers may be rapid and have poor filtering action. However, rapid flow through the aquifer tends to decrease the time of contamination events.

Groundwater Flow

Water in an aquifer usually follows the general slope of the soil surface toward streams, creeks, and rivers. However, nonuniform properties in the aquifer and sloping formations can cause differences in water movement. Pumping a well also influences groundwater flow direction and rate of movement. As water is pumped from the well, water in the aquifer surrounding the well flows toward the well.

Table 1. *Distance versus chance of well contamination in unconfined aquifers.*

Distance (feet)	Bacteria Levels	Nitrate, Pesticide(s), Volatile Organic Chemicals (VOCs)
less than 50	moderate to high	very high
50-100	low to moderate	moderate to very high
100-200	very low to low	moderate to high
200-400	very low	low to moderate
greater than 400	very low	very low

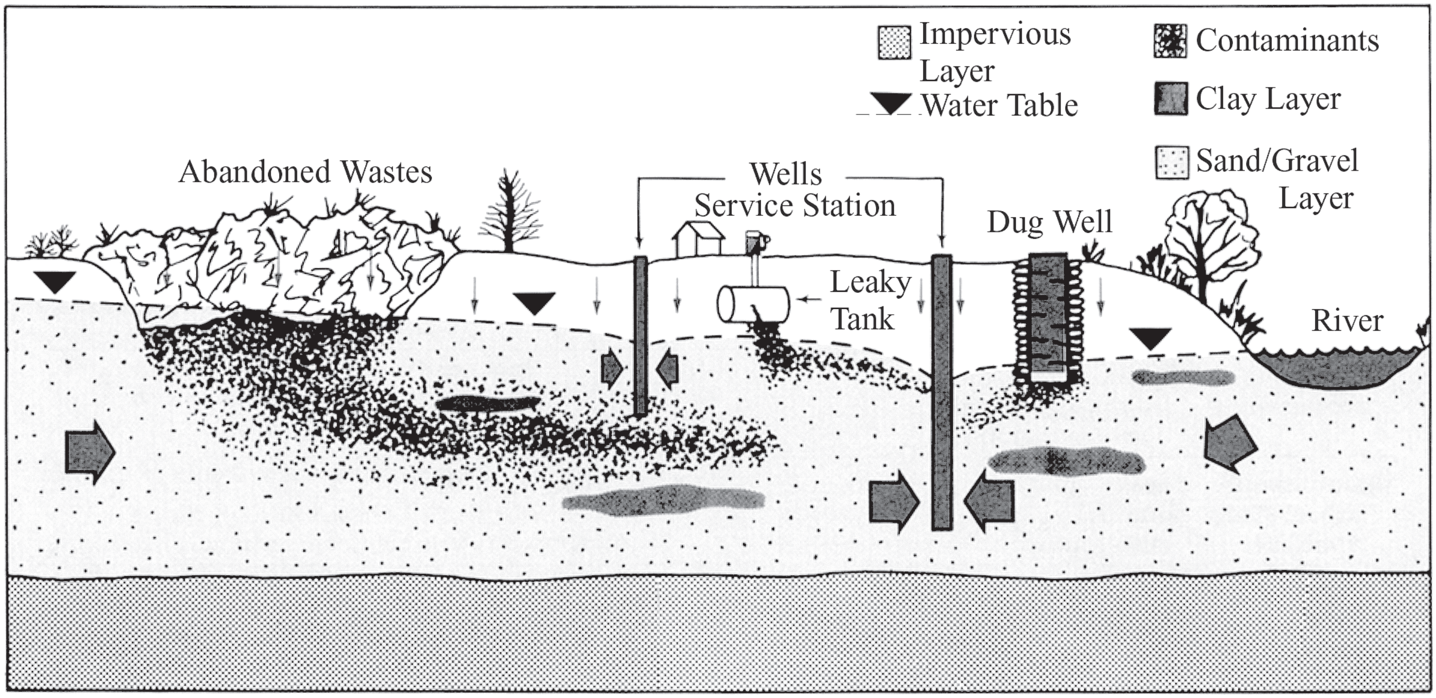

Figure 2. *Groundwater contamination occurs from many sources and usually moves in concentrated plumes.*

Household wells are usually pumped for a few minutes to a few hours at a time. In most private well situations, the natural flow of the aquifer has a greater influence on water quality than the water removal from a well.

Locating Wells to Safeguard Water Quality

On early farmsteads, water wells historically were located near the point of maximum use. This location was due to limited access to plumbing systems and power sources. Livestock usually required the most water at a farmstead, so the well was often located near livestock pens and lots. This location also placed the well near a major contamination source of nitrates and *E.coli* bacteria, which are two of the primary water quality concerns in private wells. The farmstead's house and shop were usually upslope from the livestock. These location factors placed the well downslope from other potential pollution sources. A location near, and especially downslope, from contamination sources increases the potential for well pollution. Locating a domestic well to safeguard water quality requires consideration of geology, topography, and potential contamination sources within at least 400 feet of the site.

A well is best located on a site with good drainage that is not subject to flooding, is upslope, and is removed as far as practical from possible contamination sources. A continuous layer of well-drained soil generally provides good protection from contamination by bacterial sources such as septic systems and animal waste. Although at least 50 feet of separation distance is required by state regulations, 100 feet or more provides greater protection from microbes — especially viruses — and is required by some county codes. The vertical separation distance should also be considered, including thickness of the soil cover and depth to groundwater. The greater the separation distance (both horizontal and vertical) of the well intake from sources of contamination, the greater the protection from contamination.

When the soil thickness over rock is shallow or very coarse, water can move rapidly to the aquifer. When soil is poorly drained, the soil's natural filtering capacity is reduced. Microbiological contaminants including bacteria, viruses, and cysts have a greater chance of reaching groundwater when either condition exists.

The first step in selecting a good location for a well is to inventory all potential contamination sources. These sources should be accurately located on a map. Next, find groundwater flow direction from groundwater publications, local driller knowledge, computer topographic maps, or use a surveying level to compare water levels in existing nearby wells. Groundwater flow usually follows general surface slope of surrounding land. The well site should be upslope from surface drainage from all pollution sources. It should also be upgradient in groundwater flow. The preferred horizontal separation distance is at least 400 feet.

While groundwater movement direction suggests where to locate the well protection zone, a landowner may not have that specific information. Therefore, protection in all directions is a wise procedure. Figure 2 shows possible groundwater pollution sources. Table 1 gives recommended separation distances from well location to bacteria and nitrate, pesticides, and volatile organic chemical sources. Recommended minimum separation distances are 50 feet from property boundaries, 100 feet from buildings and bacterial sources, and 400 feet from major nitrogen (nitrate) sources.

Recommended separation distances for a private well location when two houses occupy two adjoining properties and each house requires a well and septic system are shown in Figure 3. Recommended minimum separation distances are 50 feet from boundaries, 100 feet from buildings and bacterial sources, and 400 feet from major nitrogen (nitrate) sources.

Recommended separation distances for a private w ell location are shown in Figure 3. An important aspect is that any private well should be separated from all potential contamination sources, not just those of the owner. To achieve separation distances, lot sizes of at least 5 acres are needed when each lot has a septic system and a well. This generally allows for an adequate separation distance from the well to potential contamination sources on the owner's property and other adjacent properties. The system would be improved if all water supply and sewage locations for all lots would be planned before lot ownership occurs.

Water System Flow Rate

The water flow rate from a well should match the maximum desired water flow to accomplish the needs of a farmstead. The minimum flow rate for a house is 6 gallons per minute and 10 gallons per minute is desired. Other water demands such as lawn, livestock, garden, and field/crop use should be added to the house water flow rate, Size of the pressure storage tank should also be determined. Information on the design of water supply systems for farmsteads can be found in the *Private Water System Handbook*, MWPS -14 from Iowa State University.

Figure 4 shows a cross section view of a completed well equipped with a submersible pump system. The process of locating, designing and constructing a water well begins when the owner makes arrangements with a licensed driller or a professional consultant. The driller/consultant

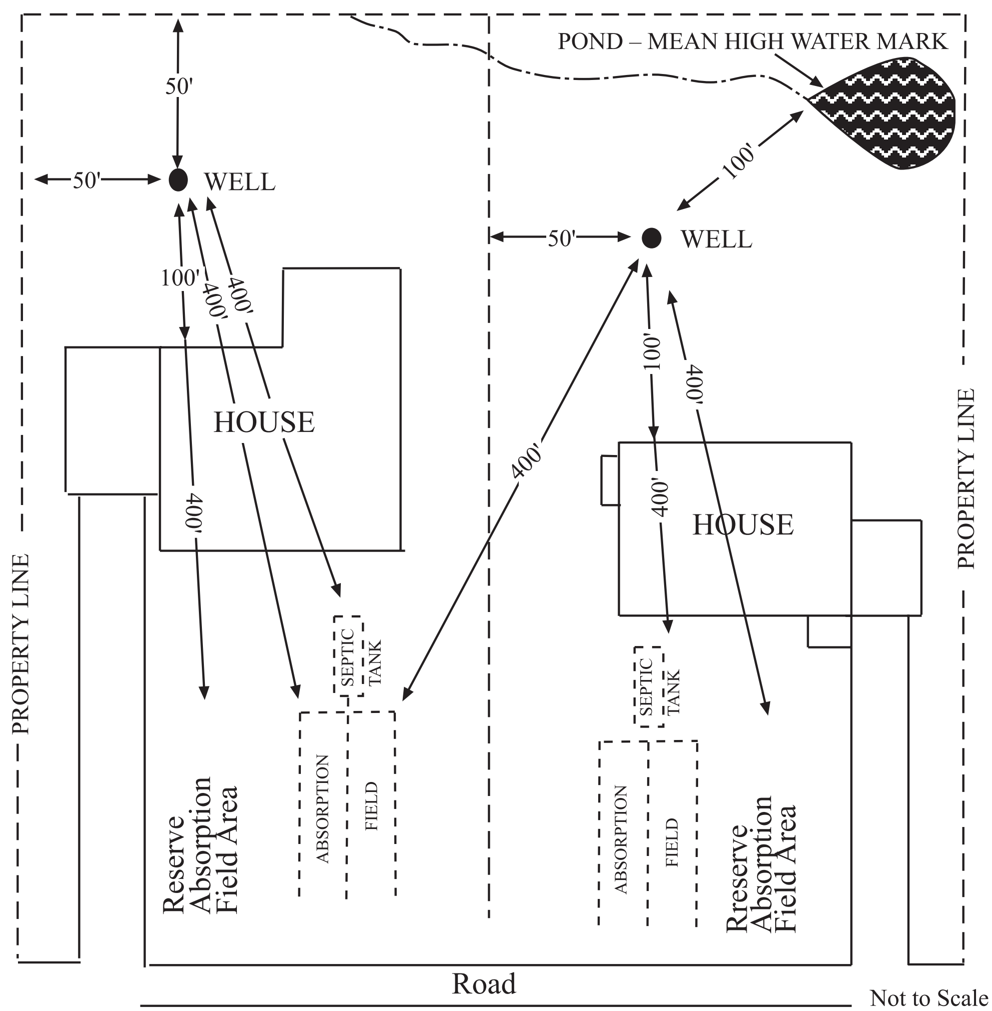

Figure 3. *Ideal private well location.*

along with the owner finds a suitable location to meet the specified purpose of the well and a preliminary design is established. When water quality is particularly important, the driller may drill a small-diameter pilot hole before drilling the final well. From information obtained from the pilot hole, a driller or consultant can determine aquifer formations and groundwater quality at various depths and then optimize the final well design for the specific hydrogeological conditions at the site. Once the final well is drilled, the driller installs the well casing, well screens, and fills the annulus (opening between casing and drilled hole) with a lower gravel pack and the appropriate cement and clay mixtures to prevent water from leaking between uncontaminated and contaminated aquifers or from the land surface into the well. Then the driller develops the well, completes the sanitary seal of the well head, and may install a pump and power source. Proper design, construction, development, and completion of the well will result in a long and efficient life for the well.

Well Regulations

Private well owners are responsible for the quality of water from their private well. No state or federal regulations apply to the quality of water supplied from private wells. However, Kansas does have regulations for proper well construction and repair, which help protect the well's water quality. A commercial business that constructs (drills), reconstructs (repairs), or treats wells must be licensed to perform these services. When following all state and local regulations, well owners can drill or repair their own well without a license. These regulations include filing the proper forms with the KDHE, which can be found at *www.kdhe.ks.gov/396/Forms-Regulations*.

Well drilling regulations and county sanitary codes recommend a minimum 50-foot separation of the well from any possible contamination source (some counties require 100 feet or more). This separation distance is based on the soil's filtering capacity for bacteria and other microbes. Many contaminants, including nitrate, volatile organic chemicals (VOCs), fuel, petrochemicals, and some pesticides are not filtered completely by the soil.

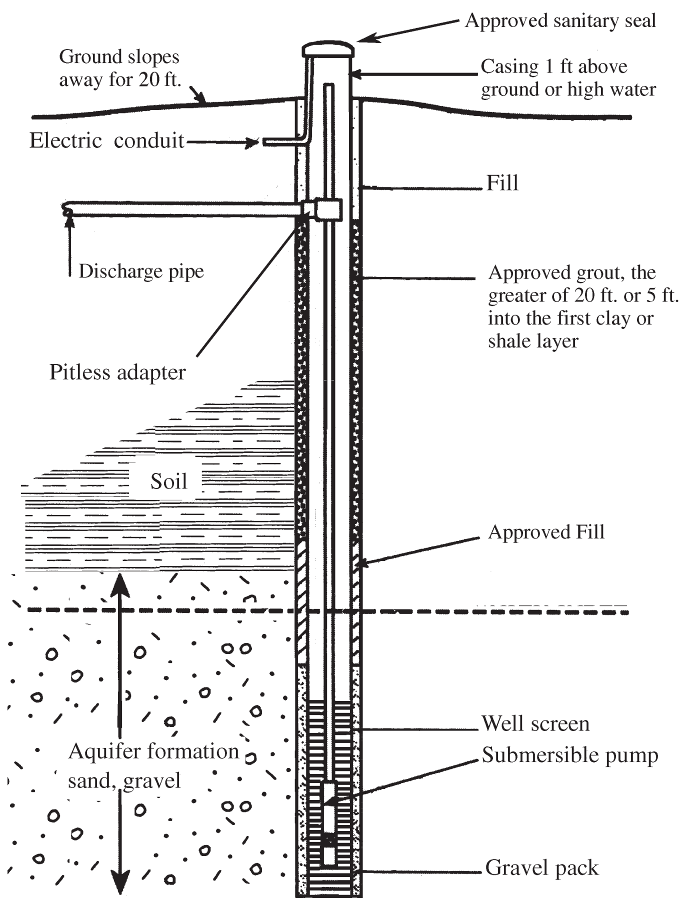

Figure 4. *Required well construction — unconfined aquifer.*

Greater separation distances from the well are needed to protect the well from contaminants not filtered by soil. Research indicates that low levels of nitrate may be present in wells when nitrogen sources are more than 400 feet from the well.

All wells will not meet household drinking water standards and could be used for livestock or irrigation. All wells require protection. Regardless of well use, no well should cause water quality problems in the aquifer where it is located (Figure 5).

Properly locating and drilling a new well is the best way to ensure a well produces safe water. Wells also need annual testing, maintenance, and protection of the water supply. More information about these subjects can be found in K-State Research and Extension publications: *Testing Private Water Systems,* MF3655 *and Private Well Maintenance and Protection,* MF3666.

All well drillers in Kansas must be licensed. A list of drillers can be obtained from the KDHE website at *www.kdhe.ks.gov/347/Water-Well-Program*. Another source to find a contractor is available through the Kansas Groundwater Association at *www.kgwa.org/FindAContractor*.

Summary

Principles for constructing and maintaining a safe well include:

- Locate the well away from potential sources of contaminants.
- Seal well pathways that would allow nonaquifer water to enter the well.
- Select quality materials that will have a long life.
- Avoid, or carefully manage, sources or activities that may contribute contaminants within 200 feet of the well. In sensitive areas, increase this distance to 300 to 400 feet.
- If contaminants are detected, locate the source, evaluate the health risk, and test more frequently to determine if there is a trend and if additional steps need to be taken.

Water wells may experience deterioration and damage. Annual maintenance helps ensure the well will continue to provide safe water for many years. This maintenance includes: inspecting the well location and construction; testing the water specifically for nitrates and *E.coli* bacteria in addition to common impurities and nuisance contaminants; and developing and following a protection plan.

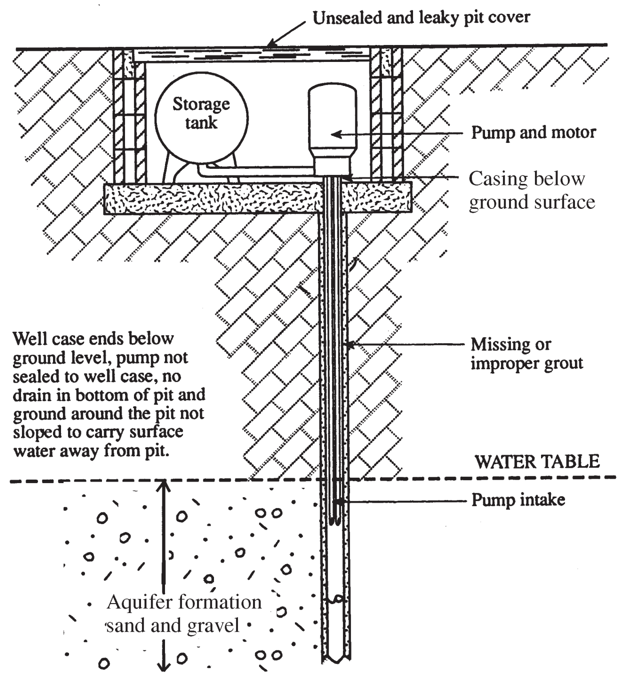

Figure 5. *This well does not meet many well configuration standards and allows contamination to enter.*

Water test kits are available at most local K-State Research and Extension Offices. To locate an office, visit, *www.ksre.k-state.edu/about/statewide-locations/*. In addition, local health or state environmental offices may have additional information and testing kits.

Additional Information

K-State Research and Extension offices — *www.ksre.k-state.edu/about/statewide-locations/*

Local health departments — *www.kdhe.ks.gov/2085/Directories-Maps*

Local environmental offices or county sanitarian — *www.kdhe.ks.gov/BusinessDirectoryII.aspx?lngBusinessCategoryID=49*

Sources

Groundwater Foundation — *groundwater.org/what-is-groundwater*

Environmental Protection Agency — *www.epa.gov/privatewells*

Well Owner Resources — *wellowner.org*

K-State Research and Extension Bookstore — *www.bookstore.ksre.ksu.edu*

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