Kansas Department of Health and Environment
Bureau of Environmental Field Services
Watershed Management Section
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Private Wells – Safe Location and Construction
Technical Guidance Document WMS 20-970

This publication provides help for water well owners and users in understanding the importance of proper well construction and safe location away from known and potential sources of contamination.

Water for residences beyond reach of public systems, either city or rural water districts, is usually supplied by a well. Safe drinking water from a well depends on location of the well, how it was constructed, and how it is maintained. According to the Kansas Geological Survey (KGS) Water Well Database, from 2013 to 2020, more than 72,000 domestic groundwater wells in Kansas were used for drinking purposes (KGS 2020). Compounds such as arsenic, nitrate, and atrazine are often found in Kansas groundwater (KDHE 2018). These contaminants usually can be traced to problems with well location or construction. Construction and location, along with proper maintenance, are the most important factors in protecting private well water. The Kansas Environmental Interest Finder (KEIF) is a web-based mapping application by KDHE designed to identify sites in Kansas where there are potential environmental impacts.

Well Regulations

The state of Kansas does not regulate the water quality from private water supply systems. In practice, the state of Kansas has relied on local governments, both city and county, to develop their own private water well policies and regulations. The well owner or water user is responsible for the quality of water from a private well. The state of Kansas does not regulate or require testing of private wells; that task is entrusted to city and county governments. Kansas state law has established specific requirements for licensed water well contractors who construct, reconstruct or treat water wells.

KDHE water well regulations and some county sanitary/environmental codes specify a minimum 50-foot separation of the well from any source of possible contamination (some counties use 100 feet or more). These minimum separation distances are based on the soil's filtering capacity for bacteria and other microbes. Many contaminants, including nitrates, volatile organic compounds (VOCs), fuel, petrochemicals, and some pesticides, are not filtered by the soil and greater separation distances are needed. (Table 1).

Wells also need annual maintenance and protection of the water supply; see the latest copy of KDHE's publication, *Private Well Maintenance and Protection*, for detailed well maintenance needs. It provides a checklist and service record form that outlines important well information needs and can serve as a record to store your well information.

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

Distance (Feet)	Bacteria	Nitrate, Pesticide(s), Volatile Organic Compounds (VOCs)
< 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
> 400	very low	very low

Groundwater and Geology

Groundwater exists below the ground surface, filling the spaces in sand, gravel, soil, and rock formations. The level below which all the pore spaces in the ground are filled with water is called the water table. The entire region below the water table is called the saturated zone, and water in this saturated zone is called groundwater. An aquifer is an underground formation of permeable rock or loose material that can produce useful quantities of groundwater when tapped by a well or as discharge via a spring. Water flows through aquifers as a result of the driving force (head) and permeability.

Aquifers and Water Quality

An aquifer that receives recharge directly from the surface is called an unconfined aquifer. As the unconfined aquifer is recharged locally, activities near a well pose a high risk to cause contamination. Unconfined aquifers are bound by the water table; that is, they have no confining rock layers over the top of them. Most wells in western and south central Kansas, and major stream valleys, are in unconfined aquifers that are susceptible to contamination.

Confined aquifers are beneath a zone of low permeability that minimizes direct recharge from the surface, so they are normally recharged at much greater distances from the well. A well in such an aquifer is called an artesian well. The water in these wells rises above the top of the aquifer because of confining pressure; the level to which it rises is called the static water level.

Drilling a well into an unconfined aquifer is often easier and less expensive than drilling into a confined aquifer. Unconfined aquifers are generally nearer the surface, so wells are shallower. On the other hand, near-surface, unconfined aquifers are more susceptible to contamination than confined aquifers that are sealed off from surface contaminants.

Porous media aquifers consist of aggregates of individual particles such as sand or gravel. Porous media where the grains are not connected to each other are unconsolidated. In consolidated aquifers, such as sandstone aquifers, grains in the porous media are cemented together. Fractured aquifers are rocks in which ground water moves through cracks, joints, or fractures in otherwise solid rock. Some limestones in Kansas are fractured aquifers. Geologic maps show the distribution of rock formations exposed at the surface, and thus indicate the nature and types of consolidated or unconsolidated materials in an area. The type of geologic materials and the topography of the earth's surface in an area influence the location of ground water. Assessing these characteristics can help you determine the potential of a specific area to yield water to wells. A map showing Kansas aquifers is available on the KGS website at http://hercules.kgs.ku.edu/geohydro/aquifer_map/aquifers_ks.jpg.

A properly constructed well is much less likely to be contaminated by nearby activities if it draws from a confined aquifer rather than an unconfined aquifer. Many wells in north central and eastern Kansas are in confined aquifers. Other factors affecting potential contamination are depth to the water table, soil and geologic materials, permeability in the recharge zone, and to a lesser extent, type and condition of vegetation. Recharge 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.

Groundwater is susceptible to contamination from multiple sources, including industrial solvents, agricultural chemicals, confined animal feeding operations, and naturally occurring minerals. Industrial solvents and agricultural chemicals can migrate into groundwater from the earth's surface from spills, leaky sewer connections, and poor disposal practices.

Water quality is greatly affected by the rate of recharge, volume of storage, and rate of flow through the aquifer. Slow rates of recharge allow greater root uptake and more time for soil organisms to break down dissolved and suspended materials in the water. Rapid flow through the aquifer makes it self-cleaning and also subjects it to water shortage during dry periods. The water quality of an aquifer is normally variable.

Aquifer types — sand and gravel aquifers, and limestone aquifers — deserve special attention when considering a private well. These conditions exist in Kansas and hiring a knowledgeable, experienced, and licensed well contactor is extremely important. It is a well contractor's business to understand and plan for these special situations.

Protect Well Water by Good Location

Locating a domestic well to safeguard water quality requires consideration of geology, topography, and potential contamination sources within at least 400 feet of the proposed location. A location near and especially downslope from contamination sources increases the potential for well pollution.

The first rule for protecting well water quality is to keep the well upslope from potential sources of contamination. Current contamination sources are easy to identify. However, past activities may not always be obvious and many contaminants have a long life in the environment. An attempt should be made to determine if potential contamination sources exist as a result of past activities at or near the proposed well location. See relationships of sources and the well in Figure 1.

The second rule for protecting water quality is adequate separation of the well from pollution sources. There is no specific distance from a potential pollution source that will guarantee the well will not be affected. Minimum separation distances regulated by K.A.R. 28-30-8 and K.A.R. 28-5-2 are presented in Table 2. The third rule for protecting well-water quality is to avoid high density or concentration of pollution sources. The third rule for protecting well-water quality is to avoid high density or concentration of pollution sources.

The third rule for protecting well-water quality is to avoid high density or concentration of pollution sources. A rural-suburban development with three-acre lots would allow more than 200 homes per square mile.

Table 2. Minimum required and recommended separation distances from private wells.
This table gives minimum separation distances between a well and its potential sources of pollution as required in Kansas Department of Health and Environment regulations K.A.R. 28-30-2(w) and 28-30-8. Whenever possible, increase separation distances as these minimum requirements do not guarantee contamination will not reach the well.

Potential Source of Pollution	Separation Distances (feet) Minimum Required	Recommended
Watertight sewer line (cast-iron, PVC, etc.)	10	50
Non-watertight sewer line (clay tile, etc.)	50	> 400
Septic tanks (watertight)	50	> 100
Abandoned wells	50	> 400
Wastewater absorption field (septic lateral lines)	50	> 400
Pit privies	50	> 400
Stables, livestock pens, lagoons and manure piles	50	> 400
Streams, lakes and ponds	50	> 100
Silage pits, fertilizer and fuel storage (above or below ground)	50	> 400
Seepage pits (or rat holes) prohibited after May 1996	50	> 400
Pump pit, including valve box for lawn sprinkler	2	4
All other wastewater systems	50	> 100
Property line	25	> 50
Public water supply sources (i.e., wells)[1]	100	> 100
Building/structure (termite treatment)[2]	50	> 100
Pesticide storage, mixing and disposal areas, or areas of repeated pesticide use	50	> 400

[1]Required by Policies, General Consideration and Design Requirements for Public Water Supply Systems in Kansas [K.S.A. 65 171h].
[2]Not required by K.A.R. 28-30-8 but is required when injecting liquid pesticides into the soil, see manufacturer's label.

If each home had a private well and an onsite sewage system, it would be difficult to select a safe location for all wells within that area. Without favorable topographic and geologic conditions, water quality problems would eventually develop.

Groundwater Flow

There is a natural movement or flow of water in the aquifer that likely follows the general slope of the surface. However, non-uniform properties in the aquifer and sloping formations can cause differences.

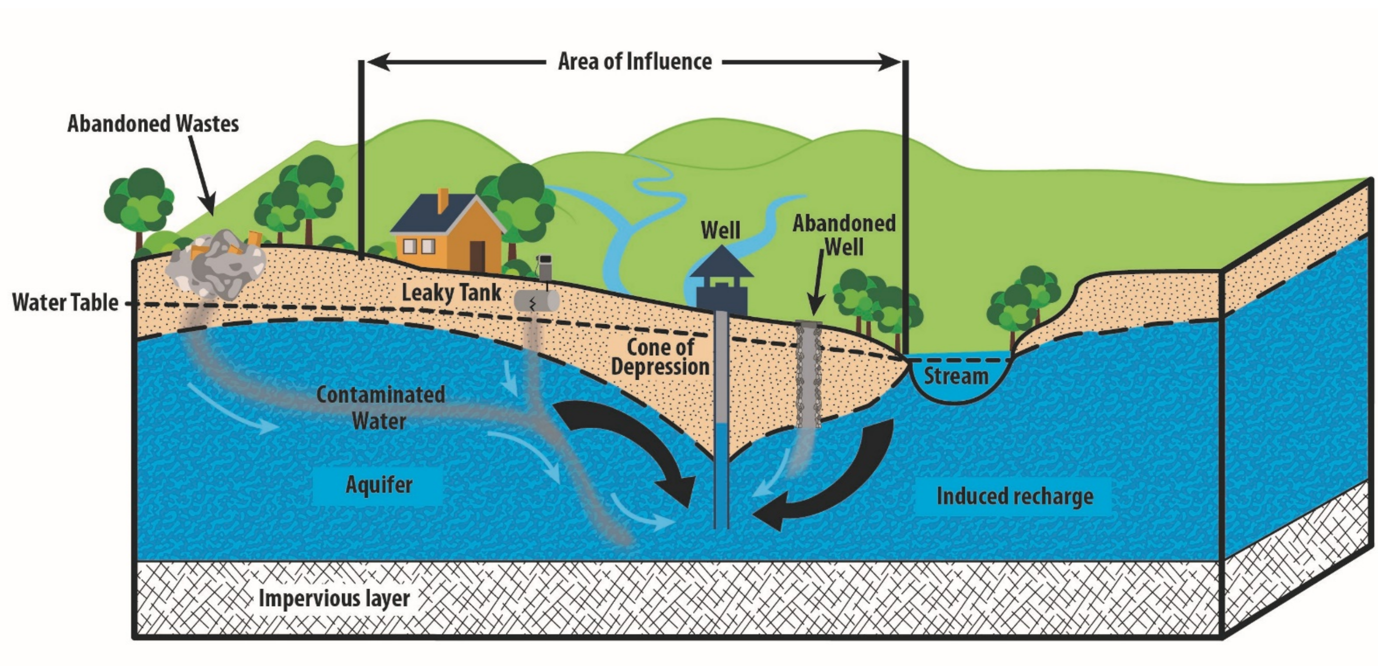

Figure 1. Cone of depression for a pumping well

Pumping from wells also influences groundwater flow direction and rate. As water is removed from the well, water in the aquifer surrounding the well flows toward the well creating a "cone of depression."

More of the water entering the well flows from the uphill side and the cone of depression becomes oval in shape. The size of the cone depends on the permeability and storage in the aquifer and the rate and duration of pumping. Household wells are usually pumped for a few minutes to a few hours at a time. In coarse gravel aquifers, both large storage and high permeability result in a small cone of depression. By contrast, an aquifer with lower permeability and storage values will have a larger cone of depression.

In most situations, the natural flow in the aquifer is more important than pumping in conveying contaminants toward a well. But, pumping does have some effect and long periods of pumping have more influence than short ones. The effect of pumping is greater during drought periods when groundwater levels and flow may be lower.

Where to Locate a Well

A well is best located on a well-drained area 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 much better protection from bacteria and other microbes — especially viruses — and is required by some county codes. Vertical separation should also be considered, including thickness of soil cover and depth to groundwater. The greater the horizontal and vertical separation of the well intake from sources of contamination, the greater the protection from contamination. When the soil cover over an unconfined aquifer is thin or very coarse, water can move rapidly to the aquifer. When soil is poorly drained, its natural filtering capacity does not function as well. 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 should be accurately located on a map or sketch. Next, find groundwater flow direction from groundwater publications, a Kansas licensed well contractor, or by using a surveying level to compare water levels in existing nearby wells. Groundwater flow information for many counties can be found under "Geology – County Bulletins" on the KGS website at: http://www.kgs.ku.edu/.

The direction of shallow groundwater flow usually follows surface topography. However, the water level in a nearby surface water body (stream or pond) can affect whether groundwater flows into (low) or away from (high) the water body. The well location should be upslope of surface drainage from all pollution sources. It should also be up gradient in groundwater flow. The preferred separation distance is at least 400 feet.

While groundwater flow direction suggests where the well protection zone should be located, a landowner may not have that specific information. Therefore, protection in all directions is a wise procedure. Table 1 shows contamination risks for various distances. Table 2 shows that recommended minimum separation distances are 50 feet from watertight sewer lines and property boundaries, 100 feet from surface water, buildings and bacterial sources, and 400 feet from major potential sources of pollution, including major nitrogen (nitrate) sources.

Ideal separation distances for a private well location are shown in Figure 2. An important aspect is that any private well should be separated from all potential contamination sources, not just those of the owner. To achieve these separation distances, lot sizes of at least five acres are needed when each lot has a septic system and a well. This generally allows for adequate separation distance from the well to potential sources on the owner's property and other adjacent properties.

Current Well Construction Standards

Well construction following current standards, together with maintenance and protection, are important in maintaining a safe water supply. When the well meets KDHE minimum well construction standards, contaminants from the surface are not likely to directly enter the well or groundwater adjacent to the well. Kansas regulations for water well construction require an approved, watertight casing from at least one foot above the finished ground surface to at least 20 feet below ground surface. Proper drainage at the well must be provided to prevent ponding of surface water within 50 feet (Figure 3). If the location is subject to surface flooding, the casing should be extended one foot above the highest flood elevation. However, locations subject to flooding are discouraged.

The casing must be capped with a KDHE-approved sanitary well seal or cap in a watertight and airtight manner that is equipped with a screened, downward pointing well vent. The well seal or cap cannot use set screws into the casing. If groundwater is brought through piping from the side of the casing below ground surface, an approved watertight pitless adaptor or pitless unit must be used. No other holes through the casing are allowed.

Electrical wires to a submersible pump must be contained in a conduit that connects to the sanitary well seal or cap in a watertight and airtight manner.

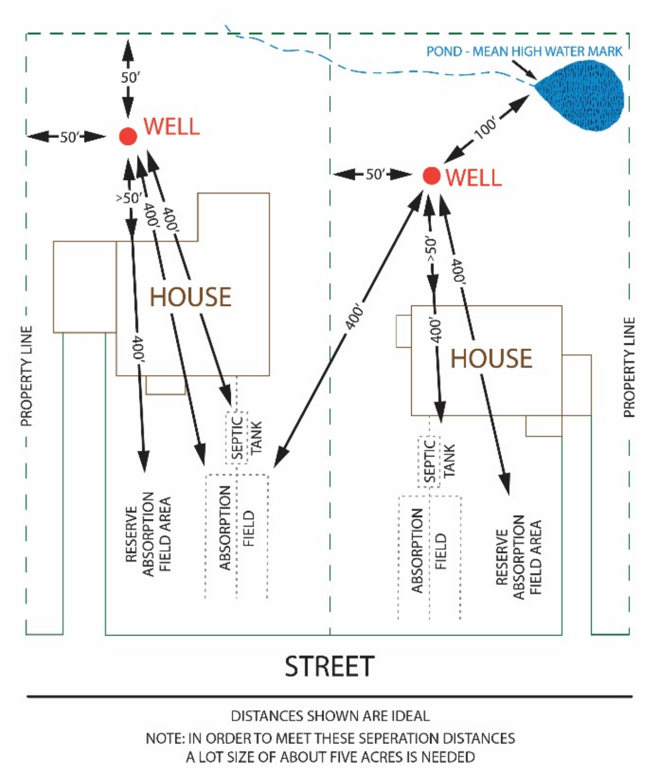

Figure 2. **Site features showing minimum and recommended separation distances**

Approved sanitary seals are designed to seal the conduit. If the well penetrates a confining layer (i.e. clay or shale) or terminates in the bedrock, the casing must be grouted with approved materials to seal it with the borehole from ground surface (or the pitless adaptor/unit), to a depth of at least 20 feet, or at least five feet into the first clay or shale, whichever is greater. In addition, water from two or more separate aquifers must be separated from each other with grout in the annular space, and groundwater-producing zones known or suspected to contain natural or man-made pollutants must be cased and grouted in the annular space to prevent upward or downward movement. To allow proper placement of grout materials, the diameter of the borehole must be at least 3 inches greater than the outside diameter of the casing. Exceptions to the minimum required lengths of casing and grout may be granted to meet local conditions. Finally, the ground surface should be shaped to slope away from the well for at least 15 feet in all directions (see Figure 3) and should not allow ponding within 50 feet.

Well Construction Details

A domestic well is normally constructed by drilling the hole four to six inches larger than the casing. The intake portion of the well is generally a screen or perforated length of pipe. The screen or perforated length of pipe is lowered into the hole and lengths of casing are connected as necessary. This is lowered until the screen or casing rests on the bottom of the hole. Centering guides may be attached to the casing to maintain a uniform space between it and the bore hole. Granular material called gravel pack is placed in the annular space around the well screen. The cuttings must be examined and logged so the depths and properties of each formation and confining zone are known and can be recorded on the water well record by the licensed water well contractor.

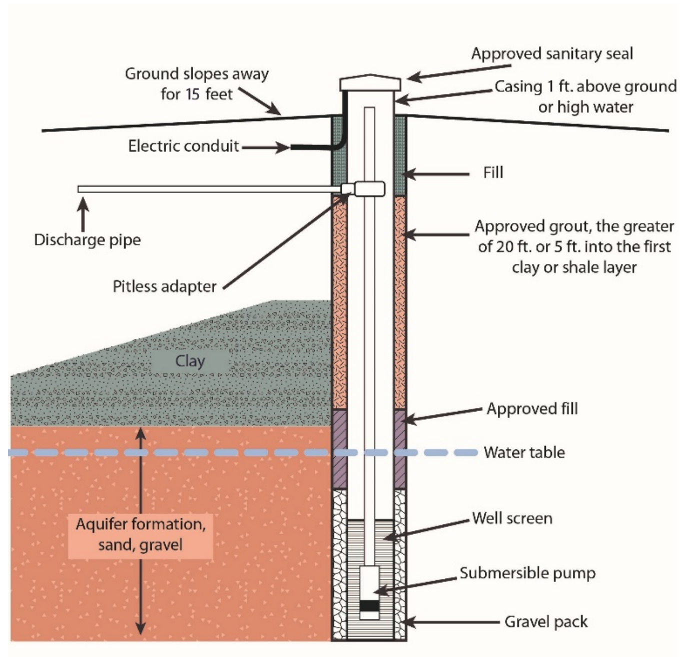

Figure 3. **Typical water well configuration**

In some formation materials, wells are not gravel-packed. When this procedure is used, the casing is extended into the aquifer and grouted to limit water movement outside the casing. A smaller hole is bored below the casing, and a screen or perforated pipe is inserted into this hole and sealed to the casing. In some rock aquifers, the intake is the open, unlined borehole. It may be smaller than the casing, the same size, or larger than the casing as in the gravel-packed well.

The well owner may not know these details of construction nor need to be too concerned about them.

The well contractor must provide the owner with a copy of the water well record and submit the original to KDHE or submit it electronically via the Kansas On-Line Automated Reporting System (KOLAR) within 30 days. The water well record must include details about the well, its location, construction, materials used, and geologic formations and groundwater encountered. For questions, the owner should ask a licensed water well contractor, the county health department, KDHE, or the local Research and Extension office.

Upgrading Wells to Present Standards

If problems develop with the yield or water quality of the well that are not easily remedied by disinfection or treatment, or construction or separation distances no longer meet minimum well standards, then repair, upgrade, or replacement of the well may be needed. Some upgrading is easily accomplished and makes sense. Other actions may be difficult and expensive. The decision about whether to upgrade an existing well should be carefully considered. Important questions to answer are where the well is located, how it is constructed, whether it currently supplies enough water of adequate quality, and type and condition of the casing. These questions and answers are diagrammed on the flow chart in Figure 4. Good judgment supplemented with the opinion of a licensed water well contractor, expert advisor, and information from other nearby wells as a guide, are important for decision making. The following paragraphs address details of the various questions.

Does the well produce an adequate yield?

Upgrading a well that currently does not provide sufficient water is of no practical value. If well yield has declined as a result of clogging of the well screen, then treatment to restore capacity is often a good option. If yield has declined because of a lowered water table, then treating or upgrading the existing well will not correct the problem.

Is water quality adequate for intended uses?

If the quality is poor, either from natural occurring minerals or pollution, will a new well location or alternate aquifer improve the quality? If the water quality issue is the result of a nearby contamination due to construction deficiencies, then a new well should correct this, provided existing wells are properly plugged to avoid contamination of the aquifer.

Is the well separated from sources of contamination?

An exclusion zone of 100 to 200 feet radius around the well is ideal. A managed zone of up to 400 feet from nitrogen sources is recommended.

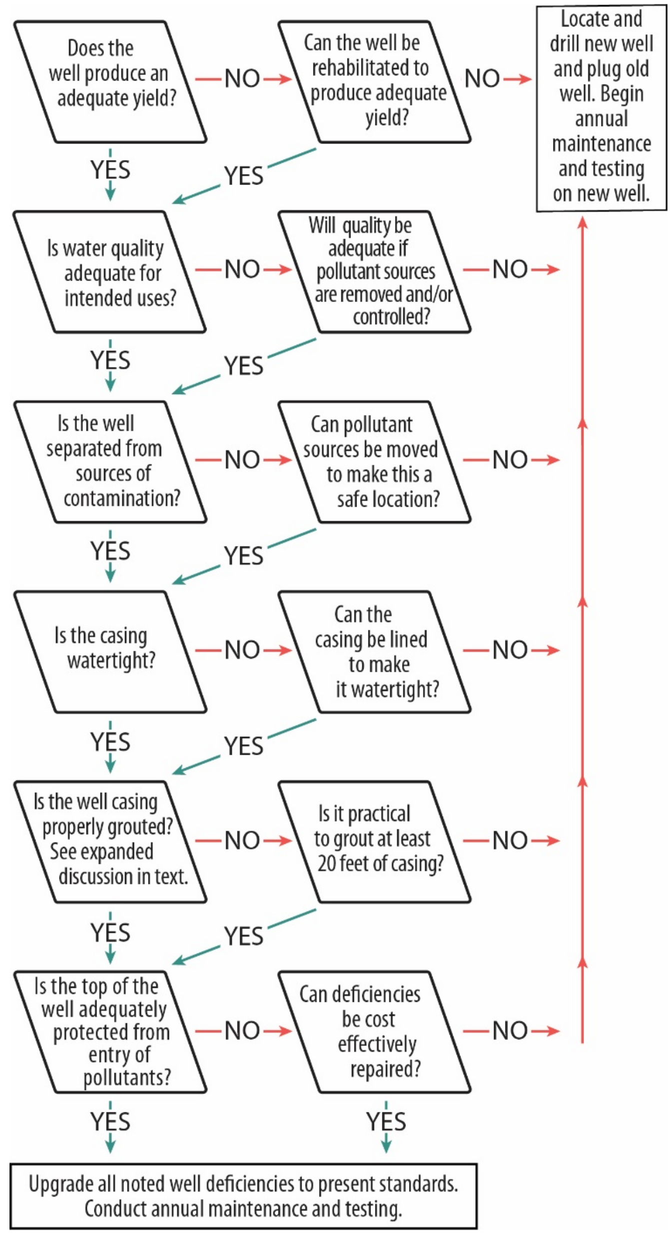

Figure 4. Well upgrade or replacement decision diagram

See KDHE's publication, *Private Well Maintenance and Protection*, for detailsabout developing a wellhead protection plan. If the well site does not have an adequate protection zone, can structures and activities be relocated? Or, can measures economically be taken to assure they will not degrade water quality? Or, is a new well in a different location a better alternative?

Is the casing watertight?

The casing should be of an approved material, have sealed joints, and extend to the screened portion of the well. If the well was constructed of a non-approved casing, but is large enough to allow lining with approved casing, it may be a candidate for an upgrade.

The approved casing could be grouted inside the old casing.

Is the well casing properly grouted?

If the well was drilled after 1974, a water well record should be available online from the KGS Water Well Record Database at: http://www.kgs.ku.edu/Magellan/WaterWell/.. The water well record should contain information about how the well was grouted. From 1974 to 1988, the minimum required grout interval in Kansas was 10 feet below ground (or below the pitless adaptor/unit). Digging or probing around the well casing may help evaluate the presence of grouting.

Usually, the grout begins just below the pitless adapter. If no grouting is present, and the well has good quality water and is in a good location, it may be worthwhile to drill grout holes around the outside of the casing and inject grout to seal the upper portion of the casing. In this case, the grout depth should be placed five feet into the first confining layer or at least 20 feet, whichever is greater. A Kansas licensed well contractor can perform this work.

Is the top of the well adequately protected from entry of pollutants?

The four components associated with the top of the well are 1) the casing, the top of which must be at least one foot above the ground surface; 2) the pitless adapter; 3) the sanitary well seal or cap, which must be a KDHE-approved type; and 4) proper surface drainage (see Figure 3).

Wells located in pits, basements, or other places where the casing terminates below the ground surface are a serious contamination threat. Wells in a basement or crawl space fail to meet separation-distance criteria and are difficult to inspect and service. They should be plugged. Wells in pits should also be plugged if needed for domestic use. The pit can continue to be used for the pressure tank and connection made to a new well located at least two feet from the pit.

A pitless adapter makes a watertight connection through the well casing that connects the pump to the water-distribution system. A pitless unit can also be used to replace the top few feet of the casing. Using the KDHE-approved sanitary well seal or cap is important to protect the well from direct surface water entry. The sanitary seal includes a connection port for the electrical conduit, which allows the electrical wires for the pump to enter without making a hole in the casing. The ground surface should be graded so surface water drains away from the well at least 15 feet in all directions. There should be no surface water, either ponding or streams, within 50 feet of the well.

Can deficiencies be cost effectively repaired?

Wells are a long-term investment with a life expectancy of several decades. The initial investment cost may be high, but this can often be the most economic long-term water supply option. Shortcuts to reduce costs often increase the risk of contamination and produce poor results. A list of Kansas licensed well contractors for your area can be obtained from KDHE's Water Well Program (785-296-3565) or Kansas Ground Water Association (620-548-2669).

Summary

Obtaining and maintaining a safe well is not always easy but the principles are relatively simple

- Use a licensed water well contractor to properly construct, reconstruct, treat, or service a water well
- Locate the well away from potential sources of contaminants.
- Seal the well against all pathways through which water and contaminants may enter.
- Select quality construction materials that will have a long life.
- Avoid, or carefully manage, sources or activities that may contribute contaminants within at least 200 feet of the well. In sensitive areas, increase this distance to at least 300 to 400 feet.

Finally, annual maintenance of the well should include inspection, disinfection, water quality testing, and adherence to the well protection plan. If contaminants are detected, take action to locate the source, evaluate the health risk, and test more frequently to determine if a trend exits.

Additional Information

Analysis of Kansas Water Well Policies and Proposal of Nonpublic Household Water Well Recommendations. Environmental Health Perspectives. https://doi.org/10.1289/EHP5507

Article 12- Kansas Groundwater Exploration and Protection Act, K.S.A 82a-1201 *et seq.* https://www.kdhe.ks.gov/DocumentCenter/View/1610/Article-12-Groundwater-Exploration-and-Protection-Act-PDF

Article 30-Water Well Contractor's License; Water Well Construction and Abandonment, Kan. Admin Regs. § 28-30-2 *et seq*. https://www.kdhe.ks.gov/DocumentCenter/View/1608/Article-30-Water-Well-Contractors-License-Water-Well-Construction-PDF

County geology and/or groundwater resources bulletins and geologic maps
http://www.kgs.ku.edu/General/geologyIndex.html
Kansas Home*A*Syst–An Environmental Risk Management Guide for the Home
https://bookstore.ksre.ksu.edu/pubs/homeasst.pdf
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KDHE Environmental handbook and LEPP Bulletins
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KDHE Environmental Interest Finder
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