Chapter 3

DRINKING WATER WELL MANAGEMENT

Keeping your well water free of harmful contaminants should be a top priority for the health of your family and for the environment. This chapter helps you examine how you manage your well, and how activities on or near your property may affect your well-water quality. The following topics are covered:

1. *Well Location*. How close is your well to potential pollution sources? How might your soil type affect water quality?
2. *Well Construction*. Do you know how old your well is and what type of well construction it is? Is your well casing properly sealed?
3. *Maintenance and Water Testing*. Do you do an annual maintenance check on your well, including shock chlorination and tests of your water? Have tests of your well water revealed any problems?
4. *Unused Wells*. Are all unused or abandoned wells properly plugged?

Why should you be concerned?

About 95 percent of rural homes out of reach of public water supplies depend on private wells to supply drinking water. These wells, which tap into local groundwater, are intended to provide clean, safe drinking water. However, improperly constructed or poorly maintained wells often have pathways for nutrients from animal and household wastes, bacteria, pesticides, or other materials to enter the water supply. Once in groundwater, contaminants can flow from your property to a neighbor's well, or from a neighbor's property to your well.

Contaminants often have no odor or color and therefore are hard to detect. They can put your health at risk. Treatment to remove contaminants is often, difficult and expensive. Once your water becomes contaminated, the only options may be to treat your water after pumping, drill a new well, or get your water from another source.

How will this chapter help you protect your drinking water and home environment?

This chapter is a guide to help you better understand the condition of your well and how to take care of it. Easy-to-understand assessment tables help identify situations and practices that are safe as well as ones that may require prompt attention. Some rural residents use water sources such as ponds or cisterns for their drinking water. Additional information on how to safeguard all water sources may be obtained from your local health department, your county K-State Research and Extension offices, your county conservation district staff, and the Kansas Department of Health and Environment.

PART 1—Well Location

Your well's location in relation to other features on or near your property will determine some pollution risks. The nearness of your well to sources of pollution and the direction of groundwater flow between the pollution sources and your well are the primary concerns. At the end of Part 1, fill out the assessment table to determine possible risks to your water supply. The information below will help you answer questions in the table.

What pollution sources might reach your well?

Whether groundwater in your area is quite shallow, or hundreds of feet down, the location of your well on the land surface is very important. Making sure your well is in a safe place takes careful planning and consideration, followed by continuing management of the area around the well. Where the well is located in relation to potential pollution sources is a critical factor.

Always seek to locate a well where surface water (stormwater runoff, for example) drains away from it. If a well is downhill from sources of contamination such as a leaking fuel storage tank, animal pen, septic system, or overfertilized lawn, it runs a greater risk of becoming contaminated than a well on the uphill side of these pollution sources. In areas where the water table is less than 50 feet from the surface, groundwater often flows in the same direction as surface water. Surface slope, however, is not always an good indicator of groundwater flow, especially for wells in rock or deeper than 150 feet.

Changing the location or depth of your well may protect your water supply, but not the groundwater itself. Any condition likely to cause groundwater contamination should be eliminated, even if your well is far removed from the potential source.

Does your well meet separation distance requirements?

Kansas statutes require that new wells be located at least 50 feet from sources of potential pollution, and some county codes specify greater separation distances (Figure 3.1). A better recommendation is to provide as much separation as possible between your well and any potential pollution source—at least 100 feet. Greater separation distances between your well and a pollution source may reduce the chance of contamination, but it does not guarantee that the well will produce safe water.

What's underground—soil and bedrock type, distance to the water table?

Pollution risks are greater when the water table is near the surface because contaminants do not have far to travel. Groundwater contamination is most likely if soils are shallow (a few feet above bedrock) or if they are highly porous (sandy or gravelly). In Kansas, rocks below the soil are generally fractured—that is, they have many cracks that allow water to seep down rapidly. Check with neighbors, local farmers, or well drilling companies to learn more about what's under your property. The Kansas Department of Health and Environment (KDHE) maintains records of well logs; contact them at (785) 296-5500—you will need the legal description of your tract. For more information on soil type, bedrock, and the water table, see Chapter 1, Part 1, "Physical Characteristics of Your Homesite Relating to Surface Water or Groundwater."

Assessment 1—Well location

Use the table (on the next page) to rate your well location risks. For each question, indicate your risk level in the right-hand column. Although some choices may not correspond exactly to your situation, choose the response that best fits. Refer to Part 1 if you need more information to complete the table.

Responding to risks

Your goal is to lower your risks. Turn to the Action Checklist on page 32 to record the medium- and high-risk practices you identified. Use the recommendations above to help plan actions to reduce your risks.

PART 2—Well Construction

Old or poorly designed wells increase the risk of groundwater contamination by allowing surface water to reach the water table without being filtered through soil. If a well is located in a pit or is not properly sealed and capped, surface water carrying nitrates, bacteria, pesticides, and other pollutants may easily contaminate drinking water. Cisterns are sometimes used to store rainwater for use by a household. Information on safe use of such water can be found in the MWPS-14, *Private Water Systems Handbook*, available through your local Research and Extension office.

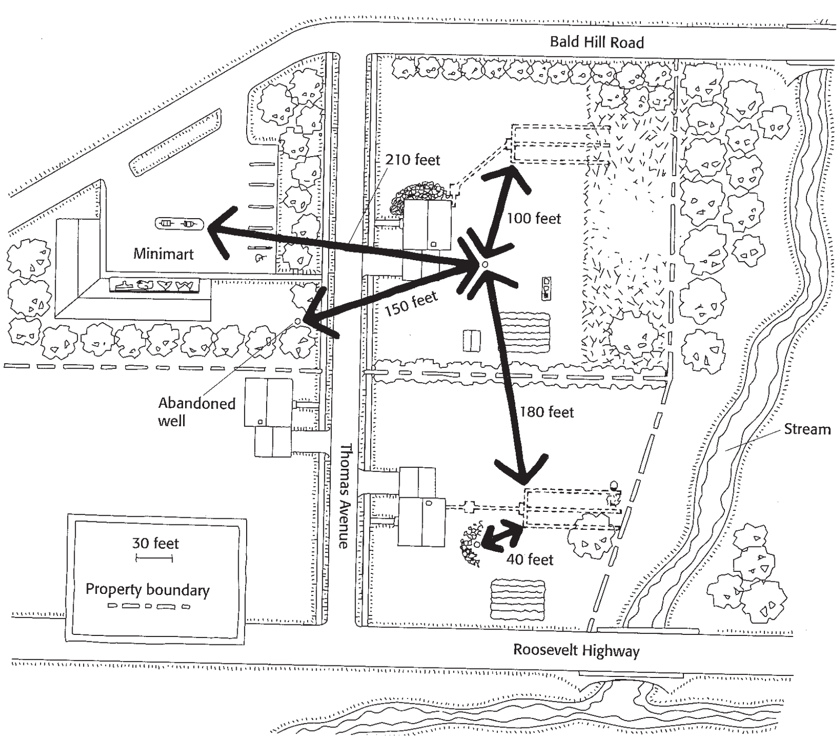


Figure 3.1 *Map of homesite showing distances of pollution sources from well.*

How old is your well?

Well age is an important factor in predicting the likelihood of contamination. Wells constructed more than 50 years ago are likely to be shallow and poorly constructed. Wells constructed before 1974 did not have to follow state regulations for construction and are more likely to have thinner casings, which may be cracked or corroded. Well pumps more than 20 years old are more likely to leak lubricating oils, which can get into the water. Even wells

ASSESSMENT 1—Well Location

	LOW RISK	MEDIUM RISK	HIGH RISK	YOUR RISK
Position of well in relation to pollution sources	Well is uphill from all pollution sources. Surface water doesn't reach well or is diverted.	Well is level with or uphill from most pollution sources. Some surface water runoff may reach well.	Well is downhill from pollution sources or in a pit or depression. Surface water runoff reaches well.	❐ Low ❐ Medium ❐ High
Separation distances between well and pollution sources*	Distances from potential pollution sources meet or exceed all state and local minimum requirements.	Some but not all distances from potential pollution sources meet state and local requirements.	Distances from most or all potential pollution source do not meet state and local minimum requirements.	❐ Low ❐ Medium ❐ High
Soil type	Soil is >3 ft. deep and fine or medium textured clay loam, silty clay, or loam	Soil is fine or medium-textured but <3 ft. deep	Soil is coarse-textured like sand, sandy loam, or gravel.	❐ Low ❐ Medium ❐ High
Subsurface conditions	The water table or fractured bedrock is deeper than 50 feet.	The water table or fractured bedrock is at least than 20 ft. but less than 50 ft.	The water table or fractured bedrock is shallower than 20 feet.	❐ Low ❐ Medium ❐ High

* Recommended minimum separation distance is 100 feet.

with modern casings that are 25 years old may not have been grouted properly to prevent surface water and undesirable groundwater from entering along the side of the casing. If you have an older well, you may want to have it inspected by a qualified person such a sanitarian or a licensed well driller. If you do not know how old your well is, assume it needs an inspection.

What type of well do you have?

A dug well is a large-diameter hole that is usually more than 2 feet wide and often constructed by hand. Dug wells are usually shallow, with unmortered rock lining the shaft. Since they are poorly protected from surface water runoff, dug wells are very vulnerable to bacterial contamination from sources such as manure and sewage. Driven or sandpoint wells, are constructed by driving lengths of pipe into the ground with a special screened driving point terminating in the underground water aquifer. These wells are normally around 2 inches or less in diameter and less than 25 feet deep and can only be installed in areas with loose soils such as sand. Driven wells are more often contaminated than drilled wells. Most other types of wells are drilled wells which, for residential use, are commonly 4 to 8 inches in diameter. Figure 3.2 on the following page shows a properly constructed drilled well.

Are your well casing and well cap protecting your water?

The casing is a steel or plastic pipe with sidewalls about a quarter-inch thick. Well drillers install the casing in the well hole to prevent collapse following drilling. The casing remains in the well hole and the space between the casing and sides of the hole becomes a direct channel for surface water and pollutants to reach the water table (Figure 3.3 on the following page). To seal off that channel, drillers must fill the space with grout (cement or a type of clay called bentonite). Before regulations enacted in1974, this channel was commonly filled with gravel and not properly sealed with grout, allowing surface waters to flow down to the aquifer.

The casing should extend throughout the entire depth of the well and be connected to the well screen. You should visually inspect the condition of your well casing for holes or cracks. Examine the part that extends out of the ground. Remove the cap and inspect inside the casing using a flashlight. If you can move the casing around by pushing it, you may have a problem with your well casing's ability to keep out contaminants. Sometimes damaged casings can be detected by listening for water falling into the well when the pump is not running. If you hear water, there might be a crack in the casing, or the casing may not reach the water table. Either situation is risky.

As noted previously, a watertight seal of grout or bentonite should extend from the ground surface to the well screen or to where solid rock is reached. (The grout should be at least 20 feet thick, or to a minimum of 5 feet into the first clay or shale layer, if present, whichever is greater, or to a confining solid rock layer.)

The casing should extend at least 12 inches above the ground surface. If there are occasional floods in your area, the casing should extend 1 to 2 feet above

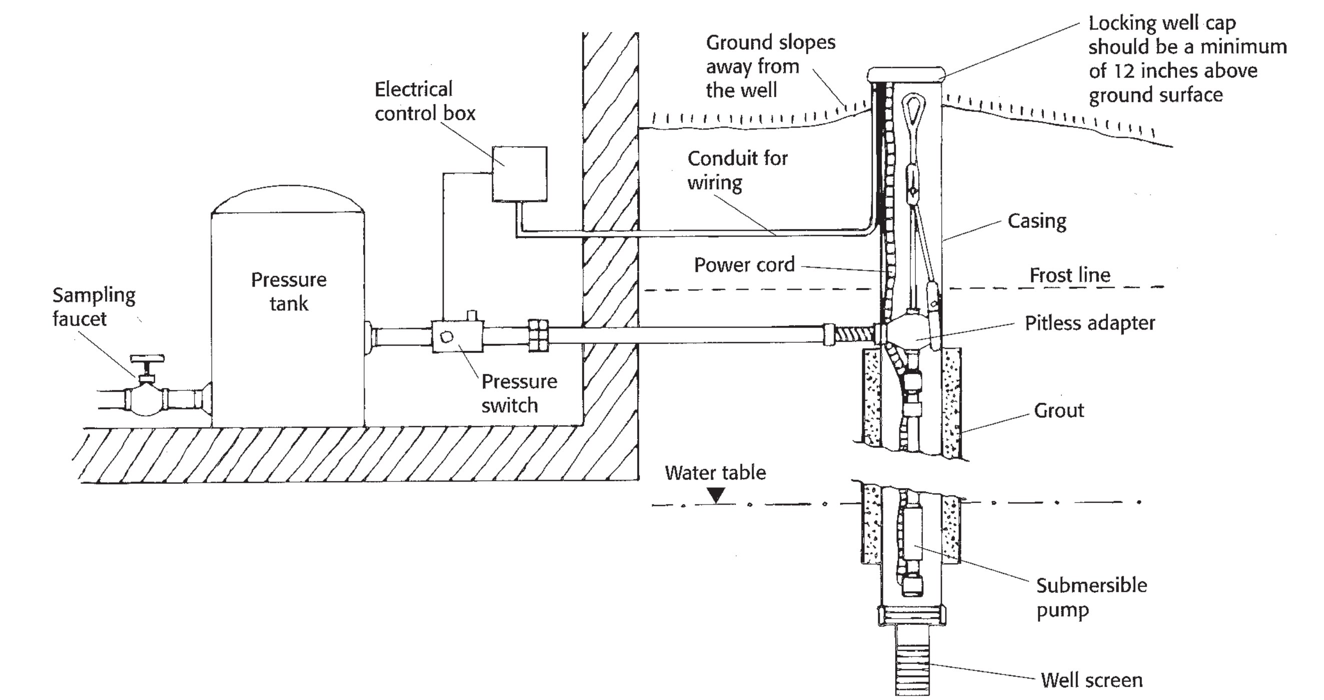


Figure 3.2 A properly constructed drilled well.

the highest flood level recorded for the site. The ground surface around the casing should slope away from the well head at least 20 feet in all directions to prevent water from pooling around the casing.

The well cap should be state approved and firmly attached to the casing, with a vent that allows only air to enter. If your well has a vent, be sure that it faces the ground, is tightly connected to the well cap or seal, and is properly screened to keep insects out. Wiring for the pump should be secured in an electric conduit pipe sealed to the sanitary well seal. The well casing should **never** be perforated. (Information regarding approved well caps can be obtained from KDHE, Bureau of Water, 785-296-3565.)

Is your well shallow or deep?

As rain and surface water soak into the soil, pollutants are carried along. The soil acts as a filter and is sometimes a site for chemical degradation. Generally, the more time it takes for surface water to reach the aquifer, or groundwater, the better and more complete filtration will be. Soils which are deep and finely textured slow the movement of water down to the water table. Conversely, soils which are shallow or course-textured allow water to pass rapidly to the water table. Local soils and geologic conditions, as well as the amount of water absorbed, determine how long this takes. In some places, the process happens quickly—in weeks, days, or even hours. Shallow wells, which draw from groundwater nearest the land surface, are most likely to be affected by local sources of contamination.

Do you take measures to prevent backflow?

Backflow is defined as the movement of water opposite to the normal pressurized flow. When the backflow occurs between a chemical or water source of poor quality and the drinking water source, pollutants are carried into the potable water, contaminating it. Backflow of contaminated

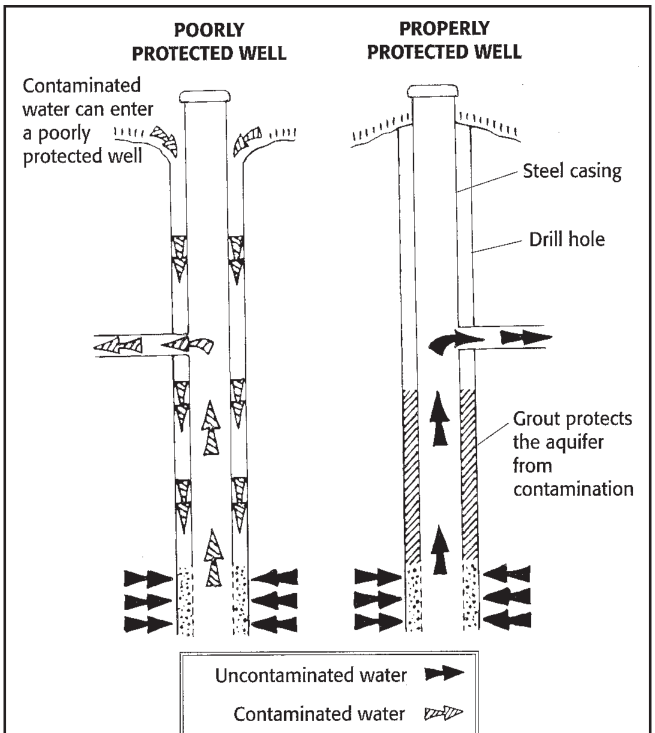


Figure 3.3 A poorly protected well versus a properly protected well.

water into your water supply can occur if your system undergoes sudden pressure loss. Pressure loss can occur if the well pump fails or, if you are on a public water system, if there is a line break in the system. The simplest way to guard against backflow is to leave an air gap between the water supply line and any reservoir of “dirty” water. For example, if you are filling a swimming pool with a hose, make sure that you leave an air gap between the hose and the water in the pool. Toilet tanks should be equipped with a fill valve labeled with the words “anti-siphon”; when the fill valve is replaced, be sure to use the anti-siphon type. Washing machines have built-in air gaps.

Where an air gap cannot be maintained, a backflow prevention device such a check valve or vacuum breaker should be installed on the water supply line. For example, if you are using a pesticide sprayer that attaches directly to a hose, a hose bib vacuum breaker or check valve should be installed on the faucet to which the hose is connected.

Inexpensive backflow prevention devices can be purchased from plumbing suppliers. It must be recognized that waters which are hard or contain dissolved lime will leave deposits that in time render the devices useless, and they will need to be replaced. If water must be provided to a chemical reservoir, always use an air gap. Whenever a hose is used, think about whether or not you would like to drink the liquid in which the hose is submerged.

Assessment 2—Well construction and maintenance

Use the table below to rate your risks related to well construction. For each question, indicate your risk level in the right-hand column. Although some choices may not correspond exactly to your situation, choose the response that best fits. Refer to Part 2 above if you need more information.

Responding to risks

To protect your well from possible contamination, you should minimize your risks by adopting actions and practices that result in lower risks. Turn to the Action Checklist on page 32 to record

ASSESSMENT 2—Well Construction and Maintenance

	LOW RISK	MEDIUM RISK	HIGH RISK	YOUR RISK
Well age	Well drilled since 1974	Well drilled prior to 1975, but since 1960	Well drilled before 1960.	❒ Low ❒ Medium ❒ High
Well type	Drilled well	Driven or sand-point well	Dug Well	❒ Low ❒ Medium ❒ High
Casing height above land surface	Casing is 12 or more inches above the surface. If the area floods, casing is 1–2 feet above the highest recorded flood level.	Casing is at the surface or up to 12 inches above the surface.	Casing is below the surface or in a pit or basement.	❒ Low ❒ Medium ❒ High
Condition of casing and well cap (seal)	No holes or cracks are visible. State approved cap is tightly attached. A screened vent faces the ground	No holes or cracks are visible. Cap is loose. Unapproved cap used.	Holes or cracks are visible. Cap is loose or missing. Running water can be heard or seen.	❒ Low ❒ Medium ❒ High
Casing depth relative to land surface	Casing extends and is properly grouted to the depth of the aquifer.	Casing extends to the depth of the aquifer, but grouting is inadequate.	Casing does not extend to the depth of the aquifer, no grout seal.	❒ Low ❒ Medium ❒ High
Backflow prevention	Measures are taken to prevent backflow and, where necessary, air gaps or backflow prevention devices are installed.	Measures are sometimes taken to prevent backflow. No backflow prevention devices are installed.	No measures are taken to prevent backflow. No backflow prevention devices are installed.	❒ Low ❒ Medium ❒ High

the medium- and high-risk practices you identified. Use the recommendations above to help plan actions to reduce your risks.

PART 3—Well Maintenance and Water Testing

You would not let a car go too long without a tune-up or oil change. Your well deserves the same attention. Good maintenance means keeping the well area clean and accessible with pollutants as far away as possible, and having a Kansas licensed well driller check the well periodically or when problems are suspected. At the end of Part 3, fill out the assessment table to determine risks related to your well's design or condition.

Following the process described in Part 2, visually inspect the condition of your well cap and casing for holes or cracks. This examination will detect physical damage and deterioration that comes with age. The gasket in the sanitary seal becomes brittle with time, compromising the seal. Underground geological conditions can change. Such circumstances as freezing/thawing cycles, flooding, or the water table dropping or rising can result in casing damage when the ground shifts.

How long since your well was inspected?

Well equipment does not last forever. Every 10 years, your well will require inspection by a licensed well driller. You should keep well construction details, as well as the dates and results of maintenance visits for the well and pump. It is important to keep good records so you and future owners can follow a good maintenance schedule.

The best indicator of risk is well location and construction; however water testing helps you monitor water quality and identify potential risks to your health. Contaminants enter drinking water from many sources. Many contaminants can only be detected through a water test.

When was your water last tested?

At a minimum, your water should be tested every year for the four most common indicators of trouble: bacteria, nitrates, pH, and total dissolved solids (TDS). If you have not had these minimum water tests done, then you do not know the characteristics of your water. Figure 3.4 shows the general procedure for taking a water sample. Always follow lab instructions.

A more complete water analysis for a private well will tell you about its hardness; corrosivity; and iron, sodium, and chloride content. In addition, you may choose to obtain additional tests targeted to specific contaminants such as chemicals or pesticides, which you know have been used on your property or in the vicinity of the well. A good source of information to determine further testing can be found in K-State Research and Extension bulletin, *Recommended Water Tests for Private Systems*, MF-871.

What contaminants should you look for?

Test for the contaminants that might be found at your location. For example, if you have lead pipes, soldered copper joints, or brass parts in the pump or water fixtures, test for the presence of lead. Test for volatile organic chemicals (VOCs) if there has been a nearby use or spill of oil, liquid fuels, or solvents. Contact the laboratory before collecting a water sample. Different containers will be necessary for each type of sample and the lab will provide the appropriate container with instructions for collection. Always follow lab instructions when taking a water sample.

Pesticide tests, though expensive, may be justified if your well has high nitrate levels—more than 10 milligrams per liter (mg/l) of nitrate-nitrogen (NO_3-N) or 45 mg/l of nitrate (NO_3). Tests are also warranted if a pesticide spill has occurred near the well. Pesticides are more likely to be a problem if your well is shallow, has less than 15 feet of casing below the water table, or is located in sandy soil and is downslope from irrigated tracts such as lawns with sprinkler systems, or golf courses where pesticides are used.

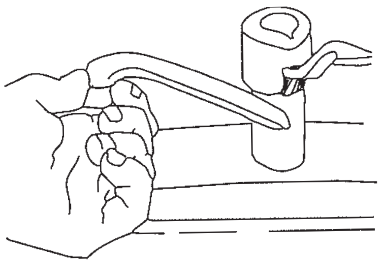
You can seek further advice on testing from your county K-State Research and Extension office or health department. You should test your water more than once a year if (1) you have an infant less than one year old; (2) someone in your household is pregnant or nursing; (3) there are unexplained illnesses in the family; (4) your neighbors find a dangerous contaminant in their water; (5) you note a change in water taste, odor, color, or clarity; or (6) you have a spill or back-siphonage of chemicals or fuels into or near your well. Water can be tested by both public and private laboratories. Once tested, keep a record of your results with your records on well construction and maintenance. This will enable you to monitor water quality over time.

Assessment 3—Well maintenance and water testing

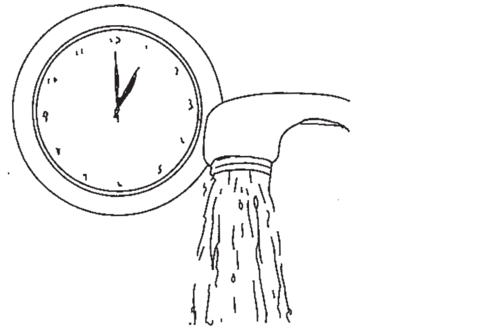
Use the table on page 31 to rate your risks related to well maintenance and water quality. Although some choices may not correspond exactly to your situation, choose the response that best fits. Refer to Part 3 above if you need more information.

Responding to risks

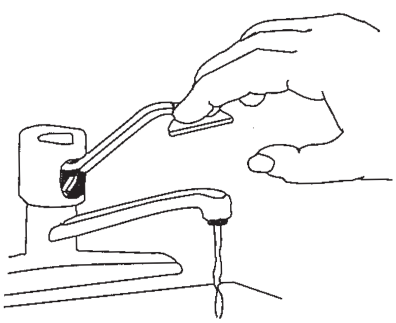
Your goal is to lower your risks. Turn to the Action Checklist on page 32 to record the medium- and high-risk practices you identified. Use the information above to help plan actions to reduce your risks.



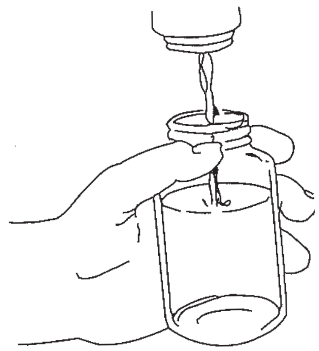
Step 1: It is important to use an indoor, leak-free tap and collect water which has not been treated by a water softener or other treatment unit. Remove the aerator from the cold water faucet. If testing for bacteria, flame the end of the faucet with a lighter. (Note: Flaming may discolor chrome or gold-finished faucets.)



Step 2: Let water run for five minutes to bring in water that has not been in contact with household plumbing. (Skip this step if testing for corrosion of household plumbing—see notes.)



Step 3: Reduce the water flow until the water is a clear stream about ¼-inch in diameter and let the water flow for another five minutes.



Step 4: Fill a specially prepared laboratory container as instructed by the laboratory. Do not set the cap down or let anything touch the inside of the cap or container.

Step 5: Close the sample container tightly and transport it as instructed by the laboratory.

Notes:
- Corrosive water may dissolve lead, copper, zinc, or iron contained in household plumbing. If testing for evidence of corrosion, let water stand in the plumbing system at least 12 hours.
- Laboratories specially prepare containers for each category of contaminant. Do not rinse laboratory containers or fill them to overflowing.
- Always follow laboratory directions.

Figure 3.4 *Generalized procedure for collecting water samples.*

ASSESSMENT 3—Well Maintenance and water testing

	LOW RISK	MEDIUM RISK	HIGH RISK	YOUR RISK
Well inspection and "tune-up"	Well was inspected within the last 3 years.	Well was inspected 3–10 years ago.	Last well inspection is not known or over 10 years ago.	❒ Low ❒ Medium ❒ High
Water testing	Consistent, good water quality. Tests meet standards for bacteria, nitrate, and other contaminants.	Some tests do not meet standards or tests approach standards.	Water is not tested. Water is discolored after a rainstorm or during spring melt. There are noticeable changes in color, odor, and taste.	❒ Low ❒ Medium ❒ High

PART 4—Unused Wells

Abandoned wells, if improperly sealed, can provide a direct route for contaminants to enter groundwater. It is important to identify old or abandoned wells and determine appropriate action. At the end of Part 4, fill out the assessment table to determine water quality risks related to water contaminants and old wells.

Are there any unused and abandoned wells on your property?

Many homesites have wells that are no longer used. Sites with older homes often have an old dug well that was installed when the house was first built. Some people dug or drilled a new well about every 30–40 years, so there may be more than one abandoned well. If not properly filled and sealed, these wells can provide a direct channel for waterborne pollutants to reach the aquifer or groundwater layer that supplies the present well (Figure 3.5).

A state licensed well driller should be hired to close these wells. Effective well plugging calls for experience with well construction materials and methods, as well as knowledge of the geology of the site and the regulations of the state. Kansas regulations govern plugging procedures and materials, and require registering the plugged well with the Kansas Department of Health and Environment (KDHE). The cost to plug a well will vary with well type, well depth, well diameter, and soil/rock type. The money spent plugging a well will be a bargain compared to potential costs of cleanup or loss of property value if contamination occurs. You can obtain specific information regarding licensed well drillers and procedures to properly plug a well from KDHE, Bureau of Water, phone (785) 296-3565.

Assessment 4—Unused Wells

Use the table below to rate your risks related to unused wells. For each question, indicate your risk level in the right-hand column. Although some

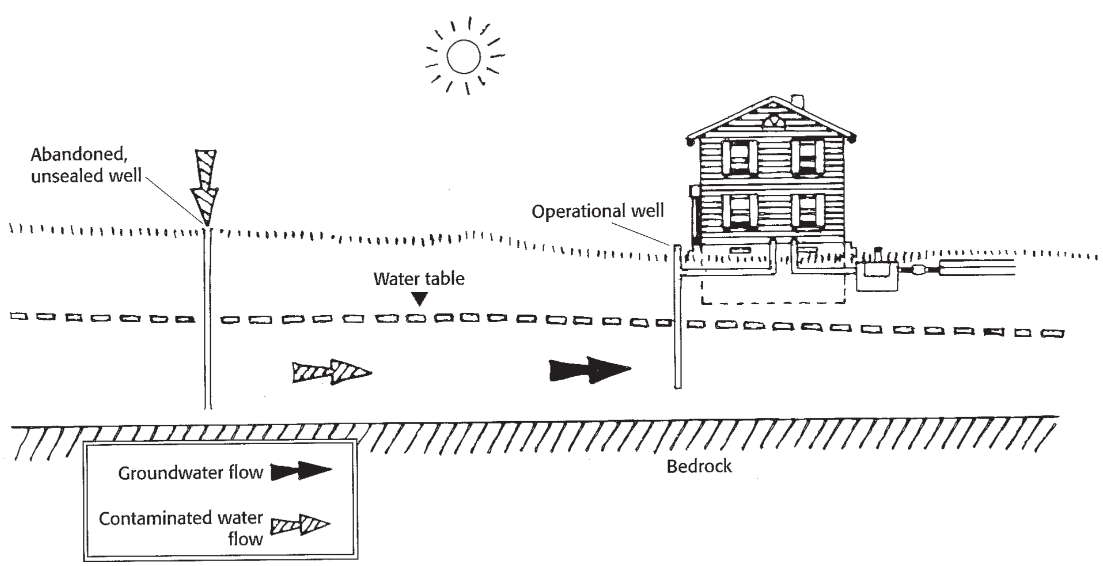


Figure 3.5 *Abandoned wells that are not properly sealed provide a pathway for contaminants to reach groundwater.*

choices may not correspond exactly to your situation, choose the response that best fits. Refer to Part 4 on page 31 if you need more information.

Responding to risks

Your goal is to lower your risks. Use the Action Checklist below to record the medium- and high-risk practices you identified. Use the information provided to help plan actions to reduce your risks.

ASSESSMENT 4—Unused wells

	LOW RISK	MEDIUM RISK	HIGH RISK	YOUR RISK
Unused wells on your property or in your area	There are no unused wells, or there are unused wells that are properly sealed.	There are unused wells that are not sealed but are capped and isolated from contaminants.	There are unused, unsealed wells that are in poor condition, near pollution sources, and/or uncapped.	❐ Low ❐ Medium ❐ High

Action Checklist

Drinking Water Well Management

Write all high and medium risks below	What can you do to reduce the risk?	Set a target date for action
Sample: Water hasn't been tested for 10 years. Smells different than it used to.	Contact county public health department for advice and collection bottle(s).	One week from today: April 8

ACTION CHECKLIST

When you finish the assessment tables, go over the questions to ensure that every high and medium risk you identified is recorded in the checklist on page 32. For each risk, write your planned improvements. Use recommendations from this chapter and from resources elsewhere. Pick a target date that will keep you on schedule for making the changes. You do not have to do everything at once, but try to eliminate the most serious risks as soon as you can. Often it helps to start with inexpensive actions.

For More Information

K-State Research and Extension bulletins are listed below.

Well construction

- *Ensuring Safe Drinking Water* (tabloid). MF-952, 3/90.
- *Groundwater and Well Contamination*. MF-932
- *Safe Domestic Wells*. MF-970

The following materials can be ordered through your county Extension office:

- *Water Quality Handbook*, a 200 page reference handbook, 4/96. $20.00.
- *Private Water Systems Handbook*, MWPS-14. A 72-page publication available from the Northeast Regional Agricultural Engineering Service (NRAES) $7.00.
- *Private Drinking Water Supplies*, NRAES-47, 8/91. $8.00.

Well maintenance and water testing:

- *Obtaining Safe Water from Private Wells*. MF-2345.
- *Recommended Water Tests for Private Systems*. MF-871.
- *Taking a Water Sample*. MF-963, 9/90.
- *Testing to Help Ensure Safe Drinking Water*. MF-951, 8/98.
- *Understanding Your Water Test Report*. MF-912.
- *Nitrate and Groundwater*. MF-857.
- *Shock Chlorination for Disinfecting Water Systems*. MF-91, 7/98
- *Private Well Operation and Maintenance*.

Contact your local health department or your county or K-State Research and Extension office, private testing laboratories, or the Kansas Department of Health and Environment (KDHE), Bureau of Water, (785) 296-3565.

Drilling and sealing wells

- *Plugging abandoned Wells*. MF-935, 7/97.
- *Plugging Cisterns, Cesspools, Septic Tanks and Other Holes*. MF-2246, 9/97.

Contact a state licensed well driller or the KDHE District office nearest you:

Dodge City (Southwest)	(316) 225-0596
Wichita (South Central)	(316) 337-6020
Chanute (Southeast)	(316) 431-2390
Lawrence (Northeast)	(785) 842-4600
Salina (North Central)	(785) 827-9639
Hays (Northwest)	(785) 625-5664

Groundwater, soil type, and geology, well location, and existing well construction log

Contact the Kansas Geological Survey, 305 Moore Hall, Lawrence, KS 66045, phone (785) 864-3965. Your county Conservation District can describe your soil type and geology. Be prepared to provide the legal description (county, township, range, section, and quarter section) of the well's location. If known, provide the year the well was drilled and the original owner's and driller's names.

Web sites: http://www.waterwiser.org—maintained by the American Water Works Association, contains information about water from fixtures to testing.

Drinking water quality standards

Call the U.S. EPA Safe Drinking Water Hotline toll-free at (800) 426-4791 from 7:30 a.m. to 4:00 p.m., CST, Monday through Friday.

*Kansas Home*A*Syst* Helps Ensure Your Safety

This *Kansas Home*A*Syst* handbook covers a variety of topics to help homeowners examine and address their most important environmental concerns. See the complete list of chapters in the table of contents at the beginning of this handbook. The end of each chapter lists resources and other useful information. For more information about topics covered in *Kansas Home*A*Syst*, or for information about laws and regulations specific to your area, contact your county environmental or K-State Research and Extension office.

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- G. Morgan Powell, Extension Natural Resource Engineer, Kansas State University
- Danny H. Rogers, Extension Irrigation Engineer, Kansas State University

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