Owning a Private Well in Alabama

Private Well Program
ALABAMA EXTENSION

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Introduction

Well Water Background

Thousands of Alabama residents rely on private water systems for their drinking water source. The 2015 Water Use Report published by the Alabama Office of Water Resources reported 11 percent of the population relied on private wells for their drinking water. With well ownership comes a specific set of responsibilities, that includes the maintenance, testing, and treatment of their own water system. Wells can become contaminated through improper construction, maintenance, or poor stewardship practices around the well. Carefully monitoring and keeping a detailed record of the well can help in preventing future problems from occurring, while annual testing can help assure safe drinking water quality for the household utilizing a private well system as their primary drinking water source.

About the Handbook

This handbook introduces the reader to important topics regarding owning a domestic water well in the state of Alabama. Important information covered include geology and groundwater of Alabama, common water contaminants, well water testing and treatment, and general well maintenance. This handbook empowers Alabama Extension Agents, Agency Partners, and citizens to advocate for the stewardship of private water wells and preserve, protect, and enhance this vital resource.

About the Alabama Private Well Program

The Alabama Private Well Program is an educational program that aims to:

- Educate citizens about water quality issues
- Provide resources to domestic well owners about the maintenance and protection of their wells
- Empower well owners to get their drinking water quality tested
- Answer questions and concerns that well owners have
- Form a network of domestic well water users in Alabama

The Alabama Private Well Program was established in 2020 and is focused on identifying stakeholder groups and engaging in outreach and consultation across the state. The Private Well Program emphasizes domestic well topics with agency partners, Extension staff, and citizens to address common questions and concerns. This is done through the creation of resources housed on the Alabama Cooperative Extension System web page, webinars, and in-person workshops. The Private Well Program works with Extension personnel, researchers, industry partners, and private well owners to assess needs, identify issues, set research priorities, and establish a well owner network.

Anyone who wants to learn about, improve, and protect community water resources can participate in the Alabama Private Well Program.

Aquifers in Alabama

Chapter 1

ALABAMA EXTENSION

Aquifers in Alabama

Understanding the geology that affects your groundwater and your well will help you understand possible sources of contamination as well as how much water your well might be able to pump. It also explains why some wells are more vulnerable to contamination than others.

The Water Cycle

To understand how wells work, you need to understand the water, or hydrologic, cycle. Almost 75 percent of the earth's surface is covered by water that has existed since the earth was formed several billion years ago. All of this water is constantly moving and recycling via an endless process known as the water cycle, which is one of the largest physical processes on earth. It is driven by energy from the sun and by the force of gravity, and it supplies all of the water needed to support life. There is no beginning or end to the water cycle—it is always happening.

As water falls to the ground as precipitation (rain, sleet, hail, or snow), it can run off into surface water such as streams, lakes, rivers, bays, or oceans. Runoff occurs when the rate of precipitation exceeds the rate at which the water can be absorbed into the soil. Runoff also occurs when water falls onto an impervious surface, such as a parking lot or a sidewalk, where it cannot be absorbed. Water evaporates from surface water, the ground, leaves, or anywhere water is exposed and condenses, forming clouds that can produce rain or snow.

Several factors affect the movement of precipitation once it lands in the watershed, which is an area of land through which rainwater drains by flowing across, through, or under the soil surface to a common low point, typically a river, stream, lake, or ocean. Each drainage is contained in its own watershed, and all watersheds are connected across the landscape and flow to a lowest point. Figure 1.1 is an example of a watershed in which all of the precipitation that falls would run off into the stream and eventually into the ocean.

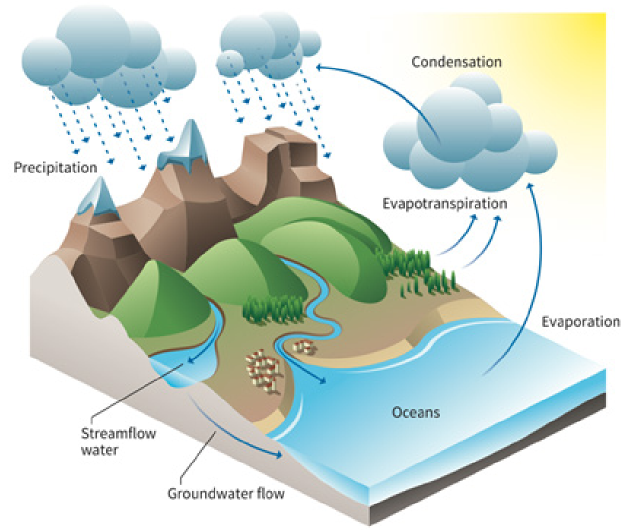


Figure 1.1. Hydrologic cycle.

Water can follow one of five pathways:

- It can be absorbed and intercepted by plants and used in various biological processes.
- It can evaporate, both from the surface of the earth and as it falls from the sky.
- It can be stored in ice caps and glaciers, which can store frozen water for thousands of years.
- It can run off into streams and rivers and become surface water that eventually makes its way to the ocean.
- It can filter through the soil profile and end up as groundwater, which is water that is stored in underground layers of rock and sand known as aquifers.

Groundwater

Groundwater accounts for about 30 percent of the world's fresh water. Groundwater is stored below the earth's surface in layers of soil, rocks, and sand. When it rains, water soaks into the ground in the open spaces between soil particles and percolates, infiltrates, or flows downward until it reaches a depth where all the spaces in between the soil particles are filled with water. The zone that is saturated with water is referred to as groundwater, or an aquifer. The boundary between the saturated zone above and unsaturated zone below is the water table.

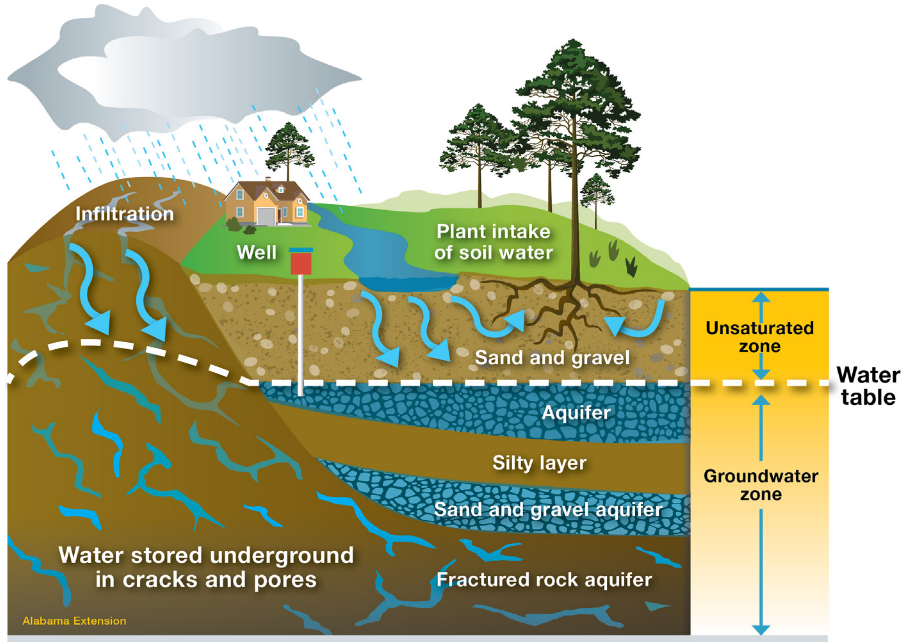


Figure 1.2. Aquifer recharge.

One of Alabama's great natural treasures is the variety and quantity of its water resources, with 586.5 trillion gallons of water, 553 trillion gallons of which is stored in underground aquifers.

Groundwater below the earth's surface ranges from a few inches to hundreds of feet deep. Water stored in the ground can also come to the surface through a spring or a well. Where the water table is close to the land surface, groundwater may discharge in the form of springs, or it might seep out slowly to form wetlands, swamps, or marshes, which are important ecologically. Groundwater also contributes to the flow of many streams. Nationally, about 40 percent of the base flow of streams comes from groundwater.

Groundwater is a reliable source of water for several people in Alabama, with several large cities and many smaller towns relying on groundwater for water needs. Groundwater is also used in several different sectors, as noted in the 2015 Water Use Report. Other sources of withdrawals included: 36% of public supplies, 100% of self supplied residential water (private wells), 44% of irrigation waters, 44% of livestock supply waters, 7% of industrial waters, and 73% of mining water usage.

How Aquifers Form

A significant amount of water in the water cycle is below ground, but the amount that is usable is only found in aquifers. Aquifers are rarely underground lakes or rivers as one might think. The vast majority of groundwater is actually found between grains in rocks, soil, and sediment.

An aquifer is formed when water-bearing rock (water-filled spaces) readily transmits water to wells and springs. How easily water can flow through an aquifer determines its ability to provide water to a well. Many rock formations are fractured, and large amounts of water can be contained in those fractures. Unconfined aquifers consist of an upper, unsaturated portion above the water table and a lower, saturated zone below the water table. Other aquifers are confined, meaning that they are sandwiched by layers of significantly less permeable materials or rock that restrict the flow of water across the aquifer boundaries. In Alabama, confining layers are usually sandstones or similar dense materials.

AQUIFER RECHARGE AREAS OF ALABAMA

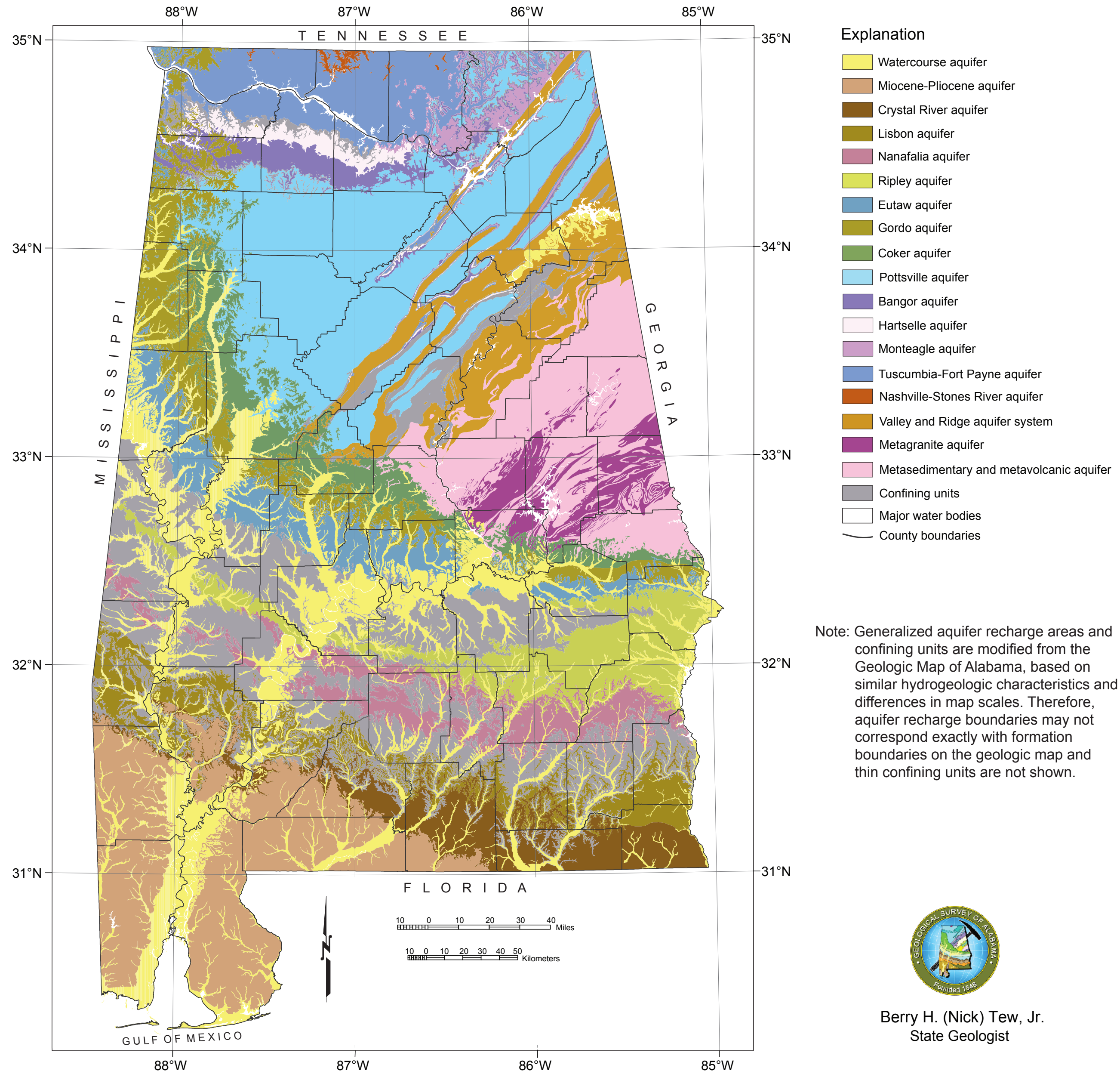


Figure 1.3. Aquifer recharge areas of Alabama.

Because confined aquifers are restricted in space, the water can be under considerable pressure. When a well is drilled into a confined aquifer, the pressure forces the water in the well to rise above the top of the aquifer itself. If the pressure is great enough, the water will actually flow from the well at the ground surface without having to be pumped. Such flowing wells are common in and near the flood plains of major streams in the southern half of the state and are sometimes called artesian wells. Prattville, Alabama, is actually called The Fountain City because of the many artesian wells once in the area.

Groundwater is a resource that is replenished by rainfall at rates that vary from days to years. Precipitation eventually adds water to the aquifer, recharging it.

Geological Formations and Aquifers

Groundwater is not evenly distributed throughout the state. In some places, the water is shallow and abundant; in other places, it is deeper and more difficult to find. Occasionally, local shortages may occur in some areas where demand is greater than recharge, causing serious problems. Groundwater availability varies from region to region and is controlled primarily by the kinds of rocks, sediments, and soils that contain the water.

The Aquifer Recharge Areas of Alabama can be seen in figure 1.3. This map created by the Geological Survey of Alabama shows the aquifer recharge areas for the water-bearing aquifers in the state of Alabama. These water-bearing aquifers have characteristics that are controlled by various geologic factors such as permeability, porosity, type, and structure of the rocks comprising the aquifer.

How Rocks Affect Water Flow and Storage

To understand the differences in water availability between different areas, one must first understand how groundwater moves from one area to another, as well as the rock, sediment, and soil properties that control water movement, storage, and availability. Groundwater moves slowly, and it changes slowly.

Rocks have different porosity and permeability characteristics, which means that water moves differently depending on the rocks below ground. If water cannot get to the well at the same rate as the pump operates, it will limit the pumping rate interrupting the water supply.

Rocks are classified as consolidated rock (bedrock), which includes sandstone, limestone, and granite, or as unconsolidated rock, which consists of granular materials such as sand, gravel, or clay.

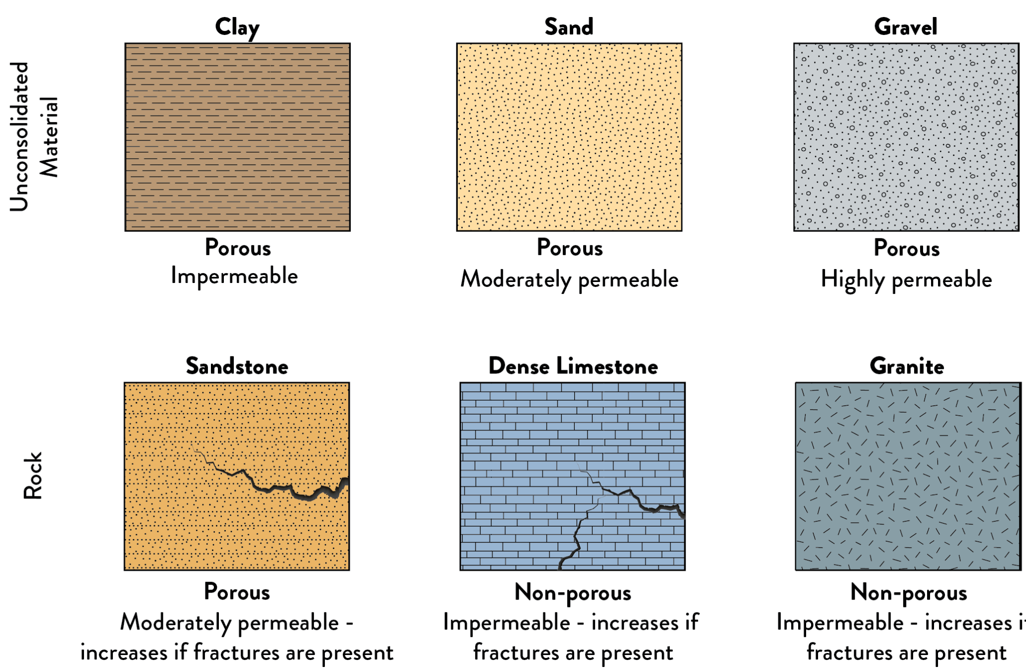


Figure 1.4. Permeability of aquifers.

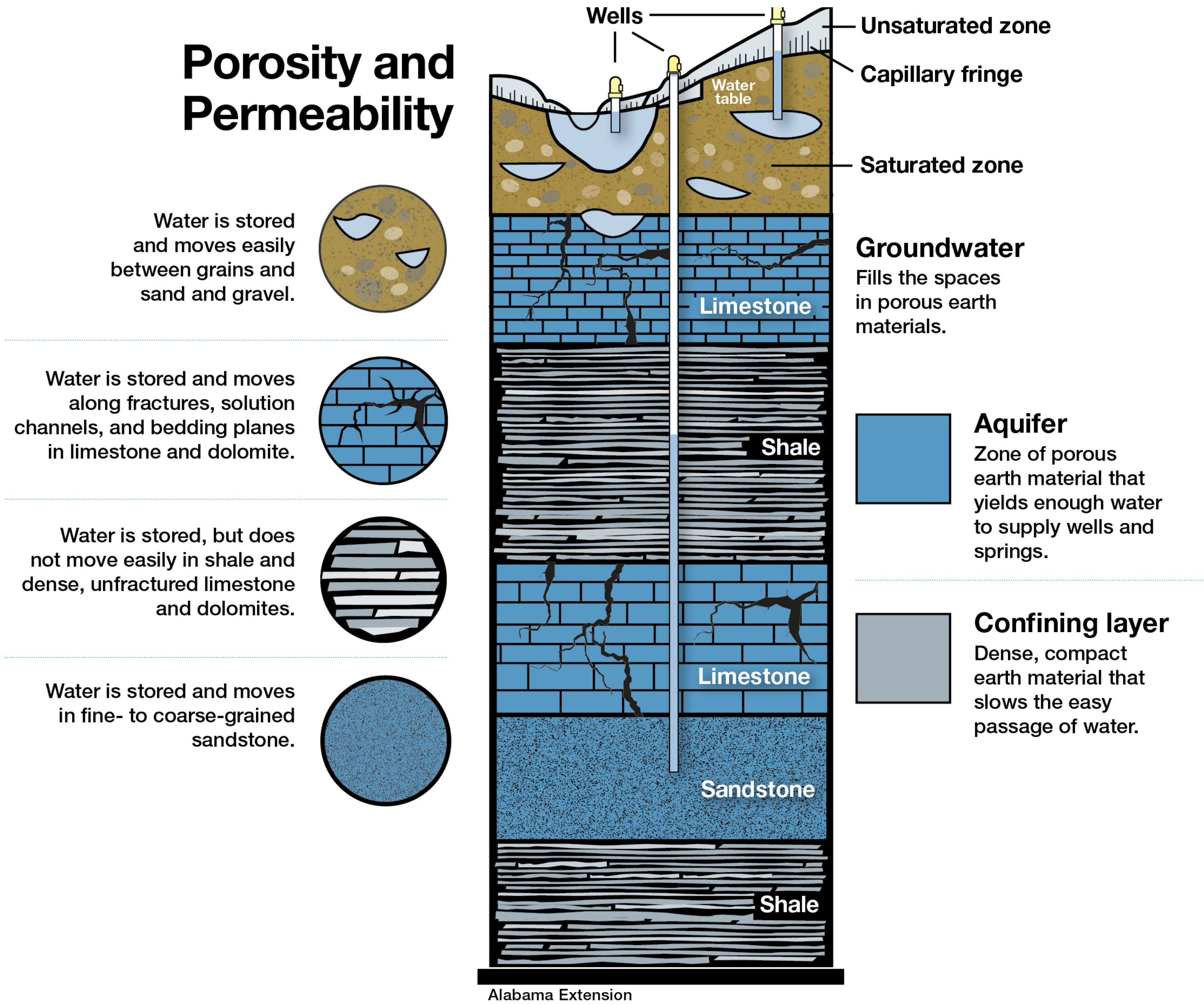


Figure 1.5. Groundwater basics.

Both porosity and permeability of rocks control how much water can be stored in them. Porosity is the size and number of void spaces, and permeability is the relative ease with which water moves through spaces. There is not always a direct relationship between the depths of rocks and their water-bearing capacity. For example, a dense granite close to the surface may yield little to no water, while a porous sandstone hundreds of feet below the surface may yield hundreds of gallons of water per minute. On average, rocks lose permeability and porosity as their depth below the earth's surface increases. This is because the weight of overlying rocks pushes closed the cracks and pores of rocks at a great depth. If you look at rocks exposed by road cuts or by streams, you can see the types of openings where groundwater can be stored and transmitted. Some bedrock exposures reveal spaces in layers extending for miles.

Aquifers in Alabama can be grouped according to the way water flows through them.

Aquifers transmit water by porous flow, conduit flow, fracture flow, or by a combination of the three.

Porous flow is typical of aquifers composed of sand or sandstone. These aquifers are made up of sand-sized particles of other rocks that were broken down by erosion, transported to their present location by wind or water, and deposited. Water is stored in and moves through the open spaces, or pores, between the individual sand grains.

Typically, water moves slowly but steadily through sand and sandstone, making many sand and sandstone aquifers reliable sources of groundwater. Slow recharge can mean that some contaminants are more likely to be filtered out but that it can take a long time to recharge.

In conduit flow, water flows through underground channels, or conduits, in rocks (often limestone and dolomite). Springs are common in limestone aquifers, discharging water where water-filled channels meet the surface. Limestone aquifers have several potential disadvantages. Because the openings are irregular in shape and distribution, groundwater flow can be unpredictable and extremely fast, sometimes up to several thousand feet per day through the larger channels. The water table in limestone aquifers may rise and fall rapidly in response to pumping and precipitation events.

Figure 1.6. Sinkhole above a former limestone mine.

Sinkholes commonly occur in areas underlain by limestone but may also occur elsewhere. A sinkhole, as shown in figure 1.6, forms when the ground surface collapses into an underlying dissolution cavity. Sinkholes are like large drains, and water entering them is immediately introduced into the groundwater system, causing potential contamination. Figure 1.7 shows the locations of known sinkholes and sinkhole density across Alabama.

Limestone aquifers often produce hard water, meaning it contains large quantities of dissolved calcium and magnesium. Aquifers characterized by conduit flow can also be fractured, which enhances the permeability of these aquifers. In nonporous rocks, fractures may be the only way water can get through. Fractures also may or may not be well connected.

In Alabama, each aquifer north of the fall line is fracture dependent (Valley & Ridge, Highland Rim). Fractured aquifers are important in the Piedmont region, and fractured granites and granitic rocks are major aquifers in large parts of Coosa, Tallapoosa, and Chambers Counties and smaller parts of several neighboring counties.

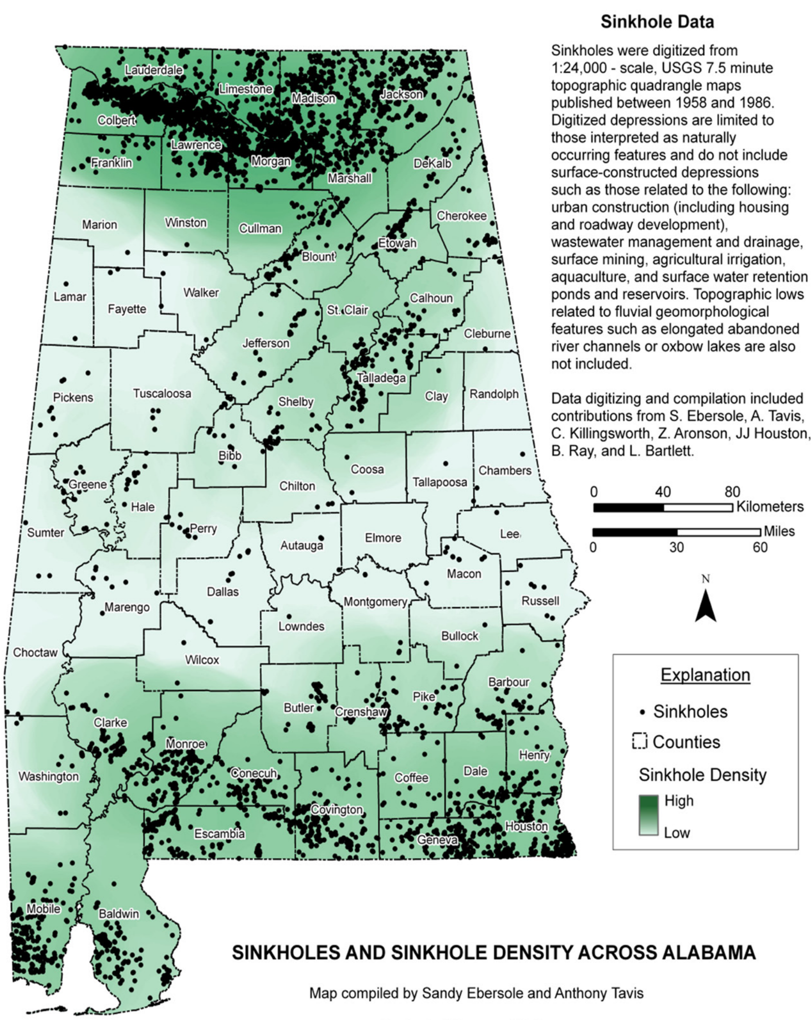


Figure 1.7. Sinkholes and sinkhole density across Alabama.

How Groundwater Relates to You

Many of us drink groundwater every day, whether we know it or not. Groundwater is readily available in many parts of our state. Turn on the faucet in Dothan, Greenville, Ozark, Selma, or Montgomery, to name a few cities, and you are probably drinking groundwater.

More than 13 million U.S. households depend on individual wells for drinking water.

Public-supplied residential deliveries and self-supplied residential water withdrawals were 358 Mgal/d in 2015. Public suppliers delivered 321 Mgal/d (90%), of residential water. The remaining 37 Mgal/d of residential water was self-supplied from groundwater. Eleven percent of the population relied on private wells for their drinking water.

Natural factors affecting groundwater quality include the amount of time the water has been underground, the composition of the rocks through which the water has moved, and local conditions underground. Groundwater typically requires less treatment than surface water. Although both must be chlorinated for use as a public water source, surface water must also be treated to remove contaminants and sediment that may be in rivers and streams.

Groundwater commonly contains more mineral matter than surface water does because groundwater moves slowly through the subsurface and has more time to react with minerals with which it comes in contact. Problems of local significance in some areas include excessive hardness (dissolved calcium and magnesium), high concentrations of iron, chlorides, and dissolved solids, and low pH (high acidity). All of these factors can make water unsuitable for some uses. Too much iron in water stains fabric and fixtures; high chloride concentrations and low pH can corrode fixtures.

Usually, underground layers of clay and other natural materials help minimize contaminants in groundwater. These materials act as natural filters, retaining contaminants and passing cleaner water on to other sediment or rock units, but groundwater can be contaminated through local human surface activities, too.

Liquid contaminants on the surface can leak directly into groundwater. These contaminants can either sit on top of the water table or can create a pool of contamination at the bottom of an aquifer. There are naturally occurring contaminants (arsenic, iron, radon, and sulfur) and anthropogenic, or human-caused, contaminants (toxic chemicals and human waste). Soil permeability affects how quickly contaminants on the ground will reach groundwater. It is critical to dispose of waste materials properly and carefully. People often have to abandon their wells because their groundwater has become contaminated and is no longer safe to drink.

For more information about aquifers in Alabama and their potential anthropogenic or natural contaminants, refer to The Geological Survey of Alabama online publications outlining the hydrology and vulnerability to contamination of major aquifers in Alabama.

How Aquifers Recharge

The rate of recharge varies for aquifers, which is an important consideration for well pumping. Pumping out too much water too quickly can draw down the water table in an aquifer, eventually leading to lower water yield and perhaps even causing your well (or your neighbor's, if drawing from the same aquifer) to run dry.

Remember, if water is being pumped from a confined aquifer, that aquifer cannot be locally recharged by

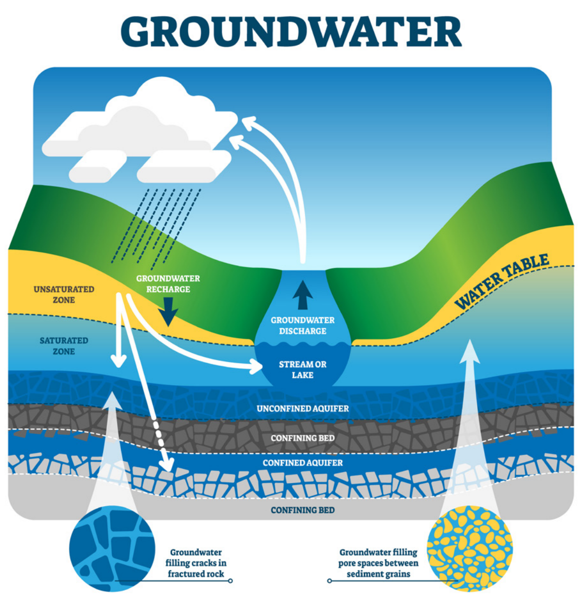


Figure 1.8. Confined and unconfined aquifer system. Confined aquifers are permeable rock units that are usually deeper under the ground than unconfined aquifers. They are overlain by relatively impermeable rock or clay that limits groundwater movement into, or out of, the confined aquifer. Unconfined aquifers are those into which water seeps from the ground surface directly above the aquifer.

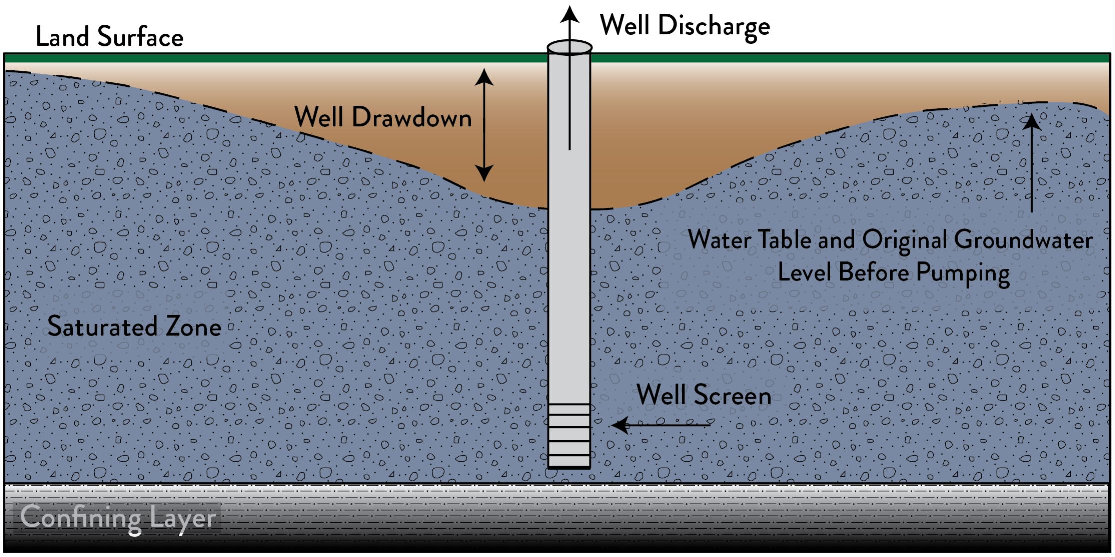


Figure 1.9. Well drawdown.

local rainwater from the earth's surface. It may be recharged somewhere far away; infiltrating surface water will only recharge confined aquifers where that aquifer is exposed to the surface or where the confinement layer is absent (figure 1.8).

Pumping of public water supply wells and irrigation wells can increase the potential for contamination of aquifers if not properly planned, managed, and monitored. When a well is pumped, the water level lowers around the well to form a cone of depression in the water table. If the cone of depression extends to other nearby wells (figure 1.9), the water level in those wells will also be lowered.

Hydrogeologic Provinces of Alabama

Alabama is divided into five hydrogeologic provinces: The East Gulf Coastal Plain, Piedmont Upland, Valley and Ridge, Cumberland Plateau, and Highland Rim (figure 1.10). These hydrogeologic provinces are closely related to the physiographic provinces, and therefore influence the way water moves and is stored in groundwater. The hydrogeologic provinces are defined on the basis of differences in water-bearing properties of rocks, rock type, structural geology, and physiography. These characteristics determine the types of aquifers in these areas.

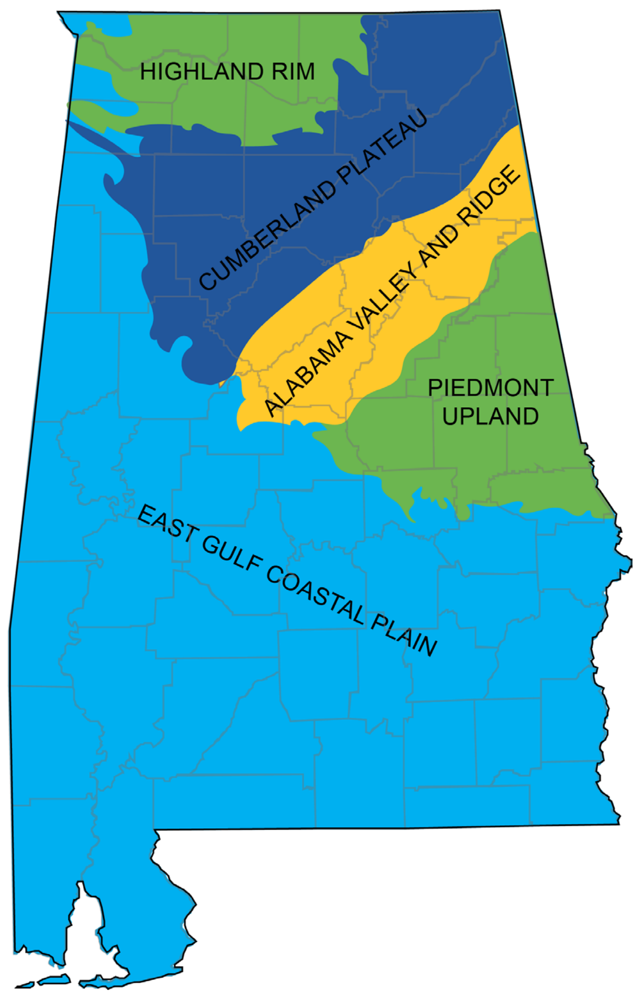


Figure 1.10. Hydrogeologic provinces in Alabama.

Coastal Plain

The Coastal Plain is the largest and most populated hydrogeologic province in the state. Groundwater availability is excellent in some locations of the Coastal Plain. Some Coastal Plain wells can yield up to several thousand gallons per minute (gpm). Average production per well is higher than in any other province in Alabama. In most parts of the Coastal Plain, wells can be expected to yield more than 50 gpm. To put this in perspective, a well producing 7 to 10 gpm is adequate for most domestic purposes.

Major groundwater users include the cities of Dothan, Enterprise, Jackson (supplied by a spring), Montgomery (which also uses surface water), Prattville, Selma, and Troy. Residents of the Coastal Plain, while including only 44 percent of the state's population, account for approximately 63 percent of the total groundwater use. The per-capita use is high primarily because of agricultural use. Although most areas in the Coastal Plain yield plenty of groundwater, some areas do not. Near the northern limit of the Coastal Plain, strata (rock layers) are too thin to store large quantities of water, and major users have to augment their groundwater supplies by developing other sources. The municipality of Tuscaloosa, for example, is located in the northern part of the Coastal Plain and relies on Lake Tuscaloosa for its water because the groundwater supplies there are insufficient to support the municipality.

Farther south in the Coastal Plain is a part of Alabama that has characteristic black, dense soils that are sticky when wet. This area is underlain by chalk, a variety of limestone that is a poor aquifer. Groundwater from subsurface sand and limestone is the primary water source for the municipality of Dothan and is an important source to people living in an area from Henry County to southern Choctaw County. Subsurface sands also supply groundwater to communities in Escambia, Washington, Baldwin, and Mobile Counties. Groundwater in the southern Coastal Plain is produced from wells ranging in depth from tens of feet to nearly 1,000 feet.

In some areas of the Coastal Plain located near the Gulf Coast, contamination of fresh groundwater supplies by salt water is a problem. Salt water occurs at relatively shallow depths near the coast. Coastal freshwater aquifers can become contaminated if wells in these aquifers are pumped heavily, or overpumped, enough to draw saltwater into the wells. Saltwater contamination, or saltwater intrusion, is a problem in southern Baldwin County and can affect any coastal area.

Piedmont

The Alabama Piedmont is the southernmost exposure of a vast physiographic province that forms the foothills of the Appalachian Mountains and stretches all the way to Pennsylvania. The ancient crystalline rocks of the Piedmont are igneous and metamorphic rocks and are the most intensely deformed rocks in the state. Rocks in the Piedmont do not hold much water compared to the sands and limestones of the Coastal Plain. Large cities in this area include Anniston, which uses water from Coldwater Spring, one of the largest springs in the state. Even though Anniston is in the Piedmont, Coldwater Spring is located in the Valley and Ridge province.

Valley and Ridge

The Valley and Ridge province is made up of folded and faulted sedimentary rocks (limestones, dolomites, sandstones, and shales), and marks the southern end of the Appalachian Mountains. Aquifers in the Valley and Ridge may be dominated by porous, conduit, or fracture-controlled flow, depending on the rock type. Groundwater is abundant in the Valley and Ridge, with limestone, dolomite, and sandstone aquifers capable of producing more than 100 gpm. A few wells can yield as much as 1,600 gpm. Because most of the valleys are underlain by limestone and dolomite and therefore are prone to conduit flow, aquifers located in these areas are relatively susceptible to groundwater contamination from the surface.

Cumberland Plateau

The Cumberland Plateau in north central Alabama is underlain by relatively flat-lying rocks. The Pottsville Formation, which consists of interbedded sandstone and shale, is the major aquifer in the Cumberland Plateau, with the Bangor Limestone and the Hartselle Sandstone supplying significant amounts of groundwater in some parts of the province. Water from the Pottsville contains enough iron in places to stain fixtures and affect the taste of the water, and water from the Bangor and to a lesser extent the Hartselle, is hard. Individual wells in the province can yield as much as several hundred gallons per minute, but 20 gpm or less is typical. Springs in the Cumberland Plateau are moderately common, yielding 10 to 100 gpm of water from limestone, sandstone, and shale.

Highland Rim

As is the case in many areas in Alabama, groundwater is unevenly distributed in the Highland Rim. High-capacity wells, producing from 100 to more than 1,000 gpm, occur in the limestones and dolomites of the Fort Payne-Tuscumbia aquifer system in the northern part of the Highland Rim and in the Bangor Limestone in the southern part. The Hartselle Sandstone and several other aquifers of local importance supply minor amounts of groundwater to the southern part of the province, mostly from wells producing 10 gpm or less. Storage and flow of groundwater is controlled by fractures.

The major aquifers in the Highland Rim province contain significant amounts of limestone. Caves and sinkholes are common, and contamination of groundwater is a serious concern. Much of the groundwater in the Highland Rim is hard and locally contains iron, carbon dioxide, or hydrogen sulfide.

Huntsville is the largest groundwater user in the Highland Rim, getting most of its water from two wells and Brahan Spring (Huntsville Big Spring).

Considerations for Owning a Well

Chapter 2

ALABAMA EXTENSION

Considerations for Owning a Well

Every well owner should know the basics of how a well functions. Knowing what kind of well you own, how it pumps water, and where it is located on your property will help in identifying and resolving problems.

Types of Wells

The three primary types of private drinking water wells are dug, driven, and drilled wells. Wells can range from 15 feet to more than 1,000 feet deep in some parts of Alabama.

Dug Wells

Dug wells are dug using a shovel or backhoe and are lined using brick, stone, or tile to prevent them from collapsing. Dug wells tend to have a large diameter, are shallow (approximately 10 to 30 feet deep), and lack continuous lining and grouting. These wells are subject to contamination from nearby surface sources, and they can go dry during periods of drought if the water table drops below the bottom of the well.

Driven Wells

Driven wells are constructed by driving a pipe into the ground to draw water from aquifers near the surface. These wells are cased continuously and are usually 30 to 50 feet deep. Though driven wells are cased, they can be contaminated easily because they can only tap shallow water and are easily contaminated from nearby surface sources.

Drilled Wells

Drilled wells are constructed using percussion or rotary drilling machines. Drilled wells can be thousands of feet deep and require casing. The most common materials for well casings are carbon steel, plastic, and stainless steel. Local geology often dictates what type of casing can be used. Drilled wells have a lower risk of contamination due to their depth and use of casing.

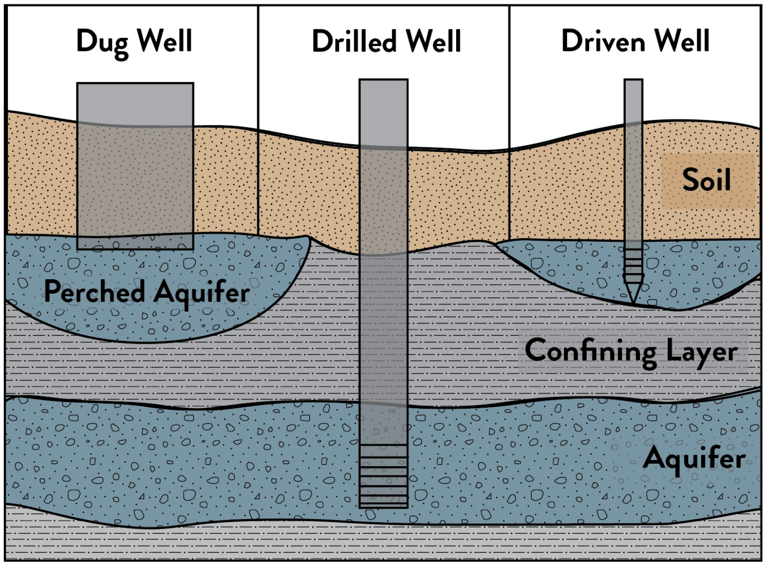


Figure 2.1. Dug, driven, and drilled wells.

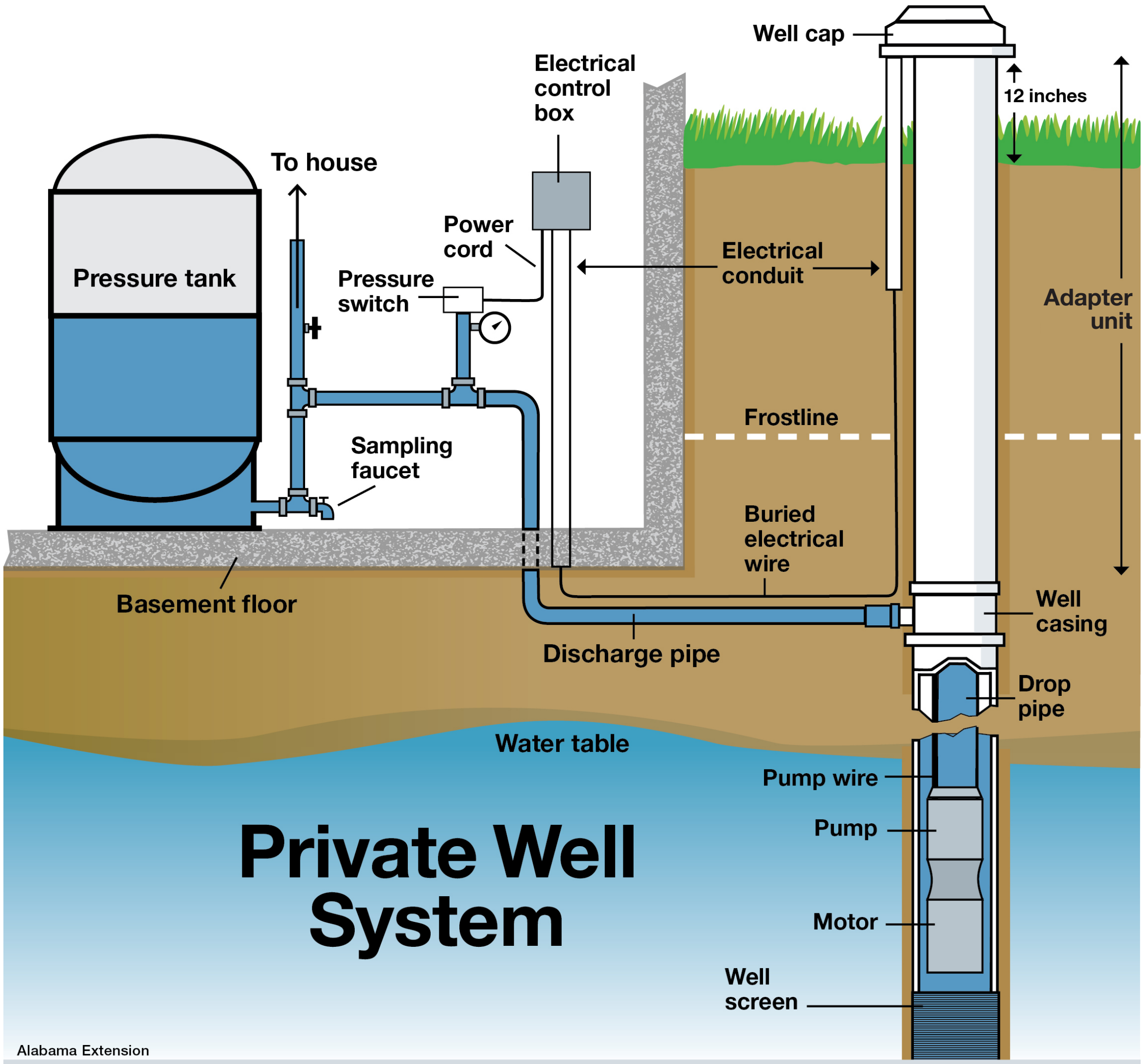


Figure 2.2. Components of a private well system.

How Wells Work

A private well system draws water from the surrounding geologic formations or aquifer. Water flows through the well screen, which is attached to the bottom of the casing in the aquifer. The sieve-like well screen allows water to flow through it while preventing sediment or large contaminants from entering the well. Because wells vary depending on their location, the slot size for these screens also depends on the size of the sand and gravel located within the aquifer. The most common well screens are continuous slot, slotted pipe, and perforated pipe.

The pump pushes the water through the drop pipe. Submersible pumps are the most commonly used pumps for deep private wells. The pumping unit is placed inside the well casing and connected to a power source on the surface. Jet pumps are the most commonly used pumps for shallow wells, or those with a depth of 25 feet or fewer. Jet pumps are mounted aboveground and use suction to draw water from the well.

When a well is initially installed, drillers typically install a steel or plastic pipe to prevent the well hole from collapsing during drilling. A specific mixture of water and cement, known as grout, is used to fill in the space between the aquifer and the casing to help prevent contaminants and surface water from moving down the casing.

The pitless adapter, if relevant, is housed in the pitless unit and is a special fitting that attaches to the well casing underground and allows the water to pass through the well casing through buried pipes, therefore providing protection from surface contamination. The pitless adapter is a connector that allows the pipe carrying water to the surface to remain below the frost line. It ensures that a sanitary and frost-proof seal is maintained[1]. In the past, a well pit was the most common way to gain access to well pipe connections below the freeze line. These pits are generally unsanitary and allow outside drainage into the well. The pitless adapter is one of three parts that make up a wellhead. The wellhead includes the pitless adapter, the well casing, and the well cap.

The well casing is the tube-shaped structure placed in the well to maintain the well opening from the target groundwater to the surface. In every well, the casing should extend 1 foot above ground, where it should be properly sealed to prevent entrance of surface water. The casing protects the interior of the well, keeping dirt and excess water out. The casing helps prevent groundwater contaminants from entering the well channel and mixing with the drinking water. In Alabama, the length of a casing may not be less than 20 feet. County environmentalists must approve any well constructed with fewer than 20 feet of casing.

The well cap is typically made of aluminum or plastic and is placed on top of the well casing to keep debris, insects, and small animals out of the well. It is important that the well cap be firmly attached to the casing with a vent that allows only air to enter to control the pressure during well pumping.

The power cord is enclosed in the casing, and wiring for the pump is secured in an electric conduit pipe. The pressure switch regulates the pump to start and stop at the preset pressure levels, allowing the system to work automatically. The electrical control box houses the fuses for the well.

Water travels through the waterline and into the pressure tank, which stores water to be used when the pump is not running, consequently building a water supply so the pump has to run less often. This is especially beneficial during peak use seasons when demand for water increases.

A sampling faucet allows direct access to a water sample from the well before it passes through the distribution system.

Benefits and Considerations for Owning a Well

Drinking water from private water wells is widely used across the United States. Private water wells provide water for urban environments and rural communities that may not have access to municipal water supplies. Without private well water sources, many rural communities would not have access to water for drinking, household tasks, or irrigation systems.

There are many benefits to owning your own water well, a prime reason being that private wells tend to be cost-effective and reliable. With private well-water systems, the water you drink is coming directly from groundwater to your tap. If, for example, a municipal water system became compromised in the area due to an influx of contaminants, private well owners may not be affected. However, private wells can also carry natural or human-made contaminants found in groundwater, and well owners have a responsibility to be vigilant about their water quality.

When pollutants are released into the ground, whether it be from a leak, spill, or inappropriate discarding, they may move through the soil much like water. The rate of flow depends on soil type and the nature of the pollutant. Treating any contaminants that enter your water system tends to be a very expensive process and usually results in homeowners switching to alternative water sources.

Owning a private water well can mean a lot more than just water use efficiency. It is also considerably more cost-effective to source your water from a private well than from municipal water systems. Water bills can vary depending on where you live and how much water your household uses. According to the Environmental Protection Agency (EPA), the average American uses 88 gallons of water per day. Most utilities charge a set flat fee (often referred to as the water base facility charge) that helps pay for the base costs of providing water to a home, including the electricity needed to transport and clean the water, the labor costs of daily maintenance of the delivery system, and other associated operating costs. According to the Birmingham Water Works Board, customers having a ⅝-inch-size meter pay $26.60 (in 2021) as a base service charge and can pay anywhere from $2.59 to $5.99 each month per centum cubic feet (CCF). This rate does not include other miscellaneous fees that municipal water systems may have. While private water well owners may not experience many of the same charges, they do have to pay for the electricity to run the pump and for any treatment devices.

In many cases, residents of rural communities simply live too far away to be included in the municipal system. The financial burden associated with municipal water use is one reason many homeowners remain on well water. On private water systems, many of these charges are avoided, and the primary expenses of the owner are the upfront installation cost, electrical costs as well as annual water quality testing and any treatment that may be necessary.

Before opting for private well water, be sure to review all your options. Some important things to consider include your household water demands, which may also include your operations (such as livestock or farming). Be aware of the minimum water yield that you could possibly accept, as some drilled wells to be low-producing. There is also a chance that multiple wells will need to be drilled to locate a well with the needed production rate.

In your budget, be sure to factor in the maintenance services for future repairs, and ensure that your cost estimate includes all aspects of well construction (drilling cost, labor, materials). Be sure to hire a qualified, licensed well driller but explore all of your options before deciding on a final candidate because, after all, this is your drinking water. A list of licensed well drillers in Alabama is available on the Private Well Program web page on the Alabama Extension website.

Your contractor should be able to walk you through the well-drilling process and answer any questions you have. The well-drilling process can be straightforward with ample communication and appropriate planning.

Purchasing a Home with a Well

Purchasing a home that has a well may be a new endeavor for a homeowner and comes with the added responsibility of properly maintaining the well and knowing about regulations and requirements associated with operating it.

Before purchasing a home with a well, educate yourself about state regulations for private water wells, as processes differ from state to state. In some cases, water wells must be inspected before a home is purchased and the well history, location, components, flow, and quality may be examined.

Alabama is known as a “caveat emptor” state for existing homes. In the real estate world, this means “let the buyer beware” in Latin. Buyers have a chance to inspect the property and should assume the responsibility of a purchase. Simply stated, this means that neither the seller nor the seller's agents, unless asked, are required to disclose defects, except those that might pose an immediate health or safety risk to the buyers. Home inspections vary by property type and situation but are usually done by licensed home inspectors. Additional inspections can be ordered if necessary. Some home-loan lenders do not require maintenance inspections to be completed when a sales contract has been drawn up, while others may require. It is strongly encouraged for prospective owners to see to it that this inspection is completed before they decide to go through with a home purchase, as a thorough home inspection can be worthwhile when assessing your private well to determine whether the water is suitable for consumption.

Lenders such as the Department of Veteran's Affairs (VA) do have a list of requirements that buyers must follow if purchasing or refinancing a home that has a private well system. The water quality of an individual water supply (such as a well) must meet the requirements of the health authority having jurisdiction. Since no health authority in Alabama has jurisdiction over well water quality, drinking water guidelines established by the EPA should apply. All testing must be performed by a disinterested third party (meaning they have no connection to the home transaction), with results only being valid for 90 days. In addition to this maintenance inspection, you should take the time to assess the property context as well. For example, assess the drainage of the landscape, familiarize yourself with the septic system or other structures and their relation to the well, and ask about water concerns in the area of the home you want to purchase or sell.

Water wells can be complex systems, and homeowners may need to consider a few extra elements when owning a property that has a water well supply. Water supply adequacy, wastewater disposal, water quality, soil properties, and land characteristics are just a few of the variables to consider. Repairs to a compromised well can be costly, making the initial home inspection even more valuable.

Information About Your Well

Because private well water systems are not state or federally regulated, it is crucial for a private well owner to stay informed about the status of their well and the quality of the water from the well. In some states, records of water wells are available for public viewing. In Alabama, some well information can be found on the Geological Survey of Alabama (GSA) website, but these may not be the most up-to-date records for private well owners, and records of private wells are combined with industrial and irrigation well records.

Well records are best understood by looking at the notification of intent to drill a water well and certification of completion (ADEM Form 060), which is a required form by the Code of Alabama, 1975. On this form, well owners can find the following information:

- Drilling contractor, including license number and address
- Property owner and address
- Well location
- Well purpose (private, public, industrial, irrigation)
- Drilling method
- Well depth
- Completion date
- Pump style
- Capacity
- Wellhead finish
- Casing material
- Well water quality at the time of development
- Description of cutting intervals (soil type)

Managing and Maintaining Wells

Other considerations for owning a well are the maintenance and testing required. Failing water infrastructure can be costly and dangerous. As water systems age, the equipment may need to be replaced to ensure acceptable water quality is maintained. All water systems are subject to mechanical failure, and troubleshooting well-water issues proves to be more difficult because most of the functions take place underground, far from view. Some examples of failure that well owners may encounter include corroded pipes, waterlogging, broken seals, cracked pumps, clogged filters, and faulty electrical systems.

So, how do you know that it is time for a checkup? Any indication of system failure should prompt a well checkup. System failure may be first seen in sediment buildup in tanks, pipes, and plumbing and indicated by reduced water yield, low water pressure, or a change in water quality.

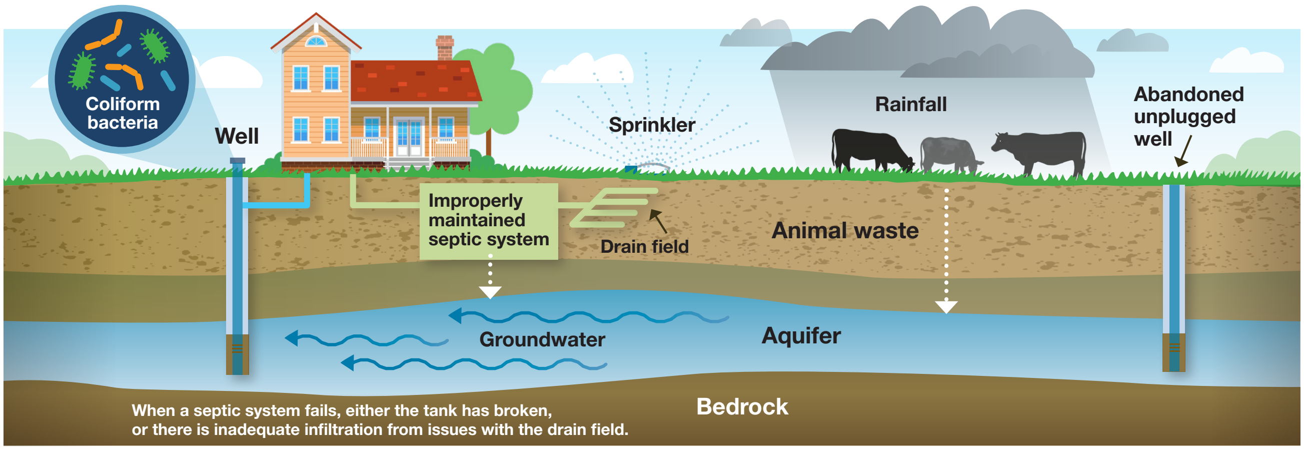


Figure 2.3. Contaminants in proximity to your well.

Routine maintenance and quality assessments are recommended each year. During this checkup, a licensed professional should evaluate the following:

- Water flow
- Pump performance
- Water level
- Electrical connections
- Water quality
- Sanitation

Be sure to keep all records related to the water well, including the following:

- Water well log/report
- Water quality test results
- Inspection reports
- Maintenance log and invoices
- Equipment manuals

Constructing a Well

If after reviewing all the considerations for owning a well, you decide to construct one, the first step is to select a proper location for your well to help protect it from contaminants. The next is to hire a licensed contractor to construct it for you.

Selecting a Well Location

The location of your well is critical to having quality water. A well should not be placed downhill from a livestock yard, septic drain field, or near a frequently fertilized area because contaminants can seep into groundwater (figure 2.3). Failing septic tanks can also contaminate drinking water, so septic field areas are to be avoided. The Alabama Department of Public Health requires that conventional septic system drain fields be at least 100 feet from a well down gradient (figure 2.3).

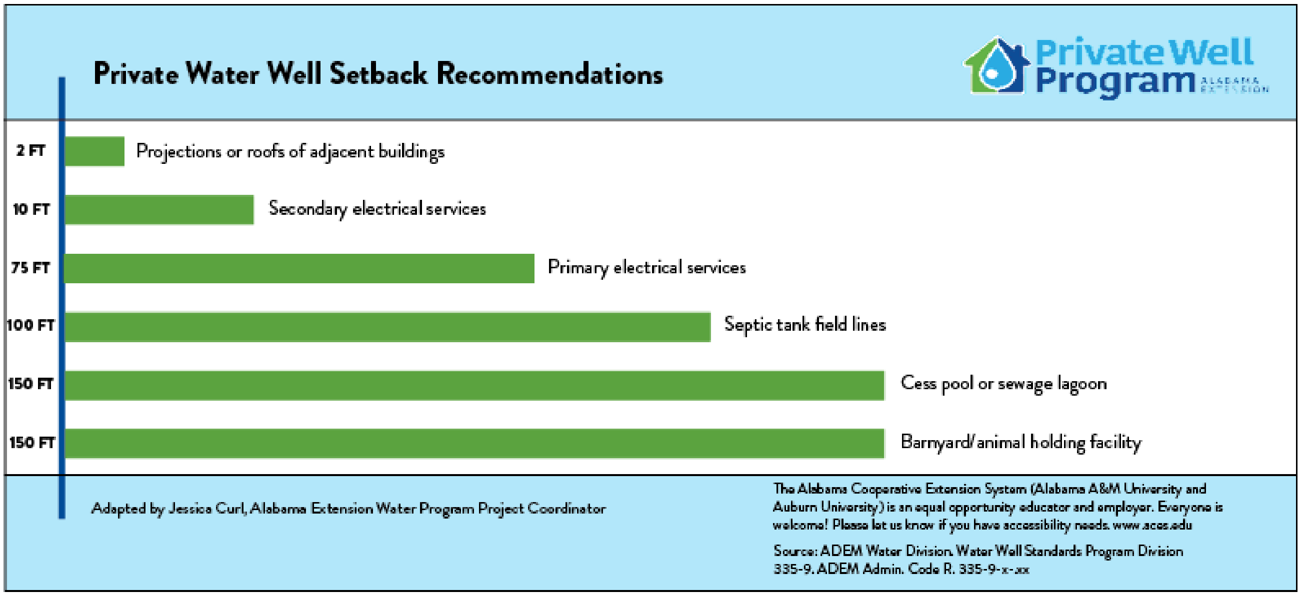


Figure 2.4. Water Well Standards Act recommendations.

While many states do regulate well setback requirements, The Alabama Department of Environmental Management (ADEM) does not explicitly regulate well spacing. However, the Water Well Standards Act of 1988 outlines location recommendations for water well placement on properties (figure 2.4).

In addition to these setback recommendations, extra precautions should be taken to ensure that a well is not being constructed in an area vulnerable to flooding, as this can lead to a surge of contaminants entering the water system. Examine your well location after a large-scale weather event to determine how the land drains.

Finally, know that the soil properties of your area also affect where wells should be placed. Heavy, sticky clay soils may restrict water movement and pollutant runoff, while thin, sandy soils may allow pollutants to travel farther through the soil profile due to their large pore spaces. Loamy soils that have a good mixture of sand, silt, and clay are the best at minimizing pollutant transport.

Having a Well Constructed

Due to the complexity of well systems, only licensed well drillers are permitted to drill water wells in Alabama. ADEM outlines licensing and certification requirements of water well construction standards. Before constructing a well, the well driller must apply for a water well driller's license on or before September 30 of each year and pay a fee of $200.00. The well driller must also be able to prove at least 2 years of experience drilling water wells and score 70 percent or above on an examination furnished by ADEM.

ADEM Form 060, Notification of Intent to Drill a Water Well, must be filed. Within 30 days of completion of construction, the driller must file a Certification of Completion to ADEM. Within 7 days of receiving the form, ADEM informs health authorities. ADEM Form 060 can be found on the ADEM website.

Conducting Visual Inspections

In addition to having a licensed professional assess your well, regular visual inspections can help you identify some immediate well concerns. Examine the well casing and cap as well as the area surrounding the well. Ensure that the well casing extends at least 12 inches from the ground, the well cap is securely attached and free of debris, and that the electrical connections are secure. Figure 2.5 shows a well that is rusted, cracked, and has no pump, meaning it could not be used.

Although a properly sealed well cap should help reduce the flow of contaminants into your well, chemicals, paint, fertilizers, feeding areas, waste systems, and pesticides should not be near your wellhead.

Figure 2.5. Well and well cap over rusted pipe surrounded by grass and weeds.

Backflow Prevention

Most community water systems have backflow prevention devices on all connections to prevent pollution of water lines. The same type of device should be used for your private well water system. Backflow containing possible contaminants such as pesticide and fertilizer mixing tanks can flow into your well from a hose when there is a drop in water pressure. A backflow prevention device can prevent these chemicals from flowing back into your water source.

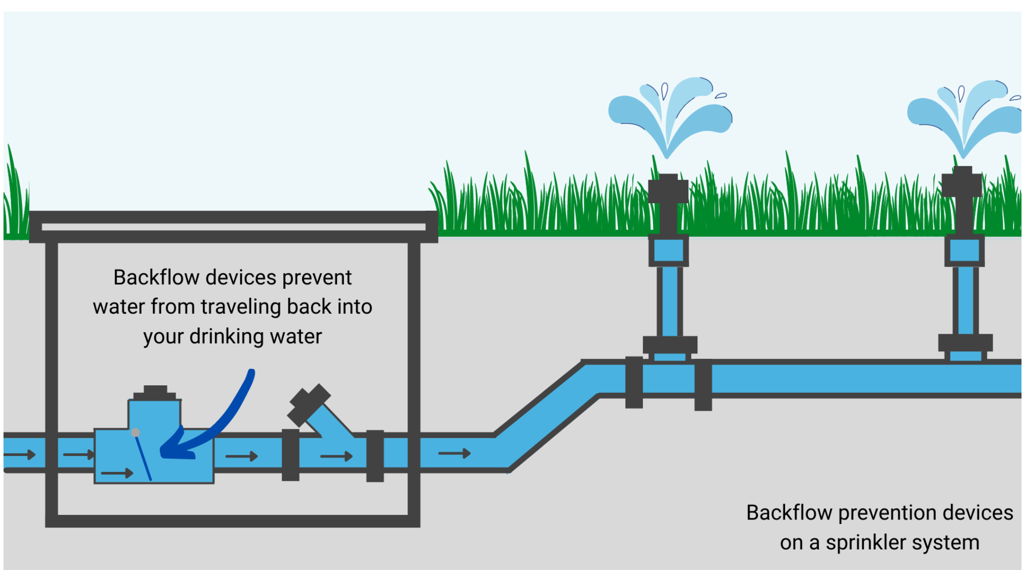


Figure 2.6. Backflow prevention device.

Regular Water Testing

It is crucial to maintain a regular testing schedule for your well and keep test results in your file for future reference and comparison. The Centers for Disease Control and Prevention (CDC) recommends that well owners check for mechanical issues each spring and perform a water quality test once a year.

The National Ground Water Association (NGWA) recommends that well owners have their water tested at least once a year for bacteria, nitrates, and any contaminants of local concern. More frequent testing should be considered if any of the following occurs:

- There is a change in the taste, odor, or appearance of the well water.
- There is a broken well cap, inundation by floodwaters, or a new contamination source.
- The well has a history of bacterial contamination.
- The septic system has recently malfunctioned.
- Family members or house guests have recurrent incidents of gastrointestinal illness.
- An infant is living in the home.

To find laboratories certified for water testing, visit the Alabama Extension or ADEM websites.

Checklist for Private Well Owners

Tips for protecting your groundwater supply and your household:

- Always use a licensed or certified water well driller or pipe installer when you have a well constructed, a pump installed, or any other general maintenance done to your well.
- Conduct a general maintenance check annually.
- Conduct a water quality test annually.
- Keep hazardous chemicals (paint, fertilizer, pesticides) away from your well.
- Check the well cover or well cap often to ensure that it is in good condition.
- Maintain proper separation between your well and sources of contamination (waste systems, chemical storage facilities, buildings).
- Prevent back-siphoning into your well.
- Keep your well head 1 foot above the ground.
- Maintain the landscaping around your well, making sure that leaves and other natural fibers do not accumulate.

Well Yield and Water Rights in Alabama

Chapter 3

ALABAMA EXTENSION

Well Yield and Water Rights in Alabama

Understanding water quantity and your well is important because well yield is related to withdrawal rates and groundwater replenishment. Yield is generally defined as the rate at which a well can be pumped while ensuring that the water level does not drop below the pump intake. Several factors influence well yield, including the characteristics of the aquifer, the construction of the well, maintenance of the well, local climate and periods of drought, and community water demands on local water resources.

It is also important for well owners to know about Alabama's policies regarding surface water and groundwater use, state agencies and their responsibilities, and what influence these might have on the water quantity available to private well owners.

Understanding Problems with Well Yield

Well yield refers to the amount of water delivered per unit of time that may flow or be pumped continuously from the well. Low-yielding wells cannot meet peak water demand for households. There are a few reasons that wells may not reach peak efficiency specific to the characteristics of the aquifer, well construction, and well maintenance.

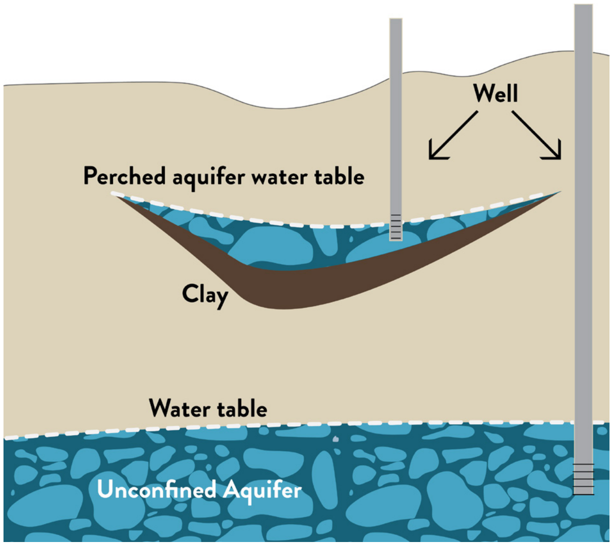


Figure 3.1. Perched aquifer.

Aquifer Composition

The composition of the aquifer your well draws from can affect how much water your well yields. Wells in more porous, saturated geologic materials routinely have higher yield. Wells in less porous clays and bedrock can slow groundwater flow to less than 5 gallons per minute (gpm). Sandstone aquifers are very common and are prolific aquifers, even in the Coastal Plains. Igneous and metamorphic bedrock as in the Piedmont and Valley and Ridge make poor aquifers.

Well Construction

Dug wells often encounter dry-well problems. They are often shallow and excavated in poor earthen material, meaning that they are easily affected by drought or other seasonal water declines in the water table. Many dug wells extend only to the bedrock surface and tap a perched aquifer, which is groundwater separated from a larger, underlying body of groundwater. These wells cannot be easily deepened. In such cases, a new drilled well is the only long-term solution.

Some drilled wells that tap shallow bedrock will yield only 1 or 2 gpm. The United States Geological Survey[1] considers 5 gpm to be adequate for domestic supply. Some drilled wells in shallow bedrock are not deep enough to adequately store water for short-term pumping cycles, but the rate of pumping depends largely on the aquifer composition, which varies across the state. Water level of a well can depend on the depth of the well, the type of well, the surrounding geology, and the amount of pumping. A deep well in a confined aquifer in an area with minimal pumping is less likely to go dry than a shallow dug well. If, for example, there are 50 feet of water above the pump intake when the water table declines 10 feet because of drought conditions, only 40 feet of water is available in the well for one pumping cycle, and the well seems to go dry.

Potential solution: Dug wells should be constructed during seasonal or climatically low-water-level periods. Wells may also be candidates for well deepening and pump lowering if the static water table elevations have dropped.

In that situation, deepening the well may solve the problem as long as the deeper water is of good quality. Another option is to lower the pump if possible. If usable water is not available at a greater depth, the pumping rate must be reduced so that less water is pumped during each cycle. Water wells may "go dry" because the pump discharge rate is greater than the recharge rate of groundwater to the well.

A well's construction can also affect water yield. The screened portion of the well allows water to move into the well while reducing the silt and sand that can enter. A screen mesh that is too large could allow sediment to pass through and clog the well, damaging the pump.

Submersible pumps that are installed just below the water table can draw down water levels too quickly, requiring the pump to cycle on and off repeatedly as the water table rises and falls, often damaging the pump. In addition, rapid and repeated water level changes around the well screen can introduce oxygen in the aquifer. Changes in aquifer geochemistry can occur when water-saturated geologic materials are exposed to oxygen, and this can cause naturally occurring minerals to dissolve into the aquifer. If the aquifer material includes arsenic-bearing minerals, there may be an increase in dissolved arsenic, a toxic chemical, in the water supply. If water table elevations drop after initial well construction, well yield may decline.

Potential solution: If you think your well may have sediment buildup, contact a licensed pump installer to clean the pump system, including well surging and scrubbing to remove sediment, bio slime, and other particulates. Test your water once a year for potential contaminants.

Well Maintenance

The development of scale in the well and on the screen is the most common cause of a reduction in well yield. Scale is the hard residue from the precipitation of minerals (calcium, iron, and magnesium carbonates) that can build up on the insides of pipes and screens. Scale is also a food source for bacteria, which can cause bio slime to form in the well, similar to the way plaque builds up on teeth. The combined effect of the growth of slime and precipitated minerals has been reported to reduce well yield by 75 percent within a year of well operation in some locations. Bio-slime can also promote the growth of bacteria that can pose serious health concerns.

Potential solutions: Test wells annually for bacteria and other contaminates to ensure that drinking water standards are met. Shock chlorination of a well exhibiting elevated bacterial contamination reduces bio slime that may be plugging the well. For more information, see the Extension publication about shock chlorination for homeowners on the Alabama Extension website.

Drought

For unconfined aquifers, the weather can also affect water yield. Extreme rain deficits lead to drought, which can alter the groundwater table and ultimately the water level in your well. The water table in an aquifer is not constant and is controlled by the amount of rain and groundwater flow rates in the aquifer. If a well is pumped faster than the aquifer around it is recharged by rain, the well can go dry.

Take these steps to help protect your water supply during a drought:

- Monitor the pump for rapid cycling. One sign of lowered water tables is the rapid turning off and on of the pump, which can burn out the motor. Allow the pump to rest or reduce the pumping rate.
- Listen for the sound of "sucking air" in the pump. Allow the pump to rest if present.
- Check for sand in the toilet tank. When the water table is drawn down below the pump intake, the well may begin to produce sand.
- Consider lowering the pump if the well is deep enough.
- Consider installing a well water meter to monitor your water use.
- Schedule water use and conserve water.

Potential solutions: Ensure that there are water-conservation measures in place to prolong the amount of water available during times of drought. To help protect your well during a drought, monitor your pump, and check for any changes in water appearance or taste. It is also wise to monitor groundwater levels to prepare for drought. The Geological Survey of Alabama (GSA) operates and maintains a real-time groundwater monitoring network of thirty wells and three caves. The period of record for some of these wells dates to the 1930s and continues to today. Long-term hydrographs from these monitoring wells can provide some insight into water-level fluctuations for private well owners, allowing them to detect problems and implement conservation measures early.

Shared Wells

Shared wells service more than one home for residential or irrigation purposes. They can service up to two or more homes; those servicing more than four are classified as community wells. Increased pumping in the immediate area due to housing developments with small lots and individual wells can occasionally contribute to wells going dry. If pumping causes a large drawdown, a cone of depression (figure 3.2) will develop around each well. Thus, several domestic wells close together can create a steady decline of the water table if pumping exceeds the natural recharge to the system.

Large-capacity wells for municipal, industrial, or agricultural purposes adjacent to residential areas can also affect private well yield if using the same aquifer source. The increased withdrawal may cause large, widespread cones of depression that intersect each other and result in a cumulative zone of influence.

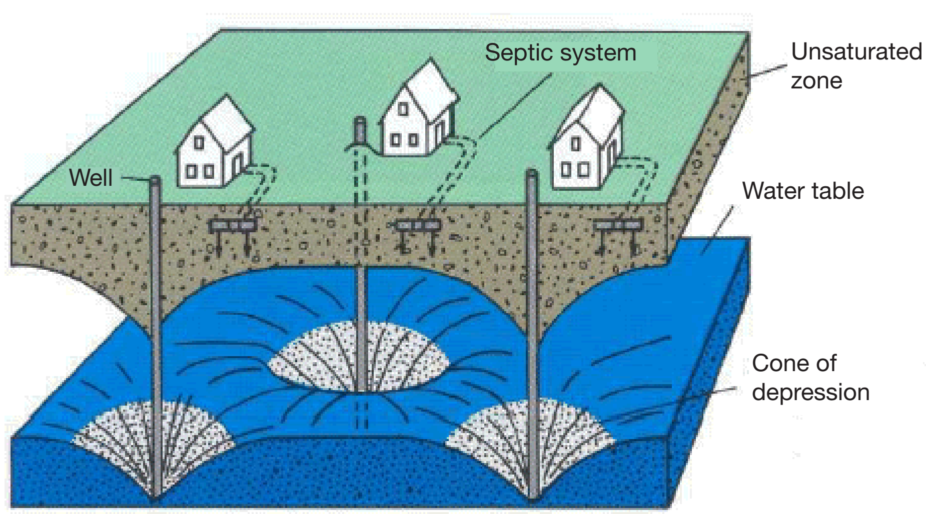


Figure 3.2. Effect of concentrated housing on groundwater level.

Potential solution: Have an attorney draft a written agreement between water users and well owners if you plan to construct a well to serve more than one household. The agreement should address the following questions:

- Who will maintain the well?
- Who may access the well for maintenance?
- Under what conditions can the property on which the well is located be bought and sold?
- How will power costs and water availability be shared?
- What is each party's interest or right to use the water?
- If the properties are to be served by individual pumps, whose pump will be the lowest in the well?
- What type of organization will manage operation of the well now and in the future?
- How will costs of well reconstruction or pump replacement be shared?

Water Rights in Alabama

Alabama has numerous water resources, including more than 132,000 miles of rivers and streams. Because all waters are linked through the hydrologic cycle and the hydrologic cycle spans geographic and political boundaries, the question of water rights is generally a question about who has the right to manage, divert, use, or sell the water.

In most states, surface waters, (streams, lakes, and coastal waters) are owned by the public. Alabama is a riparian state for surface water, meaning users must have property access to the water in order to use it. Groundwater may be privately or publicly owned. States manage their legal systems for dealing with water rights.

Although ownership of surface waters is reserved for the public, the use of water resources is determined by the laws and permits of the state. Water rights refers to the ability of users to take water from a source and use or sell it.

Most states in the eastern United States, where water is plentiful, have a riparian rights system (figure 3.3), meaning that waters of the state are a basic resource that should be conserved and managed for "full beneficial use and not be restricted unless the existing or future water usage in an area exceeds the supply capacity." Determining what exceeds supply capacity can be challenging, however. Most western states, where water is more scarce, use prior appropriation systems.

Surface Water

Although we are more concerned with groundwater when thinking about private wells, understanding how surface water is used is also important because it can influence how much water is available for groundwater recharge. The use of surface water in Alabama is based on the principle of the riparian rights doctrine, the basic premise of which is that water in its natural state, a watercourse, can be used only on that land through which it flows. A landowner that has property bordering surface water, or riparian property, can use the water on their property as long as it does not extend beyond the natural watershed of the riparian source of water.

However, the use of riparian water is subject to the reasonable use doctrine. This means that riparian water may be used for any purpose as long as quality and quantity of flow are adequate for other downstream riparian owners. Since reasonable use is difficult to define, many states now have permitting programs to monitor riparian uses so that all owners can have their reasonable share of the available sources.

With a growing interest in preserving the natural quality of scenic rivers or other areas, the public trust doctrine is likely to be adopted by more states in the future. The principle of this doctrine is that private rights to use water may be limited by the need to preserve environmental, scenic, recreational, or scientific areas that benefit all.

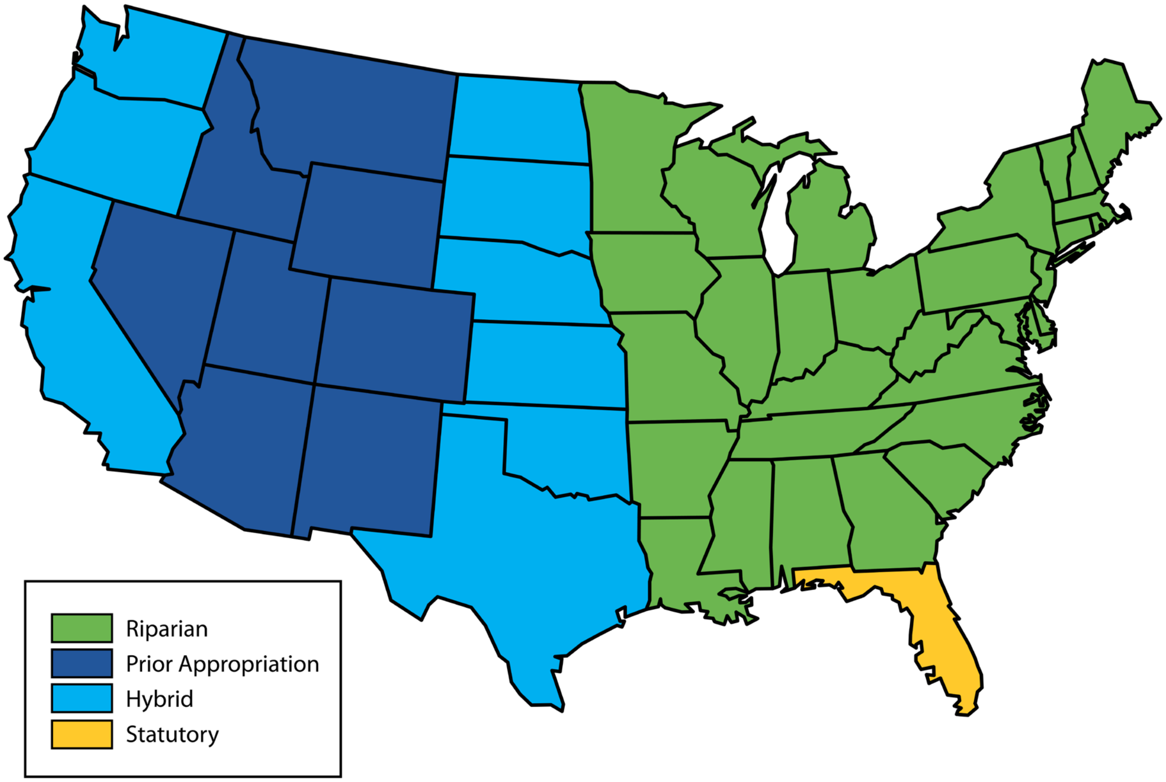


Figure 3.3. Most eastern states have riparian systems; western states have prior appropriation systems.

Groundwater

For groundwater, Alabama follows the "American Reasonable Use" rule, which holds that only the overlying landowner has the right to use the subsurface groundwater. Most groundwater supply regulations are developed and administered by the Alabama Department of Environmental Management. These regulations primarily deal with water quality issues and are based on regulations developed by the Environmental Protection Agency. The three main categories the department of environmental management regulates are:

- Public supply wells
- Nonpublic supply wells, (agricultural, domestic, and industrial)
- Injection wells

No meter is required for domestic well-water users, making it difficult to determine how much groundwater is being extracted at any given time. Water rights for small amounts (such as private wells) are generally not quantified, and historically, no public records were kept. The Office of Water Resources (OWR) maintains a database of self-reported water use by users of more than 100,000 gallons/day.

Regulatory Bodies

The Alabama Department of Environmental Management (ADEM) has primary enforcement authority over the Safe Drinking Water Act underground injection control (UIC) program.

ADEM prohibits any person from injecting pollutants into subsurface locations or constructing wells for such a purpose without obtaining and complying with the terms of a permit. ADEM also prohibits "the operation of an injection well which causes or allows movement of a pollutant into [an underground source of drinking water]."

After three droughts during the 1980s, a series of events (falling groundwater levels, saltwater intrusion, and increased withdrawals in neighboring states) prompted the legislature to pass the Alabama Water Resources Act in 1993.

The act was intended to provide a comprehensive water resources framework for water usage. It also provided a statewide procedure to handle other aspects of water management, including state response to emergencies such as floods and droughts and a unified voice for the state when dealing with interstate water issues. The Act also created the Alabama Office of Water Resources (as a division of the Department of Economic and Community Affairs), the Alabama Water Resources Commission, and the Alabama Water Resources Advisory Council.

The Water Resource Commission and the Office of Water Resources in the Alabama Department of Economic and Community Affairs (ADECA) oversee and administer a water-use reporting system. The Water Resources Commission has the specific authority to designate stress capacity areas, if a study finds that the area will not have enough water supply capacity for current or future use.

To enable the Office of Water Resources to coordinate and manage the waters of the state, certain users of ground and surface waters must file a Declaration of Beneficial Use. These water users include public water systems, persons who divert, withdraw, or consume more than 100,000 gallons of water on any day from waters of the state, and persons who have the capacity to use 100,000 gallons of water on any day for purposes of irrigation. The OWR will issue a certificate of use to users who submit a declaration of beneficial use following a review of the application. A certificate of use is issued after the declaration of beneficial use is made. Certificates of use are generally issued for 5 to 10 years and are renewable. If the terms of the certificate of use are not followed, or if a water user violates the Water Resources Act, the certificate of use can be modified.

Water Quality

Chapter 4

ALABAMA EXTENSION

Water Quality

Drinking Water Guidelines and Standards

Illnesses caused by untreated drinking water can be a product of both public and private water systems. While awareness of drinking water quality has increased considerably, awareness regarding private well health still lags behind.

The United States Environmental Protection Agency (EPA) enforces public drinking water standards to protect human health under the authority of the Safe Drinking Water Act (SDWA). Because private wells are not included in the SDWA, owners benefit from testing their well water to ensure that it is safe for consumption. Primary contaminants are those that pose a health risk and therefore have strict standards and maximum contaminant levels (MCLs) set to avoid harm from long-term exposure. If your well water contains contaminant concentrations greater than the MCLs set by the EPA, an alternate drinking source or a treatment plan should be established. Secondary contaminants do not pose health concerns for humans but affect water quality. Secondary contaminants also have maximum contaminant levels (SMCLs), but they are not enforced and only provide guidelines for maintaining desirable taste, color, and odor.

Private well water should be screened for a variety of contaminants, including nitrate, iron, fecal coliform bacteria, total dissolved solids, and sulfate. It is also important to assess pH, alkalinity, and hardness in drinking water. Water should be tested if there is a specific contaminant of concern in the well area, such as arsenic or volatile organic compounds (VOCs). It is important to note that these are just some of the tests recommended for well water quality, and it is up to the well owner to determine what other tests to perform to ensure water quality.

It is also important to note that private well health encompasses more than just water quality assurance. A responsible well owner should review the well construction, location, water source, and maintenance schedule to get a thorough understanding of the well.

Common Well Contaminants

Some common contaminants for which private well water should be screened include total dissolved solids, hydrogen sulfide, fluoride, arsenic, metals, nitrate, iron, and pathogens (such as those from bacteria). It is also important to assess pH, alkalinity, and hardness in drinking water.

Total Dissolved Solids

Total dissolved solids (TDS) is the concentration of dissolved minerals in water and may include substances such as salts, metals, cations, and anions. Calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate, and silica usually make up most of the total dissolved solids in water. TDS is included as a secondary drinking water standard and is therefore not regulated by the EPA in public drinking water.

TDS levels are largely a result of your location. Heavy rainfall and leaching of TDS through soil cause low TDS concentrations in water; arid regions with high evaporation rates tend to have high TDS. In some cases, saltwater intrusion may contribute to fluctuations in TDS concentrations in groundwater of coastal areas, while the dissolution of local geologic formations may also contribute to TDS levels. In addition to these factors, human activity can elevate TDS concentration from sources such as sewage, runoff from urban and agricultural lands, or water-treatment chemicals. TDS is not considered harmful for consumption, consumption, but high levels can cause staining and affect taste. A concentration above 500 milligrams per liter (mg/L) can stain fixtures or make water taste salty.

Hardness

Hardness is a measurement of calcium, magnesium, and other minerals in the water. Surrounding geology, such as the presence of limestone, is typically responsible for hardness; however, human application of substances such as gypsum can increase a nearby water source's hardness.

Hardness is commonly reported in mg/L of equivalent calcium carbonate ($CaCO_3$;Table 4.1). The EPA does not have an MCL or SMCL for hardness, but a high concentration can have effects around your home. If your water is hard, a solid precipitate called scale may form in fixtures and clog pipes over time. Hard water also makes it more difficult for soap to lather, so more soap may be needed for washing.

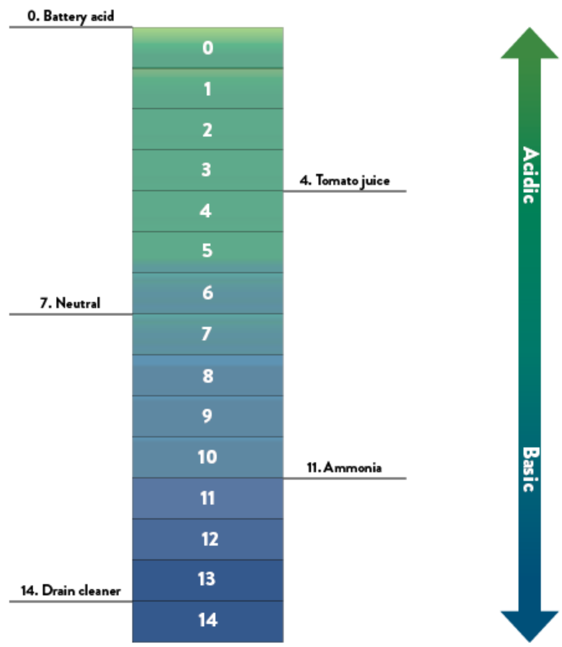


Figure 4.1. pH scale.

Table 4.1. Classification of Water Based on Hardness Measurement

Hardness (mg/L $CaCO_3$)	Classification
<50	Soft
50–150	Moderately hard
150–300	Hard
>300	Very hard

Acidity/Alkalinity

The pH of water describes the levels of acids (acidity) or bases (alkalinity) and influences many of the reactions that occur in a water source. Acids and bases are both present in water, but biological processes and interactions between the acids and bases determine the pH.

The pH is typically presented on a logarithmic scale from 0 to 14 where values less than 7 are acidic, 7 is neutral, and values greater than 7 are basic. Because the pH scale is logarithmic, what looks like a small difference can actually be very large. Each step between the whole numbers is a 10-time difference in concentration. A substance with a pH of 4 is 10 times more acidic than one with a pH of 5 and 100 times more acidic than one with a pH of 6.

Natural waters are affected by local geology and tend to have a pH between 6 and 9. Water may cause problems if it is too acidic or too basic. Elevated acidity may leach metals from plumbing fixtures, cause leaky pipes, or dissolve rocks in aquifers composed of limestone. If your water has a bitter, metallic taste, it may have elevated acidity. Elevated alkalinity may corrode fixtures and can feel slippery and taste unpleasant.

Organic Materials and Hydrogen Sulfide

Organic materials, or substances left from once-living organisms, can be found in low concentrations in groundwater. However, organic materials such as leaves can fall into well openings and affect the taste and color of the water. When organic materials decay, they can produce hydrogen sulfide (H_2S) gas which is a colorless gas that has an odor detectable at concentrations as low as 0.1 mg/L. At high concentrations, hydrogen sulfide can smell like rotten eggs and stain or corrode pipes and fixtures. Hydrogen sulfide can also be produced from bacterial decomposition of the mineral pyrite.

Fluoride

Fluoride is a primary contaminant that is beneficial at low levels. It is commonly added to drinking water supplies to help prevent tooth decay; however, local natural deposits and fertilizer-manufacturing discharge may increase fluoride concentrations to unsafe levels. When consumed above the MCL of 4.0 mg/L, fluoride can cause bone disease and mottled teeth.

Metals

Metals are naturally occurring in the environment and can dissociate into groundwater. The severity of their effects on drinking water quality varies based on the metal present and its concentration.

Arsenic

Arsenic is a primary contaminant known for its high toxicity. It has been used in pesticides, fungicides, and wood preservatives and is also a product of mining and coal processing. Arsenic is naturally present in rocks and soils, but its ability to dissolve and enter the aquifer depends on the pH and oxygen concentration of the groundwater. There are many health risks associated with consuming arsenic, including increased cancer risk, enlargement of the liver or spleen, and the development of skin lesions or growths.

Lead

Lead can enter your drinking water when corrosion, the process of materials dissolving as a result of chemical reactions, occurs on lead plumbing materials. This is especially true for areas that have high water acidity, as pipes are more likely to corrode here. While these lead-based systems were once common, now they are typically found only in older cities and homes.

Lead is a primary contaminant and is harmful to health, especially for children as it can lead to delays in physical and mental development. Pregnant women are also susceptible to issues associated with lead contamination, including reduced fetus development and premature birth, while other adults may experience kidney problems and high blood pressure.

Copper

Copper is a primary contaminant that can enter drinking water sources from pipe corrosion or local natural deposits. There is an MCL and SMCL for copper, as it can cause aesthetic problems and harm human health. Concentrations above the SMCL may leave a blue-green stain or impart a metallic taste. Short-term exposure over the MCL may lead to gastrointestinal distress; long-term exposure can cause liver or kidney damage. People diagnosed with Wilson's disease should consult their doctor when copper levels are elevated.

Aluminum

Aluminum is a secondary contaminant that can cause an undesired color, but the probability of having elevated aluminum in your drinking water is unlikely unless the pH is very low.

Iron and Manganese

Iron and manganese are secondary contaminants that can cause undesired tastes and odors. Very small, undissolved (called colloidal) particles can color the water and stain concrete, glass, and other surfaces. Iron tends to impart a red color and manganese a brownish-black color. High concentrations of these elements can also create a suitable habitat for iron and manganese bacteria that can produce slime and clog pipes. Water containing iron and/or manganese concentrations may be clear when it is drawn from the tap, but particles may soon form and settle at the bottom of a container once the water is exposed to air.

Silver

Silver is a secondary contaminant that does not affect human health, but concentrations above the SMCL can cause argyria, which is a discoloration of organs, skin, and hair.

Zinc

Zinc is a secondary contaminant that can cause a metallic taste. Although it is a secondary contaminant, zinc can cause anemia or damage to the pancreas if consumed at elevated levels over a long time period.

Nitrate

Nitrate (NO_3) is a primary contaminant that is very important in agricultural production but undesirable in drinking water. Fertilizer leaching, septic system discharge, municipal waste, and animal waste can contribute nitrate to a water supply. Nitrate concentrations in water are reported as nitrate-nitrogen or total nitrate. Ten mg/L of nitrate-nitrogen is equal to 44.3 mg/L nitrate. Water exceeding the MCL for nitrate is a substantial health risk for infants younger than 6 months of age. Consumption may cause methemoglobinemia, or blue-baby syndrome, in infants. This condition affects the ability of hemoglobin to transport oxygen, which can lead to shortness of breath or fatality.

Pathogens

Pathogens are disease-causing agents including viruses, bacteria, protozoa, and amoeba. Although less common in developed countries, infections such as typhoid, dysentery, and cholera are caused by pathogens in water. The presence of enteric pathogens, which infect the intestines, is a sign that your water contains human fecal matter from sources such as a leaky sewer line, malfunctioning septic system, or unprotected wellhead.

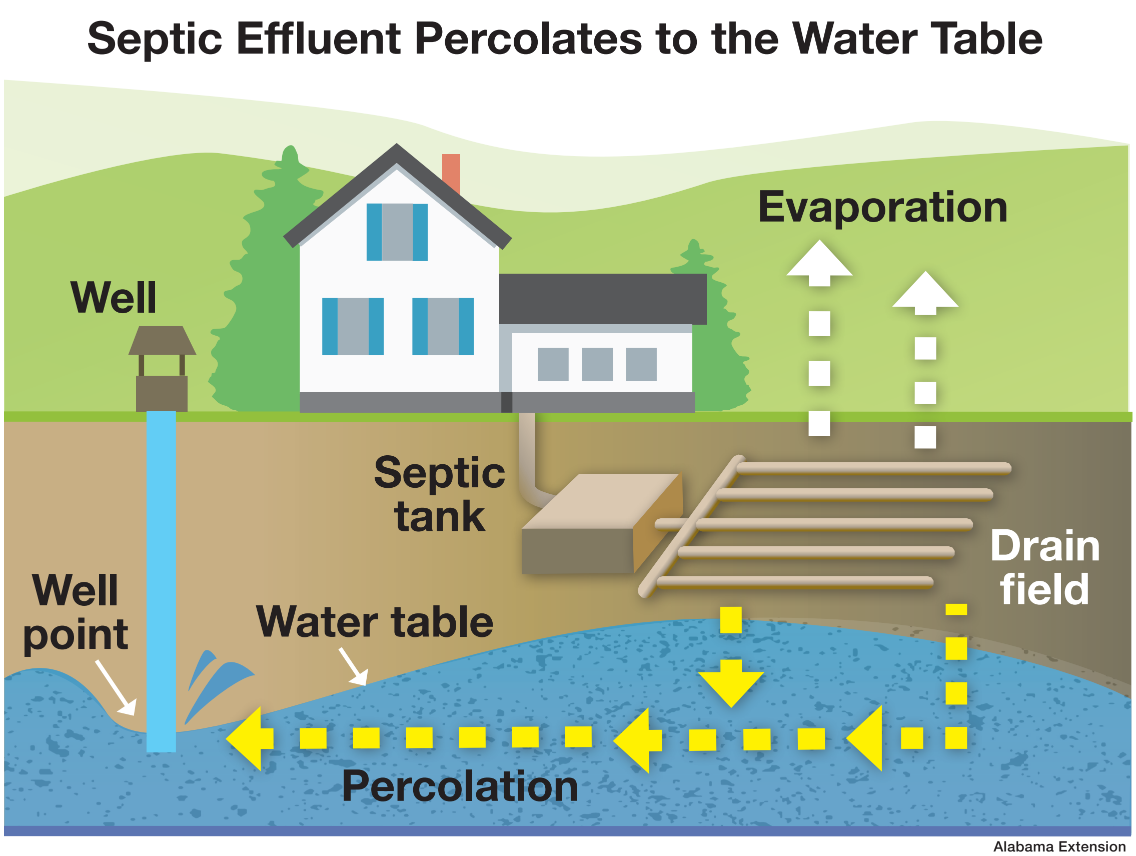


Figure 4.2. Septic system drain field in close proximity to a private well.

Bacteria

It is impossible to test for every pathogen present in a water source, so coliform bacteria are often used as indicators of the presence of pathogens. Most coliforms are found naturally in plants and soil and are not harmful. Some coliforms are also found in human and animal digestive tracts and feces, and some may cause illnesses. If your water source tests positive for coliforms, it could mean your supply has been contaminated with soil or plant matter. More tests should follow to check specifically for fecal coliforms. A positive fecal coliform or generic *E. coli* test suggests your supply is contaminated with fecal matter and is unfit for consumption. Waterborne bacterial pathogens include *E. coli* O157:H7 and *Salmonella.*

Viruses

A virus is a collection of genetic material encased in a protein coat that cannot remain viable or replicate without a host. The small size and survivability of viruses allow them to travel in aquifers and make them a serious threat to groundwater quality. Waterborne viral pathogens include adenoviruses, rotavirus, hepatitis A, and norovirus.

Well Water Contamination in Alabama

The presence of contaminants can range across the state. In some regions, contamination may be more susceptible than in others.

Natural Sources and Susceptibility

Uranium, an unstable element, is found naturally in soils and rocks, and radon is produced when uranium is broken down. Radon is a radioactive, colorless, odorless, and tasteless gas that can dissolve in water and accumulate in confined spaces such as wells. When water is collected from a tap in a home, some radon escapes into the air. Consuming water that contains radon and breathing in radon both pose serious health risks, but breathing radon is considered a bigger risk. Consuming radon can cause cancer of internal organs, and breathing it can cause lung cancer. Elevated levels of radon in private well drinking water sources have been detected in Alabama.

Some regions of Alabama are more susceptible to groundwater contamination. The Highland Rim region has aquifers that have high amounts of limestone, resulting in the formation of caves and sinkholes, thus making contamination from the surface a serious concern. Groundwater from the Highland Rim is typically hard and can contain elevated concentrations of iron and hydrogen sulfide.

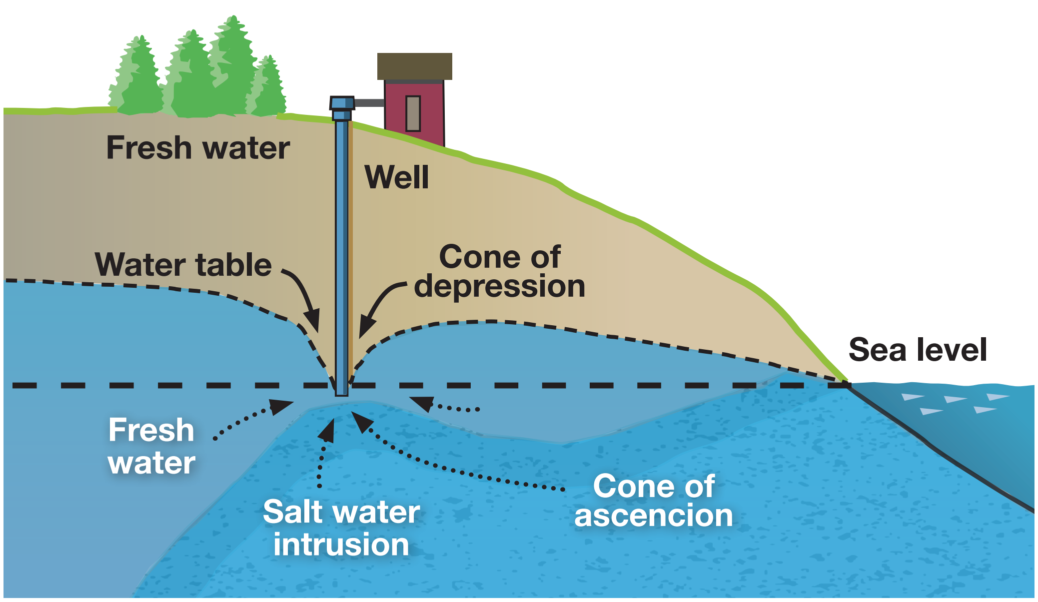


Figure 4.4. Saltwater intrusion in wells.

Wells located in the East Gulf Coastal Plain region, such as those in Baldwin and Mobile County, are at risk of saltwater intrusion. If coastal aquifers are heavily pumped, saltwater can be drawn in (figure 4.4).

The Valley and Ridge region, which includes Jefferson County, is predominantly made of sedimentary rocks. Ridges are created by erosion-resistant rocks; valleys are underlain by rocks that are easily eroded, such as limestone and dolomite. The easily erodible rocks of the valley allow fast infiltration of water and make aquifers susceptible to pollutants from the surface.

The Cumberland Plateau region has multiple groundwater sources including the Pottsville formation, the Bangor Limestone, and the Hartselle Sandstone. Well water from the Pottsville formation can exceed the SMCLs for iron, resulting in stains or bad taste, and water from the Bangor Limestone and the Hartselle Sandstone is generally hard.

Anthropogenic Sources of Contamination

Anthropogenic contamination is contamination caused by humans. Many industrial, commercial, residential, and agricultural activities require care to avoid contamination of groundwater.

The Alabama Department of Environmental Management (ADEM) has listed underground storage tanks (USTs) and failing septic systems as considerable threats to Alabama's groundwater due to their widespread use. USTs are used to safely store substances such as gasoline and oil. If the UST malfunctions, contaminants can leak out and leach into groundwater sources (figure 4.5).

Septic systems are used to treat residential wastes and protect water quality when sewer systems are not present. With proper sitting, installation, and use, this is accomplished by bacterial breakdown of wastes and filtration through soil; however, flushing oil or excess chemicals down the toilet can harm your septic system's bacteria and lead to contamination of water sources with human waste.

Pesticides are not often found at elevated concentrations in drinking water sources. Modern pesticides are regulated and usually degrade naturally. Wells sourced from shallow aquifers in areas with high soil infiltration could be at risk, however, especially if not sealed properly.

Shallow aquifers are also at risk from unregulated dumping. Dead-end roads, streams, and sinkholes are sometimes turned into makeshift dumping sites for garbage, dead animals, and hazardous materials. These are an eyesore, can attract disease-carrying insects and rodents, and may contaminate surface waters and groundwater. Unwanted material should be properly disposed of in landfills containing protective liners required by the Resource Conservation and Recovery Act (RCRA).

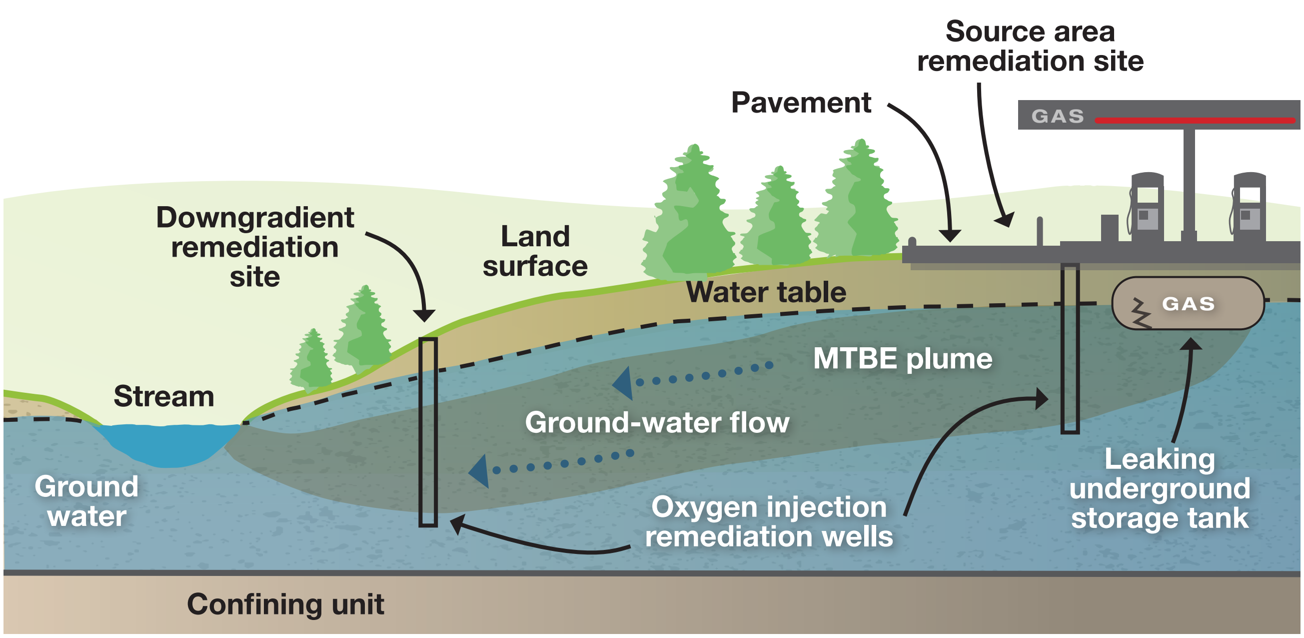


Figure 4.5. Underground storage tanks.

Testing Well Water

Chapter 5

ALABAMA EXTENSION

Testing Well Water

Why Well Water Testing Is Important

The average American consumes 1 to 2 liters of drinking water a day; therefore, water quality is a top priority for human health and safety. Several guidelines for safe drinking water exist, but for property owners with private well-water systems, no federal regulations have been mandated to enforce water-quality standards.

The Environmental Protection Agency (EPA) defines a community water system (CWS) as a public water system that supplies water to the same population year-round. Under the Safe Drinking Water Act (SDWA), public drinking water systems must follow standards enforced by the EPA. However, private wells are not regulated under these same directives; therefore, it is up to well owners to test their water regularly to ensure that it meets the quality standards suggested by the EPA.

Water should be tested regularly for microbial contamination. Even if a well appears clean and has no irregular smells, invisible microorganisms can be present and pose major health risks to those using the water. The Centers for Disease Control and Prevention (CDC) recommends that well owners check for mechanical issues each spring and perform a water quality test at least once a year. In addition to ensuring that the water is safe for drinking, a regular testing schedule helps establish a water quality record for the well.

It is helpful to gather as much information about the groundwater quality from previous owners, neighbors, local water utilities, and state agencies. Other factors such as local geology and current land-use activities also have affect well water quality. Well water quality information should be prioritized because testing for all possible contaminants can cost thousands of dollars per sample.

Well Stewardship

For private well owners, stewardship could mean establishing a testing schedule, sealing an abandoned well, and being mindful of chemicals applied near the well. Water health is entrusted to the care of families, individuals, and community leaders, and increasing community awareness and stewardship surrounding well water quality can reduce or prevent waterborne illness, thus increasing the quality of life. Table 5.1 lists some common reasons to test well water.

Table 5.1. Common Reasons to Test Well Water

Symptom	What to Test for	Source or Cause
Gastrointestinal illness	Coliform bacteria	Occurs naturally in the environment
Odor of gasoline or fuel	Volatile organic compounds	Industrial waste pollution, fuel spill, leaking vehicles
Irregular taste or smell	Hydrogen sulfide, metals	Industrial waste pollution, occurs naturally
Brown/black stained plumbing	Manganese	Occurs naturally
Salty taste	Chloride, total dissolved solids, sodium	Excessive salt content
Scaly residue	Hardness	High total dissolved solids
Rapid wear of treatment equipment	pH, corrosion	Occurs naturally
Cloudy water	Total dissolved solids	Occurs naturally
Slippery feel of water	Total dissolved solids	Occurs naturally
Musty, earthy, or woody smell	Organic matter	Occurs naturally
Chlorine smell	Chlorine	Excessive chlorination
Rotten egg smell	Hydrogen sulfide, bacteria	Occurs naturally
Foaming water	Bacteria	Septic tank leakage
Green-stained fixtures, blue-green tint to water	pH, copper, lead	Reaction with brass and copper plumbing
Reddish-brown water, reddish-brown stains on fixtures	Iron	Occurs naturally
Low water pressure or clogging of pipes	Total dissolved solids	Occur naturally

Adapted from WellOwner.org and the University of Nebraska-Lincoln Extension

Is Your Water Safe?

Well water testing is not a regulated public service offered by municipalities. If you want your water tested, it is your responsibility to contact your health department or private testing lab to obtain a sampling kit.

It is important to have your well water tested whenever you detect any changes in odor, appearance, or taste or if your household is experiencing any sudden illnesses after cooking with or drinking well water. You may also want to test your water after large-scale weather events as they can significantly alter the composition of your well water if surface contaminants enter the wellhead.

Test your water if any of the following occurs:

- If you are expecting a baby in your home
- If your well has recently been affected by a flood
- If a chemical spill occurs within 500 feet of your well
- If your neighbors have recently found contaminants in their well
- If you are purchasing a new house with a well
- If you have an old or shallow well
- If your well does not meet construction codes
- If your family has recently suffered gastrointestinal illness
- If your plumbing system shows signs of deterioration
- If a nearby development is using hazardous materials
- If you notice a change in your water taste, appearance, or smell

Types of Water Tests

Common tests that should be regularly performed include the following:

- Bacteriological analysis to confirm the presence or absence of bacteria such as total coliform bacteria, fecal coliforms, and *E. coli*
- Mineral analysis, which may include testing for calcium, magnesium, manganese, iron, copper, and zinc, to determine if the concentration is high enough to cause hard water, staining, odors, or health effects
- Chemical analysis to test for contaminants that may result from pesticide application or industrial/ petroleum contamination

Other tests may also be conducted to determine if radiological contaminants, such as radon, or heavy metals, such as mercury, lead, and cadmium, are in your well.

How Do Contaminants Enter Your Well?

Minerals such as arsenic and uranium can naturally occur and contaminate your well. In Alabama, uranium is found naturally in soils and rocks and produces radon when broken down. More information about regional susceptibility to naturally occurring minerals can be found in chapter 4.

Contaminants can also enter a well through stormwater runoff, which can carry harmful substances right into your drinking water. Land-use activities, such as agricultural operations or septic tank fields, occurring around your well may also need to be monitored for specific contaminants attributed to these uses and the proper setbacks maintained. If your well is located near a livestock housing unit, for example, you will want to run a coliform analysis. If your well is near a row-crop field, you may want to test parameters such as nitrate, coliform bacteria, and phosphorus.

Well-Water Testing Schedule

You should perform water quality tests annually. Regular water testing is the simplest way to confirm that you are consuming safe water. Establish a schedule that you and your household can follow, as this process will make it easier to remember your annual well checkup when the time comes.

Perform a well water quality test after constructing a new well or when a well is used after a period of prolonged nonuse. You should also conduct a well water test before purchasing or selling a home and after any large-scale weather event. An improperly sealed well can be a gateway for pollutants to enter your drinking water source during any rain event. If

Well-Water Testing Schedule

Frequency	Action
Initial	For baseline water quality testing, analyze for arsenic, chloride, fluoride, hardness, iron, manganese, nitrate, pH, sodium, sulfate, total coliform bacteria, total dissolved solids (TDS), and uranium.
Annually	Test for total coliform bacteria, *E.coli*, and nitrate.
Monthly	Look for changes in: Turbidity Taste, odor, appearance Health changes

Private Well Program | ALABAMA EXTENSION

Figure 5.1. Well-water testing schedule.

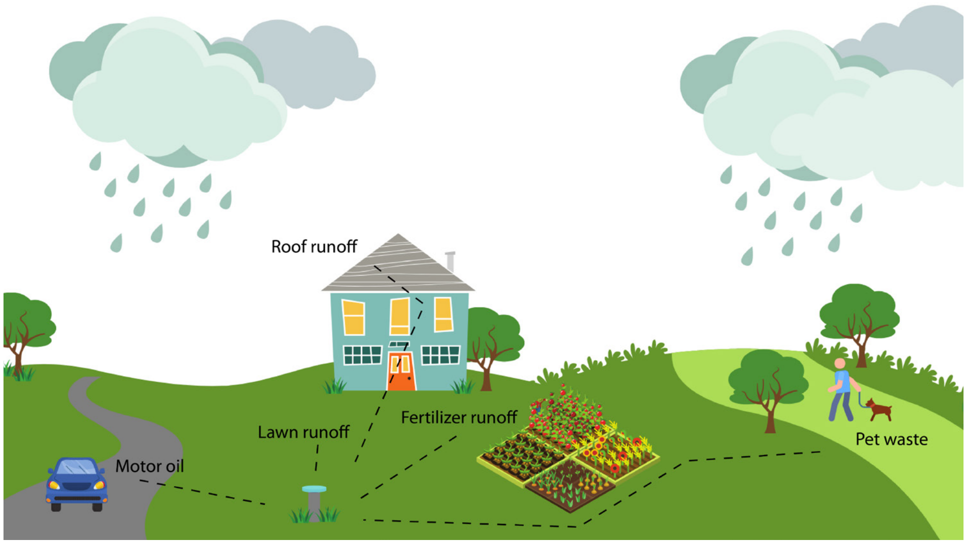


Figure 5.2. Stormwater runoff and potential impacts to wells.

you suspect your well has been contaminated after a storm, have your water tested before consuming it. Stormwater can carry fertilizers that you may have applied to your lawn and garden, oil from vehicles, sediment, animal waste, and other hazardous materials.

As an extra precaution, stock up on bottled water to use in the household until you can get your well quality assessed. If your well has been flooded, consider performing shock chlorination. For more information, visit the Alabama Extension webpage.

Establishing a Water Quality Record

Following a regular testing schedule also enables you to create a record of your well health. Important documents such as installation details, water quality test results, and maintenance details should be kept in a safe place. Record keeping is essential to tracking the health of your well over a long period of time.

Records allow you to monitor the well infrastructure and quality and make it easier to identify any changes that may have occurred between inspections. Keeping clear and organized records also helps prevent future issues with your well water system. For example, if you identify a source of contamination in your well (such as runoff from your garden) and remediate it, keeping a record of that source will help you avoid recontamination in the future.

Store the well driller's contact information, the date your well was drilled, and any information about the system's components and maintenance/warranty schedules. If you alter any part of your well water system, be sure to mark this change on your records.

Well Water Testing Process

When the time comes to test your well water, be sure you know the general well water analysis process (figure 5.3). The first step is to identify a lab that can analyze your test results. Once you choose a lab, call to inquire about the sampling process. Some labs will come to sample your water system for you, and others may require that you take the sample yourself and either ship it to or drop it off at the lab. Test results will give you an overview of any contaminants found in your water supply.

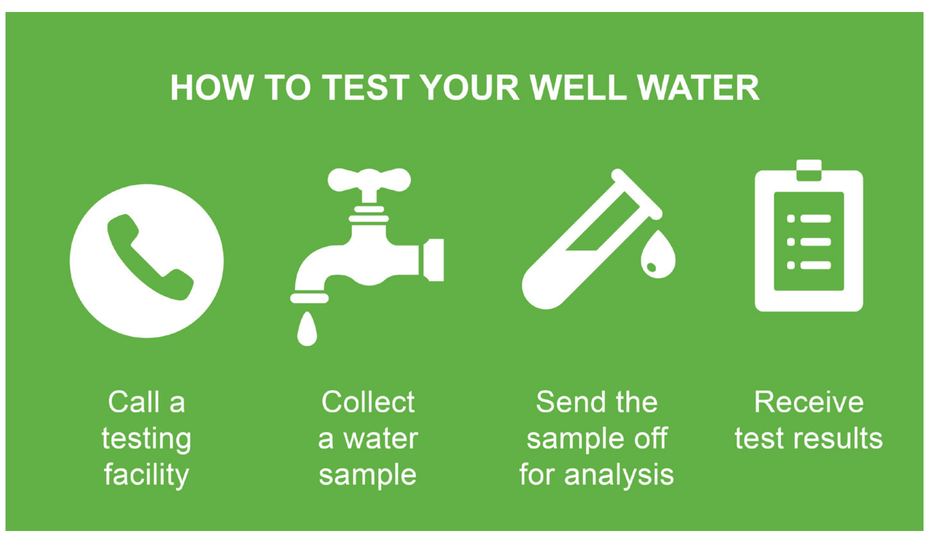


Figure 5.3. Well water testing process.

Choosing a Laboratory

You have a few options as a well owner when it comes to selecting a lab to run the analysis on your water sample. Well owners should consider their needs and limitations of time and cost when selecting a lab. Some samples, such as bacteriological, should be submitted no longer than 24 hours after sampling.

Certified Labs

The Alabama Department of Environmental Management has a list of all certified laboratories. These laboratories must use EPA approved methods, and pass periodic on-site inspections. All municipal water systems must use certified drinking water laboratories for all water quality testing.

Numerous certified private labs across the state will analyze private well water samples. The lab you select will depend on what parameters you are testing for. Many labs only offer a standard bacteriological analysis (coliform presence or absence); others may test more extensive parameters often covered in chemical analysis. In addition, some labs focus primarily on industrial water testing and do not offer testing services to private well owners. Call your selected lab or health department to receive more detailed information.

Your Local Health Department

A simple way to get your well water tested for bacterial contamination is through your county health department. Refer to the laboratory identification map on the Private Well Program webpage to find contact information for a health department near you. Tests provided by the Alabama Department of Public Health (ADPH) may differ in price depending on where you live but are usually very affordable. If you would like to perform a more comprehensive test for substances such as nitrates or alkalinity, you may need to find a private lab and see what testing services they offer for private well owners.

Non-Certified Private Labs

Some labs may offer limited water screening but may not be certified drinking-water labs. Parameters offered for screening may include:

- Nitrate
- Alkalinity
- pH
- Routine elements (Ca, Mg, K, P, Cu, Fe, Mn, Zn, B, Al, Cd, Cr, Pb, Na, Ni)

However, these labs may not have the capabilities to analyze domestic well water samples for concentrations below a certain threshold. Since limited interpretation of these test results are provided, reports from this lab may be used as a water screening tool. In addition, these labs may not offer bacteriological testing, an important test for domestic well owners. If the well water being tested is used as a drinking water source, the water should be analyzed using EPA-approved methods at a certified drinking water laboratory.

Contact a certified private lab or an ADPH office for bacteriological analysis of your well water. Limited interpretation of the test results is provided, and this analysis should only be used as a water screening tool. If the well water tested is primarily used as household drinking water, be sure to get your water fully analyzed at a certified drinking-water laboratory.

Over-the-Counter Test Kits

Other water-testing kits may measure pH, TDS, and other water quality parameters. While inexpensive, these kits often lack the sensitivity and accuracy of modern laboratory methods and instruments. Compared to EPA-approved methods used in laboratories, testing kits have some limitations.

- Contaminant detection range is limited, lacks precision
- Procedure may not be EPA approved
- Accuracy is difficult to measure
- Results may be influenced by the presence of other constituents such as dissolved iron and organic matter
- Less accurate when measuring contaminants near EPA drinking water standards

These kits may be helpful in the following ways:

- They can offer an early warning of the presence of high levels of a contaminant in water
- They are inexpensive and easy to use

How to Sample Well Water

Regular testing is encouraged to help identify problems and track well health over a period of time. Just because water appears clean does not mean that invisible contaminants are not present. Water samples are only accurate if you test appropriately, so be sure to follow sampling kit instructions carefully to get reliable results.

If you test through the health department, an environmentalist may do a site visit and take a water sample for you. Check to see if this service is available in your area. If you decide to take the sample yourself, be sure to schedule accordingly. Water samples are time sensitive and must be submitted no longer than 24 hours after sampling takes place.
Check with the lab that is providing the analysis to ensure that you are sampling on a day when they are receiving samples.

The first step is to familiarize yourself with the sampling kit and instructions. The best place to sample is at an outlet located between the well and the first treatment device. This allows you to test the aquifer's water quality before drinking water enters the home. If sampling from a sink tap, use the tap where you source your drinking and cooking water and remove the treatment devices. Before taking a sample, remove any treatment devices that are on the tap because these may result in false-positive tests and may harbor bacteria.

Properly sanitize your tap, using either rubbing alcohol or a flame, and immediately flush the tap at high flow for 5 minutes to remove any stagnant water in the pipes. Once the tap has flushed, reduce the water stream to a small, steady flow and allow it to run for 3 minutes. Carefully unscrew the sample bottle sent with the kit, and fill the bottle to the designated mark. Once full, screw on the cap tightly to avoid any spills. Complete all of the appropriate information on the sampling sheet provided with the kit if one is included.

For step-by-step instructions on how to properly sample well water with the ADPH, view the video developed by the Private Well Program and the Alabama Department of Public Health.

How to Interpret Test Results

After sampling and testing the water, it is time to interpret the results. While many of the parameters tested do occur naturally in water, users should be concerned if the water exceeds contaminant levels established by the EPA for municipal water supplies. Most labs will compare your test results to the maximum contaminant level (MCL) that the EPA sets for public water systems. Although this level is not enforced for private well owners, this comparison to EPA guidelines allows you to assess your well water quality. Results may be reported in parts per million (ppm), parts per billion (ppb), micrograms per liter (μg/L), or milligrams per liter (mg/L). Bacteriological tests are usually reported in the number of colony-forming units (CFU) per 100 milliliters (mL) of water. A complete list of drinking water primary and secondary MCLs set by the EPA can be found at the end of this document.

The format of the lab result sheet will differ depending on where the test was performed; however, each sheet should list your name, your county, and the date and time of sample collection.

Interpreting Bacteriological Tests

Because it is difficult to test for all disease causing organisms, tests for presence of total coliforms, fecal coliforms, and *E. coli* are used as indicators of pathogen presence. Total coliform bacteria are typically found in the digestive tract of warm-blooded animals and are generally not harmful to humans. The EPA considers total coliforms a useful indicator of other pathogens for drinking water, and subsequent testing should be done to determine the presence of harmful fecal bacteria such as *E. coli* O157:H7.

A general report will indicate whether coliform is present in the water. A positive coliform result means that these bacteria do exist, and you should proceed with disinfecting your well before consuming the water.

Although *E. coli* is generally not harmful to humans and most strains can live in the intestines of healthy humans and animals, a specific strain of *E. coli* (O157:H7) can lead to illness. *E. coli* can be found on livestock farms, where the bacteria can live in the stomachs of warm-blooded animals. Feces contaminated with *E. coli* O157:H7 can enter your water source in several ways, including by stormwater runoff or from agricultural runoff. To find out if you have *E. coli* in your water, contact a laboratory to run a test on your water sample.

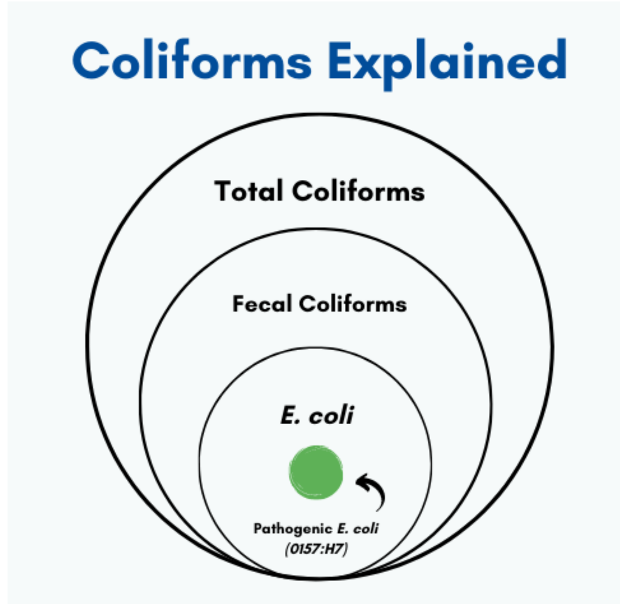


Figure 5.4. Coliform bacteria in your water.

If your water contains *E. coli*, boil the water for at least one minute to inactivate it. You can also disinfect your well by following the steps outlined in the Alabama Extension publication about shock chlorination on the Extension website.

Interpreting Chemical Tests

Results from chemical tests are usually expressed in parts per million (ppm) or milligrams per liter (mg/L). Compare your results to the MCL and SMCL standards at the end of this document. Any parameter that exceeds the MCL should be treated.

WATER QUALITY ANALYSIS REPORT

EXAMPLE

CLIENT NAME: WENDY WELL
LABORATORY: WELL TESTING FOR YOU
SAMPLE ID: 12345

COLLECTION DATE: 2/2/20222
COLLECTION TIME: 2 PM
COLLECTED BY: WELL SERVICER
PRIMARY USE: HOUSEHOLD DRINKING WATER

ANALYSIS	RESULTS	UNITS	EPA GUIDELINES
TOTAL COLIFORM BACTERIA	2	CFU/mL	0 CFU/mL
E.COLI	0	CFU/mL	0 CFU/mL
ARSENIC	0.001	ppm	0.01 ppm
FLUORIDE	0.1	ppm	2.0 ppm
COPPER	0.5	ppm	1.0 ppm
LEAD	0.001	ppm	0.015 ppm
IRON	0.05	ppm	0.3 ppm
NITRATE-N	6	ppm	10 ppm
HARDNESS (CaCO3)	600	ppm	-
SULFATE-SULFUR	300	ppm	250 ppm
TOTAL DISSOLVED SOLIDS	700	ppm	500 ppm
pH	6.7	unit	6.5-8.5 ppm

BASED ON THE RESULTS, THIS SAMPLE DOES **NOT** MEET WATER QUALITY RECOMMENDATIONS

Figure 5.6. Sample well-water results form.

Interpreting Mineral Tests

According to theexample well water report in figure 5.6, this well exceeds EPA guidelines for total coliform bacteria, sulfate-sulfur, hardness, and total dissolved solids.

Typical mineral tests give the concentration in parts per million (ppm). These tests will generally give results for calcium, magnesium, manganese, iron, copper, and zinc. Mineral tests also determine the acidity or pH of the water as well as the hardness. Compare your results to the MCL and SMCL standards at the end of this document.

ADPH Sample Results

When well water is tested by the Alabama Department of Public Health, a results key is provided on the bottom right corner of your sample results form. Helpful acronyms:

CA - Coliform absent

CP - Coliform present

FA - Fecal coliform absent

FP - Fecal coliform present

ECA - *E. coli* absent

ECP - *E. coli* present

C/T - Confluent growth or TNTC

UNS - Unsatisfactory

So, what do all of these mean? If your results show the presence of coliform (CP), fecal coliform (FP), or *E. coli* (ECP), it means that the sample is positive for these bacteria per 100 ml of water. Follow-up action is required in these cases, and individuals should contact their county health department environmentalist immediately.

If the results indicate C/T or TNTC (confluent or too numerous to count), a very high number of bacteria are present in the sample. These bacteria may mask underlying coliform bacteria, and the sample should be recollected and tested again.

Unsatisfactory results (UNS) require further clarification from the laboratory. If your sample sheet reads UNS, call the lab that completed your test for an explanation. Some sample codes for unsatisfactory tests may be as follows:

A - Sample is over 30 hours old

B - Sample leaked in transit

C - Sample received on a nonscheduled testing day

D - Incomplete or incorrect information

E - Laboratory incident

F - Unapproved sample bottle

G - Sample submitted with less than 100 ml of water

H - Sample bottle too full

J - Other

Testing at Private Laboratories

Water tests conducted elsewhere could be classified as bacteriological, mineral/inorganic, and organic chemicals tests.

- Bacteriological tests generally check for indicator bacteria (for example, total coliform, fecal coliform or Escherichia coli) and can indicate the presence or absence of disease-causing bacteria
- A mineral/inorganic test can determine if the mineral content of your water is high enough to affect either health or the aesthetic and cleaning capacities of your water. A mineral test may include calcium, magnesium, manganese, iron, copper, zinc and some others
- Organic chemical tests are generally performed only if there is reason to believe a specific contaminant has infiltrated the water system (such as pesticides entering the water supply). Industrial and petroleum contamination can also be found through organic chemical testing
- Other tests may be conducted on radiological contaminants (radium and radon) or heavy metals (such as arsenic, mercury, lead or cadmium) based on the suspected natural and anthropogenic (man-made) sources of such contaminants

What to Do After You Test

If you have questions or concerns about your water quality analysis report, contact the lab that performed your test. If you have questions about contaminants found in your water, contact an Extension agent in your county.

Seek assistance from independent water quality/treatment specialists and reputable equipment vendors before deciding on expensive water treatment options. If your well has results above the MCL/SMCL recommended by the EPA, consider doing the following:

- Use bottled water until the well has been treated
- Locate and eliminate the source of contamination
- Have a certified well driller install a new water well
- Connect to a municipal water supply
- Evaluate and install a water-treatment system

If your well requires treatment, see the recommendations in Chapter 6: Treatment Options.

Once you have recieved your results, be sure to keep track of them. Designate a folder for all of your well-related paperwork, including maintenance and testing schedules.

Continue to be a responsible well owner and adhere to the following recommendations:

- Ensure that your well cap or seal is in proper condition and that the cap is appropriately located one foot above ground level
- Keep accurate records of well maintenance and annual test results

- Avoid mixing or storing fertilizers near your well
- Do not dispose of any waste in an abandoned well
- Regularly inspect your septic system and well systems before problems arise
- Do not consume water from a flooded well without testing it first
- Seek professional guidance before performing any maintenance on your well
- Analyze your property for any potential sources of pollutants

Responsible Well Owner Checklist

- [ ] Conduct a water quality test annually.
- [ ] Perform a maintenance inspection annually.
- [ ] Keep hazardous chemicals away from your well.
- [ ] Maintain proper well spacing.
- [ ] Check the well cap frequently for damage.
- [ ] Prevent back-siphoning into your well.
- [ ] Keep your wellhead 1 foot above ground.
- [ ] Maintain the landscaping around your well.
- [ ] Seal unused wells.
- [ ] Know how to treat your well.

Private Well Program ALABAMA EXTENSION

Well Treatment Options

Chapter 6

ALABAMA EXTENSION

Well Treatment Options

Determining Which Treatment to Use

After having your well water tested and receiving the results, you will need to determine what needs to be done next. If your water analysis results show contaminants above the recommended Environmental Protection Agency (EPA) maximum contaminant level guidelines, seek professional guidance to select the appropriate treatment. The proper approach for a situation can depend on the amount of water to treat, the pollutants present and their concentration, and the cost of treatment options, including maintenance costs. Successful methods for treating water contamination include filtration, reverse osmosis, distillation, aeration, ion exchange, and disinfection.

Water-treatment systems are generally either point-of-use systems or whole-house systems. A point-of-use system addresses water quality at the location where the water is gathered for use, such as the kitchen sink. These treatment systems include typical water filters placed on faucets, pitcher filters, under-the-sink systems, refrigerator filters, and even personal water bottles. Whole-house systems are installed to treat water as it enters the plumbing system rather than at the point-of-use, resulting in pretreated water coming from all taps. Some examples of this type of system include ultraviolet radiation, water softeners, or whole-house carbon filters.

Multiple systems may be installed to work together to form a treatment train. Treatment trains place treatment systems in a planned sequence to ensure that each treatment method performs at its best capacity. For example, anion exchange is a treatment method that is negatively affected by cloudy water and can lower the water pH. An appropriate treatment train (figure 6.1) would be (1) a pretreatment to remove the particles causing cloudiness, (2) anion exchange, and (3) post-treatment to raise the pH. More examples are provided in the sections discussing treatment options below.

A summary of common contaminants and treatment options are listed in table 6.1. For a detailed list of purification systems designed to reduce contaminants, see the National Sanitation Foundation (NSF) guide links to products known to reduce specific contaminants.

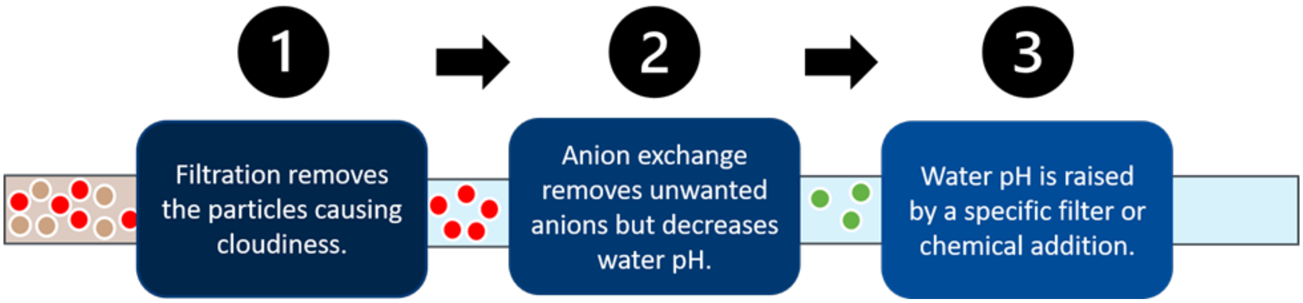


Figure 6.1. An example of a treatment train whose sequence of treatments affects removal performance.

Because the Safe Drinking Water Act does not require drinking-water filters to undergo third-party certification, it is important that you read labels before buying a water-treatment system. A certified product should state what contaminants it can reduce and display a seal of certification (figure 6.2). The EPA lists organizations certified by the American National Standards Institute (ANSI) and that use ANSI standards to certify the treatment claims made. Third-party testers include NSF International, the Water Quality Association, IAPMO, CSA Group, and UL LLC.

Table 6.1 Common Water Problems and Potential Treatment Options

	Particle Filters	Micro-filtration	Activated Carbon Filter	Reverse Osmosis	Distillation	Aeration	Cation Exchange	Anion Exchange	Disinfection **
Acidity	X*								
Arsenic ***			X	X	X			X	
Bacteria/ Coliform		X			X				X
Dissolved Iron/ Manganese	X*				X	X*	X		
Fluoride				X	X				
Hardness					X		X		
Metals			X		X		X		
Nitrate/ Nitrite				X	X			X	
Organic Chemicals			X	X	X				
PFOA/ PFOS ****				X	X				
Radon Gas			X			X*			
Sediment	X				X				
TDS (Salinity) *****				X	X				
Undesirable Tastes and Odors				X	X				
VOCs ******			X	X		X*			

*When paired with other treatment **Includes chlorination, ozonation, and ultraviolet radiation ***Treating incoming levels of 50 ppb or less
****Per- and polyfluoroalkyl substances *****Total dissolved solids (TDS) ******Volatile organic compounds

Figure 6.2. A product displaying one of these seals has been certified by a third-party organization.

Treatment Options

The treatment option that you select is dependent upon the contaminants that you are trying to remove. There are a number of treatment options, including filtration, distillation, aeration, and ion exchange.

Filtration

Filtration treatments use porous materials to remove suspended particles. One way to visualize this is by thinking of a coffee filter. When you pour coffee grounds over your filter, you hope that no large particles make their way into your cup. The smaller the filter pores, the smaller the particles it can catch and prevent from entering your drink. The size of the pores in the filter determines what contaminants will be removed, with smaller pores being able to remove smaller contaminants. For example, a filter with pore sizes of 1 micron or smaller will trap contaminants larger than 1 micron.

This concept is used to design filters to remove specific contaminants. Filtration processes include particle filtration, microfiltration, and ultrafiltration.

With particle filtration, materials such as sand and fibers are used to remove sediment particles, generally sized about 0.002 mm to 2mm. It can also treat acidic water when preceded by the addition of soda ash or remove dissolved iron or manganese when preceded by continuous chlorination, ozonation, or aeration.

Microfiltration systems have microscopic pores that can trap microorganisms such as *Giardia* and *Cryptosporidium*. Ultrafiltration is a more aggressive form of microfiltration and is used in industrial water-treatment processes to remove viruses and dissolved organic molecules.

Some filters can be used in conjunction with reactive materials to remove specific contaminants. For example, iron or activated carbon can be added to a filter to remove arsenic and organic chemicals, respectively.

Filtration and other treatment systems should be used as instructed by the manufacturer. A filter made to remove one contaminant should not be used to attempt to remove a different contaminant, such as using a bacteria filter to remove sediment. It is important to follow manufacturer recommendations for replacing filters or backflushing since contaminants build up in the filter as it treats the water. Backflushing refers to the regular maintenance practice of reversing the water flow through the filter to flush out any debris that might be blocking the filter pores. Only certain filtration systems recommend backflushing, and it should not be performed unless the manufacturer recommends it.

As with all treatment systems, filtration is not always the answer. High concentrations of bacteria or viruses should be treated using chemical disinfection or distillation.[1]

Mechanical Filtration

Mechanical filters remove silt, sediment, small organisms, and organic matter from water. Untreated water passes through a media that traps suspended particles. Cartridge filters are a commonly used form of mechanical filtration.

Cartridge filters typically include media types like pleated paper, cellulose, wound string, and spun polypropylene. Maintenance involves periodically changing filter cartridges. While these filters do not remove dissolved chemicals, they can be used in combination with other water treatment equipment. These filters have the ability to either trap particles within the filter materials or accumulate particles on the outer surface. These filters are easy to change and clean but must be serviced periodically.

Activated Carbon Filters

Activated carbon filtration is a form of ultrafiltration that incorporates carbon-rich materials such as coal or charcoal in the filtration media to bind with and remove certain chemicals. In addition to its reactivity, the carbon has been processed to increase its porosity. These filters are very common for taps and water pitchers. As with all filters, follow manufacturer recommendations for product use.

It is recommended that professionals install and maintain whole-house systems. When well water is cloudy, the activated carbon filter is at risk of clogging and reduced efficiency, and a particle filter should be installed to treat the water before it reaches the activated carbon. Replacing filters is important to avoid the growth of microorganisms and clogging.

What it removes: Activated carbon filters can remove low concentrations of organic chemicals, such as pesticides and solvents, and copper, lead, mercury, and radon gas. Activated carbon filters can also remove bad tastes and odors but will not remove hardness. They are not known to remove inorganic ions (calcium, chloride, fluoride, nitrate, and sodium).

Oxidizing Filters

These filters contain a form of media (often manganese-treated green sand), that is coated to react with the iron, manganese, and hydrogen sulfide in contaminated water to form solid particles that are trapped in the filter. It may be necessary to follow the oxidizing filter with a water softener if the concentrations are not reduced. Regular backwashing is necessary as particles can clog the filter. In some cases, the coating on the media may need “regeneration” after it is used up. As with all filters, the filter should be kept clean and free of clogging.

What it removes: iron, manganese, hydrogen sulfide (rotten egg odor).

Neutralizing Filters

Neutralizing filters treat acidic water. These devices raise the pH of water either by adding a neutralizing material or passing the water through a neutralizing agent (often limestone). This filter has the chance to increase water hardness.

A pH adjustment does not treat any type of contaminant in water; it serves to lower or raise pH until a neutral, acceptable level is reached.

Reverse Osmosis

A solute is a substance that can be dissolved in another substance; for example, sugar is a solute that dissolves in water. Osmosis moves water from an area of lower solute concentration to an area of higher solute concentration. In reverse osmosis systems, pressure forces the untreated water (which has a higher solute concentration) through a membrane and into an area of lower solute concentration. The targeted contaminants are left behind, meaning some treated water gets produced, but a waste product also forms.

As with activated carbon filters, reverse osmosis filters are common in point-of-use systems. The water requirement and creation of a waste product make reverse osmosis impractical for whole-house systems. The treatment process requires a larger amount of water than the treated water that is created. If 4 gallons enter the system, about 1 gallon of treated water will be produced. Additionally, the waste brine created contains elevated amounts of the contaminants removed from the treated water, such as total dissolved solids (TDS), which can elevate salinity. The contaminants could negatively affect septic systems and surrounding soils if produced in large amounts.

What it removes: Reverse osmosis is very successful at removing TDS, so it is frequently used to desalinate water. It can also remove contaminants that cause odor and bad taste, arsenic, uranium, and some organic chemicals. It is not effective for the removal of dissolved gases, such as radon, some pesticides, volatile organic compounds, such as degreasers and solvents, pathogens, or sediment.

Pretreating to remove particles, adjust pH, or soften the water before reverse osmosis may improve the performance. Follow manufacturer instructions for replacing filters.

Distillation

Distillation removes contaminants through the process of boiling water, collecting the steam, and condensing it back into the water. The resulting water is nearly purified, as the contaminants are left behind when the steam rises. Distillation systems can remove inorganic contaminants, such as minerals and dissolved metals, microorganisms, many pathogens, and some organic matter. Because the minerals are removed, distilled water is usually tasteless.

The presence of volatile organic chemicals (VOCs) can cause problems in distillation systems, but these can be addressed. VOCs can vaporize during boiling and travel with the steam, so VOCs should be removed with another form of treatment before distillation, or the distillation unit should contain an activated carbon filter. Some units require proper venting so that steam and VOCs that purge from the unit do not cause air contamination inside.

There are many considerations for the use of distillation units. Distillers are typically point-of-use systems used only for drinking water due to the amount of time required to treat water, the amount of water the system requires, and the need for a power source. A typical home unit can produce 1 gallon of treated water in roughly 4 hours, meaning that about 6 gallons could be produced in 1 day. The treated water is typically kept in a storage tank until it is used. The water-use efficiency of a distillation unit generally depends on the type of condensing system. Air-cooled units use less water and create about 1 gallon of untreated water for every gallon of water that is treated. Water-cooled units require much greater amounts of water and may need as much as 15 gallons to produce 1 gallon of treated water. A power source, typically electricity, is required to boil the water. Higher-producing units require more electricity—the cost for treating 1 gallon of water is 25 to 35 cents a day.

Follow manufacturer recommendations for cleaning the unit or replacing parts. Cleaning frequency and materials may vary based on the constituents and their concentration in the incoming water.

What it removes: Sediment, salt, TDS, fluoride, nitrate, heavy metals, arsenic, bacteria.

Aeration/Deaeration

Aeration systems work by introducing oxygen into the water via an aerator. This process oxidizes contaminants, causing them to form solids that can be filtered out of the water. Aeration can remove substances such as dissolved iron, manganese, and radon. With an aeration system, regular backwashing of the filter is required, and care should be taken to avoid filter obstruction. Deaeration mixes air with water to remove dissolved gases such as hydrogen sulfide gas and radon from the water.

Ion Exchange

Ion exchange systems remove either cations (positively charged particles) or anions (negatively charged particles) from water and exchange them for less objectionable ones. This requires the use of an exchange material loaded up with certain ions. Mixed-media units exchange both cations and anions.

Cation Exchange

Cation exchange units are primarily used to soften hard water by removing calcium and magnesium but are also used to remove dissolved iron and manganese and can also treat cadmium, copper, and zinc. For water softening, the exchange media is typically loaded with sodium, although some newer and more expensive units may use potassium, and exchanges the sodium for calcium and magnesium in the water. Barium and radium can also be removed this way.

Water softeners can be used as whole-house systems but are not usually needed for drinking water or outdoor use. Because the cations are typically replaced with sodium, softened water may taste salty and is not ideal for watering salt-intolerant plants. Point-of-use softeners are helpful for hot water use, bathing, and laundry to prevent scale formation or detergent residue.

As water softeners are used, the exchange sites (where the sodium is located) are replaced by ions from the water and become unavailable for exchange. Therefore, maintenance includes a process called regeneration, in which brine is passed through the media to release the ions and replace them with sodium. This may be done manually, semi-automatically, or automatically, so it is important to read manufacturer instructions. The media will also decrease in effectiveness over time and need replacing. Iron and sediments can cause serious problems in water softeners, so pretreatment may be beneficial.

Anion Exchange

Anion exchange systems usually have media loaded with chloride or hydroxide ions to remove sulfate, nitrate, and arsenic. Point-of-use systems are typically enough and only needed for drinking and cooking water.

Because anion exchange removes contaminants harmful to human health, the systems should be monitored to ensure proper removal. As with cation exchange units, anion exchange units require regeneration as part of maintenance. However, because the waste brine contains substances such as arsenic, it requires more careful disposal. Be sure to follow the manufacturer's safety precautions. Pretreating may help avoid problems with iron and sediments. Post-treatment may also be needed, as anion exchange tends to lower the water pH.

Disinfection

Water that contains pathogens can be a serious threat to the consumer, so bacteria should be killed and viruses inactivated before consumption. Of the discussed methods so far, only distillation is appropriate for continuous pathogen removal. Disinfection is another suitable process and typically involves exposure to ultraviolet (UV) radiation or the addition of chlorine or ozone.

Chlorination

Chlorination is the addition of chlorine to water to kill pathogens. Chlorine comes in dry forms as calcium as hypochlorite, $Ca(ClO)_2$, and in liquid form as sodium hypochlorite, NaClO. The effectiveness of chlorination depends on many factors. In addition to the chlorine concentration, the amount of time the chlorine is in contact with the water is very important. Water quality of the untreated water can affect chlorination, as some contaminants (iron, manganese, hydrogen sulfide, ammonia, and organic materials) can combine with chlorine and make it unavailable for the targeted contaminants. This can be addressed by pretreating. Water temperature and pH can also affect chlorination, and ideal conditions are considered high temperatures with low pH.

The amount of chlorine needed varies by chlorination method. Batch disinfection uses enough chlorine to treat large batches, which are then stored for later use. Simple chlorination maintains a low concentration of chlorine to disinfect water as it is needed. Superchlorination uses a much larger concentration of chlorine to treat water quickly and usually requires dechlorination by an activated carbon filter following treatment. New wells, newly repaired wells, wells with bacterial contamination, and temporarily contaminated wells are often treated using shock chlorination. During shock chlorination, household liquid bleach is circulated through the well and plumbing system. You can learn more about the shock chlorination process on the Alabama Extension website.

Follow manufacturer's instructions for maintaining a chlorination system, including cleaning, checking, and lubricating parts, and refilling chlorine. Unplug all power before performing maintenance. Follow safety recommendations for handling chlorine, as it can be a skin irritant and is potentially poisonous if swallowed. Chlorination kills bacteria and some viruses. It does not kill *cryptosporidium Giardia* and some other microscopic organisms. Chlorination also removes some bad odors, tastes, and colors.

Ultraviolet (UV) Radiation

UV radiation kills common pathogens by emitting light from a bulb at a specific wavelength. Unlike chlorination, UV radiation treatment can be fast without adding anything to the water or causing additional taste or odor.

In addition to the intensity of the UV light and contact time, the success of UV radiation is affected by water depth and quality. Light penetration reaches a depth of about 3 inches, so the water must be supplied in a manner that allows contact throughout the supply. Because the pathogens need to be exposed to UV light, suspended particles in the water can interfere with treatment. UV treatment is therefore often paired with a filtration method and should be the last treatment used in a sequence.

Follow manufacturer information for cleaning the system and replacing bulbs. Cleaning is important to ensure that dirty fixtures do not block UV light entry into the water.

Ozonation

Ozone is a highly reactive gas commonly used in water treatment. Ozonation is relatively expensive. It kills bacteria and some viruses, and can also remove iron, sulfur, and manganese. Ozonation is a point-of-entry treatment in which ozone is added to the water to kill bacteria and viruses and oxidize contaminants such as iron and manganese, causing them to form solids that can be filtered out of the water. Because ozone is unstable, it does not last long in water. Ozone can also react with some contaminants and produce harmful byproducts.

Table 6.2. Bleach Amounts for Emergency Disinfection		
Water Volume	**Amount of 6% Bleach to Add**	**Amount of 8.25% Bleach to Add**
1 quart or liter	2 drops	2 drops
1 gallon	8 drops	6 drops
2 gallons	16 drops (¼ tsp.)	12 drops (⅛ tsp.)
4 gallons	⅓ tsp.	¼ tsp.
8 gallons	⅔ tsp.	½ tsp.

Emergency Disinfection

Storing a package of bottled water provides an easy backup supply of drinkable water in case of emergencies. However, there are other options if you do not have bottled water available. Water can be boiled for 2 minutes to kill pathogens, but this concentrates other constituents such salts and minerals in the water, so it is not recommended for everyday use. The EPA has in-depth instructions on their website for using bleach or iodine in dire situations when boiling water is not possible.

Do not use bleach that is scented, color safe, contains additional cleaners, or has been stored for longer than a year. Add bleach to water using a dropper, stir, and let it sit for 30 minutes. The water will have a slight chlorine odor. Sanitizing household bleach typically contains 6 percent or 8.25 percent sodium hypochlorite. Table 6.2 shows amounts of bleach to use according to the volume of water to be disinfected.

After You Treat

After you treat your well system, be sure to perform regular maintenance to keep your system up to its highest quality. Replace your water filter when required and know the requirements for maintaining each piece of treatment equipment you own.

Protecting Your Well

Chapter 7

ALABAMA EXTENSION

Protecting Your Well

A well is not guaranteed to have consistent water quality over time. If you rely on groundwater for drinking, protecting your well and wellhead is important to the health of your family and your neighbors. As we learned in earlier chapters, contaminants can enter groundwater from surface contamination seeping into the water table or directly via a well itself.

Groundwater is not always confined to one area, so if contaminants enter a well, that groundwater contamination can spread to other areas and affect drinking-water quality. Hundreds of wells often tap in to the same aquifer in an area. Taking steps to protect your wellhead is often an easier and less expensive way to ensure the quality of your water supply than a water-treatment system is.

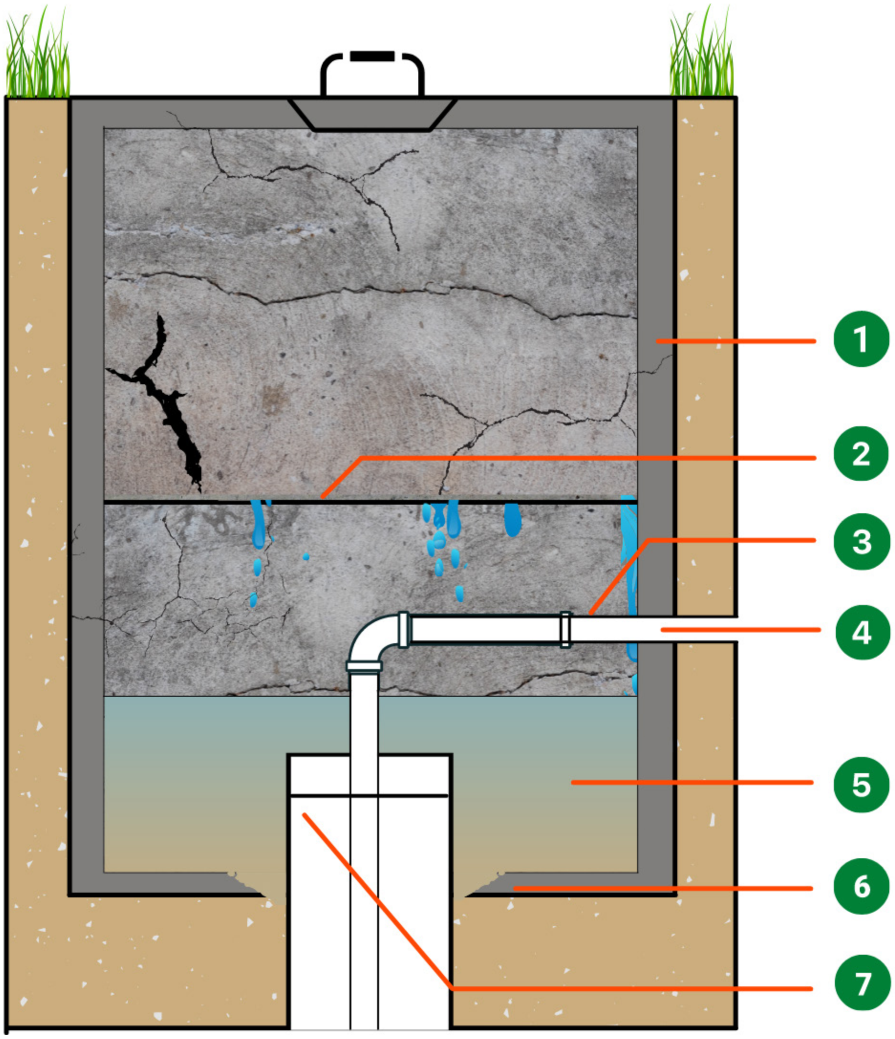
The most important aspects of protecting your well are to select a suitable location, ensure that your well is properly constructed, properly store chemicals to prevent contamination, prevent backflow, and perform regular testing of your well water.

Selecting a Well Location

Good well protection starts with the placement of your well. As was discussed, a well should be located high in the landscape so that surface water drains away from it and pesticides or other contaminants do not flow toward it. The well should not be located in a flood-prone location unless the well casing extends at least 2 feet above the level of the highest known flood of record.

The Alabama Department of Environmental Management (ADEM) recommends the following minimum separation distances between a well and various potential sources of contamination:

- 2 feet from projections or roofs of adjacent buildings
- 10 feet from secondary electrical services
- 75 feet from primary electrical services
- 100 feet from a septic tank or field lines
- 150 feet from a cesspool or sewage lagoon
- 150 feet from a barnyard
- 500 feet from a petroleum tank



1. Cracked cement tiles.
2. Construction joints in tiles, stones, or bricks that are not properly grouted.
3. Water line passages are not always sealed.
4. Water lines should be sealed inside and out of the well pit.
5. Surface water, foreign materials, and contaminants often pool in the bottom of well pits.
6. Poor grouting of the well casing allows direct passage of surface water and contaminants into the groundwater.
7. Well seals can do a poor job of preventing surface water and contaminants from entering the well.

Figure 7.1. Diagram of a well pit.

Properly Constructing a Well

It is a good idea to look into the current construction standards for wells in Alabama. Some things that were the norm even 30 years ago are now considered dangerous, unsafe, or a threat to groundwater. While your well may currently be working, its method of construction may pose groundwater contamination threats, affecting both your drinking water and the drinking water of others.

Regularly check and maintain the following components of your well:

- **Well casing.** The well casing is a plastic or steel pipe that lines the inside of the well and should extend 1 to 2 feet above the ground to prevent surface water from flowing into the well. The top of the well casing should be properly sealed using a tight-fitting sanitary well cap that can keep children, pets, or other curious visitors from accessing the well.
- **Well grouting.** When your well was installed, the open space between the well casing and the sides of the bore-hole should have been sealed with grout to prevent water and pollutants from flowing into the section outside the well casing and down into groundwater. Check to make sure that your well has been properly grouted; you should see sand-cement grout or neat cement around the outside of the well casing. Fixing inadequate grouting in an existing well is difficult, but installing a sanitary well cap and curbing with a concrete slab can help.
- **Well pits.** Wells that have well pits without a pitless adapter can be dangerous and are potential sources of groundwater contamination. Well pits were originally created to allow piping from the well to be elbowed horizontally from the top of the well into the house below the frost line to avoid freezing in winter.

- For more details on these maintenance checks and procedures, refer to chapter 2, Well Siting and Construction.

Well casing can be extended and pitless adapters can be installed to create a more sanitary well.

Well pits should be properly sealed. If not, they can pose a risk to children, livestock, and pets and could even be run over by moving equipment.

Well pits can also get flooded, carrying surface contaminants directly into your well water. To avoid these issues, a pitless adapter should be used in a well to extend the casing above the ground surface. Pitless adapters were developed so that wells no longer had to be finished below grade in a pit.

Contact a local well driller to professionally modify your well if necessary. Visit the Alabama Extension website for information about well construction. After you have had any work done on your well, be sure to disinfect your well and test for coliform bacteria before using it again.

Figure 7.2. An open well hole.

Properly Storing Chemical Contaminants

Many wells have a well house, and all too often, people treat the well house as a garden shed. Chemicals should never be stored in your well house because if they leak or spill, they can seep into the ground and into the groundwater. Never dispose of household chemicals, motor oil, or personal-care products by pouring them onto the ground or flushing them down the drain or down the toilet. Your municipality's waste-disposal service should offer services for properly disposing of chemical waste. Never flush medication down the toilet, especially if on a septic system because many of these chemicals are not filtered out, even in a public drinking-water supply. Take medication to a collection facility if possible.

Generally, pesticides, solvents, and petroleum products are *not* naturally occurring contaminants in groundwater, but improper human use of chemicals can cause well-water contamination.

The following are actions that can potentially pollute groundwater:

- Storing, mixing, or spraying chemicals or pesticides too close to a well or other water supply
- Pouring gasoline on fire ant mounds
- Accidental chemical spills
- Improperly disposing of chemicals in storm drains, household drains, or down the toilet
- Improperly disposing of chemicals from old manufacturing sites
- Petroleum leaks or spills
- Using abandoned wells for disposal of potential contaminants

The following are factors that could cause your water to be contaminated by organic chemicals:

- Proximity to the contamination source. Wells located near industrial or commercial areas, gas stations, landfills, railroad tracks, or farm fields are often contaminated by organic chemicals
- Well depth. Shallow wells are more easily affected than deep wells by spills or surface-applied organic chemicals
- Geology of the area. Aquifers under thin, porous soil or sand layers are more vulnerable than ones under dense, thickly layered clay soils that act as a barrier to slow down the movement of contaminants as well as possibly adsorbing or binding to them before they can reach groundwater
- Improper well construction and inadequate wellhead protection status. Improperly constructed wells along with inadequate wellhead-protection measures make the wells especially vulnerable to contamination because of the potential for surface runoff and spills to make their way into your water supply

Preventing Backflow

If water pumped from your well into your home accidentally flows back into your well, it can contaminate your water system. Preventing backflow is critical to protecting your water system. If your pump stops working while a hose is submerged in chemicals, the backflow due to a drop in pressure could draw those chemicals back into your well. Water from laundry, swimming pools, tubs, or sinks can also back flow through plumbing. Install a double check valve backflow preventer between a well and an irrigation system.

You can also install an atmospheric vacuum breaker (AVB), available at hardware stores, on each outside faucet. AVBs are backflow-prevention devices that incorporate an atmospheric vent with a check valve to prevent back-siphonage (reversal of the normal flow of water caused by a negative pressure in the supply piping) of nonpotable liquids into the potable water supply.

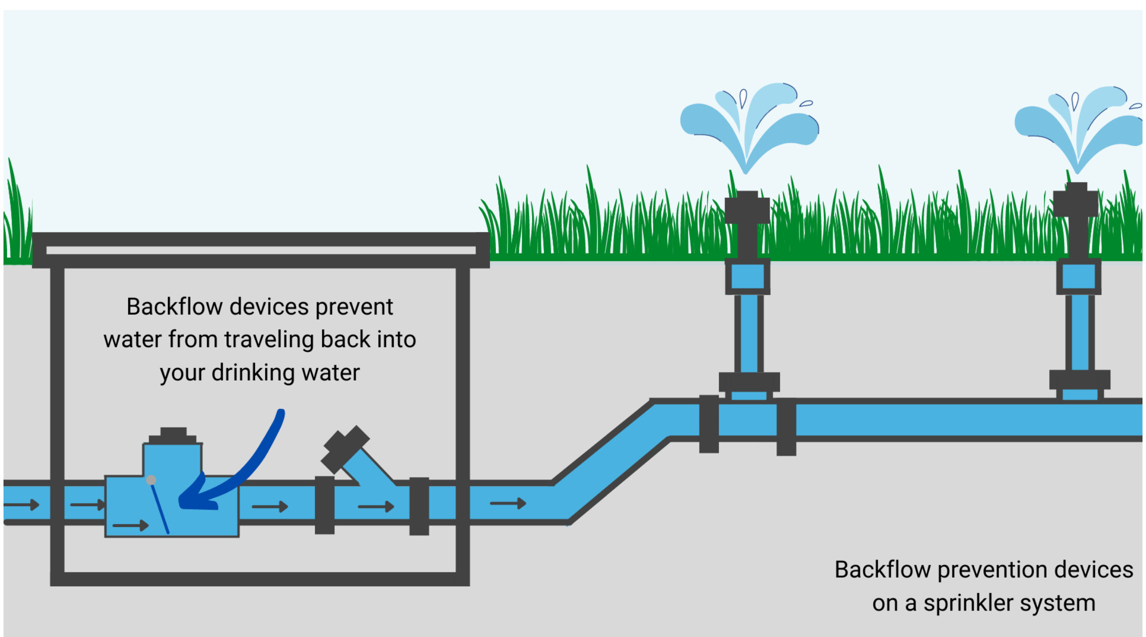


Figure 7.3. Backflow prevention device on a sprinkler system.

Testing Your Well Water

It is the responsibility of the well owner to test their own private water supply. You should test your water at least once a year, particularly for bacteria and nitrates. Testing for other contaminants should be done every few years, if there is a reason to suspect their presence, or if there is a change in the taste or smell of the water. When you test your water regularly, you develop a long-term vision of whether your water quality is changing over time. Having this information can help you pinpoint any potential sources of contamination. Steps for getting your well water tested can be found on the Alabama Extension website.

Sealing Unused Wells

You may have an unused well on property you bought, or perhaps you have transitioned to municipal water and no longer need your private well. Taking time to properly close your unused well is critical to maintaining a healthy groundwater supply for yourself and others.

Closing an abandoned well accomplishes four things: (1) it eliminates physical hazards such falling into the well, tripping, or driving over it; (2) it prevents groundwater contamination from occurring by having things fall or flow into the well; (3) it helps conserve aquifer yield and hydrostatic head; (4) it helps prevent intermixing of subsurface water.

Wells that are unused and have been improperly decommissioned (abandoned) pose a serious risk to Alabama's groundwater quality. Improperly decommissioned wells provide a direct conduit for contaminated surface waters to enter groundwater. A well is a direct line from the surface of the earth to groundwater hundreds of feet below. The threat of contamination is heightened since the surface water can move directly into groundwater, bypassing the filtering action of the soil. Extremely high levels of biological and chemical contamination can be reached very quickly. Contaminated wells can impact your individual water supply and the water supplies of some or all of the other well owners in the area if they draw from the same aquifer.

People have been known to use abandoned wells as disposal troughs for dumping sewage and other hazardous materials directly into groundwater. This is absolutely not acceptable and will directly contaminate your own drinking water and the drinking water of others. Keep in mind that individual water-supply wells are usually relatively shallow and serve one to several households with enough water for domestic purposes. A capped well is not considered a closed or decommissioned well because it could be rehabilitated and put back in service at a later date.

Procedure for Sealing An Abandoned Private Well

The safest way to seal an abandoned well is to contact a licensed well driller to do the job. ADEM provides guidance on how to deal with abandoned public, private, and monitoring wells,[1] but only private wells are covered in this section.

The most appropriate method of well closure decommissioning should be made after considering the following: (1) the casing material, (2) casing condition, (3) diameter of the casing, (4) quality of the original seal, (5) depth of the well, (6) well plumbness, (7) hydrogeologic setting, and (8) the level of contamination and the zone or zones where contamination occurs. Your licensed well driller will be helpful at making these assessments. Well construction documents, maintenance records, and other available data for the water well should be collected, reviewed, and included in a well decommissioning plan, so gather these together beforehand if possible.

Individual water supply wells are relatively shallow in depth and serve one to several households with enough water for domestic purposes. These wells are typically one of three types: shallow dug wells, driven or sand point wells, or drilled or augered wells. As with other types of wells, the type and depth of well should be determined before plugging. Any obstructions in the well should be removed before initiating the plugging operation and under no circumstances should any part of the casing be allowed to remain above the surface of the ground after plugging.

Accurate records should be kept of the well location, depth, filling material, date of plugging, etc. Shallow dug wells and hand dug wells extend down to the aquifer and are sometimes blasted or chipped into bedrock to reach the aquifer. Stone or concrete walls called *curbing* are sometimes necessary to keep the well from collapsing. These wells are rarely deeper than a few tens of feet and have diameters that are usually several feet across.

Pumps, piping, or debris should be removed and the top 3 to 5 feet of curbing should be broken before filling. Any portion of the well that extends into bedrock should be filled with a concrete using bentonite grout. The remainder of the well should be filled with clean native materials that approximate the permeability of the aquifer and overlying soils in the vicinity of the well. The soil should be compacted to prevent settling and ponding of water in the location of the former well.

Driven or Sand Point Wells

A driven or sand point well is one that is driven to the desired depth, either by hand or machine and may employ a well point or alternative equipment. These wells typically have a small diameter (2 inches or less) with a short screen near the pointed end and can only be used in soft sandy sediments or soils.

Driven or sand point wells should be removed if their diameter is 2 inches or less and their depth is 25 feet or less. The hole should be filled with a bentonite-cement grout. If greater than 25 feet in depth, larger than 2 inches in diameter, or cannot be removed, the well should be filled with a bentonite-cement grout from bottom to top using the pump-down method and a tremie pipe.

Drilled Wells

Diameters of 2 to 20 inches are typical for drilled wells, which are installed with the use of a drilling rig and may be several tens to several thousand feet deep. In Alabama, drilled domestic wells are generally less than 250 feet deep.

Drilled domestic wells are often unique in design and depth and should be closed-decommissioned only by a licensed well driller. If possible, the casing should be removed and the borehole filled with a cement-bentonite slurry. If the casing cannot be removed, the entire well should be filled with a cement-bentonite slurry using the pump-down method with a tremie pipe. In areas subject to subsidence or farming, the top of the casing should be cut off at a minimum of 3 feet below the surface of the ground before plugging operations begin. After filling the well with the cement-bentonite slurry, the excavation above the top of the cement plug should be filled with compacted soil to minimize future hazards to farming equipment, etc. In other areas, the top of the casing should be cut off at or below the ground surface.

Recording the Decommissioning Process

Make a record of the process. Include the following information:

- Location of the decommissioned well by the Global Positioning System (GPS), latitude/longitude, township/range, or other georeferencing conventions of such precision that it can be readily relocated
- Date of completion of well decommissioning
- Name of landowner
- Name, title, and address of person responsible for well decommissioning
- Total depth of well
- Length of casing
- Length of casing removed or length of casing cut off below ground level
- Lengths of casing ripped or perforated and method used
- Inside diameter of well-bore or casing
- Type of casing material or schedule (standard-weight steel or PVC sch-80)
- Static water level measured from ground surface before decommissioning
- Photographs before and after decommissioning
- Types of materials used for filling and sealing, quantities used, depth intervals for emplacement of each type, and emplacement method used
- All other pertinent information based on site conditions and any other problems encountered during decommissioning

Appendix & Additional Resources

Appendix & Additional Resources

Geological Survey of Alabama Groundwater Circulars

Geological Survey of Alabama. (2002). *Water in Alabama (including basic water data).* C1220. Online.

Geological Survey of Alabama. (2001). *Hydrogeology and Vulnerability to contamination of major aquifers in Alabama: Area 13.* C199A. Online.

Geological Survey of Alabama. (2001). *Hydrogeology and Vulnerability to contamination of major aquifers in Alabama: Area 10*. C 199B. Online.

Geological Survey of Alabama. (2001). *Hydrogeology and Vulnerability to contamination of major aquifers in Alabama: Area 5.* Circular. C 199C. Online.

Geological Survey of Alabama. (2006). *Hydrogeology and Vulnerability to contamination of major aquifers in Alabama: Area 4.* Circular. C 199D. Online.

Geological Survey of Alabama. (2004). *Hydrogeology and Vulnerability to contamination of major aquifers in Alabama: Area 11.* Circular. C 199E. Online.

Geological Survey of Alabama. (2008). *Hydrogeology and Vulnerability to contamination of major aquifers in Alabama: Area 2.* Circular. C 199F. Online.

Table A.1. Water Wells and Groundwater Information Websites	
Alabama Private Well Program	Alabama Cooperative Extension System
Aquifers in Alabama, Maps	Geological Survey of Alabama
Emergency Water Disinfection	United States Environmental Protection Agency (EPA)
Licensing and Registration of Well Drillers	Alabama Department of Environmental Management
Groundwater Information	National Ground Water Association, a nonprofit group of U.S. and international groundwater professionals, including contractors, engineers, equipment manufacturers, scientists, and suppliers. Provides information to members, governmental agencies, and the public.
Laboratories that Test Drinking Water	County health department Certified in-state laboratories
Regulations Pertaining to Water in Alabama	Alabama Office of Water Resources
Oil and Gas Development	State of Alabama Oil and Gas Board
Primary Drinking Water Contaminants	Environmental Protection Agency
Well Contractors	Alabama Department of Environmental Management
Water Treatment Systems, Standards, and Certifications	American National Standards Institute National Sanitation Foundation

National Primary Drinking Water Regulations

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	**zero**
Alachlor	0.002	Eye, liver, kidney, or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	**zero**
Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	**zero**
Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	**0.006**
Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	**0**
Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	**7 MFL**
Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	**0.003**
Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	**2**
Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	**zero**
Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	**zero**
Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	**0.004**
Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	**zero**
Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	**zero**
Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	**0.005**
Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	**0.04**

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Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	**zero**
Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort; anemia	Water additive used to control microbes	**MRDLG=4[1]**
Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	**zero**
Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	**MRDLG=4[1]**
Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Water additive used to control microbes	**MRDLG=0.8[1]**
Chlorite	1.0	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Byproduct of drinking water disinfection	**0.8**
Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	**0.1**
Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	**0.1**
Copper	TT[5]; Action Level=1.3	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	**1.3**
Cryptosporidium	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	**0.2**
2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	**0.07**
Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	**0.2**
1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	**zero**
o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	**0.6**
p-Dichlorobenzene	0.075	Anemia; liver, kidney, or spleen damage; changes in blood	Discharge from industrial chemical factories	**0.075**
1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**

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Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	**0.007**
cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	**0.07**
trans-1,2, Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	**0.1**
Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from industrial chemical factories	**zero**
1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**
Di(2-ethylhexyl) adipate	0.4	Weight loss, liver problems, or possible reproductive difficulties	Discharge from chemical factories	**0.4**
Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	**zero**
Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	**0.007**
Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	**zero**
Diquat	0.02	Cataracts	Runoff from herbicide use	**0.02**
Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	**0.1**
Endrin	0.002	Liver problems	Residue of banned insecticide	**0.002**
Epichlorohydrin	TT[4]	Increased cancer risk; stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	**zero**
Ethylbenzene	0.7	Liver or kidney problems	Discharge from petroleum refineries	**0.7**
Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	**zero**
Fecal coliform and *E. coli*	MCL[6]	Fecal coliforms and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes may cause short term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.	Human and animal fecal waste	**zero[6]**

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Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Fluoride	4.0	Bone disease (pain and tenderness of the bones); children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	**4.0**
Giardia lamblia	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	**0.7**
Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	**n/a[9]**
Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	**zero**
Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	**zero**
Heterotrophic plate count (HPC)	TT[7]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	**n/a**
Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	**zero**
Hexachloro-cyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	**0.05**
Lead	TT[5]; Action Level=0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	**zero**
Legionella	TT[7]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	**zero**
Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, and gardens	**0.0002**
Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	**0.002**
Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, and livestock	**0.04**
Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	**10**

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Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	**1**
Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	**0.2**
Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood-preserving factories	**zero**
Picloram	0.5	Liver problems	Herbicide runoff	**0.5**
Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	**zero**
Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	**zero**
Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines	**0.05**
Simazine	0.004	Problems with blood	Herbicide runoff	**0.004**
Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	**0.1**
Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	**zero**
Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	**0.0005**
Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	**1**
Total Coliforms	5.0 percent[8]	Coliforms are bacteria that indicate that other, potentially harmful bacteria may be present. See fecal coliforms and *E. coli*	Naturally present in the environment	**zero**
Total Trihalomethanes (TTHMs)	0.080	Liver, kidney, or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	**n/a[9]**
Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	**zero**
2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	**0.05**
1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	**0.07**

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Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	**0.2**
1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	**0.003**
Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	**zero**
Turbidity	TT[7]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria. These organisms can cause short term symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	**n/a**
Uranium	30µg/L	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	**zero**
Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	**zero**
Viruses (enteric)	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	**10**

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NOTES

1 Definitions

- **Maximum Contaminant Level Goal (MCLG):** The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- **Maximum Contaminant Level (MCL):** The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- **Maximum Residual Disinfectant Level Goal (MRDLG):** The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- **Maximum Residual Disinfectant Level (MRDL):** The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- **Treatment Technique (TT):** A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 Health effects are from long-term exposure unless specified as short-term exposure.

4 Each water system must certify annually, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05 percent dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01 percent dosed at 20 mg/L (or equivalent).

5 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

6 A routine sample that is fecal coliform-positive or E. coli-positive triggers repeat samples--if any repeat sample is total coliform-positive, the system has an acute MCL violation. A routine sample that is total coliform-positive and fecal coliform-negative or E. coli-negative triggers repeat samples--if any repeat sample is fecal coliform-positive or E. coli-positive, the system has an acute MCL violation. See also Total Coliforms.

7 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- ***Cryptosporidium:*** 99 percent removal for systems that filter. Unfiltered systems are required to include Cryptosporidium in their existing watershed control provisions.
- **Giardia lamblia:** 99.9 percent removal/inactivation
- **Viruses:** 99.9 percent removal/inactivation
- ***Legionella*:** No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, according to the treatment techniques in the surface water treatment rule, *Legionella* will also be controlled.
- **Turbidity:** For systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 nephelometric turbidity unit (NTU), and samples for turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU.
- **HPC:** No more than 500 bacterial colonies per milliliter
- **Long Term 1 Enhanced Surface Water Treatment:** Surface water systems or ground water systems under the direct influence of surface water serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- **Long Term 2 Enhanced Surface Water Treatment:** This rule applies to all surface water systems or ground water systems under the direct influence of surface water. The rule targets additional *Cryptosporidium* treatment requirements for higher risk systems and includes provisions to reduce risks from uncovered finished water storages facilities and to ensure that the systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts. (Monitoring start dates are staggered by system size. The largest systems (serving at least 100,000 people) will begin monitoring in October 2006 and the smallest systems (serving fewer than 10,000 people) will not begin monitoring until October 2008. After completing monitoring and determining their treatment bin, systems generally have three years to comply with any additional treatment requirements.)
- **Filter Backwash Recycling:** The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

8 No more than 5.0 percent samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli. If two consecutive TC-positive samples, and one is also positive for E. coli or fecal coliforms, system has an acute MCL violation.

9 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- **Haloacetic acids:** dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- **Trihalomethanes:** bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

NATIONAL SECONDARY DRINKING WATER REGULATION

National Secondary Drinking Water Regulations are non-enforceable guidelines regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, some states may choose to adopt them as enforceable standards.

Contaminant	Secondary Maximum Contaminant Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	Noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

FOR MORE INFORMATION ON EPA'S SAFE DRINKING WATER:

visit: **epa.gov/safewater**

call: **(800) 426-4791**

ADDITIONAL INFORMATION:

To order additional posters or other ground water and drinking water publications, please contact the National Service Center for Environmental Publications at: **(800) 490-9198**, or email: **nscep@bps-lmit.com**.

Table A.2. Contaminants and MCL, SMCL, and Potential Treatment Options						
Testing Frequency	**Contaminant**	**MCL**	**SMCL**	**Potential Effect**	**Source**	**Possible Treatment Options**
Annually	Total Coliform	0#/ CFU		Indicator of potentially harmful bacteria	Occurs naturally in environment or human/animal feces	Shock chlorination, distillation, UV radiation
	Fecal Coliforms and *E. coli*	0#/CFU		Indicator of potentially harmful bacteria that could lead to diarrhea, vomiting, cramps	Exists in human/ animal feces	Shock chlorination, UV radiation, distillation
	Nitrate	10 mg/L		Shortness of breath or blue-baby syndrome	Erosion of natural deposits, fertilizer runoff, leaking sewage and septic tanks	Reverse osmosis, distillation
	Total Dissolved Solids		500 mg/L	Water hardness, deposits, colored water, staining, or salty taste	Local geology and climate, sewage, agricultural and urban runoff, or water treatment chemicals	Reverse osmosis or distillation
	pH	6.5-8.5		Metallic taste and corrosion at low pH; slippery feel, soda-like taste, and deposits at high pH	Local geology	Neutralizing filtration

Table A.2. Contaminants and MCL, SMCL, and Potential Treatment Options (cont.)						
Testing Frequency	**Contaminant**	**MCL**	**SMCL**	**Potential Effect**	**Source**	**Possible Treatment Options**
Every 2 to 3 Years	Radon	5 pCi/L for Radium 226 and Radium 228 combined		Increased risk of lung cancer	Radon gas is given off by naturally occurring decaying radium dissolved in water	De-aeration, activated carbon filtration
	Chloride		250 mg/L	Salty taste	Saltwater intrusion, inorganic fertilizers, septic tank effluent	Reverse osmosis, distillation
	Fluoride	4.0 mg/L	2.0 mg/L	Bone disease or mottled teeth at high levels; disfiguration and coloration of teeth at low levels	Erosion of natural deposits, addition to drinking supplies, discharge from aluminum and fertilizer factories	Reverse osmosis, distillation
	Sulfate		250 mg/L	Salty taste or scale buildup	Erosion of natural deposits	Shock chlorination
	Lead	0.015 mg/L		Delays in physical or mental development, kidney problems, increased blood pressure, damage to nervous system	Erosion of natural deposits, corrosion of plumbing systems	Reverse osmosis, distillation, activated carbon filtration with special media, replace lead plumbing
	Hardness (as CaCO3)	*		Difficulty lathering soap, scale deposits	Local geology	Water softeners
	Aluminum		0.05-0.2 mg/L	Undesirable color or scale formation	Erosion of natural deposits	Reverse osmosis, distillation

Table A.2. Contaminants and MCL, SMCL, and Potential Treatment Options (cont.)						
Testing Frequency	**Contaminant**	**MCL**	**SMCL**	**Potential Effect**	**Source**	**Possible Treatment Options**
Every 2 to 3 Years (cont.)	Calcium	*		Contributes to water hardness	Local geology	Ion exchange/ water softening
	Chromium	0.1 mg/L		Allergic dermatitis	Erosion of natural deposits or discharge from steel and pulp mills	Reverse osmosis, distillation
	Copper	1.3 mg/L	1.0 mg/L	At low levels: blue-green color or metallic taste. At high levels: short-term gastrointestinal distress; Long term: liver or kidney damage	Erosion of natural deposits, corrosion of household plumbing system	Reverse osmosis, distillation, activated carbon filtration
	Iron		0.3 mg/L	Rust-colored stains, metallic taste or odor	Erosion of natural deposits	Filtration, chlorination
	Manganese		0.05 mg/L	Brown-black stains, metallic taste, or odor	Erosion of natural deposits	Shock chlorination, water softening, particle filtration

Table A.2. Contaminants and MCL, SMCL, and Potential Treatment Options (cont.)						
Testing Frequency	**Contaminant**	**MCL**	**SMCL**	**Potential Effect**	**Source**	**Possible Treatment Options**
At least once and if you suspect contamination	Arsenic	0.01 mg/L		Skin damage, circulatory issues, increased risk of cancer	Erosion of natural deposits, runoff from orchards, glass and electronics production waste	Absorption system, reverse osmosis, distillation
	Uranium	0.030 mg/L		Increased risk of cancer or kidney toxicity	Erosion of natural deposits	Reverse osmosis, distillation, absorption system
	Alpha particles	15 pCi/L		Increased cancer risk	Erosion of natural deposits of radioactive minerals that may emit alpha radiation	Ion exchange
	Beta particles and photon emitters	4 millirems per year		Increased cancer risk	Decay of natural and anthropogenic deposits of radioactive minerals that may emit beta radiation and photons	Ion exchange

Adapted from the University of Georgia Extension and the University of Nebraska-Lincoln Extension

* No current MCL or SMCL set by the EPA at this time.

References

University of Nebraska Extension, Drinking Water Treatment: An Overview

Additional Resources

For a list of licensed well drillers, visit the Alabama Extension Private Well Program webpage.
For a list of private and public labs where you can get your water tested, visit the Alabama Extension website, Private Well Program, Where to Get Your Well Water Tested.

The ADEM Permits and Services Division coordinates the private wells and drillers certification program and may be able to answer specific questions:
Phone: (334) 279-3040
Email: permitsmail@adem.state.al.us

ADEM Individual Well Closure decommissioning information online at the ADEM website, Water Well Closure/ Decommissioning at AFO/CAFO Facilities

Table A.3. Treatment Devices

Device	Primary Use	Notes to Consider
Activated Carbon Filter	Removes chlorine, volatile organic compounds (VOCs), radon, some Synthetic Organic Compounds (SOCs), and general taste and odor problems	Does not remove nitrate, bacteria, or inorganic compounds. Periodic replacement of activated charcoal required
Specialty Absorption Media	Removes arsenic	Typically use “ferric (iron) hydroxide”. Can be either Point of Entry or Point of Use units.
Reverse Osmosis	Removes more contaminants than any other treatment system except distillation, some organic chemicals (not volatile or semi volatile), pesticides, bacteria, viruses, nitrate, fluoride, lead, copper, arsenic	Does not remove all organic chemicals, such as chloroform. Does not remove 100 percent of most chemicals. Uses large amounts of water. Activated carbon or particle filtration is often used to prefilter water before reverse osmosis. Not recommended for bacteria and dissolved gases
Ion Exchange	Cation Exchange Units – Removes positively charged ions, inorganic compounds, such as iron and manganese ions, arsenic, chromium, and hard water minerals – calcium and magnesium. Anion Exchange Units – Removes negatively charged ions such as nitrates, bicarbonate, selenium, and sulfate.	Removal of one type of ion replaced with another, for example iron removed may be replaced with sodium. Periodic backwashing and regeneration required. If not regenerated at the proper frequency, these devices can discharge contaminants into the drinking water at concentrations greatly exceeding the untreated water concentrations.

Table A.3. Treatment Devices (cont.)		
Device	**Primary Use**	**Notes to Consider**
Filtration	Removes small particles and suspended solids such as ferric iron, clay, silt and sand, and some pathogens such as bacteria and viruses, and colloids (suspended matter).	Filter replacement based on concentration of contaminant, pressure head loss, and water usage in the home.
Distillation	Removes dissolved minerals, trace amounts of metals, lead, fluoride, copper, nitrate, arsenic, bacteria	Might produce bland-tasting water. Small capacity units produce limited quantity for drinking, cooking. Large units require kitchen or adjoining space or small diameter plastic plumbing can be run to the faucet location from a basement unit. Not effective against most volatile and semi-volatile chemicals and some bacteria.
Aeration	Dissolved gases like radon, carbon dioxide, methane, and hydrogen sulfide (rotten egg odor), as well as volatile organic compounds. Aeration can be used for the precipitation and removal of dissolved iron and manganese.	If iron and manganese are present in solid form, pretreatment of the water to remove these particles before entering the aeration treatment and post-treatment may be necessary. Waste air must be vented from house in such a way as to prevent contamination of indoor air quality. Not recommended for water containing bacteria which may clog the system.
De-aeration	Dissolved hydrogen sulfide gas, radon.	If water has high hardness, the system should be designed to manage precipitates and scale build-up.
Ultraviolet Radiation	Efficient at inactivating vegetative and sporous forms of bacteria, viruses, and other pathogenic microorganisms.	Not recommended if the untreated water contains high levels of total coliform bacteria, substantial color or turbidity. Does not improve the taste, odor, or clarity of water.
Ozone	Pathogenic (disease-causing) organisms including bacteria and viruses, phenols (aromatic organic compounds), some color, taste, and odor problems, iron and manganese, and turbidity.	Not effective for large cysts and some other large organisms, inorganic chemicals, heavy metals

Table A.3. Treatment Devices (cont.)		
Device	**Primary Use**	**Notes to Consider**
Chlorination	Used to treat viruses and bacteria; dissolved iron, manganese, and hydrogen sulfide; iron, manganese and sulfur bacteria	May require a post-treatment system for taste and odor removal. Chlorine must have an adequate contact time with water to disinfect it. Careful handling of chlorine is required since it is toxic. Byproducts of the chlorination process may include trihalomethanes (THM's), which may increase the risk of cancer. Activated carbon filtration may be used after chlorination to remove THMs and excess chlorine.
Oxidation (Potassium Permanganate & Oxidizing Filters)	Used to treat viruses and bacteria; dissolved iron, manganese, and hydrogen sulfide; iron, manganese and sulfur bacteria.	Requires careful calibration and monitoring. Potassium permanganate is a skin irritant.
pH Adjustment	Neutralizing filters and soda ash/ sodium hydroxide injection raise the pH of drinking water to near neutral 7. Acid injection lowers pH to near neutral 7.	pH adjustment does not treat any type of contaminants in water; it serves to lower or raise pH until a neutral level is reached. Neutralizing filters can cause hardness in treated water. Sodium hydroxide and strong acids such as sulfuric acid and hydrochloric acid can be hazardous to handle and store.

References

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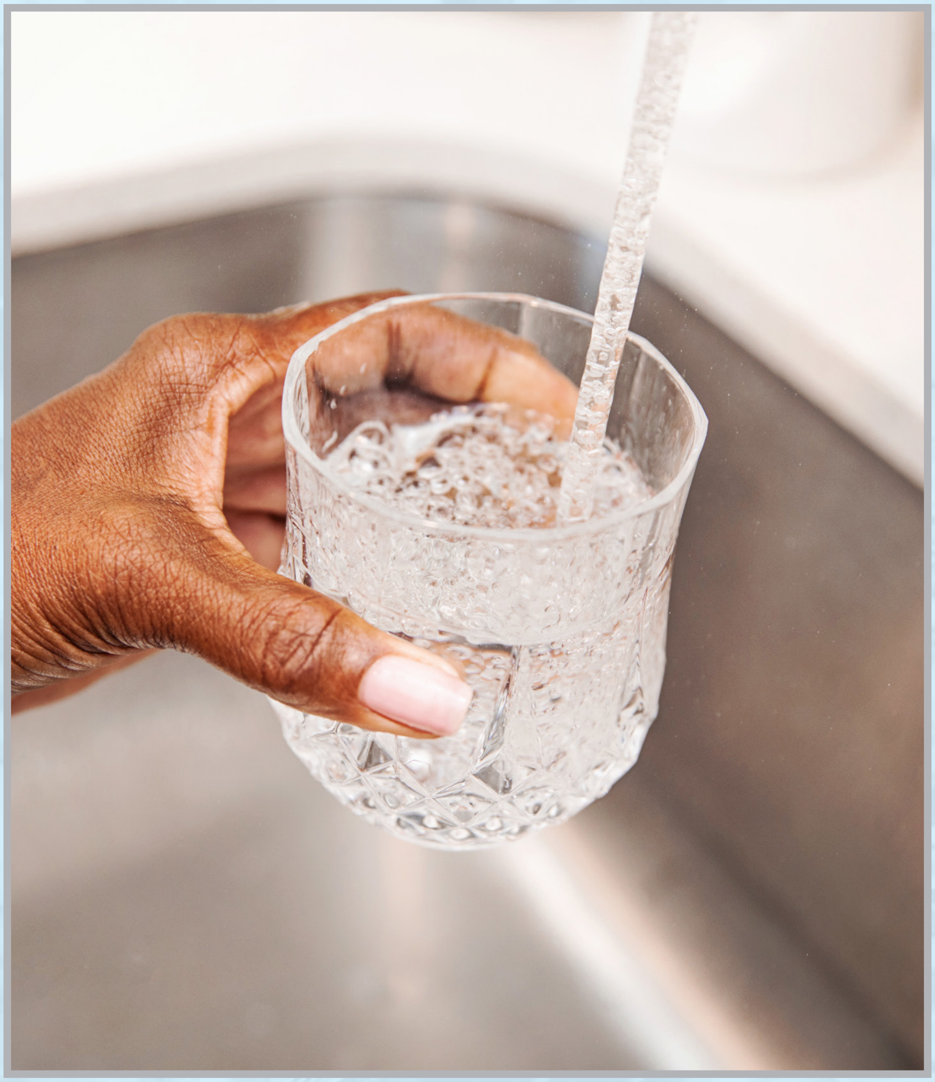

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