Private Water Wells

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Private water wells are considered a type of private water supply because they are designed to provide potable water for a single building or facility of either residential or commercial construction. Normally, a water well that provides potable water to multiple buildings or facilities is considered a community water supply. Community water supply systems require more stringent design, a greater volume of reserve storage capacity, redundant pumping systems, a highly scrutinized permit process, and, for the most part, a full-time licensed water system operator. Conversely, a private water well system is installed, controlled, operated, and maintained by the user. Safe drinking water is the ultimate goal in the design of a private water well system.

Engineering considerations in the design of private water wells include the following: the geology of the area, required demand, potential water quality, system elements, equipment, construction, initial operation, and maintenance procedures. In addition to addressing each of these areas, sources of local information and references should be consulted, including drilling logs of previously constructed wells and their respective water quality test results. The regional governmental agency or health department responsible for water quality and protection is the preferred source of information for the quality of the water supply and approximate location of aquifers. This agency should be contacted as soon as possible to determine the adequacy and quality of the supply and any local regulations governing the construction of private water wells.

Wells often are classified as deep or shallow. A shallow well is considered to be 50 to 100 feet (15 to 30 meters) deep. A deep well generally is considered to be a superior source because the water is less susceptible to contamination and the depth of the aquifer usually fluctuates less than that in a shallow well.

CODES AND STANDARDS

The Safe Drinking Water Act governs the quality of water from wells. U.S. Environmental Protection Agency manuals include standards establishing maximum contamination levels. The Association of State Drinking Water Administrators provides potable water information. State, local, and regional regulations provide minimum construction standards.

For additional information on groundwater protection, contact the National Ground Water Association at ngwa.org. For additional information on safe drinking water standards, contact the Association of State Drinking Water Administrators at asdwa.org.

SOURCES OF SUPPLY

The source of water for private water well systems is groundwater, which by definition is subsurface water flowing or stored in a saturated state within certain types of geological formations beneath the Earth's surface. The Earth's crust is comprised of multiple layers of various geological formations of different minerals and many different substrates. Water-filled voids occur in both bedrock and regolith (a layer of loose rock over bedrock) formations. The glacial drift (sand and gravel) and sandstone regions are examples of shallow water-bearing zones, whereas shale and dolomite regions do not contain any saturated water properties.

The water-saturated voids or regions are considered aquifers, and it is possible to find multiple aquifers at various elevations at the same location. Aquifers store subsurface water that can be yielded in a usable quality and quantity through the use of water wells. The water quality and volume that can be obtained from aquifers substantially change from region to region and from elevation to elevation. Groundwater supply is recharged through surface runoff that soaks into the ground and is not absorbed by surface agriculture. Commercial development and drought reduce the available recharge water for applicable aquifers. Thus, aquifer recharge is necessary to preserve the well's water source. Protecting our environment from pollution is critical to the quality of future groundwater supplies.

WELLS

A water well (usually vertical) is a cased hole (pipe lined near the surface) that is drilled through the Earth's substrate to access water that is stored within the Earth's aquifers. Modern wells generally are drilled using a machine that advances a bore hole to an aquifer, where a casing is installed to prevent collapse of the boring. This casing also prevents the well's aquifer from being contaminated by surface water or other sources of surface pollution at or near the surface of the ground.

The size of the well is determined by the building's water demand, equipment size (pump and pipe), and static pumping elevation. Deeper wells typically require larger-diameter pumps and impellers, thus requiring larger-diameter casings. Residential wells providing water for a single dwelling generally range from 2 to 6 inches (5 to 15 centimeters) in diameter and produce several hundreds of gallons of water per day. High-capacity wells, such as wells for industry or municipal water supplies, may range from 6 to 36 inches (15 to 91 cm) in diameter or larger and may produce several million gallons of water per day.

The bore hole is advanced until either adequate water is encountered or bedrock is reached. In either case, the bore hole must be of a significant depth to isolate the well so it is not contaminated from surface water and pollutants. In porous formations of sand or gravel, a casing is installed with a well screen at the base to allow the water to easily enter the well from the aquifer. If bedrock is encountered before water, the bore hole is advanced into the bedrock a few feet, a casing is installed, and the well is advanced into the bedrock until water is encountered. The annulus between the casing and the bore hole must be sealed with an impervious material to prevent the infiltration of surface water into the aquifer.

Specific state, local, and regional regulations provide minimum construction standards for wells regarding potential sources of contamination, structures, surface features, and property lines. Additionally, state regulations may specify a minimum depth of the well, minimum amount of casing, type of casing, and grouting specifications for the annulus of the casing to prevent surface contamination. Typically, well permits are required before actual drilling can begin, with follow-up jurisdictional inspections.

Dug and Augered Wells

Dug and augured wells can be 65 feet (20 m) or more deep, depending on the position of the water table, while diameters are usually 3 to 30 feet (1 to 9 m). Dug and augered wells can yield relatively large quantities of water from shallow sources. They are the most common type of well used for individual water supplies. Their large diameters permit the storage of considerable quantities of water if the well extends some distance below the water table. Some large municipal wells called collectors are dug wells with lateral, screened horizontal pipes.

A dug well must be permanently lined with a casing of wood staves, brick, rock, concrete, or metal to support it from cave-in. It is difficult to provide a proper sanitary seal on a dug well, but augering allows the installation of a welded steel casing to prevent ground source contamination. The construction of dug wells is prohibited or at least discouraged in some areas because of the increased possibility of surface contamination compared to deeper wells constructed by other means.

Bored Wells

Bored wells are constructed with hand-operated (shallow depths) or power-driven earth augers, which are available in several shapes and sizes, all operating with cutting blades at the bottom that bore through the Earth's substrate in a rotary motion. Hand-boring operations rarely exceed 50 feet (15 m) in depth, whereas power drilling/augering equipment can exceed 1,000-foot (305-m) depths.

Deep well construction requires casing pipe insulation to contain and prevent contamination but also to protect the well shaft from collapsing. The drilling operation may pass through loose gravel or unstable strata before it reaches an aquifer to support the necessary water quality and quantity required for the project under design.

It is important to specify a proper compound of Portland cement and bentonite to grout and seal the well casing respective to its penetration through the various geological formations. This prevents surface contamination and prohibits contamination between the various layers between the Earth's geological formations.

Driven Wells

A driven well consists of a series of connected lengths of pipe driven by repeated impacts into the ground to below the water table. Water enters the well through a drive (or sand) point at the lower end of the well. This consists of a screened cylindrical section protected during driving by a steel cone at the bottom.

Diameters of driven wells are small, with most falling in the range of 2 to 4 inches (5 to l0 cm). Standard-weight steel and galvanized steel pipe having threaded couplings serve as casing. Most depths are less than 50 feet (l5 m), although a few exceed 65 feet (20 m).

As suction-type or jet pumps extract water from driven wells, the water table must be near the ground surface if a continuous water supply is to be obtained. The practical suction limit (i.e., the vertical distance between the suction intake of the pump and the pumping level in the well) for a single-pipe installation is about 25 feet (7.6 m). However, two-pipe venturi suction designs or multistaged turbine pumps can remove water from deeper depths.

Driven wells are suitable for single-home residential water supplies, for temporary water supplies (such as those required on a remotely located construction project), and for exploration and observation. Driven wells are limited to unconsolidated formations containing no large gravel or rocks that might damage the drive point. Driving can be done with a manual sledge, ram driver, drop hammer, or air hammer. The important advantages of driven wells are that they can be constructed in a short time, at minimum cost, and by just one person.

Jetted Wells

Jetted wells are constructed by the cutting action of a downward-directed stream of water. The high-velocity stream washes the earth away, while the casing, which is lowered into the deepening hole, conducts the water and cuttings up and out of the well. Small-diameter holes of 2 to 4 inches (5 to l0 cm) to depths greater than 50 feet (l5 m) can be formed in this manner. Jetted wells typically yield small amounts of water and are best suited to unconsolidated formations.

During the jetting operation, the drill pipe is turned slowly to ensure a straight hole. To complete a shallow jetted well after the casing extends below the water table, the well pipe with a screen attached is lowered to the bottom of the hole inside the casing. The outer casing then is pulled out, gravel is inserted between the interior casing and the bore hole, and the well is ready for pumping.

The above procedure can be simplified by the use of a self-jetting well point. This consists of a tube of brass screen ending in a jetting nozzle, which is screwed to the well pipe. As soon as the well point is jetted to the required depth, the well is complete and ready for pumping. Gravel should be added around the drill pipe for permanent installation.

Construction of jetted wells is prohibited in some areas because of the inability to grout the annular space and the consequent exposure of the well to surface contamination.

HYDRAULICS OF WELLS

Figure 9-1 shows a well under two conditions: static (non-pumping) and pumping. Once the pumping of the well starts, the water table (or in the case of a confined aquifer, the potentiometric surface) is lowered in the vicinity of the well, and the resulting water table surface is

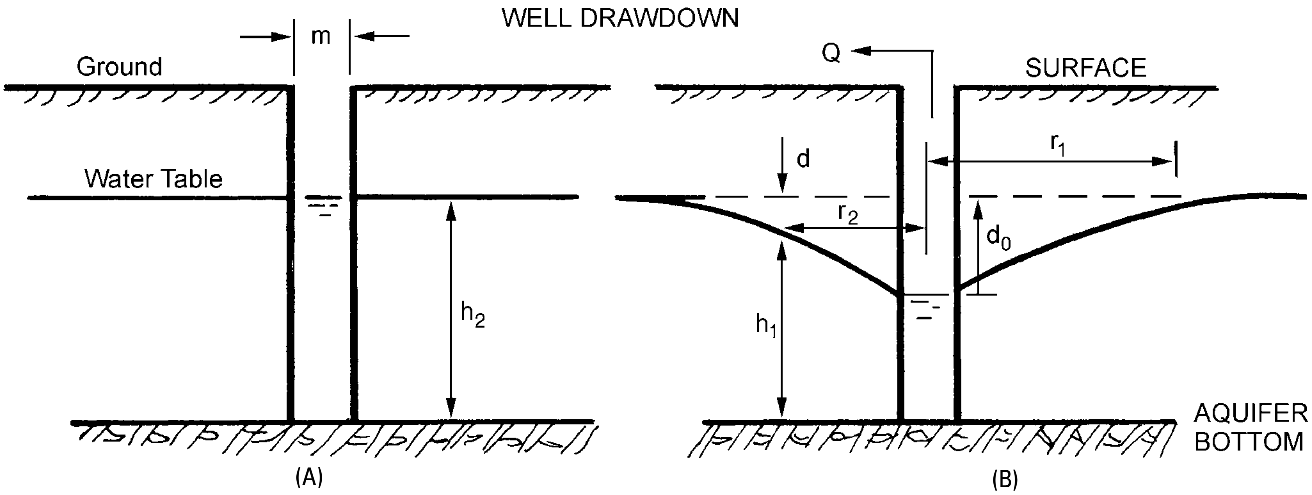

Figure 9-1 Well Under (A) Static and (B) Pumping Conditions

known as the cone of depression. The decrease in the water level at and in the vicinity of the well is known as the drawdown.

PROTECTION OF WELLS

Whenever groundwater pumped from a well is intended for human consumption, proper sanitary precautions must be taken to protect the water quality. (See the following discussion of water quality.) Pollution sources may exist either above or below the ground surface. Submersible pump installations often are equipped with a pitless adapter, which provides an excellent sanitary seal as well as frost protection for the discharge piping. A cross-section of a typical municipal or industrial pitless adaptor is illustrated in Figure 9-2.

Surface pollution can enter a well through either the annular space outside the casing or the top of the well itself. To close avenues of access outside the casing, the annular space should be filled with a sealing grout of cement, bentonite, or a combination thereof. Polluted surface water entry through the top of the well can be prevented by the provision of a water-tight cover to seal the top of the casing. This seal also allows for the removal of the submersible well pump and discharge piping for maintenance. Some pumps are available with metal bases that provide the necessary closure. For pumps with an open type of base or where the pump is not placed directly over the well, a seal is required for the annular opening between the discharge pipe and the casing.

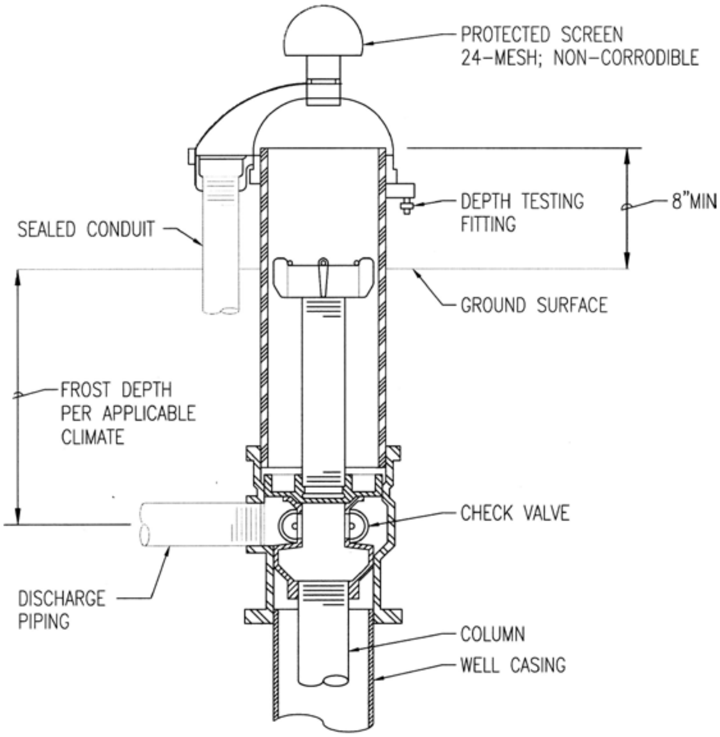

Figure 9-2 Typical Pitless Adaptor

It is desirable to provide a small (sealed) opening in or below the pump base to allow for periodic water level measurements. Covers around the well should be made of concrete, elevated above the level of the adjacent land, and sloped away from the well. Where possible, pitless adapters should be used in preference to buried well seals or seals located in a concrete pit.

Subsurface pollution may be introduced by nearby septic systems, adjacent industry, surface runoff, or numerous types of current and past land uses. A contaminated plume can extend a long distance in an underground stream or aquifer. Regular bacteriological and chemical testing of the water quality is required to ensure potability. Whenever a new well is completed or an old well is repaired, contamination from equipment, well materials, or surface water may be introduced. The addition and agitation of a chlorine compound will disinfect the well, though this may corrode old steel-cased wells. Thus, following the disinfection, the well should be pumped to waste until all traces of chlorine are removed. As a final check on the potability of the water, two samples should be collected 24 hours apart and sent to a certified testing laboratory for bacteriological examination.

In regions where winter frost occurs, it is important to protect pumps and water lines from freezing. Pitless adapters are the most common method used to protect the well head from freezing and pollution. Pitless adaptors allow for pump discharge below the frost level and at the same time provide a check valve for backflow protection.

When a well is abandoned, it should be sealed properly by filling it with cement grout, bentonite, or a combination thereof. Sealing prevents surface contamination from entering the well, prevents accidents and the possible movement of inferior water from one aquifer to another, and conserves water in flowing wells. As necessary, other sealing measures may be needed to ensure that contaminants do not migrate within the aquifer by movement in the annular space between the well casing and the bore hole. To ensure that the well is completely sealed, the cement and/or bentonite should be pumped under pressure through a tremie pipe or other means at the bottom of the well and forced upward until it reaches the surface.

WATER DEMAND

The demand for water in a new system is determined by the design engineer. The building system's dynamic and static requirements are utilized in determining the water demand. Consult with the local administrative authority regarding local codes and regulations. Designing water systems for firefighting purposes requires knowledge of a building's construction, occupancy, and use. Nationally recognized standards, acceptable to the local administrative authority under the applicable code, should be followed.

The flow from a 1½-inch (3-cm) nominal size nozzle at 45 pounds per square inch gauge (psig) (310.3 kilopascals) can be as much as 250 gallons per minute (gpm) (15.8 liters per second). It is recommended to install a water meter on the well discharge and water meters on the non-domestic demands (such as irrigation, fire protection, and heating/cooling loads) to allow the building's owner to monitor consumption.

Average daily water use per person will range from 50–100 gallons (189–379 L). For storage purposes, plan for 50–80 gallons per day (189–303 L/day) minimum. Average water use can be determined by using one of the following methods.

- For metered water, review the water bill. Divide the water usage by the number of days in the billing period and also by the number of residents of the household. If the water is measured in cubic feet, convert to gallons by multiplying by 7.48.
- If the water is not metered, determine the water use for each fixture. In addition to showers, bathtubs, sinks, and toilets, remember to include appliances such as clothes washers and dishwashers as well as home water treatment systems.

The well driller may be required to provide well pumping tests to determine the capacity of the well at various depths of drilling. When the well yields an acceptable flow at a specified depth, a 24-hour test should be performed to confirm the maximum drawdown level at a steady pump rate. The pump selected for the well should not exceed the steady-state drawdown level tested.

WATER QUALITY

The Safe Drinking Water Act of 1974, subsequently amended in 1996, requires the administrator of the EPA to promulgate national standards for the purity of drinking water and corresponding regulations to enforce them. Current EPA regulations include standards establishing maximum contamination levels, and states have adopted these standards or more stringent standards. Efforts must be made to conform to these regulations in all systems.

Well water is usually satisfactory for drinking because of the natural filtration created as the water passes through the geological formations. However, when an excess of dissolved minerals or gases is present, the water must be treated. Selection of the appropriate treatment process must be made based on a thorough knowledge of the water and its chemical composition. The processes employed include filtration, softening, coagulation and flocculation, taste and odor control, prophylaxis, and disinfection. These treatment processes are described below.

Filtration

Where the water is not of an adequate purity and/or clarity, filters are required. Filters may be either gravity or pressure type and should include automatic controls for all functions. These devices may be sand or multimedia (provided that when aggressive or low-pH water is processed, the sand does not contain excessive amounts of limestone or shells). The grade of the sand and/or type of media depends on local conditions.

Coarse sand is less effective in the removal of turbidity and bacteria, while fine sand requires a shorter period between washings. Filters may use layers of various grades of sand and gravel to minimize filter gravel upset and loss of sand. These units may include anthracite coal particles or activated carbon, both of which are often effective in removing objectionable tastes, odors, and other impurities. Filters should be backwashed and disinfected before being placed back in service. Parallel filtration prevents interruption of the supply water during backwash and/or cleaning.

Softening

The two methods of reducing any dissolved calcium and magnesium that are suitable for large water supplies are the zeolite process and the lime soda method. The zeolite process replaces the calcium and magnesium chlorides, and all residues (backwash) must be disposed of in locations where the groundwater will not be contaminated. Zeolite systems may be automated or manual. When iron is removed by this process, the oxides may clog the filter beds. Cleaning the beds requires high-velocity washing.

The lime soda method removes calcium, magnesium, manganese, iron, and carbon dioxide. The pH is raised, and most units effectively destroy any harmful organisms. This method produces considerable quantities of sludge, which requires proper disposal. The lime soda method involves a large installation and skilled operation. Equipment is needed to mix and feed chemicals and for flocculation, settling, recarbonating, and filtering. When iron is not removed, it may be held in solution in cool water up to 72 hours by the addition of hexametaphosphate. This chemical may prevent incrustation in water with a high pH.

Scale and Corrosion Control

Elimination of any excessive scale and corrosion of the piping system is important. This may be accomplished by the proper choice of piping materials or by chemical treatment of the water. Specifying a plastic distribution system will not protect the metallic piping and equipment in buildings. The control of hardness, dissolved oxygen and carbon dioxide, and acidity may be necessary. Sodium hexametaphosphate commonly is used for corrosion control, scale prevention, and removal of hardness.

Taste and Odor Control

Potassium permanganate oxidizes iron and manganese, forming a precipitate. This compound also acts as an algaecide. Oxygenation is another way to treat the water, which may (in some cases) be more effective than treating it with potassium permanganate. Activated carbon has been found to be effective in removing phenolic compounds as well as certain other undesirable materials. Sodium thiosulfate or sodium bisulfate has been used to remove chlorine from water, and copper sulfate will destroy living organic matter.

Prophylaxis

Fluoride sometimes is added to the water with the intent of reducing dental cavities. Where amounts of fluoride are excessive, tooth enamel will become mottled. Some waters have adequate or even excessive fluoride in their natural state.

Well Disinfection

For large water systems, chlorination is an inexpensive method compared to ultraviolet radiation and ozone treatment. Gaseous chlorine is used in large installations, while calcium and sodium hypochlorite are satisfactory for small systems.

Harmful bacteria or viruses can enter a well through holes or other defects in the casing. They can also enter a well when it is first constructed or later when it is repaired or serviced. Every new well must be disinfected after it is drilled and before the water is used for drinking or cooking. A well must also be disinfected whenever it is opened for repairs. If a well is flooded, assume that it has become contaminated, and both the well and the plumbing system need to be thoroughly disinfected. Disinfection should eliminate potentially harmful bacteria and viruses from the water, and it should be repeated if water testing reveals that indicator bacteria are still present. If these organisms are still present after several attempts to disinfect the well, the source of contamination in the well or water system should be located and removed, and the well should be checked for any defects.

The simplest and most effective product for disinfecting all parts of a water system is plain chlorine bleach with no additives. Whenever the pump is primed, chlorinated water should be used. With proper precautions, chlorine solutions are safe and easy to use. After disinfection, the chlorinated water should be flushed from the well and plumbing system. The chlorinated water should not be discharged directly into the septic system. An outside faucet and hose should be used to discharge the chlorine solution to a location away from lawns and gardens. After the chlorine has been flushed from the well, the relatively small amount of chlorine solution still in the plumbing can be drained directly into the septic system. Licensed well contractors are familiar with proper disinfection procedures.

Radon Contamination

In areas where radon (a radioactive gas) is present in low quantities in the ground, the water might be contaminated. Treatment may be necessary to eliminate radon from the water, and water softening often is used to accomplish this. Filtering water through a granulated active carbon filter is also an effective means of treatment. Consult an experienced water treatment system manufacturer to determine the best method of treatment based on the level of radon present.

Water Testing

Drinking water should be free of disease-causing organisms and should not contain harmful levels of chemicals. Two standard tests—for coliform bacteria and nitrate—should be performed regularly on every well. Testing for other contaminants may also be advisable.

When a new well is constructed, laws require the water to be tested for coliform bacteria, nitrate, and arsenic. The person who constructs the well is responsible for obtaining a water sample and having it tested by a certified laboratory. At a minimum, private wells should be tested for coliform bacteria once a year and for nitrates every two or three years. Before collecting a water sample for testing, contact the laboratory for bottles and instructions.

SYSTEM ELEMENTS

A typical residential water system utilizing a well as the source is shown in Figure 9-3.

Pumps

Well pumps produce flow by transforming mechanical energy into hydraulic energy. The selection of a particular size and type of pump depends on several factors:

- Required pumping capacity
- Well diameter and depth
- Depth and variability of pumping level
- Straightness of the well
- Sand pumping
- Total pumping head
- Duration of pumping
- Type of power available
- Cost

The total pumping head, or total dynamic head, of a pump represents the total vertical lift and pumped distance of the water from the well. The total pumping head increases with the discharge rate and consists of the following components:

- Drawdown inside the well (including aquifer and well losses)

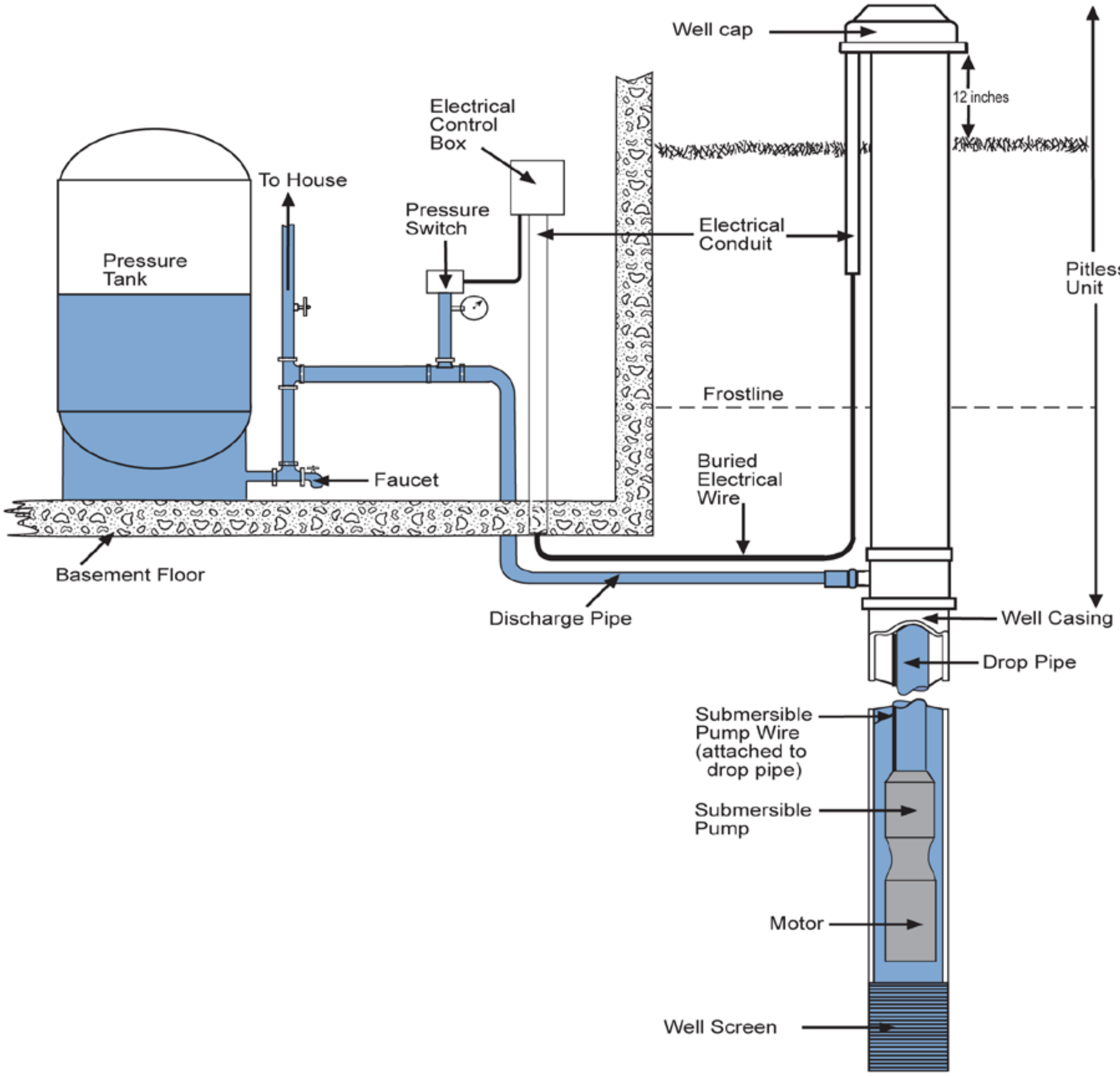

Figure 9-3 Well and Water System

Source: Minnesota Department of Health, *Well Owner's Handbook, 4th Edition*

- Static head, or the difference between the static groundwater level and the static discharge elevation
- Friction losses due to flow through the intake and discharge pipes

The three most common well pump systems are vertical turbine pumps, jet pumps, and submersible pumps.

The vertical turbine pump is a centrifugal pump in which the motor is placed on top of the well and a turbine shaft extends below the water level. The bottom of the shaft is connected to impellers that push the water to a discharge pipe at the top of the well. A cross-section of a vertical turbine pump is illustrated in Figure 9-4. More attention to the pump base (or foundation) should be given than is shown in this figure. If the pump is in an unheated building, the foundation must be below the frost line to prevent movement and have sufficient mass to eliminate vibration. Also, extreme care must be taken in setting the anchor bolts and aligning the pump and the shaft to prevent misalignment. The vertical turbine pump shown in Figure 9-4 is very practical for large-capacity, relatively straight and plumb shallow wells. Where deep wells or misaligned wells are encountered, it may be more practical to use a submersible pump. These units can be fitted with almost any number of stages (sections). The vertical turbine pump is well suited for high flow rates and high discharge heads and is typically used for municipal, industrial, and irrigation wells, which produce a large volume of water.

The jet pump is a centrifugal pump in which the motor and the impeller are placed on the ground surface. A jet of water flowing down the bore hole creates a partial vacuum at the bottom that, with a special fitting, draws an additional amount of water into the discharge pipe. The jet pump is used for small flow rates and high discharge heads.

The most commonly installed well pump is the submersible pump, which is a centrifugal pump that is entirely self-contained in a housing. An electrical motor in the waterproof housing is close-coupled with an impeller (or multiple impellers) and an attached discharge pipe to the surface. This pump is well suited for a wide variety of flow rates and high discharge heads. Most submersible pumps are used in wells 4 inches or more in diameter, but some pumps are available for wells that are 3 inches in diameter.

The design of a pumping system should take into consideration maintenance and the possible failure of one pump in the system. It is sometimes necessary to have a backup (second) pump, which can be expensive. However, if the system serves fire hydrants or fire protection equipment within a building without the use of a storage tank, a backup pump might be essential.

Storage Tanks

Storage tanks are useful as emergency sources of large volumes of water and to prevent overtaxing the well water supply system in firefighting situations. Elevated storage tanks provide uniform pressures and reduce energy and pump costs.

Storage tanks should be constructed of materials that are nontoxic and corrosion-resistant. The detailed construction requirements for water storage tanks intended for firefighting purposes are outlined in NFPA 22: *Standard for Water Tanks for Private Fire Protection.* Storage tank supports usually are designed to resist seismic movement. Tanks must have provisions for cleaning.

Storage tank capacity and the size of the pump system are related. Without storage, the pump(s) must be large enough to supply instantaneous demand. As the size of the storage tank increases, the fill rate of a gravity tank can be reduced. The well pump no longer needs to meet the peak hourly demand, so it can be sized to fill the tank based on the peak daily or weekly demand. With the reduction, or elimination, of peak hourly demands, the equipment size and power costs can be reduced. This also allows for nearly continuous operation of the pump at maximum efficiency.

Ground-mounted storage tanks must be installed on a concrete foundation with the footing below the frost line and have adequate support under the entire bottom of the storage tank. Taking soil-bearing tests prior to designing the foundation is extremely important. It is better to over-design than for a portion of the foundation to settle and allow the storage tank to become warped or possibly leak.

Prefabricated storage tanks are available in sections and constructed of steel with a glass lining. If a steel tank is field-erected, after its construction it must be coated on the inside with an FDA-approved epoxy-base paint, and it is suggested that the same coating or other equally durable coating be applied on the outside for weather protection. Underground metallic tanks require coatings and cathodic protection. It is recommended to consult an expert before specifying the coating.

Elevated storage tanks require engineered foundations. The foundation in such installations is just as critical as it is with ground-mounted tanks. The installation of ground-level or aboveground storage tanks raises the question of ice forming in the storage tank itself. If the water level within the storage tank is allowed to fluctuate over a broad range, the changes in the water level will break up the ice so it is not necessary to heat the tank or provide an air-bubbling system to keep the stored water in motion.

For a small residential system or light commercial system (e.g., a remotely located school), the use of a hydropneumatic storage tank could be considered because it is relatively inexpensive compared to an elevated storage tank. In sizing such a tank, assume that only one-third of the tank's capacity will be available as usable water, excluding the capacity of the well pump. Also, a compressed air supply with air-to-water balance controls to the top of the storage tank should be provided to recharge the unit, since the large water surface can gradually absorb the air and reduce the volume of the air cushion. Precharged hydropneumatic tanks eliminate the requirement for an air compressor for recharging. Unfortunately, the available sizes preclude their use to residential and light commercial applications. Generally, hydropneumatic tank systems do not provide sufficient storage for fire protection or for extended outages of the well pump.

Figure 9-5 illustrates storage tank suction piping and indicates the minimum distance below the water level that a suction inlet must be to avoid drawing air into the suction pipe. Minimum submergence is highly desirable to develop full pump output. In addition, the suction pipe should be a few inches above the bottom of the storage tank to avoid drawing any sediment into the suction pipe. Anti-vortex plates also can be utilized at suction connections to storage vessels to prevent the pump from drawing in air and cavitating.

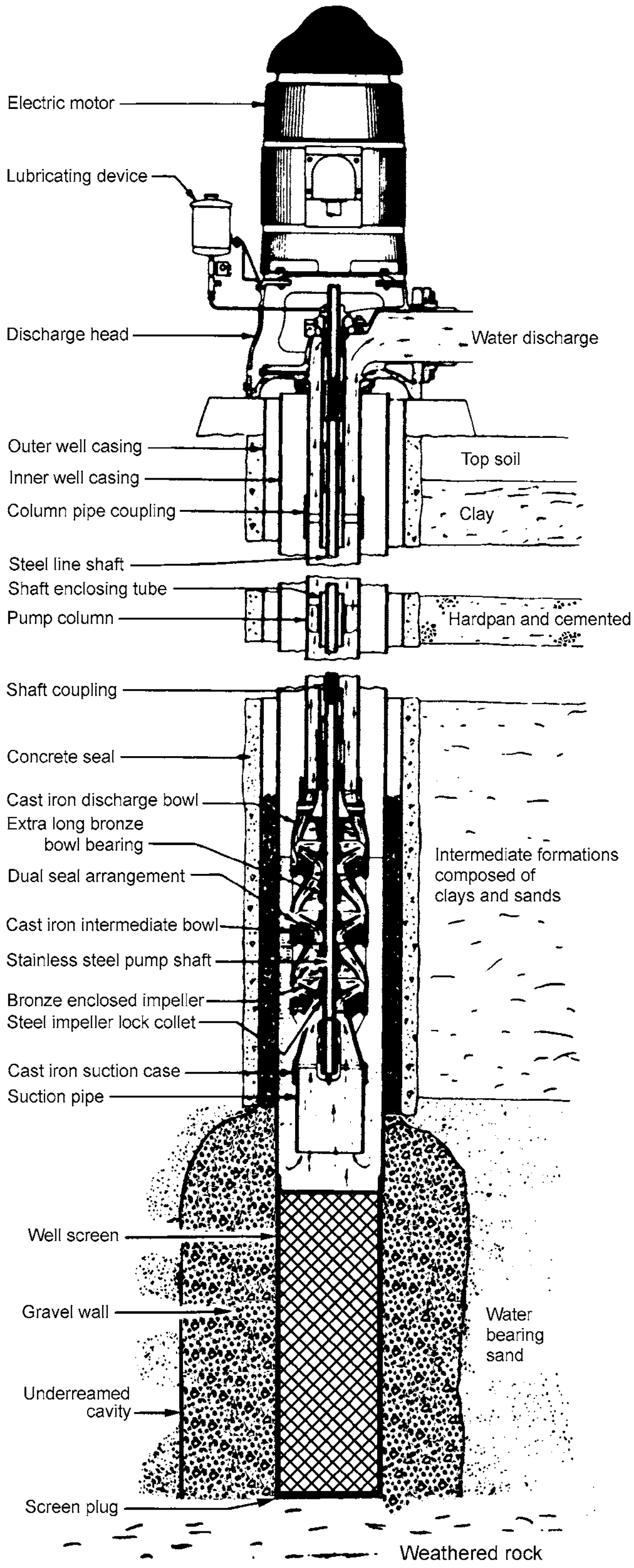

Figure 9-4 Typical Gravel Filter Well with a Vertical Turbine Pump (Note the concrete seal adjacent to the outer well casing)

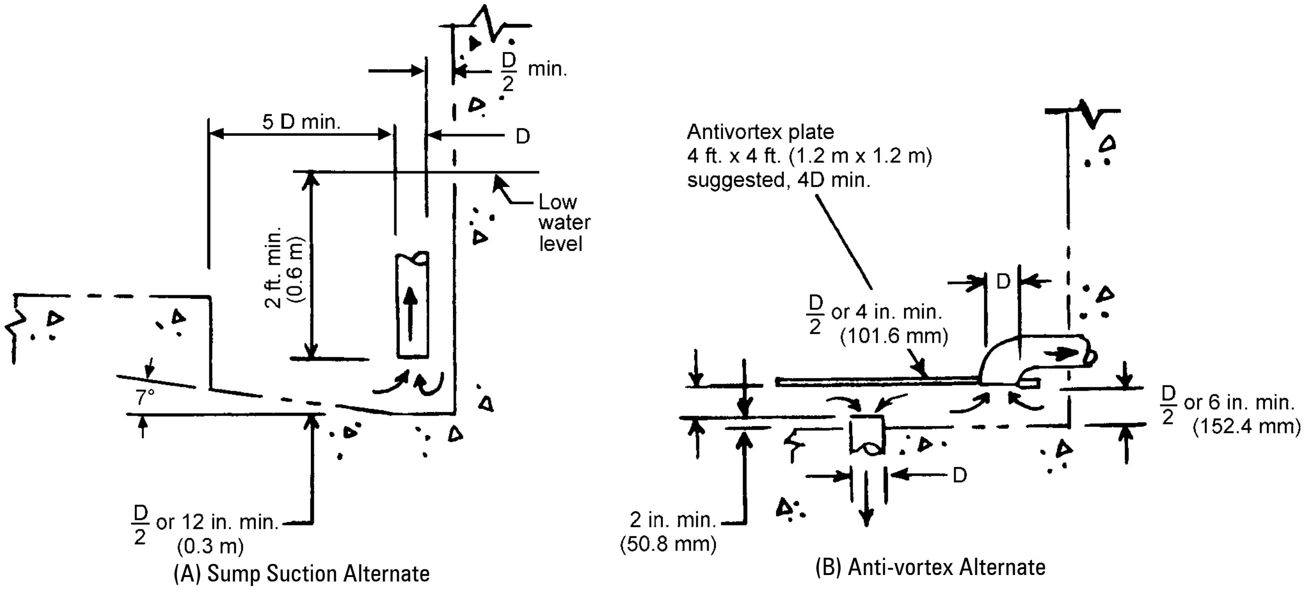

Figure 9-5 Storage Tank Suction Piping Detail

Pressure Regulators

Pressures in excess of 80 psi (551.6 kPa) in private water well systems should be avoided whenever possible; in some cases, this is required by local codes. If so, pressure-regulating devices must be installed. This condition determines the height of the elevated storage tank from the lowest point of use, as long as the highest point of the system is also satisfied. If a well pump's starting and stopping are controlled by the storage tank level, the reduced pressure condition of 80 psi (551.6 kPa) can be achieved by one of a number of acceptable means. Consult with the local administrative authority to determine the approved methods.

Unfortunately, in northern latitudes, a float-type level control in the storage tank frequently is affected by icing and, therefore, is not a very reliable device. One of the more common ways of eliminating the problem is the use of an altitude valve, which is installed in the supply line to an elevated storage tank, basin, or reservoir. The altitude valve closes at the predetermined high-water level and opens for refilling when the water level recedes. A single-acting altitude valve is employed for filling purposes only. A double-acting altitude valve is designed for two-way flows and eliminates the need for a bypass.

Another type of system currently available controls the well pump and the storage tank level by sensing the system's pressure at the point of pump discharge.

PERFORMANCE SPECIFICATIONS

Designing and specifying private water wells is not an exact science. On large-diameter wells, it may be prudent to drill an inexpensive, small-diameter test hole to determine if water is available at the proposed location. Test pumping on a small-diameter well will determine the availability of large volumes of water, as required for large-diameter wells.

It is recommended to write specifications on performance-based conditions. List estimated drilling depths through the various anticipated geographical formations, and require the installing well contractor to give a plus or minus unit cost basis for penetrating through these anticipated formations. In the event they penetrate through in a lesser depth, a legitimate credit can be received; if it is a greater depth, a pre-negotiated cost already is established. It also is recommended to establish a unit cost basis for well test pumping (per-hour basis), installed casing pipe material (per-diameter and per-foot basis), installed grout or sealing material (per pound or bag), and hourly rates for well development and clearing using shots similar to nitroglycerine blasts. Bid-form unit pricing will keep all parties on a level playing field when unexpected circumstances arise, a periodic occurrence when digging or drilling private water wells.

CORROSION PROTECTION

Metallic piping generally is chosen for well systems because of the high pressure requirements. Plastic pipes, when used, usually are not subject to corrosion, but careful selection of plastic materials should consider the pressure required and the chemical impurities in the soil and water. The occurrence of corrosion in metallic piping depends on the soil and water conditions as well. Proper water treatment and pipe linings can minimize interior attack; exterior attack may be reduced by coatings, cathodic protection, and careful selection of the backfill. Coatings must remain intact, and protection must be inspected and maintained periodically.

Require a one-year warranty and a follow-up one-year inspection of all cathodic protection devices (anodes) and protective coatings by the installing contractor for additional quality control.

INITIAL OPERATION AND MAINTENANCE

After the well has been dug, it must be developed. Every type of drilling causes some disturbance to the aquifer by clogging the pores of the formation where it exists. After the bore hole has been completed, the casing is inserted, the intake is attached, the gravel packing is installed, the pump or pumps are operational, and the 24-hour hydraulic flow test has been completed, the well is ready for disinfection.

All private water wells and potable water piping must be disinfected prior to being placed in service. This process may be accomplished by introducing a solution of chlorine followed by a thorough flushing of the system with clear water. Well-kept records of the piping and connections will facilitate good operation and maintenance. Periodic flushing, particularly of dead ends and low-velocity branches, will prevent sedimentation and fouling. Regularly scheduled valve exercising will ready the system for shutdown during an emergency. Leakage may be controlled by inspection and metering. Installation of approved backflow prevention devices will protect the private water supply from nonpotable sources. Inspections of the piping systems during and after construction will guard against cross-connections.

ASPE Read, Learn, Earn Continuing Education

You may submit your answers to the following questions online at **aspe.org/readlearnearn**. If you score 90 percent or higher on the test, you will be notified that you have earned 0.1 CEU, which can be applied toward CPD renewal or numerous regulatory-agency CE programs. (Please note that it is your responsibility to determine the acceptance policy of a particular agency.) CEU information will be kept on file at the ASPE office for three years.

Notice for North Carolina Professional Engineers: State regulations for registered PEs in North Carolina now require you to complete ASPE's online CEU validation form to be eligible for continuing education credits. After successfully completing this quiz, just visit ASPE's CEU Validation Center at aspe.org/CEUValidationCenter.

Expiration date: Continuing education credit will be given for this examination through **November 30, 2018**.

CE Questions — "Private Water Wells" (CEU 253)
Test written by Jeremy Ferriter, CPD

1. A shallow well is considered to be ___________ deep.
   a. 25 to 50 feet
   b. 50 to 75 feet
   c. 50 to 100 feet
   d. more than 100 feet

2. The size of a well is determined by ___________.
   a. the building's water demand
   b. equipment size (pump and pipe)
   c. static pumping elevation
   d. all of the above

3. As the size of a storage tank increases, the fill rate of a gravity tank ___________.
   a. can be reduced
   b. remains constant
   c. must be increased
   d. slows due to gravity

4. The most commonly installed well pump is the ___________ pump.
   a. jet
   b. submersible
   c. transfer
   d. vertical turbine

5. The most common type of well used for individual water supplies is a ___________ well.
   a. jetted
   b. bored
   c. driven
   d. dug and augured

6. The water demand for a new system is determined by ___________.
   a. the design engineer
   b. the building's owner
   c. the well driller
   d. the local administrative authority

7. A ___________ is used in regions where winter frost occurs to protect pumps and water lines from freezing.
   a. check valve
   b. drop pipe
   c. pitless adapter
   d. tremie pipe

8. ___________ is an inexpensive method of disinfecting a large water system.
   a. chlorination
   b. ultraviolet radiation
   c. ozone treatment
   d. active carbon filtration

9. Metallic piping is generally chosen for well systems because of ___________.
   a. its resistance to corrosion
   b. the high pressure requirements
   c. ease of installation
   d. price stability

10. The detailed construction requirements for water storage tanks intended for firefighting purposes are outlined in ___________.
    a. NFPA 13
    b. NFPA 14
    c. NFPA 20
    d. NFPA 22

11. ___________ is sometimes added to water with the intent of reducing dental cavities.
    a. calcium
    b. fluoride
    c. radon
    d. sodium bisulfate

12. The ___________ governs the quality of water from wells.
    a. Safe Drinking Water Act
    b. National Ground Water Association
    c. U.S. Department of Agriculture
    d. Association of State Drinking Water Administrators