Chapter 13

Well Construction

Ground water has been discussed in earlier chapters, but how to access ground water for measuring water levels, sampling water quality, and doing aquifer tests has not been described. Springs are one way to get in touch with ground water, because these are locations of ground-water discharge to the surface. But in areas where springs do not occur, hydrologists will install wells to access ground water.

In general, wells are a deep subject, so-to-speak, and this chapter won't get into all the details of how to drill and install all types of wells because this really depends on the local geology, hydrologic characteristics, depth to water, and various local, State, and Federal regulations. In this chapter, the general methods for constructing a well will be discussed.

Typically, wells are used for either water supply or scientific observation and sampling. The diameter of water-supply wells depends on the how much water is needed for specific uses. For domestic (single home) wells, the optimum diameter for well casings is around 6 inches, in which a submersible pump typically can produce up to 50 gallons per minute. For municipal (city) wells, the well diameter would be much larger, typically in the 8 to 30 inches range. Irrigation wells, where water is pumped for crops, also would be in this larger range. In contrast, many wells used for scientific observation of water levels and ground-water sampling are much smaller in diameter, often 2 to 4 inches. Even smaller wells called piezometers can be 1 inch in diameter or smaller.

Therefore, depending on the intended use, wells can widely vary in diameter. In many situations in the past, wells were actually dug by hand instead of using a drill. These wells can be very wide in diameter and often lined with stones, bricks or cement. In such cases, various objects, and even people, were sometimes

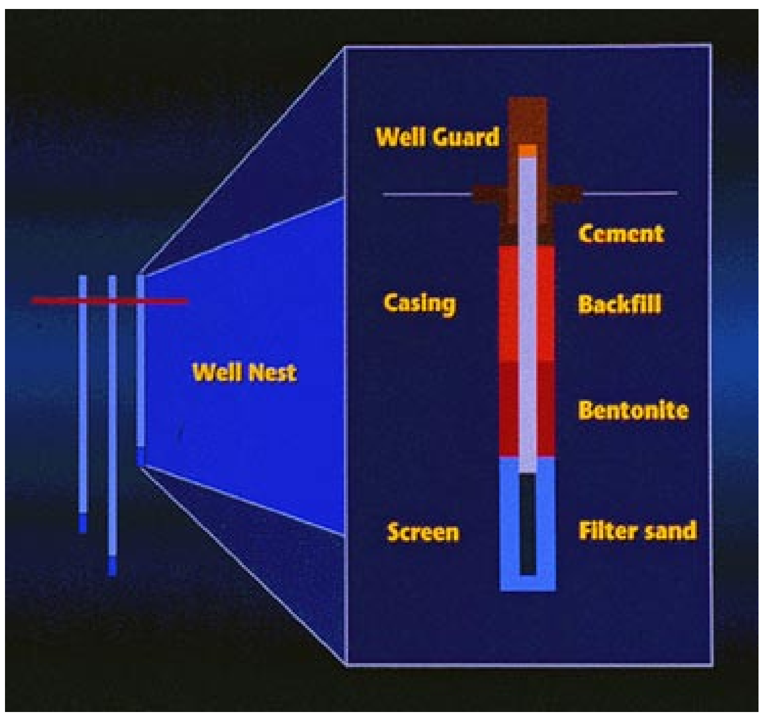
known to fall into these wells. Ancient hand-dug wells are valuable archeological sites for recovering a wide array of artifacts and remains. Hand-dug wells are rare in the U.S. today; however, several were constructed in various valleys in Nevada by early settlers and by the Civilian Conservation Corps during the Depression.

In addition to water supply and scientific observation, there are special cases for well installation. In areas of mining, wells are installed and pumped in order to lower the water table (and keep the deep mines dry). These are referred to as dewatering wells. Some wells are used for injection of water or contaminants into the ground. Many larger municipal areas now use injection wells to artificially recharge aquifers and store water underground.

Once a site has been determined for well installation (based on the hydrogeology and intended use), a well driller will be contracted to drill a hole and install a well. The type of drill used depends on the geology and depth to water from land surface. If more than one well is installed at a site, often where each well is open to different depths, the group of wells is referred to as a well nest.

In areas of unconsolidated (loose) sediments, such as in the basins of Nevada, and where the water table is less than a few hundred feet below the surface, an auger may be used, mainly for monitoring wells. This is a drill with a hollow stem in the center surrounded by auger flights to carry the cut sediments to the surface during augering. It looks a lot like a giant wood drill. The reason for the hollow stem is that the driller will auger down to beneath the water table, then place the well casing (the pipe that serves as the well) down the center of the stem and into the aquifer. The auger is left in place during this process to keep the surrounding sediments from caving in while the well is being installed. Once the well is in place, the auger is pulled up and the well is one step closer to being finished.

For domestic, municipal, or irrigation wells, or in situations where there is either solid rock or many large boulders or where one needs to drill really deep to reach water, then different drills are used. This chapter won't go into detail on these different drills, but they include cable-tool drills and direct-rotary drills, among many other types. The main objective of any of these drills is to put a hole in the ground to the aquifer and install a well. In deeper drilling methods, drillers often will inject a thick drilling mud to keep the hole open from collapse while the well is being installed.



Once the hole is in the ground, the well can be installed. In unconsolidated sediments and weathered bedrock, a well may require a well screen. A well screen is a section of slots or openings in the well casing that allows water to come into the well but holds out the sediments. Around a well screen, a driller will place filter sand, which is sand that is used to separate the surrounding sediments from the well screen and allows water to flow to the screen. The length of the screened interval of the well depends on the purpose of the well. If one wants to pump for water supply, then the screen typically will be long (10 to 20 feet or longer). If one wants to sample a specific location in an aquifer for scientific study, then a screen might only be a few feet to a few inches in length.

In consolidated bedrock, wells often will not use screens, but rather will be open hole in which water flows from the bedrock into the drilled hole. Areas in the open hole that can transmit large quantities of water, such as fractures, bedding planes, and dissolution features (caverns and holes), can control the productivity of the bedrock well.

Above the screen or open hole in bedrock, the well consists of casing that either is threaded or welded together. The casing can be made of a wide variety of materials, but often is either steel, iron, or PVC plastic. The casing is the well pipe which extends from the aquifer to land surface. Typically, a well pump is lowered down the casing to below the water level. The size and type of pump depends on the depth to water, well diameter, and intended use (how many gallons per minute is needed).

Once the well casing is in place, the well will be finished by placing bentonite (clay) in the space between the drilled hole and the casing (referred to as the well annulus) above the screen or open hole. This bentonite acts as a seal to keep water (and potentially contaminants) from seeping down the annulus and into the well. Above the bentonite seal, natural material from the drilling sometimes is used to fill in the hole. Near land surface, a cement pad is built around the top of the well again to seal the annulus and to protect the well. A heavy metal pipe, referred to as a well guard, often is placed around the top of the well and into the cement pad for added protection of the well casing.

Once well construction is complete, the well must be developed to remove drilling mud and other fine sediment produced during drilling so that the well produces clear water. This is often done by injecting compressed air above the well screen. The compressed air lifts water from the well casing, removing sediment with it and clearing the screen. The process usually takes several hours. Development also can be completed by inserting an old pump into the well and pumping the water from the well at a high rate of discharge to remove sediment. The well is then ready for pump installation for normal use. Many different types of pumps may be used and the subject is worthy of an entire chapter.

This chapter is a simplified overview of how wells are installed and constructed. Other types of wells, drills, and construction designs exist, but this provides a general overview of how many wells are installed. Special considerations and methods need to be used for wells that are very deep (thousands of feet). Innovative well installation methods are now being used that have been successful in producing larger quantities of water than the more traditional methods. Some of these new methods include angular and horizontal drilling in order to follow bedding planes, and hydrofracturing (using high pressures to produce fractures in the bedrock in order to allow more water to flow to the well).

Developing a well after completion. Photograph by D.K. Maurer, USGS.

Well drilling at Summit Lake. Photograph by J.L. Wood, USGS.