PENNSTATE

College of Agricultural Sciences Cooperative Extension

Agricultural and Biological Engineering

F 197

Before You Drill A Well

Albert R. Jarrett, Professor, Agricultural Engineering

When the decision is finally made to try to utilize groundwater as a water supply for domestic use, livestock and farmstead demands or irrigation, it is important that certain procedures be followed to insure a clean, reliable, productive well. These important steps include siting, drilling and pump testing the well. Even though following the recommendations in this fact sheet will not guarantee all the clean water you may need or desire to have, it will greatly increase your chances of having a clean, reliable, productive well which is able to meet your needs.

Siting

Groundwater exploration is not a hit or miss (or random) proposition. Excess rainwater percolates into the soil and rock beneath the earth's surface accumulating in zones of saturation called aquifers. A well is a hole drilled into the aquifer from which a small portion of the groundwater can be pumped to the surface for man's use. It is true that any well penetrating an aquifer will yield water but the amount of water produced from a randomly sited well may be very small. Such low producing wells often provide adequate water for domestic or farmstead uses. If a well is to provide irrigation water a more highly productive well will usually be needed.

Scientific methods have been developed for locating wells where they will penetrate into zones of fractured rock buried beneath the soil surface. Wells located on a fractured rock zone will produce much larger quantities of water than wells drilled into zones where the rock is not fractured. Finding the fractured rock zones, or better yet, finding the intersection of two fractured rock zones can be a time consuming and expensive procedure. Only geologists and engineers with training in aerial photo interpretation and hydrogeology are qualified to locate wells by the fracture-trace technique. If a high producing well is desired, however, the consultants fee for siting the well is worth the extra benefit.

In addition to the siting considerations discussed above which pertain to finding adequate water, wells should be located at least 50 feet from sewers and septic tanks; at least 100 feet from pastures, on-lot sewage system absorption fields, cesspools and barnyards; and at least 25 feet from a silo. Areas where groundwater comes to within 10 feet of the soil surface should also be avoided.

Drilling

Drilling a well is more than boring a hole into the earth. A finished well will consist of a borehole cut into the aquifer at a diameter large enough to accept the well casing (see Fig. 1) which will receive the pump. The decision on how large the pump must be to meet your intended demand must, therefore, be made before drilling starts. Table 1 relates the necessary well casing size to the size of pump needed to pump various quantities of water. For instance, a 6-inch casing will receive pumps which can pump up to 100 gallons per minute (gpm). If you desire to pump more than 100 gpm an 8-inch casing will be needed which will dictate at least a 10-inch borehole. Your well driller will actually make these decisions, but he must know your needs.

The borehole itself can be drilled using any one of several types of drill rigs including impact, rotary, or various combinations. After the borehole has been drilled into or through the water bearing aquifer, the well screen should be installed in the producing zone. The zones above the producing aquifer must be cased to prevent cave-ins, and the annulus between the borehole and casing must be filled with grout to keep surface contaminates from entering the well.

Development

Developing a well is the process of clearing the well of fines left by the drilling operation, and flushing these fine particles out of the gravel and aquifer between the well screen and the first few feet of the aquifer.

Development is accomplished by surge pumping, bailing or any operation which will force water through the development zone at high velocities. Developing a well is the responsibility of the well driller. Properly developed wells will yield more water than poorly developed wells.

With the well in place, the question remains "How much water can be pumped from the well on a sustained basis?" The sustained pump rate is determined by the aquifer rocks ability to move water toward the well under the influence of gravity while the well is being pumped. To determine the sustained pumping capacity of a well a **pump test** must be performed on the well. The pump test should be completed by the well drilling contractor as part of the contract to drill the well. The desire for a pump test must be made clear to the driller before drilling begins, since some drillers are not able to do pump testing. Be sure to use a driller who can complete the work including a pump test.

Pump Testing

With the well in place, the question remains "How much water can be pumped from the well on a sustained basis?" The sustained pump rate is dependent upon the aquifers ability to move water toward the well under the influence of gravity while the well is being pumped. To determine the sustained pumping capacity of a well a pump test must be performed on the well. The pump test should be completed by the contractor as part of the well drilling contract. The desire for a pump test must be made clear to the driller before drilling begins because some drillers are not able to do the pump testing. Be sure to use a driller who can complete all drilling work including the pump test.

Table 1. Well casing and borehole diameter for desired pumping rate.

Borehole Size	Casing Size	Pumping Rate
(inches)	(inches)	(gpm)
6	4	less than 20
8	6	20 to 100
10	8	75 to 175
12	10	150 to 400
14	12	350 to 600
20	16	600 to 1300
24	20	1300 to 1800
28	24	1800 to 3000

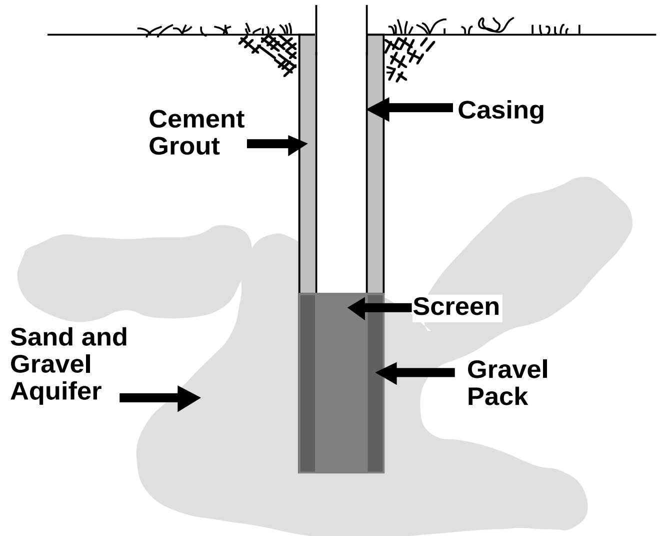

Figure 1. Well components.

Several types of pump tests have been developed, but all are designed to establish the long term equilibrium rate at which water will flow towards and enter the well. The simplest, most straightforward pump test is to place a pump in the well, after the development phase is complete, and pump water from the well at a constant rate. The discharged water must be dumped some distance from the well so it can not recirculate back into the well during the pump test. The pump rate should be great enough to stress the well, but not so great as to cause the well to be pumped dry. During the pump test, the water level in the well must be measured and recorded at regular intervals starting at the time pumping begins and continuing until pumping stops. Pumping should continue for at least 24 hours (without interruption) or until the water level in the well remains at the same elevation for three consecutive half-hour readings.

Figure 2 is a schematic of the water levels within the geologic structure while a pump is drawing water from a well. The cone of depression is produced when water is removed from the well bore by the pump, causing the water level in the well to drop. This drop in the well water level means the water surrounding the well is at a higher elevation and the gravitational water in the rock begins to flow into the well bore. As this continues, the distance between the original water table and the water level in the well, or drawdown, increases forming a large cone of depression. At some point, the drawdown reaches a point of equilibrium, where the water flows to the well at the same rate as it is being pumped from the well. This equilibrium usually occurs after 24 to 48 hours of continuous pumping at a constant flowrate.

The capacity of a well can be estimated by first determining the specific capacity of the well. Specific capacity Sc of a well is the pump rate, Q in gallons per minute during the pump test, divided by the drawdown, s (in feet) after 24 hours or at equilibrium. In other words, the specific capacity is the flowrate per foot of drawdown.

$$Sc = Q(gpm)/s(ft)$$

Knowing the depth of the well and where the permanent pump will be placed, the maximum permissible depth to water in the well can be taken to be 10 feet above the permanent pump intake location. The difference in elevation between the original water table and the maximum permissible depth to water is the maximum drawdown, S_{max}. The maximum sustainable discharge for the well is then the specific capacity times the maximum drawdown.

$$Q_{max} = Sc\ (S_{max})$$

After the pump test is completed, you will have developed knowledge about how much water the well can be expected to produce. You are now ready to proceed with your irrigation design.

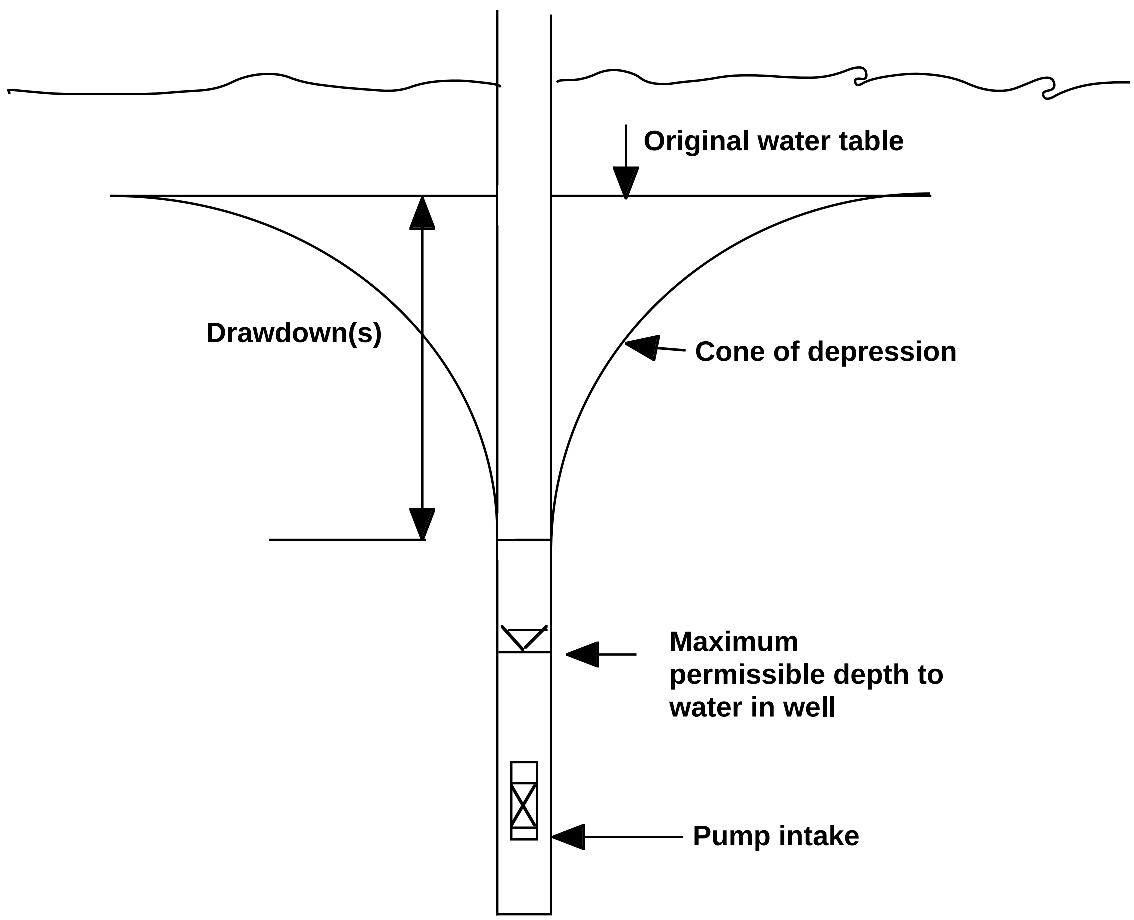

Figure 2. Well hydraulics.

PSU/90
For a copy of our Fact Sheet Listing contact:
Agricultural Engineering Department
246 Agricultural Engineering Building
University Park, PA 16802
Telephone: 814-865-7685 FAX: 814-863-1031