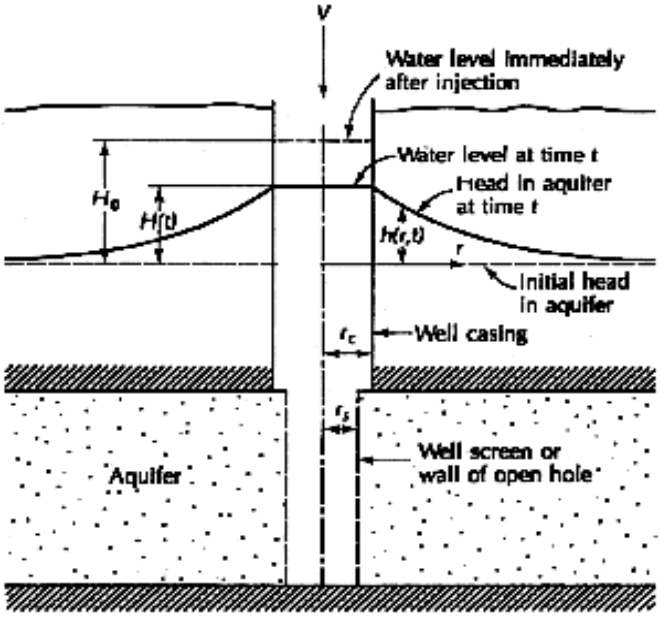
Let's Talk Water – Aquifer Tests

By Dr. Mike Strobel

In previous articles, I have referred to aquifer tests for making estimates of aquifer properties, such as hydraulic conductivity, transmissivity, and storage. In this week's article, we will explore how these tests are designed.

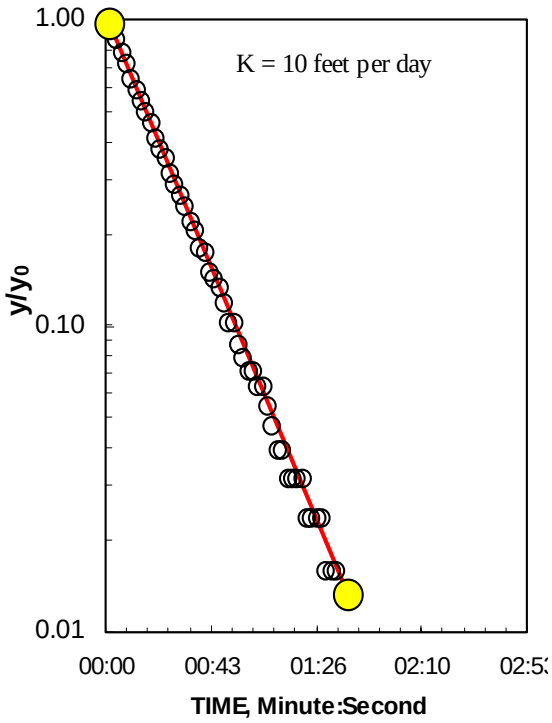
There are various methods for doing aquifer tests. These include slug tests, single well pumping tests, and multiple well pumping tests. In each test, the underlying goal is to stress the aquifer by either pumping water from a well or placing a slug (solid object or volume of water) into a well, resulting in a change in the water level in the well, then measuring the rate of change in water levels as the aquifer returns to normal (static) conditions.

A slug test is a method to test the hydraulic properties of the aquifer immediately adjacent to a well. It involves placing a solid object or volume of water quickly (i.e., a slug) into a well, thus changing the water level in the well. This also can be done by pulling a volume of water out of the well. Either way, once the water level is altered, the time it takes for the water level to return to static conditions (pre-test levels) can tell us a lot about the aquifer surrounding the well.



The changes in water levels over time (elapsed time from the initial insertion of the slug) are plotted on a graph. The shape and slope of the curve resulting from plotting water

levels verses time can provide information for calculating estimates of hydraulic conductivity and storage.



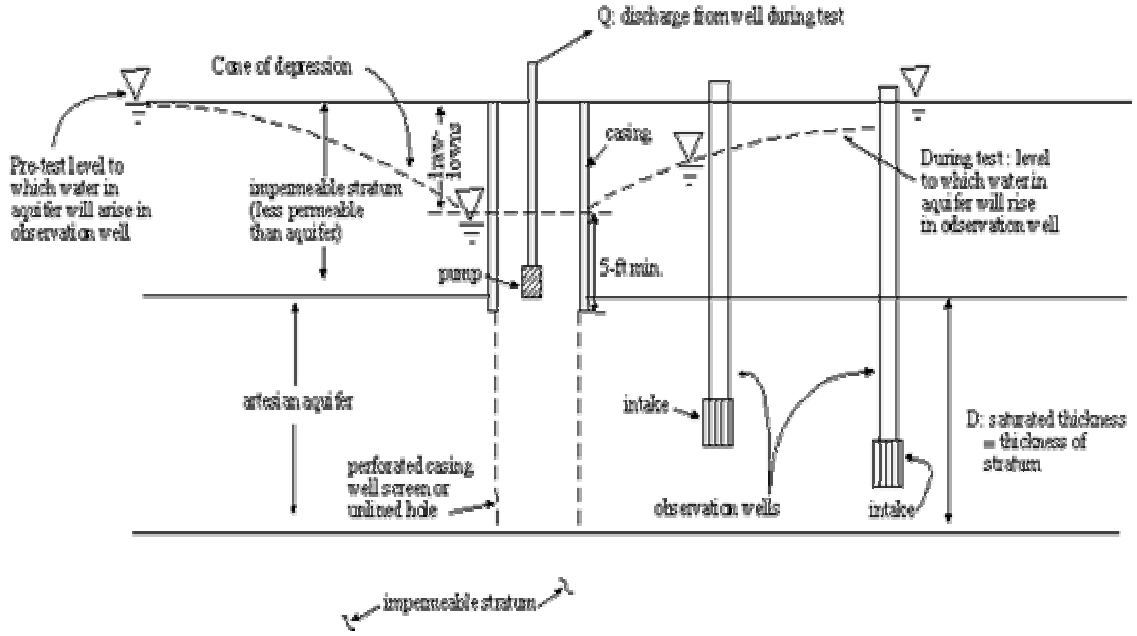
Slug tests are a quick and inexpensive way to quantify aquifer properties. The limitations of slug tests, though, are that they only stress the aquifer right around the well (zone of influence only extends a few feet from the well). Therefore, slug tests only provide information for that specific location where the well is located and do not give a regional perspective of hydraulic conductivity.

For example, if an aquifer has a lot of fractures or karst, but the well being tested does not intersect these features (it is open to the solid bedrock), then a slug test would give values of hydraulic conductivity for only that part of the aquifer adjacent to the well and would have much lower hydraulic conductivity values than most of the region. Conversely, if a well intersects a fracture or a cavern and the majority of the aquifer is solid rock, then the slug test would give much higher values of hydraulic conductivity than is typical for the aquifer.

A single well pumping test is similar to a slug test in that each well is tested independently. For a single well pumping test, a well is pumped at a set rate and water levels in the well are measured until a steady level is obtained. Then the pump is shut off and the rate of recovery in the well is measured. Similar to a slug test, the change in water levels in the well verses time are plotted on a graph. The shape and slope of the plotted curve can provide information that can be applied to calculations for estimating hydraulic conductivity and storage.

A single well pumping test is more expensive to conduct than a slug test because you need a pump and it takes more time and manpower, but it has some distinct advantages. The single well pumping test will stress a larger part of the aquifer by pumping from a wider contributing area (extending many feet to even hundreds of feet from the pumped well). Still, only the part of the aquifer contributing to the pumping well is measured, so aquifer variations over distance are difficult to identify.

Multiple well pumping tests are the best means for gathering hydraulic information about an aquifer. To conduct these tests, one well is designated as the pumping well and other wells surrounding the pumping well are used as observation wells. The pumping well is pumped for some period of time (hours or days, typically) and the water levels in the observation wells are measured. Around the pumping well, a cone of depression will occur (drawdown in pressure or water levels due to pumping). The shape of the cone of depression is assessed by looking at water levels in the observation wells.



This type of aquifer test is the best of the three methods because it provides a better, 3-dimensional view of how the aquifer reacts to stress. The more observation wells used, the more accurate the assessment. Not only can the hydraulic conductivity, transmissivity, and storage be calculated, but hydrologists also can assess how variations in the aquifer, such as if fractures, bedding, or karst affect ground-water flow velocities and directions (anisotropy) and if the aquifer is different in one area verses another (heterogeneity). In an ideal (homogeneous and isotropic) aquifer, one would expect each observation well to react in a similar fashion (proportional to distance from the pumping well). If this isn't the case, then the aquifer test can identify where the aquifer varies and how it differs. This is very useful information in assessing aquifer characteristics and dimensions.

Some people have asked how an aquifer test would benefit our understanding of the ground-water system in eastern Nevada. In the case of the proposed aquifer test in Lincoln County, this would be a multiple well pumping test. One deep well would be pumped for a long period of time and reaction measured in observation wells. The observation wells would help identify any changes in the bedrock aquifer and in the overlying aquifer due to pumping. This would help in the understanding of how deep pumping might affect the shallow alluvial aquifer. And a long-term pumping test would help hydrologists understand the aquifer properties in the deeper ground-water system.

Aquifer tests are a complex subject and I have only touched on the various topics. This may have been too technical for many folks and not enough information for others. I hope this provides a general overview of how a test is conducted and why we do aquifer tests. If there is an interest, I can go into more detail in future columns.

If you have questions concerning aquifer tests or any other water subject, please contact me through the Ely News or at mstrobel@usgs.gov. Next week, we will discuss how water is age dated (when did it recharge the ground water).