Chapter 16

Aquifer Tests

In previous chapters, aquifer tests have been referred to for making estimates of aquifer properties, such as hydraulic conductivity, transmissivity, and storage. In this chapter, the design of aquifer test will be discussed.

Various methods for doing aquifer tests 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 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 can tell a lot about the aquifer surrounding the well.

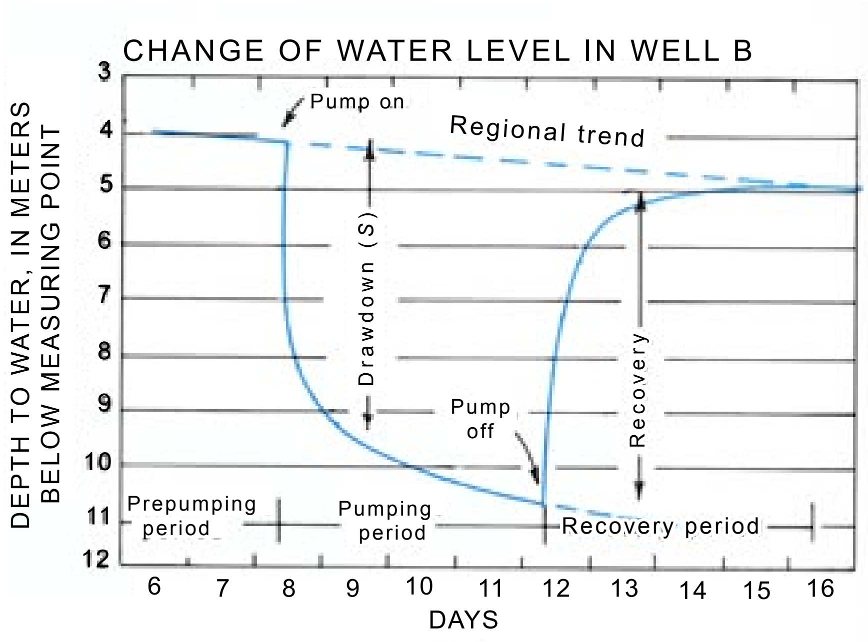
The changes in water levels over time (elapsed time from the initial insertion of the slug) are plotted on a graph. The shape and slope of the curve resulting from plotting water levels versus time can provide information for calculating estimates of hydraulic conductivity and storage.

Slug tests are a quick and inexpensive way to quantify aquifer properties. The limitations of slug tests 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 values of hydraulic conductivity 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.

Aquifer test in Dry Valley. Photograph by D.L. Berger, USGS

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 versus time are plotted in 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.



Source: Heath, 1989.

A single well pumping test is more expensive to conduct than a slug test because a pump is necessary 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, three-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 versus another (heterogeneity). In an ideal (homogeneous and isotropic) aquifer, each observation well would be expected to react in a similar fashion (proportional to distance from the pumping well). If this is not 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.