Appendix M

Identification of Confined Aquifers

Driscoll (1986) defines confined aquifer as *"a formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric"*.

Correct identification of confined aquifers is important because many management decisions regarding water supplies and land use are based on that determination. Confined aquifers are protected from local contaminant sources (underground storage tanks and septic systems, for example), and therefore provide relatively safe water for potable use. Confined aquifers occur in various hydrostratigraphic sequences. One common conceptualization of a confined aquifer is that of a water-bearing unit open to the atmosphere in the mountains where it receives recharge from precipitation. The laterally continuous water-bearing unit extends into the valley where it is buried by fine-grained sediments that confine the water-bearing unit. The distance from the confined aquifer in the valley to the mountains may be tens or hundreds of miles. In that conceptualization, the valley aquifer is correctly classified as confined even though that same water-bearing unit is considered an unconfined aquifer at a distant location in the mountains. If, in this example, the scale is reduced to tens or hundreds of feet, the confining unit is generally not considered laterally continuous and the aquifer is unconfined. The issue of scale and confined conditions is often dependent upon the management decision being considered. For example, a confining unit that is laterally continuous over a mile may adequately confine and protect the underlying water bearing zone (and protect several low-yielding domestic wells) from contaminants produced from a limited number of domestic septic systems. The same water-bearing unit might not be considered confined and protected from surface contaminants if there were multiple high-yielding municipal or industrial wells (with relatively wide cones of depression that could extend beyond and above the confining unit) with numerous sources of contaminants above and peripheral to the boundaries of the confining unit.

A criterion commonly used in the water industry for identifying confined aquifers is: if the static water elevation is above the elevation of the first water-bearing zone encountered during drilling, then the aquifer is confined. Let's look at this criterion in comparison to the two parts of Driscoll's definition:

- If the material above the water-bearing zone is a low permeability material of sufficient thickness to isolate the water-bearing zone from the atmosphere such as a clay unit or non-fractured bedrock, the aquifer is confined according to the first part of the definition; and
- if the water in the well appears to be subject to greater than atmospheric pressure because it rises above the top of the water-bearing zone, then the aquifer is confined according to the second part of the definition.

However, that commonly used criterion does not account for other factors that must be considered before the aquifer can be considered confined and thus protected from potential contamination. The most important factor is the lateral continuity of the overlying low-permeability confining unit. If the low-permeability confining unit is not laterally continuous, the aquifer cannot be considered confined. Another factor is the water-bearing characteristics of the confining unit. If the confining unit can transmit water at a significant rate, and those transmissive properties are not recognized during drilling, the aquifer beneath the assumed confining unit may be incorrectly classified as confined. Two examples will help illustrate these issues.

The first example is a well drilled into a fractured bedrock aquifer. Figure 1 shows a fracture that is intersected by and is supplying water to a well, the fracture is open to the atmosphere a short distance from the well. The static water level in the well rises above the intersection of the fracture and the well, and the rock penetrated above the fracture is relatively impermeable and dry. Based only on the lithology encountered in the borehole and the static water level, the fracture would be considered part of a confined aquifer that is protected from local contaminant sources. In this case, the confining unit (unfractured bedrock) is not laterally continuous. Therefore, the well is not completed in a confined aquifer. Somewhat paradoxically, due to the rapid velocity of groundwater flow in fractures as compared to velocities in unconsolidated sediments, the well in figure 1 is extremely susceptible to surface contaminants.

The second example (figure 2) shows a well installed through two layers of unconsolidated sediments. Layer 1 is a low permeability unit that is partially below the water table. Although it has low permeability, layer 1 is too transmissive to be considered a confining unit. However, due to its relatively low permeability no noticeable water is produced from layer 1 while the well is drilled. The lack of noticeable water production during drilling through layer 1 can be caused by the speed of drilling, the use of drilling fluids, the method of driving casing, or the smearing of fine materials along the borehole wall. A significant amount of water is produced when the drill bit penetrates layer 2, a more permeable unit, and subsequently the static water level in the borehole rises up into layer 1, which mimics confined conditions. In this scenario, the water-bearing properties of layer 1 are misinterpreted during the drilling process, which may result in an incorrect classification of layer 2 as confined.

In summary, the difference between confined and unconfined aquifers is an important distinction for those who rely on wells to provide a protected source of potable water, and for those who base management decisions on the confined or unconfined nature of ground water. More than one piece of evidence is needed to determine whether an aquifer is confined. Basing a decision only on the static water level in a well may lead to an incorrect classification.

References

Driscoll, Fletcher G. 1986. Groundwater and Wells, 2^{nd} Edition.