Theory of Aquifer Tests

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CHANGES IN ATMOSPHERIC PRESSURE

It has often been observed that water levels in wells tapping artesian aquifers respond to changes in atmospheric pressure. An increase in the atmospheric pressure causes the water level to decline, and a decrease in atmospheric pressure causes the water level to rise. The diagrams shown in figure 22 will aid in explaining why this phenomenon is observed in artesian wells and why it ordinarily is not observed in water-table wells.

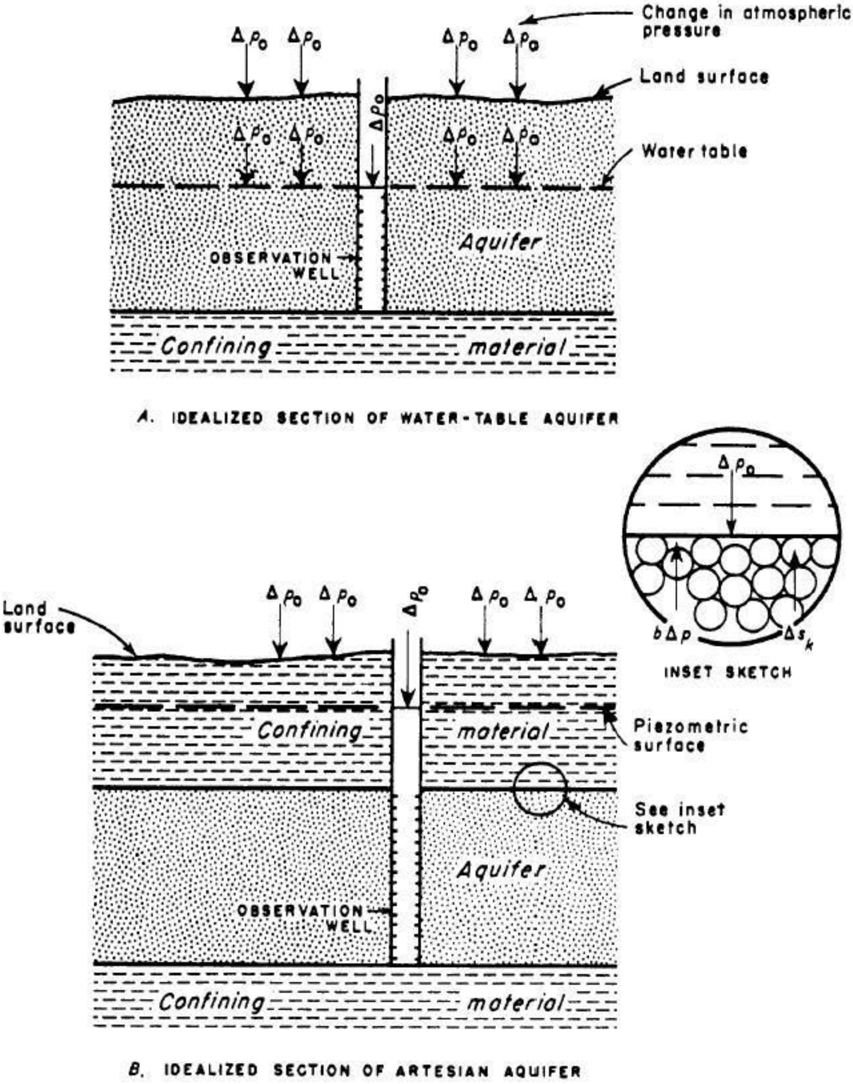

FIGURE 22.—Effect of atmospheric pressure loading on aquifers.

Referring to diagram *A*, figure 22, the force Δp_0, representing the change in atmospheric pressure, is exerted on the free water surface in the well. The same force Δp_0 is also exerted simultaneously on the water table because there is direct communication between the atmosphere and the water table through the unsaturated pore space of the soil. Thus the system of forces remains in balance and there is no appreciable change in water level in the well with changes in atmospheric pressure. Some water-table wells exhibit barometric fluctuations if the soil is frozen or saturated with water. But either of these conditions is, in effect, only a special case of the artesian condition.

Referring to diagram *B*, figure 22, the force Δp_0, which again represents the change in atmospheric pressure, acts on the free water surface in the well and also on the layer of material confining the artesian aquifer. Jacob (1940) in discussing this situation, reasons that barometric fluctuations in a well are an index of the elasticity of the aquifer. In other words the confining layer, viewed as a unit, has no beam strength or resistance to deflection sufficient to withstand or contain any sensible part of an applied load. Thus in effect any changes in the atmospheric pressure loading on a confining layer are transmitted through it undiminished in magnitude. The forces acting at a point at the interface between the aquifer and the confining layer may then be drawn as shown in the inset sketch. Observe that the change in atmospheric pressure, Δp_0, is now accommodated by a change in stress in the skeleton of the aquifer, Δs_k, plus a change in the water pressure in the aquifer, Δp, applied over the percentage b of the interface, where the water is in direct contact with the confining layer. It is evident, therefore, that in an artesian situation there will be a pressure differential between an observation well where the water is directly subject to the full change in atmospheric pressure, and a point out in the aquifer where the water is required to accept only part of the change in atmospheric pressure. Thus barometric fluctuations will be observed in the well. Some wells near the outcrop of an artesian aquifer or near a discontinuity in the confining layer will show little or no response to atmospheric pressure changes.

Although not associated with the elasticity of artesian aquifers, it is interesting to note that the phenomena of blowing and sucking wells, which exhibit a pronounced updraft or downdraft of air at the well mouth, may also be related to changes in atmospheric pressure. In areas where such wells have been noted, a bed of fine-grained, relatively impermeable material usually lies some distance above the water table, thereby effectively confining, in the intervening un-