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Guest Editorial/

Another Water Budget Myth: The Significance of Recoverable Ground Water in Storage

by William M. Alley

Considerable attention has been given in recent years to debunking the water budget myth that equates the safe or sustainable yield of ground water with recharge. There is another water budget myth that occasionally appears in water resources planning—that the volume of recoverable ground water in storage for a particular area or aquifer (i.e., the product of the area, saturated thickness, and specific yield) is by itself meaningful in analyses of water availability.

At the global scale, consider the commonly cited statistic that ground water comprises more than 95% of the nonfrozen fresh water on earth. Although this statistic illustrates the value of ground water as a reservoir, it also is misleading in that it implies much more water is available in the global ground water pool than is realistically recoverable, and it overlooks the large spatial variations in storage and transmissive properties and in water quality from location to location.

At the local or regional scale, estimates of the useful life of an aquifer are sometimes derived by dividing an estimate of recoverable water in storage by an estimate of annual ground water consumptive use. Aside from uncertainties in the numerator and denominator, the resultant estimate is only potentially useful in a ground water mining situation where recharge is minimal and no other effects beyond depletion of aquifer storage are of concern. Where the recharge is significant, this estimate grossly underestimates the useful life of the aquifer.

As a practical matter, it is impossible to remove all water from storage with pumping wells. The use of specific yield in calculations of the recoverable ground water in storage takes account of water retained in the rock matrix by capillary forces, but many other factors limit the amount of water actually "recoverable." The aquifer's permeability, water quality, the cost of drilling wells, the cost of lifting water, and the design of the well and pump all limit the volume of water that is usable in practice. Slow leakage from confining units and water quality changes make it particularly difficult to relate estimates of the volume of ground water in storage to the usable volume of ground water in confined aquifers.

In addition to considerations about the economic recoverability of ground water, depletion of a small part of the total volume of water in storage (in some cases, only a few percent) can have substantial effects on land subsidence and reduced availability of surface water for use by humans or riparian and aquatic ecosystems. These external effects can become the limiting factors to development of the ground water resource. For example, the Central Valley of California and the greater Houston, Texas, area have vast ground water resources, but land subsidence has caused expensive conversions to partial reliance on surface water with only a relatively small depletion of the entire ground water resource (Alley, W.M. 2006. Tracking U.S. groundwater: Reserves for the future? *Environment* 48, no. 3: 10–25). Well-known areas in which the effects of ground water pumping on surface water resources have become important issues with limited overall ground water storage depletion include the Edwards aquifer in Texas (where a few feet of water-level change can affect spring discharge required for endangered species habitat), the Upper San Pedro Basin in Arizona (depletion of about 1% to 2% of the 20 to 26 million acre-feet of total ground water storage in the Sierra Vista subwatershed; Arizona Department of Water Resources. 2005. Upper San Pedro Basin Active Management Area review report: 3-25, Tucson, AZ: Arizona Department of Water Resources; D.R. Pool, written communication, 2006), and the Upper Republican River Basin in Colorado, Kansas, and Nebraska (depletion of about 3% to 5% of the 350 million acre-feet in storage; D.K. Todd, written communication, 2005).

In summary, the large volume of ground water in storage is among its greatest attributes as a source of water for humans and the environment. Nonetheless, reported estimates of the volume of recoverable ground water in storage should be viewed with caution. Efforts to link such estimates with ground water availability may be highly misleading unless the full effects of ground water development are considered in the analysis. These effects are the same as those that complicate statements about ground water sustainability.

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