ground water

Discussion of Papers/ Christopher Neuzil, Discussion Editor

"*The Water Budget Myth Revisited: Why Hydrogeologists Model*," by John D. Bredehoeft, July–August 2002 issue, v. 40, no. 4: 340–345.

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In an issue paper published in *Ground Water*, John Bredehoeft challenges the unremitting idea that sustainable development of ground water resources is simply a matter of limiting pumping to the recharge rate. Bredehoeft calls this the water budget myth, and carefully explains and illustrates cases in which it is misleading. (A recent, lucid explanation of why this water budget myth persists is given by Devlin and Sophocleous [in press].) He also states that virgin or predevelopment recharge rates are unimportant to the determination of the maximum magnitude of sustainable ground water development, and supports this view using theoretical and conceptual arguments with which we are in complete accord. However, Bredehoeft condemns the association of recharge and sustainable development so forcefully that readers may be left with the impression that recharge is not worth considering at all. Our purpose in writing this discussion is to point out when and where recharge is worth considering in the study of sustainability. The point is further amplified in Sophocleous (in press).

Sustainable ground water development entails more than sustainable pumping, and it depends on such factors as water quality, ecology, and socioeconomic considerations, to name a few. All of these in one way or another depend on recharge rates. For example, in regions where virgin recharge rates are large, the virgin discharge rates (D_o) are also large, and aquifers can sustain correspondingly large pumping rates (P). In many cases where recharge is not impacted by pumping, because $P = \Delta D_o$ (where ΔD_o is the change in discharge following the onset of pumping [Bredehoeft 2002]), a large D_o can support a large ΔD_o and therefore a large P. This means that for aquifers with boundaries that undergo no flow reversals, the maximum sustainable pumping rate in a system with a high recharge rate is also large compared to a geologically similar aquifer with a low virgin recharge rate. Clearly, a general knowledge of recharge rates is needed to decide how to manage the resource—that is, whether to mine the resource (if the recharge rate is relatively miniscule) or to extract the water at a smaller rate consistent with a renewable resource without exhausting it.

Another example of the importance of recharge rates is their influence on the residence time of water in the vadose zone, which, in turn, would affect the aquifer's water quality. Similarly, recharge pathways are also important; recharge through fractures may occur over much shorter times than recharge through porous media, leading to different degrees of leaching and different geochemical evolution.

Finally, the use of numerical modeling for estimating sustainable pumping rates brings relevancy to recharge rates. Any modern assessment of ground water sustainability requires a computer-modeling component to assess the long-term behavior of the aquifer and its sustainable yield. Information on both the quantity of recharge and its spatiotemporal distribution is required for such numerical modeling, and simulation results are highly sensitive to these inputs. Notably, many models are calibrated without exact knowledge of these inputs. The tradeoff here is a pragmatic one; some of the model's representation is sacrificed because of the cost and technical challenges of obtaining accurate recharge data. Nevertheless, there is an obvious need to collect and utilize the best possible estimates of recharge to ensure that the models represent the simulated aquifer systems as accurately as possible.

The aforementioned considerations indicate that sustainability is indeed affected by recharge rates. Therefore, those concerned with sustainaiblity should not dismiss recharge rates. At the same time, practitioners should realize that estimation of sustainable pumping rates depends on how much recharge and discharge rates can be changed by well capture, a concept first explained by Theis (1940) and later elucidated by Bredehoeft (2002), among others.

References

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