From: Mayer, Tim [mailto:tim_mayer@fws.gov]
Sent: Friday, November 22, 2013 10:26 AM
To: Oppenheimer, Eric@Waterboards
Cc: Rachel Esralew; Curtis McCasland; Dale Garrison; Mark Pelz; Karen Laing
Subject: Groundwater Workplan Concept Plan

Eric,

I am a hydrologist with the US Fish and Wildlife Service in Region 1 and 8, which includes California. Our agency has a unique perspective in that we are both a consumer and a protector of groundwater. We pump groundwater on some of our wildlife refuges for water supply and we work to protect habitats (phreatophytes, springs, wetlands) that are naturally supported by groundwater or high water tables, both on and off refuges.

I looked at the draft Concept Plan briefly and I would like to add one comment. I think there could more emphasis on the connection between groundwater and surface water resources and the need to manage the two resources conjunctively. The focus in the paper now seems to be on exclusively on groundwater, specifically managing groundwater quality and preventing overdraft. "*The greatest challenge for groundwater quantity is overdraft leading to subsidence and the permanent loss of storage capacity*"

There are biological resources and aquatic ecosystems that are often connected to and supported by groundwater (springs, wetlands, streams, riparian areas, phreatophytic vegetation). These resources and systems can be impacted by pumping long before the system is overdrafted or there is a major loss of storage. We have a refuge in Nevada where we have documented major declines in spring discharge that have occurred as a result of a small, 2-foot decline in head that propagated from groundwater pumping located some 15-20 miles away from the springs. Certainly the system isn't overdrafted and we haven't lost much storage and yet the impacts to springs are a major concern to all parties, enough to halt the pumping.

As the attached editorial states (Bredehoeft, 2007), human activities that impact a groundwater system will ultimately impact the discharge from that system and this will affect surface water resources to some degree. The interaction of groundwater and surface water needs to be understood and considered whenever groundwater management plans are developed. Interested parties, communities, and society will need to decide what impacts and trade-offs are acceptable for both the groundwater and surface water systems.

I hope this comment is helpful.

Tim

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ground water

Guest Editorial/

It Is the Discharge

by John Bredehoeft

We all know the mantra *Keep It Simple*—the principle KISS. I have been thinking of another mantra for ground water—*It Is the Discharge*. Let me explain: In a recent conversation with one of my distinguished colleagues, he bemoaned our lack of understanding of ground water recharge. I keep thinking about that conversation. In a broad sense as hydrogeologists, we are hoping to understand how aquifer systems function, more particularly how much water is flowing through a particular system—the focus on recharge is simply one facet of the larger task. In studying the system, there are at least three aspects that we can focus on—(1) the recharge; (2) the aquifer itself as a transmission mechanism; and (3) the discharge from the aquifer.

One of the first principles of hydrogeology is that the recharge is balanced by the discharge before the system is perturbed. One tack commonly taken is to focus on the discharge and assume that recharge equals discharge. Of course, when we model a system in a virgin state, the mathematics demand conservation of mass, and the recharge, flow through the aquifer, and the discharge are balanced (or we do not have a solution to the problem). Often it is the capacity of the aquifer to transmit water that determines both the recharge and the discharge—the aquifer can accommodate only so much flow.

Generally, the recharge is the most difficult component of the ground water system to quantify, which brings me back to my colleague's comment—Shouldn't we be spending additional research effort to understand the recharge? My response is that it is more fruitful to examine the discharge. However, rarely do I hear hydrogeologists say that they are studying ground water discharge, especially in the academic community. Yet, the discharge is generally there to be observed—it occurs as springs, as base flow to streams, and as water for phreatophytes in the desert environment. There is a reason why hydrogeologists in Nevada still use the Maxey/Eakin method to estimate recharge, a method published in 1949—no one has come up with an improved procedure to estimate recharge even given 50+ years of further investigation. On the other hand, the methods of measuring phreatophyte discharge are greatly improved.

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Furthermore, human activities that impact a ground water system ultimately impact the discharge. It is usually the ground water discharge that is captured during ground water development. The USGS (1972) in *Definitions of Selected Ground Water Terms* published the following definition of *capture*:

> Water withdrawn artificially from an aquifer is derived from a decrease in storage in the aquifer, a reduction in the previous discharge from the aquifer, an increase in recharge, or a combination of these changes. The decrease in discharge plus the increase in recharge is termed capture.

Many aquifers can be analyzed mathematically as if they are linear systems; this includes all confined aquifers and even water table aquifers where the change in head, caused by a given stress, does not change the saturated thickness greatly. In this case, neither the recharge nor the discharge is of concern; rather, the changes in these quantities, caused by the stress—the capture, are of interest. In the linear mathematical system, if one knows (1) the geometry of the aquifer system, (2) its hydrologic properties (permeability and storage), and (3) the boundary conditions, one can determine the impact of a given stress on the system. Often it is the discharge that we end up capturing.

Even if the recharge is not of pragmatic concern, it still may be of interest—we would like to fully understand the ground water system. Other factors such as how contaminants are transported through the system sometimes depend upon the recharge.

I have no doubt that studying recharge will be high on the list of research topics for the future. I am also confident that the recharge is better understood through the discharge where there is an integrated and observable hydrologic signal, and that discharge is of much more pragmatic concern than recharge. Harold Thomas, the distinguished professor of Water Resources at Harvard, was working on the problem by studying stream hydrographs; unfortunately, he died before he could publish his ideas. I tried unsuccessfully to point out the importance of the discharge in commenting on a proposed National Academy of Sciences/National Research Council research agenda—my remarks had no impact. Still, my argument is—*It Is the Discharge*.

Editor's Note: Opinions expressed in the editorial column are those of the author(s) and do not necessarily reflect those of the National Ground Water Association or the staff of the journal.