CONJUNCTIVE USE: THE IMPACT OF PUMPING WELLS ON A NEARBY STREAM

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B15 (ALS Users Complex), Room 253, Berkeley Lab

ABSTRACT

The impact on streamflow of a well, pumping from an alluvial aquifer associated with the stream, is a classic problem in hydrogeology. Their first solved this problem analytically in 1941, using the principles of superposition; Glover and Balmer simplified the analytical solution in 1954, by showing it to be an error function. Economic studies at Resources for the Future in the 1970s demonstrated that the output from the combined system, wells and stream, could be doubled through effective management. Even though various investigators have addressed facets of this problem over the past seven decades, the problem is still misunderstood by many hydrogeologists—many myths remain.

Many wells, especially irrigation wells, pump seasonally. A well pumping seasonally from an alluvial aquifer within one quarter mile of a stream creates a seasonal streamflow depletion in phase with the pumping, and the same each year. However, as the well is further removed from the stream, the aquifer dampens the seasonal fluctuations. At a distance of approximately two miles from the steam, the streamflow depletion created by the well is approximately the same as a well pumping at a constant rate, equal to the total withdrawal averaged over the year. For example, if one were to pump the well two miles from the stream at 4 cfs for three months, the effect on the stream would be approximately the same as if the well were pumped continually at 1 cfs. The effect of distance is dependent upon the aquifer properties: transmissivity and storativity. In the case of the well two miles or further from the stream, the full impact of the pumping on the stream takes a decade, or more, to fully develop.

Wells are often more or less uniformly distributed across an aquifer associated with a stream. The impact of the ensemble of wells on the streamflow is similar to the single well two miles or more away from the stream. Again, it takes at least a decade of pumping for the full impact on the stream to occur. Were one to stop pumping an ensemble of wells, it would take at least a decade for the streamflow to return to a state where it is not impacted by the prior pumping. In other words, if one wanted to eliminate the full impact of pumping by an ensemble of wells on the stream today, one would have had to stop the pumping at least a decade ago.

Usually, the alluvial aquifer associated with a stream is the largest reservoir of water anywhere in the system; it is there as a reservoir to be taken advantage of through effective management. Managing a conjunctive stream and associated aquifer system requires long-range planning because of the lag time in response created by the aquifer. It cannot be managed effectively on a short-term basis.

BIOGRAPHICAL SKETCH

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In 1995, after 32 years, John Bredehoeft retired as a senior research geologist with the USGS, and established The Hydrodynamics Group, a consulting firm. During his years at the USGS, he held both scientific research and high-level management positions.

At the USGS, working together with George Pinder, Bredehoeft developed and published (1) the first widely utilized groundwater flow model for which they received the Horton Award of the American Geophysical Union—Pinder & Bredehoeft, 1968; and (2) the first widely used contaminant transport model (for which they received the Medal of the Geological Society of America—Bredehoeft & Pinder, 1973). During his career in research, Bredehoeft worked on a variety of other topics, including analytical methods for the field determination of aquifer parameters, and geophysical experiments for both the prediction and control of earthquakes. He spent two years at Resources for the Future (RFF), where he engaged in analytical studies related to the economics of groundwater management. He engaged in experiments utilizing water wells as strain meters at Parkfield, CA, and in studies of the hydrodynamics of deep sedimentary basins. In recent years, he has also worked on studies of contaminant movement and nuclear waste disposal.

Bredehoeft taught one year as a visiting professor at the University of Illinois and was a consulting professor at Stanford for eight years, and at UC Santa Cruz, and San Francisco State University for several years. He served on numerous national advisory committees for the National Research Council, the National Science Foundation, and the Department of Energy, and published more than 100 articles in refereed scientific journals.

He has received numerous awards: Member of the U.S. National Academy of Engineering; Editor of the scientific journal, Ground Water (1991-95); both the Horton Medal of the American Geophysical Union (the highest award given to a hydrologist); the Pocock Medal of the Geological Society of America (the highest award given to a geologist, 1997); in addition, he was made a life member of the National Ground Water Association (their highest award, 1997), and received the Lifetime Achievement Award of GRA (1997).