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SENSITIVITY OF RECHARGE AREAS TO PUMPING RATES IN WELLS IN TRANSIENT FLOW SYSTEMS

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ABSTRACT: A common strategy to ensure the quality of groundwater for drinking is to manage potential contaminant sources in areas that contribute recharge to wells. Groundwater can rarely be observed directly, and models often are used to delineate recharge areas. Most such groundwater models simulate steady flow to wells, even though groundwater flow may not be steady. Short-term recharge variations cause transient flow, but the time scale of groundwater flow often is much longer, and the effect is minimal over time; however, long-term recharge variations can lead to changes in recharge areas. Among the principal anthropogenic causes of transient flow are installation of new wells, abandonment of wells, and time-varying pumping rates at individual wells. Pumping rates vary in response to maintenance schedules, seasonal demands, and long-term demographic changes. The first two probably average out over a period of years, but demographic changes can lead to large-scale changes in patterns of water use. Changes in the pattern of pumping can lead to large changes in recharge areas that are not considered when using steady-flow simulation. Examples from a typical basin-and-range alluvial aquifer show recharge areas for individual wells that change position in response to increased demands for groundwater throughout the aquifer. We examine the year-by-year position of the recharge area by tracking particles backward from a set of wells. Particles are released from the wells on a yearly basis over the period of transient groundwater flow. Residence times and locations of all particles are collected in one dataset, and locations are extracted for given time intervals. Particle locations for a common recharge date show the position of the recharge area at that time, and the ensemble of recharge areas shows the migration of the recharge area over time. As the source of water changes, the vulnerability of the drinking-water supply may also change. We explore the sensitivity of recharge areas to uncertainty in mean annual pumping rates over the simulated period, to projected future pumping rates, and to recharge rates using Monte Carlo simulation in which the pumping and recharge rates are random variables.

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