Simulations of Ground-Water Flow and Particle Pathline Analysis in the Contributing Recharge Area of a Public-Supply Well in Temple Terrace, Tampa Bay Region, Florida

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Abstract

Shallow ground water in the north-central Tampa Bay region is affected by nitrate concentrations above background concentrations (the detection level (<0.06 milligrams per liter as Nitrogen (mg/L-N)) and detectable concentrations of volatile organic compounds and pesticides as a result of ground-water development and intensive urban land use. The region relies primarily on ground water for drinking water supplies. Sustainability of ground-water quality for public supply requires monitoring and understanding of the mechanisms controlling the vulnerability of public-supply wells to contamination. One representative public-supply well was selected based on the detection of a variety of chemical constituents for intensive study to evaluate the dominant processes affecting the vulnerability of public-supply wells in the Upper Floridan aquifer in the City of Temple Terrace near Tampa, Florida. A ground-water flow model was calibrated and used to determine the area contributing recharge to the selected public-supply well. A network of 28 monitoring wells was installed, and water and sediment samples were collected within the area contributing recharge to support a detailed analysis of physical and chemical conditions and processes affecting the water chemistry. Samples from the monitoring-well network indicated that nitrate concentrations, derived primarily from residential/commercial fertilizer use and atmospheric deposition, were highest (median 2.4 mg/L as N and maximum 6.11 mg/L as N) in shallow ground water from the surficial aquifer system and lowest (less than the detection level) in water from the Upper Floridan aquifer. Dissolved gas analysis indicated that denitrification had occurred near the interface of the surficial aquifer system and the intermediate confining unit, within the intermediate confining unit, and in the Upper Floridan aquifer because of reducing conditions. Simulations also indicated that the rapid movement of water from the surficial aquifer system to the selected public-supply well with high pumping rates, allows nitrate to reach the selected public-supply well in concentrations that resemble those of the overlying surficial aquifer system. Recharge water is most likely traveling through karst features such as sinkholes and conduits that bypass the denitrifying zones, Estimated advective travel times resulting from particle tracking from the time of recharge until discharge at the public supply well ranged from a few hours to 127 years, with a median of 13 years; nearly 45 percent of the particle ages reached the well within 10 years or less. Water from the surficial aquifer system with higher concentrations of nitrate and detectable volatile organic compounds and pesticides, is expected to continue moving to the selected public-supply well. Land-use and the proportion of young affected water contributing to the well is likely to remain relatively constant over time. The calculated nitrate concentration in the selected well indicates a lag of 1 to 10 years between peak concentrations of non-point source contaminants in recharge water and arrival at the well.