

# Hypothetical Modeling of Redox Conditions within a Complex Groundwater Flow Field in a Glacial Setting

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## ABSTRACT

As part of a NAWQA study of the glacial aquifer system, we have developed a modeling approach to study how redox conditions evolve under the influence of a realistically complex groundwater flow field in a glacial valley-fill aquifer system. The distribution of redox conditions is of interest because it affects the susceptibility of an aquifer to contaminants such as arsenic. The approach has been applied to a typical glacial aquifer setting in the eastern United States, consisting of outwash and ice-contact deposits separated by lacustrine deposits. The MODFLOW-MT3D-RT3D suite of codes has been applied to a ground-water flow model originally developed by A. Randall to simulate how complex velocity patterns, hypothetical sources of electron donors, and the availability of electron acceptors (dissolved oxygen, nitrate, ferric iron, sulfate, and carbon dioxide) influence redox. The approach incorporates a simple geochemical model based on the assumptions that redox reactions are approximately first-order with respect to electron donors and sequential with respect to electron acceptors. Estimates of electron acceptor concentrations in recharge are based on water-quality data from NAWQA studies. Hypothetical electron donor sources are simulated as organic-rich wetlands, lacustrine deposits, and pyrite-rich horizons in different parts of the flow system. The model simulates the degree to which reduced waters circulate away from areas of active redox reactions; it is also used to calculate the age mass of water moving through coarse and fine-grained material toward discharge areas. Results indicate that local electron donor sources can influence ground-water chemistry at a regional scale, giving rise to relatively widespread reducing conditions. The simulations show how pumping wells, by inducing water from surface-water bodies and altering the age mass distribution in aquifers, change the natural distribution of redox conditions, and, consequently, change the susceptibility of the aquifer to mobilization of constituents such as arsenic.

[Key words: redox conditions, transport reaction modeling, aquifer susceptibility, age mass]

## (Footnotes)

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