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Simulating nitrate response functions in watersheds: Case studies in the United States and New Zealand

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Non-point sources of nitrate contamination are a common concern in different parts of the world and are difficult to characterize. Due to the solubility of nitrate, it easily enters groundwater and may take years or decades to completely flush to a stream. During this time, it may undergo denitrification, in particular if dissolved oxygen levels are low, requiring a representation of spatially distributed nitrate input as well as detailed hydrogeology.

In this presentation, nitrate response functions are generated with four different methodologies that are listed in the order of decreasing degrees of freedom: groundwater flow and chemical transport (MODFLOW/MT3D), groundwater flow with solute particle tracing (MODFLOW/MODPATH), cross-sectional groundwater flow model (MODFLOW), and lumped parameter models (LPMs). We tested these approaches in selected watersheds in the Eastern and Midwestern United States as well as New Zealand and found similar nitrate results in all cases despite different model complexities. It is noted that only the fully three dimensional MODFLOW models with MT3D or MODPATH could account for detailed patterns of land use and nitrate applications; the cross-sectional models and lumped parameter models could only do so approximately. Denitrification at depth could also be explicitly accounted for in all four approaches, although this was not a major factor in any of the watersheds investigated.