Project Summary

Title: The Spatial and Temporal Variability of Groundwater Recharge

Project ID: R/UW-HDG-004

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Period of Contract: July 2000 – June 2001

Background / Need: Understanding the spatial and temporal distribution of groundwater recharge is a pre-requisite for effective groundwater management and modeling. Recharge, defined as the entry of water into the saturated zone, is influenced by a wide variety of factors including the vegetation, topography, climate, geology, and soils. Despite its dependence on these spatially variable parameters, recharge is typically assumed to be constant and uniform within a watershed. The recharge estimate is usually empirically derived, is a fitted parameter determined by calibration, or is calculated using baseflow of streams as a surrogate.

Since the distribution, rate, and timing of recharge are dictated by the interaction of these variable parameters, recharge should vary temporally and spatially at the watershed scale and the use of a constant value for an entire watershed may be inappropriate. Using a combination of field work and integrated modeling, we developed a suite of techniques for estimating recharge and tested our methods by quantifying the spatial and temporal distribution of recharge at the watershed scale and a daily time step for the Trout Lake basin, a small forested watershed in northern Wisconsin.

Objective: Our main objective was to develop a methodology for estimating the spatial and temporal distribution of groundwater recharge. The methodology was tested by application to the Trout Lake basin for the period 1996 – 2000.

Methods: We estimated the spatial and temporal distribution of recharge using: (1) a daily soil water balance (SWB) model, (2) an integrated terrestrial biosphere model (IBIS, (3) a two-dimensional analytic element groundwater flow model (GFLOW) linked to a parameter estimation code (UCODE) and (4) field techniques (water level fluctuations and time domain reflectometry).

Results and Discussion: The three models (SWB, IBIS, and GFLOW/UCODE) gave comparable recharge estimates, which also agreed well with estimates calculated from water-level fluctuations measured in wells. The SWB and IBIS models calculated an average annual recharge rate for the Trout Lake basin that varied more than two-fold, as well as large monthly variations. Spatial variations were not as significant although heterogeneity attributed to variability in soil and vegetation type was evident.

Conclusions / Implications / Recommendations:

- There is significant annual variation in recharge rate to the Trout Lake basin but spatial

variability is less pronounced.

- Water level fluctuations and reflectometers are useful in estimating recharge amounts and the timing of recharge events.
- The IBIS model, originally designed as a global dynamic ecosystem model, can be successfully applied at a watershed scale.
- Assuming a linear correlation between precipitation and recharge is inappropriate since soil moisture conditions and the timing of precipitation events are more important in controlling recharge rates than the actual amount of precipitation that falls.
- Collectively the models used in this research, particularly the less rigorous soil water balance model, give modelers, planners, and policy makers practical water resource management tools for estimating spatially and temporally distributed recharge for modeling and water resource planning purposes.
- Training in the use of these models and methods would be a useful follow up to this project.

Related Publications:

Dripps, W. R., Expected May 2002. The Spatial and Temporal Variability of Natural Groundwater Recharge. PhD thesis, University of Wisconsin – Madison, Department of Geology and Geophysics.

Dripps, W.R., Kucharik, C.J., Lenters, J.D., Anderson, M.P. and Foley, J.A., 2001. Modeling the Spatial and Temporal Distribution of Groundwater Recharge Across a Forested Watershed in northern Wisconsin. Abstract. American Geophysical Union, 2001 Spring Meeting, Boston, MA, Eos, Vol. 82

Dripps, W.R., Anderson, M.P., and Hunt, R.J., 2001. The Use of Temperature Profiles through Unsaturated Soils to Estimate Short-term Rates of Natural Groundwater Recharge. Abstract. American Geophysical Union, 2001 Spring Meeting, Boston, MA, Eos, Vol. 82

Dripps, W.R, Anderson, M.P., and Hunt, R.J., 2001. Use of a Coupled Heat and Water Transport Model (VS2DH) for Estimating Rates of Natural Groundwater Recharge. Abstract. American Water Resources Association – Wisconsin Section, 25th Annual Meeting, Green Lake, WI, abstracts, p. 27.

Dripps, W.R., Anderson, M.P., and Hunt, R.J., 2000. Incorporating Recharge Variability into Groundwater Flow Models. Abstract. Geological Society of America, 2000 Fall Meeting, Reno, NV, Abstracts with Programs, Vol. 33, p. 335.

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Key Words: Groundwater recharge, recharge estimation, groundwater hydrology, groundwater management, groundwater modeling, water resource management, IBIS, GFLOW, analytic element modeling, UCODE, parameter estimation

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