Groundwater systems and sustainability at new scales

Groundwater is a crucial life-sustaining resource that supplies water to ~2 billion people as well as playing a central role in irrigated agriculture and the health of many ecosystems. The goal of my research program is fundamental and applied research to enable sustainable groundwater use. Here I provide an overview of my multidisciplinary research program which examines fluid flow around geologic structures, mega-scale groundwater systems and groundwater sustainability. First, we examine groundwater flow around lineaments in the topographically-subdued Tay River watershed in the Canadian Shield of eastern Ontario where a thin veneer of soil overlies Precambrian crystalline rocks and Paleozoic sediments. Geomatic data was combined with numerical modelling and hydrogeological and structural geologic field work to show that lineaments can be watershed-scale barriers to groundwater flow, contrary to popular assumptions. Second, we examine permeability and water table type of mega-scale groundwater systems. Near-surface permeability is mapped globally by compiling existing hydrogeological models and lithology maps. Water table type is mapped for the contiguous United States using GIS data compilation, the new continental-scale permeability map and an analytical solution for water table type. Specific regions of the United States have broadly contiguous and characteristic water-table types and water table ratio relates to water table depth and the potential for regional groundwater flow. Finally, we examine tools for groundwater sustainability at new temporal scales. We emphasize three sustainability approaches: setting multigenerational sustainability goals, backcasting, and managing adaptively. As most aquifer problems are long-term problems, we propose that multigenerational goals (50 to 100 years) for water quantity and quality that acknowledge the connections between groundwater, surface water, and ecosystems be set for many aquifers.