Estimating Recharge to Heterogeneous Fractured-Rock and Karst Aquifer Systems in the Shenandoah Valley of Virginia and West Virginia

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Abstract

In recent years, the Northern Shenandoah Valley of Virginia and West Virginia has been experiencing rapid growth along the I-81 corridor and the eastern margin of the Valley. Increased development in rural areas is expected to continue as new residents commute to the Washington, D.C. metropolitan area. This growth has the potential to profoundly influence the region's land, water, and biological resources. Regional and local resource managers have major concerns over the region's ability to sustain future growth. Of particular concern is the sustainability and vulnerability of the region's water resources and the ability to provide a reliable long-term water supply. As of 2000, consumptive water use in the Shenandoah River Basin was estimated to be 33.4 million gallons per day, and is forecast to increase to over 40 million gallons per day by the year 2030. Water use is expected to increase by 30-percent in the main stem of the Shenandoah, while water use in the South Fork and North Fork are expected to increase by 16- and 25-percent, respectively. To address these concerns, the U.S. Geological Survey (USGS) Virginia, West Virginia and Leetown Science Centers are conducting cooperative investigations in the counties of Clarke, Frederick, and Warren in Virginia and the counties of Berkeley and Jefferson in West Virginia. These investigations focus on characterizing the carbonate and fractured-rock aquifer systems in these counties and providing relevant hydrogeologic information that can be used to guide the development and management of the ground-water resources. Since 2003, the Virginia and West Virginia Science Centers have also participated in a multidisciplinary regional assessment of the water resources of the Shenandoah Valley utilizing USGS Integrated Science Funding to develop and investigate methods to provide insight into the complex ground-water systems in the Valley.

A specific goal of our current studies is to improve our understanding of the recharge of ground water in the complexly folded and faulted fractured-rock and karst aquifer systems. Estimates of recharge to these fractured-rock and karst aquifer systems have been derived historically using graphical hydrograph separation techniques and, more recently, from linear regression techniques. These estimates are presented for the Valley as a whole, for different rock classes across the Valley, for individual watersheds within the Valley and, finally, for individual watersheds during both "average" and "drought" conditions. In spite of the fact that estimates of base flow and recharge from graphical separation techniques have been used for decades, substantial uncertainty is still associated with these estimates. While older, graphical methods for separating runoff from base flow are based on visual intuition, a newer chemical hydrograph-separation method is based on a physical process that can be measured in the field. An ongoing investigation using a chloride mass balance approach to calculate the components of the hydrologic budget for individual watersheds will verify and/or constrain recharge estimates obtained by graphical hydrograph-separation methods. The Shenandoah Valley was selected for more intense data collection where all current streamflow gaging stations are instrumented in addition to selected wells and springs. The objectives of this study are to (1) develop hydrologic budgets for the watersheds and counties of central and western Virginia, and (2) display this information as maps of Virginia by watershed and by county. The hydrologic budget components that will be shown in map view include rainfall, total evapotranspiration, riparian evapotranspiration, infiltration, recharge, runoff, and base flow.