

## **Monitoring water quality of shallow aquifers in areas of energy development, Piceance Basin, Northwestern, Colorado**

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Federal land administered by the Bureau of Land Management (BLM), particularly in the Piceance Basin, is currently experiencing significant energy development (natural gas, oil shale). One of the most important issues facing the BLM is how to understand and possibly forecast the cumulative effects of energy development on groundwater systems in the Piceance basin. In 2010, the U.S. Geological Survey and BLM began monitoring groundwater quality in the Green River and Uinta Formations at 5 wells in the Piceance Basin and expanded the network to 14 wells in August 2011. Isotope and age-tracer data indicate that groundwater in these wells is derived from snowmelt recharge but is mostly more than 50 years old. Preliminary estimates of groundwater age based on carbon-14 and helium-4 data indicate that some of the monitored groundwater could be as old as 45,000 years, but most of it appears to be less than 10,000-years old. Long groundwater residence times indicate that recharge to the aquifer is relatively slow, which would result in slow flushing times if groundwater contamination were to occur. Because groundwater in the monitored part of the aquifer is mostly greater than 50-years old, contamination from the land surface may be less of a concern than subsurface sources (for example, poorly constructed gas wells, fracturing, or lost circulation of drilling fluids). Surface sources of contamination could be more important at higher elevations in the basin which are closer to areas of recharge to the aquifer system. Methane concentrations in groundwater ranged from less than 1 milligram per liter to 150 milligrams per liter. Thermogenic methane was detected in one-half of the monitoring wells, where possible pathways for gas migration could occur along natural fractures or well bores. Benzene and toluene were commonly detected in the monitoring wells at concentrations well below specified water-quality standards.