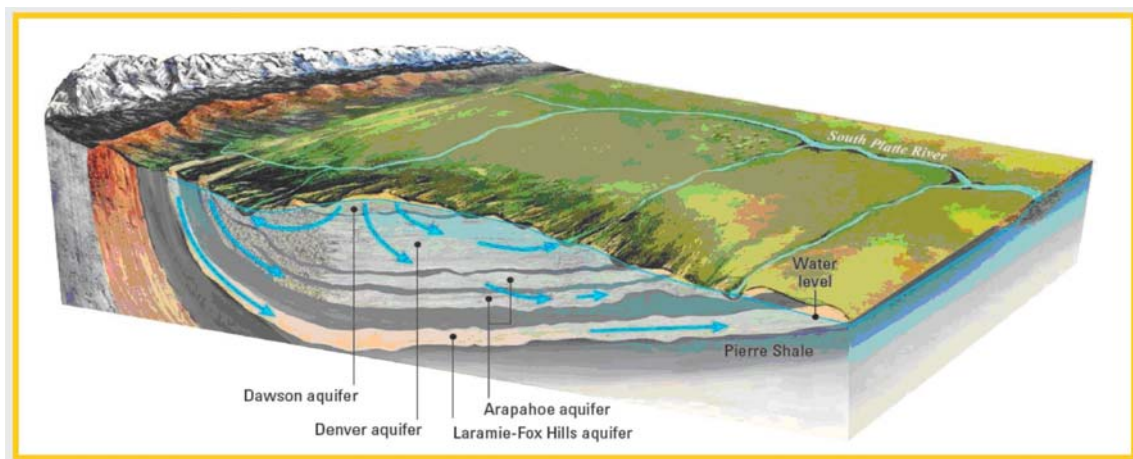


Simulation and Observation of the Denver Basin Aquifer System

At the May 14 Meeting of the Colorado Scientific Society, Dr. Suzanne Paschke, Associate Director for Hydrologic Studies at the U.S. Geological Survey described the model her organization has developed for the Denver Basin Aquifer System. The Denver Basin aquifer system is a critical water resource for growing municipal, industrial, and domestic uses along the semiarid Front Range urban corridor of Colorado. The confined bedrock aquifer system is located along the eastern edge of the Rocky Mountain Front Range where the mountains meet the Great Plains Physiographic Province. Continued population growth and the resulting need for additional water supplies in the Denver Basin and throughout the western United States emphasize the need to continually monitor and reassess the availability of groundwater resources.



West

Denver Basin Schematic

East

In 2004, the U.S. Geological Survey initiated large-scale regional studies to provide updated groundwater-availability assessments of important principal aquifers across the United States, including the Denver Basin. This study of the Denver Basin aquifer system evaluates the hydrologic effects of continued pumping and documents an updated groundwater-flow model useful for appraisal of hydrologic conditions. The updated model includes a fully three-dimensional geologic framework; explicit representation of streams and the alluvial aquifer; time-varying recharge and evapotranspiration boundary conditions; spatial variation of hydraulic conductivity and specific yield; and used recently-available modeling tools for improved model calibration and sensitivity analysis.

Dr. Paschke has 25 years of experience in hydrogeologic evaluation and water-quality Assessments. Her previous experience includes software development and teaching at the International Groundwater Modeling Center as well as hydrogeologic site investigations and modeling projects for private and government clients. Dr. Paschke holds a B.S. in Geology from the University of Wyoming and M.E. and Ph.D. degrees in Geological Engineering from the Colorado School of Mines.

Dr. Paschke began her presentation by referencing an earlier paper called “Artesian Wells in the Denver Basin”, which was published by the Colorado Scientific Society in 1884. The USGS model of the Denver Basin considers all water aquifers above the Pierre Shale, including the Dawson, Denver, Arapahoe, and Laramie–Fox Hill Aquifers as defined by the State Engineer’s office. Highly productive alluvial sands and gravels overlie the river drainage areas. Water in the northern part of the basin flows into the South Platte, while the part south of the Palmer Divide flows into the Arkansas. The older established areas have surface water rights to the South Platte and Arkansas while the more recent developments rely on groundwater wells. The issues considered include the effects of long term pumping, the variation of the aquifer quality, recharging of the aquifers, and whether monitoring is adequate.

The Denver Basin study was part of a USGS nation wide groundwater research program that includes the Central Valley, S.E. Coastal Plains, Basin and Range, Columbia Plateau, Mississippi Embayment and Lake Michigan. A Colorado study in the early 1990s was prepared by the USGS and the State, but the current model is far more comprehensive.

The model was built on a square mile horizontal grid with 12 vertical layers (the four existing aquifers were subdivided) and included five confining units. The top layer was sand and gravel. The boundaries were determined using 4,300 geophysical well logs, which were also used to calculate the percent sand. Hydraulic conductivity and specific yield were also calculated for the rock units. Inflows to the aquifers were precipitation, irrigation recharge and stream inflows, while outflows were springs, enviro–transpiration (ET) and pumping. (ET occurs if the aquifer is within 13 feet of the surface.) Pumping rates are not measured in Colorado but estimates from records obtained from the State Engineer's Office were used. The model simulation was run from 1880 to 2003.

Pumping from alluvial aquifers which account for 40% of total water yield was considered separately from bedrocks aquifers. Municipal wells represent only 2% of the number of bedrock wells, but 40% of the total yield. Residential wells represent 95% of the total, but only 30% of the yield. Various streams were modeled. Twelve hundred well observation sites were utilized. The model was processed using multiple networked PCs and the parameters were adjusted until they achieved an accuracy of a less than 16 foot difference between the computed and measured head for 95% of observations. The output for the model was a distribution of potentiometric surface.

For the initial predevelopment conditions in the Basin, there was no change in storage as there was no pumping. The potentiometric surfaces were above the confining layers and the bedrock aquifers were under pressure. With development and pumping, the potentiometric surface has dropped below the confining layer and the bedrock aquifers are being drained. We are now taking water out of storage. Most of this drainage has occurred in the Denver and Dawson Aquifers in the Denver Metro Area, and 80% of this

drawdown is due to pumping. As a result of this pumping there has been a decreased flow from bedrock to alluvial formations, an increase in flow from alluvial to bedrock and a decrease in discharge to streams. There has also been an increase in the downward flow between aquifers. The alluvial systems respond to climate, but the change in the bedrock aquifers is due to pumping. Most of the water in storage is geologic – it was deposited over 20,000 years ago at the time of the last glacial period. Fifty percent of the storage depletion has come from the south Metro area. There had been a cumulative drawdown of 3/4 million acre-ft from a total basin-wide storage of 300 million acre-ft by the end of 2003. While the withdrawal may seem small, half of it is coming from one place.

Dr. Paschke discussed a project the USGS has been performing on behalf of the Rural Water Authority of Douglas County, where most of these wells are completed in the shallow Denver and Dawson Formations. The study involves recording the water levels in domestic wells using pressure transducers. The data are posted on the web through the National Water Information System. The project has been ongoing for 3 years and is expected to continue for 2 more years. Dr. Paschke was asked about the sustainability of pumping in Douglas County. She replied that more data were needed, but in her opinion it was not sustainable in the long term. She pointed out that the surface reservoirs were empty in March, but there was still water in the bedrock aquifers. In response to a question about water quality, she answered that the water was generally good. However there are some lignite deposits in the Denver Formation that can cause issues due to trace elements.

The full report can be downloaded from the USGS website at:

<http://pubs.usgs.gov/pp/1770/>