Hydrologic Conditions and Assessment of Water Resources in the Turkey Creek Watershed, Jefferson County, Colorado, 1998–2001

Abstract

The 47.2-square-mile Turkey Creek watershed, in Jefferson County southwest of Denver, Colorado, is relatively steep with about 4,000 feet of relief and is in an area of fractured crystalline rocks of Precambrian age. Water needs for about 4,900 households in the watershed are served by domestic wells and individual sewage-disposal systems. Hydrologic conditions are described on the basis of contemporary hydrologic and geologic data collected in the watershed from early spring 1998 through September 2001. The water resources are assessed using discrete fracture-network modeling to estimate porosity and a physically based, distributed-parameter watershed runoff model to develop estimates of water-balance terms.

A variety of climatologic and hydrologic data were collected. Direct measurements of evapotranspiration indicate that a large amount (3 calendar-year mean of 82.9 percent) of precipitation is returned to the atmosphere. Surface-water records from January 1, 1999, through September 30, 2001, indicate that about 9 percent of precipitation leaves the watershed as streamflow in a seasonal pattern, with highest streamflows generally occurring in spring related to snowmelt and precipitation. Although conditions vary considerably within the watershed, overall watershed streamflow, based on several records collected during the 1940's, 1950's, 1980', and 1990's near the downstream part of watershed, can be as high as about 200 cubic feet per second on a daily basis during spring. Streamflow typically recedes to about 1 cubic foot per second or less during rainless periods and is rarely zero. Ground-water level data indicate a seasonal pattern similar to that of surface water in which water levels are highest, rising tens of feet in some locations, in the spring and then receding during rainless periods at relatively constant rates until recharged. Synoptic measurements of water levels in 131 mostly domestic wells in fall of 2001 indicate a water-table surface that conforms to topography. Analyses of reported well-construction records indicate a median reported well yield of 4 gallons per minute and a spatial distribution for reported well yield that has relatively uniform conditions of small-scale variability. Results from quarterly samples collected in water year 1999 at about 112 wells and 22 streams indicate relatively concentrated calcium-bicarbonate to calcium-chloride type water that has a higher concentration of chloride than would be expected on the basis of chloride content in precipitation and evapotranspiration rates. Comparison of the 1999 data to similar data collected in the 1970's indicates that concentrations for many constituents appear to have increased. Reconnaissance sampling in the fall of 2000 indicates that most ground water in the watershed was recharged recently, although some ground water was recharged more than 50 years ago. Additional reconnaissance sampling in the spring and fall of 2001 identified some compounds indicative of human wastewater in ground water and surface water. Outcrop fracture measurements were used to estimate potential porosities in three rock groups (metamorphic, intrusive, and fault zone) that have distinct fracture characteristics. The characterization, assuming a uniform aperture size of 100 microns, indicates very

low potential fracture porosities, on the order of hundredths of a percent for metamorphic and intrusive rocks and up to about 2 percent for fault-zone rocks. A fourth rock group, Pikes Peak Granite, was defined on the basis of weathering characteristics. Short-term continuous and synoptic measurements of streamflow were used to describe base-flow characteristics in areas of the watershed underlain by each of the four rock groups and are the basis for characterization of base flow in a physically based, distributed-parameter watershed model.

The watershed model, the Precipitation-Runoff Modeling System (PRMS), was used to characterize hydrologic conditions on the basis of precipitation and air temperature in 112 hydrologic response units for which physical characteristics were derived from mostly digital data. The watershed model also was used to characterize hydrologic conditions in subsurface portions of the watershed that are associated with streamflow. The model was conditioned, using a relatively small set of parameters, to match measurements of watershed and intrawatershed streamflow and point measurements of evapotranspiration, air temperature, and soil moisture. Results from the watershed model provide simulated estimates for water-balance terms in a contemporary simulation (January 1, 1999, through September 30, 2001) using precipitation and adjusted temperature data from within the watershed, and in a long-term simulation (October 1, 1948, through September 30, 1999) using precipitation and temperature data from near the watershed. The results of both simulations indicate that, on a watershed scale, base-flow reservoirs consistently contain about enough water to cover the watershed with 0.1 to 0.2 inch of water. The long-term simulations indicate that during a year with about 14 inches of precipitation, the watershed base-flow reservoir may have about a -0.06 inch change in contents during periods with relatively small amounts of recharge. The results from watershed simulations also indicate that contents of base-flow reservoirs vary within the watershed; base-flow reservoirs contain little or no recoverable water for significant portions of many years in about 90 percent of the watershed. In areas where base-flow reservoirs contain no water, the only source of water for wells is water that has percolated to relatively deep parts of the system that are not associated with local streamflow; water withdrawn under these conditions will need to be replaced before base flow can resume. Estimates of the amount of water withdrawn by wells in 2001 in the Turkey Creek watershed are equal to a watershed depth of about 0.43 to 0.65 inch (about 0.0012 to 0.0018 inch per day).