Hydrology and Simulation of Ground-Water Flow in Cedar Valley, Iron County, Utah

By Lynette E. Brooks and James L. Mason

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CENTRAL IRON COUNTY WATER CONSERVANCY DISTRICT; UTAH DEPARTMENT OF NATURAL RESOURCES, DIVISION OF WATER RESOURCES; UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY, DIVISION OF WATER QUALITY; CEDAR CITY; AND CITY OF ENOCH

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Summary

Cedar Valley, located in the eastern part of Iron County in southwestern Utah, is experiencing rapid population growth that needs a larger share of the available water resources. Water withdrawn from the unconsolidated basin fill is the source for public supply and also a major source for irrigation. Water managers are concerned about increasing demands on the water supply and need hydrologic information to develop a plan for efficiently using water resources and minimizing flow of water unsuitable for domestic use toward present and future public-supply sources.

Cedar Valley is a structural depositional basin located at the transition between the Basin and Range and Colorado Plateau physiographic provinces. Snowmelt runoff from the Markagunt Plateau to the east provides much of the water to the largest stream, Coal Creek. The 1939-2000 average annual flow in Coal Creek is 24,200 acre-ft of which most of the high flow occurs during April through June. Water in Coal Creek is diverted into a complex distribution system for irrigation. No surface water exits the basin because all of it is consumed by plant consumptive use, evaporation, or seepage to the ground-water system.

The thickness of permeable unconsolidated basin fill is estimated to be more than 3,500 ft in the Rush Lake area and more than 1,000 ft throughout most of the basin. Unconfined ground-water conditions exist along the basin margins and in the center of the basin above confining lenses. Confined conditions exist beneath discontinuous confining layers in the center of the basin. As water levels have declined as a result of continued ground-water withdrawals, the present extent of water under confined conditions may be less than previously defined. Ground water flows from the recharge areas near Coal Creek to three discharge areas at Rush Lake and Mud Springs Canyon, Iron Springs Gap, and Quichapa Lake.

Recharge to the unconsolidated basin fill is by seepage from unconsumed irrigation water, streams, and precipitation, and by subsurface inflow from consolidated rock and adjacent areas, and is estimated to be about 42,000 acre-ft/yr. The chloride mass-balance method indicates that recharge may be less than that, but is considered a rough approximation because of limited chloride concentration data for precipitation and Coal Creek. Stable-isotope data indicate that recharge sources are winter precipitation derived from snowmelt in upland areas or direct precipitation on unconsolidated basin fill. Continued declining water levels indicate that recharge is not sufficient to meet demand. Water levels in many areas are at or close to historic lows.

In 2000, ground-water withdrawal was estimated to be 36,000 acre-ft/yr. About 4,000 acre-ft/yr is estimated to discharge by evapotranspiration or as subsurface outflow. Prior to large-scale ground-water development, evapotranspiration is estimated to have been about 22,000 acre-ft/yr and is the largest component of discharge at that time. The large decline in evapotranspiration is a result of declining water levels, which are a result of increased withdrawals. As a result of declining water levels, most of the natural discharge has been intercepted by ground-water pumpage. Water quality in Cedar Valley is mostly suitable for domestic use except along the eastern margin where water from some wells has elevated dissolved-solids and NO_3 concentrations. Water with high dissolved-solids concentration generally has Ca and SO_4 as the predominant ions, which are likely derived by the dissolution of gypsum in some of the Mesozoic-age rocks of the Markagunt Plateau. Ground water with low dissolved-solids concentration is located west of Quichapa Lake where less soluble Tertiary-age volcanic rocks compose the Harmony Mountains.

Nitrogen-15 and oxygen-18 isotopes in the nitrate anion were measured to determine

possible NO_3 sources and whether or not denitrification is occurring. No single source can be identified as the cause for elevated NO_3 concentrations in ground water. Low $\delta^{15}N$ values north of Cedar City indicate a natural geologic source. Higher $\delta^{15}N$ values in water from wells that are located down-gradient from areas where waste-water effluent has been discharged indicate possible recharge from the effluent. Excess dissolved N_2 gas and low NO_3 concentrations in shallow ground water at two locations indicate that denitrification is occurring. These data indicate that NO_3 derived from near-surface sources might be reduced at these locations, but it is unknown whether this process is occurring in the shallow zones throughout the basin.

A computer ground-water flow model was developed to simulate flow in the unconsolidated basin fill in Cedar Valley to test the conceptual understanding of the ground-water system. This model was developed to simulate general ground-water flow through Cedar Valley and long-term water-level fluctuations; it was not developed to simulate local effects or cell-by-cell flow. In general, the model accurately simulates water levels and water-level fluctuations and can be considered an adequate tool to help determine the valley-wide effects on water levels of additional ground-water withdrawals and changes in water use.

The method of determining recharge from irrigation was changed during the calibration process to incorporate more areal and temporal variability. Simulated water levels respond more to location and amount of irrigation recharge than to any other model parameter. Measurements of distribution through canals, amount of water applied in city and residential areas, and amount of runoff in irrigated, city, and residential areas would refine the conceptual understanding of the ground-water system and may improve model fit. If recharge is substantially different from that used in the construction of this model, then simulated aquifer characteristics and other model parameters may not be realistic estimates of actual hydrologic properties. Water-level data collected at sites where data were not available during the calibration period may help refine the model and the conceptual understanding of the ground-water system. Long-term water-level fluctuations at those sites would be needed to refine estimates of specific yield, specific storage, and probably horizontal-to-vertical anisotropy.

The ground-water flow model was used to predict possible effects on water levels caused by increased withdrawal from wells, less-than-normal precipitation and streamflow, and changing water use from irrigation to municipal supply. In the projection simulations, water levels in the southern part of the valley declined 20 to 275 ft; the maximum projected drawdown of 275 ft occurred west of Quichapa Lake during projection 6 because of increased simulated ground-water withdrawal for municipal use. The continuous decline in water levels for most projections indicates that ground water is being removed from storage and that a new steady-state equilibrium has not been established after 30 years. The simulated amount of water in storage in the ground-water system during the 30 years of projection declined as much or more than from 1950 to 2000. Model projections should not be used to predict actual water levels at some future date, but can give general ideas about water-level declines likely to occur throughout the valley. The more the projected stresses vary from stresses used during the calibration period, the more likely simulated water-level declines may not accurately represent actual water-level declines.

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