An Integrated Approach to Characterizing Spatial and Temporal Variability in Canal Leakage

Christopher M. Hobza[1], Bethany L. Burton[2], Joe Vrabel[3], and James C. Cannia[1]
[1]U.S. Geological Survey Nebraska Water Science Center (cmhobza@usgs.gov; jcannia@usgs.gov), [2]U.S. Geological Survey Crustal Geophysics and Geochemistry Science Center (blburton@usgs.gov), and [3]U.S. Geological Survey Texas Water Science Center (jvrabel@usgs.gov)

In areas of Nebraska, leakage from unlined irrigation canals is the primary source of groundwater recharge. Accurately quantifying and spatially distributing canal leakage to the groundwater system is critical to the success of water management strategies that may include intentional recharge and/or canal lining. In the North Platte and Central Platte Natural Resources Districts (NPNRD and CPNRD), groundwater models are being developed to facilitate decision making and are an integral part of local integrated water management plans. The spatial variability of canal leakage is highly dependent on the near surface geology that varies from deposits of coarse sand and gravel (high leakage) to clay (low leakage). This variability is likely due to differences in the hydraulic conductivities between the sediments. Within the NPNRD the geology consists of Quaternary deposits of eolian sands and alluvium overlying the relatively impermeable siltstone of the Tertiary-age Brule Formation of the White River Group. Within the CPNRD, roughly 20 to 30 meters of Quaternary alluvium and floodplain deposits overlie the semi-consolidated to consolidated Tertiary Ogallala Formation. Sediments underlying 710 kilometers of canal have been mapped using capacitively- coupled resistivity profiling techniques and have improved estimates of canal leakage for portions of 17 canal systems in the NPNRD and CPNRD.

The NPNRD study included geostatistical analyses of resistivity profiles to further refine estimates of leakage and distribute reported canal losses. Leakage estimates were determined for individual groundwater model cells and model time steps based on annual reported canal losses.

Within the NPNRD, the temporal variability in canal leakage was characterized at two 14-kilometer reaches. Leakage rates were calculated from streamflow loss determined from stream-gaging stations instrumented with side-looking acoustic Doppler velocity profilers and using acoustic Doppler current profilers to measure discharge at upstream and downstream stations for the two reaches. Continuous temperature and water-level data were collected from one location within each reach and used as inputs for the numerical model, VS2DH, which fits simulated temperatures to observed vertical temperature profiles to estimate the vertical hydraulic conductivity of canal-bed sediments. Streamflow records and manual hydroacoustic measurements indicate intraseasonal variability in canal leakage for both reaches. Comparisons between point and reach-scale leakage estimates suggest that variability within the studied reaches is largely caused by differences in canal-bed sediment texture, depth to groundwater, and depth to bedrock.