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Quantifying Surface and Groundwater Interactions in the San Acacia Reach, New Mexico

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Effective drought management in the Middle Rio Grande Basin requires a clear understanding of surface-groundwater interactions to protect streamflow and limit groundwater overuse. These processes remain poorly defined in the San Acacia Reach, where water losses affect the state's ability to meet Rio Grande Compact deliveries to Elephant Butte Reservoir. Within this reach, the Low Flow Conveyance Channel (LFCC), an engineered drain built to support compact compliance, strongly influences surface and groundwater exchanges. Because it lies below the riverbed, it acts as a sink, and captures water from shallow alluvium, deep basin groundwater, and Rio Grande/irrigation return flow. However, their relative contributions are unresolved. This study quantifies surface-water and groundwater inputs to the LFCC across seasonal hydrologic conditions.

Five drainage and environmental tracer surveys were conducted along the LFCC and Rio Grande during the 2025 irrigation and monsoon cycle (February – December). Groundwater fluxes to the LFCC were estimated using differential gauging and 222-Rn measurements. Water samples were analyzed for major ions, trace metals, $\delta^{18}O$, δD, and $^{87}Sr/^{86}Sr$. A multi-tracer Bayesian mixing model was developed to resolve the contributions of surface water, shallow alluvium, and deep basin groundwater.

Seasonal chloride and stable-isotope patterns reflect strong irrigation and snowmelt controls on the hydrologic system. $\delta^{18}O$ values are depleted during pre-irrigation (February) and become progressively enriched by mid-monsoon and mid-irrigation (July and September), indicating a transition from snowmelt-dominated river inputs to increased contributions from irrigation-influenced shallow groundwater and return flow. At most LFCC sites, chloride concentrations were moderate in February (pre-irrigation) and decreased slightly in May (early irrigation) with the introduction of canal water, which consists of low-salinity surface water diverted from the river. Then, concentrations increased in July and September (mid-monsoon and mid-irrigation). Sulfate showed a comparable seasonal pattern. This trend suggests an early-dilution signal followed by a shift toward greater influence of saline shallow groundwater, as cumulative recharge elevates the water table and enhances seepage to the LFCC, leading to higher salinity later in the irrigation season. Summer monsoon rainfall can temporarily dilute surface water but sustain elevated groundwater levels.