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Watershed modeling to evaluate the impact of irrigated agriculture on surface water – groundwater interactions

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We examine the impacts of irrigation and associated surface water (SW) diversions and groundwater (GW) pumping on streamflow, GW recharge and SW-GW interactions using a watershed-scale coupled SW-GW flow model. The U.S. Geological Survey (USGS) model GSFLOW (Markstrom et al., 2008), an integration of the USGS Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW), is being utilized for this effort. Processes represented in the model include daily rain, snowfall, snowmelt, streamflow, surface runoff, interflow, infiltration, soil-zone evapotranspiration (ET), and subsurface unsaturated and saturated GW flow and ET. We use the upper Smith River watershed, an important agricultural and recreational area in west-central Montana, as the basis for watershed climate, topography, hydrography, vegetation, and soil properties as well as for scenarios of irrigation and associated practices. The 640 square kilometer watershed area has been discretized into coincident 200 m by 200 m hydrologic response units (for climate and soil zone flow processes) and grid blocks (for unsaturated zone and GW flow processes). The subsurface GW system is discretized into 6 layers representing Quaternary alluvium, Tertiary sediments and bedrock. The model is used to compare streamflow, GW recharge and SW-GW interactions in the watershed under natural, pre-irrigation conditions; current irrigation conditions; and a scenario of future increased irrigation. Model results reproduce observed hydrologic responses to both natural climate variability and irrigation practices. Current irrigation practices have decreased streamflow out of the watershed relative to pre-irrigation conditions as result of SW diversion. Irrigation has increased GW recharge below irrigated areas. Despite these local increases in GW recharge, more widespread lowering of the water table by GW pumping for irrigation decreases GW ET in lowlands with shallow water tables, decreases GW discharge to streams, and induces SW infiltration from streams. Irrigation practices cause SW-GW interactions to become more temporally and spatially variable. Flood irrigation in riparian zones increases GW

flow to the stream, whereas, GW pumping for irrigation can cause naturally gaining stream reaches to become losing stream reaches. These changes in SW-GW interactions could influence stream ecology.