Modeling and Managing Artificial Groundwater Recharge in Arid Regions

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Abstract. Small reservoirs in arid areas have the potential to become depleted due to low annual average rainfall and high evaporation rates. These locations therefore can be an unreliable source for municipal water supply and groundwater recharge to the underlying aquifer. This study explores the use of small dams in an arid, urban region to create artificial lakes that supply recharge water to the underlying aquifer, with the dams capturing outflow from a set of wastewater treatment plants. Recharge occurs naturally as water seeps through the base of the small reservoirs and percolates through the vadose zone to the water table. For efficient and sustainable groundwater recharge, the hydraulic head behind the dam is maintained at a constant level, achieved by using Model Predictive Control (MPC). The process is modeled using a three-dimensional groundwater flow model (MODFLOW), which takes into account the subsurface geology of the region. In the fully developed stage, the system recharges almost 7.9 MGD of water to the aquifer, out of which 6.6 MGD can be pumped and consumed sustainably on a daily basis through 50 planned production wells. The model was run under several well placement scenarios to determine optimal placement, with groundwater head drawdown and associated costs minimized. The average drawdown for the optimal placement scenario is 1 meter, as compared to 18 meters of drawdown in other scenarios. A cost-benefit analysis of the system saves a sum of $11,500 daily which would have been the cost of 6.6 MGD if it was to be purchased from the city municipality.