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Hydrogeological Assessment and Modelling of the highly variable Jericho-Auja alluvial groundwater system

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The study area of Al Auja-Jericho (AJ) is located northwest of the Dead Sea in the arid Lower Jordan Valley. Here, human activities directly depend on the annual winter precipitation in the mountain ranges that reaches the investigated AJ alluvial aquifer system primarily as wadi surface runoff, spring discharge and restricted flow across the Jordan Valley transform fault.

The major stresses on the groundwater system are related to the high variability of annual rainfall and potential adverse climate trends, an increasing demand in all water sectors due to population growth and expansion of cultivated area, as well as high potential of groundwater salinization due to a high evaporation flux and saline water up-flow caused by groundwater over-abstraction.

The development of an Integrated Water Resources Management (IWRM) concept requires a sufficient understanding of the two natural system components: hydrological variability for the provision and the hydrogeological setting for the storage of the water resources. The latter is focus of this study. It covers the investigation of the aquifer setting and characteristics as well as the groundwater flow dynamics and allows the development of optimized schemes for efficient Managed Aquifer Recharge (MAR).

The hydrogeological setting was defined based on hydrogeological cross-sections derived from geological and structural maps and well logs considering the interconnection between the Eastern Mountain and AJ alluvial aquifers. Recharge and lateral flow processes affected by varying annual rainfall patterns and human activities are comprehensively outlined. As a result, a three-dimensional finite-difference groundwater flow model based on MODFLOW was developed to investigate the variety of hydrological conditions and to simulate the flow system under different annual rainfall and MAR scenarios.

The model consists of two layers. While the lower unit represents the sand, silt and gravel deposits of the Samara formation, the upper unit refers to the marl, clay, chalk, silt and gypsum deposits of the confining Lisan formation, which reaches a maximum thickness of about 30 meters (Toll et. al, 2009). The model was calibrated for steady state using groundwater levels from the 1960s, and for transient conditions using groundwater levels for 2000–2015. Estimation of the hydraulic conductivity distribution was optimized using a combination of trial-and-error and automated inverse methods.

The simulation results show that the fluctuations of hydraulic heads depend on seasonal variation in recharge from natural infiltration of precipitation and storm water and the extraction rates from the aquifer. The model further revealed that the restricted lateral flow from the mountain aquifer with an estimated amount of 2.1 Mm3/yr constitutes a substantial fraction of the budget of the alluvial system in addition to the replenishment by surface water recharge of 3.2 Mm3/yr in average due to limited rainfall over the aquifer area. Subsequent simulations that involve different MAR option indicate that the water gap in the AJ area can only be filled by complementary measures in the framework of an IWRM concept.