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Optimization of the Implementation of Managed Aquifer Recharge – Effects of Aquifer Heterogeneity

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Managed aquifer recharge (MAR) has become a key component of integrated water resources management, especially in water scarce regions. MAR can serve the dual role of increasing the supply of available water and improving the quality of recharged water through natural attenuation processes. The performance of MAR systems is highly dependent upon site-specific hydrogeological conditions. Aquifer heterogeneity, such as the presence of high-permeability preferential flow zones and dual or even the so-called triple-porosity conditions, has been responsible for the under performance or failure of some MAR systems. Aquifer heterogeneity can result in much more rapid and unpredictable movement and mixing of recharged water and the bypassing of natural attenuation processes. A critical element of MAR projects is a detailed aquifer characterization and the development of groundwater flow and solute transport models at the appropriate spatial and temporal scales that accurately simulate local heterogeneous flow systems. Geochemical modeling based on high-quality, site-specific mineralogical and water chemistry data can also be used to predict the potential for adverse water-rock interactions such as the leaching of arsenic and trace metals into recharged water. Hydrogeological conditions that could lead to poor system performance should be identified early in the project development before the investment is made to construct a full-scale system. Hydrogeological conditions that have lead to poor MAR system performance are typically identifiable at the exploratory well stage of projects. Early detection of adverse hydrogeological conditions provides an opportunity to either abandon a likely under-performing project, select an alternative site with more favorable conditions, or modify the system design to be more compatible with local hydrogeology. Advanced borehole geophysical techniques and workflow software can allow for enhanced aquifer characterization and thus allow for more successful MAR implementation as a tool for improved water resources management.