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Subsurface modeling of a riverbed filtration system: influence of local hydraulic conductivity, stream levels, well placement, and pore clogging

C. Racine (1), **C. Paniconi** (1), R. Lefebvre (1), M. Leclerc (1), D. Pinard (2)

(1) INRS-ETE, Université du Québec, Canada (claudio.paniconi@ete.inrs.ca), (2) Génio experts-conseils, Québec, Canada

This study analyzes, via steady state 2D vertical cross-section groundwater simulations, the flow rate to a riverbed horizontal filtration system under various natural and design conditions. The natural conditions are representative of those found on the Montmorency River near Quebec City (Canada). The design parameters reflect various options being considered for a proposed riverbed filtration system that will complement direct pumping of river water and will replace a more conventional riverbank filtration system currently in use. The riverbed system is thought to have the potential to improve the source water quality through filtration and also, importantly, to alleviate the problems of ice clogging that afflict the direct pumping system. Over a series of scenario simulations where relevant natural and design parameters were systematically varied, we found the flow response to be very sensitive to the hydraulic conductivity K, and quite localized, with water intake originating mostly from the river, rather than groundwater. In practical terms this implies that accurate characterization of the sand and gravel aquifer is not essential; more important is a thorough characterization (or even design, using special-purpose natural or synthetic porous materials) of the trench overlying the intake drains, ensuring that this local conductivity is high enough to deliver the desired flow rate for water supply needs. The local nature of the flow regime also implies that the flow rate can be greatly increased by placing several conduits in a parallel configuration in a single or multiple trenches within the riverbed sediments. Other factors were also found to significantly influence the flow rate, although not to the same degree as the trench material K value or the use of multiple wells. These factors include the depth of the filtration system, the drain diameter, and the pumping pressure (compared against gravitational drainage). Given the con-

trolling effect of the trench material hydraulic conductivity, any decrease over time of this local K, through clogging processes, was shown to have a dramatic impact on the flow rate. Backwash operations were thus also simulated to evaluate their potential efficiency in alleviating clogging of the well trench. Under flow rates consistent with an eventual operational system, backwashing was shown to lead to fluidization of the trench material with velocities that allow elutriation of fine sediments from the trench (i.e., clogging particles), without purging the original trench material.