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Groundwater flow and solute transport modelling in the upper Limmat valley (Switzerland)

H.J. Hendricks Franssen (1), I. Röser (1,2), H.-P. Kaiser (3), R. Müller (3), J. Trösch (2), F. Stauffer (1) and W. Kinzelbach (1)

(1) Institute for Environmental Engineering, ETH Zurich, 8093 Zurich, Switzerland, (2) TK Consult AG, Siewerdtstrasse 7, 8050 Zurich, Switzerland, (3) Water Supply Zurich, Hardhof 9, Postfach, 8023 Zurich, Switzerland

The aquifer of the upper Limmat valley (Zurich, Switzerland) is used for groundwater abstraction and provides about 15% of the water demand of the city of Zurich. To ensure drinking water quality, the inflow of potentially contaminated groundwater from the industrial part of Zurich should be avoided. In addition, the pumped groundwater should not have a temperature above 16 C. Due to infiltration from the river Limmat, in late summer and autumn the pumped groundwater could be too warm. A coupled groundwater flow-solute transport-heat transport model is developed in order to monitor, predict and reduce the risk (by management decisions) that groundwater of inferior quality is pumped.

As a first step, a 2D steady-state finite element groundwater flow model was developed of the region, conditioned on transmissivity data and calibrated with piezometric head data. The piezometric head data have been used to estimate leakage rates from the river into the aquifer. By means of stream lines the risk has been evaluated that contaminants from the industrial area of Zurich reach the drinking water wells.

As a next step, a 3D transient finite element groundwater flow model of the upper Limmat valley was established. Additional hydraulic conductivity data have been collected and a combination of universal kriging and upscaling (simplified renormalisation) is used to estimate the spatial distribution of 3D hydraulic conductivities. Time series of recharge and the water level in the river Limmat have been constructed from meteorological and hydraulic data respectively. A part of a 14 years long time series of piezometric head data has been used to calibrate this model.

A verification period was defined in order to test the performance of the 2D steady-state and 3D transient models and evaluate whether the more complex model with additional data indeed performed better. A further step to evaluate the model performance was to carry out advective solute transport simulations and to compare them with electrical conductivity measurements.