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A Transparent Modelling Workflow for the Assessment of Surface Water-Groundwater Exchange Flux at a PCE Contaminated Site

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Contaminated sites constitute a global problem as they pollute important freshwater systems at a local scale. To effectively address these sites for remediation, we must first characterize the sites in order to gain an understanding of the geological setting. This step is crucial as it helps determine groundwater flow pathways and the dynamics of surface water-groundwater exchange within these systems.

In Hagfors, Sweden, an industrial-scale dry-cleaning facility was in operation from the 1970s to the 1990s. During this period, a large quantity (>50 tonnes) of the dry-cleaning fluid perchloroethylene (PCE) was spilled into the ground, polluting the groundwater. Consequently, a nearby stream was contaminated from polluted groundwater discharge. The stream meanders through a sparsely populated area, posing risks to the residents and local fauna exposed to the contaminant. Due to difficulties in remediating the source zone, decision makers shifted their focus towards mitigating contaminated groundwater influx into the stream.

We have developed a composite numerical model using open-source software (LUMPREM, MODFLOW, and PEST) to characterize and quantify surface water-groundwater exchange fluxes at the Hagfors site from 2016 to 2020. The modelling workflow is documented through Jupyter Notebooks, covering input dataset preparation, model setup, result analysis, and figure generation. All notebooks are available on Github: https://github.com/nikobenho/hagfors_gwm.

The model underwent history-matching, integrating conventional observations (heads, stream stage, streamflow) and unconventional data (distributed temperature sensing and expert knowledge). Predictive uncertainties were explored using the iterative ensemble smoother. The results highlighted specific segments of the stream that are particularly susceptible to contaminated groundwater influx. Based on this, we recommend decision makers to prioritize their remediation efforts on these identified segments.