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Karstification beneath the Birs weir in Basel/Switzerland: A 3D modelling approach

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Since more than two decades, the evolution of karst aquifer systems has been studied by numerical means. Most of these numerical models have described situations in one or two dimensions. We have extended such a numerical model into the third dimension, which now enables us to address much more complex and realistic scenarios, including topographical effects.

A karst aquifer, which by itself is a heterogeneous geological formation exhibiting complex hydraulic properties, is very sensitive to environmental changes. When building a dam-site above a karst aquifer, the local hydraulic boundary conditions often change significantly. Past experiences have shown that dam-sites in karst areas are likely to result in hazardous failures. Here, the development of complex three-dimensional models to study the karstification processes close to dam-sites can help to assess the risk.

We present a three-dimensional model describing the evolution of a gypsum karst aquifer along the Birs River near Basel in Switzerland. Here, a dam was built in 1890 to generate hydro-electric power from a small power plant. After subsidence of a nearby highway, geophysical and geological field studies have been carried out and a detailed hydrogeological model has been developed. Following this observation phase, construction measures have been carried out between 2006 and 2007 to prevent any further damage. The results from the geological and geophysical investigations gave us the necessary a-priori information to implement the initial and boundary conditions into our three-dimensional numerical model.

We concentrate on three main phases in the evolution of the Birs River karst aquifer: The first phase starts 1000 BC and ends with the construction of the dam. The natural evolution of the aquifer gives the initial boundary conditions for the second phase, starting with the construction of the dam and ending before the construction measures in 2006. The third phase follows right after the construction measures and is calculated for the following 100 years.

Together with the other methods applied at the site, our three-dimensional karst aquifer evolution model enhances the interpretation of the development of this heterogeneous karst aquifer system. Our study shows that our three-dimensional modelling program helps in understanding a quite complex karst aquifer system such as the Birs River.