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Optimized physical recovery of DNAPL using upwelling technique and geostatistical analysis at large field scale

David Cazaux (david.cazaux@solvay.com) (Solvay, Tavaux, FRANCE)
Stéfan Colombano (s.colombano@brgm.fr) (BRGM, Orléans, France)
Antoine Joubert (antoine.joubert@serpol.fr) and Alain Dumestre (Serpol, Venissieux, FRANCE)
Guillaume Lecuelle (UFC, Besançon, FRANCE)

Background/Objectives.
The site is a large chloralcali chemical plant located in the centre-east of France. From the 1980s to 2007, a several hectares historical DNAPL pool was physically confined while migration was monitored. The DNAPL has rapidly migrated from a landfill and reached a static state within a shallow water-table sandy aquifer at top of a clayey unit at 10 meters depth. Thicknesses of DNAPL have been observed from 20 cm to 150 cm according to substratum morphology. Migration of DNAPL has been controlled by two water pumping wells for thirty years making a water depression in the area and inverse gradient. The average flow-rate of the hydraulic confinement is 40 m3/h. The DNAPL is composed of a mixture of heavy perchlorinated compounds, mainly hexchlorobutadiene (50%), hexachloroethane (10%), perchlorethylene, carbon tetrachloride and hexachlorobenzene. The continental climate at the site, with cold winters, adds major constraints due to crystallization of hexachlorobenzene in the mixture. After a review of several DNAPL recovery strategies, various pumping techniques were selected for testing and then implemented in the field. These methods include batch DNAPL pumping with and without water pumping and batch DNAPL pumping with vacuum.

Approach/Activities.
Location of DNAPL pumping stations was optimized after implementation of drillings and a geostatistical analysis. This revealed interesting features of DNAPL accumulation at the top of the substratum, such as a main flow channel and connected and disconnected basins.
A non-enhanced low-flow batch pumping of DNAPL demonstrated that DNAPL could be recovered continuously at the beginning of the experiment (100 l/h). After a while, a lack of product feeding was observed at the pumping site revealing a threshold pumping rate (5 l/h) caused by weir effects (partially disconnected basin) of the substratum morphology. This demonstrated the limits of batch-pumping stations located above disconnected DNAPL basins.

Results/Lessons Learned.
When using hydraulic upwelling technique, during the pumping phase, water is pumped at a constant rate of 15 m3/h while DNAPL is continuously pumped with an average rate of 20 l/h. The pumping set leads to DNAPL upconing of 0,30 m while water level decrease by 3 meters. After both pumping ceased, DNAPL recovered to the initial interface static level after 50 hours while water level recover static level almost instantaneously. Water pumping induces a pressure gradient around the well that forces the DNAPL to flow at a higher rate towards the screened well without disconnecting small pools of product. Local pneumatic (vaccum) are being experimented at moment and are demonstrated good results.
In order to improve the physical recovery of DNAPL, the optimized techniques implemented in the field tripling the yearly recovery rate between 2008 and 2013 to reach 200 tons.