ABSTRACT: At the Oak Ridge Integrated Field Research Challenge (IFRC) site, Tennessee, the saprolitic aquifer was contaminated by past leaks from the former S-3 disposal ponds between 1951 and 1983. The chemistry of the contaminant plume is also episodically impacted by fresh meteoritic water infiltrating vertically from a shallow variably saturated perched zone and the ditch surrounding the former S-3 ponds. We performed a column experiment using saprolite from the contaminated aquifer to understand the geochemical and complex electrical conductivity signatures associated with such events. The changes in the pH and pore water conductivity are responsible for measurable changes in both the in-phase and quadrature conductivities. The pore water conductivity can be related to the nitrate concentration (the main ionic species in the plume) while the release of uranium is controlled by the pH. We developed a simple model to determine the pore water conductivity and pH from the recorded complex conductivity. This model is applied to time-lapse resistivity data at the IFRC site. Time-lapse inversion of resistivity data in the field shows the occurrence of an infiltration event during the winter of 2008-2009 with a dilution of the pore water chemistry and an increase of the pH. A simple numerical simulation of the infiltration of fresh water into the unconfined contaminated aquifer is consistent with this scenario.