Bioremediation and Sustainable Environmental Technologies—2017. Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies (Miami, FL; May 2017). ©2017 Battelle Memorial Institute, Columbus, OH, www.battelle.org/biosymp. A. Barton and S. Rosansky (Chairs)

# Feasibility Study of Low Temperature in Situ Thermal in DNAPL Source Zone Remediation through Numerical Simulation

***Amy Y. Fu*** (a.fu@ellisassoc.com) (Ellis & Associates, Inc., Jacksonville, FL, USA and University of Florida, Gainesville, FL, USA)
Yingqi Zhang (yqzhang@lbl.gov) and Liange Zheng (lzheng@lbl.gov) (Lawrence Berkeley National Laboratory, Berkeley, CA, USA)
Michael D. Annable (annable@ufl.edu) (University of Florida, Gainesville, FL, USA)

**Background/Objectives.** In this research, an in-depth study of low temperature in situ thermal (IST) technology (i.e. heater temperature at below 100 degrees Celsius [˚C]) for the remediation of dense nonaqueous-phase liquid (DNAPL) source zones caused by tetrachloroethene (PCE) releases has been conducted through numerical simulations.

**Approach/Activities.** Using TOUGH2 suite of nonisothermal multiphase flow simulators, the effect of low temperature IST at a temperature range of 50˚C to 90˚C combined with a soil vapor extraction (SVE) and a multi-phase extraction (MPE) system has been evaluated for various DNAPL (i.e., PCE) site conditions (i.e., sandy soil, silty sand, clayey sand, and heterogeneous soil conditions). The results of the numerical simulation help to improve understanding of the physical processes of contaminant mass removal and mass flux in various soil conditions under the influence of low temperature in situ heating. In addition, the feasibility of employing low temperature IST for DNAPL source zone treatment has been evaluated in terms of improving mass removal during active remediation and reducing back diffusion following remediation.

**Results/Lessons Learned.** Simulation results indicate that a significant increase of mass removal and reduction of mass flux could be achieved with the temperature of ISTs set as low as 50˚C comparing to an isothermal condition of 20˚C. In addition, the higher the temperature of the IST setting is, the more efficient this remedy appears to be. Secondly, during remediation, DNAPL source is largely removed from the gas phase instead of the NAPL or aqueous phase. Thirdly, subsurface temperature increase is faster and more prominent in lower permeable soils (i.e., clayey sand) than in higher permeable soils (i.e., sandy soil), suggesting that IST might be favorable for low permeable soil conditions. Numerical simulations of back diffusion following active remediation are ongoing.