Despite substantial research and technology development over more than two decades, sites contaminated by dense nonaqueous phase organic liquids (DNAPLs) remain a distinct remedial and management challenge. DNAPL contamination remaining after aggressive mass removal may lead to persistent elution of dissolved-phase contaminants that pose risks to human health and the environment. This presentation summarizes research sponsored under SERDP Project ER-1293 that relate to source zone remedial design and performance assessment.

It is now widely recognized that natural subsurface heterogeneity tends to give rise to a high level of non-uniformity in DNAPL saturation distributions, leading to significant spatial variability in near-source downstream concentrations. Laboratory and mathematical modeling studies conducted under SERDP sponsorship have further revealed that DNAPL persistence under natural gradient conditions, as well as the performance of many source zone remedial technologies, will be closely linked to the spatial distribution of contaminant mass (i.e., the DNAPL ‘architecture’) within the source region. For example, research has demonstrated that greater mass removal efficiency can be achieved under scenarios with higher ganglia-to-pool (GTP) mass ratios. The impact of mass removal on downstream contaminant mass flux and plume evolution, however, has been much more difficult to predict. Recently, a number of simplified modeling tools for site management have been developed to predict the response of mass flux to mass removal, through the incorporation of source zone architecture metrics, such as GTP ratio. Although such models can represent early time behavior, they often fail to reproduce observed concentration tailing that typically occurs at large time or high mass removal levels. In addition, model calibration and prediction accuracy are largely dependent upon the quality and extent of site characterization data. These points are illustrated with example simulations of source evolution and mass flux behavior. Aggressive mass removal, coupled with monitored bio attenuation or remediation strategies, may offer significant promise for long term plume control at many sites. The complex interplay between spatial variability in formation properties (e.g. permeability) and a non-uniform distribution of contaminant mass, however, presents significant challenges for remedial technology design and implementation. The influence of heterogeneity and process coupling on remediation performance are illustrated with results of laboratory and modeling investigations involving in situ metabolic reductive dechlorination of PCE-DNAPL.