

## Spectral induced polarization signals from aqueous film forming foam (AFFF) source zones

Lee Slater<sup>1,2</sup>, Charles Schaefer<sup>3</sup>, Dale Werkema<sup>4</sup>, Dimitrios Ntarlagiannis<sup>1</sup>, Alex Avelar<sup>1</sup>, Ethan Siegenthaler<sup>1</sup>, Tara Moghtaderi<sup>1</sup>, Maxwell Hire<sup>3</sup> and Fred Day-Lewis<sup>2</sup>

<sup>1</sup>*Department of Earth & Environmental Sciences, Rutgers University Newark, USA, lslater@newark.rutgers.edu; lee.slater@pnnl.gov*

<sup>2</sup>*Energy & Environment Directorate, Pacific Northwest National Laboratory, USA*

<sup>3</sup>*CDM Smith, USA*

<sup>4</sup>*Environmental Protection Agency (EPA), USA*

### ABSTRACT

The development of field-scale, in situ screening technologies is crucial for assessing aqueous film forming foam (AFFF) source zones at former fire training and storage sites, which are long-term sources of per- and polyfluoroalkyl substances (PFAS) contamination. Spectral induced polarization (SIP) may offer sensitivity to AFFF contamination due to the sorption of cationic/zwitterionic PFAS compounds and non-fluorinated surfactants to mineral surfaces. We explored the sensitivity of SIP to AFFF-contaminated soils with PFAS concentrations ranging from 2-30,000 ppb, confirmed by accepted analytical methods. Laboratory measurements were performed on soil samples from three AFFF source zones and field-scale SIP transects were conducted across these zones.

A statistically significant linear relationship between total PFAS concentration and laboratory-measured SIP response (phase angle) was observed for one undisturbed source zone but based on only 10 samples. A visual correlation between field SIP response and sample PFAS contamination was noted but not statistically significant. In contrast, no significant relationship between SIP response and total PFAS concentration was found at a second source zone, where soil remediation activities had been undertaken, despite the availability of an extensive set of soil samples with PFAS analysis performed (>70 samples).

These findings indicate that SIP may provide a rapid and cost-effective means to map variations in contamination across AFFF source zones, guiding the selection of soil sampling locations and minimizing the risk of missing PFAS hotspots. However, the success of this technology will depend on the complexity of the site. While SIP may yield useful information on variations in PFAS contamination at undisturbed sites with native soils, its sensitivity to sorbed

AFFF constituents may be compromised by soil heterogeneity at remediated sites. Ongoing research is focused on identifying the components of AFFF that most likely explain the observed dependence of SIP on soil PFAS concentrations.