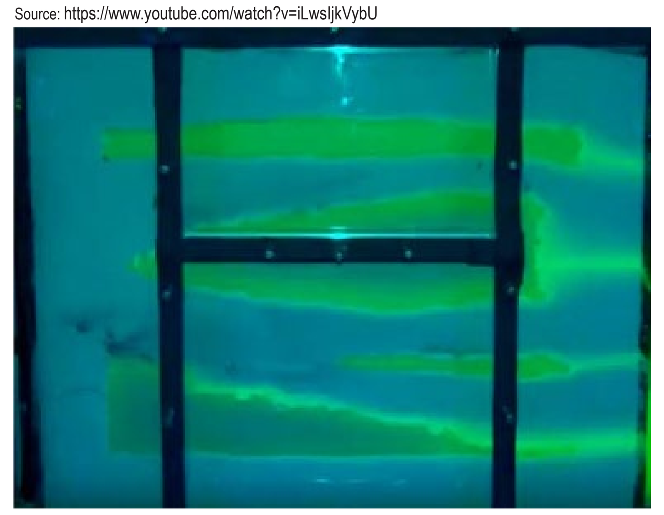
Immediate Benefits from HRSC Techniques for Three PFAS Investigations

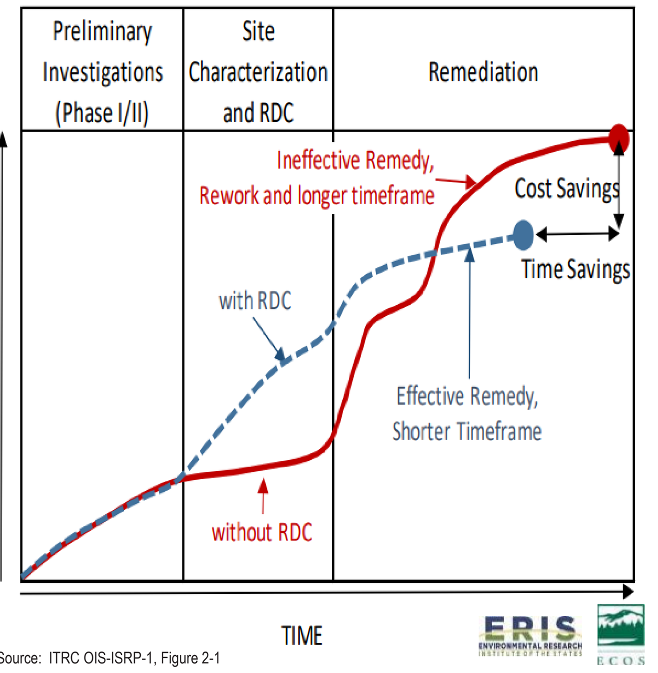
Michael Hertz, Steve Morrissette, Hannah Dennis, and Cybil Boss
EA Engineering, Science, and Technology, Inc., PBC

BACKGROUND/OBJECTIVES

PROBLEM STATEMENT: While the environmental market has matured and many of the large groundwater plumes have been brought under control, remediation optimization through HRSC has been required for many recalcitrant sites. Matrix back-diffusion and preferential groundwater flow paths (i.e. 80 percent of the mass transports through 20 percent of the aquifer) that have extended the assumed remediation timeframes and these residual sources and/or contaminant migration pathways are of the scale that have necessitated HRSC to answer the data gaps that previous investigations created or may have missed. With the emerging Per- and Polyfluoroalkyl Substances (PFAS) contaminant class, there are many questions on plume fate/transport due to low attenuation/differential mobility of the PFAS compounds, environmental mediated biotransformation rates, and source strength/leaching potential from soil to groundwater. While the questions will be answered through site/remedial investigation (RI), the lessons learned for HRSC used late in the site life-cycle can also be collected at the onset of the investigations to 1) develop more robust conceptual site models (CSM) for fate/transport analysis and 2) expedite the investigation while reducing overall total site life-cycle costs through optimized remediation planning. This presentation provides three case studies where adaptive investigation phasing utilizing HRSC has been incorporated at active PFAS RI sites across the US with immediate benefits realized by the project stakeholders.

Source: https://www.youtube.com/watch?v=iLwsljkVybU



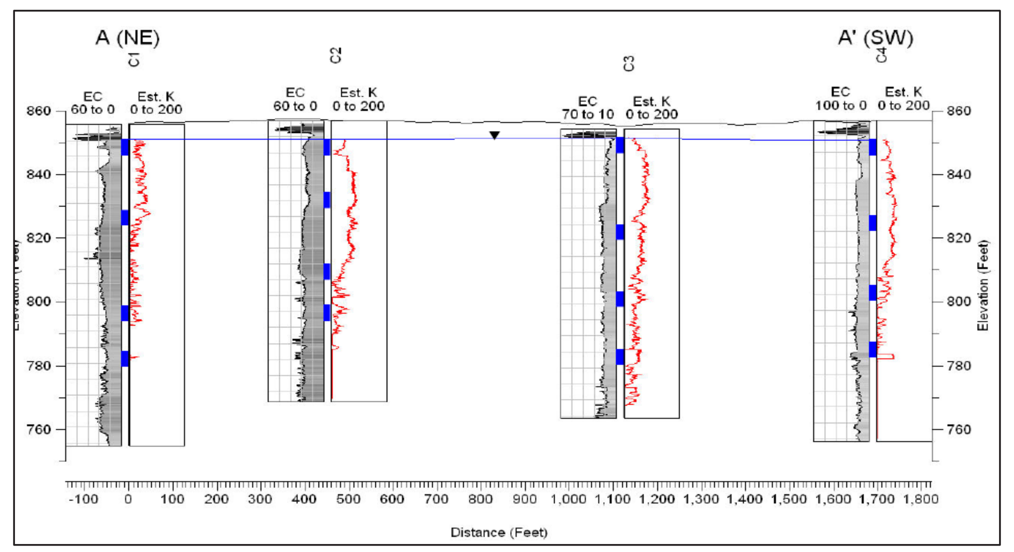


Source: ITRC OIS-ISRP-1, Figure 2-1

APPROACH/ACTIVITIES

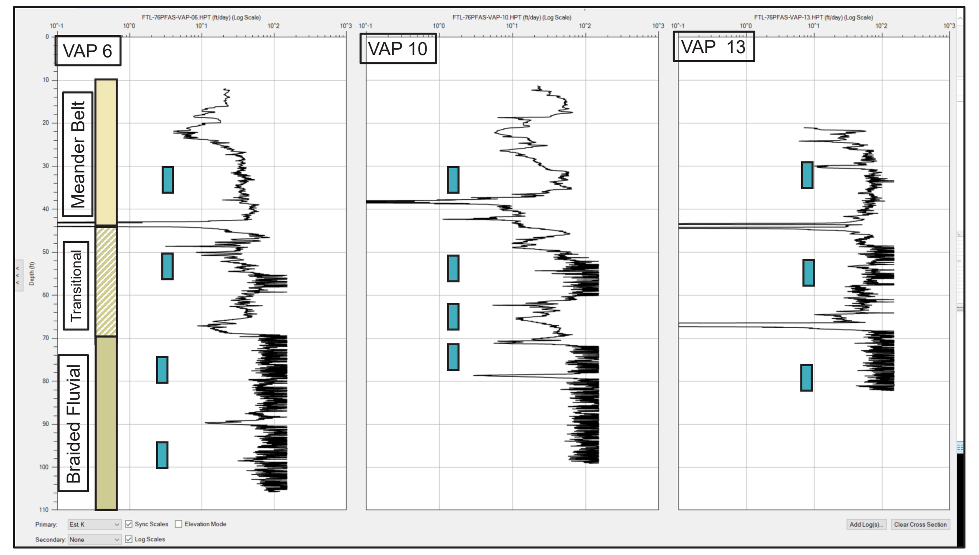
HRSC Case Study No.1 includes the hydraulic profiling tool (HPT) combined with vertical aquifer profiling in the Missouri River floodplain where generally fining upward point bar and braided fluvial deposits, sometimes in paleo bedrock channels are present that can create preferential flow paths. PFAS mass flux assessments were also performed to identify the preferential flow paths toward the river. To refine the locations for the HRSC borings, an Environmental Sequence Stratigraphy (ESS) based CSM was developed and was iteratively refined with the HRSC results. HRSC Case Study No. 2 included HPT/VAP with mass flux assessments in a glacial depositional environment but also included high-density/rapid turn-around time soil sampling in the previously unidentified source areas based on rapid HPT/VAP results. HRSC Case Study No. 3 includes high density soil sampling in identified source areas in alluvial material over basalt bedrock with co-located soil leaching samples via the Synthetic Precipitation Leaching Procedure (SPLP) to assess the potential areal mass flux from soil to groundwater considering the soil matrix chemistry/characteristics.

HRSC Boring Transect – Electrical Conductivity (EC) and Hydraulic Profiling Toll (HPT)



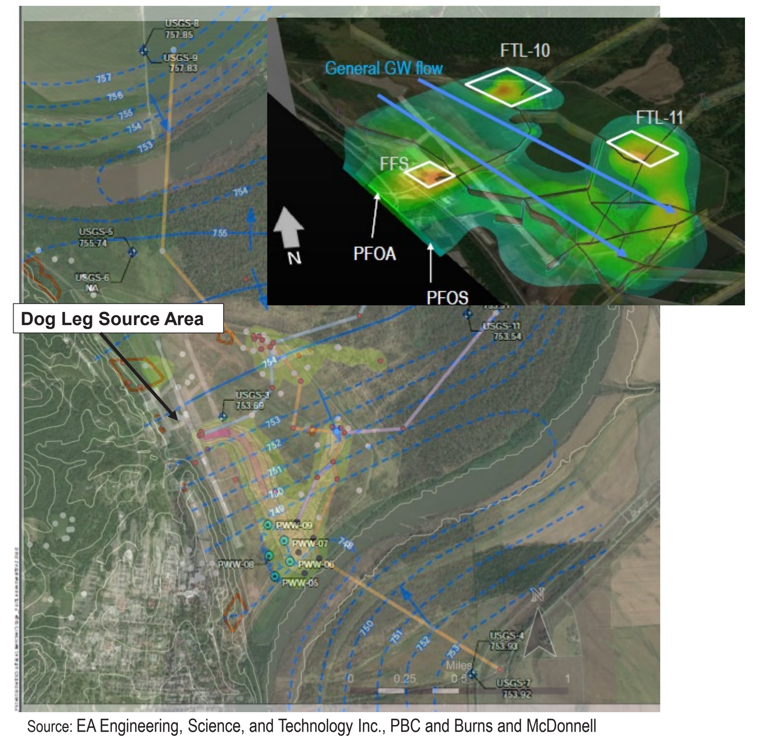
Source: EA Engineering, Science, and Technology Inc., PBC

HRSC Boring Transect – HPT and ESS-based Lithological Contact Analysis



Source: EA Engineering, Science, and Technology Inc., PBC

CASE STUDY NO. 1 – FLOODPLAIN SITE



Source: EA Engineering, Science, and Technology Inc., PBC and Burns and McDonnell

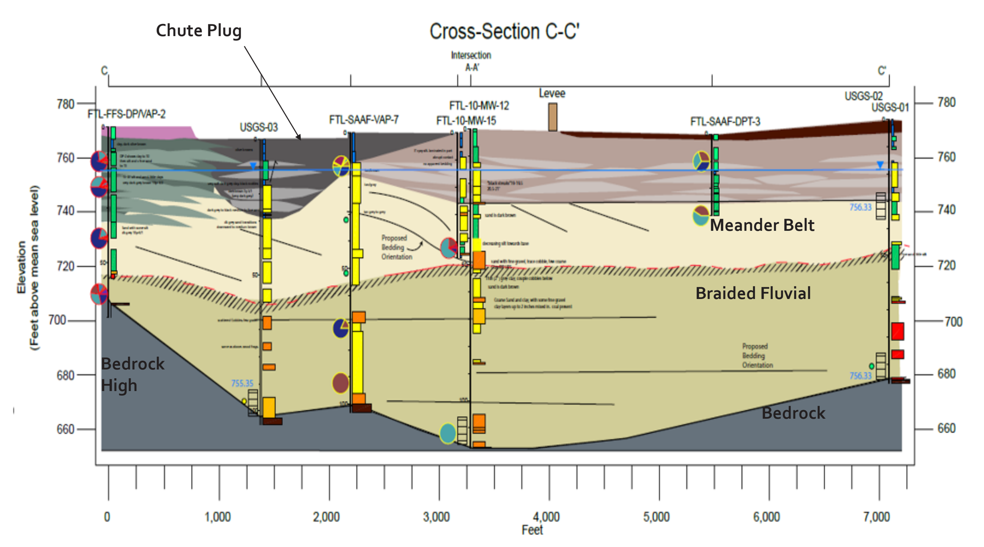
Background/Problem Statement

- Site located in floodplain of major central US river
- PFAS investigations performed prior to RI were significant (VAPs/wells)
- PFAS deep (100 ft bgs) due to groundwater production wells
- Plume(s) shape/direction did not match the historical groundwater potentiometric surface
- RI Approach included ESS analysis and HRSC to enhance the Conceptual Site Model and explain the "dog leg" source area. Was the dog-leg due:
  - Former Chute Plug deposit?
  - Groundwater pumping induced?

Benefits of High-Resolution Site Characterization

- ESS-developed hydrostratigraphic model identified chute channel PFAS flow
- HRSC (VAP and HPT/EC) boring confirmed lithologic contacts did not vary more than a few feet vertically
- Combination of ESS analysis and HRSC allowed for stakeholder agreement for 14 additional wells and 21 existing wells to monitoring 165 acres of PFAS plumes (1 well per ~5 acres)

ESS-Based Cross-Section using Previous Data (Reinterpreted)



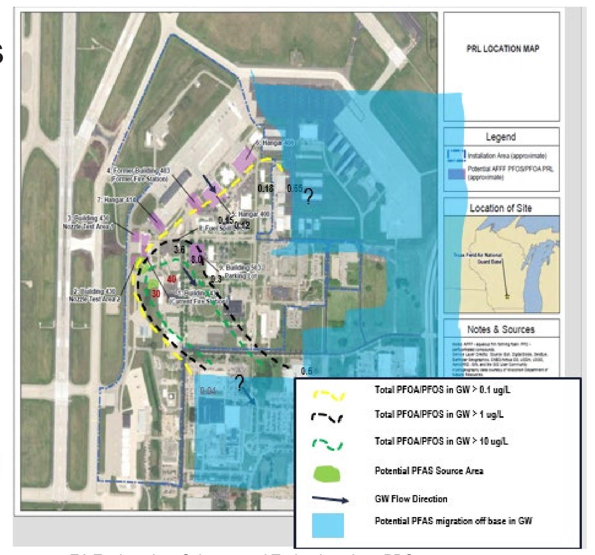
Source: EA Engineering, Science, and Technology Inc., PBC and Burns and McDonnell

CASE STUDY NO. 2 – UPPER MIDWEST SITE

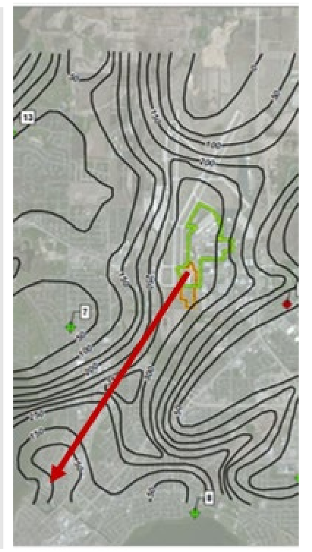
Which Way is Groundwater Flow?

- Site located in unconsolidated glacial and lacustrine sediments
- Historical documents suggested southeast flow
- Environmental Sequence Stratigraphy (ESS)-based analysis suggested southwest flow
- Insignificant number of groundwater wells on site for groundwater gauging
- Additional groundwater wells to be installed after plume delineated
- Using high-resolution site characterization borings, determined depth to groundwater and surface elevations from Digital Elevation Models (DEM), confirmed southwest flow.

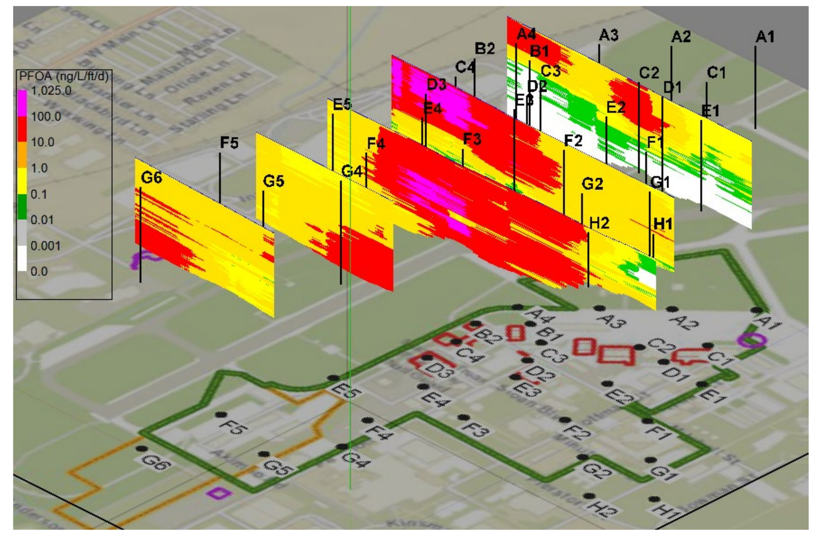
EXPECTED – HISTORICAL DOCUMENTS



MOST LIKELY – ESS BASED



Source: EA Engineering, Science, and Technology Inc., PBC

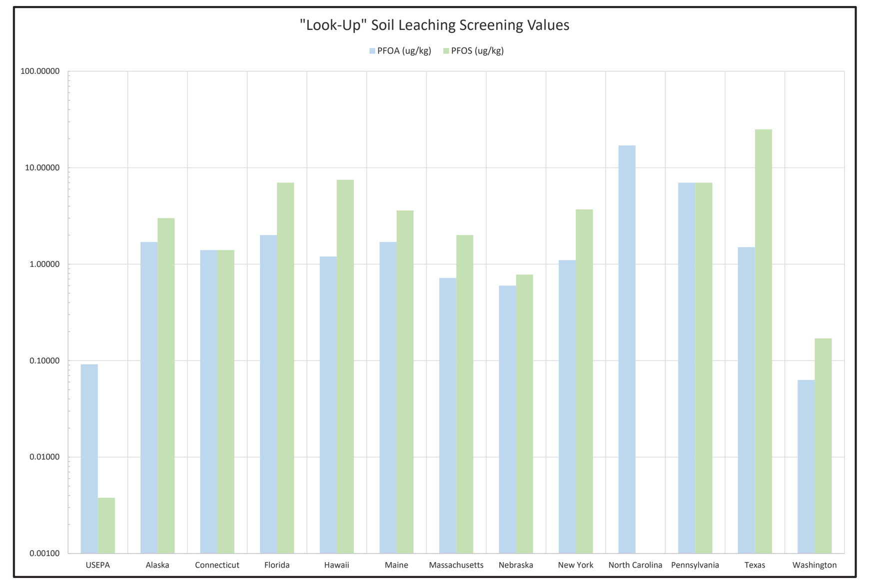


Source: EA Engineering, Science, and Technology Inc., PBC

Benefits of High-Resolution Site Characterization

- Quickly identified groundwater flow direction without wells
- Previous southeastern flow direction due to former groundwater production well
- Transect sampling approach used to assess PFAS flux zones, demonstrated downward migration along more permeable glacial outwash deposits
- Two additional PFAS source areas identified based on GW results
- Reduced the number of groundwater wells for plume delineation by 50% versus what historically was used to delineate plumes.

CASE STUDY NO. 3 – WESTERN SITE



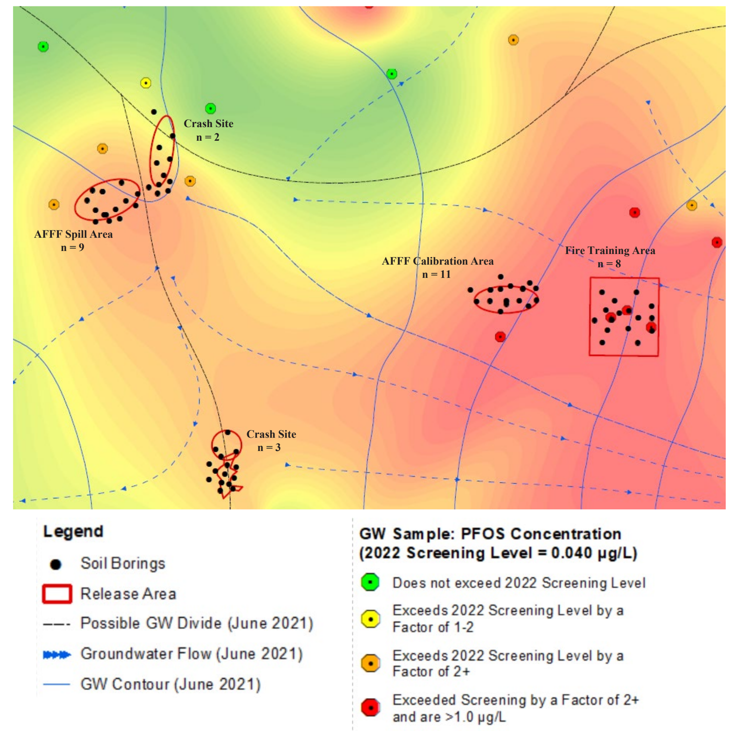
Source: EA Engineering, Science, and Technology Inc., PBC

Background/Problem Statement

- The soil to groundwater pathway for PFAS is difficult to numerically assess due to various chemical property factors
- State and Federal Screening Levels vary by orders of magnitude

Source: Eurofins Environmental Testing

Source: EA Engineering, Science, and Technology Inc., PBC



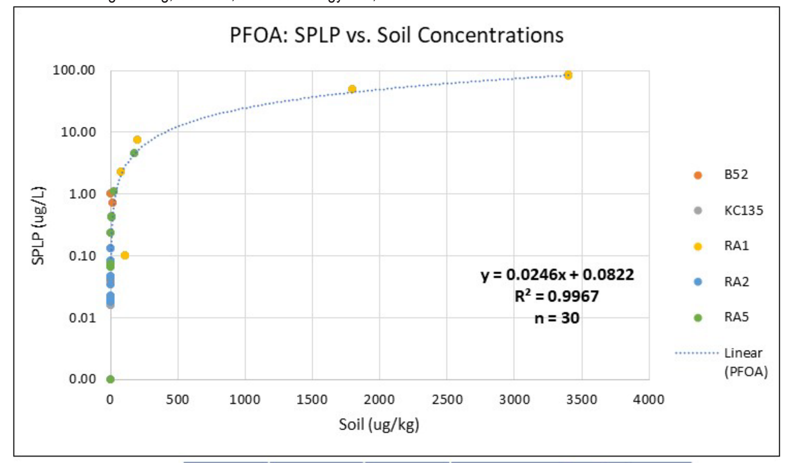
Site Background/Sampling Program

- Semi-arid environment
- Five release areas assessed

33 Synthetic Precipitation Leaching Procedure (SPLP) with co-located soil and groundwater samples collected

- Some release point groundwater affected by upgradient groundwater from other known and unknown PFAS sources

Source: EA Engineering, Science, and Technology Inc., PBC



	Slope	$\log_{KOC}$	conversion factor (soil concentration/SPLP)
PFOA	2.46E-02	2.92	40.65
PFHxS	2.24E-02	2.66	44.64
PFNA	1.89E-02	3.6	52.91
PFOS	1.54E-02	3.58	64.94
PFBS	9.70E-03	2.55	103.09

Benefits of High-Resolution Site Characterization

- SPLP data reasonable assessment of PFAS leachate to groundwater for eventual remediation considerations
- Extrapolation of soil/groundwater ratios from site-specific:
  - PFOS SSL = 18.5 ug/kg (EPA Look-up Value = 0.004 ug/kg)
  - PFOA SSL = 3.2 ug/kg (EPA Look-up Value = 0.092 ug/kg)
- Limited correlation of soil to groundwater and SPLP to groundwater suggests other PFAS-soil interactions are not well accounted and reduce leaching to groundwater.
- SPLP results are likely biased high versus actual leaching – dilution attenuation factor results comparisons support by 20 – 30%.

RESULTS/LESSONS LEARNED

HRSC Case Study No.1, based on an ESS based CSM, identified and validated a preferential flow path for PFAS associated with a filled paleo channel deposit associated with the historic course of the Missouri River that was not previously identified during the previous investigations. Through the use of ESS analysis and HRSC sampling, limited additional permanent delineation monitoring wells were required. HRSC Case Study No. 2 identified new soil sources areas for PFAS through use of rapid turn-around time VAP sampling and stakeholder discussion. These source areas were confirmed by high density and rapid turn around-time soil sampling using fixed based laboratory PFAS "screening". Additionally, through use of HRSC, the team validated that the groundwater flow was direction is generally approximately 45 degrees different from what was previously depicted in other environmental investigations using a combination of ground surface elevations from digital elevation models and water table occurrence in the HPT logs. This saved the project team time and resources associated with installing groundwater monitoring wells for groundwater flow direction determination. The soil data associated with HRSC Case Study No. 3 has demonstrated that USEPA Regional Screening Levels for the Soil to Groundwater Pathway overestimate by 2 to 4 orders of magnitude for PFOA/PFOS. The anticipated benefits from HRSC from these projects include reducing RI timeframes by over 50% and reducing permanent monitoring wells by over 60%.