TCE Source Area Investigation in Fractured Bedrock Using Phytoscreening and Membrane Interface Probe Sampling at a Former Landfill

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Presented By:

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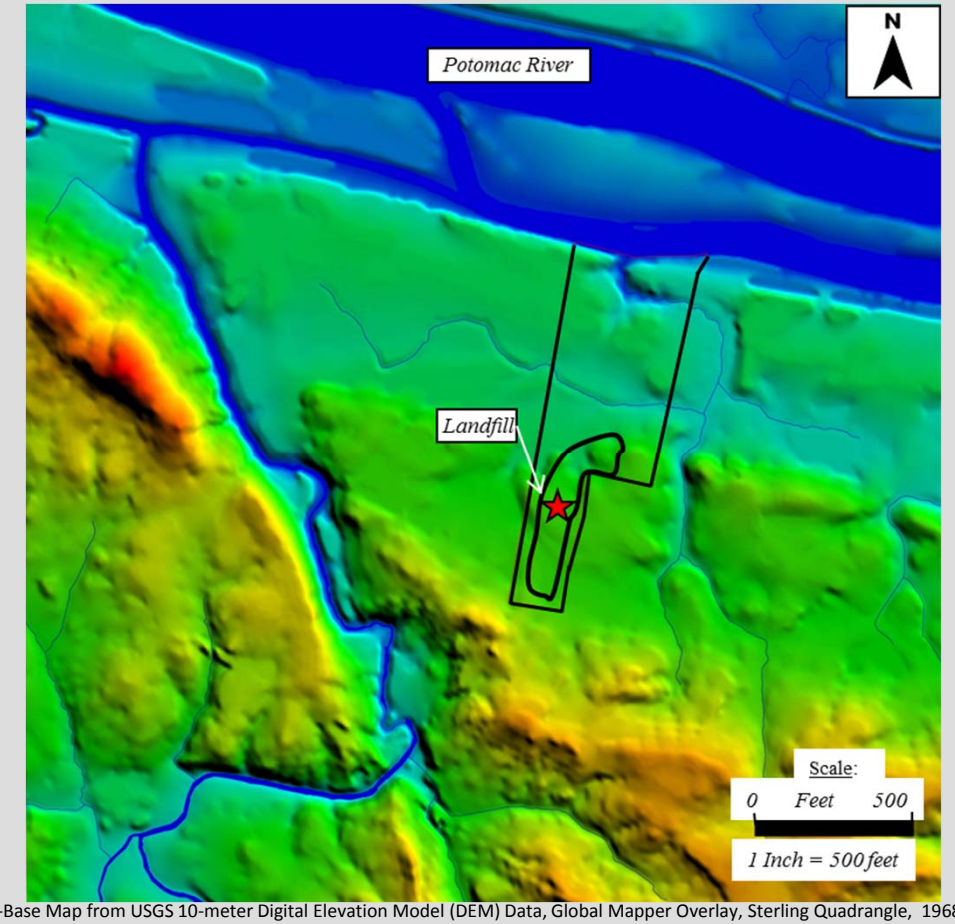
Former VA Landfill Superfund Site, EPA Region 3

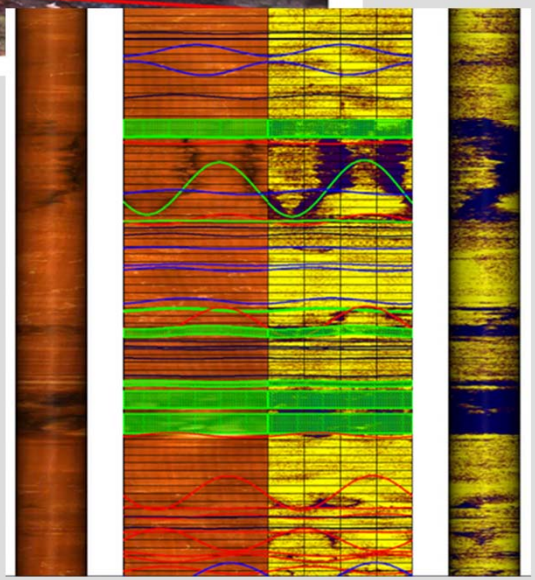
- **Site Background:**
  - 25-acre former landfill in Northern Virginia
  - Received unapproved waste from 1971 to 1984
  - TCE detected in residential drinking water wells in adjacent subdivision
  - Whole house water treatment systems in homes with contaminated wells
- **RI and Treatability Study**



-Base Map from USGS 10-meter Digital Elevation Model (DEM) Data, Global Mapper Overlay, Sterling Quadrangle, 1968

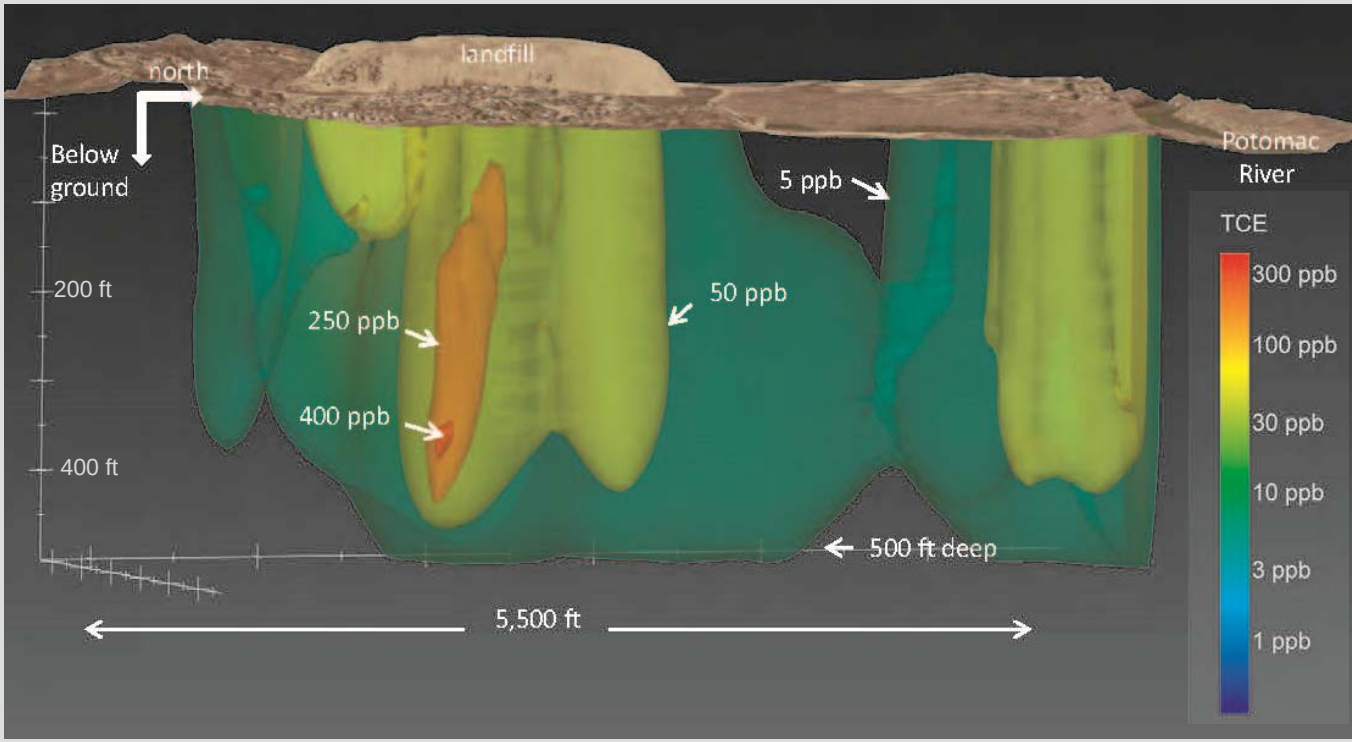
Geology and Hydrogeology

- Geology
  - Overburden - clays and sandy silts
  - Saprolite and weathered bedrock
  - Triassic age pore-cemented siltstone
  - Various fracture orientations
    - Bedding plane partings dip 10-20° WNW
    - High angle joint sets and fault related fractures (east and west dipping)
- Groundwater
  - Flow direction is to the north
  - Depth to water ranges from 16 to 57 ft bgs
  - Hydraulically interconnected overburden and bedrock



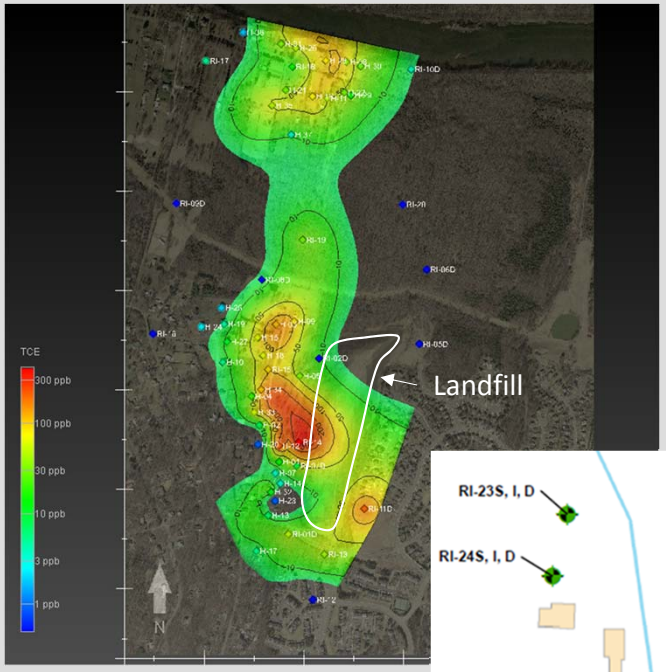
Highlights of RI Findings

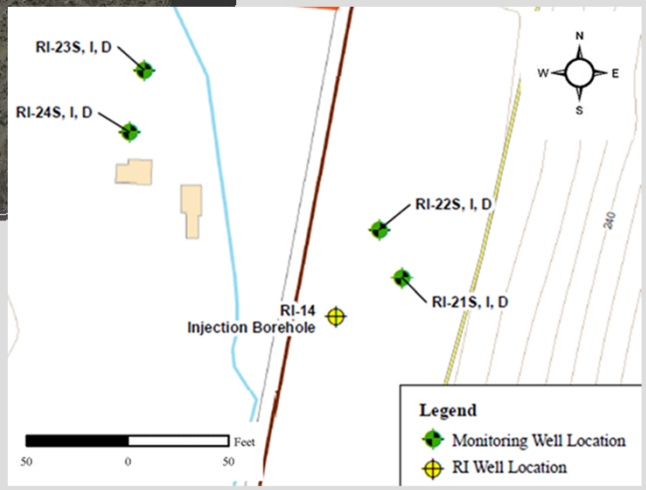
- RI identified a 207-acre TCE groundwater plume in fractured bedrock
- TCE groundwater plume extends to a depth of 50 to 480 ft bgs
- Highest observed TCE concentration during the RI was 420 ppb (RI-14 at 345-365 ft bgs)



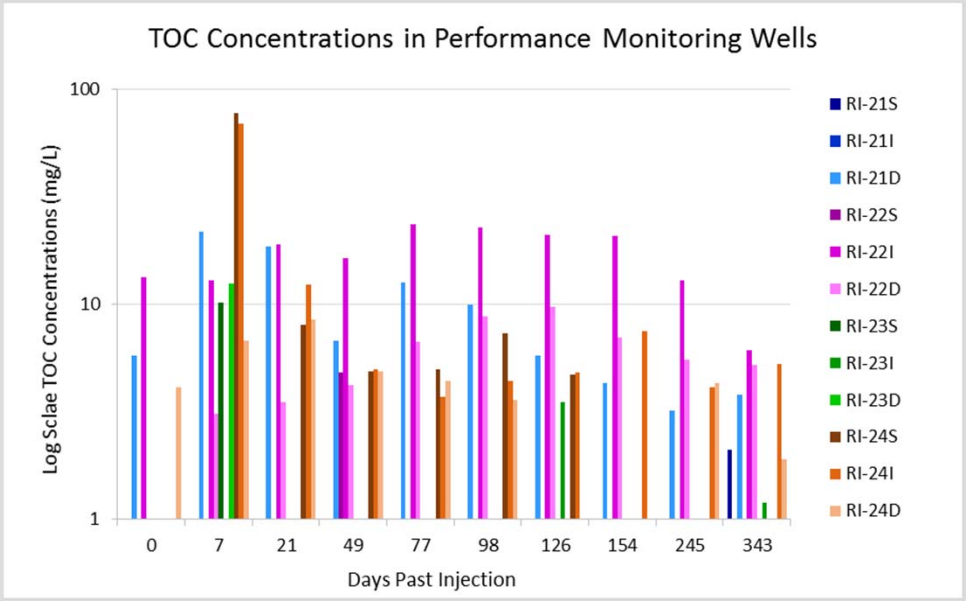
In Situ Bioremediation Pilot Study

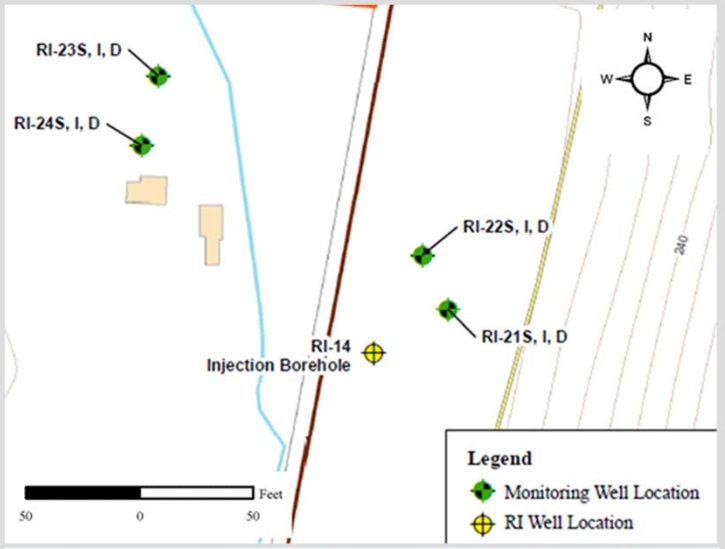
- Performance monitoring cluster wells
  - Along strike of identified joint sets
  - Along dip direction of bedding planes
- Pre-conditioned the injection water with lactate amendment
- SDC-9™culture was pre-mixed with EHC-L®
- Injected 40K gal EHC-L® into 13 zones in RI-14
  - Depth from 182 to 461 ft bgs
  - Straddle packers with 20 ft spread





In Situ Bioremediation Pilot Study



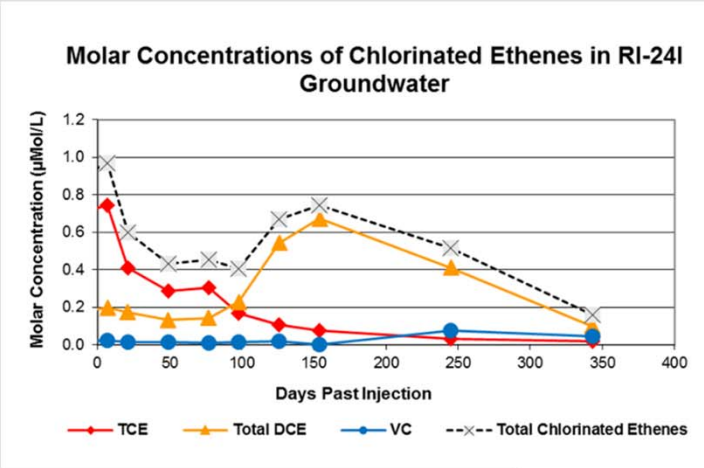


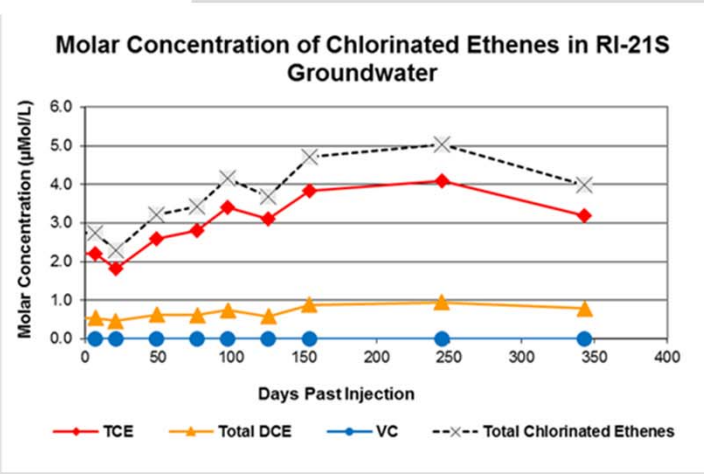
Monitoring Well ID	RI-21	RI-22	RI-23	RI-24
Distance from RI-14 (feet)	35	45	125	142

- Range of influence and observed substrate distribution was irregular
- Controlled by interconnectivity and orientation of fractures
- Substrate was delivered as far away as 142 ft from the RI-14 to RI-24

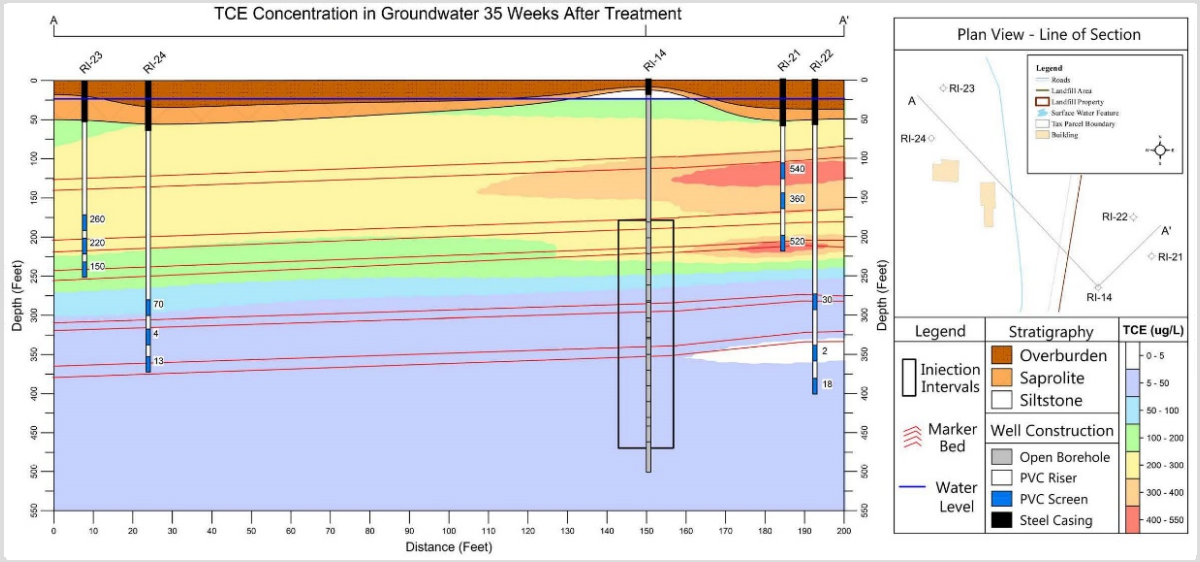
In Situ Bioremediation Pilot Study

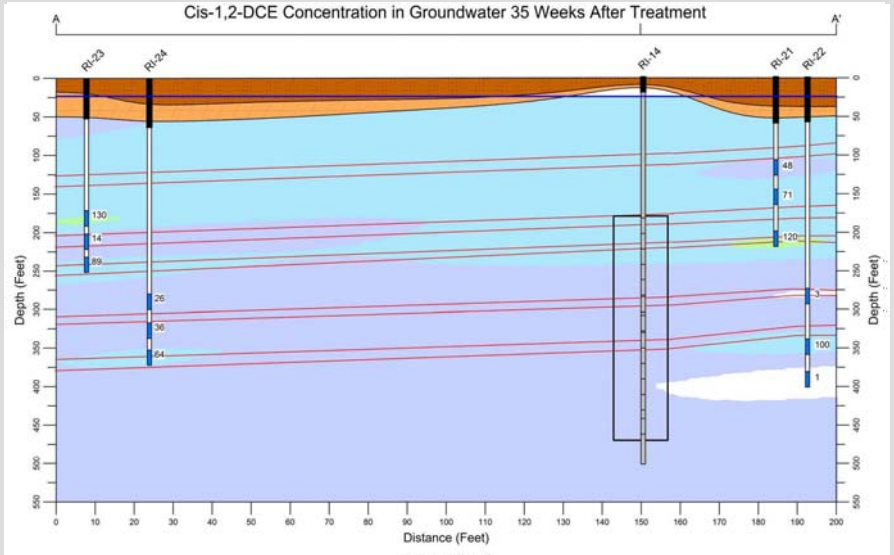
- Variable degrees of biodegradation and some abiotic degradation of TCE occurred
- TCE to VC or ethene was observed in wells with greater fracture interconnectivity
- Biogeochemical conditions for degradation of TCE was not established for wells with very little interconnectivity





In Situ Bioremediation Pilot Study

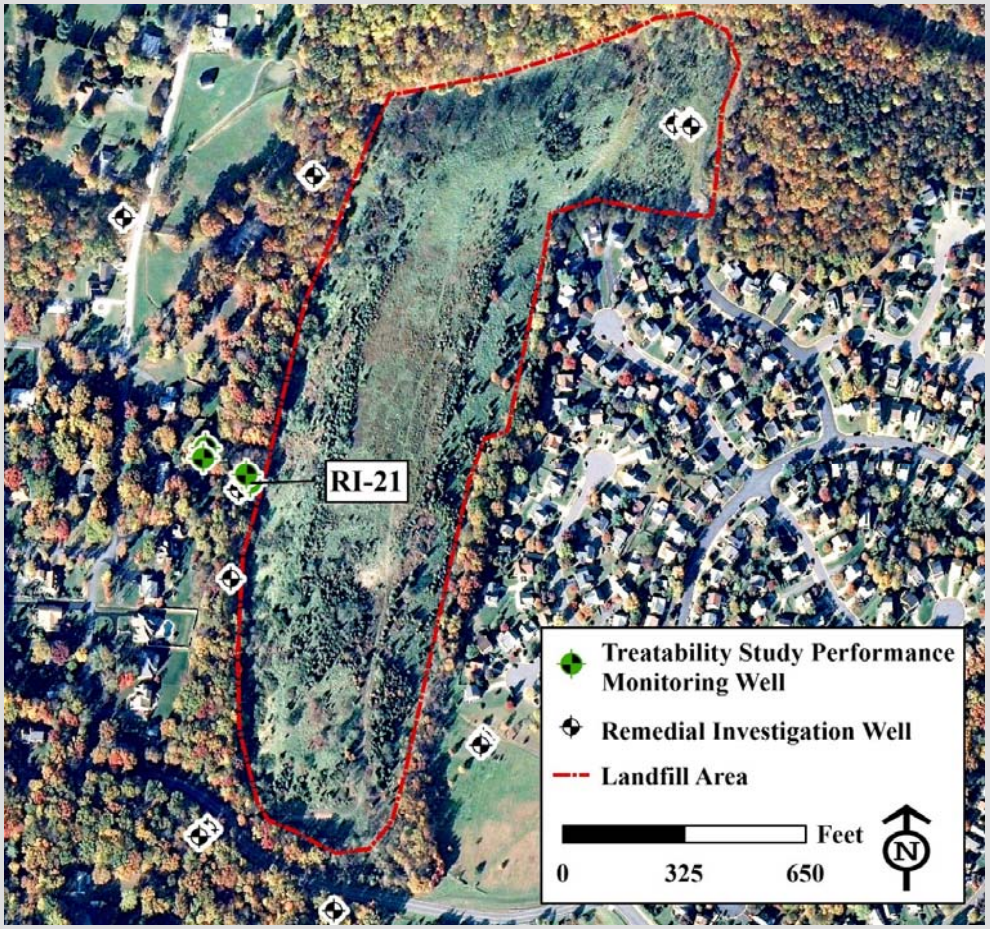




- Elevated concentrations of TCE in the shallow bedrock were observed migrating into the pilot study area from the landfill during post-injection sampling events
- DCE concentrations continued to increase
- A full scale chemical reduction remedy would not be effective until the source has been addressed

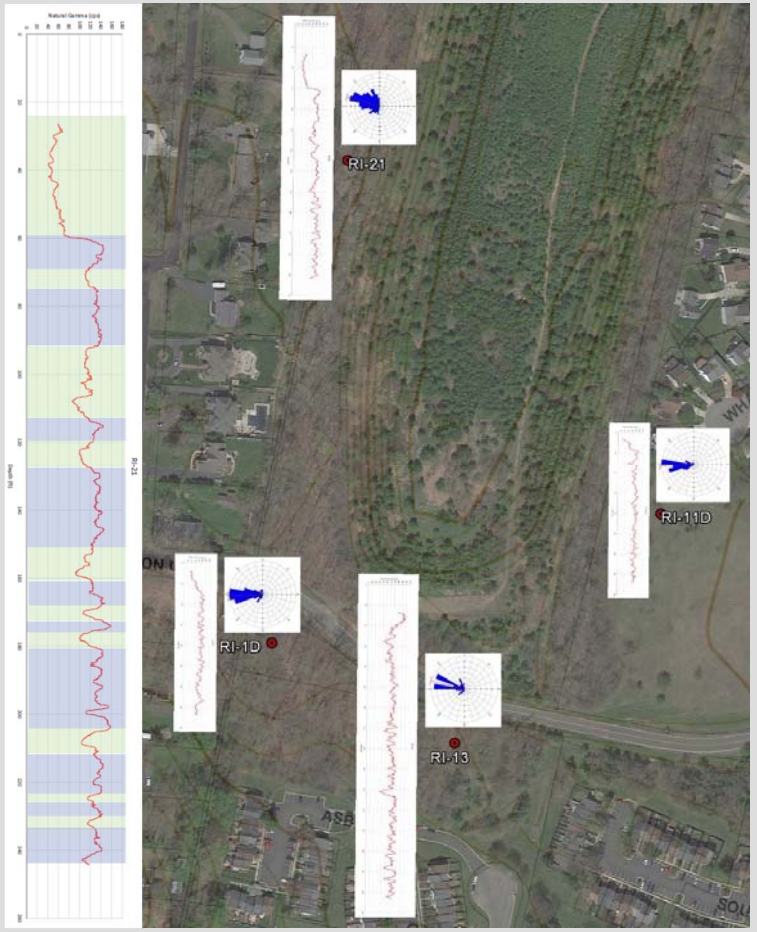
TCE Source Investigation

- Source investigation was performed to better define the shallow source of dissolved TCE mass migrating from the landfill
- Phased approach was developed to identify the source area
  - Narrow the investigation area
  - Locate and define the TCE subsurface source area
  - Well installation



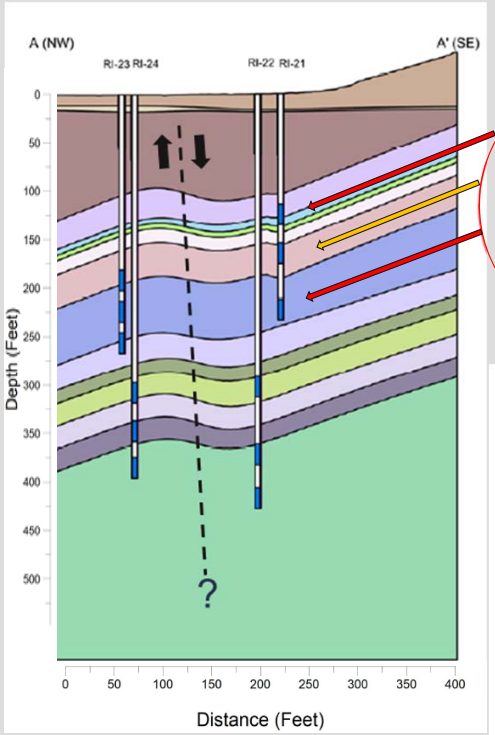
First Phase – Narrow the Investigation Area

- Evaluated bedding plane fracture orientations statistically and correlated gamma logs to:
  - Better understand bedding orientation
  - Subdivide the siltstone into multiple stratigraphic units to identify preferential zones of contaminant migration
- The stratigraphic units were projected three-dimensionally in a borehole database geologic modeling program to determine their extent up-dip and up-gradient (along strike)

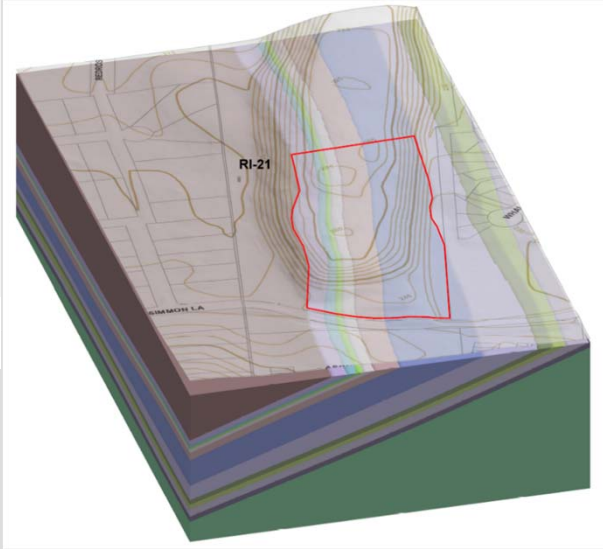


Narrow the Investigation Area Results

- Bedding plane orientations vary in some areas
- The stratigraphic units are present with a few notable anomalies (vertical offset) such as drag-folding along minor normal faults
- The units from RI-21 containing the highest TCE concentration subcrop in the southern portion of the landfill when projected up-dip and in the upgradient direction
- Focused source investigation activities to the southern portion of the landfill.

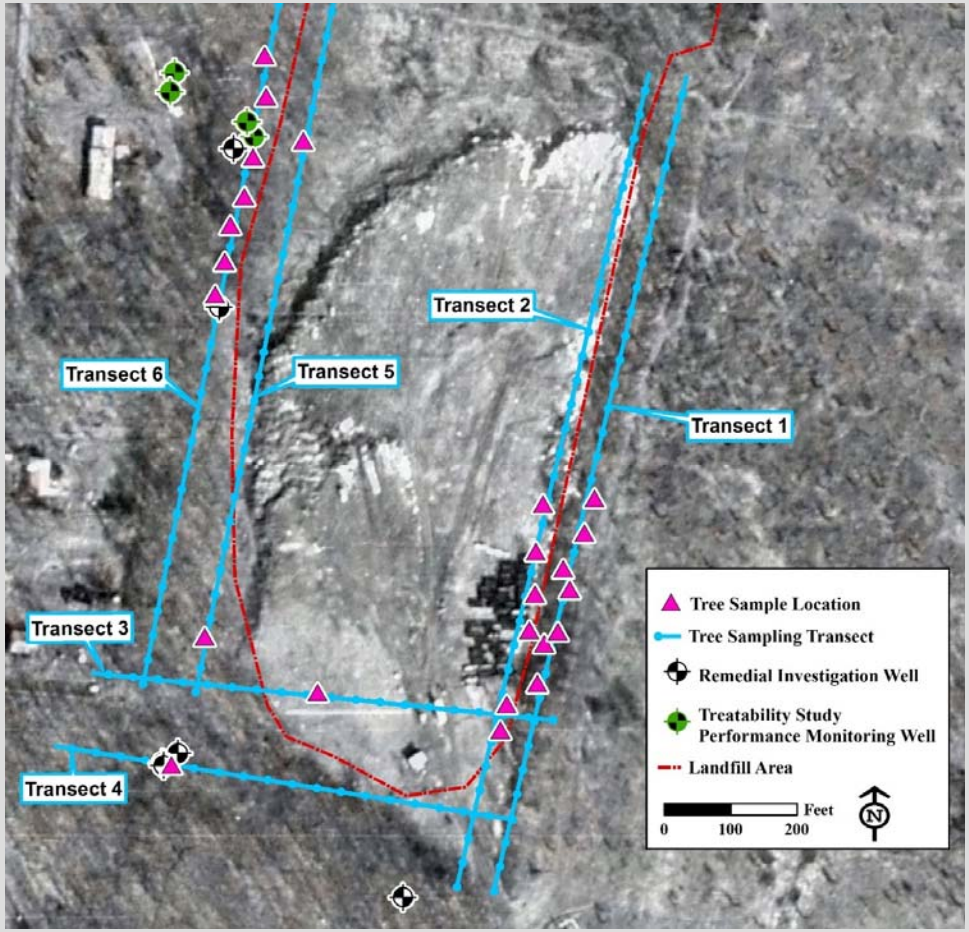


TCE Migrating into Pilot Study Area



Second Phase – Locate and Define TCE Source Area

- Phytoscreening by tree core sampling
- Screening tool to provide a direct line of evidence of contaminant uptake by the tree root system (<10 ft)
- Collected tree core samples from 24 trees along 6 transects
- Tree species included maples, oaks, and locusts

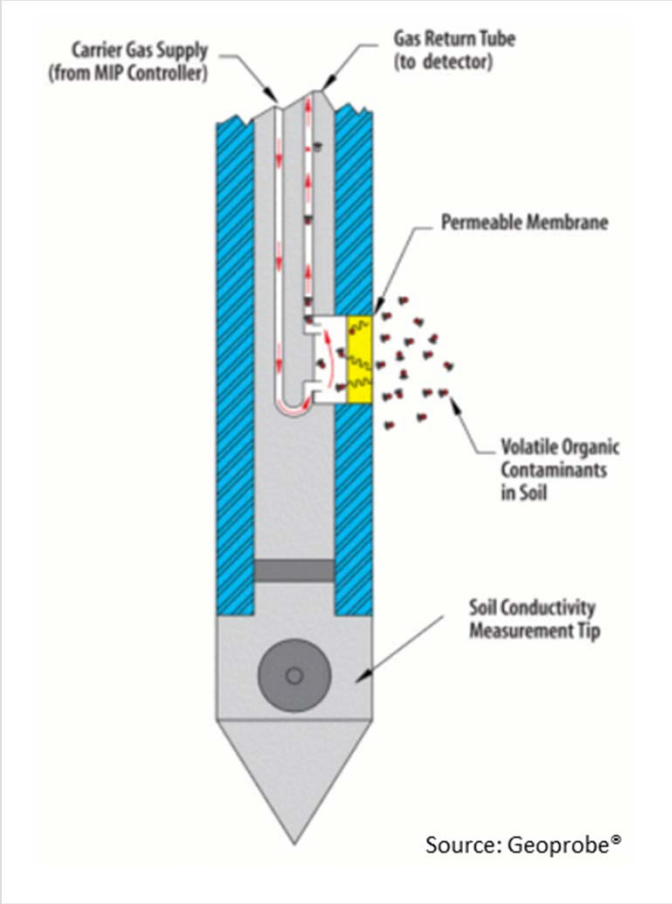


Phytoscreening Tree Core Results

- Collected 72 samples
  - Samples were placed in pre-filled vial of 5 mL of methanol
  - Each sample weighed 2 grams
- Analyzed for TCE using methanol extraction procedure and selected ion monitoring method parameters
- TCE was not detected in the tree core samples
- Indicates that the shallow (<10 ft) subsurface soil along the transects is not impacted with TCE

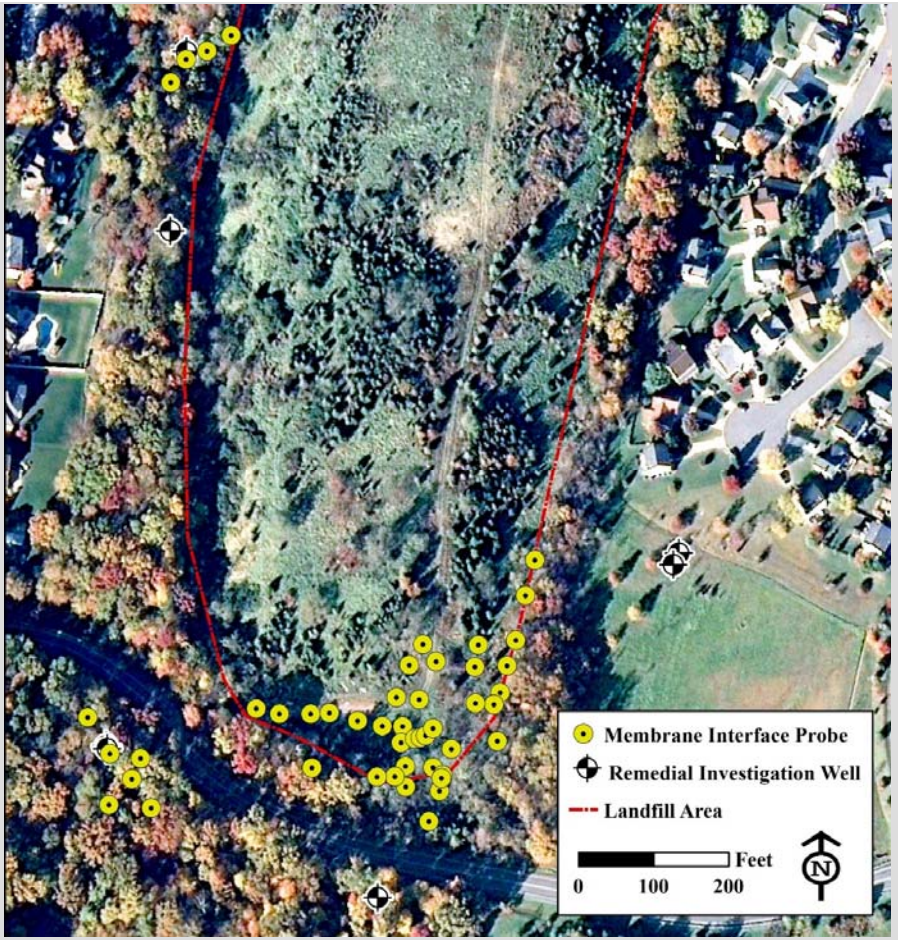
Locate and Define TCE Source Area – Traditional Method

- A high resolution site characterization using Membrane Interface Probe (MIP)
- Screening tool for detection and measurement of volatile organic compounds (VOCs) in subsurface
- Heated probe is driven into subsurface volatizing organic compounds
- These compounds cross a semi-permeable membrane, and are carried by a carrier gas to gas phase detectors for measurement



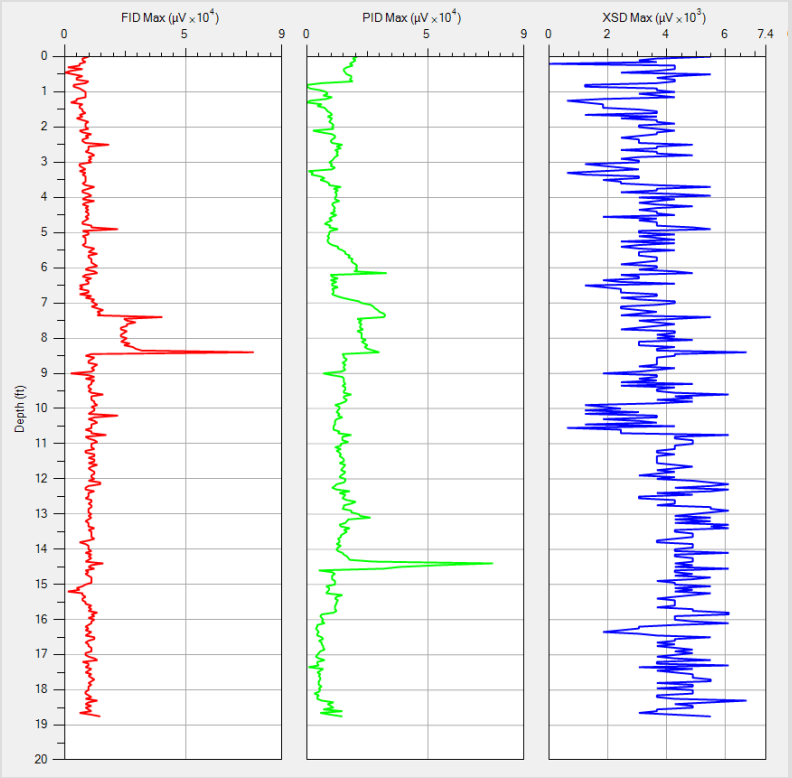
Locate and Define TCE Source Area MIP Results

- 49 MIP locations were advanced
- Borings were advanced until refusal
  - Depth ranged from 8.5 to 31.65 ft
  - Refusal interpreted as top of bedrock
- MIP results indicated two separate contamination areas
  - Residual chlorinated hydrocarbons mixed with petroleum hydrocarbons
  - Distinct TCE source area

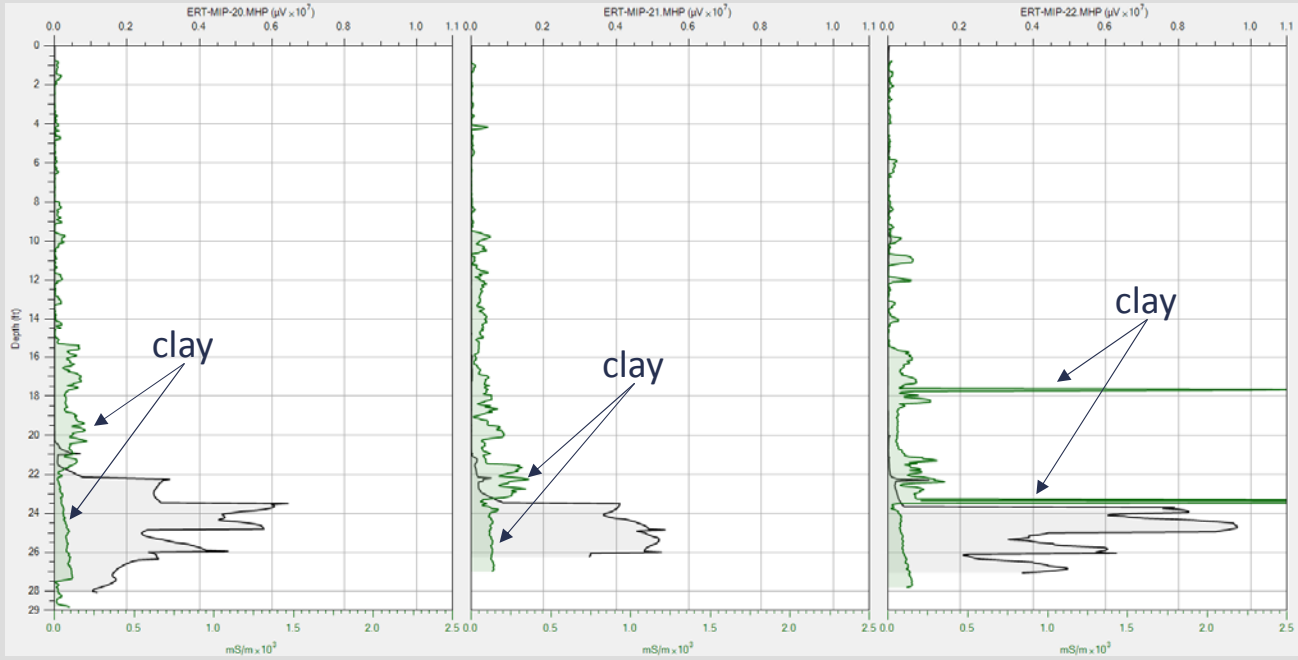


Locate and Define TCE Source Area MIP Results

VOC mixed with non chlorinated VOCs

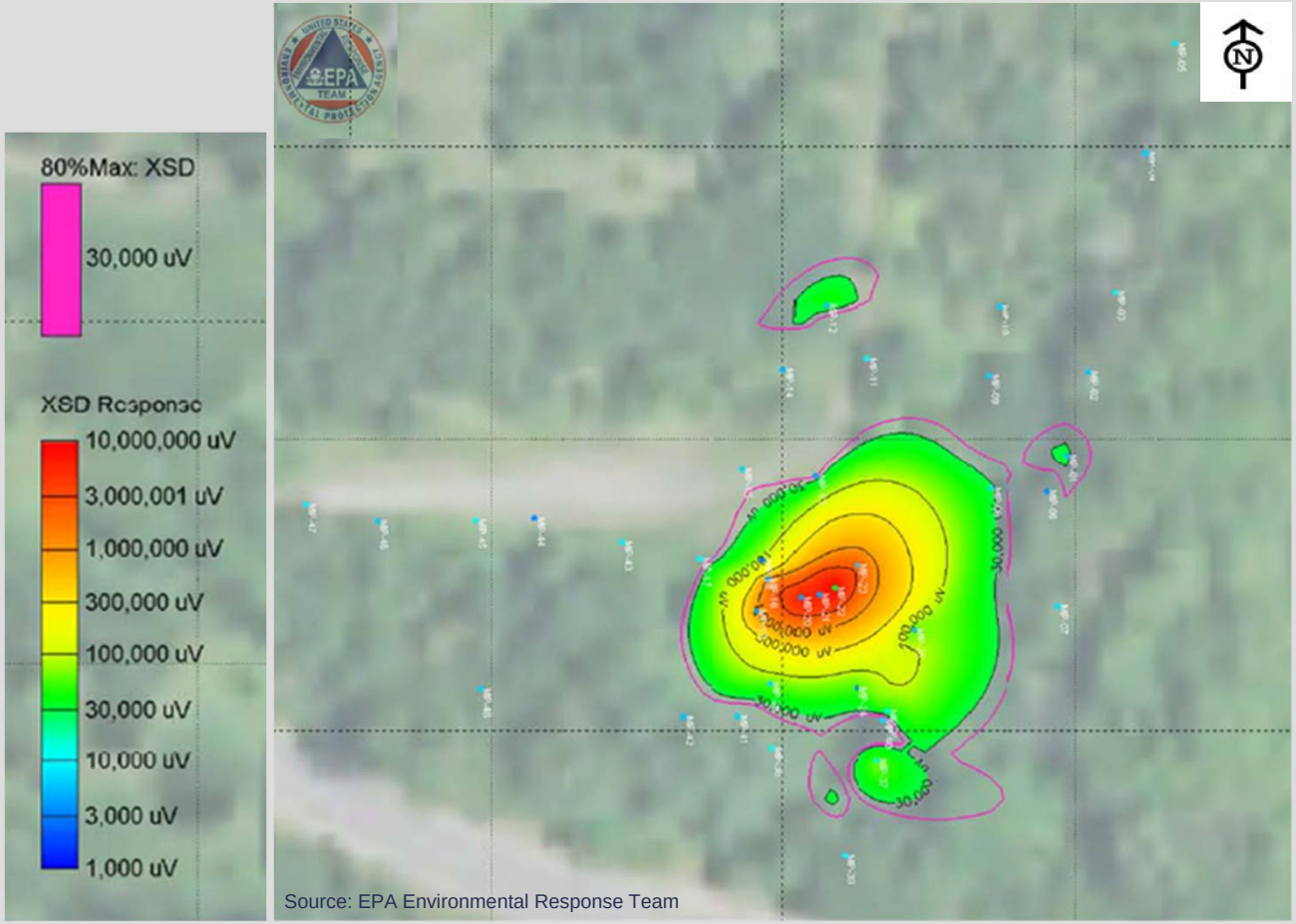


Maximum XSD readings indicate source area



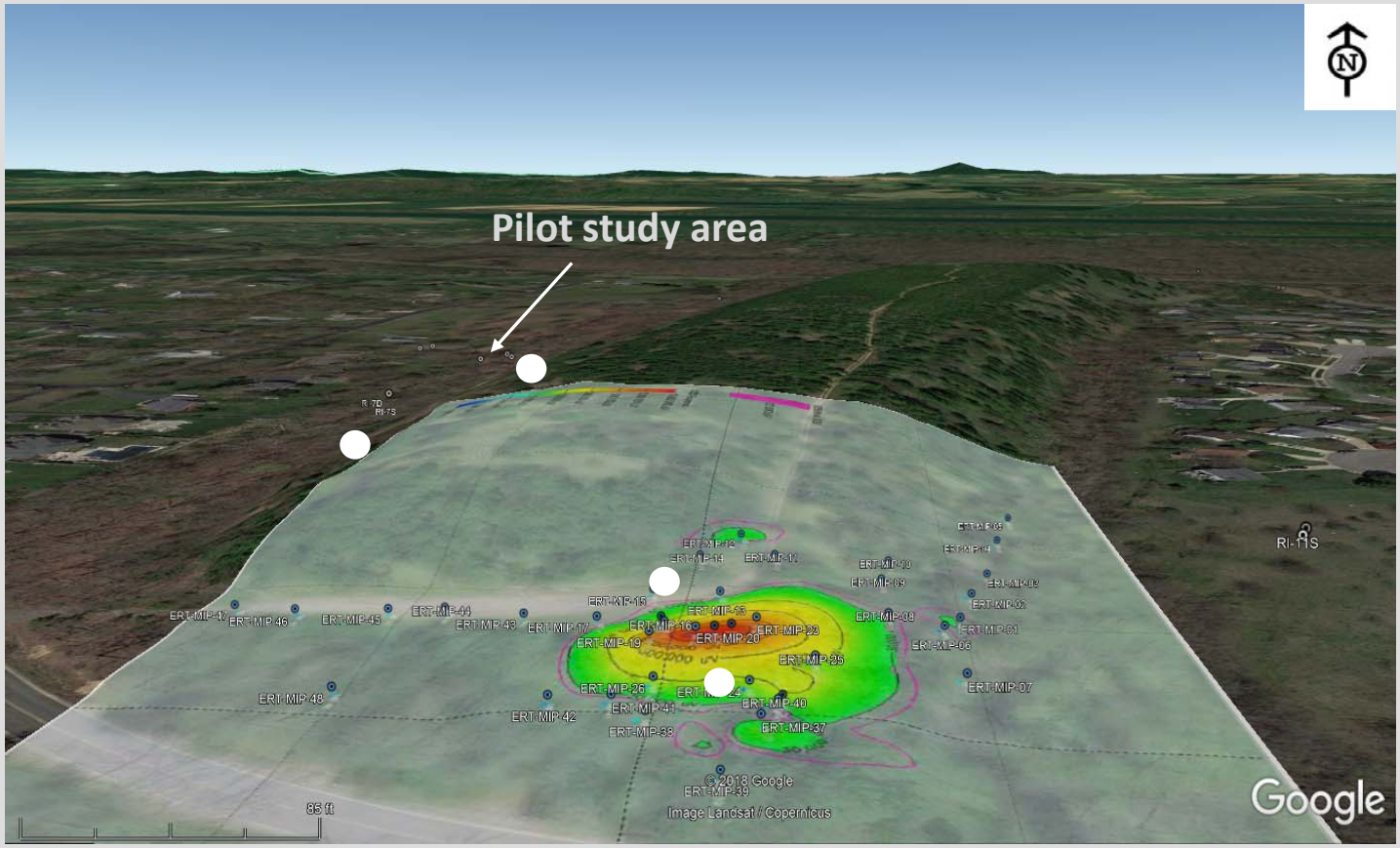
Locate and Define TCE Source Area Soil Sample Results

- MIP results showing source area on the southern end of landfill
- Confirmation soil samples were collected
- TCE concentrations ranged from 0.002 to 25,000 mg/kg
- Depth of TCE impact located within the saprolite and top of bedrock (15-29 ft bgs)

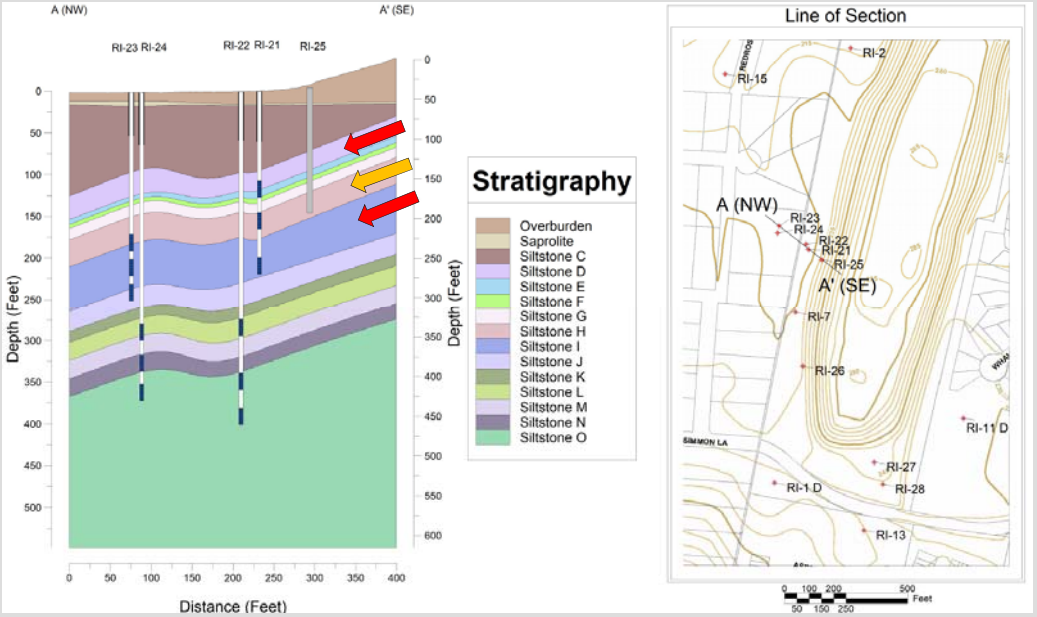


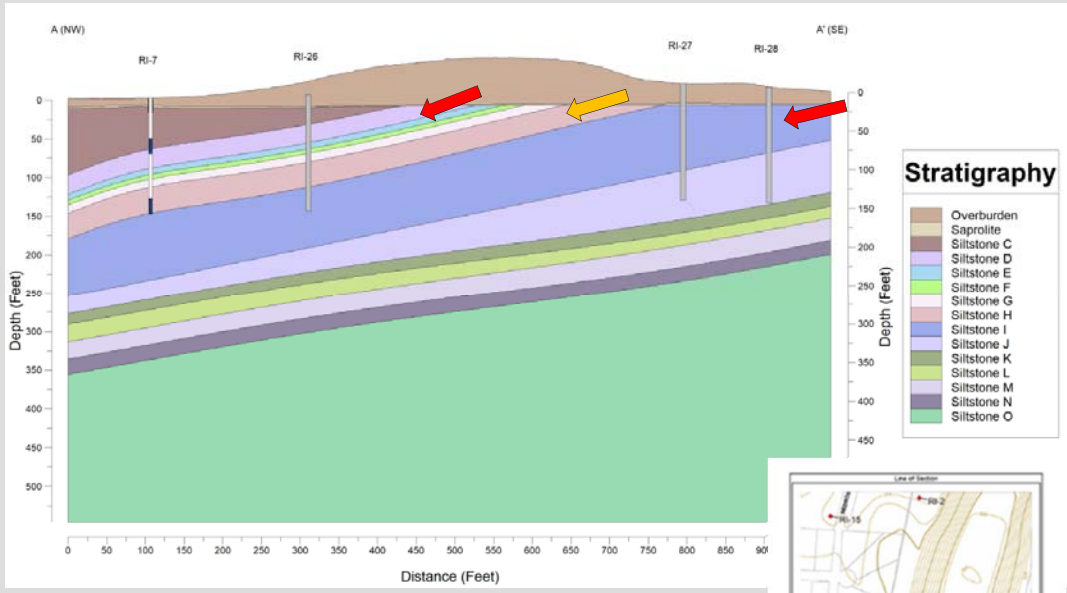
Third Phase – Well Installation

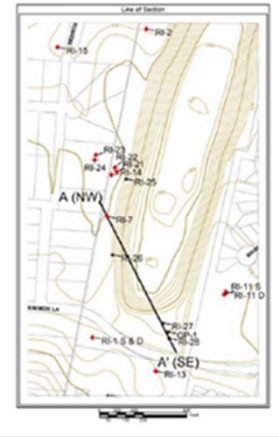
- Source area defined on the southern end of the landfill
- The units containing the highest TCE concentration subcrop in the southern portion of the landfill
- Four bedrock boreholes were installed



Boring Depth and Well Screen Placement



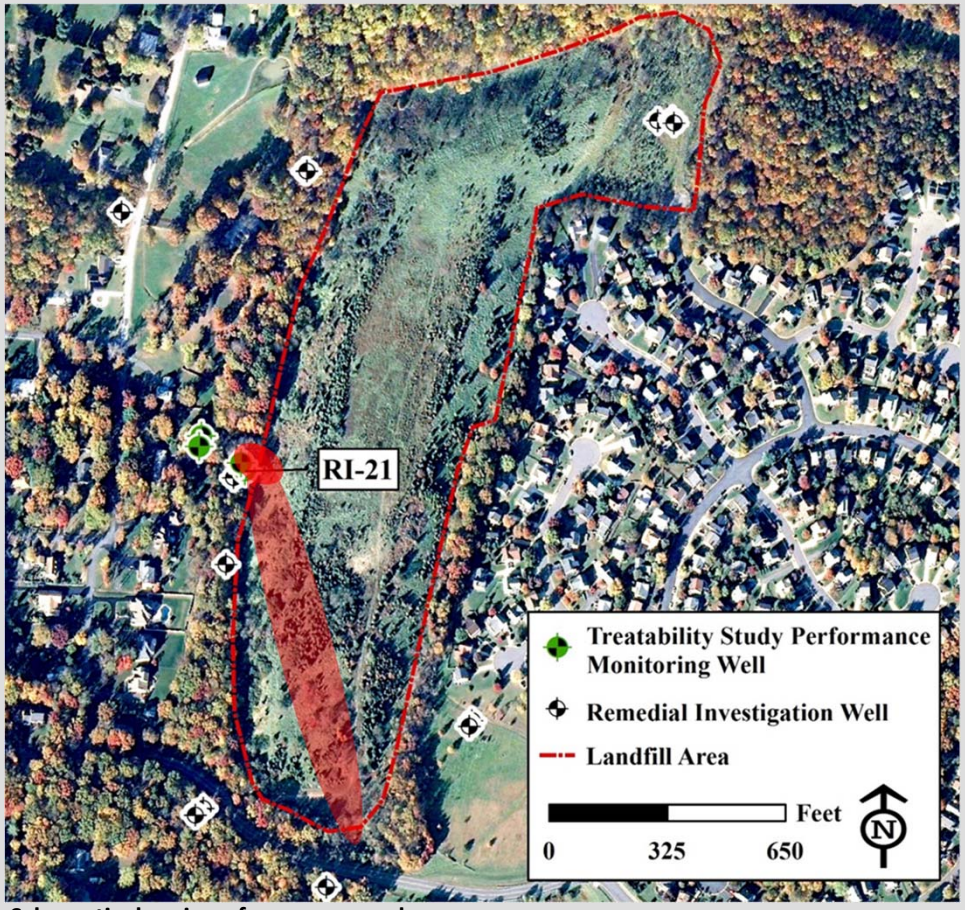




- Each bedrock borehole installed to 150 ft based on the stratigraphic units where TCE is migrating into pilot study area and projected subcrop
- Work is on-going – to convert each borehole into 3 cluster wells and screened intervals will be based on the geophysical logging data

Next Steps and Key Take Away

- **Next steps:**
  - Complete well installation and collect groundwater samples
  - Update conceptual site model
  - Source removal activities and pilot study
- **Key take away:**
  - Investigate the main cause of the groundwater plume; the source
  - Implement an effective remedy to address the source



Schematic drawing of source area plume

Thank You!

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