Groundwater Remediation at SRS

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EC&ACP Engineering Remediation Support

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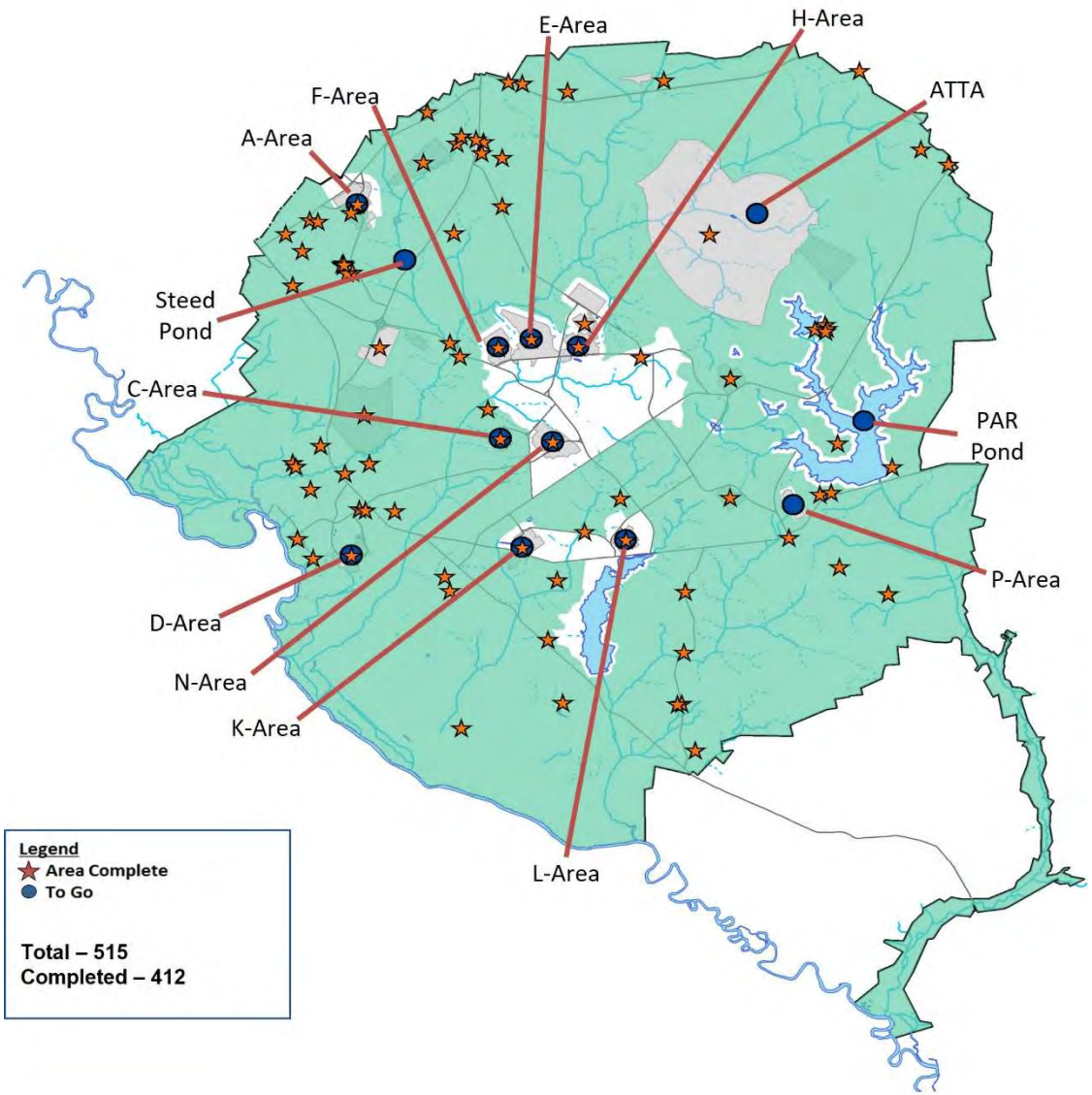
Acronyms

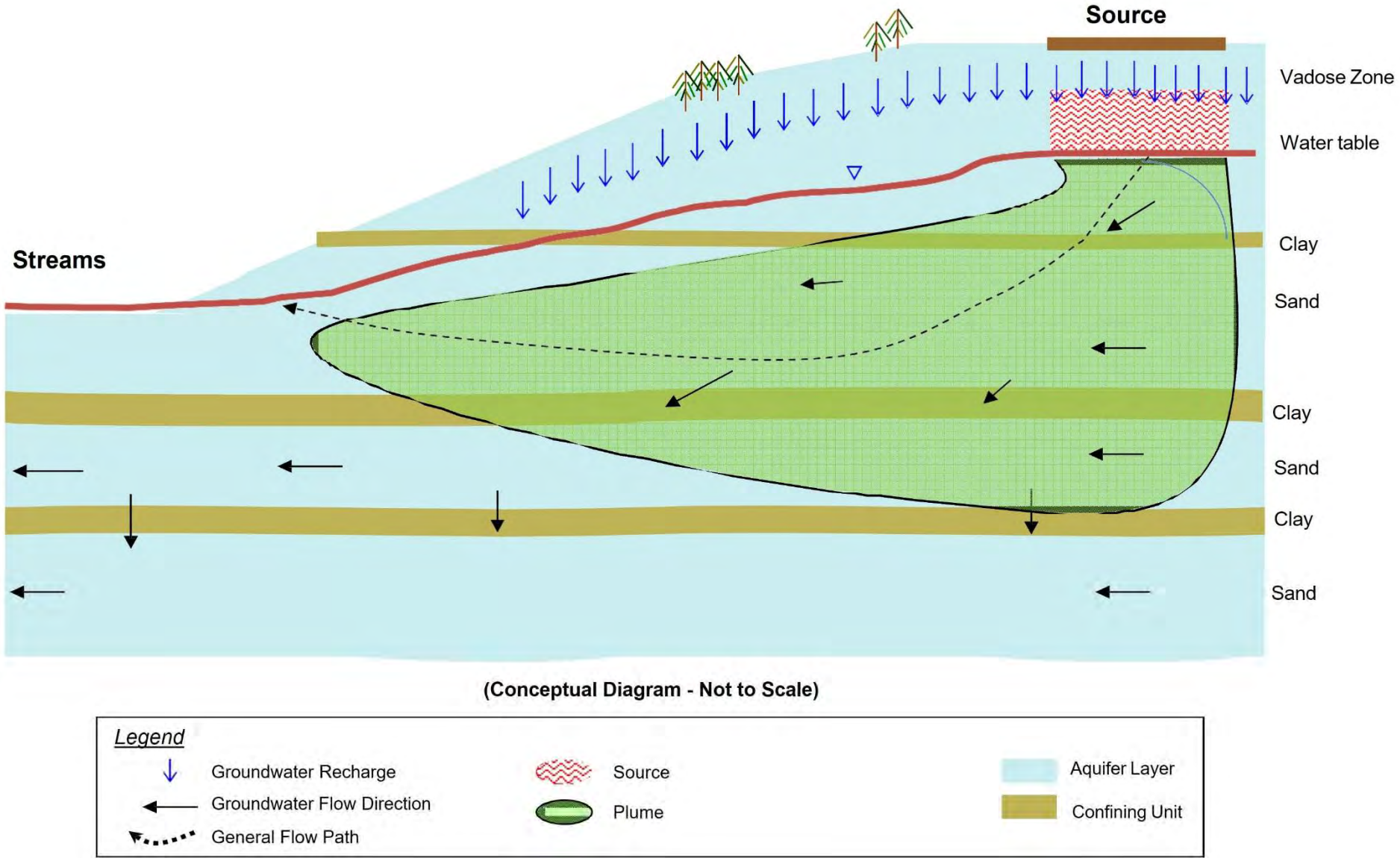
- bgs – below ground surface
- CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
- CMP – chemicals, metals, and pesticides
- DUS – Dynamic Underground Stripping
- EC&ACP – Environmental Compliance and Area Completion Projects
- FFA – Federal Facility Agreement
- gpm – gallons per minute
- m – meter
- MNA – monitored natural attenuation
- MWMF – Mixed Waste Management Facility
- ppb – parts per billion
- RCRA – Resource Conservation and Recovery Act
- SRS – Savannah River Site
- SVE – Soil Vapor Extraction
- TCE – trichloroethylene
- VOCs – Volatile Organic Compounds

Environmental Cleanup at SRS

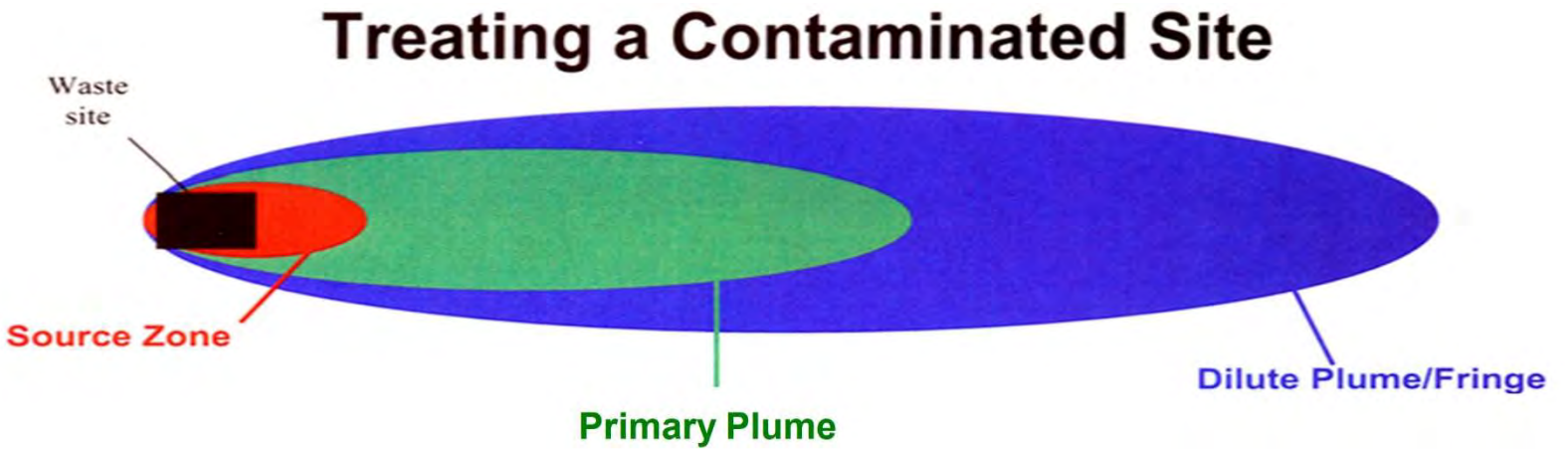
- Cleanup started in late 1980's
- Two regulatory mechanisms – RCRA Permit (DOE and SCDHEC) and FFA (DOE, USEPA and SCDHEC)
- 412 of 515 Waste Sites complete
- 85% footprint reduction



Conceptual Site Model



Remediation Strategy



Active Remediation

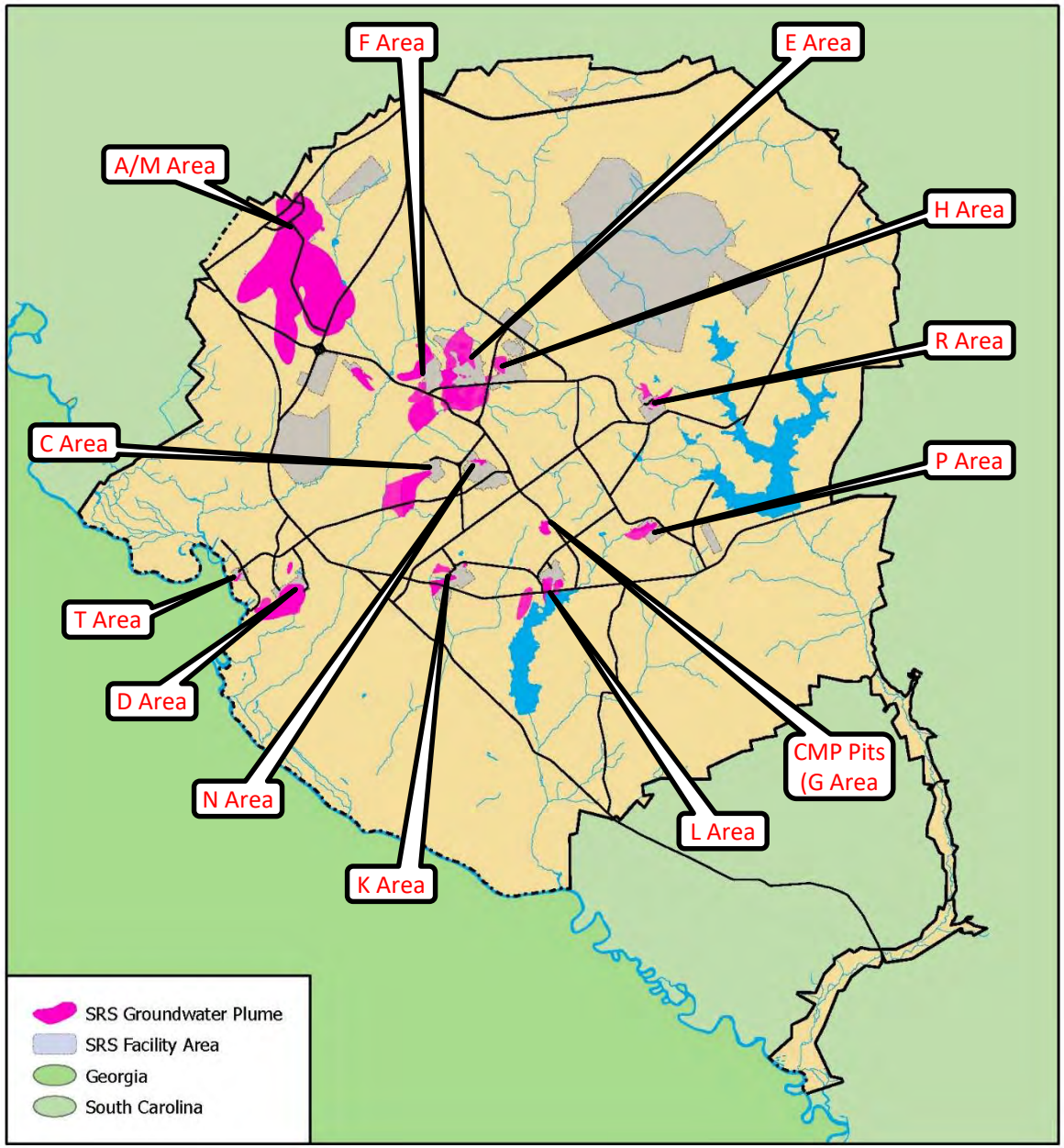
High cost

Enhanced Natural Remediation

Passive Monitored Natural Attenuation

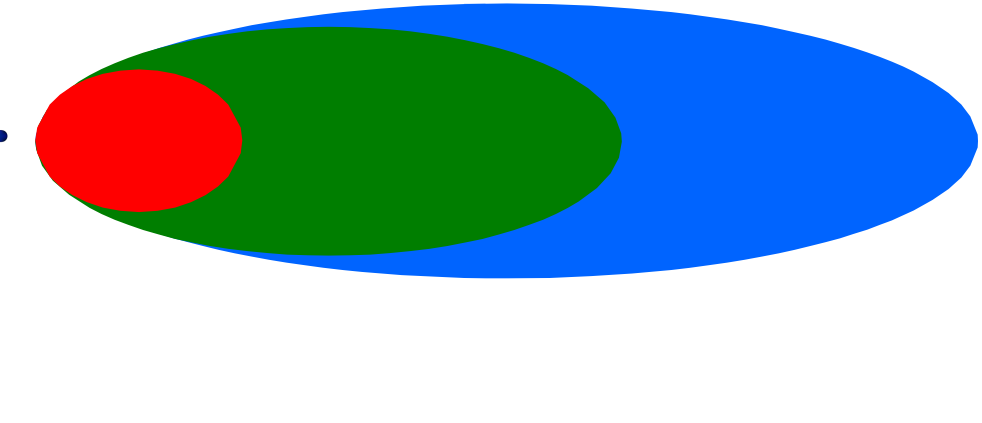
Low Cost

SRS Groundwater Contamination Areas



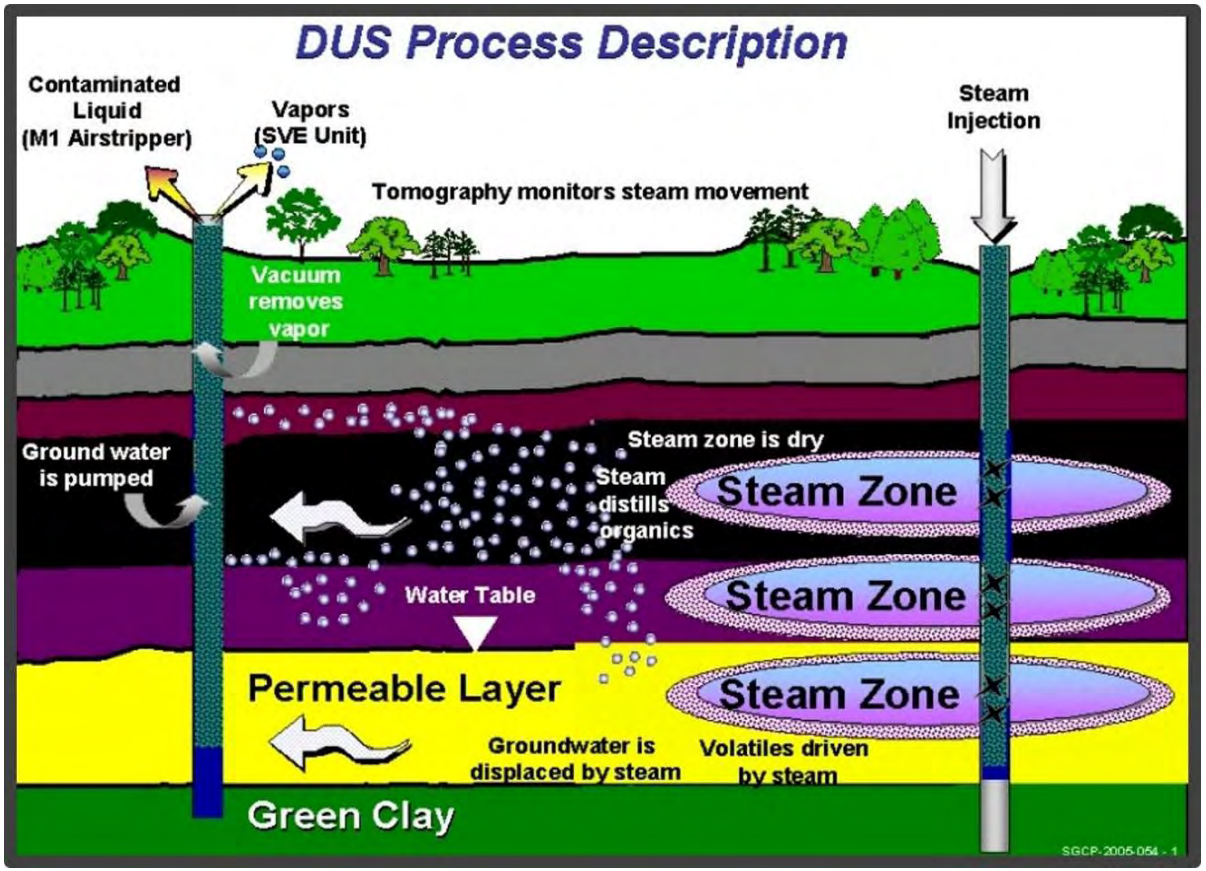
Source Zone

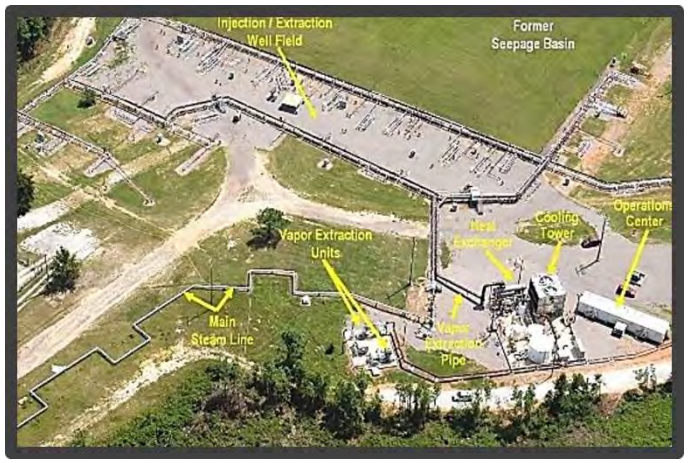
- Product extraction
- Thermal technologies
- In-situ chemical oxidation
- In-situ biodegradation



Dynamic Underground Stripping

- Inject Steam, extract and treat vapor and water (operated 2005-2012)
- Over 450,000 lbs VOCs removed





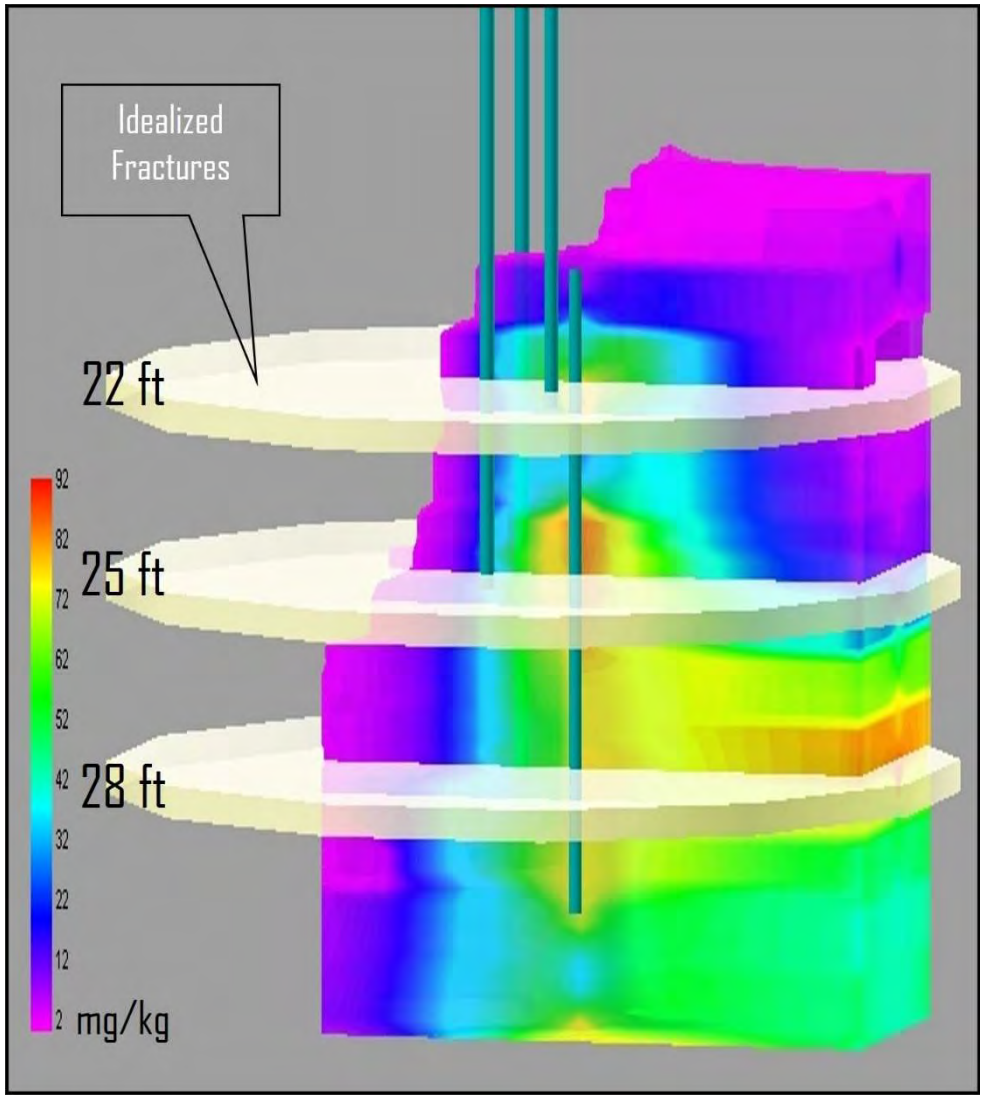
Dense Non-Aqueous Phase Liquids (DNAPL)

Fracturing

Soil notching using a high pressure jet – initiates fractures horizontally

Mixed guar/sand slurry loading into the pumping hopper

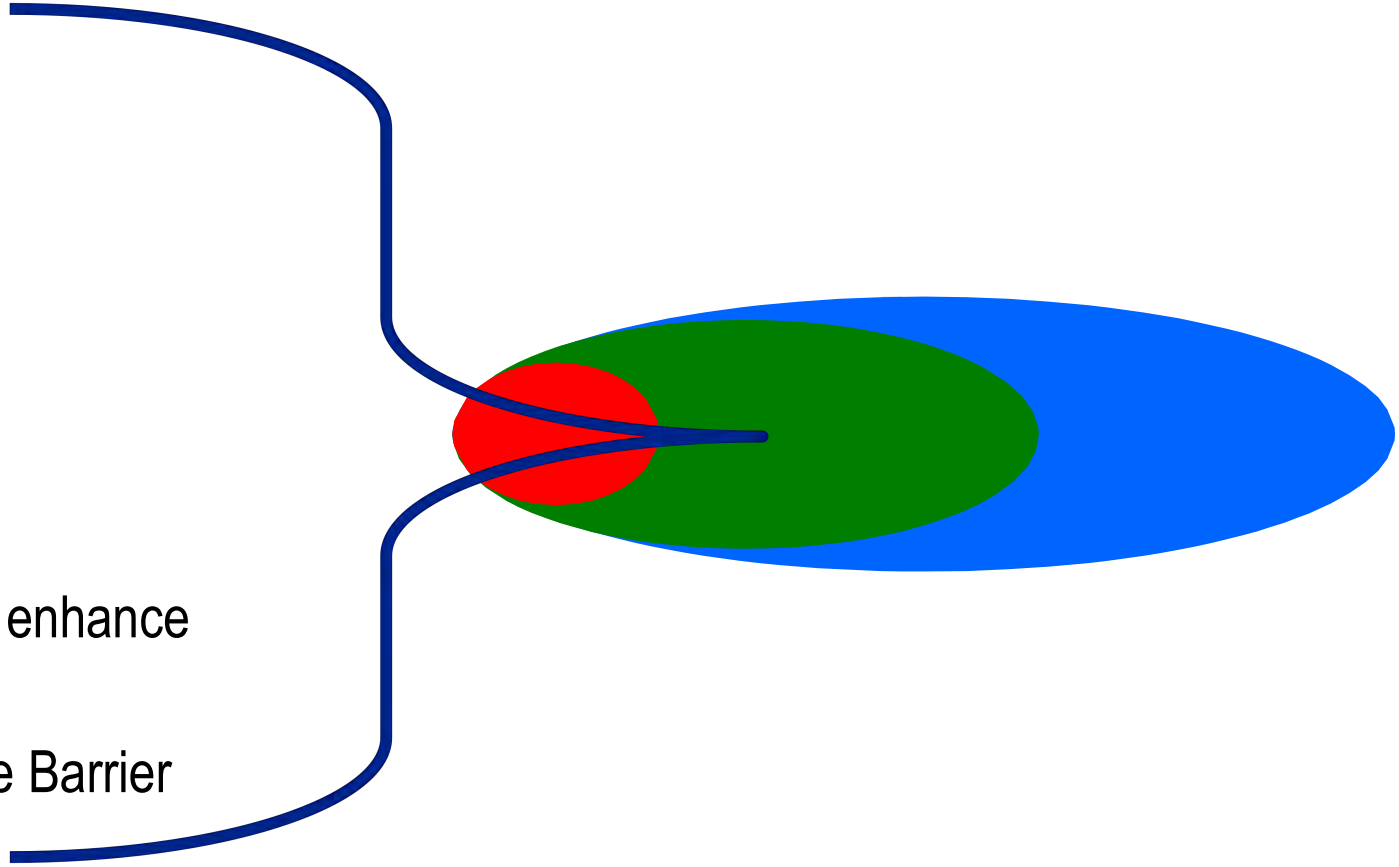
Soil Hydraulic Fracturing



- High pressure fractures
- Inject sand, water, and treatment material
- Horizontal fractures (~10-15 feet radius)
- SVE flow rates increased an order of magnitude
- Injection of iron filings or chemical oxidant to destroy VOCs

Primary Plume

- **Hydraulic Control**
  - Pump and Treat
  - Barrier walls
- **In situ**
  - Recirculation wells
  - Chemical injection
  - Nutrient injection to enhance bioremediation
  - Permeable Reactive Barrier

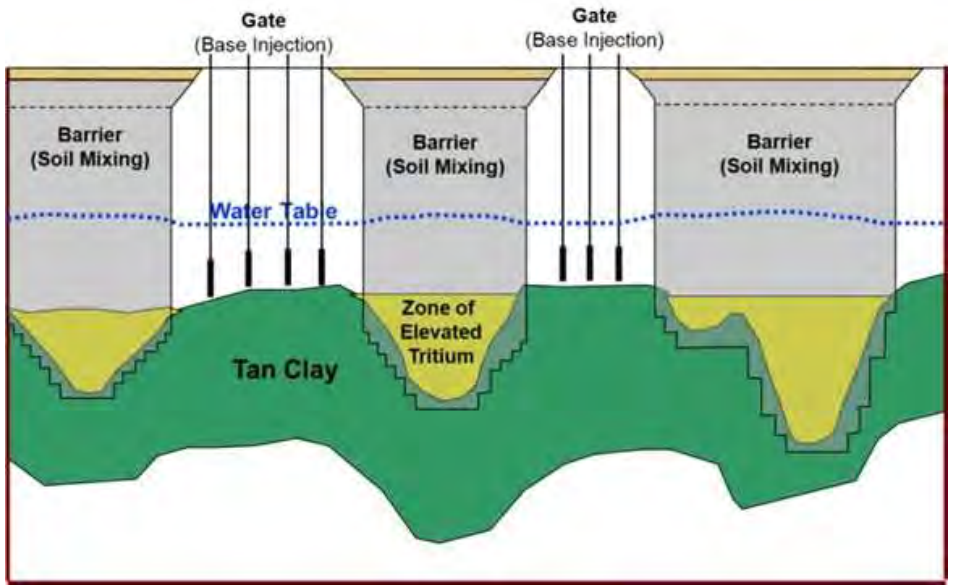


M1 Air Stripper – groundwater recovery wells

- Hydraulic control of most contaminated portion of aquifer 150 – 200 feet bgs
- Nearly 40 years operating, removed ~600,000 lbs of VOCs
- Optimization of groundwater recovery well system ~500 gpm, 10 wells, ~10,000 lbs per year

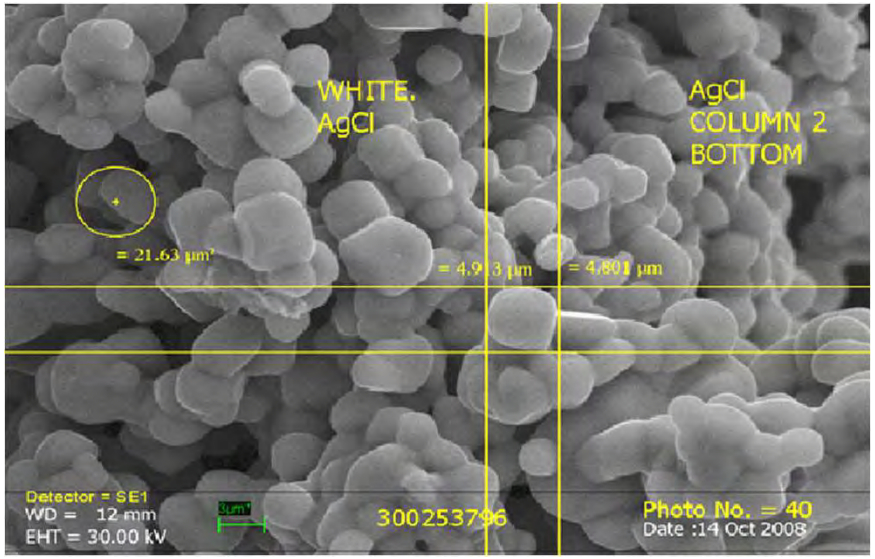
Base Injection

- Inject base chemicals to increase pH and immobilize metals/radionuclides
- Protect wetlands and creek near F-Area and H-Area Seepage Basin (2005 - present)

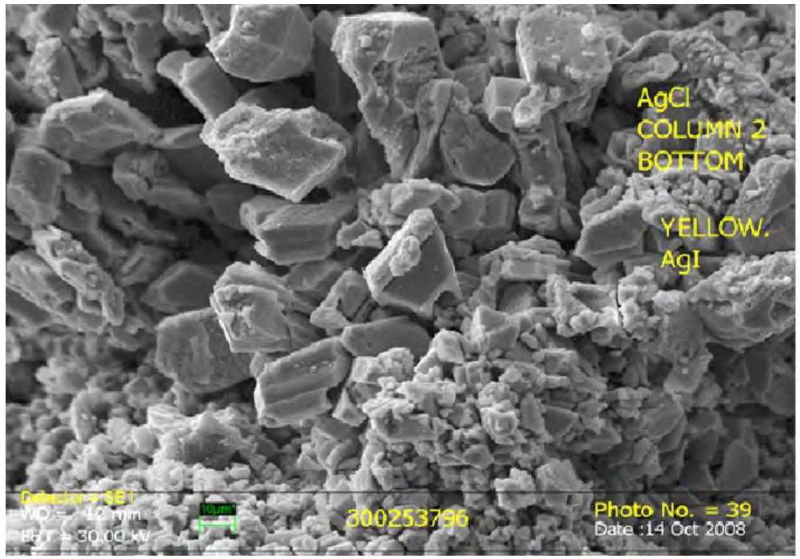


Silver Chloride Injection

- Iodine-129 mobile long lived rsdioisotope
- Protect wetlands and creek near F-Area Seepage Basins
- 3 Injections (2011, 2015, 2019, future?)



Silver Chloride Before Capture of Iodine



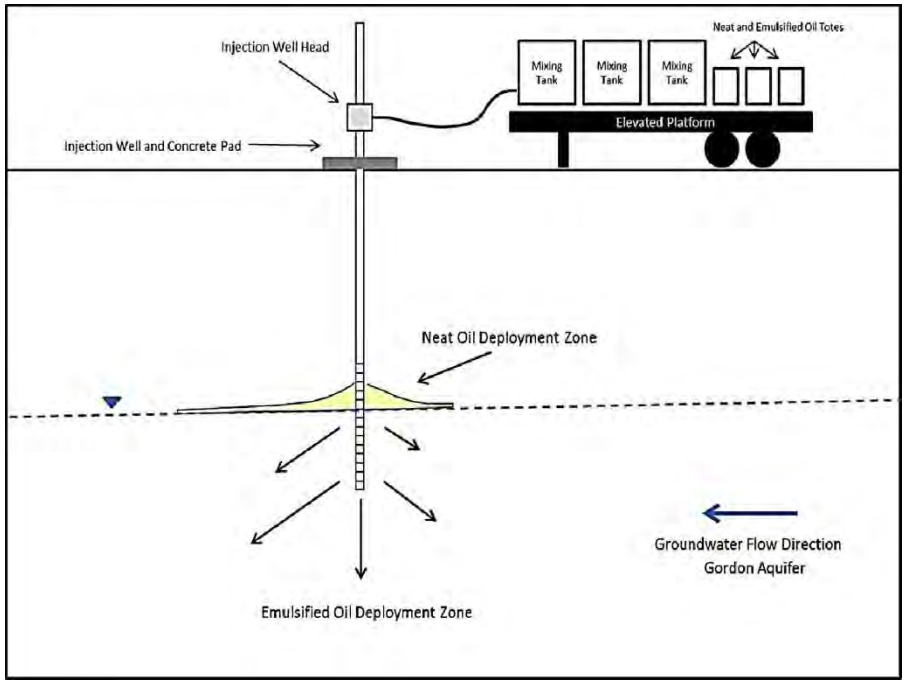
Silver Chloride After Capture of Iodine

Oxidant injection

- P-Area source zone injection in 2012
- Met VOC soil remedial goals within two years
- M-Area groundwater - targeted four high concentration VOC zones in interbedded sand and clay in 2018 and 2020
- Injection of two oxidants
  - potassium permanganate
  - sodium persulfate
- >99% destruction of VOCs
- Evaluating rebound
- Evaluating impact on metals

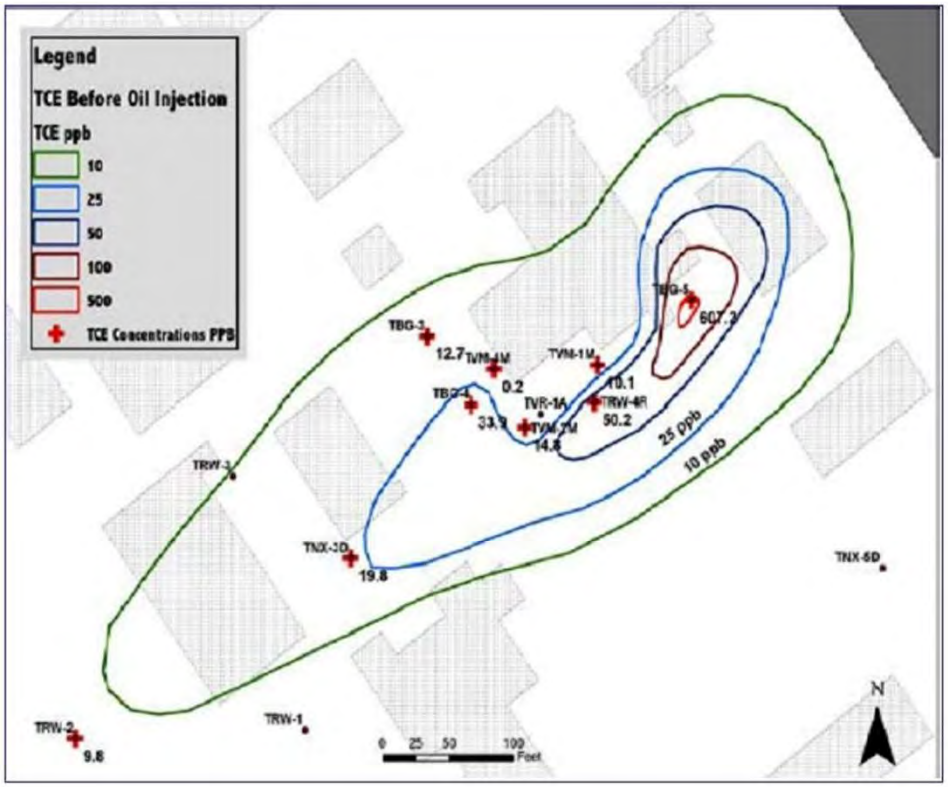
Edible Oil Injection

- Bio-remediation
- Inject nutrients to enhance growth of naturally occurring microbes
- Microbes consume the contaminants (VOCs)
- TNX groundwater (2013-2015), monitoring

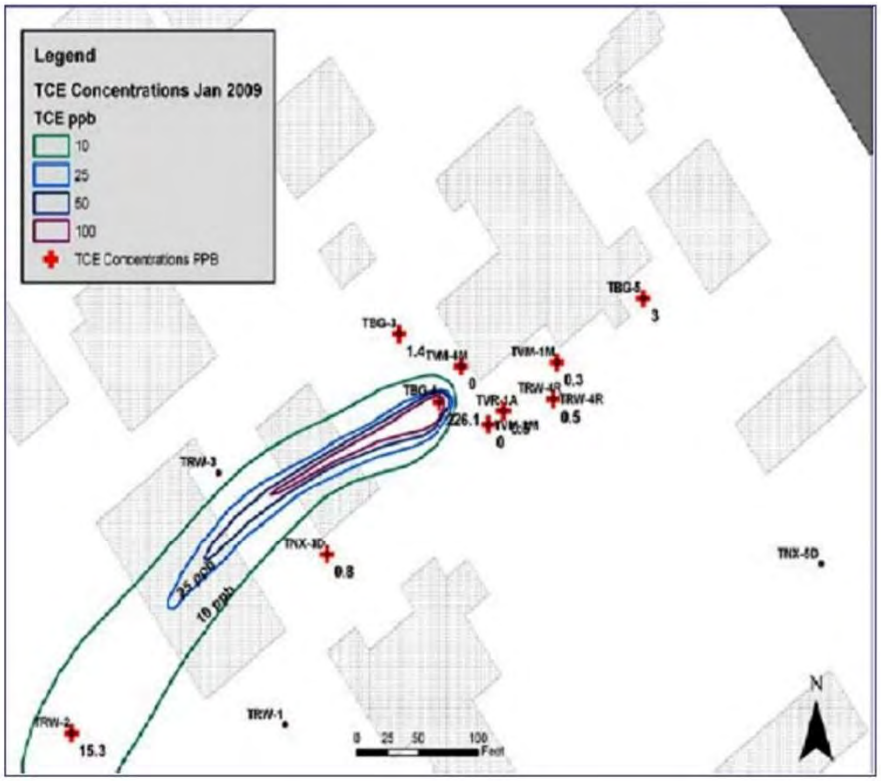


Edible Oil Injection

T Area Edible Oil (Before and After)



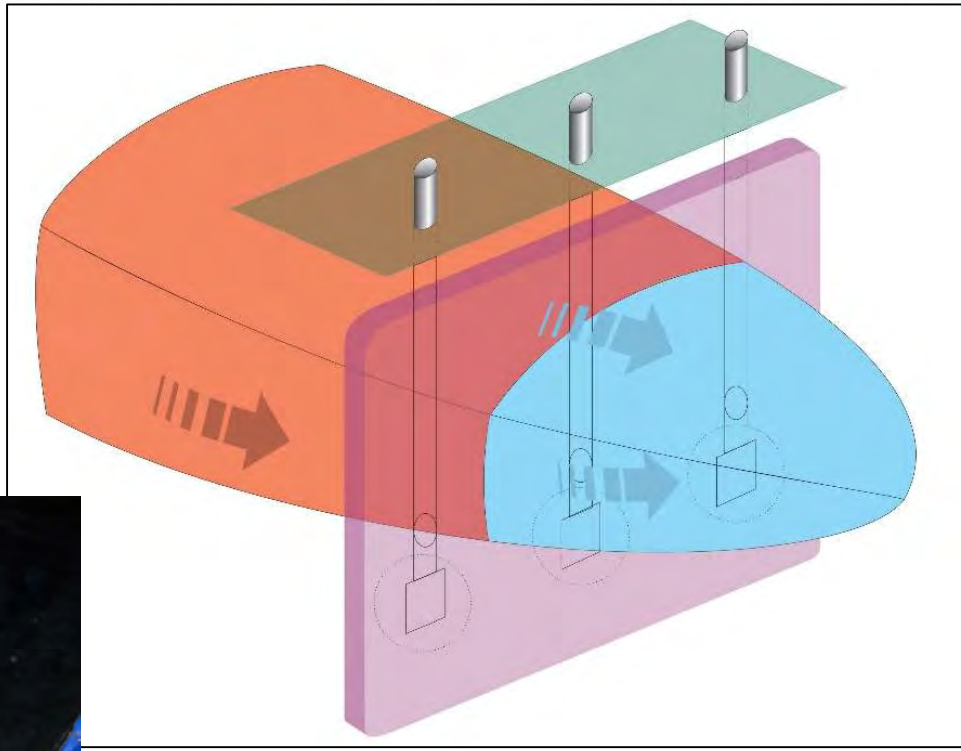
Plume before oil injection.



Plume after oil injection.

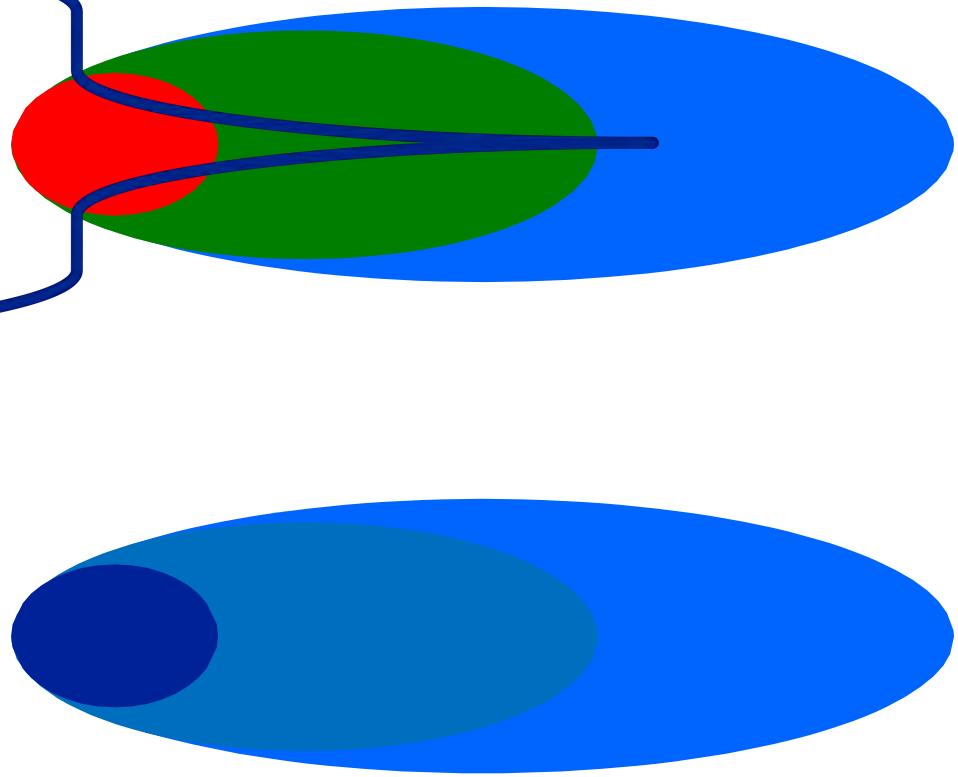
Permeable Reactive Barrier

- P-Area VOC plume in ancient stream channel
- Injected zero-valent iron recycled from engines to form 250 foot wall in 2019
- >95% destruction of VOCs in wall

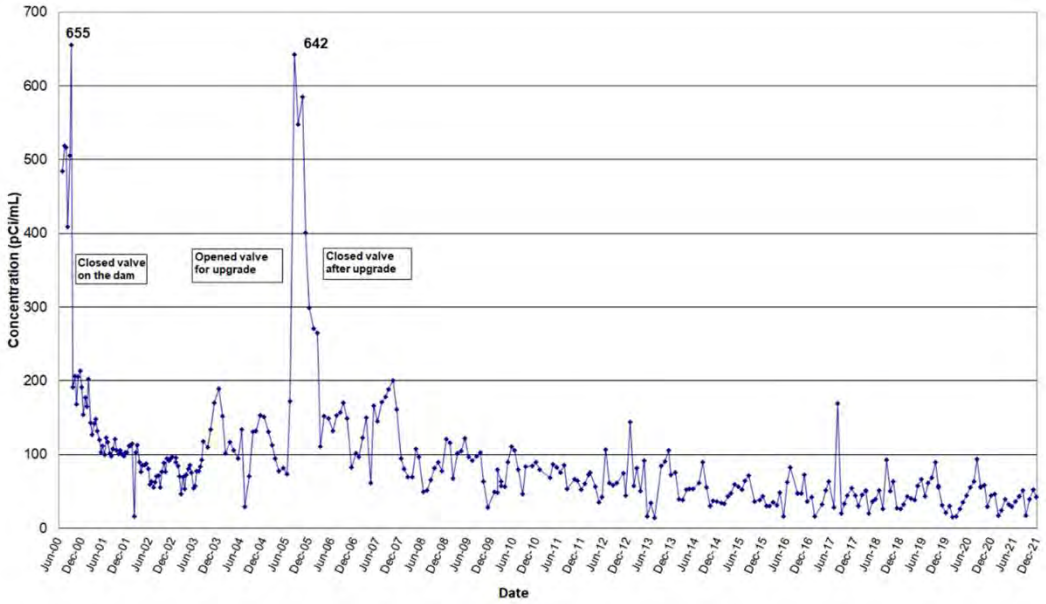


Plume Fringe and Depleted Plumes

- Phytoremediation
- Bioremediation
- Monitored Natural Attenuation

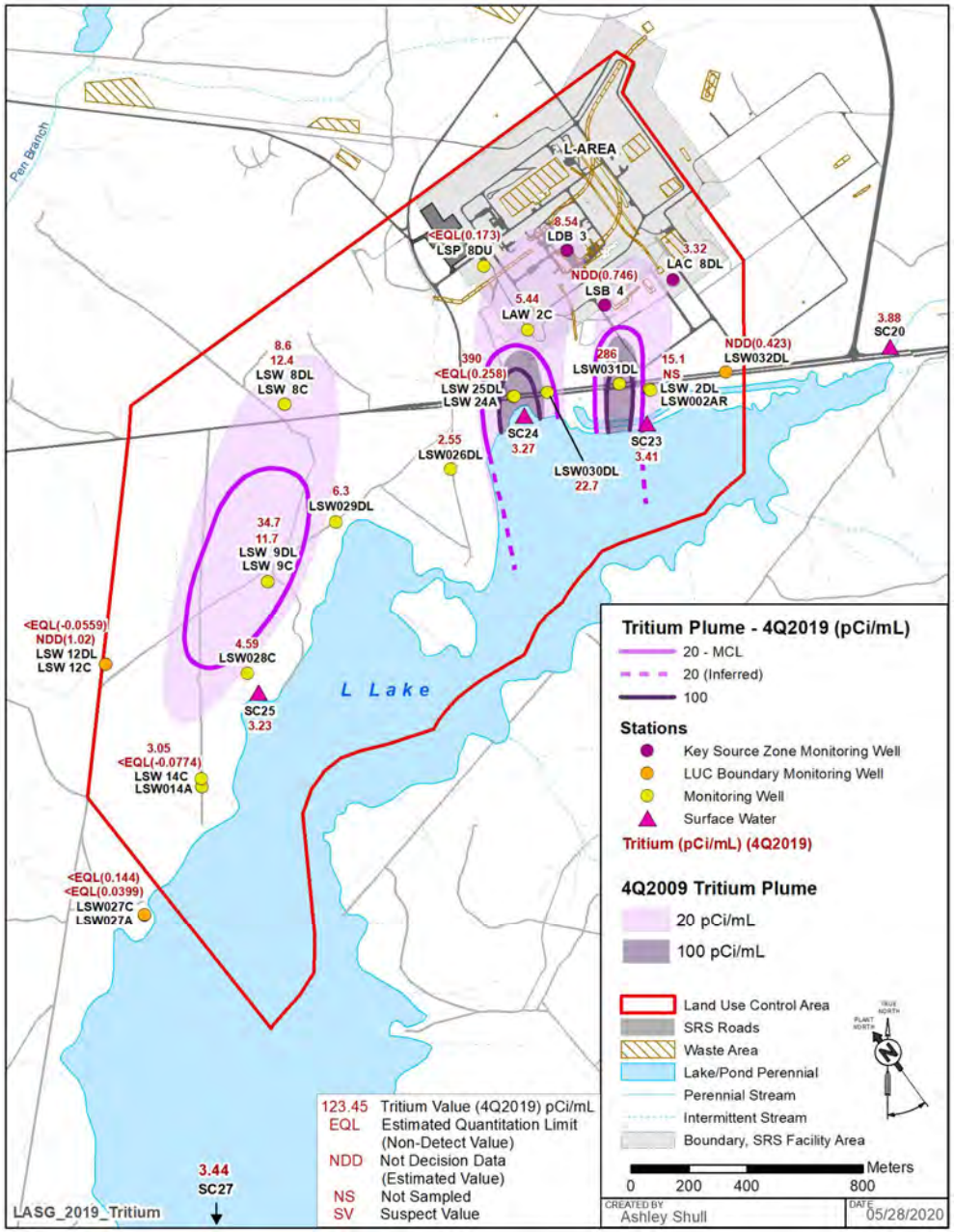


Phytoremediation: Collection Pond with Irrigation



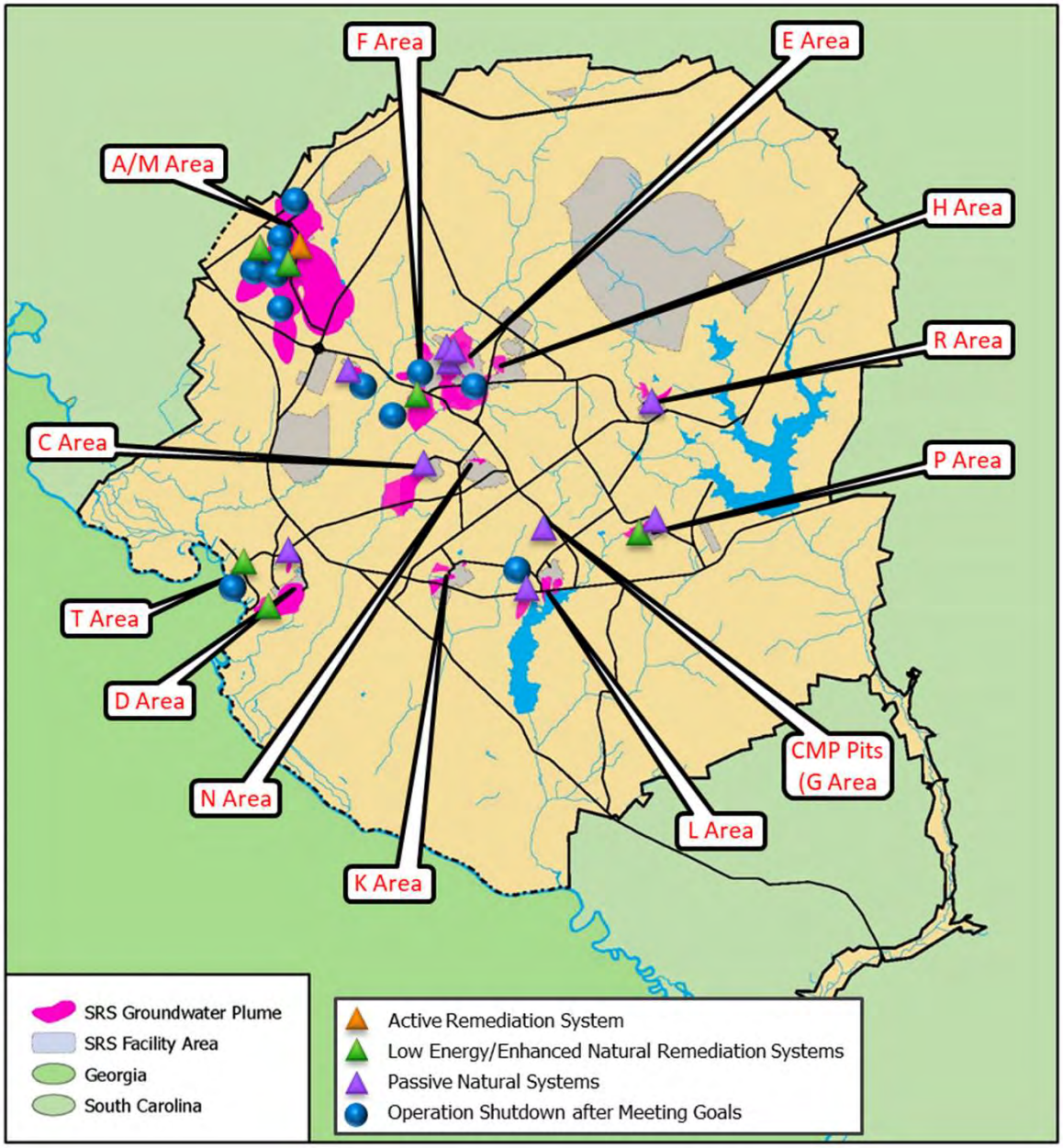
Monitored Natural Attenuation (MNA)

- Performing MNA at 9 OUs
- Source control
- No one exposed to groundwater
- Not impacting surface water above regulatory limits
- Plume not significantly expanding
- Long-term monitoring and reporting to verify



Work in Progress next 5 years

- P Area Groundwater OU
- C Area Groundwater OU
- D Area Groundwater OU
- A/M Area Groundwater under Permit



D-Area Early Action and Treatability Study

- Soil (down to 4 ft bgs) mixed with lime and covered with limestone gravel to raise the pH of vadose zone
- Deep artesian wells pumping higher pH groundwater into water table to neutralize
- Limestone check dams used in drainage ditch to raise pH

Lessons Learned

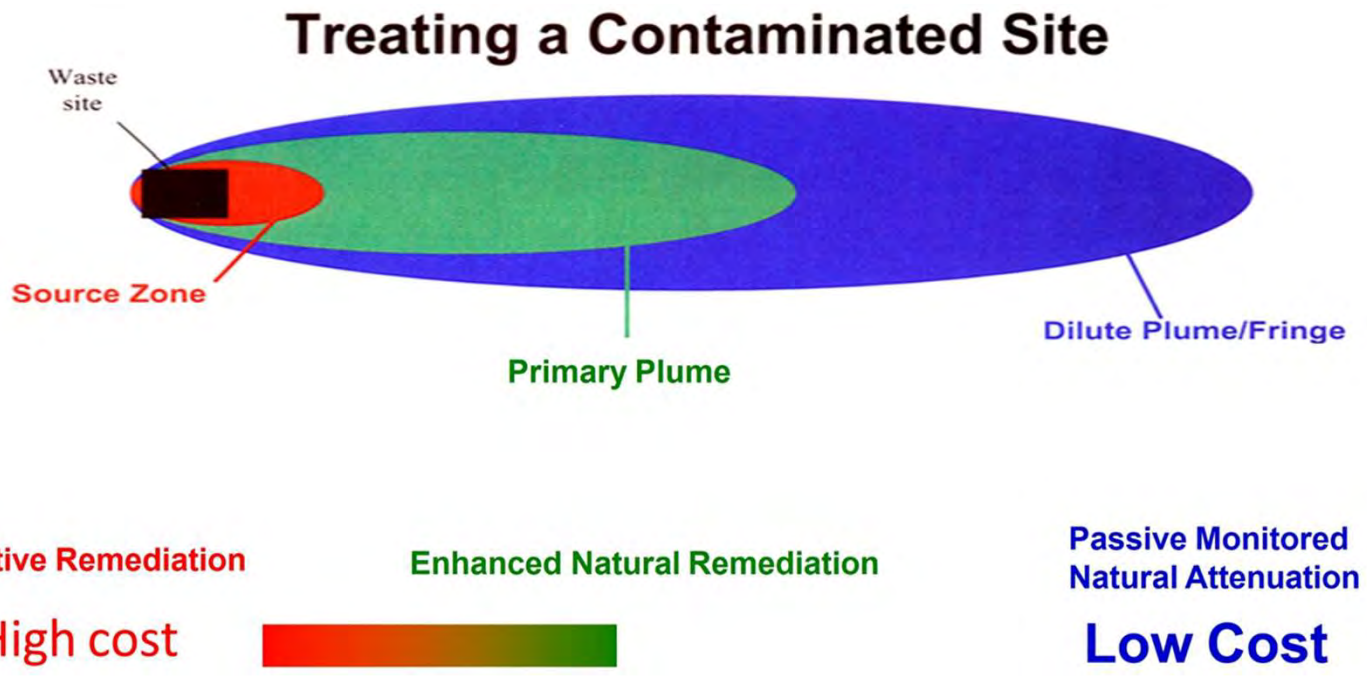
- Collaboration breeds innovation

- Robust source control offers return on investment

- Working with nature works well

Conclusions

- Accomplished much (33 groundwater remediation decisions ongoing or complete)
- Emphasis on enhanced natural remediation
- Tailor remedy to OU-specific conditions
- More work to do (final decisions still needed in 9 areas)



Questions?