



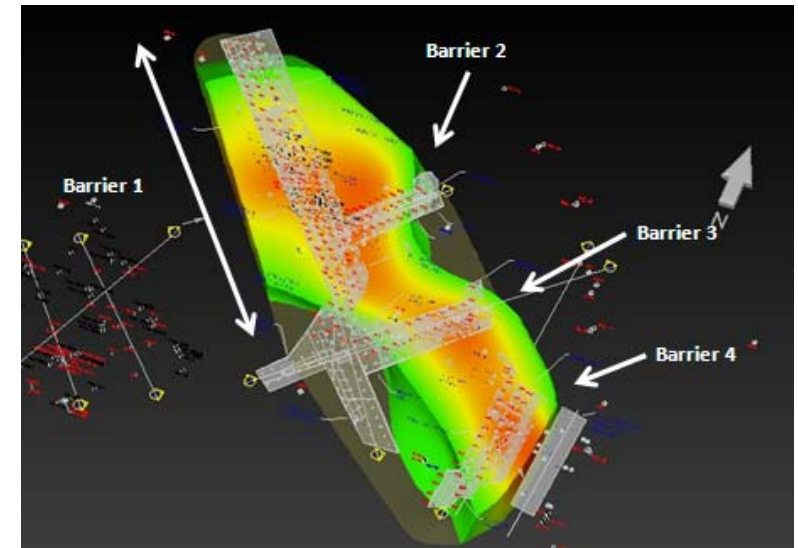
Overcoming Challenges and Closure-Strategy Development at a Long-Term Large-Scale CVOC Bioremediation/Thermal Project

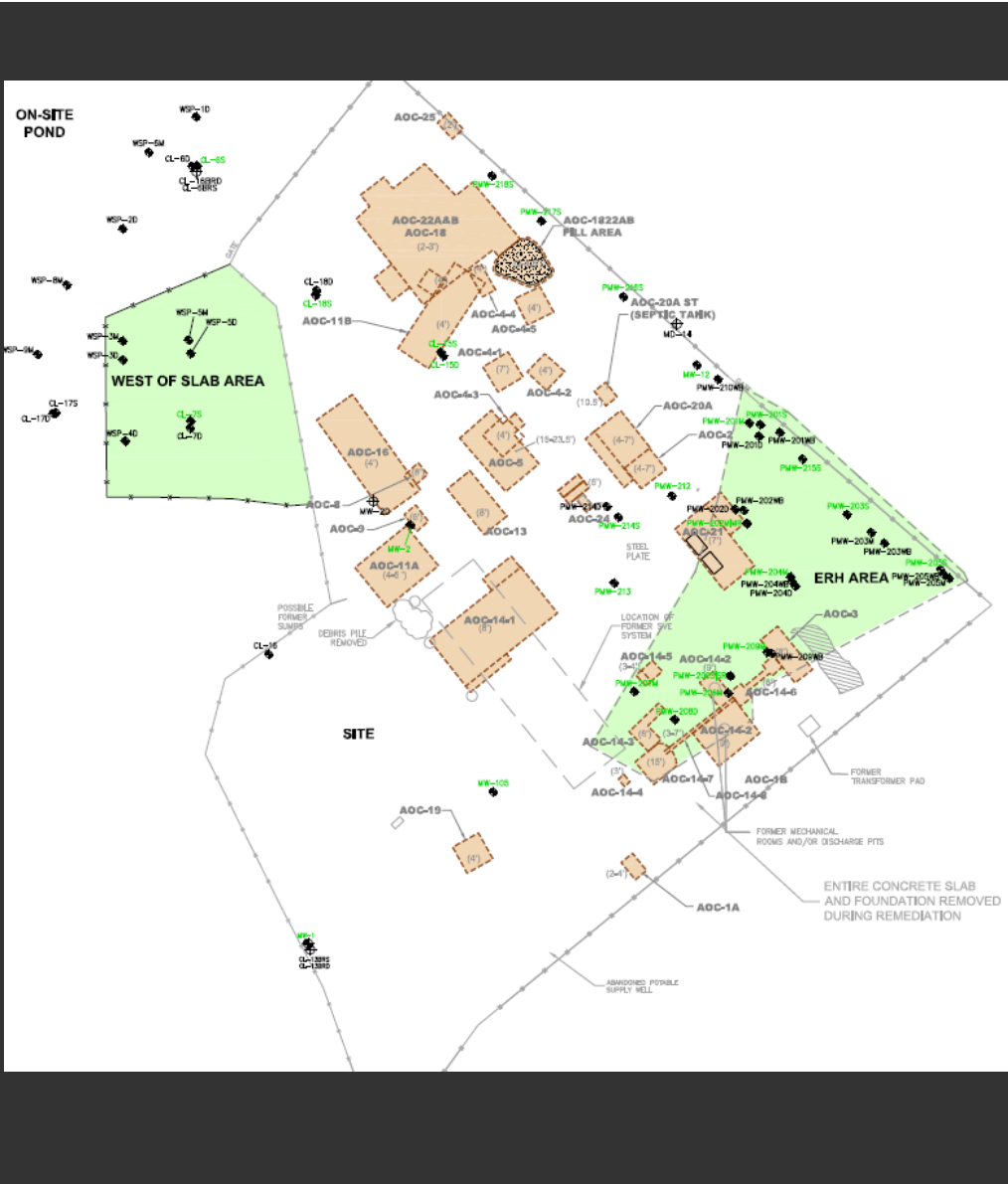
Matthew A. Panciera, P.E., L.E.P.

April, 12, 2018

Overview

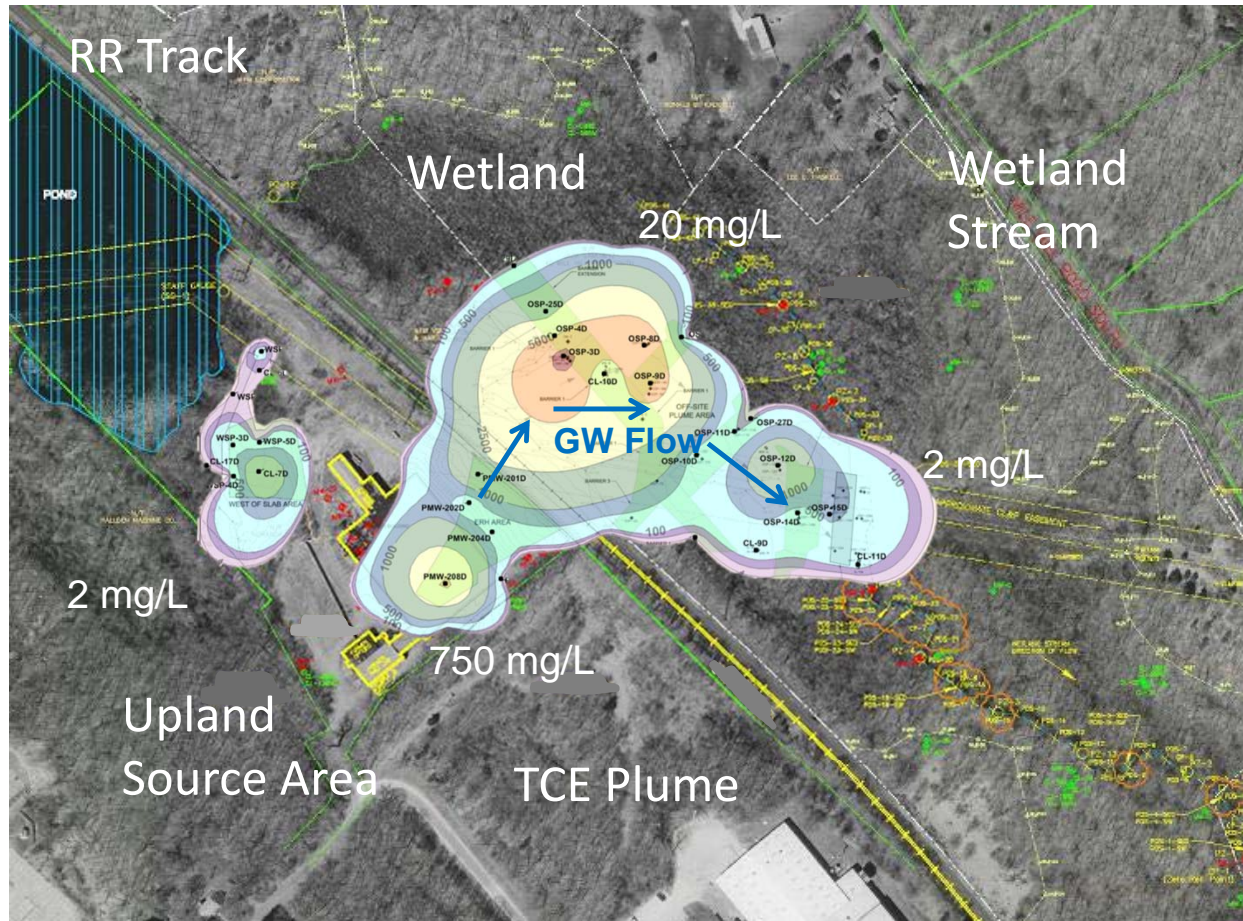
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 - Tomasz Kalinowski, Ph.D.
- Conceptual Site Model
- Remediation Goals/Objectives
- Overview of Remediation Project
 - On-Site Source Area
 - Thermal and Biopolishing Remedial Performance
 - Off-Site Plume Area
 - Bioremediation Performance and Observations
 - Lessons Learned
- Overcoming Challenges
- Closure-Strategy Development
- Conclusions



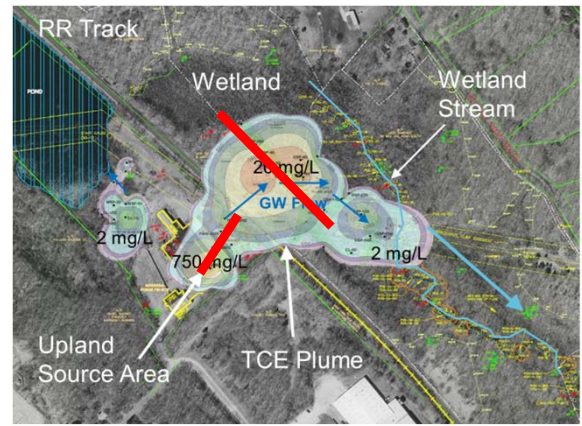
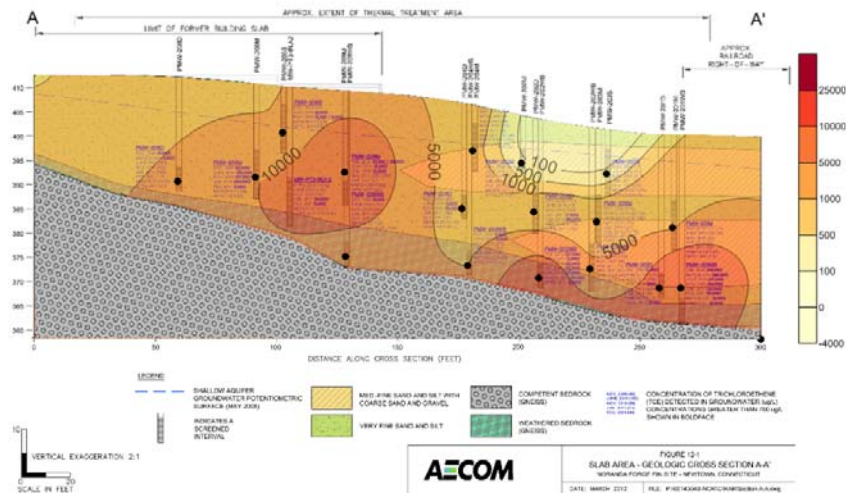


Site Background

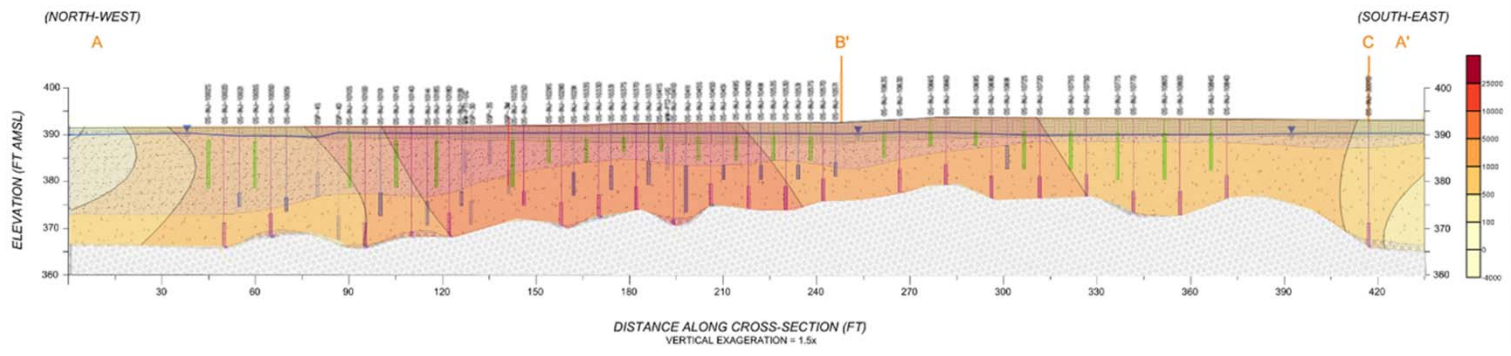
Conceptual Site Model- Plan View (2009, Pre-Treatment)



Conceptual Site Model- Cross-Section



CROSS-SECTION A-A' BARRIER 1 - OFF-SITE PLUME AREA



Remediation Goals

- Remove the Source
- Mitigate Discharge of CVOCs to the On-Site Pond and Wetland Stream
- Reduce Groundwater Plume Footprint
- Transition to Monitored Natural Attenuation

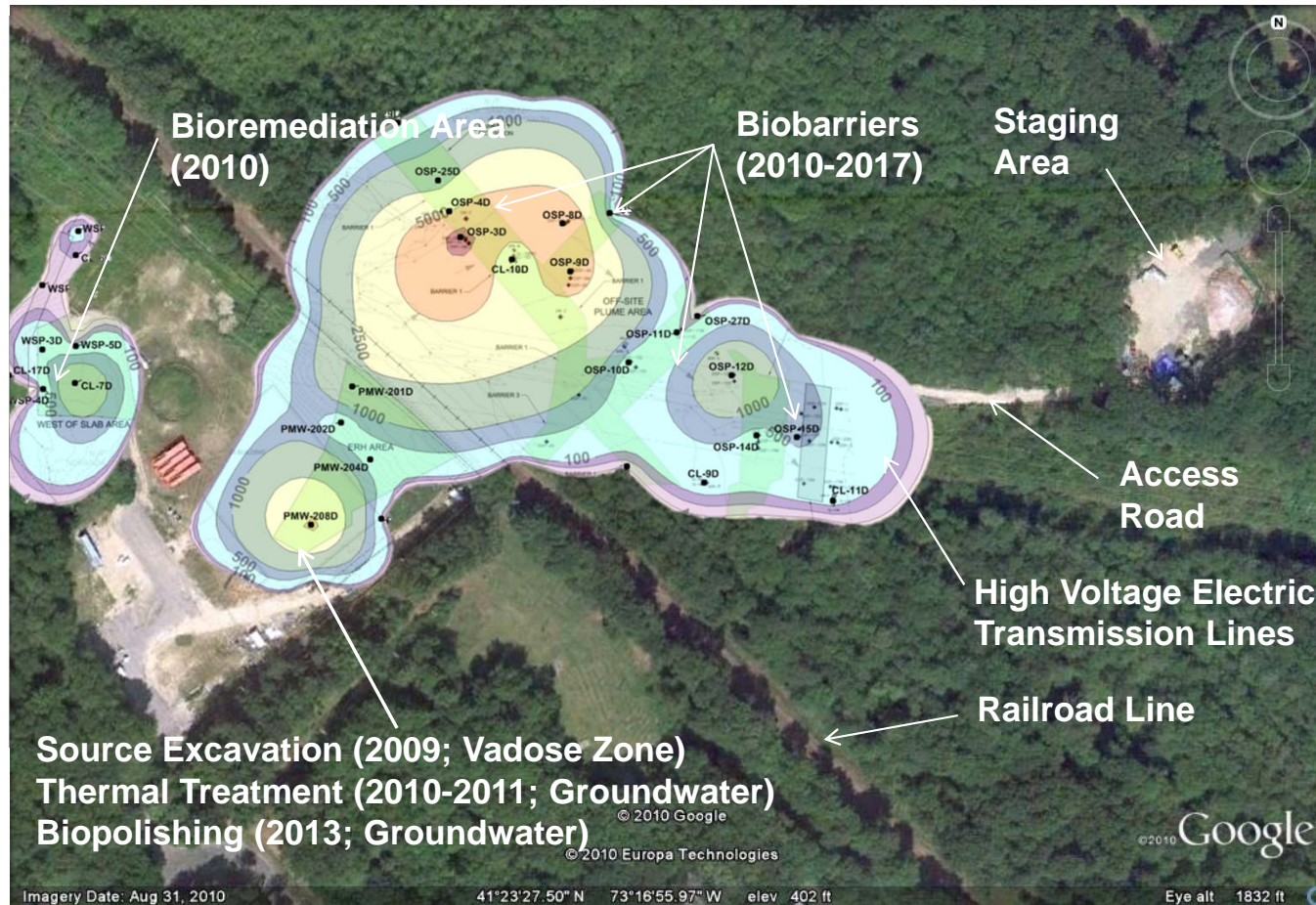


Remediation Criteria ($\mu\text{g/L}$)

COC	Source Area Goal ¹	Wetland Stream ASWPC ²
PCE	--	50.4
TCE	760 ³	34.3
c-1,2-DCE	--	620
t-1,2-DCE	--	560
1,1-DCE	--	210
VC	--	38.5
As ⁴	--	150
Fe ⁴	--	2,000
Mn ⁴	--	1,930

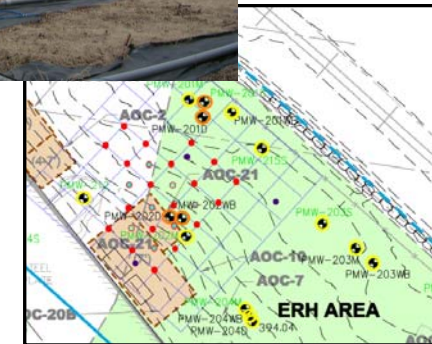
1. A cleanup goal in the source area was only developed for TCE.
2. ASWPC = Alternative Surface Water Protection Criteria
3. Model derived goal
4. Criteria for temporarily mobilized metals

Remediation Project Overview



Summary of Source Area Remediation

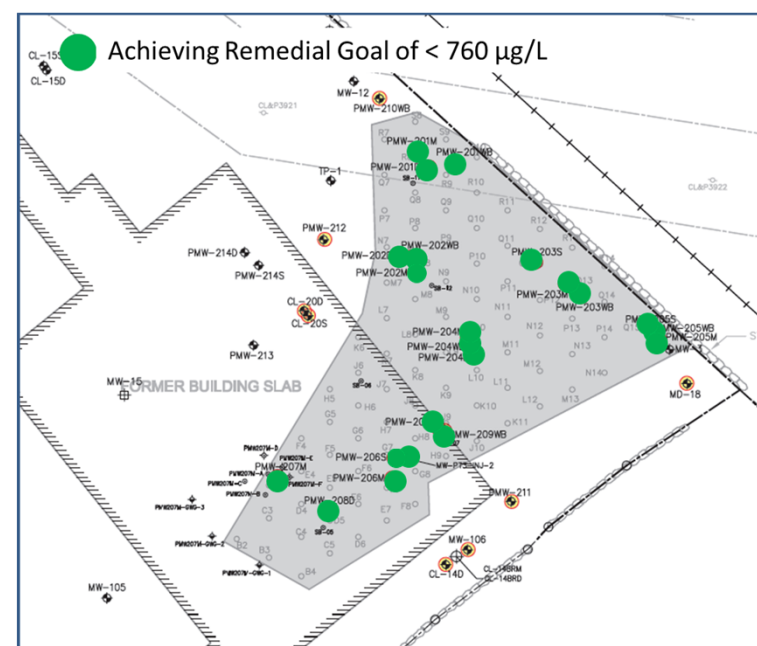
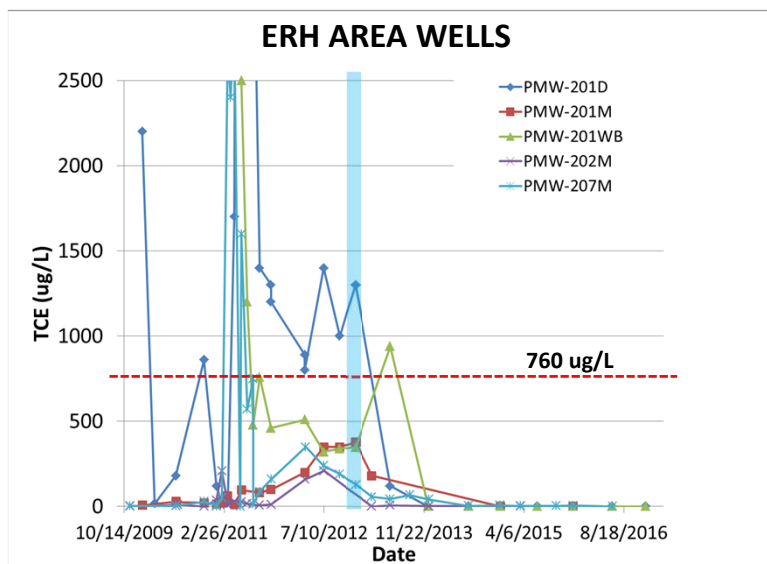
- Targeted excavations (2009)
 - Targeted excavation of multiple AOCs
 - Continued monitoring for compliance (2009-Present)
- Electrical resistance heating (Oct 2010-July 2011)
 - Phased operation
 - Focused on overburden and weathered bedrock
 - 27,000 ft², 12 to 45 ft bgs = 30,900 CY
 - 89 electrodes
 - Average temp = 95°C
 - Removed 600 lbs TCE
- Biopolishing (2013)
 - 5000 ft²
 - 27 wells
 - 19-37.5 ft bgs
 - Target was deep overburden and weathered bedrock
 - 735 gal. EVO (EOS™) diluted in ~46,000 gal. water (1.6%)



Source Area Performance to Date

- Results

- Monitoring July 2011 to Present
- >90% reduction of baseline mass flux
- Monitoring wells meet TCE cleanup criteria
- No further EVO injections
- **Soil Compliance Achieved in 2016**



Summary of Off-Site Remediation

- Enhanced reductive dechlorination
 - Overburden and weathered bedrock
 - Approx. 12 acre plume, 10 to 40 ft bgs, 4 biobarriers
 - 600 injection wells installed
 - 24,000 gallons EVO (EOS™)
 - Bioaugmentation (SiREM KB-1®)
 - 700,000 gallons dilute substrate injected to date
 - Monitoring June 2010 to present
 - Four injection events
 - 2010/2011, 2013, 2015 & 2017
 - 2017 anticipated to be final injection event



Off-Site Performance to Date

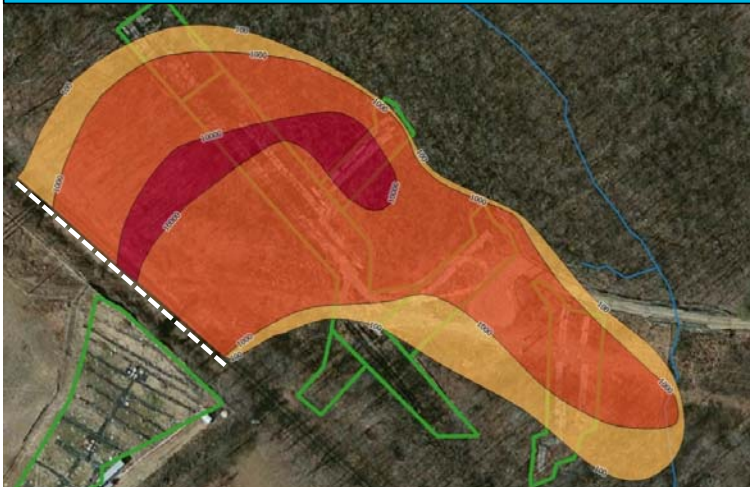
- Results

- Continued significant reduction in plume size
- Reducing conditions continue to persist in most off-site locations
- Barriers are operating as intended although some recalcitrant pockets still exist
- Data collected from key wells in 2017 indicate TCE conducting to decrease in areas of exceedance

Goals of 2017 Off-Site Injections

- Treat continued VOC flux into Barrier 1
- Substrate replenishment to maintain barrier operation for next several years.
- Treat recalcitrant pockets of VOCs

Pre-Remediation Plume Footprint - July 2010
TCE: Shallow Groundwater



Current Plume Footprint - December 2016
TCE: Shallow Groundwater



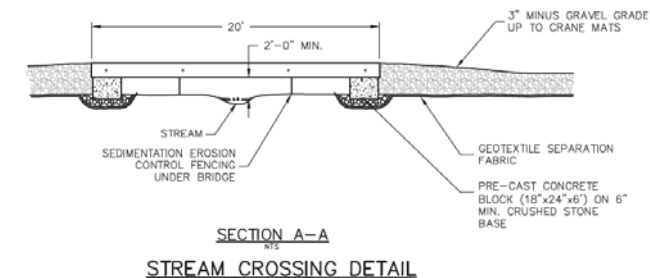


Overcoming Challenges

- Application In Wetland
- Injection Optimization
- Big Data Streams

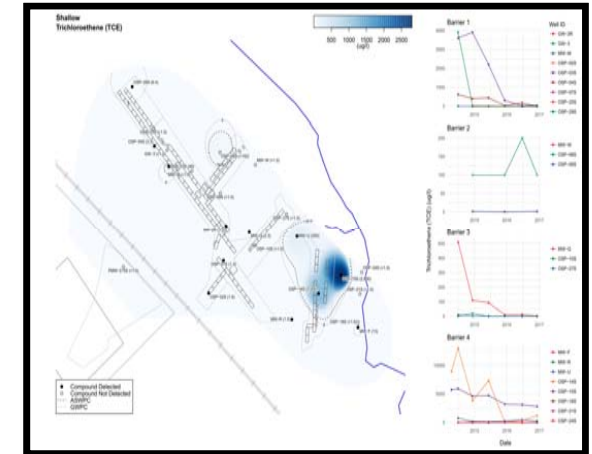
Treatment in Wetland

- Wetland with shallow water table
 - >100 temporary mats installed for safe travel across wetland
- Access Agreements for Biennial Access to Staging Area
- Treatment Barriers located >500 ft away from staging area
 - Installed temporary road w/stream crossing connecting treatment barriers to staging area
 - Install conduit along roadway for substrate, power, and emergency shut-off



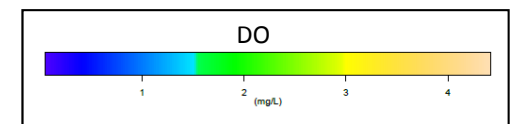
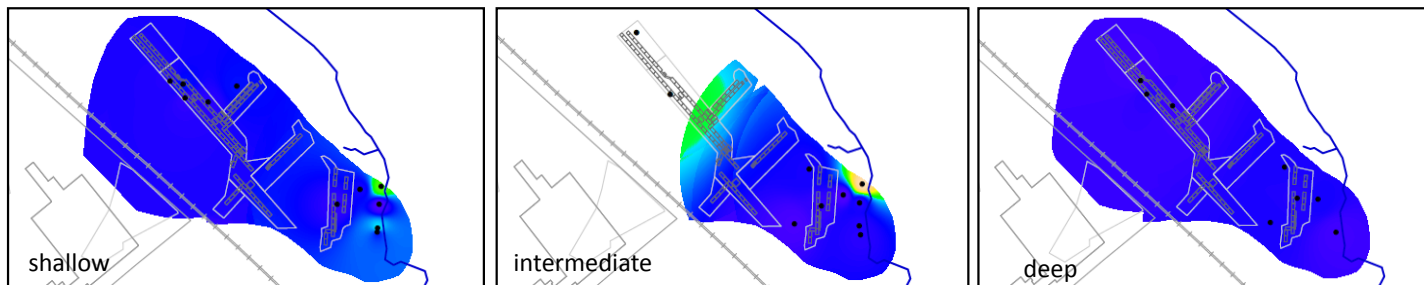
Injection Optimization

- Injection Planning/Substrate Dosing
 - Utilize data evaluation to determine substrate dosage based on recent performance monitoring data
- Daylighting/Biofouling
 - Clean injection wells using traditional well development methods
 - Use direct push injections
 - Modify substrate concentrations



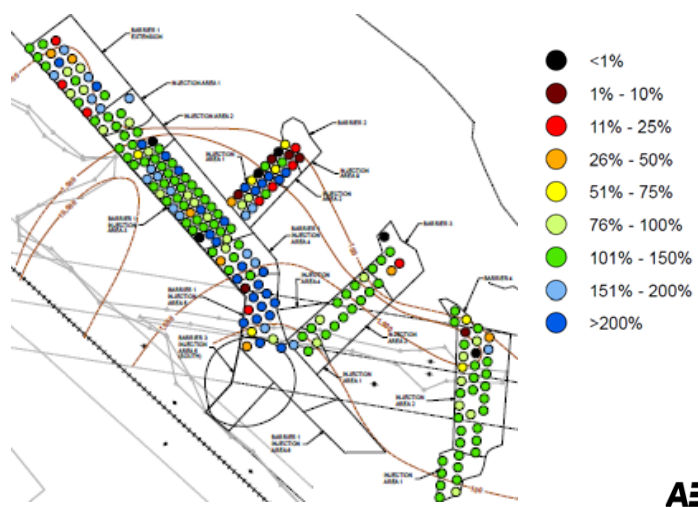
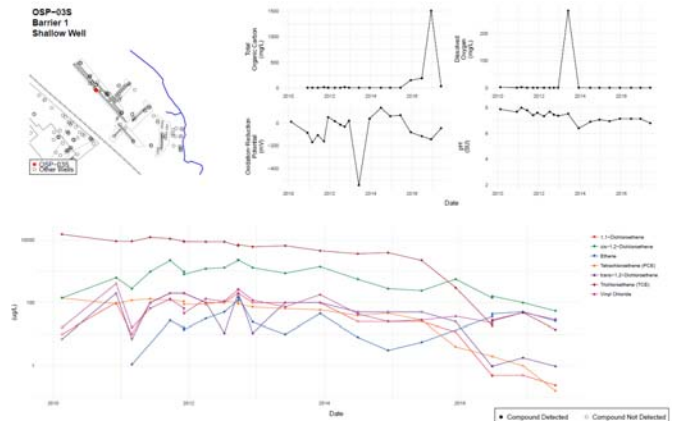
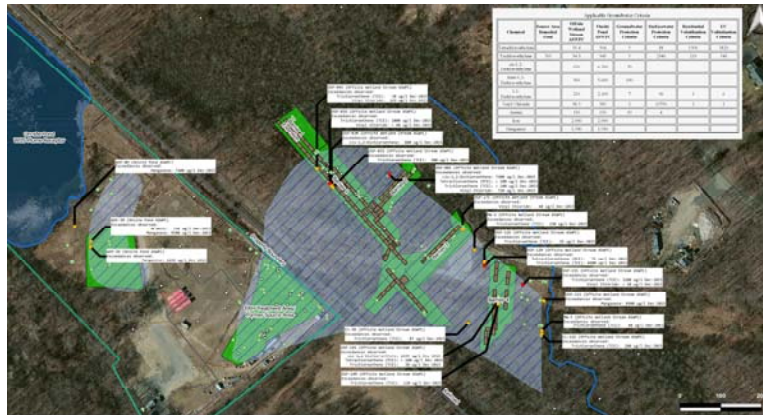
Injection Optimization

- Substrate Shelf Life
 - Insulated and installed A/C in storage unit to maintain low temperatures to maximize shelf life of substrate
- Maintaining Anaerobic Conditions
 - Dosed source water with sodium sulfite in water holding tanks to create anaerobic conditions before injecting



Dealing with Big Data

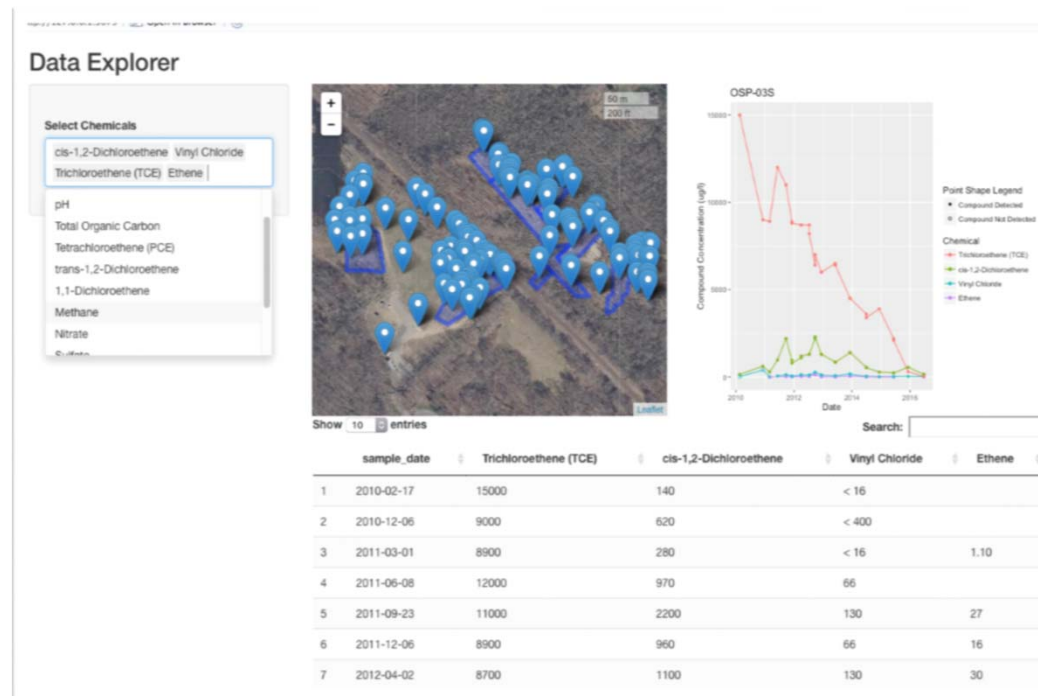
- Extensive Performance Monitoring Plan
 - Too large for traditional data analysis methods
- Daily downloads during injections
 - Comprehensive injection parameter tracking



Dealing with Big Data

– The “R” Solution

- Developed Site specific programs for automating performance data analysis
- Modeling tools to visualize progress of remediation





Closure Strategy Development

Closure Strategy Development – Regulatory Framework

– Existing Framework

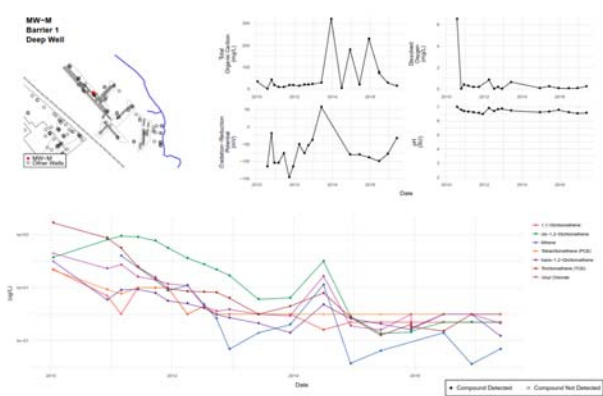
- State lead, original order issued in 1987
- Over 10 years of active remediation
- Site located in a GA/GAA groundwater zone
 - Sole source aquifer, no reclassification of groundwater
- Site-specific criteria and technical impracticability (TI) waiver
- TI waiver conditionally approved, final pending:
 - Completion of remediation in accordance with the RAP
 - Implementation of post-remediation monitoring plan
 - Delineation of final TI Zone
 - Record ELURs for on-site and off-site areas
- Alternative surface water protection criteria (SWPC) supersedes default SWPC

Closure Strategy Development – Near Term Challenges

- Access
 - Site Location and Future Access
 - Site is bisected by rail
 - Offsite areas are accessed through neighboring property.
 - Access is arranged through 2019
- Future Stakeholder Input
 - Finalization of TI waiver may require ELURs on adjacent properties
 - May not be able to compel property owners
- Expiration of Permits
 - Wetland, Injection permits expire in 2019
- Expectation of Full Demobilization during 2019

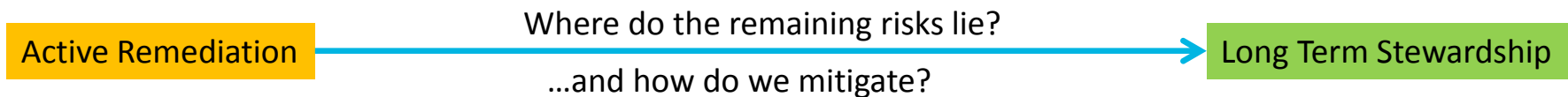
Closure Strategy Development - Recent Successes

- Soil AOCs achieved compliance in 2017
- 2017 injections will last for >5 years of continued remediation
- 2018 activities includes “Deep Dive” on groundwater remedy performance with respect to original plan and recent regulatory changes
 - Likely we will have the ability to modify original alternative criteria

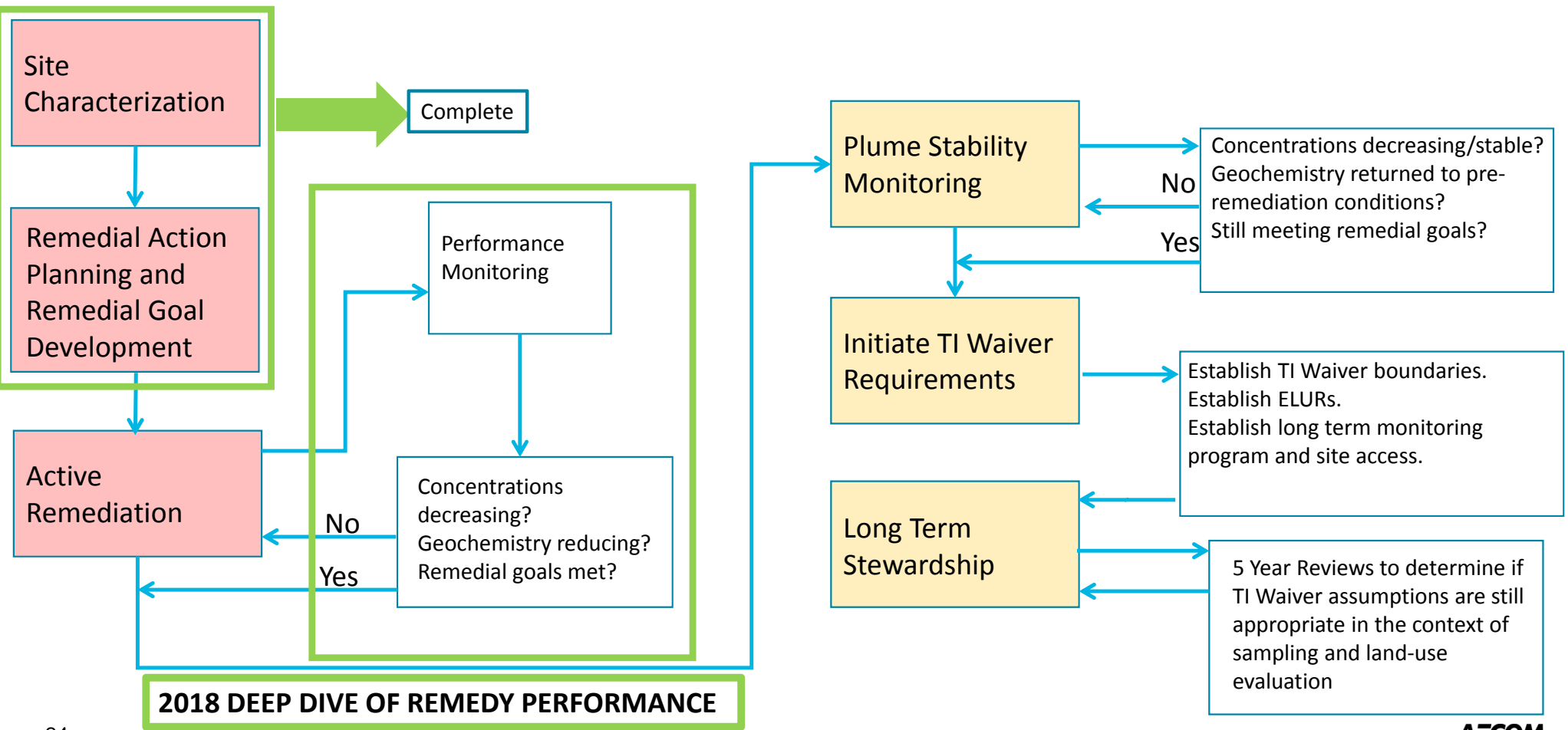


Closure Strategy Development – Identifying Future Risks

- Questions:
 - Remaining concentrations in groundwater, post-2017 injections?
 - Is plume stable, trends reducing, and what about remaining “recalcitrant” areas?
 - Attenuation beyond the life of the barriers?
 - Receptors at concentrations above the remedial goals? For how long?
 - Short-term, more aggressive remediation necessary? (e.g. excavation, ISCO)
- Deep Dive Remedy Evaluation and Regulatory Engagement key 2018 activity and critical for continued progress toward closure with regulatory buy-in.



Closure Strategy Development – Decision Framework



Closure Strategy Development – Major Milestone Timeframes

- Next steps
 - Conduct deep-dive performance evaluation on remedy for entire site (2018)
 - Transition from active remediation to plume stability monitoring (2018-2019)
 - Initiate TI Waiver requirements (2019)
 - Transition to stewardship and long term monitoring (2019-2034)
- Ultimate goal of returning property to productive use with near-term goal of on-site redevelopment

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Thank You!

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