

Designing a Treatment Solution Using Quantitative High-Resolution Site Characterization Data to Determine Life Cycle Mass Flux and Discharge



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Site Location and History



- Ann Arbor, Michigan
- Developed since at least the late 1800s
 - 2 city blocks
 - Two former dry cleaners
 - Car wash
 - Junkyard operations
 - Other commercial and residential uses
- Various on- and off-site investigations
- Significant chlorinated solvent contamination - soil and groundwater
 - Source = Broadway coin laundry
- Env. challenges ≠ redevelopment
- Unsuccessful remediation and redevelopment attempt (2006-2008)
 - Sodium Permanganate Pilot Test

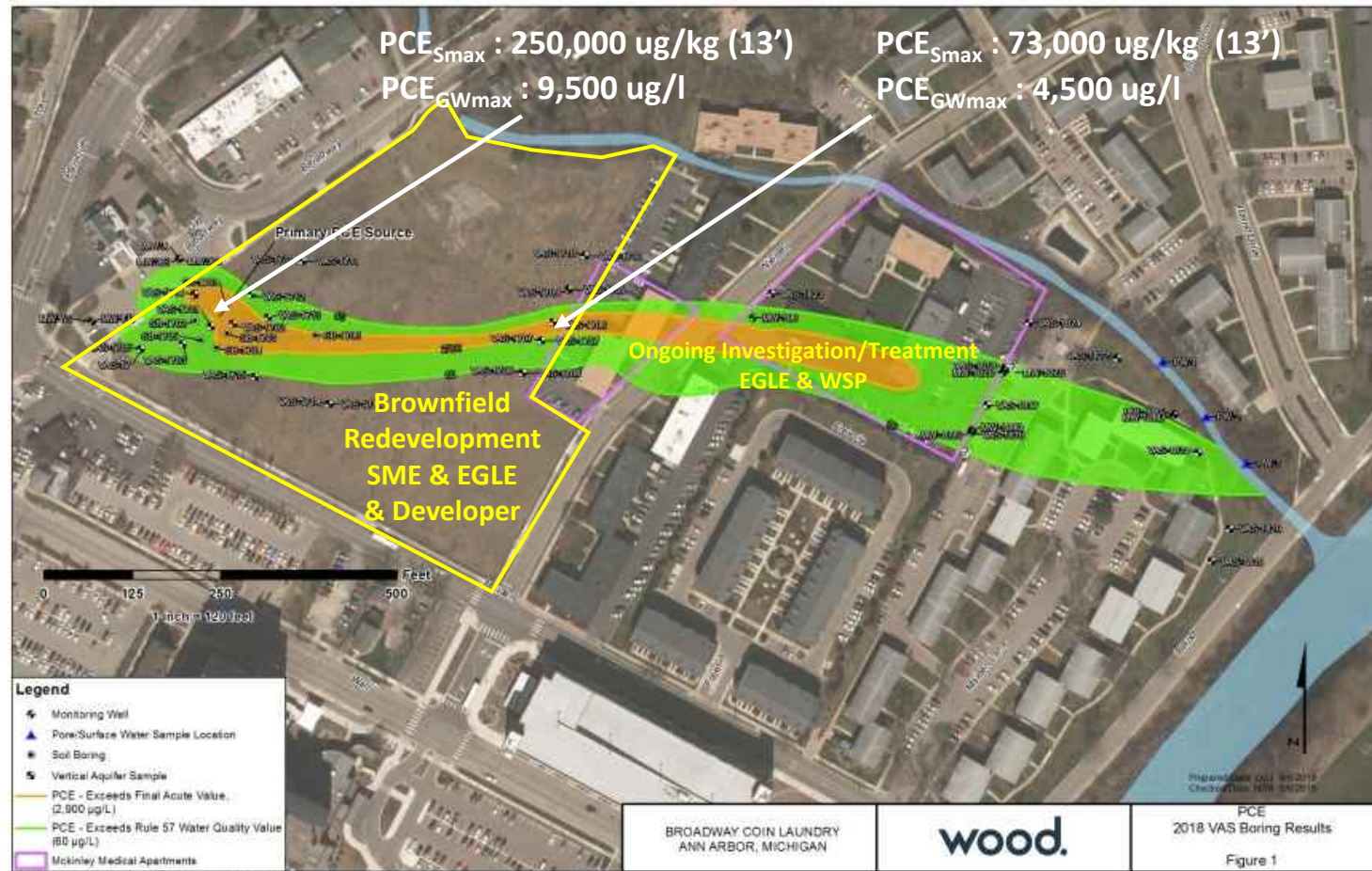
Special Thanks - Agnes Taylor, Michigan Department of Environmental, Great Lakes, and Energy (EAGLE)

Broadway Coin Laundry (the Source)

- Operated from 1961 through early 2000s
- Facility utilized a dry well for storm water discharge and that tied to floor drains
- In 2002 and 2017, EGLE completed limited investigation
- Additional investigations were completed from 2004 to 2019 by private parties
- In 2017 through 2019, EGLE conducted an offsite groundwater investigation

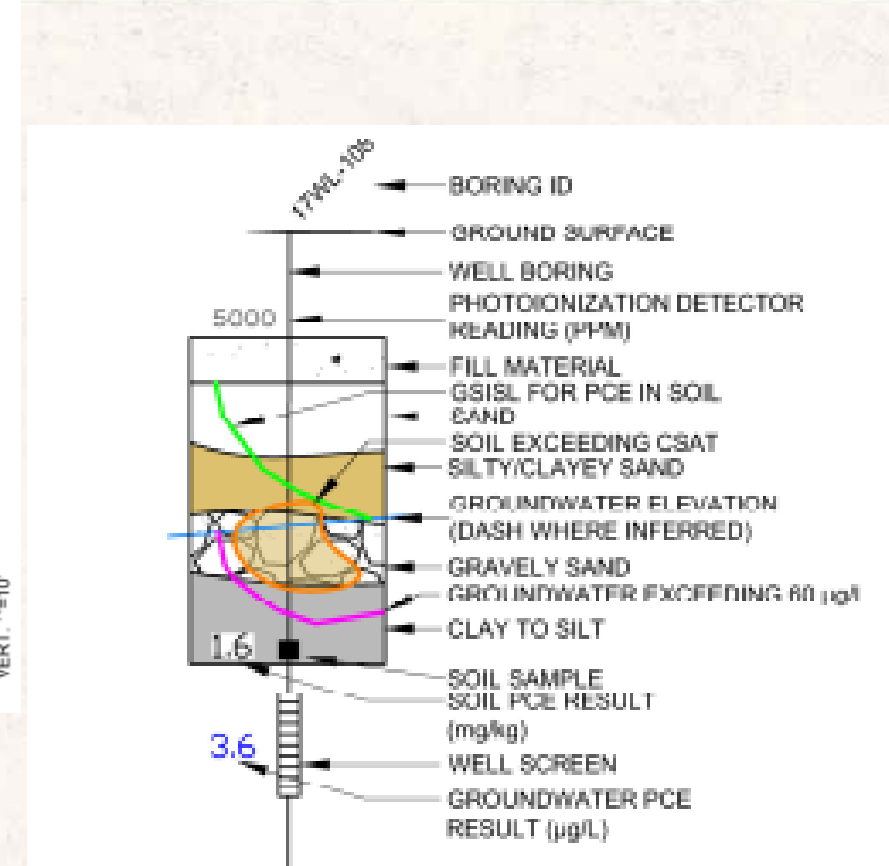
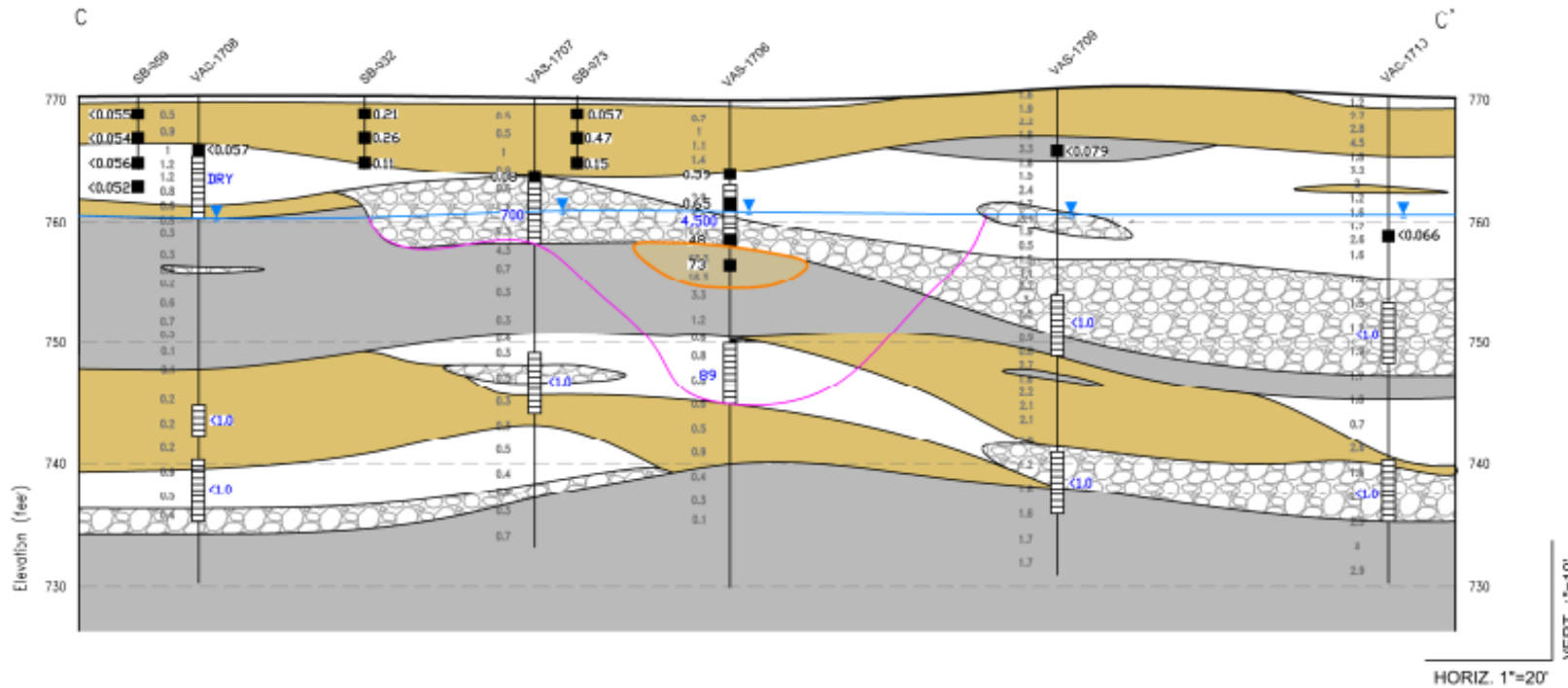


Chlorinated Groundwater Plume



- Fill underlain by **variable** sand, silts, and clays
- Groundwater
 - Encountered 8 to 13 ft-bgs.
 - Extends to ~40 ft-bgs, to confining unit
- Eastward groundwater flow
- Soil Impacts
 - Up to 33 ft-bgs. west
 - Up to 16 ft-bgs. east
 - Off-site migration

Variable Geology



Hydraulic Gradient – 0.003 ft/ft (10-20 ft bgs), 0.002 ft/ft (20-30 ft bgs)

Wide Range of Hydraulic Conductivity (Seepage Velocity)

- Source Area K values: 196 - 400 ft/day (976 – 1,991 ft/year)
- Downgradient Property Line K values: 40 - 257 ft/day (199 – 1,279 ft/year)

Motivated Stakeholders – Catalyst for Treatment

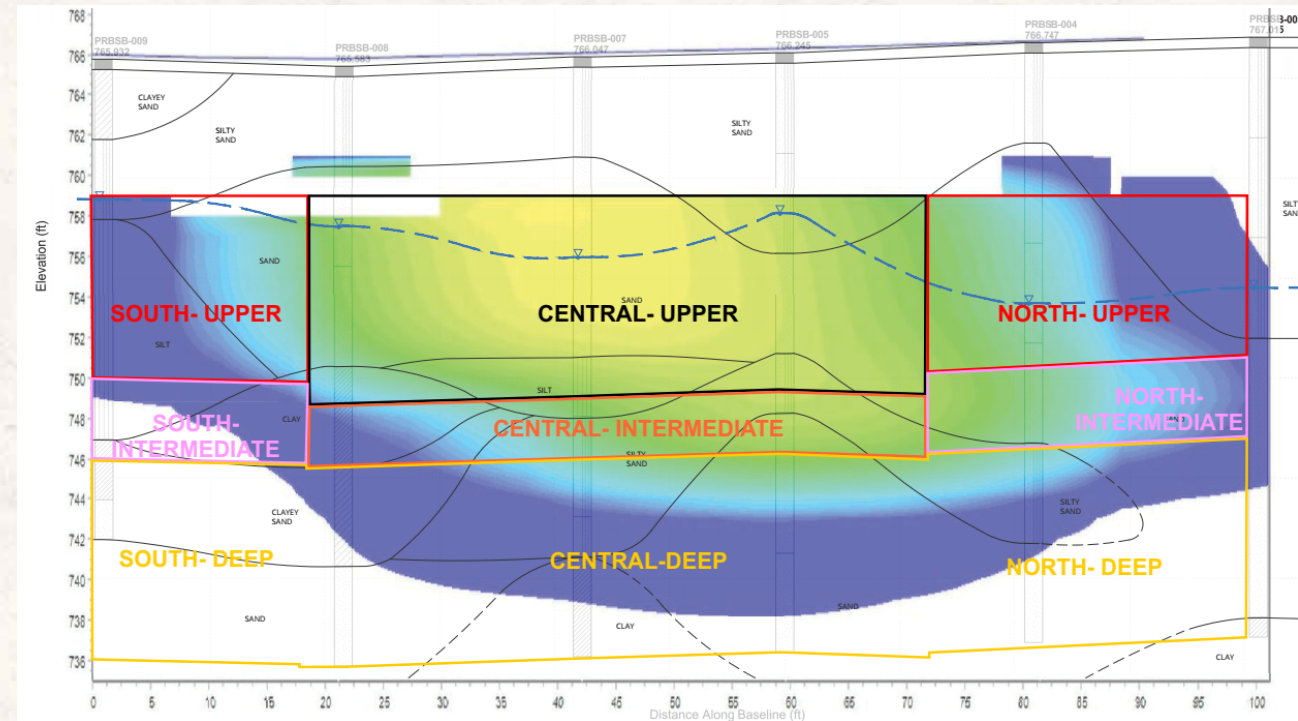
- New Purchaser/Developer
 - Mixed-use redevelopment
 - Tax Incremental Financing (TIF) Incentive
 - Agreed to voluntarily install at least one PRB at the east boundary
 - Treatment design goal of 80% PCE reduction at east site boundary
- Technology Evaluation (granular vs colloidal)
 - ZVI (Injection)
 - BAM (BioChar)
 - BOS 100®
- BOS 100® Selected
 - Highly reactive iron treatment mechanism built on the activated carbon platform
 - Provides immediate control of off-site groundwater mass migration and long-term treatment
 - Contact time not a concern and associated daughter product generation
 - Does not rely on indigenous bacteria to regenerate adsorption sites



Preliminary BOS 100® Design and Cost

Barrier Length 110 ft, Vertical Interval (9 to 30')

- Option 1 – Vs ~199 ft/year
 - BOS 100® = 13,650 lbs
 - Estimated Installed Cost - \$224,989
- Option 2 – Vs ~443 ft/year
 - BOS 100® = 19,650 lbs
 - Estimated Installed Cost - \$339,564
- Option 3 – Vs ~1,279 ft/year
 - BOS 100® = 49,050 lbs
 - Estimated Installed Cost - \$743,704



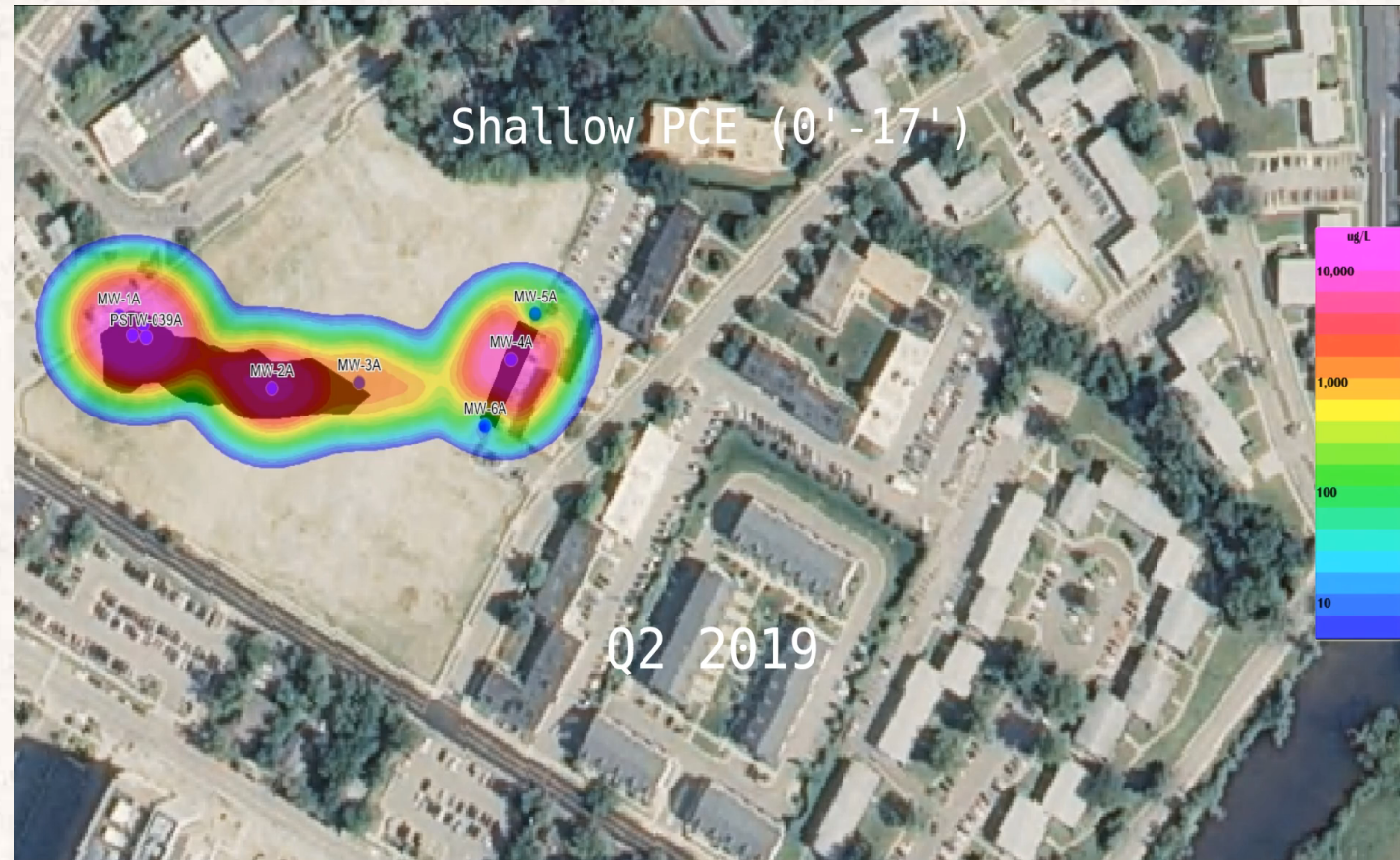
Project Challenges... the short list

- **Data gaps**
 - Subsurface conditions
 - Variable soils and Hydrogeology?
 - Contaminant distribution and nature
- **Time/Spatial Constraints**
 - Construction concurrent with treatment
 - Development footprint left minimal room at eastern boundary for PRB
- **Grant & TIF Budget**
 - Not enough to fully treat the site
 - Needed to optimize every dollar
- **Contractual Requirement**
 - Performance Based Contract (80% removal within 18 months after installation)
- **Treatment Media**
 - How do we get the biggest treatment bang for our buck?



Remedial Approach to Overcome Challenges

- **Approach 1**
 - Rely on existing source data
 - Model potential contaminant flux (30 yr.) through PRB
 - ***High uncertainty of achieving goal***
- **Approach 2 – qHRSC Program**
 - Discern cVOC mass in soil/groundwater at source, mid-plume, and property line (mass distribution)
 - *PRB design based on known location and quantity of PCE mass*
 - ***High confidence in remedial approach, Performance Based Contract Awarded***



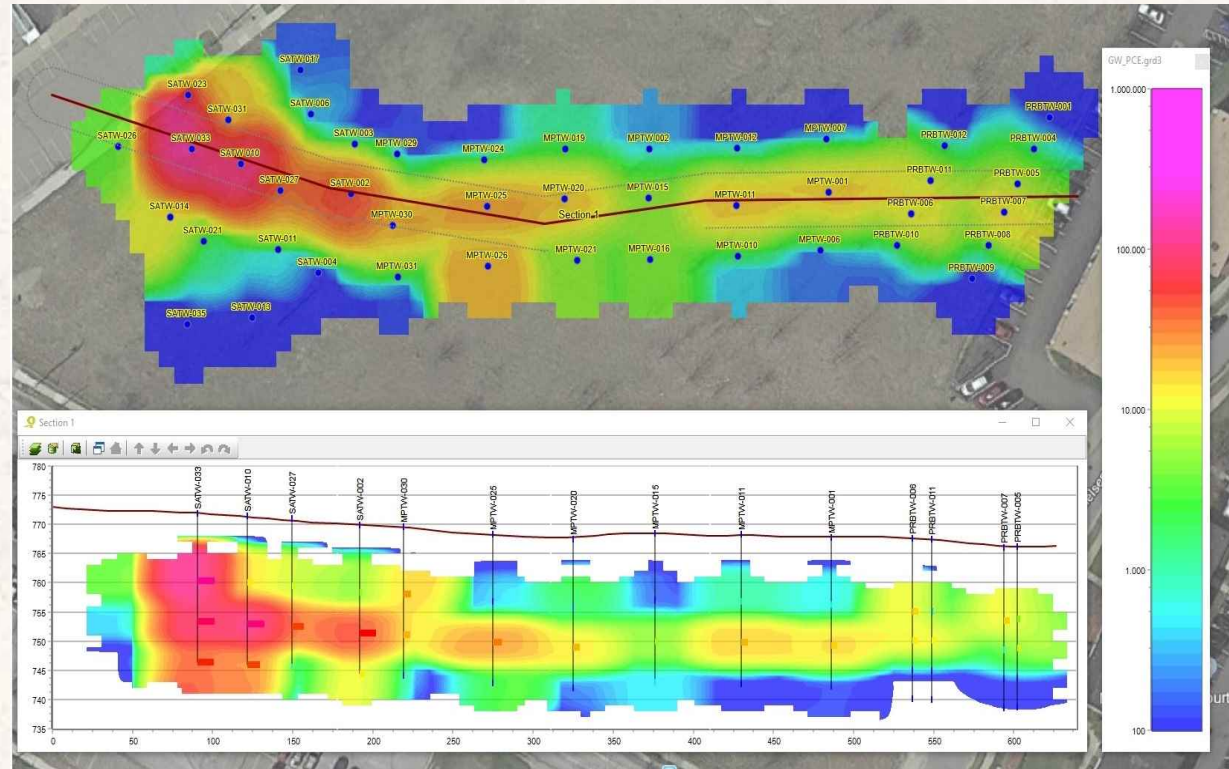
qHRSC Program

- 79 soil borings to ~40 ft-bgs.
 - Logged soils
 - Sampled every 2 vertical feet
- 46 nested GW well clusters
 - 142 individual wells sampled
 - Slug tests
- 1,120 soil and 185 groundwater samples
 - cVOCs; speciation
 - Dissolved gases
 - Anions
- Confirmed
 - Hydraulic conductivities
 - Calculated seepage velocities and gradients
 - Soil mass; mass flux



qHRSC Findings

- 4,125 lbs. of PCE present in a 60 ft band
- Soil concentrations higher than 'old' data
 - 4,640,000 ppb – source area
- Magnitude of GW concentrations on par...
 - ...but more pervasive
 - 137,000 ppb in source
 - 14,000 – 27,000 ppb in axis of mid plume
- 99% of mass was PCE
- Very little natural degradation (GW = oxic)
- Refined soil profile and hydrogeology



Mass-Driven Treatment Design

Received \$1 million EGLE grant

- Added source area treatment
- Extended longevity of PRBs

Source & Mid-Plume – CAT 100

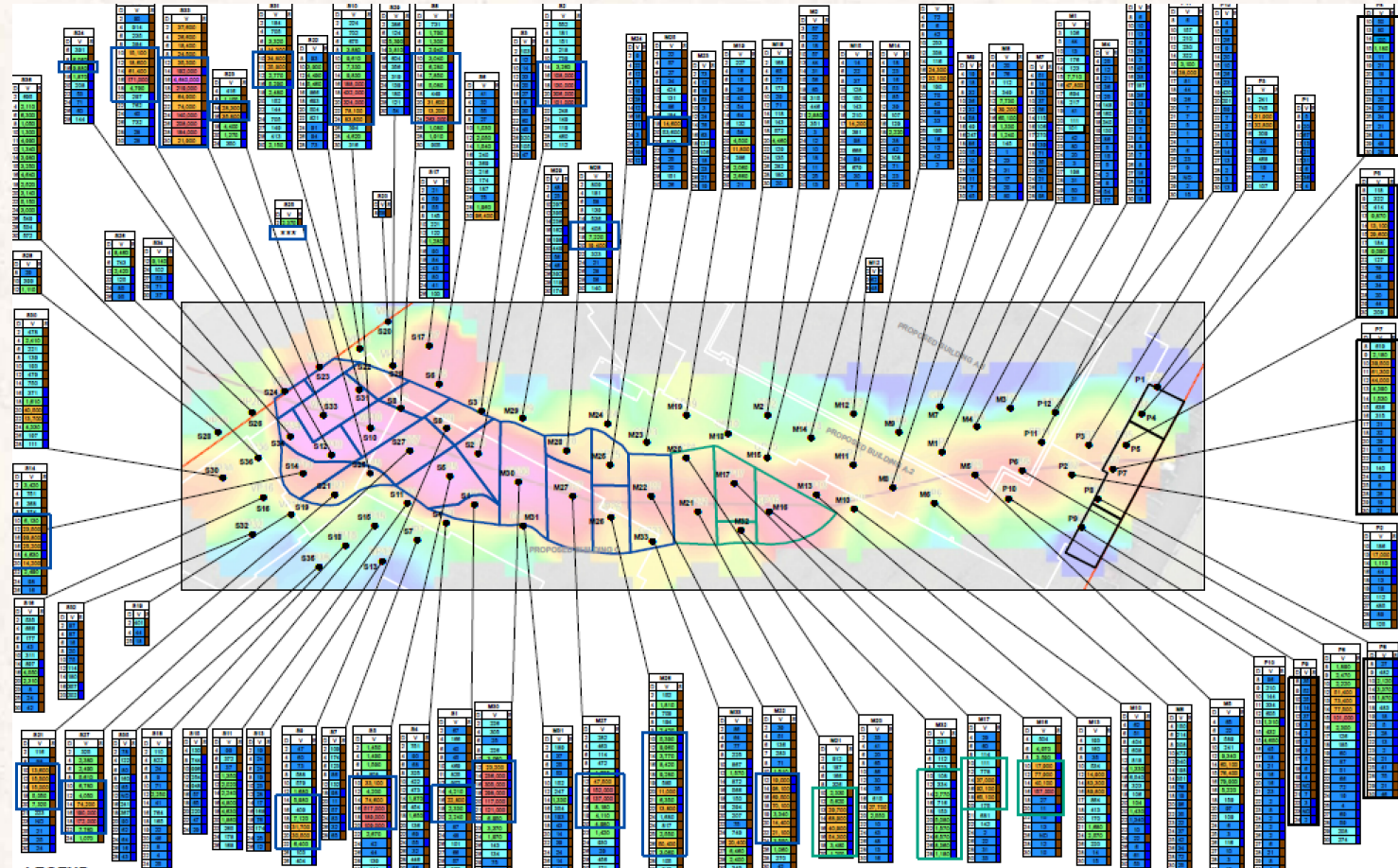
- Loadings designed on cVOCs/DNAPL
- Eliminate high-mass areas ($>5\text{mg/kg}$)
- Capable of managing oxic environment

PRB1 – CAT 100

- cVOC mass within PRB1 footprint
- 5-year lifetime (estimated mass flux)

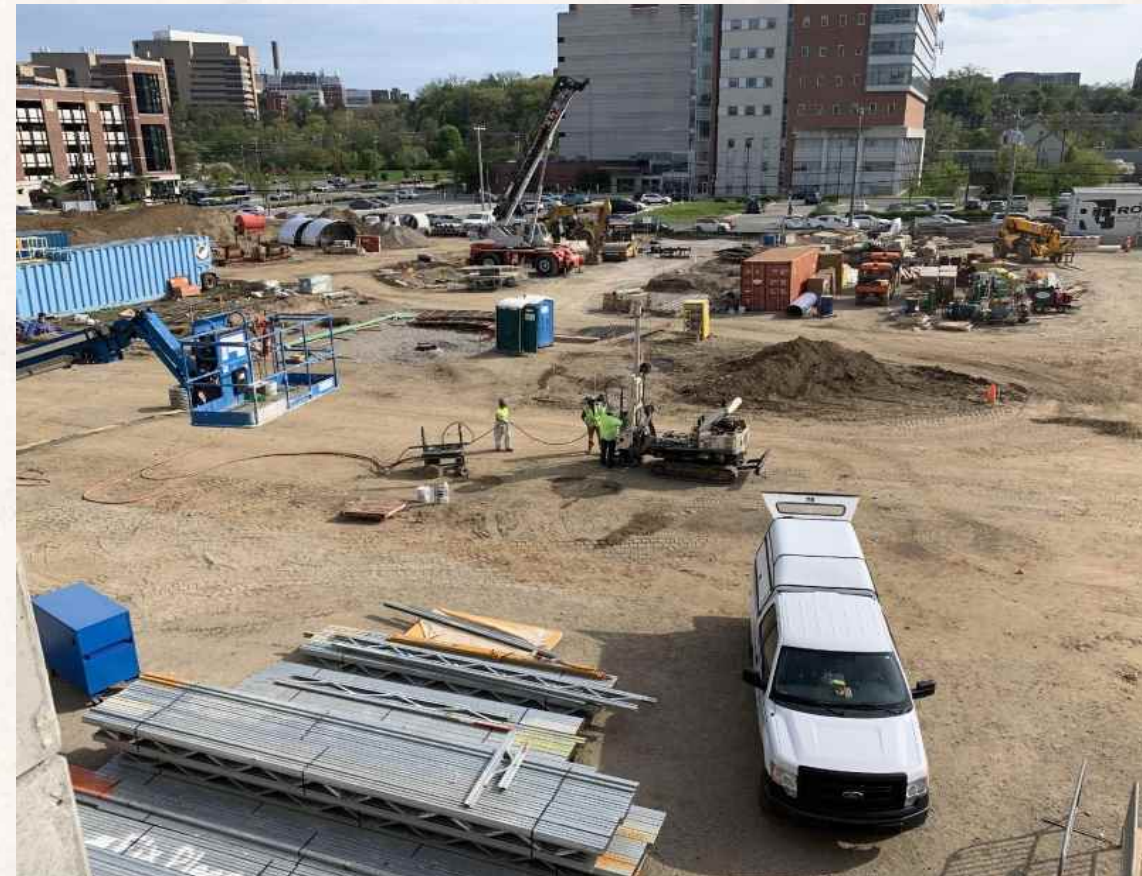
PRB2 – BOS 100®

- Mass within footprint of proposed Building A
- Mass present within footprint of PRB2
- Seepage velocities calculated (slug tests)
- 30-year lifetime



Implementation

- Pilot Study
 - CAT 100 source treatment
 - PRB1 treatment media
 - Dec 2018 through Feb 2019
- Full scale injections
 - Spring-Summer 2019
 - Concurrent with construction/redevelopment
- Post Injection Monitoring (2019 – 2022)



Findings – Chemical Signatures

Reduction in [PCE] below baseline

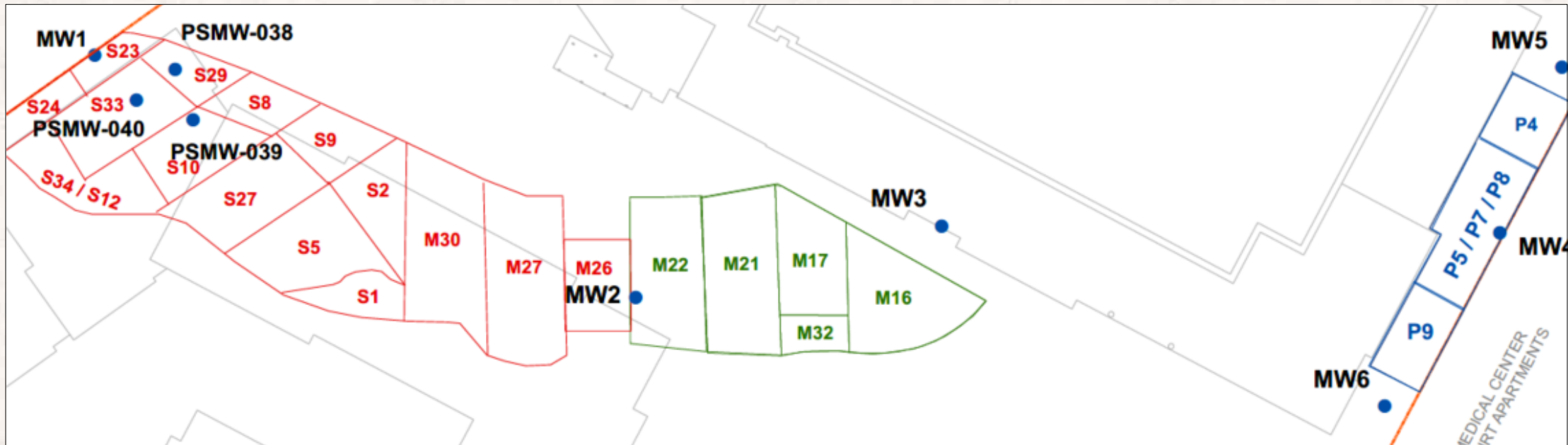
- Source area (MW2): 99.6 -100%
- PRB 1 (MW3): 99.5-100%
- PRB2 (MW4): 98-100%

CI-VOC Daughter Generation

- DCE spike in CAT100 areas 6m post injections
- VC generation at 6m, declining since
- Source Area (MW2): Total CI-VOC reduction of 92%
- PRB2 (MW4): Total CI-VOC reduction of 83%

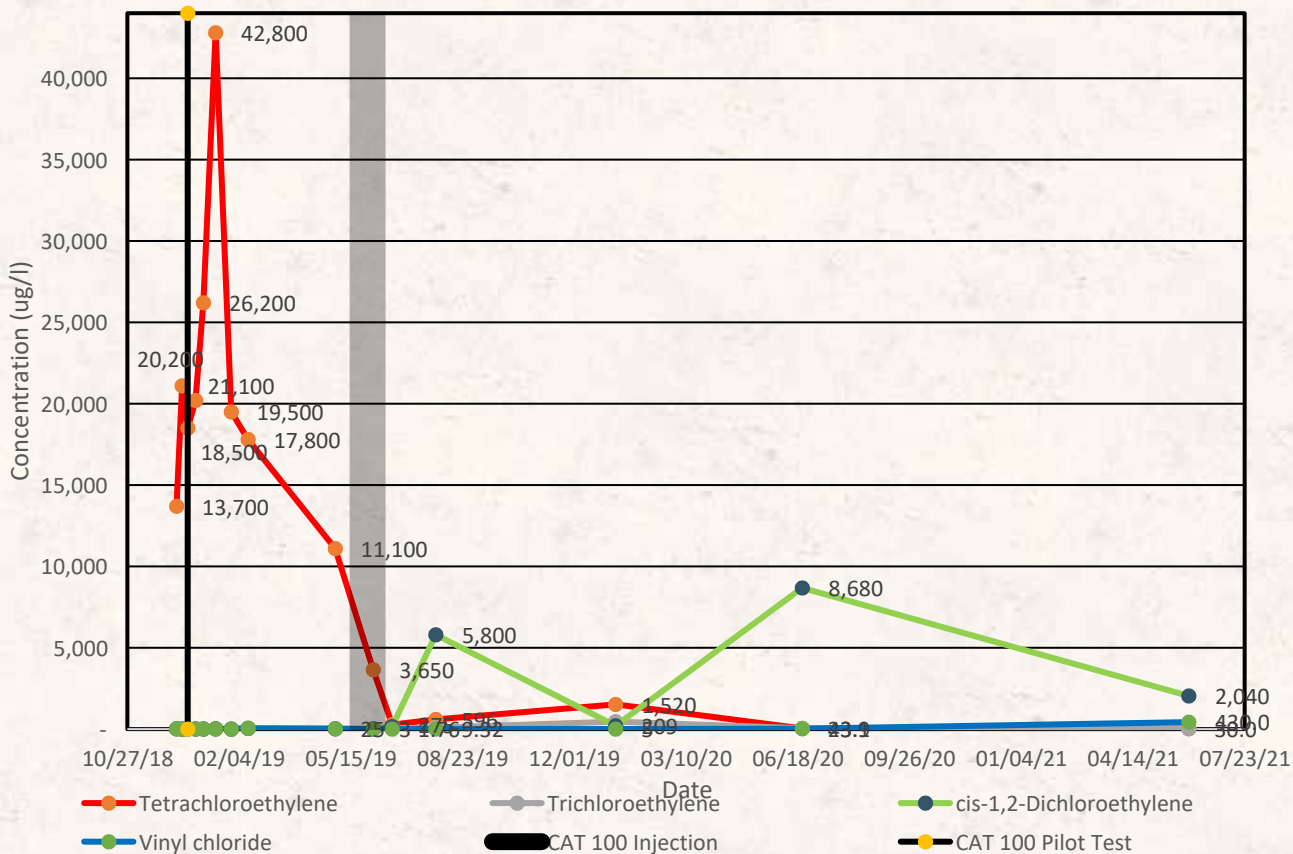
Gasses: Strong pulse @ 6m of Methane, ethylene, and ethane

Alcohols: Steady presence of acetate, formate, propionate, butyrate, pyruvate, succinate, and ammonia.

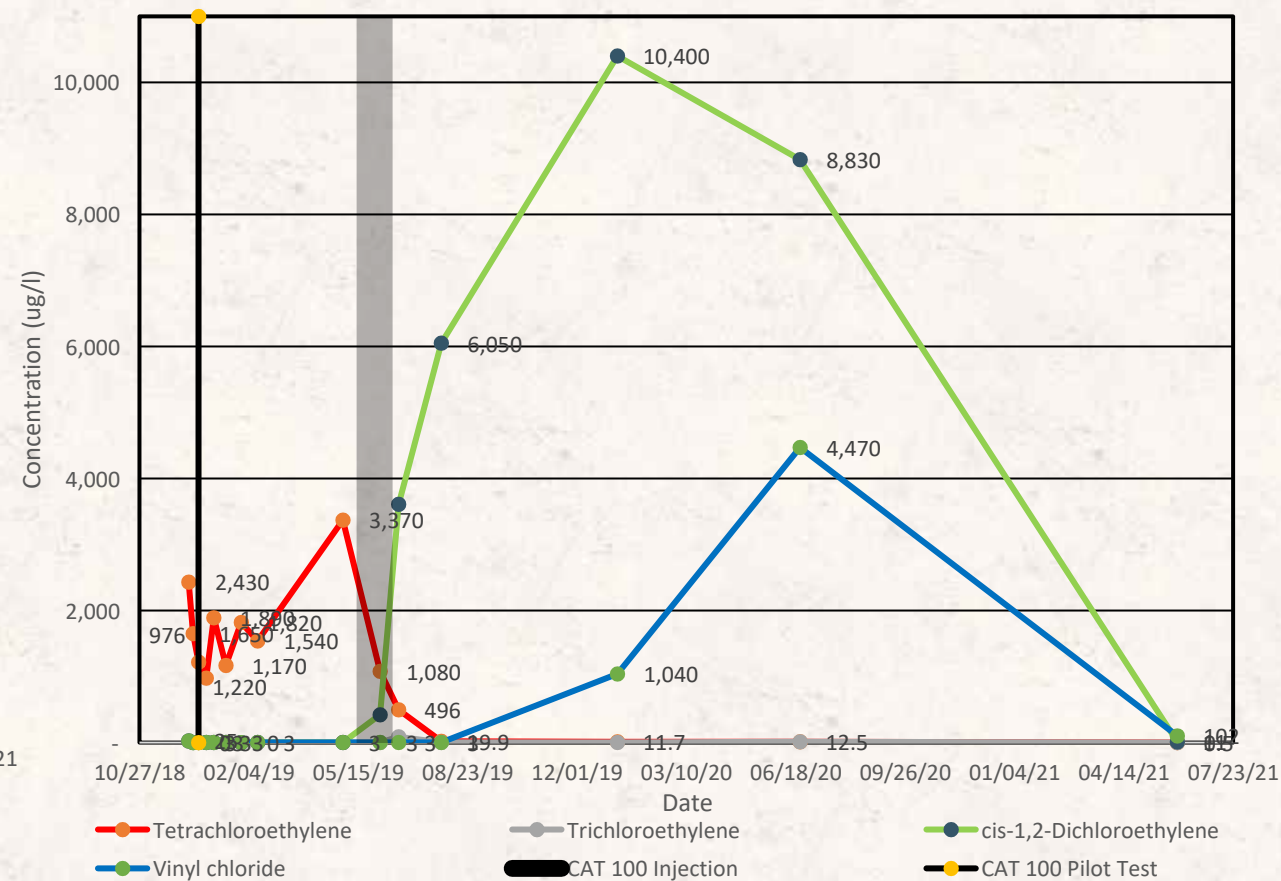


PSTW-39A Results

PSTW-39A (10 - 15')

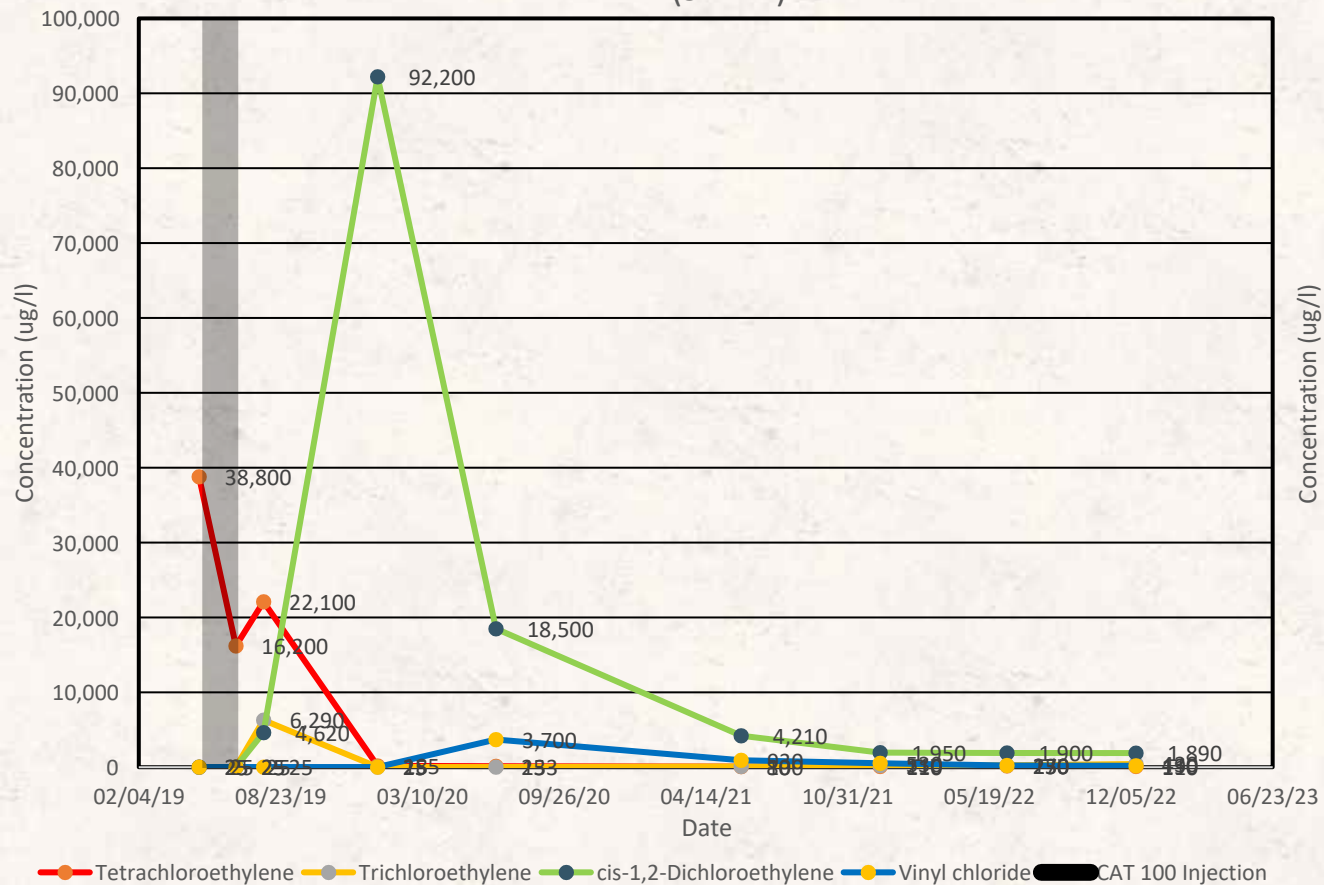


PSTW-39B (17 - 22')

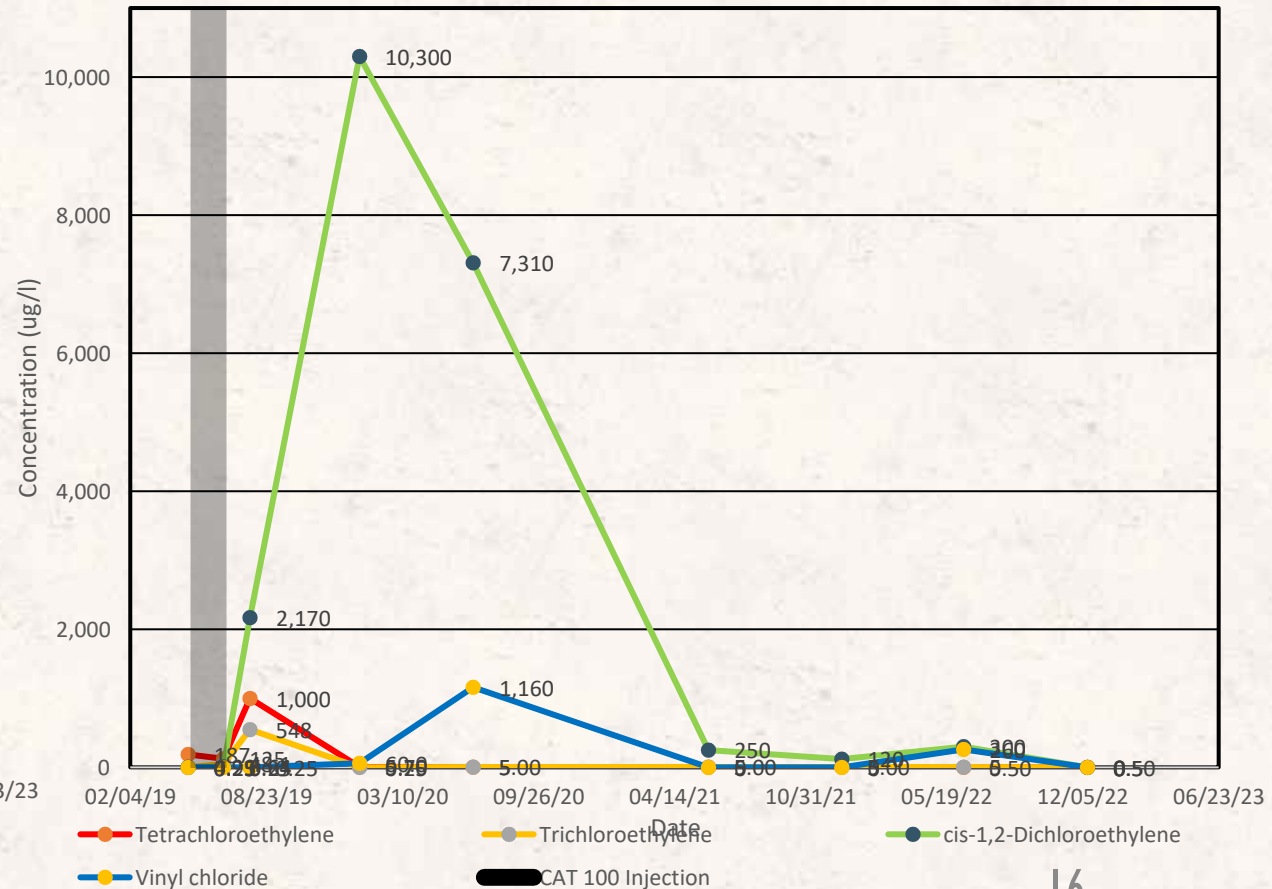


MW-2 Results

MW-2A (9 - 14')

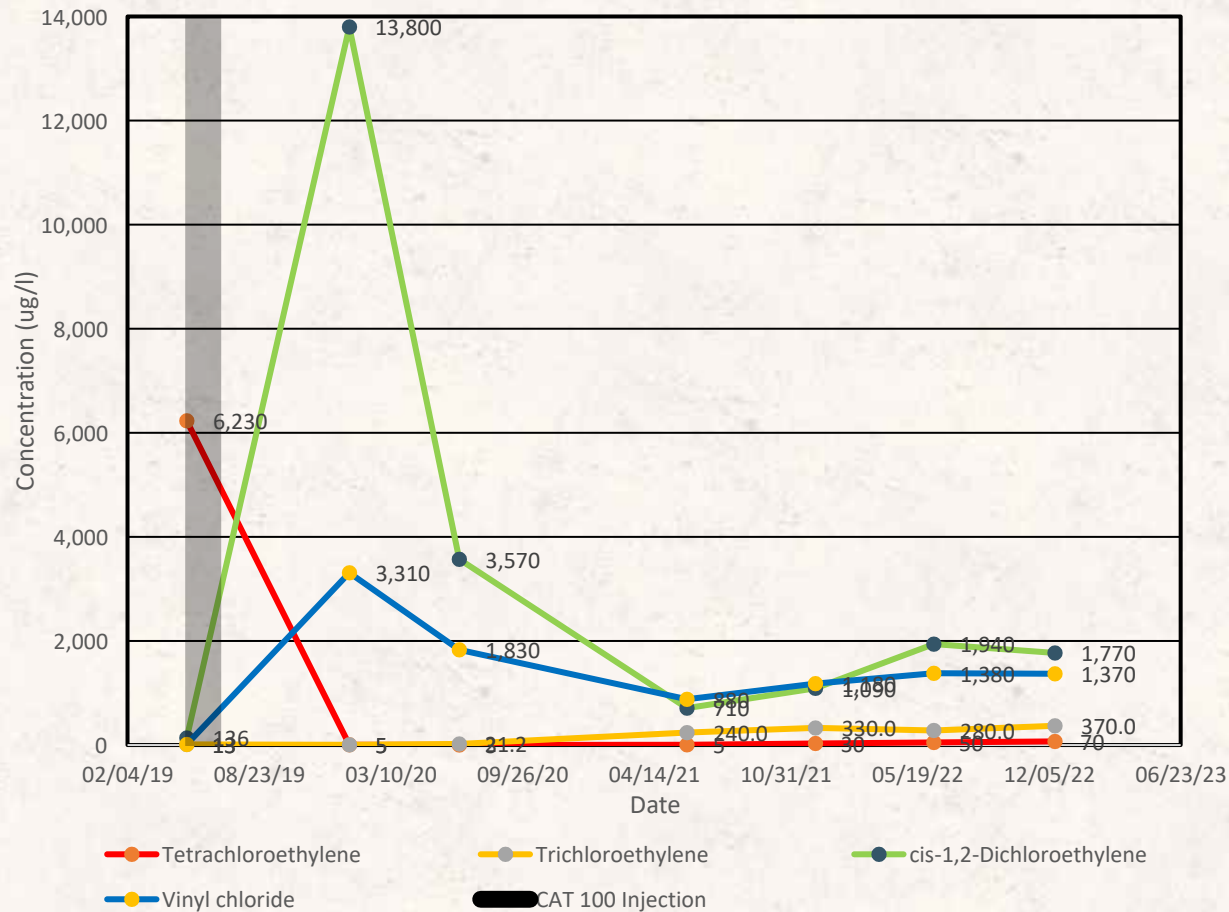


MW-2B (23 - 28')

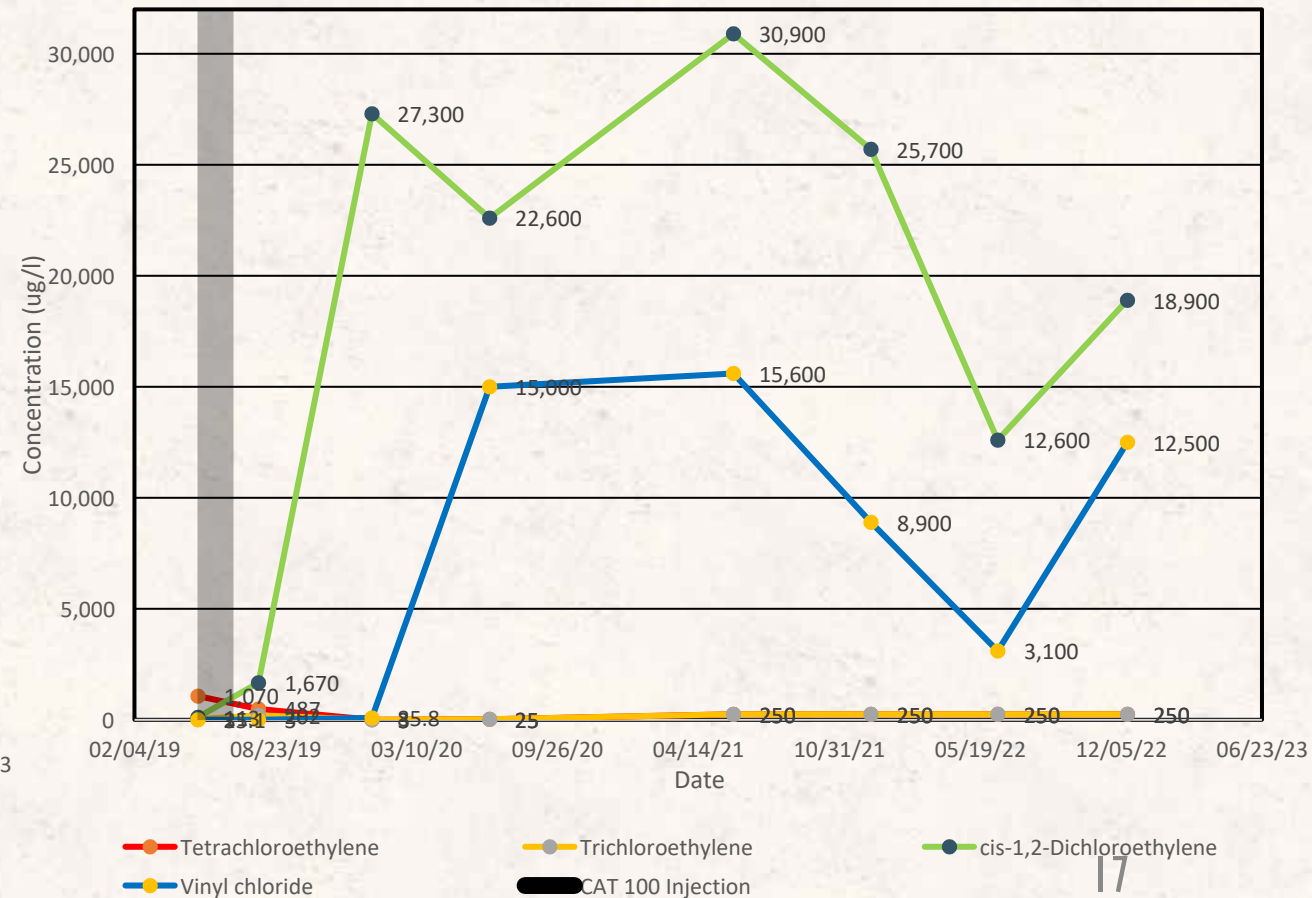


MW-3 Results

MW-3A (15 - 20')

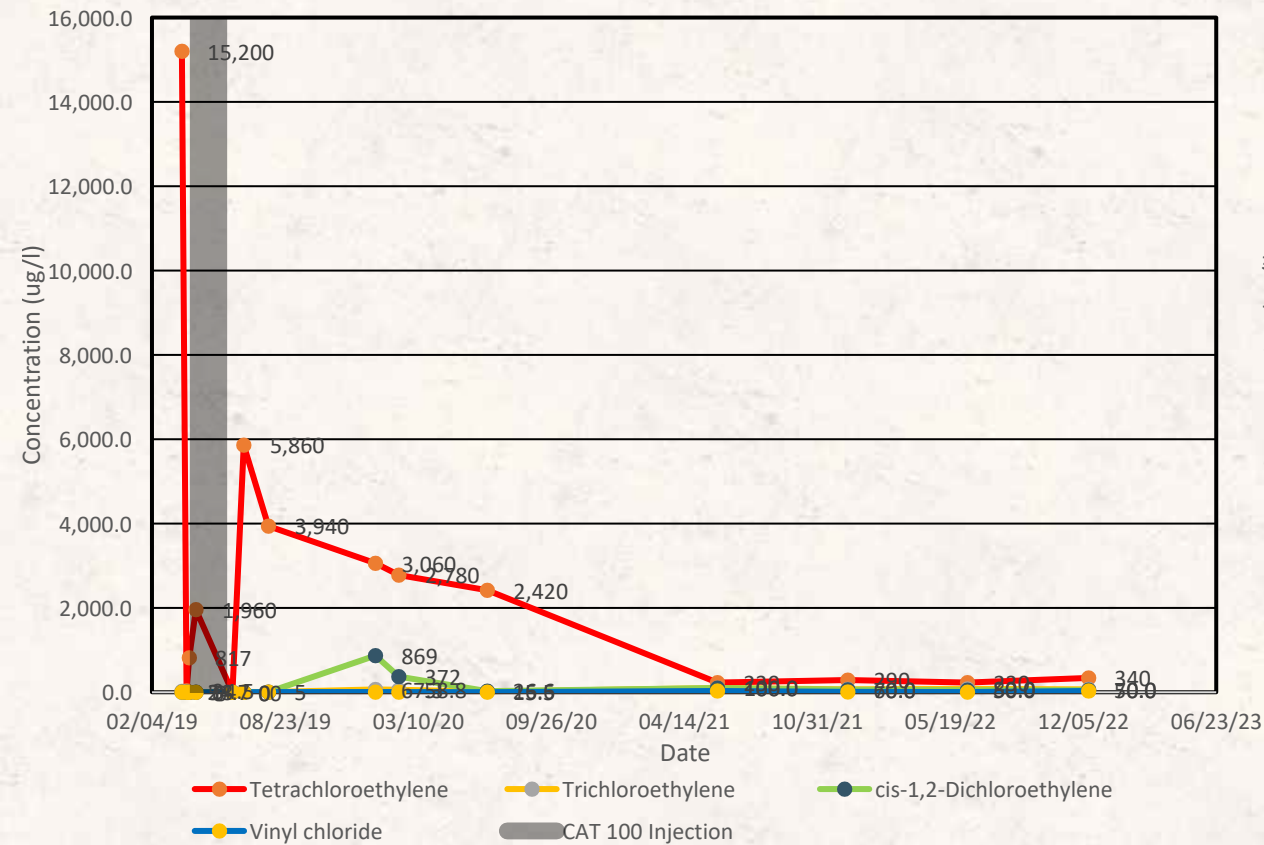


MW-3B (23 - 28')

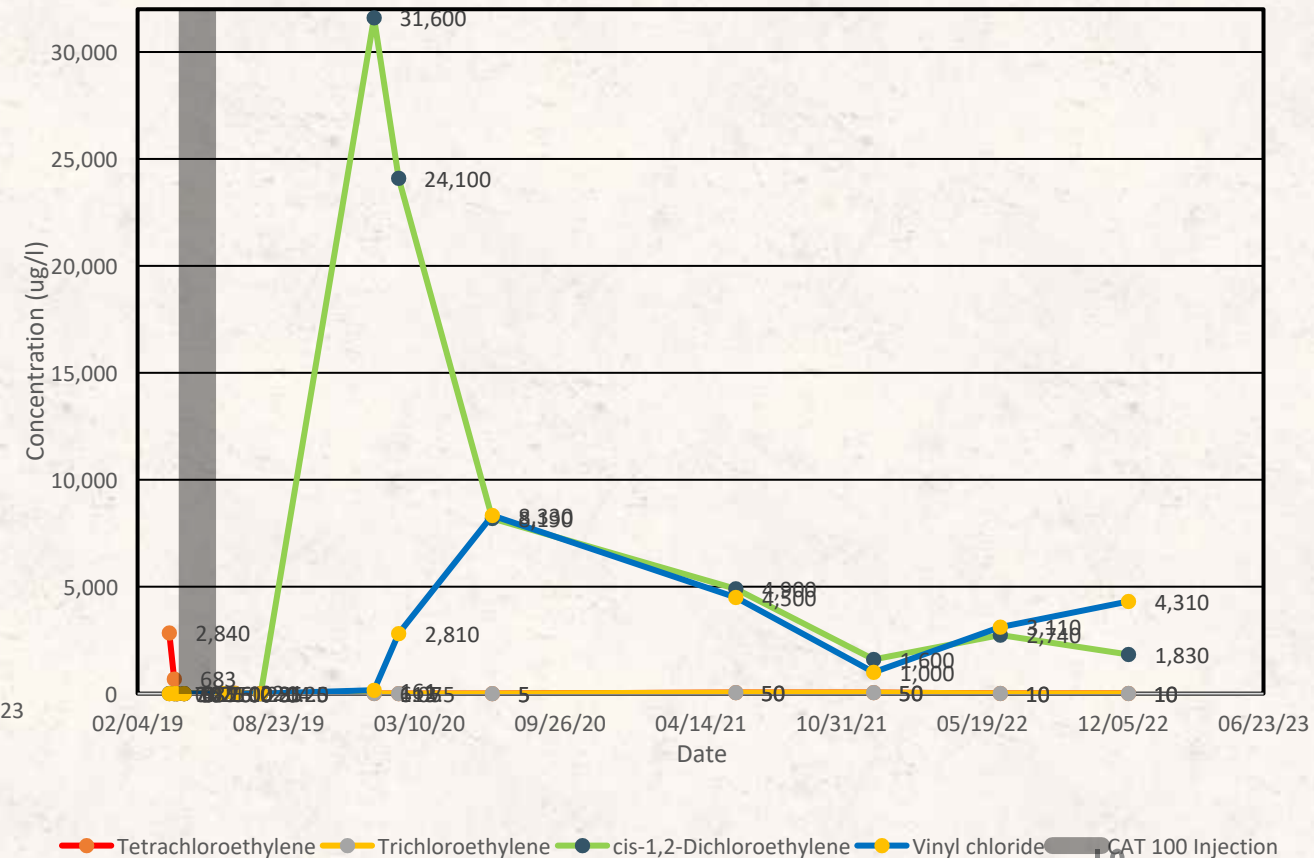


MW-4 – Results

MW-4A (9.5 - 14.5')



MW-4B (25.5 - 29.5')



Takeaways

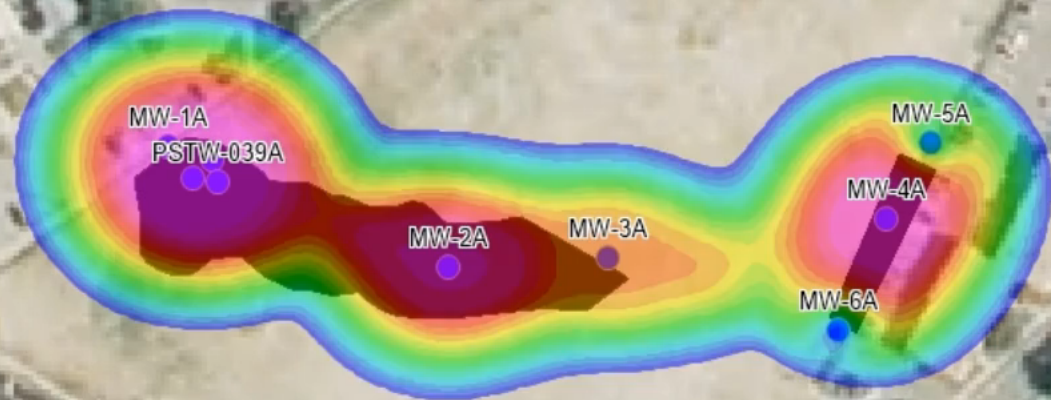
- qHRSC program filled in data gaps, provided a high-resolution quantitative conceptual site model, and allowed for a surgical design approach; preferentially targeting the most impacted intervals to remove source mass.
- A combined remedy of CAT 100® and BOS100® achieved the short-term remedial goals and continues to treat the entire mass eliminating long term liability.
- Evidence of V_s - 1,155 ft/year, significant vertical gradient
- The reduction of Cl-VOCs on this site has made additional downgradient treatment feasible. State funded injections occurred on the east-adjoining site in 2021.



Questions?

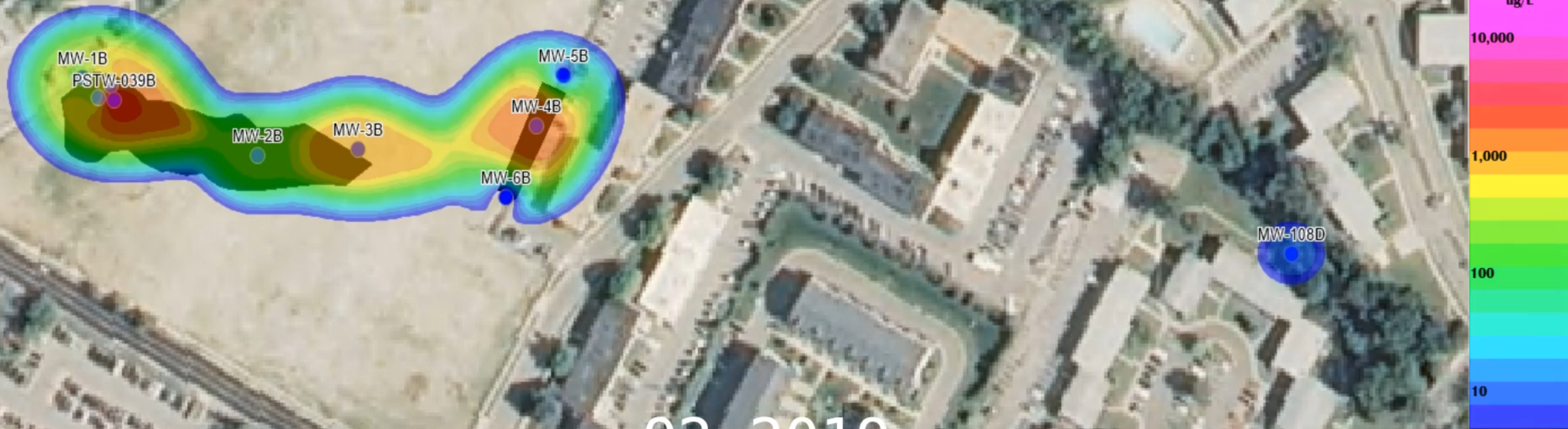
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Shallow PCE (0' - 17')



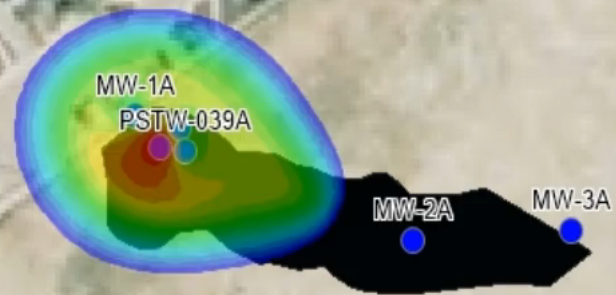
Q2 2019

Deep PCE (>17')



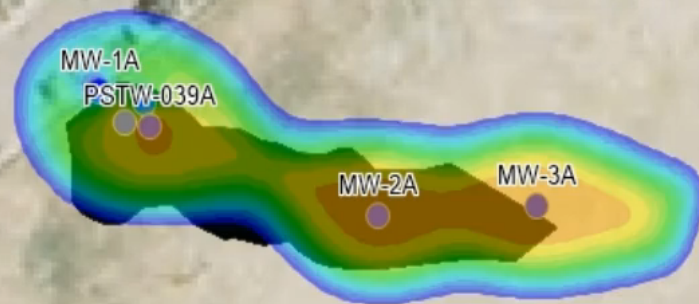
Q2 2019

Shallow TCE (0' - 17')



Q2 2019

Shallow cis-DCE (0' - 17')

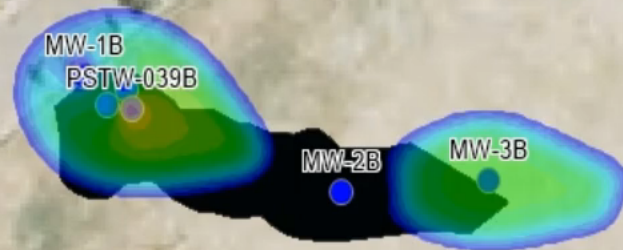


MW-5A
MW-4A
MW-6A

Q2 2019



Deep cis-DCE (>17')



MW-108D

Q2 2019



Shallow VC (0' - 17')

MW-1A
PSTW-039A

MW-5A

MW-4A

MW-2A

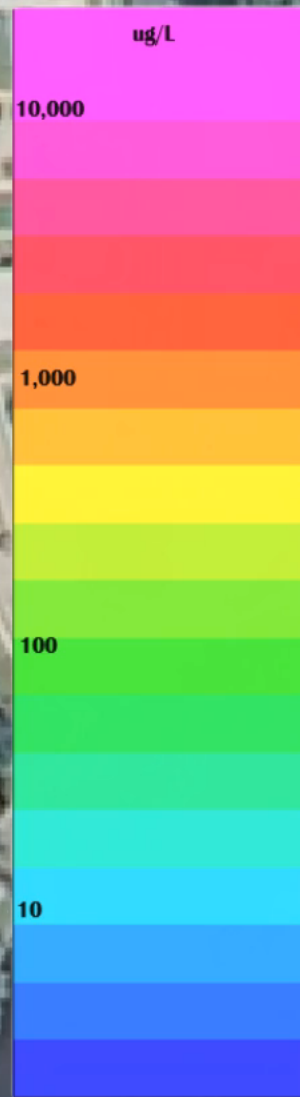
MW-3A

MW-6A

Q2 2019



Deep VC (>17')



MW-1B

PSTW-039B

MW-5B

MW-4B

MW-2B

MW-3B

MW-6B

MW-108D

Q2 2019

MW-102 – Results

