

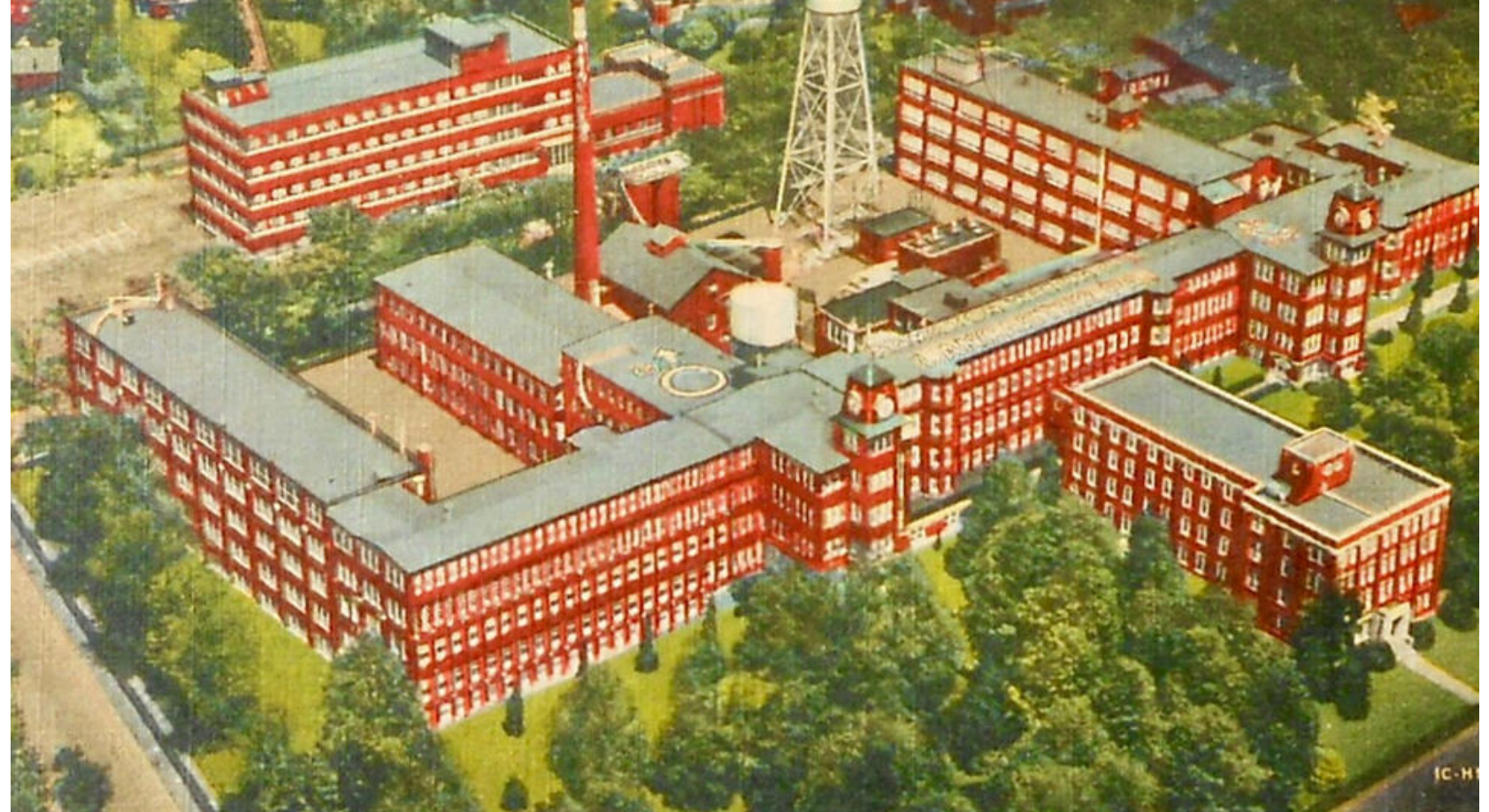
What to Expect When You Are Not Expecting: Challenges, Solutions, and Results of a Limited Bedrock Injection

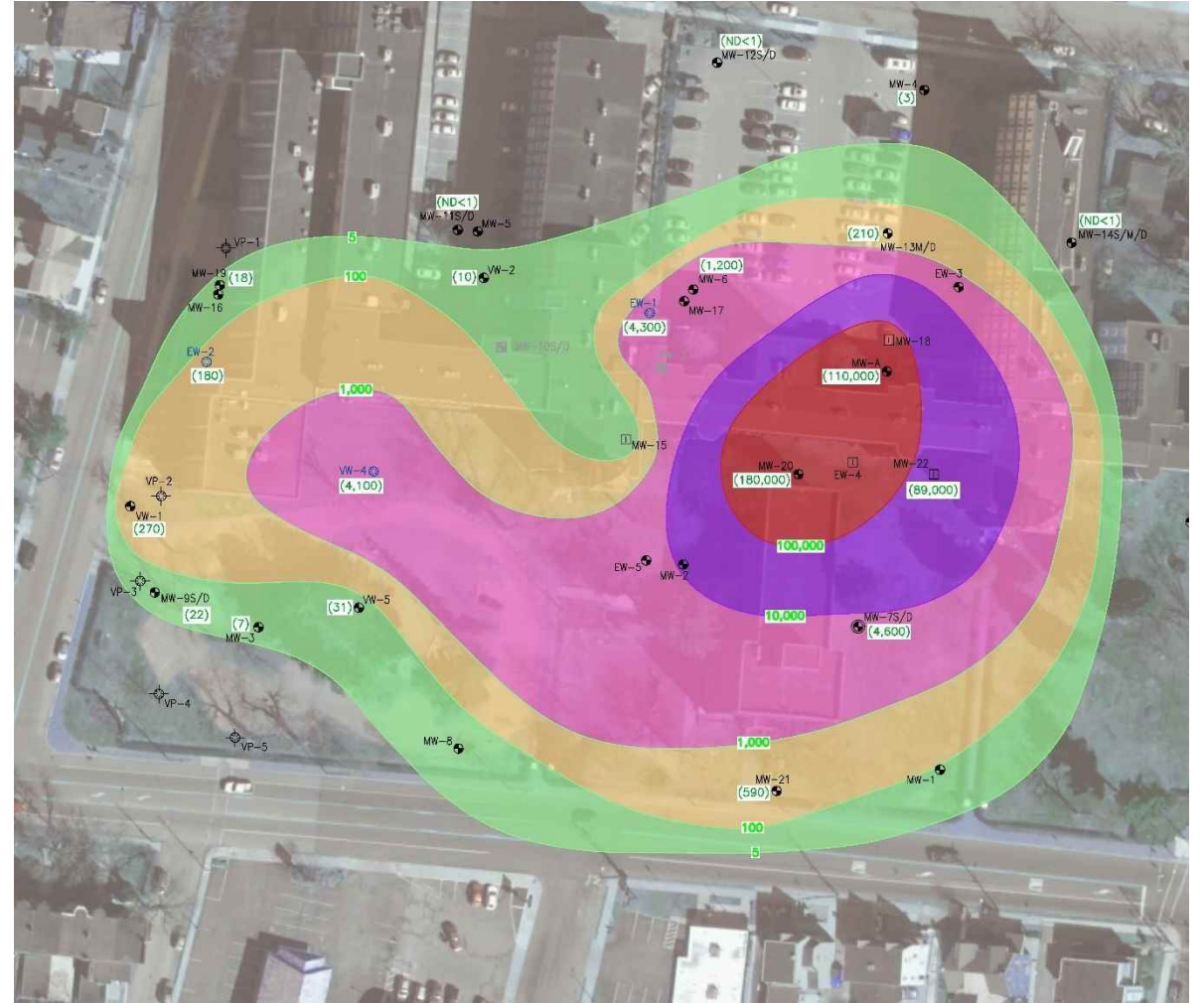
Heather Kilts, PE



Site Background

- Former Pennsylvania manufacturing facility
- Current use: condominiums, offices, and school
- Chlorinated solvent impact from several potential sources
- GW pump and treat system providing hydraulic control on western downgradient portion since 1995



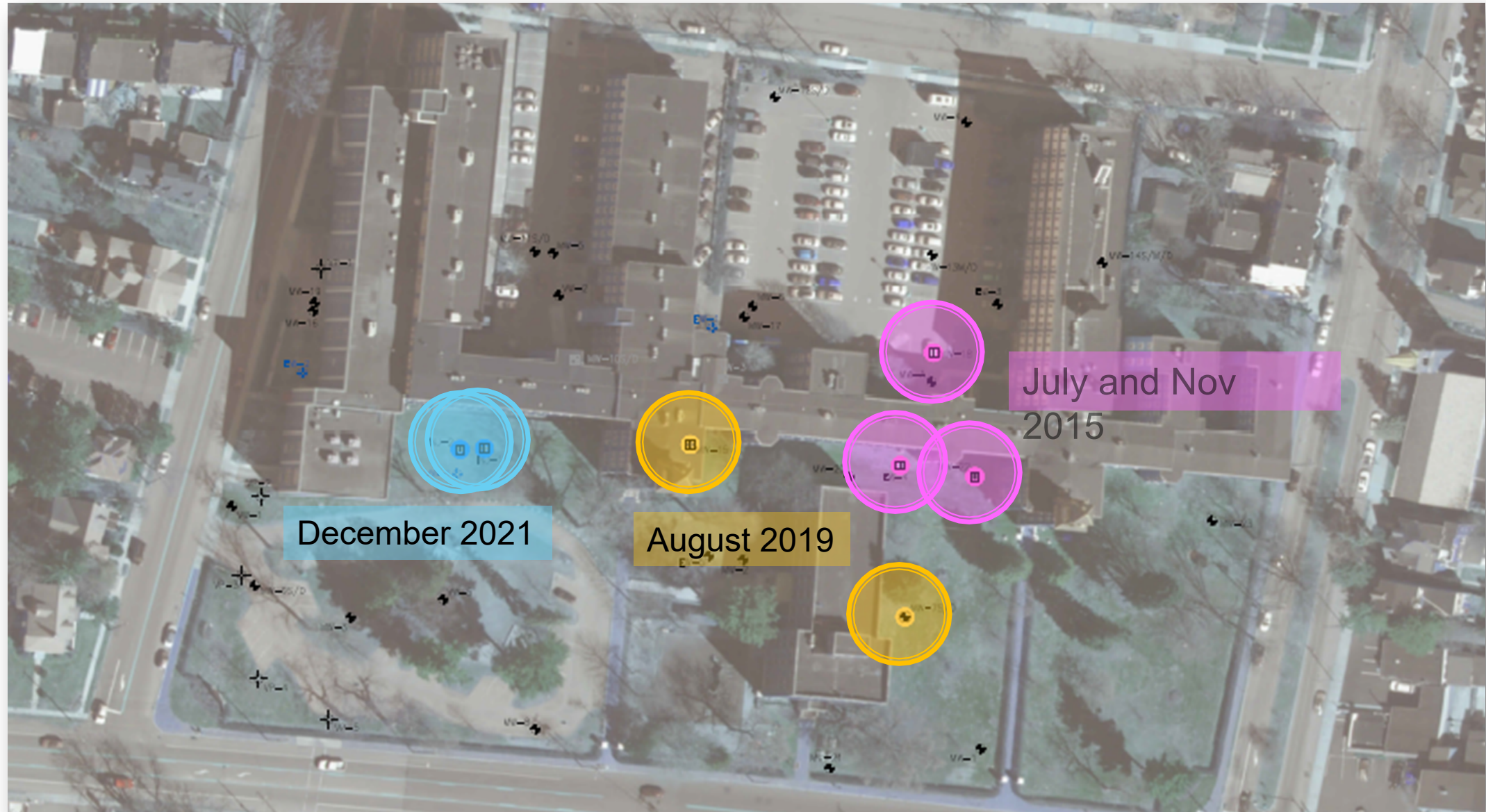


Revised Remedial Approach

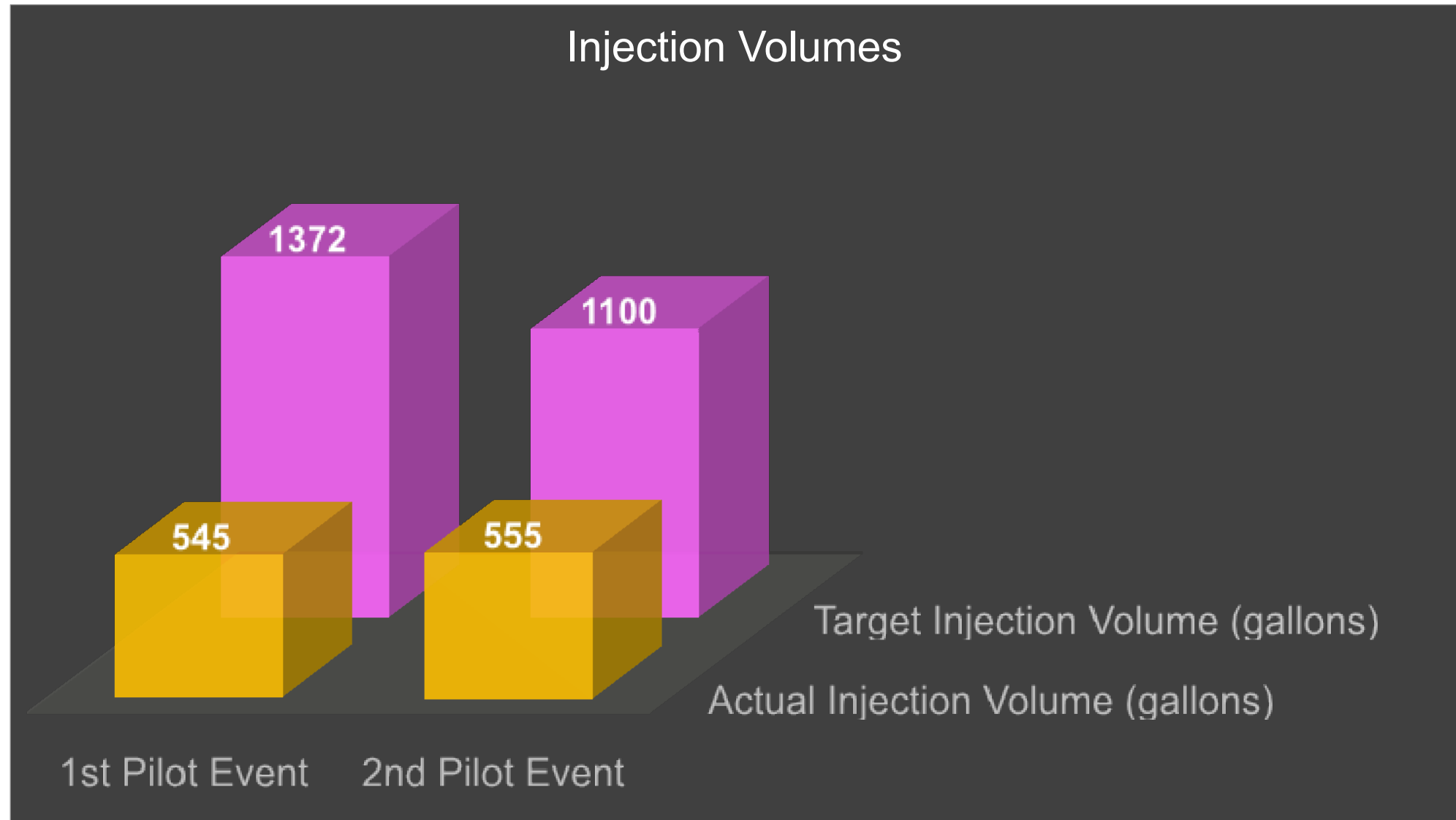
- In 2015, treatment began in central portion of the site using liquid-based reducing reagents:
 - Treatment designed to promote biological, abiotic and biogeochemical pathways to treat CVOCs
- Injected amendment was Evonik's EHC® Liquid Reagent (a mixture of lecithin [organic carbon] and ferrous iron salt) in combination with ferrous sulfate to promote the formation of iron sulfides



Injection Timeline

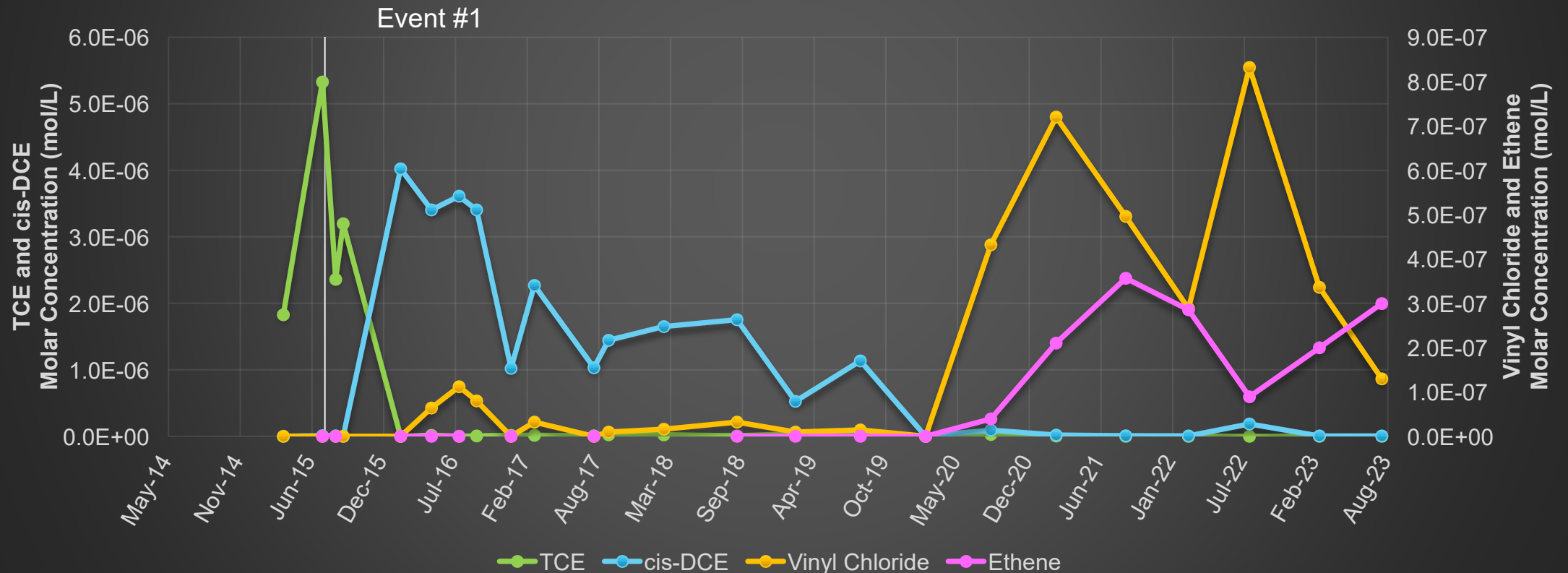


Challenge 1 – Low Injection Volume



Solution 1 – Low Injection Volume

Event #1 - Monitoring Well TCE Reduction - Molar Concentrations Over Time



Challenge 2 – Excess Precipitates

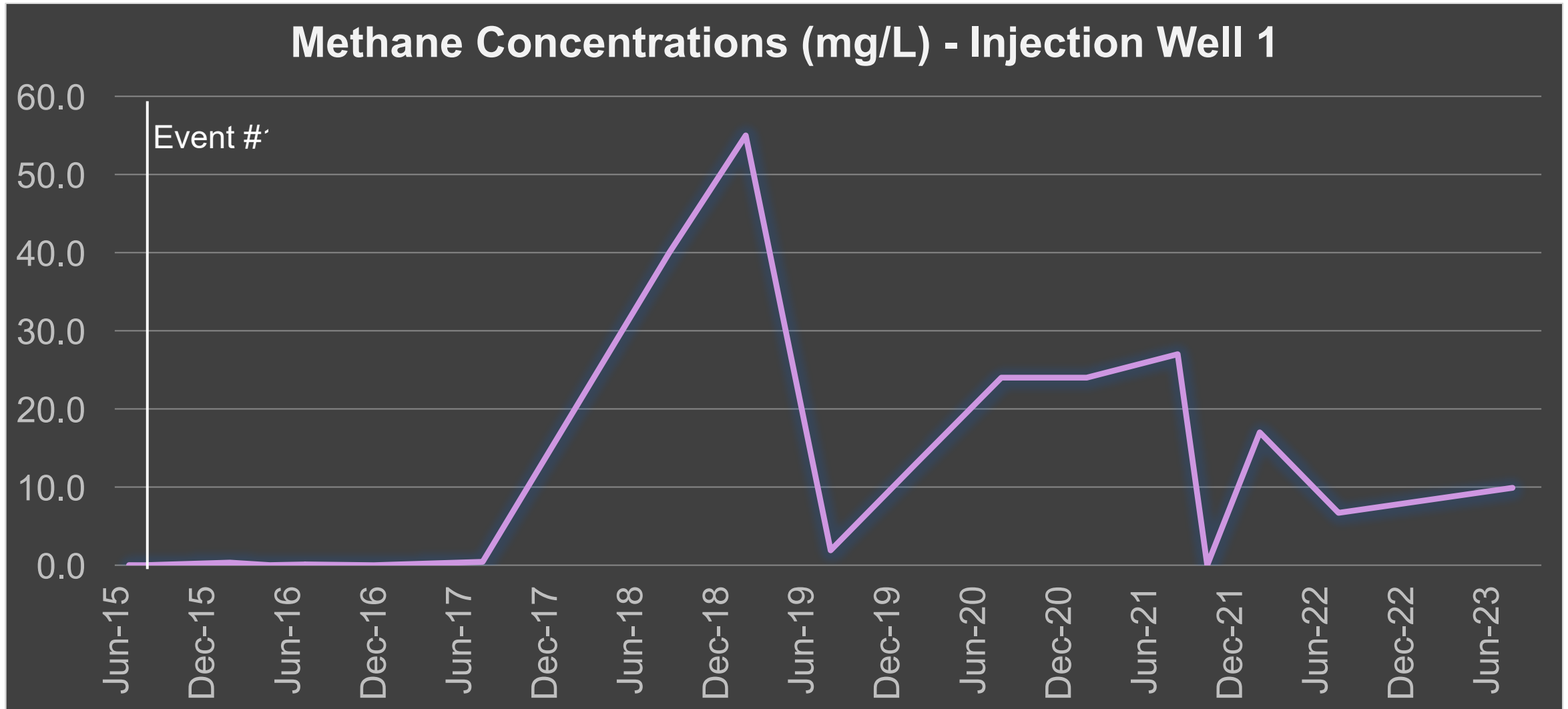


Solution 2 – Excess Precipitates

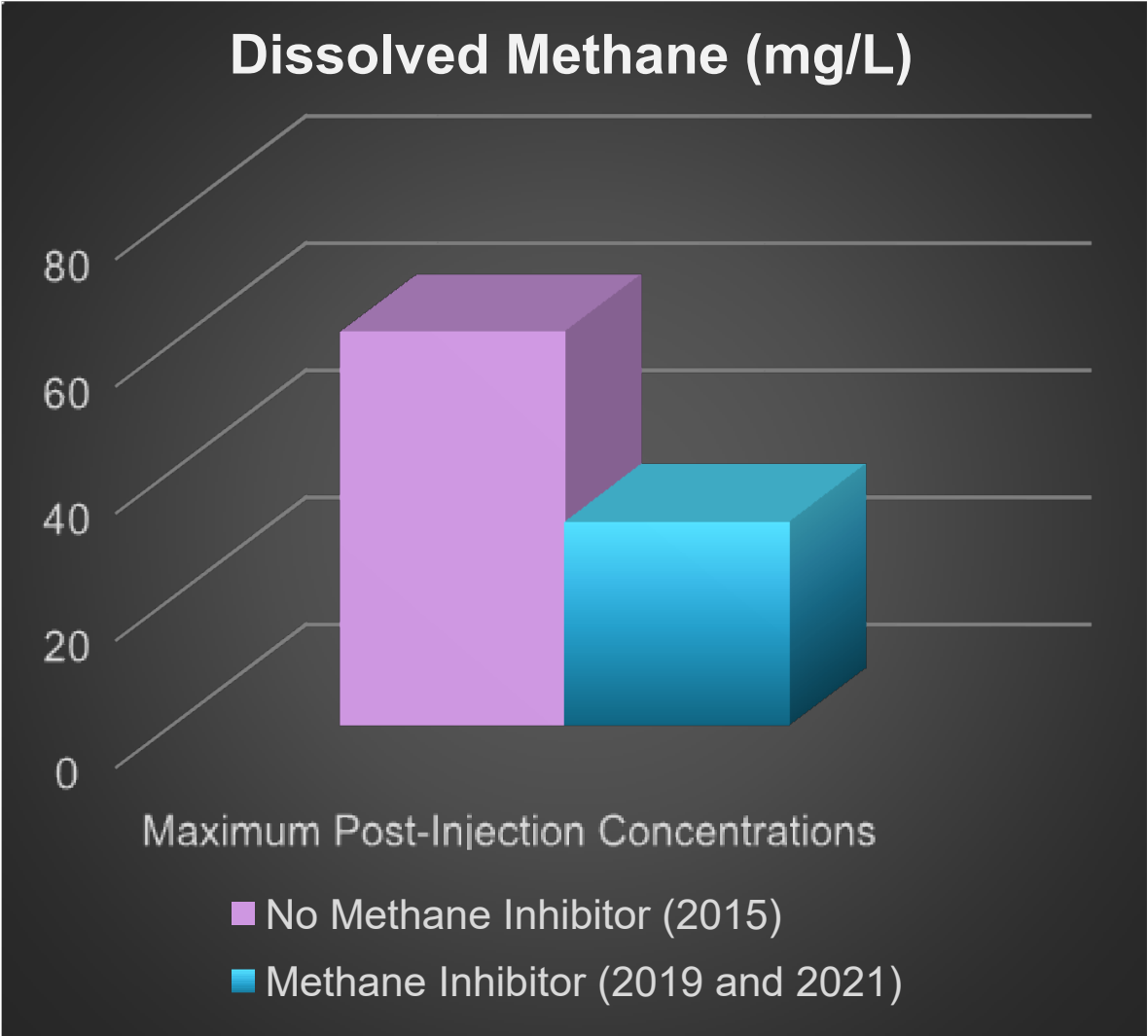
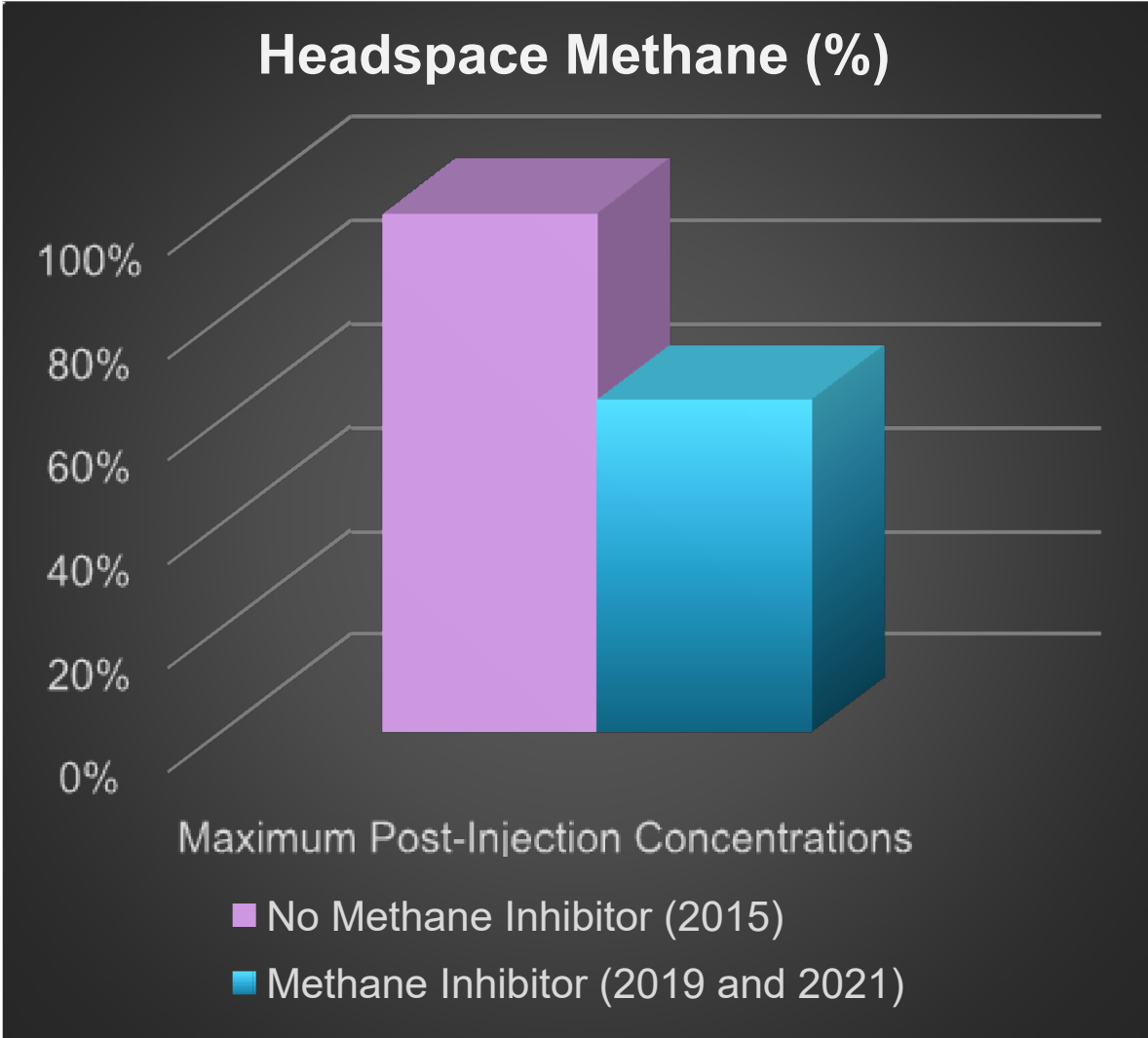
- Subsequent injections: less volume injected, and lower concentration
- Proactive injection well maintenance
 - Over pumping
 - Surging and flushing
 - Every 2 years



Challenge 3 – Methane Production



Solution 3 – Methane Production



Challenge 4 – Limited Well Network



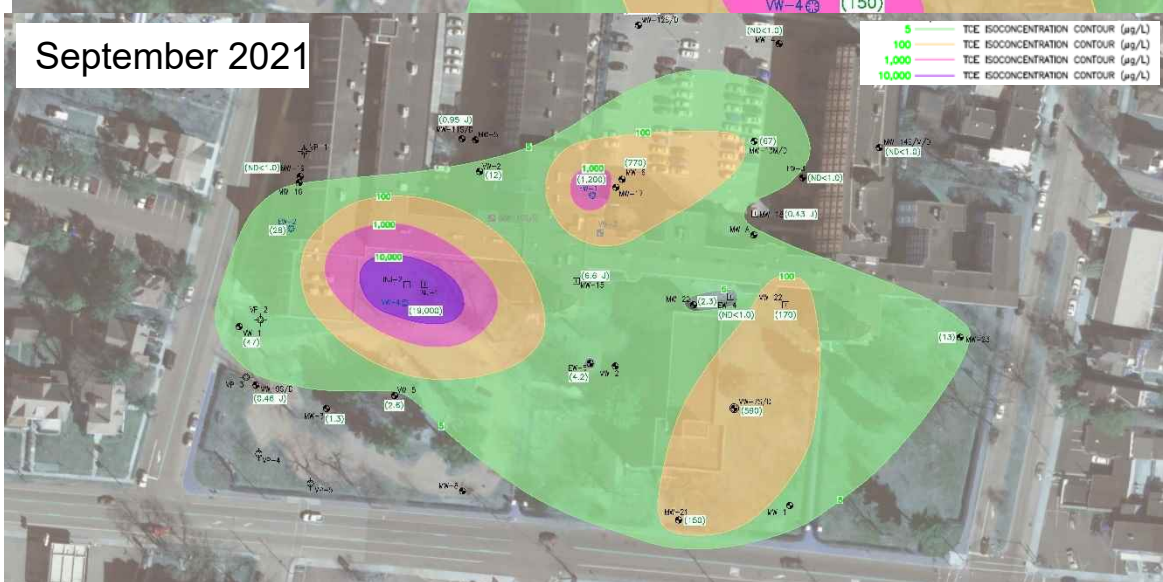
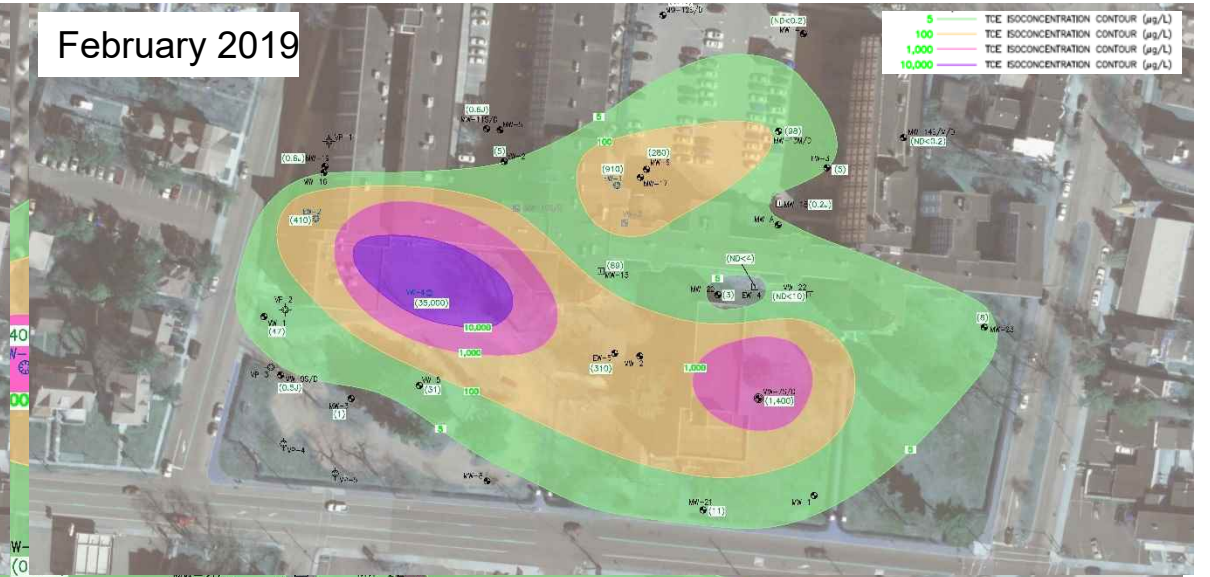
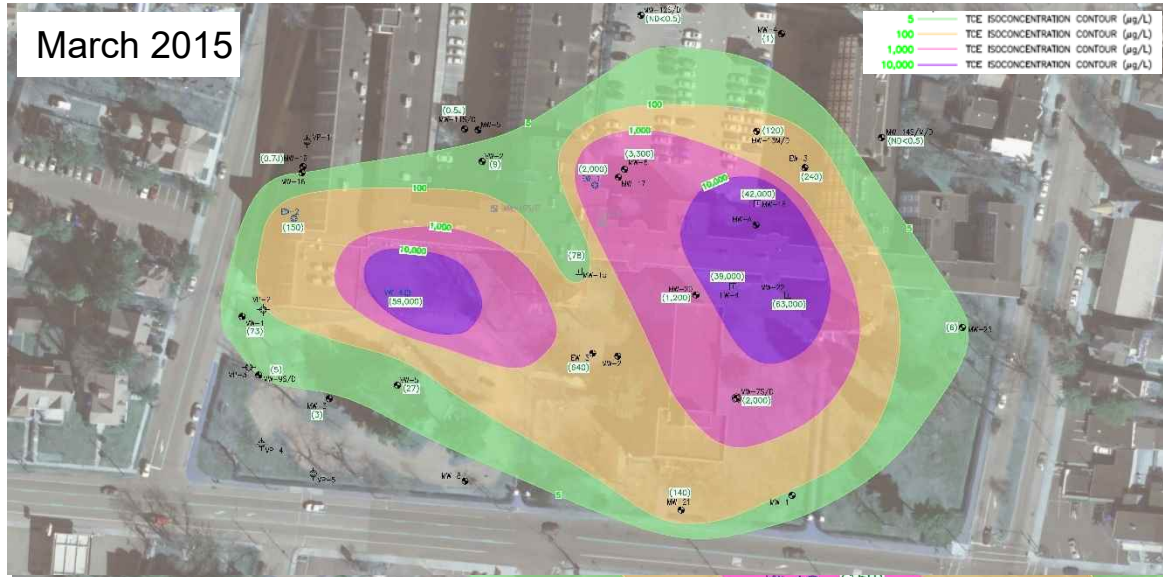
- Initially, access issues prevented drilling additional wells on-site
- For first two injections, used existing monitoring wells

Solution 4 – Limited Well Network

- During pilot injection, used packers to inject target vertical intervals
- 2015 and 2019: Some monitoring wells were screened with a short enough length for direct injection
- 2021: For final injection, received approval to install 2 dedicated injection wells



TCE Concentrations



Injection Results

- Total volume injected: 1,363 gallons (3 events)
- Over 99% reduction in TCE concentrations achieved and maintained in first two injection areas (2015 and 2019), 92% reduction in the third area (2021)
- Multiple lines of evidence to show effectiveness
 - Reductive conditions after injection
 - Total Organic Carbon
 - Select wells developed strong populations of Dehalococcoides (DHC) with no inoculation
 - Reactive iron precipitates

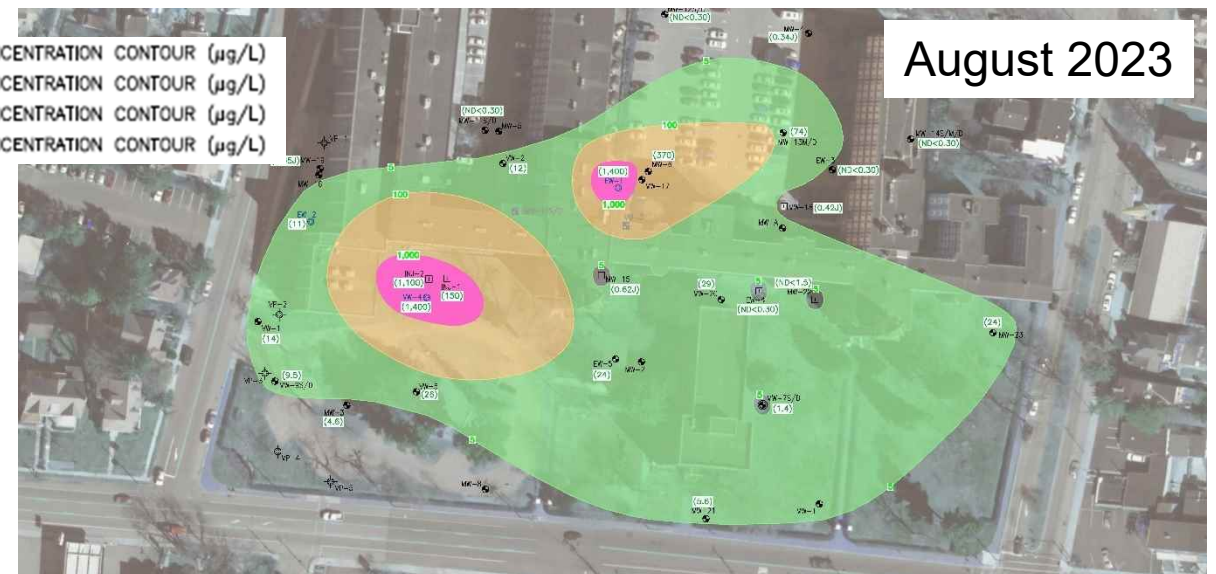
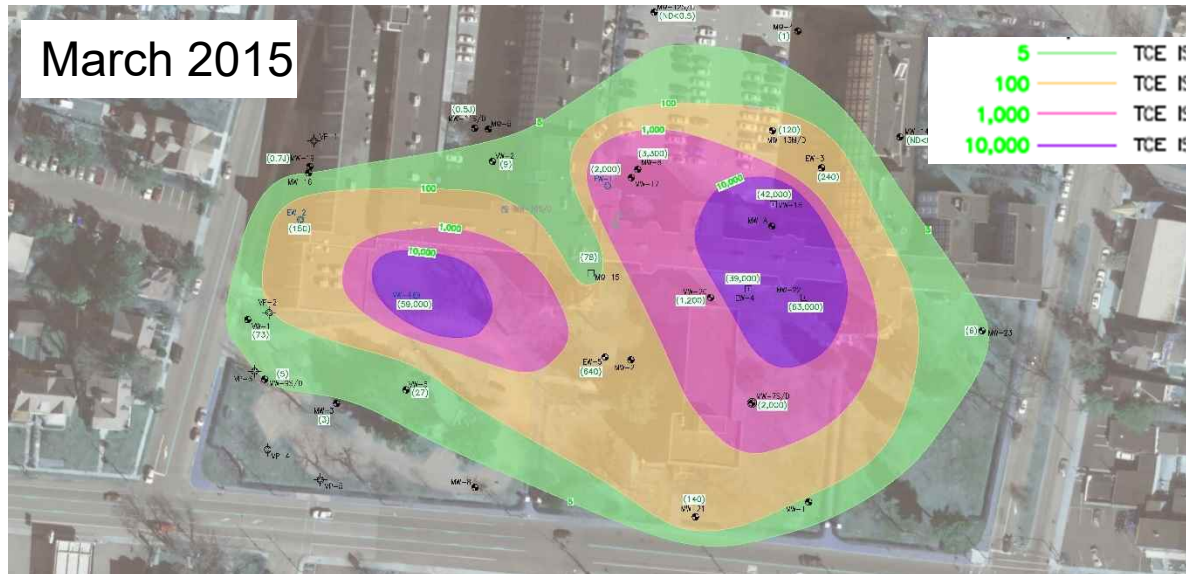
DHC Populations

Injection Well	Pre-Injection (cells/mL)	Post-Injection (cells/mL)
1	ND	524,000
2	ND	9,740,000
3	34.8	2,090,000



Key Takeaways

Challenges	Solutions
Low Injection Volume	Planned Lower Volume
Excess Precipitates	Lower Amendment Concentration; Proactive Well Maintenance
Methane Formation	Methane Inhibitor
Limited Well Network	Adaptive Approach



THANK YOU!

Co-Authors:

Denise Good, PE (GES)

Steph Grillo (GES)

Fayaz Lakhwala (Evonik)

