

Combined SVE and Enhanced Bioremediation to Reduce VOC Mass Flux in Groundwater beneath a Highway and Residential Neighborhood

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BATTELLE

2024 Chlorinated Conference

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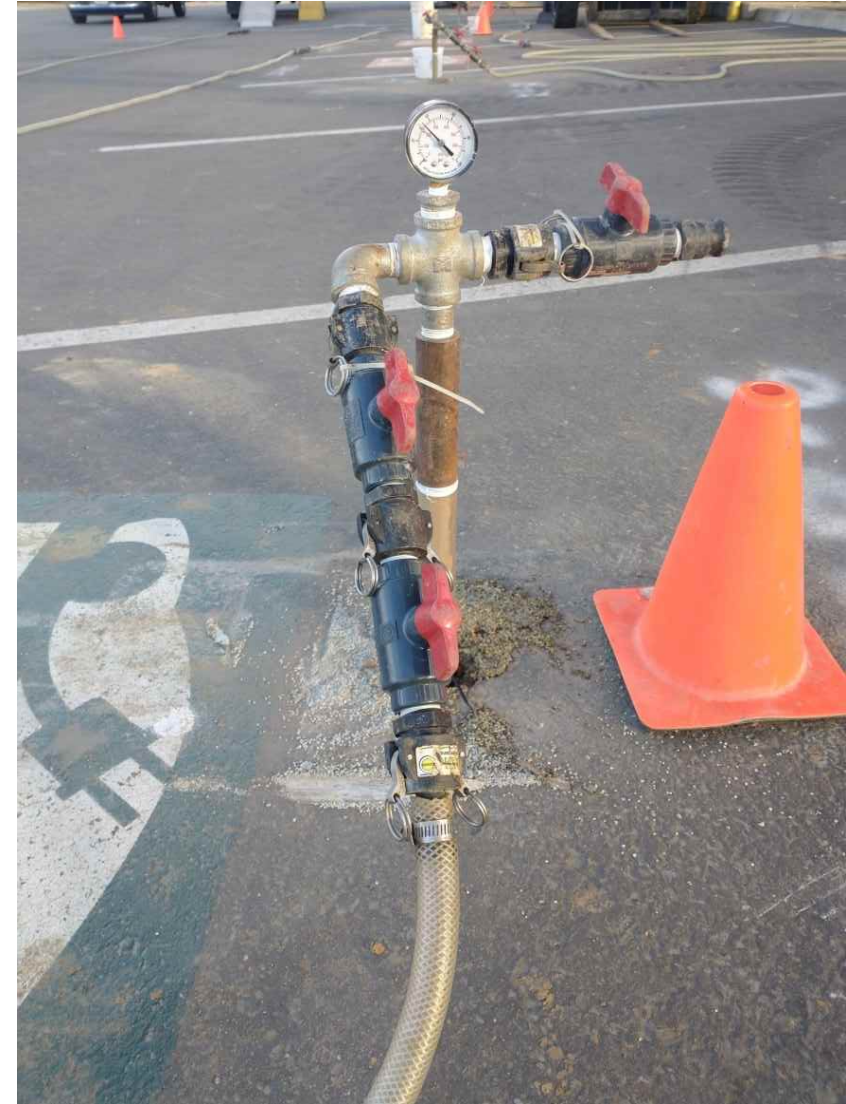
Karnam Ramanand, PhD

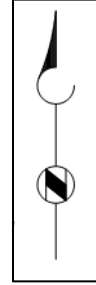
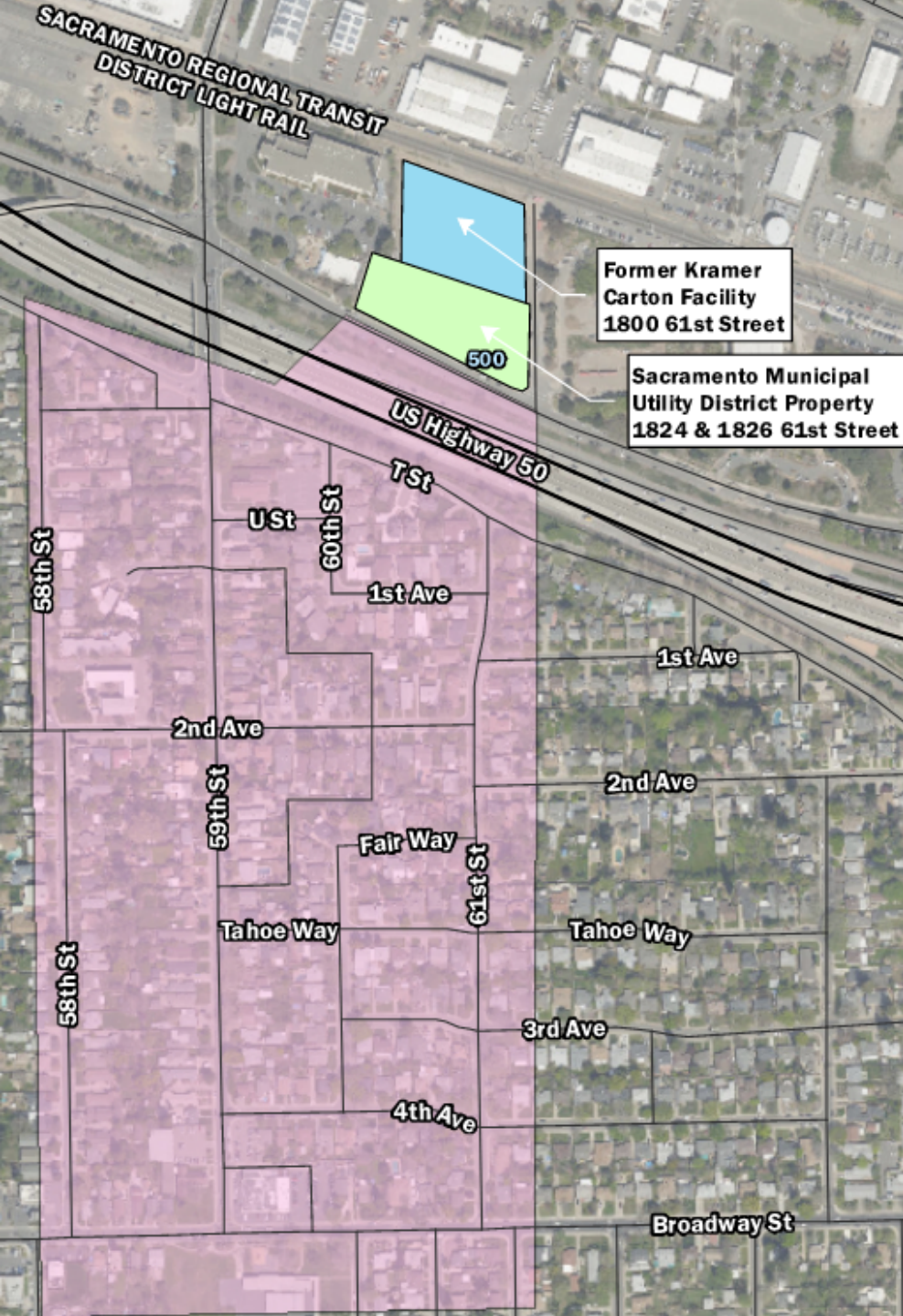
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Agenda

- Site Background
- Site Characterization and Remedial Approach
- Soil Vapor Extraction (SVE) Approach
- Enhanced In-Situ Bioremediation (EISB) Approach
- Results and Conclusions
- Next Steps





LEGEND	
	1800 61st Street (the Site)
	1824 & 1826 61st Street (the Site)
	Offsite Area

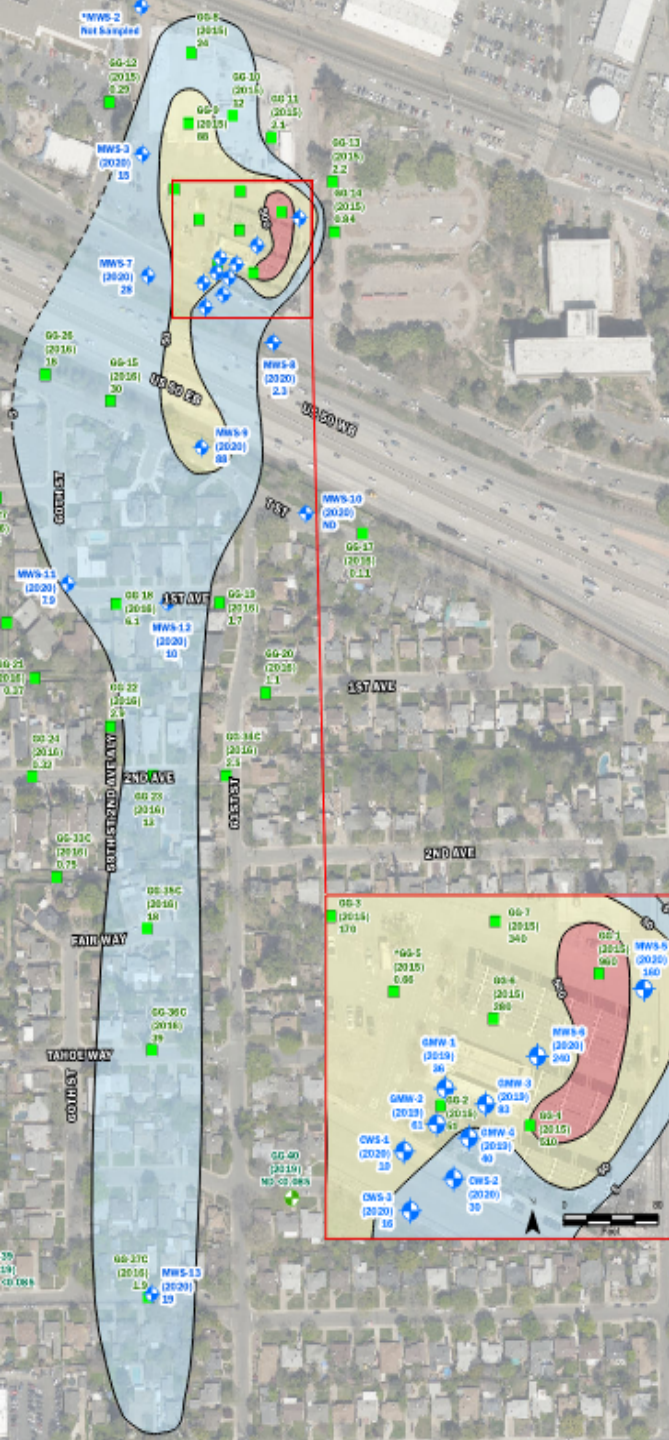


Former steam laundry and paper box manufacturing/printing facilities

Sacramento Municipal Utilities District (SMUD) purchased site in 1981 and 2009; currently EV/PV parking and office facilities

Five petroleum and one chlorinated solvent USTs removed in 1980s and 2009, respectively

Regulated by Central Valley Regional Water Quality



Conceptual Site Model

COCs = PCE and TCE

Onsite vadose zone impacts

Highway 50 inaccessible for
sampling/remediation

No immediate receptors/risk
(residents on potable water)

Remedial Approach

Soil Vapor Extraction (SVE):

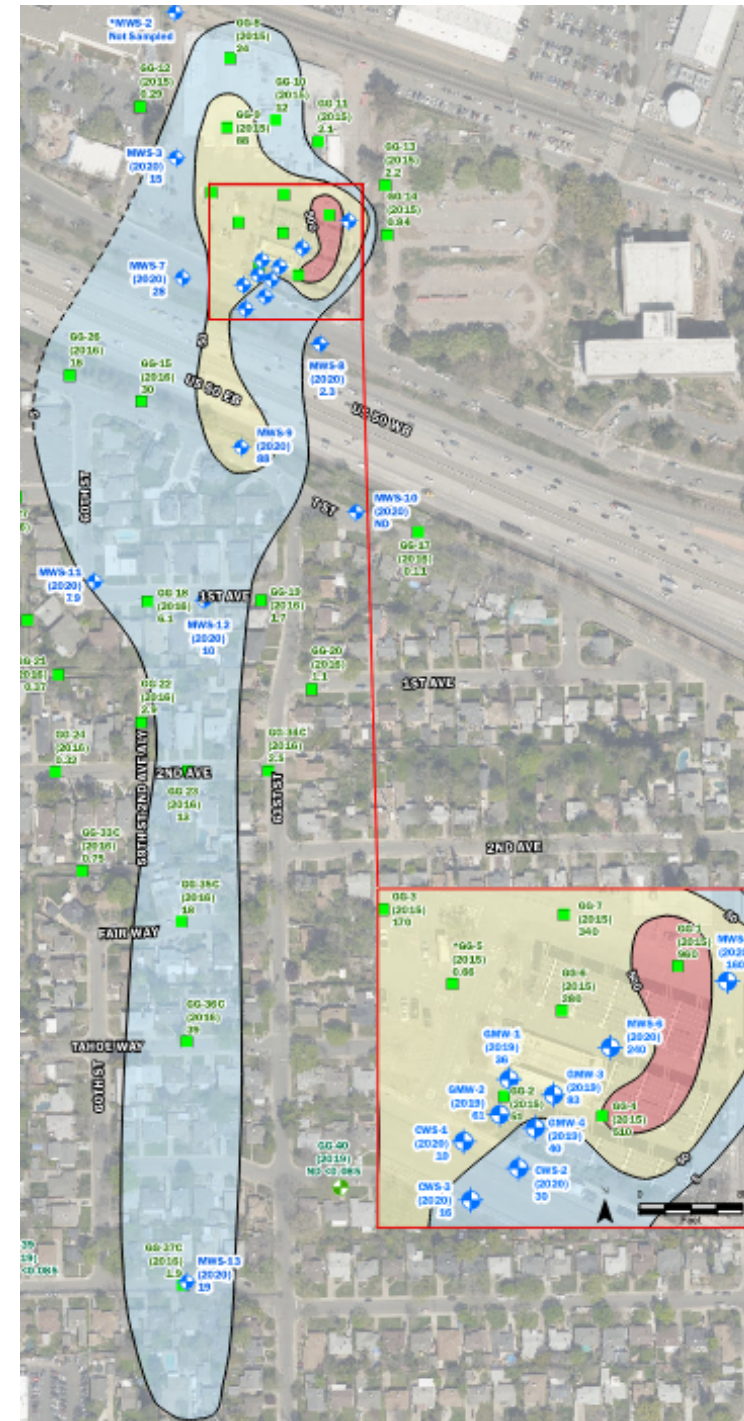
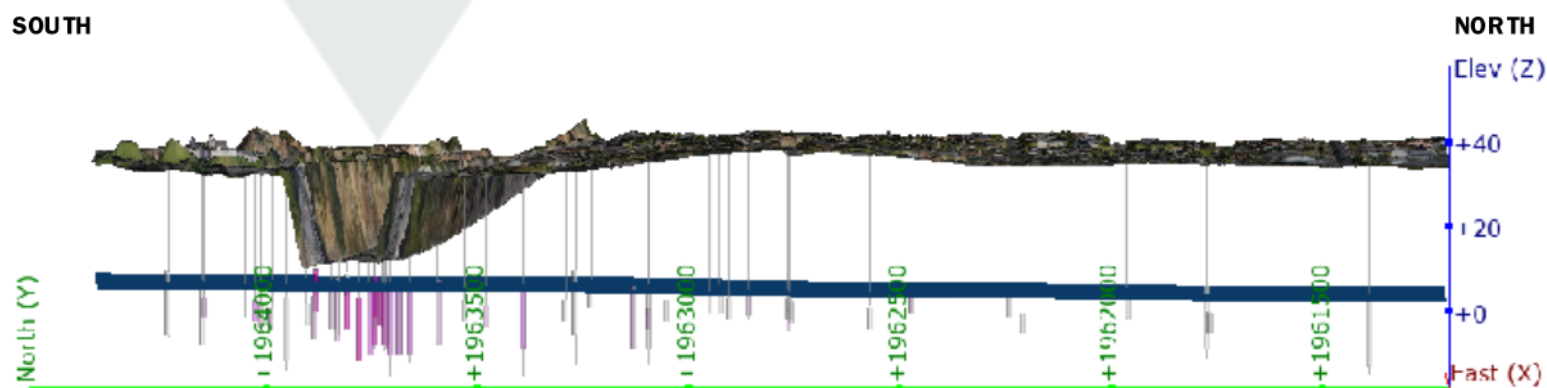
- Onsite Vadose Zone Source
- 0-30 ft bgs

Enhanced In-Situ Bioremediation (EISB):

- On/Offsite GW source
- 30-45 ft bgs

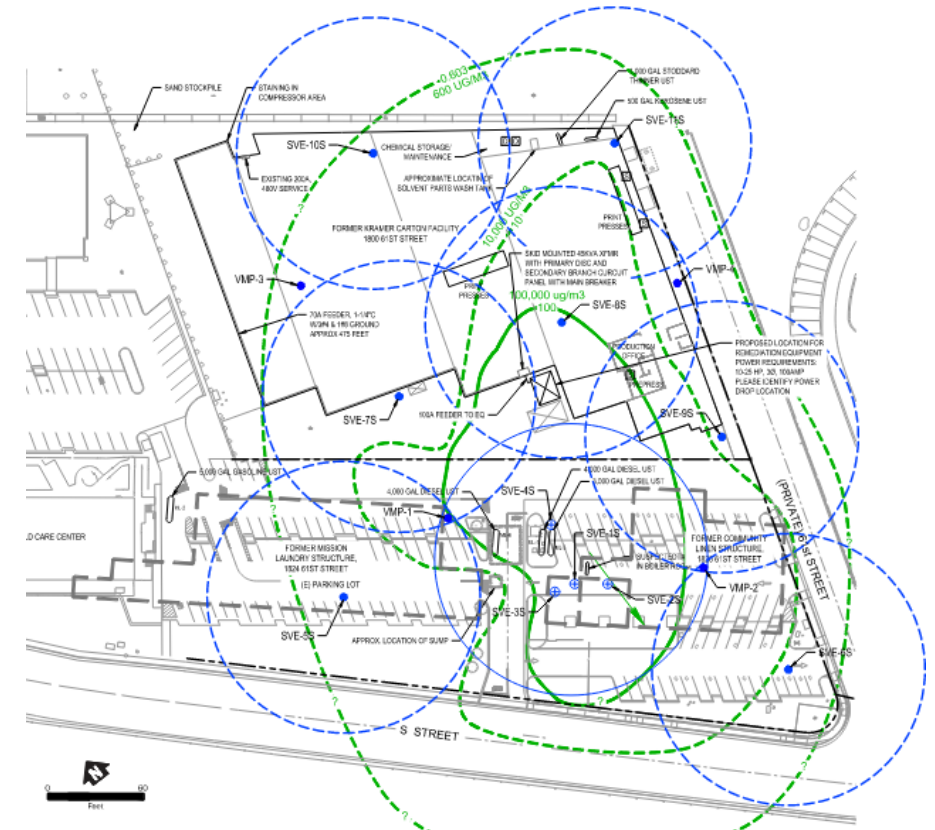
SVE and EISB pilot testing
completed in 2016-2017

The Highway Hurdle



Soil Vapor Extraction System

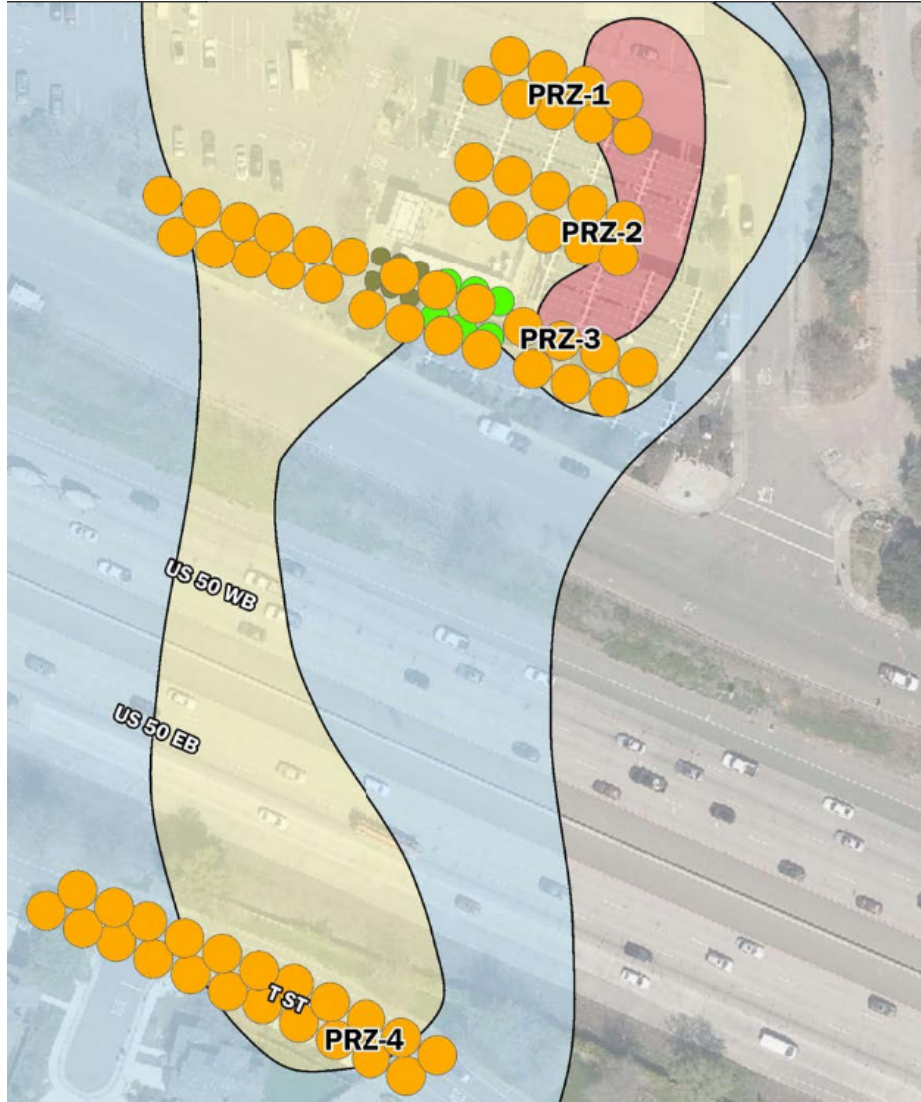
- 9 extraction wells
- 100 ft ROI
- GAC treatment + discharge to atmosphere
- Startup completed in December 2022
- **~132 pounds** of CVOCs removed through April 2024



EISB

ISOTEC

EVONIK
Leading Beyond Chemistry



● 2017 Pilot Test

- 12 DPT points spaced 10-15 ft on center
- Evonik's EHC® ISCR reagent (**slurry**) w/ Sirem's KB-1® *Dhc* culture
- Achieved reducing conditions and good CVOC degradation
- Slurry injection/distribution was difficult

● 2022 Full-Scale Injection

- Evonik's EHC-L® **liquid** amendment w/ KB-1®
- 3 onsite PRZs
- 1 offsite PRZ downgradient of Highway 50
- 64 DPT injection points
- ~20 ft on center
- 72K total gallons injected in 5 ft bottom-up lifts

The Plan - Offsite

- ☒ Daily set-up and take-down
- ☒ Reagents batched onsite and transported to offsite work area
- ☒ Full-time traffic control
- ☒ Limited work hours, no weekends

Sounds easy, right?



The Reality!

- ✖ Prolonged drilling
- ✖ Refusal encountered at most IPs ~ 30 ft bgs
- ✖ Injection interval was 30-45 ft bgs
- ✖ Tight window (permitting)

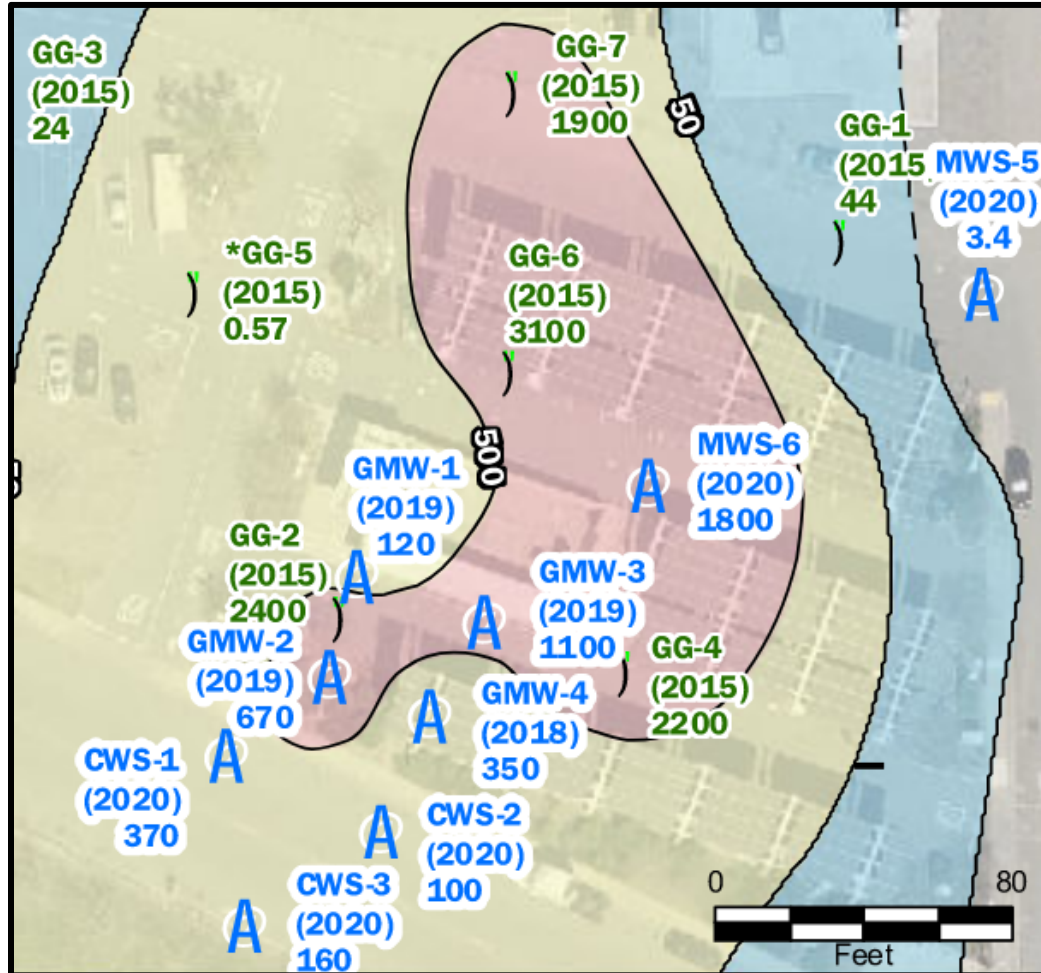
The Solution: Field Engineering!

- ✓ “Pre-drill” IPs using soil sampler
- ✓ Fill borehole w/ bentonite
- ✓ Inject via DPT
- ✓ Remove bentonite, tremie-grout to surface, and patch asphalt

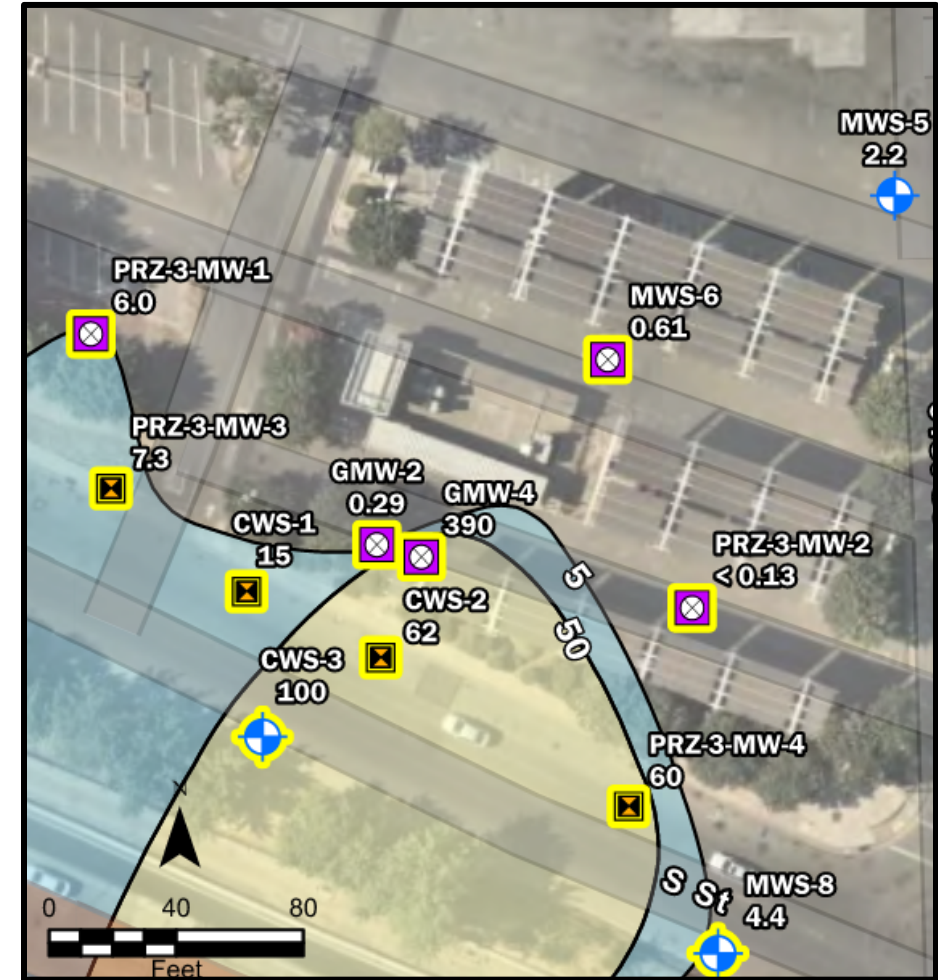
*Delivered on schedule
and under budget!*



Onsite Results -

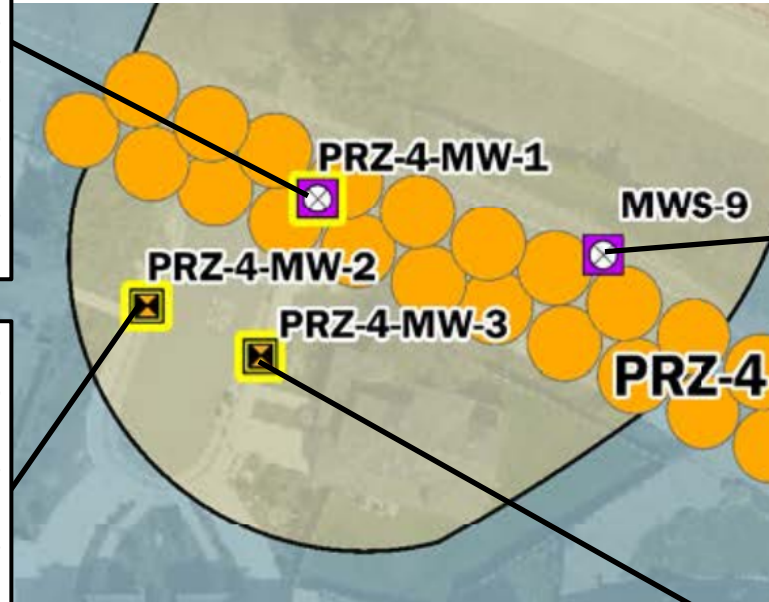
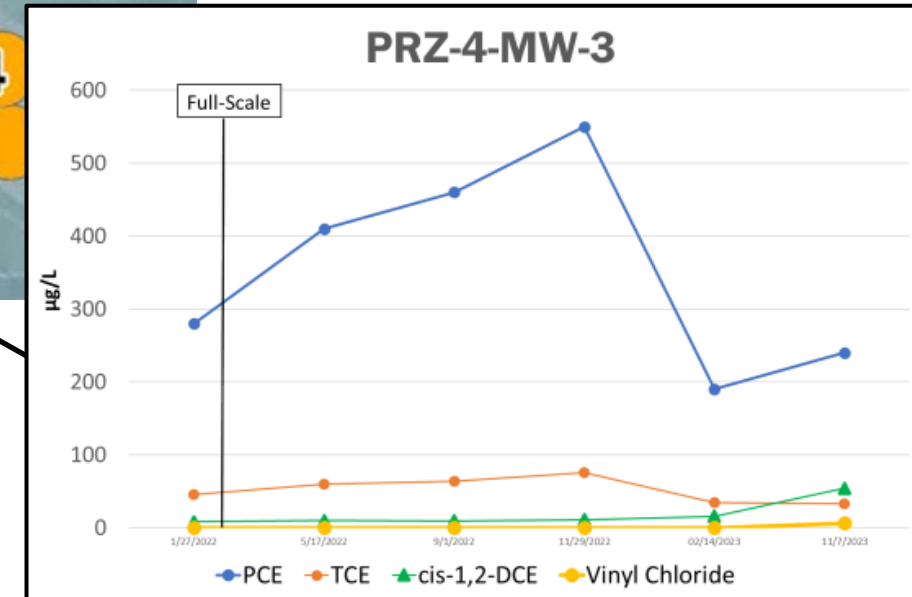
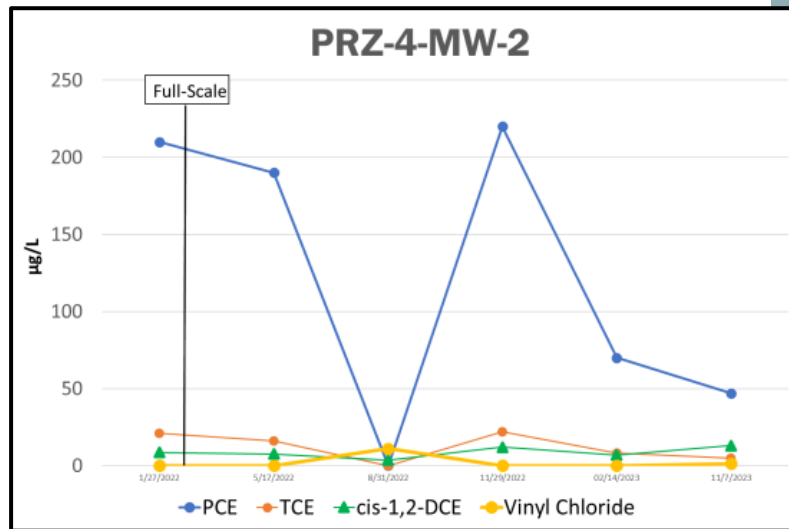
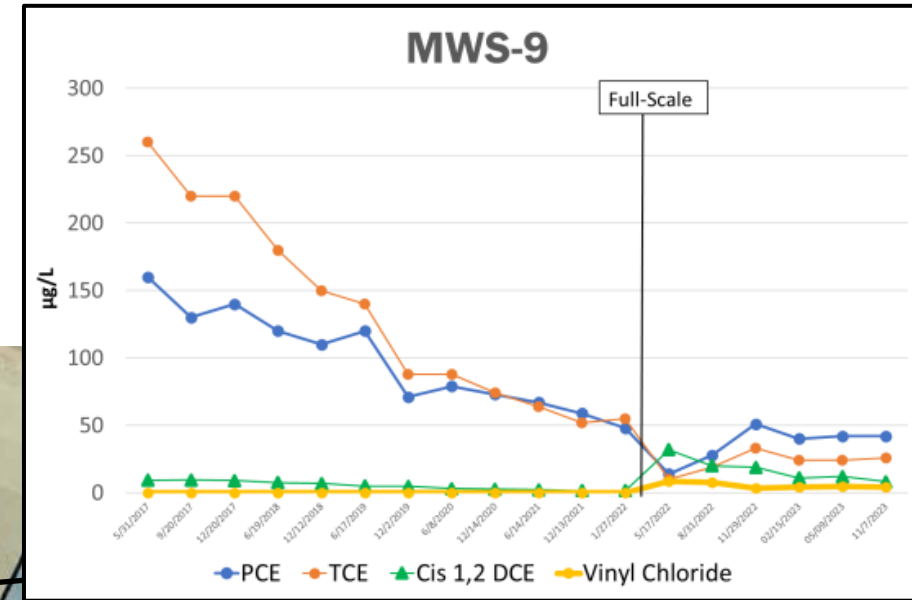
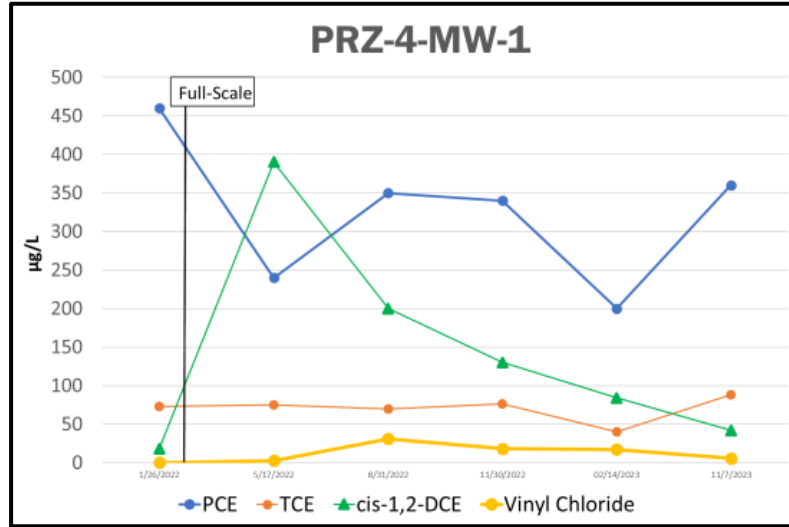


2020



2023

Offsite Results -



Offsite Results -

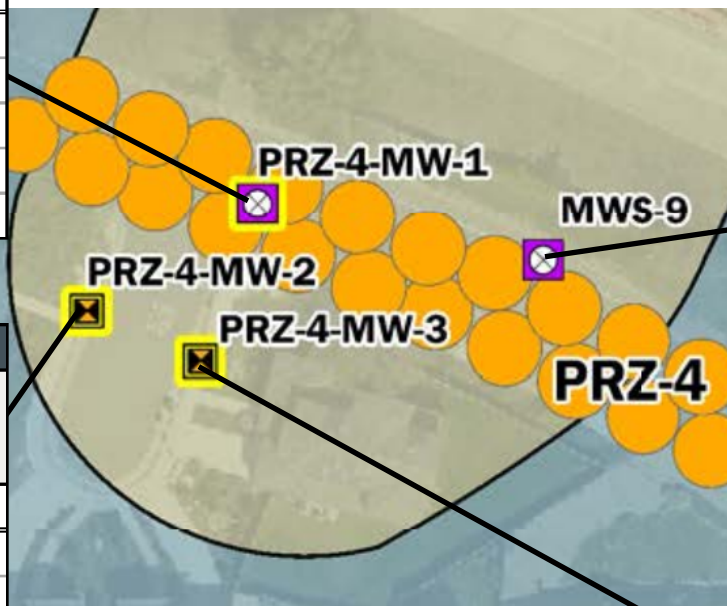


PRZ-4-MW-1					
Sample Date	pH	Specific Conductivity (μS)/cm	Turbidity (NTU)	DO (mg/L)	ORP (mV)
1/26/2022	7.02	491.0	84.6	1.05	110.3
5/17/2022	7.16	665.0	28.1	0.18	-125.6
8/31/2022	6.66	700.0	19.1	1.76	66.7
11/30/2022	6.93	612.0	10.8	1.94	166.9
2/14/2023	6.75	511.8	4.9	0.44	251.2
11/7/2023	7.09	504.0	16.0	0.24	-328.0



MWS-9					
Sample Date	pH	Specific Conductivity (μS)/cm	Turbidity (NTU)	DO (mg/L)	ORP (mV)
1/27/2022	6.72	423.1	5.8	4.50	102.1
5/17/2022	6.81	756.0	5.7	0.19	-47.1
8/31/2022	6.30	928.0	6.9	3.16	89.2
11/29/2022	6.48	618.0	3.3	0.24	204.8
2/15/2023	6.27	752.0	8.5	1.19	282.6
11/7/2023	7.66	504.0	18.0	0.32	-271.0

PRZ-4-MW-2					
Sample Date	pH	Specific Conductivity (μS)/cm	Turbidity (NTU)	DO (mg/L)	ORP (mV)
1/27/2022	6.96	491.4	25.4	2.74	104.3
5/17/2022	6.98	680.0	83.9	1.75	101.7
8/31/2022	6.88	700.0	10.8	4.42	128.5
11/29/2022	7.03	609.0	39.8	3.22	165.3
2/14/2023	7.06	479.1	27.5	0.46	199.6
11/7/2023	6.93	636.0	37.0	0.24	-233.0



PRZ-4-MW-3					
Sample Date	pH	Specific Conductivity (μS)/cm	Turbidity (NTU)	DO (mg/L)	ORP (mV)
1/27/2022	6.98	478.2	7.1	1.59	93.0
5/17/2022	7.16	688.0	60.0	1.15	102.3
9/1/2022	6.58	628.0	12.0	3.76	125.6
11/29/2022	7.11	627.0	17.4	3.98	187.2
2/14/2023	7.09	535.5	6.2	2.34	204.7
11/7/2023	7.89	625.0	25.0	0.19	-251.0

* = ethene detected

Conclusions



- Injection issues correlate with heterogeneous distribution
- Amendment longevity was shorter than anticipated (~1 yr vs 2+)
- Need to increase dose and revise injection approach

Immediate Next Steps

Second Injection - Mobilizing TODAY!

- Limited scope based on remaining budget
- 10 IPs in onsite PRZ-3
- Full-scale injection in offsite PRZ 4 (22 IPs)

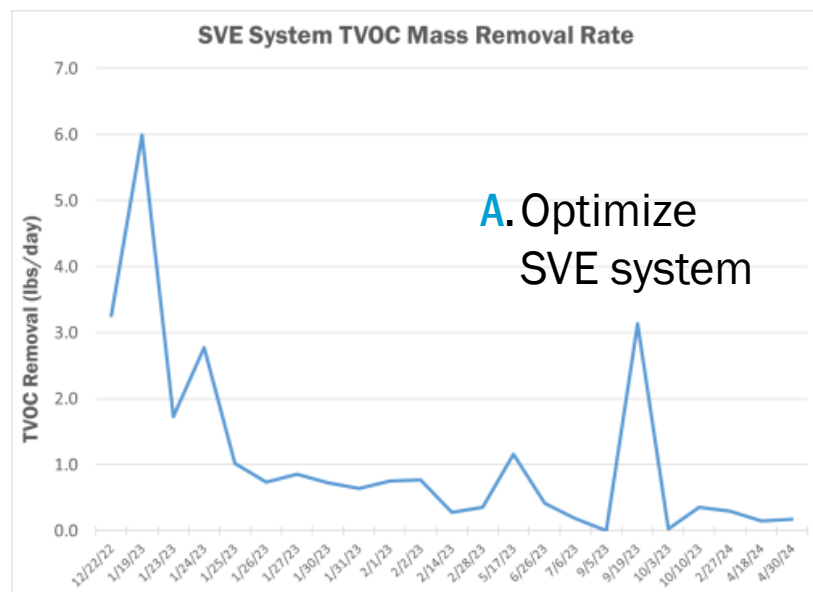


Revised Approach

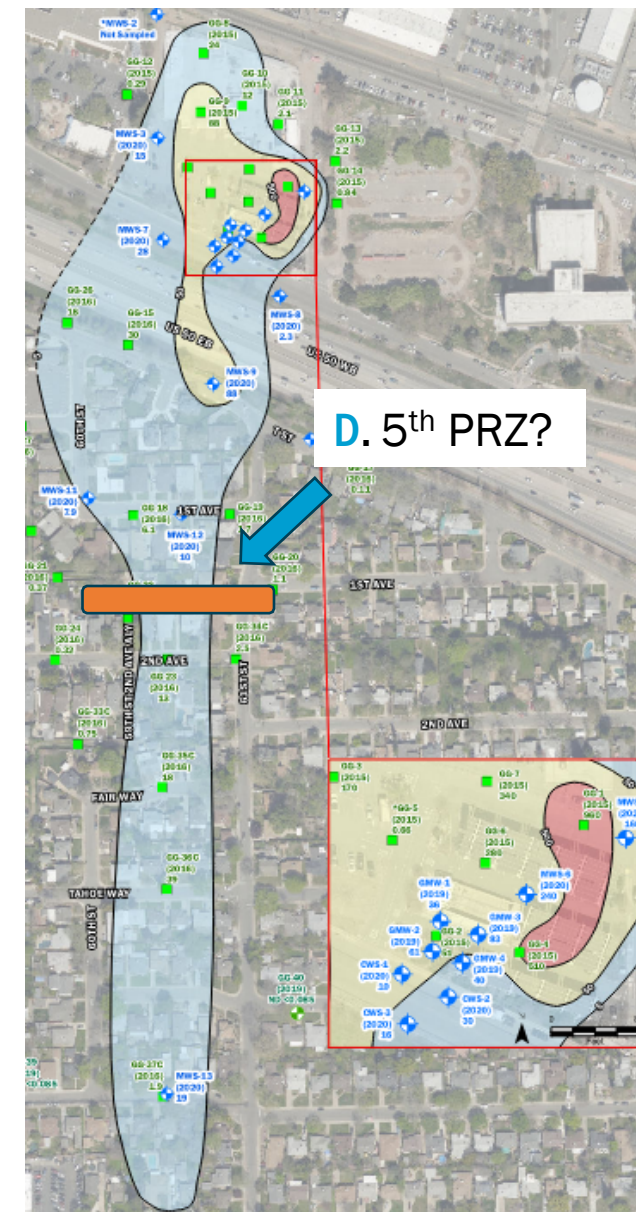
- HPT testing to determine low-perm interval(s)
- Geoprobe 7822 → 8040
- Top-down approach
- Offset/overlap w/ previous IPs
- Increase injection rate, volume, and dosing ~40%
- Adding fine ZVI (35 μm)



Long-Term Actions



- B. Evaluate 2nd injection results
- C. Long-term performance monitoring to consider benefits of 3rd injection at PRZ-3 and PRZ-4



Questions?

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