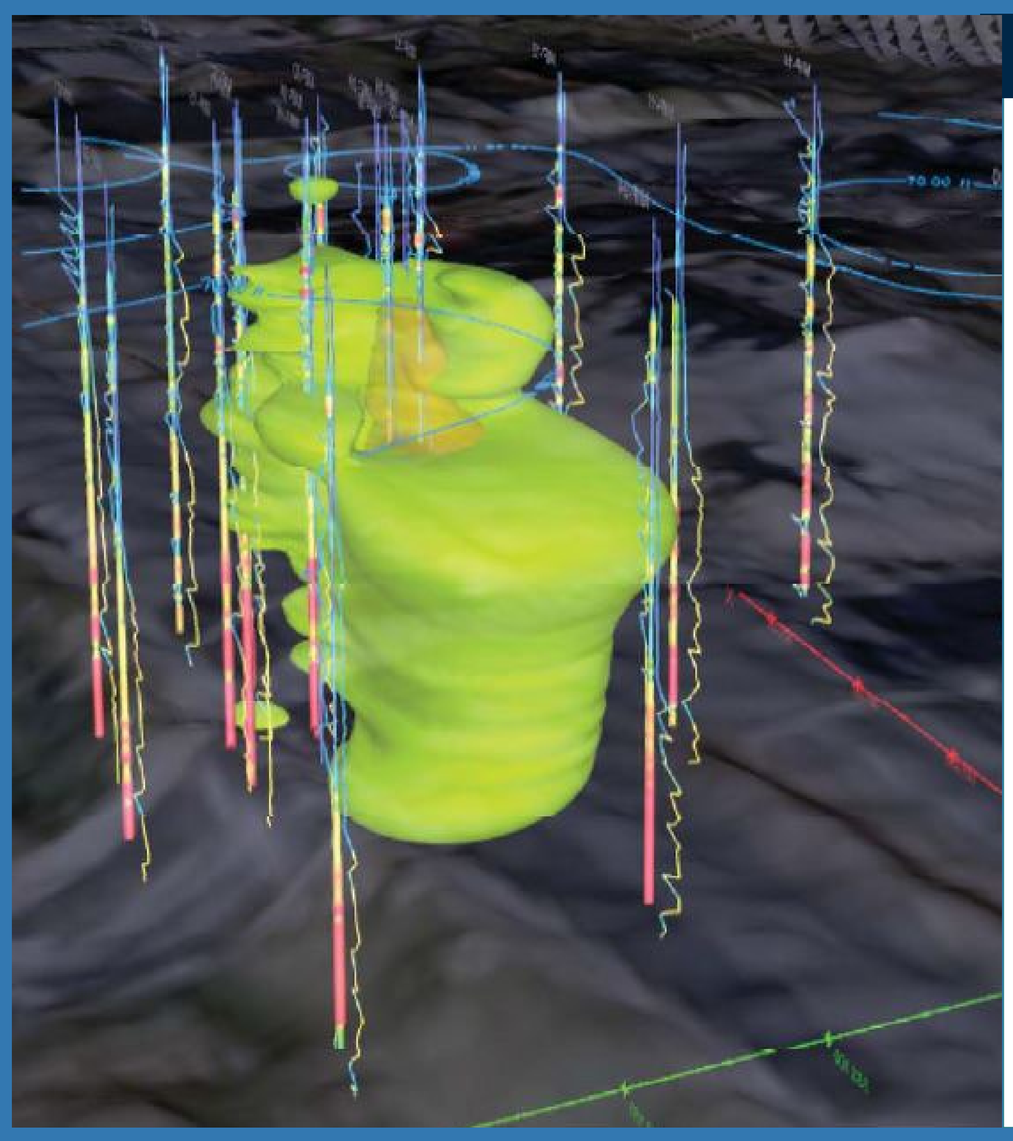
SITE BACKGROUND

SITE HISTORY: A former dry-cleaning was operated on-site from 1965 until 2018. A review of the dry cleaner's records by state regulators indicated the use and storage of hazardous chemicals. In March 1993, sampling results identified the presence of tetrachloroethylene (PCE) and related compounds in the soil and groundwater at concentrations indicative of dense non-aqueous phase liquid (DNAPL) being present. The former owners initially entered a Voluntary Cleanup Program in 1994; however, shortly thereafter, it became a state-led site because of the inability of the former owners to fund any potential remediation efforts. Building removal was completed in September 2018 with the property covered with a concrete slab, asphalt-paved former parking area, and limited vegetated areas. The site is in a densely populated residential and commercial neighborhood.

SITE CONDITIONS: The site consists of ~0.11 acres and is located in a busy residential/commercial area at the intersection of a primary street and a secondary street. It is currently unoccupied and consists of a concrete pad associated with former building, asphalt paved areas, and limited vegetated areas. A security fence surrounds the site to prevent trespassers. Off-site nearby properties include commercial and residential properties, as well as second-floor apartments at two of the adjacent commercial properties. Numerous active and inactive utilities are located at and adjacent to the site. Future use of the site is likely to be commercial, residential will not be permitted.



CONCEPTUAL SITE MODEL

- COCs at the site include PCE and daughter products (trichloroethene [TCE], dichloroethene [DCE], and vinyl chloride [VC]) present in soil and groundwater (indicative of DNAPL).
- Total volatile organic compounds in source area: up to 100 parts per million in groundwater.
- Site lithology: dense silt and clay with some sand/gravel (overburden), underlain by saprolite (weathered bedrock) at ~25 ft bgs. Bedrock at ~45 ft bgs.
- Groundwater ranges from ~5 to 7 ft bgs.
- Potential risks include inhalation and direct contact for hypothetical commercial workers/construction workers, and inhalation for nearby residents and commercial tenants.
- Remedial goal is to reduce contaminant mass to allow future commercial use and prevent off-site migration of contaminated groundwater that could be a source of off-site indoor air risk.
- In situ thermal remediation and in situ chemical reduction (ISCR) are being considered at the site.
- Site is being remediated by the state environmental agency.

PILOT STUDY OBJECTIVES

- Evaluate the ability to deliver ISCR reagents into the low permeability saprolite/weathered bedrock portion of the site subsurface through conventional direct-push injection technology.
- Assess the ability to establish a permeable reactive barrier (PRB) on the downgradient edge of the property to treat groundwater prior to leaving site, mitigating potential off-site vapor intrusion risks.
- Evaluate performance of combination of emulsified zero valent iron (EZVI-CH4™) and Provect-IR® to treat source area and dissolved-phase downgradient COC concentrations.

Combined In Situ Remediation to Address DNAPL in Shallow Overburden and Weathered Bedrock

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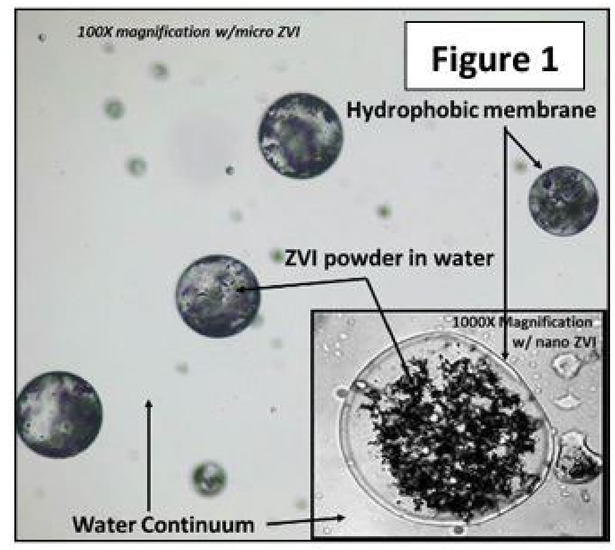
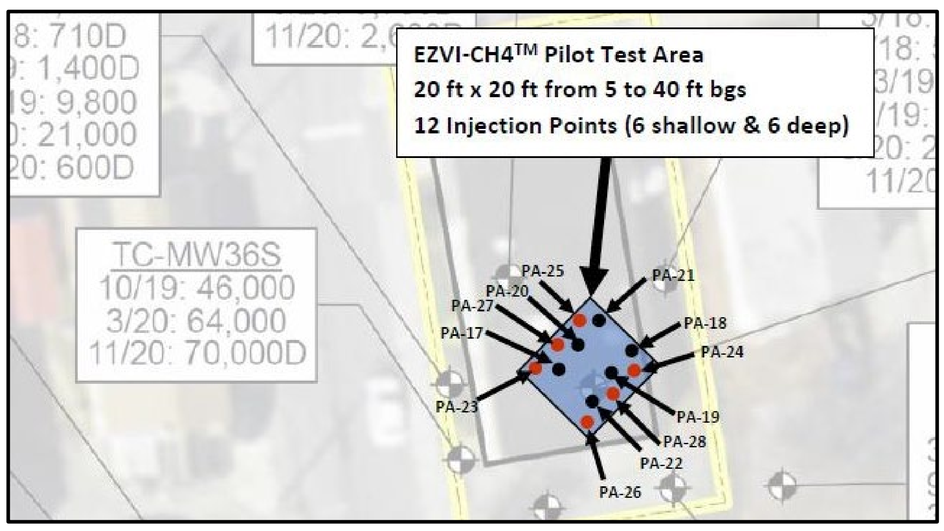
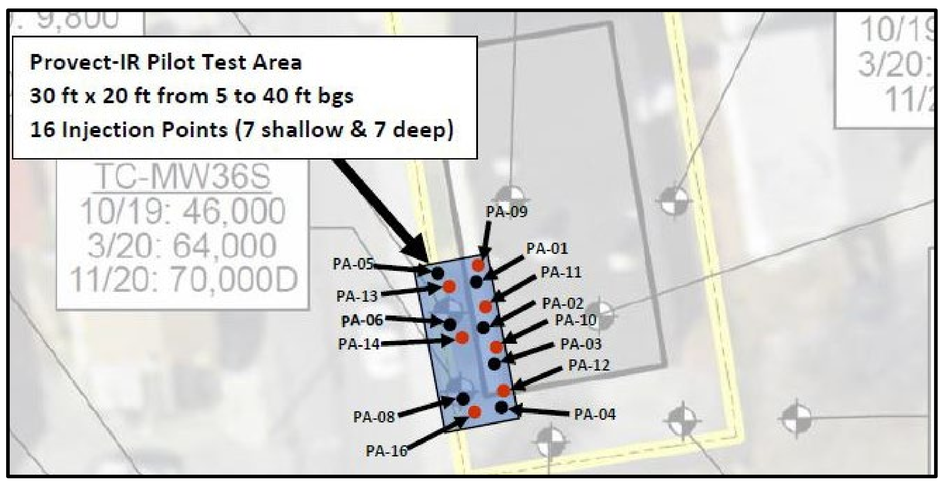
FIELD PILOT TEST APPROACH

REAGENT SELECTION: The pilot test included injection of two reagents at the site to treat the source area and dissolved-phase contaminants at the downgradient property boundary through establishment of a PRB. EZVI-CH4™ and Provect-IR® were selected for addressing contamination within the source area and downgradient of the source area, respectively, for this pilot study. Both products were provided by Provectus Environmental Products (Provectus). The EZVI amendment is an aggressive micro-scale remedial technology that will be used to address elevated PCE and TCE concentrations in soil and groundwater along with potential DNAPL within the source area. The Provect-IR® amendment is a solid, long-term remedial option that is a combination of biotic and abiotic technologies primarily designed to reduce the dissolved-phase PCE, TCE, DCE, and VC concentrations within the property boundary and prevent further off-site contaminant migration. Provect-IR® is a unique mixture of reagents combined into a single product that optimizes the in situ reductive dechlorination of chemicals present in soil and groundwater. It promotes synergistic interactions between natural anti-methanogenic compounds; hydrophilic, nutrient-rich organic carbon sources; ZVI; chemical oxygen scavengers; and vitamin and mineral sources. For this project, we utilized a 60% ZVI and 40% organic content Provect-IR® formulation.



EZVI-CH4™





PILOT INJECTION DESIGN: The source area pilot injections were focused on an area of high-concentration chlorinated solvent mass beneath the former location of the dry-cleaning equipment. The PRB injection area was focused on dissolved chlorinated solvent concentrations downgradient of the source area along the property boundary proximate to off-site residences. These locations were selected as they represent critical areas for evaluating likely success of full-scale implementation. In both areas, injection locations were spaced equally (~10-ft radius of influence) and injections targeted shallow (5-20 ft bgs) and deeper (20-40 ft bgs) zones. Locations were adjusted slightly in the field to account for utility locations and surface features. Injections were performed in multiple 2-ft intervals within each location to provide vertical coverage throughout the target zone.

Pilot Summary

Target	Injectant	# of Points	Pilot Area	Depth Intervals	Total Reagent Quantity
Source	EZVI-CH4™	12	400 SF	5-20 ft bgs (6 points) 20-40 ft bgs (6 points)	1,470 gallons
Downgradient PRB	Provect-IR®	14	600 SF	5-20 ft bgs (7 points) 20-40 ft bgs (7 points)	5,803 pounds

INJECTION ACTIVITIES: Pilot injections were performed utilizing direct-push technology by Innovative Environmental Technologies, Inc. (IET). EZVI-CH4™ was delivered in liquid form within sealed totes and injected directly as delivered. Provect-IR® was delivered dry in 50-pound sealed bags, mixed with water to form a slurry, and injected. Mixing was performed within a mobile injection trailer operated by IET. Injections were performed at a flow rate of ~10 gpm at a maximum pressure of ~65 pounds per square inch. Visual observations were conducted during injection activities to identify any areas of daylighting, as well as to document injectant volumes per point. Following injection activities, the locations were properly abandoned. Post-pilot groundwater sampling was performed approximately 30 days following the injections.


Pilot Injection Activities

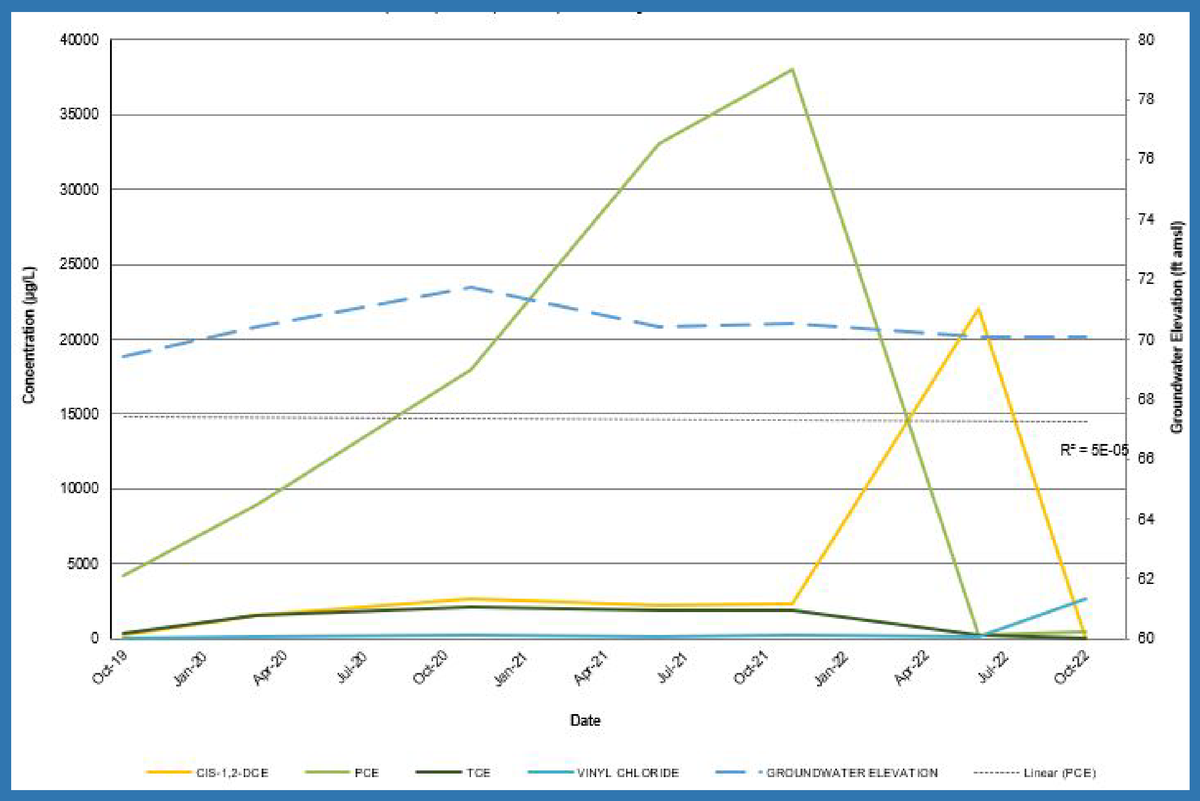

Direct-Push Rig

Group 2

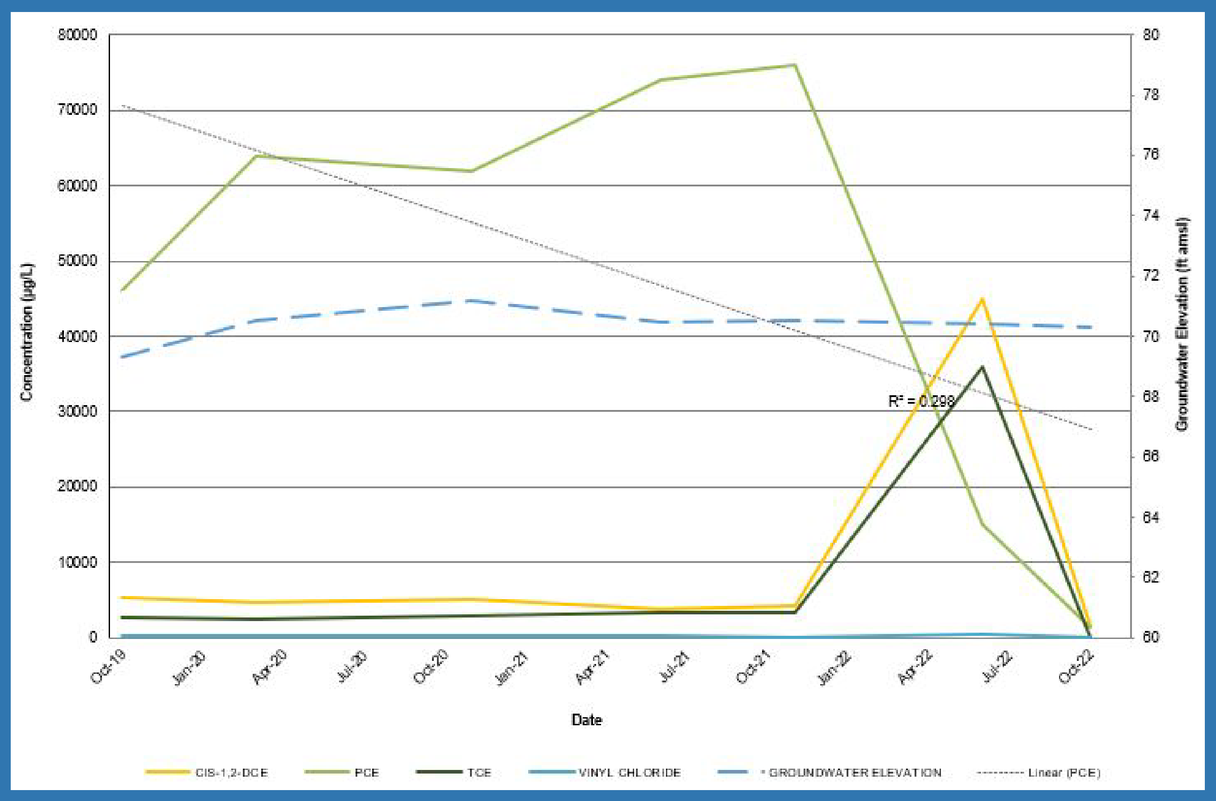
POST-PILOT RESULTS

Overall, the pilot test was a success in demonstrating delivering capabilities, as well demonstrating short-term contaminant reductions. Some specific observations:

- Delivery was successful in most of the injection points. However, some challenges were observed with injecting the designed reagent in a few locations, in particular at deeper intervals. Minimal daylighting was observed during injections, mostly in the areas where delivery at deeper depths was challenging.
- Within both injection areas, significant decreases of PCE were observed in the post-pilot sampling event in most of the locations. Orders of magnitude decreases in PCE were observed in several of these locations. Figures below demonstrate observed reductions in a source area monitoring point and a downgradient PRB monitoring point.
- Corresponding increases of TCE were observed in the monitoring points, suggesting that dechlorination already had occurred to some extent.
- Post-pilot geochemistry was favorable, including negative oxidation reduction potential, low dissolved oxygen, and near-neutral pH.
- Recent groundwater data (approximately 6 months following injections) have demonstrated sustained COC reductions.



Concentration decreases in PRB Area (Provect-IR)



Concentration decreases in Source Area (EZVI-CH4)

CONCLUSIONS/NEXT STEPS

Based on the results of the pilot study, the following conclusions were drawn and next steps proposed:

- Delivery of EZVI-CH4™ and Provect-IR® at the site is feasible using traditional direct-push injection techniques. However, due to observed challenges with delivery on some deeper zones, higher capacity injection pumps are recommended to deliver reagent at a higher pressure. A corresponding lower flow rate is also recommended to reduce the likelihood of daylighting in these areas.
- Favorable PCE reductions were observed in both targeted areas. Corresponding TCE increases were observed in the short-term, indicating desired dechlorination is occurring as expected.
- As part of further evaluation of the preferred remedy for the site, a Focused Feasibility Study (FFS) will be prepared. The FFS will focus on comparison of in situ thermal remediation and ISCR (using EZVI-CH4™ and Provect-IR®) as potential remedial alternatives for the site. Based on preliminary evaluation, it is expected that ISCRs will be proposed as the site remedy.
- Following the FFS, a Proposed Plan will be developed by the state environmental agency to present the proposed remedy to the public. A remedial design will then be prepared for implementation of the selected remedy.