Rapidly reducing chlorinated solvents in multiple media (without upsetting the neighbors!)

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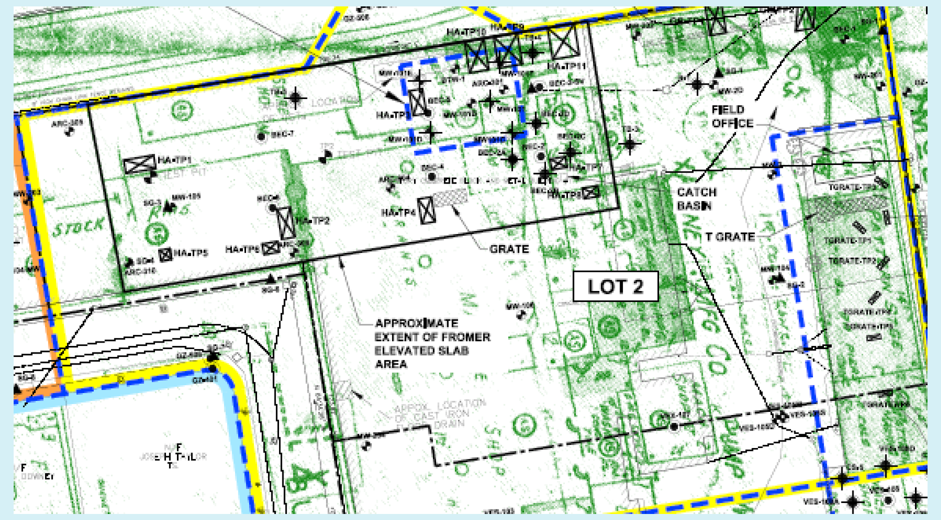
Site background

- Generations of industrial and commercial uses since the 1800s (see figure)
- High resolution site characterization revealed historic structures and process equipment
- Located in densely populated Boston neighborhood Abutters included high-occupancy residential, public transportation, and the local high school
- PCBs, mercury, and asbestos contamination in soil managed prior to CVOC remediation
- Residual petroleum NAPL comingled with CVOC source area



Site map with historical structures present

Project challenges

OVERALL CHALLENGE: Achieve Massachusetts groundwater cleanup standards on a site contaminated by high concentrations of CVOCs on developer's construction timeline.
Specific challenges:

- Health & safety: Ongoing construction activities in tandem with remediation activities, handling of remedial amendments and injection under pressure, in addition to intrinsic risks of soil vapor off-gassing to on-site workers, adjacent residents and public high school.
- Contamination: Initial concentrations of VOCs indicative of potential presence of free-phase product (> 700,000 parts per billion of TCE)
- Complex urban brownfield: Broad expertise needed on multiple topics to achieve client goals and MassDEP requirements
- Integrated services: Collaboration with Haley & Aldrich geotechnical design team to create innovative solutions that avoided interfering with ongoing remedial considerations, vapor intrusion mitigation and redevelopment timeline

Remedial selection

- Various remedial alternatives were evaluated to treat Site CVOCs including in-situ chemical oxidation, dig and haul, and in-situ enhanced reductive dechlorination (ERD); ERD approach ultimately selected. Due to elevated contamination present, in-situ soil mixing event was proposed for shallow soil and groundwater and injections proposed for deeper groundwater.
- Building construction designs were modified to include a sub-slab vapor barrier and mitigation system that could be run in either passive or active modes.

Safety considerations

- Fugitive dust monitoring for potential exposure to soil contaminants such as metals, PCBs, and asbestos
- Mitigated vapor risks to on-site personnel and site neighbors during remedial tasks such as soil mixing
- Active construction site during remediation, building activities occurring simultaneously with remediation

Remedial implementation (CVOCs)

For treatment of TCE and degradation products present in soil as well as shallow and deep groundwater, two remedial steps completed.

Step 1:

- Soil mixing with approximately 50,000 pounds of zero-valent iron (ZVI) and electron donor in shallow groundwater zone

Step 2:

- In-situ injection of ZVI and electron donor in deeper groundwater zone

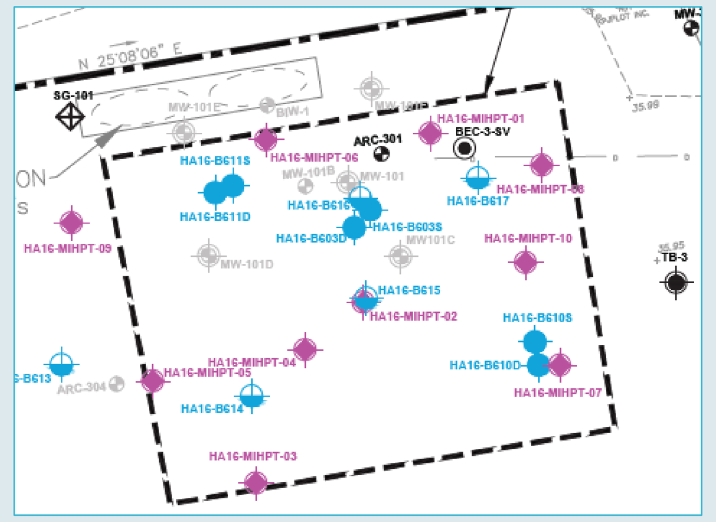
Step 3:

- Follow-up in-situ injection of ZVI and electron donor in shallow and deep zone to further enhance remediation

Step 4:

- Construction of on-site building included sub-slab vapor mitigation system and continuously accessible groundwater injection and monitoring points.

Vapor mitigation activities during soil mixing

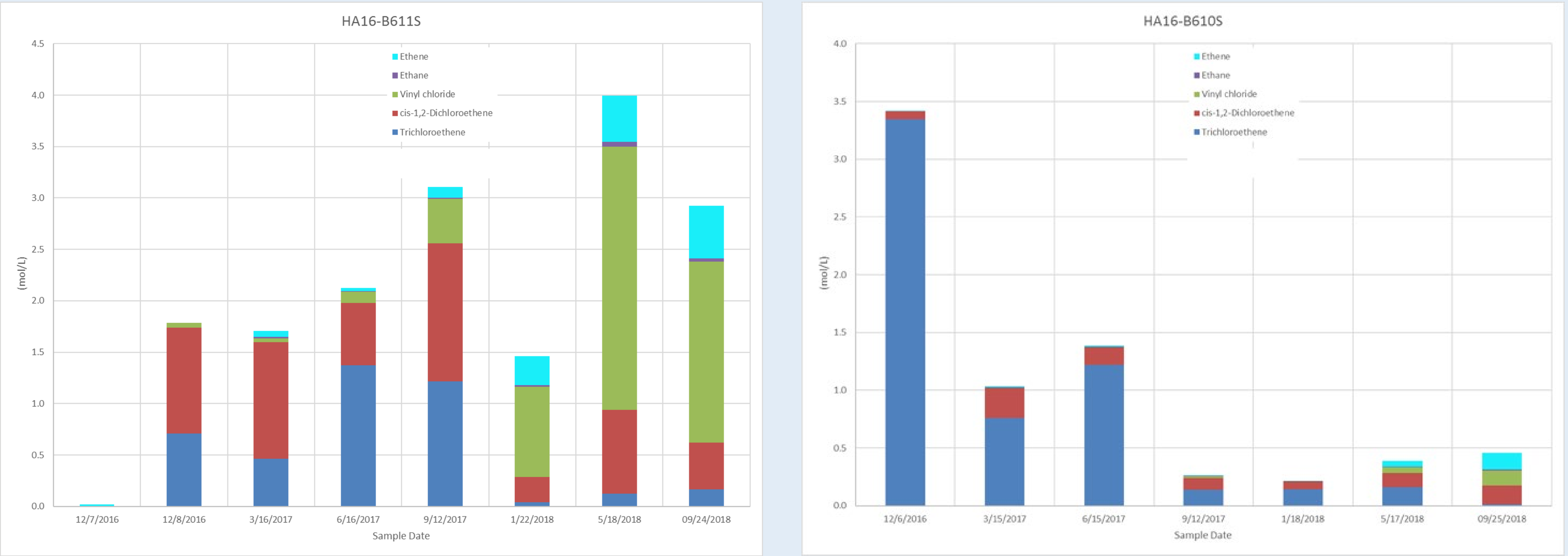


Source area remediation with shallow and deep well locations

Exterior access ports for injection ports

Remedial outcome

- Created strongly reducing conditions with elevated ethene and ethane present, showing complete degradation of TCE, and strongly reduced iron present, mostly in ferrous state.
- Concentrations of *dehalococcoides* (DHC) of between 10^7 to 10^9 gene copies per liter, with elevated reductases, and *dehalobacter* (DHB) between 10^4 to 10^7 gene copies per liter, without bioaugmentation.
- Plume contraction in both shallow and deep plumes leading to low plume fringe concentrations and limited off-site impacts.
- Elevated degradation product and end product formation, with ethene present in parts per million concentration ranges up to 9 mg/L in source area wells.
- Source area groundwater concentrations of TCE decreased between 44% and 100% in deep groundwater and between 82% and 100% in shallow groundwater.



Molar graphs of source area wells pre- and post-remediation

Highlights

- Project completed on schedule, within the remedial budget, with protection of potential receptors, and no health or safety incidents
- Worked in a heavily collaborative team of remediation, regulatory (MassDEP, TSCA), and geotechnical experts and architectural, foundation and construction contractors. Building specifically designed to not inhibit remedial activities or anaerobic site conditions through use of grouted micro-piles, early-stage design of sub-slab mitigation system, and monitoring and injection well design that remained accessible during and after construction.
- Rapid removal of source area mass has made former brownfield viable for beneficial reuse: currently an active commercial property
- Lessons learned: Need for well characterization and look at sites—holistically—taking into account health and safety considerations, receptors, contamination concentrations, geotechnical needs for reconstruction, and client's goals and timelines