



GOLDER

Thermal Soil Mixing and ZVI Injection Using Large Diameter Augers at a Former Dry Cleaner

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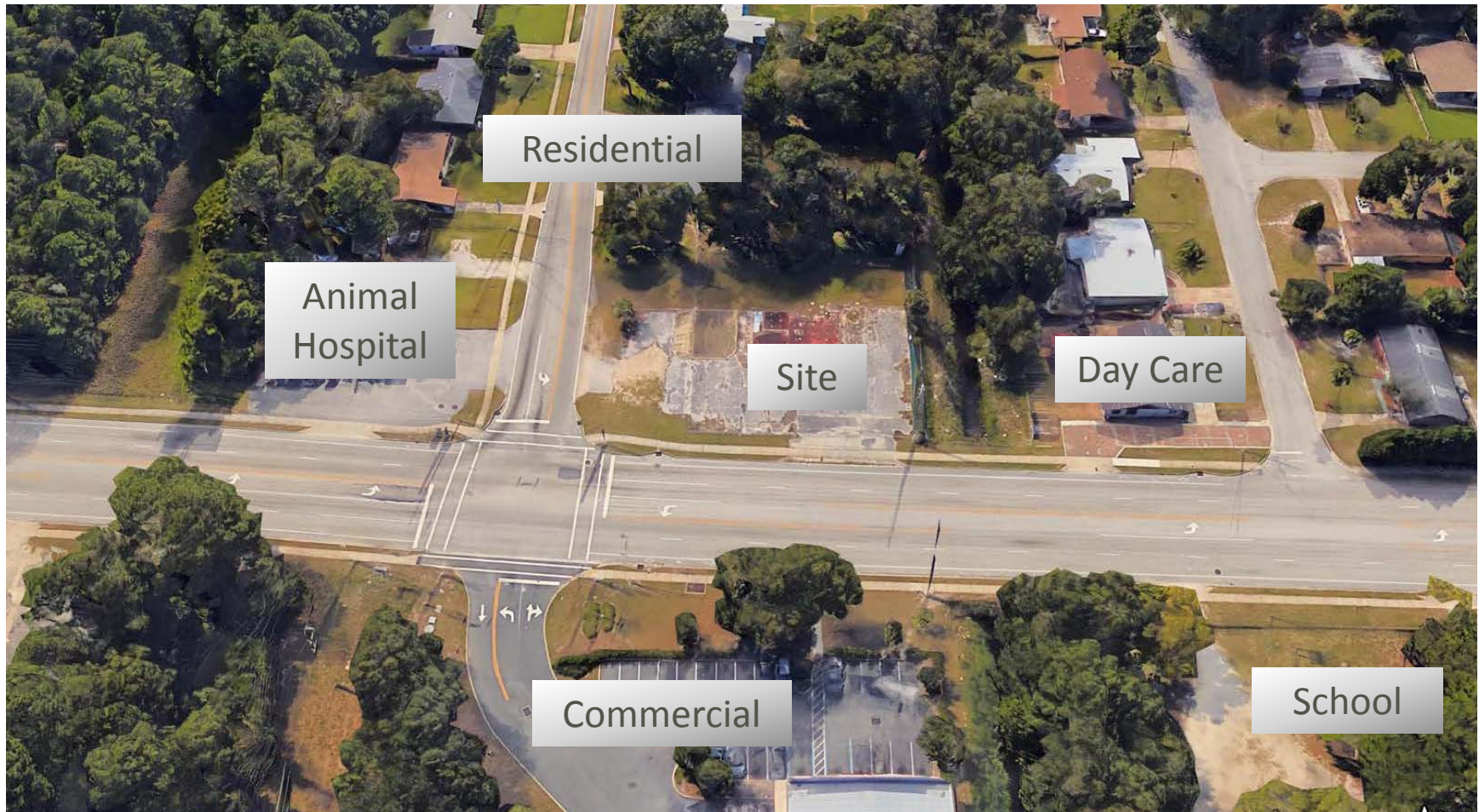
Presentation Overview

- Site Location and Background
- Conceptual Site Model
- Selected Technology
- Remedial Design
- Process Optimization
- Assessment of Remedial Effectiveness
- Results and Recommendations



Site Location

JACKSONVILLE, FLORIDA



Background

OPERATIONAL HISTORY AND SUSPECTED SOURCE AREAS

- Operational History
 - Gas and Service Station -1953-1963
 - Dry Cleaner - 1968-1989
 - Vacant since 1989
 - Building demolished - 1997
- Suspected Source Areas
 - Waste oil UST and former supply well
 - Dry cleaning machine and floor drain
 - Sump adjacent to dry cleaning machine
 - Spills associated with PCE deliveries
 - Back door



Conceptual Site Model

SITE GEOLOGY AND HYDROGEOLOGY

- Site Geology
 - Fine-grained sand from land surface to 60 feet bgs
 - Low permeability sandy clay unit from 40 to 50 feet bgs
 - Low permeability clay unit at 65 feet bgs
- Site Hydrogeology
 - Depth to groundwater – 8 feet bgs
 - Surficial groundwater flow towards the west
 - Horizontal hydraulic gradient – 0.0025 feet/foot
 - Average hydraulic conductivity – 10 to 20 feet/day
 - Estimated groundwater flow velocity – 62 feet/year



Conceptual Site Model

CONTAMINANTS OF CONCERN

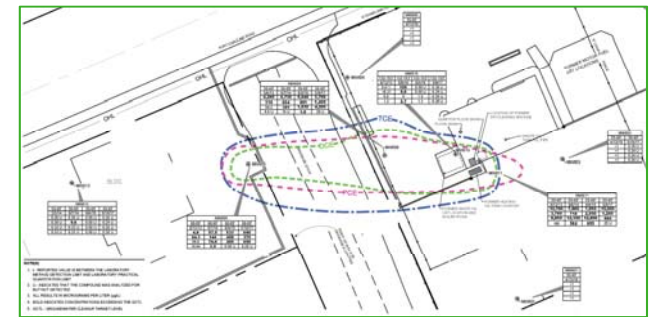
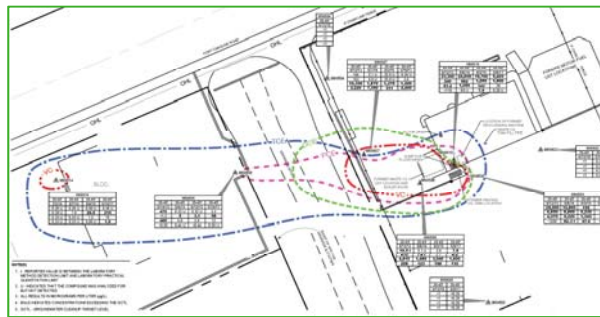
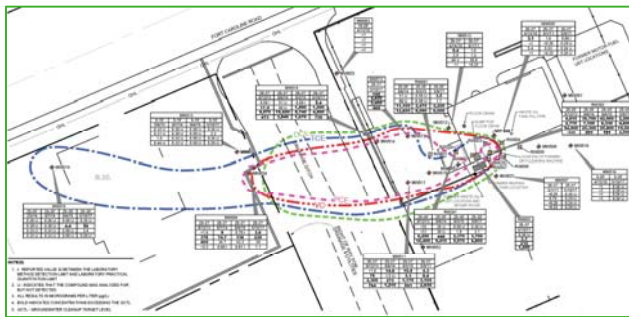
Maximum PCE Concentrations in Surficial Groundwater

Shallow Zone	Intermediate Zone	Deep Zone
(8 to 35 feet bgs)	(35 to 50 feet bgs)	(50 to 65 feet bgs)
136,000 µg/L	36,000 µg/L	54,000 µg/L

Shallow Zone

Intermediate Zone

Deep Zone



- Vadose zone soils remedied through UST closure excavation and soil vapor extraction

Selected Remedial Technology

SOIL AND GROUNDWATER REMEDIATION

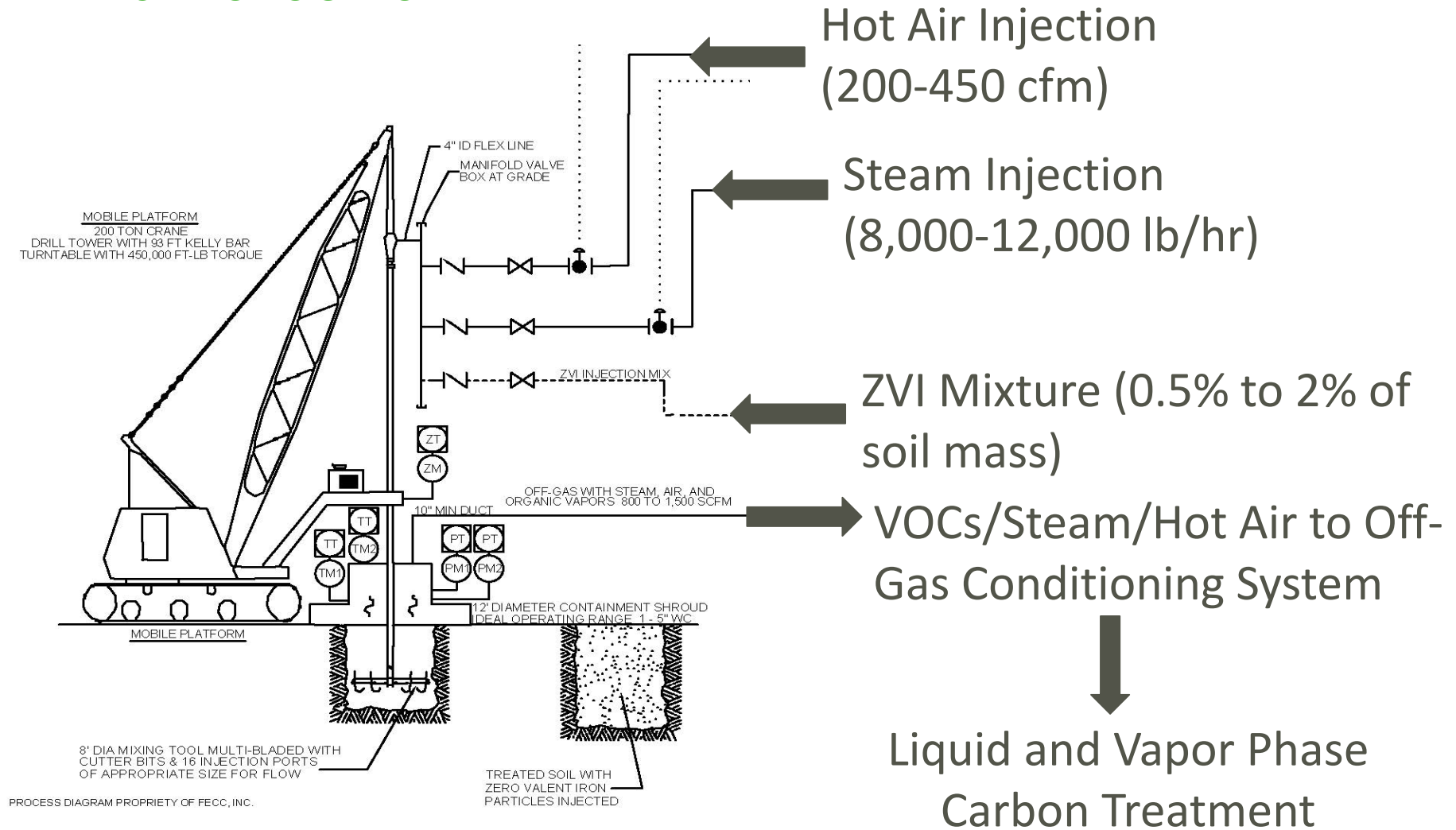


- FECC's Chlorinated Source Contamination Removal Technology
 - In-situ soil mixing using large diameter augers
 - Thermal treatment
 - Zero-valent iron injections
- Previous Remedial Technologies
 - AS/SVE for soil
 - Cosolvent flushing
 - Hydraulic control
 - Enhanced Bioremediation



Selected Remedial Technology

TECHNOLOGY OVERVIEW



Selected Remedial Technology

SOIL MIXING EQUIPMENT



- 200-ton crane with 150-foot boom
- 93-foot long drill stem (kelly bar)
- Drill platform
- 8-foot diameter LDA with injection ports
- 12-foot diameter surface shroud



Selected Remedial Technology

SOIL MIXING EQUIPMENT

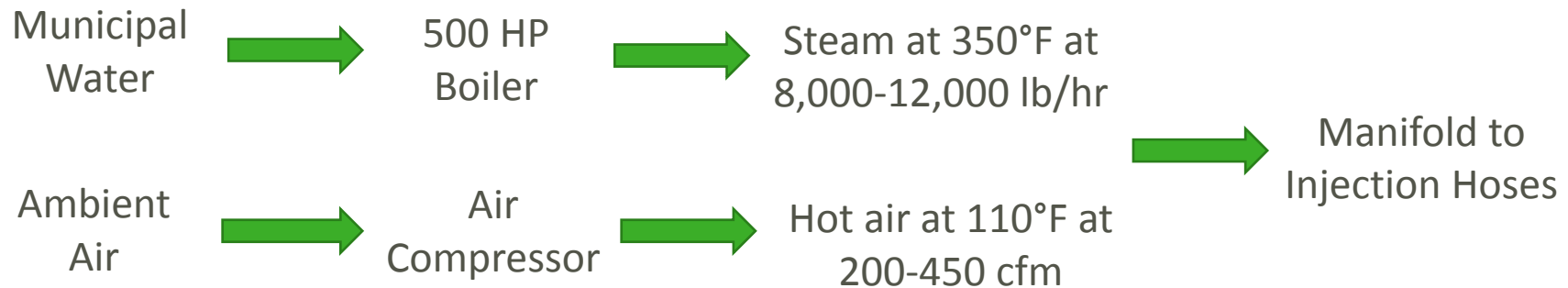


Selected Remedial Technology

THERMAL TREATMENT

Chlorinated Solvent	Pure Substance Boiling Point (°C/°F)	Heterogeneous Azeotrope with Water Boiling Point (°C/°F)
PCE	121/250	88/190

Source: Gmehling and Onken 1977



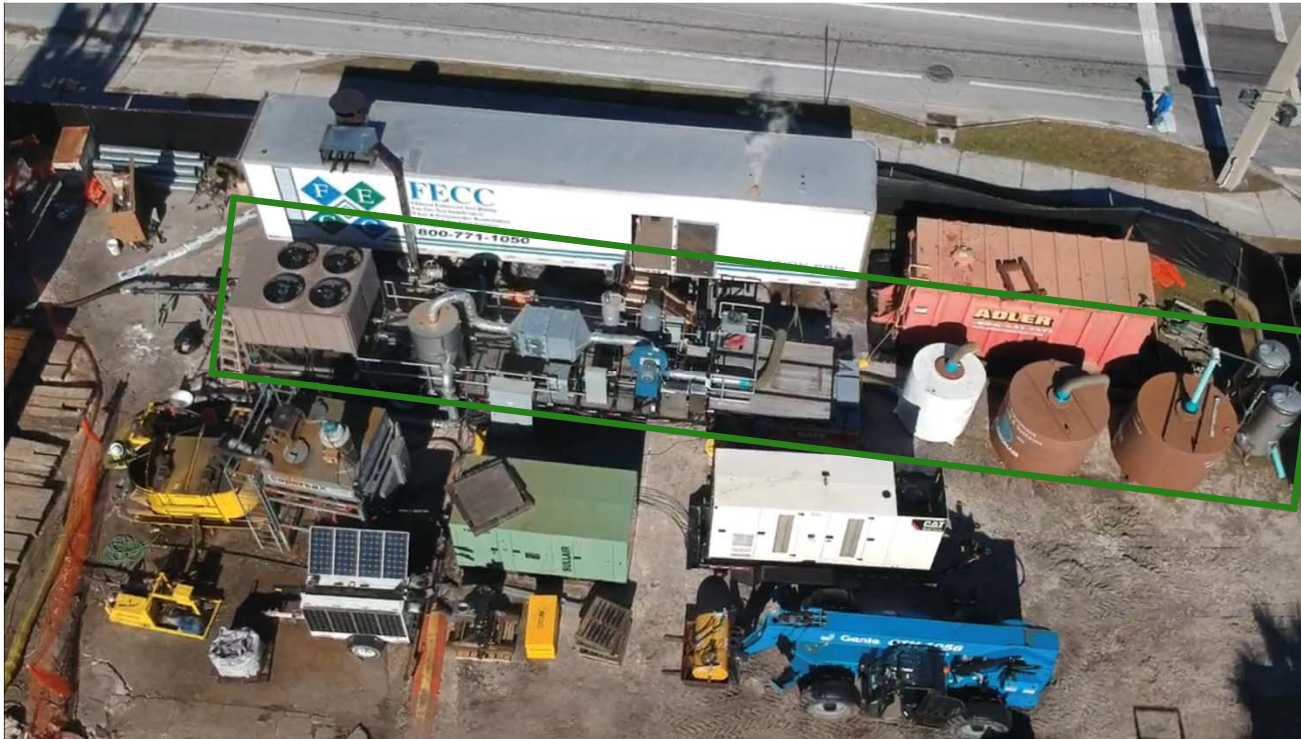
Selected Remedial Technology

THERMAL TREATMENT DELIVERY



Selected Remedial Technology

OFF-GAS CONDITIONING AND TREATMENT SYSTEM



- Vacuum blower (up to 30 in H₂O and 1,500 CFM) draws steam, air, VOCs, and particulates from shroud to off-gas conditioning
- Vapor-liquid separator, particulate filter, chiller, reheater
- Carbon treatment for liquids and vapor

Selected Remedial Technology

ZERO-VALENT IRON



- Polishing step after thermal treatment
- ZVI at 0.5% to 2% of the soil mass
- Guar Gum
- Water



Selected Remedial Technology

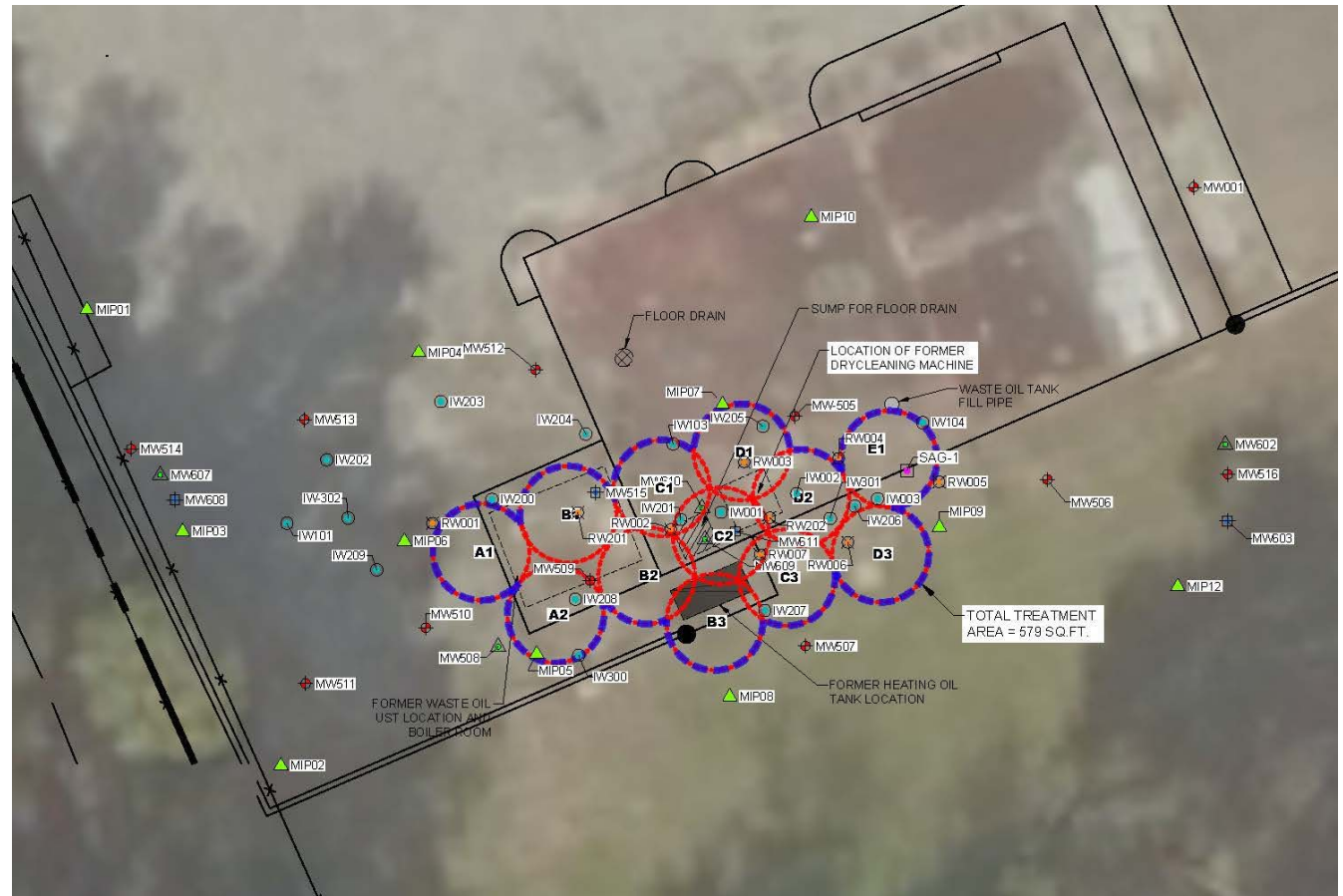
EQUIPMENT LAYOUT



Remedial Design

SCOPE OF WORK

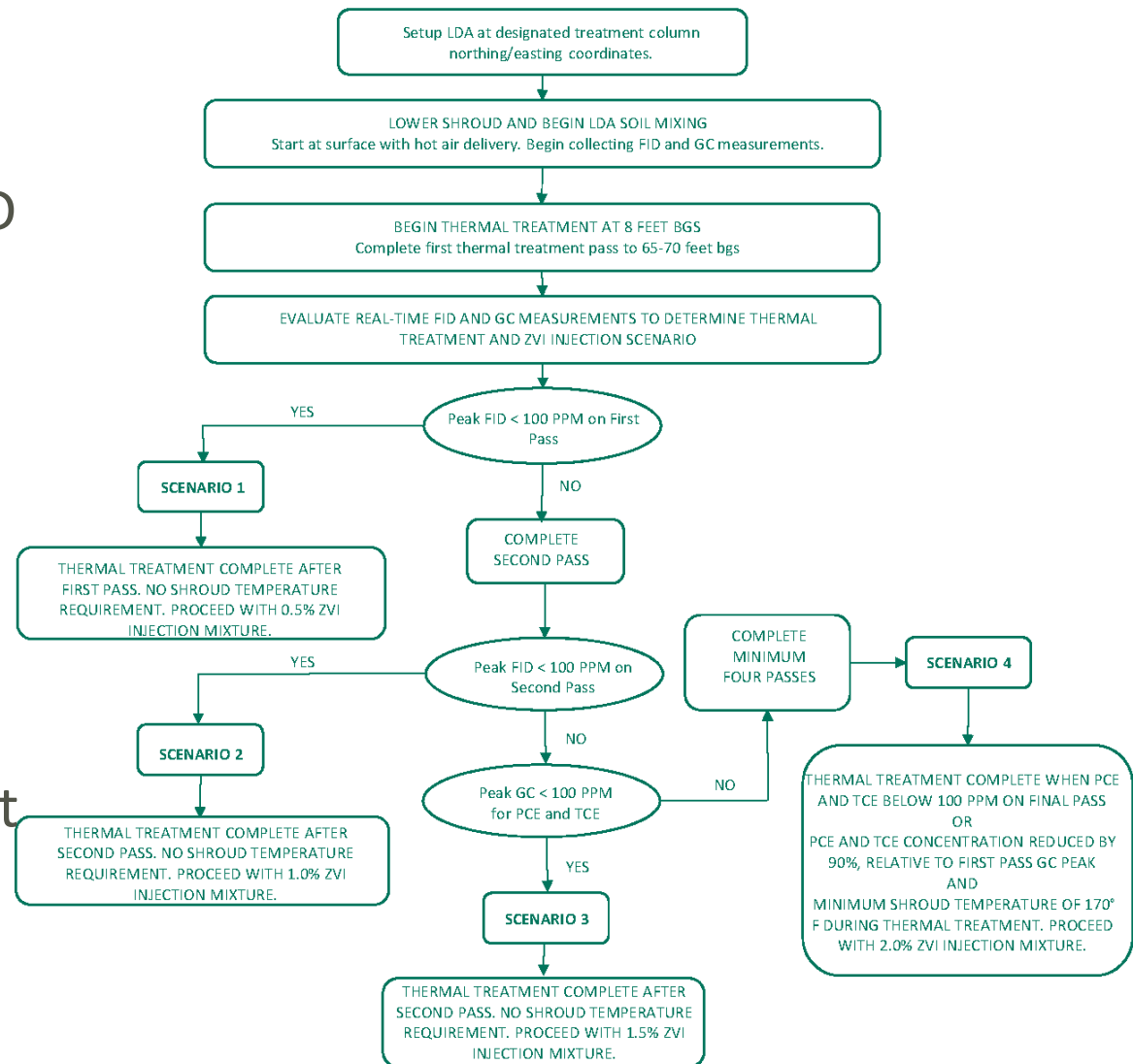
- 12 treatment columns
- Treatment depth of 65 feet bgs
- Treatment area of ~580 ft²
- 1 to 4 mixing & thermal treatment passes per column
- ZVI at 0.5% to 2% of soil mass per column



Remedial Design

DECISION TREE

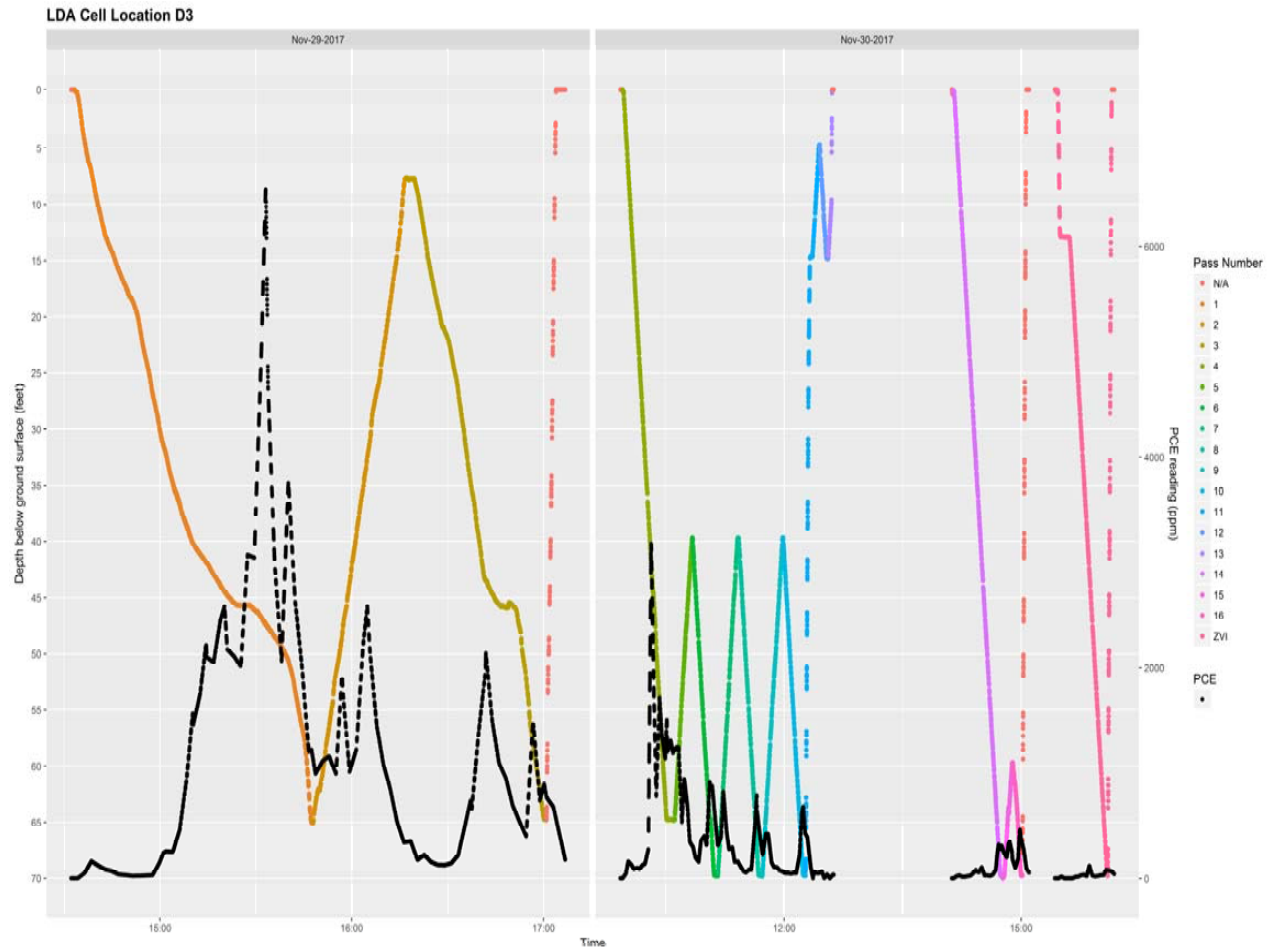
- Included 4 scenarios based on real-time FID and GC readings
- Determined actual number of treatment passes per column
- Determined ZVI application rate
- Required minimum shroud temperature at most impacted locations



Process Optimization

REAL-TIME DATA MONITORING AND SYSTEM CONTROLS

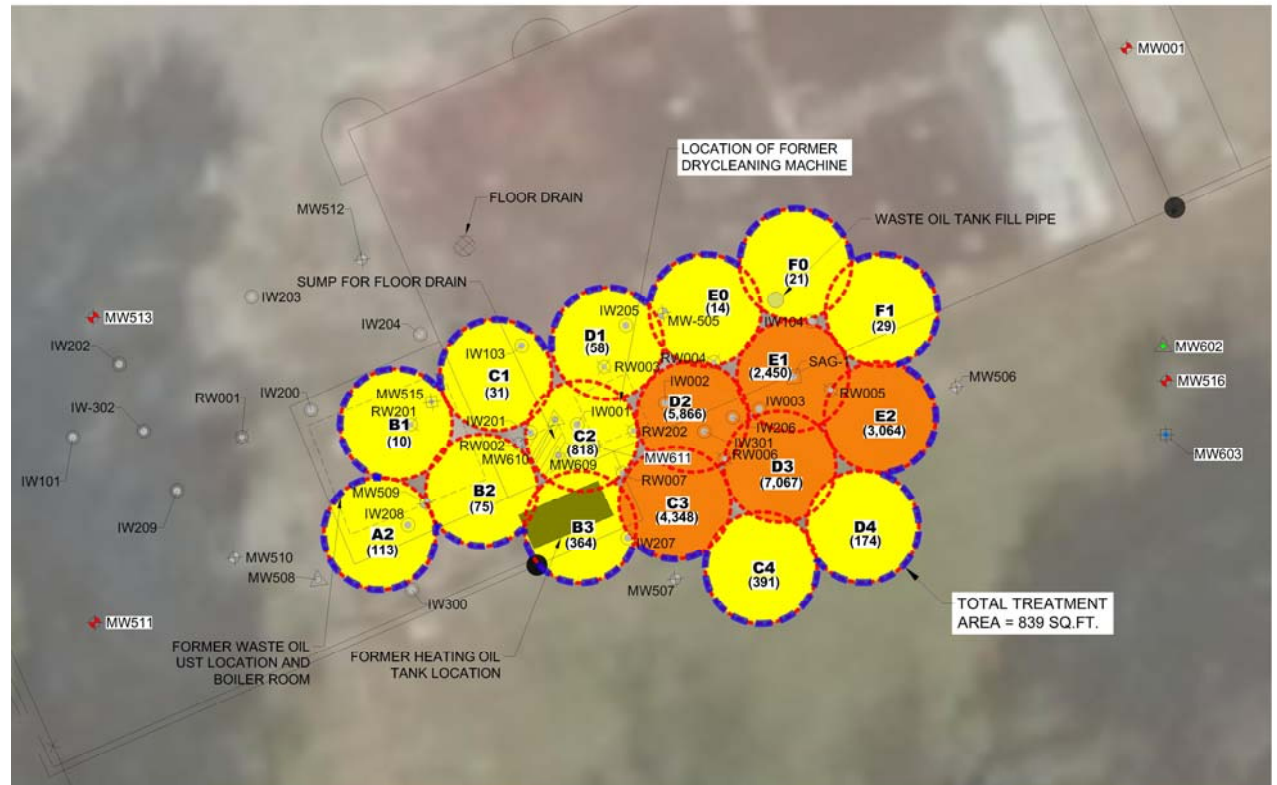
- Continuous FID and depth measurements
- 4 GCs for PCE, TCE, cis-1,2-DCE, and VC analysis
- Remote control of steam and hot air injection flow rates
- Remote control of off-gas extraction rates
- Data recording



Process Optimization

HORIZONTAL AND VERTICAL DELINEATION OF SOURCE AREA

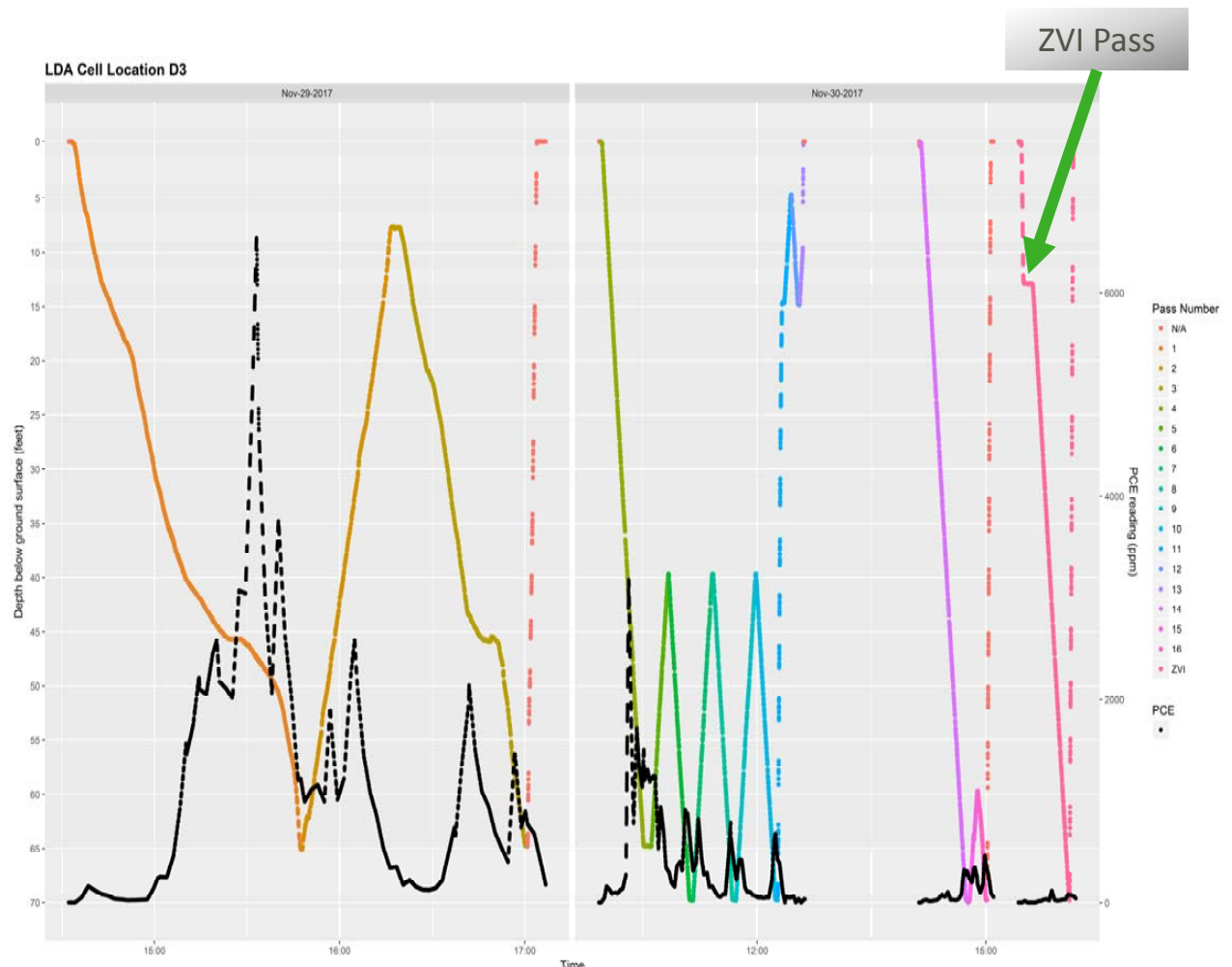
- 17 total treatment columns
- Treatment depth ranged from 65-70 feet bgs
- PCE in off-gas GC samples below 100 ppm or reduced by 90% relative to baseline during final pass
- “Confirmatory columns” around most impacted columns



Process Optimization

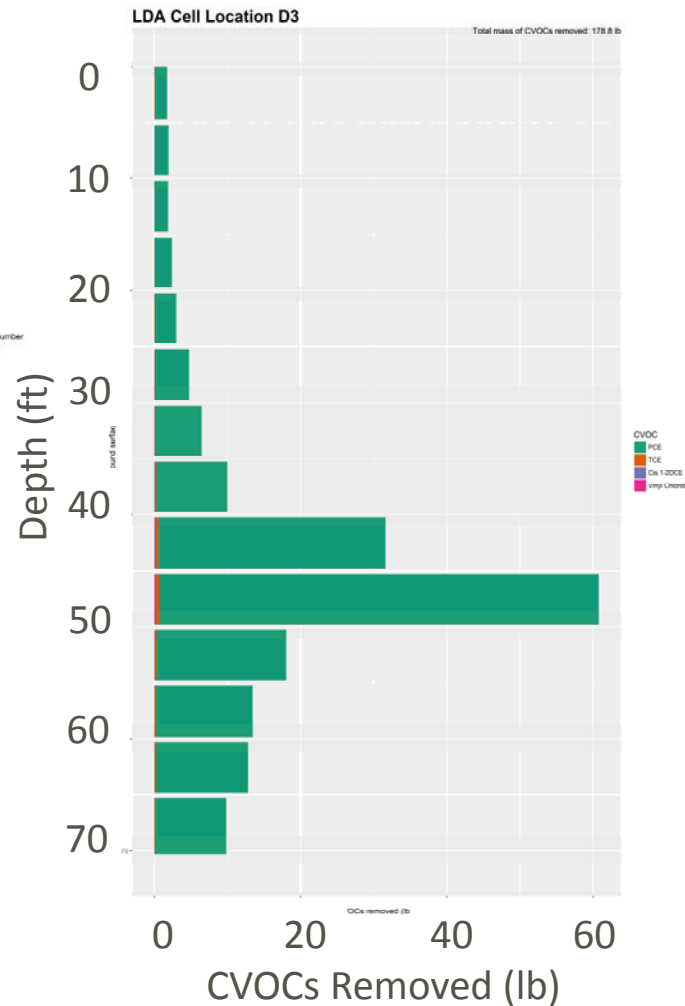
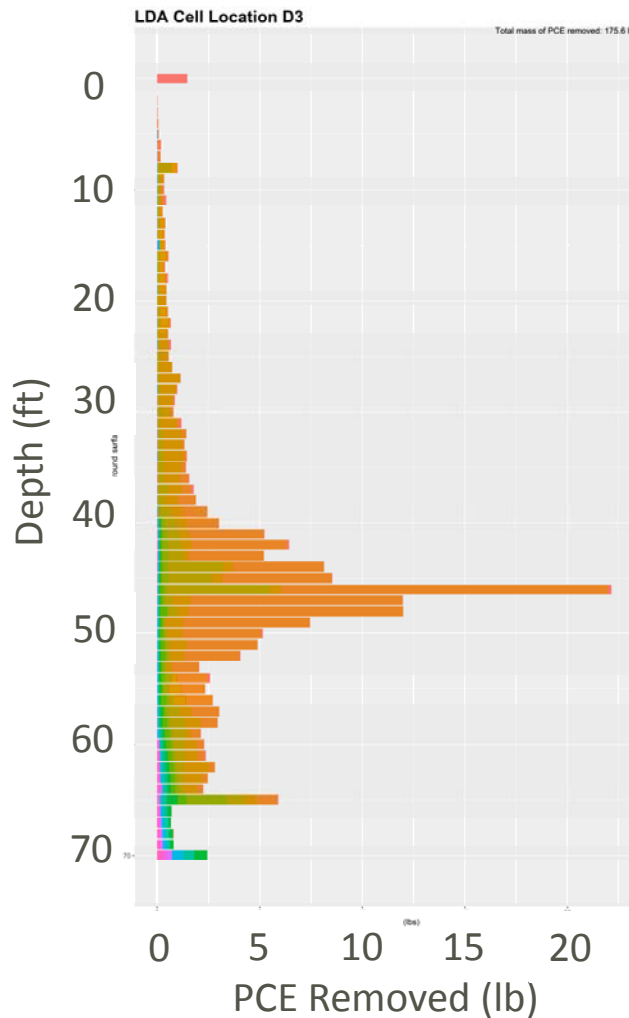
ZERO-VALENT IRON

- ZVI injected during final pass from 8 feet bgs to total column depth
- Concentration at 0.5% to 2.0% of soil mass based on FID and GC results
- 800-900 gal batches injected at 20 GPM
- Nearly 72,200 lb of ZVI applied in source area



Assessment of Remedial Effectiveness

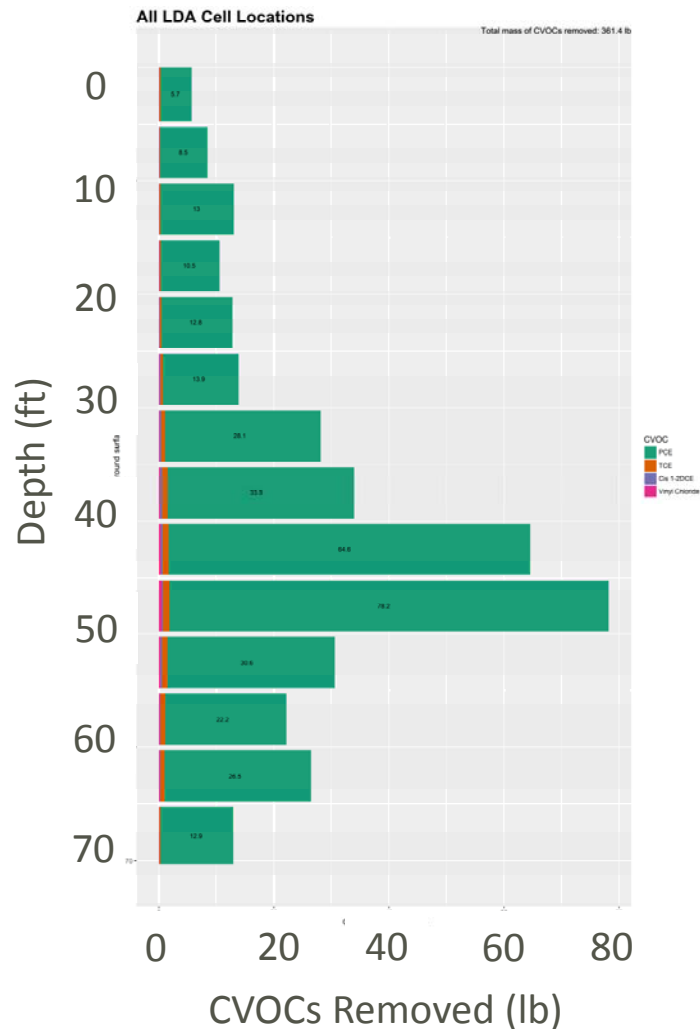
DATA EVALUATION



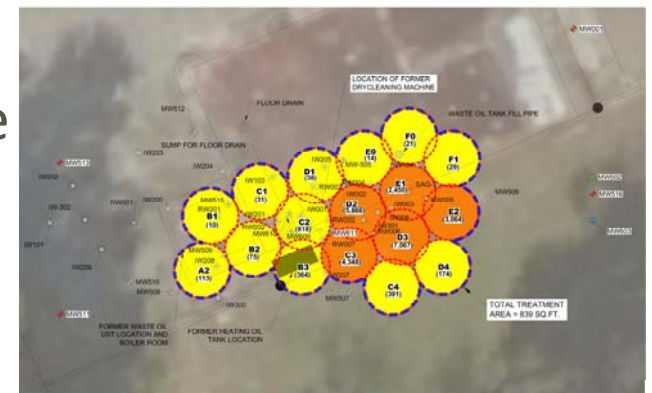
- 179 lb of total CVOCs removed at Column D3 (nearly half of total mass removed)
- 98% PCE
- Most concentrated depth interval was from 40 to 50 feet bgs (clay rich soils)

Results and Recommendations

ESTIMATED MASS REMOVAL AND PERFORMANCE MONITORING



- 361 lb CVOCs removed from 17 LDA treatment columns
- 97% of CVOCs consisted of PCE and corresponded to ~26 gallons of pure product
- 94% of mass removed from 5 of the 17 columns (near former supply well)
- 143 lb (40%) removed 40 to 50 feet bgs
- Performance monitoring June 2018
- Risk-based closure





Questions