

Combined In Situ Chemical Reduction and In Situ Bioremediation Groundwater Treatment for a Chlorinated VOC Plume

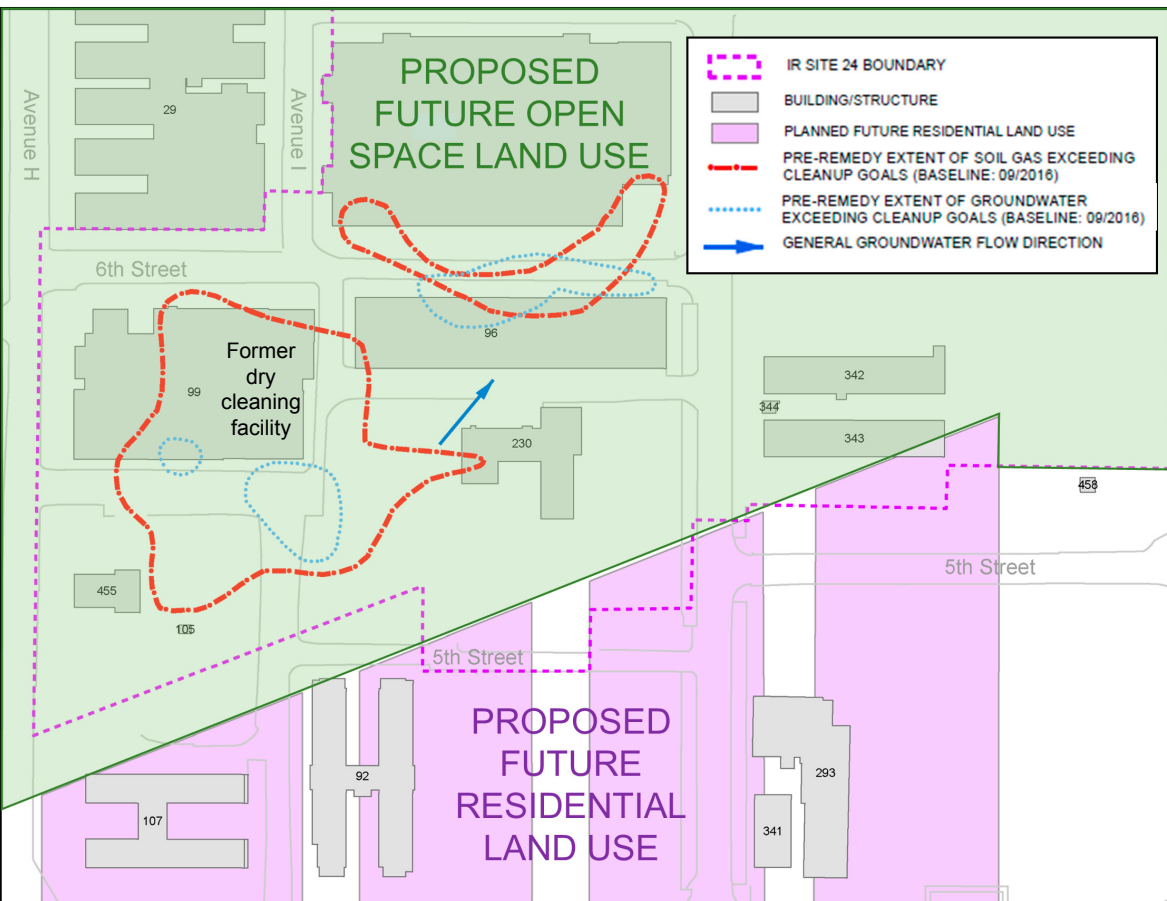
Overview

Site Description/Background

- Former dry cleaning facility in Building 99 at the former Naval Station Treasure Island
- Tetrachloroethene (PCE) releases resulted in a groundwater plume extending over 1,100 feet to the San Francisco Bay
- Interbedded sand, silt, clay; groundwater flows east to northeast; hydraulic gradient ranges from 0.001 to 0.008 foot per foot
- In situ bioremediation (ISB) treatability studies from 2003 through 2012 reduced the extent of contamination to several smaller plumes

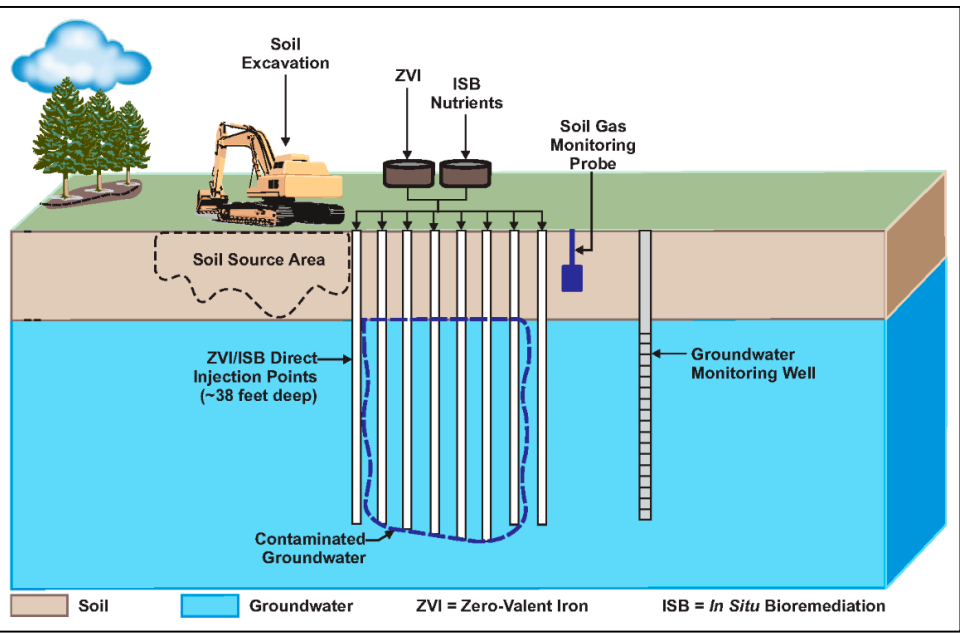


Pre-Remedy Extents of Contamination and Proposed Future Land Use



- Proposed future land use is primarily open space
- Groundwater is of insufficient quality to be a potential drinking water source
- Groundwater cleanup goals based on construction worker exposure pathways
- Soil gas cleanup goals based on commercial/industrial worker and residential vapor intrusion exposure pathways

Schematic of Remedy



Remedial Action

Objectives and General Approach

- ISCR = reducing agent (e.g. microscale zero-valent iron [mZVI]) drives abiotic degradation
- ISB = organic substrate (electron donor) provides a carbon source to stimulate biological dechlorination

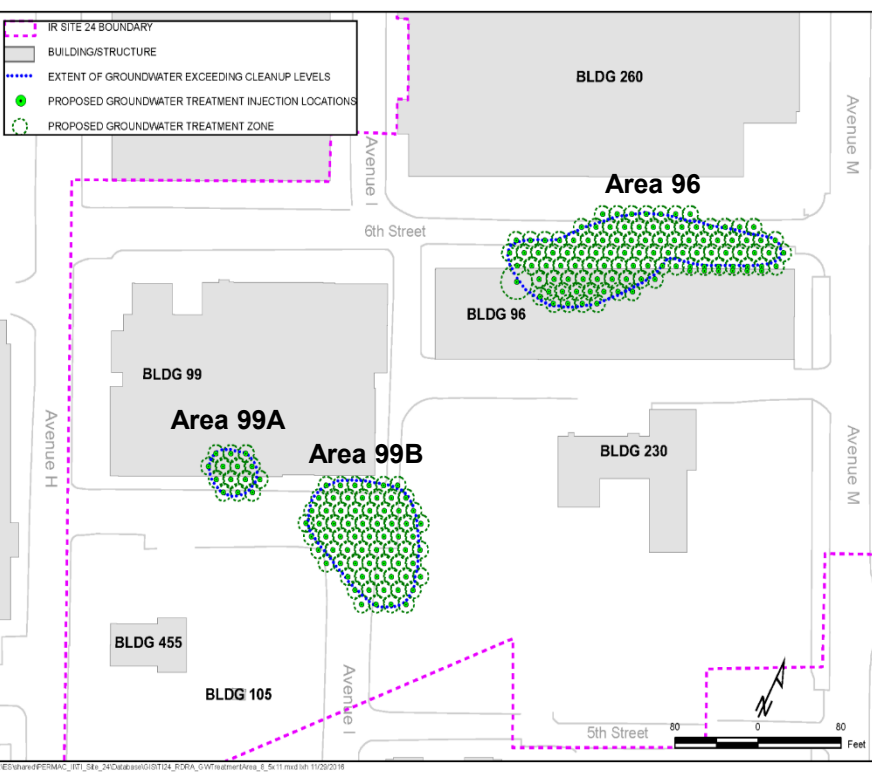
Combined groundwater remedy intended to:

- Destroy saturated zone cVOC mass while reducing the potential for generation of toxic intermediate dechlorination products
- Manage back diffusion from low-permeability zones
- Meet unrestricted use for future redevelopment of the site

Field Work

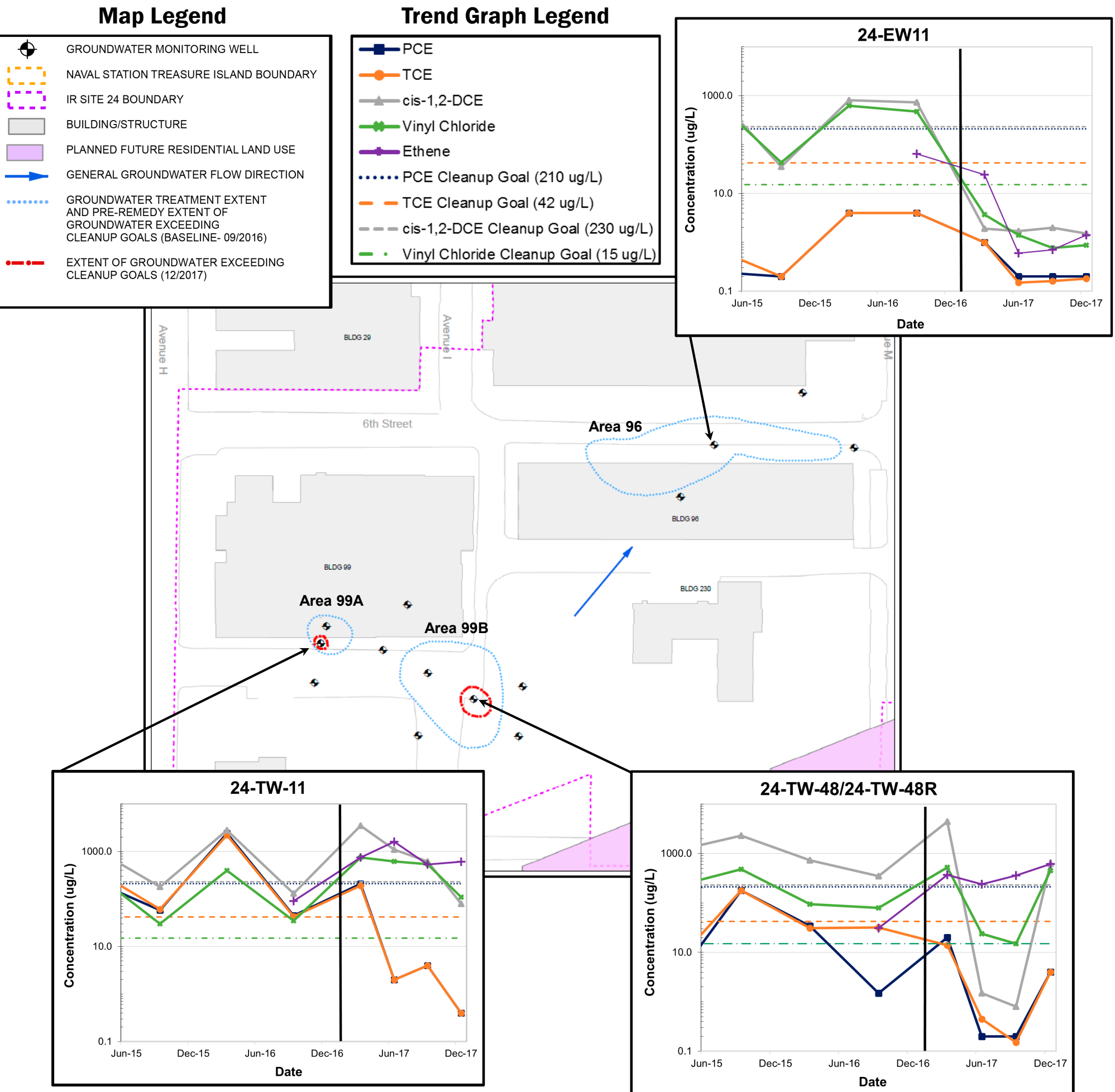
- Pre-design study delineated horizontal and vertical extent of groundwater contamination
- Completed 182 temporary direct injection points
- Emplaced injection materials at high pressure in 2.5-foot vertical intervals to promote vertical and lateral distribution
- At each interval, amendments injected in separate batches
 - Target dose of ISB reagent mixed with extracted groundwater
 - Target dose of mZVI mixed with guar and extracted groundwater
- Injected ~74,000 pounds of mZVI and ~43,000 pounds of ISB reagent
- Conducted four quarters of groundwater and soil gas performance monitoring

Groundwater Treatment Remedial Design



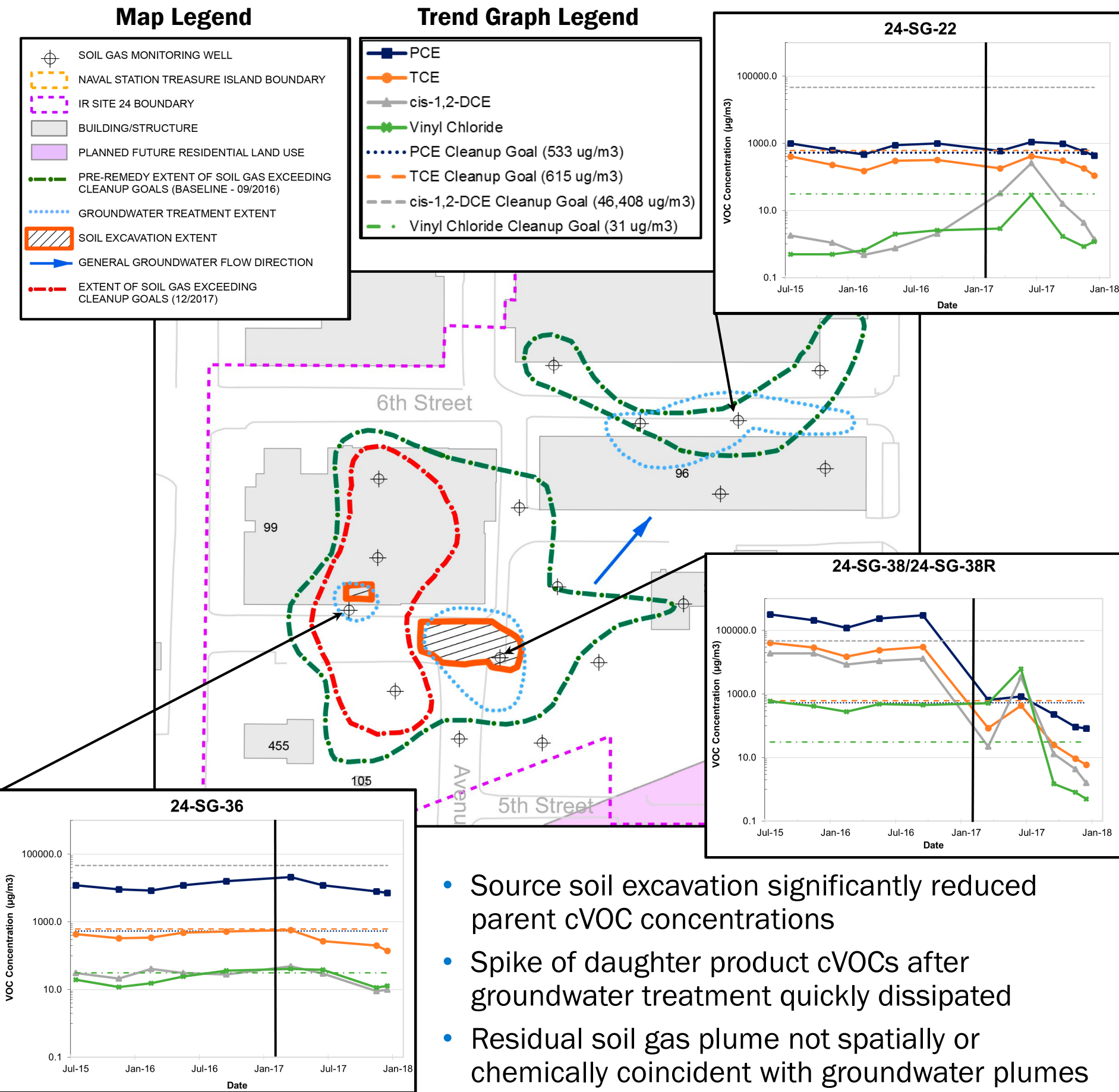
Treatment Area	Injection Point IDs	Number of Injection Points	Injection Interval (feet)	Injection Length (feet)
Area 96	1 to 100	100	15-25	10
Area 99A	101-114	14	7-25	18
Area 99	115-182	68	7-35	28
Total:		182		

Groundwater Performance Monitoring Results



- Area 96 – groundwater cleanup goals were achieved 6 weeks after the injections
- Area 99A and 99B – additional cVOC mass was likely liberated during remedy injection into groundwater from low-permeability soil zones
 - Significant reductions in cVOC mass since 2nd sampling event
 - Anomalous daughter product concentrations measured at well 24-TW-48R during 4th sampling event corresponds to anomalous high groundwater level in that one well
 - Continuing soil source not suspected cause, as this well was reinstalled after excavation of vadose zone soil in that area
- High ethene concentrations document complete reductive dechlorination
- Geochemical and microbial conditions indicate groundwater conditions conducive to continued contaminant degradation

Soil Gas Performance Monitoring Results



Conclusions

- Combined ISCR and ISB effectively destroying saturated zone cVOC mass without stall at intermediate dechlorination products
- At lower concentrations (cVOCs < 1,200 micrograms per liter), cleanup goals were achieved within 6 weeks after injections
- Continued monitoring will determine when cleanup goals are achieved and whether back diffusion from low-permeability zones has been eliminated
- Residual soil gas plume is not result of volatilization of cVOCs from groundwater
- Institutional controls will be implemented to manage risk to residents and workers, if cleanup goals are not met before property transfer