

Remediating 46 Acres of Jet Fuel with Biologically-enhanced Soil Vapor Extraction/Bioventing

Endpoint Strategy and Regulatory Closure Process

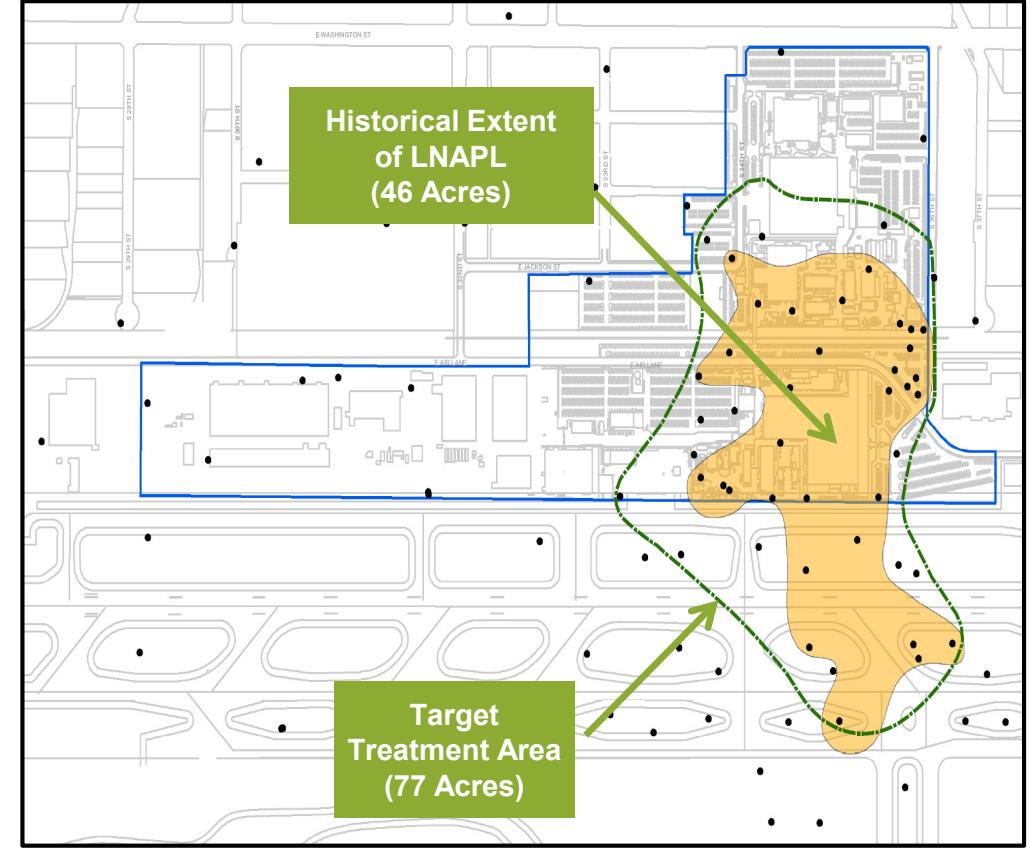
Authors

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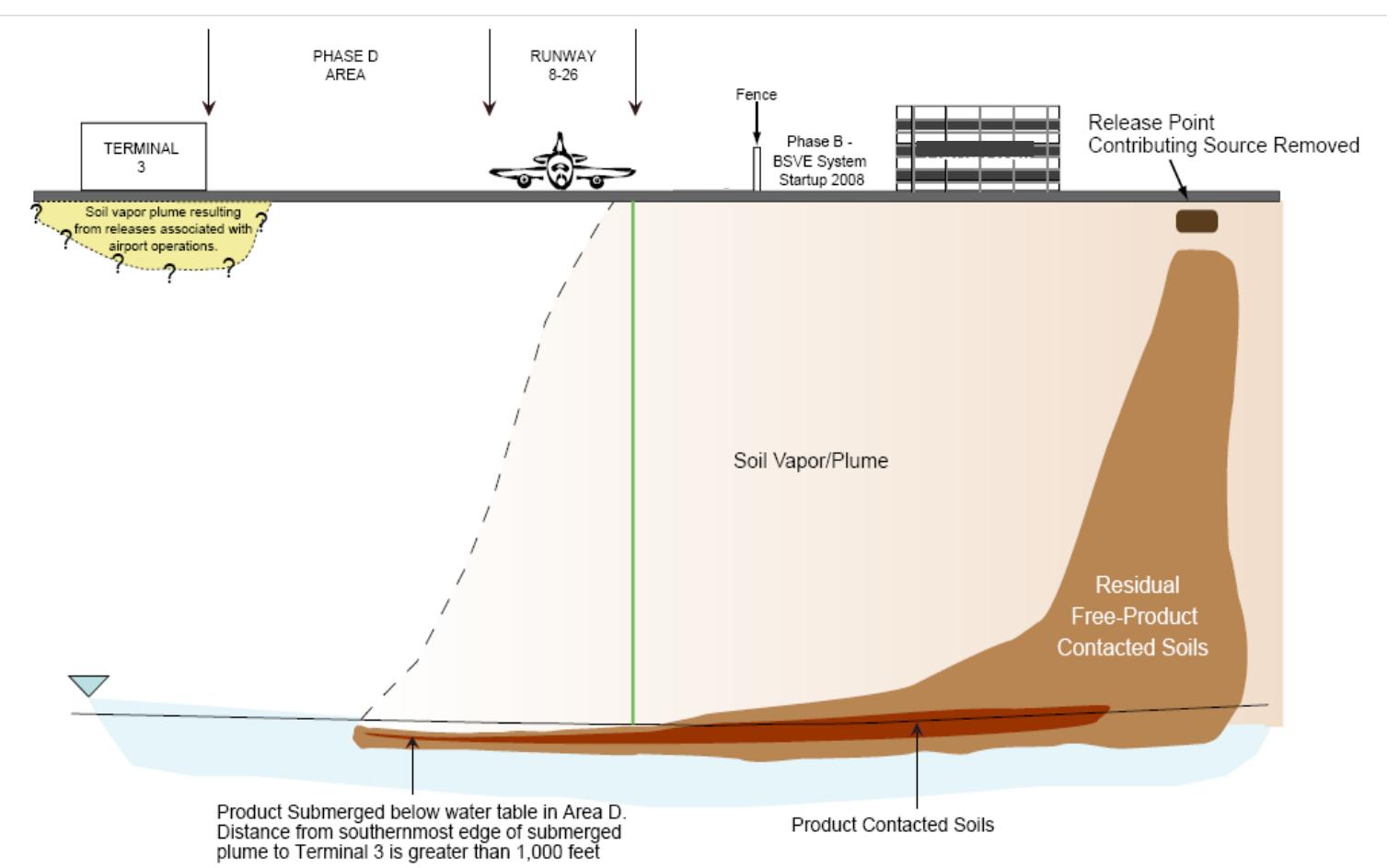
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The Site

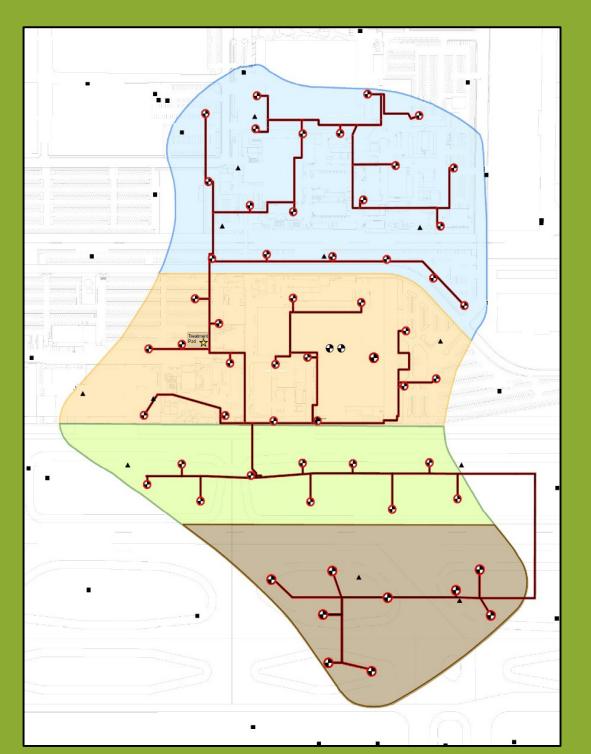


- 118-acre aircraft engine manufacturing and testing facility
- Began operations in the 1950s
- Jet fuel usage of approximately 1 to 2 million gallons per year

Historical Conceptual Site Model

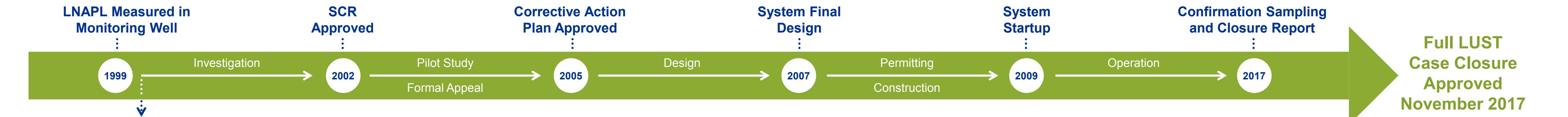


Remedial Alternative Selection

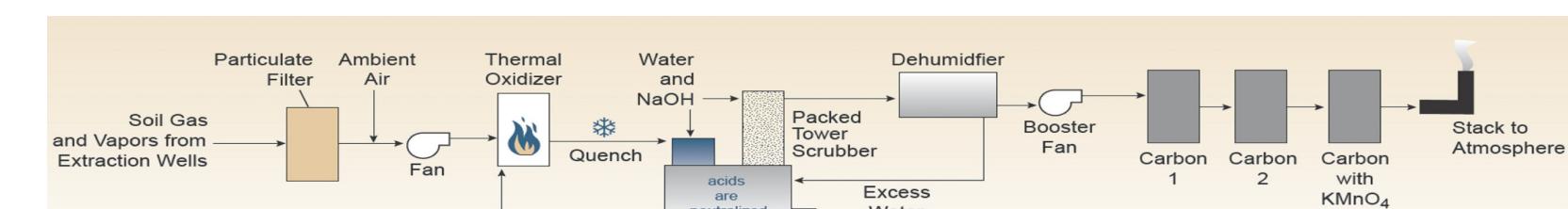


- BSVE/bioventing with limited LNAPL skimming
- 77-acre target treatment area
- 58 injection/extraction wells
- 17 process monitoring wells
- 14 sentinel monitoring wells clusters, and 53 groundwater monitoring wells
- 1 mile of trenches
- Over 5 miles of subsurface and aboveground piping

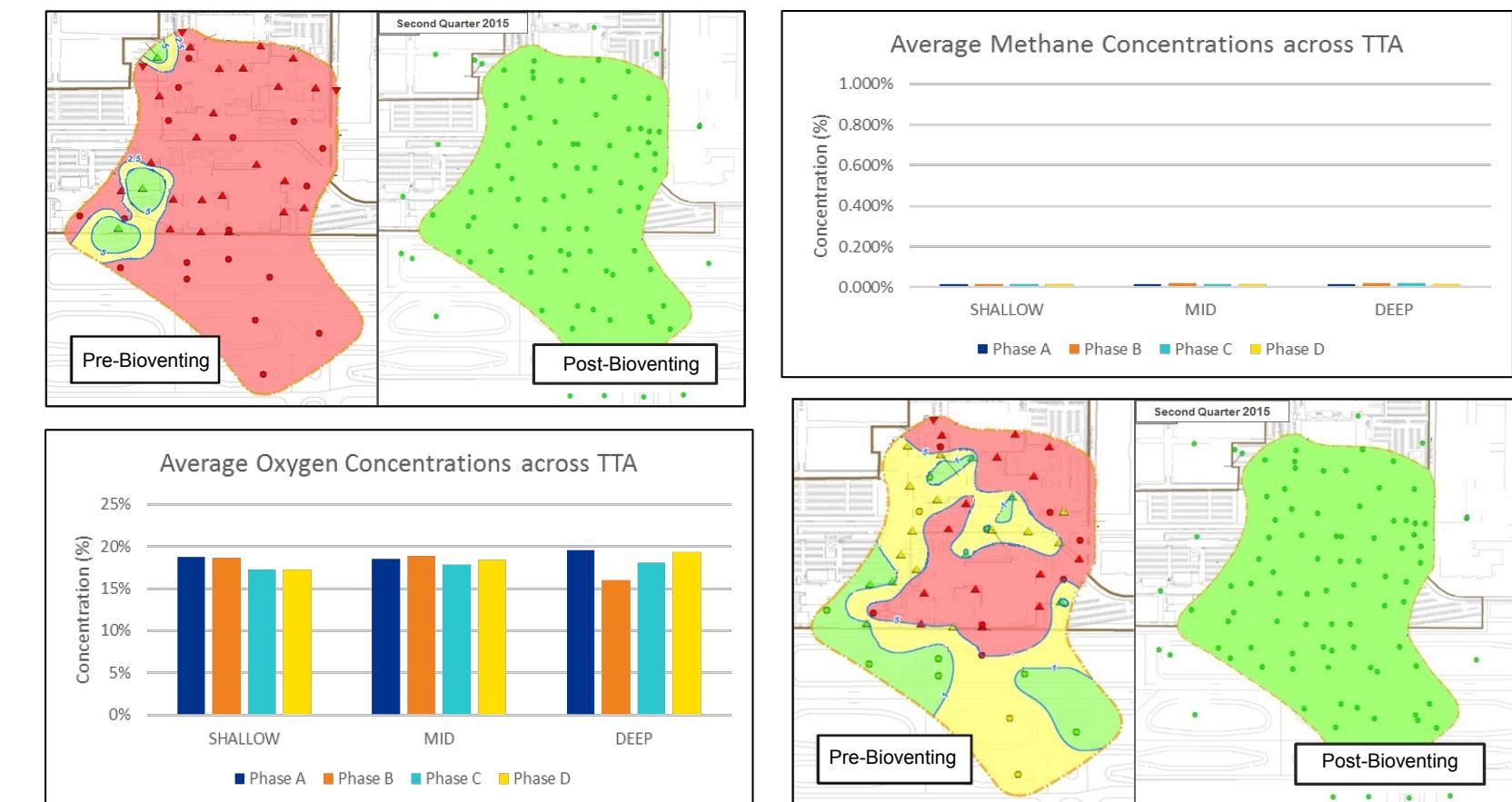
Major Events Timeline



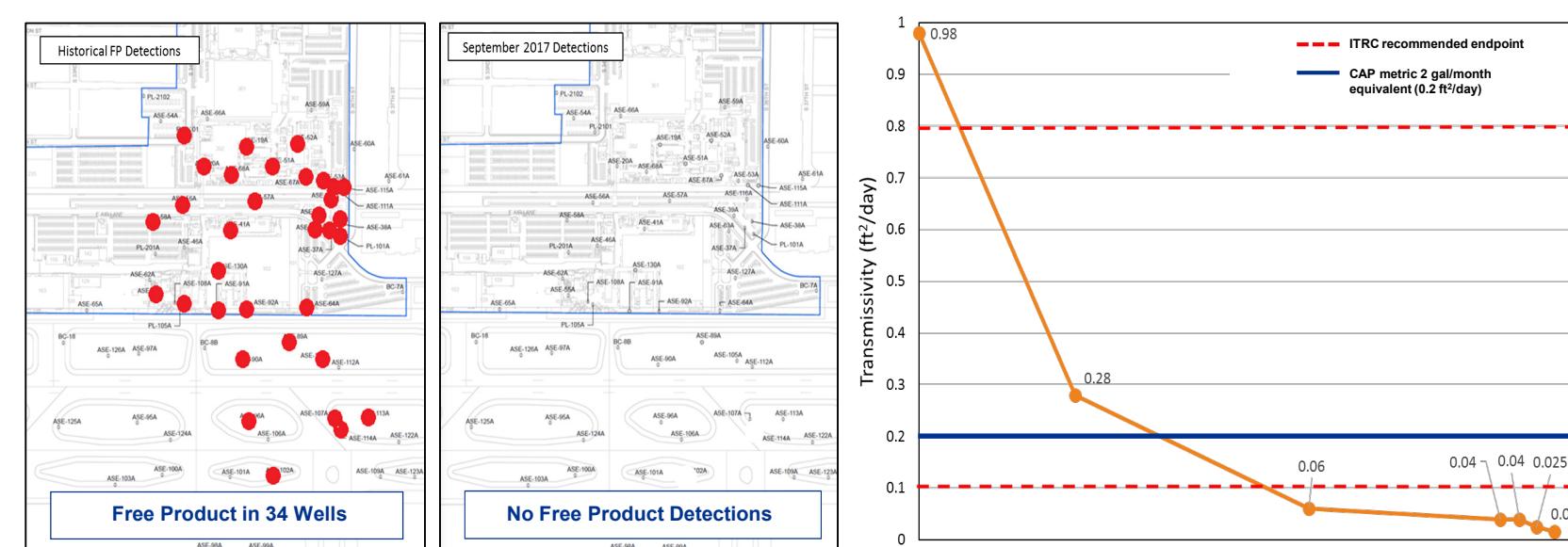
BSVE/Bioventing System



Deep Oxygen/Methane



LNAPL Detection and Transmissivity



Corrective Action Confirmation

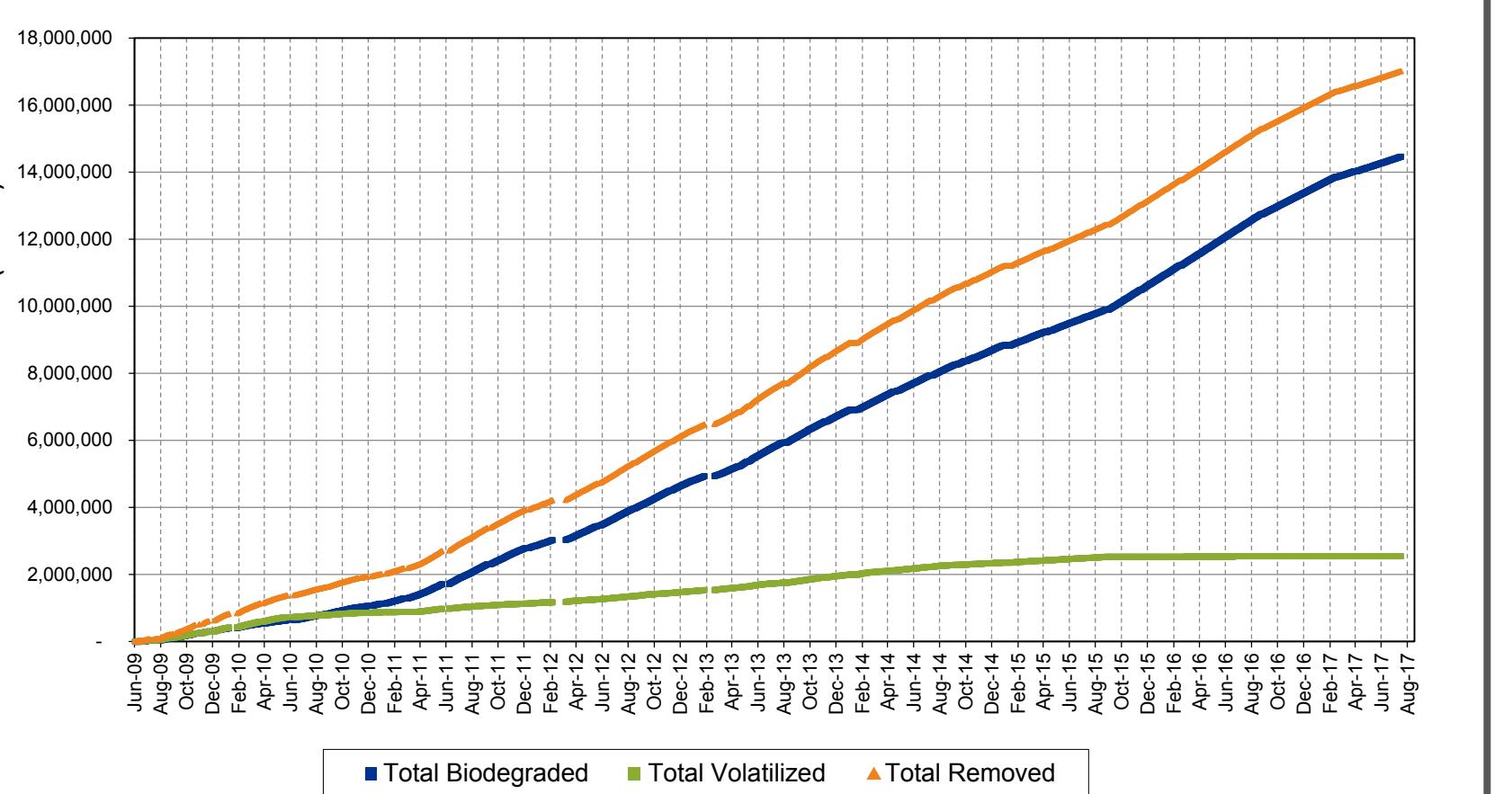
2005 Corrective Action Plan Confirmation Requirements

- LNAPL: LNAPL thickness <0.1 foot or LNAPL recovery rates <2 gallons per month
- Groundwater (Tier 1): COC concentrations below MCLs
- Soil (Tier 1): COC concentrations below Soil Remediation Levels in whole soil samples quotient <1

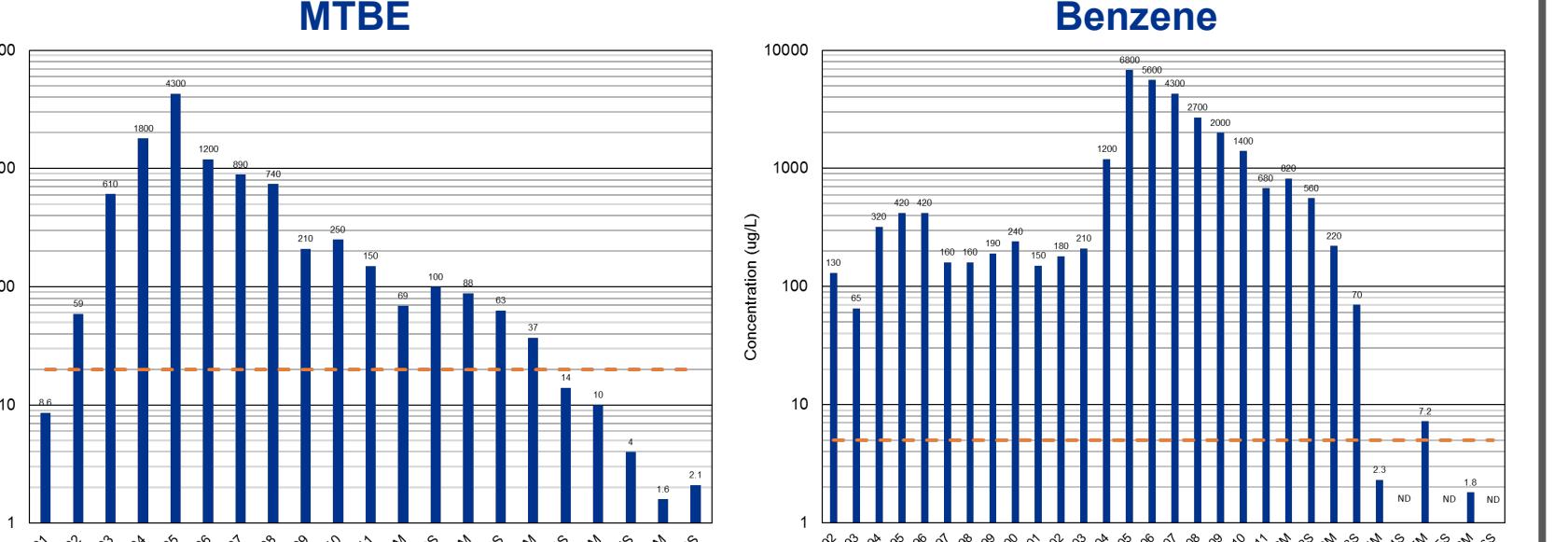
2017 Final Confirmation Requirements

- LNAPL: Based on LNAPL not being a source to groundwater and (indirectly) decreasing LNAPL transmissivity
- Groundwater (Tier 1): Based on declining benzene and MTBE concentrations to levels below MCLs
- Soil (Tier 3): Based on historical soil data and modeling new soil-gas sample data showing cumulative cancer risk <1x10⁻⁶ and hazard quotient <1

Petroleum Hydrocarbon Mass Removal



Historical Groundwater Quality



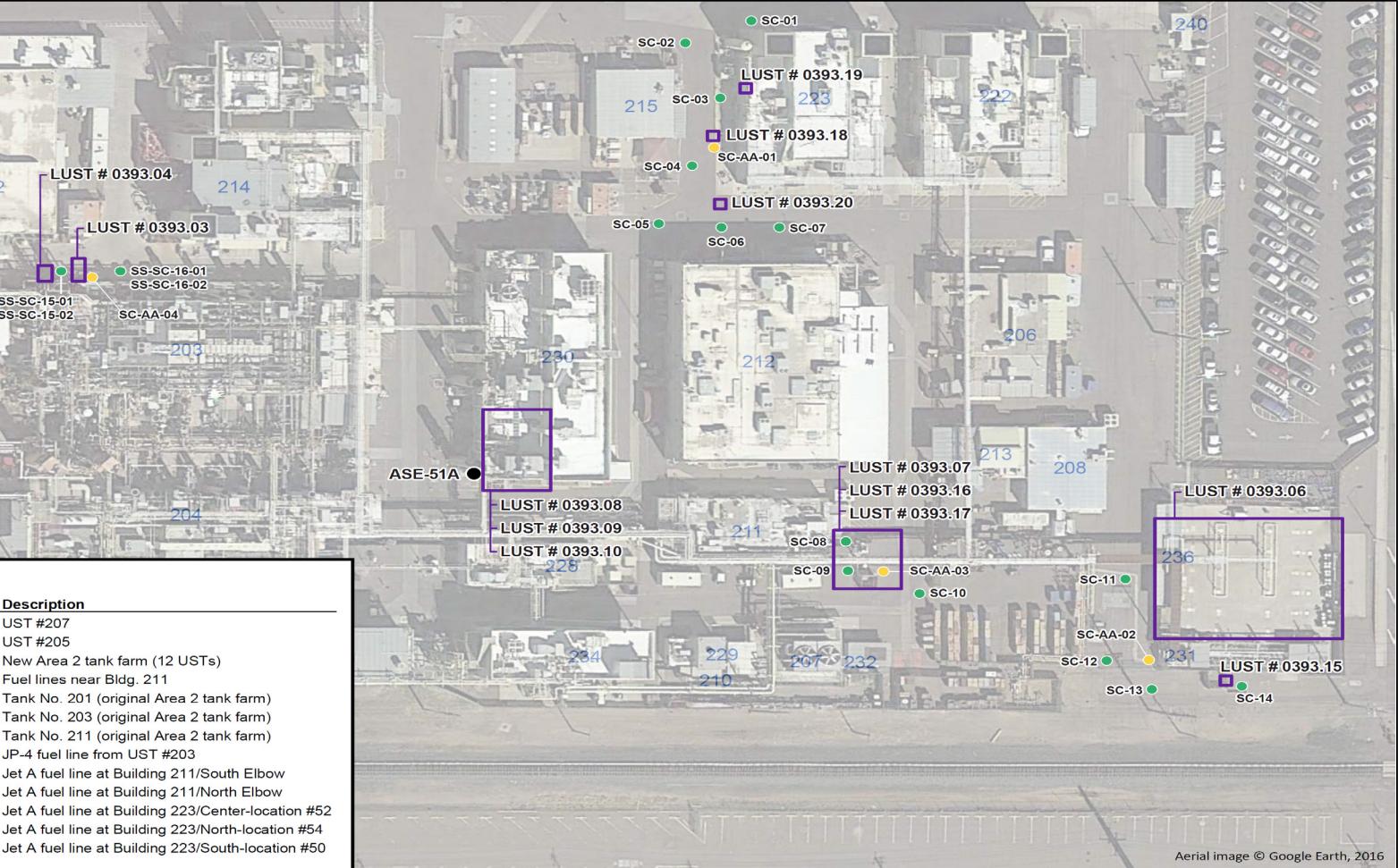
Johnson and Ettinger Vapor Intrusion Model

Forward Calculation

- All compounds with a maximum concentration exceeding 10 percent of the RSL were modeled
- Model inputs
 - Chemical-specific properties
 - Soil properties
 - Structural properties of the building
 - Exposure parameters
- High indoor air prediction results were used for a conservative approach
 - Cumulative cancer and hazard risks calculated separately
 - petroleum-based COCs (associated with the UST jet fuel releases)
 - nonpetroleum based compounds
 - Standards were <1x10⁻⁶ (cancer risk) and <1 (hazard quotient)

Enter Site Name (optional): BSE
Enter sample concentration, unit and media type:
What's the depth of the soil gas sample or ground-water table for the ground-water contamination? (ft)
What is your concern of concern (COC)?
What type of building are you investigating at your site?
What is the average annual rate (annual)?
Chemical Properties
CAS Number: 111-04-3
Molecular Weight (g/mol): 111
Henry's Law Constant at ground-water temperature (H): 0.0002 g/m³
Fre-Air Diffusion Coefficient (Df): 0.0002 cm²/sec
Unit-Risk Factor (URF): 0.0002
Reference Concentration (RfC): 0.0002 mg/m³
Soil Properties
Total Porosity (n): Low (0.023)
Unsaturated Zone Moisture Content (n): High (0.23)
Capillary Zone Moisture Content at Air-Entry Pressure (n):
Building Properties
Air Exchange Rate (AER): 0.000165
Building Mixing Height (MMH): 3
Building Footprint Area (BFA): 0.000165
Building Volume (BV): 0.000165
Building Crash Ratio (BCR): 0.000165
Exposure Duration for Carcinogen (EDC): 0.000165
Exposure Frequency for Carcinogen (EDF): 0.000165
Averaging Time for Carcinogen (ATC): 0.000165
Exposure Duration for Non-Carcinogen (END): 0.000165
Exposure Frequency for Non-Carcinogen (EDN): 0.000165
Averaging Time for Non-Carcinogen (ATD): 0.000165
Exposure Parameters
Indoor Air Concentration (IAC): 0.000165 ug/m³
Indoor Air Diffusion Coefficient (IDC): 0.000165 cm²/sec
Unsaturated Zone Effective Diffusion Coefficient (UDC): 0.000165 cm²/sec
RESULTS
Unsaturated Zone Effective Diffusion Coefficient (UDC): 0.000165 cm²/sec
Unsaturated Zone Effective Diffusion Coefficient (UDC): 0.000165 cm²/sec
* 'Parameter' concentration produced with DEEPEST moisture content and DEEPEST depth to contamination.
* 'Parameter' concentration produced with COVEST moisture content and SHALLOWEST depth to contamination.

Confirmation Soil and Soil-gas Sampling Locations



Results

- Remediation
 - Removed more than 7,500 gallons of free product via direct liquid recovery
 - Removed over 17 million pounds of petroleum hydrocarbons via BSVE/bioventing
 - Reduced dissolved-phase concentrations to below corrective action standards
- Confirmation Sampling and Risk Modeling
 - Results from soil samples collected at seven LUST locations were below residential standards
 - Results from soil-gas samples collected at eight LUST locations with subsequent modeling were below risk-based corrective action standards
 - Cumulative cancer and hazard risks for petroleum-based COCs ranged from 4.30×10^{-7} and 0.0136 to 4.87×10^{-7} and 0.0527 , respectively
 - 80 percent of compounds not detected

Summary

- BSVE/bioventing successfully remediated the site
 - Full LUST case closure granted November, 2017
 - Free product was reduced from a 46-acre plume to undetectable
 - Dissolved benzene and MTBE concentrations reduced from thousands of ug/L range to below drinking water standards
 - Total operational cost below \$1.00 per pound
- Biodegradation was the primary treatment mechanism
 - 15,000,000 pounds (86% of total) biodegraded
 - 2,550,000 pounds (14% of total) volatilized
 - 53,000 pounds (<1% of total) removed as free product
- Confirmation of soil remediation was conducted with soil-gas sampling and site closure was approved using a risk-based approach
 - Saved client thousands of dollars in drilling/soil sampling costs