

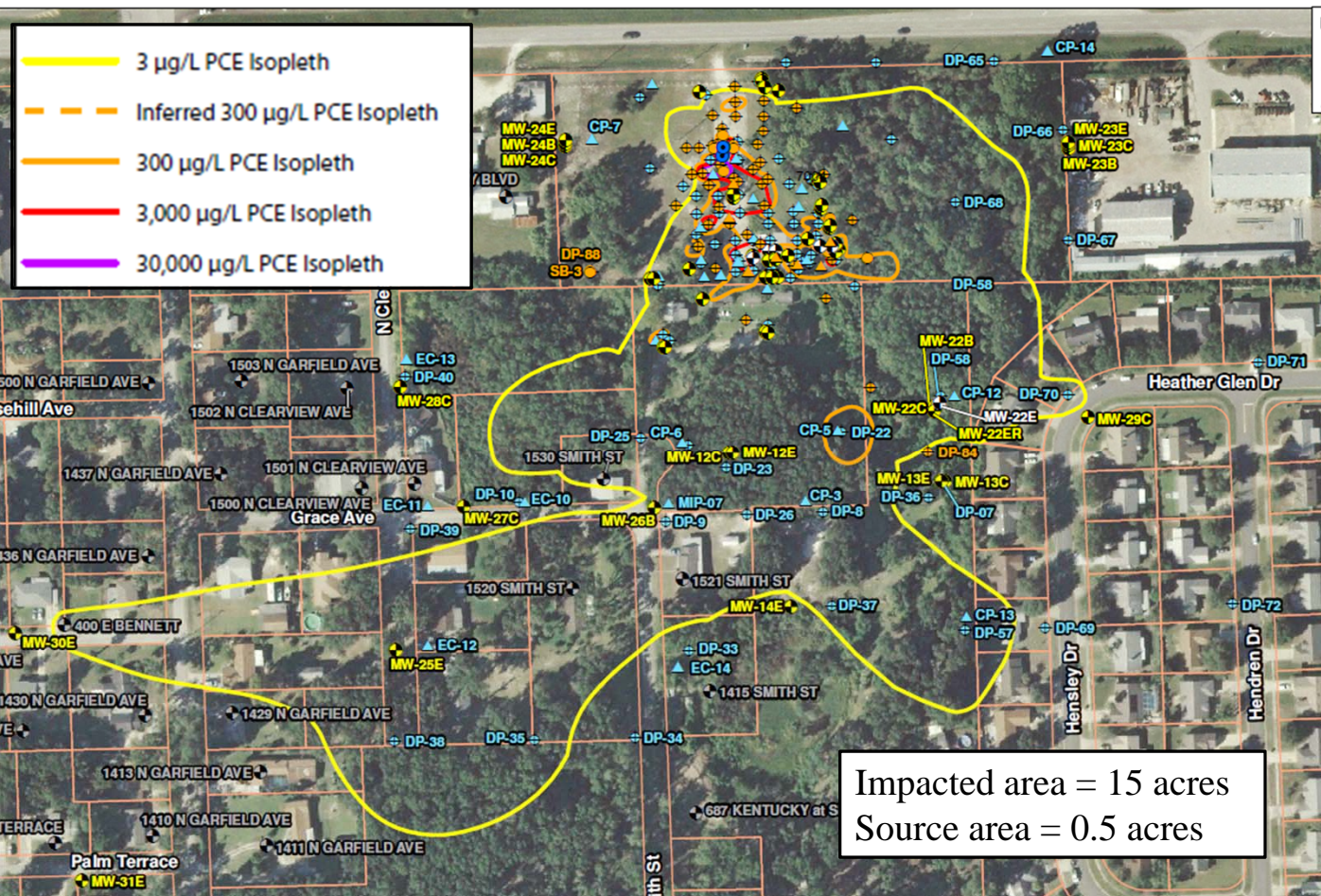
CREATIVE THINKING
EXCEPTIONAL SOLUTIONS

Geosyntec[®]
consultants

Real-Time Data Monitoring during Source
Zone Remediation using Large Diameter
Auger with Steam and Zero-Valent Iron

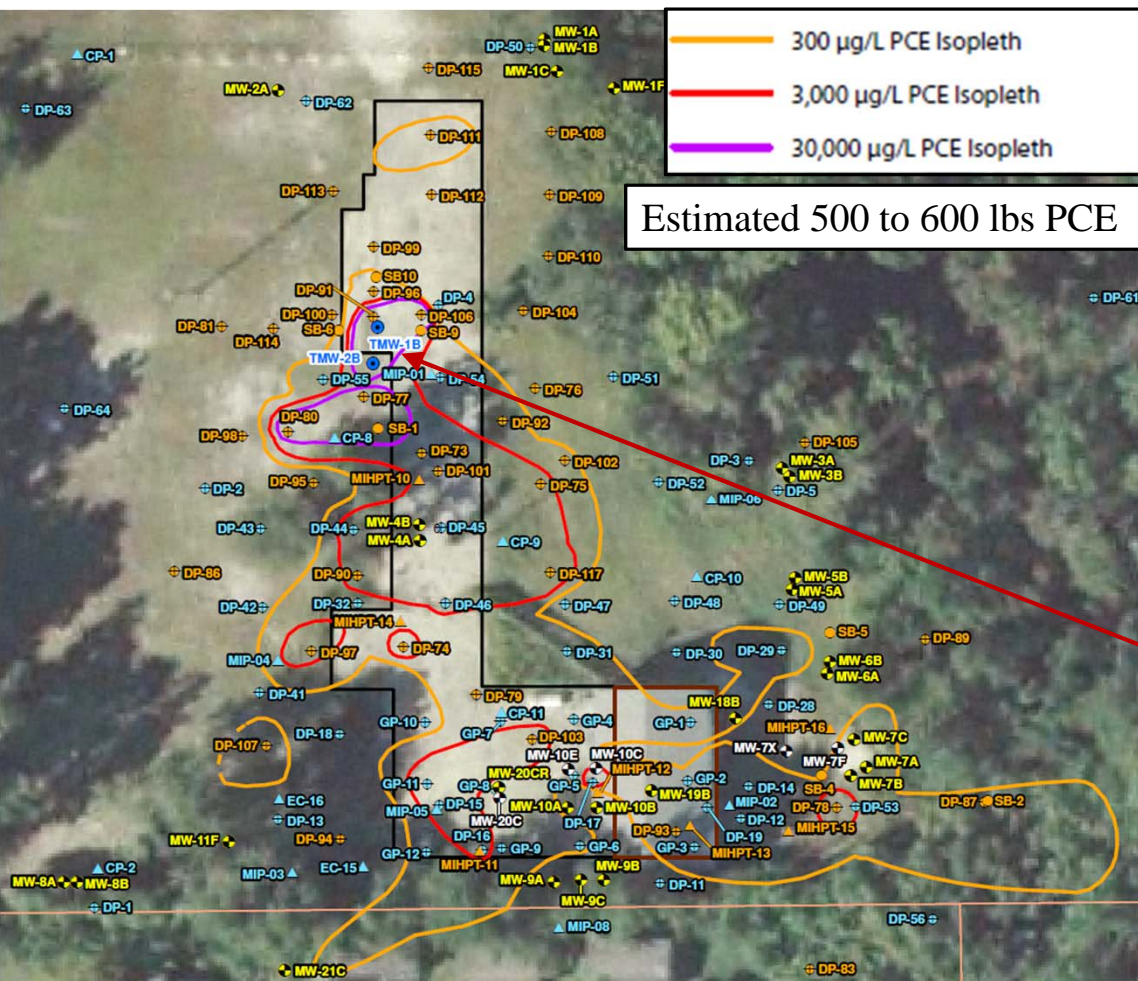
Catherine Soistman, P.E.

Site Background



- Building G – Former syringe manufacturer in Central Florida
- Chlorinated solvents – PCE and daughter products
- Maximum groundwater concentration of 400,000 µg/L PCE
- Remedial goal of 3 µg/L PCE

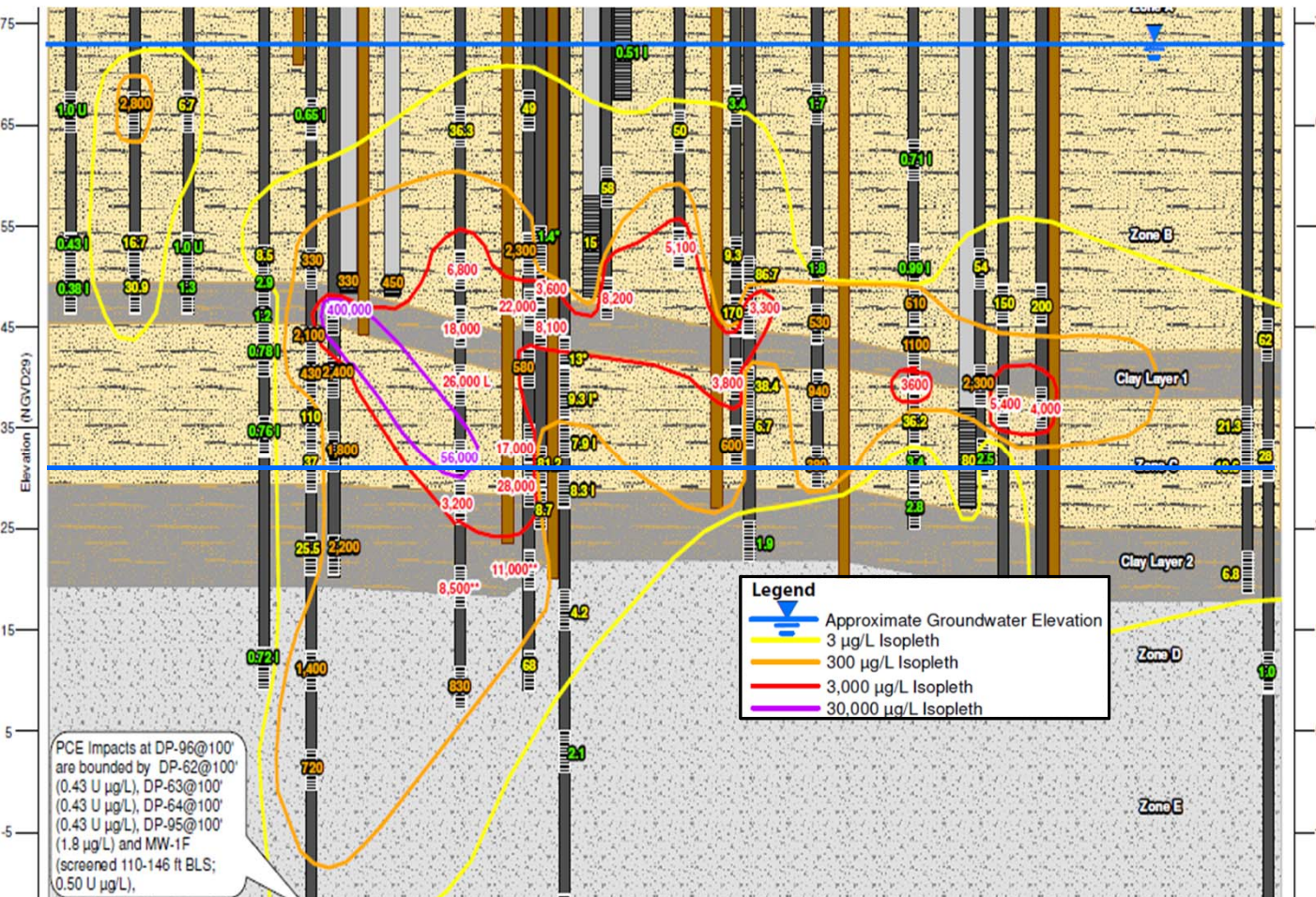
Site Background



- Discrete interval soil and groundwater sampling identified DNAPL source likely associated with historical sump feature



Site Background



- Sandy lithology with two clay layers
- Contamination focused in and between the clay layers
- Large dilute plume below the clay layers (90 ft bls)
- 40 ft head difference across the clay layers – strong vertical downward gradient



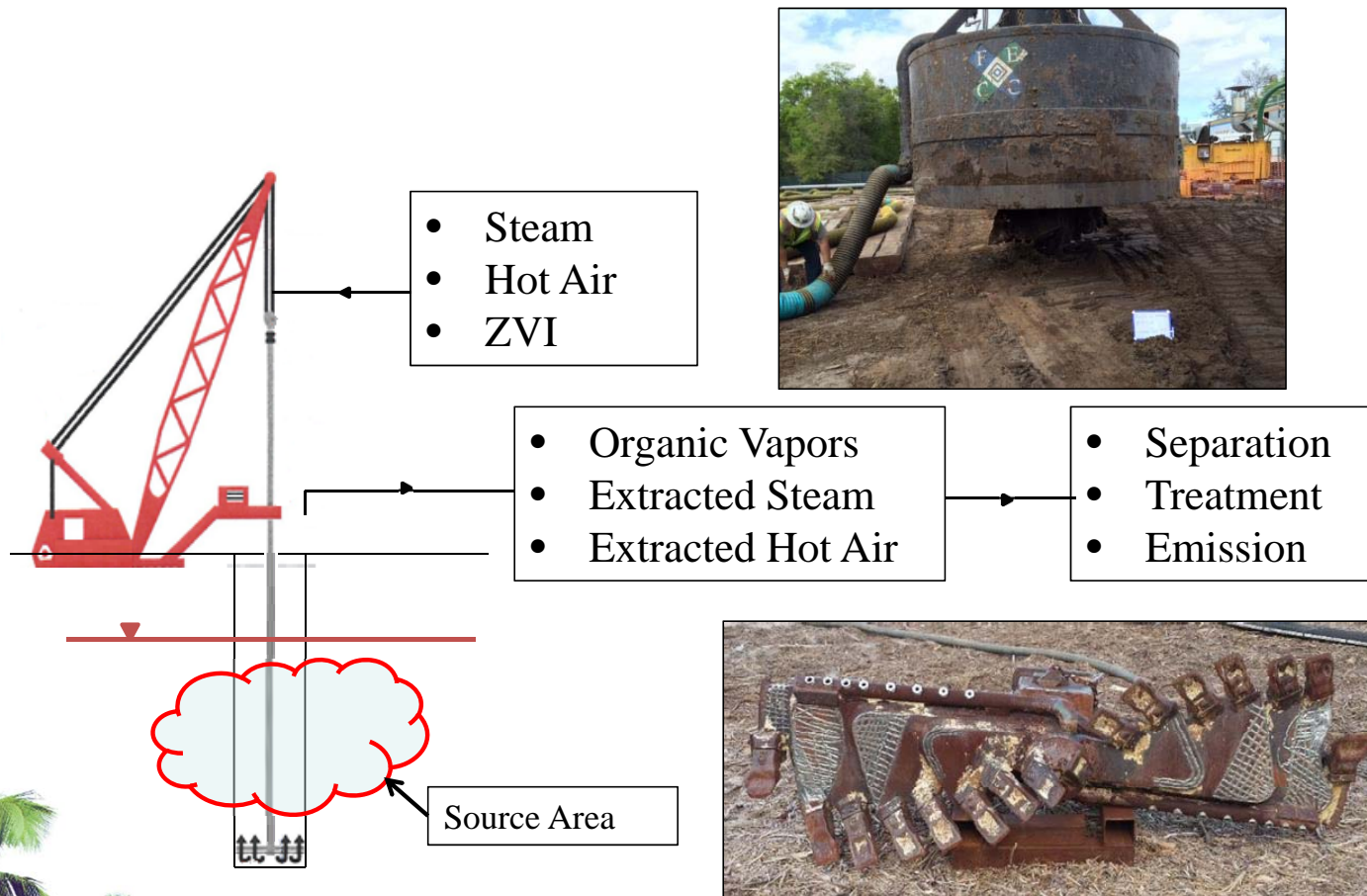
Remedial Action Plan

- Aggressive remediation of source area (defined as area with PCE $>3,000 \mu\text{g/L}$)
 - Remove the majority of the mass and
 - Enhance plume natural attenuation and stability
- Long-term monitoring of lower concentration VOC plume and source area (following aggressive remediation)

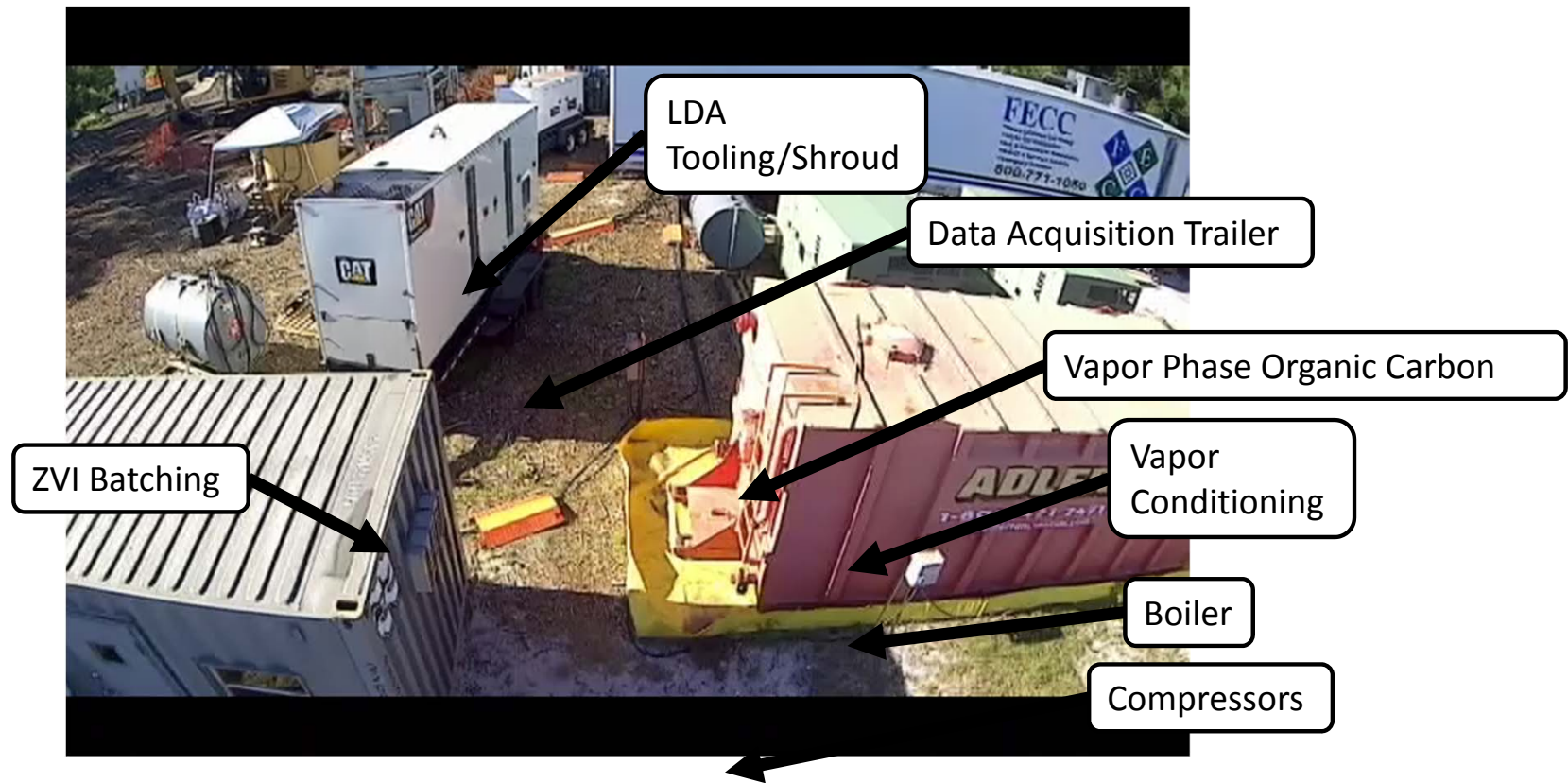
LDA-Steam/ZVI Technology Overview

- Large diameter auger (LDA) mixing with injection of steam and zero valent iron (ZVI):
 - 8 ft diameter LDA soil mixing
 - Steam injection
 - Extraction and treatment of vapors using a closed vacuum system
 - Injection of ZVI slurry treatment mixture to address residual VOCs
- Benefits of the technology:
 - Particularly effective in heterogeneous source zones and low permeability layers
 - Flexible – can easily move tool for lateral step-outs
 - Able to adaptively target intervals based on actual contaminant removal

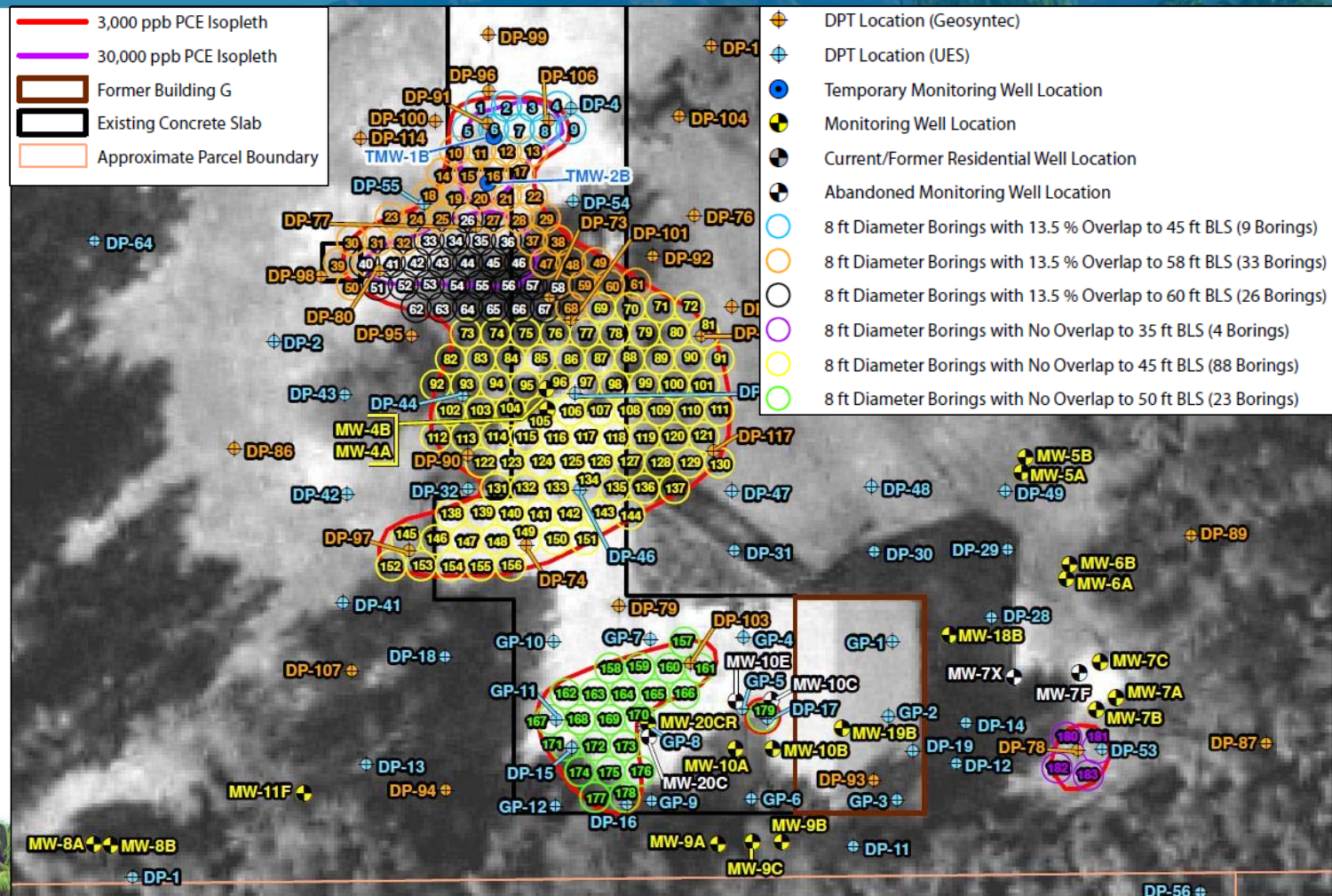
LDA-Steam/ZVI Technology Overview



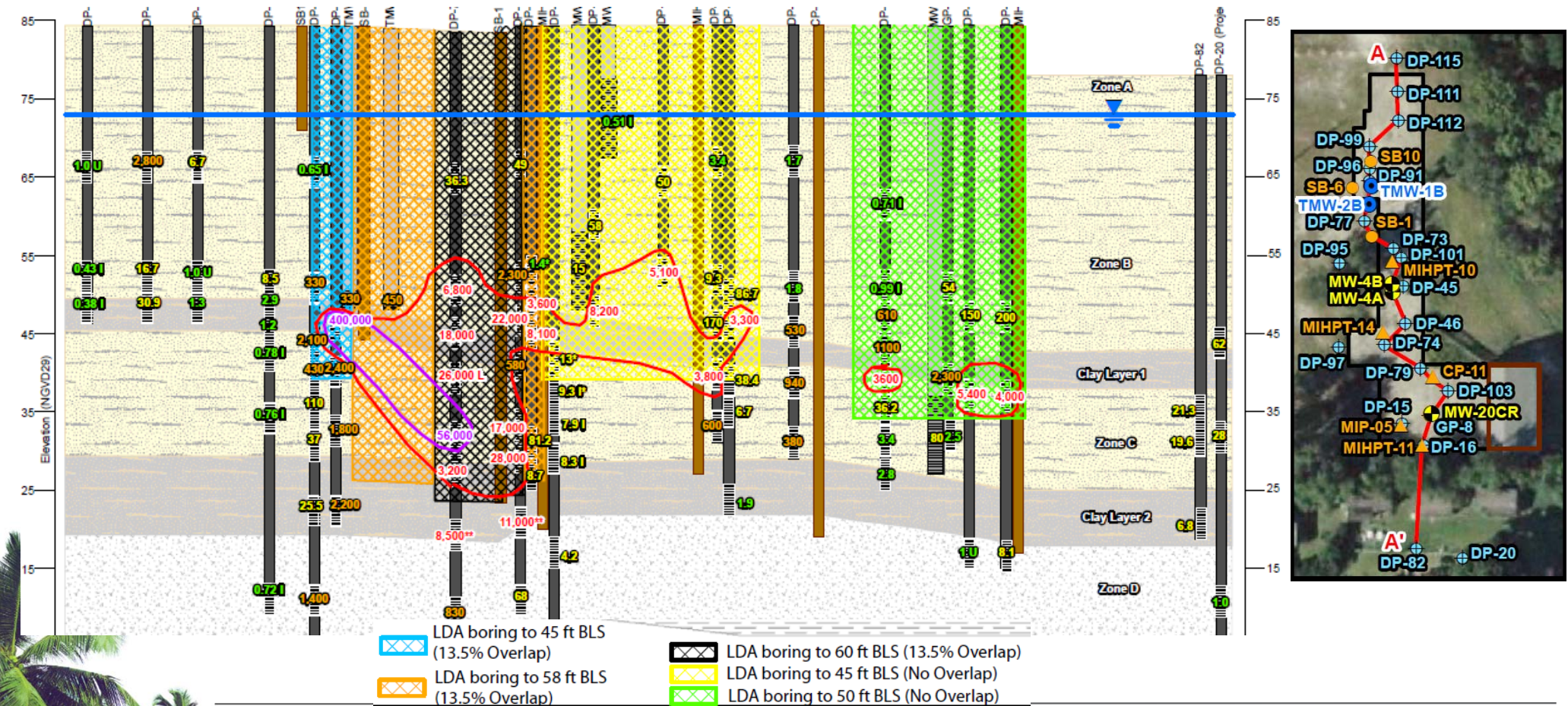
LDA/Steam/ZVI Treatment Process



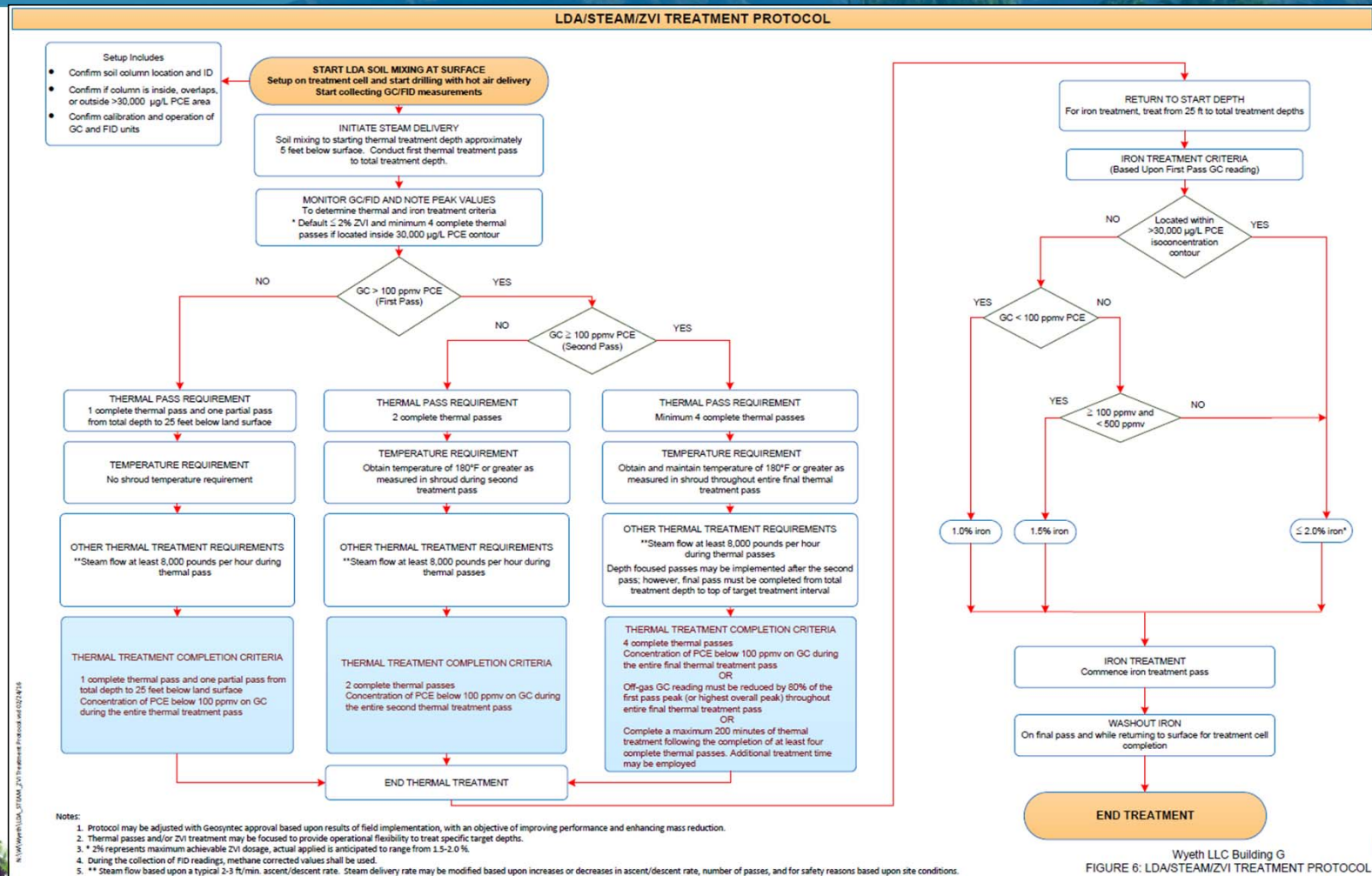
Planned LDA Boring Layout



Planned LDA Boring Layout: Cross-Section



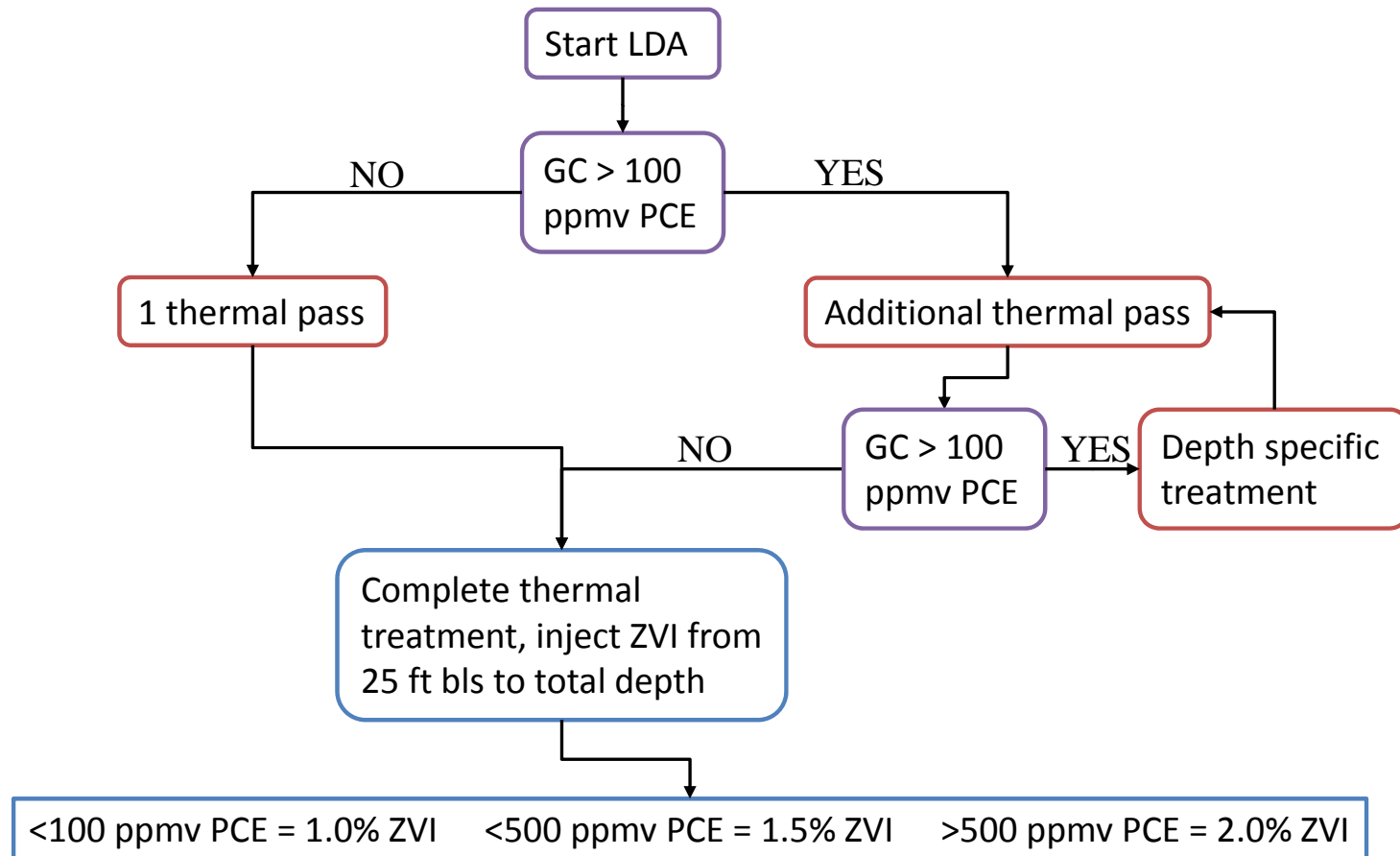
LDA/Steam/ZVI Treatment Protocol



Notes:

- Protocol may be adjusted with Geosyntec approval based upon results of field implementation, with an objective of improving performance and enhancing mass reduction.
- Thermal passes and/or ZVI treatment may be focused to provide operational flexibility to treat specific target depths.
- * 2% represents maximum achievable ZVI dosage, actual applied is anticipated to range from 1.5-2.0%.
- During the collection of FID readings, methane corrected values shall be used.
- ** Steam flow based upon a typical 2-3 ft/min. ascent/descent rate. Steam delivery rate may be modified based upon increases or decreases in ascent/descent rate, number of passes, and for safety reasons based upon site conditions.

LDA/Steam/ZVI Treatment Protocol



Real-Time Data Monitoring

- Parameters monitored during thermal treatment and used to make real-time decisions include:
 - Auger depth;
 - Shroud temperature;
 - VOCs in the off gas using an organic vapor analyzer-flame ionization detector (FID); and
 - CVOCs in the off gas using gas chromatographs.
- Additional parameters were monitored and used for mass calculations during post-processing.

Real-Time Decision Making

Building G

LDA Boring Location

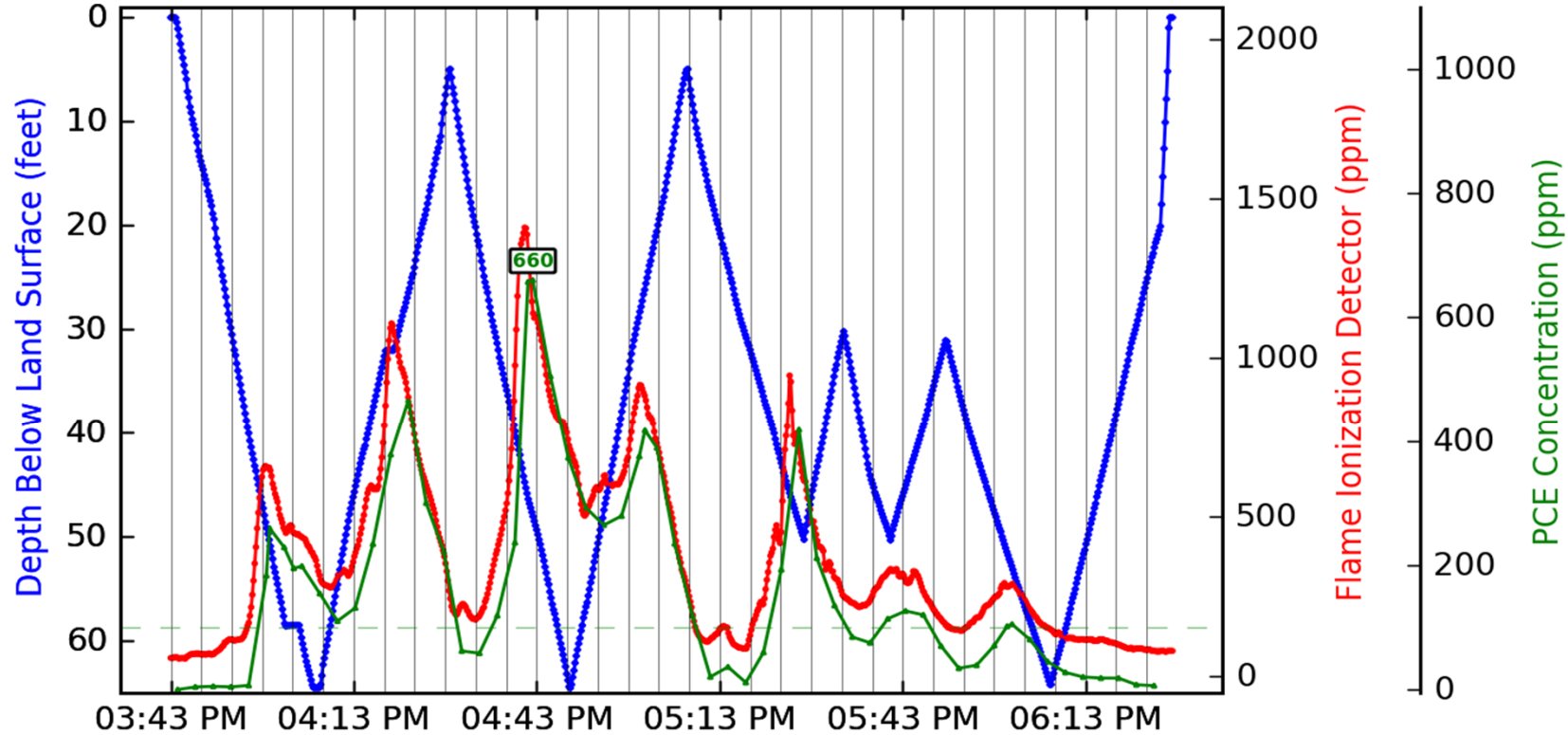
Date 27 Mar 2017
Boring Start Time 03:43 PM
Boring End Time 06:27 PM
Elapsed Time (minutes) 164.2
Boring Total Depth (feet) 64.6

Cell 032

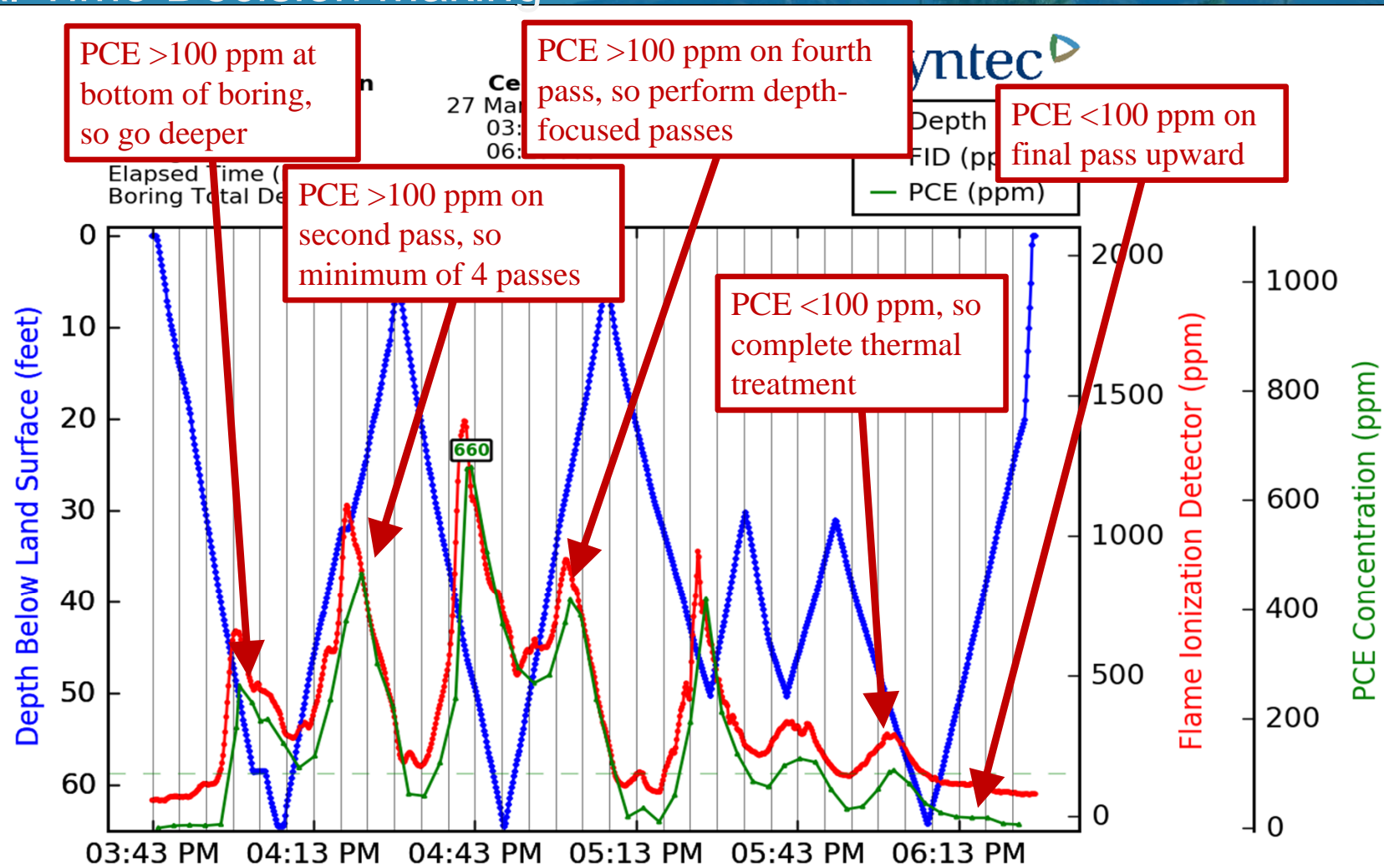
27 Mar 2017
03:43 PM
06:27 PM
164.2
64.6

Geosyntec

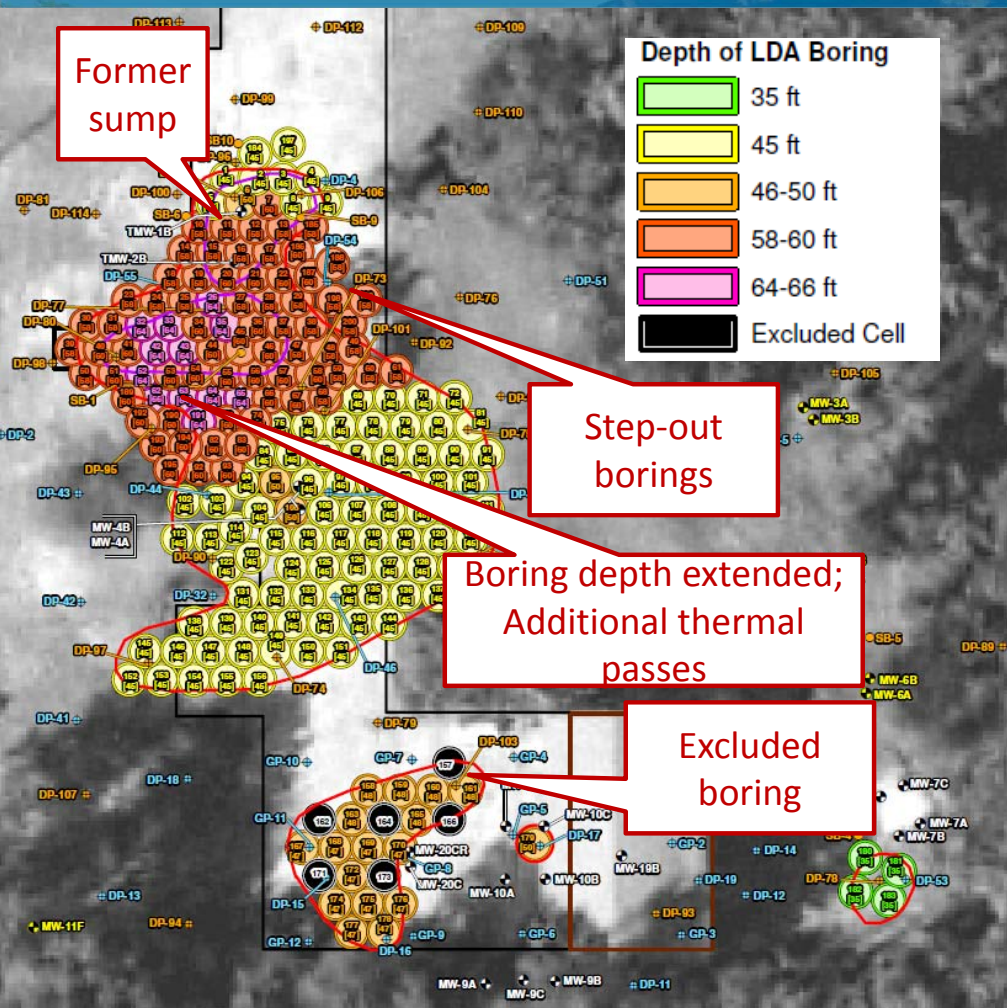
— Depth (feet)
— FID (ppm)
— PCE (ppm)



Real-Time Decision Making

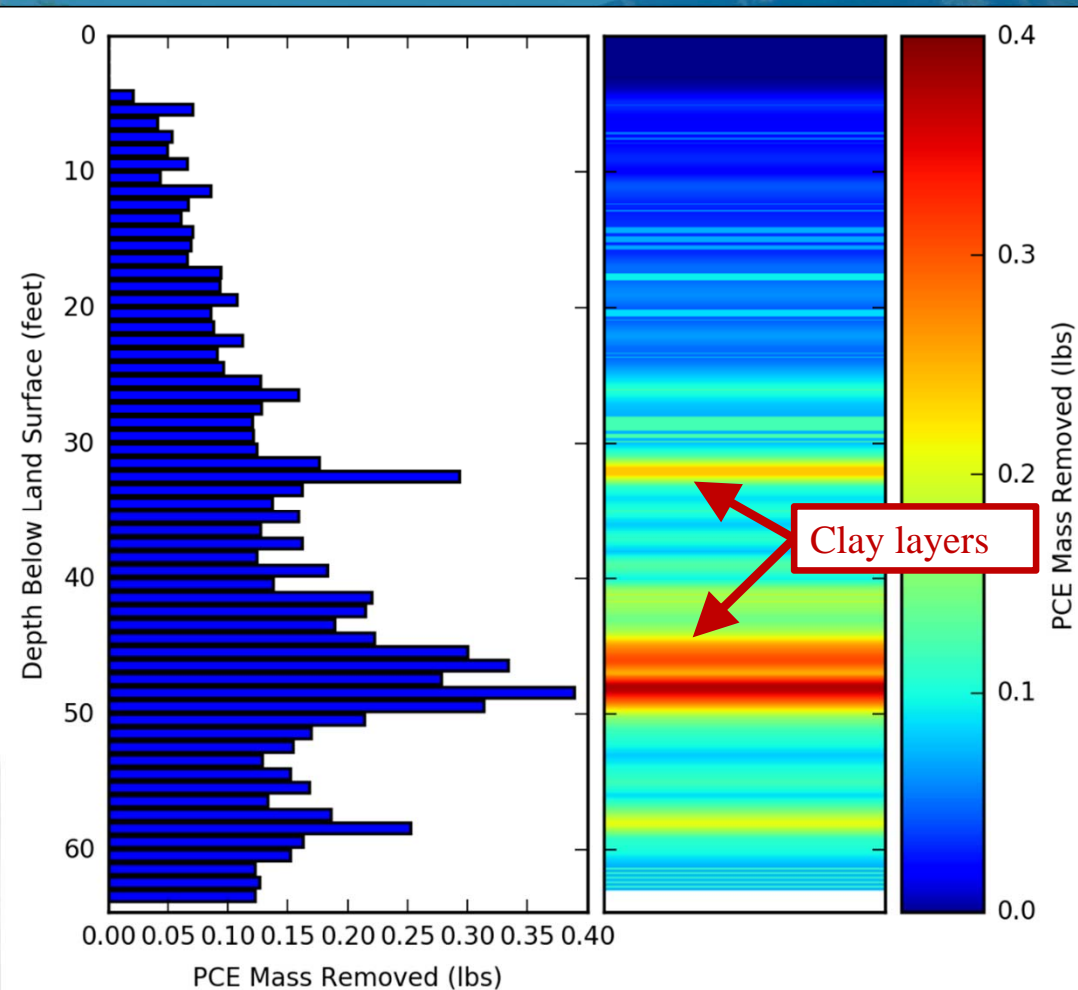


Real-Time Decision Making



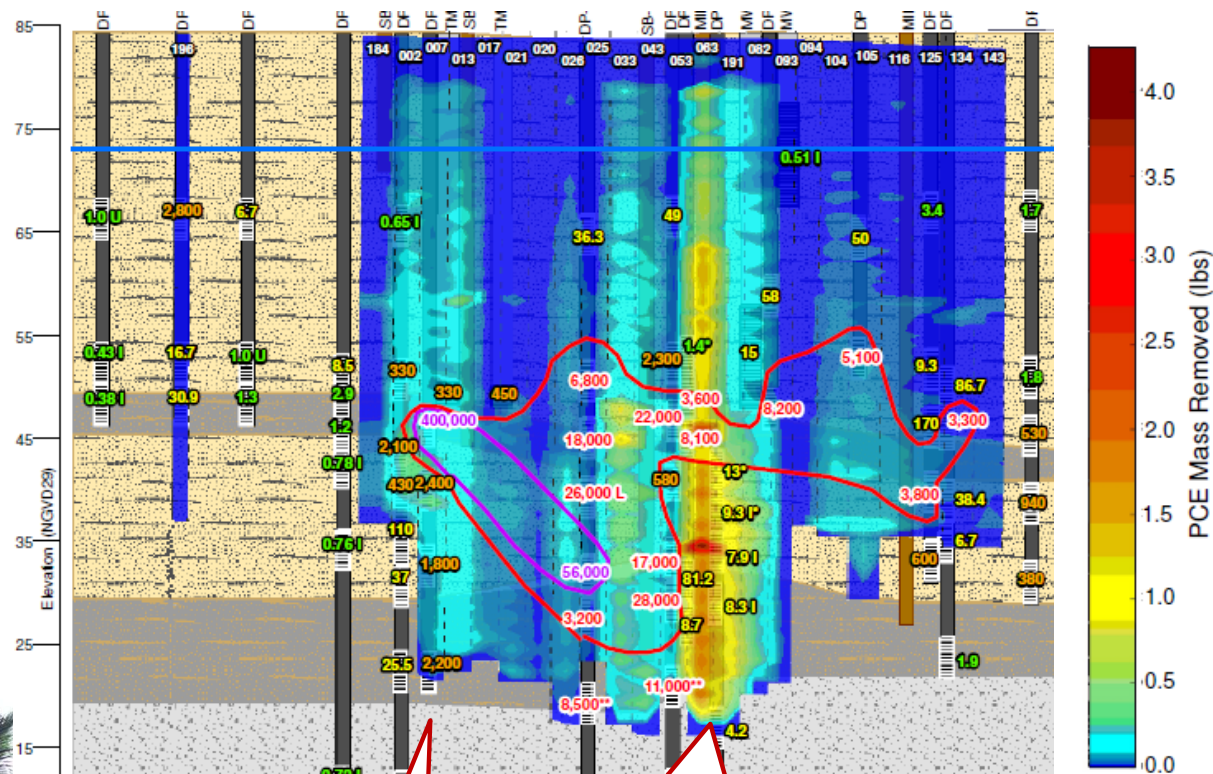
- Real-time data was also utilized to refine the treatment area by excluding planned borings and adding step-out borings.

Post-Processing of Data: Mass PCE Removed



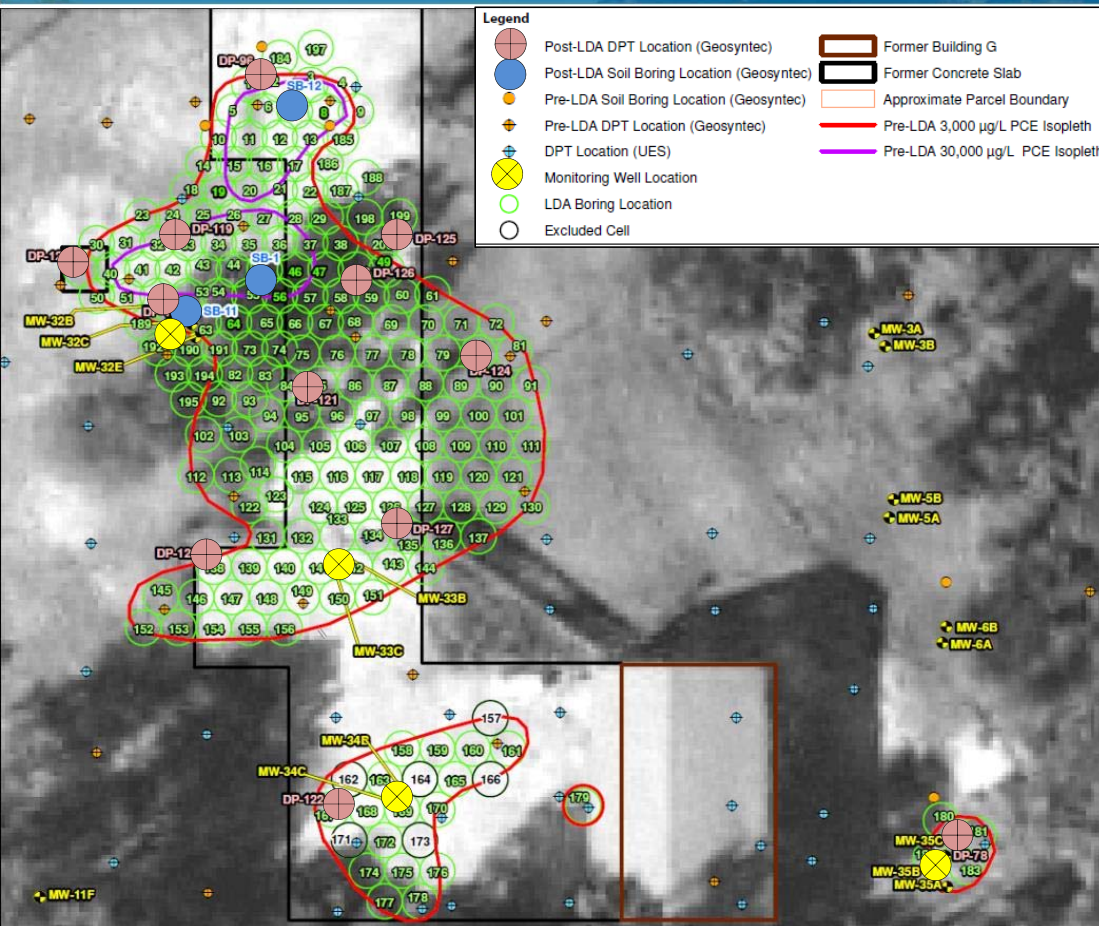
- Post-processing of data allowed us to calculate the mass removed per depth interval in each boring.
- The majority of the mass was removed from the two clay layers.

Post-Processing of Data: Mass PCE Removed



- Combining the data from individual borings allowed us to visualize a cross-section of the distribution of mass removed.

Performance Monitoring



- Collected discrete groundwater samples at 11 locations using direct push technology (DPT)
- Performed three soil borings with saturated soil sampling
- Installed and sampled four monitoring well clusters

Performance Monitoring: Soil Analytical Results

Pre-LDA Saturated Soil Results

DP-96					
Date	Depth	PCE	TCE	cis-1,2-DCE	VC
2/19/2014	37	86	2.0 U	2.0 U	1.4 U
	37 (DUP)	89	2.0 U	2.0 U	1.4 U

DP-96

SB-1

SB-1					
Date	Depth	PCE	TCE	cis-1,2-DCE	VC
8/29/2013	37	1,700	0.23	0.20 U	0.20 U
	41	100	0.32	0.010 U	0.010 U
	44	1.9	0.01 U	0.010 U	0.010 U
	49	19	1.0 U	1.0 U	1.0 U
	54	0.18	0.01 U	0.010 U	0.010 U
	58	0.098	0.01 U	0.010 U	0.010 U

PCE detected in every sample with maximum of 1,700 mg/kg at SB-1@37 ft bls

Post-LDA Saturated Soil Results

SB-12					
Date	Depth	PCE	TCE	cis-1,2-DCE	VC
1/8/2018	30	0.015 U	0.015 U	0.015 U	0.005 U
	35	0.016 U	0.016 U	0.016 U	0.0052 U
	37	0.016 U	0.016 U	0.016 U	0.0053 U
	41	0.014 U	0.014 U	0.014 U	0.0046 U
	44	0.015 U	0.015 U	0.015 U	0.005 U

SB-12

SB-1

SB-11

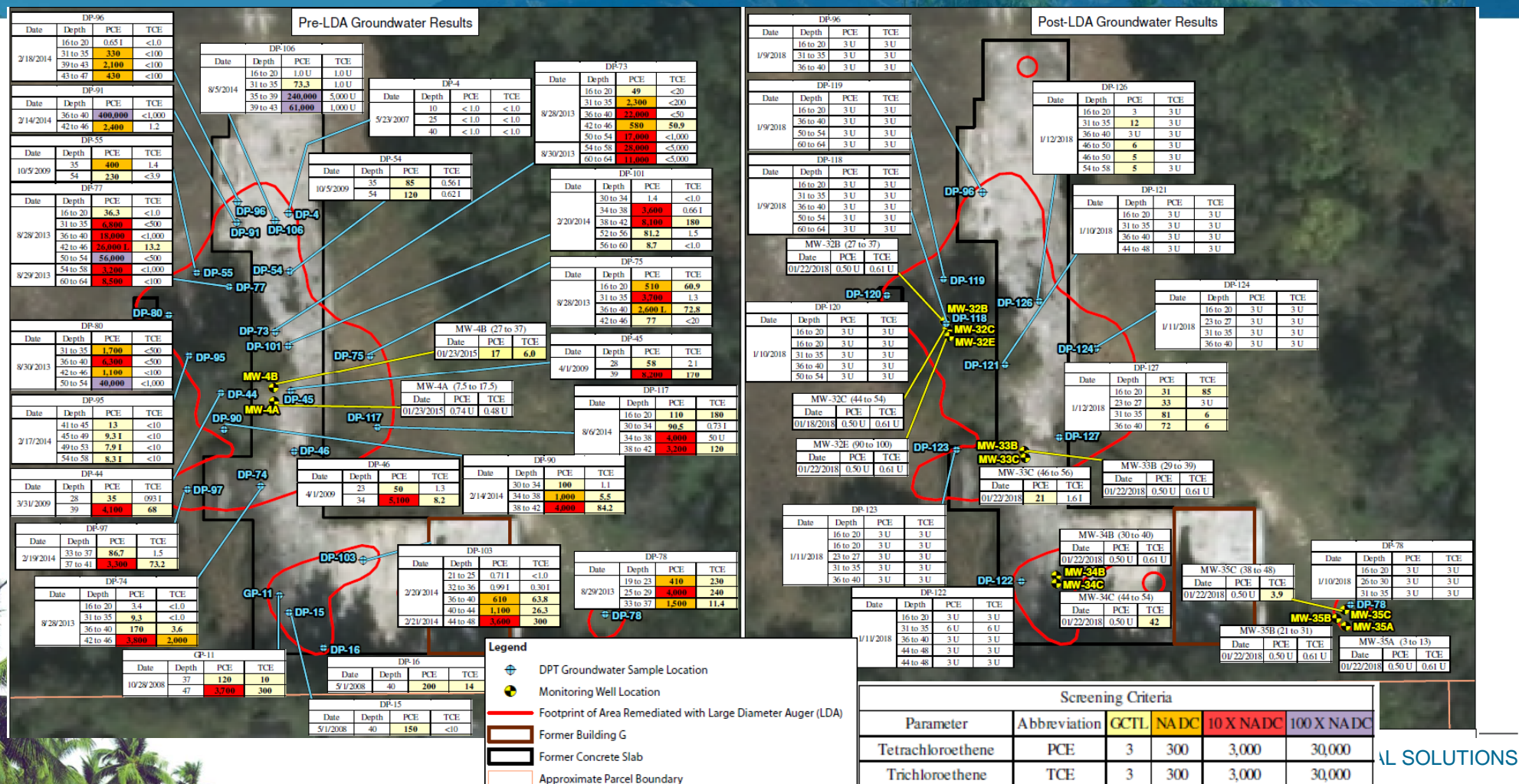
SB-11					
Date	Depth	PCE	TCE	cis-1,2-DCE	VC
1/8/2018	23	0.017 U	0.017 U	0.017 U	0.0055 U
	31	0.013 U	0.013 U	0.013 U	0.0044 U
	38	0.013 U	0.013 U	0.013 U	0.0043 U
	41	0.013 U	0.013 U	0.013 U	0.0043 U
	47	0.016 U	0.016 U	0.016 U	0.0054 U
	47	0.016 U	0.016 U	0.016 U	0.0054 U
	52	0.016 U	0.016 U	0.016 U	0.0053 U
	59	0.016 U	0.016 U	0.016 U	0.0052 U
	64	0.017 U	0.017 U	0.017 U	0.0057 U
	68	0.014 U	0.014 U	0.014 U	0.0047 U

SB-1					
Date	Depth	PCE	TCE	cis-1,2-DCE	VC
1/8/2018	31	0.015 U	0.015 U	0.015 U	0.005 U
	33	0.015 U	0.015 U	0.015 U	0.005 U
	35	0.014 U	0.014 U	0.014 U	0.0047 U
	37	0.015 U	0.015 U	0.015 U	0.005 U
	40	0.015 U	0.015 U	0.015 U	0.0052 U
	44	0.015 U	0.015 U	0.015 U	0.005 U

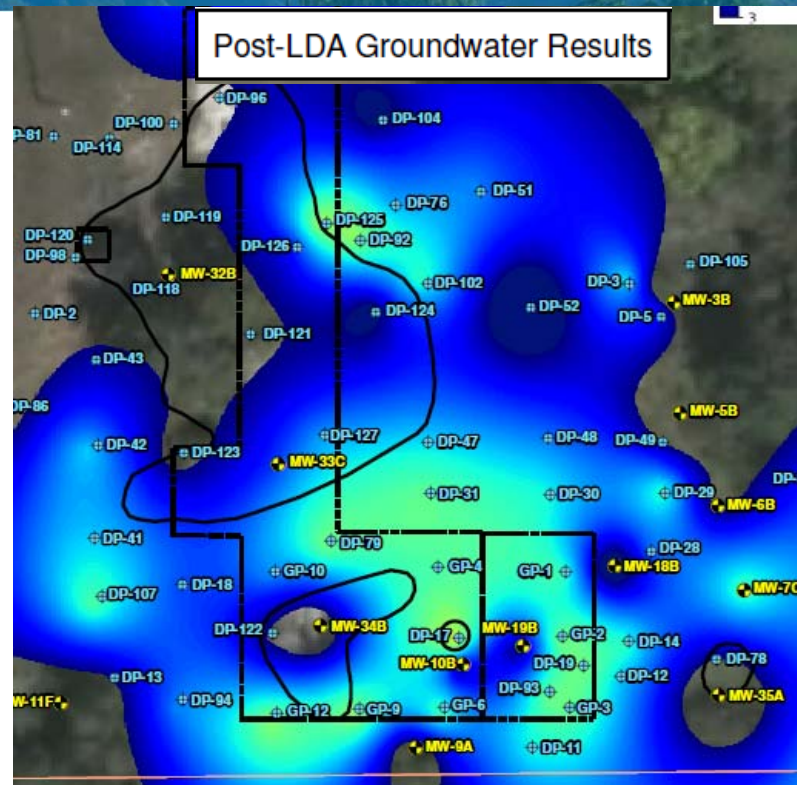
No CVOCs detected, including at SB-1@37 ft bls

- Soil Boring Location
- Footprint of Area Remediated with Large Diameter Auger (LDA)
- Former Building G
- Former Concrete Slab
- Approximate Parcel Boundary

Performance Monitoring: Groundwater Analytical Results



- Groundwater 300 m



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Summary of Benefits of Real-Time Data Monitoring

- Real-time data was utilized to maximize treatment efficiency including:
 - Performing additional thermal passes at borings
 - Treating deeper at borings
 - Excluding planned borings
 - Adding step-out borings
- The data was used to confirm that the requirements of the treatment protocol were achieved.
- Post-processing of data allowed us to calculate the incremental mass removed throughout the treatment area and depths.



Results

- Real-time data collection and an adaptive treatment protocol enabled Geosyntec to maximize remediation efficiency and effectiveness by focusing treatment on areas of elevated mass
- Post-LDA soil and groundwater sampling indicate that the treatment goals were achieved, allowing the site to transition to natural attenuation



Acknowledgements

We would like to acknowledge...

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