Highly Complex In Situ Thermal Remediations

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Outline

- Technology fundamentals
- ISTR methods
- Site complexities
- Implementation tools
- Case studies

1,2-DCB boils at 179°C

Azeotrope boils at 98°C

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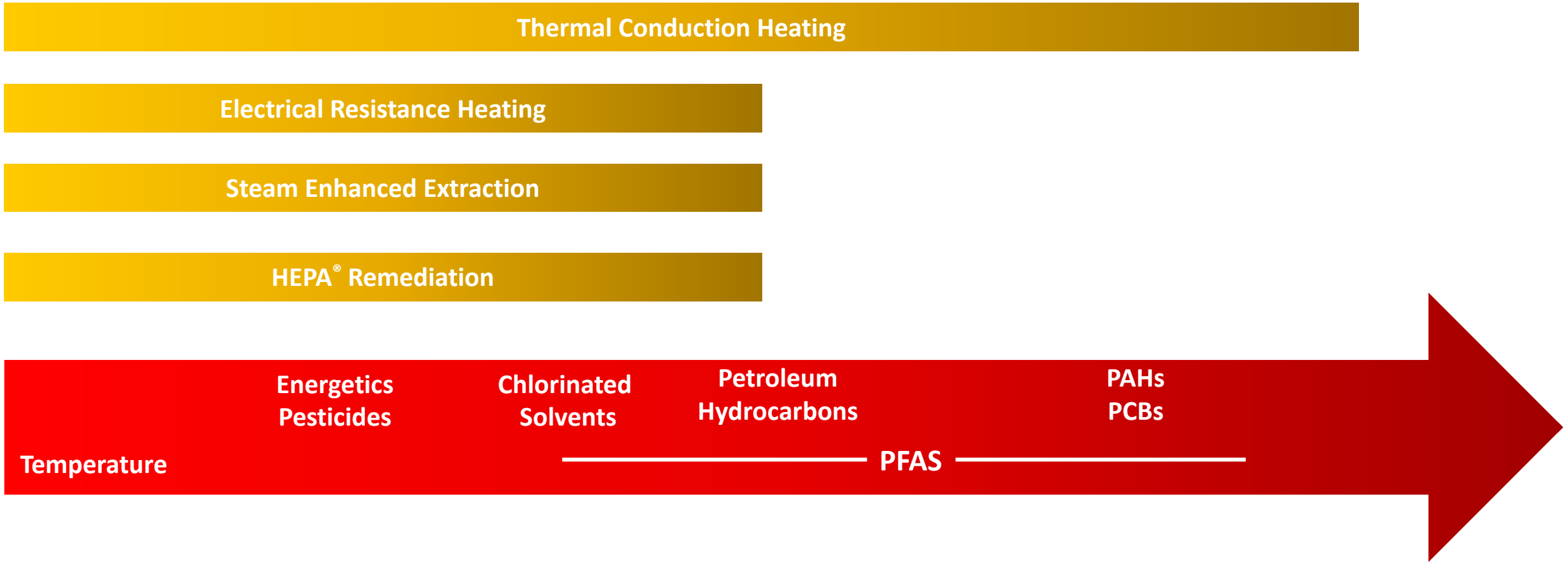
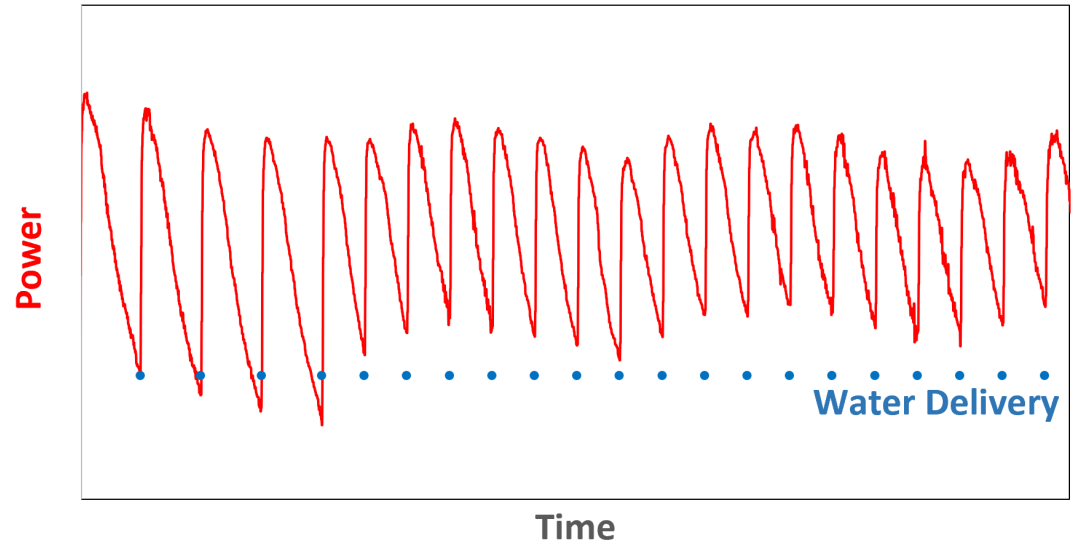
Thermal Technologies – “All in”



Selection Driven by Cost Effectiveness

- Efficient power delivery
- Robust HeatWave™ modeling
  - Optimizes energy density
  - Informs technology selection
- SCADA platform for process control
- Remote monitoring systems



Maximized **power density**
Optimized **water delivery**

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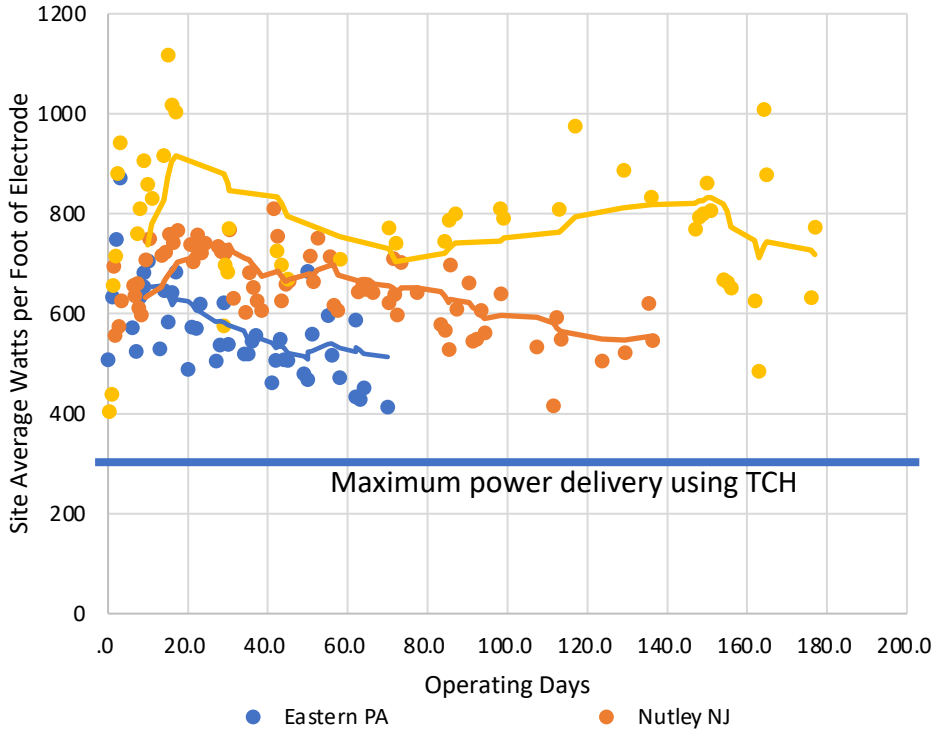
Site Complexities

- Existing infrastructure
- Conceptual site model
  - Type and amount of contaminant
  - Geology and hydrology
- Monitoring program



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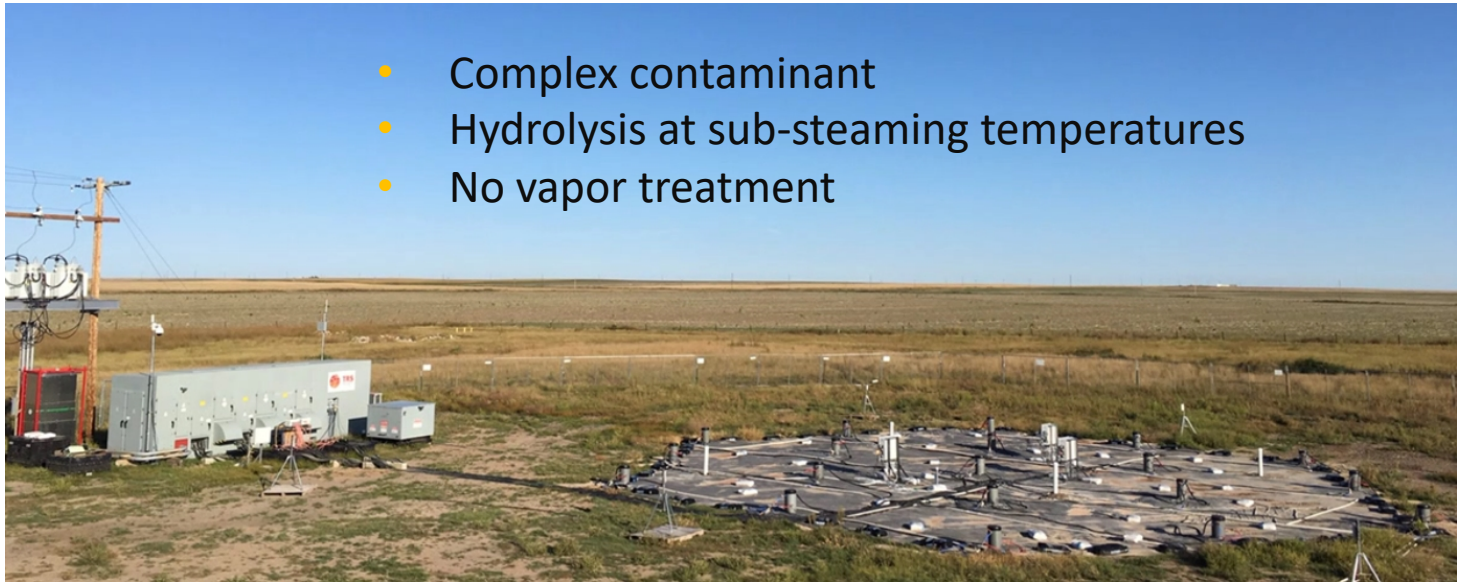
Sensitive Infrastructure

- ISTR subsurface spacing
- Type of infrastructure
- High angled drilling
- Horizontal drilling
- Robust vapor recovery

Contaminant Type

- Boiling point
- Positive heteroazeotrope
- Target temperature



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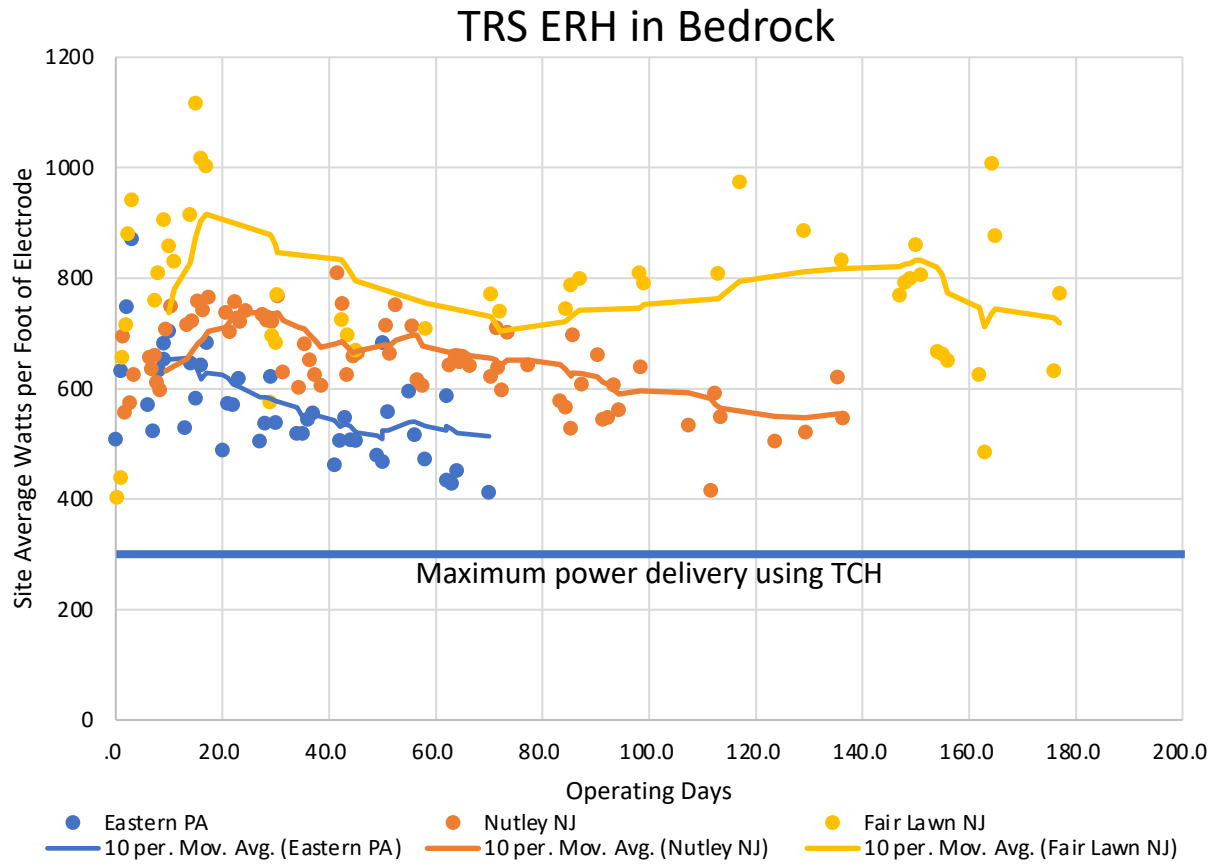
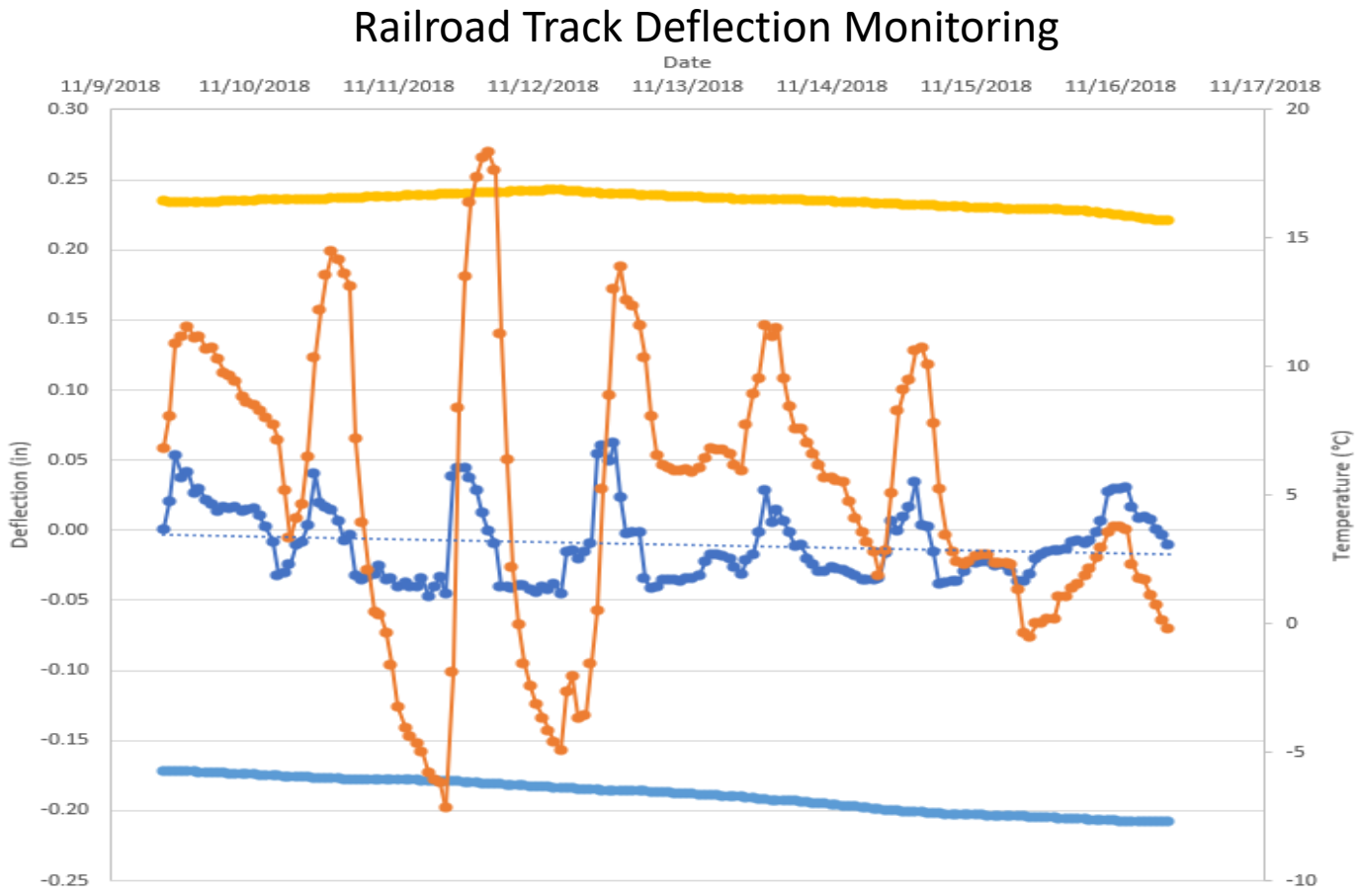
Geology and Hydrology

- Energy density
- Applied voltages
- Plenum
- Hydraulic management
- Surface cover



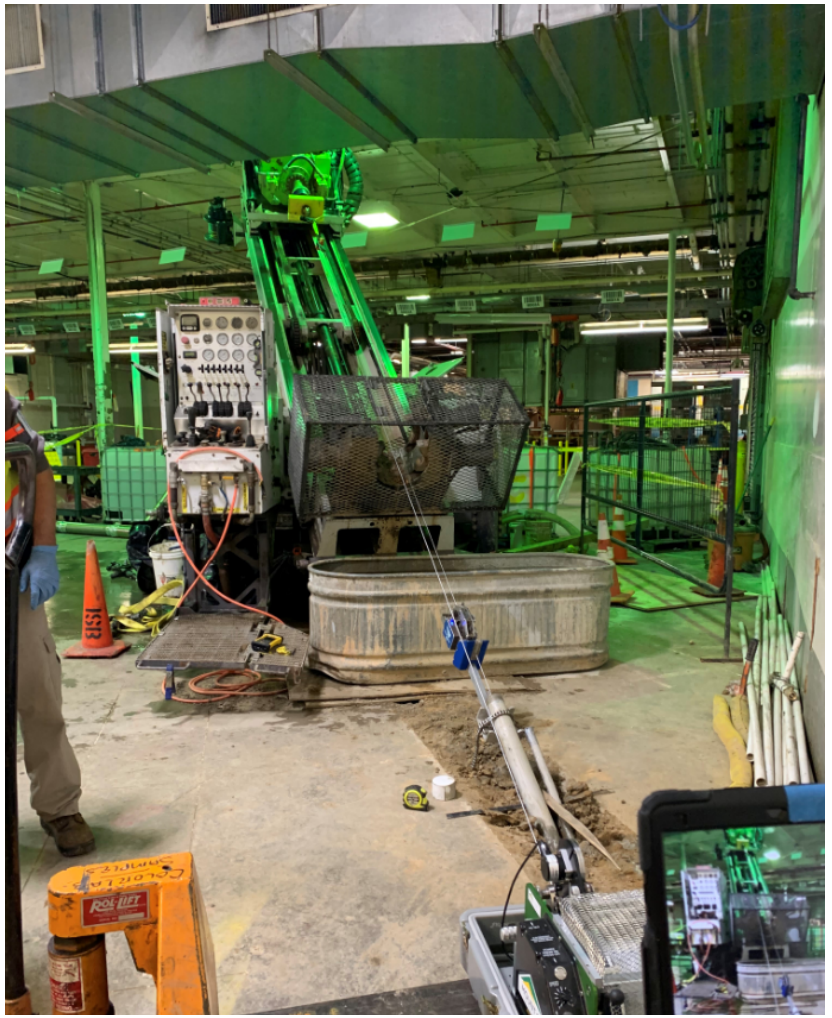
Monitoring Program

- System performance
  - Temperature
  - Process vapor
  - Soil vapor
  - Indoor air
  - Deflection
- Compliance monitoring
  - Hot soil
  - Hot groundwater
  - Soil vapor

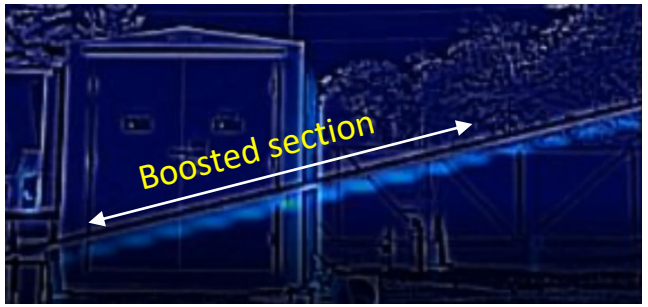


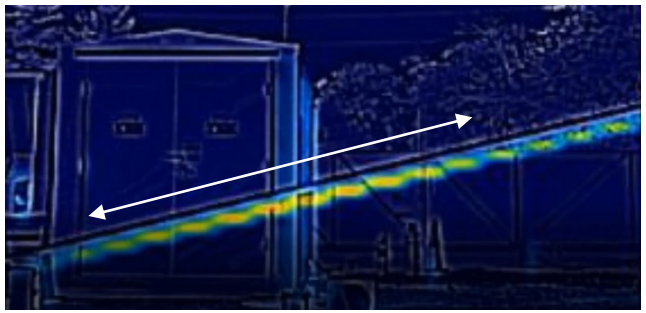
TCH at Confidential Northeast US Site

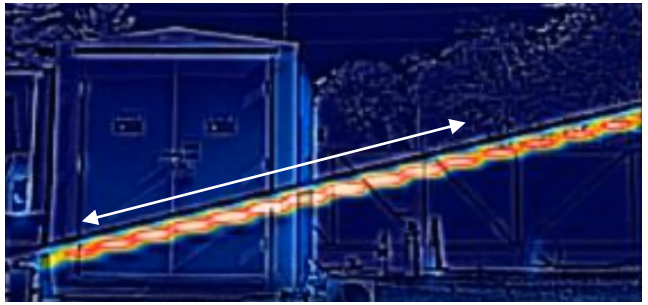
- 26,000 square feet
- 28,000 cubic yards
- Depth of treatment 65 to 120 feet
- Vadose zone
- Dense glacial till with boulders
- Access limited to a single room



Angled TCH







- Large implementation
- Angled heater elements under building
- 200 ft long borings
- Long unheated sections

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Site Adaptations

- Construction and operation sequencing
- Drilling approach
  - Multiple rigs
  - Short and long masts
  - Ventilation system
- Realtime design adjustments

DeviFlex Auto Rotate tool

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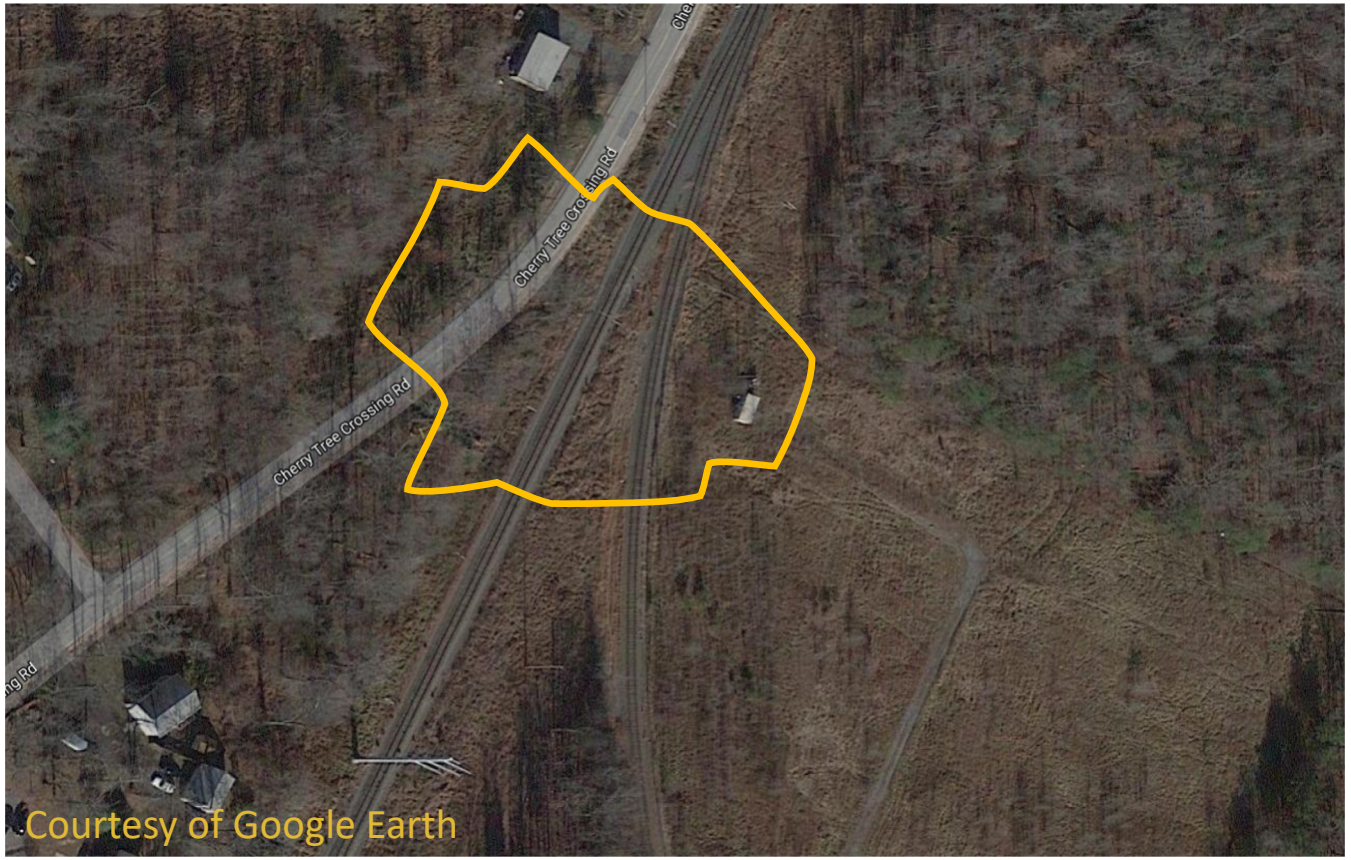
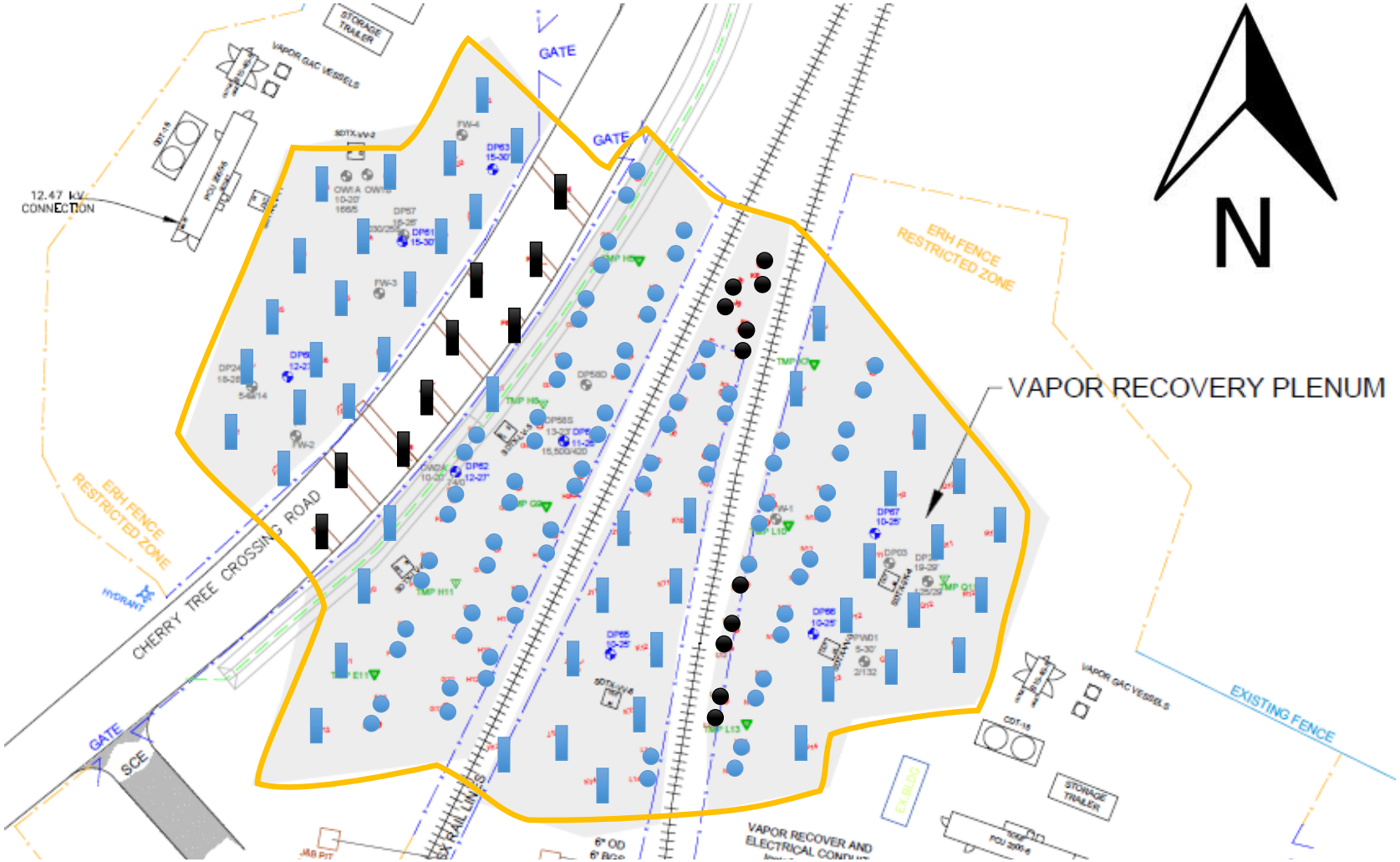
Brandywine Superfund Site, Maryland

- 37,800 square feet
- 49,000 cubic yards
- 2 to 37 feet bgs
- Vadose and saturated zone
- Sand and clay



ERH Site Plan



Subsurface Infrastructure

Vapor Recovery

CSX Railroad Tracks

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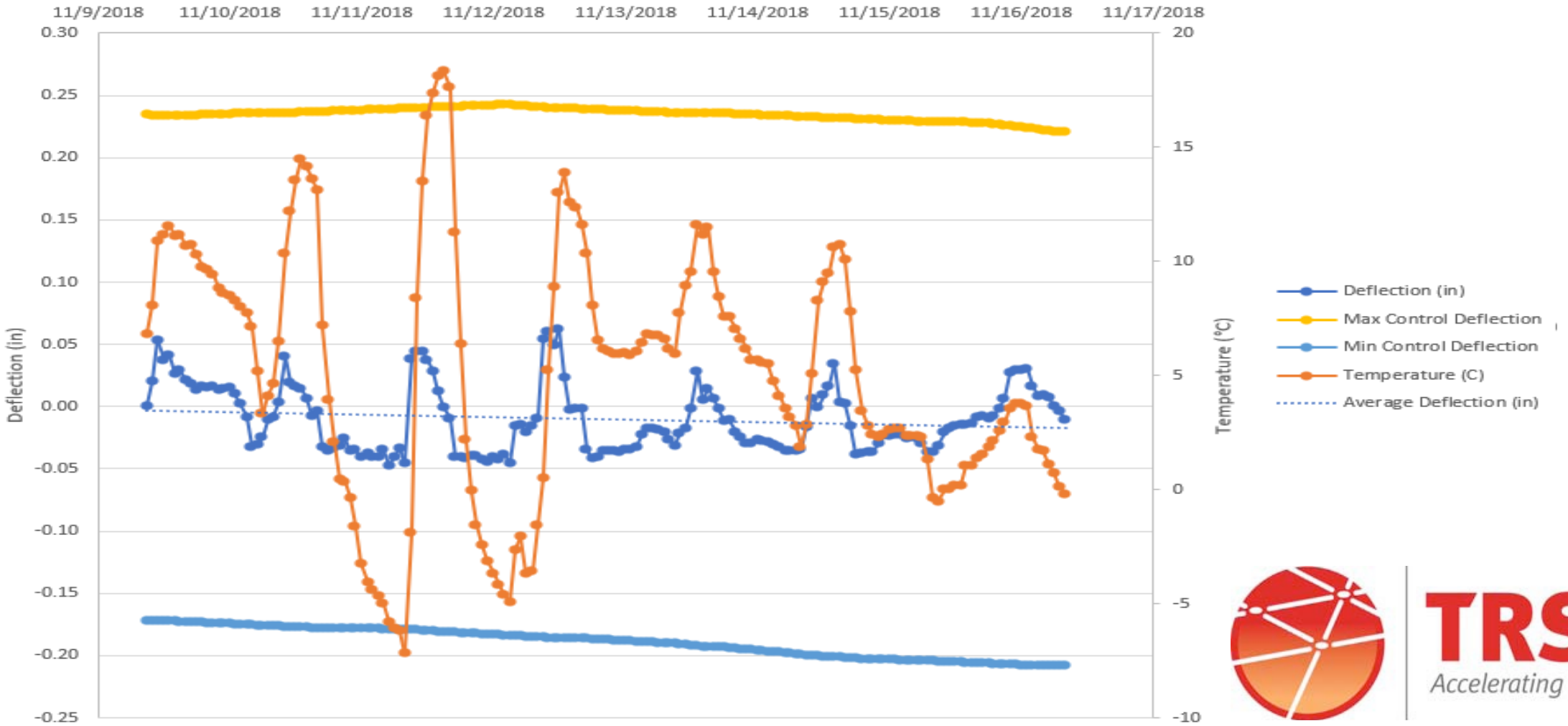
Deflection Monitoring



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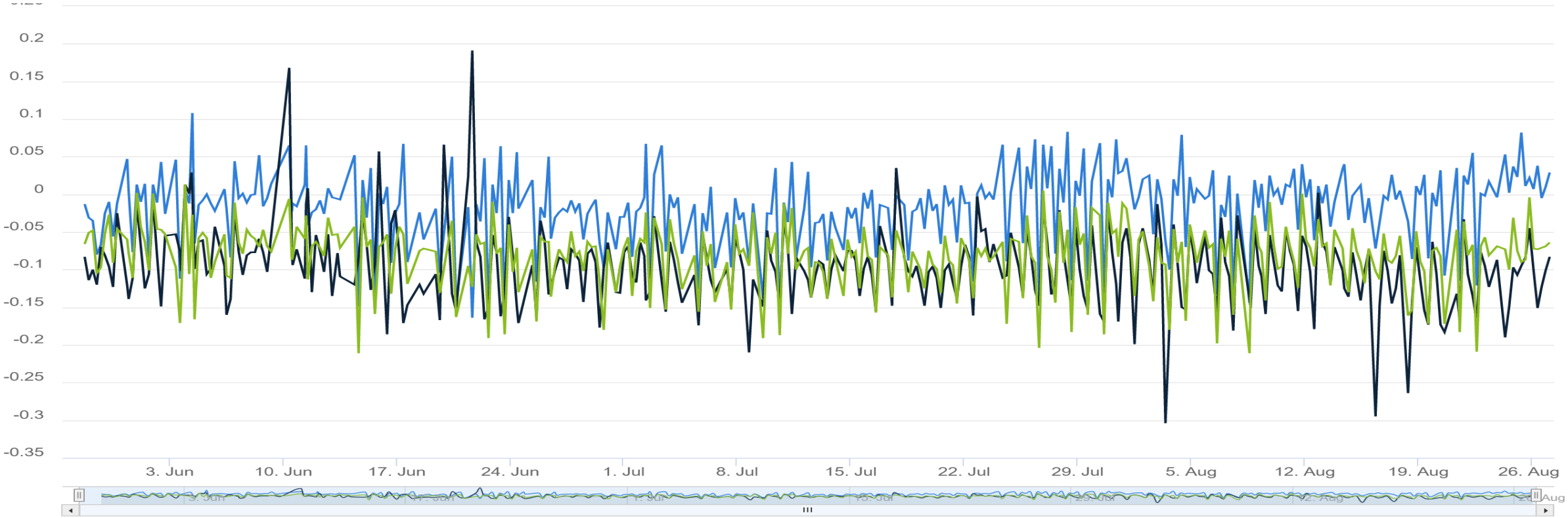
CSX Response Action Plan

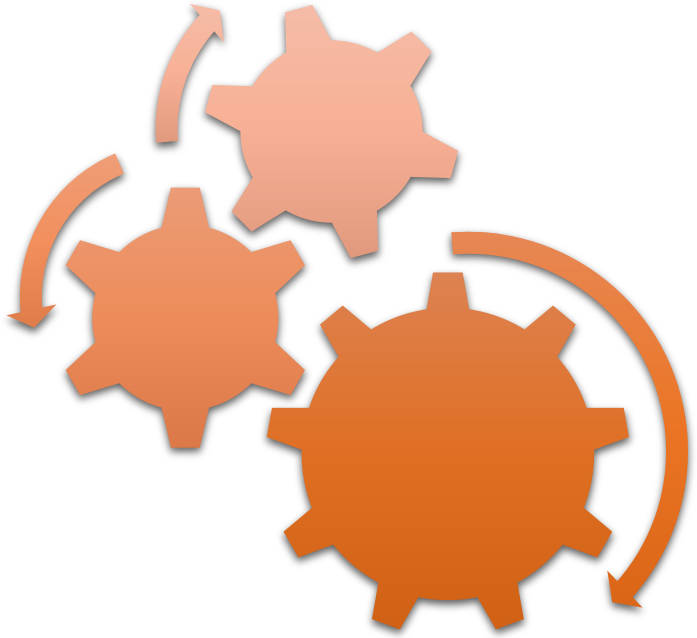
49 CFR Part 213 Requirement	No Action	Notification and Visual Inspection	Notification and Manual Survey for Confirmation	Notification and ERH System Shutdown
The deviation of the mid-offset from a 62-foot[1] line or chord[2] may not be more than 3”	<0.75”	>0.75” but <1.5”	>1.5” but <2.5”	>2.5”

Railroad Track Deformation Monitoring



Multiple Lines of Evidence

- Guarantee remediation
- Temperatures
  - Average temperature 106.3˚C
  - Over 4 months of boiling
- VOC mass removal
  - 1,716 lbs of VOCs removed
  - <0.1 lbs per day



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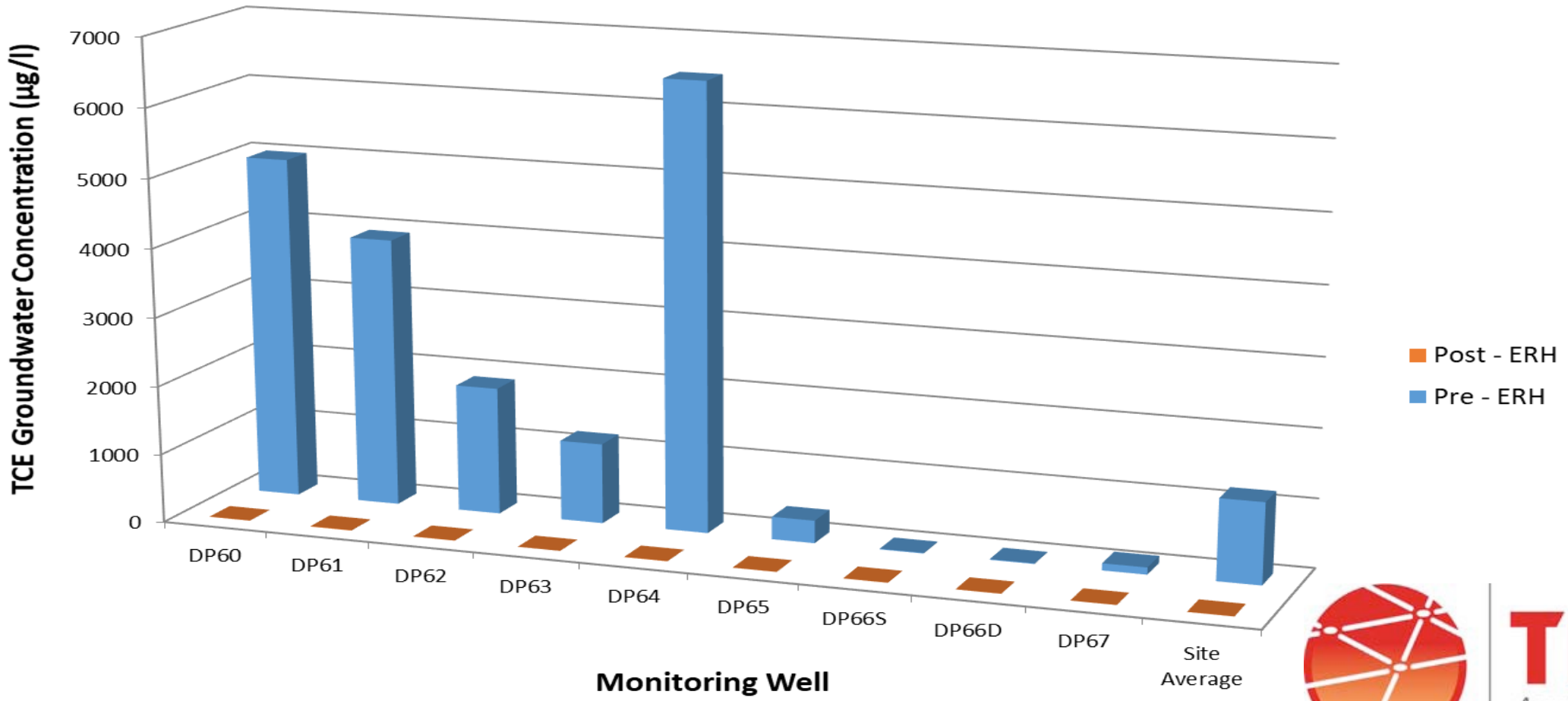
Results - Trichloroethene



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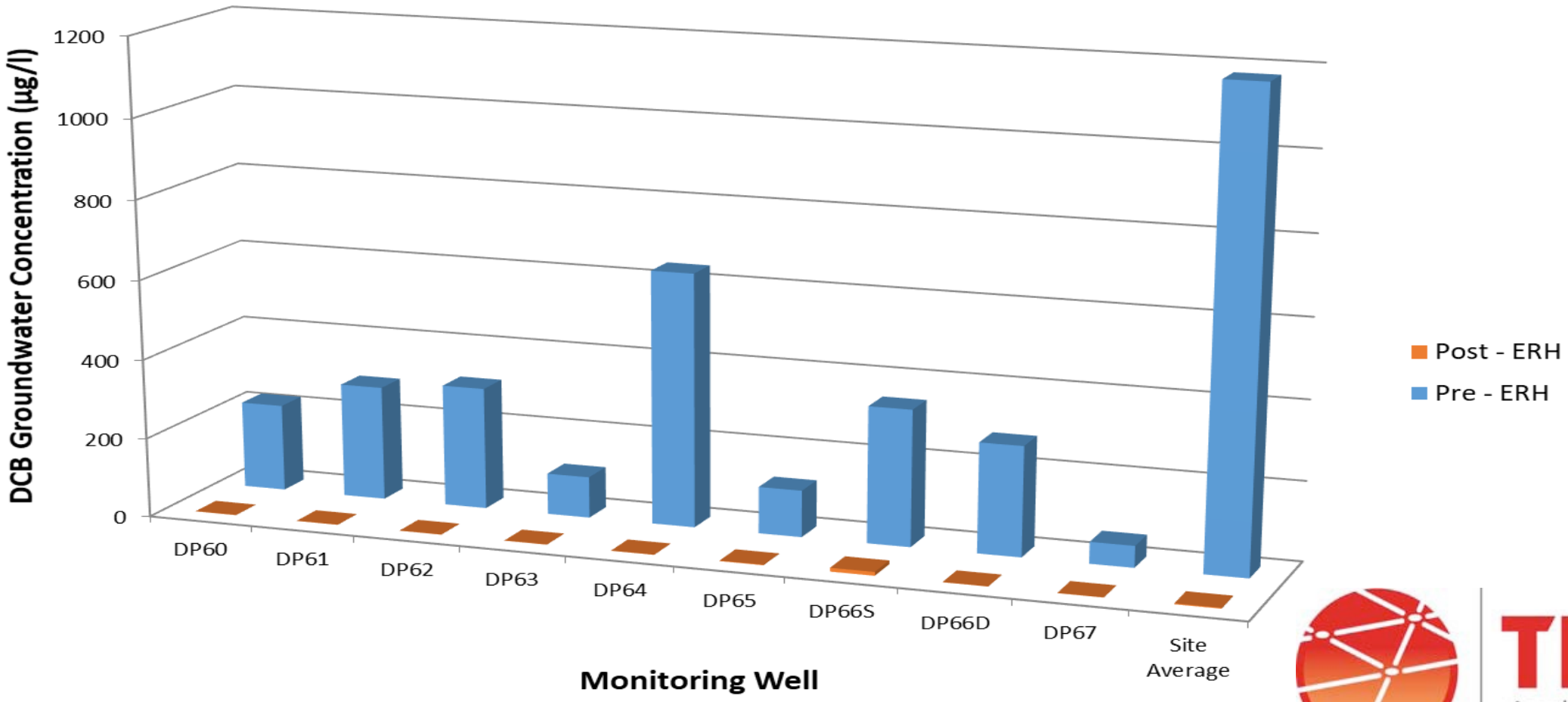
Results – 1,4-Dichlorobenzene



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Conclusions

- Power and energy densities are key parameter
- Modeling drives technology selection
- Variety of tools available for ISTR implementation
- Powerful means to overcome complexities
- Embrace monitoring programs
- Collaboration for project success

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