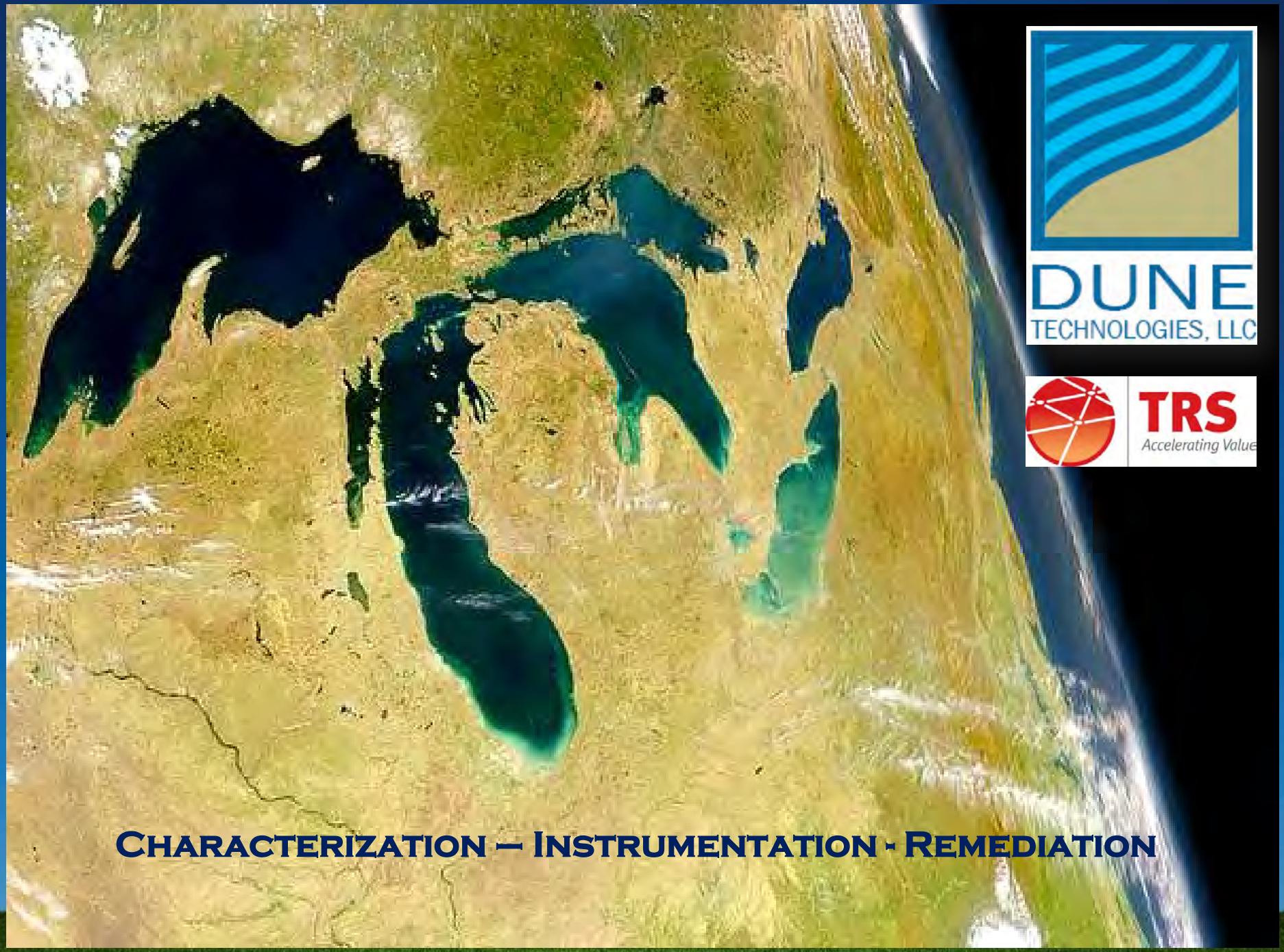

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TRS Accelerating Value

Characterization – Instrumentation - Remediation

Thermal Remediation of PCE in Complex Glacial Lithology

Using

Electrical Resistance Heating (ERH)

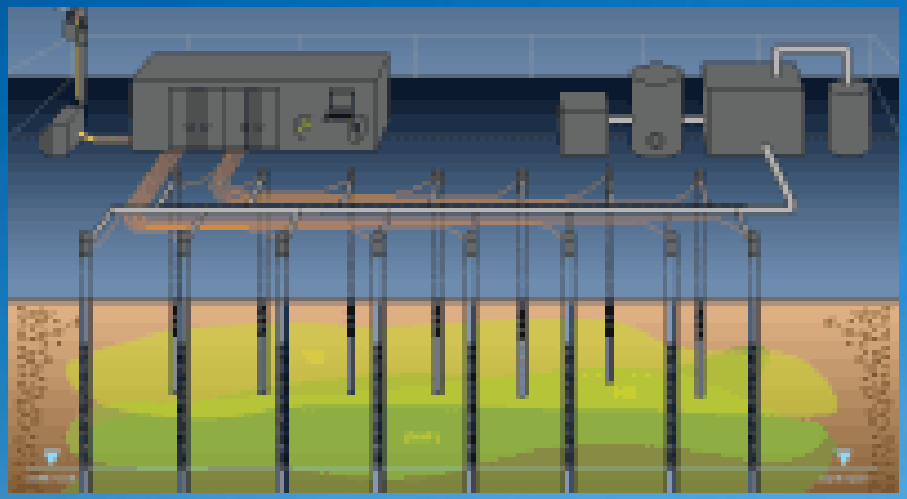
Ohio Brownfield Conference
May - 2012

Dave Wardwell
Dune Technologies

CarbonFree™ Partner

Thermal Remediation - Electrical Resistance Heating (ERH)

- In-Situ Electrical Resistance Heating
- Electricity is Applied in the Subsurface Through Electrodes
- Horizontal and Vertical Installation Options
- Works in Saturated and Unsaturated Zones (Soil & Groundwater)
- Effective on VOCs – Solvents – Hydrocarbons - SVOCs



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Thermal Remediation - Electrical Resistance Heating (ERH)

Process:

- Electrical Resistance Causes Heating
- Electricity Passes Through Water & Soil Moisture
- Soil Resists Passage of Electricity – 1.5 Degrees C/Day
- Heat Subsurface to 100 Degrees C
- Phase Change – Liquid to Vapor Phase
- SVE System Recovers & Treats Vapors
- Lower Viscosity of SVOCs & Recover with DPE
- Increased In-Situ Degradation
- 99%+ Contaminant Reduction, ND & MCLs

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Thermal Remediation - Electrical Resistance Heating (ERH)

Capabilities/Advantages:

- Extremely Effective – Reach Very Low Remedial Objectives
- Rapid – Months not Years
- Proven Technology – Market/Regulatory Acceptance
- Effective in Difficult Hydrogeology – Tight Lithology
- Does Not Rely on Advective Flow
- No Contaminant Rebound
- Guaranteed/Fixed Price Contracting Options
- Affordable – Consider Life Cycle Costs of Project
- As Effective as Excavation Without Transfer of Liability

TRS Accelerating Value
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Thermal Remediation - Electrical Resistance Heating (ERH)

Capabilities/Advantages:

- Easily Deployed Beneath Existing Structures
- Horizontal Deployment Capabilities
- No Real Depth Limitation
- No Soil Desiccation or Subsidence

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Thermal Remediation - Electrical Resistance Heating (ERH)

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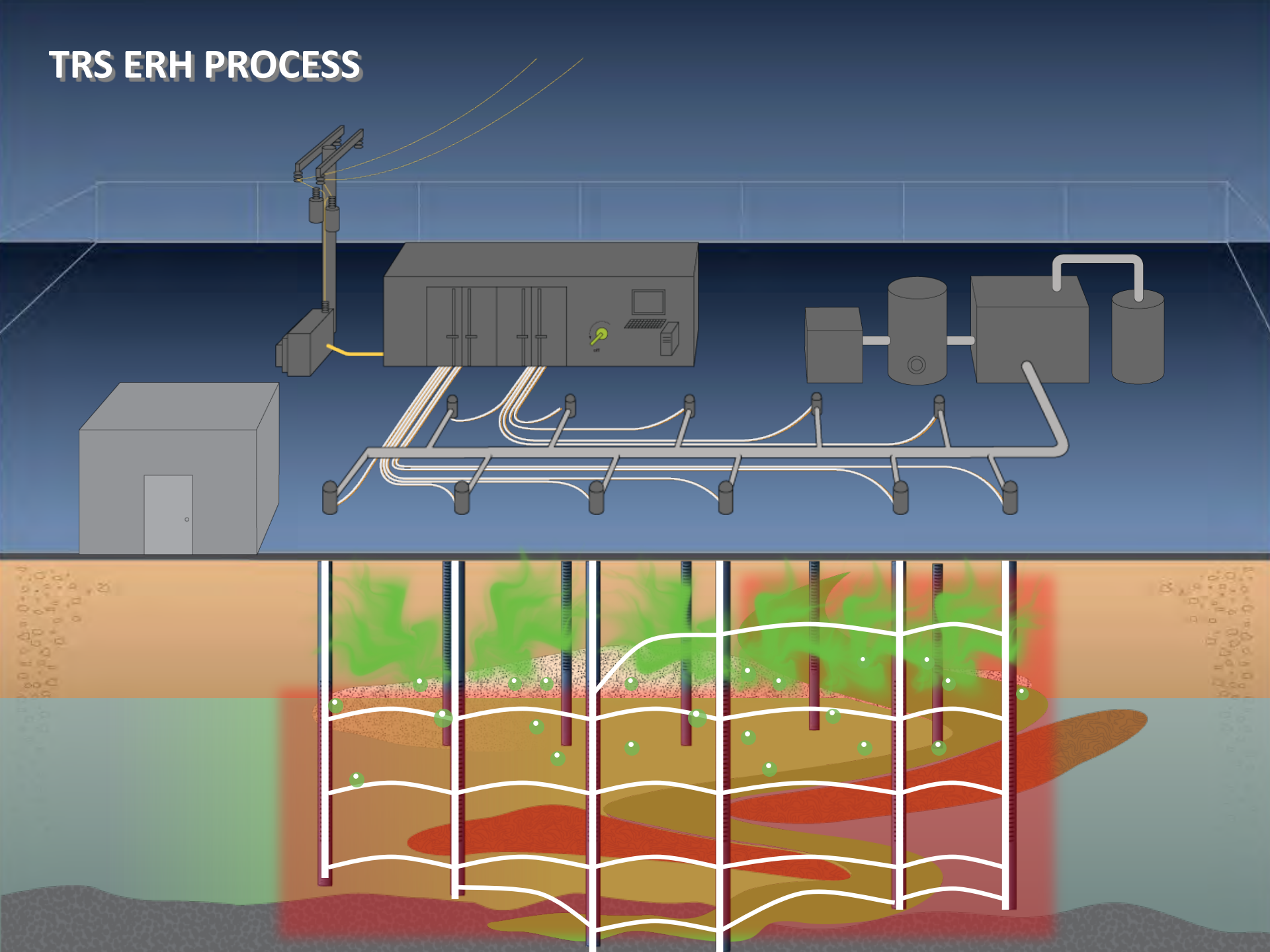
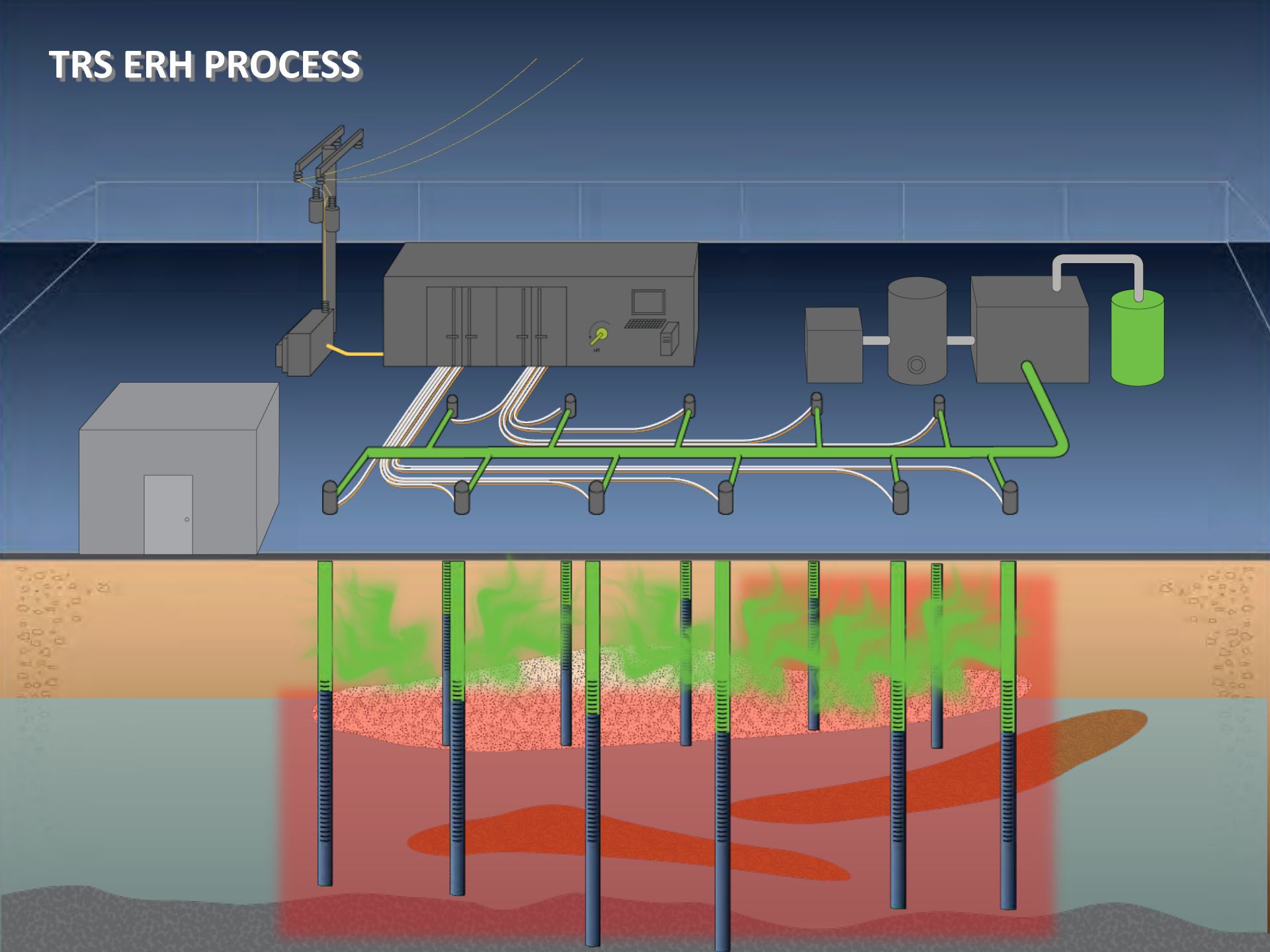
TRS ERH PROCESS

TRS ERH PROCESS



TRS ERH PROCESS



Thermal Remediation - Electrical Resistance Heating (ERH)

Polishing Mechanisms:

- **Hydrolysis of Halogenated Alkanes**
  - Compounds such as TCA have a hydrolysis half-life of less than one day at steam temperatures.
- **Iron Reductive Dehalogenation**
  - Steel shot used as electrode backfill provides an iron source for reductive dehalogenation (iron filing wall)
- **Temperature Accelerates Reactions**
  - The above reaction rates are increased by factor of thousands at 100°C (Arrhenius Equation)
- **Bioremediation by Thermophiles**
  - Dehalogenating bacteria *Dehalobacter, Desulfuromonas, and Desulfotomaculum* prefer 40-80°C
  - Dehalogenating bacteria *Dehalococcoides* prefer 30-40°C

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Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:

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Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:

- PCE - Primary Contaminant
- 0-15’ Silty Clay
- 15-40’ Silty Sand
- 40-50’ Silt – 50’ Clay
- Groundwater – 22’ BGS
- Source Area = 1,610 ft^2, 2,000 yd^3, 4-36’ BGS
- Beginning Concentration = 2,700 mg/kg PCE
- Remedial Goal = 99% Reduction 27 mg/kg

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Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:

- 7 – Electrodes Installed w/SVE Points
- 2 – Temperature Data Locations
- 6 Thermocouples each
- ERH Operations Begin – February 2010
- 24-Hour/Day Operations
- Estimated Contaminant Mass = 2,052 lbs CVOC
- Operated Until July 2010

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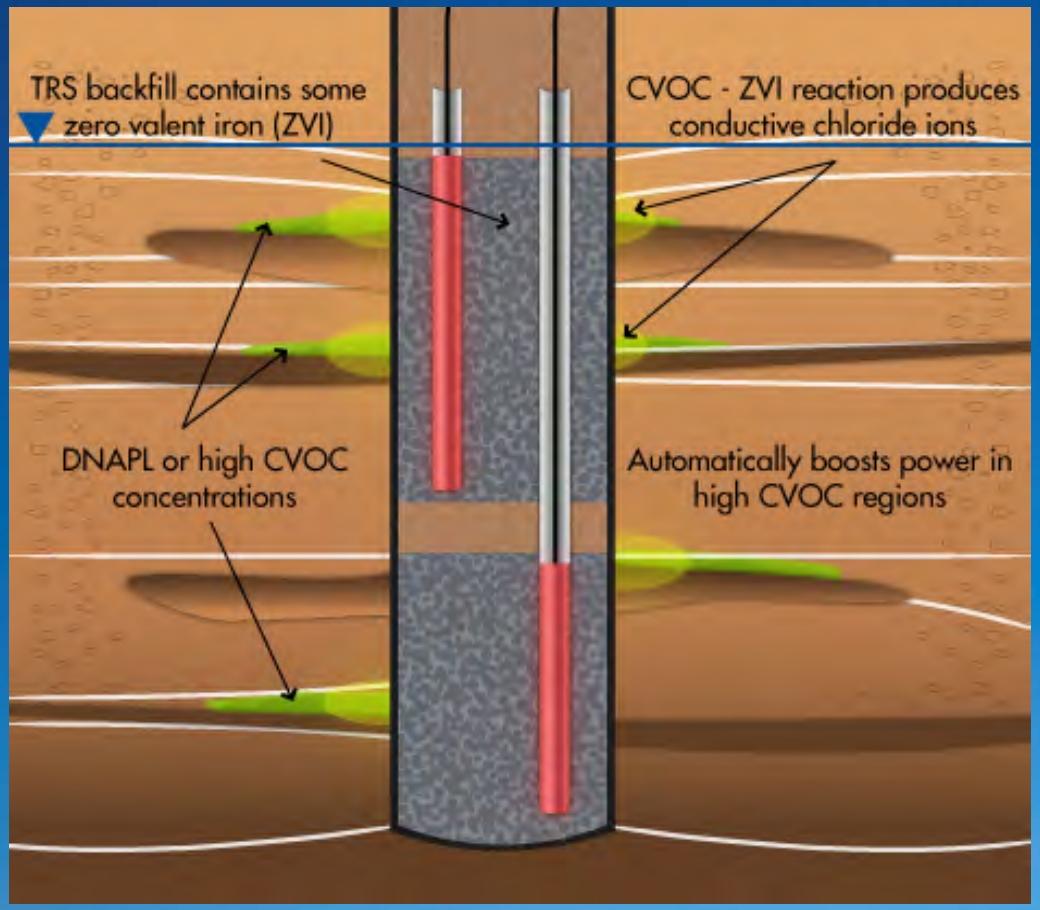
Thermal Remediation - Electrical Resistance Heating (ERH)

TRS Patented Adaptive ERH Electrode



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Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:

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Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:

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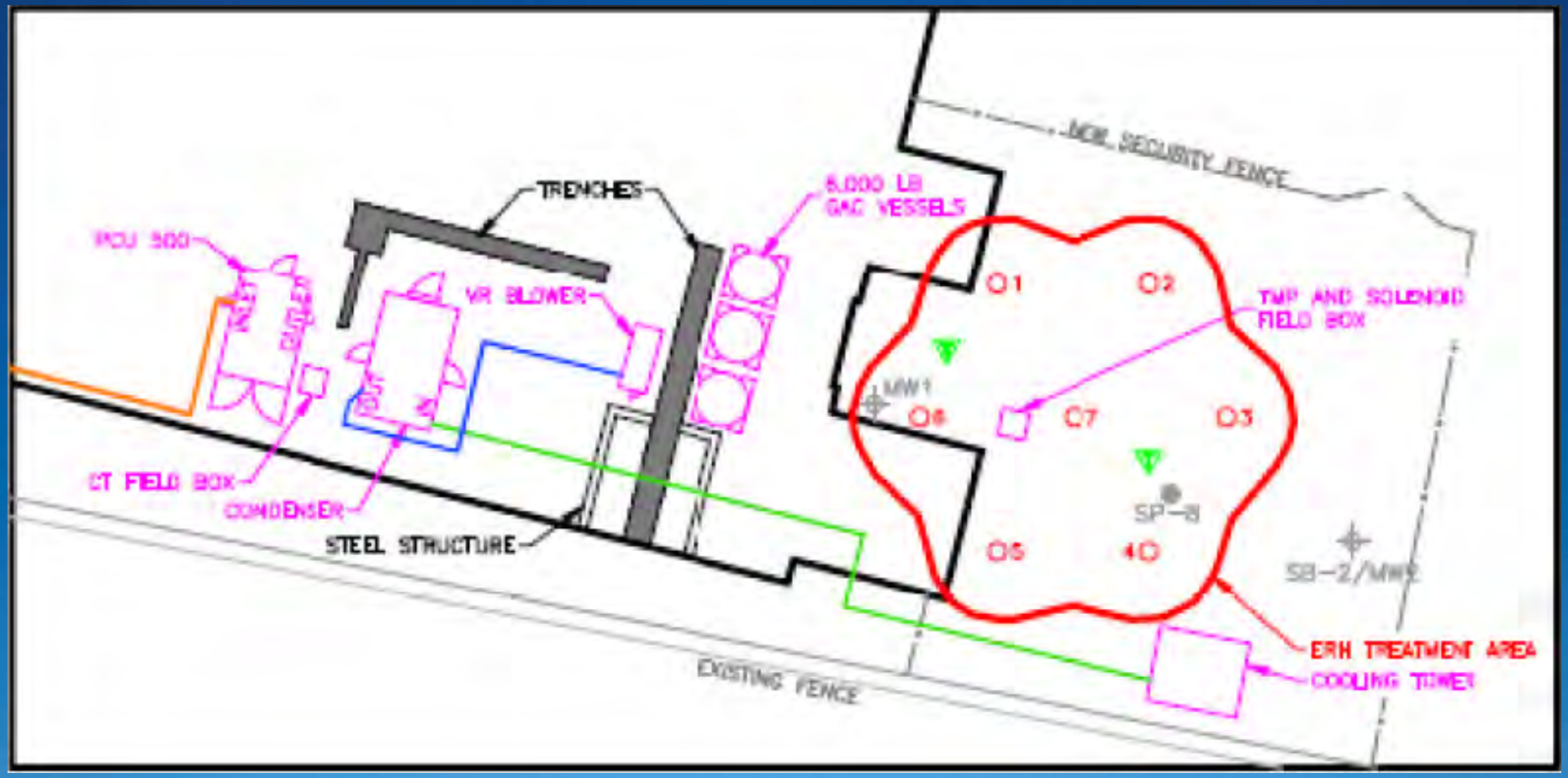
Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:



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Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:

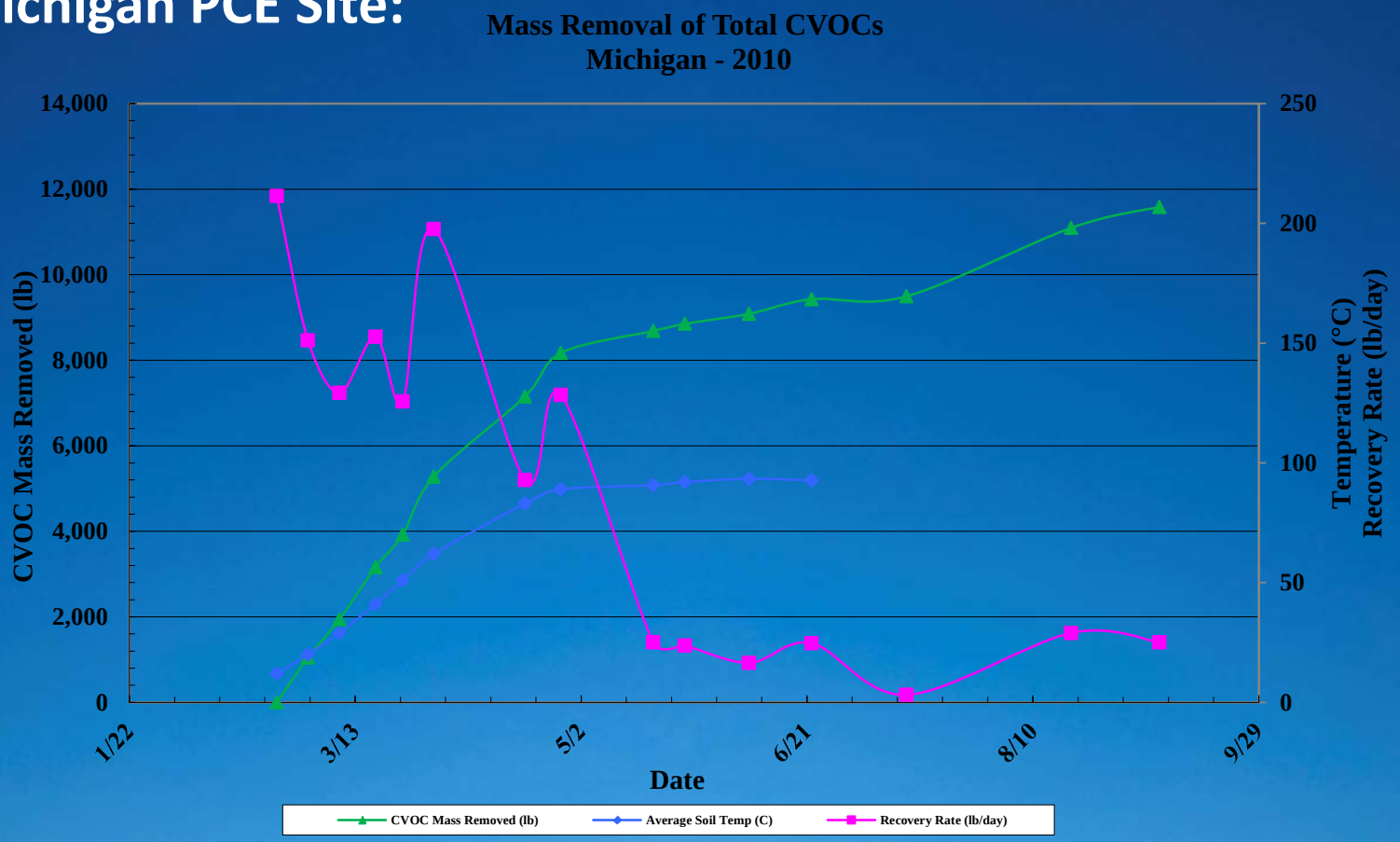
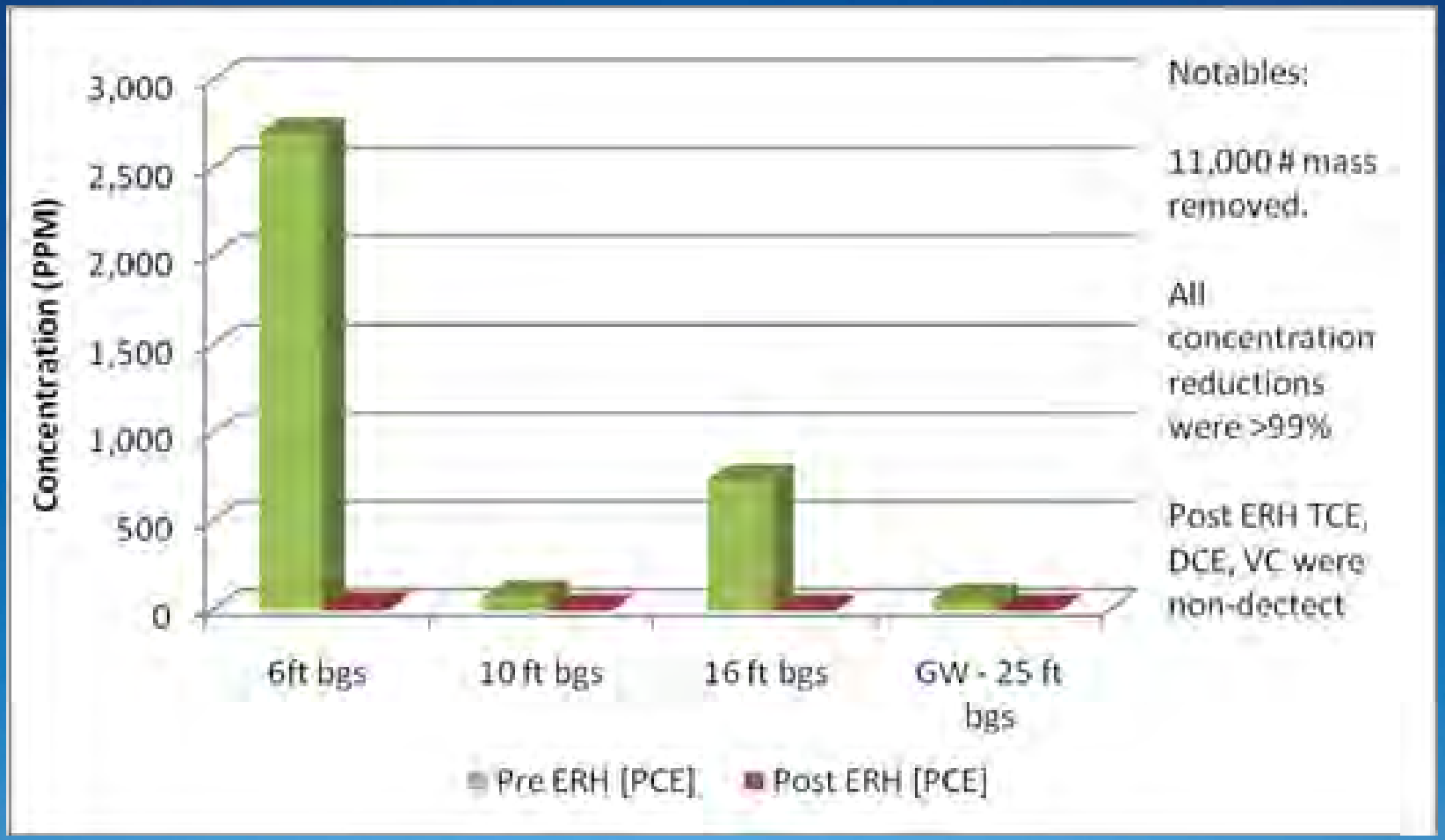


Figure 3. CVOC Recovery Rate and Mass Removed

Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:



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Thermal Remediation - Electrical Resistance Heating (ERH)

Michigan PCE Site:

- 99% Contaminant Reduction
- Original Estimated Mass = 2,052 lbs CVOC
- Final Mass Removal = 11,000 lbs CVOC
- Operated Until July 2010
- No Rebound

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