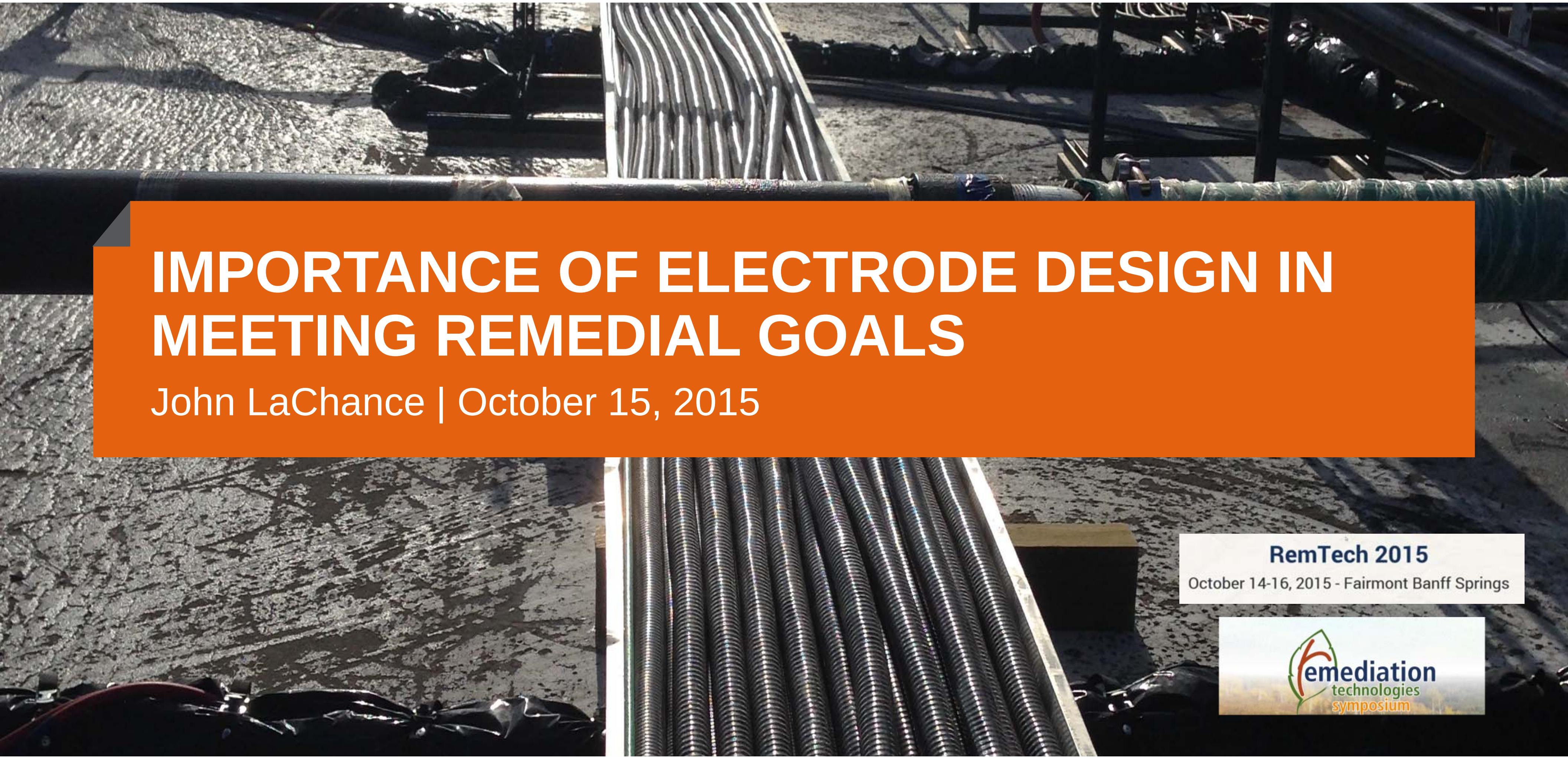
ARCADIS Design & Consultancy for natural and built assets



IMPORTANCE OF ELECTRODE DESIGN IN MEETING REMEDIAL GOALS

John LaChance | October 15, 2015

RemTech 2015
October 14-16, 2015 - Fairmont Banff Springs
remediation technologies symposium

ARCADIS Design & Consultancy for natural and built assets

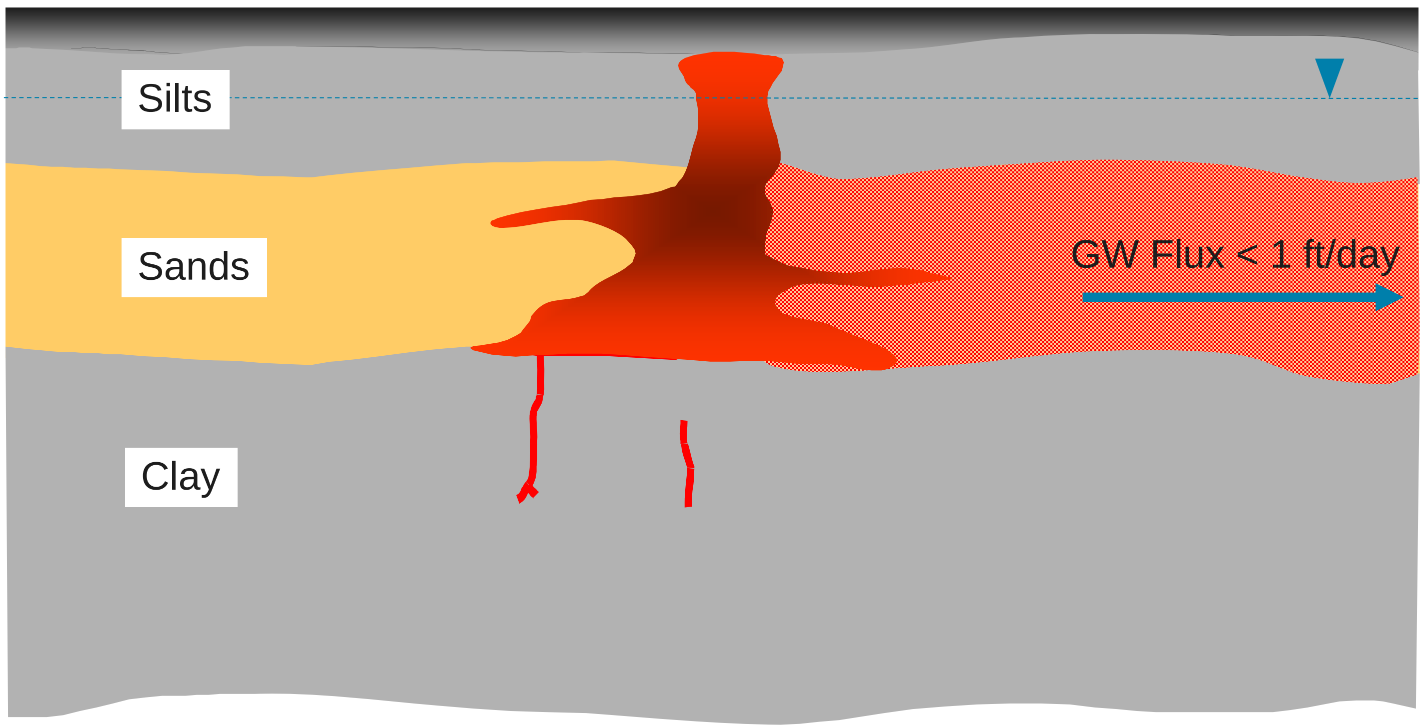
Maximizing Your Potential for Meeting Remedial Goals: *The Importance of Electrode Design and Installation at a Site with Varying Treatment Depths*

Outline

- **Introduction and Problem Statement**
- **Case Study**
  - **Site Background**
  - **Analysis of Electrode Design Options**
  - **Results**
- **Summary**

"Not all designs are created equal"

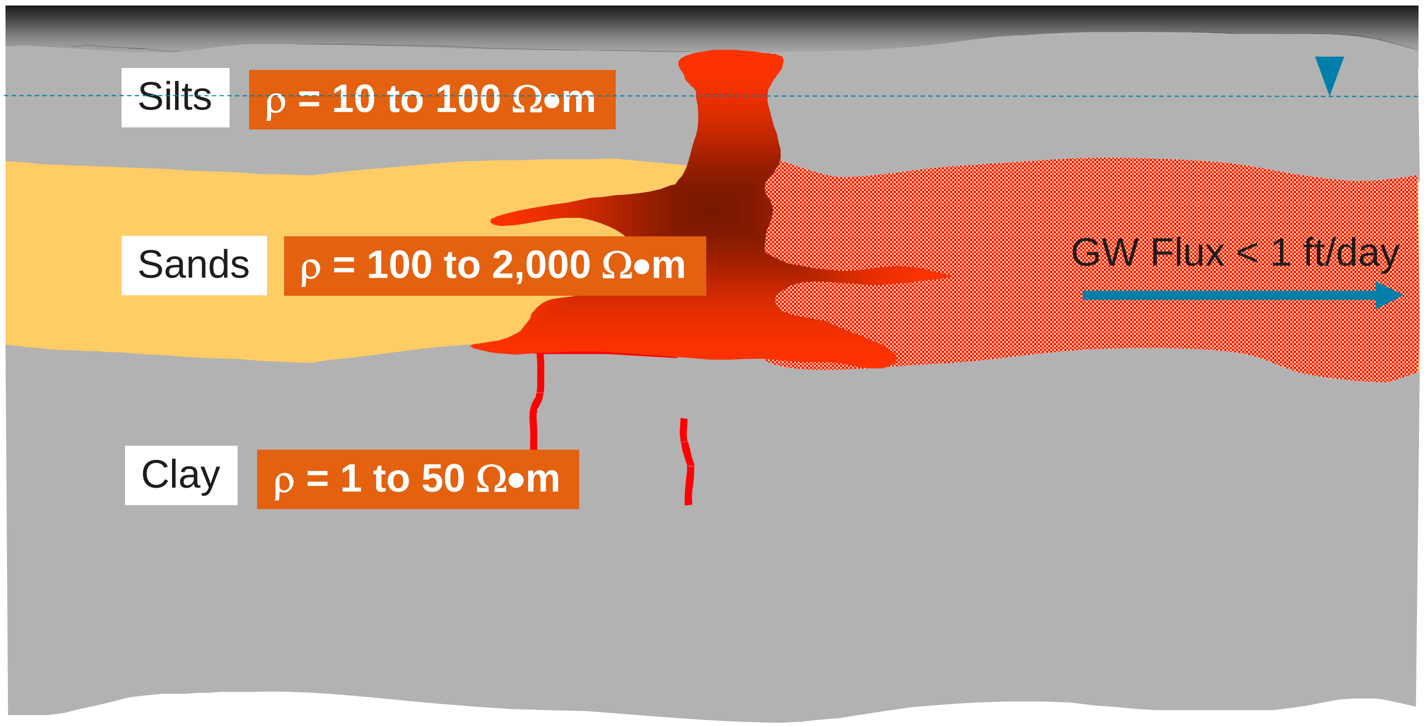
Introduction – Problem Statement



CVOC Source Zone to be Treated With Electrical Resistance Heating

(ERH)

Introduction – Problem Statement



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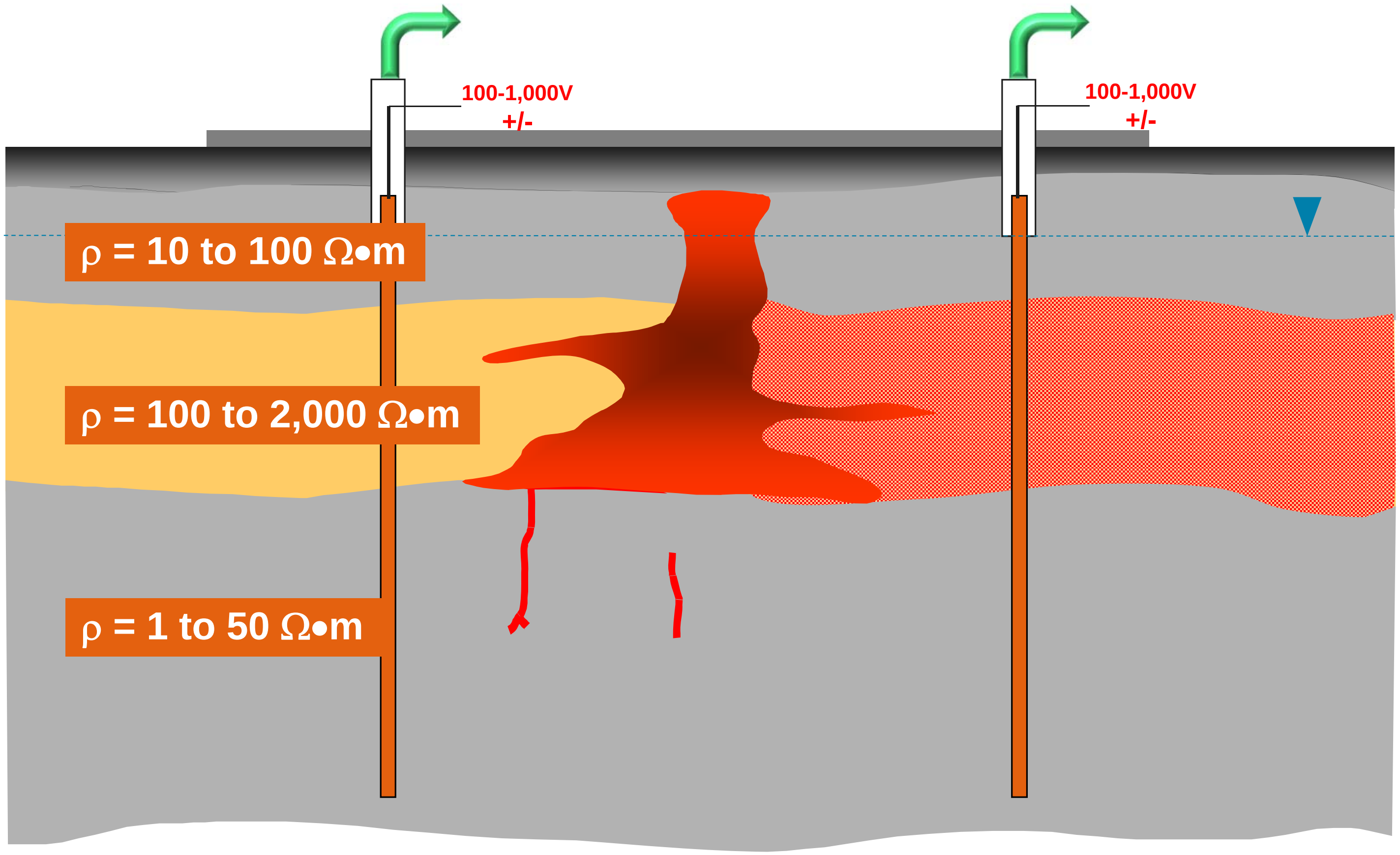

But is one long electrode the best approach?

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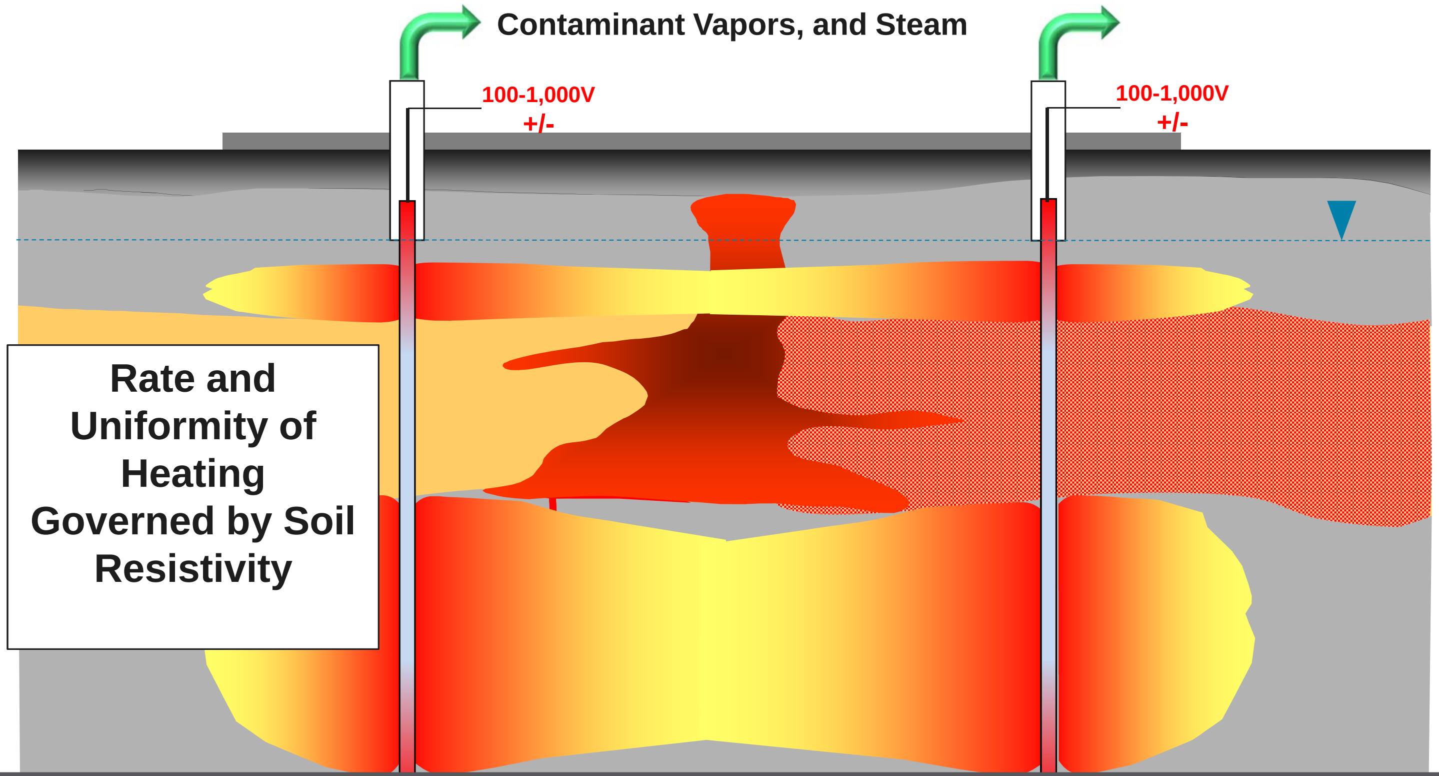
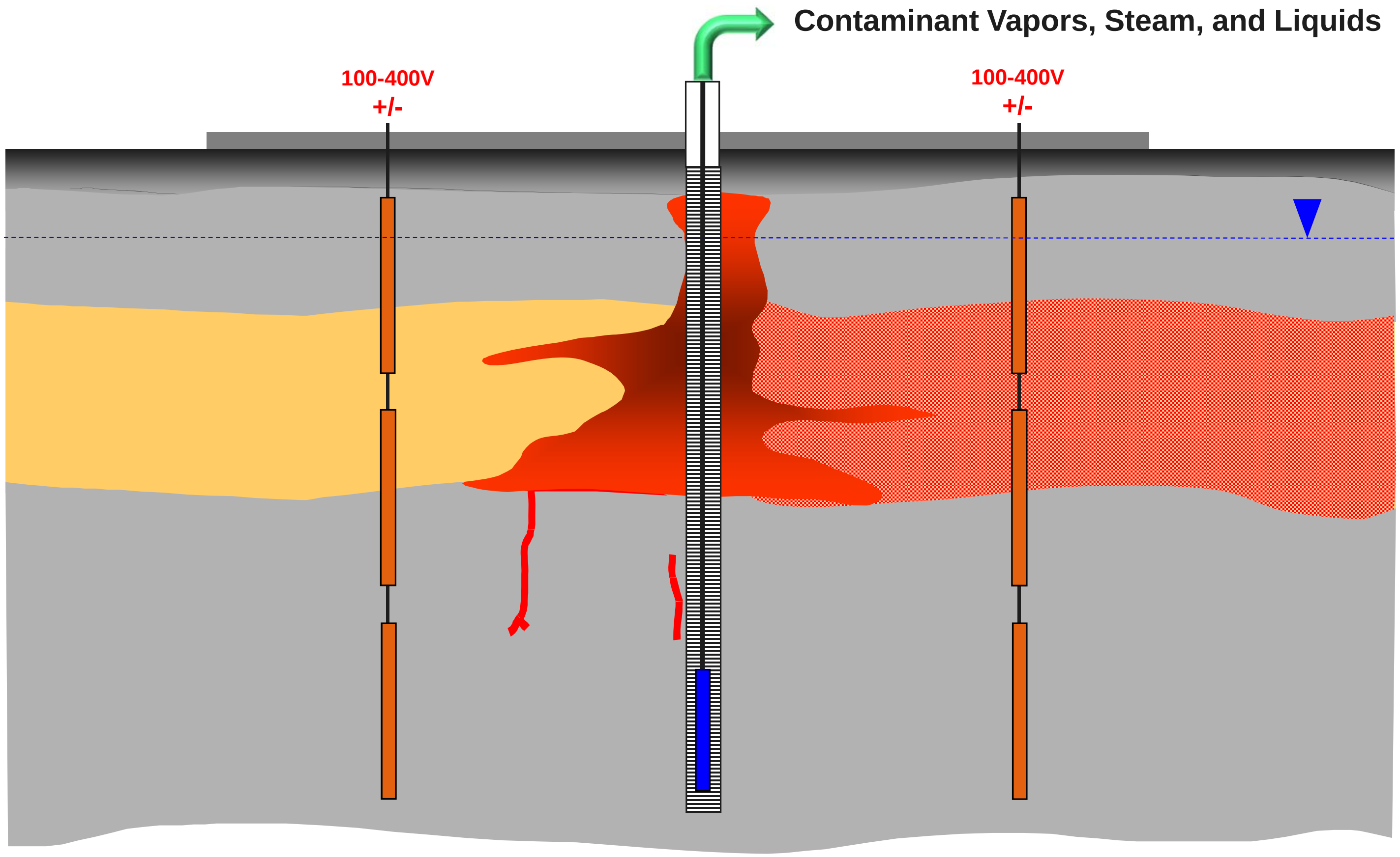
Introduction – Problem Statement



The challenges of using one long electrode: may be cheaper to install but harder to control.

Non-Uniform and Potentially Insufficient Heating

Alternate Approach:
Finite Length Stacked Electrodes



ElectroThermal-Dynamic Stripping Process (ET-DSP™)

McMillan-McGee Corp.

Calgary, AB

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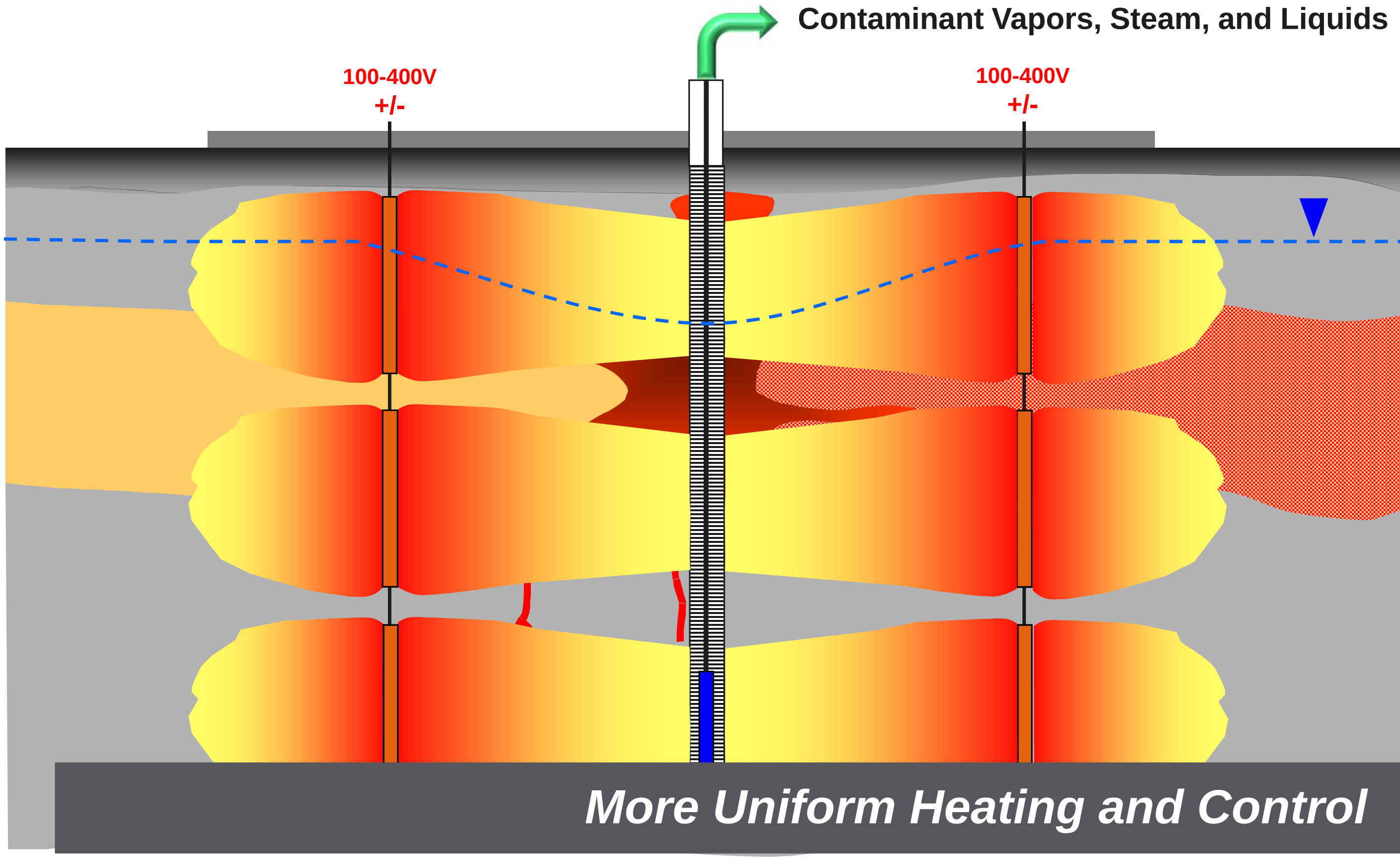


ElectroThermal-Dynamic Stripping Process (ET-DSP™)

McMillan-McGee Corp.

Calgary, AB

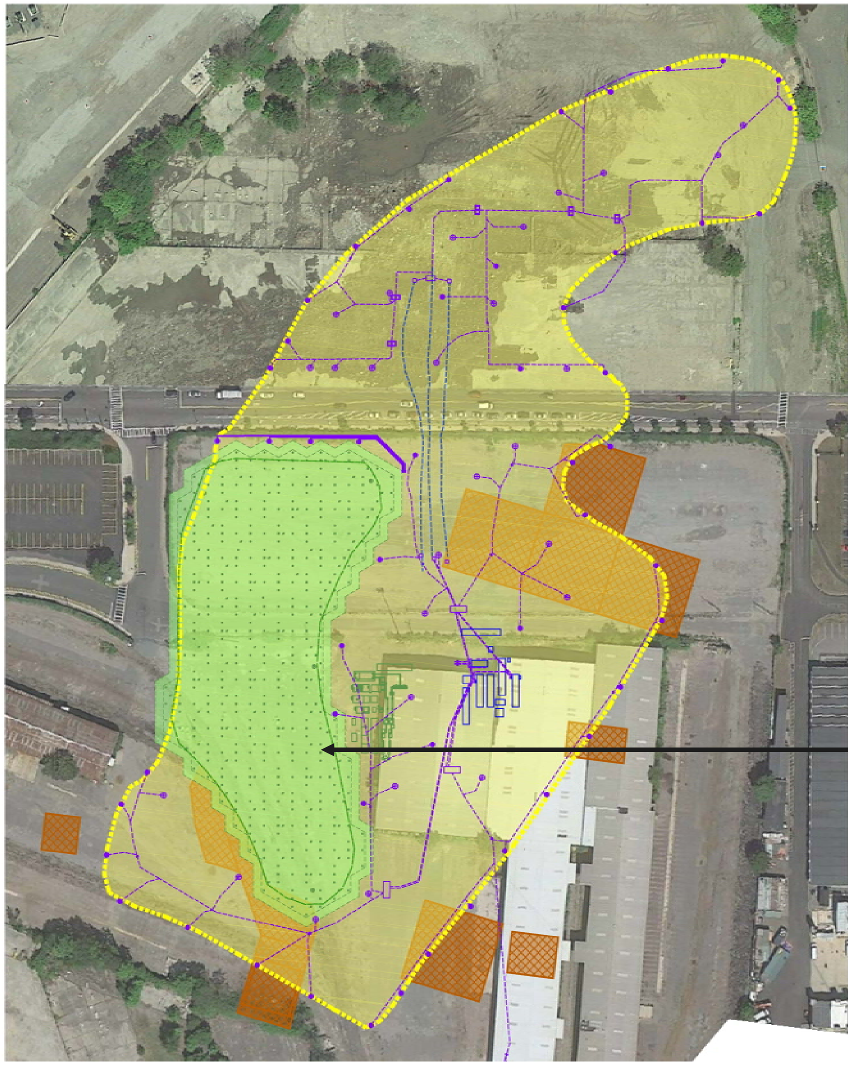
More Uniform Heating and Control

ET-DSP™ Electrode Design

(McMillan-McGee)

Case Study: ET-DSP™ Site
Boston, MA

Site Background



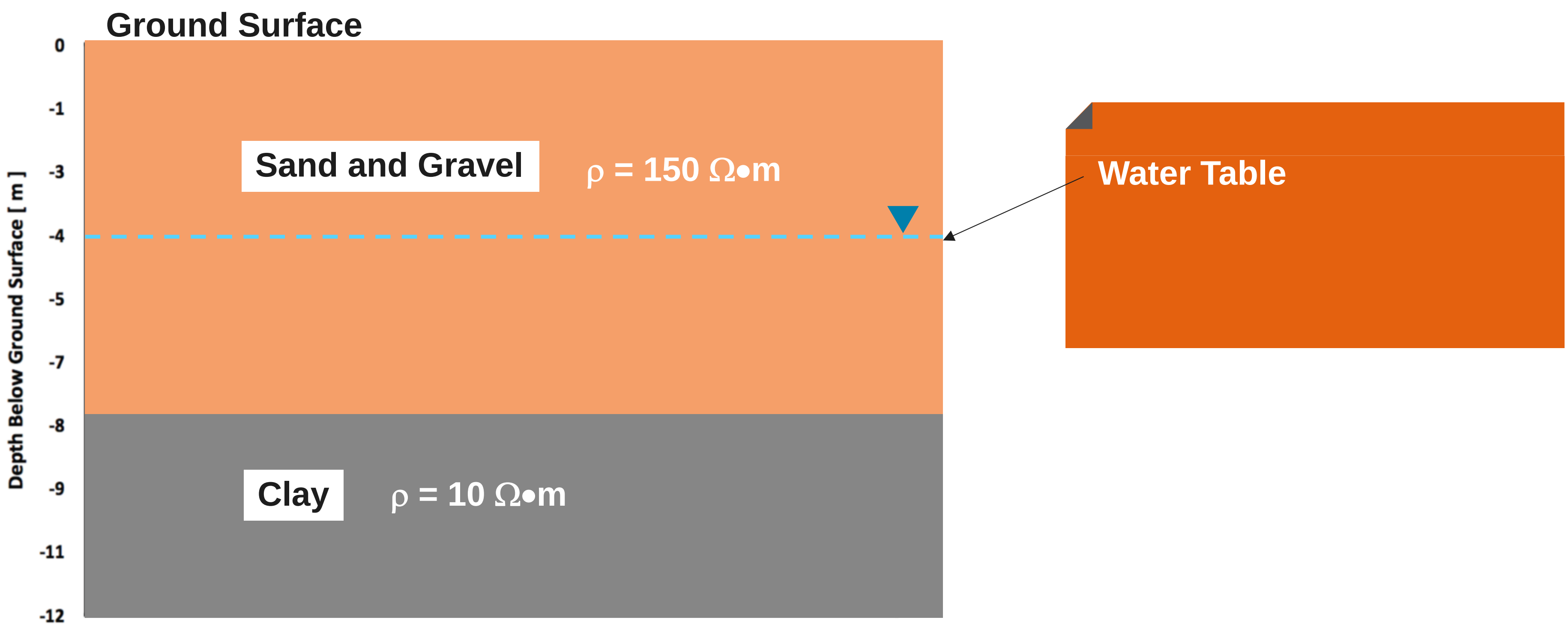
Thermal Treatment Area = 8,900 m2 (2.2 acres)

Site Remedy:

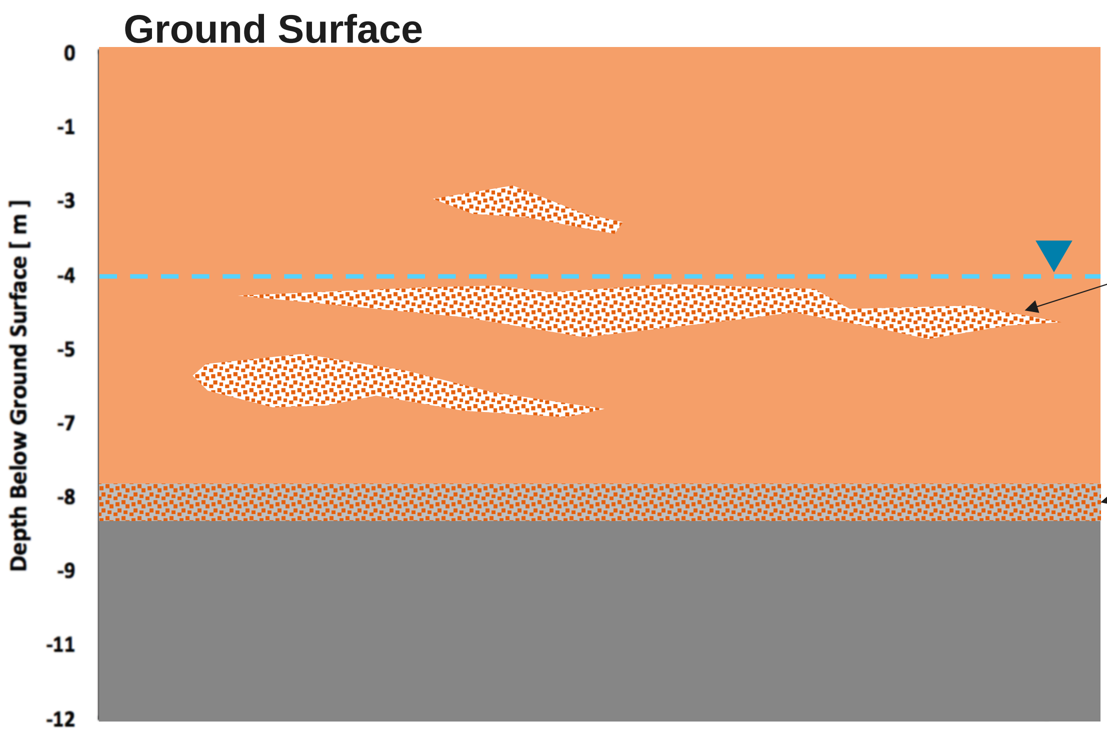
- Thermal for CVOC Source Zone
- Directed Groundwater Recirculation for CVOC Plume
- Excavation of Metals and TPH Hotspots

Site Geology

Conceptual Site Model



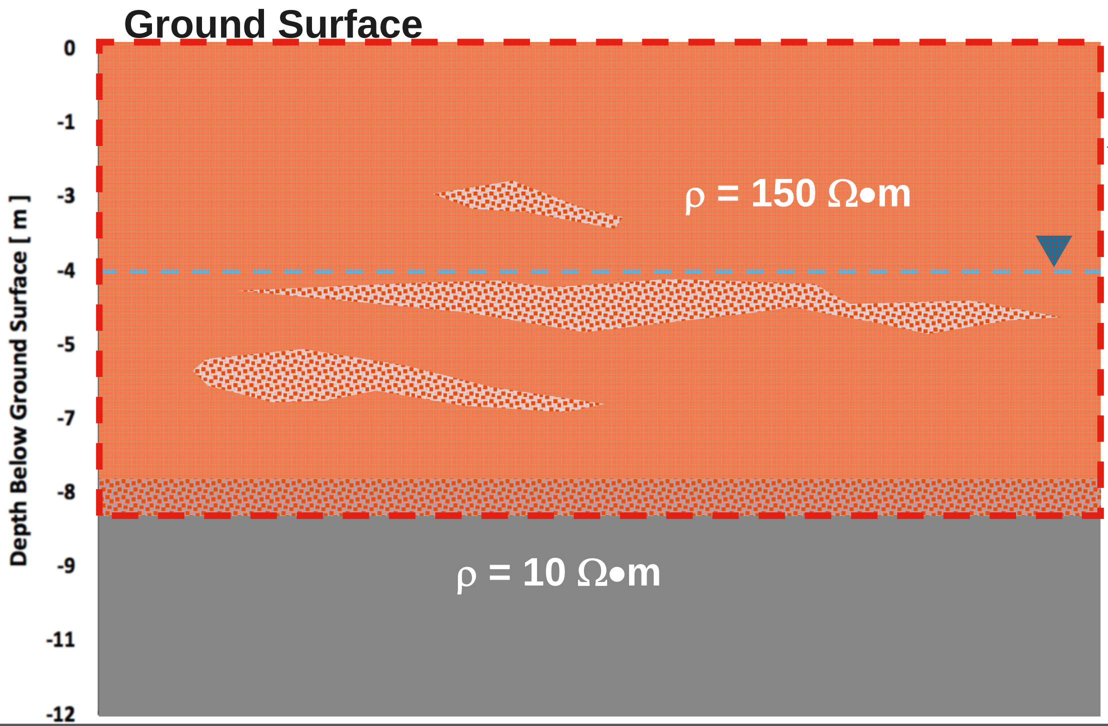
Conceptual Site Model



CVOC Mass Diffused Into Low K Deposits

CVOC Mass Diffused Into Upper 1-ft (0.3m) of Clay

Conceptual Site Model



Target Treatment Zone

Remedial Goals:

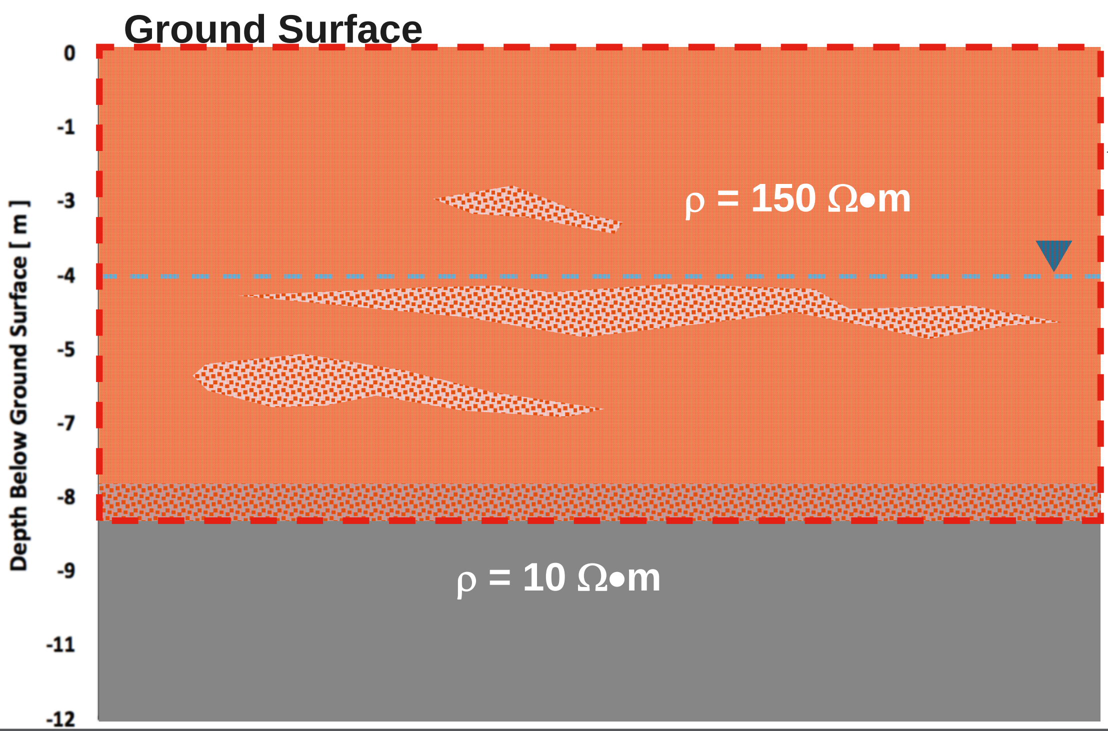
- **Heat to ~100C**
- **Boil off 10 to 20% of PV of Water**
- **Reach 2 - 20 μg/L in Groundwater**
- **Treat 0.3 m Into Top of Clay**

How to Ensure Uniform and Adequate Heating Given Resistivity Contrasts?

Case Study: ET-DSP™ Site Boston, MA

Electrode Design and Analysis

Conceptual Site Model



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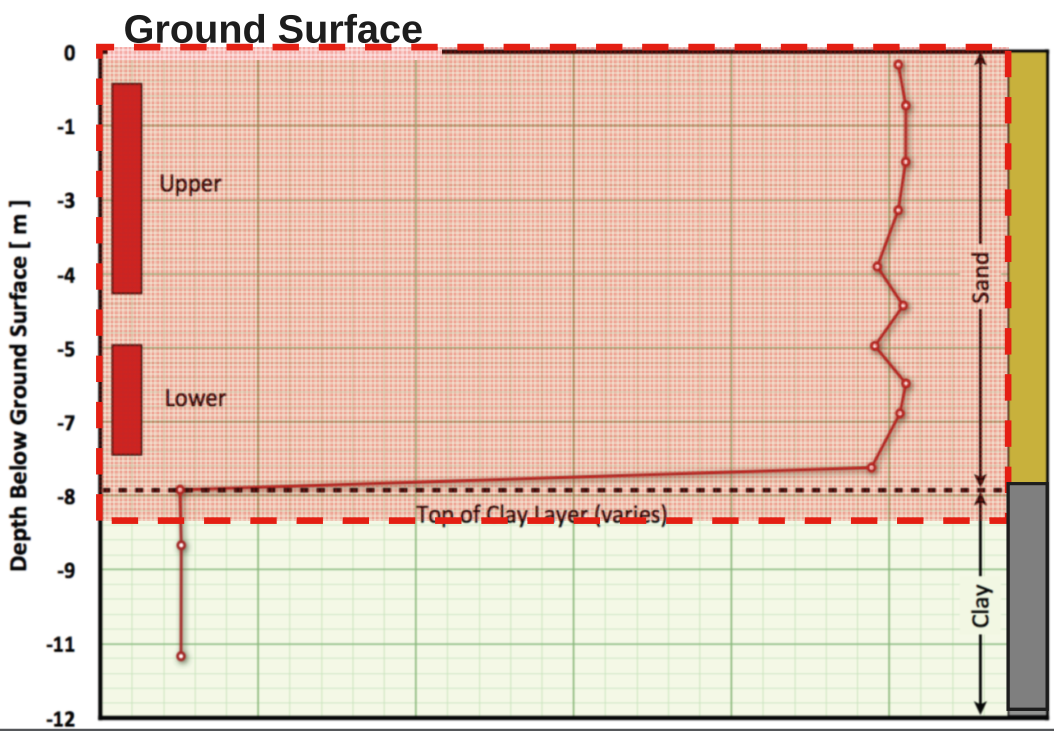
Ideal Electrode Design

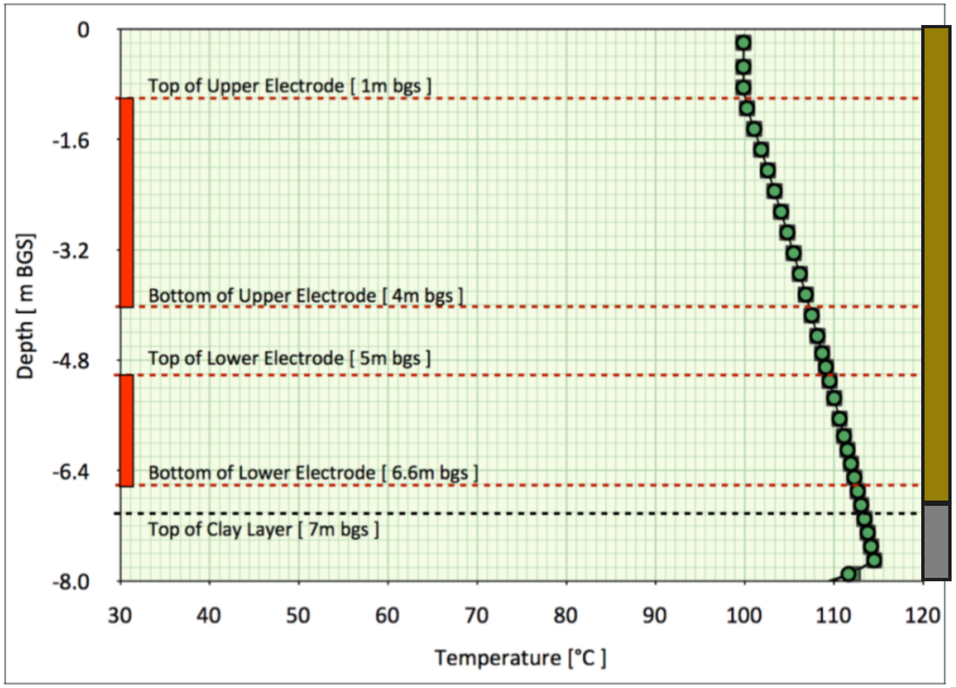


Two Electrode Approach:

- **Allow for potential increase in resistance as vadose zone dries**
- **Ability to target lower zone separately**
- **Thermal conduction and some currently flow heats clay**

How to Ensure Uniform and Adequate Heating Given Resistivity Contrasts?

Simulated Temperature After 210 Days of Heating



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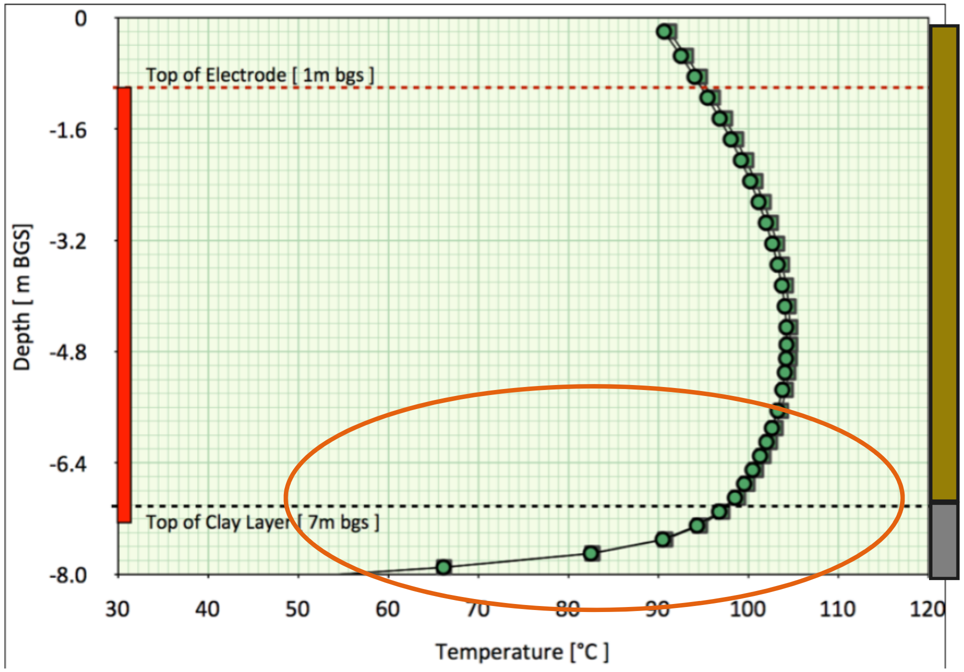
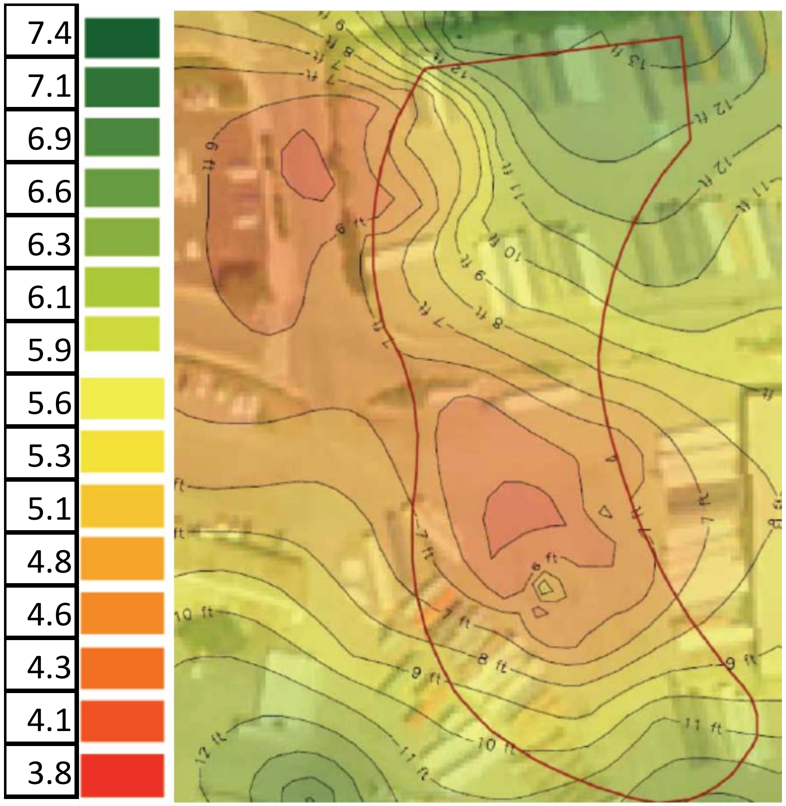


One Electrode Approach:

- Short-circuiting occurs and current flow is directed through clay
- But because of lower resistance, clay does not heat up sufficiently
- Insufficient heating of lower sands does not result in optimal thermal conduction heating of clay.

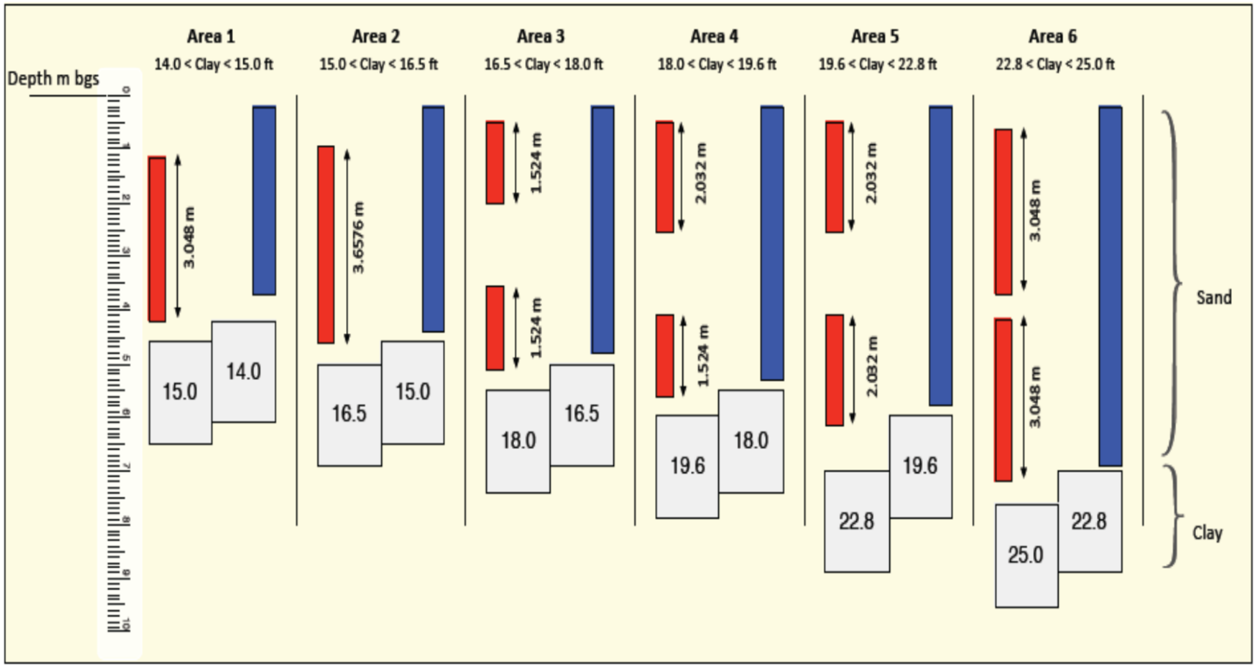
Short-Circuiting Leads to Insufficient Heating

m BGS



Electrode Design Based on Mapping of Clay Surface

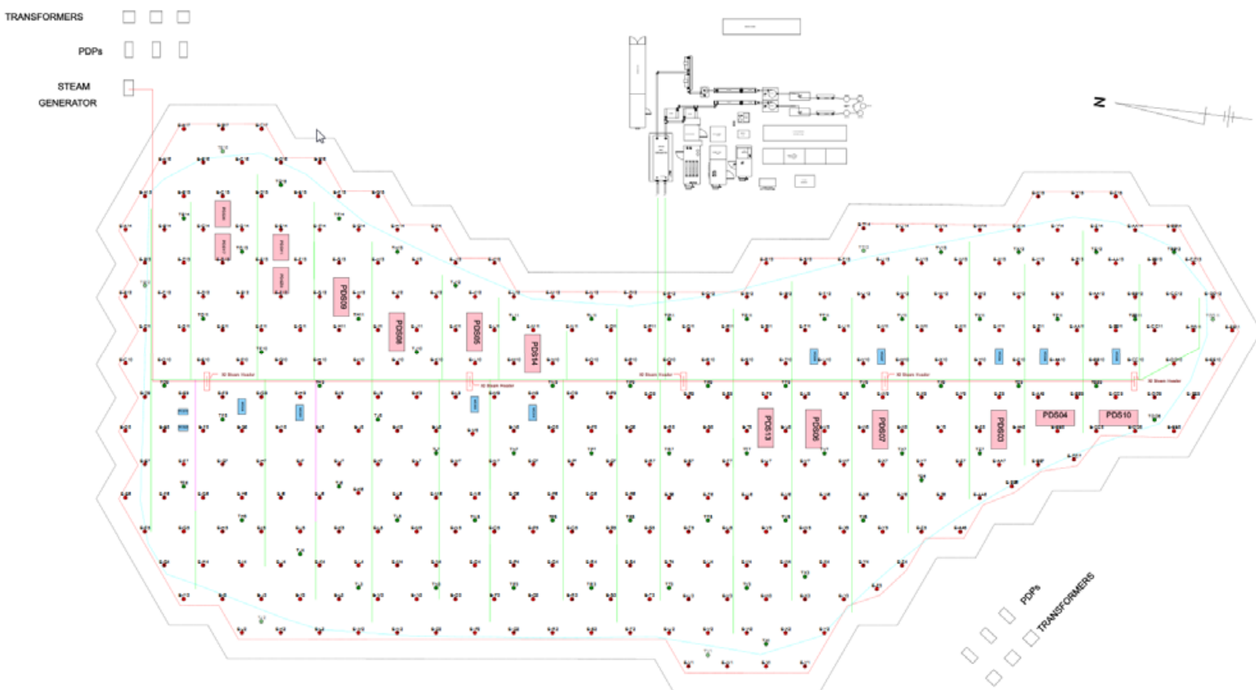
CSM: Clay Surface Gently Variable



Electrode Design:

- **Site Divided Into 6 Areas**
- **Custom Design for Each Area**
- **Bottom Electrode 0.3 m From Top of Clay**

Avoid Short-Circuiting and Ensure Uniform Heating



Electrode Layout:

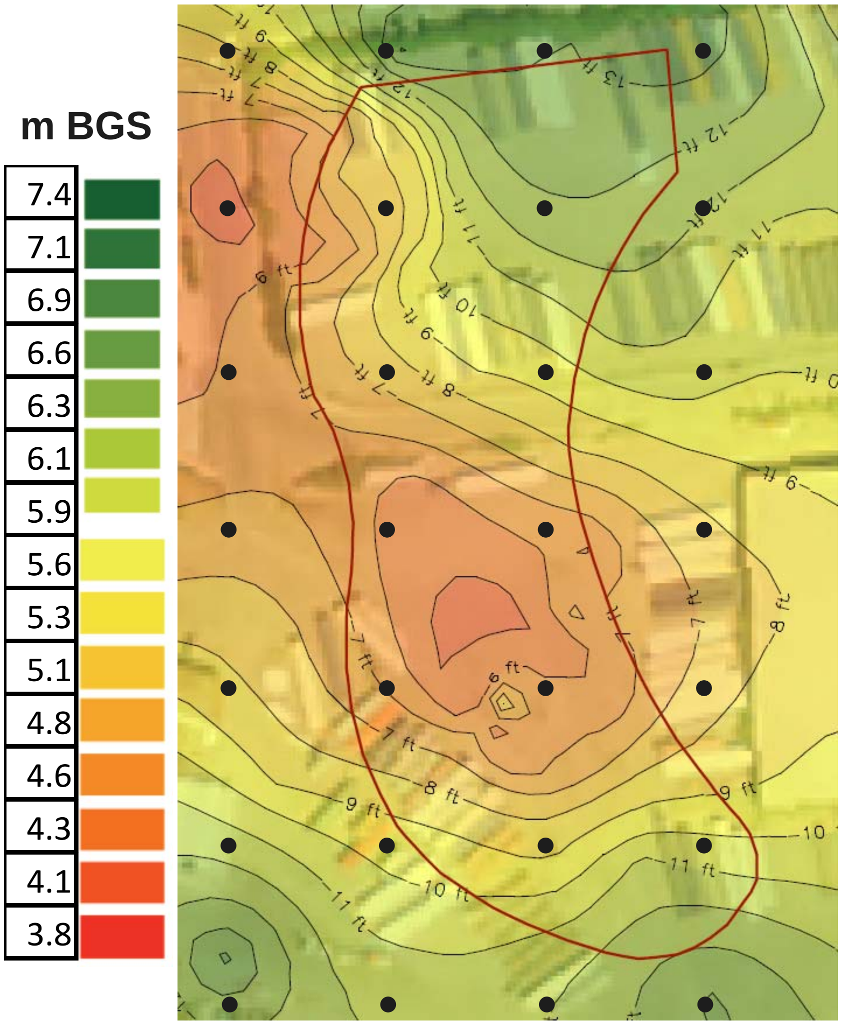
- **335 Locations**
- **576 Electrodes**
- **104 MPE Wells**
- **70 Temperature Monitoring Locations**
- **394 Sensors Within Treatment Zone**

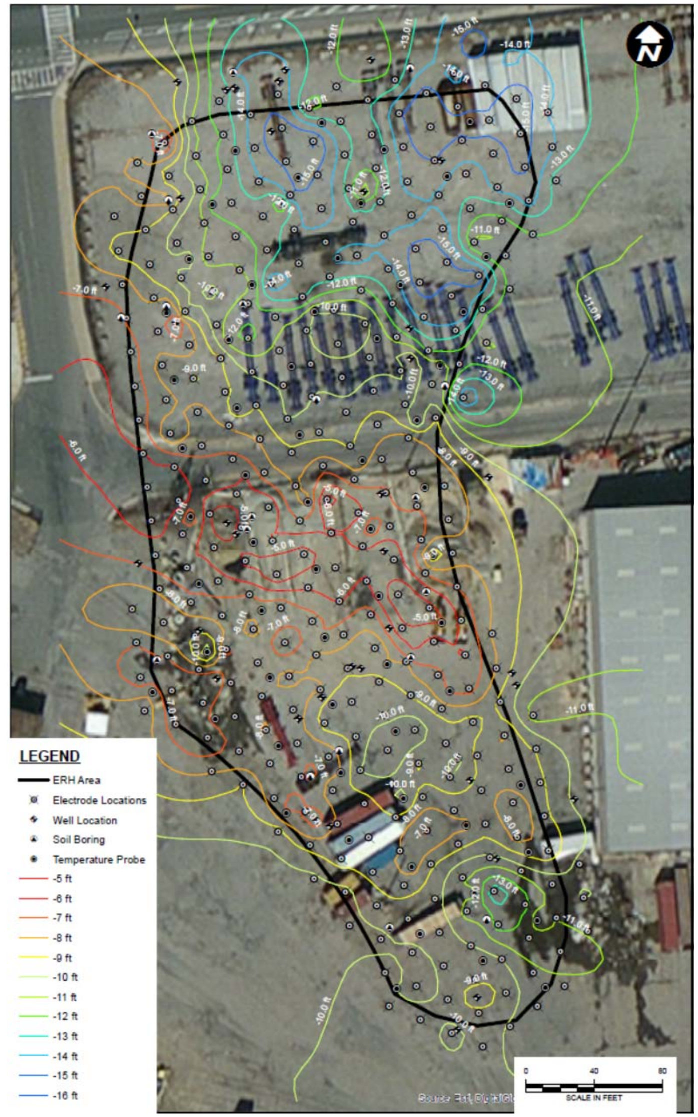
Short-Circuiting Leads to Insufficient Heating

Case Study: ET-DSP™ Site
Boston, MA

Results

Unfortunately, Sometimes Things Don't Go as Planned





Site conditions more variable than anticipated

Required custom electrode configurations

Design and manufacture in real-time!

ET-DSP™ System Construction Photos

Electrodes

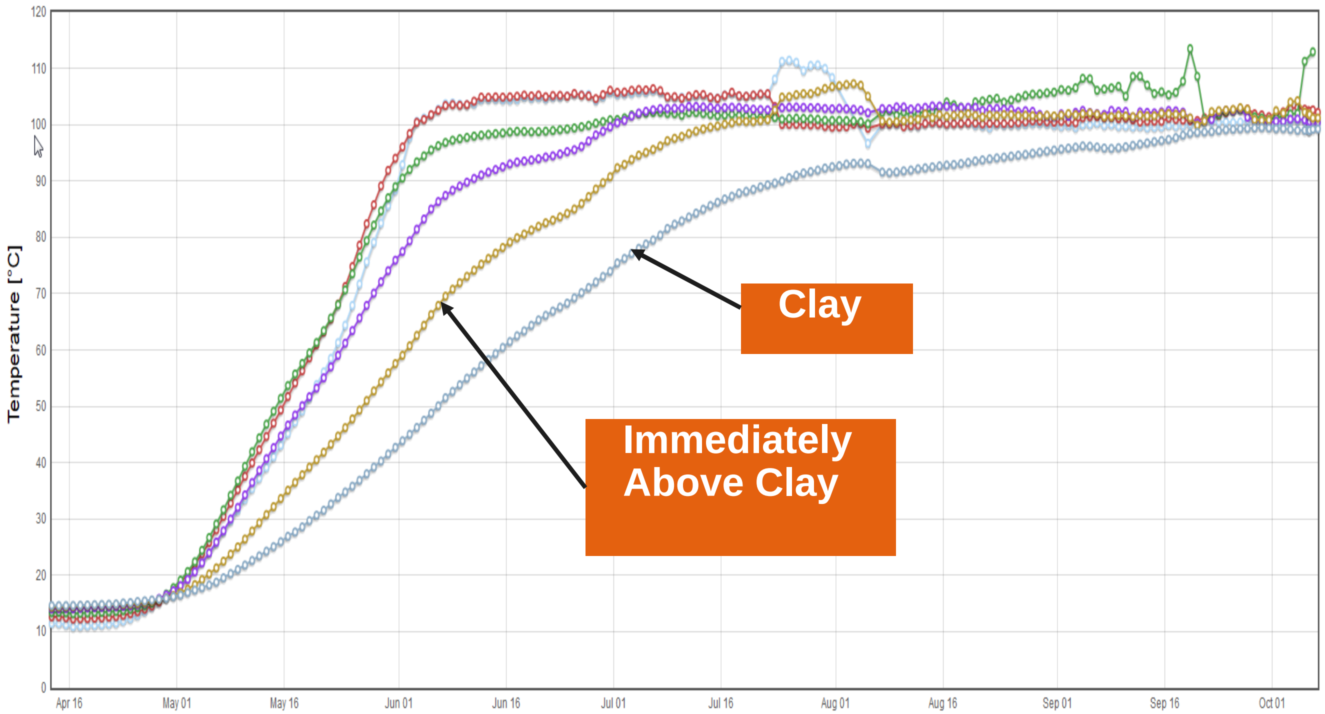
Installation of Electrodes

Completed Well Field and Vapor Cover

Extraction and Treatment System

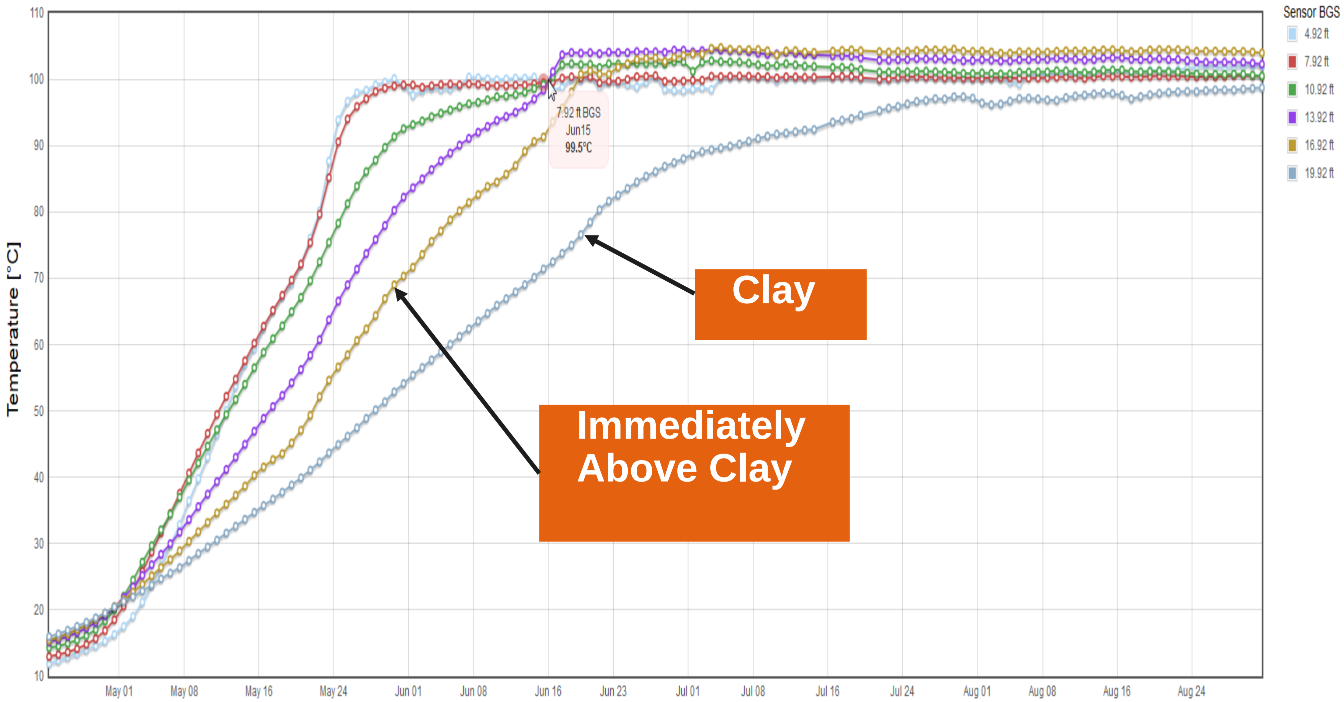
Completed ET-DSP™ System

Observed Temperatures After 170 Days of Heating



Proper Electrode Design Results in Uniform Heating

Observed Temperatures After 170 Days of Heating



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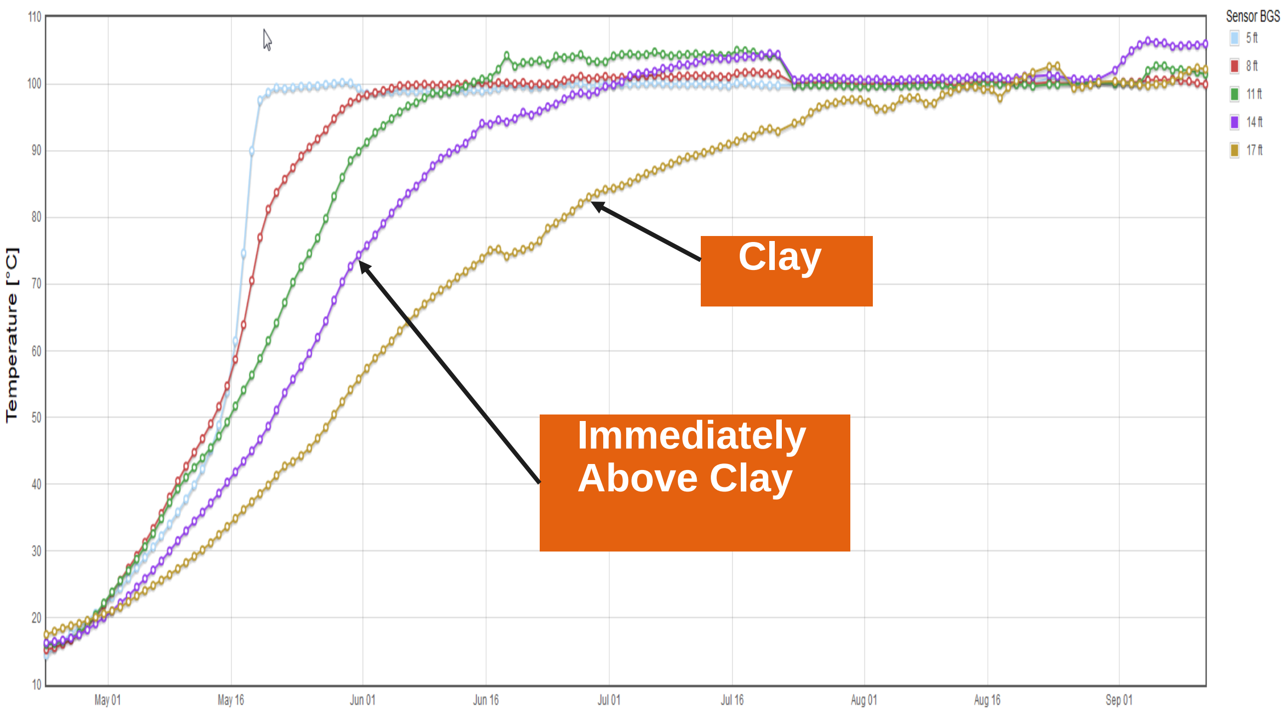

Proper Electrode Design Results in Uniform Heating

Summary

Summary

Identification of Key Issues and Proper Analysis of Problem Required for Effective Design and Performance

Sites are more complicated than they seem….

In critical aspects, allow for field verification of assumptions (e.g., depth to clay); and

Be prepared to modify design if required based on actual field conditions to preserve design aspects critical to success.

Temp goals achieved in <180 days:

100% >90C (394 sensors)

>90% > B.P. (355 sensors)

Questions?