IMPORTANCE OF ELECTRODE DESIGN IN MEETING REMEDIATION GOALS

John LaChance | October 15, 2015
Maximizing Your Potential for Meeting Remedial Goals: *The Importance of Electrode Design and Installation at a Site with Varying Treatment Depths*

- 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)

GW Flux < 1 ft/day

Silts
Sands
Clay

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CVOC Source Zone to be Treated With Electrical Resistance Heating (ERH)

- Silts: \( \rho = 10 \text{ to } 100 \, \Omega \cdot \text{m} \)
- Sands: \( \rho = 100 \text{ to } 2,000 \, \Omega \cdot \text{m} \)
- Clay: \( \rho = 1 \text{ to } 50 \, \Omega \cdot \text{m} \)

GW Flux < 1 ft/day
Introduction – Problem Statement

But is one long electrode the best approach?

\[ \rho = 10 \text{ to } 100 \, \Omega \cdot \text{m} \]
\[ \rho = 100 \text{ to } 2,000 \, \Omega \cdot \text{m} \]
\[ \rho = 1 \text{ to } 50 \, \Omega \cdot \text{m} \]
Introduction – Problem Statement

The challenges of using one long electrode: may be cheaper to install but harder to control.
Alternate Approach: Finite Length Stacked Electrodes

ElectroThermal-Dynamic Stripping Process (ET-DSP™)
McMillan-McGee Corp.
Calgary, AB
Alternate Approach: 
Finite Length Stacked Electrodes

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More Uniform Heating and Control
ET-DSP™ Electrode Design

(McMillan-McGee)
Case Study: ET-DSP™ Site
Boston, MA

Site Background
Site Remedy:
• Thermal for CVOC Source Zone
• Directed Groundwater Recirculation for CVOC Plume
• Excavation of Metals and TPH Hotspots

Thermal Treatment Area = 8,900 m² (2.2 acres)
Site Geology
Conceptual Site Model

- **Ground Surface**
- **Sand and Gravel** \( \rho = 150 \ \Omega \cdot m \)
- **Clay** \( \rho = 10 \ \Omega \cdot m \)
- **Water Table**
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 ~100°C
• 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?

\[ \rho = 10 \, \Omega \cdot m \]

\[ \rho = 150 \, \Omega \cdot m \]
Case Study: ET-DSP™ Site
Boston, MA
Electrode Design and Analysis
Conceptual Site Model

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Ideal Electrode Design

How to Ensure Uniform and Adequate Heating Given Resistivity Contrasts?

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
Simulated Temperature After 210 Days of Heating

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Simulated Temperature After 210 Days of Heating

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
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

Proper Electrode Design Results in Uniform Heating
Observed Temperatures After 170 Days of Heating

Proper Electrode Design Results in Uniform Heating
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)