SOLAR POWERED ELECTROKINETIC SOIL DESALINATION OF BRINE RELEASES

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Current Remediation Technologies for Brine Spills

• Dig and Haul
• Amend and/or Flush
  Protective of an aquifer? Chloride?
• Cap
  Generally not acceptable to land owner
• Others??
Electrokinetic Remediation?

- Application of direct current (DC) electricity to the soil
- Polarized electrodes invoke movement of pore water and ions contained in the pore water, even in low permeability soils
Electrokinetics

- **Electroosmosis** – Movement of pore water and dissolved contaminants toward the cathode

- **Electromigration** – Migration of ionic species toward respective electrodes (anions toward anode, cations toward cathode) by electrical attraction
  - $EM \sim 10 \times EO$, depending on size and charge
Principles of Electrokinetics

Electroosmosis = Water Transport from anode to cathode

Electromigration = Ion Transport to the opposite electrode
Rate of ion migration (electromigration) is proportional to voltage gradient and ionic mobility plus electroosmosis flow and any bulk convectional flow.
Field Scale Design

- Readily available equipment and parts (lowest costs)
- Electrodes are installed like miniature wells
  - Slotted 1” PVC well screen (24 cathodes, 69 anodes)
  - DSA wire wrapping as primary electrode
  - Backfill annulus with conductive backfill material (example-Loresco SWS®)
  - Installed with hydraulic push (Geoprobe®) or small drill rig
- Extraction equipment is multi-head peristaltic pumps (peristaltic) operated on a timer
- Passive as possible operation
EK Desalinization Process

Typical Setup

480 Volt AC Line Feed From Jack Pump Generator

Brine Tote

Brine Discharge Pump

Multi-head Peristaltic Pumps

Siphon tubes

Anode buss feed

Cathode buss feed

Rectifier

Electrodes arranged in hexagons or parallel rows

Anode (multiple)

Cathode (multiple)

Pore Water

Na+

Cl−
EK Desalination Process

Brine Tote

Brine Discharge Pump

Multi-head Peristaltic Pumps

Siphon tubes

Anode buss feed

Cathode buss feed

480 Volt AC Line Feed From Jack Pump Generator

Line feed and rectifier may be replaced with solar grid

Electrodes arranged in hexagons or parallel rows

480 Volt AC Line Feed From Jack Pump Generator

Rectifier

Anode (multiple)

Cathode (multiple)

Na+

Cl−

Pore Water

+ −
Electrode/Wells are pushed in using a Direct-Push system
Installed EK system at the Connie Site
Lessons Learned to Date

- Small amount of chlorine gas generated at anode (expected) due to oxidation of chloride
- Choose materials and pump equipment wisely
- Rectifier sensitive to “noisy power” from well head generator
Current Status

• EK desalination is working at the demonstration site *(and some valuable lessons learned)*

• Regulators and Corporate on board

• Next step is to incorporate solar power
Schmitz Site
Schmitz Site Layout

Naturally south sloping area nearby for solar grid

48 Anodes and 48 Cathodes aligned parallel with groundwater flow to deflect chloride and sodium ions toward electrode wells

16 Sub grid area of 2 KW each serviced by 8 250W panels – 128 total panels
Sodium & Chloride Removal

– Model predicts 2 summers for the chloride to reach anodes
– System to be operated from late spring to early fall each year
– Operations coincide with peak solar incidence. Siphon pumps and tubing will need to be removed during winter months
– Removed ion-rich water will be monitored for conductivity as operations guide
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<th>Project Associated Expense</th>
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Budget

• Installation requires:
  – Equipment
    • Multi-head peristaltic pumps
    • Electrode wells (96)
    • Wire and tubing for each well
    • Data system
    • 32KW Solar Array + infrastructure
  – Labor – Electrical hookups and plumbing
  – Direct – Well installation and drilling
Budget

• Operation requirements:
  – Oversight and data management (Terran)
  – Fluids management (Oasis subcontractor)
  – Sampling and analysis (Oasis + subcontractor)
Budget

• Management and Reporting:
  – Required summaries and updates
  – Annual report and evaluation
Summary

• EK Desalinization shows promise
• Solar appears to be a natural fit
• The Schmitz site lends itself a good test case with back-up provisions available

• **Ideal outcome:**
  – Oasis gets a cleaned site
  – Terran develops a proven remediation tool
  – North Dakota has a viable option for remote brine release sites