Applicability of ISCO Using Rotating Dual Axis Blending Technology at MGP Sites

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ISCO at MGP Sites

• In-situ chemical oxidation (ISCO) has been used with varied degrees of success at MGP sites
• Typically applied using injection methods
• Less disruptive than many other treatment options
• Application flexibility
• Injections can target many depth intervals and otherwise difficult to reach treatment zones
ISCO at MGP Sites

- Generally effective in treating MGP-related COCs (dissolved phase and lower concentration chemicals)
- Most effective in treating higher permeability soil types
- Limited effectiveness in treating NAPL, coal tar, and purifier wastes
- Success or failure of ISCO for MGP treatment is largely dependent on:
  - Sound conceptual site model
  - Development of site-specific treatment goals
  - Oxidant type
  - Reagent delivery method
  - Contact of chemical reagent with COCs

Traditional Subsurface Delivery Methods

- Direct Injection
  - Temporary injection points (e.g., DPT borings, Geoprobe®)
  - Fixed injection wells (e.g., screened wells)
  - Bedrock injection wells (e.g., inflatable isolation packers)
  - Trenches and horizontal well systems

- Soil Mixing
  - Backhoe methods
  - Auger methods
ISCO Application Challenges at MGP Sites

- MGP sites often require large quantities of reagent:
  - **HIGH** oxidant demand = **LARGE** oxidant volume
  - Numerous injection rounds are typically required
- Reagent delivery by injection is limited by soil pore space
  - Difficult injecting large oxidant volume
- Reagent short-circuiting/surfacing
- Contaminant displacement
- Reagent contact with COC is critical

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Dual Axis Soil Blending Technology

Key components and benefits

- Dual-axis rotation (optimal soil mixing performance)
- Reagent application at point of mixing (maximize chemical contact)
- Large amounts of reagent introduced in a single application
- Control of chemical dosing
- Appropriate for most soil, COC, and oxidant types
Dual Axis Soil Blending Technology

• Site conditions favorable for technology
  – Variable soil types
  – Shallow or moderately deep soil and groundwater impacts
  – Dissolved fraction and higher concentration MGP chemicals (COC < Csat)

• Less favorable site conditions
  – Limited working space availability
  – Bedrock/ subsurface obstructions
  – Significant NAPL or coal tar (COC > Csat)
Design and Implementation Techniques

Example of reagent distribution plan and treatment grid

- Soil treatment verification sampling
### Technology Considerations

- Re-blending limitations
- Large rocks or boulders
- Poor drainage in fine-grained soil (ponding of water and chemical reagents)
- Soil expansion
- Post-blending soil structure – site redevelopment considerations

### Soil Blending/Mixing Effectiveness

#### Soil Void Ratio Comparison

<table>
<thead>
<tr>
<th>Type</th>
<th>Void Ratio Pre-Blending</th>
<th>Void Ratio Post-Blending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>0.448</td>
<td>0.448</td>
</tr>
<tr>
<td>Clay</td>
<td>0.460</td>
<td>0.460</td>
</tr>
<tr>
<td>Clay</td>
<td>0.462</td>
<td>0.462</td>
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<tr>
<td>Clay</td>
<td>0.437</td>
<td>0.437</td>
</tr>
<tr>
<td>Clay</td>
<td>0.449</td>
<td>0.449</td>
</tr>
<tr>
<td>Clay</td>
<td>0.491</td>
<td>0.491</td>
</tr>
<tr>
<td>Sand</td>
<td>0.644</td>
<td>0.644</td>
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<tr>
<td>Sand</td>
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<tr>
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<td>Sand</td>
<td>0.396</td>
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</tr>
<tr>
<td>Sand</td>
<td>0.760</td>
<td>0.760</td>
</tr>
</tbody>
</table>
Soil Blending/Mixing Effectiveness

Pre-blending Soil Porosity

0.309 0.315 0.31 0.3 0.31 0.41

Post-blending Soil Porosity

0.713 0.701 0.706 0.711 0.692 0.72

Total Porosity

Soil Total Porosity Comparison
Pre-Blending vs. Post Blending

Decision Factors Affecting Performance

• Real-time soil treatment verification sampling
• Adjusting mixing duration and/or reagent dosage

• Soil management
• Chemical supply logistics
• Chemical mixing quality control
### Cost of Dual-Axis Blending Technology

**Example for ~15,000 CY soil treatment volume using alkaline activated sodium persulfate (2011)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil Blending</strong></td>
<td></td>
</tr>
<tr>
<td>&lt; 15 feet depth (no soil excavation)</td>
<td>$0.88 to $3.08/yd³</td>
</tr>
<tr>
<td>15 feet and &lt; 30 ft. depth (with soil excavation)</td>
<td>$0.45 to $4.05/yd³</td>
</tr>
<tr>
<td><strong>Chemical Reagents (Alkaline activated sodium persulfate)</strong></td>
<td></td>
</tr>
<tr>
<td>92% Sodium Hydroxide Solution</td>
<td>$3.00 to $4.20/gallon</td>
</tr>
<tr>
<td>Municipal Water</td>
<td>$0.15 to $0.40/yd³ of soil treated</td>
</tr>
<tr>
<td><strong>Equipment Mobilization and Demobilization</strong></td>
<td></td>
</tr>
<tr>
<td>400-mile radius</td>
<td>$30,000 to $40,000</td>
</tr>
<tr>
<td><strong>Auxiliary Project Costs</strong></td>
<td></td>
</tr>
<tr>
<td>Sediment and Erosion Controls</td>
<td>$1.00 to $2.00/acre</td>
</tr>
<tr>
<td>Temporary facilities, perimeter fencing, drilled</td>
<td>$1.50 to $1.70/yr ft² of treatment area</td>
</tr>
<tr>
<td>Site grading, topsoil placement, seeding and mulch</td>
<td>$10,000 to $12,000/acre</td>
</tr>
</tbody>
</table>

### Observations/Lessons Learned

- Site planning is critical
- Requires application flexibility
  - Adjust dosing rates based on field/laboratory test results
  - Soil management
- May require significant mixing water to be added — delays site restoration
- Resulting soil structure will make redevelopment efforts more complex
- Schedule should allow for downtime (e.g. large boulders break teeth on rotating mixer head)
- Customized sampling equipment/techniques are beneficial
- Odor controls must be considered at MGP sites
- Reagent contact with COCs is maximized!
Thank You

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