CHEMICAL TRACERS, INC.

Single Well Chemical Tracer Testing Services
Lab Core Flood Evaluation

- 3-6 Months Work
- Scale; PV < 250 milliliters (0.001 bbls)
- Cost ~ $200K
- Justification: Essential Screening Step

Single 5-Spot, (or More) Pattern

- 3-5 Years Work
- Scale; PV ~ 500,000 bbls
- Cost ~ $10MM-$20MM
- Justification: Oil in Tank
  In-Situ Test
  Reduce Further Risk

Field Wide or Expanded Flood Pattern

- 5-15 Years Work
- Scale; PV ~ 10MM to >100MM bbls
- Risk ~ $100MM-$400MM
- Justification: Additional OOIP Recovery

TYPICAL EOR IMPLEMENTATION APPROACH
Lab Core Flood Evaluation

- 3-6 Months Work
- Scale; PV < 250 milliliters (0.001 bbls)
- Cost ~ $200K
- Justification: Essential Screening Step

SWCT One-Spot-Pilot

- One Month of Work
- Scale; PV ~ 1,000 bbls
- Cost ~ $150-200K
- Justification: Establish EOR Target Oil
  EOR Injectivity Test
  In-Situ Demonstration
  Reduce Further Risk

Single 5-Spot, (or More) Pattern

Field Wide or Expanded Flood Pattern

BETTER EOR IMPLEMENTATION APPROACH

Porosity = 0.25

20-feet
Single Well Chemical Tracer Test
For
Residual Oil Saturation
\( \beta \) Measurement
Step 1
Ester Injection
Step 2
Ester Push
Step 3
Shut-In (Reaction) Period

\[ \text{EtAc} + \text{H}_2\text{O} \rightarrow \text{EtOH} + \text{HAc} \]
Step 4
Production Period
Step 4
Production Period
(Continued)
Step 4
Production Period
(Continued)
Single Well Chemical Tracer Test Production Profile

\[ \frac{Q_a}{Q_b} = 1 + \beta \]

\[ \beta = \frac{K_i S_{or}}{(1 - S_{or})} \]

\[ K_i = \frac{C_i(oil)}{C_i(water)} \]

\[ S_{or} = \frac{\beta}{(\beta + K_i)} \]
Volume Produced (bbls)

Sor = Zero Case

Product Alcohol and Ester

Concentration Tracers (ppm)

Concentration Tracers (ppm)

Un-reacted Ester Tracer

Product Alcohol Tracer
Product Alcohol and Ester

Sor = 0.10 Case (K = 5.0)

Concentration Tracers (ppm) vs. Volume Produced (bbls)

- Product Alcohol Tracer
- Un-reacted Ester Tracer

Concentration Tracers (ppm)
Product Alcohol and Ester

- **Sor = 0.30 Case (K = 5.0)**
- **Product Alcohol Tracer**
- **Un-reacted Ester Tracer**

Concentration Tracers (ppm)

Volume Produced (bbls)
Pore Volume (PV)
Calculation Basis

\[ PV = \pi r^2 h \phi \]

Example: PV = \((3.14)\cdot(20 \text{ ft})^2\cdot(14.9 \text{ ft})\cdot(0.30) = 5,614 \text{ ft}^3\cdot0.1781 \text{ bbls/ft}^3 = 1,000 \text{ bbls} \]
SWCT One-Spot Pilots Have Successfully Evaluated:

- ASP (12)
- Lignin-Surfactant-Polymer (2)
- Surfactant-Polymer (9)
- Lo-Sal Water Flood (62)
- Miscible Hydrocarbon / WAG (5)
- Carbon Dioxide (6)
Recent Field Projects Carried out by Chemical Tracers, Inc.
### Results of 6 One-Spot-Pilot CO₂ Flood Studies

<table>
<thead>
<tr>
<th>Flood ID</th>
<th>Initial WF Sor</th>
<th>Post-CO₂ Flood Sor(m)</th>
<th>Change In Sor % Reduction</th>
<th>Produced Water Sal Ppm TDS</th>
<th>Reservoir Pressure psi</th>
<th>Temp. Deg. F.</th>
<th>Interval Size Feet</th>
<th>Porosity</th>
<th>PV bbls</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.25</td>
<td>0.02</td>
<td>92%</td>
<td>5,000</td>
<td>2,850</td>
<td>210</td>
<td>20</td>
<td>0.23</td>
<td>772</td>
<td>SS</td>
</tr>
<tr>
<td>2</td>
<td>0.36</td>
<td>0.11</td>
<td>69%</td>
<td>55,000</td>
<td>2,600</td>
<td>105</td>
<td>15</td>
<td>0.21</td>
<td>528</td>
<td>Carb.</td>
</tr>
<tr>
<td>3</td>
<td>0.38</td>
<td>0.28</td>
<td>26%</td>
<td>22,000</td>
<td>2,200</td>
<td>210</td>
<td>115</td>
<td>0.20</td>
<td>3,860</td>
<td>Frac. Shale</td>
</tr>
<tr>
<td>4</td>
<td>0.28</td>
<td>0.15</td>
<td>46%</td>
<td>22,000</td>
<td>2,200</td>
<td>210</td>
<td>115</td>
<td>0.20</td>
<td>3,860</td>
<td>Frac. Shale</td>
</tr>
<tr>
<td>5</td>
<td>0.23</td>
<td>0.21</td>
<td>9%</td>
<td>8,000</td>
<td>1,600</td>
<td>100</td>
<td>8</td>
<td>0.14</td>
<td>305</td>
<td>Dol.</td>
</tr>
<tr>
<td>6</td>
<td>0.27</td>
<td>0.19</td>
<td>30%</td>
<td>8,000</td>
<td>1,650</td>
<td>100</td>
<td>13</td>
<td>0.16</td>
<td>340</td>
<td>Dol.</td>
</tr>
</tbody>
</table>
### Sor Results from Permian SOZ Zone

<table>
<thead>
<tr>
<th>Initial WF Sor</th>
<th>Produced Water Sal Ppm TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.23</td>
<td>8,000</td>
</tr>
<tr>
<td>0.27</td>
<td>8,000</td>
</tr>
<tr>
<td><strong>0.09</strong></td>
<td><strong>48,000</strong></td>
</tr>
<tr>
<td>0.13</td>
<td>48,000</td>
</tr>
<tr>
<td><strong>0.10</strong></td>
<td><strong>48,000</strong></td>
</tr>
<tr>
<td>0.28</td>
<td>55,000</td>
</tr>
<tr>
<td>0.36</td>
<td>55,000</td>
</tr>
</tbody>
</table>

**Injection Wells**

<table>
<thead>
<tr>
<th>Injection Wells</th>
<th>Ppm TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.06</td>
<td>150,000</td>
</tr>
<tr>
<td>0.09</td>
<td>150,000</td>
</tr>
</tbody>
</table>