Casper WY Treatment Wetland
Former refinery (1912 – 1991)

• Extensive LNAPL with natural gradient toward river
• 1.5 mile long sheet pile wall with inward hydraulic gradient (6”)
  • 600 to 900 gpm needed (+Soda Lake = 1,200 to 2,200 gpm)
Reuse Plan
Golf course and commercial park

- Extensive use of vegetation and water features
- But, long, cold winters (-35 °C; high winds)
Pilot Study
Benzene results

- Mixed species:
  - *Cornus, Juncus, Phragmites, Salix, Scirpus, Typha*
- With and without aeration
- With and without insulation

\[
y = 3.3187x
\]

\[
y = 2.1929x
\]
Rate Coefficients, $K_A$ (m/yr)

$$\frac{C_0 - C^*}{C_i - C^*} = \exp\left(-\frac{K_A}{A}\right) = \exp\left(-K_v t\right)$$

<table>
<thead>
<tr>
<th>Compound</th>
<th>Aeration</th>
<th></th>
<th>No Aeration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mulch</td>
<td>No Mulch</td>
<td>Mulch</td>
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</tr>
<tr>
<td>Benzene</td>
<td>518</td>
<td>456</td>
<td>317</td>
<td>226</td>
</tr>
<tr>
<td>BTEX</td>
<td>356</td>
<td>311</td>
<td>257</td>
<td>244</td>
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<tr>
<td>TPH</td>
<td>1058</td>
<td>965</td>
<td>725</td>
<td>579</td>
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<tr>
<td>MTBE</td>
<td>64</td>
<td>60</td>
<td>35</td>
<td>22</td>
</tr>
<tr>
<td>Average Rate Increase</td>
<td>2.1x</td>
<td>1.9x</td>
<td>1.3x</td>
<td>1.0x</td>
</tr>
</tbody>
</table>
Full-Scale System Based on Pilot Benzene as Driver

- Passive Stripping (Biofilter)
- Sediment Basin
- Radial Flow Aeration Wetland

- From Oil/Water Separator
- Cascade Aerator
- FWS Wetlands
- SSF Wetlands
- To Soda Lake

- 1.5 mg/L
- 0.5 mg/L
- 0.05 mg/L

- 0.9 ha
- 0.4 ha
- 0.3 ha
- 0.3 ha
During Construction
Post-Construction
Opening Day
Outfall 001 Benzene below detection levels (<0.001 mg/L)
Benzene influent and effluent, entire system

- Lime deposits plugging aeration lines in radial flow wetland
- Blowers turned off in late 2007
- Effluent targets still being met

Outfall 001 Benzene below detection levels (<0.001 mg/L)
Trees and grasses
“Phytoscape”
= Phytoremediation + Landscapes
Examined over 60 deep-rooted native prairie species (grasses, forbs, wildflowers)

Injected pure gasoline (+/- 10% oxygenates) at various volumes

Measured gasoline concentrations over time (4-8 weeks)

Some species VERY tolerant; others more susceptible

Confirmed roots growing through soil (yellow)

Clean topsoil

Clayey soil

Sub-irrigation only source of water

1 L total soil volume
45 mls per 1 L cell (7.5% by wgt)

**Final Soil Concentrations:**

**Unplanted Control Pots (not shown):**
- BTEX: 1,875 ug/kg
- MTBE: 2,700 ug/kg

**Planted Pots: Bottom Soil Layer**
- BTEX: 46 ug/kg (ND, 11, ND, 35)
- MTBE: 50 ug/kg

orders of magnitude lower
Yahoo or Google Maps?

Both searched on November 23, 2009
Acknowledgements

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