Natural Recovery of PCB-Contaminated Sediments at the Sangamo-Weston/Twelve Mile Creek/Lake Hartwell Superfund Site

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Monitored Natural Recovery (MNR) of sediments is a remedial option that relies on natural environmental processes to permanently reduce risk, and which includes careful assessment, modeling, and monitoring to ensure success (RTDF).

Natural processes most often associated with MNR:
- Sediment containment through natural capping
  Requires net depositional areas
- Contaminant weathering
  Biological Processes
  Physical/chemical processes
  Contaminant sorption/sequestration
Natural Recovery Program Objective

- Investigate natural recovery of contaminated sediments at two sites
  - **PCB-contaminated sediments**
    Sangamo-Weston/Twelve Mile Creek/Lake Hartwell Superfund Site (Pickens County, SC)
  - **PAH-contaminated sediments**
    Wyckoff/Eagle Harbor Superfund Site (Bainbridge Island, WA)
- Develop **field evaluation** techniques
- Use a **snapshot** approach
Sample Collection at Lake Hartwell

- Collected sediment cores
- Extruded cores into 5-cm segments
Lake Hartwell Site Map

- Sediment cores at 10 locations
- Locations matched USEPA transects
- Extruded samples after coring

**Transect Locations**
T16, W7, Q, P, O, N, L, J, I, T6
Lake Hartwell Site, South Carolina

- Documented history of contaminated sediments
  - Capacitor Manufacturing (1955-1978)
  - Single primary PCB source (Aroclors 1016, 1242, and 1254)
- Natural Recovery selected to restore Lake Hartwell sediments (EPA/ROD/R04-94/178)
- Terrestrial PCB contamination has been removed/contained
Lake Hartwell Results

- Vertical and horizontal PCB distribution
- Sediment age dating and sedimentation rates
- PCB homologue and congener distribution analyses
Vertical t-PCB Concentration Profile
Transect Q (Upgradient)

Core Segment Depth (cm)

Concentration (µg/kg) dry weight
Vertical t-PCB Concentration Profile
Transect L (Downgradient)

Core Segment Depth (cm)

Concentration (µg/kg) dry weight

Silt

1999
1997
1994
1991
1988
1985
1981
1977
1973
1969
1965
1960
1956
1951
1944
1935
1926
# Estimated Sedimentation (cm) to Achieve Sediment Cleanup Goals

<table>
<thead>
<tr>
<th>Core</th>
<th>1 mg/kg t-PCB</th>
<th>0.4 mg/kg t-PCB</th>
<th>0.05 mg/kg t-PCB</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>2.8</td>
<td>16</td>
<td>45</td>
</tr>
<tr>
<td>N</td>
<td>0</td>
<td>7.8</td>
<td>29</td>
</tr>
<tr>
<td>L</td>
<td>2.7</td>
<td>11</td>
<td>31</td>
</tr>
<tr>
<td>I</td>
<td>0</td>
<td>11</td>
<td>42</td>
</tr>
<tr>
<td>T6</td>
<td>0</td>
<td>3.5</td>
<td>13</td>
</tr>
<tr>
<td>Avg.</td>
<td><strong>1.2 ± 1.7</strong></td>
<td><strong>10 ± 4.7</strong></td>
<td><strong>32 ± 13</strong></td>
</tr>
</tbody>
</table>

- **1 mg/kg**: ROD surface sediment cleanup goal (EPA, 1994)

- **0.4 mg/kg**: Mean site-specific sediment quality criteria (EPA, 1994)

- **0.05 mg/kg**: NOAEL effects range-low (EPA, 1994)
## Estimated Time (yrs) to Achieve Sediment Cleanup Goals

### Table: Estimated Time (yrs) to Achieve Sediment Cleanup Goals

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<th>0.05 mg/kg t-PCB</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>1 - 3</td>
<td>8 - 10</td>
<td>&gt; 28</td>
</tr>
<tr>
<td>N</td>
<td>—</td>
<td>5 - 10</td>
<td>25 - 30</td>
</tr>
<tr>
<td>L</td>
<td>3 - 5</td>
<td>5 - 7</td>
<td>15 - 20</td>
</tr>
<tr>
<td>I</td>
<td>—</td>
<td>2 - 5</td>
<td>10 - 15</td>
</tr>
<tr>
<td>T6</td>
<td>—</td>
<td>2 - 5</td>
<td>10 - 15</td>
</tr>
<tr>
<td>Range</td>
<td>1 - 5</td>
<td>2 - 10</td>
<td>10 - 30</td>
</tr>
</tbody>
</table>

- **1 mg/kg**: ROD surface sediment cleanup goal (EPA, 1994)
- **0.4 mg/kg**: Mean site-specific sediment quality criteria (EPA, 1994)
- **0.05 mg/kg**: NOAEL effects range-low (EPA, 1994)
Core L Homologue Plots
Cl-1 through Cl-3
Core L Homologue Plots
Cl-4 through Cl-10

Depth (cm)

Percent of t-PCB

- CI 4
- CI 5
- CI 6
- Sum

- CI 7
- CI 8
- CI 9
- CI 10

Percent of t-PCB

(Cl7, Cl8, & Sum)

(Cl9 & Cl10)
PCB Congener Distribution in Surface and Deep Sediments

Core L, Section 1, 0-5 cm depth interval
Total PCB = 1.58 mg/kg

Core L, Section 10, 35-40 cm depth interval
Total PCB = 48.7 mg/kg

Core L: Relative Change
Section 8 (35-40 cm) minus Section 1 (0-5 cm)
## Major Congener Shifts Observed Between Core Segments L-1 and L-8

<table>
<thead>
<tr>
<th>IUPAC No.</th>
<th>Congener Name</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB 1</td>
<td>2-chlorobiphenyl</td>
<td>4.4</td>
</tr>
<tr>
<td>PCB 4/10</td>
<td>2,2'/2,6-dichlorobiphenyls</td>
<td>29</td>
</tr>
<tr>
<td>PCB 8/5</td>
<td>2,4'/2,3-dichlorobiphenyls</td>
<td>5.8</td>
</tr>
<tr>
<td>PCB 16/32</td>
<td>2,2',3/2,4',6-trichlorobiphenyls</td>
<td>5.8</td>
</tr>
<tr>
<td>PCB 19</td>
<td>2,2',6-trichlorobiphenyl</td>
<td>8.4</td>
</tr>
<tr>
<td>PCB 24/27</td>
<td>2,3,6/2,3',6-trichlorobiphenyls</td>
<td>2.5</td>
</tr>
<tr>
<td>PCB 66 -156</td>
<td>tetra- through hexachlorobiphenyls</td>
<td>-45</td>
</tr>
</tbody>
</table>
Summary and Conclusions

- Highest t-PCB associated with silt/clay layers
- Decreasing surface t-PCB, at or approaching 1.0 mg/kg (Max surface PCB = 1.58 mg/kg at Transect L)
- Time to achieve surface sediment concentrations
  - 0 to 5 yrs to achieve 1.0 mg/kg
  - 2 to 10 yrs to achieve 0.4 mg/kg
  - 10 to 30 yrs to achieve 0.05 mg/kg
- Homologue shifts from higher to lower chlorinated congeners
  - Cl4/Cl5/Cl6 congeners reduced from 80% to 20% t-PCB with depth and time
  - Cl1/Cl2/Cl3 congeners increased from 20% to 80% t-PCB with depth and time
- Significant accumulation of ortho chlorinated congeners
Effectiveness of Natural Recovery Approach

- Sediment isotope analyses provided an effective means of calculating sedimentation rates and surface sediment recovery rates.
- High resolution PCB chromatography (107 congeners eluted) used to characterize vertical PCB dechlorination with sediment depth and age.
- Evaluate relationship of sediment contamination with benthic animals and fish.
- Assess long-term stability.