Evaluating the Effectiveness of BMPs to Reduce Hg and PCB Loads from Urban Runoff

Lester J. McKee
San Francisco Estuary Institute

Peter Mangarella
GeoSyntec Consultants
What started it all?

Office of Environmental Health Hazard Assessment (OEHHA)

- 1994 fish consumption advisory in relation to Hg and PCBs in fish

- 1999 Updated in relation to Hg
Bans

PCBs
- 1974: Dissipative open-ended applications
- 1977: U.S production
- 1979: Importation

Mercury
- 1991: Hg use in latex paint
- 1991: Hg use in batteries reduced to 0.025%
- 2003: Dental insurance alternatives
- 2005: Hg switches in California
- 2005: Hg switch use in vehicles
Changing Understanding of Supply

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediment</td>
<td>3.54 Mt</td>
<td>1.7 Mt</td>
</tr>
<tr>
<td>Mercury</td>
<td>840 kg</td>
<td>550 kg</td>
</tr>
<tr>
<td>PCBs</td>
<td></td>
<td>76 kg</td>
</tr>
<tr>
<td><strong>Rivers</strong></td>
<td><strong>11 kg</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Small Tribs</strong></td>
<td><strong>?</strong></td>
<td></td>
</tr>
</tbody>
</table>

- Red: Central Valley
- Yellow: Small Tributaries
Regulatory Process

- 303(d) listings for PCBs and Hg
  - TMDL reports
  - Basin Plan amendments
## Hg Load Allocations

### Urban Storm Water Runoff

<table>
<thead>
<tr>
<th>Source</th>
<th>2003 Mercury Load (kg/yr)</th>
<th>Allocation (kg/yr)</th>
<th>Reduction (%)$^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed Erosion</td>
<td>460</td>
<td>220</td>
<td>53</td>
</tr>
<tr>
<td>Atmospheric Deposition</td>
<td>27</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>Non-Urban Storm Water Runoff</td>
<td>25</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Wastewater (municipal and industrial)</td>
<td>20</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Dredging and Disposal$^b$</td>
<td>net loss</td>
<td></td>
<td>≤ ambient concentration</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,220</strong></td>
<td><strong>706</strong></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ This load does not account for mercury captured in sediment removal programs conducted in the watershed.

$^b$ Sediment dredging and disposal often moves mercury-containing sediment from one part of the bay to another. The dredged sediment mercury concentration generally reflects ambient conditions in San Francisco Bay sediment. This allocation is concentration-based. The mercury concentration of dredged material disposed in the bay must be at or below the baywide ambient mercury concentration. This allocation will ensure that this source category continues to represent a net loss of mercury.

$^c$ The 2003 mercury load for each source is rounded from calculated values. The percent reduction for each source was calculated prior to rounding.
# PCB Load Allocations

<table>
<thead>
<tr>
<th>Source Category</th>
<th>Current PCBs Loads (kg/yr)</th>
<th>Proposed PCBs Loads (kg/yr)</th>
<th>Proposed Load Reductions (kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric</td>
<td>-7</td>
<td>-7</td>
<td>0</td>
</tr>
<tr>
<td>Delta</td>
<td>42</td>
<td>32</td>
<td>10 (76%)</td>
</tr>
<tr>
<td>Westamer, Bird</td>
<td>33</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Dredged Material</td>
<td>12</td>
<td>1.4</td>
<td>11 (88%)</td>
</tr>
<tr>
<td>In-Bay PCBs &quot;Hot Spots&quot;</td>
<td>NQ</td>
<td>NQ</td>
<td>NQ</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>83</strong></td>
<td><strong>31</strong></td>
<td><strong>53</strong></td>
</tr>
</tbody>
</table>

NQ = Not Quantified

**Urban Storm Water Runoff**
- Current: 34 kg/yr
- Proposed: 2 kg/yr
- Reduction: 94 kg/yr
Urban Stormwater Managers are asking how?

- Where are the contaminated sites?
Urban Stormwater Managers are asking how?

• What about atmospheric deposition?
Urban Stormwater Managers are asking how?

- Will conventional source control, treatment control, or maintenance control work?
- If so – which practices and when and under what circumstances?
- How much will it cost?
Urban Stormwater Managers are asking how?

• Where are the contaminated sites?
• What about atmospheric deposition?
• Will conventional source control, treatment control, or maintenance control work?
• If so – which practices and when and under what circumstances?
• How much will it cost?
Urban Stormwater Managers are asking how?

• Where are the contaminated sites?
• What about atmospheric deposition?
• Will conventional source control, treatment control, or maintenance control work?
• If so – which practices, and when and under what circumstances?
• How much will it cost?
### Hg Uses

<table>
<thead>
<tr>
<th>Use</th>
<th>1970 (% usage)</th>
<th>1997 (% usage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batteries</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Paint</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td>Instruments</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Switches</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>Dental</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Laboratory</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Lighting</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>
Hg Uses

• Still about 7 metric t being imported into the Bay Area annually

• About 1% of the 1950-90 total
# National PCB Uses

*Before bans in 1977*

<table>
<thead>
<tr>
<th>Class</th>
<th>(%)</th>
<th>$10^6$ kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controllable closed systems</td>
<td>60</td>
<td>385</td>
</tr>
<tr>
<td>Uncontrollable closed systems (nominally closed)</td>
<td>10</td>
<td>63</td>
</tr>
<tr>
<td>Dissipative (open-ended)</td>
<td>30</td>
<td>191</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td><strong>640</strong></td>
</tr>
</tbody>
</table>
PCB Uses

- Still >200,000 kg reported use in the Bay Area today
- About 2% of the 1950-90 total
Answering Management Questions

• Used a mass balance approach at the scale of the Bay Area

• Scaled national use to the Bay Area
  – Population
  – Land use
  – Used local information where available

• Estimated mass entering impervious surfaces and rivers, creeks and storm drains
  – Literature
  – Hydrological principals
  – Reasonable guesstimates
Hg in Batteries

- US battery demand 10 billion in 2002 growing by 6% annually

- Each modern battery contains ~0.025% Hg by weight

- Guesstimated between 1:1000 and 1:10,000 entered storm water
Hg in Paint

- Estimated paint use based on population
- Studies indicate 66% of use is released to the environment
- Assumed use life is 20 years before repaint

Fight mold with mercury
PCBs in Power Transmission and Use

- Scaled use based on population
- 2-3% transformers and large capacitors had leaks
- 0.05-0.35% of the oil leaks out
- Used literature to estimate escape stormwater
Railway Lines

- Oil used as a dust suppressant
- Used literature Hg and PCB soil concentrations
- Estimated erosion of soil based on literature

1950s spur lines
Hg Entering Creeks Rivers and Storm Drains

- Atmospheric Deposition: 27%
- Watershed Surface Sediment Erosion: 34%
- Bed and Bank Erosion: 12%
- Instruments: 6%
- Auto-Recycling: 0%
- Switches and Thermostats: 13%
- Laboratory: 1%
- Gasoline: 1%
- Fluorescent Lighting: 2%
- Industrial Hotspots: 1%
- Landfill: 1%
- Railway Lines: 1%
- Dental: 0%
- Batteries: 0%
- Other Uses: 0%
- Paint: 1%
- Fluorescent Lighting: 2%
- Laboratory: 1%
- Instruments: 13%
- Auto-Recycling: 0%
- Switches and Thermostats: 6%
- Industrial Hotspots: 1%
- Landfill: 1%
- Railway Lines: 1%
- Dental: 0%
- Batteries: 0%
- Other Uses: 0%
- Paint: 1%
Hg Entering Creeks, Rivers and Storm Drains

- Watershed Surface Sediment Erosion: 34%
- Bed and Bank Erosion: 12%
- Atmospheric Deposition: 27%

RMP Annual Meeting 2006
Hg Entering Creeks, Rivers and Storm Drains

- Fluorescent Lighting: 2%
- Switches and Thermostats: 6%
- Instruments: 13%
PCBs Entering Creeks, Rivers and Storm Drains

- Watershed Surface Sediment Erosion: 58%
- Bed and Bank Erosion: 6%
- Small Capacitors: 1%
- Plasticizers: 2%
- Lubricants: 0%
- PCBs Still in Use: 8%
- Transformers and Large Capacitors: 5%
- Industrial Hotspots: 4%
- Auto-Recycling: 1%
- Railway Lines: 2%
- Atmospheric Deposition: 5%
- Building Demolition and Remodeling: 8%
- Other Dissipative Uses: 0%
- Landfills: 0%
- Other: 8%
- Industrial Hotspots: 4%
PCBs Entering Creeks, Rivers, and Storm Drains

- Watershed Surface Sediment Erosion: 58%
- Bed and Bank Erosion: 6%
- Atmospheric Deposition: 5%
- Other sources: 5%
PCBs Still in Use 8%
Transformers and Large Capacitors 5%
Building Demolition and Remodeling 8%
PCBs Still in Use 8%
Industrial Hotspots 4%
Railway Lines 2%
Auto-Recycling 1%

PCBs Entering Creeks, Rivers and Storm Drains
### How is the Mass Distributed by Land Use?

#### Mercury

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Load (kg/yr)</th>
<th>Area (^1) (km(^2))</th>
<th>Unit Loading (g/(km(^2)-yr))</th>
<th>Unit Loading Normalized on Open Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>34</td>
<td>374</td>
<td>92</td>
<td>7</td>
</tr>
<tr>
<td>Commercial</td>
<td>30</td>
<td>404</td>
<td>74</td>
<td>6</td>
</tr>
<tr>
<td>Residential</td>
<td>39</td>
<td>1,726</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>Open/ Agriculture</td>
<td>52</td>
<td>4,147</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>155</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# How is the Mass Distributed by Land Use?

## PCBs

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Load (kg/yr)</th>
<th>Area (km²)</th>
<th>Unit Loading (g/(km²·yr))</th>
<th>Unit Loading Normalized on Open Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>18</td>
<td>374</td>
<td>48</td>
<td>16</td>
</tr>
<tr>
<td>Commercial</td>
<td>8</td>
<td>404</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Residential</td>
<td>10</td>
<td>1,726</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Open/ Agriculture</td>
<td>12</td>
<td>4,147</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>4,147</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Modeling Load Reduction Scenarios

- Desktop analysis evaluating alternative control scenarios out to 2025
  - Source control
  - Treatment control
  - Maintenance activities
Scenarios Discussed To-date

- Increased recycling
- Street sweeping (changes)
- Street washing
- Drain inlet cleaning
- Channel desilting
- Redevelopment treatment
- Retrofit treatment
- Targeting contaminated areas
- Pump station diversion
Example - Street Sweeping

Preliminary – subject to change

• Scenario
  - convert present fleet to high efficiency by 2025

• Key assumption
  - assume improvement from 30% to 50% efficiency

![Graph showing mass removed (kg) from 2000 to 2030 for Hg and PCB]
Example - Drain Inlet Cleaning – e.g. Hg

- **Scenario**
  - Frequency increased from annual to biennial

- **Key Assumption**
  - Volume of material removed is proportional to area

![Graph showing mass removed over years](image)

**Preliminary – subject to change**
Mercury and PCBs Removed Per Year in 2025

TMDL Targets
Hg: 78 kg
PCB: 32 kg

Note Interim product – to be finalized in 2007
Next Steps – Focused GIS Analysis

• Storm drains and storm-sewershed boundaries
• Land use (Ind., Comm., Res. Open/Ag.)
• Old Industrial v new industrial
• Known “hotspots” and “orange zones”
• PGE facilities
• Auto wreckers
• Railway lines
• Watershed sediment supply classification
• Stormwater pump stations
• Wastewater treatment facilities
Next Steps – Focused Sample Collection

- Reconnoiter hotspots and orange zones in selected watersheds to assess offsite soil movement
- Measure Hg and PCBs in urban soils
- Characterize sediment and water on a particle size basis (<25, 25-75, >75 microns)
  - Street dust, sweepings, and street wash-water
  - Runoff water
Old Industrial

Preliminary subject to change
Dominant Sediment Supply Classification

Preliminary subject to change
Acknowledgements

• Funding
  – RMP
  – CEP
  – Prop 13

• Oversight
  – RMP SPLWG
  – Prop 13 BASMAA Stakeholder Group
  – Prop 13 Technical Advisory Committee