LESSONS LEARNED FROM LONG-TERM BIOLOGICAL MONITORING PROGRAMS

Mark Peterson  James M. Loar
Mark Greeley Jr  Michael Ryon
John Smith  George Southworth

Oak Ridge National Laboratory

May 19, 2004
National Monitoring Conference
Chattanooga, Tennessee
Presentation Road Map

- Oak Ridge Reservation
- Overview of Biological Monitoring Programs
- General Trends
- Unexpected Results and other Surprises
- Lessons Learned
The Department of Energy’s OAK RIDGE RESERVATION

Multiple land uses

• DOE industrial mission
• Research purposes
• Native land and T&E species protection
• Security buffer
• Waste storage
• Hunting
• Logging
Sources of contamination/impacts

Groundwater Plumes

Storm drains

Effluent discharges

Waste storage sites

Non-point sources
BIOMONITORING FOCUSED ON AQUATIC PATHWAYS

• Early characterizations revealed low-level terrestrial risks; surface soils first and easiest to clean-up
• Remedial approach via watershed zones
• Majority of ecological COCs are aqueous, bioaccumulative contaminants like Hg and PCBs
• Primary vector for off-site contaminant transport
• Links groundwater, surface water, biota
• Can measure risks to aquatic and terrestrial endpoints
The Biological Monitoring and Abatement Programs (BMAP)

• Streams near DOE facilities in Oak Ridge primary focus

• Regulatory drivers: CWA (NPDES), CERCLA (ER), RCRA, DOE Order 5400.1, NEPA EA

• Multi-disciplinary

• Watershed scale, multiple sites

• Long-term, consistent sampling (1984-2004)
BMAP Tasks

- **Toxicity Testing:**
  - Effluent and ambient
- **Bioindicators:**
  - Fish health
  - Reproduction
- **Bioaccumulation:**
  - Aquatic
  - Terrestrial
- **Instream monitoring:**
  - Periphyton
  - Benthic macroinvertebrates
  - Fish community

- Quantitative methods
- Special studies in all tasks
Watershed Units
Sampling Sites
Integration Points
Spatial Strategy
For Each Watershed

Mean number of EPT taxa in Bear Creek, 1988 - 1997

- Reference site range
- Lower reach
- Middle reach
- Headwaters
- Stream exit point
- Integration point (below S-3; burial grounds)
- Downstream of S-3 pond plume
General Trends - Spatial

Average seasonal PCB concentrations in redbreast sunfish

East Fork Poplar Creek

1985-2003

EFK 24.8
EFK 23.4
EFK 18.2
EFK 13.8
EFK 6.3

2003 metal and PCB concentrations in whole stonerollers

Bear Creek

PCBs
Nickel
Cadmium
Uranium

Highest [ ] upstream, near discharges

Downstream
General Trends - Temporal

-Steady improvements over time

-Reference sites important measure of natural variation

-Same season monitoring

Fish communities
TIME TRENDING IN EAST FORK POPULAR CREEK

Facility Abatement Actions, 1984-2003

<table>
<thead>
<tr>
<th>EVENT:</th>
<th>Pond replaced</th>
<th>Dechlorination</th>
<th>Flow management</th>
<th>Pond bypassed</th>
<th>Bank stabilized</th>
</tr>
</thead>
</table>

Sites

- East Fork Poplar Creek
- Y-12 Plant
- EFK 6.3
- EFK 13.8
- EFK 18.2
- EFK 23.4
- EFK 24.8

orl
# MERCURY TRENDING

(Average seasonal mercury concentrations in redbreast sunfish)

<table>
<thead>
<tr>
<th>EVENT:</th>
<th>Pond replaced</th>
<th>Dechlorination</th>
<th>Flow management</th>
<th>Pond bypassed</th>
<th>Bank stabilized</th>
</tr>
</thead>
</table>

Early years

- Decrease with distance from Y-12

- | Year | Event |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>EFK</td>
</tr>
<tr>
<td></td>
<td>24.8</td>
</tr>
<tr>
<td>1985</td>
<td>EFK</td>
</tr>
<tr>
<td></td>
<td>23.4</td>
</tr>
<tr>
<td>1986</td>
<td>EFK</td>
</tr>
<tr>
<td></td>
<td>18.2</td>
</tr>
<tr>
<td>1987</td>
<td>EFK</td>
</tr>
<tr>
<td></td>
<td>13.8</td>
</tr>
<tr>
<td>1988</td>
<td>EFK</td>
</tr>
<tr>
<td></td>
<td>6.3</td>
</tr>
<tr>
<td>1989</td>
<td>EFK</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
</tr>
</tbody>
</table>
**MERCURY TRENDING**
(Average seasonal mercury concentrations in redbreast sunfish)

<table>
<thead>
<tr>
<th>EVENT:</th>
<th>Pond replaced</th>
<th>Dechlorination</th>
<th>Flow management</th>
<th>Pond bypassed</th>
<th>Bank stabilized</th>
</tr>
</thead>
</table>

**Early years**

- Decrease with distance from Y-12

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EFK</td>
<td>24.8</td>
<td>23.4</td>
<td>18.2</td>
<td>13.8</td>
<td>6.3</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pond closure**

- Decrease below new basin

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EFK</td>
<td>24.8</td>
<td>23.4</td>
<td>18.2</td>
<td>13.8</td>
<td>6.3</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

 Sites
MERCURY TRENDING
(Average seasonal mercury concentrations in redbreast sunfish)

EVENT:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond replaced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dechlorination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pond bypassed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank stabilized</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Early years

Decrease with distance from Y-12

Dechlorination

Fish move into contaminated UEFPC

Pond closure

Decrease below new basin

Sites

EFK 24.8  EFK 23.4  EFK 18.2  EFK 13.8  EFK 6.3  EFK 2.1
MERCURY TRENDING
(Average seasonal mercury concentrations in redbreast sunfish)

<table>
<thead>
<tr>
<th>EVENT:</th>
<th>Pond replaced</th>
<th>Dechlorination</th>
<th>Flow management</th>
<th>Pond bypassed</th>
<th>Bank stabilized</th>
</tr>
</thead>
</table>

- **Early years**: Decrease with distance from Y-12
- **Dechlorination**: Fish move into contaminated UEFPC
- **Pond closure**: Decrease below new basin
- **Flow mgt; Bypass**: Similar levels throughout EFPC
# MERCURY TRENDING

(Average seasonal mercury concentrations in redbreast sunfish)

<table>
<thead>
<tr>
<th>EVENT:</th>
<th>Pond replaced</th>
<th>Dechlorination</th>
<th>Flow management</th>
<th>Pond bypassed</th>
<th>Bank stabilized</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Mercury Concentration (μg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>EFK 24.8</td>
</tr>
<tr>
<td>1985</td>
<td>EFK 23.4</td>
</tr>
<tr>
<td>1986</td>
<td>EFK 18.2</td>
</tr>
<tr>
<td>1987</td>
<td>EFK 13.8</td>
</tr>
<tr>
<td>1988</td>
<td>EFK 6.3</td>
</tr>
<tr>
<td>1989</td>
<td>EFK 2.1</td>
</tr>
</tbody>
</table>

*2000-2003*
### MERCURY TRENDING

<table>
<thead>
<tr>
<th>EVENT:</th>
<th>Pond replaced</th>
<th>Dechlorination</th>
<th>Flow management</th>
<th>Pond bypassed</th>
<th>Bank stabilized</th>
</tr>
</thead>
</table>

**TEMPORAL:**

- **EFK 24.8**
- **EFK 23.4**
- **EFK 18.2**

- **EFK 13.8**
- **EFK 6.3**
- **EFK 2.1**

![Graph showing temporal mercury trends](image)

**2000-2003**

Years since Jan 1984:

- Left graph: Decrease with distance.
- Right graph: Increase with distance.

Ornl
Use of comparable and consistent methodologies across time and space

3 10 fish composites (94-00) 1 20 fish composite (00 – 03)
But be flexible enough to investigate difficult problems

“Muck and Truck” initially preferred cleanup option
Source Identification Studies

- High PCB inputs via storm drains
- Pond likely a PCB sink
- SD100 a major source

Caged clams

Total PCBs (ug/g) in caged clams placed at major SD outfalls

1995 data, except at SD120, 124 (1998)
Lessons learned

• Use biomonitoring methods sensitive to the stresses of the system (e.g., focus on aquatic pathways)
• Multidisciplinary program important
• Conduct quantitative monitoring that will ensure data can be analyzed and is repeatable
• Evaluate locations that are within the range of site exposure/effects (integrate upstream)
• Maintenance of regular, same-season monitoring over a time scale adequate to detect change
• Use of appropriate reference sites
• Use of comparable and consistent methodologies across time and space
• Add-on studies can be extremely valuable