Ecological and Contaminant Studies at 100-N; A Discussion – Meta data

- Slides that had animation when presented have been expanded into separate slides so that all figures can be viewed.
- References have been added to the first slide in a series of slides that cover a specific topic with a listing of all references cite in the presentation on the last slide in this Powerpoint slideshow. The references are indicated in brackets and in blue text [author date].
Ecological and Contaminant Studies at 100-N; A Discussion

100-N CERCLA RI/FS Working Group
February 17, 2010

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Pacific Northwest National Laboratory
Objectives/Agenda

- Summarize past ecological and contaminant work at 100-N
  - Site wide integrated surveillance
  - Focused initiatives
- What we monitor now and to what extent we monitor is predicated on past monitoring, special studies and risk assessments
- Development of biota dose assessment methods
- The focal point at 100-N is the discharged of strontium-90 via groundwater at the shoreline, near shore aquatic environment, and hyporheic zone
- Diesel plume
Agenda

➢ Prior Studies – Emphasis on 100-N
  ■ Surveillance data (1971-date, recent trends)
  ■ Early risk assessments CRITR II
    ◆ Poston and Soldat 1992
    ◆ PNNL/DOH 1997 Study
  ■ Salmon embryo assessment - DOE Technical Standard
  ■ Aquatic Impact Assessment (Interim ROD 2005)

➢ Science and Technology Programs

➢ CERCLA Risk Assessments
100-N Samples
1971-2009, HEIS

Air 37.6%
Biota 15.2%
External Radiation 28.4%
Sediment/soil 2.2%
Water 16.7%
Trends in Surveillance Data

- Releases
- Whitefish
- Canada goose muscle
- Canada goose bone
- Canada goose egg shells
- Shoreline vegetation (1990-92)
- Canada goose metals
Annual releases of Sr-90 and Cs-137 to the Columbia River 1982-1992 (Source: Annual Environmental Reports) [Poston 1994]
Cobalt-60 in goose muscle (1971-2008)
[Simmons et al. 2010]
Cesium-137 in Goose muscle 1971-2008
[Simmons et al. 2010]

- Year (x-axis)
- Concentration (pCi/g wet wt.) (y-axis)

- Offsite
- 100 Areas
- Hanford Townsite to 300 Area
Strontium-90 Goose Bone

[Simmons et al. 2010]

![Graph showing the concentration of strontium-90 in goose bones over time. The graph includes data points for Offsite, 100 Areas, and Hanford Town Site to 300 Area. The x-axis represents the year from 1991 to 2009, and the y-axis represents the concentration (pCi/g wet wt.).]
Strontium-90 in Canada Goose Egg Shells (mean +/- 1 SE) in the Hanford Reach

[Simmons et al. 2010]
Strontium-90 in shoreline vegetation (1990-92)

[Antonio et al. 1993]
Trace metals in Canada Goose Liver (µg/g +/- 1 SE, log scale, dry wt., 2003-2007) [Simmons et al. 2010]
Metal concentrations in Canada goose livers do not exceed toxicity benchmarks for Anadidae [Simmons et al. 2010]

The point – no system wide indication of contamination
Strontium-90 upstream and downstream of the Hanford Site 2003-2008 (pCi/L) [Poston et al. 2009]
Strontium-90 upstream and downstream of the Hanford Site 2003-2008 (pCi/g)

[Poston et al. 2009]
### CRITR II Dose Modeling: 100-N Screening Study (rad/day) 1997

[VanVerst et al. 1998]

<table>
<thead>
<tr>
<th>Radio-nuclide</th>
<th>Fish</th>
<th>Mollusk</th>
<th>Crawfish</th>
<th>Plant-eating duck</th>
<th>Fish-eating duck</th>
<th>Heron</th>
<th>Muskrat</th>
<th>Crawfish eating raccoon</th>
<th>Fish eating raccoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr-90</td>
<td>1.4E-3</td>
<td>2.9E-3</td>
<td>2.9E-3</td>
<td>9.0E-1</td>
<td>2.0E-2</td>
<td>2.0E-3</td>
<td>9.0E-1</td>
<td>2.7E-2</td>
<td>1.4E-2</td>
</tr>
<tr>
<td>H-3</td>
<td>2.0E-7</td>
<td>2.0E-7</td>
<td>2.0E-7</td>
<td>6.0E-5</td>
<td>3.8E-7</td>
<td>3.0E-7</td>
<td>2.6E-7</td>
<td>2.6E-7</td>
<td></td>
</tr>
<tr>
<td>Total Internal Dose</td>
<td>1.4E-3</td>
<td>2.9E-3</td>
<td>2.9E-3</td>
<td>9.0E-1</td>
<td>2.0E-2</td>
<td>9.0E-1</td>
<td>2.7E-2</td>
<td>1.4E-2</td>
<td></td>
</tr>
</tbody>
</table>

**Aquatic Organism:** 1 rad/day  
**Riparian organisms:** 0.1 rad/day
Screening dose and sculpin dose (CRITR II)

Sculpin body burdens
- Good indicator species of fish
  - Benthic species
  - Small home range
- 0.75 pCi/g wet wt. = 0.000044 rad/day [Van Verst et al. 1998]
  - Internal dose rate > beta emissions Sr-90 & Y-90

Salmon Embryo
- 70 pCi/L Sr-90 in salmon redds = 0.00004 rad/d
Follow-on

Taking the embryo dose estimate – an activist made a public claim that DOE was saying that 1,750,000 pCi/L was safe:

\[
1750000 \text{ pCi/L} = \left(\frac{1.0 \text{ rad/day}}{0.00004 \text{ rad/day}}\right) \times 70 \text{ pCi/L}
\]

- This is an indication of the conservative bias built into the dose models and inappropriate math, and
- This is the concentrations necessary to evoke an adverse effect

In a similar vein, the 8 pCi/L DWS that is applied to the hyporheic zone is also inappropriate

- Methods now exist to establish a number that is appropriate for clean up
PNNL/DOH Summary

- Modeled Dose rates are highly conservative
- Where modeled dose rates approach guidelines, exposure scenarios require inspection for bias and accuracy
- Temporal, spatial and biological factors work to reduce dose rates from point source releases
If salmon spawned in the Columbia River next to the 100-N Area shoreline
Salmon Egg/Larva Screening Dose Assessment – DOE Graded Approach

[Doston et al. 2003]

- Dose attributed to ground water seepage-riverbank spring monitoring data
- Reactor areas and Old Hanford Town site
- Dose assessments assumes spawning occurs under influence of groundwater seepage
Tier 1 Screening

► Maximum observed seep concentration – 6 years
► Default bioaccumulation factors
► Default sediment/water partitioning coefficient ($k_d$)
► No dilution of seep water
### 100-N Dose Driven by Sr-90

<table>
<thead>
<tr>
<th></th>
<th>Tier I</th>
<th>Tier II</th>
<th>Species/site Specific</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seep water dilution</strong></td>
<td>100 %</td>
<td>100 %</td>
<td>22%</td>
</tr>
<tr>
<td><strong>Sr-90</strong></td>
<td>Maximum 9870 pCi/L</td>
<td>Median 0.066 pCi/L</td>
<td>Median 0.066 pCi/L</td>
</tr>
<tr>
<td><strong>BAF</strong></td>
<td>320</td>
<td>320</td>
<td>5.7 (Ca=17 mg/L)</td>
</tr>
<tr>
<td><strong>$K_d$</strong></td>
<td>30</td>
<td>30</td>
<td>--</td>
</tr>
</tbody>
</table>
Results of Salmon Embryo/Larval Screening

![Bar chart showing dose (rad/day) for different locations (100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F, OHT) categorized by Tier 1, Tier 2, and Embryo-Specific. The x-axis represents location, and the y-axis represents dose in rad/day. A horizontal line at 1 rad/day indicates the threshold.]
Factors influencing dose rate to salmon embryos from Strontium-90 [Peterson and Poston 2000]

- Strontium-90 has no driver for accumulation – no calcification of tissue during embryogenesis while residing in the cobble.
- As the sac fry emerge from the cobbles, calcification is just beginning, once in the water column, exposure goes to river background.
- Salmon don’t spawn around the area impacted by 100-N Strontium-90 plumes.
- Concentrations of Strontium-90 are below sensory levels – no avoidance or attraction.
Purpose: Provide site-specific parameters to reduce significant uncertainties in ecological risk assessments for use in clean up decisions at the U.S. Department of Energy’s Hanford Site.

Focus of FY02:
Technetium-99
Uptake and Depuration rates:
Periphyton
Rainbow Trout

Focus of FY03:
Strontium-90
Uptake and Depuration rates:
Periphyton
Rainbow Trout
Sr-90 Results [unpublished data]

► Periphyton
  ▪ Periphyton communities rapidly accumulate Sr-90 and its progeny Y-90
  ▪ Retained a significant fraction of the label following exposure
  ▪ Uptake patterns were similar at all exposure concentrations tested

► Trout
  ▪ Rapid uptake and retention of Sr-90
  ▪ Sr-90 retained for depuration periods of 14 to 21 days
  ▪ Exposure concentrations did not cause an apparent toxicological effect
2005 Aquatic and Riparian Impact Assessment [DOE 2009]

- Dose rates to clams approach the 1.0 rad/day guidance level
- Presence of Diesel hydrocarbons at river shoreline
- Metal concentrations met or slightly exceeded some benchmarks
  - Elevated lead in two mice (siblings)
Clam shell Sr-90, 2004-05 data [DOE 2009]
Remediation and Closure Science Project

[Mendoza et al. 2007]

▶ Strontium-90 plume Investigation 2006 (PNNL-16894)
  ■ 16 pore water or soil samples – metals, anions, tritium, technetium-99, strontium-90
  ■ Gross beta, Metals in river tube and aquifer tubes 100s
  ■ DO, Temperature, pH, Redox potential in river tubes

▶ Summary
  ■ Mapped spatial and depth distribution of Sr-90 plume
  ■ Evaluated season fluctuations
  ■ Evaluated gross beta, specific conductance, metals, ions, field parameters, river level fluctuations
Diesel Oil Study 2008-09 [Fritz et al. 2009]

- Sediment, water, periphyton and clam (Corbicula) collected
- PAHs not present in water, present in soil
- Not present in water or clams, present in periphyton and sediment
- Concentrations below environmental thresholds
Summary

- The extensive data historically and in recent years provides a comprehensive foundation for assessing impact and risk at 100-N in association with clean-up.
- Potential for impact is limited to the immediate shore line area – site wide monitoring does not indicate appreciable contamination or impact to the river at large.
References


DOE. 2009. Aquatic and Riparian Receptor Impact Information for the 100-NR-2 Groundwater Operable Unit, DOE/RL-2006-26, Revision 1, U.S. Department of Energy, Richland, WA


