Pore Water Remedial Goals (PWRGs) for the Protection of Benthic Organisms

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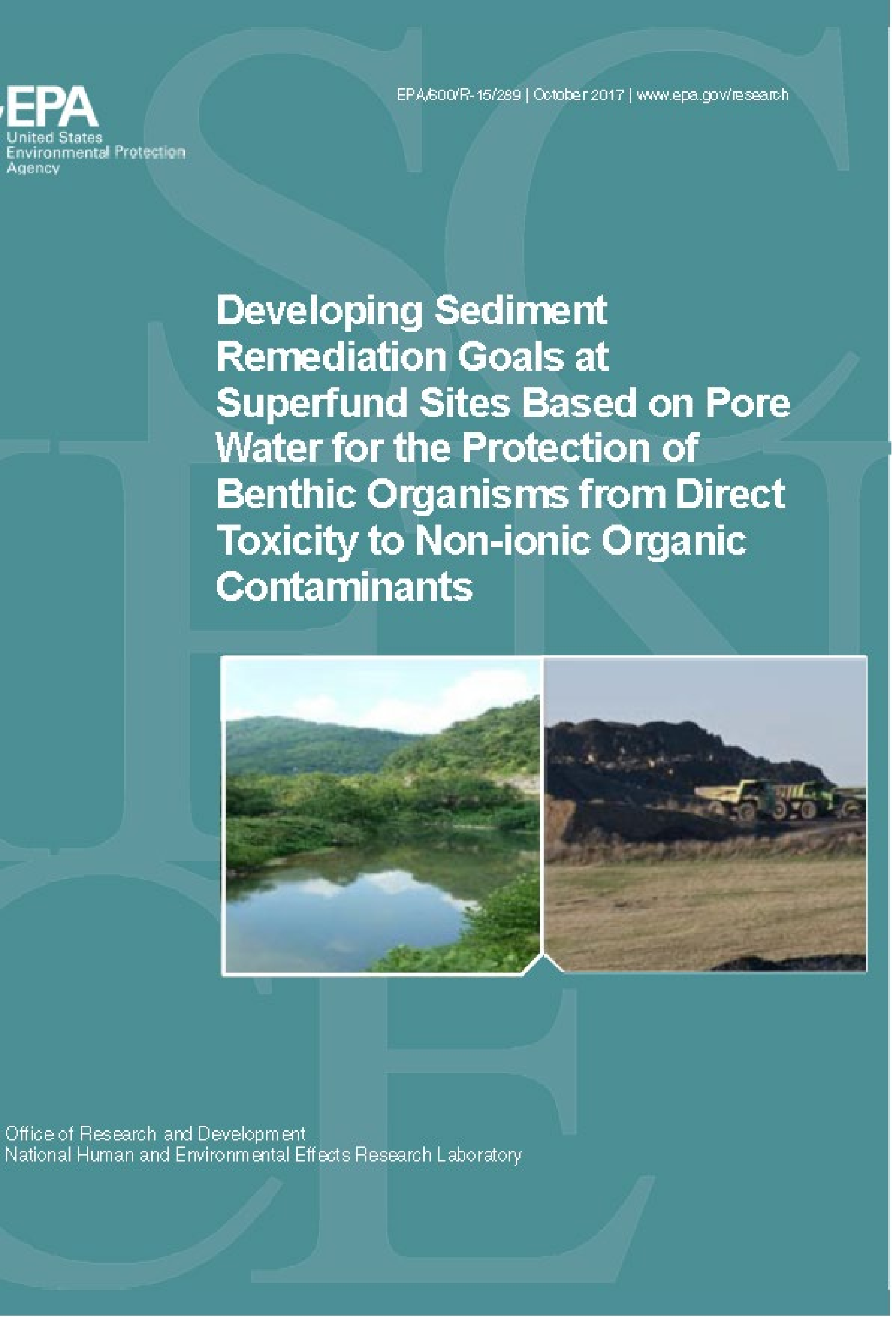
Yes or No Question

- Sediment toxicity testing on samples from your site
- YES or NO

Goal

- Goal today:
  - Show how PWRGs and sediment toxicity testing data can be examined together
  - When consistent
    - Reasonably assured
      A. The causes of toxicity are identified properly
      B. PWRGs will be protective of benthic organisms at the site



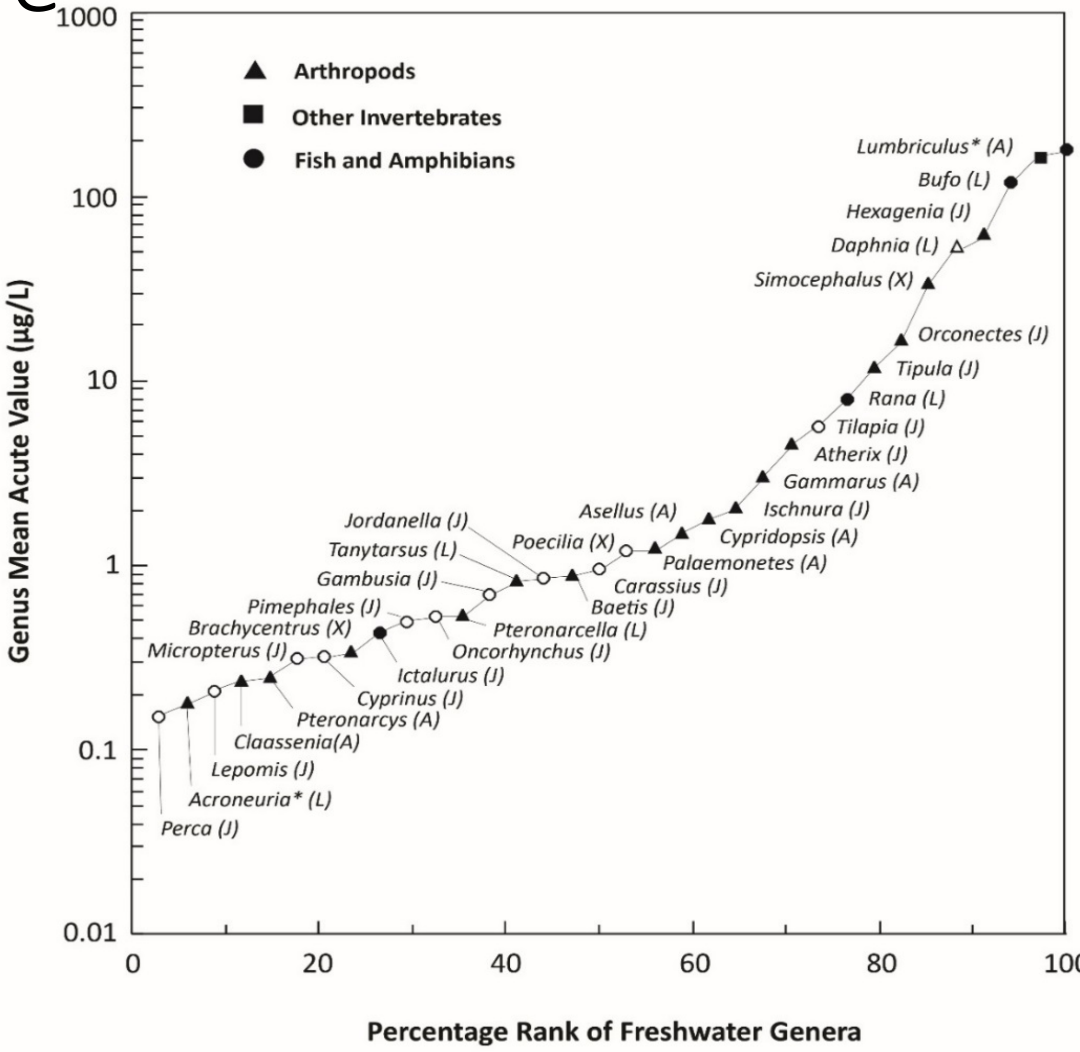
Guidance Approach

- Two basic elements
  - Method of measuring/inferring freely dissolved chemical concentrations in sediment pore water
  - Threshold chemical concentrations that delineates acceptable and unacceptable exposures

Acceptable and Unacceptable Exposure Thresholds from EPA's Ambient Water Quality Criteria (AWQC) for Aquatic Life

- Species sensitivity distribution for Endrin
  - Freshwater species

- Final Acute Value (FAV) 5^{th} percentile
  - 0.1803 µg/L
- Final Acute to Chronic Ratio (FACR)
  - 3.106
- Final Chronic Value (FCV)
  - 0.05805 µg/L



Toxicity Testing Results

PAH mixture species sensitivity distribution genus mean acute values for marine and freshwater toxicity testing species		
Species	Genus Mean Acute Value (µmole/ g octanol)	Percentage Rank of Genera
5th Percentile distribution value	FAV = 9.32	5.0%
Hyalella azteca**	13.9**	10.2%**
Leptocheirus plumulosus	19.0	22.4%
Rhepoxynius abronius	19.9	26.5%
Eohaustorius estuarius	22.1	32.6%
Ampelisca abdita	30.9	55.1%
Chironomus tentans	68.4	79.5%

PWRG Methodology

Follows Superfund's eight-step ecological risk assessment guidance

1. **Screening Level Characterization of the Nature and Extent of Contamination**
   A. Measure f_{OC} and C_S for all COCs (µg/kg-dw) in surficial sediments across the site
   B. Compute C_{SOC} (µg/kg-OC) for all COCs
2. **Screening Level Ecological Risk Assessment**
   C. Compute Toxic Units (TUs) for COCs
   - For single toxicant case, $TU = C_{SOC}/ESB$
   - For mixture of toxicants,
     - For each COC: $TU_i = C_{SOC,i}/ESB_i$
     - Total $TUs = \sum TU_i$

ESB=Equilibrium Sediment Benchmark
Developed by EPA 2003, uses EqP theory
Assumes all organic carbon in sediments is from diagenesis of plant materials.
Conservative, units – $\mu g/g_{OC}$

PWRG Methodology

5. **Site Investigation and Data Analysis**
   - D. Passively sample surface sediments where total TUs > 1.0
   - E. Derive C_{free} and K_{OC} values for surface sediments with total TUs > 1.0
7. **Baseline Ecological Risk Assessment**
   - F. Compute Toxic Units (TUs) for COCs
     - For single toxicant case, PWTU = C_{free}/FCV
     - For mixture of toxicants, for each COC in the mixture:
       - Compute pore water TU for each COC, $PWTU_i = C_{free,i}/FCV_i$
       - Compute total mixture pore water TUs, $PWTU_{Mixture} = \Sigma PWTU_i$
   - G. For locations where:
     - Total PWTUs ≤ 1.0, little potential for risk to benthic organisms.
     - Total PWTUs > 1.0, unacceptable risks to benthic organisms indicated, proceed to Remedial Goal Development

PWRG Methodology

8. Remedial Goal Development

PWRGs expressed on bulk sediment basis ($C_{S:PWRG}$ µg/kg dry weight):

- Derive site specific $f_{OC:SS}$ and $K_{OC:SS}$ values for each COC

$$K_{OC:SS} = C_S/(f_{OC:SS} \times C_{free})$$

a) For single toxicant:

PWRG for COC:

$C_{S:PWRG} = K_{OC:SS} \times f_{OC:SS} \times C_{free:PWRG}$

where $C_{free:PWRG} = FCV$

PWRG Methodology

8. Remedial Goal Development

b) For mixture of toxicants:

Derive site-specific composition of the mixture

PWRG for each COC:

$C_{S:PWRG,i} = K_{OC:SS,i} \times f_{OC:SS,i} \times C_{free:PWRG,i}$

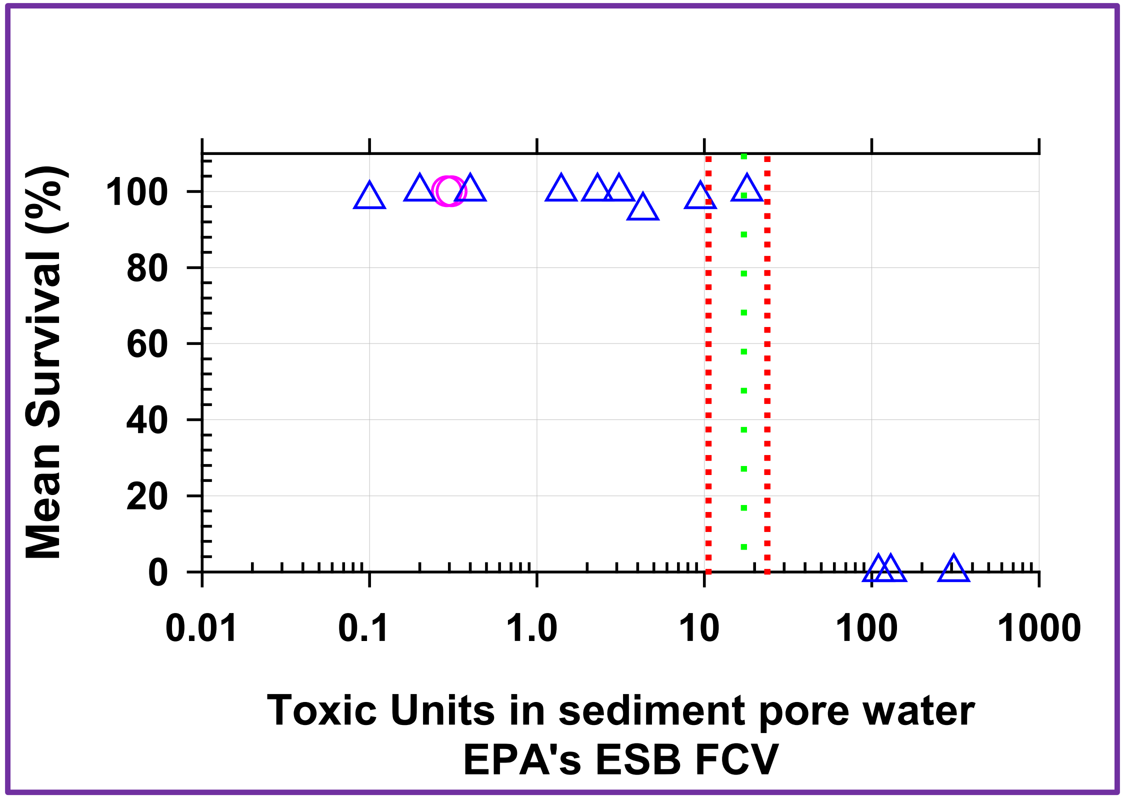
where $C_{free:PWRG,i} = FCV_i \times PWTU_i / PWTU_{Mixture}$

$PWTU_i = C_{free,i}/FCV_i$

Sum $C_{S:PWRG,i}$ for all mixture components to provide total bulk concentration of mixture

$C_{S:PWRG,Mixture} = \Sigma C_{S:PWRG,i}$

Toxicity Testing Results

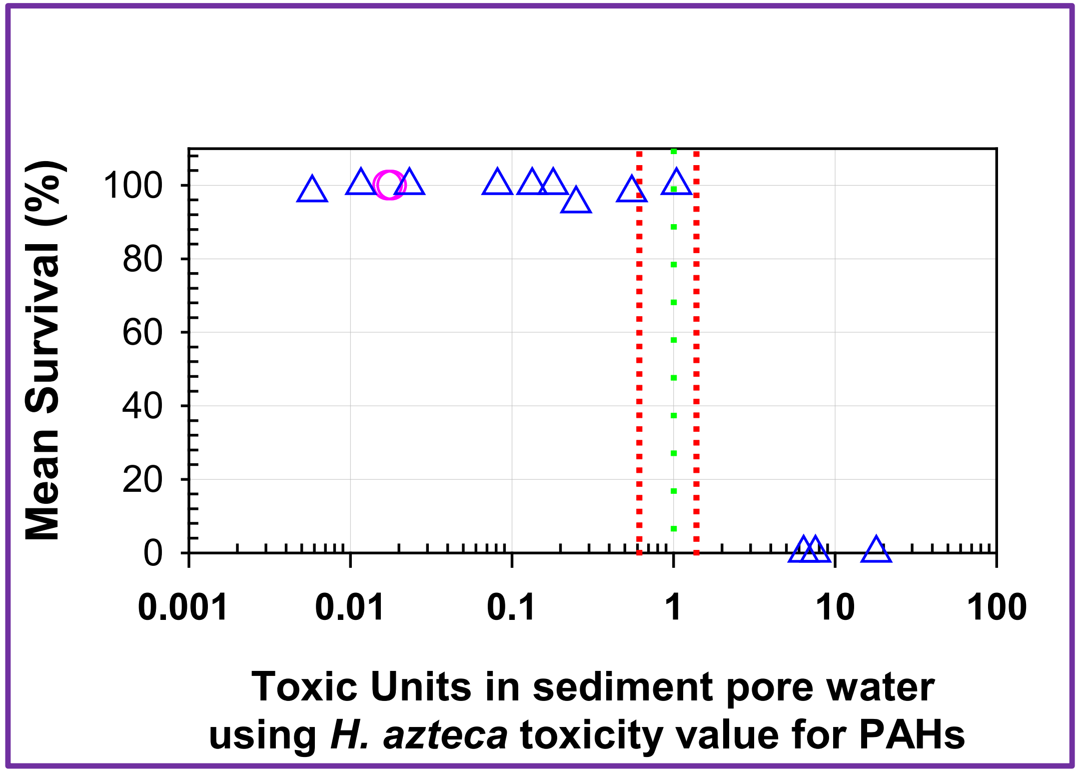


H. azteca less sensitive than the 5th percentile species for PAHs.

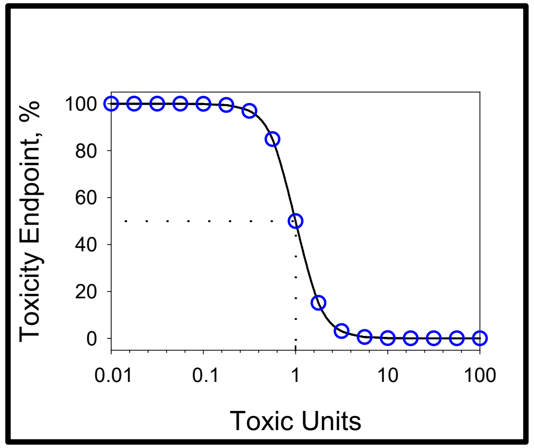
PWTU = C_{free}/(ESB FCV)

Measured sediment toxicity survival data for *Hyalella azteca* in 28-day test with sediments contaminated with PAHs (Kreitinger et al 2007). - - - - and •••• lines are the mean and 95% confidence levels for the EC50 derived from the water-only toxicity testing data for *H. azteca*.

Toxicity Testing Results



Results follow dose-response curve and breakpoint aligns with toxicity data for *H. azteca.*



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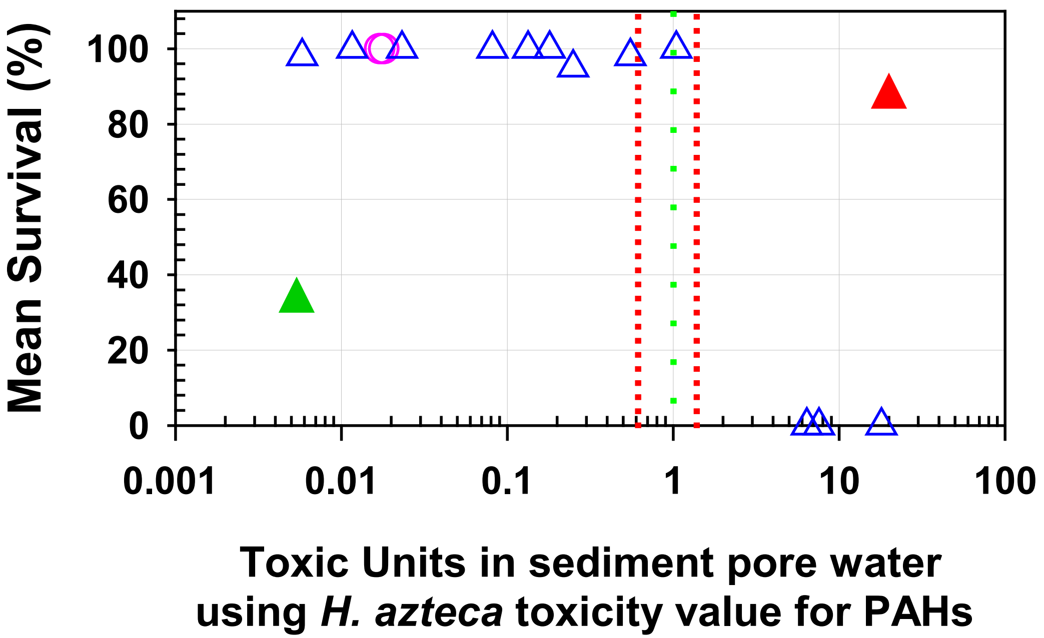
Toxicity Testing Results



If data exists in the data set illustrated by

▲ - Suggests: Presence of other unidentified toxicants

▲ - Suggests: Wrong toxicants have been identified

Consistency not demonstrated!

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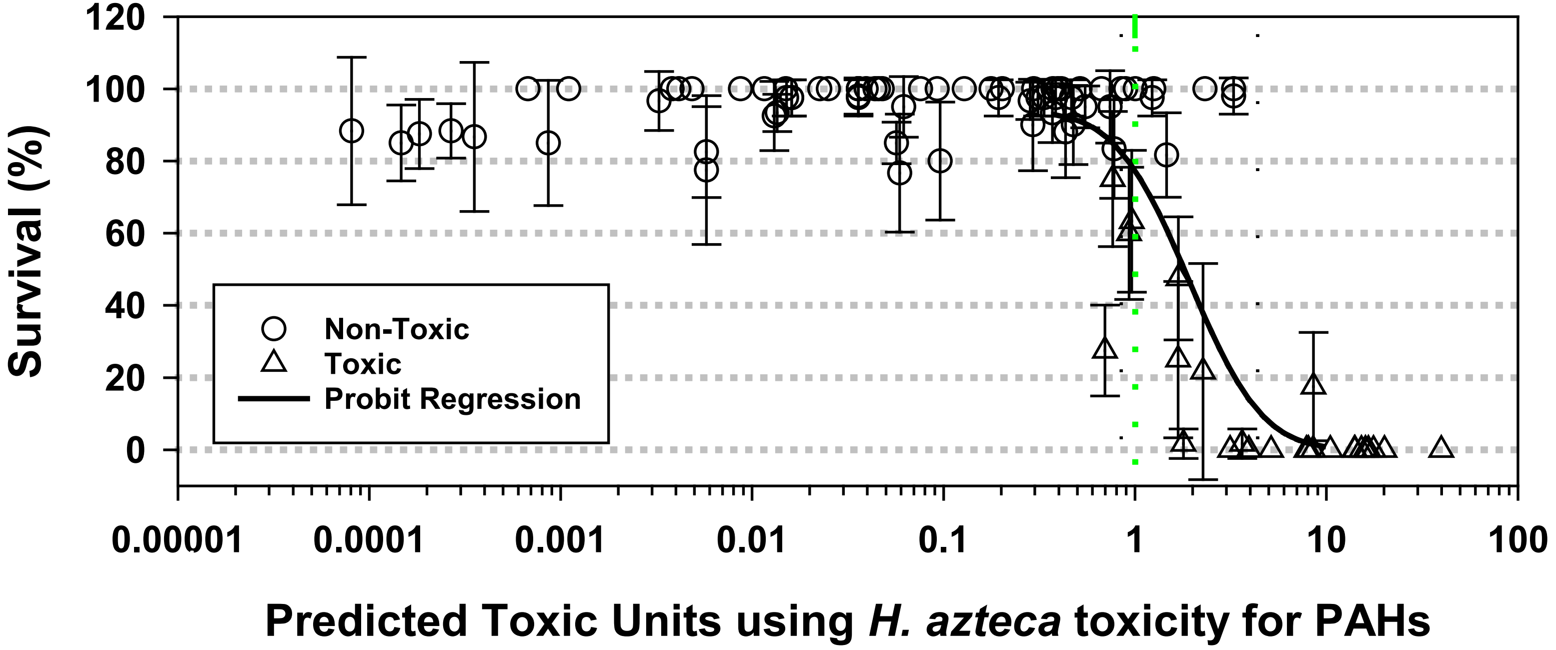
Toxicity Testing Results

- 28-day survival data for 97 samples from six MPG and two Al-smelter sites (Hawthorne et al. 2007)
  - Results:
    - Form dose-response shape 👍
    - Breakpoint between toxic and non-toxic samples 👍



Summary

- When PWRGs and toxicity testing data are consistent
  - Reasonably assured
    A. The causes of toxicity are identified properly
    B. PWRGs will be protective of benthic organisms at the site

- PWRGs
  - Accounts for contaminant bioavailability considerations

- Looking for sites where and/or planning to do PWRG development