Department of Environmental Quality

Public Workshop

Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment

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Presenters: Ann Levine – Northwest Region
Angie Obery – Western Region
Mike Poulsen – Northwest Region

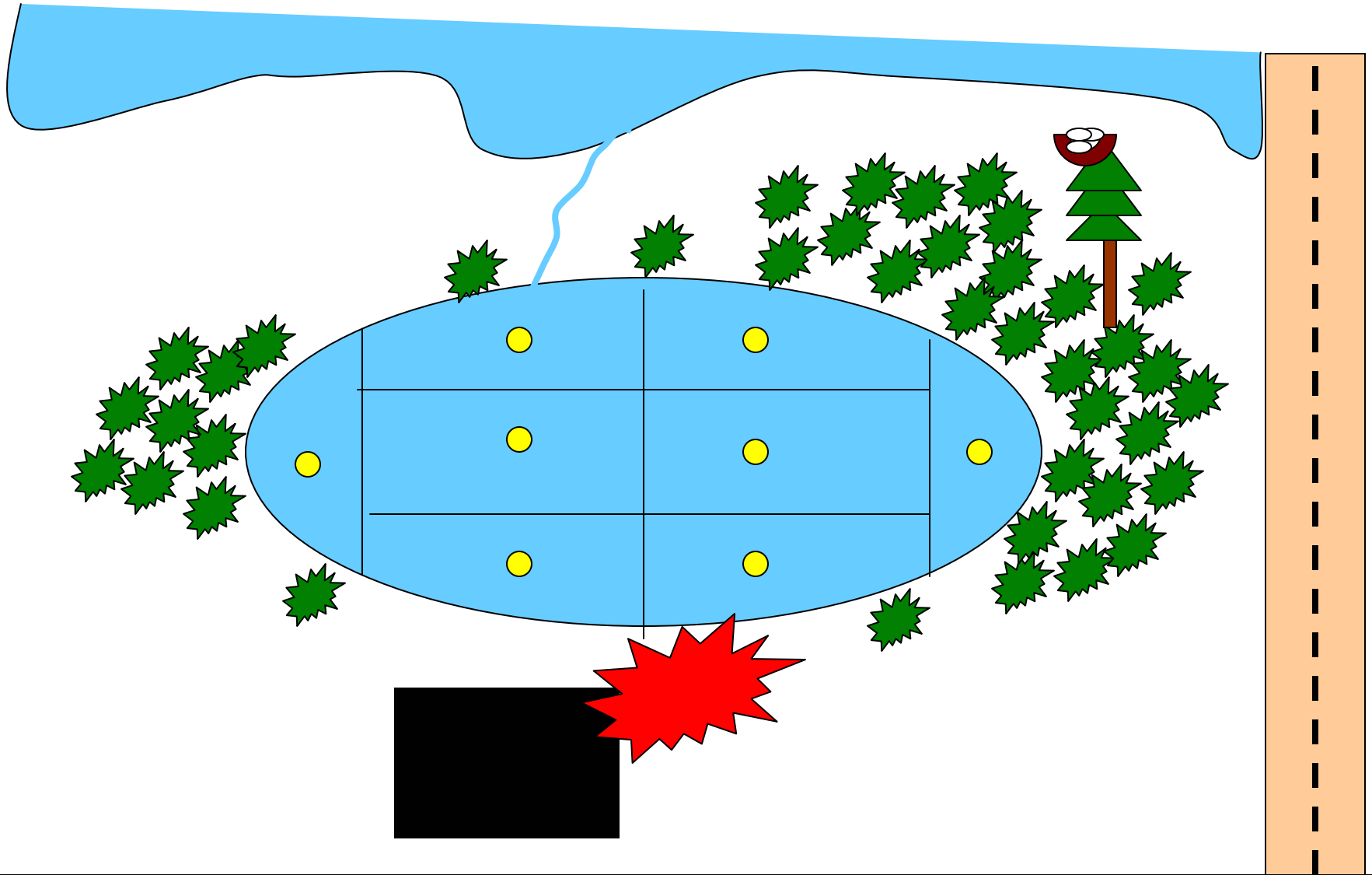
Agenda

- Sediment evaluation process
- **Bioaccumulative contaminants of interest**
- Use of generic sediment screening values
- Calculating site-specific screening values
- Use of generic tissue screening levels
- Calculating site-specific tissue levels
- Updates to Risk Based Concentrations

Identify Potential Bioaccumulative Chemicals of Interest

- Review historical site use information to develop list of chemicals of interest (COI)
- Compare site-specific COI list to the chemicals listed in Table A-1
- Chemicals found in both lists are potential bioaccumulative chemicals of interest (BCOIs)
- Chemicals not listed in Table A-1 are assumed not to be BCOIs

Example Site Figure



Exercise 1a – Identify BCOIs

- **Identify Bioaccumulative Chemicals of Interest (BCOIs) in sediment at your site.**

Comparison with Screening Level Values (SLVs)

Bioaccumulative Chemicals
Arsenic
Cadmium
Lead
Selenium
DDx (DDT/DDE/DDD)
Fluoranthene
Pyrene
PCBs

Not Bioaccumulative Chemical
Benzo(a)pyrene
Copper
Nickel

More Information Required
Chlordane

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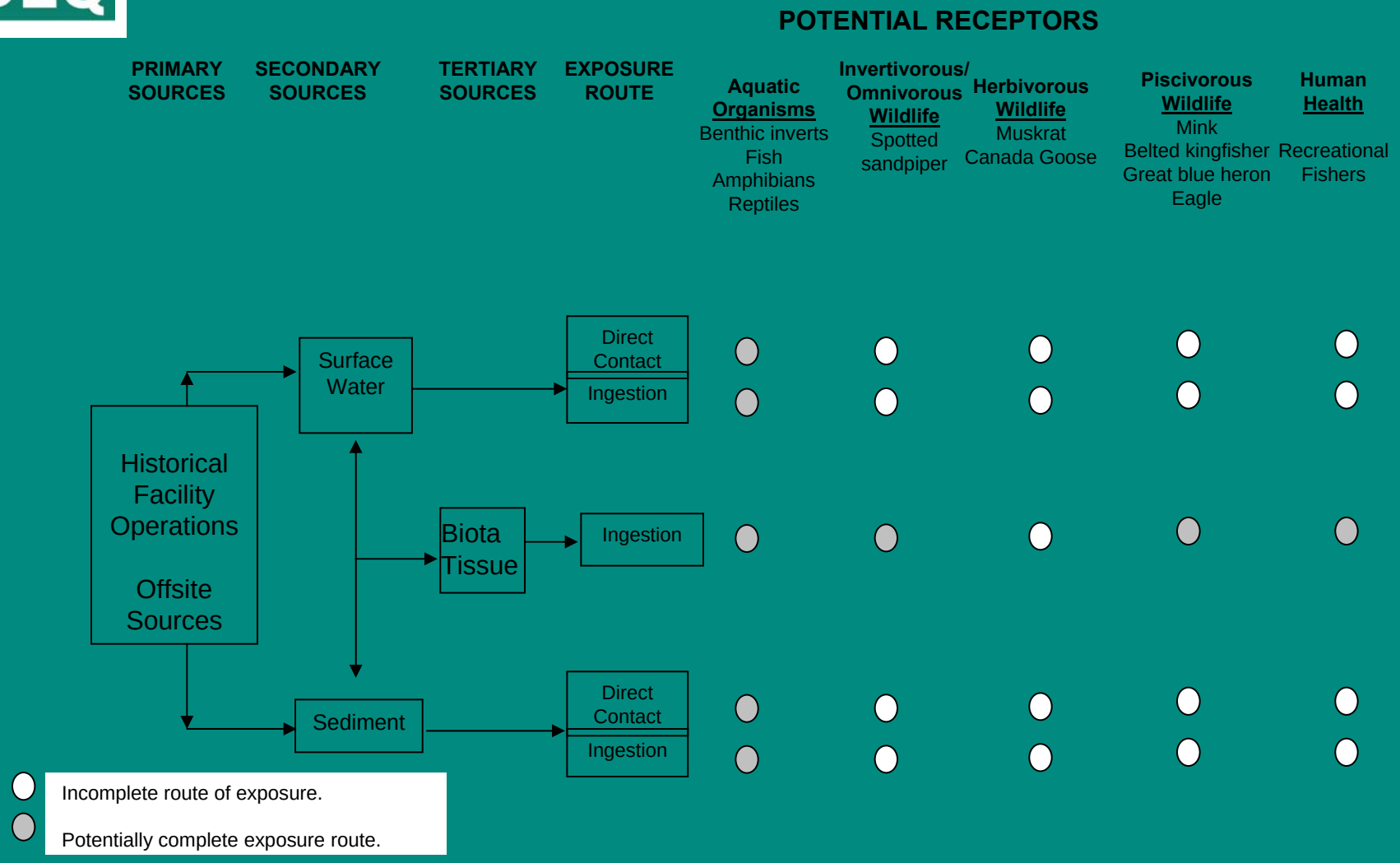
Identify Bioaccumulative Chemicals of Potential Concern

Site Conceptual Model

- **Characterize receptors & pathways**
  - Human
    - Recreational/tribal fishing?
  - Wildlife
    - Threatened & endangered species?
    - Use individual values rather than population

Exercise Conceptual Site Model



Exercise 1b – Screening Sediment

- Identify which columns of Table A-1 will be used for the screening assessment.

Are Sediment Concentrations Less than Generic Screening Levels?

- Compare sediment concentrations to SLVs in Table A-1
- Chemicals with concentrations less than screening levels can be screened out (considering multiple chemicals)
- If all concentrations are lower than screening values, then NFA for bioaccumulation

Exercise 1c – Screening Sediment

- Compare sediment results to appropriate sediment screening values. (Table A-1).

Exercise 1d – Screening Sediment

- **Calculate the Bioaccumulation Quotients**

  $$\text{Bioaccum Quotient} = \frac{\text{Sed Conc}}{\text{SLV}}$$

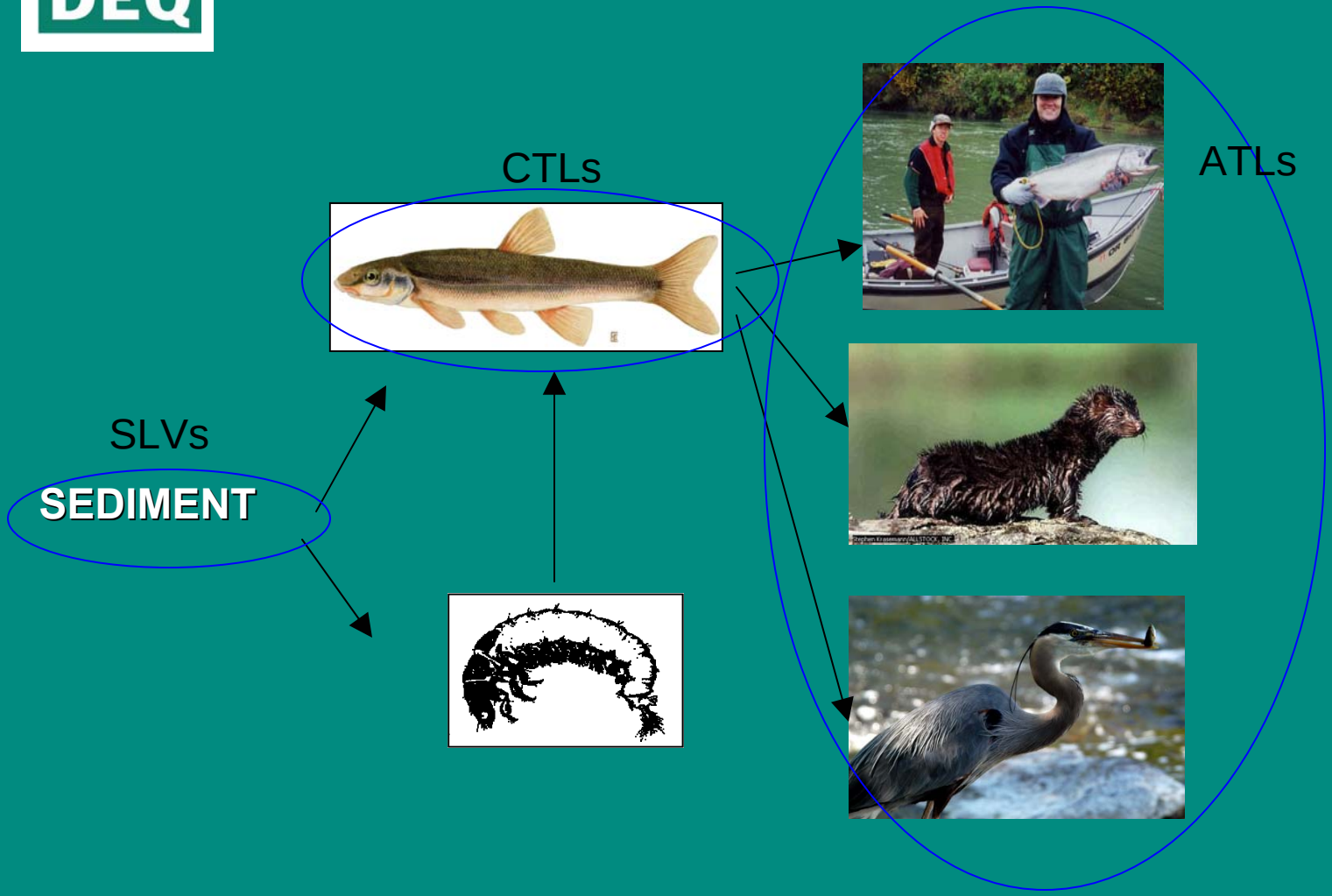
- **Calculate the Bioaccumulation Index**

  $$\text{Bioaccum Index} = \sum(\text{Quotients})$$

Development of Screening Levels

- **Protection of consumers of fish/shellfish -- Acceptable Tissue Levels (ATLs)**
  - Humans
  - Wildlife
    - Bird (great blue heron)
    - Mammal (mink)
    - Threatened & Endangered and non-T&E
- **Protection of fish/shellfish themselves --Critical Tissue Levels (CTLs)**

Food Web for Developing Screening Values



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Calculation of Site-Specific Sediment Screening Levels

- Human Health
- Wildlife
- Fish/Shellfish

Calculate Site-Specific Human Health SLVs

- **Receptors**
  - High fish consumption consumers
    - Recreational, subsistence/tribal
    - Site-specific consumption rates?
- **Area use factor**
- **Other factors**
  - Biota-sed accumulation factor (BSAF)
  - Fraction organic carbon in sediment (f_{oc})
  - Fraction lipid in tissue (f_L)

Biota-Sediment Accumulation Factor (BSAF)

$$BSAF = \left(\frac{C_{tissue} / f_L}{C_{sed} / f_{oc}} \right)$$

Use of Biota-Sediment Accumulation Factor (BSAF)

Empirical data

$$BSAF = \left(\frac{C_{tissue} / f_L}{C_{sed} / f_{oc}} \right)$$

SLV

ATLs
CTLs

$$C_{sed} = \left(\frac{C_{tissue}}{BSAF} \right) \cdot \left(\frac{f_{oc}}{f_L} \right)$$

Calculate Site-Specific Wildlife SLVs

- **Receptors**
  - Body weight, ingestion rate
- **Area use factor**
  - Important for small sites
- **Other factors**
  - BSAF , f_{oc} , f_L

Calculation of Human Health SLV

$$SLV_{BH} = f_{oc} \cdot \left(\frac{ATLh}{BSAF \cdot f_L} \right)$$

Calculation of Wildlife SLV

$$SLV_{BW} = f_{oc} \cdot \left(\frac{ATLw}{BSAF \cdot f_L} \right)$$

Calculation of Fish SLV

$$SLV_{BF} = f_{oc} \cdot \left(\frac{CTL}{BSAF \cdot f_L} \right)$$

Exercise 2 – Site-Specific SLVs

- **Calculate new SLVs for 2 chemicals**
  - Human Health
  - Birds and Mammals
  - Fish

Example BSAF with Empirical Data

- **Exercise handout has example**
- **Questions/Uncertainties**
  - Type of fish to sample
  - Averages or Max/Min
  - Amount of data required

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Are Fish Tissue Concentrations Less than Generic Screening Levels?

- **Compare fish tissue concentrations to ATLs/CTLs in:**
  - Table A-3 (birds, mammals, and humans)
  - Table A-4 (fish)
- **Use fillet results for humans and whole body results for wildlife.**
- **Chemicals with concentrations less than screening levels can be screened out (considering multiple chemicals)**
- **If all concentrations are lower than screening values, then NFA for bioaccumulation**

Exercise 3 – Use of Generic ATLs

- **Compare fish/shellfish tissue concentrations to**
  - Acceptable tissue levels (ATLs in Table A-3) and
  - Critical tissue levels (CTLs in Table A-4)

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Calculation of Site-Specific ATLs/CTLs

- **Human Health - ATL**
- **Ecological**
  - Birds - ATL
  - Mammals - ATL
  - Fish - CTL

Calculation of Site-Specific Human ATLs

$$ATLh_C = \frac{ARL_C \cdot BW \cdot AT}{SF_O \cdot IR_P \cdot ED}$$

$$ATLh_N = \frac{ARL_N \cdot BW \cdot RfD}{IR_P}$$

Calculation of Site-Specific Wildlife ATLs

$$ATLw = \frac{TRV_w}{(IR/BW)}$$

Toxicity Reference Value (TRV)

TRV_w for T&E = NOAEL based

TRV_w for non-T&E = LOAEL based

Bird Egg Calculation

$$ATL_{BW-egg} = \frac{TRV_{W-egg}}{BMF_{egg}}$$

Exercise 4a – Site-Specific ATLs

- Develop site-specific Acceptable Tissue Levels for humans, birds, and mammals.

Critical Tissue Levels

Calculation of Fish/Shellfish CTLs

- Critical Tissue Level – level of a chemical in tissue at or below which approx. 95% of aquatic organisms are highly unlikely to experience adverse health effects
- Consistent with ambient water quality criteria (AWQC)

Main approach for Calculating CTLs

$$CTL = AWQC \times BCF$$

CTL = critical tissue level

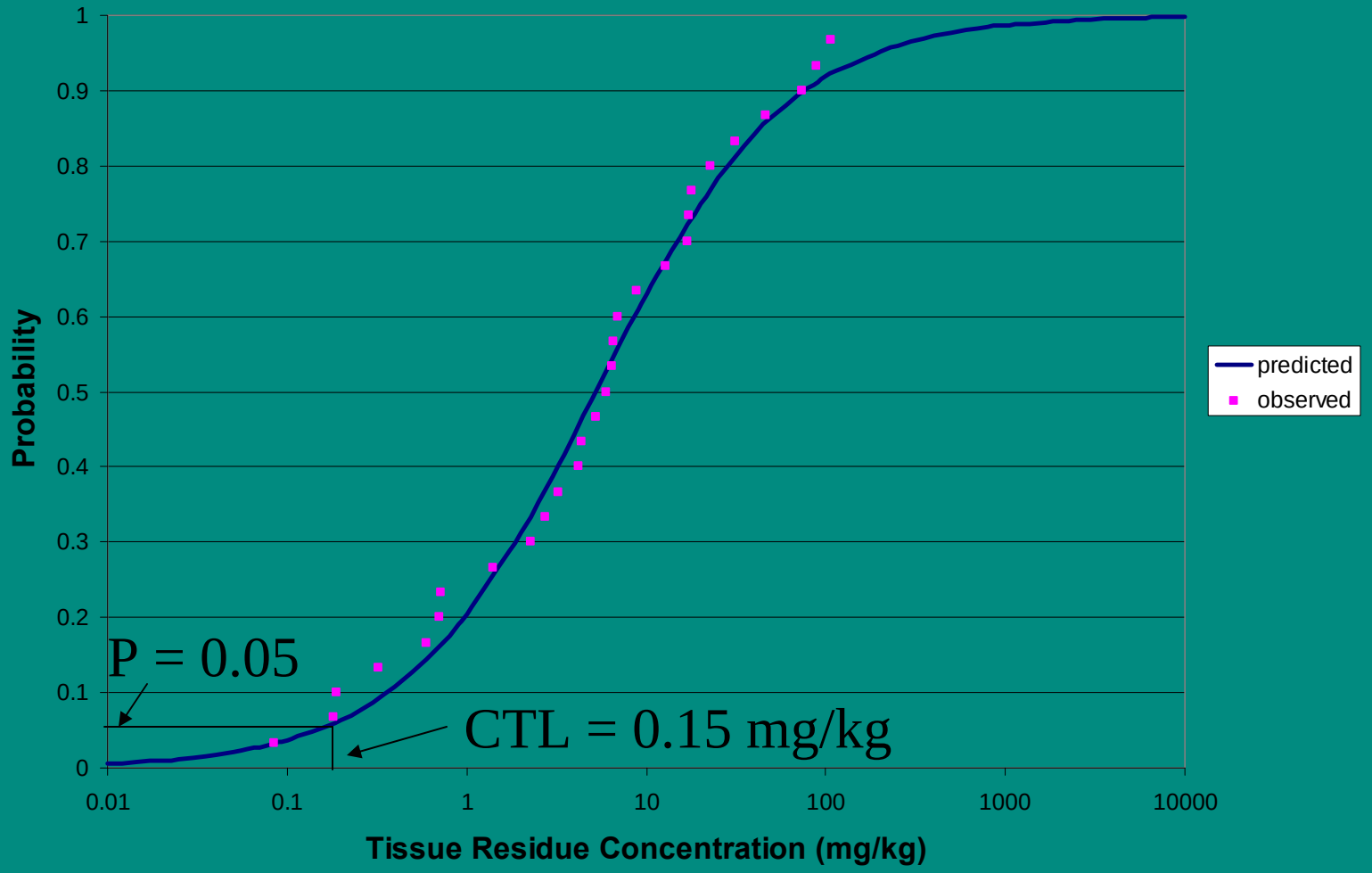
AWQC = ambient water quality criteria

BCF = bioconcentration factor

Species Sensitivity Distribution (SSD) Approach

- SSD – statistical distribution describing the variation among a set of species in response to a toxic compound
- Estimated from a sample set of toxicity data (cumulative density function)

Example SSD


Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.01
0.1
1
10
100
1000
10000
Tissue Residue Concentration (mg/kg)
P = 0.05
CTL = 0.15 mg/kg
predicted
observed

Develop Site-Specific Critical Tissue Levels for Fish

- **AWQC x BCF Approach**
- **Lead AWQC is based on hardness (increase hardness, decrease toxicity)**
  - Default is 100 mg/L as $CaCO_3$

Exercise 4b – Site-Specific CTL

- **Calculation of Site-specific CTL (AWQC hardness adjusted)**

$$AWQC = e^{(mc \cdot \ln[hardness] + bc)} \cdot CF$$

From DEQ Water Quality Table 33A
For lead in freshwater (chronic):

mc = 1.273
bc = -4.704
CF = 1.46203 – (ln(hardness) · 0.145712) = 0.9245
hardness = 40 mg/L

Inorganics

- BSAF approach works for organics, not inorganics
- A bioaccumulation factor (BAF) approach for inorganics may be appropriate in the future
- For now, inorganics are evaluated based on tissue concentrations
- Inorganic SLVs are based on natural background

What are Your Options?

- **Conduct a feasibility study for remedial action or an EE/CA for removal action**
- **Additional evaluation or testing**
  - Fish tissue data from area of site impact
  - Bioaccumulation testing – lab or *in situ*

Field Evaluation Options

- **Perform laboratory bioaccumulation tests**
  - *Lumbriculus* (**Blackworms**)
  - *Corbicula* **(clams)**
- **Perform *in situ* bioaccumulation tests**
  - Caged bivalves **(mussels)**

Field Evaluation Results

- Do results indicate that bioaccumulation is a concern?
- If yes, conduct a feasibility study for remedial action or an EE/CA for removal action
- If no, NFA for bioaccumulation.

Note

- This evaluation process only addresses bioaccumulation
- For efficiency, consider other potential risk pathways (*e.g.*, sediment toxicity) prior to taking action on bioaccumulation

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Incorporating into Remedial Investigation (RI)

- **This guidance process constitutes the bioaccumulative portion of the human health and ecological risk assessments**
- **Combine with other portions of risk assessment**
  - Human health exposure other than fish consumption
  - Other ecological pathways, *e.g.*,
    - Dietary pathway
    - Benthic toxicity

Incorporating into Feasibility Study (FS)

- **Screening levels or site-specific SLVs can be used as the basis for cleanup levels**
  - Human health
  - Ecological