

Water Quality Standards Academy

Module 9 - Aquatic Life Criteria

Wade Lehmann
EPA Office of Water, Health and Ecological Criteria Division



National Recommended Water Quality Criteria

Human Health Criteria (Fish consumption)

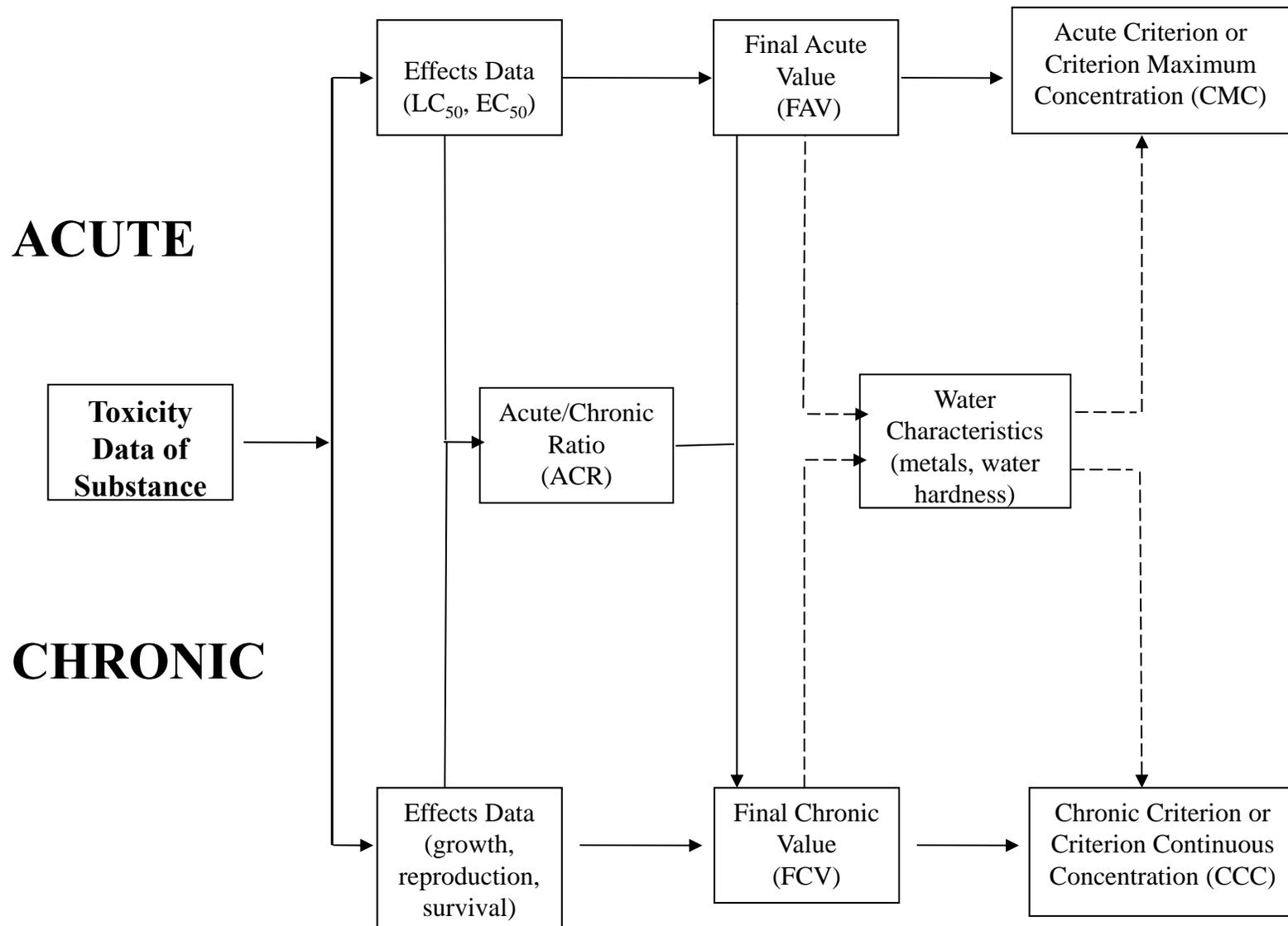
Aquatic Life Criteria

Acute and Chronic

Freshwater and Saltwater

| Priority Pollutant | CAS Number | Freshwater | | Saltwater | | Human Health for the consumption of | | FR Cite/ Source |
|--------------------|------------|--------------------------|----------------------------|--------------------------|----------------------------|-------------------------------------|-------------------------|----------------------------|
| | | CMC (acute) (µg/L) | CCC (chronic) (µg/L) | CMC (acute) (µg/L) | CCC (chronic) (µg/L) | Water + Organism (µg/L) | Organism Only (µg/L) | |
| 1 Antimony | 7440360 | | | | | 5.6 | 640 | 65 FR 66443 |
| 2 Arsenic | 7440382 | 340 | 150 | 69 | 36 | 0.018 | 0.14 | 65 FR 31682 57 FR 60848 |

Aquatic Life Criteria: Derivation Overview



Toxicity Data of Substance

Chemical Criteria Selection Process Overview

- Select chemicals of national concern and chemicals needing re-evaluation
- Risk-based selection process
 - looks at chemicals most frequently found in ambient water and/or fish tissue (occurrence)
 - pose the greatest potential risk to the health of humans and aquatic life (toxicity)
- Ensure the latest science and toxicity data are incorporated into the assessment

Aquatic Life Criteria Selection Process

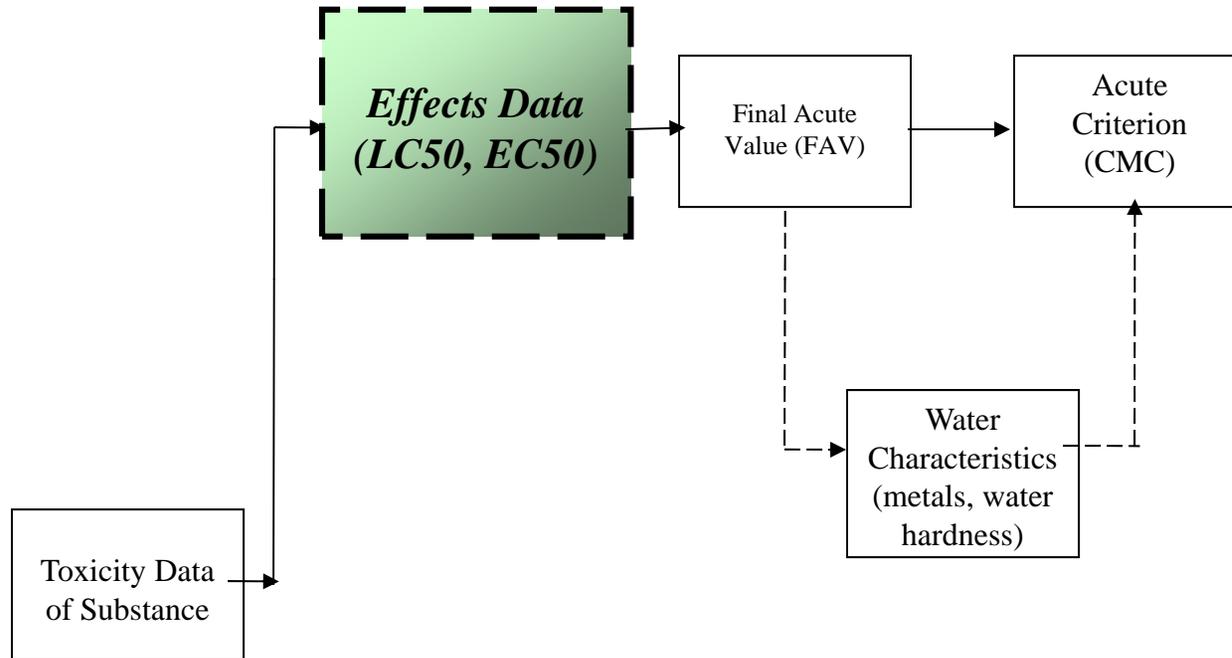
- Review chemical lists from regions, States and stakeholders
- Compile list of chemicals that appear on multiple priority lists
- Categorize chemicals according to availability of toxicity data to meet *1985 Guidelines* Minimum Data Requirements
 - Guidelines require data for at least 8 families for acute and 3 families for chronic criteria derivation (ACR)
- Score & Rank chemicals with toxicity data for 6 or more families

Aquatic Life Criteria Selection Process

Prioritization for Aquatic Life Criteria Derivation

- **Toxicity:** Chemicals ranked in order of highest to lowest toxicity
- **Occurrence in ambient water:** Chemicals ranked in order of highest to lowest frequency of detection in water
- **Occurrence in fish tissue:** Chemicals ranked in order of highest to lowest frequency of detection in fish

Acute Effects Data



MINIMUM DATASET FOR FRESHWATER CRITERIA DERIVATION

SALMONID



**SECOND
FISH
FAMILY**



CHORDATA



**PLANKTONIC
CRUSTACEAN**



**BENTHIC
CRUSTACEAN**



INSECT



**ROTIFERA,
ANNELIDA,
MOLLUSCA**

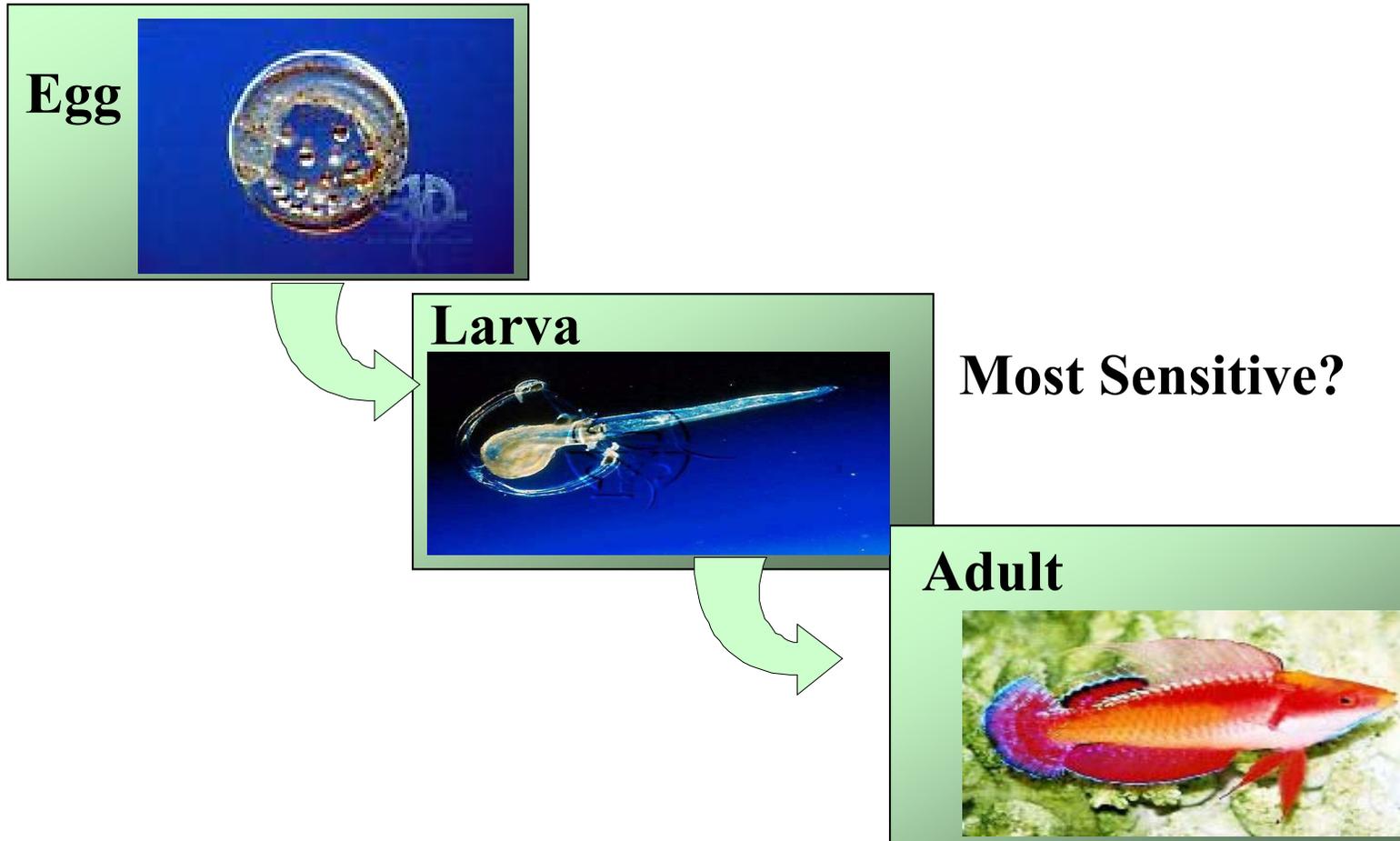


**OTHER
INSECT OR
MOLLUSCA**



Data Requirements

Data from the most sensitive life stage



Toxicity Test Data

Data Sources and Endpoints

Data is pulled from ecological toxicity database (Ecotox, maintained by EPA). This is constantly updated, on a compound specific basis, from literature.

A data pull is also performed from a number of current sources, to be certain that data is current and accounted for.

Acute: 48-hr or 96-hr toxicity test

- measured as LC_{50} , EC_{50}
 - lethal concentration/effects concentration of 50% tested organisms
-

ACUTE TOXICITY DATA

96-hour LC₅₀

Concentration:

0.0 µg/L

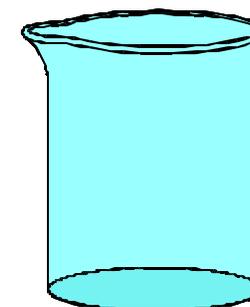
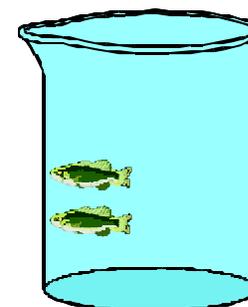
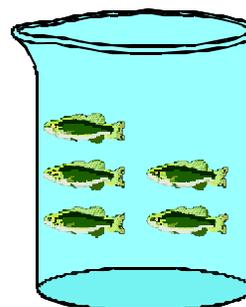
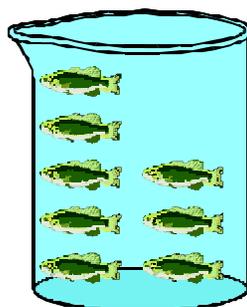
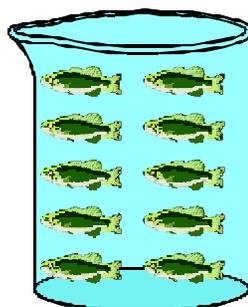
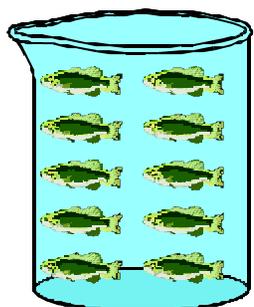
13 µg/L

25 µg/L

50 µg/L

100 µg/L

200 µg/L



Control
(10)

1
(10)

2
(8)

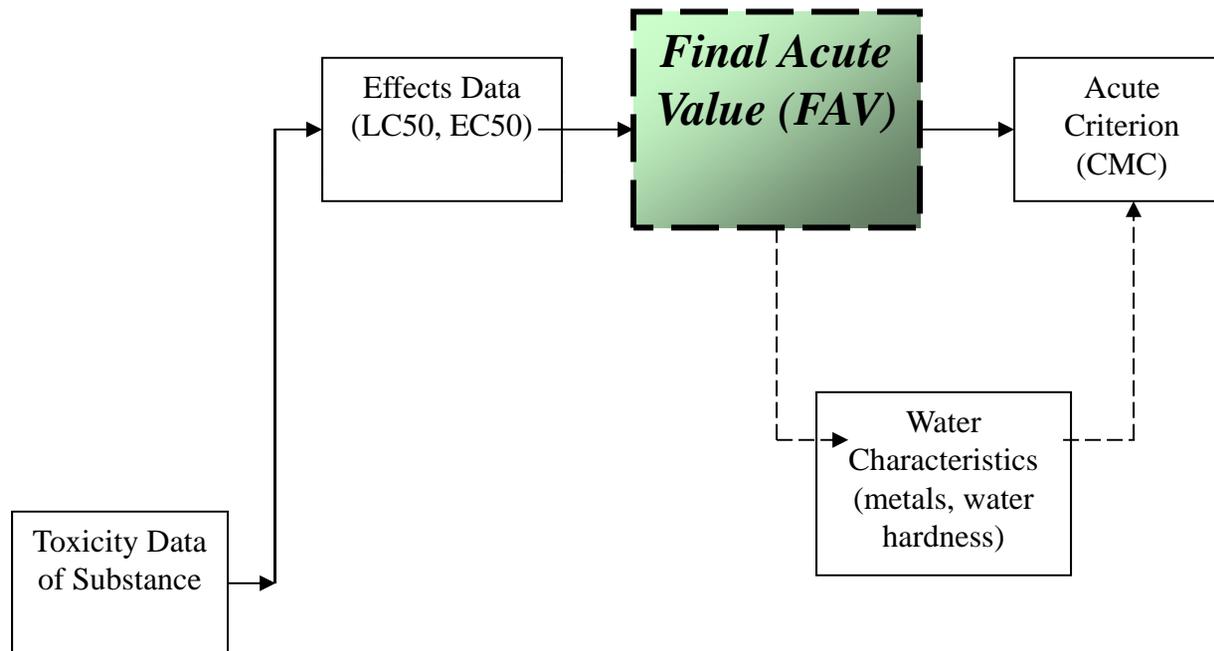
3
(5)

4
(2)

5
(0)

96-hr LC₅₀ = 50 µg/L

Final Acute Value (FAV)



FAV CALCULATION OVERVIEW

- Step 1. Calculate Species Mean Acute Values (SMAVs)**
- geometric mean of all acceptable acute values for species
- Step 2. Calculate Genus Mean Acute Values**
- geometric mean of all SMAVs for genus
- Step 3. Rank Genus Mean Acute Values**
- from most sensitive (#1) to least sensitive (n)
- Step 4. Calculate Final Acute Value Using 4 Lowest GMAVs**
-

GENUS MEAN ACUTE VALUE (GMAV)

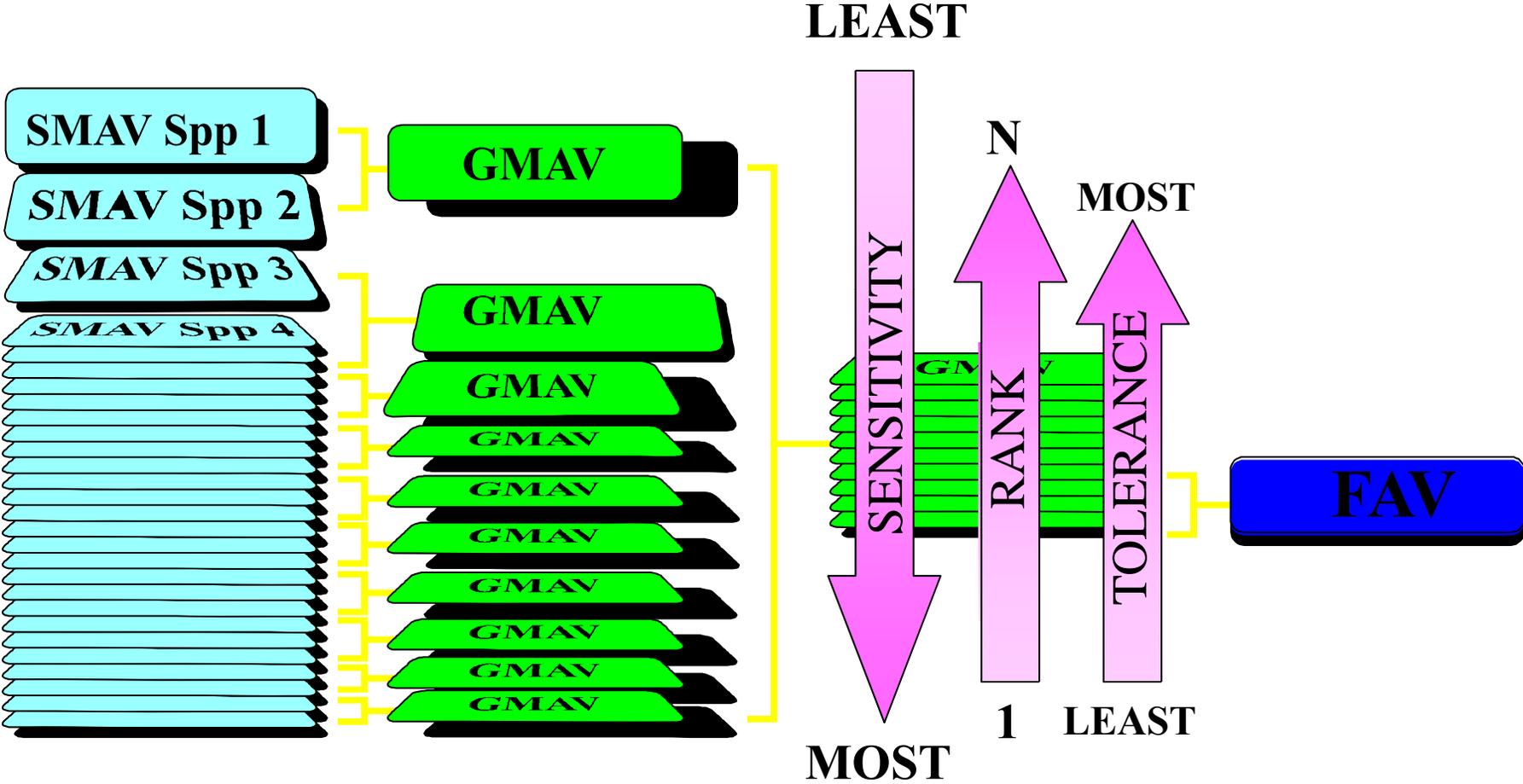
| | | |
|------------------------|-------------|----------------|
| <i>Daphnia magna</i> | SMAV | 29 µg/L |
| <i>Daphnia pulex</i> | SMAV | 38 µg/L |
| <i>Daphnia ambigua</i> | SMAV | 42 µg/L |

GMAV = 36 µg/L

Table 3 - Rank GMAVS

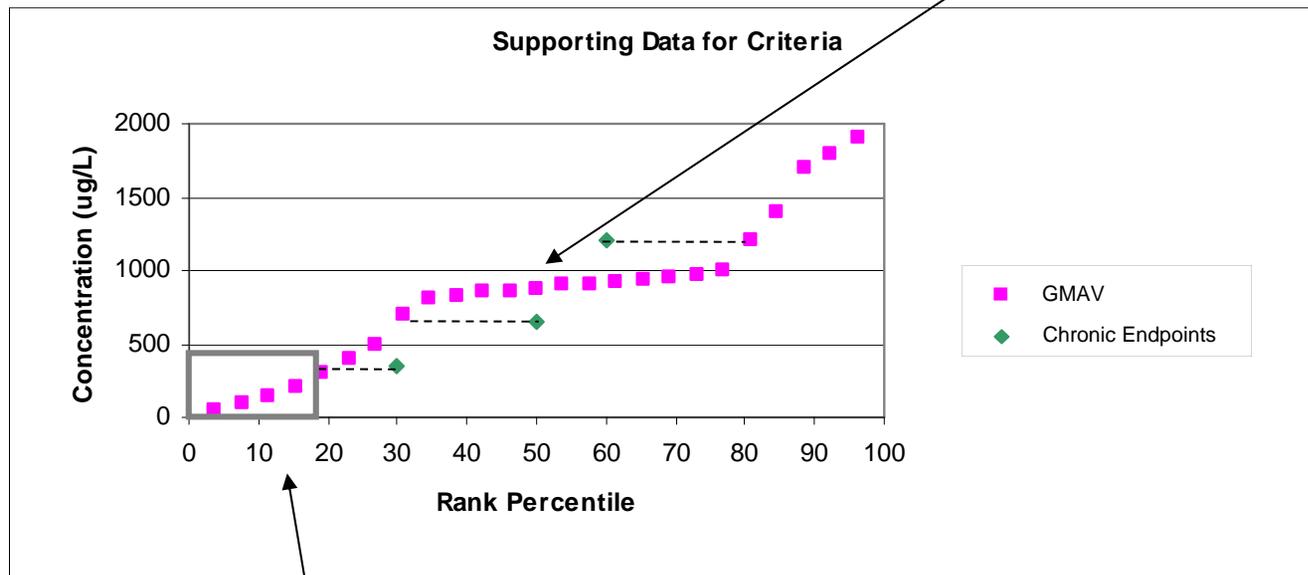
| <u>RANK</u> | <u>GMAV (µg/L)</u> | <u>Species</u> | <u>SMAV (µg/L)</u> |
|-------------|------------------------|--|------------------------|
| 4 | 100 | Rainbow Trout, <i>Oncorhynchus mykiss</i> | 100 |
| 3 | 36 | Cladoceran, <i>Daphnia ambigua</i> | 42 |
| | | Cladoceran, <i>Daphnia pulex</i> | 38 |
| | | Cladoceran, <i>Daphnia magna</i> | 29 |
| 2 | 25 | Amphipod, <i>Gammarus pseudolimnaeus</i> | 25 |
| 1 | 19 | Amphipod, <i>Hyalella azteca</i> | 19 |

Aquatic Life Criteria Derivation



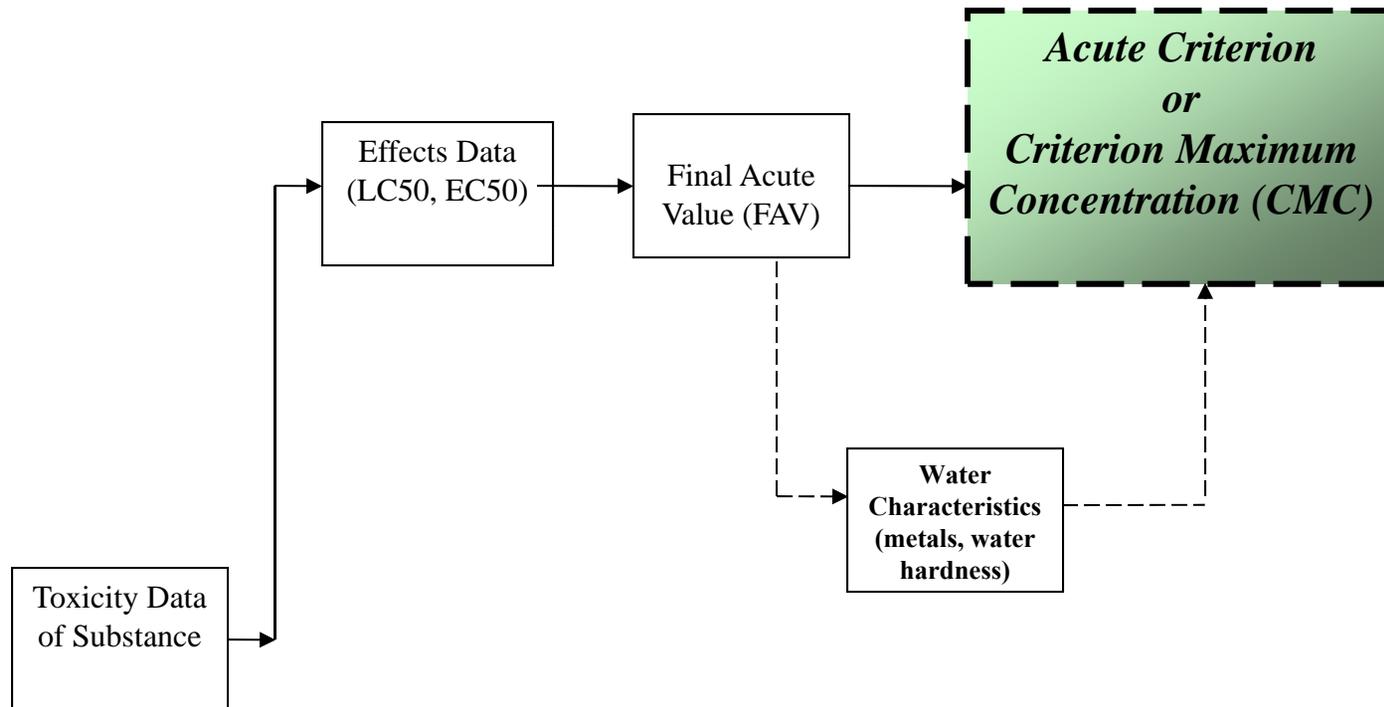
Aquatic Life WQC Calculation

GMAV and Calculate the Percentile of each rank ($100 R/(N+1)$)

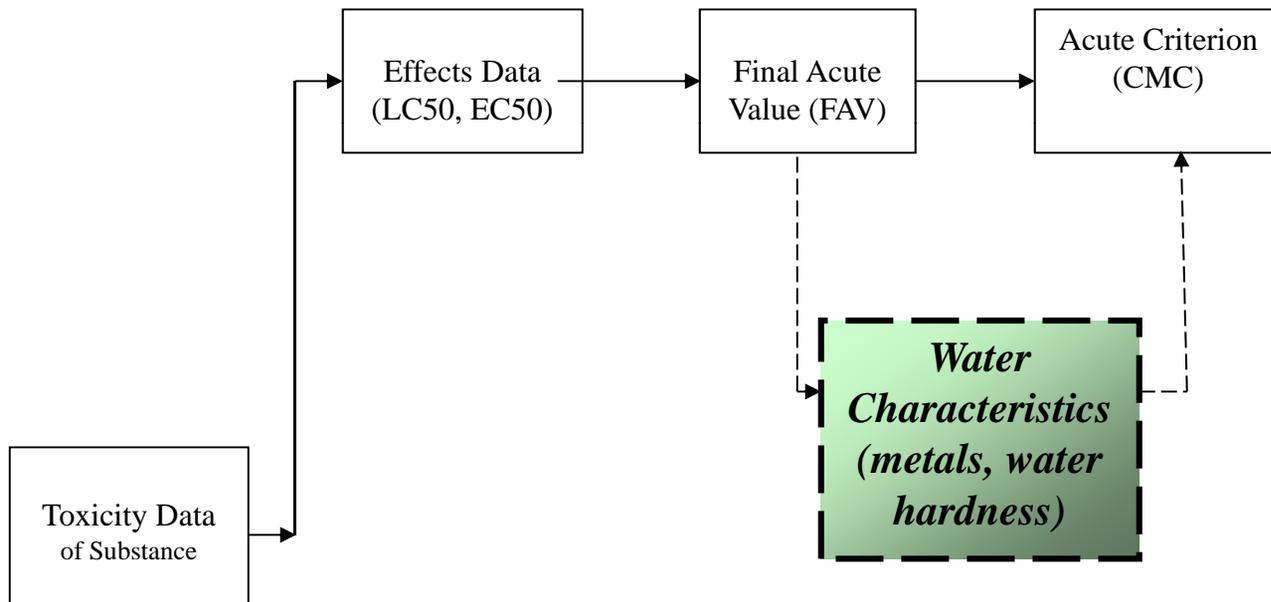


Using the 4 Most Sensitive Genera, Perform a Least Squares Regression of the GMAV (log values) on the Percentile Ranks (square roots)

Acute Criterion (CMC)



Water Characteristics



Freshwater Criteria Using Hardness

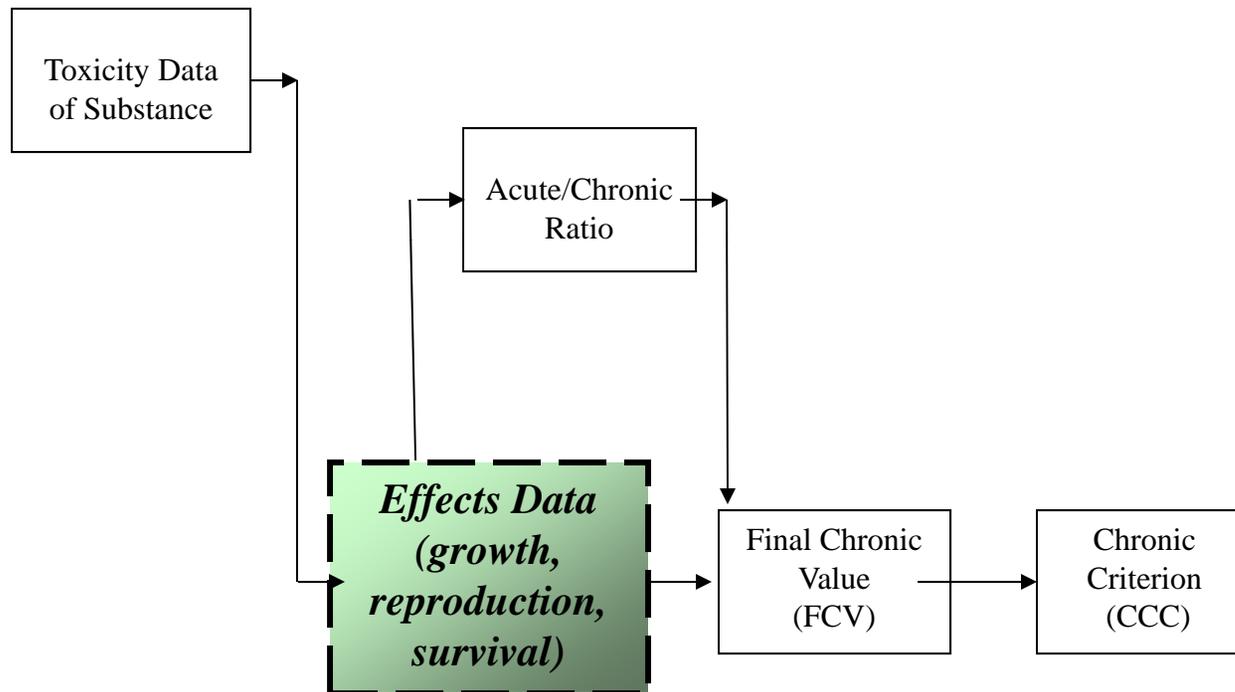
Cadmium Criteria Equation*

$$= e^{(1.0166 (\ln \text{Hardness}) - 3.924)}$$

| Hardness (mg/L) | Equation | Criteria Value (µg/L) |
|--------------------|----------------------------------|--------------------------|
| 50 | $e^{(1.0166 (\ln 50) - 3.924)}$ | 1.1 |
| 100 | $e^{(1.0166 (\ln 100) - 3.924)}$ | 2.1 |
| 200 | $e^{(1.0166 (\ln 200) - 3.924)}$ | 4.3 |

* Based on total recoverable metal

Chronic Effects Data



Toxicity Test Data Endpoints

Chronic endpoints

- **Species –appropriate test durations**
- **Endpoints include long term mortality, growth and reproduction**
- **Test endpoints include NOECs, LOECs, and EC20s**

CHRONIC TOXICITY DATA

Fathead Minnow Early Life Stage Test: Growth Measured as Length

Chronic Value = 21.2 $\mu\text{g/L}$

(NOEC = 15; LOEC = 30)

Concentration:

Control

0.0 $\mu\text{g/L}$

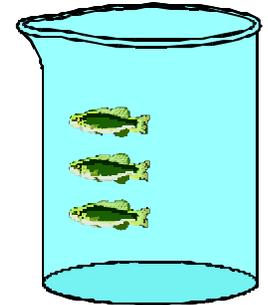
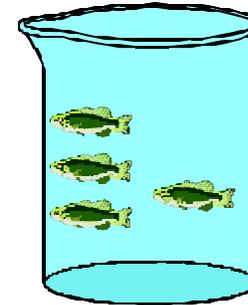
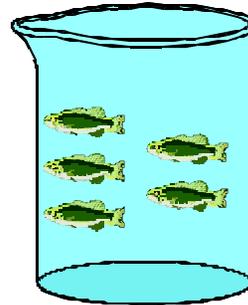
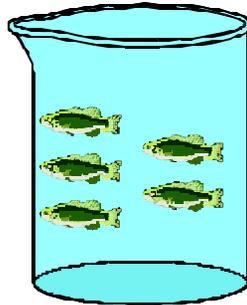
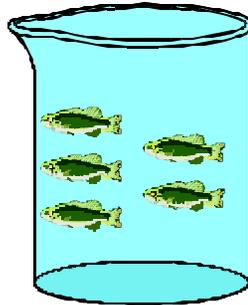
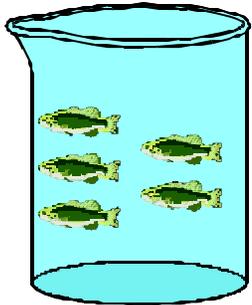
3.8 $\mu\text{g/L}$

7.5 $\mu\text{g/L}$

15 $\mu\text{g/L}$

30 $\mu\text{g/L}$

60 $\mu\text{g/L}$



Length:

40 mm

41 mm

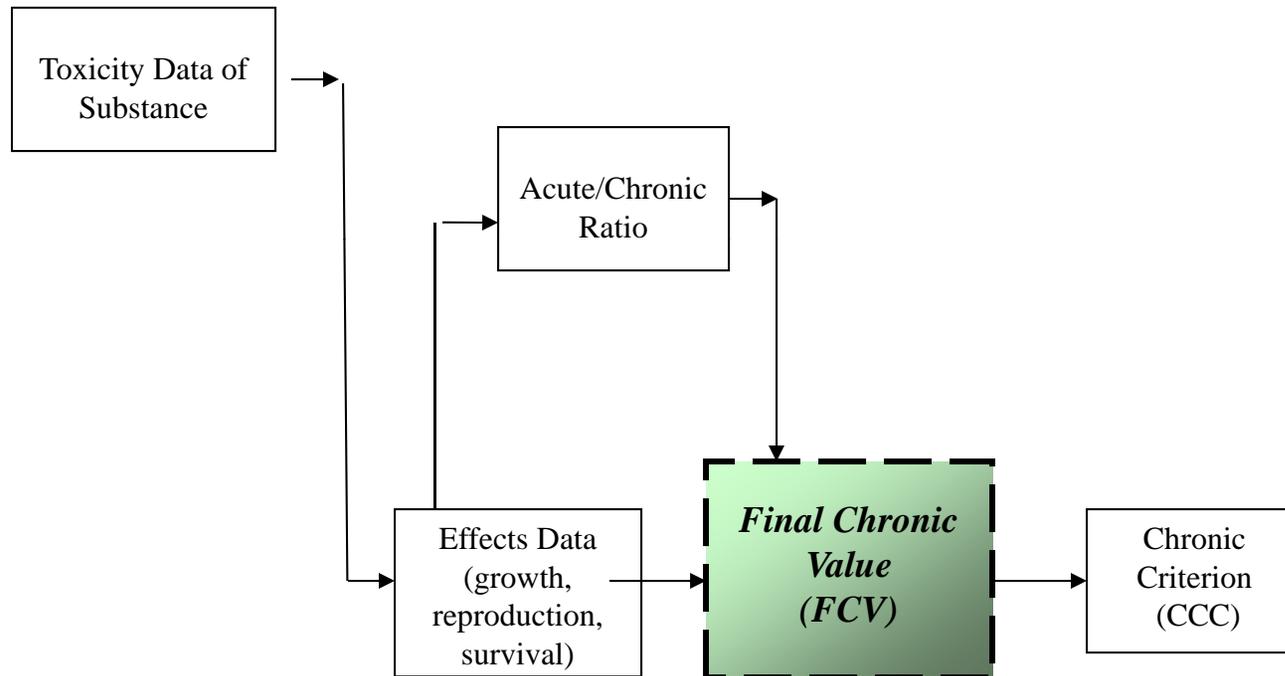
38 mm

37 mm

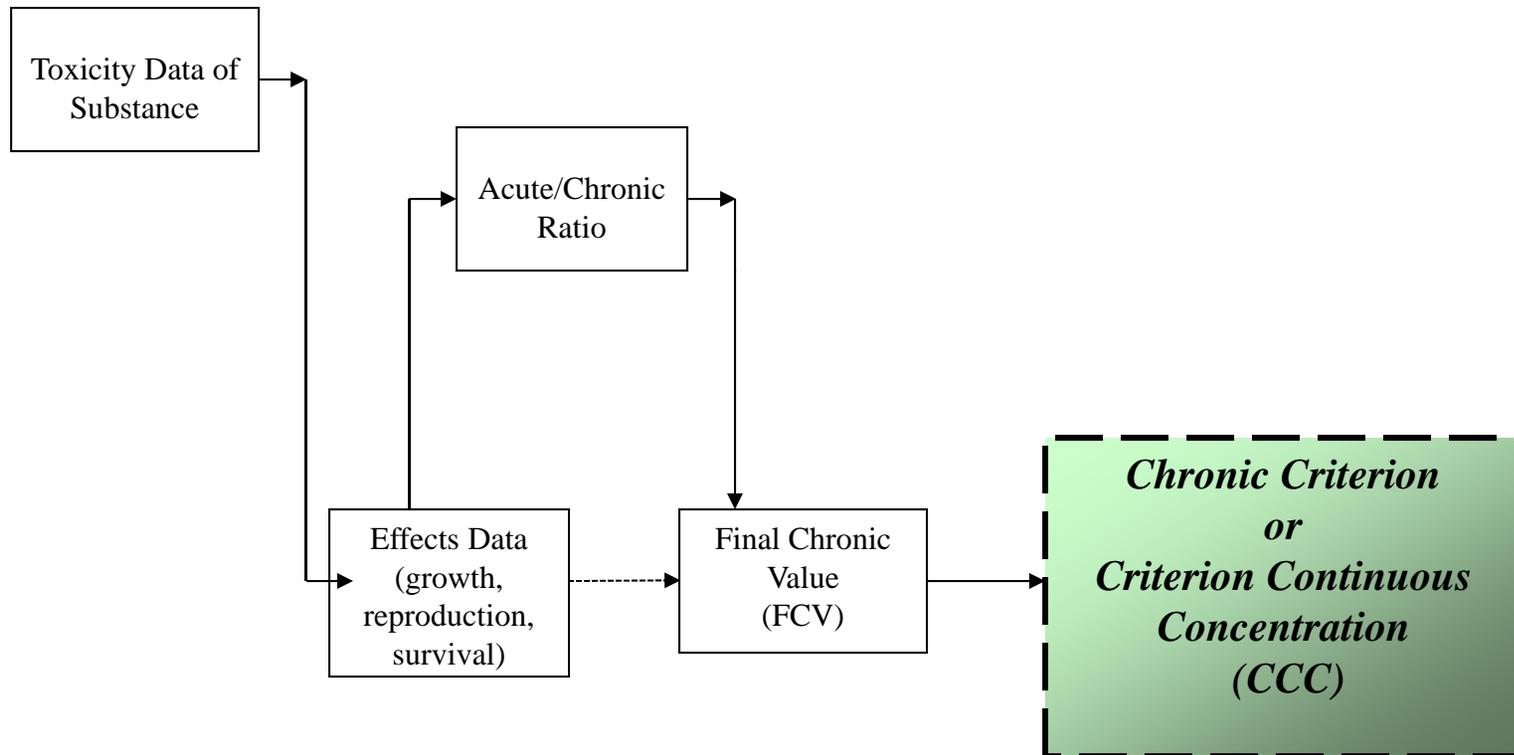
25 mm

5 mm

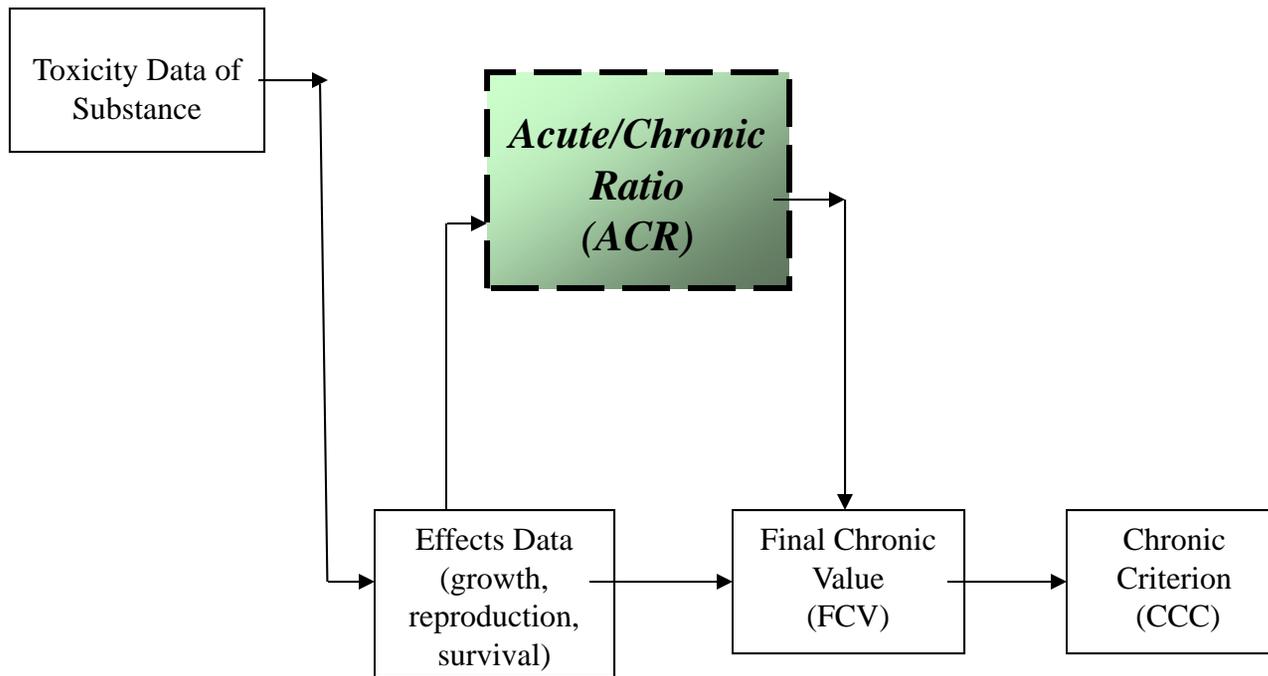
Final Chronic Value (FCV)



Chronic Criterion (CCC)



Acute-Chronic Ratio (ACR)



Calculation of Final Chronic Value

using Acute-Chronic Ratio

1. Perform Acute & Chronic Testing Using Same Species in Same Dilution Water

2. Use Results to Calculate Acute-Chronic Ratios (ACR)

$$\text{ACR} = \frac{\text{Acute Value}}{\text{Chronic Value}}$$

3. Develop a Final Acute-Chronic Ratio (FACR) by taking a Geometric Mean of the appropriate Acute-Chronic Ratios

4. Calculate the Final Chronic Value (FCV) using the Final Acute-Chronic Ratio

$$\text{FCV} = \frac{\text{Final Acute Value}}{\text{FACR}}$$

Other Criteria

EPA has National Recommended Water Quality Criteria for non-toxicants and non-traditional toxics as well:

- **Organoleptics (taste and odor)**
- **Nonpriority Pollutants**
 - **dissolved oxygen**
 - **oil and grease**
 - **pH**
 - **Nutrients**
 - **dissolved solids/turbidity**
 - **color**
 - **alkalinity**
 - **bacteria**

Example of Aquatic Life Criterion

Chlordane

For chlordane the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.0043 ~g/l as a 24-hour average, and the concentration should not exceed 2.4 ~g/l at any time.

For chlordane the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.0040 ~g/l as a 24-hour average, and the concentration should not exceed 0.09 ~g/l at any time.

Aquatic Life Criteria: Components

Question: What is an Aquatic Life Criterion?

Answer: The highest instream concentration of a toxicant to which organisms can be exposed for a period of time without causing an unacceptable adverse effect.

Question: What is it intended to protect?

Answer: Aquatic animals (e.g., fish, invertebrates, crustaceans) and plants from acute and chronic exposure to a toxicant or condition.

Aquatic Life Criteria: Components

Question: What are the three components of an Aquatic Life Criterion?

Answer: **Magnitude (how much)**

- $\mu\text{g/L}$

Duration (how long)

- **four days**

Frequency (how often)

- **once every three years**

Aquatic Life Criteria: Components

Question: Are there “defaults” for these components of an Aquatic Life Criterion?

Answer: Magnitude (how much):

- **No. The concentration is based on toxicity testing.**

Duration (how long):

- **For acute exposure, 1-24 hour averaging period**
- **For chronic exposure, 4 day averaging period.**

Frequency (how often):

- **Once every 3 years, for both acute and chronic criteria.**

Aquatic Life Criteria: Components

Question: What are the data requirements to calculate an Aquatic Life Criterion?

Answer: Acute and chronic test data from 8 taxonomically different families of organisms.

Aquatic Life Criteria: Derivation Overview

Q: What is the Acute-Chronic Ratio?

A: The Acute-Chronic Ratio Is Used To Quantify the Difference in the Toxicities Observed in an Acute Test & a Chronic Test.

Q: Why use it?

A: In cases where there are only chronic toxicity data from 3 different families, and to calculate a Final Chronic Value.

Aquatic Life Criteria: Site-Specific Criterion

What is a Site?



What is a Site?



Aquatic Life Criteria: Site-Specific Criterion

Q: Why would you develop a site-specific criterion?

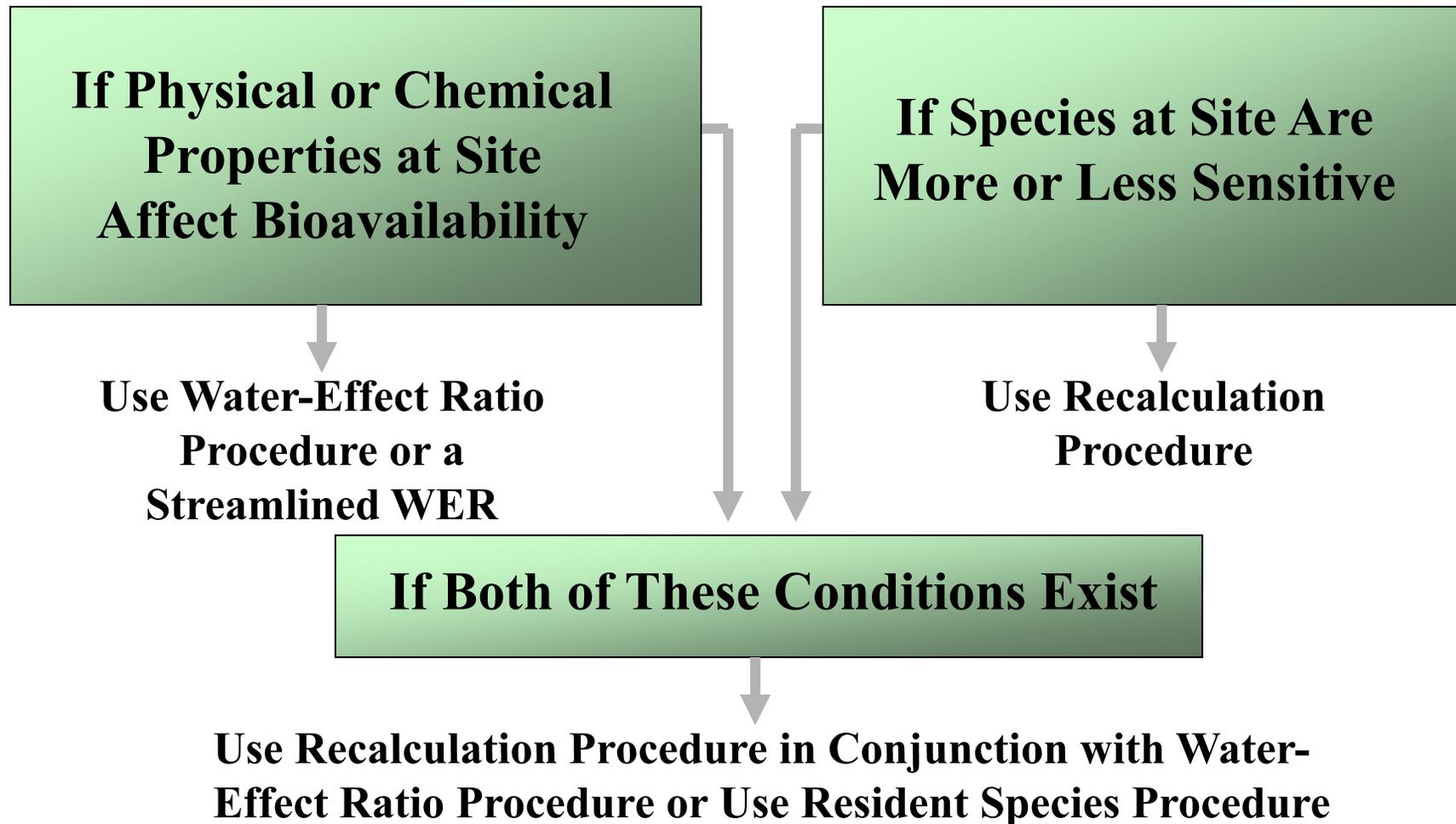
A: The Sensitivities of the Site-Species Differ from the National Data Base

and/or

The Physical/Chemical Characteristics of the Site Alter the Bioavailability/Toxicity of the Pollutant

Site-specific Criteria

PROCEDURES



Aquatic Life Criteria: Final Review

1. Is Toxicity related to WQ Characteristic?

Yes

Develop Equation & Adjust

No

2. Check Agreement within Species (if <10x difference proceed)

3. Check Sensitive Life Stages (use most sensitive life stage)

4. Calculate Species Mean Acute Values (SMAVs)

5. Calculate Genus Mean Acute Values (GMAVs)

6. Rank GMAVs

7. Calculate Cumulative Probability

8. Calculate Final Acute Value (FAV)

9. Calculate CMC (CMC = FAV/2 since LC50's are used)

So EPA has a number – Now What?

- EPA –Review Process
 - Internal Review
 - Expert EPA Peer Review
 - External Review
 - External Peer Review (external experts – multiple views)
 - Request for Scientific Views on Draft Criteria from the public via Federal Register
 - Publication of Final Recommended 304(a) criteria via Federal Register
- States Review and Adoption Process
 - Public Comment/Scientific Views on Draft EPA Criteria
 - Triennial Review/Adoption of Criteria into WQS
 - Public Comment/Scientific Views on Draft WQS according to States regulatory adoption process