Derivation of Oklahoma's Numeric Water Quality Criteria for Protection of Aquatic Life & Human Health

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Aquatic Life Criteria

- **What is an aquatic life criterion (ALC)?**

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

- **What is the criterion intended to protect?**

Aquatic animals (fish, invertebrates, crustaceans) and plants from acute & chronic exposure to a toxicant or condition. I.E. The *Fish and Wildlife Propagation* beneficial uses

- **What is the criterion based on?**

Based solely on data & scientific determinations about the relationship between concentrations of a pollutant & its effects on aquatic life

Aquatic Life Criteria

- 1985 Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms & Their Uses
- Acute & chronic endpoints
  - Acute: interpreted as *exposed briefly,* generally 1 hour
  - Chronic: interpreted as *exposed indefinitely*
- Criteria are expressed with 3 components
  - Magnitude
  - Duration
  - Frequency

Aquatic Life Criteria – Data Needs

- 2 Types of values from toxicity test needed
  - Median Lethal Conc. (LC 50): specific concentration of a chemical that has been found to lethal to 50 % of individuals in a group of aquatic organisms exposed for 48 – 96 hours
  - Median Effective Conc. (EC 50): a specific concentration of a chemical that has been found to cause a particular effect in 50% of individuals in a group of aquatic organisms exposed over a given time period

Aquatic Life Criteria – Data Needs

- Data needed from at least 8 different families to address diversity in the aquatic community

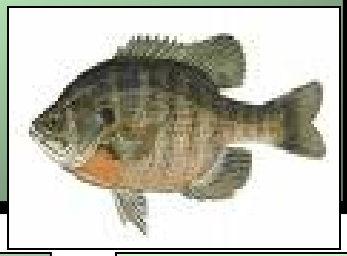
Vertebrates	Invertebrates
Salmonid fish	Planktonic crustacean
Fish from family other than salmonidae	Benthic Crustacean
3rd Chordate family (salamander, frog)	Insect
	Species from phylum other than Chordata or Arthropoda (rotifer, worm, mollusk)
	Species from another order of insect or fourth phylum

- Data from the most sensitive life stage must be used, when available

Toxicity Data Requirements

SALMONID

2ND FISH FAMILY



3rd CHORDATE FAMILY (Fish or Amphibian)

PLANKTONIC CRUSTACEAN

BENTHIC CRUSTACEAN

AQUATIC INSECT

3rd PHYLUM (e.g., Rotifera, Annelida, Mollusca)

4th PHYLUM OR ANOTHER AQUATIC INSECT ORDER

Aquatic Life Criteria - Acute

- Step 1: Gather & evaluate toxicity data, ECOTOX database & Literature

- Step 2: Calculate the Final Acute Value (FAV)
  - Calculate the Genus Mean Acute Value (GMAV), which is the geometric mean of the toxic effect concentration from all species within the given genus
  - Rank the GMAVs based on sensitivity
  - The 4 lowest values are used in a regression to extrapolate the concentration that would cause the threshold effect (i.e. mortality) for the 5th percentile of most sensitive species

Rank	GMAV	SMAV	
	µg/L	Species	µg/L
4	100	Rainbow Trout, *Oncorhynchus mykiss*	100
3	36	Cladoceran, *Daphnia ambigua*	42
		Cladoceran, *Daphnia pulex*	38
		Cladoceran, *Daphnia magna*	29
2	25	Amphipod, *Gammarus pseudolimnaeus*	25
1	19	Amphipod, *Hyalella azteca*	19

Aquatic Life Criteria - Acute

- Acute criterion
  - The FAV divided by 2
  - The Acute criterion is divided by 2 as safety factor for a low level effect for the 5^{th} percentile genus rather than the 50 % effect.

Aquatic Life Criteria - Chronic

- Step 1: Gather & evaluate toxicity data, ECOTOX database & Literature
- Step 2: If there is enough chronic toxicity data available for all 8 families, the chronic criterion is calculated in the same manner as the acute criterion.
- Often enough chronic data is not available due to the difficultly and expense of conducting chronic toxicity testing
- In this case the Acute to Chronic Ratio approach is used

Aquatic Life Criteria - Chronic

- Acute to Chronic Ratio (ACR)
  - Calculated based on parallel acute and chronic toxicity test

$$ACR = AV \div CV$$

  - 3 different species with taxonomic diversity are required
  - Final ACR is the geometric mean of all ACRs

- Chronic criterion
  - The FAV divided by the Final ACR

Aquatic Life Criteria Updates

- 2015 OWRB updated 15 ALC criteria
  - 9 metals
  - 4 organic chemicals
  - 2 corrections

- EPA approval in progress

Human Health Criteria

- What are human health criteria?

The highest concentration of a pollutant in water that is not expected to pose a significant risk to human health

- 2 Types of Human Health Criteria

1. Protection from ingestion of water and aquatic organisms
2. Protection from ingestion of aquatic organisms only

- Developed consistent with EPA's 2000 Human Health Methodology (Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health)

Human Health Criteria – Data Needs

- Toxicity
  - Toxic effect & dose response properties
  - Risk Specific does for linear carcinogens
  - Point of Departure (POD)/Uncertainty Factor (UF) for nonlinear carcinogens
  - Reference dose (RfD) for non-carcinogens
- Exposure
  - Relative Source Contribution
  - Exposure parameters: Body weight, drinking water intake, fish intake

Human Health Criteria – Data Needs

- Bioaccumulation Factors (BAF)
  - Site-specific BAFs or National BAFs
  - Trophic level data on accumulation of chemical in fish or shellfish

Human Health Criteria

- **Non-Cancer Effects:**

$$AWQC = RfD \cdot RSC \cdot \left(\frac{BW}{DI + \sum_{i=2}^{4} (FI_i \cdot BAF_i)} \right)$$

- Cancer Effects:
  - Non-linear

$$AWQC = \frac{POD}{UF} \cdot RSC \cdot \left(\frac{BW}{DI + \sum_{i=2}^{4} (FI_i \cdot BAF_i)} \right)$$

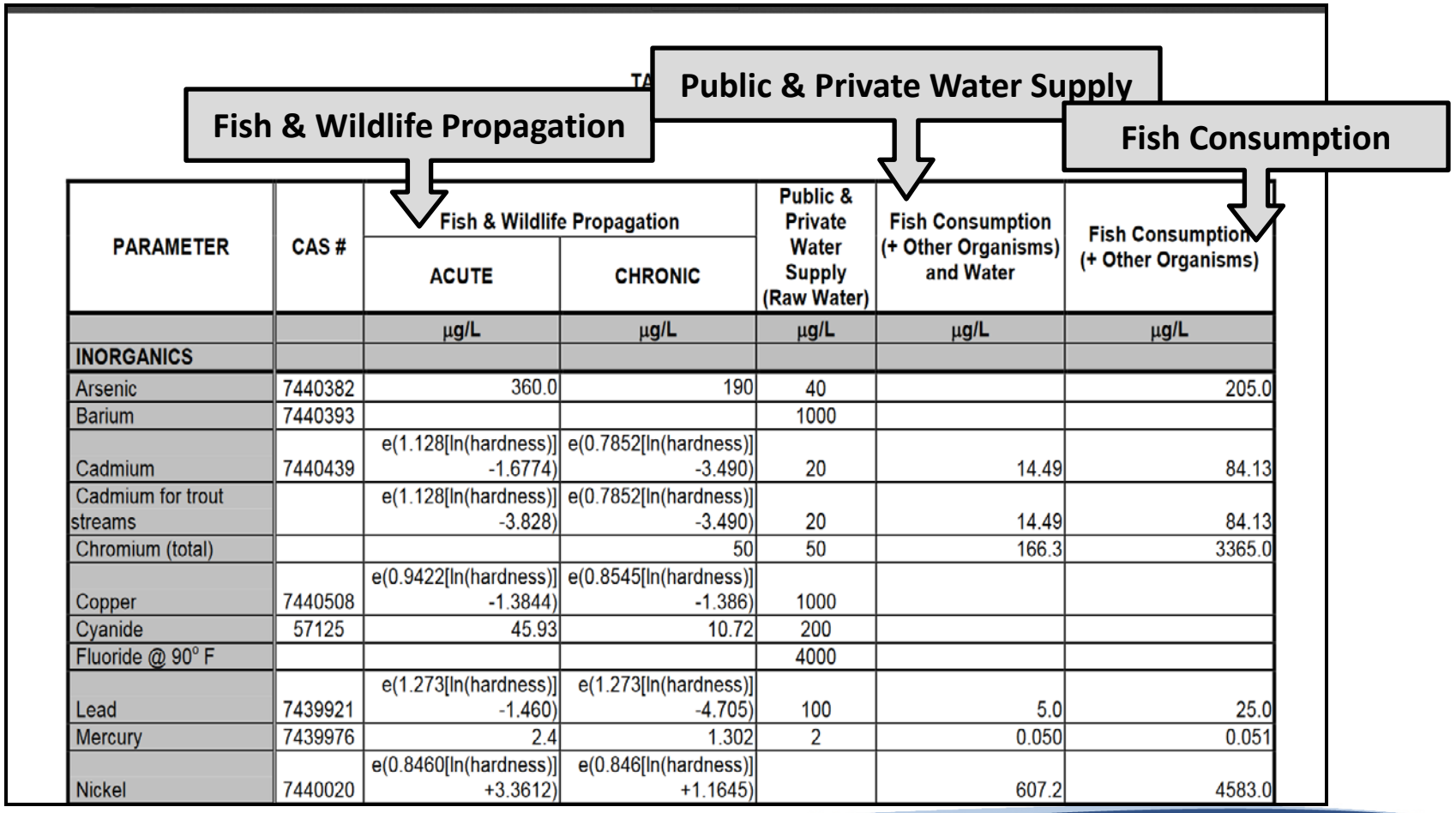
- **Cancer Effects:**
  - **Linear**

$$AWQC = RSD \cdot \left(\frac{BW}{DI + \sum_{i=2}^{4} (FI_i \cdot BAF_i)} \right)$$

Human Health Criteria – Progress

- Methylmercury in fish tissue – 2017
- Review of EPA's nationally recommend Human Health Criteria - 2018
  - 94 constituents
- More on these projects and details on human health criteria development as part of 2017-2018 stakeholder meetings

Aquatic Life & Human Health Criteria



PARAMETER	CAS #	Fish & Wildlife Propagation		Public & Private Water Supply (Raw Water)	Fish Consumption (+ Other Organisms) and Water	Fish Consumption (+ Other Organisms)
		ACUTE	CHRONIC			
		µg/L	µg/L	µg/L	µg/L	µg/L
INORGANICS						
Arsenic	7440382	360.0	190	40		205.0
Barium	7440393			1000		
Cadmium	7440439	e(1.128[ln(hardness)] -1.6774)	e(0.7852[ln(hardness)] -3.490)	20	14.49	84.13
Cadmium for trout streams		e(1.128[ln(hardness)] -3.828)	e(0.7852[ln(hardness)] -3.490)	20	14.49	84.13
Chromium (total)			50	50	166.3	3365.0
Copper	7440508	e(0.9422[ln(hardness)] -1.3844)	e(0.8545[ln(hardness)] -1.386)	1000		
Cyanide	57125	45.93	10.72	200		
Fluoride @ 90° F				4000		
Lead	7439921	e(1.273[ln(hardness)] -1.460)	e(1.273[ln(hardness)] -4.705)	100	5.0	25.0
Mercury	7439976	2.4	1.302	2	0.050	0.051
Nickel	7440020	e(0.8460[ln(hardness)] +3.3612)	e(0.846[ln(hardness)] +1.1645)		607.2	4583.0

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Questions

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