Site Specific Criteria
and
Site-dependent Criteria

Criteria: not "just a number" anymore…

May 2023

Virtual WQS Academy

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In aquatic life criteria, you learned that states usually adopt criteria statewide, and often they look something like…

National Recommended Aquatic Life Criteria table excerpt

Pollutant	CAS #	Freshwater CMC[1] (acute) (µg/L)	Freshwater CCC[2] (chronic) (µg/L)	Saltwater CMC[1] (acute) (µg/L)	Saltwater CCC[2] (chronic) (µg/L)	Publication Year	Notes
Carbaryl	63252	2.1	2.1	1.6	—	2012	

Setting the Stage

- **'Traditional' Site Specific Criteria (SSC):** Refer to SSC where a state/tribe takes a traditional aquatic life criteria that apply state/tribe-wide, like described in the Aquatic Life Module, and modifies it to reflect site specific conditions– adopt and submit to EPA.
  – Modifications can be made via Water Effect Ratio (WER), recalculation, reference water body approaches

- **Site-dependent criteria**: Equation/model-based criteria that can be adopted statewide, but the input conditions and, therefore, numeric values resulting from the outputs will be different at each site.
    - Ammonia
    - Metals criteria that are hardness dependent
    - Copper (Biotic Ligand Model)
    - Aluminum (Calculator based on Multi-Linear Regression)

Site Specific Criteria: a tool to tailor standards to local conditions / key species

- Best used when you have additional scientific information that more accurately expresses a level / concentration for a water quality parameter to protect a designated use.
- States and tribes may adopt numeric criteria based on: CWA Section 304(a) guidance, CWA Section 304(a) guidance modified to reflect site-specific objectives; or other scientifically defensible methods (40 CFR 131.11(b)(1)).

Site Specific Criteria: Purpose

- Adjust the criteria level to something that is still protective of the designated use but specific to the site
  - Less **or** more ‘stringent’ than national recommended criteria values.
  - Still “a number”
- Does not allow for additional time to meet standards; is applicable immediately upon EPA approval.

When Site Specific Criteria May Be a Good Idea

Depends on the situation and quality of the data.

- When the physical/chemical characteristics of the site alter the bioavailability/toxicity of the pollutant (e.g., DOC binding metals), different from the laboratory dilution water.
- When the sensitivities of the site species differ from those used to develop the national criteria (e.g., trout don't exist at the site).
- When there are naturally high background levels of a pollutant.

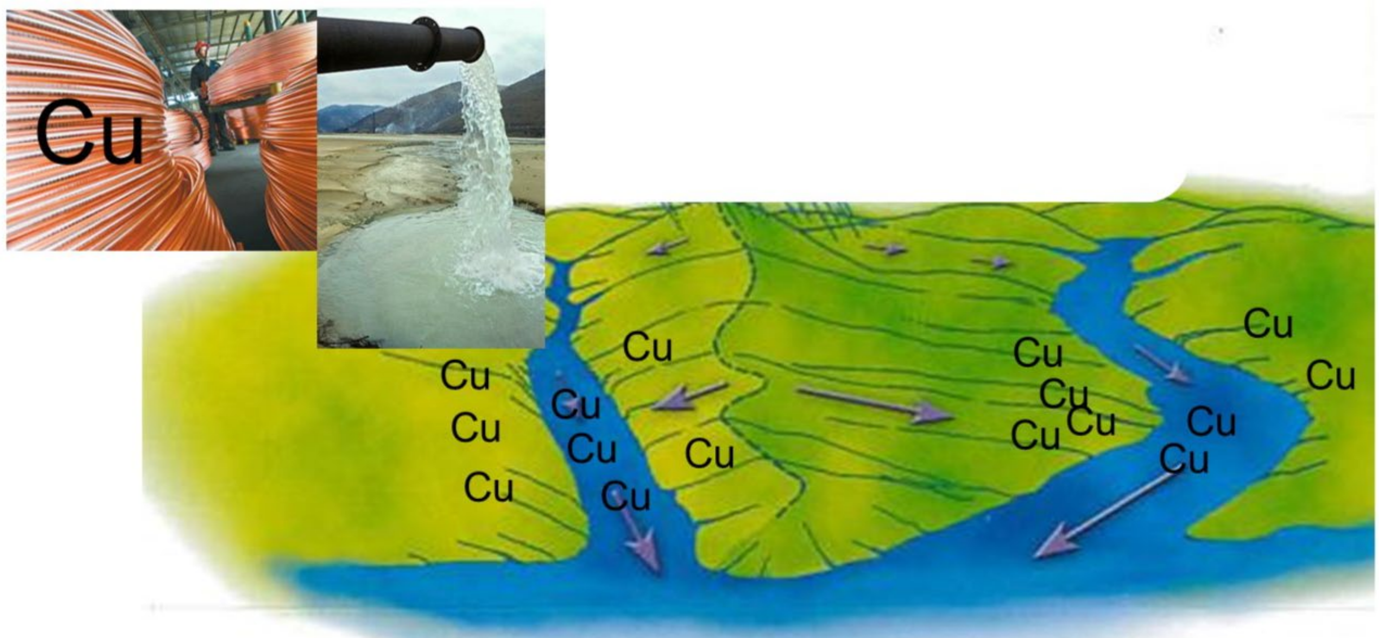
Site Specific Criteria: How

- **Resident Species Recalculation Procedure**
  - Takes into account differences between species used to calculate national recommended criteria and the waterbody in question.
    - Adjusts for the lack of a sensitive species (e.g., trout) that was included in national criteria calculations, but isn't found in this particular waterbody.
- **Reference water body approach**
  - Compares the waterbody in question to a reference waterbody that may have similar physical, chemical, or biological conditions but is meeting the designated uses.
    - Used in cases where there is a natural component to the pollutant in question.
- **Site Water Chemistry Approaches**
  - Help make the translation of the criteria based on the differences in physical/chemical characteristics.
    - **Water-Effect Ratio (WER).** Compares the lab water used to set the current criteria with the ambient water (e.g., water containing higher dissolved organic carbon) to set appropriate criteria.

Metal Toxicity and Criteria

- Historically, when more refined site-specific criteria are needed, they have been derived using “Water Effect Ratio” procedure.
  - States/tribes/dischargers sometimes think the hardness-based criteria are unnecessarily stringent at a site because site conditions modify the metal’s toxicity.
  - They take large samples of site water and perform at least 2-3 sets of toxicity tests.
  - WER-modified criteria = WER x [hardness based criteria]
  - The ‘WER’ is a number (usually less than 5) that serves as a multiplier to make the criteria (usually) less stringent

Reference Water Body Example



- Cu criteria not being achieved. Is it because of the anthropogenic sources, or the natural background levels?
- Natural background of Cu in reference site may be higher than the current criteria. But does the water support the aquatic life uses at that level of Cu?
- It can be a difficult demonstration.

Site Specific Criteria: Conditions

- Can be less or more stringent than national recommended values.
- Do not change the designated use. (No UAA needed)
- Are water quality standards, so they must:
  - be submitted to EPA for approval (typically SSC apply to a specific water body, or some subset of similar water bodies)
  - go through public hearing(s) consistent with 40 CFR Part 25.5, including the 45-day notice of hearing.
  - include supporting data and analysis methods.
  - continue to protect the designated use.

Site-dependent criteria: The Future is Complex

- In recent years, the state of science has evolved regarding toxicity for many parameters that affect aquatic life: it's more complex than before.
- EPA has published 304(a) recommendations for parameters whose toxicity depends on other constituents of water chemistry.
- For these "site-dependent criteria," the equation/model can be adopted as the state/tribe-wide criteria, but different values may be calculated from it at different sites.
- Examples:
  - Ammonia (depends on pH, temperature, life stage)
  - Several metals (depend on hardness)
  - Copper (depends on 10 parameters)
  - Aluminum (depends on pH, total hardness, DOC)

EPA's 304(a) recommendation for Ammonia (2013)

Table 5a. Temperature and pH-Dependent Values of the CMC (Acute Criterion Magnitude) – *Oncorhynchus spp.* Present.

pH	Temperature (°C) 0-14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
6.5	33	33	32	29	27	25	23	21	19	18	16	15	14	13	12	11	9.9
6.6	31	31	30	28	26	24	22	20	18	17	16	14	13	12	11	10	9.5
6.7	30	30	29	27	24	22	21	19	18	16	15	14	13	12	11	9.8	9.0
6.8	28	28	27	25	23	21	20	18	17	15	14	13	12	11	10	9.2	8.5
6.9	26	26	25	23	21	20	18	17	15	14	13	12	11	10	9.4	8.6	7.9
7.0	24	24	23	21	20	18	**17**	15	14	13	12	11	10	9.4	8.6	8.0	7.3
7.1	22	22	21	20	18	17	15	14	13	12	11	10	9.3	8.5	7.9	7.2	6.7

Table 5b. Temperature and pH-Dependent Values of the CMC (Acute Criterion Magnitude) – *Oncorhynchus spp.* Absent.

pH	Temperature (°C) 0-10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
6.5	51	48	44	41	37	34	32	29	27	25	23	21	19	18	16	15	14	13	12	11	9.9
6.6	49	46	42	39	36	33	30	28	26	24	22	20	18	17	16	14	13	12	11	10	9.5
6.7	46	44	40	37	34	31	29	27	24	22	21	19	18	16	15	14	13	12	11	9.8	9.0
6.8	44	41	38	35	32	30	27	25	23	21	20	18	17	15	14	13	12	11	10	9.2	8.5
6.9	41	38	35	32	30	28	25	23	21	20	18	17	15	14	13	12	11	10	9.4	8.6	7.9
7.0	38	35	33	30	28	25	23	21	20	18	**17**	15	14	13	12	11	10	9.4	8.6	7.9	7.3
7.1	34	32	30	27	25	23	21	20	18	17	15	14	13	12	11	10	9.3	8.5	7.9	7.2	6.7

Why site-dependent criteria for metals?

- Metals are naturally occurring and ubiquitous…
  - But not always bioavailable / toxic.
  - A single criteria magnitude (concentration) might be ‘overprotective’ in cases where the water chemistry mitigates toxicity.
  - EPA recognized that water hardness was a mitigating factor in toxicity for several metals and published 304(a) recommendations that are equations in which hardness is the variable.

Metals in EPA 304(a) table, Appendix B

Hardness-dependent metals' criteria may be calculated from the following:
Criteria Maximum Concentration (CMC) (dissolved) = exp{mA [*ln*(hardness)]+ bA} (CF)
Criteria Continuous Concentration (CCC) (dissolved) = exp{mC [*ln*(hardness)]+ bC} (CF)

Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent

Chemical	**mA**	**bA**	**mC**	**bC**	**Freshwater Conversion Factors (CF)**	
					CMC	**CCC**
Cadmium	0.9789	-3.866	0.7977	-3.909	1.136672-[(*ln*hardness)(0.041838)]	1.101672-[(*ln*hardness)(0.041838)]
Chromium III	0.8190	3.7256	0.8190	0.6848	0.316	0.860
Lead	1.273	-1.460	1.273	-4.705	1.46203-[(*ln*hardness)(0.145712)]	1.46203-[(*ln*hardness)(0.145712)]
Nickel	0.8460	2.255	0.8460	0.0584	0.998	0.997
Silver	1.72	-6.59	—	—	0.85	—
Zinc	0.8473	0.884	0.8473	0.884	0.978	0.986

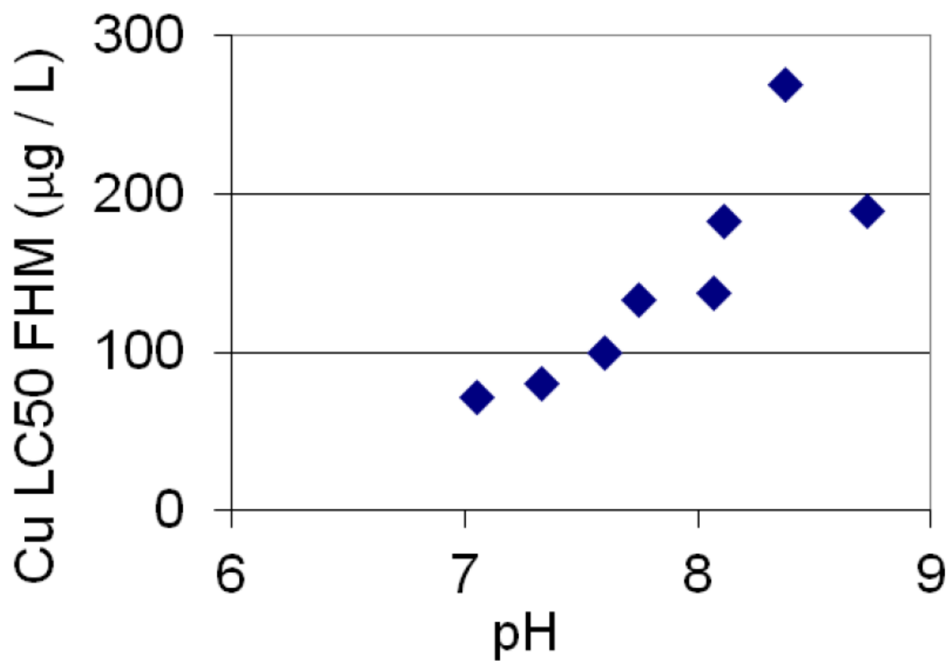
Example 304(a) Metals criteria

- The EPA recommended 304(a) criteria table boils down to formulating the equation and inputting the ambient hardness to generate criteria values for the site:
  - e.g., Ni Acute criterion = $\exp^{\{0.8460\,[\mathit{ln}(\text{hardness})]+2.255\}} * (0.998)$

EPA's approach for Copper

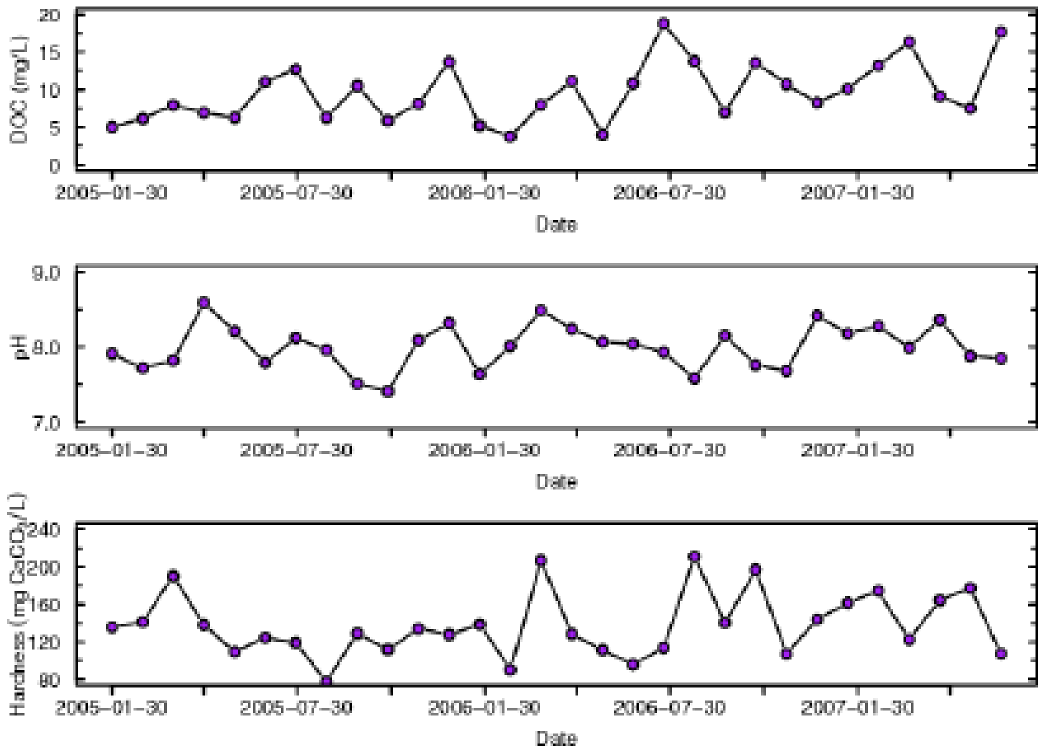
The hardness-based approach did not directly consider other water chemistry parameters (e.g., pH and DOC) that have a great influence on copper bioavailability.

Traditional metals criteria do not account for **pH effects**



Copper toxicity varies over time with varying water chemistry

Time variable water chemistry



Influences the bioavailability of Cu, and this is accounted for with the BLM

EPA's 304(a) recommendation for Cu in freshwater: A model

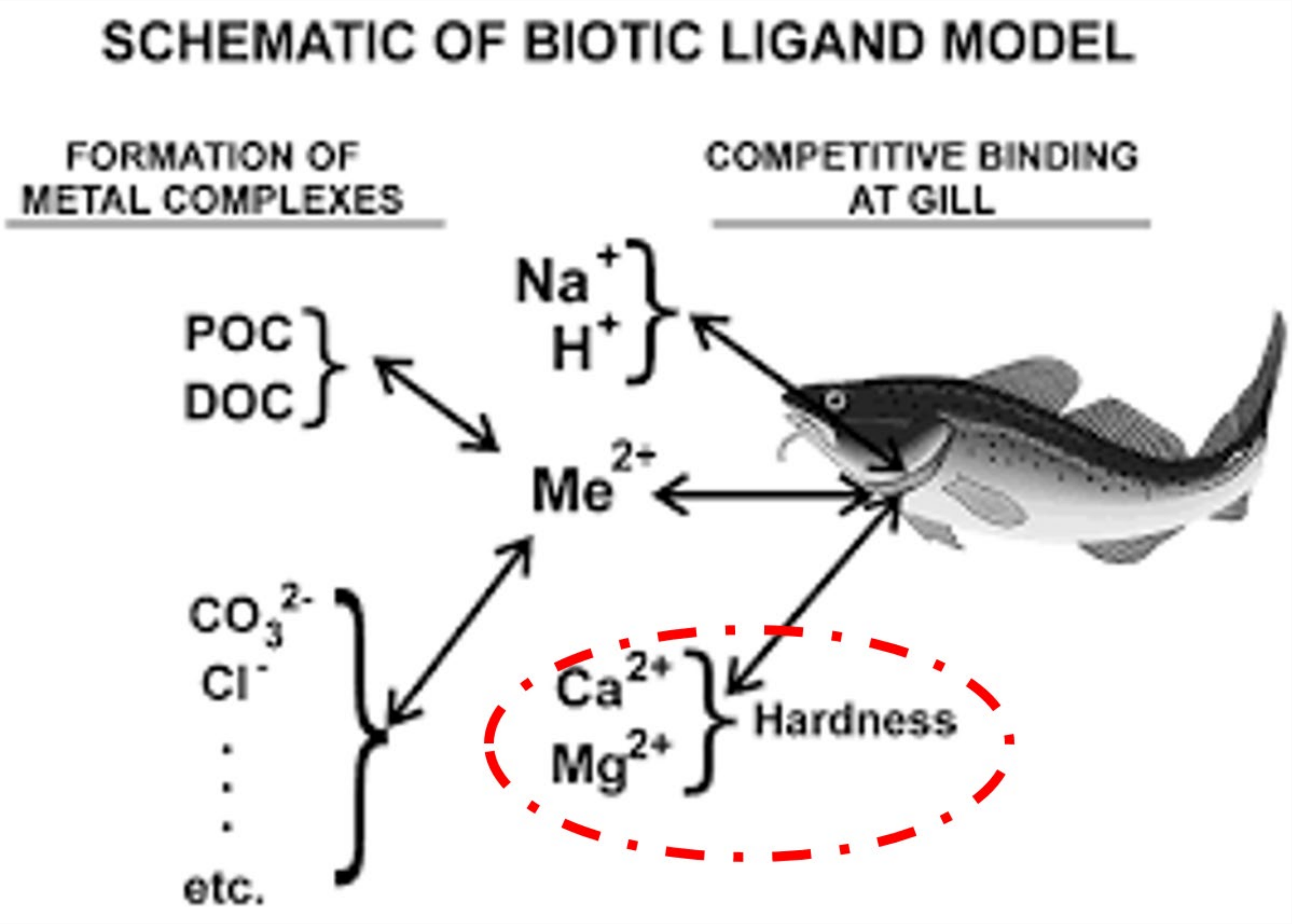
- Since 2007, EPA recommends a model (the Cu Biotic Ligand Model, Cu-BLM) that can incorporate multiple variables that affect the metal's toxicity. *Aquatic Life Ambient Freshwater Criteria – Copper 2007 Revision (EPA-822-R-07-001).*

- The Cu-BLM reflects the latest science on metals toxicity to aquatic organisms.

- The model can take a time series of ambient data inputs and generates a series of outputs that represent the criteria that would be protective at each given point in time ("instantaneous water quality criteria," or "IWQC").

- The freshwater Cu-BLM uses ten input parameters: pH, DOC, Ca, Mg, Na, SO_4, K, Cl, alkalinity, temperature.

Freshwater Cu-BLM Conceptual Framework



EPA’s History with Cu criteria

- Before 2007, EPA recommended hardness-based Cu criteria, and states often modified those with WERs.
- EPA's Science Advisory Board (SAB) 2000 report found that BLMs can “significantly improve predictions of the acute toxicity of certain metals across an expanded range of water chemistry parameters compared to the WER [Water-Effect Ratio]".
- EPA supports use of the Cu-BLM and encourages states and tribes to replace their hardness-based criteria with the Cu-BLM, which is based on the most current science. Furthermore, sampling for the Cu-BLM is more cost-effective than doing WER studies to modify hardness-based criteria.

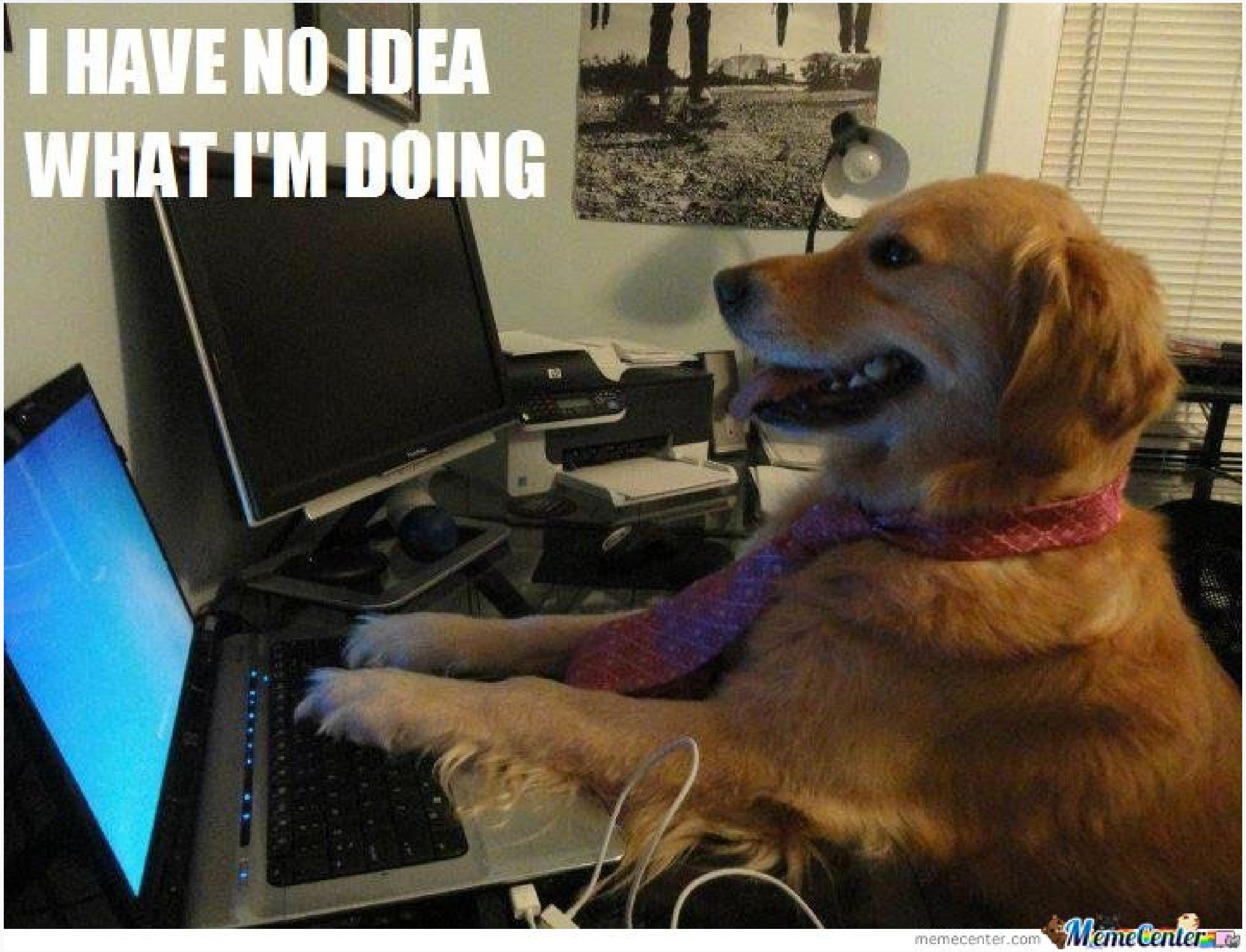
Using the Cu-BLM model: inputs

					Humic Acid % of							
Site	Date	Temp	pH	DOC	DOC	Ca	Mg	Na	K	SO4	Cl	Alka-linity
KR 89	7/22/1987	29	8.45	5.6	10	81	16	76	10	140	100	192
KR 89	10/20/1987	10	8.5	6.6	10	82	17	90	9	130	110	203
KR 89	11/23/1987	7	7.9	6.7	10	110	23	130	9	180	170	233
KR 89	12/22/1987	3	7.5	9.6	10	61	13	35	6	67	36	151
KR 89	1/19/1988	2	8	3.9	10	110	23	110	8	180	140	232
KR 89	2/17/1988	1	7.3	6.7	10	91	20	73	7	120	77	256

Using the Cu-BLM model: outputs

Site	Date	Final Acute Value (FAV), ug/L	CMC (CMC=FAV/2), ug/L	CCC (CCC=FAV/ ACR), ug/L	Cu ug/L	Acute Toxic Units (Acute TU=Cu/CMC)
KR 68	7/22/1987	212.10	106.05	65.87	6.00	0.06
KR 68	10/20/1987	173.43	86.71	53.86	2.50	0.03
KR 68	11/23/1987	116.44	58.22	36.16	1.20	0.02
KR 68	12/22/1987	87.19	43.59	27.08	4.00	0.09
KR 68	1/19/1988	69.62	34.81	21.62	2.50	0.07
KR 68	2/17/1988	56.05	28.03	17.41	2.00	0.07

But wait…



Implementation Challenge: Input data

- The BLM requires 10 input parameters. States have limited resources for monitoring water chemistry on a statewide basis. How to run the BLM without complete datasets?
  - Measured pH and temperature are often collected routinely. EPA recommends measured data for these inputs.
  - For geochemical ions, alkalinity, and DOC, it is possible to use existing large national surface water quality datasets to generate estimates of protective input values (for example, 10^{th} percentile of the values for a Level III Ecoregion).

Implementation Challenge: Processing multiple outputs

- How to develop criteria that will be protective of the site at all times when the water chemistry varies over time?
  - Each model “run” (based on one set of input data) generates an individual “instantaneous water quality criteria” (IWQC)
  - Need to process the outputs in a way that will generate an overall numeric criteria value that will be protective of the site at all times, and particularly when Cu is most bioavailable based on conditions at that site.
    - For example, pick the lowest IWQC, or a low percentile of IWQCs

Aluminum 304(a) recommendation

- EPA published a final 304(a) recommendation for freshwater aluminum in December 2018.
- The final criteria comprise a multilinear regression (MLR)-based calculator for which pH, DOC, and total hardness are the inputs.
- Like the freshwater Cu-BLM:
  - User inputs time series of ambient data, and needs to reconcile outputs to come up with protective values
  - Default inputs or default criteria can be used if sufficient ambient data are not available.
- The aluminum model can be used by using a spreadsheet tool or lookup tables published with the recommended criteria.

Performance-Based Criteria

- A performance-based approach is an adoption of a process (i.e., a criterion derivation methodology) rather than a specific outcome (i.e., concentration limit for a pollutant) consistent with EPA's criteria regulations.
- The performance-based approach (according to EPA's preamble to "the Alaska Rule"):
  - Has a rigorous <u>scientific basis</u>.
  - Is sufficiently detailed and have suitable safeguards to <u>ensure predictable, repeatable outcomes</u>.
  - Includes implementation procedures (methodologies, minimum data requirements, and decision thresholds) in regulation that are <u>binding, clear, predictable, and transparent</u>."
- EPA approval of the approach ➔ approval of the outcomes.

Thank you. Questions?