Aquatic Life Criteria: Cadmium, Lead, and Zinc

Spokane River Metals TMDL
Watershed Advisory Group Meeting
May 3, 2016

Jason Pappani
Water Quality Standards Lead
DEQ- State Office

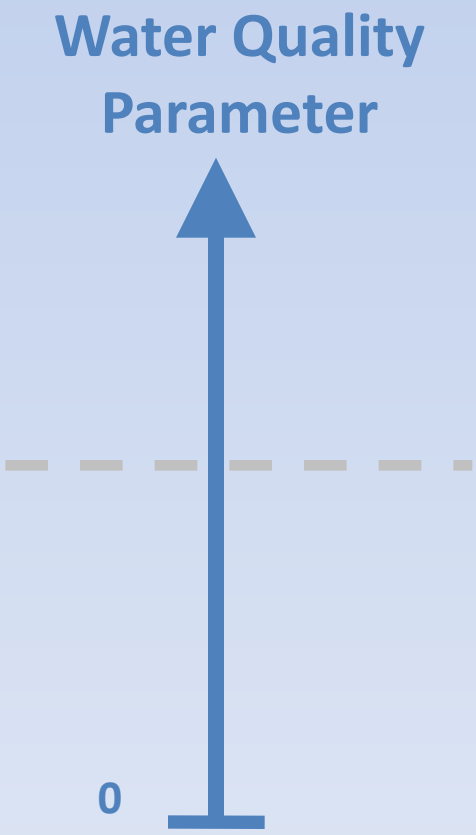
Outline

- Overview
  - EPA 304(a)
  - State Process
- Specifics on Cd, Pb, and Zn in Idaho
  - Criteria equations
  - History
  - New EPA 304(a) for Cd

Criteria

- Must protect designated uses
- Must be based on sound science

Numeric Criteria and Risk



Designated Use not Supported

Unacceptable Risk to Aquatic Life

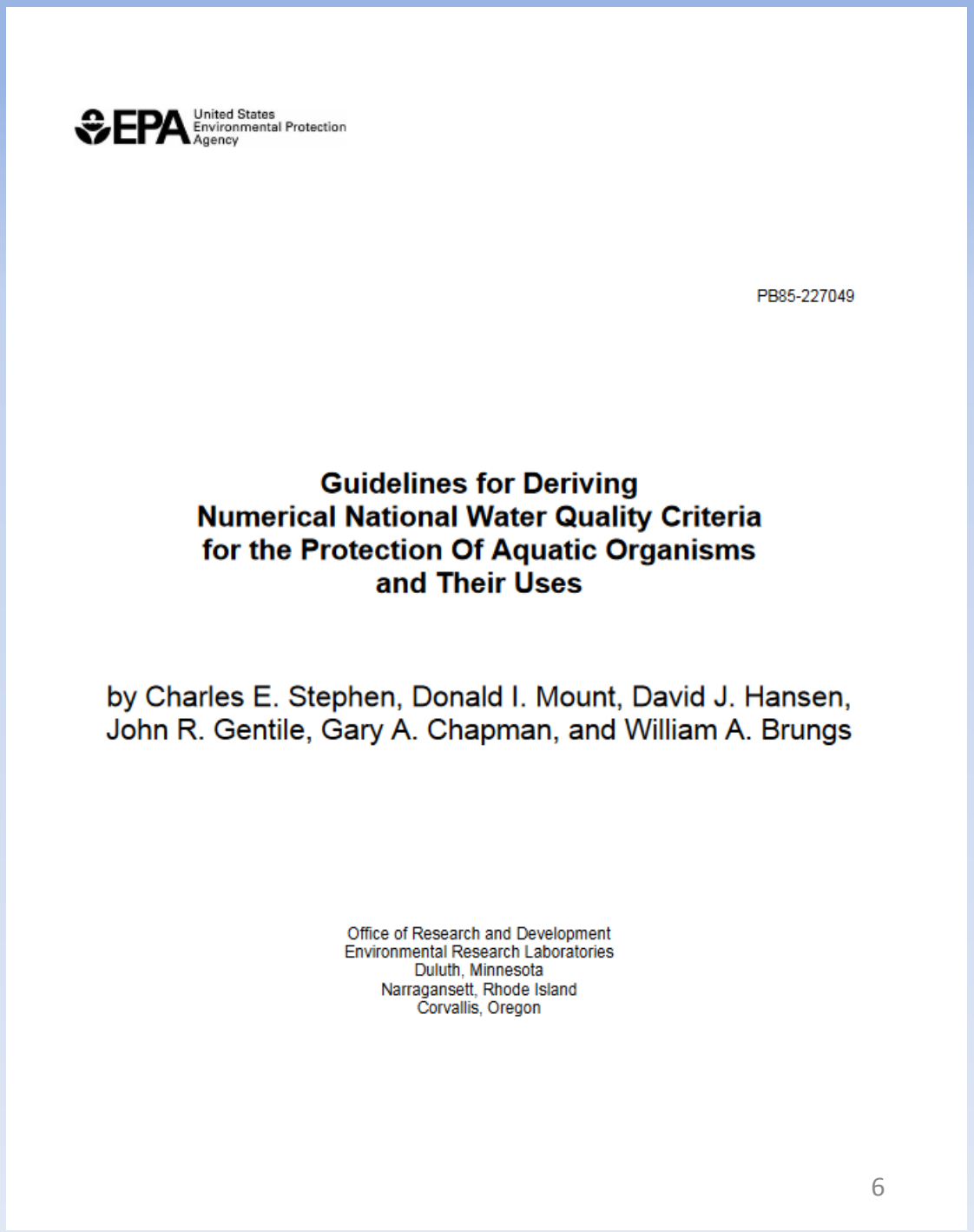
CRITERION LEVEL

Designated Use Supported

No Significant Risk Posed

EPA 304(a) Recommendations

How are Aquatic Life Criteria Developed?



EPA United States Environmental Protection Agency

PB85-227049

Guidelines for Deriving Numerical National Water Quality Criteria for the Protection Of Aquatic Organisms and Their Uses

by Charles E. Stephen, Donald I. Mount, David J. Hansen, John R. Gentile, Gary A. Chapman, and William A. Brungs

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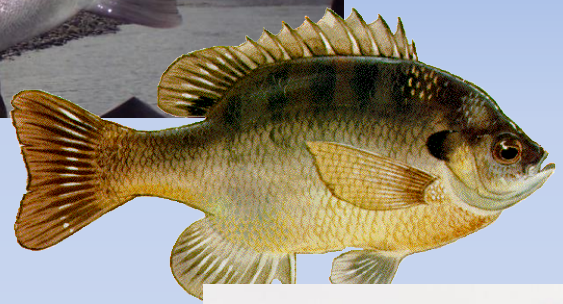
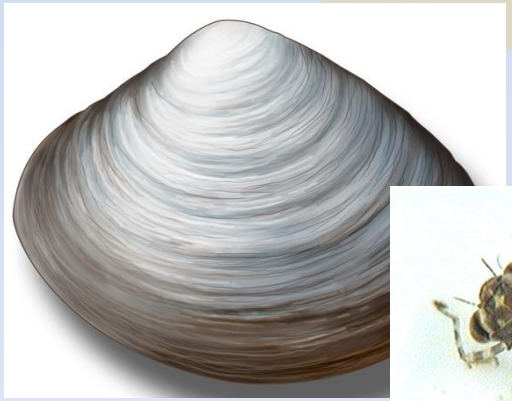
How are Aquatic Life Criteria Developed?

Acute Toxicity Data



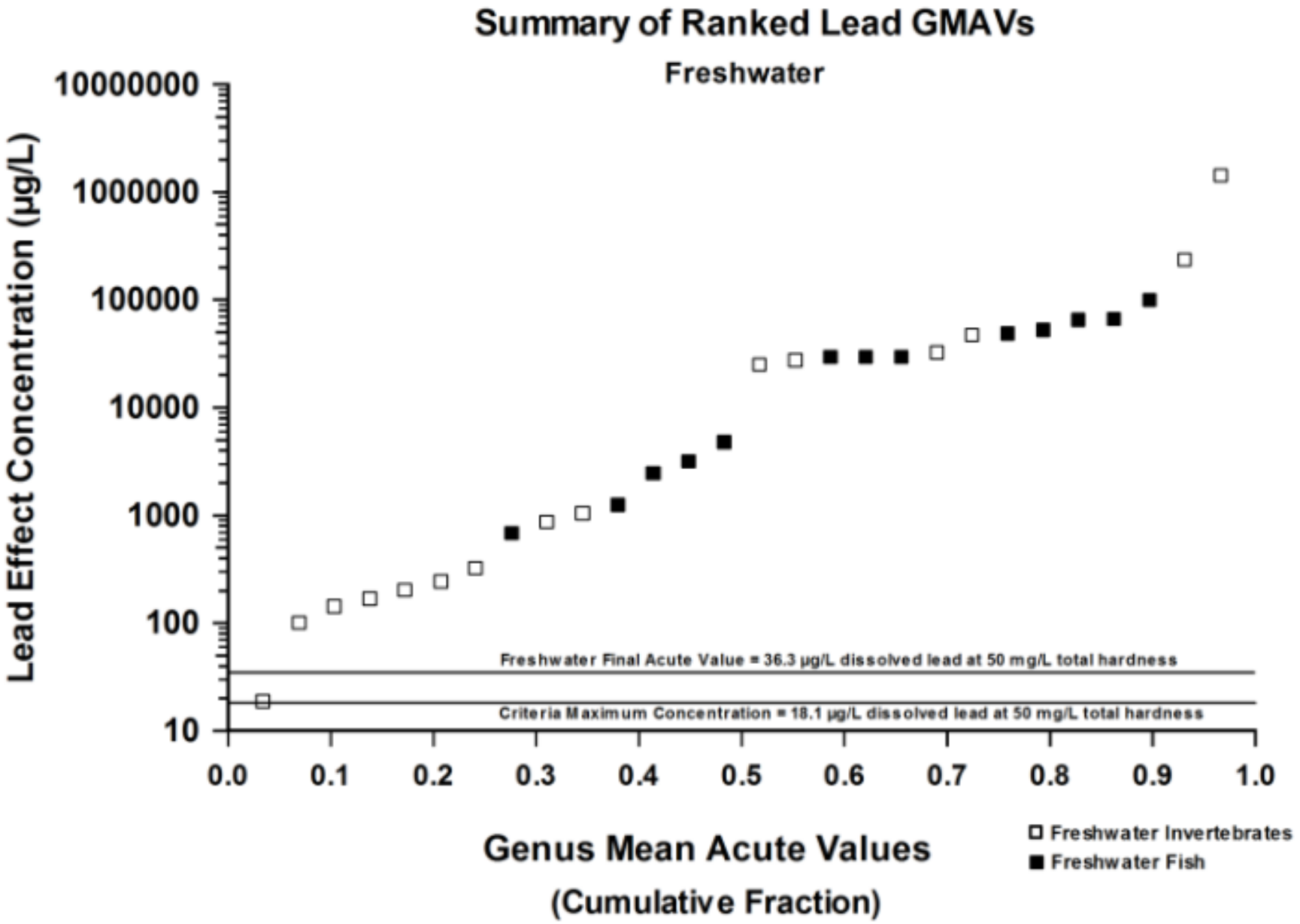


How are Aquatic Life Criteria Developed?

Acute:Chronic

How are Aquatic Life Criteria Developed?

- Plant
- Bioconcentration


Summary of Ranked Lead GMAVs
Freshwater
Lead Effect Concentration (µg/L)
10000000
1000000
100000
10000
1000
100
10
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Freshwater Final Acute Value = 36.3 µg/L dissolved lead at 50 mg/L total hardness
Criteria Maximum Concentration = 18.1 µg/L dissolved lead at 50 mg/L total hardness
Genus Mean Acute Values
(Cumulative Fraction)
Freshwater Invertebrates
Freshwater Fish

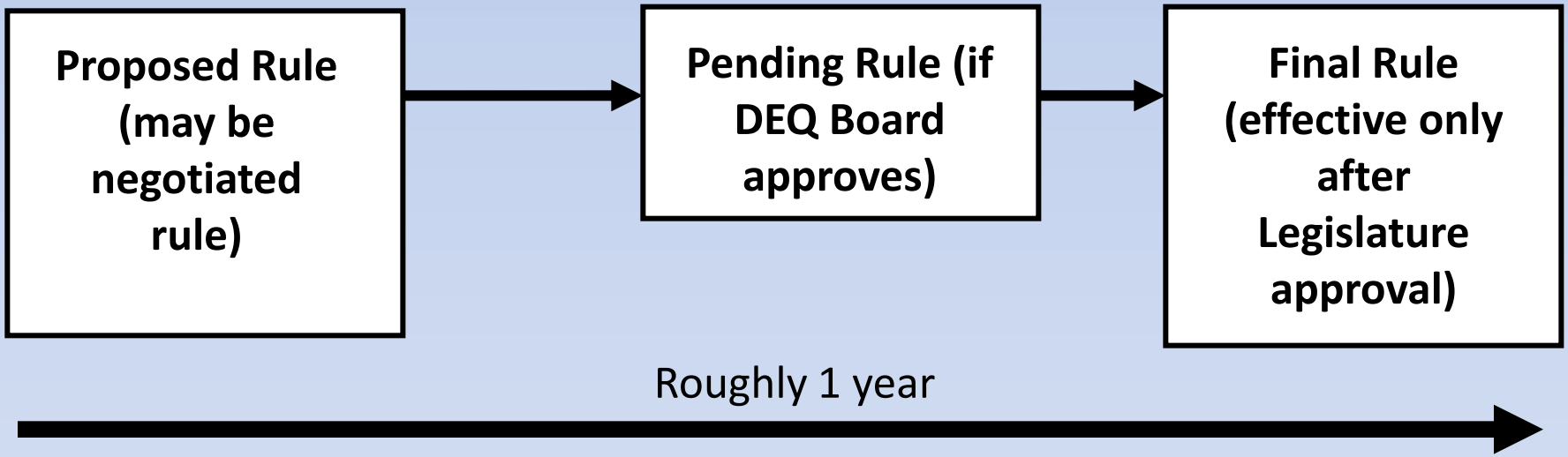
304(a) Recommended Criteria

- Criterion Maximum Concentration (CMC) = Acute Criterion
  - Maximum instantaneous or 1 hour average

- Criterion Continuous Concentration (CCC) = Chronic Criterion
  - 4 day average

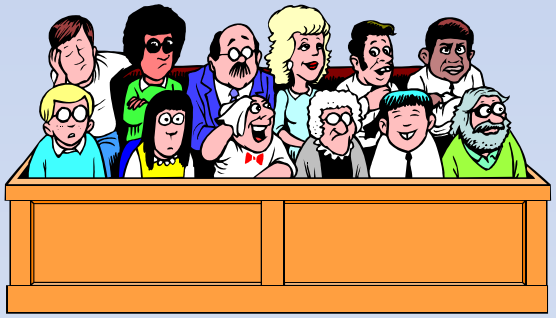
State Rulemaking Process

Rulemaking Oversimplified



Negotiated Rulemaking

- Optional informal process among interested parties and DEQ to seek consensus on rule content.



May lead to a proposed rule.

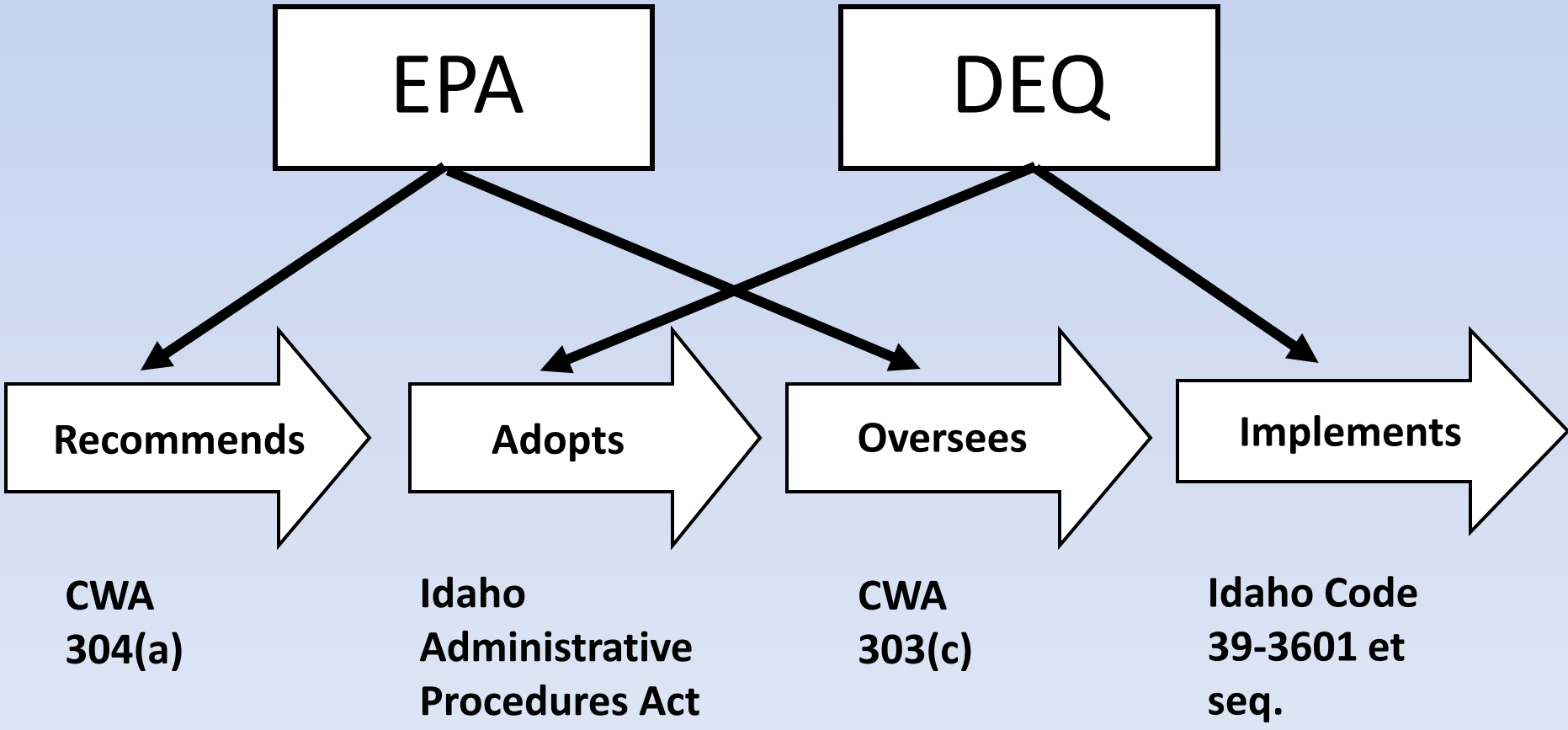
DEQ's policy is to encourage this process, whenever feasible.

Notice of negotiated rulemaking, an invitation for all interested parties to participate.

Final Rules

- Final Rules are effective upon conclusion of the legislative session they are reviewed (unless …)
- Final rules are codified in the Idaho Administrative Code (cited as IDAPA), published annually in July
- But available on the Web sooner …
- State adopted WQS not effective for CWA purposes until EPA approves them

The EPA/DEQ WQS Partnership Flowchart



The best source for rules is on the Web…

http://adm.idaho.gov/adminrules/rules/idapa58/0102.pdf

Cd, Pb, and Zn

- Section 210

A			B Aquatic life			C Human health for consumption of:			
(Number) Compound		[a] CAS Number	[b] CMC (µg/L) B1		[b] CCC (µg/L) B2	Carcinogen?	Water & fish (µg/L) C1		Fish only (µg/L) C2	
1	Antimony	7440360					5.2	c	190	c
2	Arsenic	7440382	340	e	150 e	Y	10	dfq	10	dfq
3	Beryllium	7440417						h		h
4	Cadmium	7440439	1.3	i	0.6 i			h		h
5a	Chromium III	16065831	570	i	74 i			h		h
5b	Chromium VI	18540299	16	e	11 e			h		h
6	Copper	7440508	17	i	11 i		1,300	q		
7	Lead	7439921	65	i	2.5 i			h		h
8a	Mercury	7439976		g	g					
13	Zinc	7440666	120	i	120 i		870	c	1,500	c

A		B Aquatic life			C Human health for consumption of:			
(Number) Compound	[a] CAS Number	[b] CMC (µg/L) B1		[b] CCC (µg/L) B2		Carcinogen?	Water & fish (µg/L) C1		Fish only (µg/L) C2	
1 Antimony	7440360						5.2	c	190	c
2 Arsenic	7440382	340	e	150	e	Y	10	dfq	10	dfq
3 Beryllium	7440417							h		h
4 Cadmium	7440439	1.3	i	0.6	i			h		h
5a Chromium III	16065831	570	i	74	i			h		h
5b Chromium VI	18540299	16	e	11	e			h		h
6 Copper	7440508	17	i	11	i		1,300	q		
7 Lead	7439921	65	i	2.5	i			h		h
8a Mercury	7439976		g		g					
13 Zinc	7440666	120	i	120	i		870	c	1,500	c

i. Aquatic life criteria for these metals are a function of total hardness (mg/L as calcium carbonate), the pollutant's water effect ratio (WER) as defined in Subsection 210.03.c.iii, and multiplied by an appropriate dissolved conversion factor as defined in Subsection 210.02. For comparative purposes only, the example values displayed in this table are shown as dissolved metal and correspond to a total hardness of one hundred (100) mg/L and a water effect ratio of one (1.0).

Cd, Pb, and Zn

- Hardness dependent: criteria determined by an equation, with variables found in Subsection 210.03.c.iii (WER) and Subsection 210.02 (equation)

210.03.c.iii

- Expressed as dissolved metal (0.45µm filter)
- WER: site specific, shall be 1.0 unless otherwise specified in rule

210.02

a. CMC=WER exp{mA[ln(hardness)]+bA} X Acute Conversion Factor. (5-3-03)

b. CCC=WER exp{mc[ln(hardness)]+bc} X Chronic Conversion Factor.

Metal	mA	bA	mc	bc	aAcute Conversion Factor	aChronic Conversion Factor
Arsenic	b	b	b	b	1.0	1.0
Cadmium	0.8367	-3.560	0.6247	-3.344	0.944 see footnote a	0.909
Chromium (III)	0.819	3.7256	0.8190	0.6848	0.316	0.860
Chromium (VI)	b	b	b	b	0.982	0.962
Copper	0.9422	-1.464	0.8545	-1.465	0.960	0.960
Lead	1.273	-1.460	1.273	-4.705	0.791	0.791
Mercury	b	b	b	b	0.85	0.85
Nickel	0.846	2.255	0.8460	0.0584	0.998	0.997
Silver	1.72	-6.52	c	c	0.85	c
Zinc	0.8473	0.884	0.8473	0.884	0.978	0.986

Note to table: The term "exp" represents the base e exponential function.

Footnotes to table:

a. Conversion factors (CF) are from "Stephan, C. E. 1995. Derivation of conversion factors for the calculation of dissolved freshwater aquatic life criteria for metals. U.S. Environmental Protection Agency, Environmental Research Laboratory – Duluth." The conversion factors for cadmium and lead are hardness-dependent and can be calculated for any hardness (see limitations in Subsection 210.03.b.i.) using the following equations. For comparative purposes, the conversion factors for a total hardness of one hundred (100) mg/L are shown in the table. The conversion factor shall not exceed one (1).

Cadmium

Acute: CF=1.136672–[(ln hardness)(0.041838)] NOTE: The cadmium acute criterion equation was derived from dissolved metals toxicity data and thus requires no conversion; this conversion factor may be used to back calculate an equivalent total recoverable concentration.

Chronic: CF=1.101672–[(ln hardness)(0.041838)]

Lead (Acute and Chronic): CF=1.46203–[(ln hardness)(0.145712)

b. Not applicable

c. No chronic criteria are available for silver.

(3-29-10)

$$\boldsymbol{CMC = 1.0e^{\{mA[ln(Hardness)]+(bA)\}} \times ACF}$$

$$\boldsymbol{CCC = 1.0e^{\{mc[ln(Hardness)]+(bc)\}} \times cCF}$$

Cadmium:

$$CMC = 1.0e^{\{0.8367[\ln(Hardness)]+(-3.560)\}} \times 1$$

$$CCC = 1.0e^{\{0.8190[\ln(Hardness)]+(-3.344)\}} \times 0.909$$

*CCC CF is also hardness dependent

*Hardness floor – 10 mg/L calcium carbonate

*Hardness ceiling – 400 mg/L calcium carbonate

$$\boldsymbol{CMC = 1.0e^{\{mA[ln(Hardness)]+(bA)\}} \times ACF}$$

$$\boldsymbol{CCC = 1.0e^{\{mc[ln(Hardness)]+(bc)\}} \times cCF}$$

Lead:

$$CMC = 1.0e^{\{1.273[\ln(Hardness)]+(--1.460)\}} \times 0.791$$

$$CCC = 1.0e^{\{1.273[\ln(Hardness)]+(-4.705)\}} \times 0.791$$

*CMC and CCC CF are also hardness dependent

*Hardness floor – 25 mg/L calcium carbonate

*Hardness ceiling – 400 mg/L calcium carbonate

$$\boldsymbol{CMC = 1.0e^{\{mA[ln(Hardness)]+(bA)\}} \times ACF}$$

$$\boldsymbol{CCC = 1.0e^{\{mc[ln(Hardness)]+(bc)\}} \times cCF}$$

Zinc:

$$CMC = 1.0e^{\{0.8473[\ln(Hardness)]+(0.884)\}} \times 0.978$$

$$CCC = 1.0e^{\{0.8473[\ln(Hardness)]+(0.884)\}} \times 0.986$$

*Hardness floor – 25 mg/L calcium carbonate

*Hardness ceiling – 400 mg/L calcium carbonate

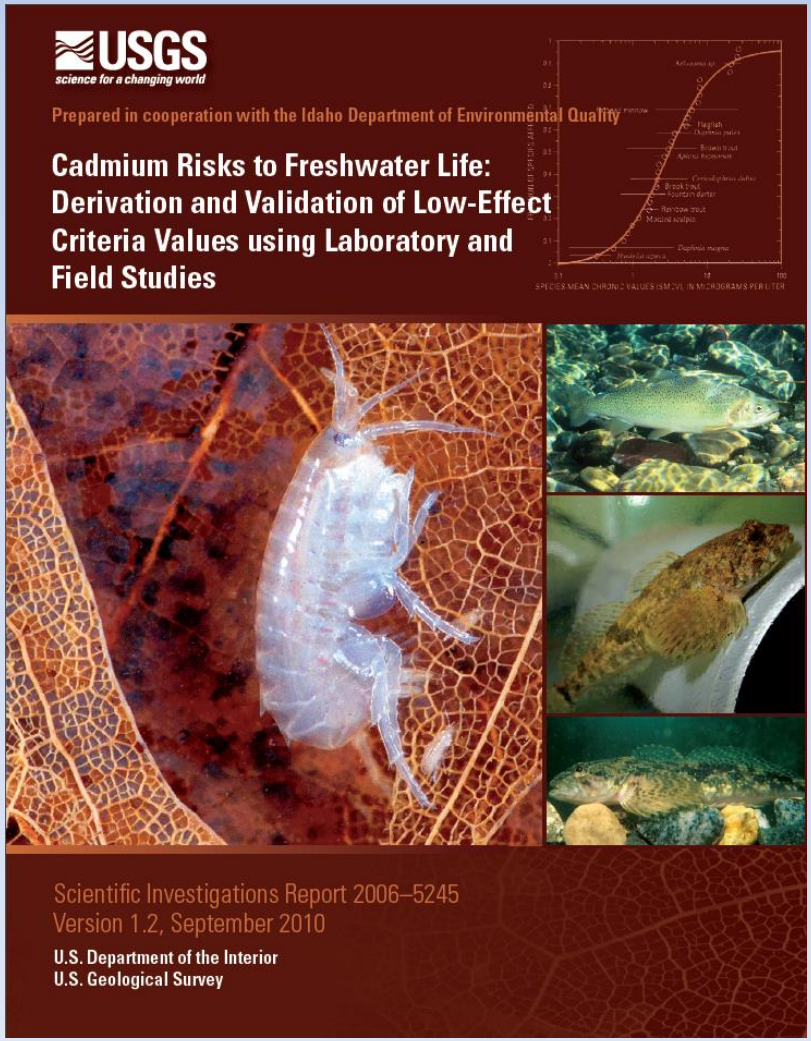
History

- Lead and Zinc: Based on EPA 304(a) criteria
  - Pb: 1980
  - Zn: 1995

History

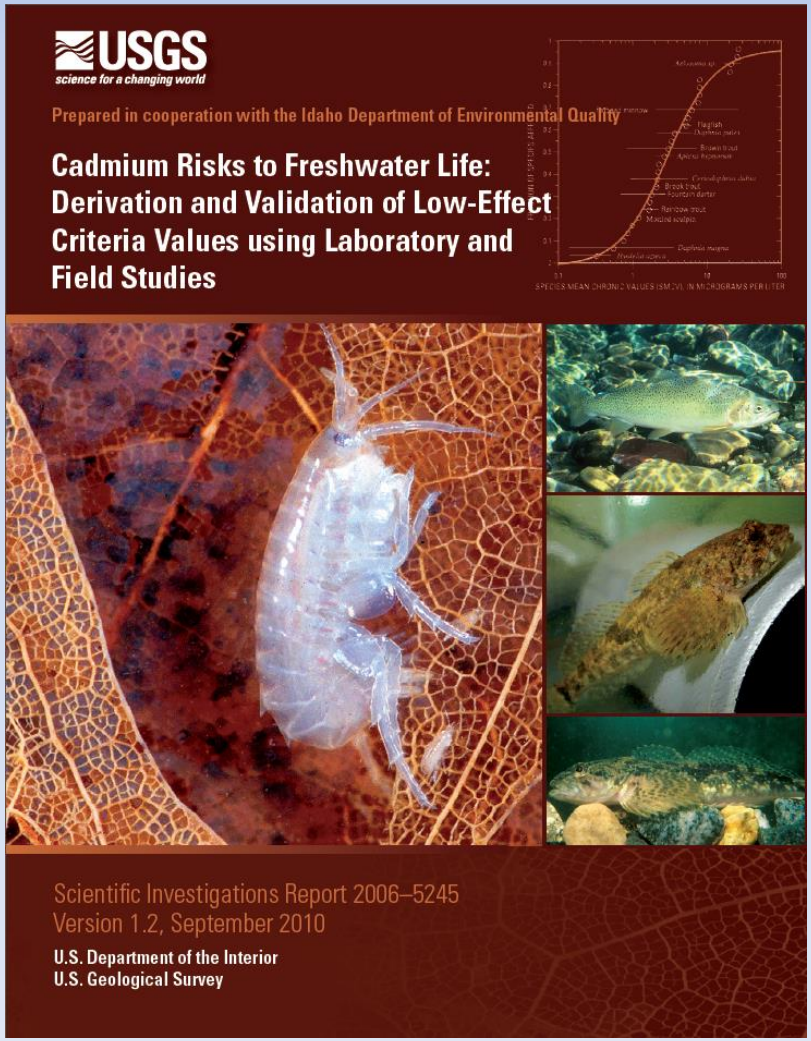
- Cadmium
  - Initiated negotiated rulemaking in 2005
  - Update both Aquatic Life and Human Health
  - Idaho specific – used updated toxicity data
  - Submitted July, 2006

*Did not include change to low-end hardness cap



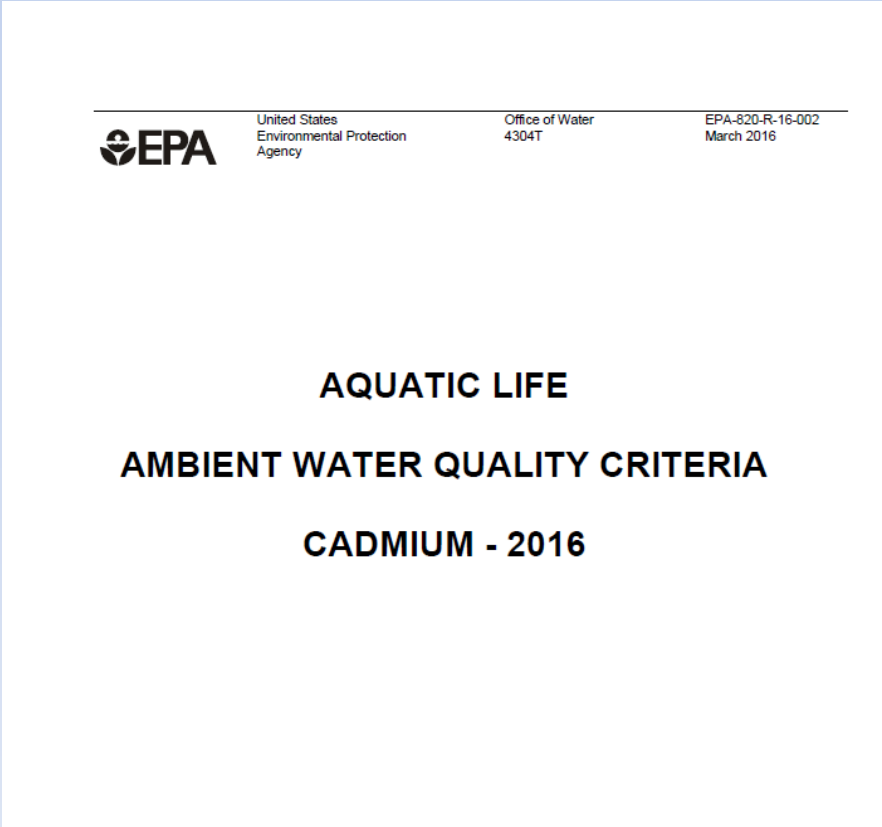
History

- Revision of low-end hardness cap for Cd submitted in 2010
- EPA approved both Cd criteria and low-end hardness cap of 10 µg/L in 2011



New 304(a) for Cd

- Federal Register April 4, 2016


United States Environmental Protection Agency | Office of Water 4304T | EPA-820-R-16-002 March 2016

AQUATIC LIFE

AMBIENT WATER QUALITY CRITERIA

CADMIUM - 2016

Table 1. Summary of 2001 and 2016 Aquatic Life AWQC Recommendations for Dissolved Cadmium.

	2016 AWQC Update[a]		2001 AWQC[a]	
	Acute (1-hour, dissolved Cd)[d]	Chronic (4-day, dissolved Cd)	Acute (1-day, dissolved Cd)	Chronic (4-day, dissolved Cd)
Freshwater (Total Hardness = 100 mg/L as $CaCO_3$)[b]	1.8 µg/L[c]	0.72 µg/L	2.0 µg/L[c]	0.25 µg/L
Estuarine/marine	33 µg/L	7.9 µg/L	40 µg/L	8.8 µg/L

[a] Values are recommended not to be exceeded more than once every three years on average.

[b] Freshwater acute and chronic criteria are hardness-dependent and were normalized to a hardness of 100 mg/L as $CaCO_3$ to allow the presentation of representative criteria values.

[c] Lowered to protect the commercially and recreationally important species (rainbow trout), as per the 1985 Guidelines, Stephan et al. (1985).

[d] The duration of the 2016 acute criteria was changed to 1-hour to reflect the 1985 Guidelines-based recommended acute duration.

	Idaho		EPA 304(a)	
	Acute (µg/L)	Chronic (µg/L)	Acute (µg/L)	Chronic (µg/L)
Cadmium	1.3	0.6	1.8	0.72
Lead	65	2.5	65	2.5
Zinc	120	120	120	120

Cadmium	Idaho WQS uses minimum hardness of 10 mg/L
Lead and Zinc	Idaho WQS uses minimum hardness of 25 mg/L
Cadmium	EPA Cd 304(a) criteria for AL released 4/4/2016

Summary

- Criteria developed based on toxicity studies from multiple organisms
- EPA recommends – 304(a)
- State initiates rulemaking – negotiated
- Final rule – EPA must approve before becomes enforceable for CWA purposes

Questions?

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Site Specific Criteria
South Fork Coeur d'Alene River

284. SOUTH FORK COEUR D'ALENE SUBBASIN, SUBSECTION 110.09, HUC 17010302, AQUATIC LIFE CRITERIA FOR CADMIUM, LEAD AND ZINC.

The following criteria are to be met dependent upon the hardness, expressed as mg/l of calcium carbonate, of the water. Criterion maximum concentrations (CMC), one (1) hour average concentrations, and criterion continuous concentrations (CCC), four (4) day average concentrations, of the dissolved metals (in µg/l) are not to exceed, more than once every three (3) years, the values calculated using the following equations: (3-15-02)

01. Cadmium. (3-15-02)

a. $CMC = 0.973 \times e^{[(1.0166 \times \ln(\text{hardness})) - 3.924]}$ (3-15-02)

b. $CCC = [1.101672 - (\ln(\text{hardness}) \times 0.041838] \times e^{[(0.7852 \times \ln(\text{hardness})) - 3.490]}$ (3-15-02)

02. Lead. (3-15-02)

a. $CMC = e^{[(0.9402 \times \ln(\text{hardness})) + 1.1834]}$ (3-15-02)

b. $CCC = e^{[(0.9402 \times \ln(\text{hardness})) - 0.9875]}$ (3-15-02)

03. Zinc. (3-15-02)

a. $CMC = e^{[(0.6624 \times \ln(\text{hardness})) + 2.2235]}$ (3-15-02)

b. $CCC = e^{[(0.6624 \times \ln(\text{hardness})) + 2.2235]}$ (3-15-02)

04. Application. (3-15-02)

a. The maximum hardness allowed for use in the equations in Section 284 shall not be greater than four hundred (400) mg/l even if the actual ambient hardness is greater than four hundred (400) mg/l. (3-15-02)

b. The criteria described in Section 284 apply to all surface waters within the subbasin, except for natural lakes, for which the statewide criteria given in Section 210 apply. (3-25-16)

Site Specific Criteria
Boise River

02. Boise River, SW-5 and SW-11a -- Copper and Lead Aquatic Life Criteria. The water-effect ratio (WER) values used in the equations in Subsection 210.02 for calculating copper and lead CMC and CCC values shall be two and five hundred seventy-eight thousandths (2.578) for dissolved copper and two and forty-nine thousandths (2.049) for lead. These site-specific criteria shall apply to the Boise River from the Lander St. wastewater outfall to where the channels of the Boise River become fully mixed downstream of Eagle Island.

(5-3-03)