To: 'Suplee, Mike'[msuplee@mt.gov]
From: Laidlaw, Tina
Sent: Fri 3/15/2013 8:11:09 PM
Subject: main ppt
NNCderivation_MTDEQ.pptx

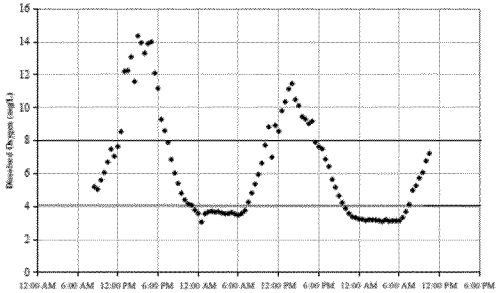
;

Process by which MT DEQ Derives Numeric Nutrient Criteria for Wadeable Streams, 2012

Michael Suplee, PhD
Water Quality Standards
MT Dept. of Environmental Quality

EPA Region VIII States and Tribes Meeting-RTAG
Cheyenne, WY
October 18, 2012

Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers



Prepared By

Michael Suplee, Ph.D. — Montana Department of Environmental Quality
Vicki Watson, Ph.D. — University of Montana
Arun Varghese and Josh Cleland — ICF International

November 2008

Montana Department of Environmental Quality

Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers: Addendum 1

DRAFT

May 2012

Prepared by:
Water Quality Planning Bureau, Standards Section
Montana Department of Environmental Quality
Water Quality Planning Bureau
1520 E. Sixth Avenue
P.O. Box 200901
Helena, MT 59620-0901

WQPBWQSTR-002

Basic Approach

- Use dose-response studies, reference site nutrient concentrations, and scientific principles (e.g., Redfield Ratio) in tandem to derive appropriate criteria for streams at a regional scale

- Develop reach specific criteria where needed

MT Nutrient Criteria: 2008

1. Reviewed regional stressor-response studies for applicable ecoregions
2. Reviewed studies from outside the region
3. Compared nutrient concentrations from 1, 2 to reference site data (used all available data)
4. Criteria set at:

- 90th percentile of reference in mountains
- 75th percentile of reference in plains

Pros/Cons with 2008 Approach

- Pros:
  - Straightforward/transparent, easy to explain to stakeholders
  - same process across large areas (equitable)
- Cons:
  - Removed flexibility to consider each ecoregion individually (which is the point)
  - Resulted in too stringent concentrations in some areas, un-protective ones in others

Numeric Nutrient Criteria Recommendations for TN, TP, 2008

Table E1. Recommended Numeric Nutrient and Benthic Algae Criteria for Different E

Level III Ecoregion	Period When Criteria Apply	Nutrient Criteria Total P (mg/L)	Nutrient Criteria Total N (mg/L)
Northern Rockies	July 1 -Sept. 30	0.012	0.233
Canadian Rockies	July 1 -Sept. 30	0.006	0.209
Middle Rockies	July 1 -Sept. 30	0.048	0.320
Idaho Batholith	July 1 -Sept. 30	0.011	0.130
Northwestern Glaciated Plains	June 16-Sept. 30	0.123	1.311
Northwestern Great Plains, Wyoming Basin	July 1 -Sept. 30	0.124	1.358

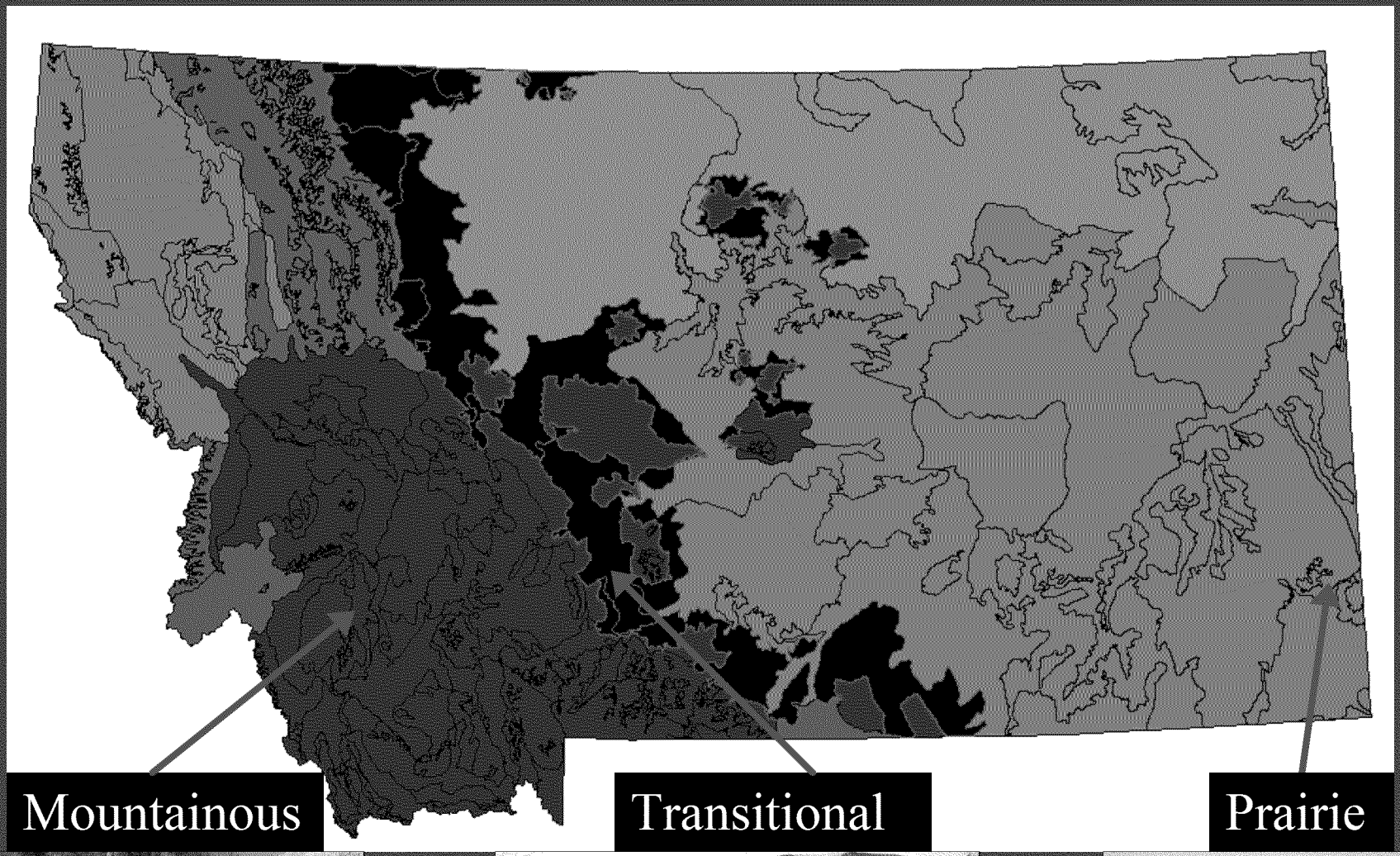
MT Nutrient Criteria: 2012

1. Developed criteria for statistically different level IV ecoregions, and transitional level IVs
2. Reviewed stressor-response studies for applicable ecoregions, & studies outside region

>Endpoints included DO, benthic algae, warm-water fish metrics, macroinvertebrates, y-intercept modeling

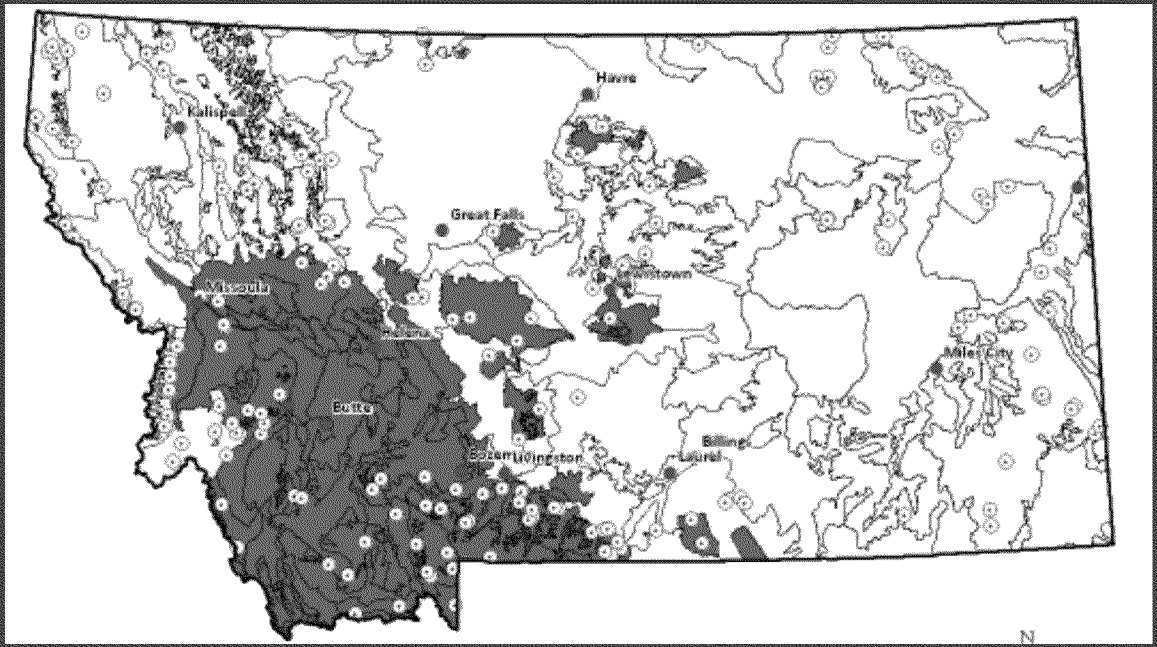
3. Within conc. range provided by 1 & 2, selected value — emphasis on regional studies
4. N:P ratio of criteria set to match reference streams
5. Documented where within reference distribution each criterion falls

> Evenness Index used to compile ecoregional TP and TN dataset in which each reference site provides equal information


Mountainous
Transitional
Prairie

0015569

The Middle Rockies Ecoregion (Level III)



Recommended Numeric Criteria

Total Phosphorus: **30 µg TP/L**
Total Nitrogen: **300 µg TN/L**

N:P Ratio of Criteria: **10:1**
N:P Ratio of Reference Sites: **10:1** (Redfield N:P ratio = 7:1)

Descriptive Statistics of Regional Reference Sites

Table 3-1. Descriptive Statistics for TN and TP concentrations in Reference Streams of the Middle Rockies ecoregion.

			Nutrient Concentration (µg/L)					
					Conc. at given Percentile			
Nutrient	Number of Reference Sites	Number of Samples	Min	Max	25th	(Median)50th	75th	90th
TN	57	148	3	9580	55	95	141	220
TP	61	245	0.5	840	6	10	20	70

The 30 µg TP/L criterion matches to the 80th percentile of reference.
The 300 µg TN/L criterion matches to the 93th percentile of reference.

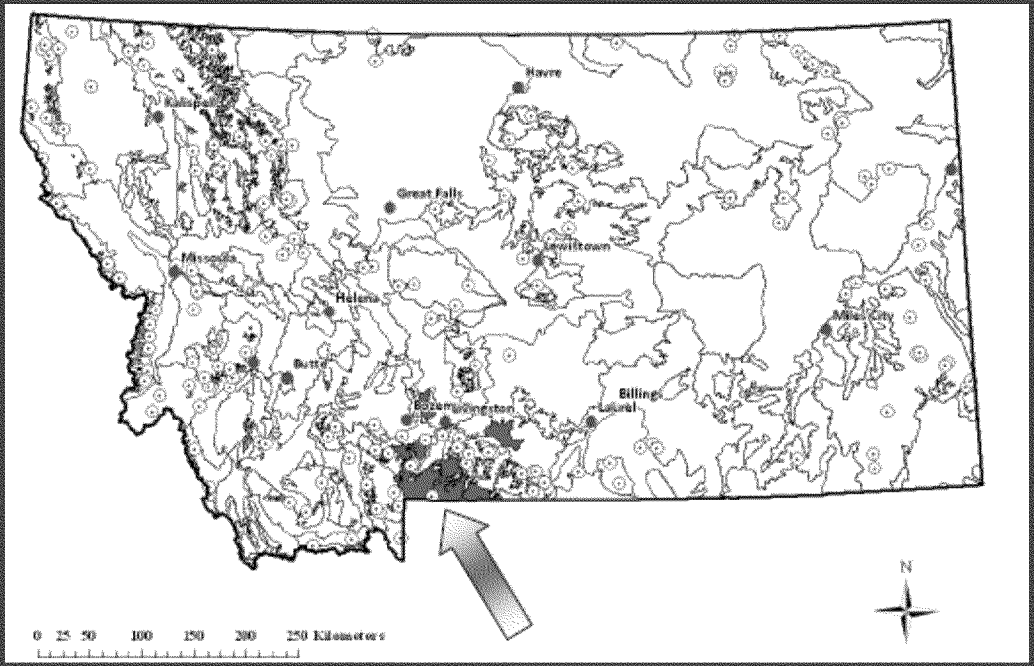
0015570

Key Studies:

A. Clark Fork River algae-nutrient relationships (Dodds et al. 1997, Suplee et al. 2009 and 2012

B. Idaho nutrient diffuser study in wadeable streams (Mebane 2009)

The Absaroka-Gallatin Volcanic Mountains Ecoregion (Level IV)



Recommended Numeric Criteria

Total Phosphorus: **105 µg TP/L**

Total Nitrogen: **250 µg TN/L**

N:P Ratio of Criteria: **2:1**

N:P Ratio of Reference Sites: **1:1** (Redfield N:P ratio = 7:1)

Descriptive Statistics of Regional Reference Sites

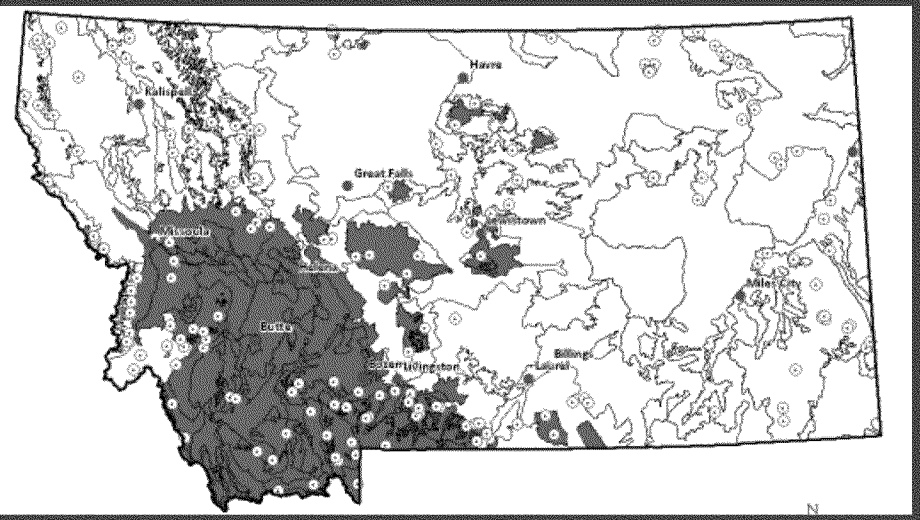
Table 3-2. Descriptive Statistics for TN and TP concentrations in Reference Streams of the Absaroka-Gallatin Volcanic Mountains (17i) ecoregion.

			Nutrient Concentration (µg/L)					
					Conc. at given Percentile			
Nutrient	Number of Reference Sites	Number of Samples	Min	Max	25th	(Median)50th	75th	90th
TN	4	13	7	181	52	80	100	163
TP	4	16	16	144	61	81	105	127

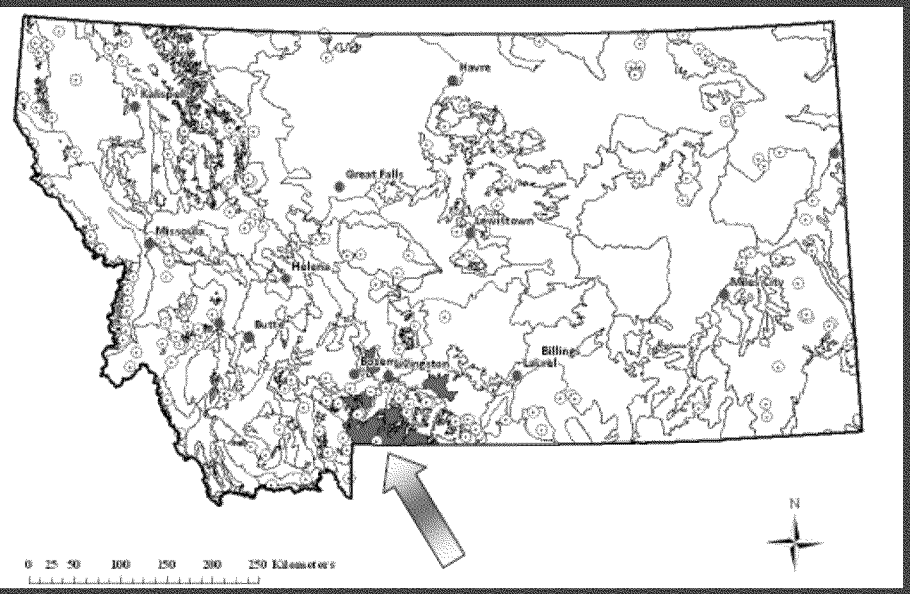
The 105 µg TP/L criterion matches to the 75th percentile of reference.

The 250 µg TN/L criterion is greater than the 100th percentile of reference.

Reach Specific Criteria



Middle Rockies TP Criterion:
30 µg/L

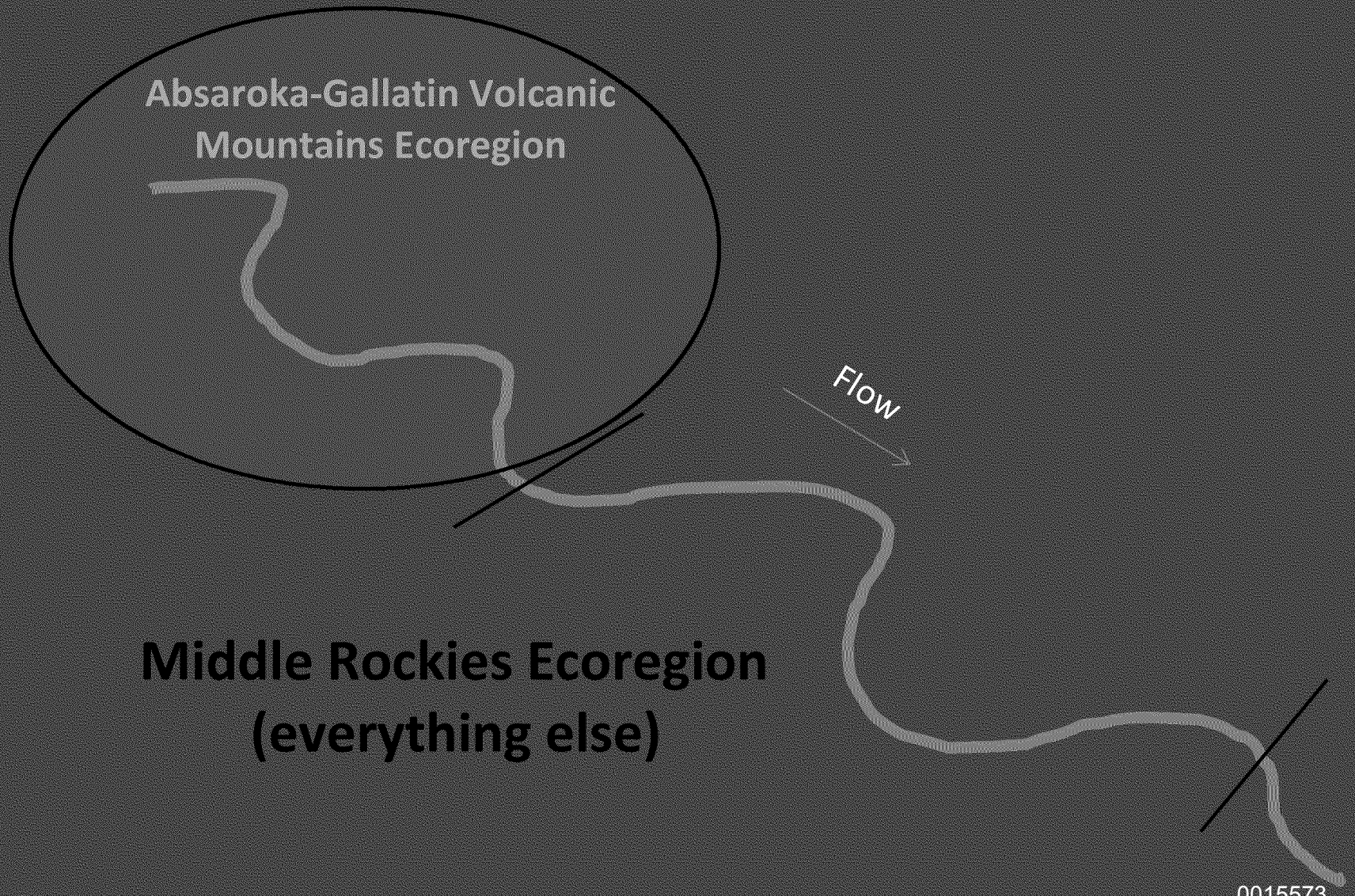


Absaroka-Gallatin Volcanic Mountains (in Middle Rockies) TP Criterion:
105 µg/L

How to set criteria for streams flowing from Absaroka-Gallatins to the Middle Rockies?

0015572

Reach Specific Criteria-Example



Reach Specific Criteria

Not undertaken for all cases; as-need basis (e.g., WWTP on reach)

$$\text{Reach-specific for reference } (\mu g/L) = \frac{(Conc_1 * Q_1) + (Conc_2 * Q_2)}{Q_1 + Q_2}$$

Where:

$Conc_1$ = Level IV ecoregion nutrient conc. (µg/L), 75th percentile of reference

$Conc_2$ = Level III ecoregion nutrient conc. (µg/L), 75th percentile of reference

Q1, Q2 are average summer flows (L/sec) that can be allocated to the respective ecoregions

Reach Specific Criteria

Reach-specific for reference (µg/L) =

$$\frac{(Conc_1 * Q_1) + (Conc_2 * Q_2)}{Q_1 + Q_2}$$

Where:

$Conc_1$ = Level IV ecoregion nutrient conc. (µg/L), 75th percentile of reference

$Conc_2$ = Level III ecoregion nutrient conc. (µg/L), 75th percentile of reference

Q1, Q2 are average summer flows (L/sec) that can be allocated to the respective ecoregions

If the reach specific value based on reference is ≥ the nutrient criterion established for the ecoregion in which the stream resides, a reach-specific criterion is developed

Reach Specific Criteria-Example*

75th percentile of Absaroka Gallatin Volcanic Mountains

75th percentile of Middle Rockies

Reference-condition value exceeds Middle Rockies criterion of 30 µg/L

([105 µg TP/L * 833 L/sec] + [20 µg TP/L * 481 L/sec]) ÷ (833 + 481 L/sec) = 74 µg TP/L

A reach-specific criterion was then calculated for TP using the ecoregional numeric criteria:

([105 µg TP/L * 833 L/sec] + [30 µg TP/L * 481 L/sec]) ÷ (833 + 481 L/sec) = 76 µg TP/L

There was good support for this approach by all three academic peer reviewers of our 2012 document

0015576

*Bozeman Creek, from Forest Service Boundary to mouth at the E. Gallatin River

Deriving the Critical Low Flow for Permitting Numeric Nutrient Criteria

- Duration & frequency integral parts of the critical low flow:
- For toxics, 7Q10 commonly used: lowest average 7 consecutive day low flow, occurring with an average recurrence frequency of once in ten years

7Q10

Duration Frequency

For nutrients, went back to the drawing board to evaluate duration and frequency to assure basis would be correct

Deriving the Critical Low Flow for Permitting Numeric Nutrient Criteria

- Basis found in EPA (1985)* and in the TSD (EPA, 1991)
  - 7Q10 was found to be a rough hydrologic surrogate for the biologically based 4 day, once in three years recommendation from EPA (1985)

- EPA (1985) clear about the recovery period of aquatic life after a chronic exceedence:

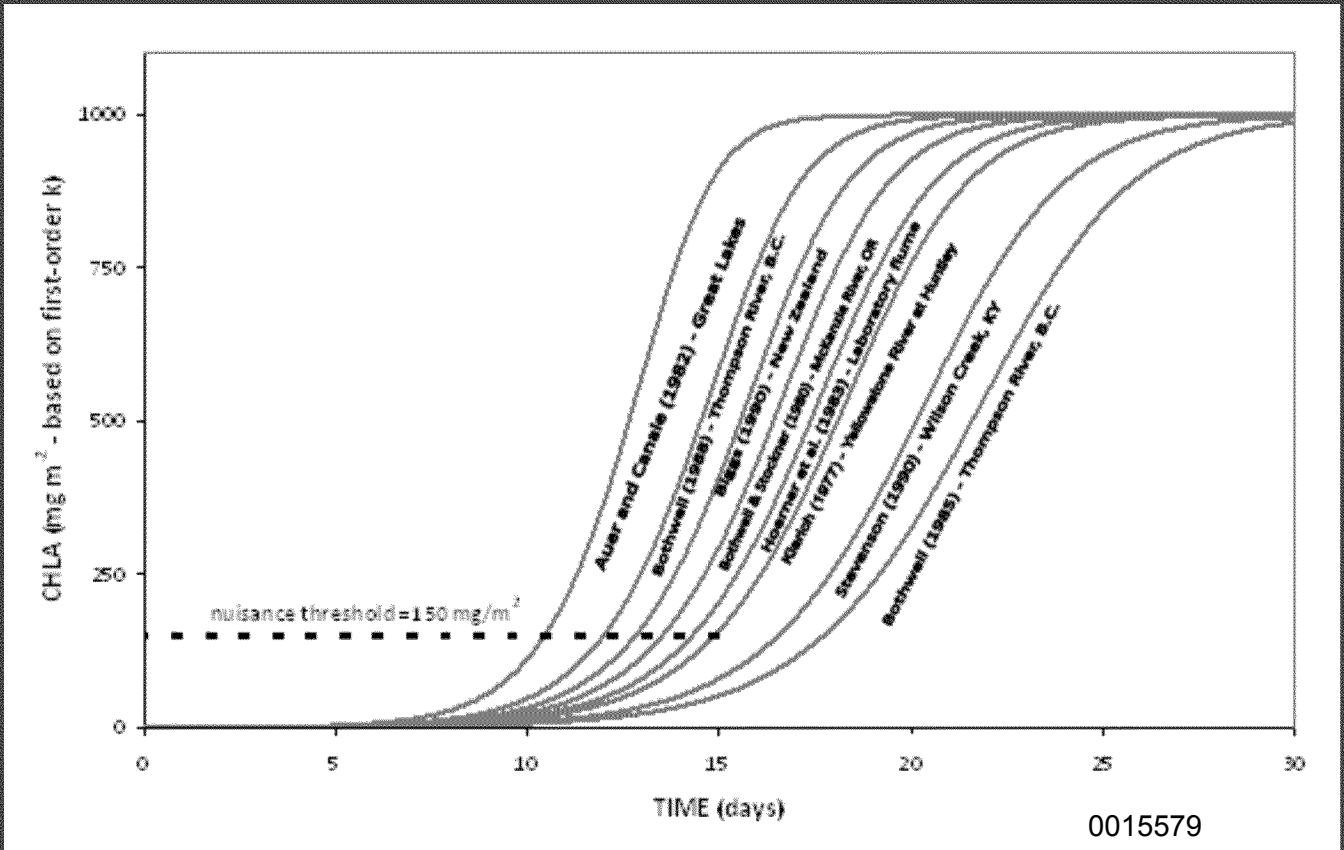
"Most aquatic ecosystems can probably recover from most exceedences in about three years. Therefore, it does not seem reasonable to purposely design for stress above that caused by the CCC to occur more than once in every three years, on the average, just as it does not seem reasonable to require that these kind of stresses only occur once in every five or ten years on the average."

*EPA, 1985. *Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses*

Deriving the Critical Low Flow for Permitting Numeric Nutrient Criteria — Duration

- 150 mg Chl*a*/m^2 is a thresholds for aesthetic impacts as well as aquatic life impacts (links via DO, etc.)

Benthic algae growth rates (K, day^{-1}) compiled from the literature, normalized to 20 C, and modeled



0015579

ALSO: In DEQ's stream dosing study, peak algal biomass occurred ≤ 20 days after dosing started

Deriving the Critical Low Flow for Permitting Numeric Nutrient Criteria—Duration

- Based on modeling of literature values and first-hand experience with the nutrient dosing study, MT DEQ believes that a duration of about 14 days is the appropriate duration to prevent stream algae from reaching 150 mg Chl*a*/m^2
  - Durations longer than this would lead to the development of benthic algae growth beyond the desired level

Deriving the Critical Low Flow for Permitting Numeric Nutrient Criteria—Frequency

"Most aquatic ecosystems can probably recover from most exceedences in about three years. Therefore, it does not seem reasonable to purposely design for stress above that caused by the CCC to occur more than once in every three years, on the average, just as it does not seem reasonable to require that these kind of stresses only occur once in every five or ten years on the average."

- MT DEQ selected a recurrence frequency of 5 years, because:
  - Slightly lower flow than the 3 year reoccurrence interval, thus somewhat more protective
  - 14 day, 5 year reoccurrence for season flows (July-Oct) routinely reported by USGS — readily available to Permitting

Thank You

Box Elder Creek Aug 29, 2010, 20 days after N and P dosing was initiated