NEIWPCC

# Chemical Phosphorus Removal With Aluminum Sulfate or Poly-aluminum Chloride and Impacts to Aluminum Criteria

Richard K. Friesner, Ph.D.
New England Interstate Water Pollution Control Commission

2017 ACWA Nutrients Permitting Workshop

# We are NEIWPCC

A community of problem solvers advancing clean water in the Northeast, in service to the states and the people.

Our mission includes:

- Research and Monitoring
- Outreach and Education
- Training and Supporting Environmental Professionals
- Representing the Region in Matters of Federal Policy

# Problem Statement

- Phosphorus removal necessary to prevent eutrophication in surface water.
- Removal can accomplished by:
  - chemical precipitation and sedimentation
  - enhanced biological uptake
- Here we will focus on chemical removal using aluminum compounds.
  - Aluminum Sulfate - Alum: $Al_2(SO4)_3$
  - Aluminum Chloride: $AlCl_3$

# Problem Statement - continued

- 2017 Draft Aquatic Life Criteria & 1998 Criteria:

**Table 1: 2017 Draft Aluminum Aquatic Life Criteria Compared to Current 1988 Criteria[a]**

| Version | Freshwater Acute (1 day, total aluminum) | Freshwater Chronic (4-day, total aluminum) |
|---|---|---|
| 2017 Draft AWQC Criteria (MLR normalized to pH = 7, hardness = 100 mg/L, DOC = 1 mg/L) | 1,400 µg/L | 390 µg/L |
| 1988 AWQC Criteria (pH 6.5 – 9.0, across all hardness and DOC ranges) | 750 µg/L | 87 µg/L |

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

Note: Values will be different under differing water chemistry conditions as identified in this document.

# Problem Statement - continued

- 2017 Draft Aquatic Life Criteria & 1998 Criteria:

**Table 1: 2017 Draft Aluminum Aquatic Life Criteria Compared to Current 1988 Criteria[a]**

| Version | Freshwater Acute (1 day, total aluminum) | Freshwater Chronic (4-day, total aluminum) |
|---|---|---|
| 2017 Draft AWQC Criteria (MLR normalized to pH = 7, hardness = 100 mg/L, DOC = 1 mg/L) | 1,400 µg/L | 390 µg/L |
| 1988 AWQC Criteria (pH 6.5 – 9.0, across all hardness and DOC ranges) | 750 µg/L | 87 µg/L |

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

Note: Values will be different under differing water chemistry conditions as identified in this document.

| Contaminant | In Water As | Secondary Maximum Contaminant Level |
|---|---|---|
| **Aluminum (Al)** | $Al^{3+}$<br>$Al(OH)_3$ | **US EPA** SMCL* = 0.05 to 0.2 mg/L<br>**WHO† Guideline** = 0.1 to 0.2 mg/L<br>**Health Canada** OG** = 0.1 to 0.2 mg/L |

# Problem Statement - continued

- 2017 Draft Aquatic Life Criteria & 1998 Criteria:

**Table 1: 2017 Draft Aluminum Aquatic Life Criteria Compared to Current 1988 Criteria[a]**

| Version | Freshwater Acute (1 day, total aluminum) | Freshwater Chronic (4-day, total aluminum) |
|---|---|---|
| 2017 Draft AWQC Criteria (MLR normalized to pH = 7, hardness = 100 mg/L, DOC = 1 mg/L) | 1,400 µg/L | 390 µg/L |
| 1988 AWQC Criteria (pH 6.5 – 9.0, across all hardness and DOC ranges) | 750 µg/L | 87 µg/L |

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

Note: Values will be different under differing water chemistry conditions as identified in this document.

| Contaminant | In Water As | Secondary Maximum Contaminant Level |
|---|---|---|
| **Aluminum (Al)** | $Al^{3+}$<br>$Al(OH)_3$ | **US EPA** SMCL* = 0.05 to 0.2 mg/L **50-200 ug/L**<br>**WHO† Guideline** = 0.1 to 0.2 mg/L<br>**Health Canada** OG** = 0.1 to 0.2 mg/L |

# Problem Statement - continued

- 2017 Draft Aquatic Life Criteria & 1998 Criteria:

**Table 1: 2017 Draft Aluminum Aquatic Life Criteria Compared to Current 1988 Criteria[a]**

| Version | Freshwater Acute (1 day, total aluminum) | Freshwater Chronic (4-day, total aluminum) |
|---|---|---|
| 2017 Draft AWQC Criteria (MLR normalized to pH = 7, hardness = 100 mg/L, DOC = 1 mg/L) | 1,400 µg/L | 390 µg/L |
| 1988 AWQC Criteria (pH 6.5 – 9.0, across all hardness and DOC ranges) | 750 µg/L | 87 µg/L |

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

Note: Values will be different under differing water chemistry conditions as identified in this document.

Some high quality waters contain more than 87ug/L

# Aluminum

$Al^{3+} + H_nPO_4^{3-n} \leftrightarrow AlPO_4 + nH^+$

1:1 molar ratio, but in reality usage is 9.59 lbs Alum / 1lb P.

# Phosphorus or Aluminum that is the question

Which rules?

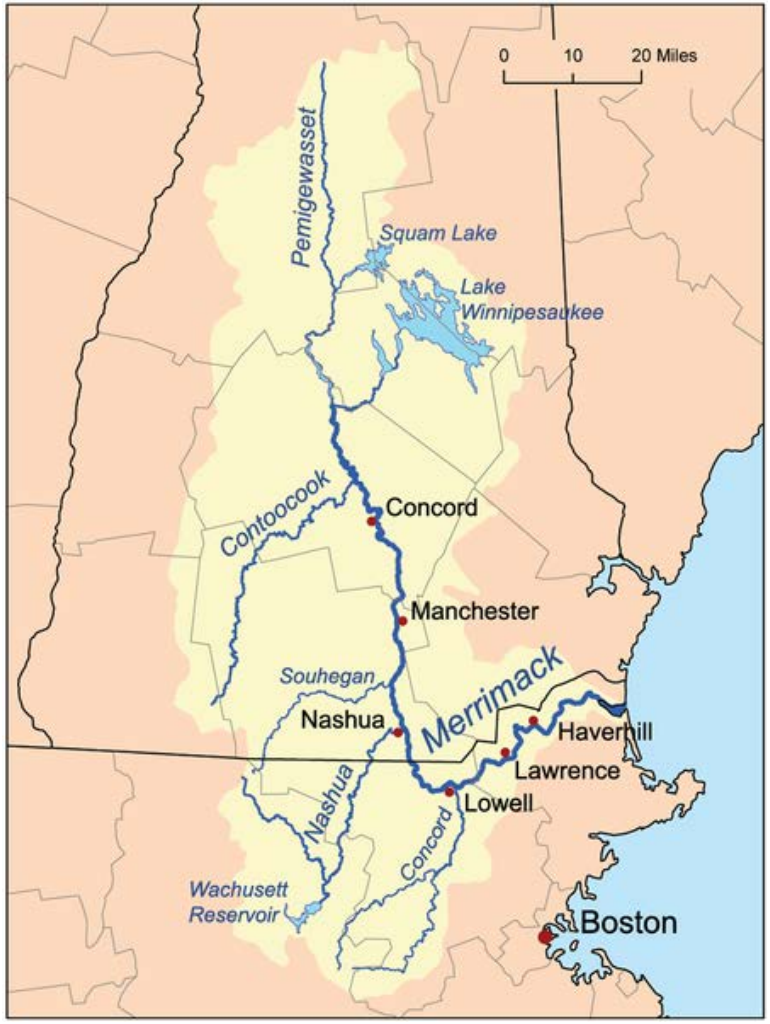
# How does a municipality comply?

- Spend lots of $$$ to remove aluminum
- Appeal permit
- Use alternative coagulants
- Look to develop an alternative

# City of Manchester, NH
# $Al^{3+}$ Study - 2011

- **WWTP Background**
  - 1975 - 26 mgd (original)
  - 1994 - 34 mgd (upgrade)
  - 1999 – 83 mgd (CSO bypass)
  - 60% combined system
  - Discharge to Merrimack River

# Merrimack River Drainage Basin




## Merrimack River Drainage Basin

- Pemigewasset & Winnipesaukee Rivers, headwaters
- 78 miles in NH
- 50 miles in MA
- 5,000 sq mile watershed

# WET Toxicity Testing Report Results for Aluminum

| Year 2005 | Effluent Al | River Al | Difference |
|---|---|---|---|
| 1st QTR 2005 | 100 ppb | 110 ppb | 10 ppb – higher upstream |
| 2nd QTR 2005 | 19 ppb | 34 ppb | 15 ppb – higher upstream |
| 3rd QTR 2005 | <10 ppb | 54 ppb | 44 ppb – higher upstream |
| 4th QTR 2005 | 74 ppb | 210 ppb | 136 ppb–higher upstream |

# WET Toxicity Testing Report Results for Aluminum

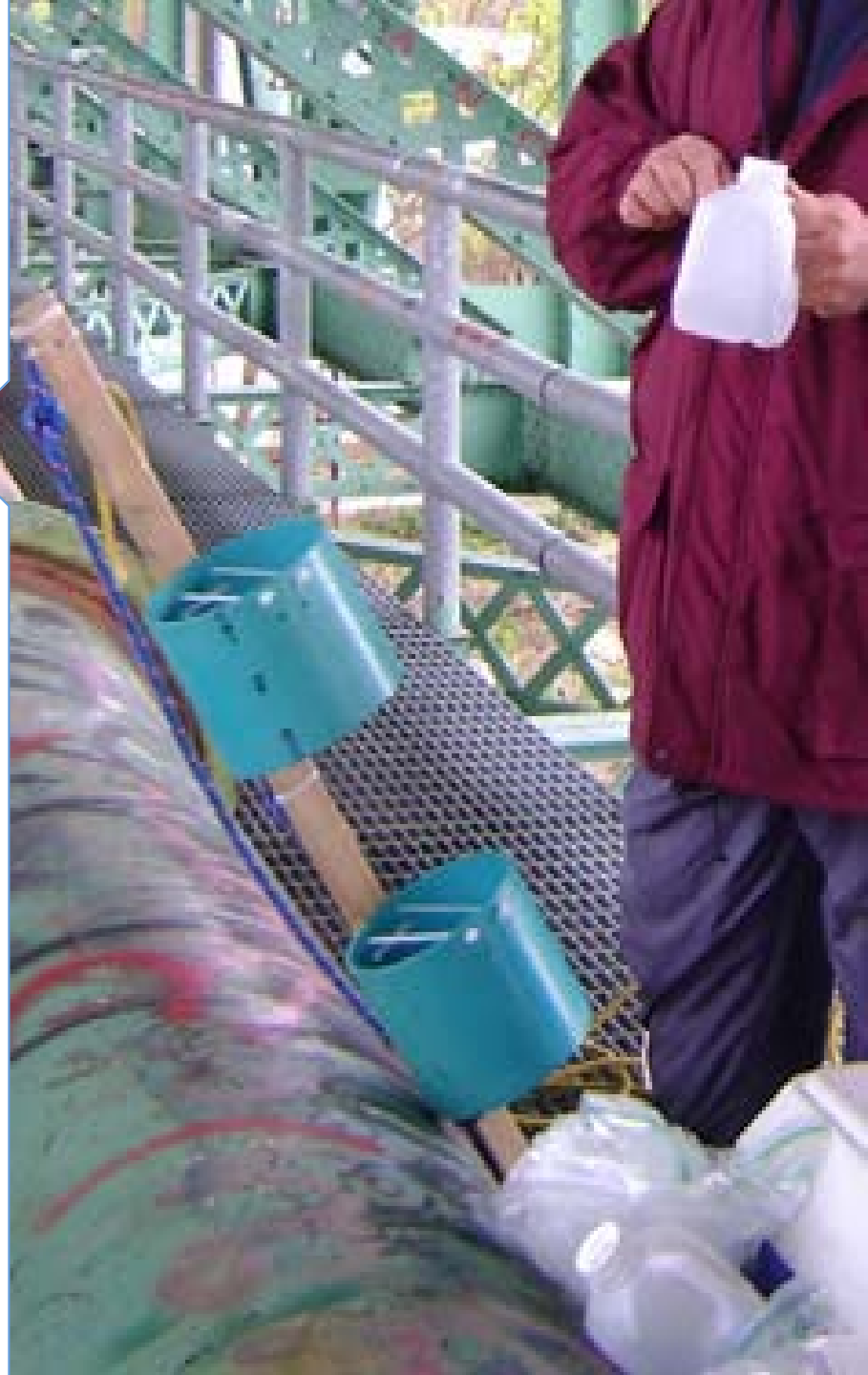
| Year 2006 | Effluent Al | River Al | Difference |
|---|---|---|---|
| 1st QTR 2006 | 97 ppb | 320 ppb | 223 ppb – higher upstream |
| 2nd QTR 2006 | 110 ppb | 290 ppb | 180 ppb – higher upstream |
| 3rd QTR 2006 | 510 ppb | <10 ppb | 500 ppb - higher effluent |
| 4th QTR 2006 | <10 ppb | 460 ppb | 450 ppb – higher upstream |

# Historical WET Findings

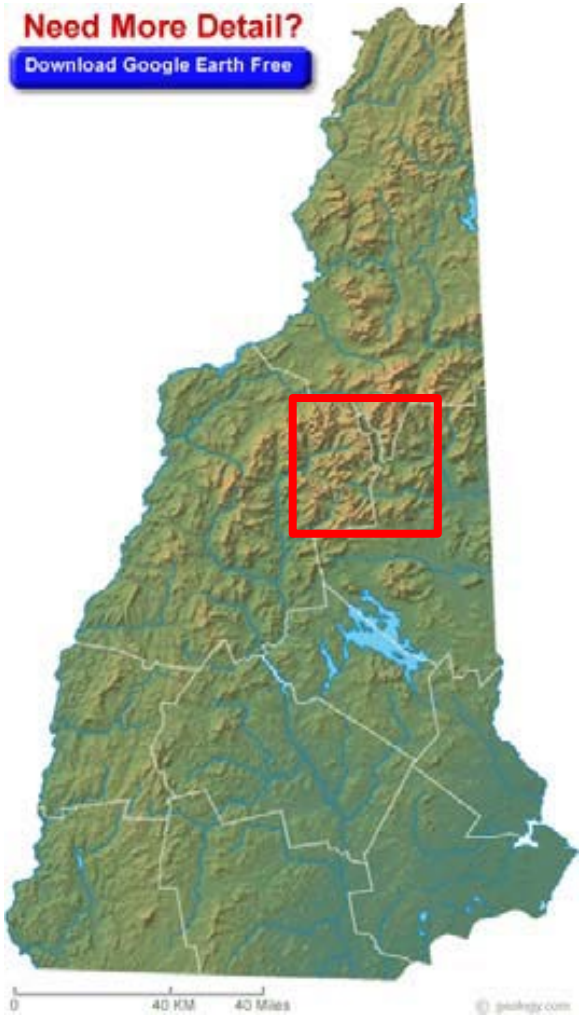
- More Aluminum in river than effluent
- Significantly higher at times
- Alum used in WTPs
- source water contribution

## Sampling Program

- Start June 2009
- End May 2010
- Captured seasonal cycle
- Logged cfs & rain
- 500 tests for ASA, pH, conductivity & turbidity
- 100 tests for TDS, hardness & TRA



# Feeder Ponds in White Mts Aluminum Contribution




- 7% of samples below 50 ug/l
- 93% of samples between 100 ug/l and 300 ug/l
- No Stormwater, or human activity
- “Natural Occurrence”

# Feeder Ponds Aluminum Concentration

- 303(d) impaired list includes aluminum
- Reason is ‘Natural Occurrence’
- This condition exists in most feeder brooks north of Franklin, NH

# Report Findings

- $Al^{3+}$ highest in feeder ponds
- $Al^{3+}$ concentration dilutes out in travel down river
- $Al^{3+}$ concentration higher above WWTP outfall
- WWTP effluent dilutes $Al^{3+}$ concentration by 3%
- $Al^{3+}$ concentration is directly proportional to 7Q10
    - Lower cfs = lower $Al^{3+}$

# Presentation Summary

- WWTP's can do anything with appropriate resources
  - But as an industry do we have the $?
- WWTPs cannot "just" change their process
  - Consider implications of:
    - Cost
    - Time to completion
    - O&M
    - Tim to the next permit

NEIWPCC

Richard Friesner, Ph.D.
www.neiwpcc.org
rfriesner@neiwpcc.org
(978) 349-2506

# Lake Winnipesaukee!!!