Cyanobacteria Product Solutions: Alum

Lake Lawerence, WA

John Holz, PhD
Senior Limnologist

SOLITUDE LAKE MANAGEMENT

Restoring Balance. Enhancing Beauty.

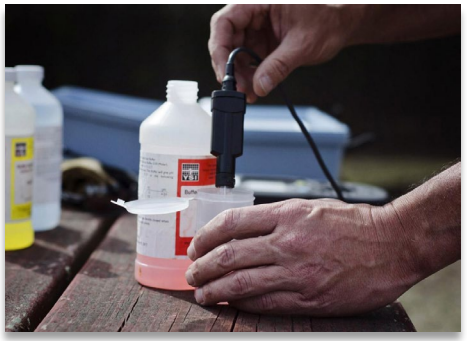
SOLitude Lake Management

- Largest & most comprehensive lake management company since 1998
- 500+ employees in 32 states
- Services include all aspects of lake management
    - Planning, Water Testing, Algae & Weed Control, Aeration & Fountains, Shoreline Erosion, Sediment Removal, Fisheries Management, Wetland Management, Mapping, Invasive Species Control, Mosquito & Midge Control, and **Nutrient Inactivation**
- Unparalleled expertise and state-of-the-art equipment

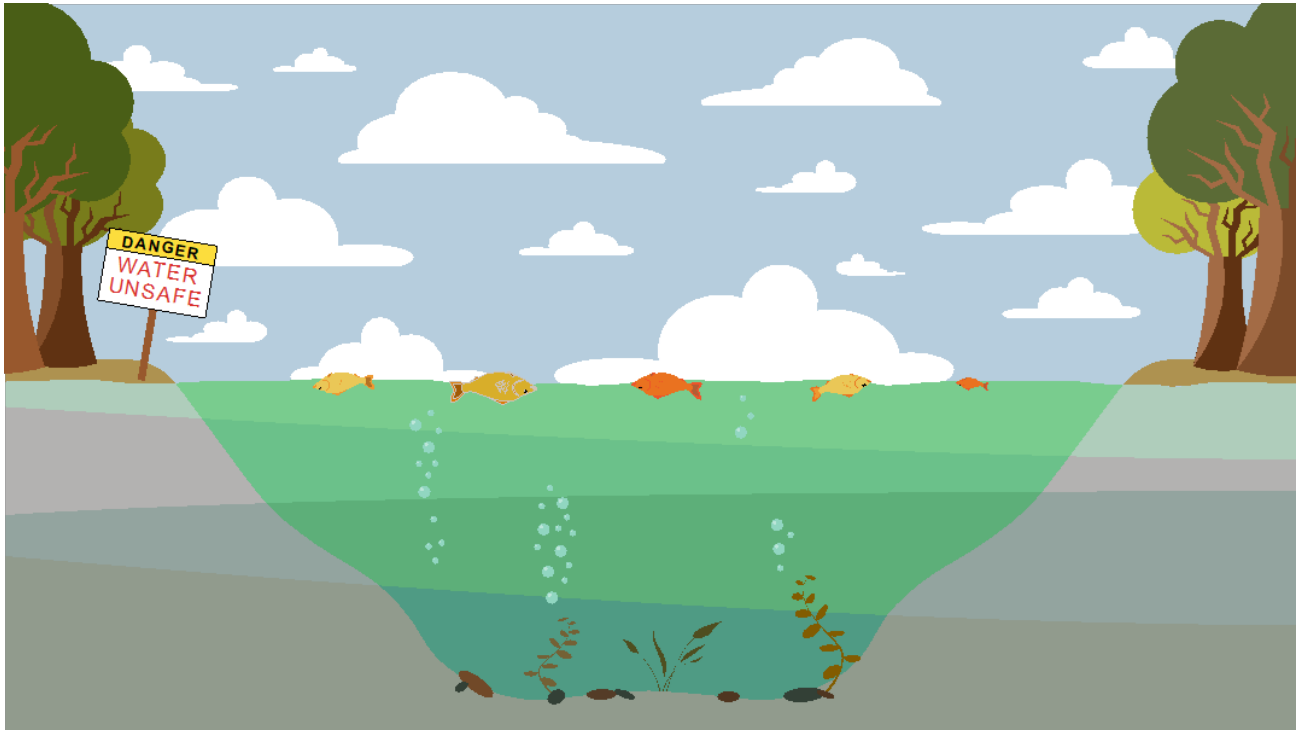



Dr. John Holz

- PhD in Aquatic Ecology/Lake Management; former University Professor & Business Owner
- Senior Limnologist leading SOLitude's Nutrient Inactivation/Alum Services Division
- 30+ years experience, including 300+ nutrient inactivation/alum projects across the US & 18+ million gallons of alum applied
- Technical advisor to EPA on water quality & policy
- North American Lake Management Society: Board of Directors, Best Symposium Presentation Award, Technical Excellence Award, Corporation of the Year Award




The Problem: Poor Water Quality



✓ Poor water quality in lakes has many symptoms, most of which are associated with *excessive algal growth.*

The Symptoms

✓ Excessive Algae

✓ Algal Toxins

✓ Low clarity

✓ Odors

✓ Low Oxygen

The Symptoms

- ✓ Potential Fish Kills
- ✓ Reduced Recreational Value
- ✓ Reduced Property Values

The Cause: Phosphorus

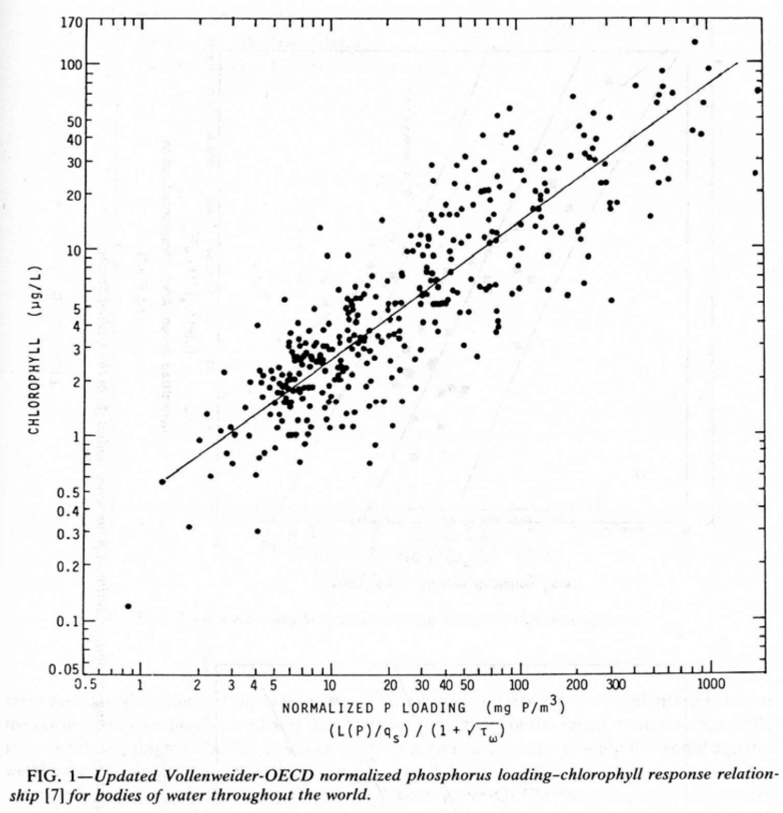
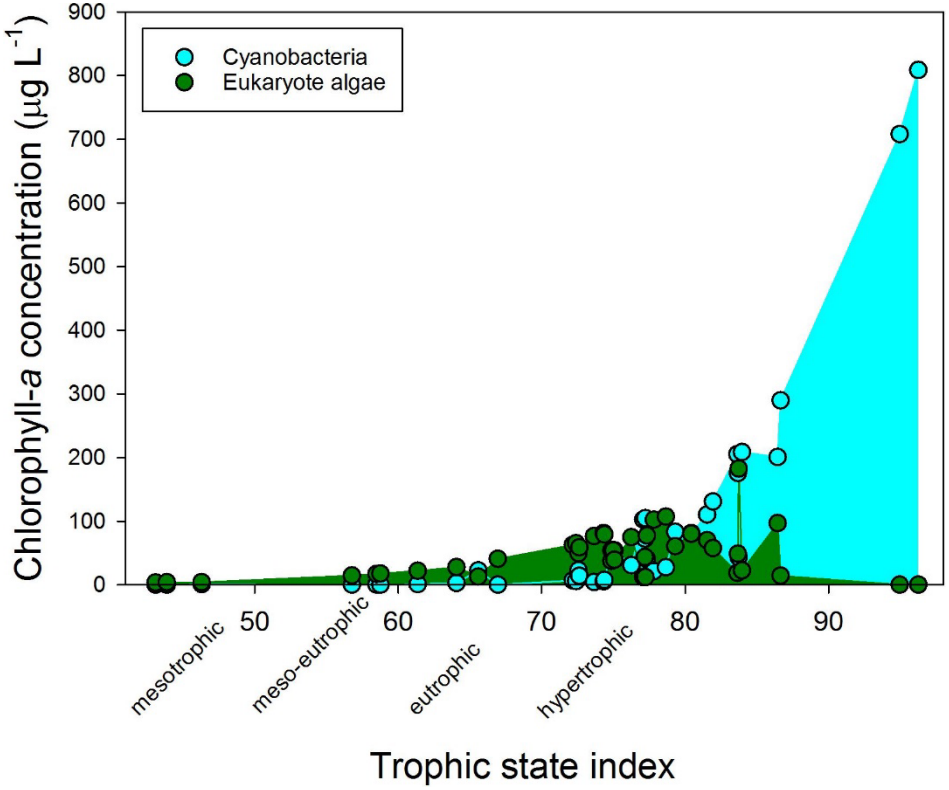


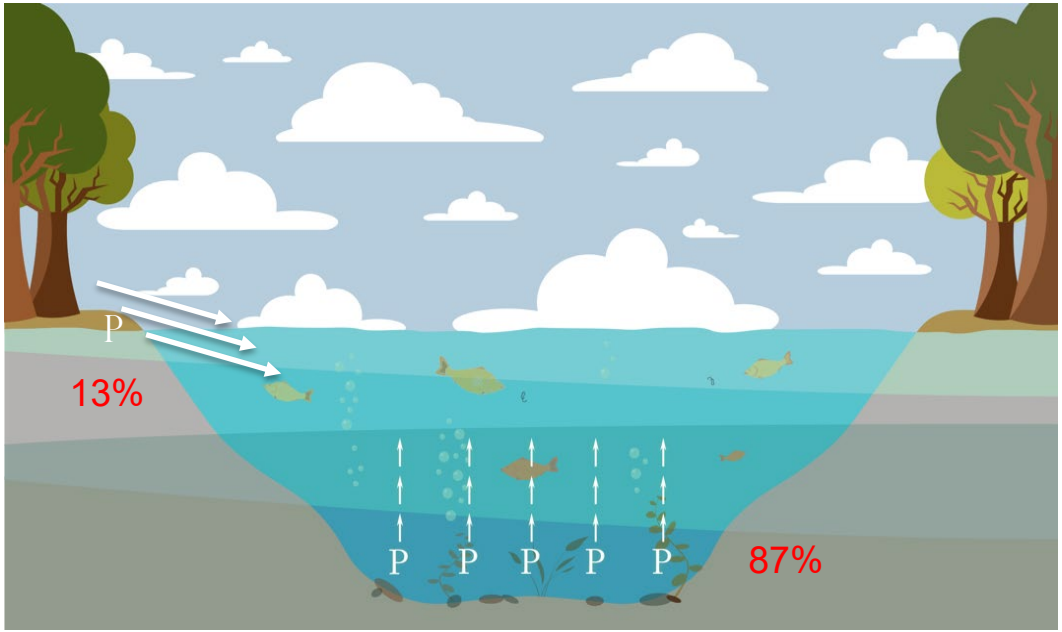
FIG. 1—*Updated Vollenweider-OECD normalized phosphorus loading–chlorophyll response relationship* [7] *for bodies of water throughout the world.*

Vollenweider 1968



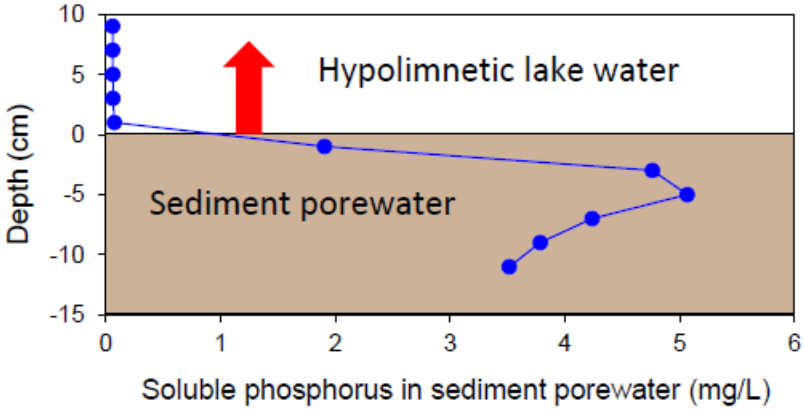
Lurling et al. 2018

The Sources: External & Internal

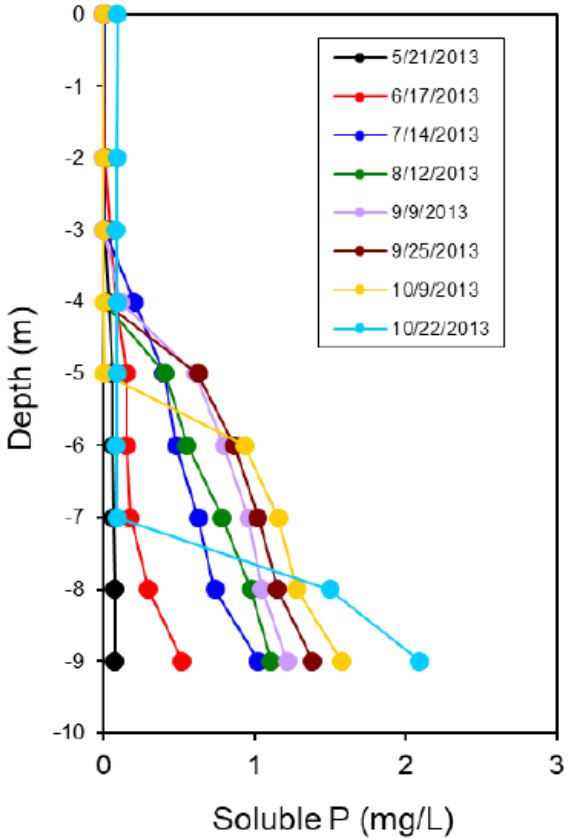


- ✓ High P leads to excessive algae & associated water quality issues
- ✓ Both external & internal loads combine to determine water column P
- ✓ Much of Lake Management in P-Management

Internal P Loading



- P is tightly bound to iron in the sediment *under aerobic conditions*
- P is released from iron *under anaerobic conditions*
- P accumulates in the hypolimnion
- Transported to the surface water for algae by wind mixing



Lake Alum Applications

- Controls phosphorus inputs from the sediments, which ultimately reduces the amount of phosphorus available algal growth

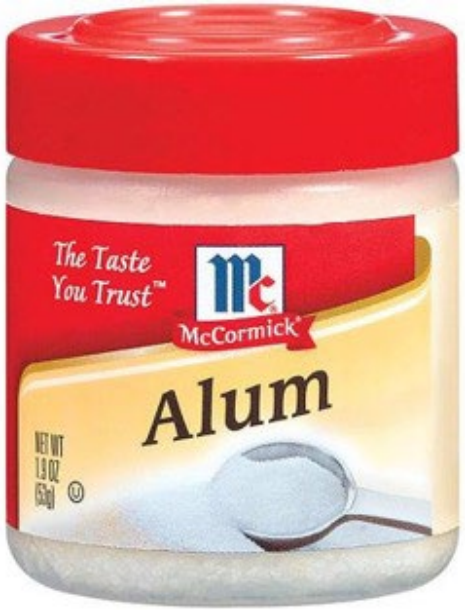
- Not toxic to algae. It reduces the amount of algae by reducing water column P and limiting growth

History of Alum Use in Lakes

Credit: Lautan Air

- Alum has been used for more than 200 years for drinking water clarification, and its use is essential in wastewater & drinking water treatment plants today
- First suggested for use in lakes in 1955
- First application in Sweden in 1968
- First US application in 1970 (Wisconsin)

History of Alum Use in Lakes



Credit: McCormick

- Alum is a common food additive & essential in drinking/wastewater treatment
- Drinking water grade (NSF 60) is used in lakes
- Aluminum chemistry is well-understood & predictable
- Hundreds of studies documenting the safe use of alum in lakes (58-yr history)
- Use in lakes endorsed by the North American Lake Management Society
- Alum is not toxic & doesn't harm plants & fish. Fishery improvements are common after alum use due to increased clarity & habitat

Sediment P Inactivation with Alum

- Specialized equipment & application technology used to permanently inactivate P in the lakebed & control internal loading
- Holistic approach: complements external P loading reduction efforts
- Liquid alum precisely applied
- Mixes with water form a precipitate (floc)
- Floc settles & unfilled binding sites intercept future sediment P release

Credit: J. Bischoff, Barr

Alum Floc

- Floc = colloidal aluminum hydroxide with highly efficient P binding capacity

- Aluminum phosphate complex ($Al(OH)_3PO_4$)

  - Very stable in the environment

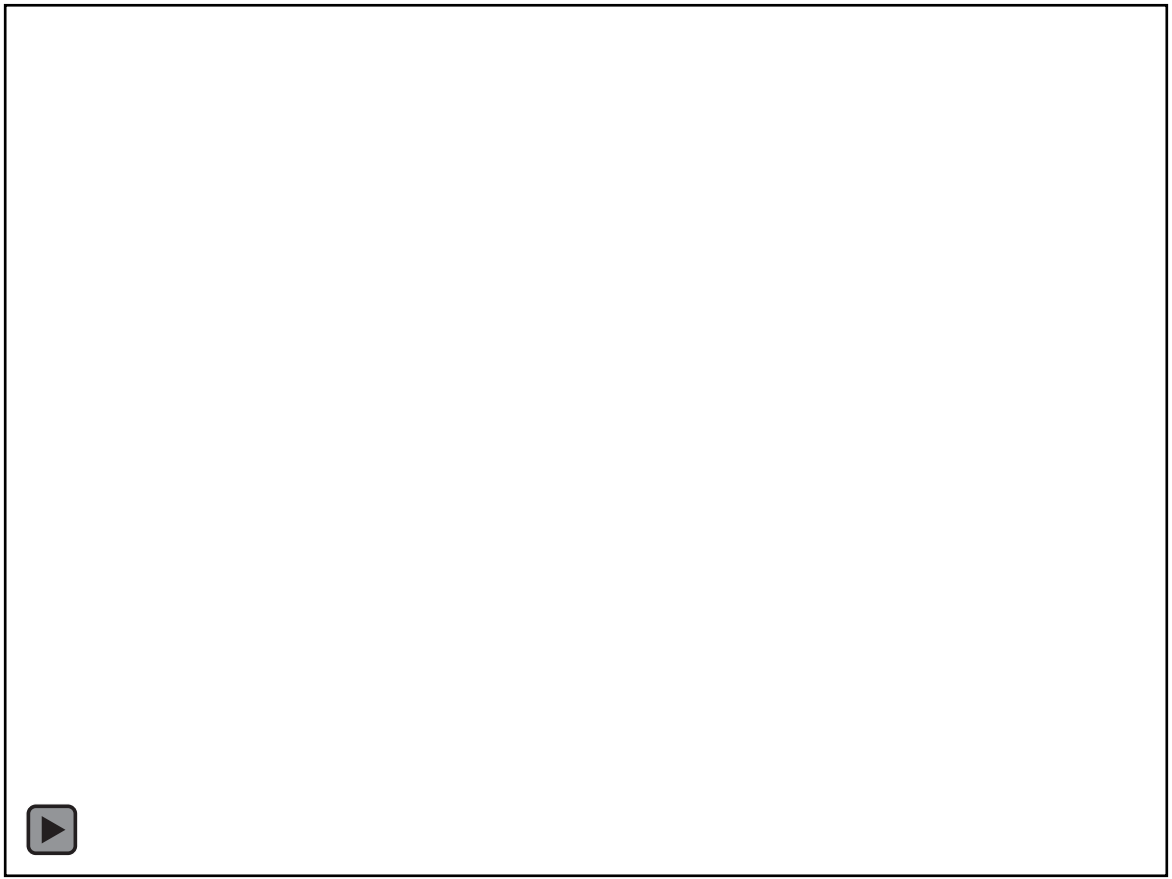
  - Not sensitive to anoxia (low oxygen)

- Settles rapidly (1 m in 6.5 min)

- Thin layer (2-3 cm) quickly incorporated into unconsolidated sediment layer

Credits: J. Holz

Alum Floc: Post Application Video, Green Lake, WA (2016)



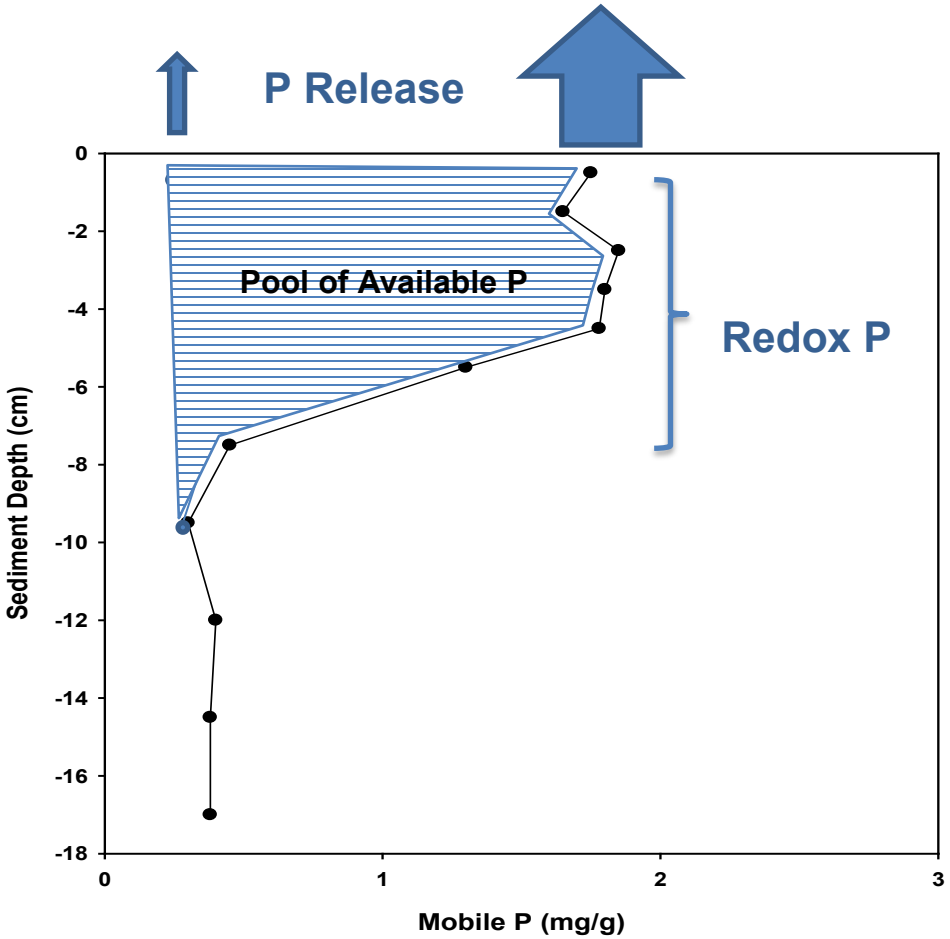
Credit: R. Zisette, Herrera

Alum: How it Works

P-forms in the sediment:

- Dissolved (PO_4, organic P)
- Particulate

Iron:	Fe (III) hydroxides, Fe (OOH), (ads.) Strengite, Fe PO_4 Vivianite, Fe_3 $(PO_4)_2$ 8 H_2O
Alum:	Al $(OH)_3$ (ads.) Variscite, Al PO_4
Calcium:	Hydroxyapatite, Ca_{10} $(PO_4)_6$ OH_2 Monetite, Ca H PO_4 Calcite (ads.)
Clay:	(ads.)
Organic:	"Labile" "Refractory"



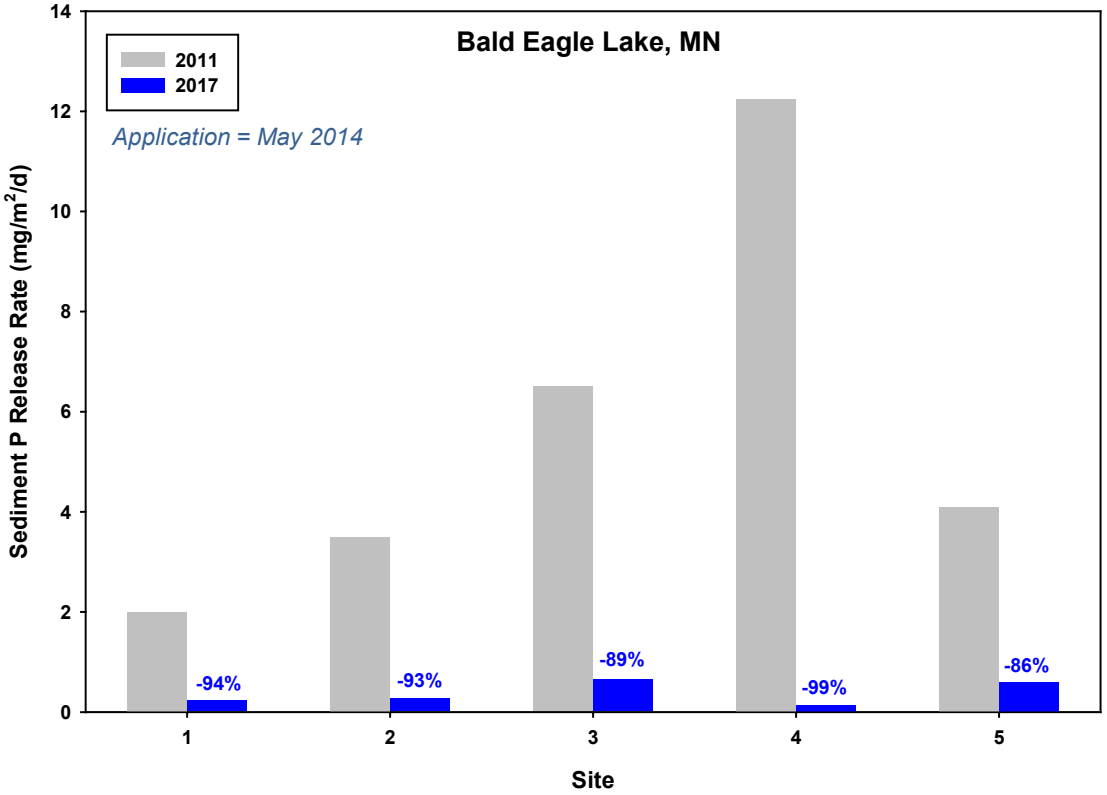
Benefits: Immediate Clarification

Spring Lake, MN

First Day of Application:
Day 0

Last Day of Application:
Day 13

Benefits: Control of Sediment P Release



Credit: W. James, UW-Stout, unpublished data

Benefits: P & Algae Reduction

White Lake, NC

October 2017

May 22, 2018

Typical result is ~50-90% reduction in water column P and algae

Credits: Town of White Lake, NC

Benefits: Increased Clarity & Reduction/Elimination of Algal Toxins

Upper Prior Lake, MN

July 2019

July 2020

Credits: S. Reinders, Homeowner

Benefits: Improved Fishery

Increased clarity, oxygen, structure & habitat

Credits: R. Menard, ACC

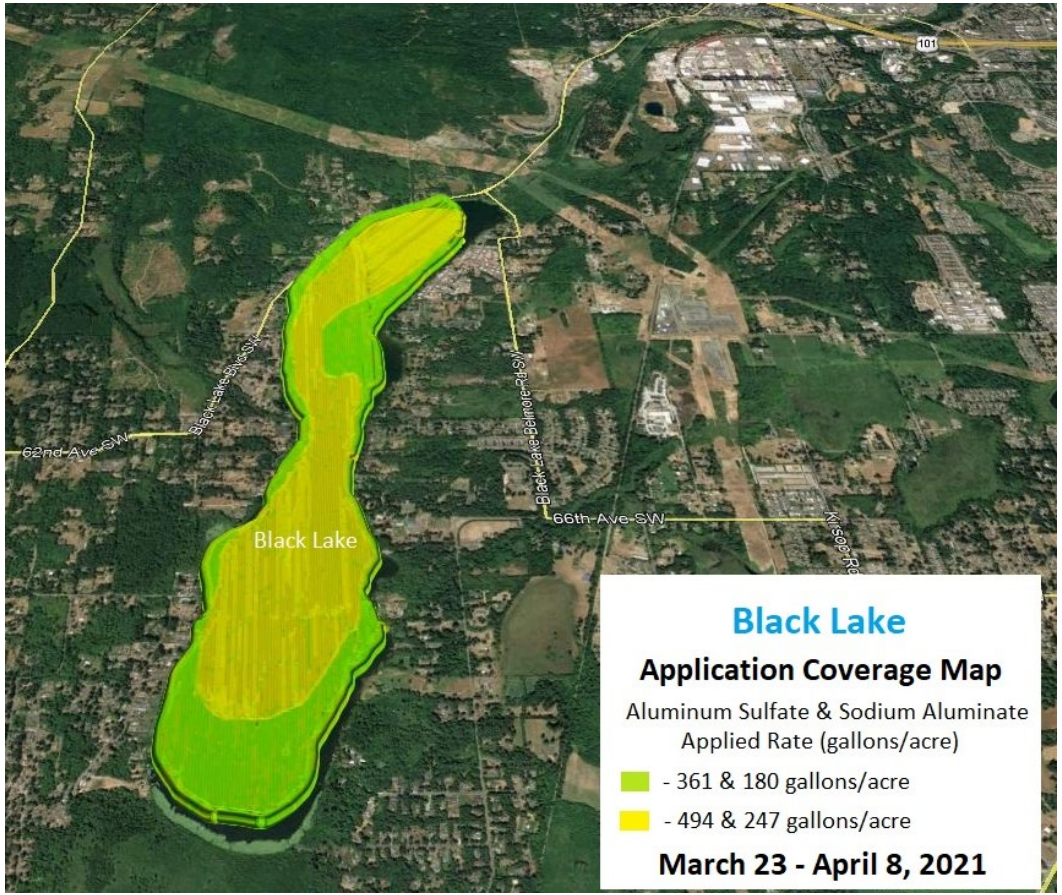
Washington Lake Experience

- Black Lake
- Blackmans Lake
- Lake Fenwick
- Green Lake
- Heart Lake
- Lake Ketchum
- Long Lake (Kitsap)
- Moses Lake
- Wapato Lake
- Waughop Lake

Credit: J. Holz

Case Study: Black Lake, WA

- 570 surface acres
- Max. Depth = 29 ft
- Mean Depth = 19 ft
- History of algal toxin health alerts
- P Budget = 40% External, 60% Internal Loading

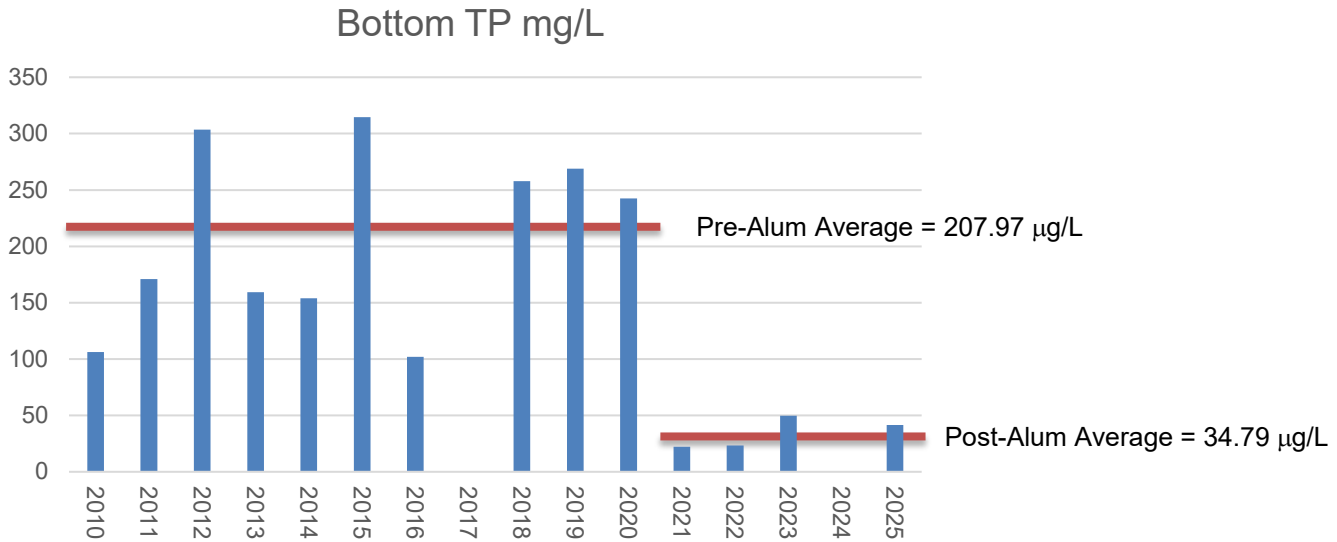


Case Study: Black Lake, WA

Credit: J. Holz

- 234,394 gals of Alum & 117,098 gals of Sodium Aluminate applied over 17 days in late March/early April of 2021
- Alum is a lower pH aluminium product and sodium aluminate is a higher pH aluminium product, applied simultaneously to maintain a neutral pH
- Full dose in one application (not phased)

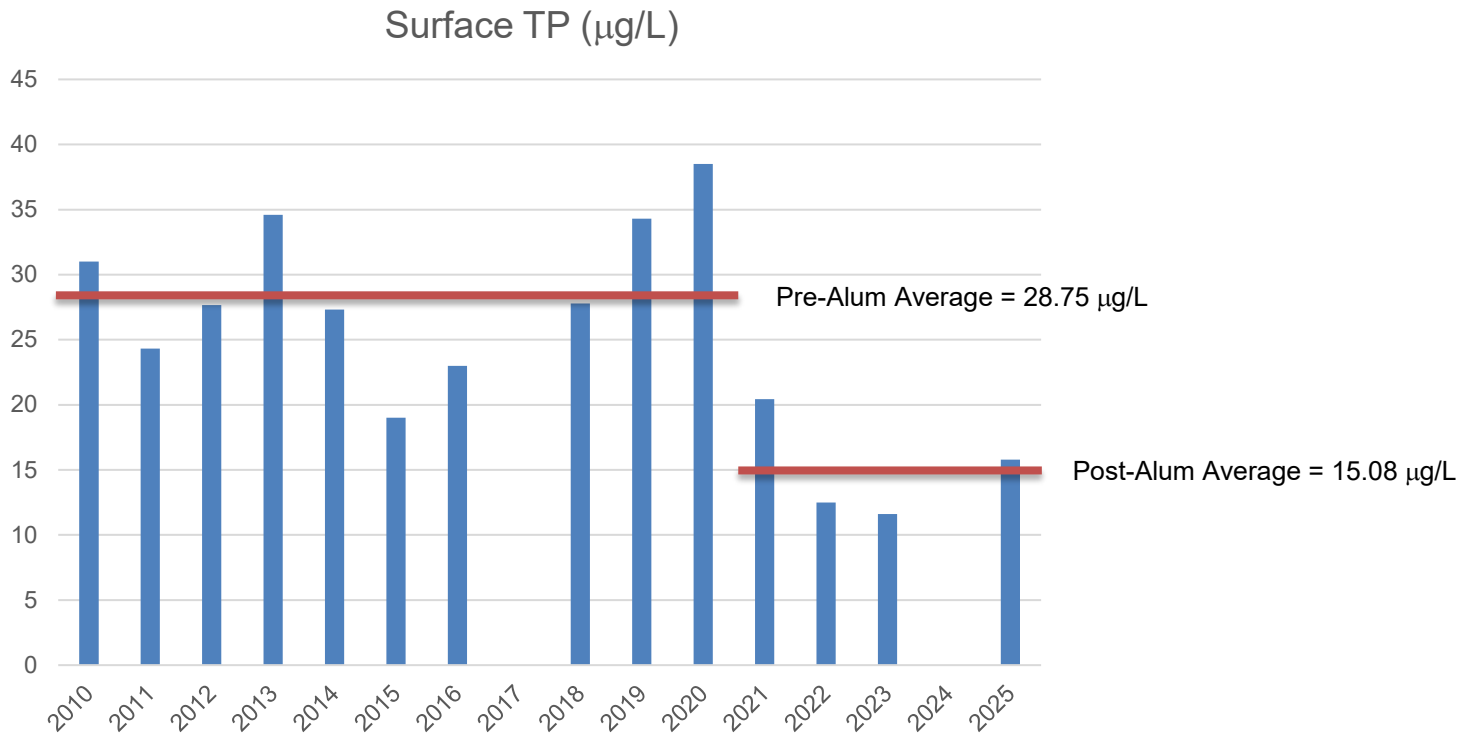
Black Lake, WA: Total Phosphorus Near Bottom



83% reduction in bottom TP

Data Source: Thurston County

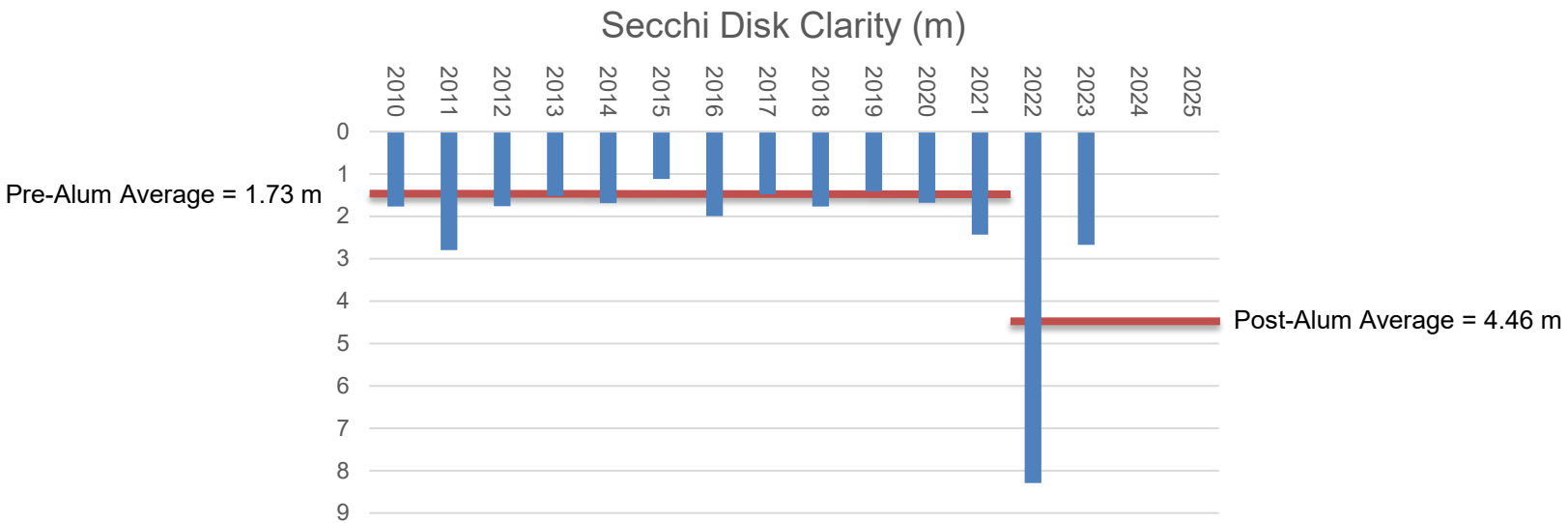
Black Lake, WA: Total Phosphorus Near Surface



48% reduction in surface TP

Data Source: Thurston County

Black Lake, WA: Secchi Disk Clarity



2.58x increase in Secchi Disk Clarity

Data Source: Thurston County

Lawerence Lake Alum: Water Quality & Lake Response

- ✓ Improves dissolved oxygen conditions by reducing organic matter processing by bacteria, which removes oxygen
- ✓ No meaningful pH impact expected
- ✓ Consistent, effective P removal from water column
- ✓ Strong, permanent & long-term P binding in sediments
- ✓ Multi-year longevity

Credit: J. Holz

Lawerence Lake Alum: Cyanobacteria Considerations

- ✓ Demonstrated reduction in bloom frequency & duration
- ✓ No known risk of short-term bloom stimulation

Credit: J. Holz

Lawerence Lake Alum: Implementation & Flexibility

- ✓ Easily applied incrementally with cumulative benefits
- ✓ Performs reliably across lake conditions

Credit: J. Holz

Lawerence Lake Alum: Cost & Logistics

- ✓ Recommended ratio of Al:P for sediment inactivation = 20:1
- ✓ No shipping & handling costs
- ✓ Best application method is injection from a barge, with specialized equipment (closed system, GPS guidance, automated flow control, separate two channel application system for multiple products.
- ✓ Estimated application time = 96-hr (8, 12-hr days)
- ✓ Lump sum cost estimate = $195 per pound of P sequestered

Credit: J. Holz

Lawerence Lake Alum: Monitoring & Regulatory

- ✓ Required testing of 4 or more laboratory analytes during & after treatment, as per permit requirements
- ✓ Fully approved for intended use

Credit: C. Bosley

Lawerence Lake Alum: Ecological & Human Safety

- ✓ Aquatic Life & Habitat Safety: No known harm based on field use
- ✓ No known risk to Human, Pet & Wildlife Safety

Credit: C. Bosley

Questions & Discussion

John Holz, PhD

Senior Limnologist

SOLitude Lake Management

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Credit: J. Holz