Planning and Executing a Successful Alum Treatment

A Collaborative, Science-Based Path to Lake Restoration

May 2026

BARR

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Barr Engineering Co.

BARR

Lake Carmi Vermont

Lake Carmi Campers Association

Conference Theme:

This year's conference is focused on the roles that lake associations, government, and lake scientists play in lake management and preservation.

The Cast:

Katherine King—VDEC

Mark Mitchell—VDEC

Peter Isles—VDEC

Pete Benevento—Lake Carmi Association

Rob Evans-Franklin Watershed Committee

The Cast:

Lisa Larivee—Town of Franklin

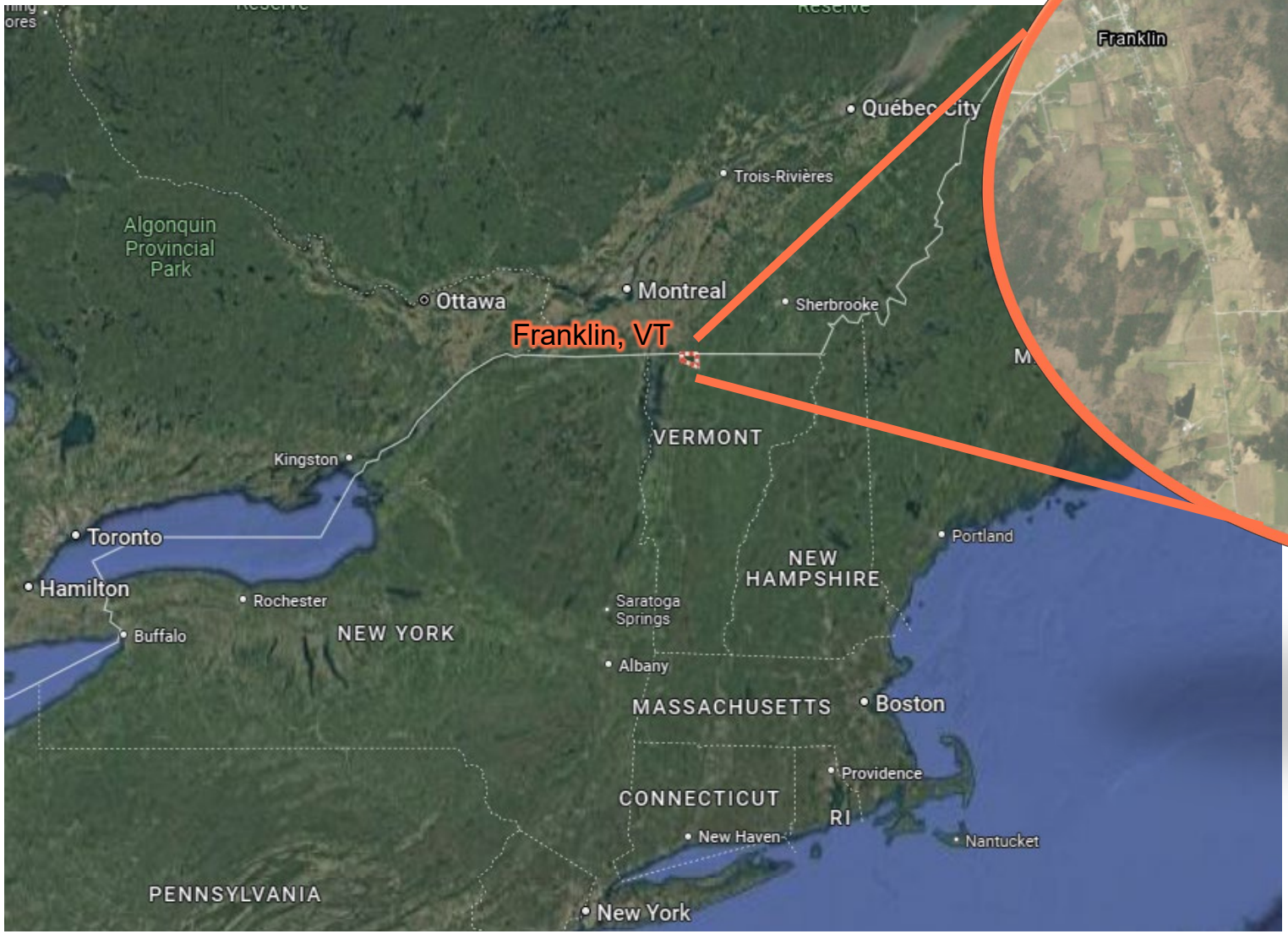
Dave Bennion—Town of Franklin

Michelle Kolb—VDEC

Tim Greenleaf—Barr Engineering

Lake Carmi a “Lake in Crisis”

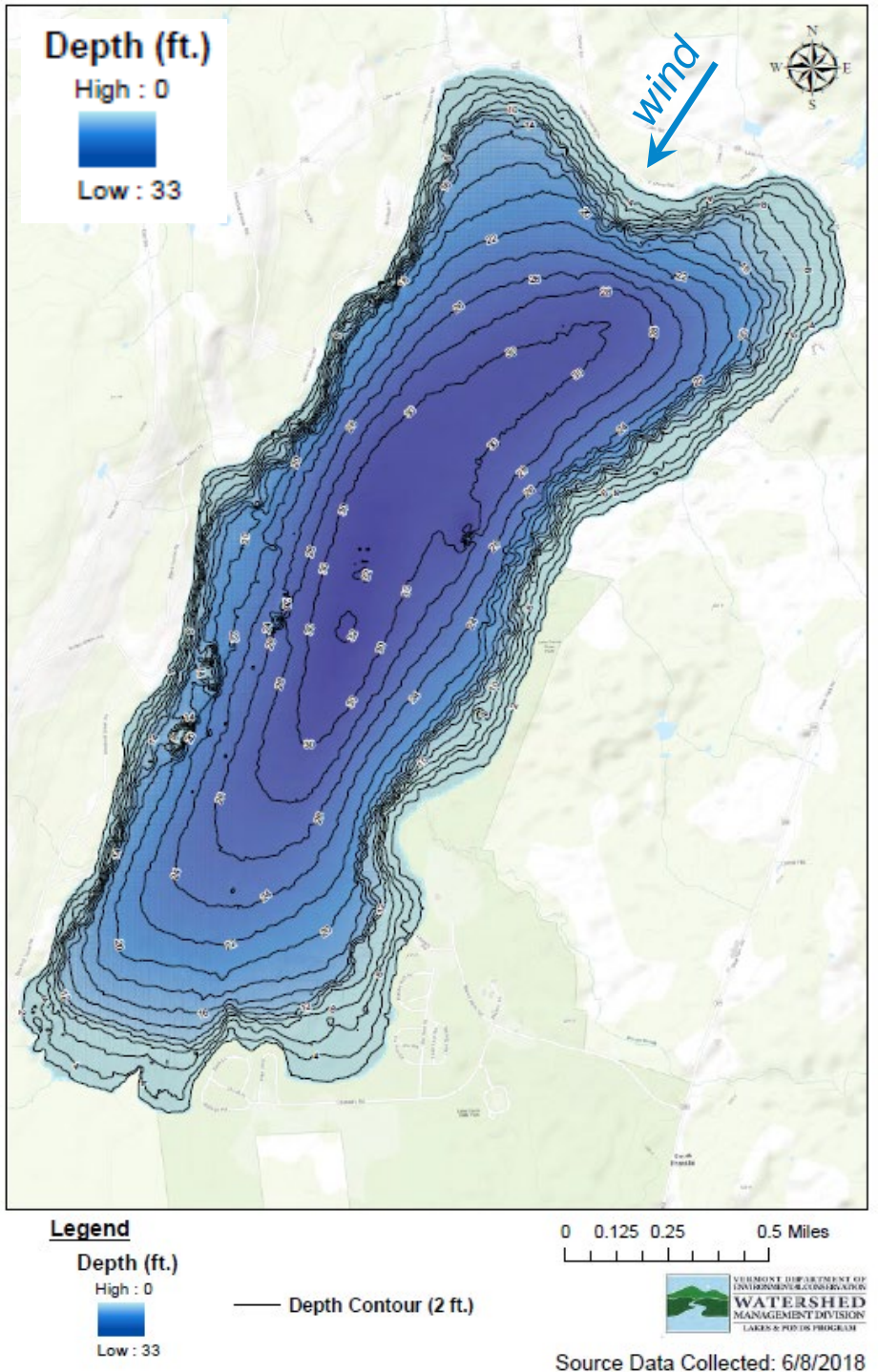
Background - Project Location



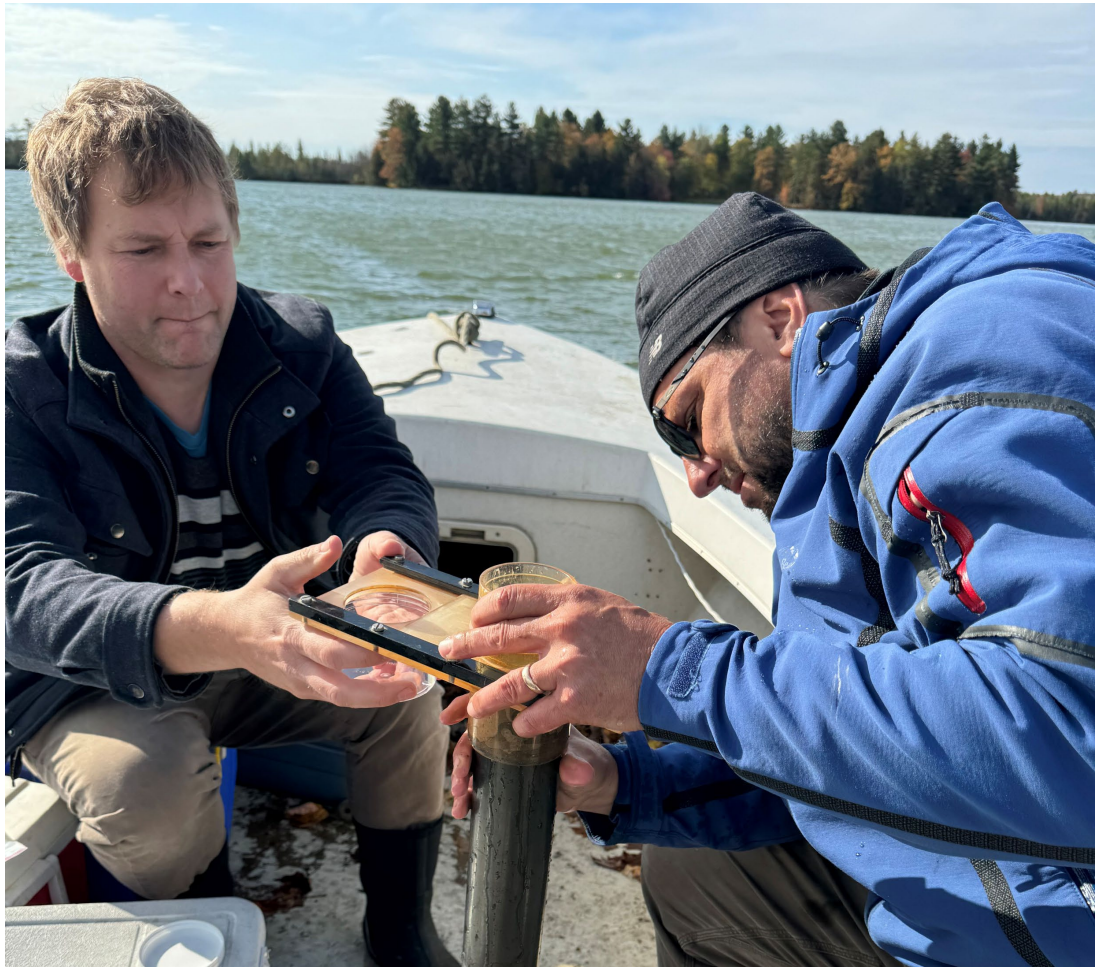
Background – Lake Carmi

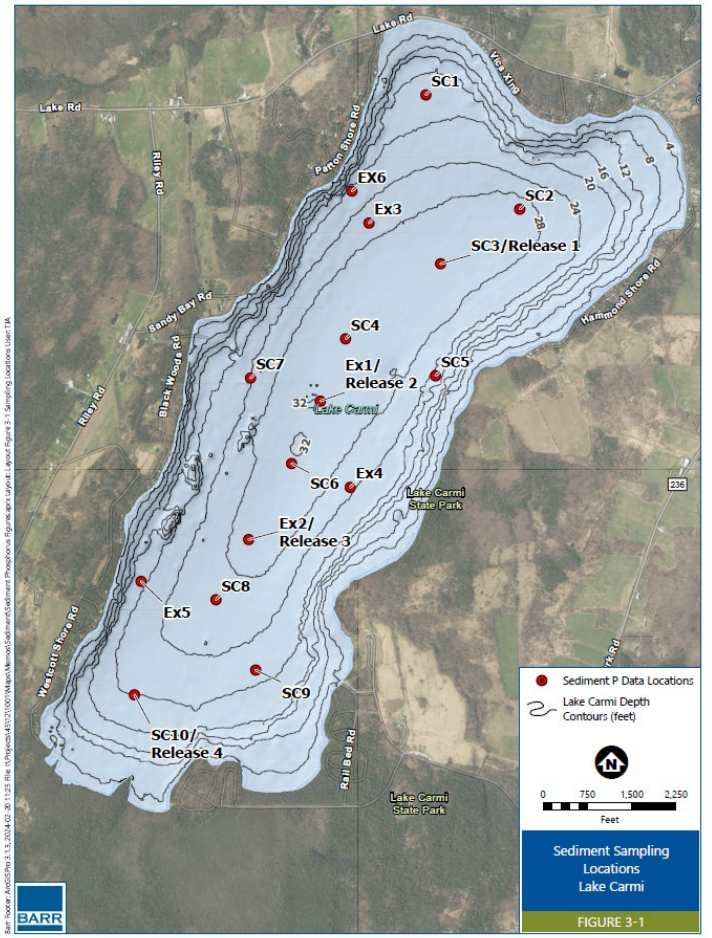
- Large Surface Area = 1,400 acres
- Long Fetch = 13,000 feet
  - Predominant NE to SW wind direction
- Relatively Shallow
  - Depth = 33 feet (max); 20 feet (mean)
- Watershed to Lake Area Ratio
  - 6:1
- High Ratio of Lake Area to Depth → Weak Stratification

- Watershed Area = 7,570 acres
  - 45% Forest
  - 34% Agriculture
  - 19% Open Water
  - 1% Other (Residential, Streets)



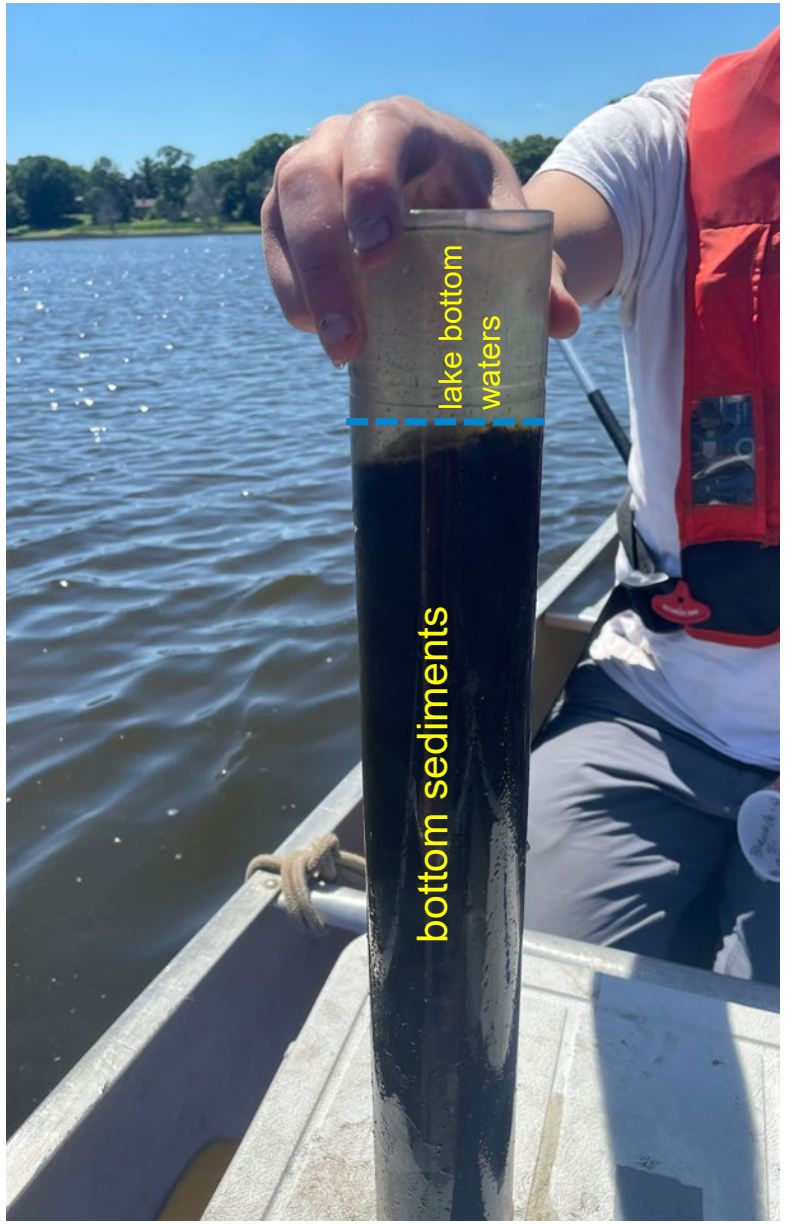
Step 1: Sediment Coring



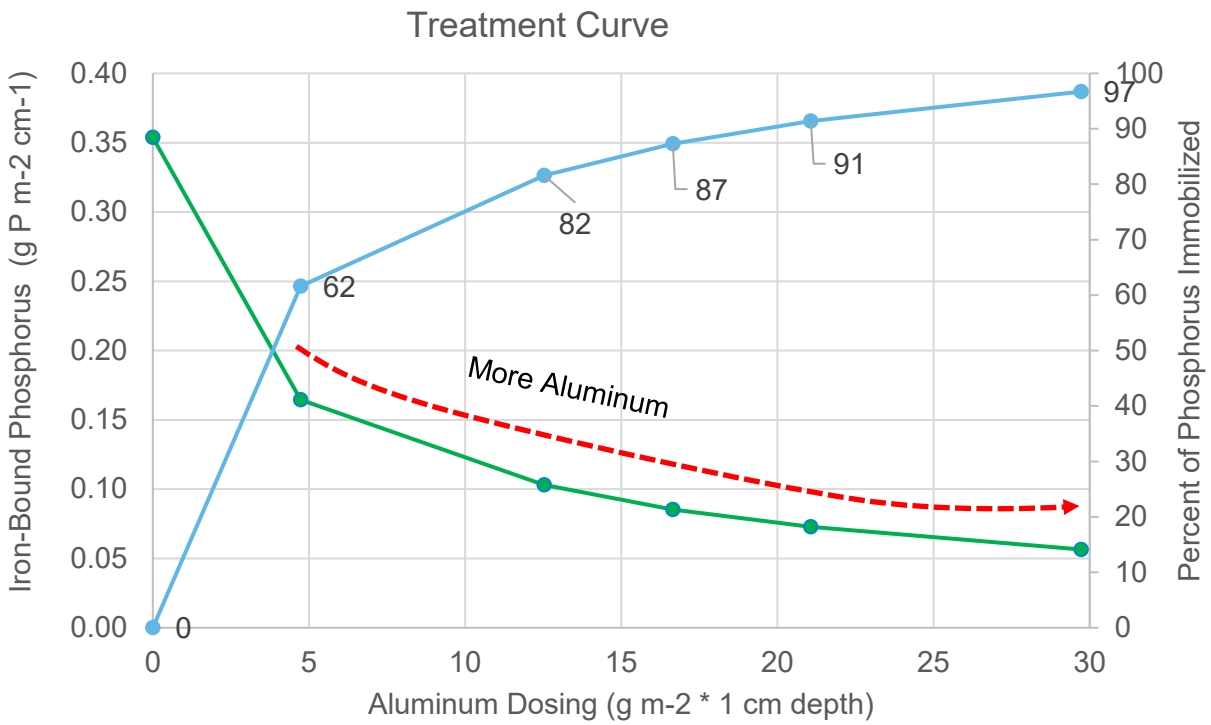


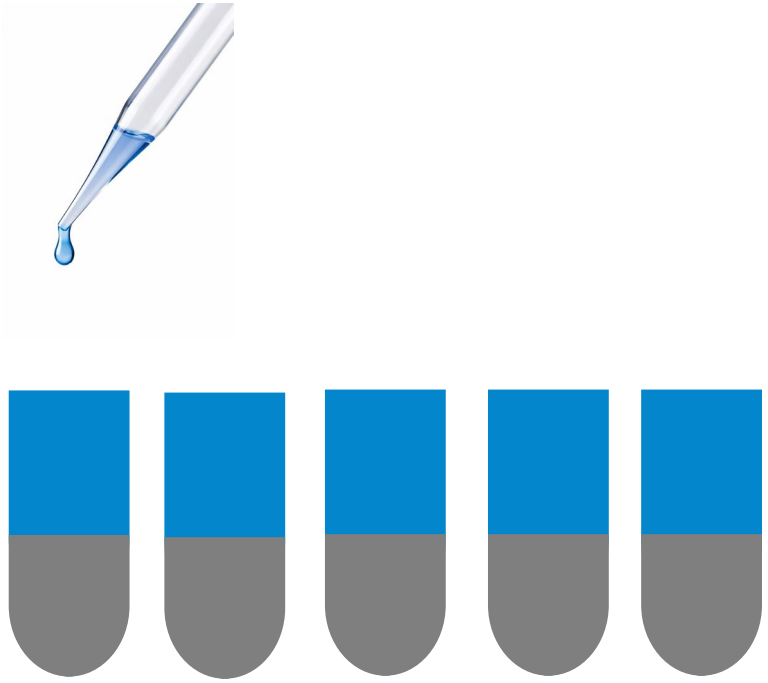
Aluminum Dosing and Application

- How much to add
- Where to put it

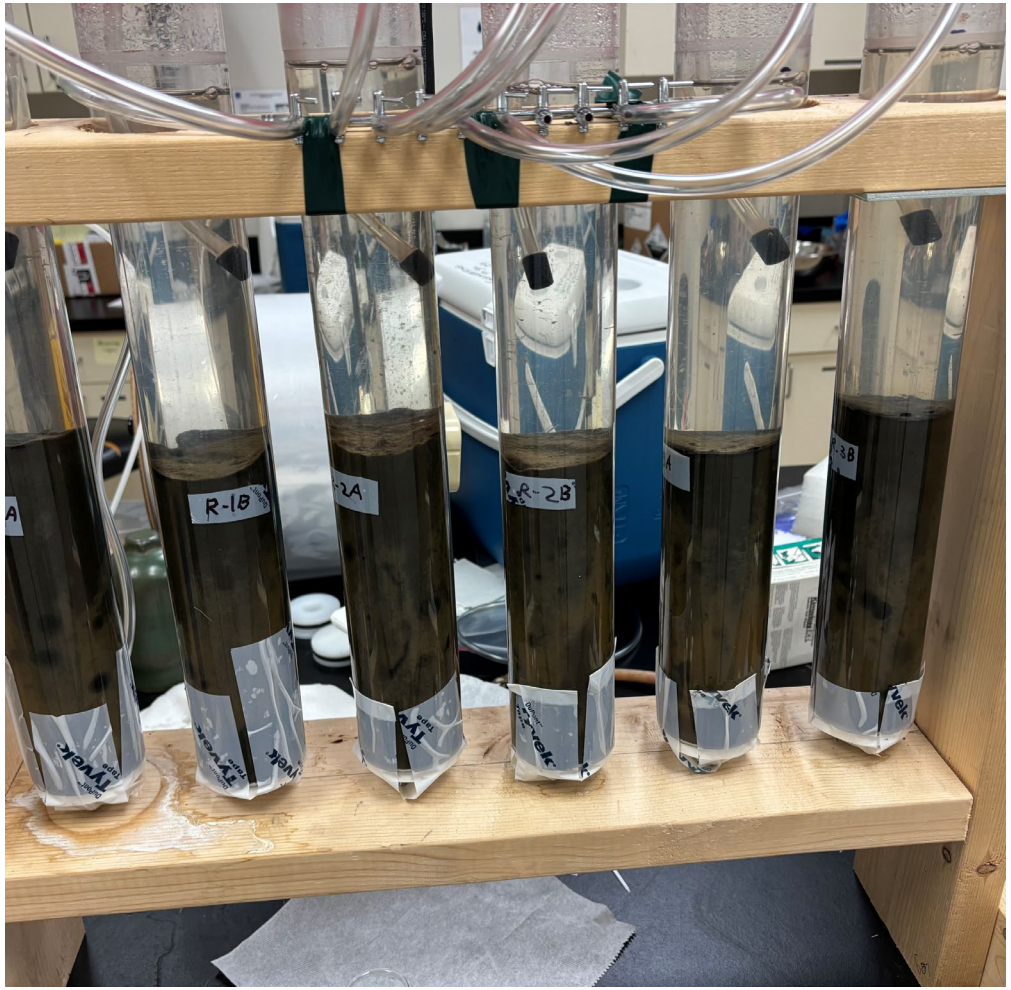


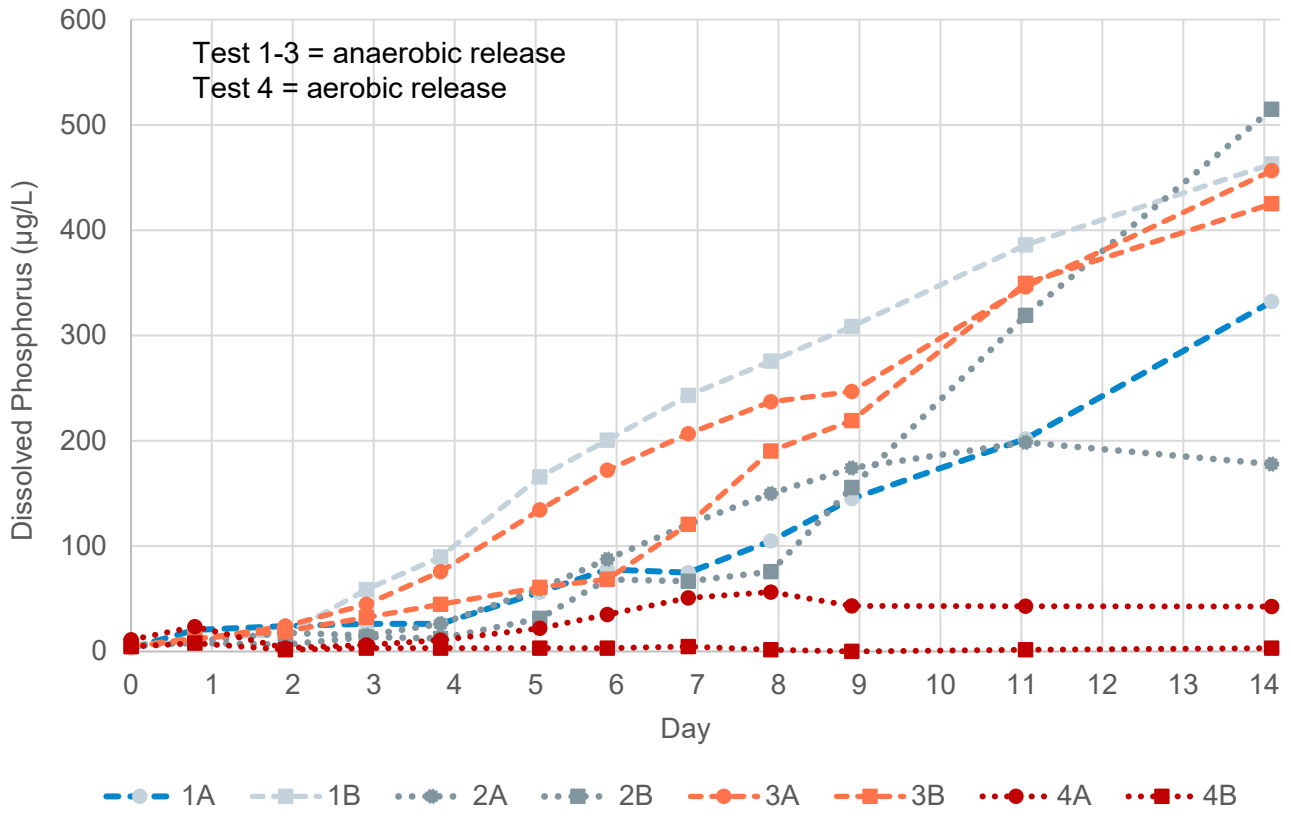
Alum Dosing


Treatment Curve
Iron-Bound Phosphorus (g P m-2 cm-1)
Percent of Phosphorus Immobilized
Aluminum Dosing (g m-2 * 1 cm depth)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
0
62
82
87
91
97
More Aluminum



Anaerobic and Oxic Phosphorus Realse

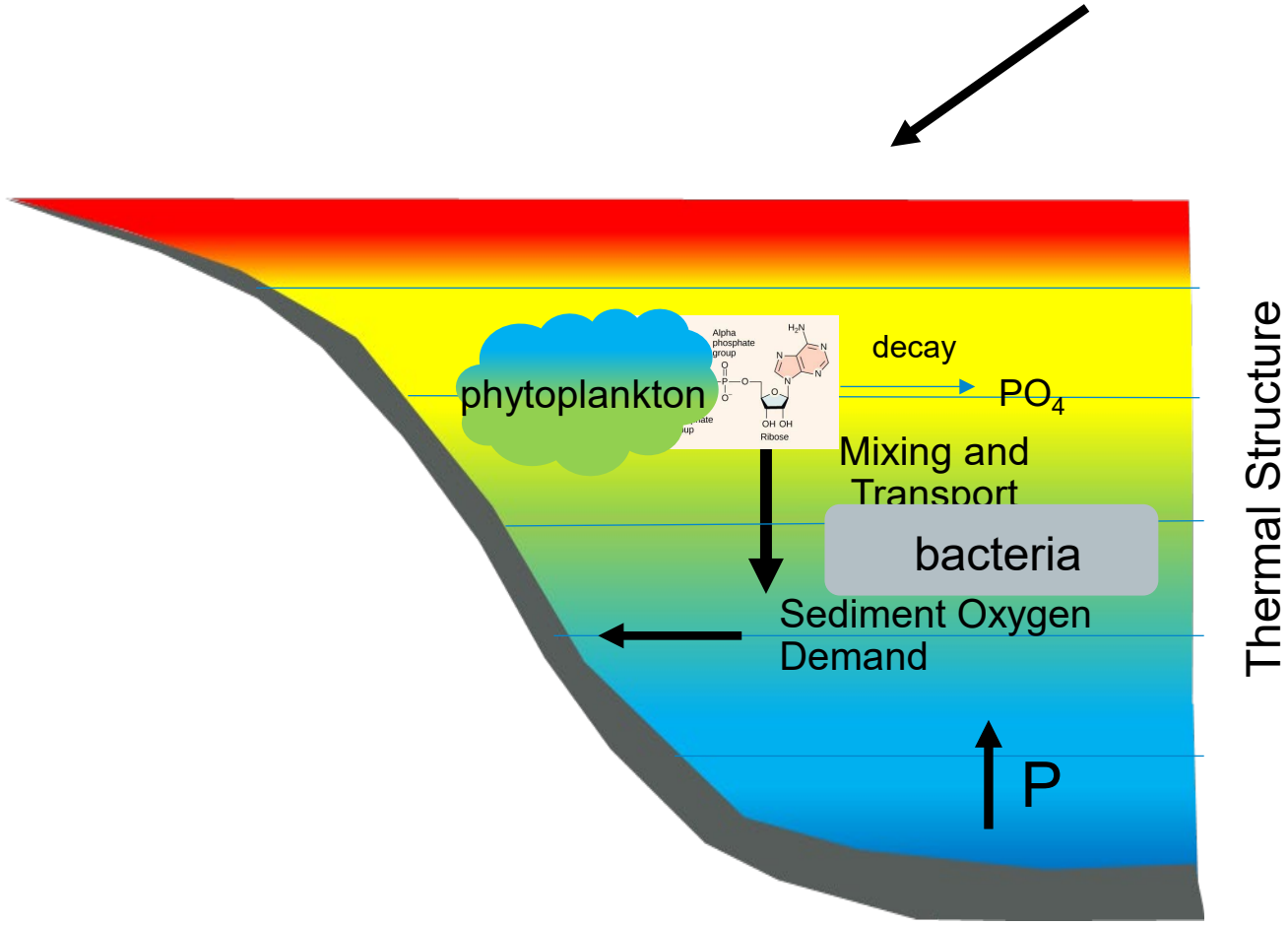




Lake Modeling

- How much is external vs internal loading contributing to algal blooms?
- Why do we have cyanobacteria blooms in this lake?
- What's the best way to reduce cyanobacteria blooms?
- How much internal loading control is needed to prevent algal blooms?
- Will internal loading control alone prevent the persistent algal blooms on our lake?

1-D Lake Model

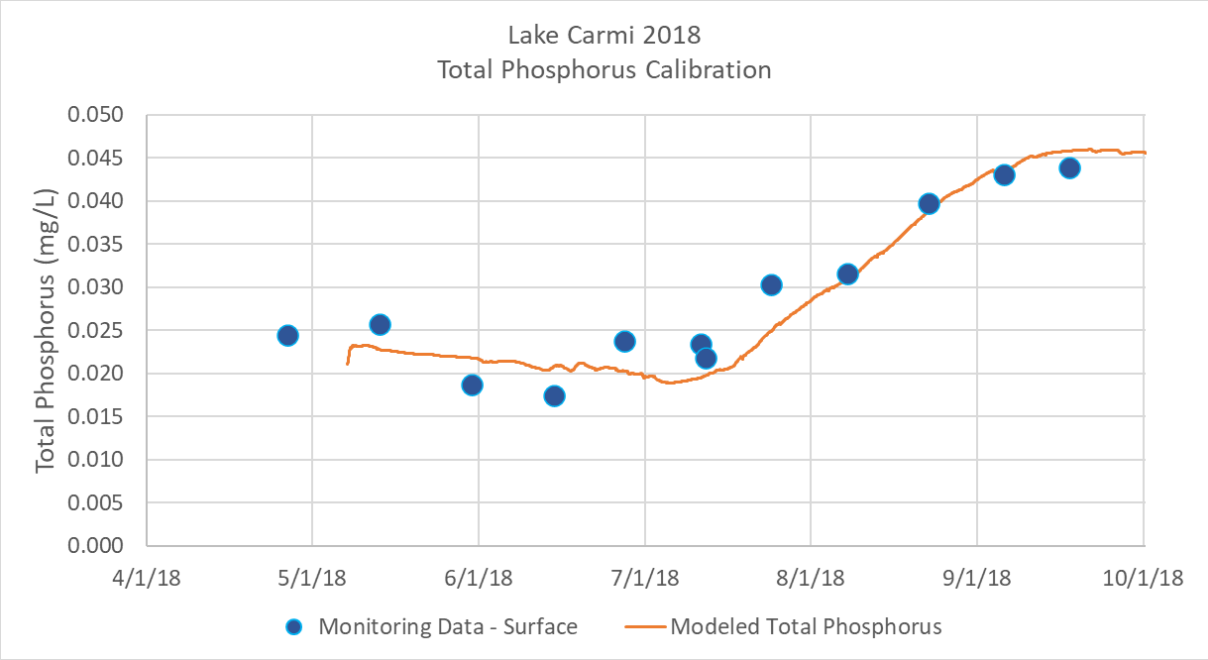


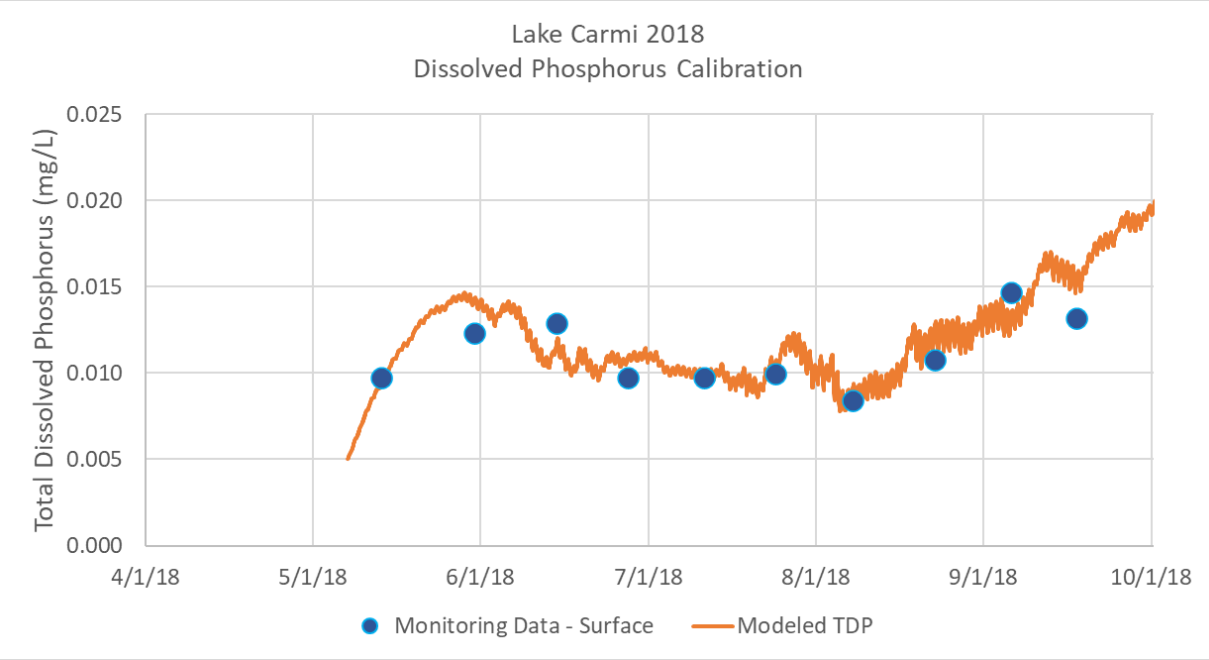
Physical Environment

Chemical Processes

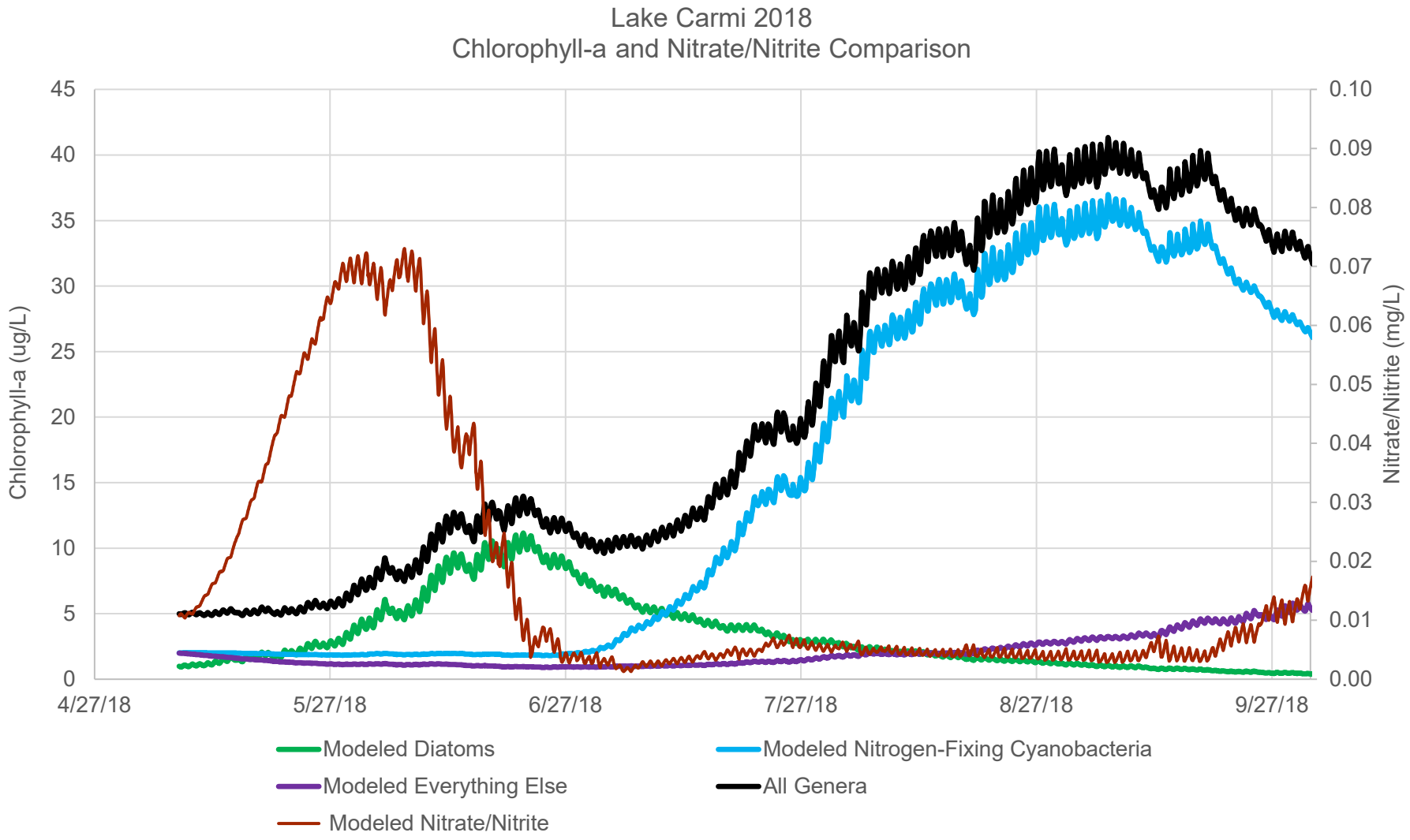
Biological Processes

1-D Lake Model

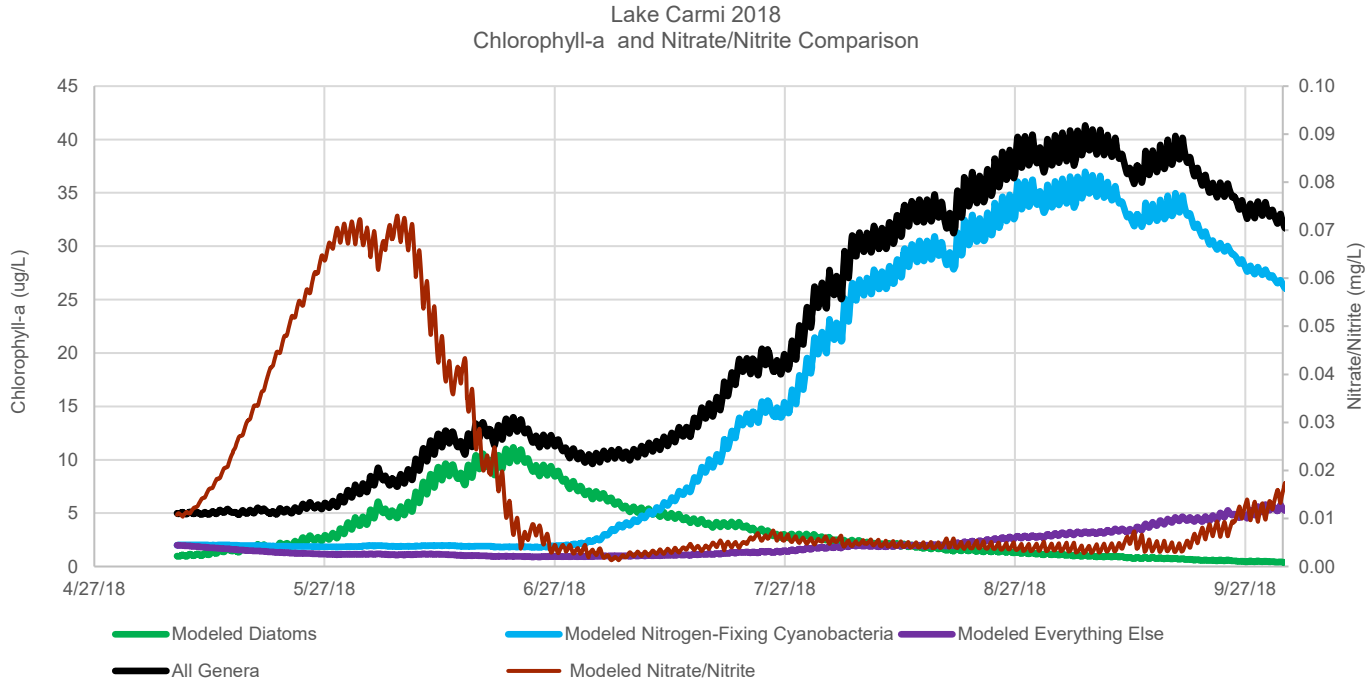


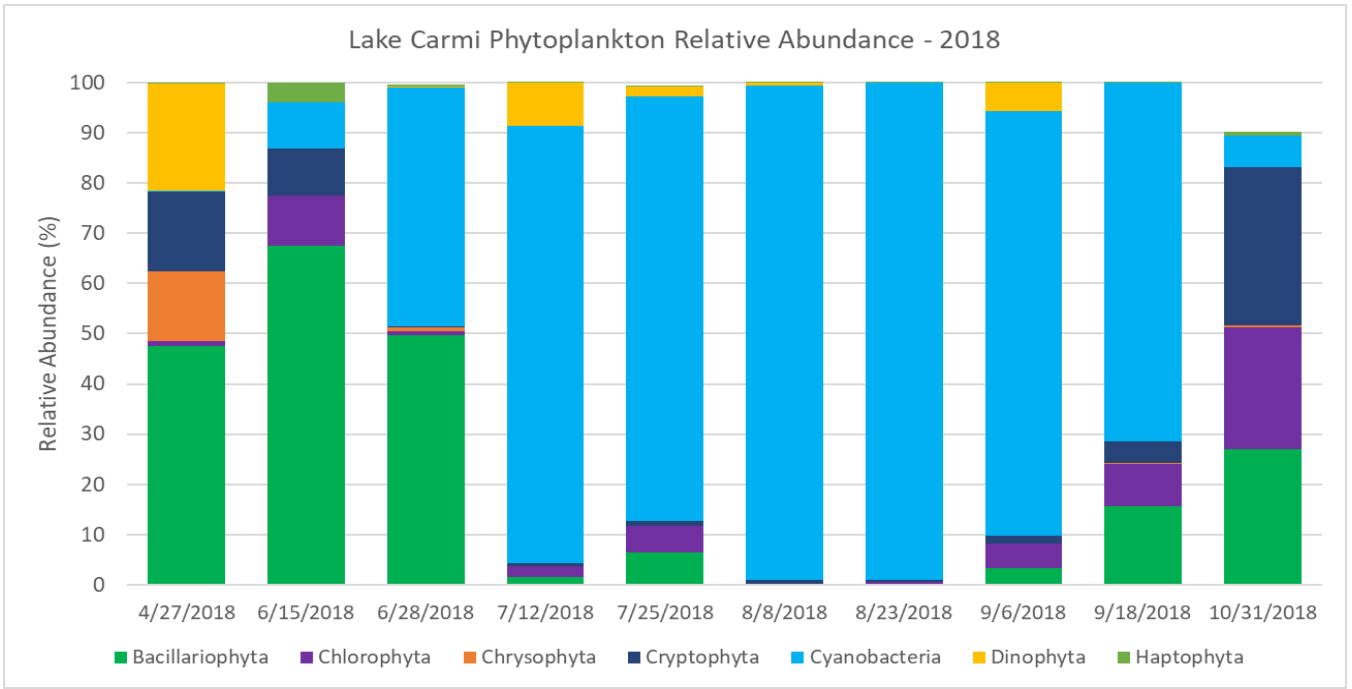


1-D Lake Model

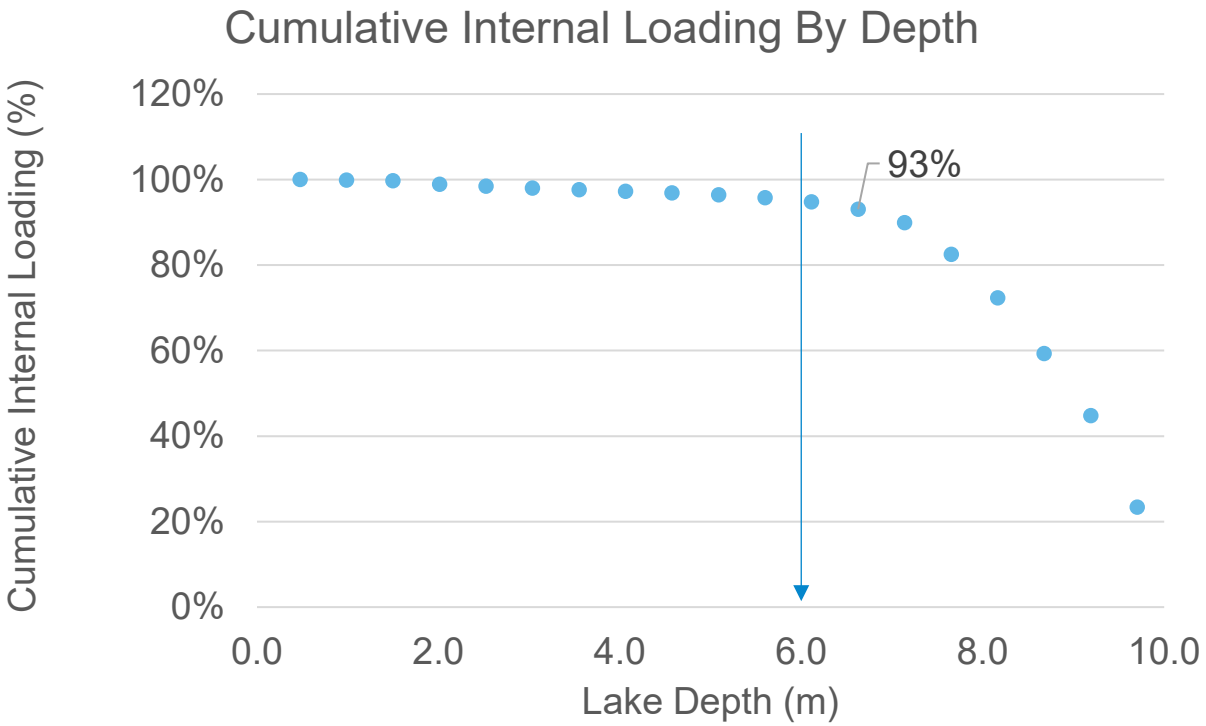


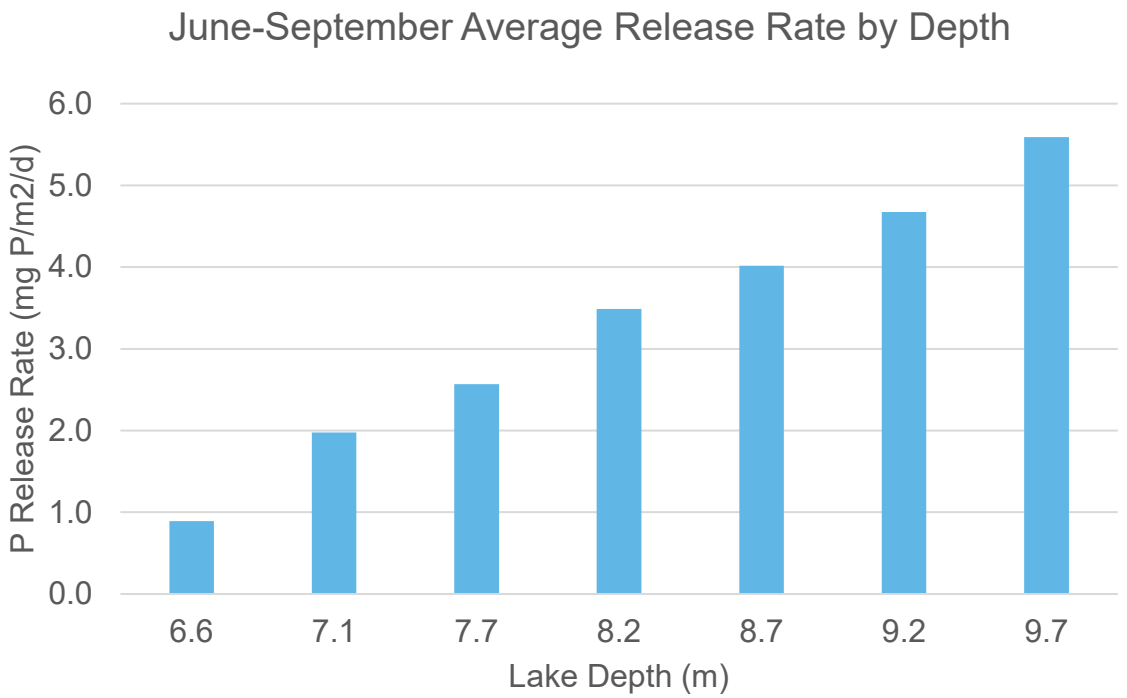
1-D Lake Model



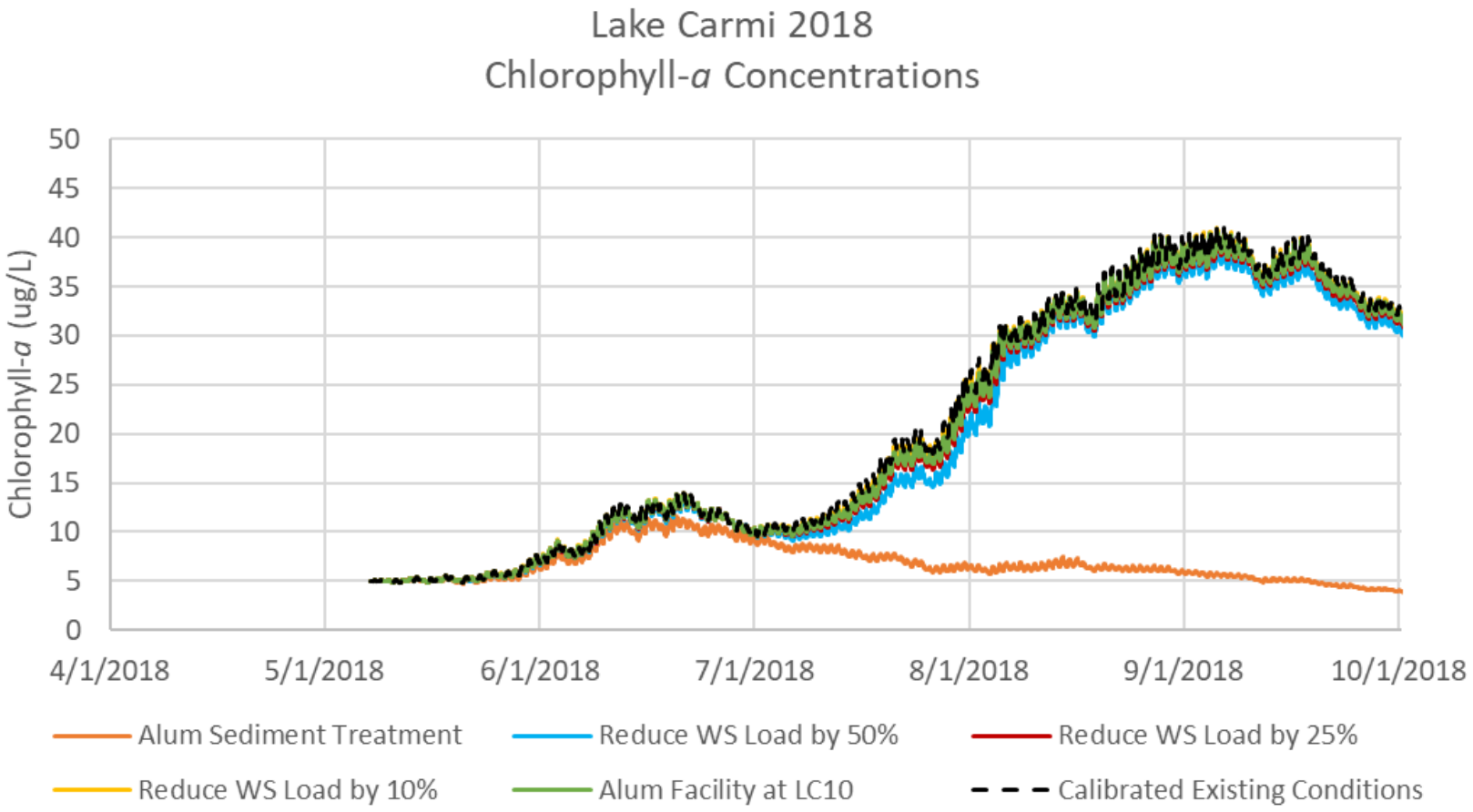


1-D Lake Model—Predicting the Lake Response \ Targeting Treatment Depth

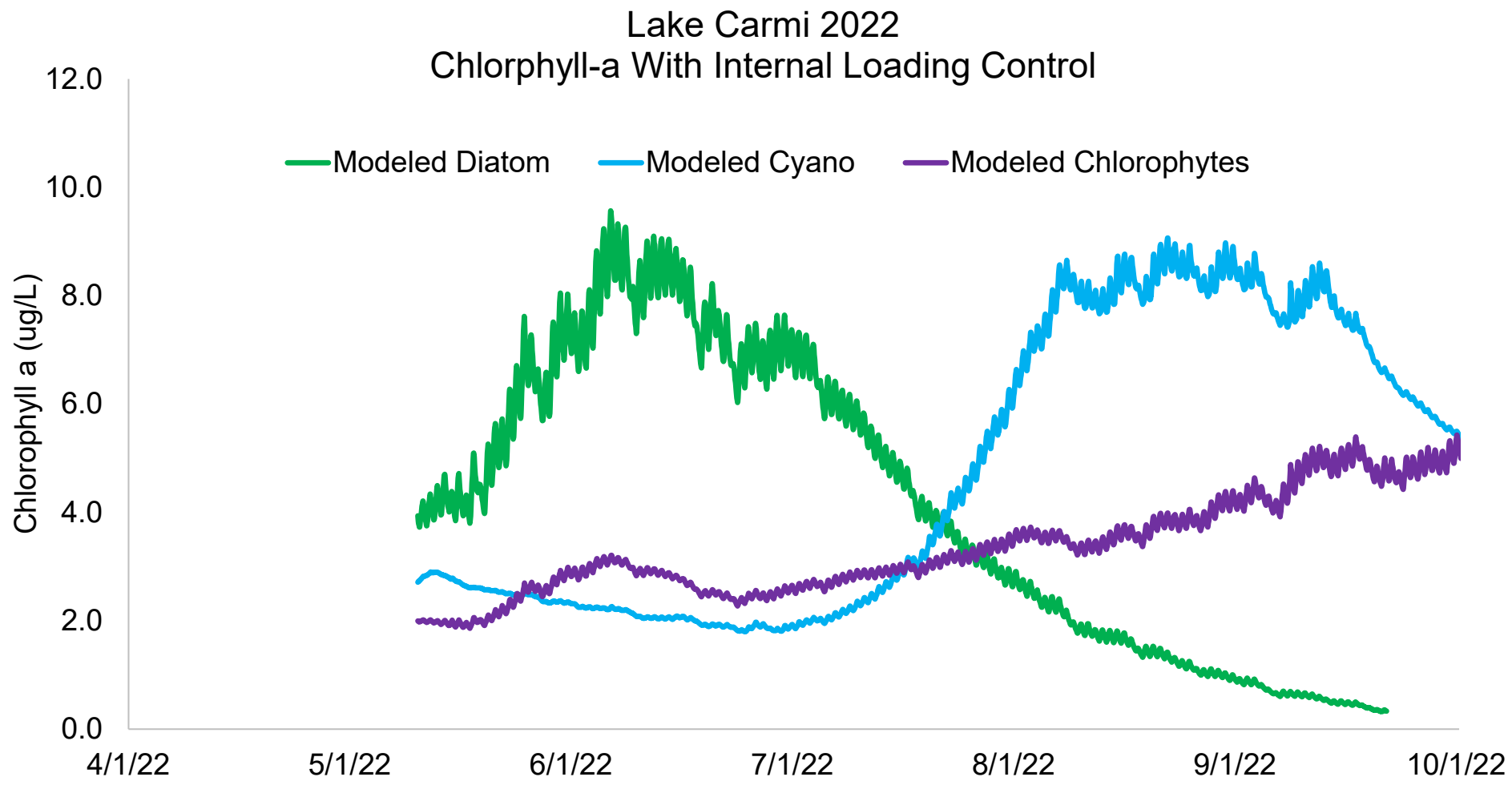




1-D Lake Model—Predicting the Lake Response \ Graph of Lake Response



1-D Lake Model—Phytoplankton Groups After Treatment



The Application Process

Funding—Contracting--Permitting—and—Application

State and Federal Funding

- Increased complexity of contract documents
- More comprehensive reporting
- Fair wage / build America / etc.

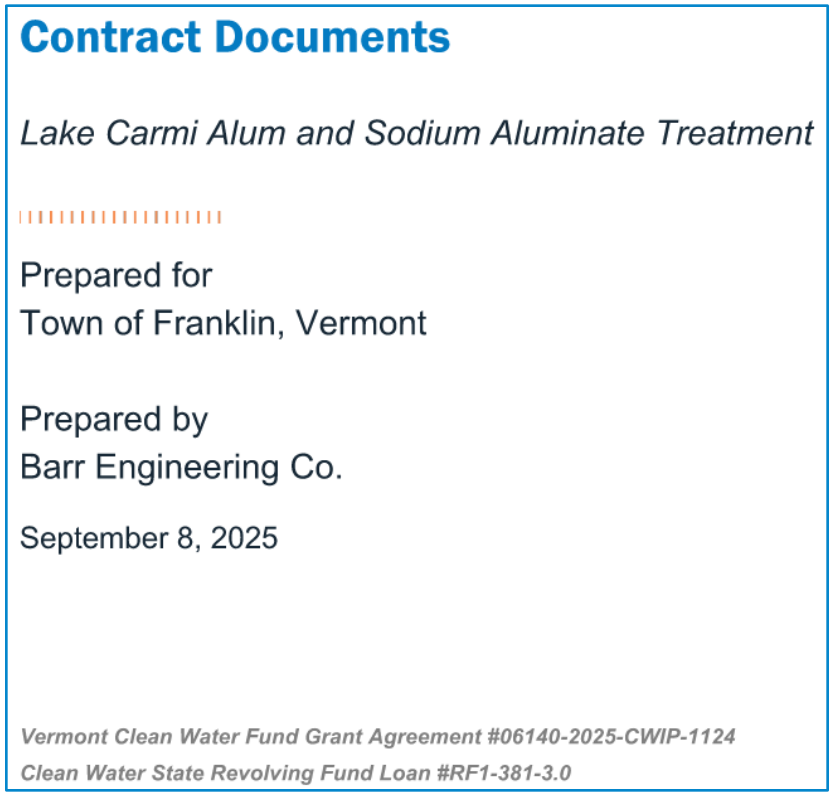
Fisheries Concerns

- Will the lake get too clear!

NPDES Permitting and Reporting

- Federal aluminum criterion applied to the lake
- Aluminum and pH limits
- Extensive monitoring

Funding and Contracting



Funded Through VT Clean Water Fund Grant Agreement and Clean Water State Revolving Fund Loan / Emerging Contaminants Fund

- Required compliance with state and federal funding conditions
- Compliance requirements integrated into design, bidding, construction, and payment application reviews
- Engineer certification required
- Deliberate planning = smooth implementation

Contract Docs + Bidding

- EJCDC-based – tailored for grant-funded work
- Clear allocation of responsibilities – owner, engineer, contractor
- Flexibility incorporated to address risks (IFB before final permit, potential for delays in event of permit compliance issues, etc.)
- Clear requirements for contractor minimum contractor qualifications: specialized work, large treatment area

NPDES Permit Conditions

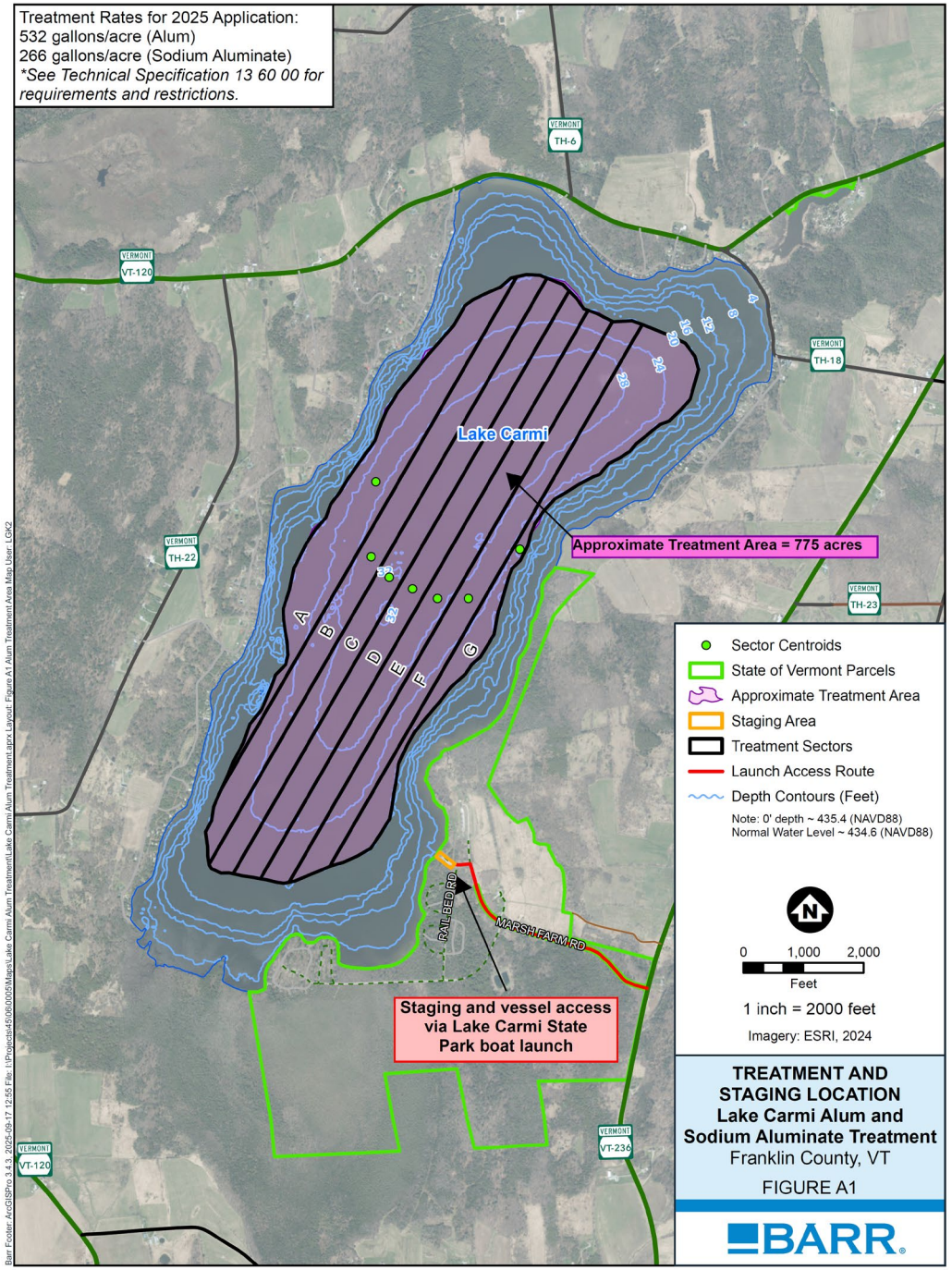
1. During alum application, the Permittee is required to monitor the water column in the centroid of the treated area following all alum applications that day and the next morning.

   →Composite samples shall be collected at 1-meter intervals starting at one meter below the surface and ending one meter above the sediment surface

Lake Profile Monitoring			
Constituent; Sampling Point; Sample Type	Season and Sampling Frequency	Limit 1	Limit 2
Total Aluminum; Water Column; Composite	During Treatment Daily	0.59 mg/L Weekly Avg	1.6 mg/L Daily Max

Treatment Plan

- Contractor required to develop a treatment plan per the NPDES permit referenced in the contract documents.
- Treatment zones identified
- Tripple pass treatment approach
- Spill containment
- Training
- Reporting requirements
- Emergency response



NPDES Permit Conditions

2. During alum application, the Permittee is required to monitor the water column at one meter below the water surface in the centroid of the treated area following all alum applications that day. The

One Meter Below Water Surface Monitoring		
Constituent; Sampling Point; Sample Type	Season and Sampling Frequency	Limit 1
pH; 1 meter below surface; Grab	During Treatment Daily	Monitor SU Instantaneous Max
Turbidity; 1 meter below surface; Grab	During Treatment Daily	Monitor NTU Weekly Avg
Temperature; 1 meter below surface; Grab	During Treatment Daily	Monitor °C Instantaneous Max
Dissolved Organic Carbon; 1 meter below surface; Grab	During Treatment Daily	Monitor mg/L Instantaneous Max
Total Hardness; 1 meter below surface; Grab	During Treatment Daily	Monitor mg/L Instantaneous Max
Total Aluminum; 1 meter below surface; Grab	During Treatment Daily	Monitor mg/L Instantaneous Max

NPDES Permit Conditions

3. During alum application, the Permittee is required to monitor the water column at one meter above the sediment surface in the centroid of the treated area following all alum application that day.

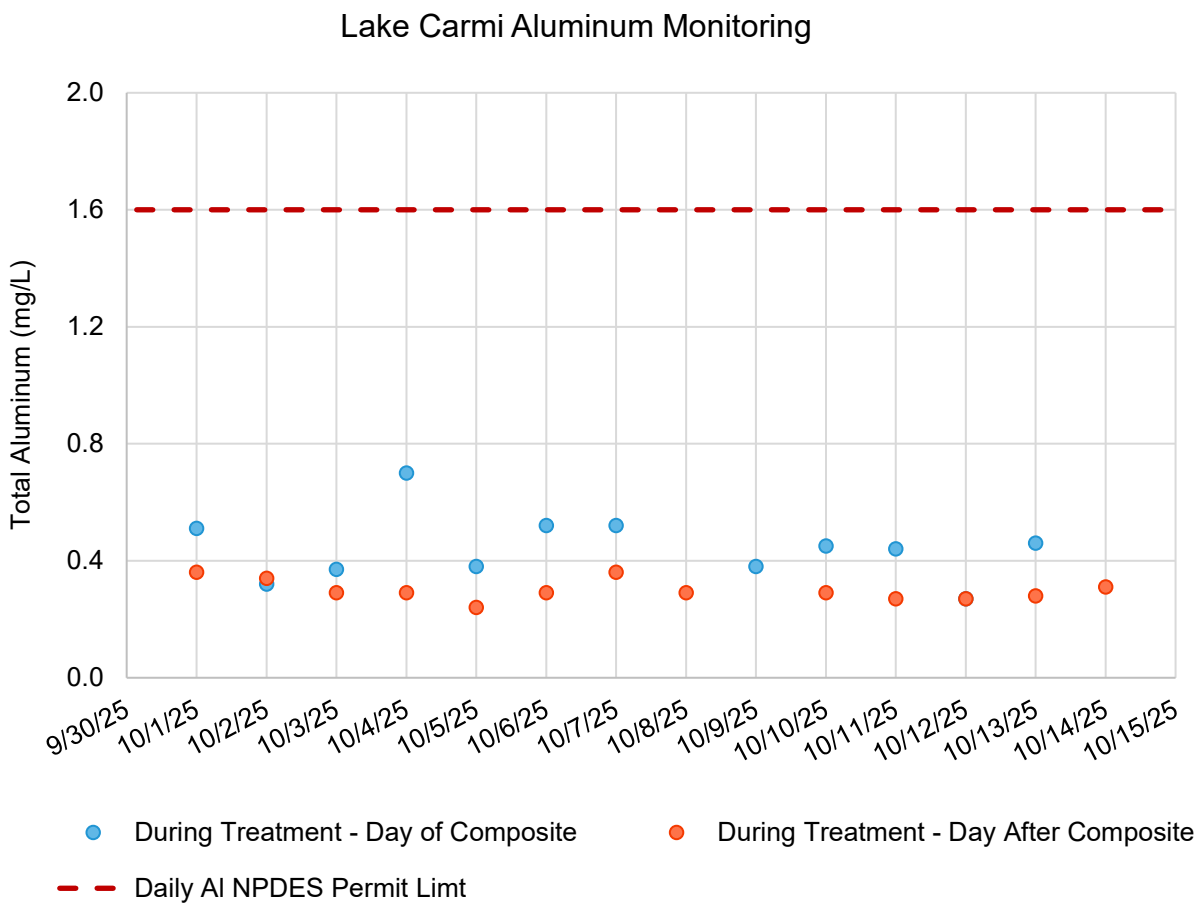
One Meter Below Water Surface Monitoring		
Constituent; Sampling Point; Sample Type	Season and Sampling Frequency	Limit 1
pH; 1 meter below surface; Grab	During Treatment Daily	Monitor SU Instantaneous Max
Turbidity; 1 meter below surface; Grab	During Treatment Daily	Monitor NTU Weekly Avg
Temperature; 1 meter below surface; Grab	During Treatment Daily	Monitor °C Instantaneous Max
Dissolved Organic Carbon; 1 meter below surface; Grab	During Treatment Daily	Monitor mg/L Instantaneous Max
Total Hardness; 1 meter below surface; Grab	During Treatment Daily	Monitor mg/L Instantaneous Max
Total Aluminum; 1 meter below surface; Grab	During Treatment Daily	Monitor mg/L Instantaneous Max

NPDES Permit Conditions

Special Conditions

Prior to application each day, the Permittee shall monitor each zone to be treated for pH. Samples shall be taken 1 meter below the water surface in the centroid of the treatment area. Application shall not commence unless pH is confirmed to be within 7.2 and 9.5.

NPDES Permit Conditions / Did We Meet the Aluminum Limit?



Communication Was Critical

Building Trust Through Communication

Effective communication with residents and agencies built trust and prevented misinformation throughout the project.

Information Sharing Tools

Use of public information sharing, signage, and meetings kept the community informed and engaged consistently.

Transparency Throughout Project

Transparent communication before, during, and after treatment maintained support and clarified project goals and risks.

Longevity Matters

Long-Term Water Quality

Alum treatment designed for Carmi provides 10 to 30 years of water quality benefits based on phosphorus levels and sediment behavior.

Ongoing Monitoring

Consistent monitoring and adaptive management ensure sustained water quality and address new environmental challenges.

Collaborative Stewardship

Shared responsibility among stakeholders promotes watershed improvements and long-lasting environmental health.

Key Lessons for Lake Managers

Science-Based Decision Making

Using defensible data ensures treatments are effective and scientifically sound for lake management.

Early Regulatory Engagement

Engaging regulators early helps secure necessary approvals and facilitates project success.

Clear Communication and Oversight

Transparent communication and diligent oversight foster trust and ensure project accountability.

Collaborative Sustainable Outcomes

Applying these lessons promotes shared responsibility and sustainable lake management results.

It Was Long Road...

But They Are Stoked!

Photo Courtesy of
Pete Benevento

Tim is awesome