Improving Lake Water Quality with Alum: The Wisconsin Experience

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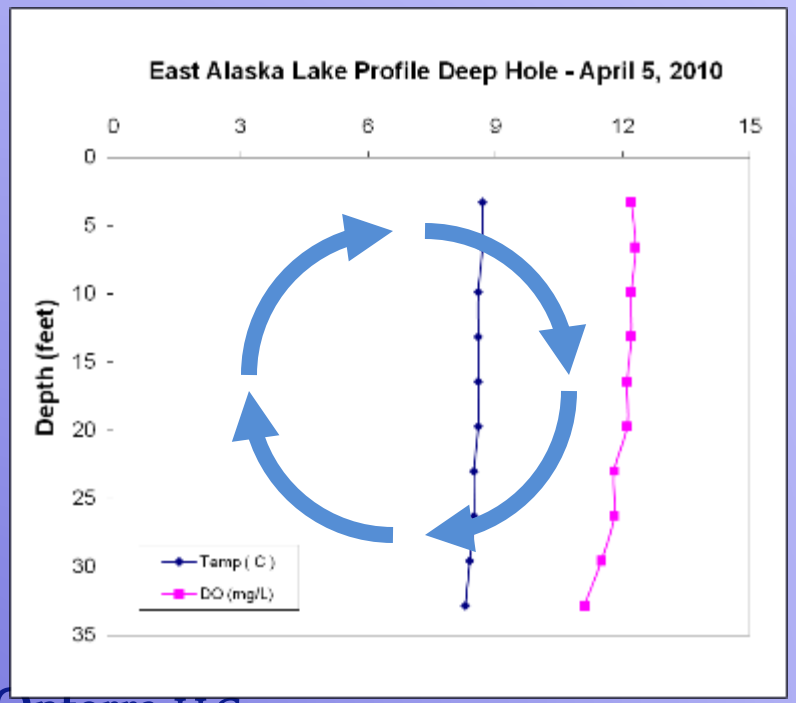
Onterra LLC
Lake Management Planning

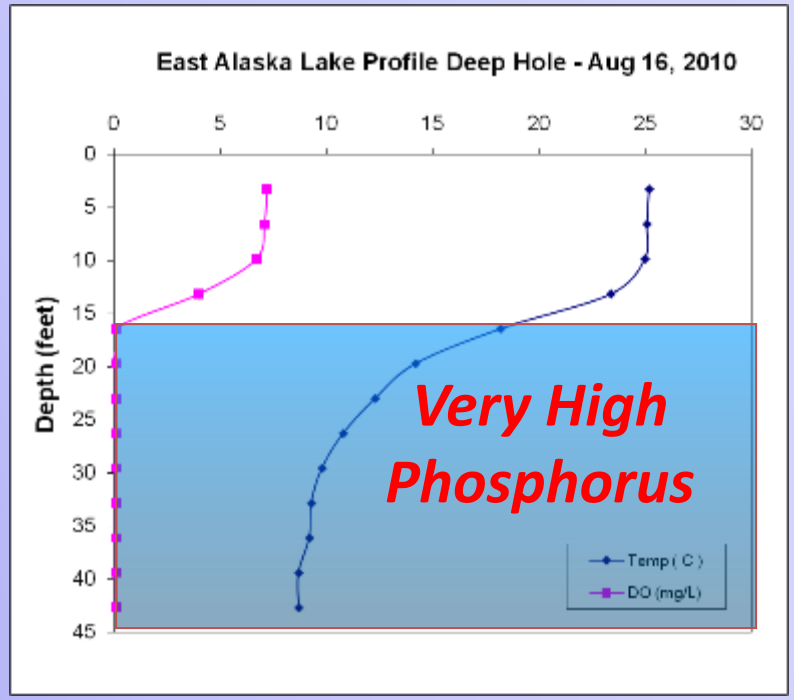
Presentation Outline

- **What is internal loading?**
- **How does an alum treatment work?**
- **How do you determine how much alum to add?**
- **How effective is an alum treatment?**
  - When is it effective?
  - When does it not work?
- **How long does a treatment last?**
- **The East Alaska Lake experience**

What is Internal Nutrient Loading?

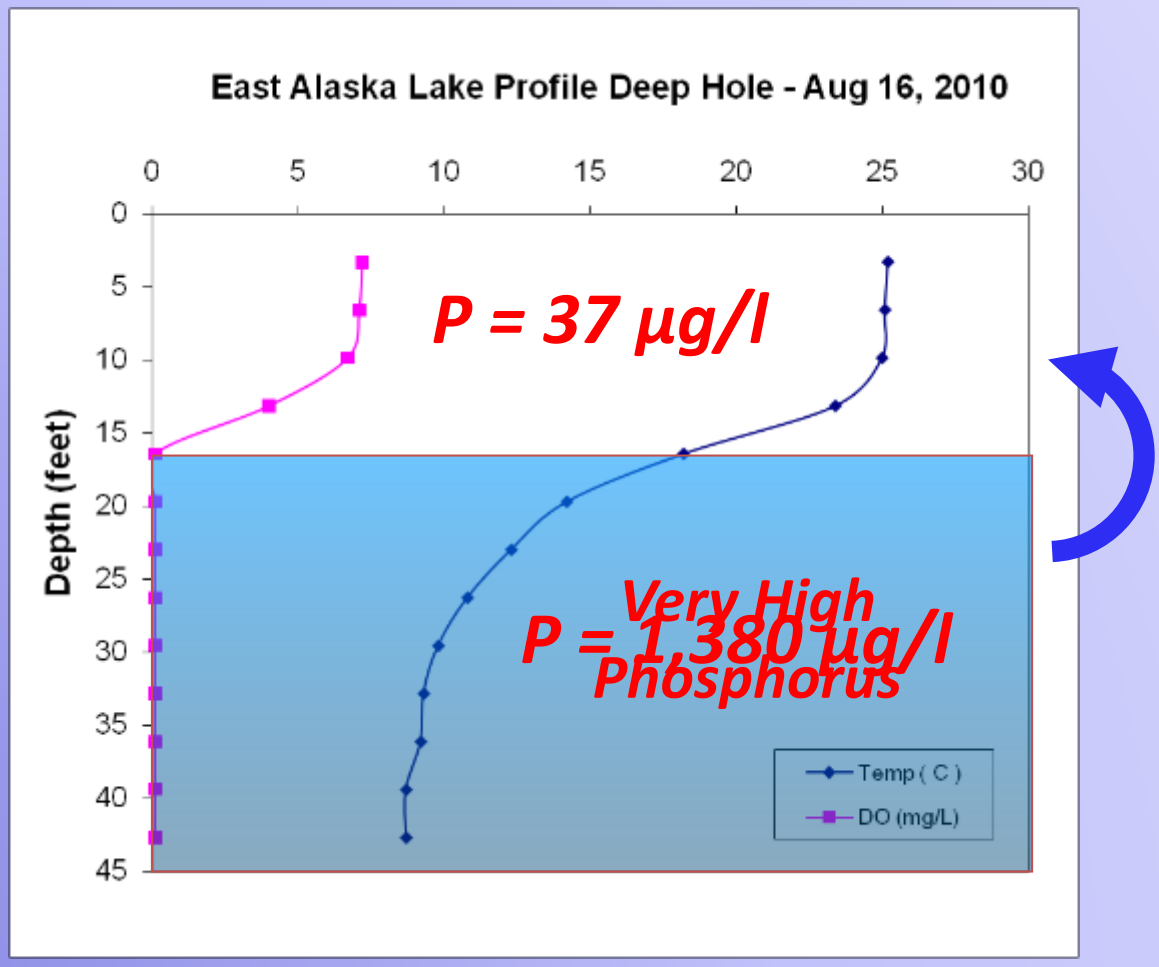
- **Chemical binding**
  - Calcium-carbonate – stable bind
  - Iron
    - Oxic conditions – binds with phosphorus
    - Anoxic conditions – releases phosphorus





What is Internal Nutrient Loading?

- High hypolimnetic phosphorus concentrations
  - Indication that internal loading is likely

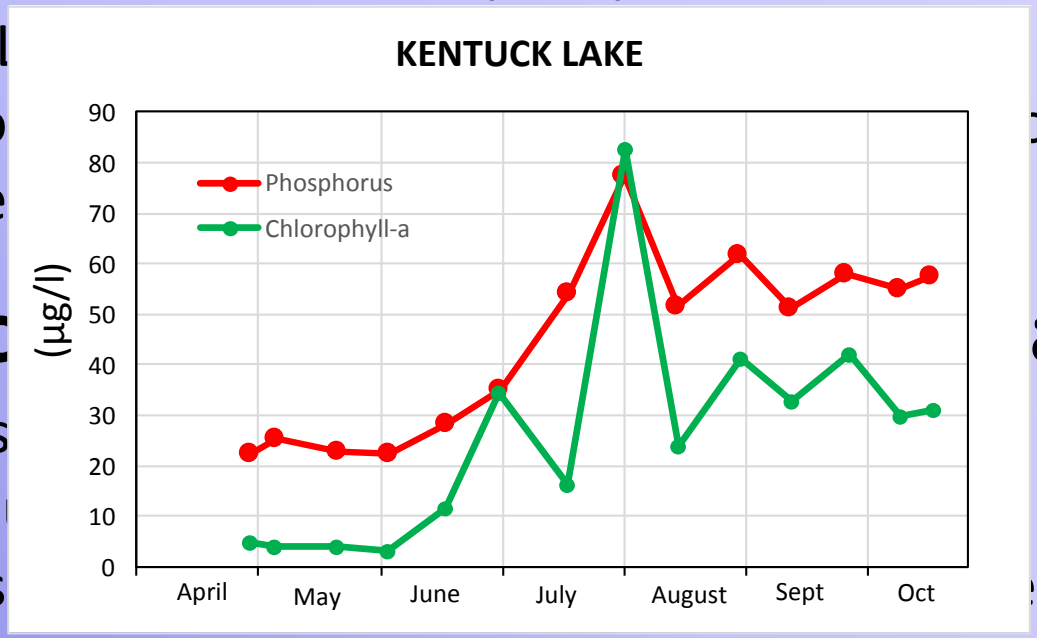


Internal Loading in Different Lake Types

- **Stratified lakes (dimictic)**
  - Lakes that only mix in the spring and fall
  - Internal load more important the following summer
- **Mixed lakes (polymictic)**
  - Lakes that mix during the summer
  - Internal load impacts the same summer

Initial Signs that Internal Loading may be Significant

- Predictive phosphorus from watershed modelling is much lower than measured lake phosphorus
- Hypolimnion is anoxic and phosphorus concentrations exceed 300 µg/l
- In shallo concentrations increase



Suspec ading

Diagnos
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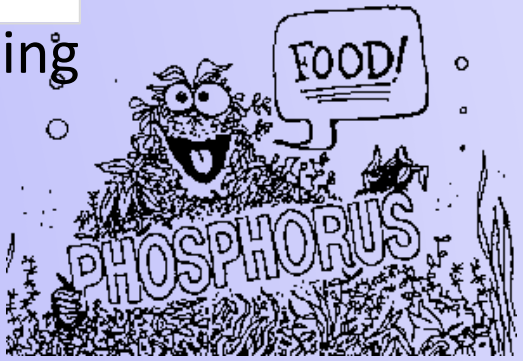
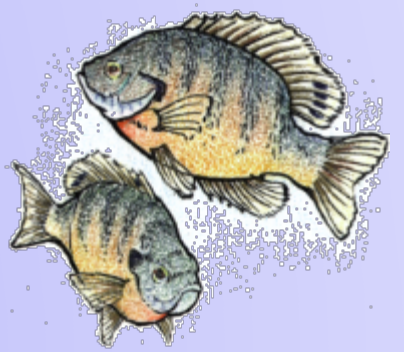
phosphorus and significance of internal loading



Alum Treatment

- **What is it?**
  - Phosphorus inactivation
    - Aluminum Sulfate Addition
      - Forms aluminum hydroxide floc
      - Floc settles to the bottom of lake "dragging" phosphorus with it.
      - Floc forms barrier to sediment phosphorus release
        - Binds sediment phosphorus



Alum Treatment

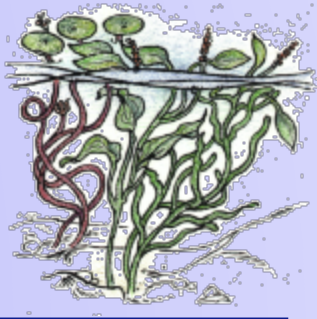
- **Aluminum toxicity**
  - Based upon pH

Also Important is a Lake's Alkalinity

- **Alkalinity is a lake's acid buffering capacity**

  A hardwater lake naturally has enough buffering capacity to prevent Al toxicity

  A softwater lake has a lower alkalinity which means it has less capacity to buffer the acidic alum. A base, sodium aluminate is added



Sediment Phosphorus

- **One large source of internal loading is the lake sediments**

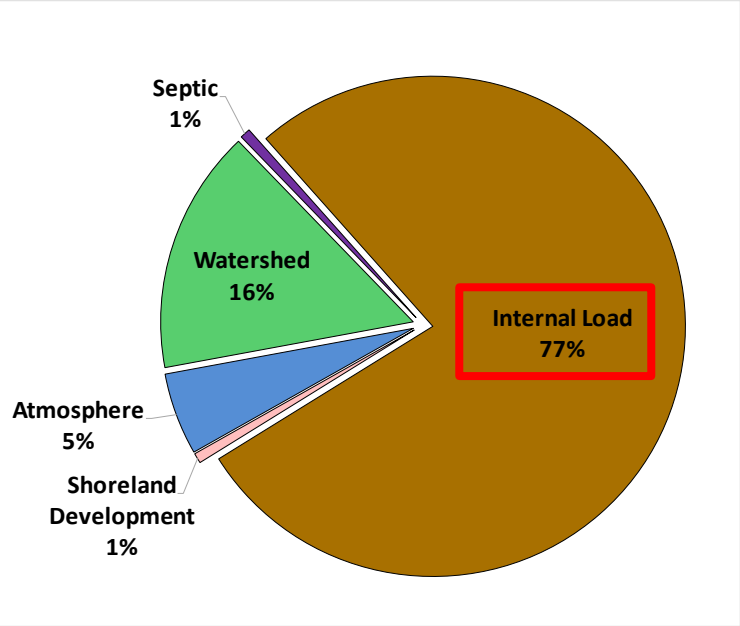
- **The amount of internal loading is dependent upon the amount of different forms of sediment phosphorus**
  - Calcium bound phosphorus not a problem
  - Organic phosphorus can slowly become available
  - Iron bound phosphorus very mobile

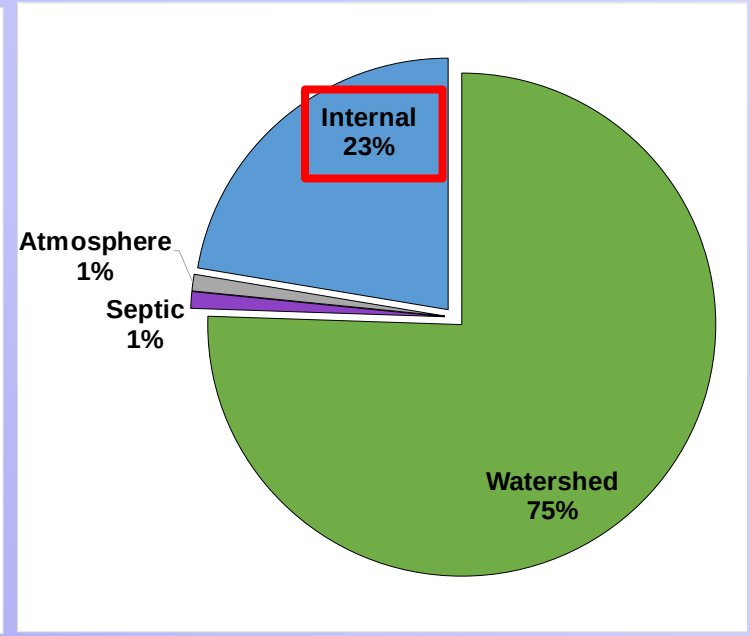
How Much Alum to Apply?

- Progression of more accurate dosing
  - Jar tests
  - Past project experiences
  - Dosing based upon mobile phosphorus in the sediments

What Lakes are Good Candidates?

- **Phosphorus budget is important**
- **Minimize the external load**





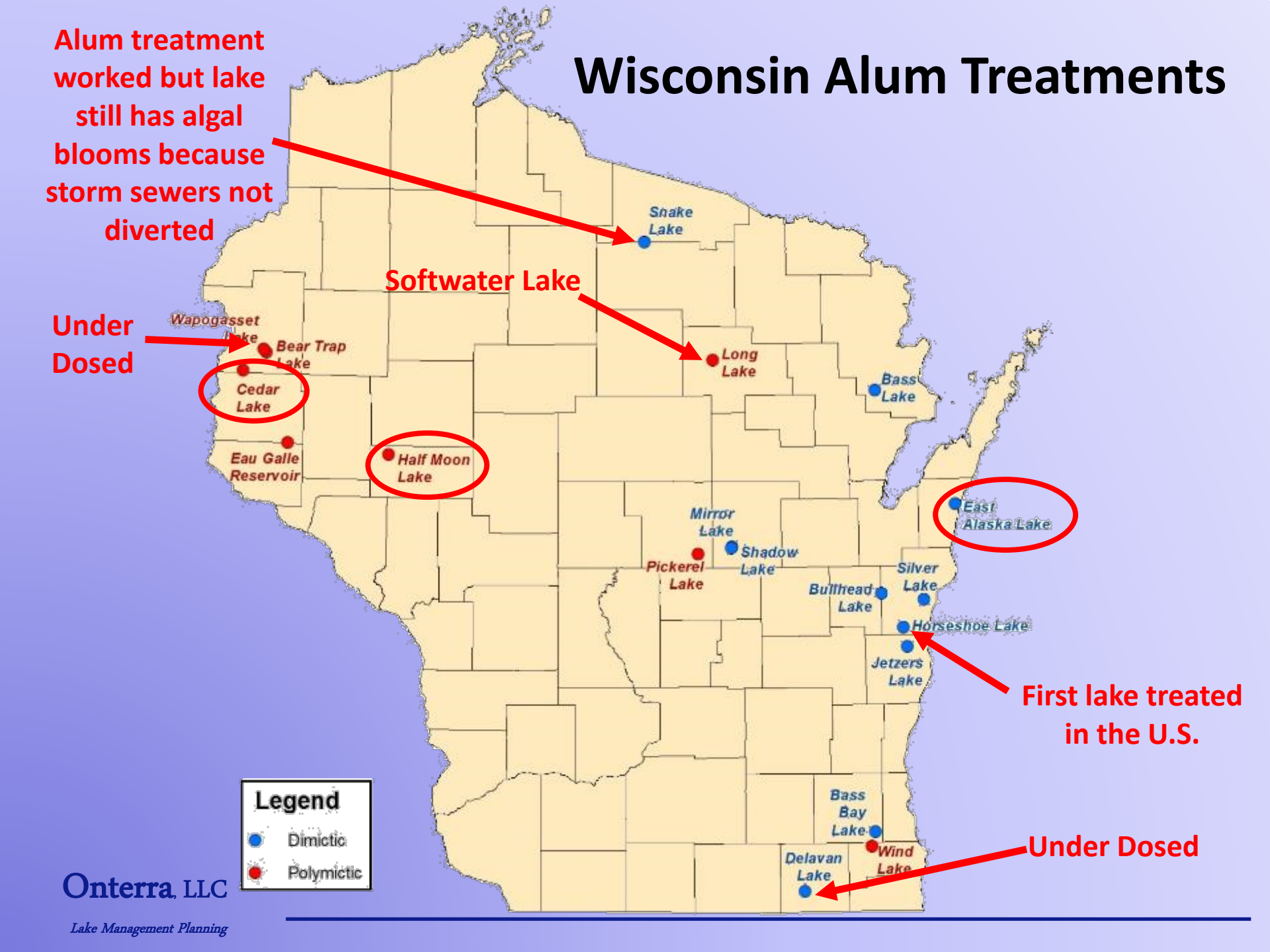
Good Candidate Not Good Candidate

How Long Does a Treatment Last?

- **Huser et al. ke treatments**
  - Mean long) -- 21 years
  - Mean long ictic) -- 5.7 years

- **Main fact**
  - Correct do actor
  - Dimictic la polymictic lakes
  - Lakes with ger because generally l s enter the lake
  - Moderate ivorous fish shorten th

Wisconsin Alum Treatments



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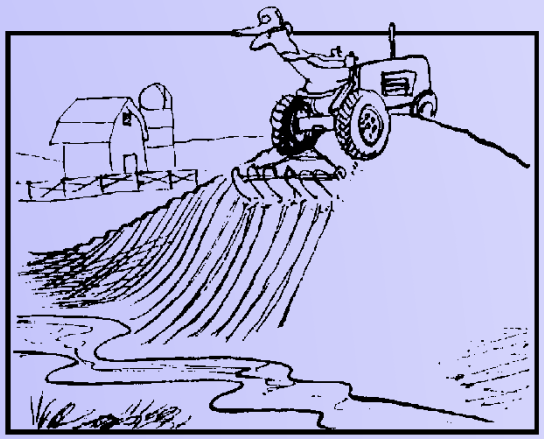
Lake Management Planning

EAST ALASKA LAKE

Kewaunee County

Historic Overview

- **1999 Management Planning Study**
  - Baseline studies to understand lake ecosystem
  - Determined lake was productive because of past and present impacts
    - ✓ Agricultural runoff
    - ✓ Septic systems
    - ✓ Cheese factory discharge
    - Internal loading?



Historic Overview

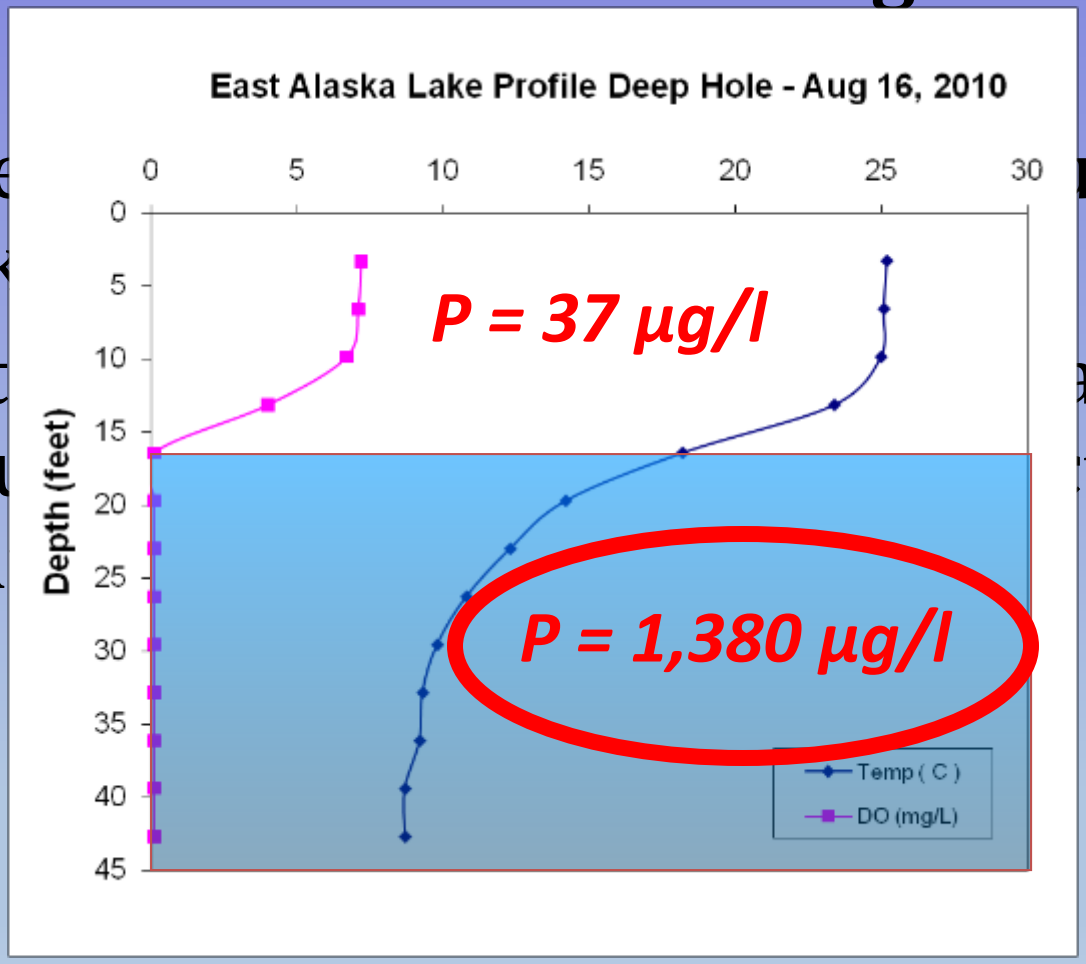
- **2005 Alum Treatment Feasibility Study**
  - Measured hydraulic and phosphorus loads entering from inlet (West Alaska outlet) and draintile outfall.

Historic Overview

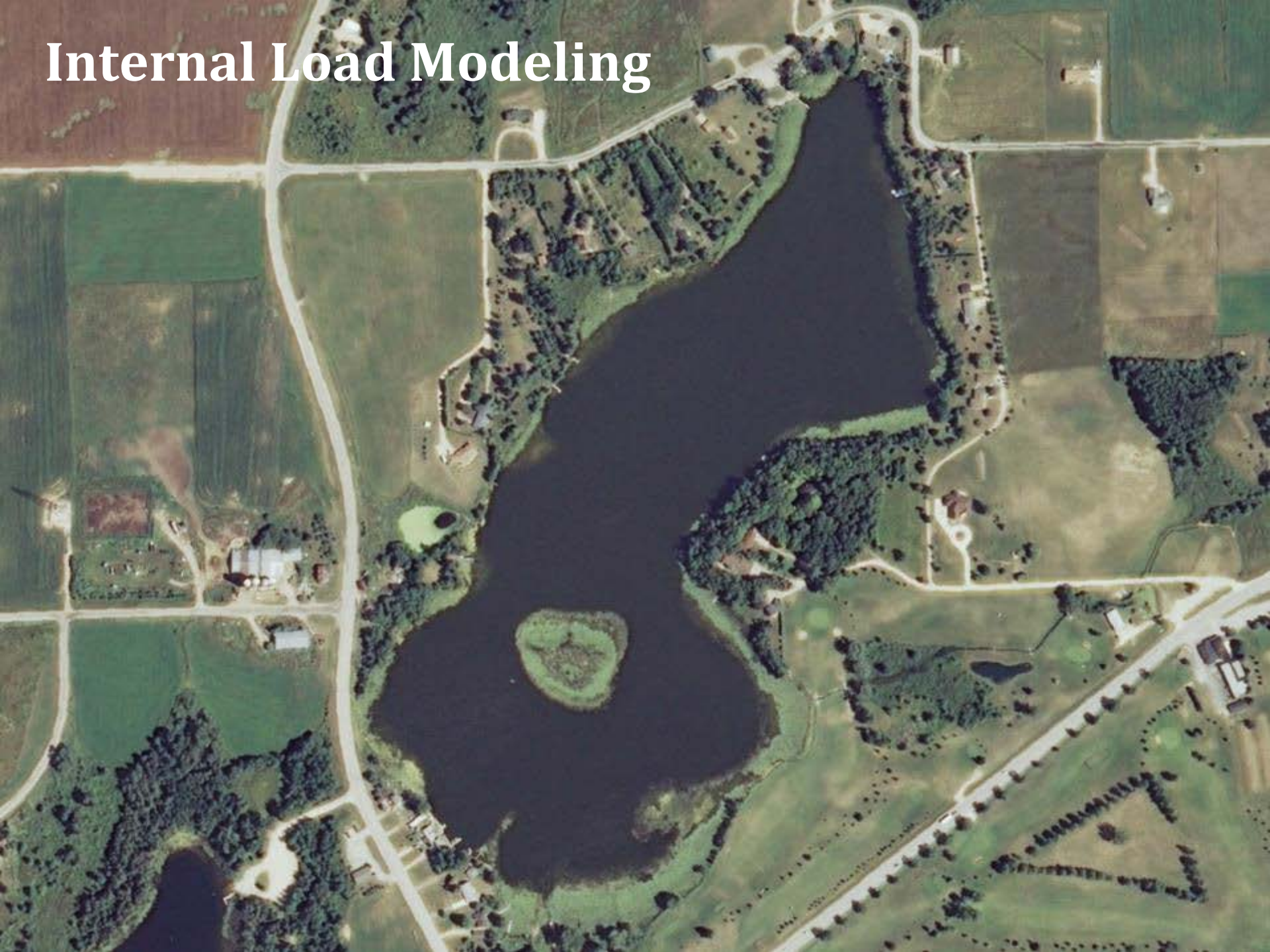
- **2005 Alum Treatment Feasibility Study**
  - Modeled internal phosphorus loading and found it to be significant
  - Overall: Lake not ready for alum treatment
  - Recommended:
    - ✓ Septic inspections and corrections
    - ✓ Construction of sedimentation basin to minimize draintile inputs

Alum Treatment

- **Would an alum treatment be good for East Alaska**
  - Mode… …lt on East Alask…
  - Must… …akes it into u… …ts water quali…



Internal Load Modeling



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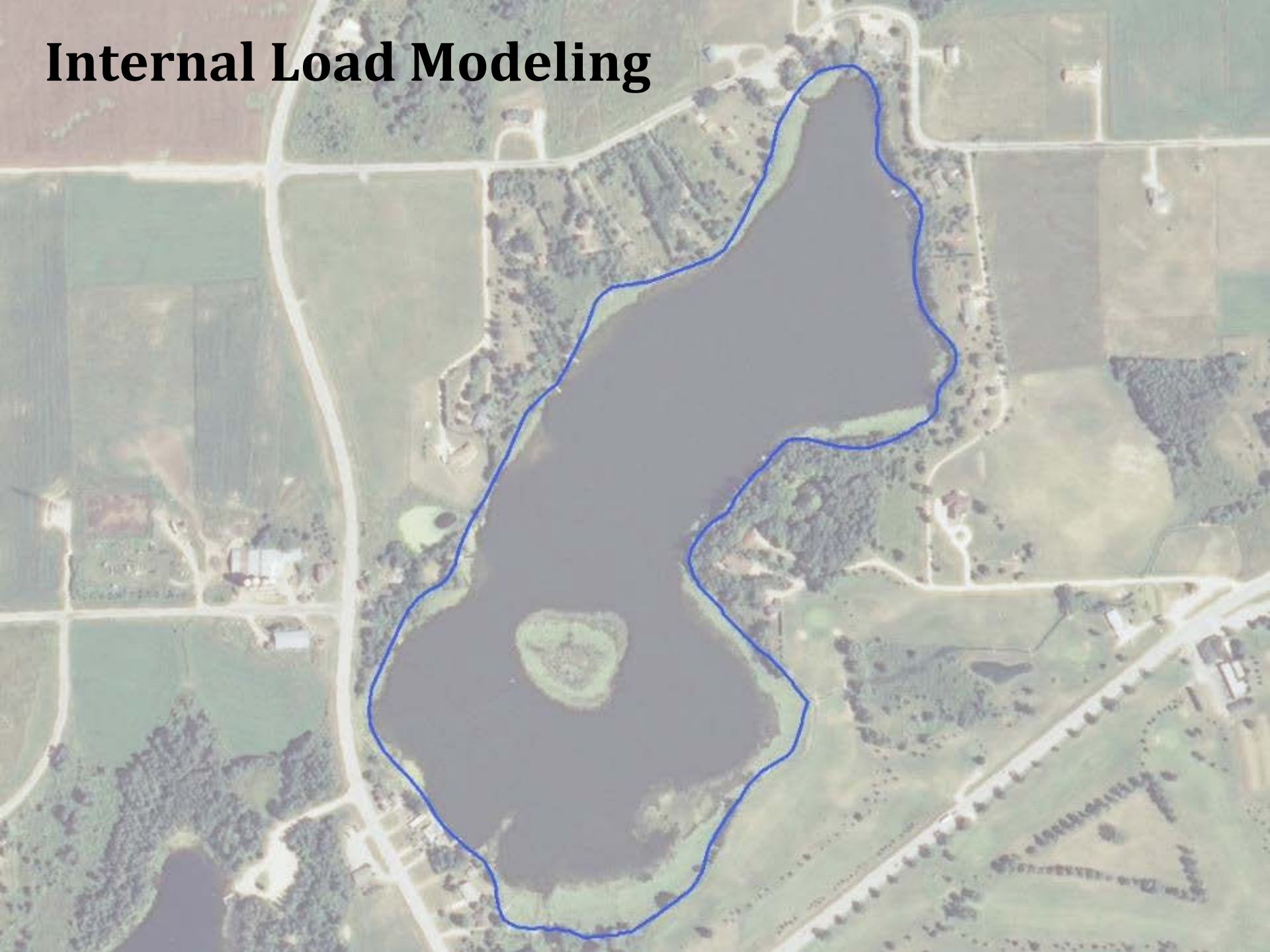

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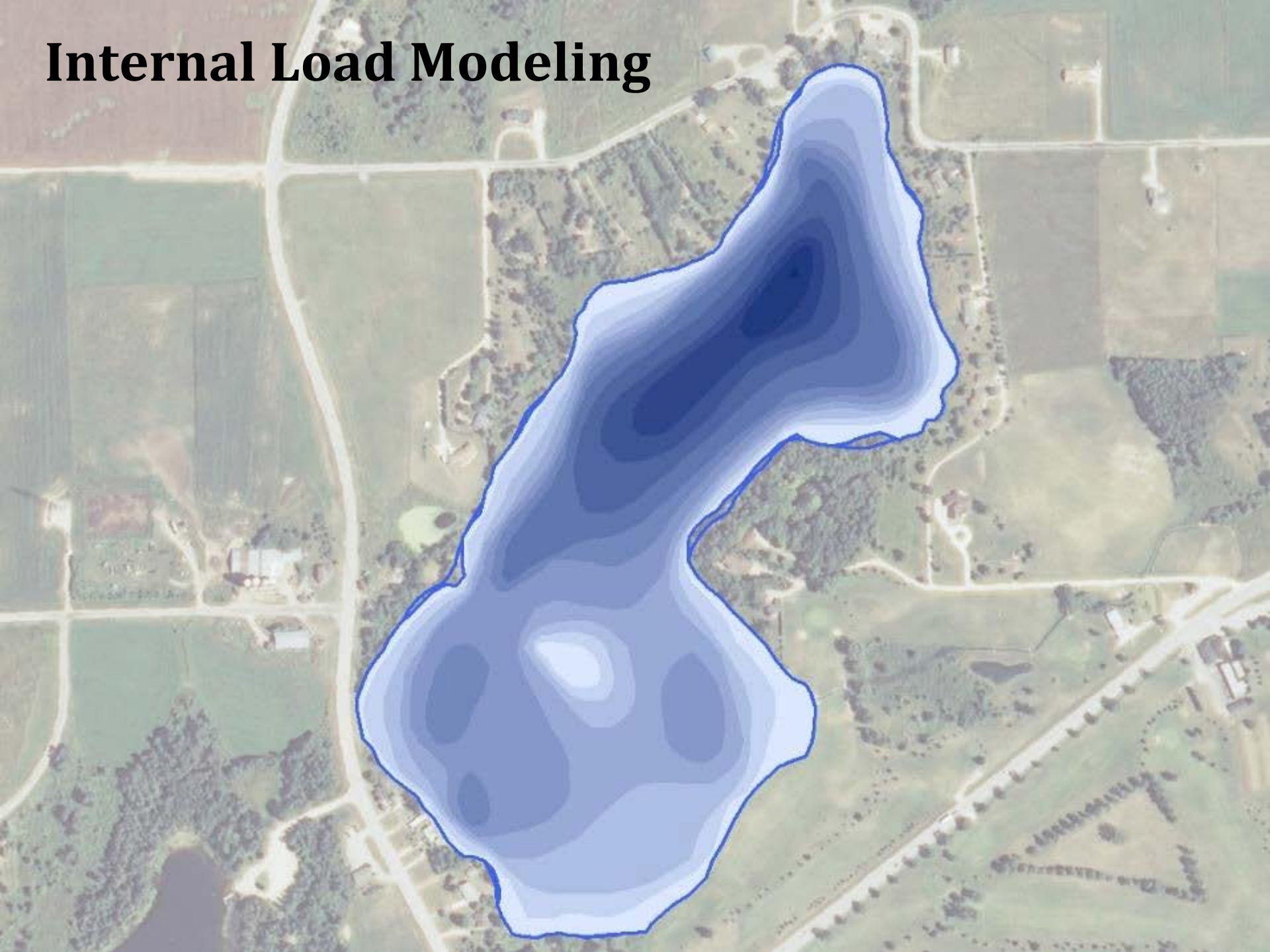
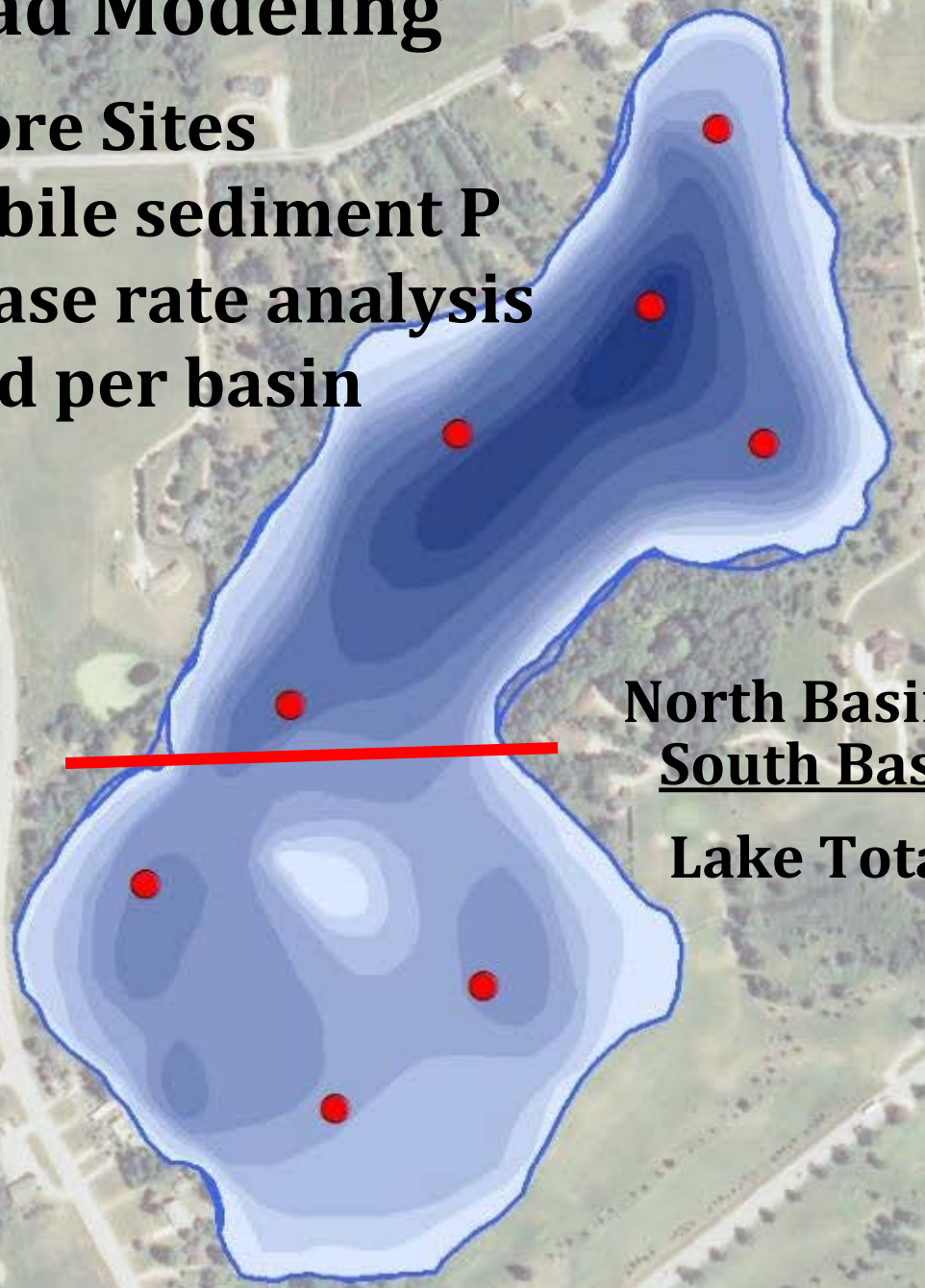


Internal Load Modeling

8 Sediment Core Sites
Measured mobile sediment P
Each had release rate analysis
Estimated load per basin



North Basin: 88 lbs/yr
South Basin: 7 lbs/yr

Lake Total: 95 lbs/yr

Alum Treatment

Would an alum treatment be good for East Alaska Lake?

Internal Load Modelling

2004-2010 In-lake Summer Phosphorus Average : 37 µg/l

	External Load (lbs)	Internal Load (lbs)	In-lake P Ave (µg/l)	Secchi Ave (Feet)
Original	77	95	37	4.0
Predicted after Alum Treatment				
90% Int. Load Reduction	77	9.5	23	7.3

Increase Secchi disk by 3.3 on average

Treatment Cost

Recommended Treatment

Treat 10' and deeper

Dose to bind 90% of Phosphorus in top 10cm of sediment

Cost: $125,000

Secondary Treatment

Treat between 5'-10'

Reduce phosphorus available to filamentous algae

Cost: $40,000

Total Cost: $165,000

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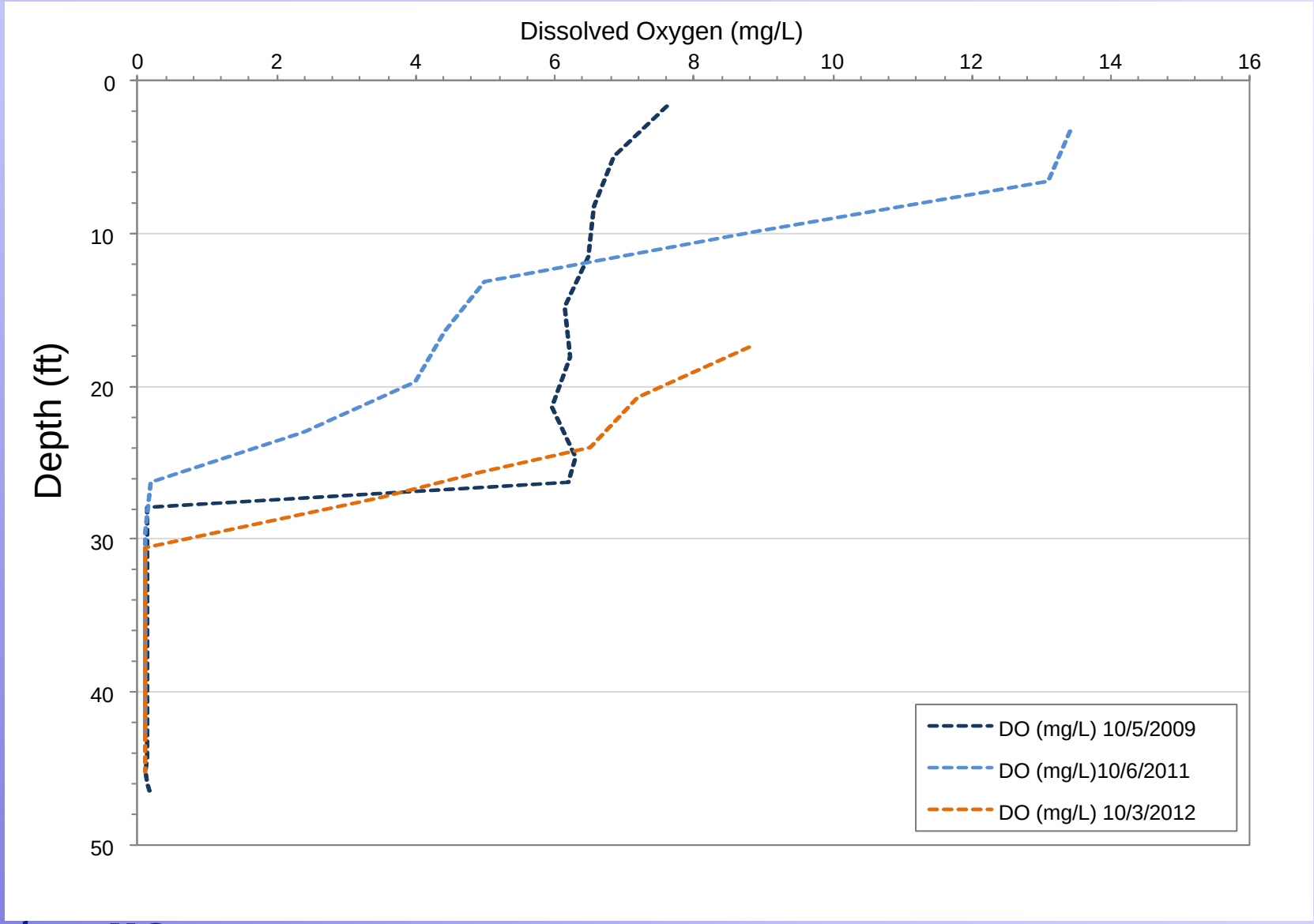
Lake Management Planning

Alum Applied October 2011

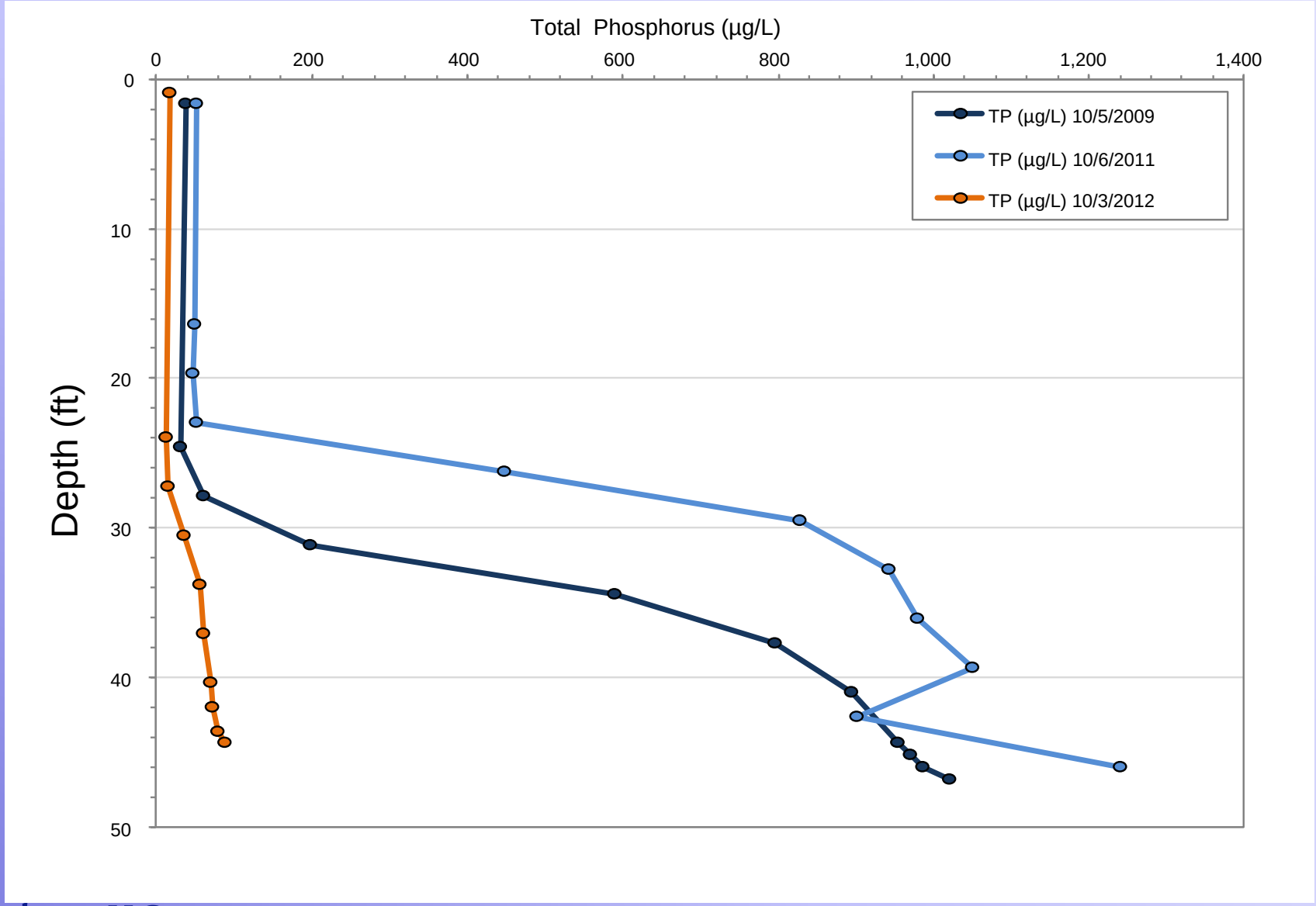
Alum Applied October 2011

Alum Layer in Sediment Core One Year Later

Alum Treatment Results



Alum Treatment Results



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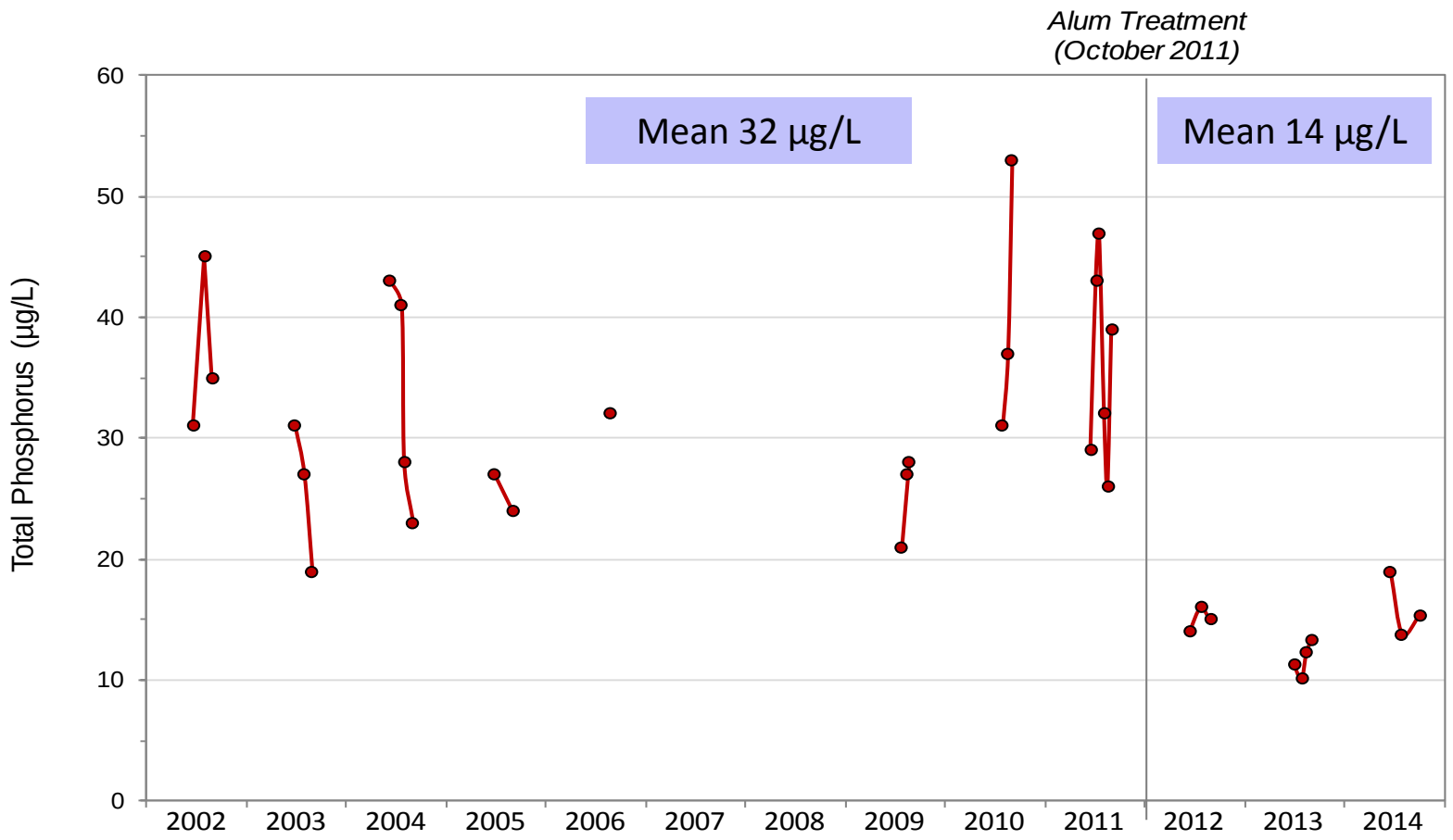

Thank You

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