Long-Term Ecological Responses to Alum Treatment in Spring Lake, Michigan

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Internal vs. External Phosphorus Loads

External Phosphorus Loading:

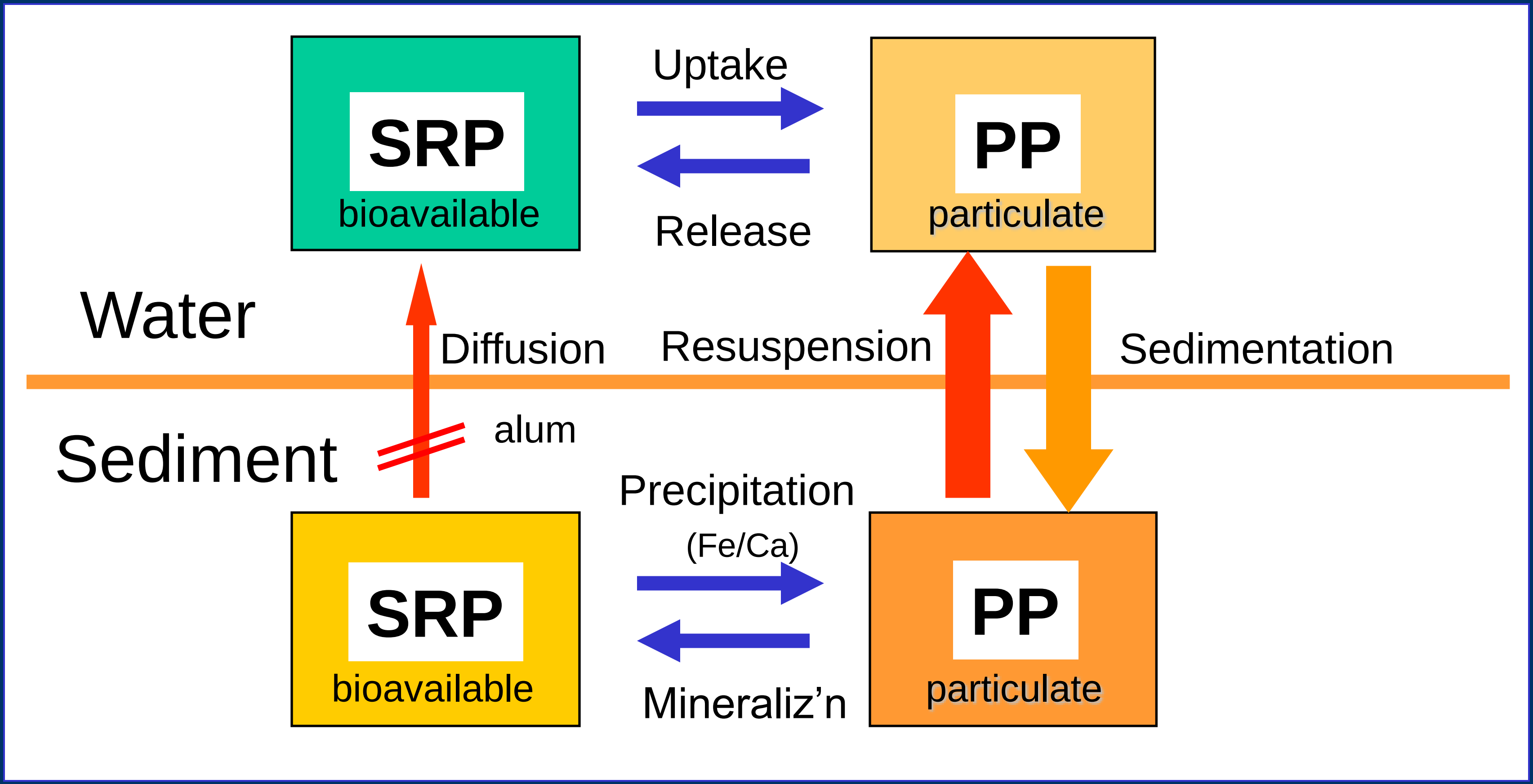
Phosphorus entering surface waters that originates outside the water body (watershed, atmosphere)

Internal Phosphorus Loading:

Release of P from sediments

1) diffusion of soluble phosphorus from sediments during periods of anoxia
2) resuspension-driven processes whereby soluble P is desorbed from particulate matter or released from the pore water

Sediment-Water Interactions



Alum as a Management Tool

Highly effective P inactivation

- Formation of insoluble precipitate
- AlOH floc adsorbs P

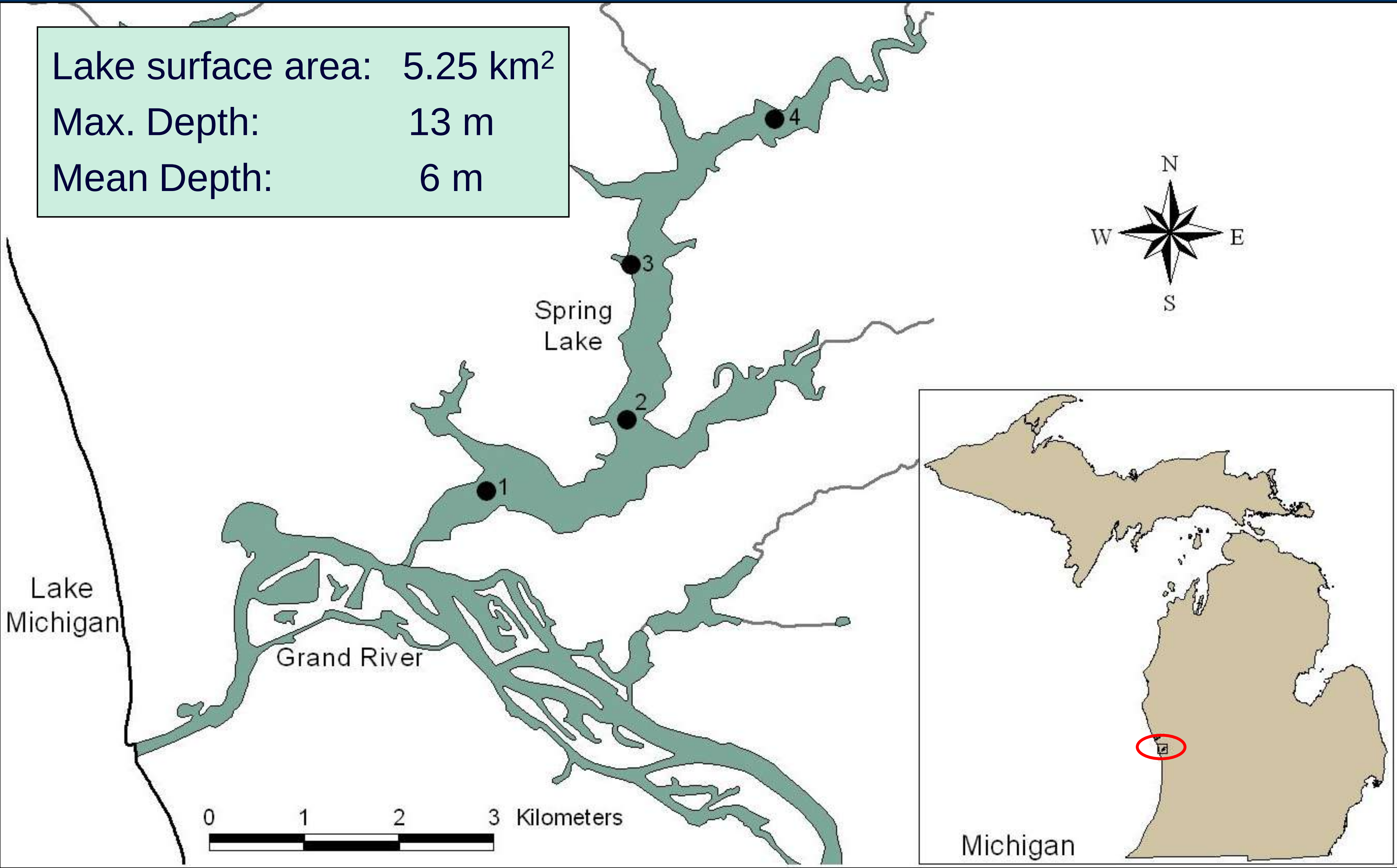
Longevity of treatment varies

- 4-20 years?
- Simultaneous control of <u>external</u> loading is essential

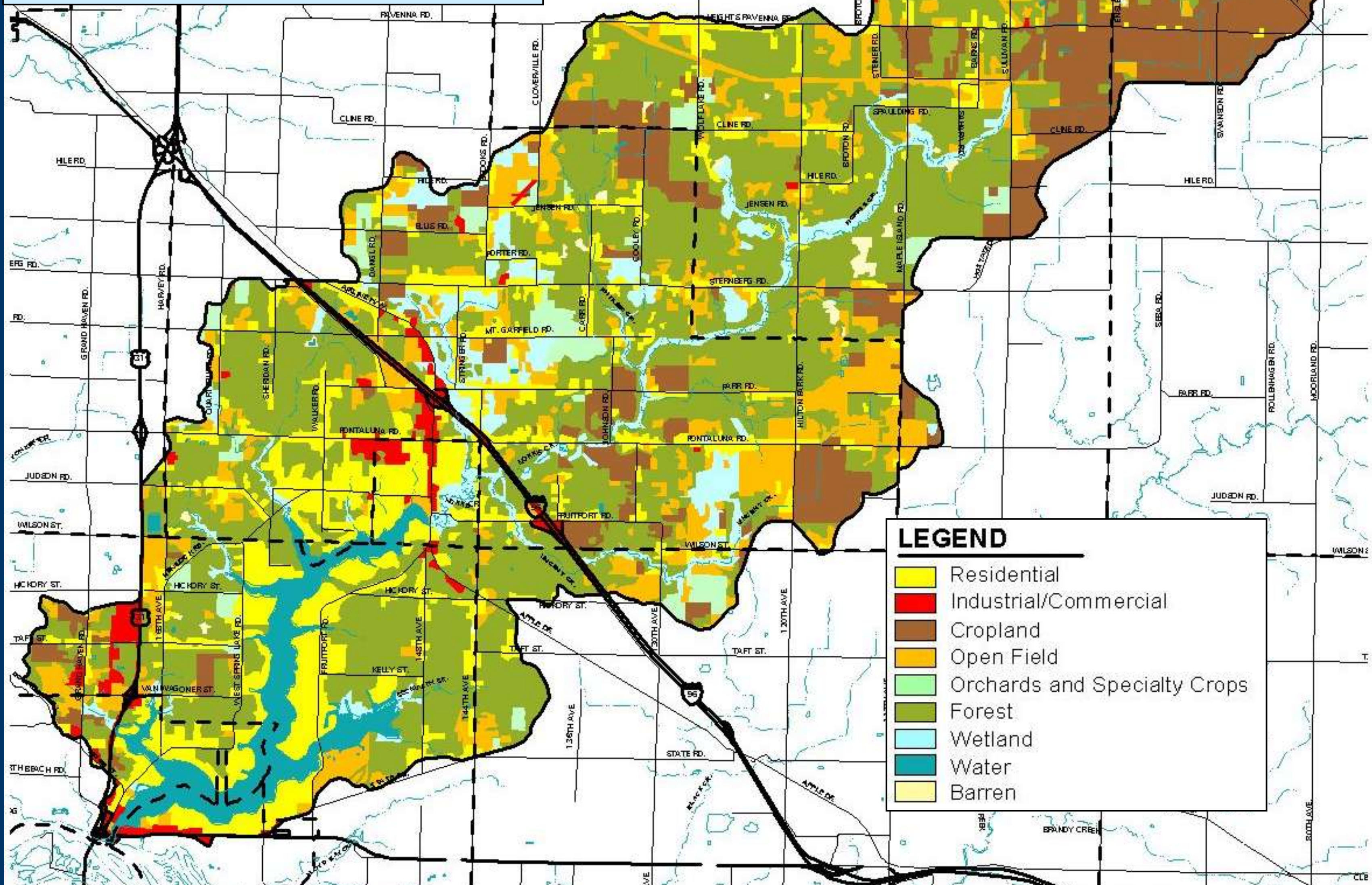
Lake surface area: 5.25 km^2

Max. Depth: 13 m

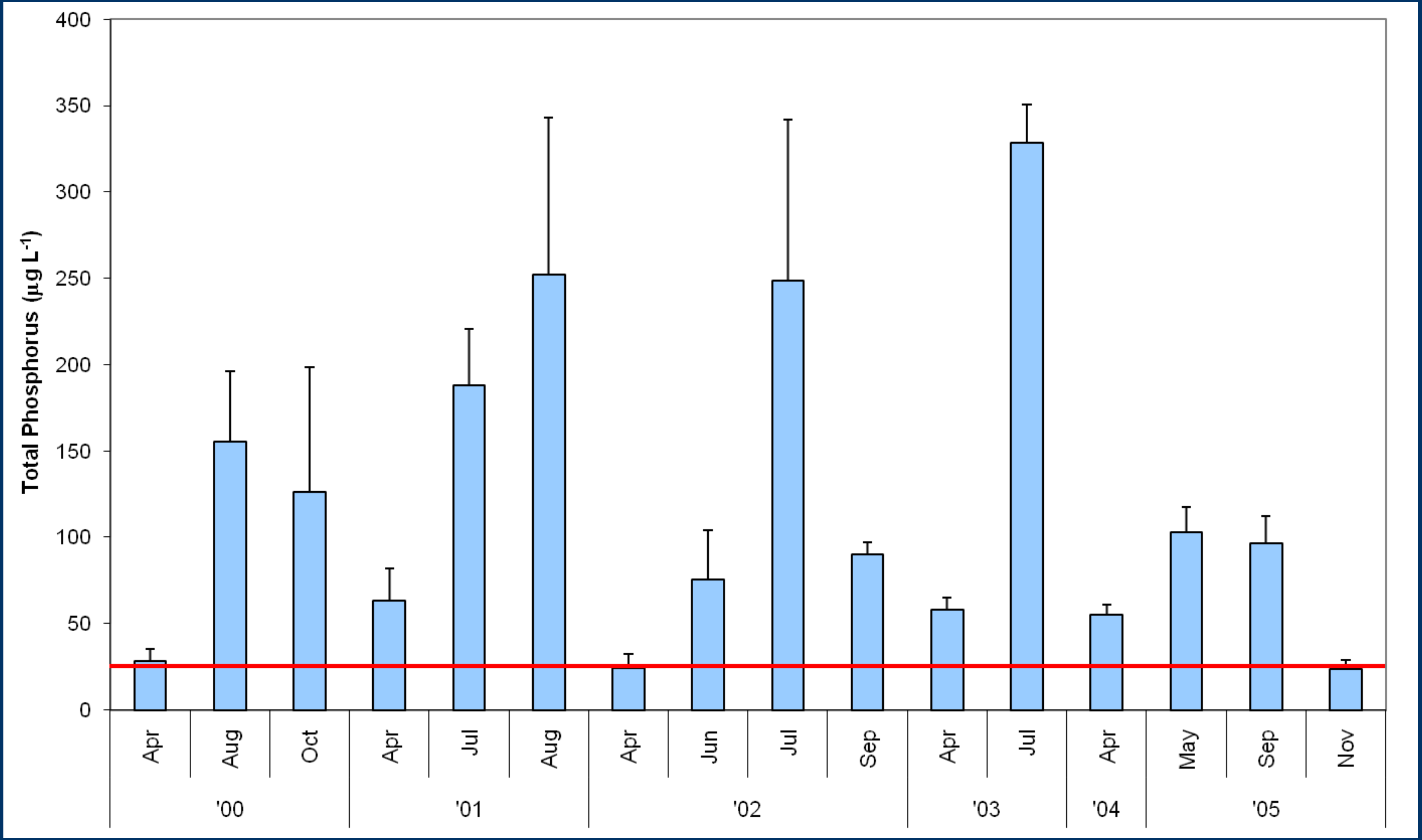
Mean Depth: 6 m



Agriculture	**18%**
Forested/Undeveloped	**57%**
Wetlands	**6%**
Urban	**19%**



Total Phosphorus: Spring Lake



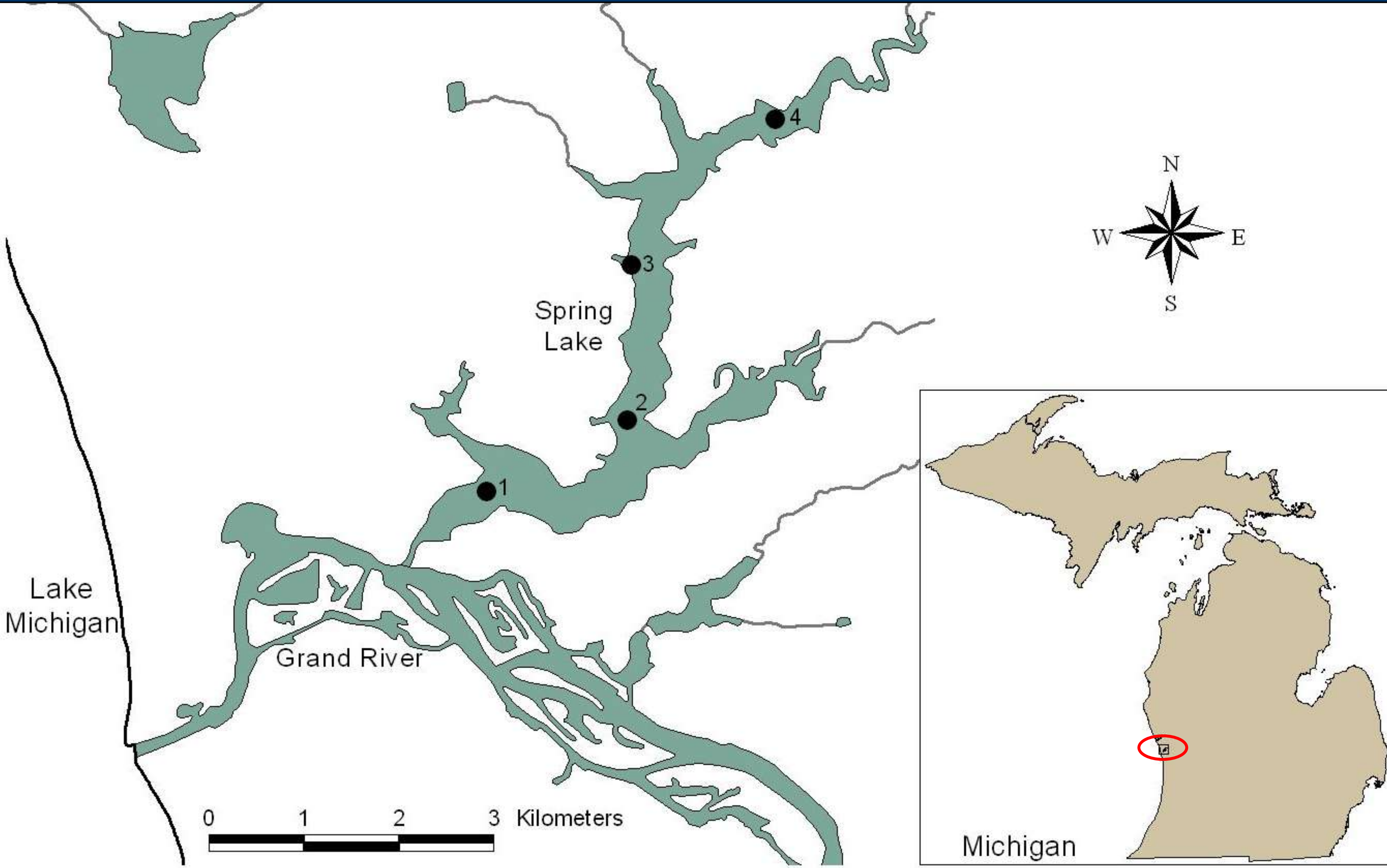
Source: Progressive AE

Objectives:

Experiment 1: 2003-2004

Before field application of alum

- Compare internal vs external P loading rates
- Determine the effectiveness of alum in reducing internal P loading
- Based on lab studies, assess whole-lake alum application


4
3
Spring
Lake
2
1
N
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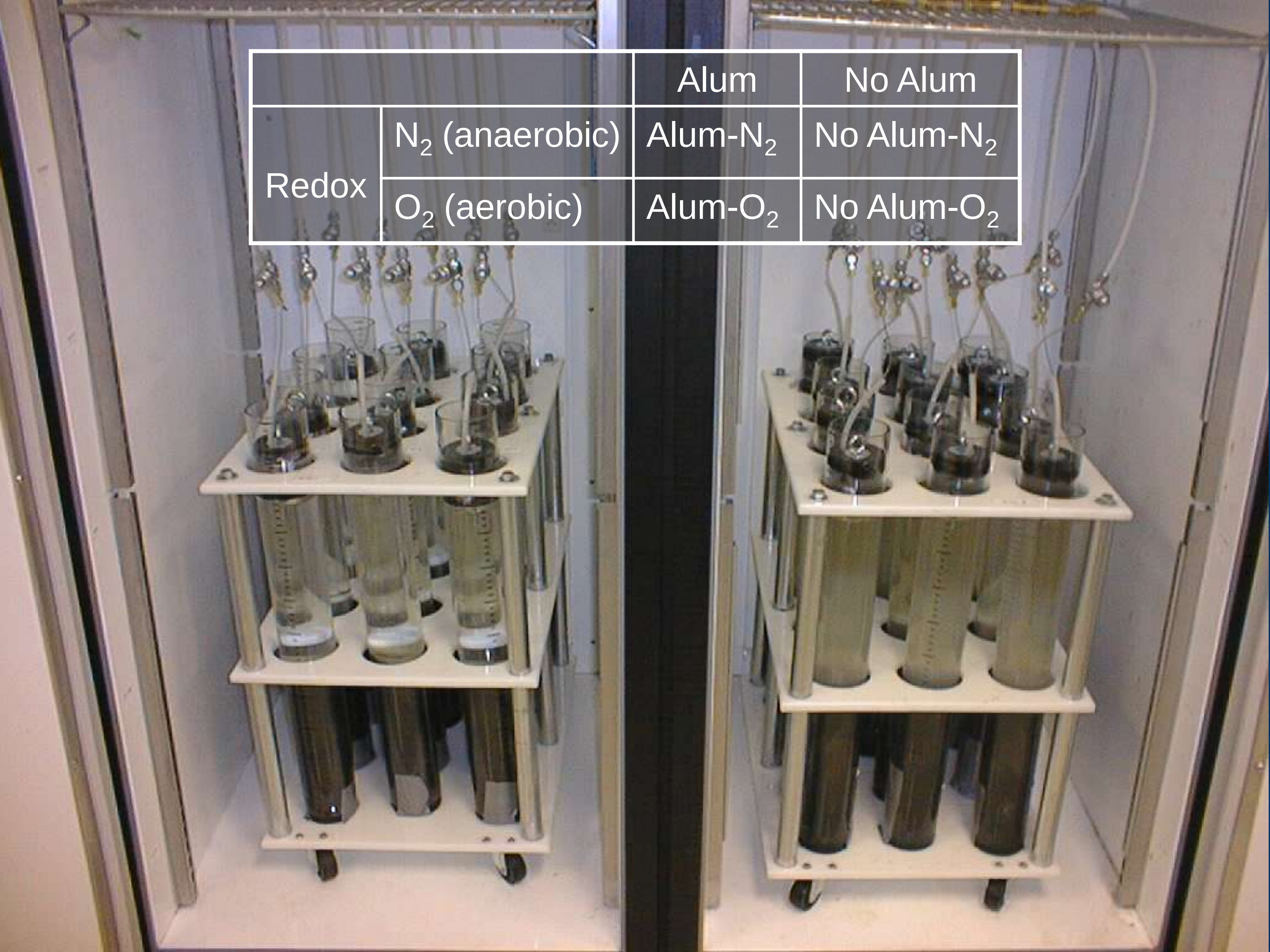
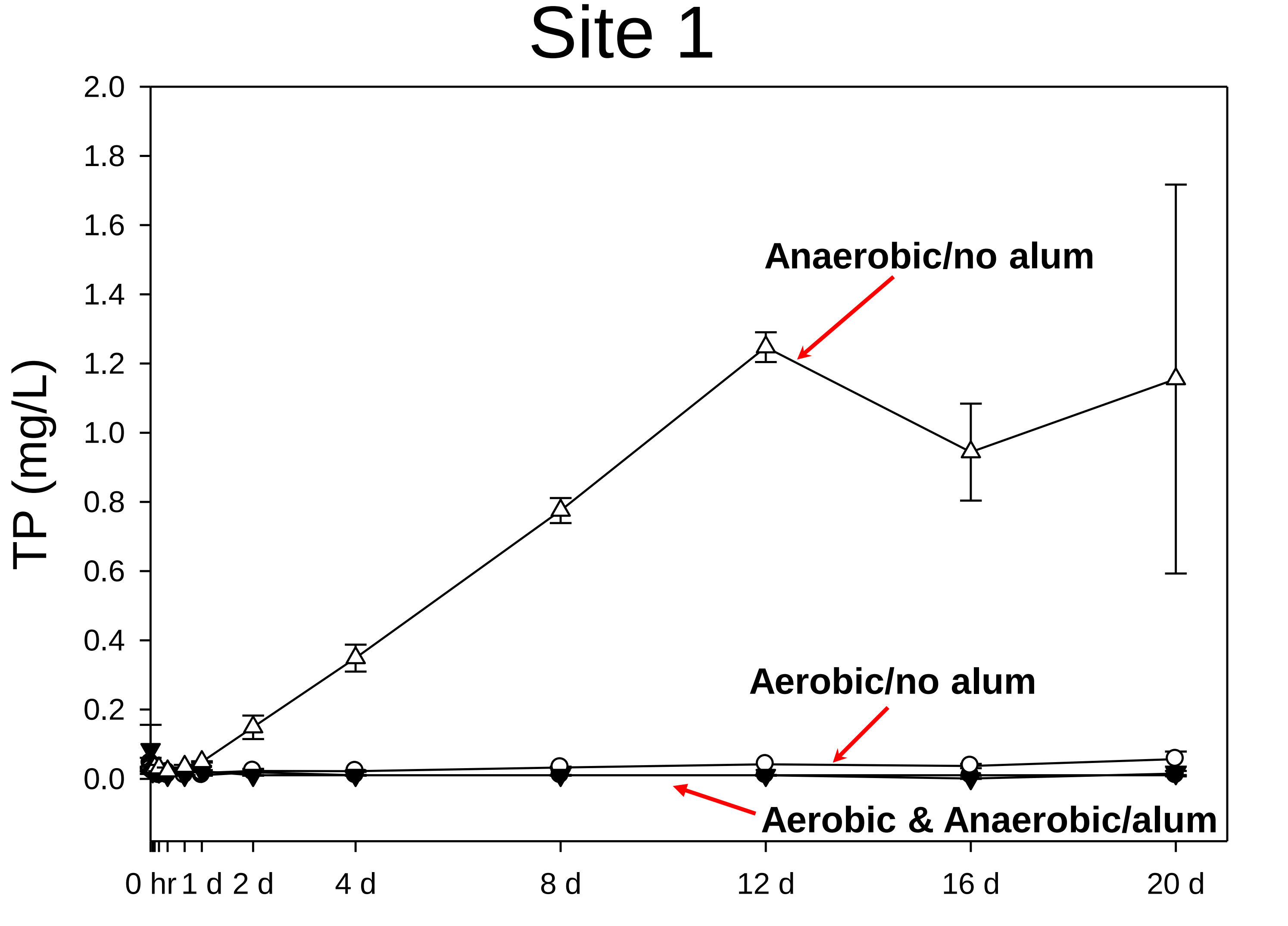
E
S
Lake
Michigan
Grand River
0
1
2
3
Kilometers
Michigan



		Alum	No Alum
Redox	N_2 (anaerobic)	Alum-N_2	No Alum-N_2
	O_2 (aerobic)	Alum-O_2	No Alum-O_2

TP Release from Sediment Cores

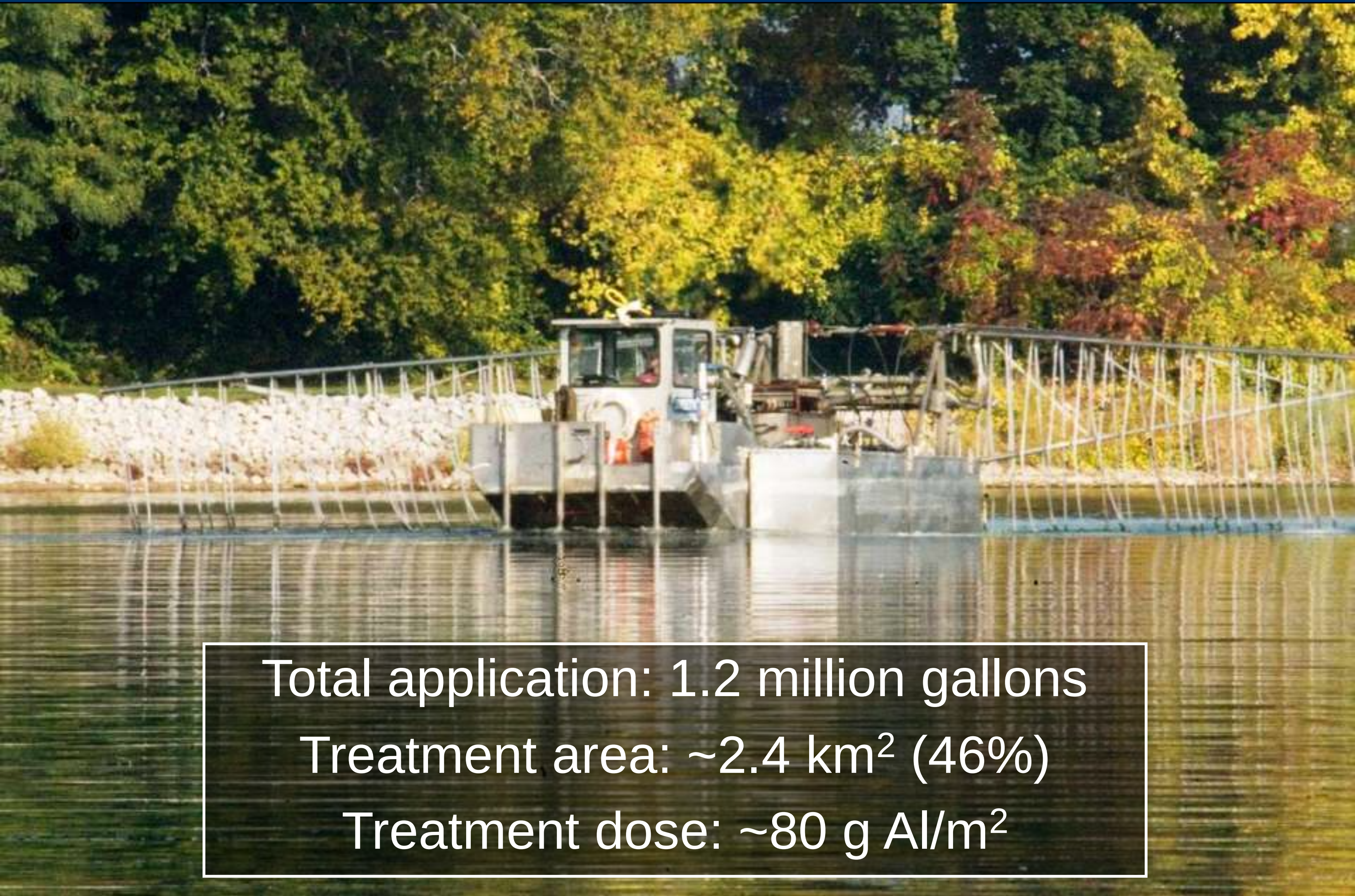


Steinman et al. 2004

TP Load Estimates

External Load*	2.2-4.7 tons yr^{-1}
Mean Internal Load**	2.7-6.4 tons yr^{-1}
Internal:Total Load **	55-67%

*Lauber 1999
**Steinman et al. 2004



Total application: 1.2 million gallons

Treatment area: ~2.4 km^2 (46%)

Treatment dose: ~80 g Al/m^2

Objectives:

Experiment 2: 2006

<u>1 year after</u> alum treatment

- Measure short-term internal P release rates
- Evaluate the short-term ecological effects

Experiment 3: 2010

<u>5 years after</u> alum treatment

- Measure long-term internal P release rates
- Evaluate the long-term ecological effects

Maximum TP Release Rates (mg P m^{-2} d^{-1})
- Anaerobic Cores -

Site	Pre-alum*	1 y after**	5 y after
1	29.54		
2	17.33		
3	13.33		
4	11.67		

* Steinman et al. 2004
** Steinman and Ogdahl 2008

Maximum TP Release Rates (mg P m^{-2} d^{-1}) - Anaerobic Cores -

Site	Pre-alum*	1 y after**	5 y after
1	29.54	0.33	
2	17.33	0.88	
3	13.33	0.49	
4	11.67	-0.05	

* Steinman et al. 2004
** Steinman and Ogdahl 2008

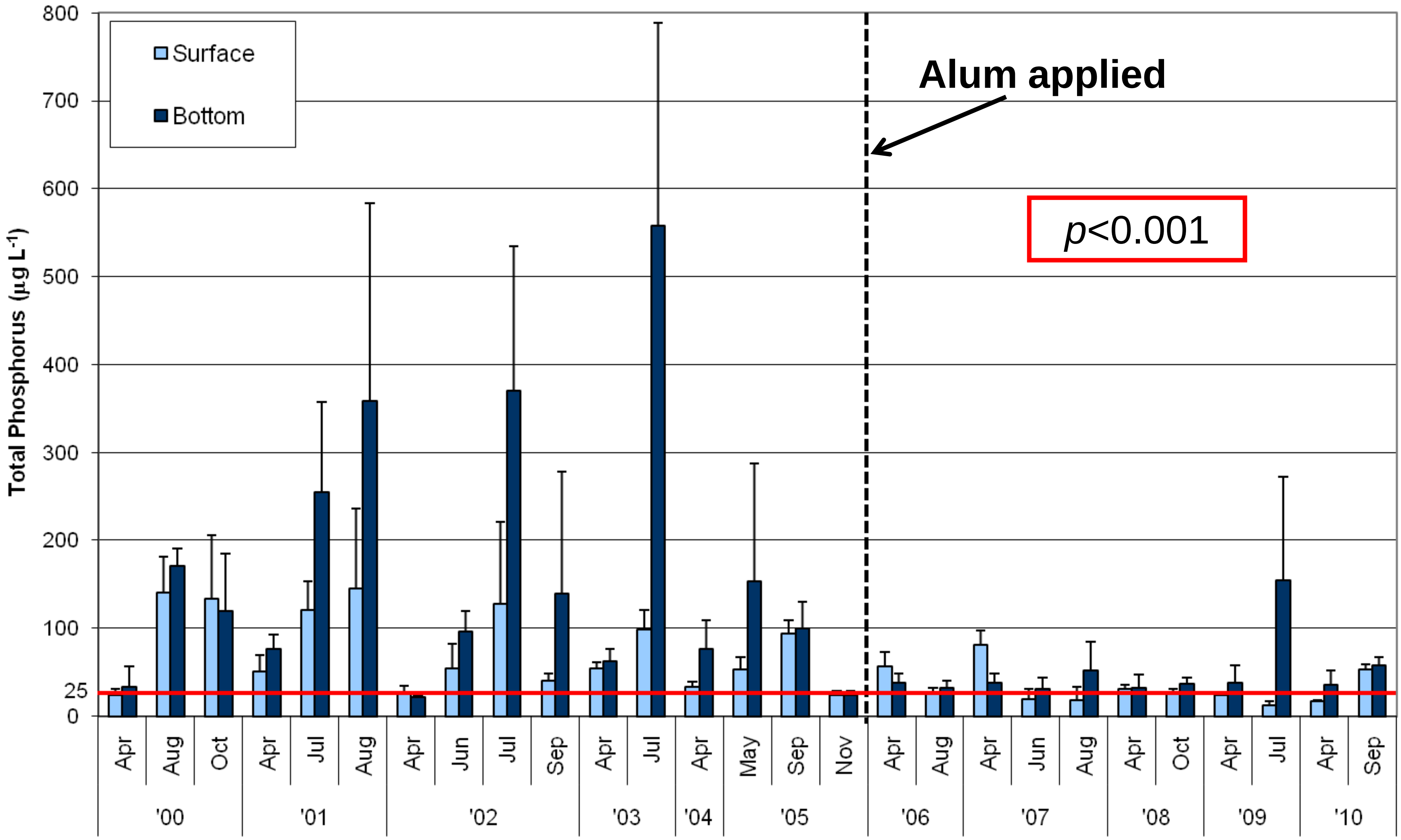
Maximum TP Release Rates (mg P m^{-2} d^{-1}) - Anaerobic Cores -

Site	Pre-alum*	1 y after**	5 y after
1	29.54	0.33	2.81
2	17.33	0.88	1.68
3	13.33	0.49	2.33
4	11.67	-0.05	2.25

* Steinman et al. 2004

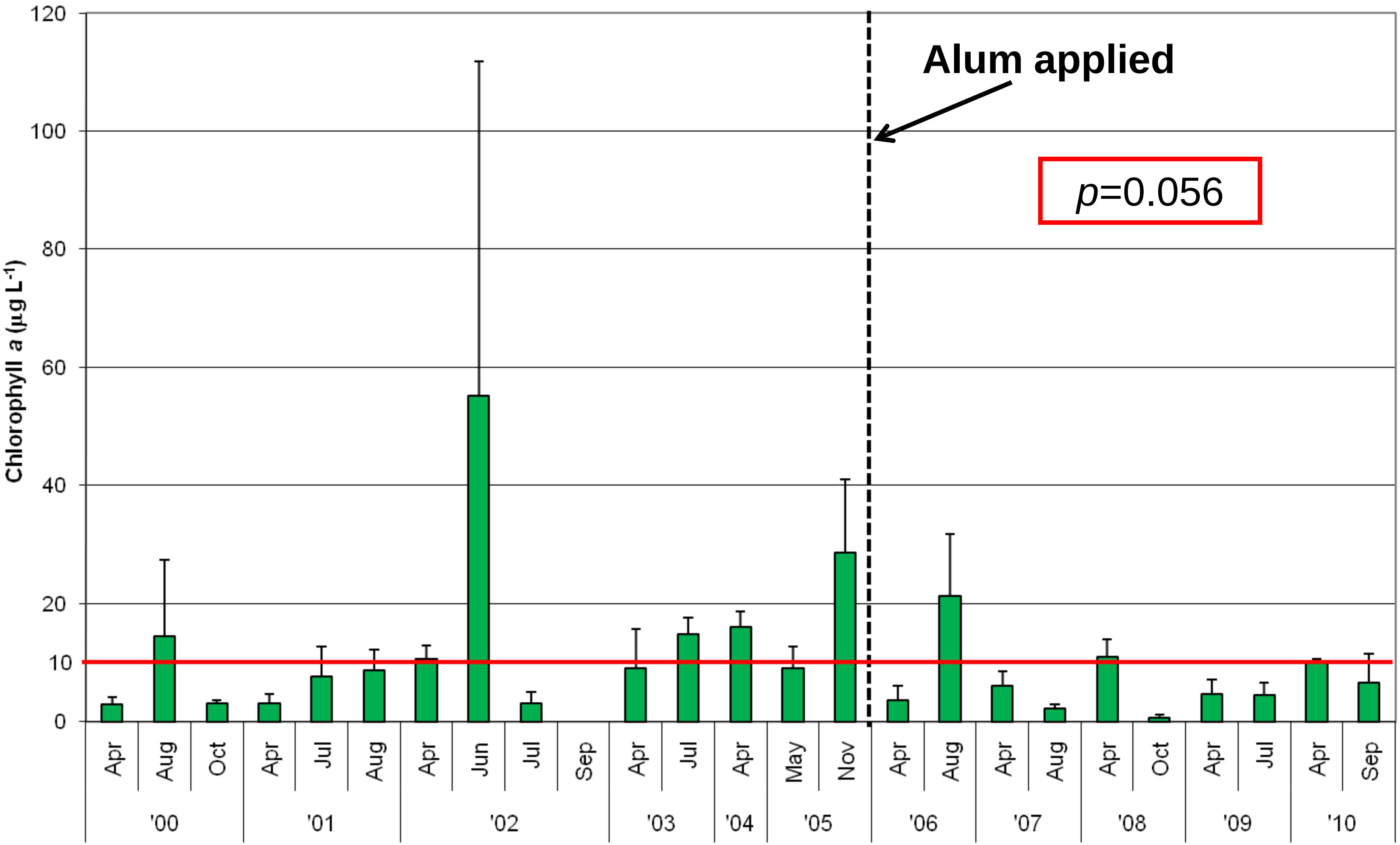
** Steinman and Ogdahl 2008

Total P: Before vs. After Alum



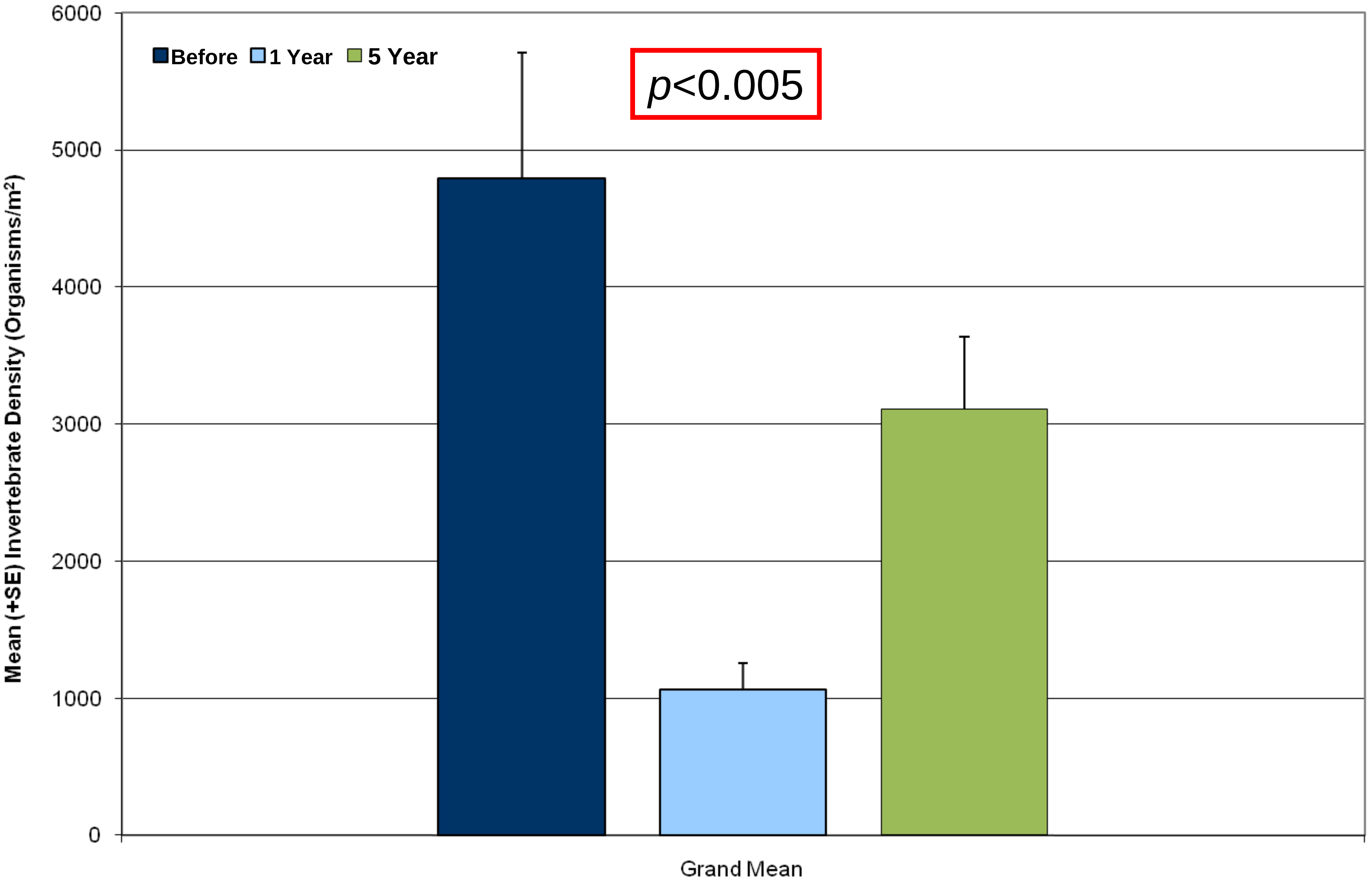
Source: Progressive AE

Chlorophyll *a*: Before vs. After Alum

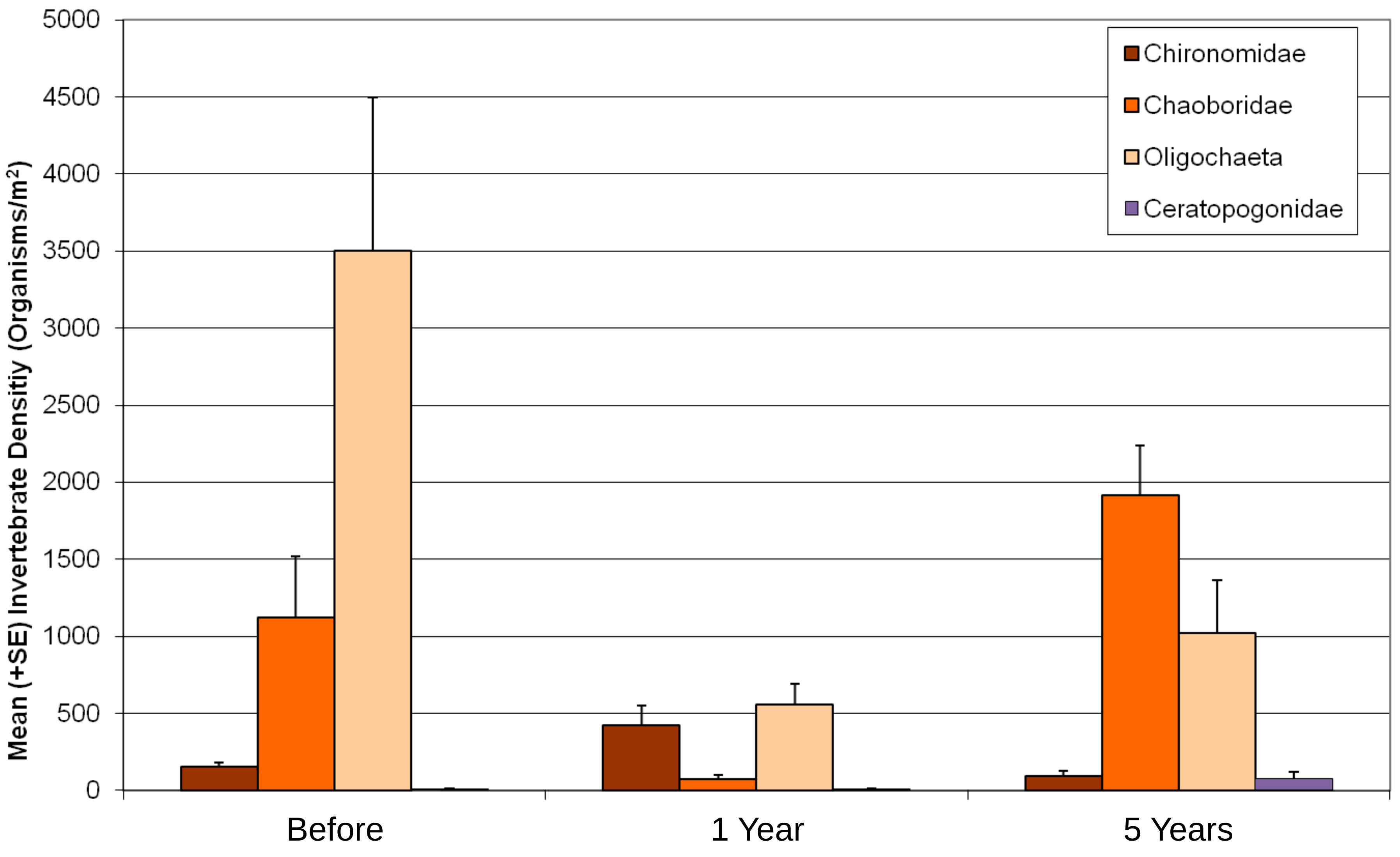


Source: Progressive AE

Invertebrate Density: Before vs. After Alum



Invertebrate Community Composition



Conclusions

- The invertebrate community has recovered from the decline observed 1 year after treatment
- Alum continues to be highly effective at reducing sediment P release rates, but its efficacy is beginning to decline
- Water column P remains sufficiently high to fuel algal biomass at or above eutrophic levels
- Control of external sources of P is essential for further improvements in the lake and continued success of the alum treatment

Acknowledgements

- Maggie Weinert
- Brian Scull
- Kurt Thompson
- Rick Rediske
- Kelly Wessell
- Scott Kendall
- Gail Smythe
- Jennifer Cymbola
- Lori Nemeth
- Eric Nemeth
- Tony Groves – Progressive AE
- Pam Tyning – Progressive AE
- Funding sources:
  - Spring Lake-Lake Board
  - Michigan Department of Environmental Quality