Ann Lake Treatment Public Forum #2

Ogilvie Civic Center, Ogilvie
September 26, 2020

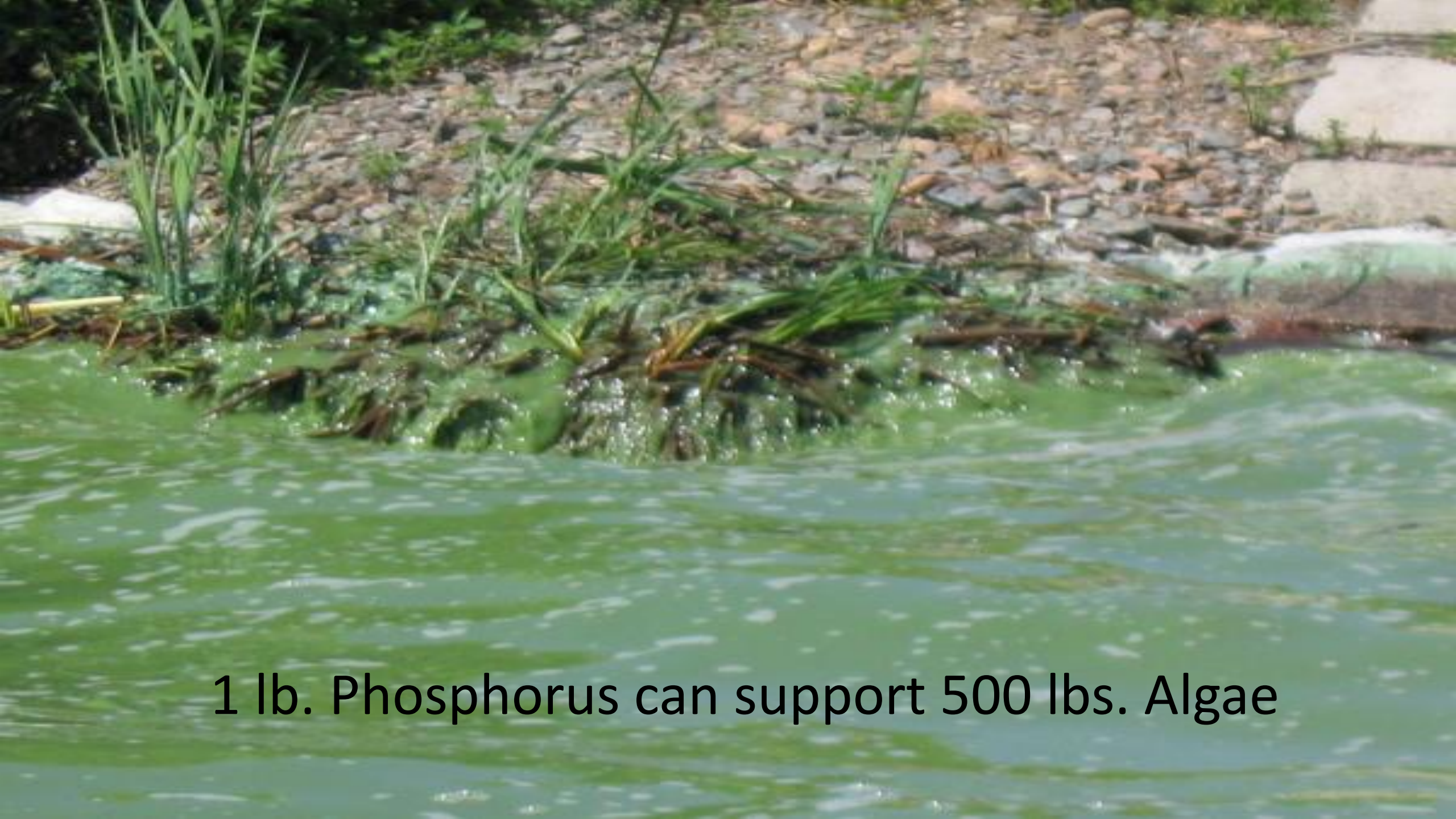
Deanna Pomije
District Manager

Josh Votruba
District Technician

A very nice Deep Lake

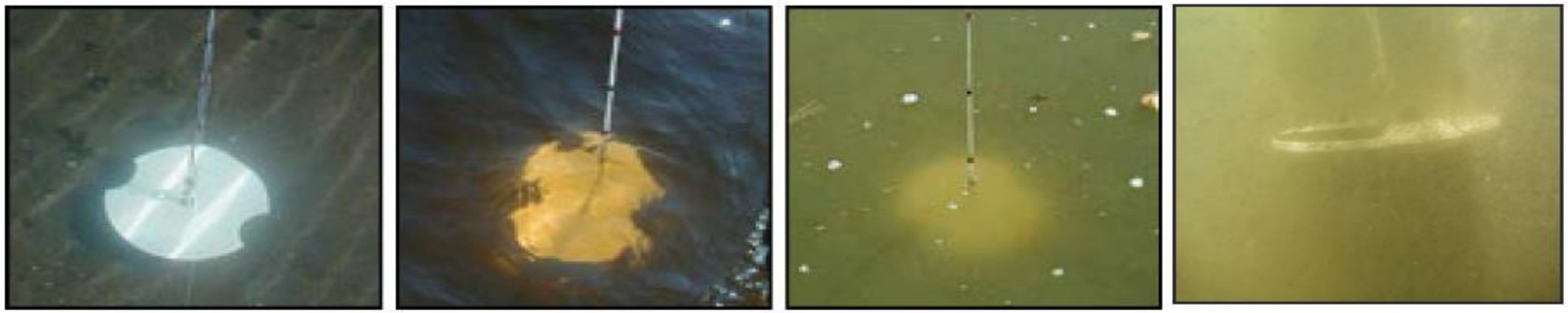
Flathead Lake, Montana

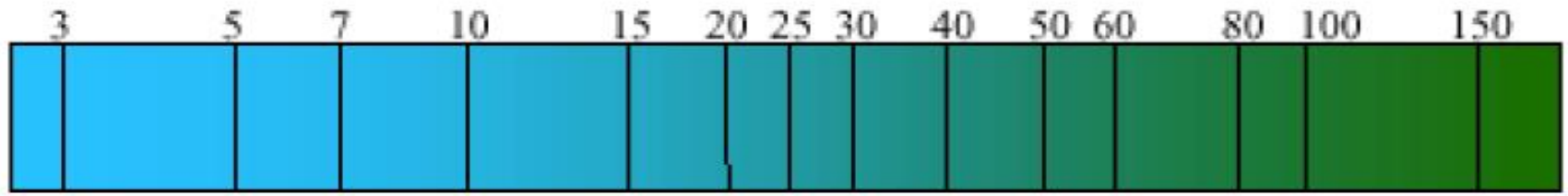
From John Erdman, MPCA


1 lb. Phosphorus can support 500 lbs. Algae

Relationship between Total Phosphorus and Transparency

Oligotrophic **Mesotrophic** **Eutrophic** **Hyper-Eutrophic**





Total Phosphorus (µg/L)

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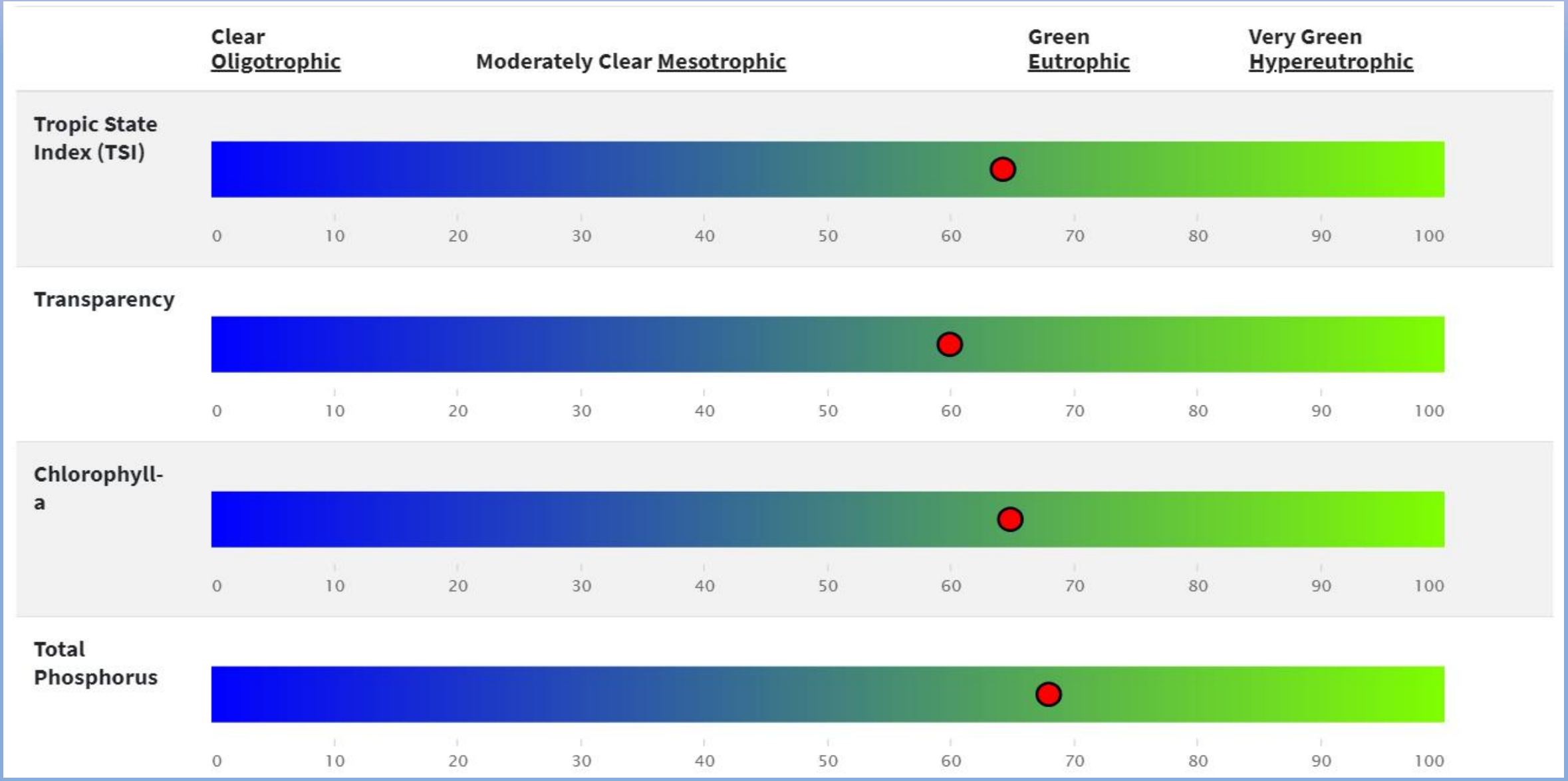
Ann Lake - Trophic State Index - 64



(2008-2017)

WENCK File #2583-0003
June 2018

Ann Lake Internal Load Feasibility Study

Prepared for:
Kanabec SWCD
Ann Lake Watershed Alliance
MPCA

WENCK ASSOCIATES
Responsive partner. Exceptional outcomes.

Prepared by:
WENCK Associates, Inc.
7500 Olson Memorial Highway
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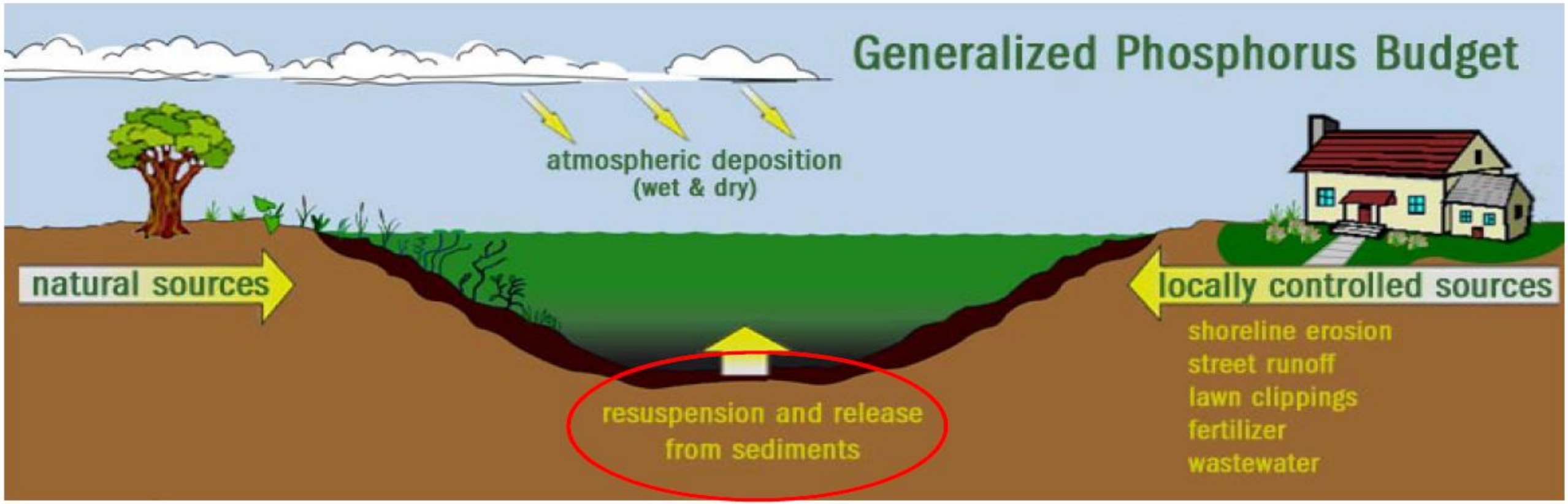
Golden Valley, MN 55427
Phone: 763-252-6800

Ann Lake Internal Load Feasibility Study

(Completed 2018)

- Bottom Sediment Cores Analyzed – 3 sites
  - Phosphorus Content
  - Treated with Phoslock
- 4 Treatment Options Analyzed
  - Cost
  - Environmental Considerations
  - Treatment Schedule
  - Benefits/Limitations

Lake Watershed Phosphorus Loading



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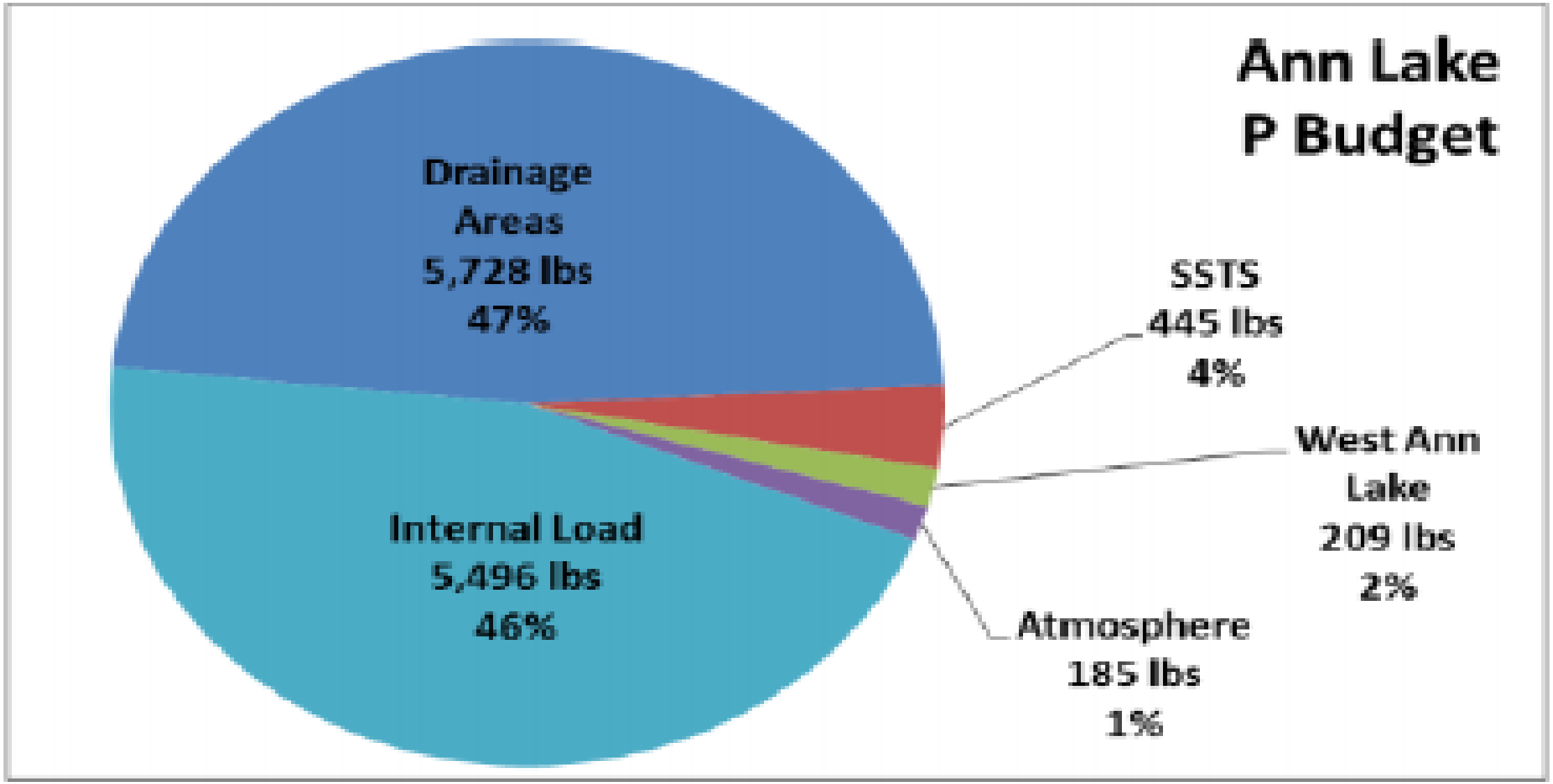

Figure 2-1. Ann Lake phosphorus budget based on the 2013 TMDL study.

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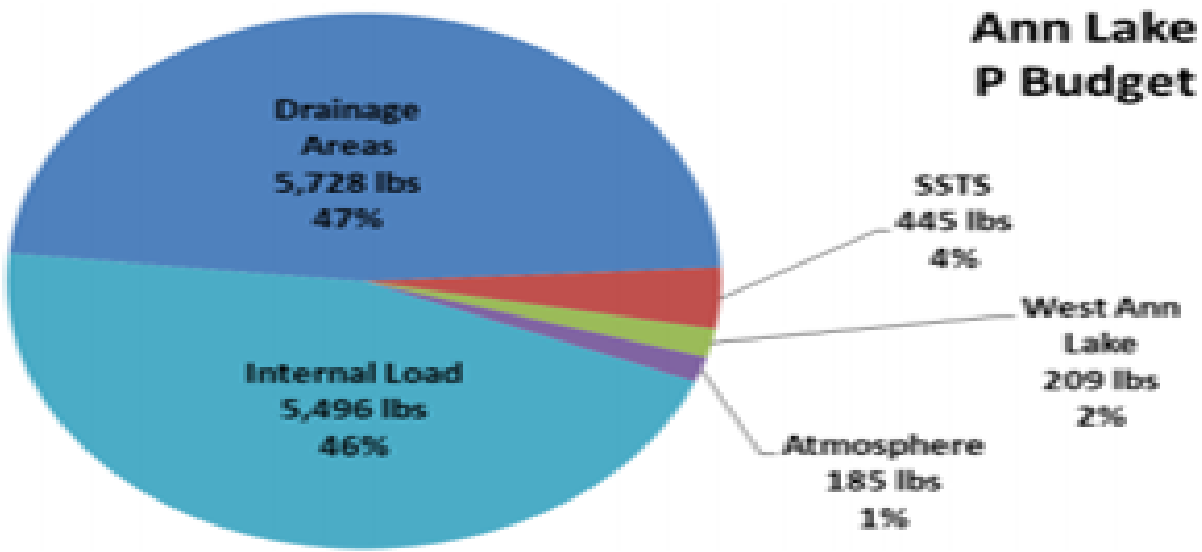
Ann Lake TMDL

(Total Max. Daily Load)



		Existing TP Load	Allowable TP Load	Estimated Load Reduction	
		lbs/yr	lbs/yr	lbs/yr	%
Wasteload	**Total WLA**	115	115	0	**0%**
	Construction & Industrial Stormwater	115	115	0	0%
Load	**Total LA**	11,948	7,190	4,758	40%
	Atmosphere	185	185	0	0%
	Septics	445	0	445	100%
	Watershed	5,822	5,605	217	4%
	Internal	5,496	1,400	4,096	75%
Total Load		**12,063**	**7,305**	**4,758**	**39%**

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“The internal load reduction goal for Ann Lake is significantly greater than the watershed reduction goal. It will be extremely difficult, if not impossible to restore Ann Lake to meet state water quality standards without some sort of management strategy to decrease phosphorus loading from the lake's sediments.”

- from the 2018 Ann Lake Internal Load Feasibility Study completed by Wenck

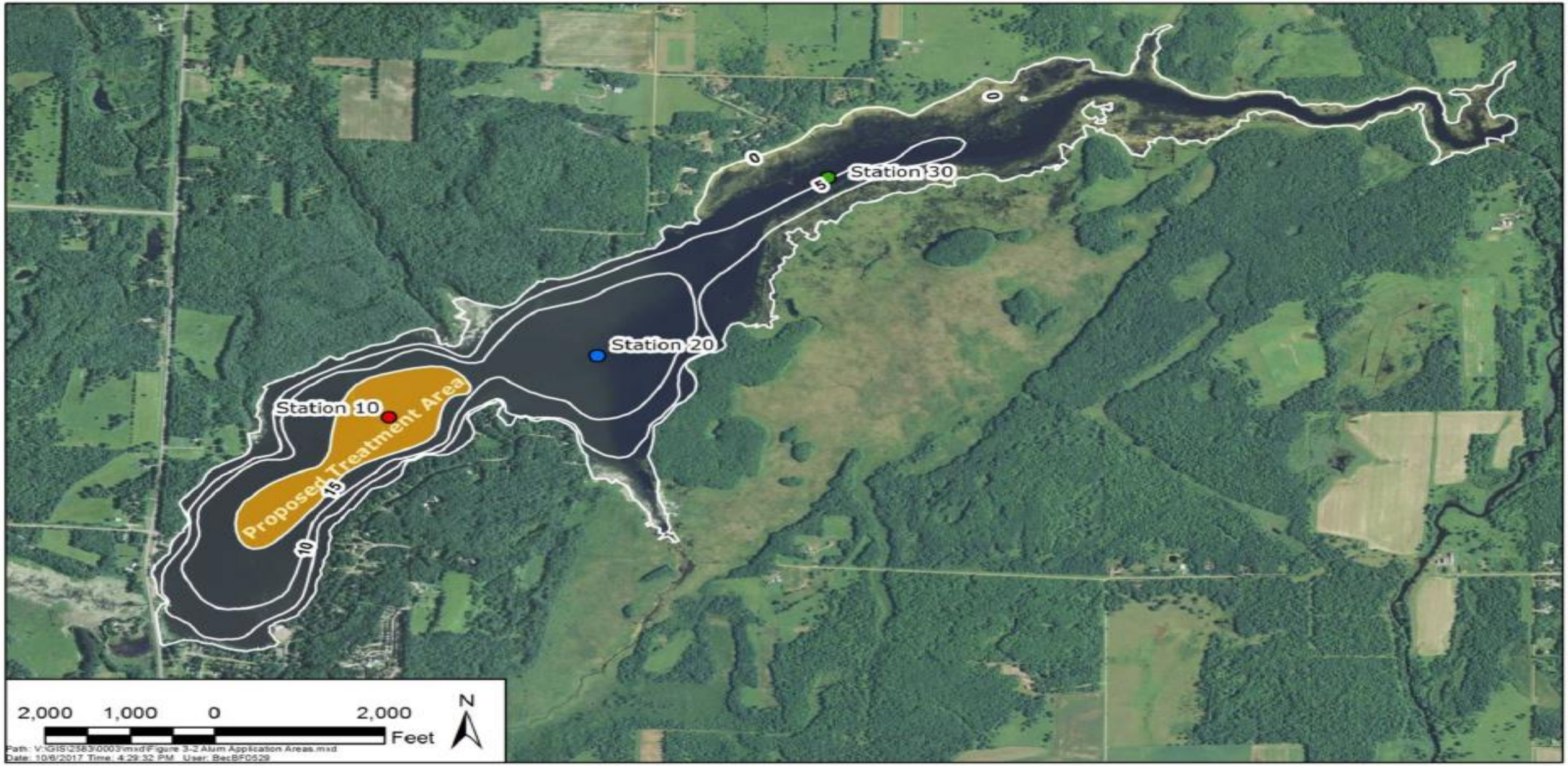

Figure 3-3. Proposed internal load treatment area for Ann Lake.

Table 5-1. Summary of internal load treatment options for Ann Lake.

Alternative	Cost Estimate	Proposed Treatment Schedule/Area	Environmental Concerns	Benefits/Limitations
Alum	$651,000	7 separate applications in the >15-foot contour	MN state sulfate standard should not be exceeded if product is applied across 7 different treatments	• Known effectiveness • Readily available in USA • Most Cost-Effective alternative
Phoslock ®	$1,325,000	1 application in the >15-foot contour	None if applied correctly	• No apparent environmental concerns • Less commonly used
Polyaluminum chloride	$870,000	7 separate applications in the >15-foot contour	MN state chloride standard should not be exceeded if product is applied across 7 different treatments	• Rarely used in US for internal load reduction
Hypolimnetic Aeration	$1,250,000 Investment Cost $29,000 Annual Operating Cost	two units deployed in >15-foot contour	None	• Must be operated in perpetuity to meet water quality goals • May not be effective for internal phosphorus load control

Aluminum Sulfate (Alum)

What is Alum?

- Aluminum Sulfate (liquid)
  - Dissolves in water to form aluminum hydroxide and sulfate
  - Aluminum hydroxide is a white solid that settles out of the water column
- Permanently binds phosphorus in the sediments
- Aluminum phosphate complexation ($Al(OH)_3PO_4$)
  - Very stable in the environment
  - Not sensitive to anoxia (low oxygen)

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Aluminum and Human Health

- Al is the third most abundant element in the earths crust
  - food, water, air, and soil contain aluminum
  - Occurs naturally in lake sediments
- The average adult eats 7–9 milligrams (mg) aluminum per day in their food
- Only very small amounts of aluminum will enter the bloodstream
- The FDA concluded that aluminum as a food additive is generally safe

One dose of Maalox includes 400 mg Aluminum Hydroxide

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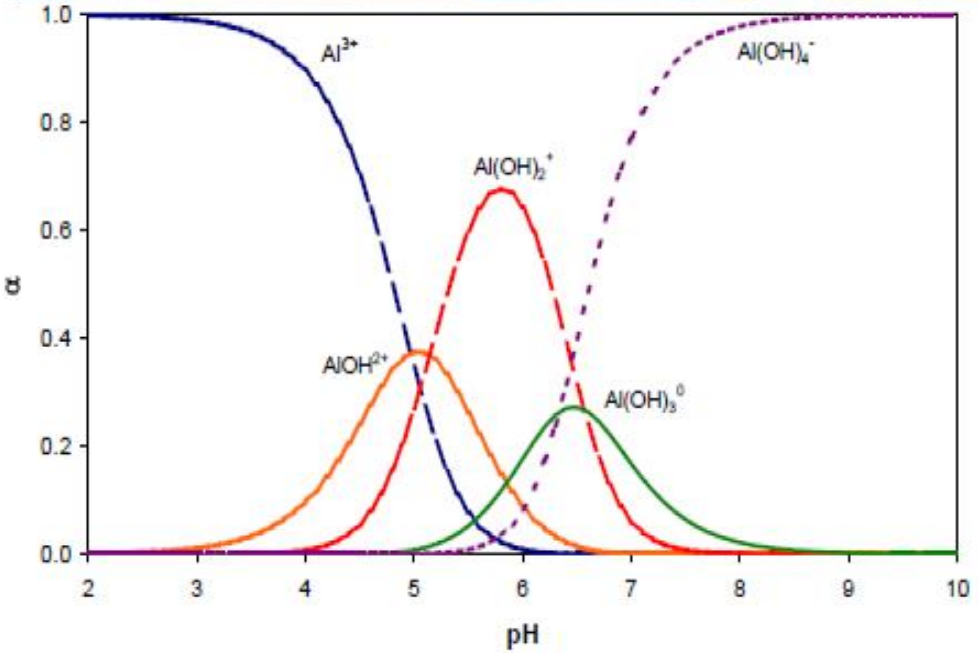
Aluminum Toxicity

Fish and Macroinvertebrate Impacts

- Toxic dissolved aluminum (Al^{3+}) forms if pH drops below 6
  - pH can be controlled with proper dosing or buffering
- Aluminum does not bioaccumulate in algae or fish tissue
  - Huser and Kohler, 2012
- Macroinvertebrates show short term impacts followed by community recovery and improvement
  - Smeltzer at al. 1999; Harper et al.; Huser and Kohler 2012



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Conclusions

- Sediment P inactivation is more cost effective that watershed BMPs on a cost per pound removal
- Alum can be effective for 15 to 30+ years if dosed correctly
- Controlling external P loads is important, but alum treatments can be effective even when watershed loads are moderately high
- Alum is effective in shallow lakes and can support restoration efforts
- Alum use is safe for both humans and lake organisms

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Polyaluminum Chloride

Polyaluminum Chloride (PACl)

- Aluminum settles to the sediment surface
- Aluminum is capable of converting mobile phosphorus to immobile phosphorus in sediments
- Not commonly used in the United States

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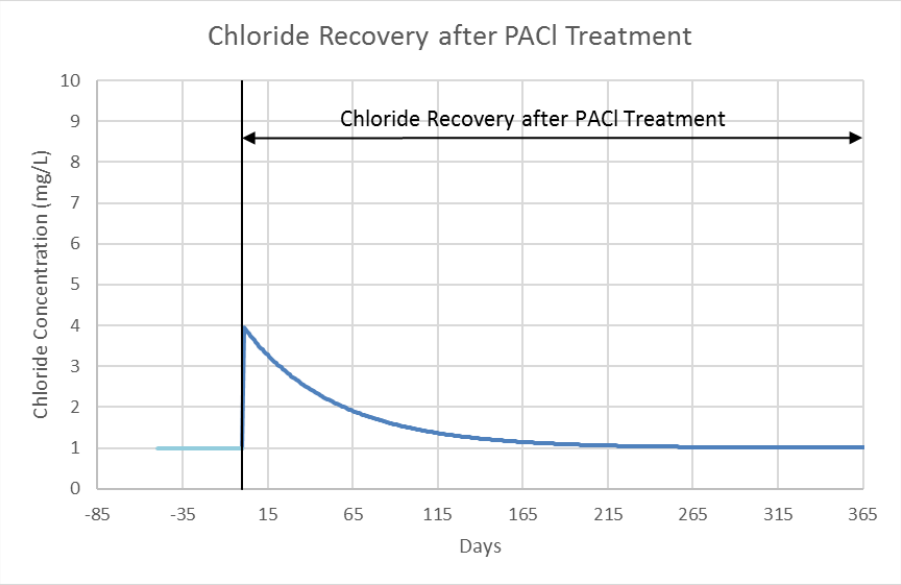
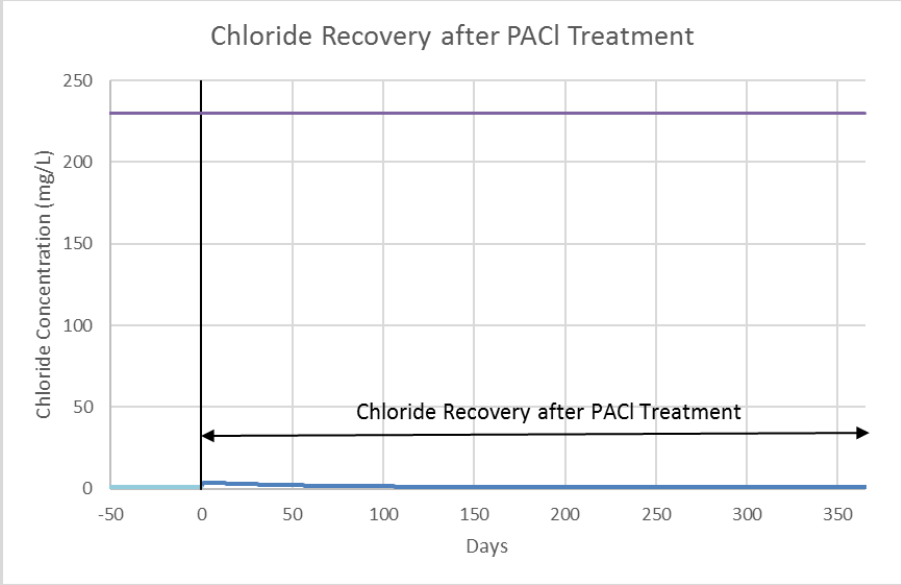
PACl Environmental Considerations

- Each application will result in a small chloride spike that is well below the chloride standard





One thing for sure about shallow lakes ….
you never have to worry about these!

From John Erdman, MPCA

Phoslock

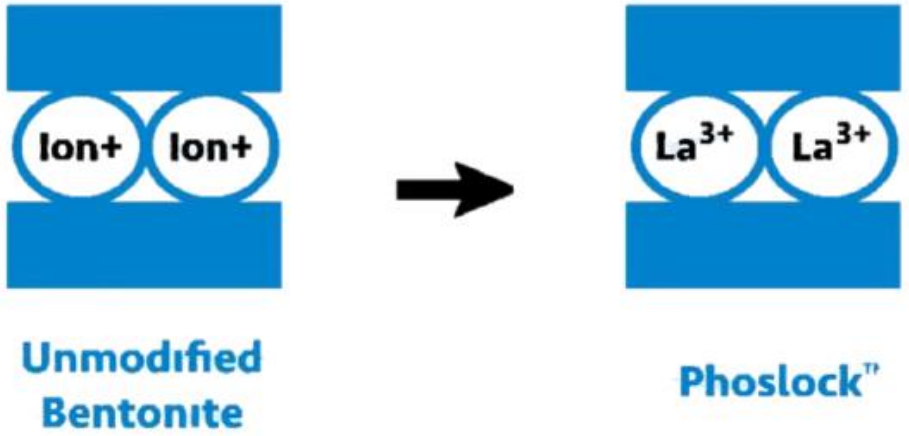
Key features

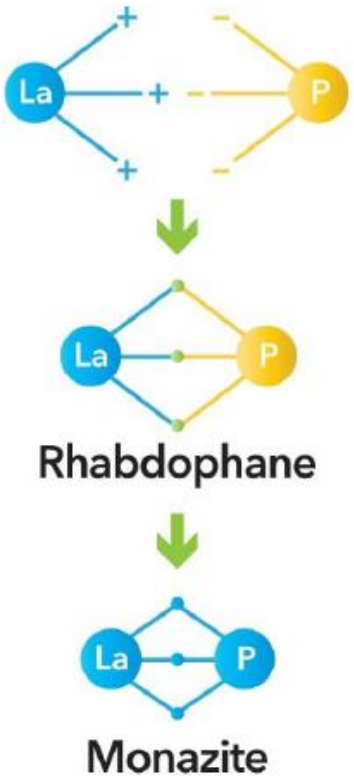
- 5% Lanthanum + 95% Bentonite Clay
- Specific to phosphorus binding
- Immediate and permanent
- Does not impact water chemistry (no pH buffering)
- Binding effective over a wide range of water quality (pH 4-11, oxic/anoxic)
- NSF/ANSI 60 certified
- Highly researched and used worldwide
- Not a pesticide

Benefits

- Safe
- Effective
- Proven

Ultimate Fate



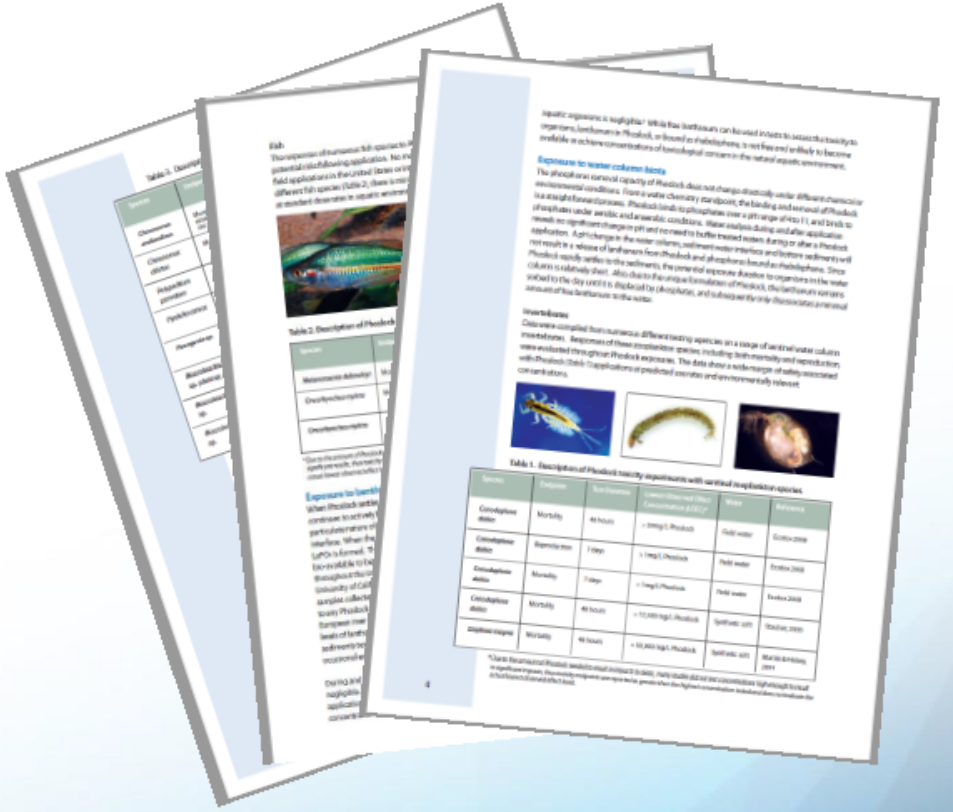


Granular Bentonite clay matrix with Lanthanum

Highly stable and strong bond with free reactive phosphorus

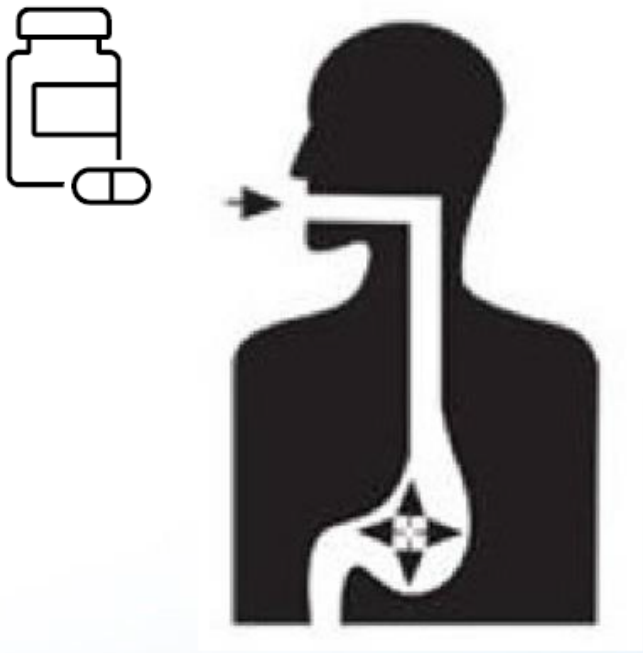
Ecotoxicology – Aquatic Organisms

- **Phoslock usually applied 2-3 orders of magnitude less than amounts which impact organisms (LOEC or EC_{50})**
- Extensive laboratory and field studies on ecotoxicity
  - Zooplankton
  - Fish
  - Benthic Invertebrates
- Technical overview and publication list will be provided



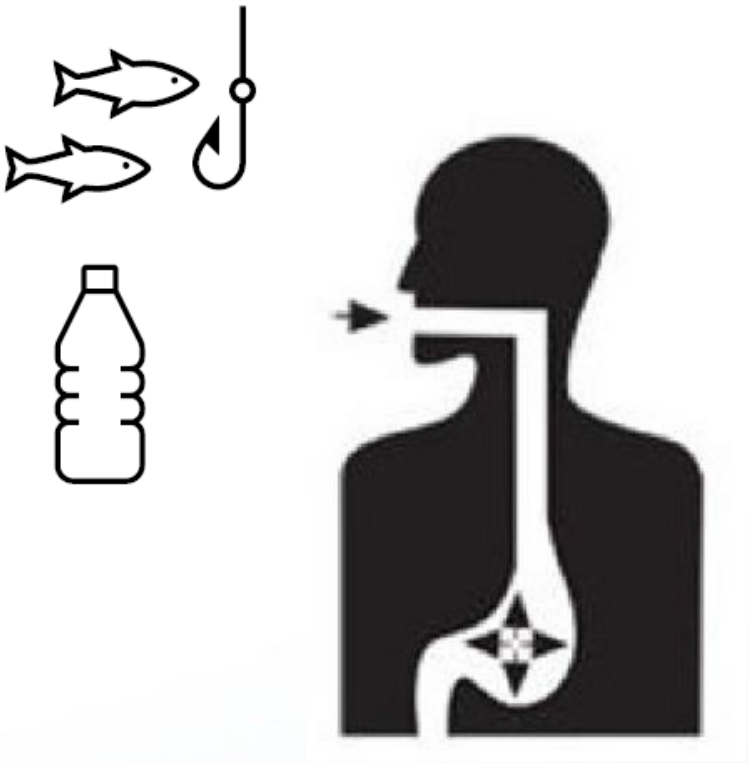
Human health

- **Very low potential for exposure**, and if occurs lanthanum is readily processed by the liver and excreted with no negative impacts observed
- Drug Fosrenol® composed of Lanthanum Carbonate used to safely treat high phosphate levels in patients.
  - Doses of 750 to 3,000 mg La/day
  - Have to drink 80-317 gallons of Phoslock treated water in a day to reach similar safe dose
- Bentonite is not considered toxic to humans
  - Approved by EPA as an inert ingredient for food and non-food use
  - Generally Recognized as Safe (GRAS) according to the FDA

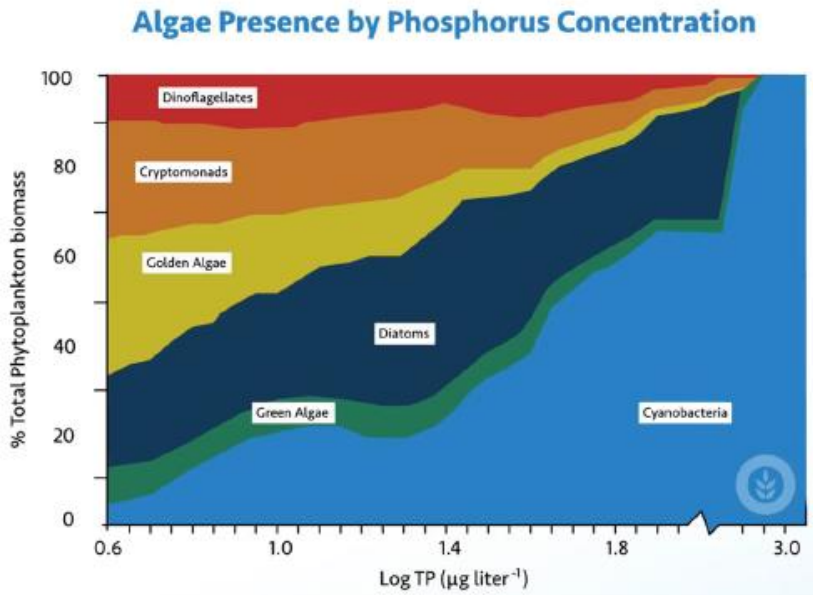


Human health

- Fish only found to accumulate lanthanum in liver and hepatopancreas tissues, not flesh/muscles
- Study of long term daily phoslock intake in rats does not pose a toxicity risk, no significant increases in organs (except liver, no hepatotoxicity) (Behrt et al. 2020)
- NSF/ANSI 60 certified for use in Drinking Water!



Restoring Water Quality with Phoslock



- Reduce the available phosphorus in the water
- Target sources of legacy phosphorus
  - Inactivation in sediments
- Rapid restoration of lakes
  - Offset eutrophication
  - Decades of watershed management – now
- Improve results of lakes with TMDLs
  - Complimentary to watershed management activities
- Support better algal assemblage
  - Positive shift to N:P ratio

SePRO

Ann Lake

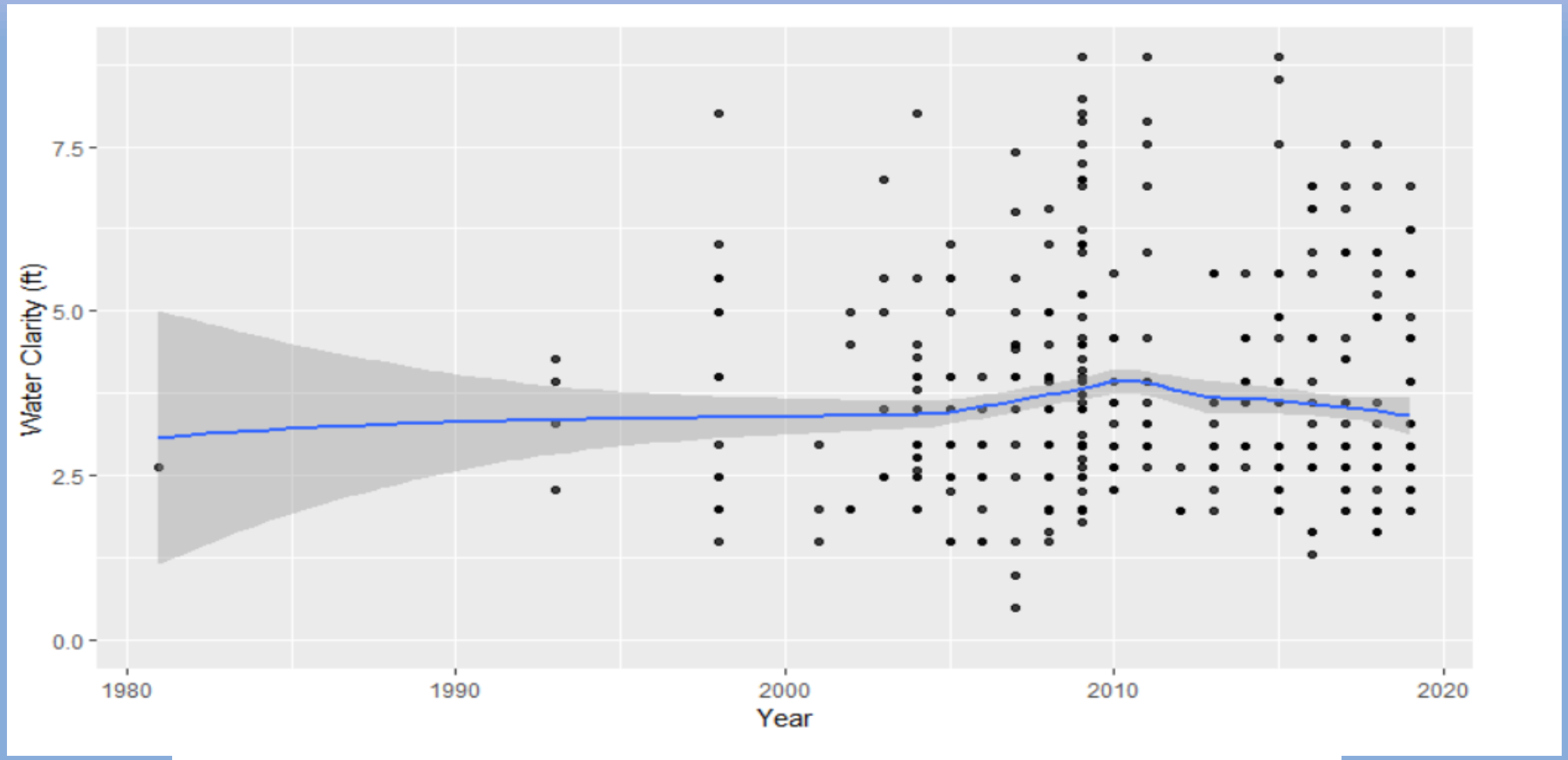
Year	Phoslock (lbs.)	Phoslock Cost	Lab Services (estimate)	Application
1	300,000	$405,000	$15,000	TBD
2	150,000	$202,500	$15,000	TBD
3	0	$0.00	$15,000	TBD
4	100,000	$135,000	$15,000	TBD
5	50,000	$67,500	$15,000	TBD
Total	600,000	$810,000	$75,000	TBD

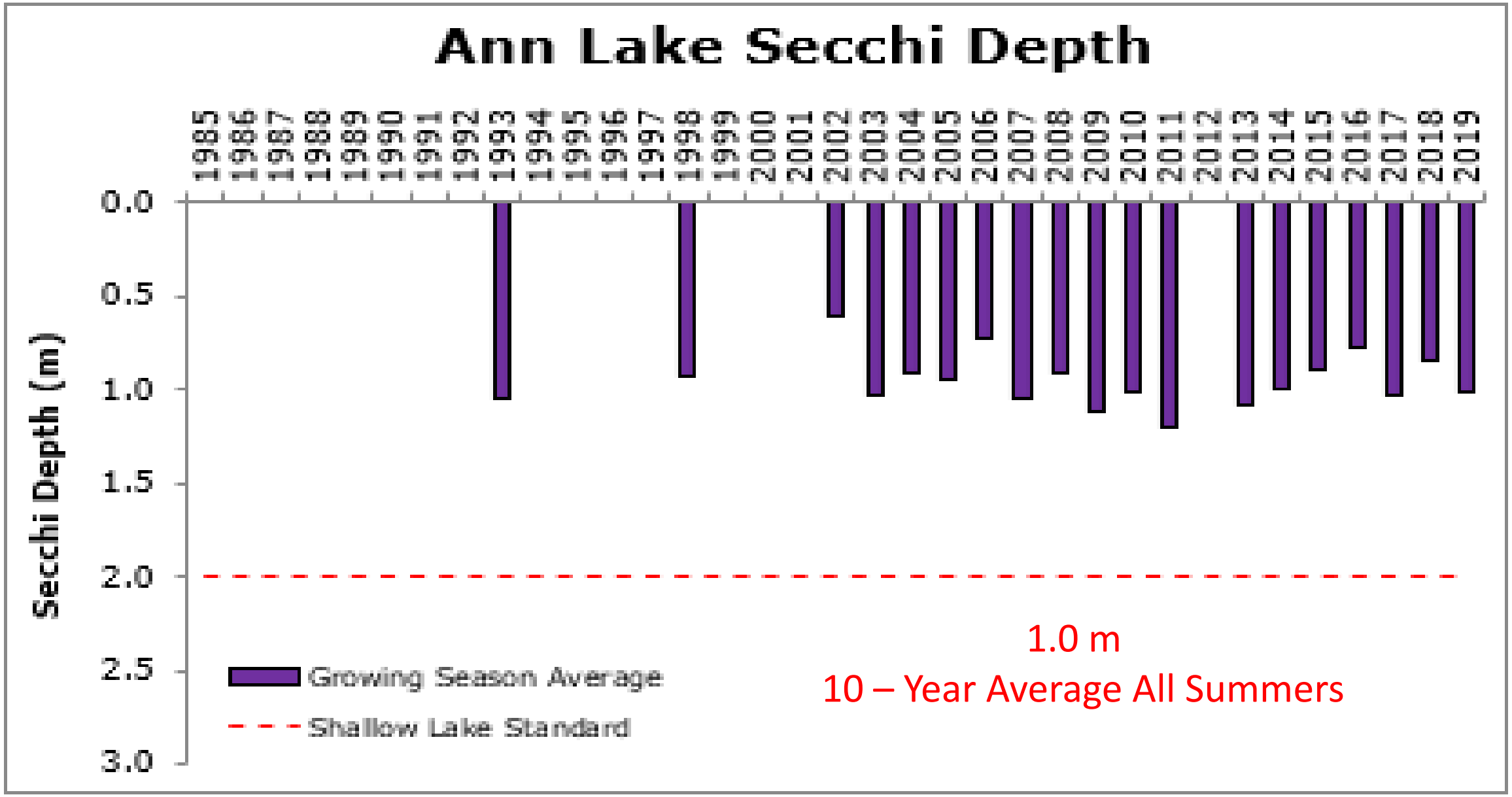
Total $885,000 + Application Cost

- ***We can start now…***
- **Collect sediment cores for updated analysis**
- **Initiate 5-year treatment and monitoring plan**

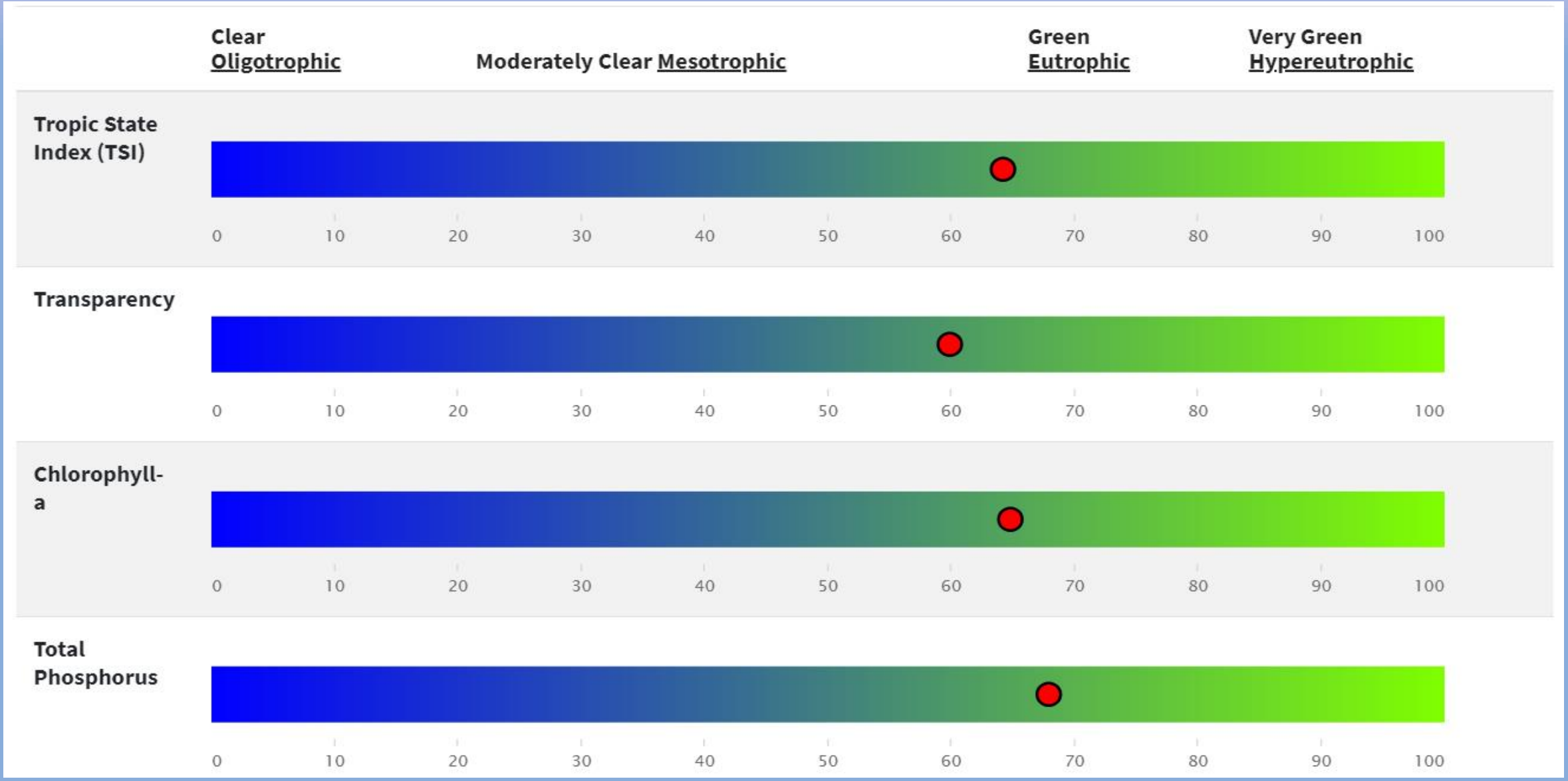
Ann Lake Water Quality

Ann Lake – Transparency Trends

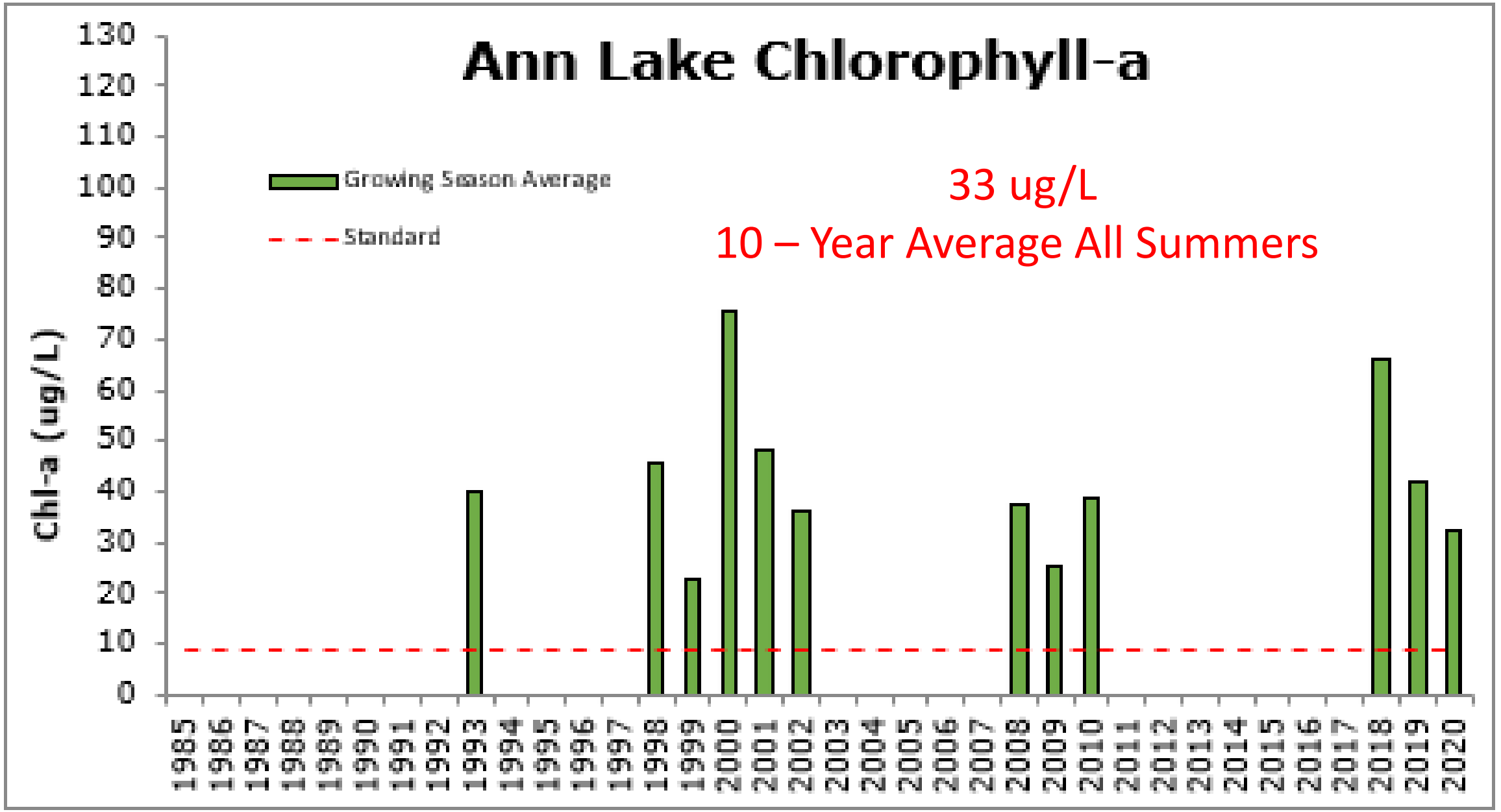



Ann Lake Secchi Depth
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Secchi Depth (m)
Growing Season Average
Shallow Lake Standard
1.0 m
10 – Year Average All Summers

Ann Lake - Trophic State Index - 64



(2008-2017)


Ann Lake Chlorophyll-a
Growing Season Average
Standard
33 ug/L
10 – Year Average All Summers
Chl-a (ug/L)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1985
1986
1987
1988
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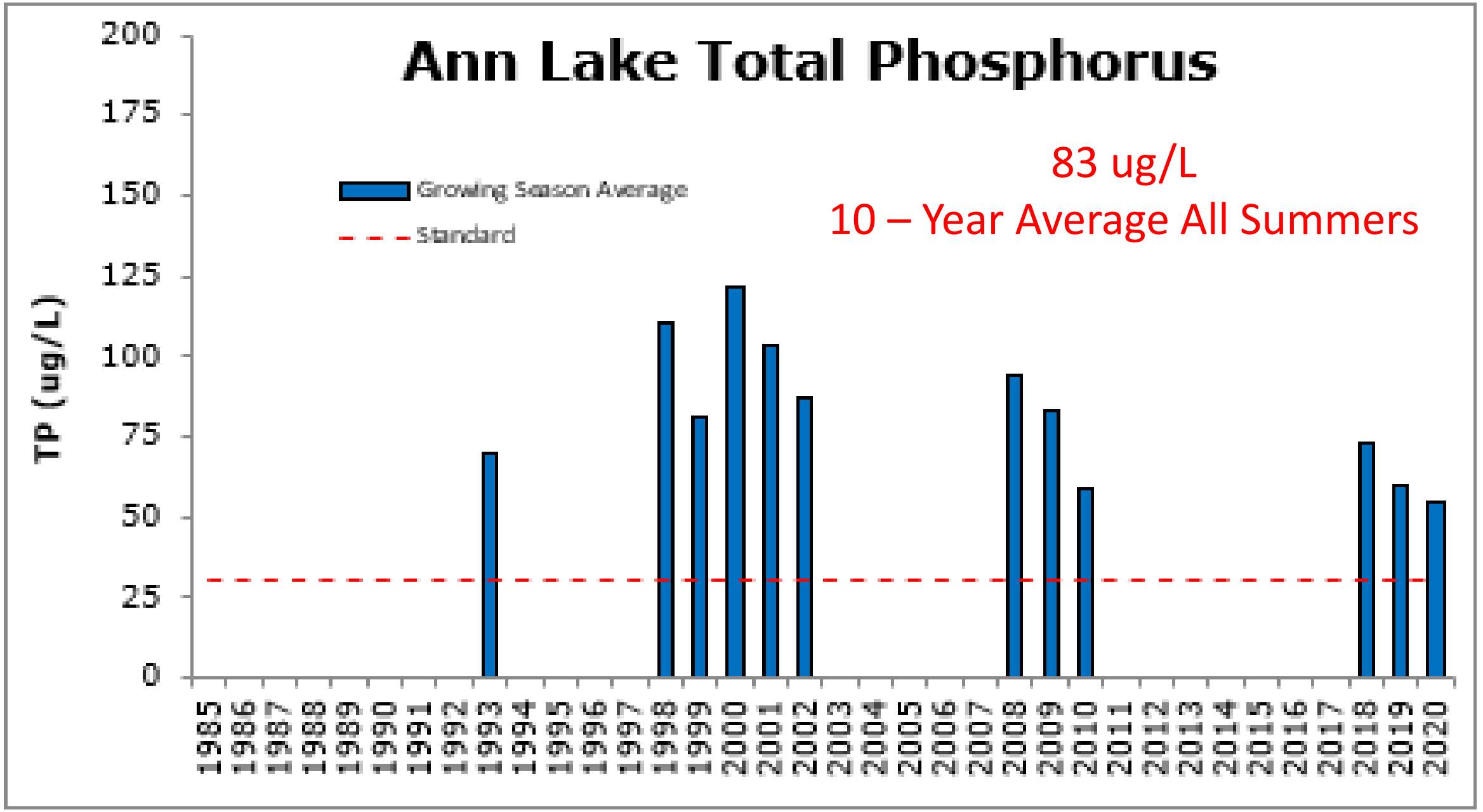
Ann Lake Total Phosphorus
83 ug/L
10 – Year Average All Summers
Growing Season Average
Standard
TP (ug/L)
200
175
150
125
100
75
50
25
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
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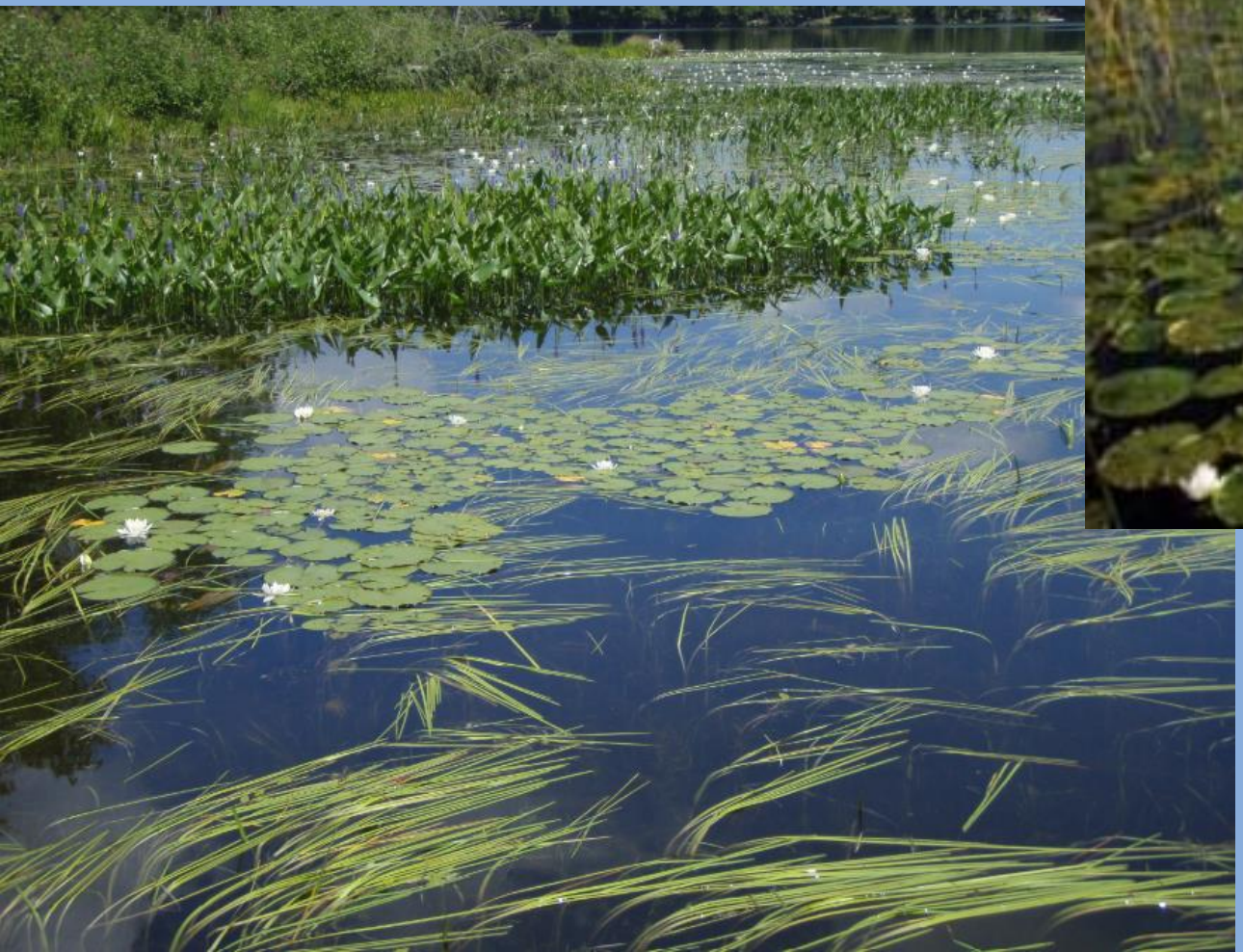
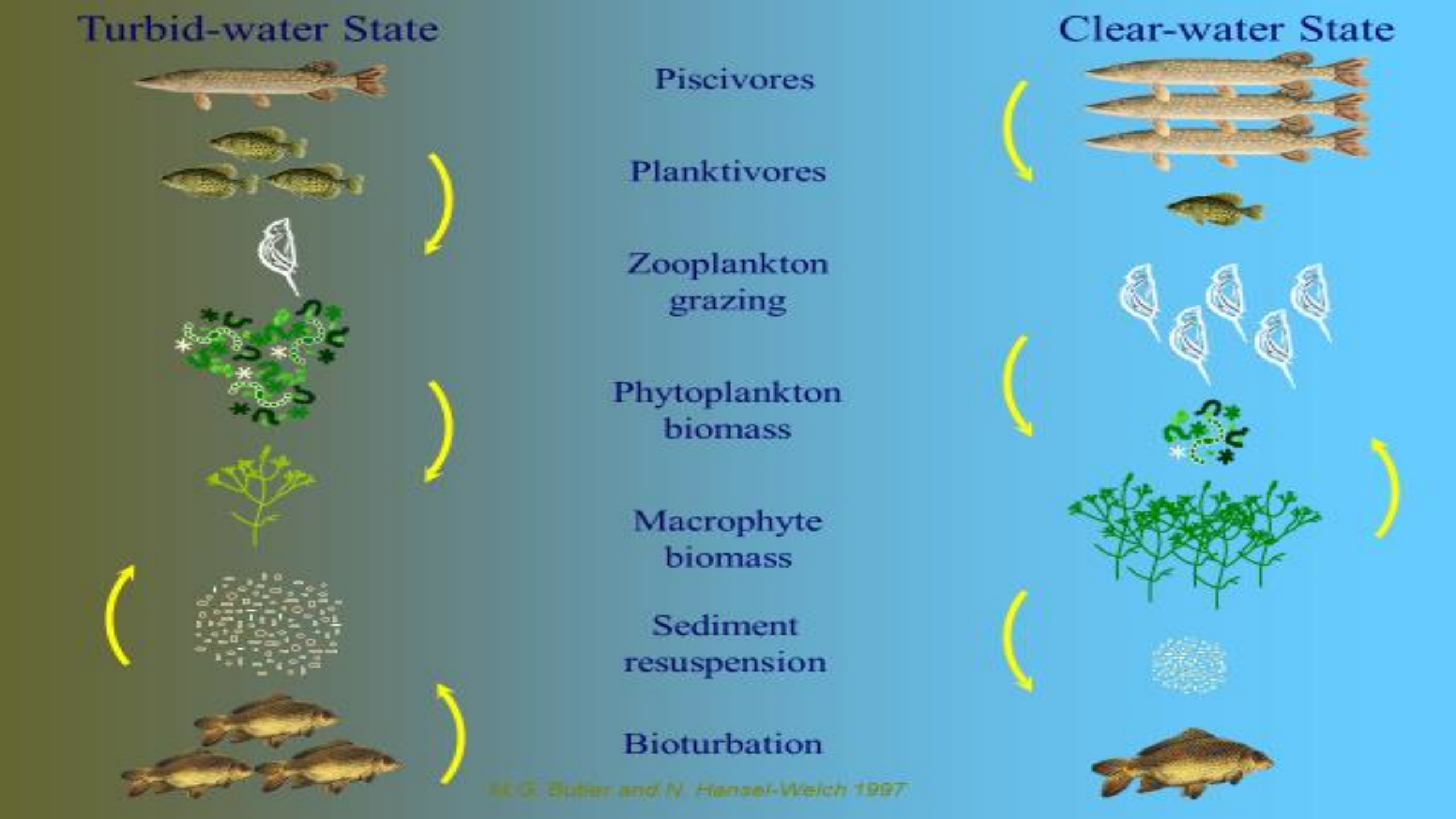
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

Kanabec Lakes Water Quality & Standards

Name	Total Phosphorus ug/L	Chlorophyll-a ug/L	Secchi disk depth ft.
Northern Lakes & Forests	30	9	6.6
Eleven Lake	43	34	2.9
Pomroy Lake	25	6	7.2
Ann Lake	80	28	3.8
N. Central Hardwood Forests, Shallow	60	20	1
Knife Lake	95	25	3
Quamba Lake	98	20	2.4
Fish Lake	95	39	2.9
N. Central Hardwood Forests, Deep	40	14	4.6
Lewis Lake	30	16	7.1

Anticipated Treatment Results




Turbid-water State
Clear-water State
Piscivores
Planktivores
Zooplankton grazing
Phytoplankton biomass
Macrophyte biomass
Sediment resuspension
Bioturbation
M. S. Butler and N. Hansel-Welch 1997

Snake River

One Watershed
One Plan

Public Comments
around Lakes / Rivers
Thurs. Nov. 5, 6-7:30 pm

https://www.millelacsswcd.org/snake-river-one-watershed-one-plan/

CLEAN WATER LAND & LEGACY AMENDMENT

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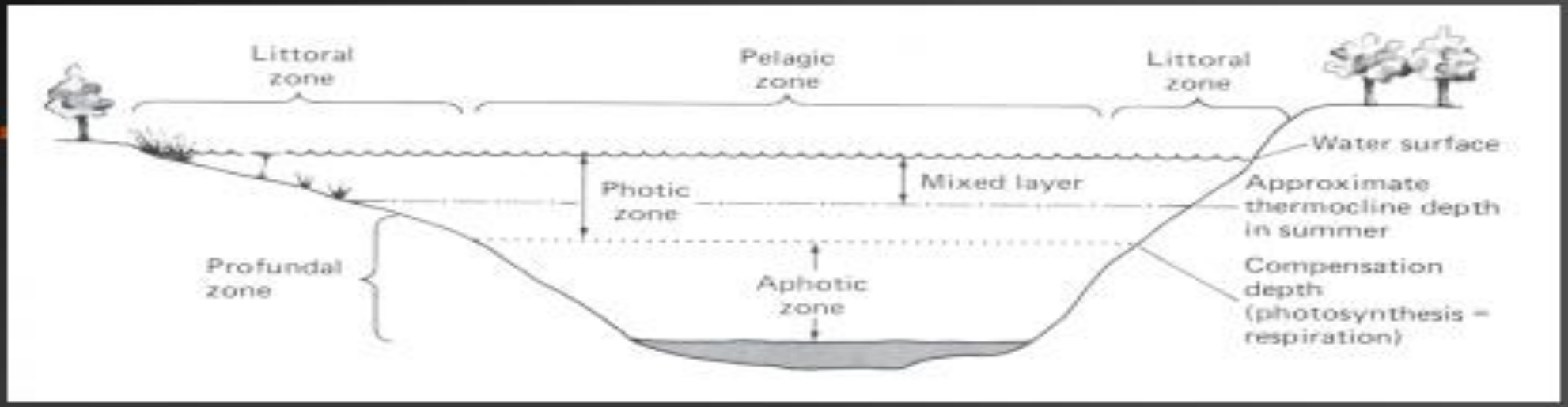
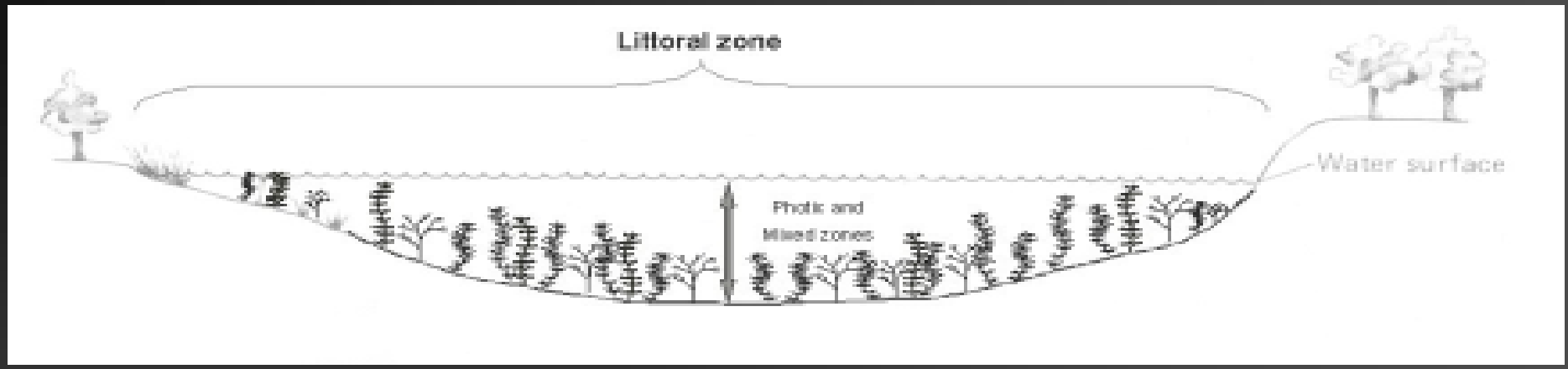
Characteristics of a Deep Lake



- Separates into layers based on temperature (stratifies)
- Nutrients do not mix throughout the basin
- Supports fish populations long term; winter-kill rarely, if ever
- Wind & waves do not have a major effect on the entire lake
- Plants grow only in the shallow zone along the shoreline

Characteristics of a Shallow Lake



- Water does not separate into layers, but mixes constantly
- Constant exchange of nutrients between sediments and water column
- More sensitive to nutrient inputs
- Fish can winter-kill often
- Wind & wave effects can be substantial on the sediment
- Potential for plants to grow throughout the basin
- Complex interactions between plants, fish, nutrients and invertebrates
- May switch between clear-water and turbid-water states

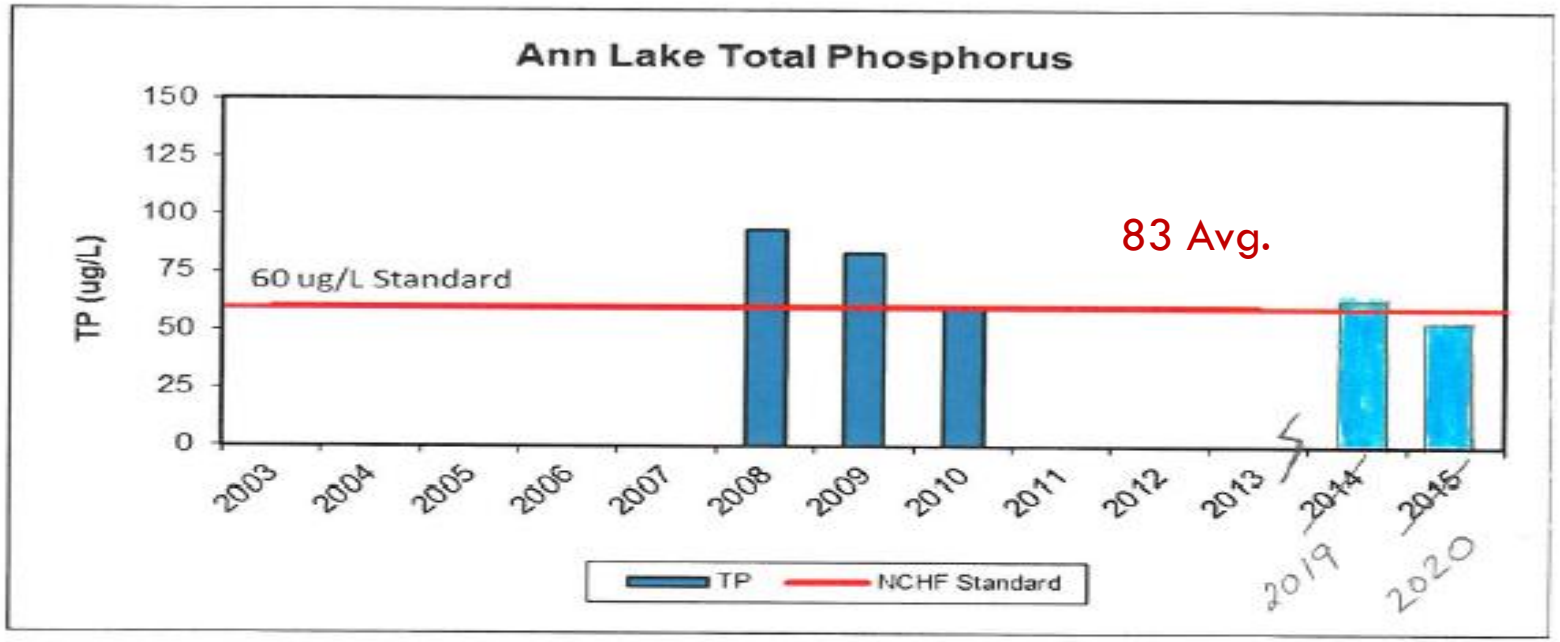
RUNOFF TRIVIA

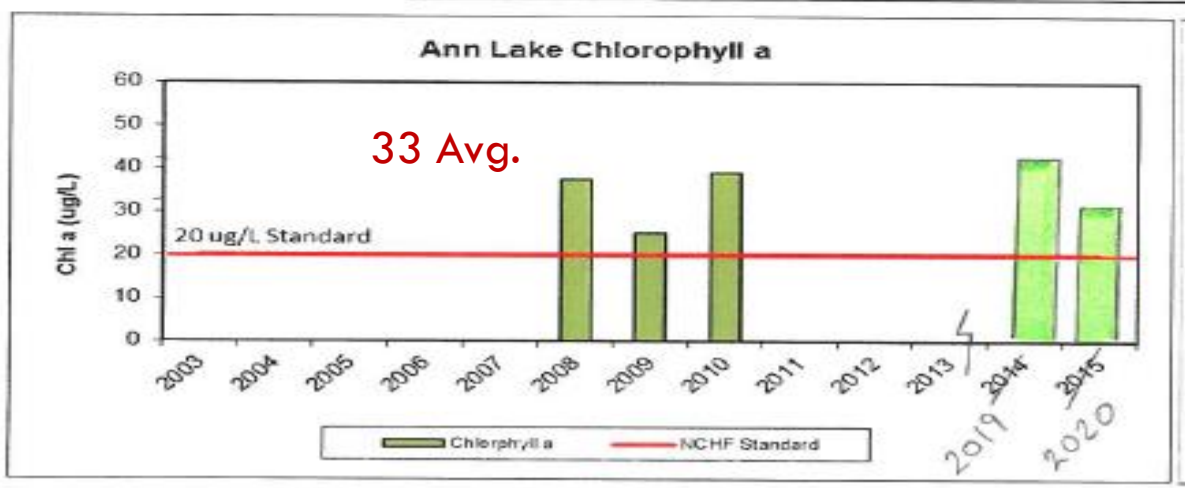
1 LB OF PHOSPHORUS FERTILIZER CAN SUPPORT 500 LB OF ALGAE AND PLANT GROWTH

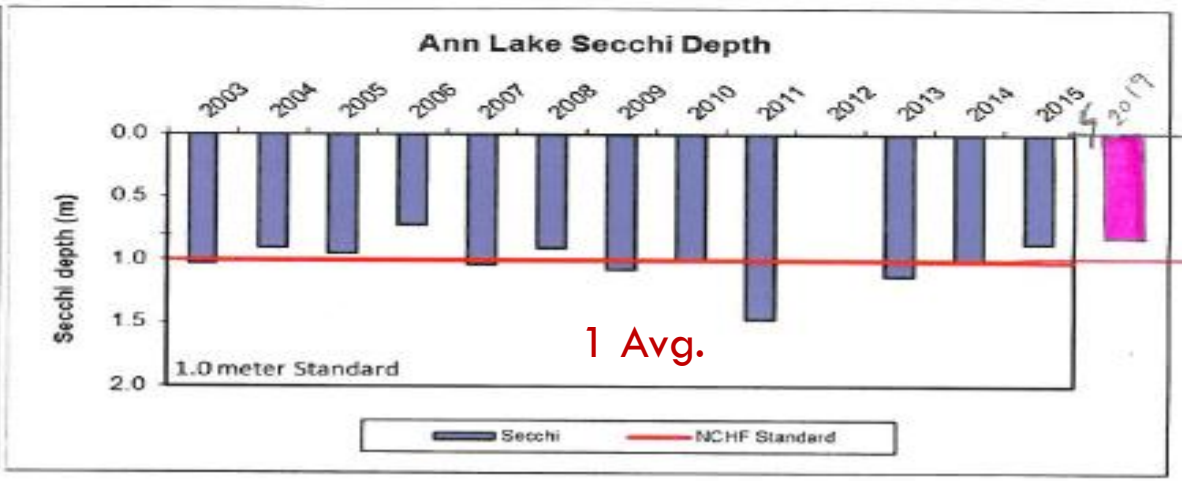
EXCESSIVE PLANT AND ALGAE GROWTH CONSUME OXYGEN AS THEY DECOMPOSE AND DIE. THIS MAY LEAD TO OXYGEN DEPLETION AND FISH KILLS AS WELL AS DANGEROUS BLUE-GREEN ALGAE

Ann Lake Water Quality

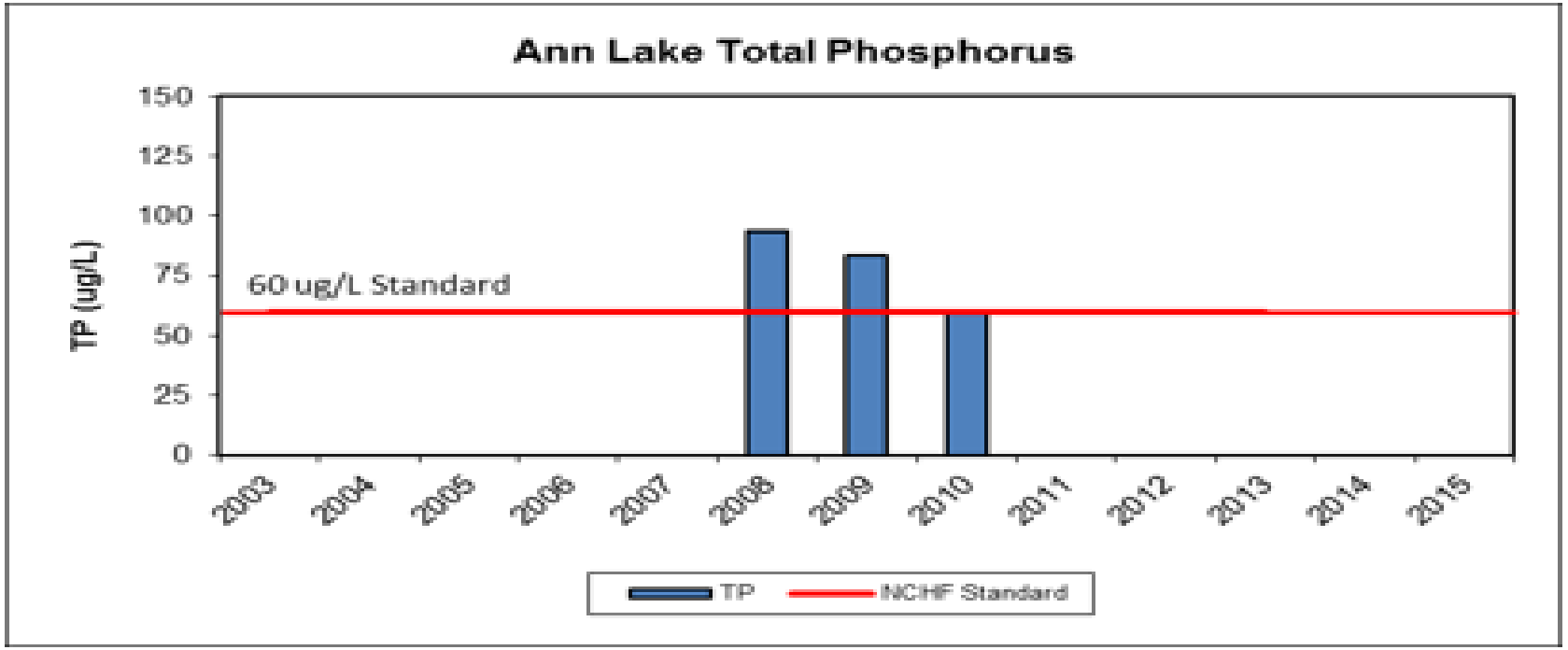
10-Year
Average
All Summers

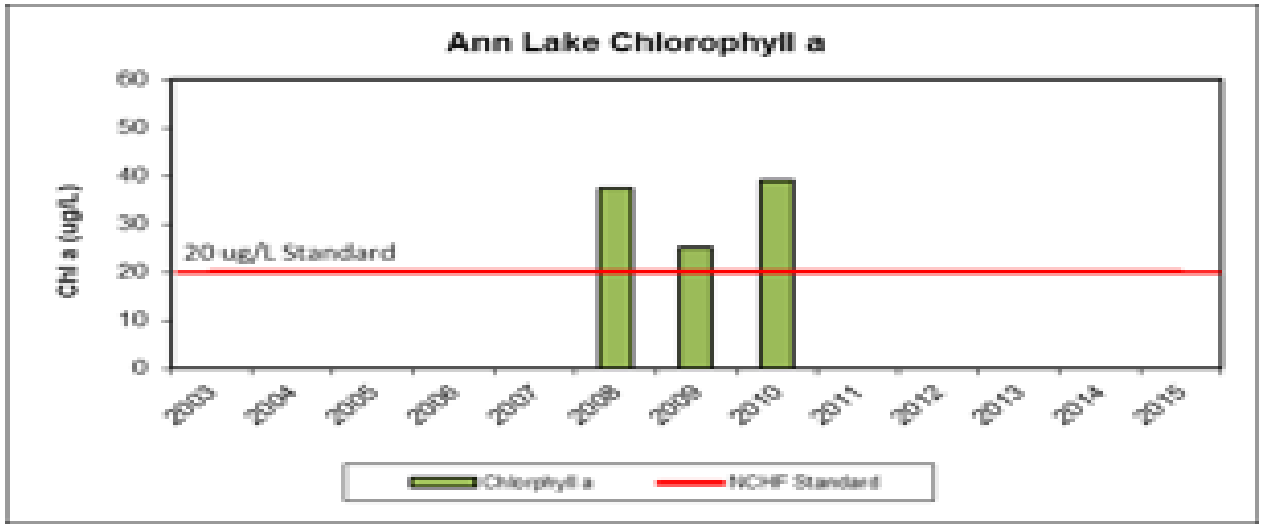


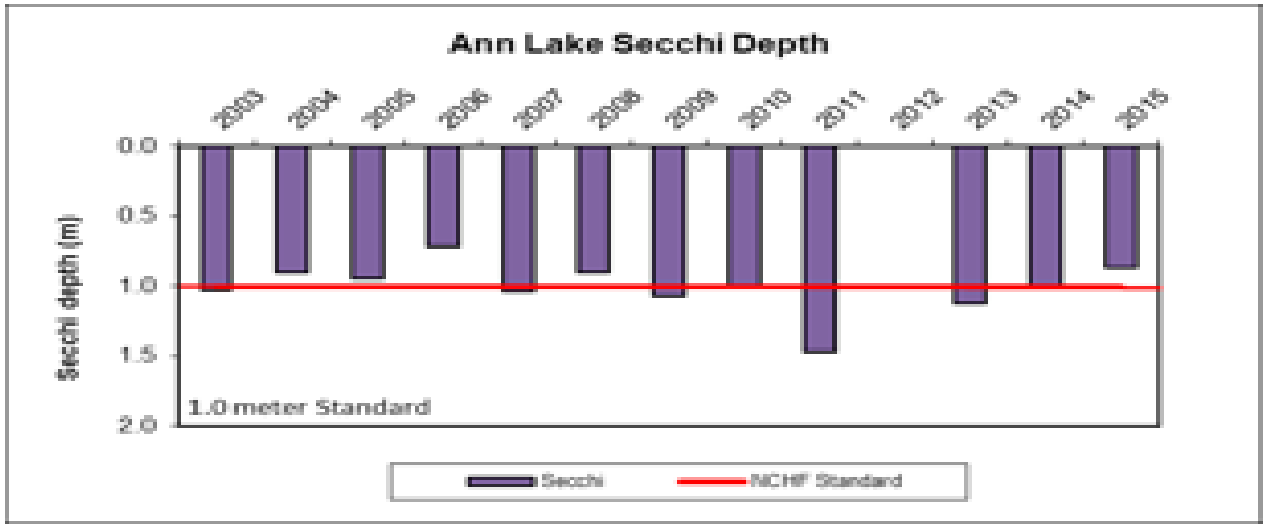




Ann Lake Water Quality







Parameters	10-Year average of all summer samples	Parameter TSI	Expected TSI range of lakes in same ecoregion	Number of samples
Transparency (meters)	1	60	38 - 47	78
Chlorophyll-a (parts per billion)	33	65	44 - 53	21
Total Phosphorus (parts per billion)	83	68	42 - 52	22

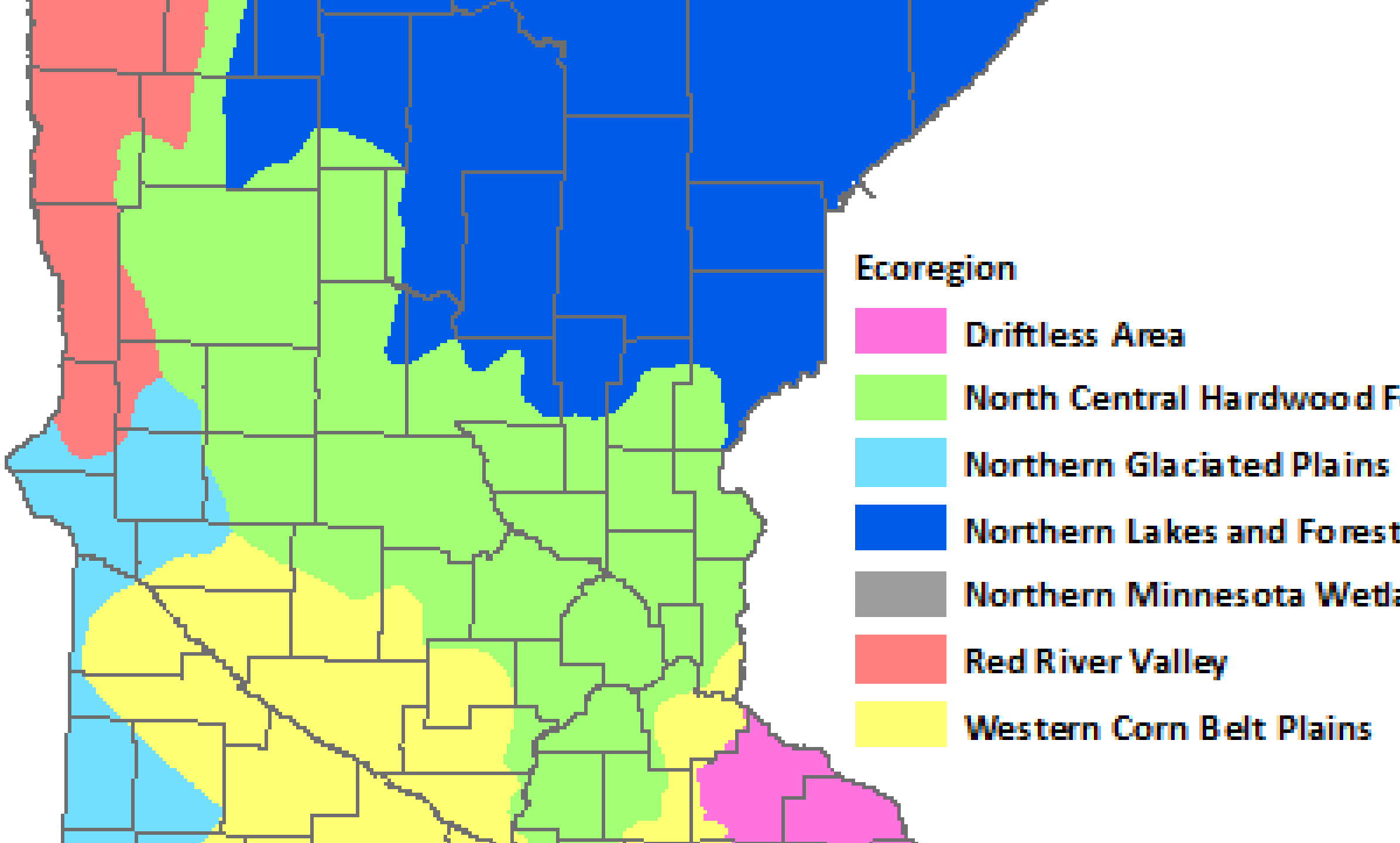
Minnesota Lake Water Quality Standards

(Secchi depth in meters)

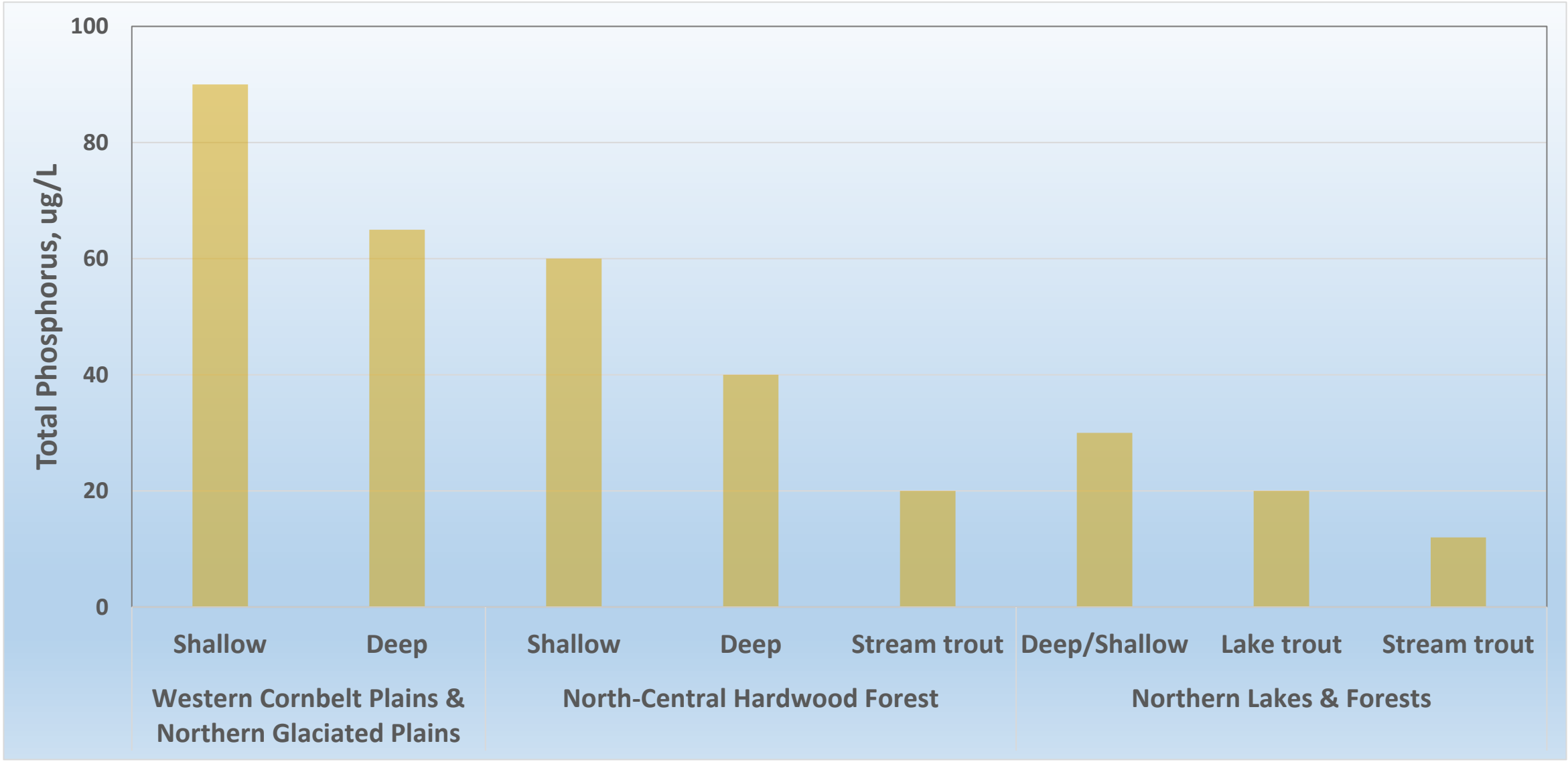
		Total Phosphorus	Chlorophyll-a	Secchi Depth
Ecoregion(s)	**Sub-Class**	**ug/L**	**ug/L**	**meters**
Western Cornbelt Plains & Northern Glaciated Plains	Shallow	90	30	0.7
	Deep	65	22	0.9
North-Central Hardwood Forest	Shallow	60	20	1.0
	Deep	40	14	1.4
	Stream trout	20	6	2.5
Northern Lakes & Forests	Deep/Shallow	30	9	2.0
	Lake trout	20	3	4.8
	Stream trout	12	6	2.5

Kanabec Lakes Water Quality

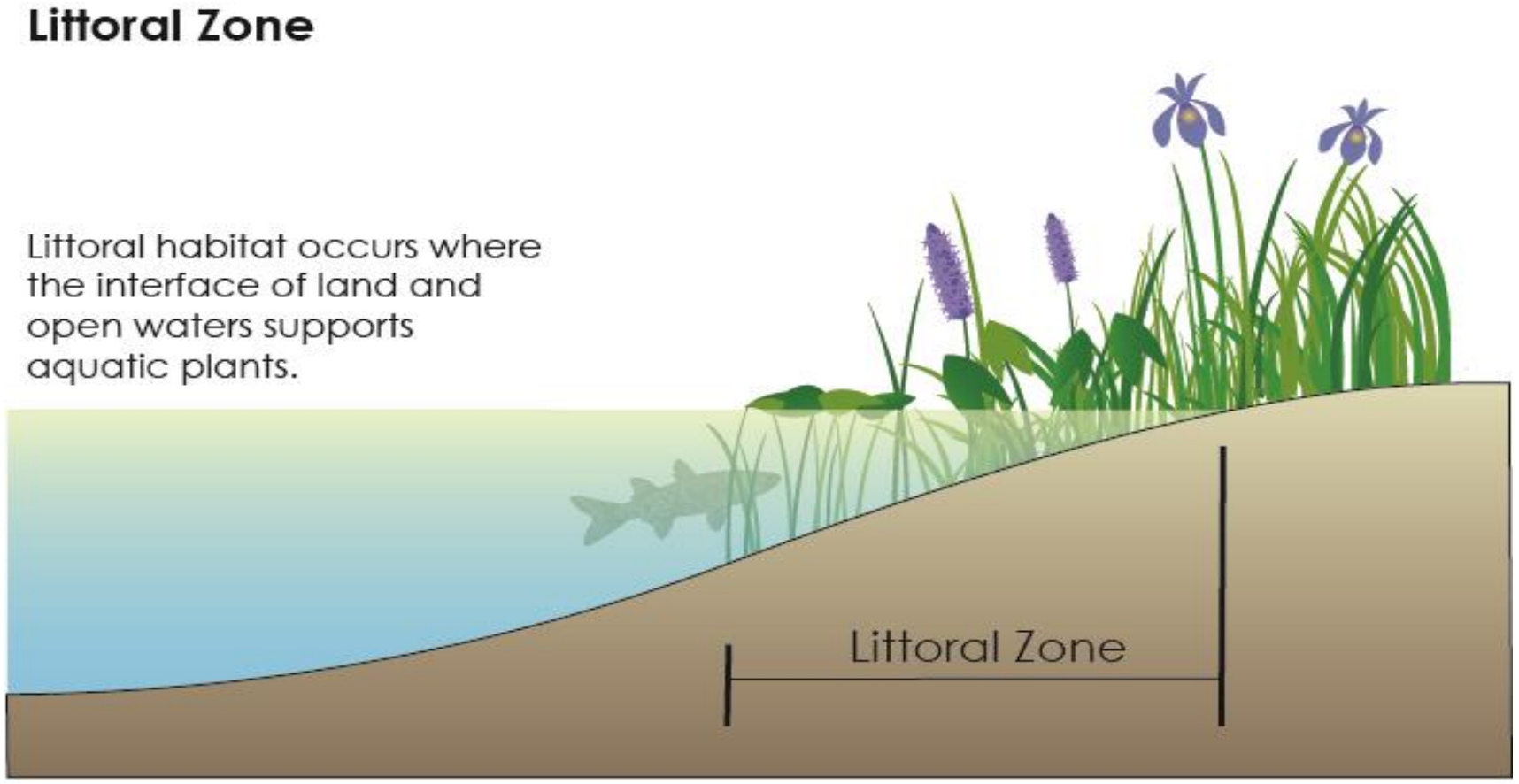
	Total Phosphorus	Chlorophyll-a	Secchi disk depth		number
Name	ug/L	ug/L	ft	Years	of samples
Eleven	43	34	2.9	2008 - 2016	15 - 23
Pomroy	25	6	7.2	2009 - 2014	15 - 80
Knife	95	25	3.0	2009 - 2011	13 - 38
Ann	80	28	3.8	2008 - 2016	26 - 133
Quamba	98	20	2.4	2008 - 2011	10 - 17
Fish	95	39	2.9	2008 - 2016	25 - 92
Lewis	30	16	7.1	2008 - 2016	30 - 232


Ecoregion
Driftless Area
North Central Hardwood F
Northern Glaciated Plains
Northern Lakes and Forest
Northern Minnesota Wetla
Red River Valley
Western Corn Belt Plains

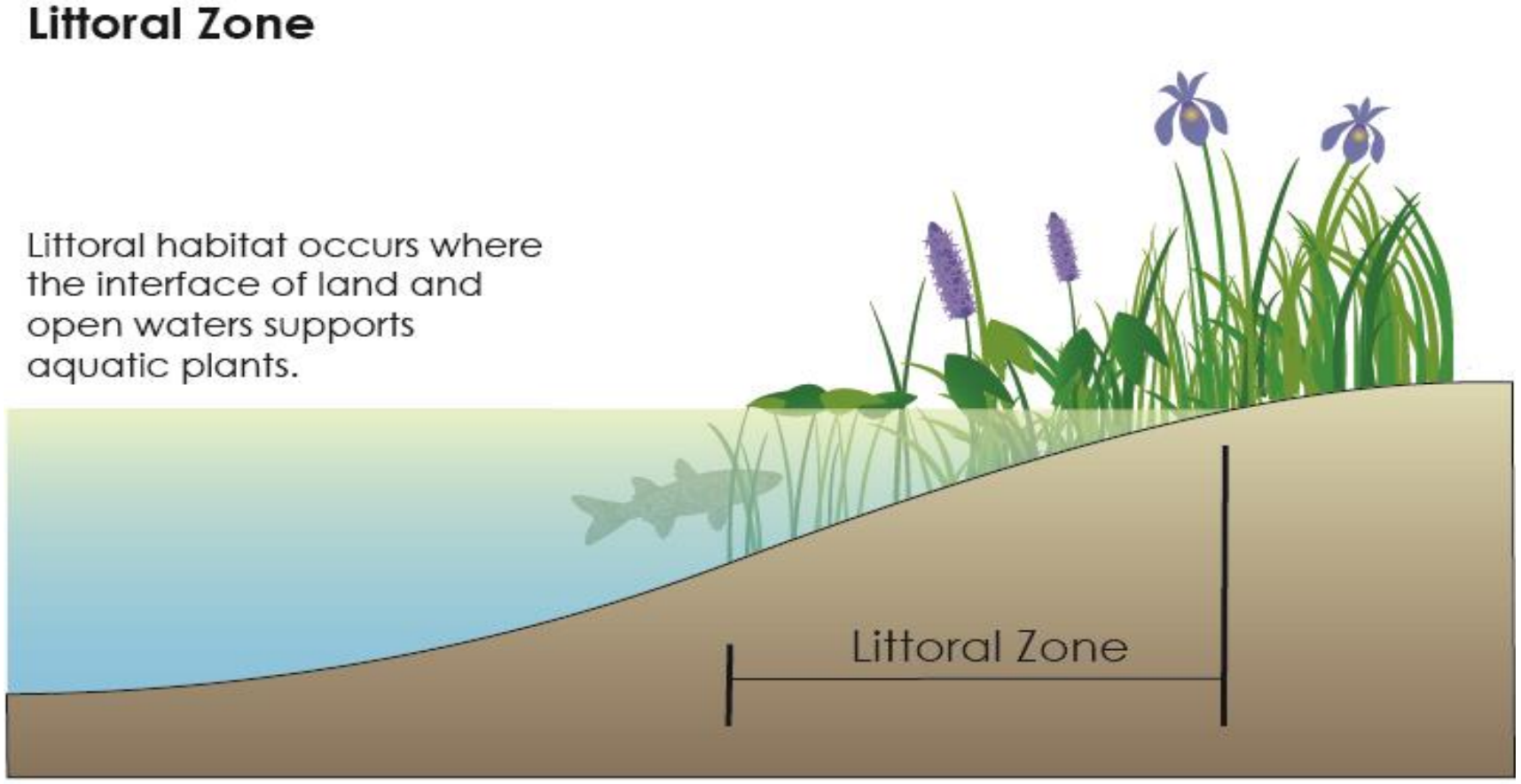
MN Lake Water Quality Standards
Total Phosphorus



The Littoral Zone



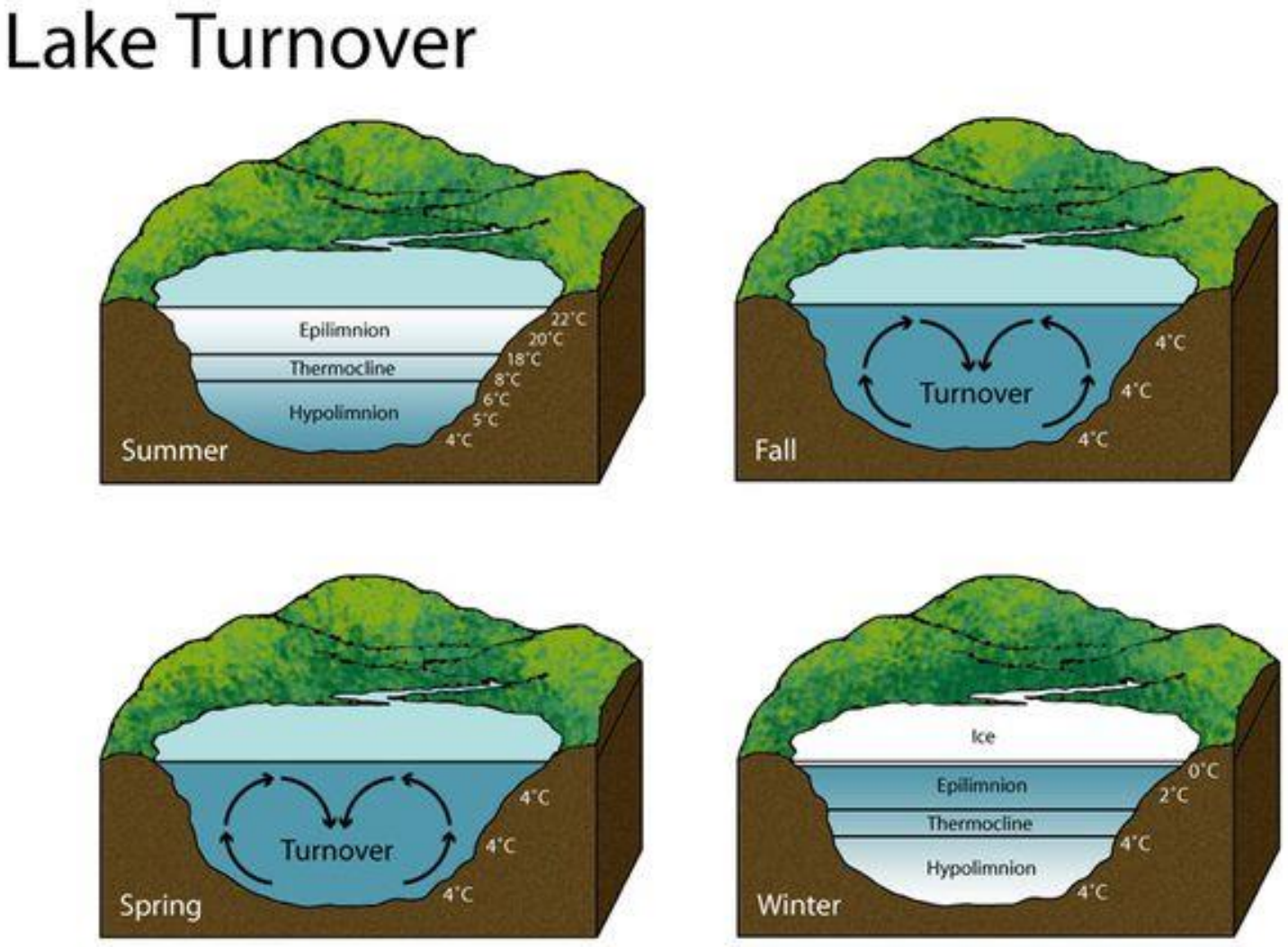
The Littoral Zone: this is what a shallow lake is!



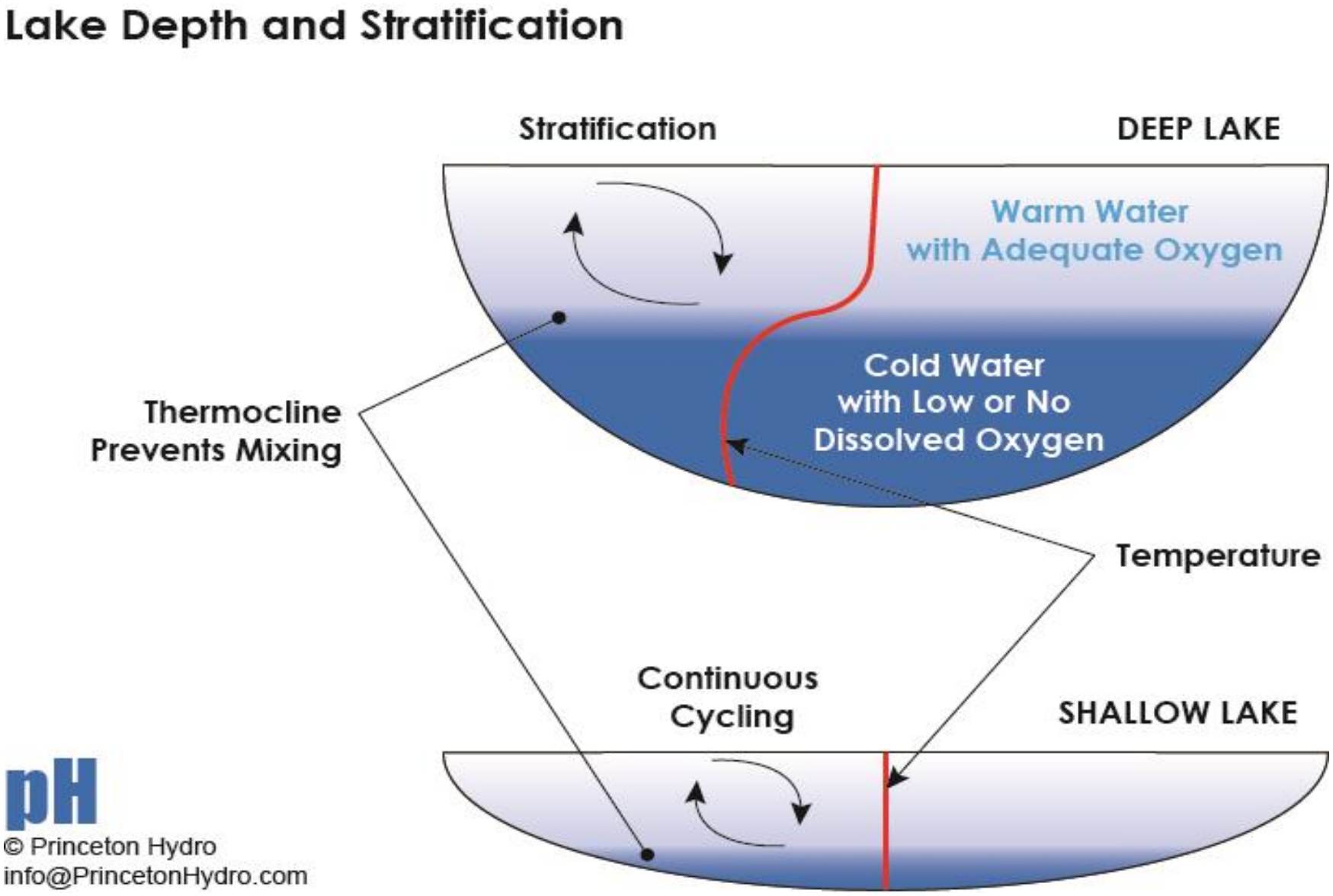
pH

info@PrincetonHydro.com

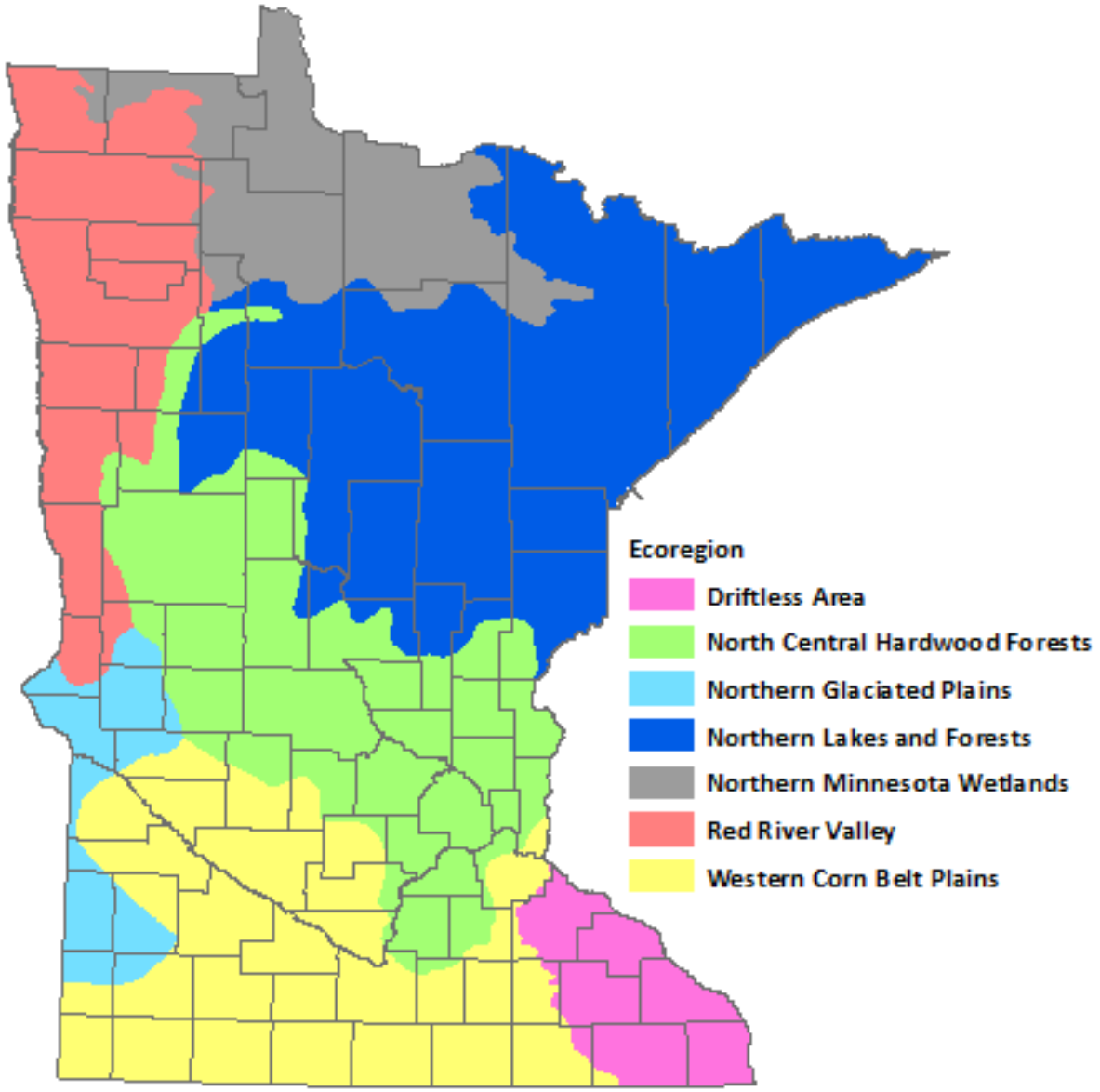
What a deep lake in MN (mid-latitude) does seasonally:



But a shallow lake remains well-mixed.



Ecoregions in Minnesota



Minnesota Lake Water Quality Standards

(Secchi depth in feet)

		Total Phosphorus	Chlorophyll-a	Secchi Depth
Ecoregion(s)	**Sub-Class**	**ug/L**	**ug/L**	**feet**
Western Cornbelt Plains & Northern Glaciated Plains	Shallow	90	30	2.3
	Deep	65	22	3.0
North-Central Hardwood Forest	Shallow	60	20	3.3
	Deep	40	14	4.6
	Stream trout	20	6	8.2
Northern Lakes & Forests	Deep/Shallow	30	9	6.6
	Lake trout	20	3	15.7
	Stream trout	12	6	8.2

Minnesota Lake Water Quality Standards

Chlorophyll-a & Secchi depth