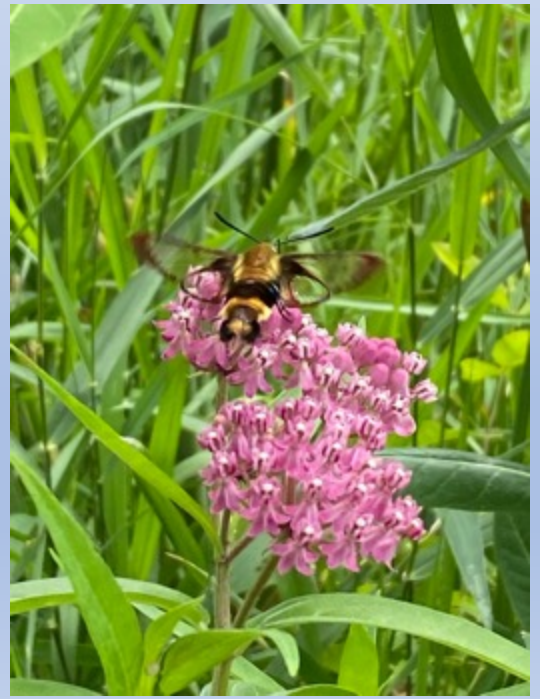
Nitrogen Loading, Sulfate Reduction, and the Over-Fertilization of Normandale Lake, Bloomington, MN



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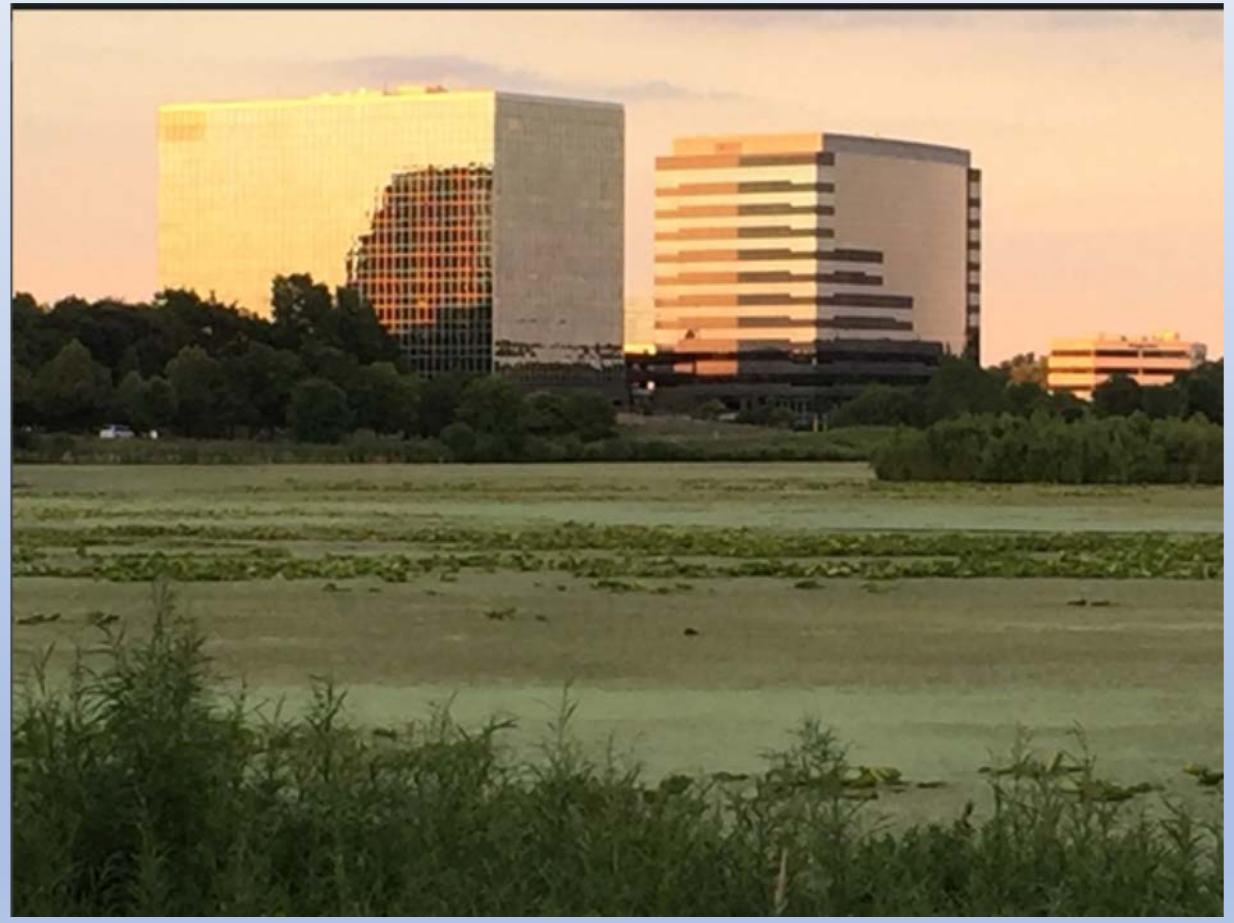
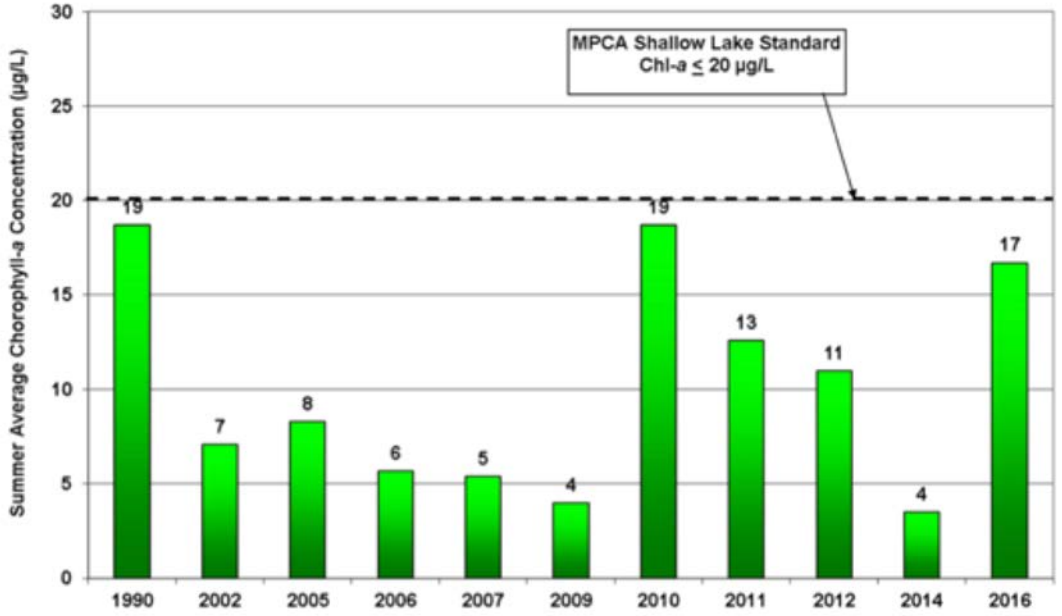
Freshwater Society Brown Bag Presentation – July 14, 2021

Acknowledgements

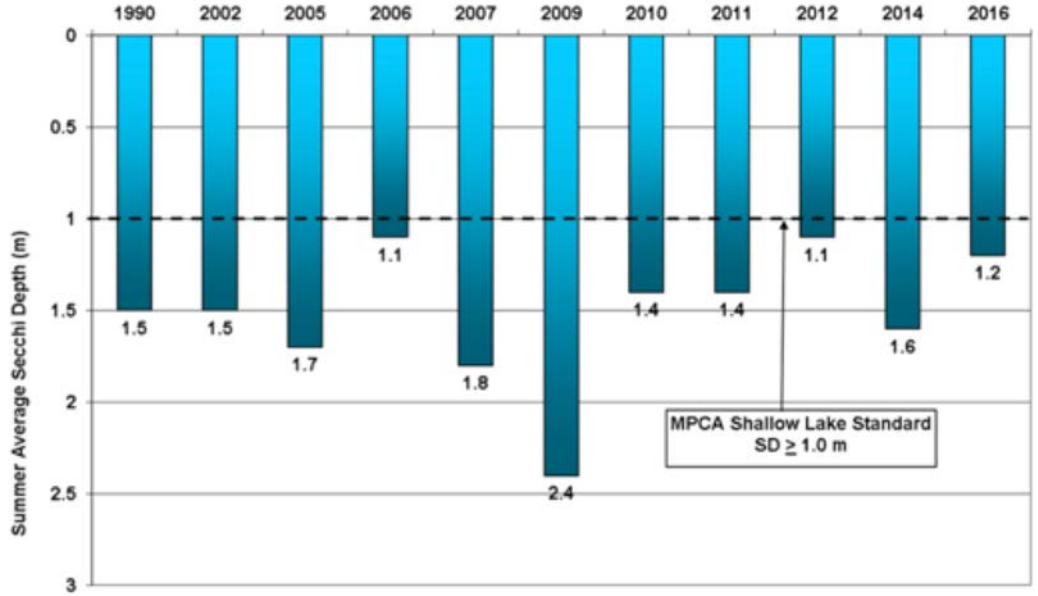
- Nine Mile Creek Watershed District
  - Randy Anhorn, Erica Sniegowski
- Barr Engineering
  - Janna Kieffer, Keith Pilgrim
- Retired Colleague
  - Edward Swain
- Ion Chrome Analytical
  - Rick Knurr
- Freshwater Society
  - Carrie Jennings

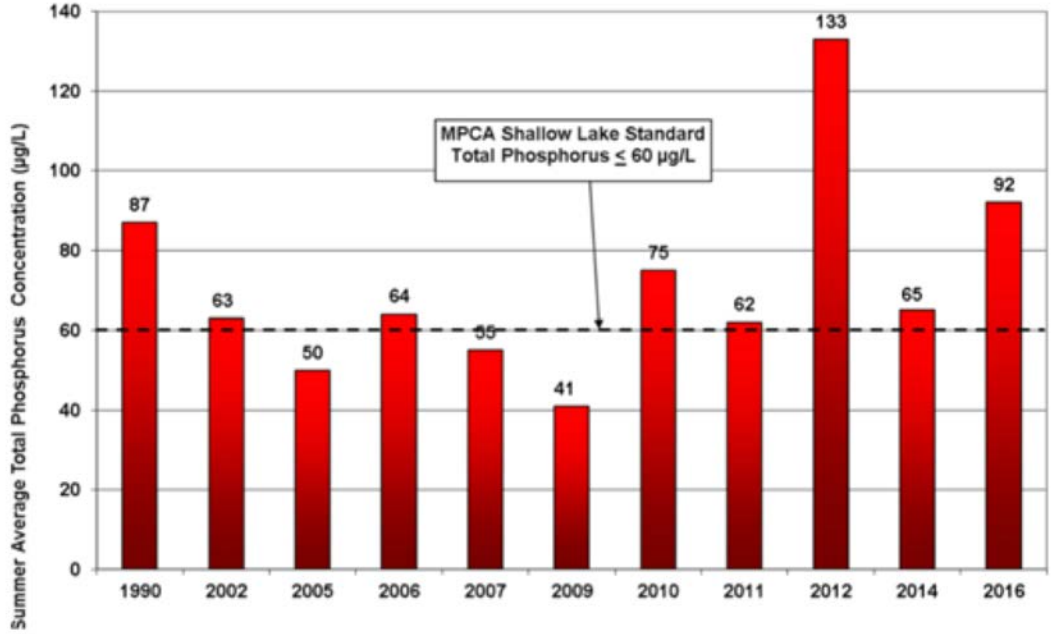
Lake Conditions Before Treatment (June 28, 2016)



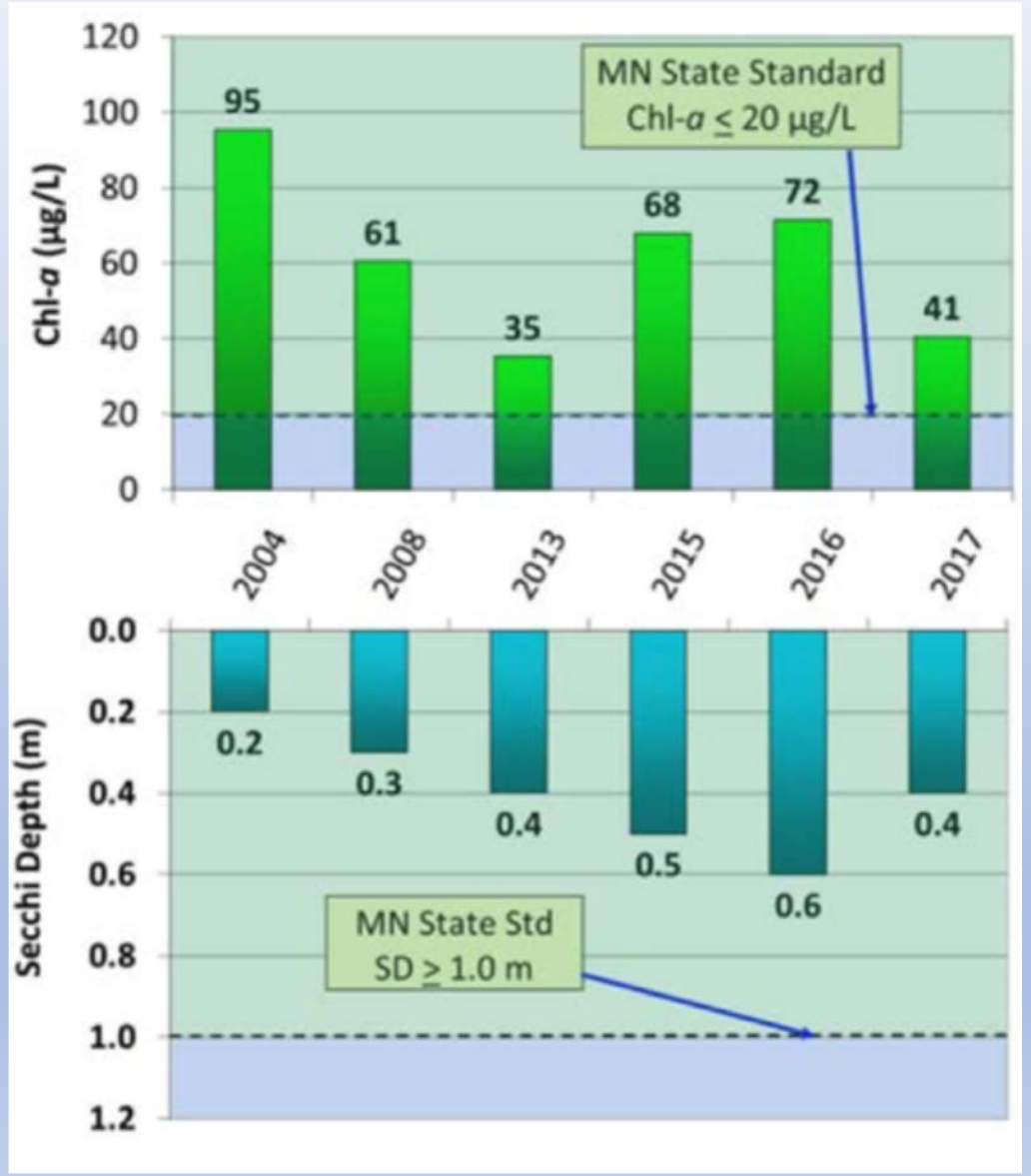

Summer Average Chorophyll-a Concentration (µg/L)
MPCA Shallow Lake Standard
Chl-a ≤ 20 µg/L
19
7
8
6
5
4
19
13
11
4
17
1990
2002
2005
2006
2007
2009
2010
2011
2012
2014
2016

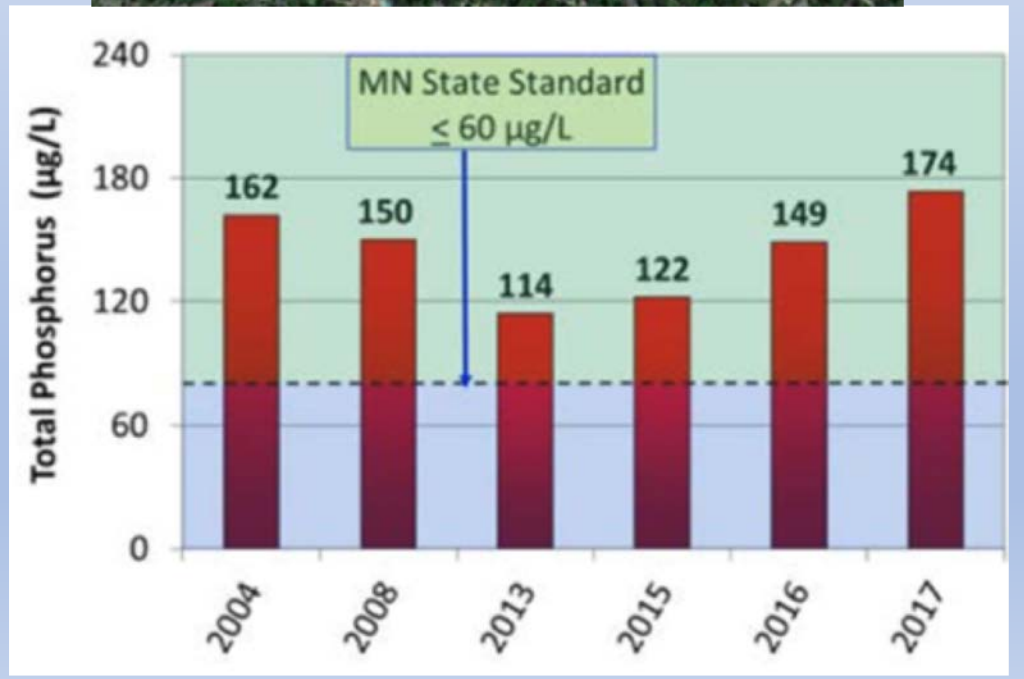

Mt Normandale Lake


Summer Average Secchi Depth (m)
1990
2002
2005
2006
2007
2009
2010
2011
2012
2014
2016
1.5
1.5
1.7
1.1
1.8
2.4
1.4
1.4
1.1
1.6
1.2
MPCA Shallow Lake Standard
SD ≥ 1.0 m


Summer Average Total Phosphorus Concentration (µg/L)
MPCA Shallow Lake Standard
Total Phosphorus ≤ 60 µg/L
87
63
50
64
55
41
75
62
133
65
92
1990
2002
2005
2006
2007
2009
2010
2011
2012
2014
2016

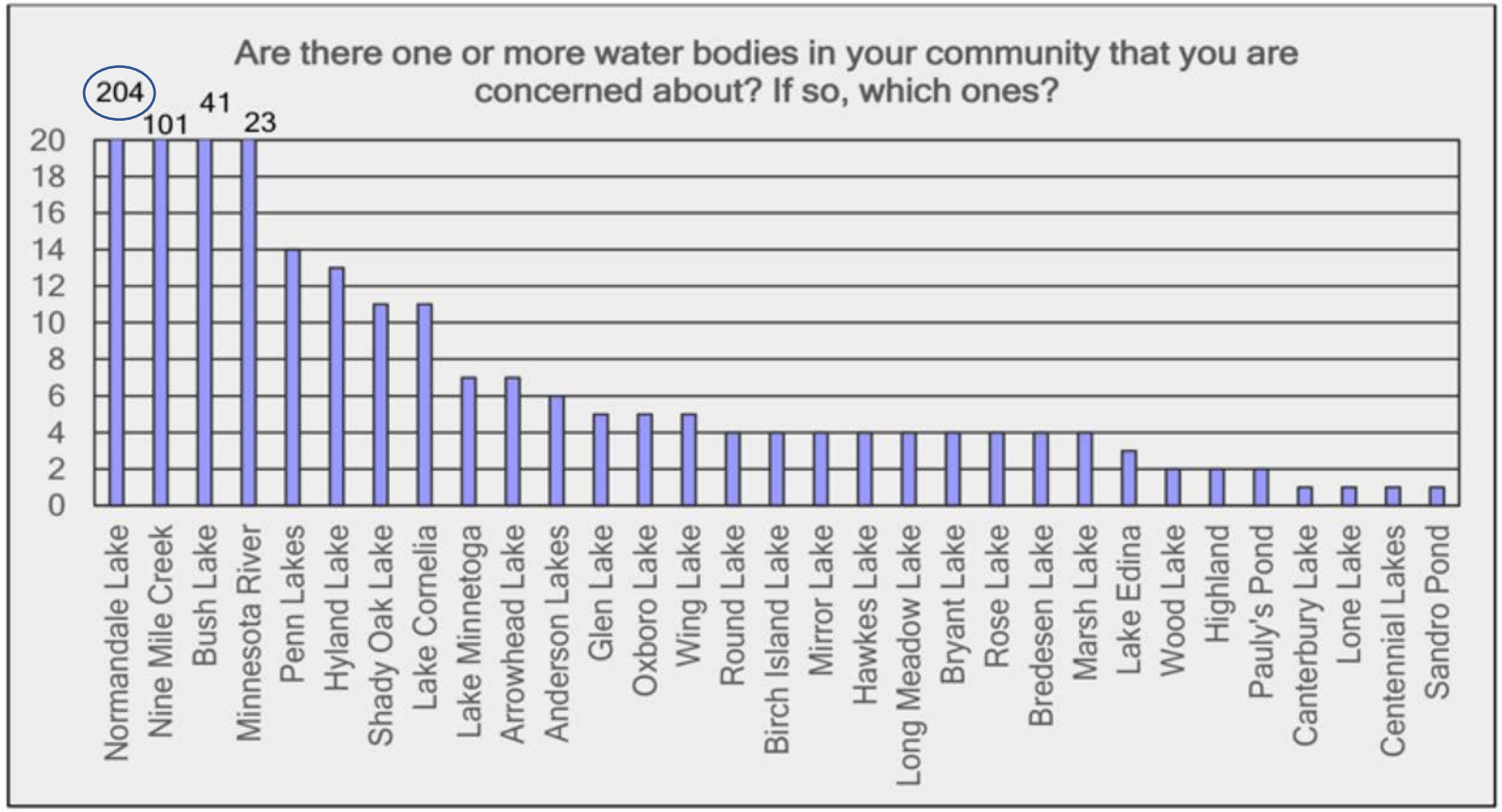
South Lake Cornellia: P, Secchi, Choro-A.





2016 Citizen Survey Results: Nine Mile Creek Watershed

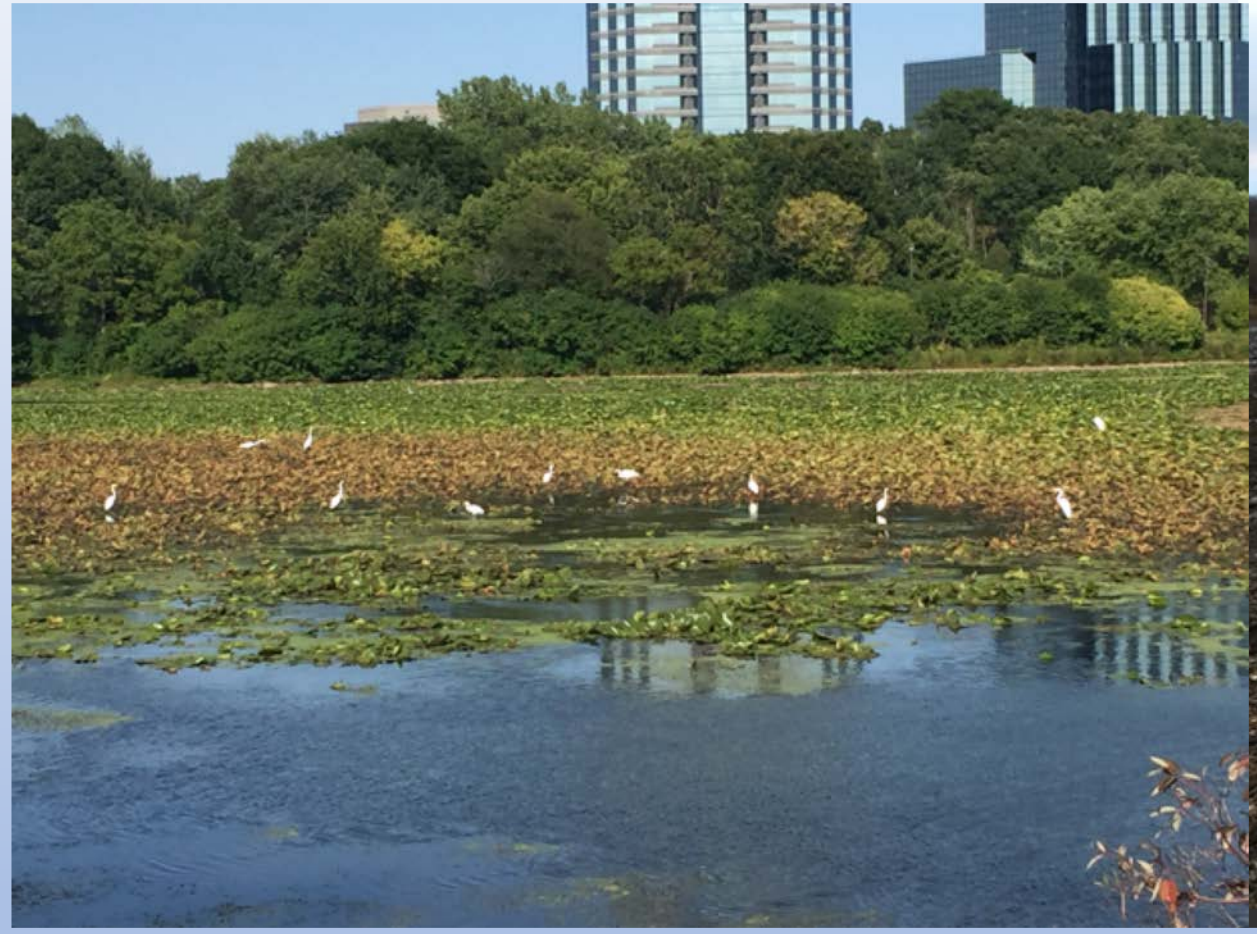
Question 10: Are there one or more water bodies in your community that you are concerned about? If so, which ones? (662 responses)



Weir on lake’s upstream side:

Large pipe on downstream side>>>>

Draining Normandale Lake: 2018

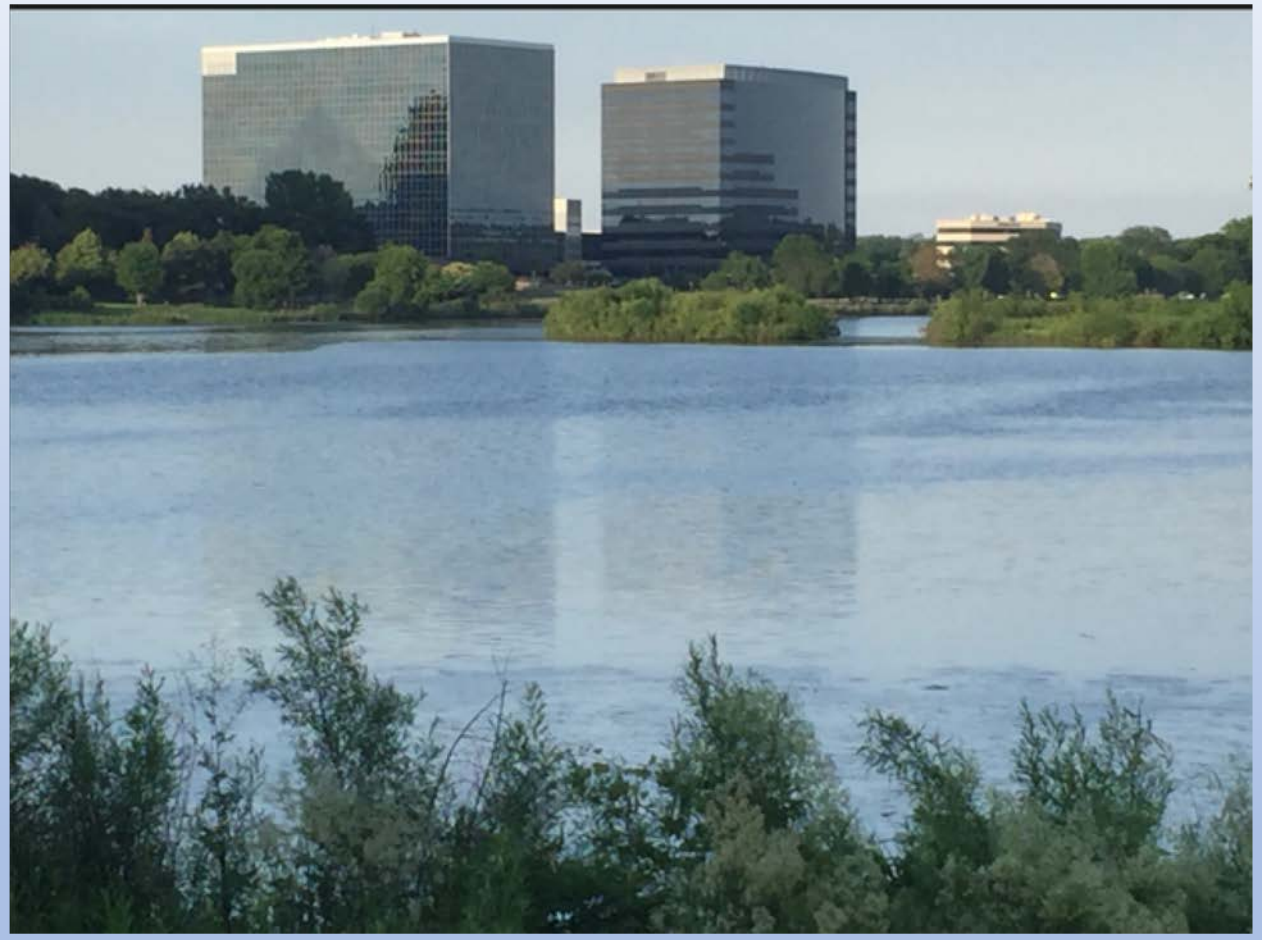


August 30

Drained lake

Alum Treatments on refilled lake:

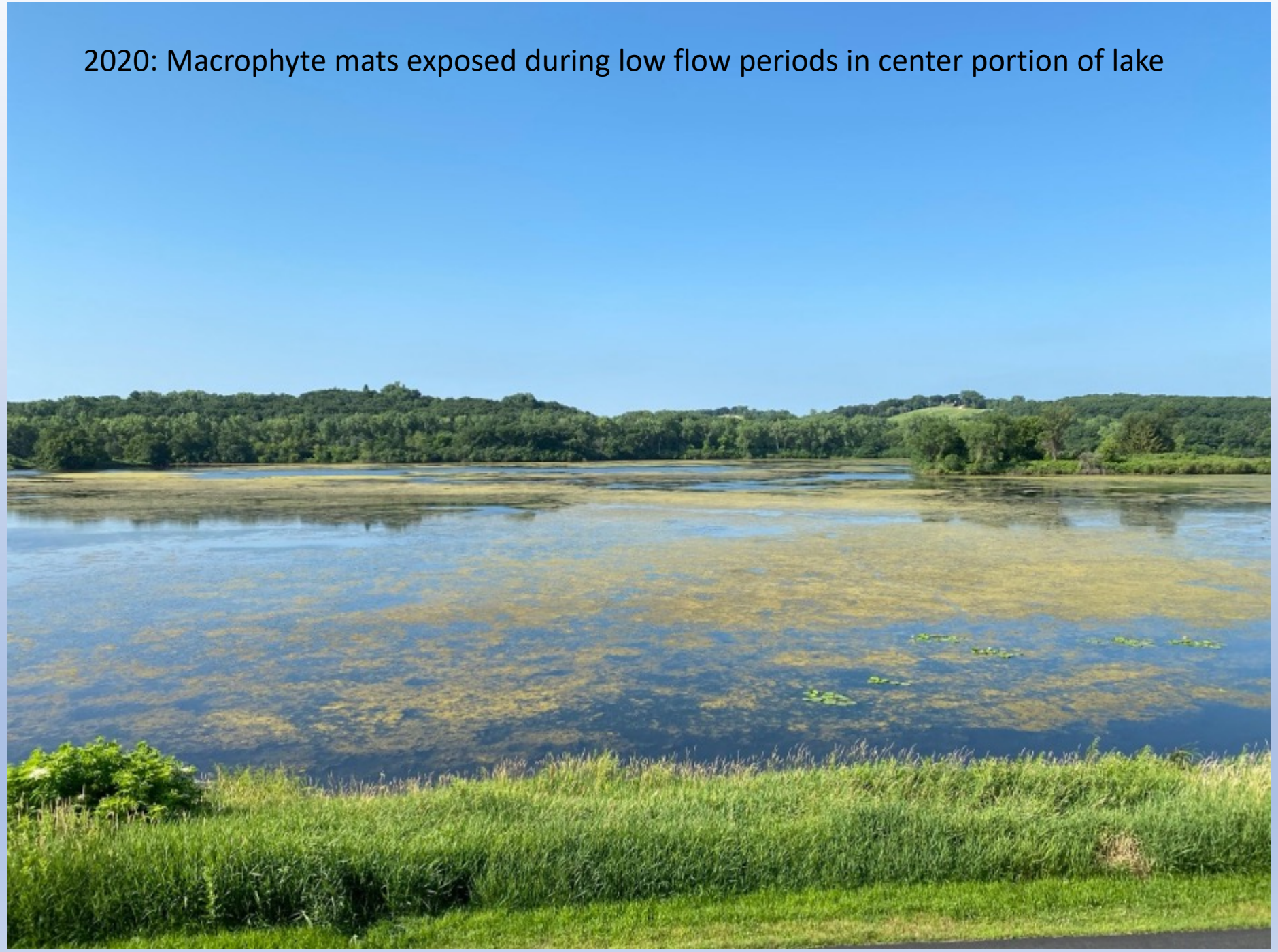
After Treatment (June 28, 2019)

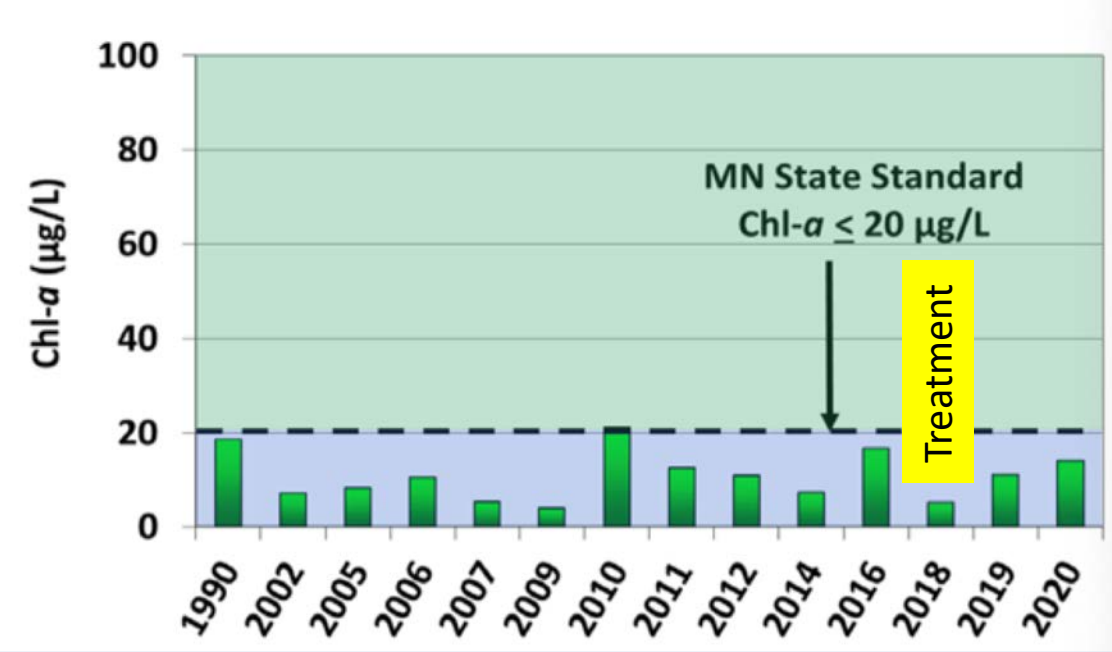


July 3, 2019 (Facebook Photo posted by Doug Wallick)

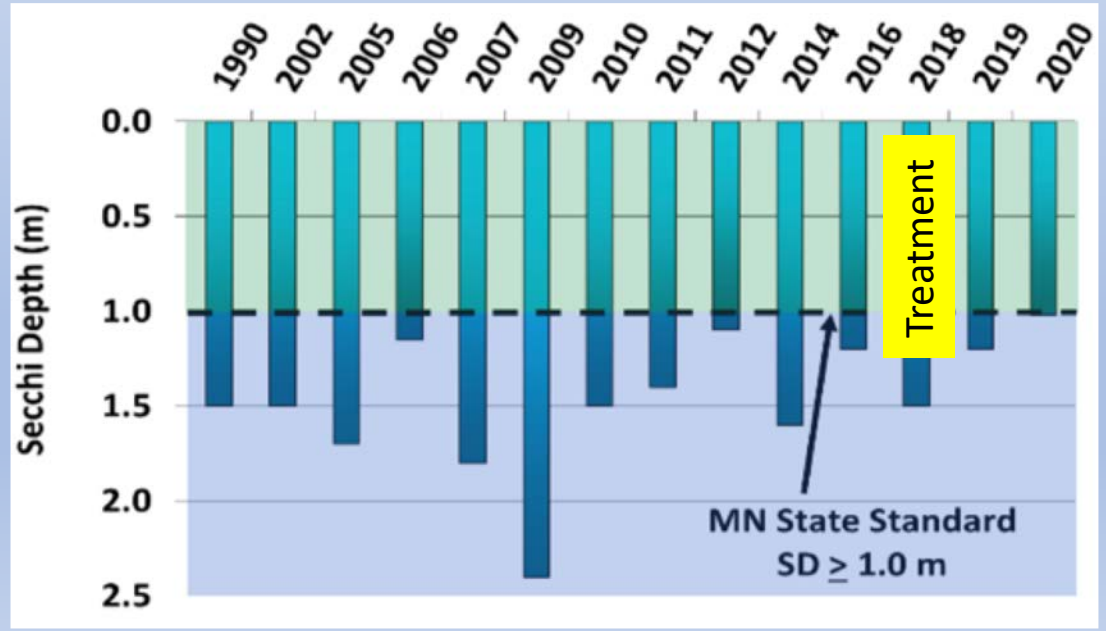
July 24, 2019. Image of macrophyte regrowth in west end of Normandale Lake

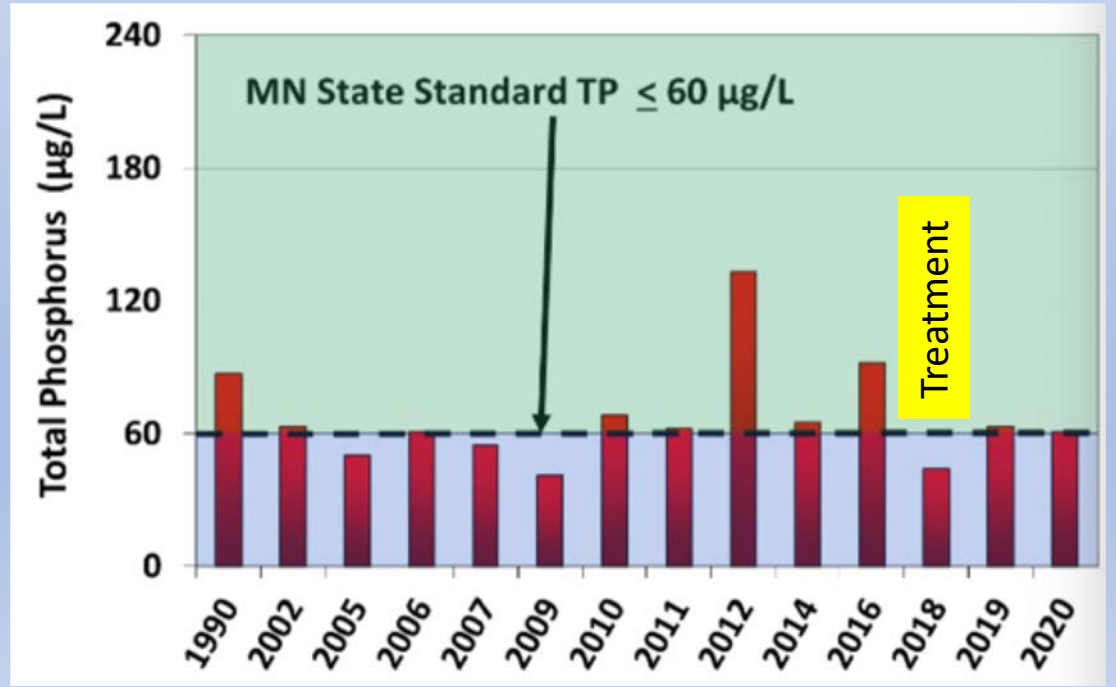
2020: Macrophyte mats exposed during low flow periods in center portion of lake





Normandale Lake:
Total P, Chl-A, and Secchi Depth.



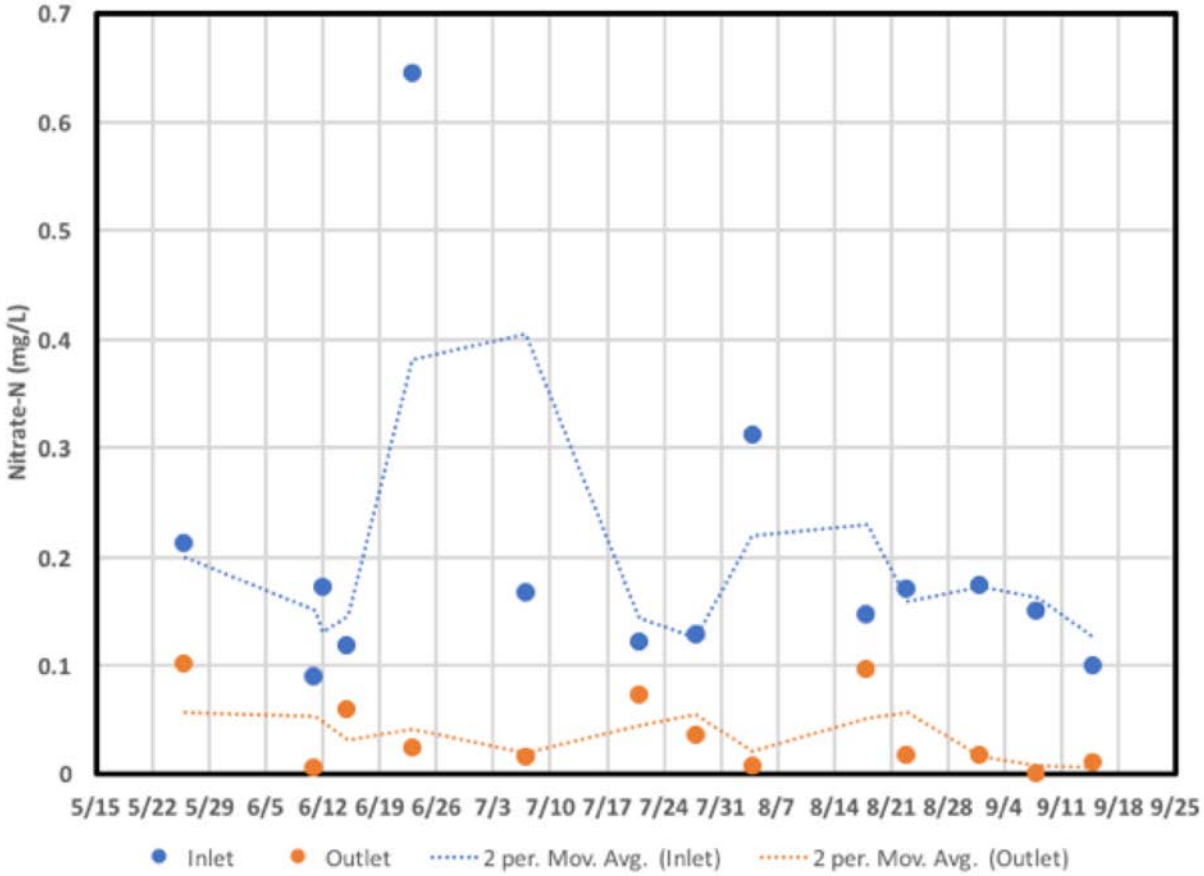


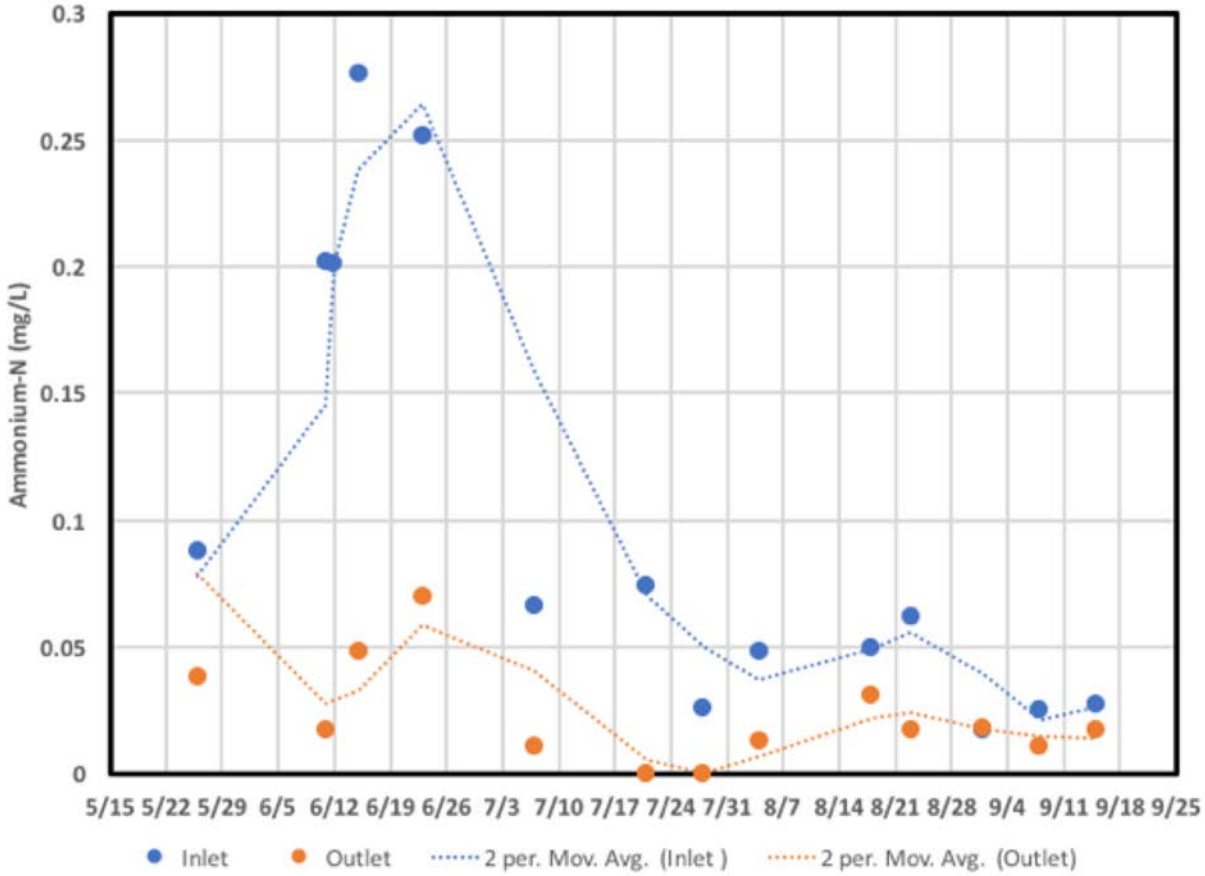
Inlet/Outlet Chemistry, before and after lake treatment

Filtered

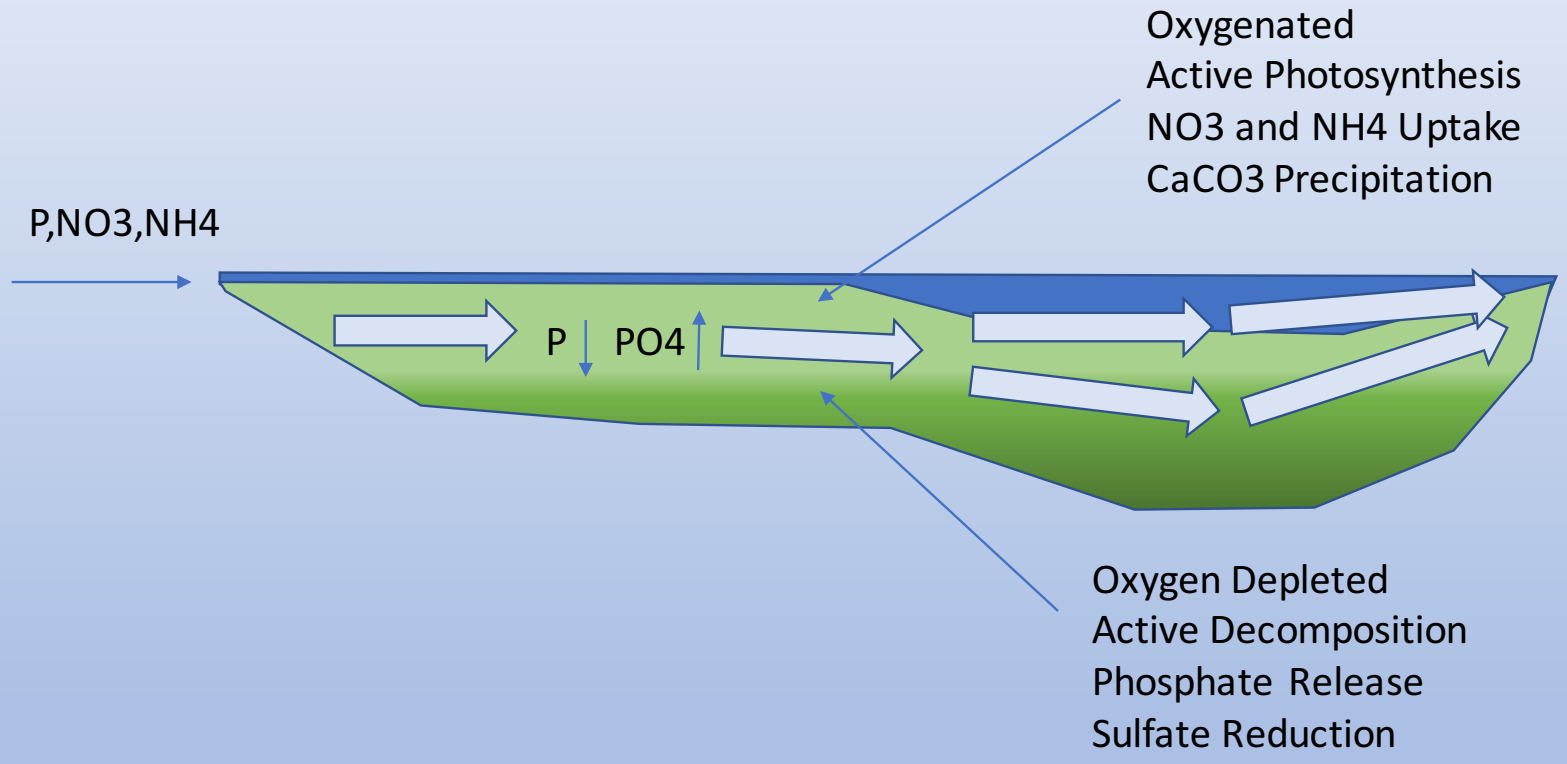
Anions and Cations by Ion Chromatography

NO3 and NH4 at Normandale Lake's inlet and outlet in 2017 (Pretreatment)

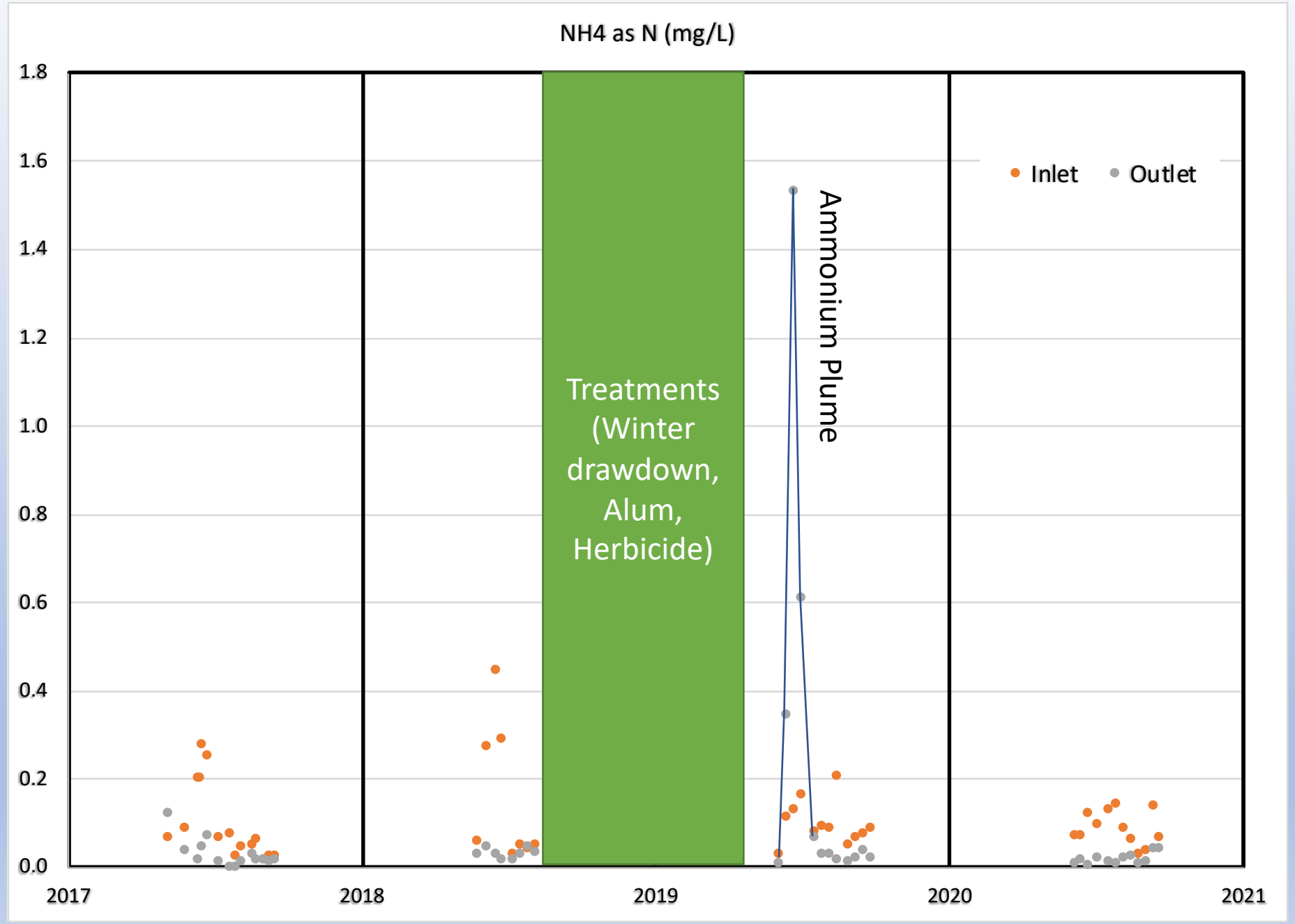




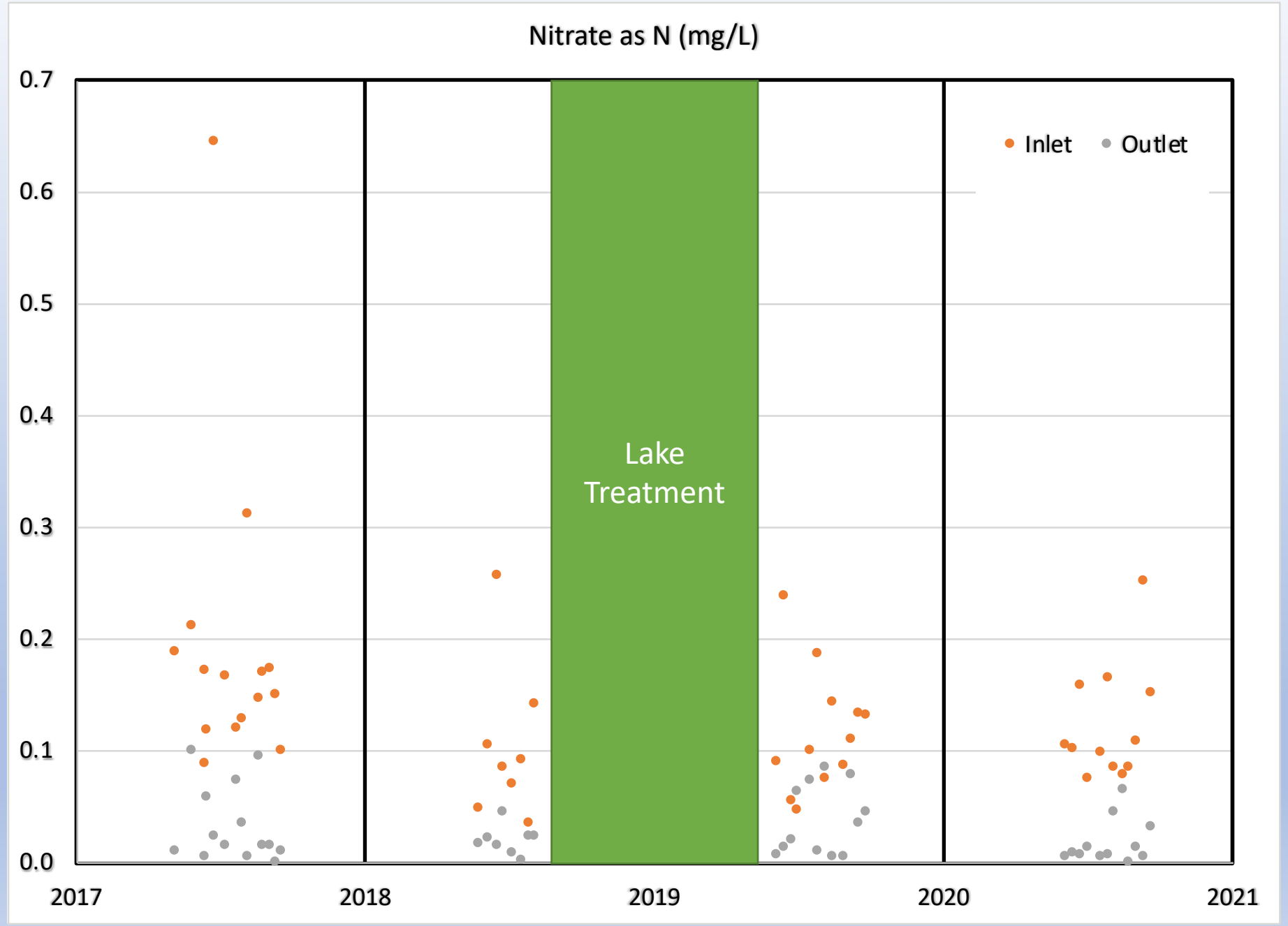
Proposed Mechanism for nutrient uptake and sulfate reduction in Normandale Lake



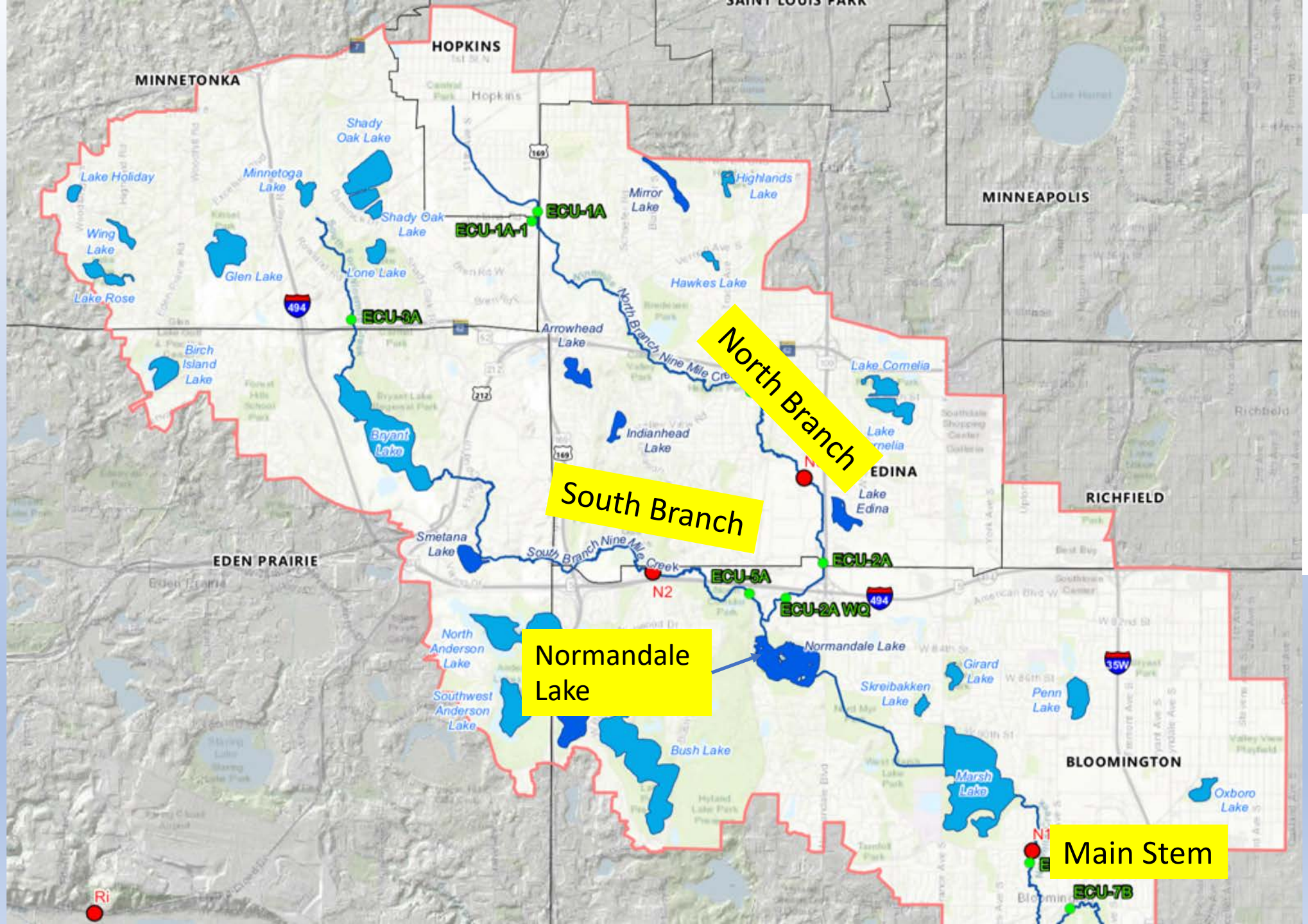
Berndt and Knurr, 2017, *Normandale Lake Inlet and Outlet Chemistry in 2017: A case for considering Nitrate and Ammonium limitation in Treatment Options*.



Notes:
(1) A large amount of ammonium left the lake in June, right after treatment.
(2) Ammonium was utilized in lake before and after treatment.

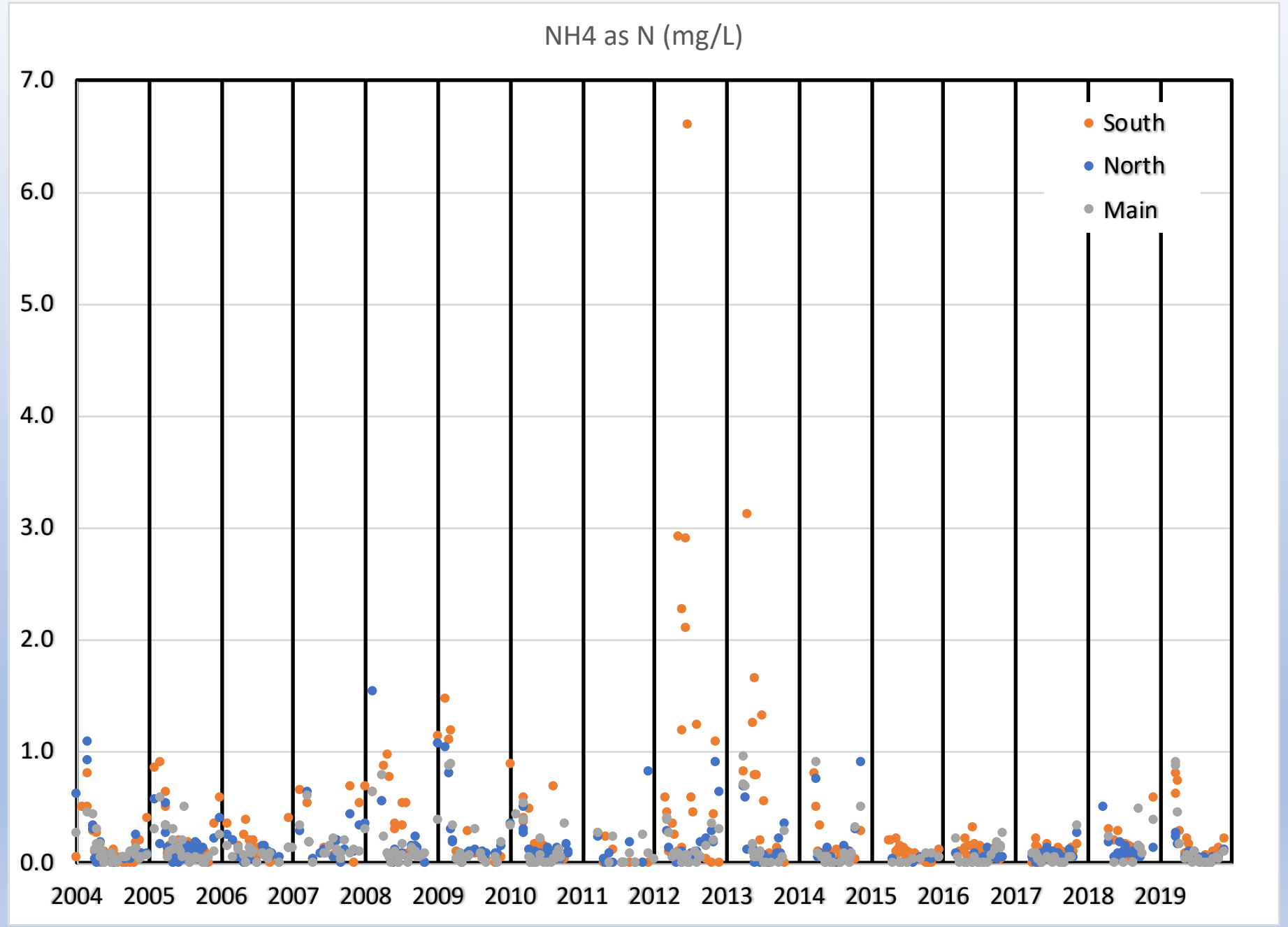


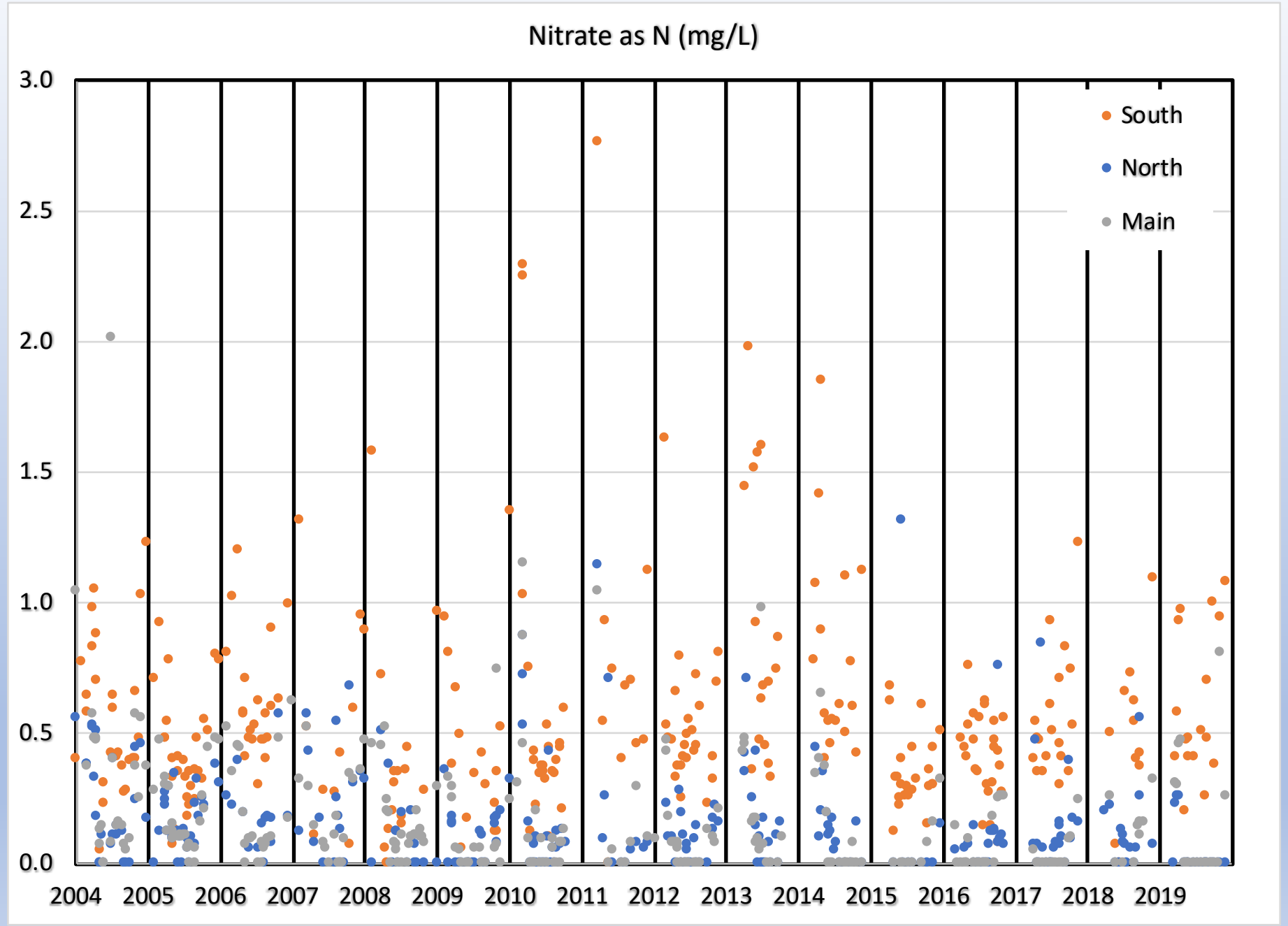
Notes:
Lake appeared to become N limited again, shortly after lake treatments.



NMCWD Sampling Locations in relation to Normandale Lake

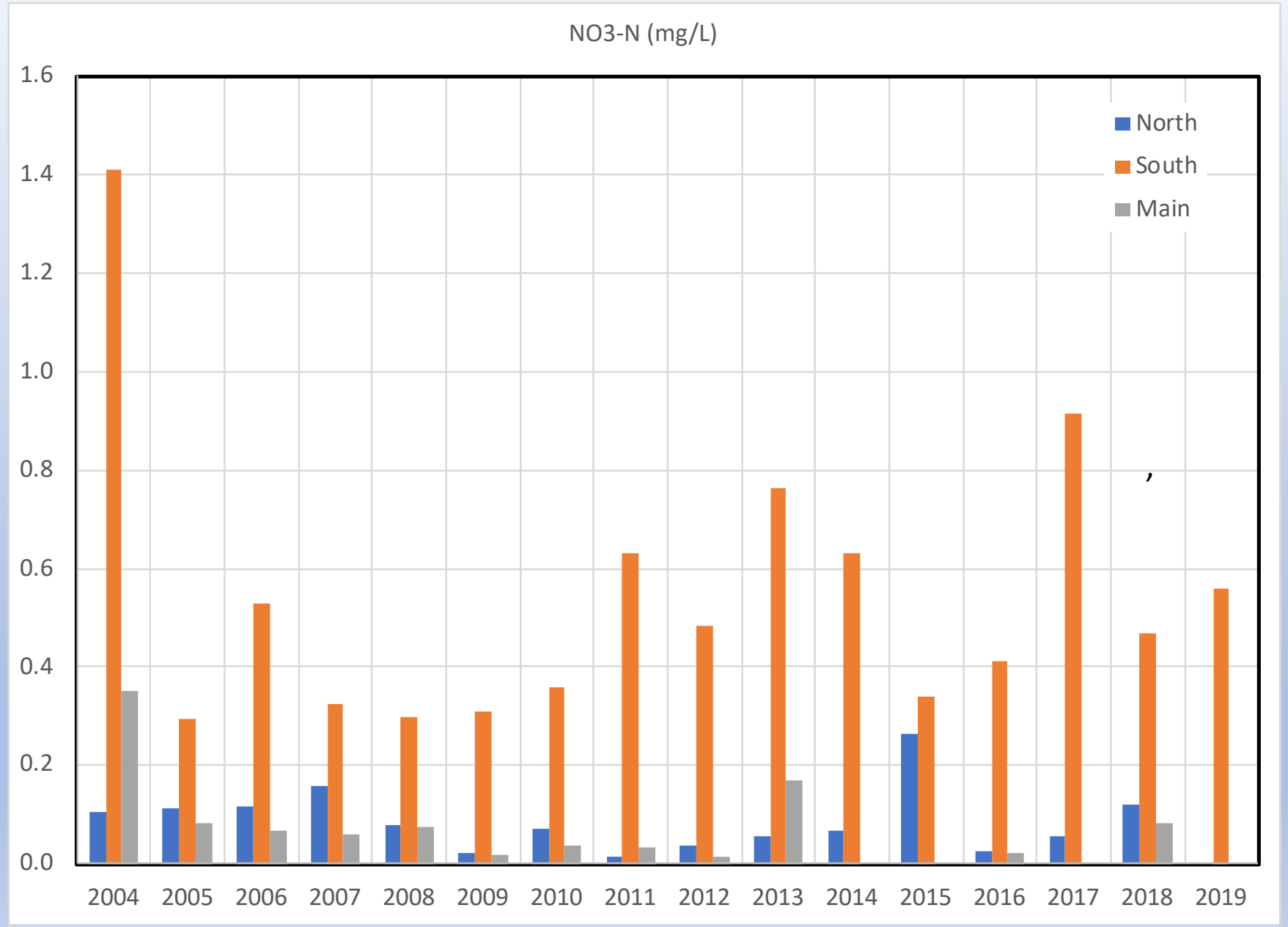
- Sampling Site

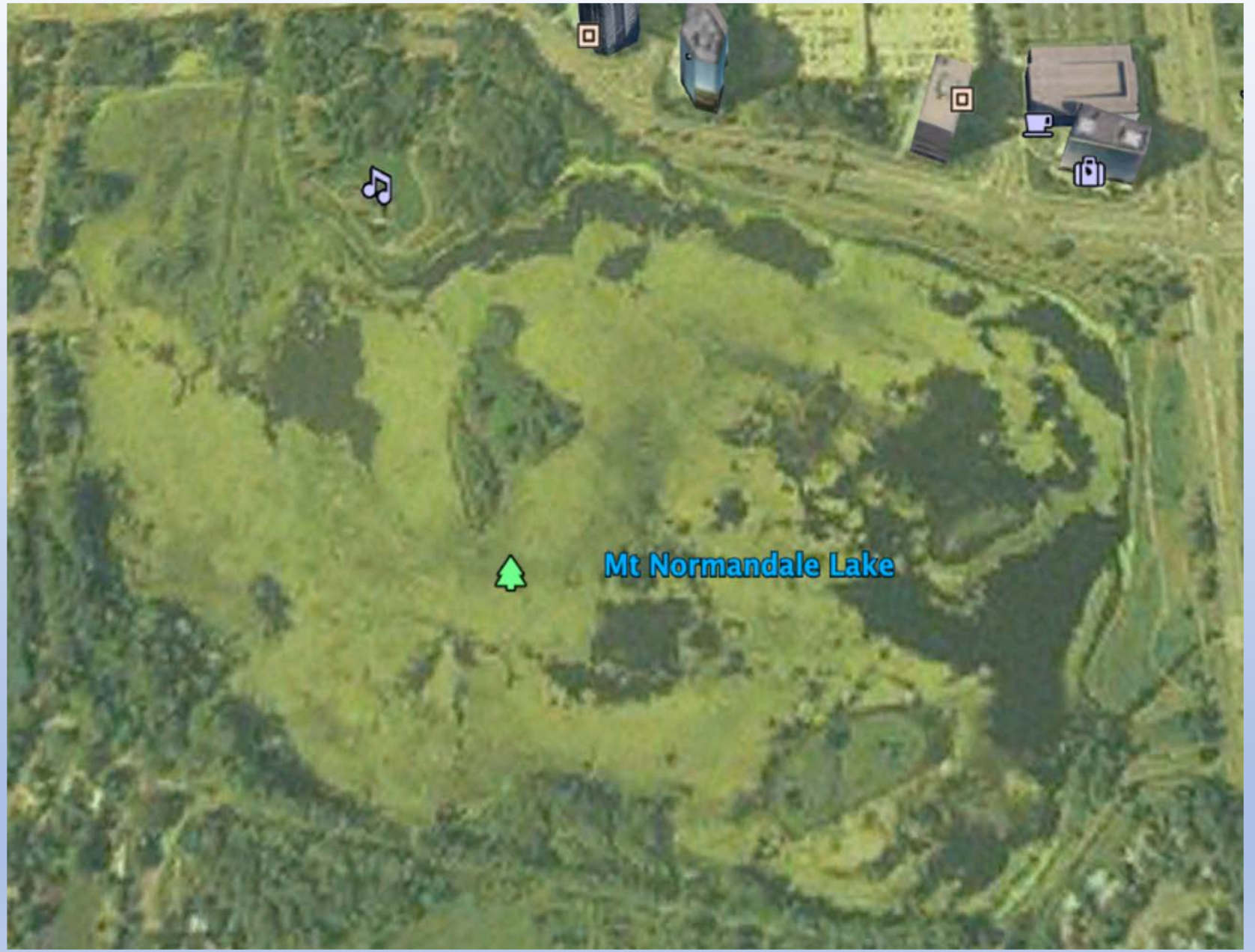

NH4 as N (mg/L)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
South
North
Main



(scale cut off at 3.0)

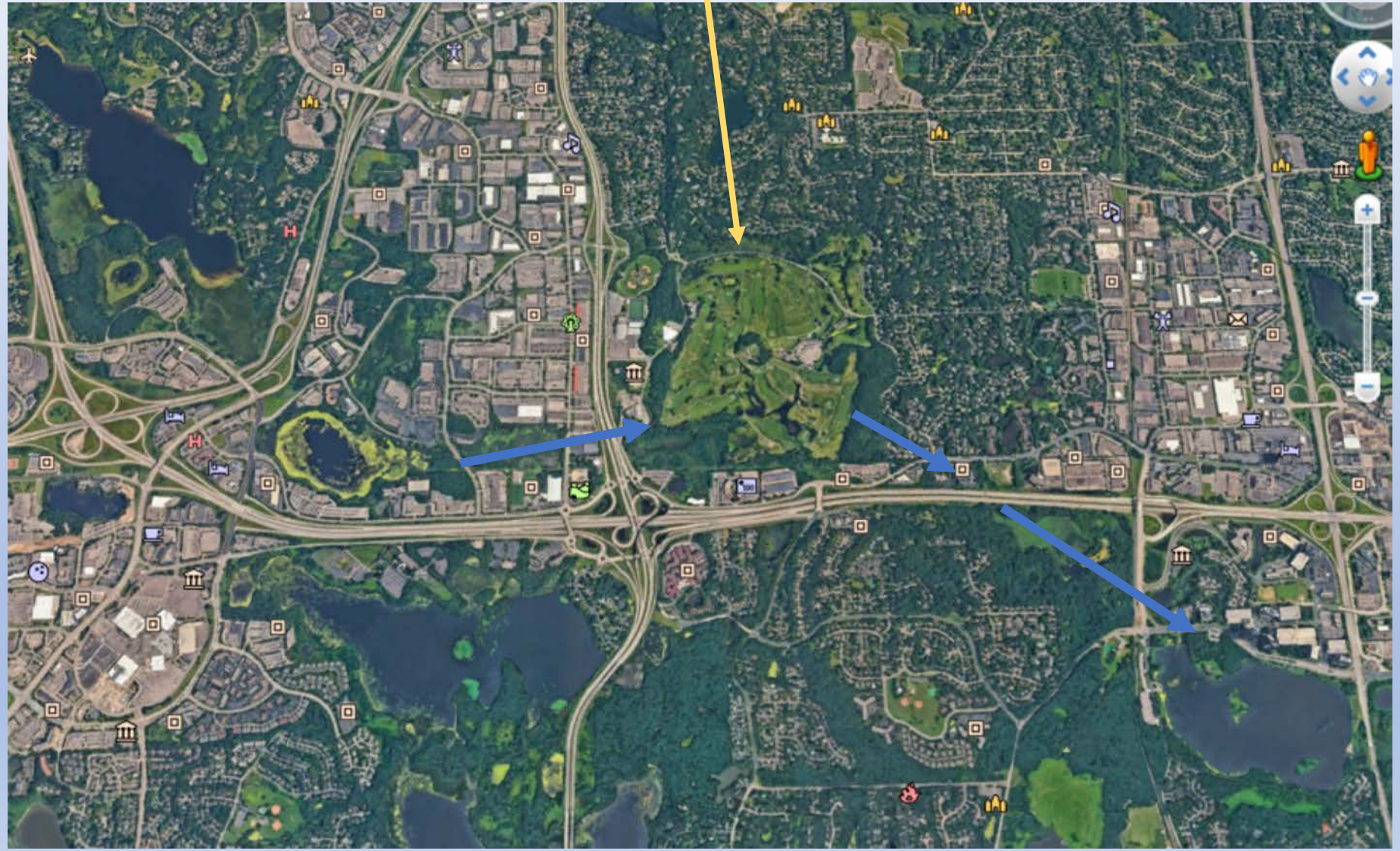
Summer Averages



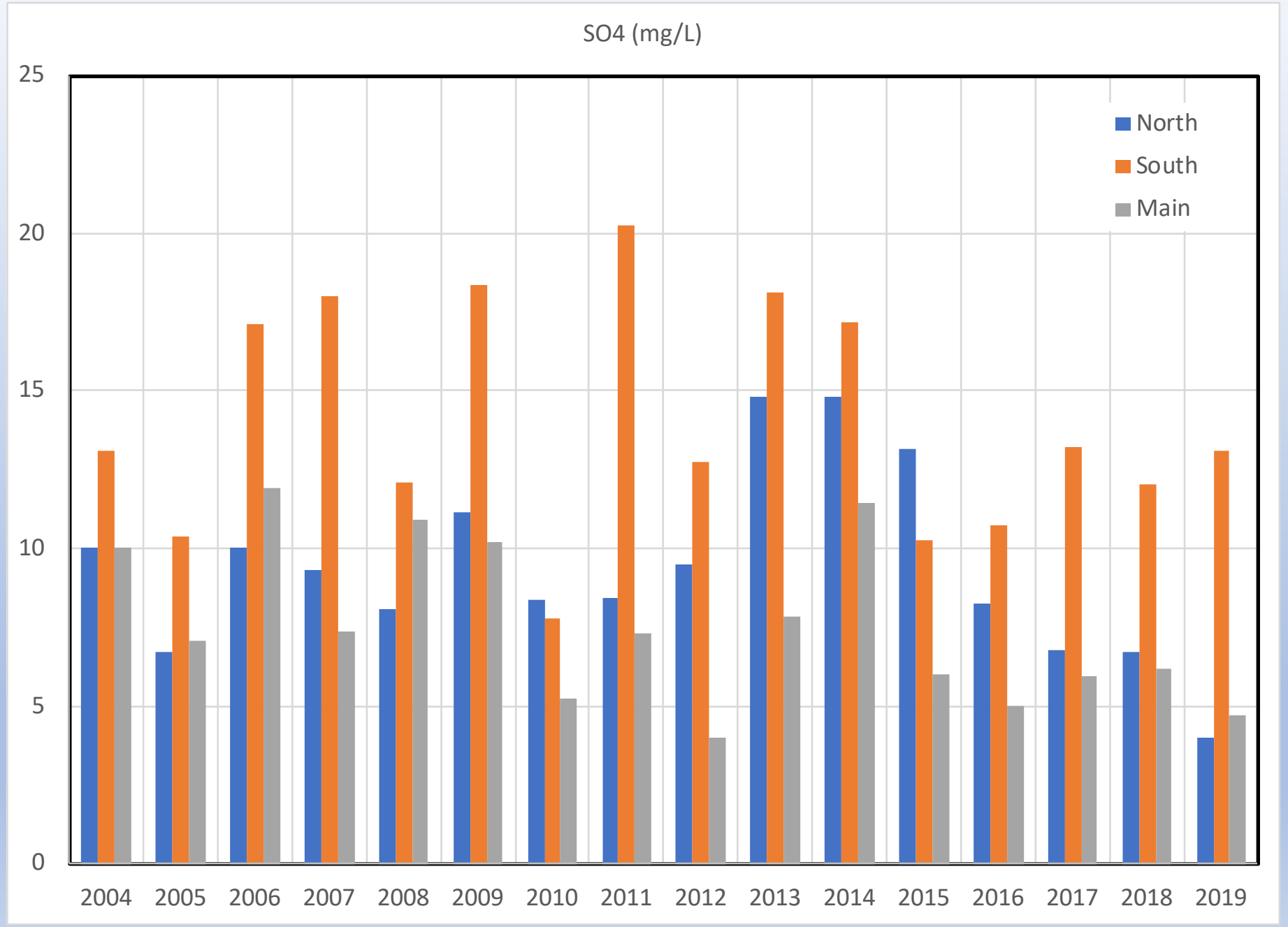


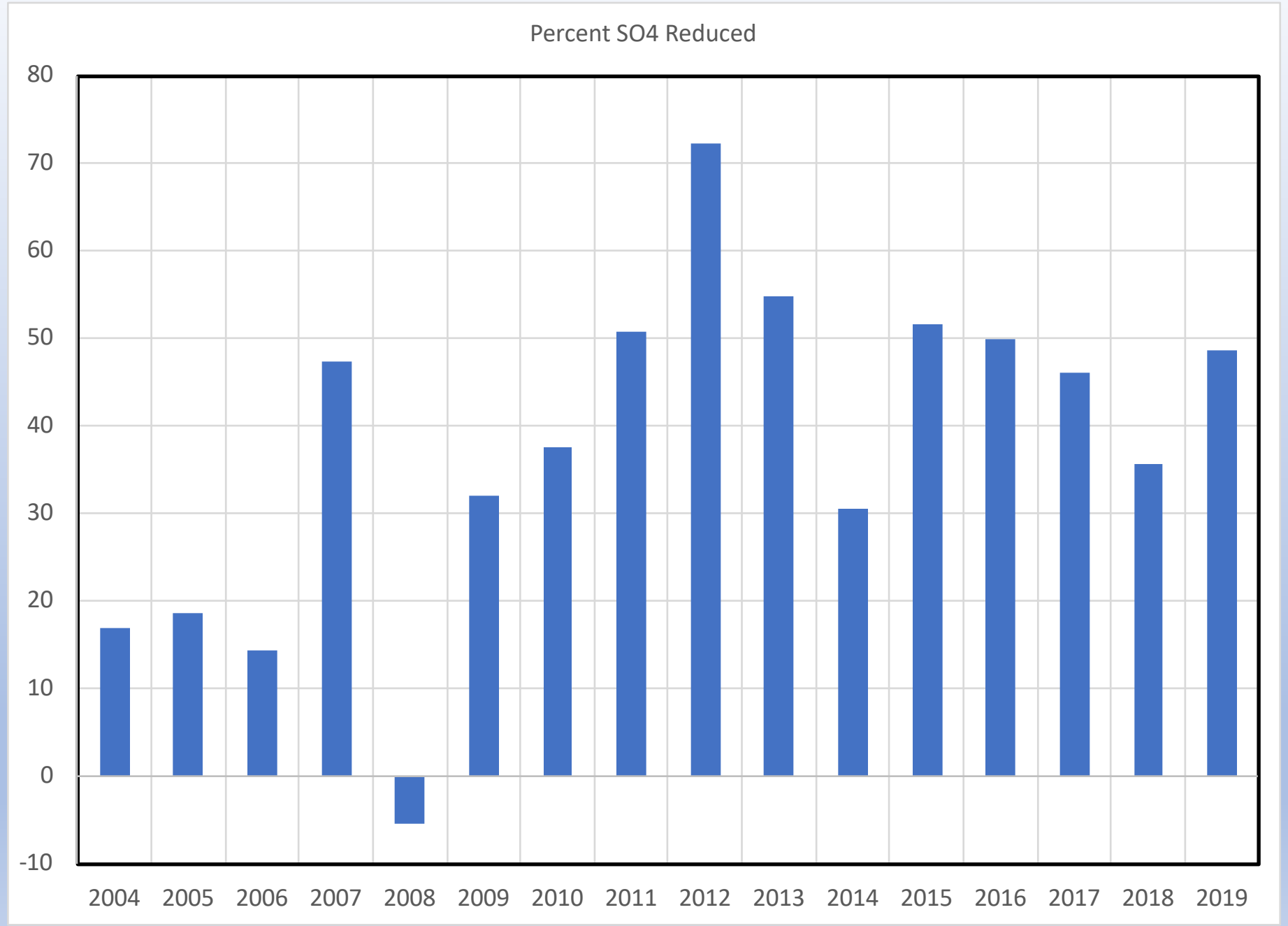
8/2/2004 Satellite Image

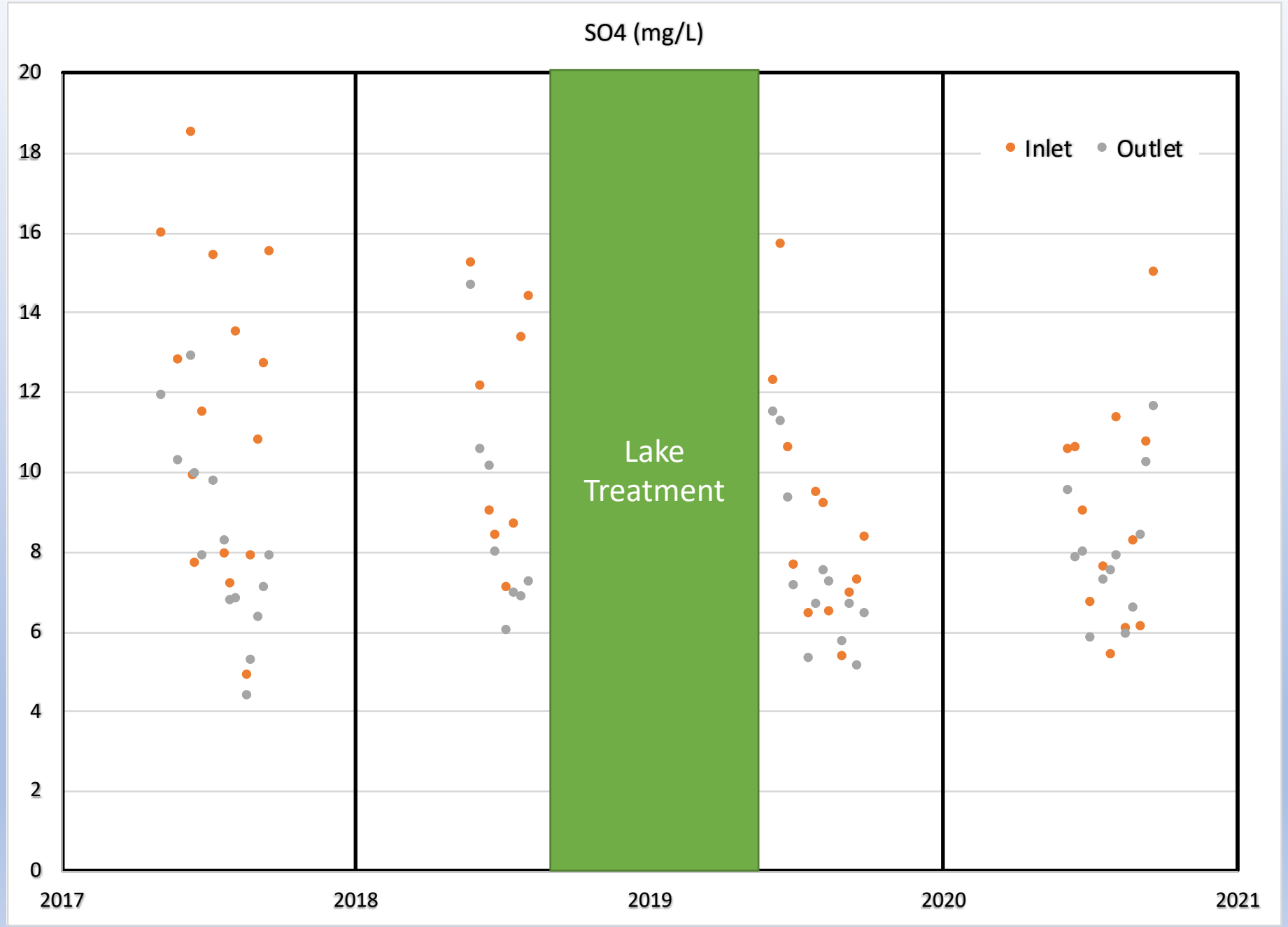
Golf course upstream of Normandale Lake on South Branch



Normandale Lake


SO4 (mg/L)
25
20
15
10
5
0
North
South
Main
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019


Percent SO4 Reduced
80
70
60
50
40
30
20
10
0
-10
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019



Notes:
Sulfate concentration at the inlet is often higher than at the outlet.

Negative impacts of sulfate reduction

(1) H_2S is poisonous and smells bad

(2) Creates MeHg as a toxic byproduct

(3) Promotes nutrient release from sediments (Myrbo et al, 2017).

Interpretation – Normandale Lake:

(1) Macrophytes accumulate in the lake all summer by capturing the N passing through the lake.

(2) Shallow “Flow-through” lakes can have very high external N-loading rates.

(3) Excess macrophyte growth leads to sulfate reduction.

Summary

- Total P, Secchi disk, Chlor-A standards identify floating algae blooms but missed Normandale Lake's macrophyte problem.
- Alum treatment and lake drawdown had excellent initial results but N limitation returned by the end of the first summer.
- External N loading leads to nutrient feedback loop:
  - Macrophyte over-abundance
  - promotes summer O2 depletion
  - sulfate reduction => accelerated nutrient release from sediments