Water Quality Summary Report

Summer 2023

Hidden Lakes

Mt. Pleasant, SC

September 15, 2023

Prepared For:

Mr. Pete Dirkes

QUALITY LAKES

Stormwater • Aquatic Weed Control • Fish Management

Quality Lakes Inc.
C. Wade Bales, Fisheries Biologist
2646 Langfordville Rd., Ridgeland, SC 29936
843.812.6844
www.qualitylakes.com

Hidden Lakes Water Quality Monitoring Winter + Spring + Summer 2023 Summary:

The 2023 water quality monitoring program for Hidden Lakes has two additional main lake sites that are monitored quarterly for total phosphorous levels. These two sites were added to determine potential point-sources for phosphorous input. Remaining seasonal and/or monthly monitoring scope mirrors 2022.

The third scheduled application of phoslock was applied to the main lake in January 2023. Grass carp and tilapia were stocked as scheduled in April. Aeration systems in the West Arm were turned on in March and were maintained with new air filters and cooling fans.

Quarterly water quality sampling revealed elevated phosphorous levels remained since fall 2022 despite phosphorous mitigation efforts. High densities of cyanobacteria colonies persisted during winter and spring with levels documented in the spring triggering an algaecide treatment in the main lake. A significant cyanobacteria bloom occurred in the west arm of Hidden Lake during summer, the first documented. Salinity and alkalinity levels continued to increase through spring 2023.

Water Quality Monitoring Schedule:

Quarterly Samples

Dissolved oxygen, temperature, and salinity was measured at three fixed stations in the main body of Hidden Lake (Figure A8) and from one fixed station on Center Lake. Measurements were taken from the surface to the lake bottom at every one-foot interval. Water samples were taken at site 1, site 3 (West Arm), and Center Lake for water chemistry, algae identification and density estimates. Water samples were taken at site 4 and site 5 for phosphorous testing.

Water samples taken at Site 1, Site 3, Site 4, Site 5, and Center Lake were processed at the SePRO Corp. lab to document water chemistry including nutrient levels (phosphorous,

nitrogen) and to document plantktonic algae present. E. coli samples taken during summer months were processed at Aquatic Analytics lab locally.

Figures for water temperature and dissolved oxygen were constructed for all but Site 2. Site 2 is used to corroborate temperature and oxygen profiles and for long-term monitoring of salinity. Tables for water chemistry, nutrients, and algae were also included (Appendix A).

Monthly Samples

In addition to quarterly water samples, monthly algae samples were taken from Center Lake, April-September during non-quarterly sample months. This increased sampling effort was due to high levels of cyanobacteria detected seasonally on Center Lake in 2019. E. coli samples were taken at Site 1, Site 3, and Center Lake monthly, May-September.

Variants

Center Lake oxygen, temperature, and salinity profiles were not collected due to boating access site being blocked. Staff notified Hidden Lakes managers of this obstacle. The April algae sample from Center Lake was missed by mistake in scheduling. Summer treatment of cyanobacteria and E. coli was not performed due to blocked access to Center Lake.

Observations- Hidden Lake

While seasonal phosphorous levels were variable, we documented at the least a stabilization of phosphorous levels in the main lake from 2019 – 2021. 2022 results however revealed a seasonal increase in phosphorous levels, peaking in fall 2022 at the highest level documented in the main lake. Relative to fall 2022, phosphorous levels remained higher than previously documented through summer 2023 (Figures 1 and 3).

Hidden Lake Site 1

Figure 1. Total phosphorous levels (ug/L) documented at Site 1, Hidden Lake, seasonally from 2019 to summer 2023.

The elevated phosphorous levels observed in fall 2022 we feel are a result of annual phosphorous input and the natural mixing of the lake due to air temperature changes. The fall mixing occurs naturally in our region of the country. Increased cyanobacteria blooms that have occurred over the last two years have caused a larger portion of the lake basin to become anoxic during the growing season (the area of the lake below the thermocline, where oxygen

drops to below 4 mg/l). This deep region (approximately 30 acres- area ten feet+ deep) is a major source of free phosphorous as lack of oxygen makes phosphorous readily available from the sediments.

Sustained higher phosphorous levels resulted in excessive cyanobacteria growth during 2023. The highest cyanobacteria density documented in the main lake basin was observed in spring 2023 samples at 1.1 million cells/ml (Figure 2). This marks only the third time in five years bacteria levels have surpassed the treatment threshold of 100k cells/Ml. A treatment was performed on May 20, 2023. Cyanobacteria levels remained at 100k-425k cells/ml through

June and July 2023. We chose not to treat these elevated blooms due to high air and water temperatures and lake stratification. These conditions present significant risk for oxygen depletion when treating phytoplankton or cyanobacteria.

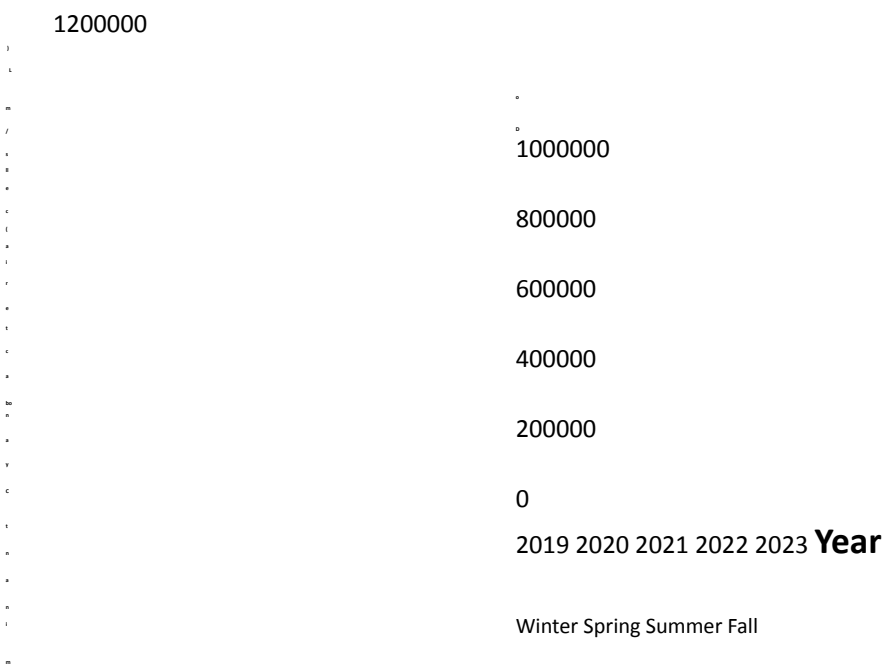


Figure 2. Plot of dominant cyanobacteria documented at Site 1, Hidden Lake seasonally from 2019 to summer 2023. Results are reported as cells/Ml. If no seasonal data is present, then no cyanobacteria were documented. Red line represents our current

treatment threshold of 100k cells/Ml.

A similar spike and prolonged higher phosphorous levels were also observed at Site 3 (West Arm) of Hidden Lake 2022-2023 (Figure 3). The first and highest cyanobacteria density documented at Site 3 was observed in summer 2023 with samples at 1.0 million cells/ml (Figure 4). This dense cyanobacteria bloom caused a thermocline/stratification to occur in the West Arm despite aeration operation, with oxygen levels dropping below 5 mg/l at ten feet (Figure A7). Similar to main lake conditions, this excessive cyanobacteria bloom was not treated due to stratification and temperatures. While aeration offers some insurance for oxygen depression,

the fact that we had stratification with aeration in operation precluded in our opinion safe treatment conditions.

Salinity levels have remained elevated since summer 2022 from 0.10 to 0.46 mg/l in Hidden Lake. Directly related to salinity, alkalinity levels have remained elevated since summer 2022 from 100 mg/l to 400+ mg/l. The observed shift to higher salinity and alkalinity levels in the main lake (Site 1) was also observed at Site 3 (West Arm) (Figures 5 - 8).

Oxygen and temperature profiles were seasonally normal. Stratification continues to occur in the main lake and as previously mentioned in the West Arm for the first time during summer 2023. Plots of oxygen and temperature were included in Appendix A. Complete algae and cyanobacteria density sampling results were listed in Table A1 and complete water chemistry results were listed in Table A2.

Hidden Lake Site 3

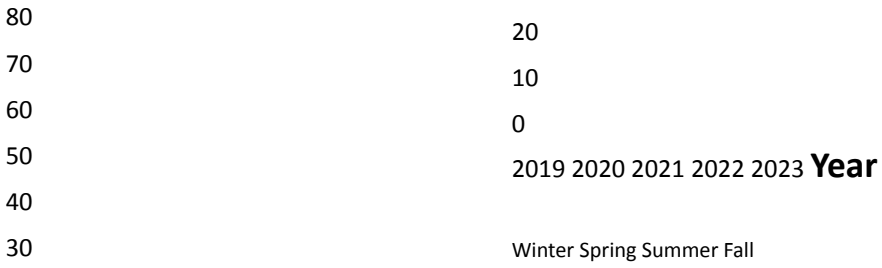


Figure 3. Total phosphorous levels (ug/L) documented at Site 3, Hidden Lake, seasonally from 2019 to summer 2023.

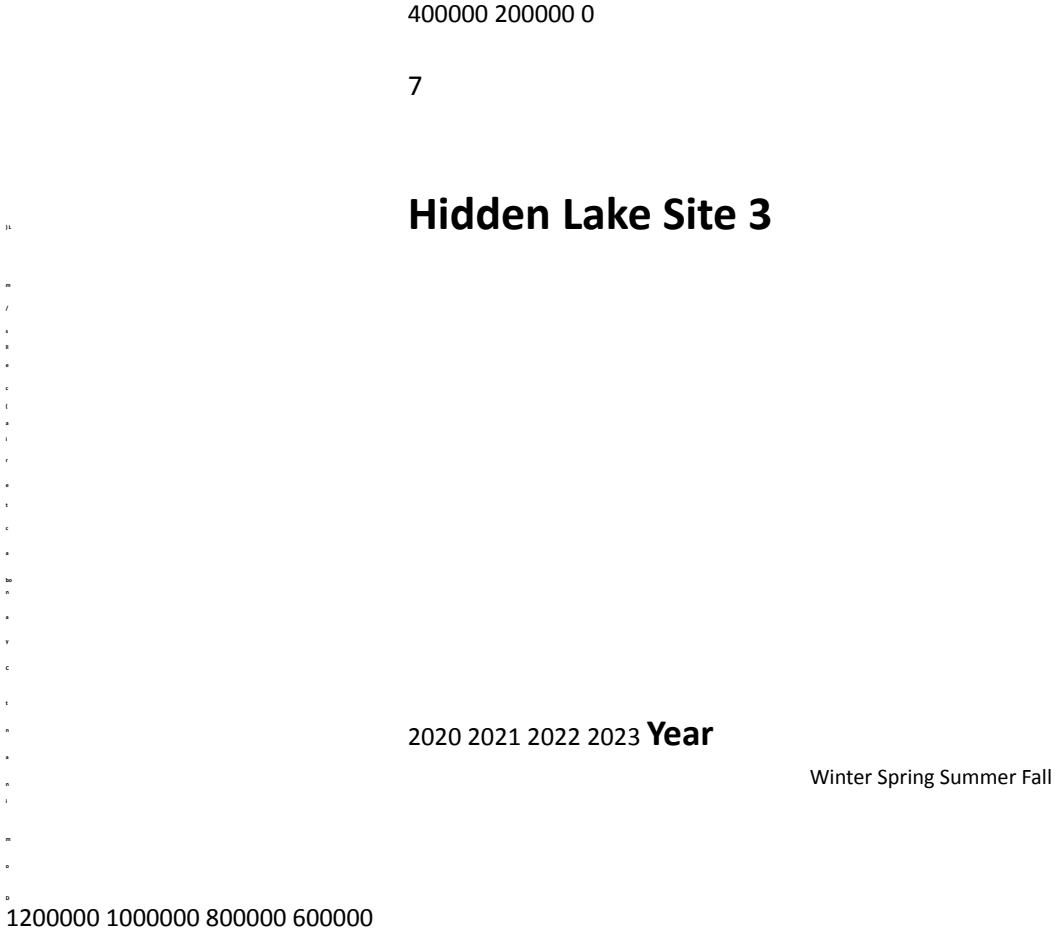
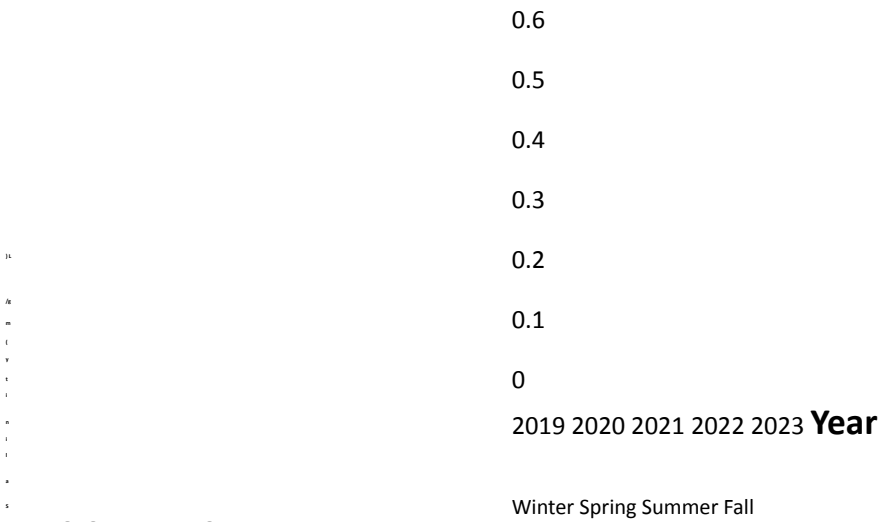


Figure 4. Plot of dominant cyanobacteria documented at Site 3, Hidden Lake seasonally from 2020 to summer 2023. Results are reported as cells/Ml. If no seasonal data is present, then no cyanobacteria were documented. Red line represents our current treatment threshold of 100k cells/Ml.



Hidden Lake Site 1

0.7

Figure 5. Salinity levels (mg/l) documented at Site 1, Hidden Lake seasonally from 2019 to summer 2023.

Hidden Lake Site 1

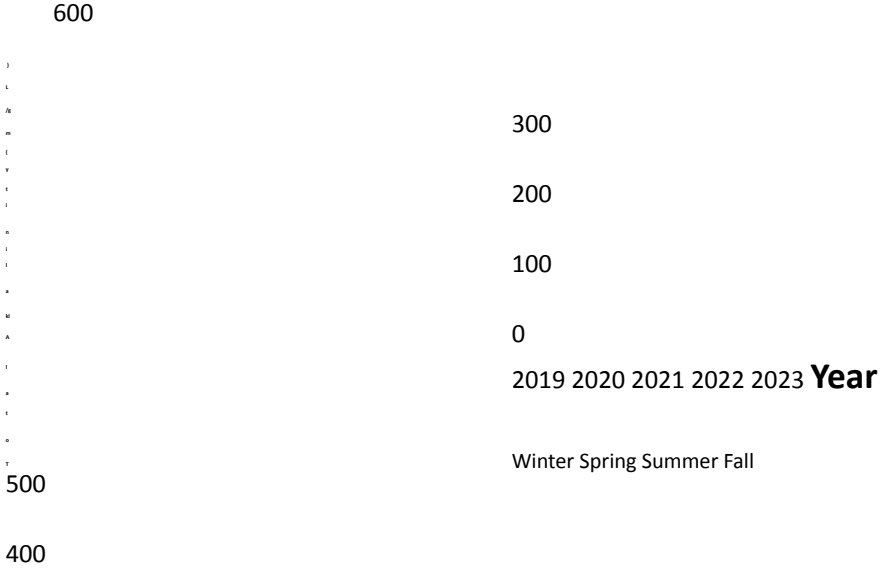


Figure 6. Alkalinity levels (mg/l) documented at Site 1, Hidden Lake seasonally from 2019 to summer 2023.

Hidden Lake Site

Figure 7. Salinity levels (mg/l) documented at Site 3, Hidden Lake seasonally from 2019 to summer 2023.

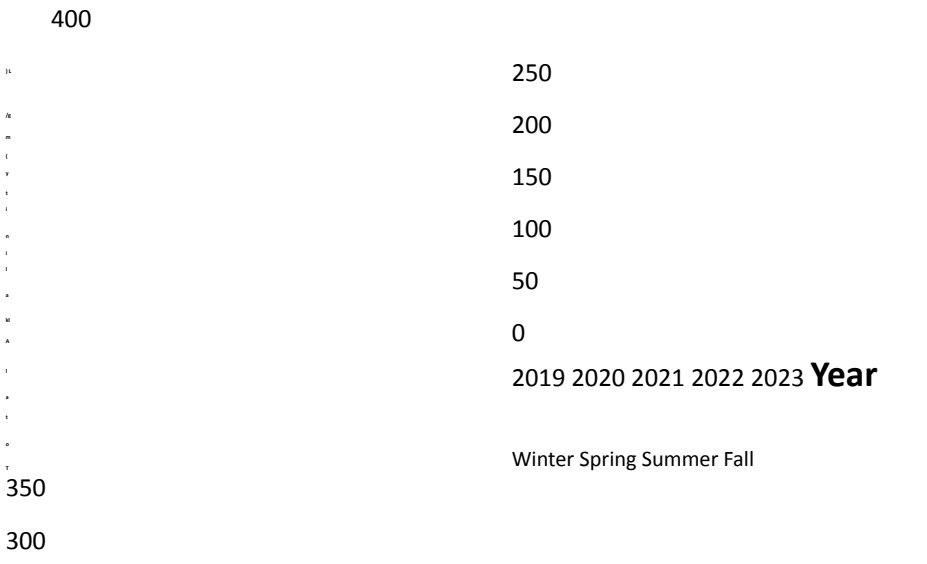


Figure 8. Alkalinity levels (mg/l) documented at Site 3, Hidden Lake seasonally from 2019

to summer 2023.

Observations- Center Lake

Center Lake phosphorous levels have been more variable than Hidden Lake's results prior to 2022, with two large spikes in phosphorous levels referenced in previous reports. However phosphorous levels have trended higher since 2021 (Figure 9). Phoslock applications were performed in 2020 and 2021.

Multiple treatments were performed on Center Lake in 2020 and 2021 as cyanobacteria densities surpassed the 100k cells/ml threshold. Cyanobacteria densities surpassed 1 million cells/ml in summer 2023 (Figure 10). Watercraft access to Center Lake has been blocked which prohibited treatment.

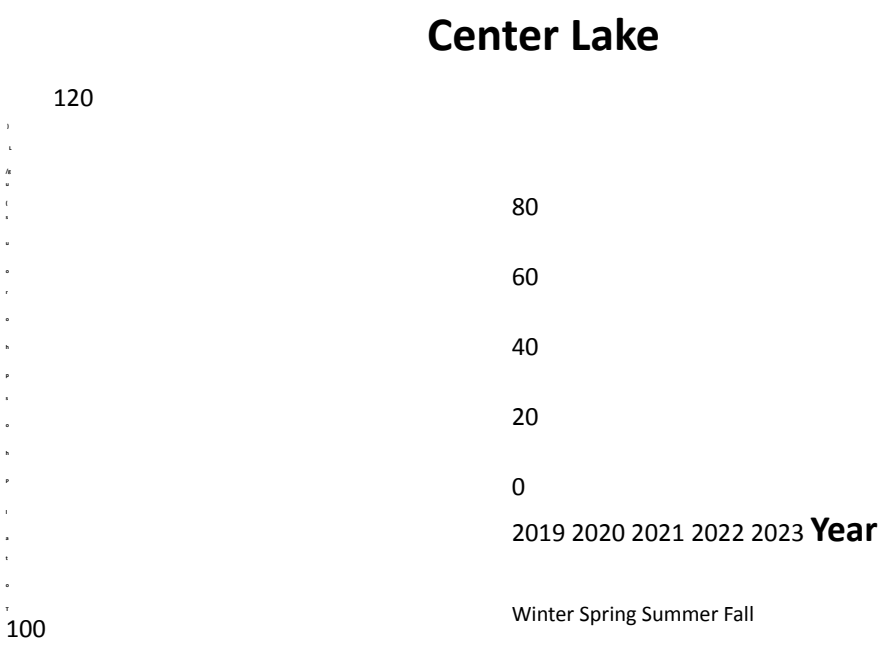


Figure 9. Total phosphorous levels (ug/L) documented in Center Lake seasonally from 2019 to summer 2023.

400000 200000 0

11

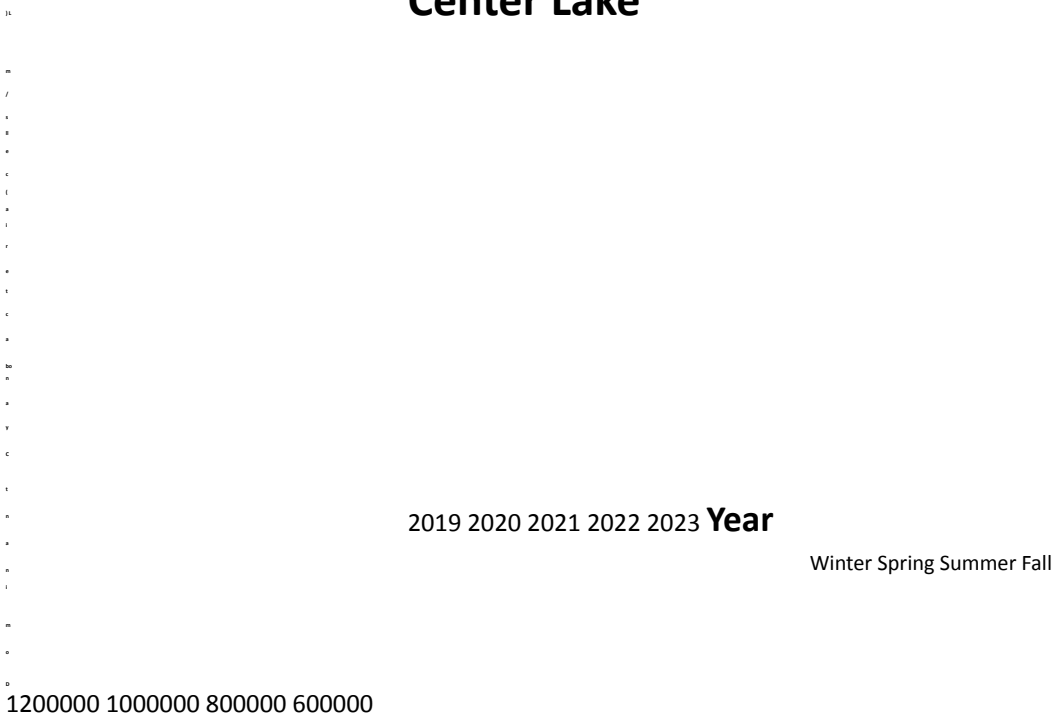


Figure 10. Plot of dominant cyanobacteria documented at Center Lake seasonally from 2019 to summer 2023. Results are reported as cells/Ml. If no seasonal data is present, then no cyanobacteria were documented. Red line represents our current treatment threshold of 100k cells/Ml.

Observations- E. coli

E. coli samples are taken monthly May-September in Hidden Lake and Center Lake. Historically one site was sampled on each lake; in 2023 an additional site was added on Hidden Lake (Site 3 West Arm). SCDHEC requires closing of recreational waters if E. coli levels are above 349 MPN/100 ml. The summer sample from Center Lake was at the treatment threshold; as previously mentioned access for watercraft has been blocked therefore a treatment was not performed (Table 1).

Table 1. Results of monthly E. coli (fecal colliform) samples from Site 1 (Hidden Lake), Site 3 (West Arm), and Center Lake, May through September 2023. Results are reported as MPN/ml (Most Probably Number per milliliter) from lab samples processed using state-certified methodology. The threshold for prohibitive water- use as established by SCDHEC is 329 MPN/ml. Sample results that surpassed the SCDHEC threshold were highlighted in yellow.

E. coli	Site 1	Treatment Date	Site 3	Treatment Date	Center Lake	Treatment Date
May	17.1		**4.1**		9.7	
June	**<1**				61	
July	**5.2**		**27.9**		65.7	
August	**5.2**		**26.5**		128.4	
September	**2.0**		**5.2**		58.1	

Summary

Our data from 2019 to present shows a significant shift in water quality, chemistry, and lake-quality aesthetics. Why the shift? As discussed in previous reports, a biological shift occurred in the mid 20-teens that removed a significant bivalve population that in our opinion was providing significant nutrient removal. Since that time significant development upstream/increased nutrient inflow from Towne Center has occurred. Geothermal discharge began in 2021. These factors coupled with age/time and weather variability has created conditions for optimal phosphorous availability within the lake system.

Modeling we did for designing the OST system indicated the watershed for Hidden Lake is relatively small; the two lagoon inputs from off-property are the primary direct storm water sources of input. Thus the basin is producing what it can from years of nutrient input. We do not consider current annual phosphorous input to be insignificant; it likely is feeding the flames once these blooms take off in the spring and post stratification.

We have good tools to battle phosphorous in the water column (that is, free

phosphorous or orthophosphate). Those levels are seldom high however. The sediment

phosphorous is driving all the conditions we are witnessing in terms of phosphorous levels and cyanobacteria occurrence. We do not know where the higher alkalinity and salinity is coming from but we suspect shallow aquifer input which is typically well-buffered from limestone deposits in the aquifer. These waters can also be a source for phosphorous.

Our sediment treatments for phosphorous were never designed to remove all the phosphorous in the sediments but to reduce overall levels. Due to what we believe to be increased levels of phosphorous input and a significantly higher bank of sediment phosphorous than previously measured, we feel a change in scope water quality management is warranted. We have more tools and more effective tools to battle sediment phosphorous now than in 2022. As proposed to Hidden Lakes managers for 2024, there are better options for managing current water quality conditions.

APPENDIX A

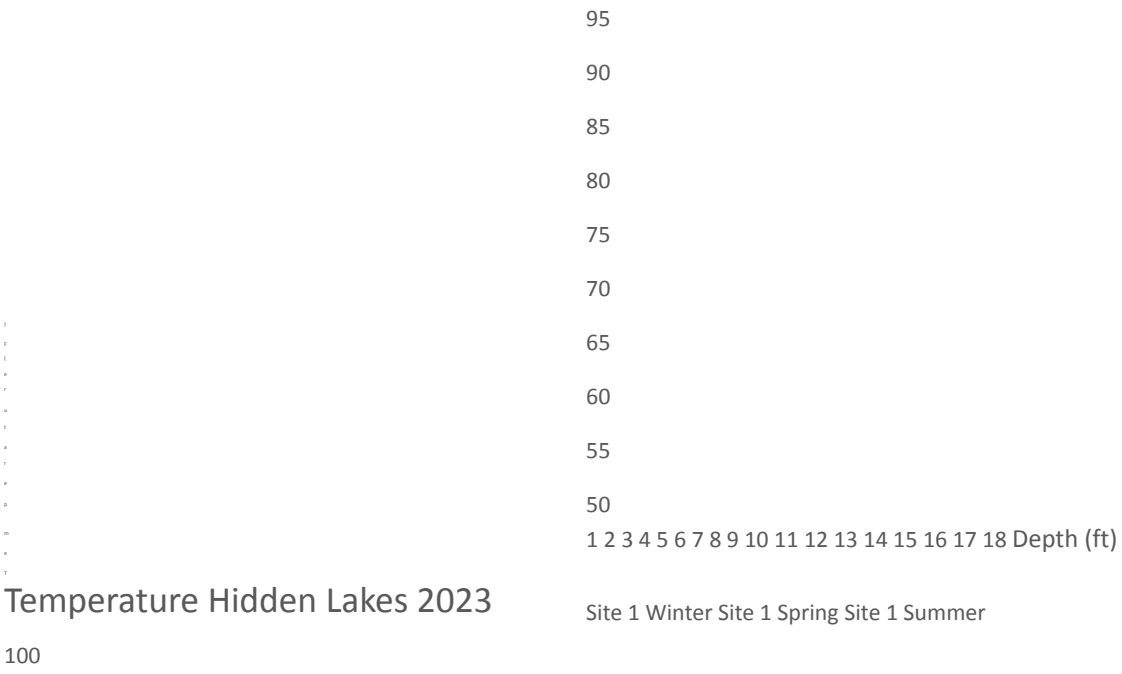


Figure A1. Water temperature (F) recorded at each foot of depth at Site 1 on Hidden Lake, 2023.

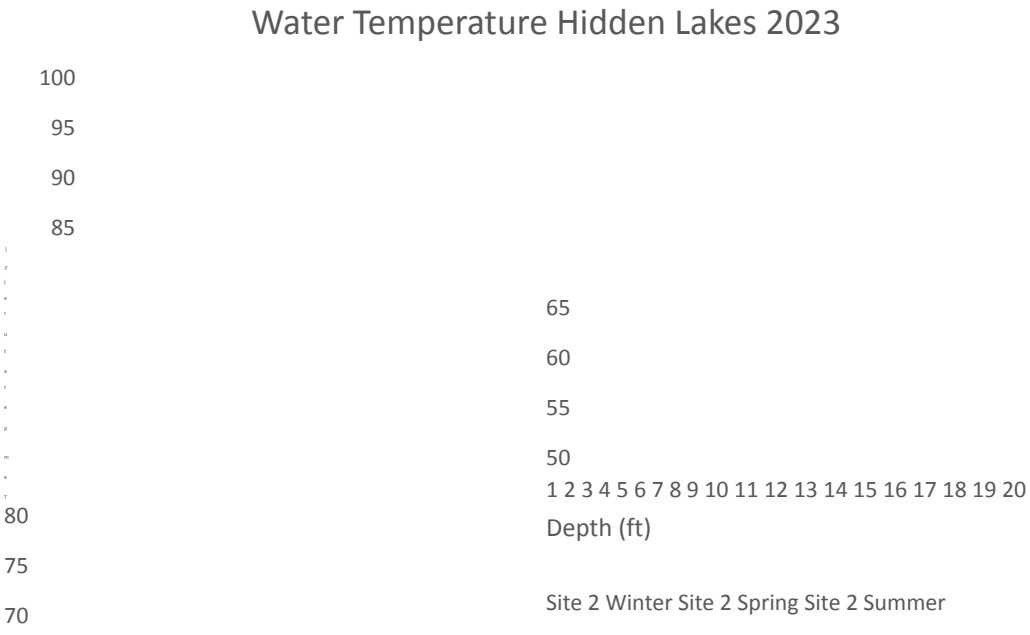


Figure A2. Water temperature (F) recorded at each foot of depth at Site 2 on Hidden Lake, 2023.

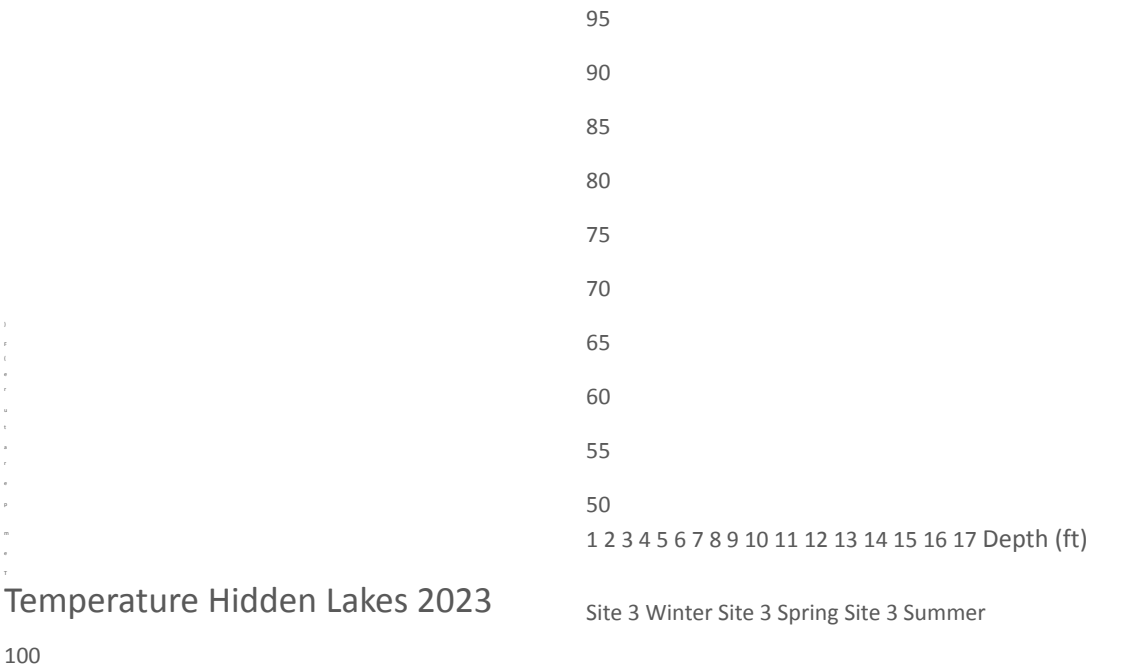


Figure A3. Water temperature (F) recorded at each foot of depth at Site 3 on Hidden Lake, 2023.

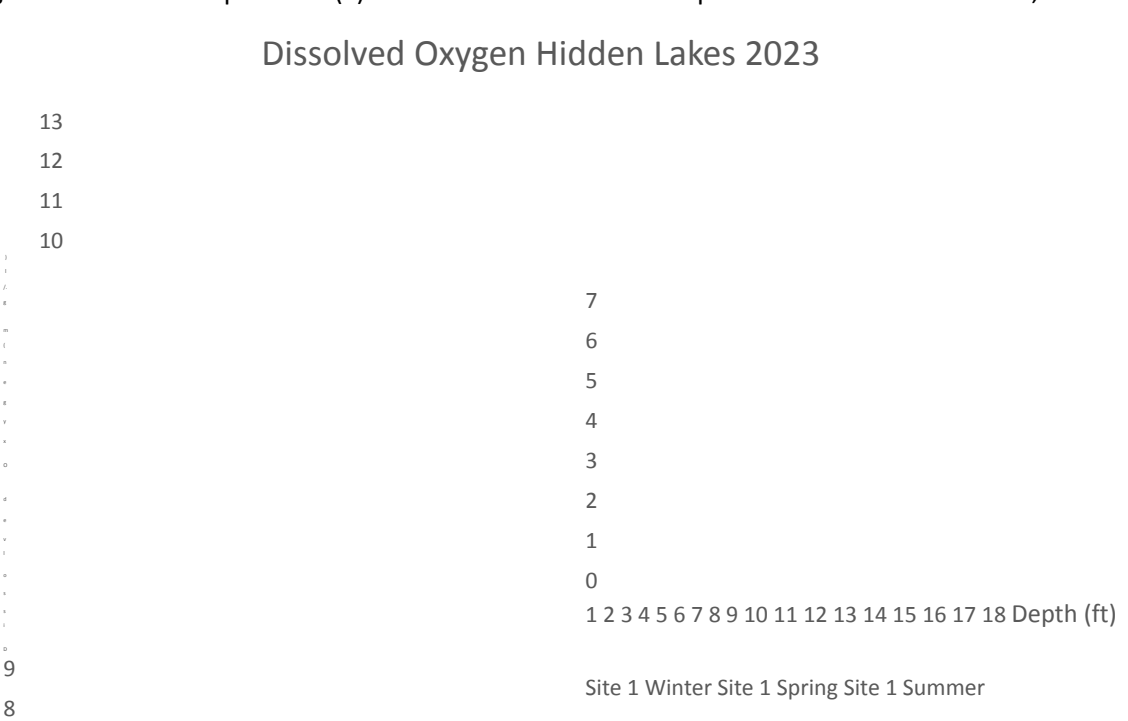


Figure A5. Dissolved oxygen (mg/l) recorded at each foot of depth at Site 1 on Hidden Lake, 2023.

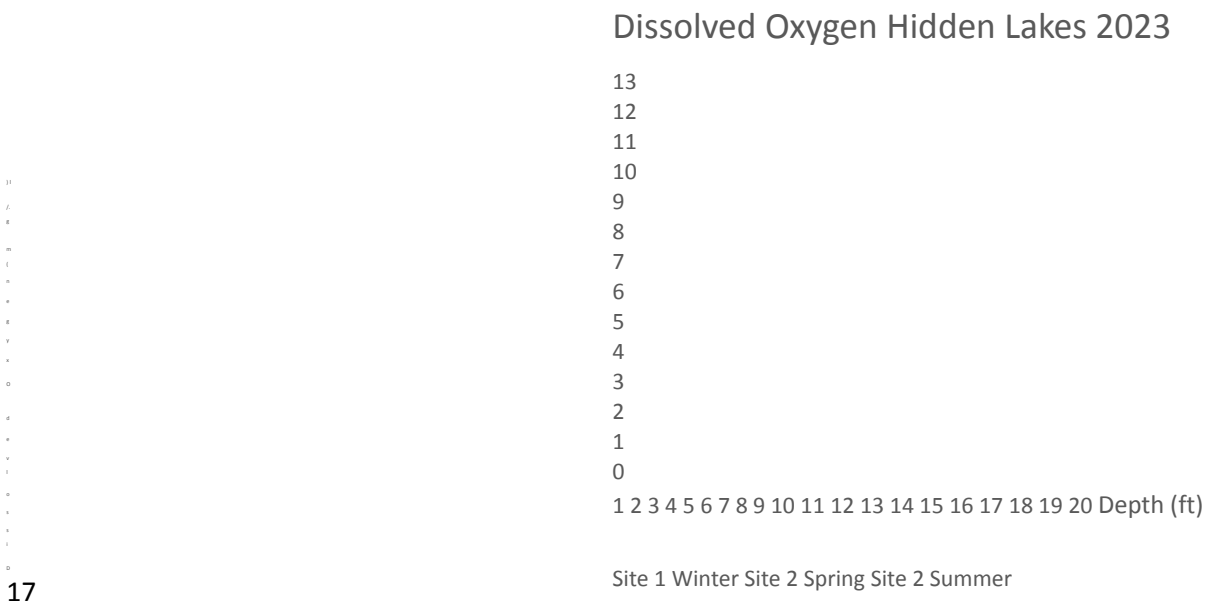


Figure A6. Dissolved oxygen (mg/l) recorded at each foot of depth at Site 2 on Hidden Lake, 2023.

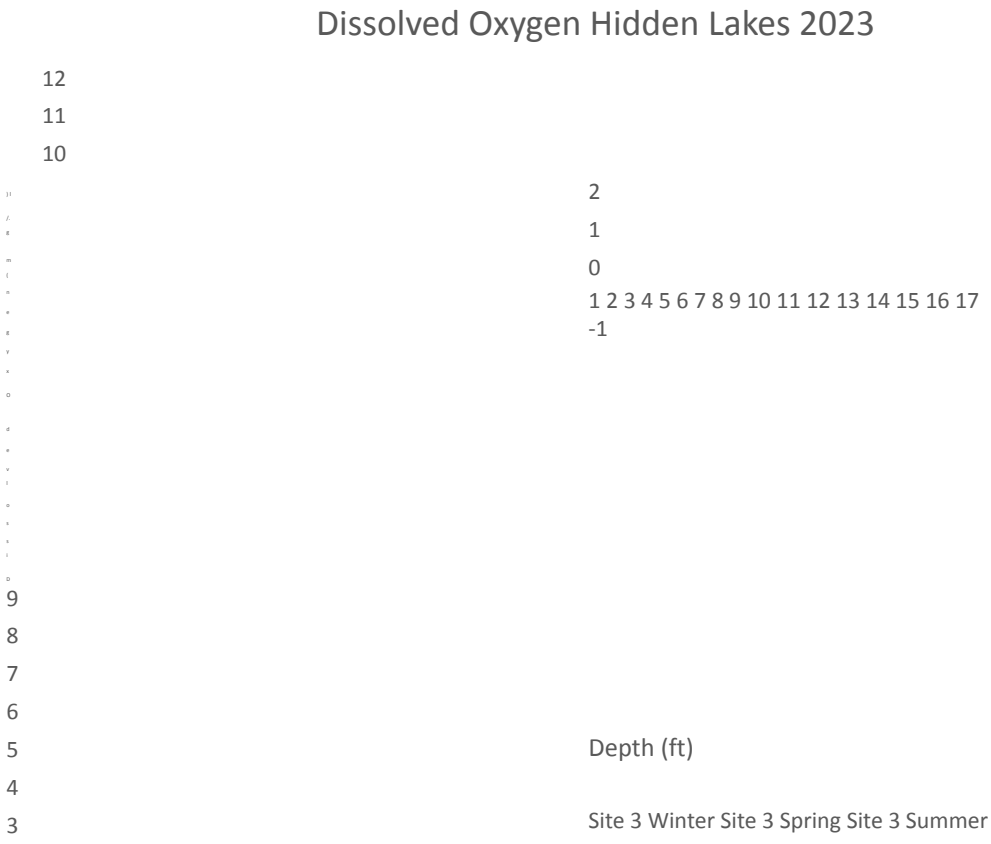


Figure A7. Dissolved oxygen (mg/l) recorded at each foot of depth at Site 3 on Hidden Lake, 2023.

Table A1. Planktonic algae ID results for Site 1 & 3, Hidden Lake and Center Lake 2023. Sample results that triggered cyanobacteria treatments were highlighted. The threshold for treatment is 100,000+ cells/ml.

Hidden Lake	**2023**			
	Identification	**Classification**	**Density (cells/mL)**	**Description**
Site 1 Reference Site @ Geo Discharge				
Winter	Aphanocapsa sp.	Cyanophyta-	69,800	Colonial, planktonic, potential toxin producer
February		Blue-green algae		
	Merismopedia sp.	Cyanophyta-	12,800	Colonial, planktonic, potential toxin producer
		Blue-green algae		
	Pseudanabaena sp.	Cyanophyta-	4,500	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
	Peridinim sp.	Dinophyta-	1,900	Single-celled, flagellated, planktonic
		Dinoflagellates		
Spring	Planktolyngbya sp.	Cyanophyta-	1,160,000	Filamentous, planktonic, potential toxin producer
May		Blue-green algae		
	Gymnodinium sp.	Dinophyta-	3,900	Single-celled, flagellated, planktonic
		Dinoflagellates		
				*treated 5/20/23
June	Planktolyngbya sp.	Cyanophyta-	130,600	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
	Glenodinium sp.	Dinophyta-	5,400	Single-celled, flagellated, planktonic
		Dinoflagellates		
July	Raphidiopsis sp.	Cyanophyta-	325,600	Filamentous, planktonic, potential

				toxin producer
		Blue-green algae		
	Planktolyngbya sp.	Cyanophyta-	95,900	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
	Tetraedon sp.	Chlorophyta-	20,100	Single-celled, planktonic
		Green algae		
Summer	Planktolyngbya sp.	Cyanophyta-	50,200	Filamentous, planktonic, potential toxin producer
August		Blue-green algae		
	Peridinim sp.	Dinophyta-	1,600	Single-celled, flagellated, planktonic
		Dinoflagellates		

Fall				
Site 3				**West Arm**
Spring	Gymnodinium sp.	Dinophyta-	650	Single-celled, flagellated, planktonic
		Dinoflagellates		
Summer	Planktolyngbya sp.	Cyanophyta-	990,300	Filamentous, planktonic, potential toxin producer
August		Blue-green algae		
	Aphanocapsa sp.	Cyanophyta-	49,700	Colonial, planktonic, potential toxin producer
		Blue-green algae		
Fall				

Winter	Cyclotella sp	Bacillariophyta-	<40	Single-celled, planktonic
		Diatoms		
	Desmodesus sp.	Chlorophyta-	<40	Colonial, planktonic
		Green algae		
Center Lake				
Spring				
April				
May	Pediastrum sp.	Chlorophyta-	5,600	Colonial, planktonic
		Green algae		
	Desmodesus sp.	Chlorophyta-	2,400	Colonial, planktonic
		Green algae		
June	Planktolyngbya sp.	Cyanophyta-	155,100	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
	Raphidiopsis sp.	Cyanophyta-	60,700	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
	Pediastrum sp.	Chlorophyta-	19,900	Colonial, planktonic
		Green algae		

July	Raphidiopsis sp.	Cyanophyta-	101,400	Filamentous, planktonic, potential toxin producer
		Blue-green algae		

	Planktolyngbya sp.	Cyanophyta-	45,800	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
	Tetraedon sp.	Chlorophyta-	9,900	Single-celled, planktonic
		Green algae		
Summer				
August	Planktolyngbya sp.	Cyanophyta-	1,510,000	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
	Aphanocapsa sp.	Cyanophyta-	98,600	Colonial, planktonic, potential toxin producer
		Blue-green algae		
September	Planktolyngbya sp.	Cyanophyta-	475,100	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
	Raphidiopsis sp.	Cyanophyta-	78,300	Filamentous, planktonic, potential toxin producer
		Blue-green algae		
Fall				
Winter	Synedra sp.	Bacillariophyta-	650	Single-celled, planktonic
		Diatoms		
	Chromulina sp.	Chrysophyceae-	410	Single-celled, flagellated, planktonic
		Golden-brown algae		

Table A2. Water quality results for Sites 1,2, & 3 Hidden Lake, and Center Lake, 2023. Legend describes parameters reported.

Hidden Lake	pH	Alkalinity	Hardness	Salinity	Turbidity	Total Phosphorous	Total Nitrogen	Chlorophyll a
Site 1								
Spring	9.2	540.4	14.1	0.60	8.5	58.5	2.1	137.2
Summer	9.2	330.8	14.7	0.44	5.6	59.5	1.47	49
Fall								
Winter	8.6	399.4	56.5	0.42	4.1	59.5	0.5	24.5
Site 2								
Spring	9.0	714	17	0.60				
Summer	9.5	476	34	0.46				
Fall								
Winter	8.5	510	68	0.40				
Site 3								
Spring	8.6	352.5	45.0	0.30	2.9	39.0	0.74	13.5
Summer	9.0	321.5	19.0	0.40	5.4	83.1	1.27	45.7
Fall								
Winter	8.3	251.6	68.5	0.30	2.4	42.5	0.80	<10
Site 4-NE Canal								
Spring						50.6		
Summer						57		
Fall								
Winter						44.1		
Site 5- SW West Arm								

Spring						60.7		
Summer						62.7		
Fall								
Winter						46.2		
Center Lake								
Spring	8.6	215.1	53.7		7.2	69.4	1.44	25.4
Summer	8.8	202.9	19.9	0.20	6.7	83.6	1.31	25.8
Fall								

Winter	7.9	143.1	92.6		2.7	34.0	0.60	<10

pH – measure of how acidic or basic the water is. 6-9 is normal, pH=7 is neutral

Alkalinity- measure of the buffering capacity of the water, waters with low (<49 mg/L) alkalinity are more susceptible to wide pH shifts

Hardness- measure of the concentration of divalent cations in the water, primarily calcium and magnesium, hardness levels below 61 mg/L are considered soft waters

Salinity- salt concentration in water expressed as parts per thousand (ppt) or %. <0.50 ppt in freshwater is normal

Turbidity- measurement of water clarity. Turbidity > 50 NTU presents potential impact to aquatic life, <10 NTU meets typical drinking water standards

Total Phosphorous- phosphorous is essential nutrient correlating to growth of algae, total phosphorous refers to the total amount of phosphorous estimated to be available for aquatic life. 12-24 is considered medium level of phosphorous, 25+ is considered high level of phosphorous, measured as micrograms/L

Total Nitrogen- all nitrogen measured in the system that can enhance algae growth. <1 is normal, 1-10 potentially harmful, measured in micrograms/L

Chlorophyll-a- primary light-harvesting pigment found in algae, measure of algal productivity and water quality. 21+ considered high algal productivity, measured in micrograms/L

Figure A8. Water quality sample sites on Hidden Lake 2023.

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Hidden Lake #1

The Mapping Network