Constitution Gardens Lake Water Quality, Algae, and Cyanobacteria Monitoring 2019-2022
Final Report

Prepared for:
National Park Service
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Cover Photo: CCWS Staff collecting surface grab samples at Constitution Gardens, Washington D.C., September 2020

Introduction

The Constitution Gardens Lake (COGA) is a shallow, 6.7-acre artificial water body on the Washington, DC Mall. Restricted flow and long residence time of water in the lake result in very high summer water temperatures and extensive accumulations (blooms) of bottom and floating algae and cyanobacteria. These, in turn, lead to occasional fish-kills from very low oxygen concentrations and possibly cyanobacterial toxicity or other stresses. Past studies in the lake have indicated elevated concentrations of dissolved nitrogen and some dissolved phosphorus, but previous studies and data are sparse. Hood College Center for Coastal and Watershed Studies (Hood-CCWS) entered into a Task Agreement in 2019 to conduct water quality monitoring to provide baseline data for possible mitigation of the expected late summer cyanobacteria blooms. The original task agreement was extended on January 29, 2021, to continue water quality monitoring until April 2022 and support of NPS until June 1, 2022.

Per the Task Agreement from August 2019 to April 2022, Hood-CCWS sampled Constitution Gardens monthly from April to October, and twice in winter months December and February. Sampling was suspended April – May 2020 due to State and local work restrictions during the COVID-19 pandemic.

Methods

Sampling events were conducted during mid-morning field trips. Each sampling event included subsurface water grab samples and field measurements (temperature, dissolved oxygen (DO), conductivity, and pH) were collected at six stations around COGA (Figure 1). If visible surface algae were observed at the time of sampling additional surface algal grab samples were collected for algal/cyanobacteria identification.

Figure 1: Sampling locations for evaluation of water quality, algae and cyanobacteria in Constitution Gardens Lake in Washington, D.C. (Google Maps, 2020)

Water samples were transported to the Hood-CCWS lab and analyzed for:

- Nutrients (dissolved Ammonia-N, dissolved Nitrate-N and dissolved orthophosphorus (OP)) concentrations,

- Algal screening in the form of pigment levels as indicated by *in vivo* fluorescence (chlorophyll *a*, present in all plants, and phycocyanin, an accessory pigment in cyanobacteria only),
- Turbidity
- In 2021, Adjusted Chlorophyll *a* estimate concentrations derived from fluorescence measurements were included in monitoring reports.

In collaboration with NPS, Hood-CCWS developed Cyanobacteria Action Criteria as a threshold for further analysis of lake samples for presence of toxins, and to assist with decision making on lake management strategies.

In 2019 and 2020, the two action criteria used were: 1) the ratio of phycocyanin to chlorophyll fluorescence of 0.3 or greater, to evaluate if cyanobacteria are abundant within the total algal biomass and 2) chlorophyll fluorescence of 50 RFU.

In 2021, the second criterion was modified and updated from chlorophyll fluorescence to an "estimate of total chlorophyll *a* content" for each sample, adjusted per instrument calibration.

Cyanobacteria Action Criteria 2021-2022

1. A **PC:CHL ratio** of 0.3 or greater.
2. An **adjusted CHL *a* estimate** of 50 μg/L CHL *a* or greater.

Algal and cyanobacterial taxonomic identification was conducted on a composite water sample collected from all stations around the lake. Water samples were also analyzed to distinguish the type and abundance of algae/cyanobacteria present.

NPS reported four various treatments occurred at the lake, just prior to and at the start of the study period:

Date	Treatment description
4/1/2019	Partial drain and clean
7/2/2019	Contractor treated COGA with algaecide (Captain XTR, Flumioxazin 51% WDG)
8/22/2019	NPS Treated with 200lbs of GreenClean Pro. Application occurred during sampling event
11/1-9/2019	Nanobubble treatment by Blue Nano Technologies, LLC

A fish kill was reported on August 26, 2020 just prior to the sampling event scheduled for that month.

Results

Progress reports were submitted at the end of each quarter to describe the monitoring activities, results of field and lab analyses, and specific taxonomic identifications for each reporting time period. Raw data are provided in Appendix A. The following summarizes overall trends and observations during the entire task agreement period.

Physical Parameters

Lake water temperature fluctuated as expected with seasonal weather patterns in the region. The warmest water temperatures reached over 31°C on average each summer and the coldest temperature was measured at 3.9°C on December 8, 2020. Lake average DO concentrations were generally within acceptable ranges (i.e., > 5.0 mg/L) and varied inversely with water temperature trends. It should be noted however, Station 1 on the east end of the lake generally measured very low DO concentrations, nearing hypoxic levels, on several occasions during the study period. These low DO concentrations are presumably due to the high volumes of wind-blown decomposing leaf litter and algal debris that tends to accumulate on this side of the lake.

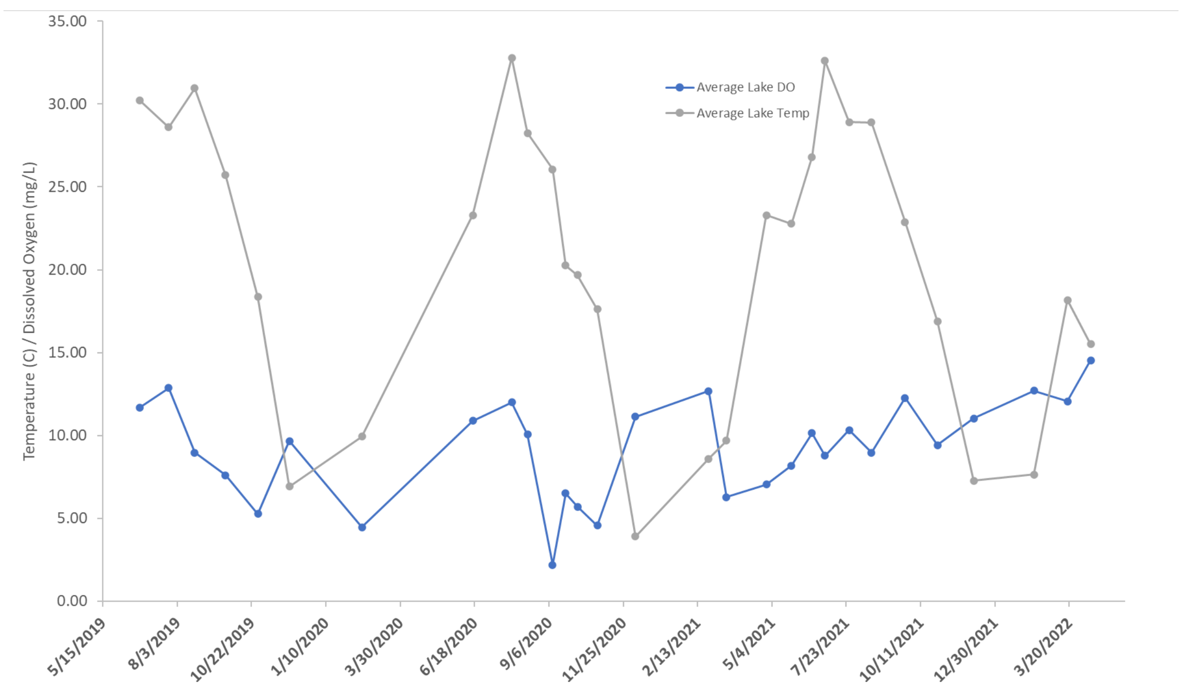

Figure 2: Dissolved oxygen and lake water temperature trends over the 2019-2022 study period at NPS-COGA, Washington D.C.

Nutrients

Dissolved Nitrate-N fluctuated little during the study period, with results between 0.17–0.37 mg/L. Ammonia levels varied between 0.31-0.75 mg/L. Dissolved OP levels were often below detection limits (0.15 mg/L), however concentrations did increase on several occasions, primarily in late fall.

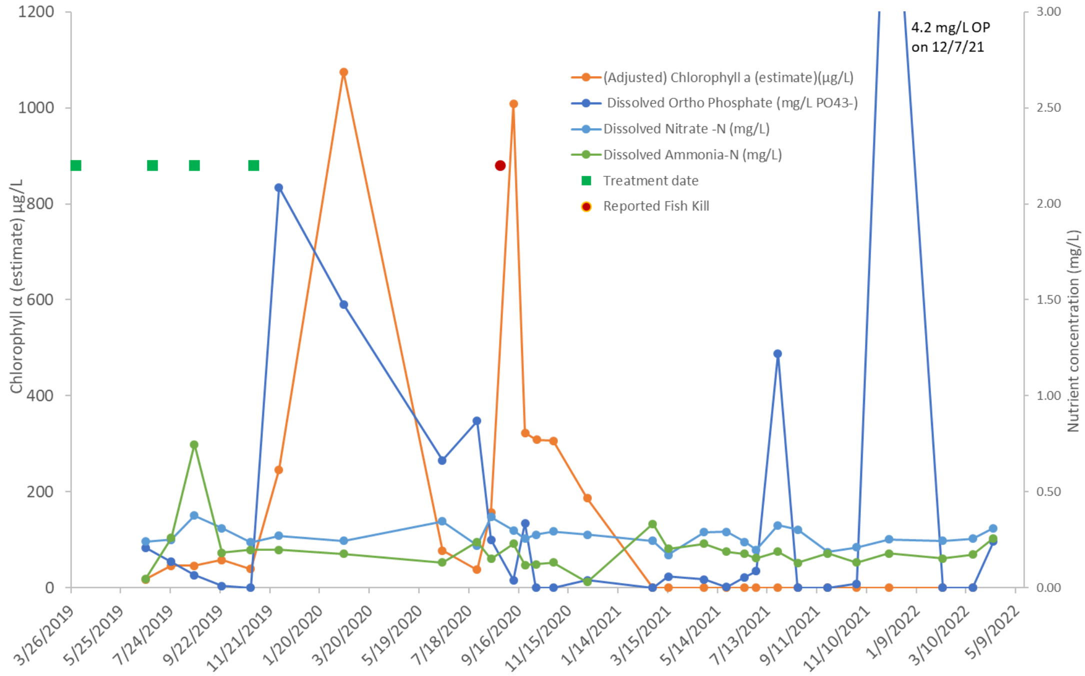

Figure 3: Dissolved nutrient and estimated Chlorophyll α concentrations from sampling events in 2019-2022 at COGA, Washington D.C.

Algal Screening

For each sampling date, an Index of Algal Community Composition has been presented for three parameters:

1. **Total Phytoplankton**: This is based upon the concentration of living algae or cyanobacteria in the water. High amounts of phytoplankton are associated with nutrient enrichment and summer oxygen depletion in the lake.

Total Phytoplankton
Good – low Total Phytoplankton (Estimated Chlorophyll < 10 µg/L)
Acceptable – moderate Total Phytoplankton (Estimated Chlorophyll 10-49 µg/L)
Problematic – high Total Phytoplankton (Estimated Chlorophyll > 50 µg/L)

2. **Cyanobacterial Fraction**: This is based on the predominance of these organisms in the water sample (as indicated by plant pigment ratios, Action Criterion 1 as described above). They are noteworthy in that they are often associated with nutrient-rich waters and may have the capacity to produce toxic compounds.

Cyanobacteria Fraction
Good – Cyanobacteria concentration very low or not present (<0.1)
Acceptable – Cyanobacteria moderately predominant (0.1-0.3)
Problematic – Cyanobacteria very abundant (>0.3)

3. Overall: This is an estimated composite score that captures attributes of the two previously described parameters. It is based upon the concentration of living algae and cyanobacteria in the water. However, the Total Phytoplankton parameter plays the dominant role in determining the Overall Score. This is because high amounts of phytoplankton are associated with both the aesthetic decline of the lake, as well as summer oxygen depletion which can cause fish kills. Problematic cyanobacterial fraction scores only become injurious if Total Phytoplankton is elevated. At that point cyanobacterial biomass could be sufficiently high to produce toxic compounds. The following is a matrix of outcomes that would generate different Overall Scores:

If “Total Phytoplankton” equals:	🟢	🟢	🟢	🟡	🟡	🟡	🔴	🔴	🔴
And if “Cyanobacteria Fraction” equals:	🟢	🟡	🔴	🟢	🟡	🔴	🟢	🟡	🔴
Then “Overall” equals:	🟢	🟢	🟡	🟡	🟡	🔴	🔴	🔴	🔴

The Index of Algal Community Composition for each sampling date is given in Table 1 below. The composite index for algal/cyanobacteria levels resulted in no instances of overall “good” conditions, and only nine instances of “acceptable” conditions out of 28 sampling events at COGA during the study period.

Table 1. The Index of Algal Community Composition for each sampling date at Constitution Gardens Lake 2019-2022. Total Phytoplankton values are estimates of CHL *a* (µg/L). Cyanobacteria Fraction values are PC:CHL ratios.

Sample Date	Total Phytoplankton	Cyanobacteria Fraction	Overall
6/24/2019	17.5 🟡	0.43 🔴	🔴
7/25/2019	46.0 🟡	0.28 🟡	🟡
8/22/2019	46.2 🟡	2.6 🔴	🔴
9/24/2019	58.4 🔴	0.22 🟡	🔴
10/29/2019	39.7 🟡	0.26 🟡	🟡
12/2/2019	246 🔴	0.19 🟡	🔴
2/18/2020	1075 🔴	0.23 🟡	🔴
6/16/2020	77.8 🔴	0.35 🔴	🔴
7/28/2020	37.5 🟡	0.37 🔴	🔴
8/14/2020	158 🔴	3.8 🔴	🔴
9/10/2020	1008 🔴	0.35 🔴	🔴
9/24/2020	323 🔴	0.48 🟡	🔴
10/8/2020	309 🔴	0.26 🟡	🔴
10/28/2020	307 🔴	0.23 🟡	🔴
12/8/2020	187 🔴	0.58 🔴	🔴
02/25/2021	63.8 🔴	0.11 🟡	🔴
03/16/2021	BD 🟢	0.53 🔴	🟡
04/28/2021	13.7 🟡	0.30 🔴	🔴
05/25/2021	15.7 🟡	0.43 🔴	🔴
06/16/2021	4.22 🟢	0.40 🔴	🟡
06/30/2021	1.79 🟢	0.49 🔴	🟡
7/26/2021	7.51 🟢	0.48 🔴	🟡
8/19/2021	15.5 🟡	0.60 🔴	🔴
9/24/2021	2.60 🟢	0.58 🔴	🟡
10/29/2021	11.3 🟡	0.26 🟡	🟡
12/07/2021	36.0 🟡	0.20 🟡	🟡
02/10/2022	52.1 🔴	0.13 🟡	🔴
03/18/2022	58.4 🔴	0.14 🟡	🔴

BD=below detection; 🟢=good, 🟡=acceptable, 🔴=problematic

All algal taxa identified from COGA samples are provided in Appendix B. The potentially toxic cyanobacteria identified in COGA over the course of this study are listed in Table 2. A total of six potential toxin-producing forms were found. As a total they could account for seven different classes of toxins. These toxins exhibit a variety of modes of action (e.g. hepatotoxic, neurotoxic, or cytotoxic) and levels of toxicity (Nienaber and Steinitz-Kannan, 2018).

Table 2: List of cyanobacterial taxa identified from Constitution Garden Lake and their reported potential toxin production (from Nienaber and Steinitz-Kannan, 2018).

Identified Cyanobacteria genera	Micro-cystins	Anatoxins	Cylindro-spermopsins	Saxitoxins	Aplysia-toxins	Lyngbya-toxins	Geosmin
Anabaena sp.	X	X	X	X			
Aphanizomenon sp.		X	X	X			
Dolichospermum sp.	X	X		X			
Microcystis sp.	X	X					
Oscillatoria sp.	X	X		X	X	X	
Planktothrix sp.	X	X		X	X	X	X

Over the course of the entire study, the two cyanobacteria action criteria were simultaneous exceeded only once. This occurred on 8/19/21 with a PC:CHL ratio of 0.517 and an estimated CHL *a* estimate of 79.5 µg/L at COGA Site 2. We subsequently performed a microsystin/nodularian dip-stick test on this sample which indicated that no toxin was present.

While toxins were not observed during the study, numerous observations indicated nuisance algal conditions which negatively impacted the aesthetic quality of the lake and likely contributed to chronic stress of fishes and waterfowl inhabiting the catchment. These conditions are likely caused by potential diurnal sags in DO and elevated levels in nutrients that occur from time to time.

Discussion

Dissolved nitrogen levels in the lake remain relatively constant throughout the study period. Any variations ammonia-N likely reflect periods of elevated algal biomass decay and ammonification or fish excretion. Subsequently, ammonia levels would decline via direct uptake of ammonia-N by growing phytoplankton or bacterial conversion to other dissolved nitrogen species via nitrification. Since these dissolved nitrogen species (nitrate and ammonia) are present throughout the year, this nutrient is consistently available for phytoplankton growth.

Orthophosphorus (OP as PO_4) is most likely the nutrient controlling primary production in the lake. Orthophosphorous fluctuates through the seasons, generally becoming elevated in the winter months coinciding with algal die-off, then declining throughout the summer due to algal incorporation of this nutrient. Periodic elevations in phosphate may be the result of episodic runoff and/or periodic fertilizer applications during landscape maintenance. OP decline in the summer likely masks continuous phosphorous inputs from the lake sediments under conditions of diurnally elevated pH and/or anoxic events. (Sediment anoxia was inferred by the collection of subsurface methane gas bubbles emanating from the periphery of the lake in August 2019.)

The OP increase measured in December 2019 was anticipated due to the “nanobubble treatment” that had occurred in the month prior (Sellner and Ferrier, 2020). The treatment was thought to result in the oxidation of algae, cyanobacteria, and organic debris in the bottom sediments, which, in turn, caused the expected release of nitrogen and phosphorus from cells, thus increasing nutrient levels as seen in the OP values; however, these values remained high for the summer months.

The overall nanobubble treatment results and outcomes are summarized in a separate report (Sellner and Ferrier, 2020). It appears that dispersing 100 nm ozone-rich bubbles into COGA had several positive effects, including rapid increases in concentrations of dissolved oxygen (to >20 mg/L) and lower levels of TN, ammonium, total phosphorus, and total suspended solids. However, due to inconsistencies of pre- and post-treatment measurements, assessment of nanobubble effects on algae, and particularly cyanobacteria, were not possible. Recommendations to improve assessment of the treatment method are provided in the report.

To control excessive algal growth, the U.S. EPA generally recommends a limit of 0.05 mg/L for total phosphorus in streams that enter lakes and 0.1 mg/L for total phosphorus in flowing waters (U.S. Environmental Protection Agency, 1986). Although over the study period, dissolved phosphate levels measured at COGA were often below detection limits (0.15 mg/L), OP did increase in the winter months on several occasions during similar periods of high chlorophyll *a* biomass concentrations (a.k.a. algal blooms) which included potentially toxin-producing cyanobacteria genera.

We believe that the preponderance of "Problematic" results for the overall Index of Algal Community Composition in Table 1 are the result of chronic and systemic issues experienced by the Constitution Gardens Lake. A combination of factors likely contribute to this situation:

- The lake is a constructed water-feature of the garden which is shallow and infrequently flushed. Water inputs and losses appear to be predominated by precipitation/runoff and surface evaporation.
- The shallow nature of the lake results in significant portions of the water column and lake bottom surface receiving sufficient solar radiation to support vigorous phytoplankton and benthic algal growth, respectively.
- Sediments in the catchment have likely increased over the years. They sequester nutrients during some seasons (based on changes in pH and DO concentrations) but likely contribute nutrients to the water column particularly during summer and late fall to support algal blooms typical of that period.
- Nutrient inputs from runoff into the lake are likely augmented by waterfowl excrement.

The treatments applied just prior to or during the study period (partial drain and cleaning, applications of flumioxazin or peroxide, and nanobubble ozonation) have caused short-term improvements to the lake at best. None have provided lasting impacts on algal production.

Recommendations

It may be time to consider more holistic long-term treatments for COGA such as: 1) complete lake drainage and sediment removal, 2) physical removal of algal production/organic debris on a systematic, regular schedule, 3) systematic management of waterfowl, and/or 3) continuous lake aeration to enhance water movement and decrease the likelihood of ephemeral DO sags that could lead to fishkills.

Over the short term, we recommend:

- The continuation of water quality monitoring and algal/cyanobacteria screening due to the high visibility of the lake, the possibility of cyanotoxin production, and likelihood of human contact since the lake is part of a high-foot traffic public park.

- Continued monitoring should include periodic diurnal measurements of pH and DO changes by deploying subsurface data loggers. Short-term increases in pH could be enhancing release of nutrients from lake sediments. Likewise, periodic hypoxia/anoxia could enhance sediment-bound phosphorus release and stress fish populations.
- The posting of noticeable signage of the potential hazards to humans and pets when toxin-producing cyanobacteria are present above select criteria. To assist the NPS in managing Constitution Gardens Lake and other waterbodies in the District of Columbia, a Draft "Harmful Algal Bloom Action Plan and Decision Tree for National Park Service in the District of Columbia" is provided in Appendix C.

Acknowledgments

Hood-CCWS would like to acknowledge student technicians that assisted on the field work and laboratory analysis for this project: Brooke Gooding, Kate Maltby, Alex Marinelli, Nate Purser, and Gabe Urso.

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Appendix A: Comprehensive Data Summary 2019-2022

Sample	Date	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)	Chlorophyll Fluorescence (RFU)	Phycocyanin Fluorescence (RFU)	PC:CHL	Estimated Total Chl (ug/L)	REPORTED Adjusted Estimated Total Chl (ug/L)	Dissolved Ammonia-N (mg/L)	Dissolved Nitrate-N (mg/L)	Dissolved Ortho Phosphate-P (mg/L)
COGA 1	6/24/2019				9.57	1.02	39.54	19.62	0.50	18.17		0.02	0.26	0.17
COGA 2	6/24/2019				9.73	1.33	32.99	15.15	0.46	16.96		0.05	0.24	0.14
COGA 3	6/24/2019				9.83	1.16	42.34	15.47	0.37	18.69		0.02	0.27	0.23
COGA 4	6/24/2019				9.79	1.47	36.54	14.69	0.40	17.62		0.08	0.24	0.24
COGA 5	6/24/2019				9.80	1.26	29.12	13.12	0.45	16.25		0.07	0.22	0.22
COGA 6	6/24/2019	30.2	11.7	263.8	9.43	1.54	36.01	14.98	0.42	17.52		0.04	0.23	0.25
COGA 1	7/25/2019				9.95	4.86	193.97	121.80	0.63	46.68		0.25	0.25	0.11
COGA 2	7/25/2019				9.96	3.07	147.43	33.08	0.22	38.09		0.24	0.26	0.16
COGA 3	7/25/2019				9.94	2.90	169.90	36.34	0.21	42.23		0.23	0.26	0.15
COGA 4	7/25/2019				10.09	3.36	211.60	47.08	0.22	49.93		0.29	0.26	0.13
COGA 5	7/25/2019				10.13	4.06	204.10	46.18	0.23	48.55		0.26	0.24	0.13
COGA 6	7/25/2019	28.6	12.87	228.7	9.95	3.17	215.63	39.30	0.18	50.67		0.29	0.23	0.13
COGA 1	8/22/2019				8.03	194.13	679.43	3760.00	5.53	136.28		0.09	0.41	-0.01
COGA 2	8/22/2019				9.26	17.27	128.60	214.50	1.67	34.61		1.51	0.38	0.15
COGA 3	8/22/2019				9.24	10.81	67.40	143.67	2.13	23.31		0.97	0.36	0.08
COGA 4	8/22/2019				8.94	17.93	113.67	264.90	2.33	31.85		0.51	0.33	0.02
COGA 5	8/22/2019	30.9	11.94	0.2671	9.53	15.21	98.38	242.03	2.46	29.03		0.44	0.39	0.04
COGA 6	8/22/2019	31	5.98	0.4284	9.70	10.64	60.66	96.57	1.59	22.07		0.97	0.39	0.12
COGA 1	9/24/2019				9.46	5.26	242.60	53.85	0.22	55.65		-0.01	0.29	0.00
COGA 2	9/24/2019				9.65	5.74	230.23	50.61	0.22	53.37		0.13	0.32	0.04
COGA 3	9/24/2019				9.91	6.94	271.47	62.66	0.23	60.98		0.44	0.32	-0.01
COGA 4	9/24/2019				9.73	7.23	282.53	65.37	0.23	63.02		0.16	0.31	-0.01
COGA 5	9/24/2019	24.3	4.07	0.2556	8.40	4.79	249.53	50.16	0.20	56.93		0.14	0.32	0.00
COGA 6	9/24/2019	27.1	11.14	0.2669	9.41	5.86	268.60	57.84	0.22	60.45		0.24	0.31	0.04
COGA 1	10/29/2019	18.9	1.74	0.2462	7.52	5.34	174.60	39.68	0.23	43.10		0.16	0.22	0.00

Sample	Date	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)	Chlorophyll Fluorescence (RFU)	Phycocyanin Fluorescence (RFU)	PC:CHL	Estimated Total Chl (ug/L)	REPORTED Adjusted Estimated Total Chl (ug/L)	Dissolved Ammonia-N (mg/L)	Dissolved Nitrate-N (mg/L)	Dissolved Ortho Phosphate-P (mg/L)
COGA 2	10/29/2019	18.2	6.37	0.1194	8.03	4.86	151.10	41.16	0.27	38.76		0.18	0.24	0.00
COGA 3	10/29/2019	18.8	7.53	0.2403	7.11	5.39	156.27	42.94	0.27	39.72		0.23	0.24	0.00
COGA 4	10/29/2019	17.8	4.6	0.2434	6.96	4.06	143.07	38.18	0.27	37.28		0.21	0.24	0.00
COGA 5	10/29/2019	18.2	5.37	0.2455	8.17	4.18	151.07	38.58	0.26	38.76		0.18	0.26	-0.01
COGA 6	10/29/2019	18.2	6	0.2415	7.41	4.67	160.40	38.21	0.24	40.48		0.23	0.23	-0.01
COGA 1	12/2/2019	6.9	2.04	-	8.02	8.92	270.03	72.26	0.27	60.71		0.44	0.57	2.90
COGA 2	12/2/2019	7.5	10.68	-	9.23	19.49	1472.33	265.37	0.18	282.62		0.21	0.21	4.15
COGA 3	12/2/2019	7.0	10.67	-	8.94	17.81	1475.67	254.70	0.17	283.24		0.20	0.23	1.50
COGA 4	12/2/2019	6.5	11.27	-	8.98	12.42	1458.00	242.10	0.17	279.98		0.08	0.21	0.37
COGA 5	12/2/2019	6.5	11.97	-	9.43	13.92	1491.67	248.70	0.17	286.19		0.10	0.21	1.72
COGA 6	12/2/2019	7.1	11.38	-	8.74	14.87	1480.33	251.27	0.17	284.10		0.16	0.20	1.88
COGA 1	2/18/2020	9.4	13.065	0.1628	7.84	11.89	2212.67	457.20	0.21	2104.15		0.23	0.27	0.01
COGA 2	2/18/2020				8.80	8.91	891.23	206.57	0.23	850.18		0.20	0.23	1.38
COGA 3	2/18/2020	10.7	0.1641	0.1641	10.23	7.72	461.10	111.67	0.24	442.01		0.15	0.24	4.55
COGA 4	2/18/2020				9.62	10.88	926.20	226.70	0.24	883.36		0.17	0.24	0.54
COGA 5	2/18/2020				10.54	10.40	1246.00	294.53	0.24	1186.83		0.16	0.24	2.36
COGA 6	2/18/2020	9.7	0.1523	0.1523	9.94	9.87	1033.00	233.97	0.23	984.71		0.16	0.26	0.02
COGA 1	6/16/2020	21.1	0.27	214.7	8.17	3.71	150.93	35.57	0.24	147.67		0.11	0.43	0.57
COGA 2	6/16/2020	23.3	13.32	239.3	10.80	5.06	116.76	24.73	0.21	115.25		0.17	0.34	0.71
COGA 3	6/16/2020	23.7	6.74	233.1	10.21	4.68	38.27	19.68	0.51	40.76		0.12	0.34	0.82
COGA 4	6/16/2020	23.4	14.43	264.4	10.39	4.08	30.06	15.42	0.51	32.97		0.14	0.32	0.66
COGA 5	6/16/2020	24.1	15.25	246.1	9.82	3.33	72.38	20.28	0.28	73.13		0.12	0.34	0.61
COGA 6	6/16/2020	24.2	15.34	263.7	10.54	4.06	55.13	18.86	0.34	56.76		0.14	0.33	0.63
COGA 1	7/28/2020	32.3	5.84	284.8	8.86	2.54	37.17	13.42	0.36	39.72		0.23	0.31	1.01
COGA 2	7/28/2020	32.2	9.14	282.8	9.82	1.76	29.28	11.91	0.41	32.23		0.25	0.28	0.93

Sample	Date	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)	Chlorophyll Fluorescence (RFU)	Phycocyanin Fluorescence (RFU)	PC:CHL	Estimated Total Chl (ug/L)	REPORTED Adjusted Estimated Total Chl (ug/L)	Dissolved Ammonia-N (mg/L)	Dissolved Nitrate-N (mg/L)	Dissolved Ortho Phosphate-P (mg/L)
COGA 3	7/28/2020	33.2	15.04	302.7	10.15	1.86	30.81	11.76	0.38	33.68		0.26	0.30	0.79
COGA 4	7/28/2020	32.5	12.82	290	9.88	1.89	32.44	12.91	0.40	35.23		0.23	0.33	0.80
COGA 5	7/28/2020	33.2	15.09	301.5	10.10	2.14	37.82	12.61	0.33	40.33		0.25	0.05	0.82
COGA 6	7/28/2020	33.3	14.07	299.7	10.48	2.05	41.49	12.82	0.31	43.82		0.23	0.05	0.88
COGA 1	8/14/2020	28	1.79	264.1	9.28	14.67	105.33	160.53	1.52	104.40		0.16	0.37	0.47
COGA 2	8/14/2020	28.2	11.68	250.9	10.32	31.84	187.30	814.87	4.35	182.18		0.14	0.37	0.17
COGA 3	8/14/2020	28.8	16.77	313.2	11.90	46.08	230.73	1233.00	5.34	223.40		0.17	0.37	0.12
COGA 4	8/14/2020	28.2	13.82	251.5	10.50	31.12	181.63	856.83	4.72	176.81		0.16	0.37	0.18
COGA 5	8/14/2020	28.2	10.91	245.4	10.35	23.33	134.23	546.83	4.07	131.83		0.13	0.37	0.25
COGA 6	8/14/2020	28.1	5.44	244.5	9.03	16.61	130.03	397.40	3.06	127.84		0.15	0.37	0.32
COGA 1	9/10/2020	25.9	0.83	244.5	7.31	9.34	769.77	178.23	0.23	734.91		0.29	0.29	0.03
COGA 2	9/10/2020	26.2	2.61	244.5	8.91	23.32	1038.33	500.43	0.48	989.77		0.30	0.30	0.04
COGA 3	9/10/2020	26.3	3.68	244.5	9.19	20.71	1019.33	465.00	0.46	971.74		0.15	0.31	0.05
COGA 4	9/10/2020	25.8	0.91	244.5	9.01	19.26	1119.67	411.07	0.37	1066.95		0.25	0.29	0.04
COGA 5	9/10/2020	26	2.59	244.5	9.23	15.71	1202.00	340.03	0.28	1145.08		0.14	0.32	0.04
COGA 6	9/10/2020	26.1	2.57	244.5	9.07	17.52	1200.00	363.97	0.30	1143.18		0.25	0.30	0.05
COGA 1	9/24/2020	20.1	2.2	159.8	8.35	12.40	411.90	199.30	0.48	395.32		0.11	0.26	0.58
COGA 2	9/24/2020	20.6	7.62	153.8	9.31	8.61	233.10	128.10	0.55	225.65		0.13	0.27	0.14
COGA 3	9/24/2020	20.3	5.44	153.4	9.27	13.49	447.83	196.80	0.44	429.42		0.14	0.26	1.22
COGA 4	9/24/2020	20.1	7.54	151.8	9.50	9.60	310.80	145.50	0.47	299.38		0.10	0.24	0.04
COGA 5	9/24/2020	20.07	7.4	153.9	9.60	9.36	313.57	149.43	0.48	302.00		0.12	0.24	0.02
COGA 6	9/24/2020	20.4	8.88	152.6	9.67	9.60	296.70	143.40	0.48	286.00		0.13	0.25	0.01
COGA 1	10/7/2020	18.6	1.54	203.4	7.08	4.62	296.63	68.91	0.23	285.94		0.11	0.27	-0.29
COGA 2	10/7/2020	20.7	8.42	198.7	8.33	5.87	297.57	84.75	0.28	286.82		0.10	0.27	-0.28
COGA 3	10/7/2020	20.2	4.88	204.3	7.90	5.58	317.60	83.34	0.26	305.83		0.16	0.27	-0.28
COGA 4	10/7/2020	19	5.16	195.2	8.09	5.72	377.43	93.31	0.25	362.61		0.09	0.31	-0.29

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COGA 5	10/7/2020	19.7	6.05	197.5	8.27	5.09	297.87	82.69	0.28	287.11		0.12	0.28	-0.29
COGA 6	10/7/2020	19.9	8.24	197.7	8.65	5.95	335.93	91.16	0.27	323.23		0.14	0.27	-0.29
Far West	10/7/2020	19.8	5.8	198.1										-0.05
COGA 1	10/28/2020	17.7	1.88	212.2	6.90	4.06	287.00	64.66	0.23	276.79		0.13	0.28	-0.32
COGA 2	10/28/2020	17.9	4.11	215.9	7.45	4.34	312.30	74.26	0.24	300.80		0.10	0.31	-0.32
COGA 3	10/28/2020	17.6	4.73	207.1	7.58	4.24	325.60	77.84	0.24	313.42		0.20	0.28	-0.32
COGA 4	10/28/2020	17.4	5.55	205.2	7.71	4.02	348.37	79.68	0.23	335.03		0.13	0.29	-0.32
COGA 5	10/28/2020	17.5	5.62	205.9	7.82	3.58	317.70	68.32	0.22	305.93		0.11	0.31	-0.32
COGA 6	10/28/2020	17.6	5.49	207	7.91	3.88	318.87	75.64	0.24	307.03		0.13	0.29	-0.32
Far West	10/28/2020	17.5	4.05	207.9										
COGA 1	12/8/2020	2.6	1.85	93.1	6.36	1.95	79.03	56.01	0.71	79.44		0.02	0.33	0.36
COGA 2	12/8/2020	4.2	13.12	126.3	7.87	3.77	196.03	117.93	0.60	190.47		0.02	0.28	-0.03
COGA 3	12/8/2020	5	12.75	132.6	8.22	3.94	225.87	117.50	0.52	218.78		0.01	0.27	-0.01
COGA 4	12/8/2020	3.8	12.92	124.8	8.44	3.70	199.07	118.43	0.59	193.35		0.10	0.27	-0.02
COGA 5	12/8/2020	3.7	12.99	124.4	7.11	4.04	236.80	119.53	0.50	229.16		0.02	0.27	-0.03
COGA 6	12/8/2020	4.2	13.14	126	7.73	3.99	217.43	125.03	0.58	210.78		0.02	0.24	-0.03
COGA 1	2/25/2021	7.6	5.59	135.5	7.04	2.65	284.10	36.46	0.13	108.75	46.51	0.36	0.22	-0.01
COGA 2	2/25/2021	8.8	14.27	133.8	8.84	3.01	349.40	39.27	0.11	142.85	62.51	0.31	0.24	-0.01
COGA 3	2/25/2021	9.3	14.11	136.5	8.79	3.05	357.90	38.76	0.11	154.42	67.95	0.30	0.27	0.00
COGA 3.5	2/25/2021	9.3	14.75	136.1	8.84	2.76	352.50	38.87	0.11	161.89	71.46	0.32	0.23	-0.01
COGA 4	2/25/2021	8.5	13.97	134	8.77	2.73	344.90	35.34	0.10	154.33	67.90	0.36	0.24	-0.01
COGA 5	2/25/2021	8.7	14.01	134.10	8.77	2.78	337.40	36.89	0.11	146.05	64.02	0.33	0.24	0.01
COGA 6	2/25/2021	8.7	14.18	133.2	8.82	2.49	345.30	34.43	0.10	150.89	66.29	0.35	0.26	0.00
COGA 1	3/16/2021	8.5	3.81	164.1	7.00	2.84	61.80	22.57	0.37	18.47	4.12	0.15	0.18	0.08
COGA 2	3/16/2021	9.8	7.11	161.5	7.53	2.35	23.40	14.01	0.60	8.38	BD	0.26	0.20	0.05
COGA 3	3/16/2021	9.6	6.53	162.4	7.73	3.76	33.90	15.21	0.45	11.23	0.72	0.24	0.15	0.04

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COGA 3.5	3/16/2021	10	6.16	163.4	7.62	2.32	20.30	12.85	0.63	6.75	BD	0.24	0.18	0.06
COGA 4	3/16/2021	10.1	6.52	163.2	7.65	2.91	22.50	12.88	0.57	6.88	BD	0.19	0.15	0.07
COGA 5	3/16/2021	10.1	6.72	162.7	7.68	2.54	23.10	14.60	0.63	7.15	BD	0.19	0.21	0.08
COGA 6	3/16/2021	10	6.98	161.2	7.78	2.50	28.80	13.79	0.48	8.86	BD	0.20	0.14	0.03
COGA 1	4/28/2021	24.3	2.08	254.2	7.29	7.36	152.10	40.85	0.27	52.95	20.31	0.34	0.32	0.27
COGA 2	4/28/2021	23.1	6.41	241.4	8.05	2.24	78.80	28.17	0.36	31.60	10.28	0.30	0.27	-0.02
COGA 3	4/28/2021	23.4	7.47	240.3	8.19	2.57	81.80	23.68	0.29	26.22	7.76	0.19	0.29	0.00
COGA 4	4/28/2021	22.9	8.25	237.2	8.30	2.01	86.90	27.79	0.32	34.08	11.45	0.20	0.29	0.01
COGA 5	4/28/2021	23.2	8.52	237.3	8.48	2.05	99.50	25.30	0.25	35.14	11.95	0.18	0.29	0.00
COGA 6	4/28/2021	22.9	9.62	232	8.46	1.93	112.70	36.76	0.33	53.60	20.62	0.17	0.28	0.00
COGA 1	5/25/2021	22.5	12.51	219.6	8.71	2.82	131.90	43.36	0.33	46.70	17.37	0.21	0.46	0.02
COGA 2	5/25/2021	22.7	6.89	215	8.48	2.28	97.50	49.31	0.51	43.67	15.95	0.17	0.25	-0.01
COGA 3	5/25/2021	23.3	6.99	222.6	8.46	2.93	119.50	38.27	0.32	43.63	15.94	0.17	0.25	-0.01
COGA 4	5/25/2021	22.2	4.66	220.8	9.17	2.20	99.90	58.65	0.59	48.02	17.99	0.16	0.25	0.00
COGA 5	5/25/2021	23	11.78	204.9	9.38	2.31	108.80	40.98	0.38	38.23	13.40	0.19	0.28	0.00
COGA 6	5/25/2021	22.9	6.22	217	8.53	1.90	103.90	47.10	0.45	38.21	13.39	0.22	0.26	0.05
COGA 1	6/16/2021	25.9	9.37	154.7	7.54	1.10	31.70	14.86	0.47	10.85	0.54	0.20	0.26	0.08
COGA 2	6/16/2021	27.3	10.78	130.8	9.98	1.33	57.90	17.68	0.31	16.13	3.02	0.16	0.23	0.03
COGA 3	6/16/2021	27.5	10.4	173.6	10.92	1.12	51.50	20.76	0.40	15.42	2.69	0.17	0.24	0.03
COGA 4	6/16/2021	26.5	9	164.9	10.73	1.23	84.10	36.73	0.44	25.80	7.56	0.21	0.22	0.09
COGA 5	6/16/2021	26.8	10.41	169.6	10.47	1.31	76.50	29.06	0.38	21.72	5.65	0.17	0.24	0.03
COGA 6	6/16/2021	26.8	10.95	169.5	10.32	1.62	86.20	32.79	0.38	22.16	5.85	0.17	0.24	0.06
COGA 1	6/30/2021													
COGA 2	6/30/2021	32.5	9.33	181	9.98	1.08	40.70	22.36	0.55	15.91	2.92	0.14	0.19	0.24
COGA 3	6/30/2021	32.8	9.1	176.5	10.30	1.08	36.70	16.70	0.46	13.87	1.96	0.16	0.20	0.01
COGA 4	6/30/2021													

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COGA 5	6/30/2021													
COGA 6	6/30/2021	32.5	7.93	10.296	9.91	1.03	31.00	14.82	0.48	10.75	0.50	0.16	0.20	0.01
COGA 1	7/26/2021	27.5	2.43	221.5	7.56	3.59	270.90	26.51	0.10	25.97	7.64	0.20	0.48	2.14
COGA 2	7/26/2021	28.8	9.49	164.6	9.22	4.52	176.10	66.00	0.38	48.57	18.25	0.19		-0.02
COGA 3	7/26/2021	29.2	12.97	159.9	9.72	3.06	62.40	39.22	0.63	24.56	6.98	0.18	0.30	2.91
COGA 4	7/26/2021	29.3	11.71	157.4	9.94	2.68	49.00	36.50	0.75	18.87	4.31	0.17	0.29	2.04
COGA 5	7/26/2021	29.5	12.76	170.6	9.99	1.98	40.70	18.38	0.45	16.82	3.35	0.19	0.29	0.13
COGA 6	7/26/2021	29.2	12.62	170.8	10.11	2.29	50.90	28.54	0.56	19.34	4.53	0.20	0.28	0.13
COGA 1	8/19/2021	26.4	0.6	168.3	6.55	3.05	95.50	20.95	0.22	17.82	3.82	0.18	0.33	-0.29
COGA 2	8/19/2021	28.2	0.41	296.5	9.19	8.66	208.20	107.73	0.52	178.96	79.47	0.16	0.31	-0.29
COGA 3	8/19/2021	29.2	10.75	187.2	11.82	1.42	58.90	26.34	0.45	15.43	2.69	0.17	0.32	-0.29
COGA 4	8/19/2021	29.3	12.78	162.7	12.12	2.34	43.70	49.52	1.13	13.98	2.01	0.10	0.30	-0.29
COGA 5	8/19/2021	30.1	14.03	178.7	10.82	2.34	42.40	25.37	0.60	16.04	2.98	0.10	0.29	-0.29
COGA 6	8/19/2021	30.1	15.23	174.4	12.60	0.97	39.60	27.82	0.70	14.09	2.07	0.07	0.28	-0.29
COGA 1	9/24/2021	22.1	2.14	150	9.14	2.49	29.00	35.04	1.21	9.94	0.12	0.18	0.22	-0.28
COGA 2	9/24/2021	23.6	19.27	171.9	10.60	2.32	61.90	19.63	0.32	24.44	6.93	0.21	0.16	-0.28
COGA 3	9/24/2021	23.7	16.01	150.1	10.05	2.10	34.60	15.16	0.44	10.42	0.34	0.16	0.18	-0.28
COGA 4	9/24/2021	21.3	10.27	135.3	10.10	2.50	35.10	20.57	0.59	12.07	1.12	0.17	0.18	-0.28
COGA 5	9/24/2021	23.4	12.23	145.1	10.04	2.23	41.00	17.88	0.44	17.63	3.73	0.19	0.22	-0.28
COGA 6	9/24/2021	23.2	13.7	145.5	10.18	1.97	43.50	21.58	0.50	16.83	3.35	0.17	0.17	-0.28
COGA 1	10/29/2021	16.2	2.13	132.2	6.61	1.82	75.90	18.32	0.24	14.85	2.42	0.14	0.22	-0.03
COGA 2	10/29/2021	17	8.78	182.4	8.25	3.15	123.40	34.74	0.28	40.55	14.49	0.12	0.21	-0.01
COGA 3	10/29/2021	18.6	16.87	186.4	9.37	3.67	105.90	30.05	0.28	36.28	12.48	0.13	0.23	-0.01
COGA 4	10/29/2021	16.1	8.97	173.8	8.55	2.32	104.10	26.33	0.25	37.28	12.95	0.14	0.20	-0.02
COGA 5	10/29/2021	16.6	9.56	175.1	8.45	2.20	107.80	26.38	0.25	38.20	13.38	0.11	0.22	-0.02
COGA 6	10/29/2021	16.9	10.19	176.4	8.47	2.29	97.00	24.53	0.25	35.25	12.00	0.15	0.19	0.21

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COGA 1	12/7/2021	5.9	4.13	153.4	7.05	2.34	82.10	25.25	0.31	26.85	8.06	0.15	0.31	6.32
COGA 2	12/7/2021	7.8	12.63	134.6	8.73	3.26	247.60	45.73	0.19	90.58	37.98	0.18	0.25	1.29
COGA 3	12/7/2021	8	12.06	136.1	8.55	3.12	255.00	45.67	0.18	92.36	38.81	0.18	0.25	6.22
COGA 4	12/7/2021	7	12.53	131.7	8.87	3.26	306.20	55.02	0.18	114.62	49.26	0.19	0.23	7.51
COGA 5	12/7/2021	7.3	12.53	132.7	8.89		281.70	44.15	0.16	102.70	43.67	0.20	0.25	2.50
COGA 6	12/7/2021	7.7	12.27	134.3	8.82	2.96	250.90	43.75	0.17	91.47	38.39	0.18	0.23	1.58
COGA 1	2/10/2022	7.4	8.45	127.1	7.97	0.64	58.40	13.54	0.23	14.60	2.31	0.15	0.25	0.03
COGA 2	2/10/2022	7.7	12.95	126.1	8.41	1.87	231.10	26.98	0.12	231.07	103.93	0.18	0.26	-0.02
COGA 3	2/10/2022	8.3	13.42	129	8.66	1.93	273.80	26.39	0.10	107.18	45.77	0.18	0.25	-0.02
COGA 4	2/10/2022	7.2	13.82	122.7	8.79	1.90	332.60	36.69	0.11	132.51	57.66	0.13	0.24	-0.02
COGA 5	2/10/2022	7.2	13.95	122.6	8.59	2.06	316.10	34.13	0.11	121.71	52.59	0.13	0.25	-0.02
COGA 6	2/10/2022	8.1	13.7	124.9	8.98	1.85	270.10	36.43	0.14	116.83	50.30	0.14	0.23	-0.03
COGA 1	3/18/2022	19.8	10.25	206.1	8.23	1.77	111.70	19.58	0.18	41.15	14.77	0.18	0.26	0.01
COGA 2	3/18/2022	18.4	8.71	202.1	8.59	2.25	260.00	28.96	0.11	98.02	41.47	0.18	0.27	0.00
COGA 3	3/18/2022	19.1	11.59	209.6	8.80	3.61	541.80	174.77	0.32	149.26	65.52	0.16	0.25	-0.01
COGA 4	3/18/2022	17.3	14.29	190.6	9.17	3.43	477.40	41.42	0.09	170.00	75.26	0.17	0.25	-0.03
COGA 5	3/18/2022	16.4	14.95	185.7	9.12	3.16	402.30	33.51	0.08	166.91	73.81	0.16	0.26	-0.02
COGA 5 dup	3/18/2022					3.02	413.30	35.60	0.09	166.42	73.58	0.21	0.24	-0.02
COGA 6	3/18/2022	18.1	12.54	192.6	9.25	2.62	424.80	35.18	0.08	178.71	79.35	0.19	0.25	-0.03
COGA 1	4/12/2022	15.2	2.22	204.2	7.21	7.88	38.90	27.68	0.71	11.62	0.91	0.24	0.31	1.13
COGA 2	4/12/2022	15.4	15.66	144.2	10.27	6.60	87.10	45.65	0.52	29.69	9.39	0.23	0.29	0.07
COGA 3	4/12/2022	16.1	18.54	153.5	10.66	3.80	75.90	29.05	0.38	24.63	7.02	0.27	0.32	0.08
COGA 4	4/12/2022	15.5	15.64	147.8	10.67	2.77	50.60	20.90	0.41	16.28	3.10	0.27	0.29	0.06
COGA 5	4/12/2022	15.4	17.68	145.3	10.75	3.80	92.00	29.56	0.32	31.56	10.27	0.27	0.33	0.06
COGA 6	4/12/2022	15.5	17.51	147.7	10.59	3.71	97.10	28.79	0.30	30.75	9.89	0.27	0.33	0.05

Appendix B: COGA Algal ID Counts 2020-2022 *(Identifications were not provided in 2019)*

The following table summarizes the number of times a genera was identified in a composite water or scum sample.

	Scum Grab Sample						Composite Water Sample			
Count of General Identification	Common	Present	Abundant	Present-Common	Common-Abundant	Scum Grab Sample Total	Common	Present	Abundant	Composite Water Sample Total
Non-toxic	**1**	**50**	**5**	**2**	**1**	**59**	**9**	**34**	**9**	
Scenedesmus sp.		7	1			**8**	2	6		**8**
Unidentified Pennate Diatoms		4				**4**	2	2		**4**
Pediastrum sp.		4				**4**		3		**3**
Monoraphidium sp.		3				**3**		1	2	**3**
Actinastrum sp.		1		1		**2**	1	1	1	**3**
Staurastrum sp.		1				**1**		3		**3**
Cosmarium sp.		3	1			**4**				
Navicula sp.		1				**1**		3		**3**
Unidentified coccoid green algae		1				**1**		1	1	**2**
Mallomonas sp.		1				**1**		2		**2**
Unidentified Dinoflagellates		1				**1**	1	1		**2**
Haematococcus sp.			1			**1**		1	1	**2**
Phacus sp.			1			**1**	1	1		**2**
Unidentified green filaments	1					**1**		1		**1**
Unidentified centric diatoms		1				**1**	1			**1**
Spirogyra sp.		2				**2**				
Diatoms		2				**2**				
Ankistrodesmus sp.		1				**1**		1		**1**
Dinoflagellates		1			1	**2**				
Green Flagellates		1				**1**	1			**1**
Chroococcus sp.		1				**1**		1		**1**
Coelosphaerium sp.								2		**2**
Cladophora sp.		1				**1**		1		**1**

Count of General Identification	Common	Present	Abundant	Present-Common	Common-Abundant	Scum Grab Sample Total	Common	Present	Abundant	Composite Water Sample Total
Unidentified green filamentous algae (tentatively identified as Pithophora or Cladophora)								1	1	**2**
Nitzschia sp.		1	1			**2**				
Unidentified Green Flagellates				1		**1**			1	**1**
Eudorina sp.								1		**1**
Meridion sp.		1				**1**				
Unidentified filamentous diatoms		1				**1**				
Sphaerocystis sp.		1				**1**				
Volvox sp.		1				**1**				
Closterium sp.		1				**1**				
Gonium sp.		1				**1**				
Hydrodictyon sp.		1				**1**				
Unidentified flagellated green cells									1	**1**
Stigeoclonium sp.		1				**1**				
Merismopedia sp.		1				**1**				
Tetrastrum sp.								1		**1**
Coelastrum sp.		1				**1**				
Selanastrum sp.		1				**1**				
Cryptomonas sp.									1	**1**
Pithophora sp.		1				**1**				
Potential toxin-producer	**2**	**10**	**6**			**18**	**1**	**2**	**8**	**11**
Dolichospermum sp.	1	1	3			**5**			2	**2**
Microcystis sp.		3	1			**4**		1	1	**2**
Planktothrix sp.		3	1			**4**			1	**1**
Anabaena sp.		3	1			**4**				

Count of General Identification	Common	Present	Abundant	Present-Common	Common-Abundant	Scum Grab Sample Total	Common	Present	Abundant	Composite Water Sample Total
Planktolyngbya sp.							1	1	1	**3**
Pseudoanabaena sp.									2	**2**
Aphanizomenon sp.									1	**1**
Oscillatoria sp.	1					**1**				
Toxicity Unknown	**1**	**1**	**1**			**3**	**2**	**1**	**3**	**6**
Unidentified coccoid cyanobacteria		1	1			**2**	2		3	**5**
Unidentified Green Flagellates	1					**1**				
Unidentified cyanobacteria filaments (final identification is pending)								1		**1**

Harmful Algal Bloom Action Plan and Decision Tree For National Park Service in the District of Columbia

This action plan and decision tree will assist NPS in responding to harmful algal blooms (HABs). While not all HABs produce toxins dangerous to humans and animals, their presence can create unpleasant recreational environments. Additionally, environmental conditions can change quickly causing toxins to be produced; therefore, having a plan of action is important for managers.

It is difficult to define "safe" concentrations of cyanobacteria in recreational water due to rapidly changing environmental conditions such as wind direction and temperature, individual sensitivities from exposure (e.g., dermal contact or ingestion by humans, pets or wildlife), and the wide variations in algal bloom, mat, and scum densities and their dispersal within a water body. In addition, regulatory guidance on signage and exposure limits have not been created in every State or for all cyanotoxins.

This HAB Action Plan and Decision Tree was created following guidelines compiled from numerous sources to serve as a conservative approach to manage HABs and protect the public from HAB exposure during recreational activities. This guidance does not address cyanobacteria or cyanotoxins in drinking water.

*The following flow chart serves as a **decision tree** to guide actions for additional sampling, analysis, reporting, and posting of public safety advisories and/or signage. Explanations for each step and action criteria are provided in the **narrative table** which follows the decision tree. **Resources** are offered within each numbered step in the decision tree within the narrative table. These can be shared with NPS staff or other professionals assisting the NPS in managing its water bodies. **References, contacts,** and additional resources are provided at the end of the document.*

Figure 1: Constitution Gardens in D.C. undergoing an algal bloom, 2020

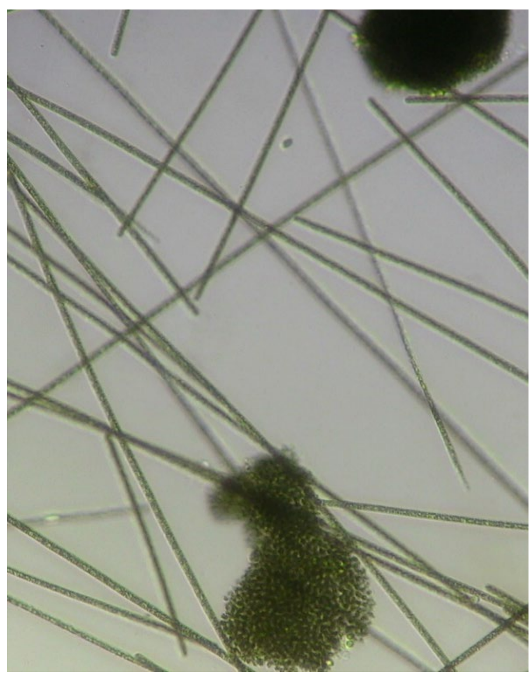
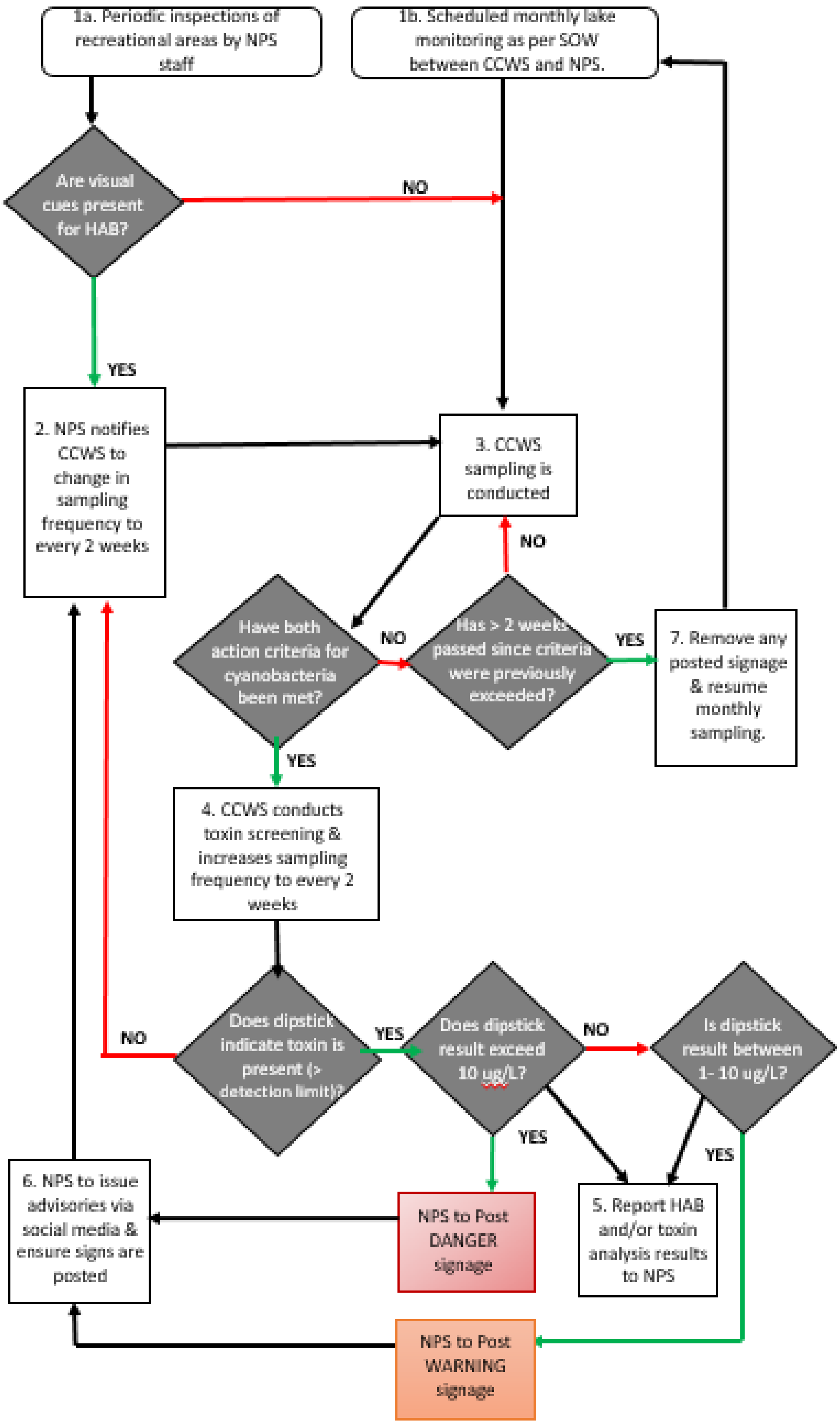


Figure 2: Aphanizomenon sp. and Microcystis sp,, 400x

HAB Management DECISION TREE for NPS in the District of Columbia



NARRATIVE TABLE With Key Resources	
1. Inspection & Routine Sampling	Prepare a regular schedule for staff to visually inspect the lake(s), particularly at public access points during recreation season for potential HABs.(Ensure staff is adequately trained) Schedule periodic monitoring. Post signage displaying public information on how to identify potential algal problems. Include a contact number to report any suspicious colors or algae on/in the lake. Cues that suggest a bloom is occurring or imminent: • Visual cues: water appears bright green, soupy, surface scum or mat appears, foul odors, obvious plankton growth • Extended warm weather with light or no winds, • Change in chemical factors: increase in nitrogen, phosphorous, pH • Historic trends may provide clues to anticipate a bloom. NPS staff should be familiarized with the types of HABs that have historically occurred at NPS lakes, perhaps by scheduling a workshop at Hood-CCWS. **Resources:** • VA Department of Health HAB Training • District of Columbia (D.C.) HAB website • SWAMP's Visual guide to Observing Blooms • USGS Field & Laboratory Guide to Cyanobacteria HABs • Hood-CCWS (301) 696-3652
HAB visual cues	NPS Staff should visually inspect algal bloom to determine if the color/accumulation/type suggests it is an algae of concern and if the algae is similar to algae historically seen at the lake. Many references are available online to generically determine algal varieties. Take photographs of the algal bloom, note the day and time of the event. Record unusual details such as color, odor, or whether a fish kill occurred. Email any photos or descriptive information to CCWS. Schedule sampling and analysis of the area if HAB is suspected, particularly if water monitoring has not occurred within the last two weeks. **Resources:** • SWAMP Visual Guide to Observing Blooms • To schedule sampling with Hood-CCWS, call (301) 696-3652

2-4. Sampling Schedule & Frequency Changes	Hood-CCWS will use field screening methods for initial determination if cyanobacteria and cyanotoxins are present. As necessary, samples may be collected for lab analysis of water, scum, or algal mat. General taxonomic identification will provide insight on algal\bacteria type and whether it may be potentially toxin-producing. Screening results will be compared to criteria[4] to determine the need for further action. Hood-CCWS will use criteria listed below in 2021. If initial sample results exceed BOTH the following criteria, toxin screening will occur: 1. A **PC:CHL ratio** of 0.3 or greater AND 2. An **estimate CHL *a* (adjusted)** of 50 ug/L CHL *a* or greater. Toxin screening using Abraxis Microcystin Strips will quantify if microcystin and/or nodularins are present or below limits of detection, If present, notification will be provided as to approximate concentration (i.e., < 10 or > 10 ug/L). Hood-CCWS will notify the NPS of the results recommendations for further action. If a HAB is occurring, additional sampling and analysis may be increased in frequency to track the presence of HAB and/or cyanotoxins (e.g., every two weeks). **Resources:** • SWAMP Visual Guide to Observing Blooms • Field Guide – Field Screening Methods
5. Reporting	To report a HAB, elevated cyanotoxin levels, or a fish kill, the NPS will contact: -in D.C.: • Tess Danielson, DOEE's Water Quality Division at (202) 724-5348 or tess.danielson@dc.gov. Include your name, phone number, the location of the algae bloom, and the date and time you observed it. If possible, please also include the approximate size of the bloom and a photo of the site. • Suspected algae blooms information may also be submitted via the app bloomWatch including photos and GPS location data of potential algae blooms

6. Issue Advisories and Signage	If analyses or observations meet or **exceed action levels** for toxins or HABs, OR **HAB-related illness is confirmed**, then NPS will post appropriate WARNING or DANGER signage. Coordination of public advisories issuance and posting signage should occur. Public notification should include electronic news and social media postings targeting users of the public spaces where an issue occurring. The design and wording of the warning and danger signage should be created in collaboration with NPS staff. **Resources:** • Recommended signage to be discussed with NPS • CCHAB Veterinary Reference and Fact Sheet

7. De-posting and Routine Monitoring	Sampling and analysis should continue and may be increased in frequency to track the presence of HAB and cyanotoxins. When screening action criteria and cyanotoxin concentrations are below the action levels for HAB for minimum of two consecutive weeks, signage can be removed. Notification of de-posting may also be decimated by electronic notices or social media. Routine sampling, if any, may resume to the original schedule frequency (e.g., monthly)
Consider Mitigation Strategy for recurring HAB	• *Physical Options:* barriers, raking, skimming, flushing • *Chemical Options*: nutrient mitigation, dyes, registered algacides such as BioSafe Systems GreenClean granular and liquid hydrogen peroxide paired with peroxyacetic acid (granules available on Amazon). • *Mechanical options*: aeration, harvesting, sonification, ozonation, UV light • *Biological options*: barley straw application, floating wetlands, buffers, enzymes, microbes, planktivorous fish ○ Barley Straw application – proactive application prior to warm spring months; ~7 bales/acre

REFERENCES & ADDITIONAL RESOURCES

General:

- California Cyanobacterial and Harmful Algal Bloom (CCHAB) Network Mitigation Subcommittee's Resources for Mitigating HABs page.
- District of Columbia (D.C.) HAB site: https://doee.dc.gov/service/algaeblooms

Contacts

- Tess Danielson, DC DOEE's Water Quality Division at (202) 724-5348 or tess.danielson@dc.gov.
- Hood College Center for Coastal & Watershed Studies (CCWS). www.hood.edu/ccws (301)696-3652

Decision Tree References

- California Cyanobacterial and Harmful Algal Bloom (CCHAB) Network Mitigation Subcommittee's HABs Response Plan, Action Criteria table, and Resources https://mywaterquality.ca.gov/habs/resources/habs_response.html, last accessed 4/29/2021
- CCHAB Decision Tree and Narrative https://mywaterquality.ca.gov/monitoring_council/cyanohab_network/docs/2016/decision_tree_and_narrative_2016.pdf, last accessed 4/29/2021
- CCHAB Blue-Green Algae: A Veterinarian Reference (Fact Sheet), https://mywaterquality.ca.gov/habs/what/vet_habs_factsheet.pdf, last accessed 4/29/2021
- DC HAB site: https://doee.dc.gov/service/algaeblooms, last accessed 4/29/2021
- SWRCB's Surface Ambient Monitoring Program (SWAMP): https://www.waterboards.ca.gov/water_issues/programs/swamp/, last accessed 9/2022
    - SWAMP Cyanobacteria and Toxin Guide, https://drive.google.com/file/d/1jSK9zEW-POTILXB0S60KQB7ksNEvc0nP/view?usp=sharing last accessed 4/29/2021
    - SWAMP Visual Guide to Observing Blooms, https://mywaterquality.ca.gov/habs/resources/field.html#visual_guide, last accessed 4/29/2021
- Virginia Department of Health Harmful Algal Bloom Training 101, 2017 https://www.vdh.virginia.gov/waterborne-hazards-control/harmful-algal-bloom-training/, last accessed 09/2022
- WHO, 1999. Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management. Chapter 5. Safe Levels And Safe Practices, edited by Ingrid Chorus and Jamie Bartram. (https://www.who.int/water_sanitation_health/resourcesquality/toxcyanbegin.pdf)

Field and Lab References

- Nienaber, M., and M. Steinitz-Kannan, 2018. A Guide to Cyanobacteria: Identification and Impact. The University Press of Kentucky. ISBN 9780813195591.
- USGS 2015. Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities, Open-File Report 2015–1164, https://pubs.usgs.gov/of/2015/1164/ofr20151164.pdf

- WHO, 1999. Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management. Edited by Ingrid Chorus and Jamie Bartram. ISBN 0-419-23930-8 (https://www.who.int/water_sanitation_health/resourcesquality/toxcyanbegin.pdf)

Regulations, Advisories, and Guidelines

- Center for Disease Control (CDC), December 14, 2017 Harmful Algal Bloom (HAB)-Associated Illness https://www.cdc.gov/habs/illness-symptoms-freshwater.html, last accessed 4/29/2021.
- Ingrid Chorus, Ian R. Falconer, Henry J. Salas, Jamie Bartram, 2000. Health Risks Caused By Freshwater Cyanobacteria In Recreational Waters, Journal of Toxicology and Environmental Health, Part B, 3:4, *323-347*
- U.S.EPA, 2019. Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin. EPA 822-R-19-001. https://www.epa.gov/sites/production/files/2019-05/documents/hh-rec-criteria-habs-document-2019.pdf
  and
  https://www.federalregister.gov/documents/2019/06/06/2019-11814/recommended-human-health-recreational-ambient-water-quality-criteria-or-swimming-advisories-for, last accessed 4/2021
- WHO 1998 *Guidelines for Drinking-water Quality. Second edition, Addendum to Volume 2, Health Criteria and Other Supporting Information.* World Health Organization, Geneva

Laboratories for Indepth Toxin Analysis

- Green Water Laboratories, Palatka, FL 386-328-0882 cyanolab.com
- CA SWAMPs list of laboratories SWAMP Visual Guide to Observing Blooms last accessed 9/2022

Mitigation Options

Green Clean Algaecide https://biosafesystems.com/product/