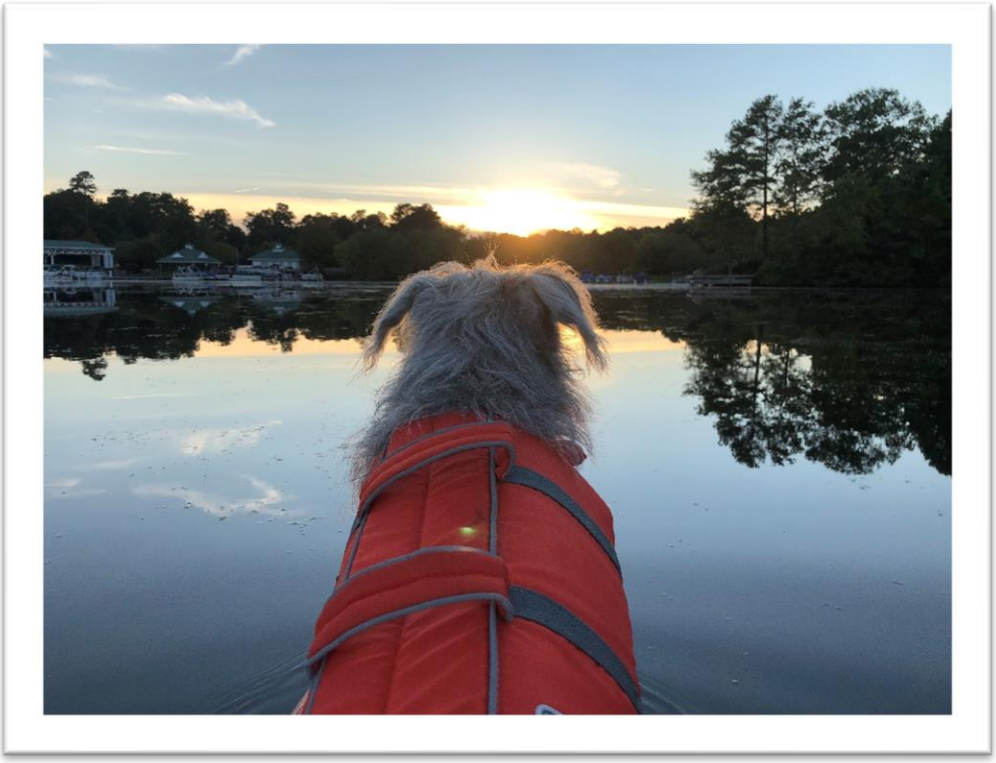
Swift Creek Reservoir
Water Quality Data Report 2020



Chesterfield County
Department of Environmental Engineering
Water Quality Section
&
Department of Utilities
Addison-Evans Water Production/Laboratory Facility

December 2021

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Executive Summary

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory Staff for the period of January through December 2020 and represents the twenty eighth consecutive year of monitoring of the Swift Creek Reservoir. Reservoir sampling occurred once a month at eight stations with additional samples obtained every other week at the lacustrine zone. Rainfall over the reservoir and its watershed totaled 61.76 inches, approximately 17.79 inches above the average. During June 2020, algaecides were applied to the reservoir three times to improve source water quality for the optimization of the water treatment process within the plant.

A higher concentration of chlorophyll *a* was observed in 2020 as compared to the previous year indicating an increased presence of algae in the reservoir. The growing season 90th percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 37.8 µg/L (Table 3), an increase from the 29.1 µg/L observed in 2019. Stations 5, 6 and 7 exceeded the 35 µg/L criteria value for the growing season 90th percentile indicating higher than acceptable levels of algal growth.

Throughout the reservoir, the 2020 total phosphorus concentrations remained consistent with previous years. The growing season median total phosphorus concentration for the surface water of the main body stations (Stations 4, 5, 6 and 8) was 0.031 mg/L as P; below the Virginia Department of Environmental Quality (VADEQ) nutrient threshold of 0.04 mg/L as P. The annual median phosphorus concentration for the surface water at all eight sites in Swift Creek Reservoir was 0.032 mg/L as P, also below the county threshold goal of 0.05 mg/L as P.

During 2020, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in late May and lasting through early November. During the stratification period, dissolved oxygen concentrations within the epilimnion were above the VADEQ minimum criterion of 4.0 mg/L for all stations.

Median growing season Secchi disk readings ranged from 2.5 to 3.0 feet. The growing season turbidity median (4.3 NTUs) was slightly lower than the median observed in 2019 (5.4 NTUs). The observed Secchi disk depths and relative consistency in turbidity readings indicate an overall high degree of water clarity throughout the reservoir system over time. The 2020 growing season median total suspended solids concentration for all stations (4.0 mg/L) was slightly decreased compared to the concentration observed in 2019 (4.6 mg/L). Total nitrogen levels were mostly consistent throughout the reservoir with growing season median concentrations ranging from 0.69

to 0.75 mg/L as N at the eight stations. *E. coli* median densities remained acceptable with only no individual value greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season.

Water temperature in Swift Creek Reservoir varied normally according to season during 2020. Surface pH values ranged from 6.1 to 9.1 units with an annual in-lake median of 7.1 units. Conductivity measurements within the reservoir ranged from 40 to 104 µS/cm with an annual median of 74 µS/cm. There were two measurable lead concentrations (reporting limit of <0.0025 mg/L) observed and no measurable zinc concentrations observed (reporting limit of <0.10 mg/L, respectively) during 2020.

A total of 51 individual genera of algae representing ten phyla were documented during 2020. Analysis of the general types of algae by phyla in the reservoir indicated that the community structure continued to be comprised largely of diatoms (Bacillariophyta) and blue-green algae (Cyanoprokaryota). The frequency of occurrence for the taste and odor producing blue-green algae concentration decreased from 2019 concentrations potentially accounting for any decline in potential taste and odor complaints reported to the Department of Utilities.

The Reservoir *Hydrilla* Management Group continues to monitor and manage the impact of the invasive aquatic weed *Hydrilla verticillata* on the reservoir. Detailed information about the management strategies, past *Hydrilla* reports, and current updates on the ongoing control efforts can be found on the Utilities department's webpage under the Swift Creek Reservoir page: https://www.chesterfield.gov/428/Swift-Creek-Reservoir.

Introduction

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory staff between January and December 2020 and is the 28th consecutive year of monitoring of the Swift Creek Reservoir. The Swift Creek Reservoir is a public water supply for Chesterfield County located approximately 20 miles southwest of Richmond, Virginia. The reservoir is a 1,700-acre impoundment containing approximately 5.0 billion gallons of water at full pool elevation (177.0 feet above mean sea level). The portion of the Swift Creek Reservoir watershed located within the northwest corner of the county encompasses approximately 55.9 square miles. Current data on land use characteristics of the Swift Creek Reservoir Watershed and the entirety of Chesterfield County is available through the Chesterfield County Planning Department.

Rainfall was measured at three automated tipping bucket rain gages within the watershed. The average rainfall over the watershed totaled 61.76 inches during 2020 (Figure 1). Rainfall was approximately 17.8 inches above the long-term average (43.97 inches). Reservoir sampling occurred once a month at eight stations with additional samples obtained every other week at the lacustrine zone Stations 5 and 8 (Figure 2). At these deeper water sites, discrete epilimnion, metalimnion, and hypolimnion samples were taken for nutrient analysis. All other stations in the reservoir (sites 1, 2, 3, 4, 6 and 7) were sampled at the surface only.

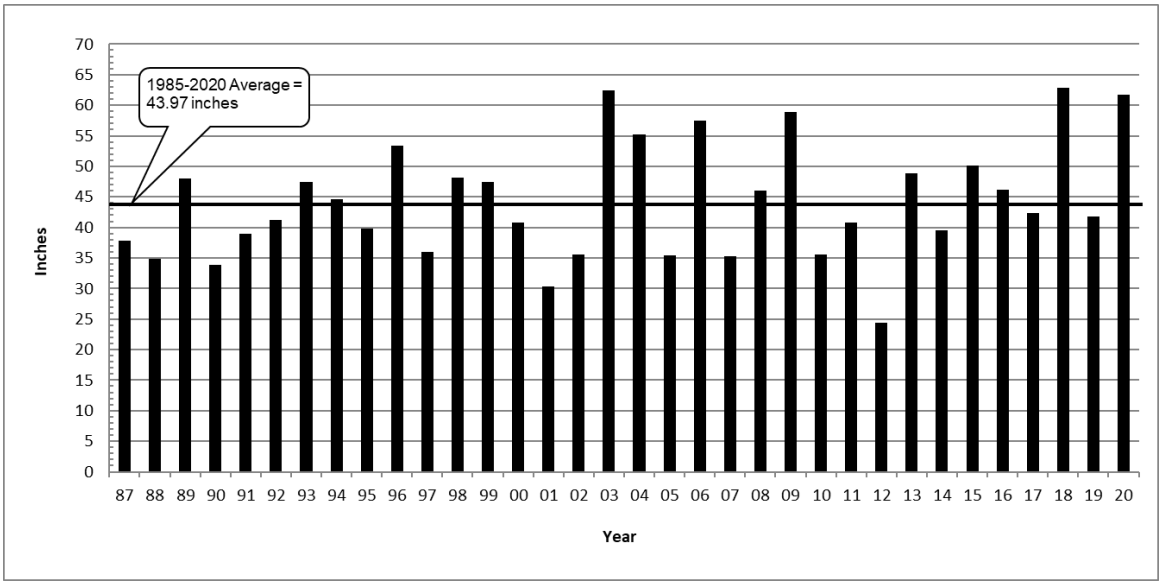

Figure 1. Total Annual Estimated Rainfall Recorded for Swift Creek Reservoir Watershed from 1986-2020 (Source data: Department of Utilities).

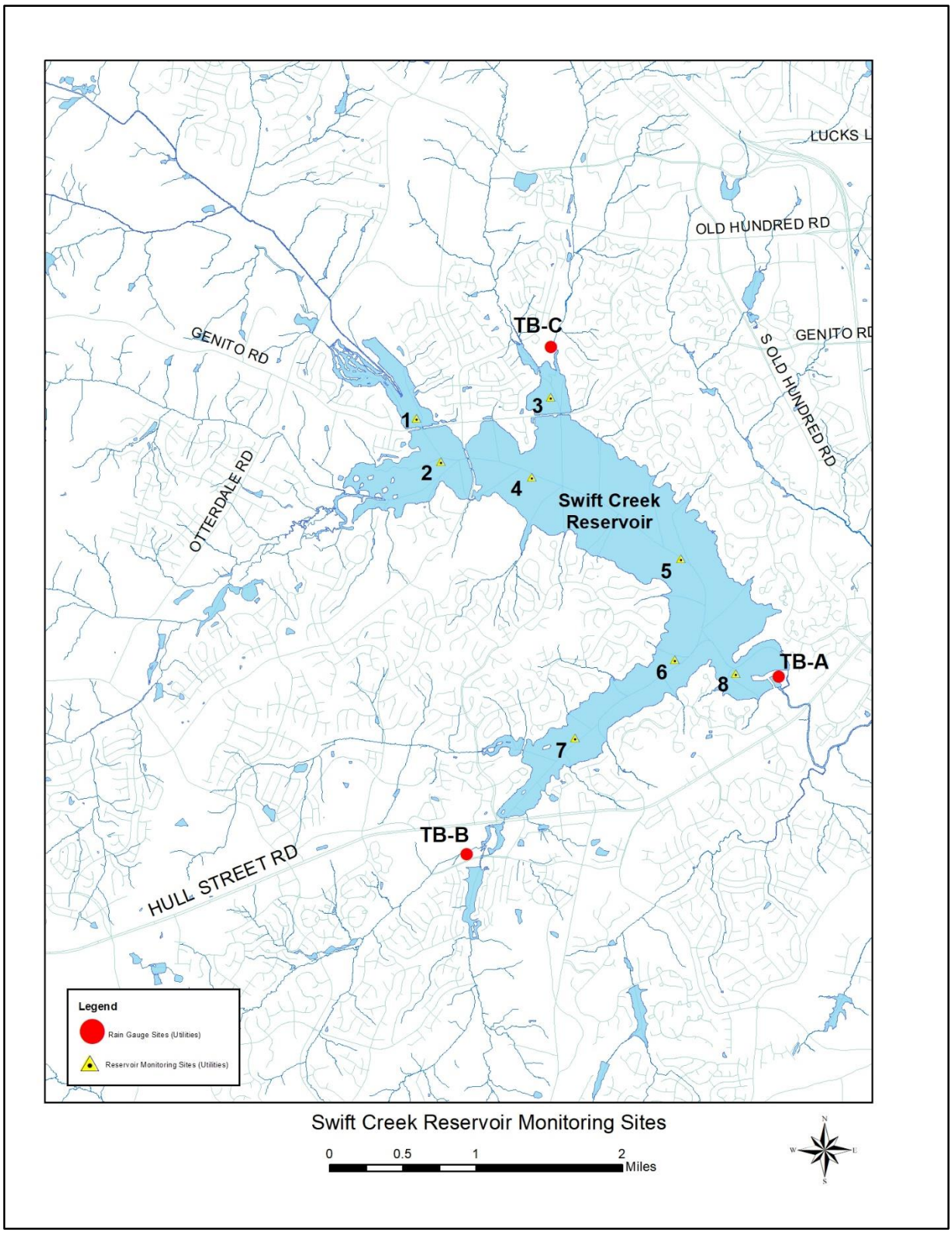

Figure 2. Map of Swift Creek Reservoir monitoring stations.

Water quality parameters (Table 1) were chosen to provide information on basic water quality and the ecological health of the reservoir. Details concerning specific analytical procedures are listed in Table 2.

Table 1. Sampling Regime for Swift Creek Reservoir 2020.

PARAMETER	RESERVOIR STATIONS 1,2,3,4,6,7	RESERVOIR STATIONS 5,8
DEPTH	X1	X1A
SECCHI DISC	X	X
WATER TEMPERATURE	X1	X1A
DISSOLVED OXYGEN (Given as mg/L & % saturation)	X1	X1A
CONDUCTIVITY	X1	X1A
pH	X1	X1A
OXIDATION REDUCTION POTENTIAL	X1	X1A
TOTAL PHOSPHORUS	X2	X3
ORTHO PHOSPHATE PHOSPHORUS	X2	X3
TOTAL KJELDAHL NITROGEN	X2	X3
OXIDIZED NITROGEN	X2	X3
AMMONIA NITROGEN	X2	X3
TOTAL ORGANIC CARBON	X2, 1/QTR	X2, 1/QTR
LEAD	X2, 1/QTR	X2, 1/QTR
ZINC	X2, 1/QTR	X2, 1/QTR
SUSPENDED SOLIDS/TURBIDITY	X2	X2
CHLOROPHYLL *a*	X4	X4
PHEOPHYTIN *a*	X4	X4
ALGAE COUNTS	X4	X4
Escherichia coli (E. coli)	X2	X2

X1 – ONE METER INTERVALS
X1A – ONE FOOT INTERVALS
X2 – SURFACE SAMPLING ONLY
X3 – DISCRETE SAMPLES OF EPILIMNION, METALIMNION AND HYPOLIMNION WHEN STRATIFICATION EXISTS **OR** SURFACE, MID-DEPTH AND NEAR BOTTOM WHEN NO STRATIFICATION IS PRESENT
X4 – A COMPOSITE OF BENEATH SURFACE, 1/2/ SECCHI DEPTH, SECCHI DEPTH AND 1-1/2 SECCHI DEPTH SAMPLES

Table 2. Parameters and Analytical Methods 2020. When Reporting Limit based upon detection is not an applicable measurement for a parameter, it has been replaced by an estimation of accuracy (e.g. pH measurement has an estimated accuracy of 0.2 units as indicated by *).

Parameter	Analytical Method	Detection Limit
Depth	Probe: Hydrolab MiniSonde	± 0.08 m*
Dissolved Oxygen	Probe: Hydrolab MiniSonde	± 0.2 mg/L*
Oxidation Reduction Potential	Probe: Hydrolab MiniSonde	± 20mV*
Water Temperature	Probe: Hydrolab MiniSonde	± 0.1 °C*
Conductivity	Probe: Hydrolab MiniSonde	± 0.1 µmhos/cm*
pH	Probe: Hydrolab MiniSonde	± 0.2 units
Secchi Depth	20 cm Standard Secchi Disk	± 0.1 ft*
Total Phosphorus	Skalar:EPA Approved, Autom.	0.005 mg/L as P
Orthophosphate	Skalar:EPA Approved, Autom.	0.005 mg/L as P
Total Kjeldahl Nitrogen	Skalar:EPA Approved, Autom.	0.05 mg/L as N
Oxidized Nitrogen	Skalar:EPA Approved, Autom.	0.01 mg/L as N
Ammonia-N	Hach, Method 10205	0.015 mg/L as N
Total Organic Carbon	Standard Methods, 5310C	0.5 mg/L
Lead	EPA 200.9, Platform Furnace	2.5 µg/L
Zinc	EPA 289.1, Flame	0.10 mg/L
Total Suspended Solids	Standard Methods, 2540D	1.0 mg/L
Chlorophyll *a*	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Pheophytin *a*	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Algae Counts	Standard Methods, 10200F	1 cell/mL
Escherichia coli (E. coli) Density	Standard Methods, 9222B (Quanti-Tray)	1.0 MPN/100mL

Quality Assurance and Quality Control

Analytical methods followed EPA approved or *Standard Methods for the Examination of Water and Wastewater*, 22nd Edition (Standard Methods) or, where applicable, followed methods provided by the equipment manufacturer. For each parameter analyzed, Method Detection Limits (MDL) were calculated following the EPA procedure as detailed in the Code of Federal Regulations (CFR), Volume 46, Part 136l; "Definition and Procedure for the Determination of the Method Detection Limit, Revision 2 (EPA December 2016). Stock and standard solutions were prepared from American Chemical Society reagent grade materials for preparation of calibration standards. When applicable, correlation coefficients were evaluated for each calibration curve and had to be greater than or equal to 0.995 to be used for analysis. To ensure calibration validity throughout analysis, Continuing Calibration Verifications (CCV) standards were tested after every 10 samples analyzed. Similarly, Continuing Calibration Blanks (CCB) were evaluated after every 10 samples to detect baseline drift errors. With each analysis,

digestion/analytical blanks were evaluated to ensure detection of contamination during the analytical process. Independent source Standard Reference Materials (SRM) were purchased and used to verify the accuracy of each analysis calibration. When any standard (or SRM) was not within 10 percent of the true value, or CCB showed baseline drift, corrective actions were implemented. Proficiency Testing (PT) of nutrients using a blind sample from a reputable vendor is tested annually. Reported concentrations for orthophosphate and total phosphorus, ammonia, oxidized nitrogen, and total Kjeldahl nitrogen continue to be within the limits of acceptable analytical values. Manufacturers recommended preventive maintenance procedures were followed for all instruments.

Results and Discussion

Eight stations in the reservoir were sampled monthly during 2020. Stations 5 and 8 were sampled twice per month throughout the year to obtain additional data for the deep-water areas. Sampling at all stations included surface grab samples and water column profiles of physical parameters. Supplemental bottom water quality samples were obtained at the mainbody Stations 5 and 8. Specific reports concerning reservoir data are available upon request from the Departments of Environmental Engineering or Utilities.

The county's water quality goal for the annual median concentration of total phosphorus in surface waters is 0.05 mg/L as P or less and was originally based on a Nutrient Controls Standards Workshop held in 1987 by the Virginia Department of Environmental Quality (VADEQ). In June 2006, VADEQ adopted freshwater nutrient standards for 116 lakes and reservoirs in Virginia, including the Swift Creek Reservoir. The EPA approved regulations in July of 2007 and the amended water quality standards [9 VAC 25 - 260] became effective August 14, 2007. These regulations set growing season (April through October) chlorophyll *a* and total phosphorus criteria for Swift Creek Reservoir at 35 µg/L (0.035 mg/L) and 40 µg/L (0.040 mg/L as P) respectively. These growing season measurements are intended not to be exceeded for two consecutive years as measured by the State in their Lake Monitoring Program. Specifically, VADEQ considers the reservoir nutrient enriched if the 90^{th} percentile of the chlorophyll *a* data in surface waters of the main body of the reservoir (Stations 4, 5, 6, and 8) during the growing season exceeds the criteria for two consecutive years. However, algaecides use can make chlorophyll *a* measurements unreliable. If algaecides are used, then both chlorophyll *a* and total phosphorus criteria are applicable. In the Swift Creek Reservoir, the algaecide sodium carbonate peroxyhydrate is used occasionally to spot treat algal blooms. The algaecide use is variable over the reservoir between months and between years. Because of the algaecide treatments, analysis of the reservoir data has always included both the total phosphorus and chlorophyll *a* criteria. Additionally, VADEQ would

consider the reservoir nutrient enriched if the growing season median concentration of total phosphorus in surface waters of the main body of the reservoir exceeded the criterion for two consecutive years. Algal blooms are known causes of taste and odor issues in drinking water and can clog filters, decreasing available potable water production and supply. During June 2020, algaecide applications were needed to improve source water quality for the optimization of the water treatment process within the plant. The algaecides copper sulfate pentahydrate (800 lbs.) and sodium carbonate peroxyhydrate (1050 lbs.) were applied from June 2nd to June 5th to the intake bay and the main body areas. Additionally, the two LG Sonic system buoy platforms installed in the intake bay in December of 2017 assisted in the prevention of significant algae blooms. These buoy platforms are floating, solar-powered systems that use real-time monitoring and ultrasonic sound waves to effectively control algae in lakes and reservoirs. The system has significantly decreased the need to apply algaecide treatments to the intake bay and allow for a more environmentally friendly manner to control the algae.

Chlorophyll *a*

VADEQ has identified chlorophyll *a* as the most important parameter that can be measured to determine the nutrient enrichment status of a reservoir. Chlorophyll *a*, a green photosynthetic pigment found in algae, is an indirect measure of biological response to nutrient loadings. VADEQ considers the threshold value for nutrient enrichment in Swift Creek Reservoir to be the 90th percentile concentration that exceeds 35 µg/L, measured between April and October (*i.e.* the growing season) within the main body for two consecutive years. Seventy (70) chlorophyll *a* samples from the eight sites were collected and analyzed during the growing season.

A higher concentration of chlorophyll *a* was observed in 2020 as compared to the previous year indicating an increased presence of algae in the reservoir. The growing season 90th percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 37.8 µg/L (Table 3), an increase from the 29.1 µg/L observed in 2019. In 2020, all eight stations combined had a 90th percentile concentration during the growing season of 37.3 µg/L, an increase from the 28.3 µg/L observed in 2019. The greatest individual measurement observed (46.0 µg/L) occurred at lacustrine Station 5 on May 26, 2020. The highest growing season 90th percentile concentration (40.5 µg/L) was observed at Station 6. Stations 5, 6 & 7 each exceeded the 35 µg/L criteria value for the growing season 90th percentile indicating higher than acceptable levels of algal growth at these sites.

Table 3. Growing Season Chlorophyll a Concentrations (Surface) 2020.

Station	Growing Season 90th Percentile Chlorophyll *a* (µg/L)
1	20.8
2	28.1
3	27.1
4	29.5
5	36.3
6	40.5
7	39.5
8	28.3
Mainbody Stations (4, 5, 6, 8)	**37.8**

Total Phosphorus

Total phosphorus is measured as an indicator of nutrient enrichment. The VADEQ has adopted a freshwater nutrient criterion of 40 µg/L (0.040 mg/L as P), measured as the median value, for the surface waters of the reservoir's main body for the growing season. Seventy (70) total phosphorus samples from the eight sites were collected and analyzed during the growing season. The growing season (April – October) median total phosphorus concentrations for each reservoir station are provided in Table 4.

Table 4. Growing Season Median Total Phosphorus Concentrations (Surface) for 2020.

Station	Growing Season Median Total Phosphorus (mg/L as P)
1	0.031
2	0.034
3	0.033
4	0.030
5	0.031
6	0.031
7	0.032
8	0.028
Mainbody Stations (4, 5, 6, 8)	**0.031**

In 2020, the growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.031 mg/L as P, remaining consistent with the 0.030 mg/L as P concentration noted in 2019. The growing season median value observed in the main body was below the VADEQ freshwater nutrient criterion threshold of 0.04 mg/L as P (Figure 3). Each of the reservoir's stations had median phosphorus concentrations below the 0.04

mg/L as P threshold (Table 4) during the growing season, indicating a continued decline from the nutrient enrichment observed in 2018 in both the lacustrine and shallower areas of the reservoir. It should be noted that the state phosphorus criterion is only applicable for the lacustrine zone (Stations 4, 5, 6 and 8) and is not intended as a regulatory value for the shallow, backwater areas of the reservoir. During 2020, for all sites monitored in the reservoir, 17 individual measurements (16.8%) were at or exceeded 0.04 mg/L as P, a decrease from the 2019 observations (n=30; 25.6%). The annual median phosphorus concentration for all eight sites was 0.032 mg/L as P and was below the county's maximum goal of 0.05 mg/L as P. The total phosphorus levels present in Swift Creek Reservoir indicated a decrease in nutrient enrichment during 2020.

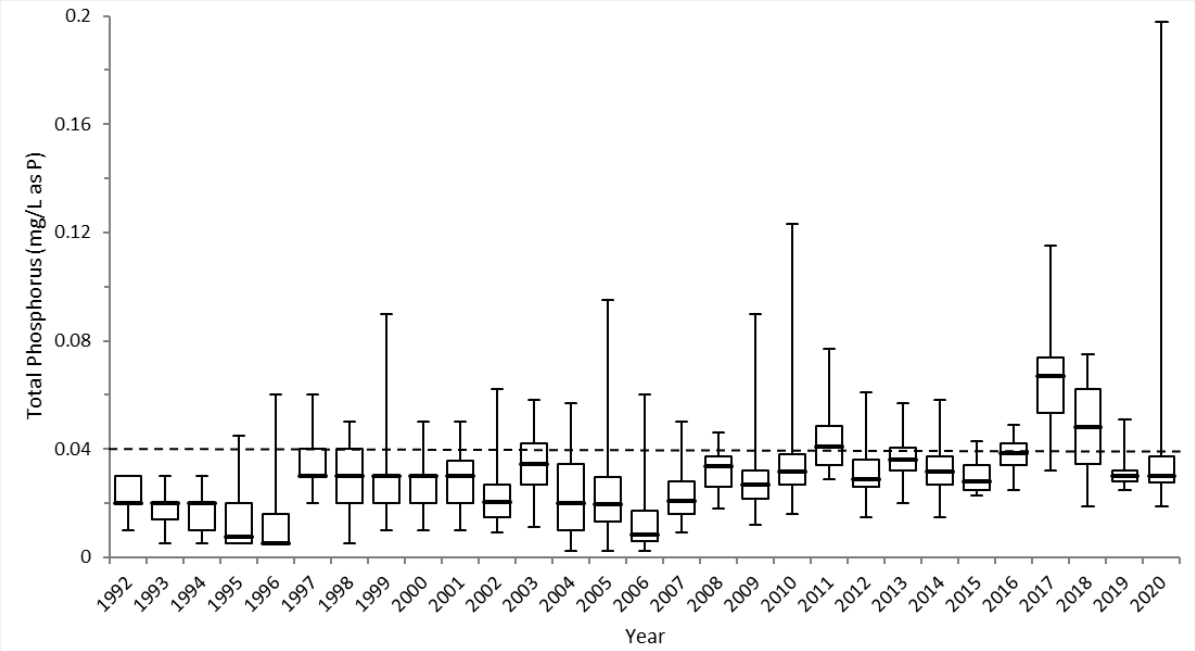

Figure 3. Box plot demonstrating the growing season median total phosphorus concentrations and ranges of observations for the surface waters of main body sites within Swift Creek Reservoir 1992 – 2020. The dashed line denotes VADEQ maximum threshold of 0.04 mg/L as P for acceptable water quality.

Higher concentrations of total phosphorus in anoxic (oxygen depleted) bottom waters as compared with surface water concentrations indicate active phosphorus release from sediments. The release of phosphorus from the sediments results in additional nutrient loading to the reservoir, as this phosphorus is then mixed with the upper water layers during de-stratification. At Stations 5 and 8 during 2020, there were 12 instances where the concentrations of total phosphorus in the benthic sample were greater than the values obtained at the surface; a decrease from the 41 instances observed in 2019. Of these 12 instances, none was considered substantial (*i.e.* ≥ 50% difference), a decrease from the one observed substantial difference in 2019. The bottom phosphorus

concentrations at Stations 5 and 8 ranged from 0.018 to 0.091 mg/L as P. This represented a median bottom concentration of 0.039 mg/L as P; slightly higher than the annual median surface concentration (0.032 mg/L as P). The 2020 bottom concentration was equivalent to the 2019 bottom concentration of 0.039 mg/L. All other differences noted were minor (≤ 50% difference).

Dissolved Oxygen

Adequately oxygenated water is critical for a healthy aquatic environment and as good quality source water for municipal treatment facilities. Hypoxic conditions occur when dissolved oxygen drops below 5.0 mg/L, resulting in stress on fish and other aquatic life. An anoxic condition occurs when dissolved oxygen drops below 1.0 mg/L, which can result in fish kills and the release of phosphorus, iron, manganese and other elements from the sediments. The release of these elements can result in increased algal blooms and treatment problems (undesirable tastes and odors) in the production of drinking water.

In July 2007, EPA approved the VADEQ's proposed dissolved oxygen standard (5.0 mg/L daily average, 4.0 mg/L minimum), which had been modified to account for naturally occurring decreases in dissolved oxygen due to thermal stratification in reservoirs. These new standards apply to the entire water column when the reservoir is well mixed and only to the surface waters (epilimnion) when the water column is vertically stratified. The most recent 2020 VADEQ's 303(d) listing of impaired water bodies lists the Swift Creek Reservoir as fully supporting in all categories: aquatic life, fish consumption, recreational contact, and wildlife.

Thermal stratification is a natural process in many lakes and reservoirs that occurs when summer conditions warm the upper water column while the lower water column remains cooler. The warmer surface waters become lighter than the colder and denser bottom waters, resulting in layers of water separated by a zone of sharply changing temperature, known as a thermocline, which inhibits vertical mixing. The thermal stratification continues until falling temperatures in the autumn cool the surface water sufficiently and disrupt the thermocline. Often a large fall storm event will result in rapid destratification of the lake.

During 2020, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in late May at Station 5 and Station 8 lasting through late September at Station 5 and early November at Station 8. Thermal stratification of Swift Creek Reservoir was first observed on May 26, 2020 at Stations 5 & 8, corresponding with the first substantial drop in dissolved oxygen levels at and near the bottom of the water column. Stratification continued until November 9, 2020 at Station 8, indicating the lake completed the seasonal turn over and became

thoroughly mixed. During the stratification period, dissolved oxygen concentrations within the epilimnion were at or above the VADEQ standard of 4.0 mg/L minimum for all stations. The time period and degree of thermal and dissolved oxygen stratification within Swift Creek Reservoir were consistent with past observations.

Secchi Depth, Total Suspended Solids, Turbidity, Total Nitrogen and *E. coli*

During the 2020 growing season, 77 Secchi depth readings and 70 turbidity, total suspended solids, total nitrogen, and *E. coli* samples from the eight sites were collected and analyzed. Secchi depth is a measurement of water transparency using a weighted black and white disk that is lowered into the water until the distinction between the black and white portions are no longer visible. The depth at which the distinction is no longer visible is then recorded as "Secchi disk transparency." Secchi disk transparency is a function of the reflection of light from the surface of the disk. Secchi disk transparency is affected by the light absorption characteristics of the water as well as by dissolved and suspended particulate matter. It provides an estimate of water clarity and is closely related to turbidity.

Table 5. Growing Season Median Values for Select Parameters (Surface) 2020

STATION	SECCHI DEPTH (Feet)	*E. coli* DENSITY (MPN/100 mL)	TOTAL NITROGEN (mg/L as N)	TOTAL SUSPENDED SOLIDS (mg/L)	TURBIDITY (NTUs)
1	2.5	7.5	0.75	5.6	7.3
2	2.5	2.0	0.73	5.2	6.3
3	3.0	4.1	0.74	2.4	2.8
4	3.0	1.0	0.70	4.0	4.3
5	3.0	2.0	0.72	4.0	4.3
6	3.0	3.1	0.72	4.0	4.3
7	3.0	4.1	0.73	4.0	4.8
8	3.0	3.6	0.69	3.4	3.9
Mainbody Stations (4, 5, 6, 8)	**3.0**	**2.0**	**0.70**	**4.0**	**4.1**

All stations had median growing season Secchi disk readings ranging from 2.5 to 3.0 feet (Table 5); these results are a slight decrease in clarity when compared with the previous year but are still comparable to 2019. The 2020 growing season median value for all sites (3.0 feet) was slightly decreased from the median observed in 2019 (3.2 feet) indicating a slight decrease in the clarity observed throughout the reservoir. Individual site growing season medians for turbidity ranged from 2.8 to 7.3 NTUs with the greatest turbidity observed in the shallow backwater stations. The growing season turbidity median (4.3 NTUs) for all stations was decreased from the median observed in 2019 (5.4 NTUs). The Secchi disk depth and turbidity indicate an overall high degree

of water clarity in 2020 and continue to reflect clear water throughout the reservoir system over time.

The 2020 growing season median total suspended solids concentration for all stations (4.0 mg/L) was slightly decreased compared to the concentration observed in 2019 (4.6 mg/L). Overall, the growing season total suspended solids concentrations in the reservoir have continued to be consistently low supporting the observation of good water clarity. Total nitrogen levels were mostly consistent throughout the reservoir with growing season median concentrations ranging from 0.69 to 0.75 mg/L as N (Table 5). The 2020 growing season median for all stations (0.72 mg/L as N) was decreased from the 2019 observation (0.75 mg/L as N) and indicated a decreased degree in nitrogen enrichment throughout the reservoir. The mainbody stations' growing season medians were again consistent with the shallow backwater stations.

E. coli densities, as expressed as the Most Probable Number (MPN) of *E. coli* per 100mL, ranged from a growing season median of 1.0 MPN/100mL at Station 4 and 5 to 7.5 MPN/100mL at Station 1. The growing season median for all stations in 2020 was 3.4 MPN/100mL. There were no values greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season. During the non-growing season months, there were three (3) instances in the reservoir when *E. coli* densities were greater than the VADEQ maximum threshold (2.5% of total observations). In these three (3) instances, *E. coli* densities ranged from 308.0 to 648.8 MPN/100mL.

Temperature, pH, Conductivity, Lead and Zinc

Water temperature in Swift Creek Reservoir varied normally according to season during 2020. Surface temperatures throughout the reservoir ranged from 4.9^{o}C to 32.3^{o}C during the year with a median value of 18.3^{o}C. Three individual surface temperatures exceeded the VADEQ maximum standard of 32.0^{o}C during 2020. Surface pH values ranged from 6.1 to 9.1 units with an annual in-lake median of 7.1 units, consistent with the annual pH concentrations previously observed. One of the individual surface values measured in 2020 fell outside of the 6.0 to 9.0 unit VADEQ acceptable range for pH. Conductivity measurements within the reservoir ranged from 40 to 104 µS/cm with an annual median of 74 µS/cm; an observation consistent with previously recorded values. Thirty-two zinc and lead samples were collected and analyzed from all eight stations during the year. Only two lead concentrations were observed to be above the reporting limit (<0.0025 mg/L) during 2020. There were no measurable zinc concentrations observed in 2020 as each were below the laboratory's detection limit (<0.10 mg/L).

Algal Community Structure of Swift Creek Reservoir

In 2018, the Department of Utilities updated and refined the counting and identification of algae resulting in an increase in the number of descriptive phyla categories. A total of 51 individual genera of algae representing ten phyla were documented in Swift Creek Reservoir during 2020. The 2020 median algal density per month (4822 cells/mL) increased by 8.7% when compared with the 2019 (4174 cells/mL) density. Analysis of the general types of algae by phyla in Swift Creek Reservoir (Figure 4) indicated the community structure was comprised largely of diatoms (Bacillariophyta, 62.1%) and blue-green algae (Cyanoprokaryota, 20.7%). These two phyla combined represented 82.3% of the algal community observed. The frequency of occurrence for the taste and odor producing blue-green algae (Cyanoprokaryota, 20.7%) decreased from the 2019 frequency (28.3%) potentially accounting for any decline taste and odor complaints reported to the Department of Utilities.

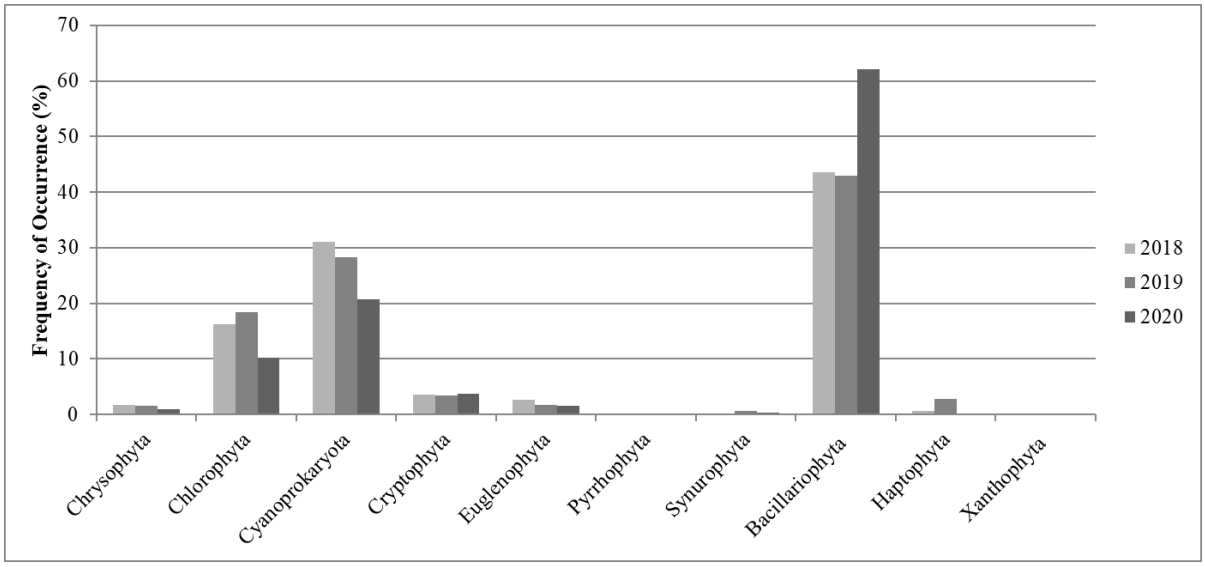

Figure 4. A comparison of the frequency of occurrence of the ten algae phyla observed in Swift Creek Reservoir 2018 - 2020.

The ten most common algal genera were identified (Table 6). These ten genera combined represented approximately 82.3% of all algae observed in 2020.

Table 6. Ten most common genus of algae observed in Swift Creek Reservoir 2020.

Number	Phyla	Genus	% of Total Observed
1	Bacillariophyta	*Asterionella*	23.0
2	Bacillariophyta	*Melosira*	21.3
3	Bacillariophyta	*Aulacoseira*	11.0
4	Cyanoprokaryota	*Anabaena*	9.5
5	Cyanoprokaryota	*Lyngbya*	4.4
6	Cyanoprokaryota	*Cylindrospermopsis*	3.5
7	Chlorophyta	*Ankistrodesmus*	3.2
8	Cryptophyta	*Chroomonas*	2.5
9	Cyanoprokaryota	*Aphanizomenon*	2.0
10	Bacillariophyta	*Nitzschia*	1.9

Status of *Hydrilla* and its Control in the Swift Creek Reservoir

The rapid growing invasive aquatic weed, *Hydrilla verticillata*, was first identified in the Swift Creek Reservoir in August 2009. The Department of Utilities created the Reservoir *Hydrilla* Management Group, comprised of county employees, residents, and lake management scientific experts, to manage this invasive species and its impact on the reservoir. Detailed information about management strategies, past *Hydrilla* reports, and current updates on the ongoing control efforts can be found on the Utilities department's webpage under the Swift Creek Reservoir page: https://www.chesterfield.gov/428/Swift-Creek-Reservoir.

Conclusion

Indicators of water quality continue to suggest acceptable conditions in the Swift Creek Reservoir. A higher concentration of chlorophyll *a* was observed in 2020 as compared to the previous year indicating an increased presence of algae in the reservoir. Throughout the reservoir, total phosphorus concentrations decreased as compared with observations from 2019. The growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.031 mg/L as P, below the VADEQ nutrient threshold of 0.04 mg/L as P. The annual median phosphorus concentration for the surface water at all eight sites in Swift Creek Reservoir was 0.032 mg/L as P, below the county threshold goal of 0.05 mg/L as P.

As in prior years, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in late May and lasting through November. During this stratification

period, dissolved oxygen concentrations within the epilimnion remained above the VADEQ standard of 4.0 mg/L for all stations.

The median Secchi disk readings during the growing season ranged from 2.5 to 3.0 feet and were consistent with the medians noted in prior reports. Individual site growing season medians for turbidity ranged from 2.8 to 7.3 NTUs with the greatest measurements observed in the shallow backwater stations. The growing season total nitrogen concentrations were lower than in previous years with site medians ranging from 0.0.69 to 0.75 mg/L as N and indicated a decreased degree in nitrogen enrichment. There were no observations of individual *E. coli* density values greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season. Water temperature in Swift Creek Reservoir varied normally throughout the year. Surface pH values ranged from 6.1 to 9.1 units. Conductivity values within the reservoir were acceptable with an annual median of 74 µS/cm. Only two measurable lead concentrations were observed with all other measurements below the reporting limit (<0.0025 mg/L) during 2020. There were no measurable zinc concentrations observed in 2020 as all results were below the laboratory's detection limit (<0.10 mg/L).

A total of 51 individual genera of algae representing ten distinct phyla were documented in Swift Creek Reservoir during 2020 and analysis of the general types of algae indicated that the community structure continued to be dominated by diatoms and blue-green algae. *Hydrilla* distribution and growth within the reservoir continues to be monitored and managed.