Smith Mountain Lake
Water Quality Monitoring Program
2025 Report

Prepared by

Dr. Clay Britton, Dr. Dana Ghioca Robrecht, Dr. Delia R. Heck,
Dr. David M. Johnson, Ms. Frances 'Chekka' Lash, Ms. Carol C. Love,
Dr. Bob R. Pohlad,
School of Undergraduate Studies
Ferrum College

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Moneta, Virginia

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Bacteria Monitors

Gael and Smith Chaney, Union Hall
Sam and Gale Easter, Union Hall

1. EXECUTIVE SUMMARY

The 2025 monitoring season began in May with the annual training session. Citizen volunteer monitors measured water clarity and collected water samples every other week until early August. Student technicians from Ferrum College traveled around the lake every other week to pick up the samples for analysis at the Ferrum College Water Quality Lab. During this trip, the interns also collected grab samples from 21 tributaries that were analyzed for total phosphorus. Also, on a bi-weekly schedule, Ferrum College personnel collected additional lake samples for bacterial analysis.

The overall conclusion in regard to the water quality in Smith Mountain Lake is that it is very good. The lake is not aging as fast as would have been predicted for a reservoir. However, weather and climate are significant drivers of the lake's trophic status. Another concern in recent years is the presence of Harmful Algal Blooms (HABs). There were fewer algal blooms this year than in 2023. We will continue to monitor the lake's water quality to provide data that helps ensure a healthy lake and protect this valuable resource in the region.

1.1 Conclusions – Trophic Status

In general, water quality improves greatly as the water moves from the upper channels toward the dam. This is consistent with observations made since the second year of the monitoring project. Eroded soil is carried to the lake by silt-laden streams, but sedimentation begins in the quiescent lake water. Phosphorus, primarily in the form of phosphate ions, strongly associates with the soil particles and settles out during the sedimentation process. Concentrations of total phosphorus, chlorophyll-*a*, and Secchi depth are all influenced to varying degrees by distance to the dam, with Secchi depth showing the strongest historical linear relationship.

In 2025, average lake total phosphorus and chlorophyll-*a* concentrations increased, and the average Secchi depth decreased.

1.2 Conclusions – DO, Temperature, pH, and Conductivity Lake Depth Profiles

Sufficient depth profile data have now been collected to enable meaningful comparison between rates of change and absolute parameter values over the course of the summer. The temperature profiles indicate that the thermocline at most sample sites remains slightly higher in the water column. As has been the case since 2015, the bottom of the lake becomes anaerobic (DO is depleted) in June rather than July. This trend negatively affects aquatic life by forcing them to move closer to the surface earlier in the summer, thereby increasing thermal stress. Atmospheric carbon dioxide is increasing globally and may be affecting Smith Mountain Lake. Increased carbon dioxide levels decrease pH and promote photosynthesis, thereby increasing algal production. While DO will increase at the surface, the amount of organic matter settling into the hypolimnion will also increase, and the hypolimnetic oxygen deficit will become more severe. Continued depth profiling and algal dynamics studies will provide scientific data to support effective management of Smith Mountain Lake as it ages.

1.3 Conclusions – Escherichia coli

The *E. coli* populations in Smith Mountain Lake in 2025 were higher than the levels in 2024, but none exceeded safe thresholds.

The comparison of marinas, non-marinas, and headwaters sites shows differences in *E. coli* values consistent with data collected over the last ten years. This year, we looked at bacterial numbers in the Roanoke and Blackwater channels as well as at headwaters, flow, and static sites. These designations will continue to be analyzed to identify possible patterns or nuances in the data.

1.4 Conclusions – Algae

The 2025 season had a low number of HABs but higher phytoplankton concentrations than in 2024. The lake's phytoplankton diversity remains high, but the trend of increased cyanobacteria (i.e., *Aphanizomenon*) numbers associated with harmful algal blooms, as seen in 2023, is a concern, and monitoring efforts to determine sources and climate impacts are important. Future research will need to analyze correlations between lake characteristics (e.g., water temperature and phosphorus levels) and changes in land use and other practices (e.g., fertilizer application) around the lake to determine what might be driving the spike in HABs observed this season. Ferrum College's WQP is continuing to work with the SML Association and Department of Environmental Quality (DEQ) to monitor these yearly variations in phytoplankton and HAB concentrations, as well as looking at sources of nutrient inputs and climate impacts. Additionally, Ferrum College expanded its lab equipment to monitor HAB-associated toxin levels beginning this season.

2. INTRODUCTION

The Smith Mountain Lake Water Quality Monitoring Program (SMLWQMP), now in its thirty-ninth year, is a water-quality program designed to monitor the water quality and trophic status of Smith Mountain Lake, a large (20,000+ acres) pump-storage reservoir located in southwestern Virginia. Scientists from Ferrum College and designated members of the Smith Mountain Lake Association (SMLA) jointly manage the project. This report describes the 2025 monitoring season.

The sampling season for the monitoring program runs roughly from Memorial Day to the middle of August. On a biweekly schedule, citizen volunteer monitors measure water clarity at both basic and advanced monitoring stations and collect samples at the advanced monitoring stations. The monitoring network includes "trend stations" on the main channels and "watchdog stations" in coves off the main channels. In 2025, there were 84 stations in the monitoring network: 56 advanced stations and 28 additional basic stations, all but one of which were located in coves (see *Methods* for a description of the different station types). Ferrum College student technicians pick up the samples from the homes of monitors and then analyze them for total phosphorus and chlorophyll-*a* concentrations in the Water Quality Laboratory at Ferrum College. Sample collection began the week of May 18 – 24, and the first sample bottles and filters were picked up on Tuesday, May 27. The last week of sample collection was July 27 - August 2, and the samples and filters were picked up on August 5 (Table 2.1).

Table 2.1 Description of Sample Periods for the 2025 Sampling Season

Sample Period 1	Start Date	Purpose	Monitor's Parameters	Ferrum's Parameters
Week 1	5/18	Trophic Levels & Bacteria	TP, SD, CA*	*E.coli* & Horz. Algal Tow
Week 2	5/25	Depth Profile	N/A	Temp, DO, pH, Vert Algal Tow, Trib TP
Sample Period 2				
Week 3	6/1	Trophic Levels & Bacteria	TP, SD, CA*	*E.coli* & Horz. Algal Tow
Week 4	6/8	Depth Profile	N/A	Temp, DO, pH, Vert Algal Tow, Trib TP
Sample Period 3				
Week 5	6/15	Trophic Levels & Bacteria	TP, SD, CA*	*E.coli* & Horz. Algal Tow
Week 6	6/22	Depth Profile	N/A	Temp, DO, pH, Vert Algal Tow, Trib TP
Sample Period 4				
Week 7	6/29	Trophic Levels & Bacteria	TP, SD, CA*	*E.coli* & Horz. Algal Tow
Week 8	7/6	Depth Profile	N/A	Temp, DO, pH, Vert Algal Tow, Trib TP
Sample Period 5				
Week 9	7/13	Trophic Levels & Bacteria	TP, SD, CA*	*E.coli* & Horz. Algal Tow
Week 10	7/20	Depth Profile	N/A	Temp, DO, pH, Vert Algal Tow, Trib TP
Sample Period 6				
Week 11	7/27	Trophic Levels & Bacteria	TP, SD, CA*	*E.coli* & Horz. Algal Tow
Week 12	8/3	Depth Profile	N/A	Temp, DO, pH, Vert Algal Tow, Trib TP

* TP - Total Phosphorous; SD - Secchi Depth; CA - Chlorophyll a

There were 21 tributary samples collected by student technicians in 2025 during the weeks that samples are picked up from monitors' homes to assess tributary inputs of nutrients to the lake. Site T21a, in the upper Roanoke channel just below the confluence of Back Creek (34 miles from the dam), was not sampled in 2025 due to accessibility issues. (See Section 3. Methods for an explanation of the numbering system). Sample site T3 is the headwaters station designated for the Blackwater channel; it is located at the SR834 bridge. All other tributary stations are on flowing tributaries near their confluence with the lake, except for three sites from below the dam (which impact the lake through pump-back) and the upper Gills Creek site. This site, T0a, is several miles from the lake and is important because Gills Creek has been a water quality concern for many years due to the sediment coming into the lake from the surrounding watershed. The tributary sites are listed in Table A.2 and shown in Figure A.2 and A.2.a.

Since 1995 water samples have been collected at 14 sites, to be tested for bacterial concentrations. Ferrum College student technicians collected these bacterial samples every other week in 2025, for a total of six samples at each site.

Depth profile measurements have been taken on Smith Mountain Lake since 2005 measuring dissolved oxygen, temperature, conductivity, and pH versus depth. Every other week during the summer season these measurements are made at five sites around the lake, including two sites on the Roanoke channel, two sites on the Blackwater channel and one site in the main basin near the dam. The depth of the profile varies according to the bottom depth of the specific site.

Since 2008 algal population samples have been collected weekly during the summer season by using ten-meter plankton tows. Horizontal plankton tows are taken at the 14 bacterial sites (at one station per site) and vertical plankton tows are taken at the five depth profile sites on alternating weeks.

Ferrum College scientists Clay Britton, Dana Ghioca Robrecht, Delia Heck, David Johnson, Chekka Lash, Carol Love, and Bob Pohlad, along with Tom Hardy, the SMLA Volunteer Monitoring Coordinator, carried out the 2025 training session in May. They were assisted by student technicians Richard Marshall, Arron McNeal, and Nathan True. The program included a review of the previous year's findings and plans for the upcoming season. Experienced monitors reviewed their sample site locations and sample site identification numbers, received new supplies (sample bottles and filters), and had their monitoring equipment checked, if needed. New volunteer monitors were assigned sample station locations and identification numbers, practiced sampling procedures, and were issued sampling equipment and supplies. The Ferrum College student technicians delivered sampling equipment and supplies to the monitors who were unable to attend the training.

Newsletters were written and published by the program scientists and student technicians during the summer, reporting on program activities. Announcements were included in the newsletters in addition to advice and tips on sample collection. Bi-weekly data summaries were provided to the SMLA and these were incorporated into press releases sent to local news outlets. The Annual Volunteer Appreciation Event to recognize the contributions of the SMLA volunteers and present the preliminary report of results in the final newsletter was held in October.

Significant financial support for the program in 2025 came from the Appalachian Power Company with additional support from the Smith Mountain Lake Association, The Bedford Regional Water Authority, the Western Virginia Water Authority, and the Virginia Department of Environmental

Quality. This year's monitoring results, data analyses, and comparisons with the other thirty-eight years of data are discussed in the full report, which follows.

Monitoring results from 1987 onward can be found in the project's annual reports for those years and most are available electronically in the Ferrum archives.

3. METHODS

Detailed descriptions of the methods of sample collection, preservation and analyses, and quality control/quality assurance procedures can be found in the *Ferrum College Water Quality Lab Procedures Manual* (Love et al, 2022). The water quality parameters measured include water clarity (turbidity), measured as Secchi disk depth; total phosphorus, measured spectrophotometrically (λ=880 nanometers or nm) after persulfate digestion using the ascorbic acid method (QuikChem Method 10-115-01-1-F); and chlorophyll-*a*, determined using the acetone extraction method and measured fluorometrically with a Turner Trilogy Instrument. The specifics of each method are outlined in the appropriate section below. Additionally, quality control and quality assurance procedures evaluate laboratory procedures and are described later in this report.

These three water quality parameters are measured at trophic channel sampling stations located approximately every two miles on the Roanoke and Blackwater channels to monitor the movement of the silt and nutrient laden waters moving toward the main basin of the lake. These sites begin at the dam and extend to the Hardy Ford Bridge on the Roanoke channel and to the B49 channel marker on the Blackwater channel. The trophic cove sampling stations are also important for trend analysis and help us fulfill the role of "watchdogs". In the "watchdog" mode, we monitor as much of the lake as possible for signs of localized deterioration of water quality, which may be due to site-specific problems such as malfunctioning septic systems.

Trophic sampling station codes contain information on the location of the station. The sample station codes for trophic stations are based on:

(1) The section of the lake in which the station is located ("C" for Craddock Creek, "B" for Blackwater, "M" for main basin, "R" for Roanoke, and "G" for Gills Creek).

(2) The approximate number of miles to the Smith Mountain Lake Dam (e.g. 23 miles from the dam would have a "23" in the station code).

(3) Designation of the sampling station as a cove, main channel, or tributary (cove sampling station codes start with "C", tributary sampling station codes begin with "T", channel sampling station codes have no letter designation and begin with the letter of the channel as given in (1) above).

(4) Basic monitoring station codes begin with an "S" (for Secchi depth).

(5) A lowercase letter following a tributary station number indicates a change to the original sampling location for that tributary, usually made for safety reasons.

An example of a sampling station code would be "CB14" which would indicate a cove station off the Blackwater channel approximately 14 miles from Smith Mountain Lake Dam. The trophic stations are listed in Table A.1 and shown in Figure A.1.

To evaluate tributary loading of nutrients, technicians collect grab samples (to fill a bottle with water) every other week at 21 tributary stations on their rounds to pick up lake water samples. The tributary stations are listed in Table A.2. Tributary station T21a was not sampled in 2025 due to accessibility issues.

The five sample stations used for depth profiling and vertical phytoplankton sampling represent the major sections of Smith Mountain Lake. PM2 is in the main channel approximately two miles from the dam, PB7 and PB13 are in the Blackwater River channel approximately seven and 13 miles from the dam and PR11 and PR19 are in the Roanoke River channel approximately 11 and 19 miles from the dam. These sites are shown in Figure A.3.

The bacterial and horizontal phytoplankton sites were selected to allow comparison between Smith Mountain Lake non-marina sites and marina sites. These sites are shown in Figure A.4. The non-marina sites include: Beaverdam Creek (Site 2), a tributary of the Roanoke River; Fairway Bay (Site 6), which is surrounded by homes and multi-family residences and is on the Roanoke channel; Smith Mountain Lake State Park (Site 7), which is sampled where it intersects the main channel; Forest Cove (Site 8), which is surrounded by a residential area and is located downstream from the confluence of the two main channels and in close proximity to Smith Mountain Lake Dam; the main basin site at the confluence of the Blackwater and Roanoke channels (Site 10), which was selected to provide samples not influenced by runoff from nearby shoreline; Palmer's Trailer Park Cove (Site 11), which is surrounded by trailers that have been there for a long time, each with a septic tank and drain field, and is located off Little Bull Run, a tributary of the Blackwater channel; and B49 (Site 14), located far upstream on the Blackwater River not far from the non-navigable portion of the river.

The marina sites include: Bay Roc Marina (Site 1), which is located on the Roanoke River at the "beginning of the lake"; Indian Point Marina (Site 3), which is in a cove off the main channel of

the Roanoke River, and has very few permanently docked boats; Goodhue Boat Company, Eastlake (formerly Crystal Shores Marina) (Site 4), which is in a cove off the Roanoke channel in Bedford County and is a storage place for many houseboats; Bayside Marina and Yacht Club (Site 5), which is up Becky's Creek, a tributary of the Roanoke channel in Franklin County; The Dock at Smith Mountain Lake (Site 9), which is in a cove off the main basin in Pittsylvania County, in close proximity to Smith Mountain Lake Dam and is a storage place for many houseboats; Pelican Point Marina (Site 12), which is on the Blackwater channel in Franklin County and is a storage place for many large sailboats; Gills Creek Marina (Site 13), which is on the channel of Gills Creek, a major tributary of the Blackwater River.

Beginning in 2023, a new designation of headwater, flow and static has been added to the analysis. There are two headwaters sites, which primarily indicate specific watershed influences and not within-lake influences. Organic compounds and other nutrients in a body of water come from two possible sources, allochthonous inputs and autochthonous inputs. "Allochthonous" refers to input from outside the body of water (in other words, from the watershed). The two headwaters sites reflect the allochthonous inputs to Smith Mountain Lake: Bay Roc Marina (Site 1) and B49 (Site 14). "Autochthonous" refers to input from within the body of water (for example, the algal population that is dependent on the in-lake process of photosynthesis). The remaining sites are all autochthonous. These sites are further designated as either flow or static. Sites which are located closer to the main body of the lake and are more influenced by channel currents are classified as flow sites. Sites which are located in coves and are further from the main flow of the channel currents are classified as static. Beaverdam Creek (Site 2), Indian Point (Site 3), SML State Park (Site 7), the Confluence (Site 10), and Gills Creek Marina (Site 13) are the flow sites where water is moving and relatively less sedimentation is occurring. Crystal Shores Marina (Site 4), Bayside Marina (Site 5), Fairway Bay (Site 6), Forest Cove (Site 8), The Dock at SML (Site 9), Palmer's Park (Site 11) and Pelican Point (Site 12) are the static sites where water and sediments are more likely to settle. Additionally, an analysis was done relative to which of the three channels the sites are located to compare the three areas of the lake: Roanoke channel, Blackwater channel or main basin (at or below the confluence of the two channels). It is hypothesized that *E. coli* values will be lower at sites with flowing water than at sites with static water due to the *E. coli* being flushed out of the flowing sites. These classifications with marina type, flow type and river channel are listed in Table 3.1.

Table 3.1. Classification system for *E-coli* analysis

Site Number	Name	Old Type	New Marina Type	New Flow Type	Channel
1	Bay Roc	Headwater	Marina	Headwater	Roanoke
2	Beaverdam Creek	Headwater	Non-marina	Flow	Roanoke
3	Indian Point	Marina	Marina	Flow	Roanoke
4	Goodhue Boat Co, Eastlake	Marina	Marina	Static	Roanoke
5	Bayside Marina	Marina	Marina	Static	Roanoke
6	Fairway Bay	Non-marina	Non-marina	Static	Roanoke
7	SML State Park	Non-marina	Non-marina	Flow	Roanoke
8	Forest Cove	Non-marina	Non-marina	Static	Main basin
9	SML Dock	Marina	Marina	Static	Main basin
10	Confluence	Non-marina	Non-marina	Flow	Main basin
11	Palmer's Park	Non-marina	Non-marina	Static	Blackwater
12	Pelican Point	Marina	Marina	Static	Blackwater
13	Gills Creek Marina	Marina	Marina	Flow	Blackwater
14	B 49	Headwater	Non-marina	Headwaters	Blackwater

4. TROPHIC STATUS MONITORING

4.1 Introduction

Trophic status monitoring on Smith Mountain Lake this summer consisted of three components: total phosphorus, chlorophyll-*a*, and Secchi depth. Total phosphorus (TP) concentration is an indication of the level of nutrient enrichment in the lake. Chlorophyll-*a* (CA) is closely correlated with phytoplankton density (algal cells/L) in the water, so chlorophyll-*a* concentration is a good measure of algal biomass in the lake. Secchi depth is a reliable and longstanding method of measuring water clarity. Secchi depth (SD) depends on the amount of sediment and algae in the lake water.

Phosphorus is a plant nutrient that stimulates the growth of algae. Phosphate, the form of phosphorus most immediately available to algae, is the limiting nutrient in Smith Mountain Lake. As a result, monitoring of total phosphorus concentrations in Smith Mountain Lake can provide early warning of increased nutrient enrichment and the possibility of algal blooms.

4.2 Methods

Detailed descriptions of the methods of sample collection, preservation, analyses, and quality control/quality assurance procedures can be found in the *Training Manual for Smith Mountain Lake Volunteer Monitoring Program* (Thomas and Johnson 2012), and in the *Ferrum College Water Quality Lab Procedures Manual* (Love et al. 2022). The methods used are adapted from *Standard Methods for Water and Wastewater Analysis* (APHA 1999), and audited by the Virginia Department of Environmental Quality (DEQ). Channel sampling stations are located approximately every two miles on the Roanoke River and Blackwater River channels on Smith Mountain Lake to monitor the movement of silt and nutrient-laden waters moving toward the main basin of the lake. These sites begin at the dam and extend two miles beyond the Hardy Ford Bridge on the Roanoke River channel and to the B49 channel marker on the Blackwater River channel. Cove sampling stations are also monitored to provide additional information for trend analysis. Thus, the sample set consists of 56 sites for total phosphorus and chlorophyll-*a*, and 84 sites for Secchi depth measurements. Samples are also collected from 21 tributary stations and analyzed for total phosphorus to provide information about inputs to Smith Mountain Lake. Maps of the

lake sampling stations and tributary sampling stations are provided in the Appendix of this report (Figures A.1 and A.2).

At the sites below the dam (T9, T10, and T11), student technicians collect samples from bridges in the same manner as the other tributary samples. These samples are collected below the dam and are not tributaries flowing directly into the lake. Because of the pump-back system, some water from these sites does enter the lake. Station T9 is on the Roanoke River just below the dam at the Smith Mountain Visitor's Center, Station T10 is on the lower Pigg River, near its confluence with the Roanoke River, and Station T11 is on the Roanoke River after its confluence with the Pigg River.

A Lachat QuikChem 8500 Series 2 Flow Injection Analyzer (FIA) with an automated sampler is used to analyze TP. One advantage of the FIA is that the reagents used to detect TP are mixed in real time during the measurement. Thus, there is no concern that the color will fade during the analysis. The other advantage is that the instrument uses less reagent than the previous method, reducing analysis cost and time.

The samples are analyzed for TP based on the QuikChem method 10-115-01-1-F. This procedure requires an acidic digestion to convert the various forms of phosphorus into orthophosphate. The concentration of orthophosphate ion is determined using the FIA. The orthophosphate ion reacts with ammonium molybdate and antimony potassium tartrate under acidic conditions to form a complex. This complex is reduced with ascorbic acid to form a blue complex, which absorbs light at a wavelength of 880 nm. The absorbance measured by the FIA is proportional to the concentration of TP in the sample.

Chlorophyll-*a* is determined using the Fluorometric Method (Method 10200H). Water samples are passed through glass fiber filters that retain algal cells. The chlorophyll-*a* is extracted in a buffered acetone solution and the chlorophyll-*a* concentration is measured on a Turner Trilogy™ fluorometer equipped with chlorophyll-*a* non-acidification module.

4.3 Results

The trophic status parameters for Smith Mountain Lake and its tributaries for the past 10 years are presented in Table 4.1.

Table 4.1. Average trophic parameter values in parts per billion (ppb) and meters (m) for Smith Mountain Lake and its tributaries

Year	Smith Mountain Lake Average Total Phosphorus (ppb)	Tributaries Average Total Phosphorus (ppb)	Smith Mountain Lake Average Chlorophyll-*a* (ppb)	Smith Mountain Lake Average Secchi Depth (m)
2025	**30.7**	**48.3**	**8.7**	**2.0**
2024	26.2	64.8	3.2	2.2
2023	29.0	56.7	11.1	2.0
2022	27.5	66.1	4.9	2.0
2021	31.2	65.3	5.4	2.1
2020	34.7	59.8	13.6	1.6
2019	41.2	70.5	12.6	1.8
2018	30.7	68.3	13.4	1.8
2017	30.6	58.7	12.9	1.8
2016	29.1	73.2*	8.7*	2.1
10 Year Average	***31.1***	***63.2***	***9.5***	***1.9***

* See 2016 Smith Mountain Lake Water Quality Monitoring Report for explanation of data issues

Table 4.1 shows that the average TP concentration for the lake in 2025 (30.7 ppb) was higher than the 2024 average of 26.2 ppb. This value is the fourth highest lake TP seen in the past ten years. The average TP concentration for the tributaries in 2025 (48.3 ppb) was lower than the 2024 average of 64.8 ppb. This value is the lowest in the past ten years. Average chlorophyll-*a* concentration increased in 2025 to 8.7 ppb, which is higher than the 2024 average concentration of 3.2 ppb. Average Secchi depth in 2025 (2.0 m), is slightly lower than 2024 (2.2 m). (Note: there were a large number of missing CA readings for period 6 due to a procedural error.)

Figure 4.1 shows the comparison of the six sampling periods with the average value of each trophic status parameter monitored in 2025. The maps in Figure 4.2 show the spatial variations of the average values of these parameters at each sampling location in 2025.

The average TP concentration for lake sampling sites over the sampling periods was 30.7 ppb. The highest average lake TP concentration was observed in sample period 1 (55.6 ppb) and the lowest average TP concentration was observed in sample period 5 (21.3 ppb). The average TP concentration for tributary sampling sites over the six sampling periods was 48.3 ppb. The highest average tributary concentration was observed in sample period 3 (67.0 ppb) and the lowest average concentration was observed in sampling period 5 (28.9 ppb). The complete results for TP

concentration for the 2025 sampling season are included in the Appendix of this report (Tables A.3 and A.4).

The average chlorophyll-*a* (CA) concentration for lake sampling sites over all six sampling periods was 8.7 ppb. The highest average lake CA concentrations were observed in sampling period 6 (14.9 ppb) and the lowest average CA concentration was observed in sampling period 5 (4.2 ppb). The results for chlorophyll-*a* concentration for the 2025 sampling season are included in the Appendix of this report (Table A.5).

The average Secchi depth (SD) over all six sampling periods was 2.0 m. The shallowest average Secchi depth was observed in sample period 1 (1.5 m) and the deepest average Secchi depth was observed in sample period 4 (2.4 m). The complete results for Secchi depth for the 2025 sampling season are included in the Appendix of this report (Table A.7).

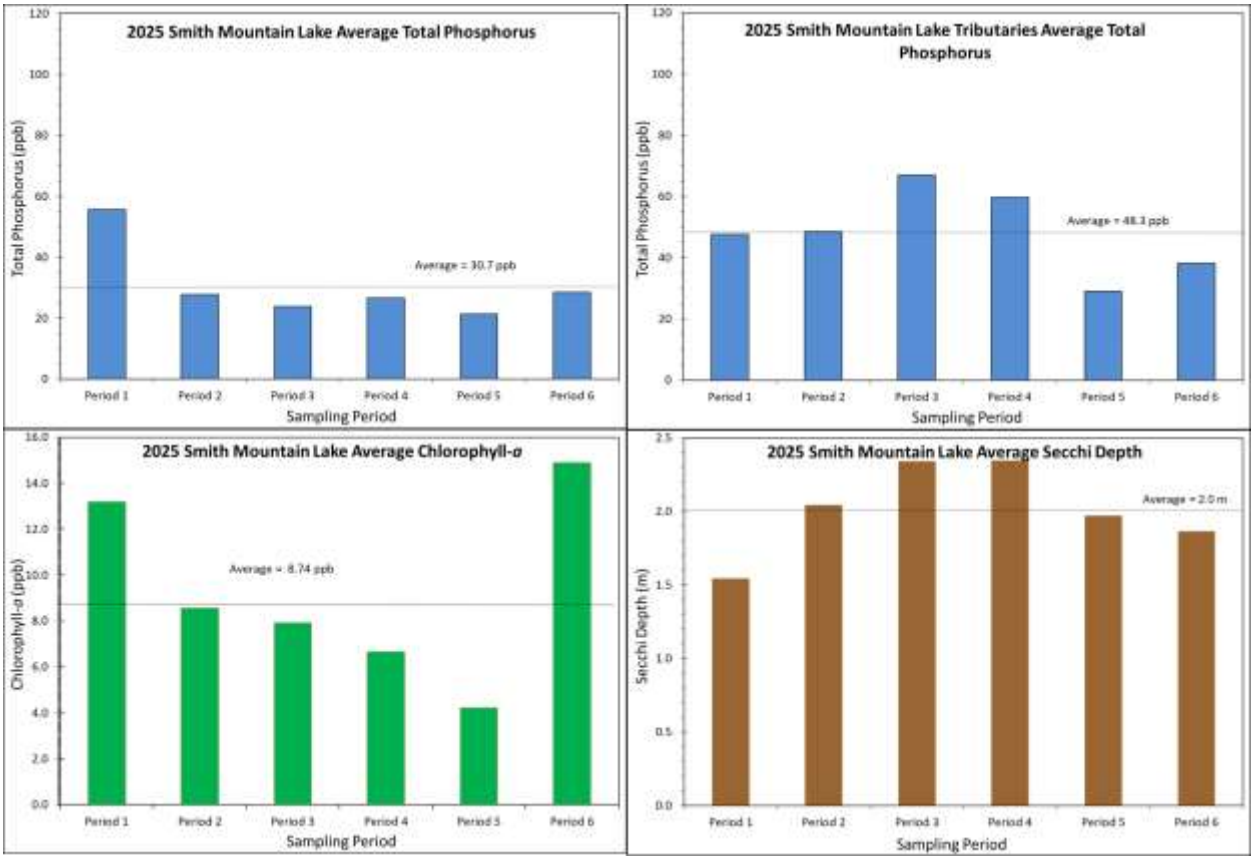
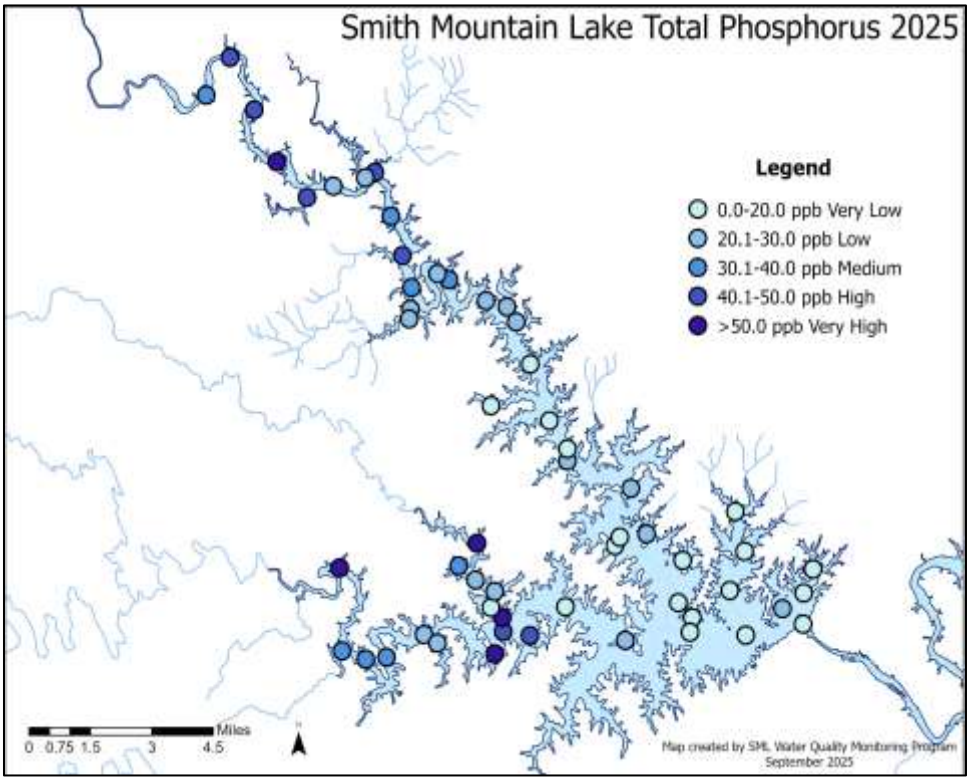
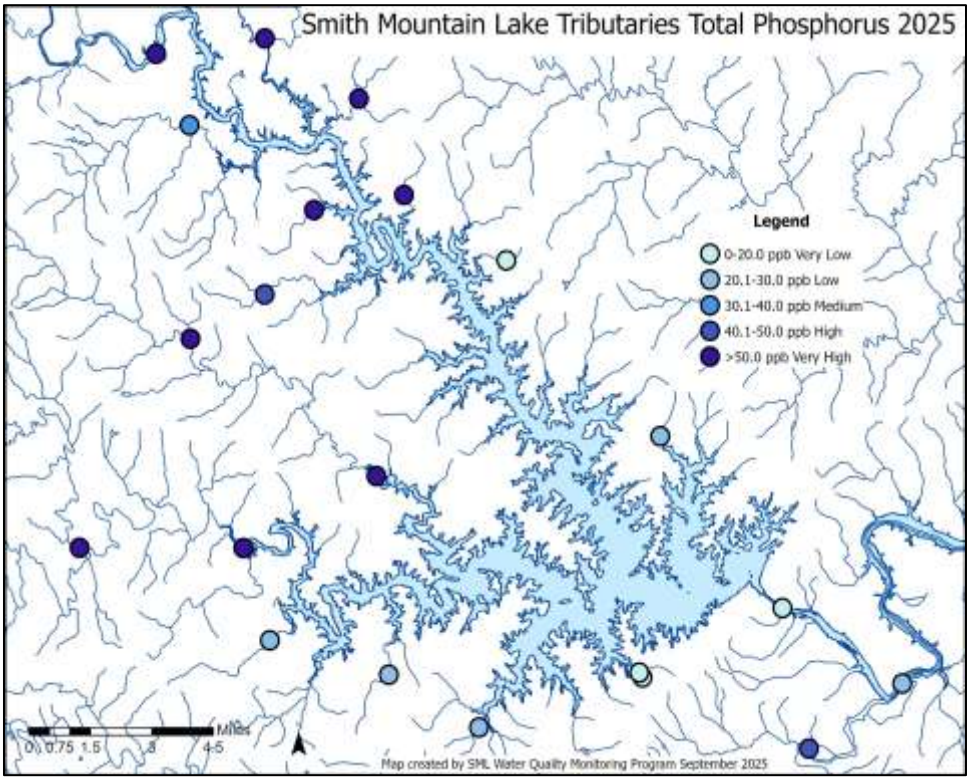
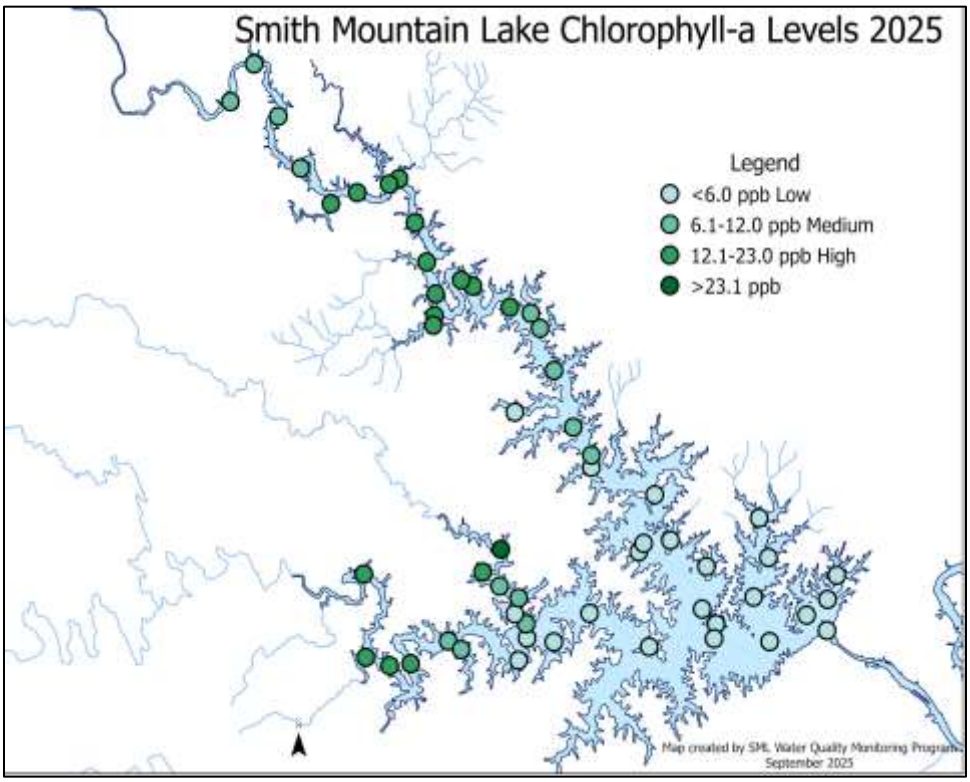


Figure 4.1. Trophic status parameters (TP, CA, and SD) for Smith Mountain Lake for each sampling period in 2025


Smith Mountain Lake Total Phosphorus 2025
Legend
0.0-20.0 ppb Very Low
20.1-30.0 ppb Low
30.1-40.0 ppb Medium
40.1-50.0 ppb High
>50.0 ppb Very High
Miles
0 0.75 1.5 3 4.5
Map created by SML Water Quality Monitoring Program
September 2025


Smith Mountain Lake Tributaries Total Phosphorus 2025
Legend
0-20.0 ppb Very Low
20.1-30.0 ppb Low
30.1-40.0 ppb Medium
40.1-50.0 ppb High
>50.0 ppb Very High
Miles
0 0.75 1.5 3 4.5
Map created by SML Water Quality Monitoring Program September 2025



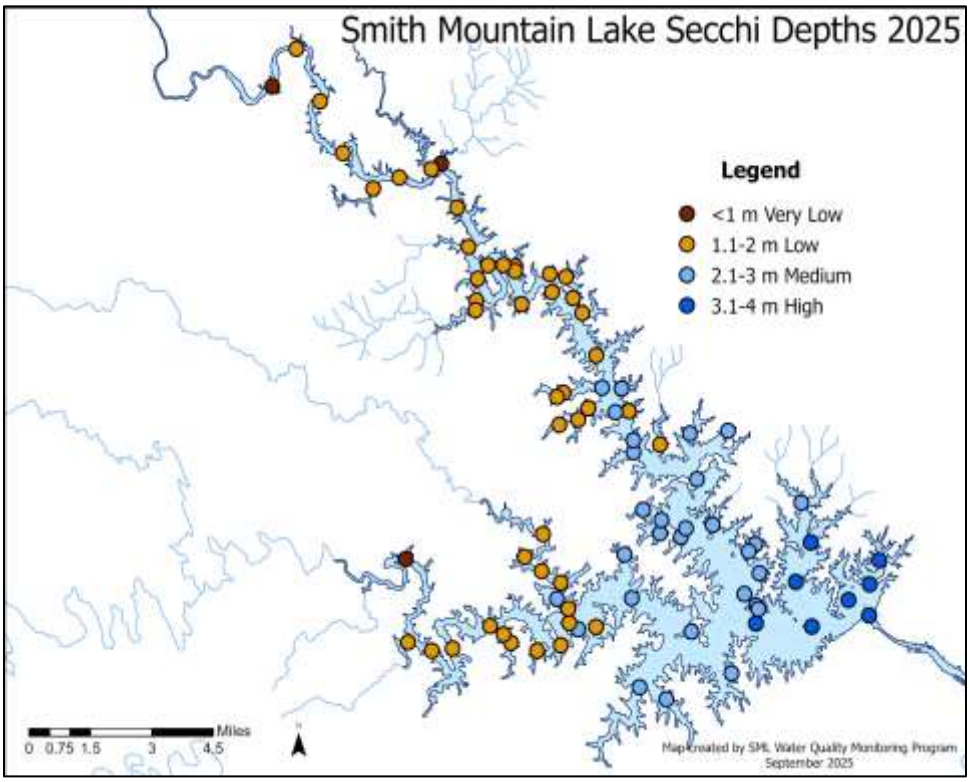


Figure 4.2. Maps showing variation in trophic status parameters for 2025 (TP - lake, TP - tributaries, CA, and SD).

Table 4.2. 10-year comparison of average total phosphorus concentrations for Smith Mountain Lake and its tributaries, including three sites below the dam

Total Phosphorous (ppb)	2025	2024	2023	2022	2021	2020	2019	2018	2017	2016	*AVG*
Average Lake Total Phosphorous	**30.7**	26.2	29	27.5	31.2	34.7	41.2	30.7	30.6	29.1	***31.1***
Average Tributary Total Phosphorous	**48.3**	64.8	56.7	66.1	65.3	59.8	70.5	68.3	58.7	73.2	***63.2***
		Tributary Sites below Dam									
T9 Avg (Roanoke River)	**13.8**	14.0	18.7	14.3	24.5	22.0	30.8	17.7	16.4	16.3	***18.9***
T10 Avg (Pigg River before conflence)	**40.6**	52.7	60.1	58.3	53.1	74.4	66.5	63.1	59.0	61.0	***58.9***
T11 Avg (Roanoke River after confluence with Pigg River)	**21.0**	21.9	38.6	21.2	35.0	44.8	49.8	22.0	37.5	50.9	***34.3***

Table 4.2 is a 10-year compilation of TP data for Smith Mountain Lake, its tributaries, and the three sites below the dam. The Pigg River (T10) has a relatively high TP concentration that increases the TP concentration in the Roanoke River from T9 to T11 (see Appendix Figure A.2). Because of pump-back, the Pigg River is a source of phosphorus to Smith Mountain Lake. There was a decrease in the average TP concentration in the three below-dam sites from 2024 (29.5 ppb) to 2025 (25.1 ppb).

4.4 Discussion

During the 2025 sampling season, water samples from tributaries and locations farther from the dam generally had higher total phosphorus and chlorophyll *a* levels, along with lower Secchi depths, than those from lake sites closer to the dam (Figure 4.2). In addition, the average total phosphorus was higher in the tributaries than in the lake (Figure 4.1).

Comparing 2025 and 2024, the average total phosphorus increased slightly; however, tributary contributions decreased (Table 4.2). There is an increase (3.2 to 8.7) in chlorophyll-*a* between the 2024 and 2025 sampling seasons, most likely due to higher algal concentrations during the 2025 sampling season (see Section 8). The average Secchi depths between 2025 and 2024 show a slight decrease, most likely due to higher chlorophyll-*a* levels associated with higher phytoplankton concentrations.

4.5 Conclusions

In general, water quality improves greatly as the water moves from the upper channels toward the dam. This is consistent with observations made since the second year of the monitoring project.

Eroded soil is carried to the lake by silt-laden streams, but sedimentation begins in the quiescent lake water. Phosphorus, primarily in the form of phosphate ions, strongly associates with the soil particles and settles out during the sedimentation process. Concentrations of total phosphorus, chlorophyll-*a*, and Secchi depth are all influenced to different degrees by the distance to the dam, with Secchi depth showing the strongest linear relationship, historically. In 2025, average lake total phosphorus and chlorophyll-*a* concentrations increased, and the average Secchi depth decreased.

5. WATER QUALITY TRENDS BY ZONE

5.1 Introduction

After monitoring water quality in Smith Mountain Lake for over 39 years, it is clear that the lake cannot be described as a homogeneous water body. There is a gradation in trophic status from the headwaters of the lake to the dam. This characteristic is typical of reservoirs and distinguishes them from most natural lakes that tend to be more homogeneous. Dr. William Walker spent many years studying southern reservoirs for the Army Corps of Engineers and found that a generalized eutrophication model for reservoirs must be able to handle morphologically distinct sections that develop a distinct water quality (Walker 1999). To provide a more accurate representation, Smith Mountain Lake is described in terms of zones delineated by distance from the dam. The need to evaluate water quality by zone indicates the potential for managing Smith Mountain Lake for multiple uses. For example, the more productive (greater algae growth) upper zones farther from the dam can support the large fish population desired by fishermen, while the less productive, clearer water found in the lower zones closer to the dam is ideal for water recreation and as a source of potable water.

5.2 Methods

The trophic status of a lake indicates the degree of nutrient enrichment and the resulting suitability of that lake for various uses. Eutrophication is the nutrient enrichment of a body of water, resulting in a significant increase in aquatic plant life (including algae). Phosphorus is most often the nutrient that limits algal production when concentration is low, and attempts have been made to relate the trophic status of a lake to the concentration of phosphorus. In other words, the concentration of phosphorus controls the algal population. Table 5.1 shows one such effort (note that the relationships shown are for northern temperate lakes and do not represent southeastern lakes).

Table 5.1. Proposed relationships among phosphorus concentration, trophic state, and lake use for northern temperate lakes (Reckhow and Chapra 1983)

Phosphorus Concentration (ppb)	Trophic State	Lake Use
< 10	Oligotrophic	Suitable for water-based recreation and cold water fisheries. Very high water clarity and aesthetically pleasing.
10-20	Mesotrophic	Suitable for recreation, often not for cold water fisheries. Clarity less than in oligotrophic lakes.
20-50	Eutrophic	Reduction in aesthetic properties reduces enjoyment from body contact recreation. Generally productive for warm water fish.
> 50	Hypereutrophic	A typical "old-aged" lake in advanced succession. Some fisheries, but high levels of sedimentation and algae or macrophyte growth diminish open water surface area.

The algal growth resulting from inputs of phosphorus can also be used to evaluate the trophic status of a lake. This is done by extracting the green pigment, chlorophyll-*a*, from algae filtered from lake water samples and measuring its concentration. Table 5.2 shows the trophic status delineation based on the concentration of chlorophyll-*a*. It also shows that evaluating trophic status is a matter of professional judgment, not a parameter to be measured exactly.

Trophic status can also be evaluated from Secchi disk measurements since algal growth decreases water clarity. Researchers have also attempted to relate water quality parameters such as conductivity and total organic nitrogen to trophic status. Regardless of how trophic status is evaluated, a particular parameter is used to summarize the water quality in a lake with respect to certain uses. The specific summary term, such as mesotrophic, is assigned to a lake based on a summary statistic, such as the average total phosphorus concentration. Researchers have devised water quality indices based on one or more summary statistics to better communicate water quality information to the general public. Using an index, trophic status can be placed on a scale from 1 to 100, with 1 being the least eutrophic or least nutrient-enriched. An index can be derived from any summary statistic by means of a mathematical transformation and provides a way to directly compare parameters measured in different units. For example, without indexing, most people would have a hard time comparing the water quality significance of a 14 ppb total phosphorus concentration with a 3.5 meter Secchi depth.

Table 5.2. Trophic status related to chlorophyll-*a* concentration in different studies
(Reckhow and Chapra 1983)

	Chlorophyll-*a* Concentration (ppb)	
Trophic Status	**NAS**	**EPA-NES**
Oligotrophic	0-4	< 7
Mesotrophic	4-10	7-12
Eutrophic	> 10	> 12

One of the best-known trophic state indices is the Carlson Trophic State Index (TSI) named after the researcher who developed it (Carlson 1977). This index is used to help interpret the water quality data collected on Smith Mountain Lake. The Carlson TSI may be calculated from total phosphorus concentration (TP), chlorophyll-*a* concentration (CA), or Secchi disk depth (SD). In addition, the index obtained from each of these parameters can be averaged to give a combined TSI. This is important because any individual parameter can be misleading in some situations. Secchi disk readings are a misleading indicator of trophic status in lakes with non-algal turbidity caused by soil erosion, such as in the upper river channels and near shore areas of Smith Mountain Lake. Phosphorus will not be a good indicator in lakes where algal growth is not limited by the availability of phosphorus (algal growth in Smith Mountain Lake is phosphorus-controlled). Chlorophyll-*a* may be the best indicator during the growing season and the worst at other times.

The following equations are used for the calculation of TSI (TSI-C is the combined trophic state index):

$$TSI\text{-}TP = 14.42 \ln TP + 4.15$$
$$TSI\text{-}CA = 9.81 \ln CA + 30.6$$
$$TSI\text{-}SD = 60 - 14.41 \ln SD$$
$$TSI\text{-}C = [TSI\text{-}TP + TSI\text{-}CA + TSI\text{-}SD]/3$$

The lake zones have been delineated as follows:

Zone 1 = 0-5 miles
Zone 2 = 5-10 miles
Zone 3 = 10-15 miles
Zone 4 = 15-20 miles
Zone 5 = 20-25 miles
Zone 6 = 25 + miles

5.3 Results

The average annual value for the three trophic parameters and TSI-C is displayed by zone in Figure 5.1. There are very strong relationships ($R^2 > 0.9$) when 39-year averages are computed for each of the three parameters and for the six zones representing distance to the dam. There is a clear trend toward higher

water quality closer to the dam (Figure 5.1). Settling is the likely mechanism that leads to the improved water quality moving from the upper zones towards the dam. The 2025 TSI-combined data for each sampling station are presented in Table A.6.

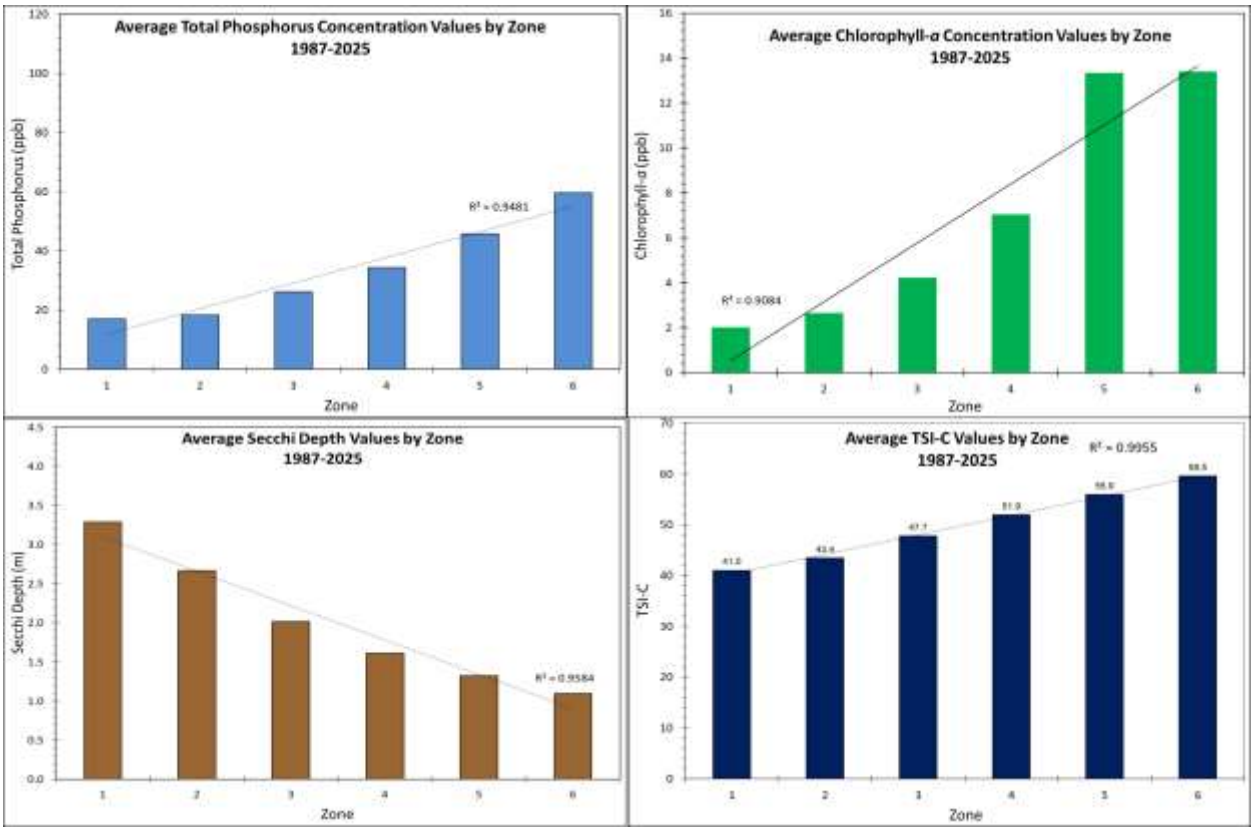


Figure 5.1. Average parameter value by zone for 1987-2025 Carlson's Trophic State Index and its Components

5.4 Discussion

The combined trophic state index, averaged by zone from 1987 to 2025, is displayed in Figure 5.1. The coefficient of determination (R^2 = 0.99), based on thousands of individual measurements, indicates a strong relationship between average TSI-C and the zone from which the samples were collected.

In Figure 5.2, the combined trophic state index has been plotted as a function of its distance from the dam. The results again demonstrate a strong trend toward improved water quality near the dam (R^2 = 0.76). Figure 5.3 shows the spatial distribution of the combined trophic state index throughout the lake.

Table A.6 gives the monitoring stations with miles-to-dam (MTD) ordered alphabetically by site. For each station, especially those with high TSI-C values, it is useful to look at the TSI calculated on the basis of each trophic parameter to examine the contribution of each. The highest TSI-C value (64.6) was at B22 this year, while the lowest TSI-C value (39.1) was at CM1.

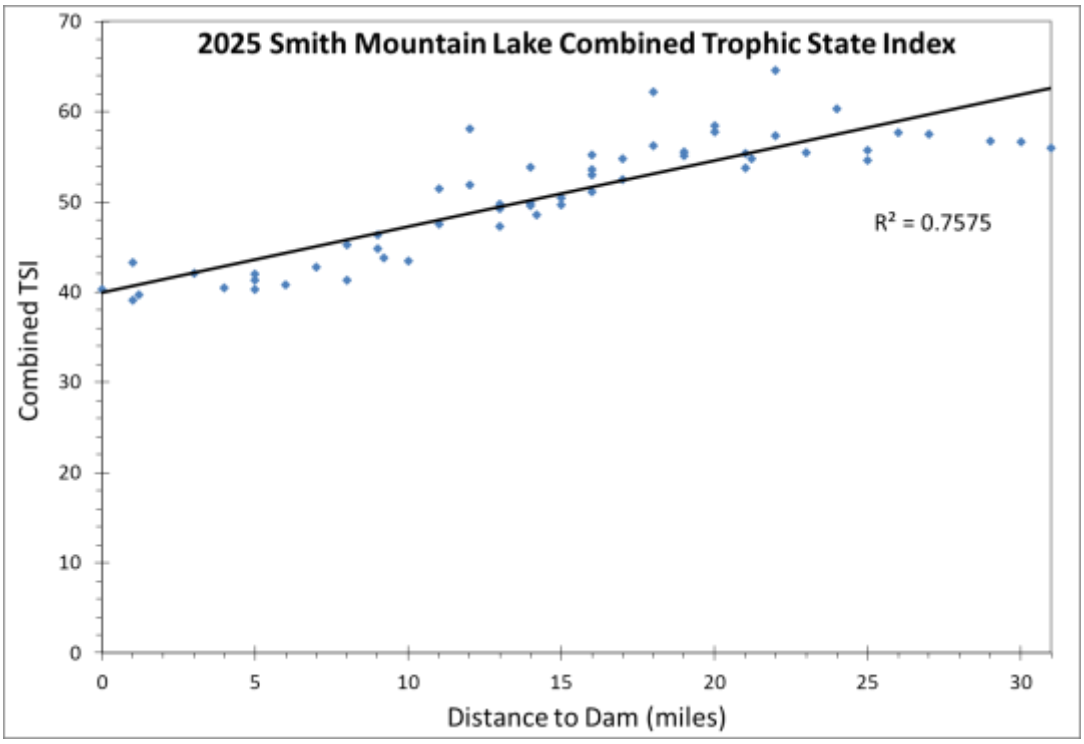


Figure 5.2. Combined Trophic State Index as a function of distance from dam

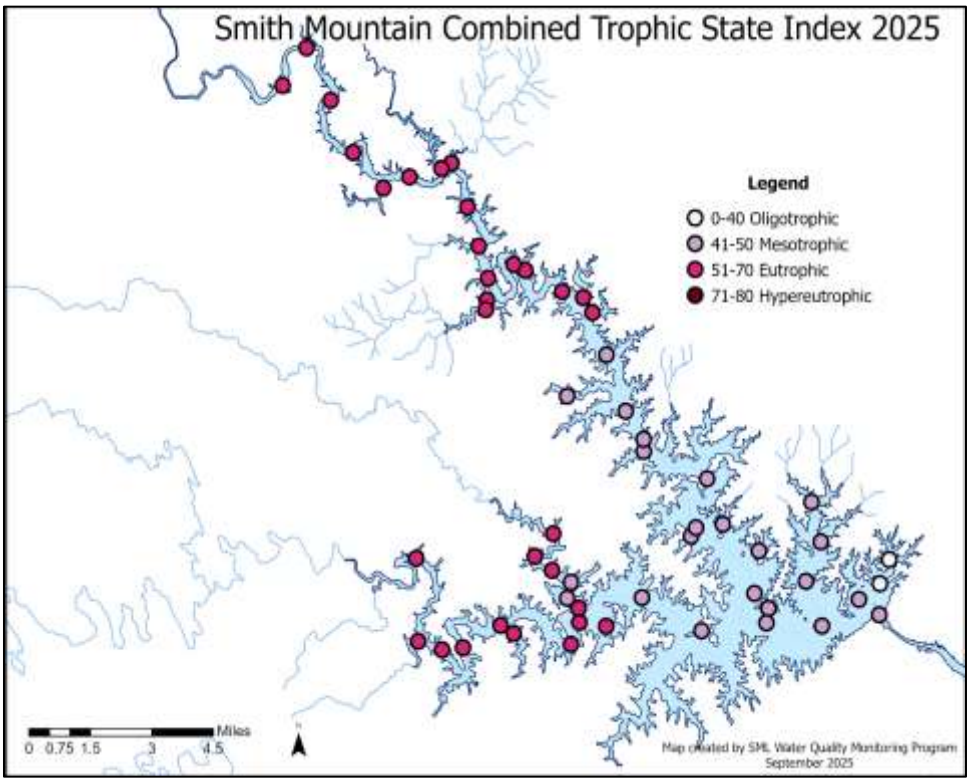


Figure 5.3. Map showing the Trophic State Index Combined results throughout the lake

For Smith Mountain Lake in 2025, the average TSI-TP (51.2), TSI-CA (49.0), and TSI-SD (51.7) are higher than 2024 values. The 2025 average combined TSI (TSI-C = 50.6) was higher than in 2024 (TSI-C = 46.0). The lake varies from early-stage mesotrophic to near-eutrophic depending on location. Additionally, since the 2025 TSI-TP, TSI-CA, and TSI-SD were similar, it indicates agreement between the three parameters.

The annual average TSI-C values from 2016–2025, shown in Table 5.3, have shown no trend over the period.

Table 5.3. Combined Trophic State Index for Smith Mountain Lake, 2016-2025

Year	Average Combined TSI	TSI Range	R^2 (TSI vs. MTD)
2025	50.6	39.1 – 64.6	0.76
2024	46.0	35.7 – 59.8	0.89
2023	51.5	40.1 – 64.6	0.85
2022	48.2	39.1 – 65.1	0.79
2021	49.1	40.3 – 63.3	0.83
2020	53.9	43.7 – 65.6	0.73
2019	54.1	44.0 – 68.2	0.80
2018	52.4	40.9 – 65.9	0.92
2017	52.9	42.4 – 65.2	0.87
2016	48.8	31.9 – 66.4	0.80

For the period of record (1987-2025), over 99 percent of the variation in trophic status is explained by proximity of the sample sites to the upper channels of the lake where inputs of nutrients and silt are received from the lake's watershed. In terms of explaining water quality, there is very little left to be accounted for by direct inputs from the shoreline and the many smaller tributaries that flow directly into Smith Mountain Lake. Local impacts are discernible in the trend line displayed in Figure 5.2 by those stations that deviate from the trend line. Lake-friendly and lake-unfriendly conditions can be discovered and described by investigating shoreline land use near those stations that do not follow the anticipated trend. The monitoring program can then begin acting more as a "watchdog" as areas of unusually low water quality are investigated.

5.5 Conclusions

At the present time, water quality in Smith Mountain Lake is much more dependent on silt and nutrient inputs from the 1,000 square-mile watershed than from the 500-mile shoreline. However, Virginia's Total Maximum Daily Load (TMDL) Program continues to address water quality problems in the impaired streams of the Smith Mountain Lake watershed and nutrient pollution from nonpoint sources is being reduced. Future commercial and residential development around the lake, coupled with inputs from its watershed, will continue to alter the relative contributions to the trophic status of Smith Mountain Lake.

6. VERTICAL PROFILES OF WATER QUALITY PARAMETERS

6.1 Introduction

In thermally stratified lakes, depth profiles provide important information on lake dynamics. In Smith Mountain Lake, vertical profiles of temperature, dissolved oxygen (DO), pH and conductivity are collected every two weeks during the summer sampling season. The variation of DO with depth is especially important and used in the evaluation of lake health and trophic status. During the warm season, surface water temperature increases and thermal stratification develops. Stratification results in the formation of three layers; a warm upper layer (the epilimnion) and a cool bottom layer (the hypolimnion), separated by a transition layer with rapidly changing temperature (the metalimnion). The thermocline is the depth at which the maximum rate of temperature change occurs. Thermal stratification is a stable condition because water density decreases with increasing temperature, so the warmer epilimnion floats on the cooler hypolimnion. The result is a density barrier that prevents mixing of the epilimnion and hypolimnion until the surface water cools again in the fall.

Algal production occurs in the photic zone (i.e., uppermost layer of a body of water that receives sunlight) of the epilimnion, consuming carbon dioxide and producing oxygen. When algae cells die, they settle and bacteria consume DO and release carbon dioxide as the organic matter undergoes biodecomposition. If nutrient enrichment occurs, photosynthesis and oxygen production increase near the surface while decomposition and oxygen consumption increase below the thermocline, depleting oxygen in the hypolimnion. The hypolimnetic oxygen deficit significantly affects the biota and nutrient dynamics. Cool water fish are stressed as DO decreases at depths where water remains cool. Depth profiles of temperature and oxygen increase the sensitivity of trophic state analysis and give early indications of nutrient enrichment and the degree of stress to cool water fish.

Because carbon dioxide is a weak acid, pH decreases as carbon dioxide concentration increases in water and, conversely, pH increases with declining carbon dioxide concentration. As carbon dioxide is removed by photosynthesis, pH increases in the photic zone and, inversely, as carbon dioxide is produced by decomposition, pH decreases. This consumption-production pattern gives

the typical pH profile. As atmospheric carbon dioxide increases, the pH of aquatic systems is decreasing and this may eventually affect the ecology of Smith Mountain Lake.

Conductivity is due to ionic substances (salts) dissolved in the water and, because salts do not tend to change form, conductivity profiles give valuable information on subsurface mixing. Conductivity is higher in the Roanoke River than the Blackwater River and this is reflected in the conductivities of the respective channels.

6.2 Methods

Depth profiles are collected at five sites in Smith Mountain Lake, as indicated on the map in Appendix A.3. Site PM2 is in the main basin, approximately two miles from the dam. Sites PB7 and PB13 are in the Blackwater channel, approximately one third (~seven miles) and two thirds (~13 miles) of the way up the channel. Sites PR11 and PR19 are approximately one third (~11 miles) and two thirds (~19 miles) of the way up the Roanoke channel. Depth profiles were obtained using a multi-sensor probe. Data was collected using a Xylem YSI EXO3s™ with a handheld reader and 66 meters (216 feet) of cable at five sample sites on Smith Mountain Lake on six days in 2025: May 28, June 11, June 25, July 9, July 23, and August 6. At each profile location, parameter readings are logged at the bottom of the lake and then at each meter up to the surface (~0.25 m). Because of currents and boat drift, the sensor probe does not often drop straight down, so a pressure sensor is used to provide accurate depth readings for each measurement and is used to determine when to record (or 'log') data from the sensors on the tablet for the handheld reader of the Xylem YSI EXO3s™. Between profile sites, the probe is kept hydrated in a jug of lake water. The sensors for DO, pH, and conductivity are calibrated less than 24 hours before each sampling event and checked against standards after each sampling event.

6.3 Results

The depth profile for the current sample year are presented in the following four figures: temperature (Figure 6.1), DO (Figure 6.2), pH (Figure 6.3), and conductivity (Figure 6.4).

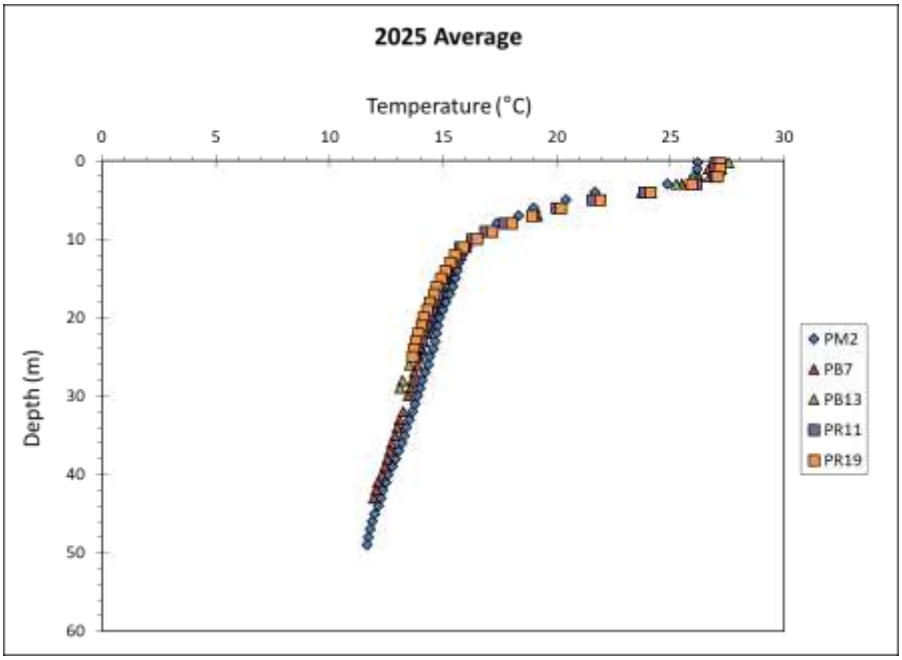


Figure 6.1. Average temperature depth profiles for 2025.

The 2025 temperature-depth profiles display a stable, well-defined thermal stratification during the summer is an important characteristic of Smith Mountain Lake. Three key patterns emerged: (1) Thermal stratification had occurred prior to the first sampling event; (2) The thermocline was located at a depth of approximately 5 meters; and (3) The entire column exhibited a steady thermal increase from the first to sixth profiling date, consistent with seasonal trends.

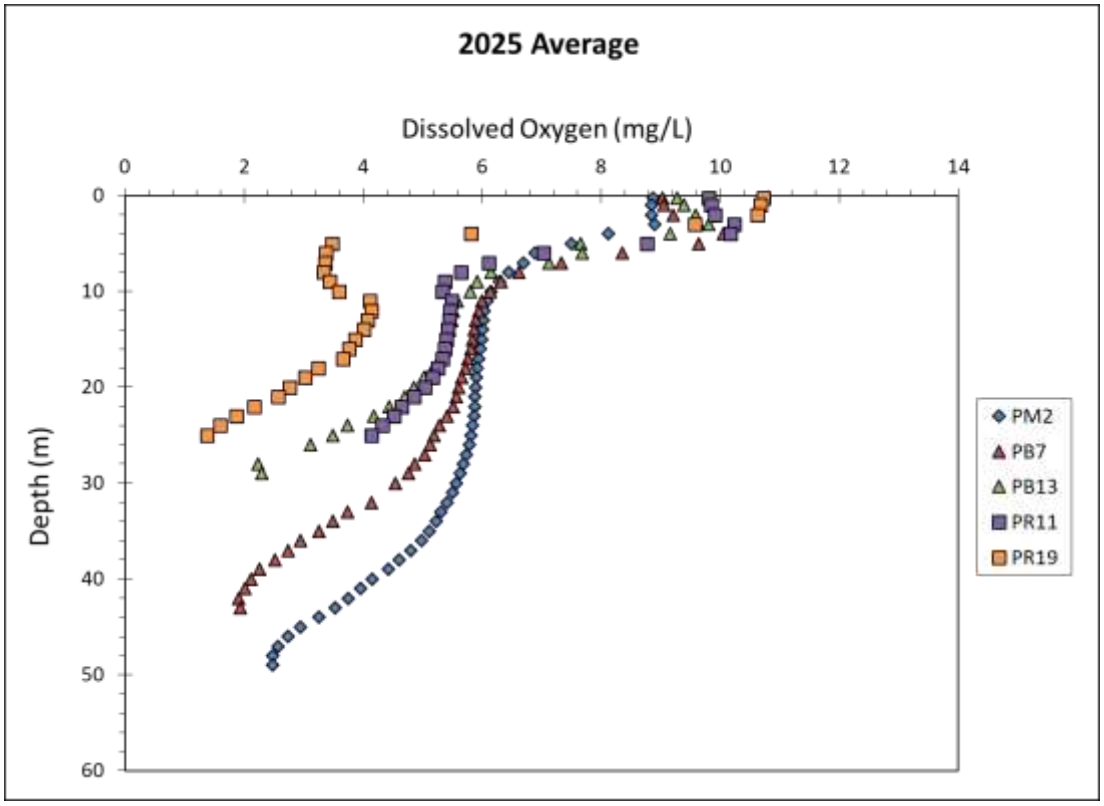


Figure 6.2 Average dissolved oxygen depth profiles for 2025.

The 2025 dissolved oxygen (DO) levels followed the expected inverse relationship with depth. Above the thermocline, most sites were consistently supersaturated in DO, driven by high rates of algal photosynthesis in the photic zone. Below the thermocline, the increased organic matter produced by these blooms settles onto the benthos (the community of organisms living on, in, or near the bottom of aquatic environments), and bacterial decomposition consumes oxygen, decreasing oxygen levels. DO concentrations below the thermocline decreased steadily throughout the sampling season. All bottom water was anoxic (depleted of DO) at all stations by the end of July.

The 2025 seasonal averages highlight a distinct longitudinal gradient in water quality from the headwaters to the dam. The station located closest to the dam (PM2) exhibited a classic orthograde profile where the DO concentration is stable as depth increases, maintaining well-oxygenated conditions (>6.0 mg/L) to depths exceeding 40 meters. In contrast, upstream stations (PR19, PB13) displayed characteristic clinograde profiles where the DO concentration decreases significantly

with depth driven by high biological productivity. Notably, surface dissolved oxygen at PR19 averaged 10.8 mg/L, significantly higher than the 9.0 mg/L recorded at the dam. This supersaturation indicates intense algal photosynthesis in the nutrient-rich upper channels. However, this excess oxygen was strictly confined to the epilimnion (top layer). Below the thermocline, bacterial decomposition rapidly consumed available oxygen, resulting in hypoxic (<2 mg/L) averages in the bottom waters of the Roanoke channel.

The 2025 oxygen data confirms that while the main basin of Smith Mountain Lake remains healthy and aerobic, the upstream tributaries continue to experience significant organic loading. The combination of early-onset stratification (observed in May) and high algal production created a prolonged period of hypolimnetic anoxia (lack of oxygen in the bottom of the lake) in the riverine sections, compressing the available habitat for cool-water fisheries.

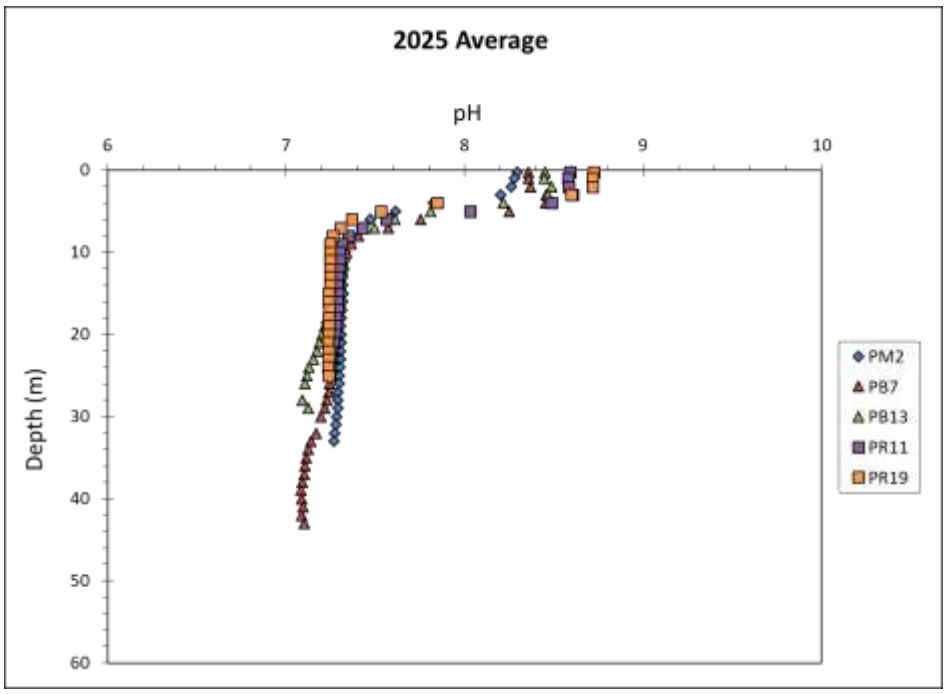


Figure 6.3 Average pH depth profiles for 2025

The 2025 pH profiles followed typical patterns for Smith Mountain Lake, driven by the balance of photosynthesis and respiration. All pH depth profiles showed slightly alkaline conditions (pH 8.3-8.7) in the epilimnion, reflecting high photosynthetic rates in the uppermost levels (the photic

zone). Since photosynthesis removes carbon dioxide, which forms a weak acid (carbonic acid) when dissolved, this biological process raises the pH of the water.

Below the thermocline, the pH decreased as expected. This vertical decline is caused by the lack of photosynthesis in the dark hypolimnion and carbon dioxide accumulation from the decomposition of settling organic matter. By a depth of 15 meters, the pH across all stations reaches a consistent range of 7.2-7.4, matching trends observed in previous years.

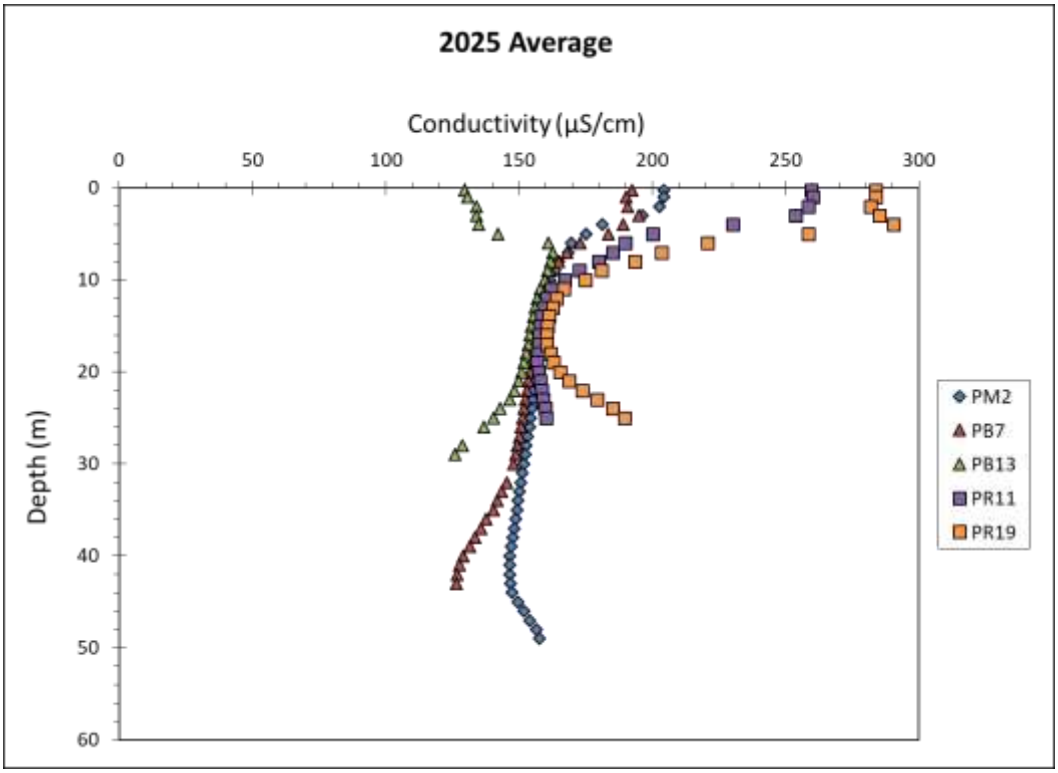


Figure 6.4 Average conductivity depth profiles for 2025.

Conductivity is a conservative parameter in Smith Mountain Lake, meaning it is minimally affected by biological processes and varies primarily due to mixing of distinct tributary waters. As observed in previous years, 2025 surface values were significantly higher in the Roanoke channel (>275 μS/cm) compared to the Blackwater channel (~130 μS/cm), attributed to the limestone-rich bedrock and higher urbanization in the Roanoke watershed. As usual, the 2025 profiles reveal a convergence of these contrasting waters in the metalimnion (middle layer), where all stations approach a mean value of ~160 μS/cm between 10 and 20 meters.

6.4 Discussion

In 2025, thermal stratification followed a consistent seasonal pattern, though the onset was notably earlier than historical norms. As observed in the Period 1 profiles, stable density barriers were already established before the end of May, accelerating the depletion of hypolimnetic oxygen.

The dissolved oxygen (DO) and conductivity profiles differed from the headwaters to the dam, confirming the classic trophic gradient of the reservoir. The variation in DO profiles (Figure 6.2) clearly illustrates a transition from eutrophic conditions in the river channels (PR19, PB13) to near-oligotrophic conditions at the dam (PM2). This year, the eutrophic nature of the upper channels was evidenced by significant surface supersaturation (DO > 10 mg/L) driven by algal photosynthesis, followed by a sharp decline.

A distinct metalimnetic oxygen minimum was observed at upstream stations, where DO levels dropped to <3 mg/L at the thermocline (4 meters). This suggests that organic matter is settling on the cool density barrier long enough for intense bacterial decomposition to drive down oxygen near the thermocline.

The pH profiles mirror these biological processes, showing alkaline conditions (>8.5) in the epilimnion due to photosynthesis and decreasing pH with depth as decomposition releases carbon dioxide. These profiles have immediate management implications, as the combination of high surface temperatures and low metalimnetic oxygen created a severe 'habitat squeeze' for cool-water fish species earlier in the season than typically observed.

6.5 Conclusions

Sufficient depth profile data have now been collected to enable meaningful comparison between rates of change and absolute parameter values over the course of the summer. The 2025 temperature profiles indicate that the thermocline remains stable at approximately 5–6 meters, but the critical finding of 2025 is the early onset of stratification.

Unlike previous trends where bottom waters became anaerobic in June, 2025 data indicates that hypolimnetic oxygen depletion was already well-advanced before the end of May in the upper channels. This shifts the window of 'thermal stress' for aquatic life forward by nearly a month, forcing fish into a narrowing habitable zone much earlier in the summer.

Atmospheric carbon dioxide trends continue to be relevant for Smith Mountain Lake. While increased CO_2 promotes algal production (raising surface pH and DO), the subsequent settling of this organic matter drives severe oxygen deficits in the hypolimnion. The 2025 data confirms that this cycle is intensifying in the tributary arms. Continued depth profiling remains essential to track this 'early onset' phenomenon, as it fundamentally alters the length and severity of the stress period for the lake's fishery.

7. BACTERIA IN SMITH MOUNTAIN LAKE

7.1 Introduction

Bacterial analysis in Smith Mountain Lake consisted of *Escherichia coli* (*E. coli*) monitoring. This reflects the Commonwealth of Virginia's bacterial standard, which uses *E. coli* as the indicator organism. Because this is a controversial water quality parameter and is related to human health, the Ferrum College Water Quality Lab has been monitoring bacteria levels in the lake using fecal coliforms as the indicator organism from 1995 until 2004 and *E. coli* as the indicator organism since 2004.

7.2 E. coli Methods

Samples were collected in sterile 125 mL polypropylene bottles at 0.25 m depth and stored according to *Standard Methods for Water and Wastewater Analysis* (APHA 1999). Two stations were sampled at each site and at each station a 100 mL sample was evaluated. A Colilert™ media packet was added to these 100 mL water samples and mixed thoroughly by shaking vigorously until the powdered media was dissolved. The mixture was poured into a sterile Quanti-Tray 2000™ and passed through the Quanti-Tray™ Sealer after being placed in a rubber insert to seal the sample into the wells in the Quanti-Tray 2000™. The sealed trays were incubated for 24 hours at 35 °C. For the Colilert™ media, a color change from clear to yellow indicates a positive result for total coliform and fluorescence indicates a positive result for *E. coli*. The numbers of yellow and fluorescent wells (both large and small) were counted and the values were evaluated using a Most Probable Number (MPN) chart developed by the Colilert™ method developers (IDEXX Company). A geometric mean is then calculated for each site based on those two stations. MPN is used instead of colony forming units (CFU) and is generally considered an equivalent measure of the microbial and bacterial populations. The IDEXX™ method for Colilert™ has been rated as the "best" in agreement with a reference lab, has the lowest detection limit and the Colilert™ method is EPA approved for ambient water (O'Brien 2006).

Water samples for *E. coli* analysis were collected from 14 sites on Smith Mountain Lake on May 20, June 3, June 17, July 1, July 15, and July 29, 2025. The sites are described in Section 3 of this report and are listed and shown in Table A.8 and Figure A.4 in the Appendix.

7.3 E. coli Results and Discussion

The mean *E. coli* most probable number (MPN) in the population for the six sample dates are shown in Figure 7.1. In 2025, the overall mean *E. coli* count was 28.5 MPN, which is 150 percent higher than the 2024 overall mean *E. coli* count (11.4 MPN). None of the means of *E. coli* populations of the fourteen sample sites averaged over the six sample periods for 2025 exceeded the Virginia Department of Health (VDH) standard for recreational waters (standard is 235 CFU/100 mL for greater than one sample geometric mean) and one exceeded the Virginia Department of Environmental Quality (DEQ) standard of 126 CFU/100mL for greater than one sample geometric mean (site 14 geometric mean of 164.1 MPN).

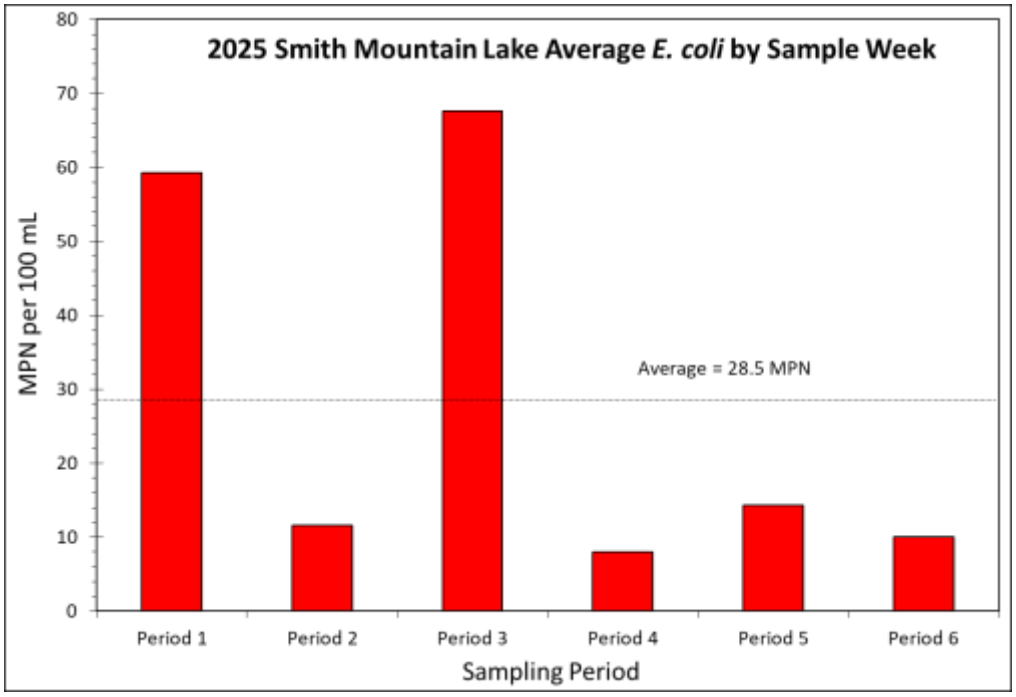


Figure 7.1. *E. coli* versus week sampled on Smith Mountain Lake in 2025 (each sample date included 14 sites with 2 stations per site, n = 28)

This year the *E. coli* population means were variable over time (Figure 7.1). Periods one and three (May 20 and July 29 sample dates) exhibited the highest means (59.2 and 67.6 MPN, respectively), and the lowest mean (8.0 MPN) occurred in sampling period four (July 1 sample date). The variability of *E. coli* counts is shown by the high standard deviations of some of the means (Table A.9).

E. coli populations are also variable based on site location. The mean *E. coli* counts for marinas in 2025 (23.2 MPN) are 31 percent lower than the mean *E. coli* counts for non-marinas (33.7 MPN) as shown in Figure 7.2. As mentioned in Section 3. Methods, Bay Roc (Site 1) is included in both the marina and headwater classifications. Beaverdam Creek (Site 2) is classified as non-marina and flow, and B49 (Site 14) is classified as non-marina and headwater.

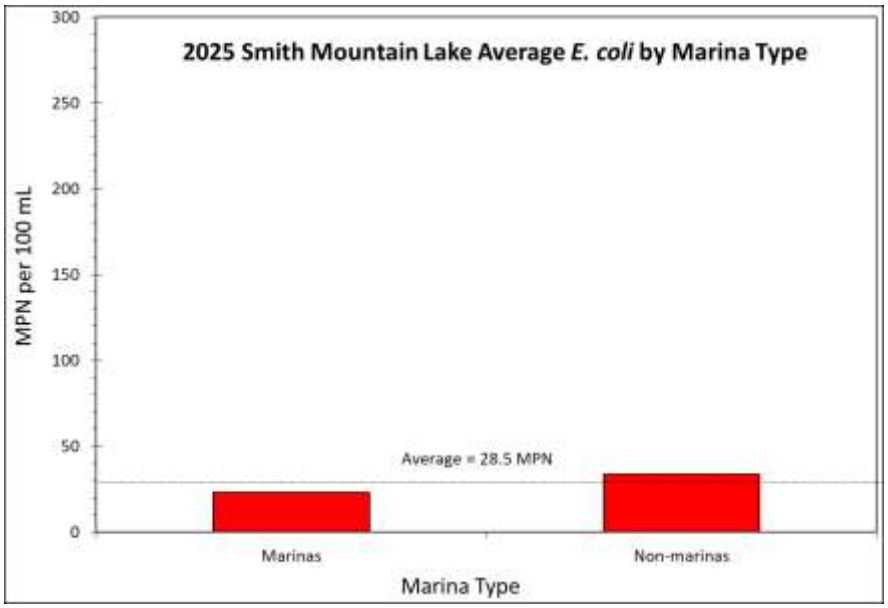


Figure 7.2. Mean *E. coli* count vs. site type in 2025 (7 marina sites, 7 non-marina sites)

The mean *E. coli* counts for headwater sites (105.0 MPN) are 322 percent higher than for static sites (24.9 MPN) and 3521 percent higher than for flow sites (2.9 MPN). The static sites are 759 percent higher than the flow sites. This is shown in Figure 7.3. The very large percent differences among these sites can be attributed to the extremely low numbers of *E. coli* found at the flow sites throughout the sampling season.

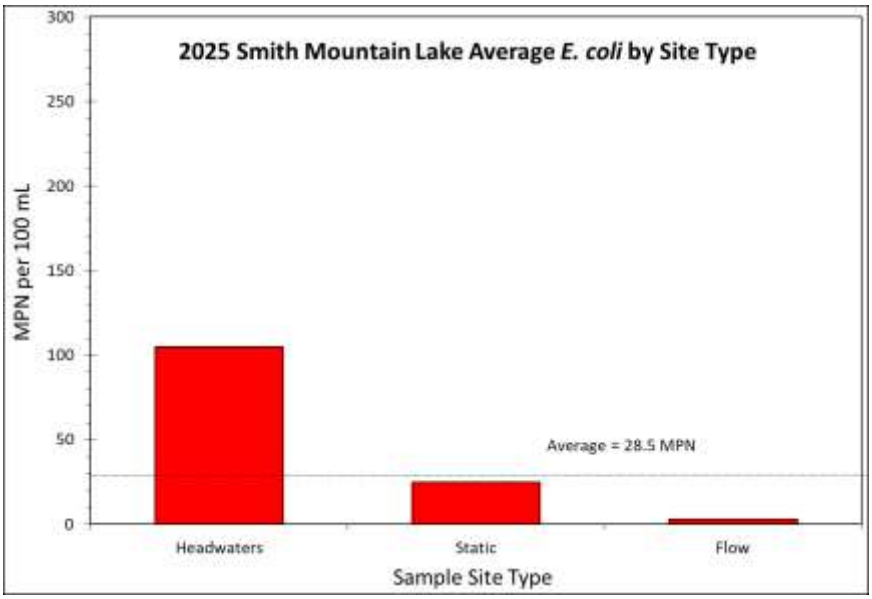


Figure 7.3. Mean *E. coli* count vs. site type in 2025 (2 headwater sites, 7 static sites, 5 flow sites)

The mean *E. coli* counts for the Roanoke channel (20.0 MPN), Blackwater channel (53.6 MPN) and the main basin (i.e., confluence and below) (14.8 MPN) show spatial variability found at Smith Mountain Lake in 2025. The mean *E. coli* counts for all sample sites on the Blackwater channel were 54 percent higher than for the combined Roanoke channel sites and 262 percent higher than the combined main basin sites. The mean E. coli counts for all sites on the Roanoke channel were only 35 percent higher than the main basin sites (Figures 7.4 and 7.6).

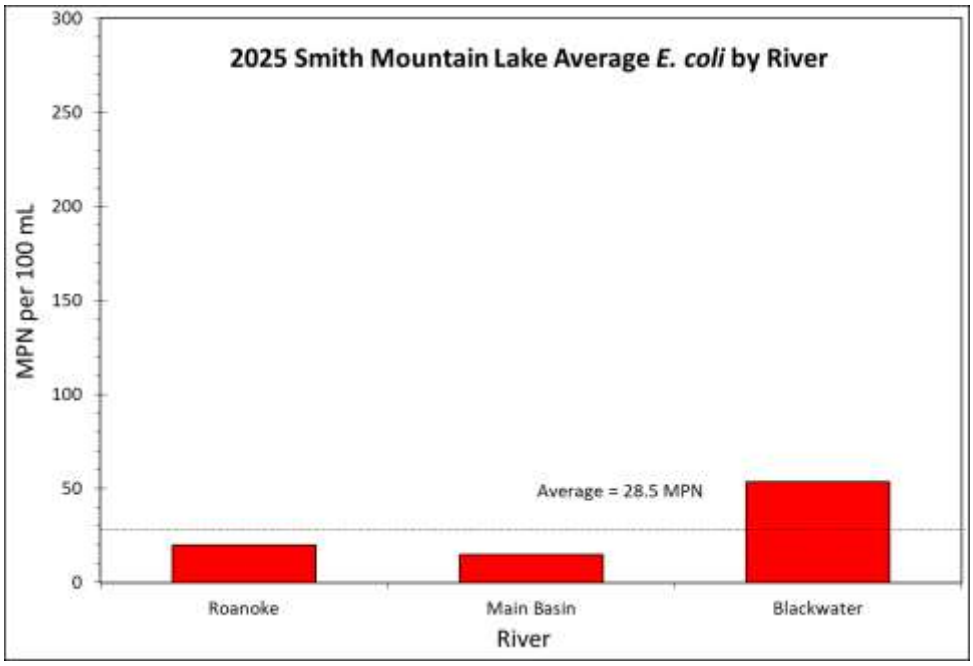


Figure 7.4. Mean *E. coli* counts in 2025 (7 Roanoke channel sites, 4 Blackwater channel sites, and 3 main basin sites)

Figure 7.5 and Table 7.1 show a comparison of mean *E. coli* counts from 2016 to 2025 for combined marina sites, non-marina sites and headwater sites. Since *E. coli* bacteria have a short life in an aquatic system like Smith Mountain Lake, these data should not be interpreted as having a long-lasting cumulative presence of the bacteria at any site as the samples and the analyses are only valid for a single point in time. The data from these designations will be included in yearly reports until enough data is accumulated using the new site-type designations to include those as well.

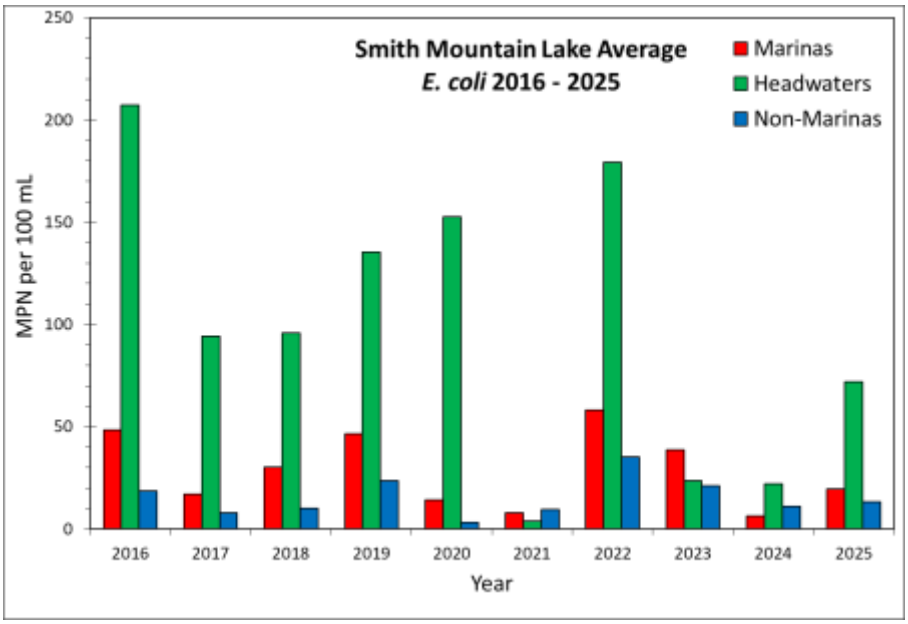


Figure 7.5. Mean *E. coli* counts per site type from 2016-2025

Table 7.1 10-year comparison of mean *E. coli* counts by site type

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	*Ten Year Average*
Marinas	48.3	17.1	30.1	46.6	14.3	7.9	58.3	38.6	6.3	19.5	28.7
Non-Marinas	18.5	7.8	10.2	23.5	3.1	9.5	35.1	21.0	11.0	13.1	15.3
Headwaters	207.4	94.2	95.6	135.2	152.6	3.9	179.3	23.7	21.9	72.0	98.6
Overall Lake	71.7	30.3	37.0	57.4	39.9	6.8	75.9	29.1	11.4	28.5	38.8

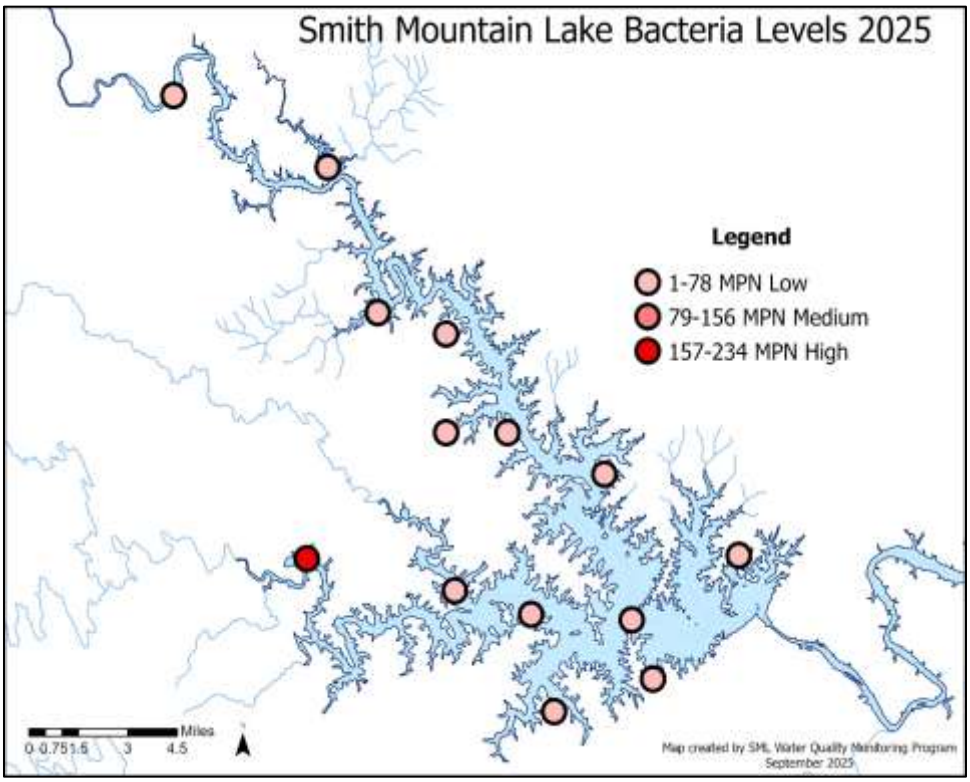


Figure 7.6. Map of bacterial sampling results in Smith Mountain Lake for 2025

7.4 E. coli Conclusions

The *E. coli* populations in Smith Mountain Lake in 2025 were higher than the levels in 2024. In 2025, the overall mean *E. coli* count was 28.5 MPN, which is 150 percent higher than the 2024 overall mean *E. coli* count (11.4 MPN). Since we began monitoring *E. coli* in 2004, the overall mean counts have been highest in 2013 (92.0 MPN) and lowest in 2014 (6.6 MPN). The 2025 overall mean is lower than the ten-year average, as shown in Table 7.1.

The comparison of marinas, non-marinas, and headwaters sites shows differences in *E. coli* values consistent with data collected over the last ten years. Since 2023, we have analyzed bacterial numbers in the Roanoke and Blackwater channels as well as at headwaters, flow, and static sites. These new designations will continue to be analyzed to determine possible patterns or differences that might be gleaned from the data.

8. ALGAE IN SMITH MOUNTAIN LAKE

8.1 Introduction

Sampling for algae biodiversity in Smith Mountain Lake for this project began in 2007 because of concern over potential harmful algal blooms (HABs), which occur when toxin-producing algae grow excessively in a body of water. Algal toxins can cause serious harm to people, fish, animals, and other parts of the ecosystem. The diversity of algal species is of interest in lake management because the presence of high numbers of blue-green (cyanobacteria) and green algae would indicate potential pollutants in the water. High levels of green algae can indicate high nutrient levels. Diatoms can indicate increased nutrient levels, but have also been found to increase with fluctuations in lake levels and are often found in relatively clean water. In addition to our regular monitoring at bacterial and profile sites around the lake, we now recommend using the Virginia Department of Health (VDH) reporting tool for HABs (https://www.vdh.virginia.gov/waterborne-hazards-control/harmful-algal-blooms/). We monitor these reports for Smith Mountain Lake and follow up with onsite sampling to identify potential toxin-producing cyanobacteria in the blooms.

In 2023, there were numerous reports of algal blooms and potential HABs. Samples were received from members of the Smith Mountain Lake Association, volunteer monitors, and lake residents. In addition, Ferrum College scientists and technicians collected numerous samples during regular and supplemental water-quality sampling. Microscopic examination of samples found to contain potential HAB cyanobacteria species was reported to both VDH and the Virginia Department of Environmental Quality (DEQ). Monitoring of HABs continued into the 2025 season, during which the algal concentrations were notably lower than in 2023 but slightly higher than in 2024. The Ferrum College Water Quality Program (WQP) is a member of the SML Water Quality Alliance and will partner with the Dock Watch initiative to assist with continued monitoring of this water quality issue.

Because cyanobacteria (blue-green algae), such as *Microcystis*, *Anabaena*, *Dolichospermum*, and *Aphanizomenon*, found in the lake may produce toxins that can be harmful to fish and potentially to humans, the levels of toxins (e.g., microcystin) in the water can be tested. Testing procedures for these toxins have been developed and are used when high levels of blue-green algae are found

in samples. Toxin testing may be performed when an algal bloom (visible green or blue-green water) involving certain species is reported from lake observations during the sampling season and beyond. In 2025, Ferrum College WQP worked with the SMLA and DEQ to collect water samples and conduct toxin analysis using the ELISA method.

8.2 Methods

Plankton tow samples are used to collect representative populations of diatoms, green algae, and blue-green algae in the water. Horizontal or surface plankton 10-meter tows were collected six times during the 2025 sampling season at the 14 sites used for bacterial sampling, which are described in section three, as well as listed in Table A.8 and shown in Figure A.4 in the Appendix.

Vertical water-column 10-meter tows were conducted six times during the season at the sites used for depth profiling. These sites are described in section three and shown in Figure A.3 in the Appendix.

A standard plankton tow net (12" ring, 63-micron mesh) was towed for ten meters for each sample. Samples were preserved using 1 milliliter (mL) of Lugol's solution per 100 mL of sample. The phytoplankton counting method procedure followed the field method outlined in *Standard Methods for Water and Wastewater Analysis* (APHA 1999). The algae were identified and counted within 50 random Whipple Disk grid fields across a 1 mL sample in a Sedgwick Rafter counting cell and recorded on a Nikon Biphot compound microscope at 200X magnification. Counts were corrected by number of potential number of grids across the 1 mL Sedgwick Rafter chamber. This year, the counting methodology remained the same as previous years.

8.3 Results

In 2023, the algal enumeration focus shifted to counting specific indicator genera of phytoplankton which reduced the number of genera counted. These indicator genera included four genera of diatoms (*Asterionella, Dinobryon*, *Fragilaria* and *Navicula*), three genera of green algae (*Pediastrum*, *Scenedesmus*, and *Staurastrum*) and three genera of blue-green algae (*Dolichospermum* [formerly known as *Anabaena*], *Microcystis*, and *Oscillatoria*). During the 2023 sampling season, *Woronochinia* and *Aphanizomenon* (both blue-green algae) were added to the counts and these are the 12 genera that were counted in 2025.

Figure 8.1 illustrates the various phytoplankton groups by i.) site type (i.e., headwater, static, and flow), ii.) marina type (i.e., marina or non-marina), iii.) river source (i.e., Roanoke, Blackwater, and main basin), and iv.) profile sites.

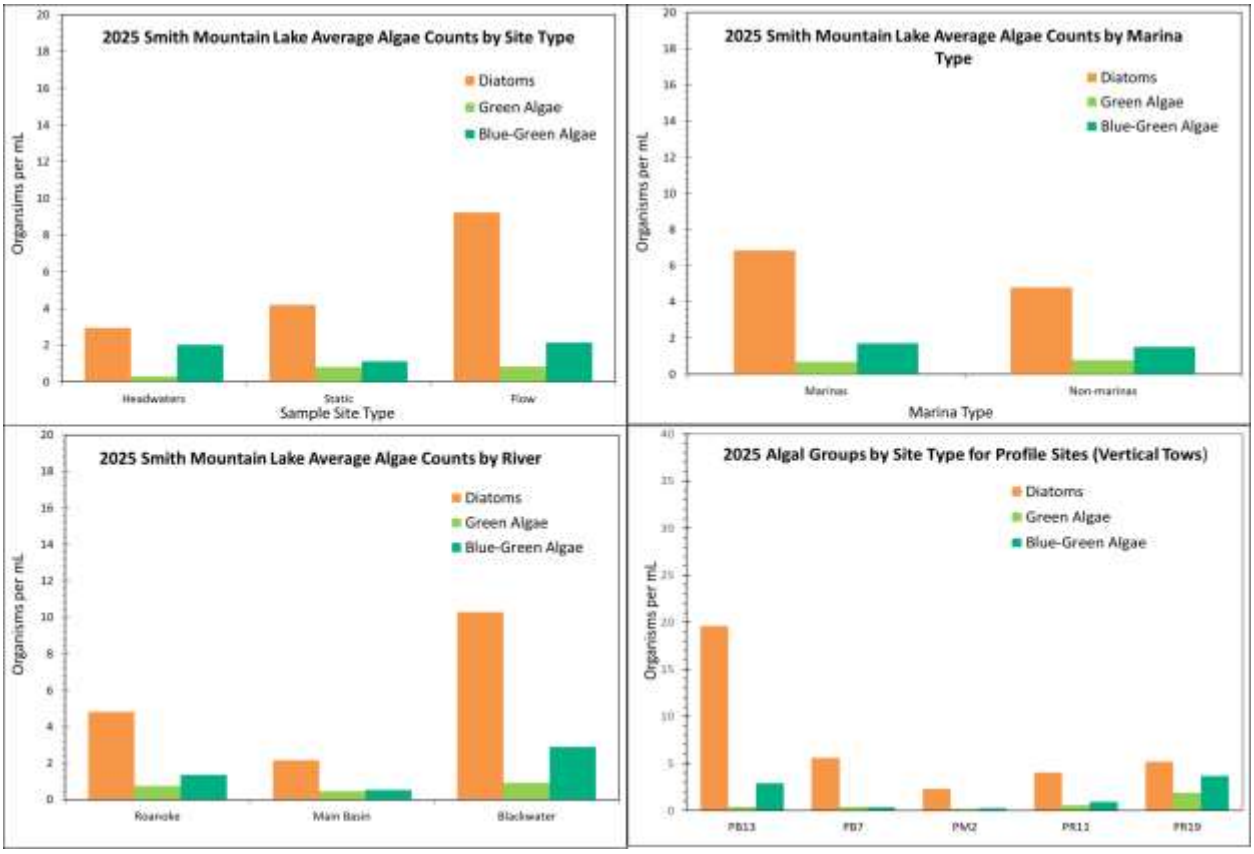


Figure 8.1. Algae counts organized clockwise by i.) site type (i.e., headwater, static, and flow), ii.) marina type (i.e., marina or non-marina), iii.) river source (i.e., Roanoke, Blackwater, and Main Basin), and iv.) profile sites. Note the scale differences.

Figure 8.2 shows the overall patterns of growth for the three algal groups (four genera of diatoms, three genera of green algae, and five genera of blue-green algae) counted during the 2025 sampling season for both depth profile sites (left) and all lake sites (right).

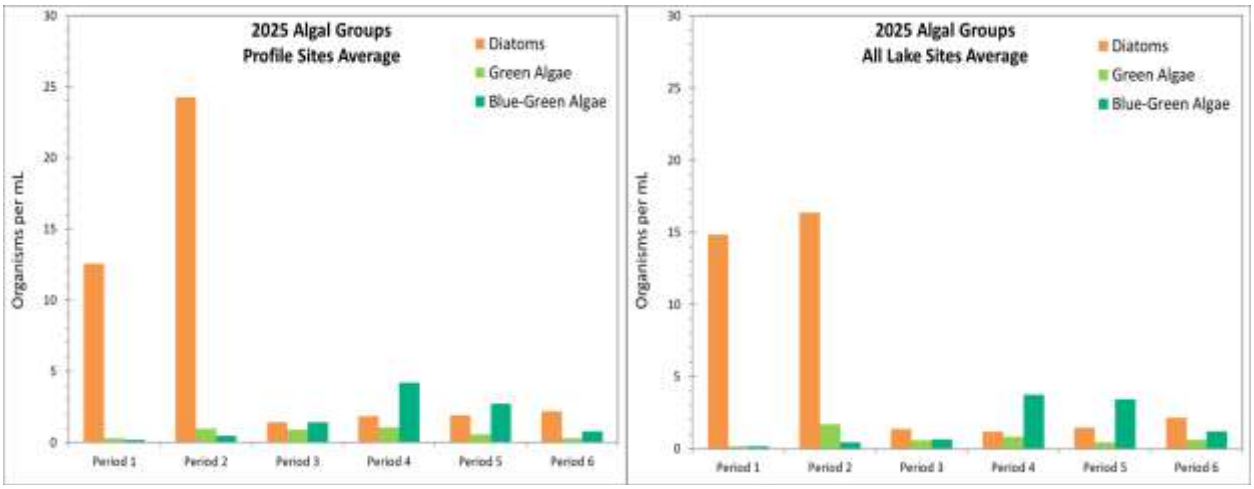


Figure 8.2. Overall patterns of algae groups enumerated in 2025 for each sampling period

8.4 Discussion

During the 2023 sampling season, several changes to the number of genera that were counted from the horizontal and vertical tow samples were implemented. Focus was placed on those genera that were morphologically distinct within each algal group, but also are representative of a historical presence in the lake. Additionally, some genera (e.g., as *Chlorella*) were removed because their concentrations in previous years have potentially skewed the percentage of algal groups represented during the sampling season. Finally, by reducing the number of genera across all groups being enumerated, it allowed for a focus on the more concerning and potentially problematic cyanobacterial genera associated with harmful algal blooms. This protocol was maintained during the 2025 season.

Generally, analysis of algae in Smith Mountain Lake shows a high diversity of genera across the algal groups. In 2025, when comparing ‘Sample Site Type’, ‘Marina Type’, and the various sites and locations around the lake, there did not appear to be any significant trends. However, this may not be the case every year, and it will be important to continue to monitor for any trends using these newer designations in future years.

8.5 Conclusions

Although the 2023 sampling season provided the highest number of reports for harmful algal blooms in the 39-year history of the Smith Mountain Lake Water Quality Project, the 2025 season had a low number of HAB-associated genera and slightly higher phytoplankton concentrations

than 2024. The phytoplankton diversity of the lake remains high, but the prospect of seeing increased numbers of cyanobacteria associated with harmful algal blooms which occurred in 2023 is a concern and monitoring efforts to determine sources and climate impacts are important. This is being addressed by the Water Quality Alliance, of which Ferrum College WQP is a member. The cyanobacteria most commonly associated with the current HABs at Smith Mountain Lake are nitrogen-fixing genera, indicating that nitrogen is not a limiting nutrient for these organisms. Future research will need to analyze correlations between lake characteristics (e.g., water temperature and phosphorus levels) as well as changes in land usage and other practices (e.g., fertilizer application) around the lake to see what might be leading to the spike in HABs that were noticed in 2023. Ferrum College's WQP is continuing to work with the SML Association and DEQ to monitor these yearly variations in phytoplankton and HAB concentrations as well as looking at sources of nutrient inputs and climate impacts. Additionally, Ferrum College, in partnership with the Water Quality Alliance, has expanded its lab equipment to monitor HAB-associated toxin levels during the 2025 season.

9. QUALITY ASSURANCE/QUALITY CONTROL

9.1 Introduction

The QA/QC procedures for each of the parameters described below are included as part of each analysis method in the *Ferrum College Water Quality Lab Procedures Manual* (Love et al. 2022).

9.2 Calibration Data for Total Phosphorus Method and Results

Every time samples are analyzed, sets of standards are prepared so that calibration curves can be constructed to determine the relationship between total phosphorus concentration in a sample and its absorption of light at 880 nm. The concentrations of the standards used for total phosphorus are as follows: 0 ppb, 10 ppb, 20 ppb, 40 ppb, 80 ppb, and 160 ppb. The calibration curve is constructed using the readings from standards run at the beginning of the analysis. Table 9.1 summarizes the calibration data for 2025. The coefficient of determination (R^2) is a measure of how well the calibration line fits the data points with values ranging from 0 (no fit) to 1 (perfect).

Table 9.1. Summary of 2025 calibration data for total phosphorus (TP)

Sampling Period*	TP - R^2
1	0.9995
2	0.9998
3	0.9996
4	0.9997
5	0.9994
6	0.9997
Average	**0.9996**
Standard Deviation	**0.0001**

*See Table 2.1

With an average value over 0.999, the average R^2 for total phosphorus indicates excellent precision and shows both the care with which the standards were prepared and the stability of the instrument and reagents.

9.3 Comparison of Standards Method and Results

The procedure for measuring total phosphorus involves the formation of a dye that fades over time. One of the advantages of using flow injection analysis is that the reagents are mixed and the dye

is formed in real time, during the course of an individual measurement. This means there is no concern that the dye will fade during the time required for analysis. To assure that no changes in detector sensitivity occurred during the analysis, the concentration of two of the standards were periodically checked, as has been done in previous years.

In 2025, the 40 and 80 ppb standards were run periodically during each analysis for a total of eight readings of each of those two standards except in week 1 where seven readings were taken. The readings obtained were compared to 40 and 80 ppb respectively, and average relative percent differences (RPD) were calculated. These are reported, along with maximum and minimum relative percent differences, in Table 9.2.

Table 9.2 Comparison of 40 and 80 ppb standards over the course of analysis for total phosphorus for 2025

Sampling Period*	Avg. RPD 40ppb std.	Max. RPD 40ppb std.	Min. RPD 40ppb std.	Avg. RPD 80ppb std.	Max. RPD 80ppb std.	Min. RPD 80ppb std.
	(%)	(%)	(%)	(%)	(%)	(%)
1	1.0	1.9	0.1	0.4	1.0	0.3
2	1.6	2.4	1.0	0.4	1.2	0.2
3	1.6	2.7	0.3	0.5	1.4	0.2
4	1.2	2.8	0.0	2.1	2.4	1.4
5	1.9	2.5	1.1	1.9	2.6	1.5
6	6.3	7.1	5.4	0.7	1.2	0.0
Overall Averages	**2.3**			**1.0**		

*See Table 2.1

9.4 Comparison of Standards Discussion and Conclusions

The results of analysis for the 40 and 80 ppb standards for total phosphorus over the course of the sampling season were excellent for the 40-ppb standard with an overall average of 2.3 percent RPD and excellent for the 80-ppb standard with an overall average of 1.0 percent RPD. The target value for RPD is 0 percent and 10 percent is the DEQ acceptable upper limit. This further indicates reliability of the instrument, reagents, and lab technique.

9.5 Blank and Spiked Blank Method and Results

In 2025, three blanks of deionized (DI) water and three spiked blanks were run with each analysis. The spiked blanks were 5.0 mL DI water spiked with 0.1 mL of 2 ppm phosphate standard to give a final concentration of 39 ppb.

Table 9.3. Average error for total phosphorus for 2025 lab blanks and average percent recovery for spiked blanks

Sampling Period*	TP blanks - average error (ppb)	TP spiked blanks - average % recovery
1	0.2	123.1
2	0.3	108.2
3	0.2	125.9
4	0.2	114.6
5	1.2	108.9
6	0.6	108.0
AVERAGES	**0.4**	**114.8**

*See Table 2.1

The average for lab blanks for total phosphorus was excellent for all sample periods (target value is 0 ppb). The overall average of 0.4 ppb shows stability of the instrument and minimal carry-over contamination from previous samples. The overall average percent recovery for the spiked blanks for total phosphorus was good at 114.8 percent (target value is 100 percent with $\pm$20 percent acceptable upper and lower limits).

9.6 Duplicate and Spiked Sample Analysis Method and Results

During every analysis, five samples were divided and run as duplicates. Five additional samples were divided and one of the aliquots was spiked by the addition of a very small quantity of total phosphorus standard solution (0.1 mL of 2 ppm solution in 5.0 mL sample) to give a known final added concentration. The duplicate samples were compared to their initial analyzed values and relative percent differences (RPD) were calculated. The results are reported in Table 9.4. The spiked samples were compared to their initial analyzed concentrations plus the value of the added phosphorus, and percent recovery was calculated. The results are also reported in Table 9.4.

Table 9.4 Results of analysis of 2025 duplicates and spikes for total phosphorus

	TP DUPLICATES			TP SPIKES		
Sampling Period*	**Average RPD**	**Maximum RPD**	**Minimum RPD**	**Average % Recovery**	**Maximum % Recovery**	**Minimum % Recovery**
1	9.0	40.1	0.0	113.9	118.8	107.8
2	5.9	24.6	0.0	102.3	105.9	96.0
3	2.9	4.5	0.0	105.8	124.8	99.0
4	6.4	12.5	0.4	109.6	120.1	100.6
5	3.5	11.1	0.4	109.3	111.8	107.6
6	8.3	35.7	0.6	104.9	106.1	103.7
Overall Avg	**6.0**	**21.4**	**0.2**	**107.6**	**114.6**	**102.5**

*See Table 2.1

The results of duplicate analysis for total phosphorus were good this year at 6.0 average relative percent difference (acceptance criteria is RPD < 20 percent) and also good for spiked samples with 107.6 average percent recovery (acceptance criteria is 80-120 percent recovery).

9.7 Analysis of Certified Standard Method and Results

Each time samples were analyzed, a certified standard purchased from Environmental Resource Associates (ERA) was also analyzed in triplicate. These results are reported in Table 9.5.

Table 9.5. Results of analysis of purchased standard for total phosphorus for 2025

Sampling Period	ERA conc. - expected (ppb)	ERA conc. - measured, avg. (ppb)	Average RPD
1	65.2	66.4	1.8
2	65.2	66.3	1.6
3	65.2	65.9	1.1
4	65.2	64.3	1.4
5	65.2	63.0	3.5
6	65.2	65.7	1.0
Averages		**65.3**	**1.7**

9.8 Analysis of Certified Standard Discussion and Conclusions

The results of the analysis of the certified standard for total phosphorus were excellent with an overall average relative percent difference (RPD) of 1.7 percent (target value is 0 percent). All measured values fell within the QC performance acceptance limits established by ERA.

9.9 QA/QC for Chlorophyll-a

At the beginning of every sampling season, the fluorometer is calibrated using a standard purchased from Turner Designs (Sunnyvale, CA) and secondary solid standards (supplied with the instrument) are checked. Before every sample analysis, the instrument is calibrated to the values established for these solid standards. These standards, along with a reagent blank (buffered acetone) are read periodically throughout the sample analysis. A method blank (glass fiber filter through which 100 mL of DI water has been filtered and is stored frozen) is analyzed each time samples are run to assure that the processing of the samples does not introduce contamination or interferents. In 2025, the method blanks ranged from 0.00 ppb to 0.03 ppb with an average of 0.01 ppb.

9.10 QA/QC for Secchi Disk Depth

The training received by the volunteer monitors, the simplicity of the technique, and the fact that Secchi depth is recorded to the nearest quarter meter gives inherent reliability to this measurement.

9.11 QA/QC for E. coli Methods and Results

Sterile distilled water is run with each set of lake samples analyzed for *E. coli*. In every analysis, the sterile distilled water gave readings of <1.0, which is the lowest most probable number (MPN) that can be obtained. In 2025, replicates were run at two sites from each sample set for the six samplings. The replicates are obtained by collecting a large field duplicate sample along with the regular sample at the replicate site and dividing the larger sample into four replicate subsamples at the lab. These replicate samples are analyzed in the same manner as the rest of the samples, and the results are compared both to each other and to the regular sample collected at the replicate site. Results of the replicate analysis are shown in Table 9.6.

Table 9.6. Results of replicate analysis of *E. coli* samples for 2025

Sampling Period	Replicate Site	MPN *E. coli* at replicate site	Replicate Avg. (MPN)	Replicate Range (MPN)
1	1-1	98.3	83.4	70.5-101.4
1	14-2	686.7	659.3	501.2-816.4
2	10-1	1.0	0.5	0.0-1.0
2	12-2	0.0	1.0	0.0-3.1
3	13-2	5.2	5.8	4.1-7.4
3	3-1	12.2	10.6	7.4-16.9

4	5-1	35.5	63.0	47.9-83.3
4	11-1	4.1	8.1	6.3-11.0
5	1-2	7.5	4.4	3.0-7.4
5	14-1	131.4	163.3	118.7-209.8
6	5-1	53.0	60.8	45.7-69.1
6	14-1	31.8	22.9	14.8-28.2

In addition, a QuantiCult™ kit was processed with every analysis. This kit is made by the manufacturer of the Colilert media and consists of three cultures: *Escherichia coli* (*E. coli*), *Pseudomonas aeruginosa,* and *Klebsiella pneumoniae.* The cultures are rehydrated according to the kit directions and analyzed. *E. coli* should give a positive reading for color change as well as fluorescence. *Klebsiella* should give a positive reading for color (coliform test) but none of the wells should fluoresce (since it is not *E. coli*). *Pseudomonas* should give a negative test for color (since it is not a coliform) and none of the wells should fluoresce (since it is not *E. coli*). Additionally, where there is a reading, the MPN obtained should fall within specified limits (1-50 MPN). Results are shown in Table 9.7.

Table 9.7. Results of QuantiCult™ analysis for 2025

Sampling Period 1	**MPN total coliforms**	**MPN *E. coli***
E. coli	39.9	39.9
K. pneumoniae	19.9	0.0
P. aeruginosa	0.0	0.0
Sampling Period 2	**MPN total coliforms**	**MPN *E. coli***
E. coli	38.9	38.9
K. pneumoniae	21.6	0.0

P. aeruginosa	0.0	0.0
Sampling Period 3	**MPN total coliforms**	**MPN *E. coli***
E. coli	39.9	39.9
K. pneumoniae	24.6	0.0
P. aeruginosa	0.0	0.0
Sampling Period 4	**MPN total coliforms**	**MPN *E. coli***
E. coli	29.2	29.2
K. pneumoniae	14.5	0.0
P. aeruginosa	0.0	0.0
Sampling Period 5	**MPN total coliforms**	**MPN *E. coli***
E. coli	19.9	19.0
K. pneumoniae	20.1	0.0
P. aeruginosa	0.0	0.0
Sampling Period 6	**MPN total coliforms**	**MPN *E. coli***
E. coli	24.3	24.3
K. pneumoniae	12.2	0.0
P. aeruginosa	0.0	0.0

9.12 QA/QC for E. coli Discussion and Conclusions

All QA/QC results for *E. coli* analysis for the 2025 sampling season were very good with MPN numbers in the expected ranges. The sterile distilled water gives assurance that the bottles, media, and Quanti-Tray 2000™ trays are sterile and that good technique was used. There was no relevant difference between the results for the replicate analysis, the replicate average and the regular sample collected at the replicate site. The QuantiCult™ results were as expected.

10. SAMPLING EFFICIENCY

The monitoring program depends on volunteers for sample collection and one measure of success for the program is the consistency with which these volunteers attend to their stations. Table 10.1 indicates the sampling efficiency data for 2025 and Table 10.2 presents the collection efficiencies from 2016 through 2025. The figures show that the volunteer monitors are very conscientious about sample collection. Volunteer monitor sample efficiency for total phosphorus was 99 percent, chlorophyll-*a* samples correctly collected at 99 percent, and 99 percent for Secchi readings. The volunteers' sampling efficiency is as good as that of professionals in agencies responsible for environmental sampling. This degree of commitment no doubt carries over to the care with which samples are collected and is evidence of the volunteers' dedication to the program.

Table 10.1. Sampling efficiency for Smith Mountain Lake data for 2025

Sample Type	Monitoring Stations	Possible Samples	Samples Collected	Percent Efficiency
Secchi Depth	84	504	498	99
TP	56	336	333	99
CA	56	336	333	99
Profiles*	5	30	30	100
Bacteria*	28	168	168	100
Algae*	19	114	114	100

*Indicates samples taken by students and faculty from Ferrum College

Table 10.2. Ten-year sampling efficiencies for Smith Mountain Lake data

% Efficiencies/Year	2025	2024	2023	2022	2021	2020	2019	2018	2017	2016
Secchi Depth	99	99	98	97	99	97	99	95	84	95
TP	99	99	98	99	100	98	100	96	97	98
CA	99	99	98	98	99	97	96	95	98	97

11. CONCLUSIONS

In general, water quality improves greatly as the water moves from the upper channels toward the dam. This is consistent with observations made since the second year of the monitoring project. Eroded soil is carried to the lake by silt-laden streams, but sedimentation begins in the quiescent lake water. Phosphorus, primarily in the form of phosphate ions, strongly associates with the soil particles and settles out during the sedimentation process. Concentrations of total phosphorus, chlorophyll-*a*, and Secchi depth are all influenced to different degrees by the distance to the dam, with Secchi depth showing the strongest linear relationship, historically.

In 2025, average total phosphorus and chlorophyll-*a* increased, and the average Secchi depth slightly decreased compared to the 2024 averages.

Sufficient depth profile data have now been collected to enable meaningful comparison between rates of change and absolute parameter values over the course of the summer. The temperature profiles indicate that the thermocline at most sample sites remains slightly higher in the water column. As has been the case since 2015, the bottom of the lake becomes anaerobic (DO is depleted) in June rather than July. This trend negatively affects aquatic life by forcing them to move closer to the surface earlier in the summer, thereby increasing thermal stress. Atmospheric carbon dioxide is increasing globally and may be affecting Smith Mountain Lake. Increased carbon dioxide levels decrease pH and promote photosynthesis, thereby increasing algal production. While DO will increase at the surface, the amount of organic matter settling into the hypolimnion will also increase, and the hypolimnetic oxygen deficit will become more severe. Continued depth profiling and algal dynamics studies will provide scientific data to support effective management of Smith Mountain Lake as it ages.

The *E. coli* populations in Smith Mountain Lake in 2025 were higher than the levels in 2024. In 2025, the overall mean *E. coli* count was 28.5 MPN, which is 150 percent higher than the 2024 overall mean (11.4 MPN). Since we began monitoring *E. coli* in 2004, the overall mean counts were highest in 2013 and lowest in 2014. The 2025 overall mean is lower than the ten-year average (38.8 MPN).

The comparison of marinas, non-marinas, and headwaters sites shows differences in *E. coli* values consistent with data collected over the last ten years. The past three years, we have analyzed bacterial numbers in the Roanoke and Blackwater channels as well as at headwaters, flow, and static sites. These designations will continue to be analyzed to identify possible patterns or differences in the data.

Although the 2023 sampling season provided the highest number of reports for harmful algal blooms in the 39-year history of the Smith Mountain Lake Water Quality Project the 2025 season is the opposite. The lake's phytoplankton diversity remains high, and continued observation of increased numbers of cyanobacteria (e.g., *Aphanizomenon*) associated with harmful algal blooms is a concern. The cyanobacteria most commonly associated with the current HABs at Smith Mountain Lake are nitrogen-fixing genera, indicating that nitrogen is not a limiting nutrient for these organisms. Future research will need to analyze correlations between lake characteristics (e.g., water temperature and phosphorus levels) and changes in land use and other practices (e.g., fertilizer application) around the lake to determine what might be driving the spike in HABs observed last season. Ferrum College's WQP is continuing to work with the SML Association and DEQ to monitor these yearly variations in phytoplankton and HAB concentrations.

The results of the quality control and quality assurance procedures range from good to excellent. We measure the precision and accuracy of our analyses in many ways, including blank samples, spiked samples, and analyzing certified standards. The Smith Mountain Lake and Ferrum College Water Quality Program has been certified by the Virginia Department of Environmental Quality for the following parameters: total phosphorus, chlorophyll *a, Escherichia coli* populations, temperature, dissolved oxygen, and conductivity depth. All QA/QC results for *E. coli* analysis for the 2025 sampling season were very good.

The sampling efficiency of the Smith Mountain Lake and Ferrum College Water Quality Program was excellent in 2025. Volunteer monitor sample efficiency for total phosphorus, chlorophyll-*a* samples, and Secchi readings was at least 99 percent. These figures show that the volunteer monitors are very conscientious about sample and data collection and remain engaged in the program.

The overall conclusion in regard to the water quality in Smith Mountain Lake is that it is very good. The lake is not aging as fast as would have been predicted for a reservoir. However, weather and climate are significant drivers of the lake's trophic status. We will continue to monitor the lake's water quality to provide data that helps ensure a healthy lake and protect this valuable resource in this region.

12. ACKNOWLEDGEMENTS

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REFERENCES

[APHA] American Public Health Association. 1999. Standard methods for examination of water and wastewater. 20th edition. Washington DC: APHA Press.

Bellinger EG, Sigee DC. 2010. Freshwater algae: identification and use as bioindicators. Oxford (UK): John Wiley & Sons, Ltd.

Bigham DL, Hoyer MV, Canfield Jr. DE. 2009. Survey of toxic algal (microcystin) distribution in Florida lakes. Lake Reserv. Manag. 25:264-275.

Brylinsky M. 2012. Evaluation of two test kits for measurement of microcystin concentrations. report prepared for the Nova Scotia Department of the Environment. Wolfville (Nova Scotia): Acadia University.

Carlson RE. 1977. A trophic state index for lakes. Limnol. Oceanog. 22(2):361-369.

Carlson RE, Simpson J. 1996. A coordinator's guide to volunteer lake monitoring methods. Madison (WI): North American Lake Management Society.

Downie NM, Heath RW. 1974. Basic statistical methods. New York (NY): Harper and Row, Publishers. p. 314.

Harwood VJ, Whitlock, J, Withington, V. 2000. Classification of antibiotic resistance patterns of indicator bacteria by discriminate analysis: use in predicting the source of fecal contamination in subtropical waters. Appl. Envir. Microbiol. 66(9):3698-3704.

Heck DR, Britton C, Ghioca Robrecht DM, Johnson, DM, Love CC, Pohlad BR. 2020-2021. Smith Mountain Lake Water Quality Volunteer Monitoring Program. Annual reports. Ferrum (VA): Ferrum College.

Hoehn RC, Long BW. 2008. Toxic cyanobacteria (blue-green algae): an emerging concern. Portland (OR): Envirologix ed. Natural Water Toxins.

Love CC, Britton C, Ghioca Robrecht DM, Heck DR, Johnson DM, Pohlad BR. 2022. Ferrum College Water Quality Lab Procedures Manual. Ferrum (VA): Ferrum College.

Ney JJ. 1996. Oligotrophication and its discontents: effects of reduced nutrient loading on reservoir fisheries. American Fisheries Society Symposium 16:285-295.

O'Brien E. 2006. Volunteers conduct bacteria methods study. Volunteer Monitor 18(1):1-6.

O'Reilly CM, Sharma S, Gray DK, Hampton SE, Read JS, Rowley RJ, Schneider P, Lenters JD, McIntyre PB, Kraemer BM, et al. 2015. Rapid and highly variable warming of lake surface waters around the globe. Geophys. Res. Lett. 42(24):10,773–10,781. doi:10.1002/2015GL066235.

Reckhow KH, Chapra SC. 1983. Engineering approaches to lake management, Vol. 1: Data analysis and empirical modeling. Ann Arbor (MI): Ann Arbor Science Book Publishers; pp. 189-193.

Thomas CL, Heck DR, Johnson DM, Love CC, Pohlad BR, Puccio M. 2012-2019. Smith Mountain Lake Water Quality Volunteer Monitoring Program. Annual reports. Ferrum (VA): Ferrum College.

[U.S. EPA] U.S. Environmental Protection Agency. 1974. The relationships of phosphorous and nitrogen to the trophic state of northeast and north-central lakes and reservoirs. National Eutrophication Paper No. 23, Corvallis (OR): U.S. EPA

[U.S. EPA] U.S. Environmental Protection Agency. 2005. Guidance for 2006 assessment, listing and reporting requirements pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act. [accessed 2007 October 1]; http://www.epa.gov/owow/tmdl/2006IRG/report/2006irg-report.pdf

Walker WW. 1999. Simplified procedures for eutrophication assessment and prediction: user manual instruction report W-96-2 USAE Waterways Experiment Station. Vicksburg (MS): U.S. Army Corps of Engineers.

APPENDIX

Table A.1. 2025 Smith Mountain Lake trophic monitoring stations with monitor names and station locations

Station	Monitor	Latitude	Longitude
B8	Chaney	37.0393	-79.6159
B10	Chaney	37.0504	-79.6417
B12	Brinkerhoff	37.0422	-79.6686
B14	Jamison	37.0348	-79.6723
B16	Jamison	37.0412	-79.7027
B18	Flowers	37.0337	-79.7189
B20	Flowers	37.033	-79.7279
B22	Easter/Gross	37.0634	-79.7391
C4	Trinchere	37.0558	-79.5709
C5	Trinchere	37.0689	-79.5645
C6	Trinchere	37.0821	-79.5685
CB11	Brinkerhoff	37.0409	-79.6571
CB16	Jamison	37.0384	-79.697
CB20	Easter/Gross	37.0358	-79.7382
CM1	Rupnik/Edgerton	37.055	-79.539
CM1.2	Rupnik/Edgerton	37.063	-79.535
CM5	Anderson	37.0468	-79.5871
CR8	Anderson	37.0659	-79.5912
CR9	Heyroth	37.0747	-79.6068
CR9.2	Heyroth	37.0708	-79.6204
CR13	Green	37.0989	-79.6409
CR14.2	Koontz	37.1172	-79.6739
CR16	McCord	37.145	-79.663
CR17	McCord	37.15	-79.667
CR19	Sanders	37.159	-79.692
CR21	Gardner	37.1492	-79.7086
CR21.2	Gardner	37.146	-79.7091
CR22	Lovatt	37.167	-79.712
CR24	McWilliams	37.1946	-79.7239
CR25	McWilliams	37.1928	-79.7281
CR26	Watson	37.1863	-79.7532
G12	Brinkerhoff	37.0469	-79.669
G13	Toone	37.0502	-79.6739
G14	Butterfield	37.0555	-79.6723
G15	Toone	37.0594	-79.6805
G16	Butterfield	37.0641	-79.6878

Table A.1. 2025 SML monitoring stations with monitor names and station locations (cont.)

Station	Monitor	Latitude	Longitude
G18	Butterfield	37.0716	-79.6799
M0	Rupnik/Edgerton	37.0447	-79.5392
M1	Sakayama/Earnhardt	37.0498	-79.5481
M3	Sakayama/Earnhardt	37.041	-79.564
M5	Sakayama/Earnhardt	37.042	-79.588
R7	Anderson	37.0518	-79.5931
R9	Heyroth	37.0736	-79.6183
R11	Anderson	37.0898	-79.6135
R13	Green	37.1029	-79.6409
R14	Koontz	37.1122	-79.6487
R15	McCord	37.131	-79.657
R17	Sanders	37.152	-79.676
R19	Sanders	37.161	-79.697
R21	Gardner	37.1564	-79.7081
R23	Lovatt	37.18	-79.717
R25	McWilliams	37.19	-79.7419
R27	Watson	37.1981	-79.7663
R29	Watson	37.2153	-79.776
R30	Ferrum College	37.2327	-79.7864
R31	Ferrum College	37.2202	-79.7967
SB12	Moyer	37.0401	-79.6648
SCB 8	Bleier	37.0254	-79.5986
SCB10	Bleier	37.0208	-79.6382
SCB11	Bleier	37.0168	-79.6267
SCB11.5	Bleier	37.0649	-79.6448
SCB14	Moyer	37.033	-79.6824
SCB16	Moyer	37.0356	-79.6937
SCM5	Sears	37.048	-79.5879
SCR7	Sears	37.0587	-79.5866
SCR8	Sears	37.0683	-79.5883
SCR10.1	Hardy	37.0719	-79.6295
SCR10.2	Hardy	37.0763	-79.6289
SCR10.3	Hardy	37.0797	-79.6368
SCR11.1	Garcia	37.106	-79.6001
SCR11.2	Garcia	37.1051	-79.6166
SCR11.3	Garcia	37.1015	-79.6295

Table A.1. 2025 SML monitoring stations with monitor names and station locations (cont.)

Station	Monitor	Latitude	Longitude
SCR14	West	37.1125	-79.6429
SCR14.1	Barr	37.1097	-79.6648
SCR14.2	Barr	37.108	-79.6729
SCR14.3	Barr	37.1135	-79.6603
SCR15	Bull	37.12	-79.646
SCR 15.1	West	37.1203	-79.6544
SCR 15.2	West	37.1186	-79.6711
SCR17	Bull	37.157	-79.67
SCR17.1	Bull	37.158	-79.677
SCR18	Reingarber	37.148	-79.6892
SCR19.2	Reingarber	37.1605	-79.6918
SCR20	Reingarber	37.1609	-79.7037

Figure A.1. Smith Mountain Lake trophic monitoring stations

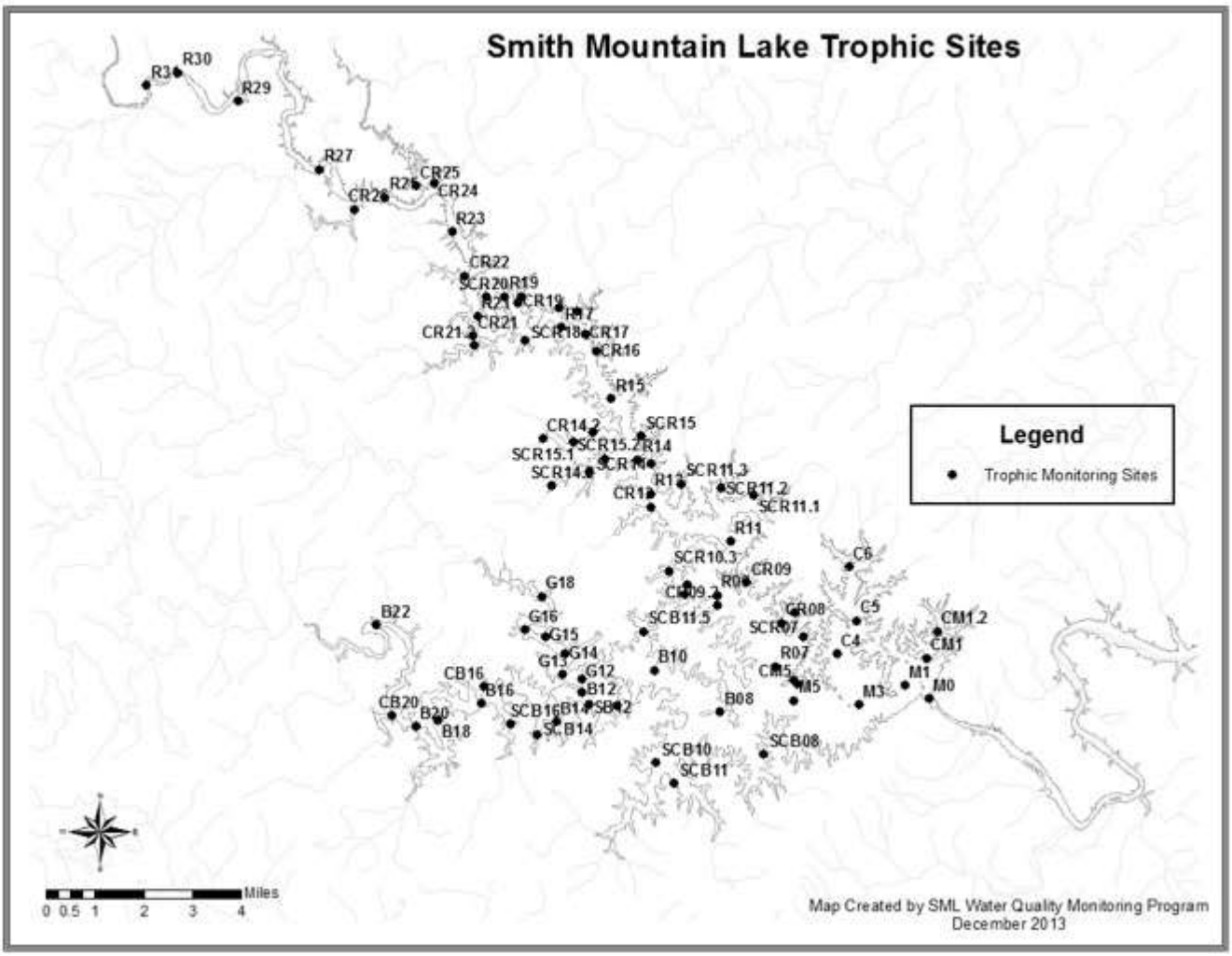

Table A.2. 2025 Smith Mountain Lake tributary stations and other downstream stations

Tributary Station Number	Stream Name / Location
T0a	Upper Gills Creek
T1a	Maggodee Creek
T2a	Gills Creek
T3	Blackwater River
T4	Poplar Camp Creek
T5	Standiford Creek
T6	Bull Run
T7	Cool Branch (Google Maps = McField Branch)
T8	Lumpkins Marina Creek
T9	Roanoke River below SML dam
T10	Pigg River
T11	Leesville Lake
T12	Surrey Drive
T13	Snug Harbor
T14	Stoney Creek
T15	Jumping Run
T16	Beaverdam Creek
T17	Bay Roc Marina
T18	Lynville Creek
T19a	Grimes Creek
T20	Indian Creek

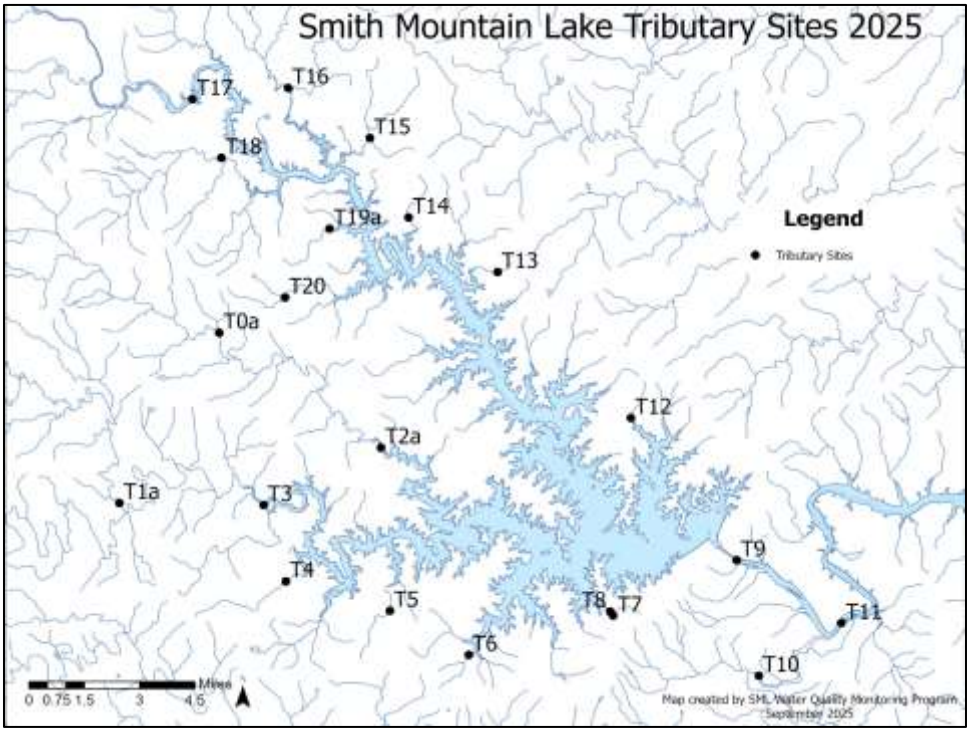

Figure A.2. Smith Mountain Lake Tributary monitoring stations

Table A.3. 2025 Total phosphorus (ppb) data for Smith Mountain Lake sample stations

	Sampling Period 1	Sampling Period 2	Sampling Period 3	Sampling Period 4	Sampling Period 5	Sampling Period 6	Station Avg.	Std. Dev.
Station	conc (ppb)	conc(ppb)	conc(ppb)	conc(ppb)	conc(ppb)	conc(ppb)	(ppb)	
B8	65.0	16.4	14.8	13.7	10.6	12.9	22.2	21.0
B10	20.9	17.9	14.2	14.3	10.5	11.1	14.8	4.0
B12	89.5	61.0	36.6	34.2	28.1	48.4	49.6	22.8
B14	193.1	28.8	15.5	25.9	18.6	36.6	53.1	69.0
B16	41.0	20.0	18.6	33.4	21.7	24.0	26.5	8.9
B18	51.9	25.8	25.9	37.0	21.5	26.5	31.4	11.3
B20	57.9	30.6	31.9	46.6	22.9	32.6	37.1	12.8
B22	83.3	108.1	67.6	71.8	61.4	87.9	80.0	16.9
C4	19.2	12.9	11.5	14.5	8.5	8.1	12.4	4.1
C5	13.8	11.1	10.3	13.0	6.8	8.8	10.6	2.6
C6	15.0	10.4	10.5	12.1	7.3	10.0	10.9	2.6
CB11	118.2	39.0	28.5	22.5	17.7	41.2	44.5	37.2
CB16	43.2	25.2	16.9	26.8	17.3	26.4	26.0	9.6
CB20	60.4	40.1	41.1	40.3	24.1	33.9	40.0	11.9
CM1	16.6	14.0	11.1	11.2	12.4	12.0	12.9	2.1
CM1.2	19.9	15.1	14.3	12.6	9.8	12.6	14.0	3.4
CM5	18.9	12.8	12.4	12.4	10.7	11.3	13.1	3.0
CR8	18.3	12.4	12.6	11.4	9.8	11.2	12.6	3.0
CR9	87.4	32.2	12.2	12.0	11.2	13.3	28.0	30.2
CR9.2	30.4	16.5	15.0	12.2	11.1	12.6	16.3	7.2
CR13	71.3	29.4	22.2	20.0	17.1	15.1	29.2	21.2
CR14.2	30.7	18.8	20.4	16.6	16.3	16.7	19.9	5.5
CR16	33.7	16.1	16.3	19.4	16.3	19.5	20.2	6.8
CR17	46.2	21.8	20.7	19.4	17.2	22.3	24.6	10.8
CR19	49.8	29.6	29.1	28.1	19.7	28.9	30.9	10.0
CR21	46.5	22.2	25.5	18.4	19.3	24.0	26.0	10.4
CR21.2	51.4	26.7	25.0	23.0	20.9	22.9	28.3	11.5
CR22	101.5	38.5	25.6	31.2	44.2	26.5	44.6	28.8
CR24	69.4	38.5	39.5	52.6	42.6	46.1	48.1	11.6
CR25	40.5	29.2	28.1	26.6	24.0	25.9	29.0	5.9
CR26	54.7	36.0	32.5	40.8	32.5	74.4	45.1	16.6
G12	380.0	90.0	60.5	53.4	59.7	157.0	133.4	126.8
G13	22.9	21.3	13.9	18.3	14.0	16.4	17.8	3.7
G14	34.5	23.7	17.1	18.0		14.3	21.5	8.0
G15	26.3	27.9	16.7	24.8	16.1	23.0	22.5	5.0
G16	43.0	29.0	31.0	31.8		21.0	31.1	7.9
G18	129.9	45.9	70.8	53.1		36.6	67.3	37.2
M0	17.6	11.9	11.0	17.2	7.1	10.7	12.6	4.1
M1	38.3	20.4	17.9	14.9	19.2	29.5	23.4	8.8

Table A.3. 2025 Total phosphorus data for Smith Mountain Lake sample stations (cont.)

M3	35.0	14.3	12.0	13.9	11.0	14.0	**16.7**	**9.1**
M5	20.6	15.5	13.4	11.7	9.0	15.1	**14.2**	**3.9**
R7	19.7	12.9	13.1	11.3	9.2	10.6	**12.8**	**3.7**
R9	23.2	19.4	18.2	13.6	12.1	15.4	**17.0**	**4.1**
R11	22.0	14.6	13.9	51.5	11.1	12.7	**21.0**	**15.4**
R13	27.6	18.3	18.1	17.1	16.9	18.7	**19.4**	**4.0**
R14	33.7	19.3	17.9	17.4	13.0	15.7	**19.5**	**7.3**
R15	28.8	17.2	16.3	15.8	13.2	18.0	**18.2**	**5.4**
R17	59.0	21.8	25.6	29.9	20.2	23.6	**30.0**	**14.6**
R19	47.3	23.0	30.6	27.7	21.4	24.5	**29.1**	**9.5**
R21	60.4	28.6	24.0	26.2	22.3	26.1	**31.3**	**14.4**
R23	48.9	36.0	29.8	25.5	26.6	27.5	**32.4**	**8.9**
R25	32.3	30.3	25.2	23.7	22.4	25.6	**26.6**	**3.9**
R27	141.3	52.7	25.7	72.6	42.6	65.2	**66.7**	**40.2**
R29	71.0	35.2	27.5	55.6	46.6	57.7	**48.9**	**15.9**
R30	50.9	36.6	39.8	47.4	50.7	65.5	**48.5**	**10.2**
R31	37.8	28.2	32.7	21.6	54.5	45.8	**36.8**	**12.0**
AVG.	**55.6**	**27.7**	**23.7**	**26.6**	**21.3**	**28.5**	**30.7**	**14.4**
STD. DEV.	**56.1**	**17.6**	**13.2**	**15.5**	**13.8**	**24.6**	**20.7**	**19.3**

Table A.4. 2025 Total phosphorus data for Smith Mountain Lake tributaries

	Sampling Period 1	Sampling Period 2	Sampling Period 3	Sampling Period 4	Sampling Period 5	Sampling Period 6	Station Avg.	Std. Dev.
Station	conc(ppb)	conc(ppb)	conc(ppb)	conc(ppb)	conc(ppb)	conc(ppb)	(ppb)	
T0a	57.7	63.2	73.4	97.5	39.8	45.2	**62.8**	**20.9**
T1a	54.1	67.3	79.8	88.5	59.4	51.7	**66.8**	**14.7**
T2a	62.3	73.3	80.1	105.5	49.4	37.9	**68.1**	**23.9**
T3	65.0	51.6	68.2	60.8	71.7	45.2	**60.4**	**10.2**
T4	19.6	23.9	22.5	27.0	15.5	21.3	**21.6**	**3.9**
T5	24.9	26.4	31.1	35.6	9.6	14.3	**23.7**	**9.9**
T6	27.9	33.6	30.3	29.7	11.5	13.6	**24.4**	**9.4**
T7	14.2	13.8	21.8	22.4	10.2	15.2	**16.3**	**4.8**
T8	15.2	13.0	14.4	17.9	8.0	14.2	**13.8**	**3.3**
T9	14.4	15.5	13.2	16.1	9.1	14.6	**13.8**	**2.5**
T10	41.0	29.2	39.8	40.3	30.8	62.6	**40.6**	**11.9**
T11	26.5	17.9	25.9	18.9	11.4	25.0	**21.0**	**6.0**
T12	23.3	20.3	27.2	24.7	13.6	20.0	**21.5**	**4.7**
T13	22.0	13.3	14.6	47.7	7.6	9.8	**19.1**	**14.8**
T14	141.0	239.0	431.1	149.5	47.7	45.8	**175.7**	**144.5**
T15	83.8	90.3	142.7	113.4	41.7	46.1	**86.4**	**38.8**
T16	45.9	61.8	68.2	131.8	39.6	55.7	**67.2**	**33.3**
T17	48.1	32.2	60.8	50.9	50.5	175.4	**69.7**	**52.6**
T18	36.1	35.2	44.6	43.6	17.8	21.3	**33.1**	**11.2**
T19a	77.8	55.2	63.7	70.9	45.6	40.2	**58.9**	**14.6**
T20	99.9	43.4	53.0	59.4	17.4	25.0	**49.7**	**29.4**
Average	**47.7**	**48.5**	**67.0**	**59.6**	**28.9**	**38.1**	**48.3**	**22.2**
St. Dev.	**32.5**	**49.1**	**89.0**	**40.0**	**20.0**	**35.4**	**37.1**	**30.9**

Table A.5. 2025 Chlorophyll-*a* data for Smith Mountain Lake sample stations

Station	Sampling Period 1	Sampling Period 2	Sampling Period 3	Sampling Period 4	Sampling Period 5	Sampling Period 6	Station Avg.	Std. Dev.
	conc(ppb)	conc(ppb)	conc(ppb)	conc(ppb)	conc(ppb)	conc(ppb)	(ppb)	
B8	3.30	3.96	2.83	0.75	4.25		3.02	1.38
B10	4.06	3.24	2.59	1.63	3.17		2.94	0.90
B12	4.17	4.63	4.17	2.50	2.07		3.51	1.14
B14	11.42	6.89	3.42	1.74	2.40		5.17	4.02
B16	13.00	10.67	9.29	4.72	2.96		8.13	4.18
B18	26.83	14.12	9.36	8.42	3.15		12.38	8.97
B20	37.90	27.45	11.88	8.16	10.72		19.22	12.90
B22	8.39	24.35	17.01	15.73	12.17		15.53	5.96
C4	2.59	4.06	1.69	0.81	0.66		1.96	1.40
C5	1.98	4.90	2.63	1.20	0.91		2.32	1.59
C6	2.82	2.82	3.30	0.69	1.04		2.13	1.18
CB11	6.12	5.73	3.52	1.25	2.95		3.91	2.02
CB16	13.63	8.86	9.23	4.27	2.06		7.61	4.54
CB20	29.00	23.60	12.38	10.74	3.06		15.76	10.42
CM1	2.69	1.93	1.44	0.40	0.53		1.40	0.96
CM1.2	2.30	2.47	1.65	0.54	0.61		1.51	0.91
CM5	2.99	2.52	2.27	0.97	0.81		1.91	0.97
CR8	3.25	3.26	2.45	1.11	0.60		2.13	1.23
CR9	4.67	2.96	2.86	0.83	1.23		2.51	1.54
CR9.2	4.60	2.93	2.81	0.70	1.58		2.52	1.48
CR13	14.70	4.50	4.03	4.53	1.61		5.87	5.08
CR14.2	2.41	2.65	9.41	8.04	2.41		4.98	3.45
CR16	20.88	7.29	6.99	11.23	7.14		10.71	5.96
CR17	26.11	9.65	6.71	5.16	11.62		11.85	8.36
CR19	26.25	14.96	16.91	19.00	6.86		16.80	7.01
CR21	26.60	14.54	14.36	13.02	6.70		15.04	7.21
CR21.2	26.19	14.84	12.91	16.11	10.62		16.13	5.99
CR22	26.36	17.76	12.71	17.25	4.53		15.72	7.97
CR24	20.97	7.01	20.85	22.47	15.16	29.50	19.33	7.58
CR25	17.56	11.38	18.18	15.25	4.45	18.72	14.26	5.51
CR26	20.42	9.76	10.58	20.45	4.38	16.37	13.66	6.48
G12	5.89	4.60	2.29	18.52	1.70	3.71	6.12	6.26
G13	4.57	7.63	3.35	9.48	1.14	6.66	5.47	3.04
G14	11.16	7.29	4.73	7.86		9.62	8.13	2.44
G15	6.21	10.14	6.43	5.45	1.11	14.02	7.23	4.40
G16	13.15	8.90	11.73	20.99		17.73	14.50	4.83
G18	17.10	21.84	29.50	39.00		30.30	27.55	8.43
M0	3.24	3.40	1.79	0.27	0.99	3.10	2.13	1.32
M1	3.18	3.26	2.33	0.25	1.05	2.45	2.09	1.20

Table A.5. 2025 Chlorophyll-*a* data for Smith Mountain Lake sample stations (cont.)

M3	3.37	3.64	1.89	0.35	1.14	2.73	**2.19**	**1.29**
M5	3.45	3.65	1.99	0.53	1.04	4.99	**2.61**	**1.71**
R7	4.65	3.57	2.97	0.65	0.85	4.88	**2.93**	**1.83**
R9	4.61	2.59	2.80	0.58	2.19	6.92	**3.28**	**2.20**
R11	7.19	3.91	3.59	1.05	1.85	12.81	**5.07**	**4.35**
R13	13.58	5.24	5.80	1.26	12.72	14.46	**8.84**	**5.45**
R14	18.61	8.43	6.10	2.09	3.65	14.51	**8.90**	**6.45**
R15	18.33	9.92	6.13	1.12	3.69	10.75	**8.32**	**6.11**
R17	34.70	14.45	18.47	7.66	5.98	26.68	**17.99**	**11.12**
R19	34.20	17.64	22.11	6.55	5.76	24.65	**18.49**	**10.98**
R21	36.30	17.13	11.33	3.76	5.94	22.34	**16.13**	**12.05**
R23	21.05	17.27	19.12	3.83	6.34	19.62	**14.54**	**7.46**
R25	16.75	9.38	15.19	6.89	11.99	13.06	**12.21**	**3.65**
R27	15.25	8.20	5.98	4.75	0.60	17.41	**8.70**	**6.44**
R29	25.34	8.36	7.40	4.57	4.28	19.40	**11.56**	**8.73**
R30	1.28	2.53	6.34	3.38	10.07	23.97	**7.93**	**8.47**
R31	0.97	0.83	3.89	1.76	7.19	25.40	**6.67**	**9.48**
AVG.	**13.18**	**8.56**	**7.92**	**6.65**	**4.22**	**14.88**	**8.74**	
St.Dev.	**10.67**	**6.39**	**6.43**	**7.74**	**3.83**	**8.51**		**3.33**

Table A.6. 2025 TSI-Combined data for Smith Mountain Lake sample stations

Station	MTD (mi)	TP (ppb)	CA (ppb)	SD (m)	TSI-TP	TSI-CA	TSI-SD	TSI-C
B8	8	22.2	3.0	2.8	48.9	41.4	45.4	45.2
B10	10	14.8	2.9	2.6	43.0	41.2	46.1	43.4
B12	12	49.6	3.5	1.7	60.5	42.9	52.3	51.9
B14	14	53.1	5.2	1.6	61.4	46.7	53.4	53.8
B16	16	26.5	8.1	1.1	51.4	51.2	58.3	53.6
B18	18	31.4	12.4	1.0	53.9	55.3	59.4	56.2
B20	20	37.1	19.2	1.0	56.2	59.6	59.4	58.4
B22	22	80.0	15.5	0.5	67.3	57.5	68.8	64.6
C4	4	12.4	2.0	3.1	40.5	37.2	43.6	40.4
C5	5	10.6	2.3	3.1	38.2	38.9	43.8	40.3
C6	6	10.9	2.1	2.7	38.6	38.0	45.9	40.8
CB11	11	44.5	3.9	1.8	58.9	44.0	51.6	51.5
CB16	16	26.0	7.6	1.2	51.1	50.5	57.3	53.0
CB20	20	40.0	15.8	1.1	57.3	57.6	58.3	57.8
CM1	1	12.9	1.4	3.4	41.0	33.9	42.5	39.1
CM1.2	1.2	14.0	1.5	3.5	42.3	34.7	42.1	39.7
CM5	5	13.1	1.9	2.7	41.2	37.0	45.6	41.3
CR8	8	12.6	2.1	2.8	40.7	38.0	45.2	41.3
CR9	9	28.0	2.5	2.4	52.2	39.6	47.3	46.4
CR9.2	9.2	16.3	2.5	2.4	44.4	39.7	47.3	43.8
CR13	13	29.2	5.9	2.2	52.8	48.0	48.6	49.8
CR14.2	14.2	19.9	5.0	1.8	47.3	46.4	51.9	48.5
CR16	16	20.2	10.7	1.8	47.5	53.9	51.9	51.1
CR17	17	24.6	11.9	1.7	50.3	54.9	52.3	52.5
CR19	19	30.9	16.8	1.6	53.6	58.3	53.4	55.1
CR21	21	26.0	15.0	1.6	51.1	57.2	53.0	53.8
CR21.2	21.2	28.3	16.1	1.5	52.4	57.9	54.2	54.8
CR22	22	44.6	15.7	1.4	58.9	57.6	55.4	57.3
CR24	24	48.1	19.3	0.9	60.0	59.7	61.3	60.3
CR25	25	29.0	14.3	1.2	52.7	56.7	57.8	55.7
CR26	26	45.1	13.7	1.2	59.1	56.2	57.8	57.7
G12	12	133.4	6.1	1.8	74.7	48.4	51.3	58.1
G13	13	17.8	5.5	2.2	45.7	47.3	48.9	47.3
G14	14	21.5	8.1	2.0	48.4	51.2	50.0	49.9
G15	15	22.5	7.2	1.7	49.0	50.0	52.3	50.4
G16	16	31.1	14.5	1.4	53.7	56.8	55.2	55.2
G18	18	67.3	27.5	1.1	64.8	63.1	58.6	62.2
M0	0	12.6	2.1	3.4	40.7	38.0	42.3	40.3
M1	1	23.4	2.1	3.4	49.6	37.8	42.3	43.2
M3	3	16.7	2.2	3.2	44.8	38.3	43.2	42.1

Table A.6. 2025 TSI-Combined data for Smith Mountain Lake sample stations (cont.)

M5	5	14.2	2.6	3.1	42.4	40.0	43.6	42.0
R7	7	12.8	2.9	2.6	40.9	41.1	46.1	42.7
R9	9	17.0	3.3	2.4	45.0	42.3	47.3	44.8
R11	11	21.0	5.1	2.3	48.0	46.5	48.1	47.5
R13	13	19.4	8.8	2.2	46.9	52.0	48.9	49.3
R14	14	19.5	8.9	2.0	47.0	52.0	49.7	49.6
R15	15	18.2	8.3	1.8	46.0	51.4	51.6	49.7
R17	17	30.0	18.0	1.7	53.2	58.9	52.3	54.8
R19	19	29.1	18.5	1.5	52.7	59.2	54.6	55.5
R21	21	31.3	16.1	1.5	53.8	57.9	54.6	55.4
R23	23	32.4	14.5	1.4	54.3	56.9	55.2	55.4
R25	25	26.6	12.2	1.2	51.4	55.1	57.3	54.6
R27	27	66.7	8.7	1.3	64.7	51.8	55.9	57.5
R29	29	48.9	11.6	1.4	60.3	54.6	55.4	56.8
R30	30	48.5	7.9	1.1	60.1	50.9	58.8	56.6
R31	31	36.8	6.7	0.8	56.1	49.2	62.6	56.0
Average		**30.7**	**8.7**	**1.9**	**51.2**	**49.0**	**51.7**	**50.6**

Table A.7. 2025 Secchi disk data for Smith Mountain Lake sample stations

Station	Sample Period 1	Sample Period 2	Sample Period 3	Sample Period 4	Sample Period 5	Sample Period 6	Station Avg.	Std. Dev.
	depth(m)	depth(m)	depth(m)	depth(m)	depth(m)	depth(m)	(m)	
B8	2.3	3.5	3.0	3.0	3.5	3.0	**3.0**	**0.5**
B10	2.0	3.5	3.5	3.0	3.5	2.8	**3.0**	**0.6**
B12	2.0	2.0	2.8	3.0	2.3	2.0	**2.3**	**0.4**
B14	1.5	1.8	1.5	3.0	2.3	2.0	**2.0**	**0.6**
B16	1.3	2.0	1.3	2.5	1.5	1.5	**1.7**	**0.5**
B18	2.0	1.8	1.5	1.5	1.5	1.3	**1.6**	**0.3**
B20	1.5	1.5	1.5	1.3	1.8	1.3	**1.5**	**0.2**
B22	1.0	0.8	1.0	0.8	1.8	0.8	**1.0**	**0.4**
C4	2.3	3.0	3.0	3.3	3.0	3.0	**2.9**	**0.3**
C5	2.3	3.0	3.0	3.0	3.0	3.0	**2.9**	**0.3**
C6	2.5	2.8	3.0	2.8	3.0	2.8	**2.8**	**0.2**
CB11	2.0	1.8	3.0	2.0	2.8	2.5	**2.3**	**0.5**
CB16	1.5	2.0	1.5	2.8	2.0	1.8	**1.9**	**0.5**
CB20	1.8	1.3	1.5	1.5	1.5	1.5	**1.5**	**0.2**
CM1	3.3	4.0	4.0	4.0	4.0	3.5	**3.8**	**0.3**
CM1.2	3.5	4.0	3.8	3.8	4.0	3.5	**3.8**	**0.2**
CM5	2.3	3.0	3.0	2.5	3.5	3.0	**2.9**	**0.4**
CR8	2.3	2.5	3.3	2.5	3.5	2.8	**2.8**	**0.5**
CR9	2.3	2.8	2.3	2.3	2.3	2.0	**2.3**	**0.2**
CR9.2	1.8	2.3	2.3	2.3	2.3	2.0	**2.1**	**0.2**
CR13	3.0	2.3	3.3	2.0	2.5	2.0	**2.5**	**0.5**
CR14.2	1.8	2.0	2.0	1.8	2.0	1.5	**1.8**	**0.2**
CR16	2.0	2.0	2.3	1.8	1.8	1.8	**1.9**	**0.2**
CR17	1.8	2.0	2.3	1.8	1.8	1.8	**1.9**	**0.2**
CR19	1.8	1.8	2.0	1.8	1.5	1.5	**1.7**	**0.2**
CR21	2.0	2.0	1.8	1.3	1.3	1.3	**1.6**	**0.4**
CR21.2	2.0	1.8	1.5	1.3	1.0	1.3	**1.5**	**0.4**
CR22	2.0	1.8	1.5	1.5	1.3	1.3	**1.5**	**0.3**
CR24	1.3	1.3	1.3	1.0	0.8	0.8	**1.0**	**0.2**
CR25	1.5	1.3	1.3	1.0	1.0	0.8	**1.1**	**0.3**
CR26	1.5	1.0	1.3	1.0	0.8	0.8	**1.0**	**0.3**
G12	2.0	2.3	3.0	2.8	2.8	2.5	**2.5**	**0.4**
G13	2.0	2.5	2.5	2.5	2.8	2.5	**2.5**	**0.2**
G14	3.0		3.0	2.8	1.3	2.5	**2.5**	**0.7**
G15	2.3	2.3	2.3	2.3	2.0	2.0	**2.2**	**0.1**
G16	2.5		2.5	2.5	1.8	2.3	**2.3**	**0.3**
G18	1.8		1.8	1.5	2.0	1.8	**1.8**	**0.2**
M0	3.5	4.3	4.3	3.5	4.0	3.8	**3.9**	**0.3**
M1	3.5	3.3	3.3	3.8	3.5	3.3	**3.4**	**0.2**
M3	3.0	3.5	3.5	3.8	4.0	3.5	**3.5**	**0.3**
M5	2.00	3.25	3.00	4.00	3.25	3.25	**3.13**	**0.65**
R7	1.50	2.75	3.25	3.25	2.50	2.50	**2.63**	**0.65**

Table A.7. 2025 Secchi disk data for Smith Mountain Lake sample stations (cont.)

R9	1.75	2.50	2.75	3.00	2.25	2.25	**2.42**	**0.44**
R11	1.50	2.50	3.25	2.75	1.75	2.00	**2.29**	**0.66**
R13	1.25	2.50	3.00	3.00	1.50	1.75	**2.17**	**0.77**
R14	1.50	2.25	1.75	2.75	1.75	2.25	**2.04**	**0.46**
R15	1.25	1.75	2.00	2.50	1.75	1.50	**1.79**	**0.43**
R17	1.25	2.00	2.00	1.75	1.75	1.50	**1.71**	**0.29**
R19	1.25	1.75	1.75	1.50	1.25	1.25	**1.46**	**0.25**
R21	1.00	1.75	2.00	1.50	1.25	1.25	**1.46**	**0.37**
R23	1.25	1.75	1.25	1.50	1.25	1,5	**1.40**	**0.22**
R25	1.25	1.50	1.00	1.00	1.00	1.50	**1.21**	**0.25**
R27	1.00	1.50	2.25	1.00	1.00	1.25	**1.33**	**0.49**
R29	1.00	1.50	2.25	1.25	1.00	1.25	**1.38**	**0.47**
R30	0.75	0.75	1.50	1.25	1.25	1.00	**1.08**	**0.30**
R31	0.75	0.75	1.00	1.00	0.75	0.75	**0.83**	**0.13**
SB12		2.00	3.25	1.75	2.00	2.00	**2.20**	**0.60**
SCB 8	2.00	2.25	2.75	2.75	2.75	2.50	**2.50**	**0.32**
SCB10	1.75	2.25	2.75	2.75	2.50	2.25	**2.38**	**0.38**
SCB11	1.75	2.25	2.25	2.75	2.50	2.50	**2.33**	**0.34**
SCB11.5	1.75	2.50	2.75	2.75	3.00	2.50	**2.54**	**0.43**
SCB14		1.75	2.75	1.50	1.50	1.75	**1.85**	**0.52**
SCB16		1.75	2.25	1.50	1.25	1.50	**1.65**	**0.38**
SCM5	2.25	2.75	3.00	3.50	3.50	3.00	**3.00**	**0.47**
SCR7	2.00	2.75	3.00	3.75	3.25	3.00	**2.96**	**0.58**
SCR8	2.00	2.75	2.75	3.25	3.25	2.75	**2.79**	**0.46**
SCR10.1	2.00	2.50	3.50	3.25	2.75	2.50	**2.75**	**0.55**
SCR10.2	1.75	2.50	3.75	3.50	3.00	2.75	**2.88**	**0.72**
SCR10.3	1.75	2.50	3.50	3.25	3.00	2.25	**2.71**	**0.66**
SCR11.1	1.75	2.00	2.75	3.00	1.75	2.00	**2.21**	**0.53**
SCR11.2	1.50	2.25	2.00	3.00	1.75	2.25	**2.13**	**0.52**
SCR11.3	1.25	2.25	2.00	2.75	2.00	1.75	**2.00**	**0.50**
SCR14	1.25	2.00	3.00	2.50	1.75	1.50	**2.00**	**0.65**
SCR14.1	1.75	1.75	2.00	2.50	1.75	1.50	**1.88**	**0.34**
SCR14.2	1.50	1.50	2.00	1.75	1.75	1.50	**1.67**	**0.20**
SCR14.3	1.75	1.75	2.00	2.75	1.75	1.50	**1.92**	**0.44**
SCR15	1.50	2.00	3.00	3.00	1.75	1.75	**2.17**	**0.66**
SCR 15.1	1.25	1.75	3.25	2.75	1.75	1.75	**2.08**	**0.75**
SCR 15.2	1.50	1.75	2.00	2.25	1.50	1.75	**1.79**	**0.29**
SCR17	1.75	1.75	1.75	1.75	1.50	1.50	**1.67**	**0.13**
SCR17.1	1.50	2.00	2.25	2.25	1.25	1.25	**1.75**	**0.47**
SCR18	1.75	2.00	2.50	2.25	1.75	1.75	**2.00**	**0.32**
SCR19.2	1.75	1.75	2.25	2.00	1.75	1.75	**1.88**	**0.21**
SCR20	1.75	2.00	2.25	2.00	1.75	1.75	**1.92**	**0.20**
AVG.	**1.54**	**2.04**	**2.34**	**2.35**	**1.97**	**1.86**	2.02	
STD. DEV.	**0.51**	**0.68**	**0.80**	**0.92**	**0.84**	**0.69**		**0.74**

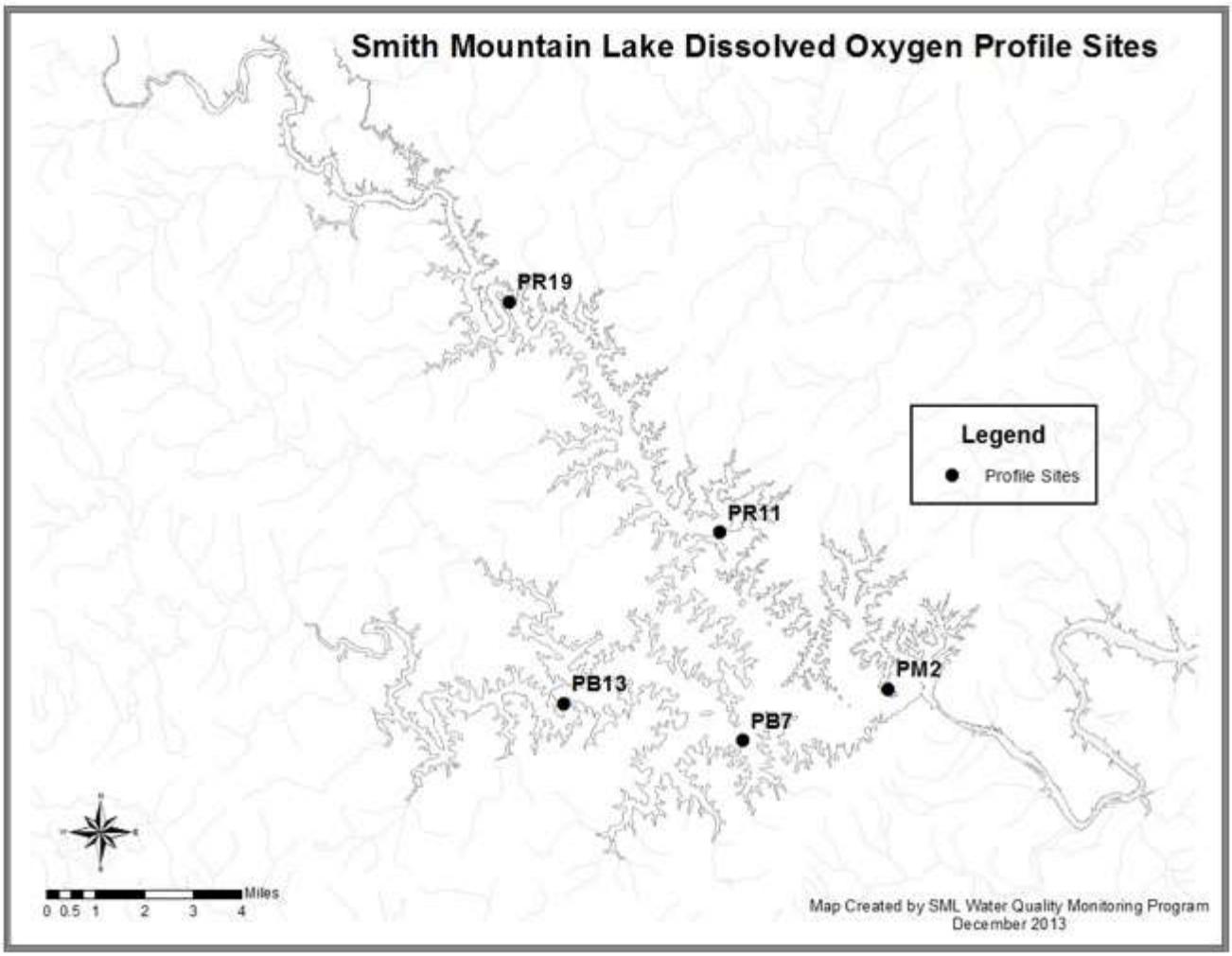

Figure A.3. Smith Mountain Lake depth profiling sites

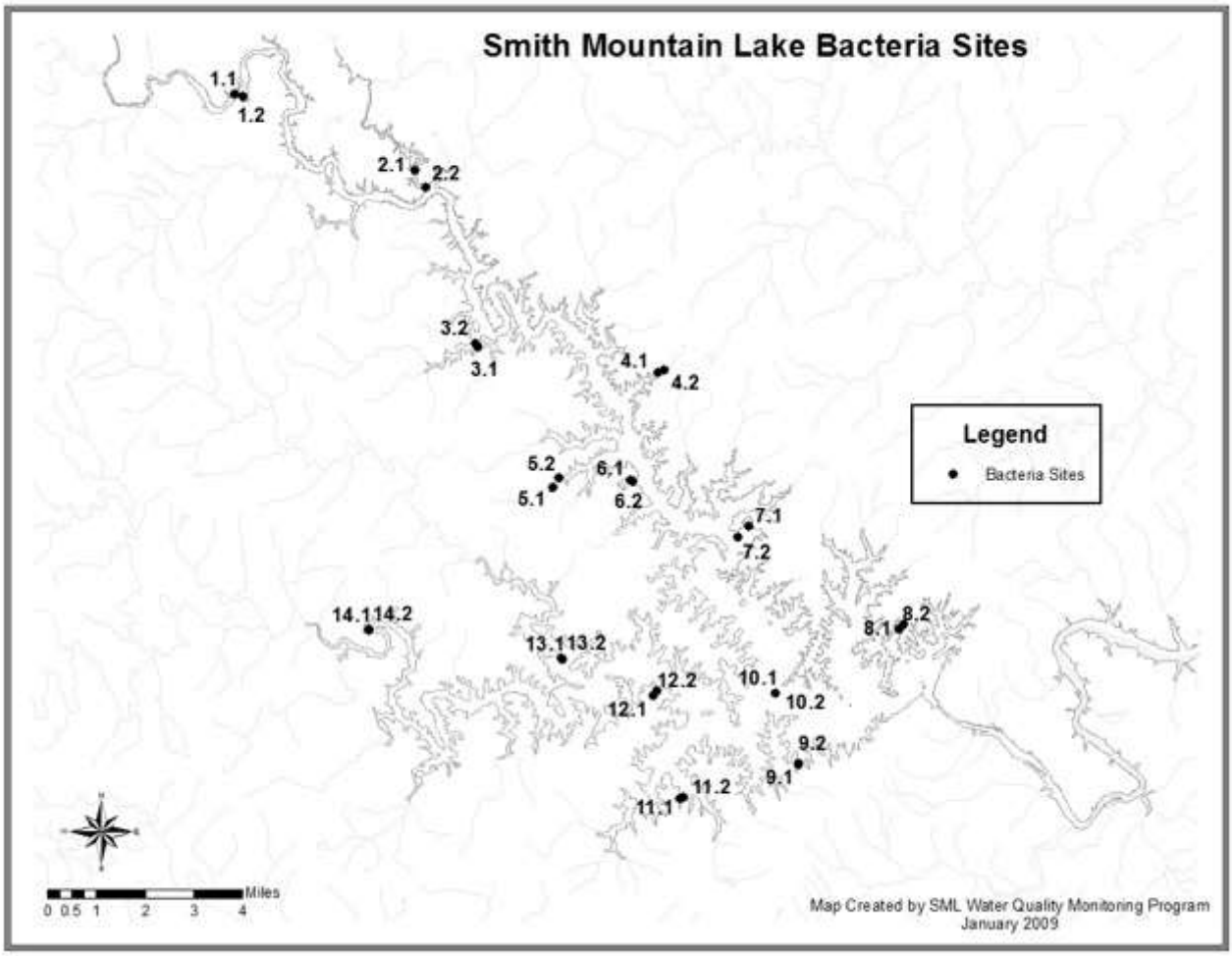

Figure A.4. Smith Mountain Lake bacterial sampling sites

Table A.8. 2025 *E. coli* data for Smith Mountain Lake sample stations (MPN = most probable number)

Station	Sample Period 1	Sample Period 2	Sample Period 3	Sample Period 4	Sample Period 5	Sample Period 6	Station Avg.	Std. Dev.
	MPN	MPN	MPN	MPN	MPN	MPN	MPN	
1-1	98.3	51.2	95.9	15.8	14.5	9.8	**47.6**	**41.1**
1-2	72.3	95.9	68.3	15.6	7.5	4.1	**44.0**	**39.5**
2-1	5.2	2.0	10.8	3.1	4.1	5.2	**5.1**	**3.1**
2-2	21.1	1.0	2.0	2.0	1.0	15.8	**7.2**	**8.9**
3-1	5.2	1.0	12.2	3.1	2.0	3.1	**4.4**	**4.1**
3-2	1.0	1.0	8.4	2.0	0.0	2.0	**2.4**	**3.0**
4-1	15.8	9.8	111.2	6.3	5.2	18.5	**27.8**	**41.2**
4-2	3.0	1.0	60.5	9.8	5.2	8.5	**14.7**	**22.7**
5-1	48.1	41.4	137.4	35.5	15.8	53.0	**55.2**	**42.3**
5-2	14.6	1.0	160.7	24.1	12.2	29.5	**40.4**	**59.8**
6-1	2.0	5.2	107.1	6.3	3.0	2.0	**20.9**	**42.2**
6-2	0.0	2.0	40.2	2.0	2.0	0.0	**7.7**	**16.0**
7-1	0.0	0.0	5.2	2.0	1.0	0.0	**1.4**	**2.0**
7-2	0.0	0.0	5.2	1.0	0.0	0.0	**1.0**	**2.1**
8-1	11.8	4.1	224.7	3.0	8.6	4.1	**42.7**	**89.2**
8-2	6.2	0.0	17.3	4.1	0.0	1.0	**4.8**	**6.6**
9-1	1.0	6.3	127.4	4.1	5.2	14.8	**26.5**	**49.7**
9-2	1.0	3.1	53.0	11.0	2.0	5.2	**12.6**	**20.1**
10-1	0.0	1.0	2.0	2.0	2.0	0.0	**1.2**	**1.0**
10-2	0.0	0.0	3.0	2.0	2.0	0.0	**1.2**	**1.3**
11-1	0.0	14.5	107.6	4.1	22.1	4.1	**25.4**	**41.1**
11-2	3.0	5.2	121.1	2.0	12.1	7.4	**25.1**	**47.2**
12-1	8.6	5.2	123.6	19.9	12.2	13.4	**30.5**	**45.9**
12-2	1.0	0.0	67.7	1.0	9.8	5.2	**14.1**	**26.5**
13-1	2.0	1.0	13.4	3.1	0.0	0.0	**3.3**	**5.1**
13-2	2.0	0.0	5.2	2.0	1.0	1.0	**1.9**	**1.8**
14-1	648.8	41.4	131.4	14.8	131.4	31.8	**166.6**	**241.6**
14-2	686.7	30.9	69.7	22.8	119.8	40.2	**161.7**	**259.6**
Average	**59.2**	**11.6**	**67.6**	**8.0**	**14.3**	**10.0**	**28.5**	
St. Dev.	**173.5**	**21.9**	**60.4**	**8.8**	**32.0**	**13.4**		**51.7**