Appalachian Power
Hydro Generation
P O Box 2021
Roanoke, VA 24022-2121
aep.com

Debbie-Anne A. Reese, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington DC 20426

VIA ELECTRONIC FILING

May 14, 2026

Re: Smith Mountain Project No. 2210
Water Quality Monitoring Plan
2025 Annual Water Quality Monitoring Report

Dear Secretary Reese:

In accordance with the Water Quality Monitoring Plan (WQMP) for the Smith Mountain Hydroelectric Project (Project), Appalachian Power Company (Appalachian) is to file an annual report of the water quality monitoring results of the previous year. Enclosed is the 2025 Annual Water Quality Monitoring Report. A draft of the annual report was provided to the Water Quality Technical Review Committee (WQTRC) via email attachment on February 23, 2026. Comments were received from the Leesville Lake Association (LLA) via email attachment on March 10, 2026. Comments were received from the Tri-County Lakes Administrative Commission (TLAC) via email on March 25, 2026. Also, the Virginia Department of Wildlife Resources (VDWR) replied via email on February 25, 2026 stating that VDWR had no additional comments. Documentation of consultation is attached.

TLAC made several comments on results documented within the report and its attachments; however, none of the comments necessitated changes to the draft report. The comments received from the LLA were predominantly about Appalachian's operations rather than the report itself. The LLA's comments did not necessitate changes to the report. Both TLAC and LLA noted that 100% compliance with Virginia's 4.0 mg/l instantaneous and 5.0 mg/l daily average dissolved oxygen requirements had not been achieved. They further indicated expectation and interest regarding the Dissolved Oxygen Enhancement Plan as required in Virginia Water Protection Permit Number 24-1547 issued by the Virginia Department of Environmental Quality (VDEQ).

In addition, the WQMP requires that the WQTRC meet at least once per year to review the monitoring results. A virtual meeting was held on April 29, 2026. Comments made during the meeting were similar to those made on the report; the VDEQ was in attendance and involved in the discussion. A copy of the meeting notes is attached.

Appalachian considers this to be a complete and timely filing of the 2025 Annual Water Quality Monitoring Report. If you have any additional questions or require additional information, please contact me at 540-985-2506 or ncsink@aep.com

Sincerely,

Nicholas C. Sink
Plant Support Specialist Senior

Attachments

Enclosure

Cc: Edward Brennan, Appalachian
Josh Blake, Appalachian
Kristina Sage, TLAC
Tom Hardy, SMLA
John Vidovich, SMLA
Charlie Hamilton, LLA
Tom Shahady, University of Lynchburg
Delia Heck, Ferrum College
Dan Wilson, VDWR
Eric Seavey, Virginia Department of Environmental Quality (VDEQ)
Mary Dail, VDEQ
George Devlin, VDEQ
Jason Hill, VDEQ

Attachment 1

Appalachian Power Company
Smith Mountain Project No. 2210
2026 Annual Water Quality Technical Review Committee Meeting (virtual)
April 29, 2026

Participants:

Appalachian Power Company (Appalachian)
Nicholas Sink, Joshua Blake, Edward Brennan,

Leesville Lake Association (LLA)
Charlie Hamilton

Tri-County Lakes Administrative Commission (TLAC)
Kristina Sage

Ferrum College
Dr. Delia Heck

EnviroScience
David Czayka

University of Lynchburg
Dr. Thomas Shahady

Virginia Department of Environmental Quality (VDEQ)
Jason Hill, Eric Seavey

Ed Brennan began the meeting by introducing the Appalachian participants and having the TRC participants introduce themselves. Ed presented a safety topic on tick exposure prevention and awareness.

Smith Mountain Dam Tailwater and Forebay 2025 Water Quality Monitoring Results Summary

Dave Czayka presented a slide summary of the 2025 water quality monitoring results for the Smith Mountain Dam tailwater and forebay. This information was provided in the 2025 Water Quality Monitoring Report previously distributed to the TRC.

- One monitoring station with 2 Hobo Loggers labeled A and B that measure temperature and dissolved oxygen (DO) at 15-minute intervals.
- Data collection period is June 1 to November 30th

- A data gap occurred from 06/10/2025 at 18:15 to 07/01/2025 at 14:15 as both loggers were damaged.
- HOBO Logger A readings were used unless suspect readings were identified.
    - B Logger data was used on 10/5/2025 at 20:15 to 10/6/2025 at 09:45, 10/9/2025 at 18:30 to 10/10/2025 at 10:30 and on 10/10/2025 at 11:00, 11:45, 12:30, and 12:45.
- 15,451 DO readings were recorded. 87% of those readings were greater than or equal to the instantaneous minimum requirement of 4.00 mg/L.
- Average instantaneous DO concentration during generation = 5.74 mg/L; average DO value during pump-back and non-operation scenarios was 5.98 mg/L
- Daily average DO concentration minimum requirement of 5.00 mg/L was achieved approximately 65% of the time.
- Reservoir profile graphs of DO and temperature with depth were similar to overall historical trends, but there are variations from year to year.

The meeting was then opened to questions.

Charlie Hamilton asked why the recommendations page has not changed in 10 years. Dave mentioned that the Smith Mountain Project is a unique project, and additional technologies have not been developed, and turned the discussion over to Ed Brennan.

Ed mentioned that the Virginia Water Protection Permit (VWP) expired and a new one has been issued in 2024. Part of the new VWP required a Dissolved Oxygen Improvement Plan, which has been submitted to VDEQ for review. The Dissolved Oxygen Improvement Plan, as proposed, involves investigations further down the stream from the bridge (i.e., monitoring location). Ed further stated that DO enhancement technology/measures applicable to Smith Mountain. Dam are limited. Auto-venting turbines (AVT) have been installed at Claytor Dam, but those are not currently feasible for Smith Mountain Dam. No manufacturer has ever made AVTs that are large enough for Smith Mountain Dam. Further, only 2 of the 5 units are potential candidates for AVTs since AVTs are not applicable to generation-pump back units. AVTs are very effective, but are not currently feasible at Smith Mountain Dam.

Dr. Thomas Shahady mentioned that he samples just below where the HOBO loggers are located (i.e. at the bridge), and about 15 years of historical data are available. Dr. Shahady commented on the intricacies of precipitation and water flow at the upper end of the Leesville Lake.

Charlie asked DEQ when the Dissolved Oxygen Enhancement Plan would be reviewed.

Eric Seavey replied that he would like to give a date but could not be sure; however, he would like to have it out within about a month or so.

Jason Hill commented that he had submitted all his comments on the plan.

Charlie Hamilton requested transparency on the Dissolved Oxygen Enhancement Plan and asked for Ed to comment.

Ed responded that Appalachian would move forward when the plan is returned from review. Ed reiterated that Appalachian has complied with the requirements of the VWP and that the Dissolved Oxygen Enhancement Plan has been submitted.

Charlie mentioned that he was sure TLAC has the same interest in transparency.

Ed stated that Appalachian met with the VDEQ and VDWR in 2025. VDWR has no issues with the Leesville Lake fishery and their comments were that the fishery is healthy. Ed stated that, of course, Appalachian would prefer to meet the state standards, but the dam was constructed in the 1960s and this kind of impoundment will thermally stratify. Water down low in the column will be oxygen deficient, and that is where the intakes are located for generation.

Charlie appreciated all the challenges but also acknowledged that Appalachian is not meeting the State's standards. Charlie recommended that Appalachian get on with it and fix it.

Kristina Sage (who had audio Issues and had to communicate via chat; Ed read the chats to the TRC) suggested that there be a separate meeting about the Dissolved Oxygen Enhancement Plan.

Ed opened the meeting to any additional questions relevant to the 2025 results and the draft report.

SMLA's 2025 Water Quality Monitoring Program and Results for Smith Mountain Lake

Dr. Delia Heck presented a summary of the 2025 SMLA Water Quality Monitoring Program results for Smith Mountain Lake.

- Average Total Phosphorus was higher at upper channels, but decreases as you go towards the dam.
- Bacterial levels exceeded the reporting levels in only two samples at site 14 on the Blackwater River; otherwise, bacteria levels were low.
- Average Secchi depths were lower than they have been. Secchi depths closer to the dam are 3m and higher, and drop to less than 1 meter at upstream locations.
- 30 sites were eutrophic while 20 were last year; these sites are further up the channels.
- The average in total phosphorus doubled from 11 to 24 ppb; however, this is in parts-per-billion, so it is still very low overall.
- Chlorophyll-a, majority of samples were less than 23 ppb. Highest concentrations were in the mid channel except for on the Blackwater River. Higher levels of nutrients further up the channels.

The meeting then opened for discussion

Dr. Shahady asked if higher chlorophyll-a values were found in the middle of the channel.

Dr. Heck confirmed this and mentioned that it is odd, as the values are usually highest at the headwaters whereas this year the values were lower at the headwaters, higher mid-channel, and then lower again further downstream. However, the values are again in PPB, so the difference is not large, but it is interesting.

Ed Brennan inquired if these results were more pronounced at the end of the summer and into the fall.

Dr. Heck confirmed this and mentioned it could potentially be attributed to lack of precipitation during that period of the monitoring season.

Dr. Heck further mentioned that Ferrum's data scientist is on sabbatical, but she has taken the last 24 years of water quality data and has been reviewing it. The data scientist is just about ready to present on that information; Dr. Heck stated she would find an appropriate venue to share all that information.

LLA's 2025 Water Quality Monitoring Program and Results for Leesville Lake

Dr. Shahady presented a slide summary of the 2025 Leesville Lake water quality monitoring results.

- Total of 8 sampling sites throughout the reservoir
- Phosphorus, Nitrogen, and Chlorophyll-*a* suggest lake is Eutrophic
- Eutrophication greatest at transition between Smith Mountain Dam and Toler Bridge
- Leesville Lake strongly stratified throughout summer season with anoxic conditions in the hypolimnion, varying greatly with lake level.
- Pigg River influx introduces pollutant loads including human waste (per bacterial source tracking analysis).
- Smith Mountain Lake pumping dynamics generate a diluting effect (to the negative impacts of poor water quality from the Pigg River) throughout the hypolimnion of Leesville Lake.
- Pumping operations generate complexities in water quality in upper regions of Leesville Lake.
- Water from Smith Mountain Dam and the Pigg River at times does not thoroughly mix for many miles downstream of the mouth of the Pigg River.
- Reservoir is stable and eutrophic at all stations.
- Apart from low dissolved oxygen during generation, the lake water quality benefits from the water introduced from Smith Mountain Lake
- High E-coli levels are observed out of the Pigg River during rain events.

Dr. Shahady also commented on debris concerns citing difficulty in navigating Leesville Lake during the spring of 2025 when high precipitation brought in a lot of debris. Generation and pump back moves debris around, and lots of debris was observed above MM9.

Charlie Hamilton mentioned Appalachian's cancellation of the Pigg River Debris Diversion Device, which Ed Brennan mentioned had been discussed during the Debris Technical Review Committee Meeting earlier in the week.

Ed asked Dr. Shahady if the lack of mixing of the water from Smith Mountain Dam and the Pigg River was more evident in the late summer months. Dr. Shahady stated that this was the case. Ed stated that the dynamics are complex and differences in water density owing to great differences in temperature between the two sources contributes to the slow mixing. Ed stated that similar conditions exist in the Smith Mountain Dam forebay during pump back operations during the summer months.

Ed inquired with the participants about whether there had been any applicants to the Soil and Water Conservation District for grant money for cattle exclusion fencing.

Charlie replied that riparian buffer zones have a positive effect on bacterial loading. There is a concerning trend for human waste, of which the source will be studied, but very little is coming from cattle. The predominant source is wildlife.

Dr. Shahady further clarified that there were some problems seen in Rocky Mount, including some sanitary pipes, and they are looking into it.

Dr. Shahady mentioned that when the reservoir is drawn down significantly, the whole reservoir can be depleted of oxygen, in reference to the drawdown of the reservoir in September of 2024. Ed noted that this was in response to Hurricane Helene, and that Appalachian manages the lake levels prior to heavy precipitation, as forecast by the National Weather Service, and needs to lower Leesville Lake to create storage to receive water from Smith Mountain Lake and the Pigg River in advance of forecast high inflows to the Project. Ed also mentioned that Appalachian has a Memorandum of Understanding with the U.S. Corps of Engineers to manage the Project as flood control to mitigate flooding downstream of Leesville Dam. Dr. Shahady noted that drawing down the reservoir will impact water quality, and this is something that could be considered when management DO in Leesville Lake. Everyone was in agreeance that public safety took precedence.

Charlie Hamilton mentioned that he had not received a completed 2025 FERC filing. Ed Brennan advised that this meeting is referenced in the report and that it will be filed with FERC by 5/15/26. Nick Sink clarified that the filing due date for Smith Mountain Lake Water Quality is 5/31/26, and Claytor's is 5/15/26.

The meeting concluded at 3:15PM.

Attachment 2

Nicholas C Sink

From:	ksage.tlac@sml.us.com
Sent:	Wednesday, March 25, 2026 12:19 PM
To:	Nicholas C Sink; 'SMLA Water Quality Monitoring'; 'Charlie Hamilton (LLA)'; 'Dr. Shahady (Lynchburg University)'; 'Dr. Delia Heck (Ferrum College)'; 'Clay Britton'; 'Dan Wilson (DWR)'; 'Seavey, Eric (DEQ)'; 'Mary Dail (DEQ)'; 'George Devlin (DEQ)'; 'Jason Hill (DEQ)'
Cc:	Joshua L Blake; Edward S Brennan; 'SMLA President'; David Czayka; 'Cory Fox'
Subject:	[EXTERNAL] RE: Draft 2025 Smith Mountain Pumped Storage Project Annual Water Quality Monitoring Report
Attachments:	TLAC Response 2025 Water Quality.pdf

Dear Nick:

The Tri-County Lakes Administrative Commission appreciates the opportunity to review the Appalachian Power Company's draft Smith Mountain Pumped Storage Project 2025 Annual Water Quality Monitoring Report.

Please see our response in the attached document.

With best regards,

Kristina Sage
Executive Director
Tri-County Lakes Administrative Commission
400 Scruggs Road, Suite 200
Moneta, VA 24121
(540) 721-4400

TRI-COUNTY LAKES
ADMINISTRATIVE COMMISSION

From: Nicholas C Sink <ncsink@aep.com>
Sent: Monday, February 23, 2026 11:30 AM
To: Kristina Sage (TLAC) <KSage.TLAC@SML.US.Com>; SMLA Water Quality Monitoring <wqm@smlassociation.org>; Charlie Hamilton (LLA) <wqc@leesvillelake.org>; Dr. Shahady (Lynchburg University) <Shahady@lynchburg.edu>; Dr. Delia Heck (Ferrum College) <DHeck@Ferrum.edu>; Clay Britton <cbritton@ferrum.edu>; Dan Wilson (DWR) <Dan.Wilson@DWR.Virginia.Gov>; 'Seavey, Eric (DEQ)' <eric.seavey@deq.virginia.gov>; Mary Dail (DEQ) <mary.dail@deq.virginia.gov>; George Devlin (DEQ) <george.devlin@deq.virginia.gov>; Jason Hill (DEQ) <JASON.HILL@DEQ.VIRGINIA.GOV>
Cc: Joshua L Blake <jlblake@aep.com>; Edward S Brennan <esbrennan@aep.com>; 'SMLA President' <president@smlassociation.org>; David Czayka <dczayka@enviroscienceinc.com>; Cory Fox

TRI-COUNTY LAKES
ADMINISTRATIVE COMMISSION
400 Scruggs Rd., Suite 200
Moneta, VA 24121
Tel.: (540) 721-4400

Leesville Lake *Smith Mountain Lake*

March 25, 2026

Nicholas C. Sink
Plant Support Specialist
Appalachian Power Co.
40 Franklin Road SW
Roanoke, VA 24011

Dear Mr. Sink:

The Tri-County Lakes Administrative Commission (TLAC) appreciates the opportunity to comment on Appalachian Power Company's (Appalachian) draft *Smith Mountain Pumped Storage Project 2025 Annual Water Quality Monitoring Report*. The community is fortunate to have the legacy data and continued refinement of the programs which produce reliable and actionable results including those of the Smith Mountain Lake Association (SMLA) in conjunction with Ferrum College and Leesville Lake Association in conjunction with the University of Lynchburg. TLAC is pleased to note that water quality in Smith Mountain Lake indicates the lake is not aging as quickly as would be predicted for a reservoir. Likewise, the water quality in Leesville Lake though slightly eutrophic, is relatively stable.

The most concerning component of the report is dissolved oxygen (DO) levels. This continues to be particularly problematic. In the upper channels, the advanced occurrence of Hypolimnetic oxygen depletion occurring before the end of May rather than June, as in prior years, is notable. TLAC is pleased that there have been improvements to the implementation and monitoring of the DO enhancement operational regime which has resulted in DO enhancement in the Smith Mountain Dam discharge. However, the daily average DO achieved minimum requirements only 65% of the time. There is much room for improvement. The Smith Mountain Lake Water Quality Monitoring Program 2025 Report also indicates concern about DO above the dam noting organic matter settling and decomposing will increase the oxygen deficit.

TLAC anticipates additional enhancements that will contribute to the tailwaters achieving minimum required DO levels of Section 401 of the Clean Water Act, as amended by 33USC section 1341, and the Virginia State Water Control Law and Regulations. The recommendations listed in *5.0 Summary and Recommendations* are useful to monitor DO and to determine factors that contribute to fluctuations in DO, however the data indicates the only change to operations with potential to improve DO levels will be engineering measures. TLAC looks forward to receiving a comprehensive plan to improve DO levels as was to be developed in accordance with APCO's final Permit VWP number 241547, July 7, 2025.

As noted in Appendix A, Smith Mountain Lake Water Quality Monitoring Program 2025 Report, an ongoing water quality concern at Smith Mountain Lake, and most waterbodies, is Harmful Algal Blooms (HABs). The 2025 season at Smith Mountain Lake (SML) had a low number of HABs, and higher phytoplankton concentrations than in 2024. Due to the negative impacts of HABs on water quality and the associated risks posed to aquatic life, humans, and other animals, identifying contributing factors to minimize and prevent future outbreaks is essential.

In 2025, the slight decrease of Secchi depth readings in Smith Mountain Lake, the increase in total phosphorus and the increase of chlorophyll-a concentrations are noted but not of primary concern. Leesville Lake results for Secchi depth readings are degrading slightly. The Leesville Lake Water Quality Monitoring Report notes this may be a pattern and bears watching, however the TSI average demonstrates Leesville Lake water quality in the reservoir is stable.

The levels of E. coli in Smith Mountain Lake increased slightly. As anticipated, non-marinas continue to have the lowest levels. The overall level of E. coli is not concerning, however the increase from headwaters is. In the Leesville Lake Water Quality Monitoring Report, E. coli levels trended as one would expect with higher levels earlier in the seasons that diminished from July to October.

Thank you again for the opportunity to comment on the *2025 Draft Annual Water Quality Monitoring Report*.

Sincerely,

Kristina Sage
Executive Director
Tri-County Lakes Administrative Commission
400 Scruggs Road, Suite 200
Moneta, VA 24121
(540) 721-4400

Nicholas C Sink

From: Charlie Hamilton <cshamilton2@gmail.com>
Sent: Tuesday, March 10, 2026 9:38 AM
To: Nicholas C Sink; Kristina Sage (TLAC); SMLA Water Quality Monitoring; Charlie Hamilton (LLA); Dr. Shahady (Lynchburg University); Dr. Delia Heck (Ferrum College); Clay Britton; Dan Wilson (DWR); 'Seavey, Eric (DEQ)'; Mary Dail (DEQ); George Devlin (DEQ); Jason Hill (DEQ)
Cc: Joshua L Blake; Edward S Brennan; 'SMLA President'; David Czayka; Cory Fox
Subject: [EXTERNAL] Re: Draft 2025 Smith Mountain Pumped Storage Project Annual Water Quality Monitoring Report
Attachments: APCo 2025 Annual Report draft LLA comments.docx

Nicholas, thanks for the opportunity to comment on APCo's 2025 WQ report. Attached are LLA comments. Thanks Charlie

---

From: Nicholas C Sink <ncsink@aep.com>
Sent: Monday, February 23, 2026 11:29 AM
To: Kristina Sage (TLAC) <KSage.TLAC@SML.US.Com>; SMLA Water Quality Monitoring <wqm@smlassociation.org>; Charlie Hamilton (LLA) <wqc@leesvillelake.org>; Dr. Shahady (Lynchburg University) <Shahady@lynchburg.edu>; Dr. Delia Heck (Ferrum College) <DHeck@Ferrum.edu>; Clay Britton <cbritton@ferrum.edu>; Dan Wilson (DWR) <Dan.Wilson@DWR.Virginia.Gov>; 'Seavey, Eric (DEQ)' <eric.seavey@deq.virginia.gov>; Mary Dail (DEQ) <mary.dail@deq.virginia.gov>; George Devlin (DEQ) <george.devlin@deq.virginia.gov>; Jason Hill (DEQ) <JASON.HILL@DEQ.VIRGINIA.GOV>
Cc: Joshua L Blake <jlblake@aep.com>; Edward S Brennan <esbrennan@aep.com>; 'SMLA President' <president@smlassociation.org>; David Czayka <dczayka@enviroscienceinc.com>; Cory Fox <cfox@enviroscienceinc.com>
Subject: Draft 2025 Smith Mountain Pumped Storage Project Annual Water Quality Monitoring Report

All,

Please find attached Appalachian Power Company's (Appalachian) draft Smith Mountain Pumped Storage Project 2025 Annual Water Quality Monitoring Report.

Please review the report and provide Appalachian with your comments by March 25, 2026. Kindly "Reply All" so that everyone may have the benefit of your comments. If you have no comments, please reply stating so.

Thanks,

-Nick

The Leesville Lake Association appreciates the opportunity to comment on the Smith Mountain Hydroelectric Project 2025 Annual Water Quality Monitoring Report. The Dissolved Oxygen challenges are well documented in this report. It shows that Appalachian Power Company (APCo) has not met its operating license requirements regarding the minimal DO content permissible in water released during SML Dam operations for at least the past eleven consecutive years.

Background

APCo's FERC Operating License P-2210 must comply with Section 401 of the Clean Water Act, as amended by 33 USC section 1341, and the Virginia State Water Control Law and regulations. Specifically these are Virginia Administrative Code Title 9, Environment Agency 25, State Water Control Board Chapter 260, Water Quality Standards (9VAC25-260). Two sections of 9VAC25-260 are pertinent: 9VAC24-260-187 "Criteria for Man-Made Lakes and Reservoirs to Protect Aquatic Life and Recreational Designated Uses from the Impacts of Nutrients"; and 9VAC25-260-50 "Numerical Criteria for Dissolved Oxygen, pH, and Maximum Temperature".

9VAC25-260-187 specifically defines Smith Mountain Lake, and Leesville Reservoir as man made lakes and reservoirs, with Chlorophyll a criterion of 25 ug/L, and Total Phosphorous of 30 ug/L. Section 187 imposes no Dissolved Oxygen criteria.

9VAC25-260-50 defines Class III Non Tidal Waters (Coastal and Piedmont Zones), as having a Dissolved Oxygen criteria minimum of 4.0 mg/l, Daily Average 5.0mg/l, pH ranging from 6.0-9.0, and Maximum Temperature of 32 degrees C. It footnotes: "For a thermally stratified man-made lake or reservoir in Class III, IV, V, or VI waters that are listed in 9VAC25-260-187, these dissolved oxygen and pH criteria only apply to the epilimnion of the waterbody." Smith Mountain Lake and Leesville Reservoir are Class III waters.

APCo's FERC Operating License P-2210 ":"The permittee shall operate the turbines at Smith Mountain dam from July 1st through September 30th in a fashion that will minimize or eliminate violations of water quality standards for dissolved oxygen in the tail waters below Smith Mountain Dam. During this time period, the permittee will dispatch the turbines with intakes that are highest in the water column first and take those offline last when generating."

Discussion

Smith Mountain Hydroelectric Project 2025 Annual Water Quality Monitoring Report, dated February 23, 2026, Tables 3.1, 3.2, 3.3, 3.4 show the numbers of days between mid July and mid October 2024 where the water quality standards were not met. Table 4.3 Annual Percentage of Time Instantaneous and Daily Average DO shows that the permittee has not met the dissolved oxygen standards between mid July and mid October over the past ten (10) years.

Year	% Time Instantaneous DO Standard Met (4.0mg/l)	% Time Daily Average DO Standard Met (5.0 mg/l)
2015	75%	83%
2016	87%	60%
2017	97%	48%
2018	60%	47%
2019	66%	37%
2020	69%	40%
2021	81%	60%
2022	76%	42%
2023	88%	57%
2024	75%	60%
2025	85%	65%

Smith Mountain Hydroelectric Project 2025 Annual Water Quality Monitoring Report, dated February 23, 2026, Summary and Recommendations states "Continue to use the "first on, last off" operating protocol from July 1 to November 15." VDEQ Individual Permit No. 24-1547 "Permit Decision Rationale (page 4 of 19) Table 1"Smith Mountain Intakes, Penstocks, and Unit Parameters

Shows: Smith Mountain Lake level at 795 feet

Penstock 1 – 655 feet - Pinstock 1 is 140 feet deep or 42.7 meters deep

Penstock 2 – 737 feet Pinstock 2 is 59 feet deep or 18 meters deep

Penstock 3 – 737 feet Pinstock 3 is 59 feet deep or 18 meters deep

Penstock 4 – 737 feet Pinstock 4 is 59 feet deep or 18 meters deep

Penstock 5 – 600 feet Pinstock 5 is 195 feet deep or 50.4 meters deep

Smith Mountain Hydroelectric Project 2025 Annual Water Quality Monitoring Report, dated February 23, 2026 oxygen curves at SML we see this with depth:

Dissolved oxygen is below 5 mg/L by 8 meters depth

Dissolved oxygen is between 2-3 mg/L by 18 meters depth

Dissolved oxygen is zero(anoxic) by 40 meters

"First on-Last Off" procedure at best yields 2-3 mg/l dissolved oxygen at the tailwater which does not meet the water quality standard. Certainly that is better than using Pinstocks 1 and 5 (0 mg/l Dissolved Oxygen), but it does not solve the issue.

Smith Mountain Hydroelectric Project 2025 Annual Water Quality Monitoring Report, dated February 23, 2026, Summary and Recommendations provides the same list of recommendations as the previous 10 reports. It is unclear what will improve water quality of either Smith Mountain Lake or Leesville Lake – specifically to achieve year-round compliance of 4.0 mg/l instantaneous dissolved oxygen, and 5.0 mg/l daily average dissolved oxygen, in order to meet Virginia state standards

Recommendations

1. It is disappointing that the Smith Mountain Hydroelectric Project 2025 Annual Water Quality Monitoring Report makes no mention, or provides any potential insights of the Permit required plan for DO correction. "APCo will develop a comprehensive plan, designed in consultation with VDEQ, the Department of Wildlife Resources (DWR) and other state or federal agencies to address depressed DO levels downstream from Smith Mountain Lake Dam. This plan is in accordance with APCo's final Permit VWP number 24 1547 signed on July 7, 2025. The plan is to protect instream beneficial uses, to ensure compliance with applicable water quality standards, to prevent impairment of state waters or fish and wildlife resources, and to provide no net loss of wetland acreage and function through compensatory mitigation and success monitoring and reporting." Hopefully, APCo's upcoming (April/May 2026) submission of a Dissolved Oxygen (DO) Improvement Plan to the Virginia Department of Environmental Quality for review and approval will go a long way to addressing these issues.

2. Recommend the annual WQTRC be fully briefed on the DO Improvement Plan.
3. Recommend the WQTRC be afforded the opportunity to react to the DO Improvement plan and provide meaningful input to APCo, and VDEQ.

Charlie Hamilton

Leesville Lake Association

Water Quality Chair

Nicholas C Sink

From: Wilson, Daniel (DWR) <Dan.Wilson@DWR.Virginia.Gov>
Sent: Wednesday, February 25, 2026 3:18 PM
To: Nicholas C Sink
Subject: [EXTERNAL] RE: Draft 2025 Smith Mountain Pumped Storage Project Annual Water Quality Monitoring Report

No additional comments.

Dan Wilson
Fisheries Biologist
O 434-525-7522 / M 434-942-0405
dan.wilson@dwr.virginia.gov
Virginia Department of Wildlife Resources
1132 Thomas Jefferson Road, Forest, VA 24551

From: Nicholas C Sink <ncsink@aep.com>
Sent: Monday, February 23, 2026 11:30 AM
To: Kristina Sage (TLAC) <KSage.TLAC@SML.US.Com>; SMLA Water Quality Monitoring <wqm@smlassociation.org>; Charlie Hamilton (LLA) <wqc@leesvillelake.org>; Dr. Shahady (Lynchburg University) <Shahady@lynchburg.edu>; Dr. Delia Heck (Ferrum College) <DHeck@Ferrum.edu>; Clay Britton <cbritton@ferrum.edu>; Wilson, Daniel (DWR) <Dan.Wilson@DWR.Virginia.Gov>; Seavey, Eric (DEQ) <eric.seavey@deq.virginia.gov>; Dail, Mary (DEQ) <mary.dail@deq.virginia.gov>; Devlin, George (DEQ) <george.devlin@deq.virginia.gov>; Hill, Jason (DEQ) <JASON.HILL@DEQ.VIRGINIA.GOV>
Cc: Joshua L Blake <jlblake@aep.com>; Edward S Brennan <esbrennan@aep.com>; 'SMLA President' <president@smlassociation.org>; David Czayka <dczayka@enviroscienceinc.com>; Cory Fox <cfox@enviroscienceinc.com>
Subject: Draft 2025 Smith Mountain Pumped Storage Project Annual Water Quality Monitoring Report

All,

Please find attached Appalachian Power Company's (Appalachian) draft Smith Mountain Pumped Storage Project 2025 Annual Water Quality Monitoring Report.

Please review the report and provide Appalachian with your comments by March 25, 2026. Kindly "Reply All" so that everyone may have the benefit of your comments. If you have no comments, please reply stating so.

Thanks,

Nicholas C Sink

From:	Nicholas C Sink
Sent:	Monday, February 23, 2026 11:30 AM
To:	Kristina Sage (TLAC); SMLA Water Quality Monitoring; Charlie Hamilton (LLA); Dr. Shahady (Lynchburg University); Dr. Delia Heck (Ferrum College); Clay Britton; Dan Wilson (DWR); 'Seavey, Eric (DEQ)'; Mary Dail (DEQ); George Devlin (DEQ); Jason Hill (DEQ)
Cc:	Joshua L Blake; Edward S Brennan; 'SMLA President'; David Czayka; Cory Fox
Subject:	Draft 2025 Smith Mountain Pumped Storage Project Annual Water Quality Monitoring Report
Attachments:	Draft 2025 Smith Mountain Pumped Storage Project Annual WQ Monitoring Report.pdf

All,

Please find attached Appalachian Power Company's (Appalachian) draft Smith Mountain Pumped Storage Project 2025 Annual Water Quality Monitoring Report.

Please review the report and provide Appalachian with your comments by March 25, 2026. Kindly "Reply All" so that everyone may have the benefit of your comments. If you have no comments, please reply stating so.

Thanks,

-Nick

APPALACHIAN POWER

NICHOLAS C SINK | PLANT SUPPORT SPEC
Pronouns: HE/HIM/HIS
NCSINK@AEP.COM | D:540.985.2506
40 FRANKLIN ROAD SW, ROANOKE, VA 24011

Enclosure

SMITH MOUNTAIN PUMPED STORAGE PROJECT

2025 Annual Water Quality Monitoring Report

Prepared for:

APPALACHIAN POWER

An AEP Company

ES Project Number: 18946
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Prepared by:

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Smith Mountain Hydroelectric Project
Water Quality Monitoring Program (2025)
EnviroScience Project Number: 18946
Document Date: 2/23/2026

Prepared for:
Appalachian Power Company

Authorization for Release

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The undersigned attest, to the best of their knowledge, that this document and the information contained herein is accurate and conforms to EnviroScience's internal Quality Assurance standards.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

License requirements associated with the Smith Mountain Hydroelectric Project (Project) require the licensee, Appalachian Power Company (Appalachian), to implement a Water Quality Monitoring Plan (Plan) as part of license Article 405. The order approving the Plan was issued on April 15, 2011. The Plan lists the following requirements:

1. Operate the turbines at Smith Mountain Dam from July 1 through September 30 to minimize or eliminate violations of water quality standards for dissolved oxygen (DO) in the tailwaters downstream from the Smith Mountain Dam, whereby the turbines with intakes that are highest in the water column are operated first and taken offline last.
2. Develop and file, in accordance with the requirements of Article 401(a) for Condition F.4 found in Part I of the Virginia Department of Environmental Quality's (Virginia DEQ) water quality certification (WQC), a feasibility study and plan for physical or mechanical alterations of water release procedures, developed in consultation with the Water Quality Technical Review Committee (WQTRC[1]), to address violations of water quality standards for DO caused by turbine discharge from Smith Mountain Lake, should the operating practices employed prove insufficient at improving DO levels in Smith Mountain's turbine discharge.
3. Monitor DO and water temperature in the tailrace of the Smith Mountain Development at the first bridge leading to the Visitors Center. The monitoring will be conducted for the first five years following issuance of the new license. For the first two years of monitoring, DO and temperature will be recorded continuously year-round. If after two years of data collection it is determined that year-round data is not warranted, the monitoring period would be reduced accordingly. (Note: as agreed to by the WQTRC during the annual meeting on June 5, 2014, the monitoring period was adjusted to include June 1 through December 1. This modified schedule was approved by FERC order dated October 21, 2015.)
4. Provide the WQTRC with the water quality data collected on a monthly (May 1 to October 31) and bi-monthly (November 1 to April 30) basis.
5. At least once per year during the five-year monitoring period, DO and temperature monitoring will be conducted along a transect just upstream of the Smith Mountain Dam, near the forebay. The forebay monitoring will be conducted during the generation mode and during the anticipated stratification period between the beginning of July and the end of September. Measurements will be taken at 2-meter intervals from the lake surface to the bottom of the lake at four locations across the transect.
6. Consult annually with the WQTRC. The WQTRC will meet at least once per year to review the monitoring results and discuss the success of the operational modifications in maintaining state standards for DO in the Project discharge water.

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[1] The WQTRC consists of the Virginia Department of Wildlife Resources (formerly named Game and Inland Fisheries), Virginia DEQ, Tri-County Administrative Commission, Smith Mountain Lake Association, LLA, Ferrum College, and the University of Lynchburg.

7. Annually monitor, or arrange for the annual monitoring of, water quality on Smith Mountain and Leesville Lakes that (i) is consistent[2] with the programs implemented prior to the issuance of the current license by the Smith Mountain Lake Association (SMLA) and the Leesville Lake Association (LLA) and (ii) is developed in consultation with the Virginia Department of Wildlife Resources (Virginia DWR), the Virginia DEQ, the SMLA, the LLA, Ferrum College, and the University of Lynchburg.

   Smith Mountain Lake Monitoring Program

   - Monitor, or arrange for the monitoring of, water quality at 26 sites on Smith Mountain Lake. The sites correspond to locations included in the SMLA water quality monitoring program and are identified in the Plan. At these 26 sites, total phosphorus, chlorophyll-a, and secchi depth will be measured monthly between June 1 and September 30, for a total of four sampling events each year. At the same time, sampling for the bacteria *Escherichia coli* (*E. coli*) will be conducted at the fourteen sampling sites identified in the 2008 SMLA water quality monitoring plan.

   Leesville Lake Monitoring Program

   - Monitor, or arrange for the monitoring of, water quality on Leesville Lake. Sampling for total phosphorus, DO, and secchi depth will be monitored at six sites identified in the licensee's plan and chlorophyll-a will be monitored at three of those six sites. In addition, sampling for bacteria (*E. coli*) will be conducted at seven sites identified in the licensee's plan. The monitoring sites correspond to locations included in the LLA's water quality monitoring program for Leesville Lake. Sampling will occur monthly between May 1 and September 30, for a total of five sampling events each year.

8. Prepare annual reports of the water quality monitoring results of the previous year. The annual reports would include the following: all monitoring data; an analysis of the effects of power generation on DO levels in the Smith Mountain Tailrace; recommendations for continued monitoring or revisions to the following year's monitoring plan; a summary of other water quality monitoring results that have been completed outside of the Project license; and any other support documents including documentation of consultation with the WQTRC. The licensee will submit the reports to the WQTRC for a 30-day review and comment period and then file final reports with the Commission.

The approved Water Quality Monitoring Plan (Plan) for the Smith Mountain Project requires Appalachian Power Company, a unit of American Electric Power Company (AEP), to monitor dissolved oxygen (DO) levels and water temperatures at one location downstream of Smith Mountain Dam on the Roanoke River. The monitoring location downstream of Smith Mountain Dam is illustrated in Figure 1.1. Water quality data will be provided to the Water Quality/Water Management Technical Review Committee (TRC) monthly for data collected from June 1 to November 30. This annual report presents water quality monitoring data collected from June 1 –

[2] In the Commission's Final Environmental Impact Statement (FEIS) for the relicensing of the Project (issued August 7, 2009) staff defined the term consistent used in this context to mean that the licensee's water quality monitoring program for the lakes would, at a minimum, be similar to (or comparable to) the existing programs implemented by the SMLA and the LLA. The licensee's program would be conducted in such a way to facilitate the use of the data to establish long-term trends for nutrients and other measured parameters.

November 30, 2025 and is the 2025 annual report required by provision No. 8 above. This also addresses provision Nos. 1, 3, and 5. The monitoring results from provision No. 7 are provided in Appendices A and B. With regard to the Smith Mountain Lake Monitoring Program, Article 405 identifies a monitoring program between June 1 and September 30 of each year. Article 405 further states that monitoring should be consistent with efforts conducted by SMLA prior to the issuance of the new license. As in the past, the 2025 monitoring efforts were conducted by SMLA in conjunction with Ferrum College. Also, consistent with recent years, the Smith Mountain Lake Monitoring Program was implemented between May 1 and August 31. While different from the aforementioned time period specified in Article 405, it is similar and comparable to previous monitoring efforts. The timing of these efforts was established by SMLA and Ferrum College.

Past monitoring has shown that while the implemented operational measures for DO enhancement provide benefits, the DO standards are not achieved 100% of the time. Therefore, beginning in 2016 an investigation of other DO enhancement techniques suitable for the Project began. The investigation is an iterative process where initial concepts are designed and then tested. Information from test results then informs subsequent decisions regarding methods and testing. For example, in 2016 turbine venting was identified as a potential DO enhancement method for the Project; however, subsequent testing in 2017 indicated that the turbine units were not conducive to venting. Appalachian continues to compare data to different operational statuses and environmental influences.

1.1 BACKGROUND

The Smith Mountain powerhouse contains five generating units. The intakes are at three different elevations. Intakes for Units 1 and 5 are the deepest in the water column with the centerline (CL) of the intake openings at an elevation of 202 meters (m) [665 feet (ft)] and 186 m (610 ft), respectively. The CL intakes for Units 2, 3, and 4 are each located at an elevation of 750 ft. The penstocks for Units 1 and 5 are each 6 m (20 ft) in diameter, and those for Units 2, 3, and 4 are each 8 m (26 ft) in diameter. Units 1, 3, and 5 have dual function; that is, they are used to generate power and to pump back water from Leesville Lake (i.e., lower development) into Smith Mountain Lake (i.e., upper development). The adjusted water surface elevation at full operating pool is 242 m (795 ft). (Note that all elevations are relative to the National Geodetic Vertical Datum). During periods of lake stratification, the lower portions of the Smith Mountain Lake water column are characterized by low DO levels and cooler water temperatures, as is typical of many reservoirs during warm summer/fall periods. Upper portions of the water column generally exhibit higher DO levels and warmer water temperatures. Intakes generally withdraw water from the immediate region of the water column in which they are located and, therefore, the water passing through them is characterized by the physical and chemical properties occurring in those regions. As a result, if an intake is located in a portion of the water column with low DO, it can be expected that the water passing through that intake would have a similar low DO level. It should be noted, however, that the withdrawal zone of a given intake can encompass a much larger portion of the water column than what is represented by the intake itself. The withdrawal zone is influenced by factors such as intake geometry, flow, and water density.

As part of the Plan to improve DO levels during warmer water temperatures, Appalachian implemented a “first on, last off” operating mode for units with intakes higher in the water column. In this mode of operation, Appalachian prioritizes the use of Units 2, 3, and 4 over Units 1 and 5 during the months of July through September since they pull water from shallower depths that are relatively higher in DO. Based on data collected during monitoring to date, the first on / last off operational mode occurs July 1 through November 15. The goal of the Plan's revised operating mode is to facilitate DO levels in the dam tailrace are meeting state standards, which are 4.00 milligrams per liter (mg/l) on an instantaneous basis and 5.00 mg/l on a daily average basis. As part of the annual review process, Appalachian will provide the data from the tailwaters of the Smith Mountain Dam to the WQTRC to determine if operational modifications are enhancing DO readings and that they meet Virginia DO requirements. DO, water temperature, and project operations have been summarized and are presented in this report.

Figure 1.1 AEP
Water Quality Study
Monitoring Location
Roanoke River, VA

Monitoring Station

0 500 1,000 Feet
0 150 300 Meters

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Date: 8/24/2020 Path: C:\AEP\GIS\AEP_SmithMountain_Map1.mxd

Basemap courtesy of Esri.

2.0 METHODS AND EQUIPMENT

2.1 WATER QUALITY MONITORING

The water quality monitoring location is in the stilling basin fixed to one of the tailrace bridge piers, which helps protect and prevent loss of data loggers. The station includes two HOBO® Dissolved Oxygen Loggers (replicates A and B) that record and store both water temperature and DO at 15-minute (min.) intervals. All loggers are calibrated on site; temperature is factory calibrated, and both parameters were verified with duplicate loggers and field measurements using a YSI handheld meter during each monthly maintenance visit to help assess data accuracy.

Table 2.1. HOBO® Dissolved Oxygen Logger specifications

Range	0 mg/L to 30 mg/L
Accuracy	± 0.2 mg/L up to 8 mg/L; ± 0.5 mg/L from 8 to 20 mg/L
Resolution	0.02 mg/L

2.2 RESERVOIR PROFILE

Water temperature and DO readings were collected in the forebay of the Smith Mountain Development using a YSI EXO1® Water Quality Sonde calibrated per the manufacturer's recommendations. One round of data was collected at four locations in the forebay and one location in the main reservoir (Figure 2.1). Locations were consistent with those used during the relicensing study efforts and time frame of previous years sampling efforts. Readings were collected at 2-meter intervals from the surface to the bottom.

Table 2.2. YSI EXO1® Water Quality Sonde specifications

Range	0 mg/L to 50 mg/L
Accuracy	± 0.1 mg/L up to 20 mg/L; ± 5 % of reading from 20 to 50 mg/L
Resolution	0.01 mg/L

Figure 2.1 Smith Mountain Lake Temperature and Dissolved Oxygen Sampling Locations

Sampling Locations

0 500 1,000 2,000 Feet

0 160 320 640 Meters

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Path: P:\10_Projects\AAEP\490CS\13361 Smith Mountain and Claytor lake\Figures\Figure 1_Smith_Map_121020.mxd

Date: 12/11/2020

Basemap courtesy of Esri.

3.0 RESULTS

Data were collected at the Smith Mountain Dam tailwater using HOBO loggers from June 1 through November 30, 2025. During this period, water temperature (°C) and dissolved oxygen (mg/L) levels were measured. A handheld YSI meter was also used to record water temperature and DO measurements at the monitoring location during monthly maintenance activities. Additionally, water quality was monitored in Smith Mountain and Leesville lakes by Smith Mountain Lake Association (SMLA) and Leesville Lake Association (LLA), respectively. Annual reports for these monitoring efforts are provided in Appendices A and B.

3.1 DOWNSTREAM WATER QUALITY

Water quality data was collected at 15-min. intervals from June 1, 2025, through November 30, 2025 (183 days). Data were unable to be downloaded from both loggers from 06/10/2025 at 18:15 to 07/01/2025 at 14:15 due to both loggers sustaining damage during monitoring. The unresponsive loggers were sent to HOBO® (i.e., manufacturer) for repair; however, the service center could not recover any usable data from the damaged loggers during repair. Additionally, both loggers recorded errant data due to monthly maintenance of the data loggers on 10/1/2025 from 09:30 to 10:00 and on 10/29/2025 at 11:45. Due to maintenance on the primary logger A, backup logger B data was used from 10/1/2025 at 09:45 to 10:15.

During data review, suspect monitoring data was observed on primary logger A on several occasions with DO recordings < 0 mg/L. These recordings occurred from 10/5/2025 at 20:15 to 10/6/2025 at 09:45, 10/9/2025 at 18:30 to 10/10/2025 at 10:30, and on 10/10/2025 at 11:00, 11:45, 12:30, and 12:45. Suspect recordings were also observed on the backup logger B during these time frames. For the data summaries developed in this report, data gaps occurred from 06/10/2025 at 18:15 hours to 07/01/2025 at 14:15 hours, on 10/1/2025 from 09:30 to 10:00, from 10/5/2025 at 20:15 to 10/6/2025 at 09:45, from 10/9/2025 at 18:30 to 10/10/2025 at 10:30, on 10/10/2025 at 11:00, 11:45, 12:30, and 12:45, and 10/29/2025 at 11:45. The suspect DO data and data gaps that occurred during the first half of October 2025 are likely attributable to low tailwater elevations due to a scheduled outage at the Smith Mountain powerhouse and corresponding drawdown of Leesville Lake. It is possible that the data loggers were not fully submerged during this period. Note the scheduled outage and drawdown of Leesville Lake took place approximately one month earlier than in prior years.

Data were analyzed based on Project operation. Operation logs, which provide discharge in cubic feet per second, were obtained for the five generating units. Data utilized during 2025 were based on 15-minute intervals aligned to the quarter hour (e.g., 12:00, 12:15, etc.). Water quality data were evaluated in two groups with regards to the state standards: during all operation periods and during times of generation only. Daily average dissolved oxygen values during generation were determined by using dissolved oxygen data for each day only from those times when the Project was discharging.

Instantaneous DO recordings during all operational conditions ranged from 0.0 mg/L (October) – suspect data – to 10.6 mg/L (November), and instantaneous water temperature recordings ranged from 11.2 ˚C (November) to 27.6 ˚C (July). A summary of instantaneous DO concentrations and water temperatures during all operational conditions (generation mode, pump-back mode, and non-operation) is presented in Table 3.1 and illustrated in Figure 3.1 (All raw data was submitted electronically with this report). Note that Appalachian generated with only Units 1 and 5 (i.e., the two units with the lowest elevation intakes) during two separate 3-day periods (total of six days) in September to conduct required testing. This is reflected in the corresponding low DO data in Table 3.1 and Figure 3.1.

Daily average DO concentrations during all operational conditions ranged from 1.5 mg/L (during October) – suspect data – to 10.1 mg/L (during November). Daily average temperatures ranged from 12.0 ˚C (during November) to 24.2 ˚C (during August). A summary of daily average DO concentrations and water temperatures during all operational conditions (generation mode, pump-back mode, and non-operation) is presented in Table 3.2 and illustrated in Figure 3.2. Note that Appalachian generated with only Units 1 and 5 (i.e., the two units with the lowest elevation intakes) during two separate 3-day periods (total of six days) in September to conduct required testing. This is reflected in the corresponding low DO data in Table 3.2 and Figure 3.2.

Instantaneous DO readings during generation periods ranged from 0.06 mg/L (October 9) – suspect data – to 10.58 mg/L (November 28); an illustration of instantaneous DO levels during generation are shown in Figure 3.3. Daily Average DO levels during generation ranged from 0.6 mg/L (October 5) – suspect data – to 9.8 mg/L (November 20). All average daily DO values during generation periods are illustrated in Figure 3.4 and presented in Table 3.3. Note that Appalachian generated with only Units 1 and 5 (i.e., the two units with the lowest elevation intakes) during two separate 3-day periods (total of six days) in September to conduct required testing. This is reflected in the corresponding low DO data in Table 3.3 and Figure 3.4.

Table 3.1. Smith Mountain Hydroelectric Project maximum, minimum, average, and median instantaneous dissolved oxygen and temperature readings per month for all operational scenarios, June 1, 2025 – November 30, 2025

Month	DO (mg/L)				Temperature (˚C)			
	Min	Max	Average	Median	Min	Max	Average	Median
June	6.2	8.6	7.7	7.7	11.8	18.5	14.9	14.6
July	4.6	9.6	6.3	6.2	16.3	27.6	19.8	19.2
August	3.8	8.5	5.5	5.3	18.4	27.1	20.5	19.9
September	0.3	6.9	4.3	4.3	18.4	22.7	20.2	20.1
October	0.0	7.8	4.7	4.8	17.0	22.4	19.4	19.4
November	5.8	10.6	8.6	8.8	11.2	18.1	15.4	15.2

Table 3.2. Smith Mountain Hydroelectric Project maximum, minimum, and median daily average dissolved oxygen and temperature readings per month for all operational scenarios, June 1, 2025 – November 30, 2025

Month	DO (mg/L)			Temperature (˚C)		
	Min	Max	Median	Min	Max	Median
June	7.3	8.1	7.7	13.8	16.1	14.3
July	5.3	8.0	6.3	17.5	23.5	19.5
August	4.5	6.9	5.4	19.0	24.2	20.0
September	3.4	5.4	4.3	19.5	20.8	20.1
October	1.5	6.6	4.6	17.9	20.6	19.3
November	6.8	10.1	8.8	12.0	17.8	15.1

Figure 3.1. Smith Mountain Hydroelectric Project instantaneous dissolved oxygen and temperature plot during all operational scenarios, June 1, 2025 – November 30, 2025

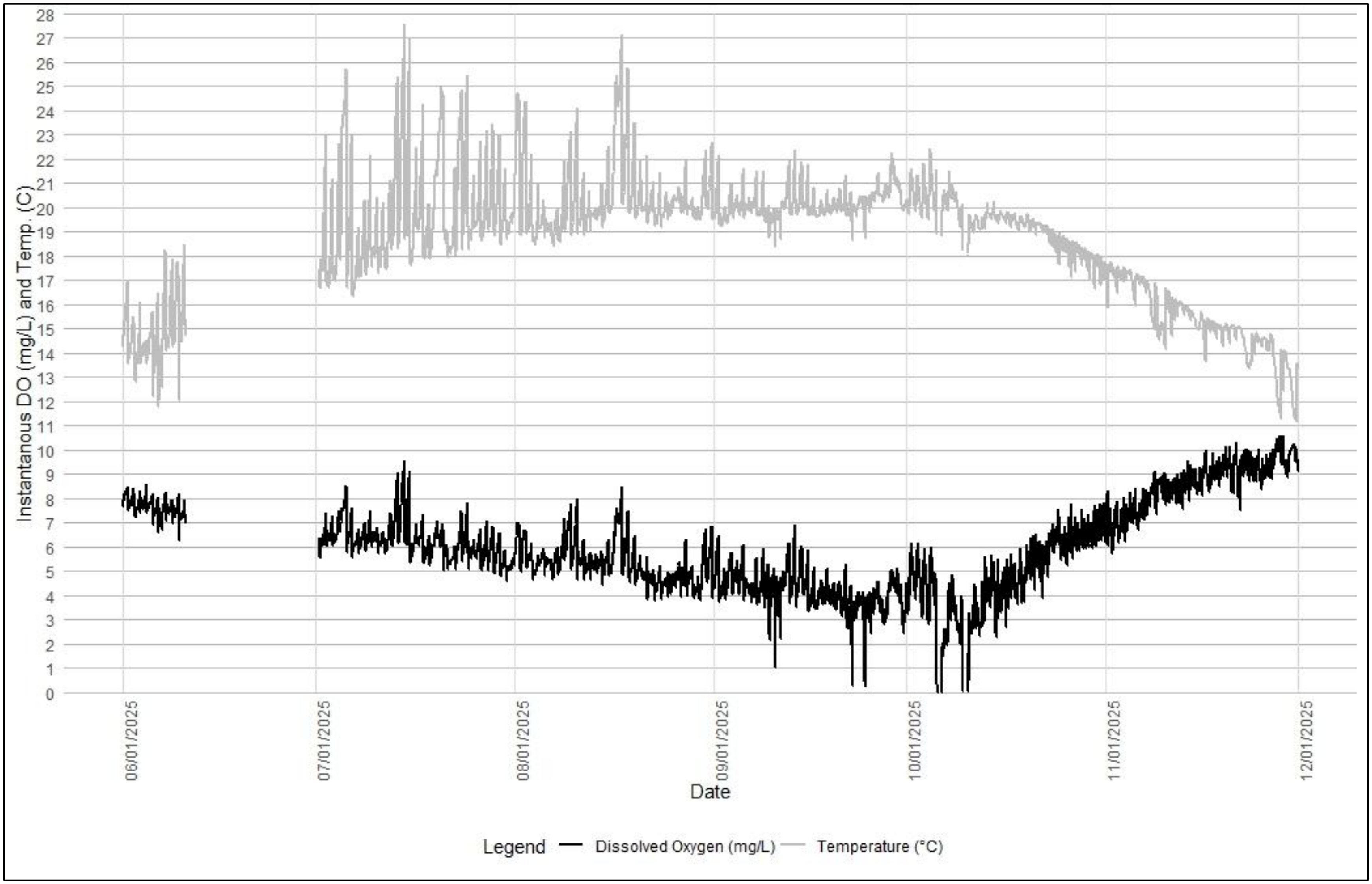


Figure 3.2. Smith Mountain Hydroelectric Project daily average dissolved oxygen and temperature plot during all operational scenarios, June 1, 2025 – November 30, 2025

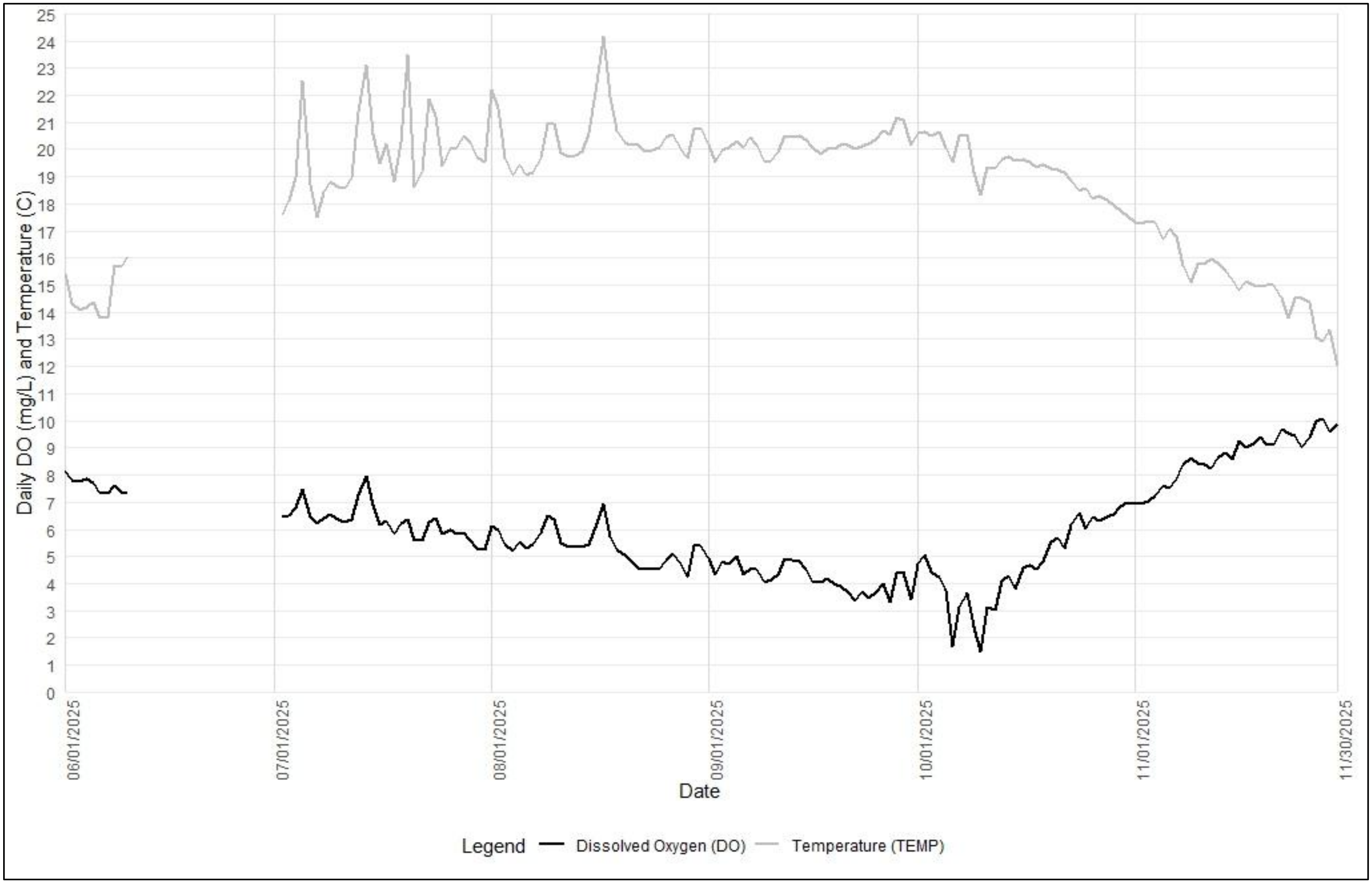


Figure 3.3. Smith Mountain Hydroelectric Project instantaneous dissolved oxygen plot during generation, June 1, 2025 – November 30, 2025

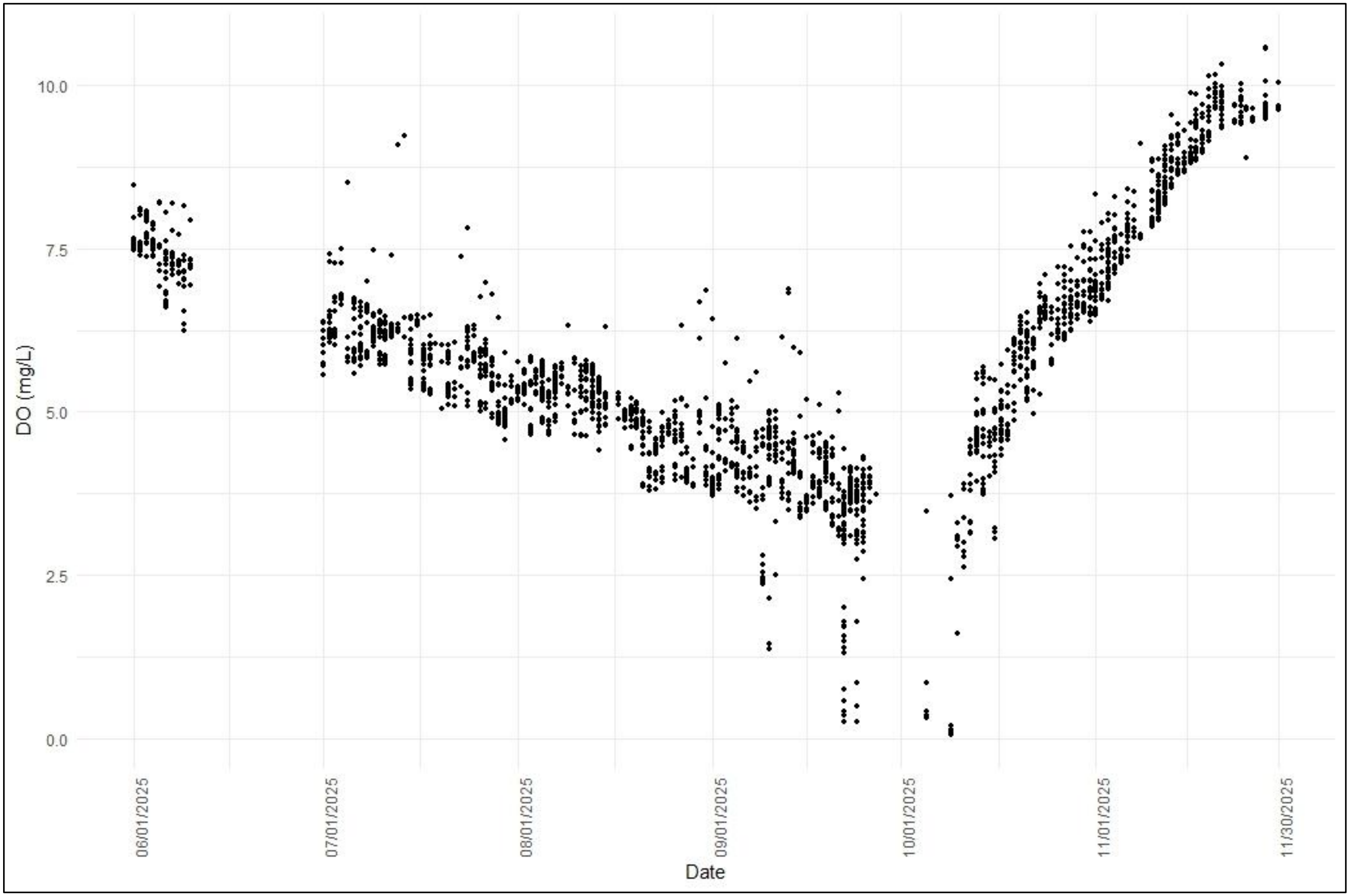


Figure 3.4. Smith Mountain Hydroelectric Project daily average dissolved oxygen plot during generation, June 1, 2025 – November 30, 2025

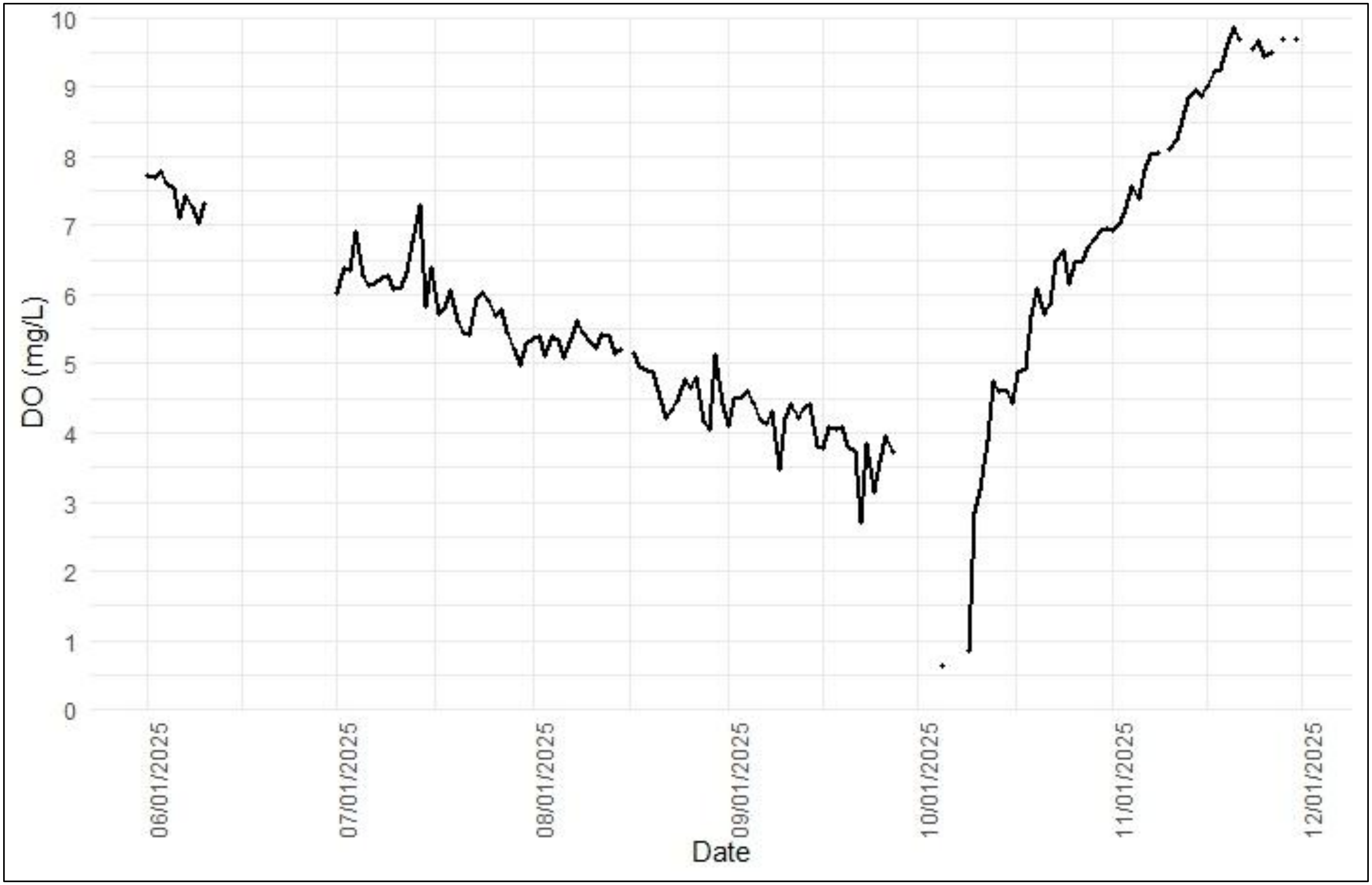


Table 3.3. Smith Mountain Hydroelectric Project daily average dissolved oxygen levels during generation, 2025

Date	Daily Ave. DO, mg/L	Date	Daily Ave. DO, mg/L	Date	Daily Ave. DO, mg/L	Date	Daily Ave. DO, mg/L	Date	Daily Ave. DO, mg/L
6/1/2025	7.7	7/24/2025	6.0	8/27/2025	4.8	10/10/2025	2.8	11/13/2025	8.9
6/2/2025	7.7	7/25/2025	5.9	8/28/2025	4.2	10/11/2025	3.2	11/14/2025	9.0
6/3/2025	7.8	7/26/2025	5.7	8/29/2025	4.0	10/12/2025	3.9	11/15/2025	8.9
6/4/2025	7.6	7/27/2025	5.8	8/30/2025	5.1	10/13/2025	4.7	11/16/2025	9.0
6/5/2025	7.5	7/28/2025	5.4	8/31/2025	4.4	10/14/2025	4.6	11/17/2025	9.2
6/6/2025	7.1	7/29/2025	5.2	9/1/2025	4.1	10/15/2025	4.6	11/18/2025	9.3
6/7/2025	7.4	7/30/2025	5.0	9/2/2025	4.5	10/16/2025	4.4	11/19/2025	9.5
6/8/2025	7.3	7/31/2025	5.3	9/3/2025	4.5	10/17/2025	4.9	11/20/2025	9.8
6/9/2025	7.0	8/1/2025	5.4	9/4/2025	4.6	10/18/2025	4.9	11/21/2025	9.7
6/10/2025	7.3	8/2/2025	5.4	9/5/2025	4.4	10/19/2025	5.7	11/23/2025	9.5
7/1/2025	6.0	8/3/2025	5.1	9/6/2025	4.2	10/20/2025	6.1	11/24/2025	9.7
7/2/2025	6.4	8/4/2025	5.4	9/7/2025	4.1	10/21/2025	5.7	11/25/2025	9.5
7/3/2025	6.3	8/5/2025	5.3	9/8/2025	4.3	10/22/2025	5.9	11/26/2025	9.5
7/4/2025	6.9	8/6/2025	5.1	9/9/2025	3.5	10/23/2025	6.5	11/28/2025	9.7
7/5/2025	6.3	8/7/2025	5.4	9/10/2025	4.2	10/24/2025	6.6	11/30/2025	9.7
7/6/2025	6.1	8/8/2025	5.6	9/11/2025	4.4	10/25/2025	6.2		
7/7/2025	6.2	8/9/2025	5.5	9/12/2025	4.2	10/26/2025	6.5		
7/8/2025	6.2	8/10/2025	5.3	9/13/2025	4.4	10/27/2025	6.5		
7/9/2025	6.3	8/11/2025	5.2	9/14/2025	4.4	10/28/2025	6.7		
7/10/2025	6.1	8/12/2025	5.4	9/15/2025	3.8	10/29/2025	6.8		
7/11/2025	6.1	8/13/2025	5.4	9/16/2025	3.8	10/30/2025	6.9		
7/12/2025	6.3	8/14/2025	5.2	9/17/2025	4.1	10/31/2025	6.9		
7/13/2025	6.8	8/15/2025	5.2	9/18/2025	4.0	11/1/2025	6.9		
7/14/2025	7.3	8/17/2025	5.2	9/19/2025	4.1	11/2/2025	7.0		
7/15/2025	5.8	8/18/2025	5.0	9/20/2025	3.8	11/3/2025	7.3		
7/16/2025	6.4	8/19/2025	4.9	9/21/2025	3.7	11/4/2025	7.6		
7/17/2025	5.7	8/20/2025	4.9	9/22/2025	2.7	11/5/2025	7.4		
7/18/2025	5.8	8/21/2025	4.6	9/23/2025	3.8	11/6/2025	7.8		
7/19/2025	6.0	8/22/2025	4.2	9/24/2025	3.1	11/7/2025	8.0		
7/20/2025	5.6	8/23/2025	4.3	9/25/2025	3.6	11/8/2025	8.0		
7/21/2025	5.5	8/24/2025	4.5	9/26/2025	3.9	11/10/2025	8.1		
7/22/2025	5.4	8/25/2025	4.8	9/27/2025	3.7	11/11/2025	8.3		
7/23/2025	5.9	8/26/2025	4.6	10/5/2025	0.6	11/12/2025	8.5		

3.2 RESERVOIR PROFILE

Water temperature and DO readings were collected at 2-m depth intervals along the four established monitoring locations on the forebay transect and at one location in the main reservoir (See Figure 2.1) on August 26, 2025. Water temperature and DO profile data are presented in Table 3.4 and illustrated in Figure 3.5 and Figure 3.6, respectively. Dissolved oxygen readings generally fell below 4.0 mg/l at depths of 8 - 10 m. at all locations. Water temperature ranged from 26.90 °C to 27.30 °C at the surface and decreased substantially starting between depths of 4 to 8 m on the date sampled (Figure 3.6).

Table 3.4. Water quality profiles at the forebay and main reservoir monitoring locations on Smith Mountain Lake, August 26, 2025

SMX 1-01			SMX 1-02			SMX 1-03			SMX 1-04			Reservoir		
Depth (m)	Temp (ºC)	DO (mg/L)	Depth (m)	Temp (ºC)	DO (mg/L)	Depth (m)	Temp (ºC)	DO (mg/L)	Depth (m)	Temp (ºC)	DO (mg/L)	Depth (m)	Temp (ºC)	DO (mg/L)
0	27.10	8.63	0	27.00	8.70	0	27.00	8.77	0	26.90	8.81	0	27.30	8.81
2	26.70	8.76	2	26.80	8.76	2	26.70	8.79	2	26.80	8.80	2	26.40	9.01
4	26.30	8.78	4	26.10	8.74	4	26.20	8.79	4	26.30	8.62	4	26.20	9.03
6	24.90	7.82	6	25.30	8.13	6	23.20	6.47	6	24.40	7.53	6	22.80	6.64
8	20.20	4.19	8	20.40	4.65	8	20.20	4.24	8	20.00	3.96	8	20.10	4.11
10	19.80	3.84	10	19.80	3.88	10	19.70	3.79	10	19.50	3.63	10	19.50	3.54
12	19.50	3.60	12	19.30	3.53	12	19.40	3.51	12	19.30	3.49	12	19.10	3.21
14	19.20	3.40	14	19.20	3.40	14	19.20	3.37	14	19.20	3.42	14	18.90	3.01
16	19.00	3.19	16	18.90	3.12	16	18.90	3.10	16	19.10	3.28	16	18.80	2.96
18	18.70	2.96	18	18.60	2.93	18	18.80	3.03	18	18.60	2.83	18	18.60	2.70
20	18.50	2.80	20	18.50	2.82	20	18.50	2.82	20	18.50	2.70	20	18.50	2.61
22	18.30	2.58	22	18.40	2.74	22	18.30	2.61				22	18.40	2.54
24	18.20	2.47	24	18.20	2.53	24	18.10	2.44				24	18.20	2.48
26	18.10	2.30	26	18.00	2.34	26	17.90	2.31				26	18.00	2.32
			28	17.80	2.08	28	17.80	2.21				28	17.90	2.07
			30	17.70	2.03	30	17.70	2.14						
			32	17.50	1.89	32	17.50	1.93						
			34	17.30	1.55	34	17.20	1.34						
			36	17.10	1.10	36	17.00	1.07						
			38	16.90	0.86	38	16.90	0.79						
			40	16.80	0.46	40	16.70	0.48						
			42	16.50	0.06	42	16.60	0.16						
			44	16.40	0.00	44	16.40	0.04						
			46	16.30	0.00	46	16.20	0.00						
			48	16.10	0.00	48	16.10	0.00						
			50	16.00	0.00	50	15.90	0.00						
			52	15.90	0.00	52	15.40	0.00						
			54	15.90	0.00									
			56	15.60	0.00									
			58	15.50	0.00									

Figure 3.5. Dissolved oxygen levels per depth at the forebay and main reservoir monitoring locations on Smith Mountain Lake, August 26, 2025

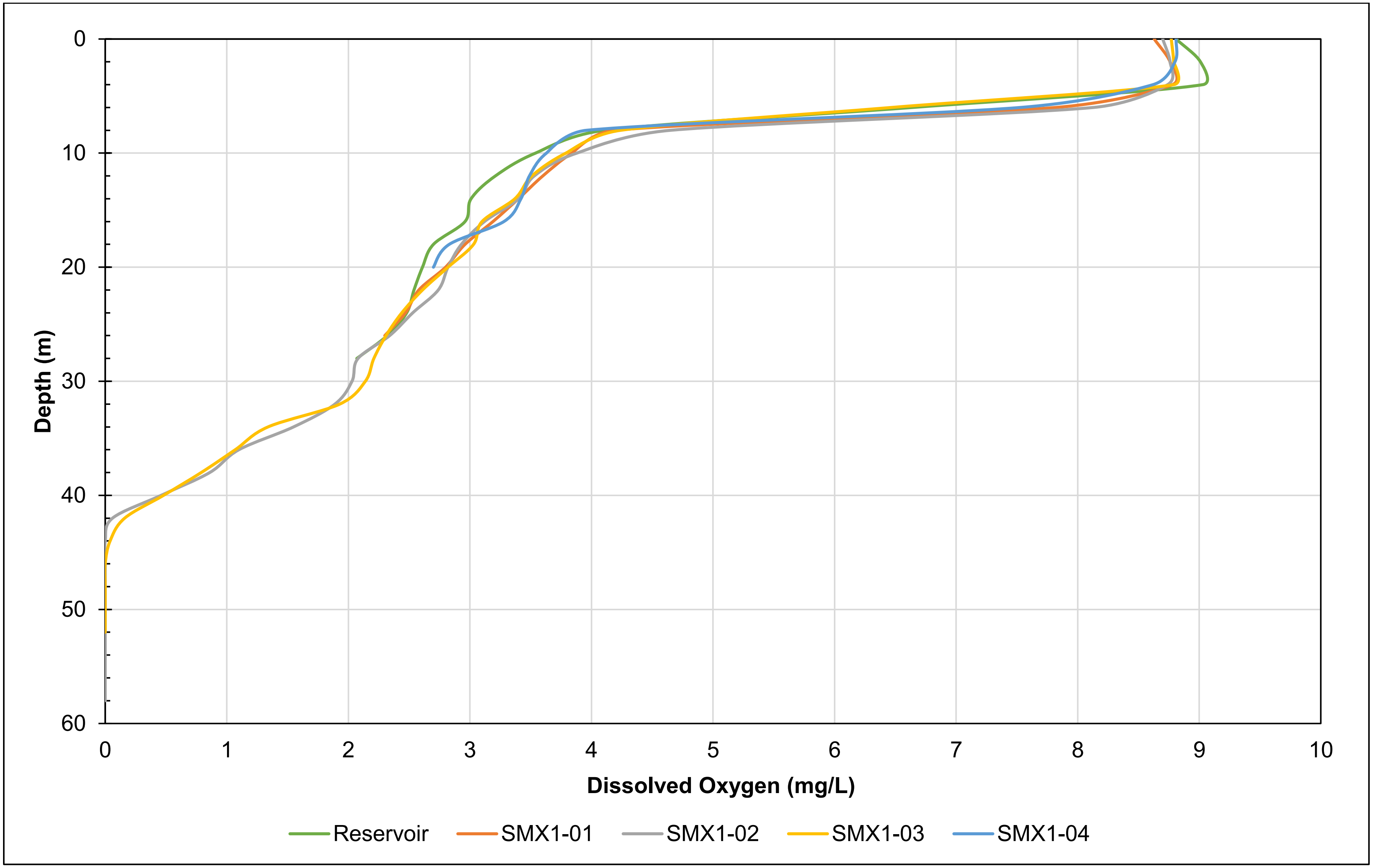
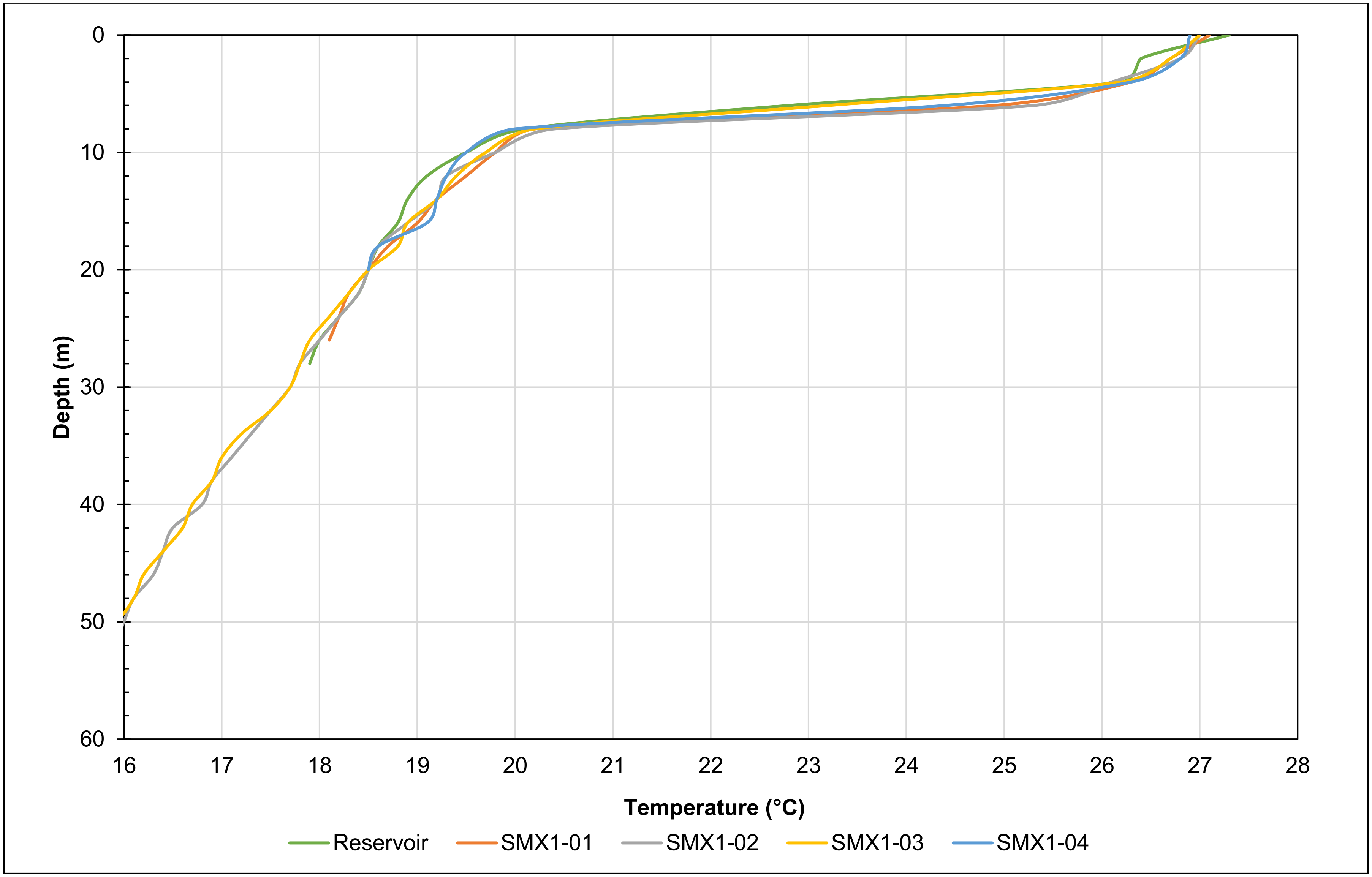


Figure 3.6. Water temperature levels per depth at the forebay and main reservoir monitoring locations on Smith Mountain Lake, August 26, 2025



4.0 DISCUSSION

Smith Mountain tailwater DO monitoring has evolved since its inception in the spring of 2011. Initial efforts were complicated by the inability to consistently collect reliable data. Continuously monitoring DO in an accurate manner over an extended period can be difficult in most locations. Dynamic environmental settings, such as the Smith Mountain tailwater, represents unique challenges. Such challenges include the presence of high-water velocities that can flow in two directions, depending on whether the Project is pumping or generating, and substantial water level fluctuations. Initial efforts consisted of using temporary, self-contained monitoring units, the maintenance of which was labor intensive. These units were also prone to damage due to the site conditions and vandalism. In the fall of 2012, a more permanent monitoring system was installed which minimized the potential for monitor damage due to environmental conditions and vandalism. The permanent monitoring system is also better able to maintain accurate calibration as well as allow access for data retrieval. As such, the system provides a reliable method of collecting accurate DO data while minimizing the potential for periods of missing data. It should be noted that no monitoring system can eliminate all potential issues associated with in-field monitoring.

The primary goal of the DO monitoring effort is to assess whether the operational modifications implemented at the Project are effective at maintaining DO levels in the Project discharge. As discussed above, the implemented operational measures consist of a “first on, last off” mode of operation during the July through mid-November period, where Units 2, 3, and 4 are the first to operate followed by Units 1 and 5, respectively. Units are then shut down in reverse order. While these modified operations have been successful in achieving the desired result, there is an ongoing learning process on how to implement the operational modifications within generation obligations. Therefore, while there has been some success in achieving DO goals at certain times of the year, this operating regime does not result in achieving standards 100% of the time. As stated in Section 3.1, the normal “first on, last off” operating mode for generating Units 2, 3, and 4 was not conducted on September 9-11, 22, and 24-25, when only Units 1 and 5 were used for power generation. Appalachian was limited to generating with only Units 1 and 5 on those dates due to required testing. Additionally, noticeable dips in recorded DO concentrations on October 5 and 9 occurred when the Smith Mountain powerhouse was in a scheduled outage. Generation occurred on these dates for a few evening hours on both days to maintain the elevation of Leesville Lake above 600 feet, when only Units 1 and 5 were available to generate. Also, on October 16, Unit 1 was run to conduct required testing.

In 2025 (June 1 - June 10; July 1 - November 30), data collection during all operational scenarios (generation mode, pump-back mode, and non-operation) occurred over the course of 163 days during which 15,451 DO readings were recorded. A total of 87% of those readings were greater than or equal to the instantaneous DO Virginia water quality standard of 4.00 mg/L, illustrated in Figure 4.1. A summary of instantaneous recordings below the 4.00 mg/L standard is presented in Table 4.1. The daily average DO Virginia water quality standard of 5.00 mg/L was achieved approximately 65% of the time, as illustrated in Figure 4.2. Daily average values below the 5.00 mg/L standard are presented in Table 4.2. As discussed in Section 3.1, the October data includes suspect low DO concentrations. Thus, the percentage data in Tables 4.1 and 4.2 and Figures 4.1 and 4.2 should be regarded as skewed.

Figure 4.1. Percent exceedance plot for instantaneous dissolved oxygen values measured in Smith Mountain Hydroelectric Project tailrace during all operational scenarios in 2025 (DO values greater than 4.00 mg/L 87% of the time)

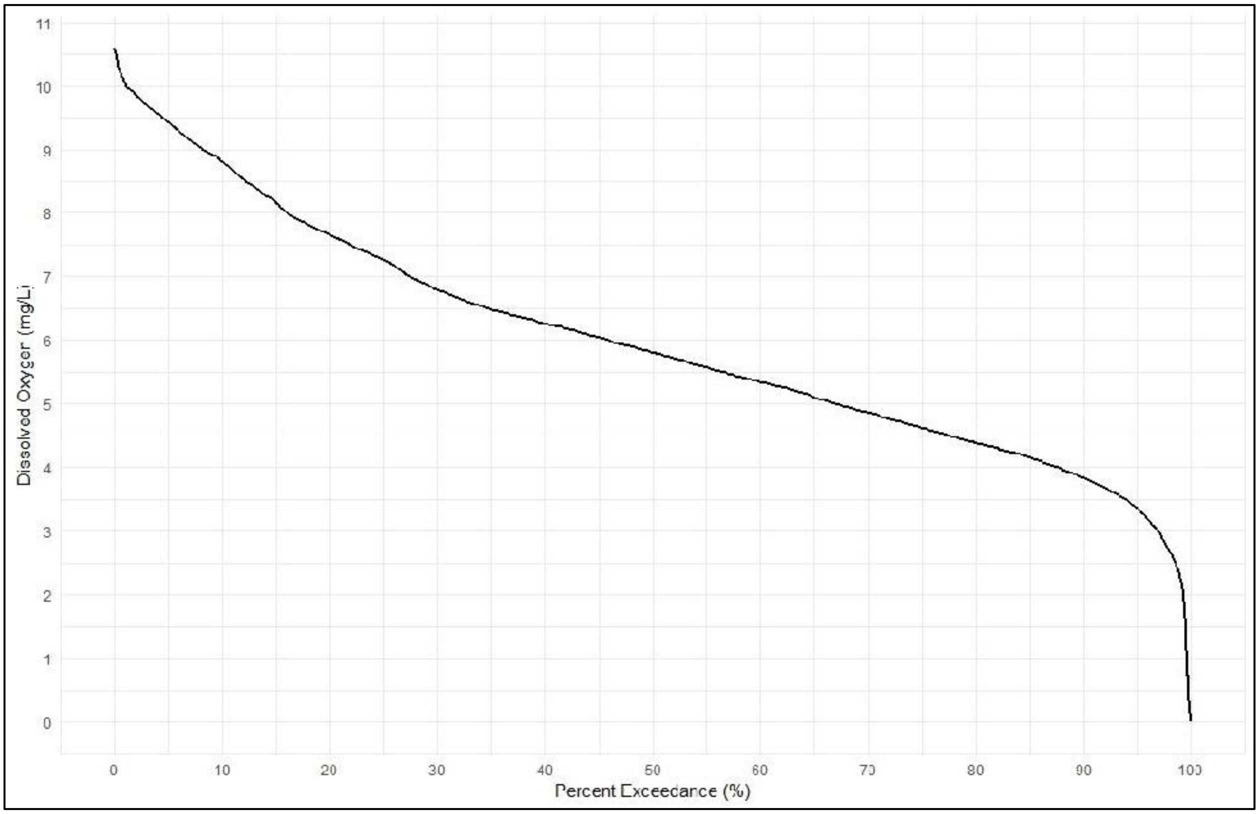


Table 4.1. Summary of instantaneous dissolved oxygen readings during all operational scenarios in 2025 less than 4.00 mg/L

Date	Number of Readings <4.00 mg/L	% <4.00 mg/L	Date	Number of Readings <4.00 mg/L	% <4.00 mg/L
8/21/2025	2	2%	9/27/2025	96	100%
8/22/2025	3	3%	9/28/2025	18	19%
8/23/2025	2	2%	9/29/2025	4	4%
8/24/2025	3	3%	9/30/2025	75	78%
8/26/2025	1	1%	10/1/2025	26	27%
8/27/2025	1	1%	10/2/2025	3	3%
8/28/2025	4	4%	10/3/2025	36	38%
8/29/2025	16	17%	10/4/2025	47	49%
8/30/2025	3	3%	10/5/2025	41	43%
8/31/2025	3	3%	10/6/2025	96	100%
9/1/2025	12	13%	10/7/2025	70	73%
9/2/2025	13	14%	10/8/2025	65	68%
9/5/2025	2	2%	10/9/2025	96	100%
9/6/2025	4	4%	10/10/2025	96	100%
9/7/2025	14	15%	10/11/2025	86	90%
9/8/2025	16	17%	10/12/2025	90	94%
9/9/2025	42	44%	10/13/2025	42	44%
9/10/2025	36	38%	10/14/2025	26	27%
9/11/2025	17	18%	10/15/2025	72	75%
9/12/2025	7	7%	10/16/2025	13	14%
9/13/2025	10	10%	10/17/2025	3	3%
9/14/2025	5	5%	10/18/2025	7	7%
9/15/2025	22	23%	10/19/2025	8	8%
9/16/2025	61	64%	10/22/2025	1	1%
9/17/2025	47	49%			
9/18/2025	42	44%			
9/19/2025	45	47%			
9/20/2025	50	52%			
9/21/2025	71	74%			
9/22/2025	68	71%			
9/23/2025	84	88%			
9/24/2025	89	93%			
9/25/2025	80	83%			
9/26/2025	38	40%			

Figure 4.2. Percent exceedance plot for daily average dissolved oxygen values measured in the Smith Mountain Hydroelectric Project tailrace during all operational scenarios in 2025 (DO values greater than 5.00 mg/L 65% of the time)

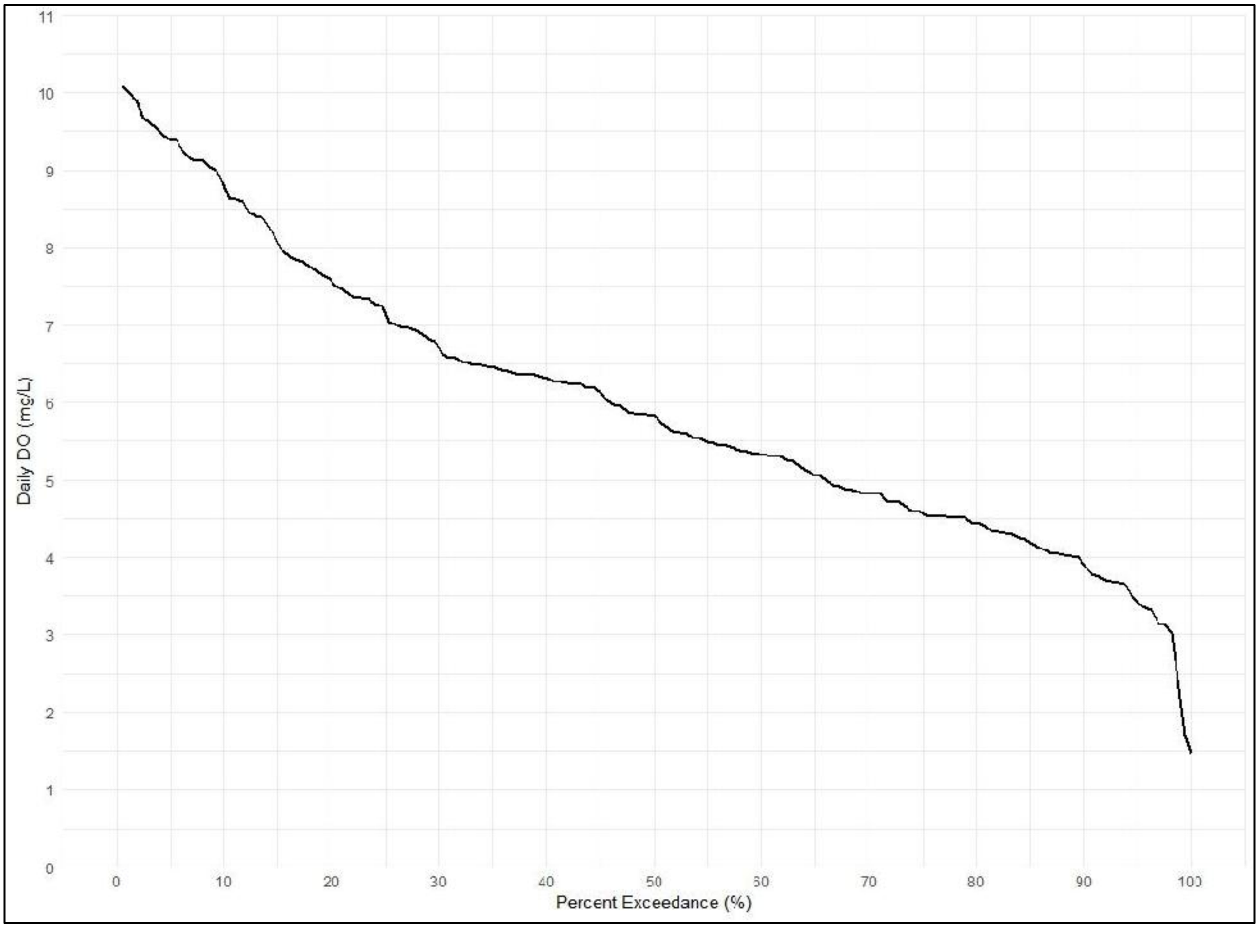


Table 4.2. Summary of daily average DO values during all operational scenarios in 2025 less than 5.00 mg/L

Date	Daily Average DO (mg/L)	Date	Daily Average DO (mg/L)
8/21/2025	4.83	9/24/2025	3.49
8/22/2025	4.59	9/25/2025	3.66
8/23/2025	4.52	9/26/2025	4.02
8/24/2025	4.51	9/27/2025	3.32
8/25/2025	4.52	9/28/2025	4.40
8/26/2025	4.87	9/29/2025	4.43
8/28/2025	4.72	9/30/2025	3.41
8/29/2025	4.24	10/1/2025	4.73
9/1/2025	4.93	10/3/2025	4.43
9/2/2025	4.33	10/4/2025	4.24
9/3/2025	4.84	10/5/2025	3.16
9/4/2025	4.72	10/6/2025	0.98
9/5/2025	4.99	10/7/2025	3.14
9/6/2025	4.33	10/8/2025	3.68
9/7/2025	4.52	10/9/2025	1.85
9/8/2025	4.53	10/10/2025	0.74
9/9/2025	4.04	10/11/2025	3.14
9/10/2025	4.13	10/12/2025	3.03
9/11/2025	4.32	10/13/2025	4.10
9/12/2025	4.92	10/14/2025	4.29
9/13/2025	4.87	10/15/2025	3.78
9/14/2025	4.82	10/16/2025	4.59
9/15/2025	4.52	10/17/2025	4.66
9/16/2025	4.05	10/18/2025	4.54
9/17/2025	4.03	10/19/2025	4.82
9/18/2025	4.18		
9/19/2025	4.00		
9/20/2025	3.90		
9/21/2025	3.70		
9/22/2025	3.35		
9/23/2025	3.69		

4.1 IMPACT OF GENERATION ON DO

The average 2025 instantaneous DO value during generation was 5.74 mg/L and the average instantaneous DO value during other operational scenarios (pump-back and non-operation) was 5.98 mg/L.

The instantaneous minimum DO requirement of 4.00 mg/L was met 85% of the time during generation (Figure 4.3). The daily average DO minimum requirement of 5.00 mg/L was achieved approximately 65% of the time (Figure 4.4) during generation. During all operational modes, the corresponding percentages meeting DO criteria for instantaneous and daily average were 87% and 65%, respectively. As discussed in Section 3.1, October data includes suspect low DO concentrations. Thus, the percentages stated and shown in Figures 4.3 and 4.4 should be regarded as skewed.

Comparing monitoring data since 2015, the percentage of readings during generation when the instantaneous DO standard was met in 2025 was the fourth highest since monitoring began in 2015. The percentage of readings when the daily average DO standard was achieved in 2025 during generation was the second highest since monitoring began, with a higher percentage only being achieved in 2015. The relatively high instantaneous and daily average percentages are despite the suspect low DO concentrations recorded in October. The percentage of readings when the instantaneous and daily average DO standards were achieved during generation over the last eleven years is presented in Table 4.3.

Note that generation during the summer months (i.e., mid-June through mid-September) occurs during the early evening when there is peak demand for electric power, which coincides with the period immediately following maximum photosynthesis (i.e., naturally occurring DO production) in the tailwater. Conversely, pump-back occurs during the night when photosynthesis is not occurring. Also note that the above comparisons are general, since no two monitoring years are the same due to variation in environmental and operational conditions. (see additional discussion below)

Figure 4.3. Percent exceedance plot for instantaneous dissolved oxygen values measured in Smith Mountain Hydroelectric Project tailrace during generation in 2025 (DO values greater than 4.00 mg/L 85% of the time)

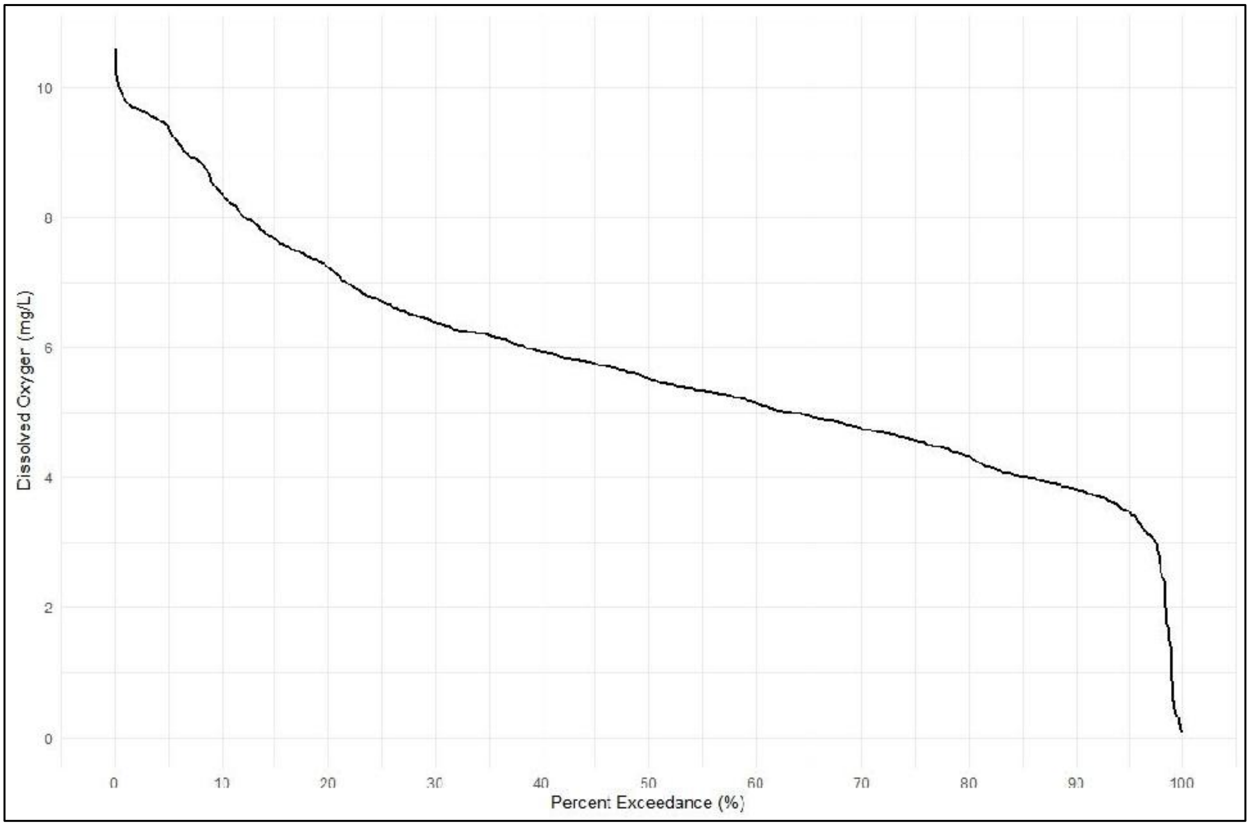


Figure 4.4. Percent exceedance plot for daily average dissolved oxygen values measured in the Smith Mountain Hydroelectric Project tailrace during generation in 2025 (DO values greater than 5.00 mg/L 65% of the time)

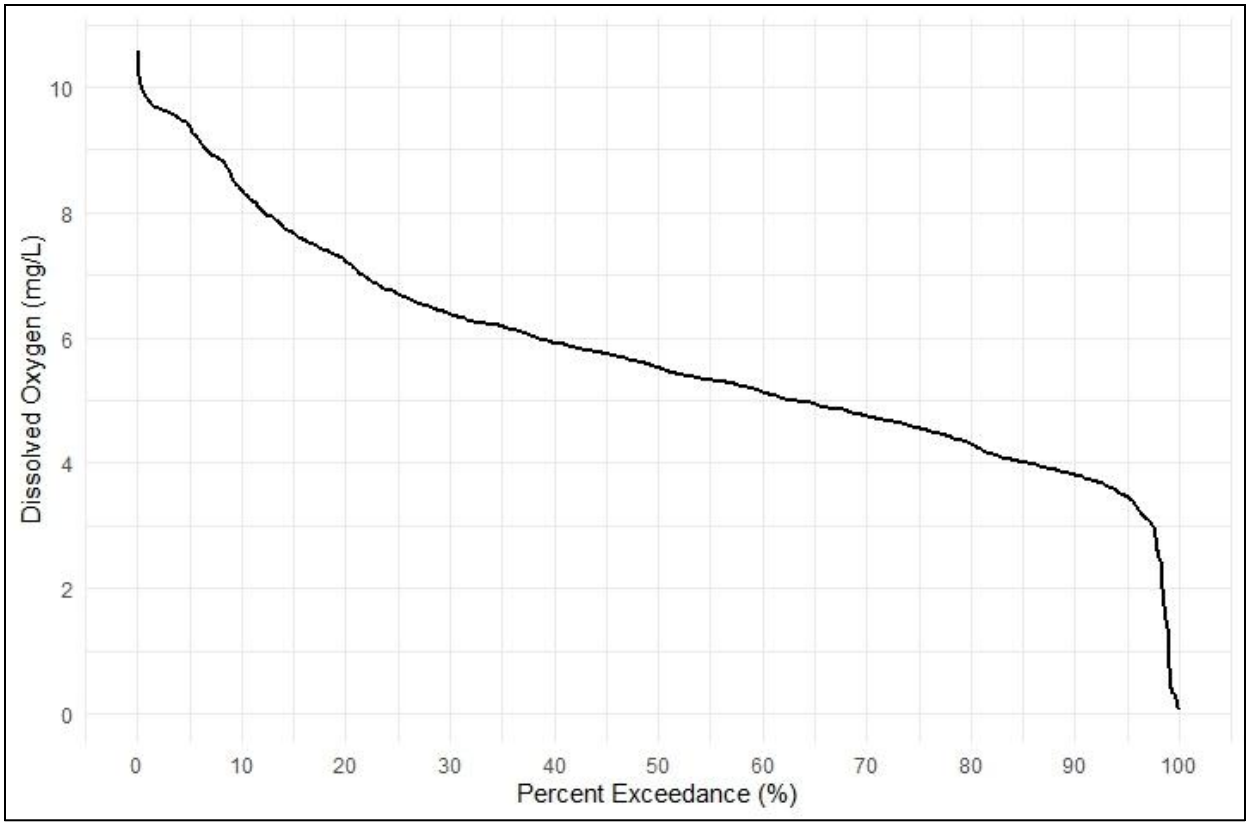


Table 4.3. Annual percentage of time instantaneous and daily average DO standards met during generation

Year	% Time Instantaneous DO Standard Met (4.00 mg/L)	% Time Daily Average DO Standard Met (5.00 mg/L)
2015	75%	83%
2016	87%	60%
2017	97%	48%
2018	60%	47%
2019	66%	37%
2020	69%	40%
2021	81%	60%
2022	76%	42%
2023	88%	57%
2024	75%	60%
2025	85%	65%

The data presented in Table 4.3 illustrates the variability in instantaneous and daily average DO concentrations during generation in any given year and is reflective of the corresponding variability in flows and other environmental factors, as well as the occurrence or absence of suspect data and/or data gaps. This variability also applies to all operational scenarios. Tailwater DO concentrations will vary from year to year due to corresponding variations in air and water temperatures, when stratification occurs in Smith Mountain Lake, inflows to the Project, duration of generation, photosynthetic production, etc.

In 2015 through 2017, instantaneous results indicated a general trend of continued improvement in meeting the tailwater DO standards. The monitoring data varied between years but marked improvement in meeting the water quality standards was documented after 2012. This improvement was attributed to several factors, including better monitoring using the stilling basin and better implementation, and extension of the “first-on, last-off” protocols, and continued development of the low DO alarm system – overall, the DO enhancement and monitoring program.

In 2018, the DO standards were achieved a relatively lower percentage of the time than for previous years, particularly for the instantaneous DO values. Multiple factors may have contributed to the lower DO values. Kleinschmidt (2019) theorized that the non-operation of Unit 5 in 2018 (due to a scheduled maintenance outage) might have been a reason for the drop in DO during that year. Because Unit 5 is a pump-turbine, when it does not operate, the deepest part of the forebay does not receive the benefit of higher DO water being pumped (back) from the tailrace. In relative terms, water from the tailrace is warmer and higher in DO than in the deeper part of the forebay during the monitoring season. When Unit 5 operates in pump-back mode, this warmer, higher DO water enters the forebay and likely mixes to some degree and/or remains isolated due to density differences. In either case, this water may then be available for subsequent discharge from not only Unit 5, but potentially the other units as well.

Conversely, Unit 5 was in operation from 2019 - 2025. The percentage exceedance of the instantaneous DO concentration varied from 66 - 88% in those years. Therefore, while operation of Unit 5 may ultimately affect DO concentrations in the tailwater, the yearly fluctuations during years when Unit 5 is operating or not operating indicate that there are other significant factors affecting the DO concentrations in the tailwater.

Precipitation throughout the Project watershed is a potential factor affecting DO concentrations. There seems to be a correlation between low precipitation years and meeting the instantaneous DO standards. Higher amounts of rainfall throughout the water quality monitoring period (i.e., when Smith Mountain Lake is stratified) result in increased inflows to the Project. Higher inflows to the Project, in turn, result in increased generation to pass the water through the Project, particularly during flood operations. Increased generation results in a greater period of time when low DO water in the Smith Mountain Dam forebay is being discharged to the tailwater. Table 4.4 provides the total precipitation in the months of June-November for the years 2015-2025 as recorded at the Roanoke, VA airport. The precipitation totals for 2018 and 2020 were above normal for the period, whereas those for 2017 and 2025 were below normal.

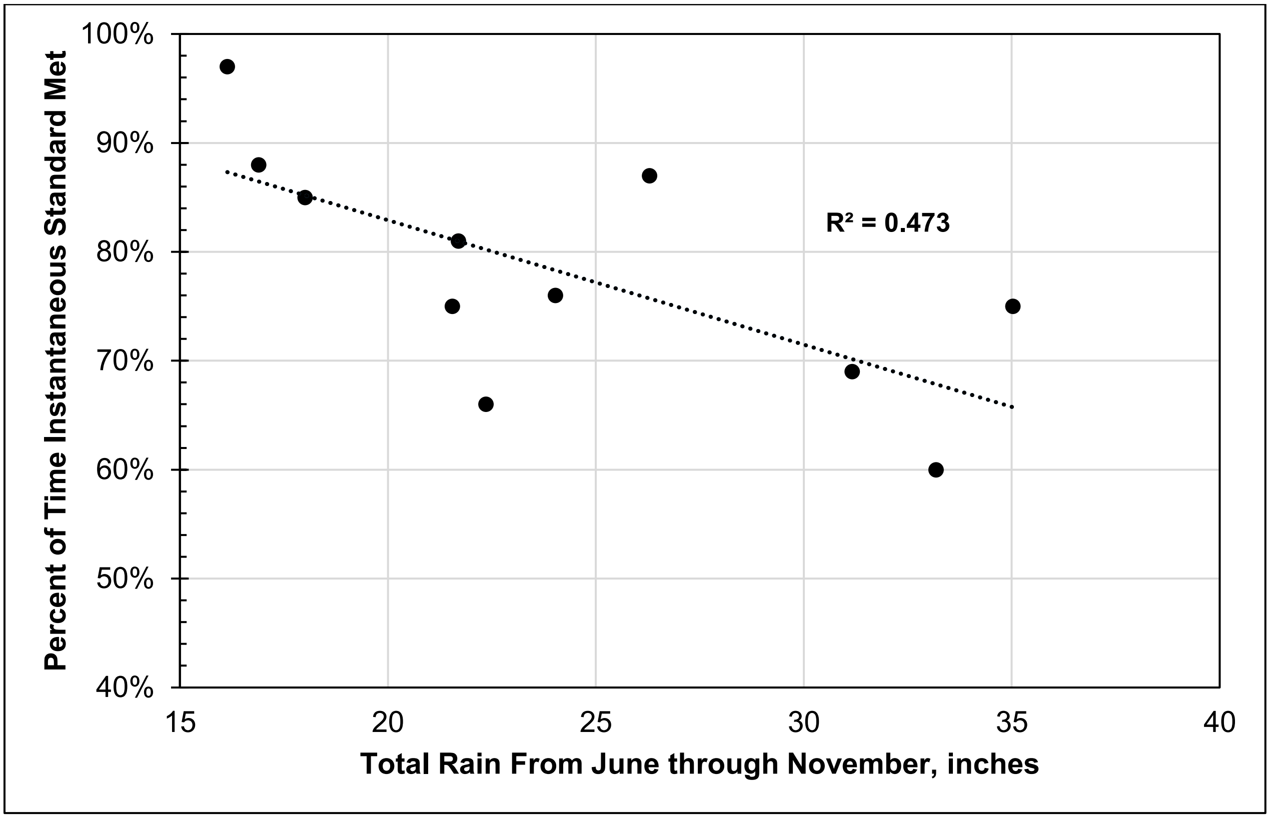
A scatterplot of the percentage of readings when the instantaneous standard is met versus the total precipitation is presented in Figure 4.5. It is clear from the figure that there is a trend between these two variables, with lower rain years generally having a higher percentage of readings where the DO standard is achieved. However, there is no analogous correlation between precipitation and the percentage of time the daily average standard is met.

Table 4.4. Total June-November monthly precipitation (inches) during 2015-2025 as recorded at the Roanoke, VA airport

Month	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
June	9.07	6.03	4.50	3.63	5.53	7.72	4.37	1.42	4.03	2.95	2.45
July	4.29	5.55	2.07	4.47	4.70	3.53	3.01	5.28	5.60	3.01	5.00
August	3.09	4.46	2.31	5.17	3.13	4.17	5.39	4.32	1.54	4.64	6.14
September	8.48	4.75	2.38	9.92	1.36	5.33	4.84	4.19	2.79	8.61	2.22
October	6.10	4.42	4.18	5.21	6.33	4.57	3.13	3.10	0.62	0.91	1.68
November	4.00	1.08	0.70	4.78	1.31	5.84	0.96	5.72	2.31	1.43	0.52
TOTAL	**35.03**	**26.29**	**16.14**	**33.18**	**22.36**	**31.16**	**21.70**	**24.03**	**16.89**	**21.55**	**18.01**

*Source: NOAA Online Weather Data, http://nowdata.rcc-acis.org/rnk/

Figure 4.5. Percent exceedance for instantaneous dissolved oxygen recordings in Smith Mountain tailrace during generation versus total precipitation, June – November



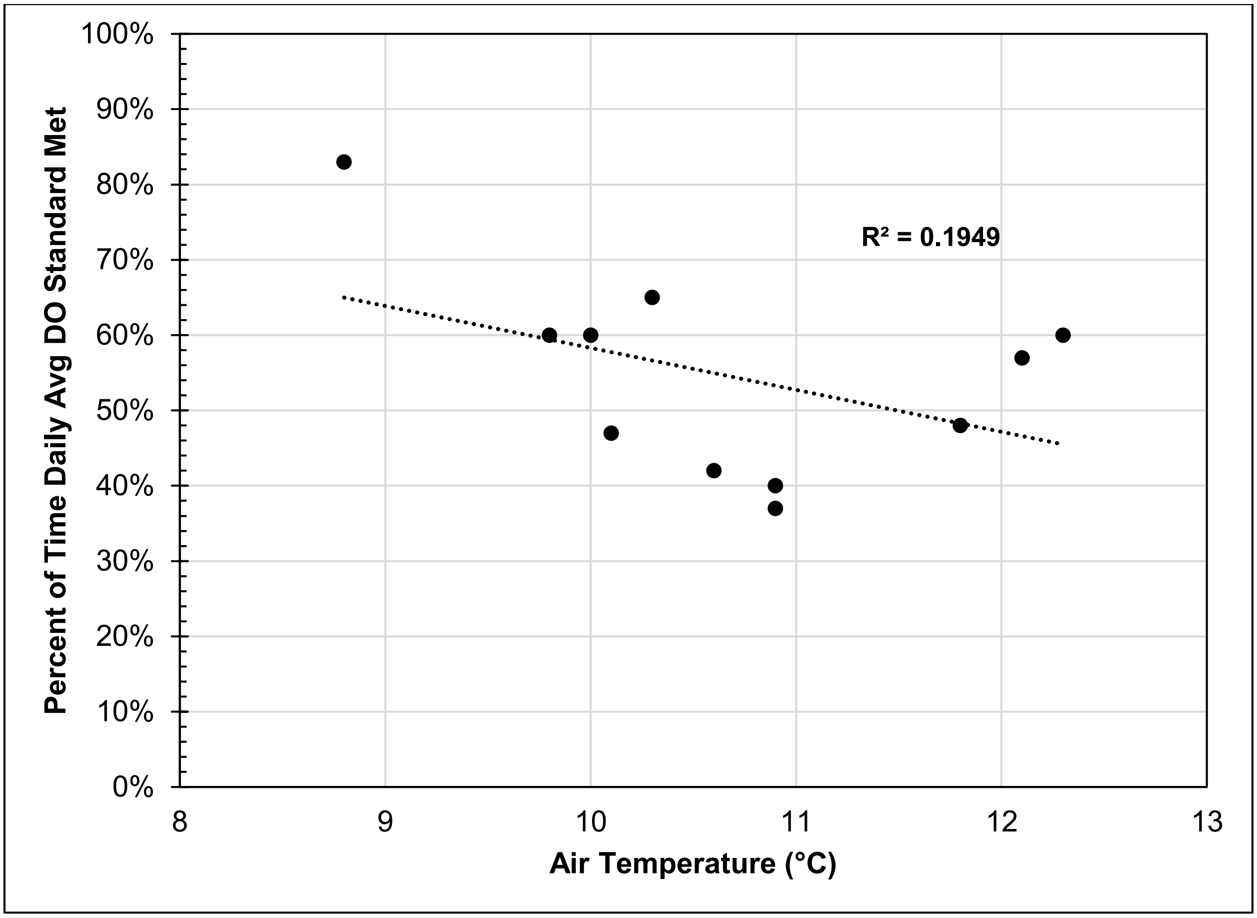
Another potential impact on DO concentrations is the water temperature of the reservoir. While several environmental factors, such as solar radiation, cloud cover, and retention time contribute to water temperature, air temperature is a reasonable basis for inferring water temperature trends. Table 4.5 provides the monthly average air temperatures for the years 2015 through 2025 as recorded at the Roanoke, VA airport. A scatterplot of the percentage of readings when the daily average standard is met versus the average air temperature prior to the monitoring period is presented in Figure 4.6. This plot compares the average air temperature leading up to monitoring instead of during monitoring. The figure does not illustrate a correlation between these two variables. Additionally, there is not a correlation between the average air temperature prior to the monitoring period and percentage of readings when the instantaneous standard is met. Nevertheless, it is reasonable that the warming of the reservoir's surface water temperature earlier in the year increases the length of time Smith Mountain Lake is thermally stratified, likewise leading to declines in dissolved oxygen concentration in deeper parts of the reservoir and corresponding discharges to the Project tailwater earlier in the monitoring season.

Table 4.5. Monthly average air temperature (°C) from 2015 to 2025 as recorded at the Roanoke, VA airport

Month	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
January	2.1	0.8	5.3	1.2	2.3	5.3	3.4	1.4	7.2	3.8	0.3
February	-0.8	3.6	9.1	8.0	6.6	6.6	3.7	6.1	10.1	7.9	5.1
March	8.4	12.3	9.2	6.2	7.8	12.4	10.4	11.5	10.1	12.2	11.8
April	13.9	14.4	16.7	12.5	15.8	13.2	14.3	14.6	15.4	16.6	16.2
May	20.5	17.9	18.6	22.5	22.2	16.9	18.1	19.5	17.9	20.9	18.1
June	24.1	23.4	22.6	24.2	22.7	23.1	23.8	24.3	21.5	24.9	24.4
July	25.2	26.2	25.9	24.9	26.4	27.7	25.9	26.6	26.3	27.1	26.5
August	24.1	25.3	23.9	24.7	25.0	25.2	26.3	24.7	25.2	24.9	22.2
September	21.2	23.1	20.4	23.1	24.2	20.1	21.9	20.9	21.6	20.4	20.4
October	14.1	16.7	16.3	15.9	16.7	15.9	17.8	13.3	16.3	15.5	14.5
November	11.3	10.9	8.6	7.0	6.8	11.8	7.8	10.4	9.6	11.4	9.8
December	9.9	4.6	3.9	5.1	6.2	4.8	9.0	3.7	7.1	3.9	3.3
Yearly Average	**14.5**	**14.9**	**15.1**	**14.6**	**15.2**	**15.3**	**15.2**	**14.7**	**15.7**	**15.8**	**14.4**
January - May	**8.8**	**9.8**	**11.8**	**10.1**	**10.9**	**10.9**	**10.0**	**10.6**	**12.1**	**12.3**	**10.3**
June - November	**20.0**	**20.9**	**19.6**	**20.0**	**20.3**	**20.6**	**20.6**	**20.0**	**20.1**	**20.7**	**19.6**

*Source: NOAA Online Weather Data, http://nowdata.rcc-acis.org/rnk/

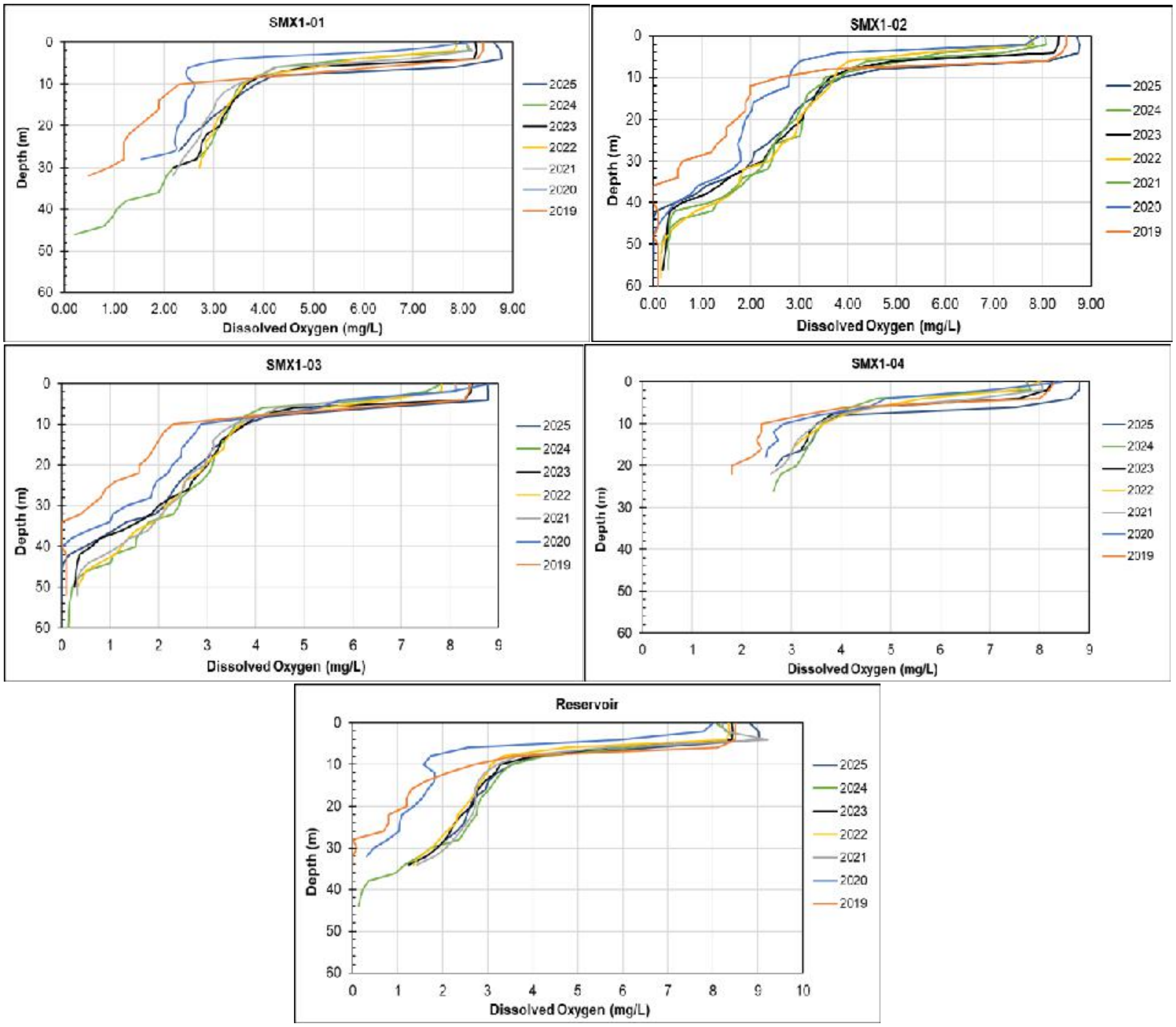
Figure 4.6. Percent Exceedance for daily average dissolved oxygen values measured in Smith Mountain tailrace during generation versus average air temperature, January – May



4.2 LAKE PROFILE DISSOLVED OXYGEN COMPARISON

Figure 4.7 shows the DO profile data collected at Smith Mountain Lake in late August / early September for 2019 - 2025. The DO concentrations above 4.00 mg/L in the water column for 2021 - 2024 fit in between those for 2020 and 2019, whereas 2025 data shows slightly higher DO readings at surface depth at some locations. The DO profile concentrations below roughly 10 meters in depth were higher in 2021 - 2025 than in 2019 and 2020. Profile data collected from 2021 – 2025 are similar across monitoring locations and depth profiles.

Figure 4.7. Smith Mountain Lake dissolved oxygen profile data collected 2019 – 2025



5.0 SUMMARY AND RECOMMENDATIONS

The above discussion of water quality results illustrates the many factors that potentially influence DO concentrations in the Smith Mountain Dam tailwater. Because these factors are variable within any given monitoring year, identifying trends and/or correlations via relative comparison of the DO results from multiple years is accordingly challenging. Therefore, such relative comparisons are understood to be general/limited.

Improvements to both the implementation and monitoring of the DO enhancement operational regime have occurred at Smith Mountain Lake. These improvements have resulted in providing DO enhancement in the Smith Mountain Dam discharge. However, as stated in previous annual water quality reports, the current enhancement measures are not sufficient to achieve the DO standards in the Project tailwater through all observed environmental conditions and under all operational scenarios during the monitoring period. Several recommendations suggested for 2026 are provided below:

- Continue to implement the use the "first on, last off" operating protocol from July 1 to November 15.
- Continue to follow the monitoring period of June 1 through December 1, as agreed upon by the WQTRC, to target the time of year when DO concerns are likely to occur.
- Continue with the procedures implemented to ensure the stilling basins are free from debris and ensure data sondes are protected from damage during deployment.
- Continue to evaluate historical data to establish correlations between environmental and operational factors and DO in the Project tailwater.
- Evaluate any new potential engineering measures that are feasible to enhance DO in the Project tailwater.

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NOAA. (2026). NOWData – NOAA Online Weather Data. NOAA Regional Climate Centers. Retrieved from http://nowdata.rcc-acis.org/rnk/

Appendix A

2025 Smith Mountain Lake Association Water Quality Monitoring Program Report

Smith Mountain Lake
Water Quality Monitoring Program
2025 Report

Prepared by
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With Additional Funding from
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Bedford County Regional Water Authority
Smith Mountain Lake Association
Virginia Department of Environmental Quality
Western Virginia Water Authority

TABLE OF CONTENTS

FIGURES

TABLES

Smith Mountain Lake Association
Moneta, Virginia

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Vice President	Keri Green
Corporate Secretary	Rob Sanders
Treasurer	Nancy Davenport

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Bill Butterfield	Jill Kurtz
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2025 SMITH MOUNTAIN LAKE VOLUNTEER MONITORS

Advanced Monitors

Eric Anderson, Moneta

Peter and Chris Brinckerhoff, Union Hall

Bill and Carol Butterfield, Wirtz

Gael and Smith Chaney, Union Hall

Mark Earnhardt, Moneta

Sam and Gale Easter, Union Hall

Eric Edgerton, Huddleston

Fred and Sandy Flowers, Union Hall

Steve Gardner, Goodview

Phillip Green, Moneta

Gary and Mary Ellen Gross, Union Hall

Pete and Susan Heyroth, Moneta

Daphne and Ron Jamison, Wirtz

Bill and Carolyn Koontz, Moneta

Ken and Elaine Lovatt, Goodview

Mike and Gail McCord, Moneta

Mac and Janie McWilliams, Hardy

John Rupnik, Huddleston

Larry Sakayama, Wirtz

Robert and Maureen Sanders, Moneta

Bob Toone, Union Hall

Sue and John Trinchere, Huddleston

Rick Watson, Hardy

Basic Monitors

Tim and Lisa Barr, Moneta

Dale and Cathy Bleier, Union Hall

Scott Bull, Moneta

Mike Garcia, Moneta

Tom Hardy, Huddleston

Mark Moyer, Wirtz

Mike and Missy Reingruber, Hardy

Phil Sears, Huddleston

Grant and Jolene West, Moneta

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).

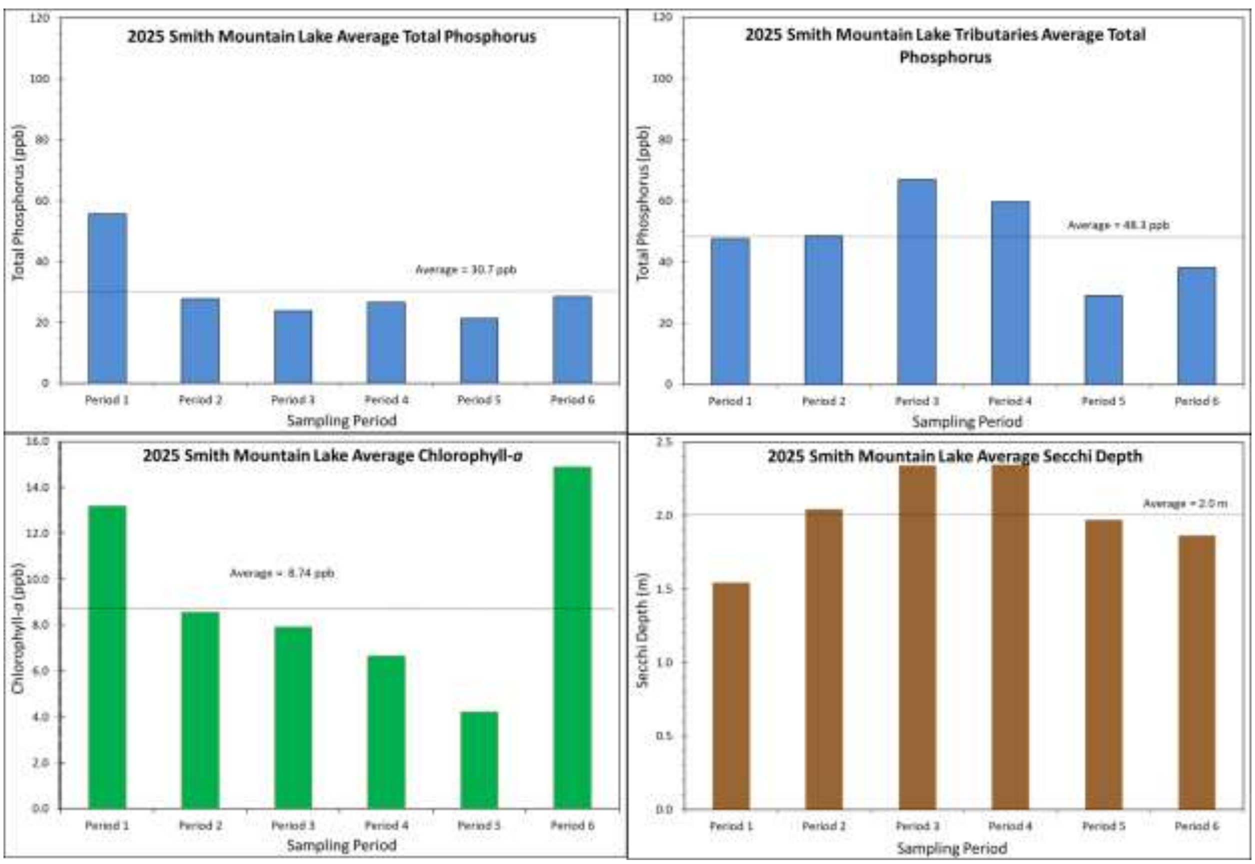
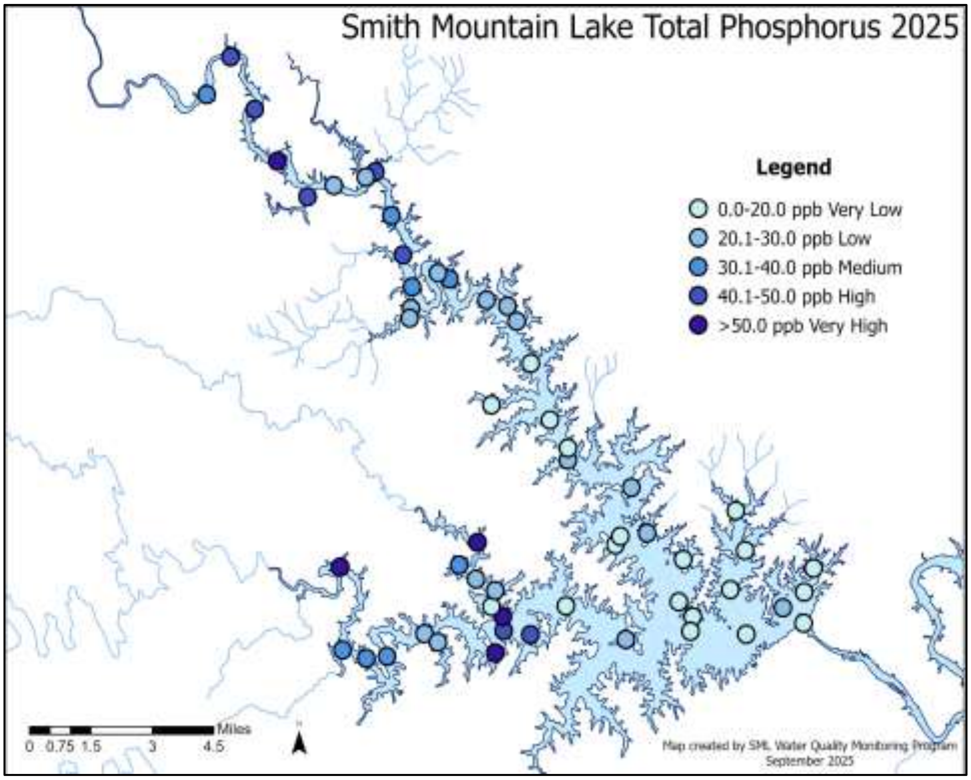
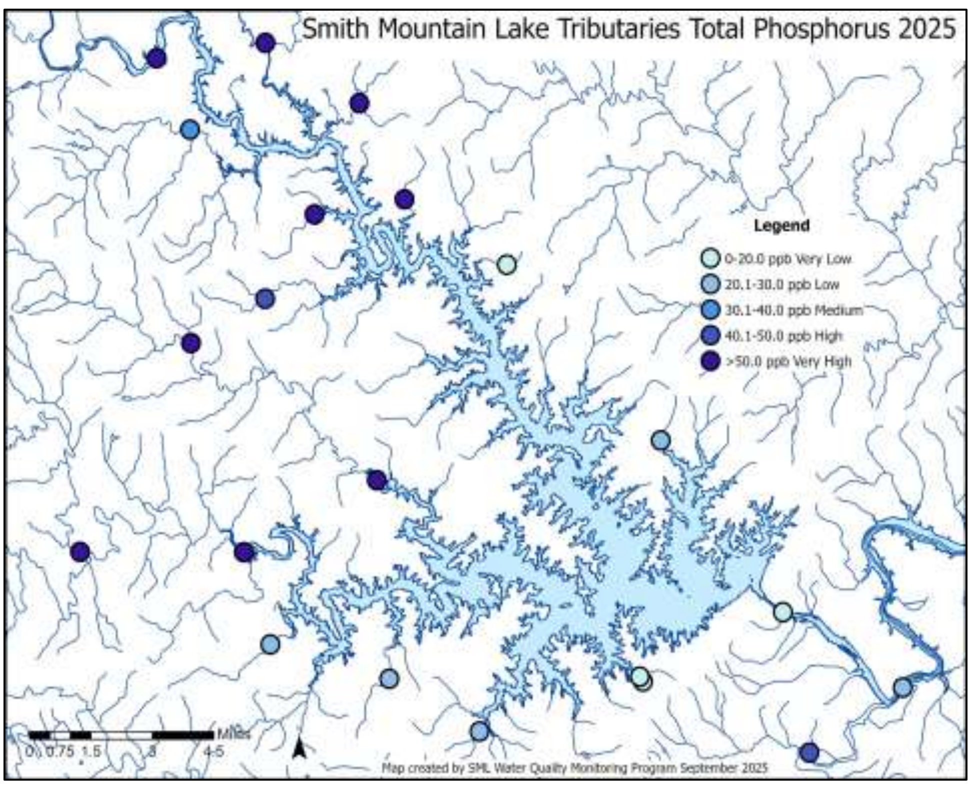
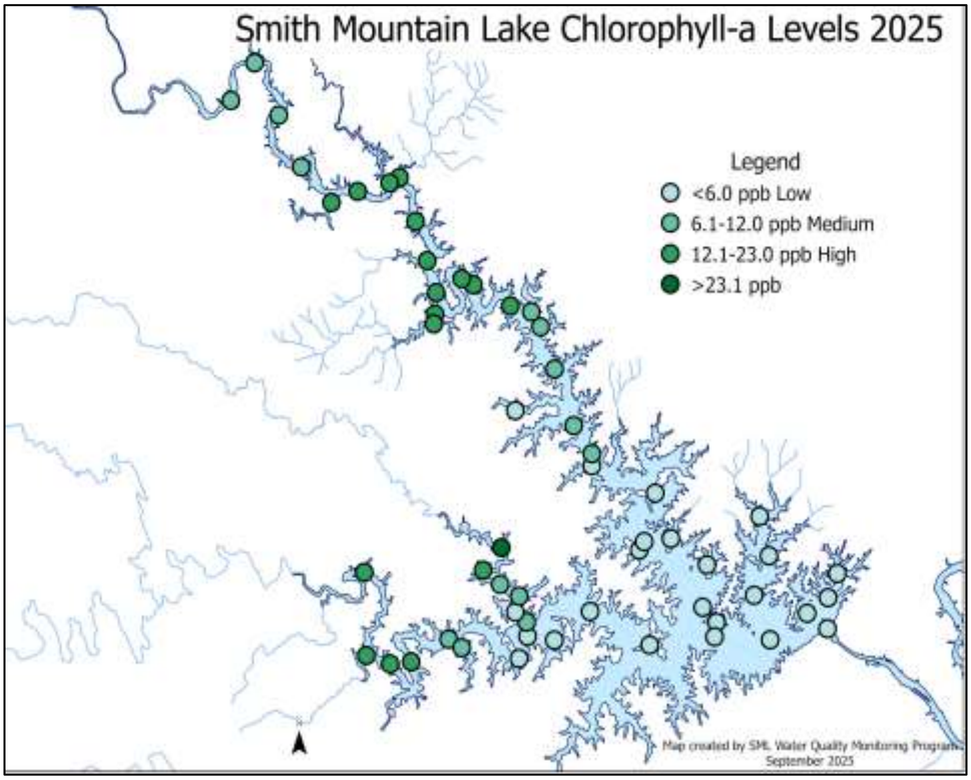


Figure 4.1. Trophic status parameters (TP, CA, and SD) for Smith Mountain Lake for each sampling period in 2025


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
0 0.75 1.5 3 4.5 Miles
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
0 0.75 1.5 3 4.5 Miles
Map created by SML Water Quality Monitoring Program September 2025



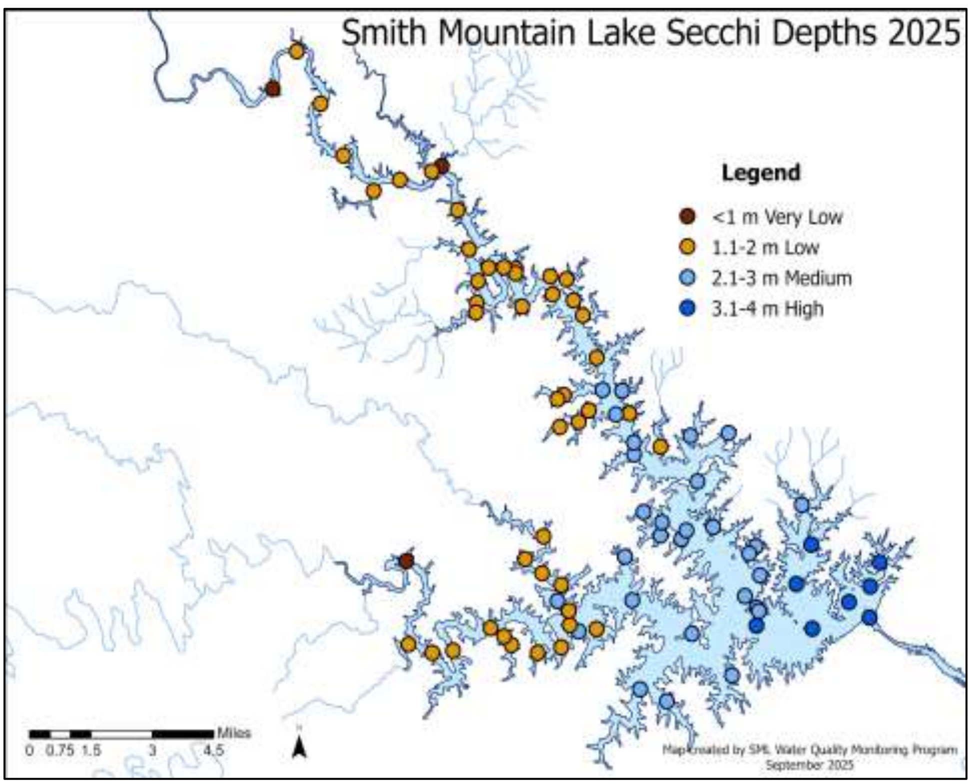


Figure 4.2. Maps showing variation in trophic status parameters for 2025 (TP - lake, TP - tributaries, CA, and SD).

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):

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

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.

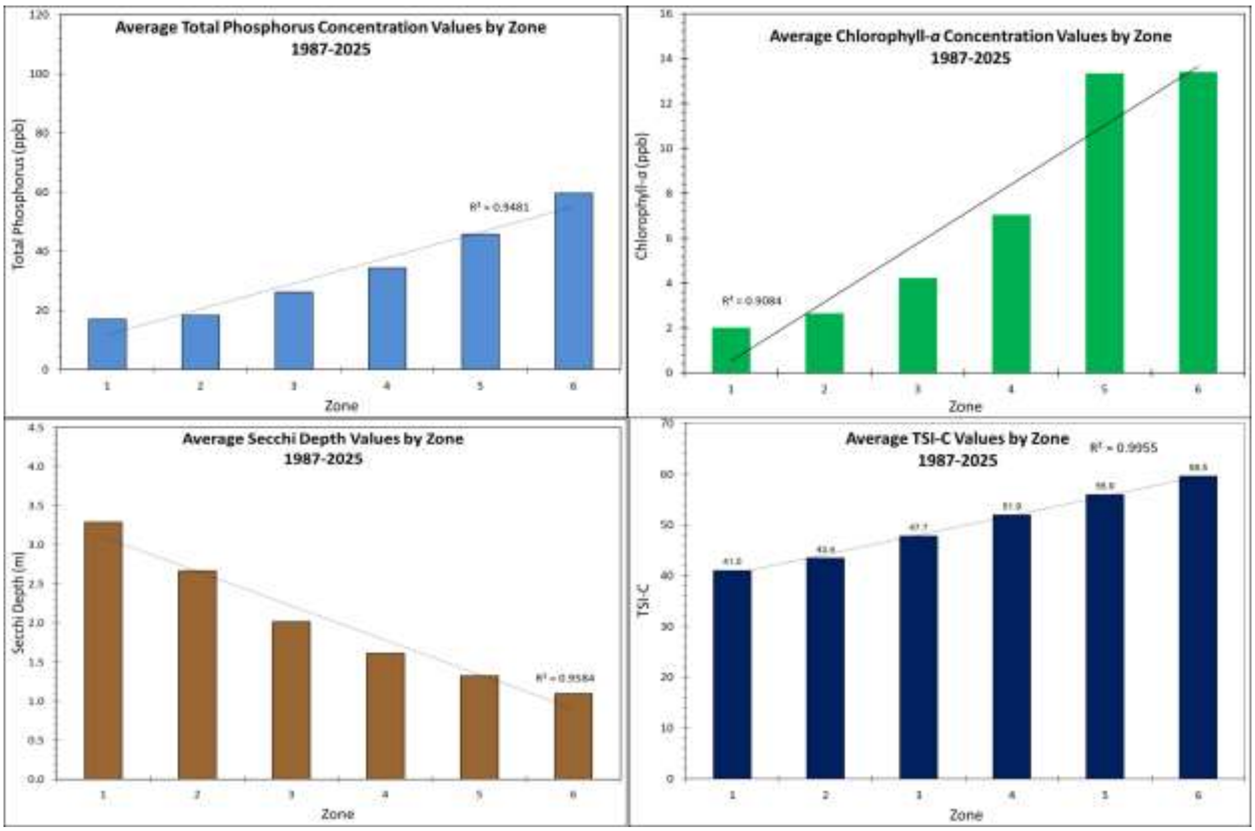


Figure 5.1. Average parameter value by zone for 1987-2025 Carlson's Trophic State Index and its Components

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.

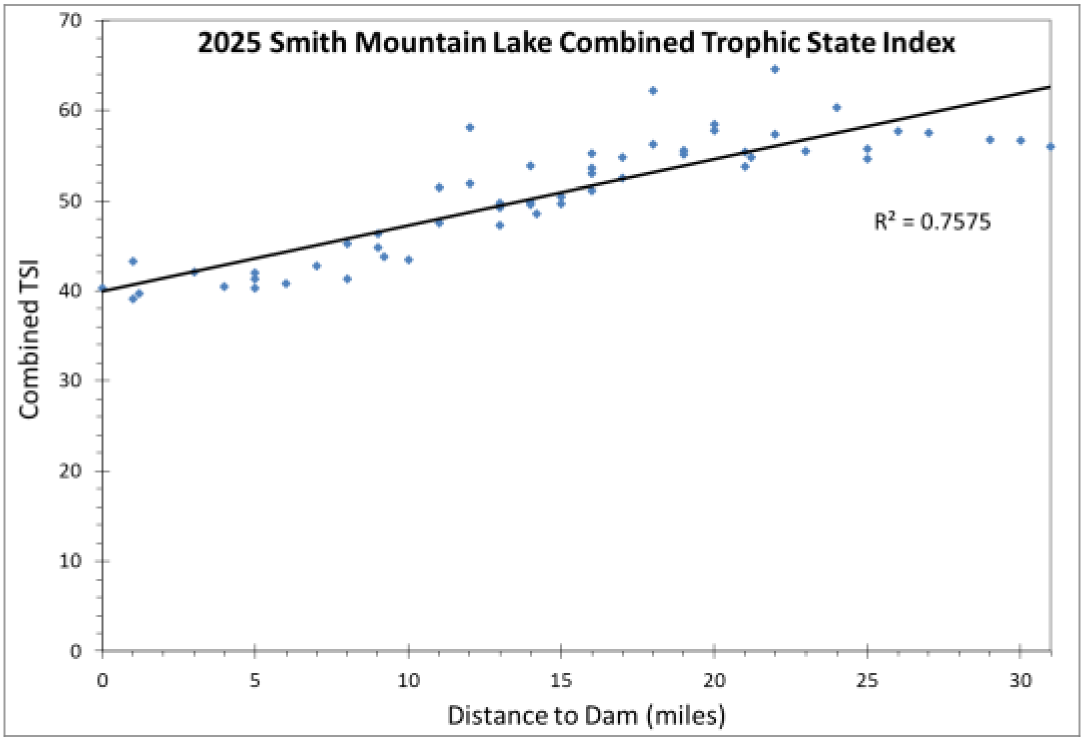


Figure 5.2. Combined Trophic State Index as a function of distance from dam

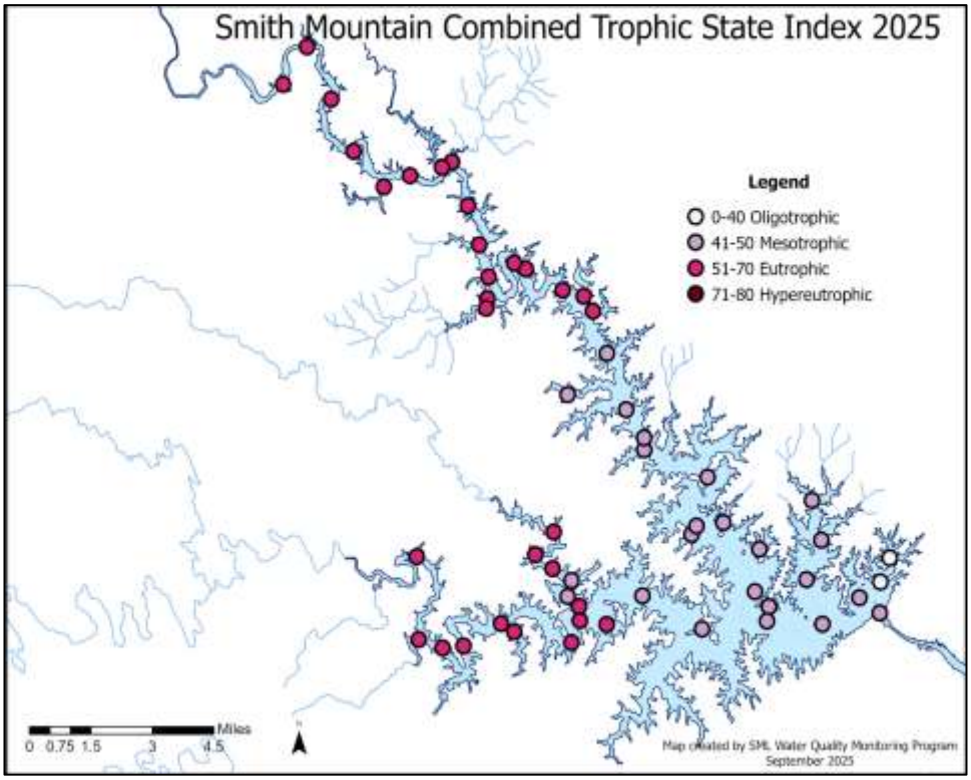


Figure 5.3. Map showing the Trophic State Index Combined results throughout the lake

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).

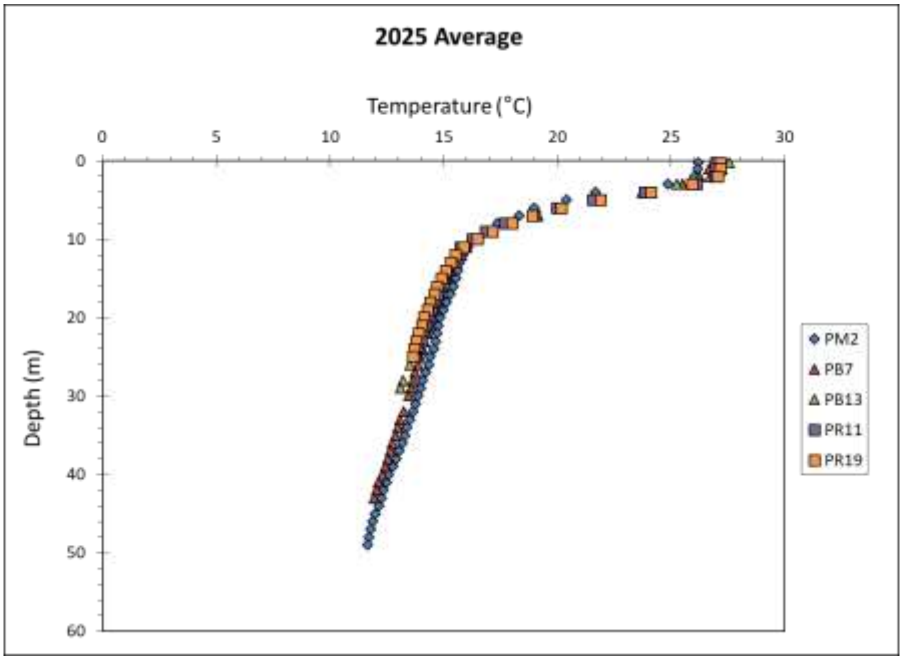


Figure 6.1. Average temperature depth profiles for 2025.

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.

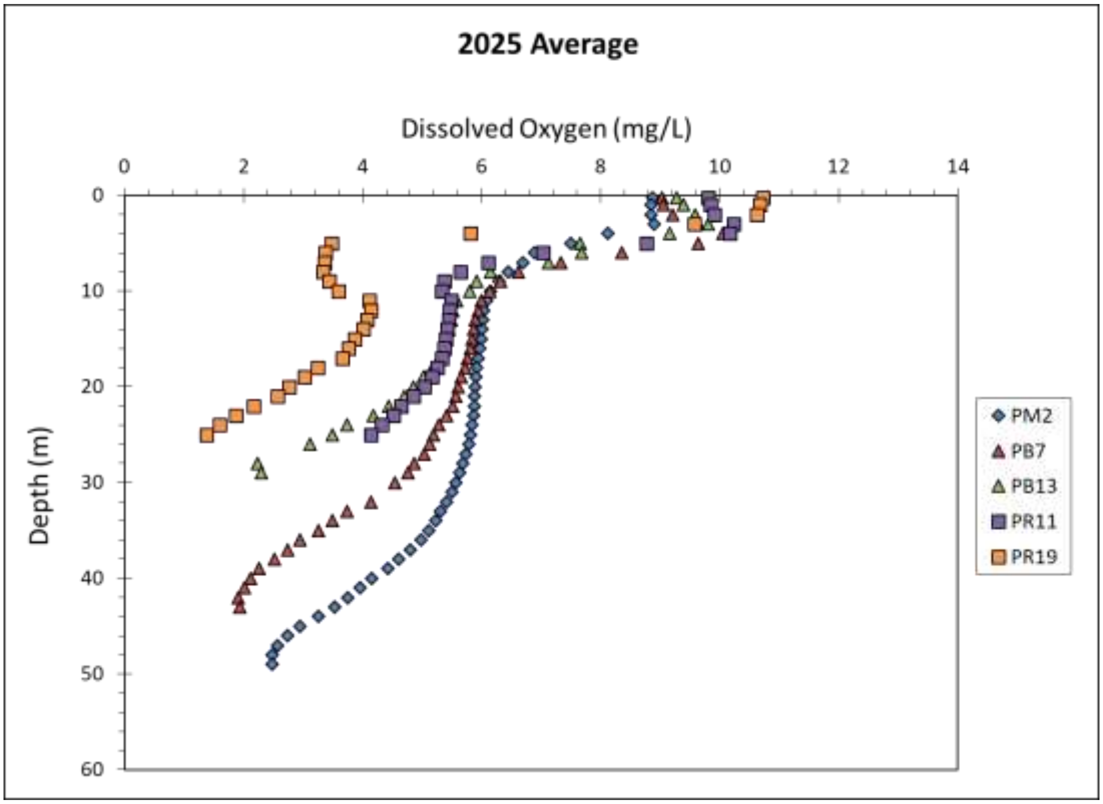


Figure 6.2 Average dissolved oxygen depth profiles for 2025.

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.

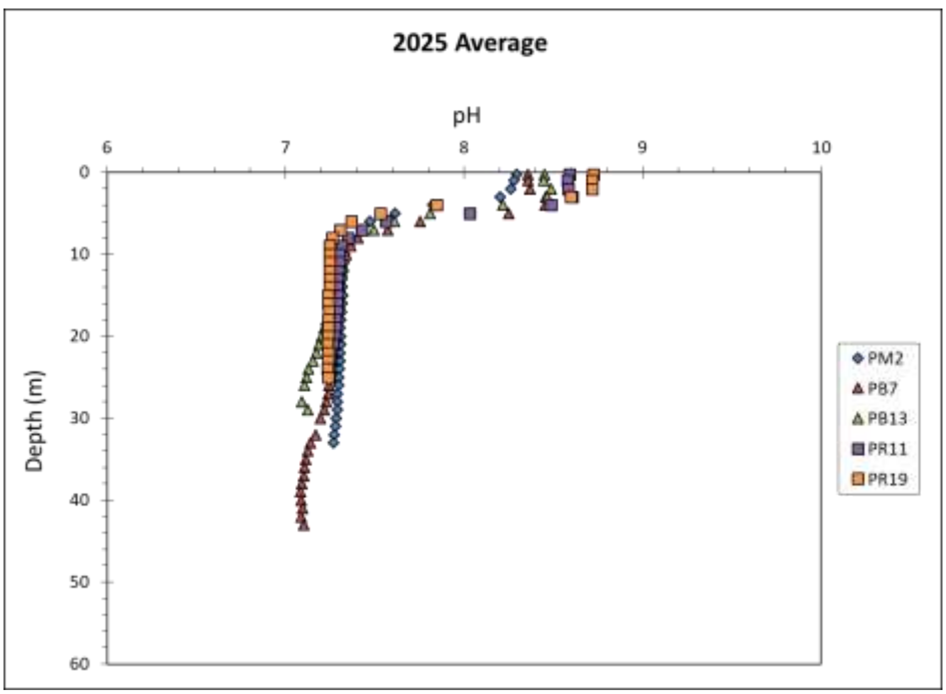


Figure 6.3 Average pH depth profiles for 2025

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.

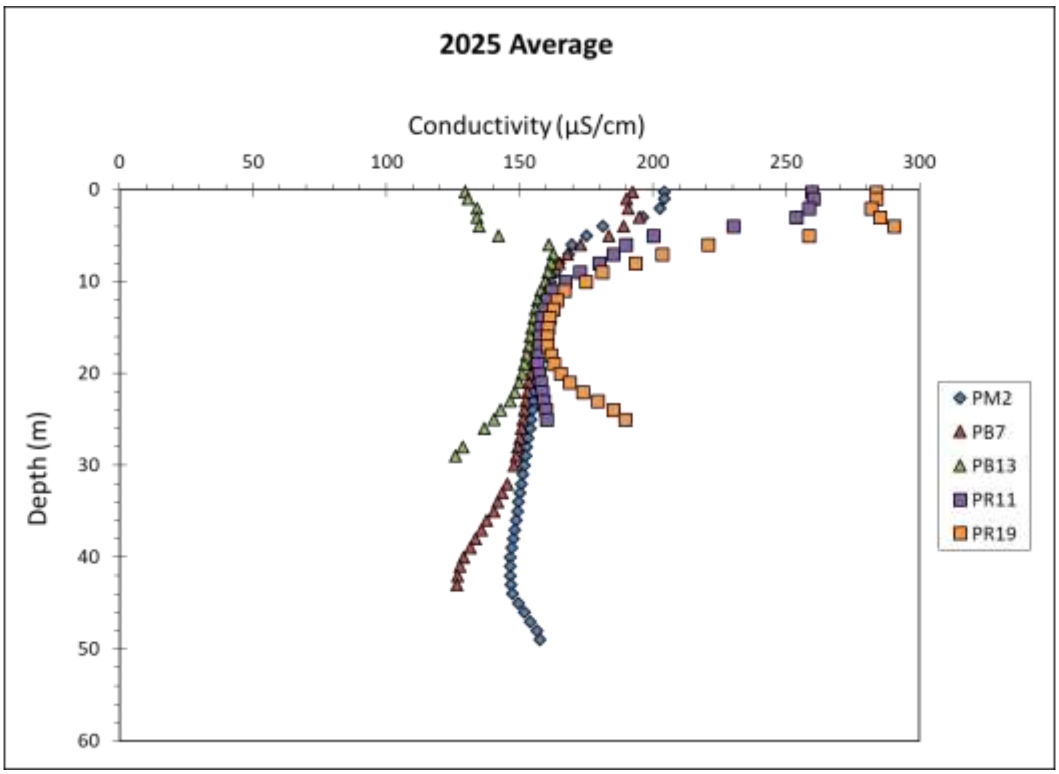


Figure 6.4 Average conductivity depth profiles for 2025.

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).

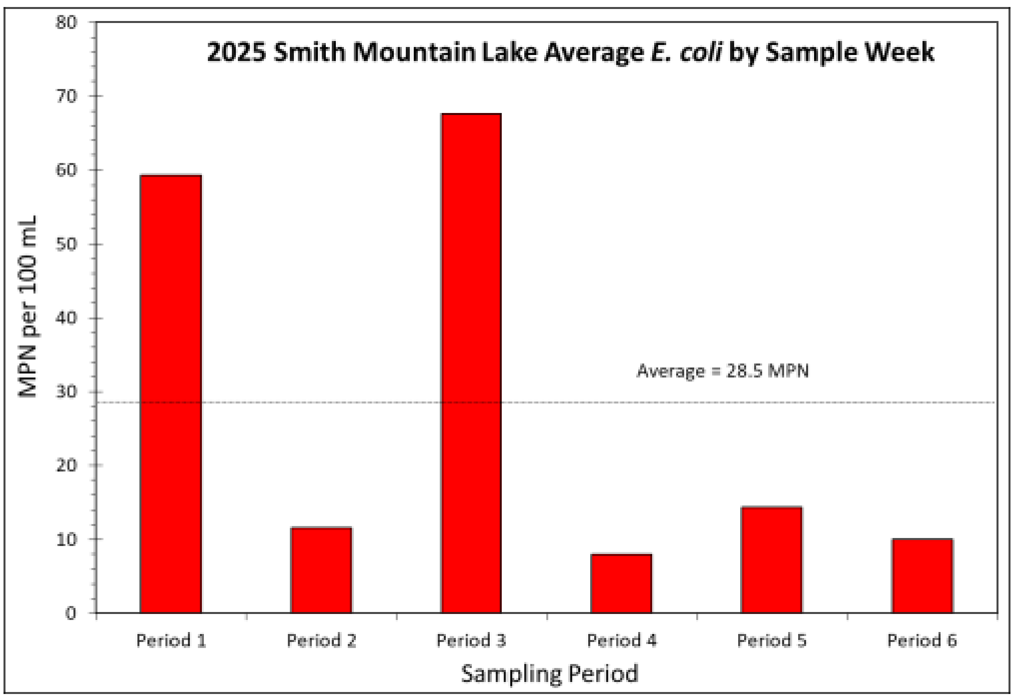


Figure 7.1. *E. coli* versus week sampled on Smith Mountain Lake in 2025 (each sample date included 14 sites with 2 stations per site, n = 28)

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.

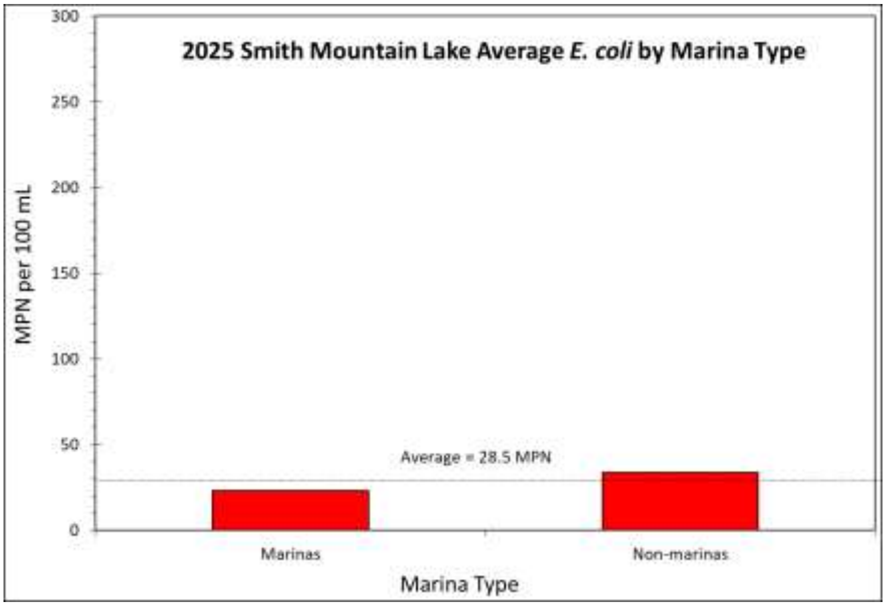


Figure 7.2. Mean *E. coli* count vs. site type in 2025 (7 marina sites, 7 non-marina sites)

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.

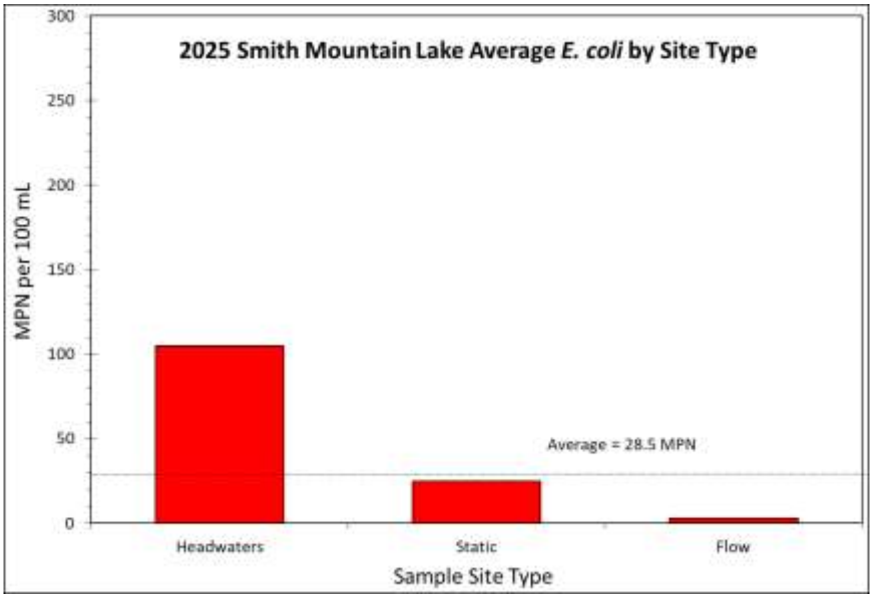


Figure 7.3. Mean *E. coli* count vs. site type in 2025 (2 headwater sites, 7 static sites, 5 flow sites)

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).

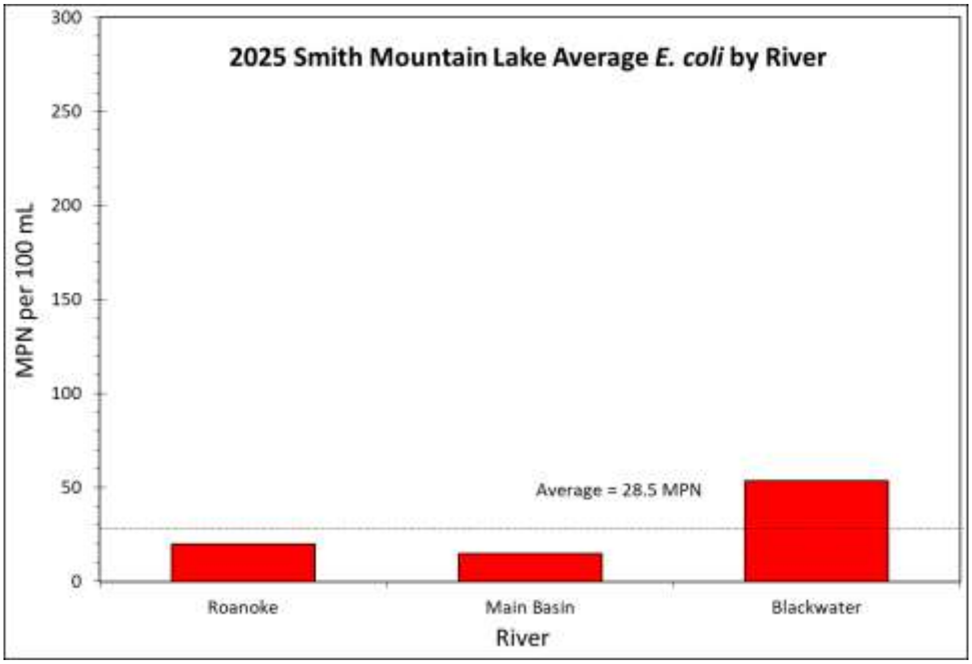


Figure 7.4. Mean *E. coli* counts in 2025 (7 Roanoke channel sites, 4 Blackwater channel sites, and 3 main basin sites)

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.

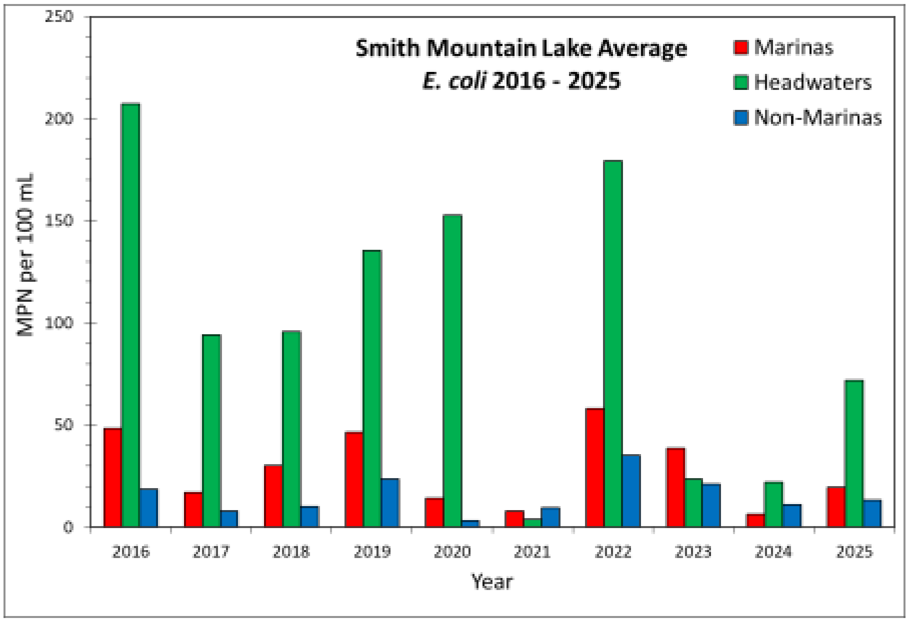


Figure 7.5. Mean *E. coli* counts per site type from 2016-2025

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

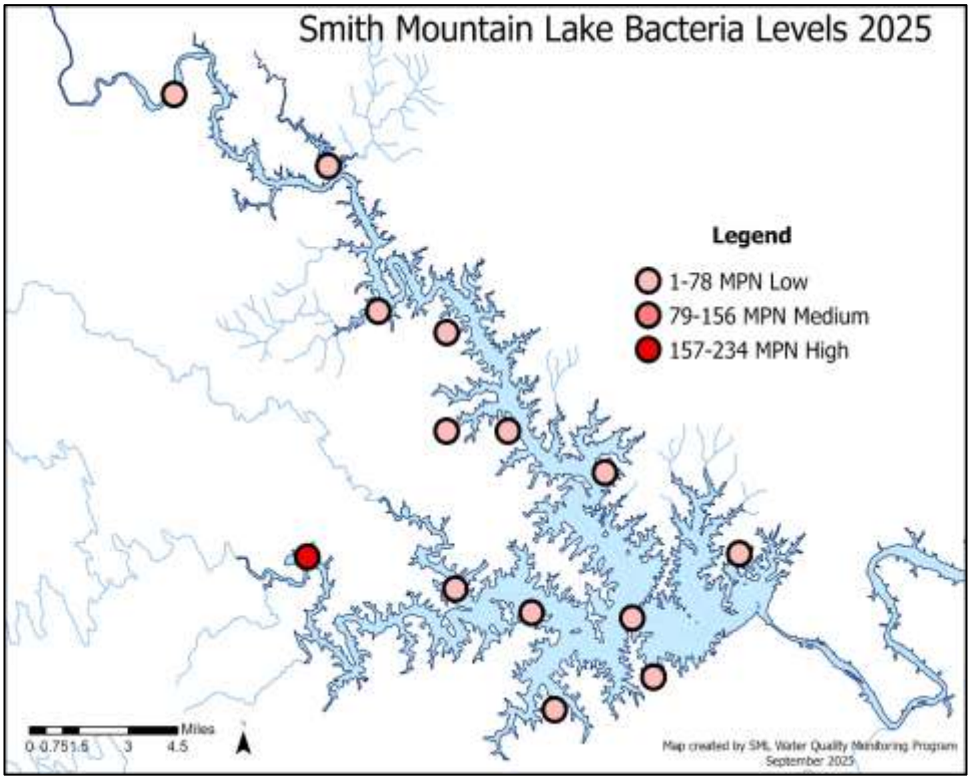


Figure 7.6. Map of bacterial sampling results in Smith Mountain Lake for 2025

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.

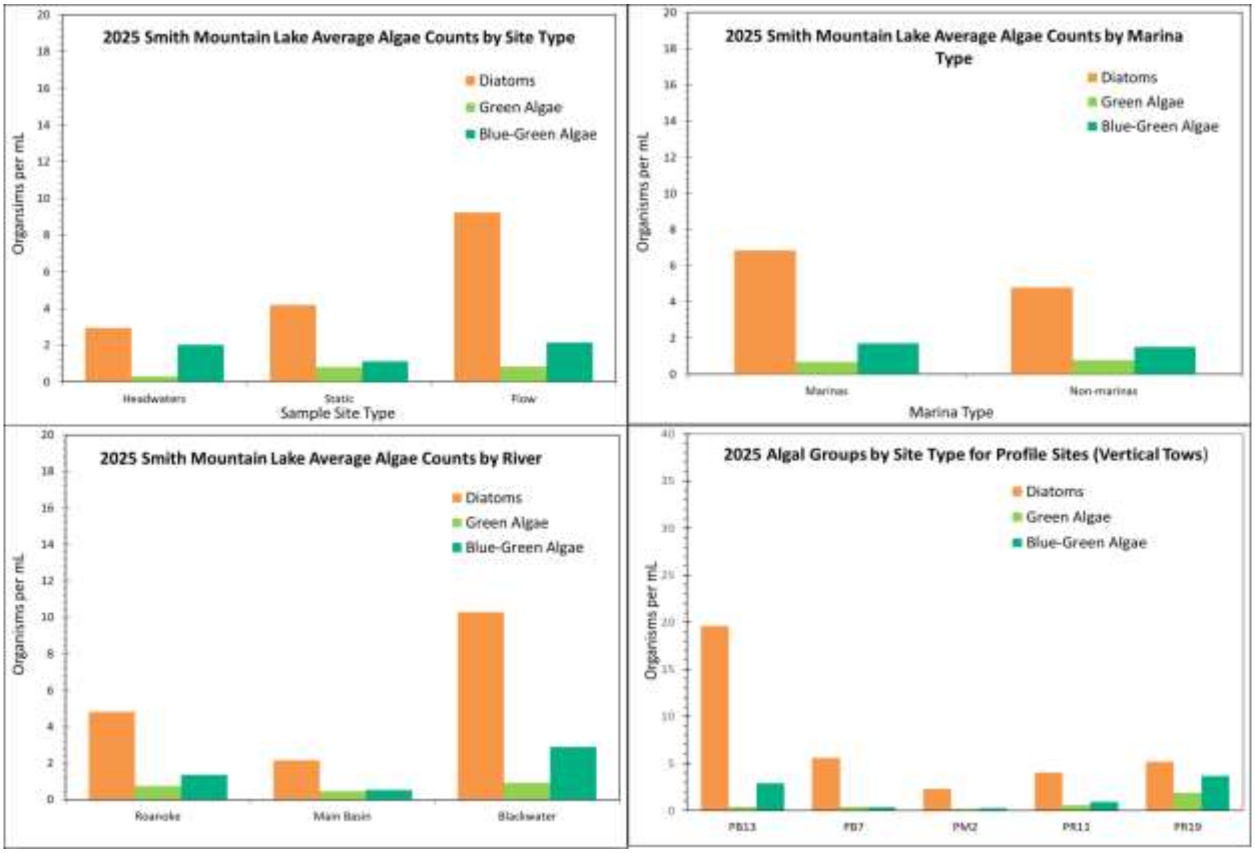


Figure 8.1. Algae counts organized clockwise by i.) site type (i.e., headwater, static, and flow), ii.) marina type (i.e., marina or non-marina), iii.) river source (i.e., Roanoke, Blackwater, and Main Basin), and iv.) profile sites. Note the scale differences.

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).

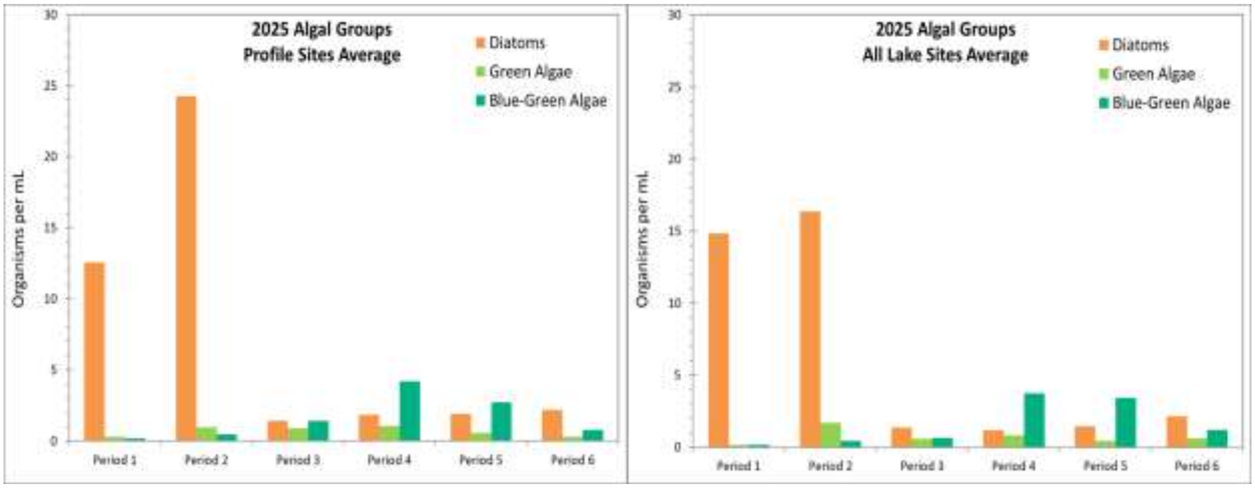


Figure 8.2. Overall patterns of algae groups enumerated in 2025 for each sampling period

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 ±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^{TM} 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^{TM} 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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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

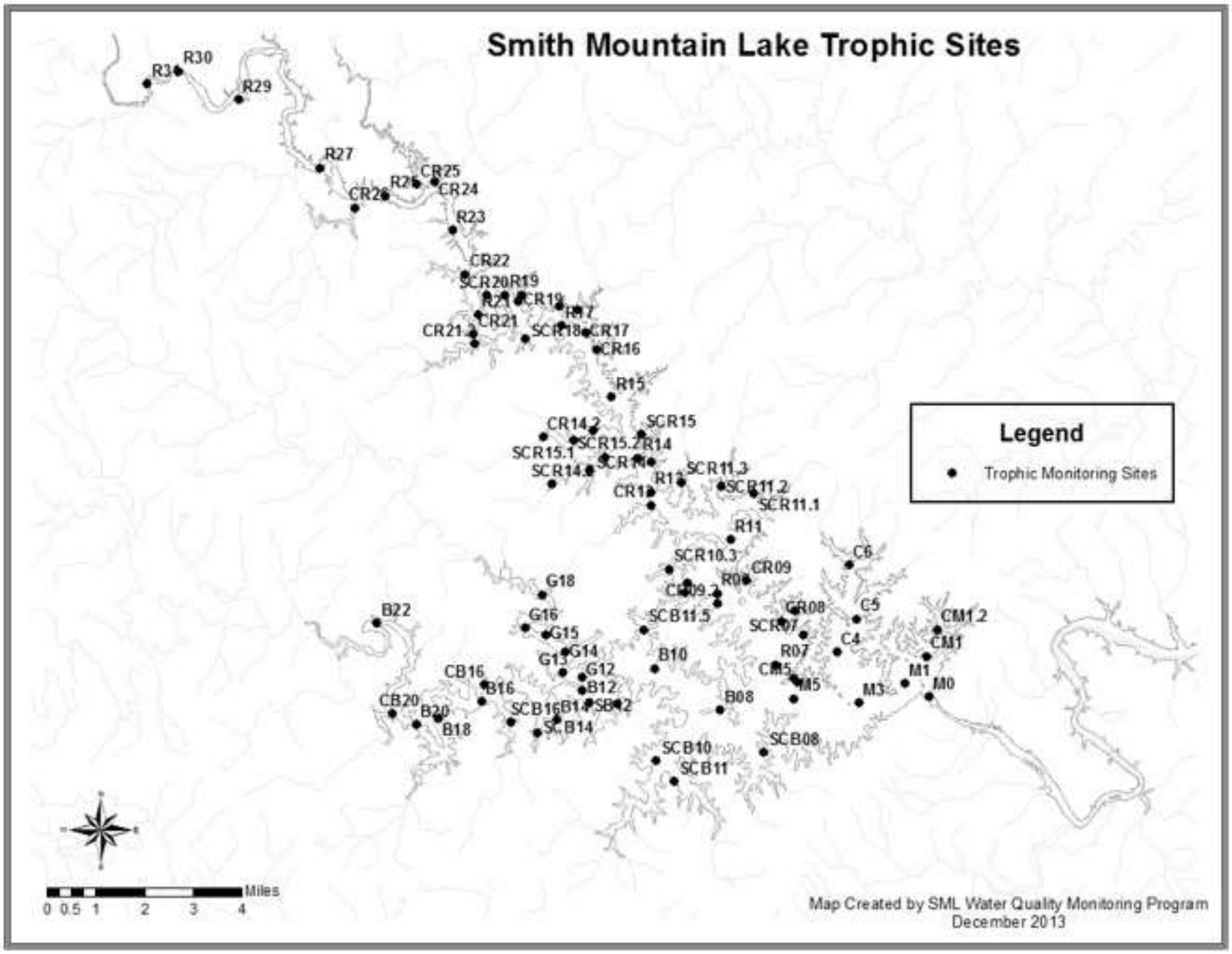

Table A.2. 2025 Smith Mountain Lake tributary stations and other downstream stations

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

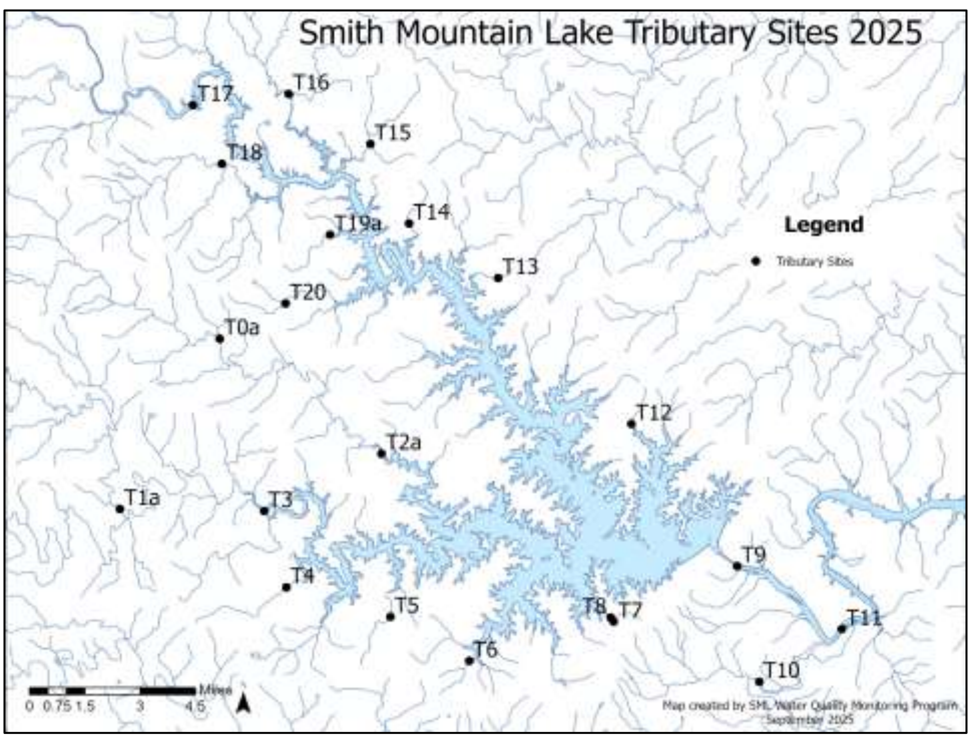

Figure A.2. Smith Mountain Lake Tributary monitoring stations

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

Station	Sampling Period 1 conc (ppb)	Sampling Period 2 conc(ppb)	Sampling Period 3 conc(ppb)	Sampling Period 4 conc(ppb)	Sampling Period 5 conc(ppb)	Sampling Period 6 conc(ppb)	Station Avg. (ppb)	Std. Dev.
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

Station	Sampling Period 1 conc(ppb)	Sampling Period 2 conc(ppb)	Sampling Period 3 conc(ppb)	Sampling Period 4 conc(ppb)	Sampling Period 5 conc(ppb)	Sampling Period 6 conc(ppb)	Station Avg. (ppb)	Std. Dev.
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**

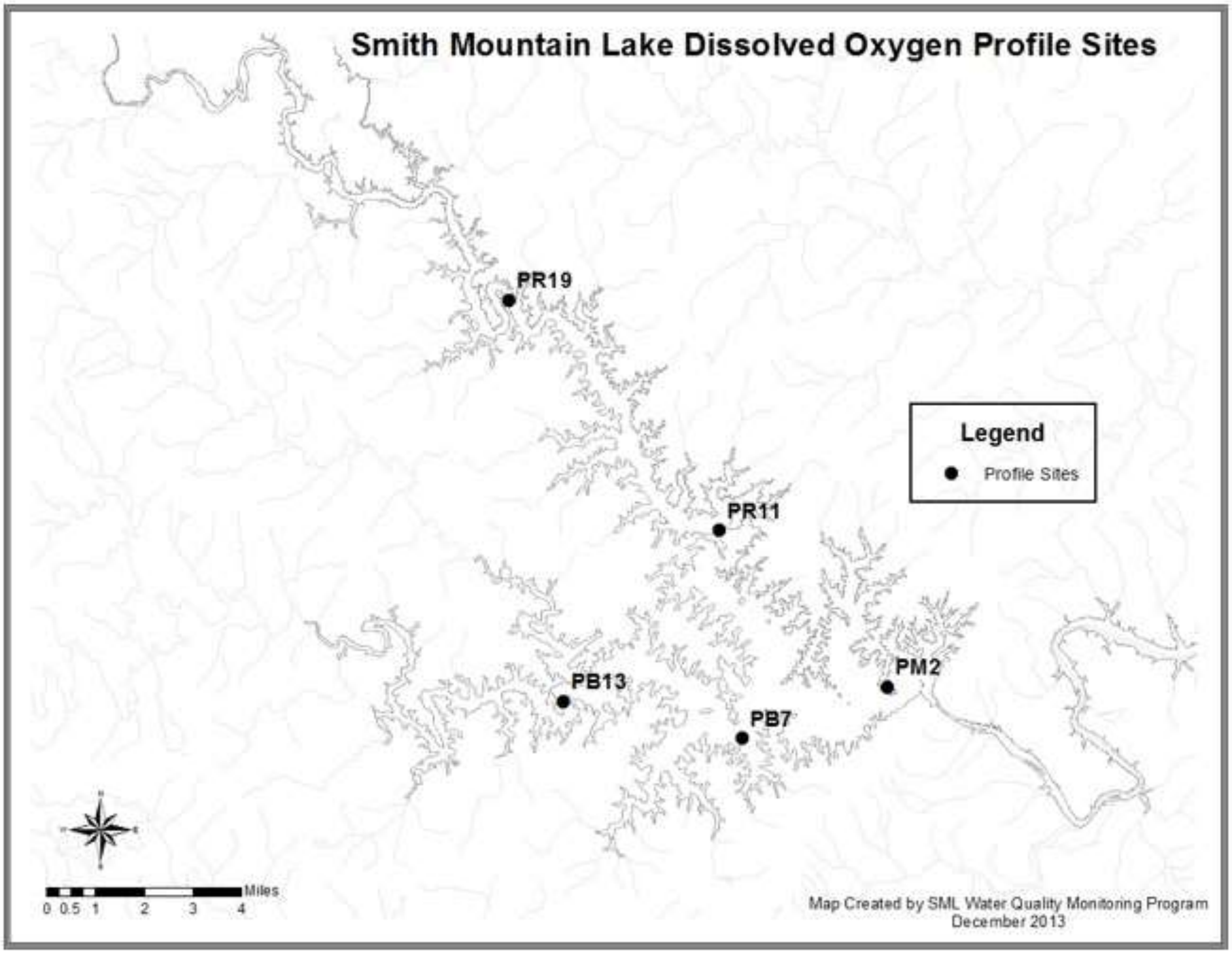

Figure A.3. Smith Mountain Lake depth profiling sites

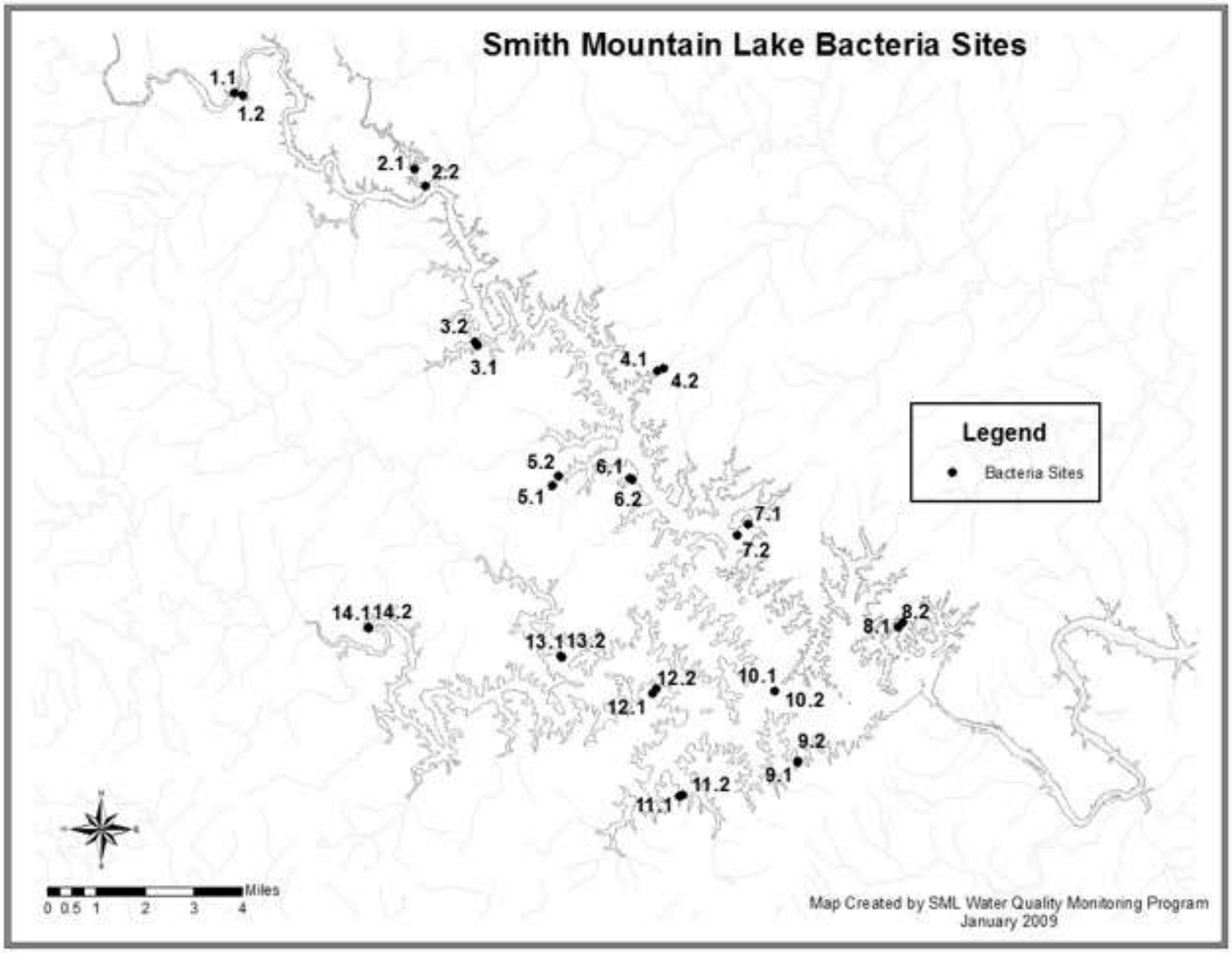

Figure A.4. Smith Mountain Lake bacterial sampling sites

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

Appendix B

2025 Leesville Lake Association Water Quality Monitoring Report

Leesville Lake 2025 Water Quality Monitoring

Prepared for:
Leesville Lake Association

Prepared by:
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February 2026

Funds Supplied by: American Electric Power & Leesville Lake Association

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Table of Contents Page

List of Acronyms and Abbreviations

AEP	American Electric Power
DCR	Virginia Department of Conservation & Recreation
DEQ	Virginia Department of Environmental Quality
DO	Dissolved Oxygen
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
LLA	Leesville Lake Association
mV	Millivolts
MPN	Most Probable Number
NTU	Nephelometric Turbidity Unit
ORP	Oxygen Reduction Potential
TP	Total Phosphorus
SML	Smith Mountain Lake
SMP	Shoreline Management Plan
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index
TSS	Total Suspended Solids
VDEQ	Virginia Department of Environmental Quality

Glossary of Terms

Jargon is used in this report to describe certain aspects of lake function and water concerns in the lake. Here we define key terms to facilitate comprehension of the document and the trends that the research reveals.

Lake or Reservoir – These terms, while not technically synonymous, are used interchangeably and in accordance with lay usage. The term reservoir is reserved for a river system with a dam to create a lake. In the southeastern United States, all of these bodies of water are reservoirs with a few notable exceptions. Lakes are the natural bodies of water typically formed through glacial processes (great lakes) or other geological phenomenon (Mountain Lake Virginia). Reservoirs are always deepest at the dam while lakes are deepest in the center.

Riverine and Lacustrine – These are terms we used to describe reservoirs. Riverine describes conditions that are dominated by river conditions and often occur in the upper portions of a reservoir. Lacustrine is a term used to describe conditions dominated by lake processes and often occur near the dam. The term **transition** is used often throughout the center of the reservoir to describe a blend between riverine and lacustrine.

Pelagic and Littoral – This is a term used to describe the deepest part of the reservoir. It is more often used to describe the open water of a lake. Littoral is the term used to describe the shallow portion of a lake and is often an area covered by floating or rooted plants. These terms are not as often associated with reservoirs because water movement prevents development of significant littoral zones.

Eutrophic – This is the condition of lakes and other bodies of water resulting from the input of excess nutrients. As this condition worsens it leads to algae blooms, formation of toxic algae growth, high pH, low dissolved oxygen and poor water quality. All of these conditions are harmful to beneficial aquatic life and enjoyment of the reservoir.

Trophic State – this is a convenient method to translate measured conditions of eutrophication into a scale. We consider lakes and reservoirs to be eutrophic (high levels of eutrophication), mesotrophic (moderate levels of eutrophication) or oligotrophic (low levels of eutrophication). Often these levels must be balanced as oligotrophic conditions are not good for fishery productivity and eutrophic conditions lead to severe water quality problems. One additional classification is **Dystrophic,** which is characterized by high levels of tannins in the water. Tannins are created when leaf litter degrades. Dystrophic water is often tea colored and found more often in coastal systems.

Polymictic – a term used to describe lakes that turn over multiple times in a year. Turn over reflects the condition where the lake is the same temperature from top to bottom, allowing the water to mix. Many lakes in temperate climates such as Leesville

Lake stratify during summer months characterized by warm water floating on top of colder water. During this period of "stratification," the warm water is isolated from the lower cooler water. When the lake is stratified it only mixes in the upper layer. When the lake warms or cools to the same temperature it mixes throughout. If this only occurs in the spring and the fall a lake is considered dimictic – or mixing only twice in a year. Leesville Lake is considered polymictic because in addition to the spring and fall stratification heavy rain input and water movement by Smith Mountain Lake will break up the stratification. After these events, stratification occurs. This causes the lake to mix many times in a year hence the term polymictic.

Hypolimnion and Epilimnion – These are terms used by limnologists (a person who studies lakes) to describe the layers that form during stratification. The epilimnion is the upper layer and the hypolimnion is the lower layer. The term **Metalimnion** is also used to describe the layer of changing conditions between the two other layers. Temperature is the most common measure used to define these layers, and the most often referenced criterion to define a new layer is a temperature in excess of 1 degree centigrade per one meter of depth. But, because these lakes are polymictic, this clear definition is often not applicable.

Heterogrades – These are terms to describe the shape of oxygen curves throughout the water column. Oxygen is influenced by many factors and the heterograde curves help describe these influences. When phytoplankton accumulate at the thermocline, they tend to photosynthesize creating a visible increase of oxygen in that area. This is called a **positive heterograde**. When oxygen decreases due to bacterial consumption of oxygen with depth without change this is a **clinograde**. Within a clinograde, an increase in oxygen below the thermocline due to the physical characteristics of the water is termed a **positive heterograde**. Oxygen that remains unchanged with depth is an **orthograde**.

Thermocline – Area in the lake defined from a depth profile where water temperature decreases at a rate greater than 1 degree centigrade per meter.

Phytoplankton and Chlorophyll *a* – These are terms to describe the algae or plant life that occupies the pelagic portion of the reservoir. Phytoplankton are single celled or filamentous microscopic plants that grow in the water and are stimulated by water movement, depth of light penetration and nutrients such as phosphorus and nitrogen. Chlorophyll *a* is the photosynthetic pigment found in all plants and a very convenient way to measure the amount of phytoplankton in the reservoir. These terms are often used interchangeably.

E. coli – This term is used to describe a group of bacteria that are associated with health risk in water. They are typically not pathogenic but are easy to quantify in the laboratory. Because their presence is associated with presence of pathogens, we measure their concentration and issue warnings when levels are high. Sediment that is brought into reservoir is often associated with high levels of *E. coli*.

Executive Summary

The Leesville Lake Association and University of Lynchburg, in partnership with American Electric Power Company, monitored water quality of Leesville Lake between April and October of 2025. University of Lynchburg monitored the lake seven times at mid-month while the Leesville Lake Water Quality Committee monitored end of month during June, July and August. The results of that monitoring are reported here with analysis of lake trends at each station and additional analysis on problems or concerns. The intent of this report is to provide a technical and scientific background for sound management of Smith Mountain Lake and Leesville Lake in order to protect and improve these lake resources for future generations.

Leesville Lake continues to meet prescribed water quality parameters measured in the main stem of the reservoir. Water quality is very stable with minimal fluctuations from a slightly eutrophic condition. Two predominate factors contribute to this condition – river input from the Pigg River emptying into the headwater region that drains primarily an agricultural watershed *and* tailwater release from Smith Mountain Lake along with American Electric Power pump-back operations. When comparing the water quality of Leesville Lake to worldwide lakes and reservoirs with agricultural watersheds the water by comparison is of very high quality.

This does not preclude concerns that need continued monitoring and management. Excessive debris pouring into the reservoir from the Pigg River during storm events continues to be a hazard. During 2025, excessive debris prevented passage beyond Toler Bridge during one of the sampling events. Pump back operations exacerbate this problem by moving debris back into the channel when water movement is reversed. If management of woody debris cannot occur in the Pigg River Watershed, a more aggressive approach needs to be considered during rain events. It is understood and then documented in this report the extent of debris entering the reservoir from heavy (> 1 inch) rain events.

Other operational considerations should include the relationship between precipitation and reservoir productivity including chlorophyll a production and dissolved oxygen concentrations. Both are dependent upon precipitation with a build-up of Chlorophyll a observed with increased oxygen during lower precipitation years and the reverse observable during higher precipitation years. Pump-storage operations integrate into this relationship, so coordination with water quality should be considered. Coordinating the movement of water with both energy production and water quality needs to be analyzed.

Year 2025 conclusions include:

1. Leesville Lake remains slightly eutrophic and this measure is very stable in the reservoir. It has maintained this status throughout the monitoring period of

study (2010-2025) and this result is currently stable and not expected to worsen or improve in the foreseeable future.

2. Leesville Lake behaves as a pump storage reservoir with headwaters impacted by tail release from the upper reservoir along with input from the Pigg River. Both are situated in the headwaters of the reservoir and both provide a unique input into the system. Each is integrated into the water quality and cannot be analyzed very well separately.
3. Analysis of all data suggests management needs to be closely aligned with precipitation as it drives productivity, the input of debris and oxygen loss in the reservoir. It additionally has a significant impact on the bacteriology of the reservoir that is analyzed in a separate study and subsequent publications.

The following management recommendations are suggested after conclusion of the 2025 sampling season:

1. Precipitation is a driver of water quality and aesthetics in the reservoir and must be part of future management of the reservoir.
2. Aggressive deployment of debris removal needs to continue. Correlations between pump-storage activity and water quality necessitate that dam operations be adjusted to preclude negative impacts on water quality when feasible. Knowing that retention of water in the reservoirs tends to increase productivity and oxygen, negative impacts of low oxygen can be countered by increasing water retention. Generally, increasing water retention in the lake will increase zooplankton populations and fish productivity.
3. Low dissolved oxygen needs to be managed at the tailwaters. All possible operational scenarios including syncing with precipitation need to be considered.
4. APCo's upcoming (April/May 2026) submission of a Dissolved Oxygen (DO) Improvement Plan to the Virginia Department of Environmental Quality for review and approval will address these issues. "APCo will develop a comprehensive plan, designed in consultation with VDEQ, the Department of Wildlife Resources (DWR) and other state or federal agencies to address depressed DO levels downstream from Smith Mountain Lake Dam. This plan is in accordance with APCo's final Permit VWP number 24 1547 signed on July 7, 2025. The plan is to protect instream beneficial uses, to ensure compliance with applicable water quality standards, to prevent impairment of state waters or fish and wildlife resources, and to provide no net loss of wetland acreage and function through compensatory mitigation and success monitoring and reporting."

Section 1: Current Conditions

1.1 General:

This is the 15th year of water quality monitoring of Leesville Lake by University of Lynchburg (formerly Lynchburg College in previous years of study) in partnership with Leesville Lake Association (LLA). Fifteen years of data continue to strengthen our understanding of Leesville Lake's water quality and support our effort to optimize management of this important natural resource. We will also incorporate broader findings in the watershed as these relate to water quality of the watershed of which Leesville Lake is a part.

Section 1 documents results from the current year's sampling. Data are reported in graphical form with interpretations. In **Appendix D**, all data are reported in tabular form to facilitate future analysis and use with other projects. This project continues to provide essential baseline data for the condition of the lake and interpretation of changing conditions. A full background of the study and its rationale is located in **Appendix A**.

1.2 Methods:

Data were collected by University of Lynchburg through a series of water samplings and testing monthly from April through October. These dates coincide with the most productive period of the reservoir, i.e., when lake productivity is greatest. Leesville Lake Association (LLA) supplements sampling over the three summer months of June, July and August to provide biweekly analysis. LLA collection is not as extensive as the university sampling but adds vital data to understanding trends in the lake (LLA and University of Lynchburg, have actively pursued additional investigations of water quality in the watershed). The following eight sites (Table 1.0) continue to be sampled, as stated in the Leesville Lake Water Quality Monitoring Plan:

Table 1.2.1. Leesville Lake Sampling Sites

LC Station	LLA Station	Site ID	DEQ Station ID	Latitude	Longitude
Leesville Lake Dam	11	2636	LVLAROA140.66	37.0916	-79.4039
Leesville Lake Marina	5	1275	LLAOQC000.58	37.05939	-79.39574
Tri County Marina	3	1273	LLATER000.33	37.05942	-79.44489
Mile Marker 6	8	1373	LLAROA146.87	37.06320	-79.47110

Mile Marker 9	2	1272	LLAROA149.94	37.03993	-79.48233
Toler Bridge	1	1271	LLLAROA153.47	37.01090	-79.47530
Pigg River	9	1374	LLAPGG000.47	37.00430	-79.48590
SML Tail Waters	12	2637	LVLAROA157.92	37.0382	-79.531306

Detailed methodologies used by University of Lynchburg and Leesville Lake Association are located in **Appendix B** for reference. Quality Control and Quality Assurance are located in **Appendix C** for reference.

Site Descriptions

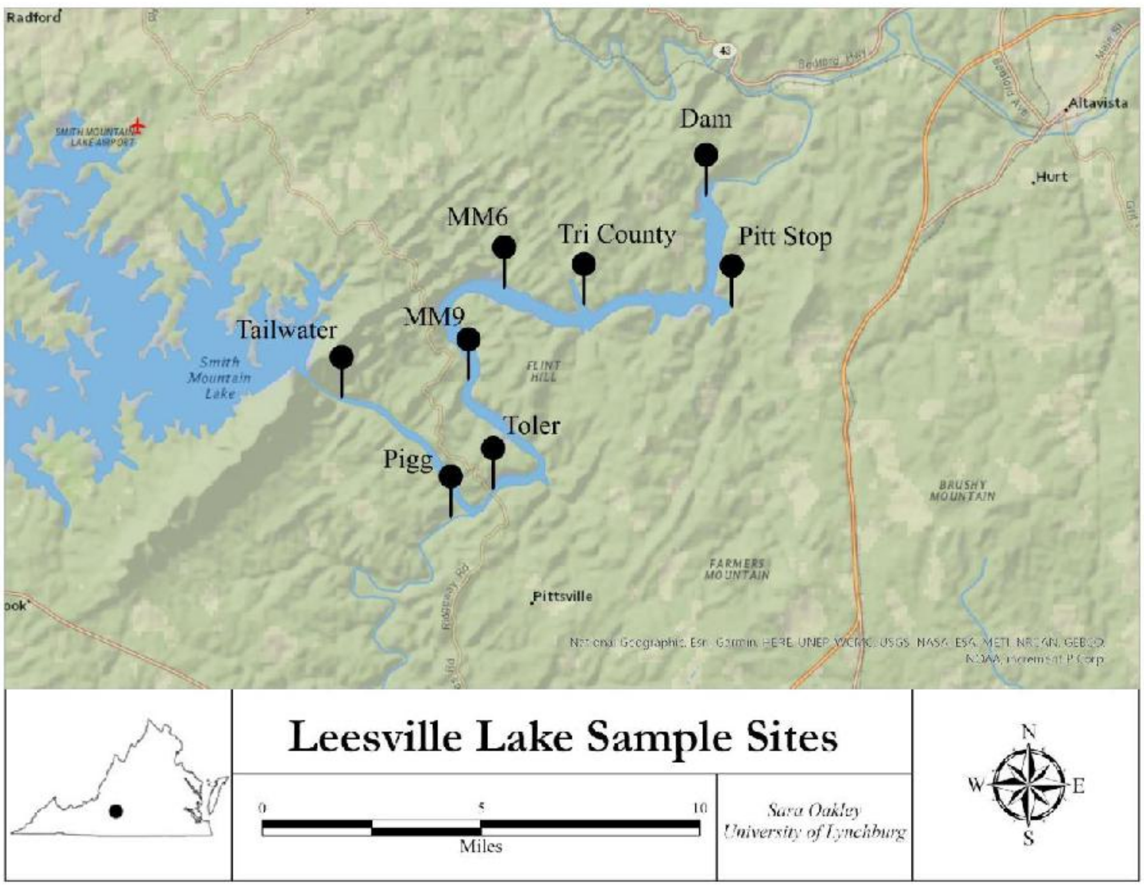


Figure 1.0 – Map of Leesville Lake showing locations of sampling stations along the reservoir.

Leesville Lake Dam

The Dam sampling site is located on the northwest (N 37° 5' 35.215", W 79° 24' 9.809") quadrant of the Old Womans Creek subwatershed (Figure

1). This part of the reservoir is considered as **lacustrine** and its characteristic resembles lake qualities. The water upstream progresses into this station as the season progresses and water characteristics are expected to be isolated from the influence from Smith Mountain Lake Operations.

Leesville Lake Marina (Originally Pitt Stop Marina)

The Leesville Lake Marina sampling site is located on the northwest quadrant (N 37°5' 35.21, W 79°24' 10.425) of the Old Womans Creek subwatershed (Figure 1). This portion of the reservoir is potentially impacted by Old Womens creek and identified by DEQ as an impacted watershed.

Tri County Marina

Tri County Marina sampling site is located further south of the northwest quadrant (N 37°3' 35.158, W 79°23' 219) of the Old Womans Creek subwatershed (Figure 1.0). This part of the reservoir is considered as a **transition zone** between **riverine** and **lacustrine**. Water in this zone is expected to not be as influenced from Smith Mountain Lake Operations, but more so by transition position. This tributary is expected to deposit nutrients and other pollutants, with periods of drawback potentially enhancing impact of effluents spent in the reservoir.

Mile Marker 6 (MM6)

MM6 sampling site is located further south of the mid- southeast quadrant (N 37° 3' 46.501, W 79° 26' 48.006") of the Old Womans Creek subwatershed (Figure 1). This part of the reservoir is also considered as a **transition zone**. Positioned further upstream the patterns observed here provide a point to compare and discern trends of that are comprised moving up or down the reservoir.

Mile Marker 9 (MM9)

MM9 sampling site is located further south of the southeast quadrant (N 37° 4' 5.7325", W 79° 28' 21.015") of the Old Womans Creek subwatershed (Figure 1). This part of the reservoir is considered as a **riverine zone**. Water transported upstream from the Toler Bridge sampling site subject this sampling site to further mixing from influxes of the tail waters of Smith Mountain Lake Dam and Pigg River are expected to be heavy influencers and expect to reflect degradation of water quality from water transported from Toler Bridge.

Toler Bridge

The Toler Bridge sampling site is located south of the southeast quadrant (N 37° 2' 23.3955", W 79° 28' 53.152") of the Old Womans Creek subwatershed (Figure 1). This part of the reservoir is also considered as a **riverine zone.** This sampling site is of interest to study as it is the confluence point of dichotic water qualities from expected poor water conditions quality from Pigg river and the expected good water quality conditions from Smith Mountain Lake. Since the resulting water quality is driven from mechanistic (SML Dam) and stochastic (Pigg River), the qualities here will be challenging to interpret.

Pigg River

The Rig River sampling site is located on the furthest southeast aspect (N 37° 0' 17.333", N 37° 0' 17.333) of the Old Womans Creek subwatershed (Figure 1). This area is considered a **riverine** zone. The water quality measures reflected clearly impact water quality in the reservoir. This sampling site here is to reflect the impacted water quality that merges into the reservoir compared to the relatively unimpaired water quality released by the Smith Mountain Lake Tail waters.

Smith Mountain Lake Tailwaters

The Smith Mountain Lake Tail waters sampling site is located further north the southeast aspect of the Clay Branch-Leesville Lake subwatershed (Figure 1). This area is considered as a **riverine** zone as the input patterns are similarly reflective of a river. The water inputs at this location are of very good water quality because of the inputs of nutrient concentration and the settling sediments from the water column. This site is of interest to sample due to the quality demonstrating which areas are of interest for sound management of Smith Mountain Lake and Leesville Lake.

1.3 Leesville Lake Water Quality: Current Test Results

1.3.1 Temporal Analysis by Station

Background

Leesville Lake is a reservoir by definition (a glossary of terms used in this report is provided on page 8 for helpful reference). It is a river course with a dam constructed and filled to form this reservoir. Leesville Lake is somewhat different than a typical reservoir because it serves as a water storage source (pump back operations) for the generation of electricity by the Smith Mountain Lake Hydroelectric Plant. The reservoir receives water input primarily from Smith Mountain Lake but secondarily from several other river systems with the Pigg River the most significant. This river drains a considerably large watershed with significant agriculture and some urban land disturbance throughout. These inputs and pumping operations at the Smith Mountain Lake Dam create a unique hydrology that impacts the water quality of the reservoir.

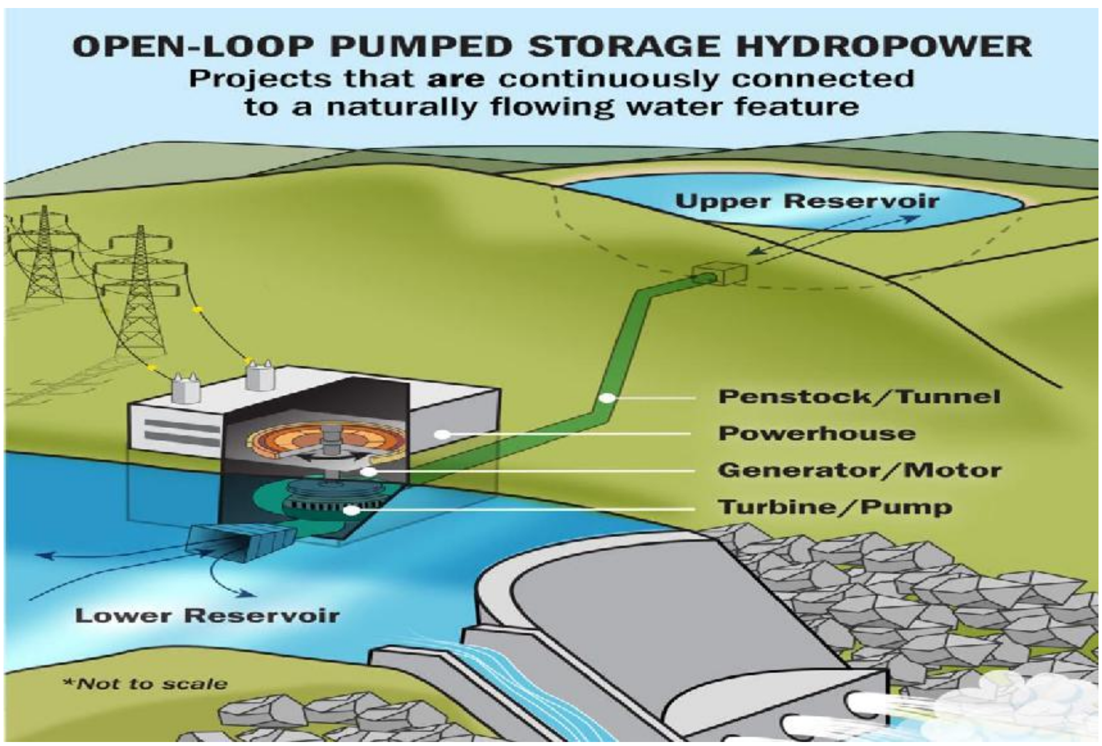


Figure 1.3.1. – Graphical representation of a pump-storage reservoir. Water from lower (storage reservoir) is pumped up to the upper reservoir to generate power by spinning turbines in the dam. (graphic from Dept. of Energy at energy.gov).

In any reservoir, water quality needs evaluation along a spatial and horizontal gradient. This gradient begins in the headwaters of the reservoir where river inputs generate patterns similar to a river. This section, characterized as riverine, is often the area with the highest productivity and nutrient input and the poorest water quality. As water travels further into the reservoir, these riverine conditions begin to lessen and more lake qualities (lacustrine), influence water quality. This middle portion of the reservoir is considered a transition zone as the riverine and lacustrine portions of the reservoir mix. This area may have the highest overall productivity in the reservoir as sediments associated with river flow settle from the water column yet nutrient concentrations are plentiful. The final sections of a reservoir are considered lacustrine and resemble lake qualities. This area often is lower in productivity due to settling of particulates and lower nutrient concentrations. If stratification is continuous, upper layers become very isolated from lower portions of the reservoir further isolating nutrients and other pollutants. The best water quality for the reservoir is located in this section.

Because Leesville Lake is a storage reservoir (Fig 1.3.1) it does not necessarily follow this typical pattern. First, the headwaters are fed by release of tail water from Smith Mountain Lake lacustrine zone. This release is of very good quality water because of the aforementioned typical water quality in a reservoir. Thus, one source of incoming water to Leesville Lake is excellent and often mesotrophic or even oligotrophic in quality. However, during later portions of the year the oxygen content of water released from Smith Mountain Lake may have very low oxygen content due to the reservoir properties of stratification that depletes oxygen in the hypolimnion of eutrophic reservoirs. A secondary source of water into Leesville Lake is the Pigg River. This is an impaired river delivering high concentrations of nutrients, sediment and bacteria into Leesville Lake particularly during storm events. While there are many pump-storage reservoir systems in the US, each one has unique properties due to the input of various river systems.

Additionally, the headwater region of Leesville Lake is subject to a bidirectional movement of water. This forces water flow from the Pigg River into the Smith Mountain Lake (SML) lacustrine zone. The fate of this mixing depends on hydroelectric operations, amount of water pumped back and time this water remains in the upper reservoir. The impacted area within Leesville Lake is 4 miles from the Pigg River mouth to the SML dam. Then during energy production, Pigg River water mixed with SML lacustrine discharge flows into Leesville Lake headwaters. This pattern is variable and at any time the water in this 4-mile stretch may consist of Pigg River water, SML release or a combination of both. This pattern significantly altered by stormwater.

The transition portion of the reservoir is not as heavily influenced by Smith Mountain Lake Operations. Water is drawn back and forth above this zone but the volume of water buffers the influence these operations exert on water quality. During periods of heavy rain, sediment-laden water does travel into the transition portions of the reservoir. Water in this zone is influenced by Smith Mountain Operations but more so by its position as the transition zone. The dam area of Leesville Lake is isolated from influence of Smith Mountain Operations and reflects the water quality of the lacustrine area. At multiple points along the reservoir, tributaries of various water quality empty into the lake. These tributaries do not account for a bulk of the water flowing through Leesville Lake but do deposit nutrients and other pollutants. And during periods of drawback, these pollutants are pulled back through the reservoir potentially enhancing impact and time spent in the reservoir.

The analyses in this report examine the data to support or revise the above described limnology of Leesville Lake. Section 1 analyzes each station relative its position (Riverine, Transition or Lacustrine) and the potential impact of each tributary has on observed water quality. Section 2 examines lake-wide trending and consideration of problems that should be investigated further. Section 3 presents management recommendations.

1.3.1.1 Dam (Lacustrine)

Background

The area near the Leesville Lake Dam is considered a Lacustrine section. It exhibits characteristics similar to a natural lake, allowing analysis for similarities to lake conditions.

Conductivity

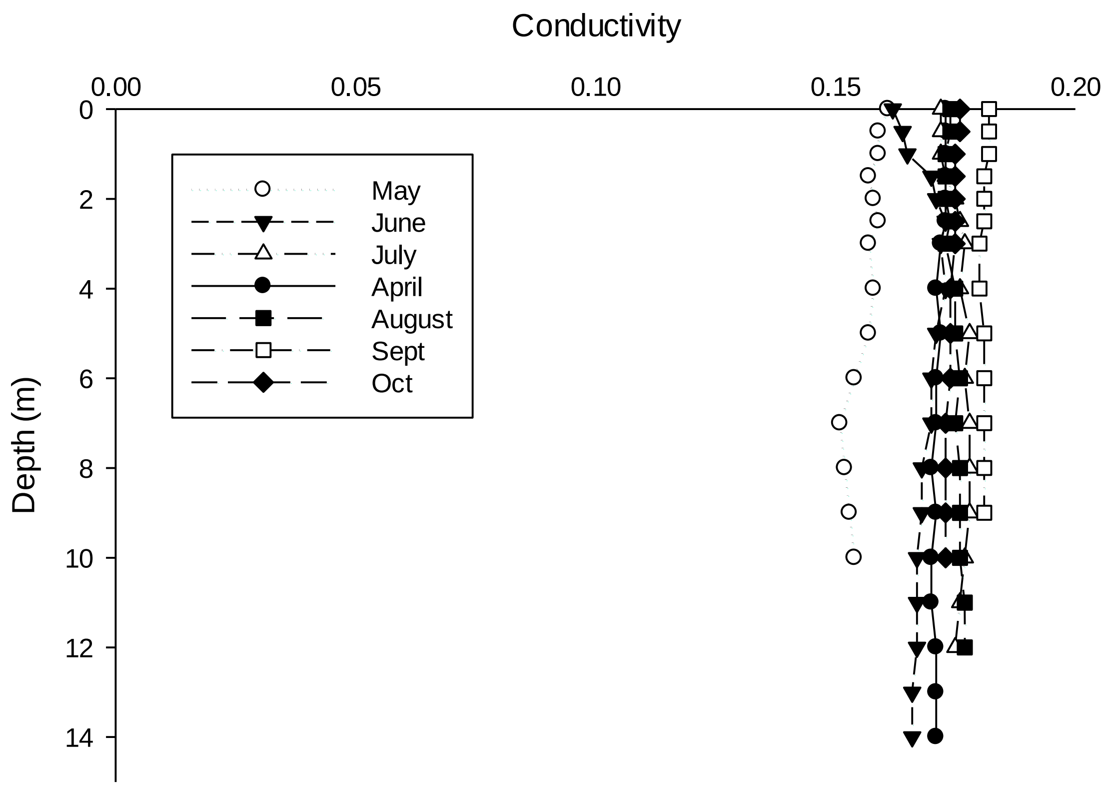


Figure 1.3.2. Dam (Lacustrine) Conductivity (ms/cm) measures over study period (2025)

Seasonal Analysis

Conductivity reflects the presence or absence of pollution or particulates that conduct an electrical current in the water. It is possible to correlate pollution or a water source with levels of conductivity as this measure reflects the concentration of dissolved material in the water. For this study, conductivity can be used to track water movement as Pigg River contains a lower conductivity than SML tail water release.

In 2025, conductivities were relatively similar throughout with May the lowest and September the greatest. This reflects greater input from Pigg River early in season with greater isolation from Pigg and connection to SML in the latter half of season as precipitation lessened relative to the first half of the season. This pattern is reflective in the other parameters.

Comparisons Across Years

All data collected in this study suggest conductivity is strongly driven by stormwater flow. Because Pigg River conductivity is considerably lower than water release from SML Dam, lower conductivity measures during any sampling date reflect increasing content of water from the Pigg River. Lower conductivity at the dam station suggests high flow from Pigg River and impact throughout the reservoir. This trend is evident in 2025.

Dissolved Oxygen

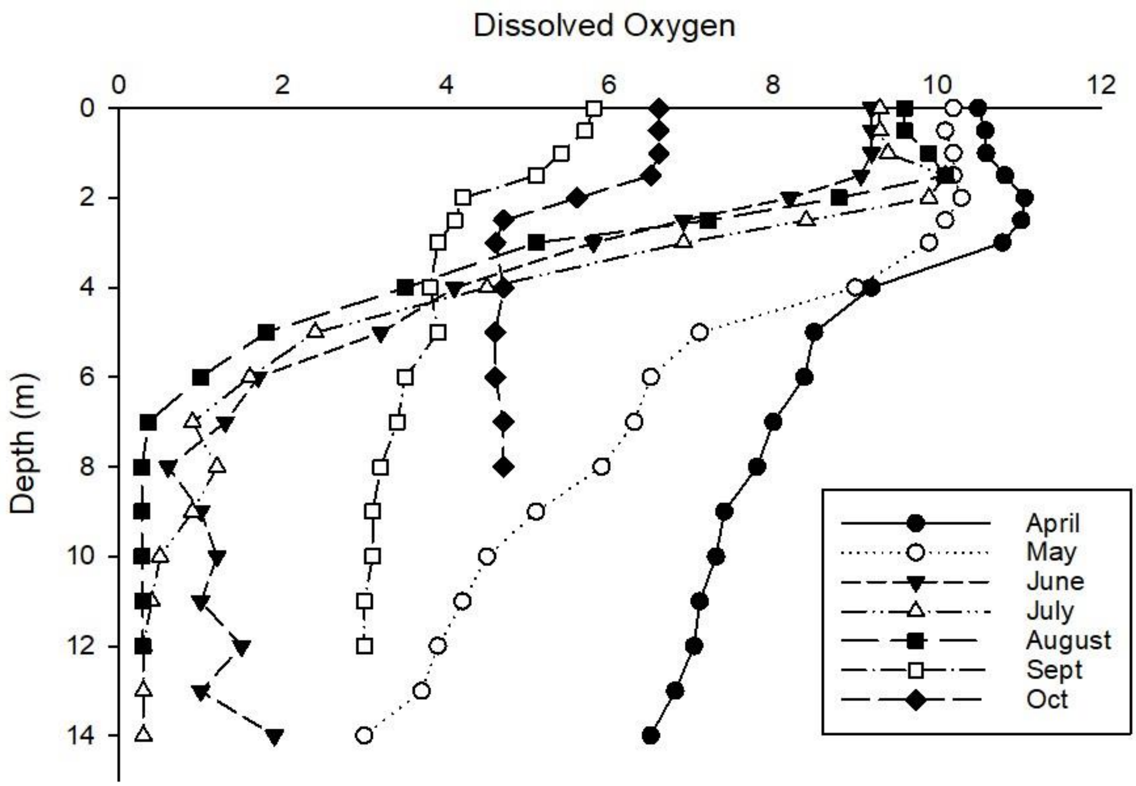


Figure 1.3.3. Dam (Lacustrine) Dissolved Oxygen (mg/L) measures over study period (2025)

Seasonal Analysis

Dissolved oxygen patterns in the reservoir demonstrate that the lake is eutrophic, that is stratifies throughout the sampling period and that oxygen loss occurs quickly beginning at approximately 2 meters depth. Between 2-4 meters depth the loss of oxygen is variable and dependent upon environmental conditions (temperature and precipitation). Water depleted of oxygen tends to be evident higher into the water column as the season progresses. Oxygen loss is continual with concentrations at depth moving below 2 mg/L from June through August. With some variation, this is the typical pattern for the reservoir. Because September and October were not impacted by stormwater the lake remained stratified in the fall months.

Comparisons Across Years

Oxygen profiles are very consistent throughout the years of study. Oxygen peaks occur between 2-3 meters of depth during months outside of July and August. These two months (July and August contain the lowest oxygen measures at depth (often below 2 mg/L). Turnover of water occurs either in September or November when temperatures in the upper water column match those lower in the column and depends on the season and temperatures. Oxygen in the water during turnover is generally close to 6 mg/L but varies between 5-7 mg/L depending on the year.

Oxygen loss throughout the reservoir is dependent upon the strength of stratification. Thus, while the reservoir is polymictic (it can mix often due to precipitation events) it takes a very strong storm event for mixing to occur at the dam. This did occur this season in September. Alternatively, the reservoir may be considered monomictic only mixing in the fall. Also, the degree of oxygen loss (how low observed levels of oxygen are in the hypolimnion) is a function of strength of stratification. Water temperature and stormwater inflow have tremendous impact on this parameter, which may at times become problematic.

Temperature

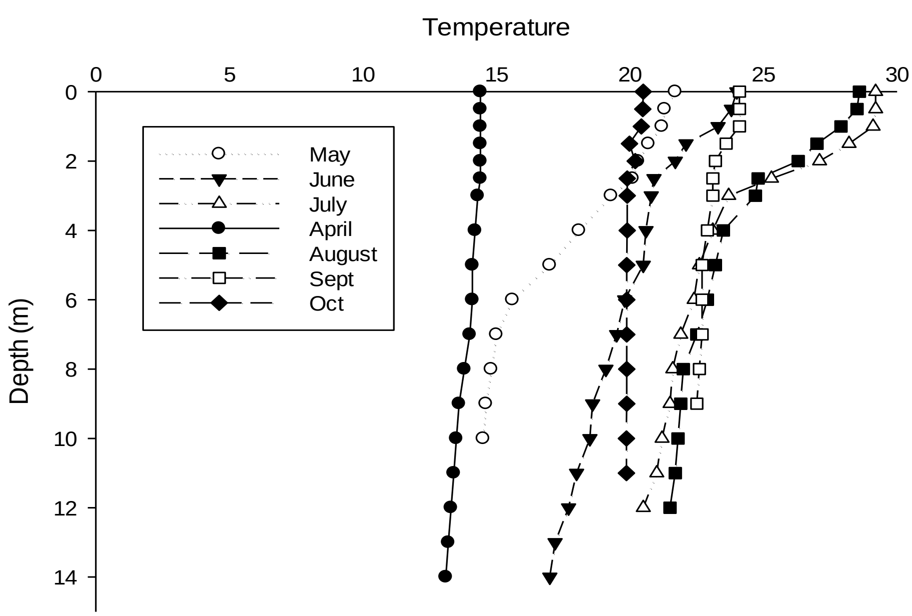


Figure 1.3.4. Dam (Lacustrine) Temperature (°C) measures over study period (2025)

Seasonal Analysis

Reservoir became stratified in May continuing through September. The reservoir was not stratified in April when sampling began and turned over as demonstrated in the October Sampling. Surface water was very warm during the July and August samplings approaching 30C (86F). Timing of stratification is the only variation we see in this pattern.

Comparisons Across Years

We do see variability in these profiles over time. Some years July is the warmest month while in other years August may be the warmest. It is not uncommon to see temperatures reach 30C in these profiles. While in 2025 precipitation did not flush the reservoir in the latter half of the year we did not see excessive warming and this may be a sole function of climate. Stratification is consistent across years usually starting in April or May. The epilimnion establishes above 2 meters depth. The depths of 2-4 meters are the transition zone or metalimnion. The hypolimnion is below 4 meters depth. Throughout the seasons this is a consistent pattern in the reservoir.

Chlorophyll *a*

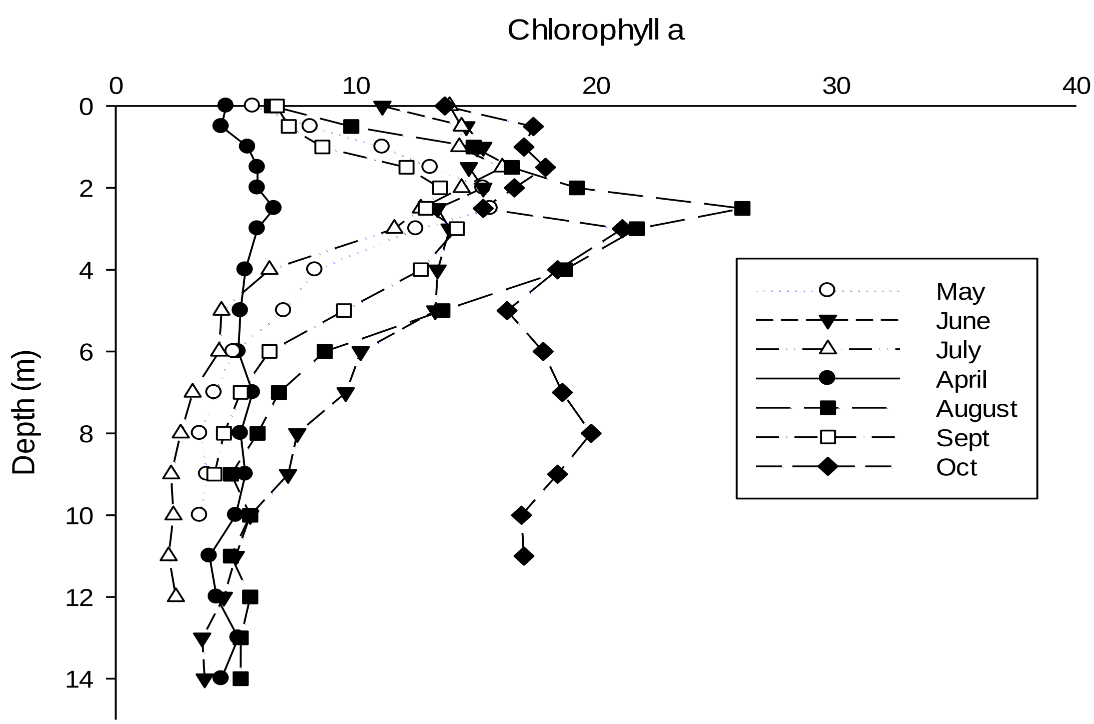


Figure 1.3.5. Dam (Lacustrine) Chlorophyll *a* (ppb) concentrations over study period (2025)

Seasonal Analysis

The reservoir continues to demonstrate a pattern of greatest phytoplankton growth, as indicated by increased chlorophyll content, just above the thermocline (between 2-4 meters). In 2025, peak production at the dam occurred in August and higher up in the water column at 2 meters. This pattern continued into the fall supporting the idea that limited precipitation leads to increased productivity due to limited flushing of the reservoir.

Comparisons Across Years

The pattern of increased phytoplankton along the 2-4 meter thermocline (metalimnion) in the reservoir is a well-established phenomenon in eutrophic lakes. This season's peak was similar to seasons past – approaching 30 ug/L in August. This measure has variability and must be monitored closely to track eutrophication. Looking at this data over many years of monitoring and in the trends analysis, stormwater entering the reservoir and flushing of phytoplankton biomass is a strong driver of this variability.

pH

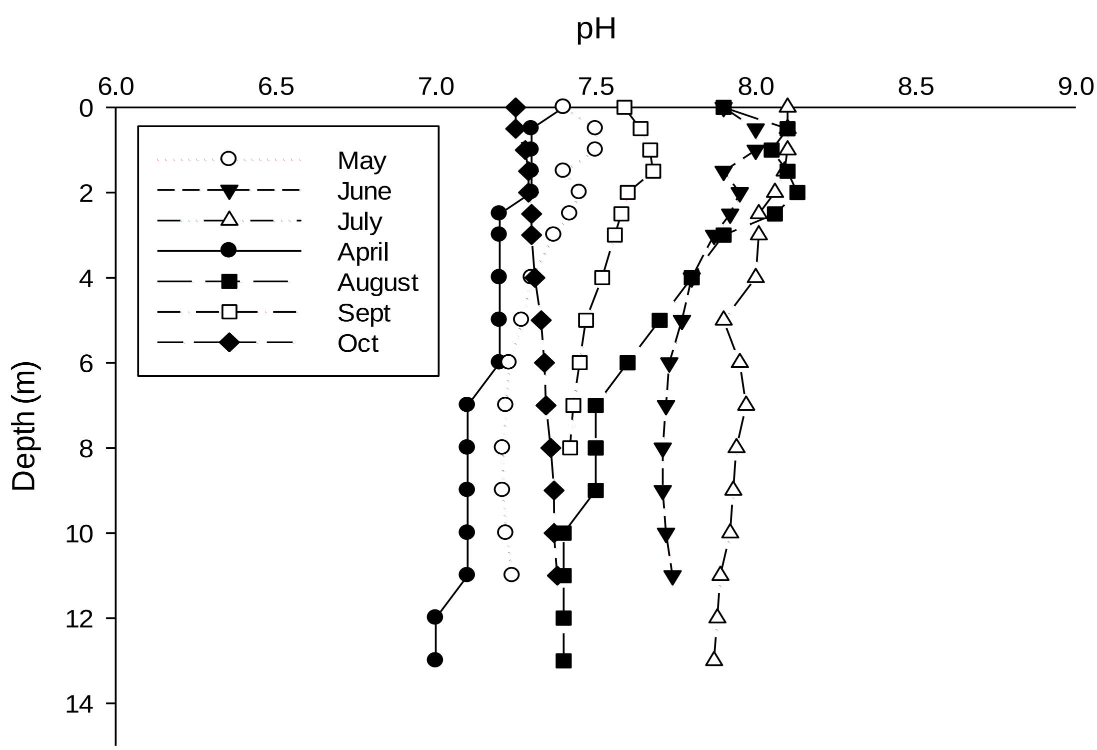


Figure 1.3.6. Dam (Lacustrine) pH measures over study period (2025)
Seasonal Analysis

The pH of water in the reservoir follows a typical curve for eutrophic reservoirs with soft water. Chlorophyll productivity is a strong driver of pH and in 2025 greatest readings for pH did coincide with summer months.

Comparisons Across Years

The pattern of pH observed in the reservoir is relatively consistent across years. High pH (9 and above) can sometimes be expected in the summer months when phytoplankton growth is at its peak with this measure strongly correlated to phytoplankton biomass. But peak pH is variable. In many seasons, the pH does not exceed 8.5. This season similar to 2024 peaks were lower.

ORP

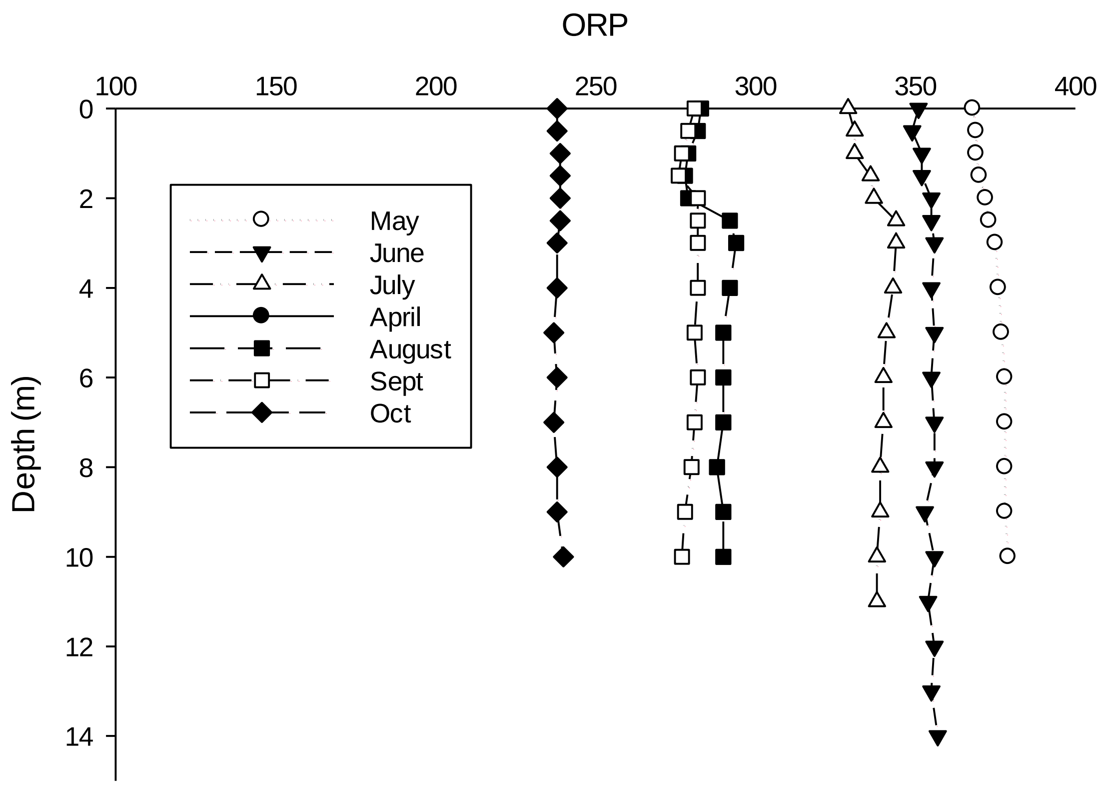


Figure 1.3.7. Dam (Lacustrine) ORP (mV) measures over study period (2025)

Seasonal Analysis

ORP remains in the very oxidized region through the sampling period. There is a pattern of slightly increased ORP with increasing water depth but this change is minimal through the water column. ORP is very high in the spring with a decrease as the season progresses. This results from stratification depleting oxygen and the warming temperatures holding less oxygen in the water.

Comparisons Across Years

On an annual scale, ORP measures differ from year to year. In some years we have observed seasonal values up to 700 or as low as 100 mV. This shows the tremendous variability with this measure occurring month to month. Consistently, the cooler and well-mixed months in the reservoir tend to have the greatest ORP measures. While this parameter only measures the potential for a redox reaction occurring, the values in the higher range (greater than 400) suggest better water quality.

Nitrate

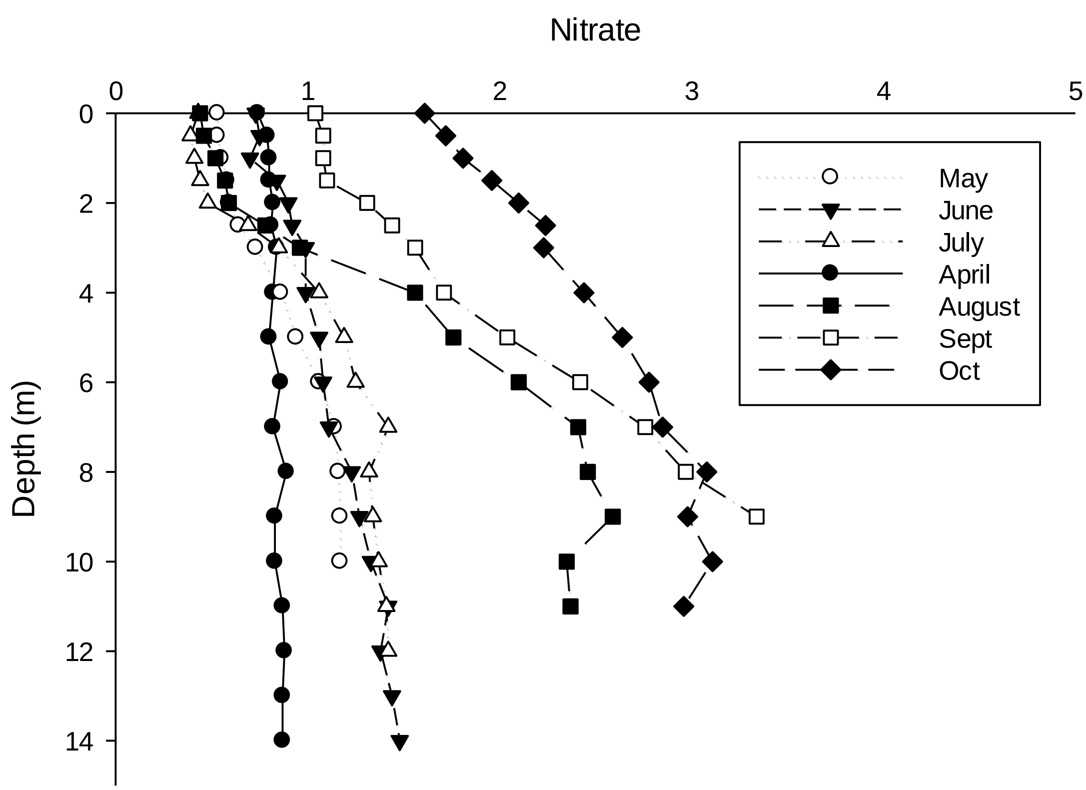


Figure 1.3.8. Dam (lacustrine) Nitrate (mg/L) measures over study period (2025).

Seasonal Analysis

Nitrate patterns suggest general availability of nutrients in the reservoir throughout the season. However, the fall (August – October) this season suggested increased availability as the season progressed. This may be a product of degradation of organic material along with limited flushing due to low precipitation. Regardless, this is concerning as increasing levels of nutrients lead to greater productivity along with deleterious effects of eutrophication.

Comparisons Across Years

Nitrate is a more recent addition to the data collected through monitoring. Results this season in 2025 were elevated and very elevated in the fall sampling season. Analysis would suggest that reservoir flushing is very important to maintain low nutrient levels in the reservoir. Similar problem (elevating nitrate in the fall) occurred in tailwaters from SML in 2025.

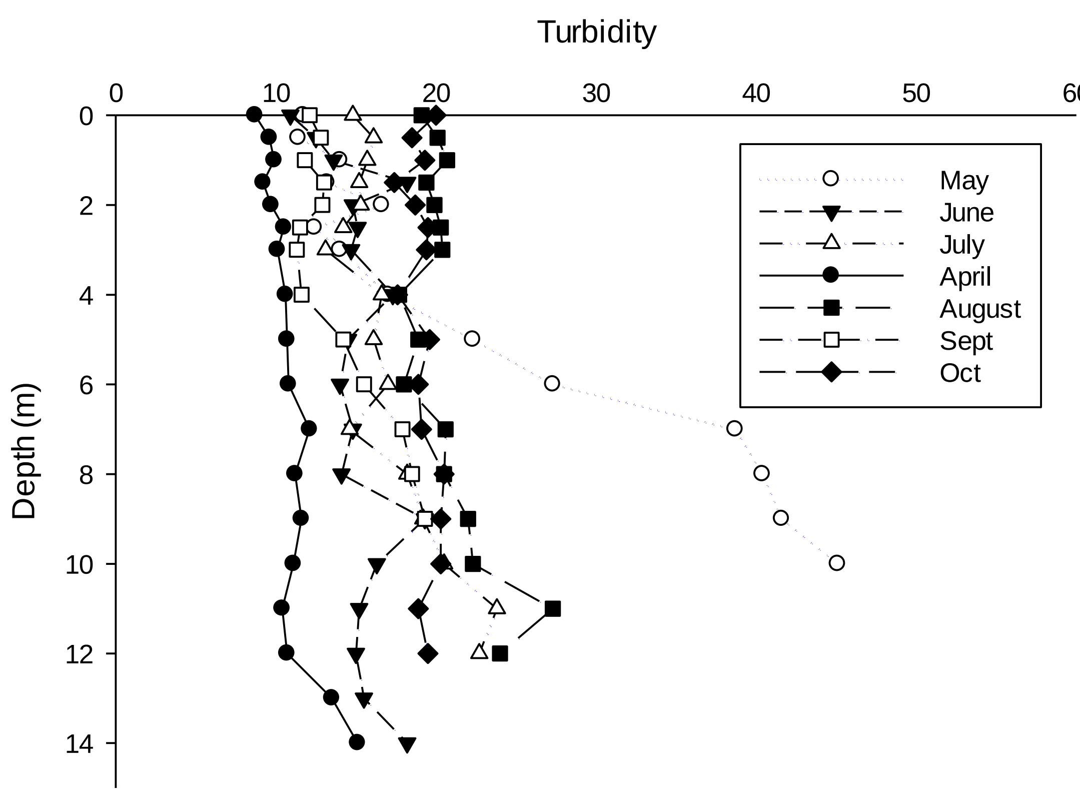


Figure 1.3.9. Dam (lacustrine) Turbidity (NTU) measures over study period (2025).

Seasonal Analysis

Turbidity patterns at the dam suggest most of the turbidity is from algal production. In general, turbidity is separated between algal and non-algal or sediment turbidity. The lower numbers < 20 NTU suggest algal turbidity is predominate at this station as much greater turbidities would be expected if sediment turbidity was predominant. May was the exception. Non-algal turbidity likely from Pigg River flow with confirmation of this from the conductivity data (Figure 1.2). Lower conductivity water is suggestive of Pigg River input.

Concerning turbidity along the vertical profile, stratification controls much of this pattern. In the upper and warmer layers, algae grow and give water its color and turbidity. Conversely and in the cooler lower layers, silt and sediment and particulates (non-algal) remain suspended and can resuspend due to density currents. Settling of particulates (non-algal) and growth of algal particles can generate similar turbidities throughout the water column while the measure of chlorophyll *a* shows a distinct pattern with much greater density in the upper water column because it is a direct measure of productivity rather than necessarily density. Yet at times (in May of this season) sediment turbidity flows from the upper reaches of the reservoir through the cooler and lower stratified layers following similar density gradients. This is what was observed this season.

Comparisons Across Years

Data in 2025 is consistent with patterns observed. Turbidity at this station follows Chlorophyll *a* production with the exception of high flow events.

Other Parameters Measured

Table 1.3.2. Other parameters measured over study period (2025). Dates represent sampling of both the volunteers and University of Lynchburg. First column represents each parameter with units of measure.

	16-Apr	19-May	17-Jun	25-Jun	18-Jul	31-Jul	18-Aug	27-Aug	22-Sep	21-Oct
Time	10:27 AM	12:35 PM	8:55 AM	8:57 AM	10:45 AM	8:40 AM	9:45 AM	9:00 AM	10:50 AM	2:50 AM
Secchi (M)	2.20	1.40	2.2	2.3	1.8	2.00	1.9	1.80	2.20	1.45
TP Surface	0.101	0.028	0.032	0.055	0.016	0.021	0.02	0.024	0.012	0.015
Integrate Chl a	5.19	8.32	10.11		7.99		11.09		9.05	17.48
TSI S	49	55	49	48	52	50		52	49	55
TSI TP	67	50	52	59	43	47	46	48	40	43
TSI CHL	47	51	53		51		54		52	59
TSI AVG	54	52	51	53	49	48	50	50	47	52
Daphnia	2.02	0.91	2.43		0.00		9.71		0.00	2.43
Bosmina	19.82	10.21	0.00		0.00		6.87		0.40	1.62
Diaptomus	2.83	0.40	0.20		0.00		2.43		1.01	1.21
Cyclops	11.32	0.30	1.62		0.00		6.07		2.43	1.01
Naupaii	0.00	0.00	0.40		0.00		0.00		0.00	0.00
Cerodaphnia	0.00	0.00	0.00		0.00		0.00		0.00	0.00
Diaphanosoma	0.00	0.00	3.44		0.00		4.25		0.00	0.40
Leotodora	0.00	0.00	0.00		0.00		0.00		0.00	0.00
E. coli MPN	4.10	6.20	5.2	28.80	1	6.30	2	35.90	2.00	13.10

1.3.1.2 Leesville Lake Marina / Old Woman's Creek

Photograph of Leesville Lake Marina taken by Jade Woll.

Table 1.3.3. Leesville Lake Marina other parameters measured over study period (2025).

	16-Apr	19-May	17-Jun	25-Jun	18-Jul	31-Jul	18-Aug	27-Aug	22-Sep	21-Oct
Time	10:55 AM	12:48 PM	9:20 AM	9:12 AM	11:20 AM	8:15 AM	10:15 AM	9:20 AM	11:12	3:15 PM
Secchi (M)	1.60	1.40	1.7	2	1.5	1.80	1.3	1.60	1.40	1.60
(PPM)	0.021	0.131	0.023		0.015		0.027		0.008	0.037
TSI S	53	55	52	50	54	52	56	53	55	53
TSI TP	47	71	48		43		50		36	54
TSI AVG	50	63	50		48		53		46	53
E. coli	7.40	17.50	6.3	9.8	3.1	42.80	2	5.20	9.70	7.50

1.3.1.3 Tri County Marina

Photograph of Tri County Marina taken by Jade Woll.

Table 1.3.4. Tri County Marina other parameters measured over study period (2025).

	16-Apr	19-May	17-Jun	25-Jun	18-Jul	31-Jul	18-Aug	27-Aug	22-Sep	21-Oct
Time	11:06 AM	1:05 AM	9:30	9:26 AM	11:25	9:10 AM	10:20	9:35 AM	11:20	3:22 PM
Secchi (M)	1.40	1.10	1.8	1.3	1.4	1.60	1.5	1.50	1.80	1.40
TP Surface (PPM)	0.145	0.040	0.017		0.053		0.024		0.047	0.042
TSI S	55	59	52	56	55	53	54	54	52	55
TSI TP	72	55	44		58		48		57	55
TSI AVG	64	57	48		57		51		54	55
E. coli cfu/100ml	10.90	77.60	9.8	30.1	3.1	35.90	3	1.00	6.30	3.10

1.3.1.4 Mile Marker 6 (Transition)[1]

Background

In discussing water quality at the transition station (MM6), comparisons are made back to Lacustrine and Riverine portions of the lake. This section does not provide further discussions of the patterns observed at the Dam (Lacustrine) or Toler Bridge (Riverine), but to discern any trends the data provides on a spatial scale moving up or down the lake.

[1] *Photograph of Leesville Lake taken by Jade Woll*

Conductivity

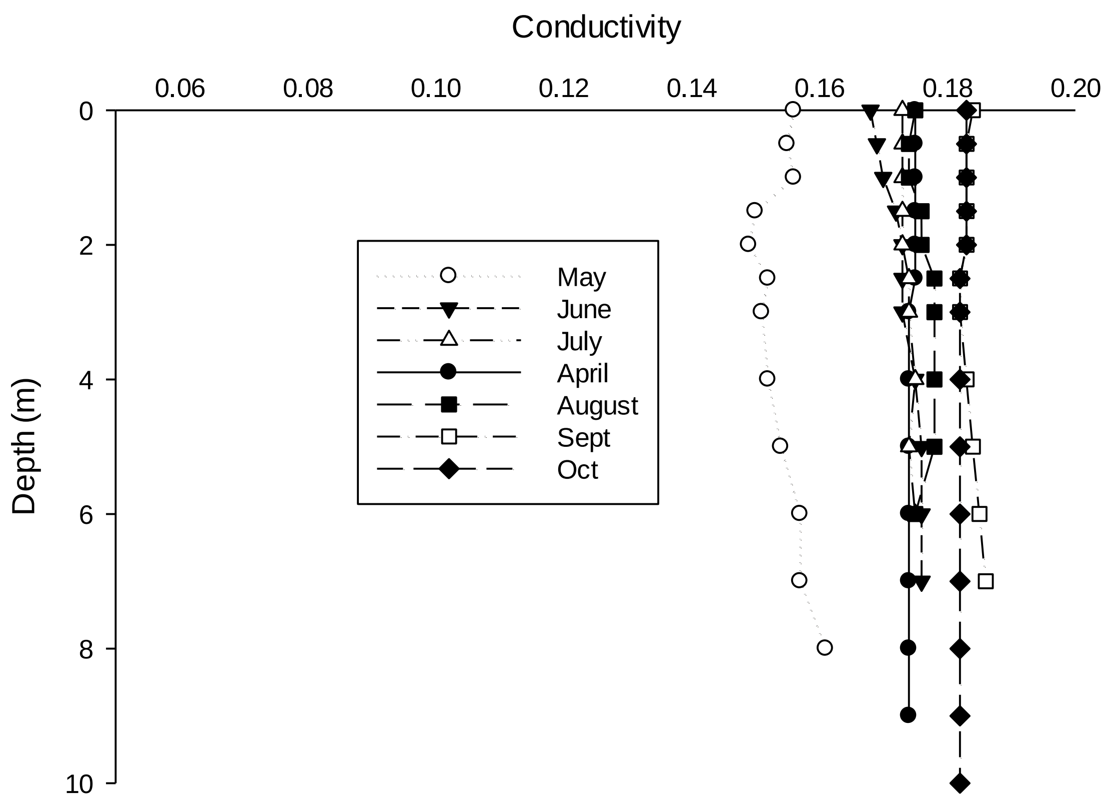


Figure 1.3.10. Mile Marker 6 (Transition) Conductivity (ms/cm) measures over study period (2025)

Seasonal Analysis

Conductivity patterns at the transition region are reflective of a mixed condition, i.e., a general absence of stratification as we see at the dam. This station is additionally more sensitive to input from Pigg River than is evident at the LVL dam, as travel distance is much shorter. This is evident in these data from 2025, where the conductivity in May was impacted by increased Pigg River flow at that time, while remaining sample dates reveal greater conductivities indicative of dominant tailwater influence.

Comparisons Across Years

Conductivity is a good predictor of water masses and movement in the reservoir. The complexity of this analysis occurs when water movement into the reservoir from the Pigg River and SML tail release mix and move below the entrainment evident in the upper portion of the reservoir.

Dissolved Oxygen

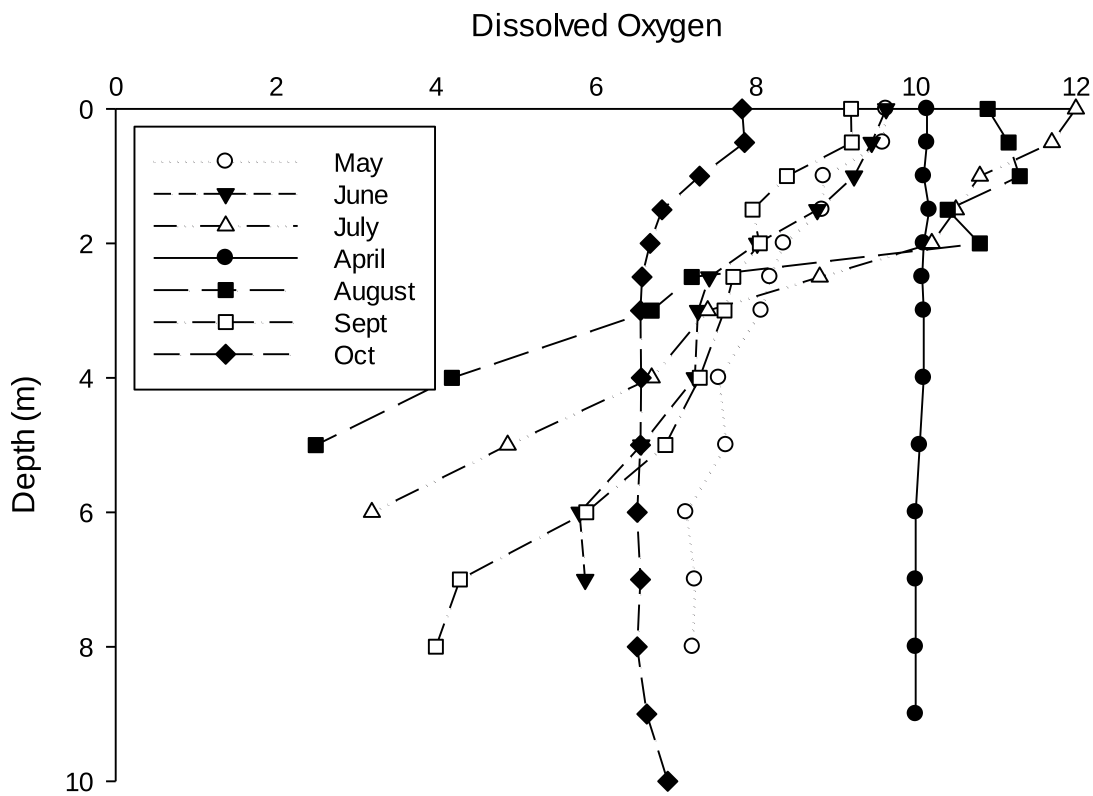


Figure 1.3.11. Mile Marker 6 (Transition) Dissolved Oxygen (mg/L) measures over study period (2025)

Seasonal Analysis

This portion of the reservoir was stratified throughout the sampling season with the exception of April sampling. As in past seasons, we did not see an overall reduction in dissolved oxygen during the fall months. As this fall was extremely dry (total precipitation for September and October = 4.14 inches) a reduction of the volume of water from SML may have been a contributing factor. Loss of oxygen is rapid below 2 meters during the warmest summer months (June – August).

Comparisons Across Years

Oxygen observations are variable across seasons and within season with supersaturated conditions in the epilimnion and hypoxic and anoxic conditions apparent in the hypolimnion typical of eutrophic lakes. In some seasons, oxygen is very low throughout the water column during turnover while in other oxygen remains relatively high as in 2025.

Temperature

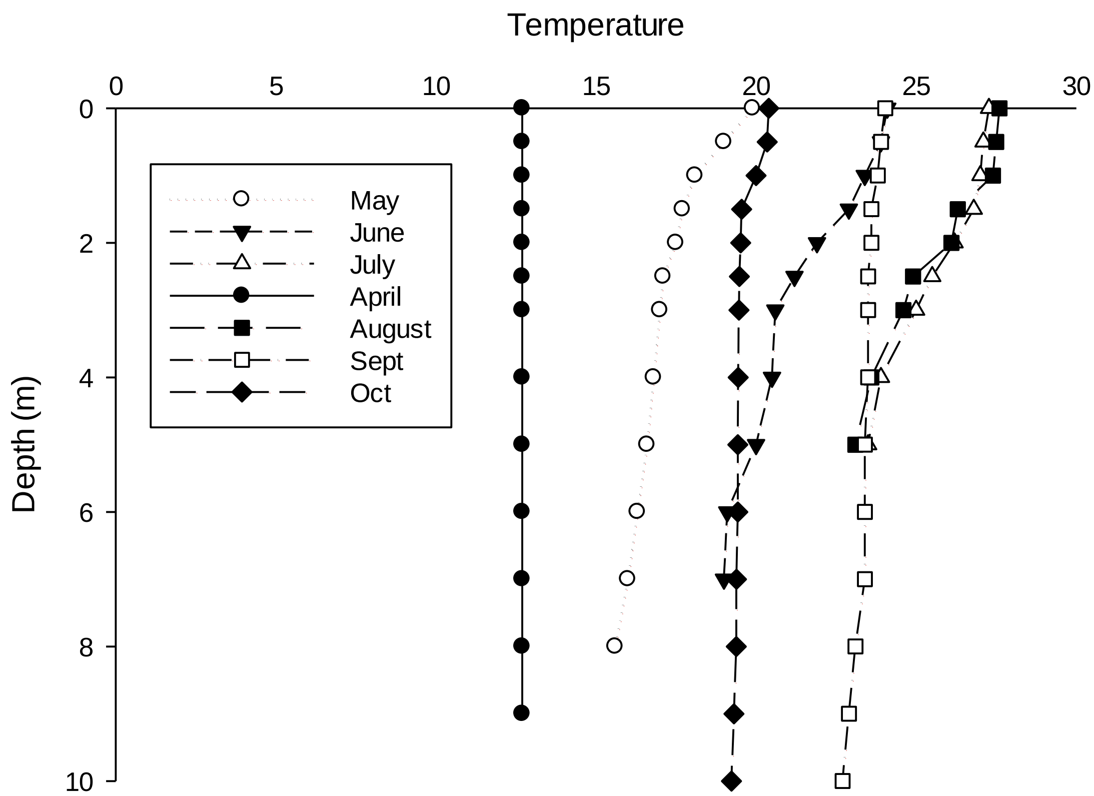


Figure 1.3.12. Mile Marker 6 (Transition) Temperature (°C) measures over study period (2025)

Seasonal Analysis

Thermal stratification in this section of the reservoir is weak (subject to fluctuation and mixing due to weather and water movement). This is consistent with the previous observations of oxygen content. The benefit of this weak stratification is that it increases oxygen content, which has become a significant concern. Conceptually, this station is situated between the LVL dam (stronger stratification because of depth and restricted water movement) and Toler Bridge headwaters (limited stratification due to water movement from Pigg River and SML dam release).

Comparisons Across Years

The pattern of minimal stratification at this site is consistent across and within years. Thus, this station is a good example of a transition zone, influenced by both riverine and lacustrine forces.

Chlorophyll *a*

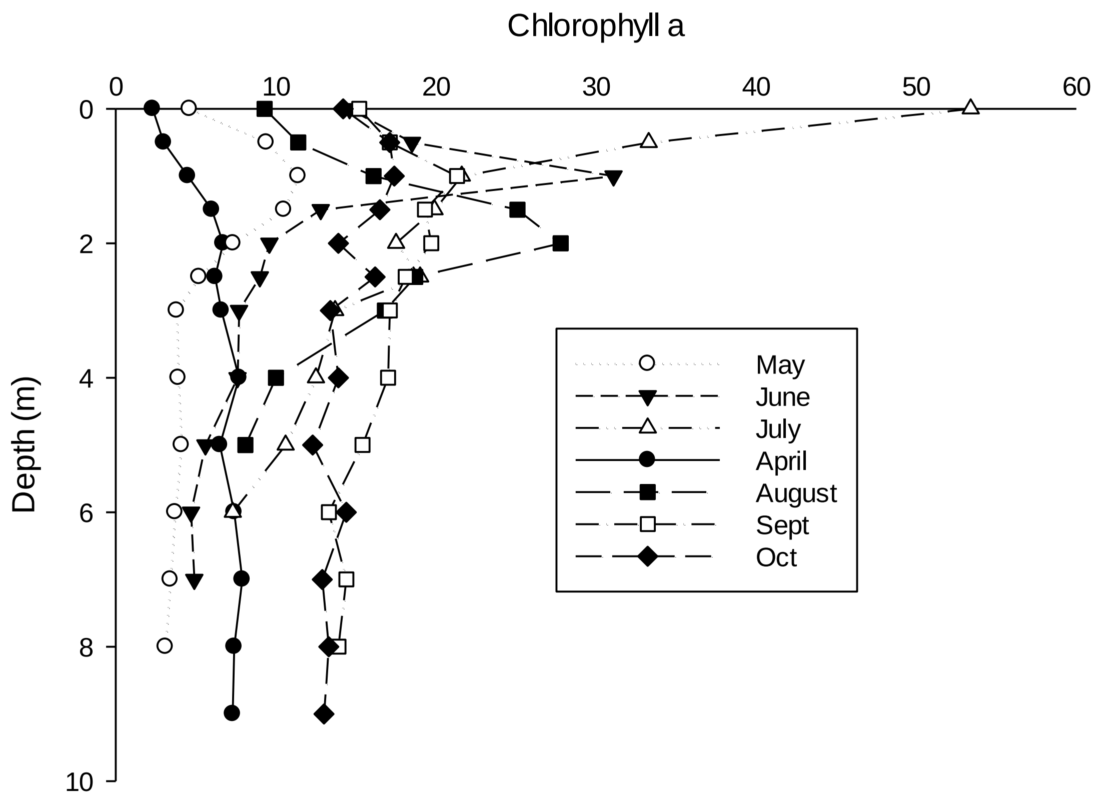


Figure 1.3.13. Mile Marker 6 (Transition) Chlorophyll *a* (ppb) concentrations over study period (2025)
Seasonal Analysis

The transition area is theoretically the portion of the reservoir where phytoplankton abundance measured by Chlorophyll *a* can be very high and may be the greatest in the entire reservoir. Nutrient input from the upper portions of the reservoir mixes with the warmer and slowly moving water mass to create ideal conditions for phytoplankton growth. This was observed this season as Chlorophyll a exceeded 50 ug/L in July. This amount of Chlorophyll a suggests hypereutrophy and is very concerning.

Comparisons Across Years

High peaks in phytoplankton biomass and pattern of growth above the thermocline are not consistently observed at this station across years. Typically, phytoplankton biomass is elevated throughout the water column from 2-5 meters depth and at concentrations of 20-30 ug/L. Chlorophyll *a* minimums may occur during flushing and turnover but respond and increase when conditions normalize (flushing stops and levels stabilize) and phosphorus is readily available.

pH

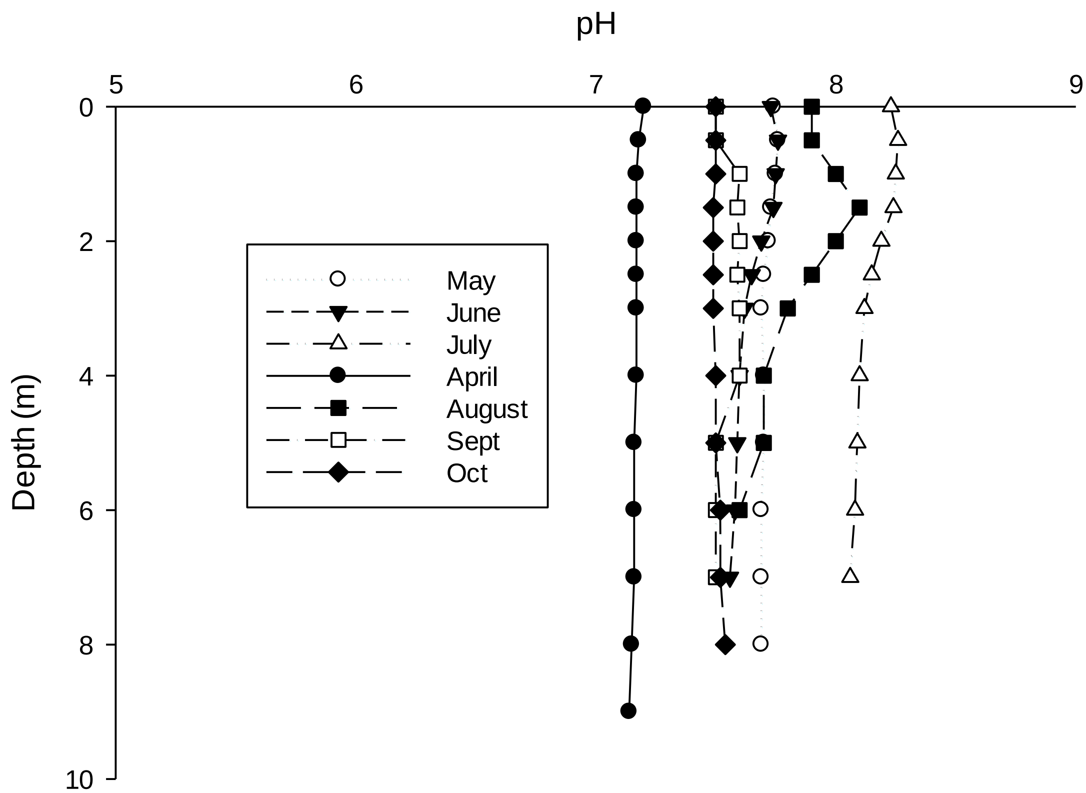


Figure 1.3.14. Mile Marker 6 (Transition) pH measures over study period (2025)

Seasonal Analysis

The seasonal pH pattern is very similar to that observed at the dam but the pattern of stratification in the reservoir is blunted at this station. Elevated pH does follow the pattern of Chlorophyll a with peak pH coinciding with high July chlorophyll.

Comparisons Across Years

This is a variable station and influenced by a multitude of factors. Readings generally reflect conditions that influence phytoplankton growth.

<u>ORP</u>

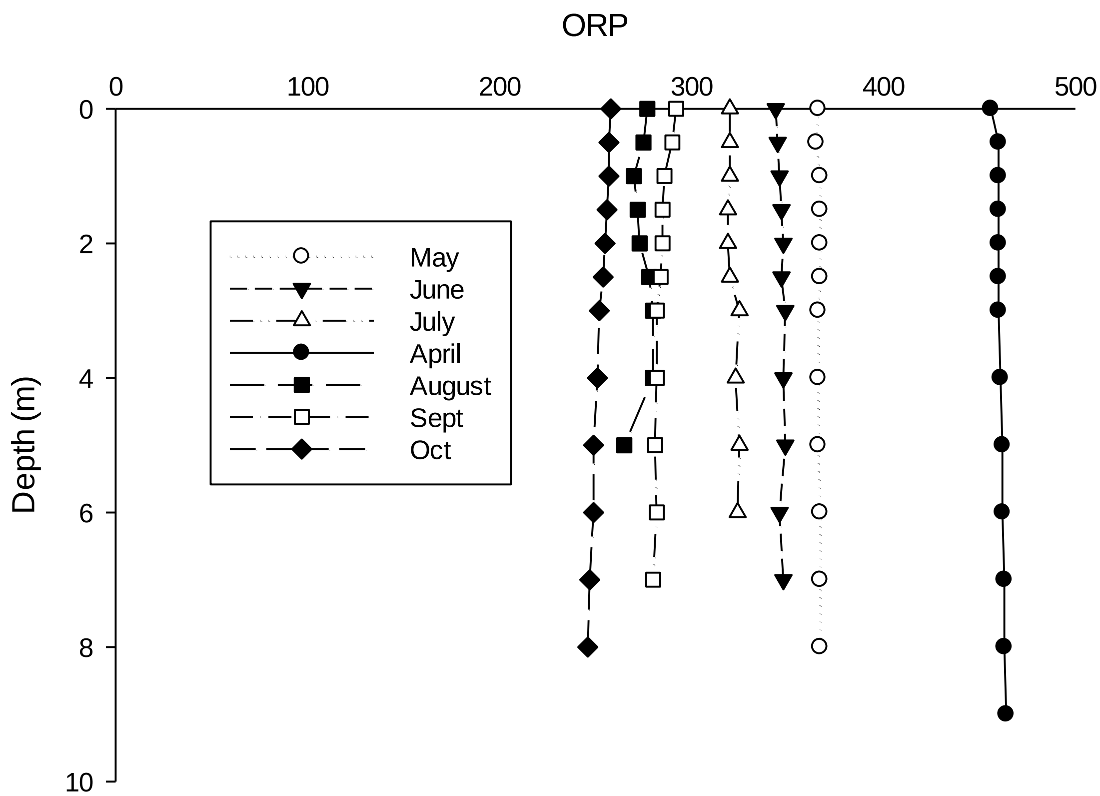


Figure 1.3.15. Mile Marker 6 (Transition) ORP (mV) measures over study period (2025)

Seasonal Analysis

Patterns of ORP at this station are similar to those observed at the dam. You might expect slightly more reducing conditions at the site (lower ORP) due to a greater influence from river inputs and this did occur in April. This measure is variable over the season reflecting tracking closely to temperature, as warmer water holds less oxygen.

Comparisons Across Years

ORP has been variable over multiple years at this station. Identifying specific factors that may have led to this trend is challenging; however, decreased ORP observed in recent years may indicate a decline in water quality. Still, observations in this year's sampling are in the expected range for this reservoir.

<u>Nitrate</u>

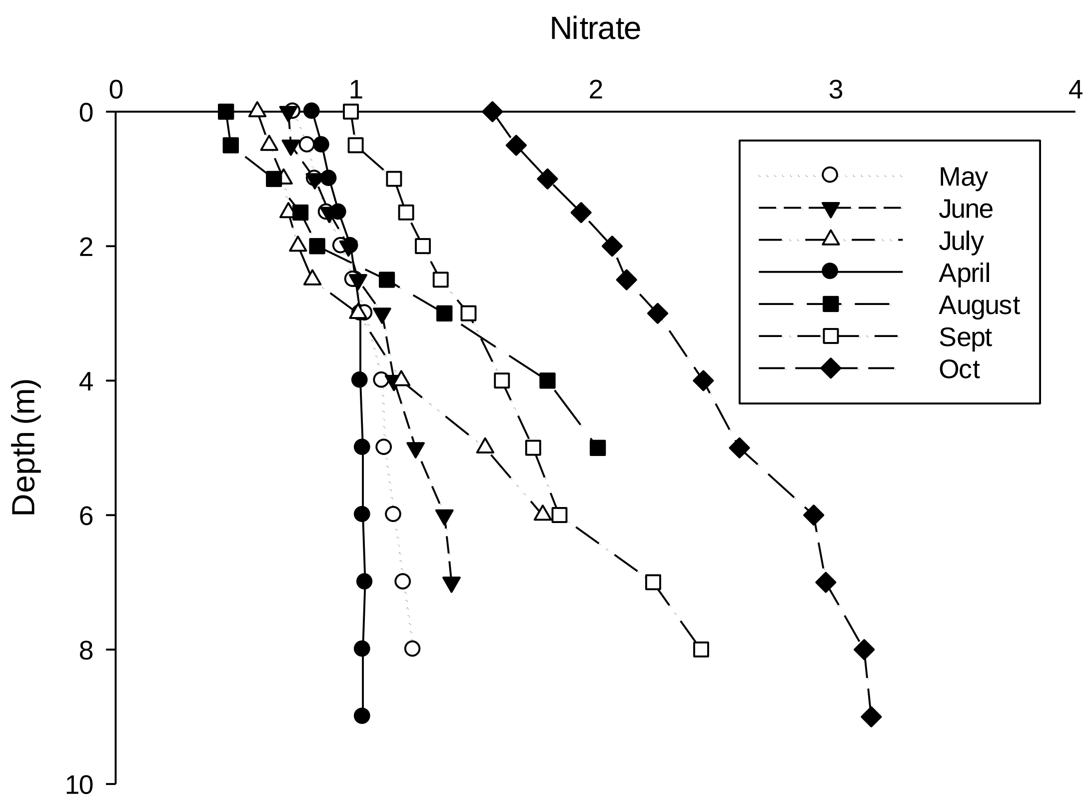


Figure 1.3.16. MM6 (Transition) Nitrate (mg/L) measures over study period (2025)

Seasonal Analysis

The pattern of nitrate concentrations at this site is very similar to that at the dam. As this station is closer to Pigg River and tailwater than the dam site, flushing may have a greater impact at this station even during dry periods. Because nitrate levels were lower than at the dam station this may be a plausible explanation. Regardless, nitrate levels were elevated at this station in the latter half of 2025.

Comparisons Across Years

Nitrate patterns consistent with those at the dam were observed here and throughout the reservoir.

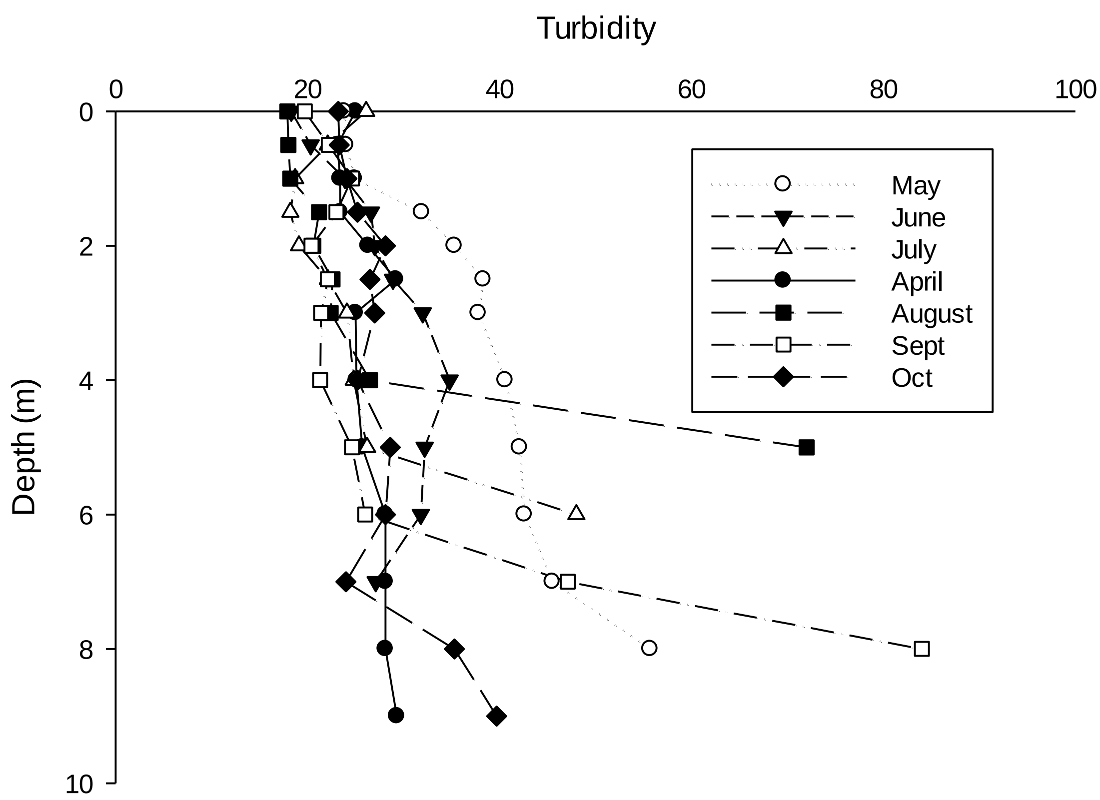


Figure 1.3.17. MM6 (transition) Turbidity (NTU) measures over study period (2025).

Other Parameters Measured

Table 1.3.5. Other parameters measured over study period (2025). Dates represent sampling of both the volunteers and university. First column lists each parameter measured along with units of measure. All TSI measures are unitless and zooplankton are in animal per liter.

	16-Apr	19-May	17-Jun	25-Jun	18-Jul	31-Jul	18-Aug	27-Aug	22-Sep	21-Oct
Time	11:15 AM	1:15 PM	9:42	9:35 AM	11:35 AM	9:20 AM	10:30 AM	9:45 AM	11:28 AM	3:30 PM
Secchi (M)	1.20	1.10	1.6	1.3	0.8	1.60	1.5	1.50	1.20	1.20
TP Surface (PPM)	0.033	0.049	0.031		0.096	0.081	0.038	0.012	0.053	0.079
Integrate Chl a (PPB)	6.12	5.87	11.46		20.88		15.92		16.82	14.50
TSI S	57	59	56	56	63	53	54	54	57	57
TSI TP	52	57	51		66	64	54	40	58	64
TSI CHL	48	48	55		60		58		58	57
TSI AVG	53	55	54	56	63	59	55	47	58	59
Daphnia	1.01	0.81	1.82		0.00		1.82		3.64	4.04
Bosmina	13.55	0.71	0.20		0.00		1.42		21.03	2.83
Diaptomus	8.09	0.40	0.40		0.00		2.83		0.61	9.30
Cyclops	4.45	0.20	1.01		0.00		0.40		2.43	2.02
Naupaii	0.00	0.00	0.61		0.00		0.00		2.22	0.00
Cerodaphnia	0.00	0.00	0.00		0.00		0.00		0.00	0.00
Diaphanosoma	0.00	0.00	5.66		0.00		5.66		3.03	1.62
Leotodora	0.00	0.00	0.00		0.00		0.00		0.00	0.00
E. coli MPN	118.70	163.20	3	35.00	4.1	12.10	6.1	4.10	5.20	1.00

1.3.1.5 Mile Marker 9 (Riverine)

Photograph of Leesville Lake taken by Jade Woll.

Table 1.3.6. Mile Marker 9 other parameters measured over study period (2025)

	16-Apr	19-May	17-Jun	25-Jun	18-Jul	31-Jul	18-Aug	27-Aug	22-Sep	21-Oct
Time	11:40 AM	1:40 PM	10:09	9:45 AM	12:03	9:35	10:50	10:02 AM	11:50	4:00 PM
Secchi (M)	1.60	0.70	1.2	1	0.4	1.20	1.1	1.20	1.40	1.25
TP Surface	0.042	0.131	0.1835		0.241		0.048		0.073	0.123
TSI S	53	65	57	60	73	57	59	57	55	57
TSI TP	55	71	75		79		57		63	70
TSI AVG	54	68	66		76		58		59	63
E. coli	118.70	312.00	4.1	77.6	231	35.00	5.2	8.50	7.50	5.20

1.3.1.6 Toler Bridge (Riverine)[2]

Background

Riverine conditions as well as influx of tail waters of Smith Mountain Lake and influx of Pigg River water heavily influence waters at the Toler Bridge station. We see a combination of the water qualities from Pigg River discharge and SML hypolimnion release. The resulting water quality is completely driven by hydrological dynamics of the SML Dam (a mechanistic event) with river flow from the Pigg River (a stochastic event) thus creating a very dynamic system that is challenging to interpret.

[2] *Photograph of Toler Bridge taken by Jade Woll.*

Conductivity

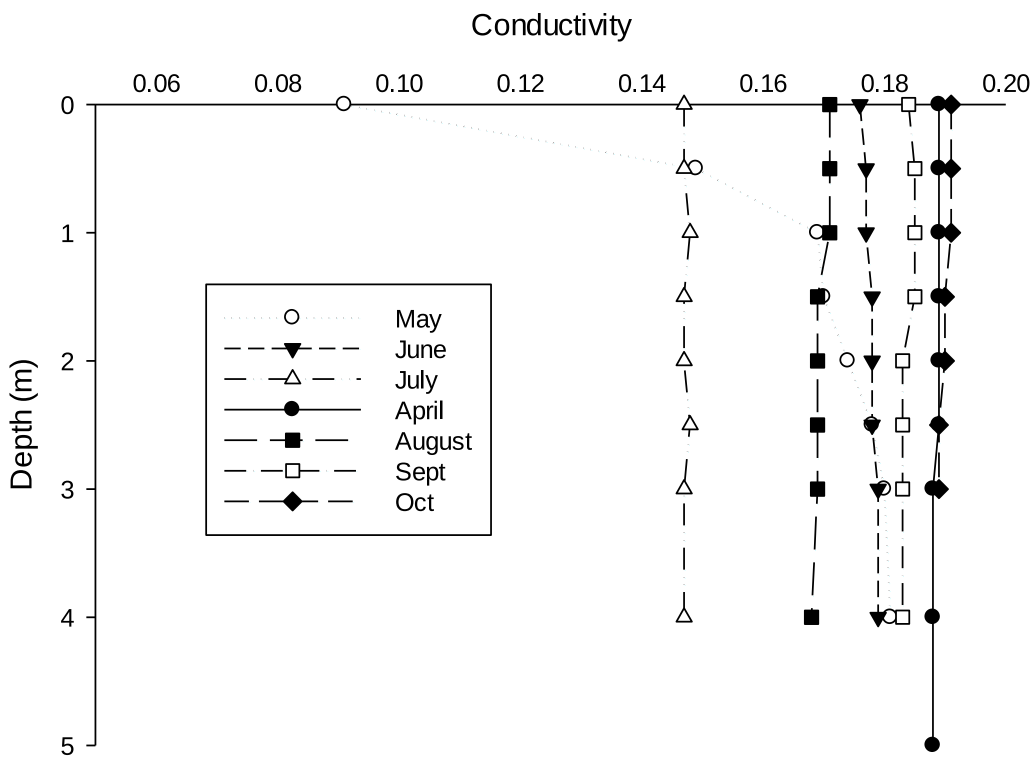


Figure 1.3.18. Toler Bridge (Riverine) Conductivity (ms/cm) measures over study period (2025).

Seasonal Analysis

Conductivity in this portion of the reservoir is usually consistent (minimal change) from top to bottom unless pumping conditions or heavy flow from the Pigg River occasionally produces stratification. However, such stratification was not observed in 2025. Water quality at this site during May and July was impacted heavily by water input from Pigg River. While the influence of Pigg River input on conductivity in May was detected throughout the reservoir, the decreased conductivity observed here in July was limited to the upper sections of the reservoir. Other conductivity measures were consistent with the remainder of the reservoir (between 0.17-0.19).

Comparisons Across Years

Observations of conductivity at this station over time demonstrate that SML release is the predominate controlling hydrology in the headwaters of LVL. Only during certain periods of time (most likely driven by stormwater flow) does the Pigg River contribute enough water to influence readings at this station. When Pigg River flow impacts water quality, these impacts may be isolated to this area or may be observed further down the reservoir depending on conditions.

Dissolved Oxygen

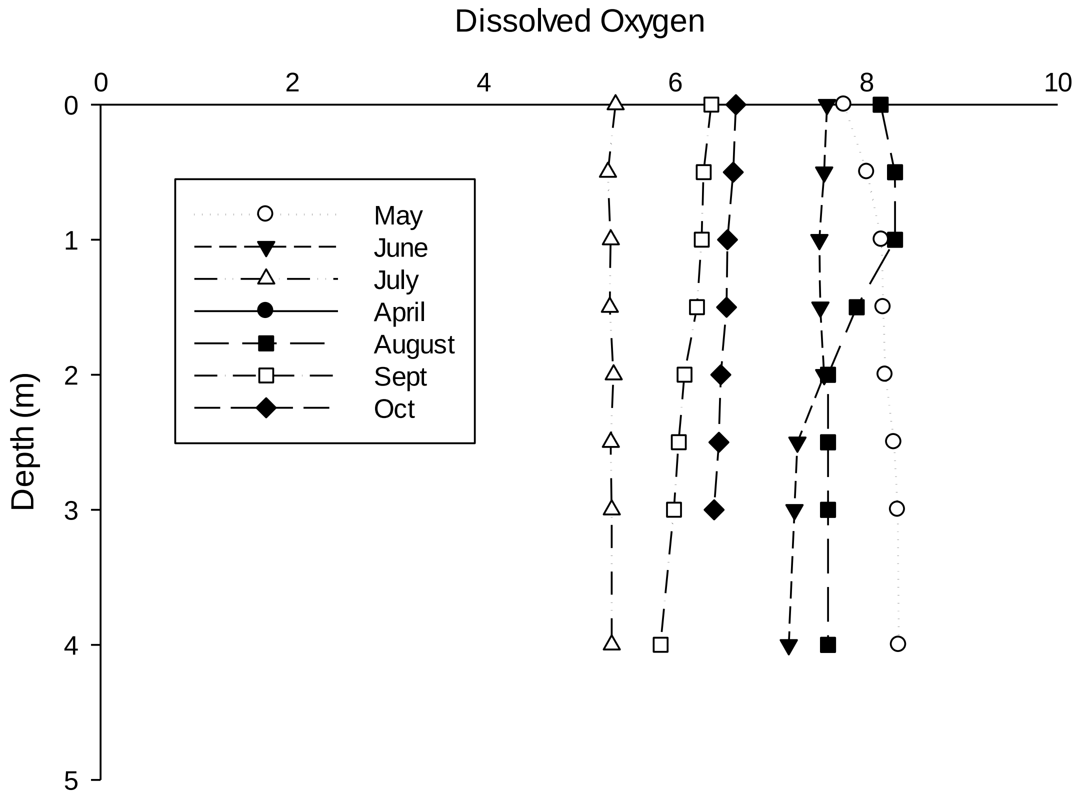


Figure 1.3.19. Toler Bridge (Riverine) Dissolved Oxygen (mg/L) measures over study period (2025)

Seasonal Analysis

Dissolved oxygen here is often a reflection of SML release but can be elevated due to Pigg River input if mixing occurs. Yet in some instances, Pigg River oxygen content is low as observed this season in July. It is unclear what is contributing to the low oxygen content from Pigg River as observed in July. Otherwise this station oxygen content maintained levels above 5 mg/L even in the late fall.

Comparisons Across Years

Dissolved oxygen at this station is a function of water release from SML and operations such as the lowering of water levels and input from Pigg River. When conductivity is elevated, dissolved oxygen is low however as observed in 2025 and a few instances in the past Pigg River water can be low in oxygen. This may be a function of water flow as tailwater when released under lower flow conditions will flow up into the Pigg River as far as Toshes Road (personal observations). In the later months of the season, dissolved oxygen levels typically fall below 5 mg/L. Tailwater release (and at times Pigg River input) have a very strong impact on water quality at this station.

Temperature

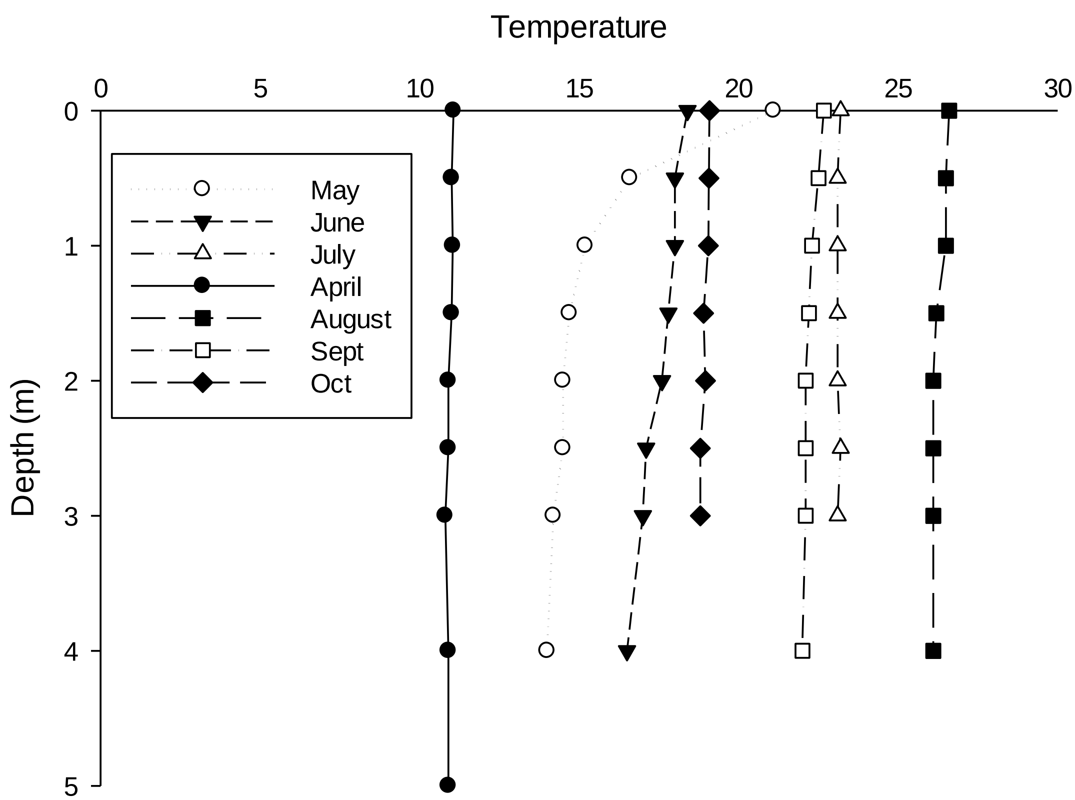


Figure 1.3.20. Toler Bridge (Riverine) Temperature (°C) measures over study period (2025)

Seasonal Analysis

This station does not stratify (or minimally as observed in May) because of water release and pumpback. The water movement is frequently too strong to allow the water enough time to develop layers, although during periods of operation where electricity demand is low this may occur due to limited water movement. This station tends to be cooler than the main stem of the reservoir due to SML release from the hypolimnion.

Comparisons Across Years

Lack of stratification at Toler Bridge is consistently observed across the years. Water flow from SML causes constant movement of the water at this station, limiting the opportunity for stratification. We usually see this only during the spring months. During the summer, electricity demand and typically lower stormwater flow set up conditions for extensive water movement from pump back and release in LVL headwaters.

Chlorophyll *a*

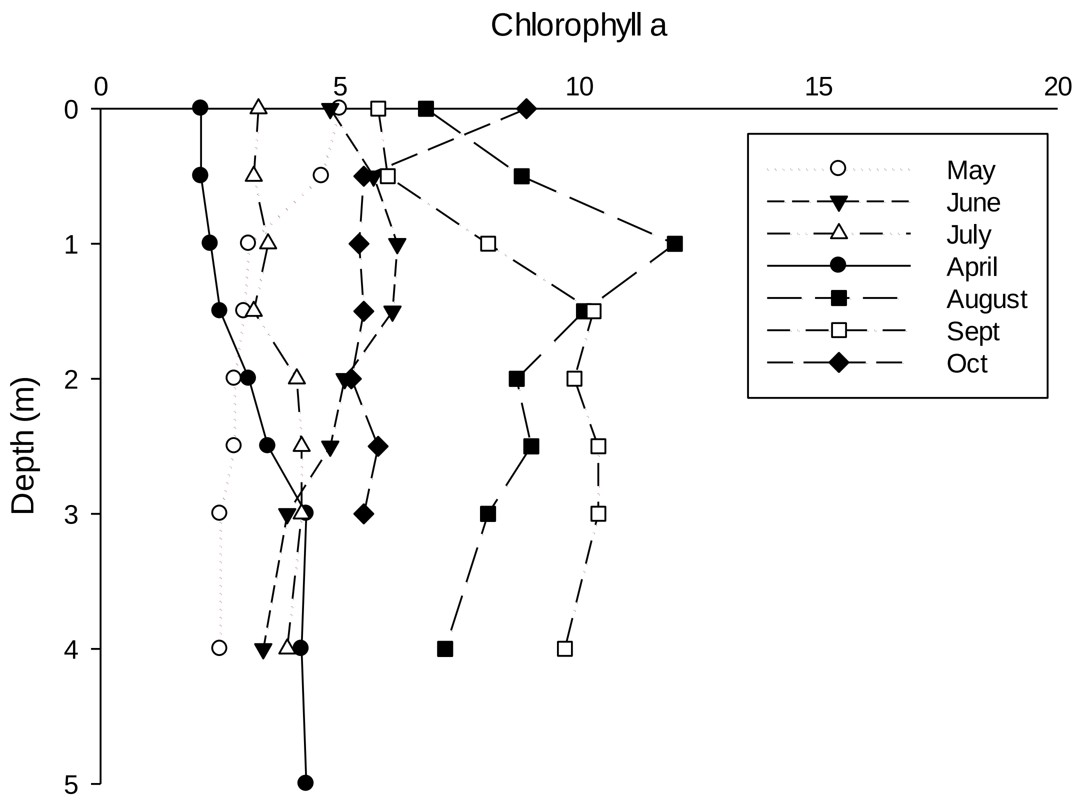


Figure 1.3.21. Toler Bridge (Riverine) Chlorophyll *a* (ppb) concentrations over study period (2025)

Seasonal Analysis

This station typically contains the lowest readings of phytoplankton biomass throughout the entire reservoir. And the pattern in this portion of the reservoir are driven by water movement. Chlorophyll *a* is relatively low and even during low precipitation periods as observed in 2025 August-October productivity at this station remained low - as opposed to conditions at stations lower in the reservoir.

Comparisons Across Years

Growth of phytoplankton in this area is completely dependent on flow and movement of water and is usually low. In some seasons we can detect a buildup and increase in

Chlorophyll *a* during the summer months, yet increased phytoplankton biomass is quickly reduced or mitigated due to the impact of hydrology.

pH

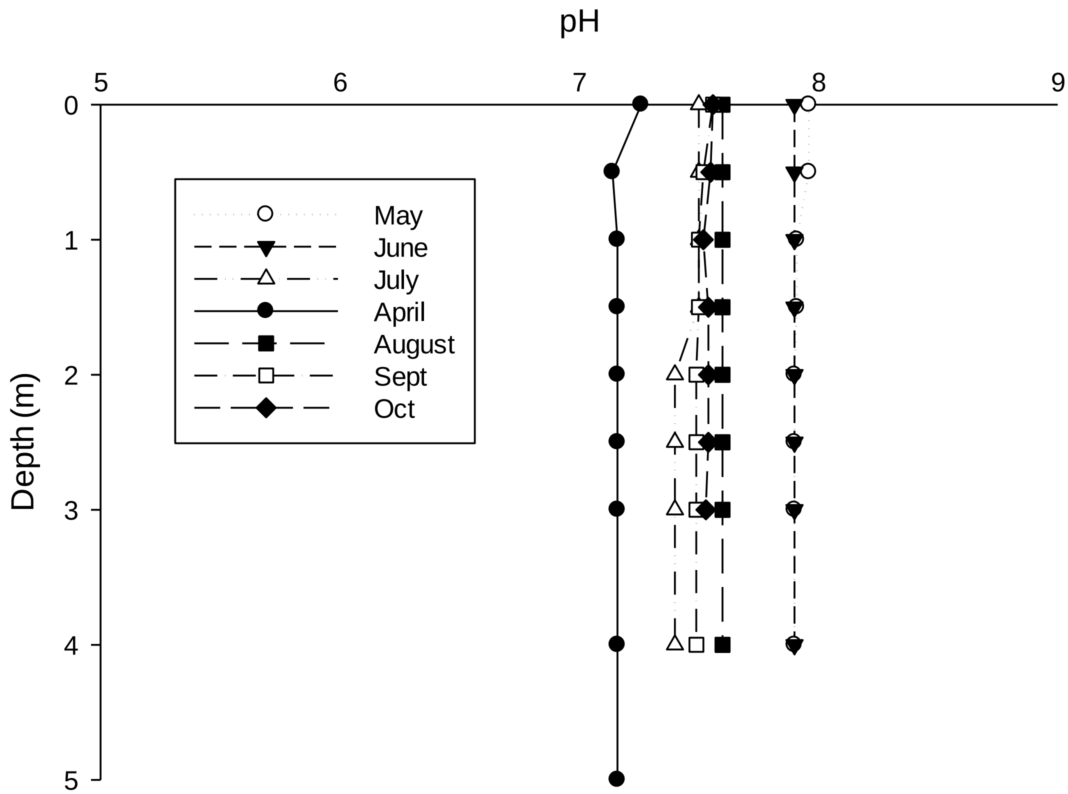


Figure 1.3.22. Toler Bridge (Riverine) pH measures over study period (2025)

Seasonal Analysis

The pH at this station is strongly influenced by water flow and reflects the chemical constituents in the water rather than phytoplankton productivity. Water movement may push water with higher pH readings into this area from LVL but more likely it is driven from the mix of Pigg River and SML tailwaters. While phytoplankton productivity may be lower, pH can remain elevated until acid – base chemistry equilibrates.

Comparisons Across Years

The pH at this station can exceed a pH of 8 as was observed in April but typically does not. It is hard to pinpoint the cause, as these higher readings do not correlate well with observed Chlorophyll *a* concentrations. Without knowledge of pH in SML or the exact movement of water between the two reservoirs it is difficult to predict this pattern.

Nevertheless, in all instances pH elevation is lower than observed downstream in the lake where readings may exceed 9.

ORP

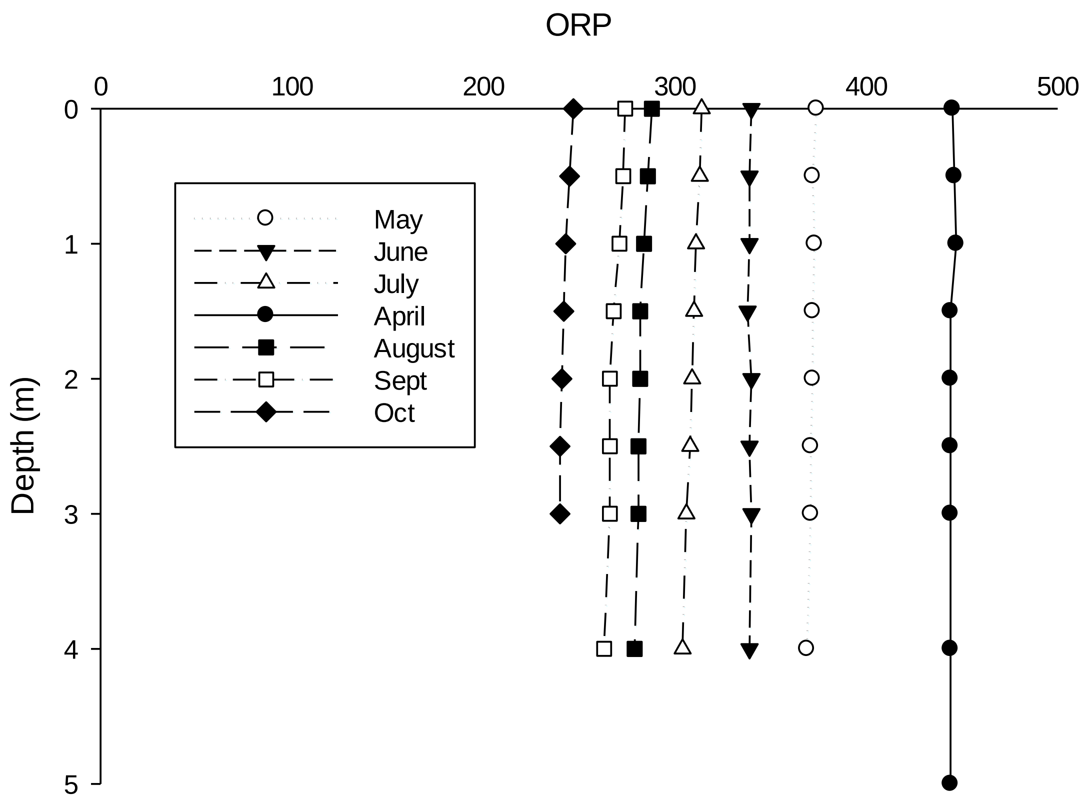


Figure 1.3.23. Toler Bridge (Riverine) ORP (mV) measures over study period (2025)

Seasonal Analysis

The ORP measures in this section of the reservoir do not provide any new interpretation between stations and the increased measures in June are discussed in MM6 section. Importantly, we do not observe reductions in ORP here creating concerns for reduced rather than oxidized conditions.

Comparisons Across Years

ORP is generally between 250 – 500 mV at this station. Some exceptions to this pattern have occurred but return to this range in the following season. ORP remains in a favorable range for the reservoir.

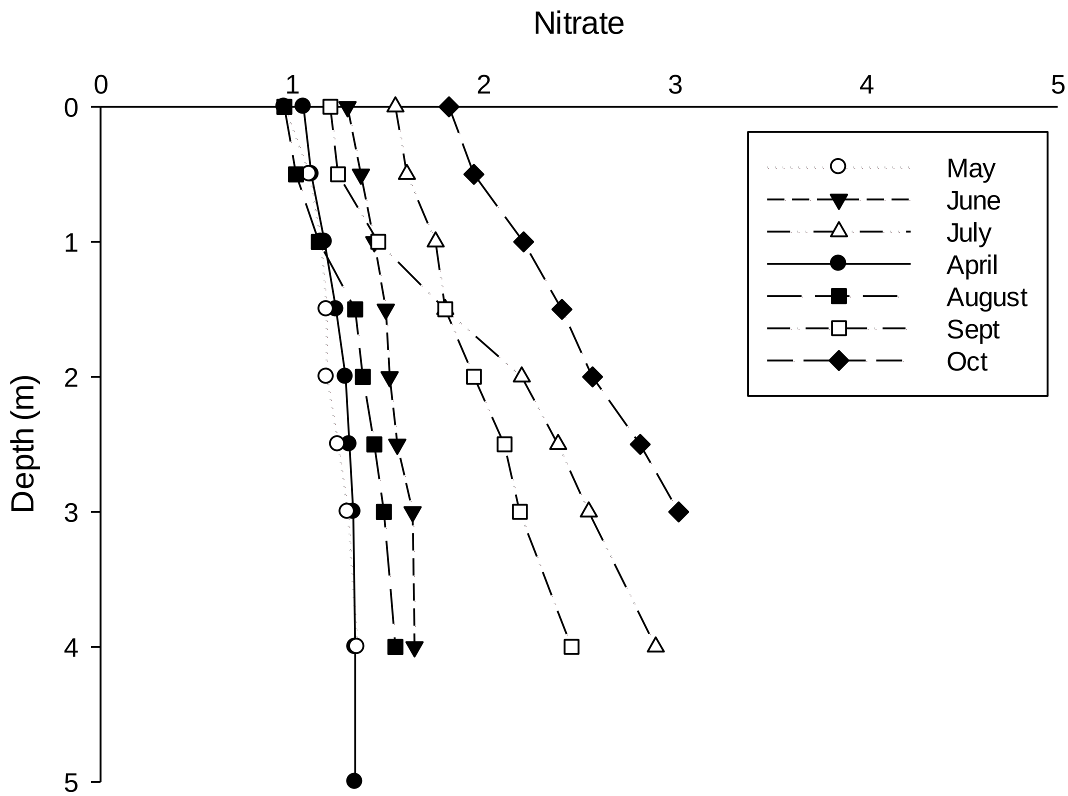


Figure 1.3.24. Toler Nitrate (mg/L) measures over study period (2025)

Seasonal Analysis

Nitrate patterns suggest greater availability during April and June. This is clearly driven by water movement rather than lake dynamics as suggested at the other portions of the reservoir. The concentrations observed were lower compared to other sections of the reservoir, likely due to reduced nitrogen release from the SML dam.

Comparisons Across Years

More data on Nitrate is needed for yearly comparisons.

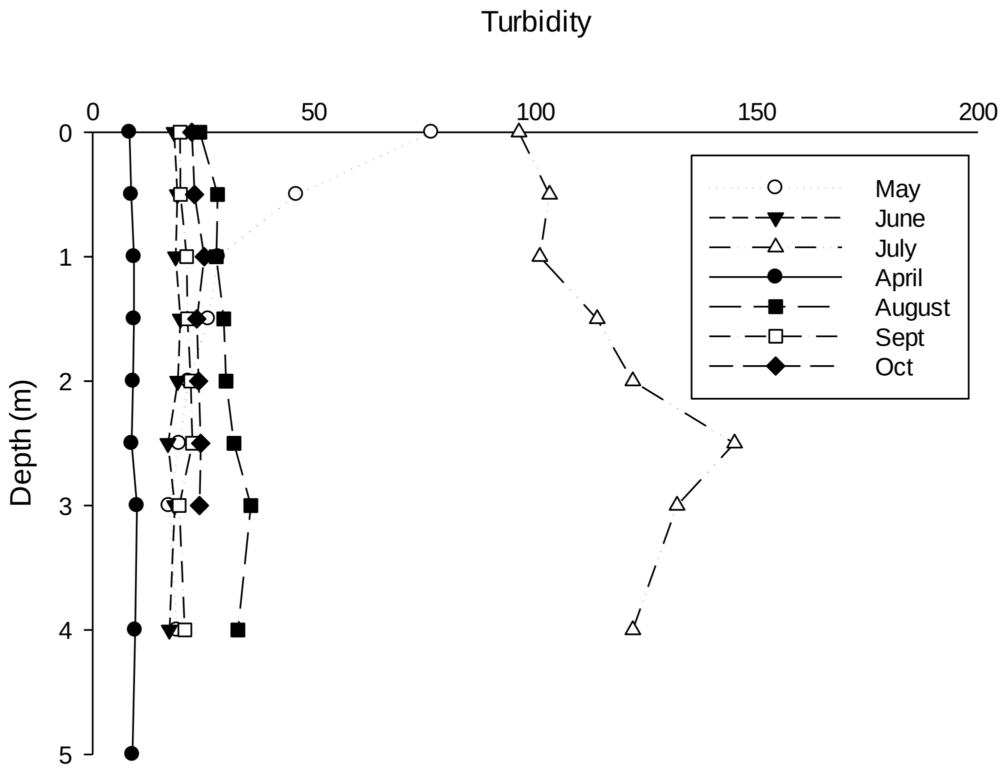


Figure 1.3.25. Toler Bridge (Riverine) Turbidity (NTU) measures over study period (2025).<u>Other Parameters Measured</u>

Table 1.3.7 Other parameters measured over study period (2025). Dates represent sampling of both the volunteers and university. First Column represents each parameter measured along with units of measure.

	16-Apr	19-May	17-Jun	25-Jun	18-Jul	31-Jul	18-Aug	27-Aug	22-Sep	21-Oct
Time	11:50 AM	1:50 PM	10:15 AM	9:58 AM	12:10 PM	9:55 AM	11:00 AM	10:20 AM	11:55 AM	4:05 PM
Secchi (M)	2.50	0.40	1.5	0.8	0.3	1.20	1.3	1.60	1.50	1.50
TP Surface (PPM)	0.023	0.138	0.004	0.026	0.135	0.026	0.044	0.031	0.021	0.035
Integrate Chl a (PPB)	3.16	3.29	5.00		3.70		8.84		8.83	5.98
TSI S	47	73	54	63	77	57		53	54	54
TSI TP	48	71	30	49	71	49	56	51	47	53
TSI CHL	42	42	46		43		52		52	48
TSI AVG	45	62	44	56	64	53	54	52	51	52
E. coli MPN	25.60	455.00	10.9	64.00	203	38.80	7.3	3.10	8.40	17.10

1.3.1.7 Pigg River

Photograph of Pigg River taken by Jade Woll.

Table 1.3.8. Pigg River other parameters measured over study period (2025). Measures are integrative throughout the entire water column. Profile data located in the appendix.

	16-Apr	19-May	17-Jun	25-Jun	18-Jul	31-Jul	18-Aug	27-Aug	22-Sep	21-Oct
Time	12:00 PM	2:05 AM	10:05 AM	10:06 AM	12:20 PM	10:05 AM	11:20 AM	10:30 AM	12:15	4:23 PM
Secchi (M)	0.60	0.30	0.2	0.5	0.1	0.70	0.6	0.80	0.80	0.80
TP Surface (PPM)	0.072	0.237	0.017	0.079	0.376	0.072	0.077	0.049	0.075	0.101
TSI S	67	77	83	70	93	65	67	63	63	63
TSI TP	62	79	44	64	86	62	63	57	63	67
TSI AVG	65	78	64	67	89	64	65	60	63	65
E. coli cfu/100ml	285.10	663.00	1850	1006	512	307.60	185	123.60	69.75	58.60
Temp C	14.27	21.2			23.3		26.9		23.5	16.57
DO mg/L	9.66	7.7			5.86		7.3		8.7	9.5
DO%	96.30	90.20			20.80		93.80		101.90	100.90
Turbidity (NTU)	34.7	117.9			373.6		70.3		39.5	44.2
Conductivity	0.102	0.068			0.129		0.094		0.095	0.107
pH	6.9	7.7			7.2		7.3		8.5	7.45
ORP	445	379			327		347		281	305
CHL (ug/L)	3.3	4.9			4		2.7		7.83	24.5
NO3 mg/L	4	2.7			2.63		1.37		0.96	2.49
Enterococci	520	850	5172	2723	1714	7270	1336	2720	3076	1576
E. coli/Entercocci	0.55	0.78	0.36	0.37	0.30	0.04	0.14	0.05	0.02	0.04

1.3.1.8 Smith Mountain Lake Tail Waters

Table 1.3.9. Smith Mountain Lake Tail Waters other parameters measured over study period (2025). Measures are at the surface.

	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
Time	12:07 PM	2:20 AM	10:05 AM	12:35 PM	11:30 AM	12:30 PM	4:35 PM
Secchi (M)	2.50	2.50	DNS	2.6	1.7	2.40	1.6
TP Surface (PPM)	0.010	0.028		0.016	0.02	0.008	0.011
TSI S	47	47		46	52	47	53
TSI TP	38	50		43	46	36	39
TSI AVG	42	48		45	49	42	46
E. coli cfu/100ml	26.20	10.90		20.1	10.9	10.90	10.9
Temp C	10.8	15.1		19.3	24.17	20.8	19.33
DO mg/L	10.76	8.5		5.7	6.87	4.42	6.29
DO%	97.7	86.9		63.1	83.5	50.6	70.2
Turbidity (NTU)	7.3	11.2		11.6	4.1	16.2	17
Conductivity (ms/cm)	0.187	0.185		0.188	0.174	0.193	0.196
pH	7.4	7.76		7.4	7.3	7.56	7.39
ORP	425	343		373	295	300	0
CHL (ug/L)	2.15	1.7		1.5	4.5	1.97	4.23
NO3 mg/L	1.3	1.25		1.27	1.85	0.74	2.46

Section 2: Lake-Wide Trends

The purpose of this section is to look at the functioning of the reservoir and establish trends. These trends are important to give a trajectory of lake health and allow us to manage the lake for optimum water quality. These trends are based on collected water quality parameters over the entirety of this study, and their compilation into trophic state indices (TSI) and other predictive indicators help track the health of the lake. The use of these indices allows ease of comparison among known parameters for lake and reservoir function and facilitates the translation of raw data into a usable management tool. As with any index, confounding parameters may, at times, reduce the value of a given index necessitating alternate interpretations and hypotheses. However, within the science of limnology (the study of lakes), use of indices is widespread and offers good explanations. There are 3 main categories under TSI; eutrophic, mesotrophic, and oligotrophic. Eutrophic lakes are highly productive and concentrated in nutrients; mesotrophic lakes experience moderate productivity and have lower nutrient levels; oligotrophic lakes have little productivity and low nutrient levels. When the TSI value is greater than 51, lakes are classified as eutrophic. Eutrophic lakes can be plagued by low water clarity, loss of oxygen in the hypolimnion, high sediment turbidity and high nutrient levels. This stimulates an abundance of algae growth and even noxious forms throughout the summer months. Excessive eutrophication is to be avoided. A TSI > 61 is considered excessive. Water has more clarity in oligotrophic and mesotrophic lakes, low concentrations of algae and typically an abundance of oxygen throughout the water. This is a desired state in management of a lake.

2.1 Analysis of Trophic State[3]

In this analysis, trends of all the measurable trophic state indices (TSI) are evaluated for all of the sampling data collected during this project. The usefulness of this is many-fold. First, we can examine several parameters that are used to predict TSI or lake

[3] *Photograph of Leesville Lake taken by Jade Woll*

health (Carlson 1977). The use of multiple parameters always strengthens any scientific investigation. Second, each parameter measured provides a predictor based on differing influences within the reservoir. Secchi depth is influenced by both sediment input and phytoplankton growth, whereas total phosphorus (TP) simply reflects the concentrations of this limiting nutrient but also dynamics within the reservoir. Additionally, Chlorophyll *a* concentration reflects use of TP for phytoplankton growth within the limitations of shading (sediment inputs) and grazing by zooplankton (*Daphnia* abundance). It is interesting and useful to note how each parameter (Secchi Depth, TP and Chlorophyll *a*) differs in predictive power. While the parameters evaluated may yield TSI that differ quantitatively, often the predictions are within similar ranges. We are also interested in trends over time. The trends observed lead to conclusions about how the reservoir is changing over time. These observations will guide our management decisions and conclusions as well as future work.

It is important to understand sediment input in this reservoir and how it may influence trophic state. Within reservoirs of the southeastern United States, sediment input constantly occurs. While sediment consists of many forms, clay is the predominate component in this region. Clay is problematic for many reasons. First, it stays in suspension for extended periods of time. Secondly, it binds with phosphorus helping to transfer this nutrient into reservoirs and depositing it into the sediments causing long term problems. It also competes for phosphorus and shades select species of phytoplankton. While lowering phytoplankton growth can be beneficial, clay often limits desirable forms of plankton and replacing them with undesirable species.

In this analysis we use the three main stations in the reservoir for ease of comparison: Dam, MM6 and Toler Bridge. Evaluation of water quality at these sites provides an overview of the spatial pattern from the headwaters to the dam. Reservoirs are typically most productive (eutrophic) in the headwaters with decreasing productivity near the dam. Mid stations in a reservoir (MM6 for Leesville Lake) reflect an area of mixing. This is the portion of the reservoir where the river flow (area higher in sediment and nutrients with greater input of water and water movement) meets the lake portions (area low in sediment and nutrients with very slow water movement). This area can be highly productive due to a multitude of factors.

Leesville Lake is unique due to headwater input from Smith Mountain Lake (a slightly eutrophic reservoir) and the Pigg River (a highly timbered and agricultural developed watershed). This unique combination has a very profound impact on water quality. This trophic state analysis (Section 2.1), precipitation and Pigg River inputs (Section 2.2), predictions of mid-summer chlorophyll peak (Section 2.3) and SML oxygen loss (Section 2.4) explore this unique relationship in the context of Leesville Lake water quality. We try to quantify these inputs and speculate on impacts. This leads to our management recommendations.

Secchi Depth TSI

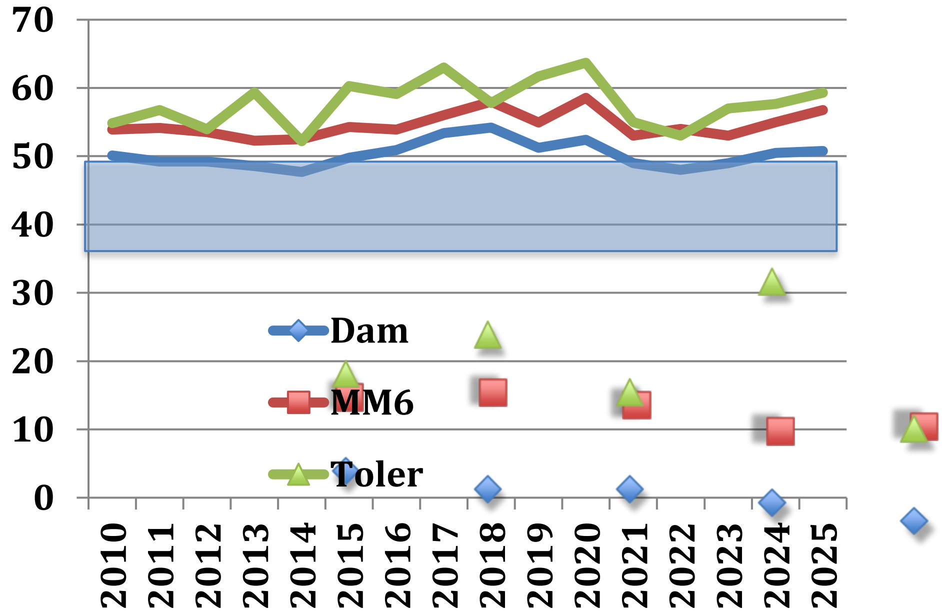


Figure 2.1. Trophic State Index (TSI) based upon Secchi disk (meters) measurements in Leesville Lake from 2010-2025. Y-axis reflects the calculated TSI for each of the three primary sampling stations throughout the reservoir. The shaded box represents the mesotrophic range for TSI where below this range is oligotrophic conditions and above represents eutrophic conditions.

Analysis

In 2025, predictions of trophic state using Secchi depth suggested LVL water clarity, while showing slight variations, is trending toward worsening (Figure 2.1). This trend has occurred previously with decreasing clarity from 2016 until 2021 when conditions improved (Table 2.1). The pattern where Secchi Depth improves (2010-2015) then worsens ((2016-2020) and then improves (2012-2025) may be repeating again. By comparison to Chlorophyll *a* trophic state (Fig 2.3) and TP TSI (Fig 2.2), this is the only parameter that may be slightly increasing over the past 5 years in the lake.

Table 2.1 – Analysis of previous 15 years of Secchi TSI data showing mean measures and standard error for each 5-year block of time.

Dates	TSI Secchi	Standard Error
2010-2015	52.93	0.83
2016-2020	56.59	1.06
2021-2025	53.40	1.05

When comparing the Secchi depth TSI from the headwaters (Toler Bridge) to the Dam we see a very distinct pattern. Toler Bridge is expected to have the most eutrophic waters based on Secchi measurements, with increasing clarity and improved TSI moving down lake to the dam. But this trend is variable and driven by two competing factors. Water from SML tail water release can be extremely clear even to the point of oligotrophic. Pigg River on the other hand can be very turbid to the point of hypereutrophy. Often what we see here is the predominance of tail release over Pigg River inputs. With the addition of 2025 data, these trends appeared consistent as we have observed in the past. Toler Bridge and MM6 are very similar in clarity with increasing clarity at LVL dam.

Total Phosphorous TSI

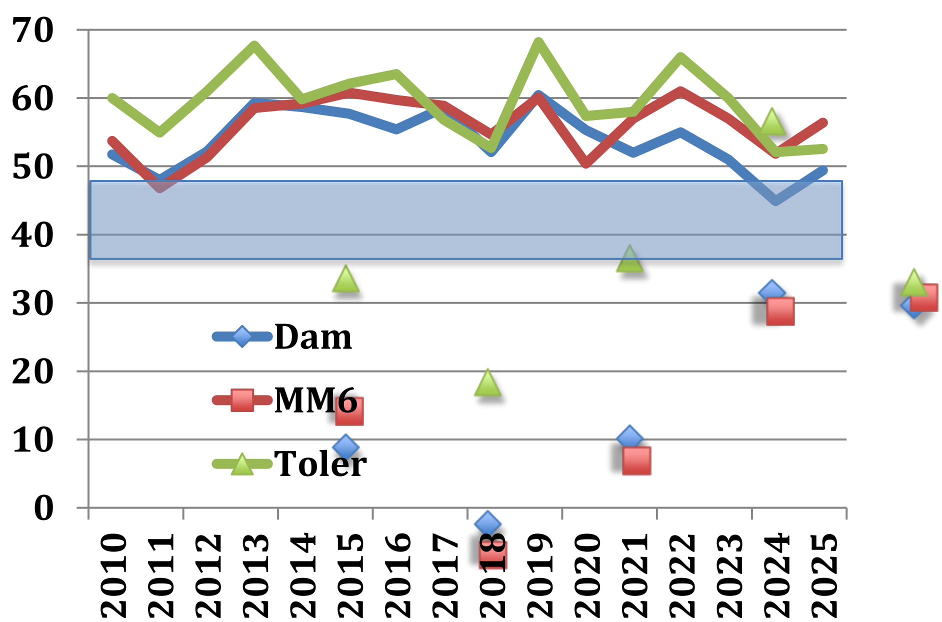


Figure 2.2. Same as Figure 2.1 but TSI based on Total Phosphorus (TP).

Analysis

By contrast to the Secchi-based TSI, trends in TP show decreasing TSI or improving conditions (Fig 2.2). Because water flow is very controlling this may be a reflection of water input and a predominance of SML Dam release which contains much less TP than the Pigg River. This index does show greater variability with MMG and Toler Bridge stations fluctuating. This suggests again the SML tailwater and Pigg River inputs are variable in impact depending upon conditions and most importantly precipitation and flow.

Chlorophyll *a* TSI

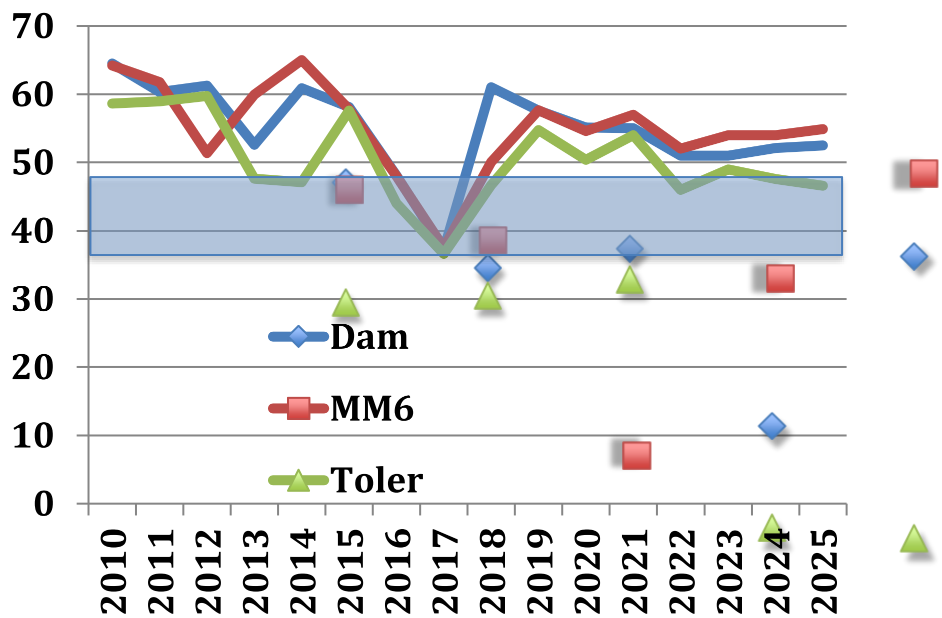


Figure 2.3. Same as Figure 2.1 but TSI is based on Chlorophyll *a*.

Analysis

Trophic state based upon Chlorophyll *a* has been relatively stable since 2018. TSI Chlorophyll *a* (Figure 2.3) continues to suggest the lake is slightly eutrophic with lowest readings occurring at Toler Bridge. The latter is is a reflection of SML tailwater and Pigg River inputs, both of which have relatively low algal content. MM6 contains the highest chlorophyll content, which is expected based on the nature of the transition station. Chlorophyll *a* in Leesville Lake is much more responsive to flushing and water movement than TP concentrations.

TSI Average

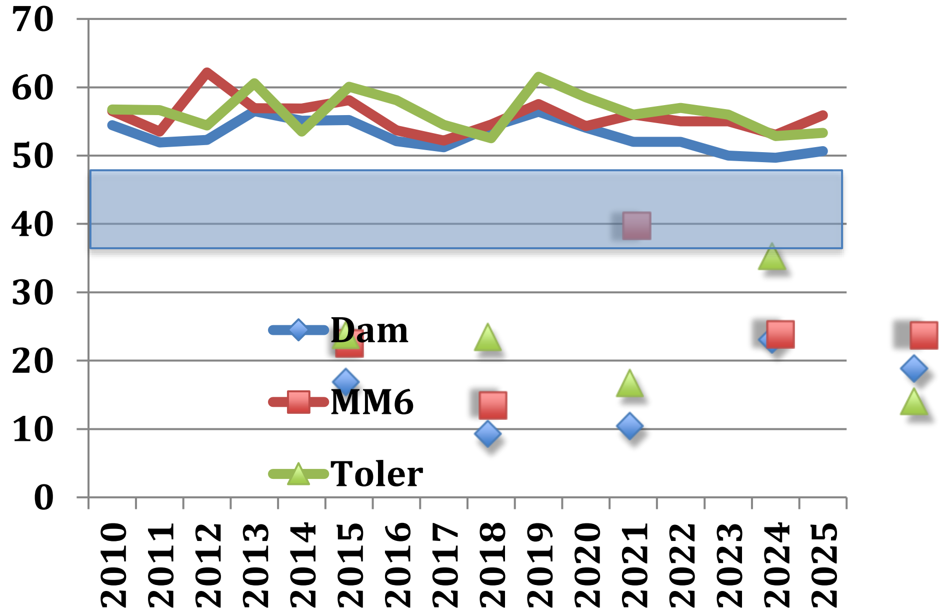


Figure 2.4. Same as Figure 2.1 but TSI presented is the average of TSI for all parameters evaluated (Secchi Depth, Total Phosphorous, Chlorophyll *a*).

Analysis

Averaging trophic state indices has value in determining if the lake is trending in a particular direction. Based upon multiple parameters the reservoir continues to be amazingly steady. The lake remains mildly eutrophic with some fluctuation but meeting desired uses. While we are observing some worsening of water quality entering the reservoir from the Pigg River, these symptoms are not expressed in the overall TSI or at the Toler Bridge station. Often, time lags are associated with changes thus it is not surprising these changes are not yet reflected in the overall TSI. However, it is important to note that we are not observing time lags at this point and can be confident the water quality in the reservoir is stable.

Daphnia Productivity

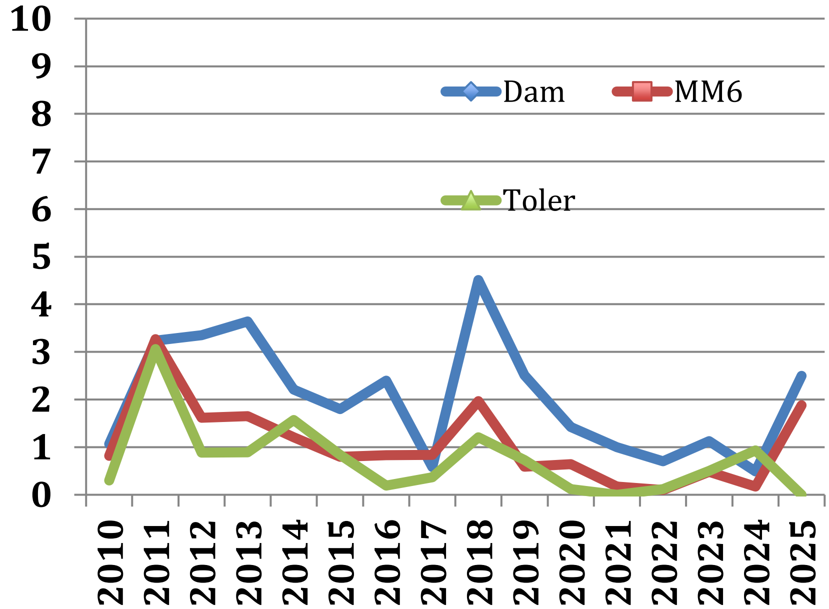


Figure 2.5. Average *Daphnia* concentrations in Leesville Lake from 2010-2025. Numbers on y-axis represent *Daphnia*/ liter.

Analysis

The abundance of *Daphnia* in 2025 increased after 5 years of very low abundances. This may be a reflection of increased phytoplankton productivity but more likely is a result of fish or other predators. It is difficult to determine the exact cause, but greater Daphnia productivity is beneficial the reservoir for both grazing of phytoplankton and providing the basis of the food chain for fish productivity.

Additional Trophic State Analysis

As in our 2024 report, an additional analysis was undertaken. Based on the literature (Sobolewski 2016), lakes in catchments with greater than 60% agricultural land use exhibit poorer water quality than those in less agricultural dominated watersheds. Greater than 60% agricultural land use in the watershed had lakes with 0-5 on the following scale. Lakes in catchments with agricultural land use less than 60% (60-35) tended to have much better water quality (8-10).

Table 2.2 – measures of water quality for lake from around the world. Leesville Lake water quality is quite good based on this scale.

Pollutant Measures	Low	Medium	High	LVL 2025	LVL 2022	LVL 2023	LVL 2024
Secchi Depth (m)	>2.10	1.15-2.10	<1.15	1.93 = 1 pts.	2.33 = 2 pts.	2.13 = 2 pts.	1.99 = 1 pts
Conductivity (uS/cm)	<289	289-402	>402	171 = 2 pts	168 = 2pts.	175 = 2 pts.	164 = 2 pts
Total Nitrogen (mg/m3)	<1.04	1.04-1.67	>1.67	0.78 = 2	0.12 = 2 pts.	0.31 = 2 pts.	0.46 = 2 pts
Total Phosphorus (mg/m3)	<0.043	0.043-0.08	>0.08	0.03 = 2 pts	0.06 = 1 pt.	0.03 = 2 pts.	0.03 = 2 pts
Chl a (ug/L)	<12.5	12.5-31.5	>31.5	9.89 = 2 pt	8.23 = 2 pts	8.12 = 2 pts.	9.28 = 2 pts
Points	2	1	0	9/10 points	9/10 points	10/10 points	9/10 points

The combination of lower than 60% agriculture in the watershed and influence of SML tailwater release keep Leesville Lake in the good zone of water quality (Table 2.1). Leeville Lake has scored 9/10 points in 3 of the past 4 years suggesting the reservoir exhibits excellent water quality even in an agriculturally dominated Pigg River Watershed. This strongly suggests that SML tailwater release mitigates the negative potential impacts from Pigg River input. This situation must be continually monitored to determine if conditions are continuing or are progressing toward greater expression of Pigg River Water quality.

2.2 Analysis of Data

In this section, long-term collection of data is analyzed to look at what is controlling productivity in the lake. Productivity is the greatest concern as eutrophication and land use surrounding the lake and watershed are of greatest concern. Excessive productivity (measured as Chlorophyll *a* and translated into TSI) causes problems such as Harmful Algal Blooms (HABs) as experienced in Smith Mountain Lake, greater loss of oxygen as this material decays and less appealing aesthetic quality of water. Management of the lake should have the goal of reducing productivity or keeping it at current levels. These levels are represented by the blue-shaded areas in Figures 2.1-2.4.

This analysis was conducted to examine what might be controlling productivity in the lake. Productivity measured as Chlorophyll *a* at station MM6 is the greatest in the reservoir as it is the point where riverine and lacustrine conditions combine. MM6 TSI measures were also used in this analysis as a response variable as this measure includes Secchi disk and Total Phosphorus measures. For this analysis, two primary drivers were examined. Water quality entering from the Pigg River represented as Dissolved Oxygen

(DO) and Total Phosphorus (TP) and the same measures from Smith Mountain Lake measured as Tail Waters. One additional variable included was precipitation. This data was collected monthly from Lynchburg Airport as a general representation throughout the area.

Data analyzed included monthly measures from April – October from 2012-2025 (Table 2.2.1). This provided a data set of 98 observations over a span of 13 years. In general, precipitation ranges from a low year of 15.97 inches in 2012 to high of 44.37 inches in 2020. This does have an impact on lake water quality as this variation represents a 2.77x difference in precipitation. Interestingly, monthly totals do not represent much variability. May and July were the wettest months but July was greatest due to very high reading in 2023 (over 10 inches). Concerning water quality, the variability in yearly totals is of much greater significance.

Table 2.3 – Monthly precipitation over a 13-year seasonal study period in Leesville Lake. Precipitation is displayed in inches for presentation here (converted to mm in the analysis) and totaled. Measures are from Lynchburg Va regional airport as representations for the watershed.

Year (Inches)	April	May	June	July	Aug	Sept	Oct	Total
2012	2.44	2.36	1.71	2.73	2.7	2.35	1.68	15.97
2013	3.38	6.12	6.32	3.41	3.55	0.48	2.34	25.6
2014	5.62	5.39	2.4	5.79	4.78	1.62	3.57	29.17
2015	4.06	1.66	5.59	3.79	1.98	7.13	4.07	28.28
2016	2.12	6.89	6.27	6	1.19	3.38	1.73	27.58
2017	4.18	7.88	2.09	3.3	2.24	1.91	2.57	24.17
2018	4.8	8.32	4.87	5.87	4.44	6.77	4.76	39.83
2019	4.02	2.09	3.79	3.24	3.24	0.17	6.73	23.28
2020	8.15	3.7	4.91	3.47	8.69	9.02	6.43	44.37
2021	3.52	1.7	5.14	2.59	2.44	2.62	2.76	20.77
2022	2.42	5.81	2.15	5.03	7.08	0.97	2.8	26.26
2023	5.15	1.91	4.29	10.83	2.32	3.53	0.9	28.93
2024	2.24	2.59	0.04	5.86	6.48	4.35	0.5	22.06
2025	2.13	7.87	1.94	8.97	1.5	2.72	1.42	26.55
Totals	54.23	64.29	51.51	70.88	52.63	47.02	42.26	382.82

Response parameters were analyzed individually but also summarized to see differences and compare inputs from Pigg River with Tail water (Table 2.2.2). The primary goal of this analysis is to determine function of the reservoir pertaining to water quality and to determine how these inputs maybe impacting water quality along with precipitation.

The greatest disparity between inputs is in phosphorus loading between the Pigg River and SML tail water. In some years the ratio (Pigg River/Tail Water) is near 1 (equal loading from both sources) but more typically it is up to 3x and even 10x as in 2025. Clearly, TP loading from Pigg River has much greater impact on the reservoir. Dissolved oxygen patterns were much less clear. Slightly greater loading of oxygen from Pigg River than SML with the deficient occurring between August – October. This is a concerning problem but the impact on overall water quality appears minimal. Precipitation inputs are variable with highs over the study period up to 3x low input years.

Table 2.4. Response parameter summaries from analysis. Ratios display the division between Pigg measures and Tail Water measures for direct comparisons. Totals represent the sum of all 7 months. TSI average are average of the 7 month totals.

	Pigg/Tail	Pigg/Tail							TSI Average
Year	DO Ratio	Tp Ratio	CHL Total	Rain Total	Pigg DO Total	Pigg TP Total	Tail DO Total	Tail TP Total	
2012	1.22	0.96	177.24	15.97	58.97	0.521	48.2	0.545	52.1
2013	1.07	3.38	71.00	25.6	62.47	1.260	58.18	0.373	54.5
2014	1.01	2.33	242.05	29.17	59.23	1.073	58.44	0.46	60.5
2015	0.98	4.90	159.12	28.28	55.82	1.648	56.96	0.336	58.8
2016	1.12	1.17	54.13	27.58	51.22	0.792	45.85	0.676	54.6
2017	1.12	1.05	19.02	24.17	52.61	0.603	47.1	0.573	52.6
2018	1.25	9.45	55.84	39.83	56.88	1.049	45.39	0.111	54.5
2019	1.11	3.33	125.14	23.28	56.96	1.810	51.14	0.544	57.6
2020	1.14	3.84	94.79	44.37	52.44	1.703	45.81	0.444	55.6
2021	1.12	3.93	113.92	20.77	47.52	1.070	42.57	0.272	55.7
2022	1.17	3.44	68.18	26.26	54.4	1.000	46.51	0.291	53.8
2023	1.15	3.27	79.67	28.93	54.77	1.038	47.69	0.317	54.2
2024	1.29	4.03	84.52	22.06	48.29	0.508	37.35	0.126	54.3
2025	1.15	10.02	91.57	26.55	48.72	0.930	42.54	0.093	56.8

To determine the impact of these parameters on response variables several statistical analyses were performed. Principal Component Analysis allows us to correlate all observations (576 total) to determine possible patterns. From the graphical output, patterns are discerned looking along both axes for clusters or increase vs decrease in the output. From this analysis (Figure 2.2.1), Chlorophyll (response variable) showed a decrease with precipitation increase. The remaining variables were not strongly associated with changes in Chlorophyll.

This relationship was confirmed using Partial Least Squares Regression Variable in the Projection (PLS-VIP) analysis (Figure 2.2.2). Here, precipitation is very strongly correlated (values over 2) with changes in Chlorophyll *a* at MM6. The pattern is clear in the reservoir, less precipitation leads to increases in Chlorophyll *a* due to reduced flushing of the reservoir. Water quality decreases with lower precipitation.

This idea can be counter intuitive as increased precipitation brings in greater loading of nutrients that stimulate plant growth. Yet because Leesville Lake is a pump-storage reservoir, this relationship can be complicated by dam operations. To look at this idea, a PLS-VIP analysis was conducted on parameters to determine if dam operations were of greater influence than precipitation on Pigg River Total Phosphorus inputs.

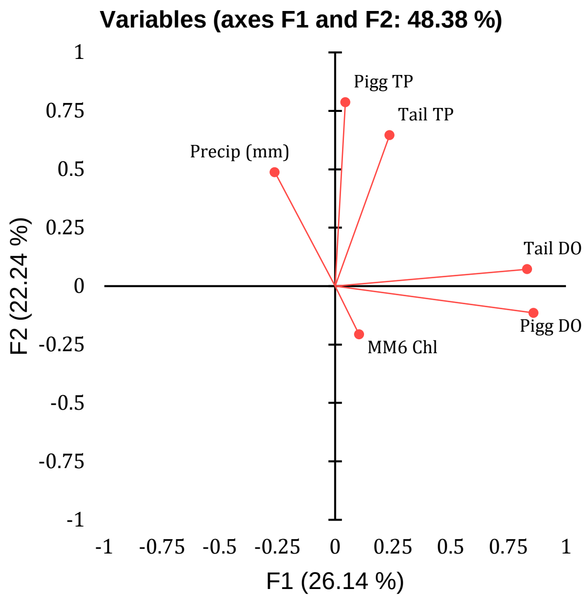


Figure 2.6. PCA analysis of all variables

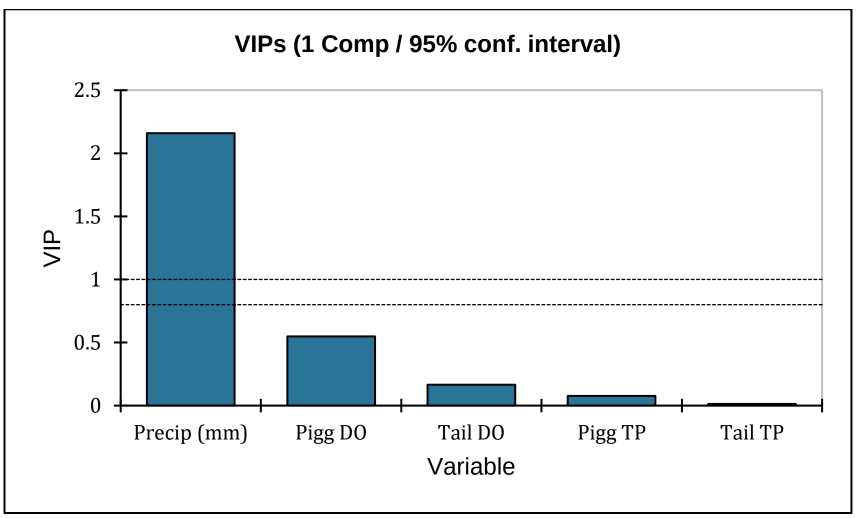


Figure 2.7. Influence of variables using partial least squares regression on MM6 Chlorophyll a. In this analysis, VIP (Variable in the Projection) is strongly associated with the test parameter (here Chlorophyll a at MM6) when the VIP correlation is greater than 1.

Section 3. Persistent Problems

3.1 Debris

Debris (primarily branches and trunks of trees) constantly plagues Leesville Lake. This debris presents a significant navigational hazard along with aesthetic and property management problems. AEP has a program to report and remove this debris, yet the continual influx of material appears to make this task difficult to manage.

The problem originates in the Pigg River. Stormwater transports not only sediment and bacteria but also debris (Figure 3.1.1). Large branches and logs can been seen flowing down river during storm events. This material may become log jammed during the journey to Leesville Lake but will eventually be transported during a significant storm or series of storms (Figure 3.1.2). The amount of debris can be significant and prevent safe navigation. Another problem occurs when pump back is in operation. Reverse water flow draws debris back into the main channel. If water flow was constant from headwater to tailwater. The main channel would clear as water flow entering and traveling down reservoir tends to short circuit remaining in the middle. The unique hydrology of Leesville Lake compounds this problem.

Figure 3.1. Stormwater flowing though old power dam location. Significantly sized debris (branches and logs) can be seen flowing with the stormwater that will eventually enter Leesville Lake.

Figure 3.2 – Debris at Toler Bridge June 17 2025 blocking the upper end of reservoir.

Table 3.1 – Precipitation data (inches) from Lynchburg Airport associated with sampling of Leesville Lake in 2025.

Date	3 day	7 day	Month
April 16	0.07	2.03	2.61
May 19	0.27	5.0	9.56
June 17	0.85	0.85	4.48
June 25	0.44	0.44	4.48
July 18	2.24	2.66	4.41
July 31	0	0	4.41
August 18	0	0.92	2.85
August 27	0	0	2.85
September 22	0	0.11	3.98
October 21	0.04	0	1.33

3.2 Dissolved Oxygen

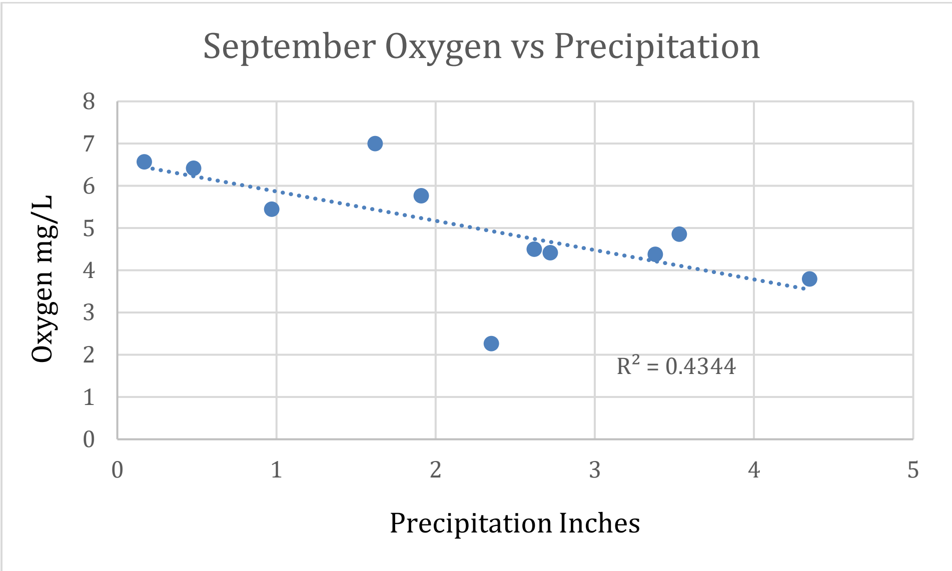
Low dissolved oxygen (DO) concentrations are a persistent problem in the lake. Stratification of Smith Mountain Lake (SML) throughout the summer generates low oxygen concentrations in the hypolimnion where various discharges from the dam occur. SML stratification and low DO in summer and through the fall months has occurred since the lake was impounded.

Table 3.2 – Monthly surface oxygen concentrations at SML tailwater. All readings are in mg/L.

	Tail DO							
Year	April	May	June	July	Aug	Sept	Oct	Average
2012	11.6	9.2	6.99	6	5.51	2.27	6.63	6.9
2013	10.7	9.9	9.5	7.4	7.34	6.42	6.92	8.3
2014	12.05	9.3	7.38	8.37	6.84	7	7.5	8.3
2015	12.66	9.7	8.8	6.38	7.22	5.26	6.94	8.1
2016	7.88	7.41	8.62	6.15	5.61	4.38	5.8	6.6
2017	8.81	7.88	7.1	6.2	4.72	5.77	6.626	6.7
2018	10.8	7.9	7.6	5.2	4.5	4.2	5.3	6.5
2019	10.07	8.11	6.99	6	6.7	6.57	6.7	7.3
2020	9.2	8.3	7.01	5.99	3.74	6.77	4.8	6.5
2021	10.25	8.54	9.62	5.84	3.82	4.5		7.1
2022	8.28	8.14	7.25	5.53	4.16	5.45	7.7	6.6
2023	9.87	8.27	8.1	6.25	5.1	4.86	5.24	6.8
2024	9.45		6.6	6.2	4.6	3.8	6.7	6.2
2025	10.76	8.5		5.7	6.87	4.42	6.29	7.1
Average	10.2	8.5	7.8	6.2	5.5	5.1	6.4	
Total	142.3	111.1	101.6	87.2	76.7	71.7	83.1	

This creates historically low dissolved oxygen (below 5 mg/L) beginning in August and often persisting through October. For reservoirs listed in 9VAC25-260-187 that undergo thermal stratification, the daily average DO criterion of 5.0 mg/L (and the instantaneous minimum of 4.0 mg/L) applies only to the epilimnion. Under non-stratified conditions, this criterion applies throughout the entire water column.

Dissolved oxygen discharge during August and September often fall below the criterion established in 9VAC25-260-187. The simplest explanation and one that correlates with the data is the relationship with precipitation. Precipitation is driving most of the functioning in the reservoir – input of debris, dilution of chlorophyll *a* and reduced dissolved oxygen concentration from SML in August and September (Figure 3.2.1). But as stated previously, pump storage operations add greater complexity to interpretation.



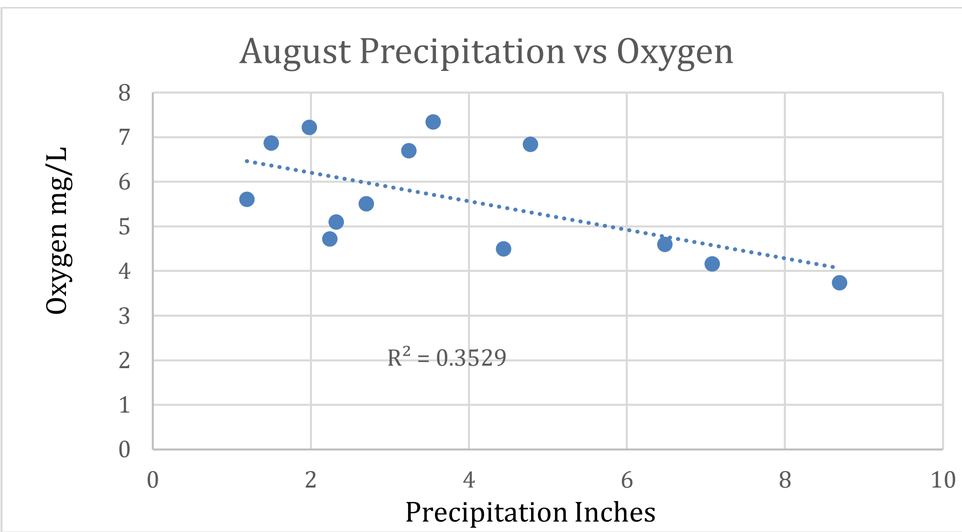


Figure 3.3. Dissolved oxygen and precipitation relationships in Leesville Reservoir during August and September from 2012-2025. Oxygen measures are from surface just beyond SML dam release. Precipitation are monthly totals from Lynchburg airport.

We know lower precipitation months generate greater Chlorophyll *a* productivity. Precipitation has a flushing impact and this appears to include oxygen as well. Thus, lower productivity and lower oxygen concentration correlate with increased precipitation. It is recommended that these relationships be considered in the movement of water throughout the project.

Section 4: Conclusions and Management Implications

4.1 Conclusions

As presented throughout this report, water quality in Leesville Lake is relatively stable and meeting goals prescribed for the reservoir. While the lake remains eutrophic and this condition can be improved, it is not worsening in trophic condition and this is a positive result.

The addition of more data improves relationships and allows continued analysis of data trends to help improve management. This season conclusions are as follows:

1. Leesville Lake remains slightly eutrophic and this measure is very stable in the reservoir. It has maintained this status throughout the monitoring period of study (2010-2025) and this result is currently stable and not expected to worsen or improve in the foreseeable future.
2. Leesville Lake behaves as a pump storage reservoir with headwaters impacted by tail release from the upper reservoir along with input from the Pigg River. Both are situated in the headwaters of the reservoir and both provide a unique input into the system. Each is integrated into the water quality and cannot be analyzed very well separately.
3. Analysis of all data suggests management needs to be closely aligned with precipitation as it drives productivity, the input of debris and oxygen loss in the reservoir. It additionally has a significant impact on the bacteriology of the reservoir that is analyzed in a separate study and subsequent publications.

4.2 Management Implications

The following management recommendations are suggested after conclusion of the 2025 sampling season:

1. Precipitation is a driver of water quality and aesthetics in the reservoir and must be part of future management of the reservoir.
2. Aggressive deployment of debris removal needs to continue. Correlations between pump-storage activity and water quality necessitate that dam operations be adjusted to preclude negative impacts on water quality when feasible. Knowing that retention of water in the reservoirs tends to increase productivity and oxygen, negative impacts of low oxygen can be countered by increasing water retention. Generally, increasing water retention in the lake will increase zooplankton populations and fish productivity.
3. Low dissolved oxygen needs to be managed at the tailwaters. All possible operational scenarios including syncing with precipitation need to be considered.
4. APCo's upcoming (April/May 2026) submission of a Dissolved Oxygen (DO) Improvement Plan to the Virginia Department of Environmental Quality for

review and approval will go a long way to addressing these issues. "APCo will develop a comprehensive plan, designed in consultation with VDEQ, the Department of Wildlife Resources (DWR) and other state or federal agencies to address depressed DO levels downstream from Smith Mountain Lake Dam. This plan is in accordance with APCo's final Permit VWP number 24 1547 signed on July 7, 2025. The plan is to protect instream beneficial uses, to ensure compliance with applicable water quality standards, to prevent impairment of state waters or fish and wildlife resources, and to provide no net loss of wetland acreage and function through compensatory mitigation and success monitoring and reporting."

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Appendix A
Background of Water Quality Program

For many years, the Virginia Department of Environmental Quality (DEQ) monitored Leesville Lake water quality either annually or biannually. Beginning in 2006, DEQ placed Leesville Lake on a six-year rotation for water monitoring. However, DEQ collected water quality data in 2009 and 2010.

In an effort to supplement DEQ water quality monitoring, the Leesville Lake Association (LLA) began a Citizen Water Quality Monitoring Program in April 2007. Citizen volunteers monitored bacteria, Secchi depth, temperature, dissolved oxygen (DO), pH, and conductivity. LLA outlined four goals for the program: (a) gain a greater understanding of the lake's water quality, (b) supplement the DEQ water quality monitoring, (c) increase the community's awareness of the importance of water quality, and (d) inform residents about harmful factors that damage water quality and age the lake (Lobue, 2010).

The Virginia DEQ provided LLA with a water quality monitoring probe to measure DO, temperature, and pH. With the DEQ Citizen Water Quality Monitoring Grant, LLA purchased Coliscan Easygel☐ test kits for *E. coli* testing along with Secchi discs and other necessary equipment (Lobue, 2010). Over the next three years, LLA published annual reports of the water quality test results. As part of the water quality monitoring plan required by its new license, Appalachian Power Company committed $25,000 for a water quality monitoring program.

Under the Federal Power Act (FPA) and the U.S. Department of Energy Organization Act, the Federal Energy Regulatory Commission has the power to approve licenses for up to 50 years for the management of non-federal hydroelectric projects (FERC, 2009, p. ii). The Commission issued the first license for the Smith Mountain Pumped Storage Project to Appalachian Power on April 1, 1960 with a set expiration date of March 31, 2010 (FERC, 2009).

As part of its relicensing process, Appalachian Power was required by the Federal Energy Regulatory Commission to implement a Shoreline Management Plan (SMP). In July 2005, FERC approved a SMP proposed by Appalachian for the Smith Mountain Project. The purpose of this plan is *"to ensure the protection and enhancement of the project's recreational, environmental, cultural, and scenic resources and the project's primary function, the production of electricity."* (FERC, 2009, p. 22). The SMP works to preserve green space, wetlands, and wildlife habitats along the shoreline. Property owners may not remove vegetation within the project boundary unless they have received permission from Appalachian Power. The project boundary for Leesville Lake lies at the 620-foot contour elevation (LLA, 2009).

To renew their license, Appalachian Power Company (Appalachian Power), a unit of American Electric Power (AEP), submitted an application for a new license in March 2008. In August 2009, the Federal Energy Regulatory Commission issued a Final

Environmental Impact Statement for the Smith Mountain Project relicensing. While reissuing, the Commission reviewed AEP's methods and proposals for "the protection, mitigation of damage to, and enhancement of fish and wildlife (including related spawning grounds and habitat), the protection of recreational opportunities, and the preservation of other aspects of environmental quality." (FERC, 2009, p. 1). In the final Environmental Impact Statement (EIS), FERC endorsed Appalachian Power's proposed $25,000 annually to the LLA to support the on-going water quality monitoring program (FERC, 2009, p. 25). The Commission approved the new license, effective April 1, 2010.

FERC recommended a few modifications to Appalachian Power's *Water Quality Monitoring Plan* including a proposal to develop a lake water quality monitoring plan. FERC determined that the primary water quality issues for Smith Mountain and Leesville lakes arise from nutrients and bacteria. Rather than coming from the dams' operations, the nutrients and bacteria come from shoreline development and overall watershed development. In conclusion, FERC recommended the (a) continuation of water-quality monitoring for Smith Mountain Lake, (b) establishment of a water quality monitoring program for Leesville Lake, and (c) ensuring the future health of the lakes by monitoring lake quality to verify that any changes in operational strategy at the Smith Mountain project do not harm water quality.

In summary, a timeline of significant events is outlined below:

- ☐ April 1960: First license for Smith Mountain Project issued
- ☐ April 2007: Development of Leesville Lake Citizen Water Quality Monitoring Plan
- ☐ 2007-2009: LLA annually reports on water quality
- ☐ 2008: AEP proposed $25,000 in 2010 to LLA for water quality monitoring plan
- ☐ August 2009: FERC issues a final EIS for Smith Mountain Project relicensing, recommending a water quality plan for Leesville Lake
- ☐ April 2010: AP's new license for Smith Mountain Project becomes effective
- ☐ June 2010: Lynchburg College begins water quality testing of Leesville Lake
- February 2011: Lynchburg College reports on 2010 water quality
- February 2012: Lynchburg College reports on 2011 water quality
- February 2013: Lynchburg College reports on 2012 water quality
- February 2014: Lynchburg College reports on 2013 water quality
- February 2015: Lynchburg College reports on 2014 water quality

Participants:

In August 2003, a group of Leesville Lake residents formed a non-profit 501(c)(3) corporation called the Leesville Lake Association. The association addresses the issues of debris, shoreline management, environmental and biological health, safety, future development, and fishing for Leesville Lake (LLA, 2003).

In 2007, the Department of Environmental Quality revised the Millennium 2000 Water Quality Monitoring Strategy. The Virginia DEQ maintains the "Water Quality

Monitoring and Assessment (WQMA) Program" with the ultimate goal to *"provide representative data that will permit the evaluation, restoration and protection of the quality of the Commonwealth's waters at a level consistent with such multiple uses as prescribed by Federal and State laws (VDEQ, 2007)."*

LLA partnered with University of Lynchburg to establish the Water Quality Monitoring Plan. University of Lynchburg agreed to conduct the samplings and testing, and report results. LLA water monitoring volunteers for 2020 were: Tony Capuco, David Waterman and Kathleen Giangi.

For a description of Leesville Lake and communities, refer to Section 2 of Lynchburg College's report titled *Leesville Lake 2010 Water Quality Monitoring* dated February 28, 2011.

Statement of Goals and Objectives
(Also stated in the 2010 and 2011 Leesville Lake Water Quality Monitoring Reports):

Goals and Objectives of the Leesville Lake Water Quality Monitoring Plan:
The Federal Energy Regulatory Commission recommended that a water quality plan for Leesville Lake be developed. In a collaborative approach, Leesville Lake Association and Lynchburg College developed a plan in February 2010 to continue and expand the testing and monitoring of water quality, to monitor nutrients and trophic status, and to supplement data collected by the Virginia Department of Environmental Quality in order to better understand the current state of Leesville Lake.

Leesville Lake Association
The objectives of the Leesville Lake Association, according to its Articles of Incorporation, are as follows (http://www.leesvillelake.org):

☐ Plan projects and studies that:
  a. Monitor and protect the water quality of Leesville Lake
  b. Contribute to the clean-up and preservation of the lake's shorelines
  c. Promote safe recreational use
  d. Improve the condition of the surrounding land as a high-quality recreational and residential area
  e. Maintain favorable water levels in Leesville Lake for the Smith Mountain Pumped Storage Hydro Project

☐ Educate to individuals, organizations, and the general public information concerning:
  a. Water quality monitoring results
  b. Management techniques and practices to preserve the environmental quality of Leesville Lake and its watersheds
  c. Safe recreational activities

d. Commercial and government activities that could harm geographic area of Leesville Lake
e. How to maintain optimum water levels in Leesville Lake

Appendix B
Water Parameter Testing Details
Oxygen

Dissolved oxygen (DO) in Leesville Lake shows a lot about the lake's metabolism. At a certain depth, the concentration of oxygen represents the temporary equilibrium between oxygen-producing processes (such as photosynthesis and aeration) and oxygen-consuming processes (such as decomposition and respiration). The amount of dissolved oxygen that lake water can retain is dependent upon the water's temperature. As temperature increases, the solubility of DO decreases. Because the solubility of gas increases in a liquid as barometric pressure increases, the amount of DO is greater at deeper parts of the lake. Lake eutrophication increases the consumption of dissolved oxygen at the bottom layer of the lake (the hypolimnion), and lowers DO concentrations (Kaulff, 2002, p. 226-236). Dissolved oxygen levels are measured in milligrams per liter (mg/L) or "percent saturation." Percent saturation of dissolved oxygen (DO%) is calculated by taking the amount of oxygen in a liter of water over the total amount of oxygen that the liter can hold.

Large amounts of decaying vegetation lower DO levels in certain areas. In addition to decreasing DO levels, the decomposing material also lowers pH by producing acids. Highly colored acids such as tannic acids, humic acids, and fulvic acids build up and color the water.

DO and percent saturation of dissolved oxygen (DO%) were measured in the field using a Hydrolab probe. Prior to sampling at Leesville Lake, the Hydrolab probe was calibrated at University of Lynchburg.

DO and DO%, along with other Hydrolab parameters, were measured near the dam, at Mile Mark 6, downstream of Toler Bridge, and near the confluence of Pigg River and the lake. Measurements were taken in milligrams per liter. Starting at the surface, readings were typically taken every half meter for 3 meters. At 3 meters and deeper, readings were taken every meter.

Temperature

Measuring temperatures at various depths indicates if the lake is stratified. Freshwater lakes typically are stratified into three zones—the hypolimnion, the epilimnion, and the metalimnion (typically called the thermocline). The hypolimnion, the deep water zone, has little turbulence and contact with the atmosphere. Its respiratory processes use organic matter from the surface layer for fuel. The uppermost layer is the epilimnion, which is turbulent and provides the energy needs of the biota's animals and microbes. In the metalimnion layer, between the hypolimnion and epilimnion, is the temperature gradient called the thermocline. The temperature difference and resulting density difference of the thermocline disrupts nutrient and gas circulation, resulting in lake stratification (Kaulff, 2002, p. 154).

Temperature was measured at the same test sites as the other Hydrolab parameters by University of Lynchburg. The Hydrolab probe measured the temperature of the lake at specific depths in degrees Celsius. Before taking readings out in the field, the temperature probe was calibrated.

pH

pH indicates the alkalinity or acidity of water. For freshwater lakes, this parameter typically lies between 6 and 8. Measuring the pH shows the softness or hardness of water and the biological activities of the water zones. At pH values below 6 and above 8, species diversity and abundance decreases, although the few remaining species can be in high abundance.

A lake's pH can change throughout the day due to photosynthesis. When phytoplankton and other aquatic plants use sunlight to synthesize energy, they remove carbon dioxide from the water and raise pH. Thus, the highest pH levels are typically found in the late afternoon while the lowest levels are found before sunrise.

pH levels can also depend on the amount of decaying vegetation. In a lake's deeper waters, decomposing plants lower pH through the production of tannic acids, humic acids and fulvic acids. These acids are colored and are characteristic of marshes and heavily-vegetated areas.

pH readings were taken by using a Quanta Hydrolab in the field at the same test sites as the other hydrolab parameters. The process for calibrating the pH probe prior to field sampling is described in the Quality Control and Quality Assurance section.

Conductivity

Conductivity shows the capacity for water to carry electrical currents. Dissolved inorganic solids that carry positive and negative charges influence conductivity. Examples of anions (negatively charged ions) include chloride, nitrate, sulfate, and phosphate; examples of cations (positively charged ions) include sodium, magnesium, calcium, iron, and aluminum. Oil, phenol, alcohol, and sugar are organic solids that remain neutral in water, and thus do not affect conductivity.

Temperature and geology are other factors that influence conductivity. As temperature increases, so does conductivity. The bedrock of the land over which water flows can affect conductivity. In areas with clay soils, conductivity is higher because the dissolved soil ionizes. Areas composed of granite bedrock do not dissolve into ionic materials, and therefore do not affect conductivity as much as areas with clay. The discharge that flows into streams has the ability to raise or lower conductivity. Sewage overflow, which contains chloride, phosphate, and nitrate ions, increases conductivity, while oil leakages lower conductivity. The measurement for conductivity is micromhos per centimeter

(⌠mhos/cm) or microsiemens per centimeter (⌠s/cm) (http://water.epa.gov/type/rsl/monitoring/).

Once established, a body of water's range of conductivity does not typically fluctuate. Noticeable differences in readings can mean that a source of discharge or pollution has entered the water.

University of Lynchburg measured conductivity with Quanta Hydrolab Monitoring Probe at the same test locations as the other Hydrolab parameters. Before sampling, the Hydrolab was calibrated. In the field, readings were taken by applying a voltage between two of the probe's electrodes in the water. The resistance of water creates a drop in voltage that the probe then uses to calculate the conductivity.

Turbidity

Turbidity focuses on levels of sediment pollution in water. Turbidity levels affect the passage of light: soil particles, algae, plankton, and microbes can block light and alter the water color. In addition to reducing light penetration, suspended particles also increase water temperatures due to their absorption of heat.

High turbidity levels also affect aquatic life by reducing photosynthesis, decreasing DO, clogging fish gills, and decreasing fish resistance to disease and growth rates. Once materials settle on the bottom of the lake or river, fish eggs and benthic macro invertebrates can be coated in sediment. According to the Environmental Protection Agency (EPA), high turbidity levels can result from soil erosion, waste discharge, urban runoff, eroding stream banks, large numbers of bottom feeders, and excessive algal growth (http://water.epa.gov/type/rsl/monitoring/). It is important to note that turbidity is a measurement often used in coordination with Secchi depth and total dissolved solid (TDS). Secchi depth, which measures a lake's transparency and clarity, is another good indicator of sediment levels. TDS measures sediment in water through filtration.

A turbidity meter was used for this parameter. Consisting of a light and a photoelectric cell, the meter measured the amount of light that was deflected at a 90-degree angle by the particles in the water sample. The units used for turbidity were nephelometric turbidity units, or NTUs.

The Hydrolab probe's transparency tube measured turbidity at the same stops as the other six Hydrolab parameters. Prior to measuring the lake's turbidity, the transparency tube in the probe was calibrated.

Oxidation-Reduction Potential

The oxidation-reduction potential (ORP), also called redox potential, of a lake defines the overall balance between oxidizing and reducing processes (Kaulff, 2002, p. 239). ORP measures the potential electrical energy of a liquid by measuring the specific electrical charges of either oxidizing or reducing agents. In water with a high pH value, there are more reducing agents (a negative ORP value), whereas in water with a low pH value, there are more oxidizing agents resulting in a positive ORP value (http://www.livingspringwaterionizer.com/water-essentials/water-ph-and-orp). Redox reactions are critical for aquatic systems: they lead to organic-matter oxidation, the recycling of nutrients, and the flow of energy from microbes to more complex organisms (Kaulff, 2002, p.246). University of Lynchburg and LLA called for the measurement of ORP in the final proposal to further understand chemical activity and developing eutrophication.

ORP is measured in millivolts (mV) by a sensor on the Hydrolab. Within the ORP sensor is a piece of platinum that built up charge without initiating any chemical reactions. This charge was then measured in comparison to the charge in the water. ORP was measured by the Hydrolab probe at three test sites by University of Lynchburg. For the lab calibration prior to field sampling, the same steps as the pH calibration were followed.

Total Phosphorus

Total phosphorus (TP) was measured to show nutrient levels in the water. TP levels were compared over time to determine if the lake had current or potential algae problems.
Phosphorus is a critical nutrient, often in short supply, for aquatic animals and plants. According to the U.S. Environmental Protection Agency, an increase in phosphorus may accelerate plant growth and algae blooms, lower dissolved oxygen, and contribute to the death of fish, invertebrates, and other aquatic animals. Phosphorus can originate from both natural and human sources such as soil and rocks, sewage, fertilizer, agricultural practices, animal manure, residential and commercial cleaning practices, and water treatment. In bodies of water, phosphorus is either organic or inorganic. Plant or animal tissue contains organic phosphate while inorganic phosphate is required by plants and used by animals (http://water.epa.gov/type/rsl/monitoring/).

Total phosphorus levels measure all forms of phosphorus, which are total orthophosphorus, total hydrolyzable phosphorus, and total organic phosphorus. Ortho phosphorus describes the plain phosphorus molecule, hydrolyzable refers to phosphorus that has undergone hydrolysis, and organic phosphorus is the phosphorus in animal or plant tissue (http://www.uga.edu/sisbl/epa-po4.html).

University of Lynchburg conducted total phosphorus testing at each test site. Leesville Lake samples were collected in labeled polyethylene bottles that had been cleaned and rinsed with tap water, soap, DI water, 10% HCl, and DI water. Samples were refrigerated until testing. At several test sites, water samples were taken at the surface and at a deeper depth.

The method for determining total phosphorus first involved digesting the sample to change all of the phosphate to orthophosphorus. Samples were then reacted with ascorbic acid to determine concentrations of both dissolved and un-dissolved ortho phosphorus. University of Lynchburg used a Systea EasyChem analyzer to test for TP in the samples. Samples were tested within 28 days of collection. Below is the Systea EasyChem method used for detecting total phosphorus.

Systea EasyChem Method
Summary:
Under this method for the determination of total phosphorus, the aqueous sample was mixed with sulfuric acid, ammonium molybdate and antimony potassium tartrate to form antimony-1, 2-phosphorous molybdenum acid. The resulting complex was then reduced by ascorbic acid to get a blue heteropoly acid (molybdenum blue). To determine the concentration of ortho-phosphate, the absorbance of the formed blue complex, was measured at 880nm.

Since only orthophosphorus formed a blue color in this test, polyphosphates (and some organic phosphorus compounds) were converted to the ortho phosphorus form by manual sulfuric acid hydrolysis. Organic phosphorus compounds were converted to the orthophosphorus form by manual persulfate digestion. The developed color was then measured automatically.

List of Chemicals:

- Ammonium Molybdate, $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$
- Ammonium Persulfate, $(NH_4)_2S_2O_8$
- Antimony Potassium Tartrate, $K(SbO)C_4H_4O_6 \cdot 3H_2O$
- Ascorbic Acid, $C_6H_8O_6$
- Isopropyl Alcohol, $(CH_3)_2CHOH$
- Phenolphthalein, $C_{20}H_{14}O_4$
- Potassium Dihydrogen Phosphate, KH_2PO_4
- Sulfuric Acid conc., H_2SO_4

Preparation of Reagents and Standards:
Stock Standards:

- 4.0g of ammonium molybdate were dissolved in 75mL DI water, and then the solution was diluted to 100mL with DI. The solution was transferred to a light-resistant polyethylene container and was stable for one month.
- 14.0mL of concentrated sulfuric acid were mixed with 70mL of DI water. The solution was diluted to 100mL with DI water and transferred to a glass container.
- 0.3g of antimony potassium tartrate were dissolved in 75mL DI water, diluted to 100mL with DI water, and transferred to a light-resistant container at 4^{o}C. The solution was stable for approximately 4 weeks.

Reagents:

- For a range up to 20mg/L, a working reagent made up of 50mL sulfuric acid stock,

5mL antimony stock, 15mL molybdate stock, and 50mL of DI water was made and transferred to an EasyChem reagent bottle.
- For the second reagent, 0.9g of ascorbic acid was dissolved in 40mL of DI water. The solution was then diluted to 100mL with DI water and transferred to an EasyChem reagent bottle.

Standards used in the digestion process:
- 15.5mL of sulfuric acid were added to 30mL of DI water. The solution was cooled, diluted to 50mL with DI water, and transferred to a glass container.
- 2.0mL of 11N sulfuric acid solution were added to 50mL of DI water and diluted to 100mL.
- 0.5g phenolphthalein were dissolved in 50mL isopropyl alcohol and 50mL DI water.

Standards:
- A phosphate stock standard of 1000mg/L was prepared by dissolving 4.395g of potassium dihydrogen phosphate in 1000mL of DI water in a 1000mL volumetric flask.
- The 100ppm and 10ppm phosphate stock standard were prepared by subsequently diluting the 1000ppm.

Dissolved Phosphorus

Dissolved phosphorus is the amount of total phosphorus that is in soluble form. This parameter indicates the amount of phosphorus immediately available for aquatic life and, just like one for total phosphate, shows potential algae growth problems.

Dissolved phosphate plays an important role in the aquatic environment. Inorganic dissolved phosphorus is consumed by plants and changed to organic phosphate as it's incorporated into the plant tissue. The organic phosphate then moves to animal tissues when aquatic animals eat the plants. Dissolved phosphate thus ends up in a continual cycle of inorganic phosphorus, organic phosphorus in plant tissue, organic phosphorus in animal tissue, and back to inorganic phosphorus once the animals die and bacteria converts the phosphorus (http://www.uga.edu/sisbl/epa-po4.html). Too much dissolved phosphorus can cause the same problems as increases in total phosphorus.

Dissolved phosphorus testing was completed for all test sites by University of Lynchburg. Leesville Lake samples were collected in labeled polyethylene bottles that had been cleaned and rinsed with tap water, soap, DI water, 10% HCl, and DI water. Samples were refrigerated until testing. At several test locations, water samples were taken at the surface and at a deeper depth.

The method for determining dissolved phosphate first involved filtering the samples to remove any suspended particles. Samples were then tested for phosphorus using the same method as total phosphorus. University of Lynchburg used a Systea EasyChem analyzer to test for dissolved phosphorus in the samples.

Nitrogen

In addition to phosphorus, nitrogen is also an important element that determines a lake's biota. Inputs of nitrogen include drainage basins and the atmosphere. The largest source of nitrogen comes from atmospheric deposits, which have doubled globally due to fossil fuel emission and other human activities (Kaulff, 2002, p. 270-271).

Excess nitrogen has detrimental effects on lake health. High nutrient levels accelerate eutrophication through algal growth. As the plants grow and decompose, the levels of dissolved oxygen (DO) in water decrease. Reduced DO levels can result in the die-off of fish, foul odors, and reduced recreational and atheistic value.

To determine nitrogen levels, University of Lynchburg tested water samples for nitrate (NO_3). Samples were collected in acid-washed, labeled polyethylene bottles, placed in a cooler with ice, and then transferred to a refrigerator upon the return to University of Lynchburg. Within 48 hours of collection, the samples were tested for NO_3 using the Systea EasyChem analyzer according to the following method.

Summary of Method:
In this method used to determine nitrate levels, nitrate was reduced to nitrite using Systea's Chemical RI. The resulting stream was treated with sulfanilamide and N-1-naptylethylenediamine dihydrochloride under acidic conditions to form a soluble dye, which was measured colormetrically at 546nm. The product was the sum of the original nitrite ion present plus the nitrite formed from nitrate. Systea has shown that, regardless of the sample matrix used, recovery of NO3 to NO2 is consistently between 95% and 105% recovery.
To determine the nitrate levels, the nitrite alone was subtracted from the total.

List of Chemicals:
Systea (1-Reagent) Nitrate Solution contained:
- Hydrochloric acid, (HCl)
- N-1-naptylethylenediamine dihydrochloride, (NEDD) $C_{12}H_{14}N_2$ 2HCl
- Sulfanilamide, $C_6H_8N_2O_2S$

Stock Standard contained:
- Potassium Nitrate, KNO_3

Preparation of Reagents and Standards:

Reagents:

- The Systea (1-Reagent) Nitrate Solution was transferred to an EasyChem reagent bottle and placed in the instrument.

Standards:
- A nitrate stock standard of 1000 mg/L was prepared by dissolving 7.218 grams of potassium nitrate in 1000 mL of DI water in a 1000mL volumetric flask.
- The 100 ppm and 10 ppm nitrate stock standard were prepared by subsequently diluting the 1000 ppm.

Summary of Run:
1. Standards and reagents were prepared by the above steps and then placed in the EasyChem instrument.
2. A standard curve for a range of 0.05-10mg/L (check) was created by the following steps:
- A 10ppm nitrate standard was placed in the instrument.
- The instrument made 5, 1, 0.5, 0.10, and 0.05ppm standards through dilutions.
- The instrument read the optical density of the calibrants. O.D. readings of a 0ppm standard and of two blanks (composed of DI water) were taken.
- A standard curve was set. The linear correlation coefficient (r^2) was always greater than 0.995.
3. The optical density of the samples was measured. By comparing the O.D. values to the standard curve set in Step 1, the concentration of nitrate in the lake samples was determined.
4. For every 10 samples, a check standard, spike, and a duplicate were included. Thus, for 40 cups of samples, there were 4 check standards of a known 10ppm nitrate solution, 4 spikes from different samples, and 4 different duplicates of lake samples. The check standards, serving as the Quality Control Samples (QCS), fell within 10% of the QCS true value.
5. The analysis ended with a blank to check the validity of the instrument's readings.

<u>Fluorescence</u>

Using a surface sample, University of Lynchburg measured fluorescence. Florescence measurements correlate with the concentration of Chlorophyll in water. University of Lynchburg field and lab verified and calibrated the barometer. A fluorescence probe connected to a monitoring screen was lowered into the water at half meter and whole meter intervals by University of Lynchburg.

<u>Integrated Chlorophyll *a*</u>

Water samples were measured for integrated Chlorophyll *a* to show the amount of productivity throughout the photic zone. Chlorophyll, a green pigment that synthesizes organic elements from sunlight in plants, is required for algal growth. Chlorophyll *a* is the most common type of pigment found in algae. High levels of Chlorophyll *a* demonstrate high algal levels (http://www.chesapeakebay.net/Chlorophylla.aspx?menuitem=14655).

University of Lynchburg took water samples at four test sites for Chlorophyll *a* testing. Water samples were collected in labeled polyethylene bottles that had been cleaned and rinsed with tap water, soap, DI water, 10% HCl, and DI water. Samples were placed in a cooler half-filled with ice at the site of the collection, and then stored in a refrigerator back at University of Lynchburg.

To determine Chlorophyll *a* levels, University of Lynchburg used the Chlorophyll *a* filtration method. Within 48 hours, the water samples were filtered through a vacuum pump. First, to prevent phytoplankton from licing to the filter, some magnesium carbonate was squirted onto a 0.45 micron 4.25 cm glass fiber filter. Then, about 150 mL or 200 mL of the lake sample was poured and drained through the filter using a vacuum pump. The filter was then folded, placed in aluminum foil, labeled, and refrigerated until it was tested.

Secchi Depth

Measured Secchi depth is one of the simplest ways to determine lake eutrophication and light transparence. The amount of nutrients in lake water determines a lake's cloudiness by accelerating the growth of phytoplankton (microscopic animals) and therefore the growth of zooplankton (microscopic animals). Inorganic solids from fertilizers, soil erosion, and sewage also increase a lake's cloudiness. Secchi disk transparency, Chlorophyll *a*, and total phosphorus together define a lake's trophic status (degree of eutrophication).

Typically Secchi depth is lowest during the spring and summer months, when water runoff and phytoplankton productivity is most vigorous. Water clarity often increases, sometimes doubling Secchi depths, during the fall and winter months. Weather is another factor: a drought will lead to increased water clarity while storms with heavy rain increase runoff and subsequently decrease Secchi depth.

A Secchi disk, consisting of a 20 cm black and white round disk attached to a line, is used to measure Secchi depth. The disk is lowered into the water until the lines separating the black and white sections on the disk are no longer distinguishable. Secchi depth is then recorded at that depth in the water column. University of Lynchburg measured Secchi depth at all of the eight stops. The rope attached to the disk was marked in meter increments. Measurements were recorded in meters and taken to the tenth decimal place. Volunteers from LLA also took Secchi depth readings on or around similar dates as University of Lynchburg.

Trophic State

Secchi depth, integrated Chlorophyll *a*, and total phosphorus (TP) are used to determine a lake's trophic status. Exposing a lake's health, a trophic state shows the lake's degree of eutrophication. There are 3 main categories under the Trophic State Index (TSI); eutrophic, mesotrophic, and oligotrophic. Eutrophic lakes are highly productive and concentrated in nutrients; mesotrophic lakes experience temperate productivity and have moderate nutrient levels; oligotrophic lakes have little productivity and low nutrient levels. When the TSI value is greater than 51, lakes are classified as eutrophic.

Water has more clarity in oligotrophic lakes rather than in eutrophic lakes due to the lower nutrient levels (http://www.rmbel.info/reports/Static/TSI.aspx).

E. coli

To determine levels of bacteria and look for health hazards, University of Lynchburg and LLA took *E. coli* readings at Leesville Lake. *Escherichia coli* (*E. coli*) is the accepted indicator organism for bacteria levels in Virginia. For the purposes of this report, *E. coli* levels are representative of coliform levels.

High levels of coliform bacteria found in lakes may point to the presence of human or animal excrement. Coliform bacteria are not harmful; however their presence shows that disease-causing bacteria or viruses may be present. Waterborne diseases such as dysentery, giardiasis, typhoid and other gastrointestinal infections can be contracted by swimming or drinking water from a lake containing human sewage. To assure the safety of water from such diseases, the water must meet the state standard for bacteria. In Virginia, the calendar-month geometric mean concentration of *E. coli* cannot exceed 126 cfu/100 mL, and no sample can exceed a concentration of 235 cfu/100mL (Virginia Tech,2006).

Conducting a fecal coliform test will show if sewage pollution is the problem. Additional tests can distinguish between human and animal sources if necessary. Nonpoint sources are the primary reason for high bacteria levels. Agriculture, land-applied animal waste, and livestock manure are the main nonpoint sources. Cattle and wildlife directly dumping feces into streams cause a large bacteria load. Nonpoint sources from residential areas include straight pipes, failing septic systems, and pet waste (Virginia Tech, 2006).

Prior to 2011, Leesville Lake Association citizen volunteers used Coliscan Easygel→ test kits for *E. coli* testing. Beginning in 2011 water samples collected by both LLA volunteers and University of Lynchburg were tested for *E. coli* with the Colilert™ test method. Samples were collected in sterile 125 ml polypropylene bottles and stored according to standard methods. A Colilert™ media packet was added to each water sample; the mixture was poured into a sterile Quanti-Tray, sealed and incubated. A color change from clear to yellow indicates a positive result for total coliform and fluorescence indicates a positive result for *E. coli*. The number of yellow and fluorescent wells are counted and the values are evaluated using a Most Probable Number (MPN) chart developed by the IDEXX Company, which developed the test method. MPN is used instead of colony forming units (cfus) and is generally considered an equivalent measure of the microbial and bacterial populations. The Colilert™ method has been rated as the "best" in agreement with a reference lab, has the lowest detection limit and the method is EPA approved for ambient water.

Zooplankton

To assess the health and structure of the lake's biological community, water samples were tested for zooplankton levels. Nutrient-rich (eutrophic) lakes, in comparison to nutrient-poor lakes have more zooplankton. As the levels of phytoplankton increase, zooplankton also increase but at a slower rate (Kaulff, 2002).

Appendix C

Quality Assurance (QA) / Quality Control (QC)

Sample Collection, Preservation, and Storage:

Leesville Lake samples were collected in labeled polyethylene bottles that had been cleaned and rinsed with tap water, soap, DI water, a 2M HCl (we used 1M HCl) acid wash and finally more DI water. Each label denoted date, location, station, and depth if relevant.

Samples were refrigerated.

For detecting nitrate, nitrite, orthophosphate, and ammonia, samples were analyzed within 48 hours of collection. For total phosphorus (TP) and Total Kjedahl nitrogen (TKN), the samples were analyzed within 28 days.

Hydrolab Calibration and Sampling post Calibration:

☐☐☐ A Hydrolab Quanta Water Quality Instrument is used for all in situ water quality measurements. Each parameter is calibrated before use according to procedures established by the manufacturer.

☐☐ The sensors were cleaned and prepared for the following parameters:

☐☐ Specific Conductance - A calibration standard was poured to within a centimeter of the top of the cup. Any bubbles within the measurement cell of the specific conductance sensor were tapped out. The conductivity of the calibration standard was 1.412.

☐☐ Dissolved Oxygen %Saturation and mg/L:

1. Cleaning and Preparation: The o-ring securing the DO membrane was removed, the old electrolyte was shaken out and the DO membrane was rinsed with fresh DO electrolyte. Fresh DO electrolyte was poured into the sensor until a meniscus of electrolyte rose above the entire electrode surface of the sensor. After checking to make sure there were no bubbles in the electrolyte, a new membrane was placed on the top of the DO sensor and secured with the o-ring. There were no wrinkles in the membrane or bubbles in the electrolyte. Excess membrane was trimmed away.
2. Calibration for DO: The Saturated Air-Method was used for the DO calibration. The Calibration cup was filled with DI water until the water was level with the o-ring. No water droplets were on the membrane. The black calibration cup cover, turned upside down, was placed on the top of the Calibration Cup. The barometric pressure, which was 762mmHg, was determined for entry as the calibration standard.

pH and ORP (Redox):

1. Cleaning and Preparation: The pH sensor was clean with a soft cloth wet with rubbing alcohol and then rinsed with DI water. The platinum band at the tip of the ORP sensor was checked for any discoloration or contamination. Then the reference sleeve was pulled away from the Transmitter and the old electrolyte from the reference sleeve was discarded. Then two KCl salt pellets (or KCl rings)

were dropped into the reference sleeve and the sleeve was refilled with reference electrolyte. With the Transmitter sensors pointed toward the floor, the full reference sleeve was pushed back onto its mount until the sleeve had just covered the first o-ring located on the mount. The Transmitter was then turned so that the sensors pointed towards the ceiling, and the sleeve was pushed the rest of the way onto its mount. The sensors were rinsed with DI water. Next, the Low-Ionic Strength Reference (LISRef) was cleaned and prepared. First the plastic LISRef soaking cap was removed and set aside. The sensor tip was then checked for any visible contamination. Following cleaning, the plastic LISRef soaking cap was filled with reference electrolyte, reinstalled over the LISRef tip, and soaked overnight. The plastic LISRef soaking cap was removed for calibration and field use.

2. Calibration for pH and ORP: A two-point calibration was used, with two pH standards. First, a pH standard of 7 was treated as the zero, and then a pH standard of 4 was treated as the slope. Both pH standards, when calibrated separately, were poured to within a centimeter of the top of the cup.

Turbidity:

1. Cleaning and Preparation: A non-abrasive, lint-free cloth was used to clean the quartz glass tube to remove any scratches that might reduce the sensors accuracy. The sensor was then rinsed with DI water.
2. Calibration for Turbidity: A Quick-Cal Cube was cleaned and dried with a non-abrasive, lint-free cloth. The cube was then placed in the turbidity sensors optical area. Turbidity analyzed and also checked at 0 with DI water.

□□□ Depth: Zero was entered for the standard at the water's surface.

□□ After all of the parameters were calibrated, the calibration cup was filled with ¼ of tap water to protect the sensors from damage and drying out during transportation to the lake and storage in University of Lynchburg.

□□□ The hydrolab was calibrated the morning of each day of lake sampling.

Post Calibration

Pre Sampling at Leesville Lake

□□ The bottled were washed according to above procedures, labeled, and placed in a milk crate. 18 bottles were taken: 3 for zooplankton, 12 for nutrients, and 3 for whole water.

□□□ The Hydrolab was calibrated and the information was recorded.

□□ An ice chest was half-filled with ice.

□□□ Batteries in the Hydrolab were checked.

□□ At the lake, the following parameters were recorded:

- o Smith Mountain Lake tailwaters: whole water for TP
- o Pigg River near its mouth: Secchi depth, TP, Hydrolab data

- Toler Bridge (after confluence with Pigg River/riverine zone): Secchi depth, TP, no Hydrolab data was taken because the flow of water was too quick
- Mile Mark 9 (mixing zone): Secchi depth, TP?
- Mile Mark 6 (end of mixing zone/beginning of lacustrine): Secchi depth, TP, hydrolab data
- Tri-County Marina: Secchi depth, TP
- Leesville Lake Marina: Secchi depth, TP
- Near dam (end point of lacustrine): Secchi depth, TP, Hydrolab data

No data for E. Coli was collected because of a lack of zithromax packs.

Nitrate Method

Summary of Method:
In this method used to determine nitrate levels, nitrate was reduced to nitrite using Systea's Chemical RI. The resulting stream was treated with sulfanilamide and N-1-naptylethylenediamine dihydrochloride under acidic conditions to form a soluble dye, which was measured colormetrically at 546nm. The product was the sum of the original nitrite ion present plus the nitrite formed from nitrate. Systea has shown that, regardless of the sample matrix used, recovery of NO3 to NO2 is consistently between 95% and 105% recovery.
To determine the nitrate levels, the nitrite alone was subtracted from the total.

Summary of Run:
1. The lake samples were chilled to about 4ºC and analyzed within 48 hours
2. Standards and reagents were prepared by the above steps and then placed in the EasyChem instrument.
3. A standard curve for a range of 0.05-10mg/L (check) was created by the following steps:

☐☐ A 10ppm nitrate standard was placed in the instrument.

Standards were prepared through dilutions at 5, 1, 0.5, 0.10, and 0.05ppm

The instrument read the optical density of the calibrants. O.D. readings of a 0ppm standard and of two blanks (composed of DI water) were taken.

☐☐ A standard curve was set. The linear correlation coefficient (r^2) was always greater than 0.995.

4. The optical density of the samples was measured. By comparing the O.D. values to the standard curve set in Step 1, the concentration of nitrate in the lake samples was determined.
5. For every 10 samples, a check standard, spike, and a duplicate were included. Thus, for 40 cups of samples, there were 4 check standards of a known 10ppm nitrate solution, 4 spikes from different samples, and 4 different duplicates of lake samples. The check standards, serving as the Quality Control Samples (QCS), fell within 10% of the QCS true value.
6. The analysis ended with a blank to check the validity of the instruments readings.

Total Phosphate Method

Summary of Method:
Under this method for the determination of total phosphate, the aqueous sample was mixed with sulfuric acid, ammonium molybdate and antimony potassium tartrate to form antimony-1, 2-phosphorous molybdenum acid. The resulting complex was then reduced by ascorbic acid to get a blue heteropoly acid (molybdenum blue). To determine the concentration of ortho-phosphate, the absorbance of the formed blue complex, was measured at 880nm.
Since only orthophosphate formed a blue color in this test, polyphosphates (and some organic
phosphorus compounds) were converted to the orthophosphate form by manual sulfuric acid hydrolysis. Organic phosphorus compounds were converted to the orthophosphate form by manual persulfate digestion. The developed color was then measured
automatically.

Summary of Run:
1. The lake samples were chilled to about 4ºC and analyzed within 48 hours
2. Standards and reagents were prepared by the above steps and then placed in the EasyChem instrument.
3. A standard curve for a range of 0-5mg/L (check) was created by the following steps:
   - □□ A 5ppm total phosphate standard was placed in the instrument.
   - □□ Standards were prepared through dilutions at 5, 2, 1, 0.5, 0.1, and 0ppm
   - □□ The instrument read the optical density of the calibrants. O.D. readings of a 0ppm standard and of two blanks (composed of DI water) were taken.
   - □□ A standard curve was set. The linear correlation coefficient (r^2) was always greater than 0.995.
4. The optical density of the samples was measured. By comparing the O.D. values to the standard curve set in Step 1, the concentration of nitrate in the lake samples was determined.
5. For every 5 samples, a blank and a duplicate were included. Halfway through the run and at the end of the run there were 2 check standards. Thus, for 40 cups of samples, there were 2 check standards of a known 1ppm phosphate solution and 2 check standards of a known 0.5ppm phosphate solution, and 8 different duplicates of lake samples. The check standards, serving as the Quality Control Samples (QCS), fell within 10% of the QCS true value.
6. The analysis ended with a blank to check the validity of the instruments readings.

Quality Assurance/Quality Control

Initial demonstration of laboratory capability was established through the following methods:

Method Detection Limit (MDL): According to the Code of Federal Regulations, the MDL is the minimum concentration that can be determined with 99% confidence that the true concentration is greater than zero. This method guarantees the ability to detect nutrient concentrations at low levels. In order to proceed with testing, the MDL in reagent water for nutrients had to be less than or equal to the concentrations in the table below. These concentrations were taken from the Ambient Water Quality Monitoring Project Plan for the Department of Environmental Quality:

Nitrate	0.04 mg/L
Nitrite	0.01 mg/L
Orthophosphate	0.01 mg/L
Total Phosphate	0.01 mg/L
Ammonia	0.04 mg/L

Initial Precision and Recovery (IPR): This practice establishes the ability to generate acceptable precision and accuracy. 4 Laboratory Control Samples (LCS) were analyzed and the average percent of recovery (X) along with the standard deviation of the percent recovery (s) for nitrate was determined. Our tested recovery did not exceed the precision limit and X did not fall outside the 90-110% range for recovery. In instances were recover was not accomplished analysis was repeated to achieve the acceptable recover limits.

Matrix spikes (MS) and matrix spike duplicate (MSD) samples were analyzed to demonstrate method accuracy and precision and to monitor matrix interferences.

Out of each set of ten samples, one sample aliquot was analyzed. First, the background concentration (B) of analyte was determined. Then the sample was spiked with the amount of analyte stock solution to produce a concentration in the sample of 1mg/L, or a concentration 1 to 5 times the background concentration. Finally, two additional sample aliquots were spiked with the spiking solution, and the concentrations after spiking (A) were measured.

The percent recovery of analyte in each aliquot was determined using the follow equation:

$$P = [100(A - B)]/T$$

The spike recovery percentage had to lie within the QC acceptance criteria of 90 to 110%. The relative percent difference between the two spiked sample results also had to be less than 20%.

Laboratory reagent water blanks were analyzed with each analytical batch to demonstrate freedom from contamination and that detected nitrate is not at a concentration greater than the MDL.

To demonstrate that the analysis system was in control, the LCS procedure was performed on an ongoing basis, with results lying within +/-10% of the true value.

Records defining the quality of data generated, including LCS data and QC charts, were maintained. A statement of laboratory data quality for each analyte, with the average percent recovery (R) and the standard deviation of the percent recovery (s_r). The accuracy as a recovery interval was expressed as $R - 3s_r$ to $R + 3s_r$.

To demonstrate that the analytical system was in control, the laboratory periodically tested an external reference sample. We have not yet conducted this analysis but will strive to this standard in 2012.

Quality Assurance (QA) / Quality Control (QC) Checklist:

General Procedures:

- Checklist of all routine material and equipment:
  Checklist should include field data sheets showing sampling sites, QA sites if QC samples are collected, containers, preservatives, and labels including QC labels
- Also a topo map, GPS unit, safety gear, and cell phone
- Print field data sheets and labels from CEDS for the run
- Clean equipment, check its condition, and charge batteries

Sampling Requirements:

- For the collection of organic materials, se non-organic or inert materials such as Teflon or stainless steel
- Water matrices: 1. Rope on spool 2. Stainless steel bucket with fitting for bacteria sample bottle 3. Syringe, filter paper, filter holder etc.

Sampling Equipment Preparation and Cleaning:

- Water Sampling Equipment:
- Daily: Rinse buckets at the end of the day with analyte free water and allow to dry; if a pump/hose was used, pump 5 gallons of analyte free water through system and allow to drain; if using Kemmerer or Alpha Bottle sampling devices, follow manufacturer’s instructions using analyte free water
- Weekly: Wash buckets with lab grade soap (Liquinox or Alconox) using a brush to remove particulate matter or surface film; rinse with tap water and then analyte free water, allow to dry
- Monthly: pump 5 gallons of a 5% solution (consists of 1 quart of vinegar mixed with 4 ¾ gallons of water) through hose and pump apparatus; pump 5 gallons of anaylte free water through hose and pump apparatus and completely drain
- Annually: replace hoses of pump and hose sampling devices
- Sample container handling and preservation:

- Refer to the DCLS laboratory catalog in CEDS for the appropriate preservation procedures. Samples not preserved properly may be rejected by DCLS.
- make sure the lids were on tight
- Sample containers should be stored with the tops fastened.
- Samples should be iced to 4°C in a cooler immediately after collection. In the cooler, samples shall be placed upright and if possible, covered with ice in such a manner that the container openings are above the level of ice. Chlorophyll a filter pad samples will be placed in appropriately sized Ziploc bags and placed on top of the layer of ice. Ziploc bags containing filters should be oriented so that the sealed opening of the Ziploc bag hangs outside the cooler lid when the lid is closed. Bacteria sample bottles should be stored in mesh bags, placed in coolers and surrounded with wet ice.
- Package glass sample containers in bubble wrap or other waterproof protective materials
- Make sure that every cooler used to ship samples to DCLS contains one temperature bottle to determine sample temp upon arrival at DCLS.
- Regional office should date boxed or packaged sample containers upon receipt and stock on shelves with the oldest dated box/packages used first.

Sample identification:

- Identify each sample by the station description, date, time, depth description, collector initials, parameter group code, sample type, container number, preservation used and volume filtered, if applicable.
- Print sample identification information on an adhesive Avery label and applied to the exterior of the container.
- Print labels for established sampling sites from CEDS

Field Sampling Procedures:

- Use protective gloves: latex or nitrile gloves may be used for common sampling conditions; disposable ones are needed for clean metal sampling
- Rinse sample equipment with sample water before taking actual sample. Dispose of rinse water away from sampling site.
- Take surface water samples facing upstream and in the center of main area of flow
- For bacteria samples, do not rinse bottle before collecting sample and always collect as a grab sample, do not composite

Sampling from a boat:

- Bacteria samples: grab from the water in direction of current, do not use a pump or hose
- Sample away from engine in direction of current (if possible)
- Clear the pump and hose using the air bubble method or calculate the clearing time

Secchi disk:

- Use disk 20 cm in diameter attached to a line/chain marked in 0.1 m increments, check these once a year

- Lower Secchi disk on shaded side of boat until black and white quadrants are no longer distinguishable
- Note the above depth, and then depth at which the quadrants are once again distinct
- Secchi depth is the average of the two depths to the closest 0.1 m

Vacuum Filtering Method (In-Line Filtering)

- Nitrogen, phosphorus, and Chlorophyll **a**
- conduct filtering as soon as possible after collection but no later than 2 hours after sample collection

Preparation:

- Muffle 25 mm diameter glass fiber filters utilized for PNC (Particulate Nitrogen and Particulate Carbon analysis),
- Acid wash the towers, graduated cylinders and plastic sample bottles
- Rinse the forceps with DI water
- Ensure proper delivery of uncontaminated, dry filter samples to DCLS.

Filtration of samples:

- Rinse acid washed and DI washed container with sample water, then fill container with enough sample water to filter more than one sample
- Rinse filtration towers and base with DI water, connect vacuum power pump to battery
- Place filters on bases, place clean NTNP bottles under PP bases, rinse graduated cylinders with sample, and transfer sample to towers
- Turn pump on
- Add $MgCO_3$ to last 25 ml of Chl a sample
- Close valves or turn off pump to remove filtration vacuum
- Bleed excess pressure off and then open vacuum valves of stacks slowly
- Rinse forceps with DI water
- Remove filters from base
- Record volume filtered
- Remove NTNP bottle from PP cylinder and cap tightly
- Label- station, date, time depth, unit code, collector's initials, group code, container #, volume of sample filtered
- Place samples on ice

Collection of samples for Chlorophyll a using syringe filtration p. 21

- Field filtration is done with positive pressure and a syringe
- Filter approx. 300 ml of site water through a 150cc polypropylene syringe

Field Quality Control Samples

- Equipment Blanks: need to be collected in field between stations, once for each 25 sites sampled, flush/rinse with analyte free water
- Field split samples: collect for each 25 sites sampled, obtain 1 bucket of water and fill 2 identical containers sequentially

Field Testing Procedures (p. 69)

pH/mV/Ion meter

- calibrate meter each day before use with minimum of 2 fresh standard buffer solutions that bracket expected pH
- check calibrations using standard buffer solutions at least once during or end of sampling and record in log sheet, if pH is off by more than 0.2 pH units, flag data collected
- check instrument at least once a month and record in log sheet

Dissolved oxygen and temperature meter

- Calibrate daily when in use, air calibration is the easiest
- Record the % saturated DO in the log sheet
- A DO% saturation confirmation needs to be performed in the middle of run
- Field probe maintenance: average life of membrane is 2-4 weeks, but may vary
- Some gases can contaminate the sensor, evidenced by discoloration of gold cathode
- Check probe performance every month when probe is in daily use
- For the DO meter, make calibration checks daily. Check calibration during sampling and at conclusion of day's sampling. Record onto log sheet; if check is off ±5%, flag data
- Monthly, place probe into a clean bucket full of analyte free or uncontaminated water, rinse BOD bottle 1 or 2 times with water, determine DO by Winkler method
- If the oxygen concentration of the air calibration disagrees with average results of Winkler value by more than 0.5 mg/l, have the electrode or meter serviced or replaced
- Check temperature probe against another multiprobe instrument's temp. probe semi-annually

DO and conductivity meter calibration checks

- Daily: check calibration during sampling and at conclusion of day's sampling, record and flag data if off by more than 5%
- Monthly: place probe in bucket of analyte free water, rinse BOD bottle with water from bucket, determine the DO by the Winkler method
- If oxygen concentration of air calibration disagrees with results of Winkler value by more than 0.5 mg/l, service or replace electrode

Thermistor Verification

- Check temperature probe against another multiprobe instrument's temperature probe semi-annually
- Check against 3 points such as an ice/water mixture, room water temperature, and warm water temperature
- Do not use thermistor if the difference is more than 0.5 degrees C

Sample Identification and Corrective Action

- Make entries in field data sheet for all field parameters
- Print label from pre-print label file in computer. Include station ID, date collected, time collected, depth, unit code, collector, group code, preservative, lab processing code, blank/dup designation, priority and container number
- Corrective Action: CAR form must be forwarded to QA officer for review and recommendations

Appendix D – Collected Data

Table 1.1. Dam (Lacustrine) Conductivity (µs/cm) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	0.173	0.161	0.162	0.172	0.174	0.182	0.176
0.5	0.173	0.159	0.164	0.172	0.174	0.182	0.176
1	0.173	0.159	0.165	0.172	0.173	0.182	0.175
1.5	0.173	0.157	0.17	0.173	0.173	0.181	0.175
2	0.173	0.158	0.171	0.175	0.173	0.181	0.175
2.5	0.173	0.159	0.173	0.176	0.174	0.181	0.175
3	0.172	0.157	0.172	0.177	0.173	0.18	0.175
4	0.171	0.158	0.173	0.176	0.175	0.18	0.174
5	0.172	0.157	0.171	0.178	0.175	0.181	0.174
6	0.171	0.154	0.17	0.177	0.176	0.181	0.174
7	0.171	0.151	0.17	0.178	0.175	0.181	0.173
8	0.17	0.152	0.168	0.178	0.176	0.181	0.173
9	0.171	0.153	0.168	0.178	0.176	0.181	0.173
10	0.17	0.154	0.167	0.177	0.176		0.173
11	0.17		0.167	0.176	0.177		
12	0.171		0.167	0.175	0.177		
13	0.171		0.166				
14	0.171		0.166				

Table 1.2. Dam (Lacustrine) Dissolved Oxygen (mg/L) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	10.3	10.4	9.68	10.1	11.04	9.48	7.17
0.5	10.3	10.2	9.72	10.19	10.8	9.48	7.06
1	10.3	10.1	9.65	10	11.8	9.41	7.03
1.5	10.3	9.8	8.79	8.78	12.4	7.9	6.5
2	10.2	9.3	8.66	7.59	12.2	7.49	6.42
2.5	10.2	9.15	8	5.86	9.72	7	6.19
3	10.2	8.4	7.92	3.68	7.5	6.52	6.19
4	10	7.33	7.62	3.6	3.6	5	6.43
5	9.4	6.58	7.5	2.2	2.2	3.64	6.1
6	9.86	6.32	6.58	2.4	2.1	2.54	6.05
7	9.78	6.89	6.29	1.52	1.43	2.08	6.04
8	9.72	7.09	5.88	1.19	1.14	1.51	5.93
9	9.54	7.08	5.46	1.07	1.04	1.57	5.92
10	9.5	7.17	5.34	0.77	0.87		5.93
11	9.5		5.07	0.53	0.07		5.97
12	9.3		4.96	0.54	0.05		
13	9		4.53				
14	8.8		4.22				

Table 1.3. Dam (Lacustrine) Temperature (°C) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	14.4	21.7	24	29.2	28.59	24.1	20.5
0.5	14.4	21.3	23.8	29.2	28.5	24.1	20.48
1	14.4	21.2	23.3	29.1	27.9	24.1	20.43
1.5	14.4	20.7	22.1	28.2	27	23.6	19.98
2	14.4	20.3	21.7	27.1	26.3	23.2	20.2
2.5	14.4	20.1	20.9	25.3	24.8	23.1	19.9
3	14.3	19.3	20.8	23.7	24.7	23.1	19.9
4	14.2	18.1	20.6	23.1	23.5	22.9	19.9
5	14.1	17	20.5	22.6	23.2	22.7	19.88
6	14.1	15.6	19.8	22.4	22.9	22.7	19.88
7	14	15	19.5	21.9	22.5	22.7	19.88
8	13.8	14.8	19.1	21.6	22	22.6	19.88
9	13.6	14.6	18.6	21.5	21.9	22.5	19.88
10	13.5	14.5	18.5	21.2	21.8		19.87
11	13.4		18	21	21.7		19.87
12	13.3		17.7	20.5	21.5		
13	13.2		17.2				
14	13.1		17				

Table 1.4. Dam (Lacustrine) Chlorophyll *a* (ppb) concentrations over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	4.6	5.7	11.1	13.9	6.5	6.7	13.7
0.5	4.4	8.1	14.6	14.4	9.8	7.2	17.4
1	5.5	11.1	15.3	14.3	14.9	8.6	17
1.5	5.9	13.1	14.7	16.1	16.5	12.1	17.9
2	5.9	15.3	15.3	14.4	19.2	13.5	16.6
2.5	6.6	15.6	13.4	12.7	26.1	12.9	15.3
3	5.9	12.5	13.9	11.6	21.7	14.2	21.1
4	5.4	8.3	13.4	6.4	18.7	12.7	18.4
5	5.2	7	13.3	4.4	13.6	9.5	16.3
6	5.1	4.9	10.2	4.3	8.7	6.4	17.8
7	5.7	4.1	9.57	3.2	6.8	5.2	18.6
8	5.2	3.5	7.56	2.7	5.9	4.5	19.8
9	5.4	3.8	7.17	2.3	4.8	4.1	18.4
10	5	3.5	5.6	2.4	5.6		16.9
11	3.9		5	2.2	4.8		17
12	4.2		4.5	2.5	5.6		
13	5.1		3.6		5.2		
14	4.4		3.7		5.2		

Table 1.5. Dam (Lacustrine) pH measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	7.4	7.4	7.9	8.1	7.9	7.59	7.25
0.5	7.3	7.5	8	8.1	8.1	7.64	7.25
1	7.3	7.5	8	8.1	8.05	7.67	7.28
1.5	7.3	7.4	7.9	8.09	8.1	7.68	7.29
2	7.3	7.45	7.95	8.06	8.13	7.6	7.29
2.5	7.2	7.42	7.92	8.01	8.06	7.58	7.3
3	7.2	7.37	7.87	8.01	7.9	7.56	7.3
4	7.2	7.3	7.8	8	7.8	7.52	7.31
5	7.2	7.27	7.77	7.9	7.7	7.47	7.33
6	7.2	7.23	7.73	7.95	7.6	7.45	7.34
7	7.1	7.22	7.72	7.97	7.5	7.43	7.345
8	7.1	7.21	7.71	7.94	7.5	7.42	7.36
9	7.1	7.21	7.71	7.93	7.5		7.37
10	7.1	7.22	7.72	7.92	7.4		7.37
11	7.1	7.24	7.74	7.89	7.4		7.38
12	7			7.88	7.4		
13	7			7.87	7.4		

Table 1.6. Dam (Lacustrine) ORP (mV) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	587	368	351	329	283	281	238
0.5	584	369	349	331	282	279	238
1	583	369	352	331	279	277	239
1.5	582	370	352	336	278	276	239
2	581	372	355	337	279	282	239
2.5	580	373	355	344	292	282	239
3	579	375	356	344	294	282	238
4	578	376	355	343	292	282	238
5	578	377	356	341	290	281	237
6	577	378	355	340	290	282	238
7	578	378	356	340	290	281	237
8	577	378	356	339	288	280	238
9	577	378	353	339	290	278	238
10	576	379	356	338	290	277	240
11	575		354	338			
12	575		356				
13	575		355				
14	575		357				

Table 1.7. Dam (lacustrine) Turbidity (NTU) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	8.7	11.7	10.9	14.8	19.1	12.1	20
0.5	9.6	11.4	12.5	16.1	20.1	12.8	18.5
1	9.9	14	13.6	15.7	20.7	11.8	19.3
1.5	9.2	13.2	18.2	15.2	19.4	13	17.4
2	9.7	16.6	14.8	15.3	19.9	12.9	18.7
2.5	10.5	12.4	15.1	14.2	20.3	11.5	19.5
3	10.1	14	14.7	13.1	20.4	11.3	19.4
4	10.6	17	17.3	16.6	17.7	11.6	17.6
5	10.7	22.3	14.5	16.1	18.9	14.2	19.6
6	10.8	27.3	14	17	18	15.5	18.9
7	12.1	38.7	14.8	14.6	20.6	17.9	19.1
8	11.2	40.4	14.1	18.2	20.5	18.5	20.5
9	11.6	41.6	19.3	19.2	22	19.3	20.3
10	11.1	45.1	16.3	20.5	22.3		20.3
11	10.4		15.2	23.8	27.3		18.9
12	10.7		15	22.7	24		19.5
13	13.5		15.5				
14	15.1		18.2				

Table 1.8. Dam (lacustrine) Nitrate (mg/L) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	0.74	0.53	0.73	0.43	0.44	1.04	1.61
0.5	0.79	0.53	0.75	0.39	0.46	1.08	1.72
1	0.8	0.55	0.70	0.41	0.52	1.08	1.81
1.5	0.8	0.58	0.84	0.44	0.57	1.1	1.96
2	0.82	0.59	0.9	0.48	0.59	1.31	2.1
2.5	0.81	0.64	0.92	0.69	0.78	1.44	2.24
3	0.84	0.73	0.99	0.85	0.96	1.56	2.23
4	0.82	0.86	0.99	1.06	1.56	1.71	2.44
5	0.80	0.94	1.06	1.19	1.76	2.04	2.64
6	0.86	1.06	1.08	1.25	2.1	2.42	2.78
7	0.82	1.14	1.11	1.42	2.41	2.76	2.85
8	0.89	1.16	1.23	1.32	2.46	2.97	3.08
9	0.83	1.17	1.27	1.34	2.59	3.34	2.98
10	0.83	1.17	1.33	1.37	2.35		3.11
11	0.87		1.42	1.41	2.37		2.96
12	0.88		1.38	1.42			
13	0.87		1.44				
14	0.87		1.48				

Mile Marker 6

Table 1.9. Mile Marker 6 (Transition) Conductivity (µs/cm) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	0.175	0.156	0.168	0.173	0.175	0.184	0.183
0.5	0.175	0.155	0.169	0.173	0.174	0.183	0.183
1	0.175	0.156	0.17	0.173	0.174	0.183	0.183
1.5	0.175	0.15	0.172	0.173	0.176	0.183	0.183
2	0.175	0.149	0.173	0.173	0.176	0.183	0.183
2.5	0.175	0.152	0.173	0.174	0.178	0.182	0.182
3	0.174	0.151	0.173	0.174	0.178	0.182	0.182
4	0.174	0.152	0.175	0.175	0.178	0.183	0.182
5	0.174	0.154	0.176	0.174	0.178	0.184	0.182
6	0.174	0.157	0.176	0.175	0.175	0.185	0.182
7	0.174	0.157	0.176			0.186	0.182
8	0.174	0.161					0.182
9	0.174						0.182
10							0.182

Table 1.10. Mile Marker 6 (Transition) Dissolved Oxygen (mg/L) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	10.14	9.63	9.63	12	10.9	9.19	7.83
0.5	10.14	9.59	9.45	11.7	11.16	9.2	7.86
1	10.1	8.85	9.23	10.8	11.3	8.39	7.3
1.5	10.17	8.83	8.77	10.5	10.4	7.96	6.83
2	10.1	8.35	8.02	10.2	10.8	8.05	6.68
2.5	10.08	8.18	7.42	8.8	7.2	7.72	6.58
3	10.1	8.07	7.28	7.4	6.7	7.61	6.56
4	10.1	7.54	7.24	6.7	4.2	7.3	6.57
5	10.05	7.63	6.57	4.9	2.5	6.87	6.56
6	10	7.13	5.8	3.2		5.88	6.52
7	10	7.24	5.87			4.3	6.56
8	10	7.21				4	6.52
9	10						6.64
10							6.9

Table 1.11. Mile Marker 6 (Transition) Temperature (°C) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	12.7	19.9	24.1	27.27	27.6	24.03	20.4
0.5	12.7	19	23.9	27.1	27.5	23.9	20.35
1	12.7	18.1	23.4	27	27.4	23.8	20
1.5	12.7	17.7	22.9	26.8	26.3	23.6	19.55
2	12.7	17.5	21.9	26.2	26.1	23.6	19.52
2.5	12.7	17.1	21.2	25.5	24.9	23.5	19.48
3	12.7	17	20.6	25	24.6	23.5	19.47
4	12.7	16.8	20.5	23.9	23.6	23.5	19.44
5	12.7	16.6	20	23.5	23.1	23.4	19.43
6	12.7	16.3	19.1			23.4	19.43
7	12.7	16	19			23.4	19.39
8	12.7	15.6				23.1	19.38
9	12.7					22.9	19.31
10						22.7	19.23

Table 1.12. Mile Marker 6 (Transition) Chlorophyll *a* (ppb) concentrations over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	2.3	4.6	14.6	53.4	9.3	15.2	14.2
0.5	3	9.4	18.5	33.3	11.4	17.1	17.1
1	4.5	11.4	31.1	21.6	16.1	21.3	17.4
1.5	6	10.5	12.8	19.9	25.1	19.3	16.5
2	6.7	7.33	9.6	17.5	27.8	19.7	13.9
2.5	6.2	5.2	9	19	18.7	18.1	16.2
3	6.6	3.8	7.7	13.7	16.8	17.1	13.4
4	7.7	3.9	7.6	12.5	10	17	13.9
5	6.5	4.1	5.6	10.6	8.1	15.4	12.3
6	7.4	3.7	4.7	7.3		13.3	14.4
7	7.9	3.4	4.9			14.4	12.9
8	7.4	3.1				13.9	13.3
9	7.3						13

Table 1.13. Mile Marker 6 (Transition) pH measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	7.2	7.74	7.73	8.23	7.9	7.5	7.5
0.5	7.18	7.76	7.76	8.26	7.9	7.5	7.5
1	7.17	7.75	7.75	8.25	8	7.6	7.5
1.5	7.17	7.73	7.74	8.24	8.1	7.59	7.49
2	7.17	7.72	7.69	8.19	8	7.6	7.49
2.5	7.17	7.7	7.65	8.15	7.9	7.59	7.49
3	7.17	7.69	7.62	8.12	7.8	7.6	7.49
4	7.17	7.7	7.6	8.1	7.7	7.6	7.5
5	7.16	7.7	7.59	8.09	7.7	7.5	7.5
6	7.16	7.69	7.58	8.08	7.6	7.5	7.52
7	7.16	7.69	7.56	8.06		7.5	7.52
8	7.15	7.69					7.54
9	7.14						

Table 1.14. Mile Marker 6 (Transition) ORP (mV) measures over study period (2025)

0	456	366	344	320	277	292	258
0.5	460	365	345	320	275	290	257
1	460	367	346	320	270	286	257
1.5	460	367	347	319	272	285	256
2	460	367	348	319	273	285	255
2.5	460	367	347	320	278	284	254
3	460	366	349	325	280	282	252
4	461	366	348	323	280	282	251
5	462	366	349	325	265	281	249
6	462	367	346	324		282	249
7	463	367	348			280	247
8	463	367					246
9	464						

Table 1.15. Mile Marker 6 (Transition) Turbidity (NTU) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	25	23.8	18.3	26.1	17.9	19.7	23.2
0.5	23.1	24	20.3	22.1	18	22.2	23.3
1	23.4	24.9	23.9	18.7	18.2	24.6	24.1
1.5	23.4	31.9	26.6	18.2	21.2	23	25.2
2	26.3	35.3	27	19.1	20.6	20.4	28.1
2.5	29.2	38.3	28.9	22.1	22.6	22.1	26.5
3	25	37.8	32	24.1	22.4	21.4	27
4	25.1	40.6	34.8	24.8	26.5	21.3	25.2
5	25.7	42.1	32.2	26.2	72	24.6	28.6
6	28.1	42.6	31.8	48		26	28.1
7	28.1	45.5	27.1			47.1	24
8	28.1	55.7				84	35.3
9	29.3						39.7

Toler Bridge

Table 1.16. Toler Bridge (Riverine) Conductivity (µs/cm) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	0.189	0.091	0.176	0.147	0.171	0.184	0.191
0.5	0.189	0.149	0.177	0.147	0.171	0.185	0.191
1	0.189	0.169	0.177	0.148	0.171	0.185	0.191
1.5	0.189	0.17	0.178	0.147	0.169	0.185	0.19
2	0.189	0.174	0.178	0.147	0.169	0.183	0.19
2.5	0.189	0.178	0.178	0.148	0.169	0.183	0.189
3	0.188	0.18	0.179	0.147	0.169	0.183	0.189
4	0.188	0.181	0.179	0.147	0.168	0.183	
5	0.188						

Table 1.17. Toler Bridge (Riverine) Dissolved Oxygen (mg/L) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	10.58	7.77	7.59	5.38	8.15	6.38	6.64
0.5	10.53	8.01	7.56	5.3	8.3	6.3	6.61
1	10.53	8.16	7.51	5.33	8.3	6.28	6.55
1.5	10.55	8.18	7.52	5.32	7.9	6.23	6.54
2	10.5	8.2	7.56	5.36	7.6	6.1	6.48
2.5	10.5	8.29	7.28	5.33	7.6	6.04	6.46
3	10.5	8.33	7.25	5.34	7.6	5.99	6.41
4	10.5	8.34	7.19	5.34	7.6	5.85	
5	10.5						

Table 1.18. Toler Bridge (Riverine) Temperature (°C) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	11.06	21.1	18.4	23.2	26.6	22.67	19.09
0.5	11	16.6	18	23.1	26.5	22.5	19.07
1	11.04	15.2	18	23.1	26.5	22.3	19.05
1.5	11	14.7	17.8	23.1	26.2	22.2	18.9
2	10.9	14.5	17.6	23.1	26.1	22.1	18.96
2.5	10.9	14.5	17.1	23.2	26.1	22.1	18.8
3	10.8	14.2	17	23.1	26.1	22.1	18.8
4	10.9	14	16.5		26.1	22	
5	10.9						

Table 1.19. Toler Bridge (Riverine) Chlorophyll *a* (ppb) concentrations over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	2.1	5	4.8	3.3	6.8	5.8	8.9
0.5	2.1	4.62	5.7	3.2	8.8	6	5.5
1	2.3	3.1	6.2	3.5	12	8.1	5.4
1.5	2.5	3	6.1	3.2	10.1	10.3	5.5
2	3.1	2.8	5.1	4.1	8.7	9.9	5.24
2.5	3.5	2.8	4.8	4.2	9	10.4	5.8
3	4.3	2.5	3.9	4.2	8.1	10.4	5.5
4	4.2	2.5	3.4	3.9	7.2	9.7	

Table 1.20. Toler Bridge (Riverine) pH measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	7.26	7.96	7.9	7.5	7.6	7.56	7.56
0.5	7.14	7.96	7.9	7.5	7.6	7.52	7.55
1	7.16	7.91	7.9	7.5	7.6	7.5	7.52
1.5	7.16	7.91	7.9	7.5	7.6	7.5	7.54
2	7.16	7.9	7.9	7.4	7.6	7.49	7.54
2.5	7.16	7.9	7.9	7.4	7.6	7.49	7.54
3	7.16	7.9	7.9	7.4	7.6	7.49	7.53
4	7.16	7.9	7.9	7.4	7.6	7.49	

Table 1.21. Toler Bridge (Riverine) ORP (mV) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	445	374	340	314	288	274	247
0.5	446	372	339	313	286	273	245
1	447	373	339	311	284	271	243
1.5	444	372	338	310	282	268	242
2	444	372	340	309	282	266	241
2.5	444	371	339	308	281	266	240
3	444	371	340	306	281	266	240
4	444	369	339	304	279	263	

Table 1.22. Toler Bridge (Riverine) Turbidity (NTU) measures over study period (2025)

Depth:	16-Apr	19-May	17-Jun	18-Jul	18-Aug	22-Sep	21-Oct
0	8.3	76.5	18.4	96.3	24.2	19.7	22.4
0.5	8.7	46	19.1	103.2	28.2	19.8	23
1	9.3	28.3	18.7	101	27.9	21.2	25.2
1.5	9.3	26.1	19.8	114	29.6	21.4	23.5
2	9.1	21.6	19.2	122	30.1	22.1	23.9
2.5	8.8	19.5	17	145	31.9	22.5	24.4
3	10	17.2	18.5	132	35.7	19.5	24.1
4	9.6	19	17.3	122	32.8	20.8	