Prepared by: EOR

For the Comfort Lake-Forest Lake Watershed District

2025 Comfort Lake-Forest Lake Watershed District Water Monitoring Report

Cover Image

Comfort Lake, 2023

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ACKNOWLEDGMENTS

Several organizations and individuals were directly involved in many aspects of this project, such as data collection and analysis, as well as technical and administrative assistance.

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EXECUTIVE SUMMARY

The Comfort Lake-Forest Lake Watershed District (CLFLWD) has a robust water quality monitoring program. Each year, surface water data (both quality and quantity) is collected throughout the District with the intent of understanding progress toward water quality goals and to guide short-term and long-term project implementation. This monitoring program is fundamental to the District's Adaptive Management approach to watershed management.

There were four types of monitoring conducted in the 2025 monitoring season (Lake Monitoring, Long-term Stream Monitoring, Diagnostic Monitoring and DIY/CAT Monitoring). There are numerous applications for surface water monitoring data, such as calibration of hydrologic and hydraulic (H&H) models, estimation of pollutant loads to key water resources, and evaluation of long-term trends in water quality.

Climate

2025 represents a near normal precipitation year characterized by seasonal variability. Total precipitation in 2025 was near the 30-year average for the area. Fewer storm events than average were noted, however these few events were of greater intensity. Precipitation was elevated in March and again during early to mid-summer, while most other months were below average. Above average March precipitation, combined with warmer winter and early spring temperatures, likely contributed to earlier snowmelt and a more concentrated spring runoff period. Wetter conditions in June and July increased summer runoff during the growing season, followed by a drier fall.

Winter and early spring were warmer than average, followed by generally average growing season temperatures and a warmer fall. This combination may have extended open water conditions and lengthened the period favorable for algae blooms and aquatic plant growth. As climate patterns continue to shift, increased seasonal variability and more frequent extremes may contribute to greater fluctuations in hydrology and water quality throughout the watershed

Lake Monitoring

In 2025, 11 lakes were monitored for surface water quality, and lake level data was collected on eight of these waterbodies. Of those lakes, six of them were also monitored for lake depth profiles, bottom ortho-phosphate to assess internal phosphorus loading, and chloride pollution. Bottom chloride samples were also collected in Comfort Lake and Little Comfort Lake to confirm profile data.

Overall, the 2025 average growing season showed an improvement in lake water quality compared to 2024. The 5-year average water quality continues to show an improvement compared to the 10-year average. Likewise, the water quality trends continue to show improvement, except in the Secchi Depth in Forest-East and Middle and chlorophyll-a concentrations in Forest Middle. Fortunately, the final alum treatment was completed on Forest Lake Middle in October 2025. Thus, the decreased load should improve water clarity and chlorophyll-a concentrations in both basins. Most of the lakes monitored in 2025 in the District received B grades. Keewahtin Lake had the best water quality with A grades across all the categories. In general, Secchi Depth produced the worst grade amongst all the lakes, except Keewahtin.

Internal loading monitoring consisted of dissolved oxygen and temperature profiles, along with bottom water orthophosphate measurements in six lakes with completed or planned alum treatments. Shields Lake and Moody Lake alum treatments continue to work. However, the hypolimnion orthophosphate concentrations have increased since 2023. Forest Lake – Middle had low bottom P concentrations throughout the stratified period. The alum treatment was conducted in September 2023 and October 2025 which reduced the hypolimnetic concentration significantly compared to pre-treatment conditions. This evidence is corroborated by sediment cores, which showed a 60% decrease in internal loading. Comfort Lake and Little Comfort Lake showed signs of increasing bottom orthophosphate concentrations, but it was not evident that this increase in orthophosphate concentration impacted surface water quality during the growing season.

Stream Monitoring

The purpose of long-term stream monitoring is to understand the status of District resources, identify changes over time, and define problems at the watershed or sub watershed level. Six long-term monitoring sites are monitored each year to track large-scale pollutant load reduction trends. There are three lake outlet sites, Bone Lake (BL2), Forest Lake (FL1), and Comfort Lake (CL1), and three lake inlet sites, Bone Lake North Inlet (BL2), Comfort Lake Inlet (CL2), and Little Comfort Lake Inlet at Itasca Avenue (LC1).

In 2025, the peak flows were observed in early spring, late June to late July and late September all sites. Peak inflows led to peaks in TP and TSS loads and corresponding peaks in in-lake concentrations, particularly in July. The loads in 2025 were less than those observed in 2024 and reflect an average year of loading compared to the most recent years of climate extremes. In general, nitrogen, orthophosphate and chloride concentrations were low throughout the monitoring season. Due to budget constraints and the robust dataset that the District has built, the long-term stream monitoring is planned to be conducted on a rotating basis going forward, instead of annually.

Diagnostic Monitoring

In 2025, diagnostic monitoring was conducted to support the Sunrise River Headwaters Project Accelerated Implementation Grant project (AIG). The results elucidate hot spots of total phosphorus loads along Sunrise River headwaters to Comfort Lake. The hot spots will be further investigated through the AIG grant with wetland sampling and potential projects will be identified.

Key findings from the diagnostic monitoring include:

- The general trend across all sites is that the water quality was the worst in late summer.
- There is a significant load reduction through Shallow Pond indicating it is acting as a phosphorus sink.
- The Bixby Park project continues to reduce loads to downstream resources.
- The wetlands and ditches in the CL4 and CL7 subwatersheds have been identified as hot spots and will be investigated further in the AIG in 2026.

DIY/CAT Monitoring

In 2025 a total of 468 water quality samples were collected from April to October over four study areas, and during 12 storm events. The 2025 CAT and DIY data indicated areas of elevated orthophosphate levels within the District. Two additional DIY study areas were added in 2025 in response to the previous year's lake monitoring data that indicated a potential decline in lake surface water quality on Shields and Moody lakes in 2024.

The main takeaways for the 2025 DIY and CAT monitoring season include:

- DIY data from 2023-2025 was used to identify one potential pond clean out project within the direct drainage network to Comfort Lake.
- There is potential loading from the agriculture areas to the southwest of Shields Lake and several wetlands (sites S-3, S-9) adjacent to a housing development in this subwatershed.
- The 2025 CAT program found several monitoring locations/subwatersheds in need of further investigation in the Forest Lake subwatershed

Recommendations

The following are recommendations for future monitoring based on 2025 monitoring results.

1. Continue monitoring the major lakes of the District using the Met Council CAMP Program. Rotate monitoring of the smaller lakes of the district as per the 10-year monitoring plan.
2. Collect bottom water samples on Little Comfort, Forest Middle , Moody, and Shields Lakes to further evaluate internal phosphorus loading.
3. Collect follow up sediment cores for Shields Lake alum treatment to evaluate effectiveness.
4. Consider diagnostic monitoring in the Shields lake subwatershed to determine possible the sources of high loading observed in DIY monitoring.
5. The 2025 results from Nielson Lake support the continued nutrient impairment and the MPCA should consider it for TMDL development.
6. Enter phase two of DIY/CAT monitoring with a focus on the micro-drainages or subwatersheds of Forest Lake and the southern drainage to Shields Lake.

1. INTRODUCTION

The Comfort Lake-Forest Lake Watershed District (CLFLWD) water quality monitoring program provides the District with an understanding the water quality of the District's water resources and guides short-term and long-term project implementation. This report summarizes the lake monitoring, long-term stream monitoring, diagnostic monitoring of the headwaters of the Sunrise River, and Do-It-Yourself (DIY) and Citizen Assisted Tributary (CAT) monitoring data that was collected in 2025. See Appendix G for an explanation of each parameter collected. This report also provides an update on lake and stream water quality trends, lake progress towards meeting the state standards and the District's water quality goals, and overall observations of the District's surface water system. Appendix A includes one-page lake factsheets highlighting individual lake characteristics, current conditions, and long-term trends.

1.1. Data collected in 2025

There were four different types of monitoring conducted in the 2025 monitoring season (Lake Monitoring, Long-term Stream Monitoring, Diagnostic Monitoring, and DIY/CAT Monitoring), which are described in Table 1. Included in Table 2 is the type of data that was collected and its purpose. Figure 1 shows the monitoring locations by monitoring type.

There are numerous applications for surface water monitoring data, such as calibration of hydrologic and hydraulic (H&H) models, estimation of pollutant loads to key water resources, assessment of the effectiveness of projects/practices implemented by the District, and evaluation of long-term trends in water quality (Table 2). The type, amount, and precision of data needed for each of these efforts may vary based on how it will be used to inform assessment and decision making. Therefore, to use District's resources efficiently, it is important to determine beforehand what monitoring data is needed and how the data will be used.

Table 1. Monitoring types for 2025

Monitoring Type	Types of data collected	Purpose
Lake Monitoring (shown in purple in Figure 1)	• Lake water elevations • Surface water quality • Dissolved Oxygen concentrations and Temperature profiles • Bottom water phosphorus concentration • Chloride	To assess progress in meeting State's standards and District's goals in lakes across the District shown in Figure 1.
Long-term Creek & Stream Monitoring (shown in orange in Figure 1, also called Legacy sites).	• Creek/stream and culverts' inlets/outlets survey elevations • Continuous water stage (water levels in the creek/stream) • Rating curves to estimate water flow rates at different water levels) • Water quality samples to determine pollutants' concentrations and loads. • Field observations about site conditions and other factors potentially affecting monitoring results.	To understand the annual loads and flows discharged from the lake management districts (LMDs) for the purpose of tracking large-scale pollutant reductions within the District.

Monitoring Type	Types of data collected	Purpose
Diagnostic Stream Monitoring	• Continuous water stage (water levels in the creek/stream/ditch) • Rating curves to estimate water flow rates at different water levels) • Water quality samples to determine pollutants' concentrations and loads • Field observations about site conditions and other factors potentially affecting monitoring	To identify possible hot spots and inform project concepts development to reduce loading to the Sunrise River and Comfort Lake.
DIY/CAT Monitoring	• Orthophosphate readings at numerous monitoring sites across the District	To gather a large amount of data to help focus and reduce diagnostic expenses with a goal of identifying cost effective water quality improvement projects.

Table 2. Uses of monitoring data

Decision tool	Description/Use
H&H Modeling	Characterizing rate and volume of runoff in a drainage area to determine where flooding issues may occur across a landscape.
Pollutant loading	Characterizing pollutants discharged from a drainage area during a specific time interval to determine the impact of a particular drainage area on downstream water resources.
Project effectiveness	Measuring flows and concentrations of pollutants at the inlet and outlet of built practices to assess the effectiveness of projects in achieving the water quality/quantity benefits for which they were designed.
Water Quality Trends	Evaluating progress in achieving State standards and District's water quality goals.
DIY/CAT Monitoring	Measuring orthophosphate as part of a volunteer assisted program that evaluates a large quantity of sites to identify phosphorus hot spots and potential sites for further diagnostic study.

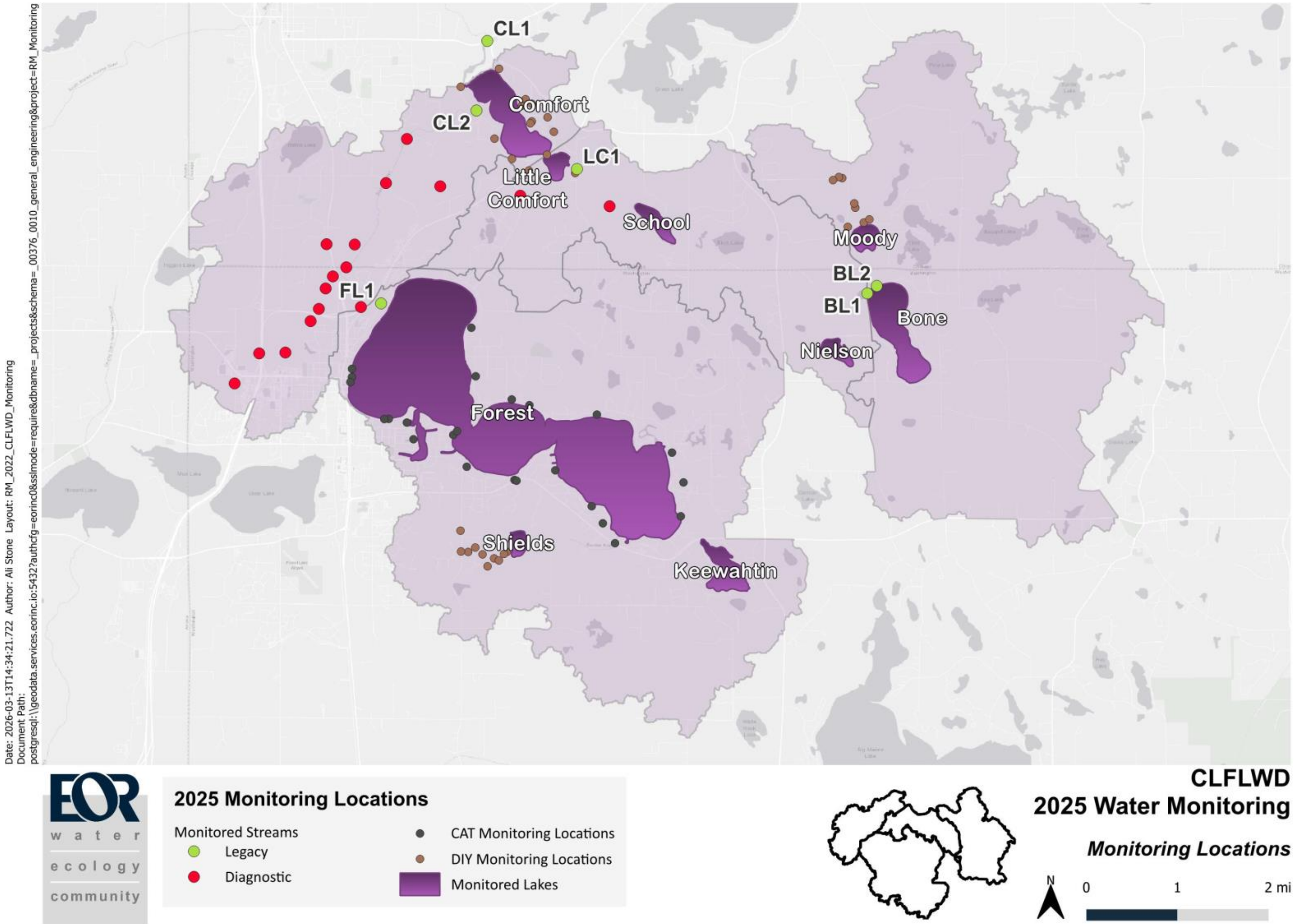


Figure 1. 2025 water monitoring locations and monitoring types in Comfort Lake Forest Lake Watershed District

1.2. 2025 climate conditions

Climate conditions are important to understand to add seasonal context to monitoring results and analysis. For instance, wet years may show higher runoff volumes and total pollutant loads may be higher than average. Conversely, dry years may show high pollutant concentrations, but lower runoff volumes may result in lower total pollutant loads. Statewide climate trends are discussed in Appendix F.

Annual precipitation in the last 20 years is summarized in Figure 2a. Monthly precipitation and temperature in 2025 are summarized in Figure 2b and compared to the 1991-2020 normal monthly precipitation and temperature based on precipitation data retrieved from the Minnesota State Climatology Office for Forest Lake, MN (at T32N, R21W, S13).

2025 represents a normal precipitation year following a wet year in 2024 and several years of generally normal to dry conditions, 2020-2023. While overall annual precipitation was not elevated, seasonal variability influenced runoff patterns throughout the year. Fewer storm events than average were noted, however these few events were of greater intensity. In 2025, precipitation levels were higher than the 1991 to 2020 averages in March, June, and July, while most other months were below average. The wetter conditions in March and early summer contributed to periods of increased runoff during the spring transition and growing season. Late summer and fall conditions were generally drier than normal.

March was warmer than average, followed by generally average growing season temperatures leading into a warmer fall (Figure 2). This extends the conditions for primary productivity within the watershed, resulting in longer periods favorable for algae blooms or aquatic plant growth.

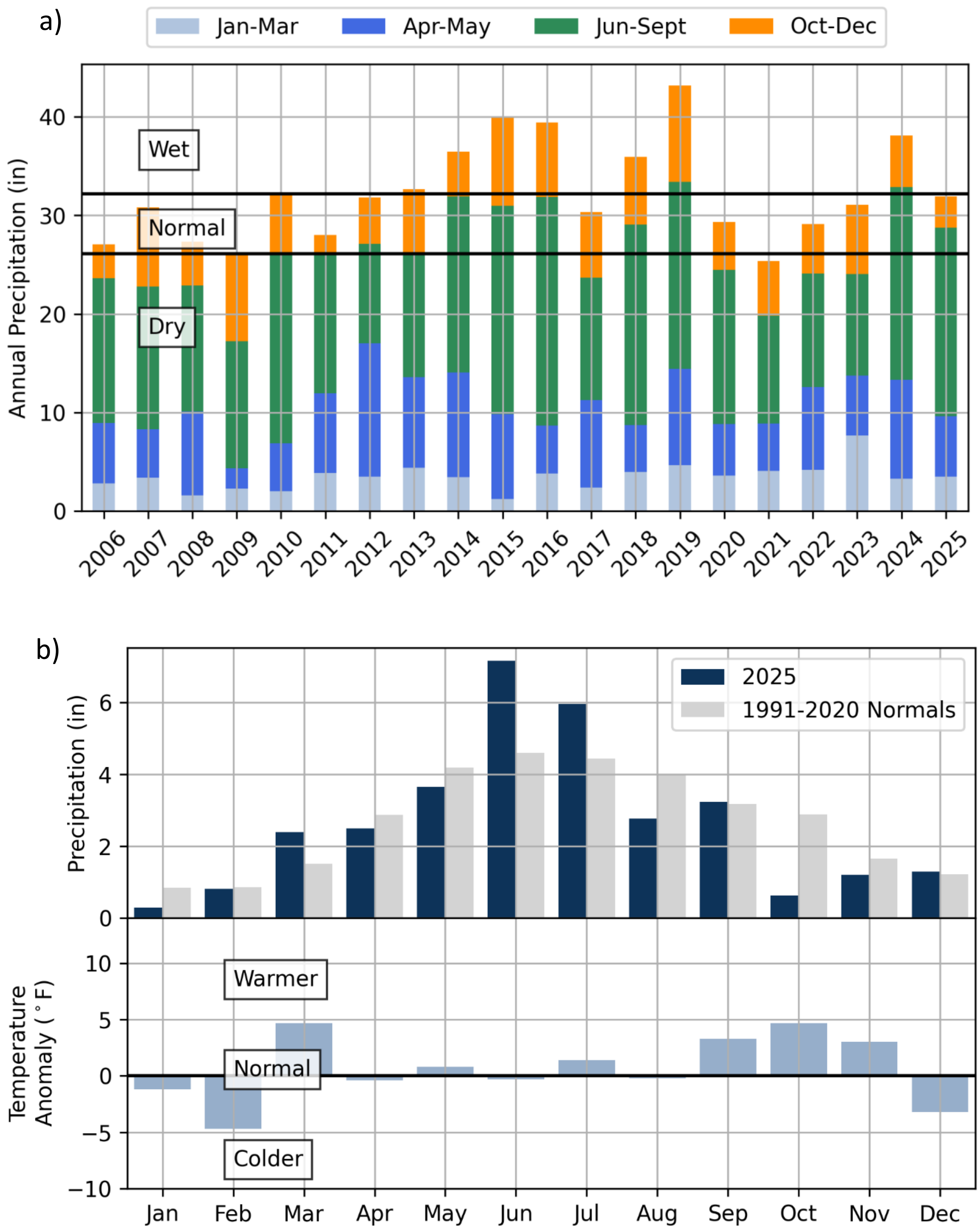


Figure 2. a) Annual precipitation summaries for 2005-2025 for Forest Lake at Township 32N, Range 21W, Section 13 b) 2025 monthly precipitation and temperature for Forest Lake at Township 32N, Range 21W, Section 13

2. LAKE MONITORING

The District's Lake monitoring program is broken down into five primary categories that include sentinel monitoring, routine monitoring, rotational monitoring, limited monitoring, and internal load monitoring. A description of these is shown in Table 3 below.

Table 3. 2022-2031 Lake monitoring recommendations

Monitoring Type	Description	Applicable District lakes
Sentinel monitoring	Surface water monitoring (total phosphorus, chlorophyl-a, Secchi Depth) 14 times a year, every year. Using the CAMP protocol and volunteers in some instances.	Moody, Bone, Forest, and Shields, Little Comfort, and Comfort
Routine monitoring	Surface water monitoring seven times a year, for two consecutive years every five years	School, Keewahtin,
Rotational monitoring	Surface water monitoring seven times a year, for two consecutive years every ten years	Lendt, Second, Third, Twin, Elwell, Heims Birch, and Nielson
Limited monitoring	No specified parameters or frequency of collection	Cranberry (limited access), Fourth (wetland), Clear, First, and Sea
Internal loading monitoring	Dissolved oxygen and temperature profiles, and fourteen bottom water phosphorus measurements	Lakes with completed or planned alum treatments

2.1. Lake Monitoring Summary

In 2025, eleven lakes were monitored for surface water quality (CAMP protocol), and lake level elevation data was collected on eight of these waterbodies. Of those lakes, six of them were also monitored for lake depth profiles, bottom ortho-phosphate (orthoP) to assess internal phosphorus (P) loading, and chloride pollution. The lakes and the respective parameters that were collected for each are shown in Table 4.

Table 4. Lakes monitored in the 2025 monitoring season and the respective parameters collected.

Lake	DNR ID	Monitoring type	Surface WQ (CAMP)	Lake Levels	Dissolved Oxygen, Chloride and Temp Profiles	Bottom orthoP	Bottom Chloride
Bone	82005400	Sentinel	X	X			
Comfort	13005300	Sentinel, internal loading	X	X	X	X	X
Forest (West)	82015900	Sentinel	X	X			
Forest (Middle)	82015900	Sentinel, internal loading	X	X	X	X	

Lake	DNR ID	Monitoring type	Surface WQ (CAMP)	Lake Levels	Dissolved Oxygen, Chloride and Temp Profiles	Bottom orthoP	Bottom Chloride
Forest (East)	82015900	Sentinel, internal loading	X	X	X	X	
Moody	13002300	Sentinel, internal loading	X	X	X	X	
Little Comfort	13005400	Sentinel, internal loading	X	X	X	X	X
Shields	82016200	Sentinel, internal loading	X	X	X	X	
Keewahtin	82008000	Routine	X	X			
School	13005700	Routine	X	X			
Nielson	82005500	Rotational	X		X	X	

2.1.1. Water Quality Methods

Lake surface water quality is sampled for total phosphorus (TP), chlorophyll-a, Total Kjeldahl Nitrogen (TKN) and Secchi depth transparency using the MN Metropolitan Council CAMP protocol. TP and TKN represent the amount of nutrients in a lake that fuel algae growth. Phosphorus and Nitrogen sources include soil erosion, stormwater runoff, leaf litter and other organic materials, manure runoff and wastewater (including septic tanks). Chlorophyll-a represents the number of algae in the surface water. Algae blooms reduce water clarity (as measured by Secchi depth) and can cause unpleasant odors. They can also use dissolved oxygen in the lake which is critical for fish and reduced aquatic plant growth that supports important habitat for fish and aquatic invertebrates. Secchi transparency depth is a measure of water clarity and is measured by lowering a Secchi disk in the lake. The depth at which the Secchi disk is still visible is the Secchi depth. More algae in the water results in more turbidity or cloudiness of the water and lower (shallower) Secchi depth; less algae in the water results in clearer water and higher (deeper) Secchi depth.

The federal Clean Water Act requires states to develop water quality standards to protect each lake. The Minnesota Pollution Control Agency (PCA) recognized the difference in natural nutrient dynamics between shallow lakes and deep lakes and, therefore, there are different standards for shallow and deep lakes (Table 5). All State water quality standards are based on growing season (June-September) averages.

The District established District water quality goals in the 2022-2031 Watershed Management Plan. The District bases its water quality goals on historic data, collecting lake sediment cores, in order to determine the predevelopment water quality level which each lake can sustain in the long-term. In many cases, the District goal exceeds the minimum state water quality standards. Note that the TP and Secchi District goals are based on scientifically based relationships between lake clarity responses to TP concentrations (Table 5).

Table 5: Lake Water Quality State Standard and District Goal Summary

<table>
<tr><th></th><th>State TP Standard</th><th>District TP Goal</th><th>Chl-a Standard</th><th>State Secchi Standard</th><th>District Secchi Goal</th></tr>
<tr><td colspan="5">DEEP LAKES</td><td></td></tr>
<tr><td>Keewahtin</td><td rowspan="6">40</td><td>20</td><td rowspan="6">14</td><td rowspan="6">4.6</td><td>10</td></tr>
<tr><td>Comfort *</td><td rowspan="4">30</td><td rowspan="4">7</td></tr>
<tr><td>Bone</td></tr>
<tr><td>Forest</td></tr>
<tr><td>Little Comfort *</td></tr>
<tr><td>Moody *</td><td>40</td><td>4.6</td></tr>
<tr><td colspan="5">SHALLOW LAKES</td><td></td></tr>
<tr><td>Nielson***</td><td rowspan="3">60</td><td rowspan="3">60</td><td rowspan="3">20</td><td rowspan="3">3.3</td><td rowspan="3">3.3</td></tr>
<tr><td>School *</td></tr>
<tr><td>Shields *</td></tr>
</table>

*** =** Impaired, included in the 2010 Six Lakes TMDL Study

**** =** Impaired, included in the 2014 Sunrise River Watershed TMDL Study but no data collected within the last 10-years

*****=**Impaired with no TMDL Study

Lake names in bold = Lakes that have been assigned goals different from State Water Quality Standards

= meets Standard; ## = does not meet Standard

Lake grades were assigned to each lake in 2025 and for the average of the last five years (2021-2025) for total phosphorus, chlorophyll-a, Secchi depth, and overall lake water quality (the average of the TP, Chlorophyll-a and Secchi grades). Lake grades followed the Met Council water quality grading system developed in 1989 (Table 6).

The Met Council's Lake Grading System is as follows:

- A = No impairment
- B = Some impairment
- C = Impaired
- D = Severely impaired
- F = Total impairment

Table 6. Metropolitan Council Lake Water Quality Grading System

Grade	Total Phosphorus (TP), µg/L	Chlorophyll-a (Chl.-a), µg/L	Secchi depth (ft)
A	<23	<10	>9.8
B	23-32	10-20	7.2-9.8
C	32-68	20-48	3.9-7.2
D	68-152	48-77	2.3-3.9
F	>152	>77	<2.3

2.2. Results

The results from the 2025 lake monitoring effort are presented below by topic. To view the full results of the lake monitoring effort by lake for 2025, see Appendix A. The historic lake water quality time series are in Appendix B. The chloride data is included in Appendix C.

2.2.1. Surface Water Quality

State Water Quality Standards-10 Year Average

Table 7 shows the standards and the level of compliance of all the District's lakes. The 10-year average water quality parameters are based on the summertime (June-September) averages for each of the ten most recently-monitored years are compared to the state standards. Lakes meeting all State Lake Water Quality Standards over a 10-year average are: Keewahtin Lake, Bone, Forest West and Comfort Lake. Lakes meeting two of the three State Lake Water Quality Standards over a 10-year average are: Forest Lake Middle and East, and School Lake. Finally, Little Comfort Lake and Shields Lake are meeting one of the three State Lake Water Quality Standards over a 10-year average. Moody Lake and Nielson are not meeting any of the 10-year average lake water quality standards. However, more recent monitoring indicates an improving WQ trends on several of these lakes despite not meeting the 10-year average standards (Shields and Moody lakes, see Lake Water Quality Trends section).

Table 7. Progress towards state water quality standards

Lakes (In order of increasing TP)	Total Phosphorus (µg/L)		Chlorophyll-a (µg/L)		Secchi (feet)	
	2016 -2025 Average	Years of Data (N)	2016 - 2025 Average	Years of Data (N)	2016 - 2025 Average	Years of Data (N)
GENERAL LAKES						
Bone	**26.4**	10	**13.9**	10	**6.1**	10
Comfort *	**28.1**	10	**11.9**	10	**5.9**	10
Forest (W)	**26.5**	10	**9.8**	10	**5.9**	10
Forest (M)	**33.5**	10	**14.8**	10	**6.4**	10
Forest (E)	**31.9**	10	**17.2**	10	**6.8**	10
Keewahtin	**14.2**	10	**2.5**	10	**15.1**	10
Little Comfort *	**40.6**	10	**15.7**	10	**5.8**	10
Moody *	**58.3**	10	**30.3**	10	**4**	10
SHALLOW LAKES						
Nielson***	**87.8**	4	**72**	4	**1.3**	4
School *	**43.7**	8	**20.8**	8	**4.9**	8
Shields *	**102.6**	10	**35.9**	10	**4.3**	10

***** = Impaired, included in the 2010 Six Lakes TMDL Study

****** = Impaired, included in the 2014 Sunrise River Watershed TMDL Study but no data collected within the last 10-years

*******=Impaired with no TMDL Study

Lake names in bold = Lakes that have been assigned goals different from State Water Quality Standards

= meets Standard; ## = does not meet Standard

District Water Quality Goals

This section outlines progress of lakes towards achieving their respective District goals included in the 2022-2031 Watershed Management Plan. These comparisons are used to help show incremental progress toward achieving District goals and are used to set priorities for implementation within the District. 5-year average phosphorus concentration and Secchi depth are based on the summertime (June-September) averages for each of the five most recently-monitored years. While state standards are compared to the most recent 10-year summer average, District goals compare the most recent 5-year summer average, which is a stricter measure.

Lakes meeting the 2031 District TP goals over a 5-year average include: Keewahtin Lake, Bone Lake, Forest Lake, Comfort Lake, Shields Lake, and School Lake (Table 8). Lakes not meeting 2031 District TP goals are Moody, and Little Comfort Lake (Table 8).

Lakes meeting the 2040 District Secchi Depth goals (last column in Table 8) over a 5-year average include: Keewahtin Lake, School Lake, Moody Lake and Shields Lake. Lakes not meeting 2040 District Secchi Depth goals include Little Comfort Lake, Forest Lake, Comfort Lake, and Bone Lake. Secchi depth District goals are stricter for these lakes compared to School Lake, Moody Lake, and Shields Lake (Table 5).

It is important to note that 2024 and 2025 are the only years of data from 2021-2025 for Nielson Lake, thus the 2-year average is reported. Nielson Lake is not meeting District goals for either TP or Secchi.

Table 8. TP and Secchi Depth 5-Year Average and progress to pre-development conditions (2031 goals)

Lake	Total Phosphorus		Secchi Depth	
	Existing 5-year Average TP (2021-2025) (µg/L)	Years of Data (N)	Existing 5-year Average Secchi Depth (2021-2025) (ft)	Years of Data (N)
Bone	**24**	5	**6.9**	5
Comfort	**24.6**	5	**6.2**	5
Forest (W)	**23.8**	5	**6.4**	5
Forest (M)	**27.7**	5	**6.1**	5
Forest (E)	**30**	5	**6.2**	5
Forest Lake	**27.1**	5	**6.2**	5
Keewahtin	**11.6**	5	**15.2**	5
Little Comfort	**34.5**	5	**6.9**	5
Moody	**42.2**	5	**5.5**	5
Nielson	**81.1**	2	**1.6**	2
School	**39.3**	5	**5.9**	5
Shields	**56.1**	5	**6**	5

N = number of years data has been collected within the 2021-2025 period.

= meets goal; ## = does not meet goal

Lake Grades

Most of the lakes monitored in 2025 in the District received B grades using Met Council's Lake Grading System (Table 9). Keewahtin Lake had the best water quality with A grades across all the categories. In general, Secchi Depth produced the worst grade amongst all lakes, except Keewahtin. The overall lake grades for 2025 were similar compared to the five-year average. Nielson Lake had the worst water quality with a D/F grade.

Table 9. CLFLWD Lake Water Quality Grades for 2025 and most recent 5-year average (2020-2025)

Lake	DNR ID	Acres	TP		Chl.-a		Secchi		Overall	
			2025	5-yr Avg	2025	5-yr Avg	2025	5-yr Avg	2025	5-yr Avg
Bone	82-0054-00	221	A	B	B	B	B	C	B+	B-
Comfort	13-0053-00	218	B	B	B	A	C	C	B-	B
Forest (West)	82-0156-00	1,086	B	B	B	A	C	C	B-	B
Forest (Middle)	82-0156-00	364	B	B	B	B	C	C	B-	B-
Forest (East)	82-0156-00	790	B	B	B	B	C	C	B-	B-
Forest (All Basins)	*82-0156-00*	*2,240*	B	B	B	B	C	C	B-	B-
Keewahtin	82-0080-00	75	A	A	A	A	A	A	A	A
Little Comfort	13-0054-00	36	C	C	B	A	C	C	C+	B-
Moody	13-0023-00	45	C	C	B	B	C	C	C+	C+
Nielson	82-0055-00	37	D	D	D	D	F	F	D-	D-
School	13-0057-00	47	C	C	B	B	C	C	C+	C+
Shields	82-0162-00	30	D	C	D	B	C	C	D+	C+

A: No impairment blue, **B:** Some impairment green, **C:** Is impaired yellow, **D:** Severely impaired orange, **F:** Total impairment red

Lake Water Quality Trends

Long-term lake water quality trends were calculated using Kendall's Tau statistical analysis which essentially reports how consistently a water quality parameter increases or decreases over time. Kendall's Tau for short-term period (since 2016) and long-term period (for the entire monitoring period, beginning with the earliest available year) were determined for each lake. Monitoring data available from the MPCA EDA Surface Water Database was used in the analysis. Many lakes had large gaps in their monitoring records and therefore, only short-term trends could be determined, as noted in Table 10 below.

- **No trend** indicates the water quality parameter is not consistently increasing or decreasing from year to year over the time-period AND that this is a statistically significant "no change".
- **Improving** or **declining** trends mean the water quality parameter is consistently increasing or decreasing from year to year over the time-period but NOT in a statistically significant way.
- **Significantly improving** or **significantly declining** means that the water quality parameter is consistently increasing or decreasing from year to year over the time-period AND does that in a statistically significant way. The percentage change in the parameter over the entire time-period is reported for statistically significant trends.
- **NA** means that there was insufficient data to determine a statistical trend. At least 4 samples must be collected per year to be included in the trend analysis, and at least 75% of all years in the total period of record have at least 4 samples collected per year. Ten lakes do not have enough monitoring data to determine long-term trends in water quality.

Lake water quality trends are shown in Table 10 for those lakes with sufficient data to calculate trends. Overall, most District lakes have improving trends in lake water quality. Despite the decline in water quality in 2024, these improving trends demonstrate the long-term benefits of water quality improvement projects. Forest Lake-East and Forest Lake-Middle are exhibiting declining Secchi depth trends but not significantly. Fortunately, the final alum treatment was completed on Forest Lake Middle in October 2025 and thus should show improvements in water clarity in both basins due to decreased load. It is important to note that although Shields experienced low water quality in 2024 and 2025, the good water quality observed in 2020-2023 are driving the long term improvement trends.

Table 10. Lake Water Quality Trends

Lake	Total Phosphorus Trend	Chlorophyll-a Trend	Secchi Disk Trend
Bone	Improving	**Significantly Improving**	**Significantly Improving**
Comfort	**Improving**	**Improving**	**Improving**
Forest – West	**Significantly Improving**	**Significantly Improving**	**Improving**
Forest – Middle	Significantly Improving	Declining	Declining
Forest – East	Improving	Improving	Declining
Keewahtin	**Significantly Improving**	**Improving**	**Improving**
Little Comfort	Improving	Improving	Improving
Moody	**Significantly Improving**	**Significantly Improving**	**Significantly Improving**
School	Improving	Improving	Improving
Shields	**Significantly Improving**	**Improving**	Improving

Short-term trends are noted for the most recent 10-years (since 2016)

Long-term trends are noted for the period of record for each lake, with the earliest year noted.
Red represents a short term declining trend that is not statistically significant
Green represents a short term improving trend that is not statistically significant
Green represents a long term improving trend that is not statistically significant
Blue represents a short term improving trend that is statistically significant
Blue represents a long term improving trend that is statistically significant

2.2.2. Internal Loading

Internal loading monitoring of dissolved oxygen, temperature profiles, and bottom water phosphorus measurements took place in six lakes with completed or planned alum treatments. See Appendix A for temperature, dissolved oxygen profiles and bottom orthoP concentrations. Some important general observations regarding internal loading include:

- Seasonal increases in orthophosphate can be measured in the hypolimnion (bottom water) while the water column is stratified.
- The lake's physical characteristics and morphology are also important factors for internal loading: including a) mixing conditions and b) diffusion across the thermocline.

The seasonal increase in bottom water phosphorus levels is driven by extended periods of temperature stratification and anoxic conditions. The phosphorus that is bound to iron (and other metals) in the sediments is released and stays dissolved in the lower layers of the lake over the summer. Phosphorus accumulation at the bottom waters is called "internal loading". The mixing influence is the release of phosphorus from the bottom layers to the lake's surface. This influence is most notable after severe storm events and winds that mix the lake waters. In the Fall, when lake temperature stratification weakens due to reduced ambient temperatures, the surface and bottom waters mix (the lake "turns over"). If a significant accumulation of phosphorus in the lower layers mixes when the lake turns over, it will be transferred to the surface waters, impacting water quality.

Summary of Internal Loading Findings, Table 11:

1. Comfort Lake and Little Comfort Lake showed signs of increasing bottom P concentrations, but this increased P concentration was not enough to impact surface water quality in either lake in 2025.
2. Forest Lake – Middle had low bottom P concentrations throughout the stratified period. The alum treatments were conducted in September 2023 and October 2025 which reduced the hypolimnetic concentration significantly compared to pre-treatment conditions.
    a. The sediment cores collected in 2025 showed a 60% decrease in the orthoP release rate compared to the pre-treatment conditions, which is meeting if not exceeding performance expectations for the first half of the alum treatment.
3. Forest Lake – East had high bottom P concentrations by August.
    a. In late July, there was a turnover event (driven by fall storms) which mixed orthophosphate concentrations from the bottom of the lake to the surface and contributed to the surface water TP, However there was already seasonal increases in TP in the surface layer from external sources at the time of mixing thus the contribution of the internal load was difficult to resolve.
4. Shields Lake alum treatment continues to work but the effectiveness seems to be waning.
    a. The hypolimnion orthophosphate concentrations have increased from a maximum of 40 µg/L in 2023 to a maximum of 1,390 µg/L in 2025.
    b. The high growing season average is not driven by the internal load as the lake was stratified throughout the growing season.
    c. Shields Lake should continue to be monitored for signs of internal loading to see if the trend in increases is continuing and by how much. Sediment core data would also elucidate any changes to the alum treatment effectiveness and sediment core collection should be considered. The concern is that the longevity of the alum treatment may have been shortened due to high runoff bringing in excess sediments or other lake conditions.
5. Moody Lake alum treatments continue to work.
    a. However, Moody Lake's hypolimnion orthophosphate concentrations have increased from 60 µg/L in 2022 to 200 µg/L in 2023 to 460 µg/L in 2025. The concentrations are similar to those observed in 2024. This is still less than the pre-treatment concentrations which had a maximum TP concentration of~2,000 µg/L.
    b. Similar to Shields Lake, Moody lake should continue to be monitored for signs of internal loading to see if the increasing trend continues and by how much. Sediment core data would also elucidate any changes to the alum treatment effectiveness and sediment core collection should be considered. The concern is that the longevity of the alum treatment may have been shortened due to high runoff bringing in excess sediments or other lake conditions.
6. Nielson Lake does not show high concentrations of P or significant accumulation of P in the bottom layers of the lake. Thus, internal load control is not recommended at this time.

Table 11. Internal Loading Results

Lake	Alum Treatment	Seasonal Increase**	Mixing Influence***
Comfort Lake	Potential (but not currently recommended)	Yes	No
Forest Lake - Middle	2023 and 2025	Yes	No
Forest Lake -East	Potential (but not currently recommended)	Yes	Yes
Little Comfort Lake	Potential (but not currently recommended)	Yes	No
Moody Lake	2018/2019	Yes	No
Shields Lake	2019/2020	Yes	No
Nielson	Not recommended	No	No

** Seasonal increase is an increase in the orthoP in the hypolimnion during a stratified period.

*** Mixing Influence is identified as a noticeable increase in surface TP after fall turnover or another mixing event

2.2.3. 2025 Seasonal Water Quality Trends

Seasonal water quality trend data is available in Appendix A. Overall, there was an improvement in water quality in the 2025 monitoring season compared to 2024. Winter and spring 2025 were warmer than average followed by an average growing season leading into a warmer fall. This extends the ideal conditions for algae blooms or aquatic plants. In Little Comfort, Shields, Moody, and School there is a TP peak observed in July. The magnitude of the peak is different depending on the lake. In Comfort Lake, Bone Lake and Forest Lake there is no significant July peak, only the smaller peak at the end of the growing season. The July peaks are likely due to the wet June and July and the late season peak is driven by smaller storms. The influence of the wet June and July was more prevalent in lakes with smaller surface area (Little Comfort, Moody, and Shields) and to a lesser extent for the larger lakes (Comfort and Bone and Forrest), likely due to dilution into the higher volume lakes.

2.2.4. Chloride

The 2025 chloride profiles are shown in Appendix C. Chloride Impairment is defined as chloride concentrations above the State Standard of 230 mg/L for four days or 860 mg/L for one measurement. All of the lakes that were monitored exhibited chloride levels below 230 mg/L. In 2023, high concentrations were reported by the chloride profiles measured by the sonde. EOR recommended collecting grab samples in the hypolimnion of Little Comfort and Comfort Lake to confirm the high concentrations. The grab samples were all well below the state standard and thus there is no need for a chloride diagnostic study at this time. The chloride grab samples were consistently low throughout the season at approximately 37 mg/L and 29 mg/L in Comfort Lake and Little Comfort Lake respectively. The 2023 exceedances were likely due to interference with the chloride sensor which gave falsely elevated concentrations. 2024 and 2025 data demonstrate there are no elevated chloride concentrations in the observed lakes, thus chloride grab samples are not recommended for 2026 and can resume on five-year cycle.

2.3. Conclusions and Recommendations

Table 12 shows conclusions specific to each of the District's lakes monitored in 2025. These conclusions are based on 5-year averages meeting state and District standard, comparison between the 5 and 10-year WQ results, and the status of 2025 WQ meeting state standards.

The lake monitoring conclusions are summarized below, Table 12:

1. All of the lakes were meeting the state standard for the 5-year average for at least one of the water quality parameters, except Nielson.
2. Bone, Comfort, Forest Lake-West, Forest Lake-Middle, Little Comfort, Keewahtin, School, and Shields were meeting the standards for all of the parameters. School, Shields, and Keewahtin are meeting the District Goals for the 5 year average.
3. All of the lakes show an equal or improvement in water quality when comparing the 5-year average and the 10-year average. Keewahtin, Forest Lake-East and Middle showed similar results from the 5-year and 10-year averages.
4. Bone Lake, Forest Lake-West, Keewahtin, Little Comfort Lake, and School Lake are meeting all water quality standards.
5. Comfort Lake, Moody, and Forest Lake – East are meeting two of the water quality standards and are within a within 1 µg/L of meeting the other standards.
6. Forest Lake-Middle is only meeting the TP standard but with the alum treatment in late fall 2025, Secchi and chl-a concentrations should improve in the future.
7. Shields Lake was only meeting Secchi standards in 2025.

Table 12: Lake Monitoring Conclusion Summary

Lake	5-year WQ Average Meeting State Standards	5-year WQ Average Meeting District Standards	5-year WQ Average vs 10-year Average	2025 WQ Meeting State Standards
Bone*	✓	*TP and Chlorophyll-a*	*Improved*	✓
Comfort*	✓	*Chlorophyll-a*	*Improved*	*TP and Secchi*
Forest Lake – West*	✓	*TP and Chlorophyll-a*	*Improved*	✓
Forest Lake – Middle*	✓	*TP and Chlorophyll-a*	*Unchanged*	*TP*
Forest Lake – East*	*TP and Secchi*	*TP*	*Unchanged*	*TP and Secchi*
Keewahtin	✓	✓	*Unchanged*	✓
Little Comfort*	✓	*Chlorophyll-a*	*Improved*	✓
Moody*	*Chlorophyll-a and Secchi*	*Chlorophyll-a and Secchi*	*Improved*	*Chlorophyll-a and Secchi*
Nielson	x	x	*Improved*	x
School*	✓	✓	*Improved*	✓
Shields*	✓	✓	*Improved*	*Secchi*

✓ = meets all Standards; **x** = does not meet Standard; **n/a** = insufficient data

*If not all three WQ are meeting standards or goals, those meeting the standard are specified in the table.

The following future monitoring is recommended based on the 2025 data:

1. Continued hypolimnion orthoP monitoring is recommended to continue, specifically:
   - Little Comfort Lake showed signs of increasing bottom orthoP concentrations and should continue to be monitored for internal loading parameters to inform potential future internal loading management.
   - Forest Lake – Middle
     - Forest Lake – Middle received an alum treatment in Fall of 2023 and Fall of 2025.
   - Moody Lake and Shields Lake
     - The alum treatment is still effective in reducing internal loading in the lake compared to pre-treatment conditions; however, hypolimnetic orthoP concentrations have increased compared to previous years. Additional years of orthoP data will elucidate the response to the alum treatment and the expected longevity.
     - Follow-up sediment coring is recommended to evaluate the effectiveness of the alum treatment.

3. STREAM MONITORING

Streams are assessed by the Minnesota Pollution Control Agency (MPCA) for their ability to support aquatic life and aquatic recreation designated uses. Those designated uses are:

- Protection of "aquatic life" means protection of the aquatic community from the direct harmful effects of toxic substances, and protection of human and wildlife consumers of fish or other aquatic organisms.
- Protection of "aquatic recreation" means protection of the ability to recreate on and in Minnesota's waters.

CLFLWD streams are Class 2B Waters, according to MPCA standards (Minn. R. 7050.0222). These types of streams are described as cool- and warm-water fisheries (not protected for drinking water). Class 2B Water Quality Standards are shown in Table 13.

Table 13. MPCA Class 2B Water Quality Standards

Parameter	Class 2B Waters Standard
Chloride (Chronic)	< 230 mg/L
Low Dissolved Oxygen (DO)	> 5 mg/L as daily minimum
pH	> 6.5 and < 8.5
Total Suspended Solids (TSS)	< 30 mg/L*
Total Phosphorus (TP)	< 100 µg/L**

***** May be exceeded no more than 10% of the time (Apr. 1-Sept. 30)

****** June-September 10-year average

3.1. Purpose of collecting stream data

Multiple water quality parameters were monitored and analyzed at each stream site in 2025. The purpose of this monitoring was to assess and document the current water quality conditions of the streams, identify problem resources or areas, climate and landscape change impacts, calibrating H&H models, and to continue a long-term baseline monitoring program which will enable the District to identify trends. It is also imperative to track these water quality standards at each stream monitoring site to determine if the waters are meeting State water quality standards and whether they are impaired.

3.2. Long-term Monitoring (Legacy)

Six long-term monitoring sites (Figure 1) are monitored each year to track large-scale pollutant load reduction trends within each of the four Lake Management Districts (LMDs): Comfort LMD, Little Comfort LMD, Forest LMD, and Bone LMD. All these sites have automated water sampling devices (ISCO units), which collect stage data (water levels) to measure flow at the sites. Flow levels trigger the collection of samples for water quality analysis. The samples are collected over a 24-hour period and are composited into one sample that would be representative of the concentration of pollutants during the event. This composited sampling reduces the lab analysis cost and provides more accurate results that represent an entire event, rather than just a point in time.

The Stream monitoring locations are shown in Table 14. The number of composited water quality samples collected during the 2025 monitoring season are indicated. Given the conditions in 2025, EOR was able to calculate loads at most of the sites this year which had been a challenge in the past drier seasons.

Table 14. Long-term monitoring sites

Lake Management District	Site Description	Site code	# of water quality samples (2025)
Bone Lake	Bone Lake North Inlet	BL1	8
	Bone Lake Outlet	BL2	8
Comfort Lake	Sunrise River at the Comfort Lake Outlet	CL1	11
	Sunrise River at the Comfort Lake Inlet	CL2	9
Forest Lake	Sunrise @ Forest Lake Outlet	FL1	7
Little Comfort Lake	Little Comfort Lake Inlet	LC1	10

3.3. Results

Stream water chemistry composite sample results for total suspended solids, phosphorus, nitrogen, iron, and chloride are reported in Appendix D.

- Bone Lake Inlet and Outlet
- Comfort Lake Outlet and Inlet
- Little Comfort Inlet
- Forest Lake Outlet

Appendix D shows the flow conditions and water quality from each of the long-term monitoring sites. Total runoff volume, TP and total suspended solids (TSS) loads, and TP and TSS flow weighted mean concentrations (FWMC) were determined using the FLUX32 software package. Table 15 summarizes the long-term monitoring site results. BL1 only had two samples for TSS due to volume collected by the sampler, thus no TSS loads could be calculated. Additionally, the ISCO at Comfort Lake Inlet has had poor battery/power source consistency beginning at the end of July. As a result, there is not enough data to calculate flow, and therefore TP and TSS loads could not be analyzed. FL1 had low TP and TSS concentrations and loads. CL1 and LC 1 had high loads which were driven by high coefficient of variance in the FWMC and should be used with caution, since the calculation is based on a few high concentrations. In general, the loads were lower than those observed in 2024.

Table 15. 2025 Long-term Stream Monitoring Site Concentrations and Loads.

Monitoring Site		MPCA Station ID	Drainage Area (acres)	Days of Flow	Number of Sample Events	Flow			Total Phosphorus			Total Suspended Solids		
						Daily Mean (cfs)	Volume (ac-ft)	Runoff depth (in)	FWMC (µg/L)	Load (lbs.)	CV	FWMC (mg/L)	Load (lbs.)	CV
Central Region Reference FWMC									**<100**			**< 30**		
Long-term Sites														
Bone Lake North Inlet	BL1*	S004-471	2,479	103	4	1	242	1.2	119	79	0.32	n/a	n/a	n/a
Bone Lake Outlet	BL2	S004-463	5,495	104	4	5	906	2.1	209	546	0.2	61	158,670	0.37
Big Comfort Outlet	CL1**	S004-468	24,558	118	6	25	5874	2.9	**136****	**2,173****	**0.59**	**73****	**1,171,068****	**0.99**
Big Comfort Inlet	CL2***	S001-223	13,625	34	5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Forest Lake Outlet	FL1	S004-466	8,719	72	4	10	1405	1.9	31	118	0.1	3	12,454	0.14
Little Comfort Inlet	LC1**	S001-232	10,513	118	6	6	1507	1.7	**212****	**891****	**0.68**	**240****	**982,217****	**1.25**

* Not enough samples to calculate FWMC and loads.

** . Possibly anomalous results are driving this calculation.

*** The ISCO at Comfort Lake Inlet has had poor battery/power source consistency beginning at the end of July. As a result, there is not enough data to calculate flow, and therefore TP and TSS loads could not be analyzed

Bolded values have very high coefficient of variation (i.e., high uncertainty > 0.5) and should be used with caution.

Shaded FWMC values exceed Central Region Reference values.

The flow time series at the long-term stream monitoring sites are in Appendix D. There were three time periods that exhibited high peaks in stream flow (early spring, late June -late July, and late September) driven by precipitation events. These peaks were observed in different iterations for different sites. BL1 showed a steep peak in late July. CL1, FL1, BL2, and LC1 showed a peak from late June to late July and then another peak in late September. These flow results were comparable to changes in lake levels. LC1 and BL2 show comparable seasonal trends, as expected since they are hydrologically connected. The data record ended in late July for CL2 because of an equipment malfunction.

The water quality monitoring data at the long-term stream monitoring sites is also in Appendix D. The TP and TSS FWMC at all of the sites, except FL1, exceeded Class 2B water quality standards. The high FWMC at LC1 was driven by one sampling date, 7/23/25, which corresponds to the peak in-lake TP. LC1 and CL1 TP and TSS exceeded the standards in spring and on 7/23/25. These high concentrations are driven by high precipitation events in spring and in July. These events corresponded to peaks in in-lake concentrations in both Comfort and Little Comfort Lake. BL1 exceeded the TP standard in late June and July. BL2 exceeded both standards during the sampling period. These concentrations at BL2 are considerably higher than the in-lake TP concentrations. TP and TSS concentrations at FL1 were below the standard throughout the sampling period. In general nitrogen concentrations were low with only a few elevated concentrations corresponding to the high TP concentrations observed in spring and late July. There were no exceedances of chloride at any of the monitoring stations. The orthoP was a low percentage of the TP in most cases.

3.4. Conclusions and Recommendations

In 2025, the peak flows were observed in early spring, late June to late July and late September at all sites. Peaks in flow led to peaks in TP and TSS loads and corresponding peaks in in-lake concentrations, particularly in July. The loads in 2025 were less than those observed in 2024 and reflect an average year of loading compared to the most recent years of extremes. In general, nitrogen, orthophosphate and chloride concentrations were low throughout the monitoring season.

Due to budget constraints and the robust dataset that the District has built, the long-term stream monitoring will be conducted on a rotating basis, instead of annually.

4. DIAGNOSTIC MONITORING

Diagnostic monitoring is conducted on a rotating basis for the four LMDs within the District. This year, diagnostic monitoring was conducted in the Comfort LMD. The results from this proposed diagnostic monitoring will be used to inform the Sunrise River Headwaters Project Accelerated Implementation Grant Project (AIG). The goal of the AIG is to identify possible hot spots and develop project concepts to reduce loading to the Sunrise River and Comfort Lake.

Diagnostic Monitoring was conducted at 17 locations, Table 16, in the Sunrise River corridor and included locations on the Sunrise River, and tributaries to the Sunrise River, including former Judicial Ditch 2 (JD2). The outlet of School Lake and the Heath Ave Iron Enhanced Sand filter project inflow site were also selected for monitoring, Figure 3.

Sites were visited after rain events and samples were collected according to Table 16. At eight of the sites continuous level monitoring and flow gauging were collected to calculate loads at the end of the season. Sites were monitored from mid-May through mid-October. Most sites were sampled six times, with some variation due to flow conditions. At the sites with flow measurements, rating curves were developed that were used to create a stage-flow equation curve that was used with the continuous stage data to estimate flow for the entire season. To generate the load calculation, the concurrent flow and concentration data were used to calculate the flow weighted mean, see Appendix E. The seasonal load was calculated by multiplying the total flow through the season by the flow weighted mean.

Table 16: Comfort Lake Management District Stream Diagnostic Sites.

Site Description	Site Code	Site Type	# of Water Quality Samples
Tributary to JD2 at 35W	CL8-A	Grab	6
Tributary to JD2 at Everton Ave	CL8-B	Flow + Grab	6
Compost Road/ Bixby Park	CL8	Flow + Grab	6
Bixby Outlet Weir	CL7-J	Grab	6
Wetland Complex South Inlet to former Judicial Ditch 2	CL7-I	Grab	6
Wetland Complex North Inlet to former Judicial Ditch 2	CL7-H	Grab	5
Former Judicial Ditch 2 at Highway 61	CL7-F	Flow + Grab	6
City Pipe at Wetland	CL7-D*	Flow + Grab	1
County Line Ditch	CL7-G	Flow + Grab	6
Heims Drainage Ditch	CL5	Flow + Grab	6
Hwy 61 Pond Outlet	CL5-B	Grab	3
Tributary to Sunrise River	CL4-A	Grab	3
Sunrise River at Greenway Ave	CL4	Flow + Grab	6
Tributary to Sunrise River	CL3-A	Flow + Grab	6
Sunrise River at 256th St.	CL3	Flow + Grab	6
Heath Ave	LC2	Flow + Grab	5
School Lake Outlet	LC3	Grab	5

*only one sample was taken at the CL7-D site as a baseline comparison, the other sites were prioritized.

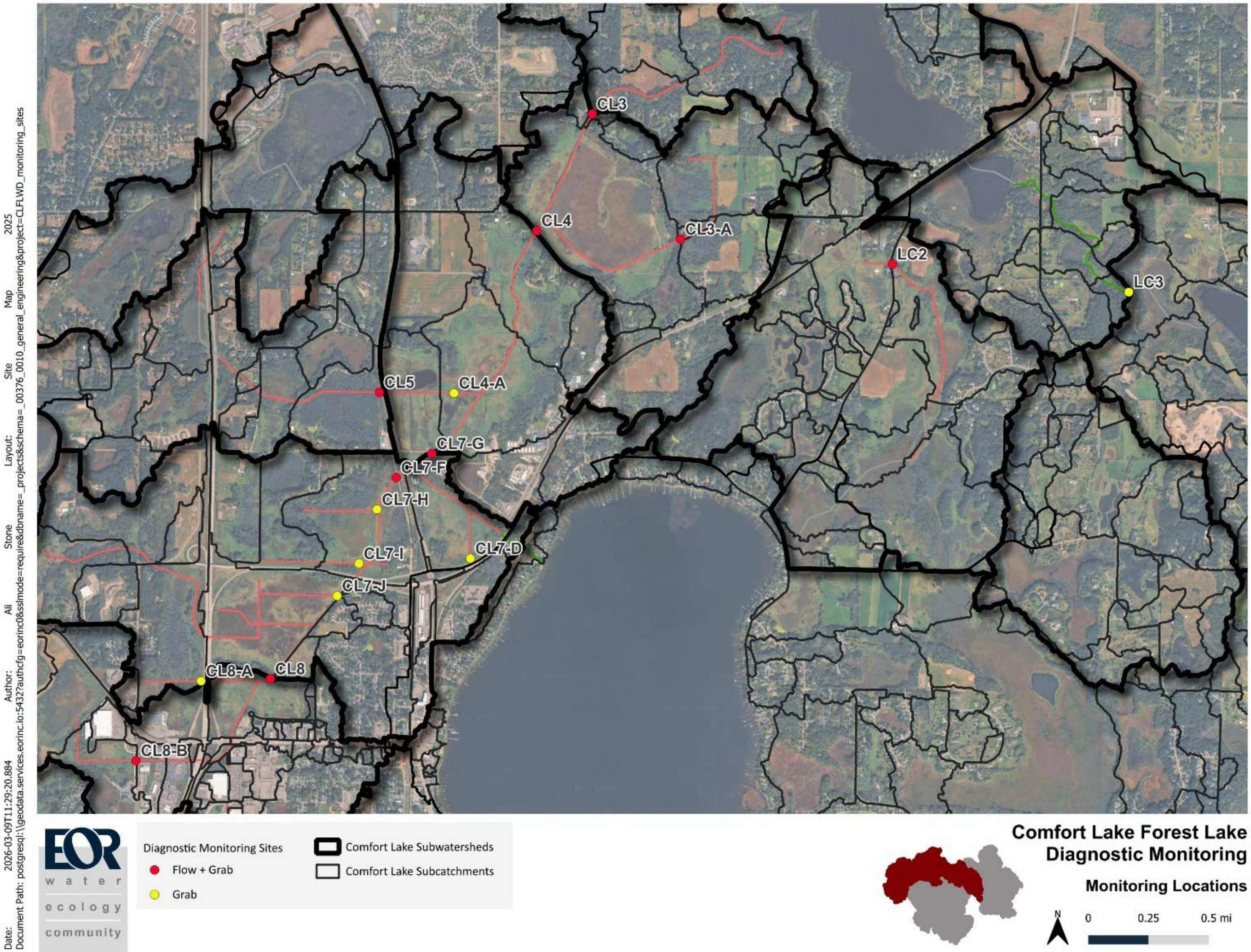


Figure 3: Diagnostic Stream Monitoring Site Locations.

4.1. Results

Flow hydrographs paired with TP, orthophosphate (orthoP) and TSS are available in Appendix E. Table 17 and Figure 4 summarize the flow and load calculations for the eight diagnostic steam monitoring sites with flow monitoring data available.

The load increases as you proceed downstream along the Sunrise River to a maximum of 2,022 lbs at the inlet to Shallow Pond, CL4. However, the outlet of Shallow Pond, CL3, shows a reduction in load at 1,263 lbs. Shallow Pond continues to act as a phosphorus sink, reducing the influent load before it enters downstream Comfort Lake.

The Bixby Park outlet, CL7-J, is showing relatively low TP concentrations (average of 116ug/L) compared to Bixby Park inlet, CL8, concentration and other tributaries in the wetland complexes, which is a good indication that the Bixby Park project is working to reduce phosphorus loading. The load increases between the Bixby park project inlet at CL8 and former Judicial Ditch 2 at Highway 61, CL7-F. This encompasses a large drainage area. There are three monitoring sites between sites CL7 J, CL7-H, CL7-I. The high concentrations are observed at CL7-I (average concentration of 563ug/L) and CL7-H (average concentration of 219ug/L). These average concentrations far exceed the state standard for this stream, 100ug/L. The wetlands between these sites could be good options to investigate for load reduction projects as part of the AIG project.

The ditches or wetlands between former Judicial Ditch 2 at at Highway 61,CL7-F, and the County Line Ditch site, CL7-G, is contributing phosphorus loads to the system and is a good option for further investigation as part of the AIG project. This is evidenced by an increase in load between CL7-F, and CL7-G, which is not accounted for by the load from outlet of Forest Lake (FL1) or historically low flow and load from CL7-D.

Table 18 and Figure 5 summarizes the average concentration data for all 17 diagnostic stream monitoring sites. Almost all of the sites exceed the TP standards .Only a few exceed the TSS standards. The general trend across all sites is the worst water quality was observed in late summer and influenced by precipitation events. The orthophosphate is a low percentage of the total phosphorus which is important to understanding which potential projects will be most effective.

Table 17. 2025 Diagnostic Stream Monitoring Site Loads.

Monitoring Site		MPCA Station ID	Drainage Area (acres)	Days of Flow	Number of Sample Events	Flow		Total Phosphorus		Total Suspended Solids	
						Daily Mean (cfs)	Volume (ac-ft)	FWMC (µg/L)	Load (lbs)	FWMC (mg/L)	Load (lbs)
Central Region Reference FWMC								**<100**		**< 30**	
Comfort LMD											
Sunrise River											
County Line Ditch	CL7-G		10,563	145	6	14	6622	108	1,945	5	89,930
Sunrise River at Greenway Ave.	CL4		12,954	141	6	13	5980	124	2,022	7	112,939
Sunrise River at 256th St.	CL3		13,311	145	6	19	5839	80	1,263	4	62,915
Heims Drainage Ditch											
Heims Drainage Ditch	CL5		1561	145	6	4	155	247	105	24	10,362
Judicial Ditch 2											
Compost Road / Bixby Park	CL8		742	141	6	2	1128	133	407	4	13,616
Former Judicial Ditch 2 at Highway 61	CL7-F		1675	145	6	5	2187	228	1,358	14	83,536
Other Tributaries											
Tributary to JD2 at Everton Ave	CL8-B		283	141	6	1	306	143	120	6	5,120
Tributary to Sunrise River	CL3-A		250	145	6	0	25	359	24	4	251

Shaded FWMC values exceed Central Region Reference values.

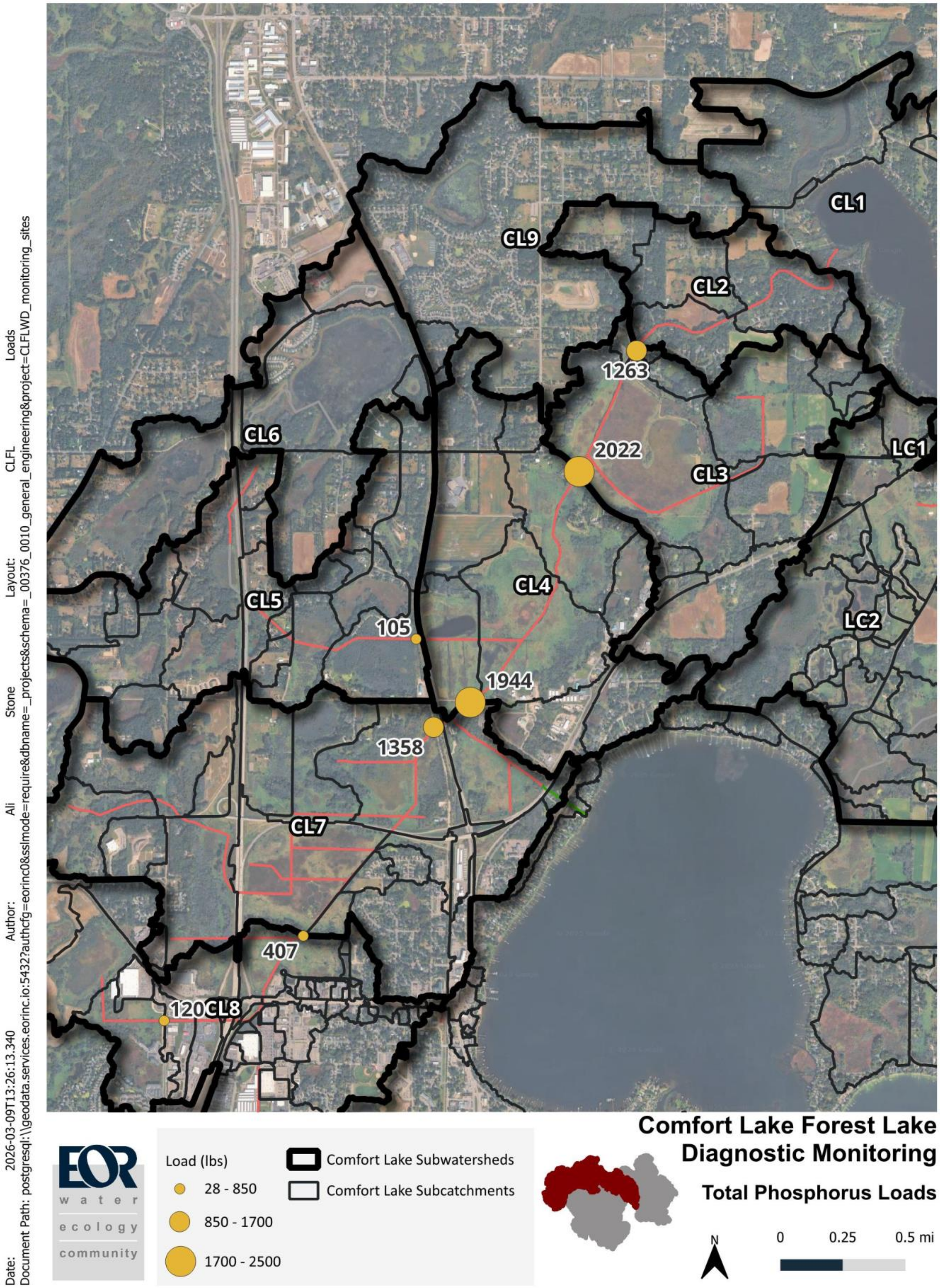


Figure 4: Total Phosphorus Load (lbs) from Diagnostic Sites.

Table 18: Diagnostic Stream Monitoring Site Concentrations

Monitoring Site		MPCA Station ID	Drainage Area (acres)	Number of Sample Events	Orthophosphate	Total Phosphorus	Total Suspended Solids
					Average (ug/L)	Average (ug/L)	Average (mg/L)
Central Region Reference FWMC						**<100**	**< 30**
Sunrise River							
County Line Ditch	CL7-G	S004-465	10,563	6	32	86	5
Sunrise River at Greenway Ave.	CL4	S004-926	12,954	6	42	159	8
Sunrise River at 256th St.	CL3	S015-161	13,311	6	38	73	5
Heims Drainage Ditch							
Heims Drainage Ditch	CL5	S001-234	1561	6	137	185	14
Tributary to Sunrise River	CL4-A		1789	3	104	361	13
Judicial Ditch 2							
Compost Road / Bixby Park	CL8	S005-686	742	6	81	130	5
Bixby Park Outlet Wier	CL7-J		495	6	64	116	4
Wetland Complex South Inlet to JD2	CL7-I		134	6	188	563	162
Wetland Complex North Inlet to JD2	CL7-H		138	5	115	219	44
Former Judicial Ditch 2 at Highway 61	CL7-F	S001-233	1675	6	112	173	10
Other Tributaries							
Tributary to JD2 at 35W	CL8-A		2	6	98	275	22
Tributary to JD2 at Everton Ave	CL8-B		283	6	107	161	11
Tributary to Sunrise River	CL3-A		250	6	371	541	14
Heath Ave.	LC2		1004	5	94	163	5
School Lake Outlet	LC3		1043	5	15	87	3

Shaded FWMC values exceed Central Region Reference values.

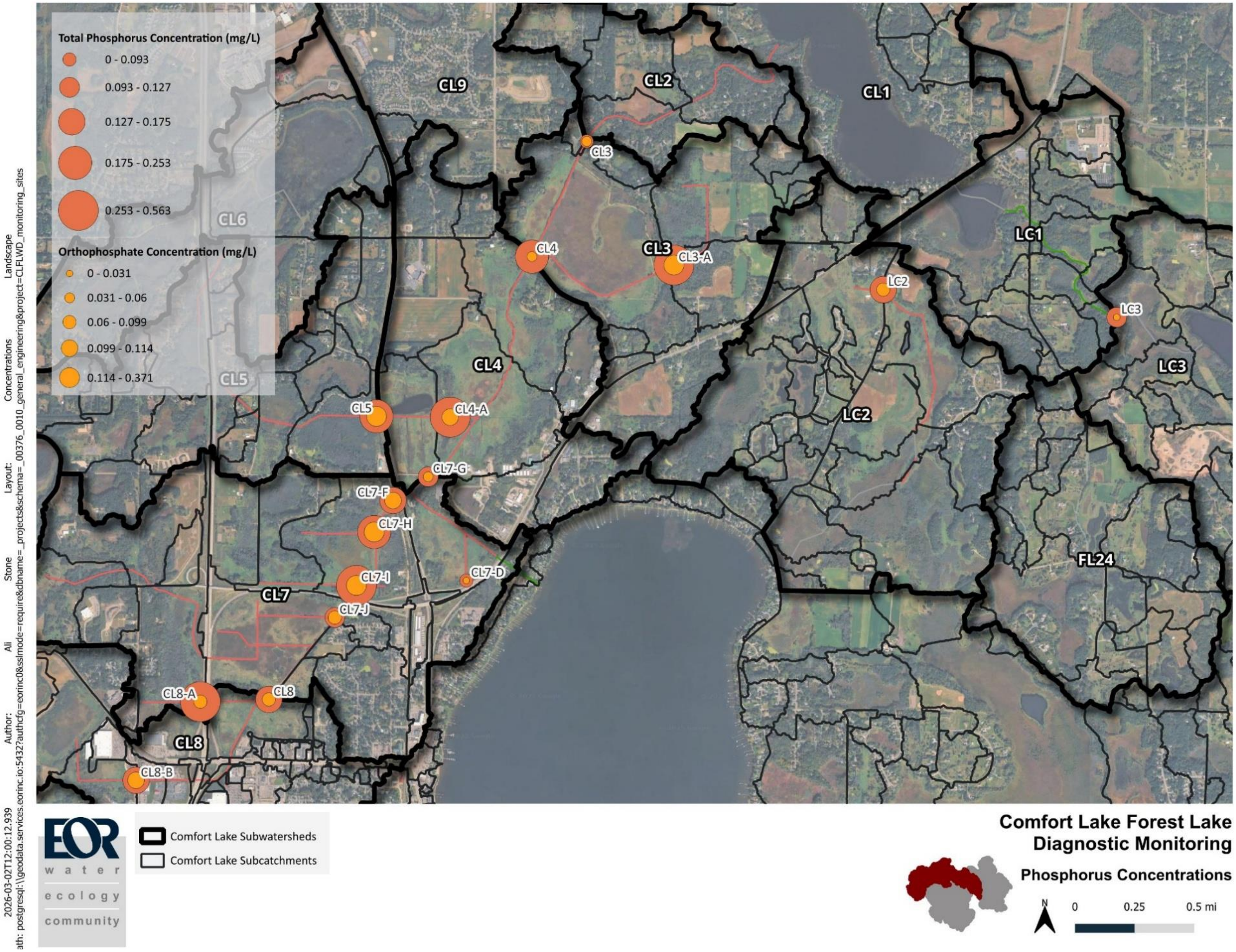


Figure 5: Total Phosphorus and Orthophosphate Concentrations at the Diagnostic Monitoring Sites.

4.2. Conclusions and Recommendations

In 2025, diagnostic monitoring was conducted to support the Sunrise River Headwaters Project Accelerated Implementation Grant. The results reveal hot spots of TP loads along Sunrise River to Comfort Lake. In 2024 the water quality was worse than in 2025 and in more recent dry years. Given these results and the internal loading monitoring results, the water quality is driven by external sources including the systems included in the diagnostic monitoring. The hot spots will be further investigated through the AIG grant and potential projects will be identified.

Key findings from the diagnostic monitoring include:

- The general trend across all sites is that the water quality was the worst in late summer.
- There is a significant load reduction over Shallow Pond indicating it is acting as a phosphorus sink.
- Bixby park continues to reduce TP load downstream.
- The wetlands and ditches in the CL4 and CL7 subwatersheds will be investigated further in the AIG.

5. DIY AND CAT MONITORING

The Do-It-Yourself (DIY) and Citizen Assisted Tributary (CAT) monitoring programs were developed as a diagnostic screening tool to help identify sources of nutrient load in between the 3-year Sequential Diagnostic Monitoring (SDM) rotation of lake management districts. The program utilizes inexpensive colorimeters to get immediate orthophosphate readings that can indicate potential nutrient loading, and when used sequentially throughout a subwatershed, can point to potential nutrient sources. This information is then leveraged in the larger SDM process to help focus and reduce overall diagnostic expenses with the ultimate goal of identifying cost effective water quality improvement projects. Greater detail into the methods behind the CAT and DIY programs can be found in past monitoring reports.

The 2025 DIY diagnostic and CAT monitoring efforts monitored four subwatersheds from April through October. The DIY diagnostic program focused on the direct drainages to Comfort Lake, as well as the Moody and Shields lake subwatersheds due to declining lake water quality in 2024. The CAT monitoring program again studied direct drainages to all basins of Forest Lake. The 2025 monitoring locations and average orthophosphate levels can be visualized in the heat maps displayed in Figure 6-Figure 9.

5.1. Results

Staff and volunteers collected 468 samples from up to 12 precipitation events – 285 samples through the DIY diagnostic program, and 183 samples through the CAT program. Several patterns of potential loading were identified from these datasets. A discussion of these results can be found below, organized by study area.

The MNPCA's recommended concentration for total phosphorus in urban residential runoff is 0.325 mg/L, (MPCA 2023). Though the MPCA study is not a direct comparison to our DIY/CAT data collection methods, which measure orthophosphate, it does provide helpful context for our efforts. It should also be noted that phosphorus is measured in milligrams per liter in runoff samples, in comparison to lake samples which use micrograms per liter. This is a difference of a factor of 1,000 as runoff is far more concentrated and becomes diluted as it enters the lake. For further details on phosphorus impairment standards in lakes, section 2.

5.1.1. DIY Monitoring

Comfort Lake Study Area

In 2025, a total of 88 water samples, from 16 sites, Figure 6, were collected in the Comfort Lake direct drainage study area over nine precipitation events. Results were similar to those found during the 2023/2024 monitoring effort in this study area. Excess nutrient loading was noted at three locations. These locations are associated with roadways, stormwater infrastructure, and at a stormwater pond located on East Comfort drive (CD-6).

The CD-6 site was identified in 2024 and is currently being developed into a water quality project for implementation using a green infrastructure grant acquired in 2024. Site CD-6 is an unmaintained stormwater pond that receives water from the southern part of the East Comfort Drive drainage area. This monitoring site was expanded in 2024 (into Sites CD-6a and CD-6b) to better evaluate the stormwater pond. DIY monitoring data indicated that water entering the pond (Site 6a) is cleaner than that exiting the pond (6b). This was verified by sending several of these samples to Instrumental Labs. These results demonstrate the value of the DIY program as the results from this effort provided sufficient data to secure grant funds for project development and implementation. The phosphorus reduction from this project is modeled to be 3-5 lbs total phosphorus per year.

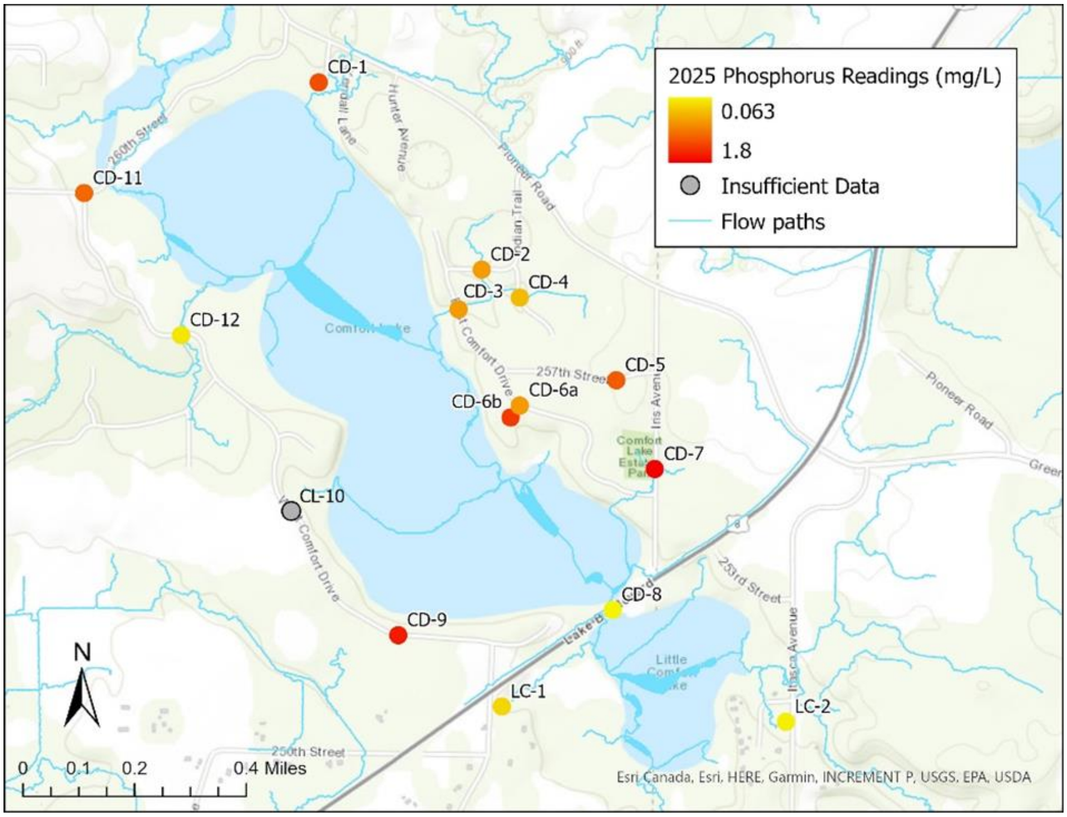


Figure 6: Map of the Comfort Lake Direct Drainage DIY Diagnostic monitoring effort for 2025. The dots represent monitoring locations, and their color indicate the average orthophosphate concentrations detected.

Moody Lake Study Area

The 2025 DIY program included the addition of the Moody subwatershed, Figure 7. This study area was added through adaptive management due to concerns of increased phosphorus levels noted in Moody Lake surface water during the 2024 CAMP lake monitoring effort. Water quality of the lake was relatively good, with a "C" lake grade in 2024, but there is some concern for the longevity of the split dose Alum treatment conducted on Moody Lake in 2018 and 2019. Recent lake bottom water sampling indicates a slight increase in phosphorus release under anoxic conditions in the fall of year (2024 data). The DIY diagnostic monitoring was added to evaluate any external loading in the subwatershed that may be contributing to the loss of efficacy of the alum treatment.

Eight sites along the Moody Lake northern flow path were monitored in 2025 (Figure B). A total of 84 samples were collected over 12 storm events. An additional four samples were also collected and submitted to Instrumental Labs for further analysis / verification of DIY analysis. Results indicate some increased loading from the Moody Wetland Project. The CLFLWD restored these wetlands in 2015, resulting in a reduction of phosphorus loading to Moody Lake by 445 lbs/year. The project also included a small Alum treatment of one of the wetland ponds to further reduce nutrient export. There is a potential that this Alum treatment has reached the end of its lifespan or is being overwhelmed by external inputs of sediment and nutrient from localized land management practices.

The easement for the Moody Wetland Restoration Project included land management guidelines for the landowner. Based on observations during sites inspections and from driving randomly past the property, it does not appear that the landowner is following these guidelines as closely as is needed. This may be contributing to wetland sedimentation, loading, and/or increased nutrient export from this project area. Despite the strained relationship with this landowner, staff will further investigate potential loading from these wetlands and work with the landowner to improve the management of the land surrounding the wetland project.

Fortunately, we see some reduction in loading as we move downstream toward Moody Lake, indicating modest treatment by projects and wetlands in between the Moody Lake Wetland project and the lake. Despite this, additional effort should be made to evaluate and resolve potential issues originating from the Moody Wetland project area.

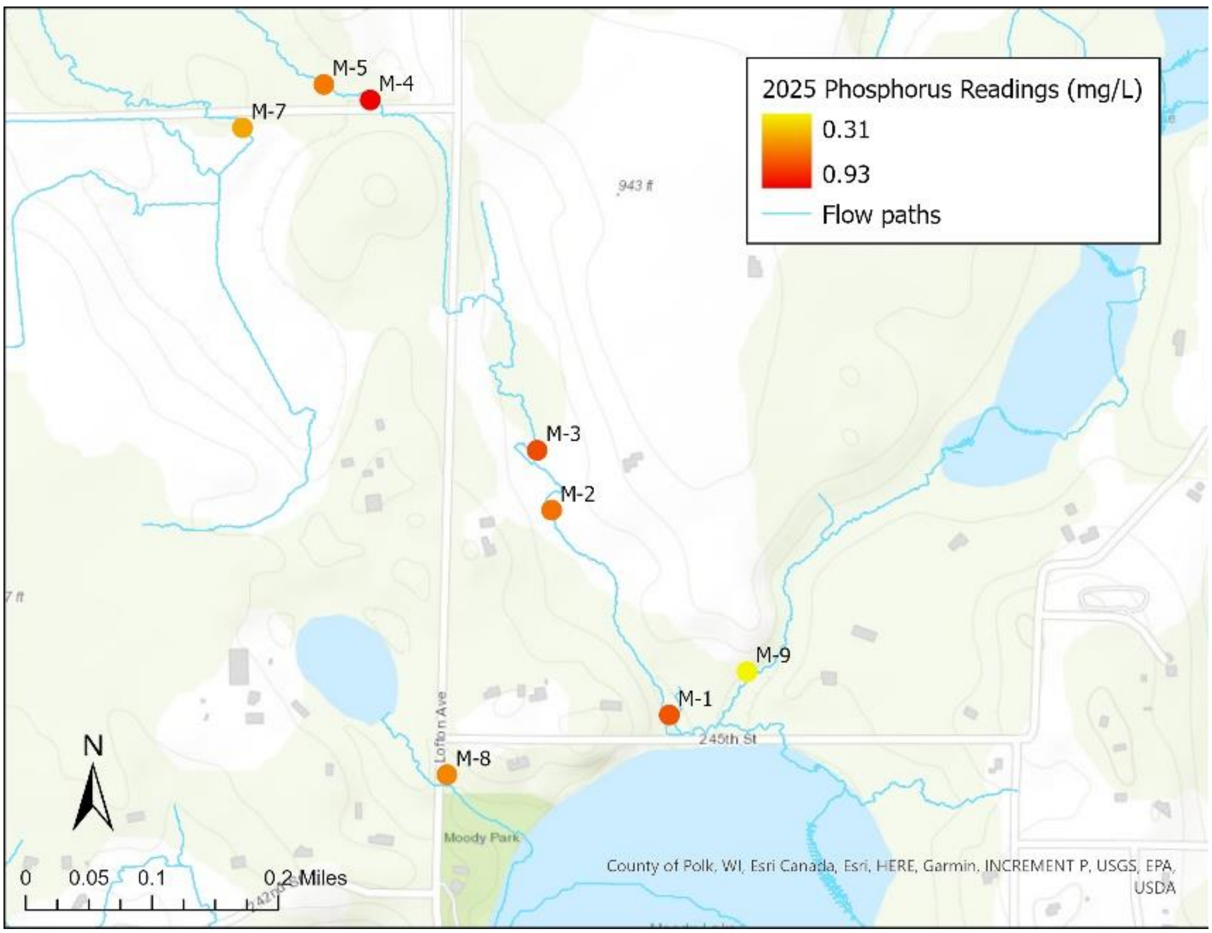


Figure 7: Map of the Moody Lake DIY Diagnostic monitoring effort for 2025. The dots represent monitoring locations, and their color indicate the average orthophosphate concentrations detected.

Shields Lake Study Area

The Shields Lake subwatershed was also added to the DIY monitoring program in 2025 to address concerns of declining lake surface water quality, as noted during 2024 lake monitoring efforts. CAMP lake monitoring results indicated increasing concentrations of chlorophyl-a, decreased Secchi depths, an increase in phosphorus levels, as well as an increase in bottom water phosphorus concentrations. This trend is a concern as the District has implemented several projects in the Shields Lake watershed to improve lake water quality, notably the Forest Hills Golf Club Stormwater Reuse project and the Shields Lake alum treatment (split doses in 2020/2022).

Shields Lake is considered a shallow, natural habitat lake with an organic rich mucky substrate. Management of shallow lakes is considered to be challenging due to their unique chemistry and ecology. As such, DIY monitoring was added to this subwatershed to evaluate any remaining external loading that may be contributing to the loss of efficacy of the Alum treatment and to better understand the ecology of this system.

Ten sites in the subwatershed were monitored in 2025, Figure 8. A total of 113 samples were collected over 12 storm events. An additional five samples were also collected and submitted to Instrumental Labs for further analysis. Results indicate some potential loading from the agriculture areas to the south southwest of Shields Lake. This area was also identified in a 2015 SMD effort in the Shields Lake subwatershed by Emmons and Olivier Resources (EOR); however, the western tributary was targeted for project implementation as it had higher loading. Based on the 2025 DIY monitoring results, staff plan to investigate this agriculture area in 2026 by adding additional monitoring location along its flow path to determine the source of the loading from this area.

The Shields Lake DIY monitoring effort also identified several wetlands (sites S-3, S-9) adjacent to a housing development in this subwatershed that may also be contributing to dissolved phosphate loading. Water quality monitoring of these resources can be challenging in that it is often difficult to isolate water flowing in and out of these wetlands. As such additional monitoring, specifically wetland soil samples could be considered to further evaluate their loading potential.

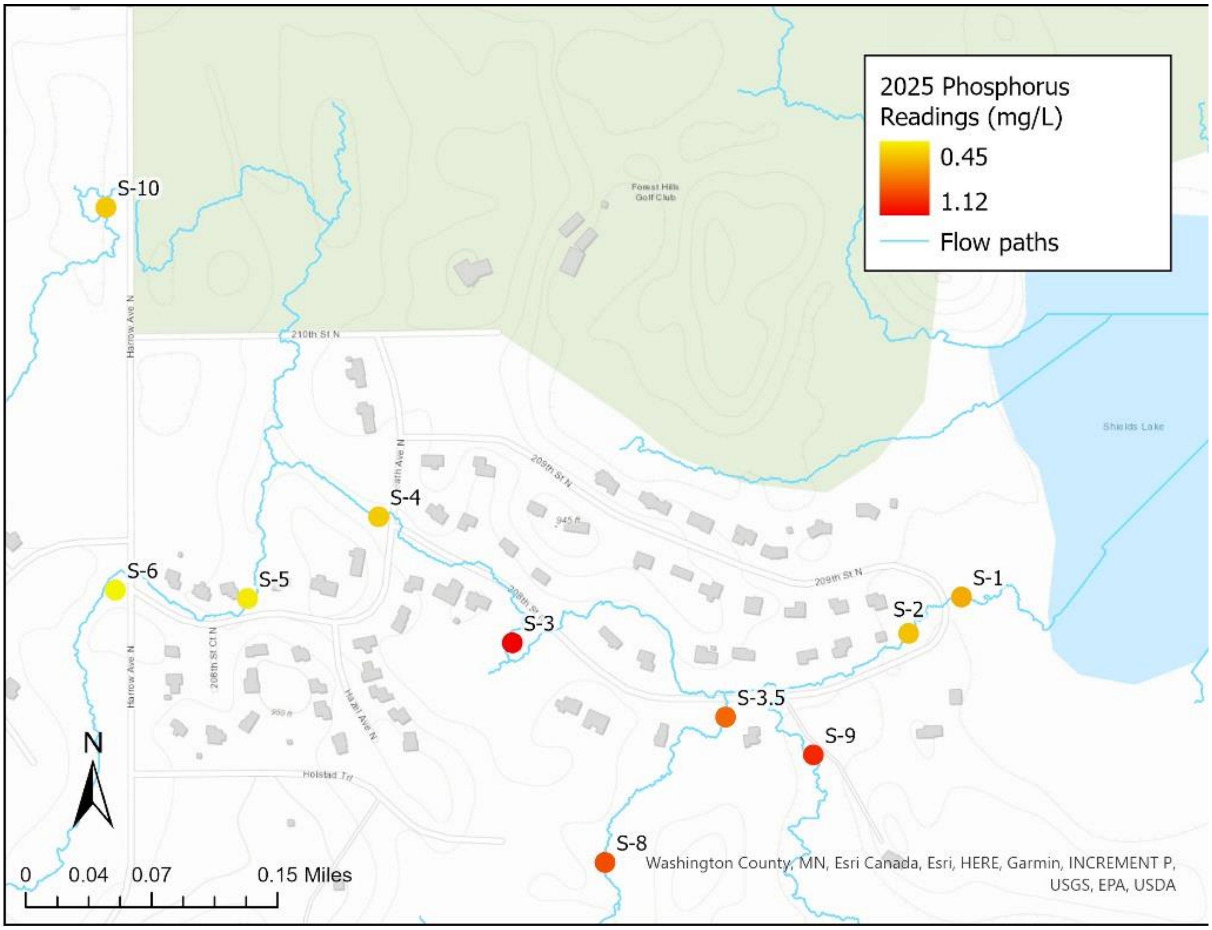


Figure 8: Map of the Shields Lake DIY Diagnostic monitoring effort for 2025. The dots represent monitoring locations, and their color indicate the average orthophosphate concentrations detected.

Forest Lake Subwatershed Citizen Assisted Tributary Monitoring

The 2025 Forest Lake subwatershed Citizen Assisted Tributary (CAT) monitoring program monitored 24 sites across all three basins of Forest Lake. The program's citizen volunteers and District staff collected a total of 183 samples during 12 rainfall events. Each site was sampled a minimum of 3 times and averaged 7.6 samples per site. Three additional sites were added this year: FL1-6, FL1-7, and FL1-8, all west of Basin 1, to assess runoff from parking lots and roads surrounding Lakeside Park.

Of the 24 sampled sites, 65% had an average orthophosphate concentration above the MNPCA's recommended concentration for total phosphorus in urban residential areas of 0.325 mg/L, (MPCA 2023), with five of the sites (21%) having highly elevated orthophosphate levels, Figure 9. Similar trends of elevated orthophosphate levels throughout the Forest Lake subwatershed have been observed in 2023 and 2024, adding credence to the CAT methodology and providing ample data to demonstrate nutrient loading.

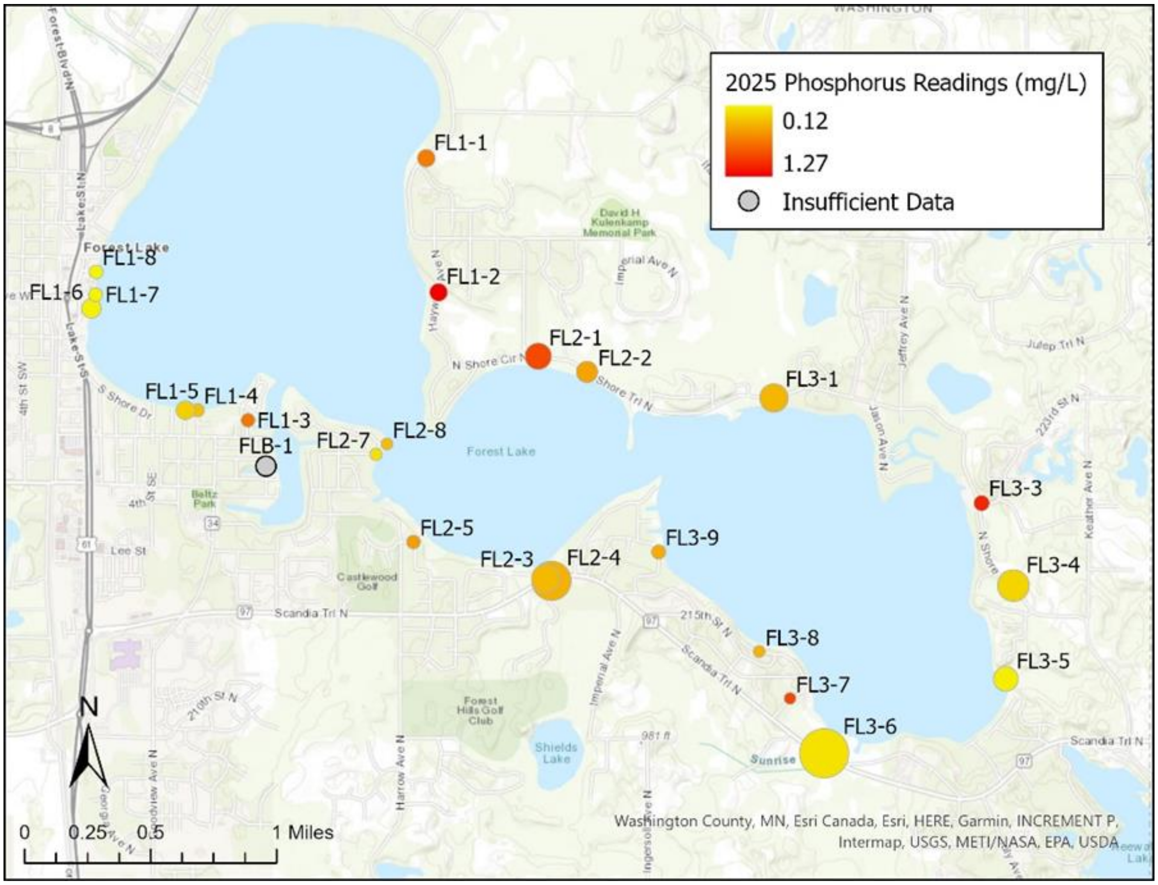


Figure 9: Map showing all 2025 monitoring locations around Forest Lake. The dots represent monitoring locations, and their color indicate the average orthophosphate concentrations detected. Their size correlates with qualitative flow observations, larger dots representing higher and more frequent flow.

Based on CAT data, flow observations, and project viability, staff have identified several monitoring sites to further investigate via upstream micro-drainage / tributary monitoring or wetland core sampling. Tributary monitoring investigates multiple locations upstream of the original high phosphorus site (identified in earlier years) to further narrow down the source of excess nutrient. Wetland core sampling can be used to determine if a wetland is a potential nutrient source, and if so, determine whether the phosphorus source can be removed via a wetland restoration project. Sites FL1-2, FL2-1, and FL3-3 will be explored as candidates for additional investigation in 2026. Additional sites may be investigated in future years and opportunities in which nutrient reduction and management practices could be implemented without a CLFLWD project will be explored with property owners as feasible.

The DNR Parsons Wetland, which flows into Forest Lake at FL1-2, has been investigated repeatedly by the District in the past and presents unique challenges. In 2019, soil samples from the wetland found relatively normal phosphorus levels and, as such, a wetland restoration project was not recommended as a priority. Similarly, a 2020 cattail harvest study evaluated cattail removal as a nutrient reduction strategy, but a removal project was not pursued due to concerns of upcoming road work that may alter the current hydrology of the wetland and the difficulty of obtaining permission from the many landowners within the wetland boundary (+25 parcels).

The Parsons wetland receives runoff from roads and residential neighborhoods. The CLFLWD has also received reports of dumping (lawn clippings and organic debris) in the wetland in more recent years, which can quickly load nutrients into wetland sediments. Based on 2023-2025 CAT readings, identifying the cause of elevated readings and reconsidering management options is worth prioritizing in 2026. Cost-effective methodology for doing so will need to be further considered.

The FL2-1 site is located at the outlet of a series of wetlands that receive runoff from the surrounding neighborhoods and a small field. The drainage area is relatively small, and the geography of the area presents several accessible potential sites for 2026 sampling. Staff intend to monitor this micro-drainage more intensely in 2026 to identify the source of orthophosphate loading.

The FL3-3 site is located at the outlet of a wetland with a large drainage area encompassing neighborhoods distributed between a handful of loosely connected wetlands. Due to the size of the drainage area and limited access to ideal sampling sites, this investigation may present more challenges in identifying specific sources of nutrient. Staff will evaluate the monitoring potential of this area in 2026, and if possible, establish additional monitoring sites to further evaluate nutrient loading.

5.2. Conclusions and Recommendations

In 2025 a total of 468 water quality samples were collected from April to October over four study areas, and during 12 storm events. The 2025 CAT and DIY data indicated areas of elevated orthophosphate levels within the district. Similar to previous years, these potential loading areas are primarily associated with roadway runoff and degraded wetland habitats. Two additional DIY study areas were added in 2025 in response to the previous year's lake monitoring data that indicated a potential decline in lake surface water quality on Shields and Moody lakes in 2024. Results from the DIY monitoring effort in these subwatershed indicated potential loading from an agriculture area southwest of Shields Lake and a 10+ year old wetland project in the upper Moody Lake subwatershed.

DIY data from 2023-2025 was used to identify one potential project within the direct drainage network to Comfort Lake. This data indicates an older stormwater pond that drains directly to the wetland fringe of Comfort Lake is exporting nutrient and needs to be cleaned out to restore function. Staff have secured grant funding and are currently developing this project for implementation in 2027 or beyond. Results also indicate some potential loading from the agriculture areas to the south southwest of Shields Lake. The Shields Lake DIY monitoring effort also identified several wetlands (sites S-3, S-9) adjacent to a housing development in this subwatershed that may also be contributing to dissolved phosphate loading

The 2025 CAT program found similar nutrient loading in the Forest Lake subwatershed consistent with previous monitoring efforts. Staff used this multi-year dataset to select several monitoring locations/subwatersheds in need of further investigation, that may include both wetland soil sampling and tributary/micro-drainage monitoring.

Plans for the 2026 DIY and CAT monitoring efforts will focus on sites identified in previous years as having a high likelihood of nutrient loading. Staff will select several tributaries (micro-drainage) of Forest Lake and the southern drainage to Shields Lake as these "phase 2" diagnostic monitoring areas. Staff will monitor these drainages at multiple locations along their lengths/drainage network to try to identify a specific source of the loading. If successful, these efforts could result in/identify future water quality improvement projects.

The CLFLWD plans to transition into a second phase of the DIY/CAT programs in 2026. Shifting focus onto the micro-drainages or subwatersheds identified as having potential loading issues in past years. Staff will monitor locations along the flow paths/tributary networks of these micro-drainages to try to identify the underlying source of the nutrient and/or better understand the loading from these drainages. The CAT program will focus on one or two micro-drainages to Forest Lake, while the DIY program will focus on the southwestern agriculture area of Shields Lake.

6. CONCLUSION AND SUMMARY

2025 reflects an average year in precipitation and loading compared to the most recent years of climate extremes. 2025 serves as a more typical representation of the conditions of the District's water resources. The following are takeaways from the 2025 lake and stream monitoring efforts.

6.1. Lake Monitoring

The main takeaways for the 2025 lake monitoring season include:

1. All of the lakes show an equal or improvement in water quality when comparing the 5-year average and the 10-year average, except Nielson as there was not enough historic data.
2. All of the lakes were meeting the state standard for the 5-year average for at least one of the water quality parameters, except Nielson.
3. Most of the lakes monitored in 2025 in the District received B grades
4. Overall, every lake experienced better water quality than last year.
5. School, Shields, and Keewahtin are meeting the District Goals for the 5-year average. Keewahtin, Forest Lake-East and Middle showed similar results from the 5-year and 10-year averages.
6. Bone Lake, Forest Lake-West, Keewahtin, Little Comfort Lake, and School Lake are meeting all water quality standards in 2025.
7. Comfort Lake, Moody, and Forest Lake – East are meeting two of the water quality standards in 2025 and are within 1 µg/L to meeting all three standards.
8. Forest Lake-Middle is only meeting the TP standard but with the alum treatment in late fall 2025, Secchi and chlorophyll-a concentrations should improve.
9. Shields Lake and Moody Lake alum treatments continue to work. However, the hypolimnion orthophosphate concentrations have increased since 2023.
10. Forest Lake – East had high bottom orthophosphate concentrations by August.
11. Forest Lake – Middle had low bottom P concentrations throughout the stratified period. The alum treatment was conducted in September 2023 and October 2025 which reduced the hypolimnetic concentration significantly compared to pre-treatment conditions. This evidence is corroborated by sediment cores, which showed a 60% decrease in internal loading.

Lake Monitoring Recommendations

The following future monitoring is recommended based on the 2025 data:

1. Continue monitoring the major lakes of the District using the Met Council CAMP Program.
2. Consider diagnostic monitoring in the Shields lake subwatershed to determine possible the sources of high loading observed in July 2024
3. Collect follow up sediment cores for Shields Lake alum treatment to evaluate effectiveness.
4. The 2025 results from Nielson Lake support the continued nutrient impairment and the MPCA should consider it for TMDL development
5. Continued hypolimnion orthoP monitoring is recommended to continue on Little Comfort Lake, Forest Lake – Middle, Moody Lake and Shields Lake

6.2. Stream monitoring

The main takeaways for the 2025 stream monitoring season include:

1. Nitrogen levels were low, and no chloride readings exceeded State standards District-wide at all sites.
2. In 2025, the peak flow was observed in early spring, late June to late July and late September all sites.
3. Peaks in flow led to peaks in TP and TSS loads and corresponding peaks in in-lake concentrations, particularly in July.
4. The loads in 2025 were less than those observed in 2024 and reflect an average year of loading compared to the most recent years of extremes.

Stream Monitoring Recommendations

Due to budget constraints and the robust dataset that the District has built, the long-term stream monitoring is proposed to be conducted on a rotating basis, instead of annually.

6.3. Diagnostic monitoring

The results revealed hot spots of TP loads along Sunrise River headwaters as its flows towards Comfort Lake. The hot spots will be further investigated through the AIG grant and potential projects will be identified.

Key findings from the diagnostic monitoring include:

1. The general trend across all sites is that the water quality was the worst in late summer.
2. There is a significant load reduction through Shallow Pond indicating it is acting as a phosphorus sink.
3. The Bixby Park project continues to reduce TP load downstream.
4. The wetlands and ditches in the CL4 and CL7 subwatersheds will be investigated further in the AIG.

6.4. DIY and CAT monitoring

The main takeaways for the 2025 DIY and CAT monitoring season include:

1. DIY data from 2023-2025 was used to identify one potential project within the direct drainage network to Comfort Lake.
    a. This data indicates an older stormwater pond that drains directly to the wetland fringe of Comfort Lake needs to be cleaned out to restore function. Staff have secured grant funding and are currently developing this project for implementation in 2027 or beyond.
2. Results also indicate some potential loading from the agriculture areas to the south southwest of Shields Lake and several wetlands (sites S-3, S-9) adjacent to a housing development in this subwatershed.
3. The 2025 CAT program found several monitoring locations/subwatersheds in need of further investigation in the Forest Lake subwatershed
    a. The monitoring may include both wetland soil sampling and tributary/micro-drainage monitoring.

The 2026 CAT/DIY monitoring is shifting focus onto the micro-drainages or subwatersheds of Forest Lake and the southern drainage to Shields Lake. Staff will monitor locations along the flow paths/tributary networks of these micro-drainages to try to identify the underlying source of the nutrient and/or better understand the loading from these drainages. The CAT program will focus on one or two micro-drainages to Forest Lake, while the DIY program will focus on the southwestern agriculture area of Shields Lake.

APPENDIX A. LAKE MONITORING SHEETS

Guidance on how to read the information in the individual lake summaries is provided in the Bone Lake example. Individual lake summaries were developed for the lakes with District goals that were monitored in 2022:

1. Bone
2. Comfort
3. Forest Lake – West Basin
4. Forest Lake – Middle Basin
5. Forest Lake – East Basin
6. Keewahtin
7. Little Comfort
8. Moody
9. School
10. Shields
11. Nielson

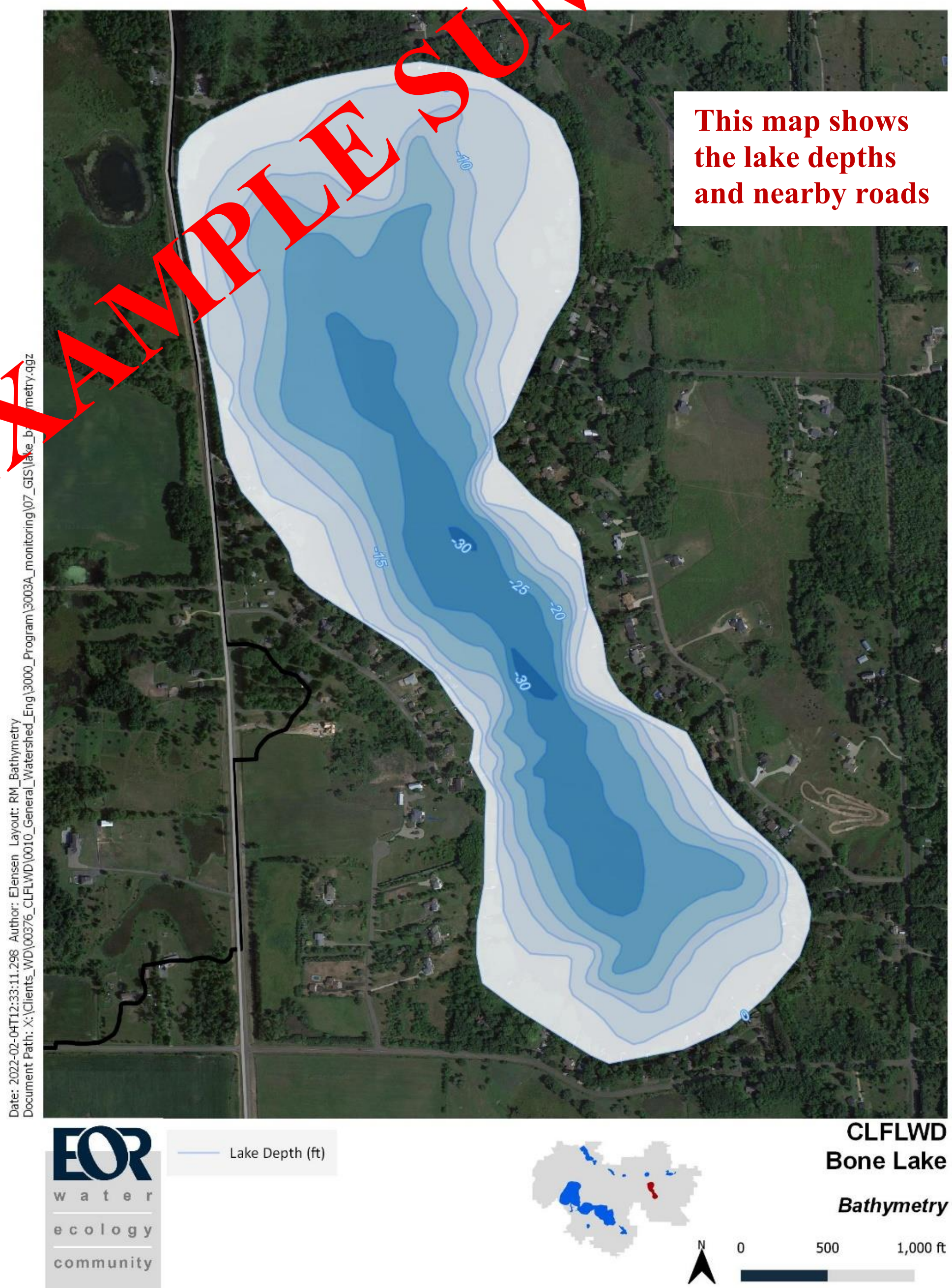
Example Lake Summary

Fast Facts:

DNR Lake ID: 82-0054-00
County: Washington
Surface Area: 221 acres
Littoral Area (depths less than 15 feet): 124 acres
Maximum Depth: 30 feet
Shore Length: 3.01 miles

Some basic information about the lake, such as how big it is and where it is

EXAMPLE SUMMARY



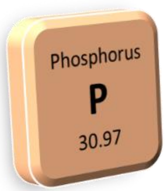
This map shows the lake depths and nearby roads

Example Lake Summary (BONE LAKE)

2025 Surface Water Quality Summary

Nutrients:

June-Sept. Average Total Phosphorus (TP, µg/L)

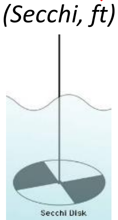


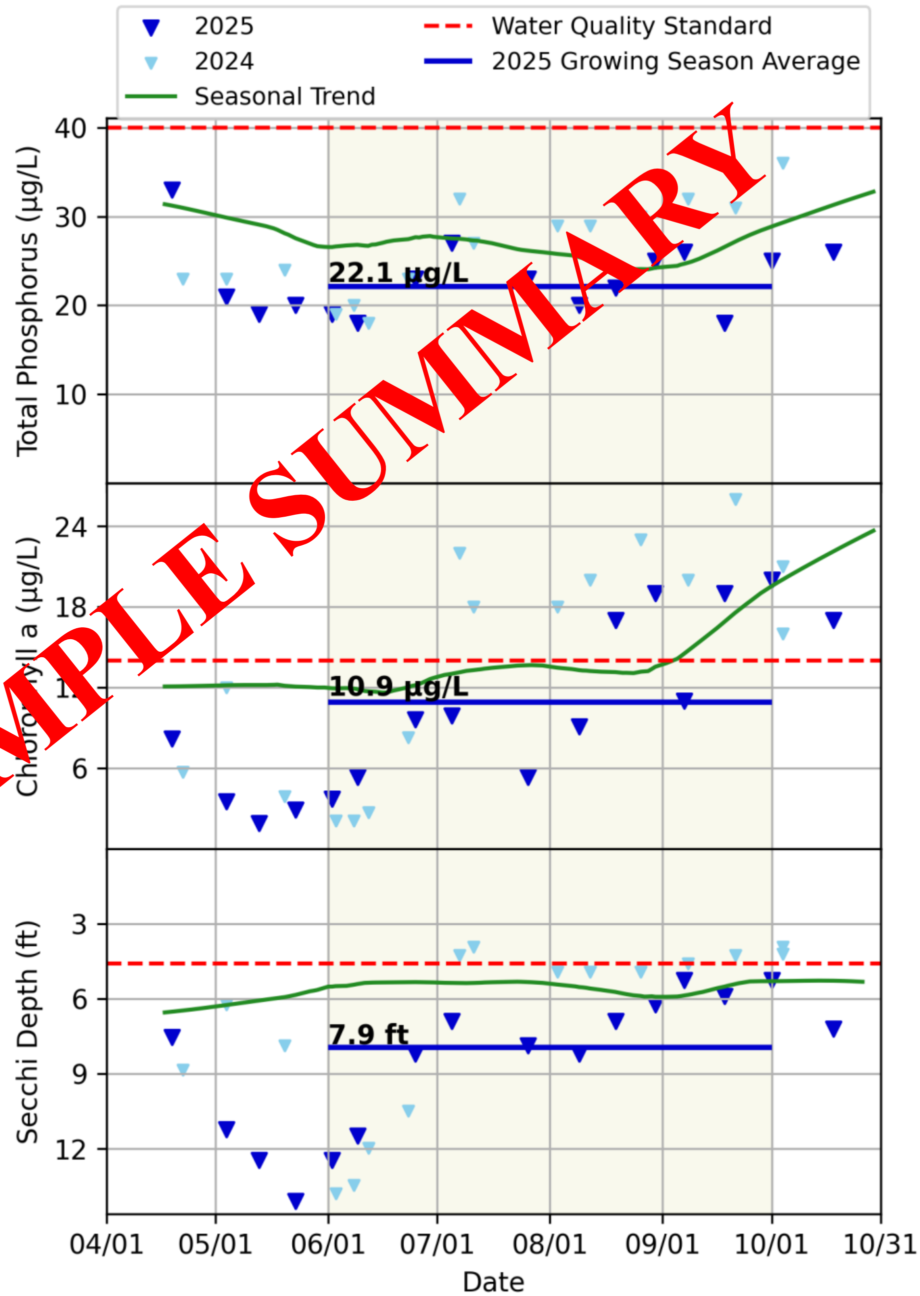
Algae:

Chlorophyll-a (Chl-a, µg/L)

Clarity:

Secchi Depth (Secchi, ft)





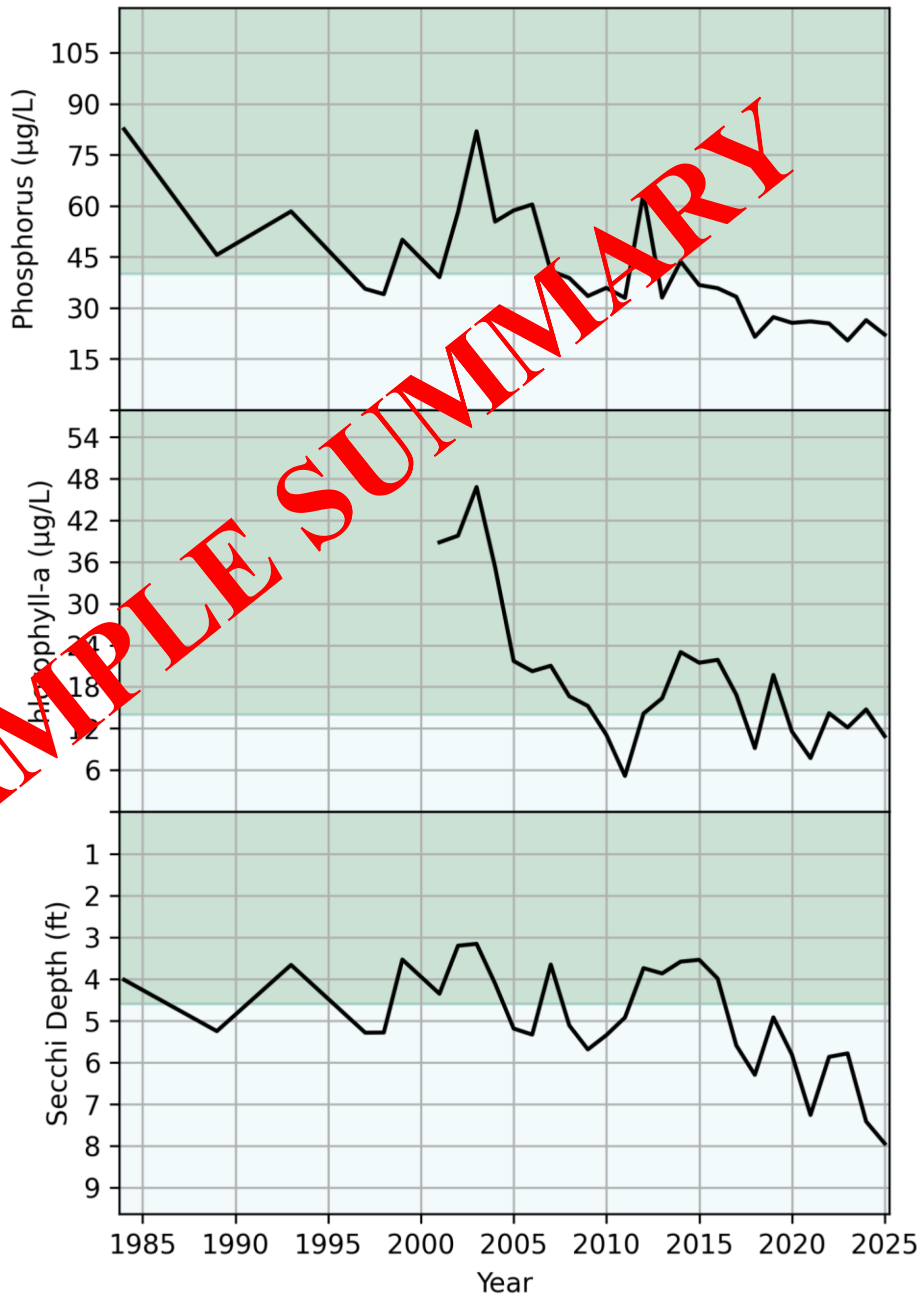
This figure shows all of the water quality samples collected in 2025. Each dot represents one sample date. Navy triangles were collected from surface water in 2025; Light blue triangles were collected in 2024, where available black dots were collected from bottom water and correspond to the secondary axis. The growing season (June-September) is shaded in tan. These samples were used to calculate a growing season average that is labeled in black and represents the navy line and the green line represents the 10-year seasonal average. The red line represents the State water quality standard for each parameter. Points above the line do not meet the water quality sample. However, lakes are only considered impaired if the average of all samples collected during the growing season do not meet the water quality standard.

Example Lake Summary (BONE LAKE)

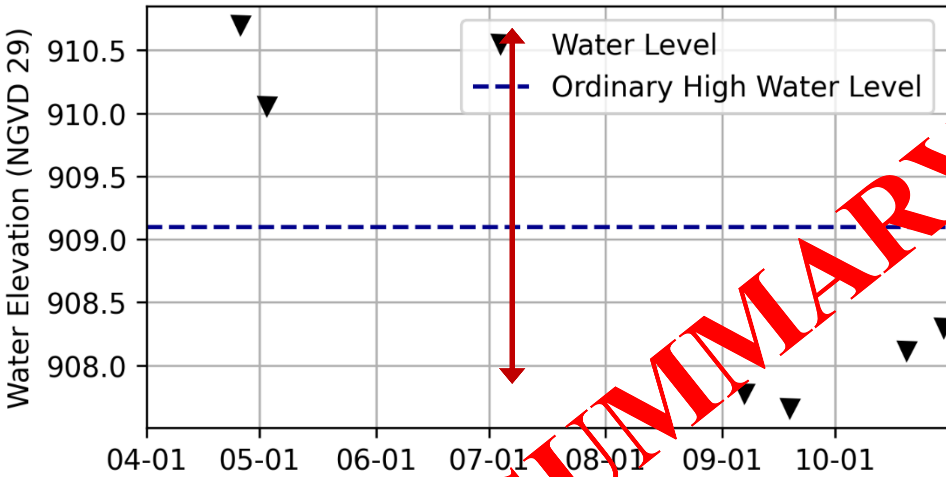
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**26.4**	**13.9**	**6.1**
2040 District Goal	<30	n/a	>7.0
5-year Average (2021-2025)	**24.0**	**11.9**	**6.9**

This figure shows the growing season average by year for each parameter. The line represents the annual growing season average. The <u>darker green area</u> represents growing season average concentrations where water quality is not meeting the State water quality standards. The <u>light blue area</u> represents growing season average concentrations that are meeting the State water quality standards the water quality standard. Lakes are considered impaired if the most recent 10-year average of the annual growing season averages do not meet the water quality standards, shown in the table at the top of the page.



Example Lake Summary (BONE LAKE)



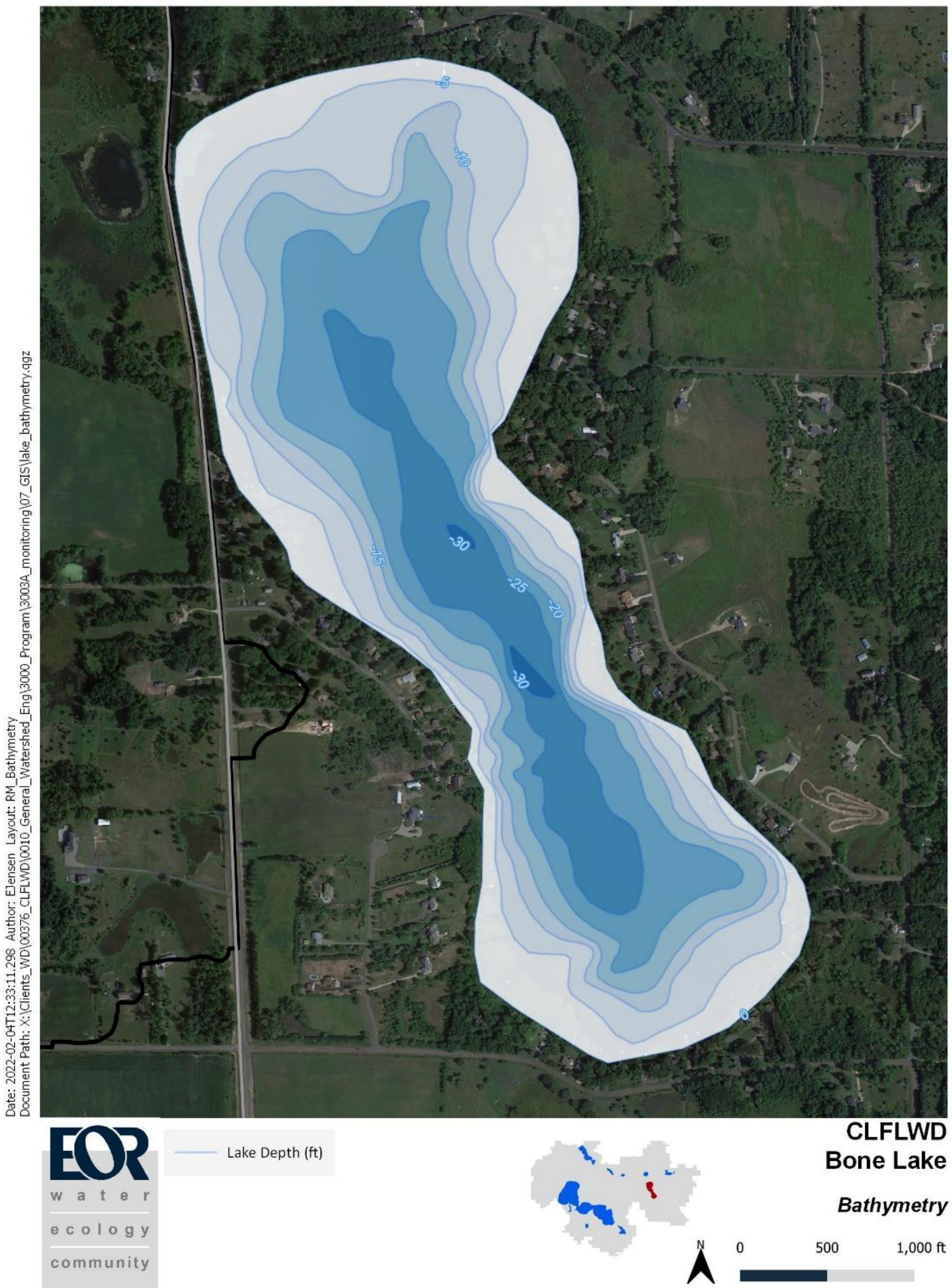
2025 Lake Levels

This figure shows the lake level measurements for 2025. Each triangle represents one measurement. The date is shown along the bottom of the figure as MM-DD. The dashed blue line shows the Ordinary High Water level.

BONE LAKE

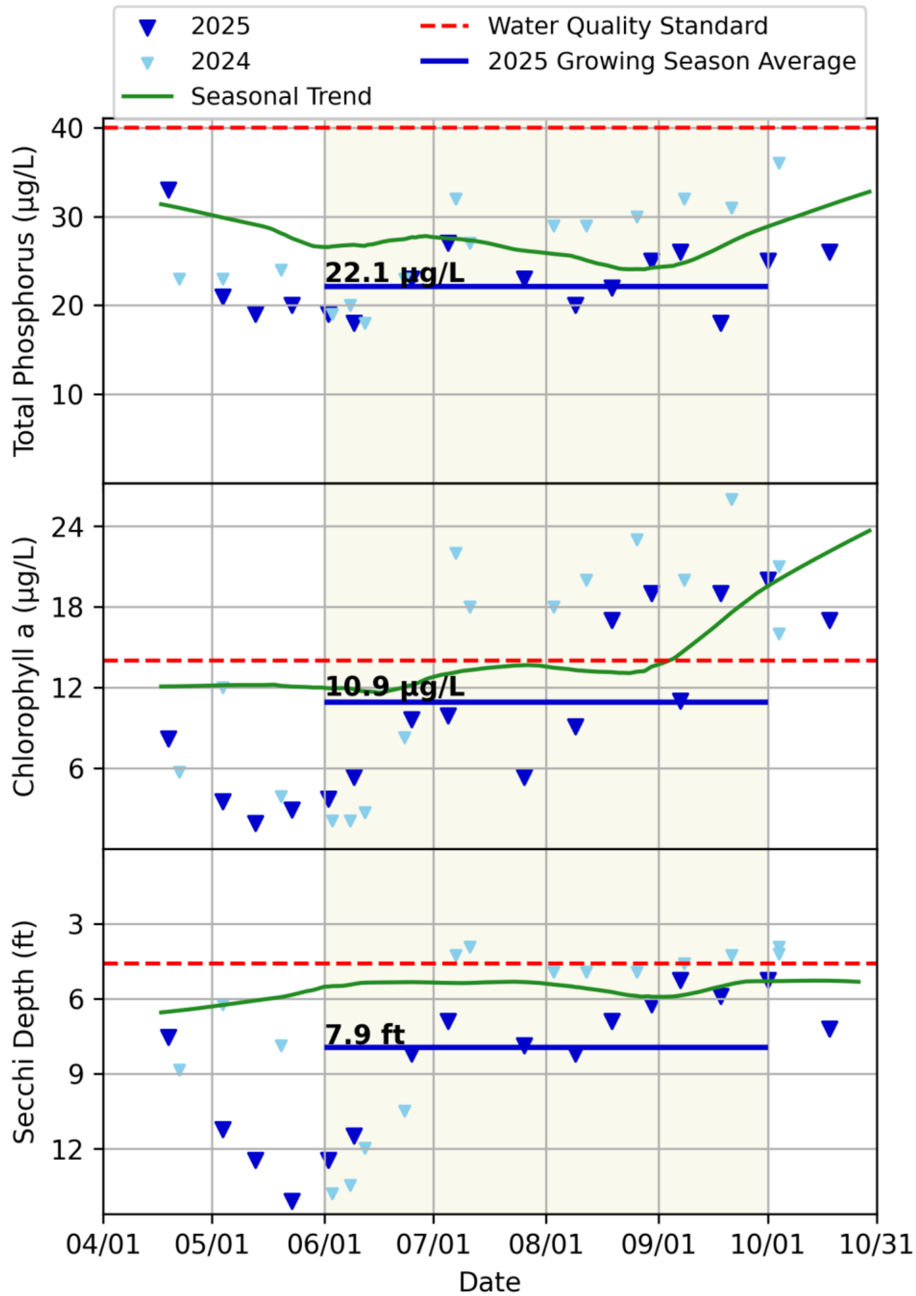
Fast Facts:

DNR Lake ID: 82-0054-00
County: Washington
Surface Area: 221 acres
Littoral Area (depths less than 15 feet): 124 acres
Maximum Depth: 30 feet
Shore Length: 3.01 miles



BONE LAKE

2025 Surface Water Quality Summary

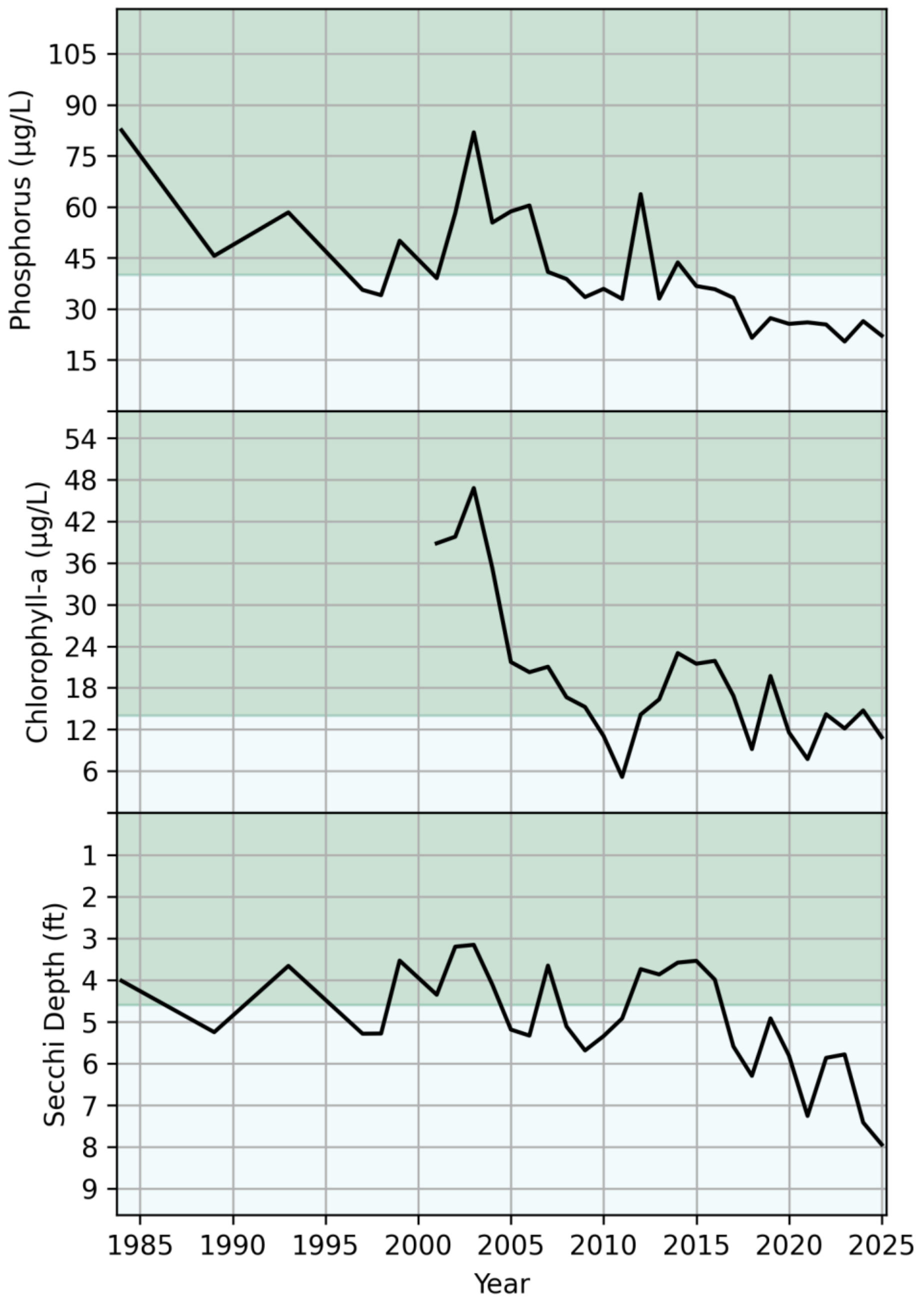


Total phosphorus concentrations in 2025 were lower than in 2024 and remained below the state standard throughout most of the growing season. Chlorophyll-a concentrations were also lower than the previous year, indicating reduced algal productivity. Secchi depth increased slightly compared to 2024, reflecting improved water clarity. Overall, water quality conditions improved slightly in 2025 compared to 2024.

BONE LAKE

Historical Water Quality Summary

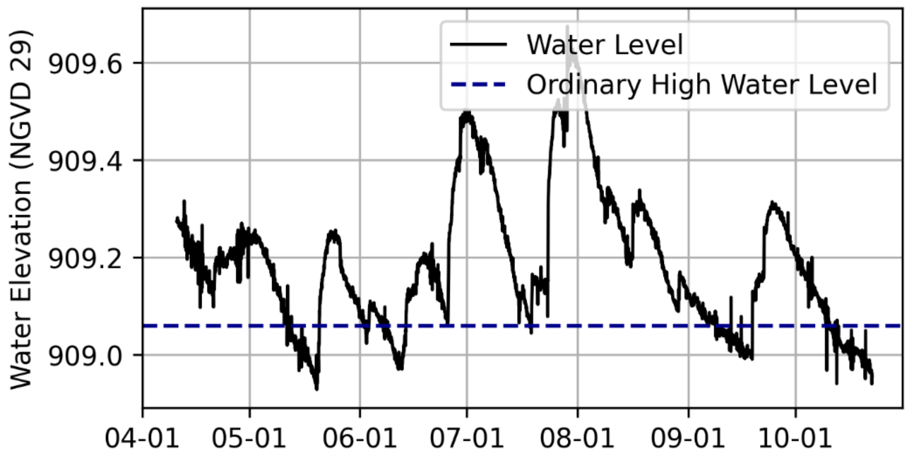
	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**26.4**	**13.9**	**6.1**
2040 District Goal	<30	n/a	>7.0
5-year Average (2021-2025)	**24.0**	**11.9**	**6.9**



The five year water quality averages meet state standards and District goals for total phosphorus and meet state standards for chlorophyll-a and Secchi depth. The five year averages remain slightly better than the ten year averages, indicating modest improvement in recent water quality conditions.

BONE LAKE

2025 Lake Levels

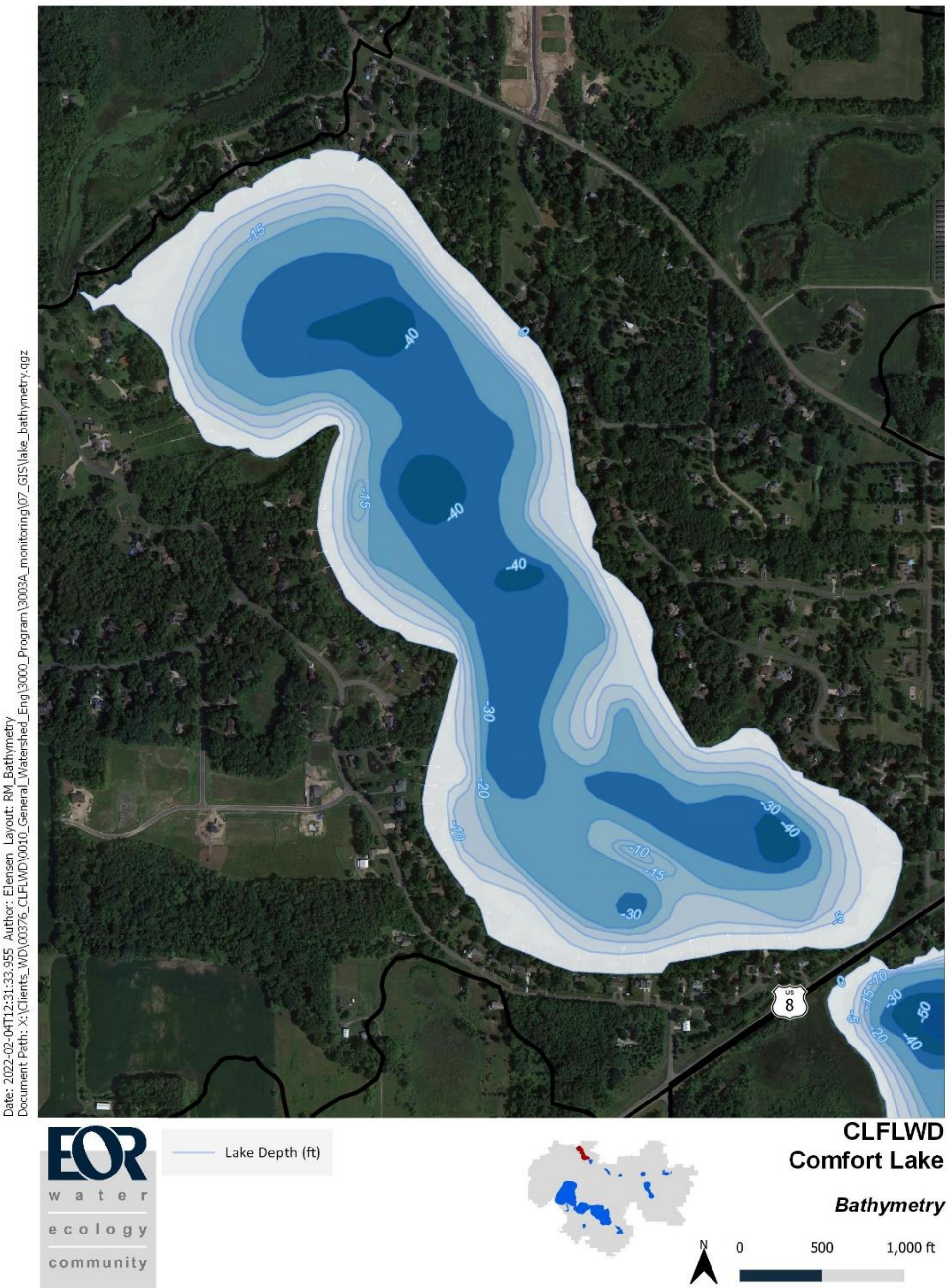


Hourly lake level measurements were recorded this year, ranging from a maximum of 909.67 feet on July 29, 2025 to a minimum of 908.93 feet on May 19, 2025.

COMFORT LAKE

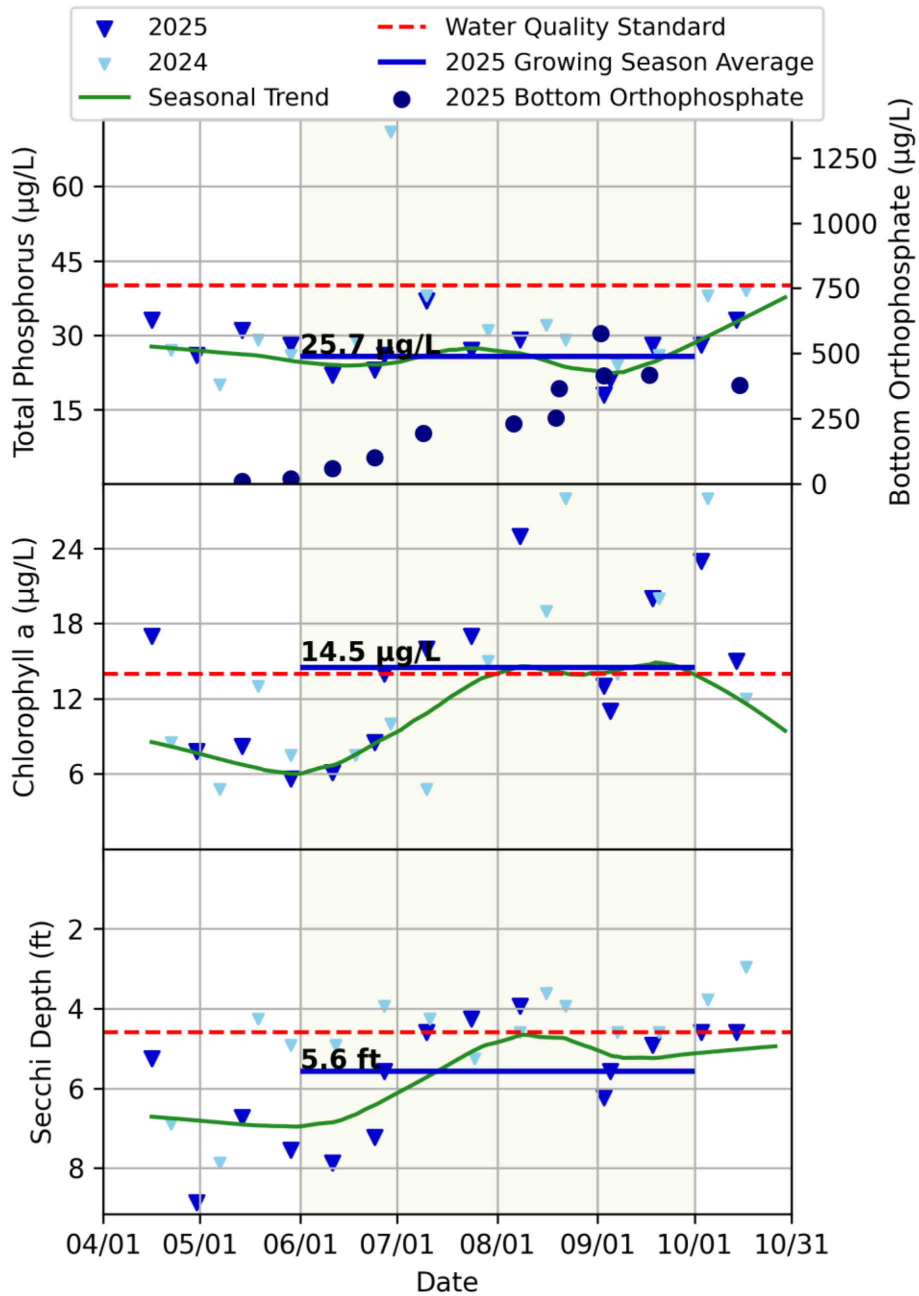
Fast Facts:

DNR Lake ID: 13-0053-00
County: Chisago
Surface Area: 218 acres
Littoral Area (depths less than 15 feet): 90 acres
Maximum Depth: 47 feet
Shore Length: 3.24 miles



COMFORT LAKE

2025 Surface Water Quality Summary

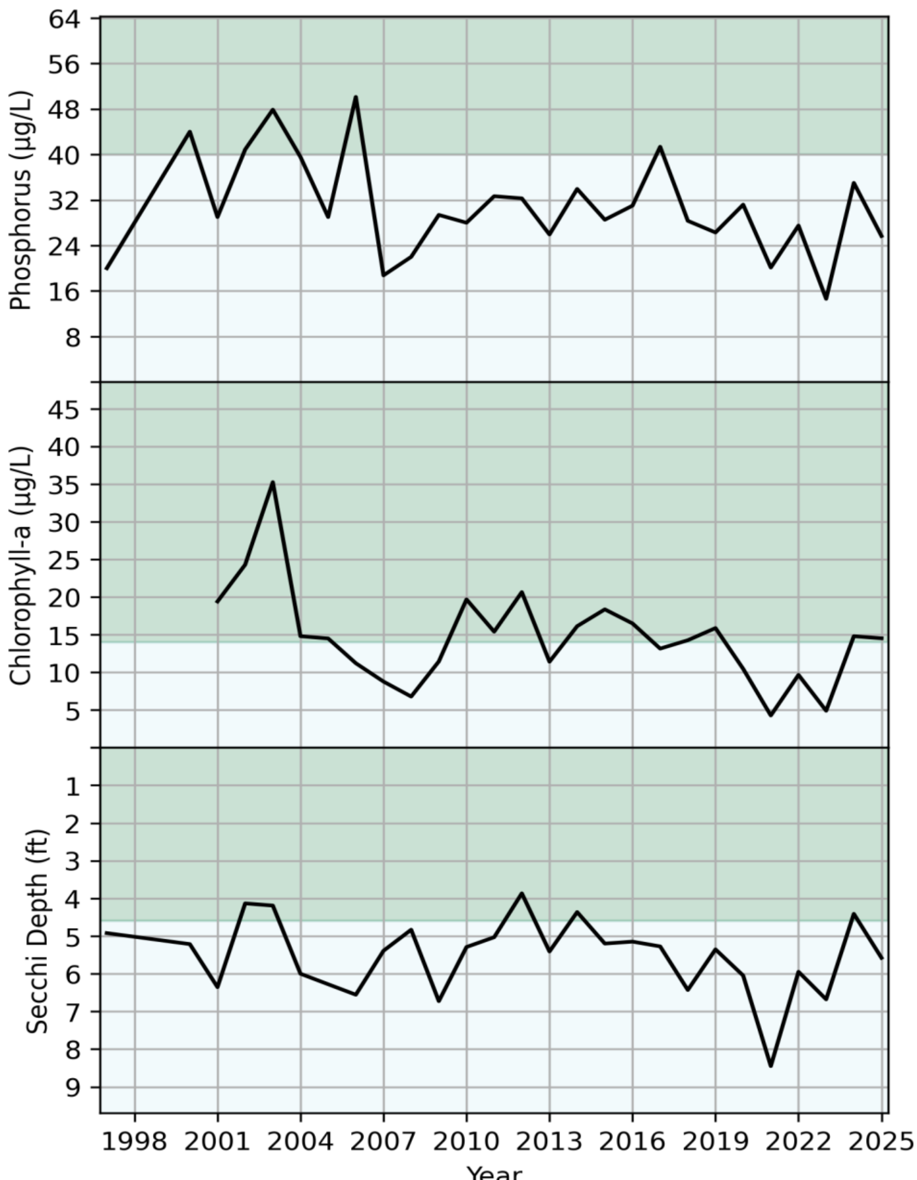


TP concentrations in 2025 were lower than those observed in 2024 and remained near or below the state standard for most of the growing season. Chlorophyll-a concentrations were similar to the previous year. Secchi depth increased compared to 2024, indicating improved water clarity. Overall, water quality conditions in 2025 were slightly improved compared to 2024.

COMFORT LAKE

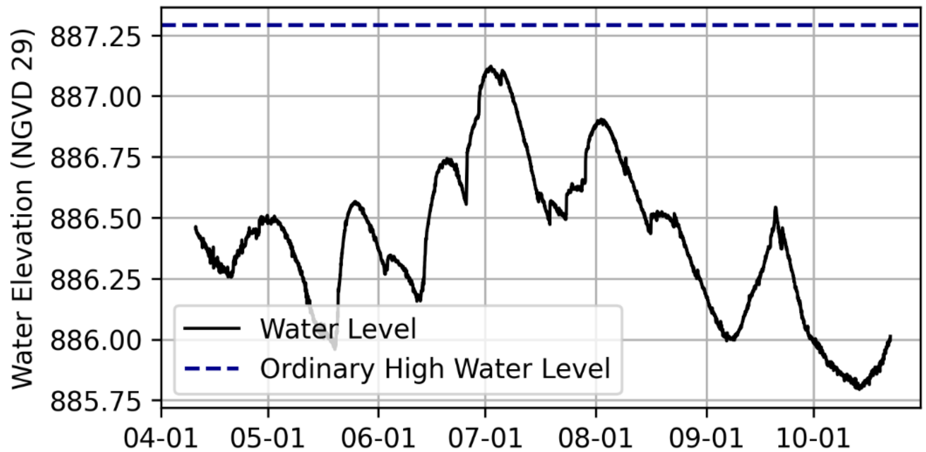
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**28.1**	**11.9**	**5.9**
2040 District Goal	<30	n/a	>7.0
5-year Average (2021-2025)	**24.6**	**9.6**	**6.2**



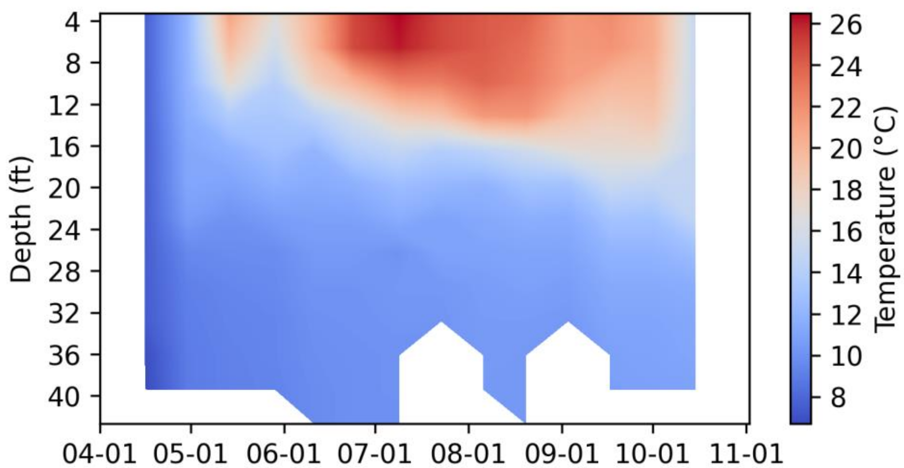
The ten year and five year averages continue to meet state standards and District goals for total phosphorus and meet state standards for chlorophyll-a and Secchi depth. The five year averages remain better than the ten year averages. The 2024 water quality represents higher contribution of external load. In recent drier years there was better water quality, likely due to less contribution from the watershed including ditched wetlands along the Sunrise River.

COMFORT LAKE



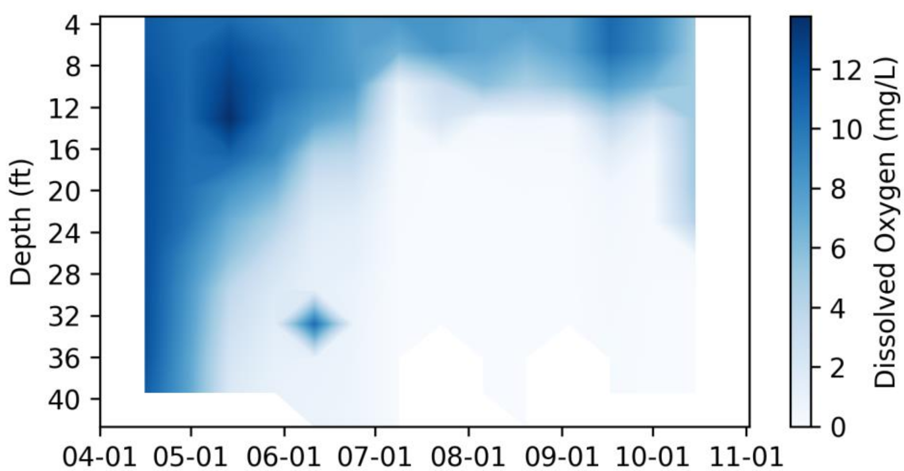
2025 Lake Levels

Hourly lake level measurements were recorded this year, ranging from a maximum of 887.12 feet on July 2, 2025 to a minimum of 885.79 feet on October 13, 2025.



2025 Temperature Profiles

Thermal stratification developed during late spring and persisted through the summer months. The lake remained stratified through much of the growing season until fall turnover occurred near the end of the monitoring period.



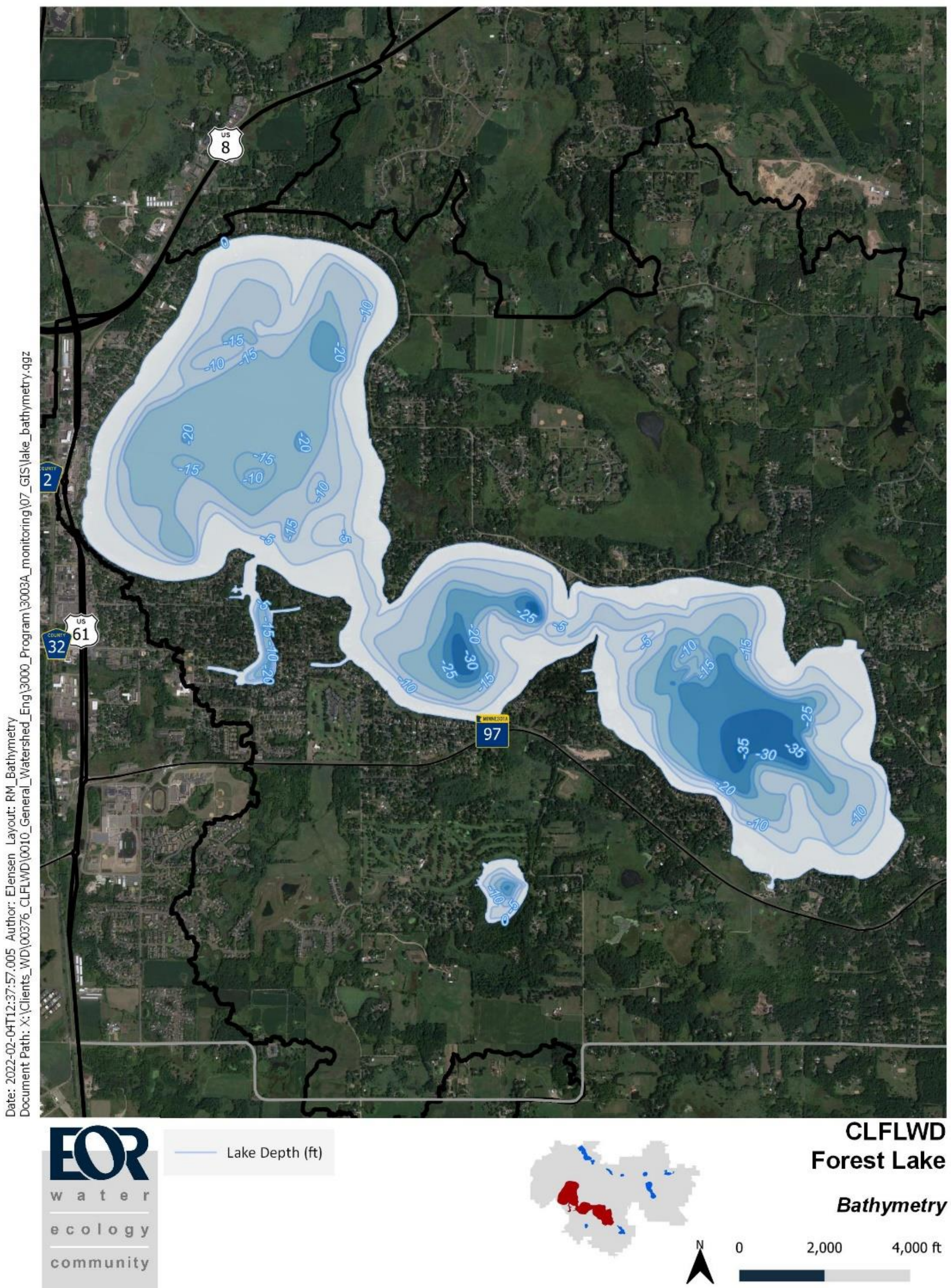
2025 Dissolved Oxygen Profiles

Dissolved oxygen concentrations declined in deeper waters during the stratified period. Periods of low oxygen were observed near the lake bottom, which may allow for internal phosphorus loading from sediments. Oxygen concentrations improved again following fall turnover.

FOREST LAKE

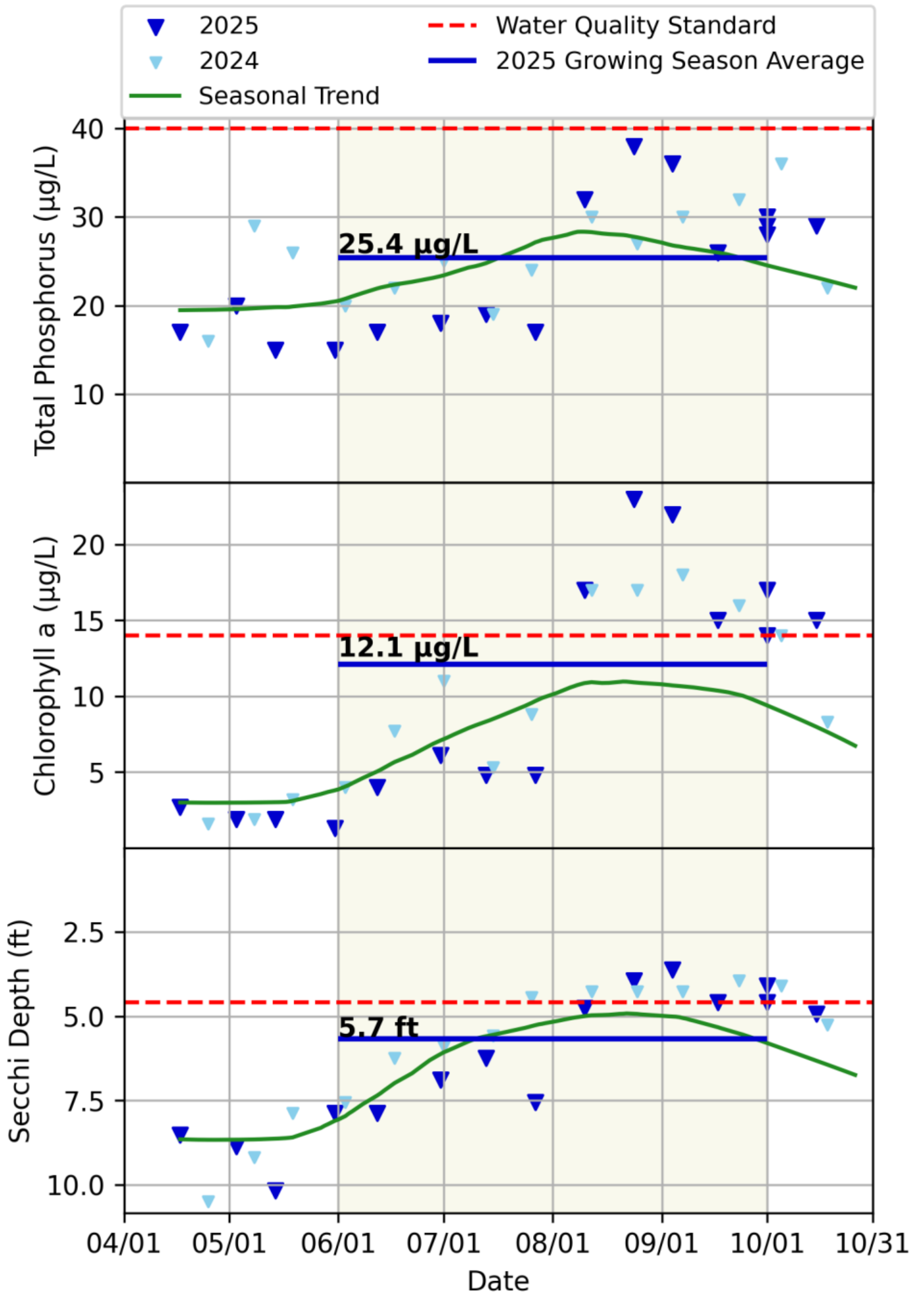
Fast Facts:

DNR Lake ID: 82-0159-00
County: Washington
Surface Area: 2,271 acres
Littoral Area (depths less than 15 feet): 1,531 acres
Maximum Depth: 37 feet
Shore Length: 15.71 miles



FOREST LAKE – WEST BASIN

2025 Surface Water Quality Summary

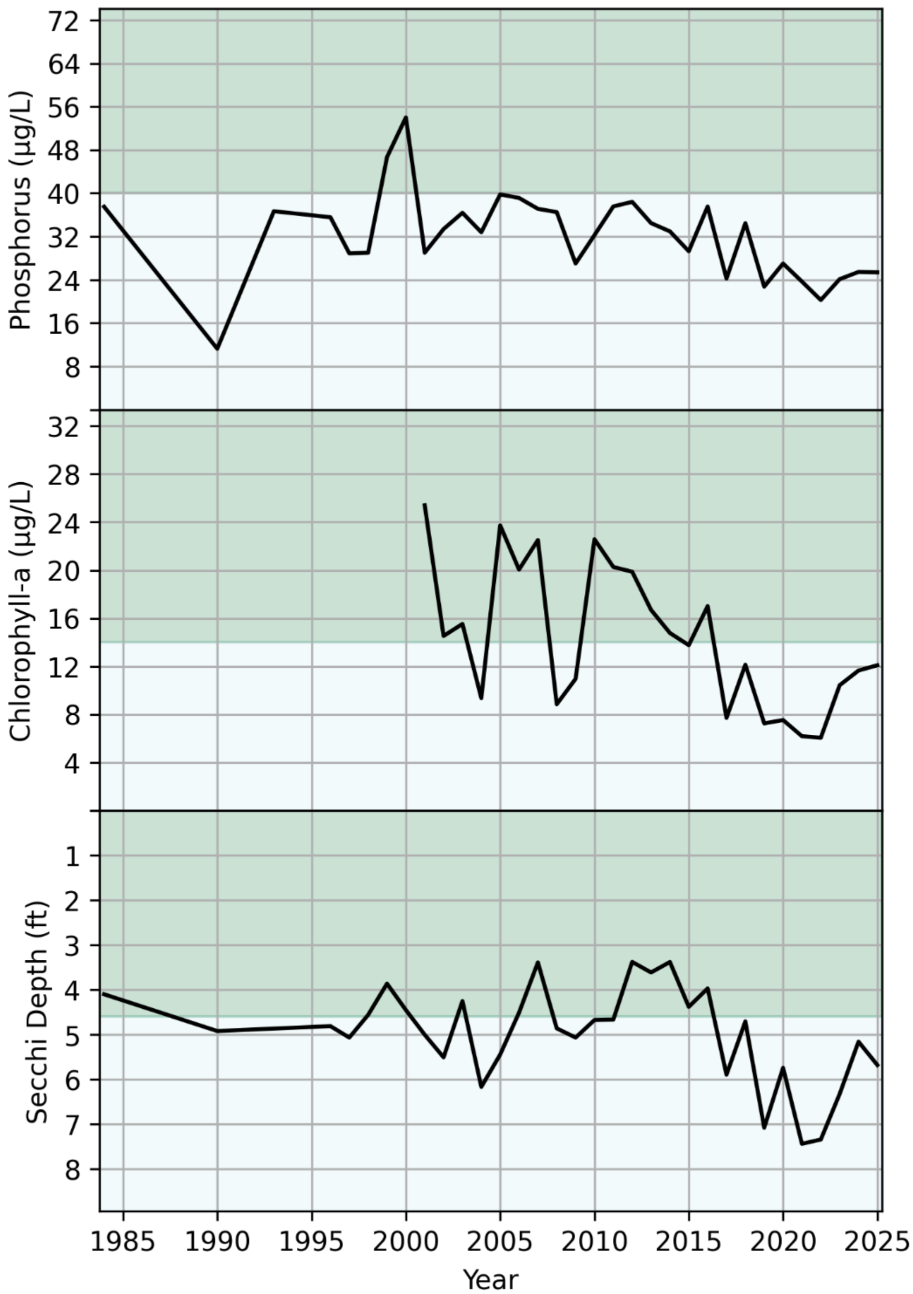


TP in 2025 were slightly below those observed in 2024 and remained within the state standard. Chlorophyll-a concentrations increased slightly compared to the previous year but average remained near the standard. Secchi depth increased slightly, indicating marginally improved water clarity. Overall, water quality conditions remained relatively stable between 2024 and 2025.

FOREST LAKE – WEST BASIN

Historical Water Quality Summary

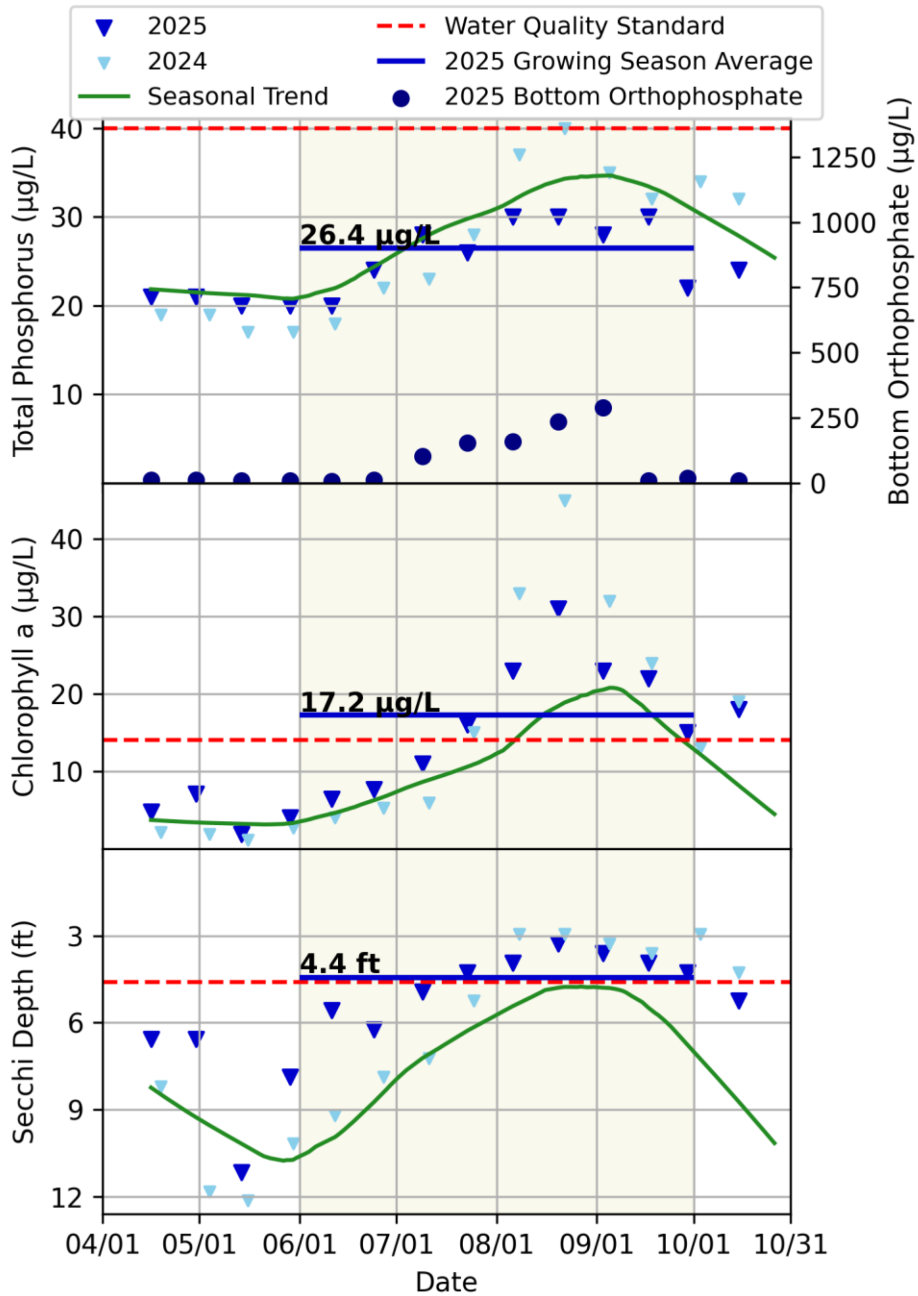
	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**26.5**	**9.8**	**5.9**
2040 District Goal	<30	n/a	>7.0
5-year Average (2021-2025)	**23.8**	**9.3**	**6.4**



Both the five year and ten year averages meet state standards and District goals for everything except five year Secchi depth is shallower than the District goal. The five year averages remain slightly better than the ten year averages, indicating gradual improvement in recent water quality conditions.

FOREST LAKE – MIDDLE BASIN

2025 Surface Water Quality Summary

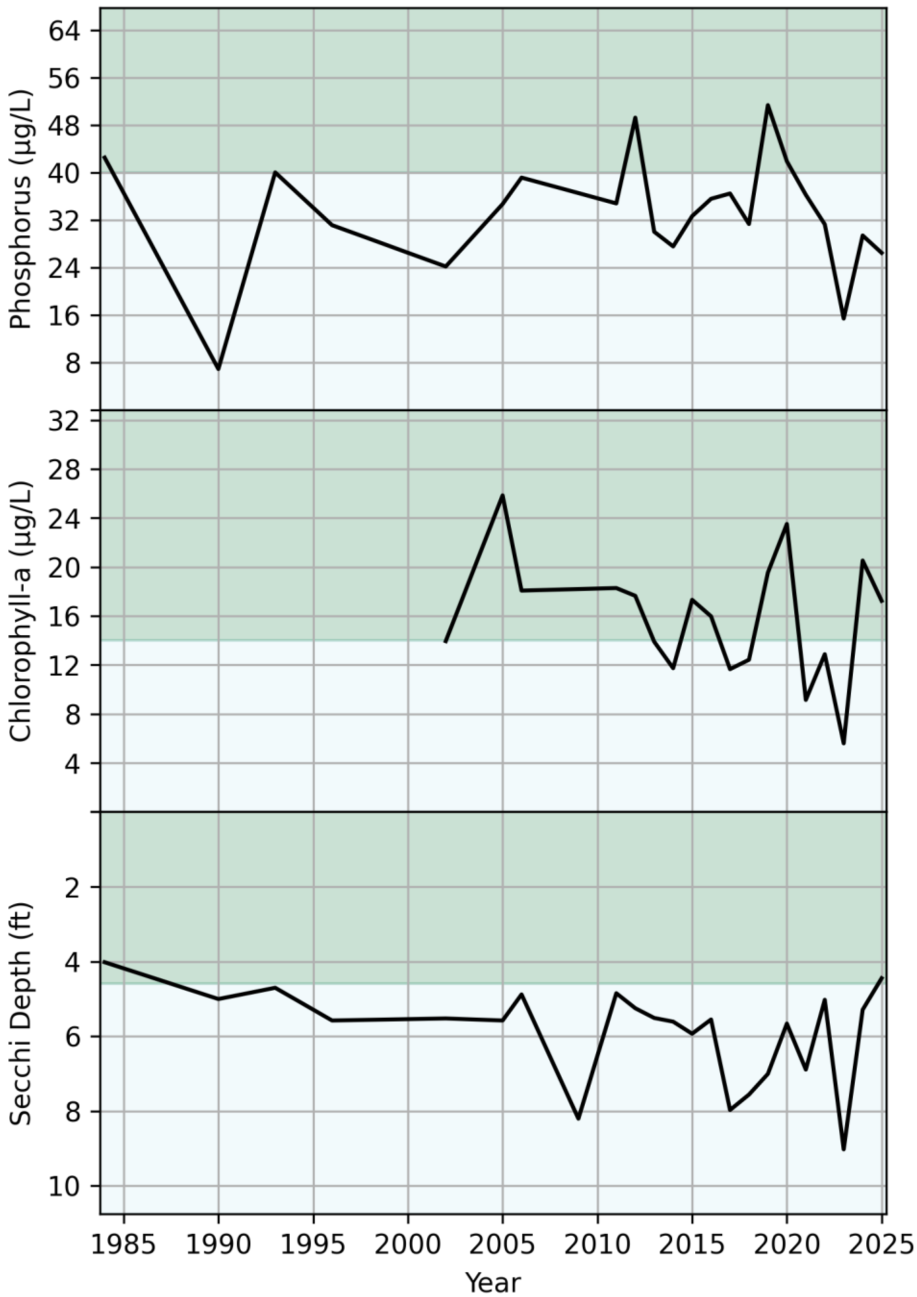


Total phosphorus concentrations decreased slightly in 2025 compared to 2024. The bottom orthoP increased slightly until lake turnover in October. The second alum treatment was applied in early October. Chlorophyll-a concentrations also declined, indicating reduced algal productivity. Secchi depth decreased slightly compared to the previous year. Overall water quality conditions similar compared to 2024.

FOREST LAKE – MIDDLE BASIN

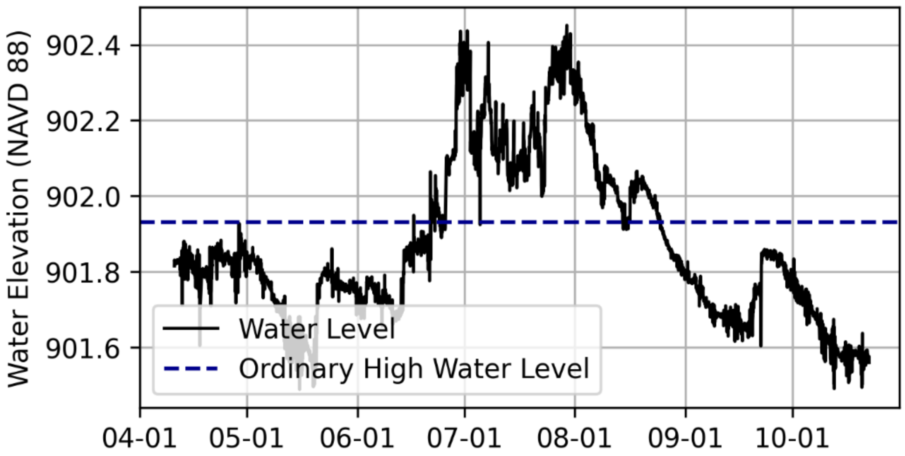
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**33.5**	**14.8**	**6.4**
2040 District Goal	<30	n/a	>7.0
5-year Average (2021-2025)	**27.7**	**13.1**	**6.1**



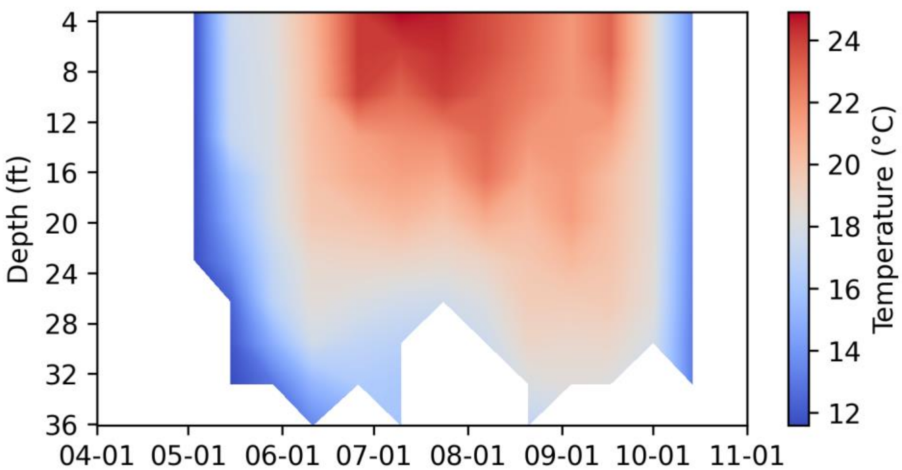
The five year averages remain better than the ten year averages. Water quality conditions remain within state standards for total phosphorus and Secchi depth, although chlorophyll-a occasionally exceeds the standard during peak growing season periods.

FOREST LAKE – MIDDLE BASIN



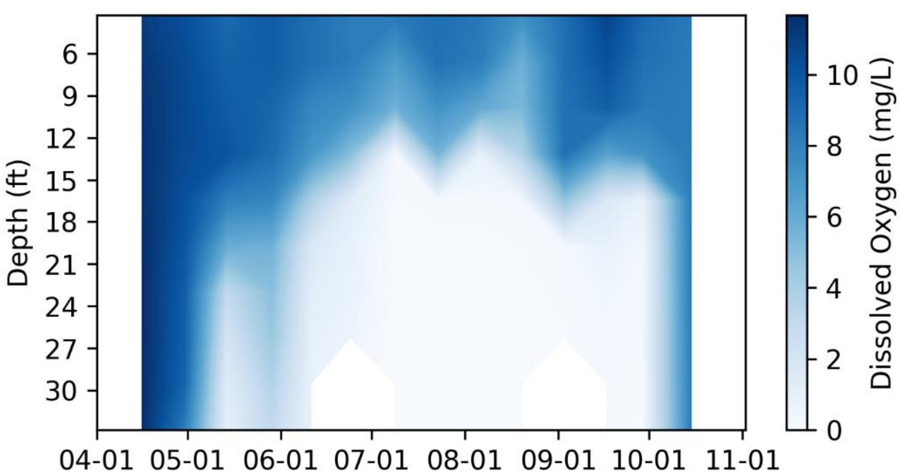
2025 Lake Levels

Hourly lake level measurements were recorded this year, ranging from a maximum of 902.45 feet on July 29, 2025 to a minimum of 901.49 feet on May 15, 2025.



2025 Temperature Profiles

Thermal stratification developed in early summer and persisted through much of the monitoring period. The lake began to mix again during early fall as surface waters cooled.

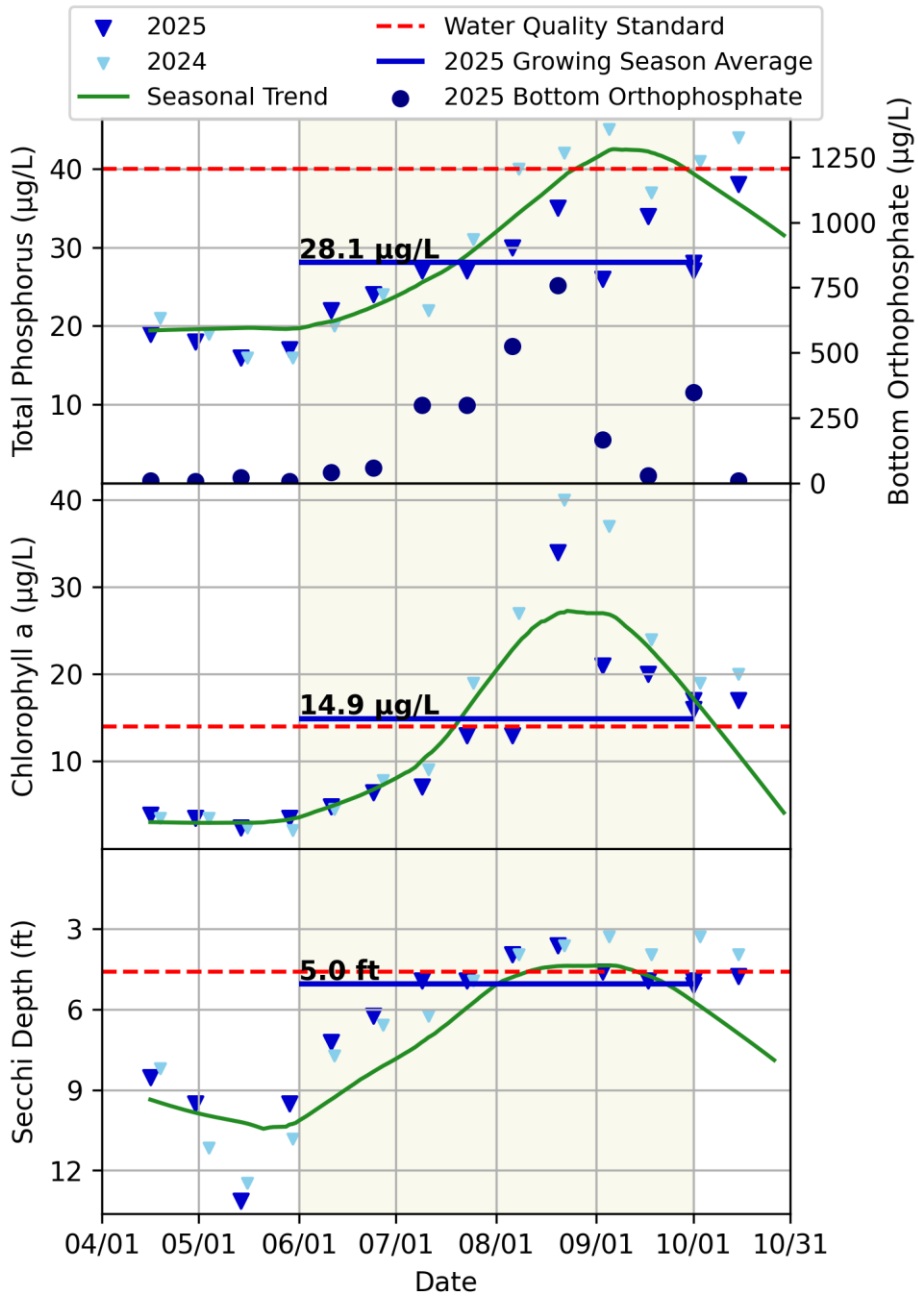


2025 Dissolved Oxygen Profiles

Low dissolved oxygen concentrations developed in deeper waters during the stratified period. These low oxygen conditions may allow phosphorus to be released from lake sediments. Oxygen concentrations improved during fall turnover.

FOREST LAKE – EAST BASIN

2025 Surface Water Quality Summary

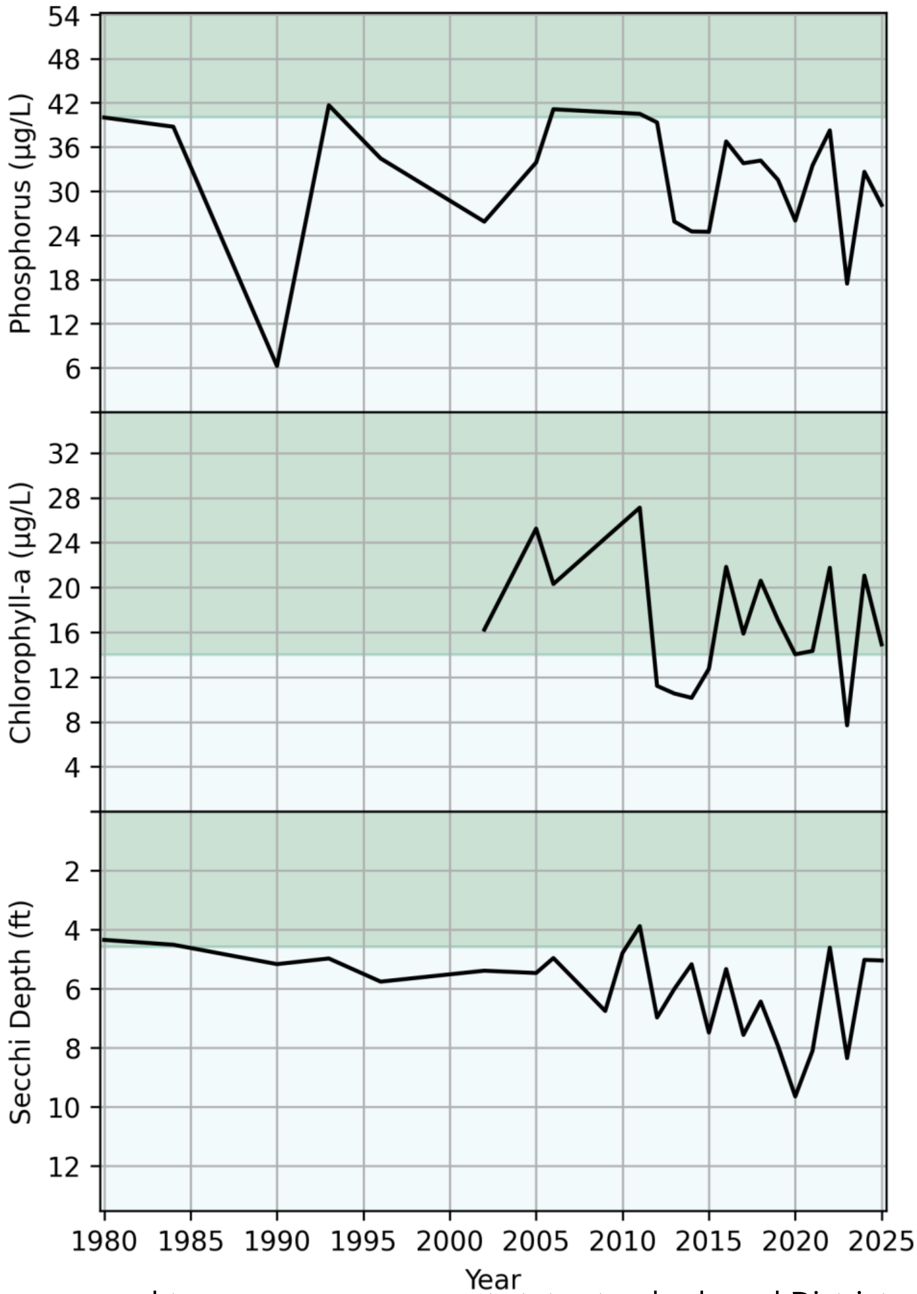


TP concentrations in 2025 were lower than those observed in 2024. Chlorophyll-a concentrations also decreased compared to the previous year, while Secchi depth remained similar between years The bottom orthoP increased until lake turnover. Overall water quality conditions improved slightly compared to 2024.

FOREST LAKE – EAST BASIN

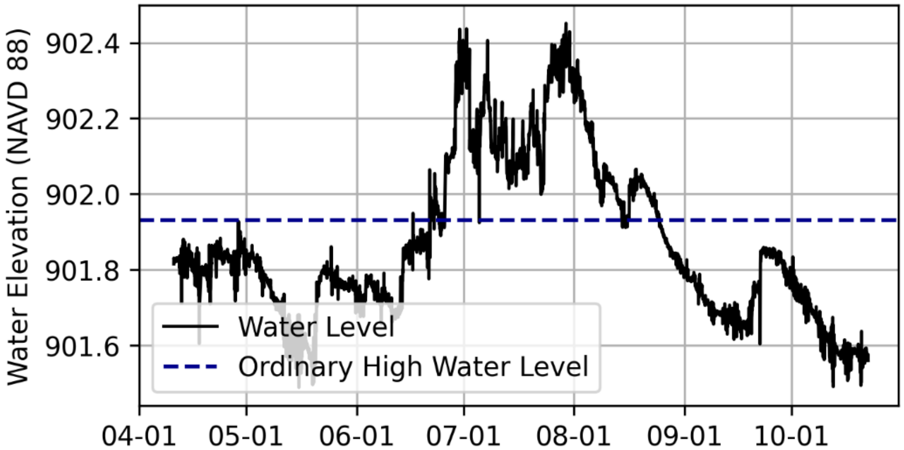
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**31.2**	**16.9**	**6.8**
2040 District Goal	<30	n/a	>7.0
5-year Average (2021-2025)	**30.0**	**15.9**	**6.2**



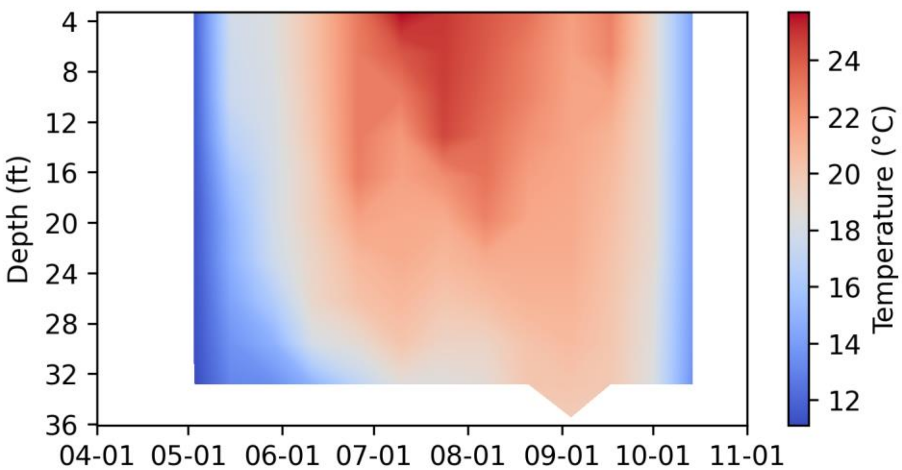
Both the five year and ten year averages meet state standards and District goals for TP. Both averages exceed the chl-a state standard and the Secchi depth is meeting state standards but not District goals. The five year averages remain slightly better than the ten year averages, indicating improved conditions in recent years.

FOREST LAKE – EAST BASIN



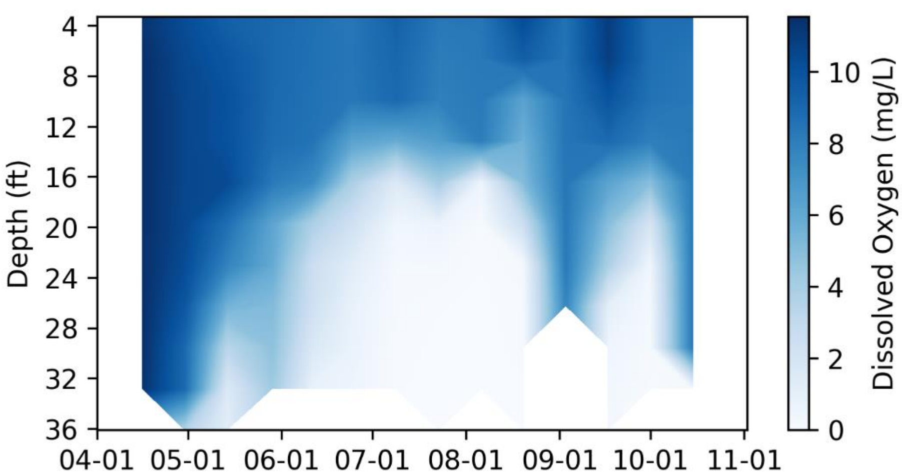
2025 Lake Levels

Hourly lake level measurements were recorded this year, ranging from a maximum of 902.45 feet on July 29, 2025 to a minimum of 901.49 feet on May 15, 2025.



2025 Temperature Profiles

The lake developed thermal stratification during early summer. Stratification persisted through much of the growing season before mixing in September and again during fall turnover.



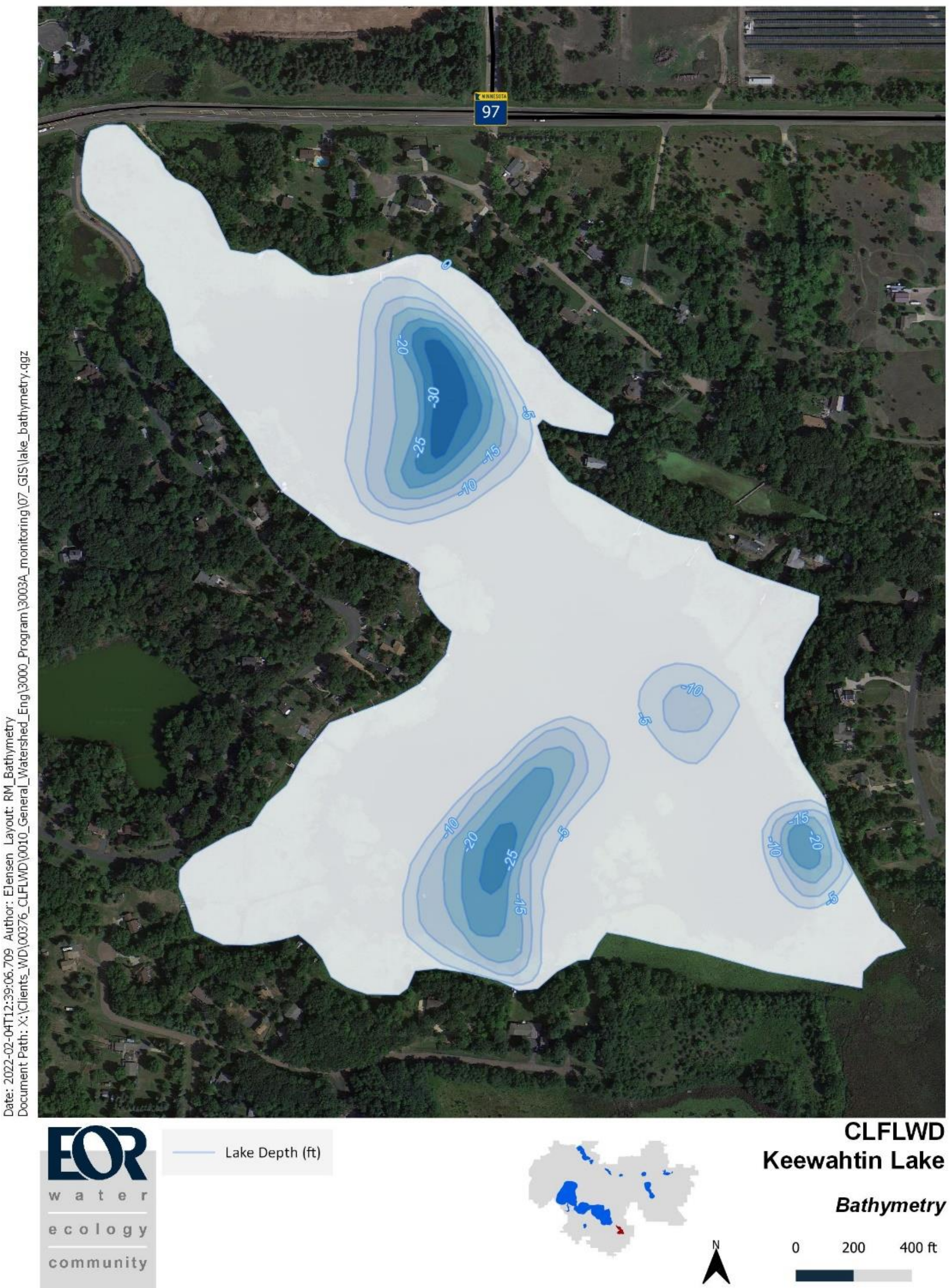
2025 Dissolved Oxygen Profiles

Dissolved oxygen concentrations declined near the lake bottom during the stratified period. Periods of low oxygen occurred in deeper waters, which may contribute to internal phosphorus loading.

KEEWAHTIN LAKE

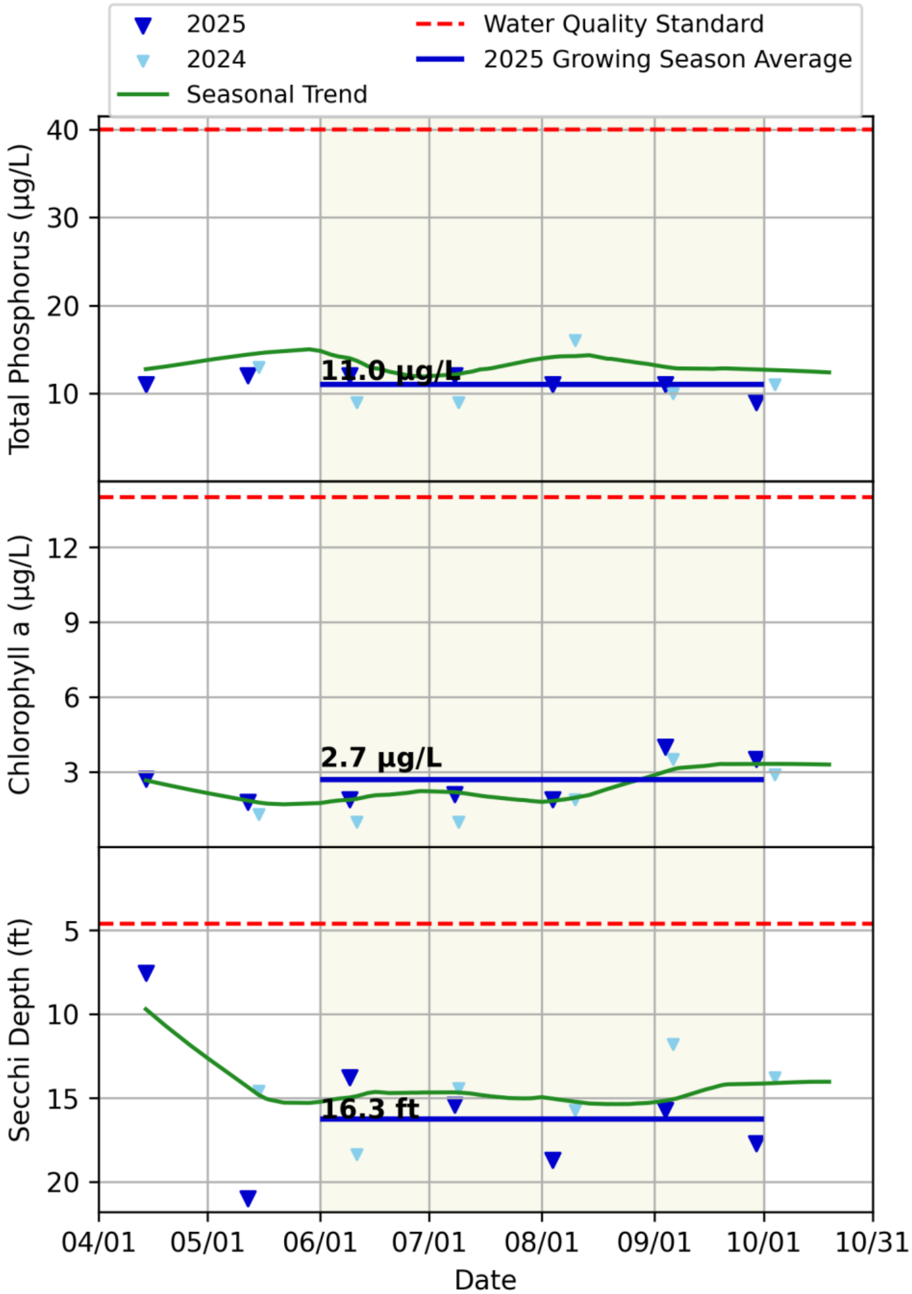
<u>Fast Facts:</u>

DNR Lake ID: 82-0080-00
County: Washington
Surface Area: 92 acres
Littoral Area (depths less than 15 feet): 67 acres
Maximum Depth: 34 feet
Shore Length: 2.2 miles



KEEWAHTIN LAKE

2025 Surface Water Quality Summary

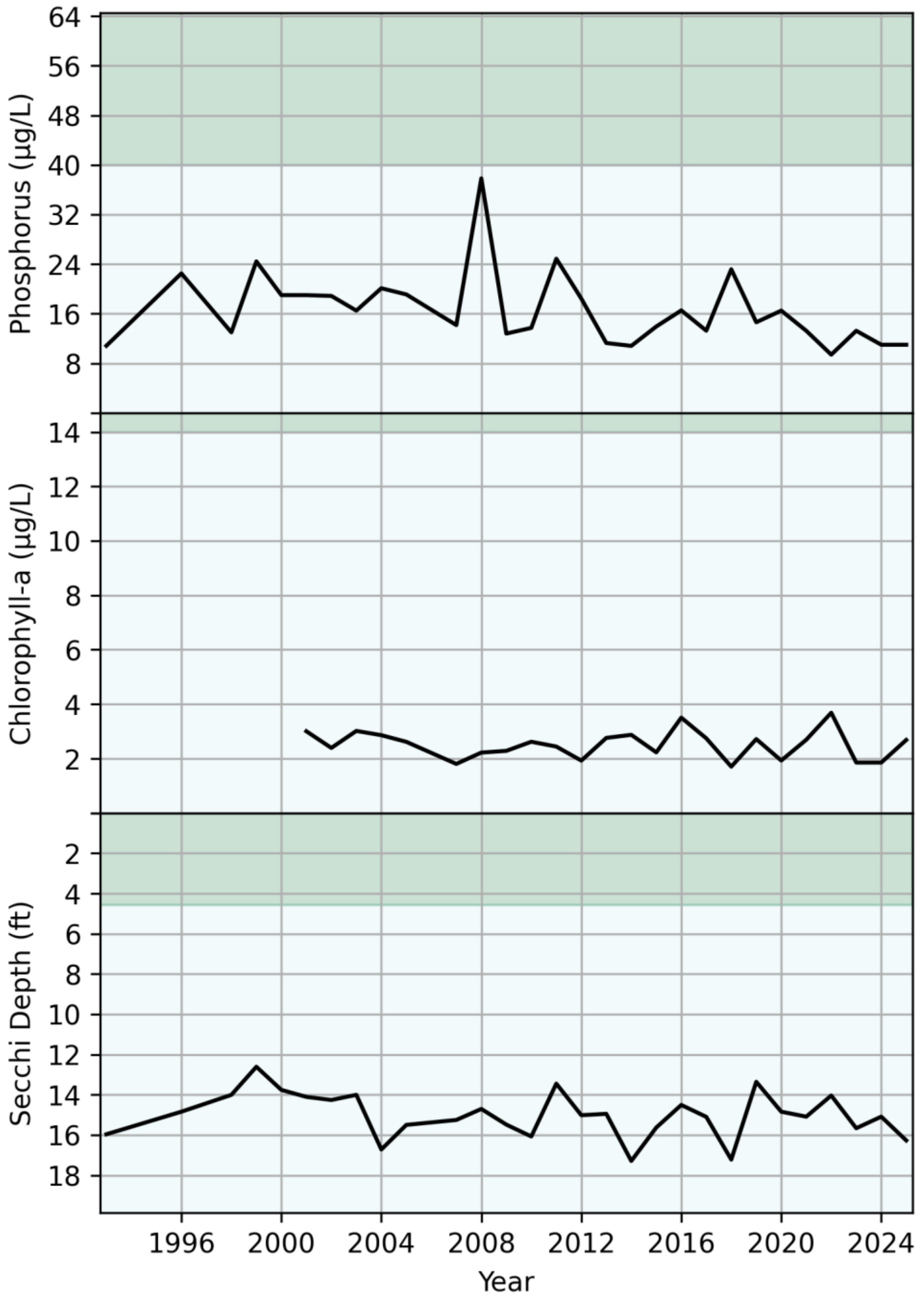


Water quality conditions in 2025 remained excellent. Total phosphorus concentrations remained low and similar to 2024. Chlorophyll-a concentrations remained very low overall. Secchi depth increased slightly compared to 2024 and continued to indicate very clear water.

KEEWAHTIN LAKE

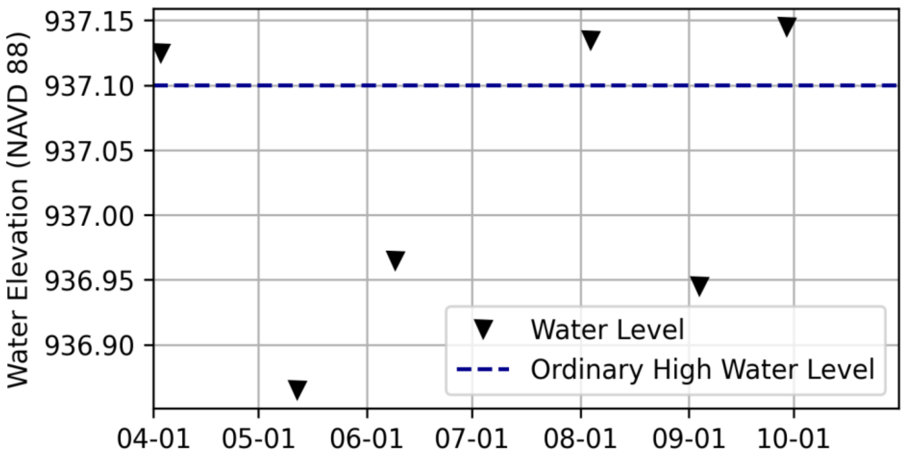
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**14.2**	**2.5**	**15.1**
2040 District Goal	<20	n/a	>10.0
5-year Average (2021-2025)	**11.6**	**2.5**	**15.2**



Historic water quality averages meet state standards and District goals. The five year averages remain slightly better than the ten year averages, indicating continued improvement in water quality conditions.

KEEWAHTIN LAKE



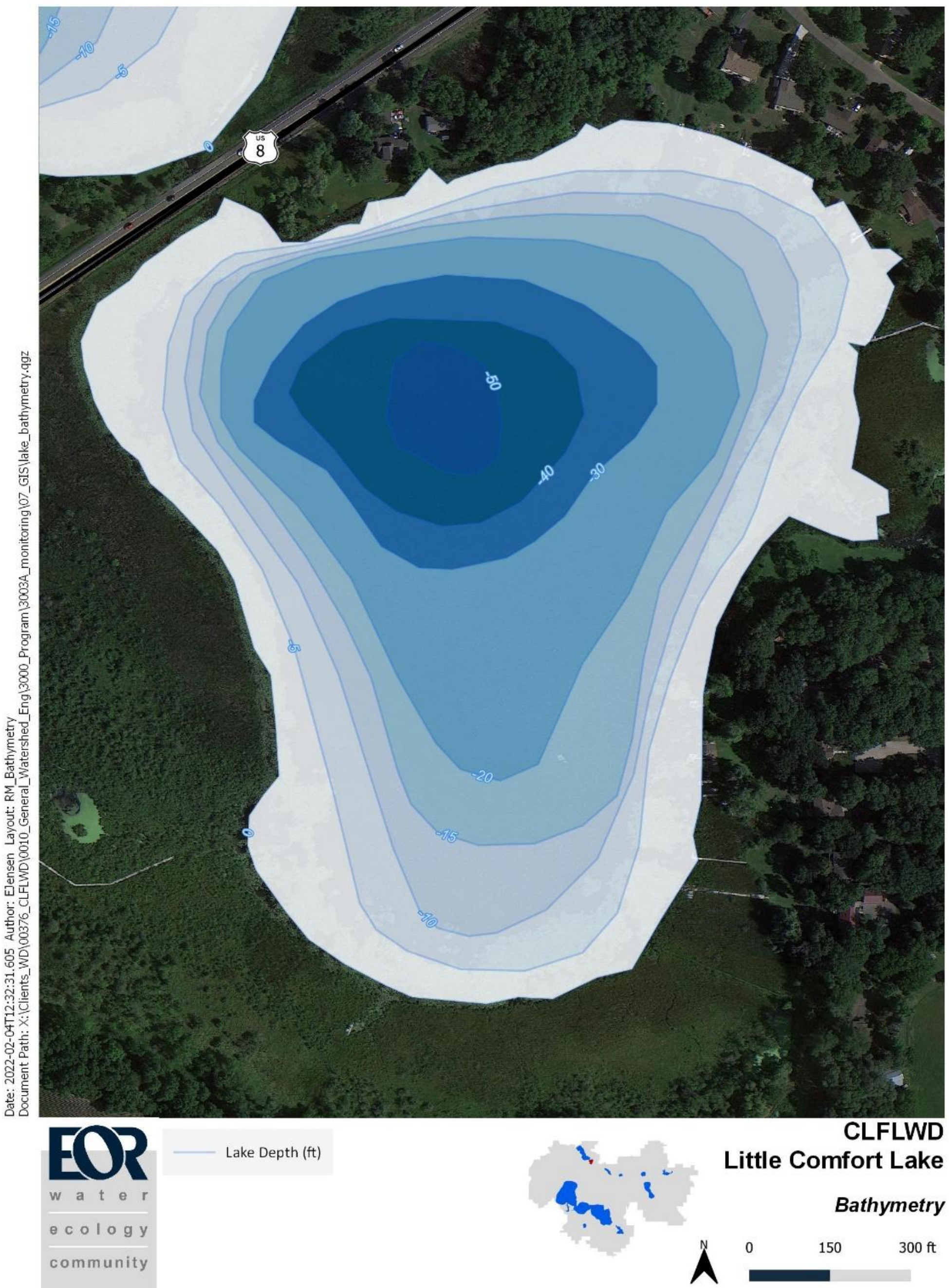
2025 Lake Levels

Lake levels ranged over a total of 0.25 feet; between a minimum of 936.895 feet on May 12, 2025 and a maximum of 937.145 feet on September 29, 2025.

LITTLE COMFORT LAKE

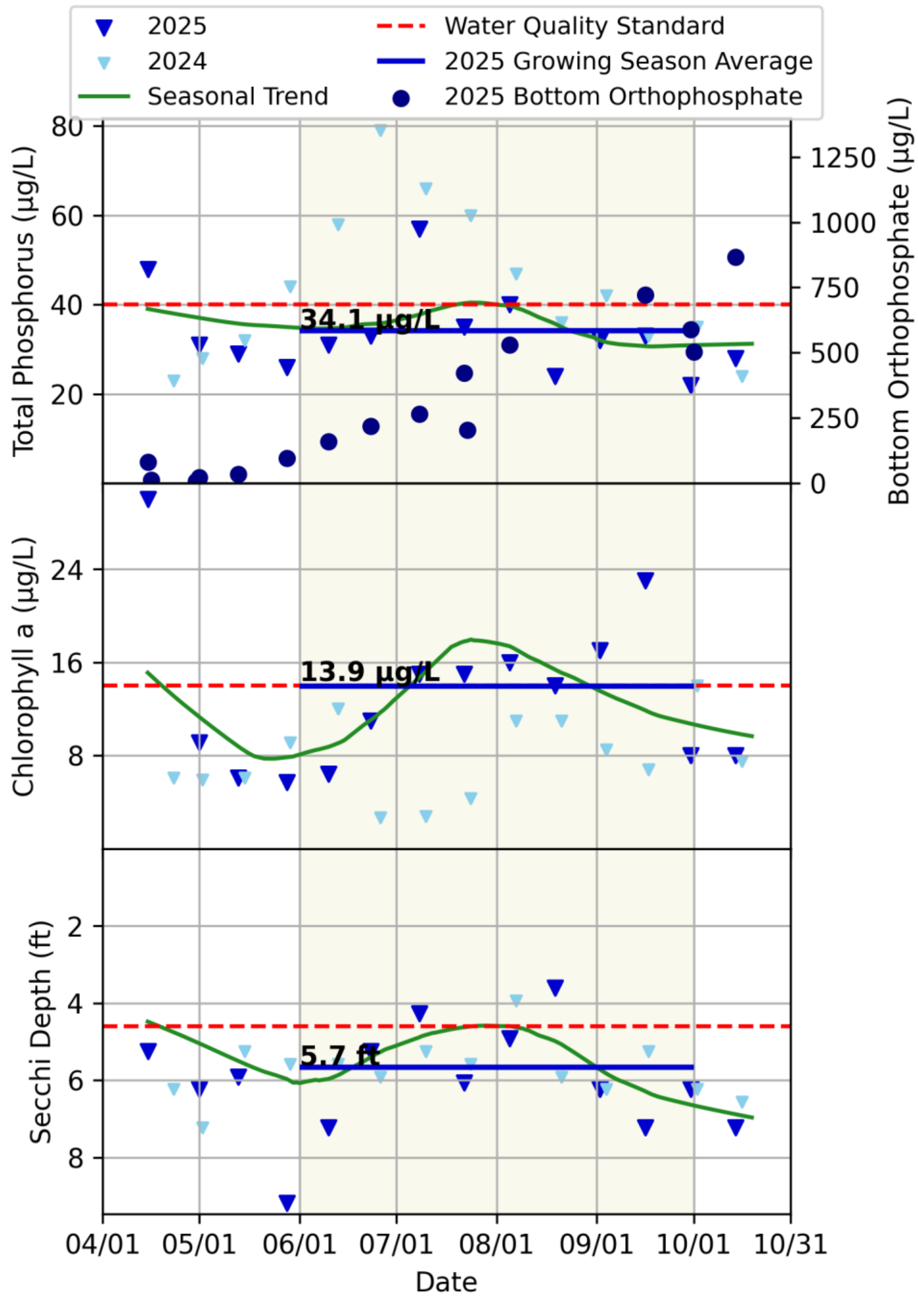
Fast Facts:

DNR Lake ID: 13-0054-00
County: Chisago
Surface Area: 37 acres
Littoral Area (depths less than 15 feet): 16 acres
Maximum Depth: 56 feet
Shore Length: 1.04 miles



LITTLE COMFORT LAKE

2025 Surface Water Quality Summary

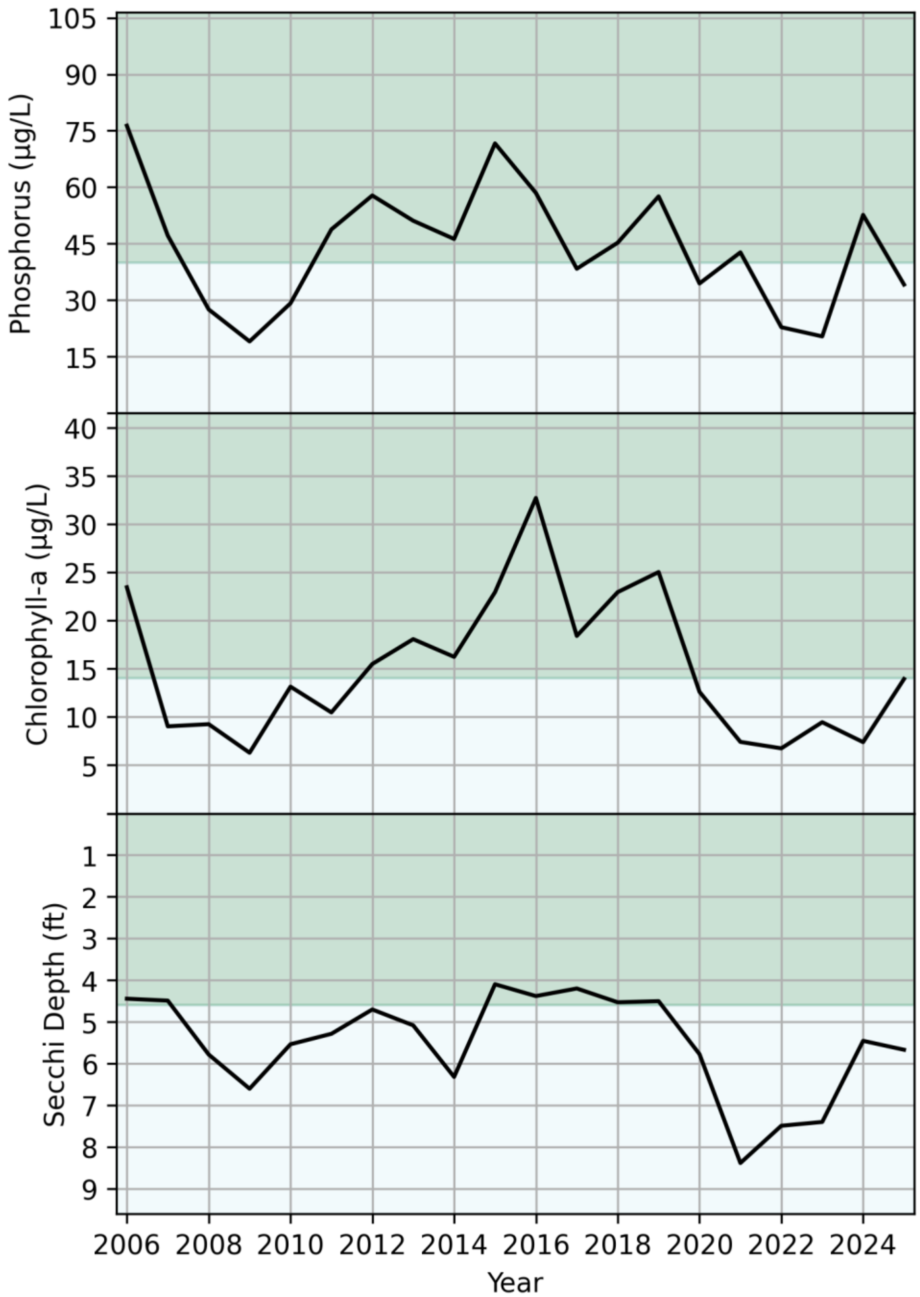


TP concentrations decreased substantially in 2025 compared to 2024. However, chlorophyll-a concentrations increased compared to the previous year. Secchi depth increased slightly compared to 2024. The bottom orthoP concentrations increased until lake turnover.

LITTLE COMFORT LAKE

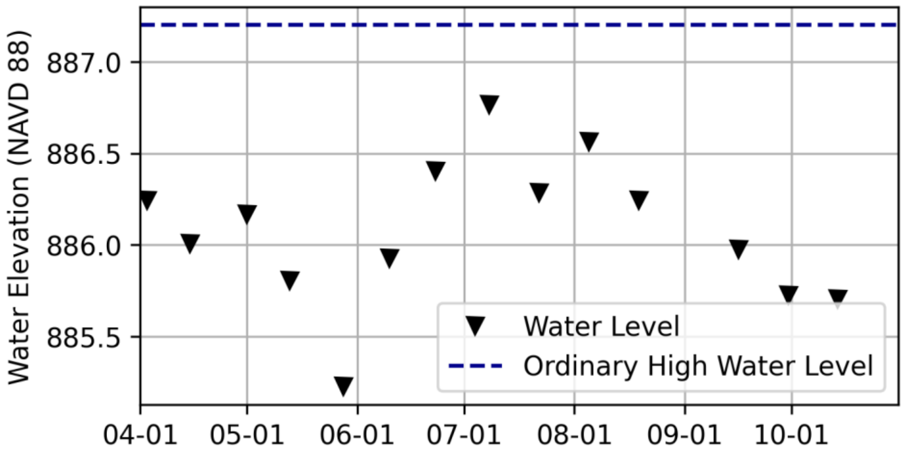
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**40.6**	**15.7**	**5.8**
2040 District Goal	<30	n/a	>7.0
5-year Average (2021-2025)	**34.5**	**9.0**	**6.9**



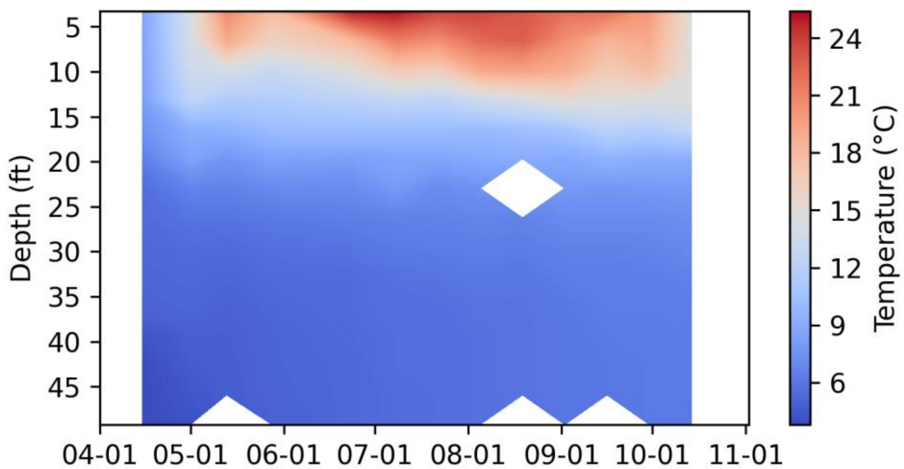
The five year averages show improved water quality compared to the ten year averages. The five year average is meeting state standards for all parameters.

LITTLE COMFORT LAKE



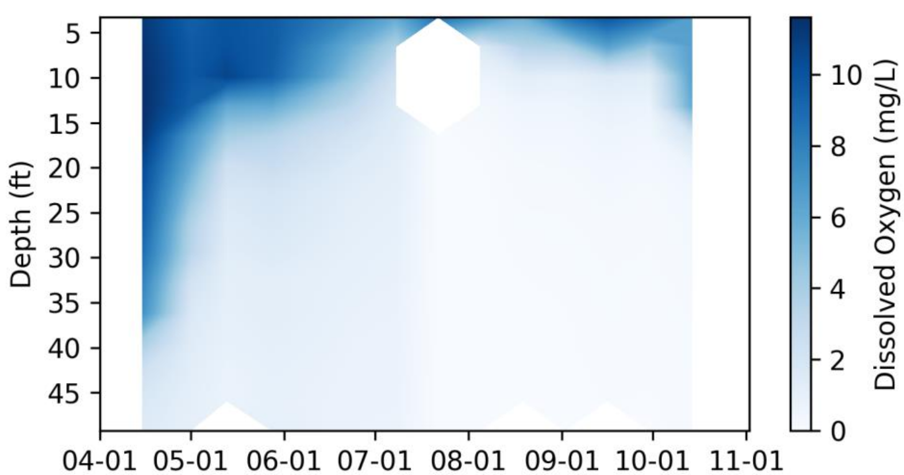
2025 Lake Levels

Lake levels ranged over a total of 2.7 feet; between a minimum of 884.09 feet on September 2, 2025 and a maximum of 886.77 feet on July 8, 2025.



2025 Temperature Profiles

The lake stratified during late spring and remained stratified through much of the summer until fall turnover began in early fall.



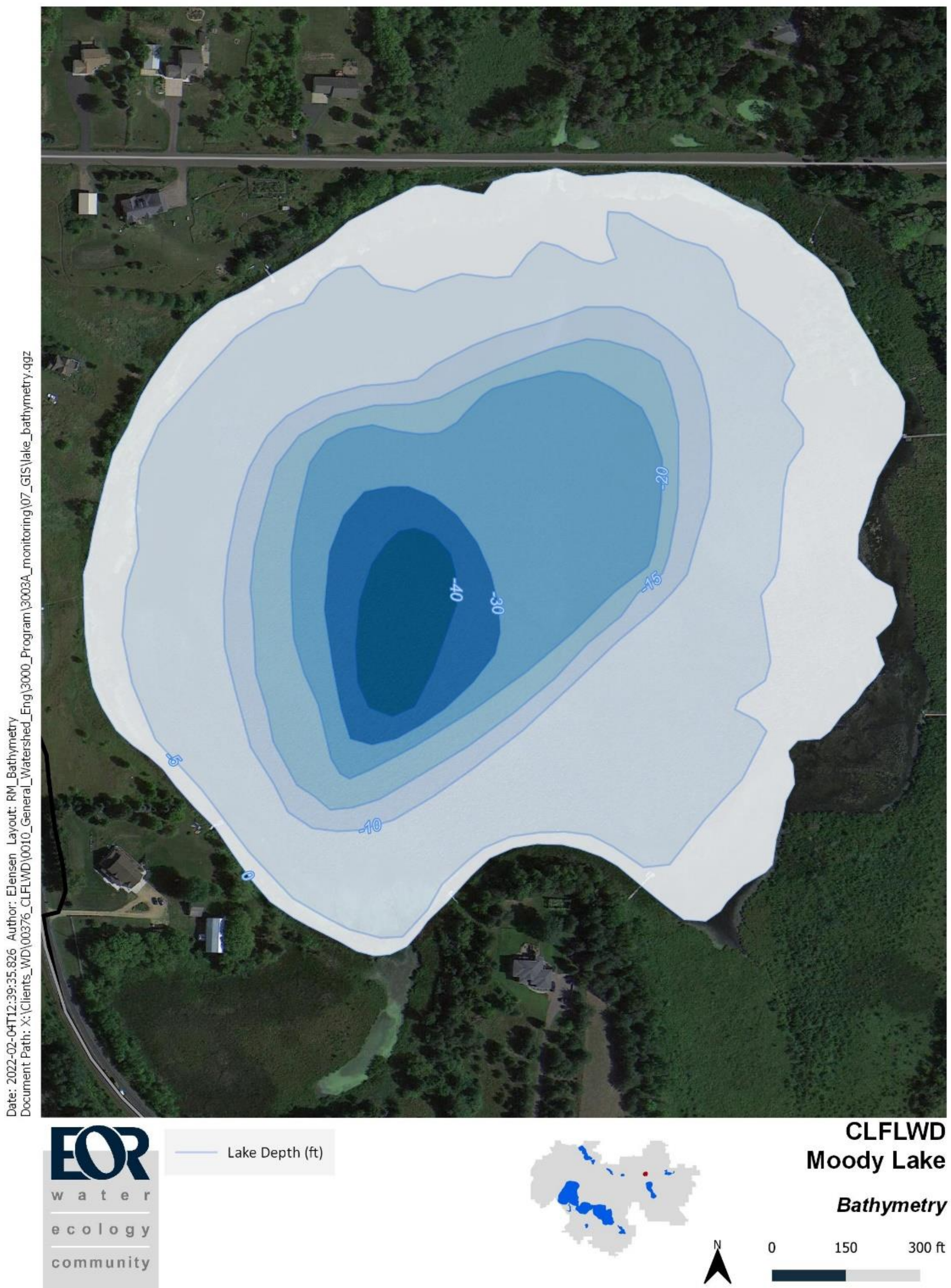
2025 Dissolved Oxygen Profiles

Low dissolved oxygen conditions developed in deeper waters during the stratified period. These conditions allow phosphorus release from sediments and contribute to internal nutrient loading.

MOODY LAKE

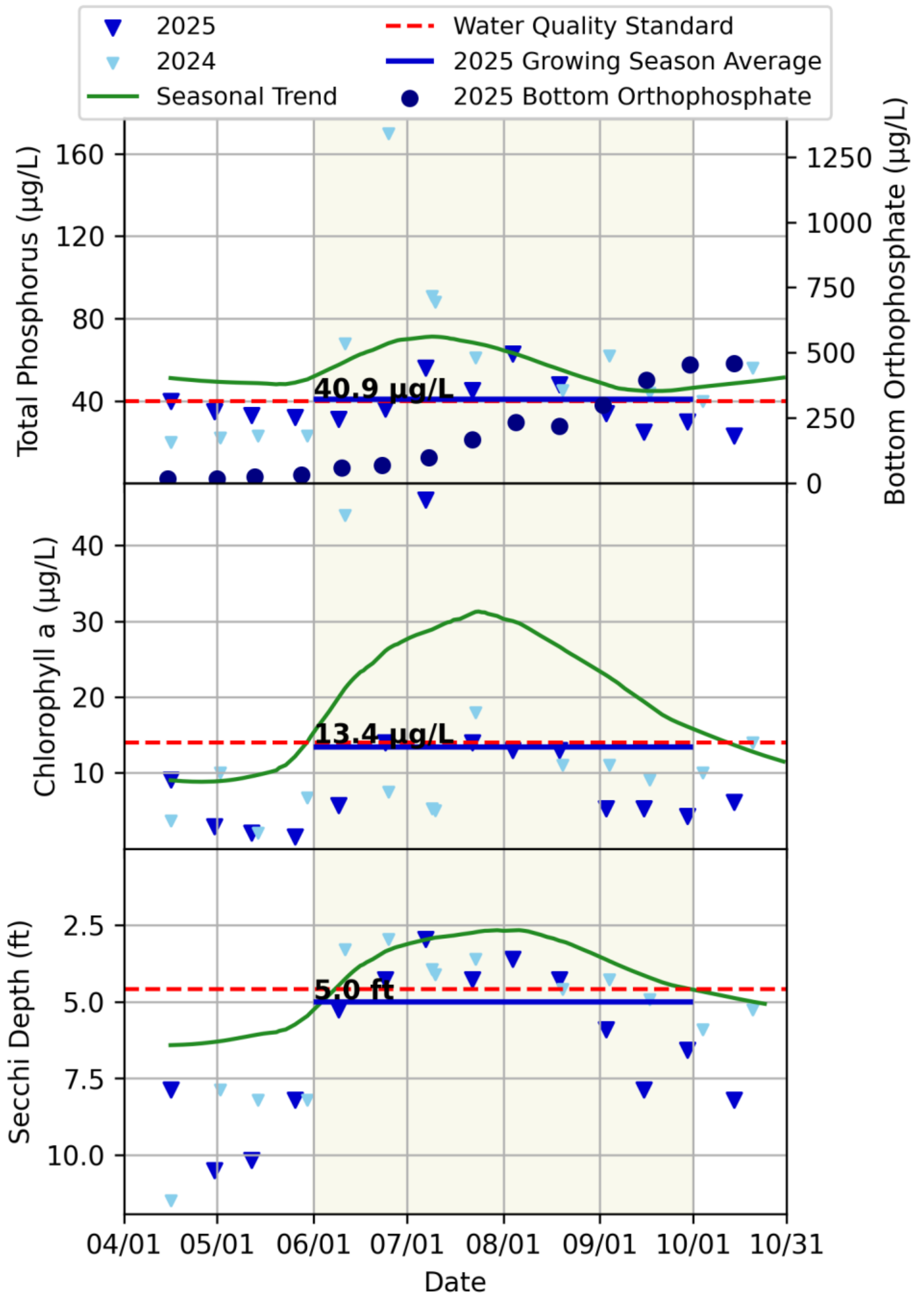
Fast Facts:

DNR Lake ID: 13-0023-00
County: Chisago
Surface Area: 45 acres
Littoral Area (depths less than 15 feet): 22 acres
Maximum Depth: 48 feet
Shore Length: 1.04 miles



MOODY LAKE

2025 Surface Water Quality Summary

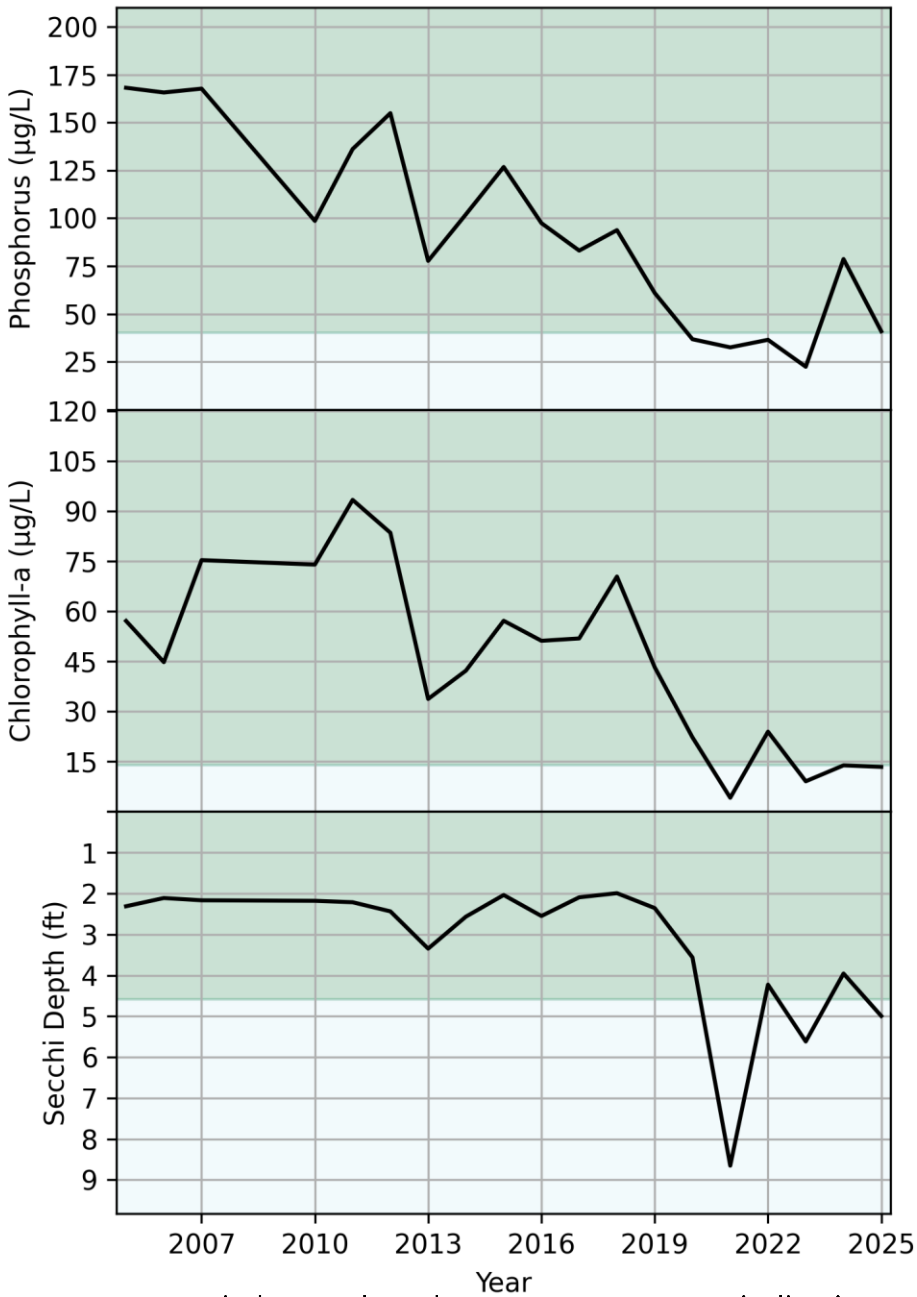


TP decreased substantially compared to 2024 during the growing season. Chlorophyll-a concentrations were better to the previous year, while Secchi depth increased slightly. Overall water quality conditions improved compared to 2024.

MOODY LAKE

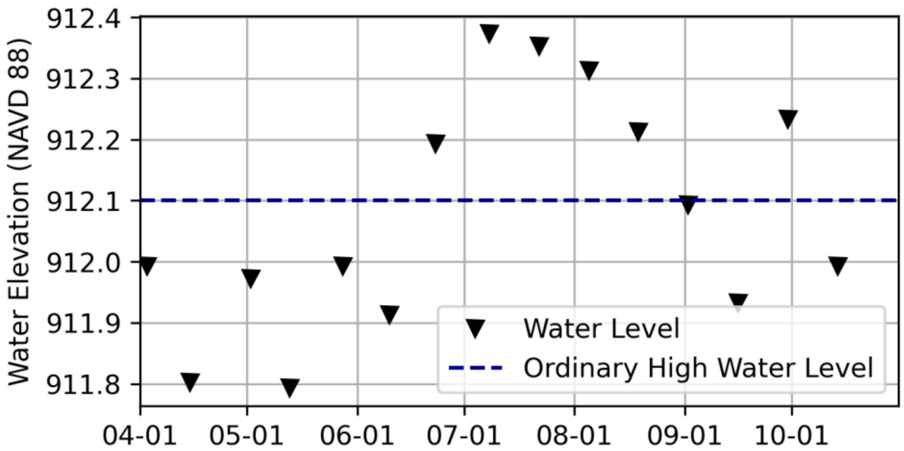
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<40	<14	>4.6
10-year Average (2016-2025)	**58.3**	**30.3**	**4.0**
2040 District Goal	<40	n/a	>4.6
5-year Average (2021-2025)	**42.2**	**12.9**	**5.5**



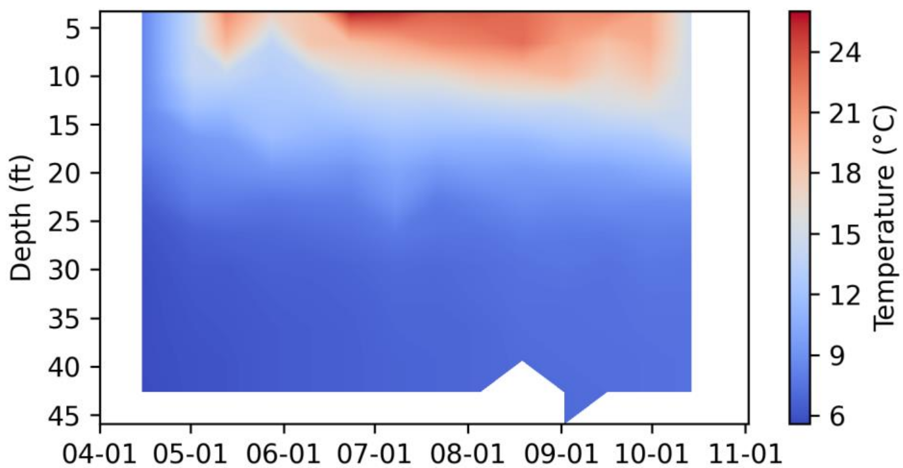
The five year averages remain better than the ten year averages, indicating gradual improvement in water quality conditions despite continued variability. The five year average were meeting the state standards for chl-a and Secchi.

MOODY LAKE



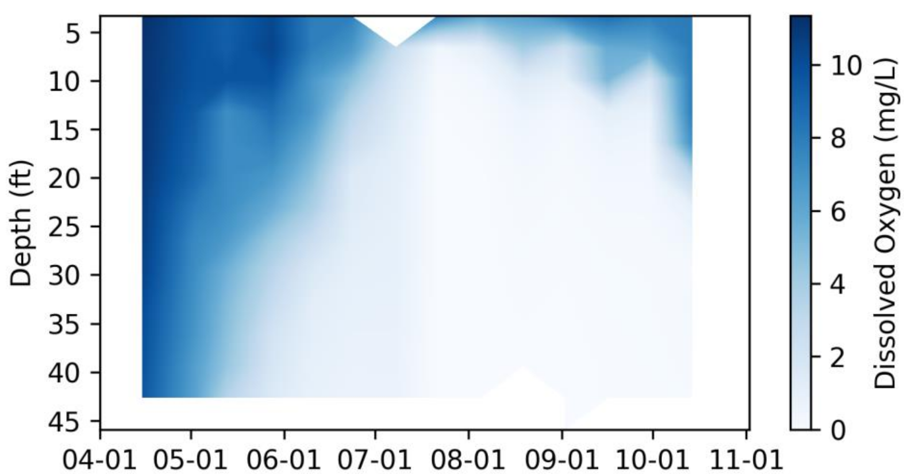
2025 Lake Levels

Lake levels ranged over a total of 0.6 feet; between a minimum of 911.793 feet on May 13, 2025 and a maximum of 912.373 feet on July 8, 2025.



2025 Temperature Profiles

Thermal stratification developed during late spring and persisted through the summer until fall turnover occurred.



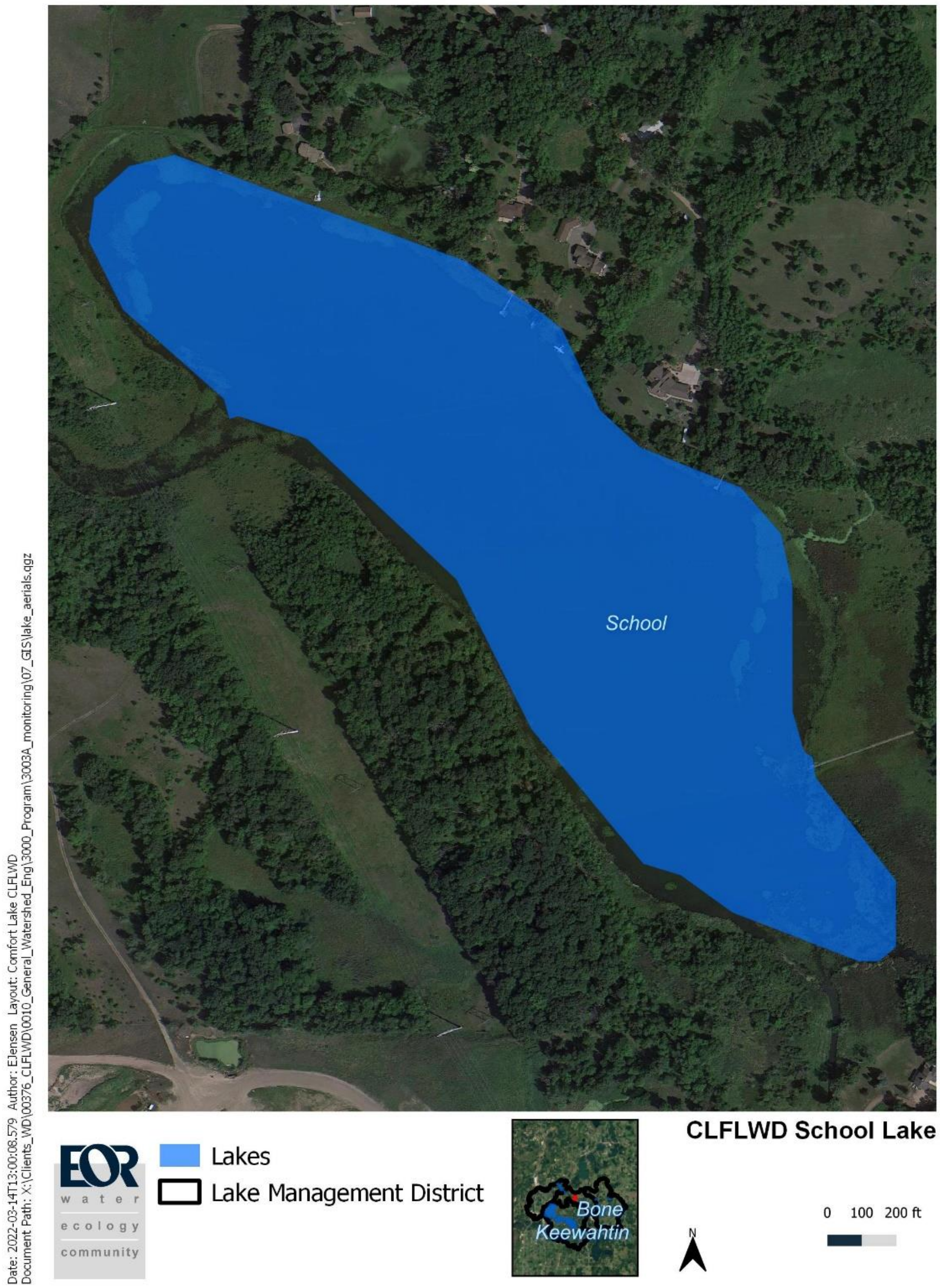
2025 Dissolved Oxygen Profiles

Low oxygen concentrations developed in deeper waters during stratified conditions, potentially contributing to internal phosphorus loading.

SCHOOL LAKE

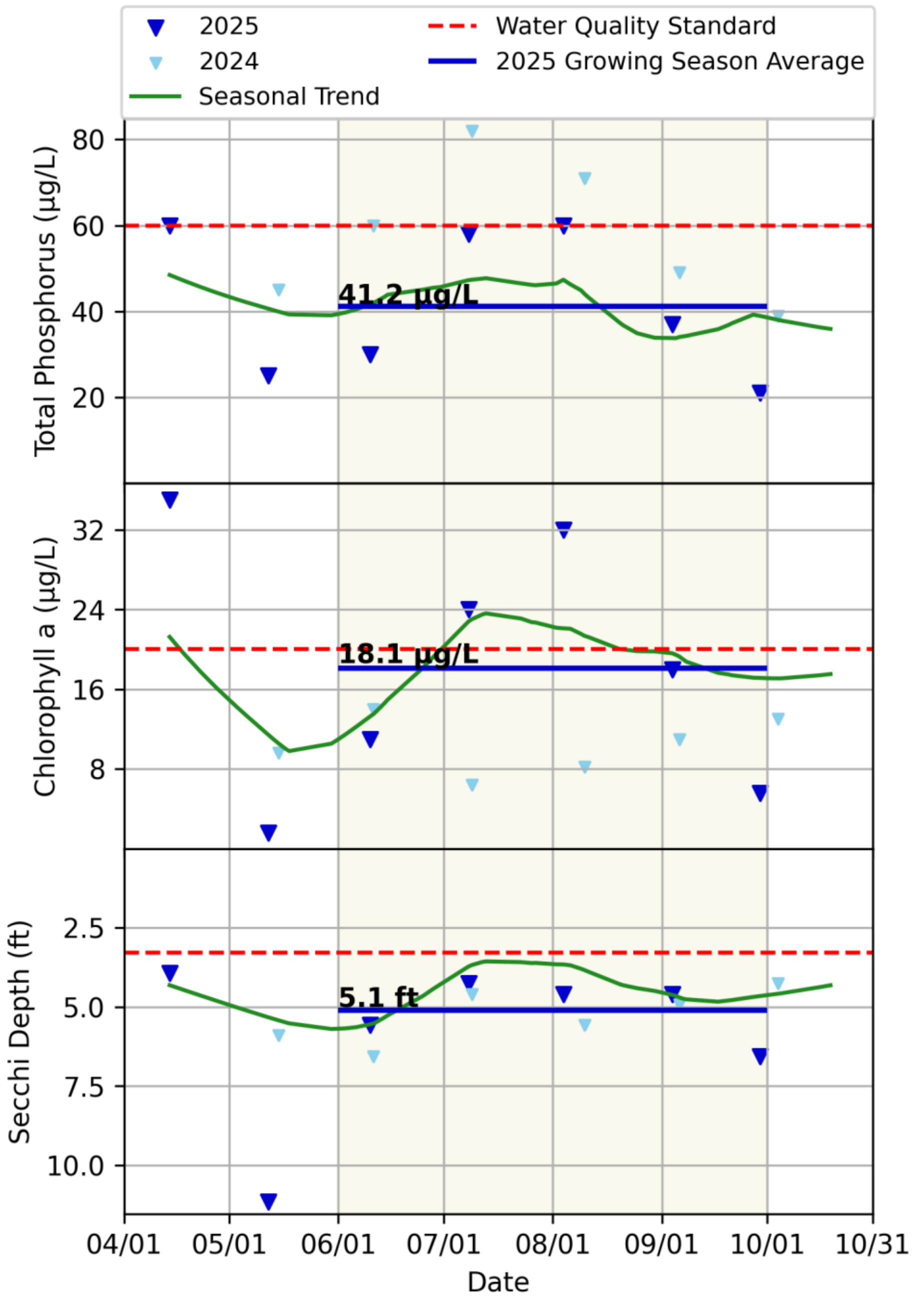
Fast Facts:

DNR Lake ID: 13-0044-00
County: Chisago
Surface Area: 49 acres
Littoral Area (depths less than 15 feet): 32 acres
Maximum Depth: 24 feet
Shore Length: 1.36 miles



SCHOOL LAKE

2025 Surface Water Quality Summary

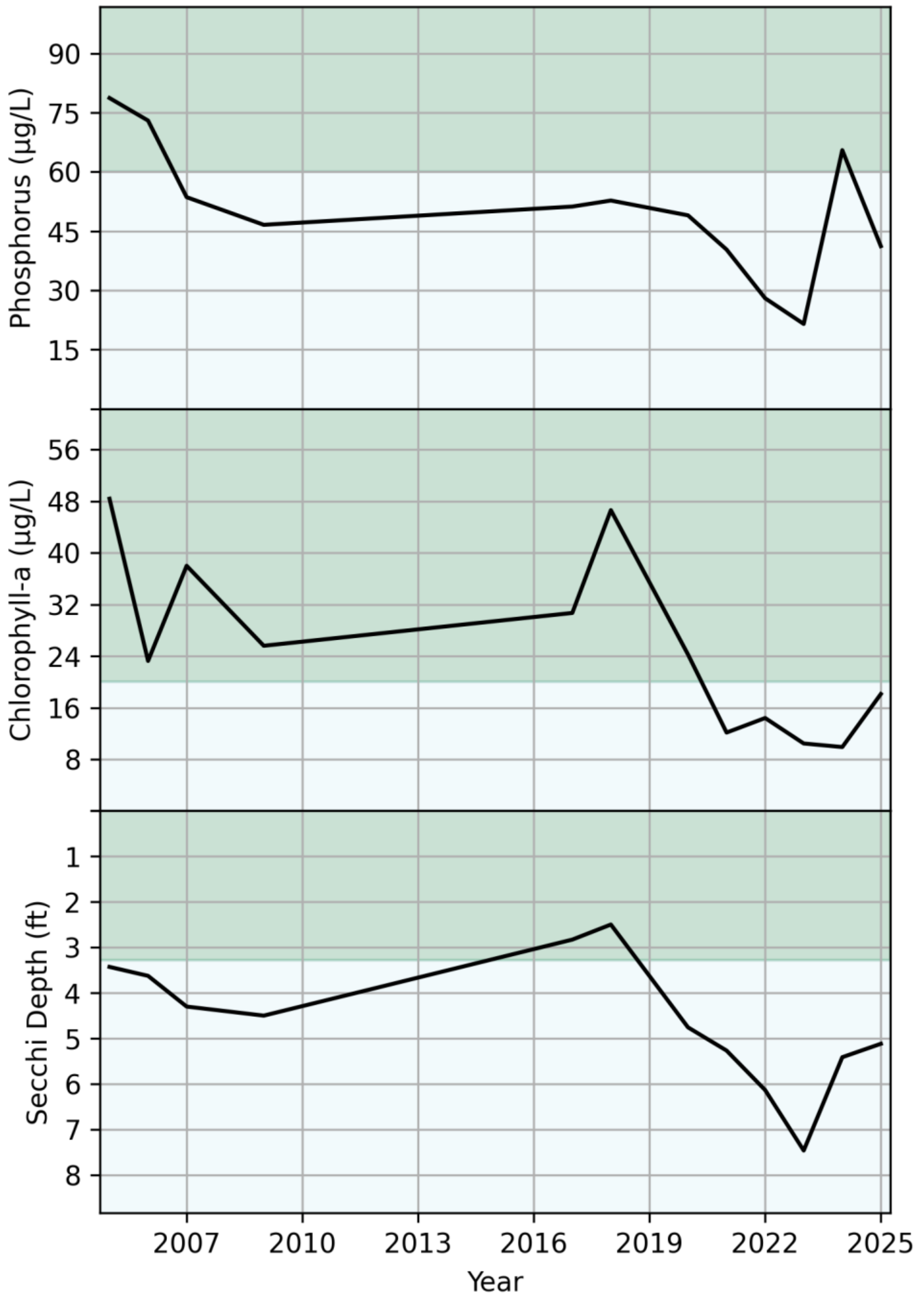


All parameters are meeting state standards.TP concentration decreased substantially compared to 2024. However, chlorophyll-a concentrations increased compared to the previous year, indicating higher algal productivity. Secchi depth decreased slightly compared to 2024.

SCHOOL LAKE

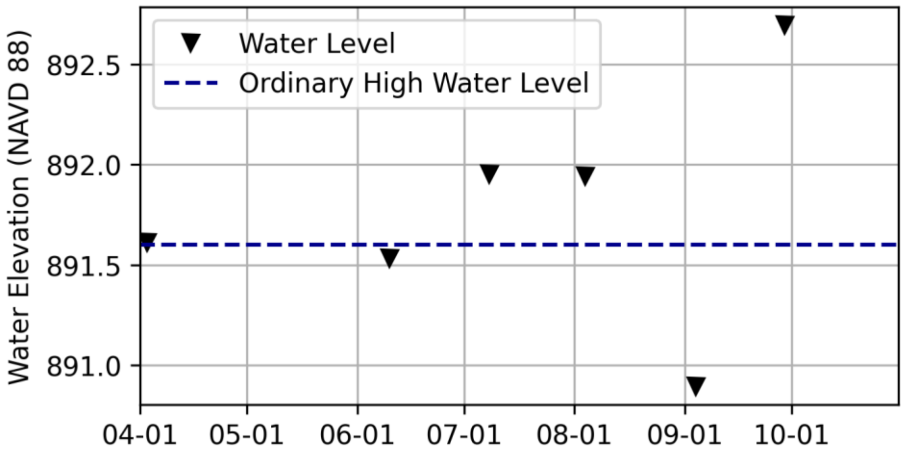
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<60	<20	>3.3
10-year Average (2016-2025)	**43.7**	**20.8**	**4.9**
2040 District Goal	<60	n/a	>3.3
5-year Average (2021-2025)	**39.3**	**13.0**	**5.9**



The five year averages remain better than the ten year averages and continue to meet state standards and District goals despite year to year variability.

SCHOOL LAKE

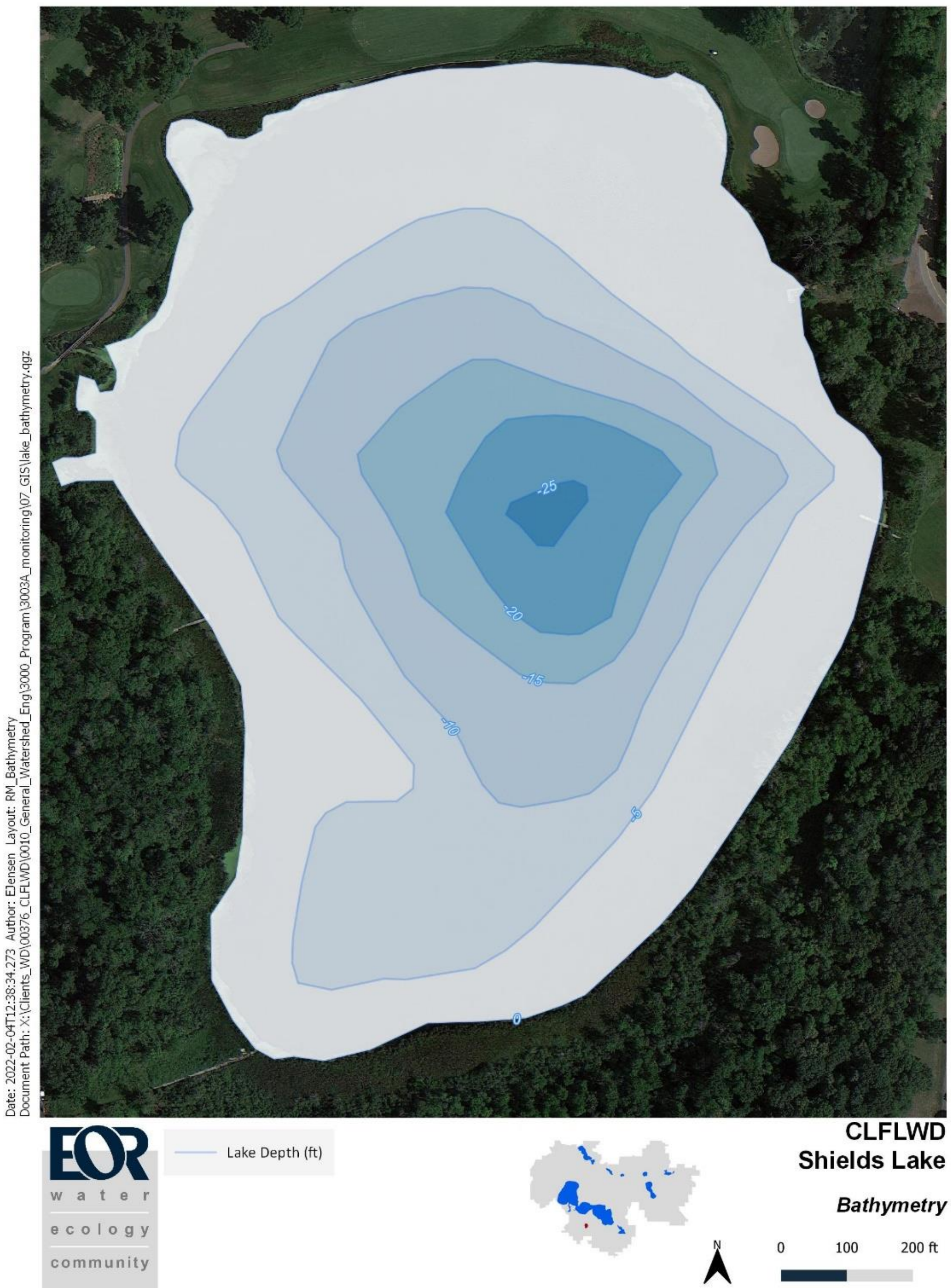


2025 Lake Levels

Lake levels ranged over a total of 1.8 feet; between a minimum of 890.895 feet on September 4, 2025 and a maximum of 892.695 feet on September 29, 2025.

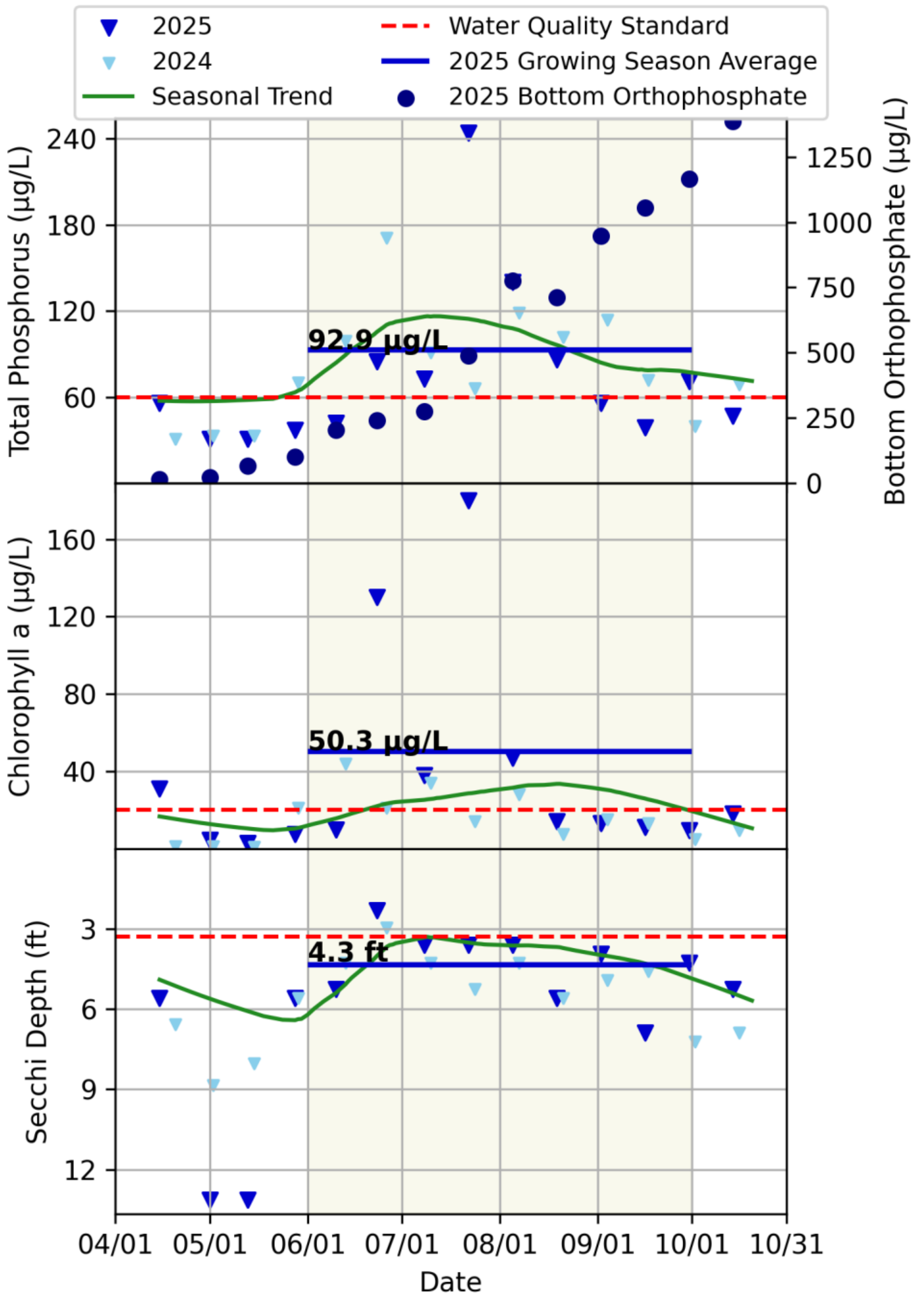
SHIELDS LAKE

Fast Facts:
DNR Lake ID: 82-0162-00
County: Washington
Surface Area: 30 acres
Littoral Area (depths less than 15 feet): 22 acres
Maximum Depth: 27 feet
Shore Length: 0.85 miles



SHIELDS LAKE

2025 Surface Water Quality Summary

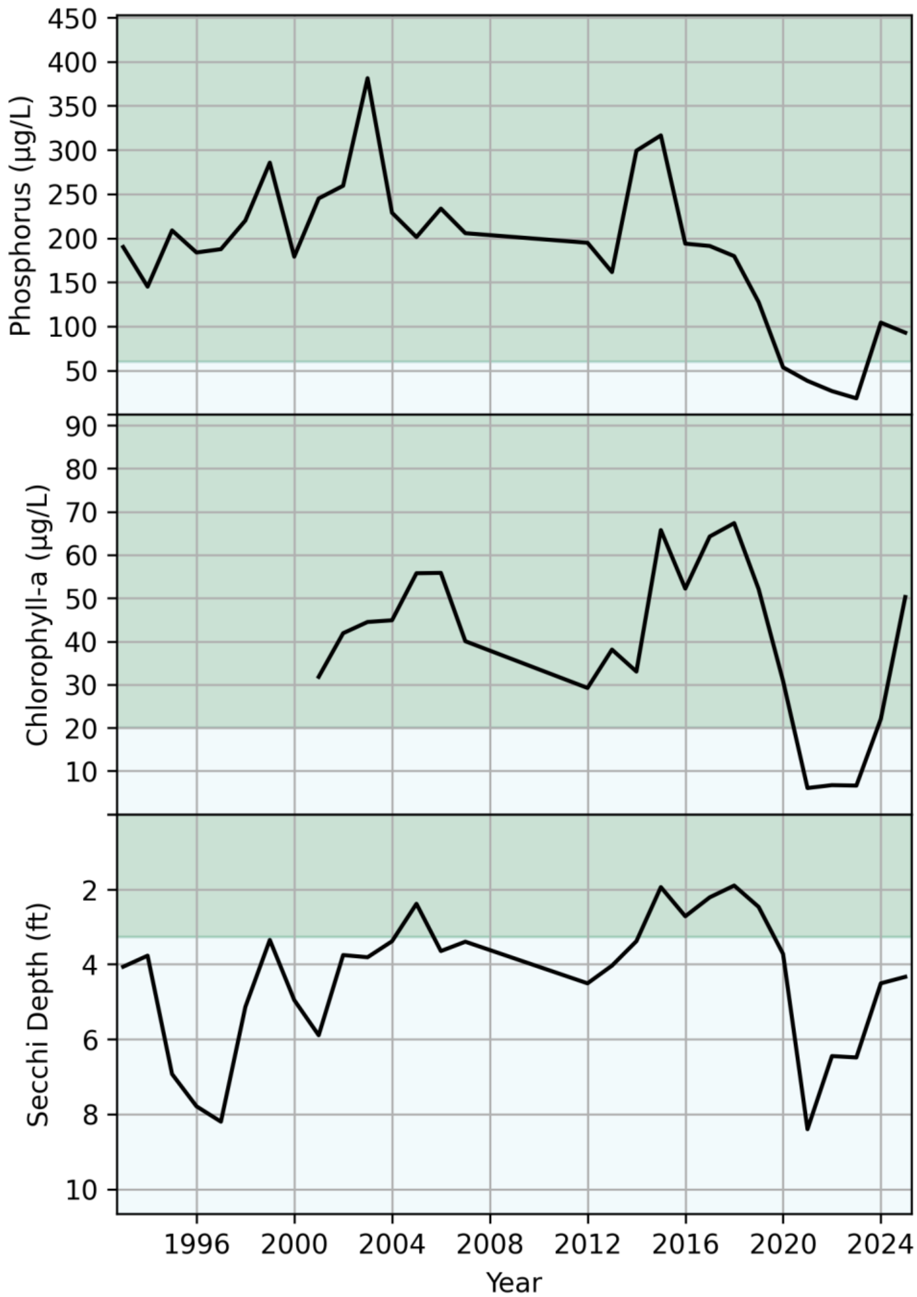


TP concentrations decreased slightly compared to 2024 but remained above standard overall. Chlorophyll-a concentrations increased substantially (two high peaks during the growing season), indicating increased algal productivity. Secchi depth decreased slightly compared to the previous year.

SHIELDS LAKE

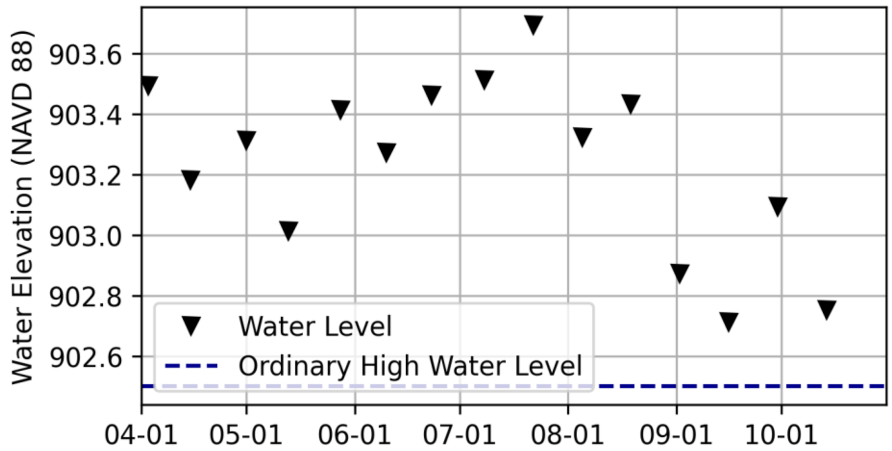
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<60	<20	>3.3
10-year Average (2016-2025)	**102.6**	**35.9**	**4.3**
2040 District Goal	<60	n/a	>4.3
5-year Average (2021-2025)	**56.1**	**18.4**	**6.0**



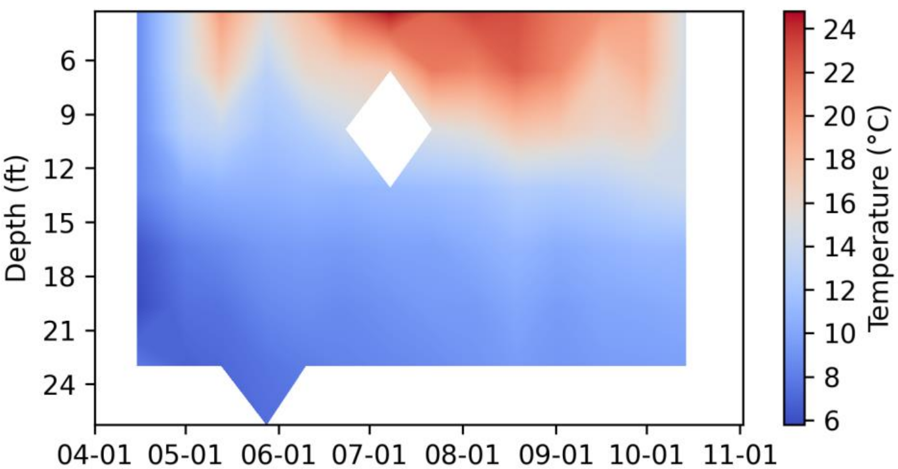
The five year averages remain slightly better than the ten year averages, although phosphorus and chlorophyll concentrations continue to exceed standards during some years. The five year averages meet state and District standards, driven by good water quality conditions from 2021-2023.

SHIELDS LAKE



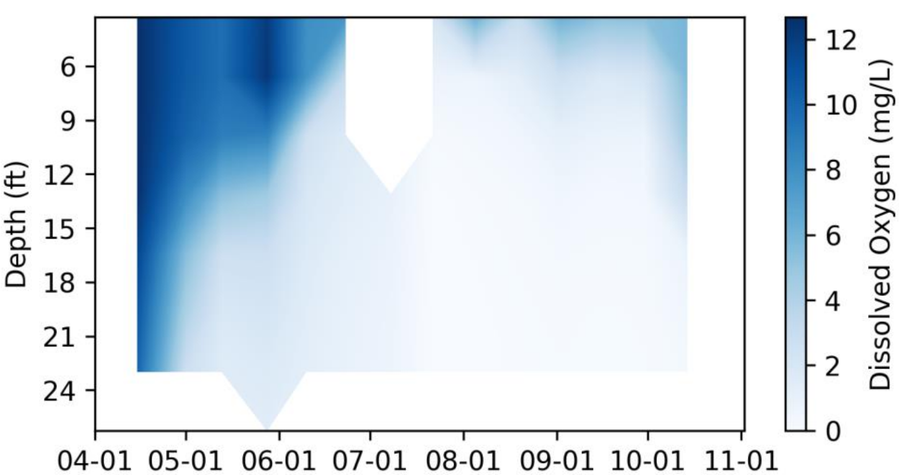
2025 Lake Levels

Lake levels ranged over a total of 0.98 feet; between a minimum of 902.714 feet on September 16, 2025 and a maximum of 903.694 feet on July 22, 2025.



2025 Temperature Profiles

The lake stratified during late spring and remained stratified through much of the growing season.

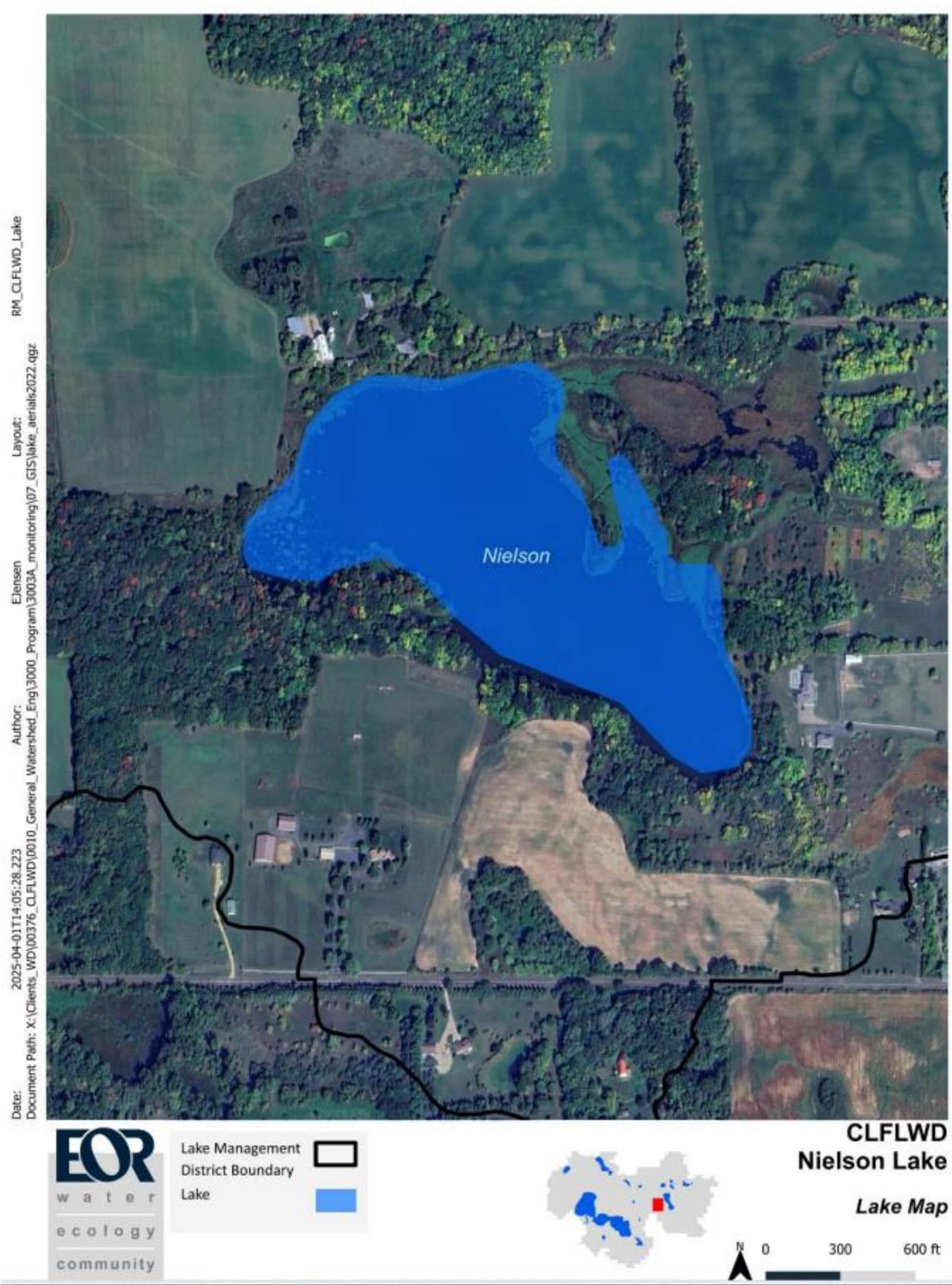


2025 Dissolved Oxygen Profiles

Low dissolved oxygen conditions developed in deeper waters during the stratified period and may contribute to internal nutrient loading.

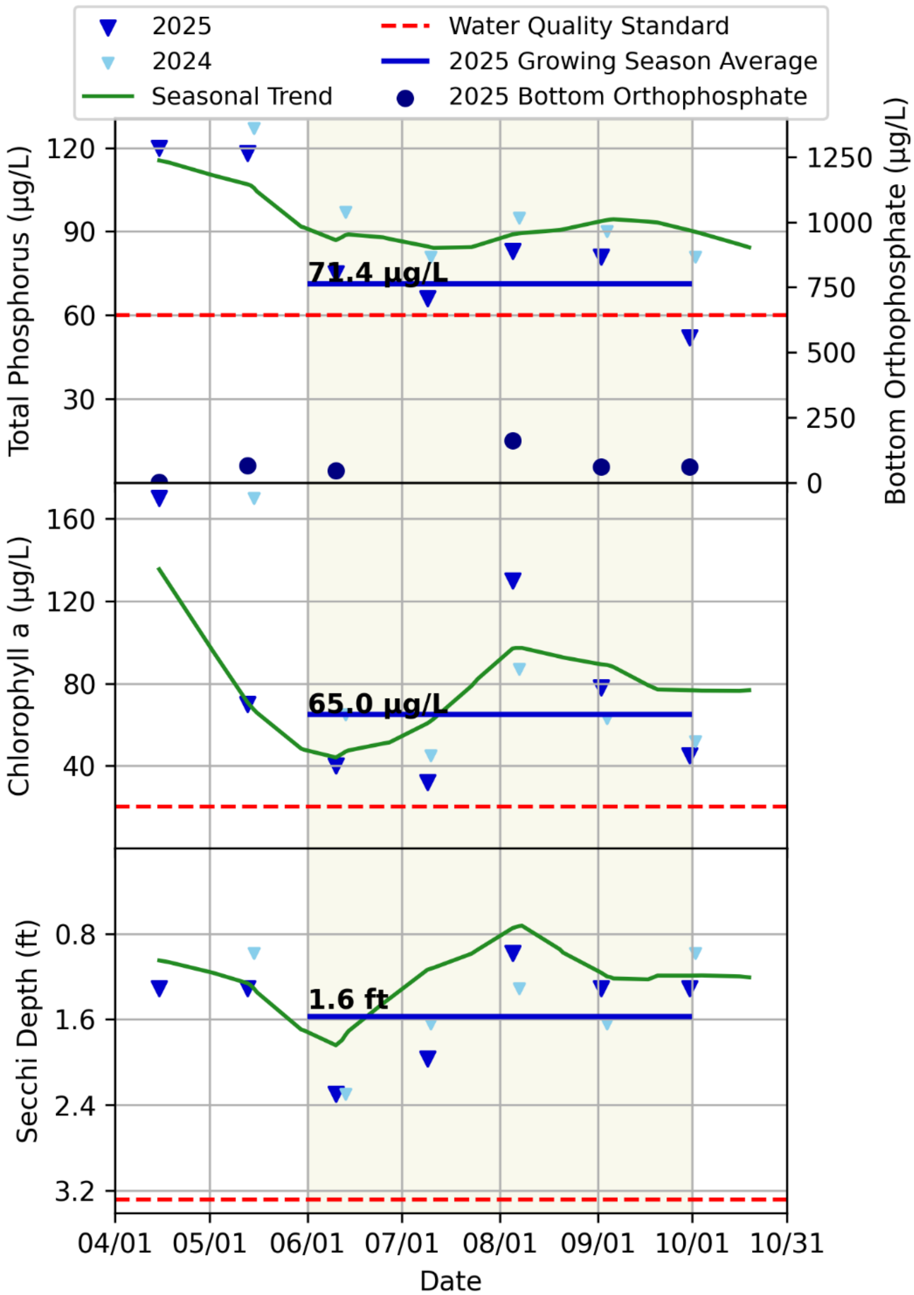
NIELSON LAKE

Fast Facts:
DNR Lake ID: 82-0055-00
County: Washington
Surface Area: 42 acres
Littoral Area (depths less than 15 feet): NA acres
Maximum Depth: NA feet
Shore Length: NA miles



NIELSON LAKE

2025 Surface Water Quality Summary

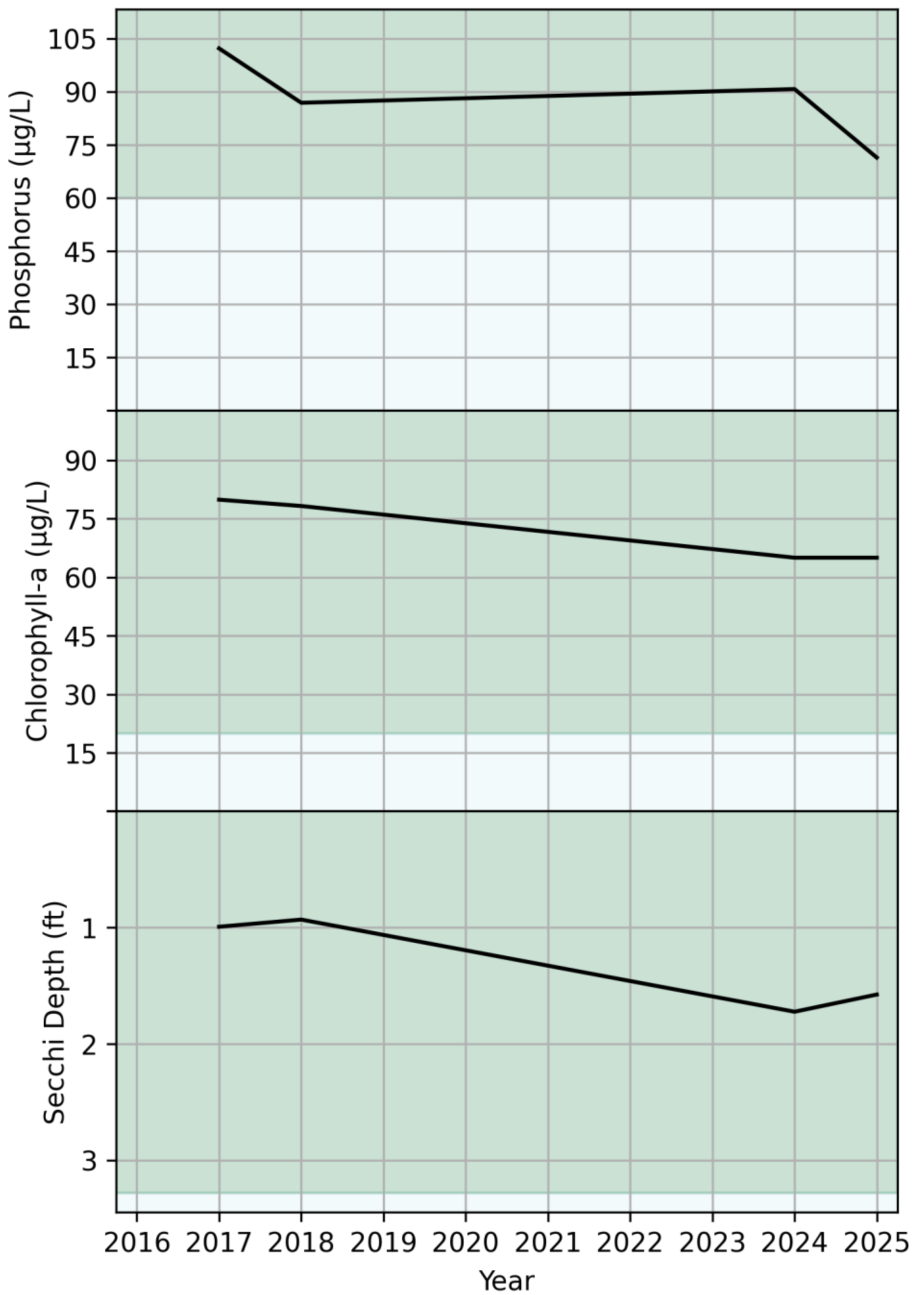


TP decreased compared to 2024 but remained relatively high overall. The bottom orthoP did not increase and remained low. Chlorophyll-a concentrations were similar to the previous year, while Secchi depth increased slightly. Overall water quality conditions improved somewhat compared to 2024 but remains poor.

NIELSON LAKE

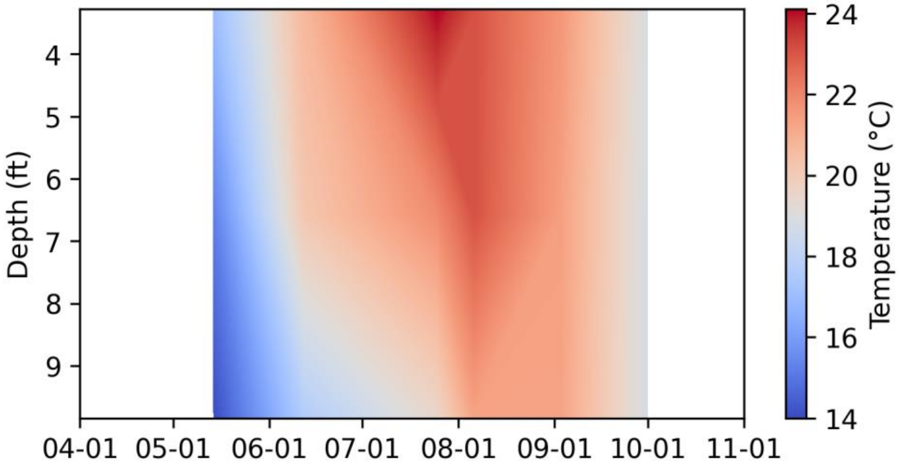
Historical Water Quality Summary

	Phosphorus (µg/L)	Chl-a (µg/L)	Secchi (feet)
State Standard	<60	<20	>3.3
10-year Average (2015-2024)	**93.3**	**74.4**	**1.2**
2040 District Goal	<60	n/a	>3.3
5-year Average (2020-2024)	**90.8**	**65.0**	**1.7**



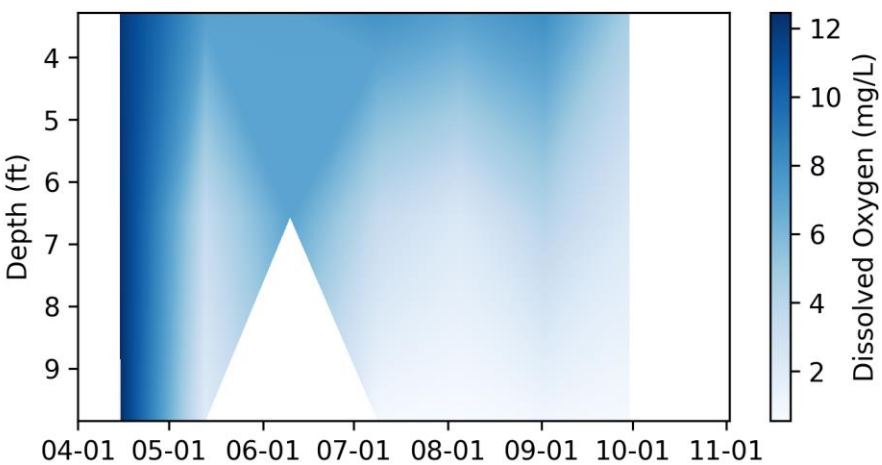
The five and ten year averages not meeting the state or District standards.

NIELSON LAKE



2025 Temperature Profiles

The lake showed short periods of weak stratification during early summer before mixing throughout the season.



2025 Dissolved Oxygen Profiles

Low oxygen conditions developed during periods of stratification but improved once the lake mixed again.

APPENDIX B. HISTORIC WATER QUALITY DATA

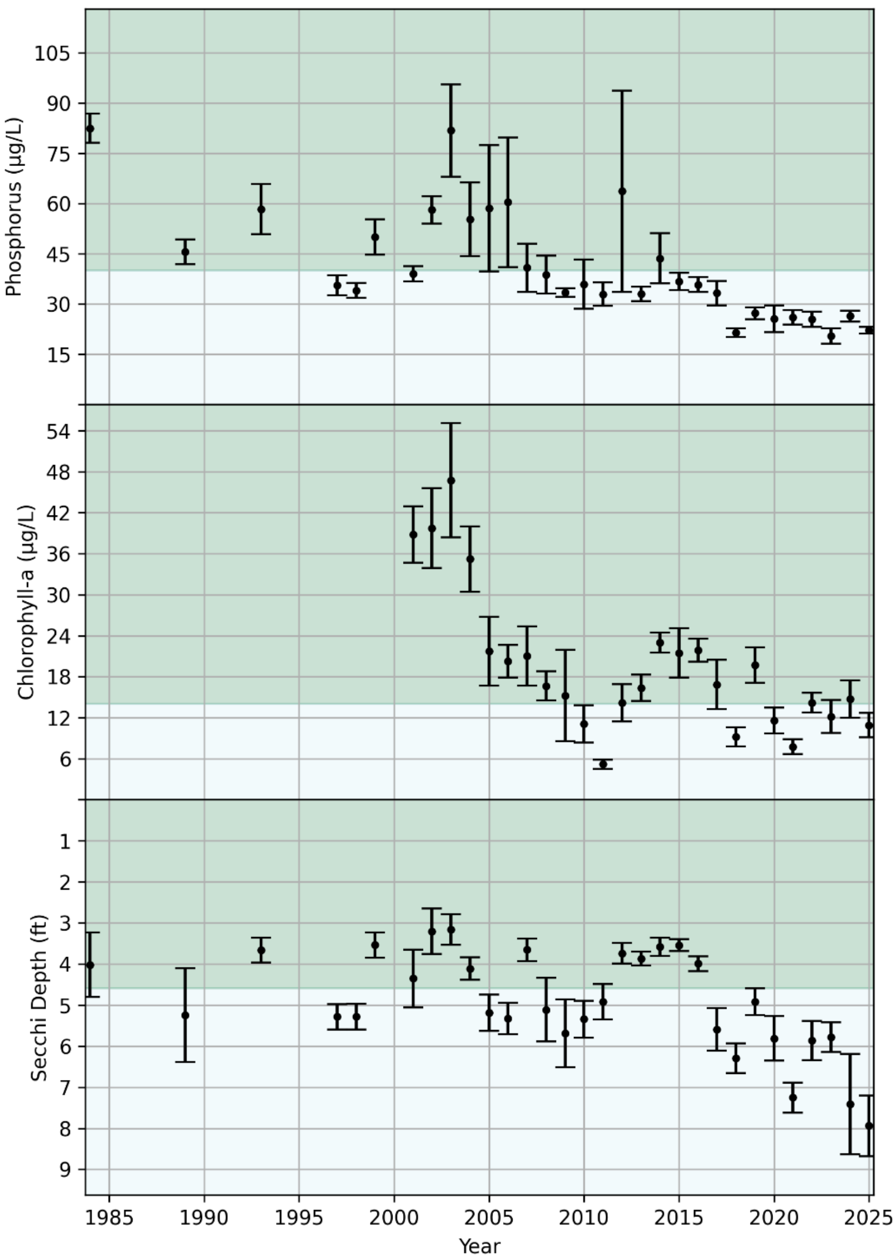


Figure 1: Bone Lake Historic Water Quality Data

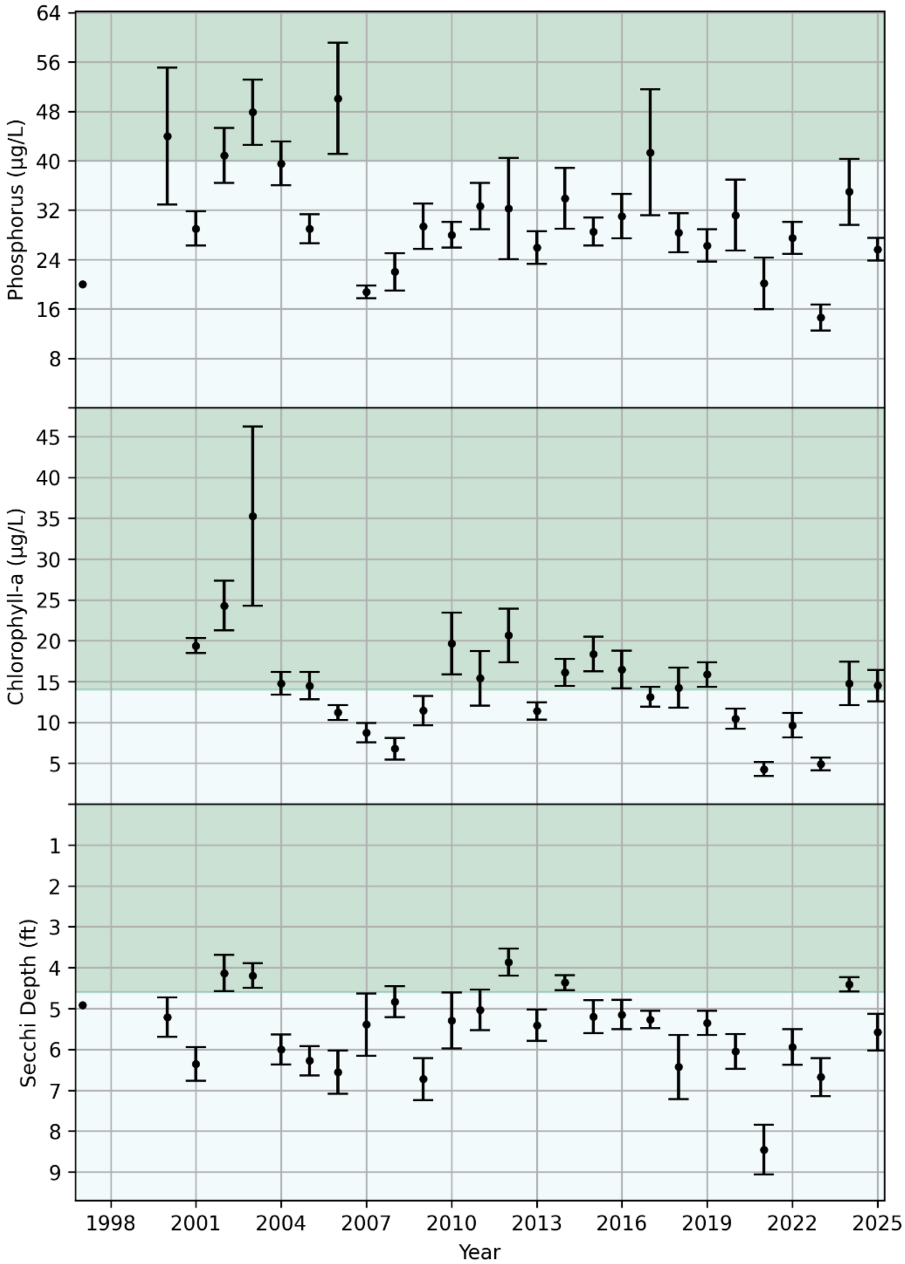


Figure 2: Comfort Lake Historic Water Quality Data

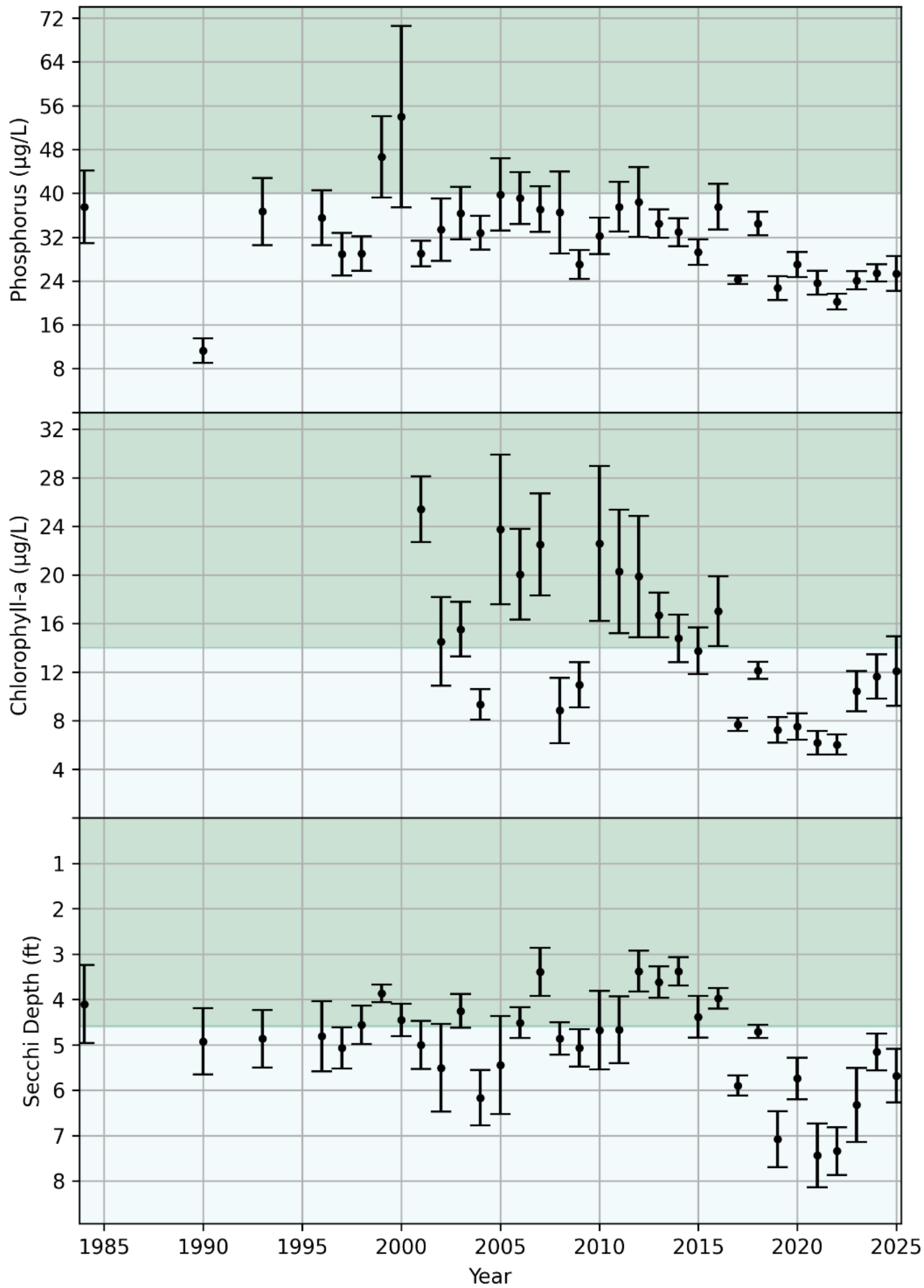


Figure 3: Forest Lake West Historic Water Quality Data

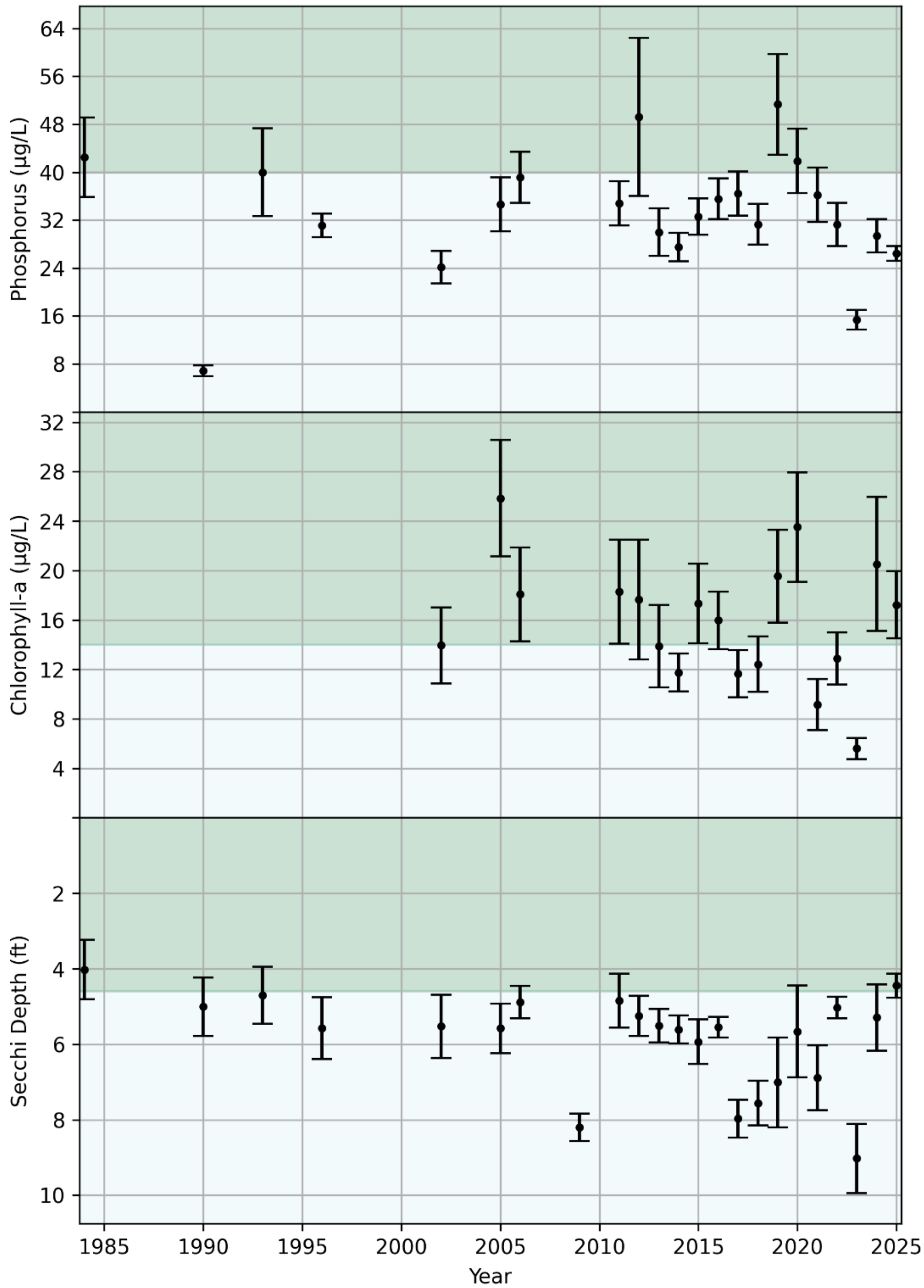


Figure 4: Forest Lake Middle Historic Water Quality Data

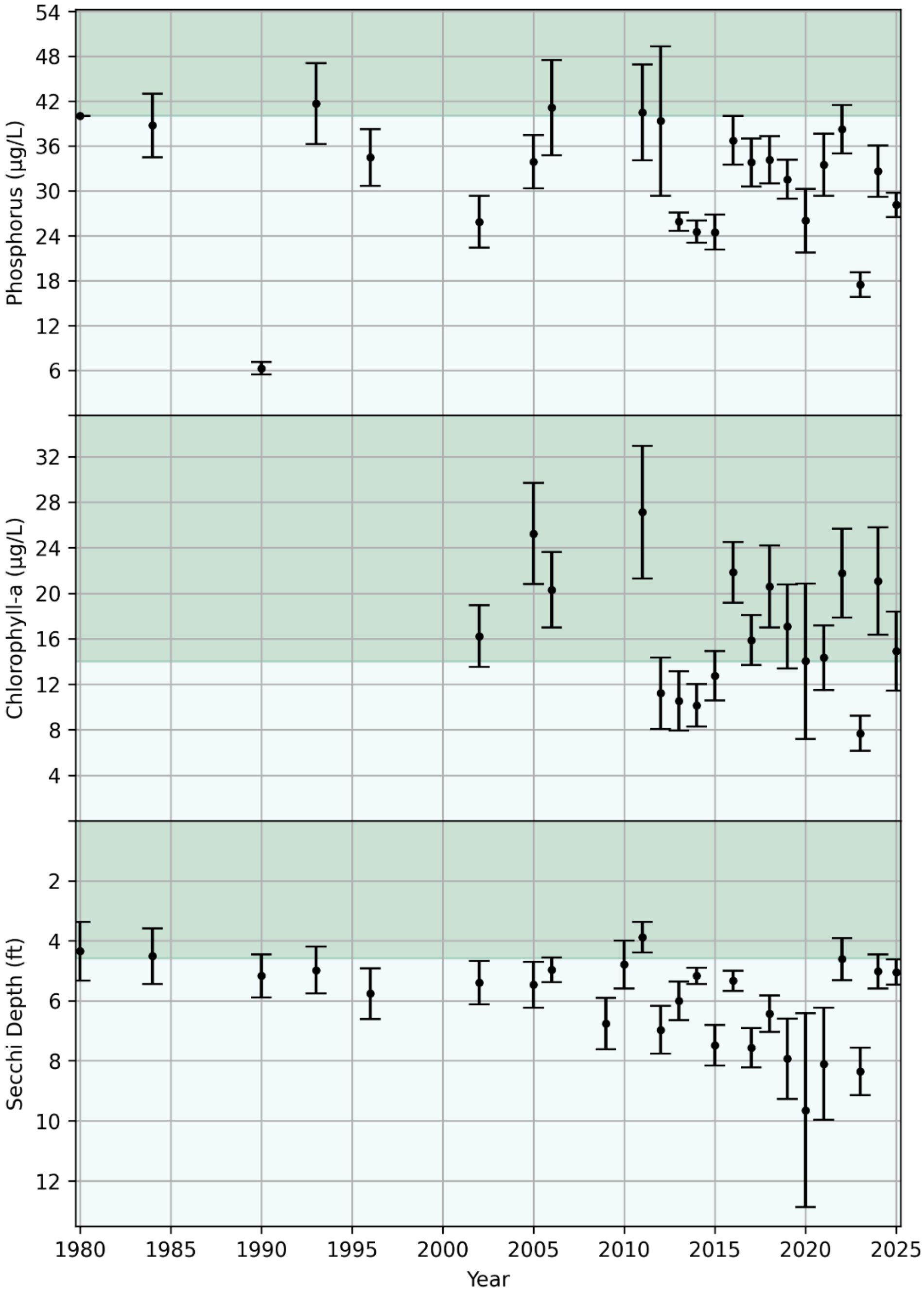


Figure 5: Forest Lake East Historic Water Quality Data

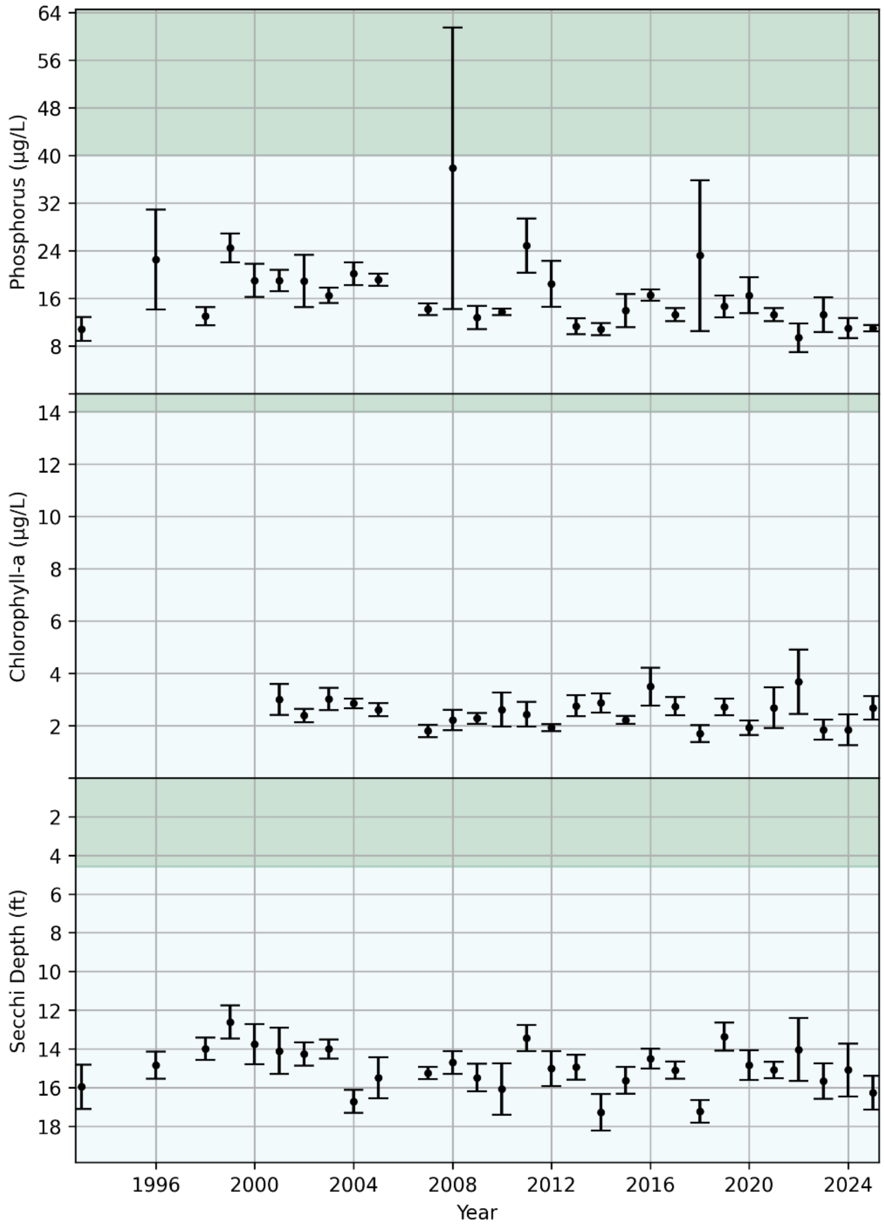


Figure 6: Keewahtin Lake Historic Water Quality Data

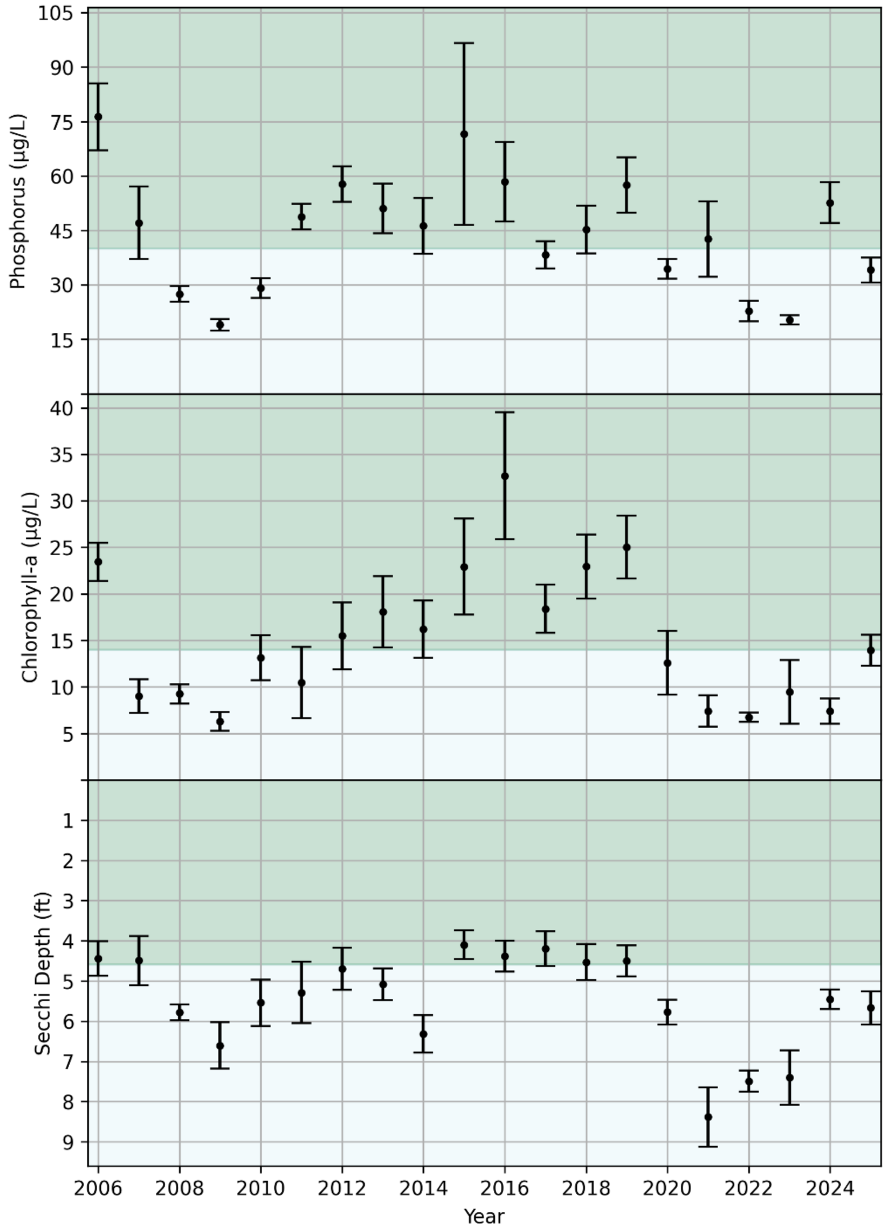


Figure 7: Little Comfort Lake Historic Water Quality Data

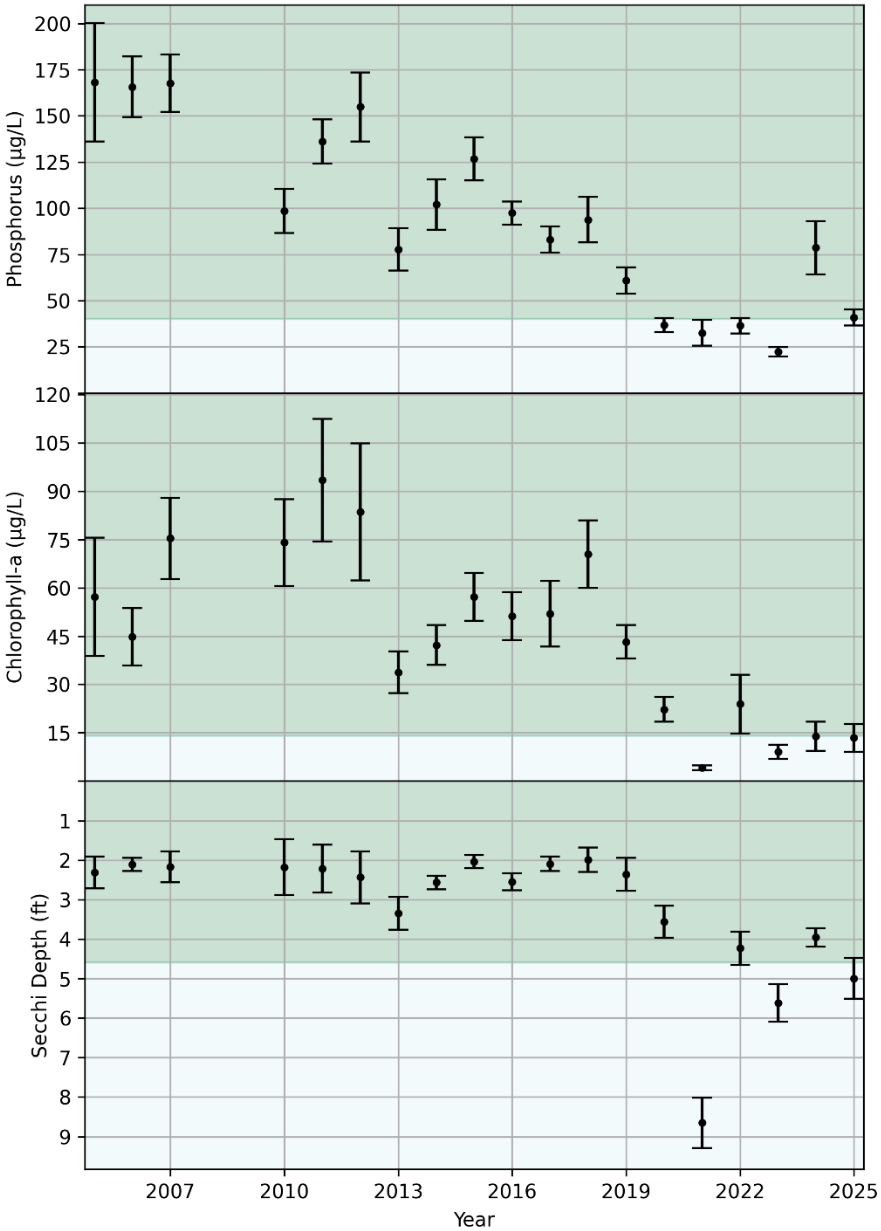


Figure 8:Moody Lake Historic Water Quality Data

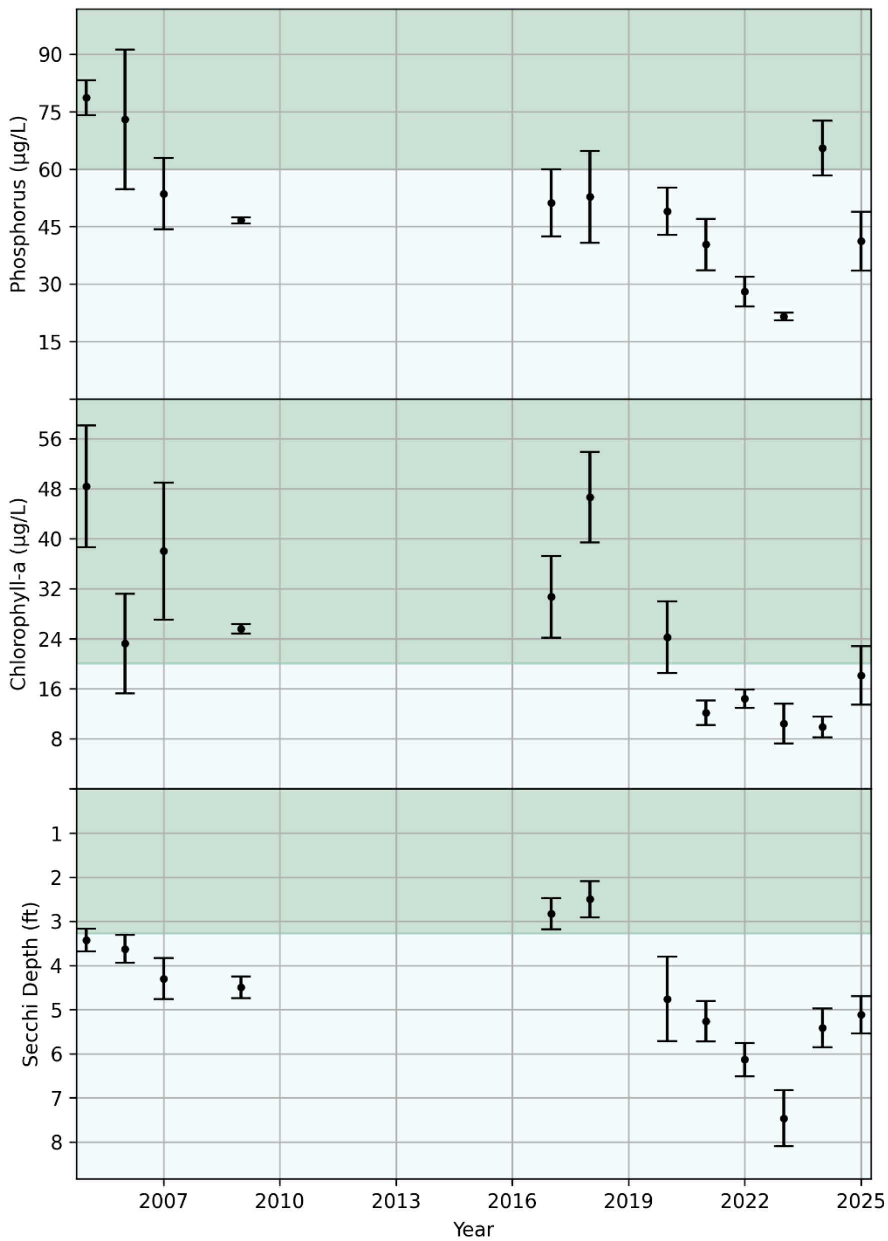


Figure 9: School Lake Historic Water Quality Data

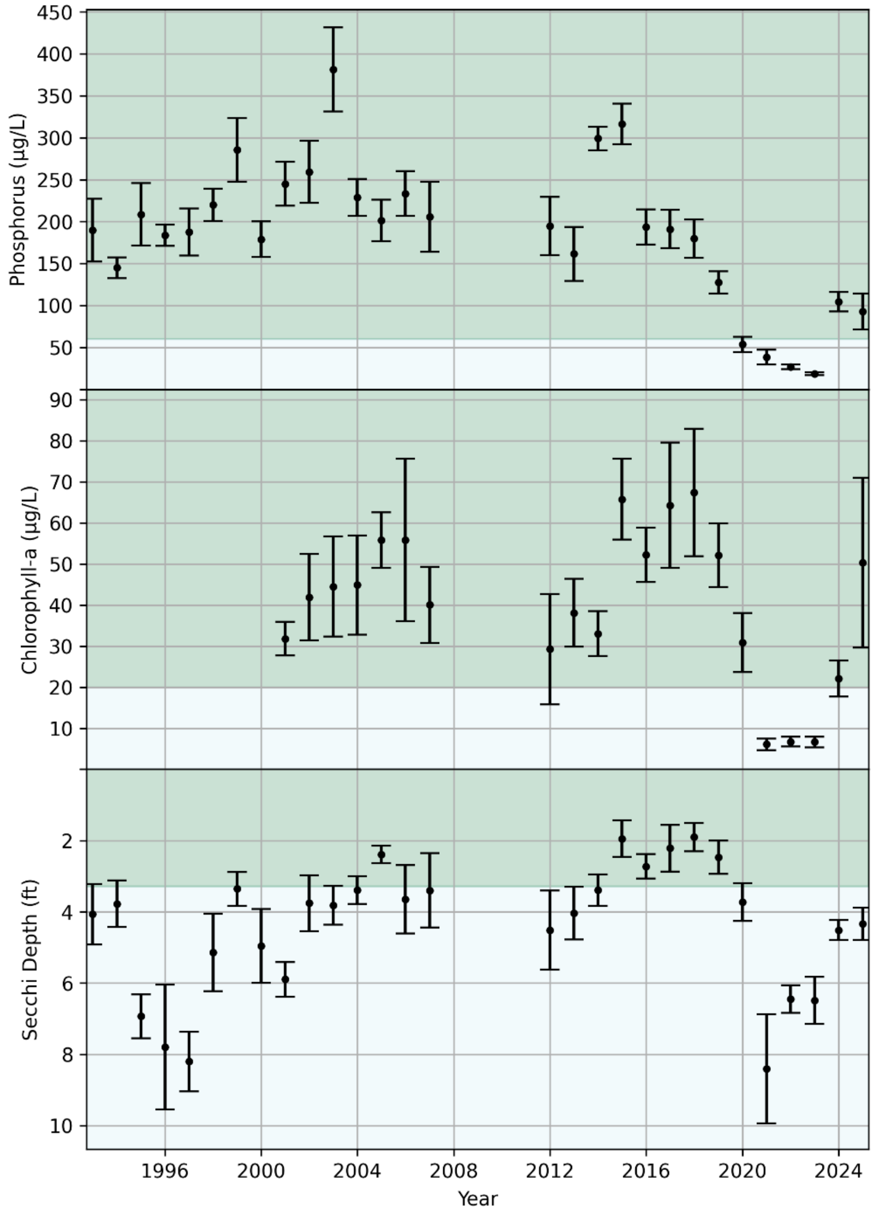


Figure 10: Shields Lake Historic Water Quality Data

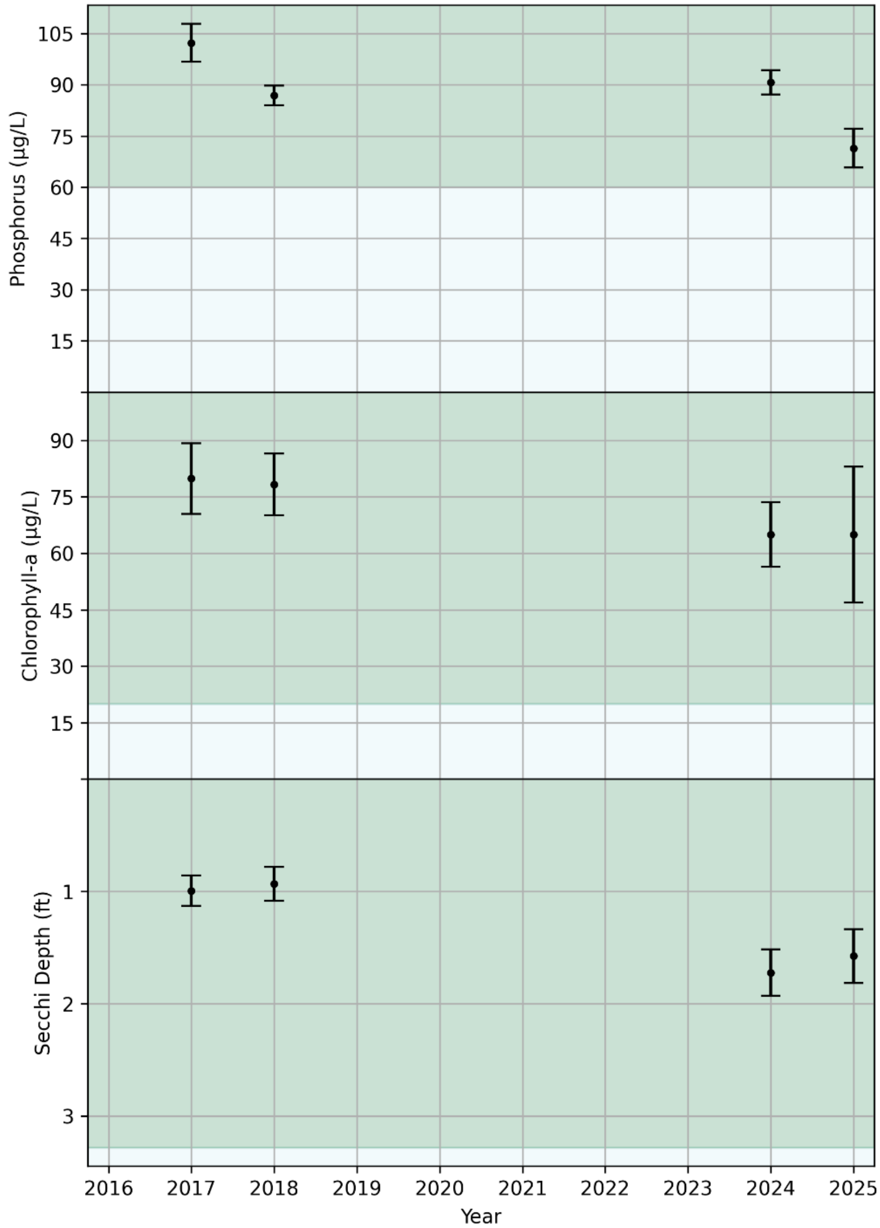


Figure 11: Nielson Lake Historic Water Quality Data

APPENDIX C. CHLORIDE PROFILES

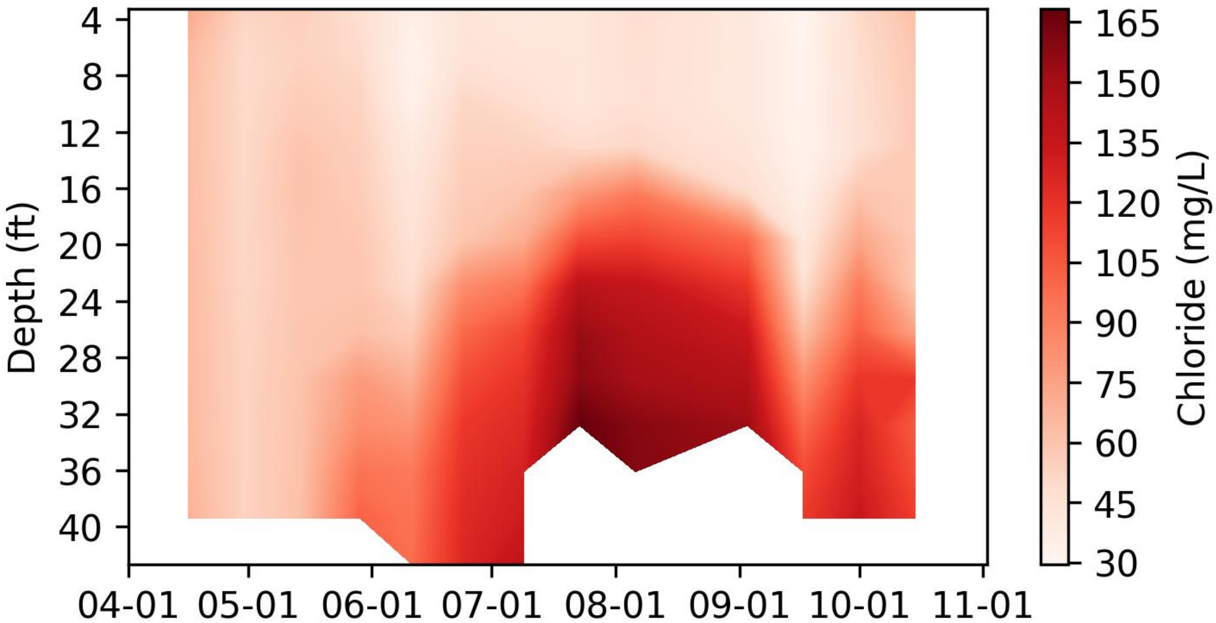


Figure 12. 2025 Comfort Lake Chloride Profiles

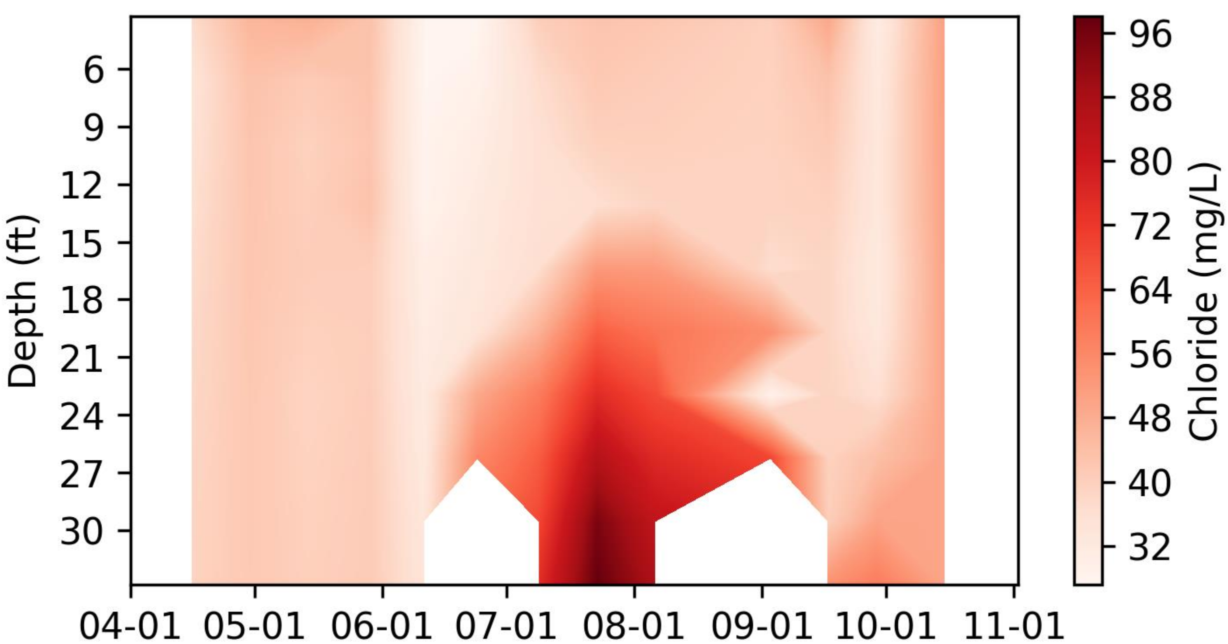


Figure 13. 2025 Forest Lake – Middle basin chloride profiles

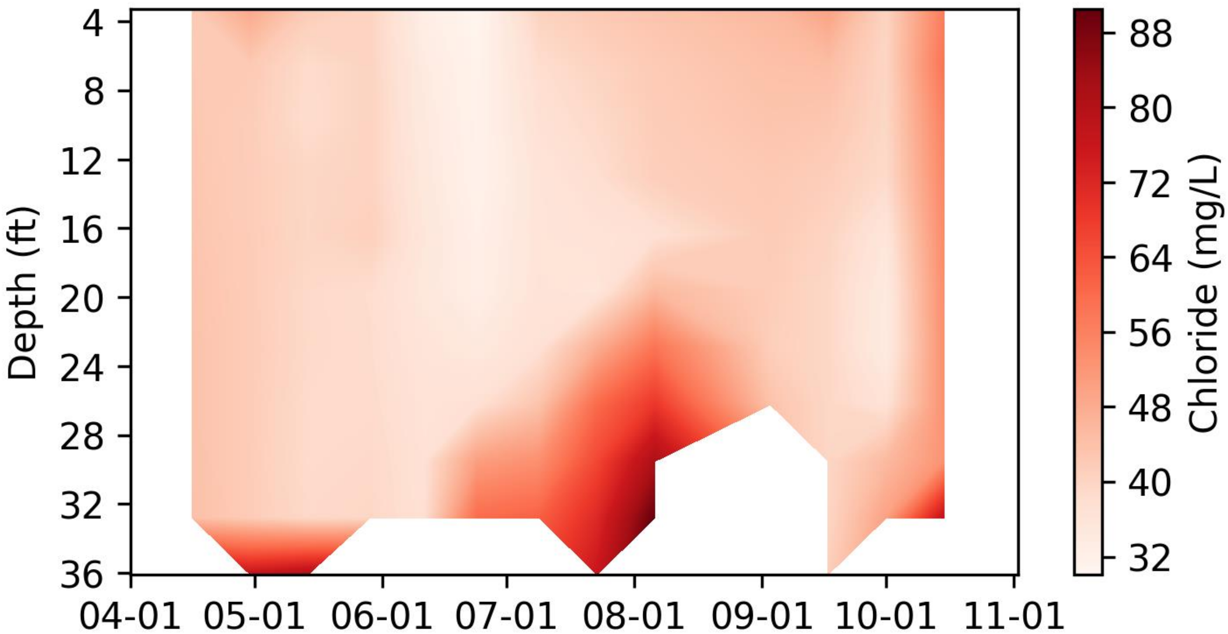


Figure 14. 2025 Forest Lake – East basin chloride Profiles

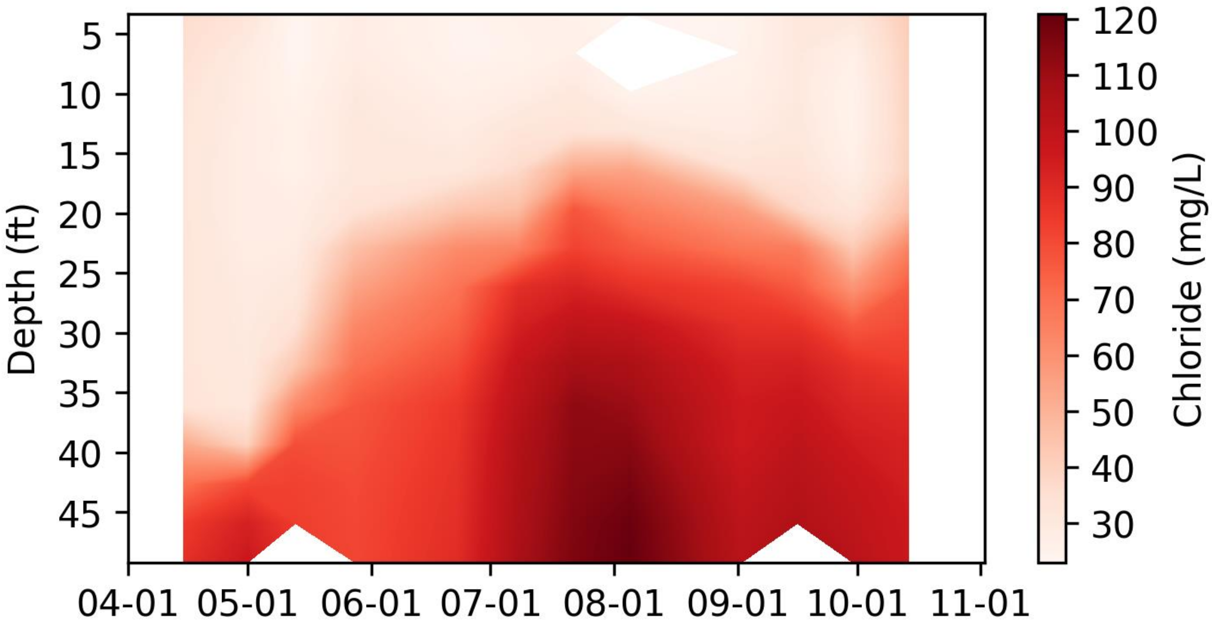


Figure 15. 2025 Little Comfort Lake chloride profiles

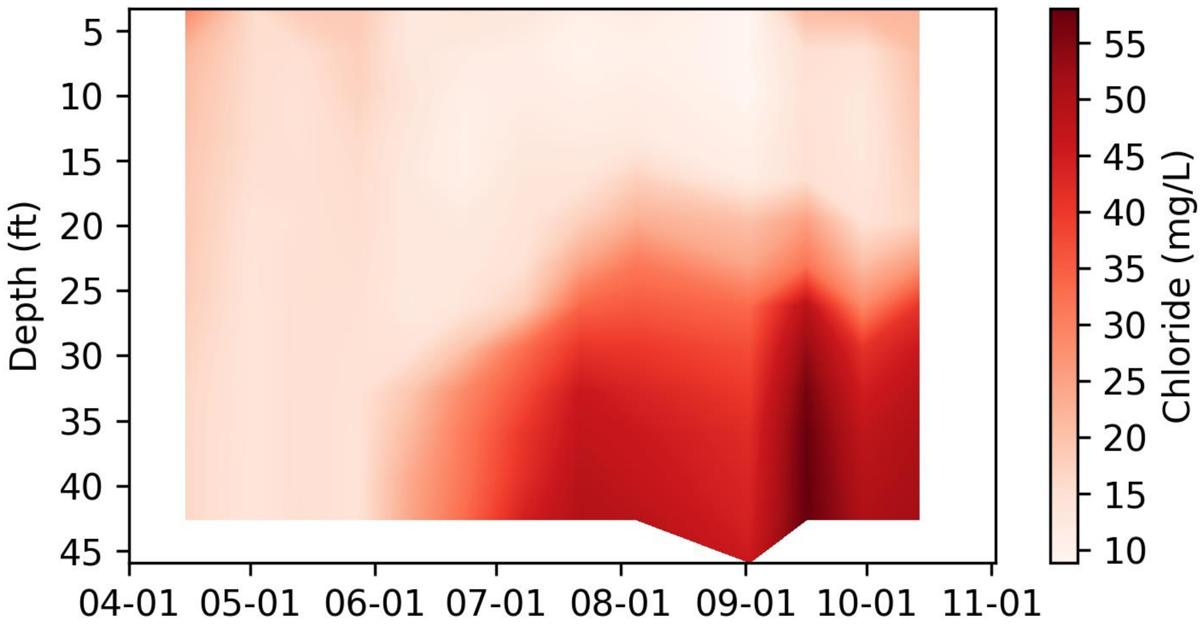


Figure 16. 2025 Moody Lake chloride profiles

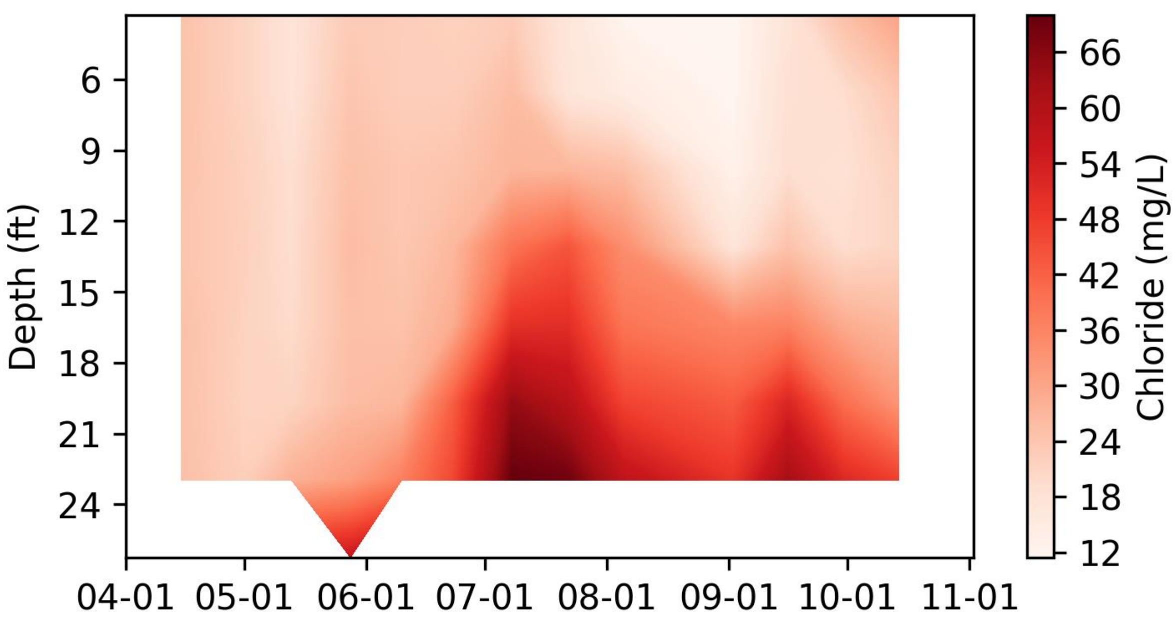


Figure 17. 2025 Shields Lake chloride profiles

APPENDIX D. 2025 LONG-TERM STREAM SITE SUMMARY

Appendix D.1. Bone Lake Management District

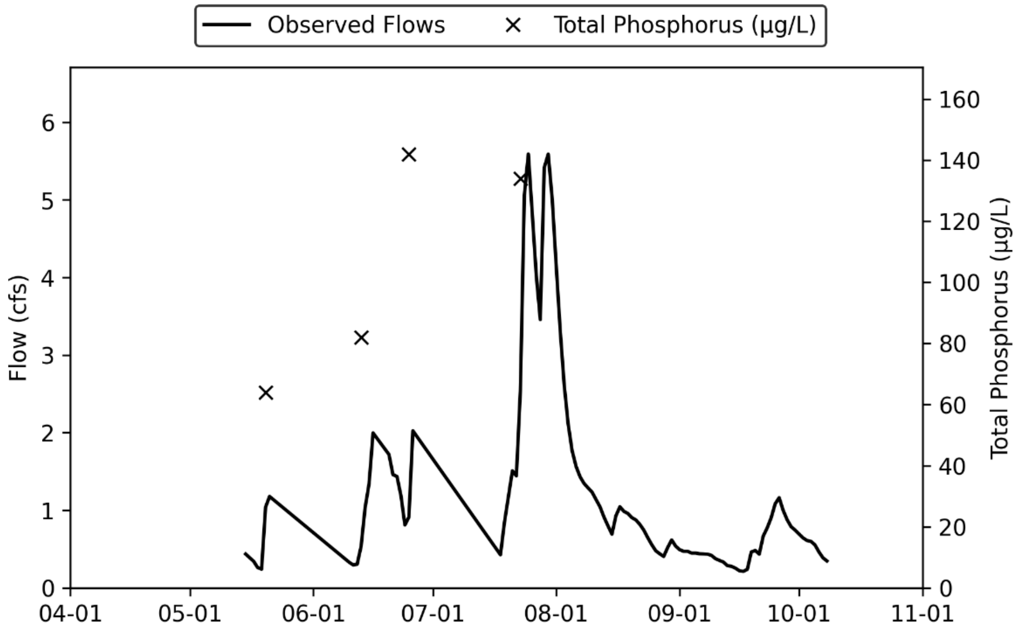


Figure 18: BL1 (inlet) TP and Daily Flow

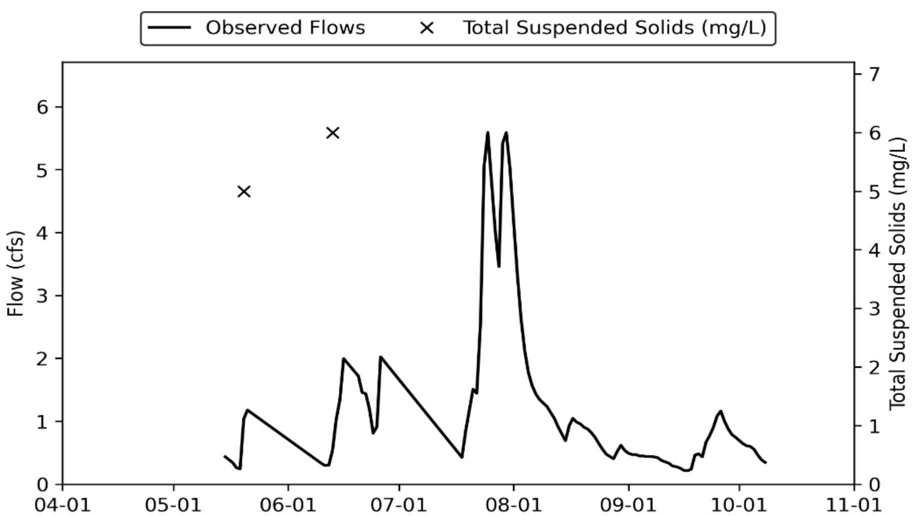


Figure 19: BL1 (inlet) TSS and Daily Flow

Table 1. BL1 2025 Stream Water Chemistry Sample Results

Red values do not meet the MN Class 2B standard.

Date/Time	Chloride (mg/L)	Iron (mg/L)	TKN (mg/L)	TP (mg/L)	Ortho-P (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	Nitrate-Nitrite (mg/L)	NH4-N (mg/L)	TSS (mg/L)	TVS (mg/L)
MN Class 2B Standards	< 230			< 0.1						<30	
2025-05-20	11.5	0.744	1.13	0.064	0.013	<0.20	<0.06	<0.20	<0.06	5	4
2025-06-13	10.9	0.786	1.13	0.082	0.022	<0.20	<0.06	<0.20	<0.06	6	4
2025-06-25	11	1.68	1.33	0.142	0.05	<0.20	<0.06	<0.20	<0.06	<6	<6
2025-07-23	8.4	1.25	1.14	0.134	0.041	<0.20	<0.06	<0.20	<0.06	<5	<5

TKN = Total Kjeldahl Nitrogen which is a measure of nitrogen contained in organic form
TP = total phosphorus which is the measure of all particulates, dissolved, inorganic and organic forms of phosphorus
Ortho-P = ortho-phosphorus which is a measure of all dissolved inorganic forms of phosphorus
NO3-N = nitrate-nitrogen which is a measure of inorganic nitrogen in nitrate form
NO2-N = nitrite-nitrogen which is a measure of inorganic nitrogen in nitrite form
NH4-N = ammonia-nitrogen which is a measure of inorganic nitrogen in ammonia form
TSS = total suspended solids which is a measure of all solids in inorganic and organic form
TVS = total volatile solids which is a measure of all solids in organic form

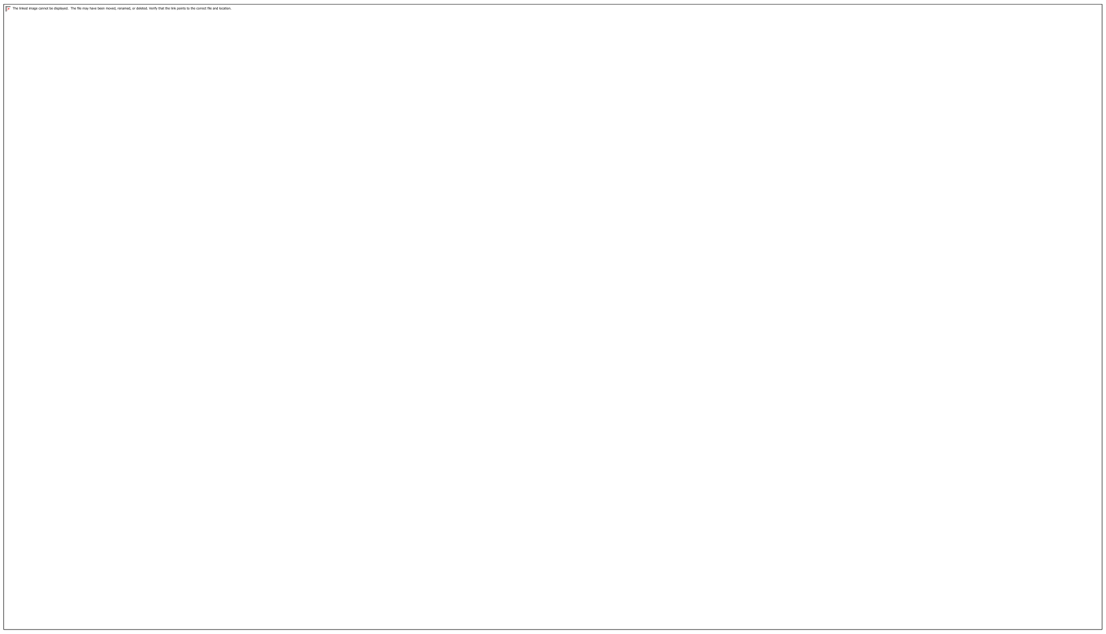


Figure 20. BL2 (outlet) TP and Daily Flow

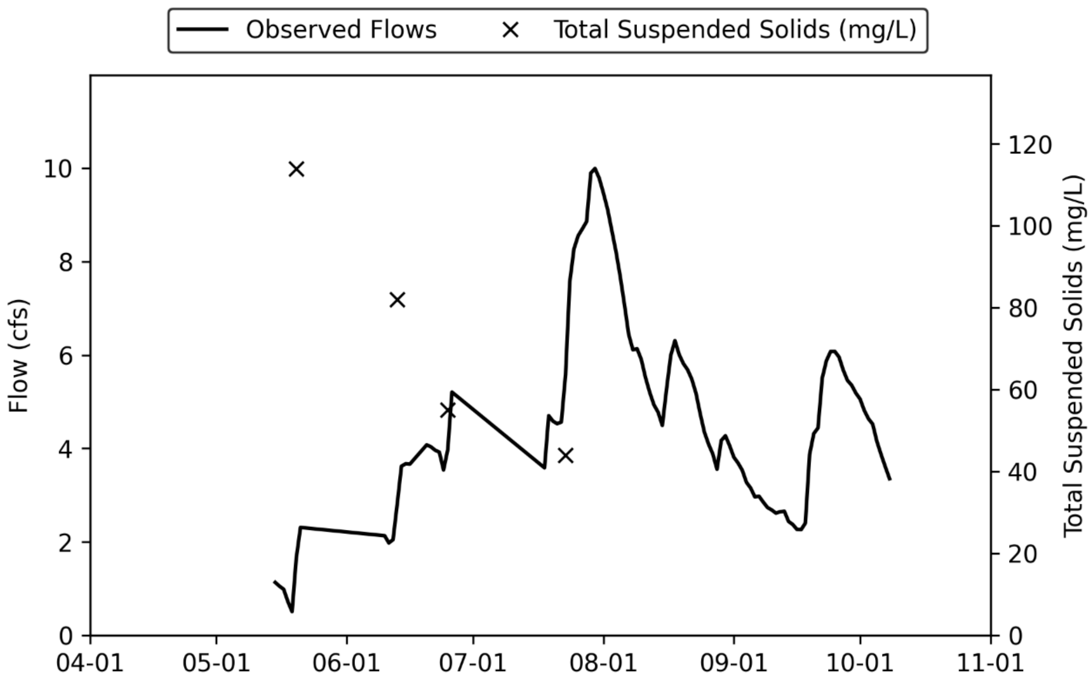


Figure 21. BL2 (outlet) TSS and Daily Flow

Table 2. BL2 2025 Stream Water Chemistry Sample Results

Red values do not meet the MN Class 2B standard.

Date/Time	Chloride (mg/L)	Iron (mg/L)	TKN (mg/L)	TP (mg/L)	Ortho-P (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	Nitrate-Nitrite (mg/L)	NH4-N (mg/L)	TSS (mg/L)	TVS (mg/L)
MN Class 2B Standards	< 230			< 0.1						**<30**	
2025-05-20	19.2	1.84	4.62	0.206	0.016	<0.20	<0.06	<0.20	0.27	114	52
2025-06-13	19.6	1.34	1.81	0.264	0.027	0.28	0.07	0.35	0.6	82	47
2025-06-25	18.3	1.15	2.43	0.249	0.046	<0.20	<0.06	<0.20	0.57	55	32
2025-07-23	18.6	0.774	3.09	0.152	0.013	<0.20	<0.06	<0.20	0.21	44	26

TKN = Total Kjeldahl Nitrogen which is a measure of nitrogen contained in organic form
TP = total phosphorus which is the measure of all particulates, dissolved, inorganic and organic forms of phosphorus
Ortho-P = ortho-phosphorus which is a measure of all dissolved inorganic forms of phosphorus
NO3-N = nitrate-nitrogen which is a measure of inorganic nitrogen in nitrate form
NO2-N = nitrite-nitrogen which is a measure of inorganic nitrogen in nitrite form
NH4-N = ammonia-nitrogen which is a measure of inorganic nitrogen in ammonia form
TSS = total suspended solids which is a measure of all solids in inorganic and organic form
TVS = total volatile solids which is a measure of all solids in organic form

Appendix D.2. Comfort Lake Management District

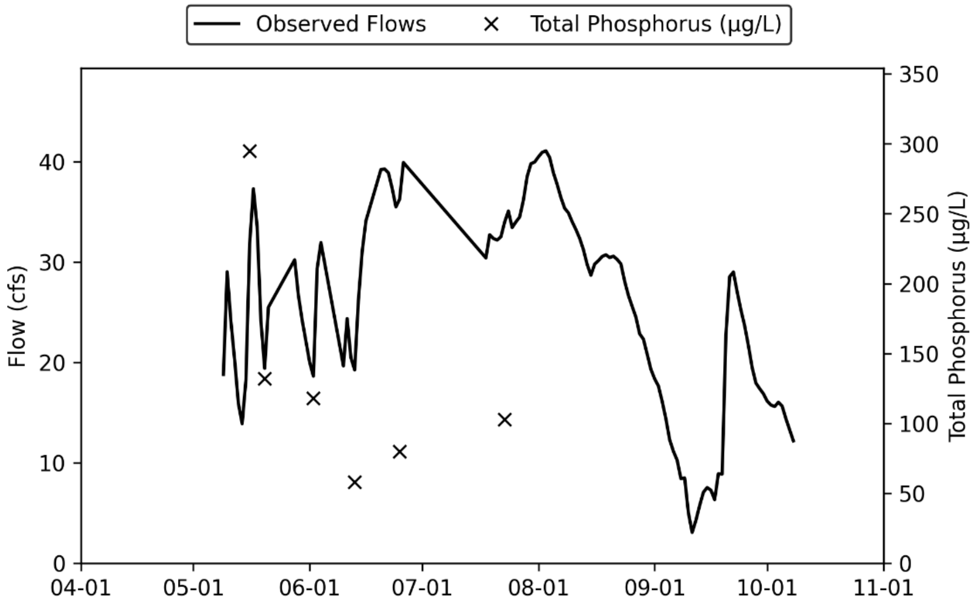


Figure 22. CL1 (outlet) TP and Daily Flow

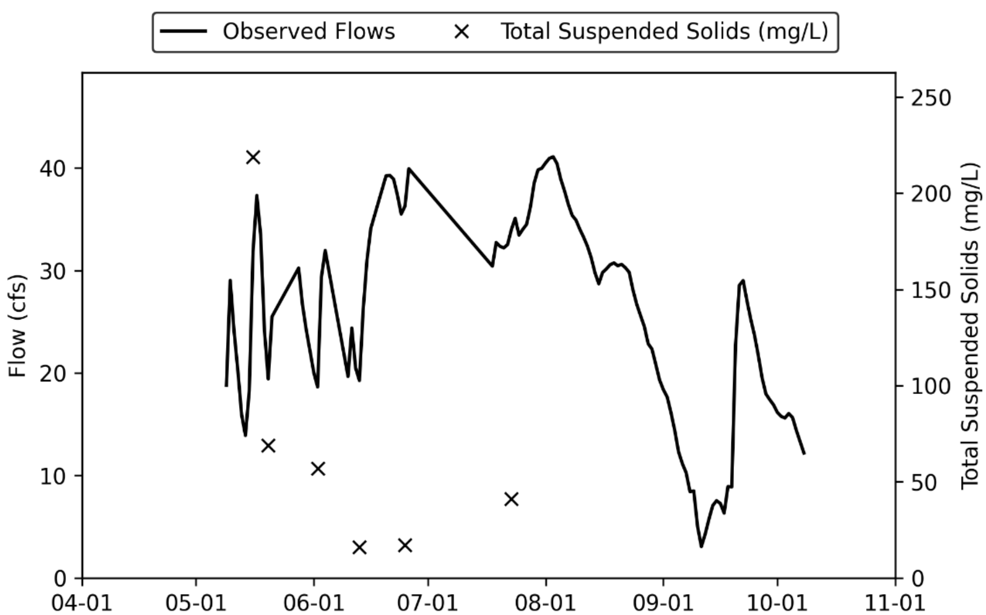


Figure 23. CL1 (outlet) TSS and Daily Flow

Table 3. CL1 2025 Stream Water Chemistry Sample Results

Red values do not meet the MN Class 2B standard.

Date/Time	Chloride (mg/L)	Iron (mg/L)	TKN (mg/L)	TP (mg/L)	Ortho-P (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	Nitrate-Nitrite (mg/L)	NH4-N (mg/L)	TSS (mg/L)	TVS (mg/L)
MN Class 2B Standards	< 230			< 0.1						**<30**	
2025-05-16	49.1	2.63	5.57	0.295	<0.010	<0.20	<0.06	<0.20	0.07	219	113
2025-05-20	42.8	1.04	2.51	0.132	<0.010	<0.20	<0.06	<0.20	<0.06	69	35
2025-06-02	46.2	1.06	2.27	0.118	<0.010	<0.20	<0.06	<0.20	<0.06	57	31
2025-06-13	42.9	0.248	1.42	0.058	<0.010	<0.20	<0.06	<0.20	<0.06	16	10
2025-06-25	42.3	0.281	1.54	0.08	<0.010	<0.20	<0.06	<0.20	<0.06	17	12
2025-07-23	38	0.627	2.08	0.103	<0.010	<0.20	<0.06	<0.20	<0.06	41	24

TKN = Total Kjeldahl Nitrogen which is a measure of nitrogen contained in organic form
TP = total phosphorus which is the measure of all particulates, dissolved, inorganic and organic forms of phosphorus
Ortho-P = ortho-phosphorus which is a measure of all dissolved inorganic forms of phosphorus
NO3-N = nitrate-nitrogen which is a measure of inorganic nitrogen in nitrate form
NO2-N = nitrite-nitrogen which is a measure of inorganic nitrogen in nitrite form
NH4-N = ammonia-nitrogen which is a measure of inorganic nitrogen in ammonia form
TSS = total suspended solids which is a measure of all solids in inorganic and organic form
TVS = total volatile solids which is a measure of all solids in organic form

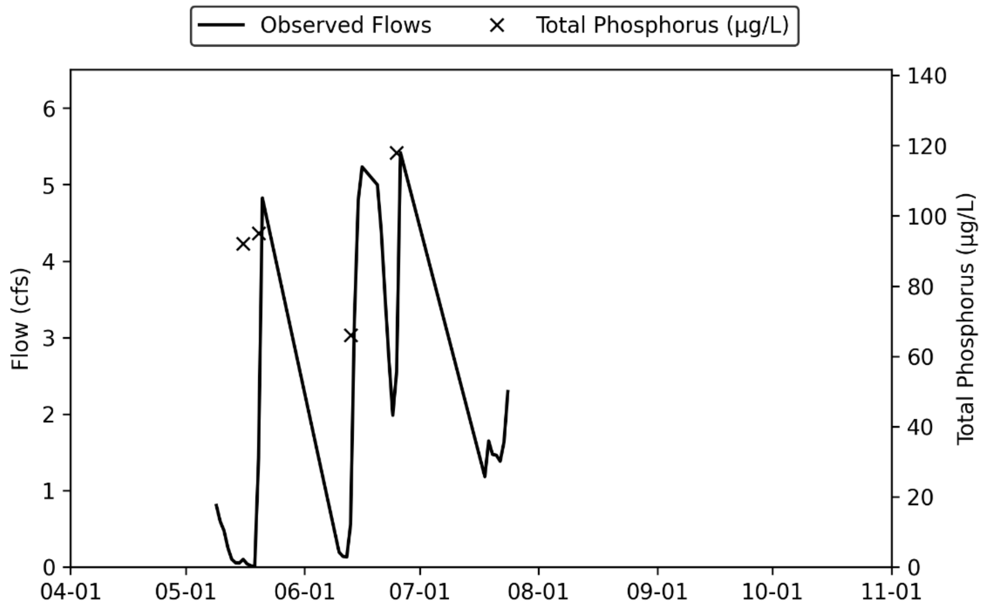


Figure 24. CL2 (inlet) TP and Daily Flow

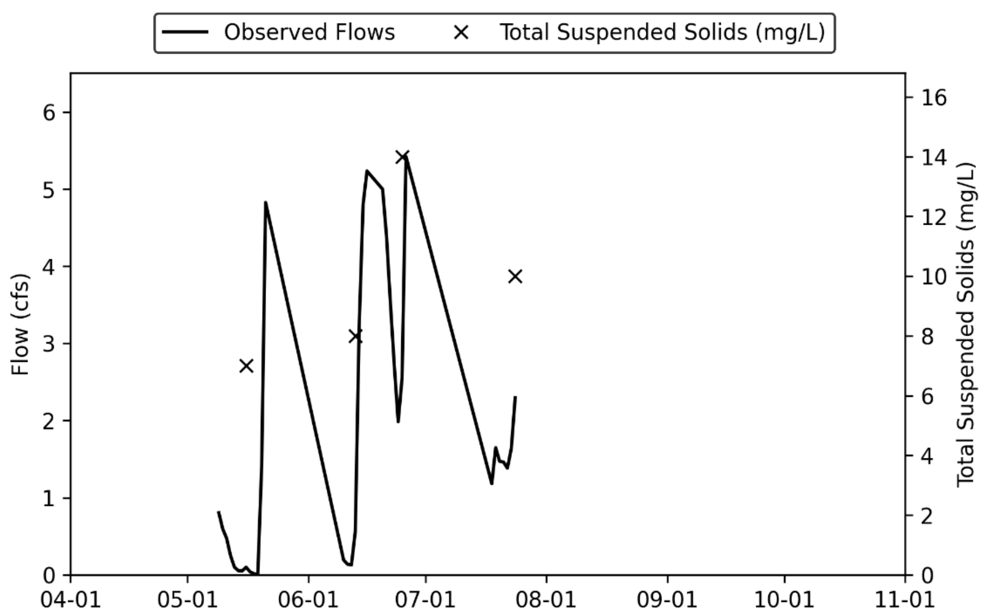


Figure 25. CL2 (inlet) TSS and Daily Flow

Table 4. CL2 2025 Stream Water Chemistry Sample Results

Red values do not meet the MN Class 2B standard.

Date/Time	Chloride (mg/L)	Iron (mg/L)	TKN (mg/L)	TP (mg/L)	Ortho-P (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	Nitrate-Nitrite (mg/L)	NH4-N (mg/L)	TSS (mg/L)	TVS (mg/L)
MN Class 2B Standards	< 230			< 0.1						**<30**	
2025-05-16	67.1	0.714	1.23	0.092	0.013	0.29	<0.06	0.29	<0.06	7	4
2025-05-20	64.5		1.39	0.095							
2025-06-13	53.5	0.492	1.03	0.066	<0.010	0.49	<0.06	0.49	0.06	8	5
2025-06-25	39.4	0.969	4.47	0.118	0.017	0.21	<0.06	0.21	<0.06	14	9
2025-07-24			1.41							10	6

TKN = Total Kjeldahl Nitrogen which is a measure of nitrogen contained in organic form
TP = total phosphorus which is the measure of all particulates, dissolved, inorganic and organic forms of phosphorus
Ortho-P = ortho-phosphorus which is a measure of all dissolved inorganic forms of phosphorus
NO3-N = nitrate-nitrogen which is a measure of inorganic nitrogen in nitrate form
NO2-N = nitrite-nitrogen which is a measure of inorganic nitrogen in nitrite form
NH4-N = ammonia-nitrogen which is a measure of inorganic nitrogen in ammonia form
TSS = total suspended solids which is a measure of all solids in inorganic and organic form
TVS = total volatile solids which is a measure of all solids in organic form

Appendix D.3. Little Comfort Lake Management District

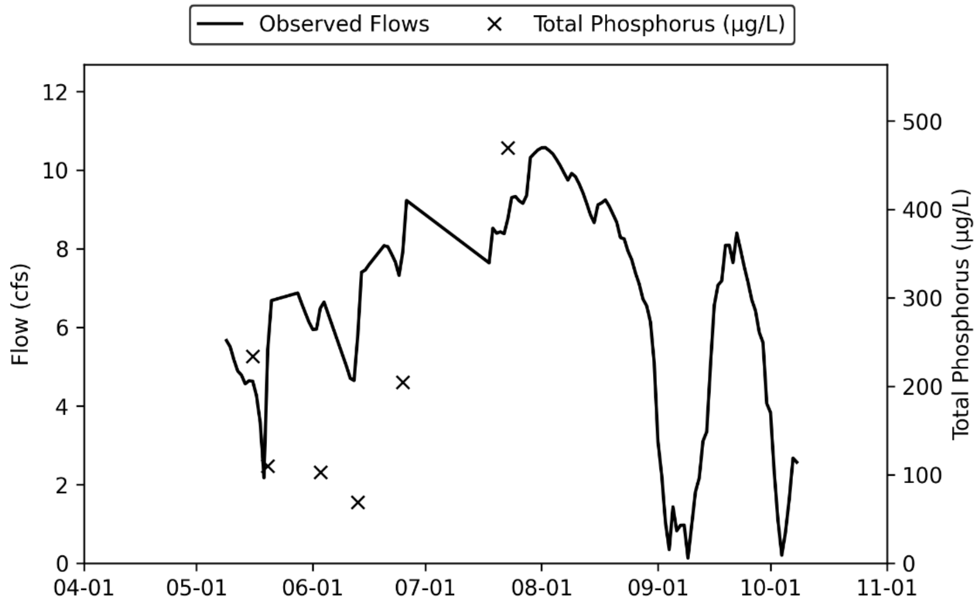


Figure 26. LC1 (inlet) TP and Daily Flow

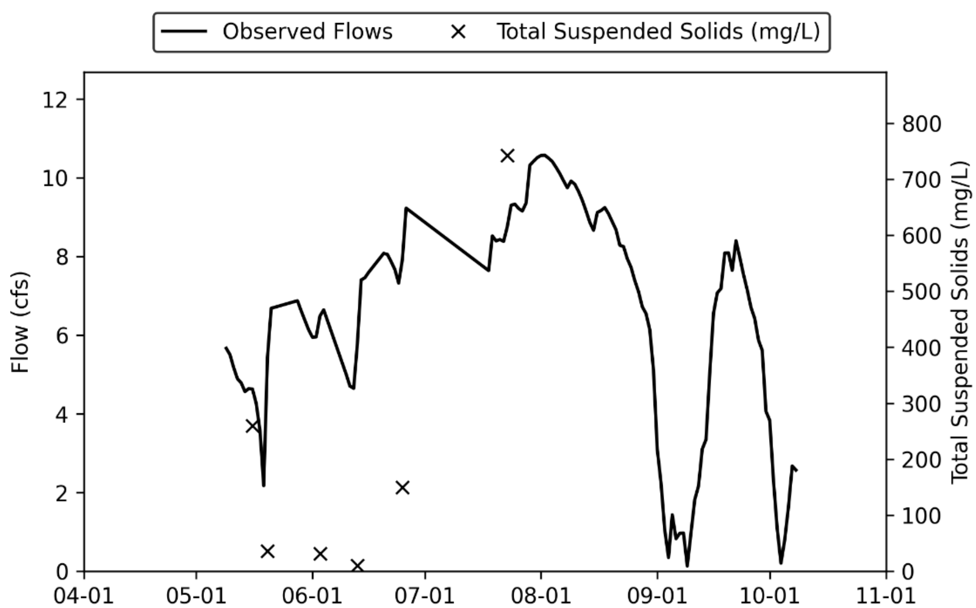


Figure 27. LC1 (inlet) TSS and Daily Flow

Table 5. LC1 2023 Stream Water Chemistry Sample Results

Red values do not meet the MN Class 2B standard.

Date/Time	Chloride (mg/L)	Iron (mg/L)	TKN (mg/L)	TP (mg/L)	Ortho-P (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	Nitrate-Nitrite (mg/L)	NH4-N (mg/L)	TSS (mg/L)	TVS (mg/L)
MN Class 2B Standards	< 230			< 0.1						**<30**	
2025-05-16			2.72	0.234						260	101
2025-05-20	16.2	1.6	1.51	0.11	0.014	<0.20	<0.06	<0.20	<0.06	36	18
2025-06-03	19.3	1.26	1.73	0.103	0.014	<0.20	<0.06	<0.20	0.12	31	17
2025-06-13	14.8	0.563	1.38	0.069	0.023	<0.20	<0.06	<0.20	0.1	10	7
2025-06-25	15.6	2.66	3.02	0.205	0.021	<0.20	<0.06	<0.20	0.08	150	86
2025-07-23	15.4	8.46	4.5	0.47	0.023	<0.20	<0.06	<0.20	<0.06	743	332

TKN = Total Kjeldahl Nitrogen which is a measure of nitrogen contained in organic form
TP = total phosphorus which is the measure of all particulates, dissolved, inorganic and organic forms of phosphorus
Ortho-P = ortho-phosphorus which is a measure of all dissolved inorganic forms of phosphorus
NO3-N = nitrate-nitrogen which is a measure of inorganic nitrogen in nitrate form
NO2-N = nitrite-nitrogen which is a measure of inorganic nitrogen in nitrite form
NH4-N = ammonia-nitrogen which is a measure of inorganic nitrogen in ammonia form
TSS = total suspended solids which is a measure of all solids in inorganic and organic form
TVS = total volatile solids which is a measure of all solids in organic form

Appendix D.4. Forest Lake Management District

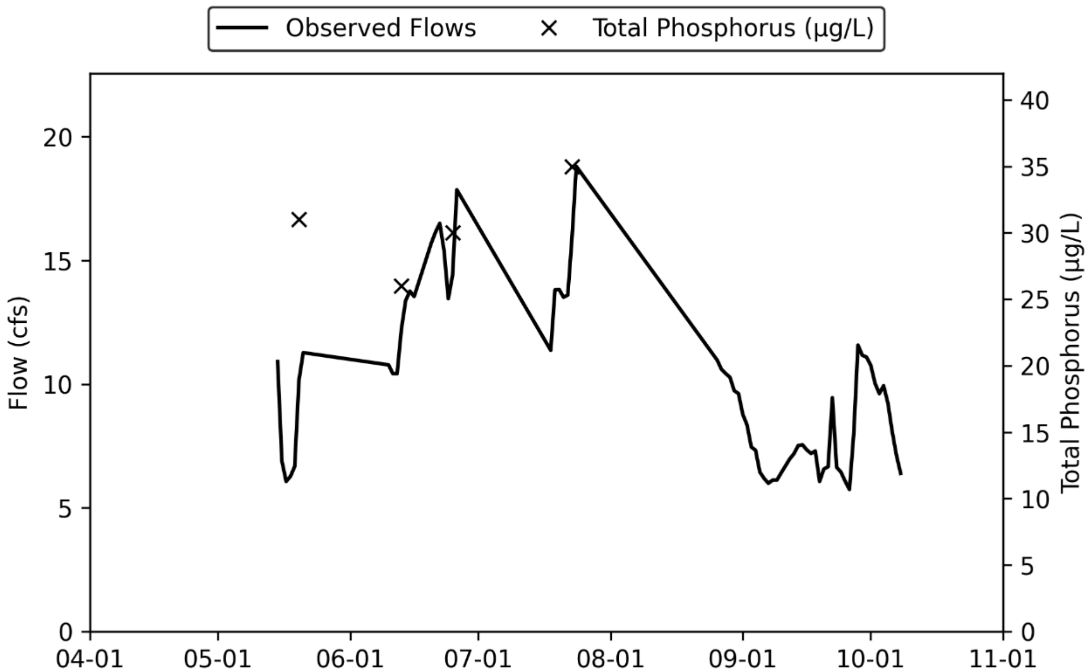


Figure 28. FL1 (outlet) TP and Daily Flow

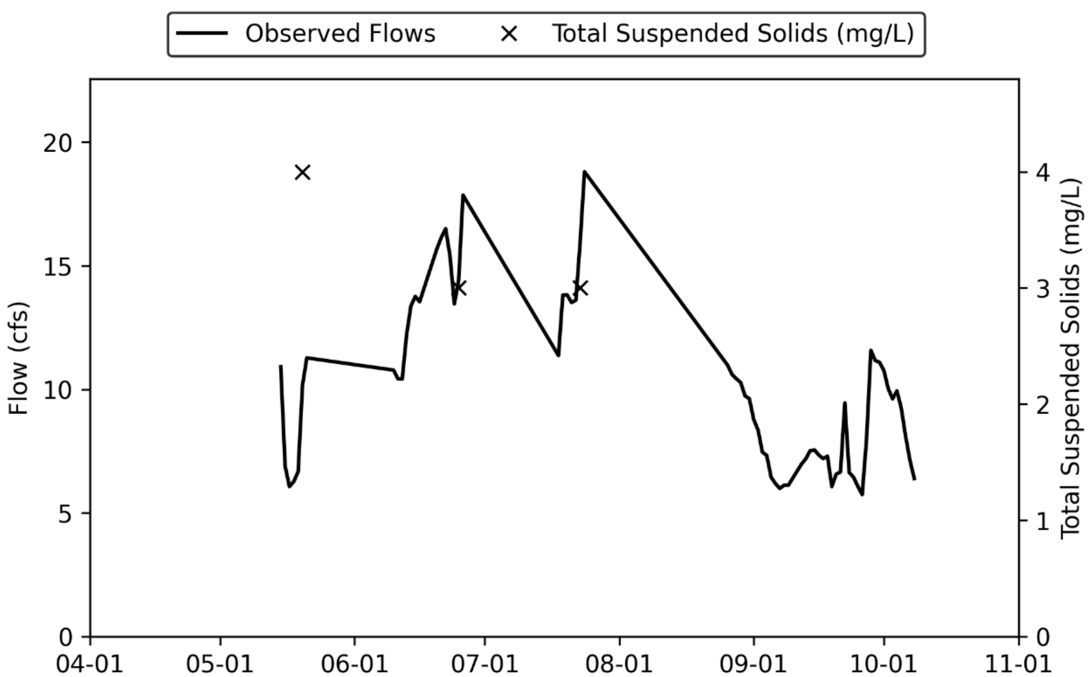


Figure 29. FL1 (outlet) TSS and Daily Flow

Table 6. FL1 2025 Stream Water Chemistry Sample Results

Red values do not meet the MN Class 2B standard.

Date/Time	Chloride (mg/L)	Iron (mg/L)	TKN (mg/L)	TP (mg/L)	Ortho-P (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	Nitrate -Nitrite (mg/L)	NH4-N (mg/L)	TSS (mg/L)	TVS (mg/L)
MN Class 2B Standards	< 230			< 0.1						**<30**	
2025-05-20	29.4	<0.125	0.64	0.031	<0.010	0.22	<0.06	0.22	<0.06	4	<3
2025-06-13	30.2	<0.125	0.65	0.026	<0.010	<0.20	<0.06	<0.20	<0.06	<3	<3
2025-06-25	30.9	<0.125	0.88	0.03	<0.010	<0.20	<0.06	<0.20	<0.06	3	<3
2025-07-23	30.1	<0.125	0.68	0.035	<0.010	<0.20	<0.06	<0.20	<0.06	3	<3

TKN = Total Kjeldahl Nitrogen which is a measure of nitrogen contained in organic form
TP = total phosphorus which is the measure of all particulates, dissolved, inorganic and organic forms of phosphorus
Ortho-P = ortho-phosphorus which is a measure of all dissolved inorganic forms of phosphorus
NO3-N = nitrate-nitrogen which is a measure of inorganic nitrogen in nitrate form
NO2-N = nitrite-nitrogen which is a measure of inorganic nitrogen in nitrite form
NH4-N = ammonia-nitrogen which is a measure of inorganic nitrogen in ammonia form
TSS = total suspended solids which is a measure of all solids in inorganic and organic form
TVS = total volatile solids which is a measure of all solids in organic form

APPENDIX E. DIAGNOSTIC MONITORING SUMMARY

Appendix E.1. CL8-B

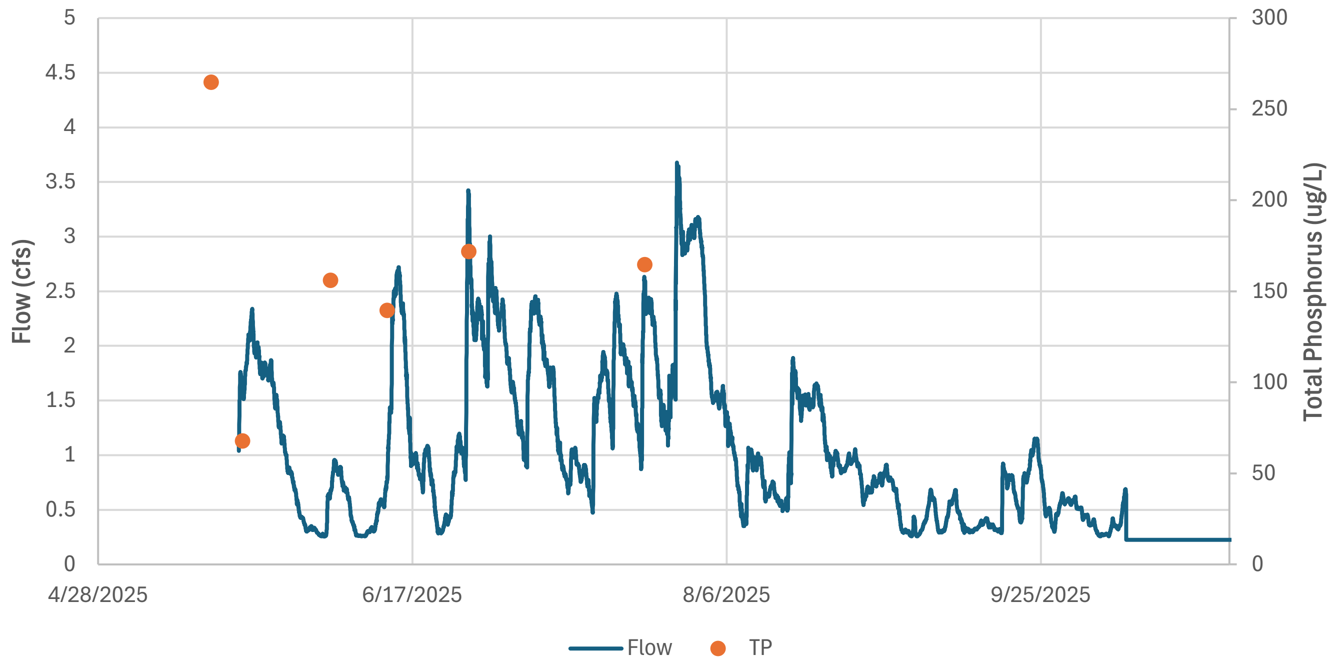


Figure 30: CL8-B Flow and TP concentrations throughout 2025.

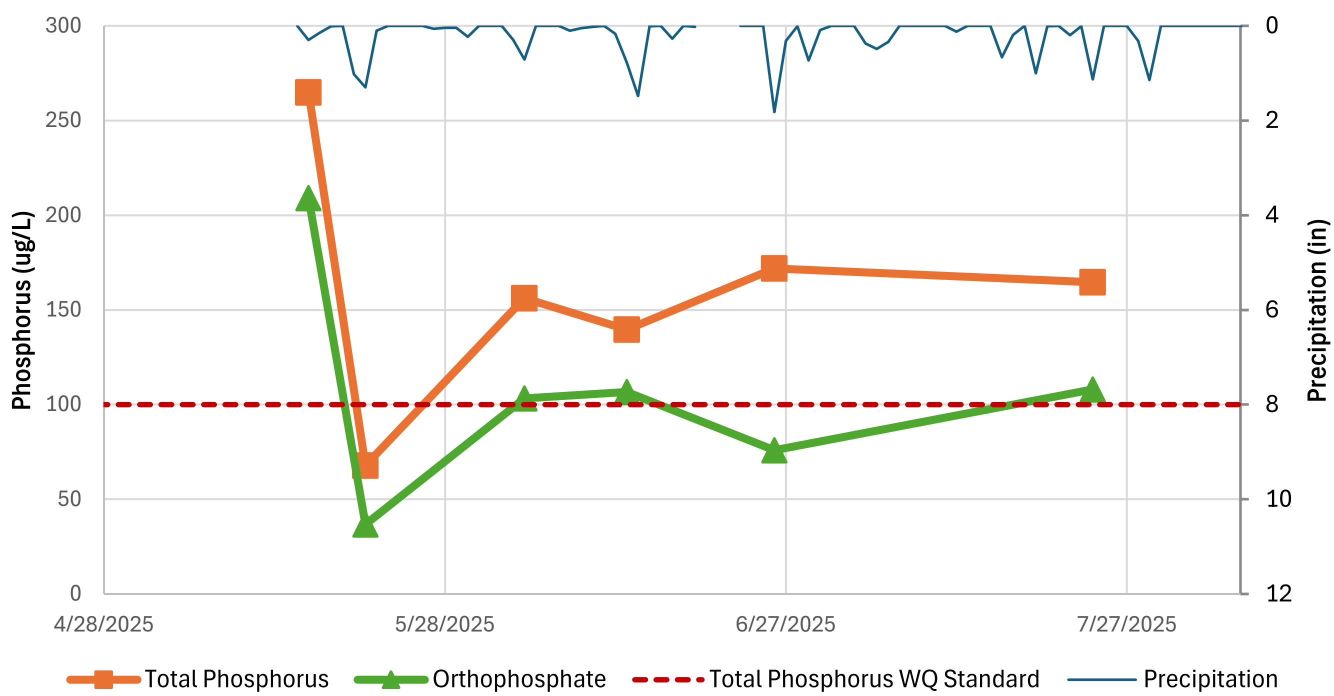


Figure 31: CL8-B Total Phosphorus and Orthophosphate Concentrations, Water Quality Standard, and Rainfall data comparison

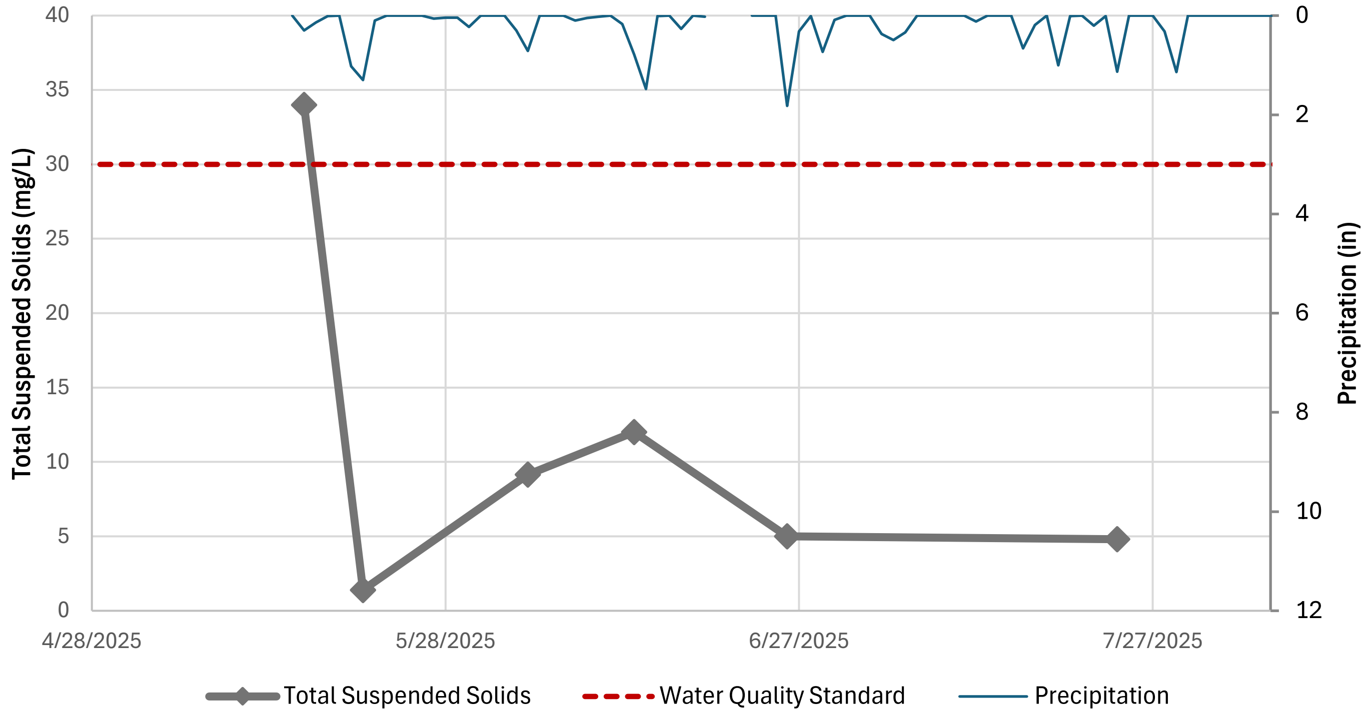


Figure 32: CL8-B Total Suspended Solids Concentrations, Water Quality Standard, and Rainfall data comparison

Appendix E.2. CL8

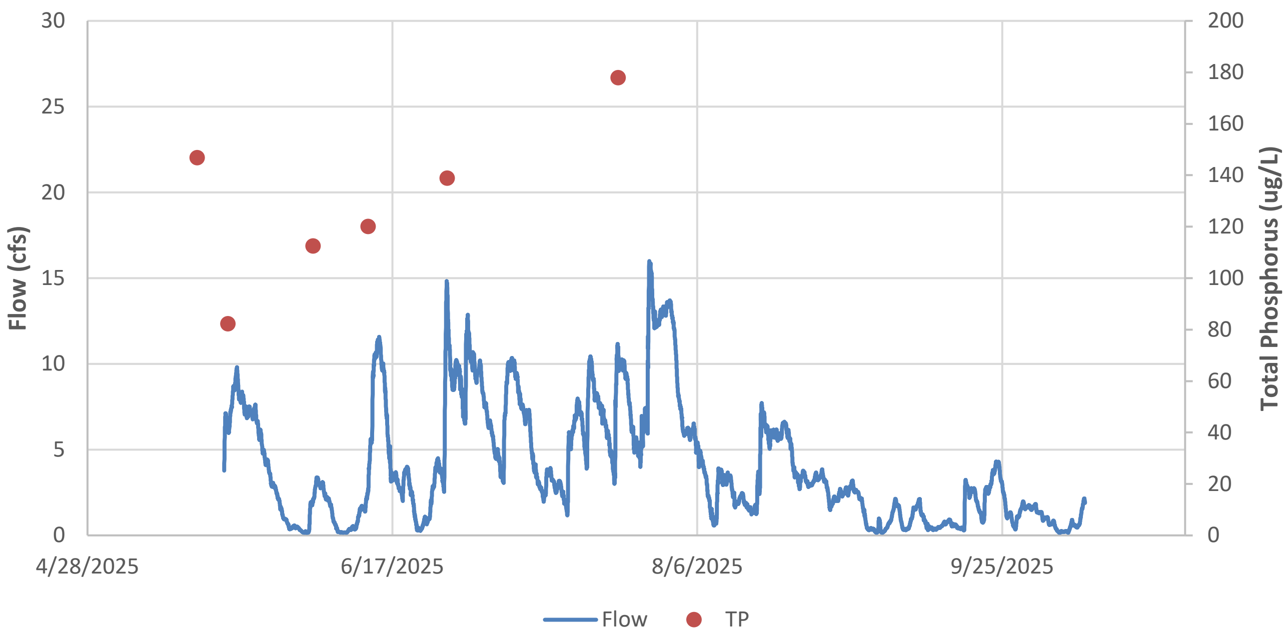


Figure 33: CL8 Flow and TP concentrations throughout 2025.

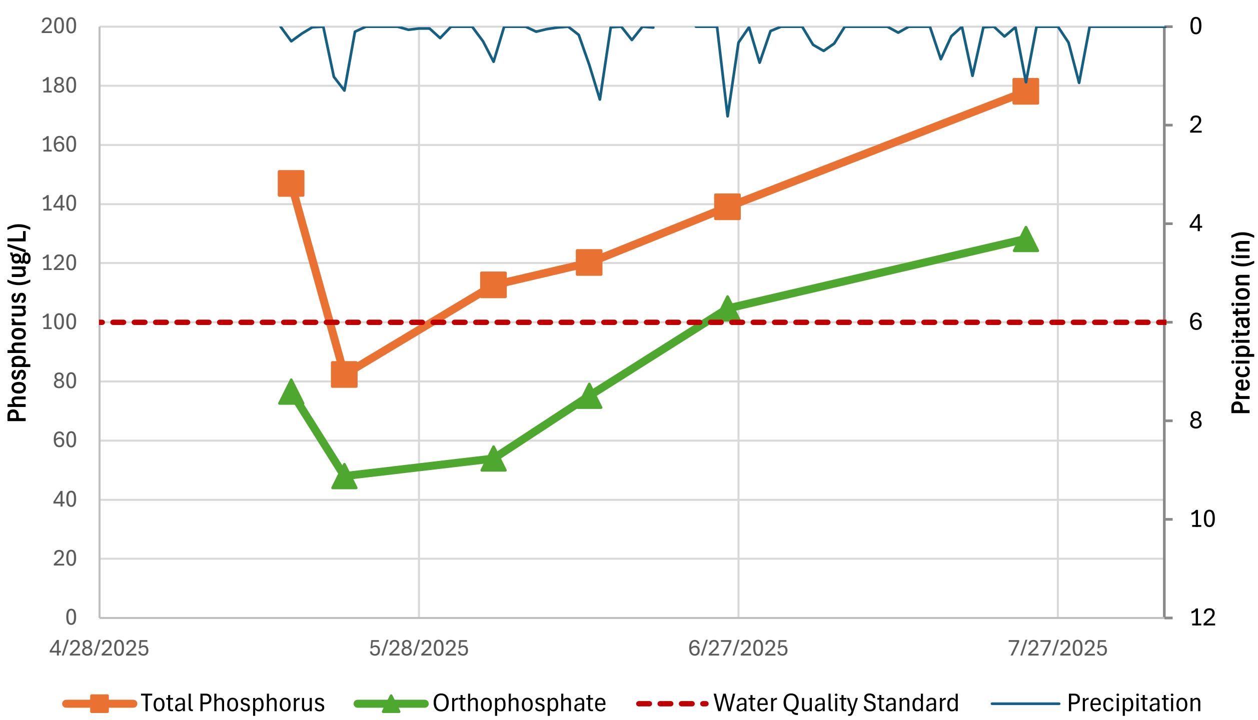


Figure 34: CL8 Total Phosphorus and Orthophosphate Concentrations, Water Quality Standard, and Rainfall data comparison

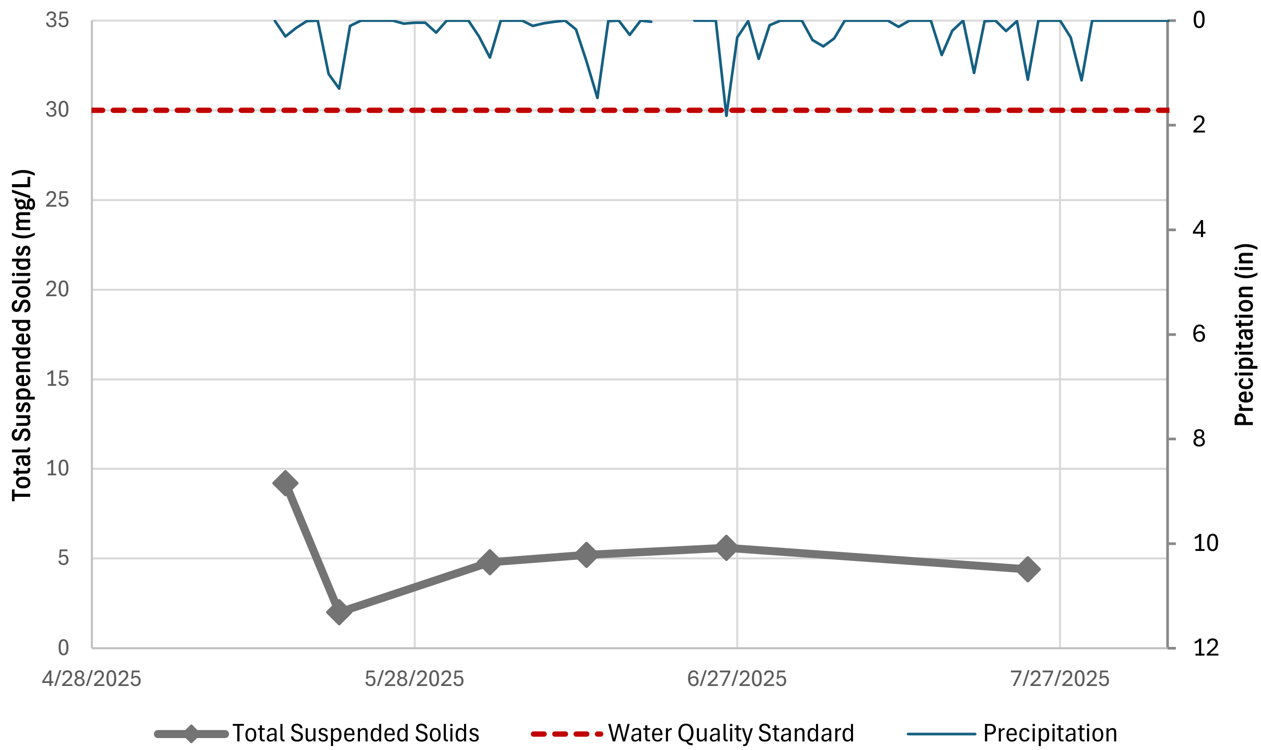


Figure 35: CL8 Total Suspended Solids Concentrations, Water Quality Standard, and Rainfall data comparison

Appendix E.1. CL7-F

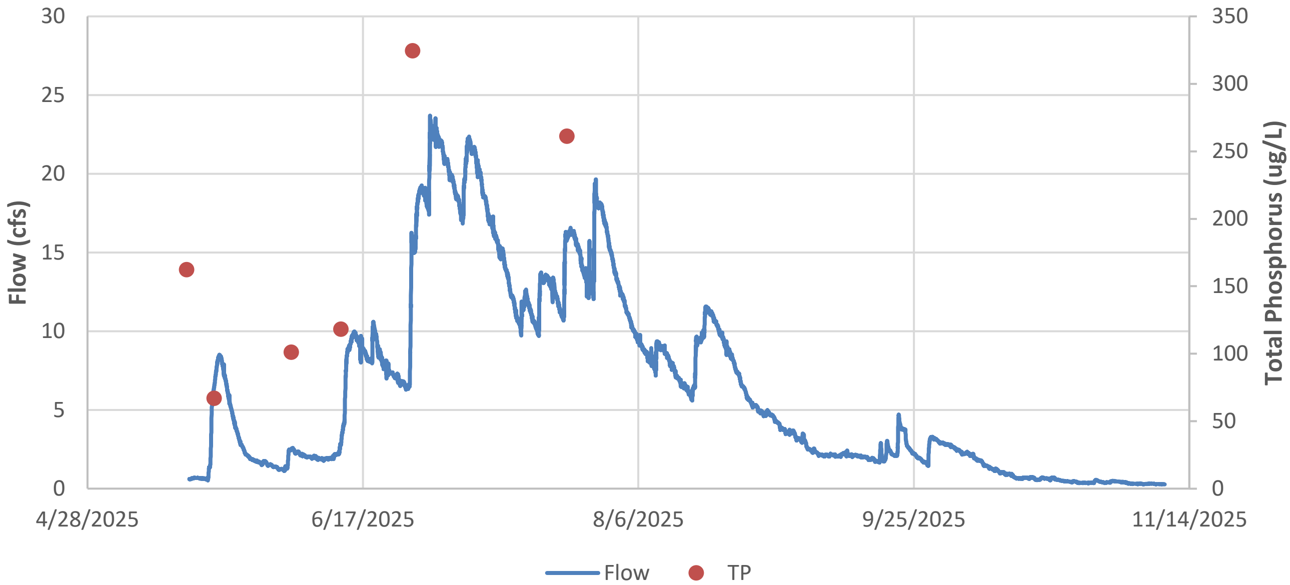


Figure 36: CL7-F Flow and TP concentrations throughout 2025.

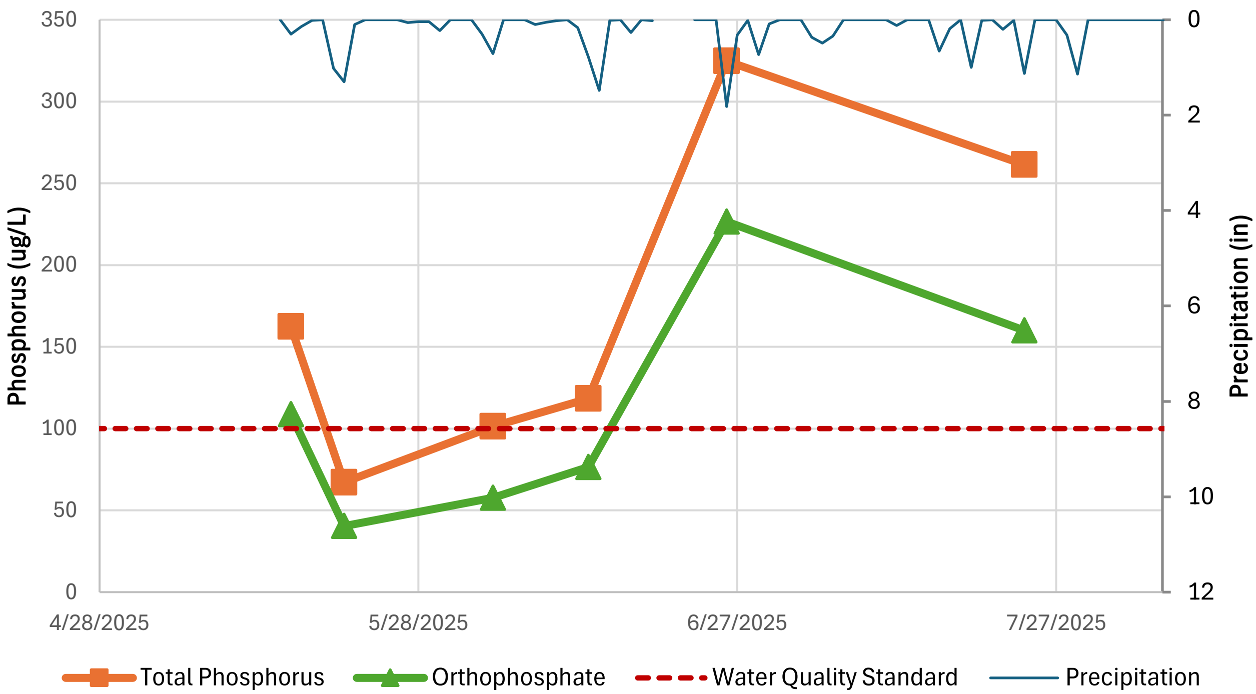


Figure 37: CL7-F Total Phosphorus and Orthophosphate Concentrations, Water Quality Standard, and Rainfall data comparison

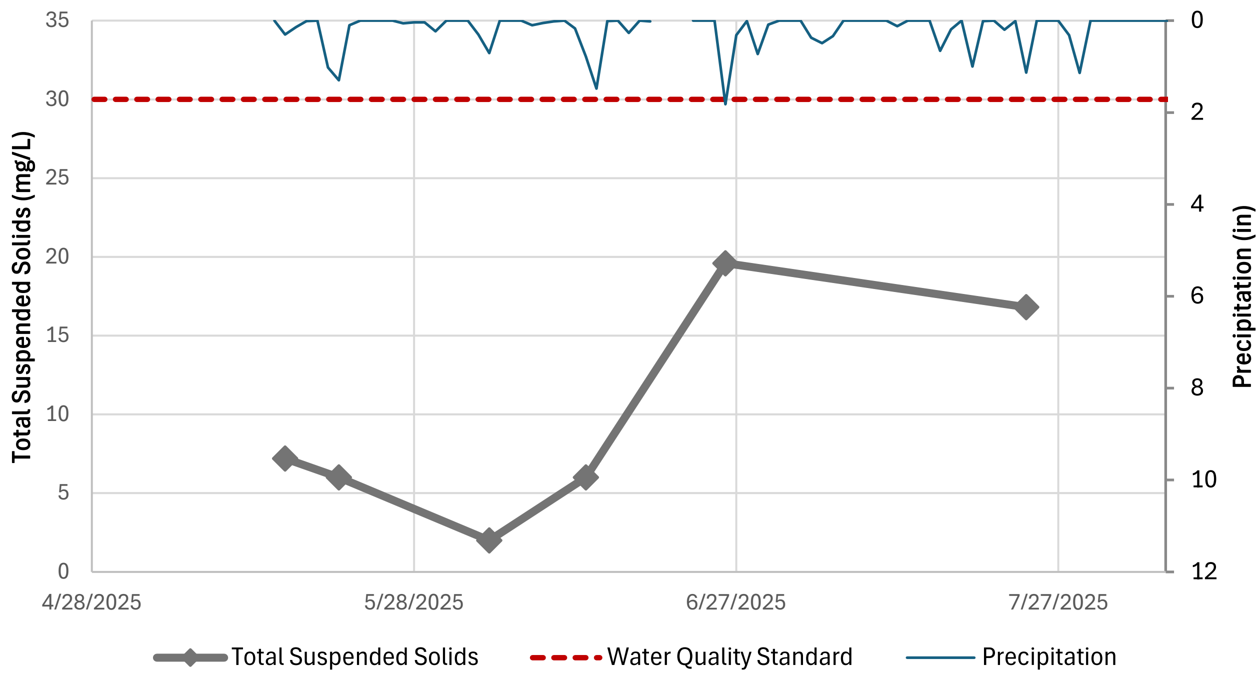


Figure 38: CL7-F Total Suspended Solids Concentrations, Water Quality Standard, and Rainfall data comparison

Appendix E.2. CL7-G

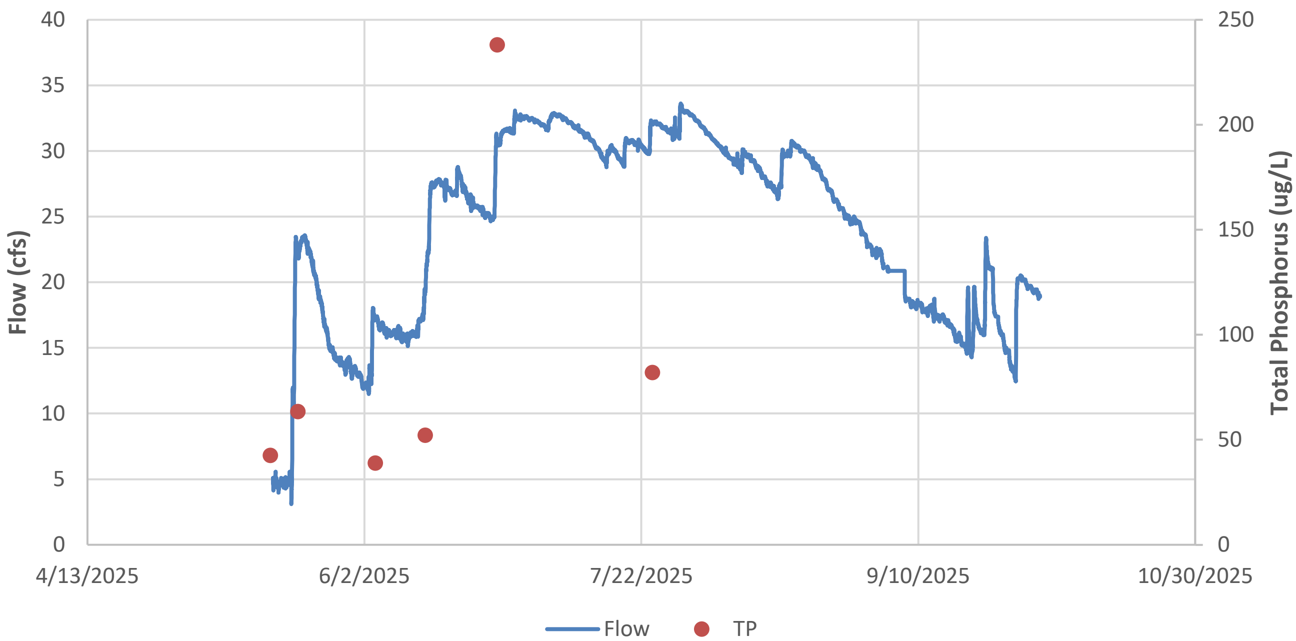


Figure 39: CL7-G Flow and TP concentrations throughout 2025.

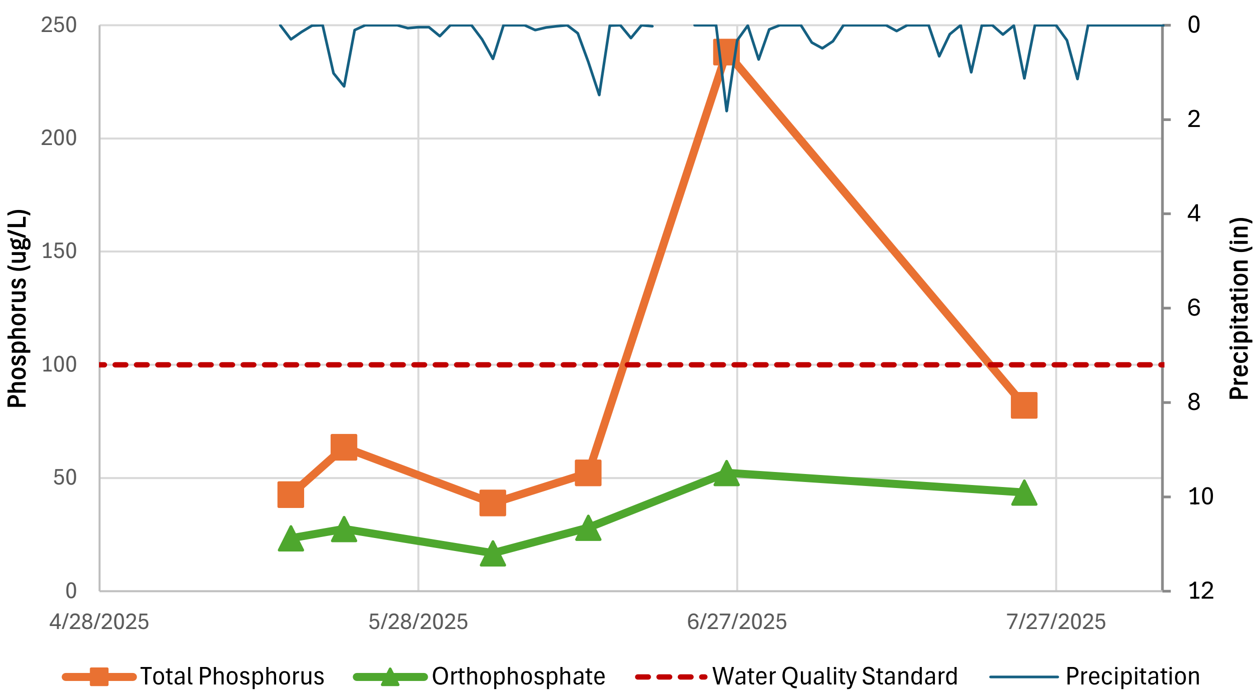


Figure 40: CL7-G Total Phosphorus and Orthophosphate Concentrations, Water Quality Standard, and Rainfall data comparison

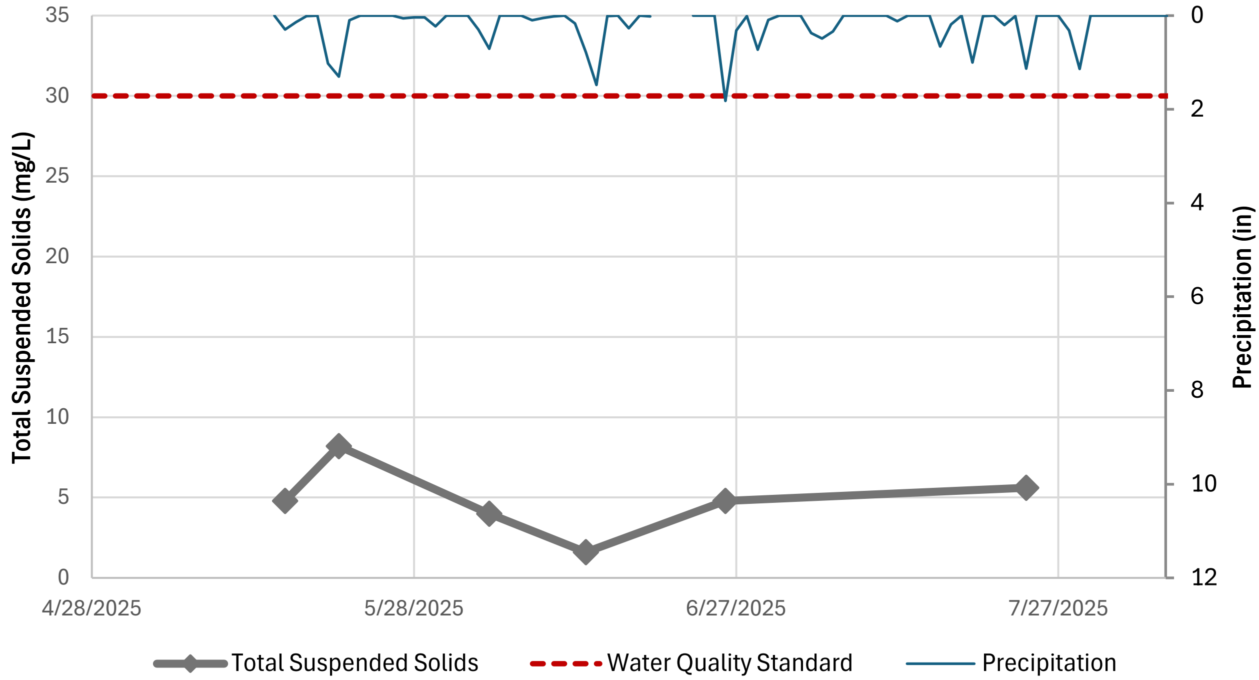


Figure 41: CL7-G Total Suspended Solids Concentrations, Water Quality Standard, and Rainfall data comparison

Appendix E.3. **CL5**

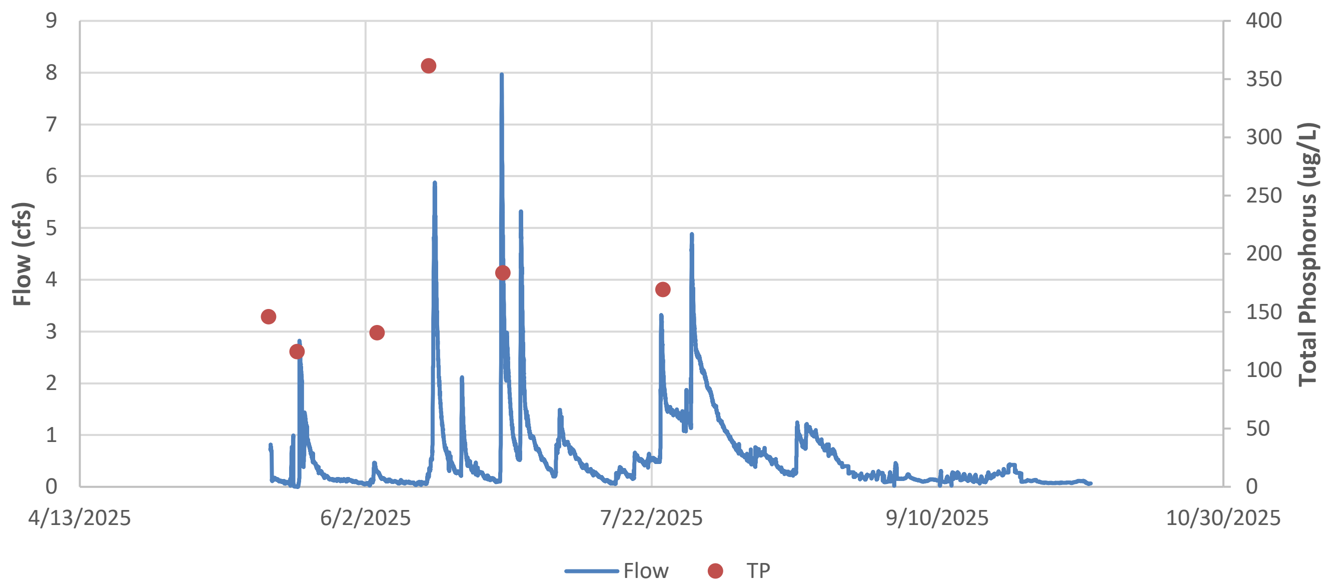


Figure 42: CL5 Flow and TP concentrations throughout 2025.

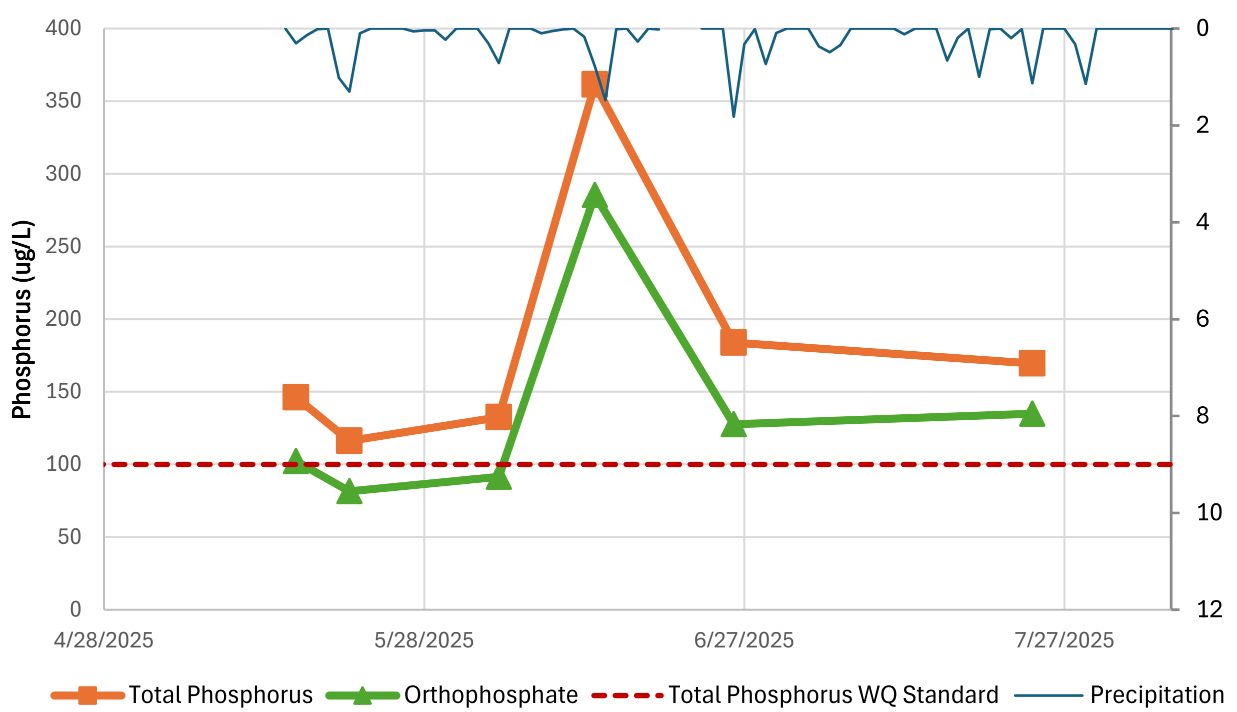


Figure 43: CL5 Total Phosphorus and Orthophosphate Concentrations, Water Quality Standard, and Rainfall data comparison

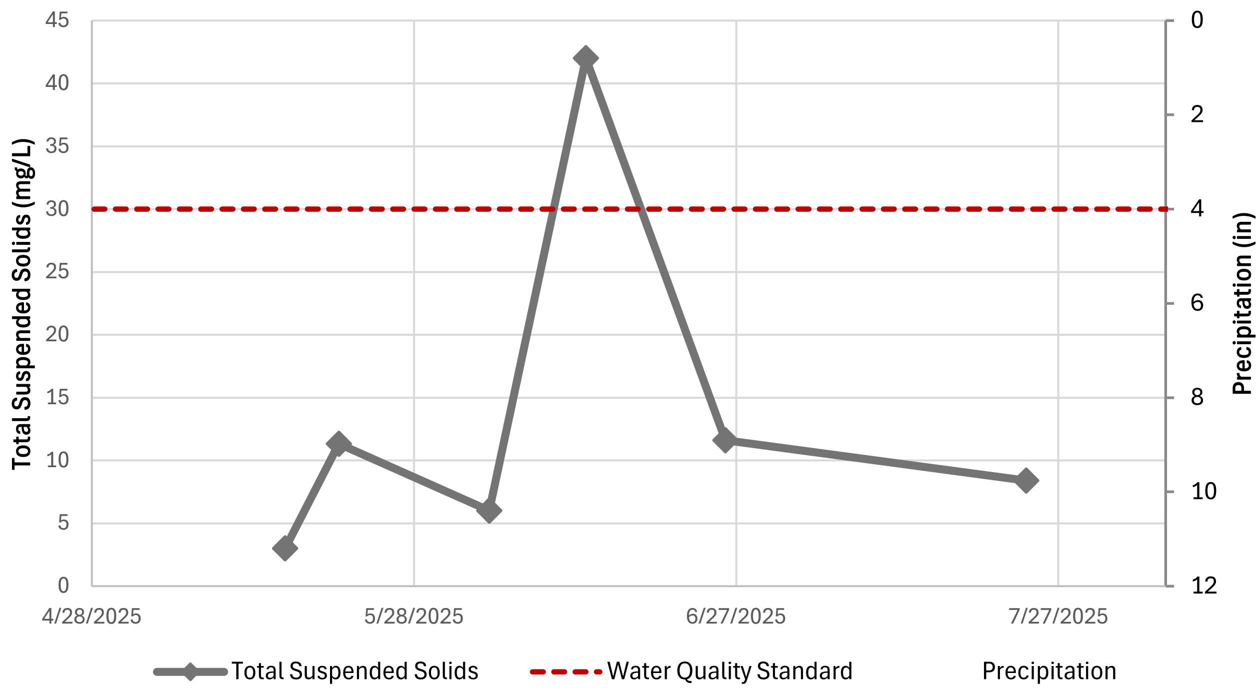


Figure 44: CL5 Total Suspended Solids Concentrations, Water Quality Standard, and Rainfall data comparison

Appendix E.4. CL4

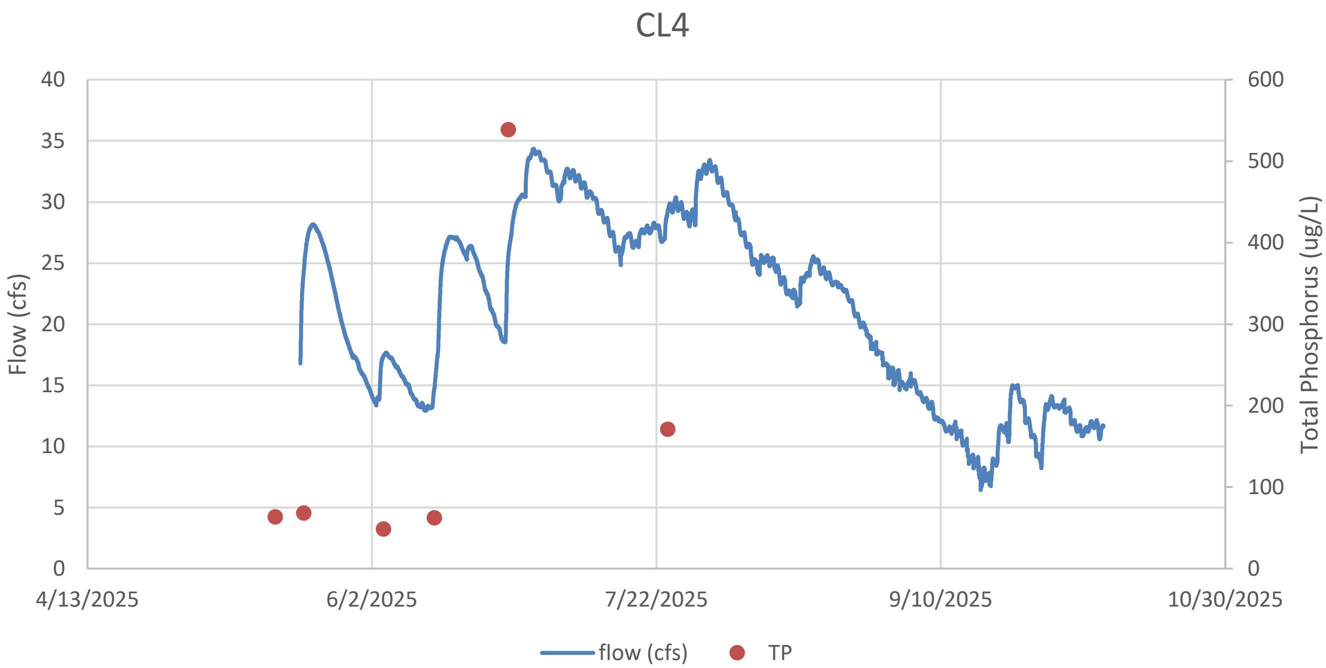


Figure 45: CL4 Flow and TP concentrations throughout 2025.

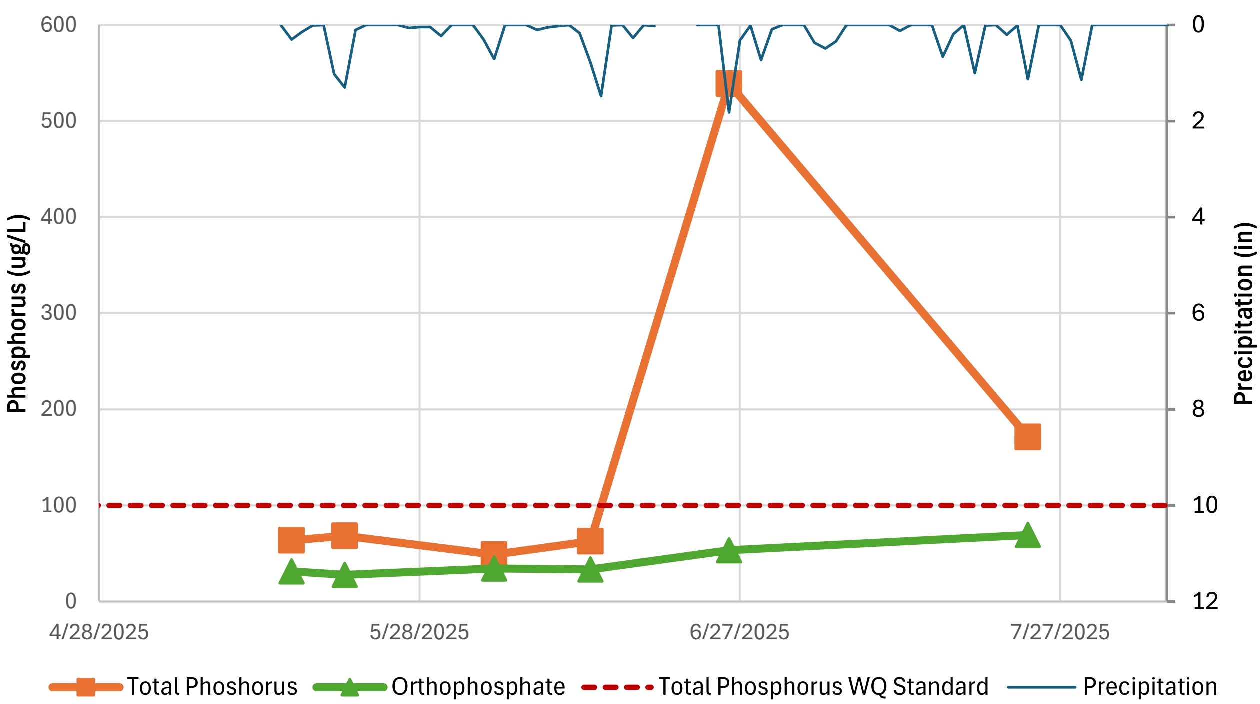


Figure 46: CL4 Total Phosphorus and Orthophosphate Concentrations, Water Quality Standard, and Rainfall data comparison

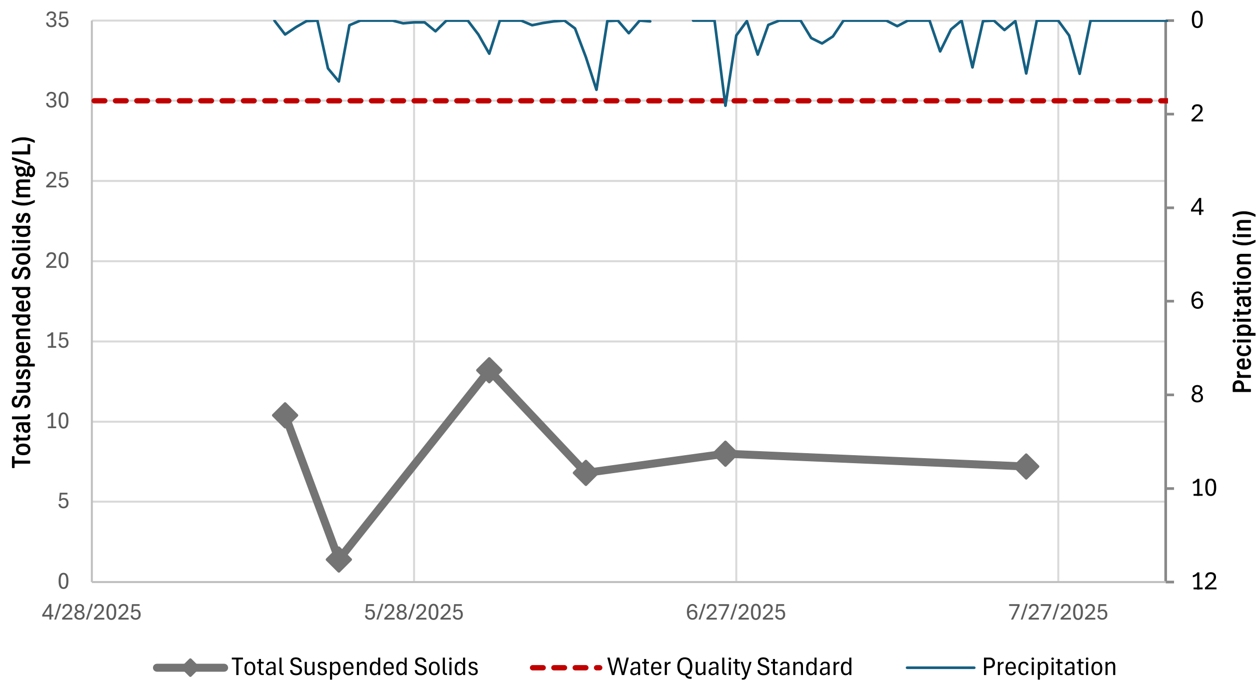


Figure 47: CL4: Total Suspended Solids Concentrations, Water Quality Standard, and Rainfall data comparison

Appendix E.5. CL3

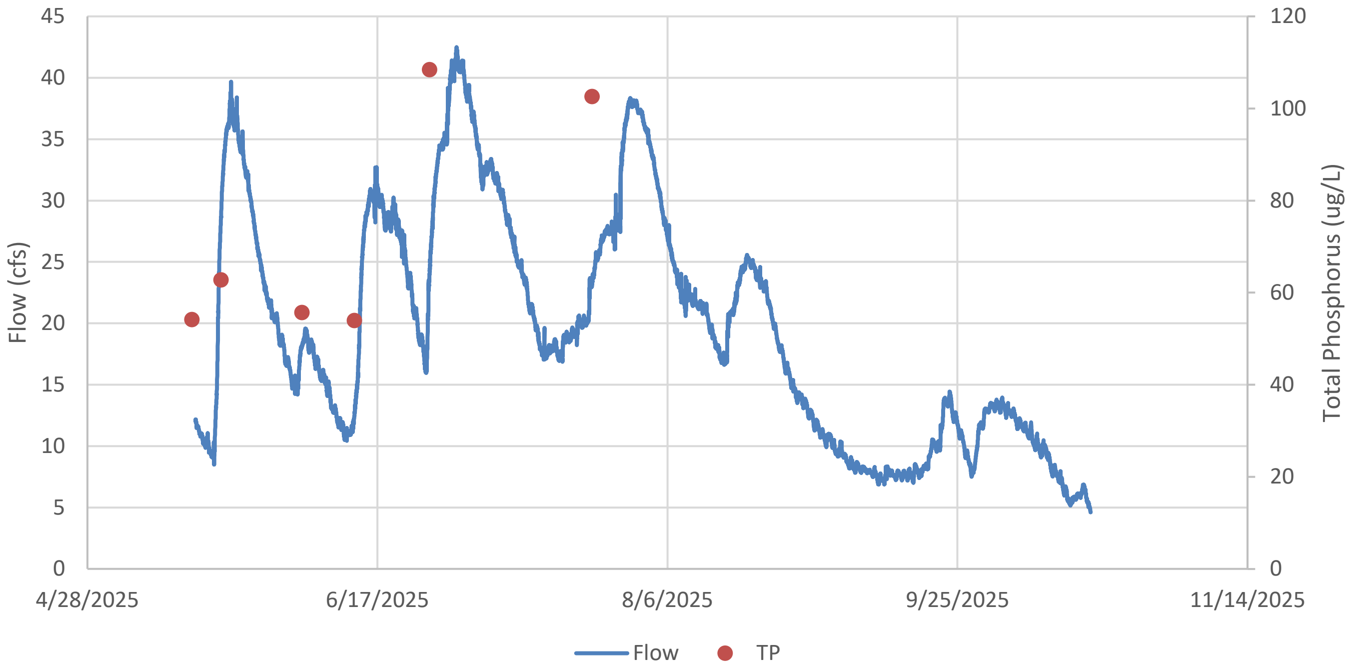


Figure 48: CL3 Flow and TP concentrations throughout 2025.

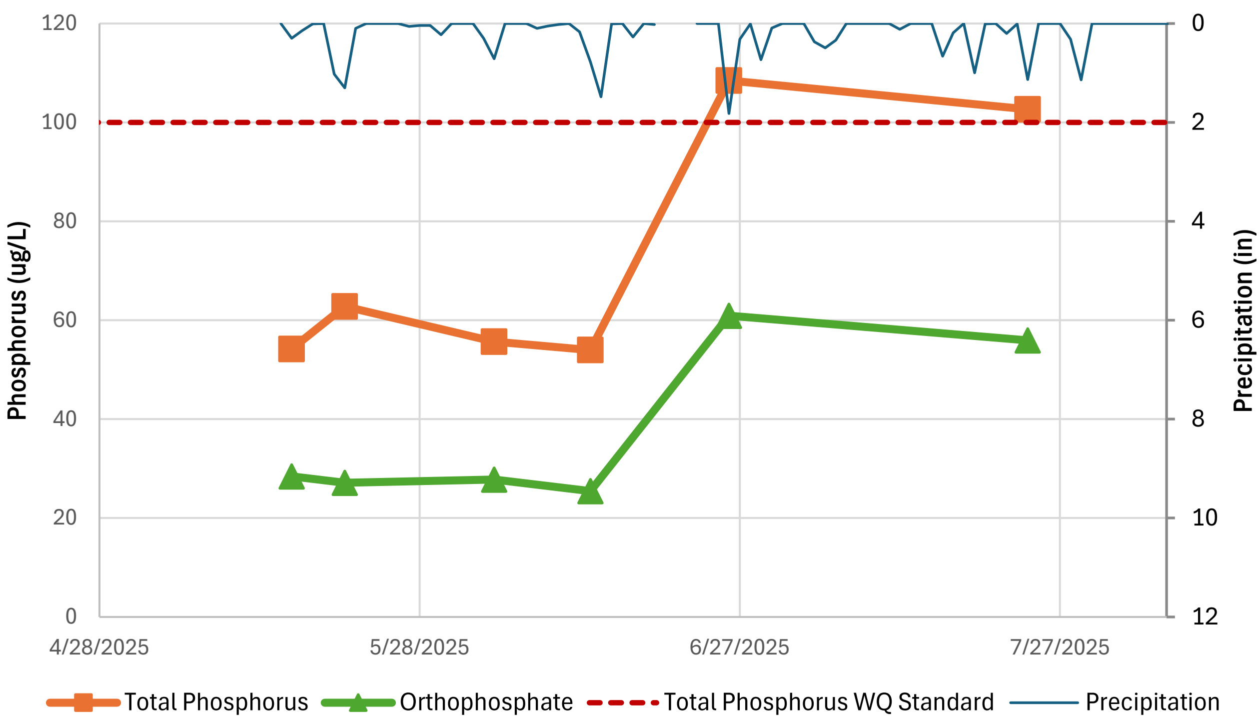


Figure 49: CL3 Total Phosphorus and Orthophosphate Concentrations, Water Quality Standard, and Rainfall data comparison

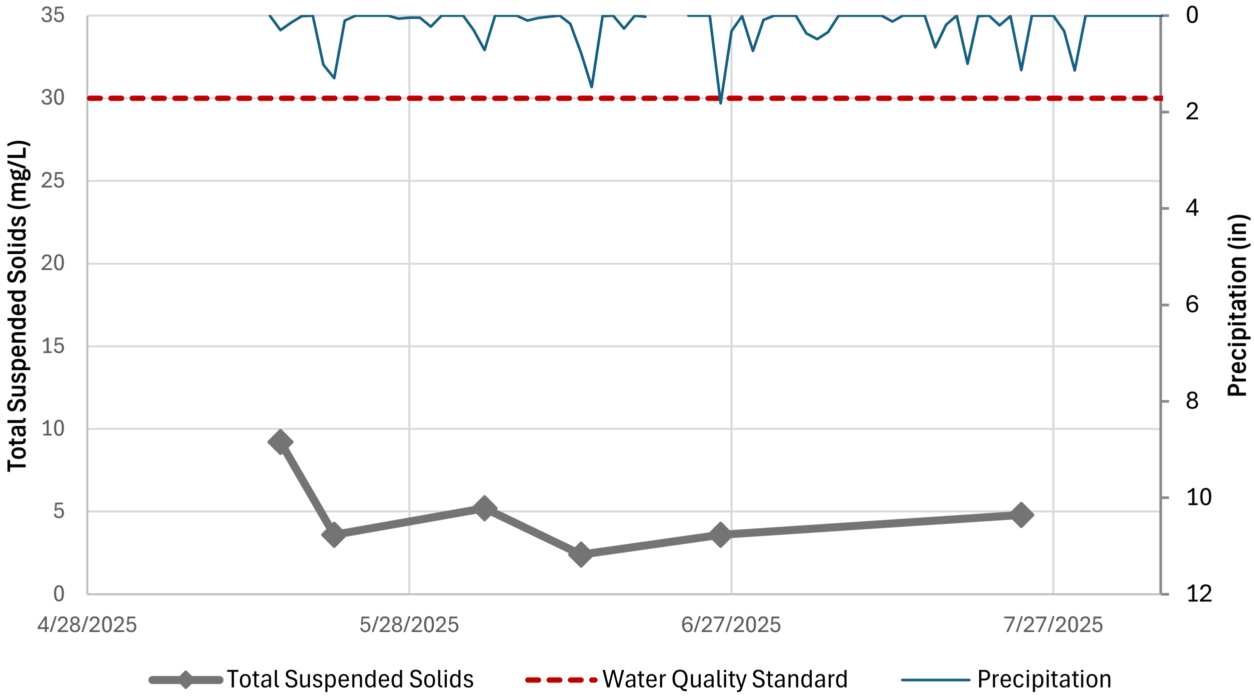


Figure 50: CL3 Total Suspended Solids Concentrations, Water Quality Standard, and Rainfall data comparison

Appendix E.6. CL3-A

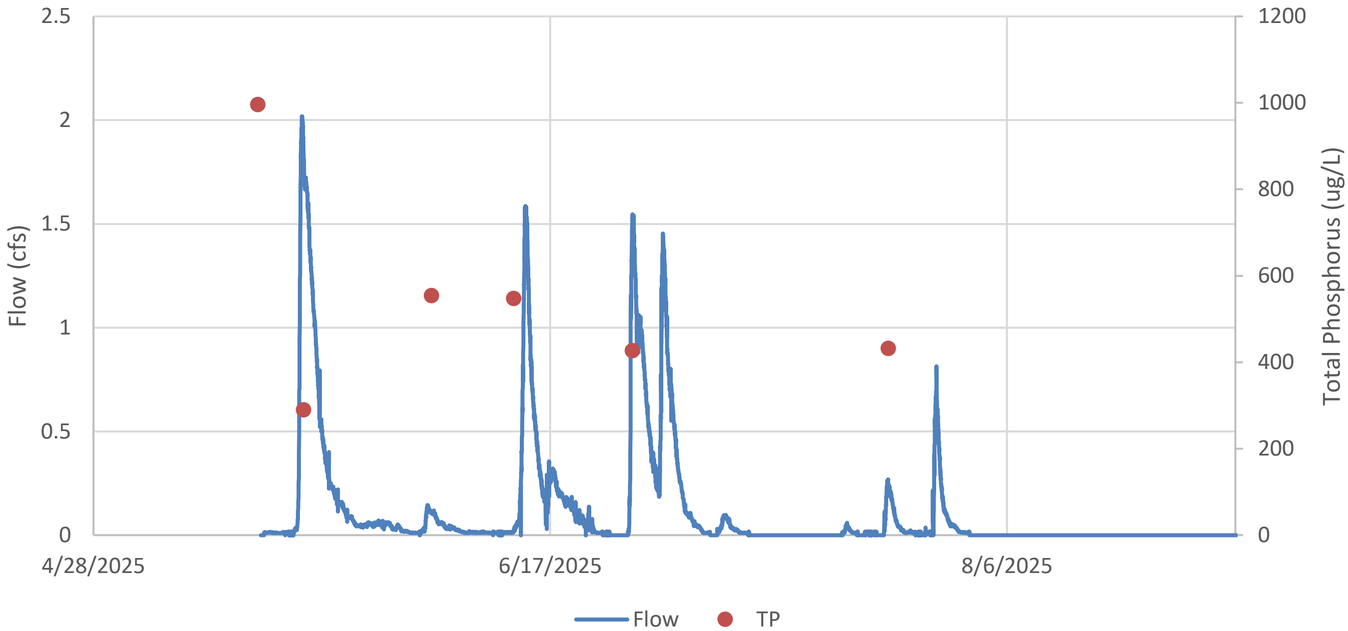


Figure 51: CL3-A Flow and TP concentrations throughout 2025.

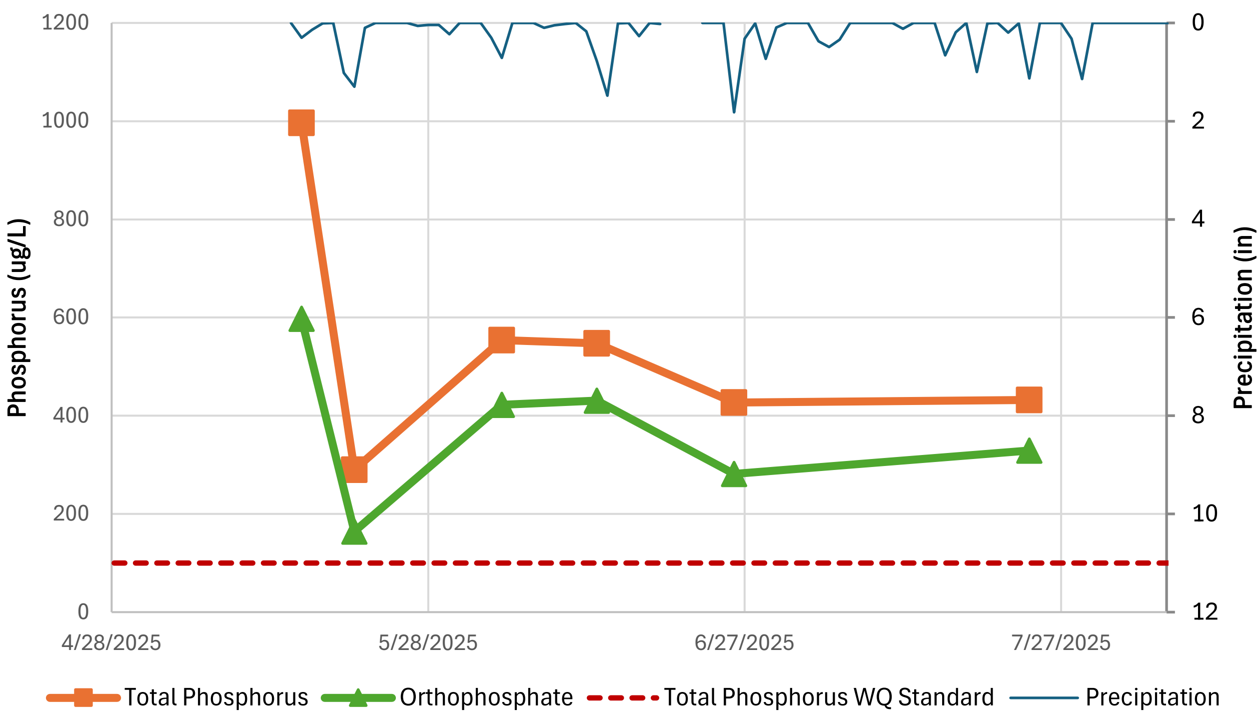


Figure 52: CL3-A Total Phosphorus and Orthophosphate Concentrations, Water Quality Standard, and Rainfall data.comaprison

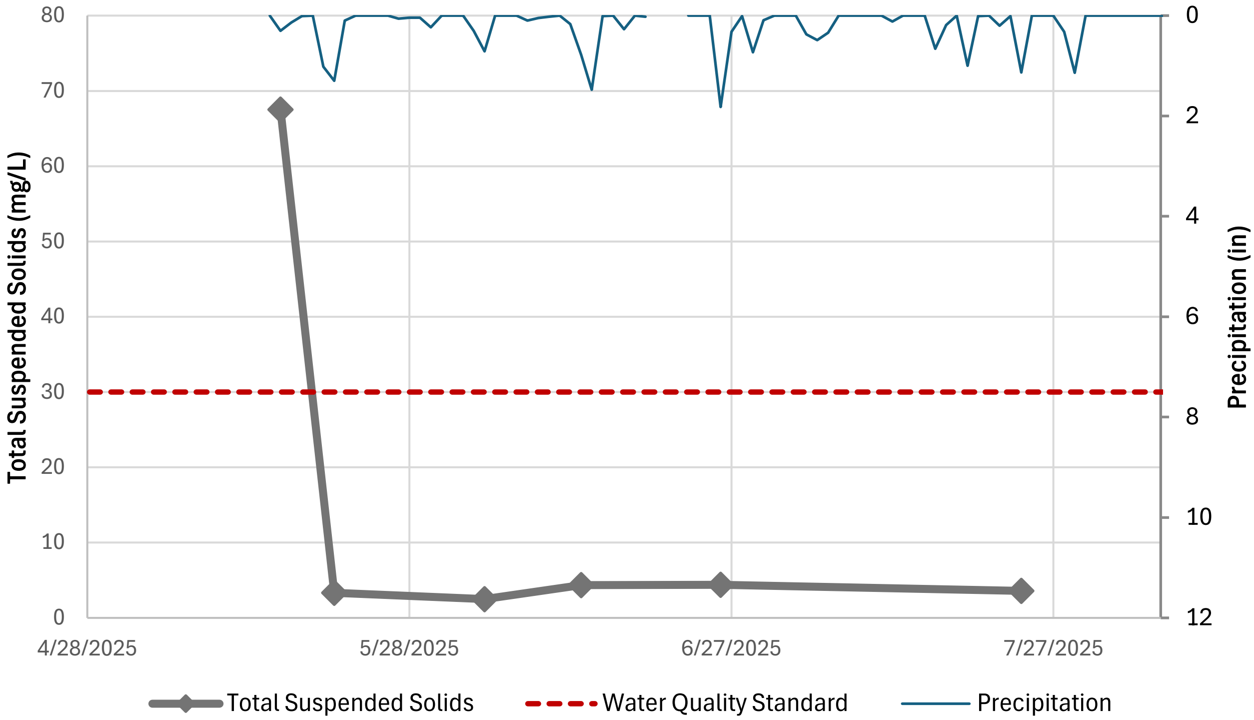


Figure 53: CL3-A Total Suspended Solids Concentrations, Water Quality Standard, and Rainfall data.comparison

APPENDIX F. STATE-WIDE CLIMATE TRENDS

State-wide temperatures in 2025 were slightly warmer than average and the total 2025 precipitation was slightly above average. The data developed by the PRISM Climate Group shows that the average annual temperature and precipitation have shifted to much warmer and wetter conditions in the last 30 years (1995-2025) compared to the years prior (1895-1994). This trend is shown in Figure 54. Annual precipitation is displayed in inches on the Y-axis and annual average temperature is shown in Fahrenheit on the X-axis. The four quadrants represent the following conditions:

- Upper left quadrant: lower temperatures, higher precipitation
- Lower left quadrant: lower temperatures, lower precipitation
- Lower right quadrant: higher temperatures, lower precipitation
- Upper right quadrant: higher temperatures, higher precipitation

The **grey dots** represent the conditions between 1895 and 1995, while the **golden dots** represent the conditions between 1996 and 2025. As shown in the figure, there is a shift in the later years into the upper right quadrant, representing higher temperatures and more annual precipitation. This is consistent with climate change predictions.

Regarding Minnesota, there are two key trends that have been observed by State's climatologists:

1. Wetter conditions due to more precipitation, more snow, and more frequent and larger storm events.
2. Increasing temperatures especially at night and during winter. In general, cold days are becoming less cold.

Regarding droughts and high temperatures, the State Climatologist has not observed heat extremes or droughts getting worse in Minnesota, but these are projected to get worse by mid-century.

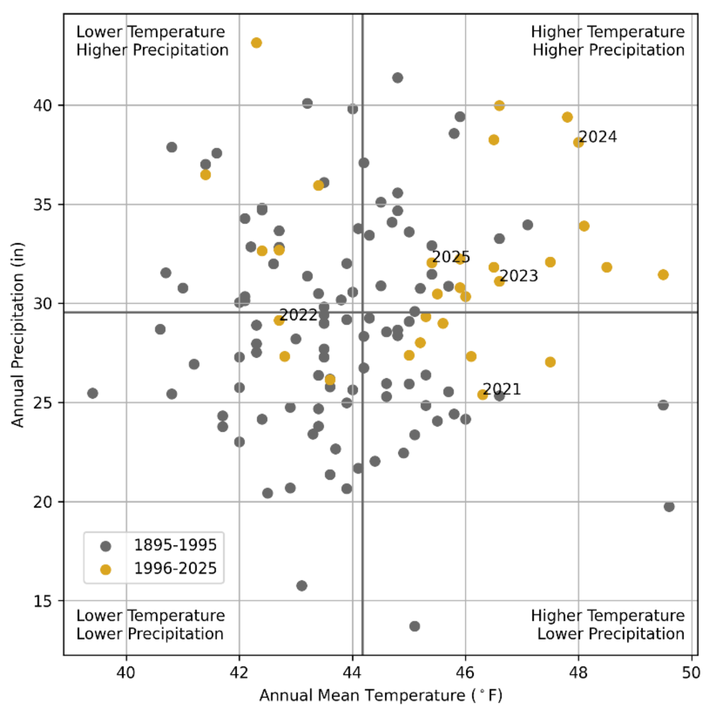


Figure 54. The shifting climate quadrants, comparing precipitation and temperature in 1895-1995 to 1996-2025 (PRISM Climate Group 2022)

APPENDIX G. AANALYSIS PARAMETERS

Appendix G.7. Lake Levels

The surface water elevation of the lakes is recorded during monitoring events and reported to DNR. These lake levels can be used to calibrate hydraulic and hydrologic (H&H) models used to identify and design the best management practices.

Appendix G.8. Internal Loading

It is common for a lake to show some temperature stratification (see Appendix A) during the summer months, when the temperature at the lake surface is higher and decreases abruptly with depth. The water temperature at the lower layers in the lake is cooler and pretty much constant. Water (and associated pollutants) vertical movement between layers is mostly the result of temperature differential (temperature gradient). Since at lower layers the temperature gradient is low, not a lot of vertical movement takes place during lake stratification.

Stratification also prevents the exchange of oxygenated water from the surface to the lower layers. With time, the layers at the bottom of the lake become anoxic (no oxygen). In an anoxic situation, phosphorus that is bound to iron (and other metals) in the sediments is released and stays at the lower layers of the lake over the summer. Phosphorus accumulation at the bottom waters is called "internal loading".

Alum treatment is one commonly used management practice for reducing this source of phosphorus. The alum (aluminum sulfate) binds with the phosphorus, a process known as flocculation, and traps the phosphorus in the sediment so it cannot migrate and be dissolved into the water column. Typically, Lakes that have completed or are planning alum treatments are monitored for internal loading. This is to assess whether an alum treatment is needed or, if already completed, how effective it was in binding phosphorus.

Monitoring for internal loading assessment includes collecting dissolved oxygen and temperature profiles to determine the length of summer stratification and collecting bottom water phosphorus concentrations to determine if phosphorus is accumulating in bottom waters over time.

Appendix G.9. Chloride

Every winter, roads and other paved surfaces require a significant amount of de-icing material to prevent unsafe conditions. The most common deicer by far is salt. The main component in salt is sodium-chloride. Salt helps prevent ice buildup and melts ice from paved surfaces. However, salt dissolves into the melted ice water and it breaks down leaving the Chloride in the runoff. This runoff eventually reaches water resources like rivers and lakes. Because deicing with salt is so common, it is one of the biggest contributors of excess chloride in our groundwater and drinking water sources.

Another major source of chloride in the environment is water softeners. Home water softener systems often use chloride to react with the sources of water hardness (calcium and magnesium). If your home has softened water, you may have noticed that it tastes a little salty. However, just as overly salty food is bad for your health, overly salty water acts in the same way. Unfortunately, chloride is very difficult to remove and as a result, the softened water that leaves houses often ends up letting chloride into the environment too. There are few natural processes that can remove chloride and reduce harmful levels in the environment, and our water treatment plants do not have technologies to remove chloride except through one costly, energy-intensive process.

Although chloride exists naturally in the environment at low levels, it is toxic to aquatic life at high levels. In low concentrations, chloride supports key biological functions; at toxic levels, chloride impacts the growth and reproduction of aquatic species, their food sources, and critical biological functions in amphibians. This is largely because chloride disrupts the natural process of molecules flowing in and out of cells. In high environmental concentrations, chloride can force water to leak out of cells while preventing other critical molecules from entering—a necessary biological function for aquatic and amphibious species.

If aquatic life is exposed to such excessive concentrations of chlorides for too long, their cells get stressed and can even die. Another issue is the link between low dissolved oxygen and high chloride levels, which is another reason high chloride levels are harmful for aquatic life. Chloride can change the density of the water entering a waterbody and prevent the natural exchange of gases from the bottom of a lake to the top. Chloride measurements were collected in the lakes using a probe for the first time in 2021, but due to possible calibration issues, the concentrations could not be verified as accurate and therefore were not reported.

Appendix G.10. Temperature

Water temperature affects the oxygen content of the water (oxygen levels become lower as temperature increases), the rate of photosynthesis by aquatic plants, the metabolic rates of aquatic organisms, and the sensitivity of organisms to toxic wastes, parasites, and diseases. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Optimal temperatures for fish depend on the species. Some species survive best in colder water, whereas others prefer warmer water. Benthic macroinvertebrates are also sensitive to temperature changes and will move in the stream to find their optimal temperature range. If temperatures are outside this optimal range for a prolonged period, organisms are stressed and can die. Warm temperatures (typically above 20 degrees Celsius, or 68 degrees Fahrenheit) can stress or cause mortality in cold water fish species. At this point, there are no known stream cold water fish species in the District.

Appendix G.11. Dissolved oxygen

The amount of dissolved oxygen (DO) available in the water is key to support aquatic life. A stream system both produces and consumes oxygen. It gains oxygen from the atmosphere and from plants because of photosynthesis. Running water, because of its churning, dissolves more oxygen than still water, such as in a reservoir behind a dam.

Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen. If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die. DO levels fluctuate seasonally and over a 24-hour period. They vary with water temperature and altitude. Cold water holds more oxygen than warm water and water holds less oxygen at higher altitudes. Thermal discharges, such as water used to cool machinery in a manufacturing plant or a power plant, raise the temperature of water and lower its oxygen content.

Aquatic animals are most vulnerable to lowered DO levels in the early morning on hot summer days when stream flows are low, water temperatures are high, and aquatic plants have not been producing oxygen since sunset. DO levels below 5 mg/L can cause stress or mortality in fish and macroinvertebrates.

Appendix G.12. Water acidity

pH is a measure of the acidity of the water. pH affects many chemical and biological processes. Different organisms flourish within different pH ranges. The largest variety of aquatic animals prefer a range of 6.5-8.0. pHs outside this range reduces the diversity in the stream. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life.

Appendix G.13. Specific conductance

Specific conductance **is** a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge).

Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore lower the water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity.

For this reason, conductivity is reported as conductivity at 25 degrees Celsius. Distilled water has a conductivity in the range of 0.5 to 3 µmhos/cm. The conductivity of rivers in the United States generally ranges from 50 to 1500 µmhos/cm. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates.

Appendix G.14. Turbidity

Turbidity is a measure of water clarity or how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the color of the water. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the dissolved oxygen concentration. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. The Minnesota Class 2B water quality standard for TSS is 30 mg/L.

Appendix G.15. Phosphorous

Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. Since phosphorus is the nutrient in short supply in most fresh waters, even a modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events in a stream including accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals.

There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, and commercial cleaning preparations.

Phosphorus has a complicated story. Pure, "elemental" phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule (PO4). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate. Both organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column).

Appendix G.16. Nitrogen

Forms of nitrogen include ammonia (NH3), nitrates (NO3), and nitrites (NO2). Nitrates are essential plant nutrients, but in excessive amounts can cause significant water quality problems. Together with phosphorus, nitrates can accelerate lake eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L or higher) under certain conditions.

The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L). In the effluent of wastewater treatment plants, it can range up to 30 mg/L. Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors.

Nitrates from land sources end up in rivers and streams more quickly than other nutrients like phosphorus. This is because they dissolve in water more readily than phosphates, which have an attraction for soil particles. As a result, nitrates serve as a better indicator of the possibility of a source of sewage or manure pollution during dry weather. Water that is polluted with nitrogen-rich organic matter might show low nitrates. Decomposition of the organic matter lowers the dissolved oxygen level, which in turn slows the rate at which ammonia is oxidized to nitrite (NO2) and then to nitrate (NO3). Under such circumstances, it might be necessary to also monitor for nitrites or ammonia, which are considerably more toxic to aquatic life than nitrate. There is currently no nitrate standard to protect aquatic life in Minnesota; nitrate levels must be below 10 mg/L in drinking water sources.

Appendix G.17. Flow

Stream flow is the total volume of water going past a point. Higher stream flows may represent more precipitation or more runoff generated by precipitation due to greater imperviousness (such as in developed landscapes) or drainage (such as ditched landscapes) in a watershed.

Appendix G.18. Runoff Depth

Runoff depth is the depth of the total volume of water going past a point if it were evenly distributed across the monitoring site drainage area. Runoff depth normalizes stream flow to annual precipitation. Higher runoff depth may represent more runoff generated by precipitation due to greater imperviousness or drainage in a watershed.

Appendix G.19. Pollutant Load

The District measures continuous stream flow and collects water quality concentration samples to model the total pollutant load discharged to and from District lakes. Load can be thought as the total amount of phosphorus or other pollutants moving past a point in the stream and is equal to the amount of pollutant per volume of water times the total volume of water going past a point (Figure 55). Higher loads may represent more precipitation or more phosphorus concentration sources compared to lower loads.

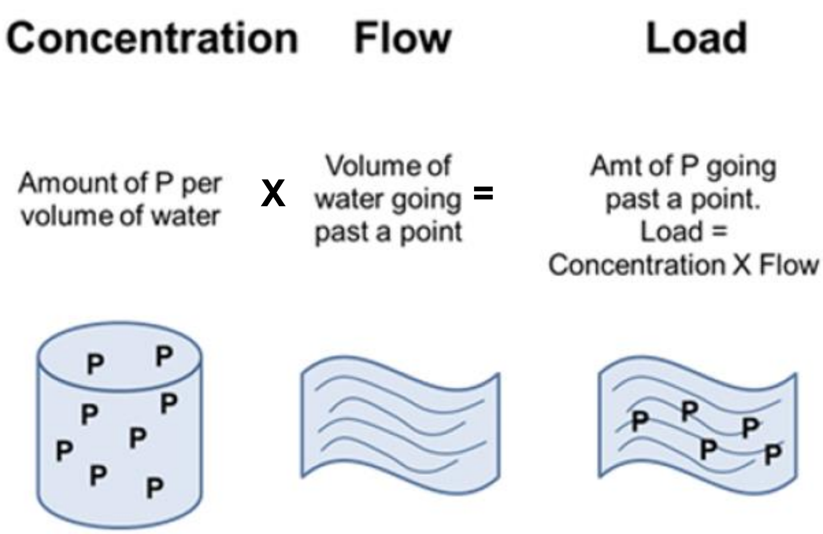


Figure 55. Relationship between stream flow and pollutant concentrations and loads

Appendix G.20. Flow-weighted Mean Concentration

The flow-weighted mean concentration (FWMC) is calculated as the total annual load divided by the total annual flow. The FWMC indicates how much pollutant is discharged relative to the flow. The phosphorus FWMC tends to have a greater impact on lake water quality than the total phosphorus load. The state lake water quality standards for deep lakes in the North Central Hardwood Forests region of 40 µg/L can typically be met when watershed runoff TP FWMC are less than 100 µg/L. For example, if the TP load and flow both increase to a lake, resulting in a similar TP FWMC, the higher TP load will have less impact on lake water quality because the time the load spends in the lake decreases under higher flows (water flows in and out of the lake faster).

Total flow and pollutant loads are most influenced by the amount and timing of precipitation, in addition to changes in land use, and implementation of BMPs. During wet years, pollutant loads may be higher due to overall higher watershed runoff and flows, even without any significant changes in land use or BMP implementation that influence the amount of pollutant loads. In this way, flow weighted mean pollutant concentrations are better indicators of watershed changes, such as land use changes or implementation of BMPs, than total phosphorus loads.