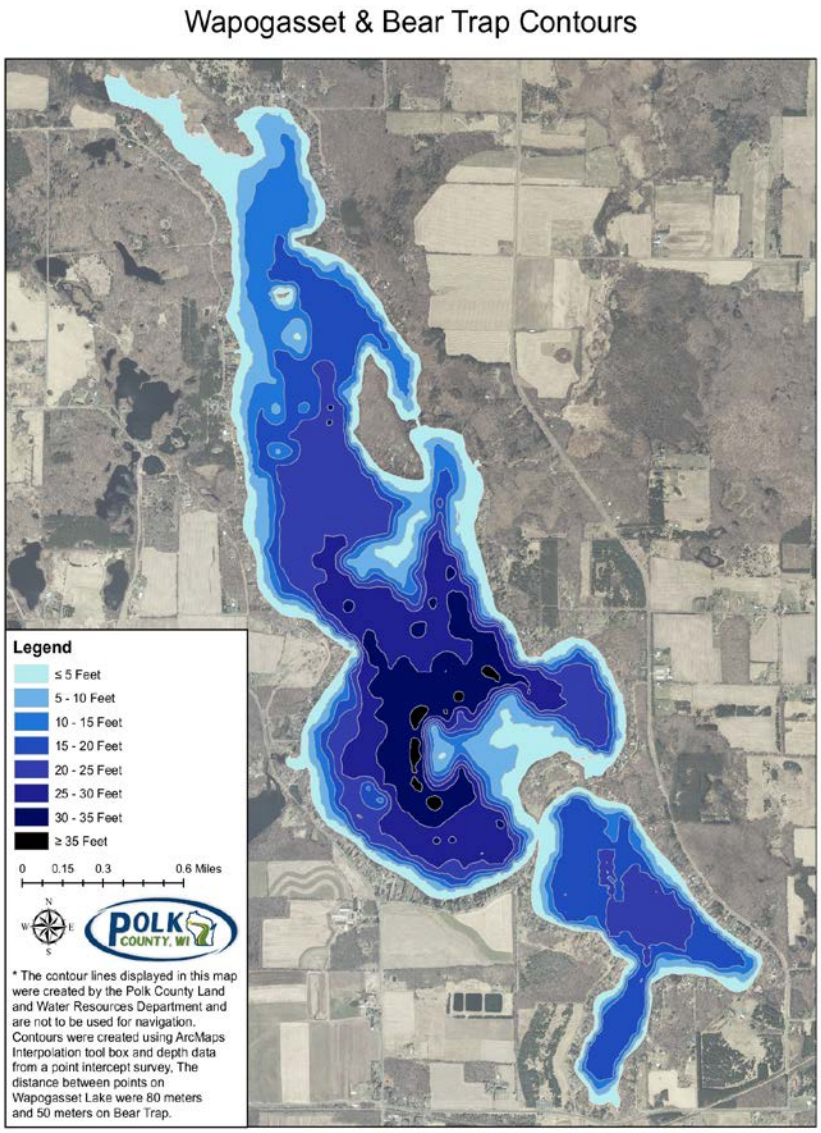
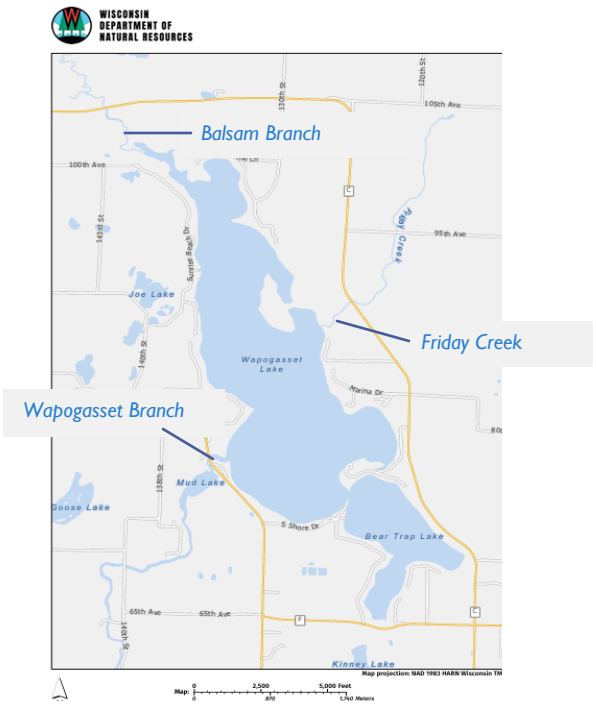
WATER QUALITY

THE LAKES

Lake Wapogasset and Bear Trap Lake are in Polk County, Wisconsin. Lake Wapogasset is a 1,189-acre lake with a maximum depth of 32 feet (WBIC 2618000). It is in the town of Garfield and the town of Lincoln. Bear Trap Lake is 247 acres and has a maximum depth of 25 feet (WBIC 2618100). It is in the town of Lincoln. A contour map for both lakes is shown below. Both Lake Wapogasset and Bear Trap Lake are drainage lakes. Friday Creek, the Balsam Branch, and Bear Trap Lake flow into Lake Wapogasset, and the Wapogasset Branch flows out of the lake and eventually reaches the Apple River.





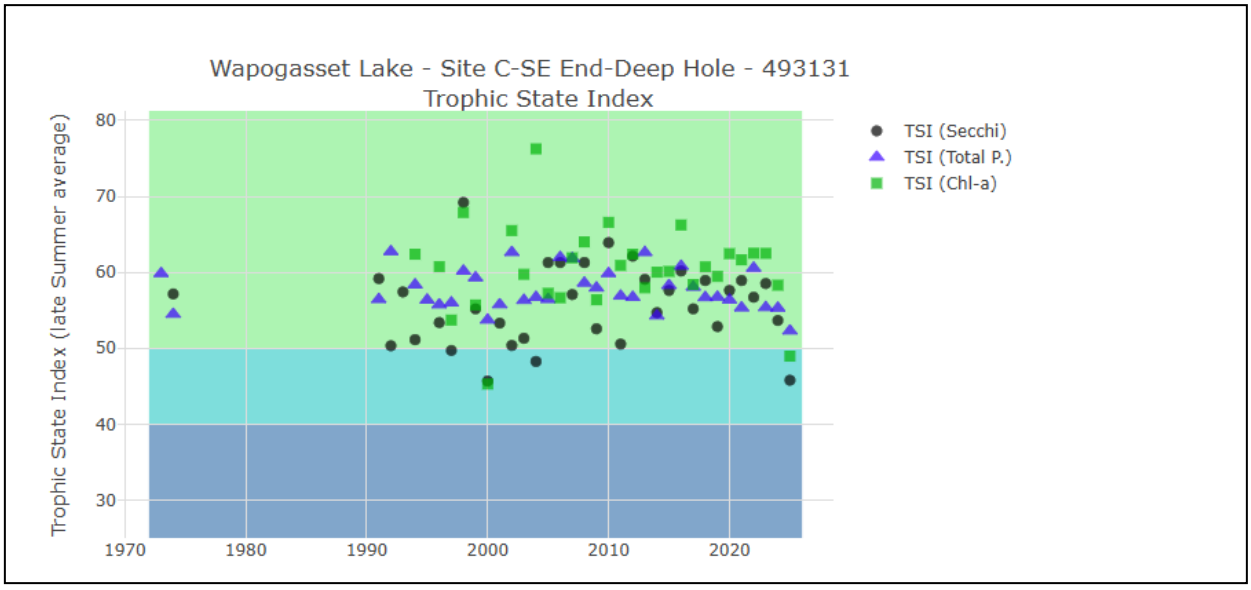
LAKES CLASSIFICATION

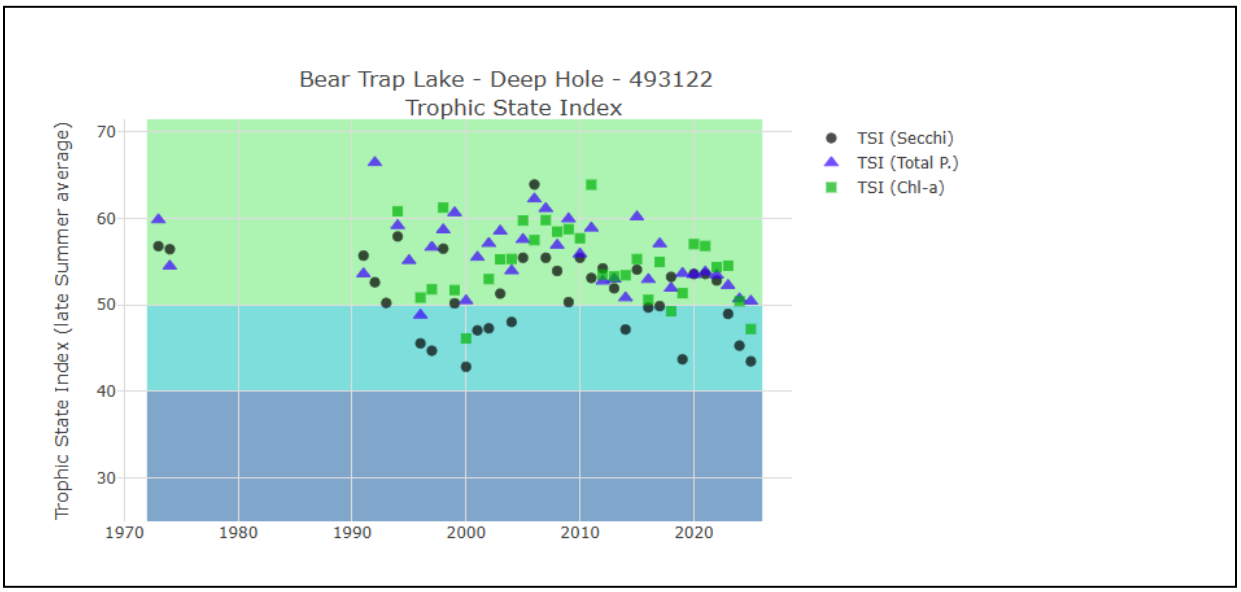
Lake Wapogasset and Bear Trap Lake are on the WDNR 2024 and draft 2026 Impaired Waters List for excessive algae growth. Both lakes are classified as shallow lowland lakes by the WDNR. Shallow lowland lakes may mix periodically throughout the summer bringing high phosphorus concentration from deep water near the lake bottom sediment. Phosphorus is the limiting nutrient that fuels algae growth in the lakes. The impairment threshold for phosphorus for shallow lowland lakes is 40*µg/L* as measured over several years from June 1 – Sept. 15. The impairment threshold for chlorophyll (a measure of algae growth) for recreation in shallow lowland lakes is to have >30% of days in sampling season with moderate algal levels (>20 *µg/L*). Chlorophyll is measured from July 15 – September 15.

TROPHIC STATE

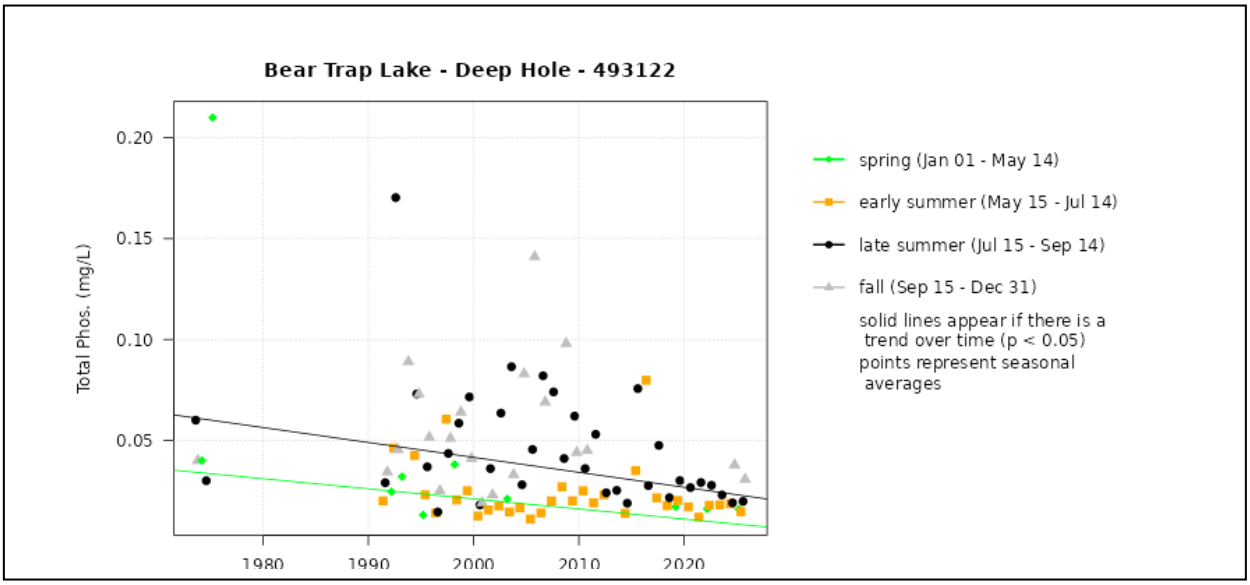
Trophic State Index (TSI) is a classification system of nutrient levels in lakes. Oligotrophic (TSI<40) lakes have low nutrients and clear water. Eutrophic (TSI>50) lakes are high in nutrients and support abundant algae growth. Mesotrophic (TSI 40-50) lakes have conditions in between these classifications. Lake Wapogasset and Bear Trap Lake are eutrophic lakes with nutrient-rich water and frequent algae blooms, especially in late summer.

Lake sediments release phosphorus when the lake water temperatures stratify in the summer and oxygen levels decrease at the lake bottom. When the lake loses temperature stratification and mixes, phosphorus-rich bottom waters are brought to the surface and increase algae growth. Phosphorus input to the lakes also comes from the watershed, atmospheric deposition, and groundwater. Lake Wapogasset receives water and phosphorus from two tributaries: the Balsam Branch and Friday Creek.





Lake Association volunteers have collected water quality data (Secchi depth (water clarity), total phosphorus, and chlorophyll-a) through the WDNR Citizen Lake Monitoring Network (CLMN) for decades. Volunteers also measure lake temperature and oxygen profiles which indicate if the lake is stratified in layers based on temperature and water density. CLMN results provide an overview of the trophic state and water quality over many years. Of the parameters measured, only Bear Trap Lake showed any statistically significant trends where improvements were found for spring and late summer total phosphorus. Bear Trap Lake also exhibited improvements in fall Secchi depth over this same time.



TRIBUTARY MONITORING

As part of the Comprehensive Lake Management Plan update, Ecological Integrity Service monitored water flow and nutrient loading from the two tributaries that flow into Lake Wapogasset in 2023 and 2024. The Balsam Branch drains a large watershed and flows into the north end of Lake Wapogasset. Friday Creek drains a smaller watershed from east of the lake.

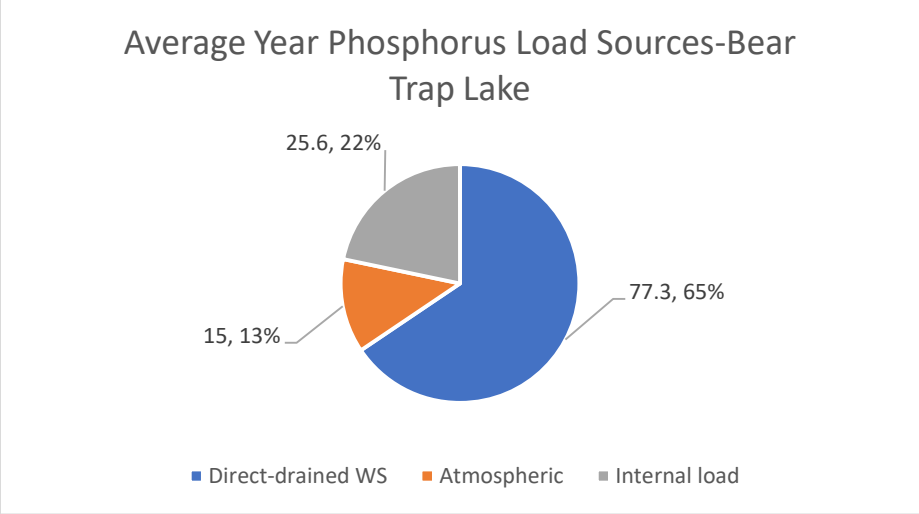
The tributary flow analysis results are consistent with past monitoring, showing the Balsam Branch has high flow but low phosphorus concentrations compared to Friday Creek. For example, in 2023 the Balsam Branch mean total phosphorus concentration was 55 µg/L and the Friday Creek mean total phosphorus concentration was 258 µg/L. The Balsam Branch has a high total load, but this is due to the significant volume of water. No correlation between high precipitation, high flow events and increased phosphorus concentrations were found for either tributary. Results from tributary monitoring were used as inputs to lake water quality modeling.

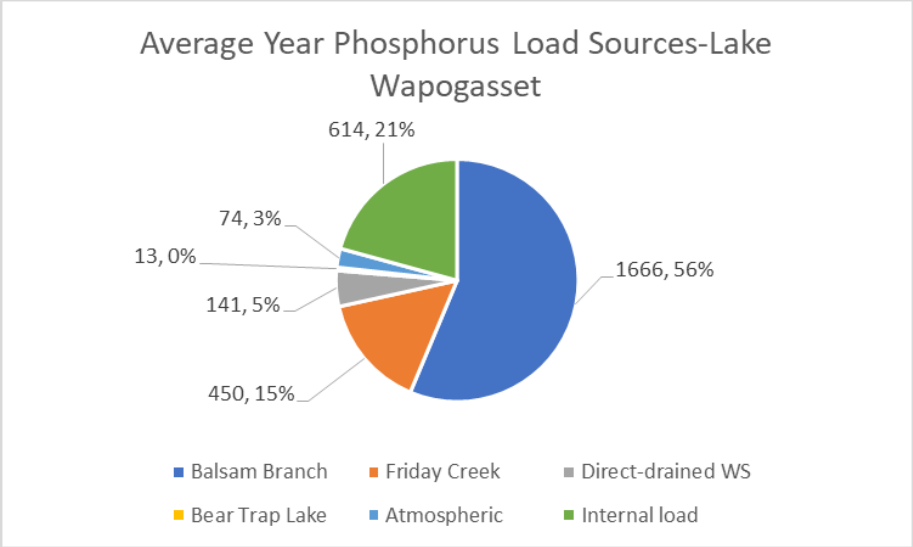
LAKE WATER QUALITY MODELING

Additional work completed to better understand lake water quality included update of watershed boundaries and land cover and nutrient loading estimates. The nutrient loading analysis integrated tributary monitoring results and two years of in-lake monitoring (2024–2025), including total phosphorus (TP), orthophosphate, chlorophyll-a, Secchi depth, and weekly temperature/dissolved oxygen profiles. Watershed boundaries and internally drained areas were refined using updated GIS and LiDAR data. These data were used as inputs to a lake model, a mathematical representation used to understand the significance of various inputs and to predict impacts of modifications of these inputs.

PHOSPHORUS SOURCES

The lake model was developed to analyze the inputs during the study years where extensive data was available. The model was tested further with in-lake monitoring data from a 10-year period. Results are shown in figures below. Bear Trap Lake phosphorus loading was dominated by the direct-drained watershed. Lake Wapogasset loading was dominated by loading from the Balsam Branch and Friday Creek. Both lakes had varied internal loading of phosphorus from lake sediments which greatly influenced water quality from year-to-year.



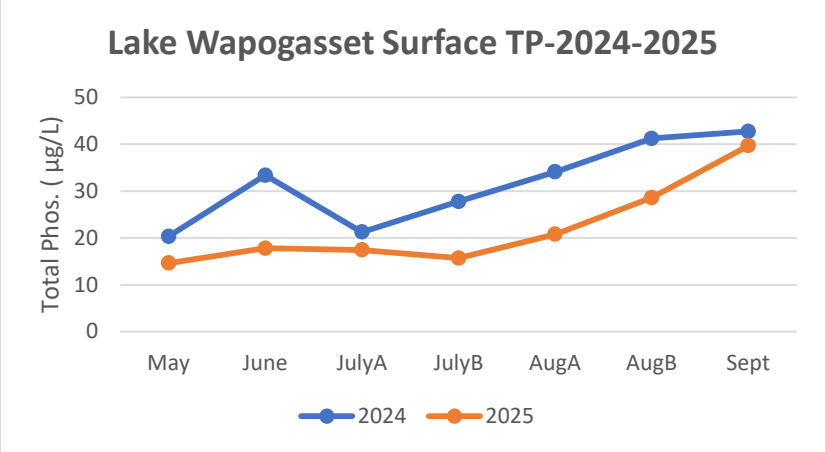


INTERNAL LOADING

Internal loading from lake sediments is a significant, but variable, source of phosphorus for both lakes. Temperature and dissolved oxygen profiles indicated prolonged periods of low oxygen in deep water, conditions where the sediments release phosphorus. Further, both lakes have the potential to mix during the growing season, increasing the likelihood that sediment-released phosphorus may reach surface waters. Lake Wapogasset is more prone to mixing than Bear Trap Lake. Sediment core testing confirmed substantial potential for phosphorus release, particularly in Lake Wapogasset.

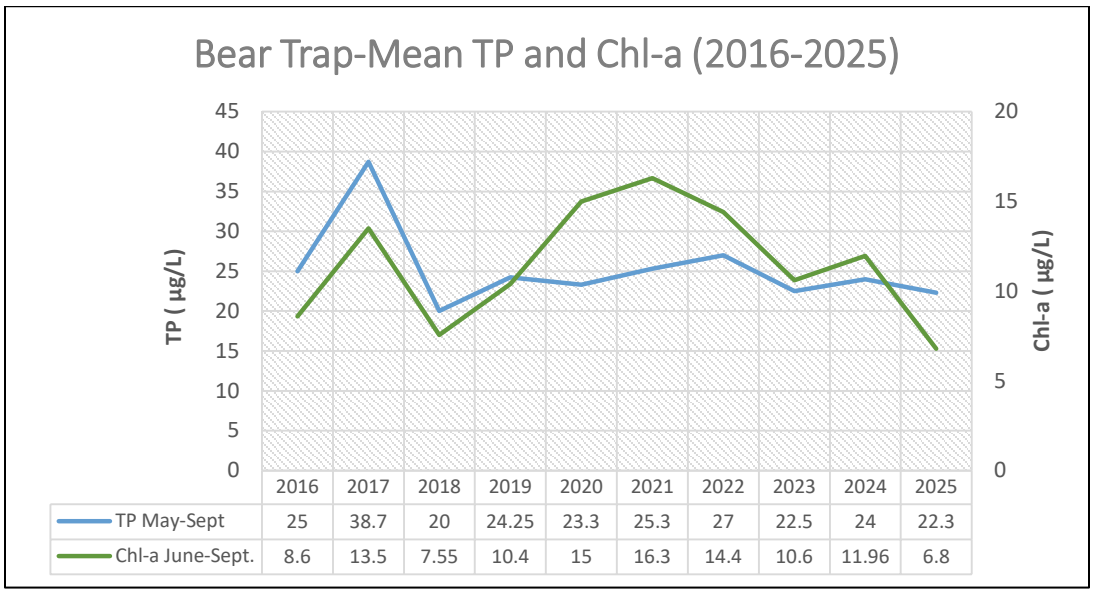
The actual amount of internal loading depends strongly on the timing and extent of stratification breakdown and mixing, which vary from year-to-year. Internal loading estimates for the study years were relatively low when compared with estimates from previous studies. In Bear Trap Lake, internal loading accounted for 20% of loading in 2024 and 7% in 2025. In Lake Wapogasset, internal loading accounted for 13.5% of loading in 2024 and 5% in 2025. Lower surface phosphorus concentrations resulted in both lakes in 2025.

Further, a 10-year analysis of lake water quality indicated that internal loading made up a higher proportion of the phosphorus load over the long-term as compared to 2024 and 2025. Variability in internal loading poses challenges for lake management. In some years, internal loading has little impact on water quality. In other years, it is a substantial portion of the phosphorus load.

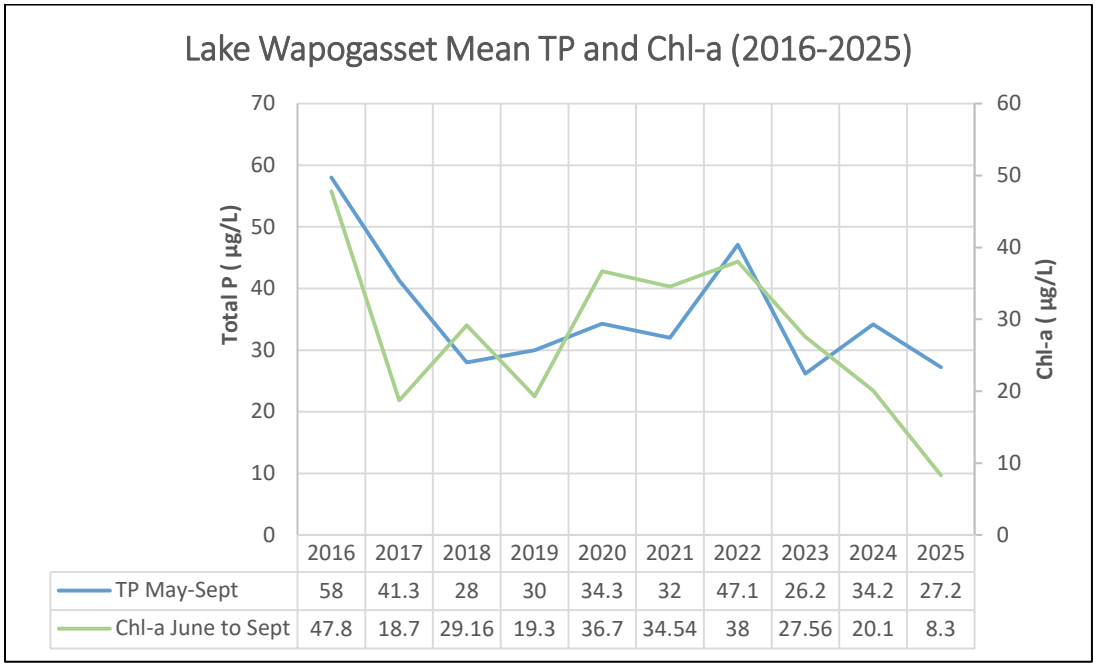


The amount of time it takes for water to flow through the lake also influences water quality. Bear Trap Lake has a lake residence time of about 4 years. Lake Wapogasset has a lake residence time of about 0.5 years, so water is completely replaced during the growing season. This further illustrates that the two tributaries drive the phosphorus in Lake Wapogasset with their high volume and nutrient concentrations. During low flow years, the residence time can increase, resulting in lower water quality as the phosphorus (especially internal load) remains longer leading to more algae growth.

Water quality measurements (growing season means) from both lakes in figures below illustrate the variability of water quality from 2016 – 2025.



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
TP May-Sept	25	38.7	20	24.25	23.3	25.3	27	22.5	24	22.3
Chl-a June-Sept.	8.6	13.5	7.55	10.4	15	16.3	14.4	10.6	11.96	6.8



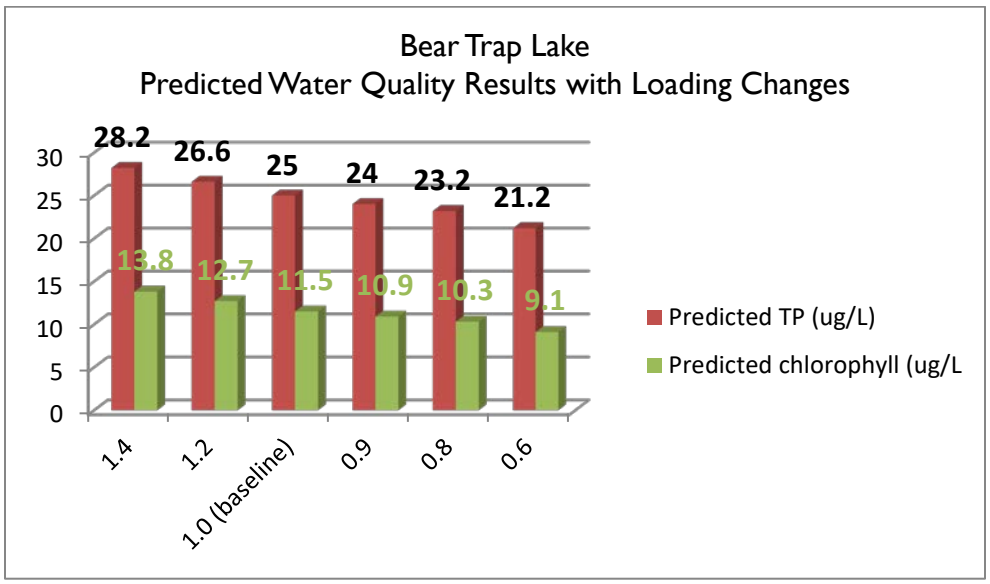
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
TP May-Sept	58	41.3	28	30	34.3	32	47.1	26.2	34.2	27.2
Chl-a June to Sept	47.8	18.7	29.16	19.3	36.7	34.54	38	27.56	20.1	8.3

PREDICTING WATER QUALITY CHANGE

A load analysis using the water quality model predicted the growing season mean for total phosphorus, chlorophyll, and Secchi depth with changes in phosphorus loading. The predicted result of increases and decreases ranging from 10 to 40 percent are shown in the figures below.

BEAR TRAP LAKE

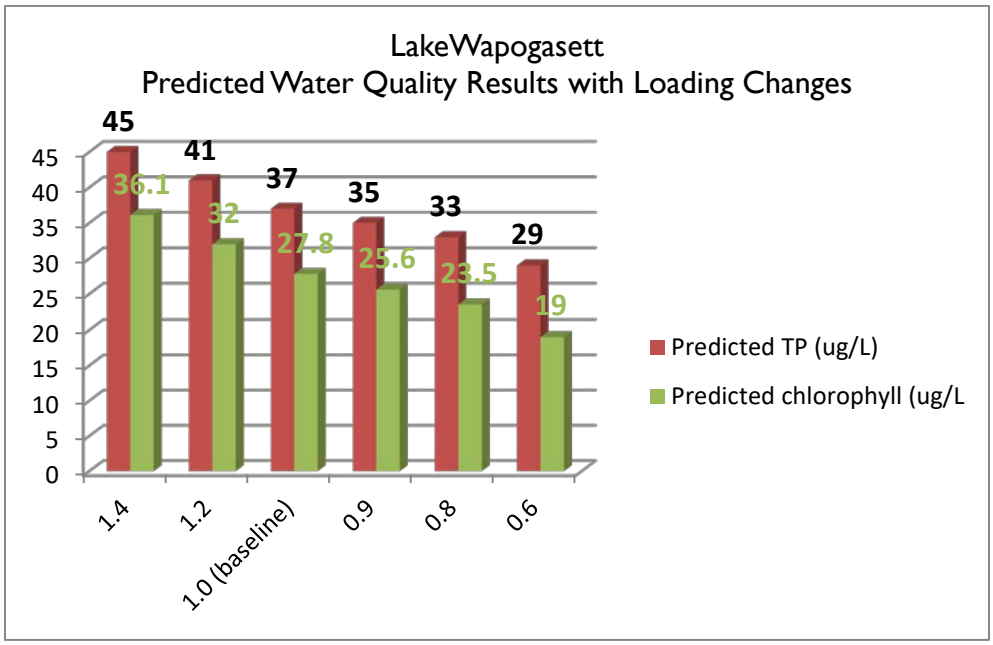
If the direct-drained watershed load was reduced by 10% (7.7 kg) the predicted total phosphorus would decrease by 1 µg/L, with a 0.6 µg/L decrease in chlorophyll concentration, and an increase of 0.2 feet in Secchi depth. As the reductions increase, the resulting concentrations of phosphorus and chlorophyll, as well as Secchi depth improve more. If loading is increased, the phosphorus concentration and chlorophyll concentrations increase accordingly, and Secchi depth decreases. Variability in internal loading will influence these results. In years with little internal loading (less than 25 kg), actual values would likely be lower (such as in 2025).



If internal loading were mitigated via an alum treatment, the model predicts the total phosphorus concentration would decrease by 2 µg/L with an 80% internal load reduction, and 3 µg/L with a 90-95% internal load reduction. The Secchi depth prediction for both is 9.2 feet from a baseline of 8.5 feet. Changes in water quality would be most evident in late summer. If an 80% internal reduction is coupled with a 10% reduction in watershed loading, the model predicts a phosphorus concentration of 21.6µg/L. The chlorophyll concentration is predicted to be 9.3 µg/L and the Secchi depth 9.5 feet. The late summer phosphorus spike and algae blooms would likely decrease, and the water clarity would likely be better throughout the summer months.

LAKE WAPOGASSET

If the total tributary loading to Lake Wapogasset was decreased by 10% (228 kg), the model predicts a decrease of 2 µg/L in total phosphorus concentration, 2.2 µg/L in chlorophyll concentration, and an increase in Secchi depth of 0.3 feet. Reductions in loading might come from the Balsam Branch, Friday Creek and/or the direct-drained watershed. Higher reductions result in larger change. As with Bear Trap Lake, increased loads would result in poorer water quality. In addition, Lake Wapogasset water quality would be greatly influenced by variation in internal loading, especially late in the summer.



If internal loading were mitigated via an alum treatment, the model predicts the total phosphorus concentration would decrease by 4 µg/L with an 80% -95% internal load reduction to 33 µg/L from a baseline of 37 µg/L. The Secchi depth prediction for an 80-90% reduction is 7.5 feet from a baseline of 6.9 feet. Changes in water quality would be most evident in late summer. If an 80% internal reduction is coupled with a 10% reduction in watershed loading, the model predicts a phosphorus concentration of 31 µg/L. The chlorophyll concentration is predicted to be 21.8 µg/L and the Secchi depth 8.2 feet. The late summer phosphorus spike and algae blooms would likely decrease. An alum application would have less impact in years like 2024 and 2025, when there was less lake mixing, because the internal load would already be low.

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