Water Column

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[Editor's note: Water Column *is a great place to showcase the work of lake and watershed diagnostic studies. We visit the doctor for physicals or well-checks as well as when we are ill. Lake managers assess watersheds and lakes to assess the same conditions. What is the health of the lake? What are the symptoms of the lake and watershed, which contributes to this health? The Friends of Lake Monroe, founded by Sherry Mitchell-Bruker, and The Nature Conservancy, have been working hard to revitalize the 20+ year gap in watershed work. Starting any diagnostic study involves finding out what we know now and looking at historic trends. This also allows the stakeholders to understand where there gaps in the data, or its "bill of health." Following is a summary of Lake Monroe's current assessment.]*

Lake Monroe Water Quality Summary (1990-2017) and Watershed Protection Considerations

~ 2018 ~

Melissa Laney & Macayla Coleman

INTRODUCTION

Water quality is essential for infrastructures worldwide. Protecting and restoring watersheds can improve water quality and protect capacity of reservoirs that store water. One possible step toward the protection of a watershed is the establishment of a water fund. Water funds are a mechanism for conservation financing that gather funds from users and direct them to conservation and protection efforts. These actions protect source water and benefit the people using the water source as well as improve and protect habitats for animals that live there. They create an avenue for downstream users to compensate upstream landowners and land managers for any actions that deliver benefits to the payer. Public and private entities may invest collectively in the conservation of their watersheds.

Cities around the world have implemented water funds and seen these benefits already. For example, San Antonio, Texas, residents voted to implement a publicly funded water fund to protect the Edwards Aquifer in 2000. This water fund finances projects that protect lands on 21 percent of the recharge zone of the aquifer. Models have shown that these protection efforts have already sidestepped bacteria concentration increases and are expected to reduce nutrients as well as lead and zinc levels (Abell et al. 2017).

In Bloomington, Illinois, The Nature Conservancy partnered with the University of Illinois to find ways that nitrogen inputs to the Mackinaw River watershed could be reduced. Modeled results showed that wetland and flooded buffers were a promising option (Abell et al. 2017) Armed with this information, a water fund has been proposed for Bloomington, Illinois, that could include both public and private funding. Additionally, they can further strengthen the

water fund by leveraging U.S. Farm Bill dollars.

With these successes evident in other cities, we seek to explore how a water fund could benefit Lake Monroe in Indiana. The purpose of this report is to summarize existing information about Lake Monroe near Bloomington, Indiana, to determine if making additional investments in watershed protection, such as establishing a water fund, will help protect the lake itself.

DESCRIPTION OF LAKE MONROE

Lake Monroe (Figure 1) is the largest man-made body of water in the state of Indiana with an area of 10,750 acres. It was built by the U.S. Army Corps of Engineers in 1964 and is maintained by the Indiana Department of Natural Resources. Lake Monroe sees approximately one million visitors annually and has served as a drinking water source for the City of Bloomington, Indiana, since 1967. Lake Monroe also serves as a drinking water source for nine other rural communities and reaches more than 100,000 users annually.

WHO IS WORKING IN THE WATERSHED?

A number of groups and agencies are already working within the Lake Monroe watershed to protect and conserve the land or water:

- *Indiana Department of Natural Resources (IDNR):* The Indiana Department of Natural Resources manages Lake Monroe recreation and the state recreation areas on Lake Monroe. IDNR also implements different educational programs at the recreation areas around the lake. These programs include live animal demonstrations and night hikes.
- *U.S.Army Corps of Engineers (USACE):* The U.S. Army Corps of Engineers built Lake Monroe. The USACE manages the shoreline and controls water levels and discharges from the lake. USACE also collects water quality data at two locations in Lake Monroe and in tributaries that flow into Lake Monroe as part of the water quality assessments done by the water quality team operating out of its Louisville District. They collect water quality data to establish baseline conditions and assess current water quality conditions to ensure compliance with state and federal water quality regulations.
- *State Soil Conservation Board (SSCB):* The State Soil Conservation Board runs the program "Clean Water Indiana." This program provides funding for landowners and conservation groups to implement conservation programs to reduce non-point pollution through education, training, technical assistance, and cost sharing programs. They also work closely with the Soil and Water Conservation Districts to match funds.

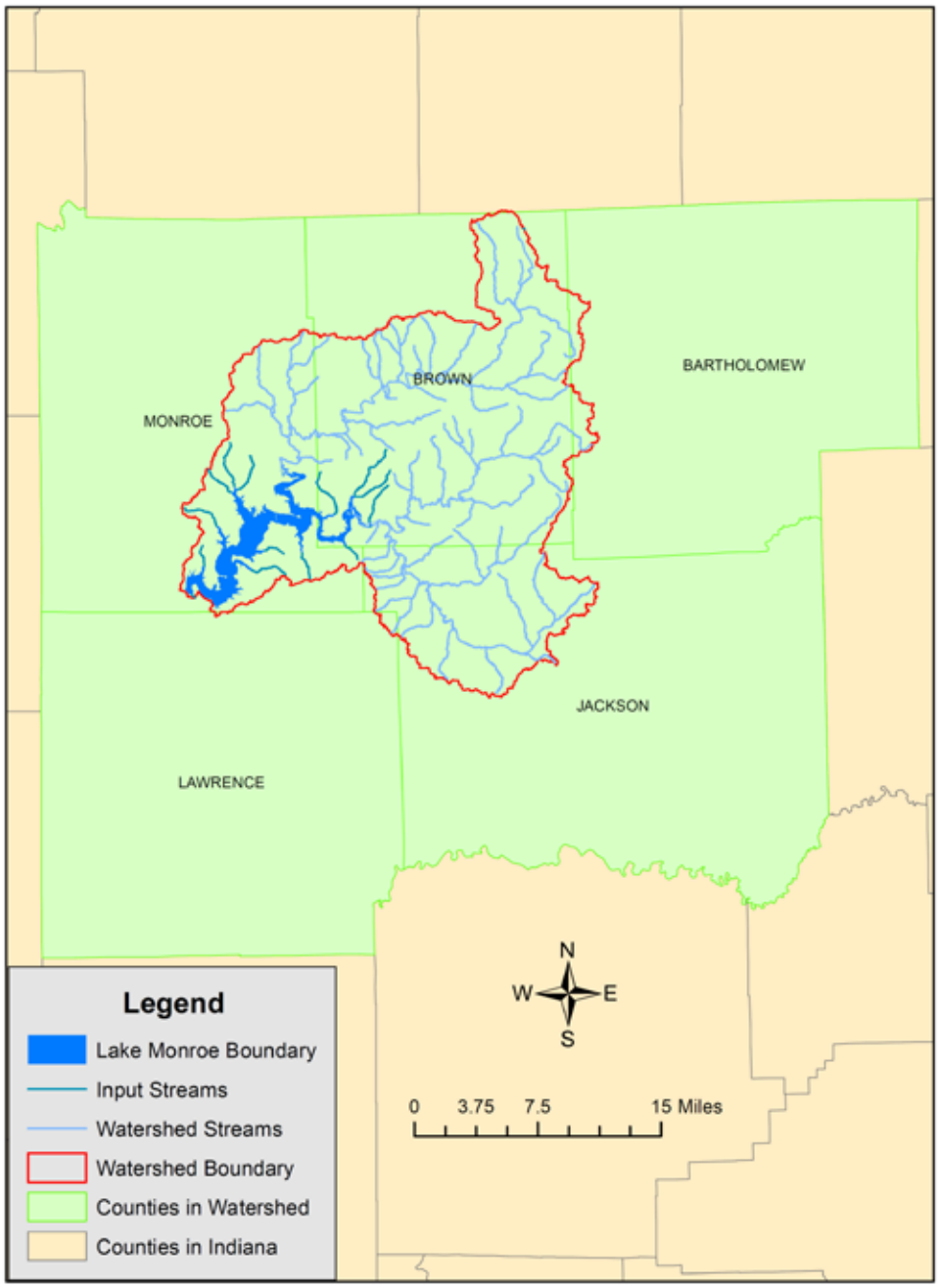

Figure 1. Lake Monroe watershed and the five included counties.

- *Soil and Water Conservation District (SWCD):* The very large Lake Monroe watershed encompasses five SWCDs: Bartholomew, Brown, Jackson, Lawrence, and Monroe. The SWCDs of Jackson, Monroe and Brown County implement educational programs, secure funding for conservation projects, and provide technical assistance to land owners. Furthermore, the SWCDs of Jackson, Monroe and Brown County work closely with other agencies in the area to implement their projects.
- *Indiana Department of Environmental Management (IDEM):* The Indiana Department of Environmental Management conducts surveys for blue-green algae and other water quality parameters at the swimming beaches on Lake Monroe. These surveys allow them to issue warnings to visitors if the cell counts are high enough to cause concern. Additionally, IDEM works with Indiana University to implement the Indiana Clean Lakes Program.
- *Indiana Clean Lakes Program (InCLP):* The Clean Lakes Program was established at Indiana University through an IDEM Clean Water Act Section 319 grant. Members of the InCLP collect and analyze water quality samples from lakes across Indiana, including Lake Monroe. All of this sampling is done in the summer months, mostly July and August.
- *Sycamore Land Trust (SLT):* Sycamore Land Trust holds and manages many lands in the Lake Monroe Watershed. Most recently, in 2016 SLT created a nature preserve along Lake Monroe called "Amy Weingartner Branigin Peninsula Preserve."
- *Friends of Lake Monroe (FLM):* Friends of Lake Monroe are a non-profit organization established in 2016 that supports water quality and sustainable recreation. FLM are working to actively to establish a comprehensive watershed plan to help protect the water quality in Lake Monroe.
- *The Nature Conservancy (TNC):* The Nature Conservancy acts as a land conservation agent by acquiring and managing nature preserves. TNC has initiated an effort to explore the feasibility of a water fund for the Lake Monroe watershed.
- *City of Bloomington Utilities (CBU):* The City of Bloomington, IN uses Lake Monroe as a drinking water source. For this reason, CBU collects water quality information related to safe drinking water at the water intake as part of the drinking water treatment procedures.

EXISTING INFORMATION

Two major groups are collecting and analyzing water quality data in Lake Monroe annually, the Indiana Clean Lakes Program (InCLP) and the U.S. Army Corps of Engineers (USACE). Figure 2 shows the location of these sampling sites in Lake Monroe. The comprehensive evaluation of lakes and streams require collecting data on a number of different, and sometimes hard-to-understand, water quality parameters.

Trophic State Index

One way to evaluate water quality data is using a trophic state index (TSI). The Carlson Trophic State Index is one used commonly in the United States. It was developed by Bob Carlson who analyzed summertime total phosphorus, chlorophyll-a, and Secchi disk transparency data for numerous lakes and found statistically significant relationships among the three parameters. He then developed mathematical equations for these relationships and these are the basis for the Carlson TSI. Using this index, a TSI value can be generated by one of three measurements: Secchi disk transparency (TSI [SD]), chlorophyll-a (TSI [Chl]), or total phosphorus (TSI [TP]). Data for one parameter can also be used to predict a value for another. The TSI values range from 0 to 100. Each major TSI division (10, 20, 30, etc.) represents a doubling in algal biomass and corresponds to a trophic state. Trophic states reflect the overall health or biological productivity of a lake (Table 1).

Increasing TSI scores for a lake from one year to the next is a sign of eutrophication. Eutrophication is the biological response observed in a lake caused by increased nutrients, organic material, and/or silt (Cooke et al. 1993). Increasing TSI scores indicates the biological condition of that waterbody has increased biological material (biomass), while a lower TSI score indicates less biomass. Natural factors such as climate variation can cause changes in TSI score that do not necessarily indicate a long-term change in lake condition. There is also no "silver bullet" on trophic state nor should it be synonymous with the water quality. While they are related, lakes naturally occur in all classifications.

TSI Secchi Disk Depth

Ninety Secchi disk depth measurements were collected by both InCLP and USACE on Lake Monroe during periods of stratification between 1990 and 2016. Of those ninety observations, 49 had a TSI (SD) value of ≥ 50 (Figure 3), indicating that more than 50 percent of the measurements taken classify the lake as eutrophic.

TSI Chlorophyll-a

Of the 36 chlorophyll-a samples collected in the epilimnion during stratification in Lake Monroe, by both InCLP and USACE, 15 were a TSI (Chl) value of ≥ 50, which is the threshold between mesotrophic and eutrophic conditions (Figure 4).

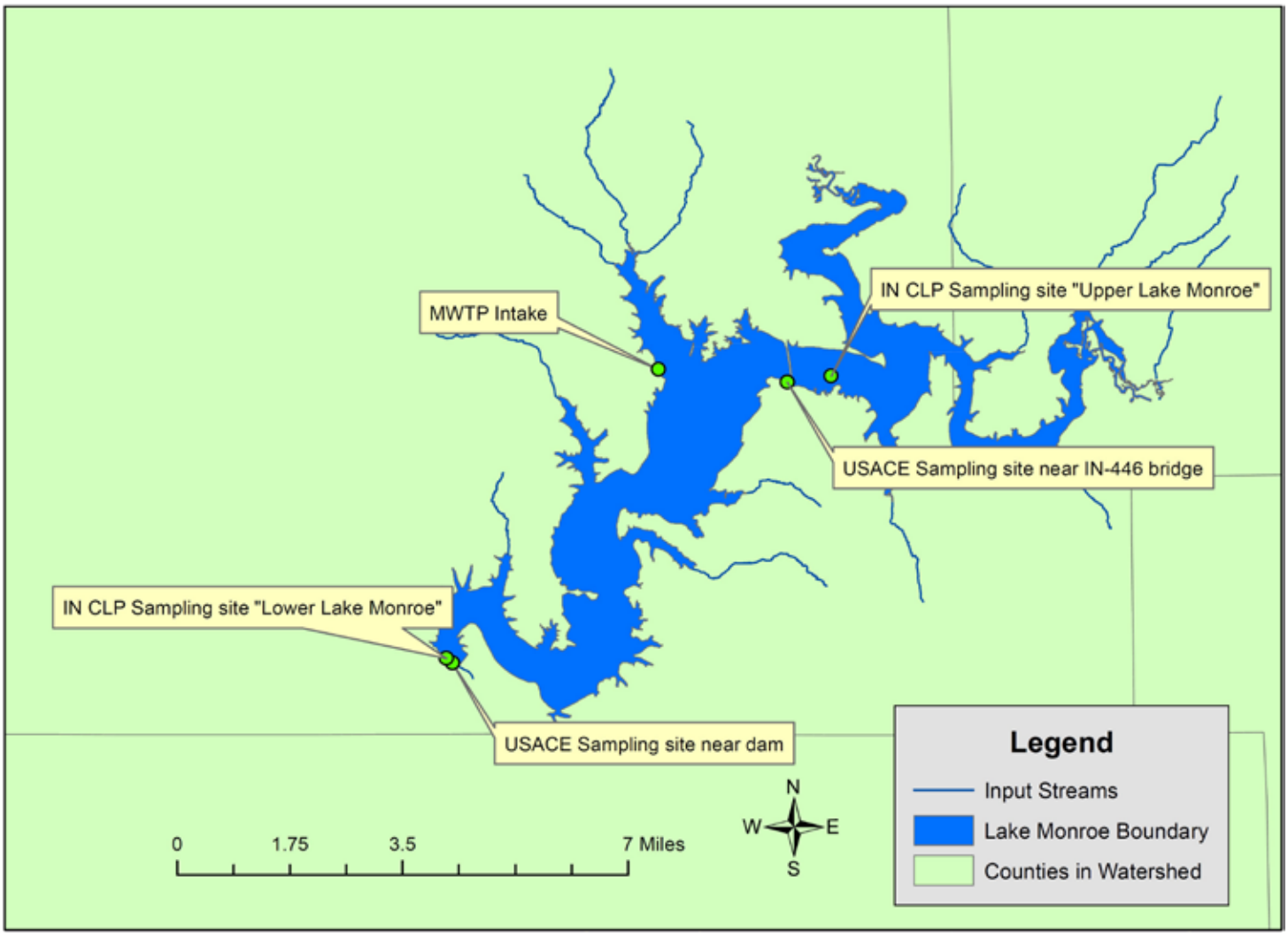

Figure 2. Sampling locations for the InCLP and USACE.

Table 1. Some Characteristics of the Different Trophic State Index Classifications.

Classification (TSI value)	Transparency	Nutrients	Algae	D.O.	Fish
Oligotrophic **(0-40)**	clear	low TP < 6 µg/L	few algae	Hypo has D.O.	can support salmonids (trout and salmon)
Mesotrophic **(40-50)**	less clear	moderate TP 10-30 µg/L	healthy populations of algae	Less D.O. in hypo	lack of salmonids
Eutrophic **(50-70)**	transparency <2 meters	high TP > 35 µg/L	abundant algae and weeds	No D.O. in the hypo during the summer	Warm-water fisheries only. Bass may dominate.
Hypereutrophic **(70-100)**	transparency <1 meter	extremely high TP > 80 µg/L	thick algal scum dense weeds	No D.O. in the hypo during the summer	Rough fish dominate; summer fish kills possible

Note: While those salmonid fisheries, which have higher oxygen requirements, are lost in more eutrophic lakes, there are still many fish species present.

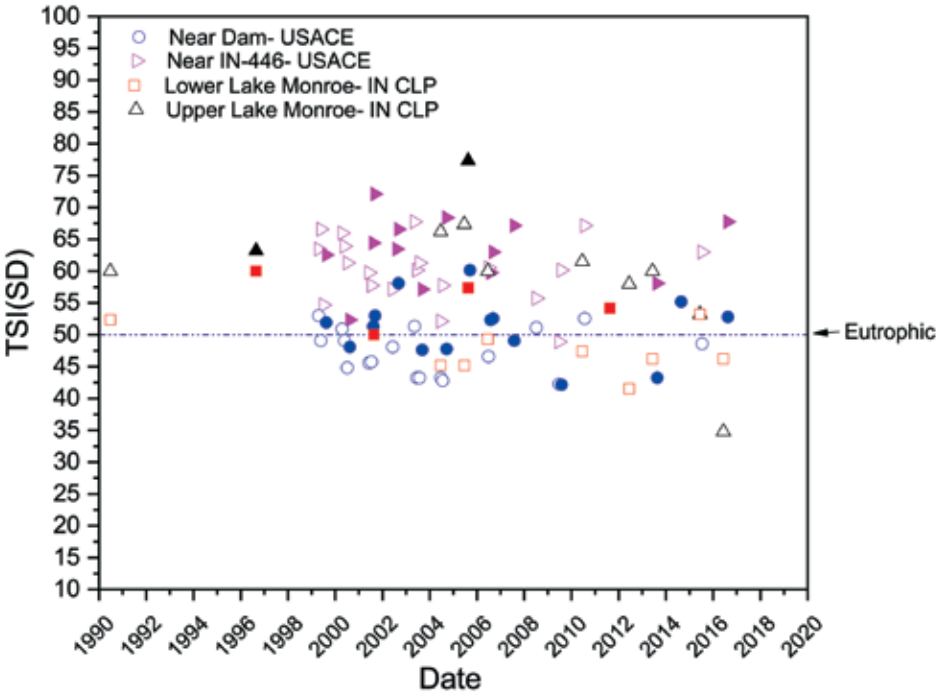

Figure 3. Trophic State Index trend for Secchi disk transparency. Data collected by USACE and InCLP. Solid markers represent data points collected in August and September, which represents the most biologically productive period of the growing season. The horizontal line represents the lower bound of the eutrophic state, with a TSI of 50.

typical in more transitional locations within reservoirs due to suspended sediment that has not had sufficient time to fall out of suspension. The shallower morphometry also encourages resuspension of sediment from boat motor turbulence, and wind and wave action.

RELATIVE HEALTH OF LAKE MONROE

Every lake, natural or artificial impoundment (reservoir), is unique with variations in watershed size, land activities, miles of tributaries feed the lakes, lake shape, among many other characteristics. However, reservoirs share the fact that they were a riverine system that we plugged with a concrete or earthen dam. The rivers and streams that feed these reservoirs still continue to flow with or without that reservoir, thus they continue to deliver nutrients and sediment, even in stable, fully vegetated lands. Indiana has many lakes that can fall into three lake type categories: natural, impoundments (reservoirs), and coal mine lakes. Due to these

TSI Total Phosphorus

Thirty-six total epilimnetic phosphorus measurements were collected by both InCLP and USACE on Lake Monroe during periods of stratification between 1990 and 2016. Of those 36 measurements, 16 were a TSI (TP) value of ≥ 50 (Figure 5), indicating the variability of snapshot monitoring but also the propensity for eutrophic lake conditions and corresponding algal blooms. The maximum TSI (TP) value for these measurements was 64.12, collected by InCLP in June of 2004 at the upper Lake Monroe sampling site.

According to Carlson's Trophic State Index, eutrophic lakes would be expected to have total phosphorus concentrations of 0.024 mg/L or more. Sixteen of the 36 epilimnetic measurements for chlorophyll-a in Lake Monroe were ≥ 0.024 mg/L with a maximum measurement of 0.064 mg/L (Figure 6). This measurement was collected by InCLP at the upper Lake Monroe sampling site. Elevated concentrations are

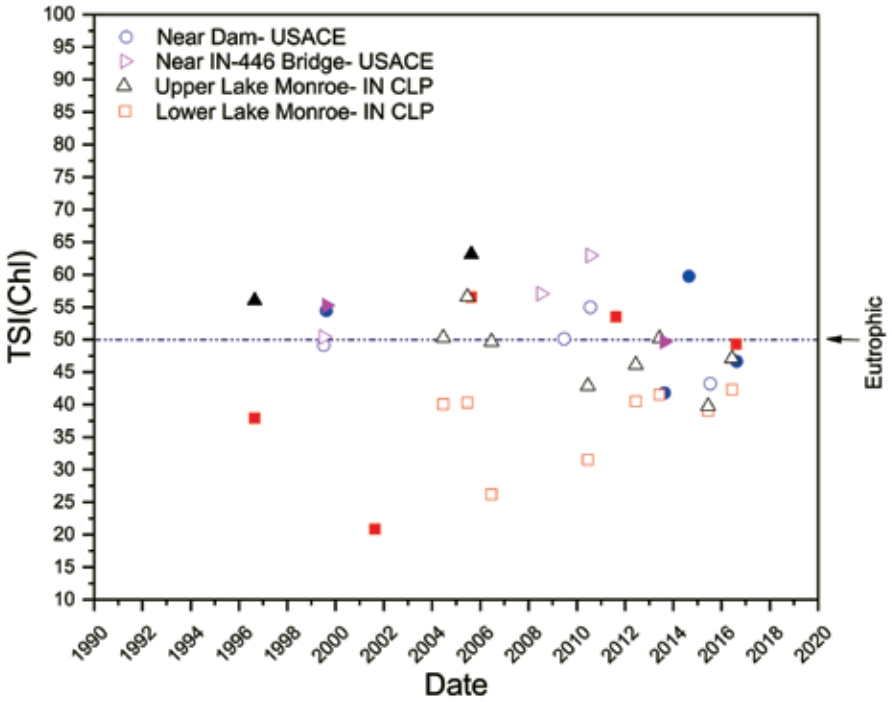

Figure 4. Trophic State Index trend for chlorophyll-a concentration. Data collected by USACE and InCLP. Solid markers represent data points collected in August and September, which represents the most biologically productive period of the growing season. The horizontal line represents the lower bound of the eutrophic state, with a TSI of 50.

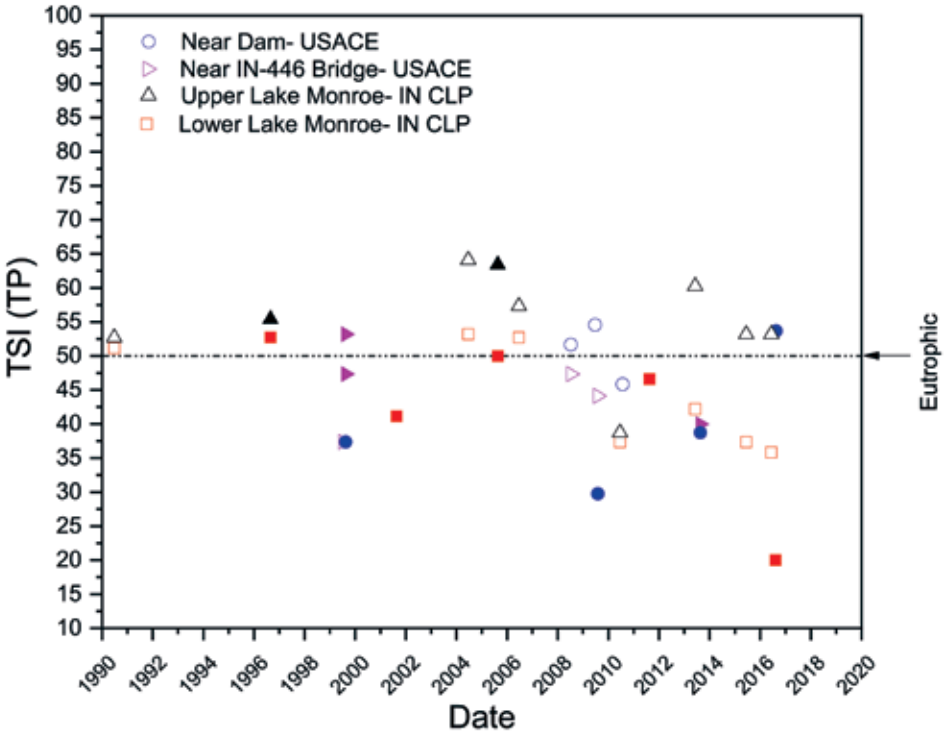

Figure 5. Trophic State Index trend for total phosphorus concentration. Data collected by USACE and InCLP. Solid markers represent data points collected in August and September, which represents the most biologically productive period of the growing season. The horizontal line represents the lower bound of the eutrophic state, with a TSI of 50.

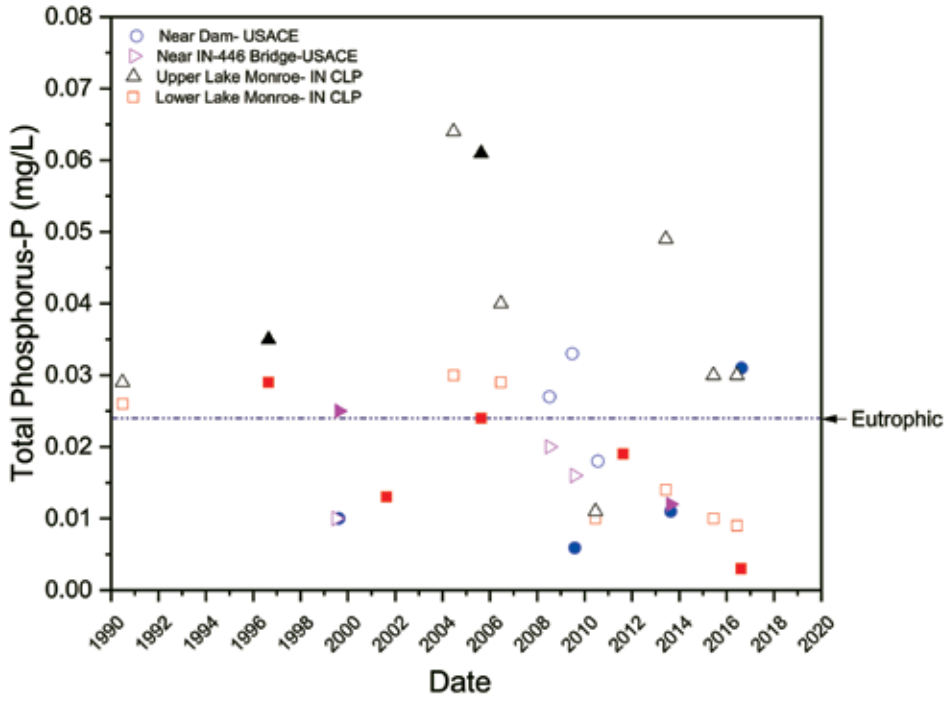

Figure 6. Total phosphorus concentration over time. Data collected by USACE and InCLP. Solid markers represent data points collected in August and September from the epilimnion, which represents the most biologically productive period of the growing season. The horizontal line represents the total phosphorus concentration threshold for eutrophic conditions (Carlson 1977).

highly dynamic flowing systems, reservoirs are by default challenged with management topics and generally more biologically productive (Figure 7).

How does Lake Monroe compare with other reservoirs? Of the many reservoirs throughout the state, if one looks at a subsample of large reservoirs, you will see that Lake Monroe is similar in biological growth, nutrient, and sediment loading (Figure 8). While it appears that Lake Monroe lines up on the lower end, the other reservoirs have been challenged with HABs and related swim advisories, sedimentation rates that threaten the functional longevity, and overall water quality thresholds. Lake Monroe may be better off than some lakes at a glance, but its current ranking presents all the same challenges making a watershed and lake management plan that more urgent.

SUMMARY AND NEEDS FOR LAKE MONROE

The available data suggests that Lake Monroe is eutrophic and that algae blooms could be influencing water quality, especially in the summer months. Although there are many groups already working to protect the watershed, more can be done to minimize the sediment and nutrient inputs that lead to algae blooms. Needs for Lake Monroe include:

1. **A Robust Water Monitoring Program**. While the data suggests eutrophication, the process of the lake receiving excessive nutrients that results in increased biota, typically algae, there are enough data gaps between the various efforts to quantify the water quality that need to be addressed. Lake Monroe's characterization matches the classification that could result in increased harmful algal blooms (HABs) and lake volume loss due to sedimentation. While this condition is well

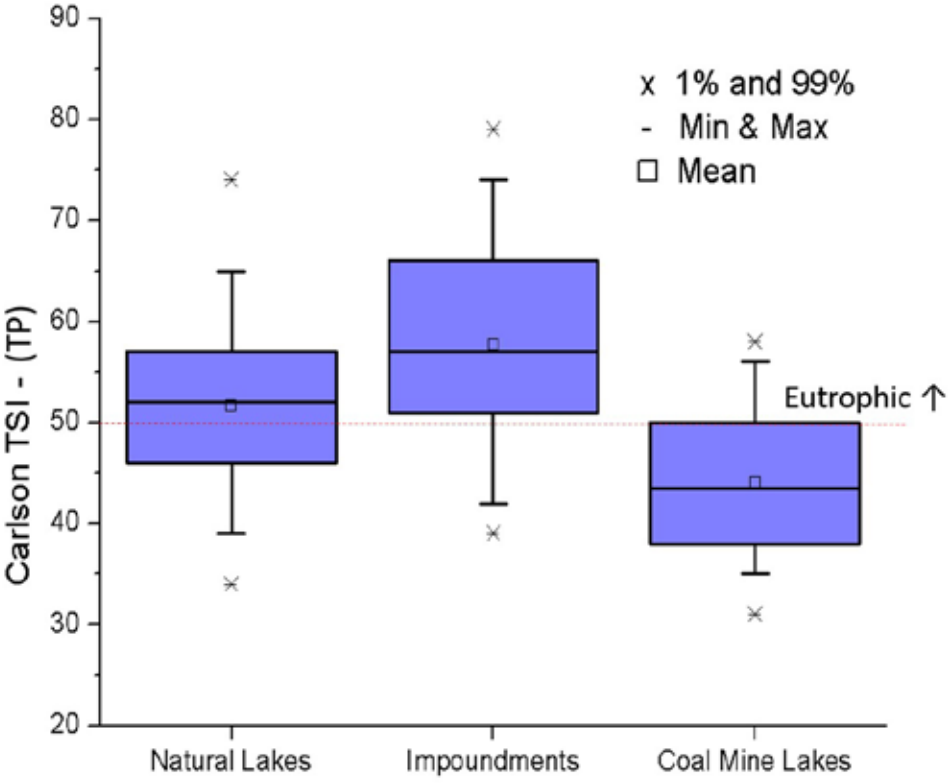

Figure 7. Carlson TSI (TP) for Indiana organized by lake type. Indiana has hundreds of lakes. Natural lakes, a result of past glacial activity, dominates the top 1/3 of the state. Past and current strip mining in the southwestern corner of Indiana has resulted in many interesting artificial lakes. Impoundments generally are classified as more biologically productive, or more eutrophic. TSI values above the 50 point threshold are eutrophic.

understood, the full watershed and tributaries need further monitoring and analysis to more specifically identify the nutrient and sediment sources, any critical land uses or locations that are watershed hotspots, and additional water quality concerns. A robust monitoring program will also lay the essential ground work for a watershed and lake management plan.

2. **A Watershed Management Plan**. Watershed and lake management plans are strategic documents that report historical and current conditions of the lake and watershed. A watershed management plan would address the critical monitoring needs of Lake Monroe and fill in data gaps, which would help lake managers enhance and protect this reservoir that provides many benefits to those in southcentral Indiana and beyond. We can improve water quality, reduce storm water, and protect Lake

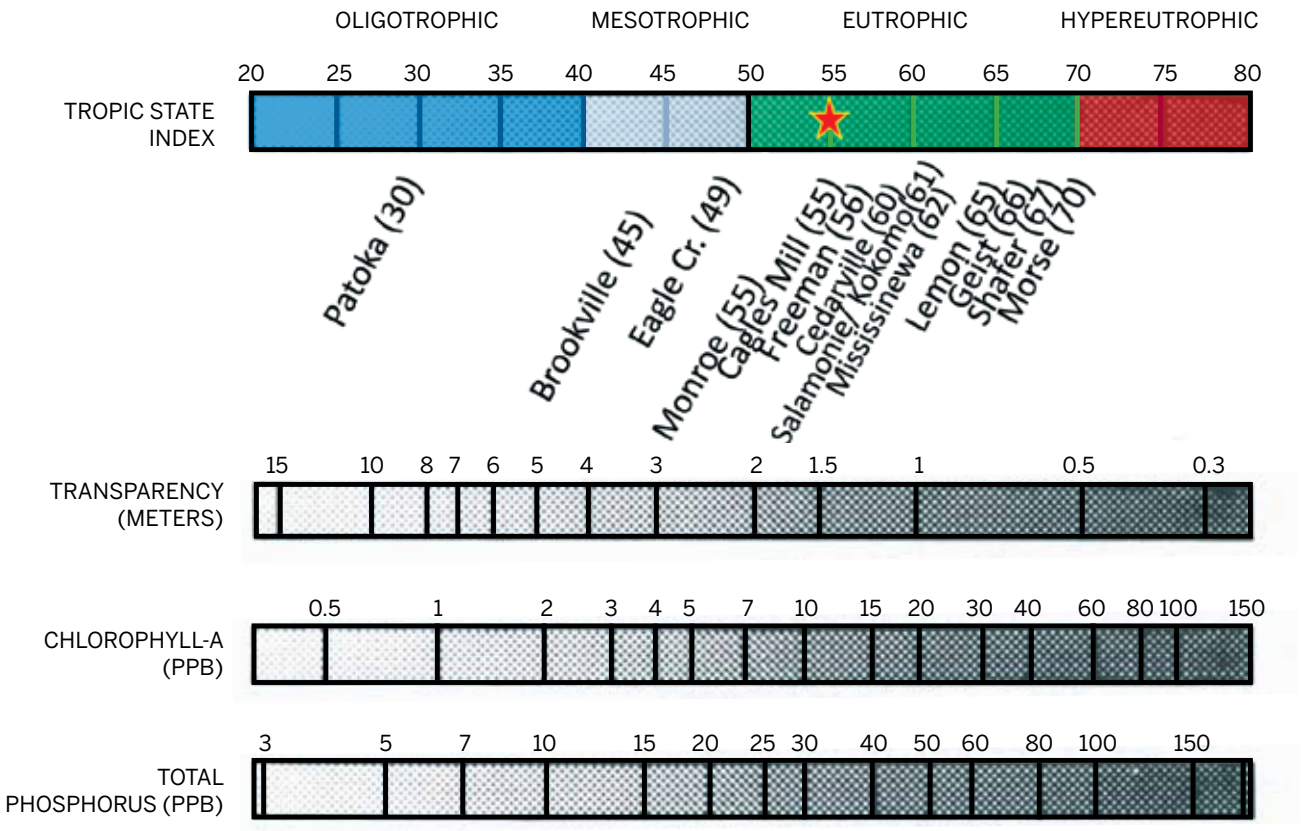

Figure 8. While Lake Monroe is classified as a eutrophic lake TSI(TP) = 55, many other large reservoirs throughout Indiana are even more biologically productive and challenged with high sediment loads and algal densities.

Monroe from nutrient and sediment loading by implementing best management practices. A management plan will create the much needed and overdue strategy to recommend best practices to safeguard this critical water resource plus explore partnerships and funding opportunities, from voluntary Citizen Scientist engagement to a possible water fund to finance and support implementation of best management practices.

3. **Growth of Best Management Practice Implementation**. Continued and improved land management strategies, focused in areas recommended by a Watershed Management Plan, could greatly benefit the watershed. Many agencies are already working to conserve and manage lands in the watershed, and this could help reduce phosphorus loading and sedimentation into Lake Monroe. Stormwater is part of the natural hydrological process. Human activities throughout the whole watershed changes the patterns of stormwater, how it flows across the land, ultimately affecting the receiving waters. These human activities contribute to pollutants such as nutrients and sediment. Best Management Practices (BMPs) are inherently pollution prevention practices. BMPs may apply to an entire site or be appropriate for discrete areas of the watershed. BMPs have historically been developed as part of the National Pollutant Discharge Elimination System (NPDES), which allows them to address stormwater runoff in the diverse land uses from urban parking lot surface runoff to agricultural row crops. Specifically, stormwater or weather is the driving force for watershed runoff. Therefore, the suggested BMPs focus on addressing stormwater quantity and quality. There are countless examples of the long-term performance for pollutant reduction by implementing these BMPs within the watersheds (Tetra Tech 2010; Clary et al. 2017).

4. **Additional Funding to Grow Implementation of Best Management Practices**. Increased funding for groups working directly with private landowners in the watershed could help to further conservation and best management practice implementation on private land, which will also help reduce phosphorus loading and sedimentation into Lake Monroe. To accomplish this, it is necessary to (a) describe the best management practices that are currently working well, (b) define the current level of investment in best management practice and conservation implementation in the watershed, (c) identify the work that these groups would most like to implement to better protect Lake Monroe from nutrients and sediments in runoff, and (d) establish a range of potential investments that would help these organization to implement the desired, yet currently unfunded, best management practices.

5. **Definition of the Additional Funding Approach (aka Water Fund)**. Water Funds are organizations that design and enhance financial and governance mechanisms that unite public, private and civil society stakeholders around a common goal to contribute to water security through nature-based solutions and sustainable watershed management. Water funds help protect watersheds and restore forests, wetlands, grasslands, and agricultural lands to provide clean water to cities. To expand the work of watershed and source water protection for Lake Monroe, it will be necessary to define what a water fund might look like. It will be useful to establish a framework for a water fund that identifies the potential governance of such a fund, potential sources of funding, and potential best management practices for which the funds might be invested.

With the above needs met, the goals of the Watershed Management Plan will more likely be realized. For the complete report, check out the Indiana Clean Lakes Program resources, https://clp.indiana.edu/.

CLEAN LAKES PROGRAM

WATER COLUMN

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31st Annual Indiana Lakes Management Conference
March 21, 2019, 9:00 a.m., EDT, Oakwood Resort, Syracuse, Indiana

Join the Indiana Lakes Management Society for the 31st Annual Indiana Lakes Management Conference.

Join us Wednesday, March 20th for Exhibitor set-up between 5:00 and 7:00 pm.

Registration opens at 8 am on Thursday, March 21st in the Hilltop Conference Center with our plenary speaker starting at 9 am.

Plenary Speaker: Dr. Allen Hamlet, University of Notre Dame will speak on "Climate Change Impacts on Water Resources".

Friday Workshops include Plankton Identification with Ann St. Amand, PhycoTech and an Inside-Outside Tour of Wawasee Area Conservancy Foundation protection and restoration efforts.

Interested in sponsoring the 31st Annual Indiana Lakes Management Conference – learn more about sponsorship levels!

Contact Sara Peel at speel@arionconsultants.com or (765) 337-9100 if you have questions about registration.

Water Funds Can Enable Healthy Watersheds for Our Communities

A healthy watershed collects, stores, and filters water. It provides benefits for biodiversity conservation, climate change adaptation and mitigation, supports food security and human health and well-being. In fulfilling these roles, healthy source watersheds are vital natural infrastructure for nearly all cities and communities around the world.

Globally, water consumption has doubled every 20 years, and by 2025, at least two-thirds of the world's population is anticipated to be living in water stressed areas. Development pressures to feed and power the world are degrading the lands and rivers from which our water comes. This degradation of watersheds is a key challenge to managing watersheds for their long-term health, both in terms of water quality and water quantity.

The Nature Conservancy has engaged Water Funds around the world as a tool to enhance and improve watershed management for the benefit of both people and nature. Water Funds are organizations that design and enhance financial and governance mechanisms that unite public, private and civil society stakeholders around a common goal to contribute to water security through nature-based solutions and sustainable watershed management.

The Nature Conservancy, along with Friends of Lake Monroe and the City of Bloomington Utilities, has convened an exploratory group that is evaluating whether a water fund can be a helpful tool to increase investment in watershed management for Lake Monroe. For more information, contact Melissa.Moran@tnc.org.

Volunteer Corner

Hello to all our volunteers! We are working on processing samples and data that have come in, and we are excited to see them keep coming. We would love you to share photos of your sampling efforts and your lake via Facebook or email. It's great to see citizen scientists in action.

As always, thank you for your efforts and stay safe out there. We couldn't do this without you!

Aquatic Invasive Monitoring Plant Highlight

This will be the 23rd plant in the plant highlight series. We will be featuring one aquatic plant in each *Water Column* issue. We will feature both native and invasive plants to improve our plant identification skills.

European Frog-Bit (*Hydrocharis morsus-ranae*), INVASIVE

COMMON NAMES: European Frog-Bit, also known as common frogbit, is a free-floating aquatic plant to can cover the whole water surface since rooting into substrate is not necessary. This means this plant isn't necessarily restricted to the shallow littoral edges.

DISTRIBUTION: European frog-bit is native to Europe and Asia. In North America, the species has been found in the wild in Washington, Michigan, New York, Vermont and Ontario, Canada. Although not currently detected in Indiana waters, European frog-bit is a prohibited invasive aquatic plant and is declared a pest under (312 IAC 18-3-23) as well as prohibited from being sold, bartered or otherwise distributed within Indiana.

DISPERSAL/SPREAD: European frog-bit is a popular water garden plant. As this invasive plant takes over small artificial ponds, the owners may opt to dispose of the plant in natural waterways. Once the plant becomes established in the wild, the movement of frog-bit to new bodies of water is likely a result of the plant hitchhiking on boats, trailers, or other equipment. Since this species is not rooted to the bottom, water currents can move the plant around as well.

DESCRIPTION: The upper side of the leaf is green with the underside being dark purplish-red. They have an extensive root system that does not anchor it to the substrate. It is a free-floating plant with leaves that sit on the water's surface. Frog-bit produces a single white flower that is 1.5 cm wide and it has three petals.

Identification tips:

- Has1-2 inch wide heart-shaped, leathery leaves
- Underside of leaves purplish-red
- White flower with three pedals
- Free-floating plant with modified roots that don't anchor into lake sediment unless in shallow edge
- Resembles a small water lily