Photo by Derek Kavanaugh

GREEN LAKE ASSOCIATION

A CASE FOR PHOSPHORUS INTERCEPTION

2024 STORMWATER WORKSHOP

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Green Lake Association

April 3, 2024

PRESENTATION GOALS

ONE

Introduction to Green Lake and its water quality challenges

TWO

BMPs alone are insufficient to reach water quality goals

THREE

Innovative approaches that intercept phosphorus should be considered

GREEN LAKE

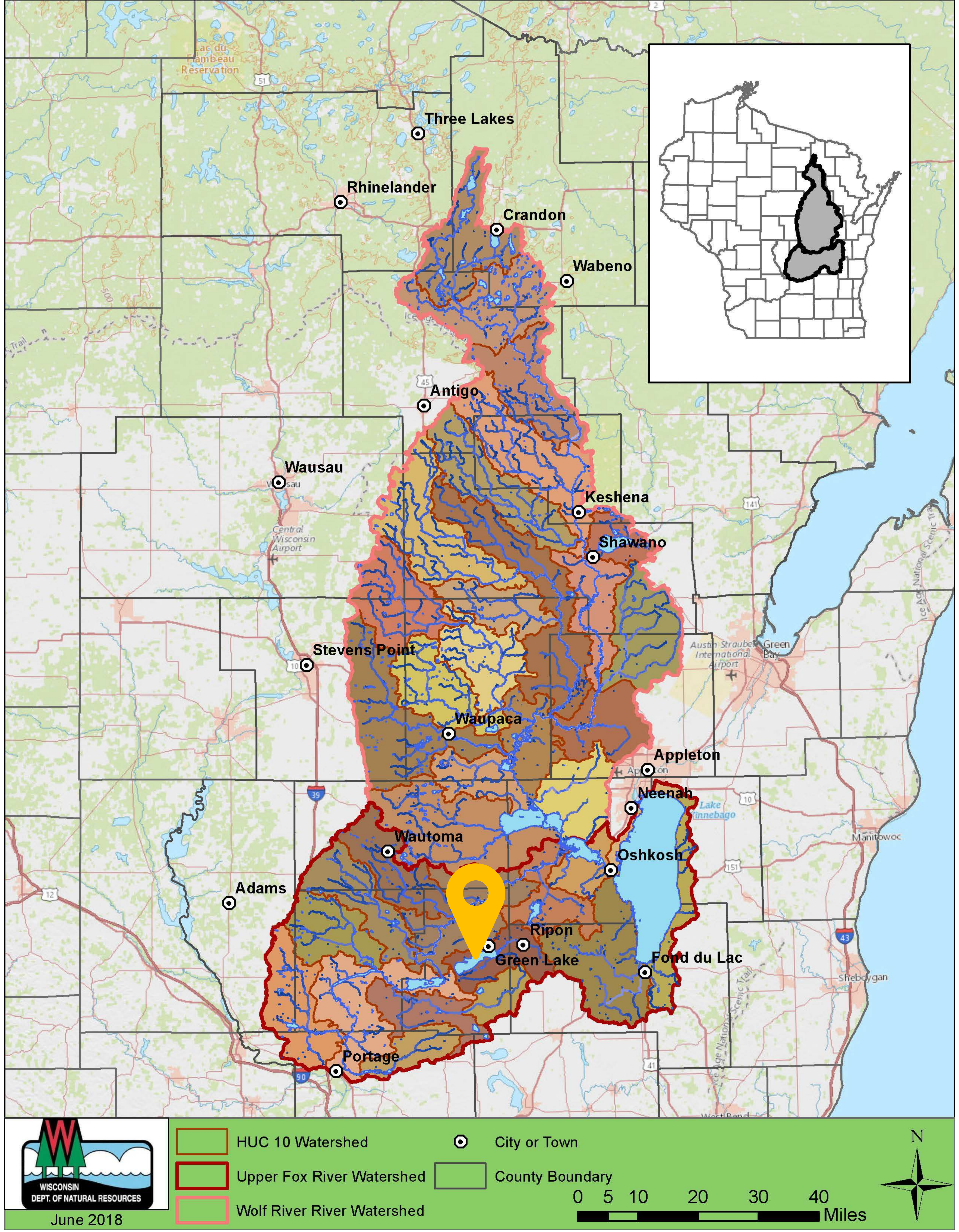
- Deepest natural inland lake in Wisconsin
- Max depth: 236 feet
- Two-story fishery
- Area: 7,660 acres
- Retention time: 15 years
- Glacial lake
- Water quality criteria = 15 µg/L

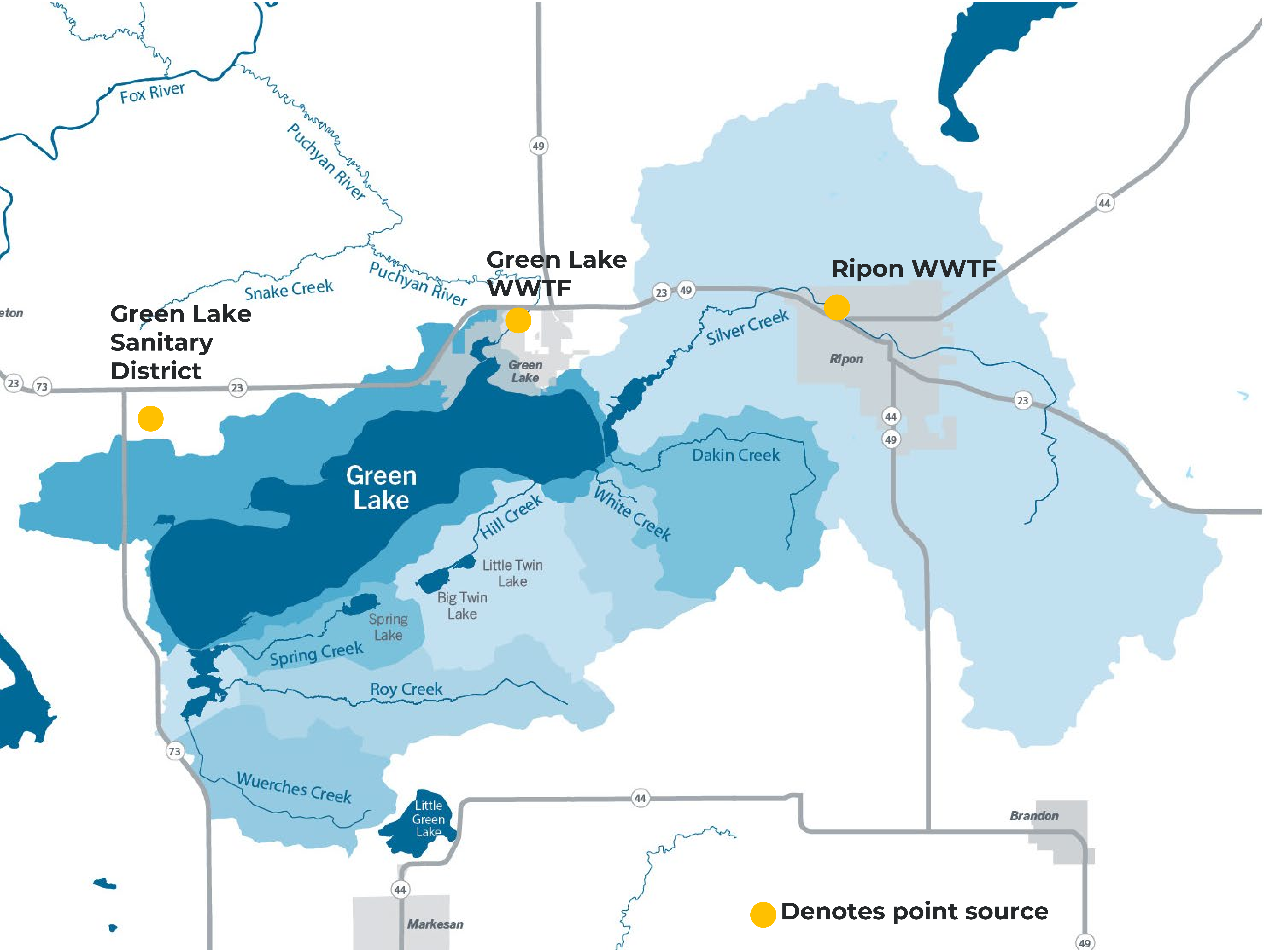
GREEN LAKE WATERSHED

Located in central Wisconsin

Within the **Upper Fox Wolf** and **Lake Michigan** watersheds

Part of the **Upper Fox Wolf TMDL** area (5,900 mi²)

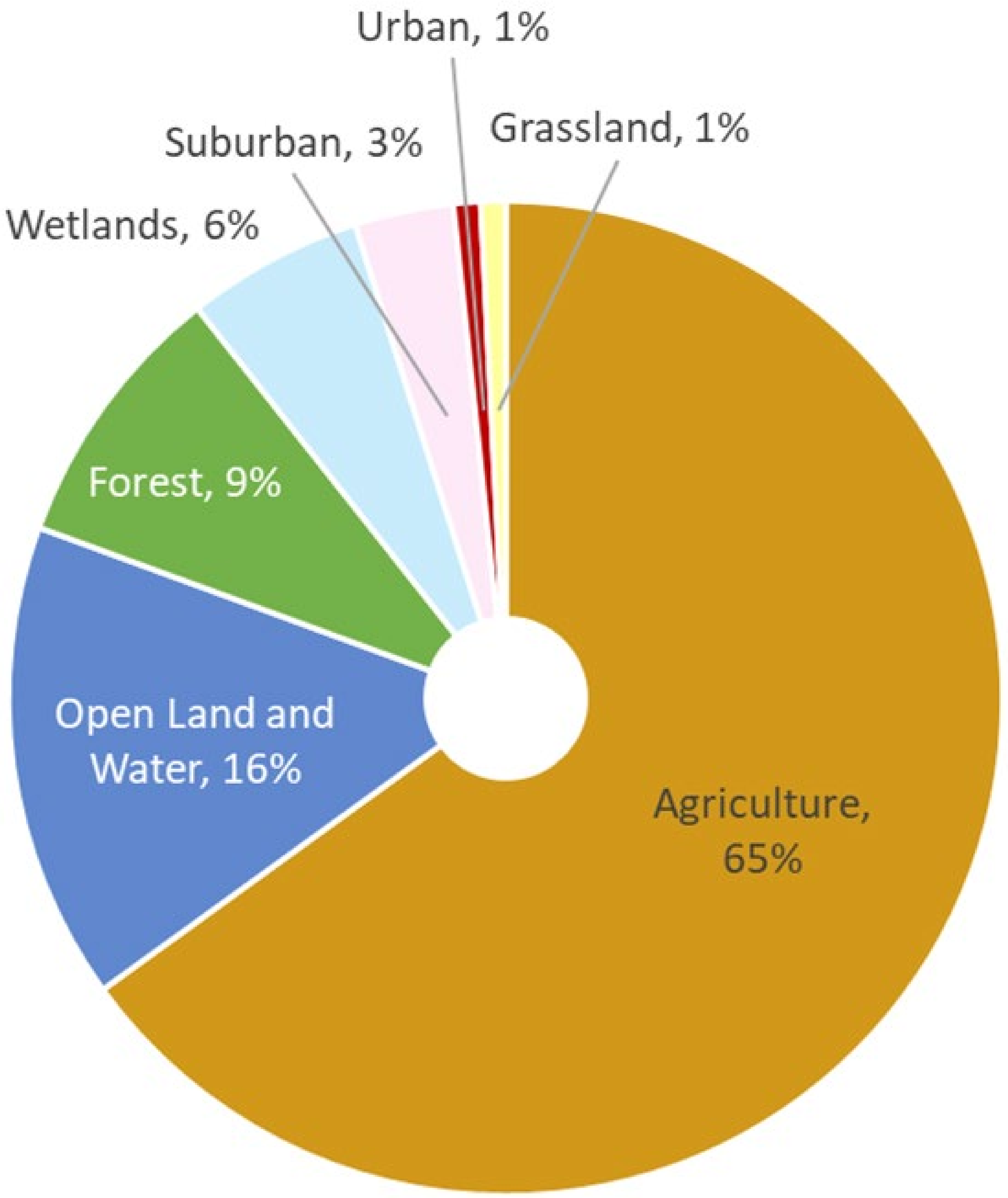


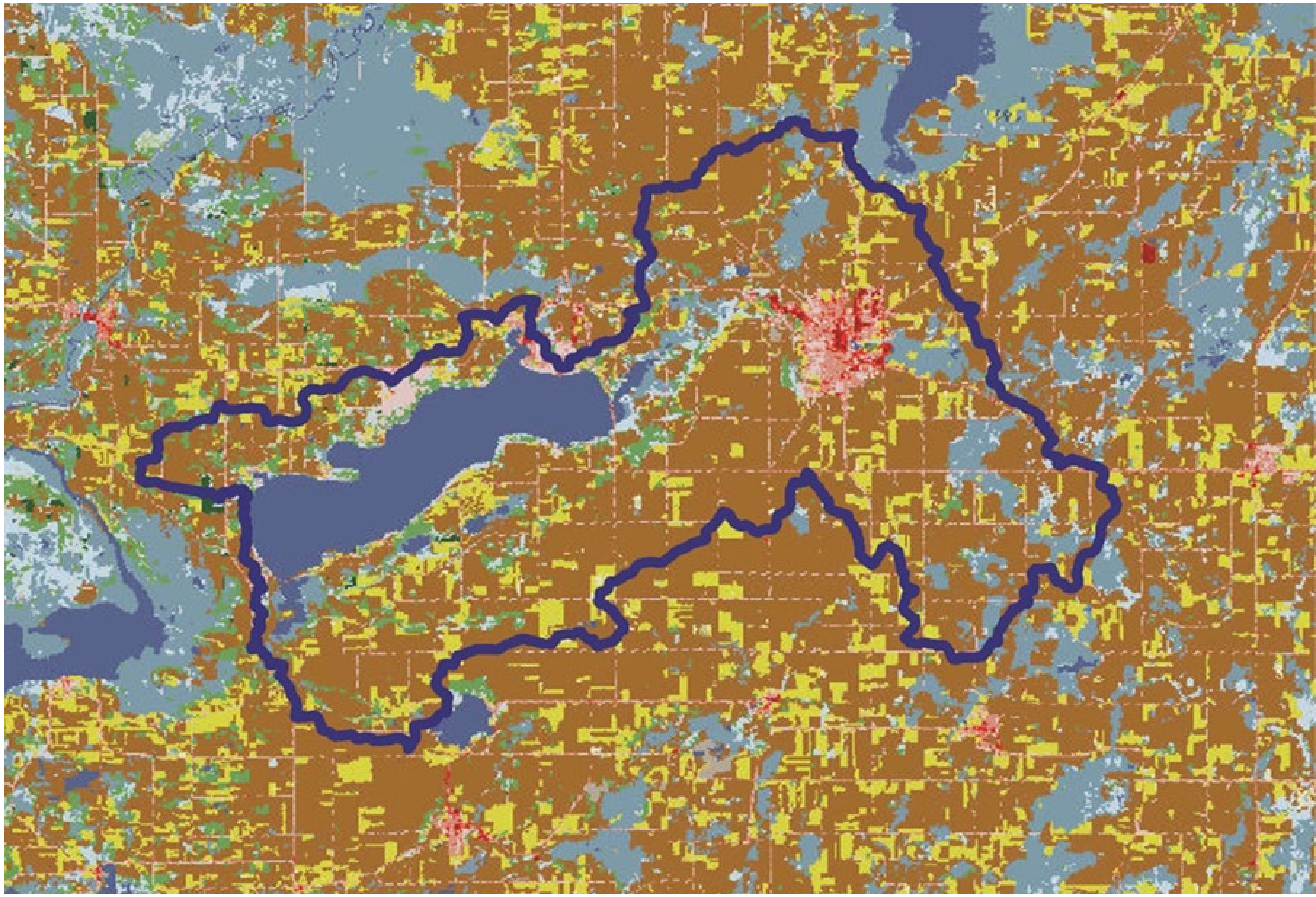


GREEN LAKE WATERSHED

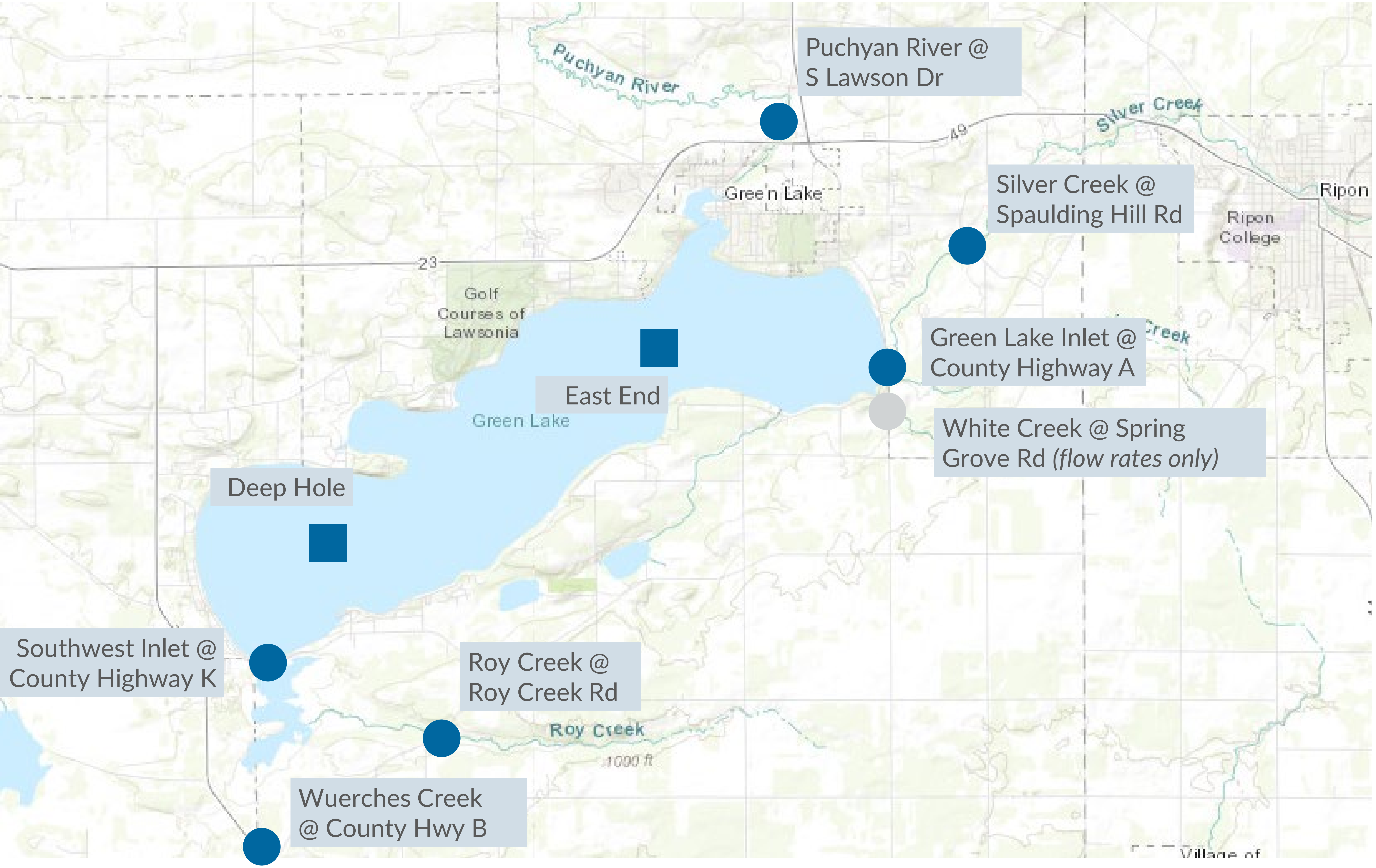
- Watershed = 107 mi^2
- Eight named streams
- Two main inlets
- One outlet: Puchyan River → Fox River → Lake Michigan
- Only one point source that discharges within the watershed

GREEN LAKE IS PRIMARILY AN AG WATERSHED





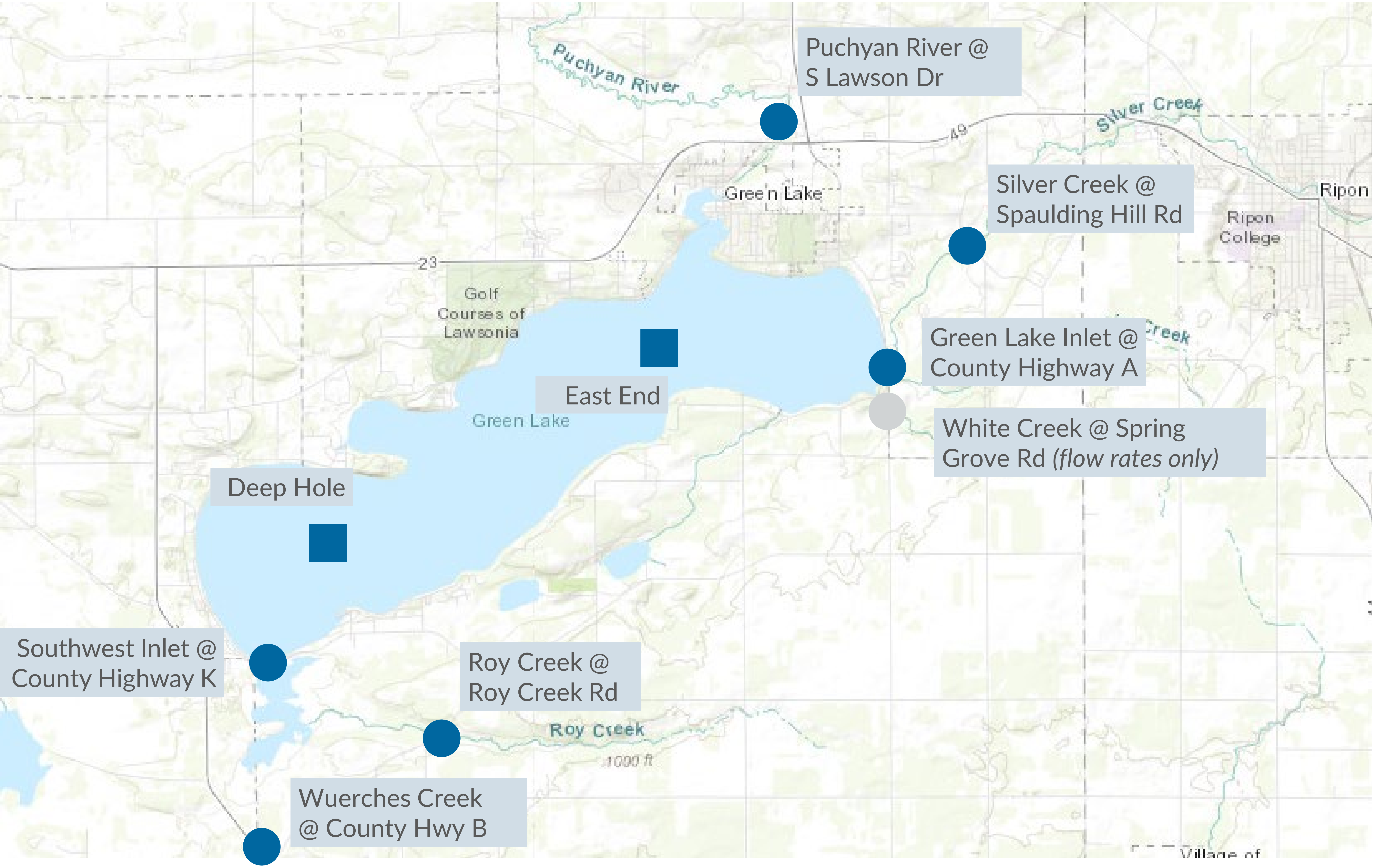
USGS MONITORING: STREAMS & LAKE



History of data collection:

- Data going back to **1905**
- History of WDNR & citizen science data
- **1981**: USGS stream monitoring begins
- **2004**: USGS lake monitoring begins

USGS MONITORING: STREAMS & LAKE



The Green Lake watershed & lake system is monitored extensively thanks to a multi-organization partnership:

USGS science for a changing world

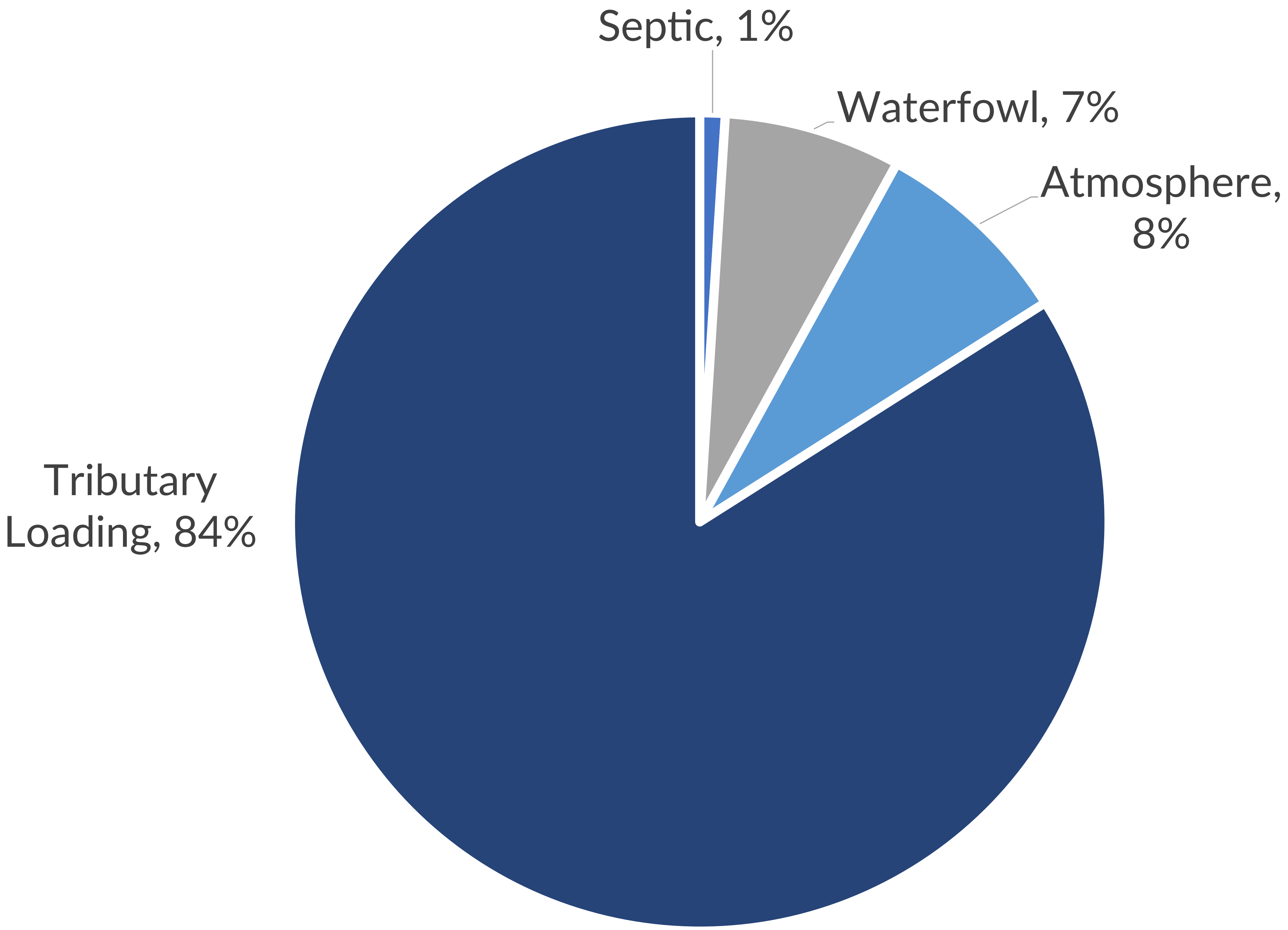
Green Lake Sanitary District

Green Lake Association

ANNUAL PHOSPHORUS LOADING
(2014-2018)[1]

Total loading=
19,800 lbs P / year

Controllable loading=
16,800 lbs P / year



TWO PRIMARY LONG-TERM WATER QUALITY CONCERNS

High Phosphorus Levels

Water quality criteria: 15 µg/L

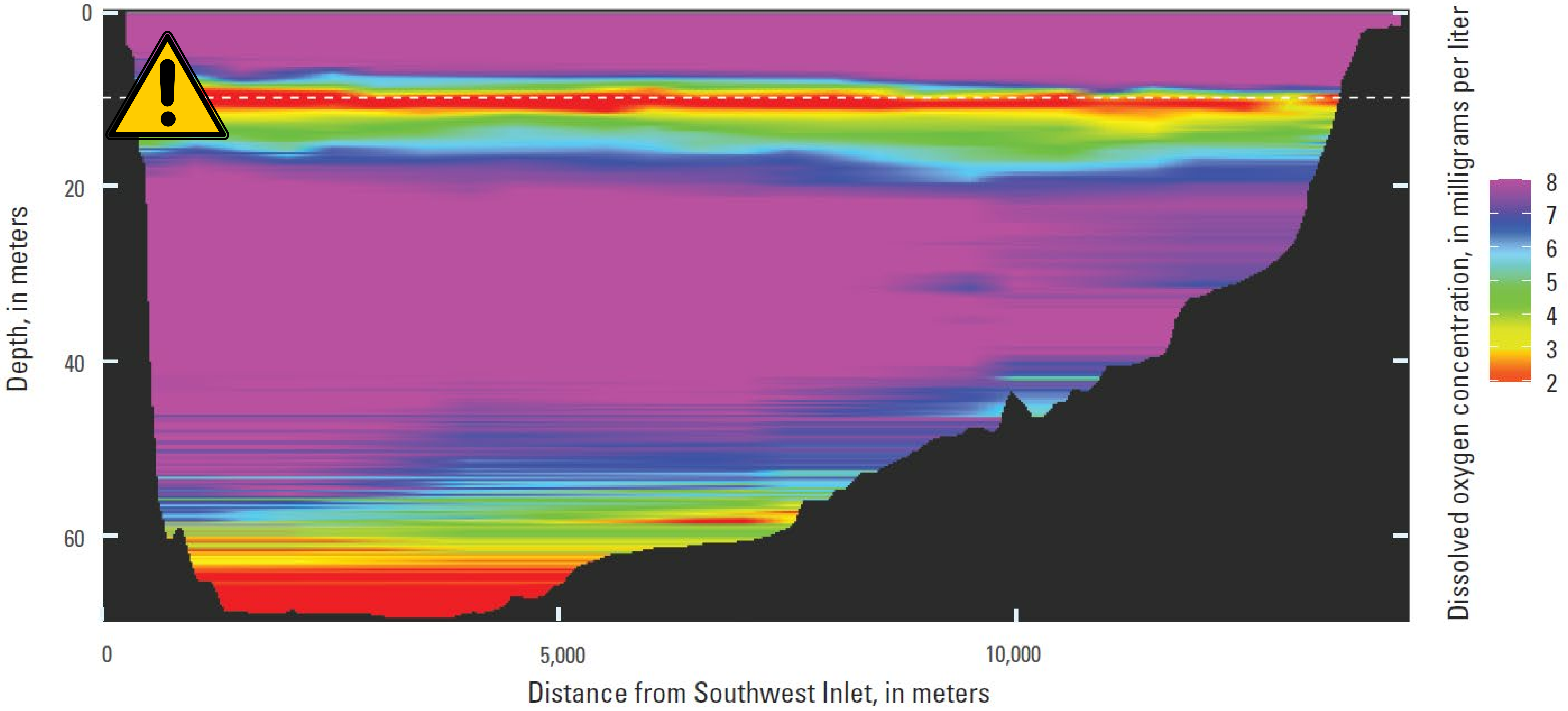
5-year average (2017-2022): 17.7 µg/L

Metalimnetic Oxygen Minima → IMPAIRED in 2014

Water quality criteria = 5 mg/L

Generally worsening since 1905

GREEN LAKE METALIMNETIC OXYGEN MINIMA[1]



SCIENTIFIC LAKE STUDY

GLA-sponsored diagnostic & feasibility study with USGS[1] and Michigan Tech[2].

Two research institutions, two approaches.

Used computer modeling & extensive monitoring to study three scenarios[3]:

1. Meet water quality criteria (15 µg/L)
2. Return to oligotrophic lake (12 µg/L)
3. Remove lake impairment

USGS
science for a changing world

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Michigan Technological University
1885

From the D&F study[1,3]:

Green Lake needs a **60% reduction** to remove the lake from the impaired waters list.

THE 1972 CLEAN WATER ACT

POINT SOURCES

NONPOINT SOURCES

THE CLEAN WATER ACT HAS RESULTED IN A CHALLENGE:

For rural watersheds dominated by agriculture & lacking industry, the Clean Water Act creates a **voluntary framework** for phosphorus reductions.

A VOLUNTARY APPROACH TO NON-POINT SOURCES

In 2023 alone, LMP partners have received over **$1.1 million** in grant funding in the watershed for best management practices.

A VOLUNTARY APPROACH TO NON-POINT SOURCES

In 2023 alone, Green Lake Management Planning partners have received over **$1.1 million** in grant funding in the watershed for best management practices.

FOUR CRITICAL QUESTIONS

Are BMPs—in and of themselves—sufficient to result in a 50% to 70% reduction in phosphorus & achieve lake water quality goals?

How does climate change affect BMP effectiveness?

How does Green Lake's long 10- to 15-year retention time and internal loading sources delay water quality outcomes?

Is there an example where a sizeable lake successfully achieved cleaner water by relying on BMPs and watershed management alone?

From a Comprehensive Evaluation of the Chesapeake Bay System[4]:

"Achieving nutrient reductions has been difficult. Runoff from ag is the single largest contributor, but existing programs are unlikely to produce the scale of reductions needed."

From the *Inadequacies of BMPs* (Osgood 2016)[5]:

"Nonpoint source phosphorus mitigation has encouraged BMPs as the primary strategy for the past three or four decades in the United States. This lax regulatory approach… has resulted in an overall lack of progress in lake management improvements."

From 2019 Lower Fox TMDL Report[5]:

“SWAT modeling indicated that BMP implementation can reduce sediment and nutrients export to Green Bay…. but none of the scenarios reduced TP loads to where the Fox River Wisconsin TMDL TP reduction goal (70%) were met.”

IS WATERSHED MANAGEMENT WORKING?

BMPs to reduce the root causes of phosphorus loading are essential.

But we cannot solely rely on:

- Often voluntary participation
- Acre-by-acre, field-by-field, farmer-by-farmer approach
- BMPs with wide ranging P removal efficiencies

THE BOTTOM LINE:

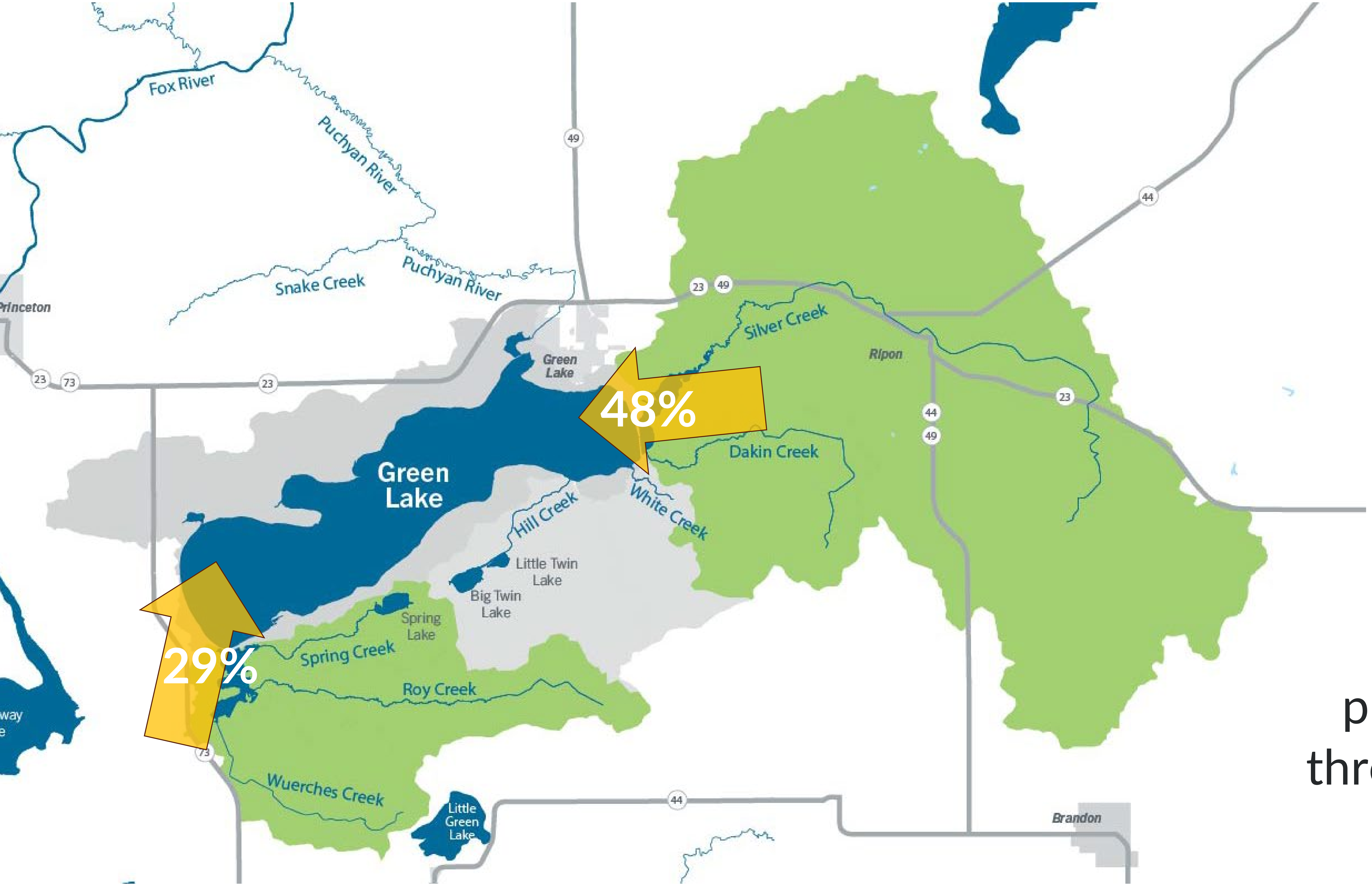
We are using voluntary, outdated tools in an attempt to improve water quality for Green Lake and we are not seeing the results we need.

We must broaden our approach.

A BROADENED APPROACH:

Use new, innovative tools to intercept phosphorus— before it reaches Green Lake

GREEN LAKE AS A MODEL FOR PHOSPHORUS INTERCEPTION



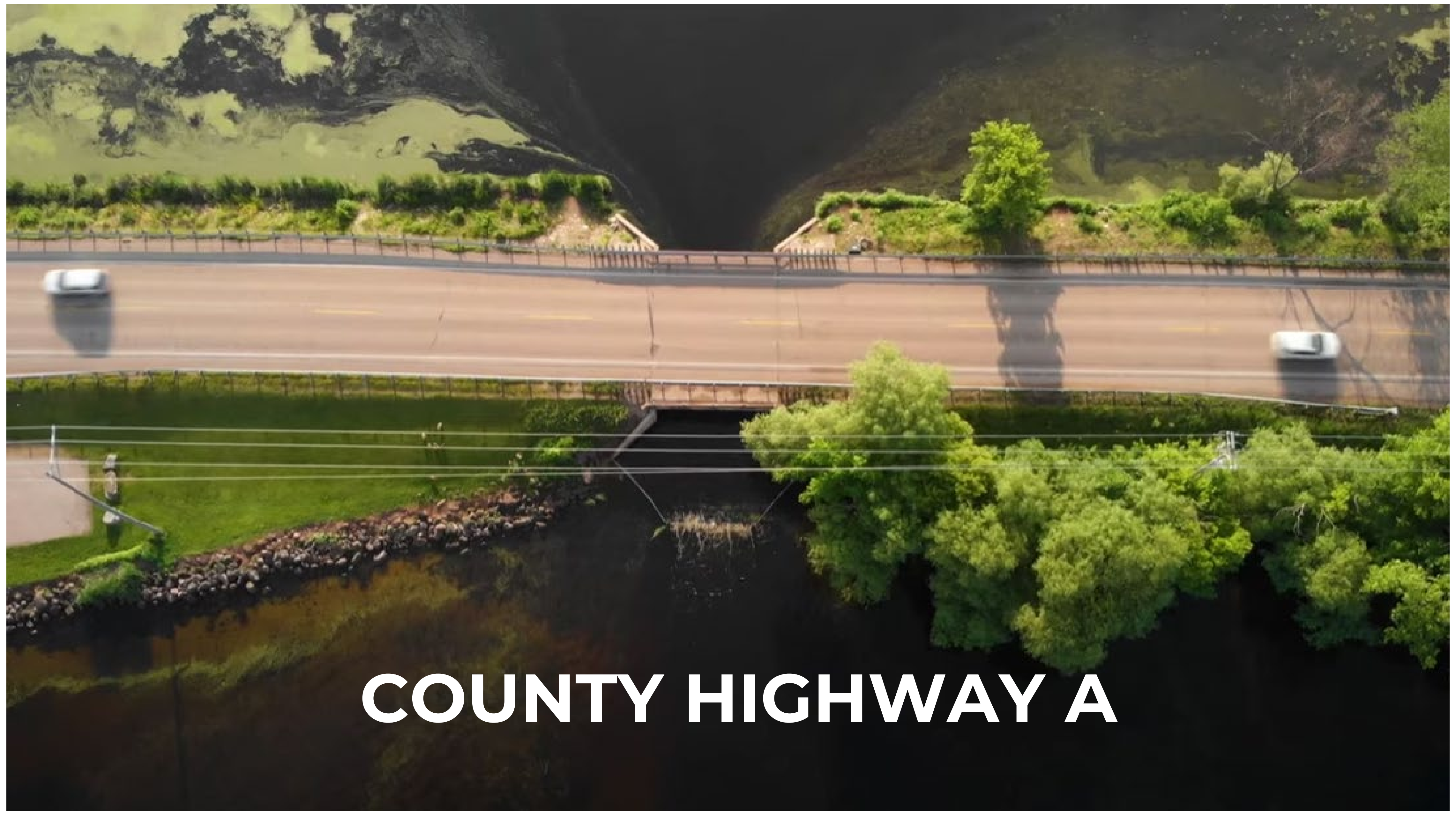
A UNIQUE OPPORTUNITY

From water quality monitoring, we know:

~80% of Green Lake's controllable external phosphorus loading flows through **two points of entry**[1]

A UNIQUE OPPORTUNITY: LEVERAGE PINCH POINTS

Utilize innovation & technology to intercept phosphorus at Green Lake's two pinch points.

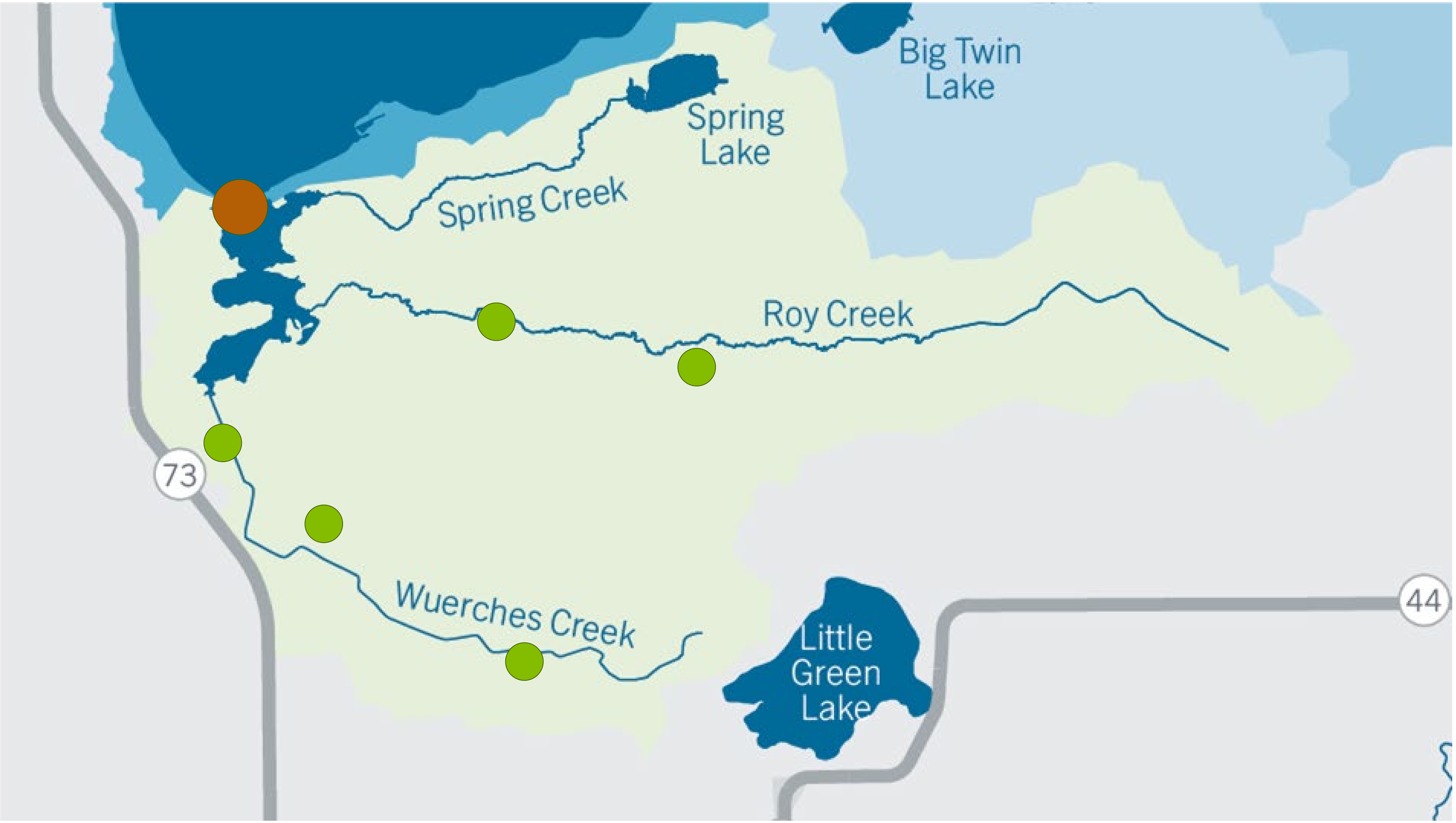


GREEN LAKE'S TWO MAIN INLETS

County Highway K Marsh

Silver Creek Estuary

PHOSPHORUS INTERCEPTION AT TWO SCALES



GLOBAL SUCCESS STORIES OF PHOSPHORUS CAPTURE & REMOVAL

SEDIMENT INACTIVATION

Cap internal loading from within Green Lake's two inlets.

Example: Morrison Lake, MI

PHOSPHORUS INTERCEPTION

Mitigate phosphorus loading from streams where higher phosphorus concentrations result in efficient treatment.

Example: Lake Rotorua, NZ

NUTRIENT REDUCTION FACILITIES

Divert a portion of stream flow, treat off-line, and return clean water to a waterway.

Example: Dixie Drain, Boise, Idaho

GLOBAL REQUEST FOR INFORMATION

2023: Partnered with The Water Council for global search of potential solutions

2024: Launching a Science Advisory Panel, comprised of national experts on phosphorus interception

THE WATER COUNCIL

ESSENTIAL QUESTIONS

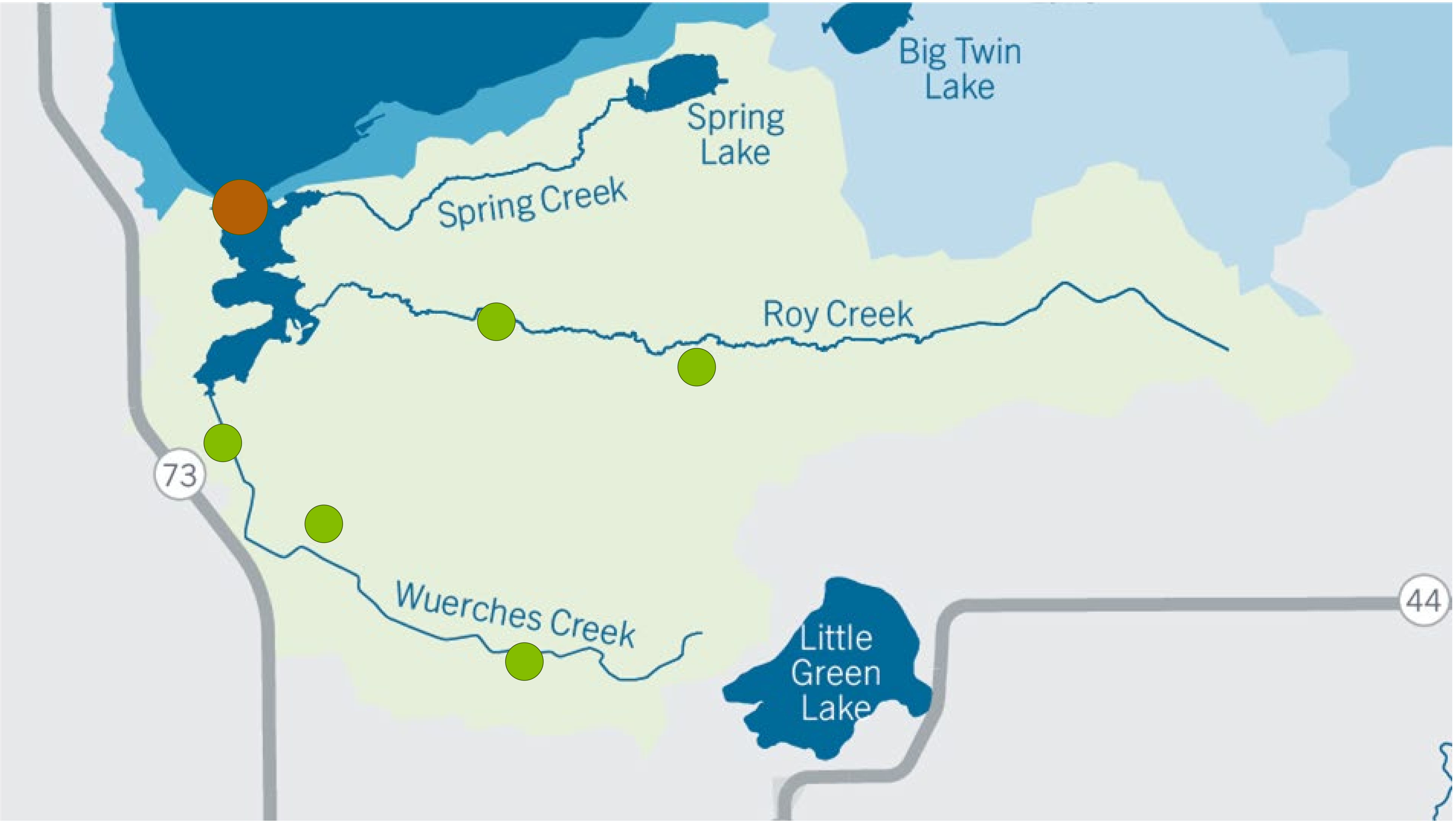
What is the WDNR permitting process?

What about floc collection and disposal?

Ongoing operation and maintenance?

Photo from SOLitude Lake Management

PHOSPHORUS INTERCEPTION AT TWO SCALES



FIELD INTERCEPTION SCALE: CAPTure™ STRUCTURE

Retrofit outlet of a retention pond with "runoff sponge"

Will treat 96 acres

PARTNERS:

Kieser & Associations

Green Lake County LCD

CAPTure™ STRUCTURE

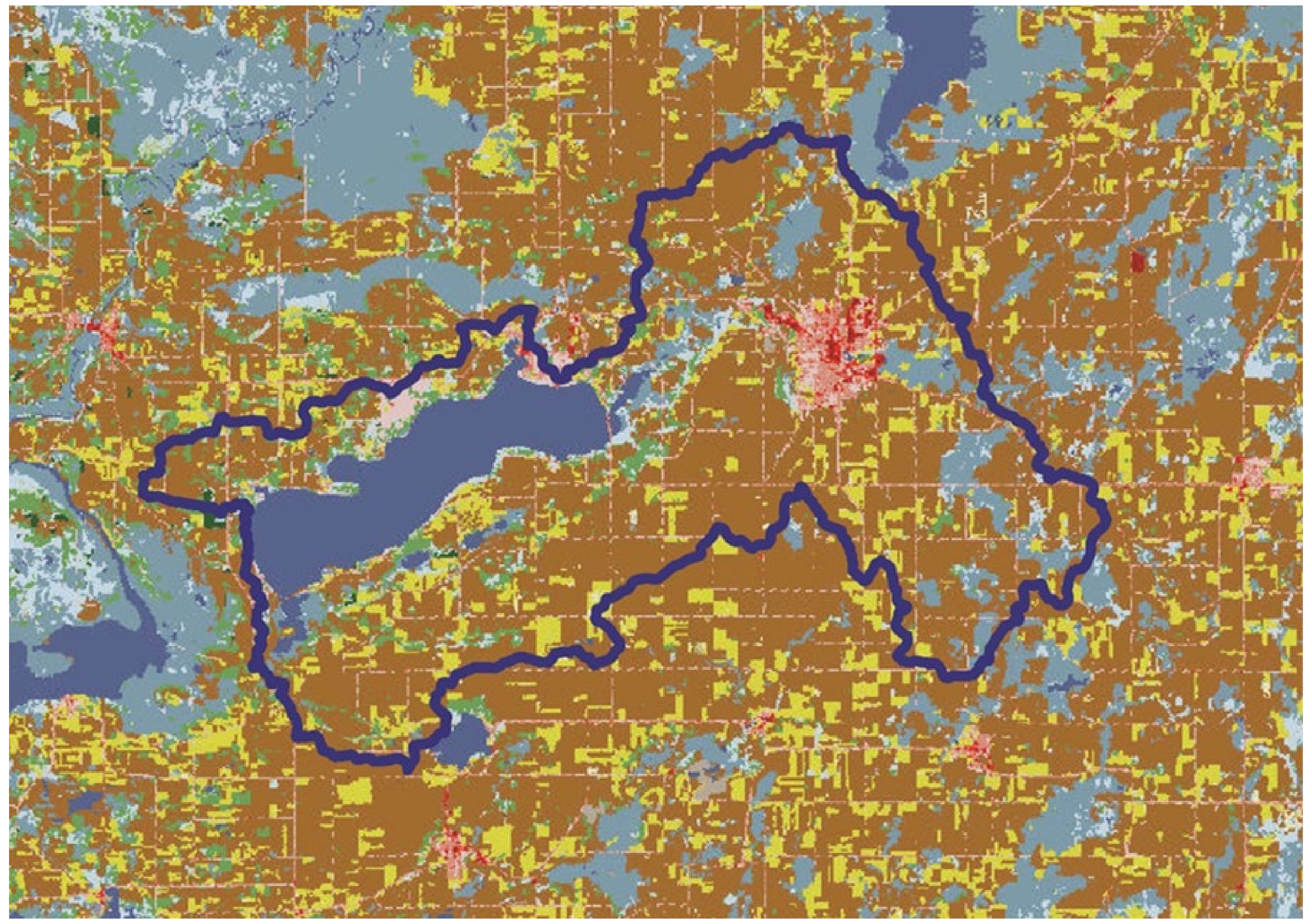
Filled with Alcan: iron-enhanced activated aluminum

>50% soluble phosphorus removal[7]

One pond = 50 lbs P/yr

50 ponds = 2,500 lbs P/yr 30% of goal

KEY TAKEAWAYS



BMPs alone **are not sufficient** to hit ambitious phosphorus reduction targets

We must broaden our approach to **consider phosphorus interception** as a viable option

The GLA is actively **pursuing pilot projects** at various scales to intercept phosphorus


QUESTIONS?
GREEN LAKE
ASSOCIATION

CONTACT INFORMATOIN

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PRESENTATION CITATIONS

[1]USGS. (2022). Response of Green Lake, Wisconsin, to Changes in Phosphorus Loading, With Special Emphasis on Near-Surface Total Phosphorus Concentrations and Metalimnetic Dissolved Oxygen Minima (Scientific Investigations Report 2022–5003).

[2]McDonald, C.P., Saeed, M.N., Robertson, D.M., & Prellwitz, S. (2022). Temperature explains the formation of a metalimnetic oxygen minimum in a deep mesotrophic lake. Inland Waters, 12(3), 331-340. https://doi.org/10.1080/20442041.2022.2029318.

[3]Prellwitz, S. (2021). Diagnostic and Feasibility Study Findings: Water Quality Improvements for Green Lake, Wisconsin. Green Lake Association.

[4]Stephenson, K., Wardop, D., & Scientific and Technical Advisory Committee. (2023). Achieving water quality goals in the Chesapeake Bay: A comprehensive evaluation of system response. Chesapeake Bay Program.

[5]Osgood, R. A. (2017). Inadequacy of best management practices for restoring eutrophic lakes in the United States: guidance for policy and practice. Inland Waters, 7(4), 401-407. https://doi.org/10.1080/20442041.2017.1368881.

[6]Fernández-Caramés, T. M., & González-Castaño, F. M. (2019). The role of artificial intelligence in achieving the Sustainable Development Goals. Technology in Society, 59, 101182. https://doi.org/10.1016/j.techsoc.2019.101182.

[7]Scott, S. P. C., Isis, C. J. Penn, & Huang, C.-h. (2020). Development of a Regeneration Technique for Aluminum-Rich and Iron-Rich Phosphorus Sorption Materials. Water, 12(6), 1784. https://doi.org/10.3390/w12061784.