The background of the slide is a photograph of a river at sunset. The sky is a mix of orange, yellow, and blue. The river is calm, reflecting the sky and the silhouettes of the kayakers. There are several kayakers on the river, some in the foreground and some further away. The trees on the banks are dark silhouettes against the bright sky.

OARS

# Indicators, Drivers, and Effects of Eutrophication in a Sudbury River Tributary

**Ben Wetherill, M.S.**

Water Quality Monitoring & Science Coordinator  
OARS—for the Sudbury, Assabet, & Concord rivers

**Northeast Aquatic Biologists (NAB) Conference**  
February 7, 2025

- Launched in 1986
- Monitoring Water Quality Since 1992
- Phosphorus in Assabet
- Mercury in Sudbury
- *E. coli* in population centers
- Conductivity around highways

# Objective of Study

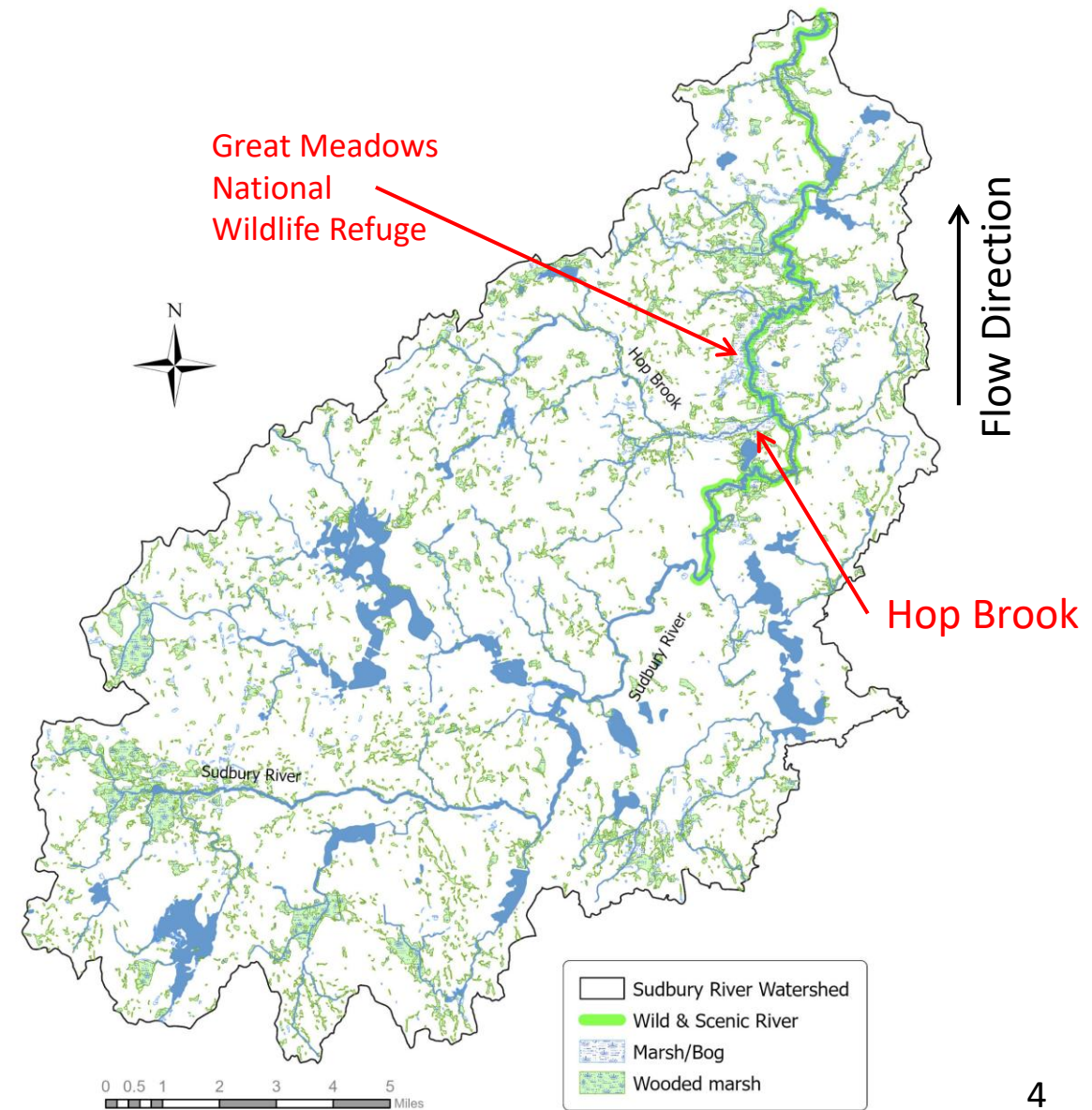
Could the obvious eutrophication in Hop Brook be having a long-term negative effect on the much larger Sudbury River ecosystem?

1. Sudbury River Description
2. Hop Brook Description
3. Hop Brook Water Quality Conditions
4. Sudbury River Water Quality Conditions
5. Potential Impact of Hop Brook on Sudbury



# Sudbury River

- 33 miles long; 163 miles<sup>2</sup> drainage area
  - Joins Assabet to form Concord River
- Flow (40-800 cfs)
  - Manipulated by major upstream reservoirs
- Low gradient
- Hop Brook – major tributary
- Wild & Scenic River
  - Lower 16.8 miles



# Sudbury River & Great Meadows



Great Meadows National Wildlife Refuge



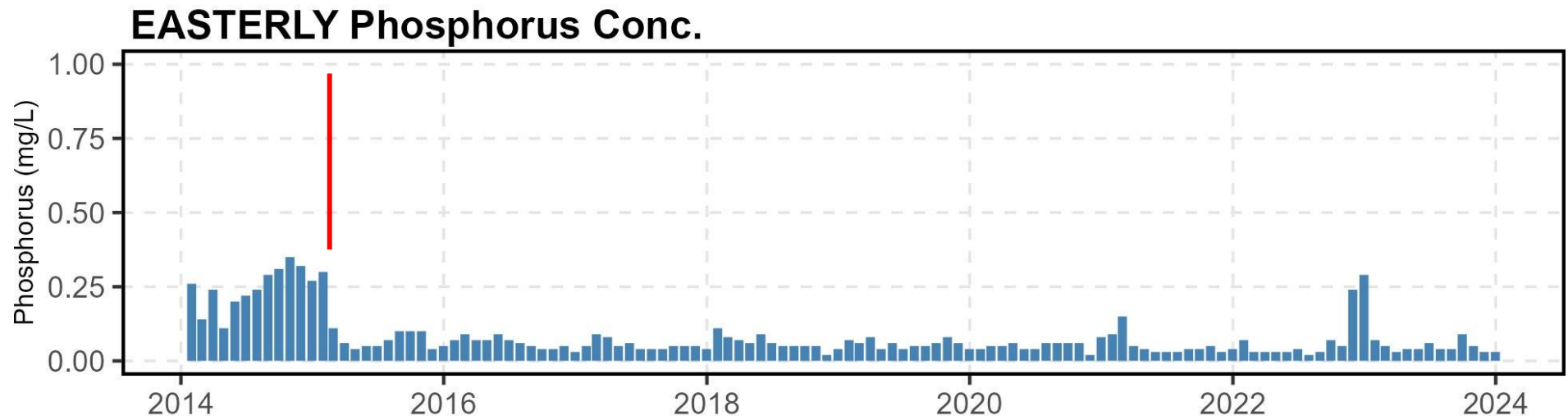
# Sudbury River & Great Meadows



# Hop Brook

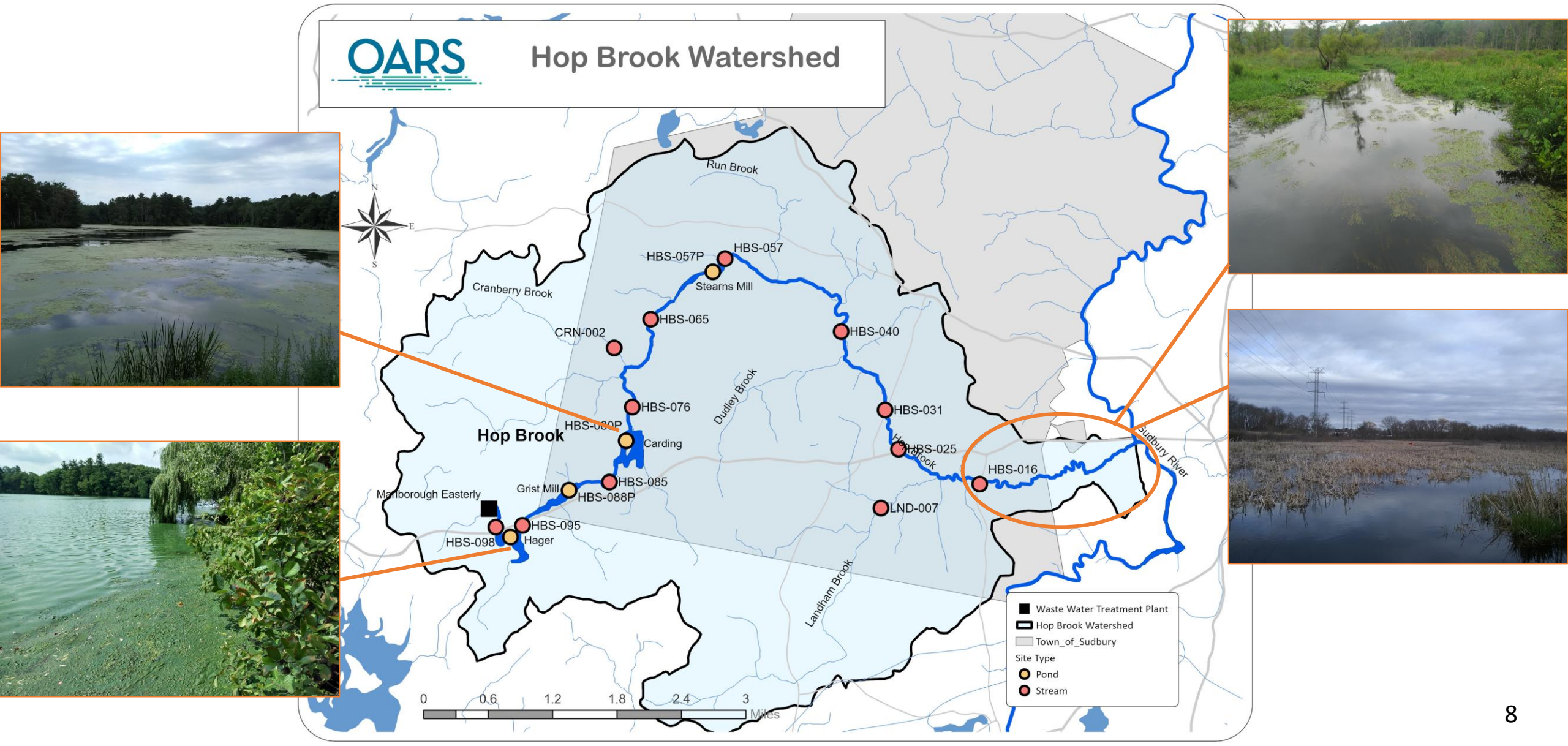
- 17 miles long; 22 miles<sup>2</sup> drainage area
- Flow (4-80 cfs)
  - 10% of Sudbury flow (60% during droughts)
- 4 large impoundments upstream
- Major wastewater treatment facility at headwaters
  - 90% of Hop Brook flow during low flows
  - Achieved 0.1 mg/L TP starting 2015

Treatment Plant  
Discharge—Total  
Phosphorus





# Hop Brook Map





# Hop Brook Studies

## Most studied brook in New England?

- 2008—Hop Brook Sediment and Dam Removal Study
- **2006—Marlborough Easterly Wastewater Treatment Facility NPDES Permit**
- 2004—Supplemental Nutrient Loading Evaluation of Hop Brook
- 2000—Nutrient Impact Evaluation of Hop Brook
- 1999—Problems and Solutions for Hop Brook
- 1999—Effects of Phosphorus Contamination on Species Diversity in Hop Brook
- 1998—Remediation Options for Elodea Dominated Ponds along Hop Brook
- 1997—Assessing the Role of Sediments as a Phosphorus Source in the Eutrophication of Ponds Along Hop Brook
- 1997—Pilot Plant for Phosphorus Removal from the Effluent of the Easterly Wastewater Treatment Plant
- 1996—Mechanical Harvesting to Control Blooms of the Green Alga *Hydrodictyon reticulatum*, Grist Millpond
- 1996—EPA Swat Team Request for Hop Brook
- 1995—Algae Harvesting Experiment on Grist Millpond
- 1995—Marlborough/Sudbury Phosphorus Removal Project
- 1994—Shoreline Survey Summary, State of the Hop Brook
- 1994 —Improving the Water Quality of the Hop Brook Watershed through Aggressive Algal Harvesting
- 1994—An Algae Harvesting System for the Hop Brook Protection Association
- 1994—A Natural History of the Hop Brook
- 1993—Marlborough Easterly WWTP Phosphorus Removal Study
- 1989—Hop Brook Ponds System Study
- 1984—Source, Movement, and Effects of Nitrogen and Phosphorus in Three Ponds in the Headwaters of Hop Brook



20 published  
studies in 24  
years

# Hop Brook Impoundments

Marlborough  
WWTP



300 kg  
P/yr



Hager

31 acres

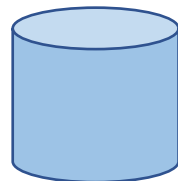


250,000  
kg P in  
sediment



Grist

17 acres

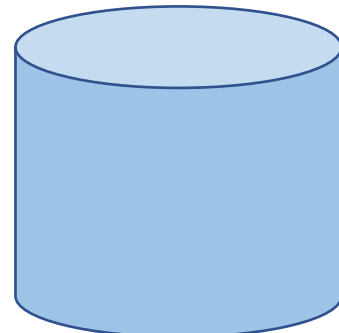


33,000  
kg P in  
sediment

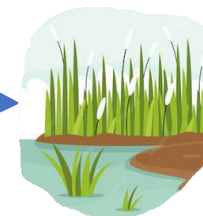


Carding

41 acres



94,000  
kg P in  
sediment

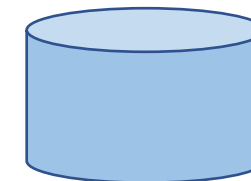


Large  
wetland

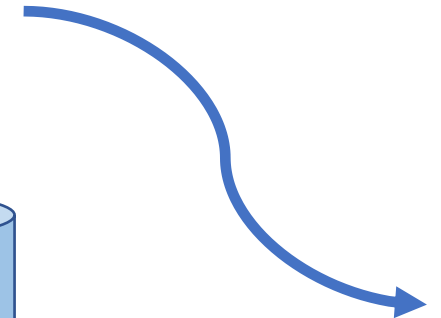


Stearns

20 acres



45,000  
kg P in  
sediment



All ponds average 2–  
3 feet deep



Graphic from Hop Brook  
Protection Association

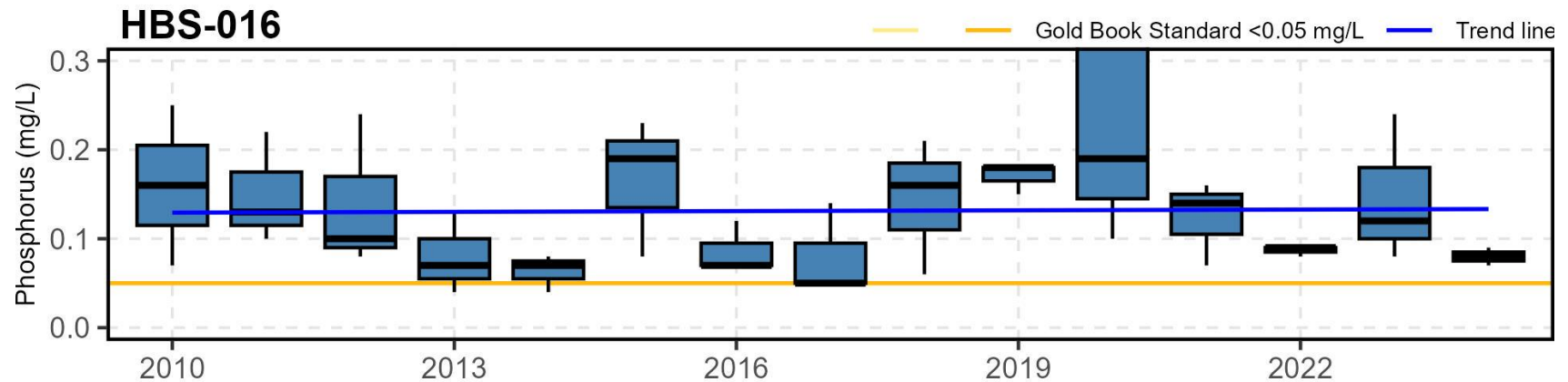
\* Sediment measured in 2000



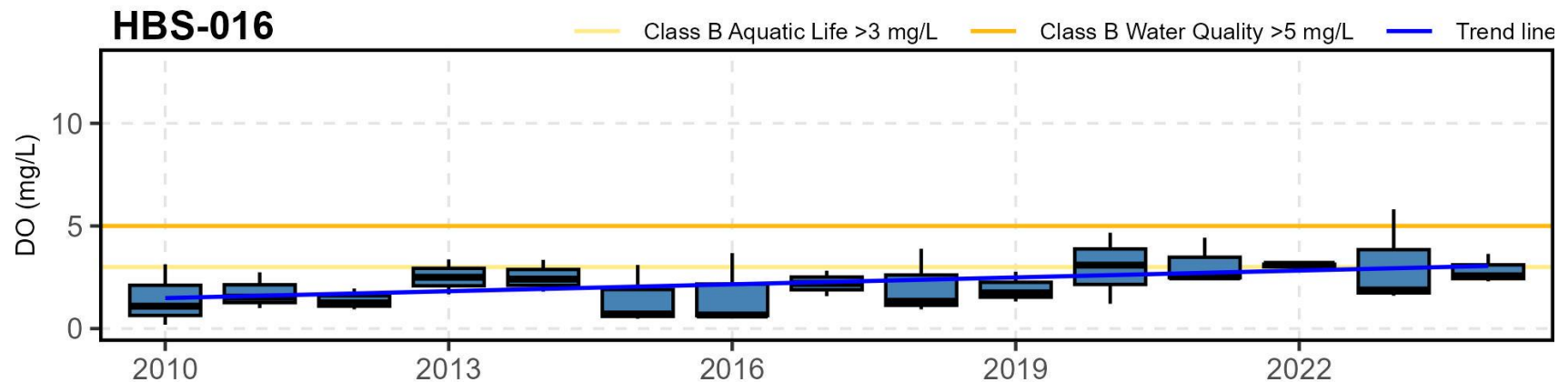
# Hop Brook Phosphorus

- Mouth of Hop Brook
  - Very high Phosphorus concentrations
  - Very low Dissolved Oxygen concentrations

**Phosphorus**  
(Jun/Jul/Aug)

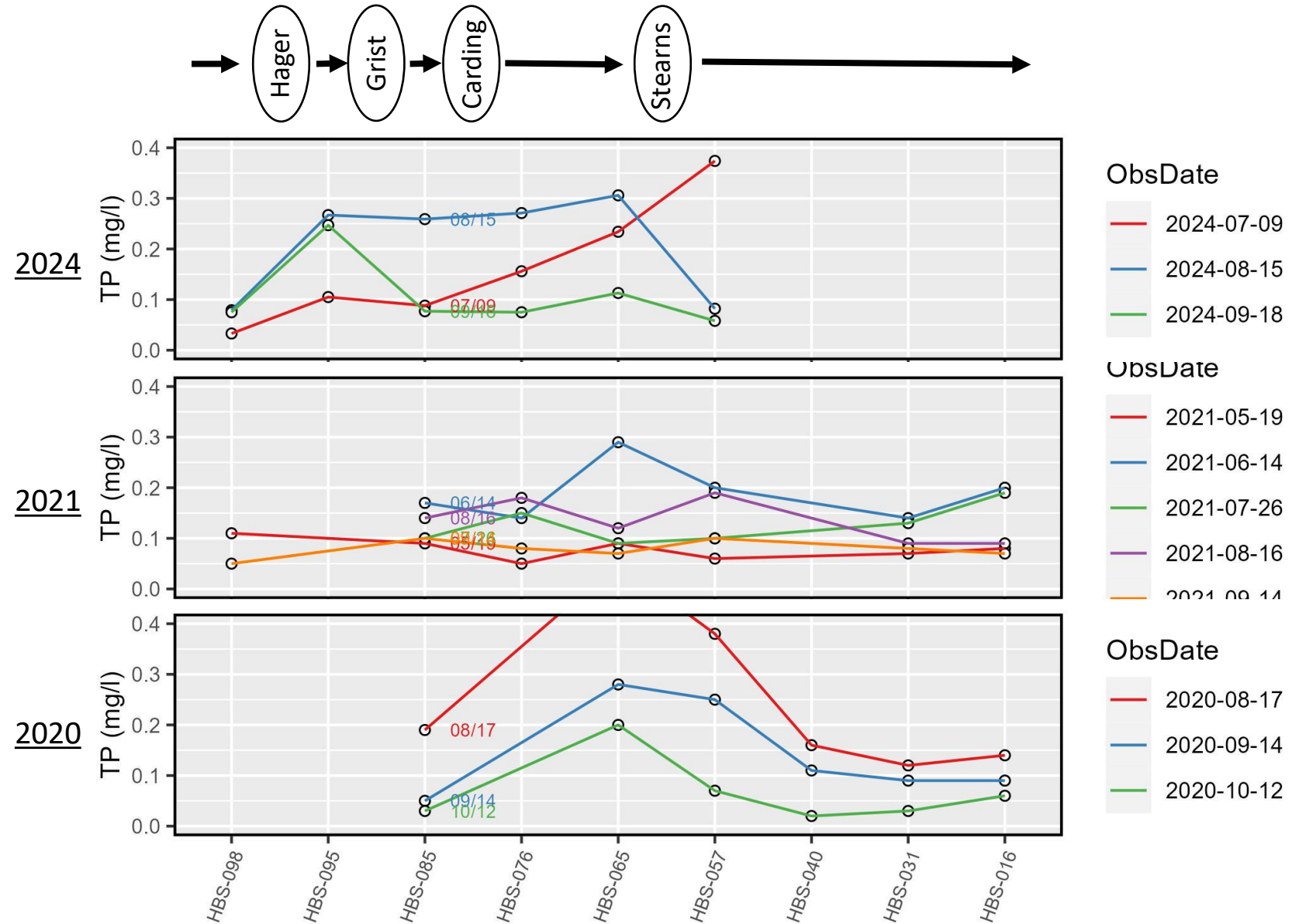


**Dissolved Oxygen**  
(Jun/Jul/Aug)



# Hop Brook Phosphorus

- Extremely high Phosphorus concentrations below impoundments
- Probably sourced from pond sediments

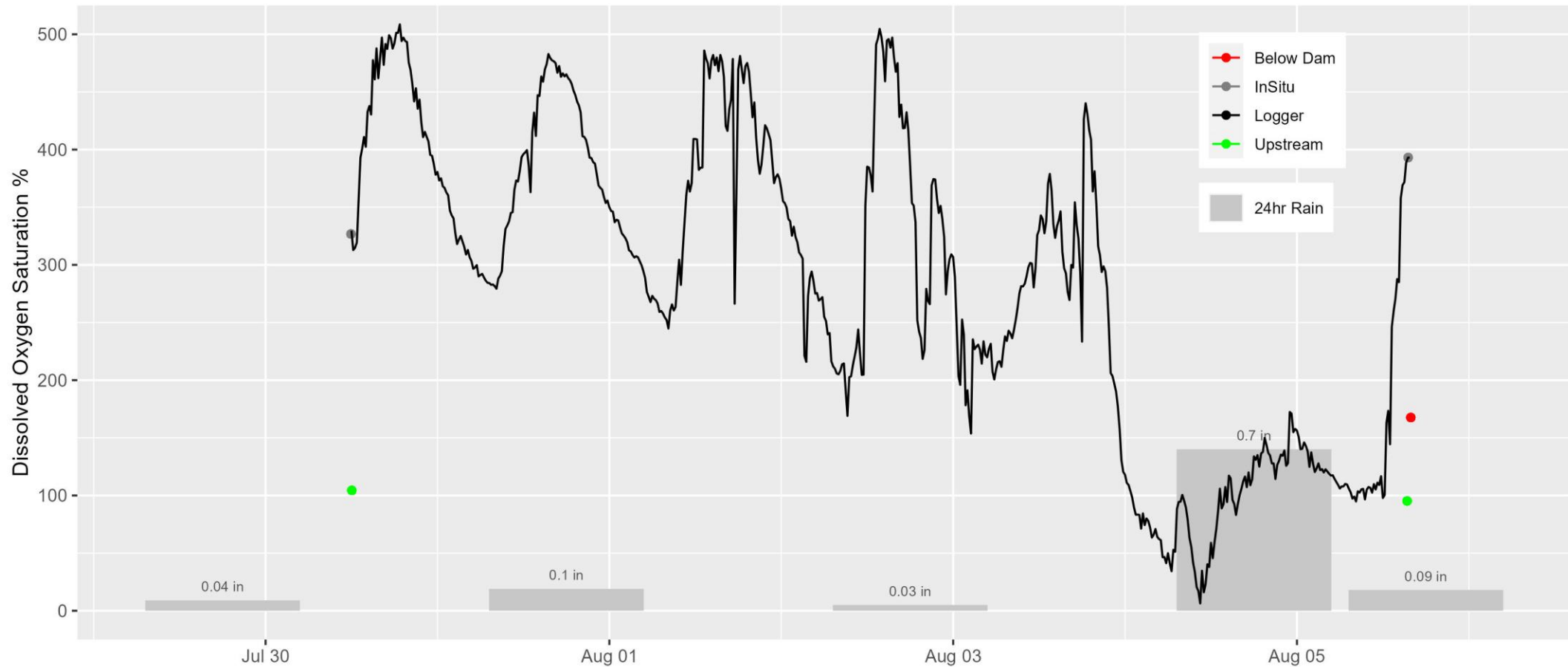




# Hop Brook Dissolved Oxygen

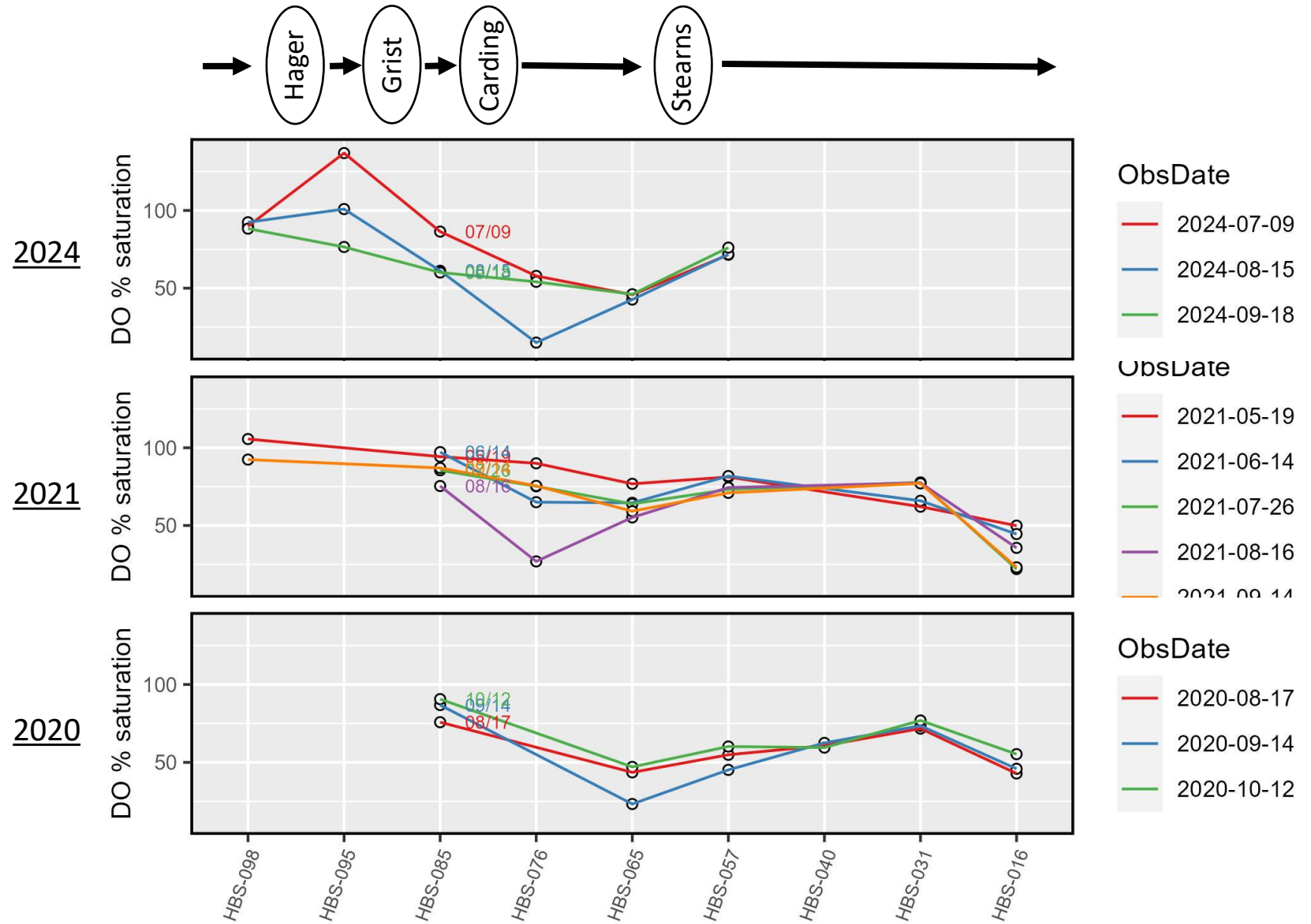
- Super saturation in Hager Pond
  - Often 200-500%

DO Logger Deployment in Hager Pond (2024)



# Hop Brook Dissolved Oxygen

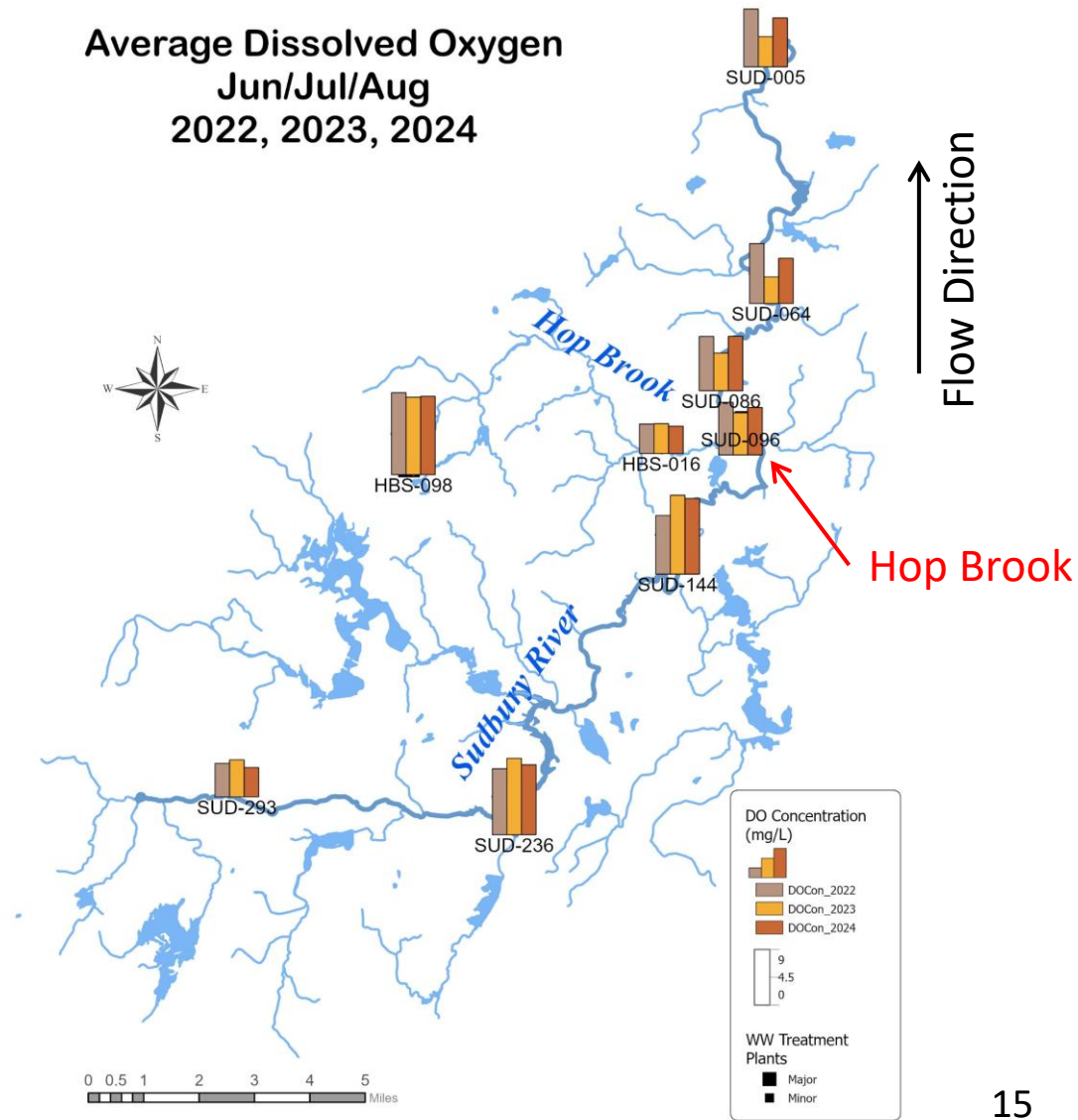
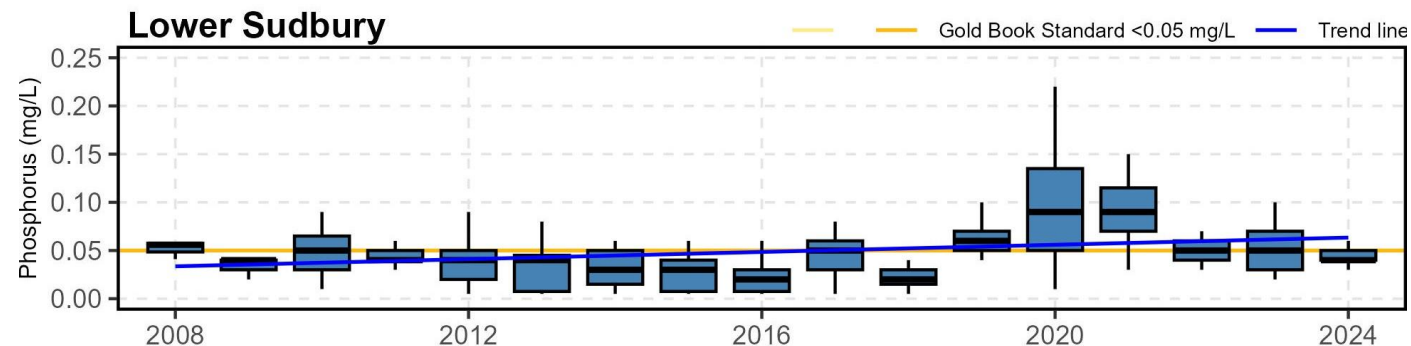
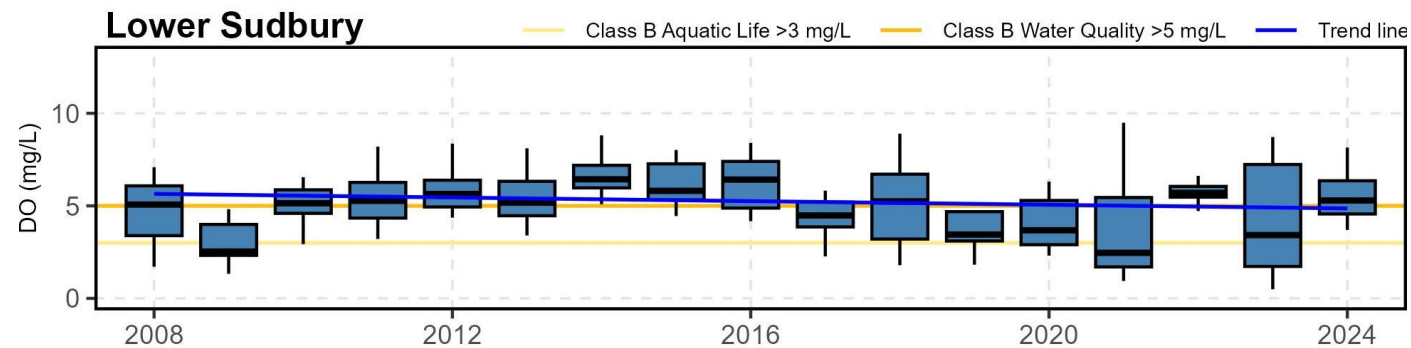
- Dissolved Oxygen declines downstream
  - Often anoxic in Carding <30%
  - Low again at mouth
- Plenty of readily degradable organic matter in downstream reaches





# Sudbury Dissolved Oxygen

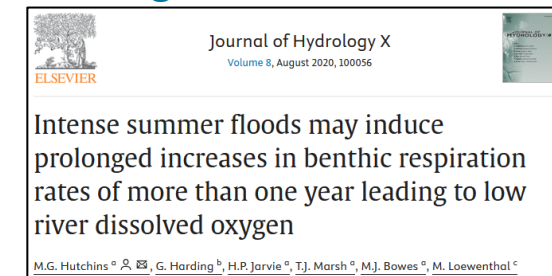
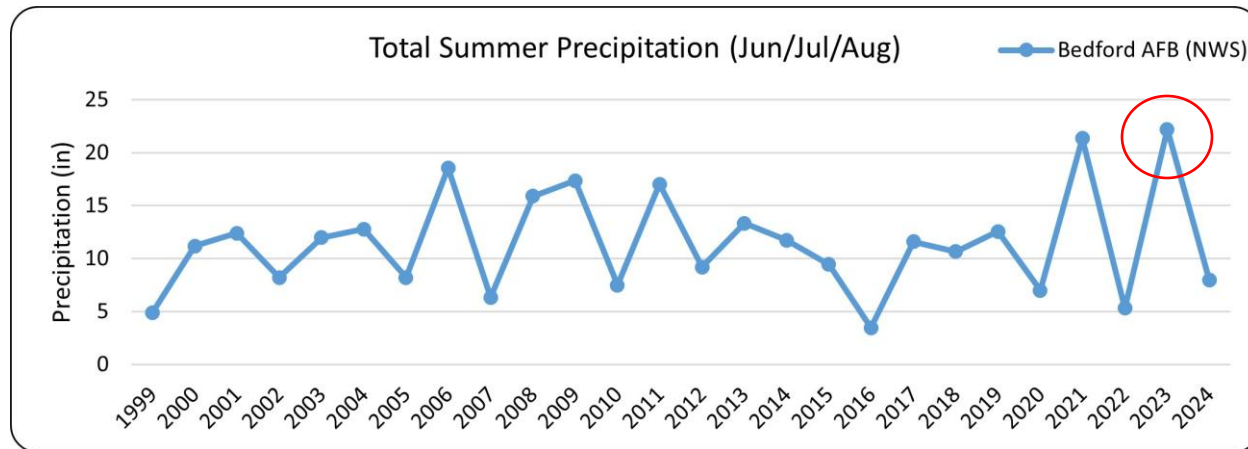
- Lower Sudbury
  - Dissolved Oxygen declining?
  - Phosphorus increasing?
  - Lower **DO** downstream of Hop Brook



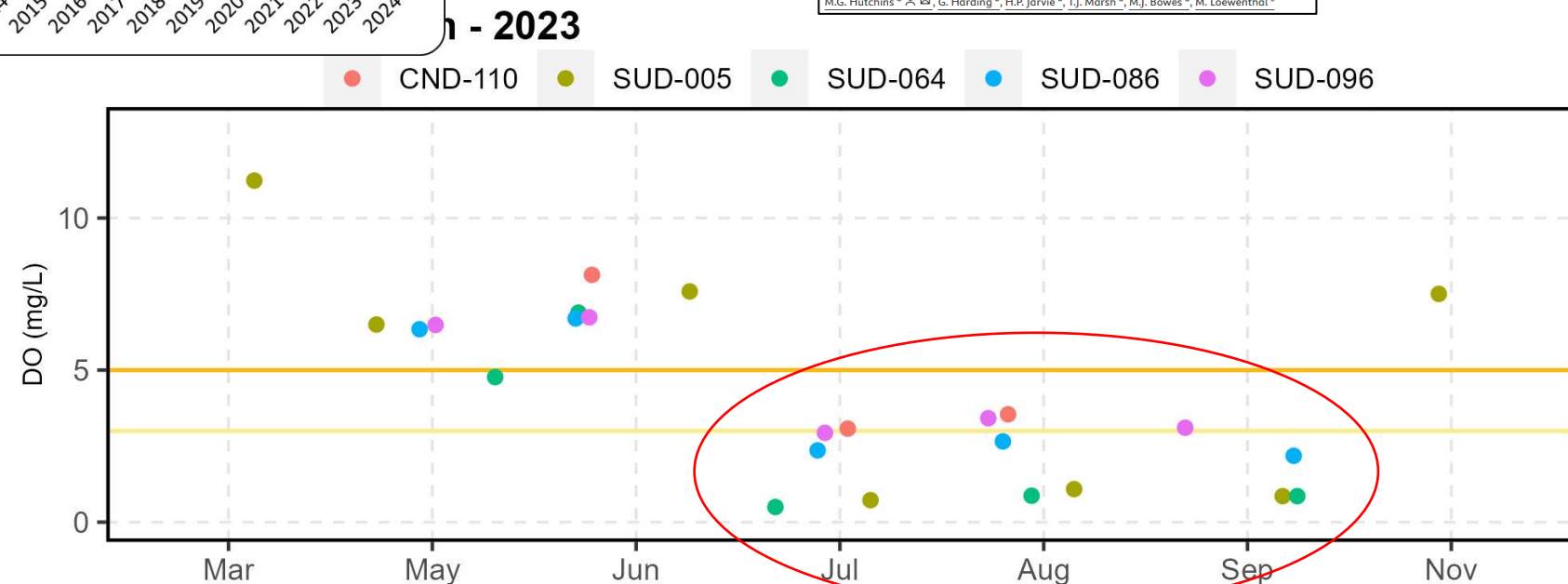
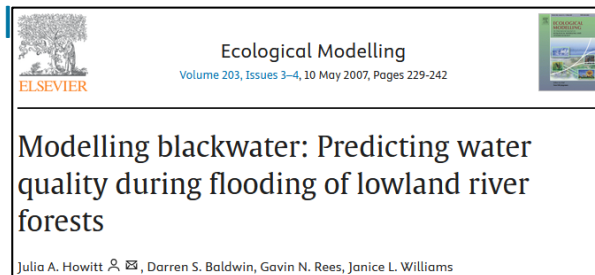
# Sudbury DO in High Flows

- 2023: extremely high flows, extremely low DO

The supply of readily-degradable organic matter to river systems can cause stress to dissolved oxygen (DO) in slow-flowing waterbodies.”

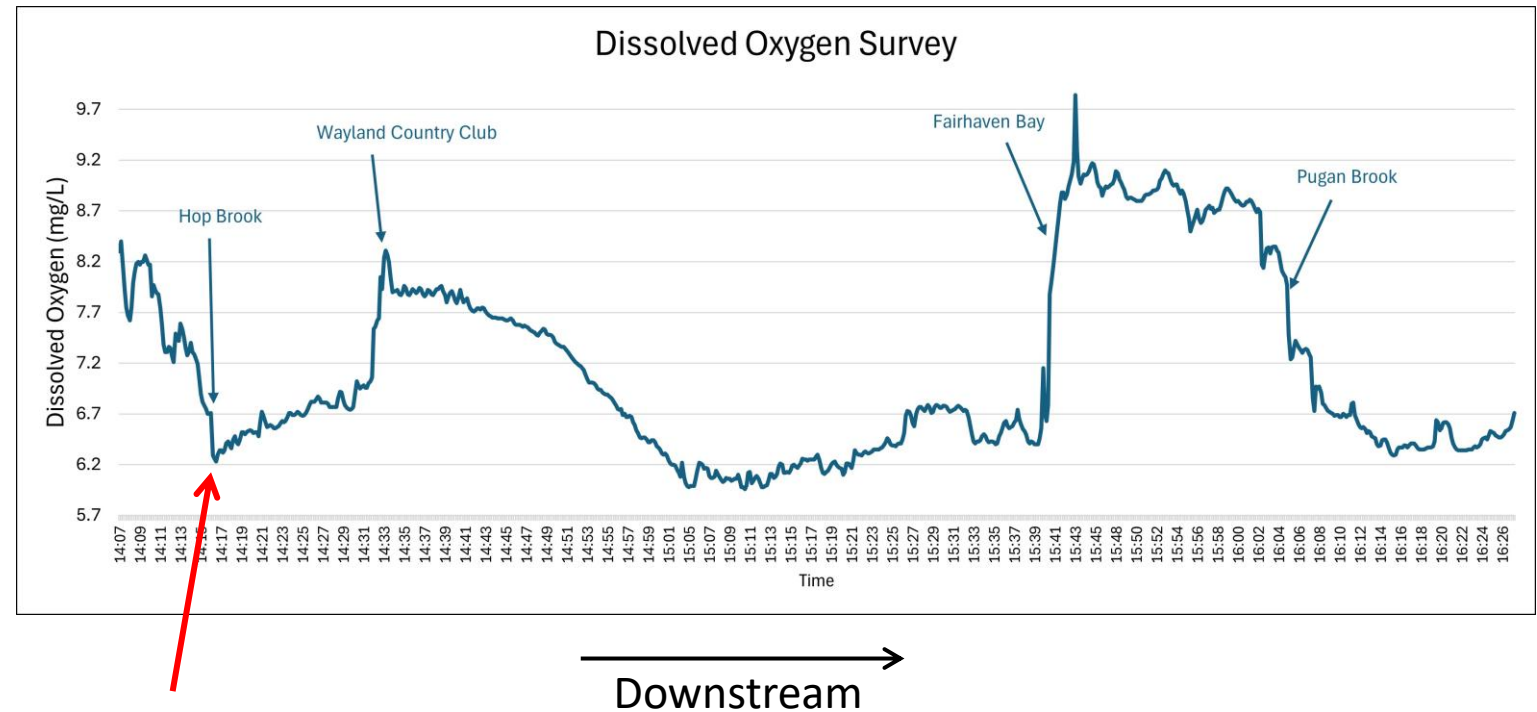
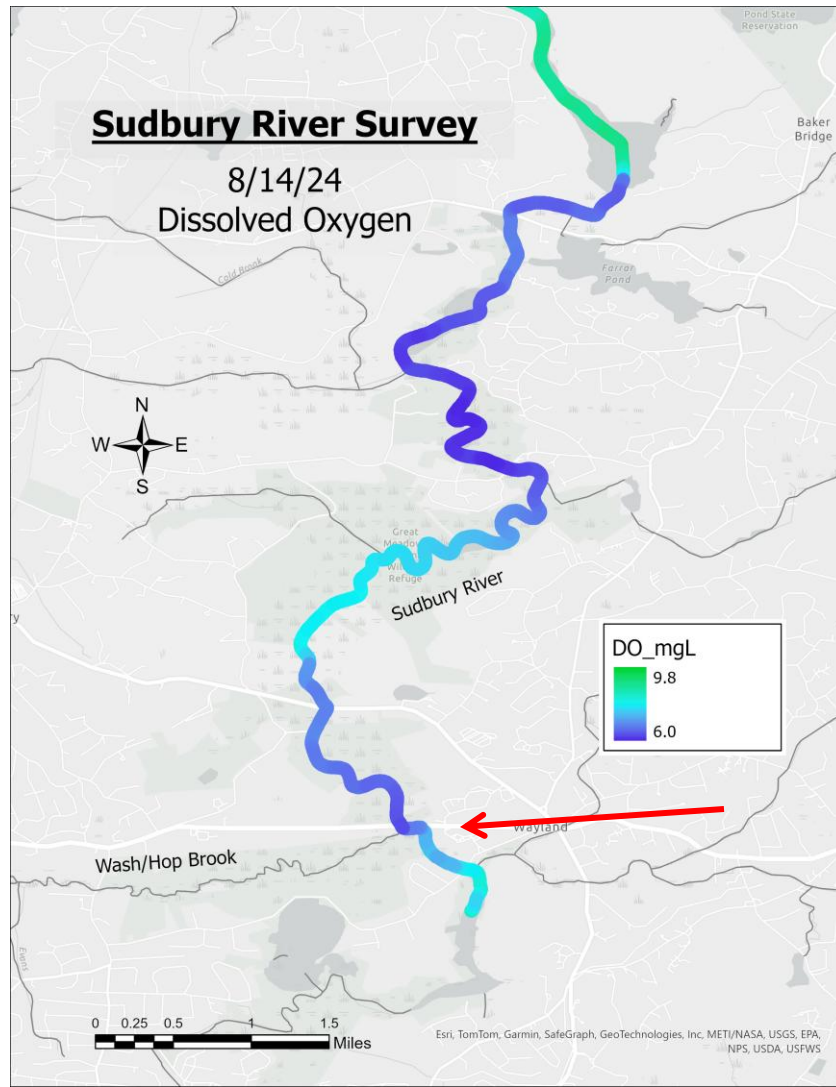


Pulse of dissolved organic matter released from floodplain during flooding associated with



# Sudbury DO Survey

- Longitudinal Survey – significant **DO** drop at Hop Brook

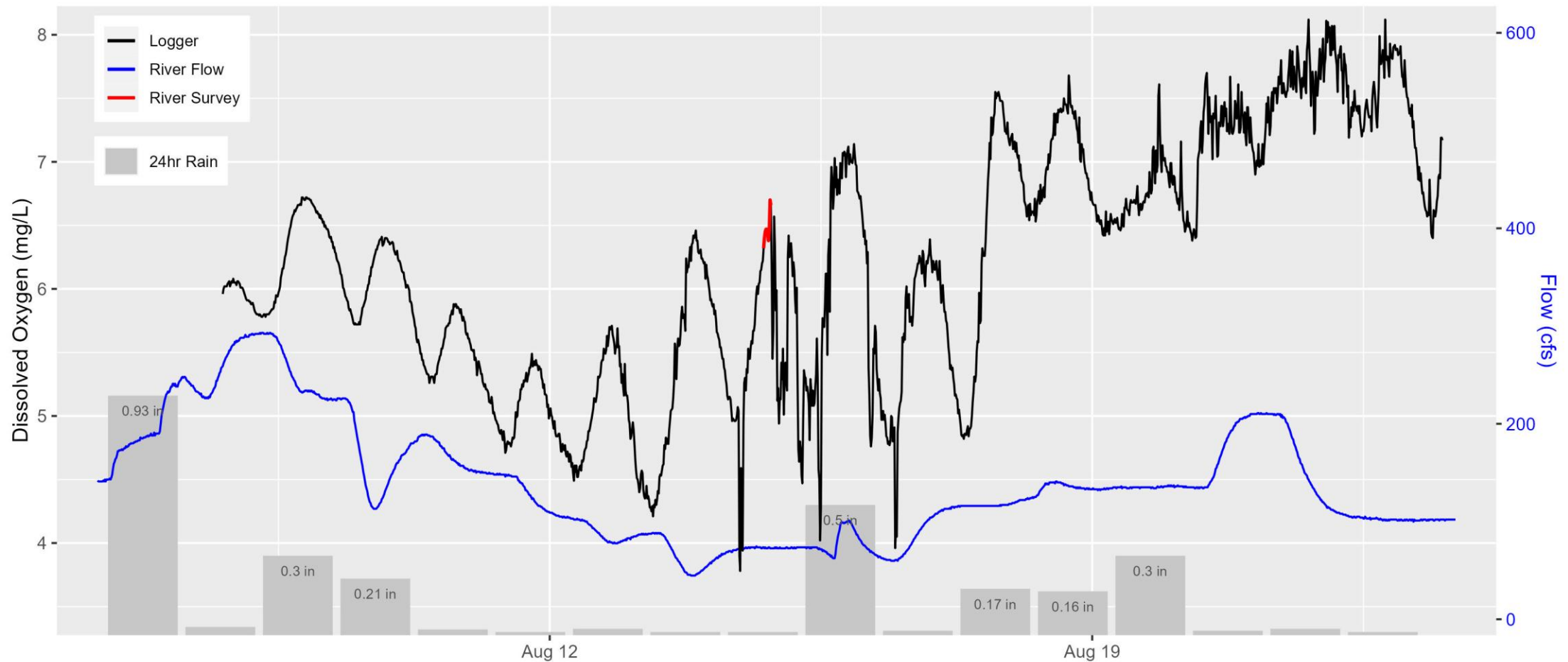




# Sudbury DO Logger

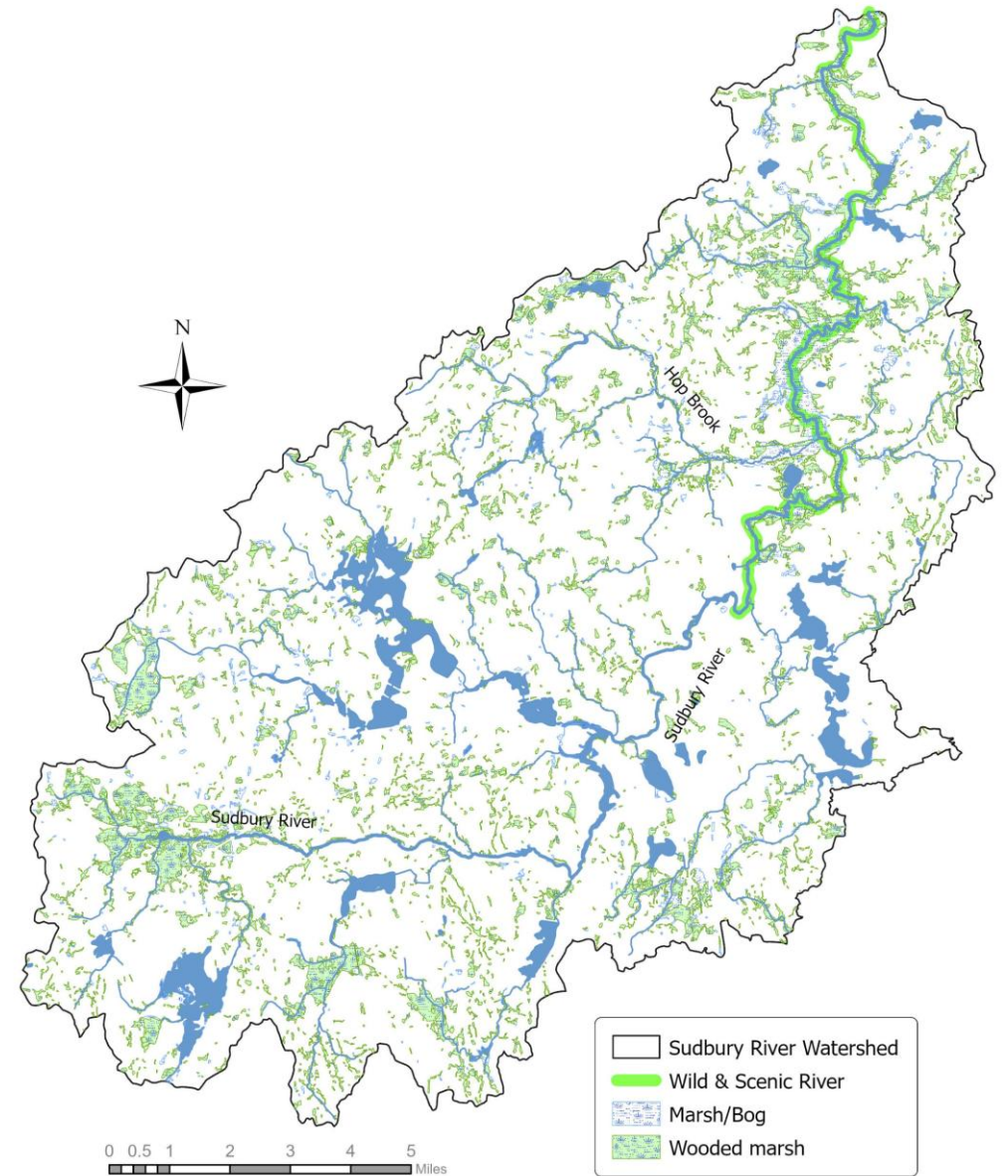
- Continuous Logger showed strong diel cycles (2 miles downstream of Hop Brook)

DO Logger Deployment at Sherman's Bridge (2024)



# Study Findings

- Well-known eutrophic conditions in Hop Brook
  - Large **P** reservoirs in impoundments
  - Consistent high **P** concentrations
  - Consistent low **DO** downstream
- **DO** in Sudbury is chronically low and may be getting lower
  - Extremely low **DO** in floods
  - Sudbury **DO** is lower downstream of Hop Brook
  - Strong diel **DO** cycling in Sudbury



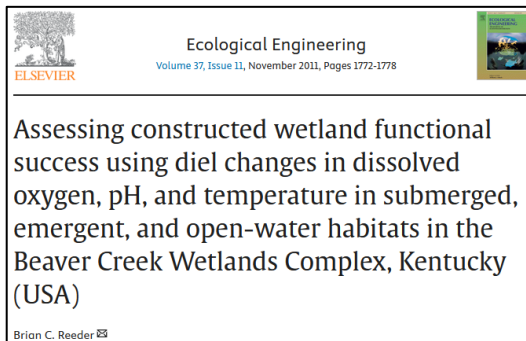
# Hop Brook's Impact on Sudbury

- Natural conditions for meadow wetlands?
  - Wetlands along Hop Brook and along Sudbury
- Hop Brook as battery of high oxygen demand water?
  - High Biochemical Oxygen Demand (BOD) of water
- Long-term accumulation of phosphorus downstream of Hop Brook?
  - High BOD of sediments

“Wetland metabolism is defined by profound daily fluctuations in pH and dissolved oxygen

High SOD and low DO concentrations may be a natural phenomenon in instream blackwater swamps in Georgia.

High P concentrations in wetlands correlate with “dampened diel fluctuations and reduced DO”.



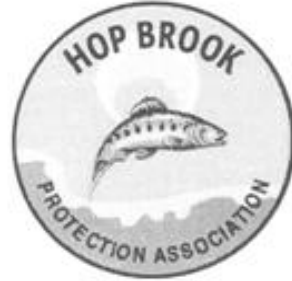
Paul V. McCormick & James A. Laing



# Thank you!

## Hop Brook Protection Association

- Glenn Pransky
- Terry Snyder
- Shannon Hache
- Jeff Winston
- Emanuel Eagle



## OARS Volunteers and Staff



## NOAA Fisheries

- Ben German



**Adam Nolde**  
DO logging  
kayaker

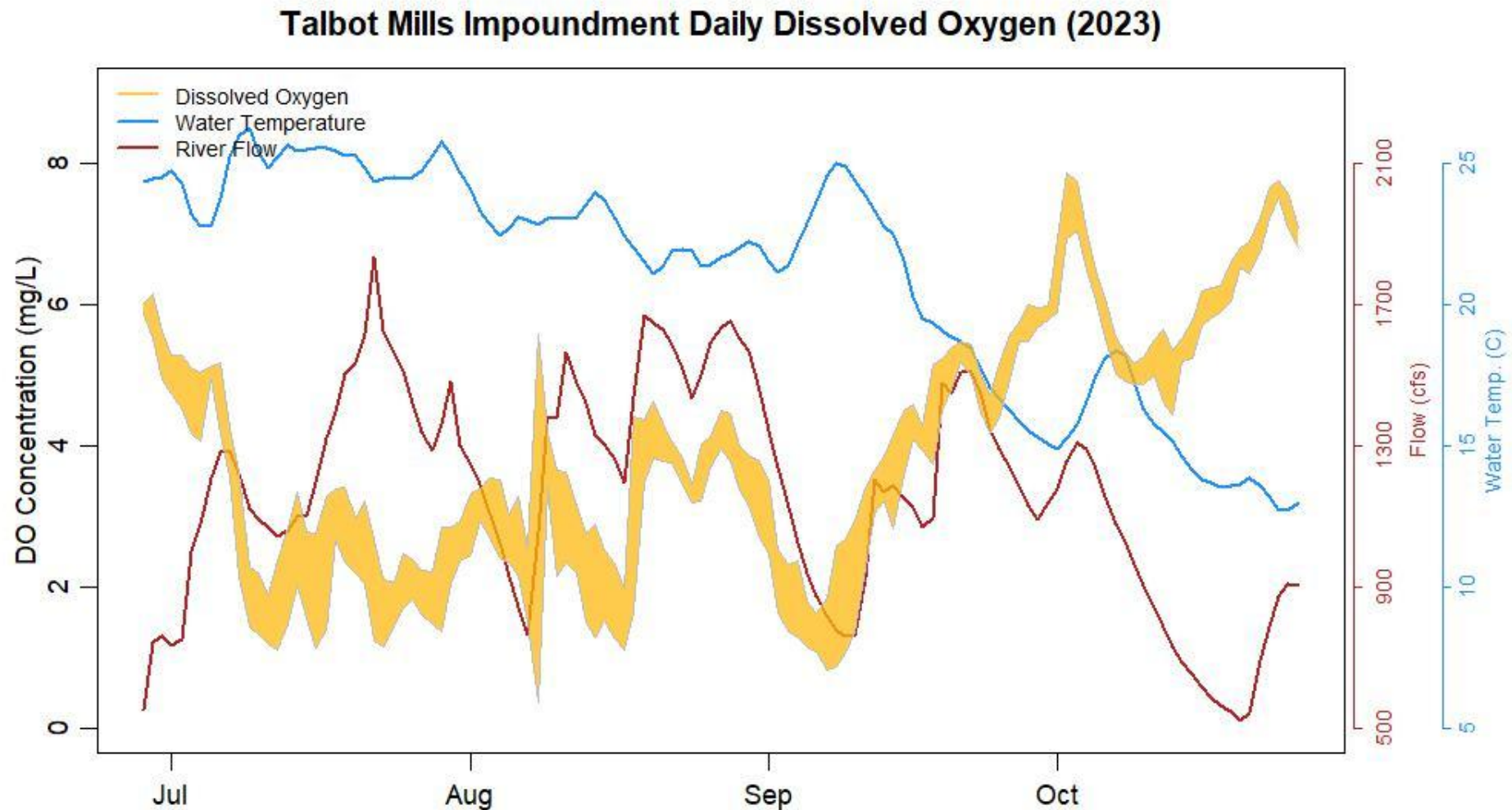


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## QUESTIONS?

# Downstream DO

- Logger in Concord River also showed very low DO levels in 2023





# Sudbury DO Survey

- DO v PH v Temp

