

July 2023 storm: preliminary analyses

Matthew Vaughan, PhD

Chief Scientist, Lake Champlain
Basin Program

Vermont Citizens Advisory
Committee

November 13, 2023



[Vermont History Museum](https://www.vermont-history-museum.org/)

- Rain
- River flow
- Phosphorus delivery
- Lake level
- Lake water quality



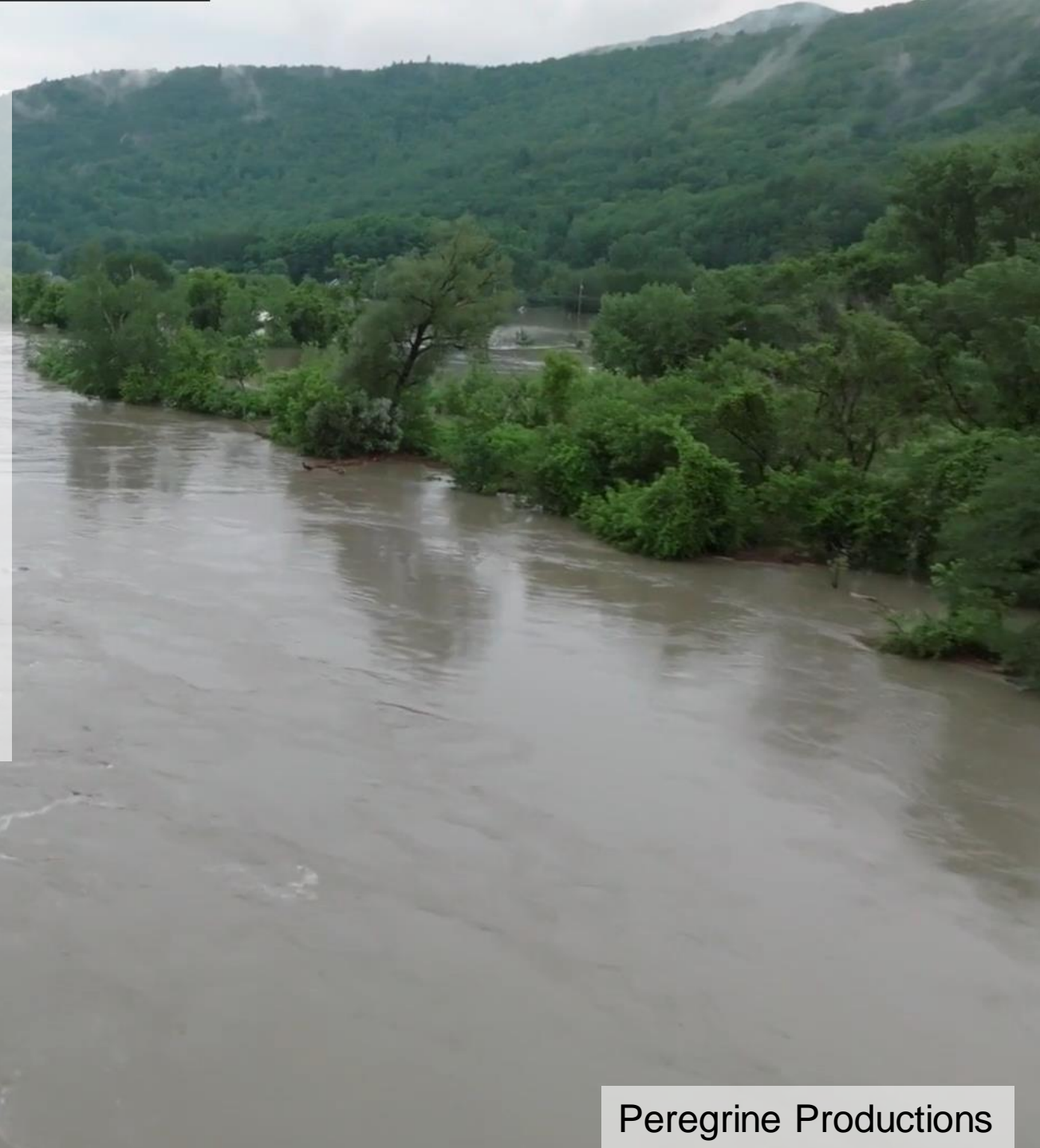
**Observations
and statistics**



Compare to

- Typical
- Tropical Storm Irene
- TMDL

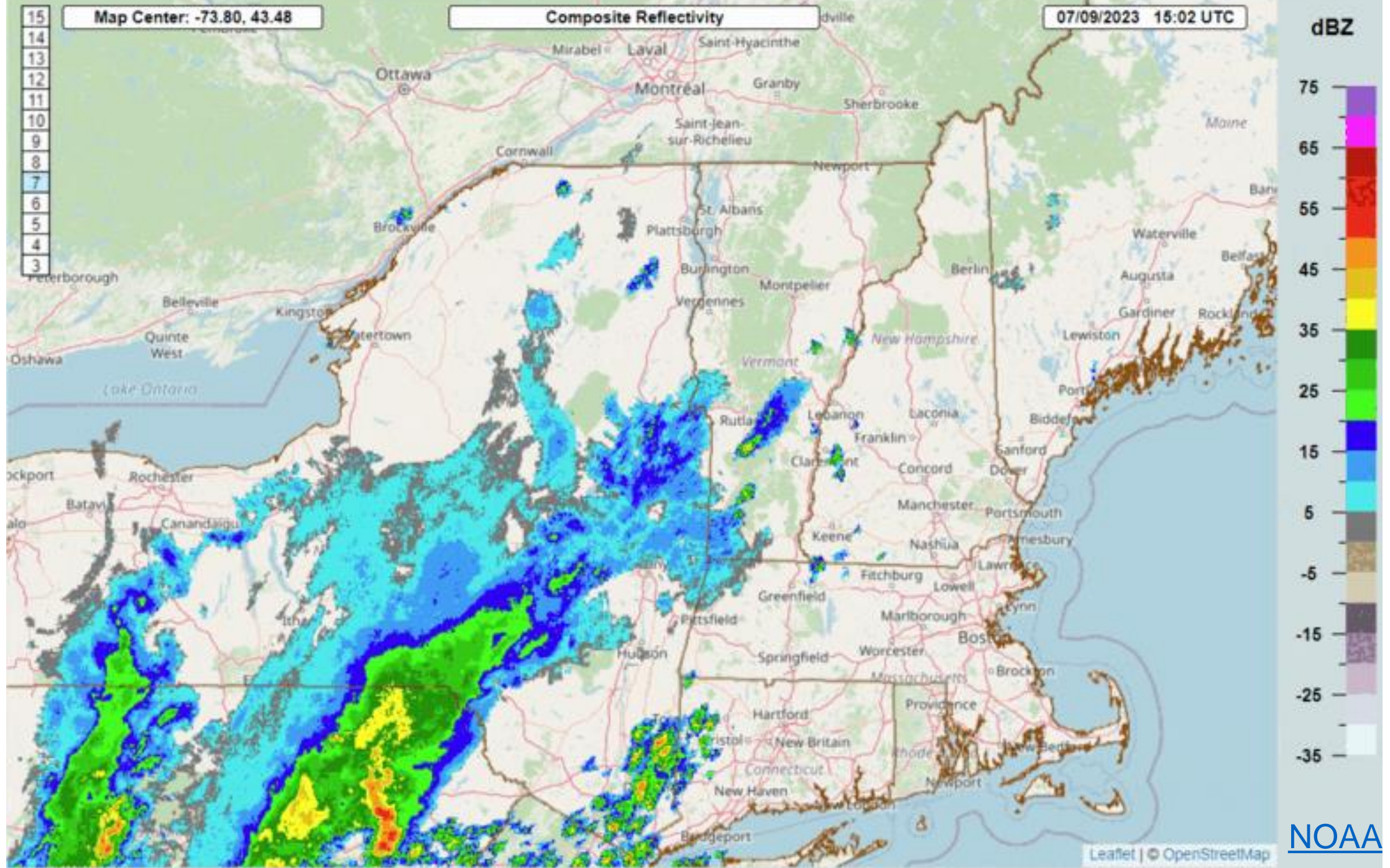
- Important impacts **not covered** in this talk
 - Loss of life and property
 - Displacement, evacuations
 - Farms – crop loss and contamination
 - Infrastructure
 - Wastewater discharges and overflows



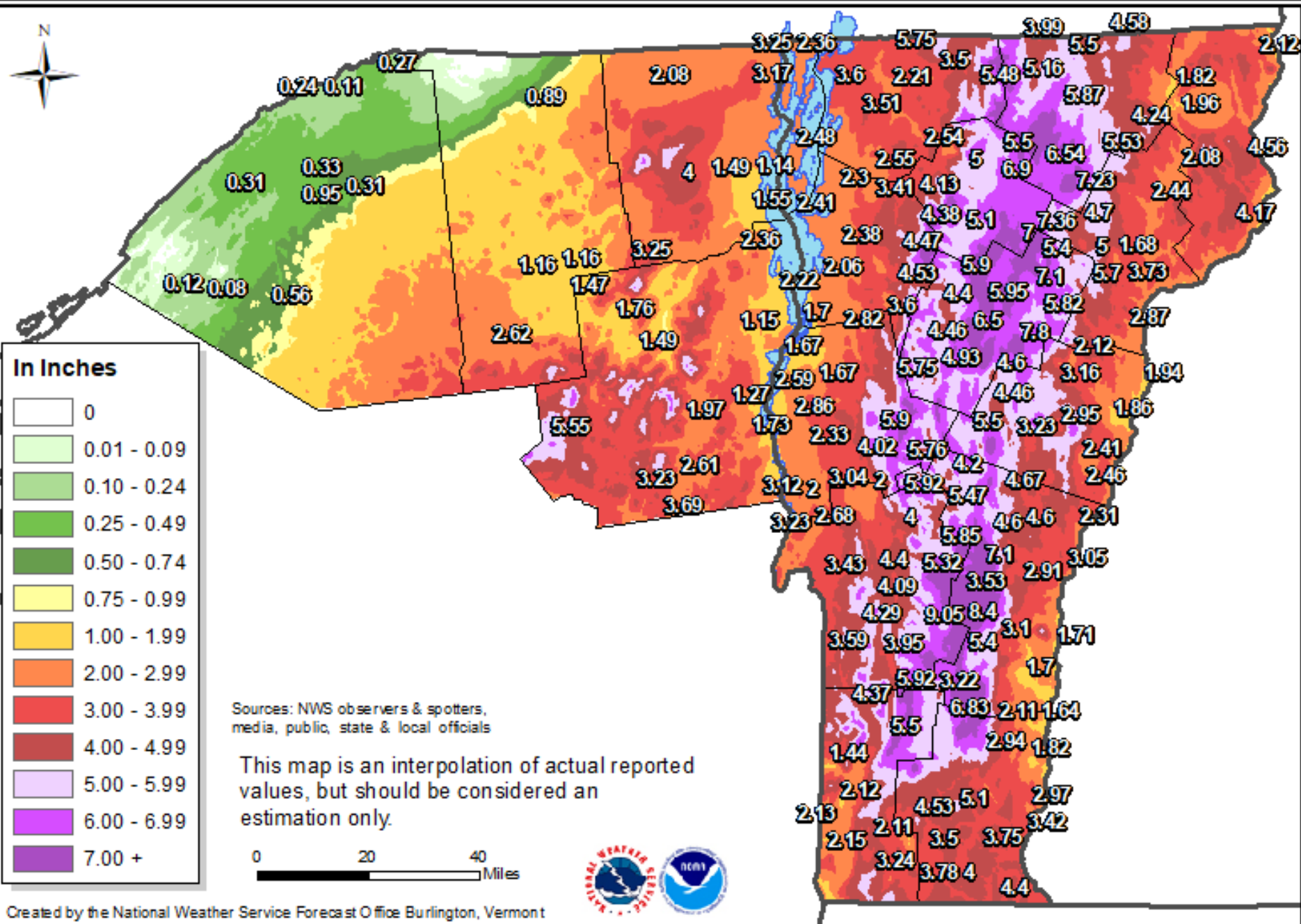
An aerial photograph showing a large area of flooding in a residential neighborhood. The water is murky brown and has inundated many yards and streets, leaving only the roofs of houses and some trees visible. In the background, there are green hills under a cloudy sky. A large white text box is superimposed over the top half of the image.

Results are provisional

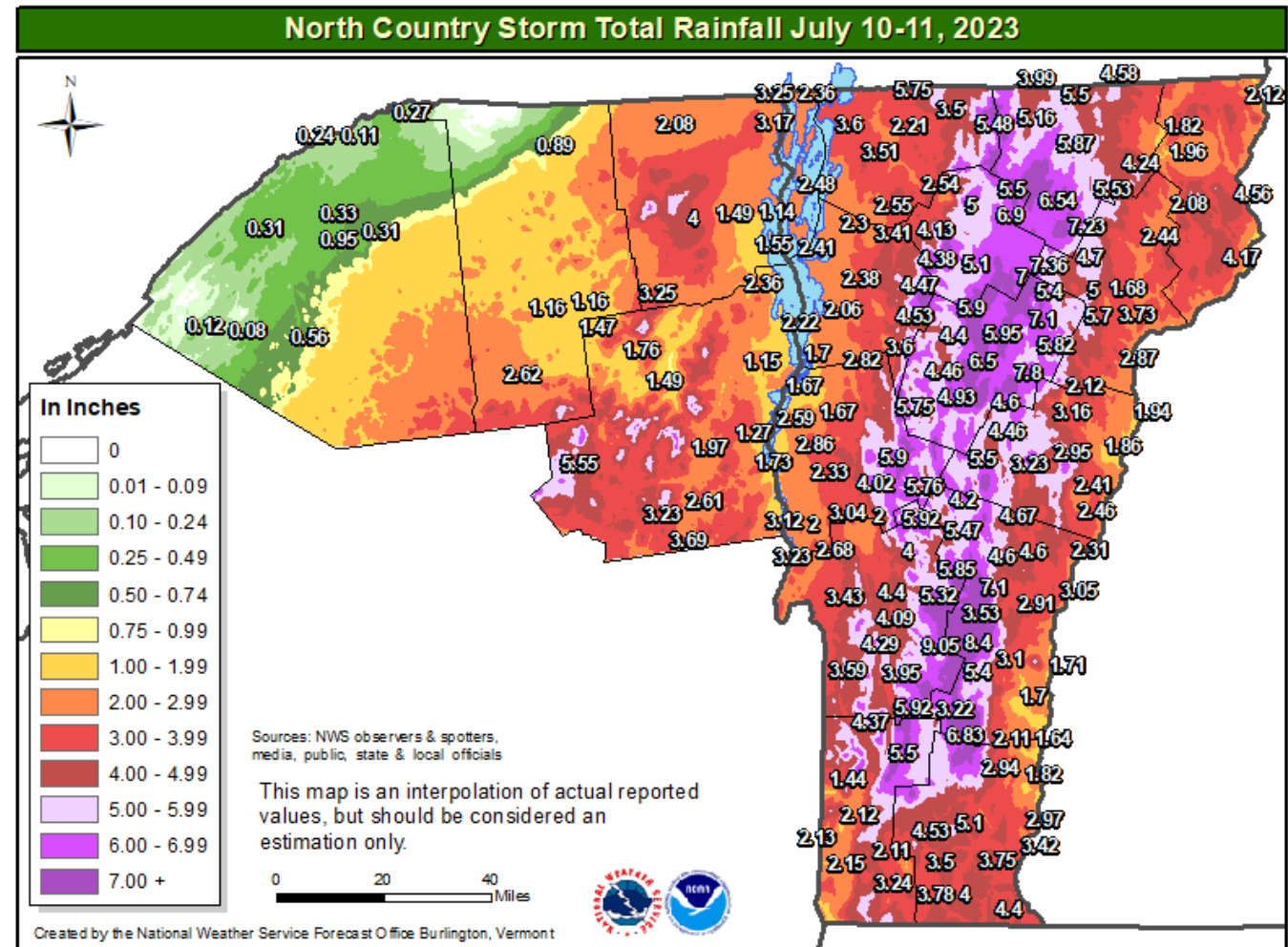
Peregrine Productions



North Country Storm Total Rainfall July 10-11, 2023



- 48-hour rainfall: **3 – 9 inches**
- Highest 48-hour rainfall: **9.20 inches** (Calais, VT)
- Montpelier stats:
 - Broke **daily rainfall record with 5.28 inches** (previous record Irene; 5.27 inches)
 - Broke **monthly rainfall record with 12.06 inches** (previous record 10.69 inches in August 1989; average 3.86 inches)

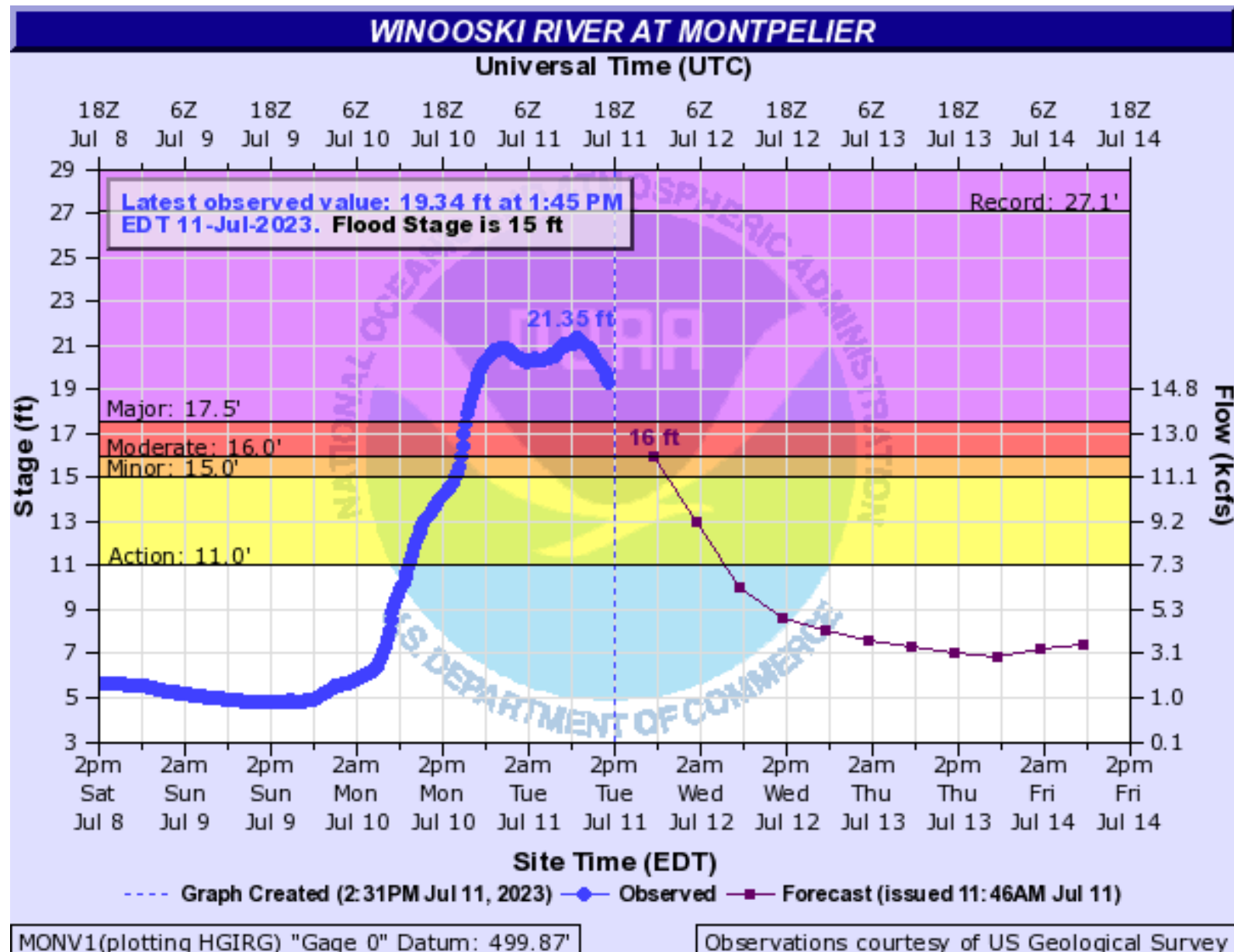
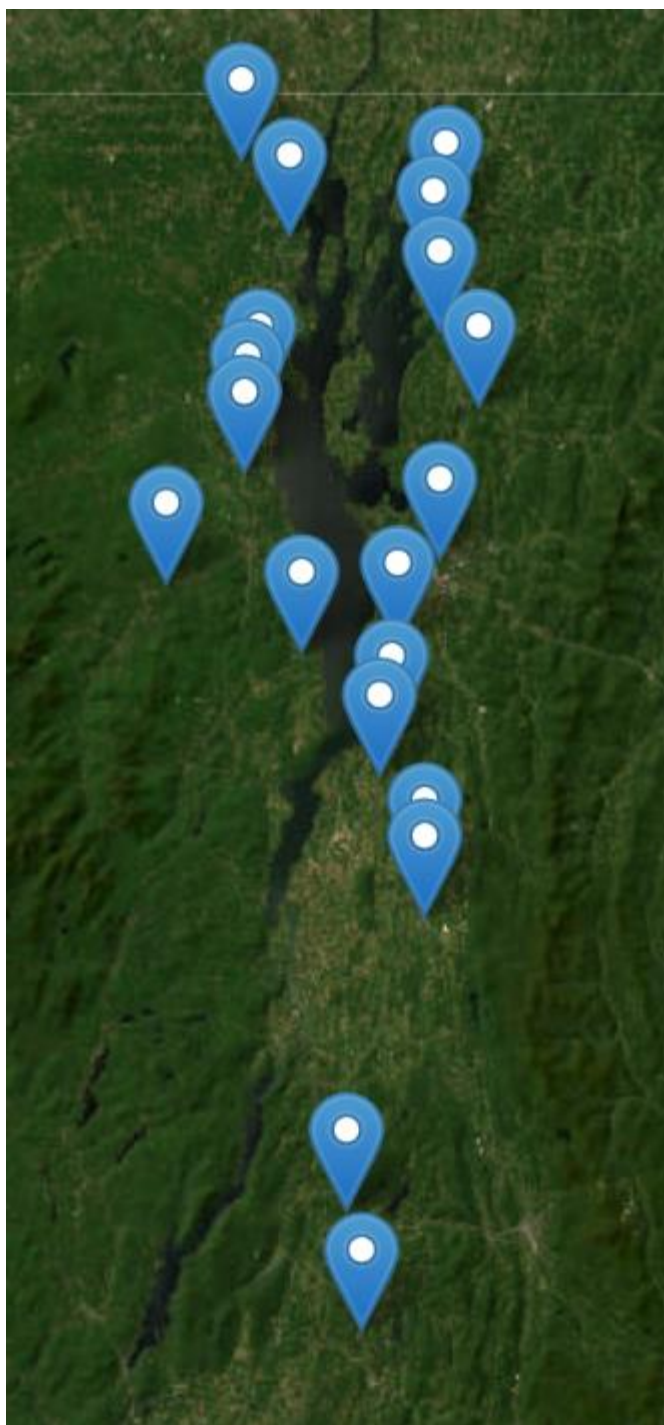


[Stats from NOAA](#)

- Widespread flooding
- Winooski, Lamoille, Otter reached major flood stage
- Flash flooding from smaller rivers and streams

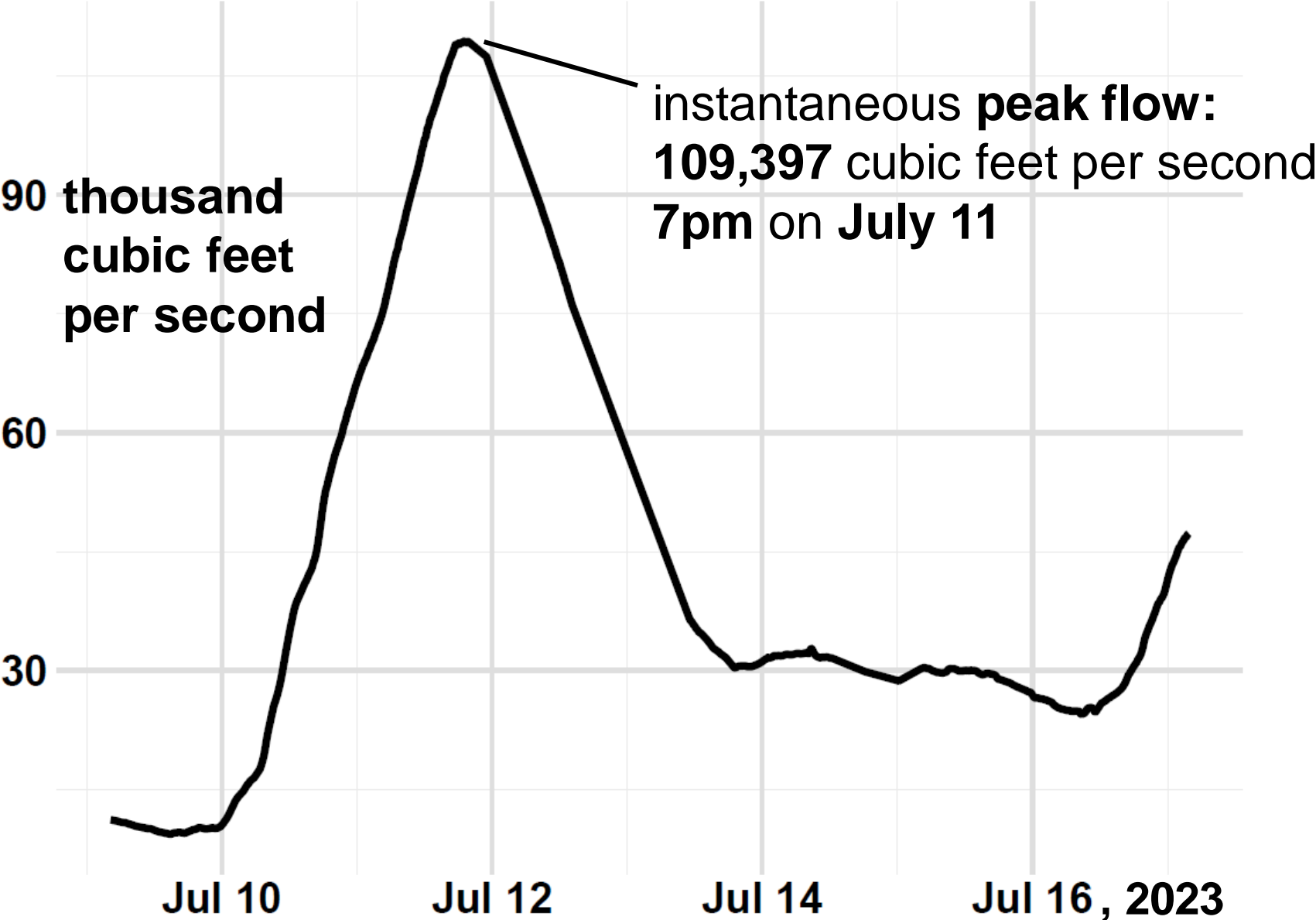


[Montpelier, VT on July 11, 2023 \(NASA\)](#)

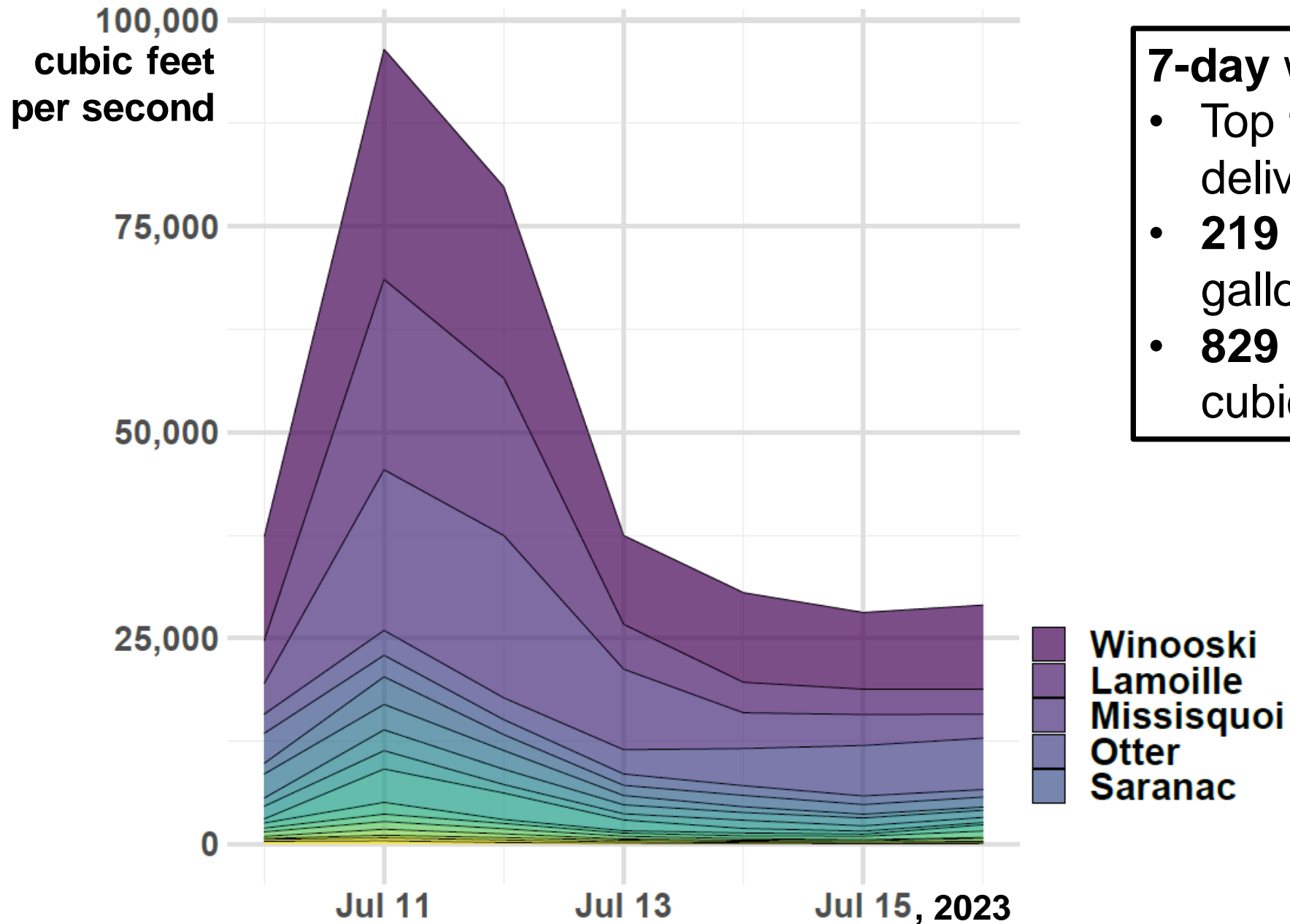


Total measured water flow to Lake Champlain

19 tributaries combined; represents roughly ¾ of watershed



Daily average flow from each tributary



7-day water flux:

- Top five delivered **80%**
- **219 billion** gallons
- **829 million** cubic meters

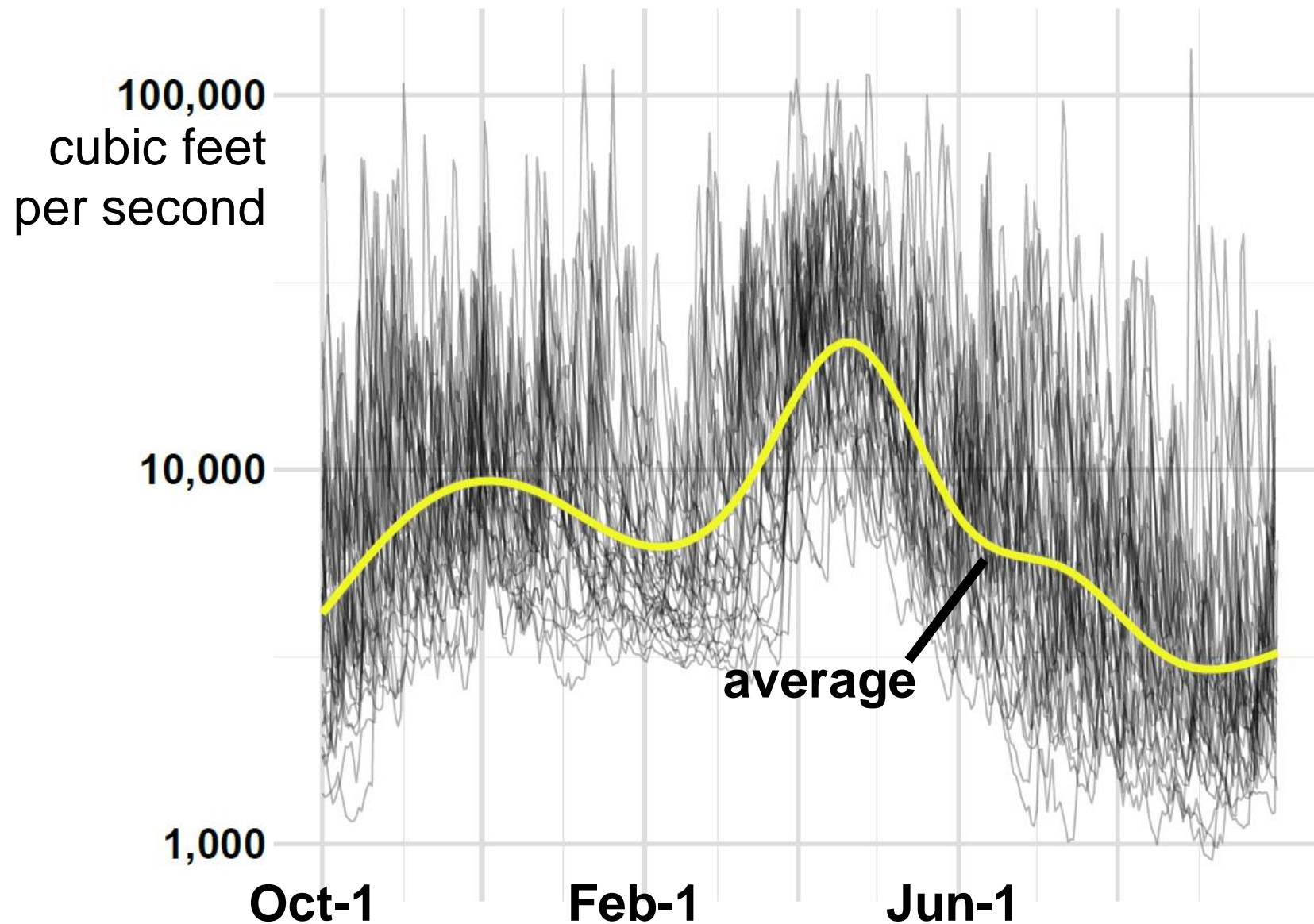
Stats dating back to 1990
**July 11, 2023 daily average
flow was:**

- **greater than 90th flow percentile** for all tributaries
- **Highest ever** for **Lamoille River**
- Second highest ever for Winooski River
- **highest flow ever for this date for nearly all tributaries** (2nd for 2)



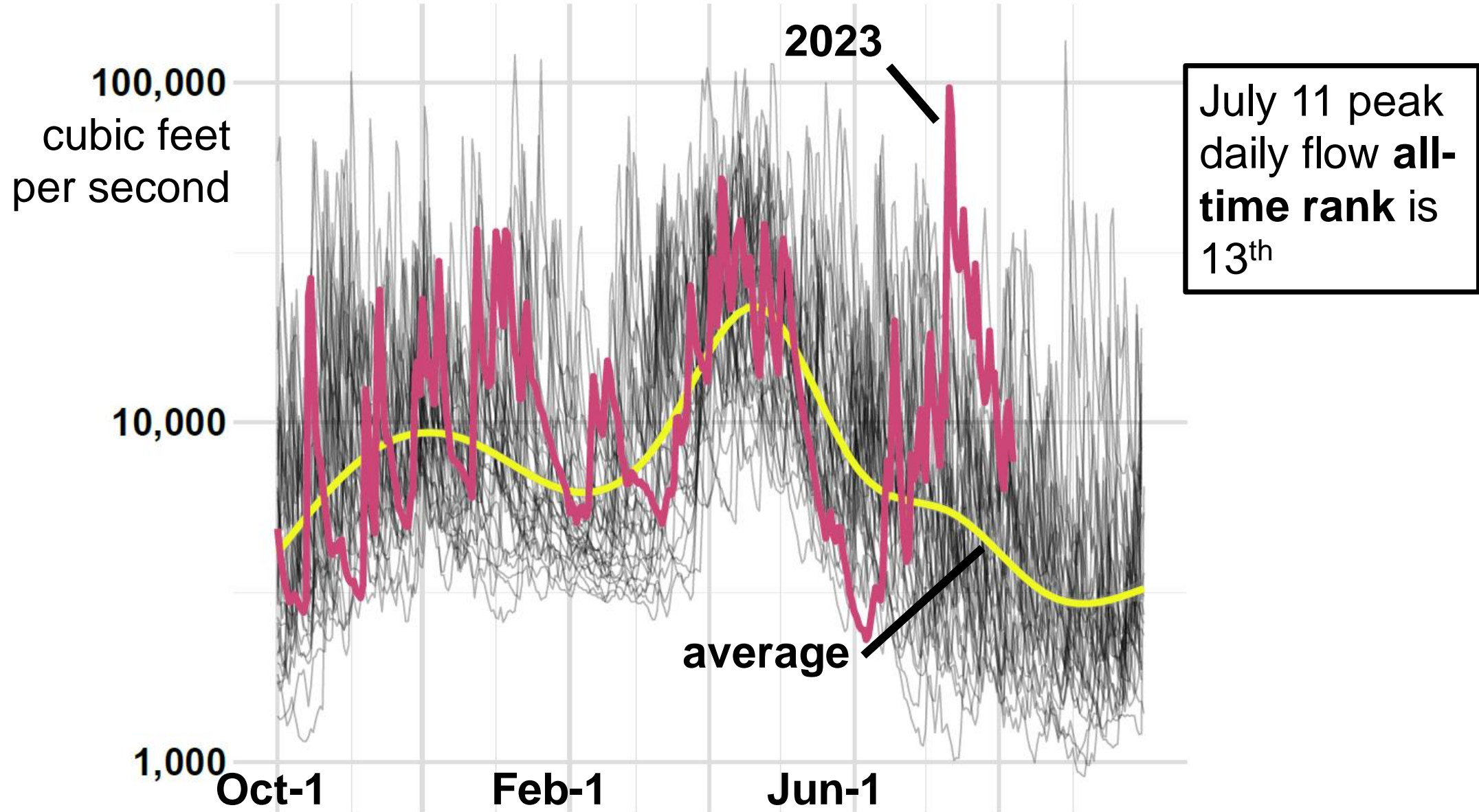
Total measured water flow to Lake Champlain

17 tributaries combined; all years since 1991

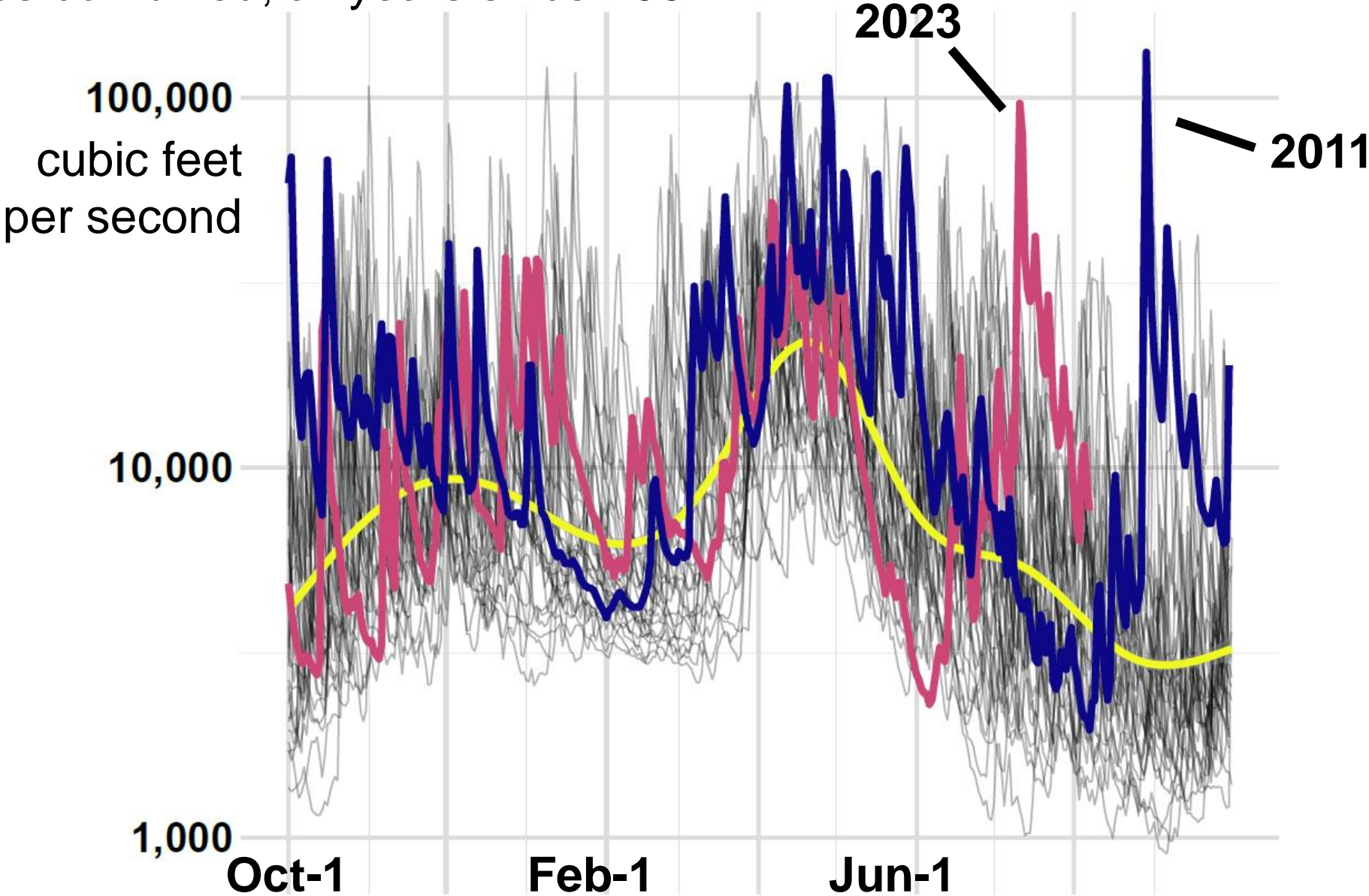


Total measured water flow to Lake Champlain

17 tributaries combined; all years since 1991

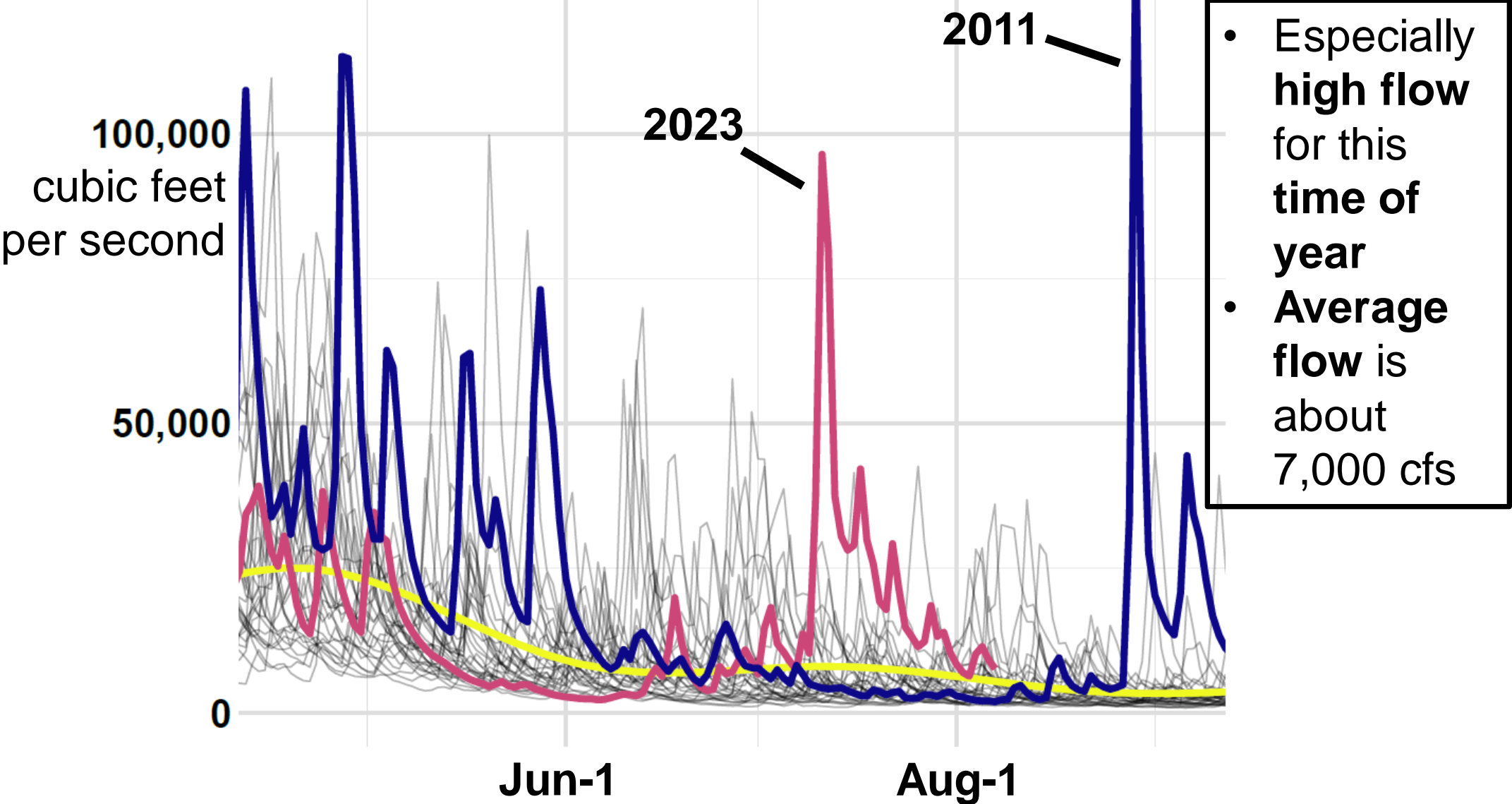


Total measured water flow to Lake Champlain
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Total measured water flow to Lake Champlain

17 tributaries combined; all years since 1991

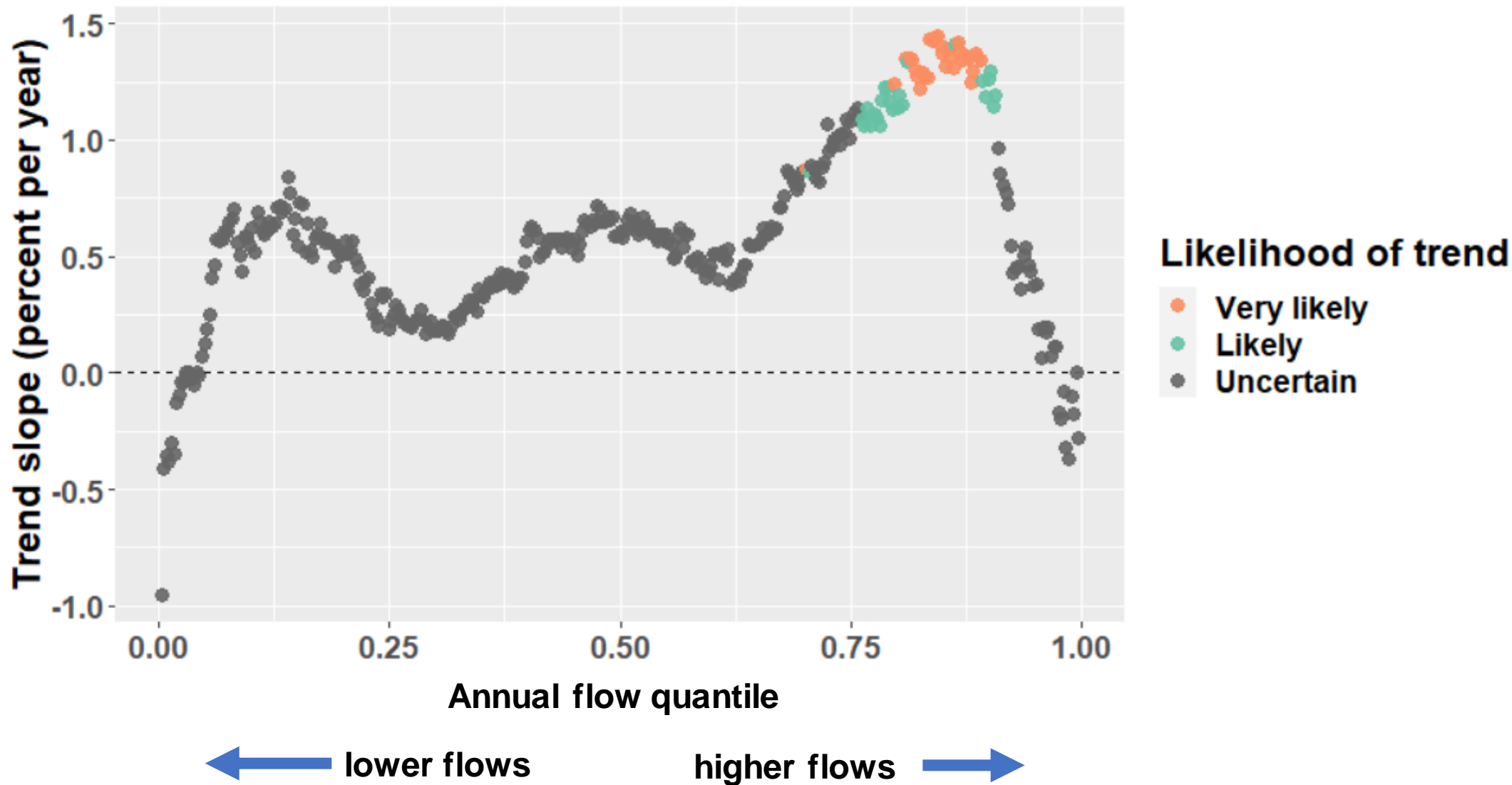


Context: **timing** and **distribution**
of **flow** is **changing**



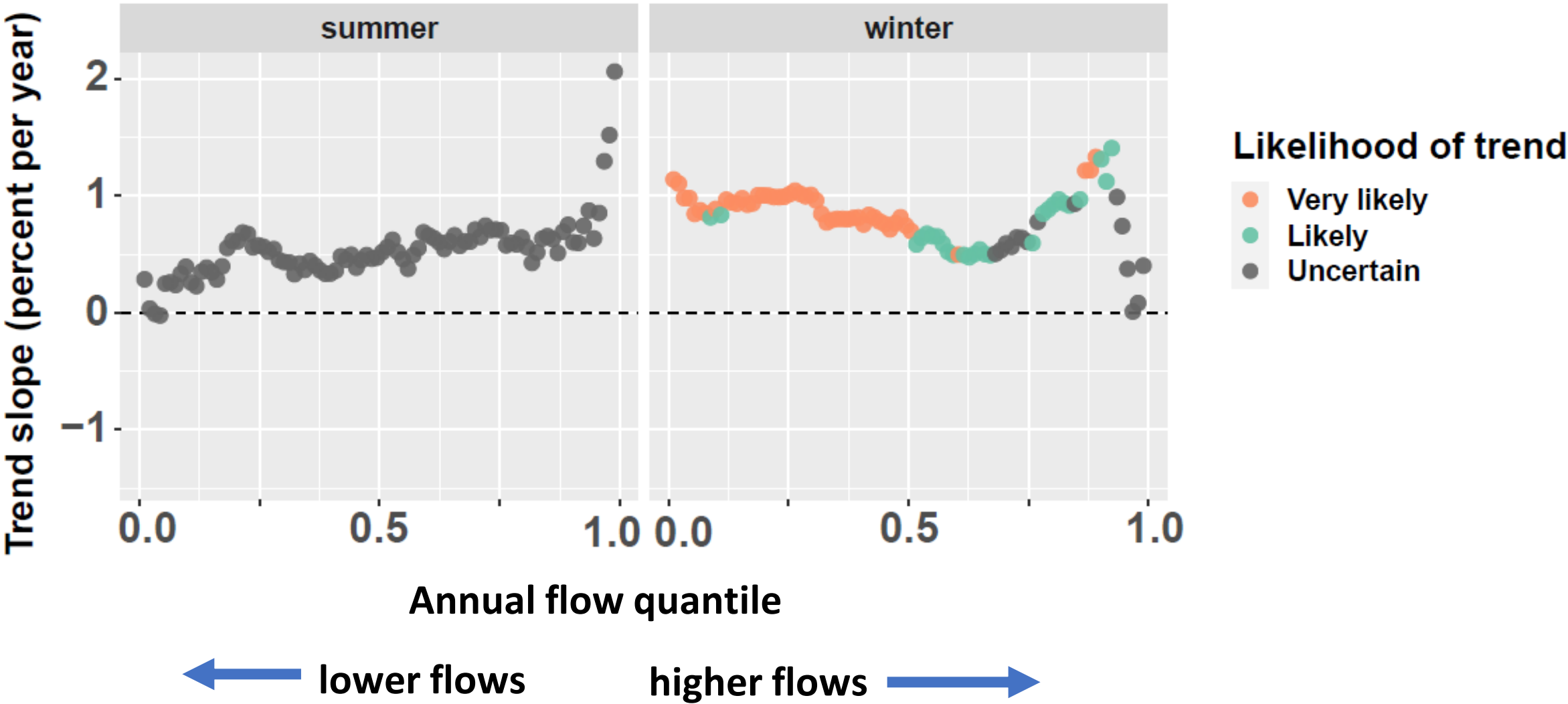
Winooski River – discharge trends


by quantile



Winooski River – discharge trends

by quantile and season

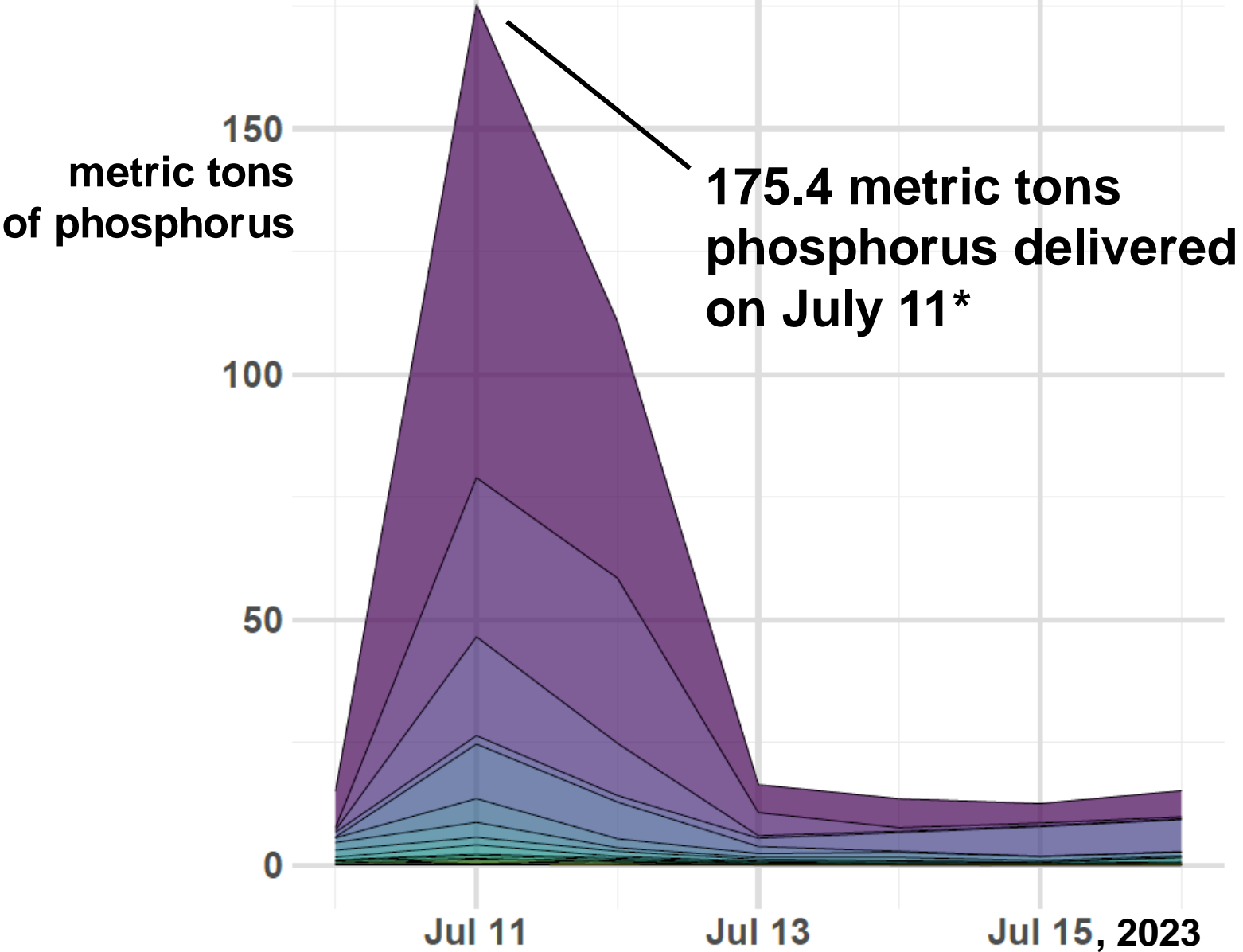


An aerial photograph showing a wide, muddy river flowing through a lush green forest. The river is surrounded by dense trees, and some smaller trees are isolated in the water. In the background, rolling hills and mountains are visible under a cloudy sky. A text box in the upper left corner contains the text "Next: phosphorus delivery".

Next: **phosphorus** delivery

Peregrine Productions

Daily phosphorus load from each tributary to Lake Champlain



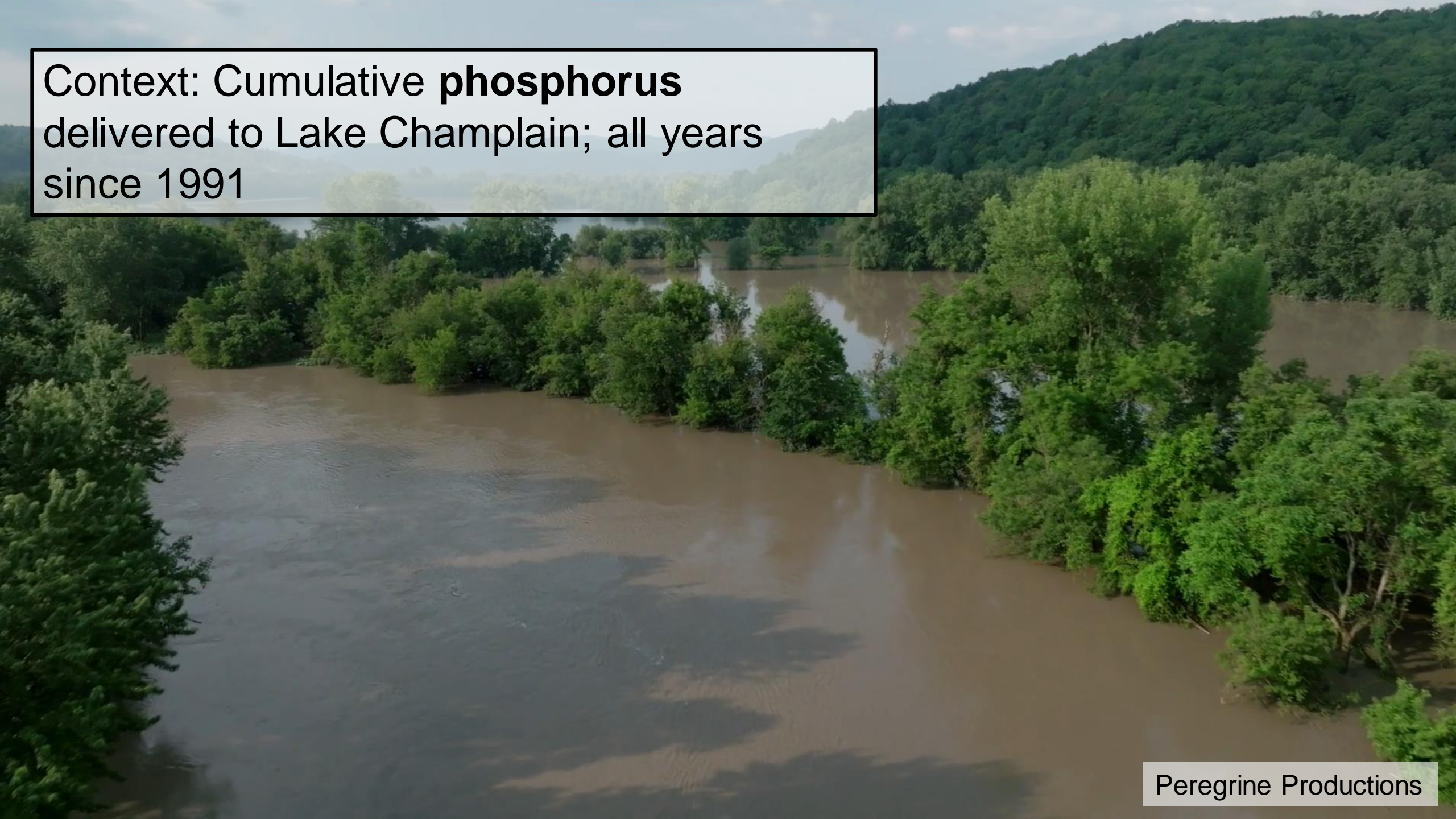
Stats dating back to 1990

July 11, 2023 daily phosphorus load was:

- **greater than 90th percentile** for all tributaries
- **Highest** daily load **ever** for **Pike River**
- Second highest ever for Winooski River
- **Highest load ever for this date** for all but two tributaries
- **Third largest daily load ever** delivered to Lake Champlain
 - Highest: Irene (586.9 mt)
 - Second: Halloween storm 2019 (187.7 mt)



Context: Cumulative **phosphorus**
delivered to Lake Champlain; all years
since 1991



Cumulative phosphorus delivered to Lake Champlain

17 monitored tributaries combined; all years since 1991

2,000 metric tons of phosphorus

1,500

1,000

500

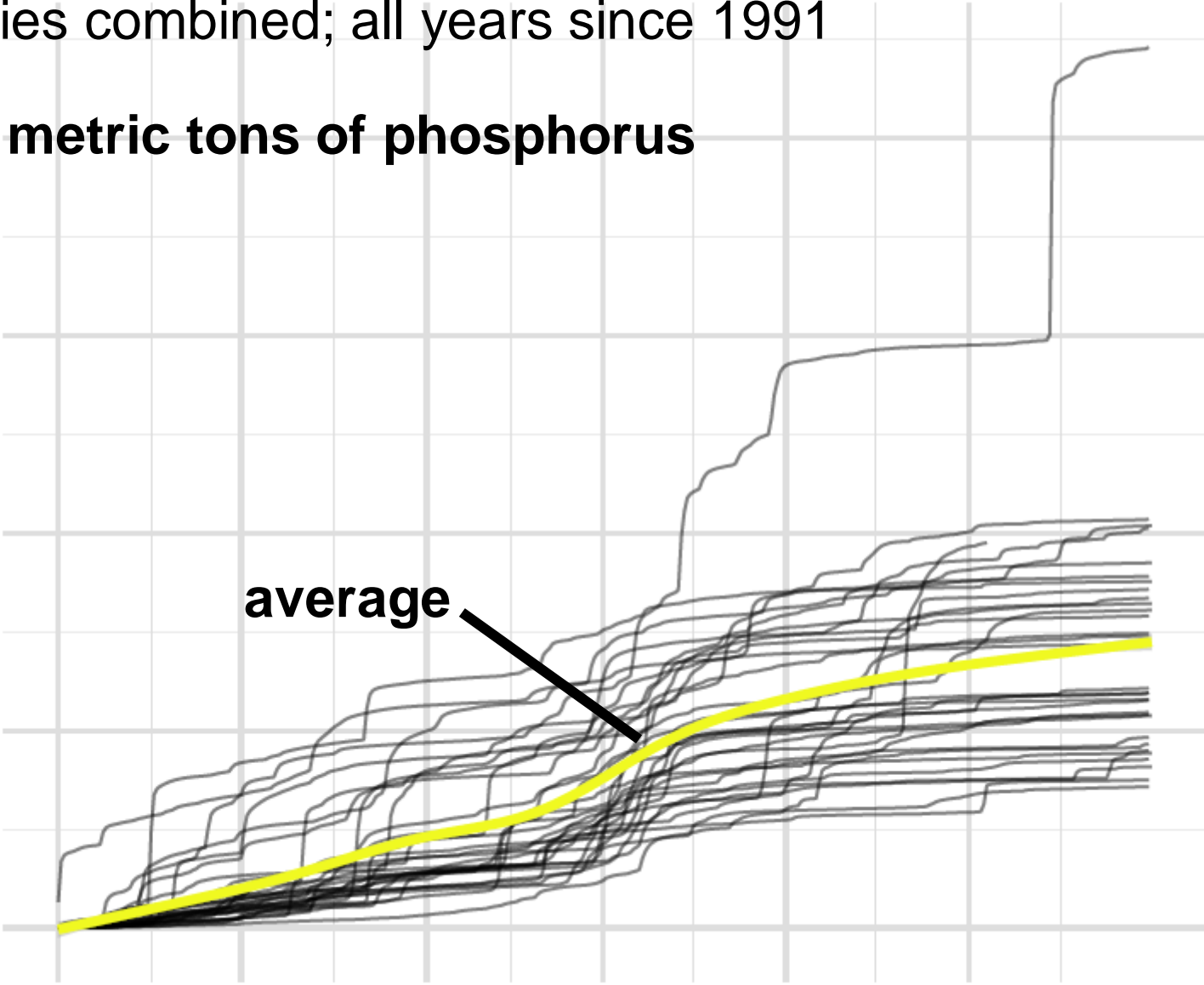
0

average

Oct-1

Feb-1

Jun-1



Cumulative phosphorus delivered to Lake Champlain

17 monitored tributaries combined; all years since 1991

2,000 metric tons of phosphorus

1,500

1,000

500

0

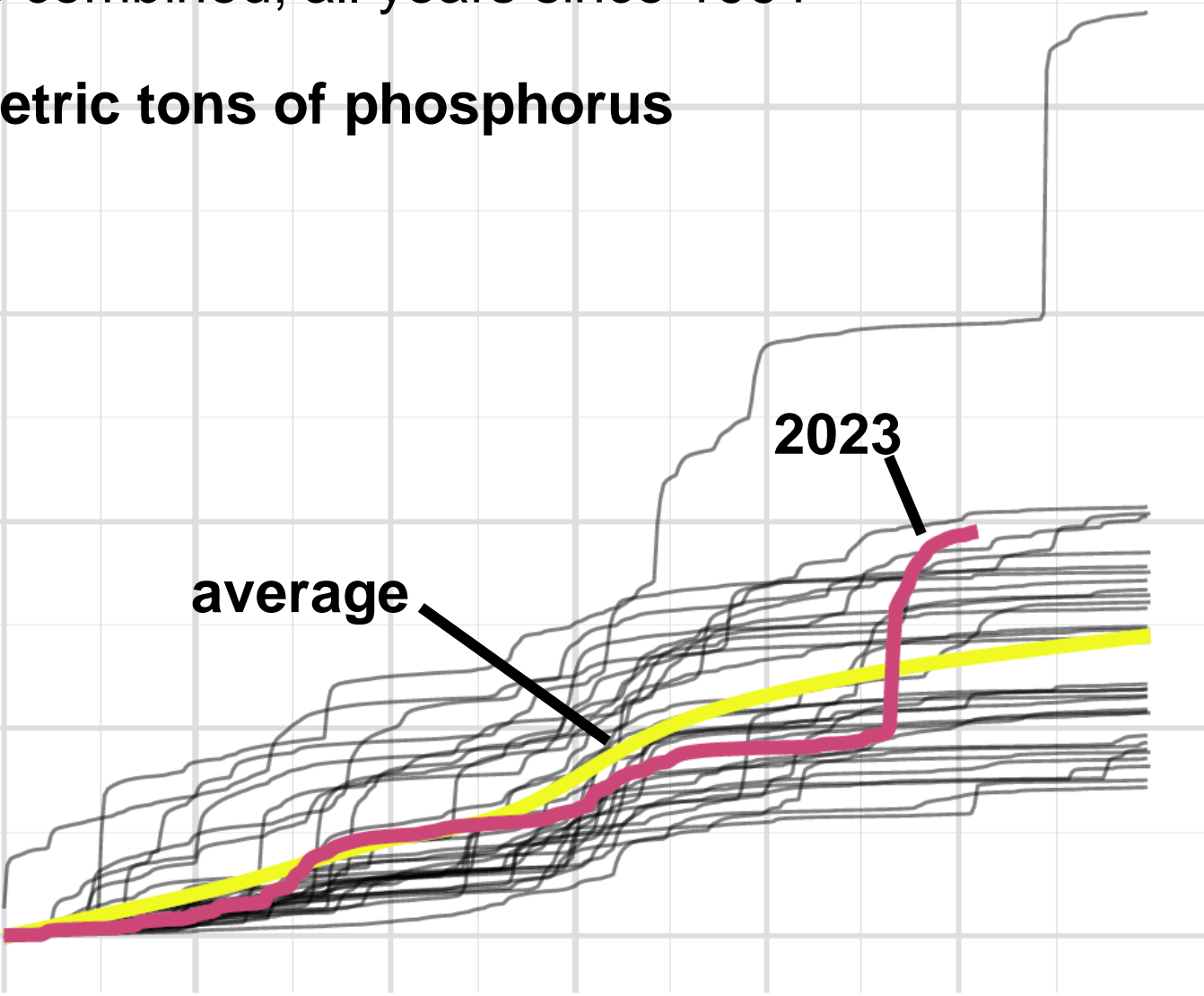
average

2023

Oct-1

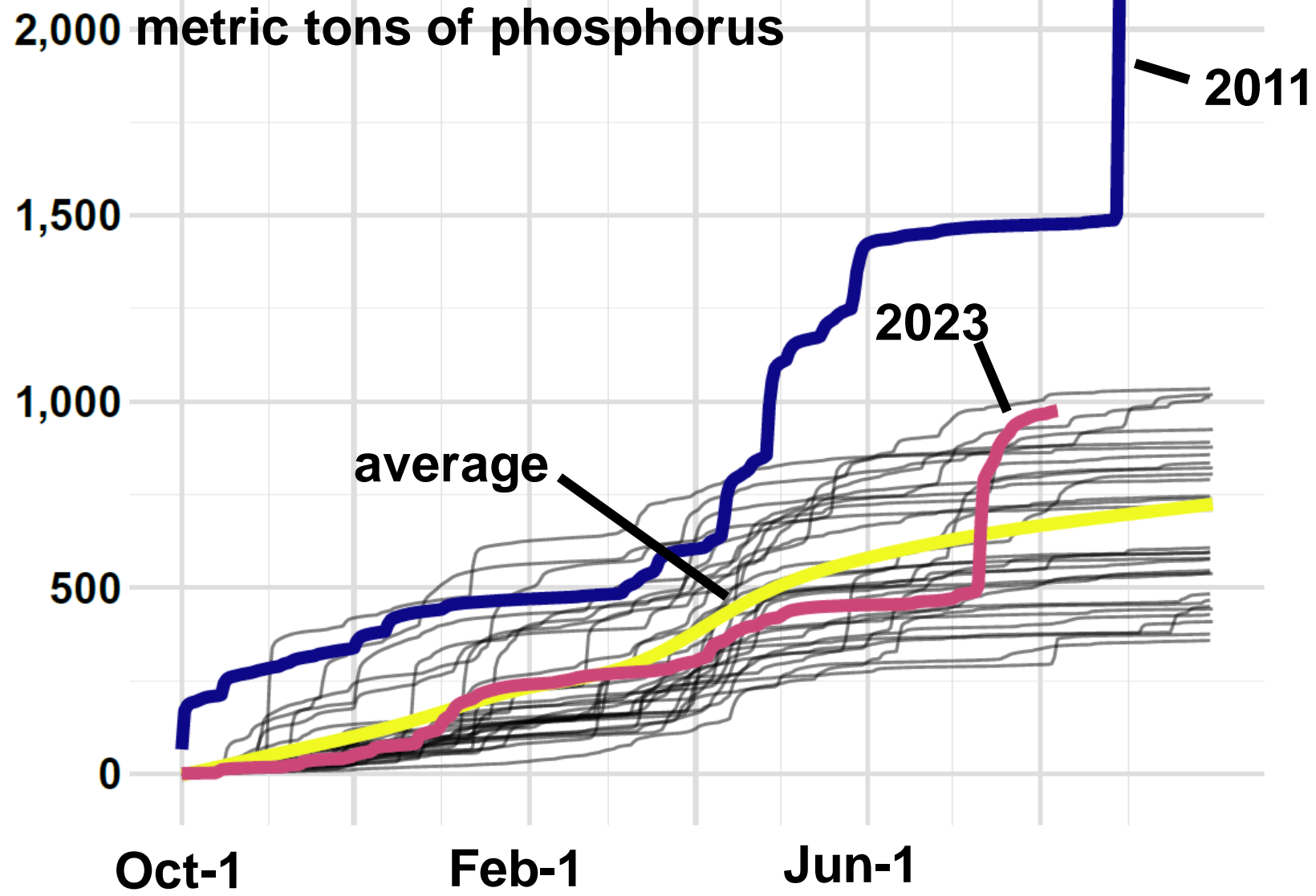
Feb-1

Jun-1



Cumulative phosphorus delivered to Lake Champlain

17 monitored tributaries combined; all years since 1991

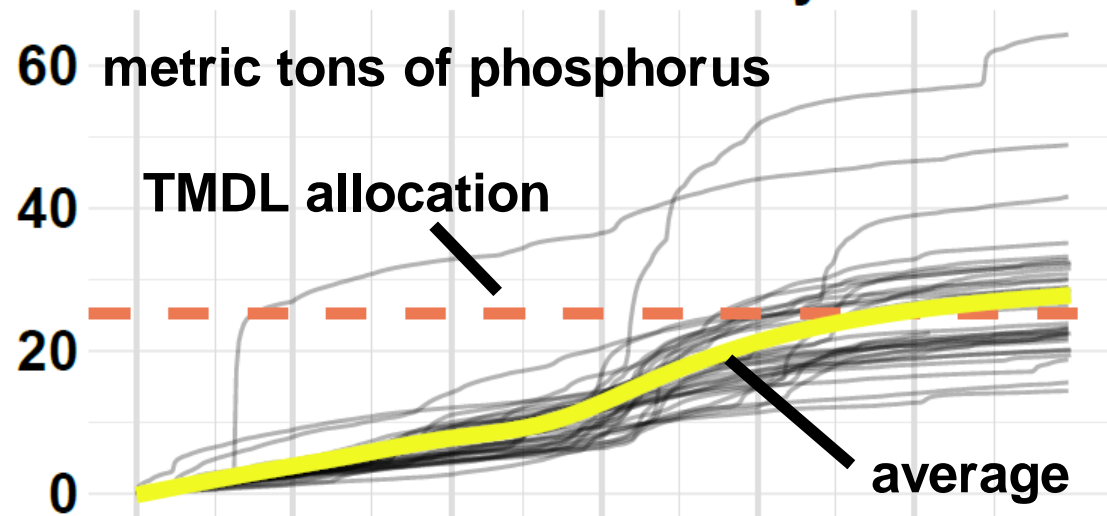


An aerial photograph of a wide river with brownish water, surrounded by dense green trees and forested hills in the background. The river flows from the upper left towards the lower right of the frame.

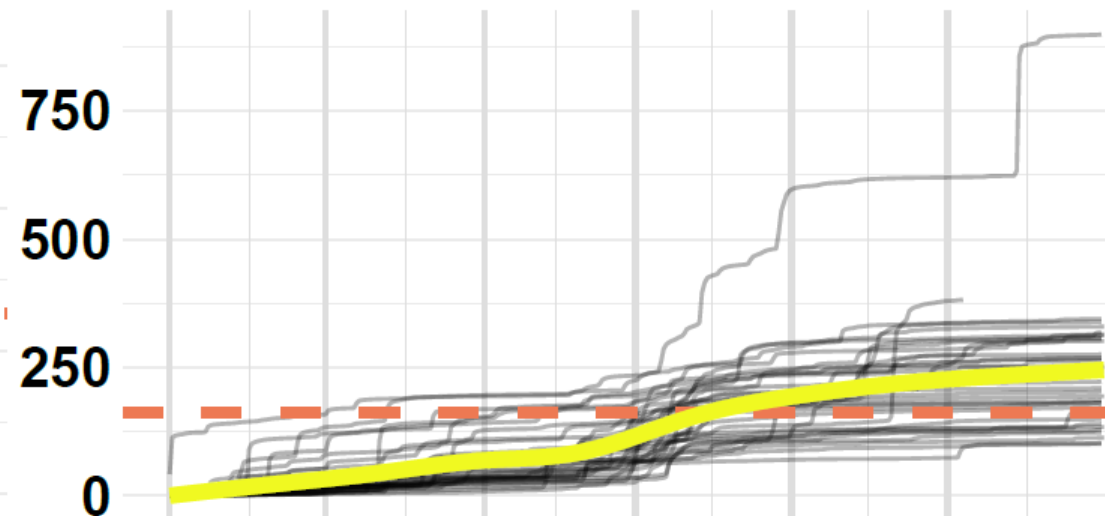
Next: Cumulative **phosphorus** delivered
to Lake Champlain **by lake segment**

- all years since 1991
- adjusted for unmonitored area
- compared to TMDL allocations

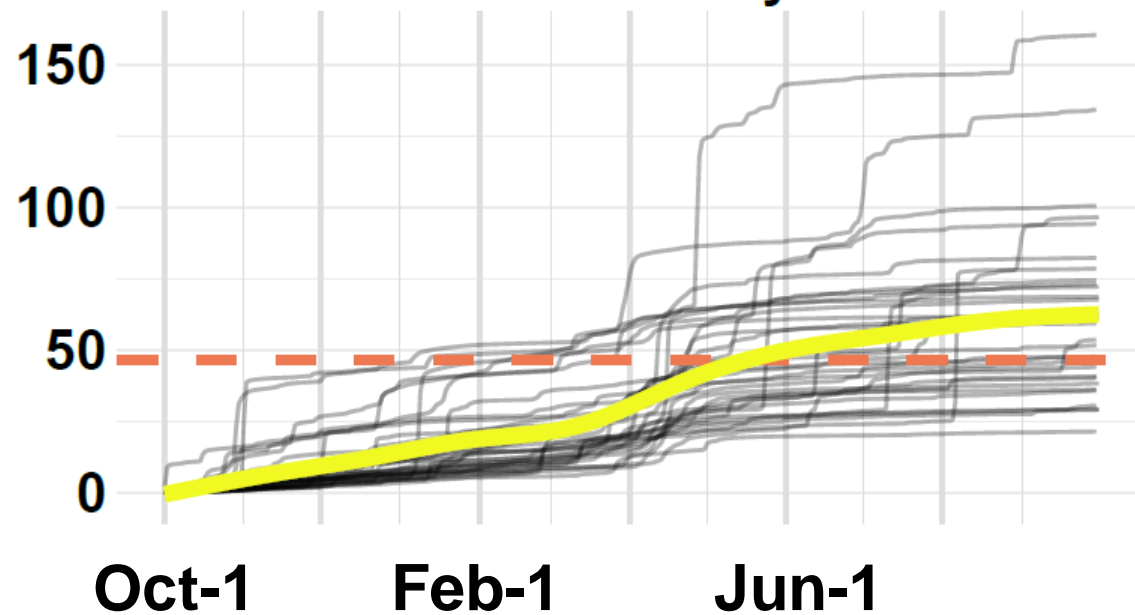
Cumberland Bay



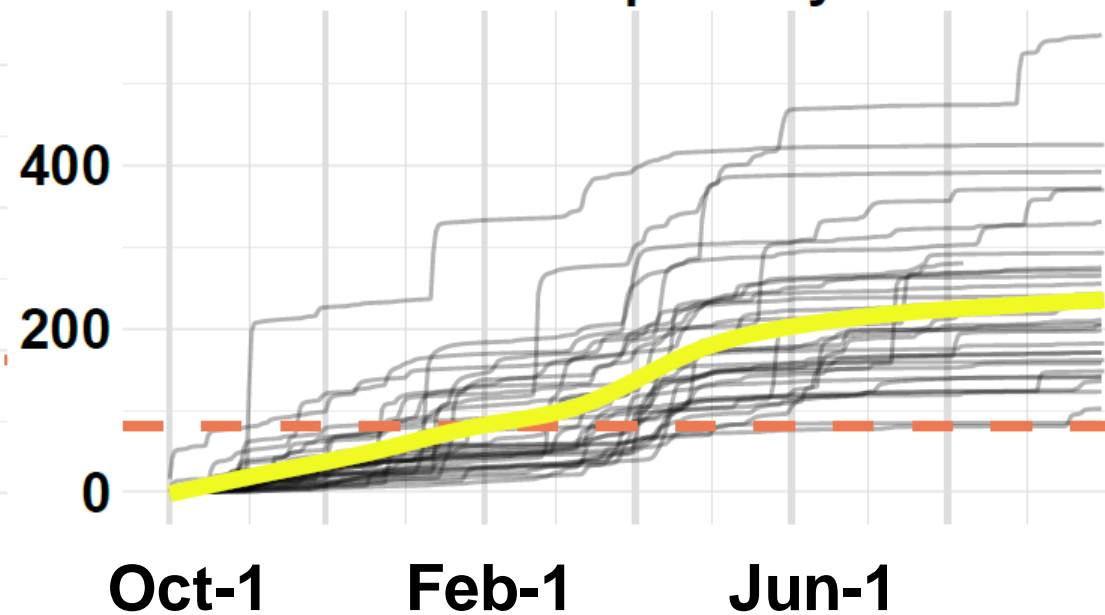
Main Lake



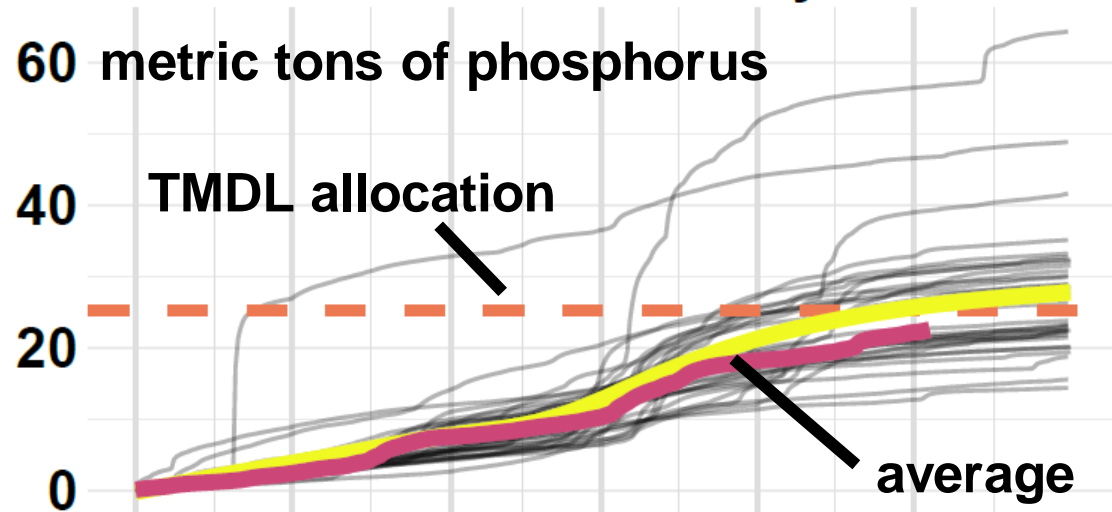
Malletts Bay



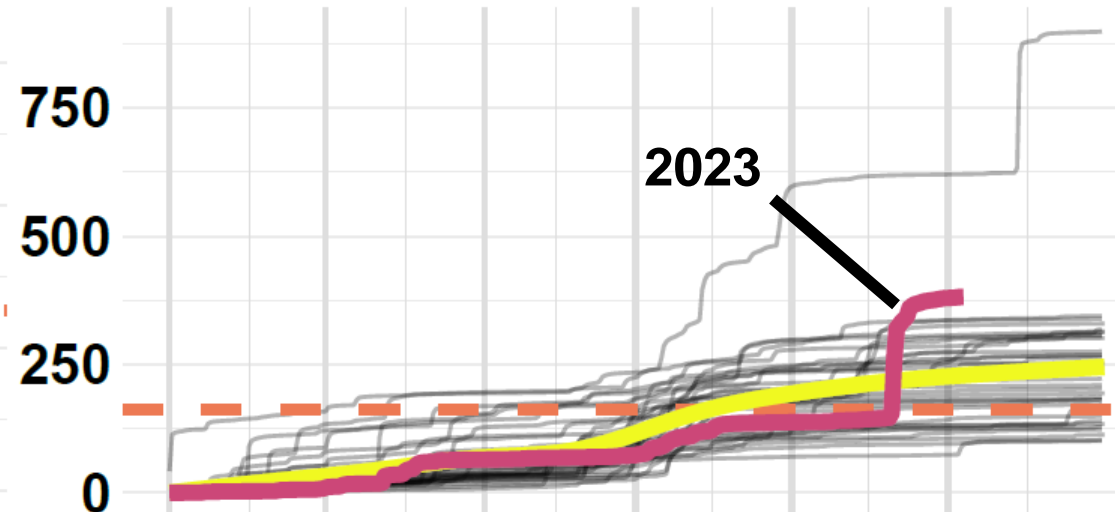
Missisquoi Bay



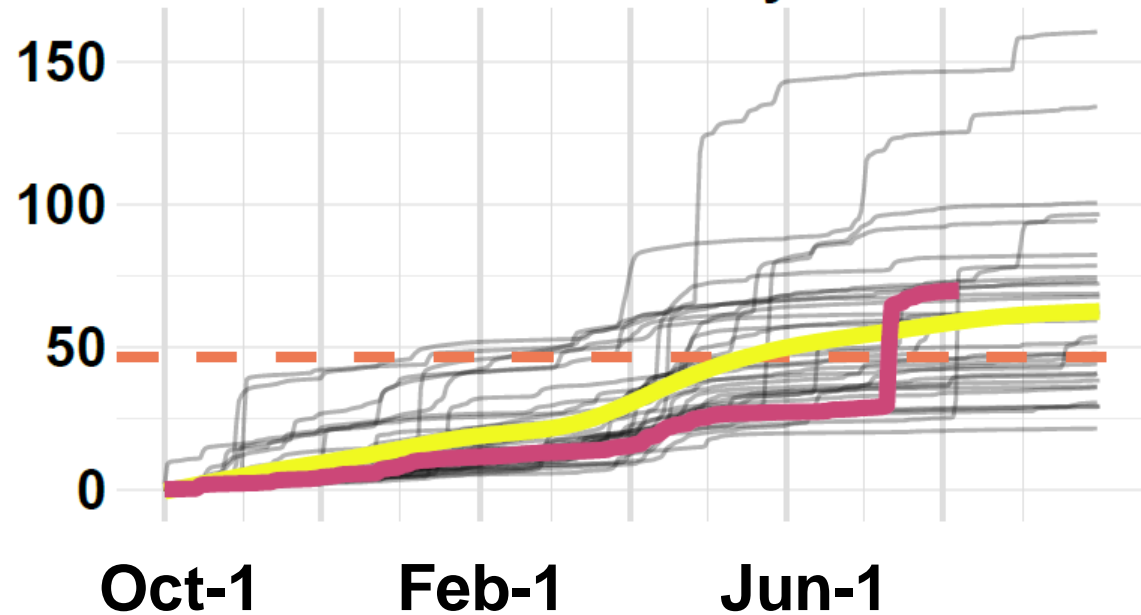
Cumberland Bay



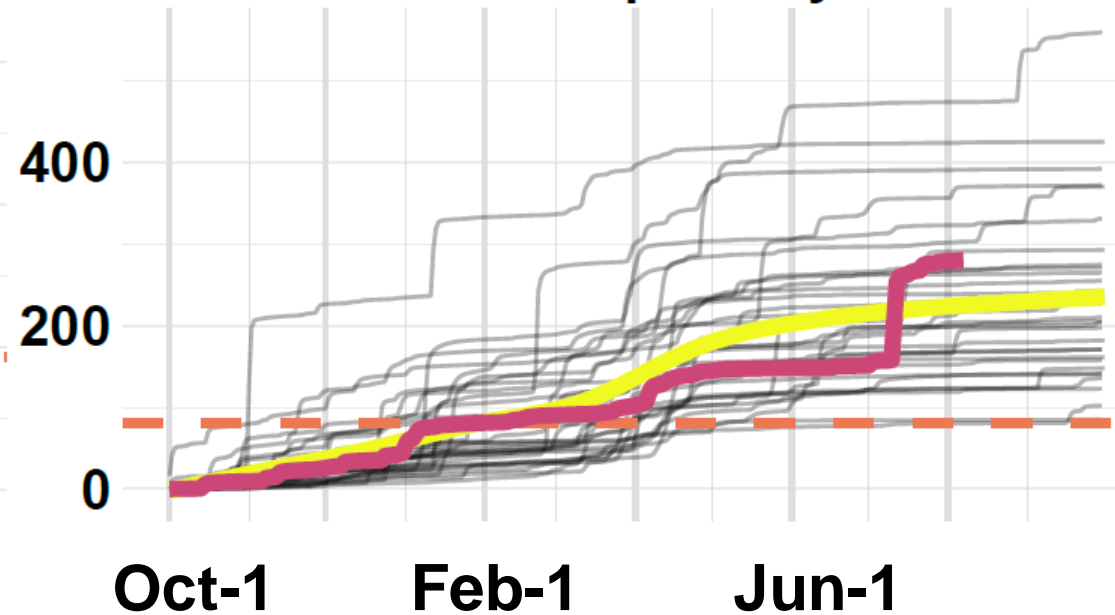
Main Lake



Malletts Bay



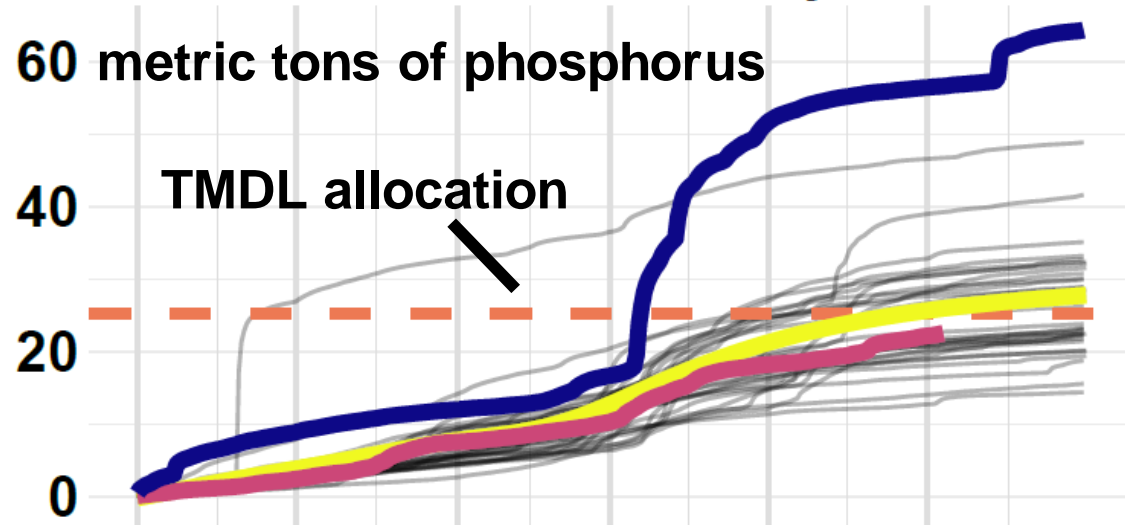
Missisquoi Bay



Cumberland Bay

60 metric tons of phosphorus

TMDL allocation

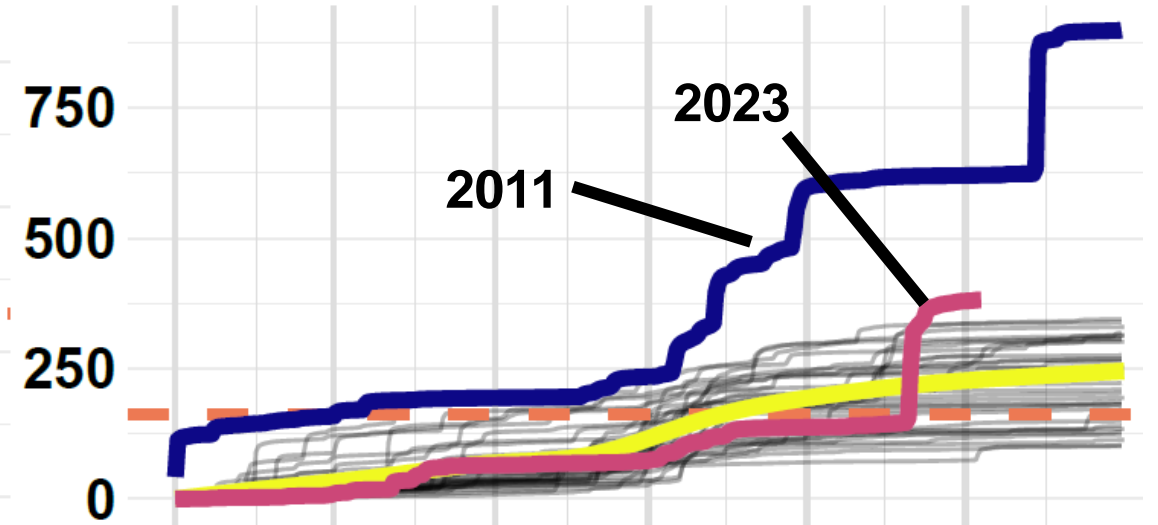


Main Lake

750

2023

2011



Malletts Bay

150

100

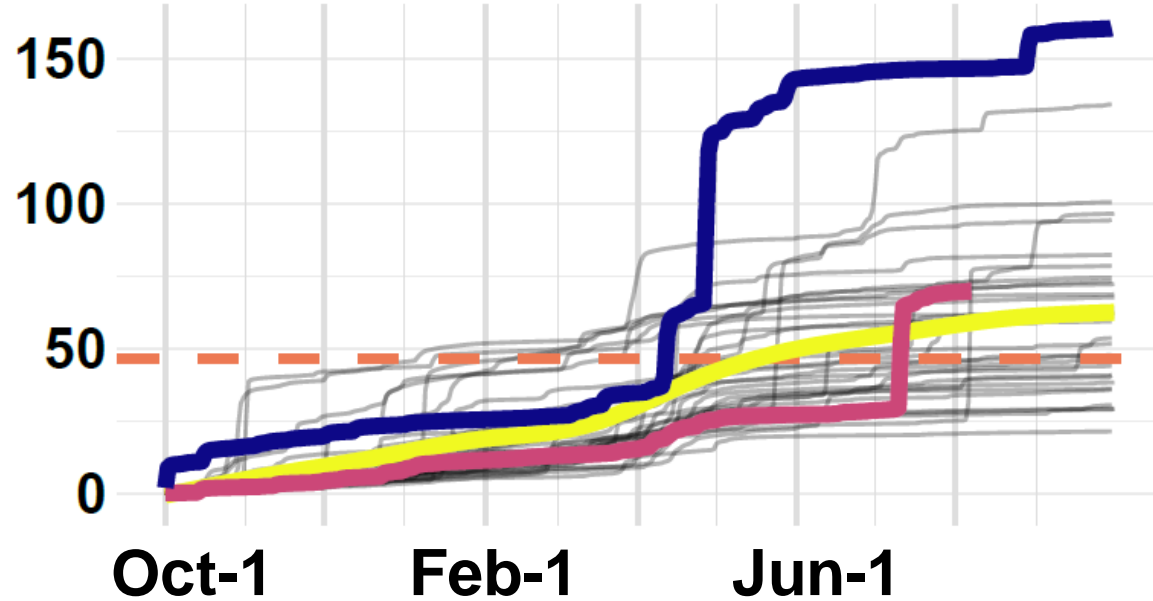
50

0

Oct-1

Feb-1

Jun-1



Missisquoi Bay

400

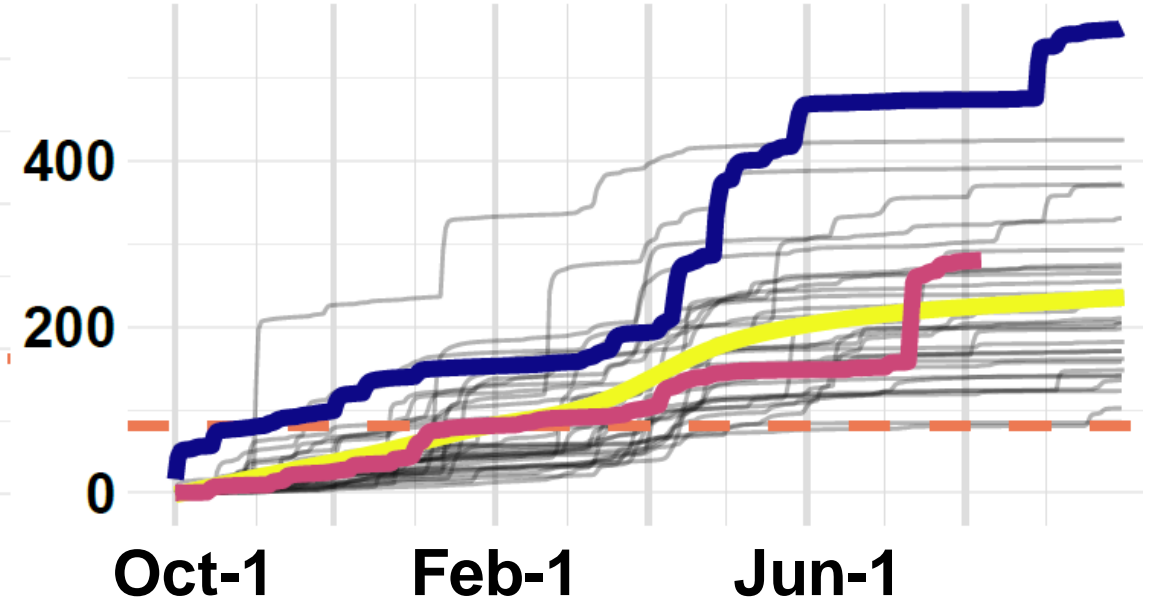
200

0

Oct-1

Feb-1

Jun-1



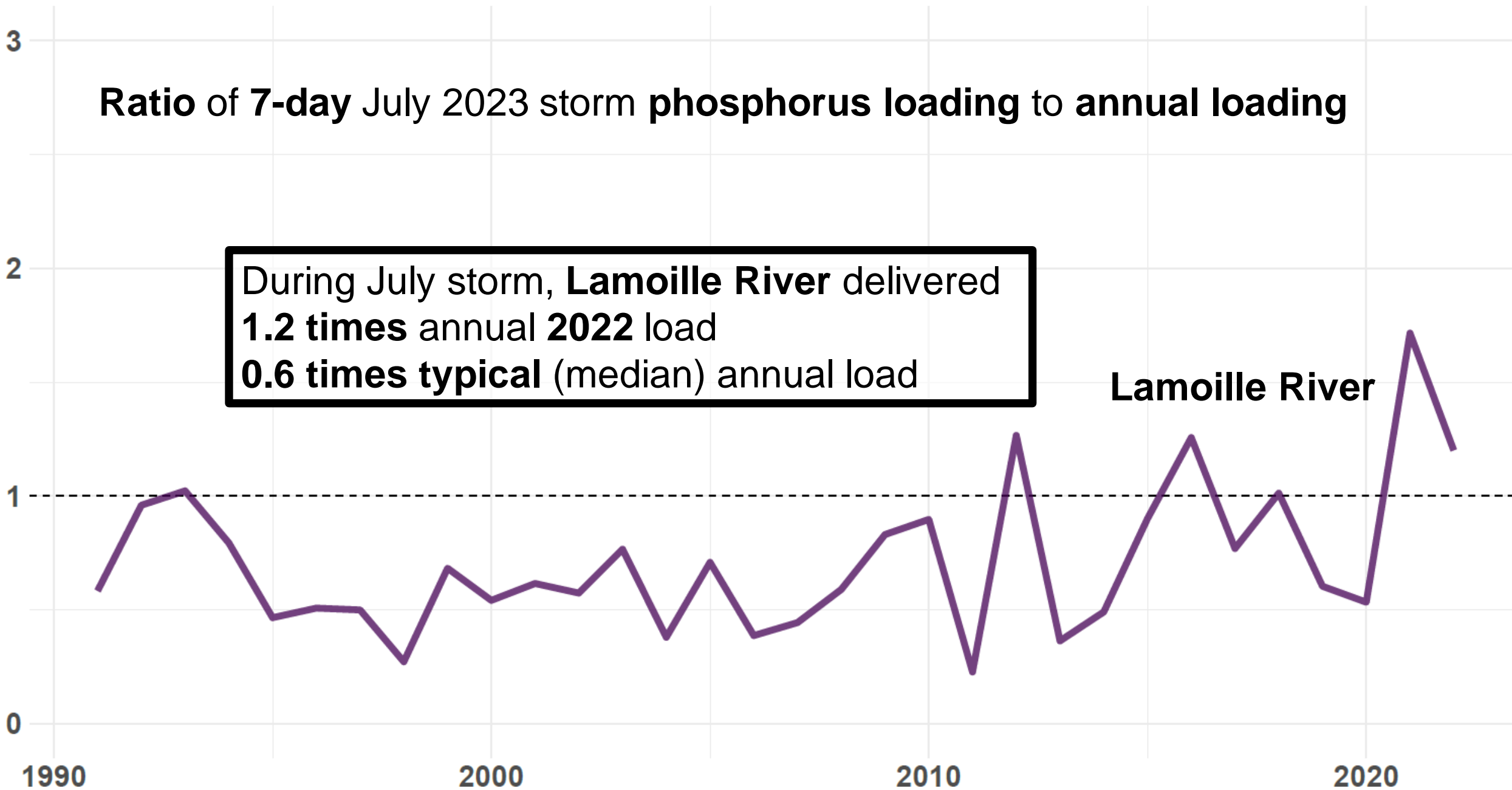
Next: how did **July 2023 storm**
phosphorus load compare to **annual**
phosphorus loads?



Ratio of 7-day July 2023 storm phosphorus loading to annual loading

During July storm, **Lamoille River** delivered
1.2 times annual **2022** load
0.6 times typical (median) annual load

Lamoille River

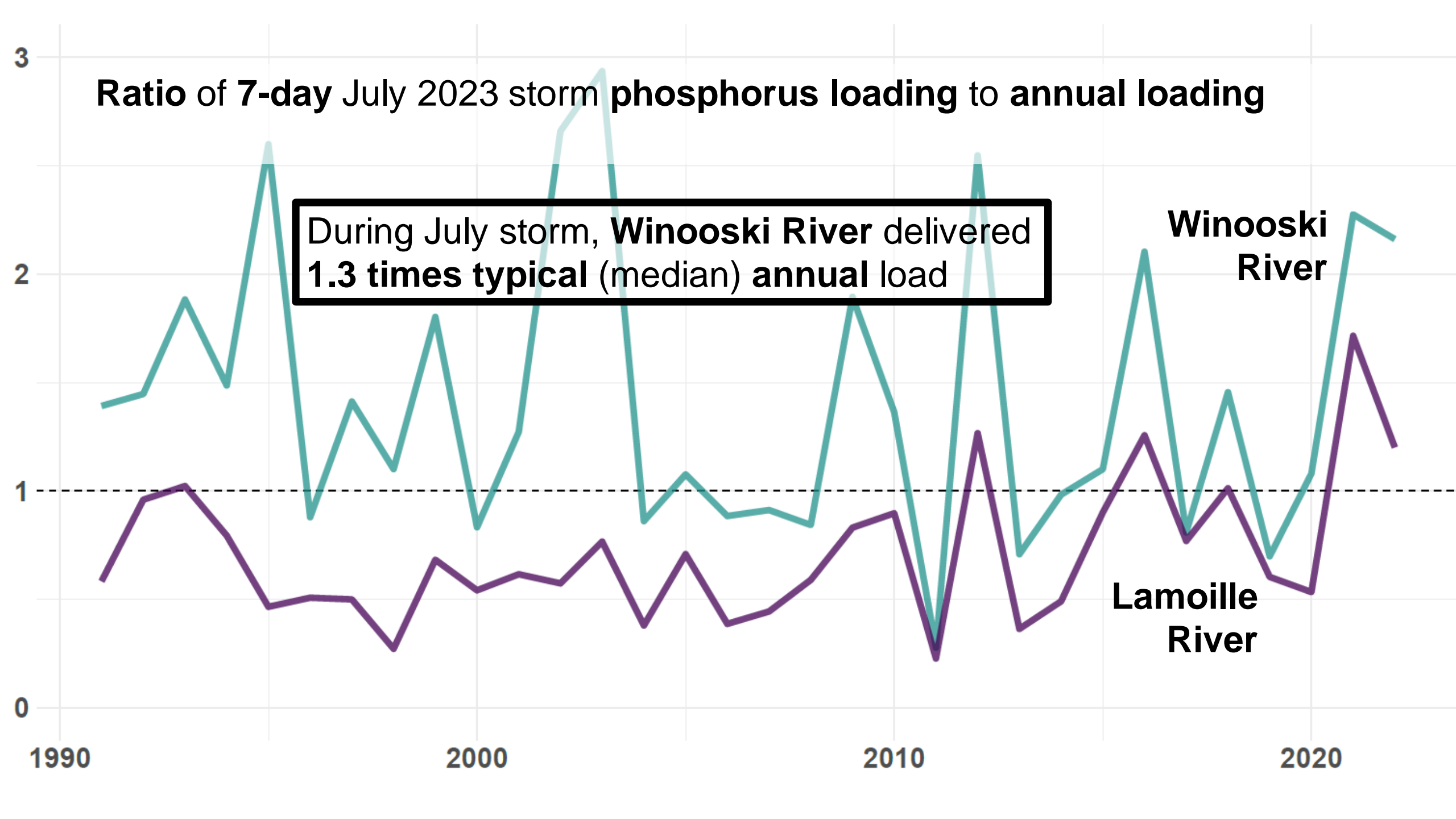


Ratio of 7-day July 2023 storm phosphorus loading to annual loading

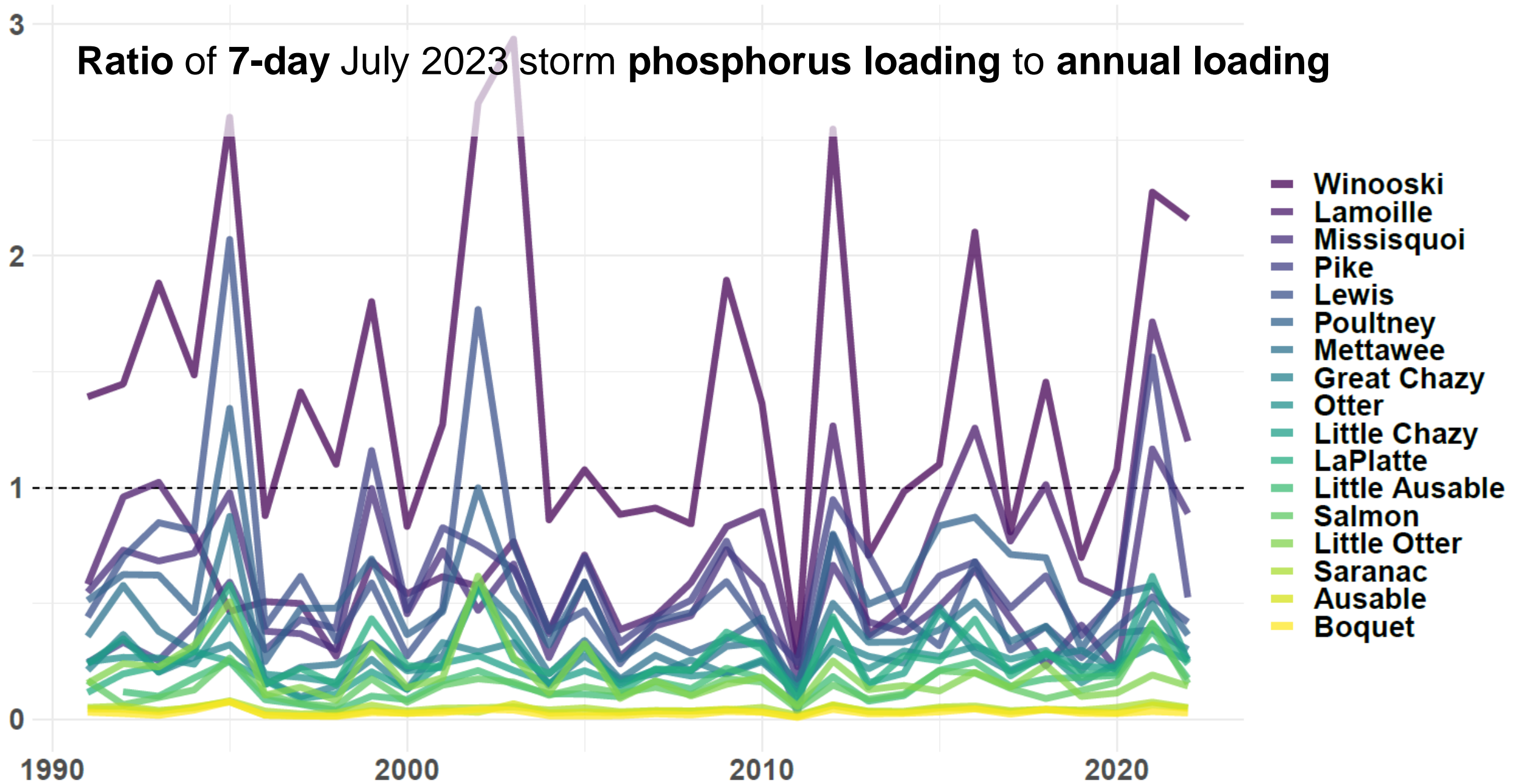
During July storm, **Winooski River** delivered **1.3 times typical** (median) annual load


Winooski River

Lamoille River



Ratio of 7-day July 2023 storm phosphorus loading to annual loading

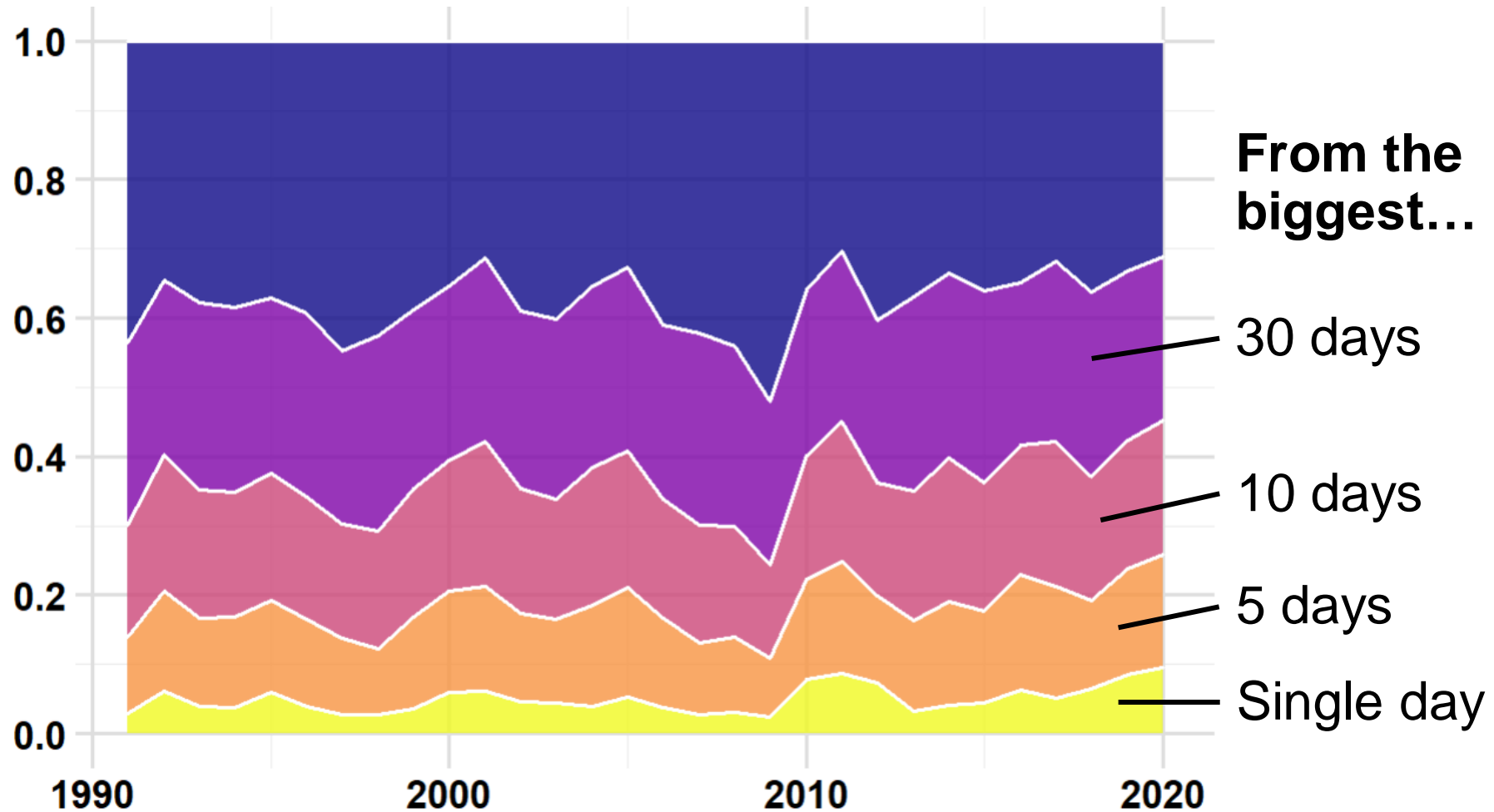




Context: **high flows** are always
important for **nutrient delivery**

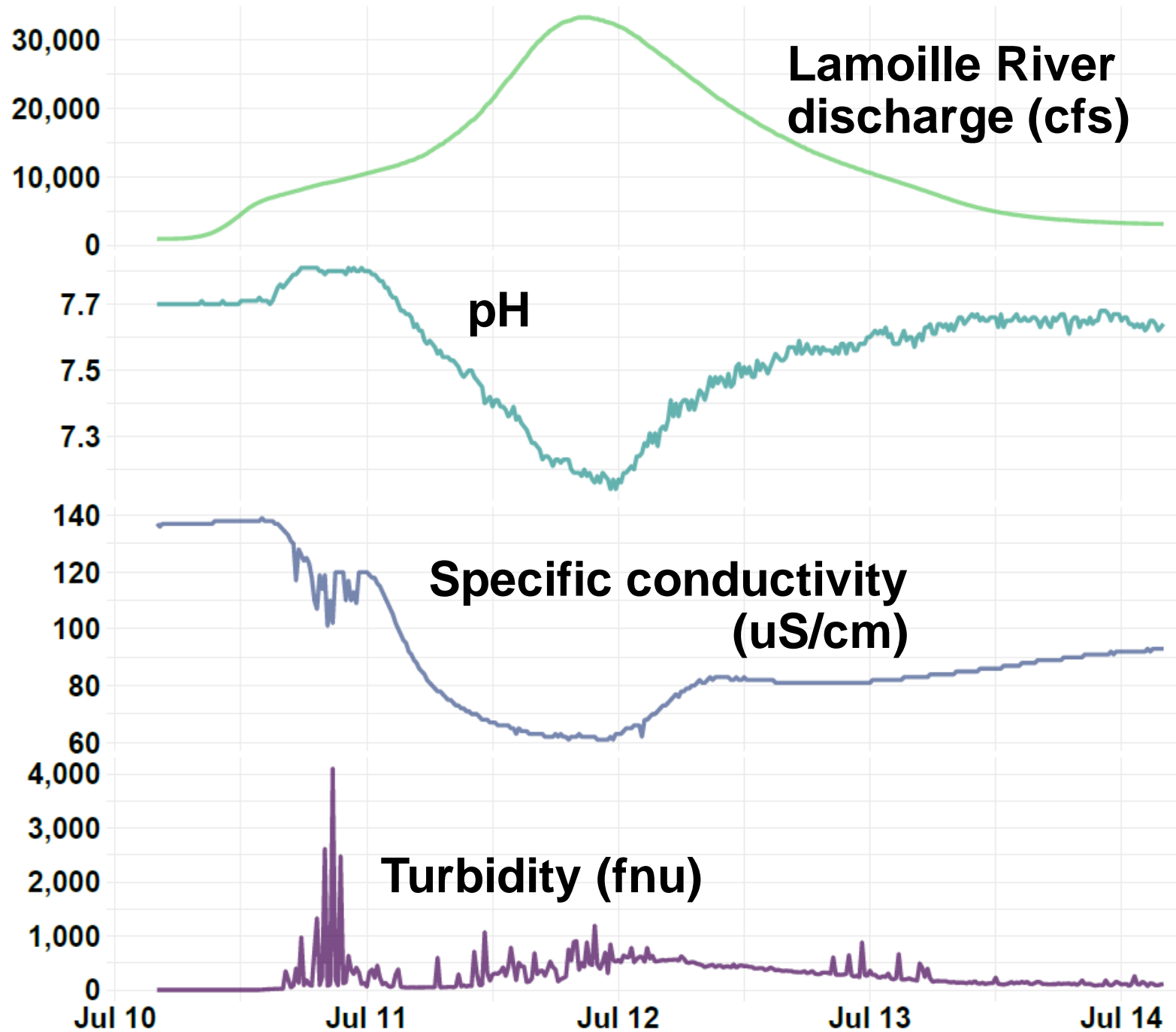
Winooski River


Portion of phosphorus load contributed







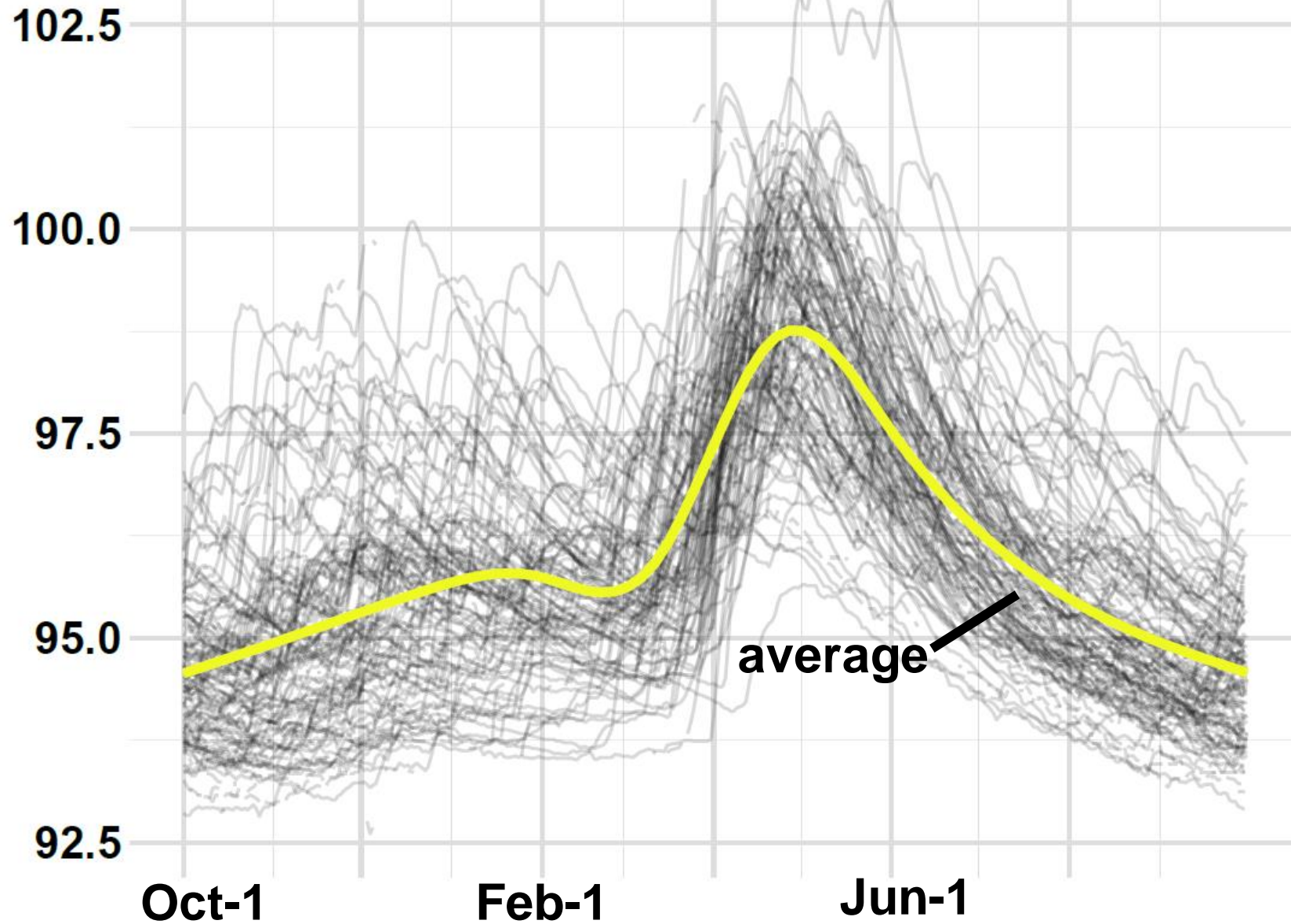


An aerial photograph showing a large body of water, likely a lake or bay, with a brownish tint. The water is surrounded by dense green forested land. In the foreground, there is a small peninsula or island with several houses and a grassy area. The sky is blue with some clouds. A text box is overlaid on the left side of the image.

Next: lake **level**
and **water quality**

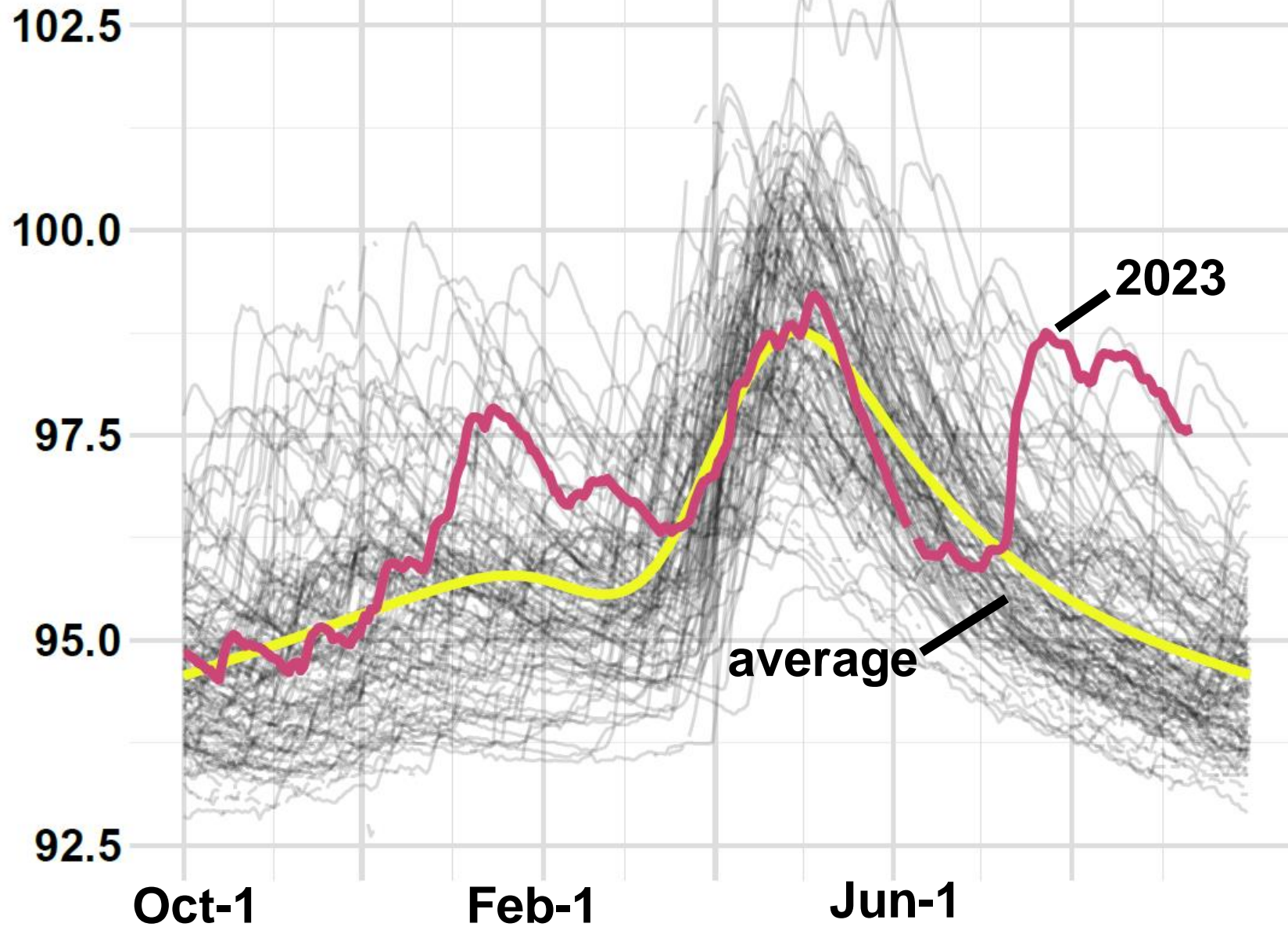
Lake Champlain level, Burlington (ft above sea level)

All years, starting 1907



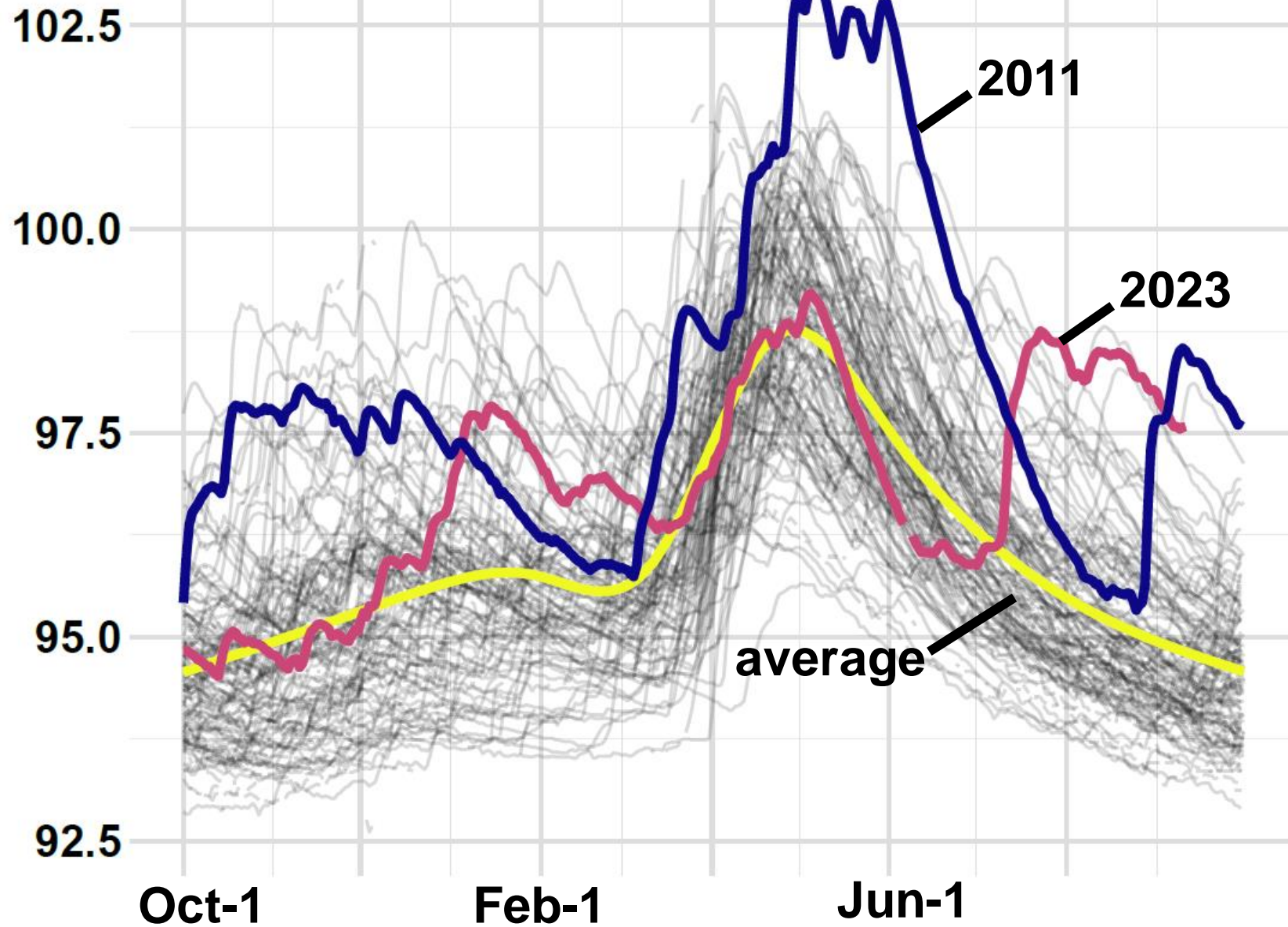
Lake Champlain level, Burlington (ft above sea level)

All years, starting 1907



Lake Champlain level, Burlington (ft above sea level)

All years, starting 1907



Malletts Bay

Secchi depth 0.4 m
on July 20

Typically about 2.5 m



Photo: Kelsey Colbert

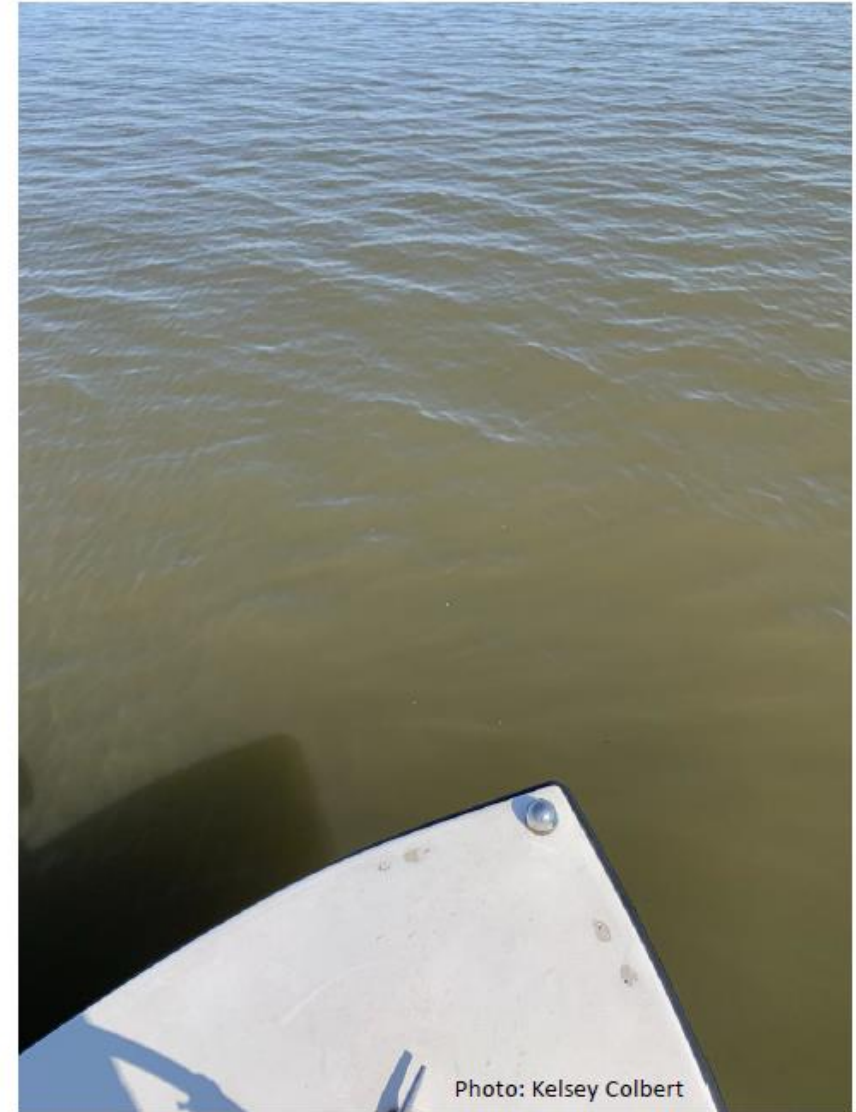
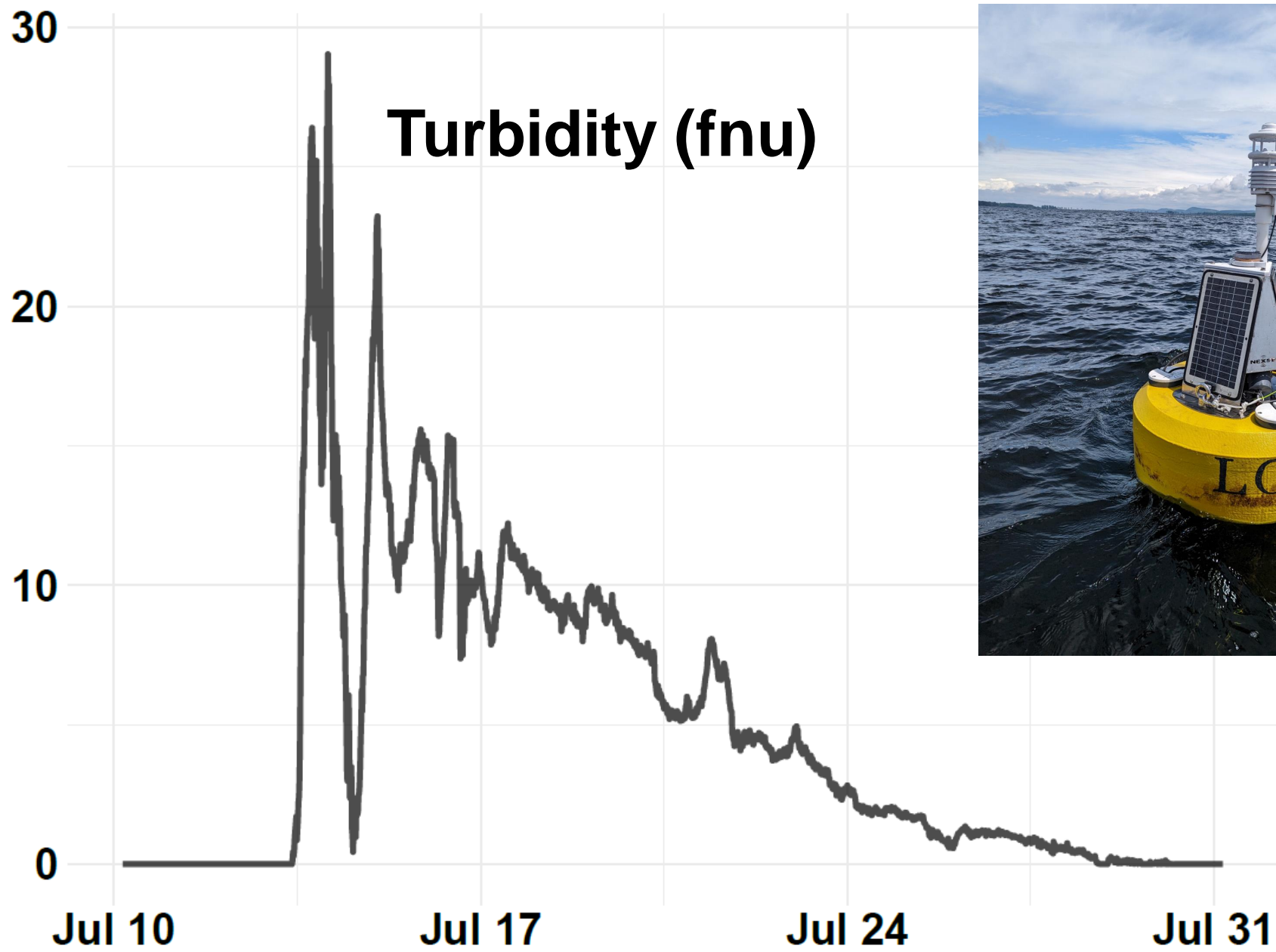
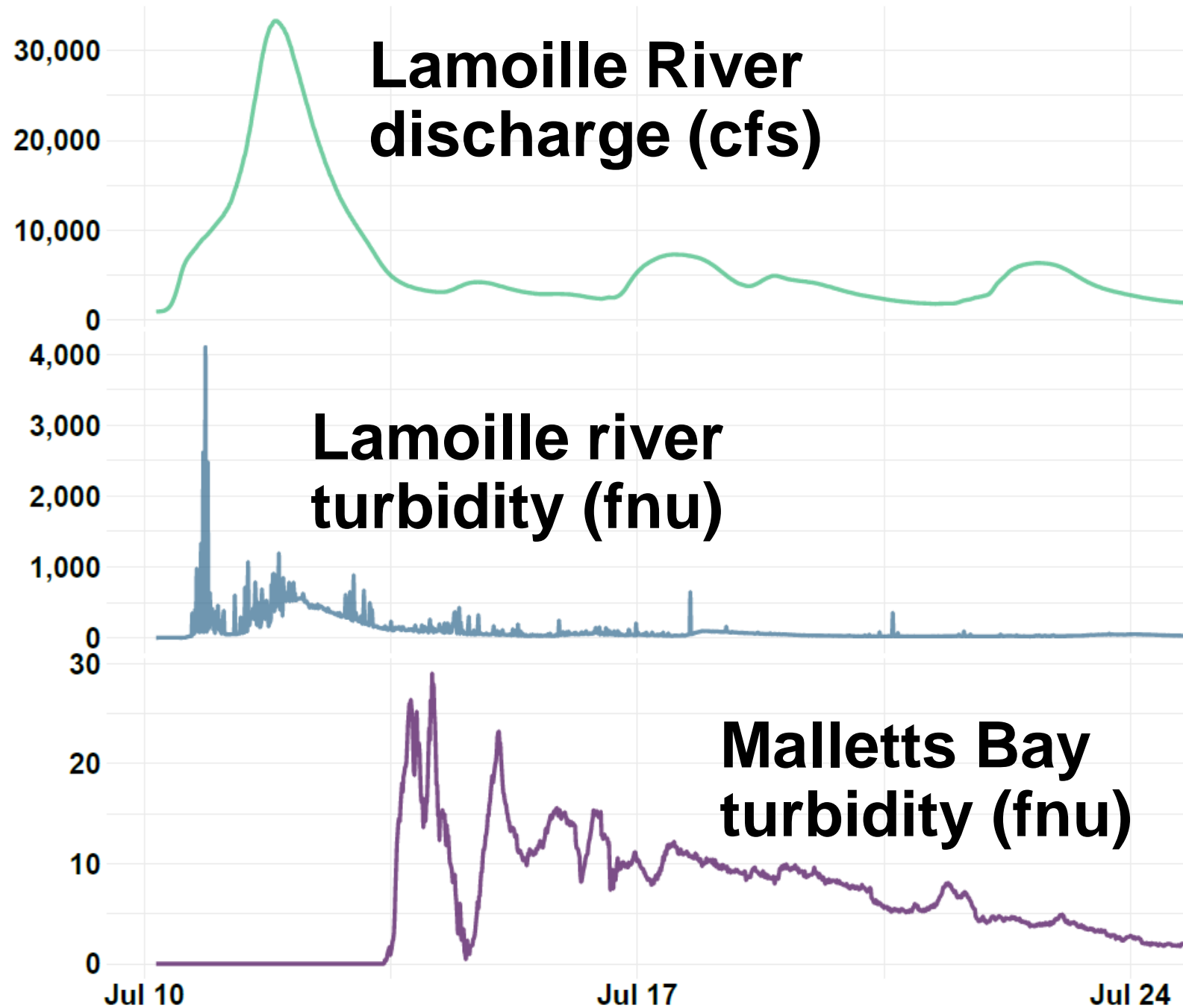


Photo: Kelsey Colbert

Photo: Kelsey Colbert
Adapted from Peter Isles' presentation







Summary

Historic **rainfall** amounts

- 48-hour totals: **3 – 9 inches**

Summary

Very high **river flows**

- **> 90th daily flow percentile** for all tributaries
- daily record for **Lamoille**, 2nd for **Winooski**
- Unusually high for the **time of year**
- Consistent with **climate change** trends

Summary

Phosphorus delivery

- Preceded by a dry spring
- Five tributaries delivered 90% of 7-day storm flux
- **More than half** of full-lake annual **TMDL** delivered in 7 days
- Esp. significant for **Main Lake**
- Consistent with **climate change** trends (time of year)

Summary

Lake level

- Rose about **3 feet**
- From **average to record high for season**, near normal for spring

Summary

Lake water quality

- High **turbidity**
- Primary productivity likely suppressed
- **Dissolved nutrients** available for later season growth
- **Short-term bacteria impacts;** not widespread
- Waiting on 2023 data

Resources

- [July 2023 flooding summary](#)
- Real-time data: data.lcbp.org
- Science blog: lcbp.org/science-blog

mvaughan@lcbp.org



Springfield, Vt.

Vermont Historical Society

TOWARD FALLS BRIDGE NOV. 4 '27
-SLADE-

