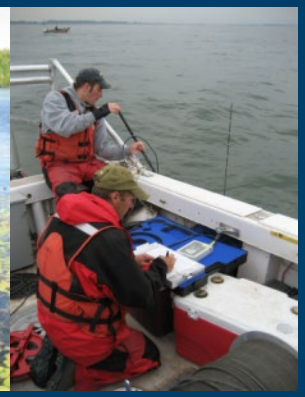
Long-term trends in St. Louis River water quality: 10 years, a historic flood, and some high lake water later

Joel Hoffman and Hannah Ramage

hoffman.joel@epa.gov



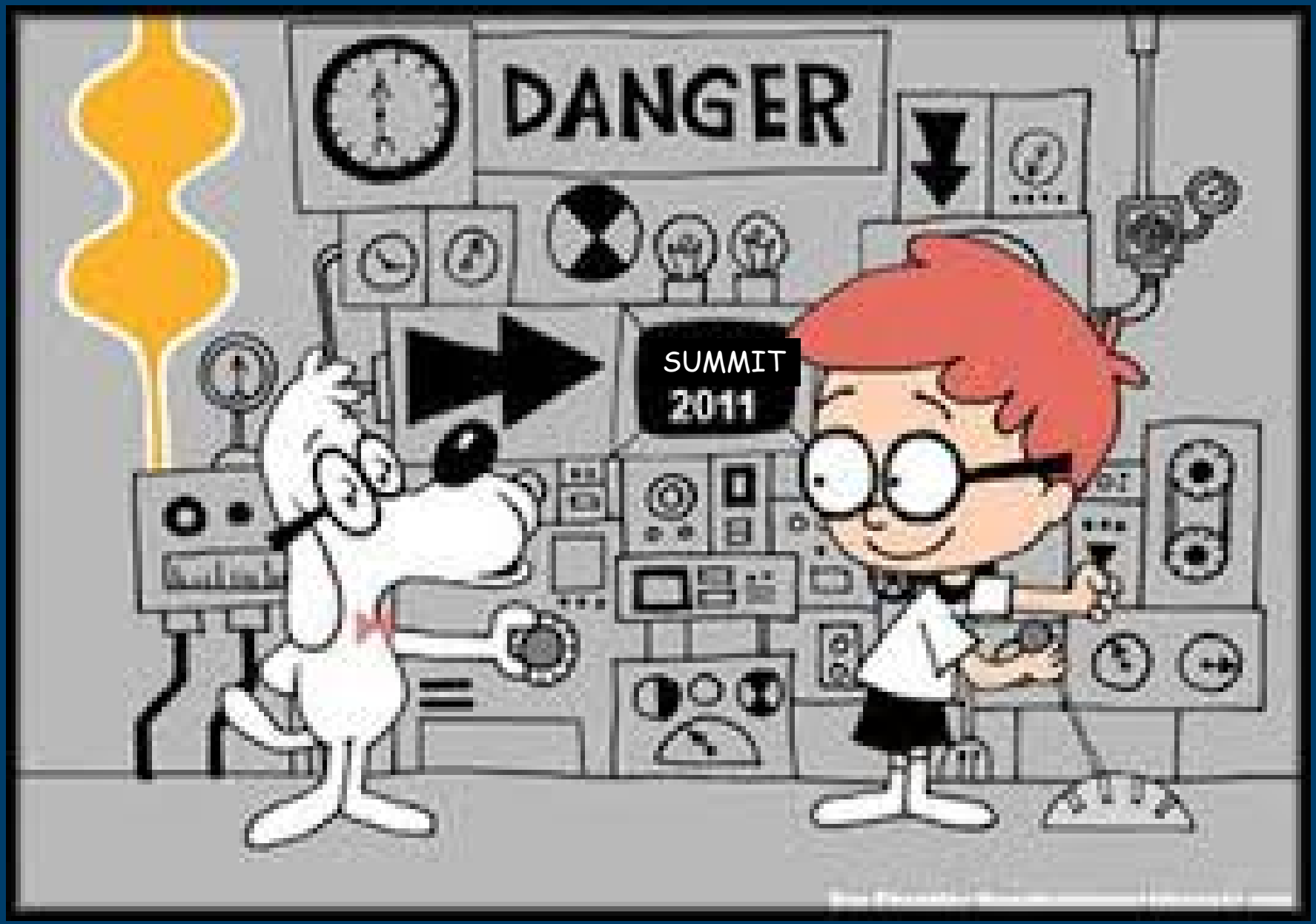


United States Environmental Protection Agency

Office of Research and Development
National Health and Environmental Effects Research Lab, Mid-Continent Ecology Division, Duluth, MN

St. Louis River Estuary Summit 2020

March 3-4, 2020



The Rocky and Bullwinkle Show

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View of Duluth, At the Head of Lake Superior.
Art Collection, Engraving, 1871 Visual Resources Database, Minnesota Historical Society
From: Harper's Weekly, April 29, 1871 Location No. MS2.9 DU1 p31 Negative No. 3623

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Historical condition

"Near the upper end of Spirit Lake and MacDougall Shipyards below Spirit Lake, samples showed that the bottom was covered with a thick layer of mud thoroughly impregnated with small globules of tarry substance. The mud and water in this portion of the lake had a strong creosote odor and an oily film covered the surface. No living organisms were found in the mud sample and it is improbable that even adult fish could enter this zone with impunity."

-MN State Board of Health, 1928-1929

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World War II era condition

"From the fisheries point of view, the greatest pollution problem in this river basin is the discharge of municipal sewage, paper mill waste, wash water, and other industrial wastes at Cloquet. Both the 1928-1929 survey and the present survey show that the effect of this pollution extends to St. Louis Bay and has nearly eliminated fishing and fish life from this lower stretch of river….Other sources of pollution in the lower river are sewage from the City of Carlton and wastes from steel mills, ship yards, and other industrial activities near or on the estuary."

-MN Division of Game and Fish, 1944

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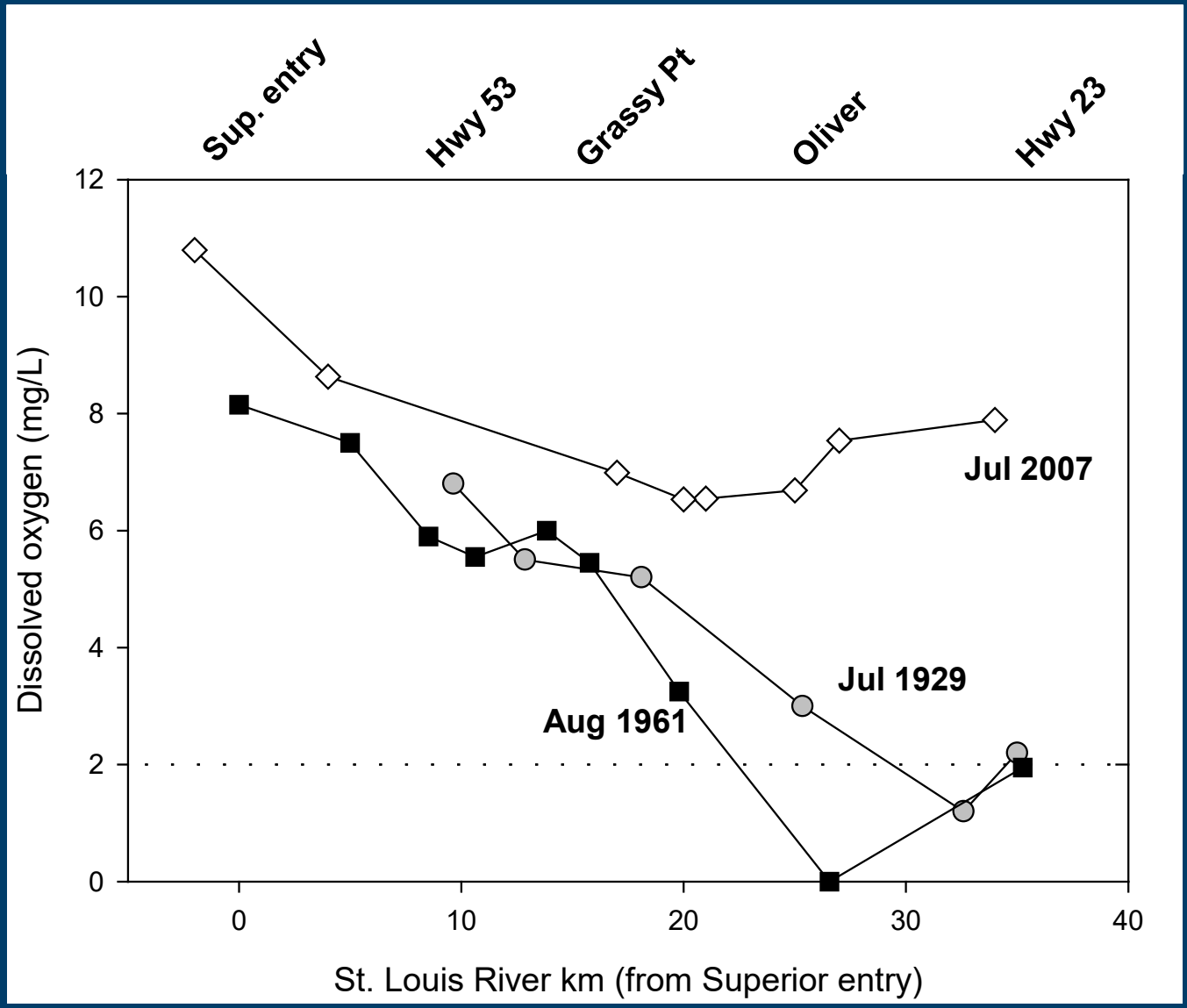
Bellinger et al., 2016



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Long-term data (STORET)

MPCA monitoring

Blatnik Bridge:
1973-2008

Arrowhead Bridge:
1973-1984

Oliver Bridge:
1973-1996

Hwy 23 Bridge:
1953-2008

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Major Findings ca. 2011

- Episodic hypoxia in the mainstem of the estuary was eliminated after 1975
- Concentration and loading of TSS and TP have decreased substantially over time
- Trends in N concentration and loading, though generally declining, were complicated by Lake Superior nitrogen inputs and changes in wastewater treatment practices

Bellinger et al., 2016

Solstice Flood 2012

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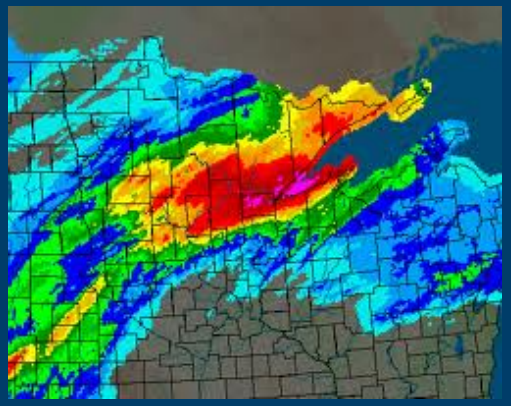
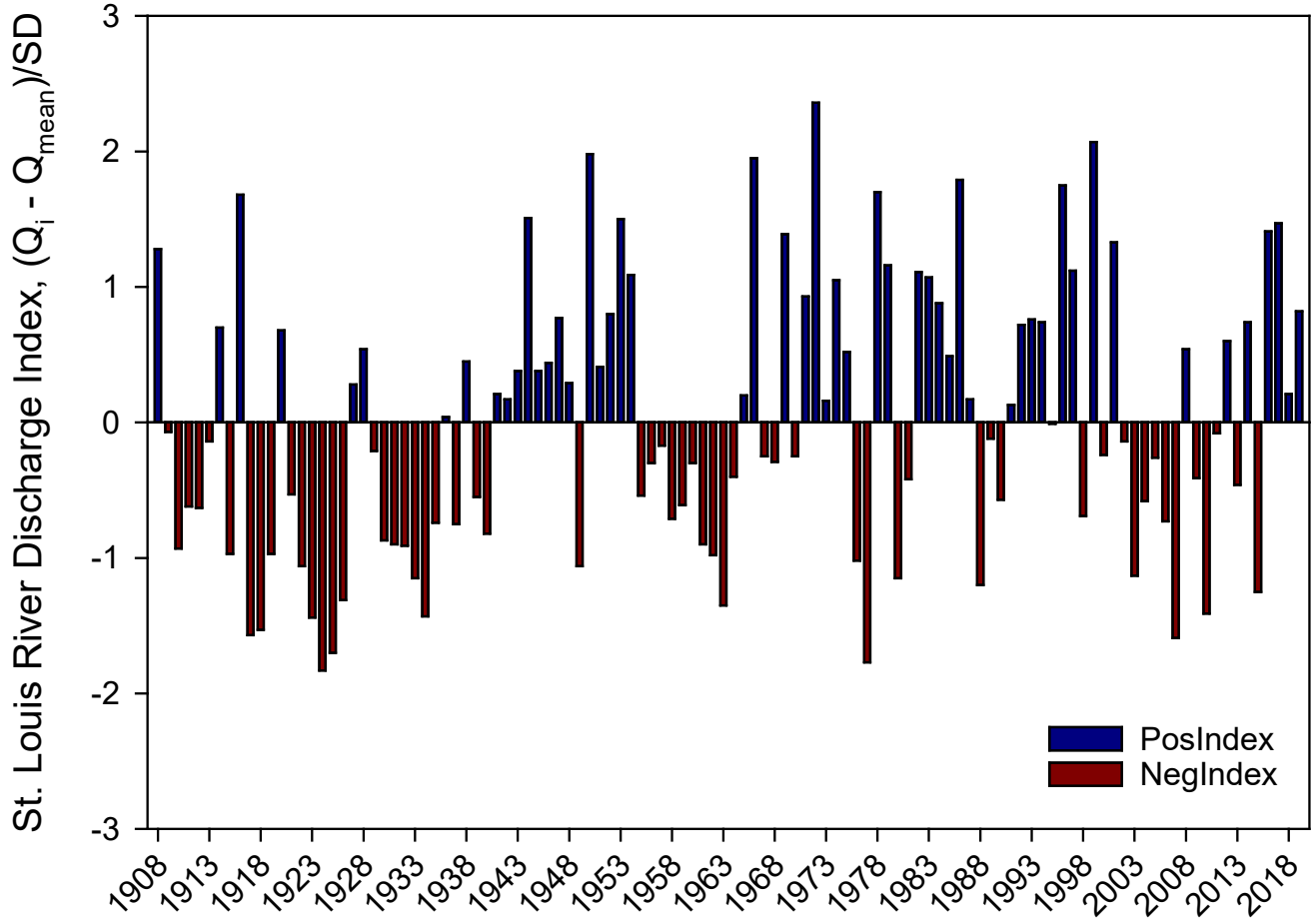


Photo credits: Lake Superior Streams, Washington Post, Minnesota Power, WCCO-TV,

Discharge (USGS @ Scanlon)



System-Wide Monitoring Program

"Identify and track short-term variability and long-term changes in the integrity and biodiversity of estuarine ecosystems."

Abiotic Monitoring

- Water quality
- Weather parameters

Biological Monitoring

- Habitat Change
- Biodiversity

Watershed and Land Use Classifications

SWMP Water Quality Stations

System-Wide Monitoring Program

Abiotic Monitoring:

Water Quality	Meteorological	Nutrients
• 4 sites • Deployed data sondes • 15-minute data • Real-time	• 1 site • 15-minute data • Real-time	• 4 sites • Grab samples 1x per month • Diel samples 1x per month at 1 site

Nutrients and Chlorophyll

"NUTCHLa"

- Dissolved Ammonium
- Dissolved Nitrite, nitrate
- Dissolved Orthophosphate
- Chlorophyll-a
- Total Suspended Solids: Dissolved Solids
- Total Phosphorus

Optional

Coming soon!

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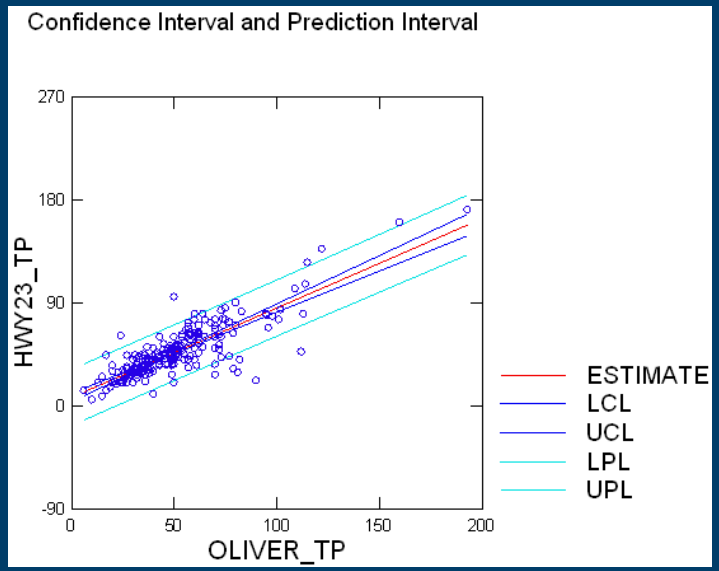
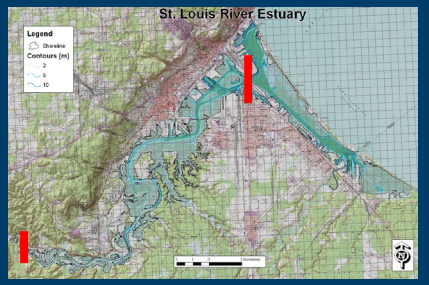
How has the system changed? Back to the present….

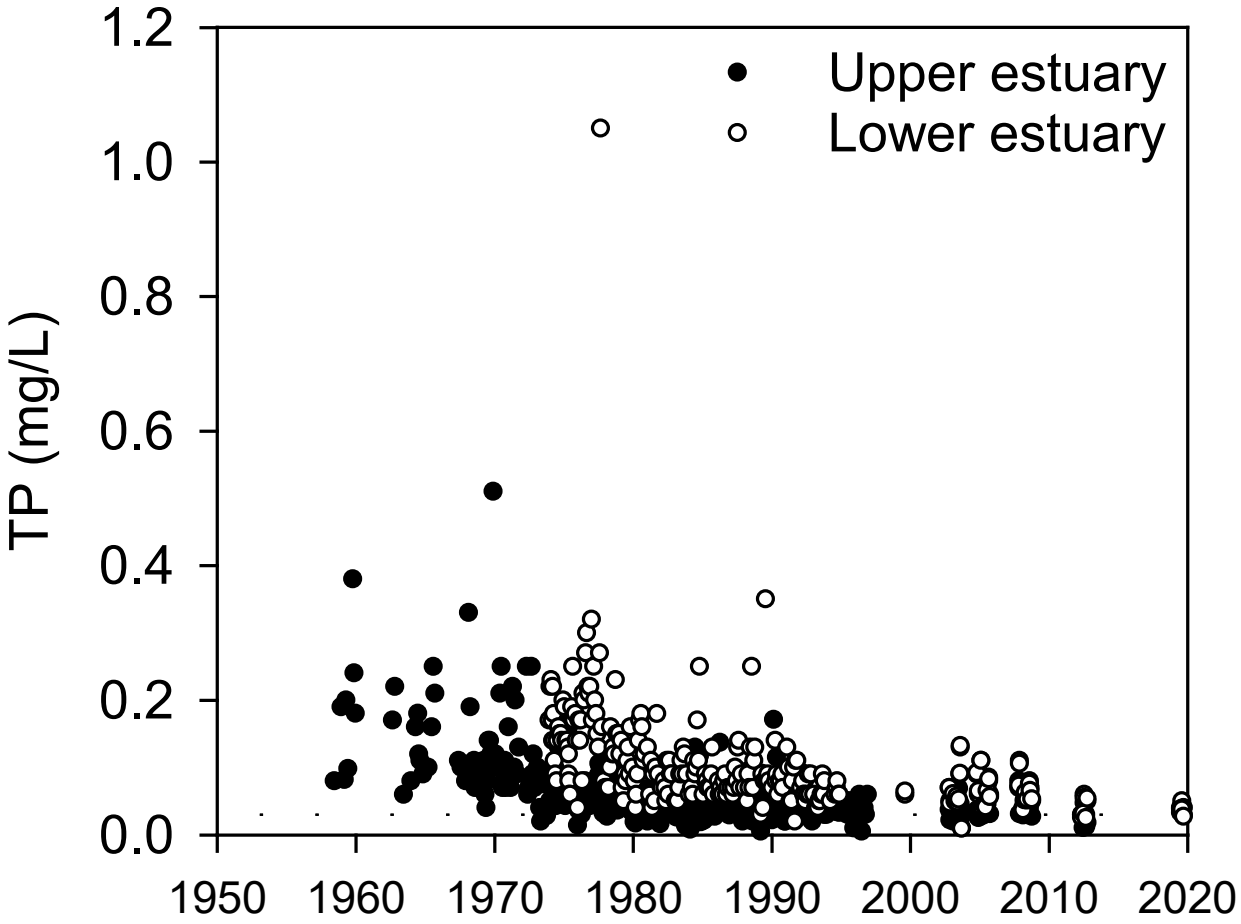
Updating the Time-Series

- SWMP data at Blatnik Bridge
- SWMP data at Oliver Bridge
  - –Best long-term historical data at Hwy 23 Bridge
  - –Compare time-series for Hwy 23 Bridge and Oliver Bridge
  - –All were significant ($p < 0.001$, $r^2 > 0.60$)
  - –Use linear regression to estimate new Hwy 23 Bridge based on LS NERR Oliver Bridge data

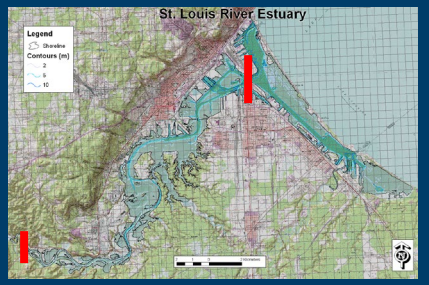


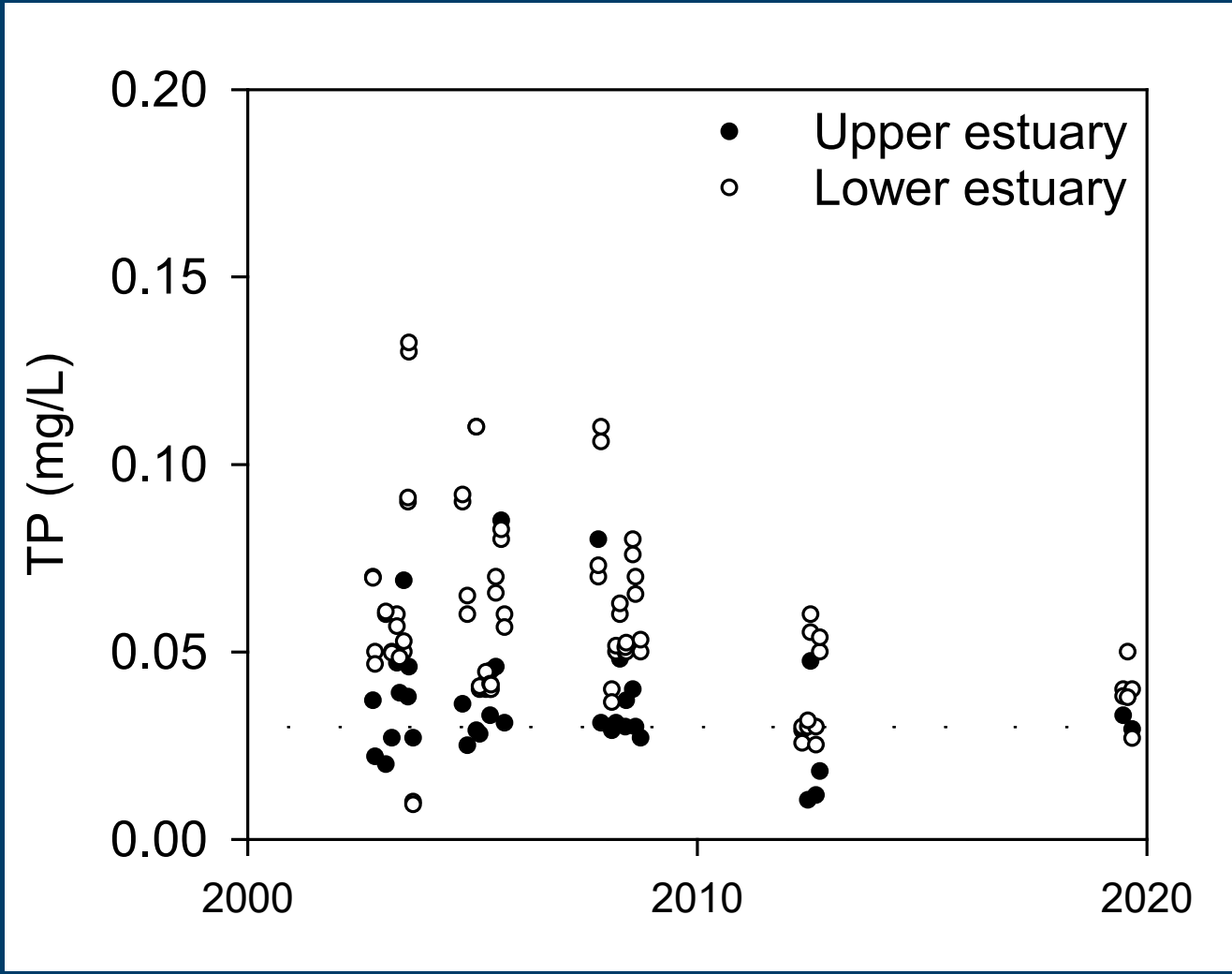
Total Phosphorous



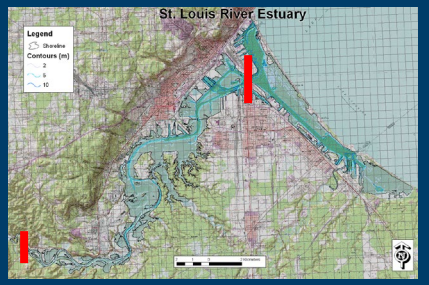


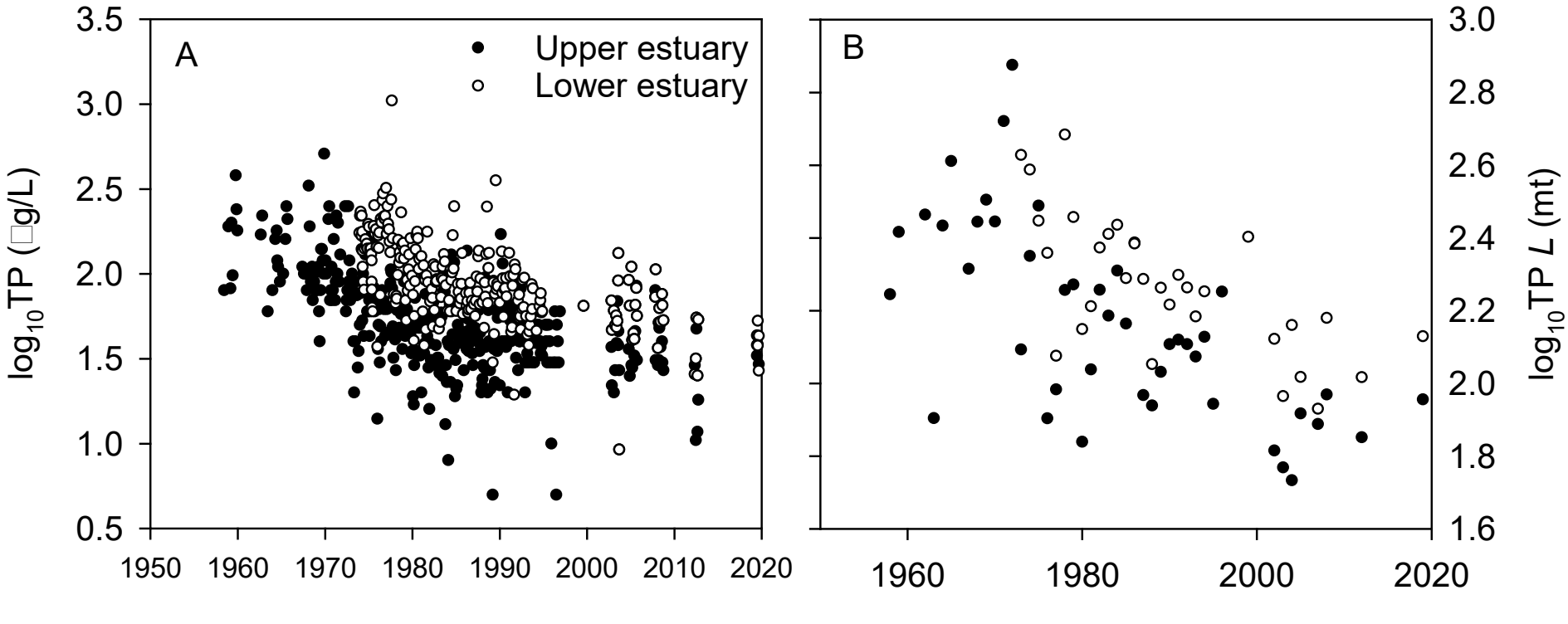
Total Phosphorous





Total Phosphorous





Since 2008 (n = 2)

- Mean of 119 mt tons yr^{-1} at Blatnik Bridge
- Mean of 81 mt yr^{-1} at Hwy 23 Bridge
- Therefore 38 mt yr^{-1} tons added internally

Total Suspended Solids

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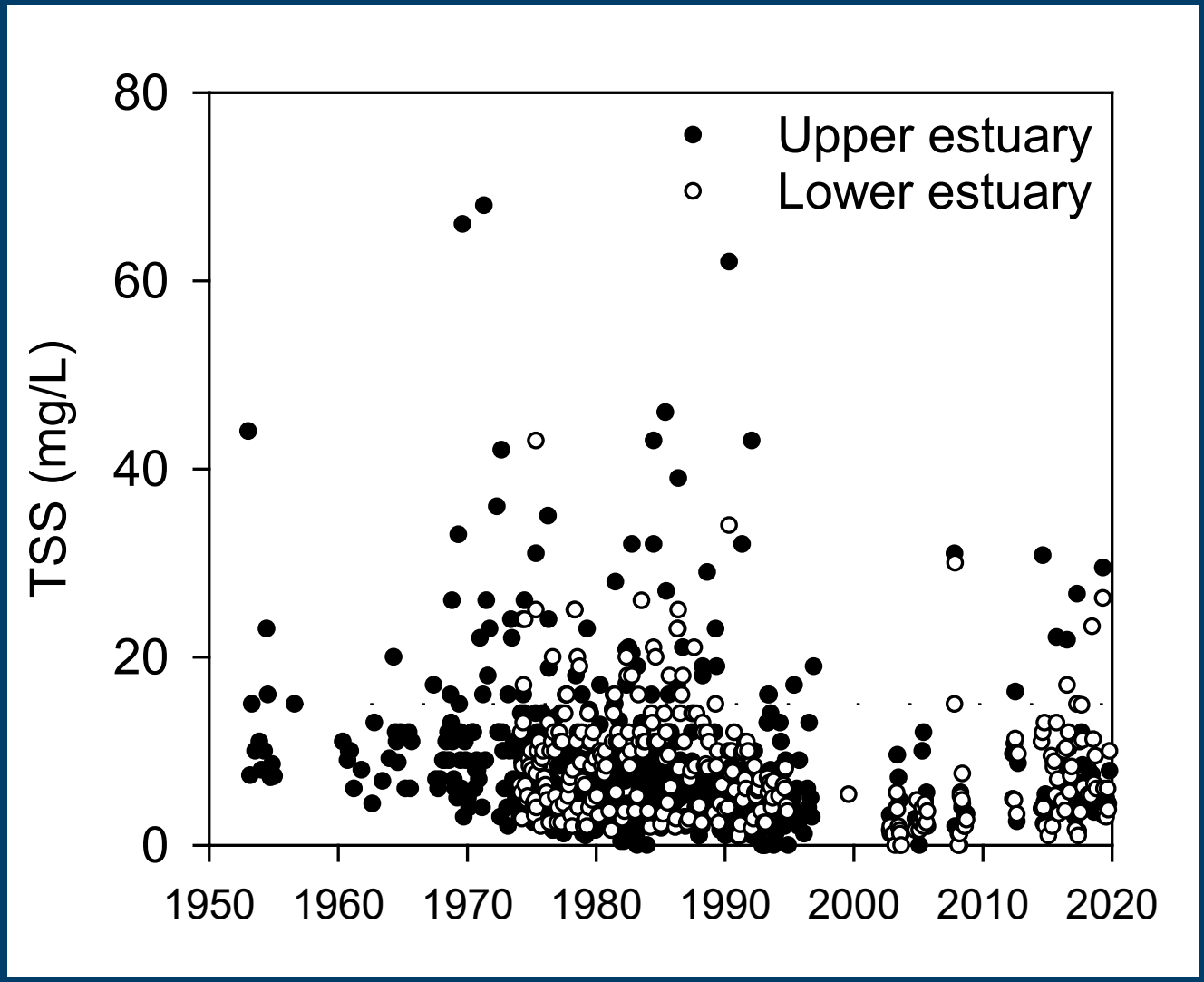
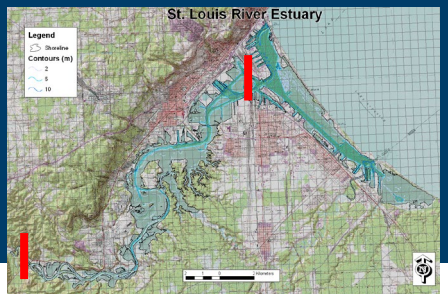
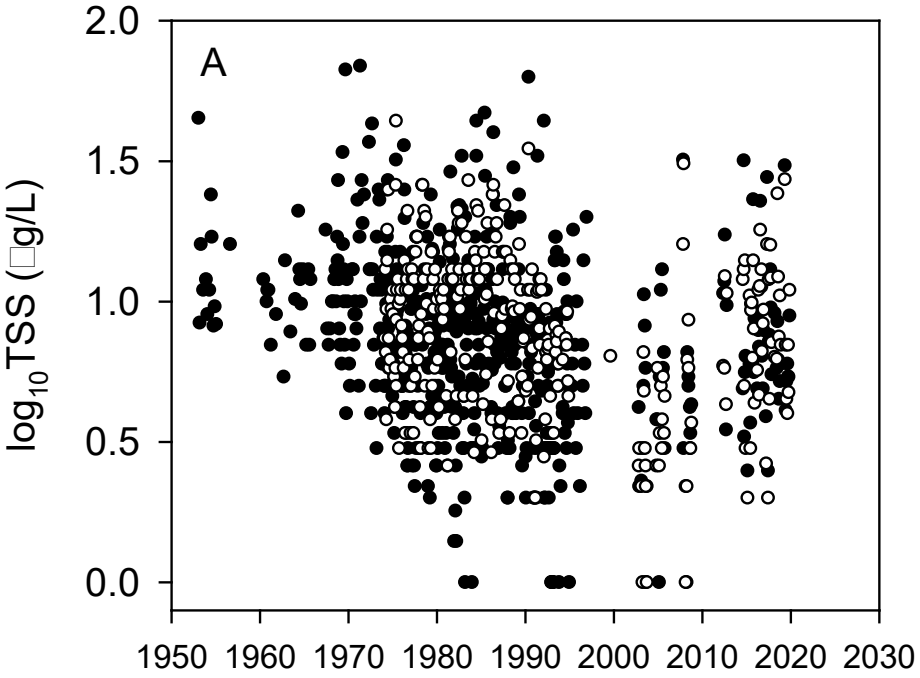
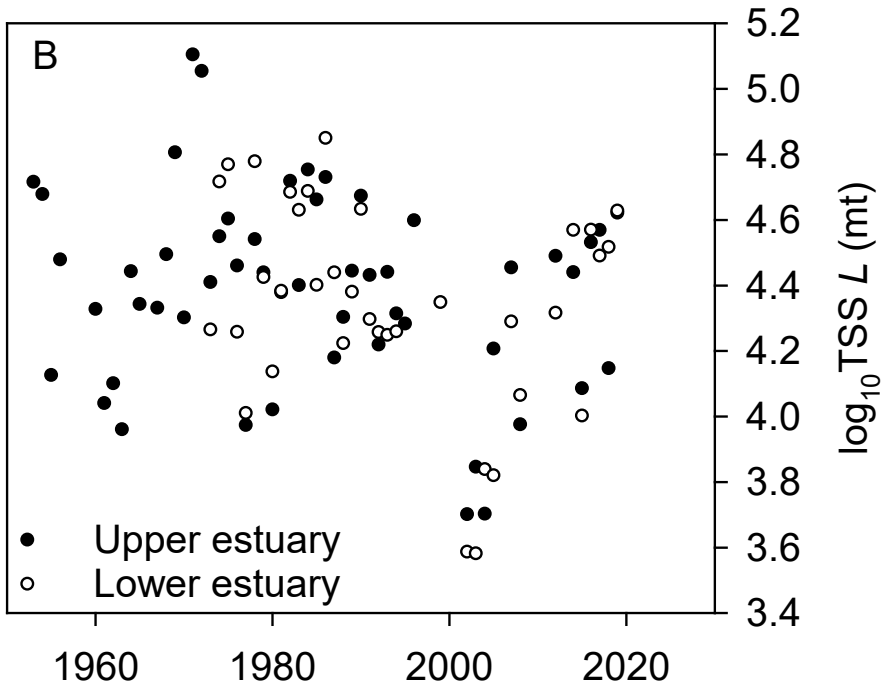


Total Suspended Solids

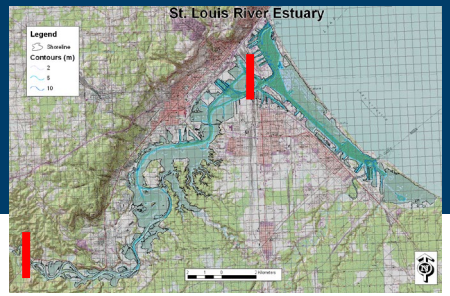


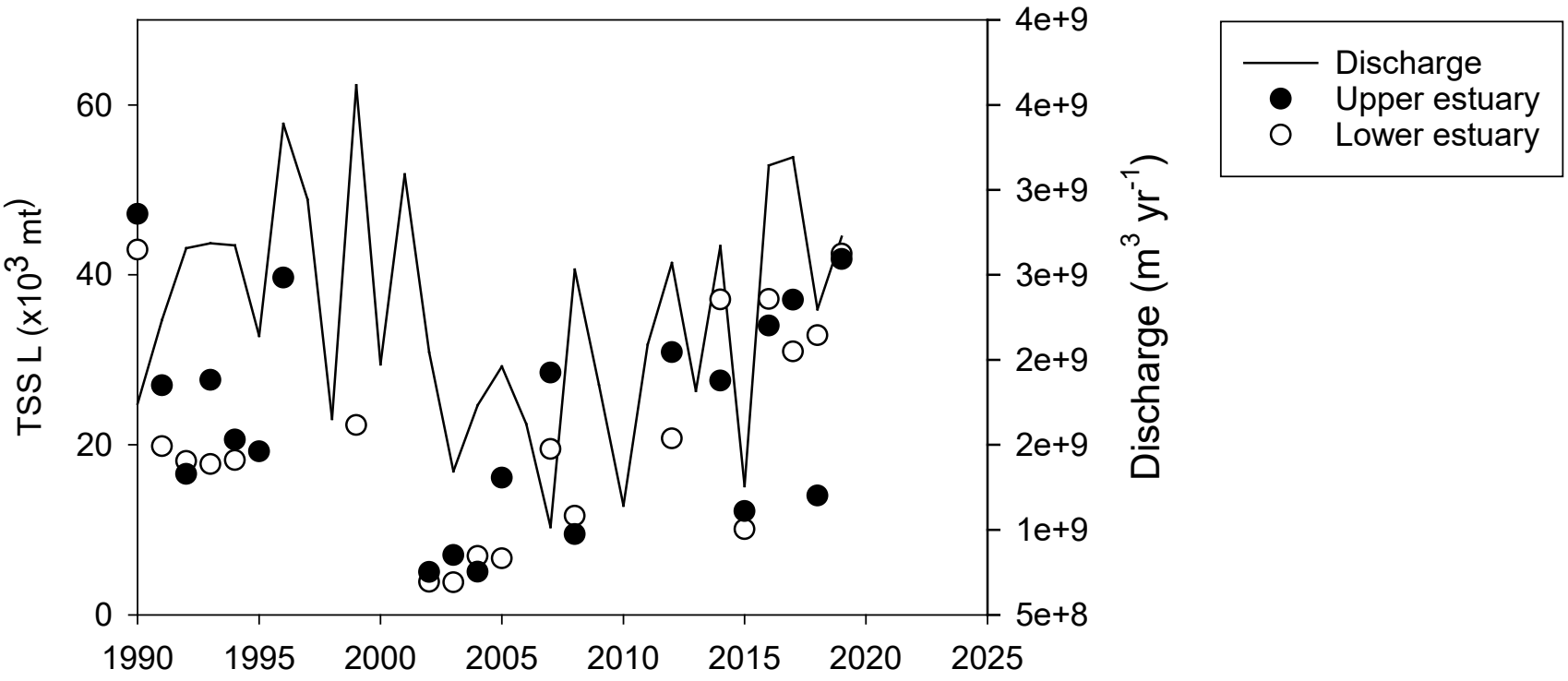




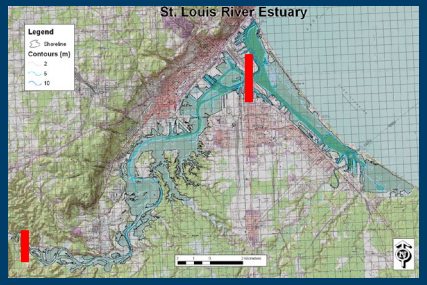
Since 2010, loadings…
Hwy 23 mean 27.1k mt
Blatnik Bridge mean 27.9k mt
Mean net addition only 0.8k mt in estuary

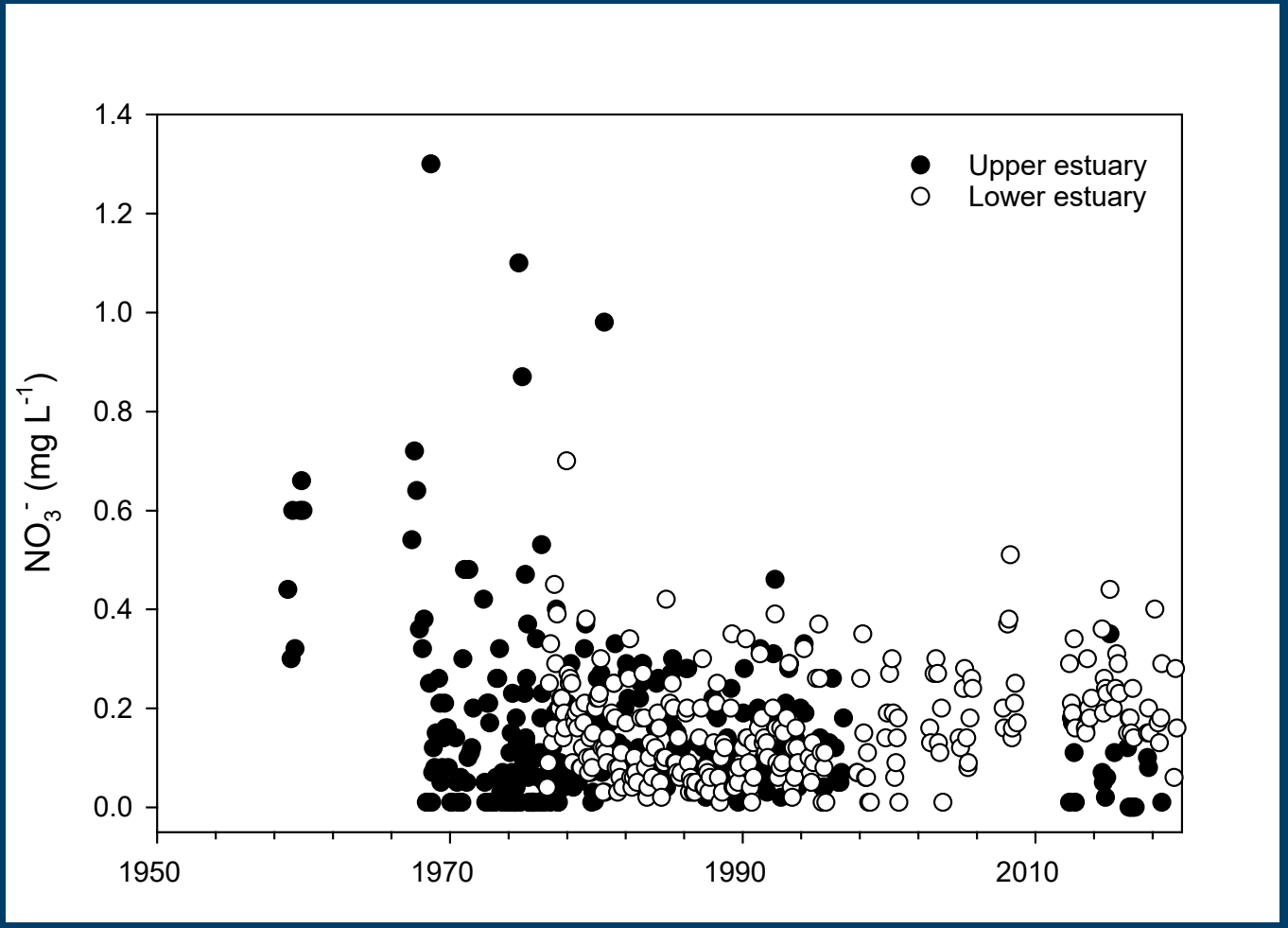
Total Suspended Solids



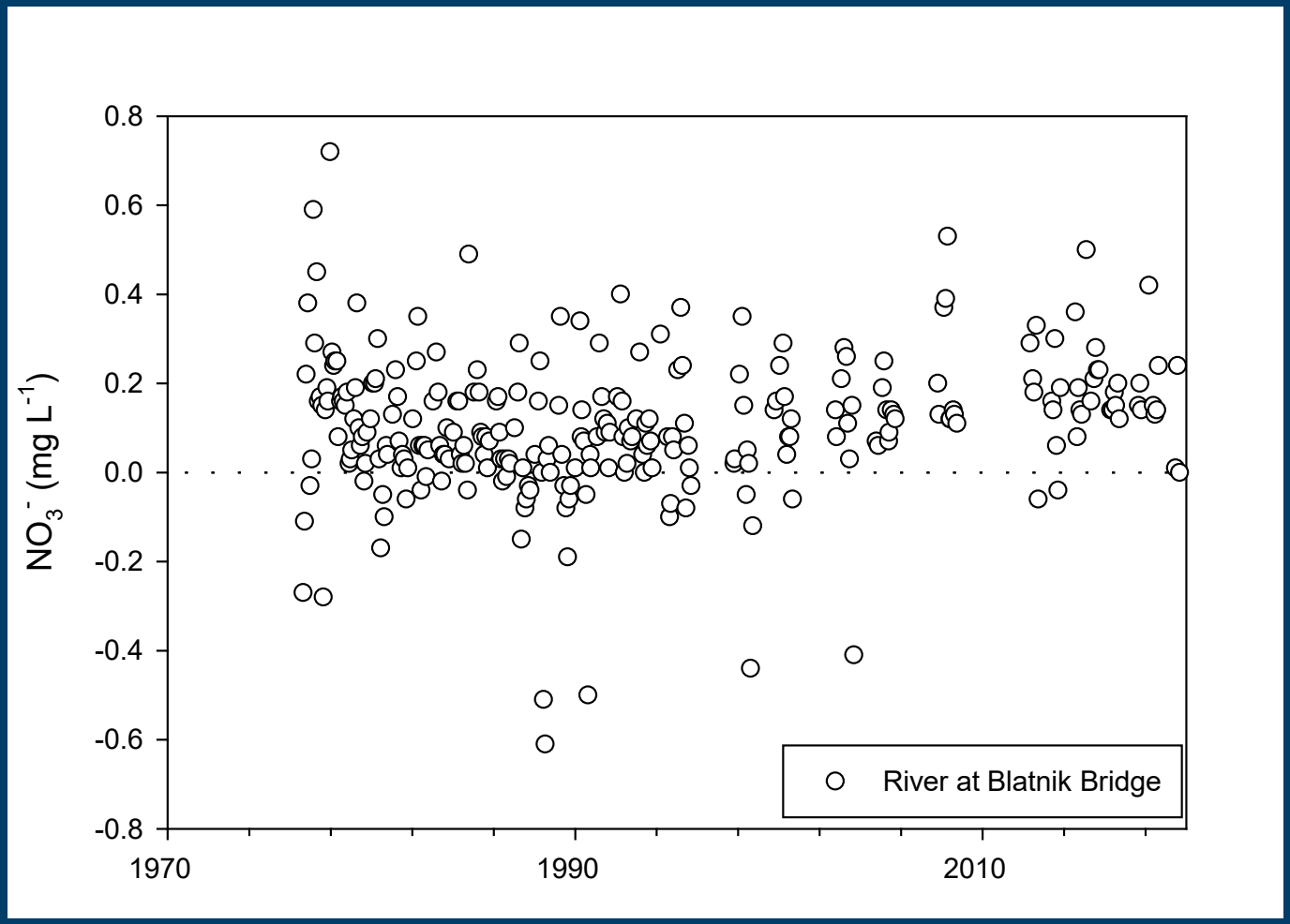


Nitrate

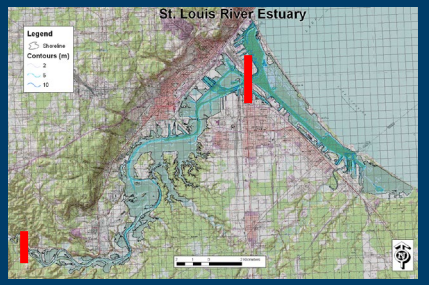

St. Louis River Estuary
Legend

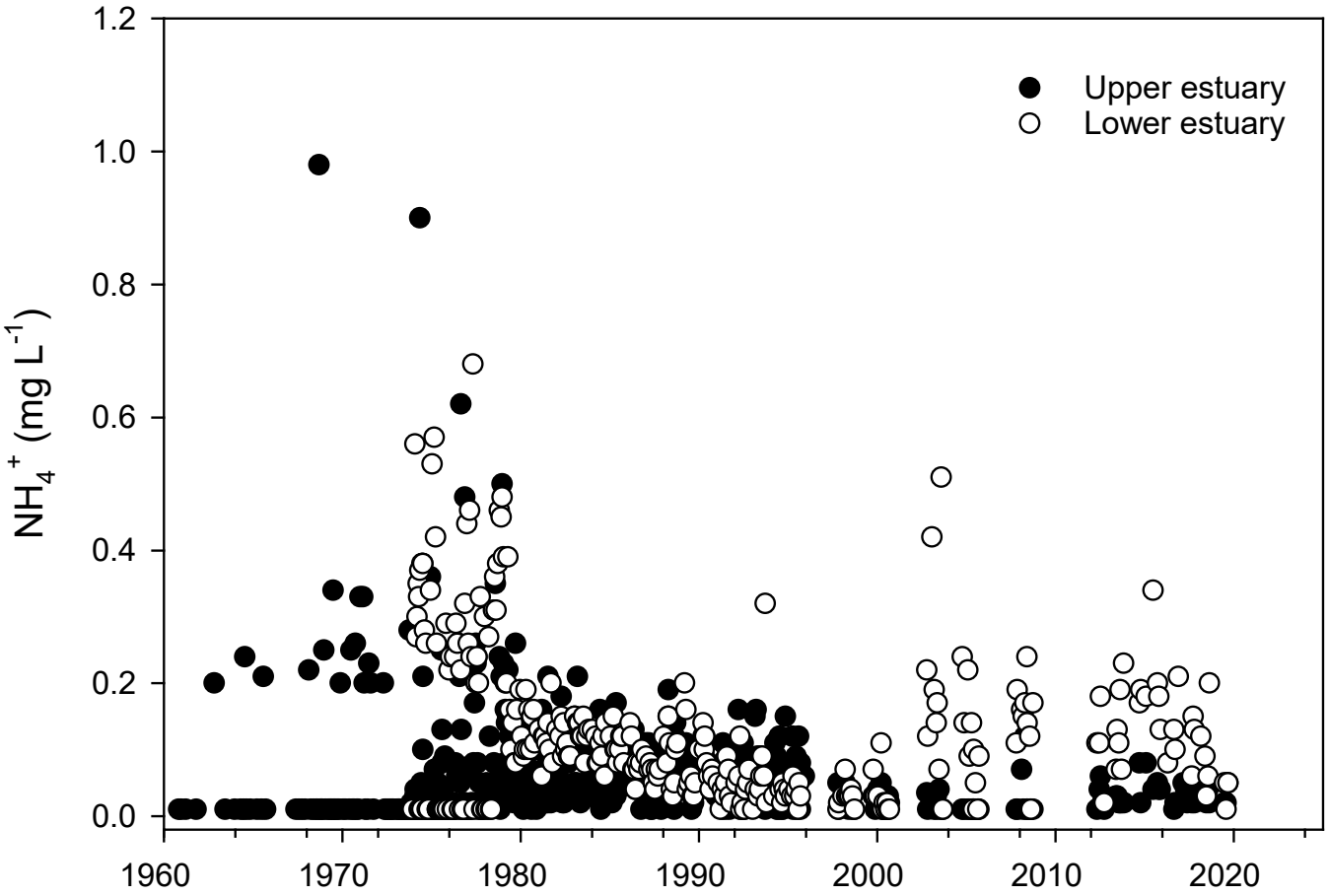

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
NO_3^- (mg L^{-1})
1950
1970
1990
2010
Upper estuary
Lower estuary

Nitrate

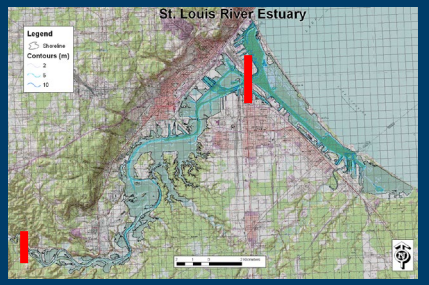

0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
NO_3^- (mg L^{-1})
1970
1990
2010
River at Blatnik Bridge
Load to Lake Superior
Uptake from Lake Superior

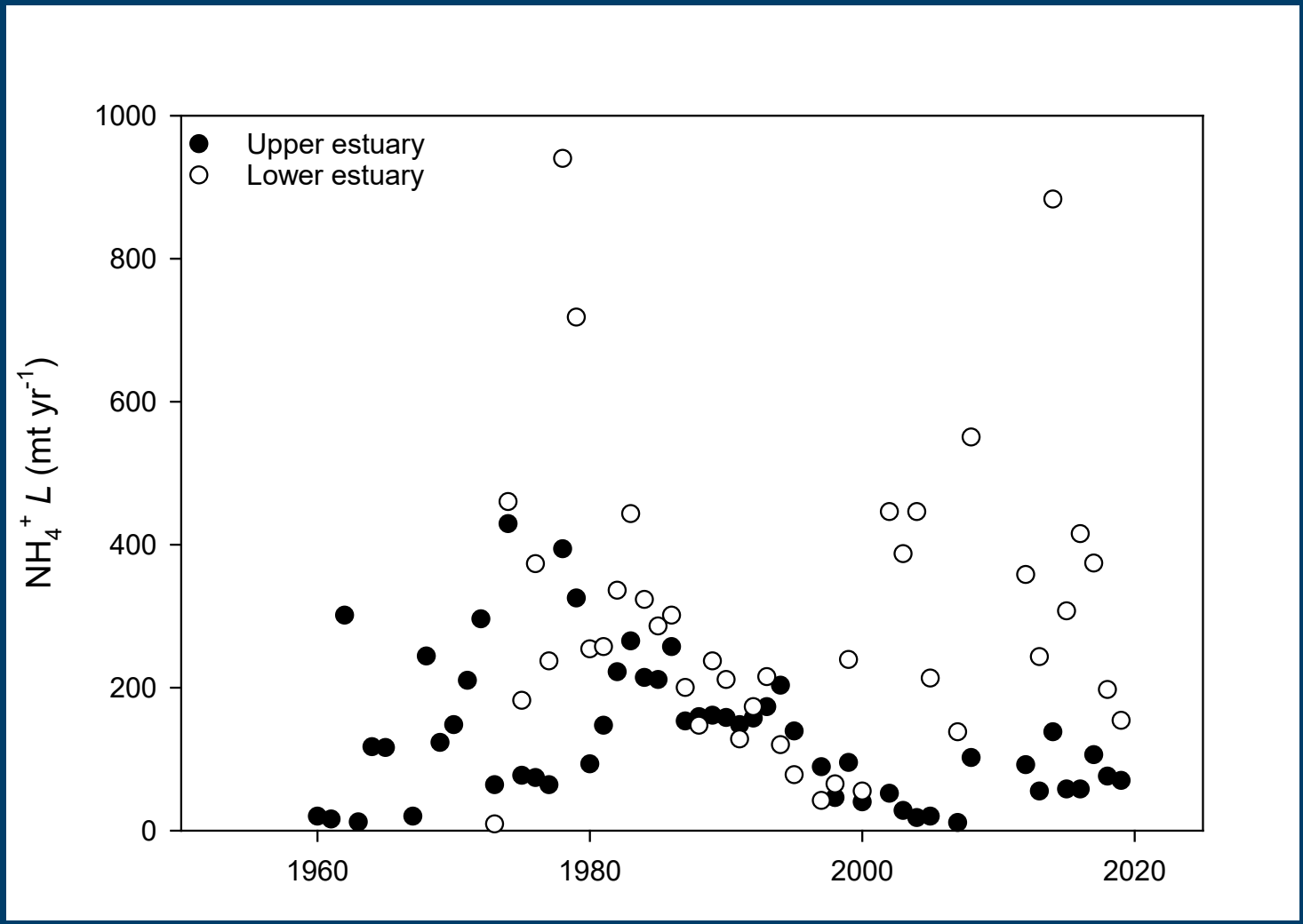
Ammonium


St. Louis River Estuary
Legend
Shoreline
Contours (m)


1.2
1.0
0.8
0.6
0.4
0.2
0.0
NH_4^+ (mg L^{-1})
1960
1970
1980
1990
2000
2010
2020
Upper estuary
Lower estuary

Ammonium


St. Louis River Estuary
Legend
Shoreline
Contours (m)
2
5
10


1000
800
600
400
200
0
1960
1980
2000
2020
Upper estuary
Lower estuary
NH_4^+ L (mt yr^{-1})

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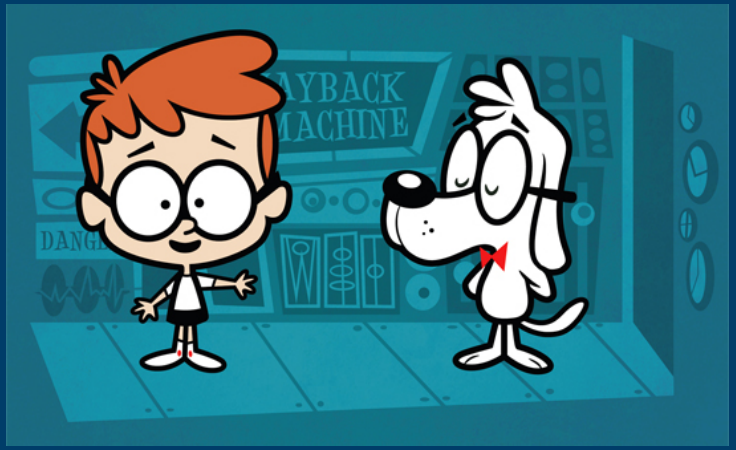
Conclusions

- Long-term trends demonstrate a dramatic recovery in water quality throughout the lower river
  - DO in the mainstem has recovered
  - Annual TP loads have decreased faster in the lower river than the upper river since the mid-1990s
  - TSS is near neutral
- Recently, dry and wet cycles appear to influence contrasting periods characterized by relatively low (dry) versus high (wet) loadings of TSS and ammonium, ***albeit not for TP and nitrate***
- The water quality record shows a dynamic evolution from a period strongly affected by unregulated discharges and poor land use practices, to an era of recovery driven by hydrologic cycles



Acknowledgements

- LS NERR SWMP Team
- MPCA Milestone Monitoring Program