Illinois NLRS Nutrient Monitoring Council

Virtual Meeting
August 2, 2022

Illinois Department of Agriculture

Illinois Environmental Protection Agency

Illinois Extension
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

ILLINOIS NUTRIENT LOSS REDUCTION STRATEGY

Roles

Welcome: *Trevor Sample, IEPA*

Moderator: *Eliana Brown, Illinois Extension*

Technology Assistance: *Layne Knoche, Illinois Extension*

Meeting minutes: *Joan Cox, Illinois Extension*

Attendance

Please type your name and affiliation into the chat box.

ILLINOIS
NUTRIENT LOSS
REDUCTION STRATEGY

Agenda

9:00 (10 min.)	Welcome *Trevor Sample, Illinois Environmental Protection Agency*
9:10 (30 min.)	Statewide nutrient load update *Tim Hodson, United States Geological Survey* Q & A
9:40 (25 min.)	Illinois River Basin Phosphorus Loads 1979-2019 *Greg McIsaac, University of Illinois* Q & A
10:05 (5 min.)	Break
10:10 (35 min.)	Rock River Basin Nitrate Loads 1980-2019 *Greg McIsaac* Q & A
10:45 (30 min.)	Preliminary results for groundwater nitrate modeling in the Rock River region *Vlad Iordache, Illinois State Water Survey* Q & A
11:15 (30 min.)	Illinois River Basin next generation monitoring *Tim Straub, USGS Geological Survey* Q & A
11:45 (15 min.)	NMC Member Updates
NOON	Adjourn

ILLINOIS NUTRIENT LOSS REDUCTION STRATEGY

Nitrate and Phosphorus Loads from Illinois Rivers

Water Year 2021 Update

Timothy Hodson

Central Midwest Water Science Center

tohodson@usgs.gov

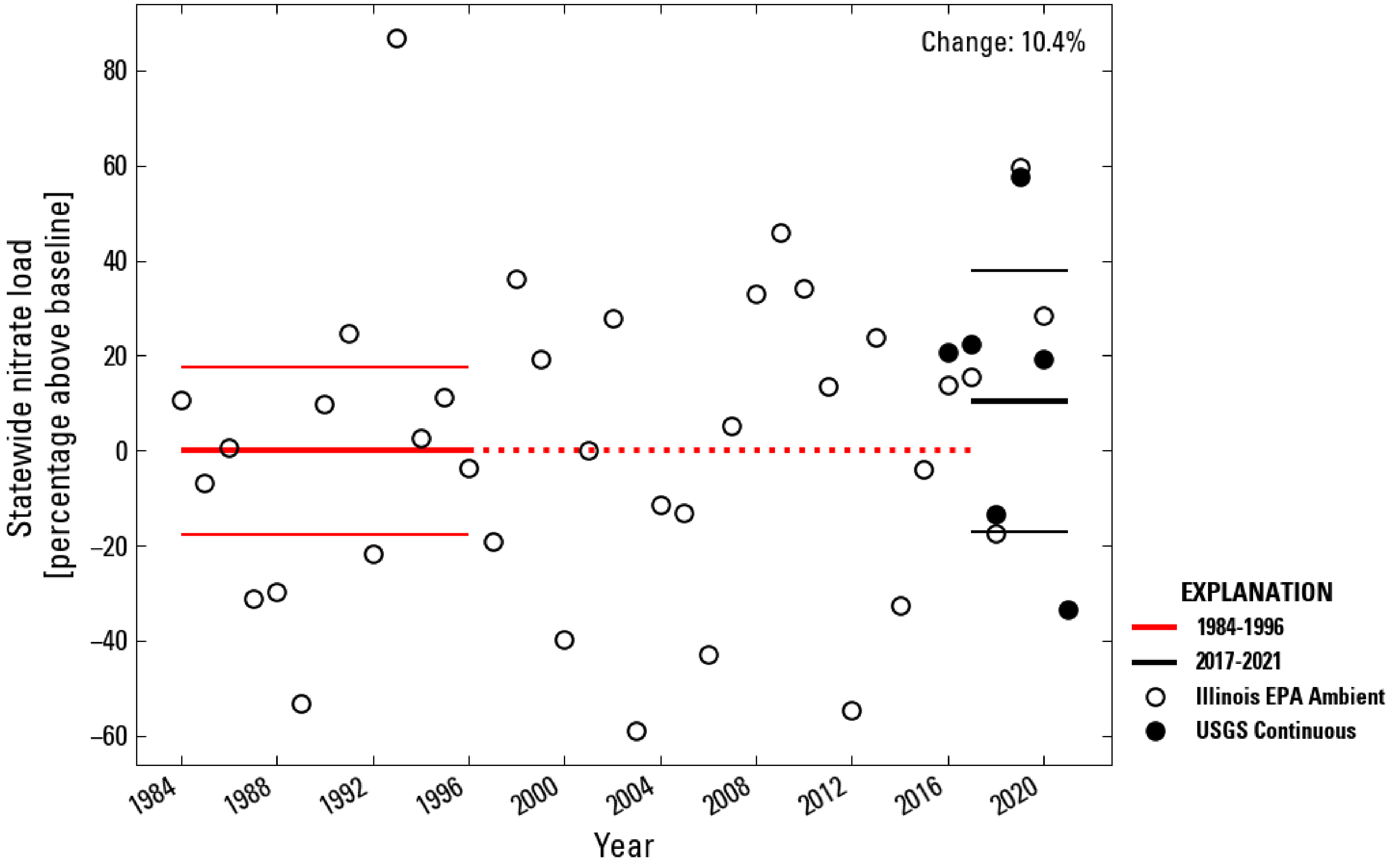
with: Illinois Environmental Protection Agency

Methods

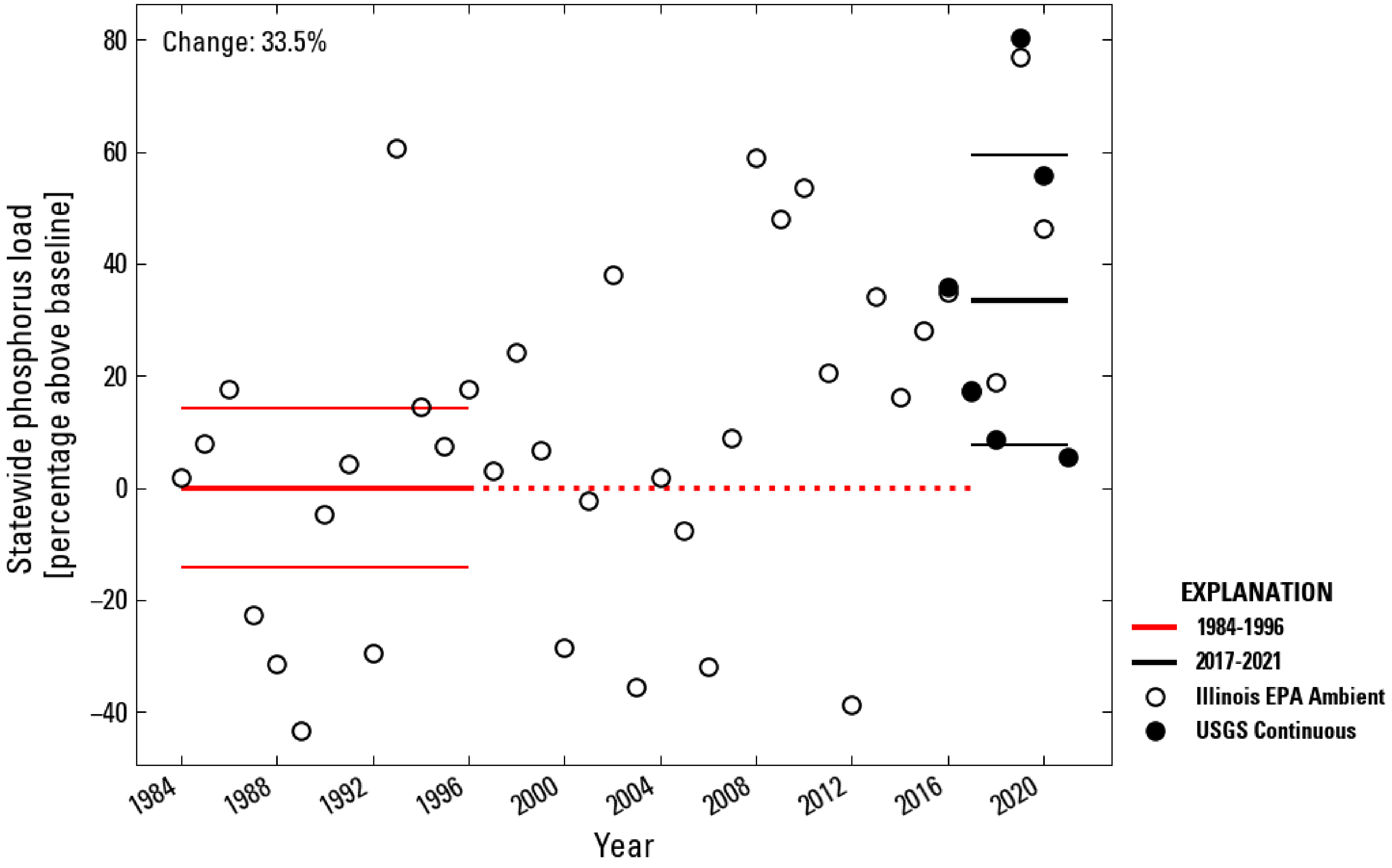
Replicates methods from previous biennial reports, except:

- **baseline period: water years 1984–1996***
- **current period: water years 2017–2021**
- **no subtraction for Rock River***
- **incorporates continuous water quality data**
- **error bars estimate 95% confidence interval**

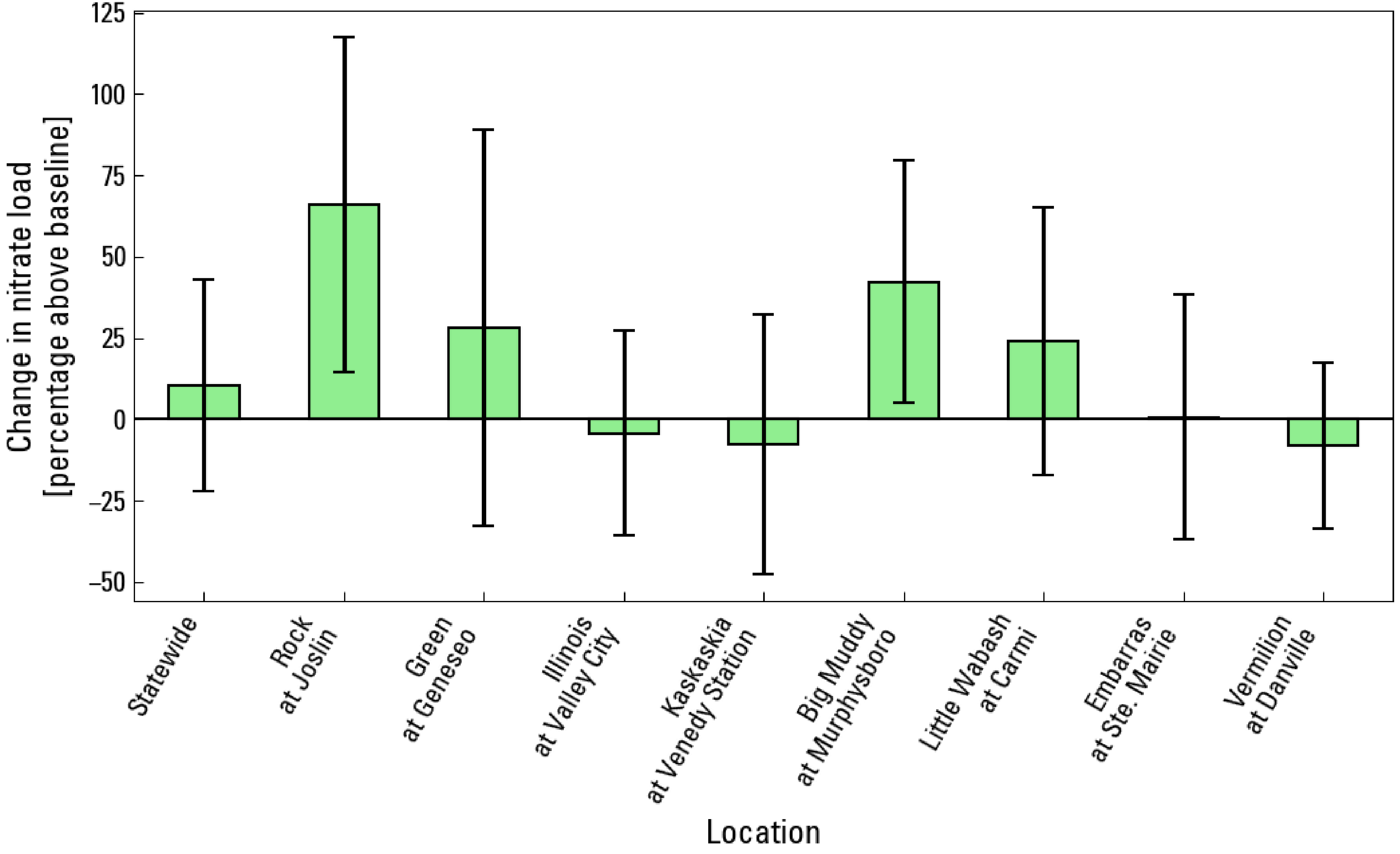
Statewide nitrate load



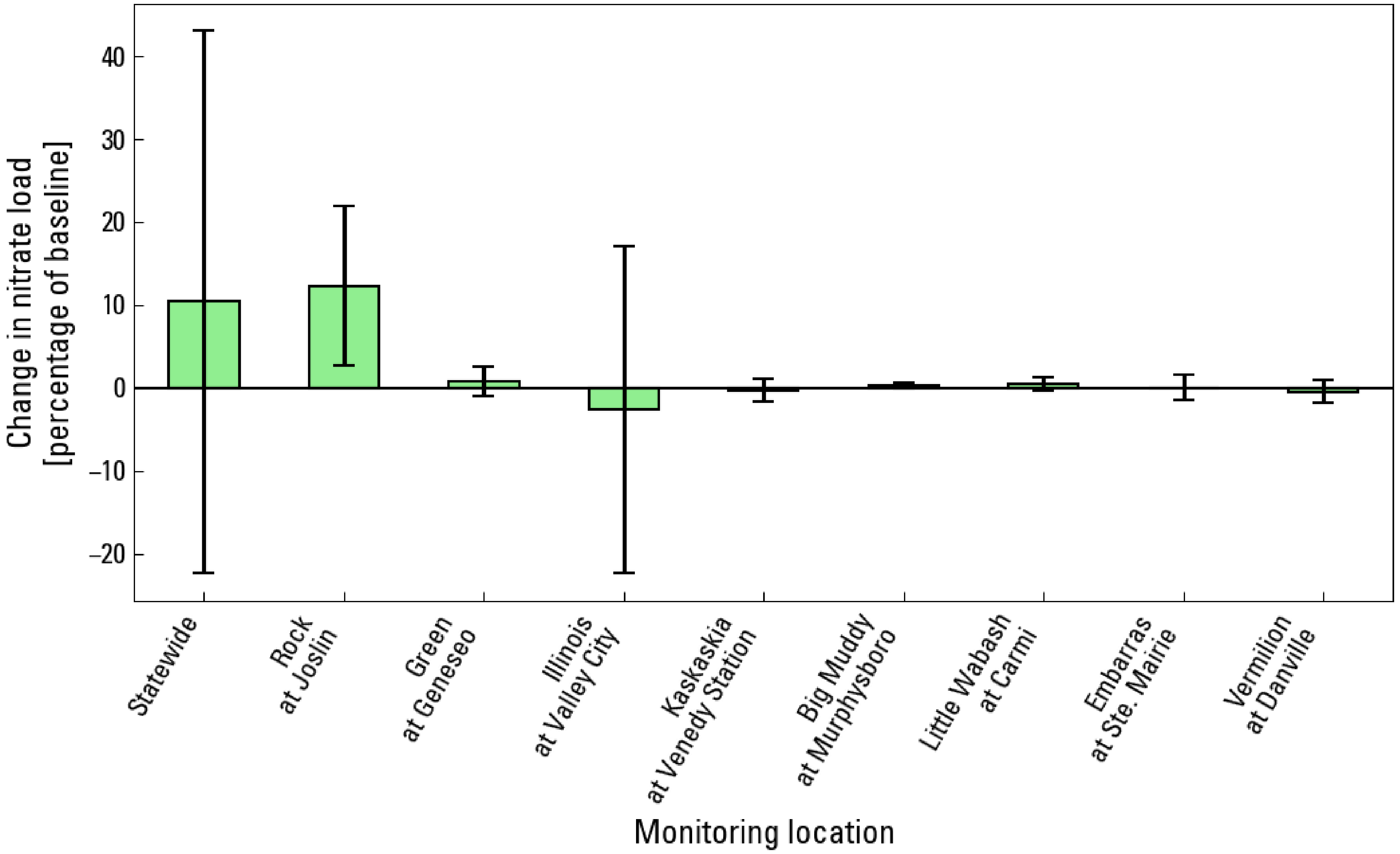
Statewide phosphorus load



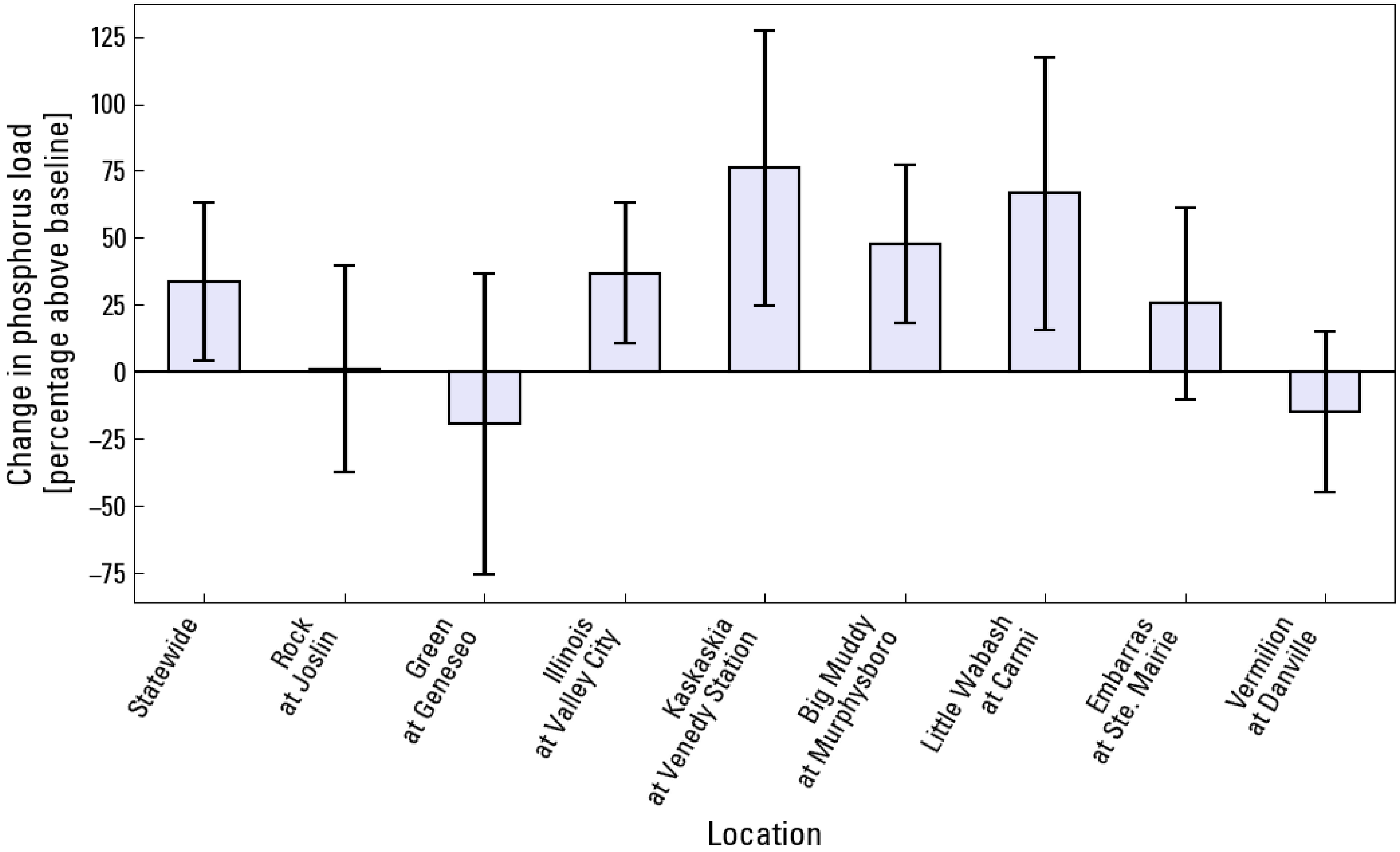
Change in nitrate relative to baseline



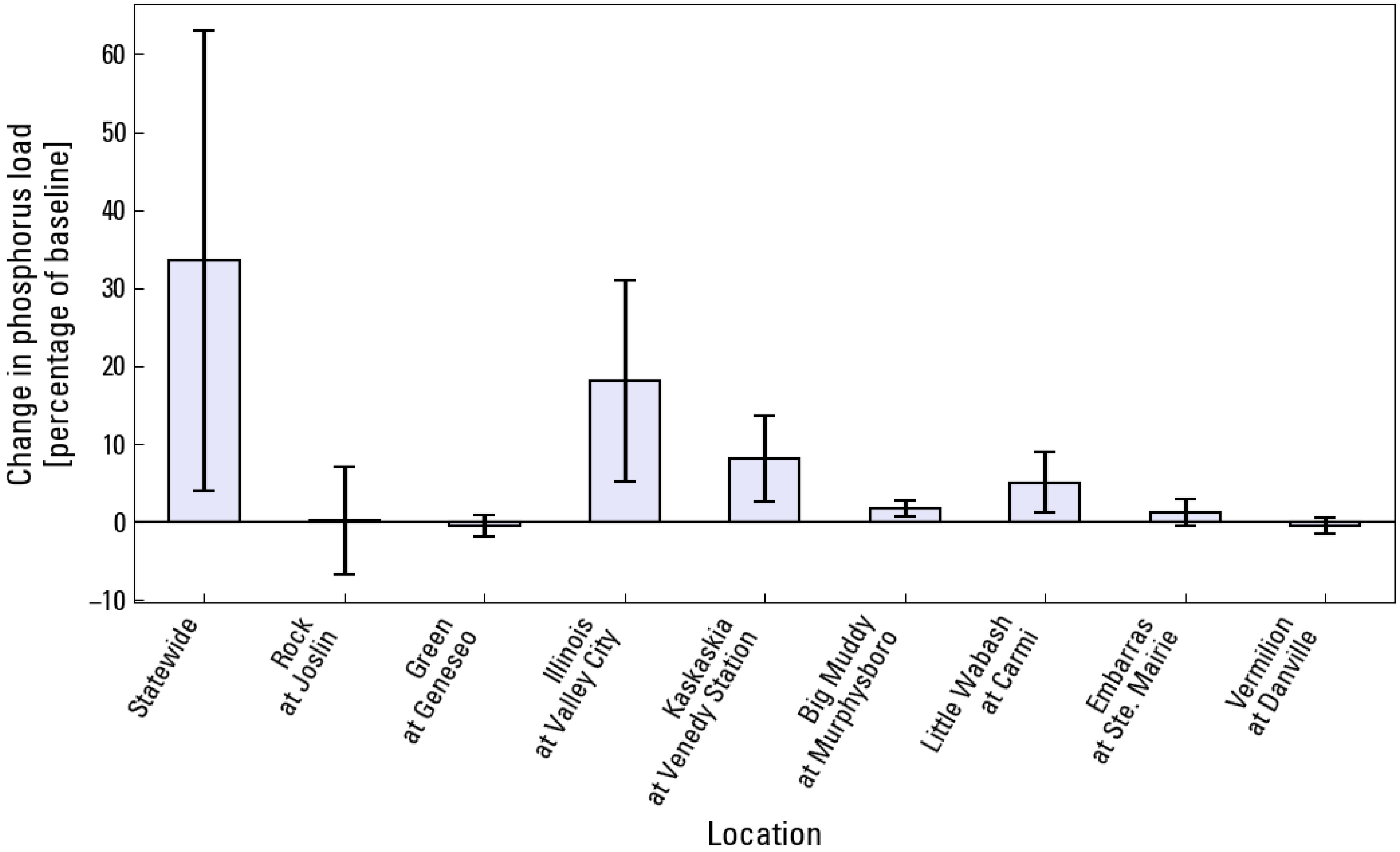
Change in nitrate relative to baseline



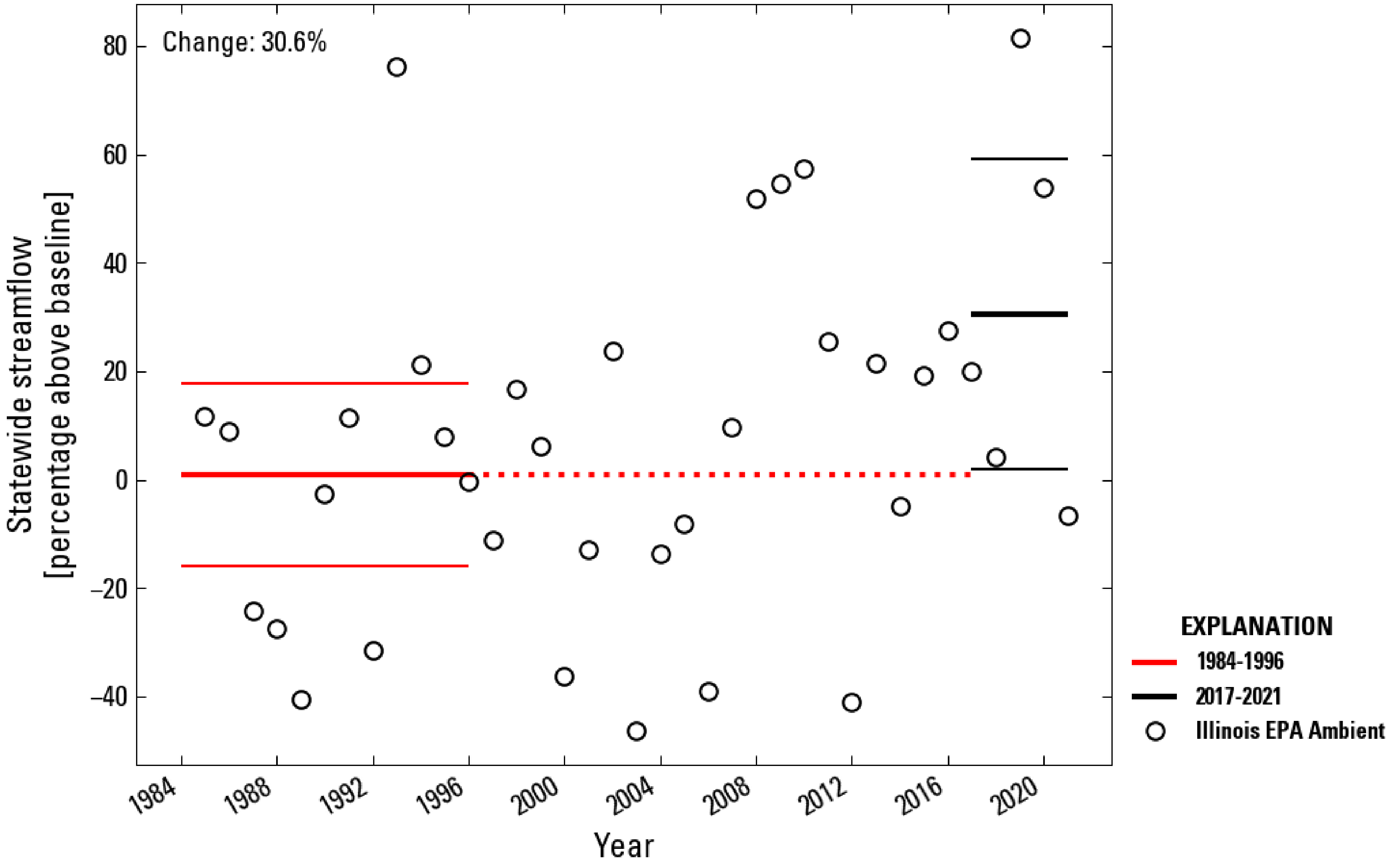
Change in phosphorus relative to baseline



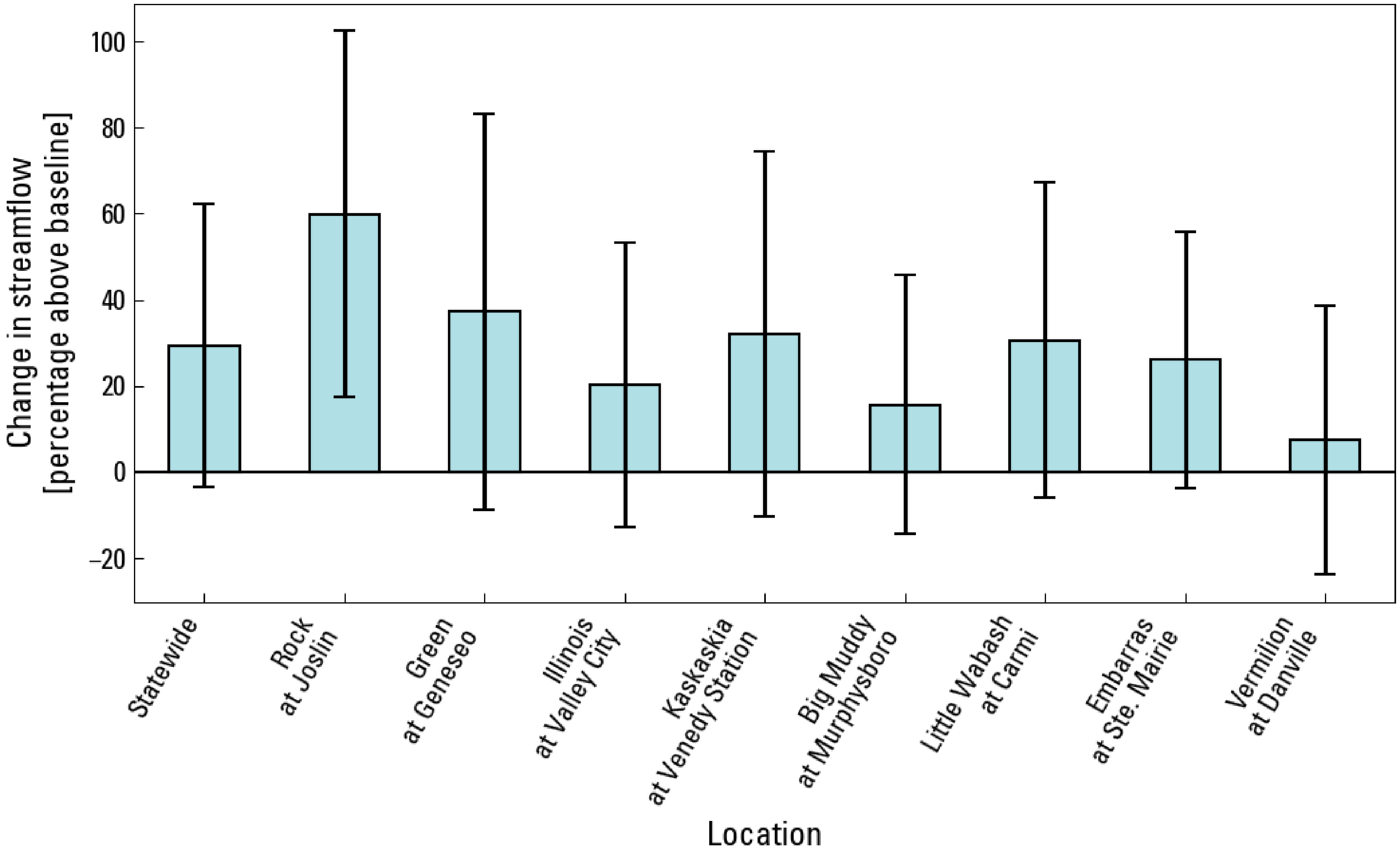
Change in phosphorus relative to baseline



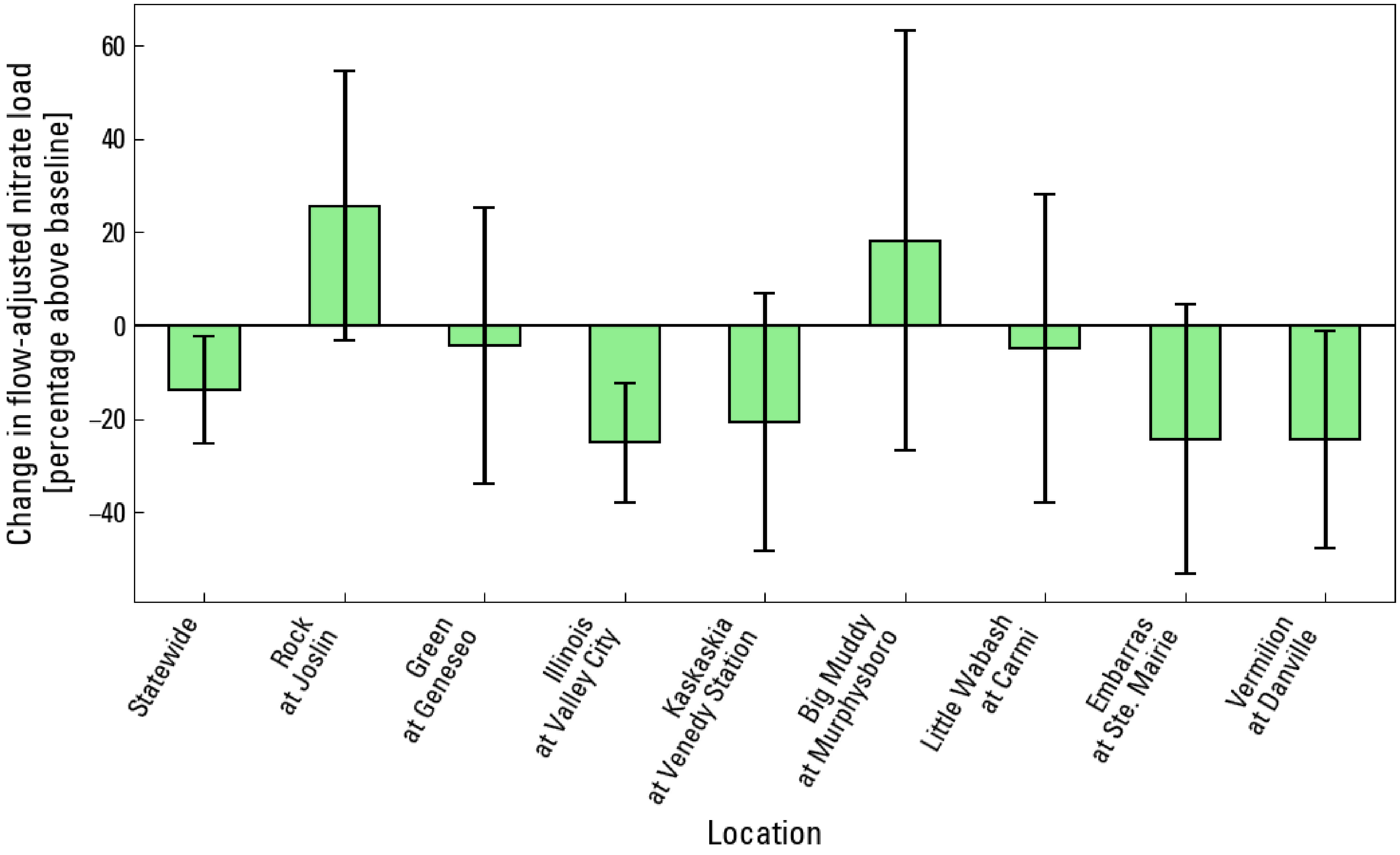
Statewide streamflow



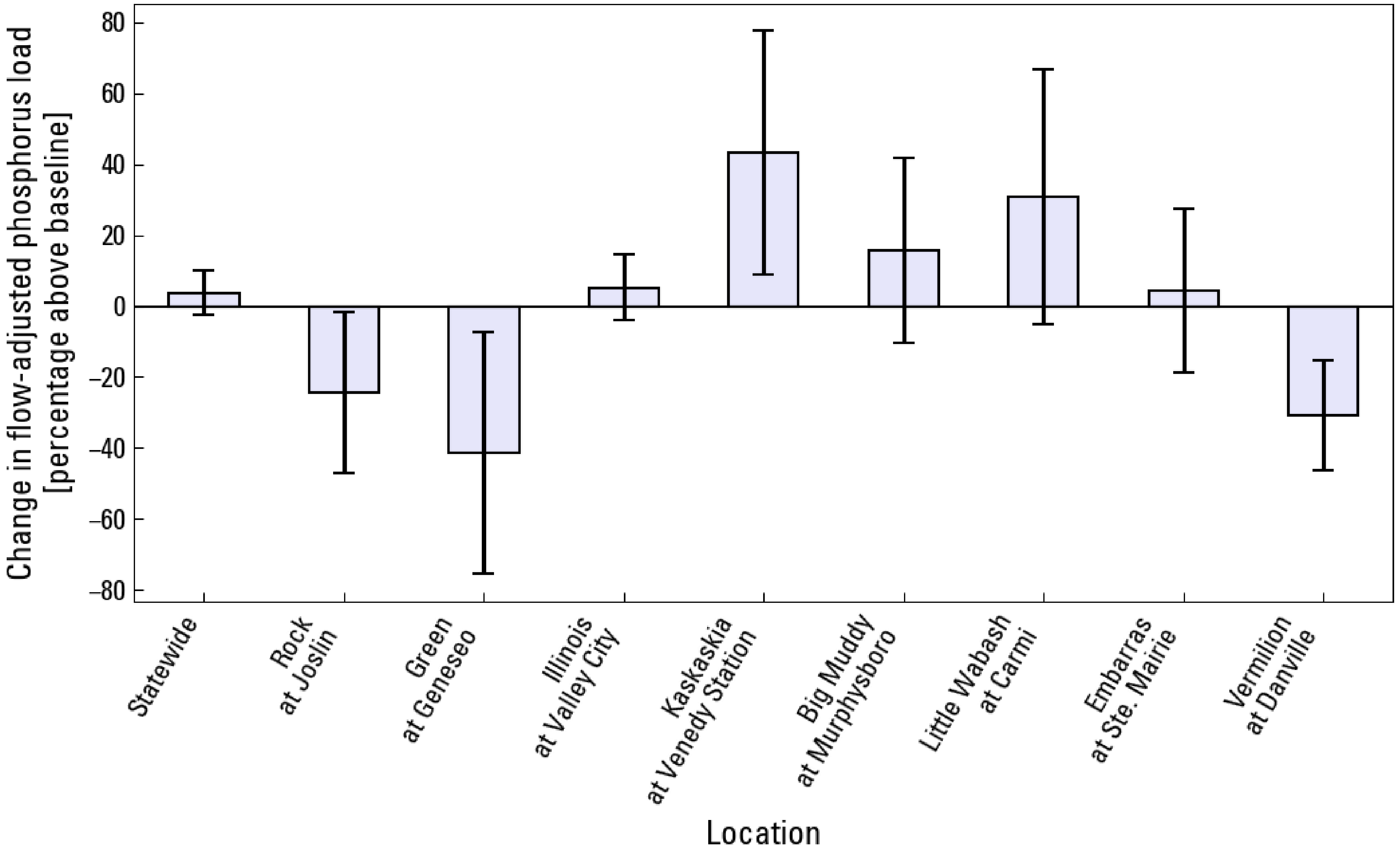
Change in streamflow relative to baseline



Change in flow-adjusted nitrate load



Change in flow-adjusted phosphorus load



Summary

1. Nitrate load has increased 10%, primarily from the Rock River
2. Phosphorus load has increased 30%, primarily from the Illinois, Kaskaskia, and Little Wabash Rivers
3. Streamflow has increased 30% statewide
4. Adjusting for streamflow, nitrate loads have declined 10%.
5. Adjusting for streamflow, phosphorus is approximately at the baseline load.

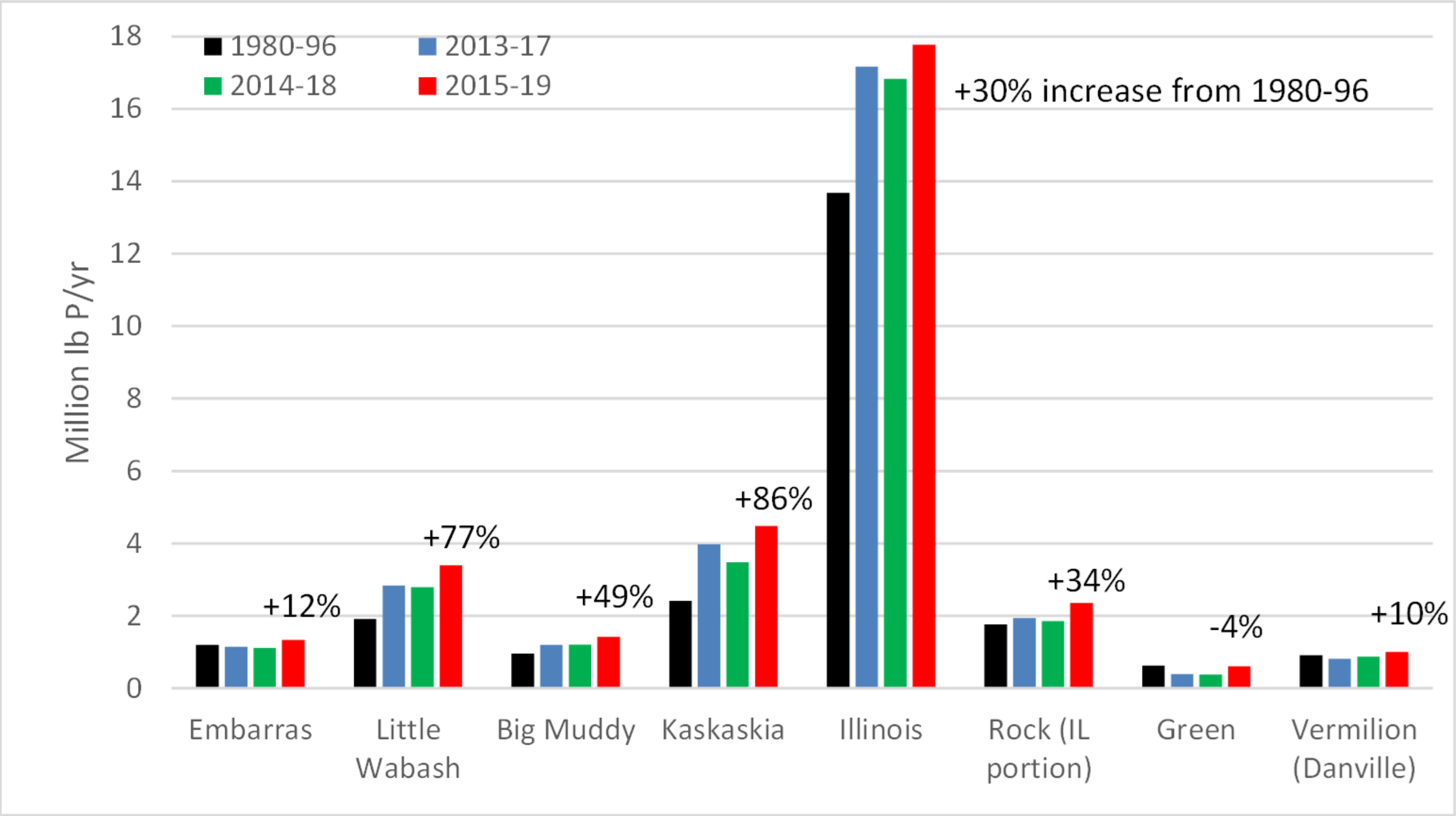
Phosphorus loads in the Illinois River Basin: 1980s-2019

Gregory McIsaac, UIUC Natural Resources and Environmental Sciences
Timothy Hodson, US Geological Survey
Momcilo Markus, Illinois State Water Survey
Rabin Bhattarai, UIUC Agricultural & Biological Engineering
Daniel Kim, UIUC Agricultural & Biological Engineering

Funding from: Illinois Nutrient Research and Education Council (NREC)
& US Geological Survey Cooperative Agreement

TP Load Estimates for Major Rivers draining Illinois

1980-96 baseline, 2013-17, 2014-18 and 2015-19



Estimated loads for the Illinois and Vermilion Rivers include reductions of 15% and 7%, respectively, to estimate the portion contributed by Indiana and Wisconsin, based on the proportion of each watershed that is outside of Illinois.

Project Objectives

Identify and quantify factors contributing to increased phosphorus loads in the Illinois River at Valley City

General Approach

1. Calculate long term riverine P loads for 41 subwatersheds

2. Identify factors that might explain spatial and temporal variations in P loads

Data & Methods

- USGS flow & discrete concentrations
- IEPA Ambient Water Quality Monitoring Network Concentrations

River Load estimations: WRTDS-K a new version of WRTDS

Total P (TP), dissolved P (DP), particulate P (PP), Total Suspended Solids (TSS), volatile suspended solids (VSS) and chloride (Cl), sulfate (SO4) and nitrate (NO3)

Point Source Data from MWRD (early 1980s-2019), Sanitary District of Decatur (mid 1990s - 2019), North Shore Water Reclamation District (2007-13 & 2017-19) USEPA ECHO system (from 2011-2019)

The past: 1989-96

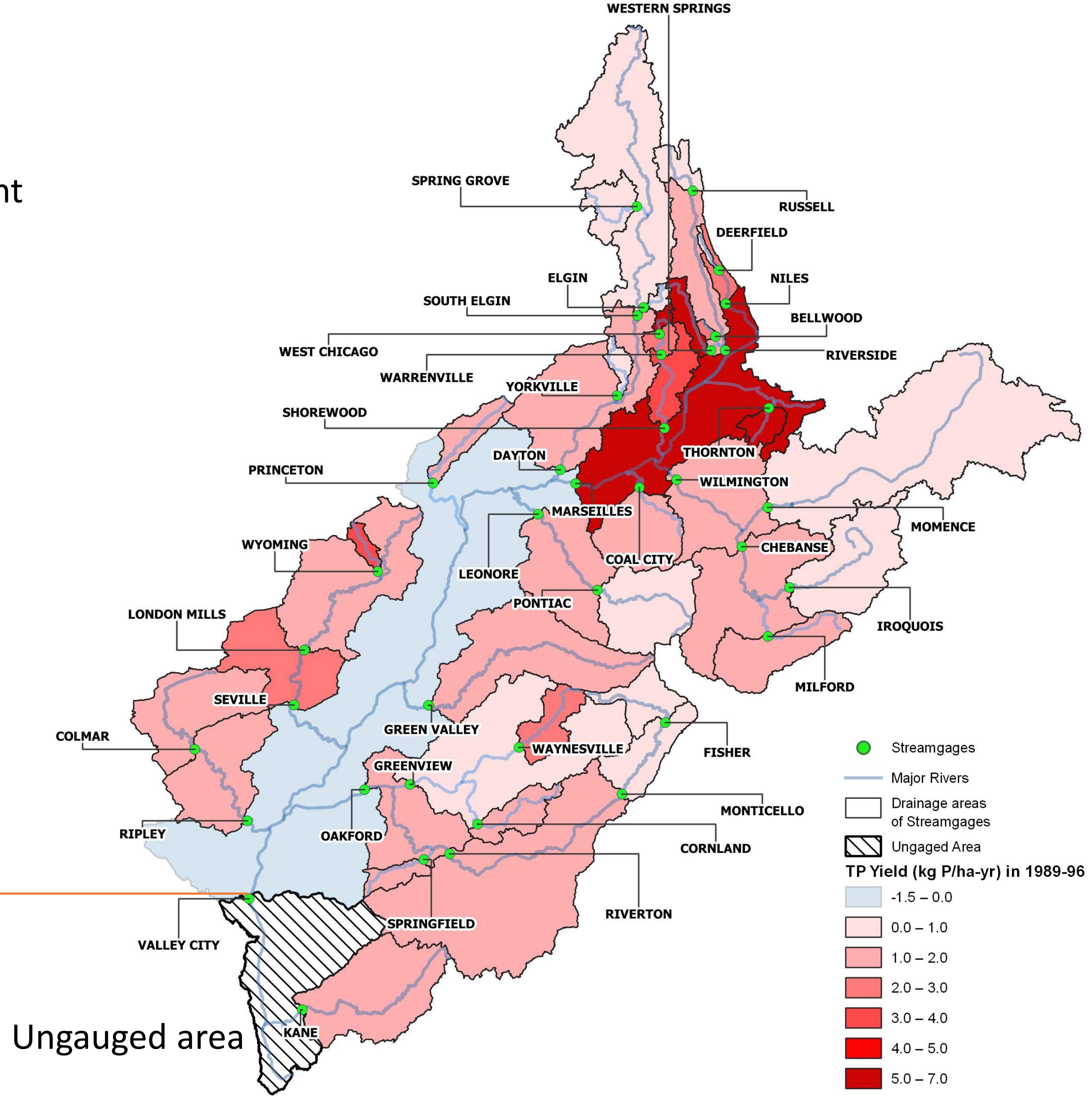
Incremental Total Phosphorus (TP) yields

TP load per unit area for each watershed segment
1 kg P/ha = 0.89 lb P/ac

TP Yield (kg P/ha-yr)

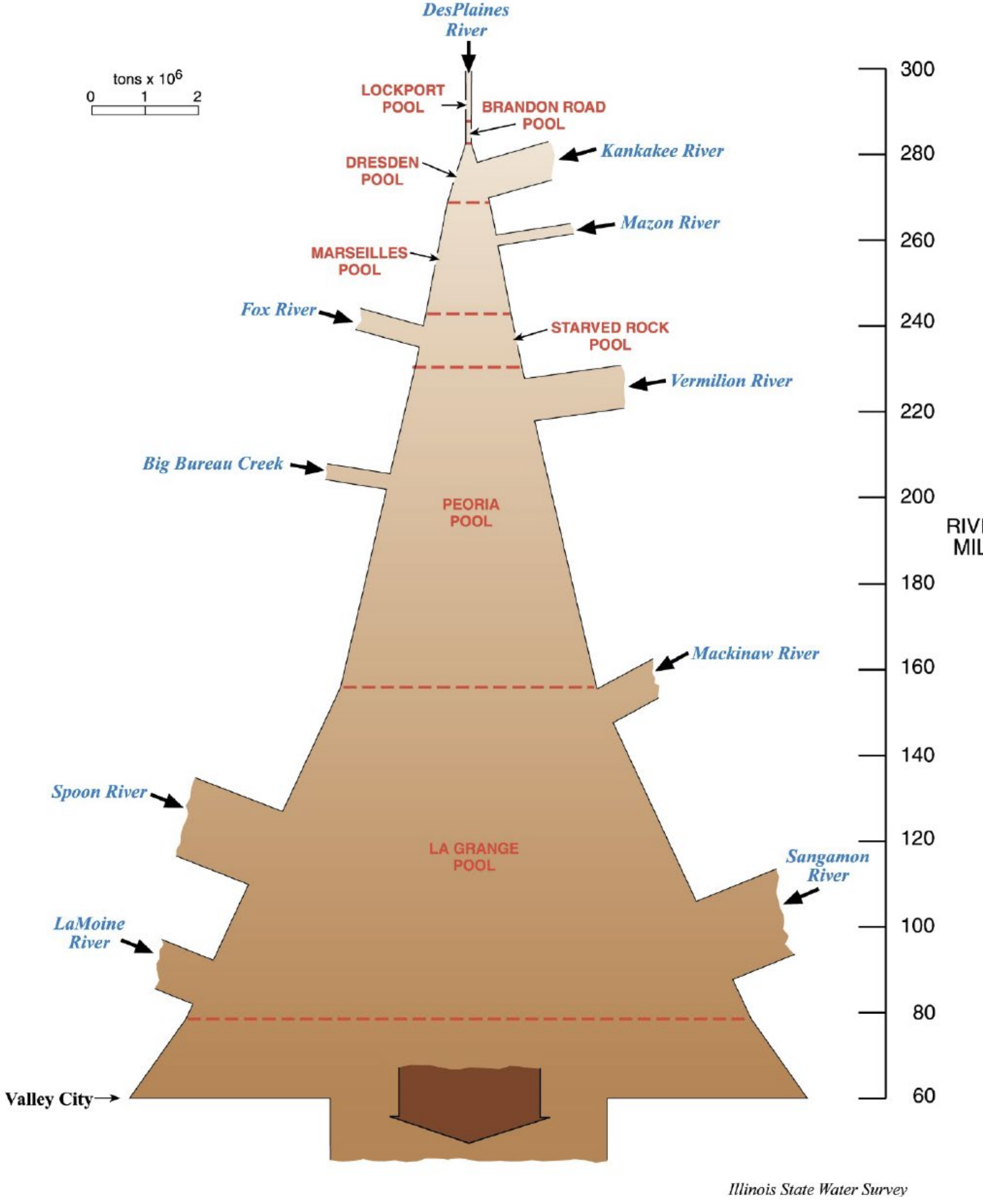
- -1.5 – 0.0
- 0.0 – 1.0
- 1.0 – 2.0
- 2.0 – 3.0
- 3.0 – 4.0
- 4.0 – 5.0
- 5.0 – 7.0

Valley City annual TP load:
15.2 Million lb P/yr
Water yield:
13.8 in/yr



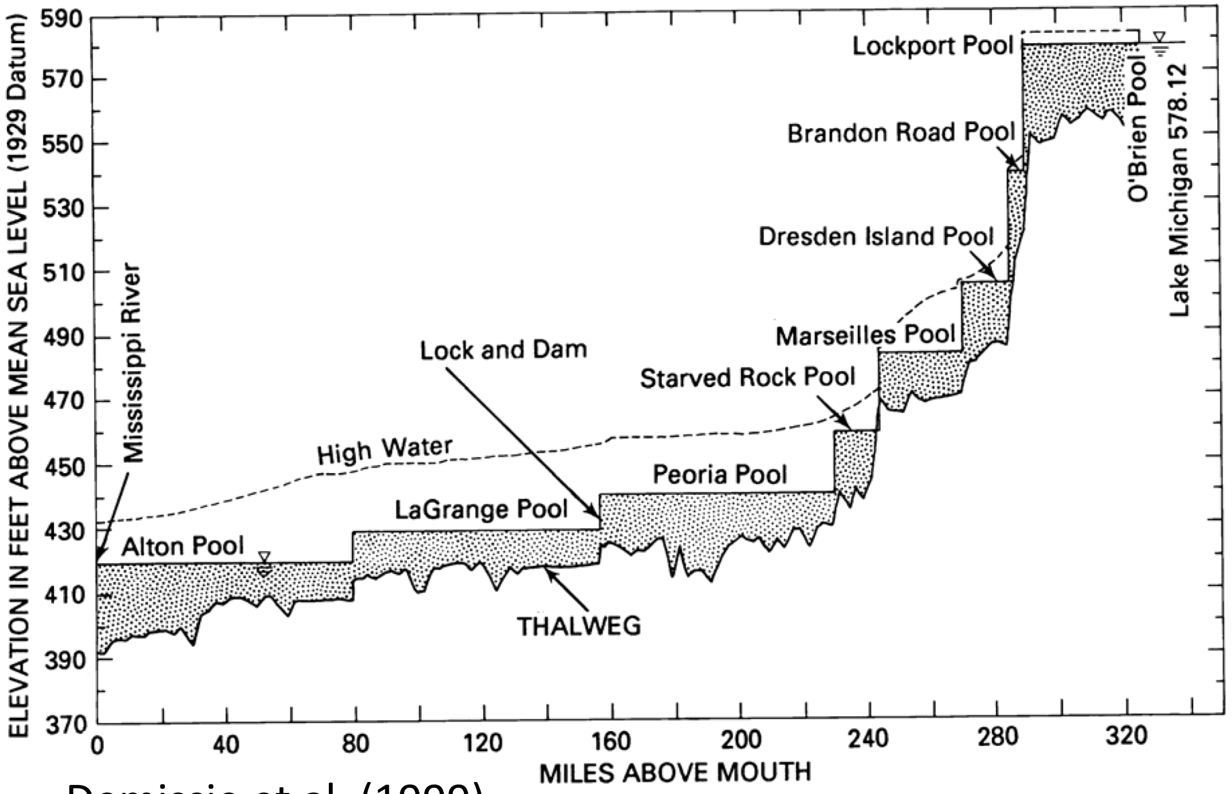
Illinois River Sediment budget 1981-2015

Demissie, Getahun and Keefer (2016)



https://www.isws.illinois.edu/pubdoc/RI/ISWSRI-122.pdf

Elevation profile of the Illinois River Waterway



Demissie et al. (1999)

The Illinois River below Marseilles and Starved Rock accumulates sediment.

Possible P sink: Zebra Mussels

- 1989 Observed in Chicago Sanitary and Ship Canal
- 1991 Observed at Marseilles, Hennepin, Bath and Pearl (below Valley City)
- Blodgett et al. (1997): population explosion in 1993, crash in 94-95
- Consume particulate P, excrete dissolved P
- Growing population could be a net sink of P, if it does not displace other consumers of P

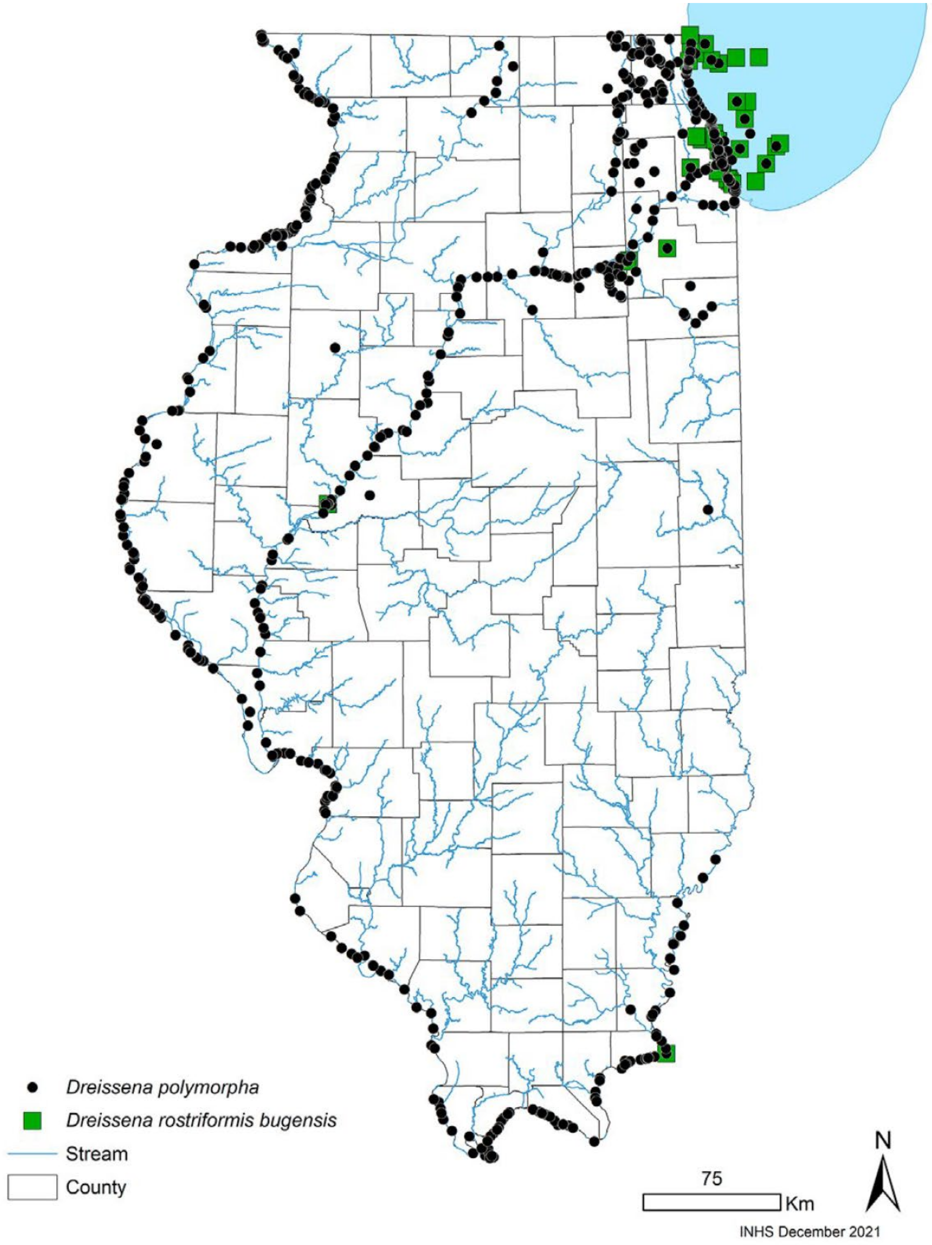


Figure 4 Distributions of Zebra Mussel *Dreissena polymorpha* and Quagga Mussel *Dreissena rostriformis bugensis* in Illinois. (Tiermann et al. 2022, INHS Bull. 43)

2015-19

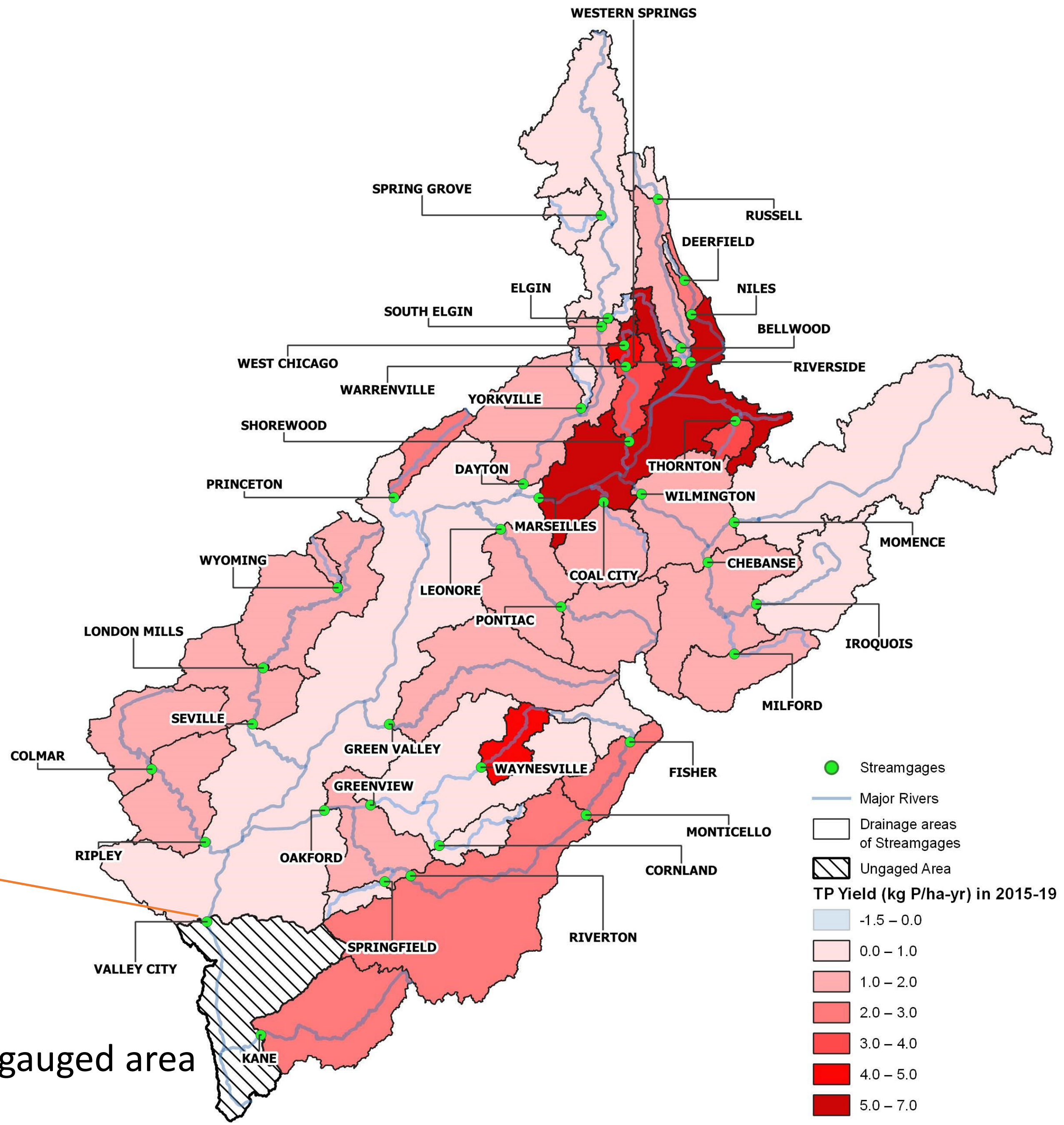
Incremental Total Phosphorus (TP) yields

TP load per area for each watershed segment

Generally:
Increased dissolved P
Reduced particulate P
Reduced Suspended Solids

Valley City annual TP load:
21.2 Million lb P/yr
(39% increase from 1989-96)
Water yield:
15.9 in/yr

Ungauged area



Change from 1989-96 to 2015-19

Incremental Total Phosphorus (TP) yields

TP load per unit area for each watershed segment

kg P/ha-yr

Blue indicates decrease

Red indicates increase

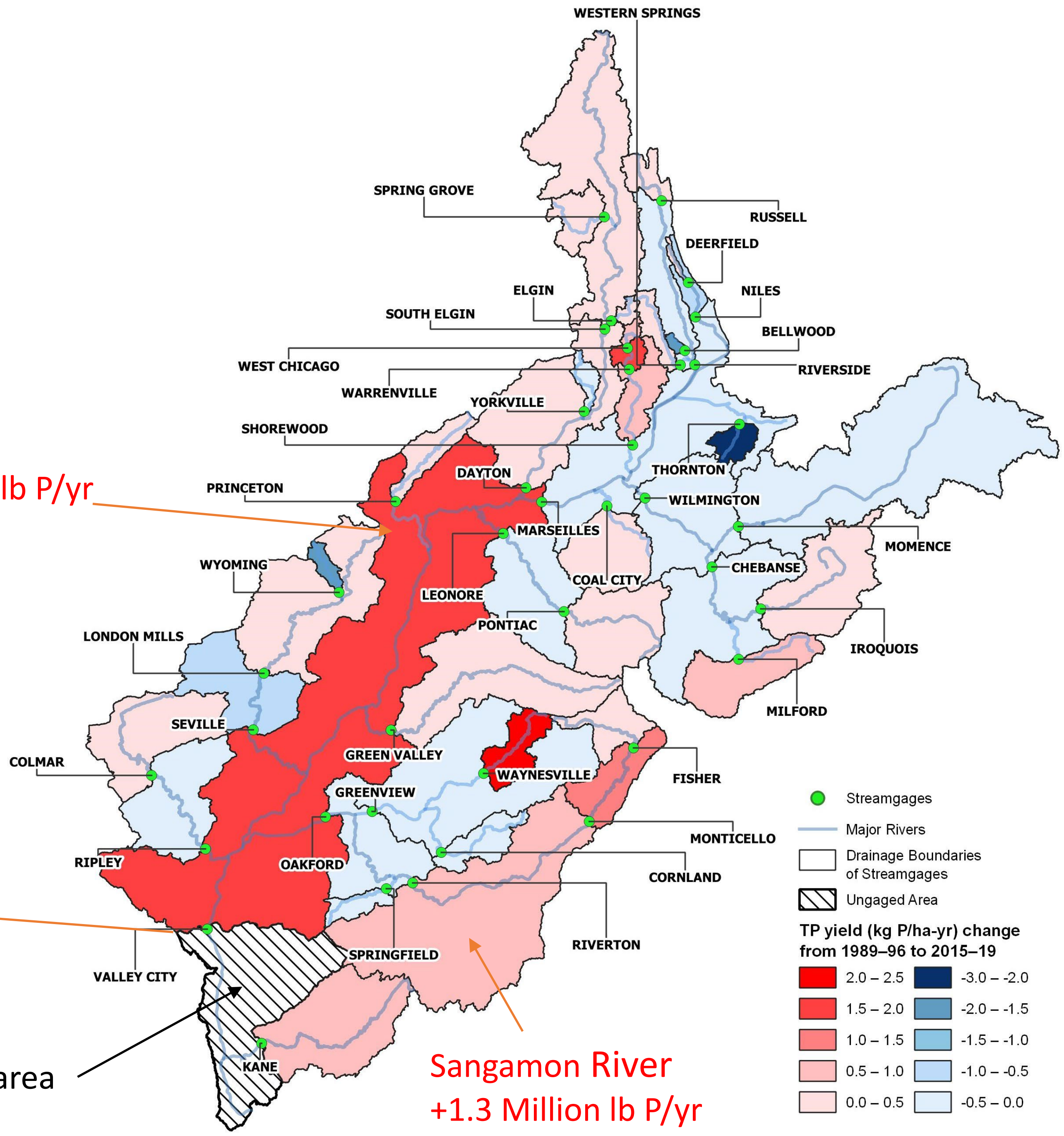
TP yield (kg P/ha-yr) change from 1989–96 to 2015–19

2.0 – 2.5	-3.0 – -2.0
1.5 – 2.0	-2.0 – -1.5
1.0 – 1.5	-1.5 – -1.0
0.5 – 1.0	-1.0 – -0.5
0.0 – 0.5	-0.5 – 0.0

+4.6 Millon lb P/yr

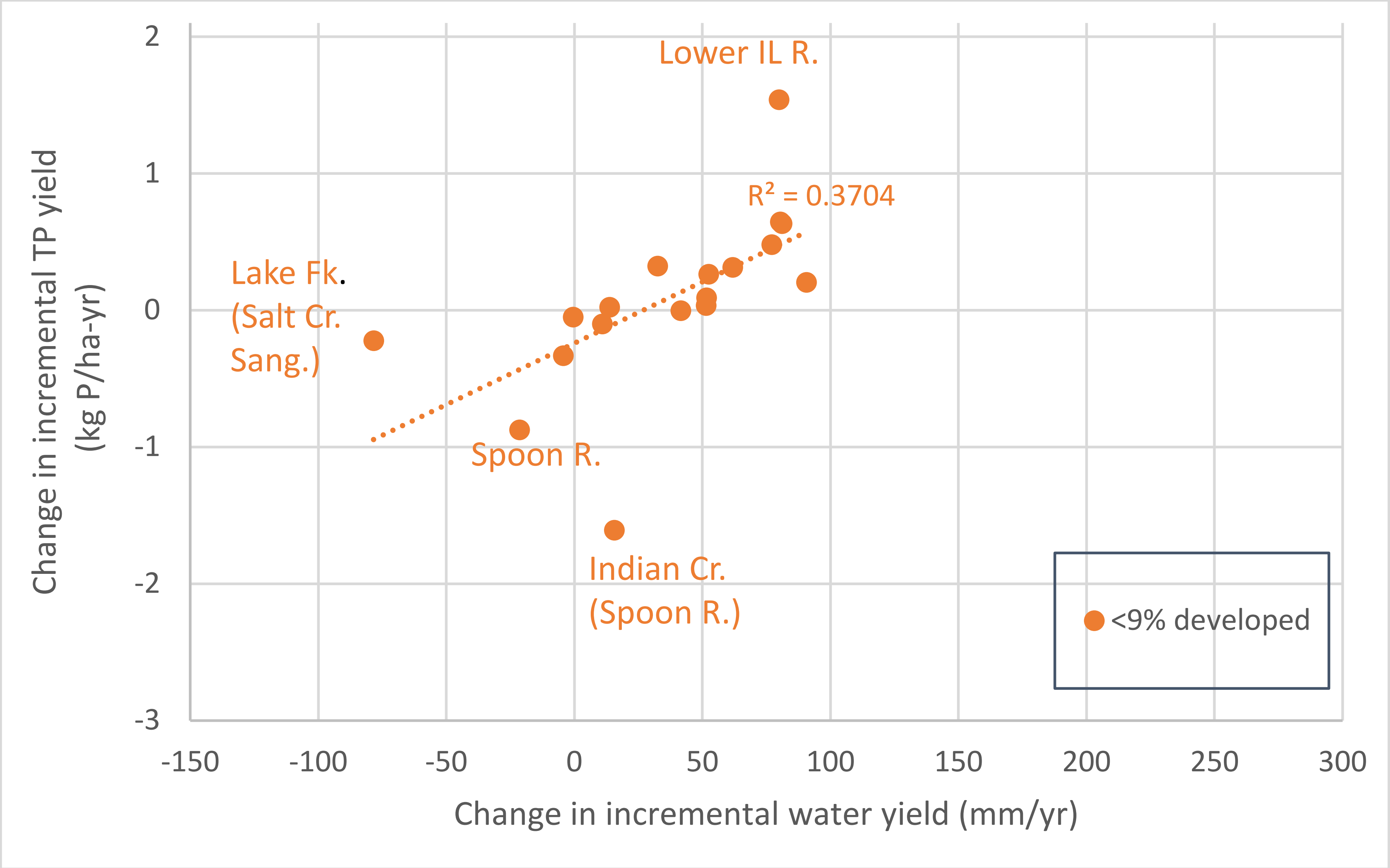
Change in load at Valley City:
+6 Million lb P/yr
(+39% from 1989-96)

Ungauged area



Sangamon River
+1.3 Million lb P/yr

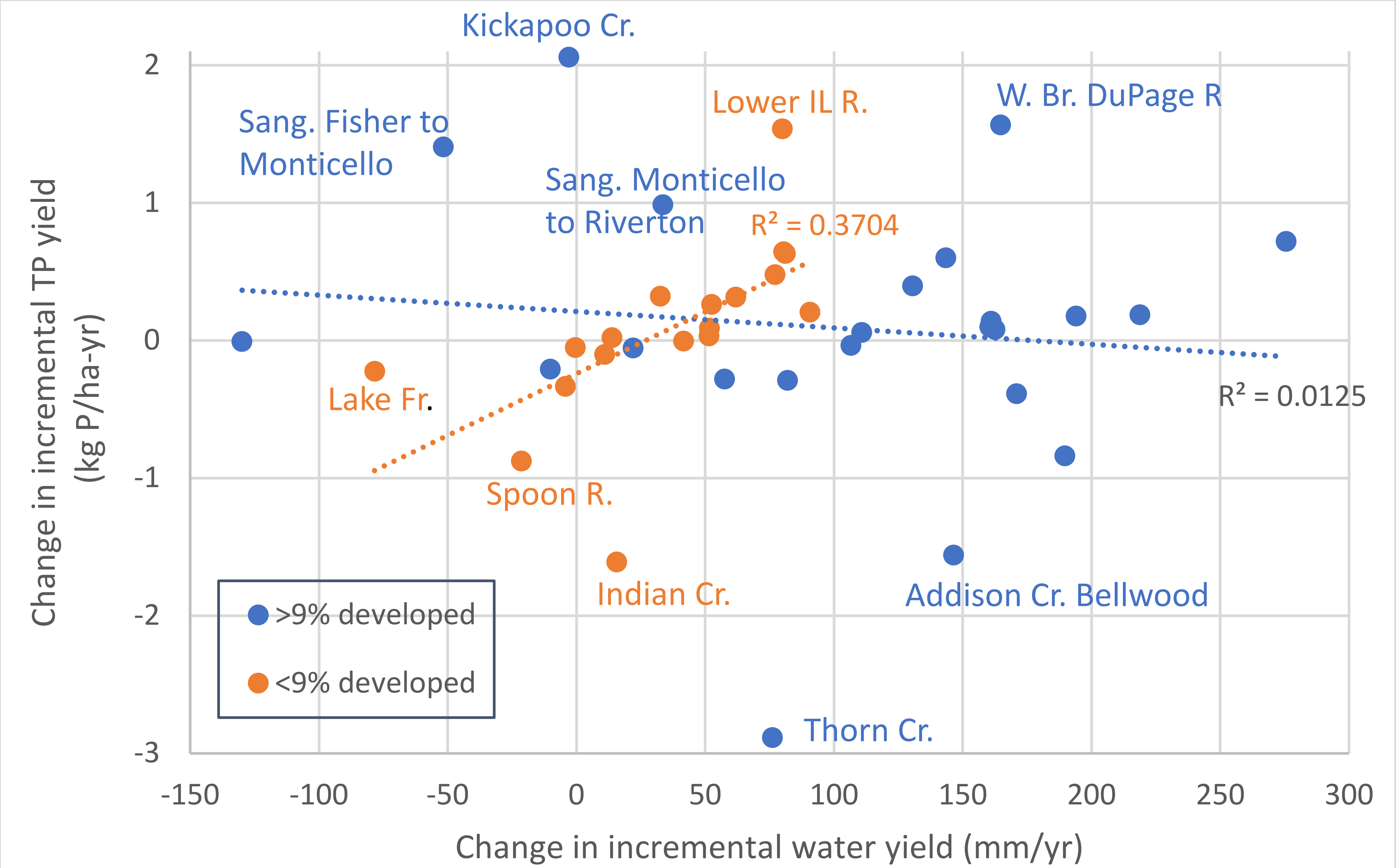
1989-96 to 2015-19 change in increment TP yields vs. change in incremental water yields for subwatersheds with less than 9% developed land cover



"developed" (urban land) associated with greater point source P discharge

100 mm = 3.9 in.

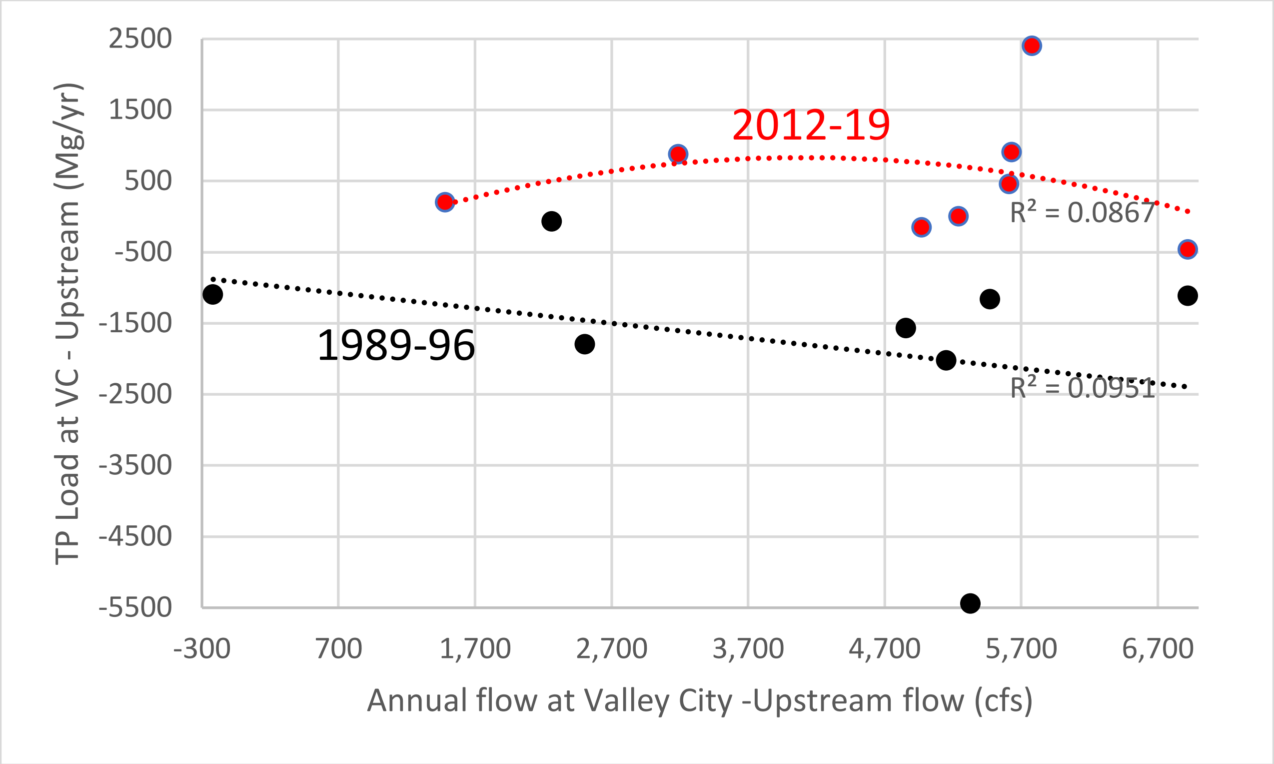
1989-96 to 2015-19 change in increment TP yields vs. change in incremental water yields for watersheds with greater than and less than 9% "developed" land cover

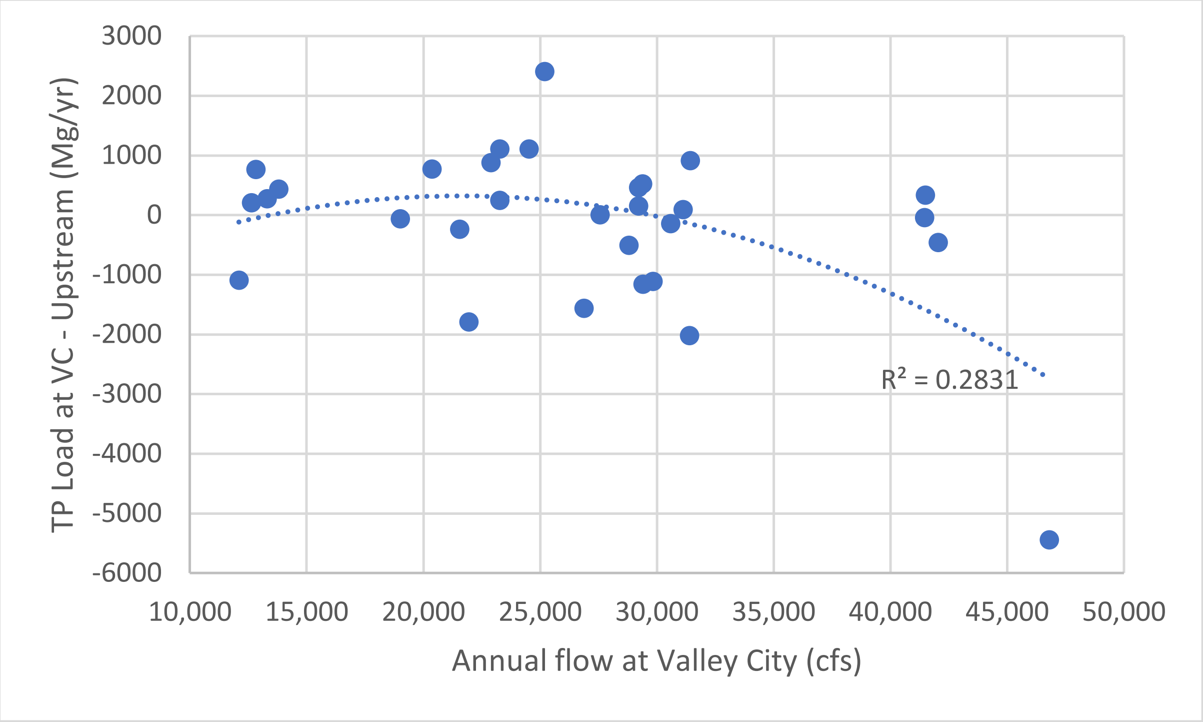


"developed" (urban land) associated with greater point source P discharge

100 mm = 3.9 in.

Incremental TP loads from the Lower Mainstem (Marseilles to Valley City minus tributaries) vs river flow variables 1989-2019

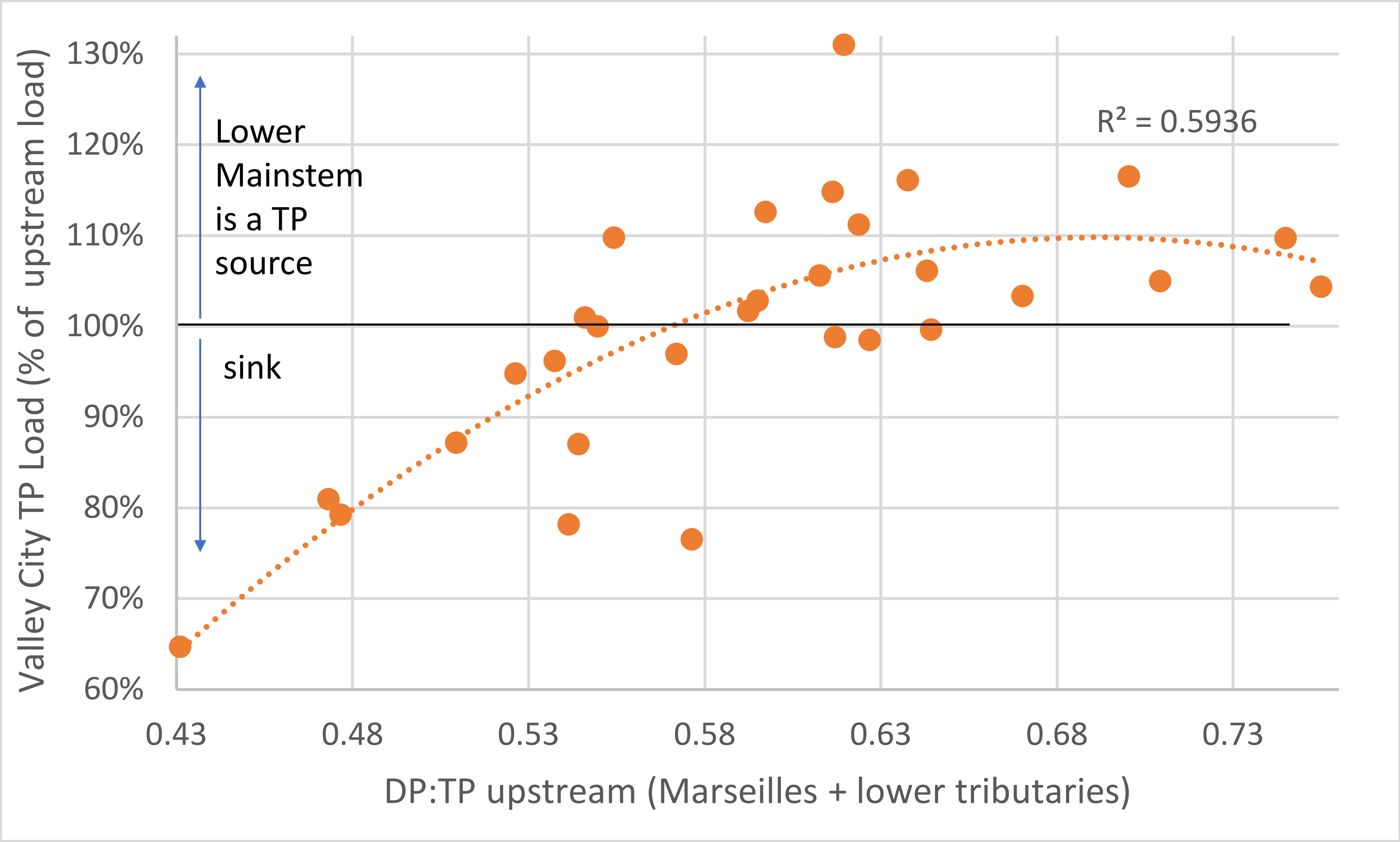




Increased TP load appears unrelated to increased flow in both periods

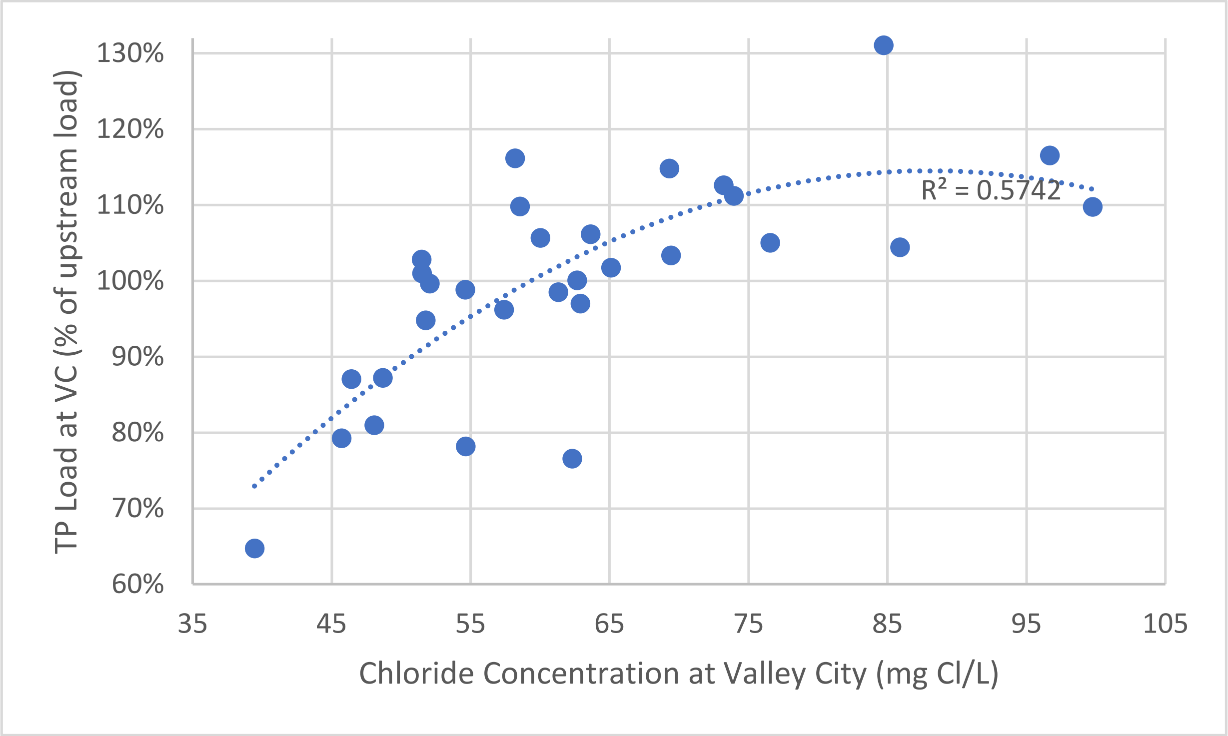
Possible deposition in flood plains and backwater lakes at high flows

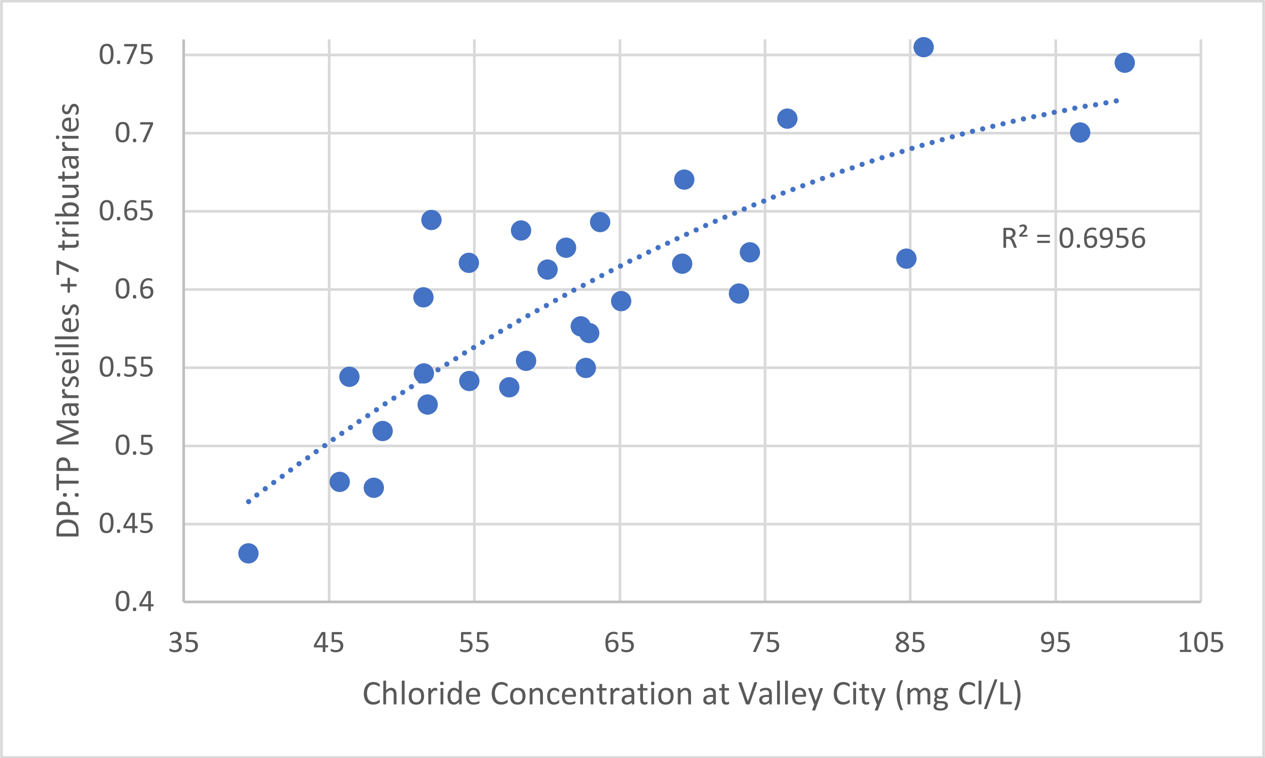
Valley City TP load as a % of upstream load (Marseilles + lower tributaries) vs ratio of dissolved to total P (DP:TP) for Marseilles + lower tributaries



Correlation does not prove a cause and effect relationship

Several Confounding Correlations:
TP load at Valley City vs Chloride Concentration vs Upstream DP:TP





77% of the chloride increase came from above Marseilles + Fox R, while these contributed 16% of the increased DP load at Valley City

Because these two factors are highly correlated, we were unable to determine how much causation to assign to each.

Nitrate and sulfate concentrations were also correlated to these and can affect redox and P desorption.

Summary & Conclusions

Increased TP load at Valley City from 1989-96 to 2015-15

78% came from the lower mainstem: the section of the Illinois River Basin between Marseilles and Valley City, excluding the monitored tributaries

22% came from the Sangamon River Basin (equal to SDD increased TP discharge)

Possible causes for increased TP loads between Marseilles and Valley City (excluding the Sangamon and other tributaries):

- Increased DP load resulting in less deposition
- Desorption from river sediments, possibly enhanced by changes in water chemistry (chloride, sulfate and nitrate)
- Zebra Mussel expansion during 1989-96 sequestered P
- Unidentified point source(s)
- CAFOs and more concentrated livestock

Summary & Conclusions

In many watersheds Dissolved P (DP) loads increased while Particulate P (PP) and Total Suspended Solid (TSS) loads decreased, possible consequences of conservation tillage and expanded tile drainage.

TP load reductions in tributaries draining Cook County were offset by increases in the suburbs (e.g., DuPage River), where population increased, and by increases from agricultural areas (e.g., Mazon River).

In agricultural watersheds (less than 9% developed land) changes in TP load were weakly correlated with changes in water yield.

Recommended Future Studies

Investigate factors influencing P desorption from and mobilization of Illinois River sediments (e.g., chloride, sulfate, zebra mussels).

Investigate reasons for large changes in TP yields from subwatersheds such as Spoon River, Indian Creek, Kickapoo Creek, and Sangamon River between Fisher and Monticello.

Thank you!

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River Load data available at

https://www.usgs.gov/data/wrtds-k-nutrient-and-sediment-loads-illinois-epa-ambient-water-quality-monitoring-network

5-minute break

If you have recently joined, please type your

name and affiliation into the chat box.

ILLINOIS NUTRIENT LOSS REDUCTION STRATEGY

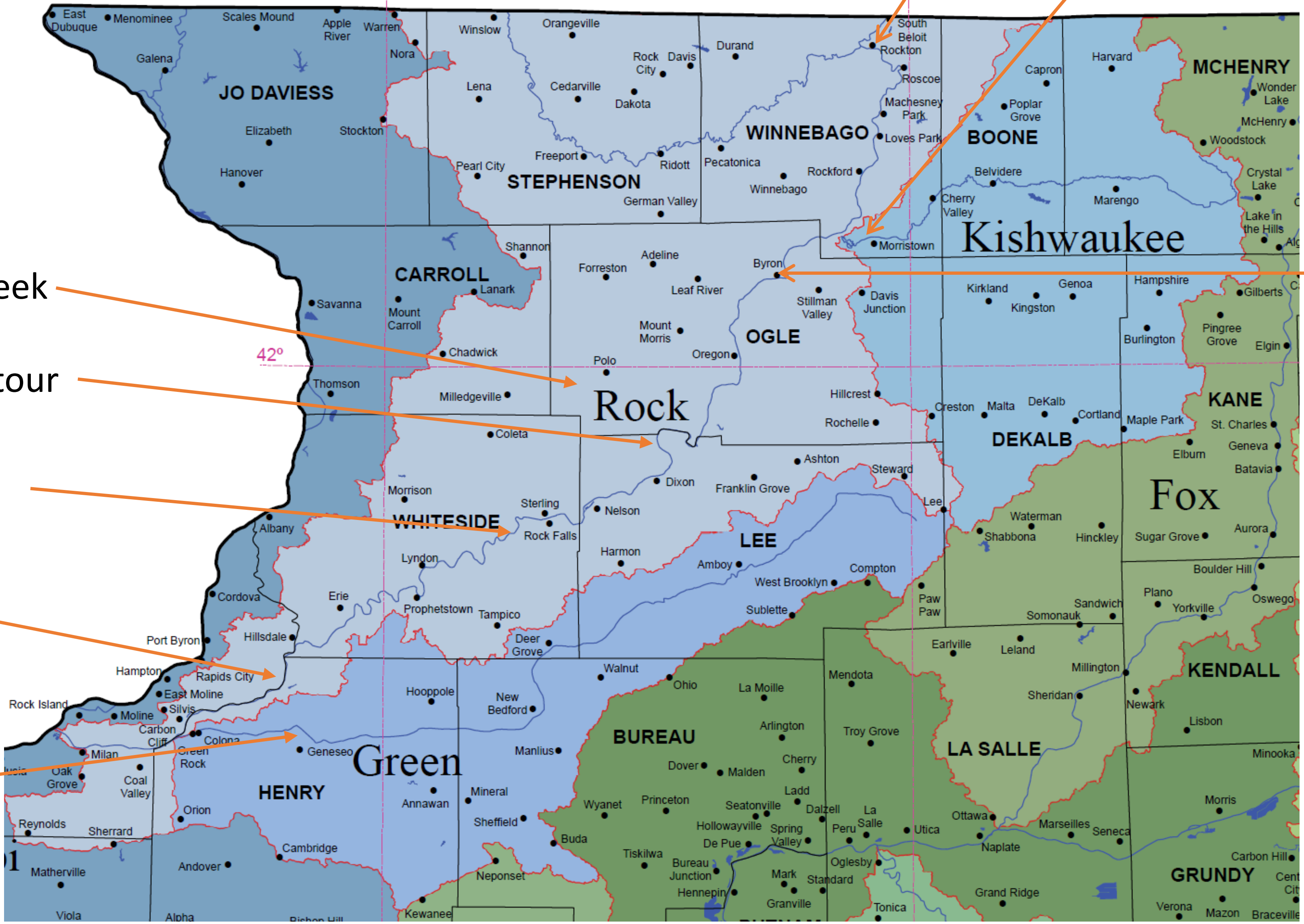
Lower Rock River Analysis

Aug 1, 2022 version

Partly funded by Illinois Corn Growers Association

Developed in consultation with Megan Dwyer and Daniel Perkins

Illinois portion of the Rock River Watershed with USGS and IEPA monitoring locations identified at Rockton, Como, Grand Detour, Joslin and Perryville on the Kishwaukee



Modified from ISWS

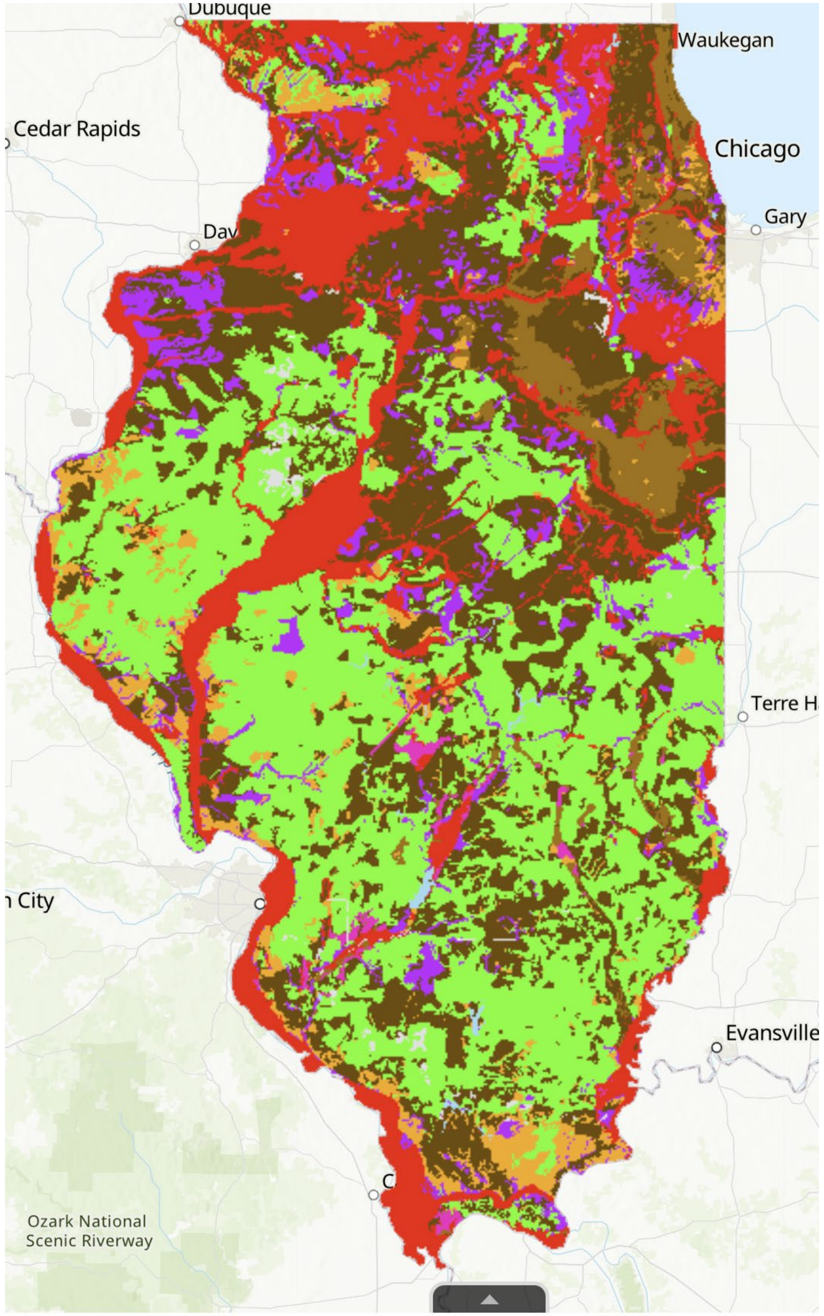
Potential for Aquifer Recharge

Source Water Assessment Protection Data

Water Resources

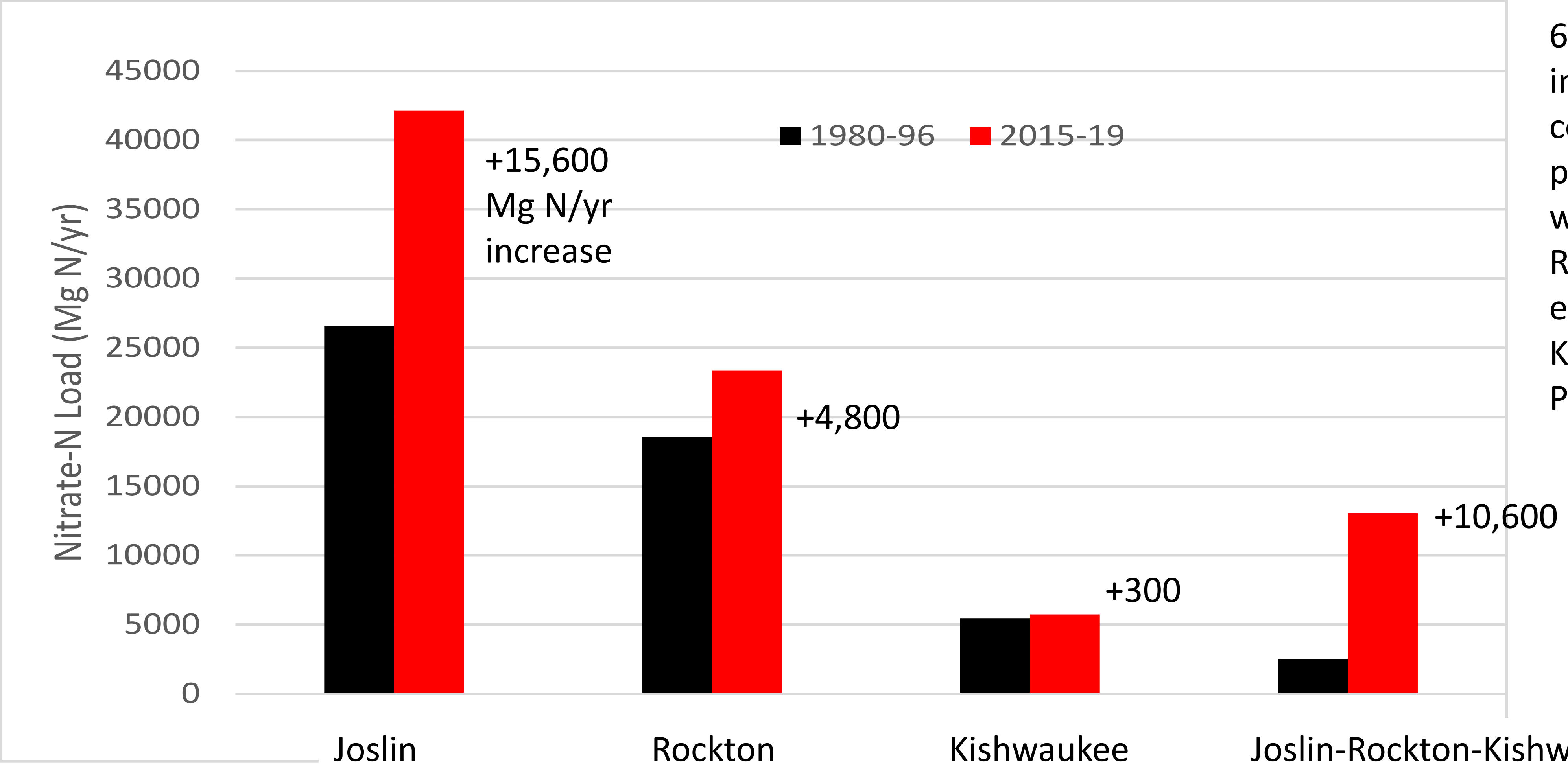
Potential for Aquifer Recharge

- Very High Potential for Recharge
- Very High to High
- High to Moderately High
- Moderately High to Moderate
- Moderate to Moderately Low
- Moderately Low to Low
- Low Potential for Recharge
- Water
- Disturbed Lands



https://illinois-epa.maps.arcgis.com/apps/webappviewer/index.html

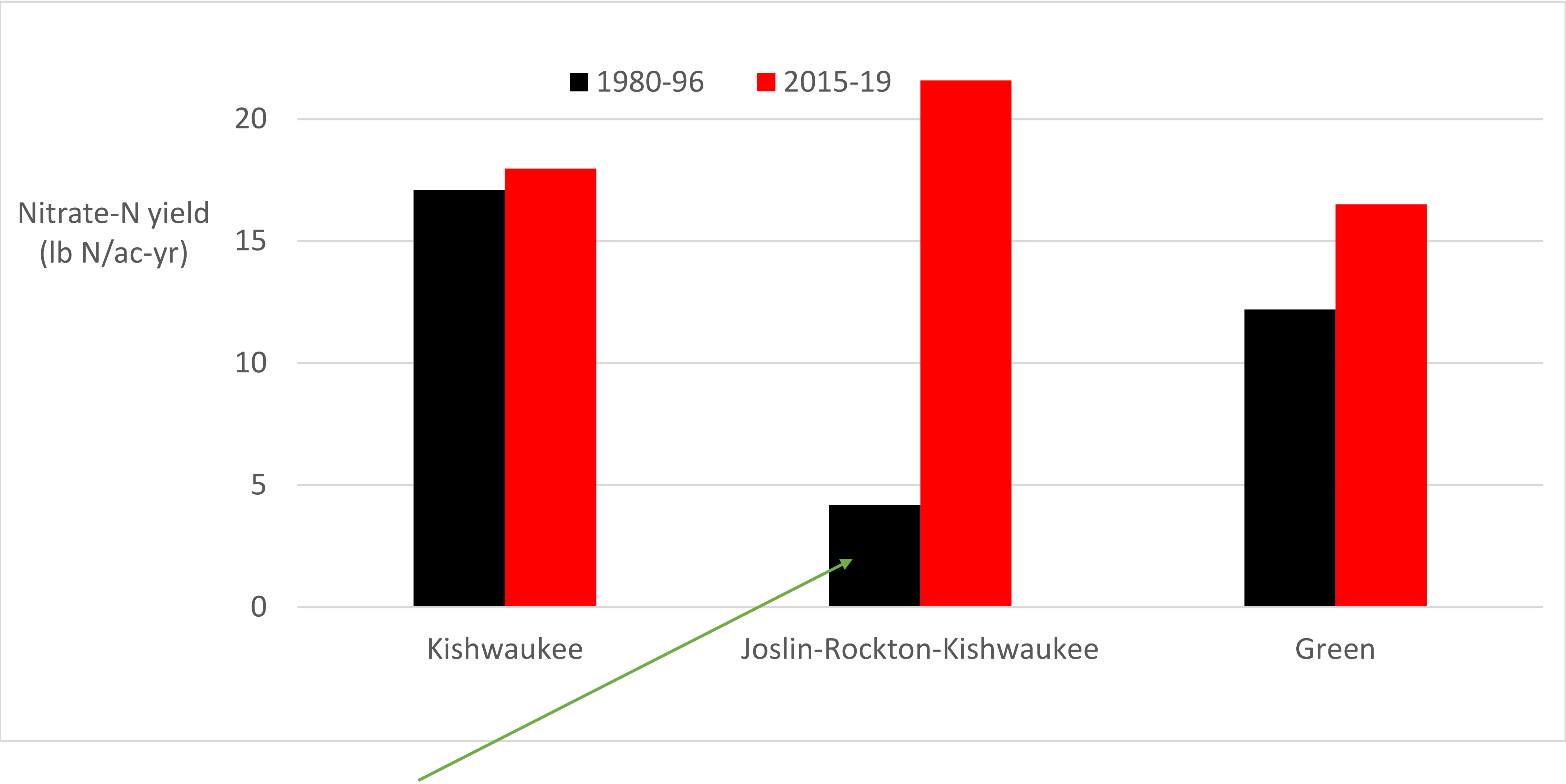
Nitrate-N loads 1980-96 and 2015-2019 Rock River and subbasins



67% of the load increase at Joslin comes from the portion of the watershed below Rockton and excluding the Kishwaukee at Perryville

	Joslin	Rockton	Kishwaukee	Joslin-Rockton-Kishwaukee
Square miles:	9,549	6,363	1,099	2,087
<u>% of NO3-N load at Joslin:</u>				
1980-96	100%	70%	21%	9.6%
2015-19	100%	55%	14%	31%

Nitrate-N yield 1980-96 and 2015-2019
Rock River subbasins and neighboring Green River



Why so low? High in-stream denitrification? Or loss to groundwater? Or other?

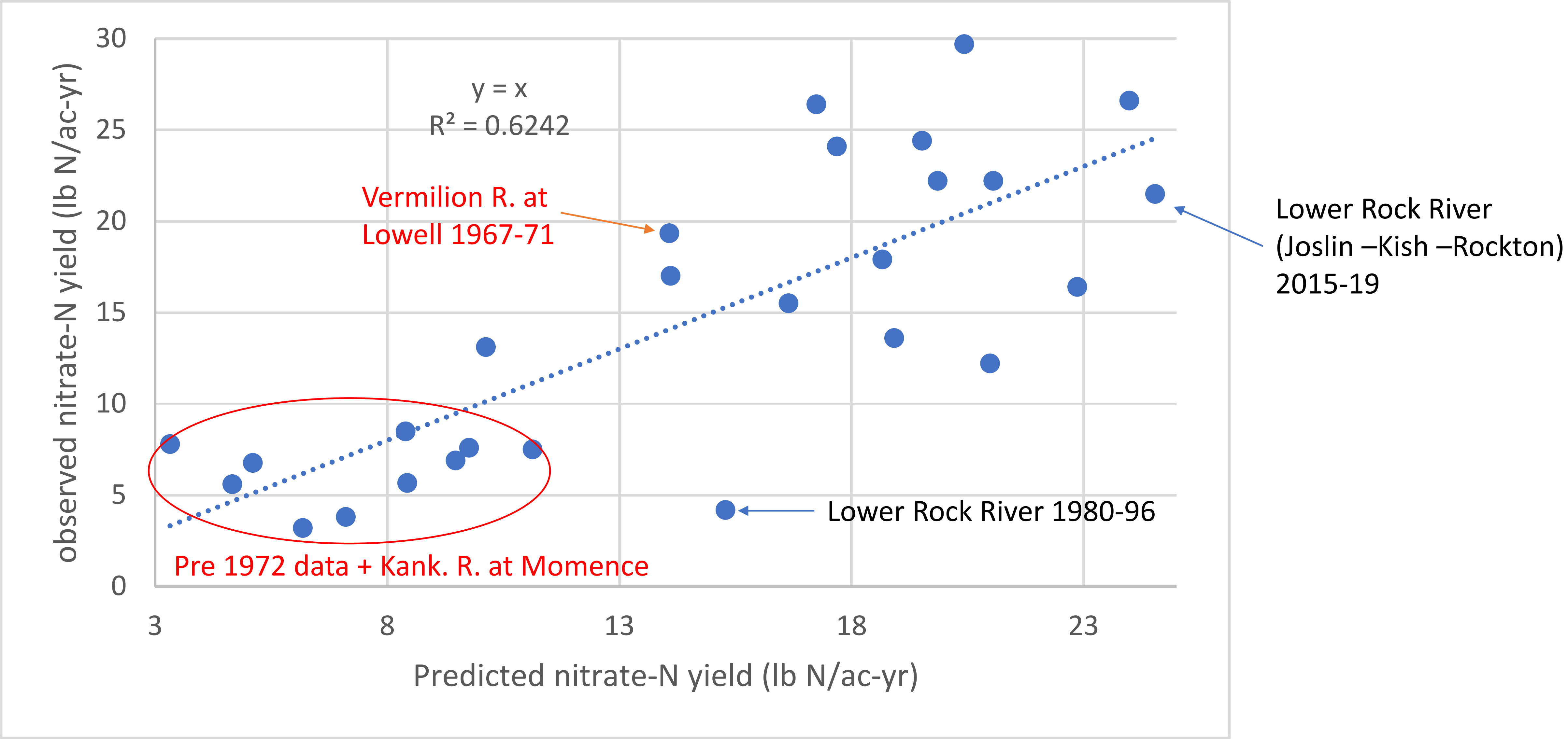
Regression analysis of Nitrate-N yield with % corn+soy, water yield and manure N

$$\text{Nitrate-N yield} = C_1*(\%\text{corn+soy}) + C_2*(\text{water yield}) + C_3*(\text{manure N})$$

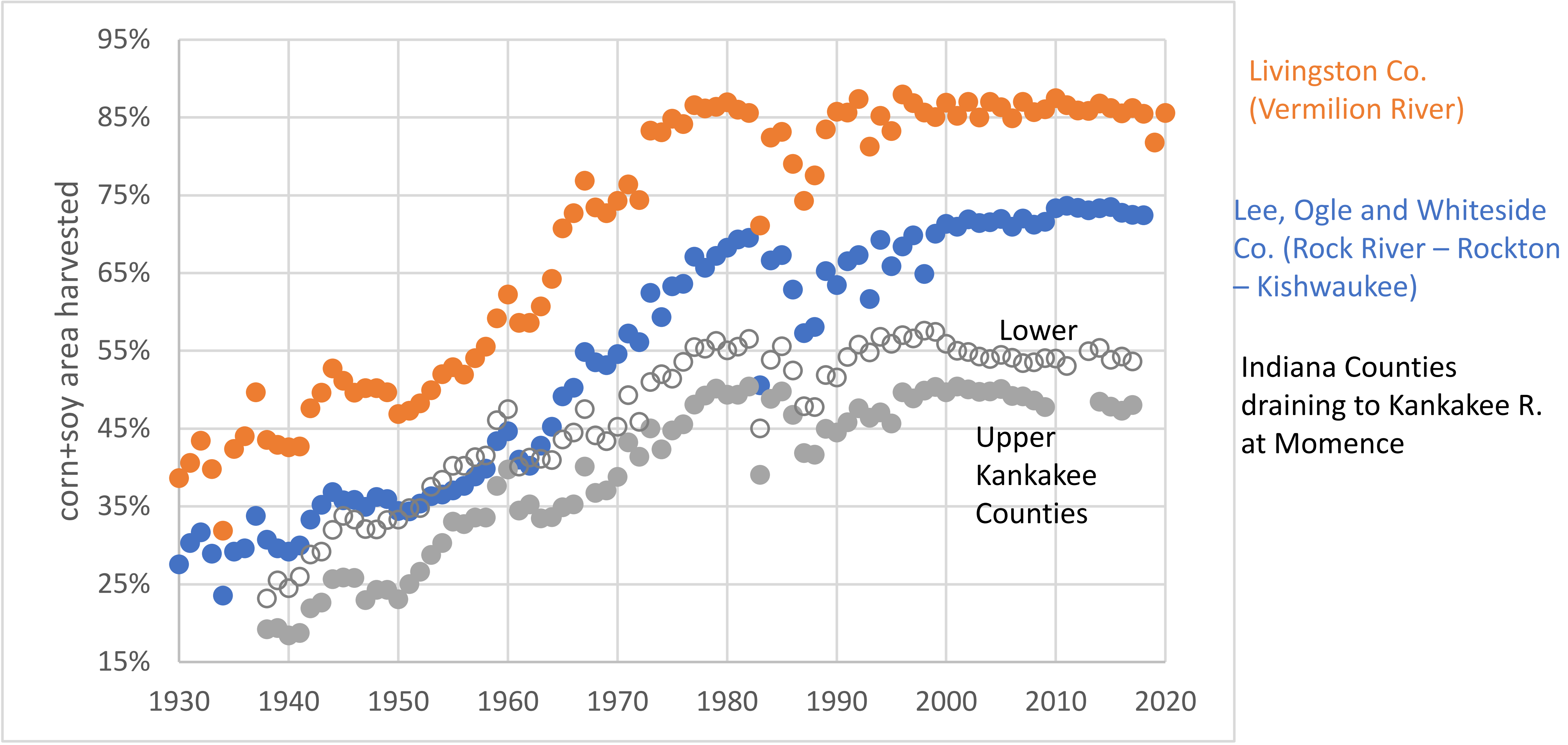
ISWS data 1946-71
IEPA and USGS data after 1979

River system	**years included**		
Vermilion at Leonore	1958-61 & ‘67-71	1980-96	2015-19
Lower Rock (Joslin-Rockton-Kishwaukee)		1980-96	2015-19
Kankakee at Momence	1967-71	1980-96	2015-19
Sangamon at Monticello	1957-61	1980-96	2015-19
Sangamon at Oakford	1957-61	1980-96	2015-19
Mackinaw at Green Valley	1951-54	1989-96	2009-19
Kishwaukee R. at Perryv.	1967-71	1980-96	2015-19
Green R. at Geneseo	1946-50	1980-96	2015-19
Pecatonica R. at Freeport	1967-71	1980-96	2015-19

Nitrate-N yield in northern IL and IN watersheds 1946-2019 vs values predicted by regression analysis with water yield, %corn-soy and manure N (county basis).

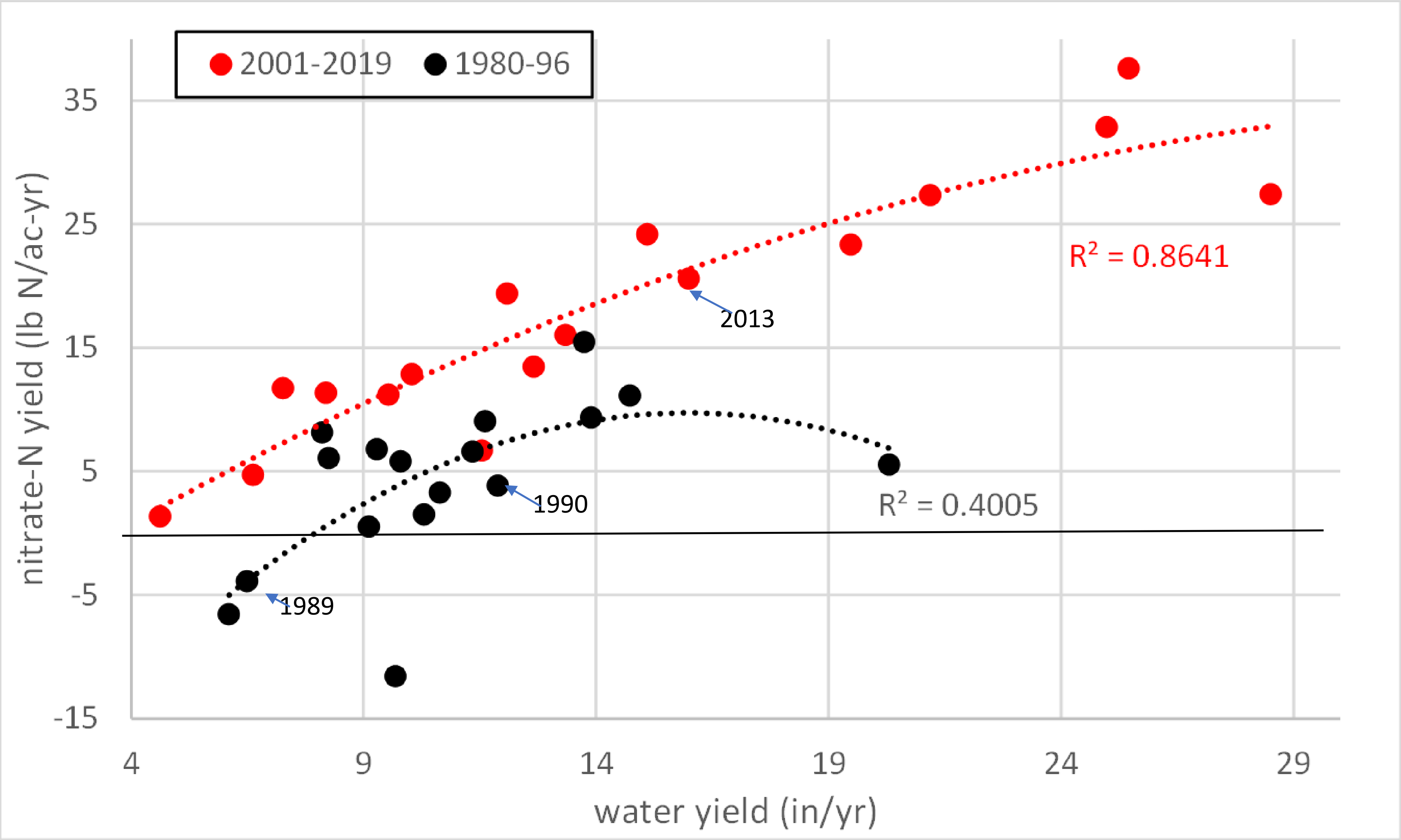


Corn + soybean area harvested as % of counties



Data from USDA NASS

Lower Rock River annual Nitrate-N yield vs water yield



Nitrate N yields less than zero may be due to measurement errors, high denitrification or transfer of nitrate to groundwater

Possible reasons for the 10,600 Mg N/yr increase in Nitrate-N yield from Lower Rock River watershed

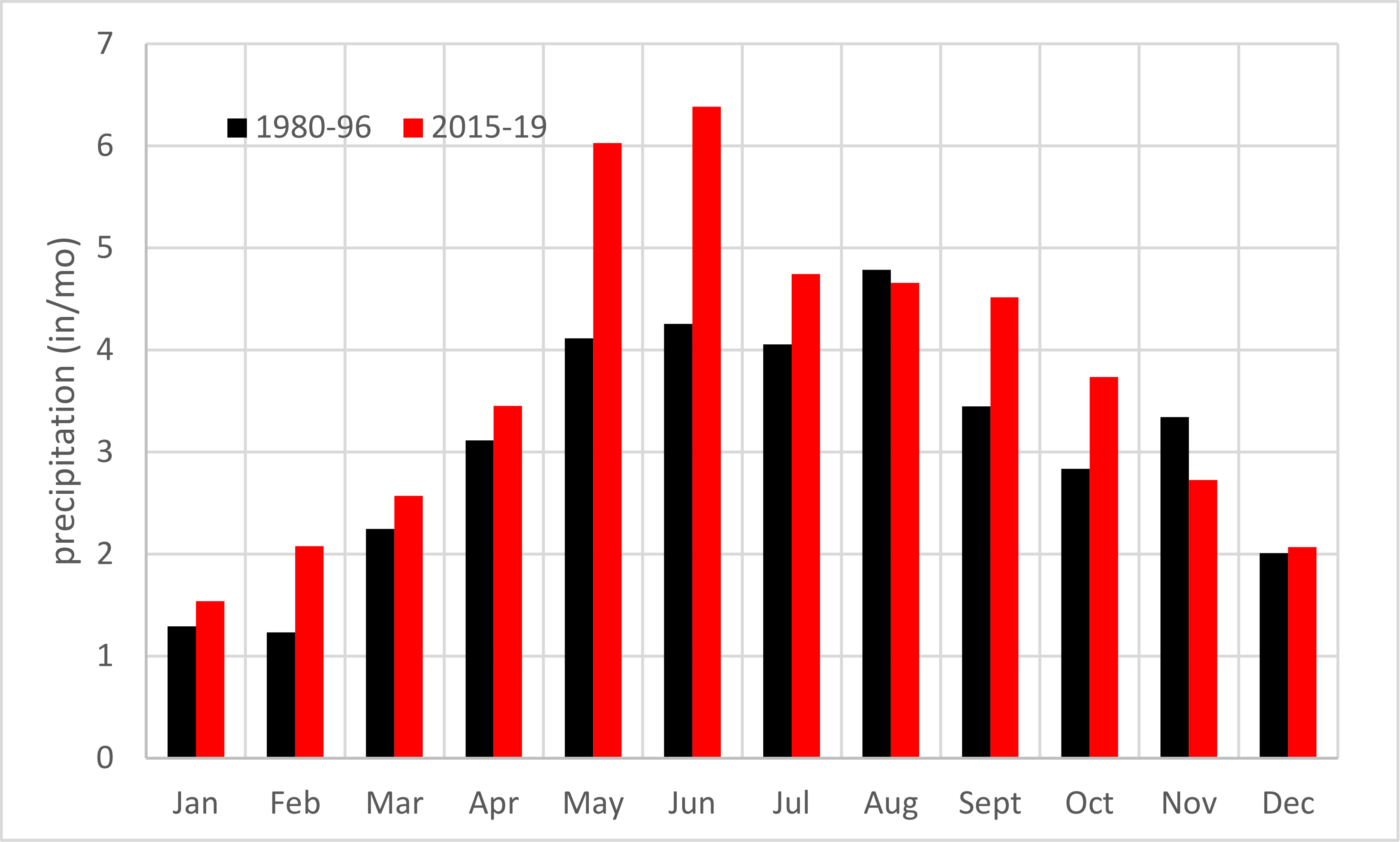
- Increased corn-soy acres: 107,000 ac x 25 lb N/ac = est. +1200 Mg N/yr
- Increased irrigated acres: 45,000 ac x 25 lb N/ac = est. +510 Mg N/yr
- Increased precipitation and 75% increase in water yield: est. +1900 Mg N/yr
- Reduced in-stream denitrification from increased stream flow (maybe)
- Increased livestock (no)
- Increased point source N? (currently not large, but no data from 1980-96)

  Increased population of 44,000 people = ~200 Mg N/yr
- Flow measurement errors at Rockton? (maybe +2200 Mg N/yr?)
- Groundwater lag ? (?? could explain the low N yield 1980-96)

Total of Estimates: 6,010 Mg N/yr

Monthly average precipitation in Rock River Basin between Rockton and Joslin

(avg of Dekalb, Dixon, Morrison, Mount Carrol, Rockford and Rochelle)

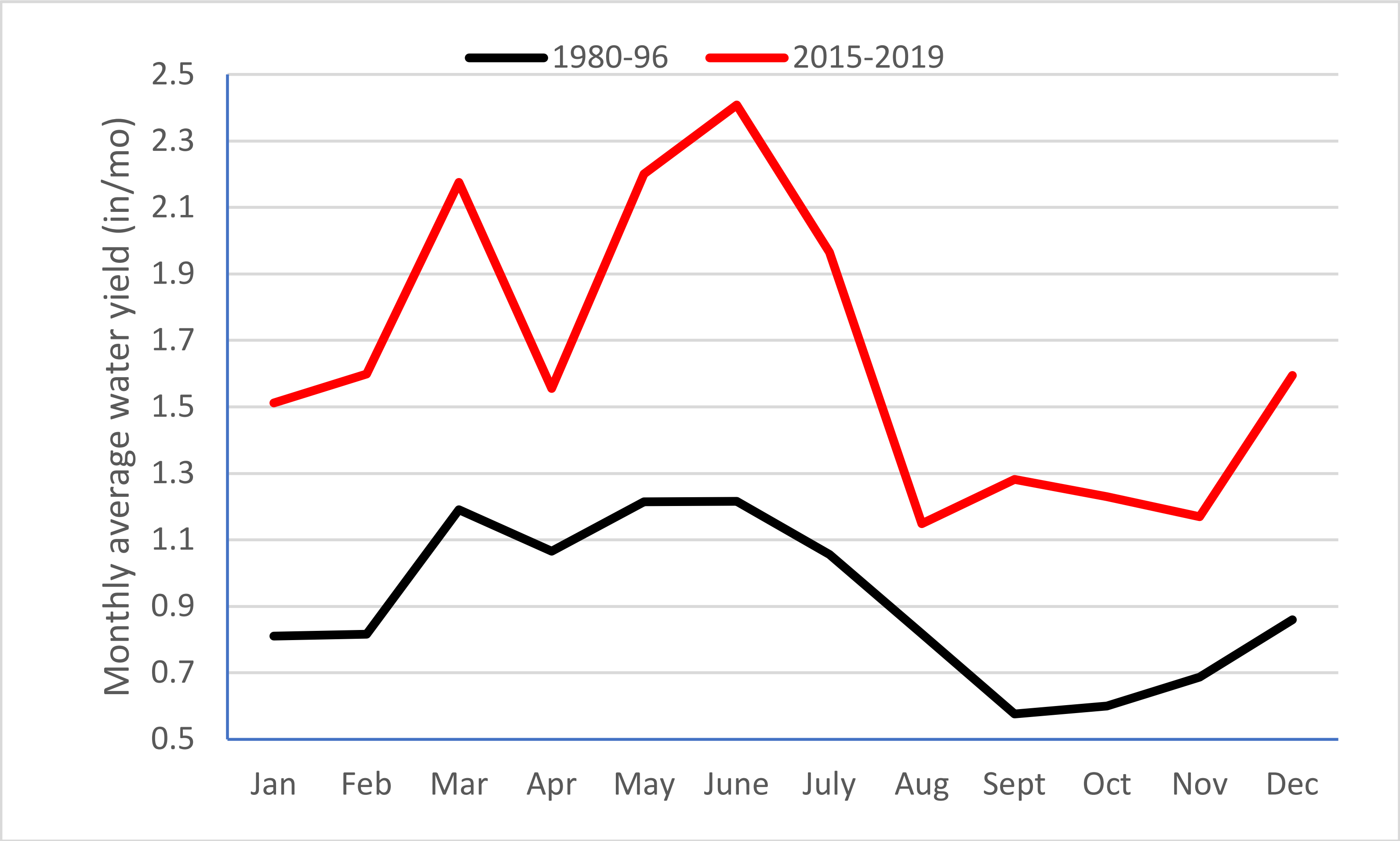


<u>Annual precip</u>
1980-96: 36.7 in/yr
<u>2015-19: 44.5 in/yr</u>
+7.8 in/yr

<u>Annual Water yield</u>
1980-96: 10.9 in/yr
<u>2015-19: 19.0 in/yr</u>
+8.1 in/yr

Average May through July precipitation increased 4.7 inches

Joslin-Rockton-Kishwaukee average monthly water yield
75% increase in annual average water flow from 1980-96 to 2015-19
75% increase in 1980-96 nitrate load = +1900 Mg N/yr



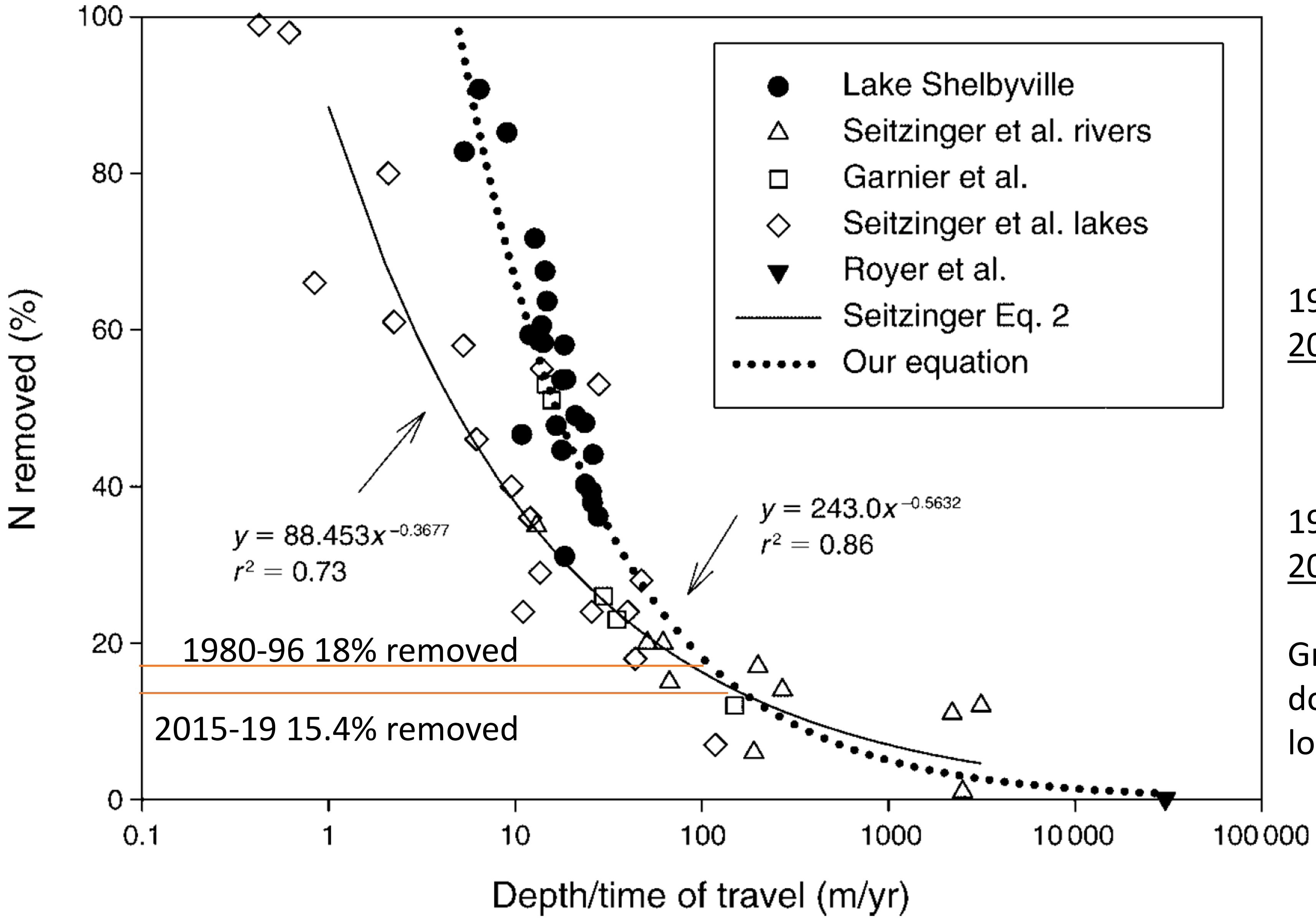
High precipitation and drainage in the growing season promotes leaching losses;

Higher flow in warmer months (June, July, August) probably reduces percentage of in-stream denitrification loss, but with greater nitrate load denitrification loss may remain the same.

May through July water yield increased 89% (3.1 in/yr)

Jan and Feb. 2017 average flows estimated at Perryville and Rockton due to some missing daily data

In-stream denitrification estimation Rockton to Joslin



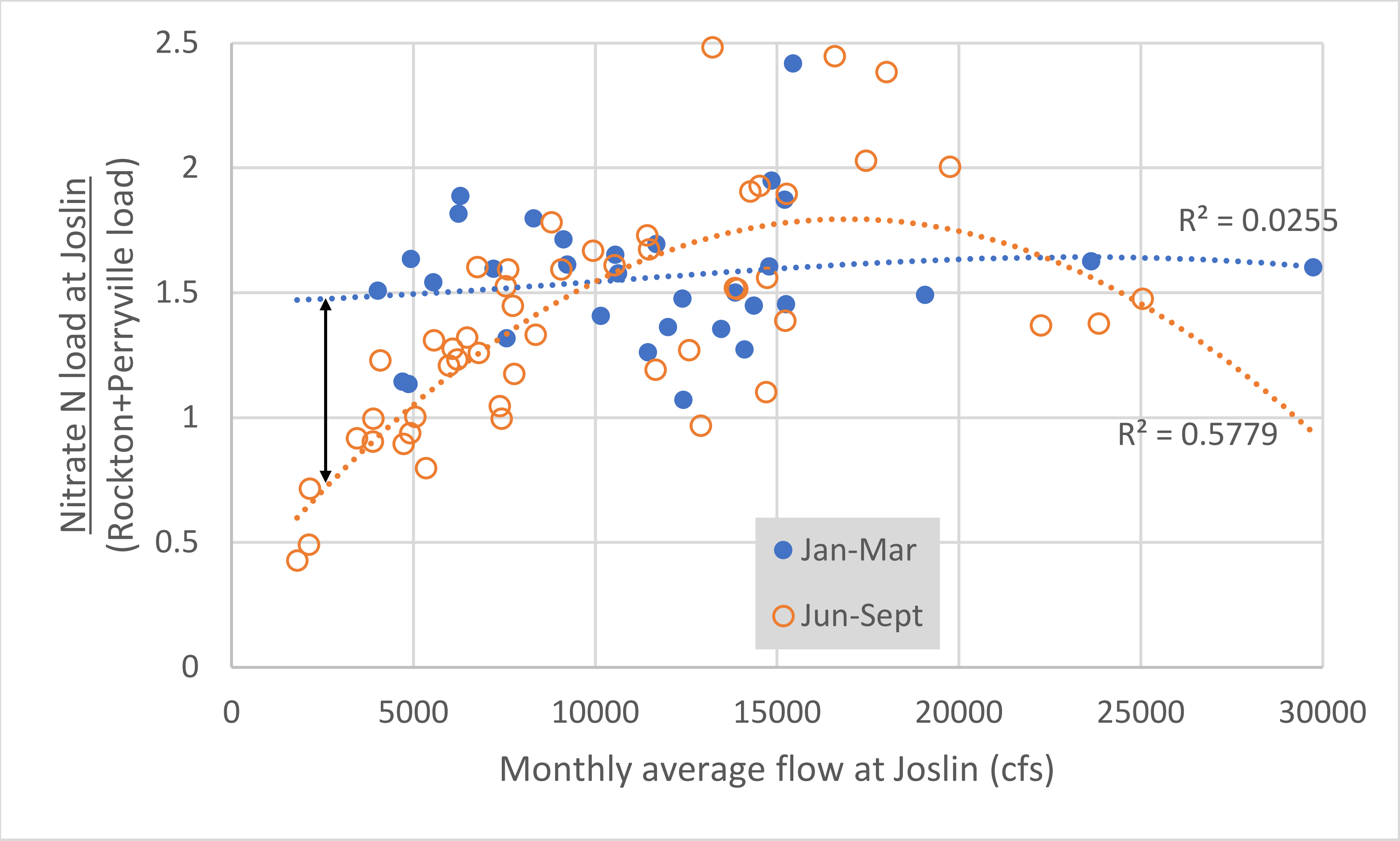
	Estimated load w/o in-stream denitrification
1980-96	31,000 Mg N/yr
2015-19	50,000 Mg N/yr

	Estimated in-stream denitrification
1980-96	6,000 Mg N/yr
2015-19	7,700 Mg N/yr

Greater denitrification in 2015-19 does not help explain the increase in load from 1980-96 to 2015-19

David et al. 2006

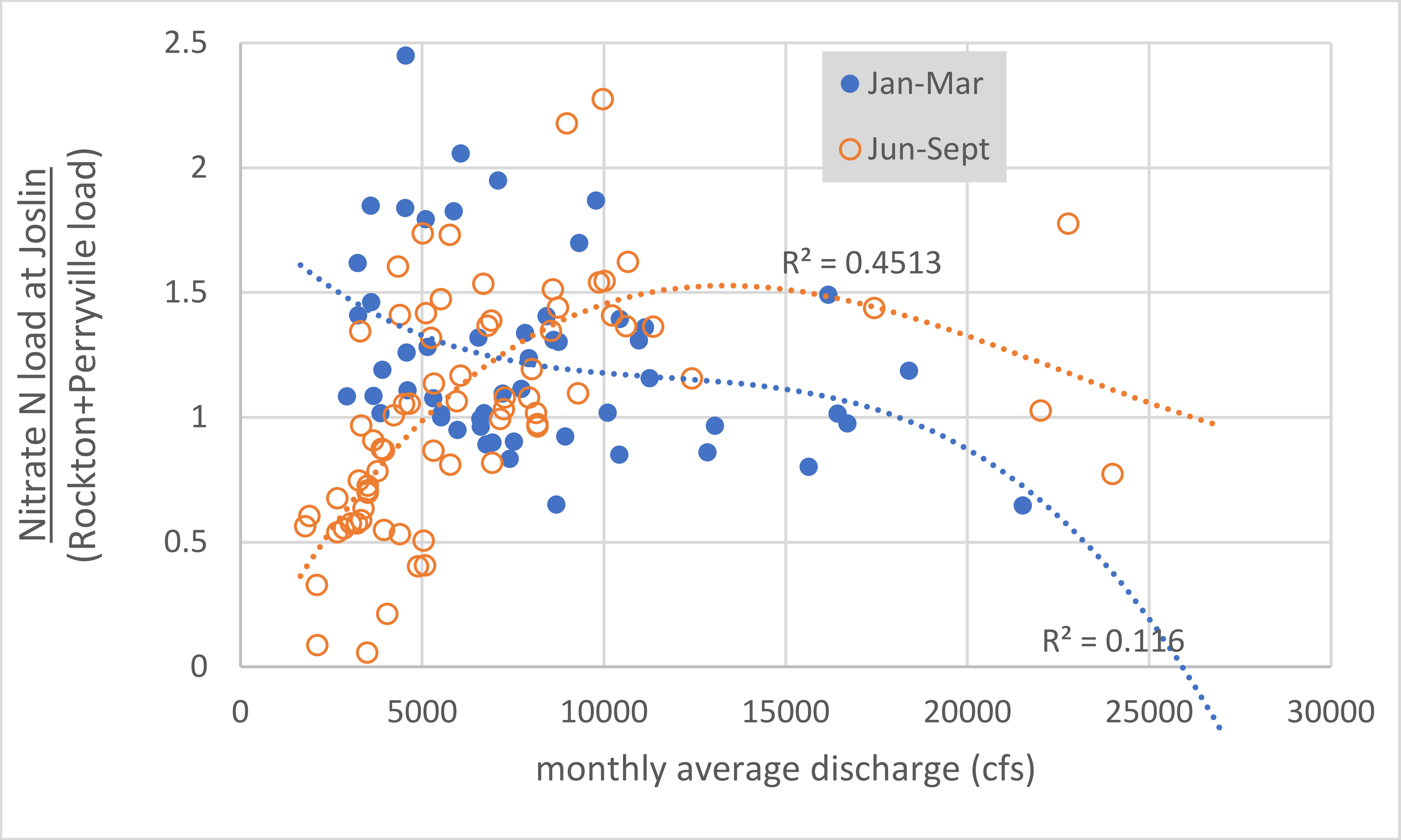
2009-2019 ratios of monthly Nitrate-N loads at Joslin to the sum of the upstream loads at Rockton and Perryville during cold months (Jan-March) and warm months (June-September)



During cold months, loads at Joslin average about 1.5 times the incoming loads at Rockton and Perryville, presumably reflecting additional inputs from upstream to downstream monitoring.

During warm months, ratios consistently less than 1.5 at flows less than 7500 cfs may be due to denitrification and/or loss to groundwater.

1980-96 ratios of monthly Nitrate-N loads at Joslin to the sum of the upstream loads at Rockton and Perryville during cold months (Jan-March) and warm months (June-September)



At flows less than 7500 cfs, during cold months, the ratio of upstream to downstream nitrate load varies between about 1.5 and 1.25.

Ratios less than one may also reflect nitrate loss to groundwater.

Estimated in-stream denitrification (Method 2)

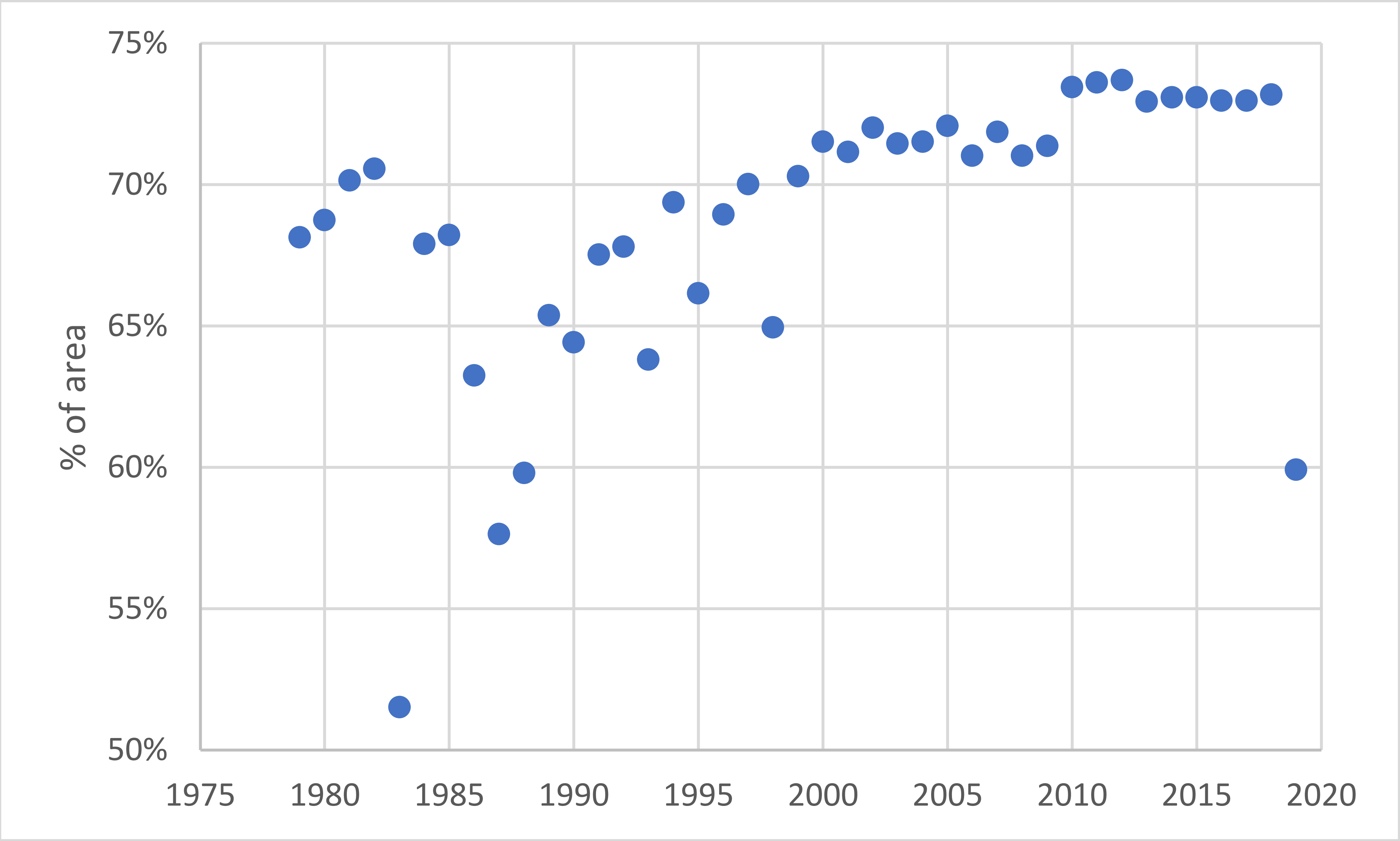
1980-96	1540 to 2860 Mg N/yr
2015-19	1290 Mg N/yr
Change	-250 to -1540 Mg N/yr

If accurate, reduced denitrification could contribute up to ~15% of the increased nitrate load at Joslin, but there is considerable uncertainty.

These annual denitrification estimates are much lower than the 6,000 to 7,700 Mg N/yr estimate using the equations in David et al. (2006).

Lower organic matter in sandy river sediments may contribute to lower in-stream denitrification

Corn + Soybean acres in Lee, Whiteside and Ogle Counties



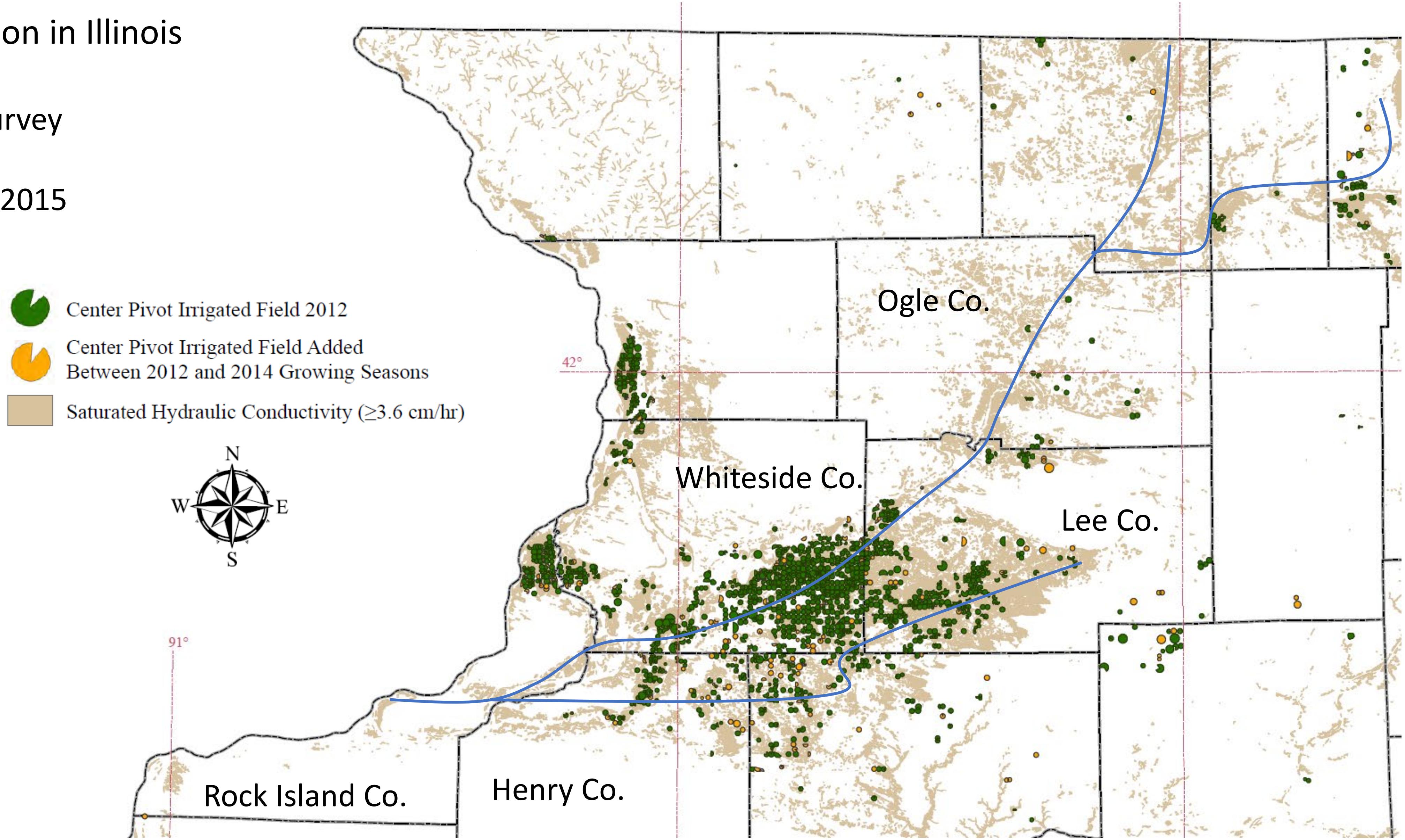
1979-95 avg: 65%;
2014-18 avg: 73%

An 8% increase in the lower Rock River Basin would be ~107,000 acres of corn-soy

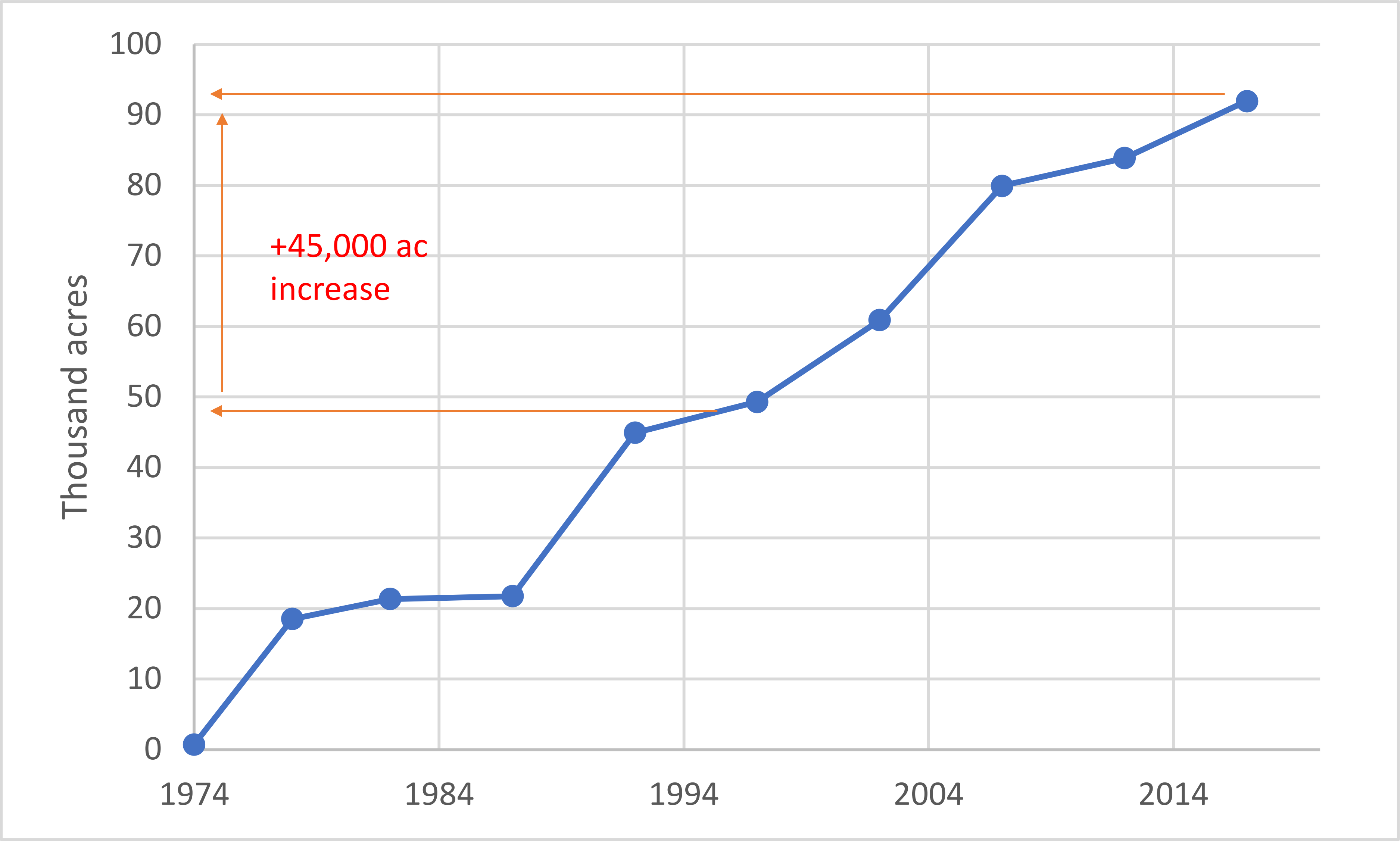
@25 lb N/ac-yr loss
= 1200 Mg N/yr

USDA National Agricultural Statistics Service

Center Pivot Irrigation in Illinois
2012 and 2014
Illinois State Water Survey
Map series 2015-03
Published November 2015



Irrigated acres in Whiteside + Ogle + Lee Counties



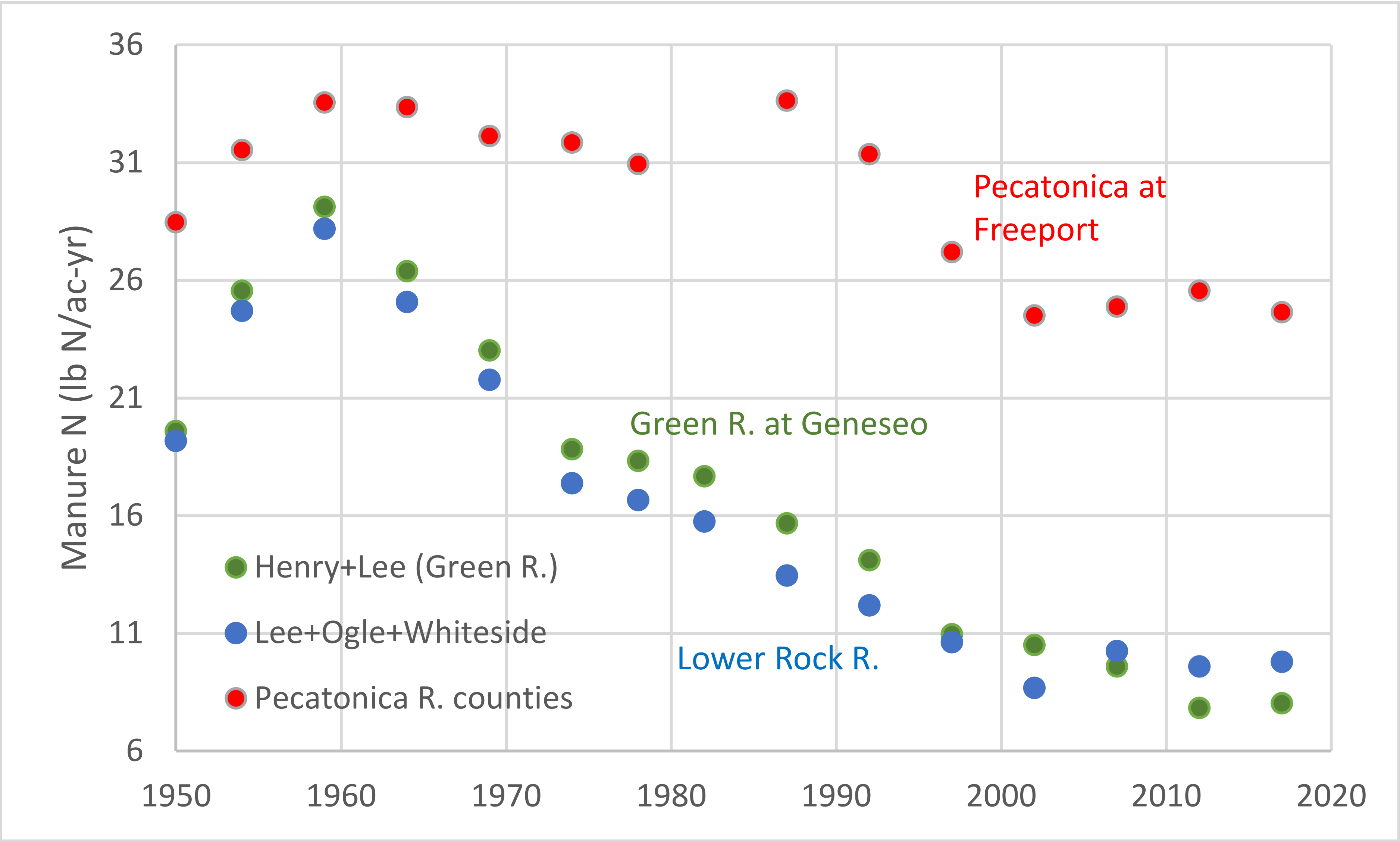
USDA Census of Agriculture data

~45,000 acre increase in irrigated acres

Much of it for seed corn and specialty crops, possibly adding ~25 lb N/ac-yr loss

Estimated additional nitrate contribution:
25 lb N/ac-yr =
=510 Mg N/yr

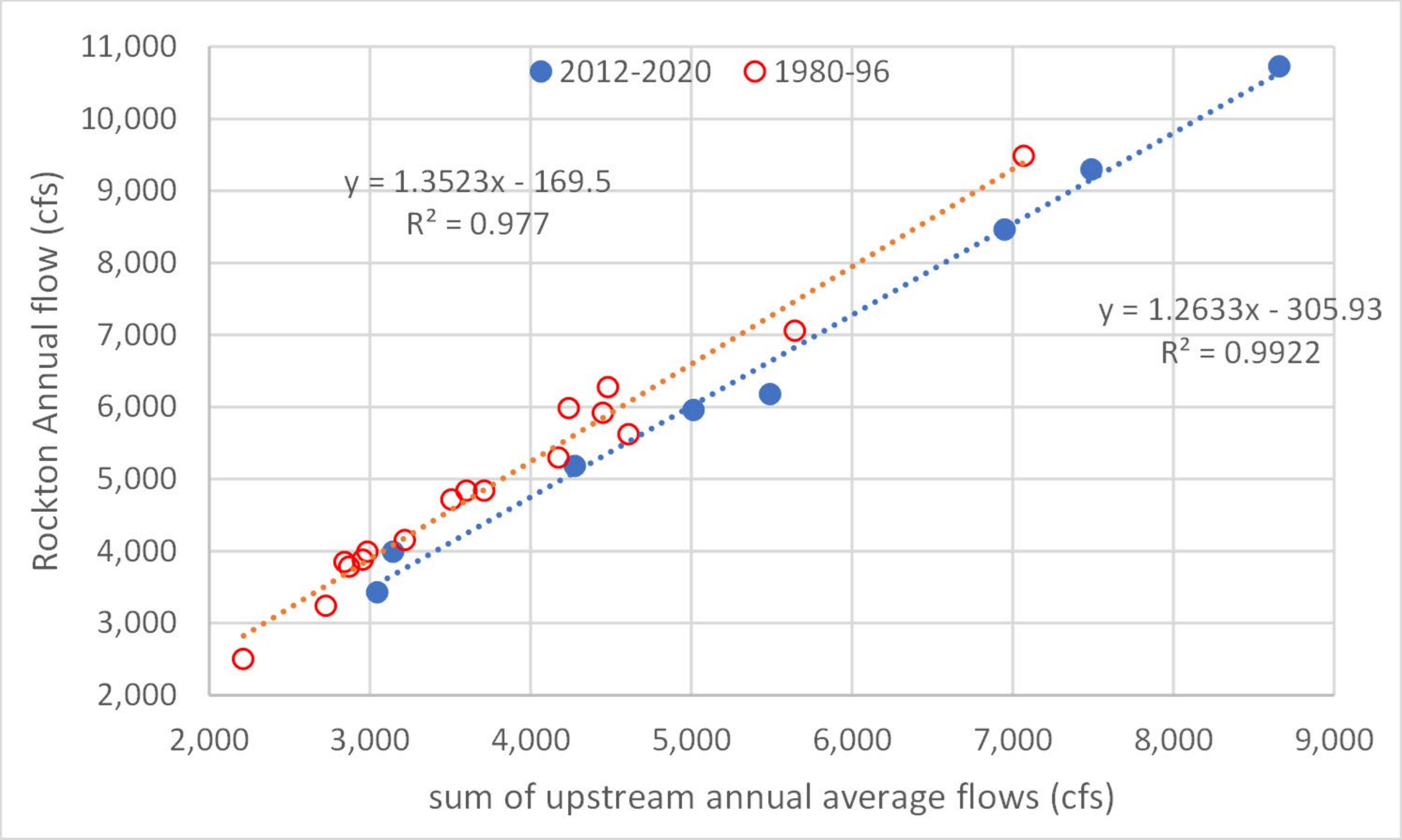
Manure N in counties draining to the Pecatonica, Green and Lower Rock Rivers



Data from USGS, Falcone 2021 https://doi.org/10.5066/P9VSQN3C

Possible flow measurement bias at Rockton

Annual average discharge at Rockton for two time periods plotted against the sum of the flows at Afton, Freeport and Brodhead



Measured flow at Rockton was highly correlated to the sum of the upstream flows, but the relationship shifted from 1980-96 to 2012-20.

This may be due to a 12% overestimation of flow at Rockton during 1980-96. If so, this would increase the 1980-96 load at Rockton by about 2,200 Mg N/yr and reduce the load increase to 8,400 Mg N/yr.

But other potential explanations for the shift include biases at other gages and/or changes in watershed or precipitation characteristics.

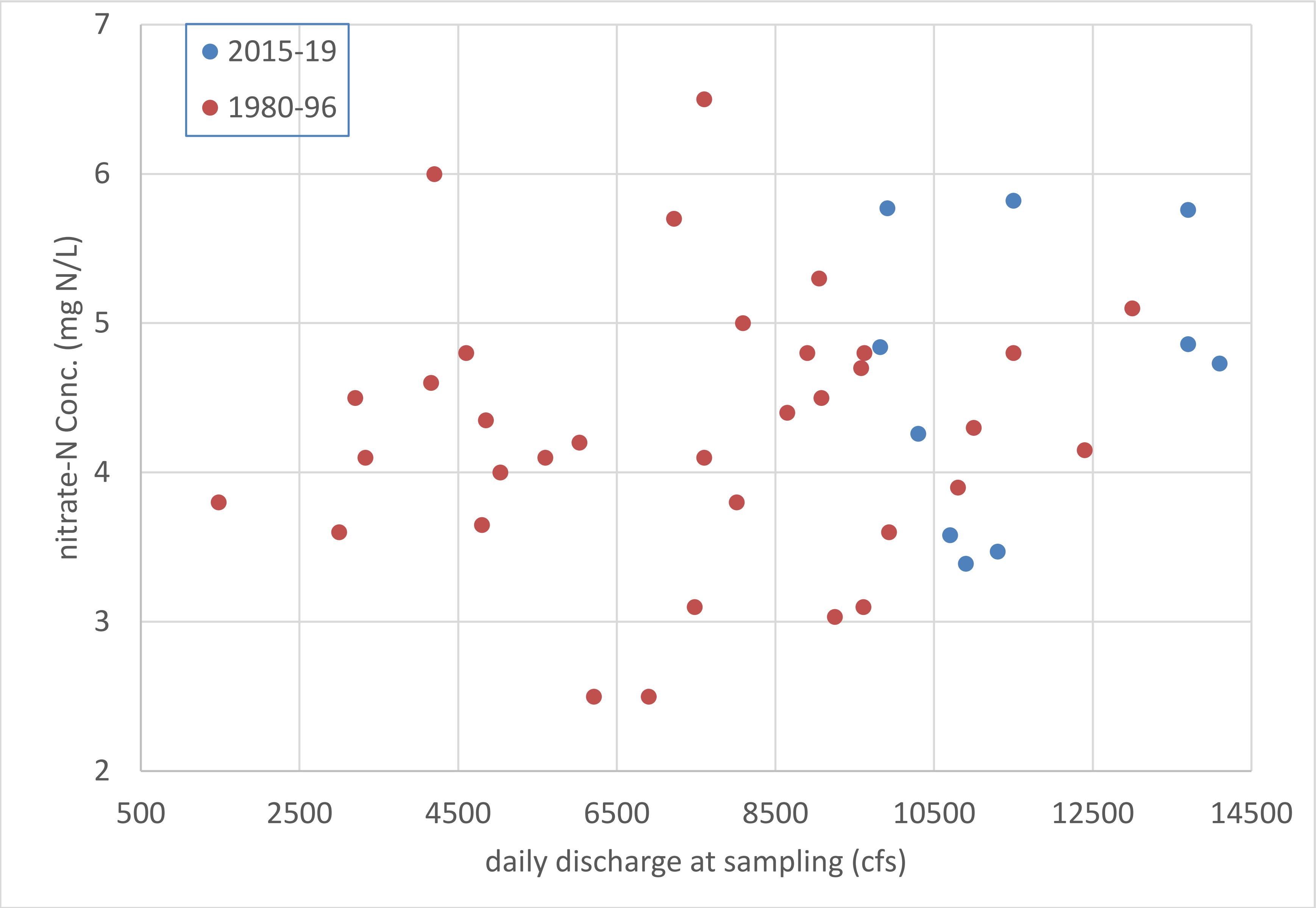
How much groundwater at 5 mg N/L is needed to put 5000 Mg N/yr into the Lower Rock River?

$$\frac{5000 \text{ Mg N/yr}}{5 \text{ mg N/L}} \times \frac{1 \text{ ft}^3}{28.32 \text{ L}} \times \frac{1 \text{ yr}}{3.15 \times 10^7 \text{ sec}} \times \frac{10^9 \text{ mg N}}{1 \text{ Mg N}} = 1{,}120 \text{ ft}^3\text{/sec}$$

$$\frac{1{,}120 \text{ cfs}}{2{,}925 \text{ cfs}} =$$ 38% of 2015-19 average flow in Lower Rock (Joslin-Rockton-Kishwaukee)

Change in flow from 1980-96 to 2015-19 = 1,250 cfs

Nitrate Concentrations at Joslin, Low flow, Jan-March



River water is not exclusively groundwater

Summary of plausible **estimates** of NO_3-N sources

Increased precipitation and water yield may account for an increased load of about 1900 Mg N/yr

Expansion of corn-soy and irrigated acres in the Lower Rock River Basin may have contributed 1700 Mg N/yr

Overestimation of flow at Rockton may account for under estimation in the 1980-96 load by 2200 Mg N/yr

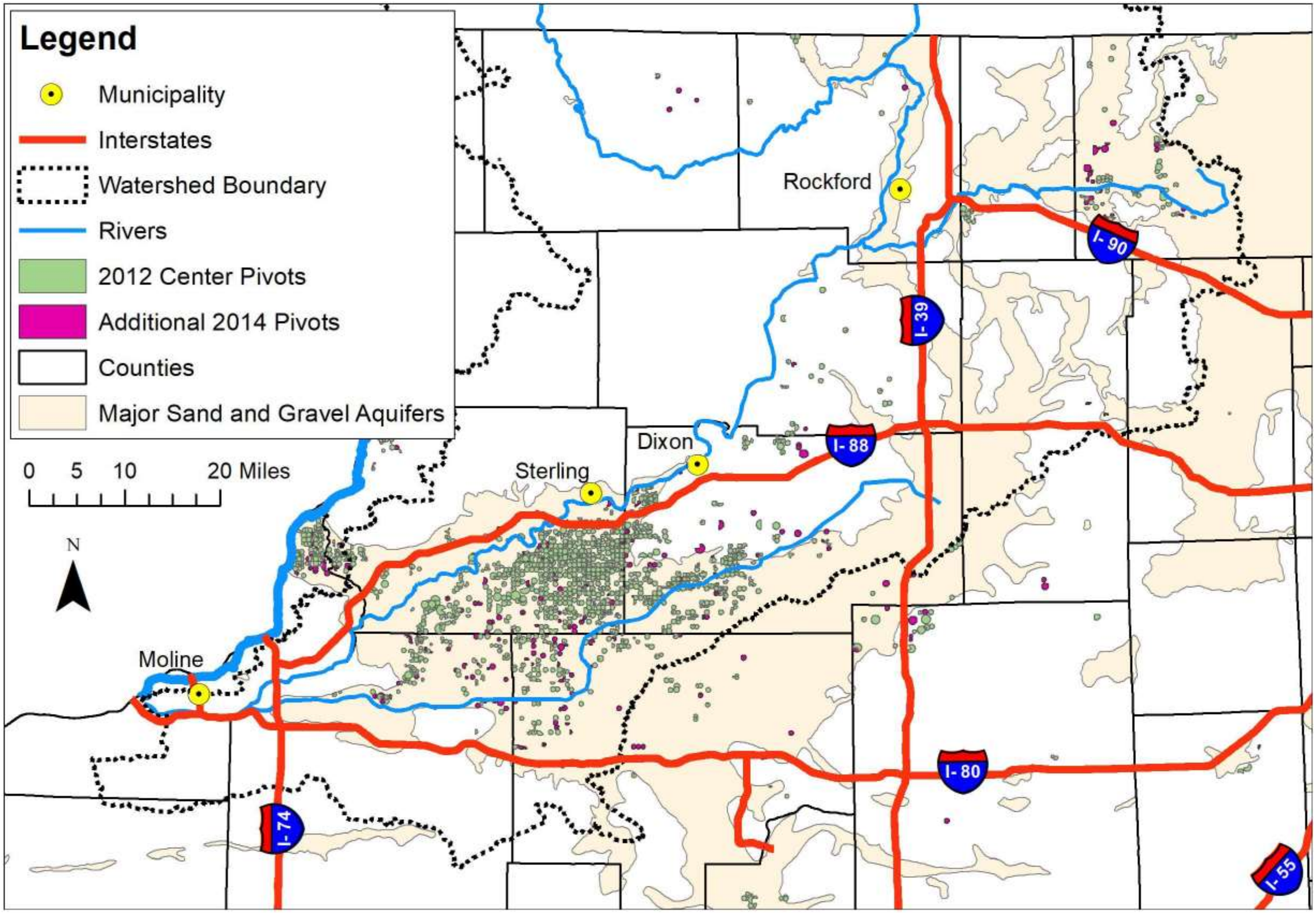
A combination of increased groundwater concentration and flow could plausibly account for about 5000 Mg N/yr, possibly derived from cropland leaching 10 to 20 years earlier

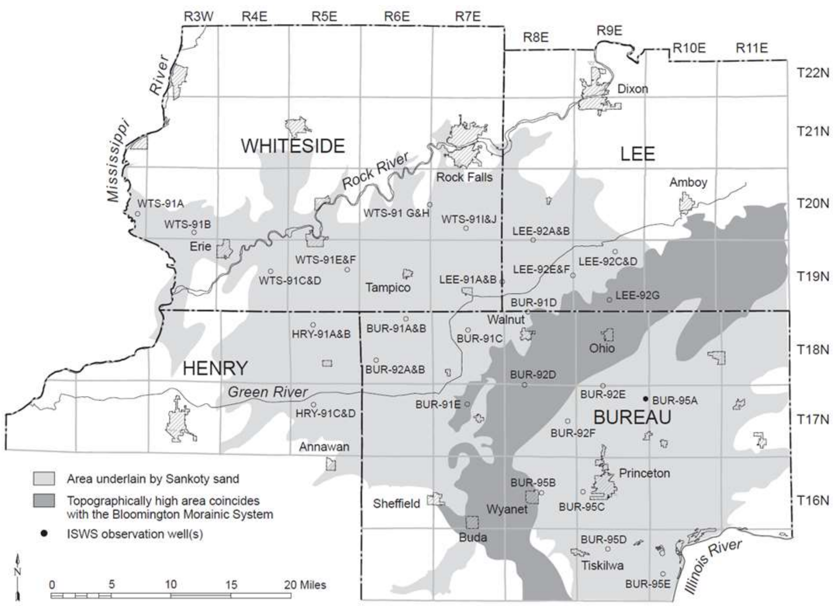
Preliminary results for groundwater nitrate modeling in the Rock River region

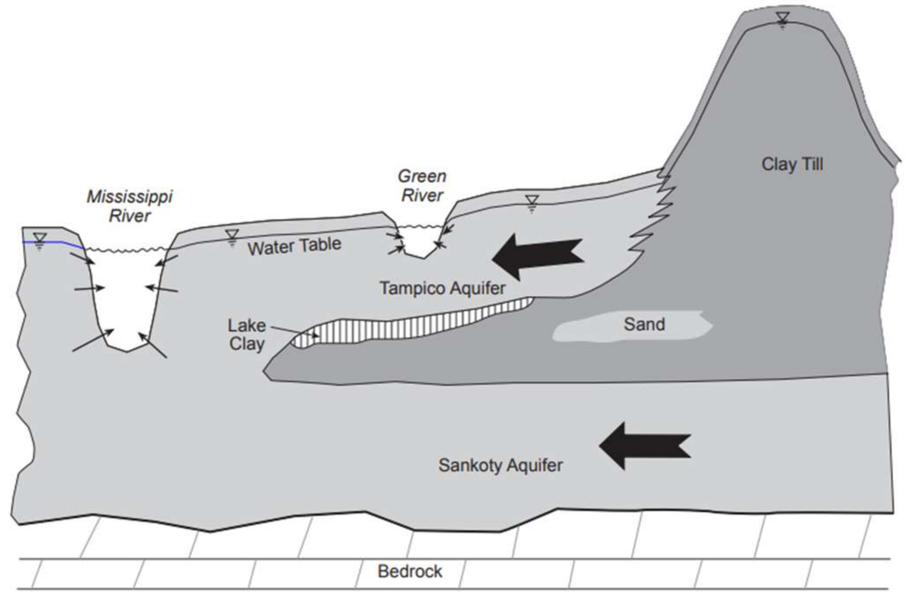
Vlad Iordache, Illinois State Water Survey

8/2/2022

Funded by: Illinois Environmental Protection Agency


Legend
Municipality
Interstates
Watershed Boundary
Rivers
2012 Center Pivots
Additional 2014 Pivots
Counties
Major Sand and Gravel Aquifers
0 5 10 20 Miles
N
Rockford
Dixon
Sterling
Moline
I-90
I-39
I-88
I-80
I-74
I-55

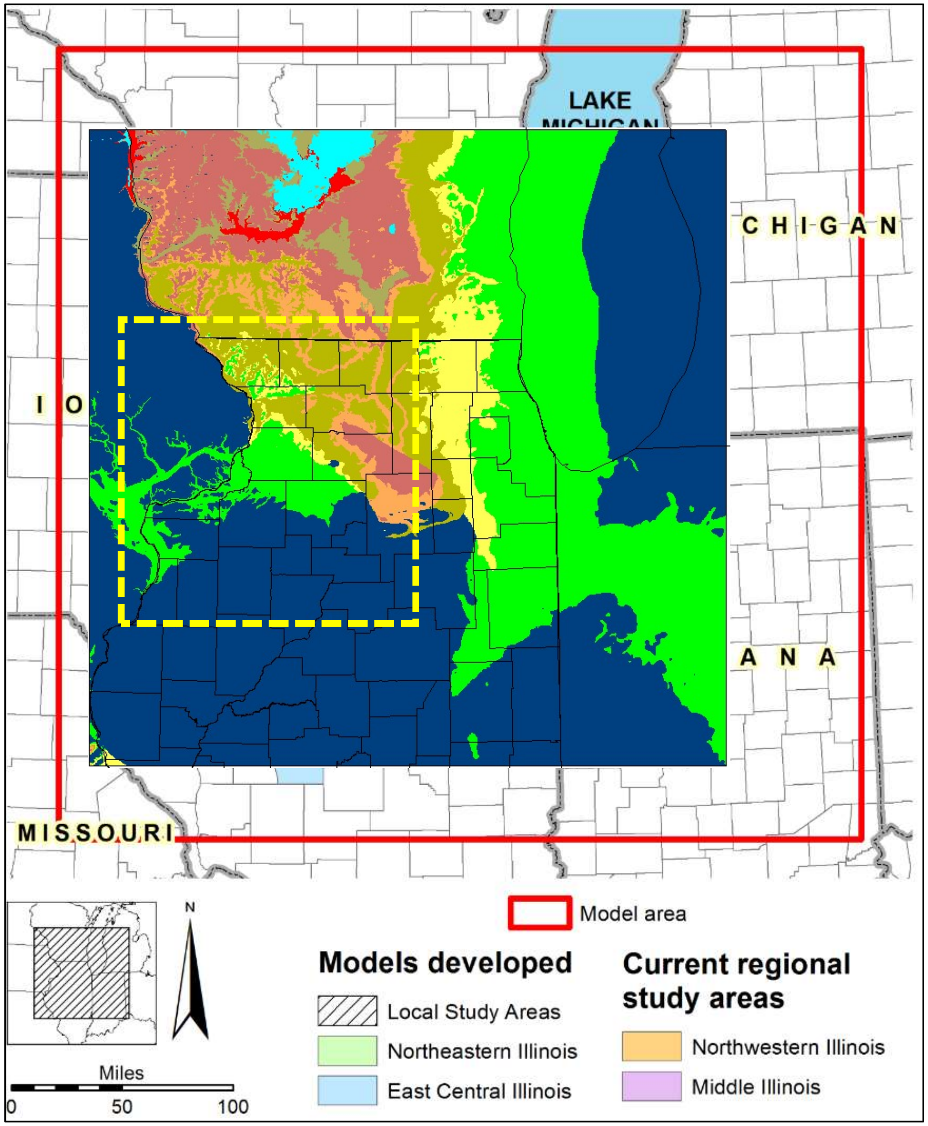

R3W
R4E
R5E
R6E
R7E
R8E
R9E
R10E
R11E
T22N
T21N
T20N
T19N
T18N
T17N
T16N
Mississippi River
Rock River
Green River
Illinois River
WHITESIDE
LEE
HENRY
BUREAU
Dixon
Rock Falls
Amboy
Erie
Tampico
Walnut
Ohio
Princeton
Annawan
Sheffield
Wyanet
Buda
Tiskilwa
Area underlain by Sankoty sand
Topographically high area coincides with the Bloomington Morainic System
ISWS observation well(s)
0 5 10 15 20 Miles


Mississippi River
Green River
Water Table
Tampico Aquifer
Lake Clay
Sand
Clay Till
Sankoty Aquifer
Bedrock

Illinois Groundwater Flow Model

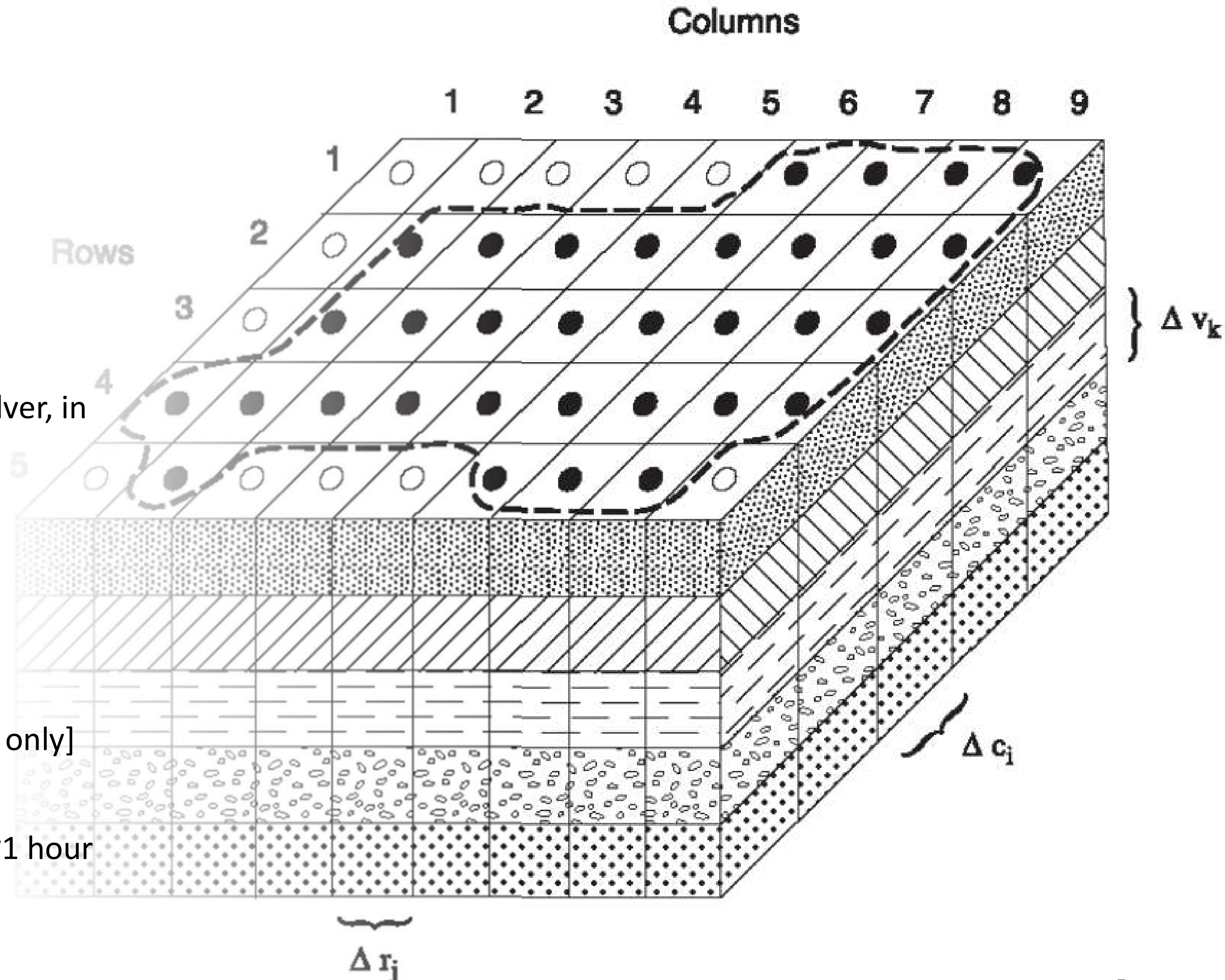
- Developed in coordination with ISGS and IDNR
- Models developed for two priority regions:
  - Northeastern IL
  - Mahomet Aquifer
- ALWAYS UPDATED
- Uniform grid spacing- 300 m

- 26 layers-
- 16 bedrock and 9 glacial



More on the model

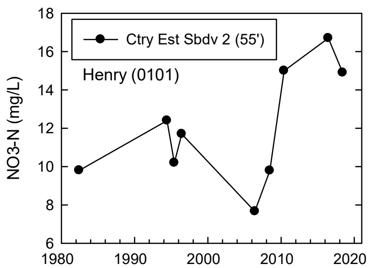
- Developed in MODFLOW
  - USGS finite difference solver, in use since 1984
  - International standard in simulating GW flow and interactions with SW
- 10 layers (9 S+G, 1 Bedrock)
  - ~100k cells/layer
- Run times:
  - Steady state [flow model only] ~10 minutes
  - Transient [flow and contaminant transport] ~1 hour [+]

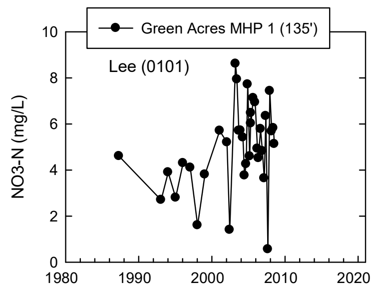


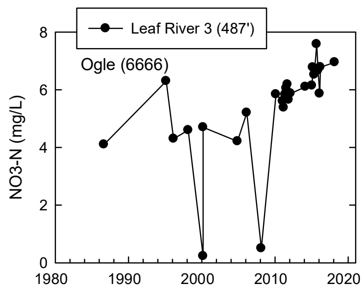
Phase 1: Compile available data

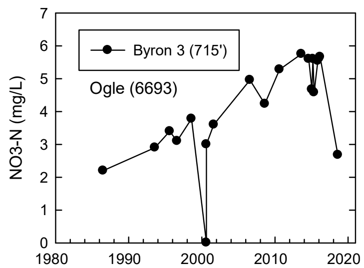
- Water quality
  - SW/GW [shallow and deep]
  - Temporal/spatial resolution
- Water demand
  - Public/Industrial – Steady State, Annual
  - Agriculture – Transient, Monthly
- Flow vectors

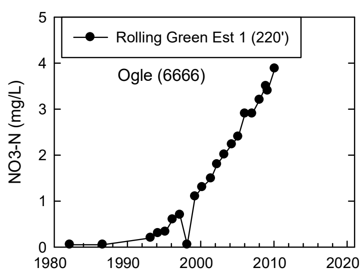
IEPA Public Water System Records

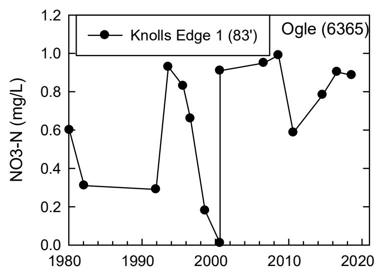




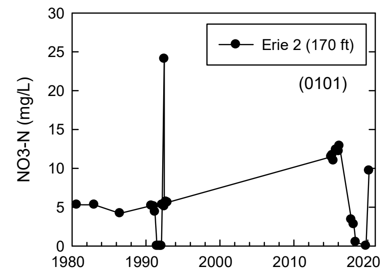


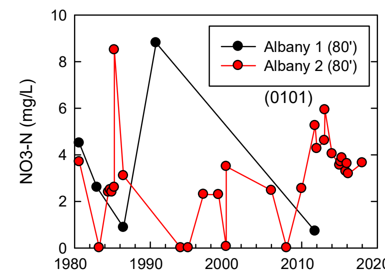


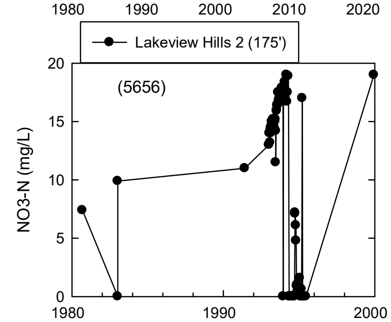


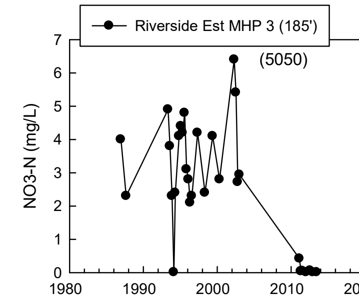


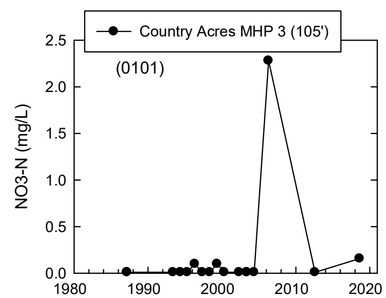
Whiteside



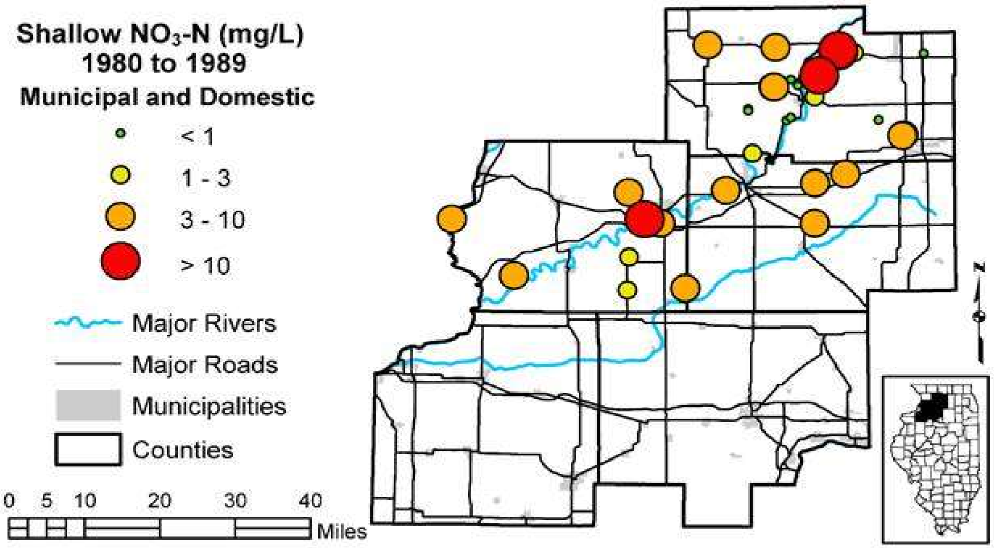


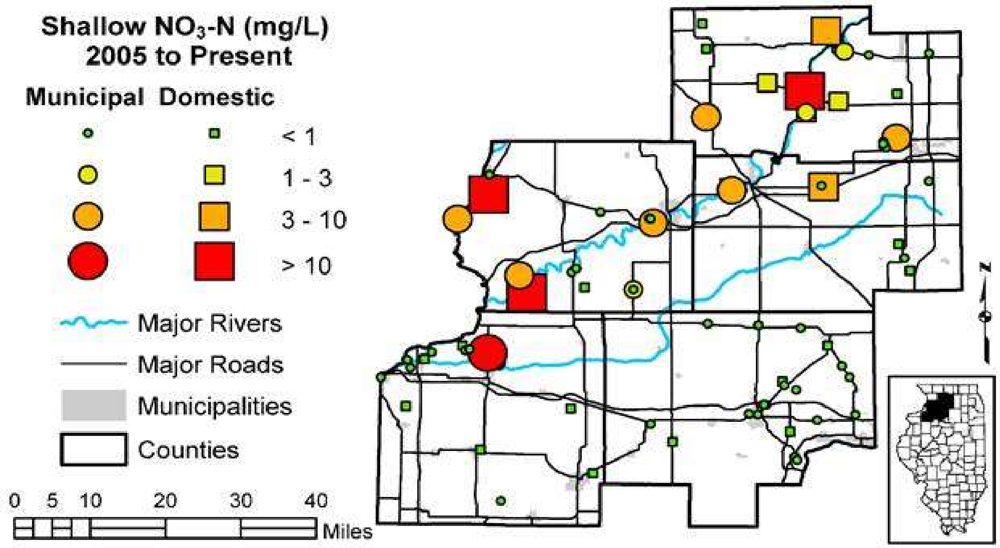




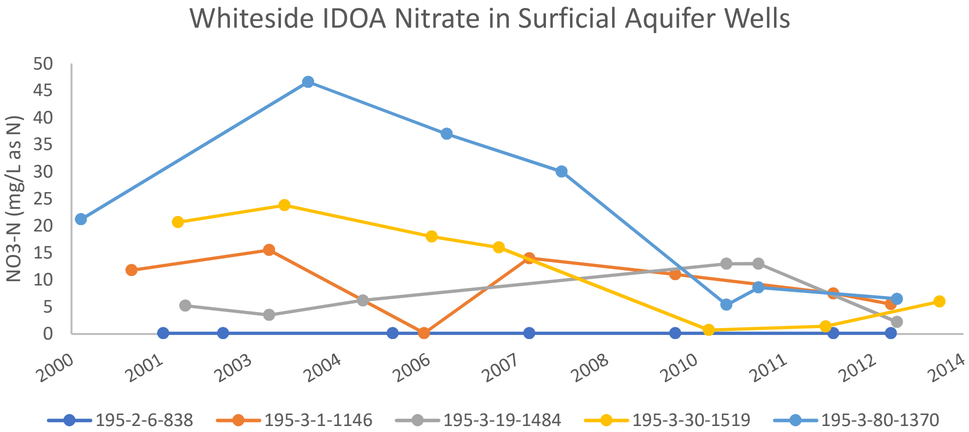


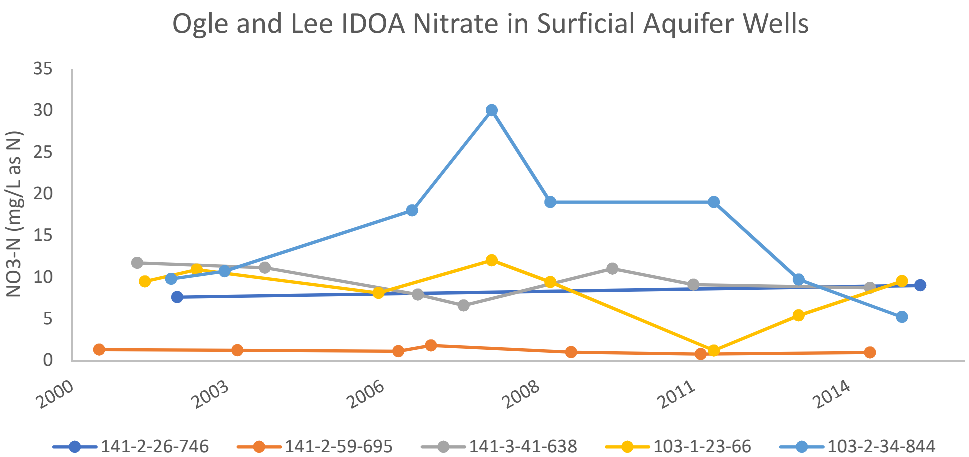
ISWS Public Service Lab Records





IDOA Nutrient Monitoring

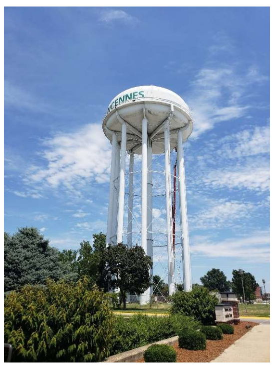




IWIP Overview – Data Collection

- Annual survey of high-capacity water withdrawals and use data

Public Water Systems



Provide water for human consumption to at least 15 service connections, or 25 people

Self-Supplied Industrial/Commercial Facilities

Wells/intakes which *combined* are *rated* to pump 100,000 gallons per day (about 70 gallons per minute or .1 million gallons per day)

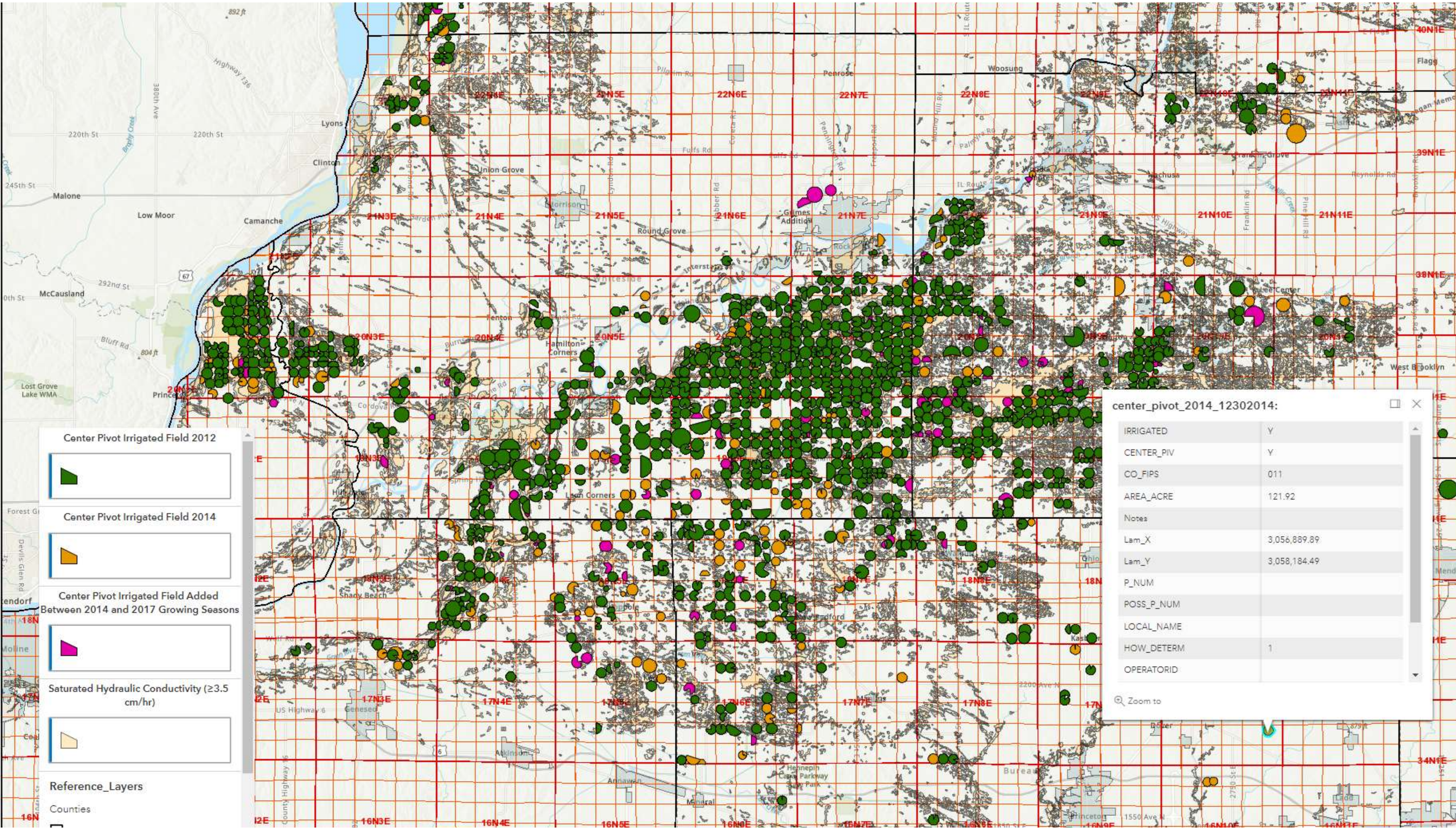
Agricultural Irrigation Systems

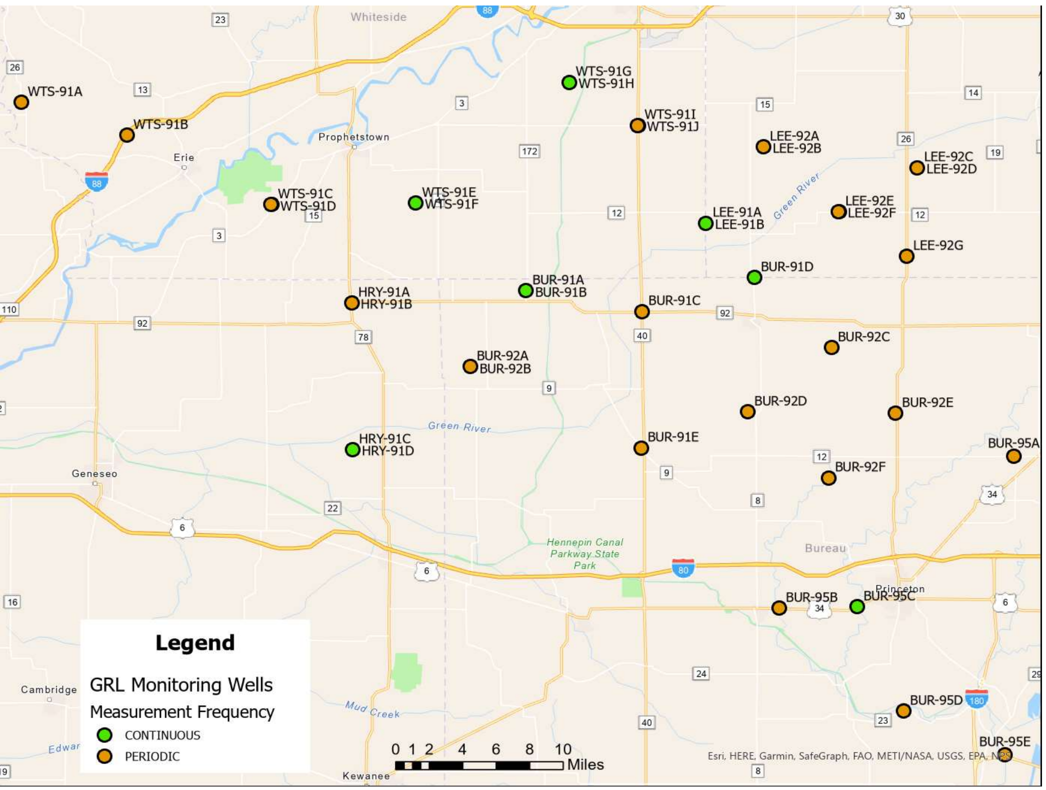
Focus on high-capacity center pivot irrigation users

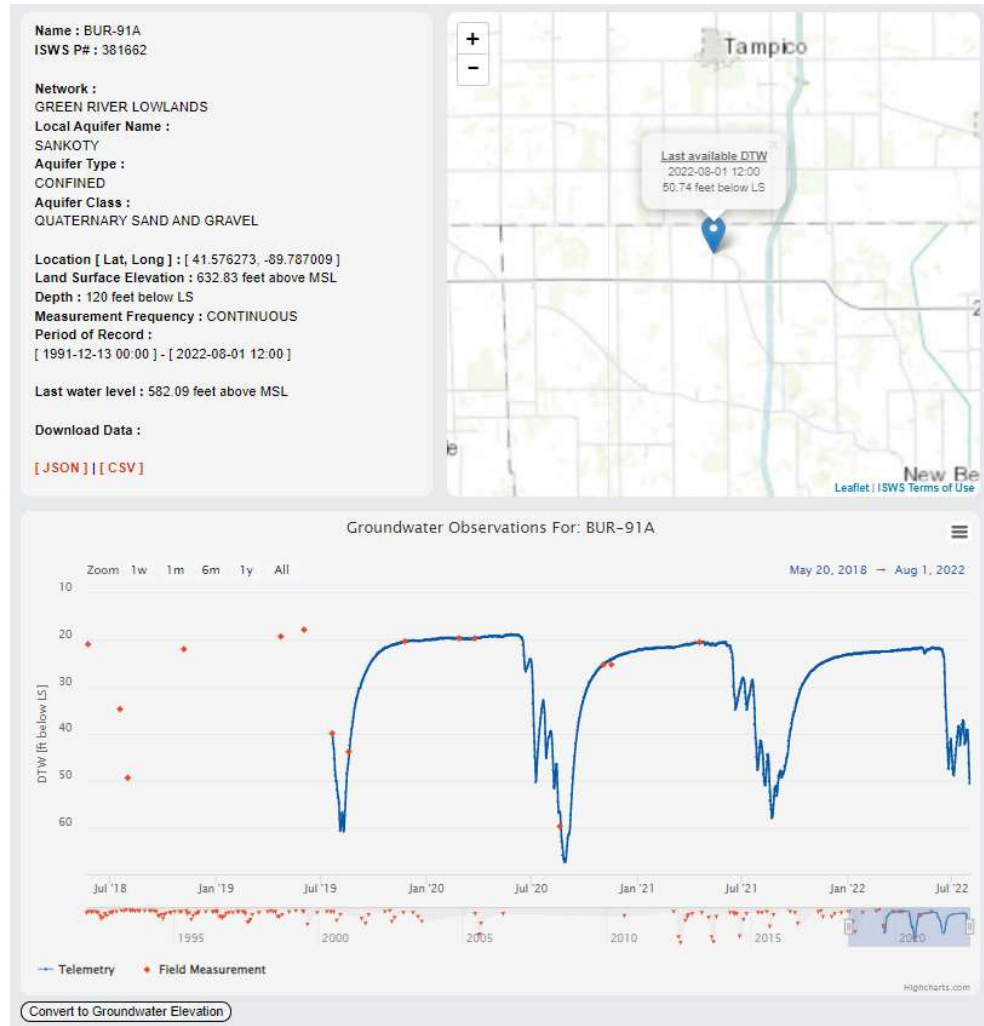
Low participation

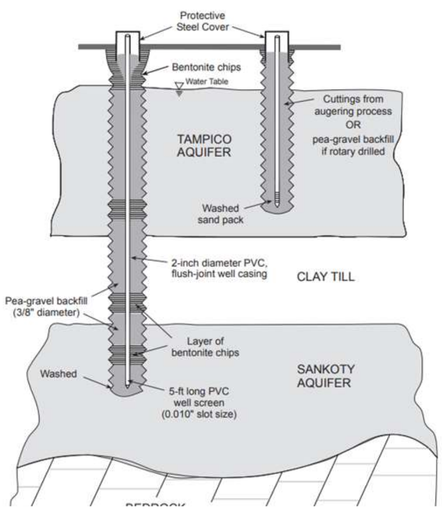
I ILLINOIS
Illinois State Water Survey
PRAIRIE RESEARCH INSTITUTE

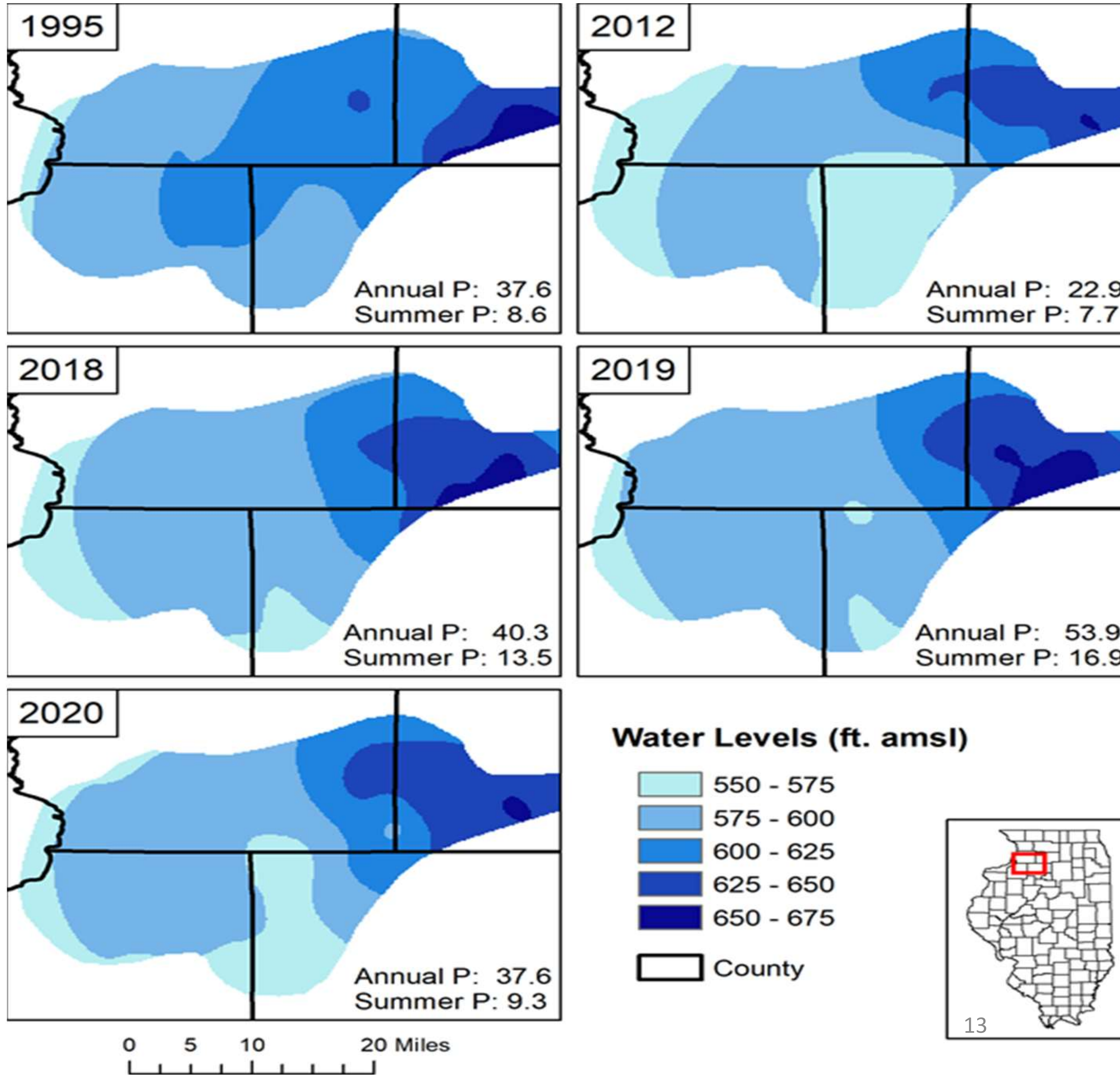
[Photo credits: Vlad Iordache, George Roadcap *ISWS,* Illinois.edu, flickr.com]

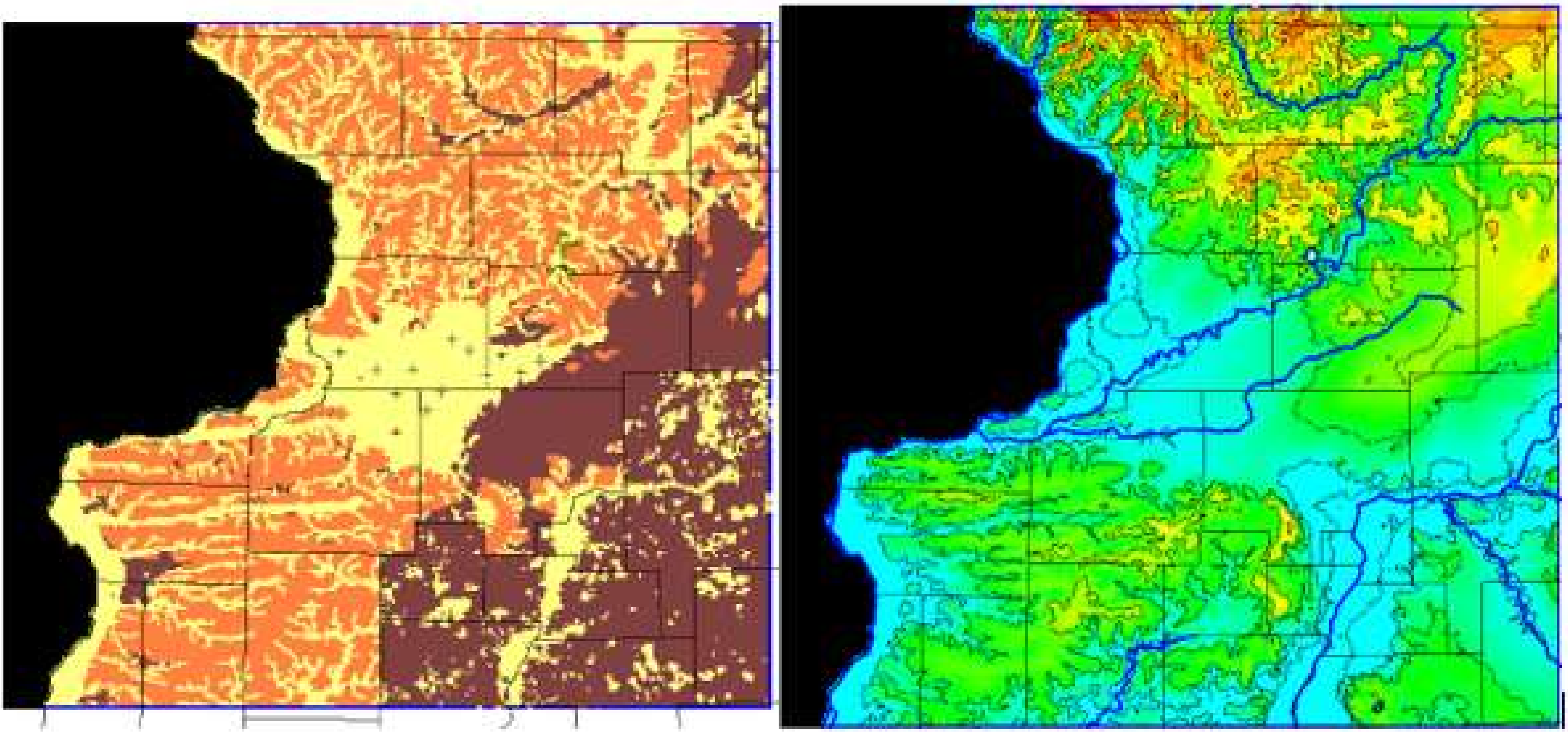

Center Pivot Irrigated Field 2012
Center Pivot Irrigated Field 2014
Center Pivot Irrigated Field Added Between 2014 and 2017 Growing Seasons
Saturated Hydraulic Conductivity (≥3.5 cm/hr)
Reference_Layers
Counties
center_pivot_2014_12302014:
IRRIGATED Y
CENTER_PIV Y
CO_FIPS 011
AREA_ACRE 121.92
Notes
Lam_X 3,056,889.89
Lam_Y 3,058,184.49
P_NUM
POSS_P_NUM
LOCAL_NAME
HOW_DETERM 1
OPERATORID
Zoom to
22N5E
22N6E
22N7E
22N8E
21N3E
21N4E
21N5E
21N6E
21N7E
21N9E
21N10E
21N11E
20N3E
20N4E
20N5E
17N3E
17N4E
17N6E
17N7E
17N8E
18N8E
16N3E
16N4E
16N5E
16N10E
40N1E
39N1E
38N1E
34N1E
Lyons
Clinton
Malone
Low Moor
Camanche
McCausland
Union Grove
Round Grove
Penrose
Woosung
Flagg
Hamilton Corners
Shady Beach
Geneseo
Atkinson
Annawan
Mineral
West Brooklyn
Lost Grove Lake WMA
Moline
220th St
245th St
292nd St
Bluff Rd
Fulfs Rd
892 ft
804 ft

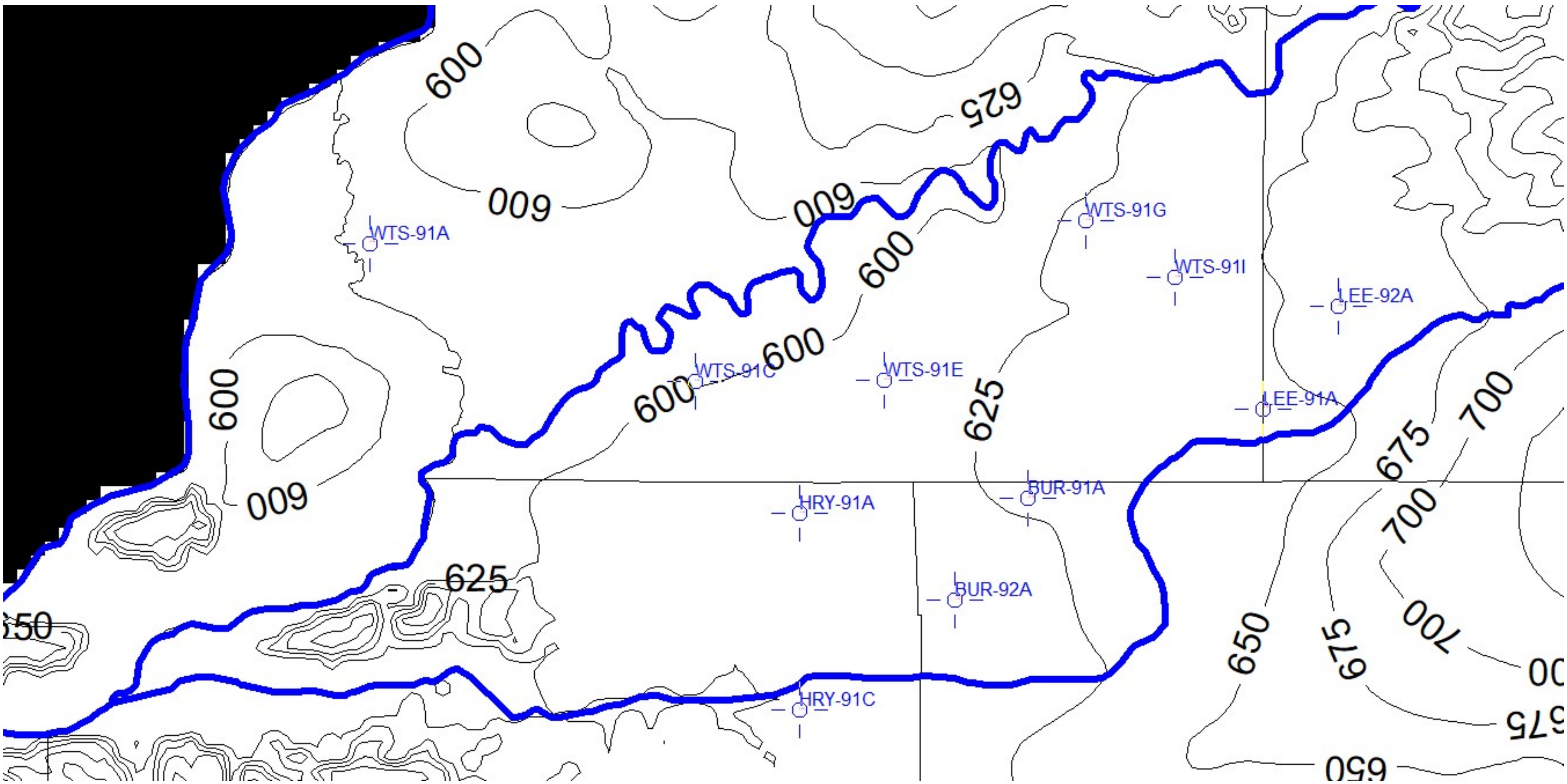

Legend
GRL Monitoring Wells
Measurement Frequency
CONTINUOUS
PERIODIC
0 1 2 4 6 8 10 Miles
WTS-91A
WTS-91B
WTS-91C
WTS-91D
WTS-91E
WTS-91F
WTS-91G
WTS-91H
WTS-91I
WTS-91J
LEE-92A
LEE-92B
LEE-92C
LEE-92D
LEE-92E
LEE-92F
LEE-92G
LEE-91A
LEE-91B
BUR-91A
BUR-91B
BUR-91C
BUR-91D
BUR-91E
BUR-92A
BUR-92B
BUR-92C
BUR-92D
BUR-92E
BUR-92F
BUR-95A
BUR-95B
BUR-95C
BUR-95D
BUR-95E
HRY-91A
HRY-91B
HRY-91C
HRY-91D
Whiteside
Prophetstown
Erie
Geneseo
Cambridge
Kewanee
Bureau
Princeton
Green River
Hennepin Canal Parkway State Park
Mud Creek
Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS

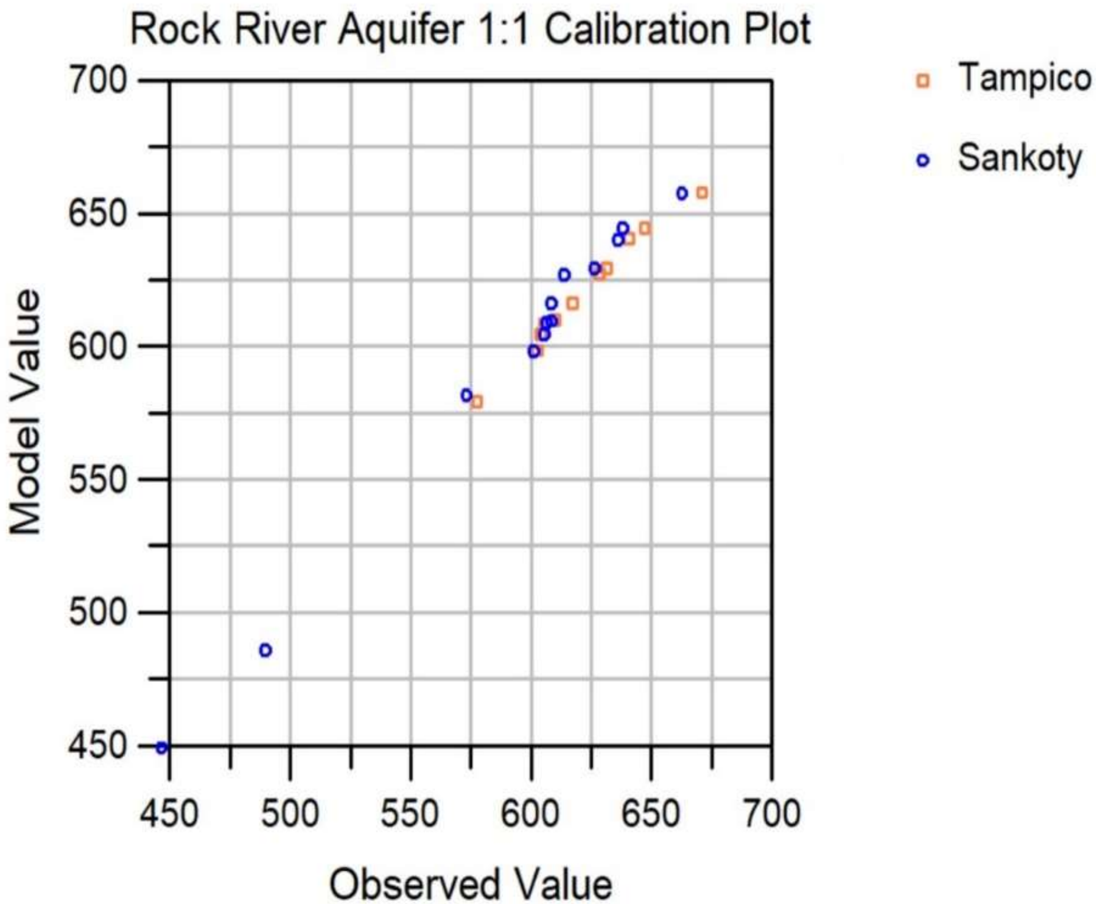

Name : BUR-91A
ISWS P# : 381662
Network :
GREEN RIVER LOWLANDS
Local Aquifer Name :
SANKOTY
Aquifer Type :
CONFINED
Aquifer Class :
QUATERNARY SAND AND GRAVEL
Location [Lat, Long] : [41.576273, -89.787009]
Land Surface Elevation : 632.83 feet above MSL
Depth : 120 feet below LS
Measurement Frequency : CONTINUOUS
Period of Record :
[1991-12-13 00:00] - [2022-08-01 12:00]
Last water level : 582.09 feet above MSL
Download Data :
[JSON] | [CSV]
Tampico
Last available DTW
2022-08-01 12:00
50.74 feet below LS
Leaflet | ISWS Terms of Use
Groundwater Observations For: BUR-91A
Zoom 1w 1m 6m 1y All
May 20, 2018 → Aug 1, 2022
DTW [ft below LS]
10
20
30
40
50
60
Jul '18
Jan '19
Jul '19
Jan '20
Jul '20
Jan '21
Jul '21
Jan '22
Jul '22
1995
2000
2005
2010
2015
2020
Telemetry
Field Measurement
Highcharts.com
Convert to Groundwater Elevation


Protective
Steel Cover
Bentonite chips
Water Table
Cuttings from
augering process
OR
pea-gravel backfill
if rotary drilled
TAMPICO
AQUIFER
Washed
sand pack
2-inch diameter PVC,
flush-joint well casing
CLAY TILL
Pea-gravel backfill
(3/8" diameter)
Layer of
bentonite chips
Washed
SANKOTY
AQUIFER
5-ft long PVC
well screen
(0.010" slot size)


1995
Annual P: 37.6
Summer P: 8.6
2012
Annual P: 22.9
Summer P: 7.7
2018
Annual P: 40.3
Summer P: 13.5
2019
Annual P: 53.9
Summer P: 16.9
2020
Annual P: 37.6
Summer P: 9.3
Water Levels (ft. amsl)
550 - 575
575 - 600
600 - 625
625 - 650
650 - 675
County
0 5 10 20 Miles




WTS-91A
WTS-91G
WTS-91I
LEE-92A
WTS-91C
WTS-91E
LEE-91A
BUR-91A
HRY-91A
BUR-92A
HRY-91C
600
625
650
675
700

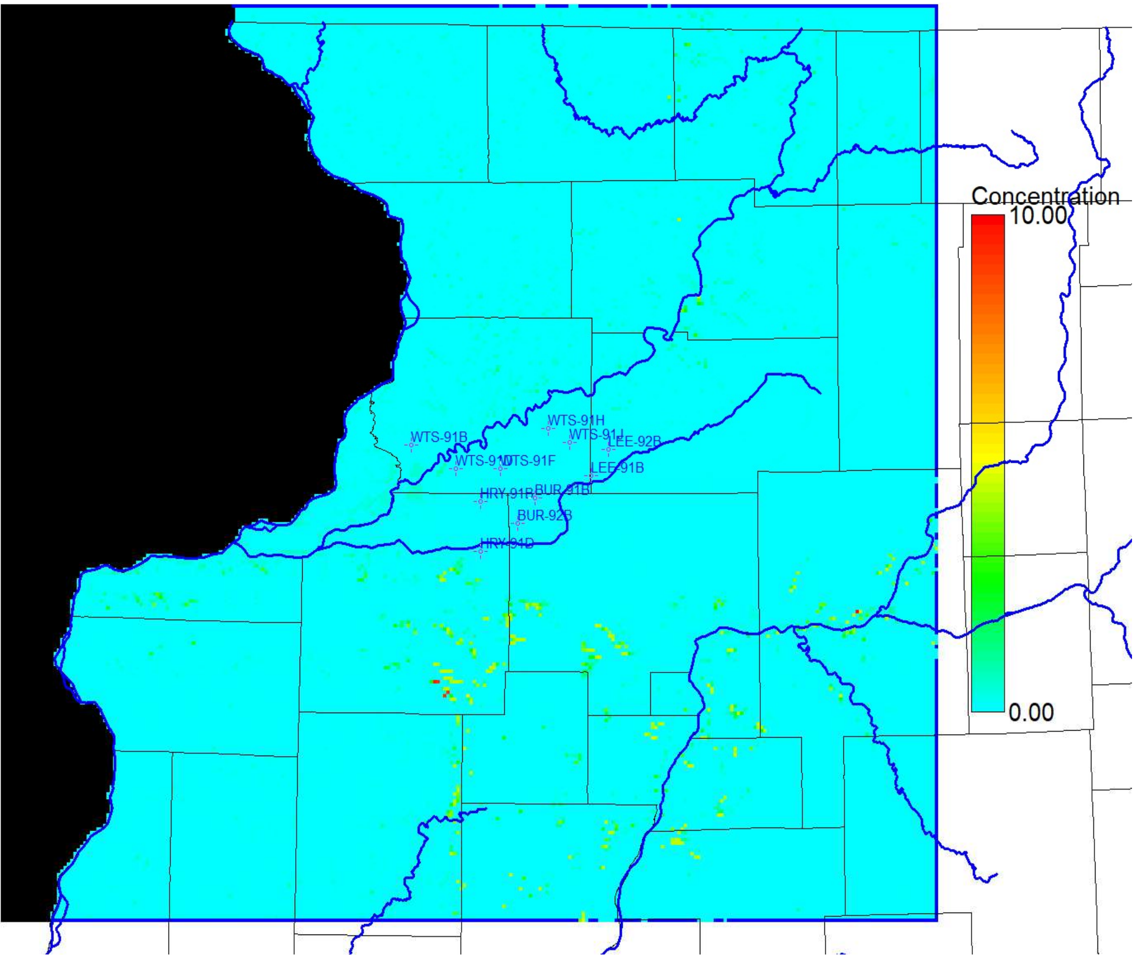


- All calibration targets
  - Mean Error: -0.69 ft
  - Absolute Mean Error: 3.78 ft
  - RMSE: 5.21 ft
- 4 suspect targets removed
  - Mean Error: -0.02 ft
  - Absolute Mean Error: 2.41 ft
  - RMSE: 2.92 ft

Let's add nitrate! [Phase 2]

- Convert to transient model
  - 101 Stress Periods [SP]
  - 2/year
    - Start in 1980, end in 2030
    - 9 months without agriculture demand
    - 3 months with agriculture demand
- Apply nitrate as "contaminated" areal recharge
  - For initial runs 10mg/L NO3-N everywhere
- Assume no initial nitrate in groundwater

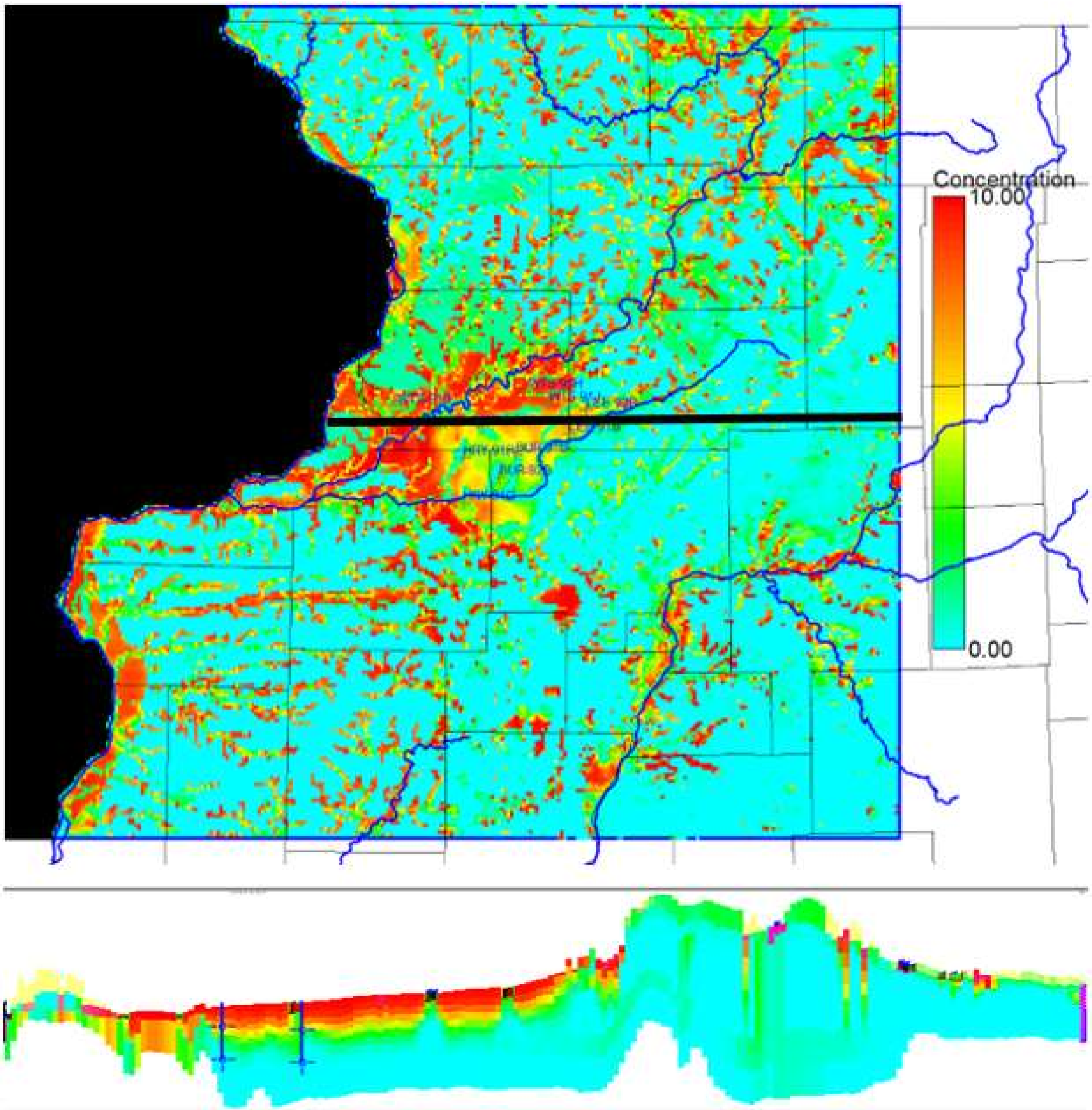
Tampico Aquifer, 1980, Spring

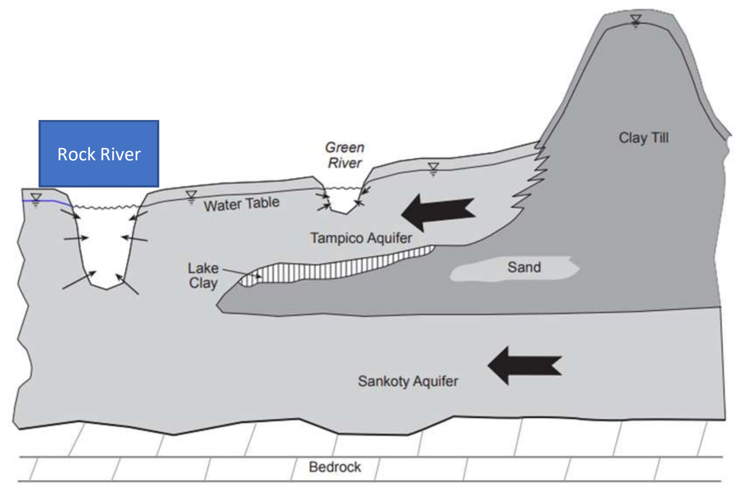


- Most applied nitrate is immediately lost to streams/wells
- Quickest infiltration of nitrate is far removed from our area of interest

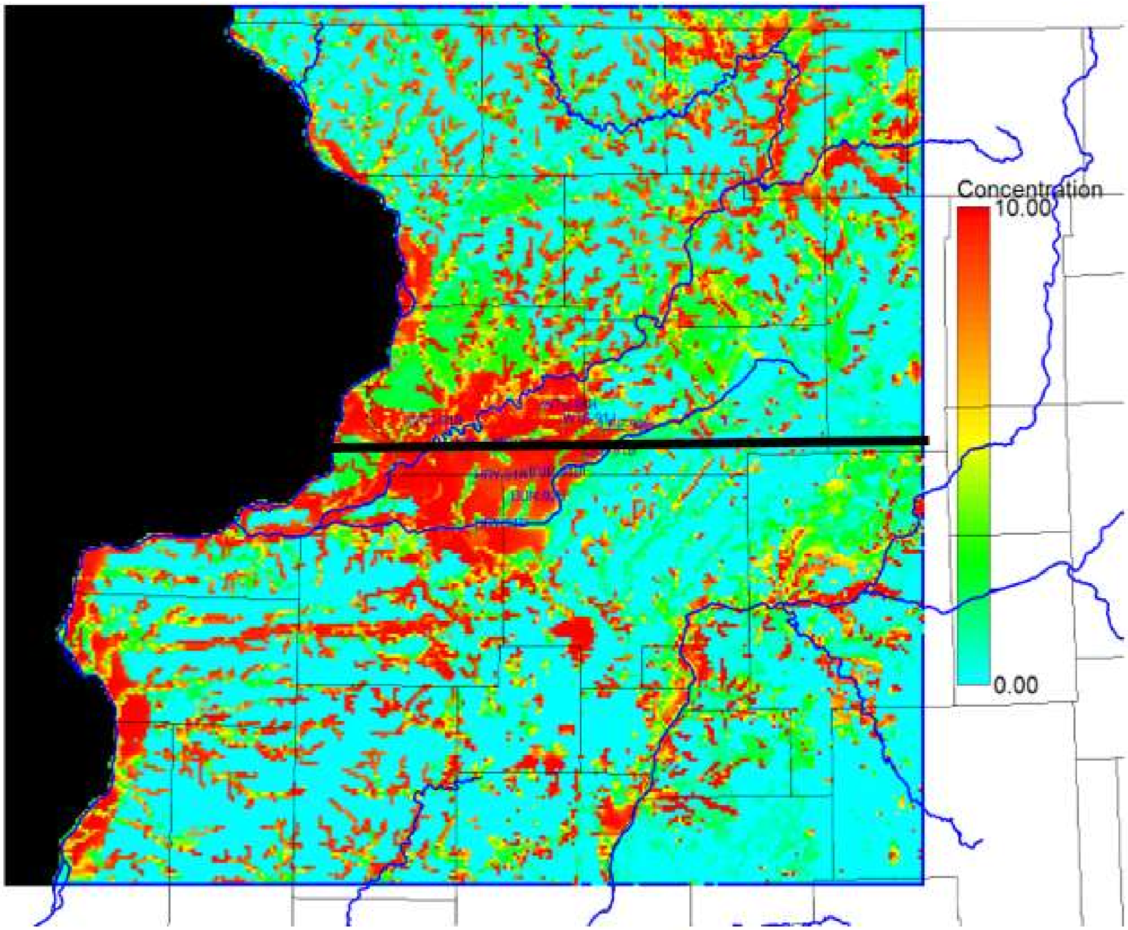
Tampico Aquifer, 2004, Winter

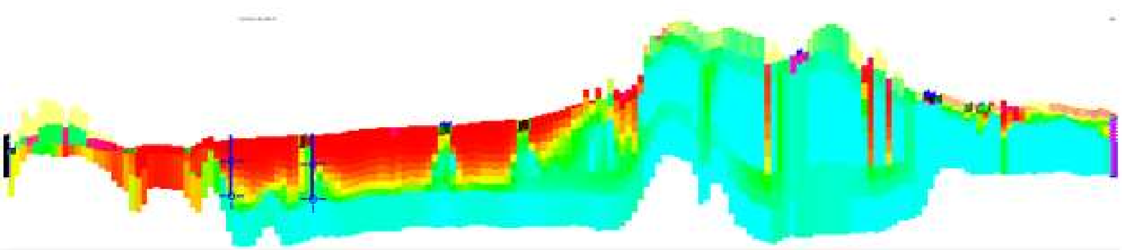
- W Tampico is saturated
- Central Tampico is able to ‘flush’ to rivers
- Local geology controls





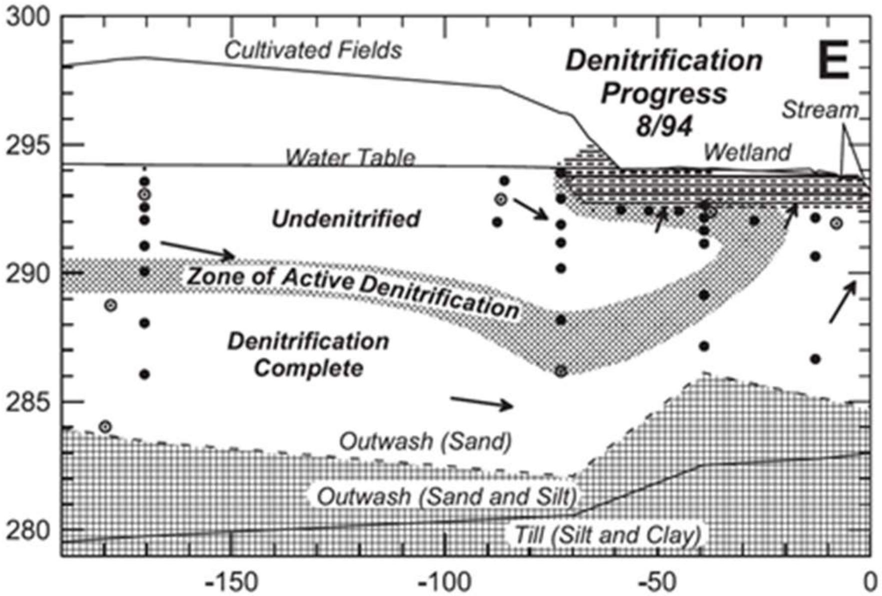
Tampico Aquifer, 2030, Spring



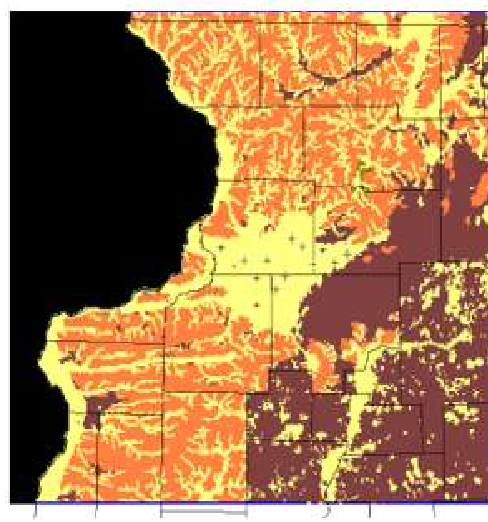


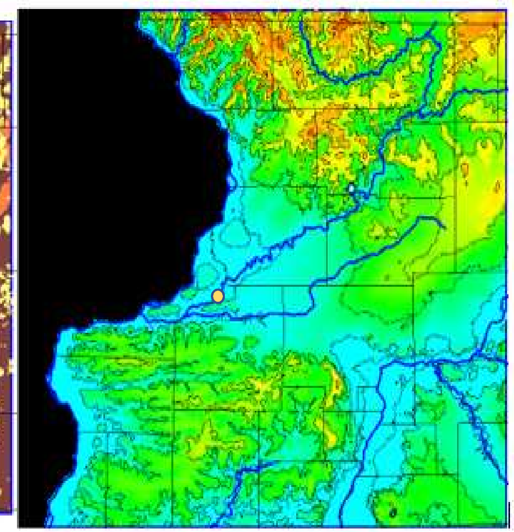
- Most of Tampico is saturated
  - “Drainage” zones persist
- Shallow Sankoty Aquifer locally contaminated*
  - If scenario is viable, domestic wells are at risk

Preliminary assessments of in-stream denitrification

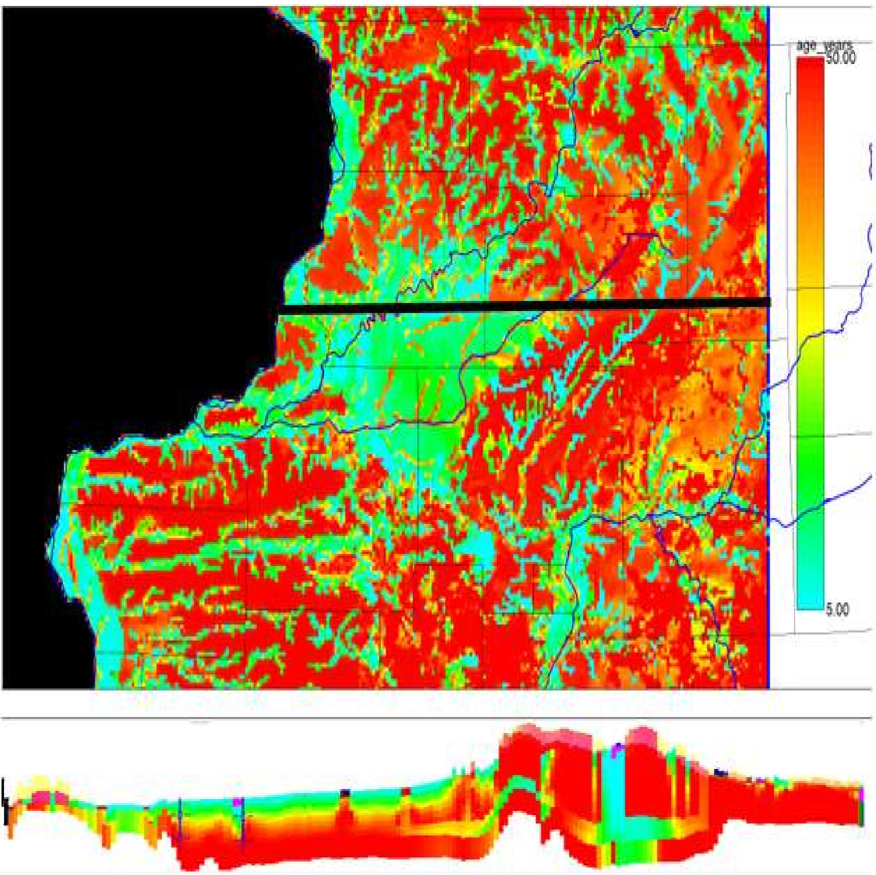


	Flow (cfs)	Conc (mg/L)-simulated	Conc (mg/L)-observed
Joslin	878	8.0	4.0-5.5





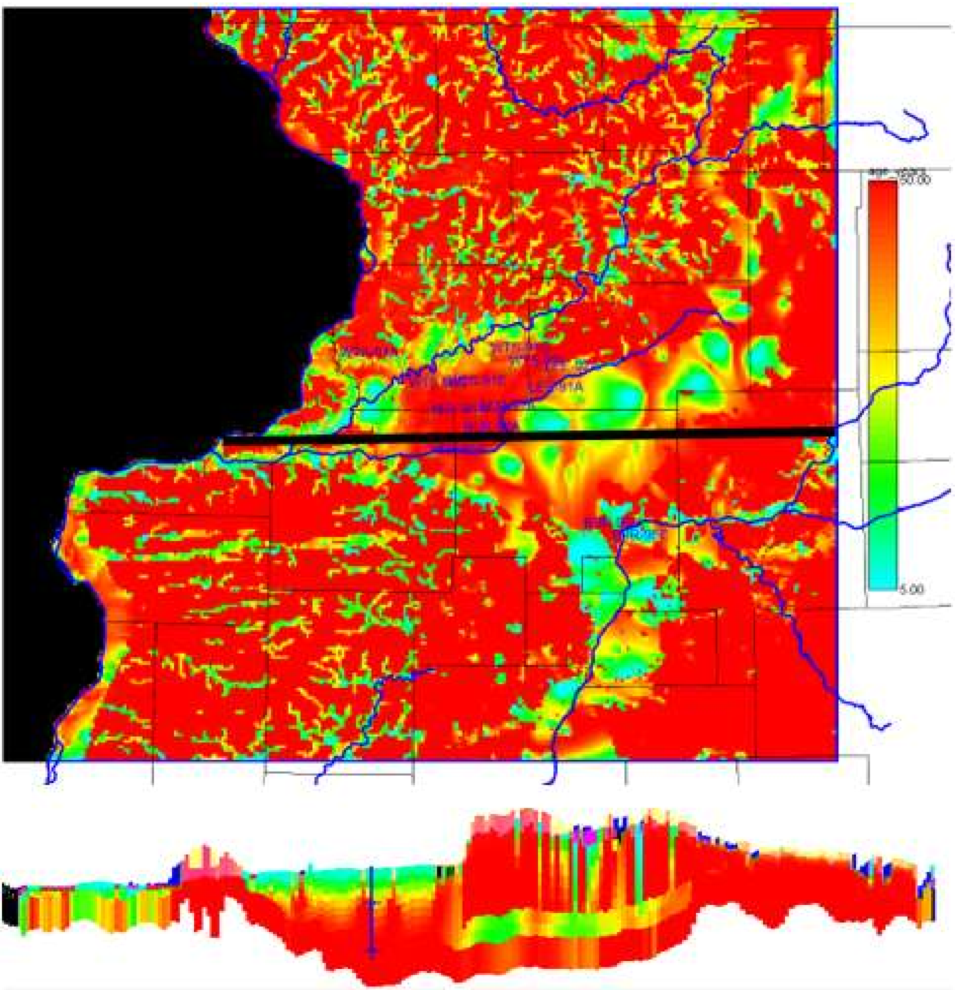
Tampico Aquifer, GW age assessment



"Groundwater age was calculated by assigning a concentration of zero to the recharge throughout the simulation and calculating a zero-order decay rate of -1/day."

Translation: **Every day a drop of water is in the model it ages by 1 day**

- Groundwater "lag" from Tampico is ~15-20 years
  - 5-10 years near river
  - Low order streams coincide with channels of "old" GW*
- Much older water near Joslin
  - Water is "cleaner"
  - Aquifer is thin to non-existant
  - Model nitrate is quickly lost to Rock or Green River



Sankoty Aquifer, GW age assessment

- Groundwater “lag” from Sankoty ~45 – 50+ years
  - 5-10 years near river [Especially N of Joslin]
  - >50-year GW coincides with aquitard and flat hyd gradient
  - South of Green River steep gradient to Illinois River
- If contamination reaches the Sankoty aquifer, remediation will be difficult

Next steps [Phase 3, end of August]

- Refine model inputs to better mimic reality
  - Nitrate application rates/timing/distribution
  - Irrigation demand/distribution
- Calibrate transient model to:
  - Water quality data [see table]
  - Summer flow conditions
- Quantify nitrogen load to Rock River at various points
- Conduct uncertainty analysis based on observed data

	Conc (mg/L)- simulated	Conc (mg/L)- observed
Rock Falls	8.0-9.5	2.0-6.0
Dixon	5.0-8.0	4.0-8.5
Byron	1.4-7.7	2.5-6.0

I need your help!

- Nitrate inputs (is 10 mg/L recharge a fair approximation)
- Legacy nitrate
- Nitrate data [especially recent]

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Illinois River Basin
Next Generation Monitoring

August 2, 2022, Nutrient Monitoring Council

U.S. Department of the Interior
U.S. Geological Survey

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Outline

- Background
- Nutrients
  - Super gages
  - Synoptic nutrient surveys
  - Source Tracking
  - GW-SW interaction
- Harmful algal blooms
  - Discrete sampling
  - Remote sensing WQ
  - eDNA monitoring

Integrated Water Science Basins

10 Intensive Reference Basins to Drive the Future of Integrated Water Science:

- Regional focus areas for intensive observation, assessments, modeling, and prediction
- 10 river basins representative of larger water-resource regions
- Goal: Establish 10 basins in 10 years
- Develop a deep, integrated understanding that can be extended to the broader region
- Basin selection process includes quantitative metrics and extensive stakeholder engagement

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Integrated Water Science Initiative

Next Generation Water Observing System (NGWOS)

NGWOS collects real-time data on water quantity and quality in more affordable, rapid, and intensive ways than has previously been possible. The flexible monitoring approach enables USGS networks to evolve with new technology and emerging threats.

Integrated Water Availability Assessments (IWAA)

IWAAs examine the supply, use, and availability of the nation's water. These regional and national assessments evaluate water quantity and quality in both surface and groundwater, as related to human and ecosystem needs and as affected by human and natural influences.

Illinois River Basin Priority Use Cases

1. Understanding the factors that contribute to **harmful algal blooms**
2. Understanding the sources, distribution and transport of **nutrients**

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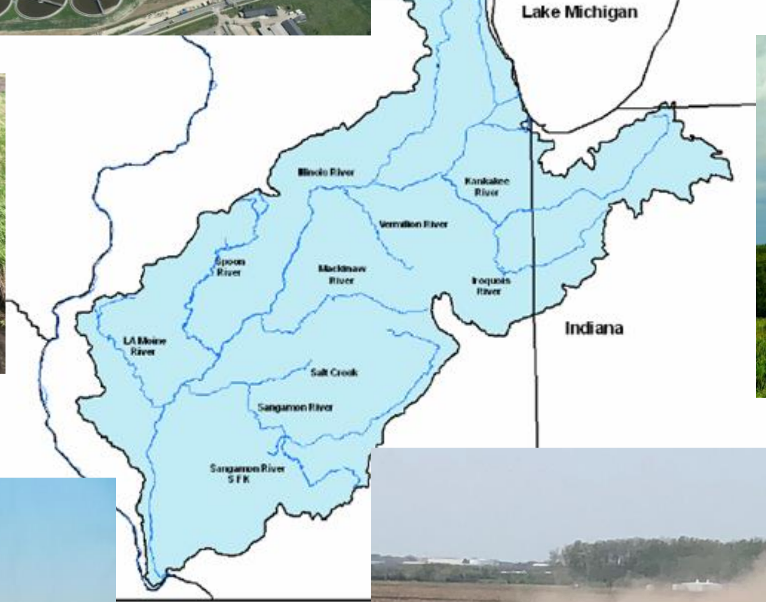
USGS Integrated Water Science Basin Activities



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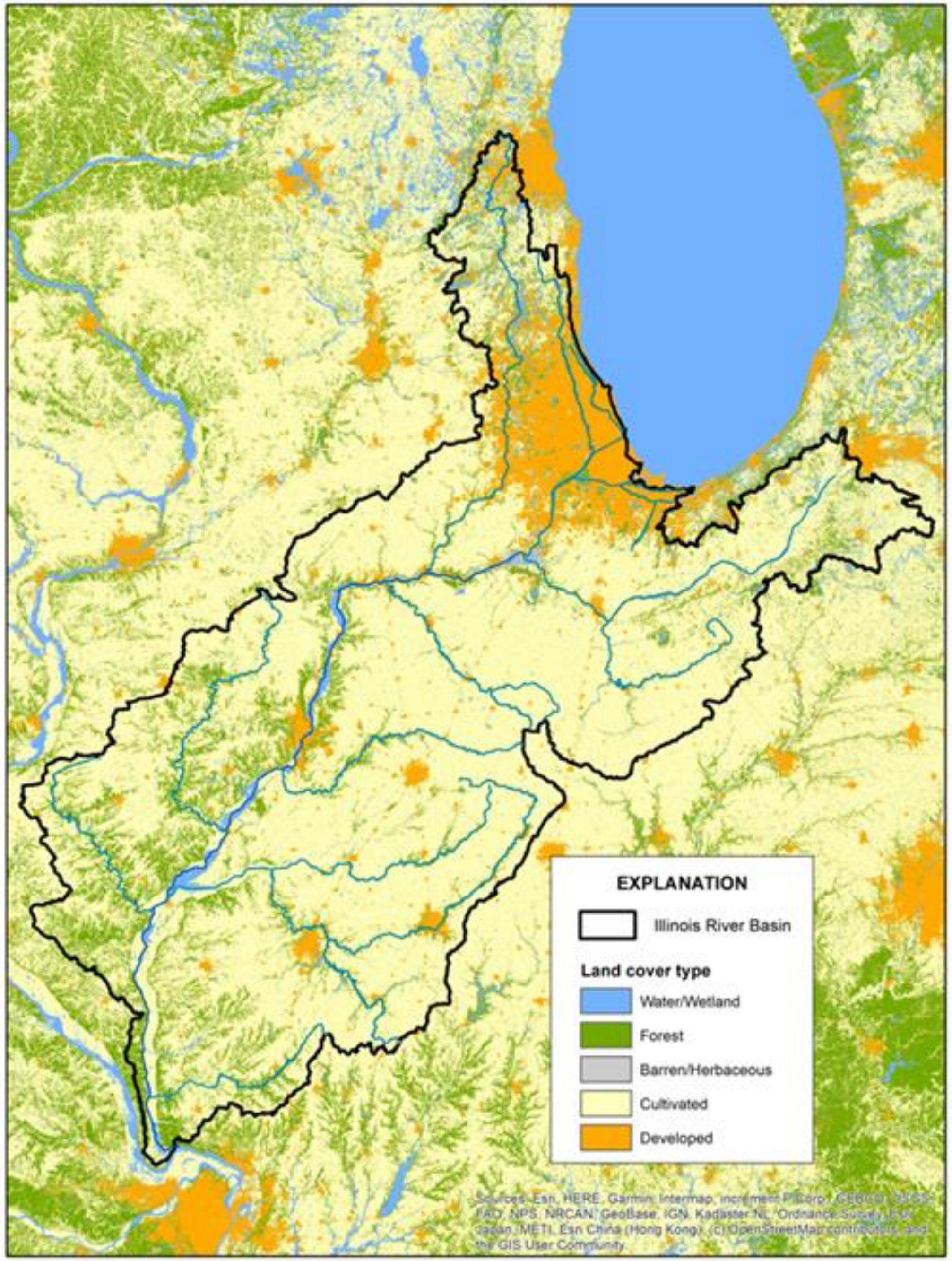
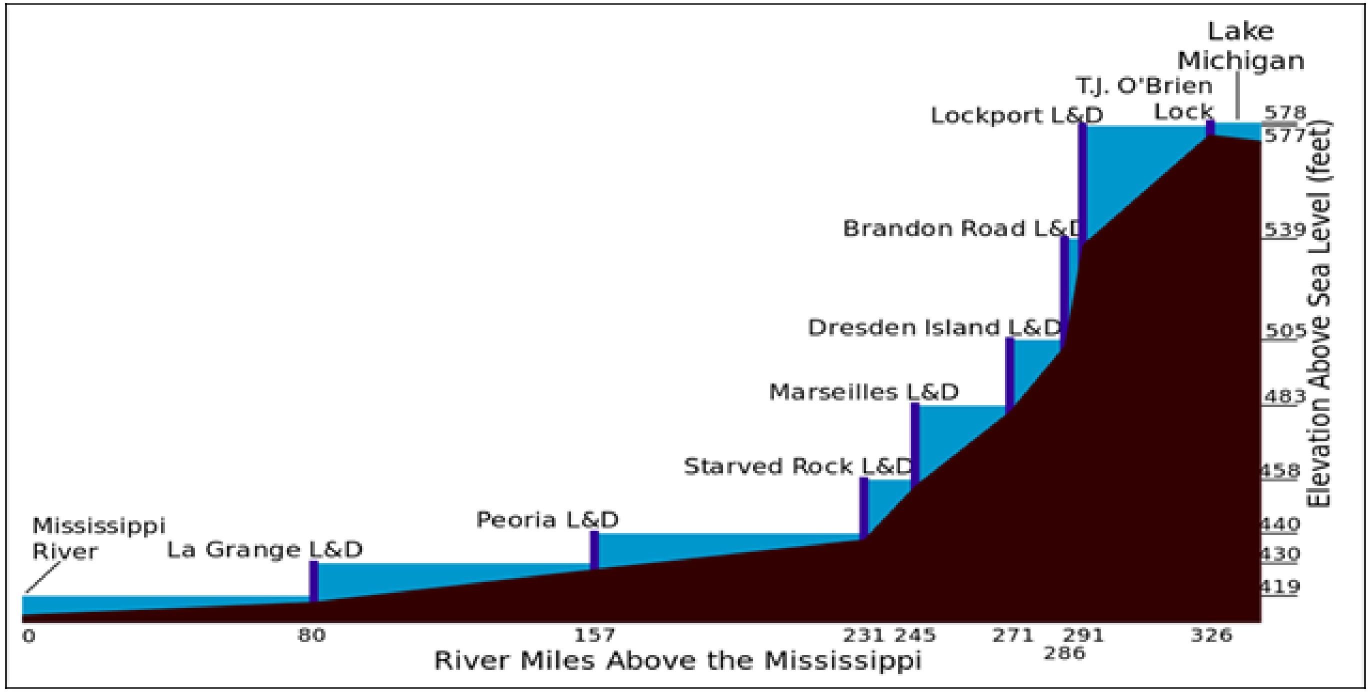


- 28,756 sq. mi drainage area
- Very diverse basin
- Major source of nutrients to Gulf Hypoxia
- Increasing frequency of HABs
- Engaged stakeholders w/in the basin
- Dense urban upper watershed
- Intensively managed agriculture lower watershed
- Illinois Waterway 273 mi in length

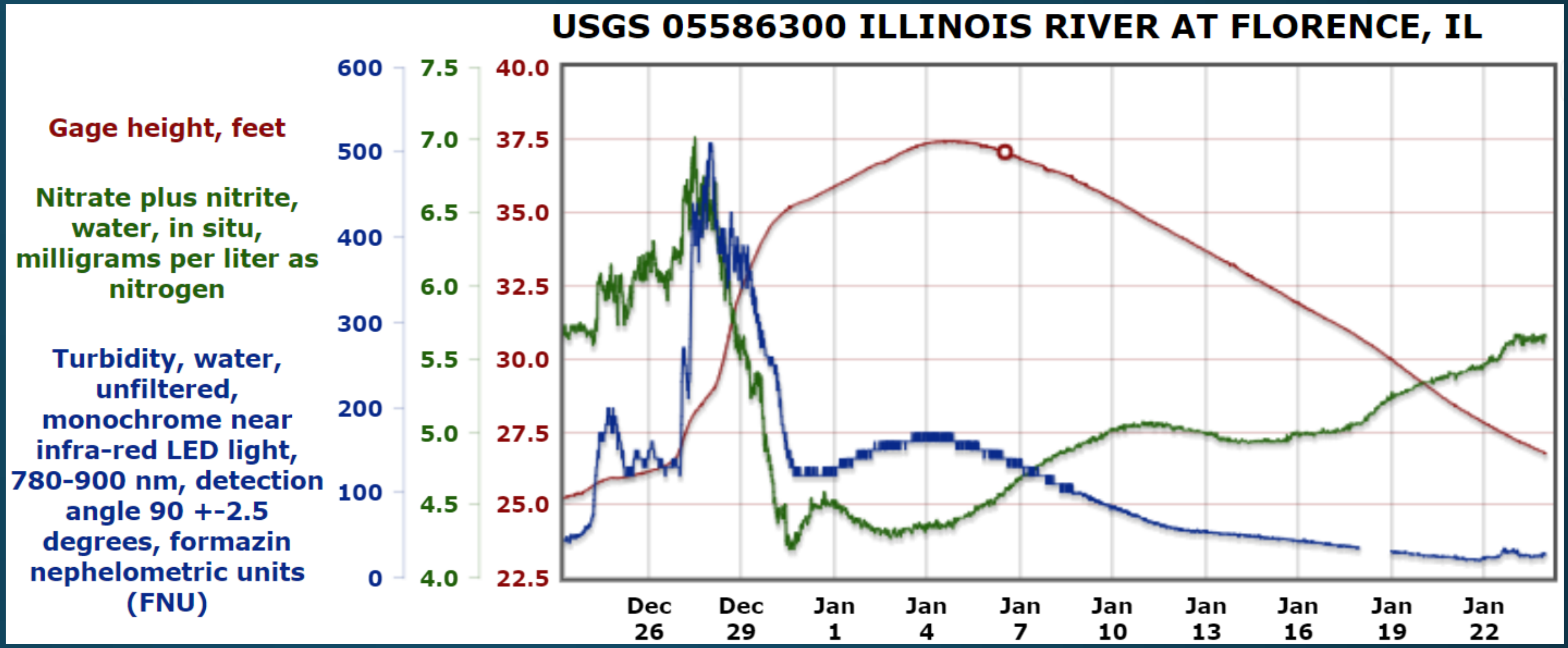


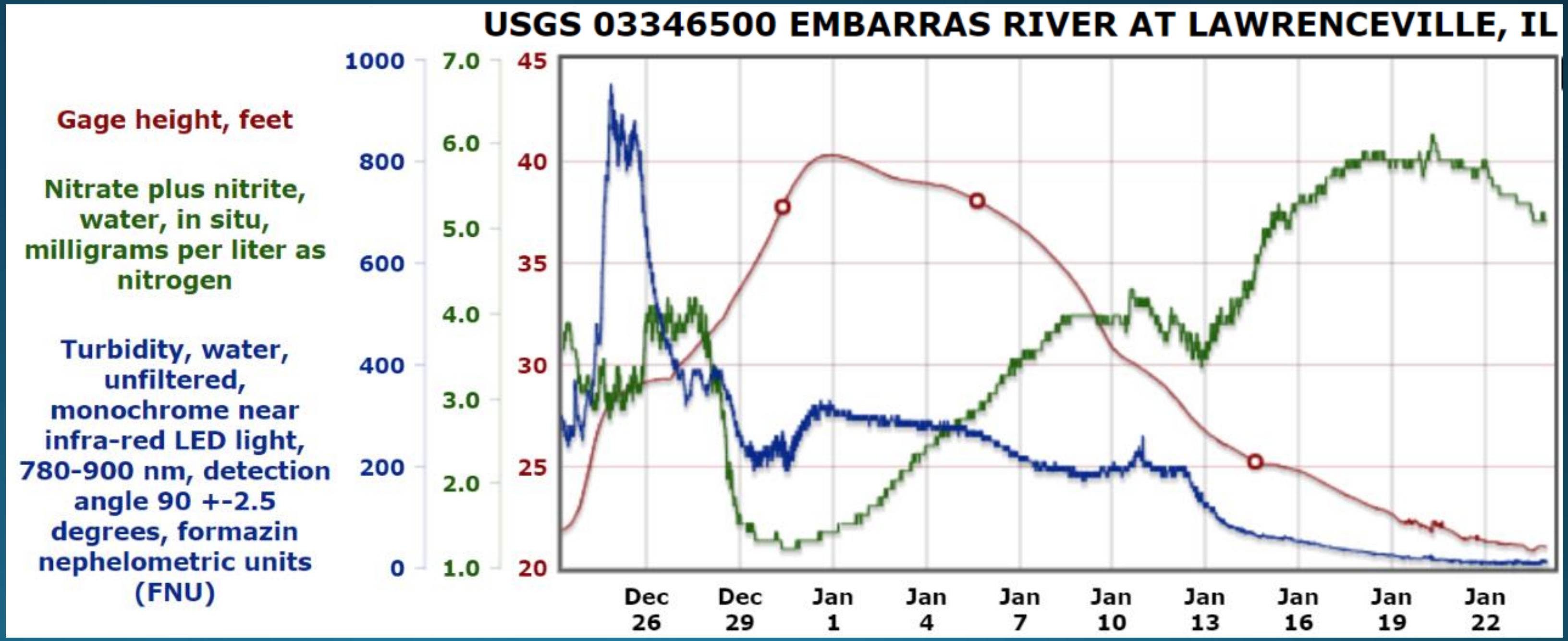
Dynamic Systems

- Gage height, nitrate, and turbidity dynamics at the

  Illinois River at Florence (top) and

  Embarras River at Lawrenceville (bottom).





Red circles indicate discharge measurements.

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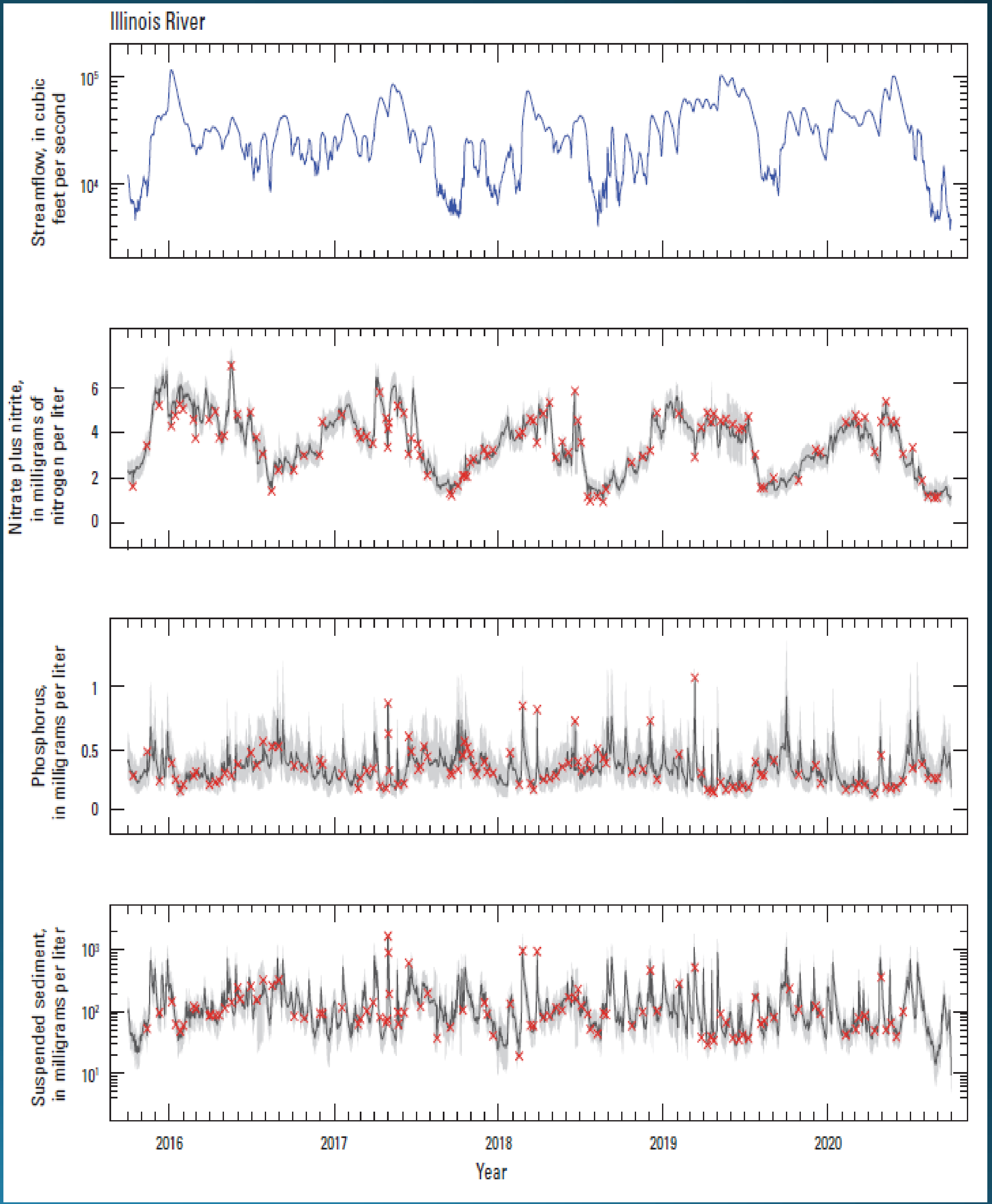
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

Data, Loadings, and Uncertainty



EXPLANATION
- 95-percent credibility intervals
- Expected (mean) value
- Expected (mean) streamflow at gaging station
- × Verification samples

Hodson, T.O., Terrio, P.J., Peake, C.S., and Fazio, D.J., 2021, Continuous monitoring and Bayesian estimation of nutrient and sediment loads from Illinois watersheds, for water years 2016–2020: U.S. Geological Survey Scientific Investigations Report 2021–5092, 40 p., https://doi.org/ 10.3133/ sir20215092.

Peake, C.S., and Hodson, T.O., 2022, Continuous monitoring of nutrient and sediment loads from the Des Plaines River at Route 53 at Joliet, Illinois, water years 2018–20 (ver. 1.1, February 2022): U.S. Geological Survey Scientific Investigations Report 2021–5125, 15 p., https://doi.org/ 10.3133/ sir20215125

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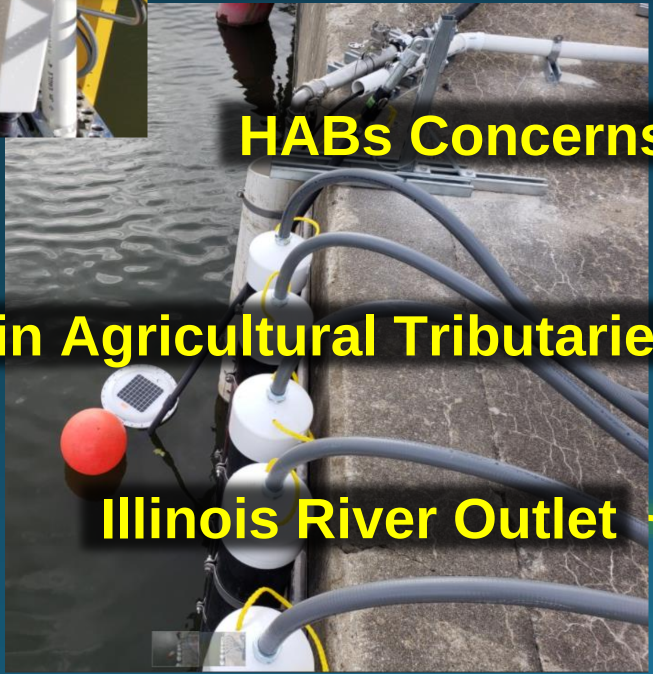
Super Gage Network

to support Nutrient and HAB Priorities



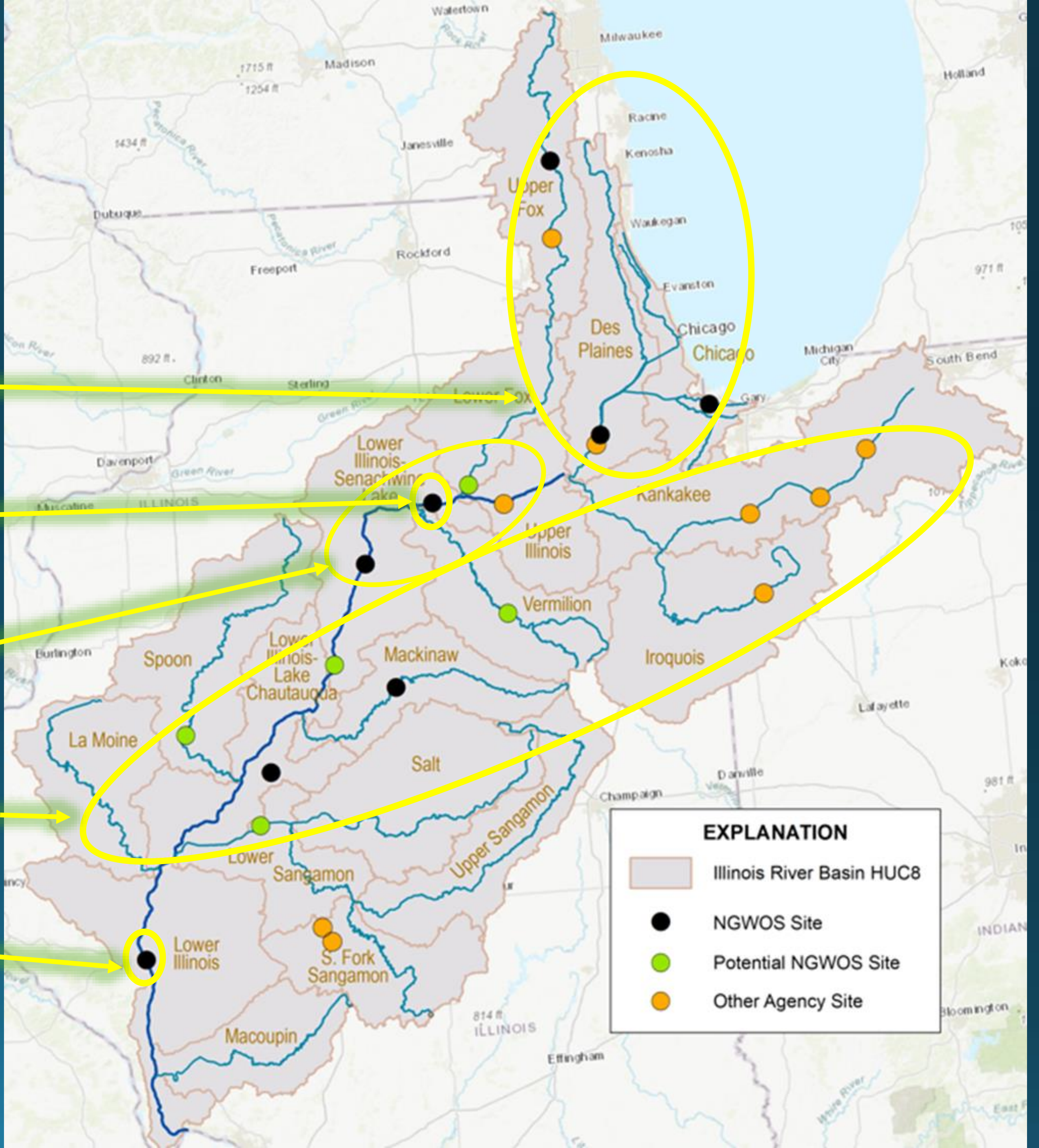
Chicago/Urban Nutrients

Starved Rock Testbed

HABs Concerns

Nutrients in Agricultural Tributaries

Illinois River Outlet



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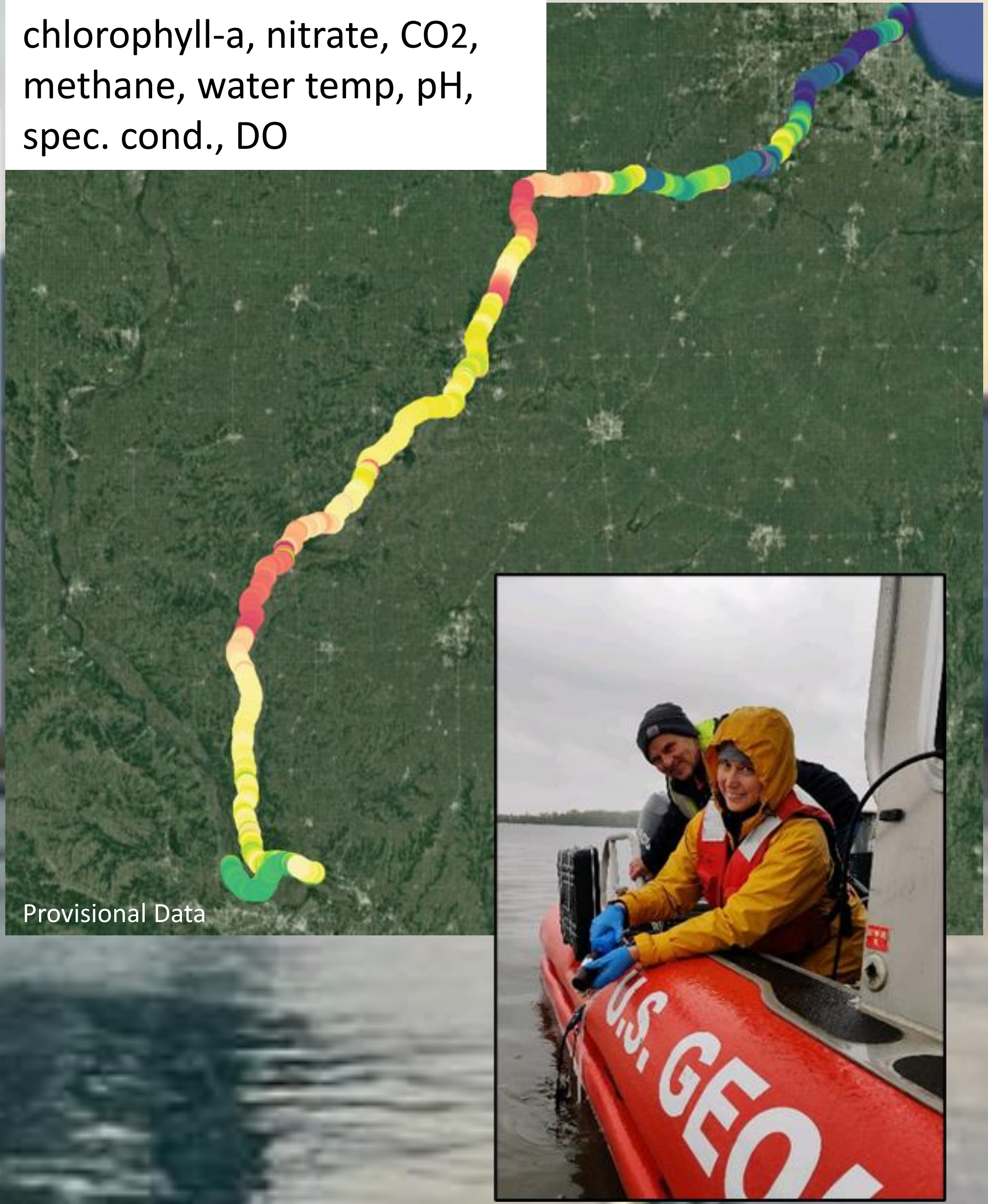
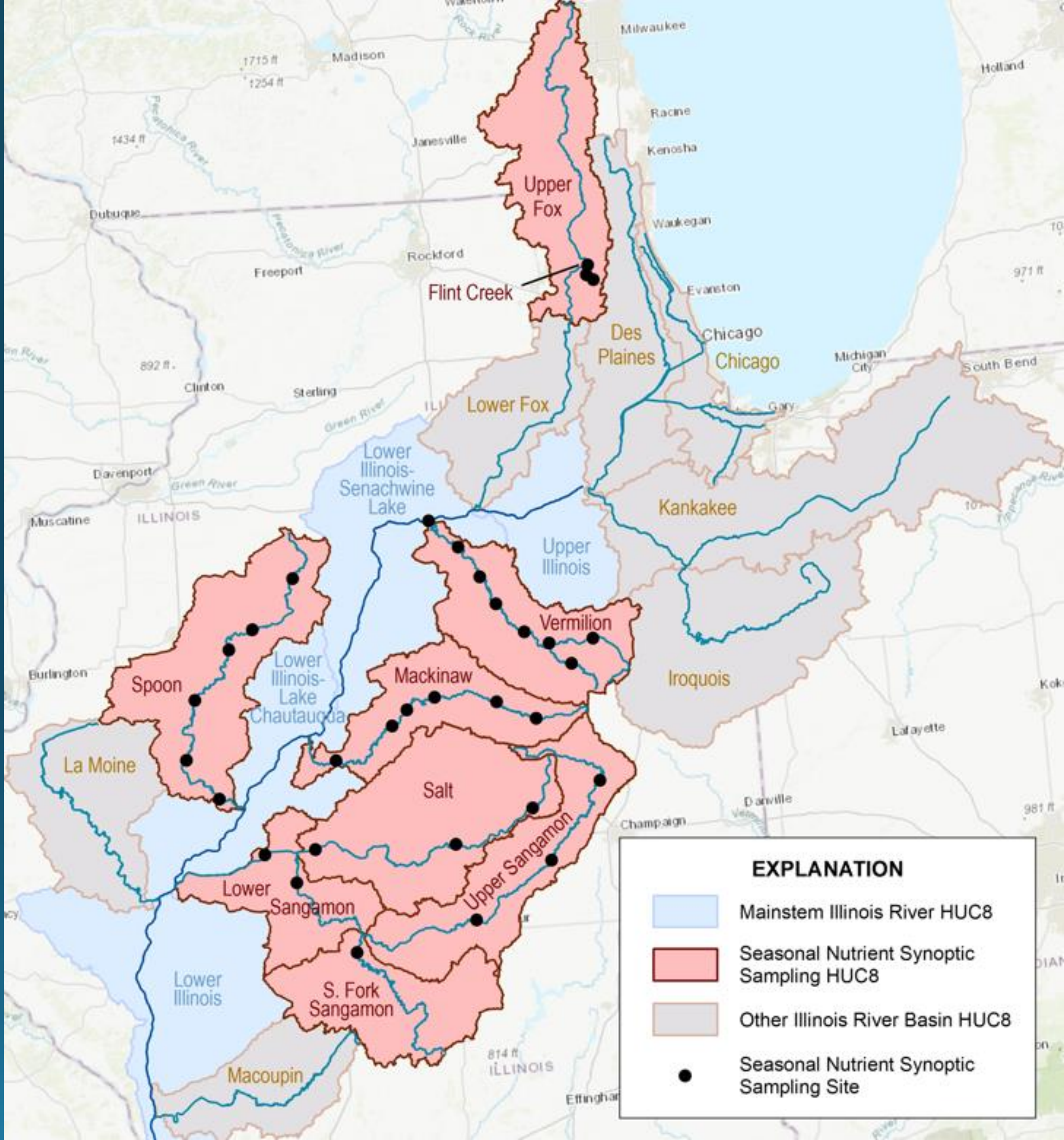
- Cruise of the entire IL River Waterway
  - Continuous flow-through water quality collection
  - May 3-7, 2022
  - Repeating August 8-13, 2022
  - Data will be used for modeled predictions to understand sources, transports, and sinks of carbon and nutrients at multiple scales



Seasonal Nutrient Synoptics

- 1-day “snapshot” from headwaters to mouth of major tributaries
- 6-8 sites per basin
- Nutrient focus
- Seasonal sampling schedules



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Sediment and Nutrient Source Tracking

- Small stream in central Illinois

- Fingerprint tracers
  - particle size analysis
  - major and trace elements
  - nutrients
  - stable carbon (^{13}C) and nitrogen (^{15}N) isotopes
- Age tracers (suspended sediment and streambed sediment only)
  - Be-7, used to measure young (weeks to months) surface-derived sediments
  - Pb-210, used to measure older (decades) surface-derived sediments

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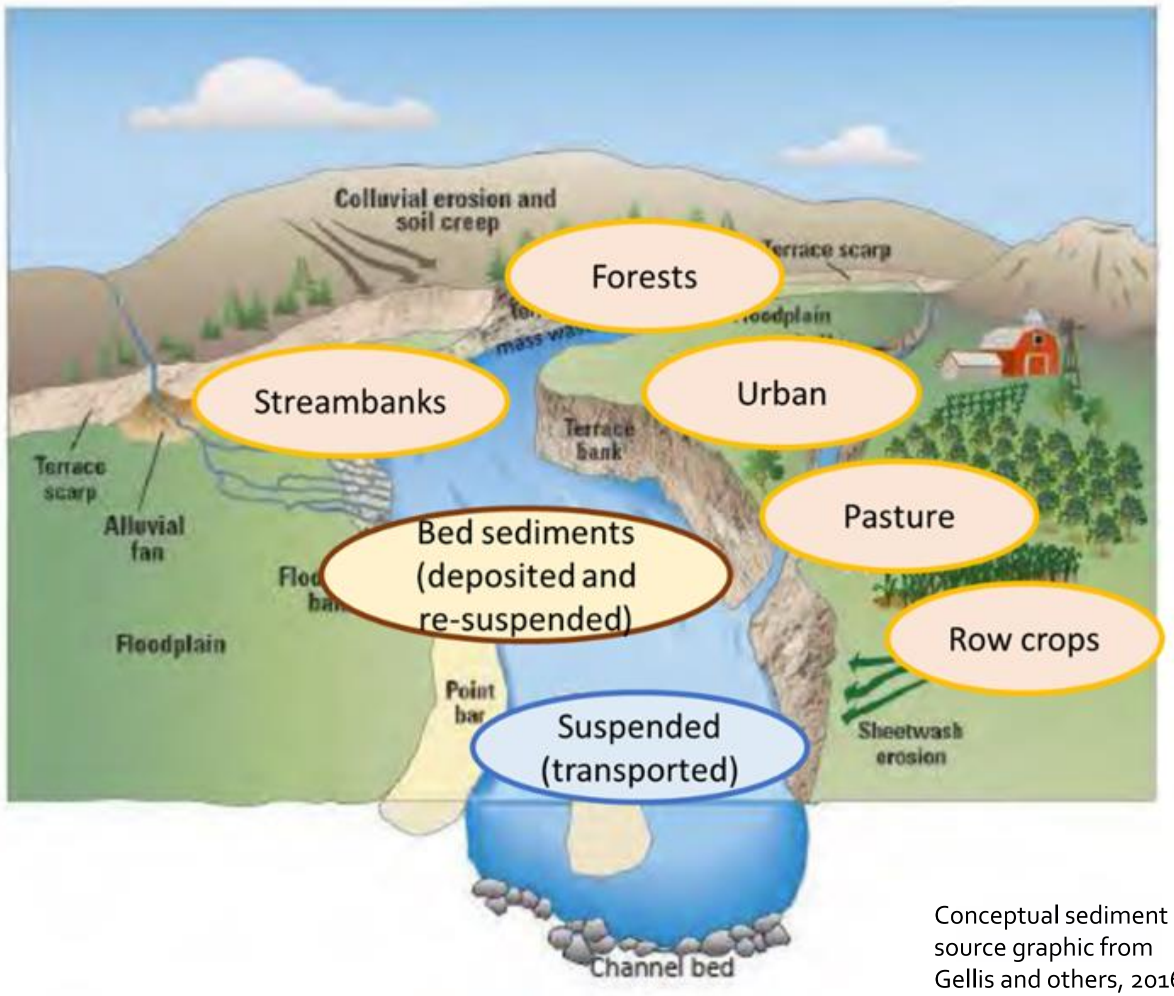
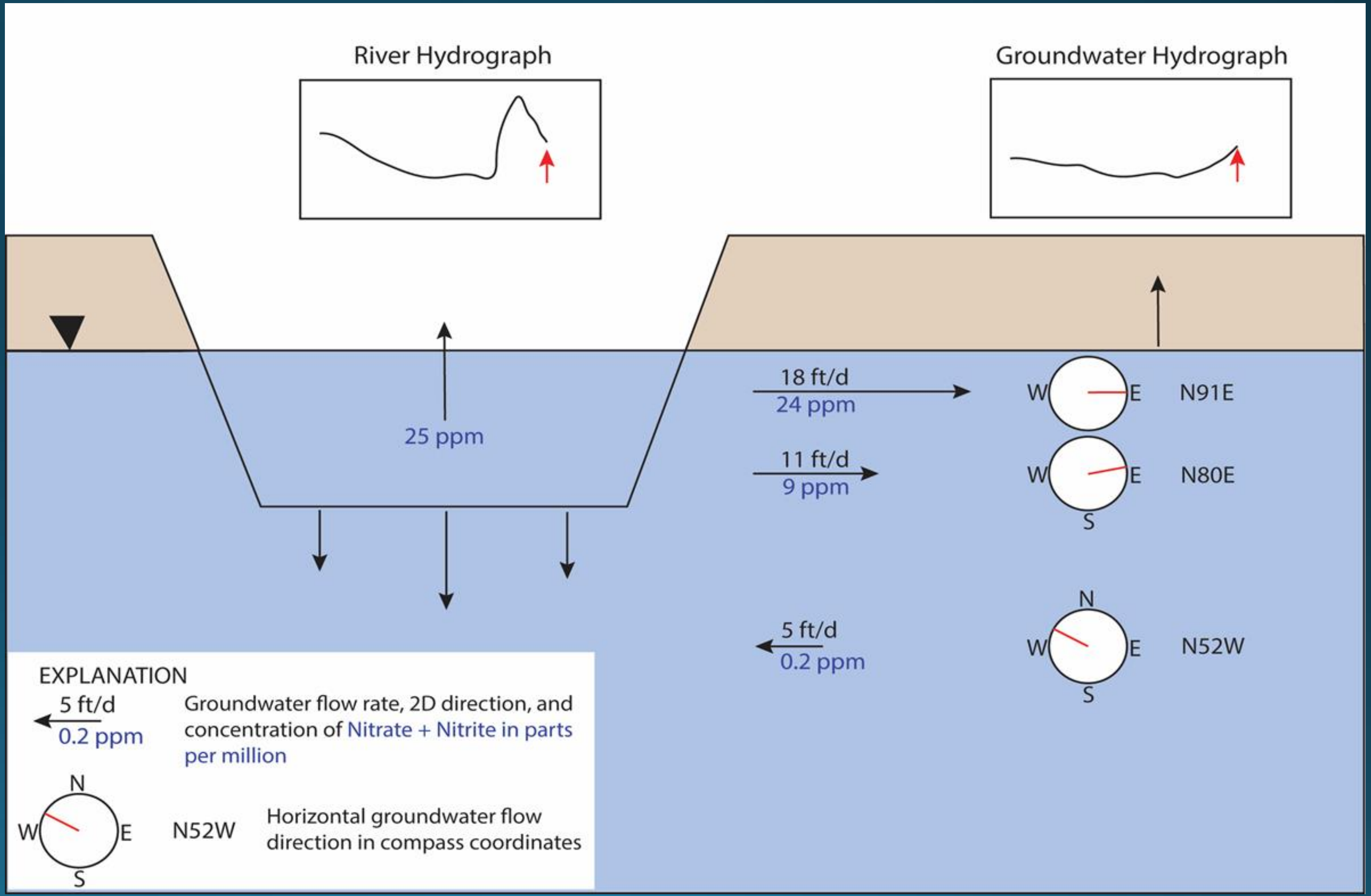


Conceptual sediment source graphic from Gellis and others, 2016

Groundwater-Surface Water Interaction and Nutrient Monitoring

- Quiver Creek Basin
- Kankakee River Basin



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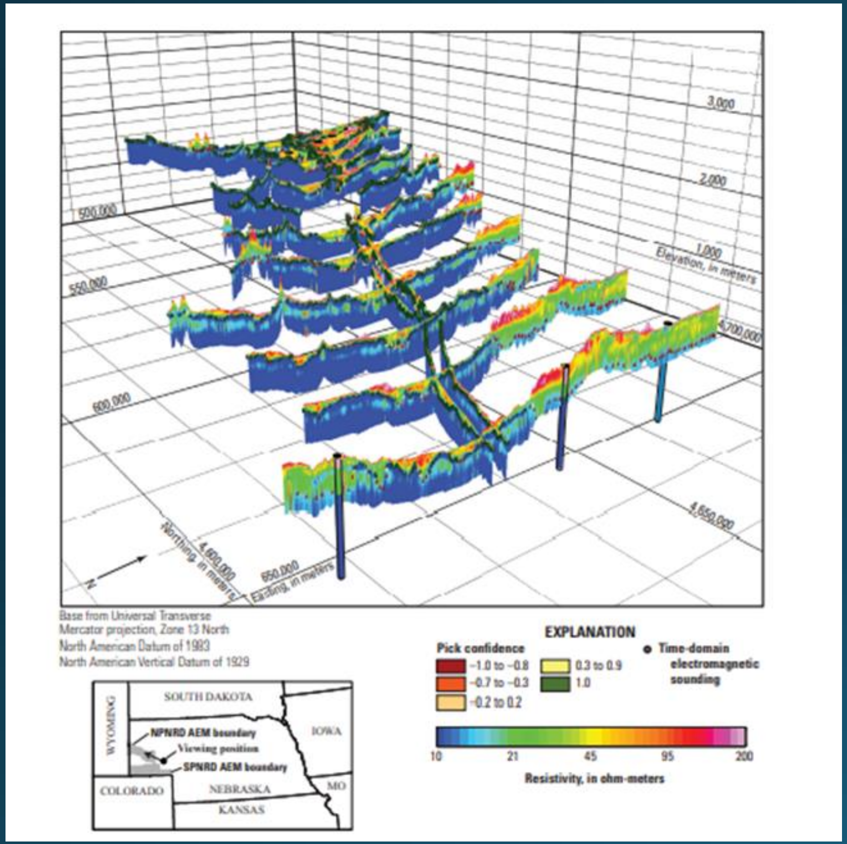
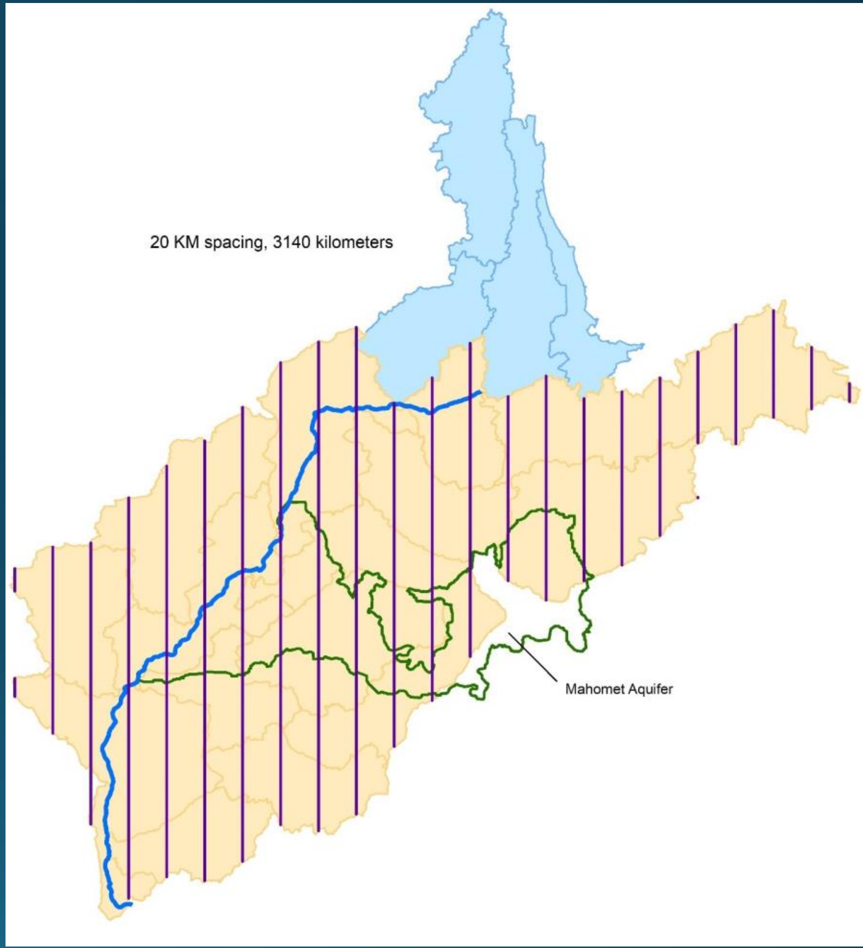
Geophysics-Airborne Electromagnetic (AEM) Survey

Upper Fox River Pilot FY22 and Lower Illinois FY23



Nebraska Example

Upper Fox River flight FY22



Lower Illinois River FY23

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Jessie Garrett collecting CyanoHAB samples.
Photograph by Katherine Summers, U.S. Geological Survey

HABs Priority Objectives

- **Improve understanding of conditions driving CyanoHAB occurrences, magnitude, and duration**
- **Evaluate remote sensing of parameters potentially related to CyanoHABs (total chlorophyll, chlorophyll *a*, and phycocyanin)**
- **Improve understanding of conditions driving cyanotoxin and T&O production**
- **Evaluate multi-spectral imaging for monitoring CyanoHABs and other water quality characteristics**
- **Evaluate environmental DNA tracker potential to identify presence of CyanoHABs related species and use for early warning detection**

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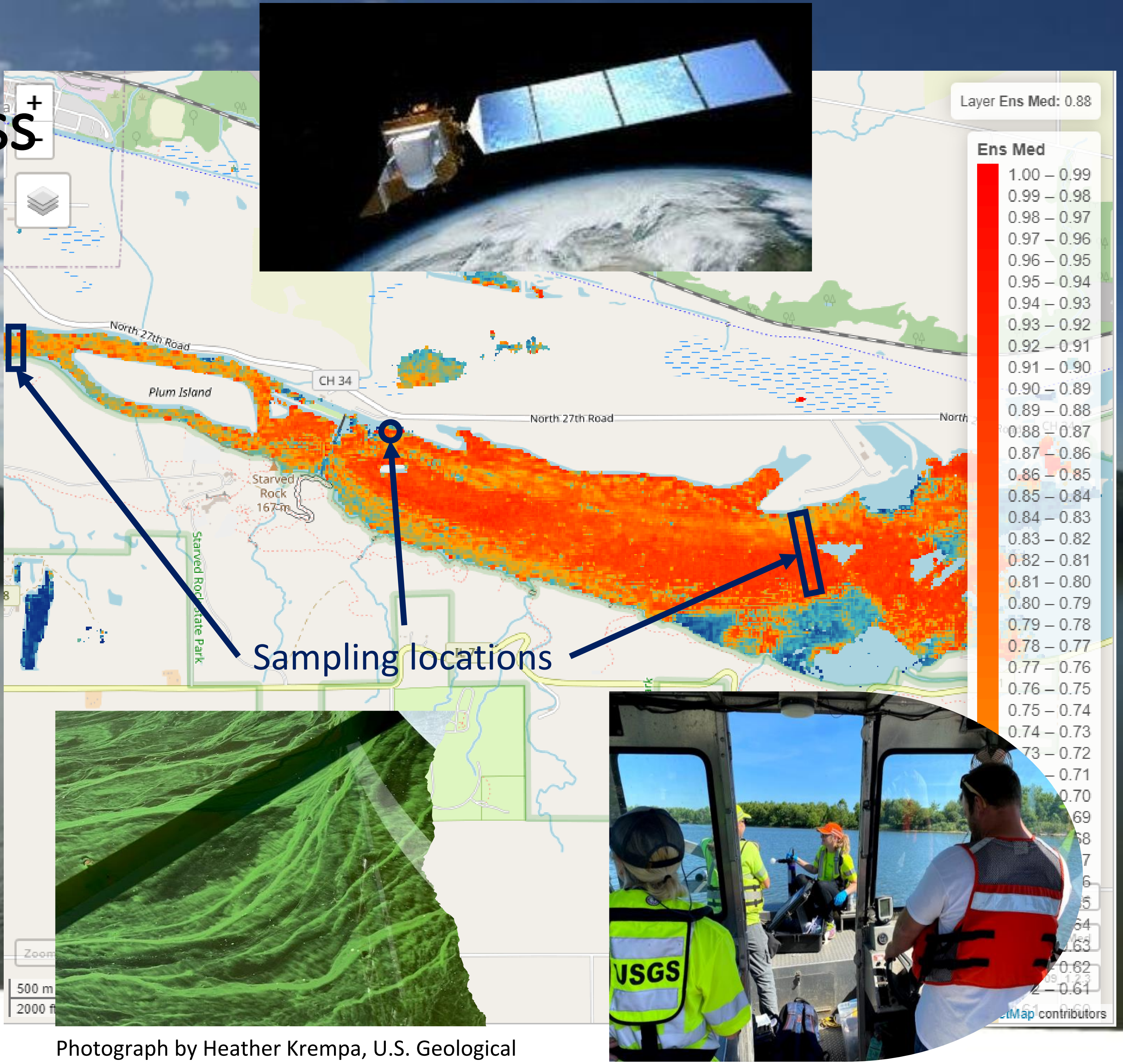
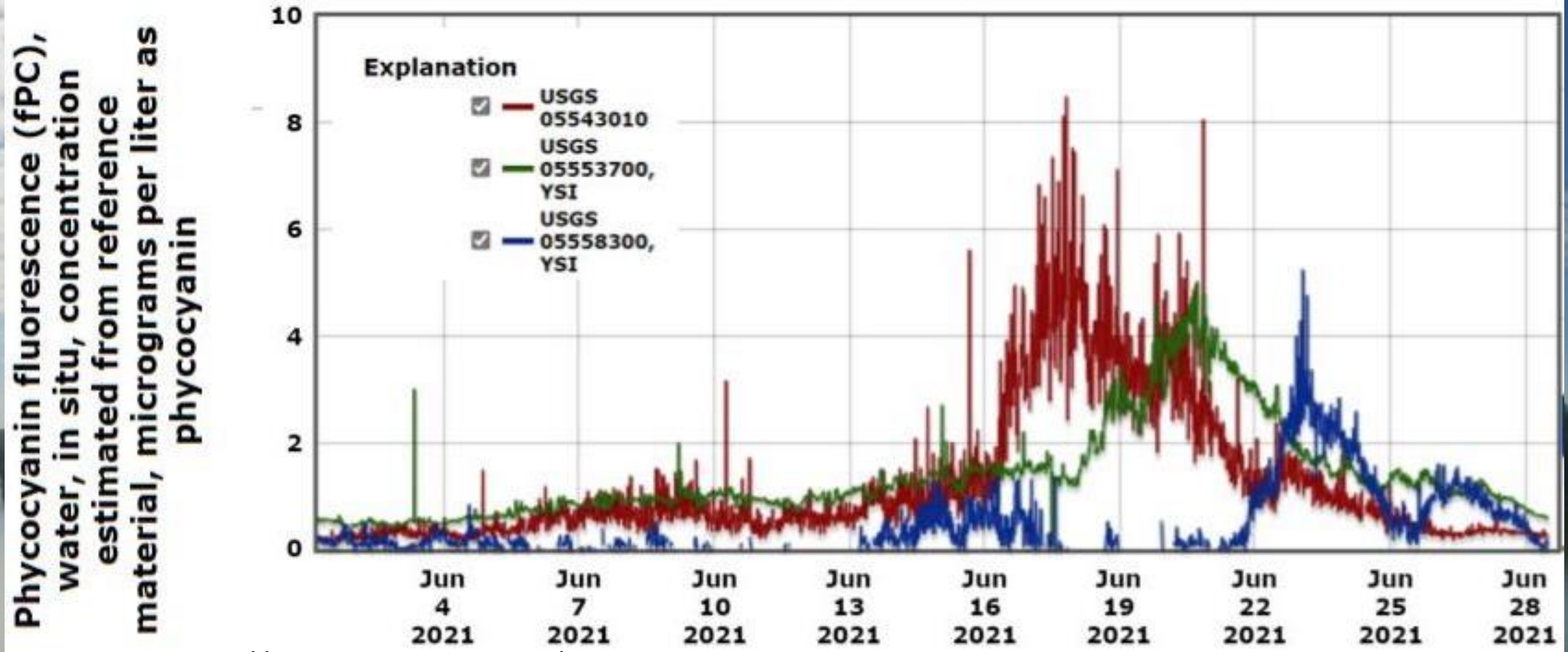
Multi-spectral data across multiple spatial scales

- In-situ sensors and samples
- Near-field remote sensing (cameras)
- Satellite remote-sensing methods

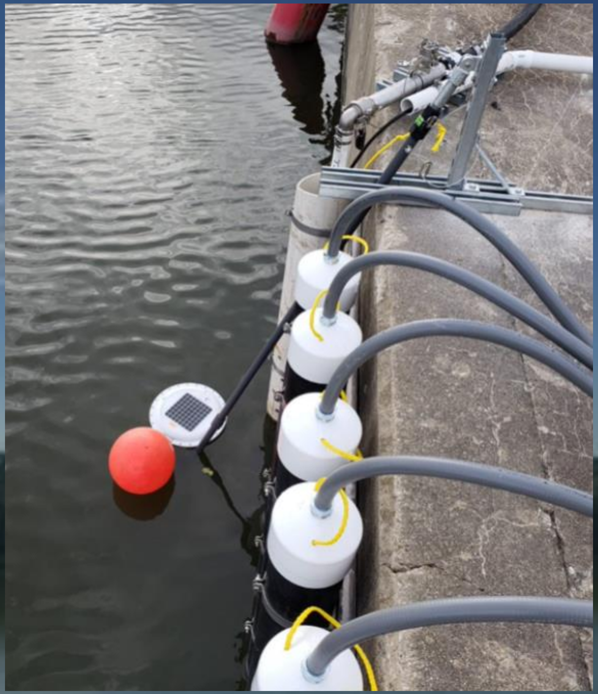


Photograph by Heather Krempa, U.S. Geological

NGWOS Illinois River Basin CyanoHAB June 2021



https://waterdata.usgs.gov/nwis



- **Continuous water-quality monitors were able to display, in real time, increases in phycocyanin concentrations as the bloom traveled downstream.**
- **Phycocyanin concentrations peaked at the upstream location near Seneca, IL then downstream near Starved Rock and later further downstream near Henry, IL.**
- **Continuous water-quality monitors will be used to remotely, in real time, identify conditions that may indicate a harmful algae bloom may be forming.**

Home (ns2co.com)

eDNA Tracker

- **Evaluate environmental DNA tracker potential to identify presence of CyanoHABs related species and use for early warning detection**
    - eDNA tracker expected delivery in September 2022
    - Can identify up to 3 known cyanobacteria taxa

Questions

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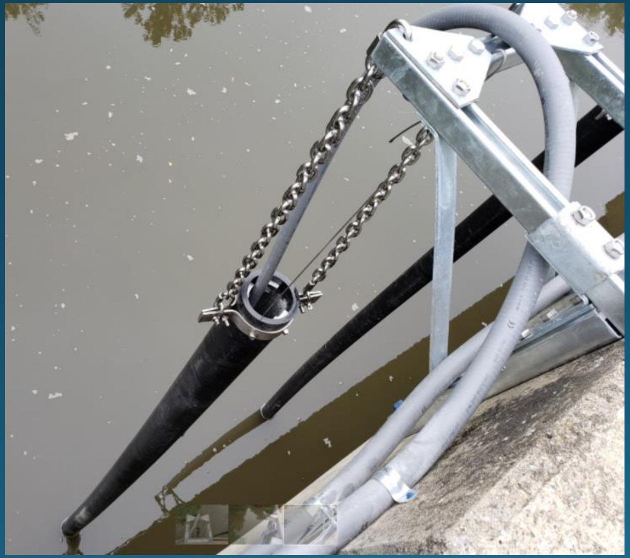

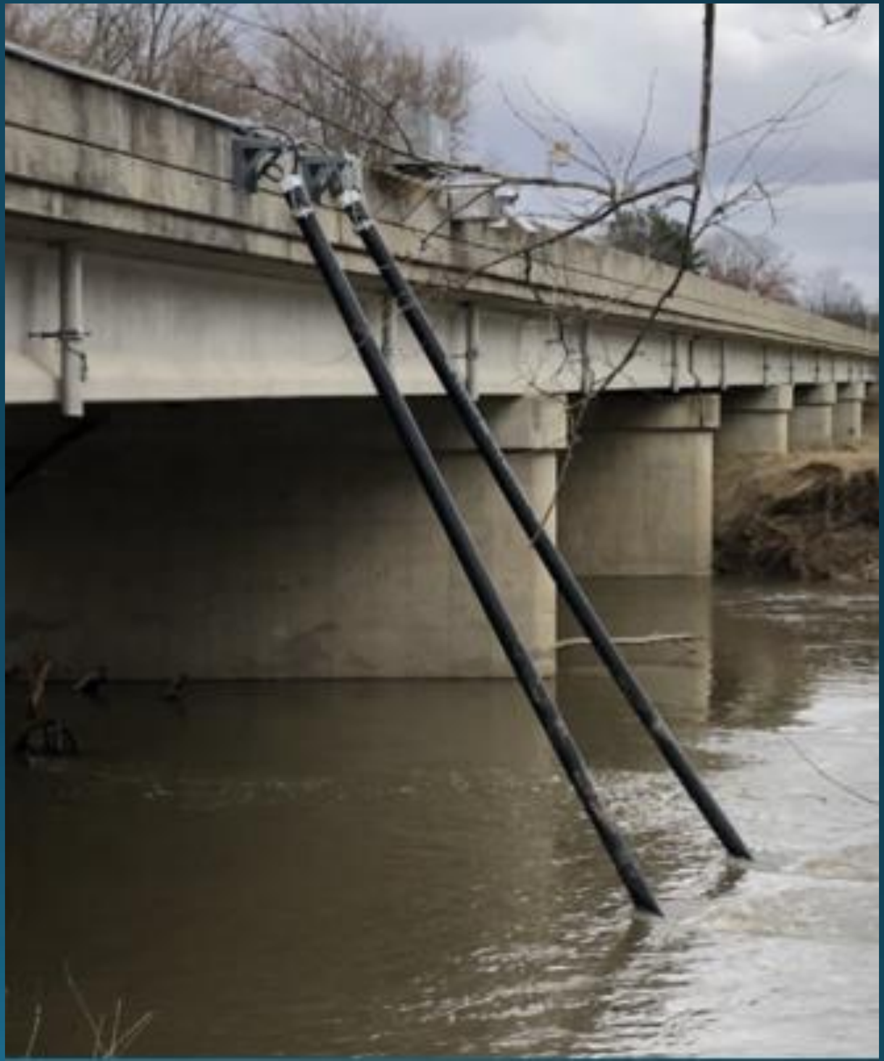

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