



*tip- hover or double click on comment bubble to see presenter notes



Northeast Lakeshore TMDL

Stream monitoring and impairments



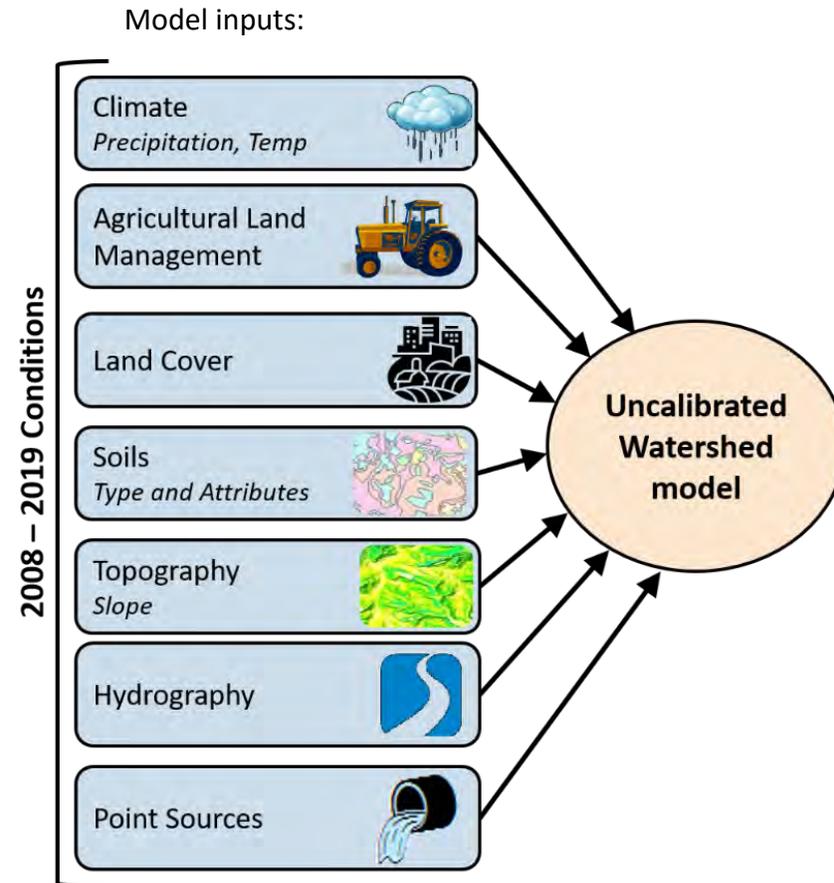
Outline

- Background and methods
- Impairments and Monitoring Results (~12 slides for each model basin)
 - Kewaunee Model Basin
 - Manitowoc Model Basin
 - Sheboygan Model Basin



Why do we need monitoring for TMDL development?

- Calibrate watershed model
- Further identification of impairments
- Nitrogen not use for calibrating the watershed model



Monitoring Summary

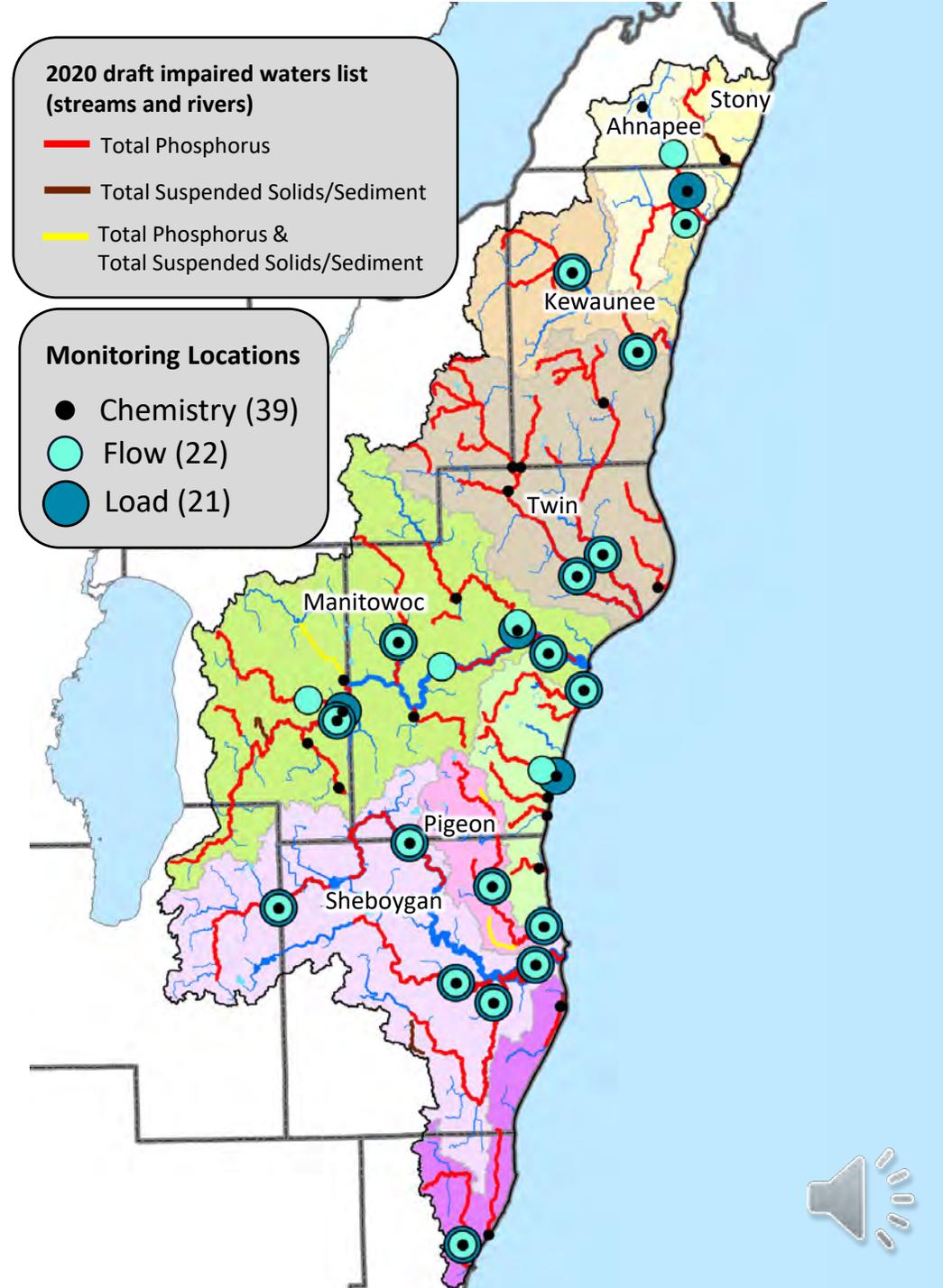
39 Chemistry sites

22 Flow Sites

- 19 DNR
- 3 USGS

21 Load Sites

Monitoring efforts identified a significant number of impaired waters for the draft 2020 list



Monitoring Team

Northern

Mary Gansberg,
DNR biologist, NE Region

Holly Stegemann

Josh Benes



Southern

Craig Helker,
DNR biologist, SE Region

Zach Kleemann



- Patrick Biever (not pictured)



Legislature funding

Statute 281.145



Citizen Monitoring Volunteers

UW GB – Manitowoc Students





Data Collection and Analysis Process

1

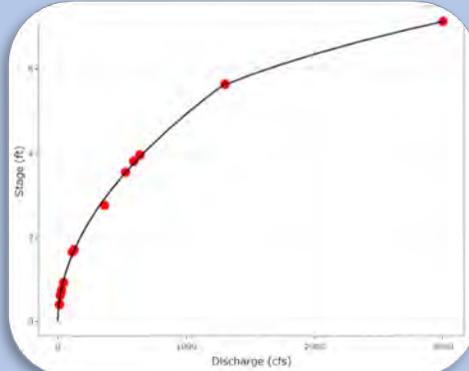
Data Collection

Stage (water level)
Flow Measurements

Water Chemistry Samples

2

Rating Curve



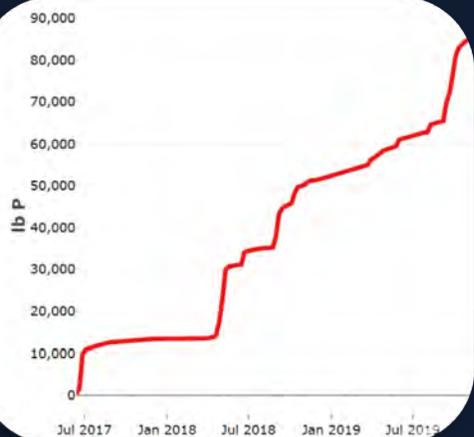
3

Discharge Record



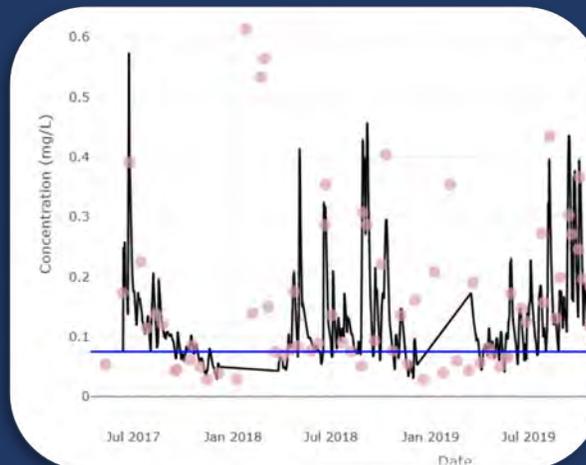
6

Daily load timeseries



5

Daily concentration timeseries



4

Statistical Modeling





1) Data Collection- Chemistry

Monitoring parameters

Primary (all 39 locations)

Secondary (select locations)



Total Phosphorus (TP)

Dissolved Phosphorus

Total Nitrogen (TN)

Ammonia

Total Suspended Solids (TSS)

Nitrate & Nitrite



Kjeldahl Nitrogen
(Ammonia & Organic Nitrogen)



1) Data collection - Chemistry

Monitoring frequency

Duration: spring 2017 – fall 2019

Exceptions:

Ahnapee River 2016 – 2019

Silver Creek (Algoma) 2016 – 2019

USGS long term sites, nearly 30 years of chemistry data

- Kewaunee River
- Manitowoc River
- Sheboygan River

Frequency: bi-weekly to monthly, year-round

Event Sampling: Select sites targeted for sampling after storm events and spring melt

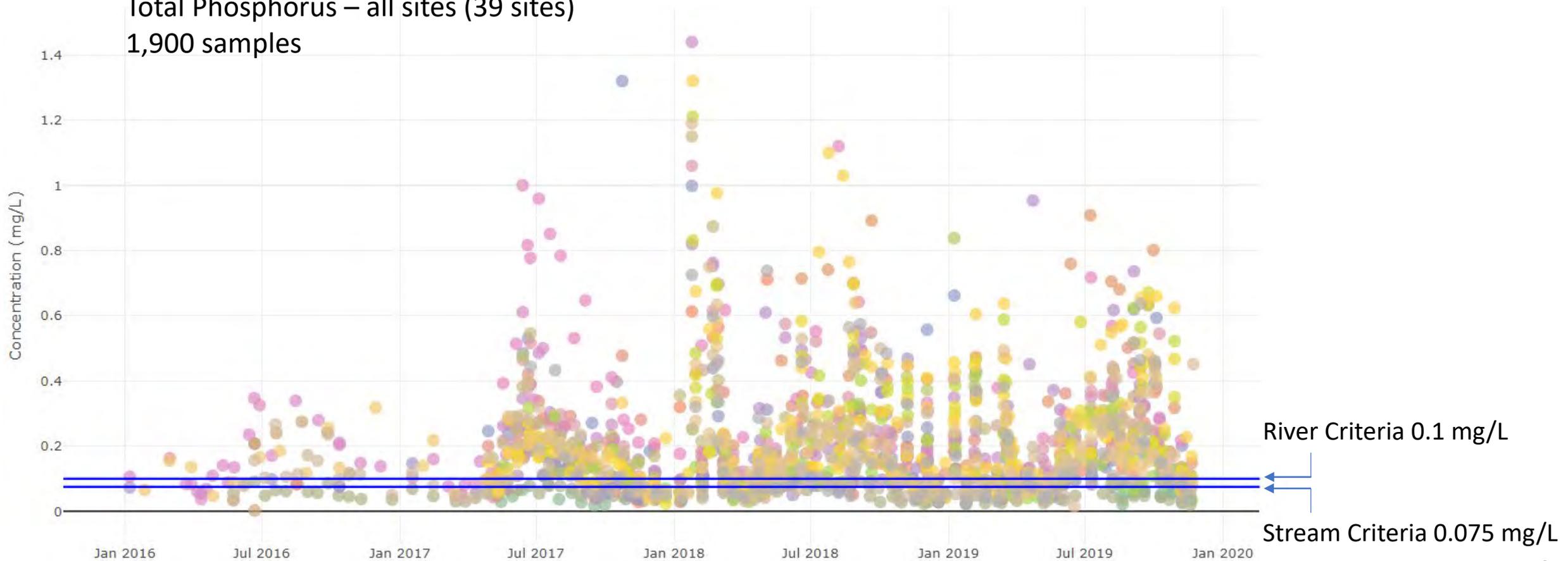




1) Data collection - Chemistry

Over 6,000 samples collected between 2017 - 2019

Total Phosphorus – all sites (39 sites)
1,900 samples



1) Data collection – Stage (water level)

Methods

Duration: spring 2017 – fall 2019

Exceptions:

Ahnapee River 2016 – 2019

Silver Creek (Algoma) 2016 – 2019

USGS long term sites, nearly 30 years of chemistry data

- Kewaunee River
- Manitowoc River
- Sheboygan River

Water level loggers

- hourly water level data



1) Data collection – Stage (water level)

Methods

Water level loggers

- hourly water level data

Elevation of water level logger periodically checked with and elevation survey



1) Data collection - Flow Methods

Duration: spring 2017 – fall 2019

Exceptions:

Ahnapee River 2016 – 2019

Silver Creek (Algoma) 2016 – 2019

USGS long term sites, nearly 30 years of chemistry data

- Kewaunee River
- Manitowoc River
- Sheboygan River

Measurement techniques:

- Flow meter
- Acoustic Doppler Current Profiler (ADCP)
65/300 flow measurements

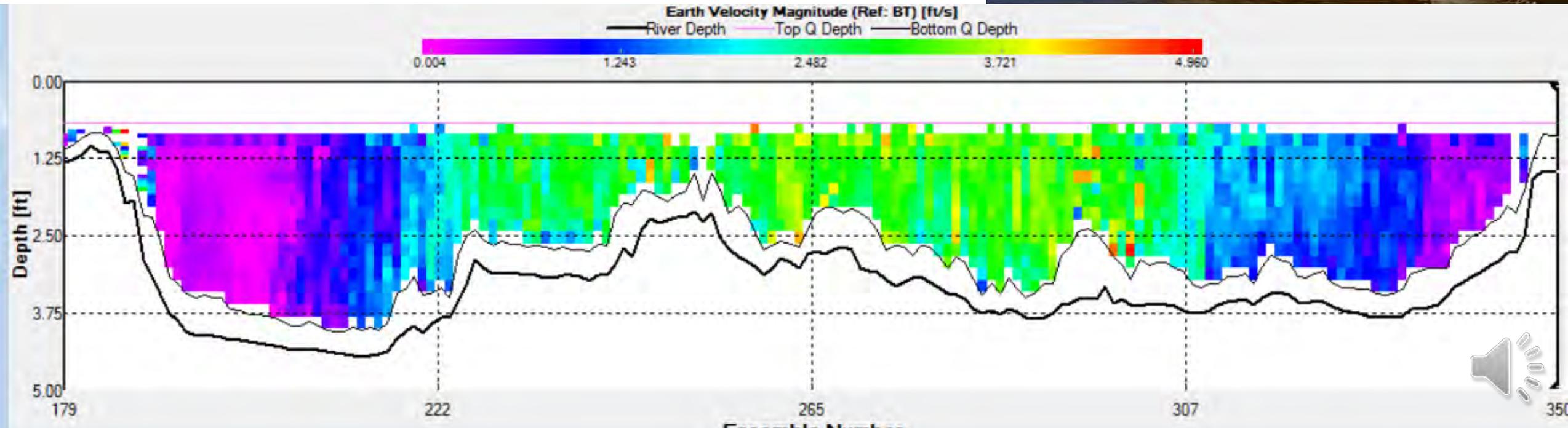


1) Data collection - Flow

Methods

- Flow meter
- Acoustic Doppler Current Profiler (ADCP)
 - 65/300 flow measurements

ADCP output: Cross section of stream velocity





Data Collection and Analysis Process

1

Data Collection

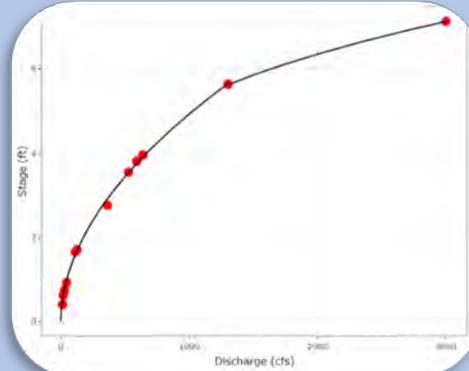
Stage

Flow Measurements

Water Chemistry Samples

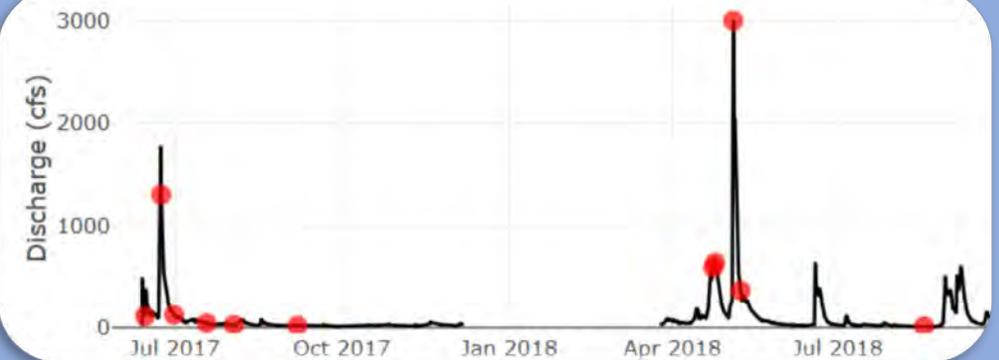
2

Rating Curve



3

Discharge Record (hourly discharge)



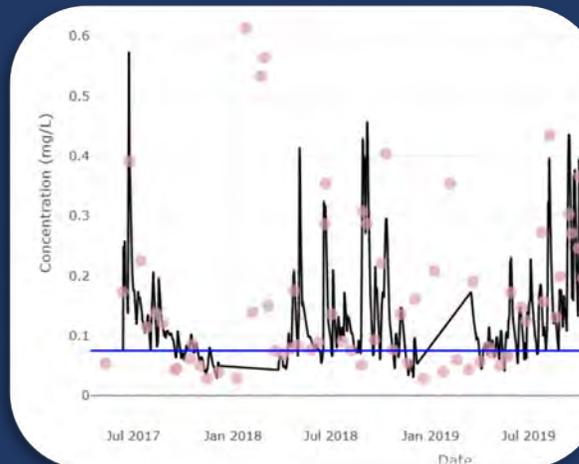
6

Daily Load timeseries



5

Daily concentration timeseries



4

Statistical Modeling



2) Rating Curves

Develop a relationship between stage and discharge so a continuous discharge time series can be developed

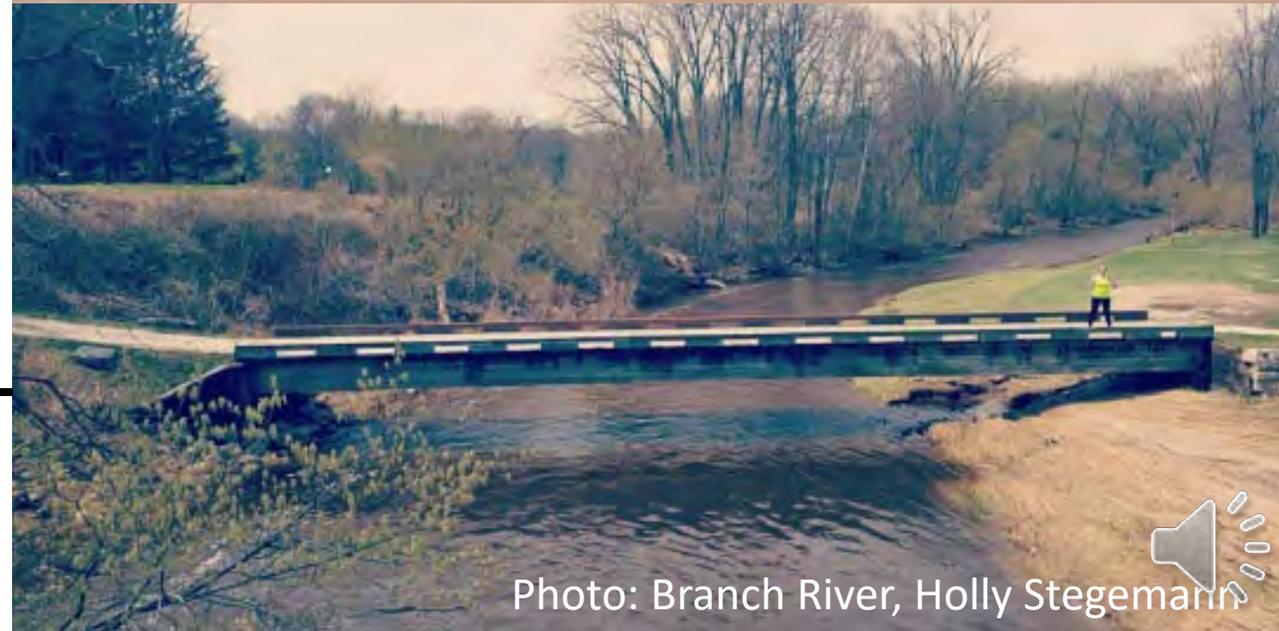
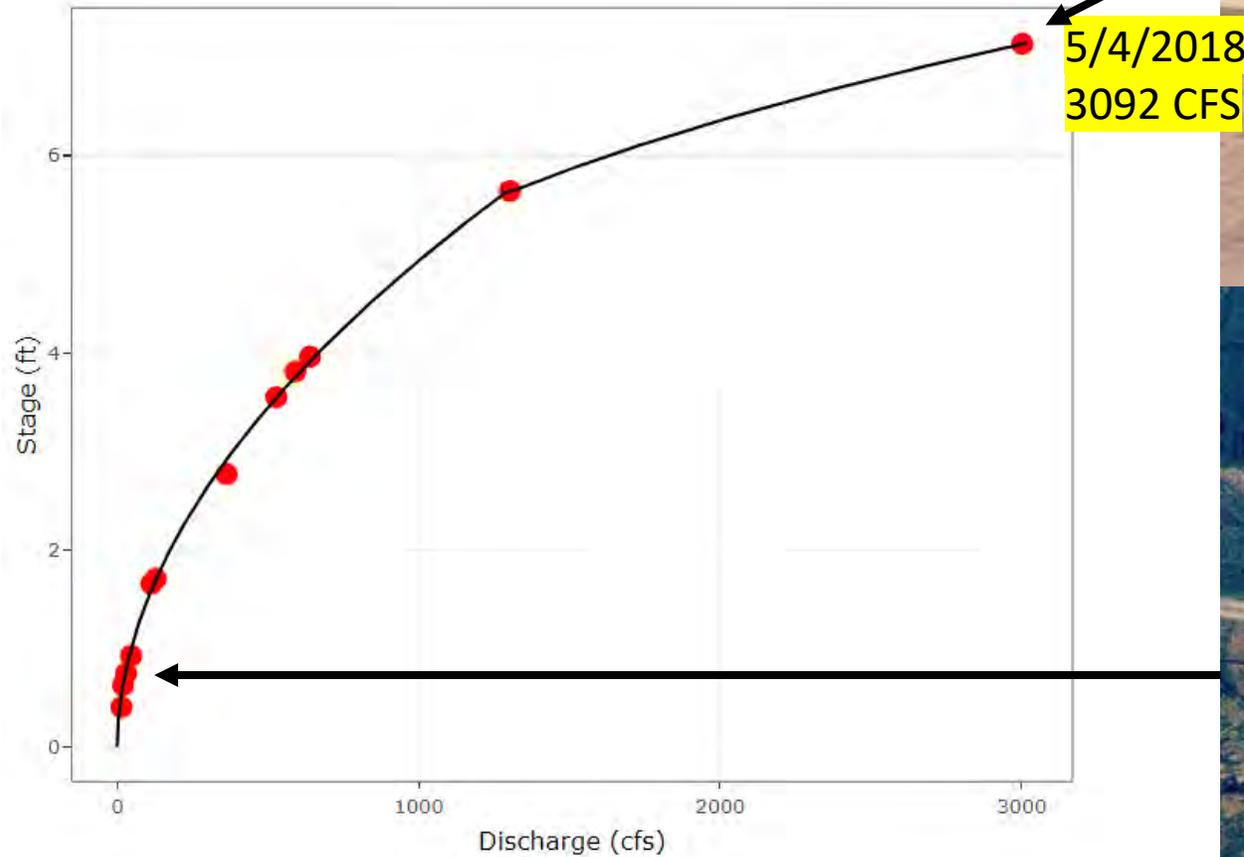
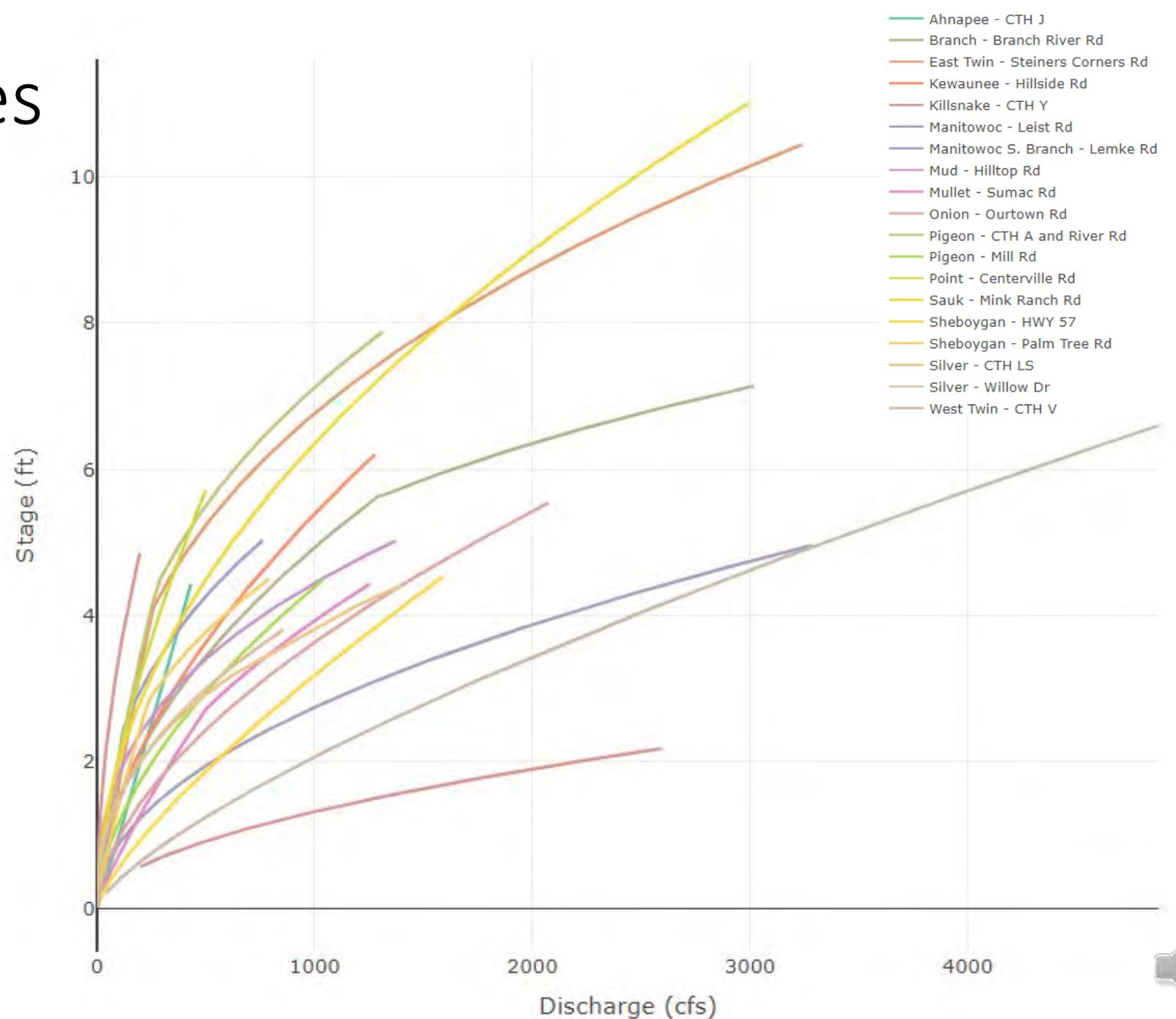


Photo: Branch River, Holly Stegemann



2) Rating Curves

Developed by WDNR at 19 locations



4) Statistical Model for estimate daily concentration

Primary model inputs include:

- 1) Discharge record
- 2) Water chemistry samples

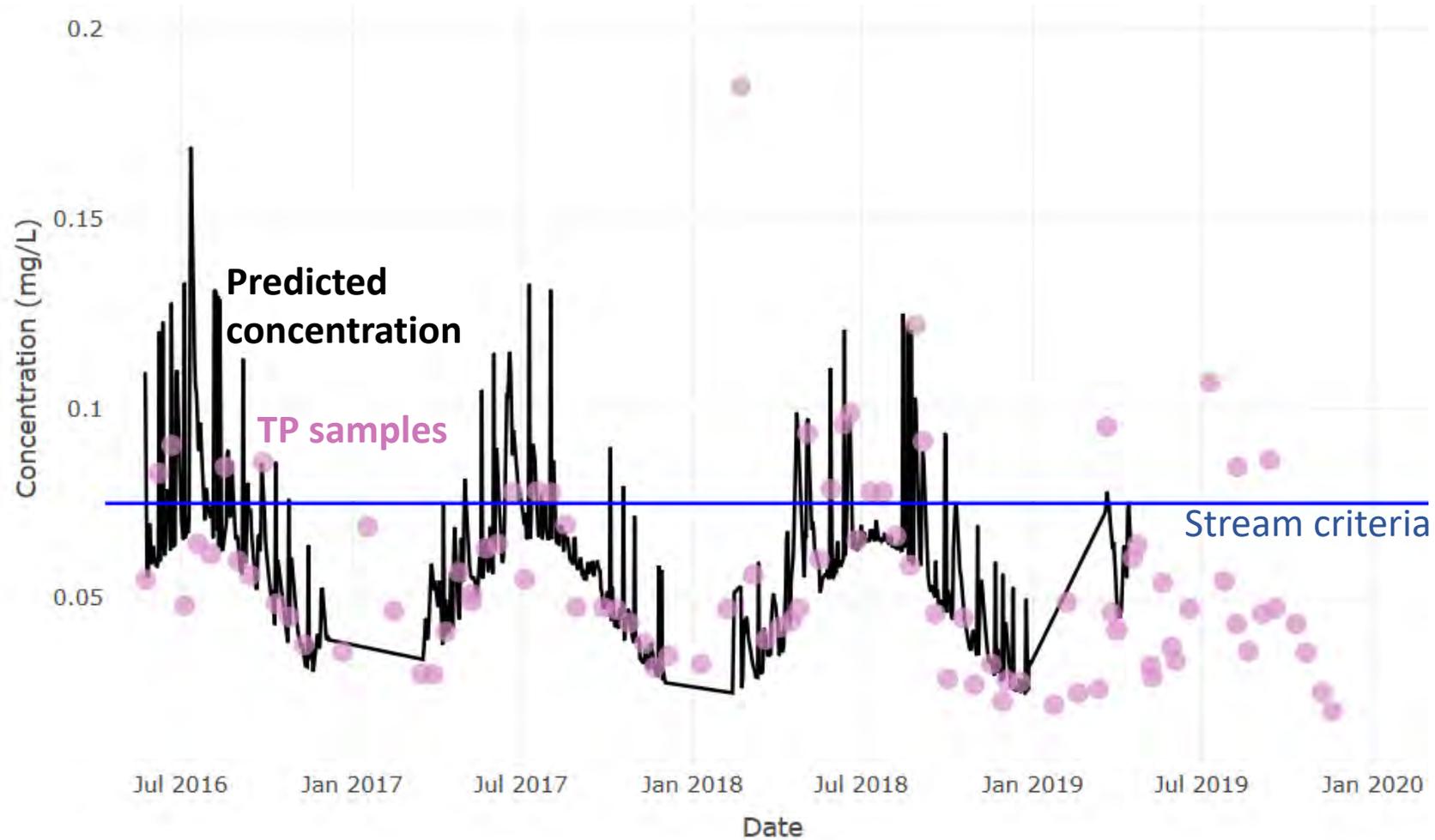


**LOAD ESTIMATOR (LOADEST):
A FORTRAN PROGRAM FOR ESTIMATING
CONSTITUENT LOADS IN STREAMS AND RIVERS**



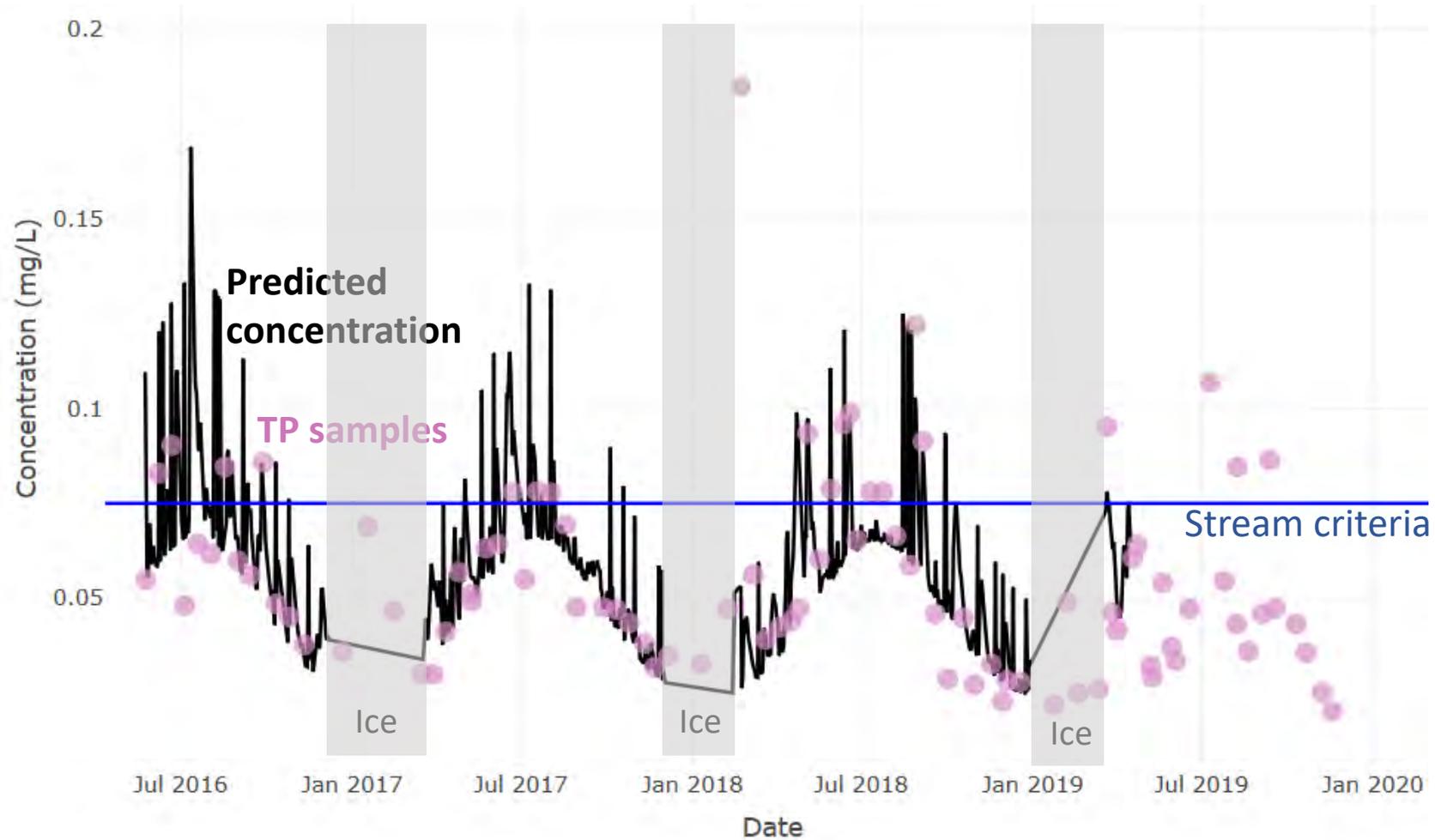
5) Daily concentration

Ahnapee Daily TP concentration



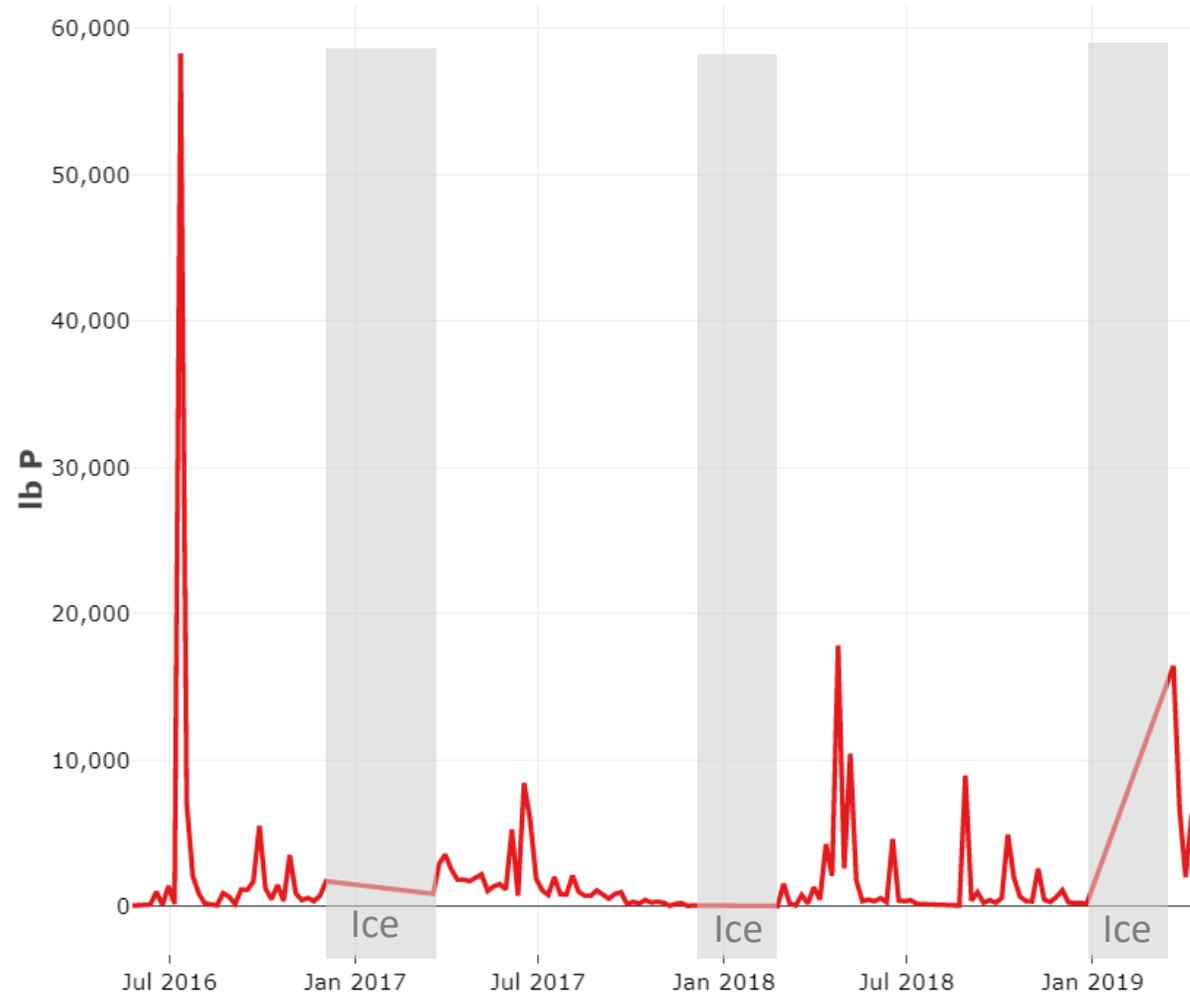
5) Daily concentration

Ahnapee continuous TP concentration





6) Daily Load

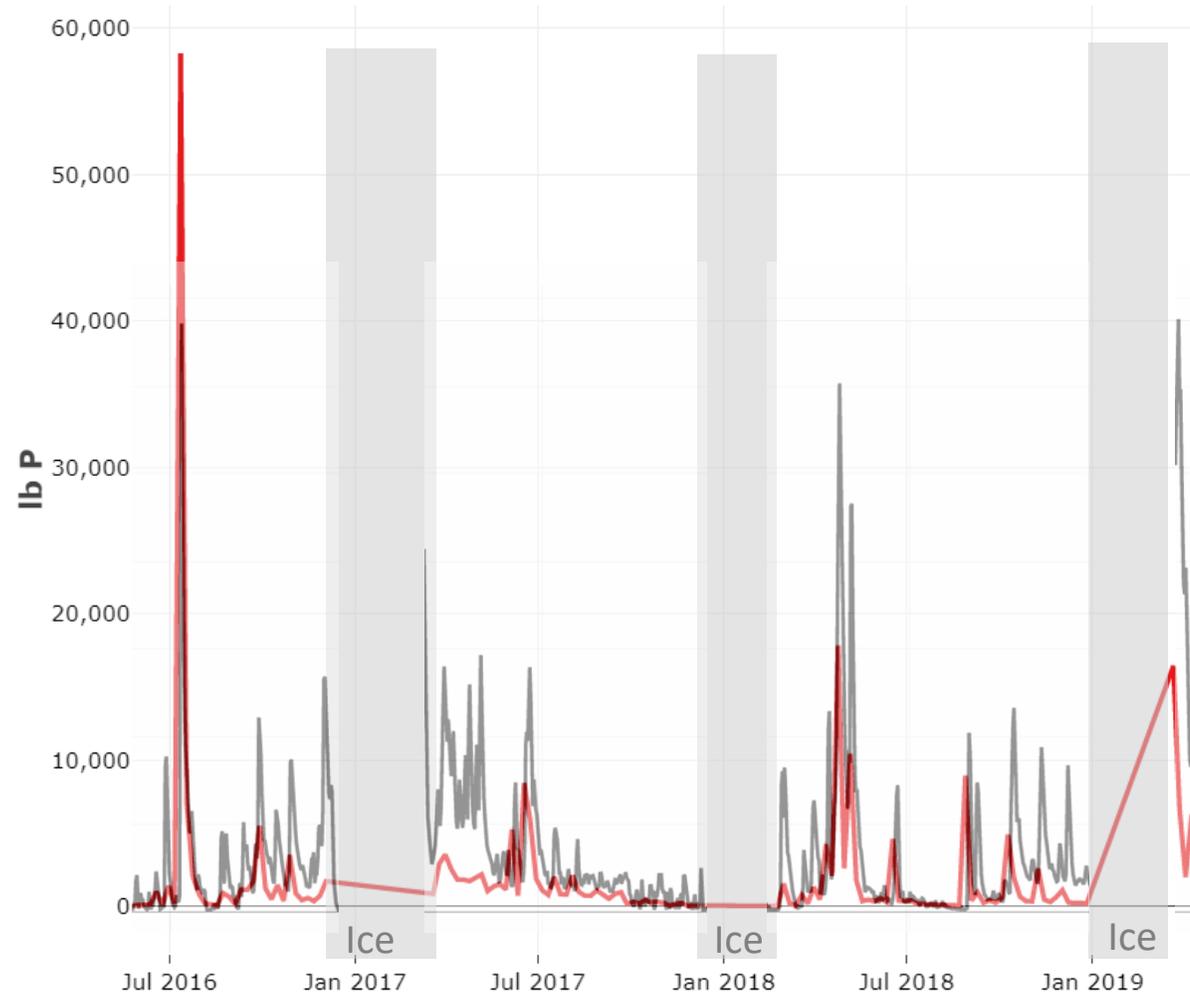




6) Daily loads

Load is driven by flow

Grey lines = flow





Data Collection and Analysis Process

1

Data Collection

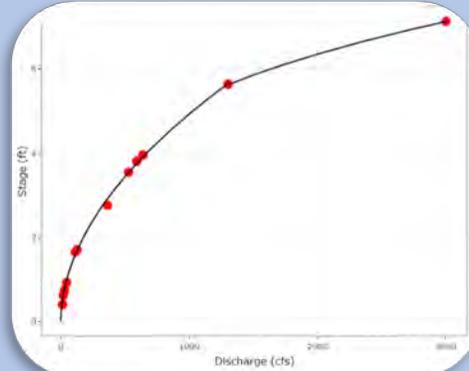
Stage

Flow Measurements

Water Chemistry Samples

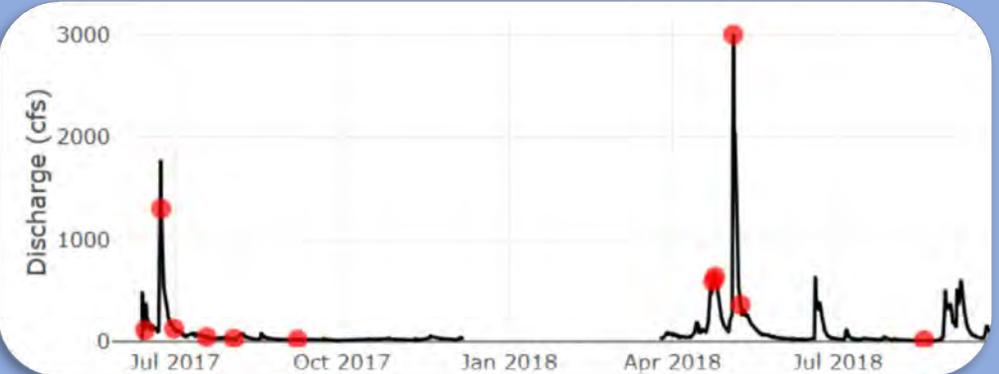
2

Rating Curve



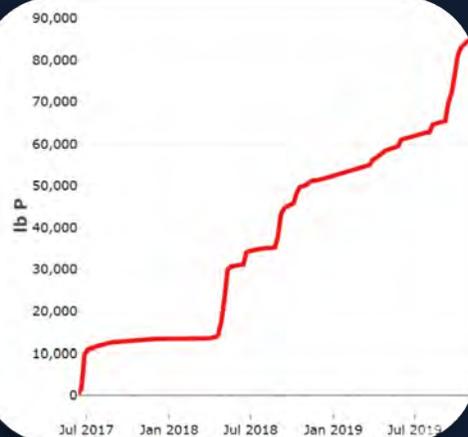
3

Discharge Record (hourly discharge)



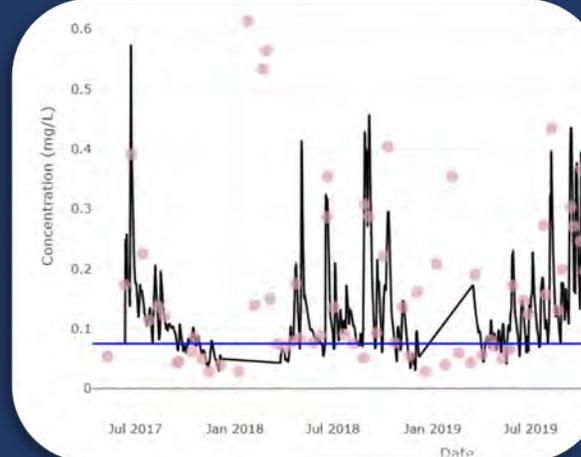
6

Daily Load



5

Daily concentration



4

Statistical Modeling

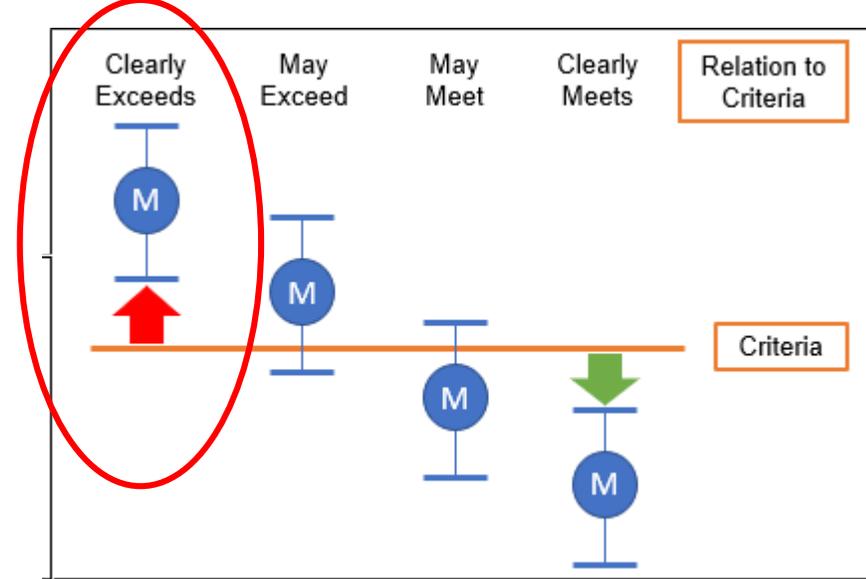


Impairment listing process

Total Phosphorus

- 1) Criteria based on waterbody type and hydrology
- 2) Minimum of 6 samples across growing season
- 3) Calculation of median (streams) or mean (lakes) and 80% confidence interval
- 4) Impairment determination based on Lower Confidence Limit (LCL)

Numeric phosphorus criteria (NR 102.06)



Rivers

100 µg/L



Streams¹

75 µg/L



Reservoirs

Not Stratified = 40 µg/L
Stratified = 30 µg/L



Inland Lakes²

Ranges from
15-30 µg/L



Great Lakes

Lake Michigan = 7 µg/L
Lake Superior = 5 µg/L

¹Excludes streams designated as 'limited aquatic life' according to NR 102.06(3)(a). Excludes Ephemeral Streams.

²Excludes wetlands and lakes less than 5 acres



Impairment listing process

Sediment & TSS

- Narrative criteria
 - In section NR 102.04(1)
- TSS Impacts
 - Turbidity
 - Habitat degradation



Kewaunee Model Basin



Kewaunee Model Basin

2020 draft Impaired Waters

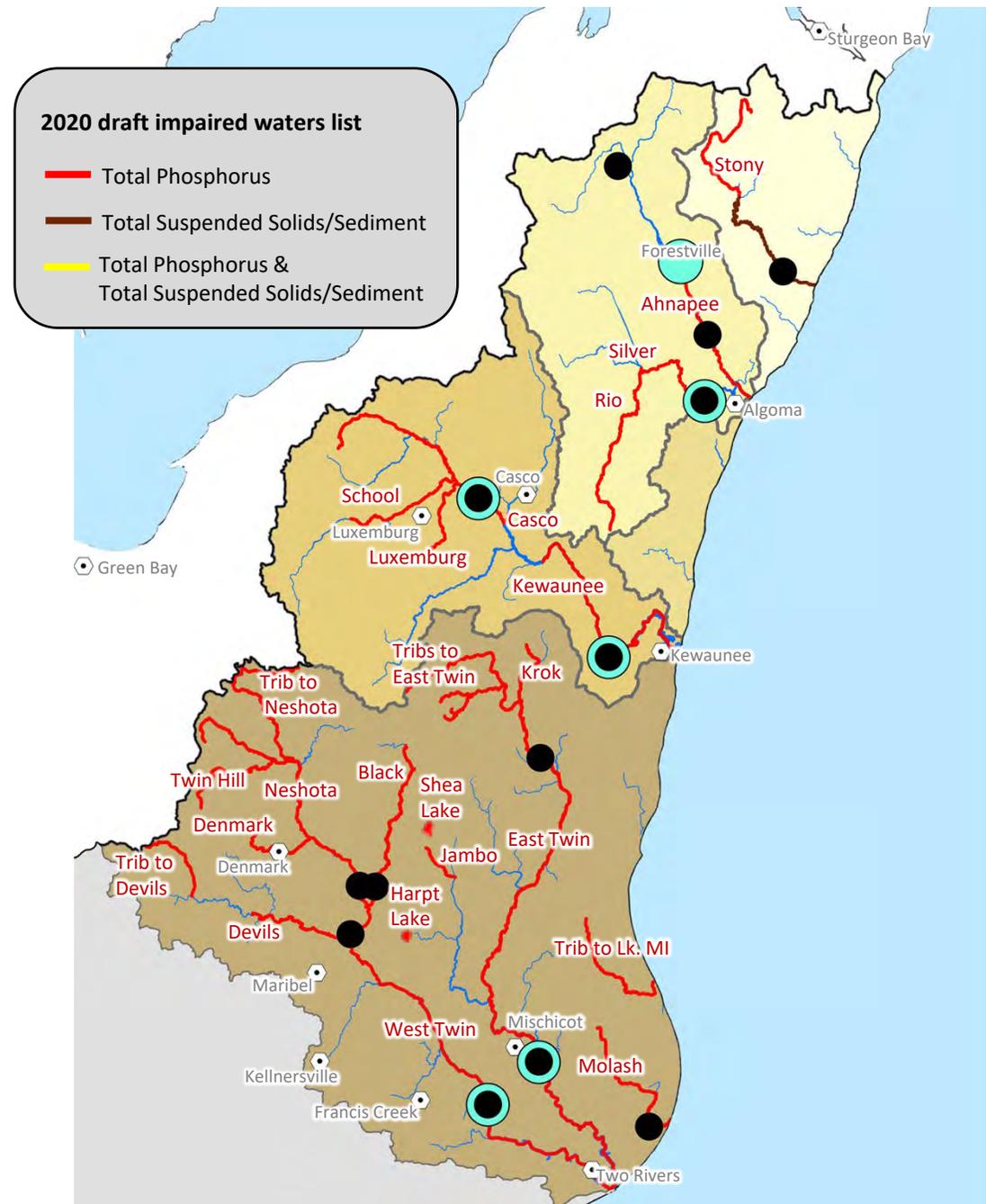
- Phosphorus
- Sediment/TSS

Phosphorus Water Quality Criteria

Stream Criteria 0.075 mg/L :

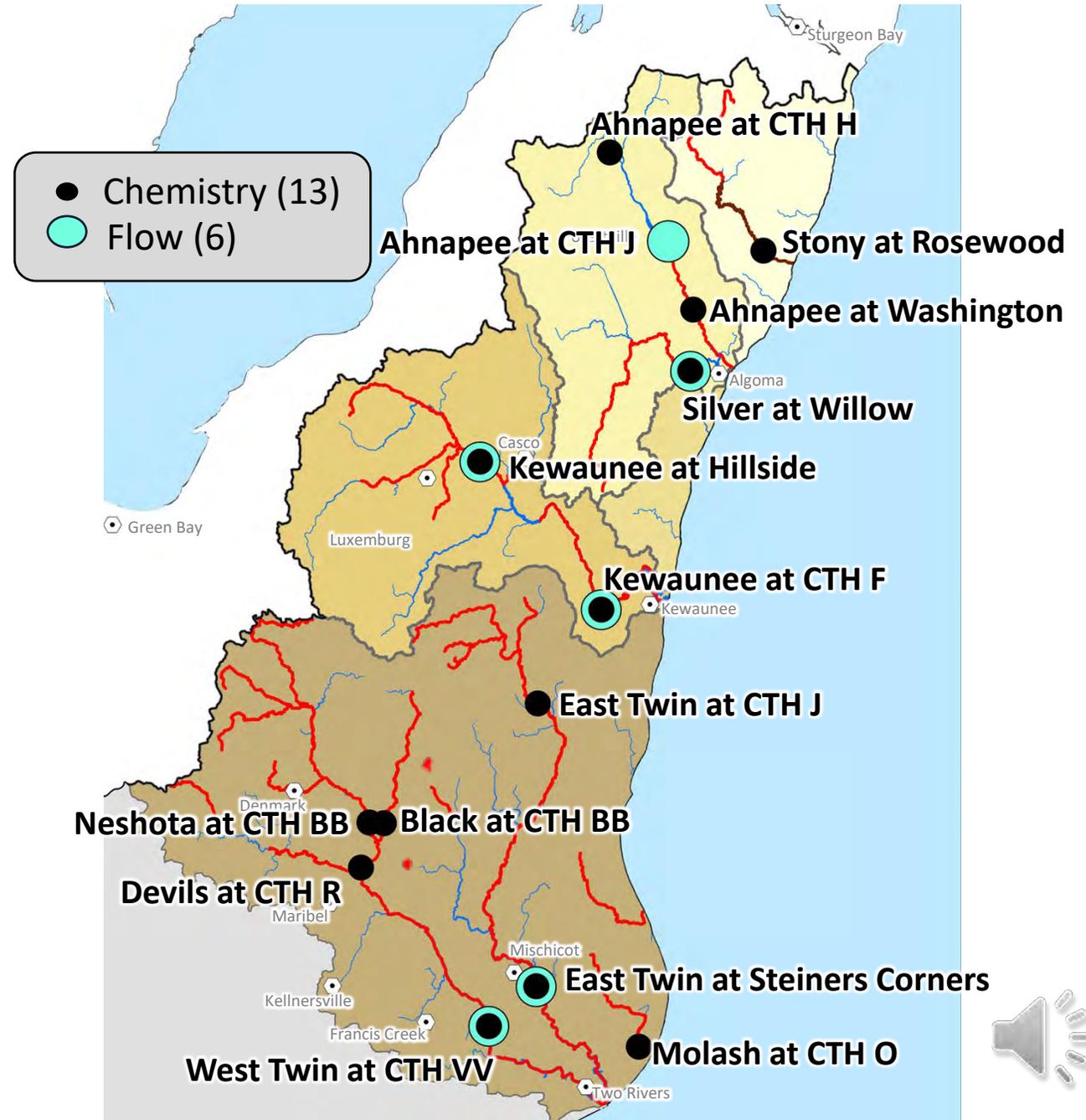
All other streams & rivers

Except ephemeral streams and those listed as 'Limited Aquatic Life' in NR 104



Kewaunee Basin

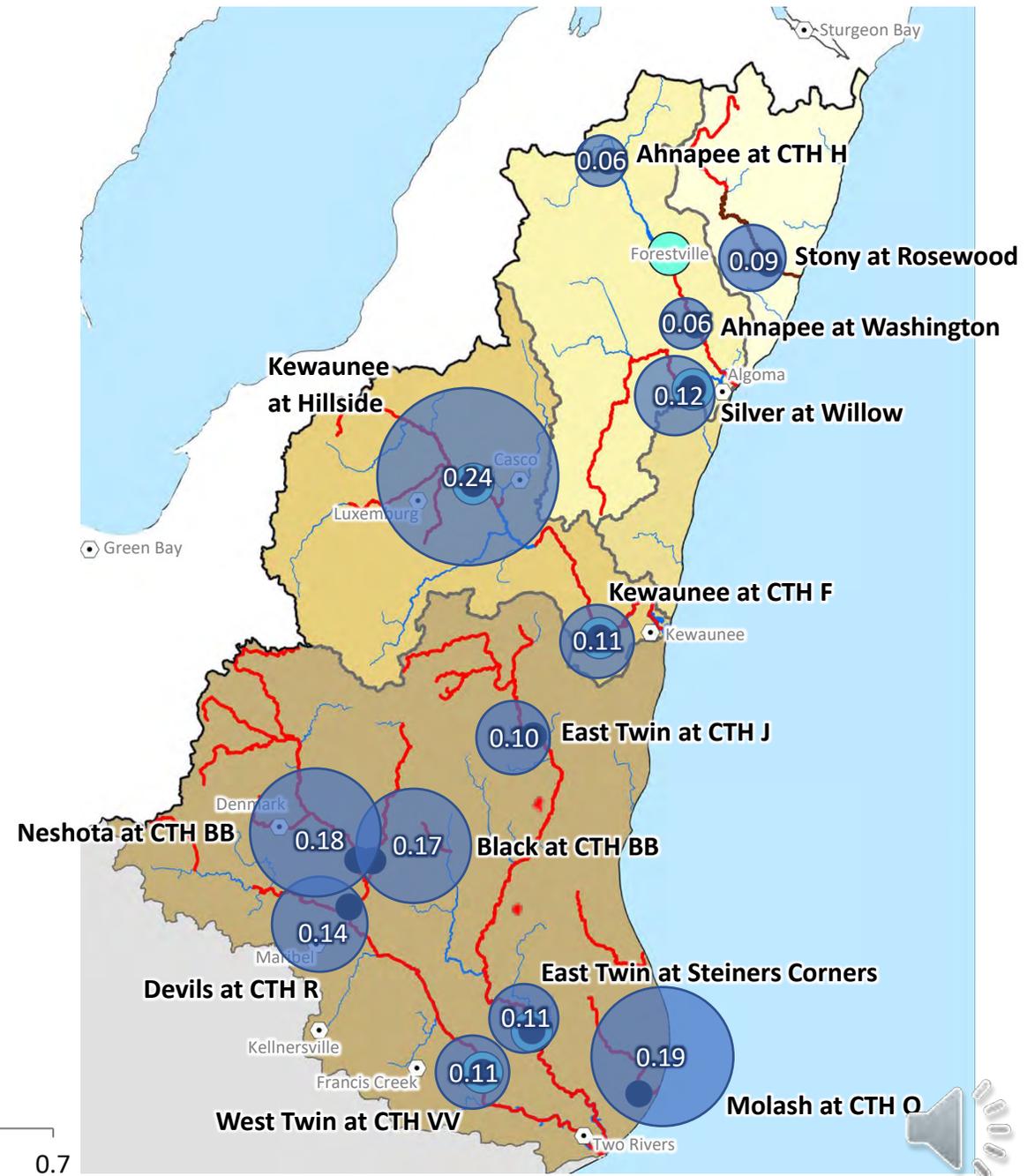
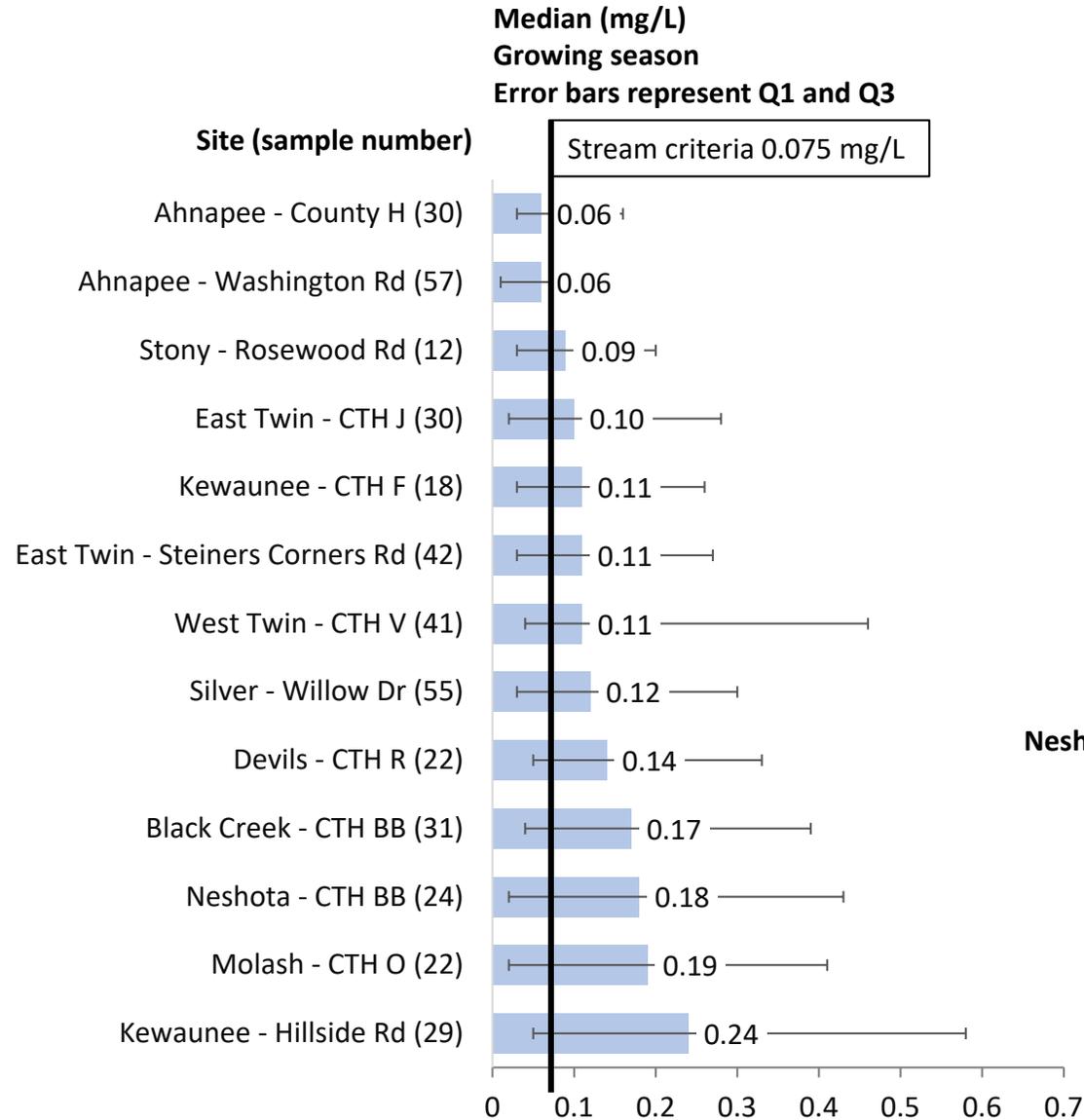
Monitoring Locations





Phosphorus

Growing season median mg/L

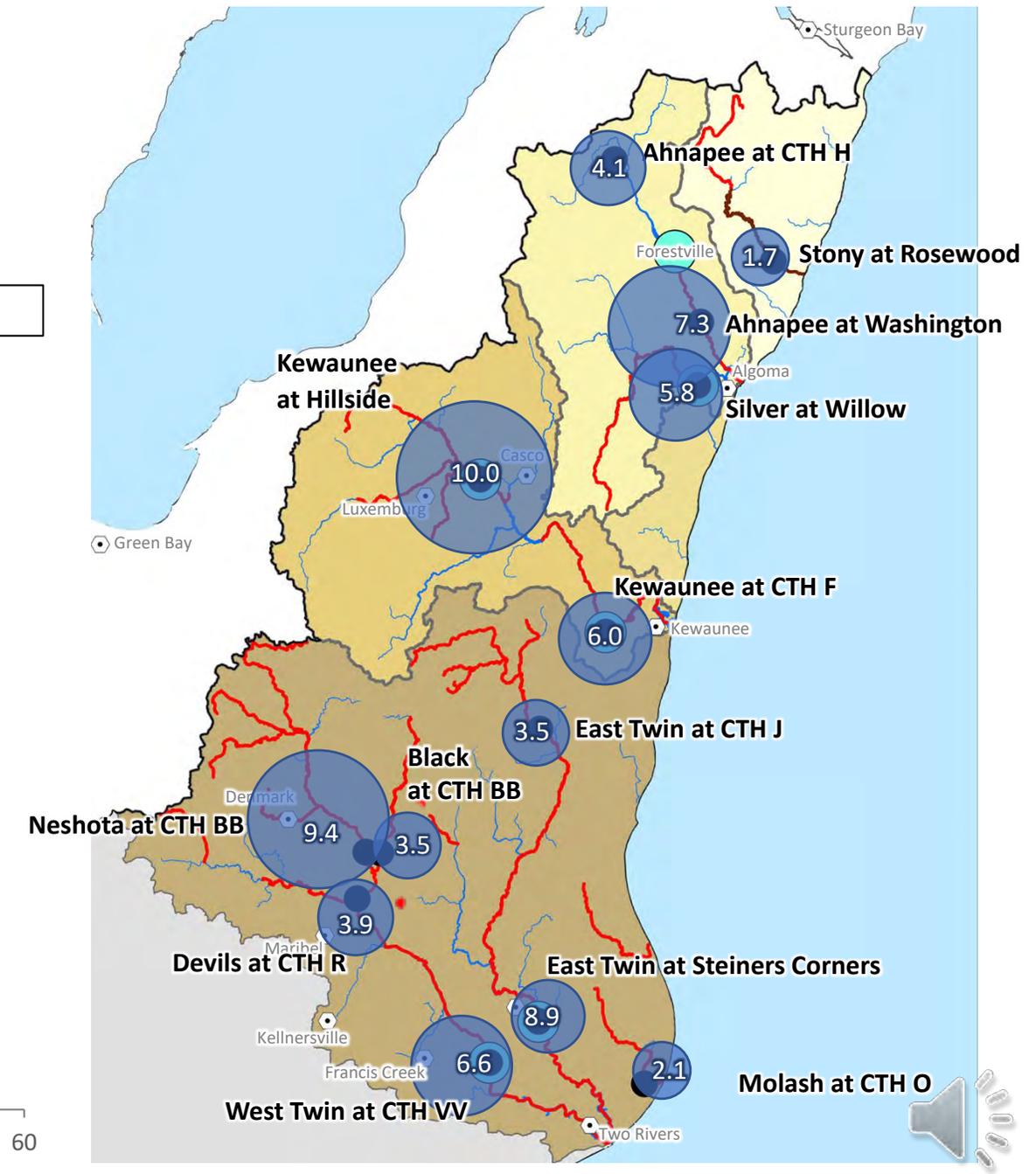
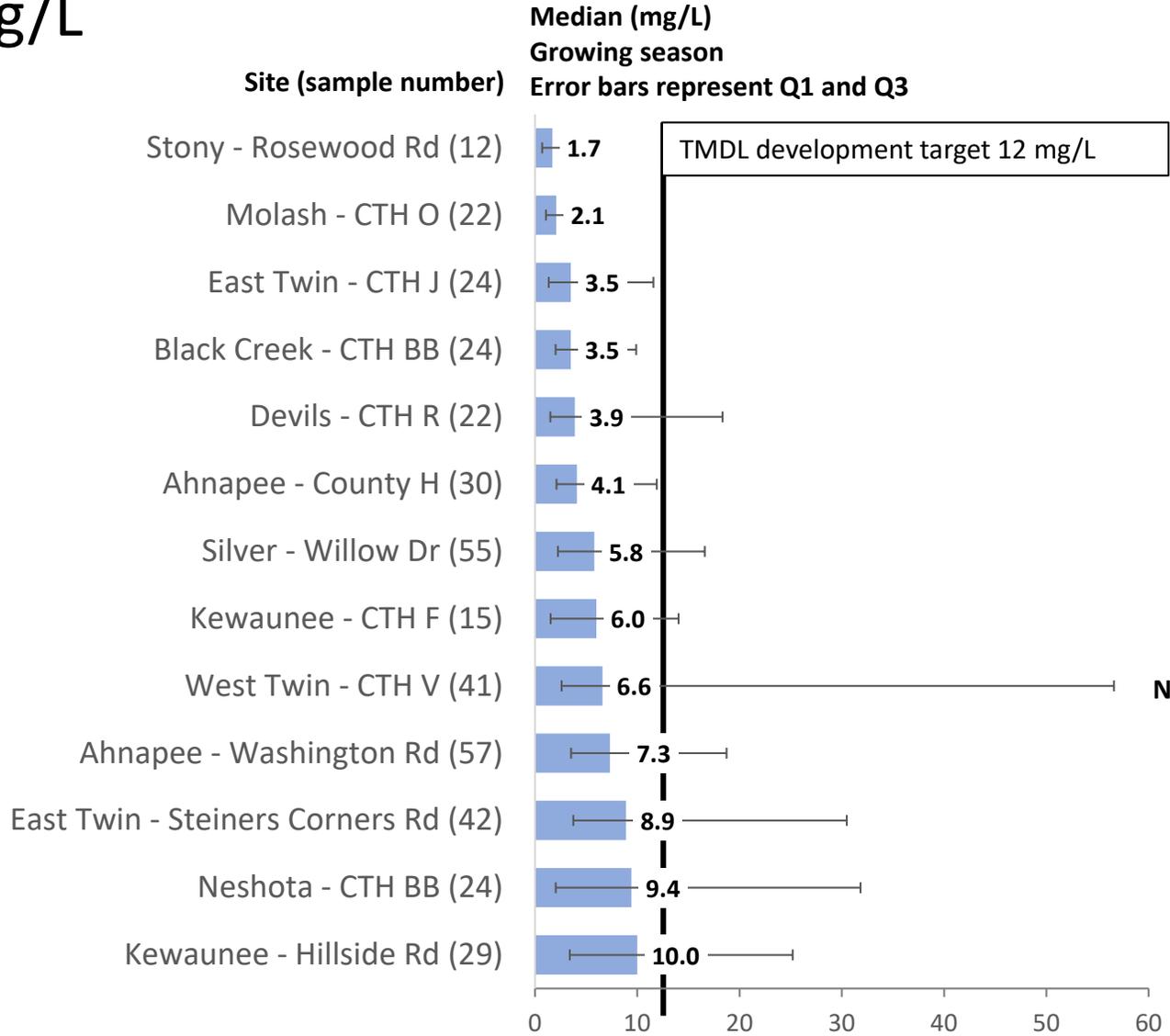




Total Suspended Solids

Growing season median

mg/L

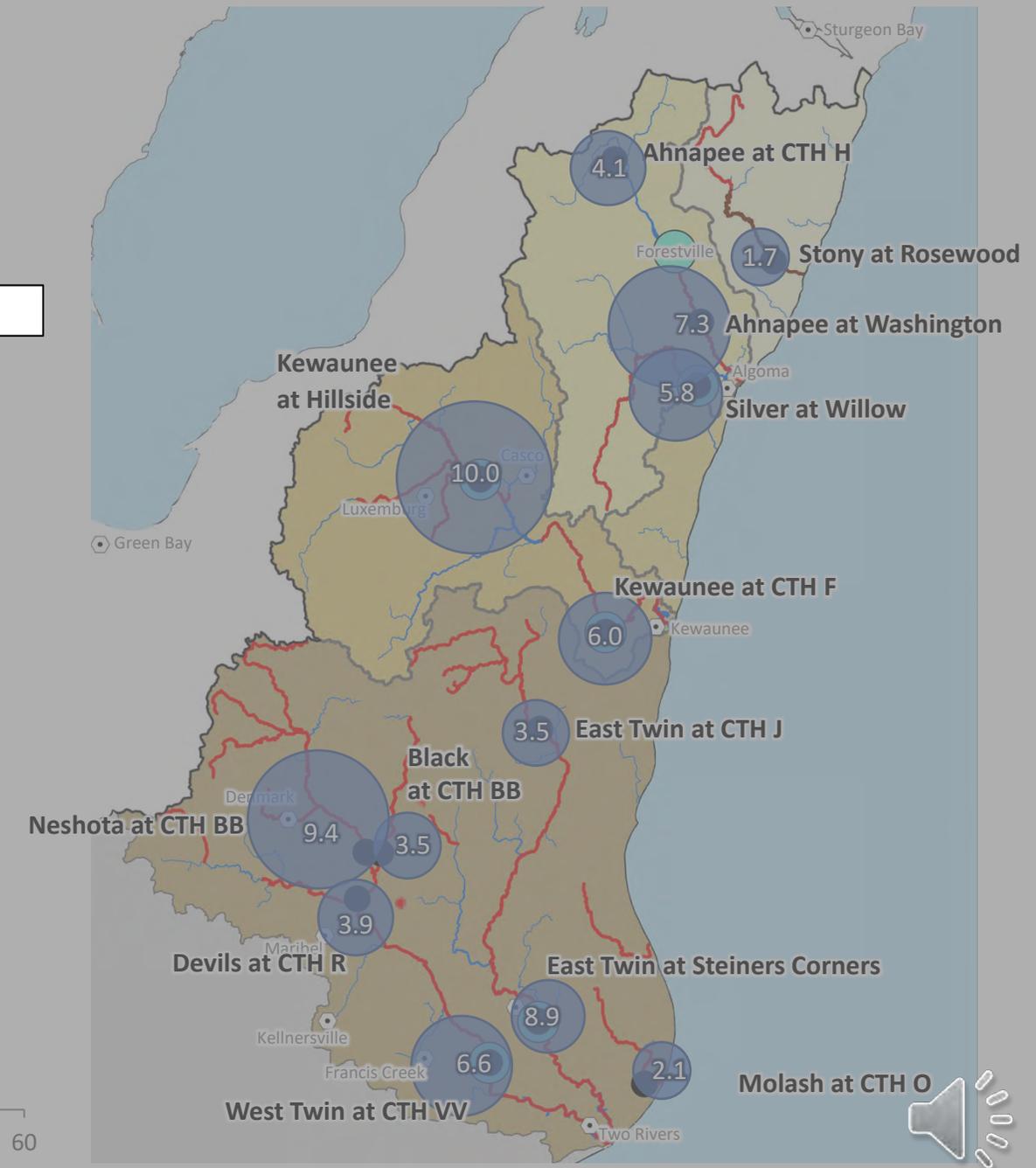
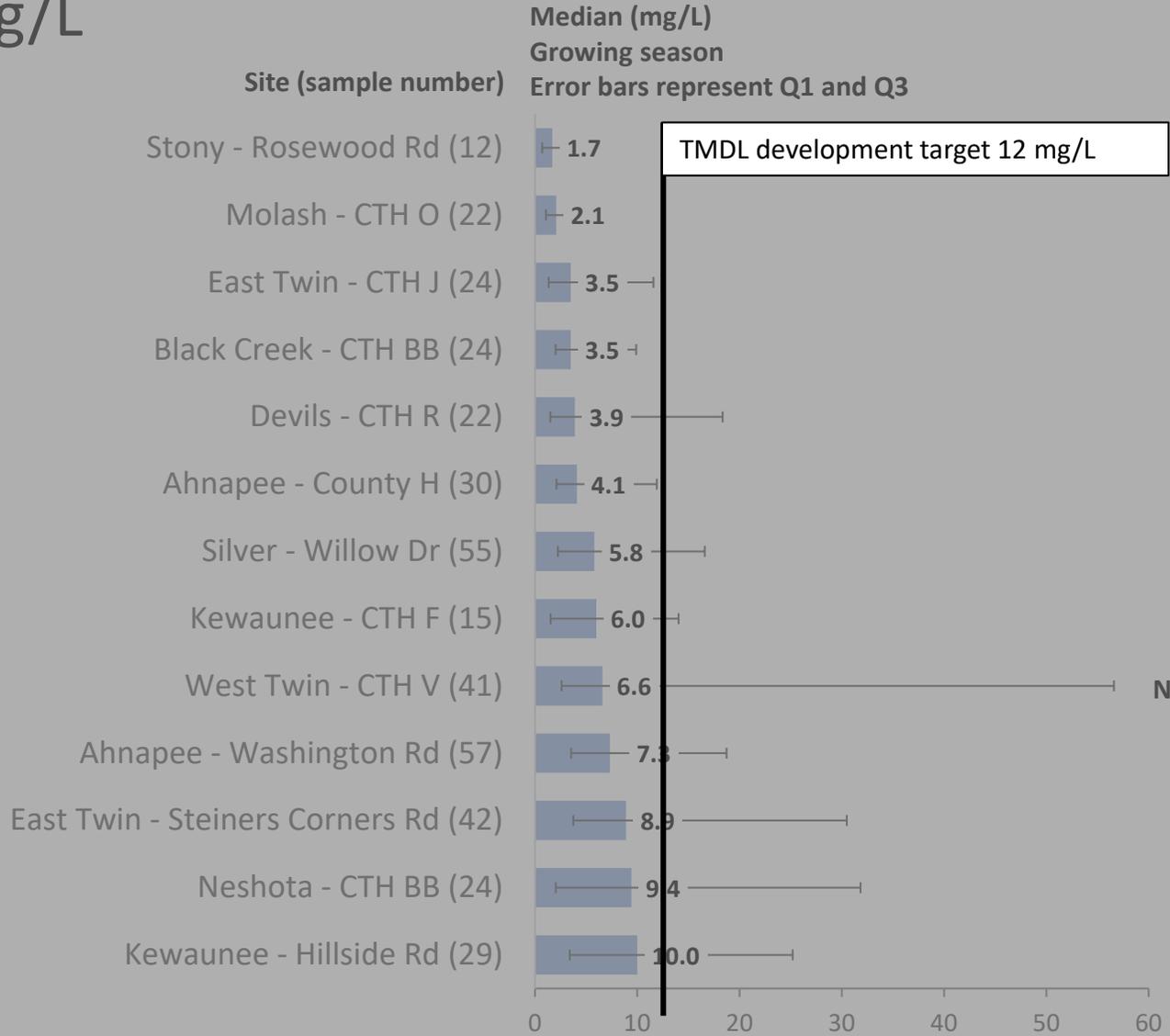




Total Suspended Solids

Growing season median

mg/L

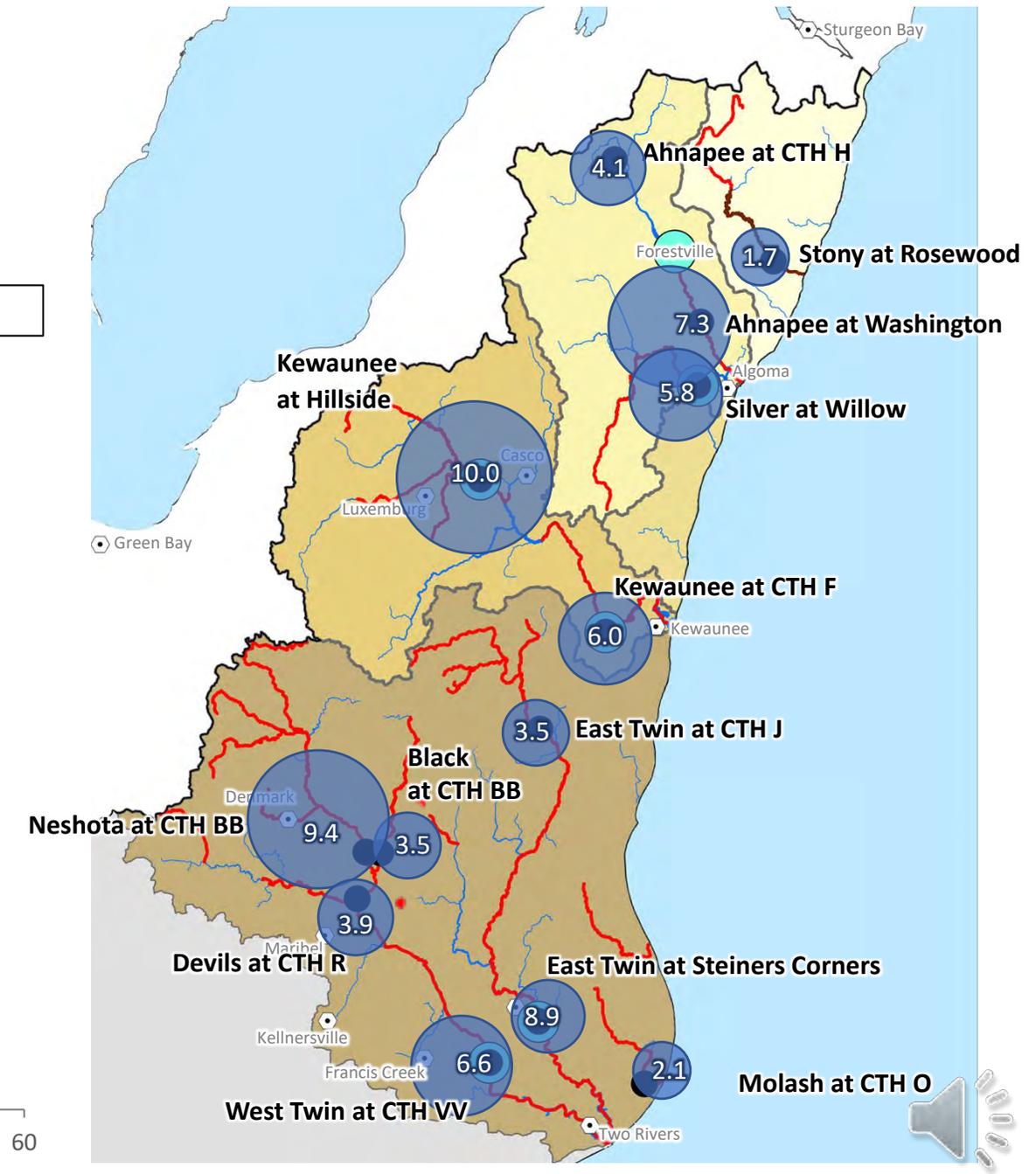
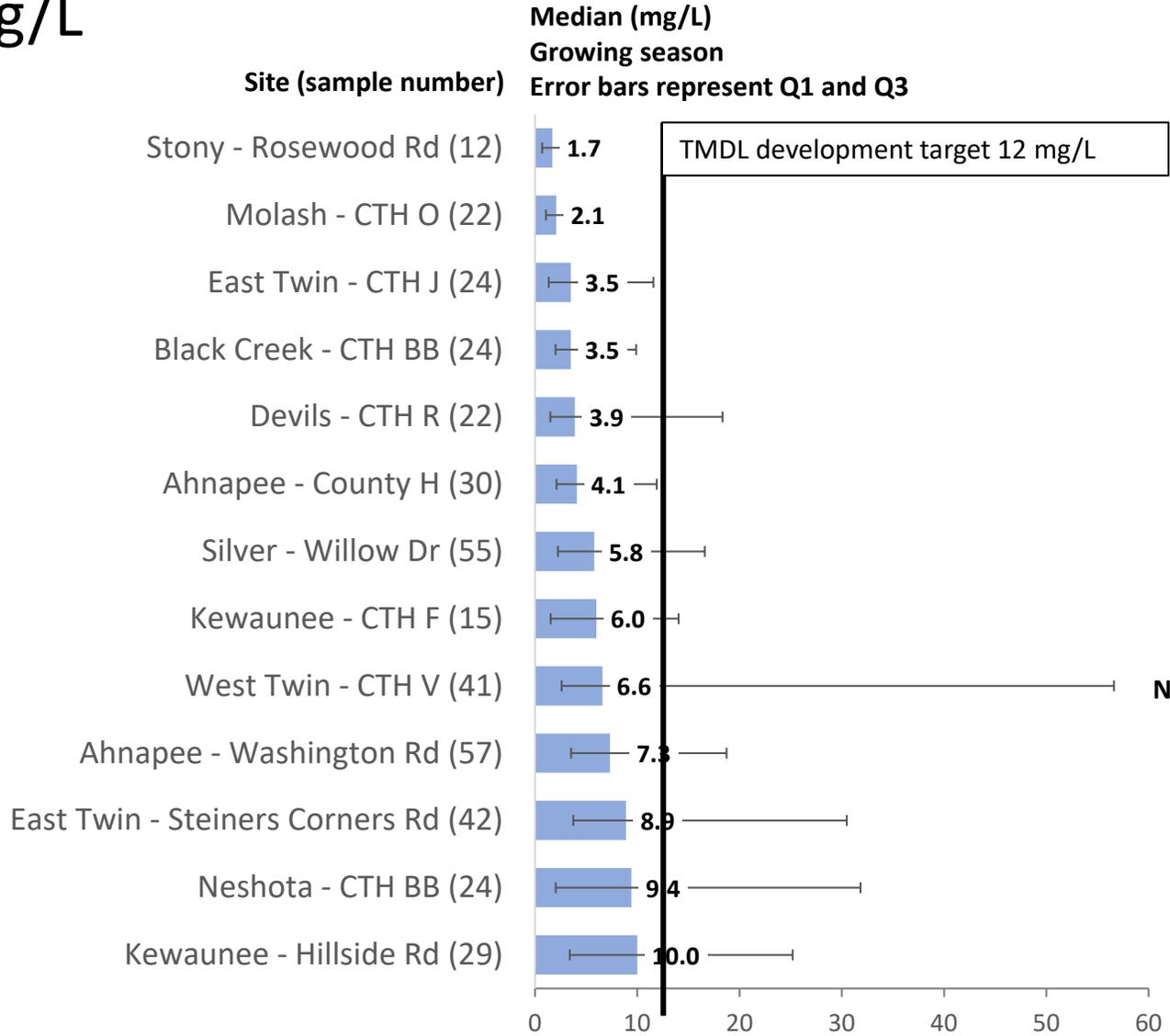




Total Suspended Solids

Growing season median

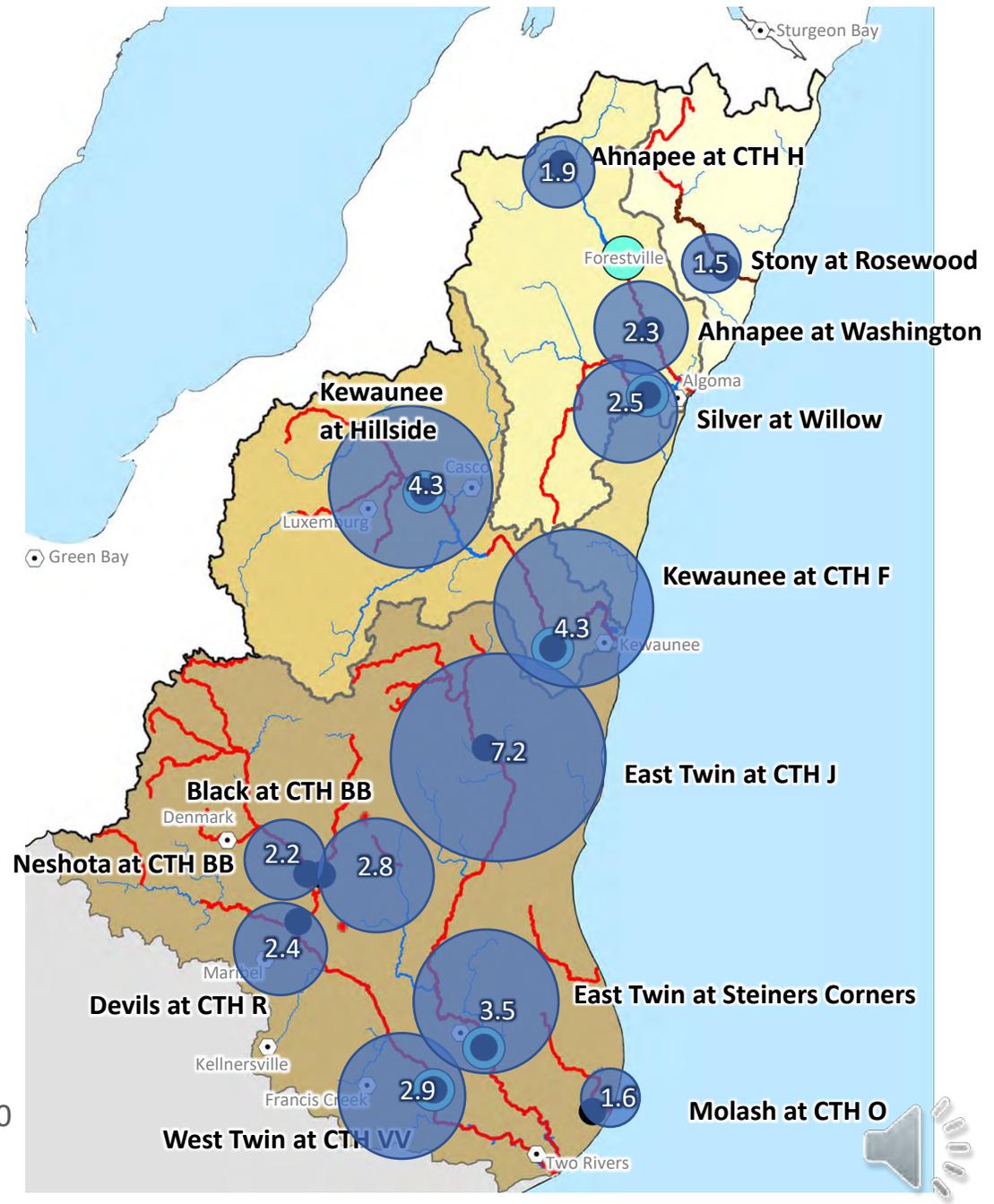
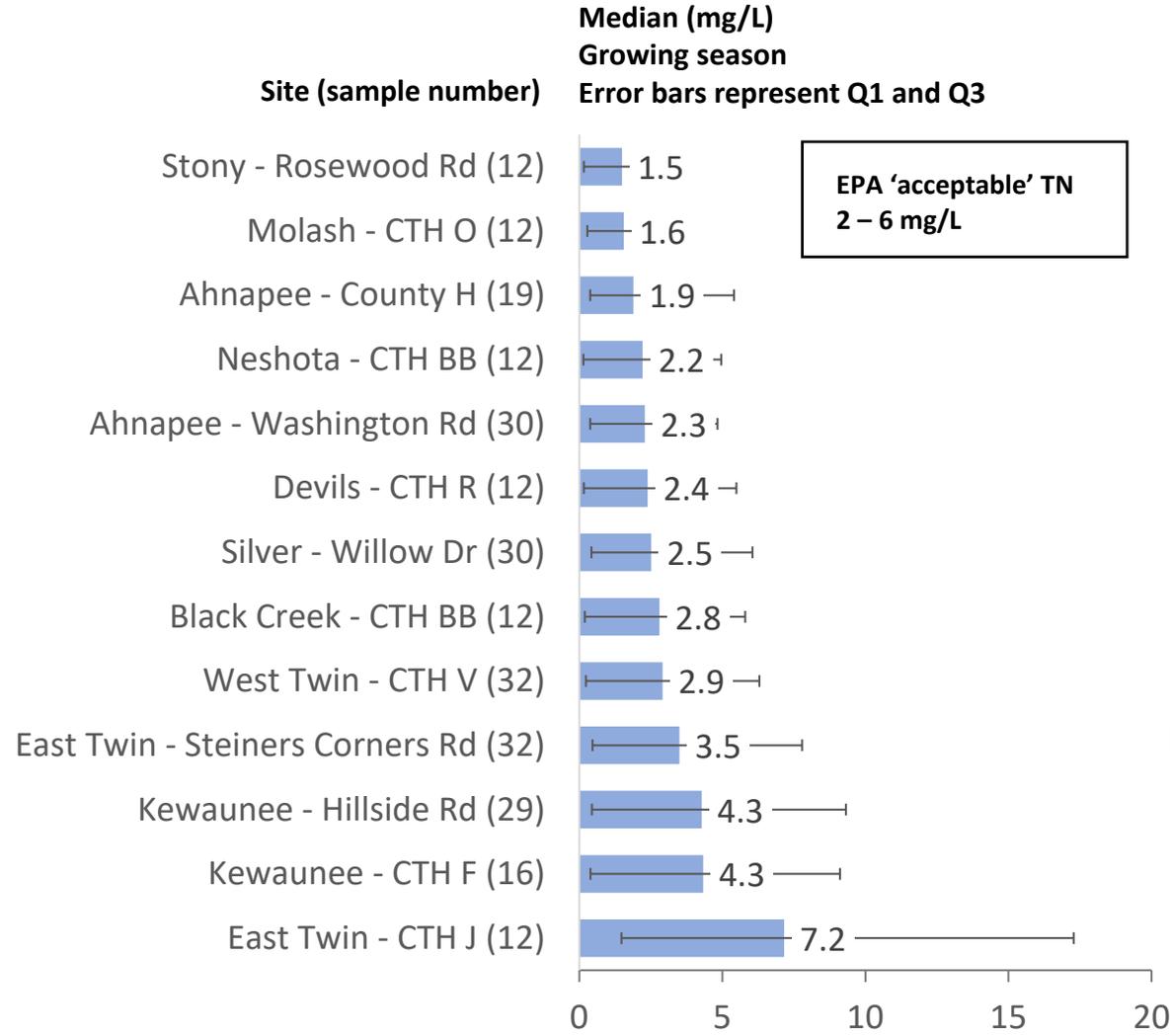
mg/L





Nitrogen

Growing season median mg/L





Kewaunee Model Basin Chemistry Summary

Phosphorus

Median concentrations above criteria all locations except the Ahnapee

Some watersheds showed higher concentrations in the headwaters than the mouths

TSS

All sites below the TMDL development target of 12 mg/L

No clear trend between headwater and mouth concentrations

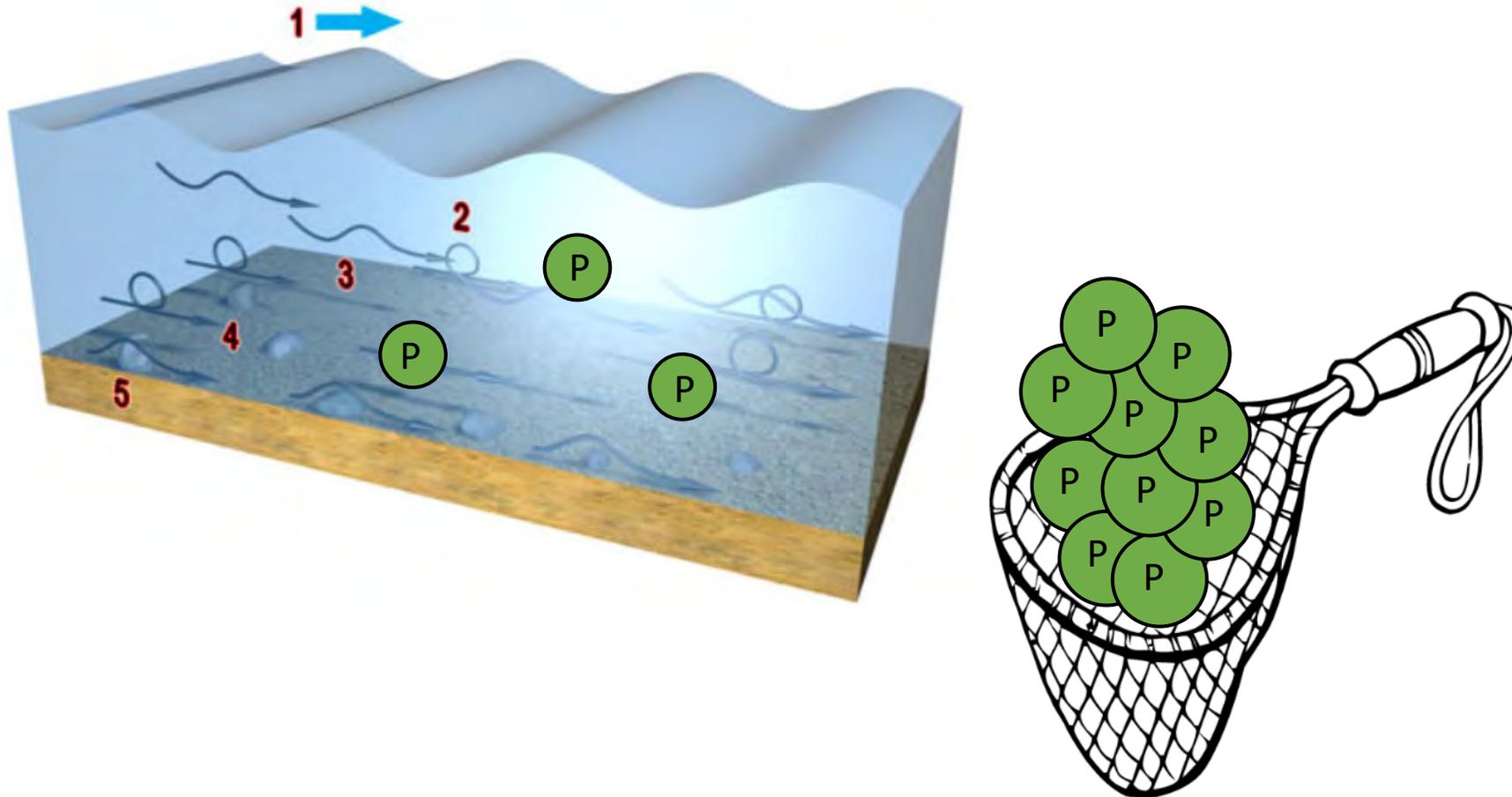
Nitrogen

All sites at 4 mg/L or less, except the upper East Twin River, at 7 mg/L

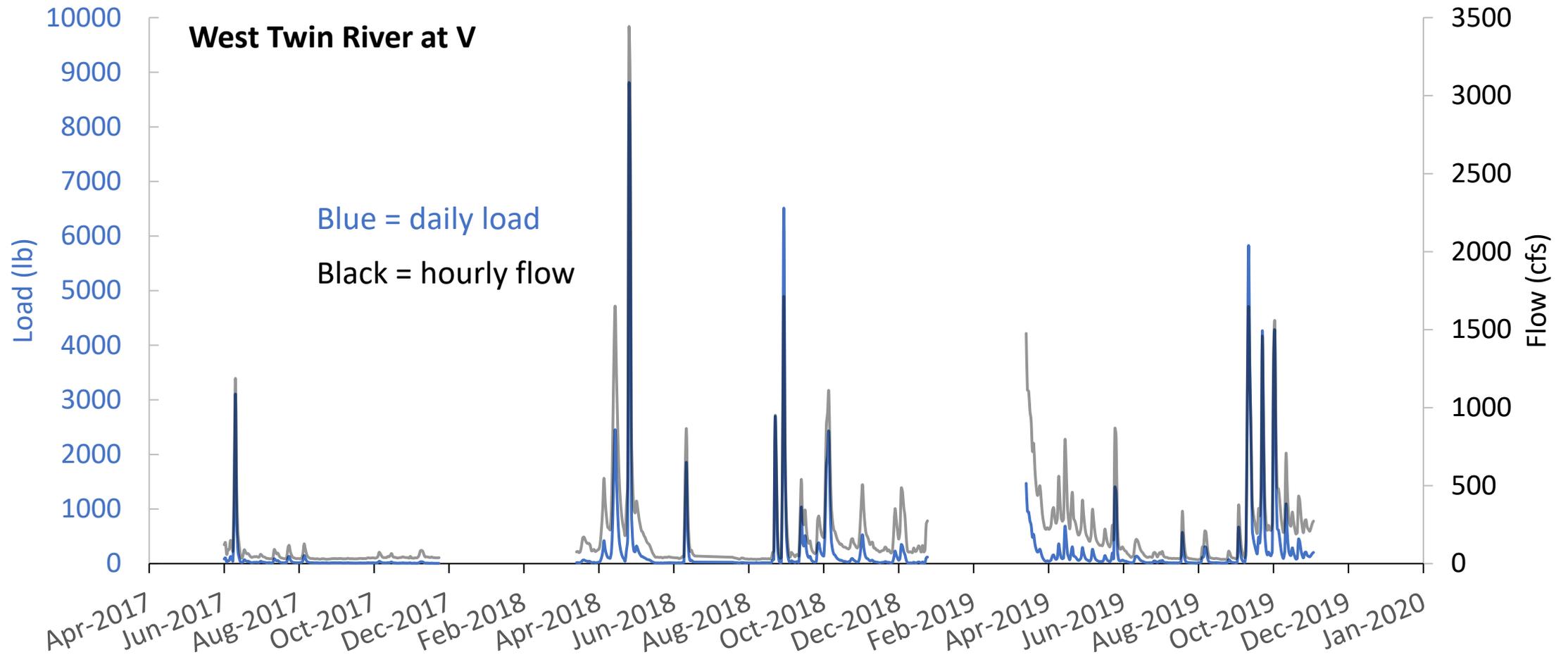


What is a stream load?

Amount of a substance carried by a stream

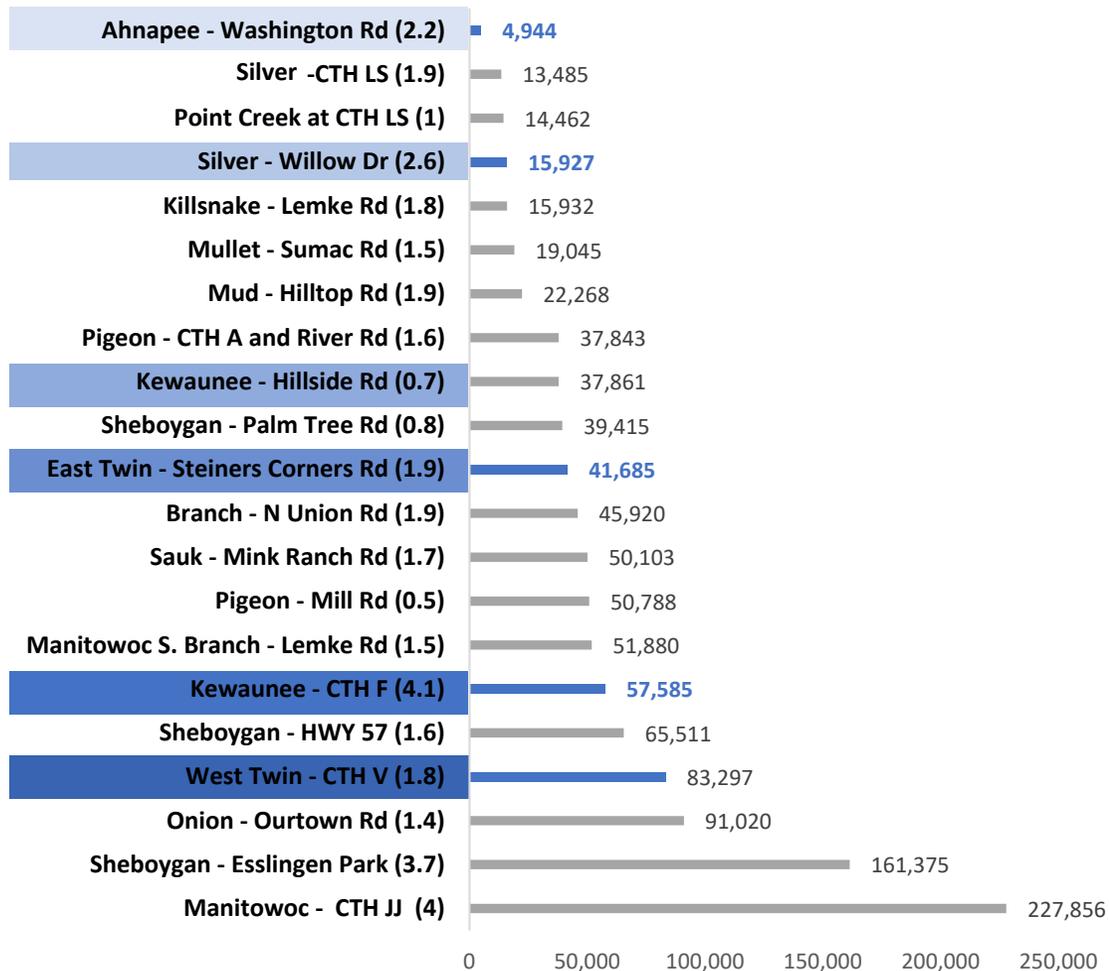


Stream load and stream flow are related

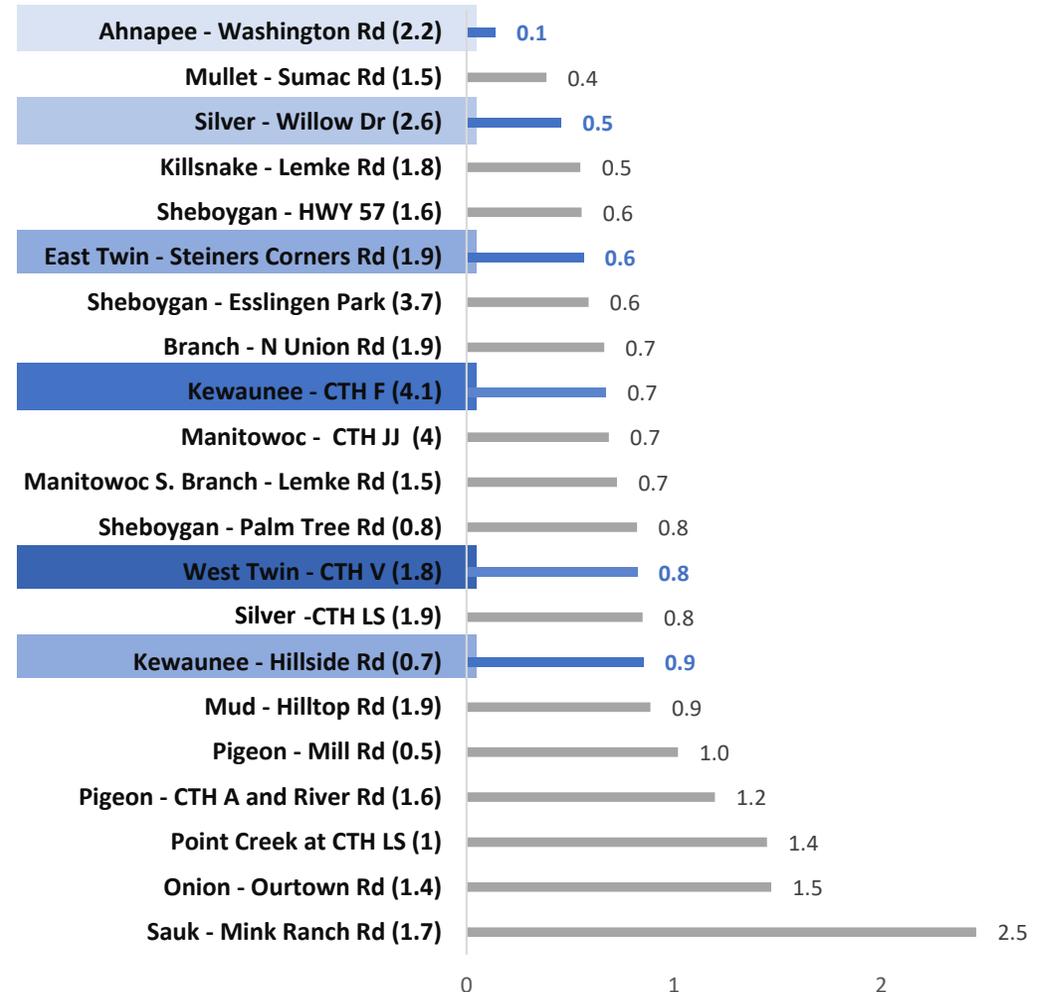


Yearly Total Phosphorus Load

Average yearly TP load (lb)

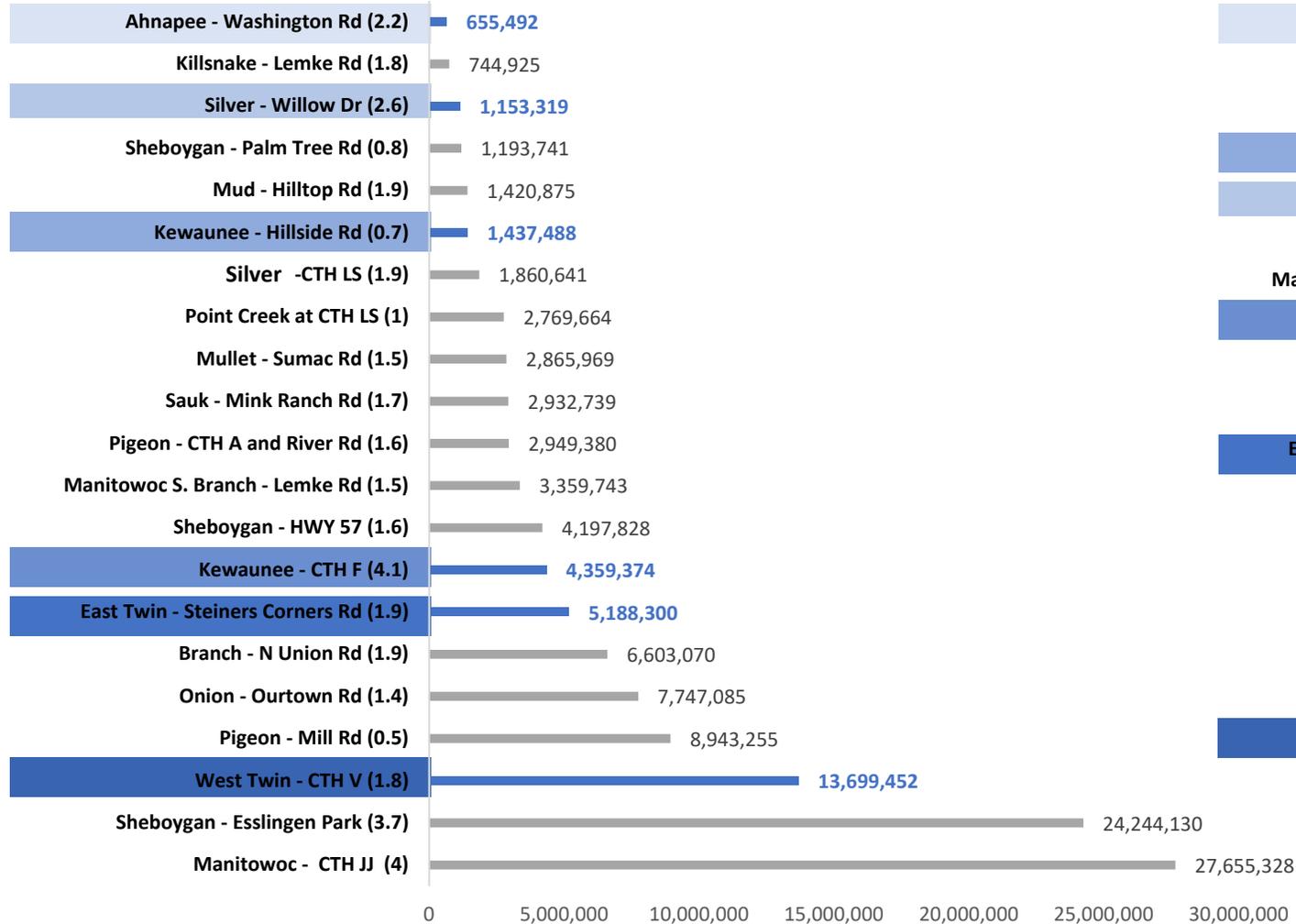


Average yearly TP load (lb) per acre

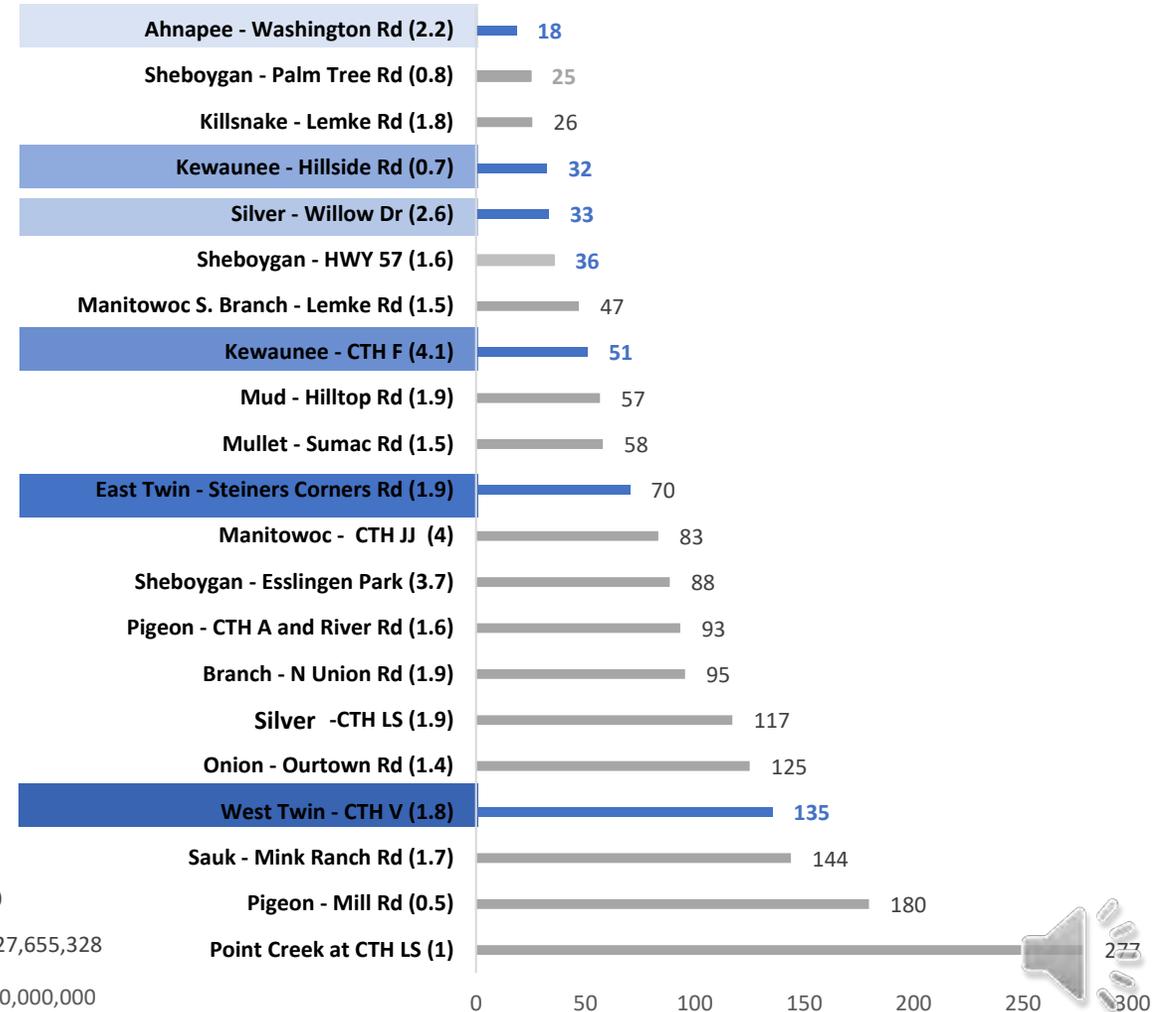


Yearly Total Suspended Solids Load

Average yearly TSS load (lb)



Average yearly TSS load (lb) per acre



Manitowoc Model Basin



Manitowoc Model Basin

2020 draft Impaired Waters

- Phosphorus
- Sediment/TSS

Phosphorus Water Quality Criteria

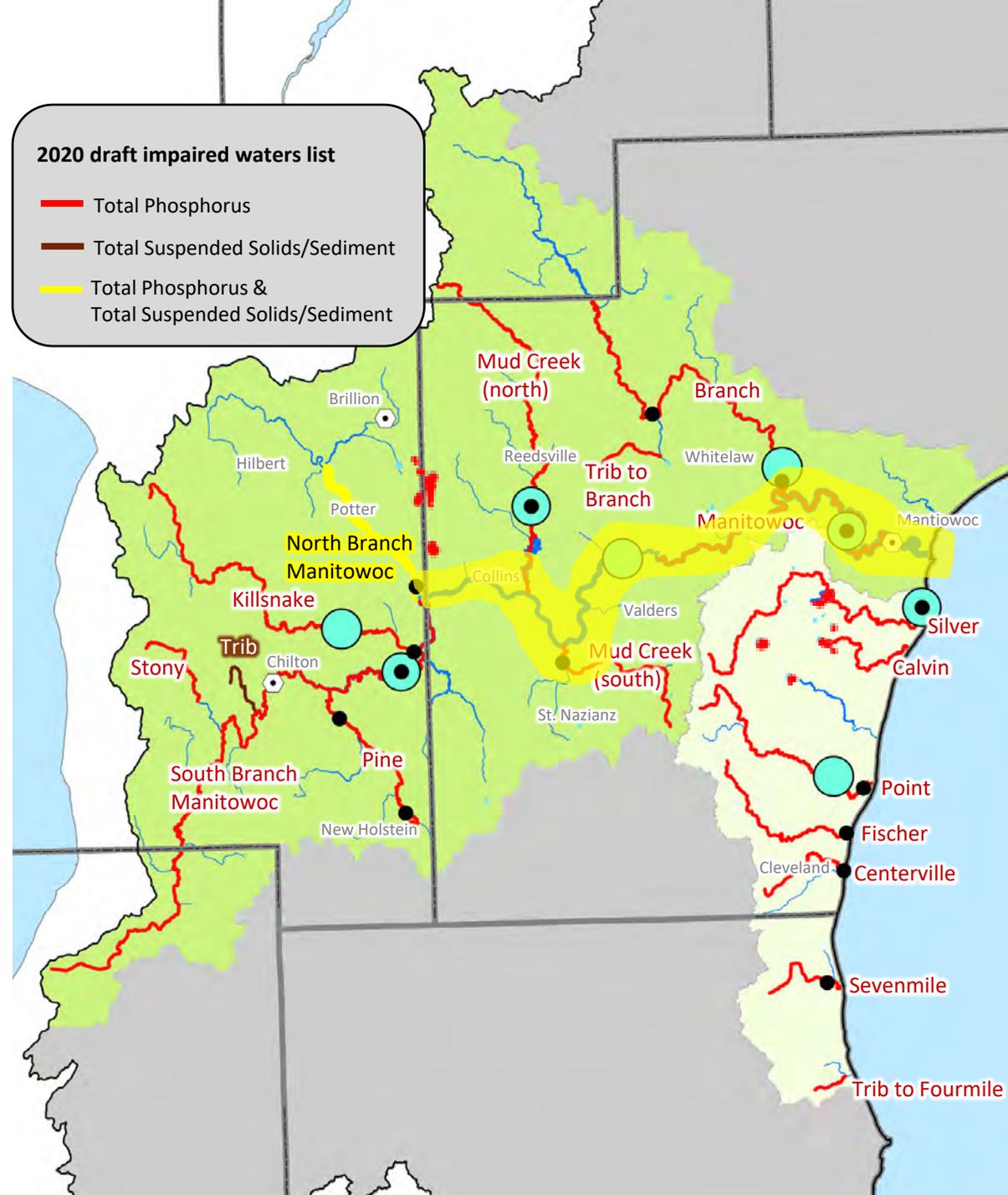
River Criteria 0.1 mg/L

Manitowoc River from confluence of North Branch and South Branch Manitowoc rivers to mouth at Lake Michigan

Stream Criteria 0.075 mg/L

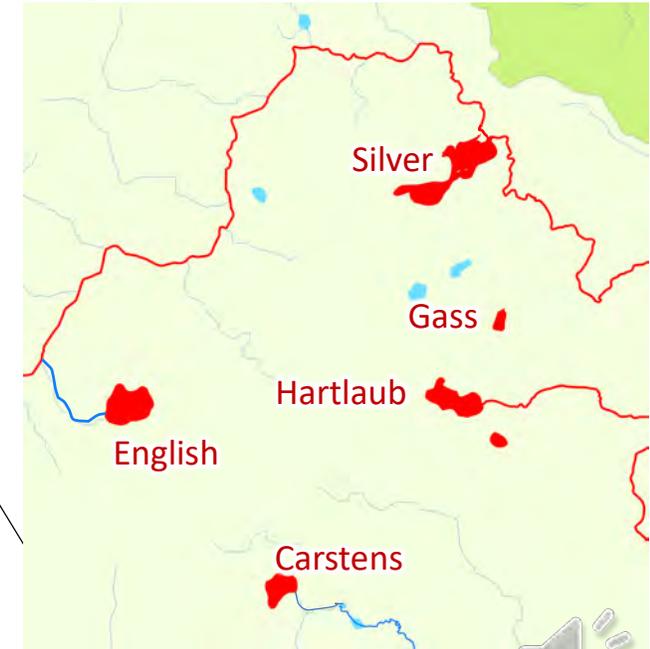
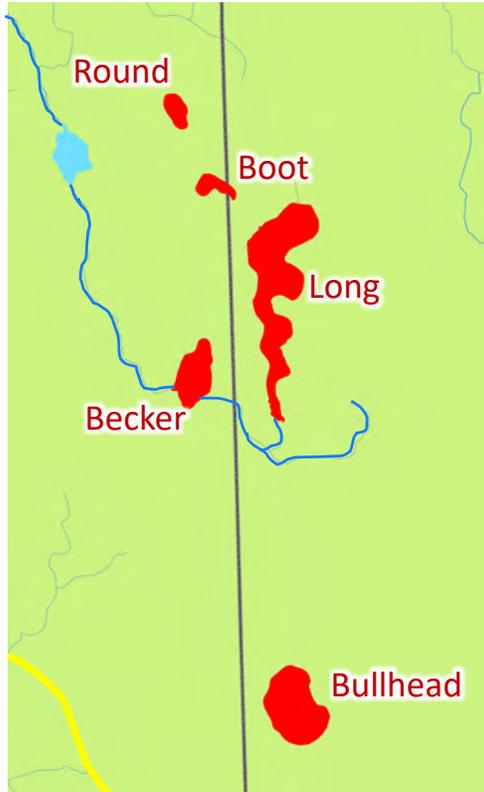
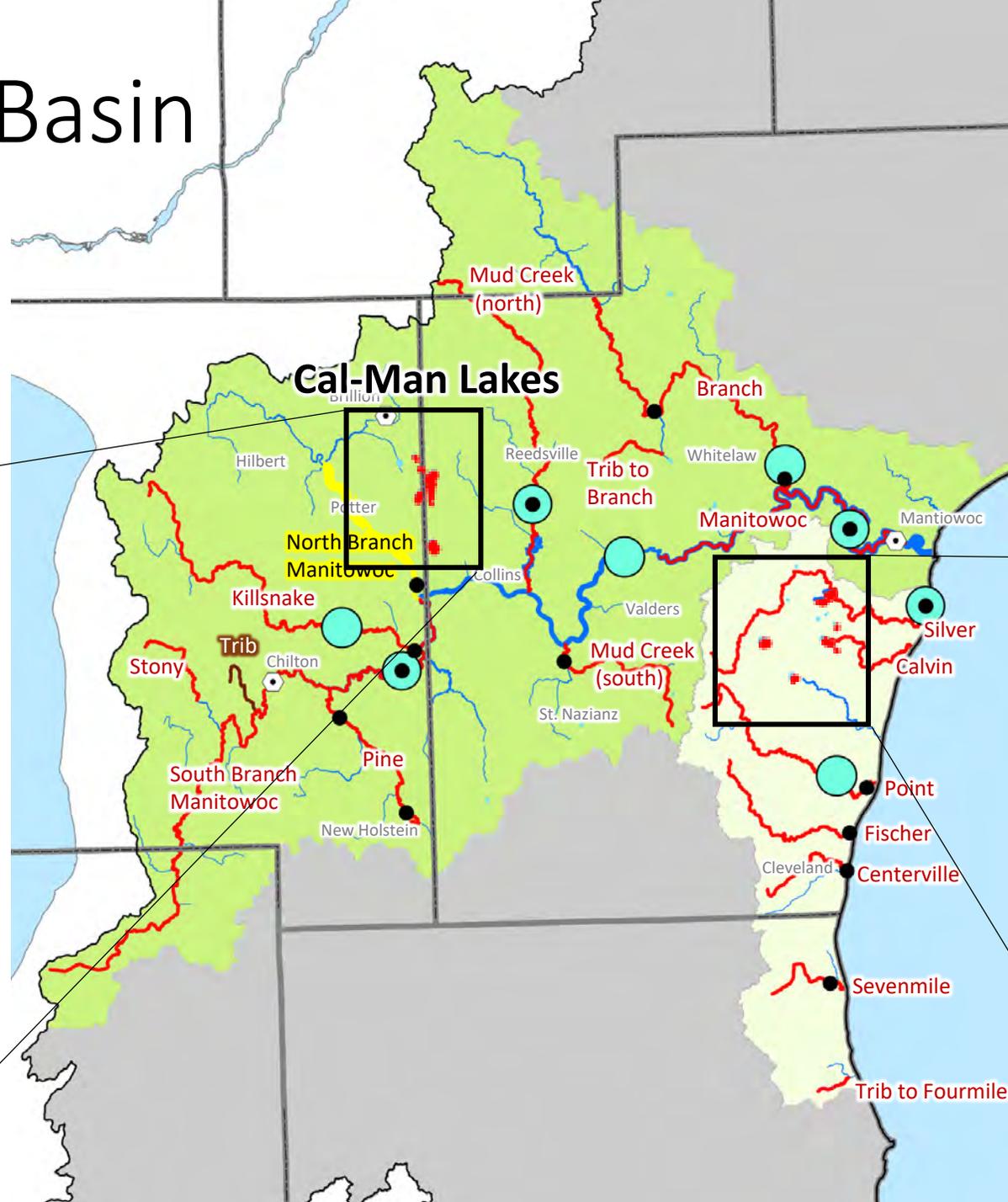
All other streams & rivers

Except ephemeral streams and those listed as 'Limited Aquatic Life' in NR 104



Manitowoc Basin

TP impaired lakes



Manitowoc Model Basin

Monitoring Locations

- Chemistry (15)
- Flow (8)

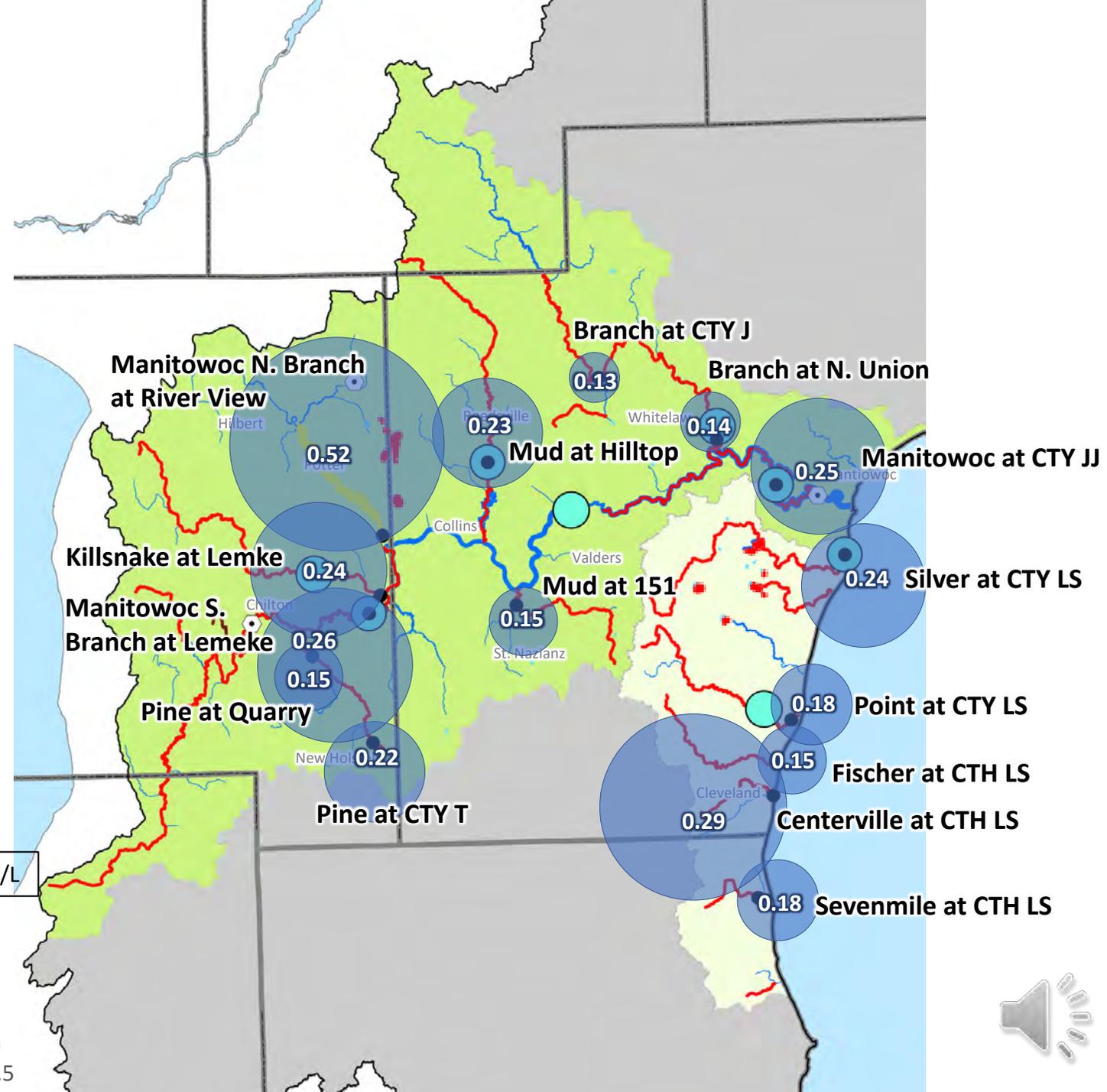
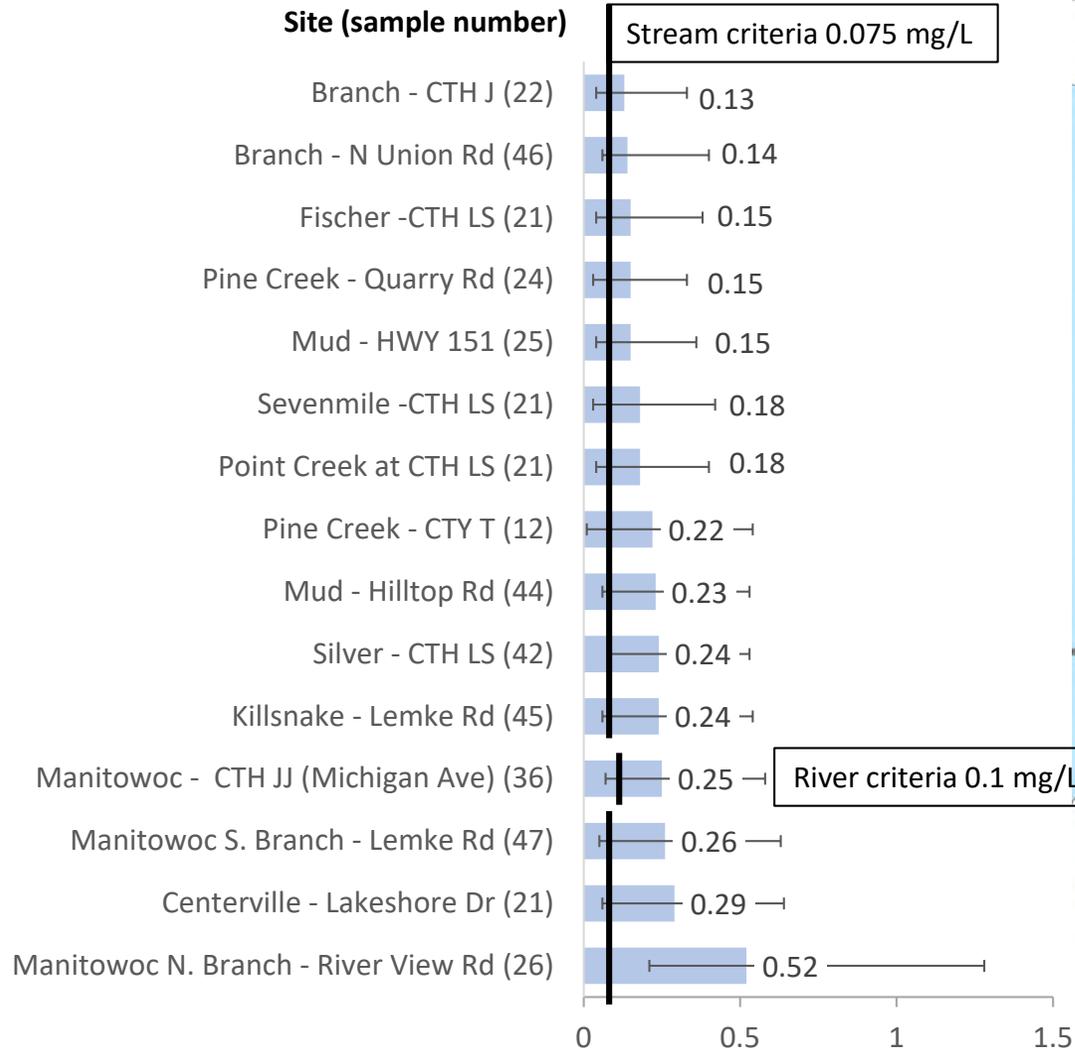




Phosphorus

Growing season median mg/L

Median (mg/L)
Growing season
Error bars represent Q1 and Q3





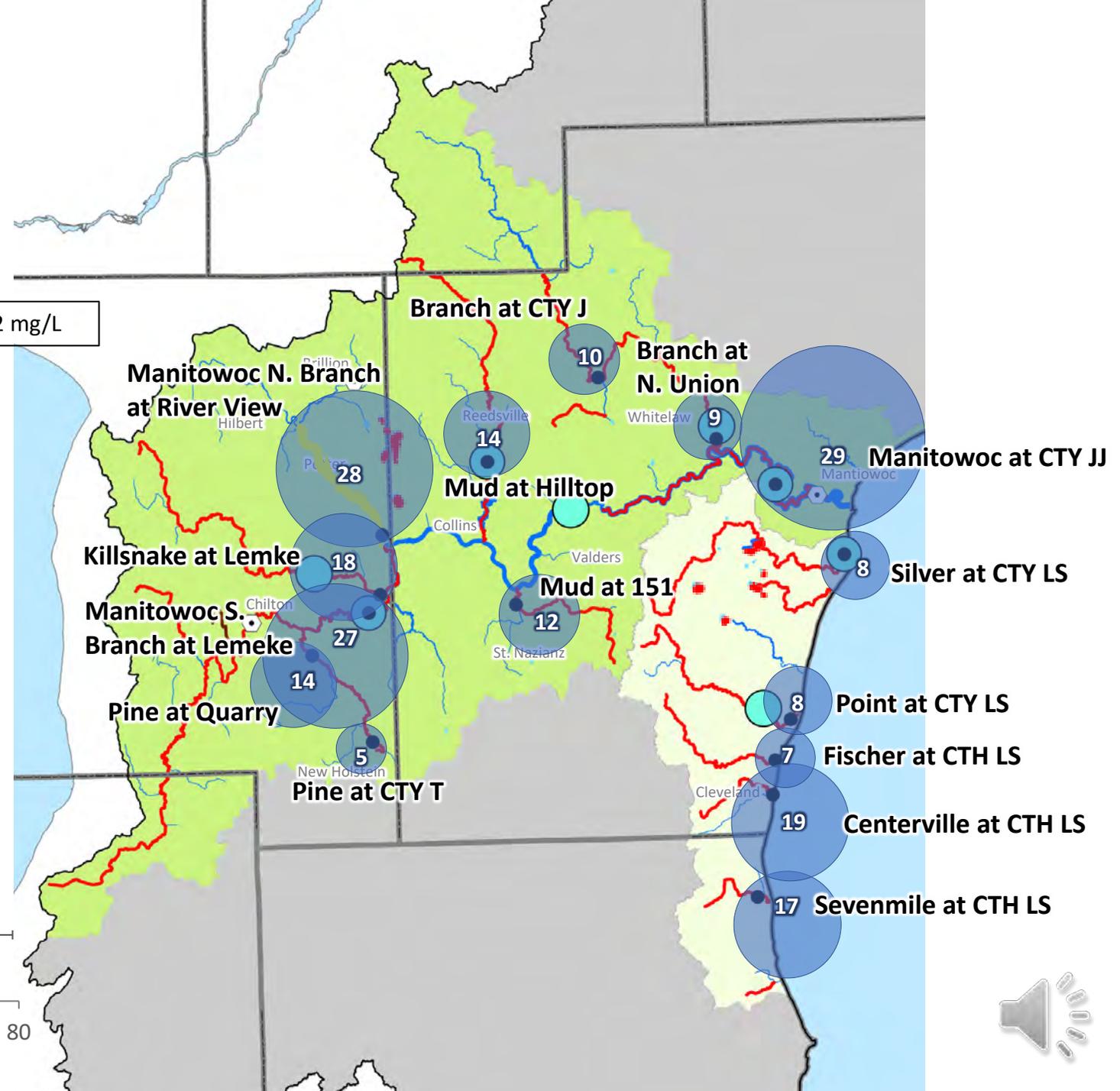
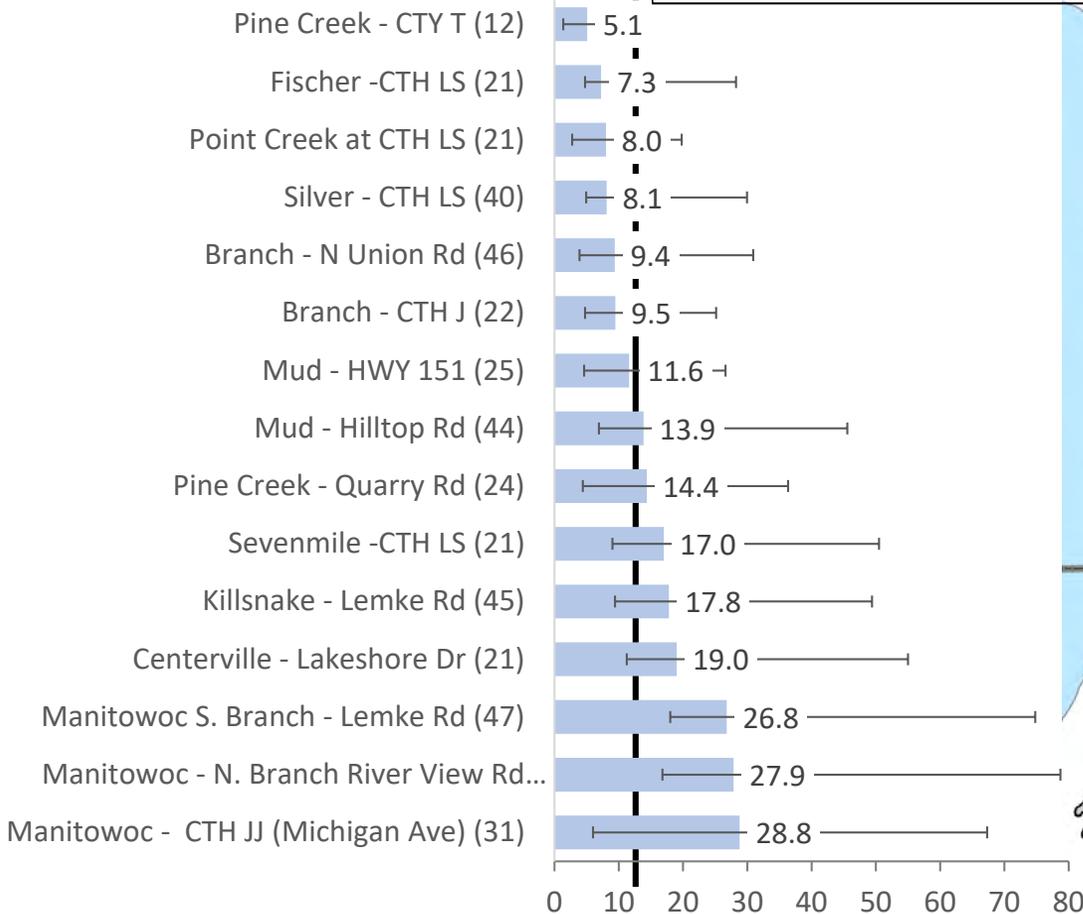
TSS

Growing season median mg/L

Median (mg/L)
Growing season
Error bars represent Q1 and Q3

Site (sample number)

TMDL development target 12 mg/L

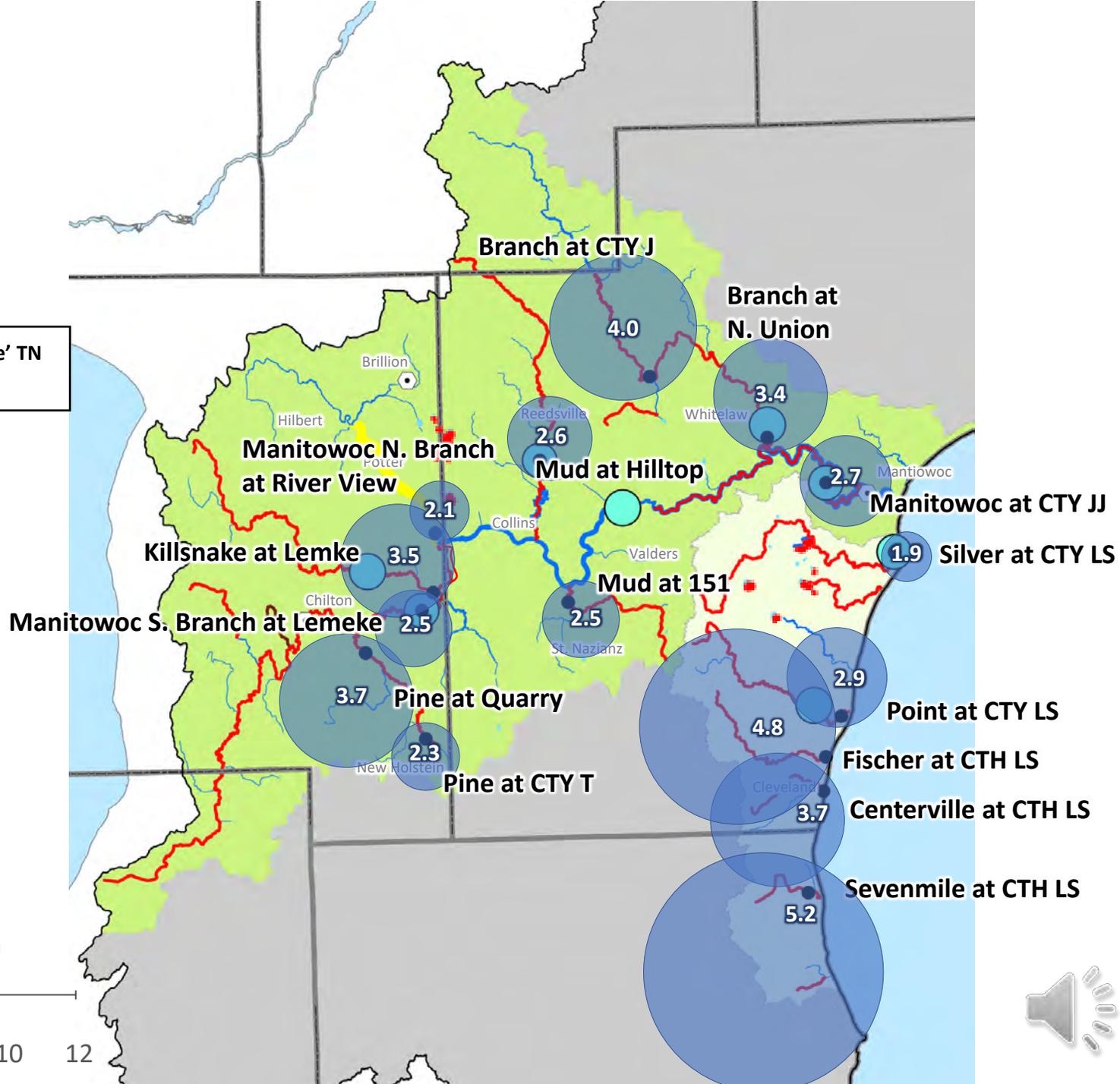
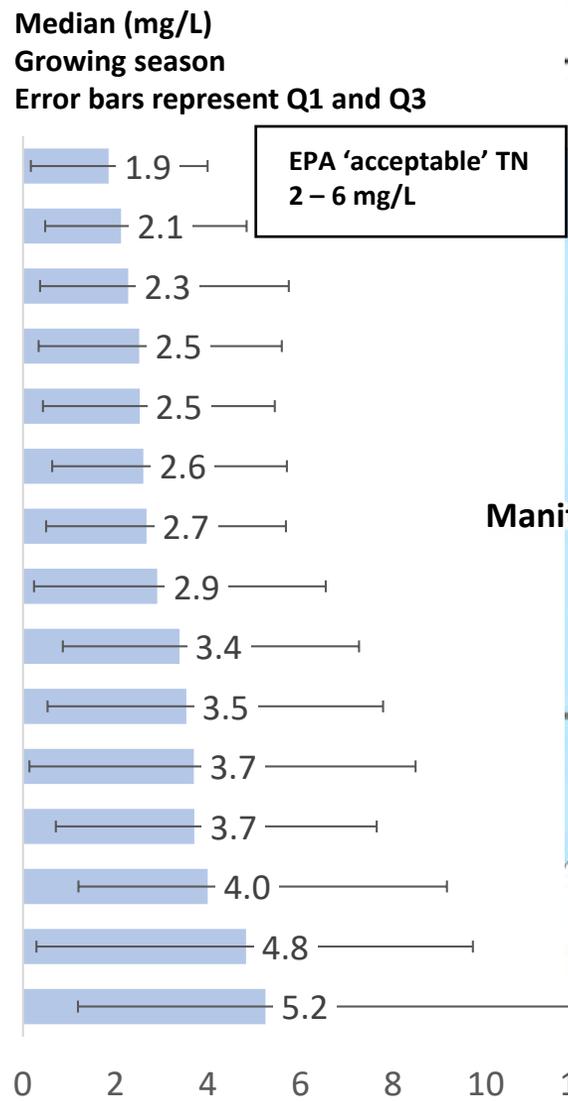




Nitrogen

Growing season median

mg/L



Manitowoc Model Basin Chemistry Summary

Phosphorus

Median concentrations above criteria all locations

Branch River locations showed lowest median concentrations

TSS

Approximately ½ sites above TMDL criteria and half below

Generally, lower concentrations in smaller tributaries and the Branch River

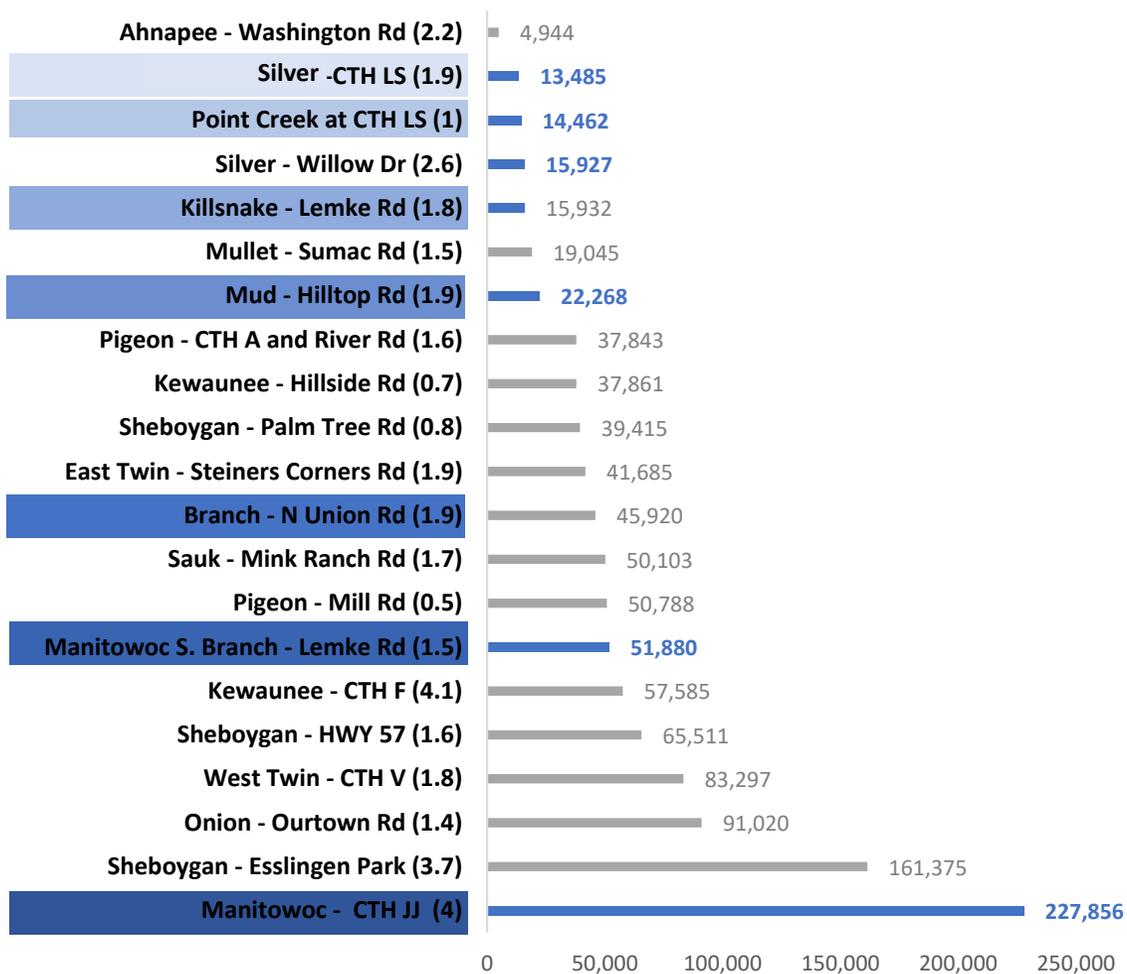
Nitrogen

- Generally, higher concentrations in the smaller tributaries

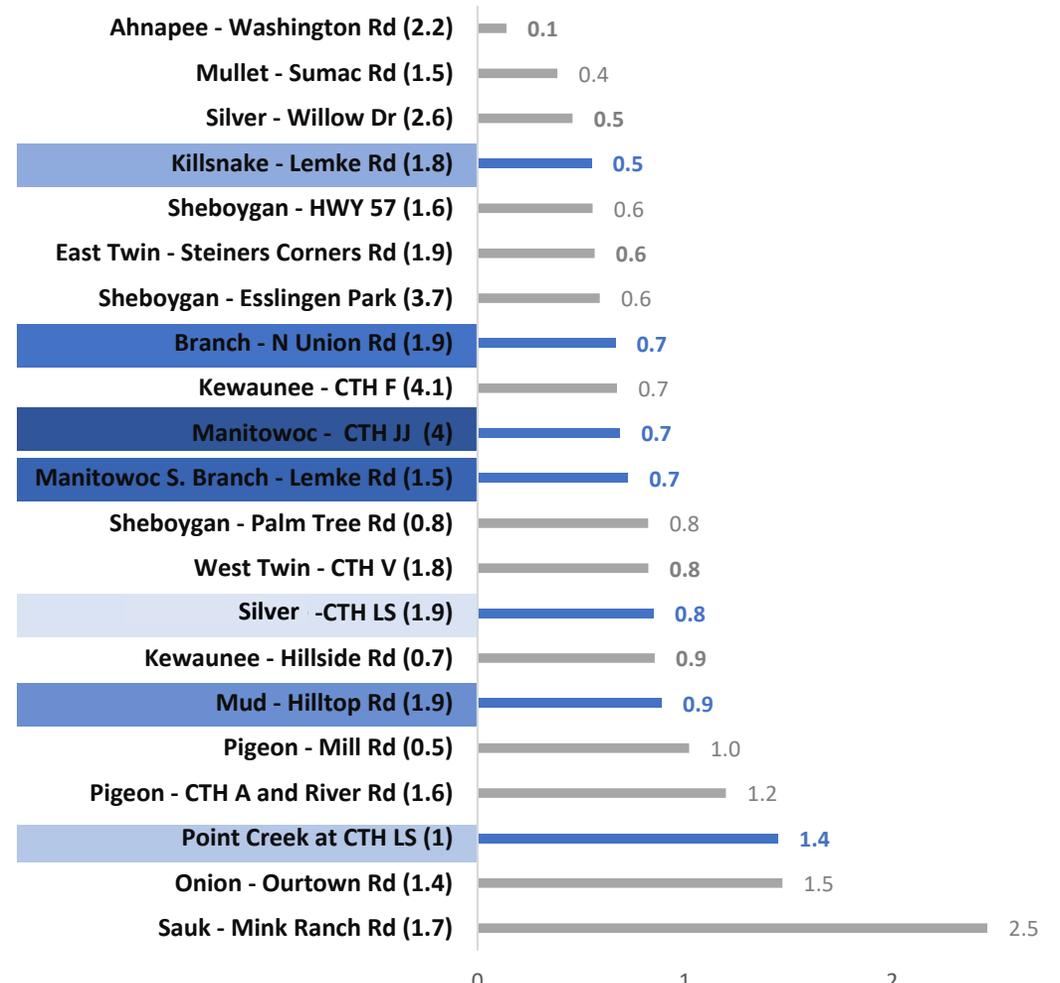


Yearly Total Phosphorus Load

Average yearly TP load (lb)

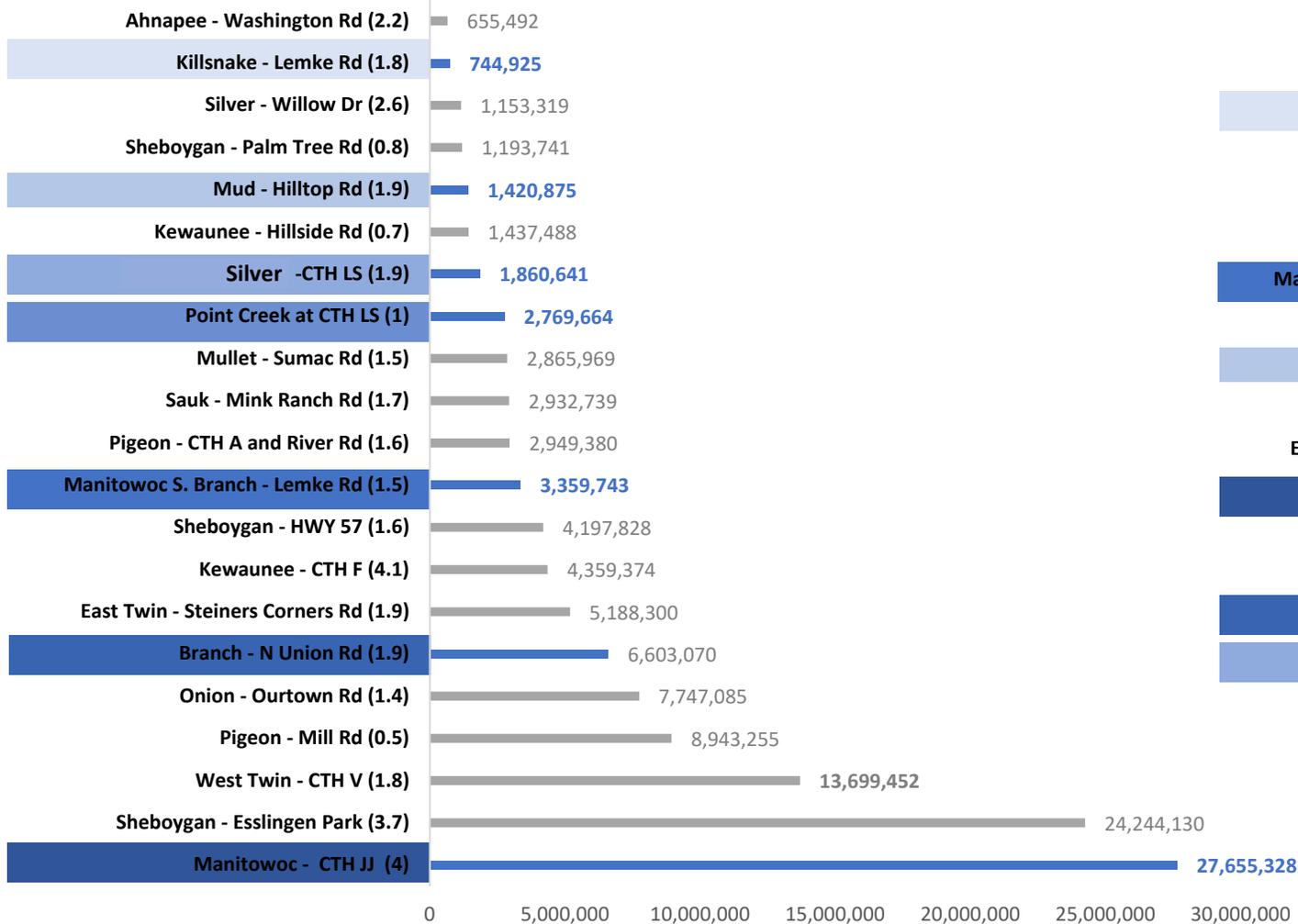


Average yearly TP load (lb) per acre

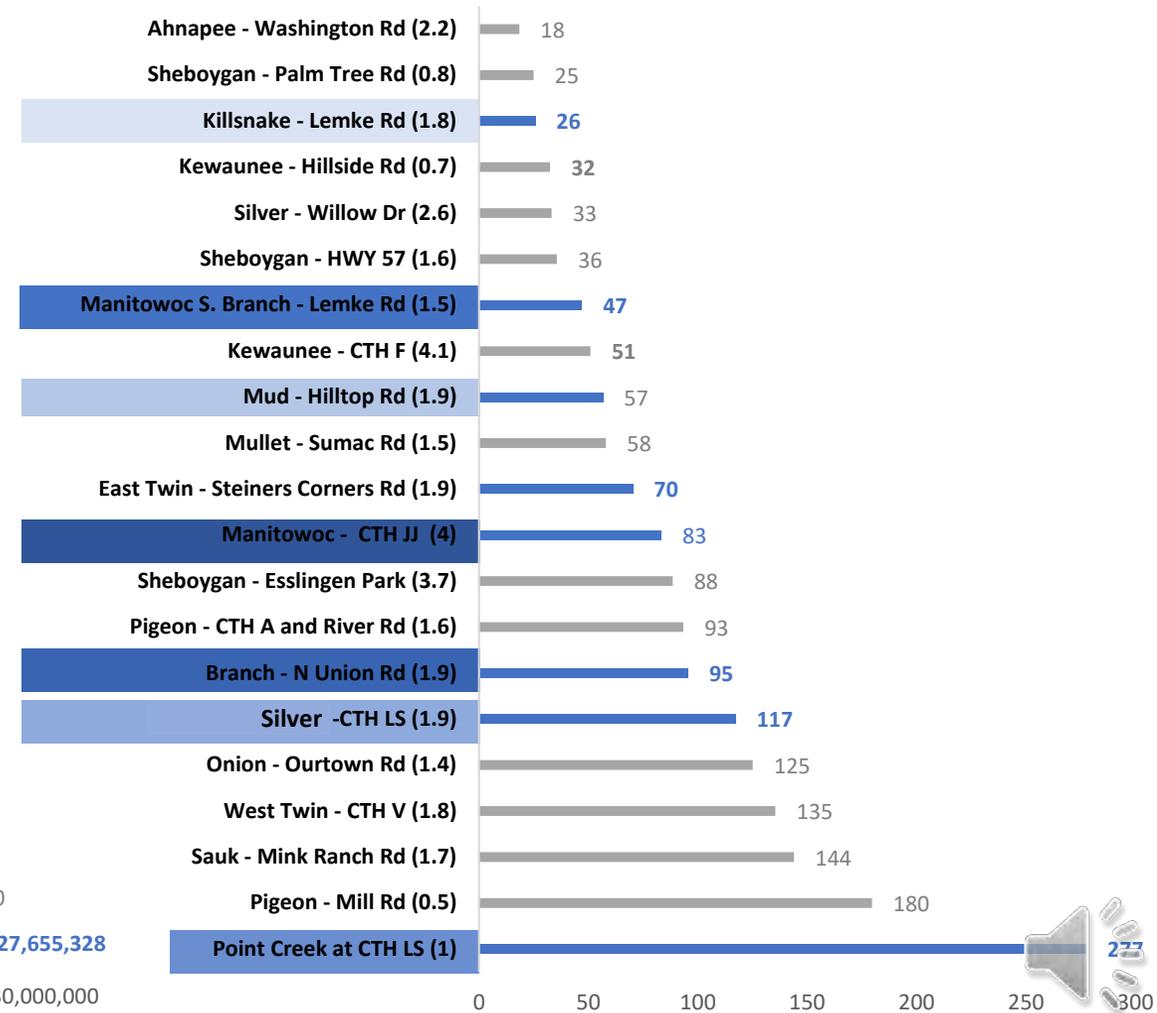


Yearly Total Suspended Solids Load

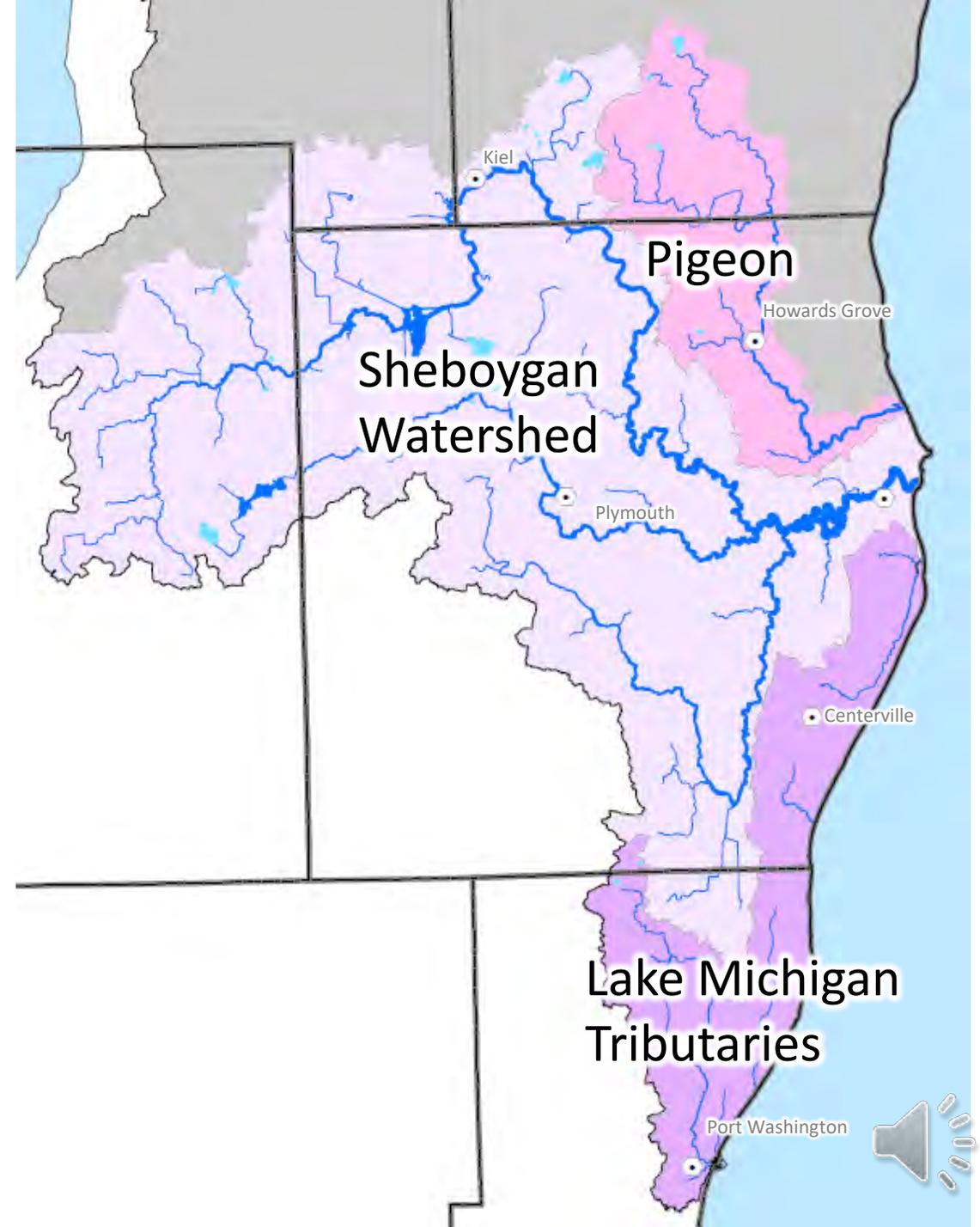
Average yearly TSS load (lb)



Average yearly TSS load (lb) per acre



Sheboygan Model Basin



Sheboygan Model Basin

2020 draft Impaired Waters

- Phosphorus
- Sediment/TSS

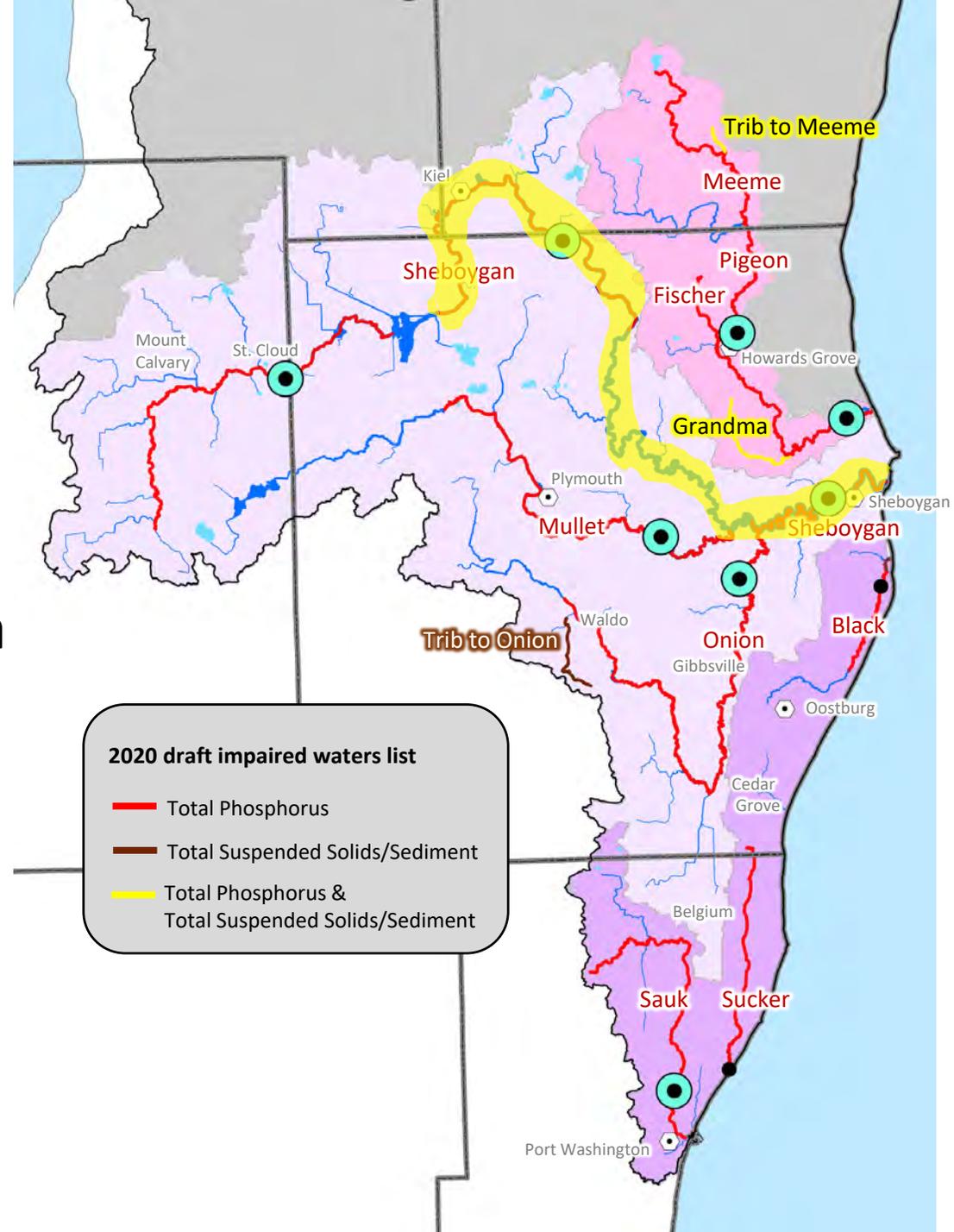
Phosphorus Water Quality Criteria

River Criteria 0.1 mg/L

Sheboygan Marsh to the mouth at Lake Michigan

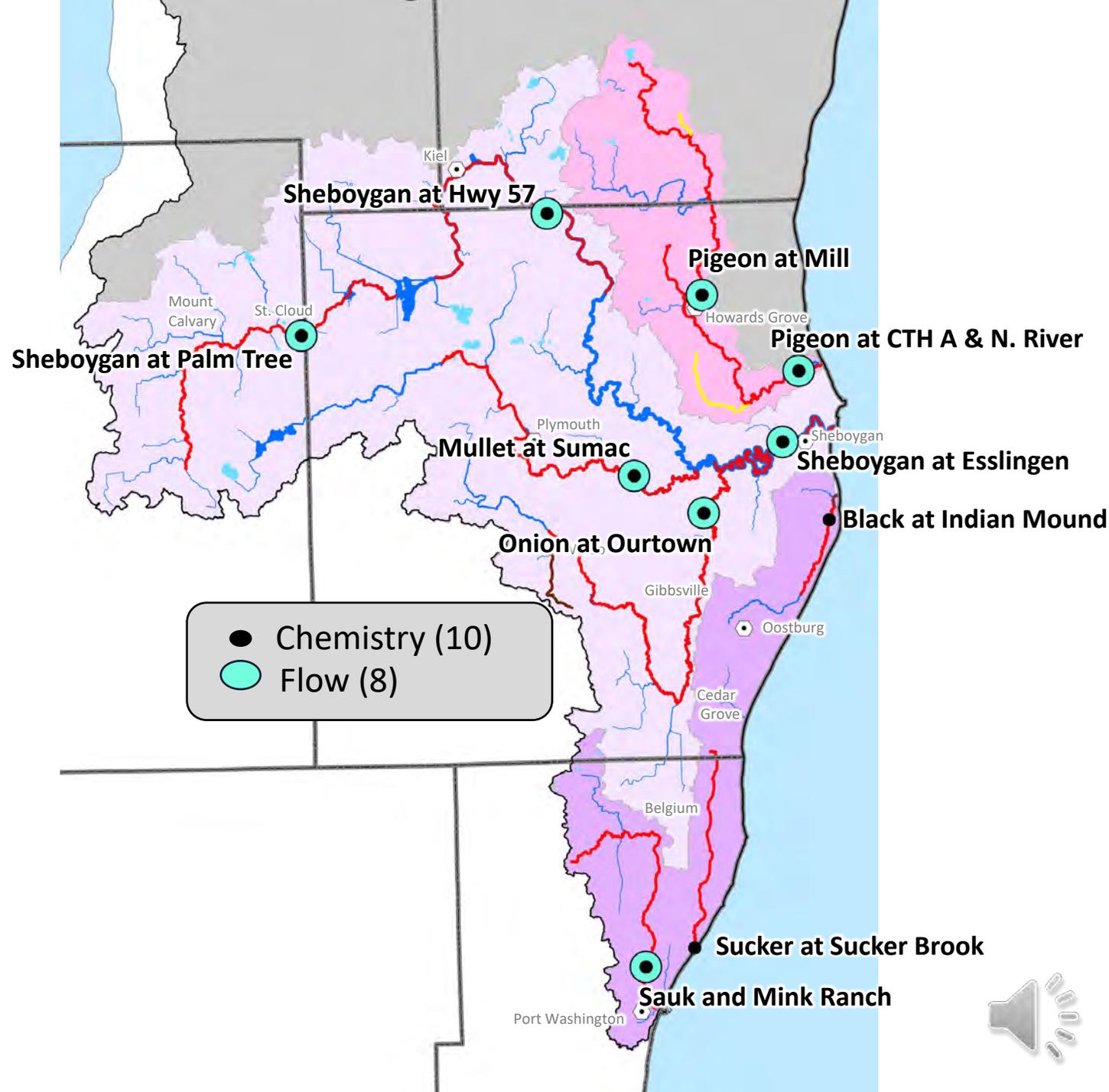
Stream Criteria 0.075 mg/L

All other streams & rivers
Except ephemeral streams and those listed as 'Limited Aquatic Life' in NR 104



Sheboygan Model Basin

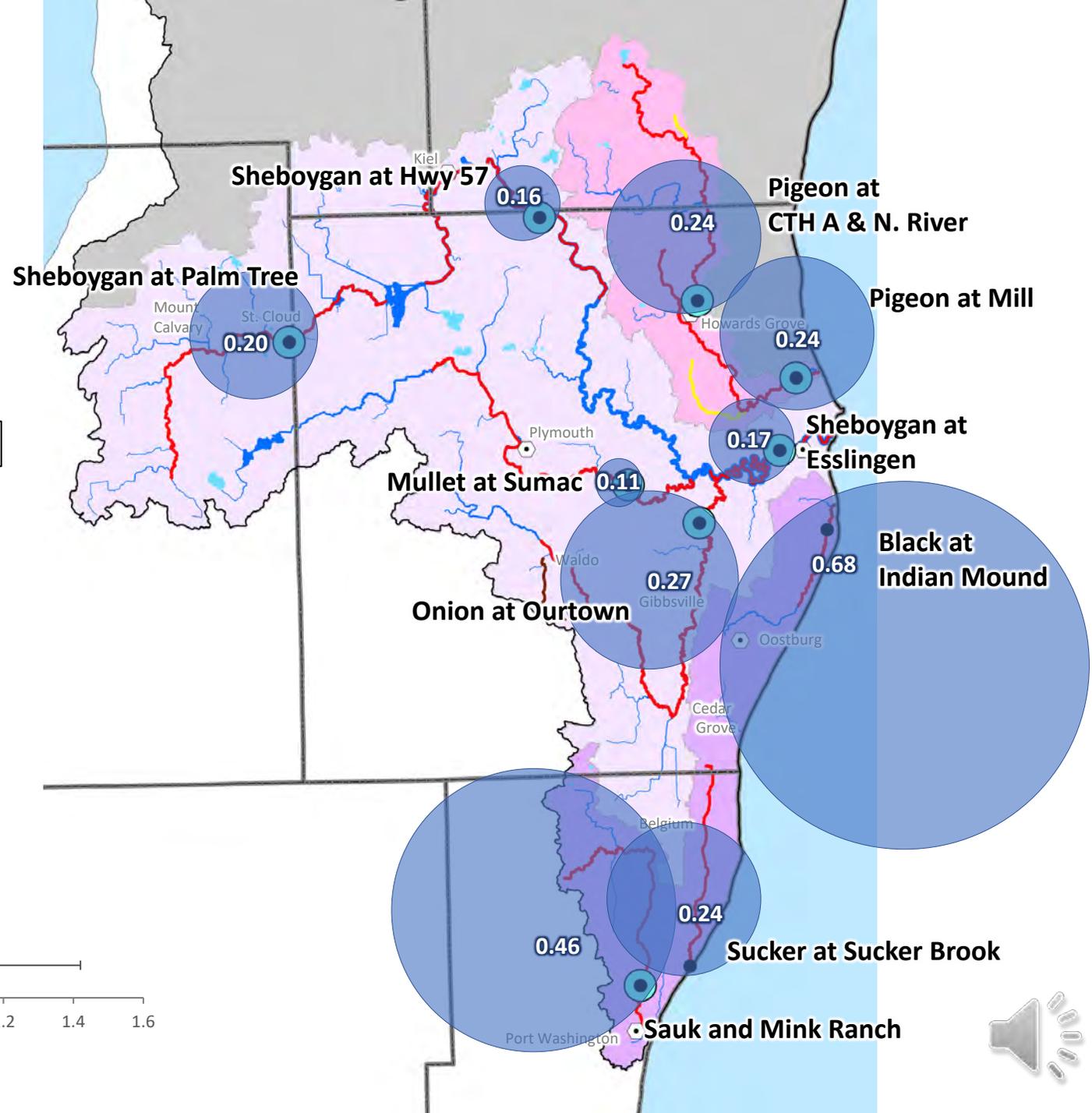
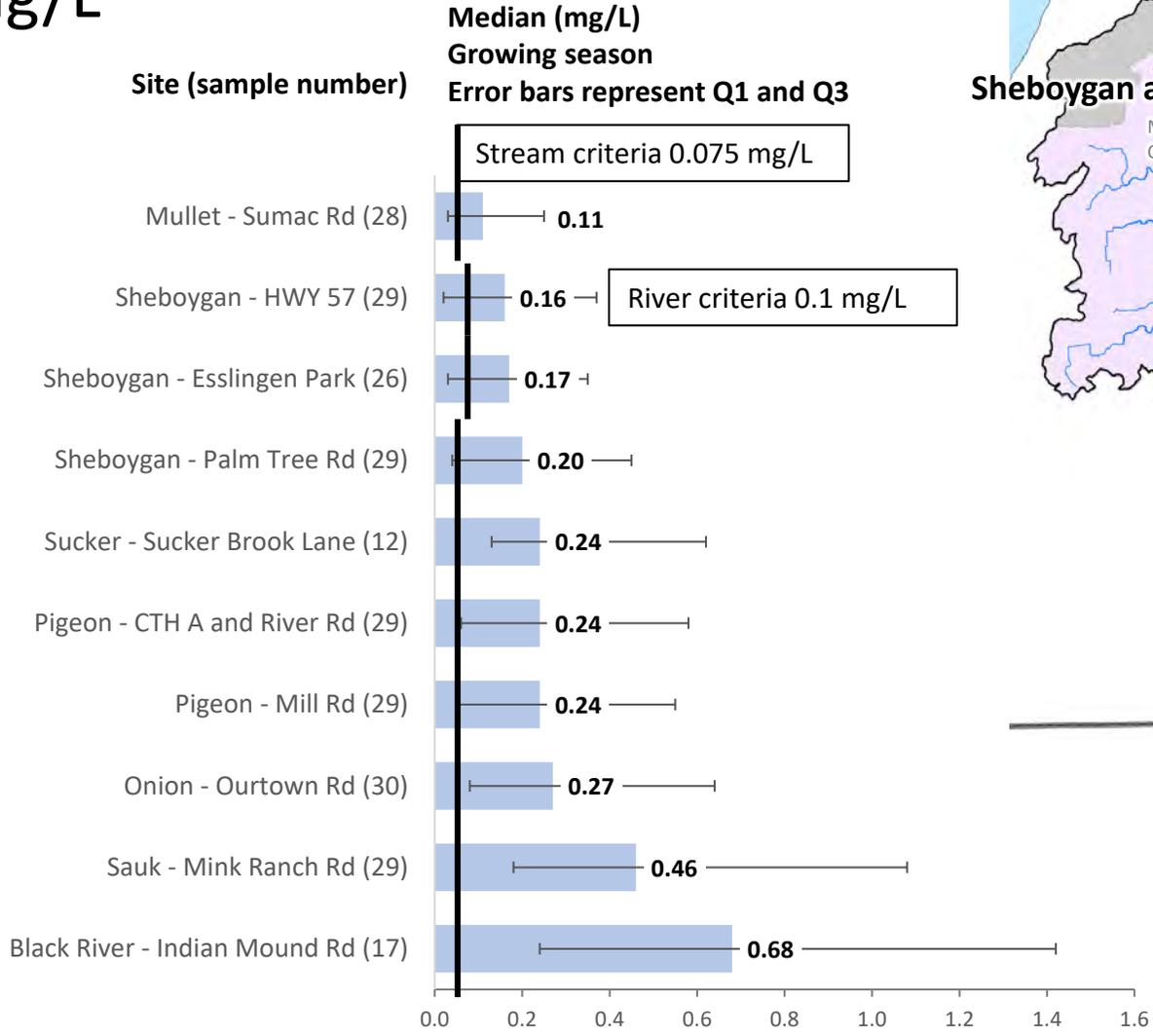
Monitoring Locations





Phosphorus

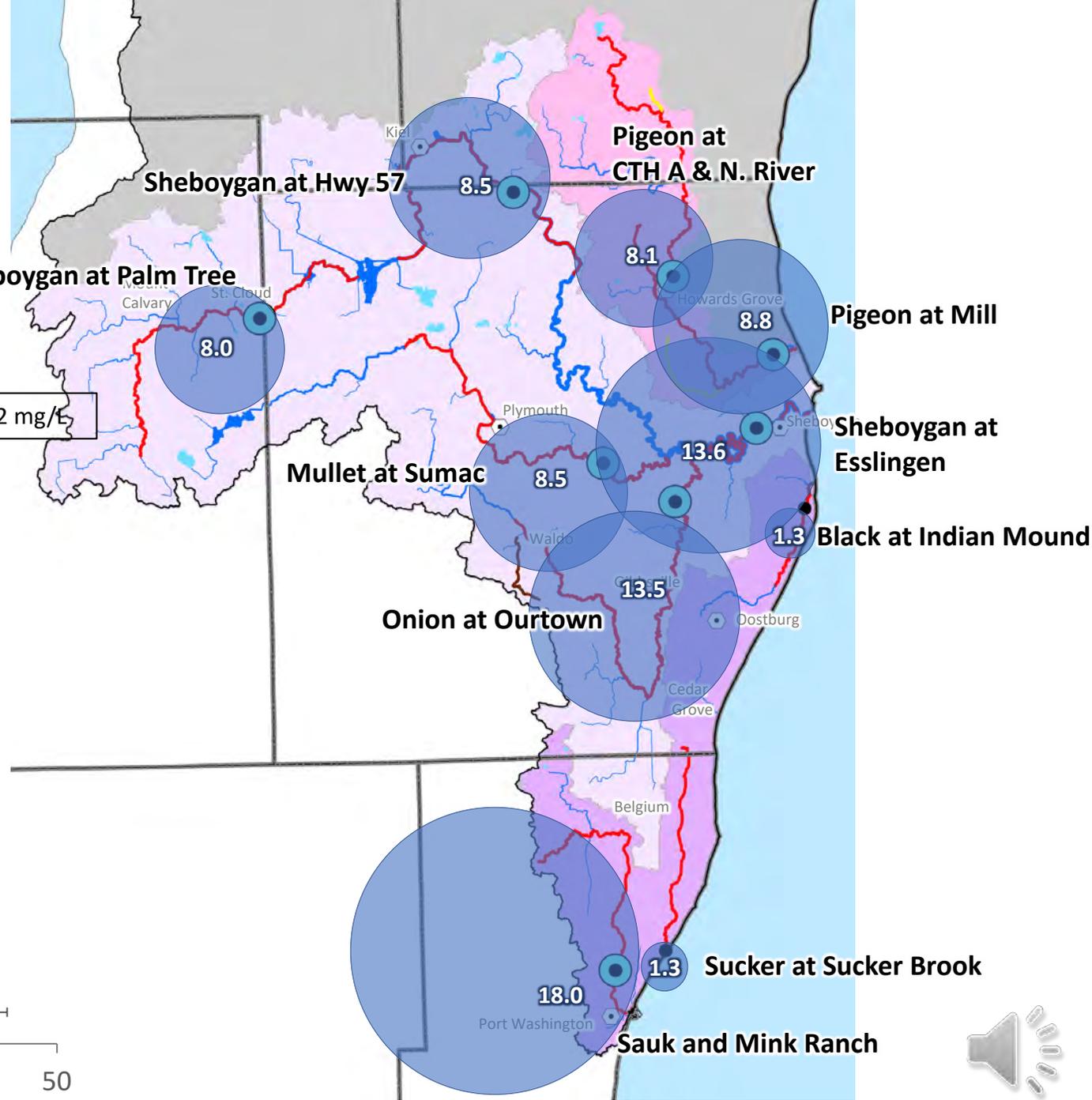
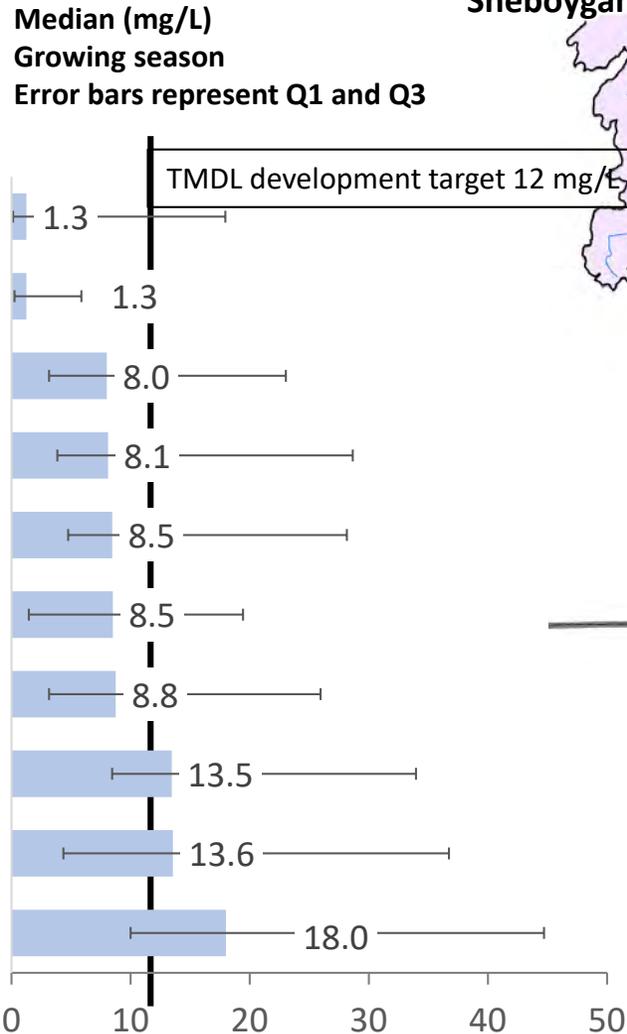
Growing season median mg/L





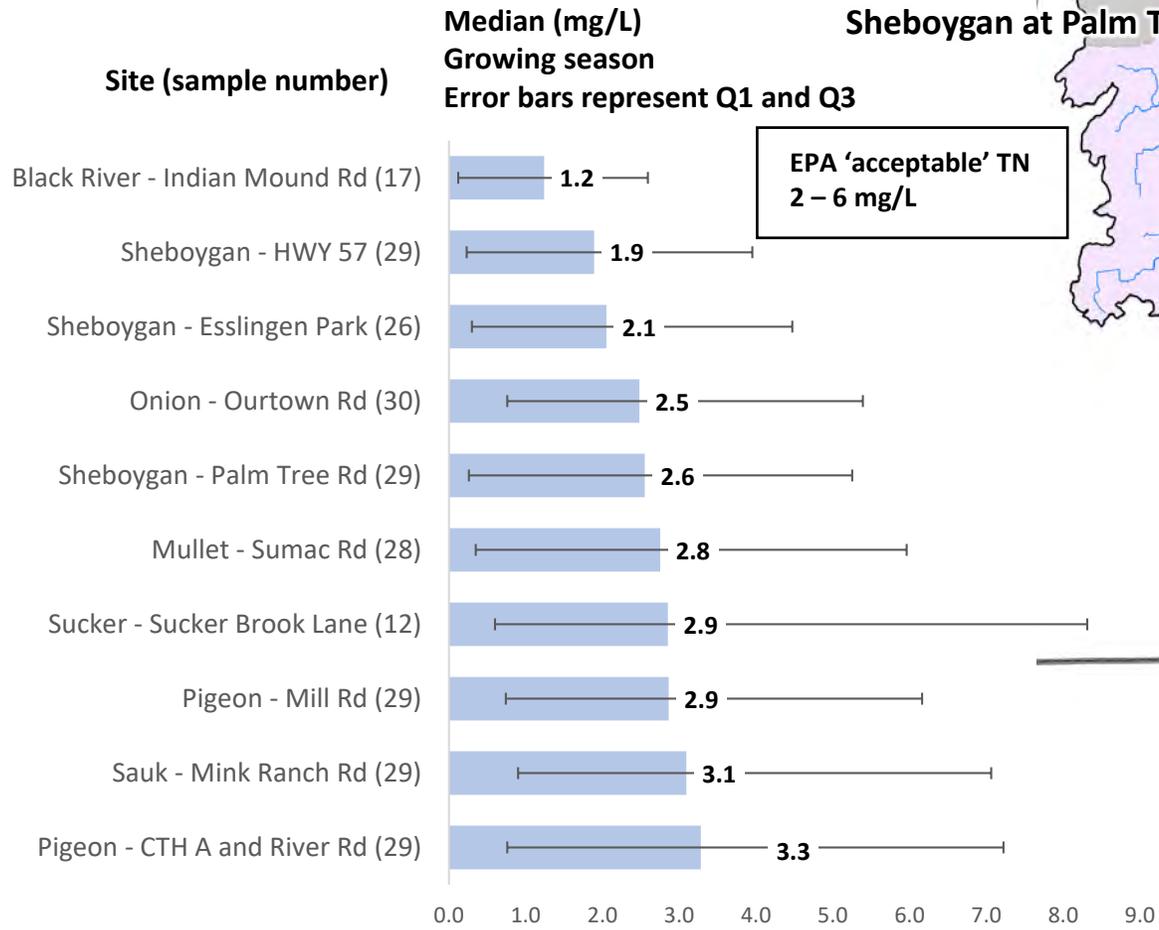
TSS

Growing season median mg/L

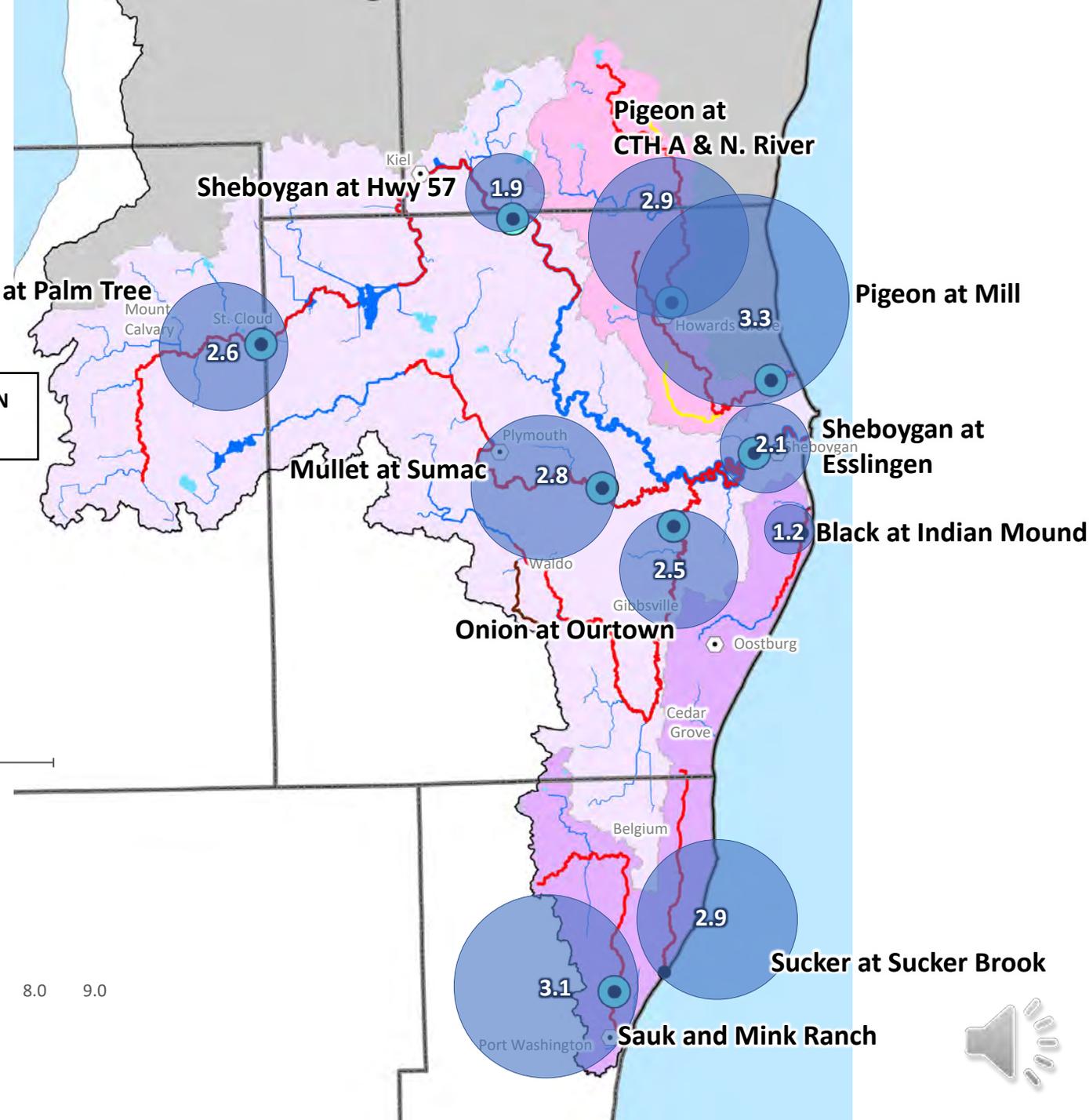


Nitrogen

Growing season median mg/L



EPA 'acceptable' TN
2 – 6 mg/L



Sheboygan Model Basin Chemistry Summary

Phosphorus

All locations had median concentration above the criteria

Lowest concentrations in the Sheboygan and Mullet, highest in Lk. MI Tribs

TSS

A majority of locations had a TSS concentration below the TMDL development target.

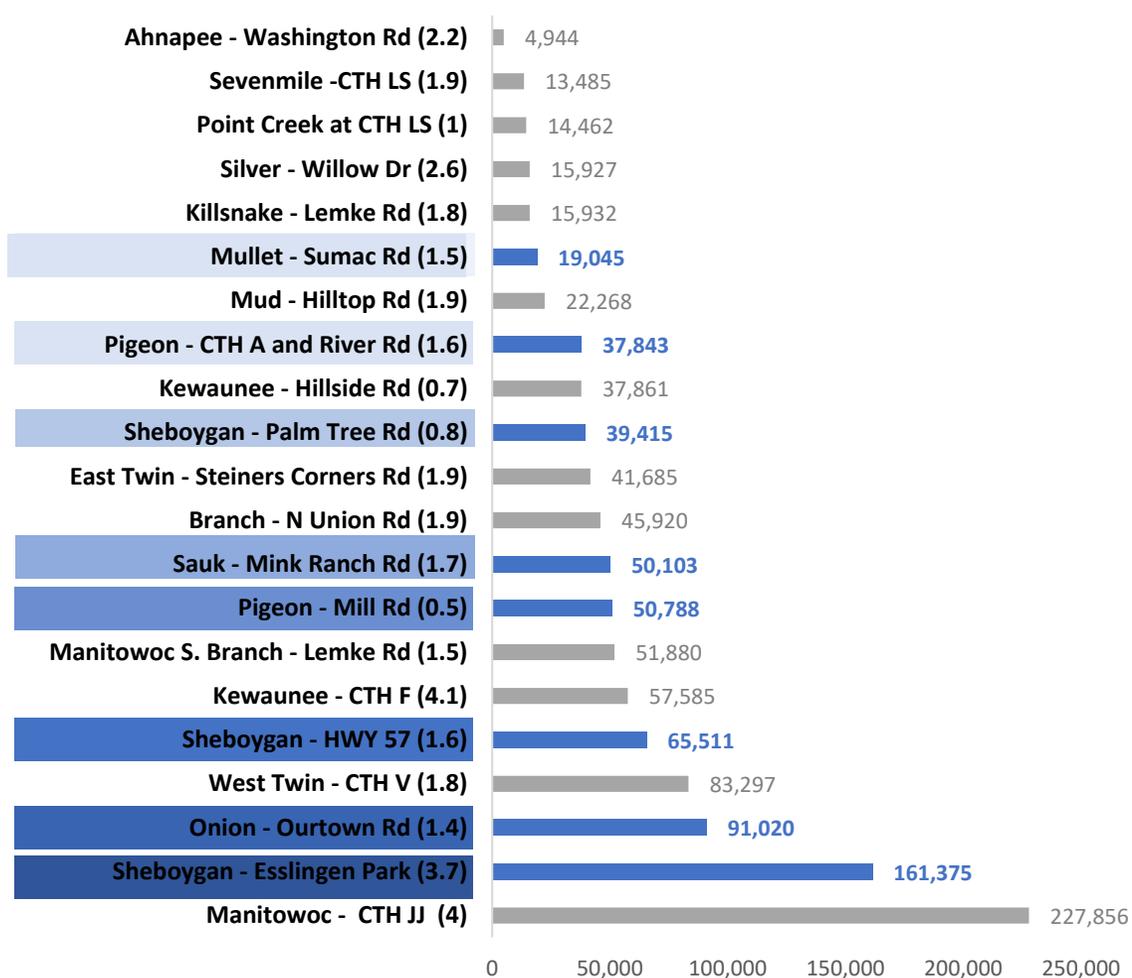
Nitrogen

Concentrations fairly consistent across all locations (1 – 3 mg/L)

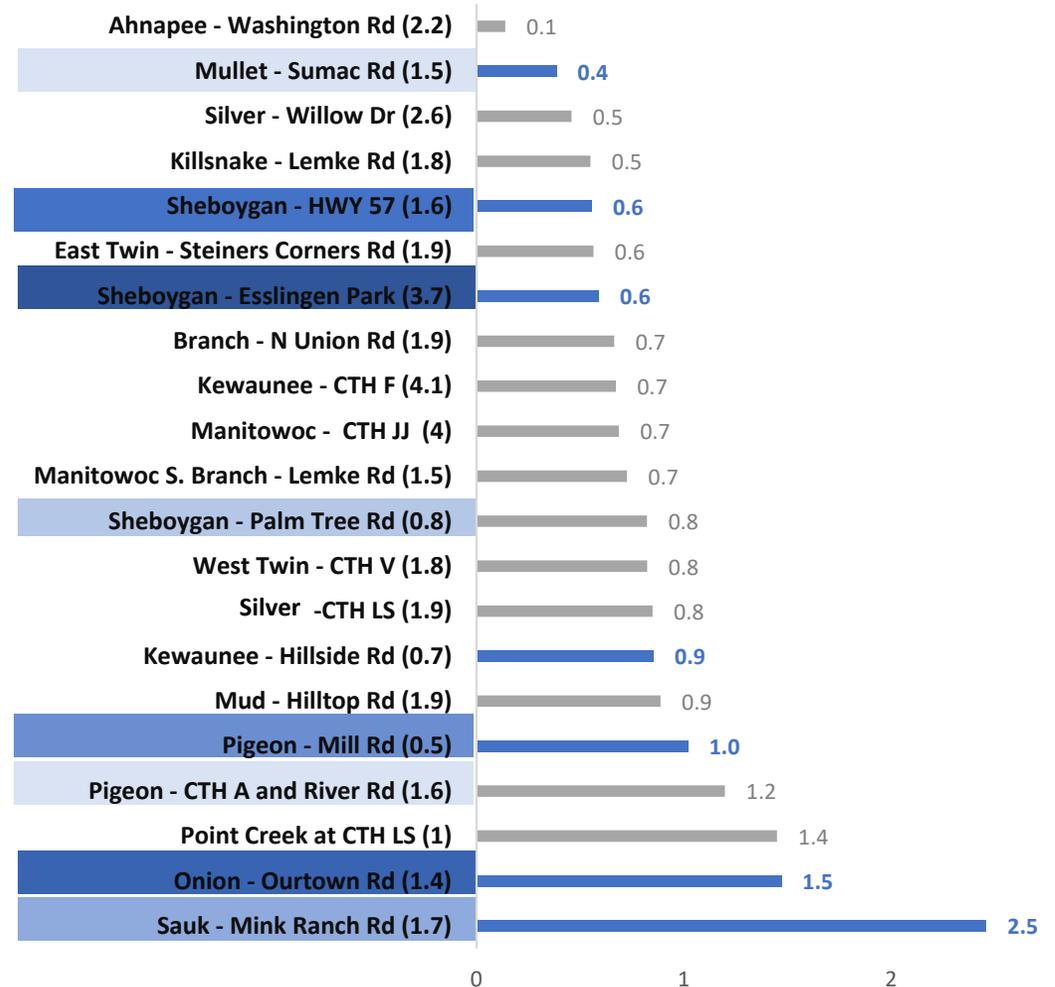


Yearly Total Phosphorus Load

Average yearly TP load (lb)

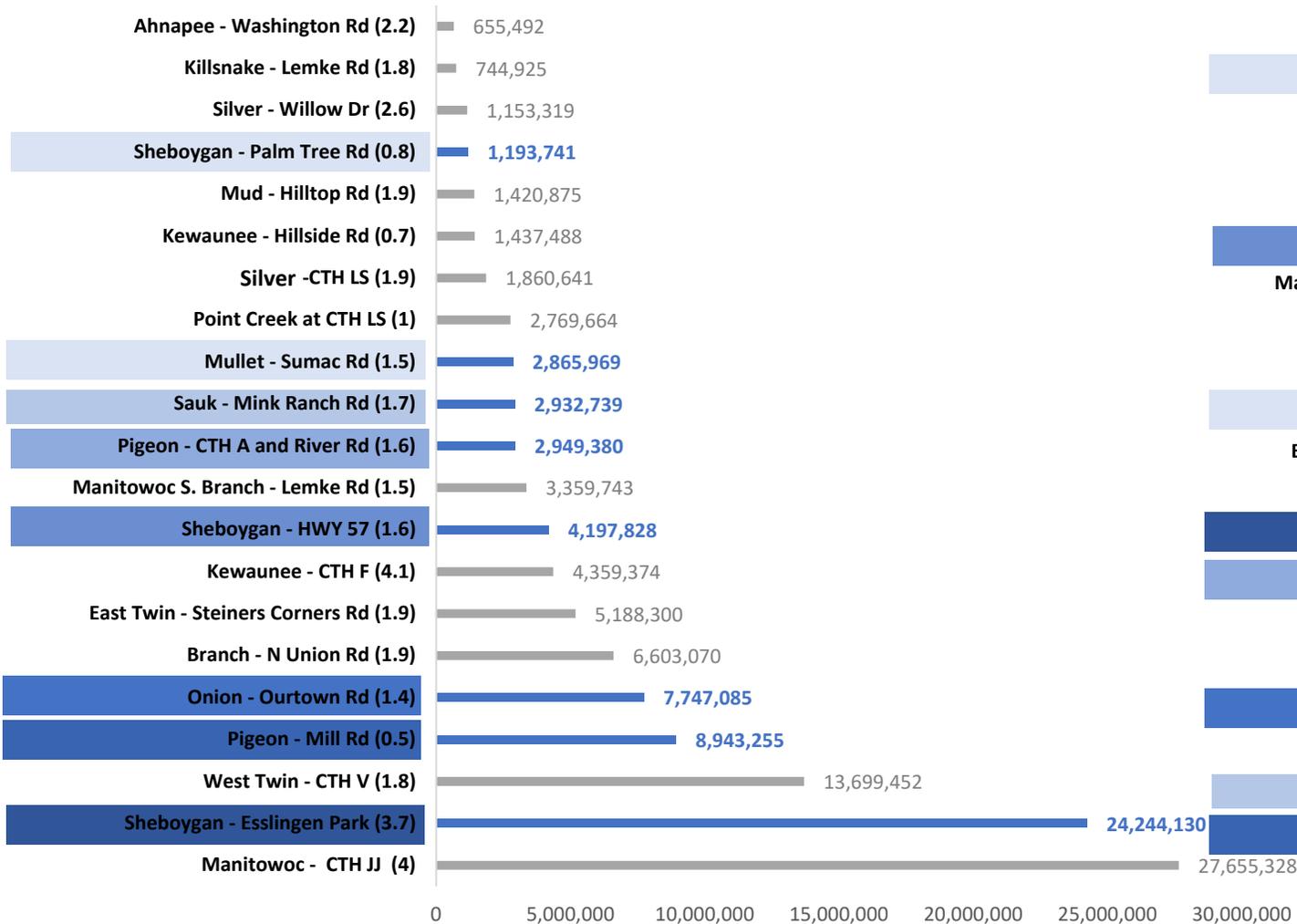


Average yearly TP load (lb) per acre

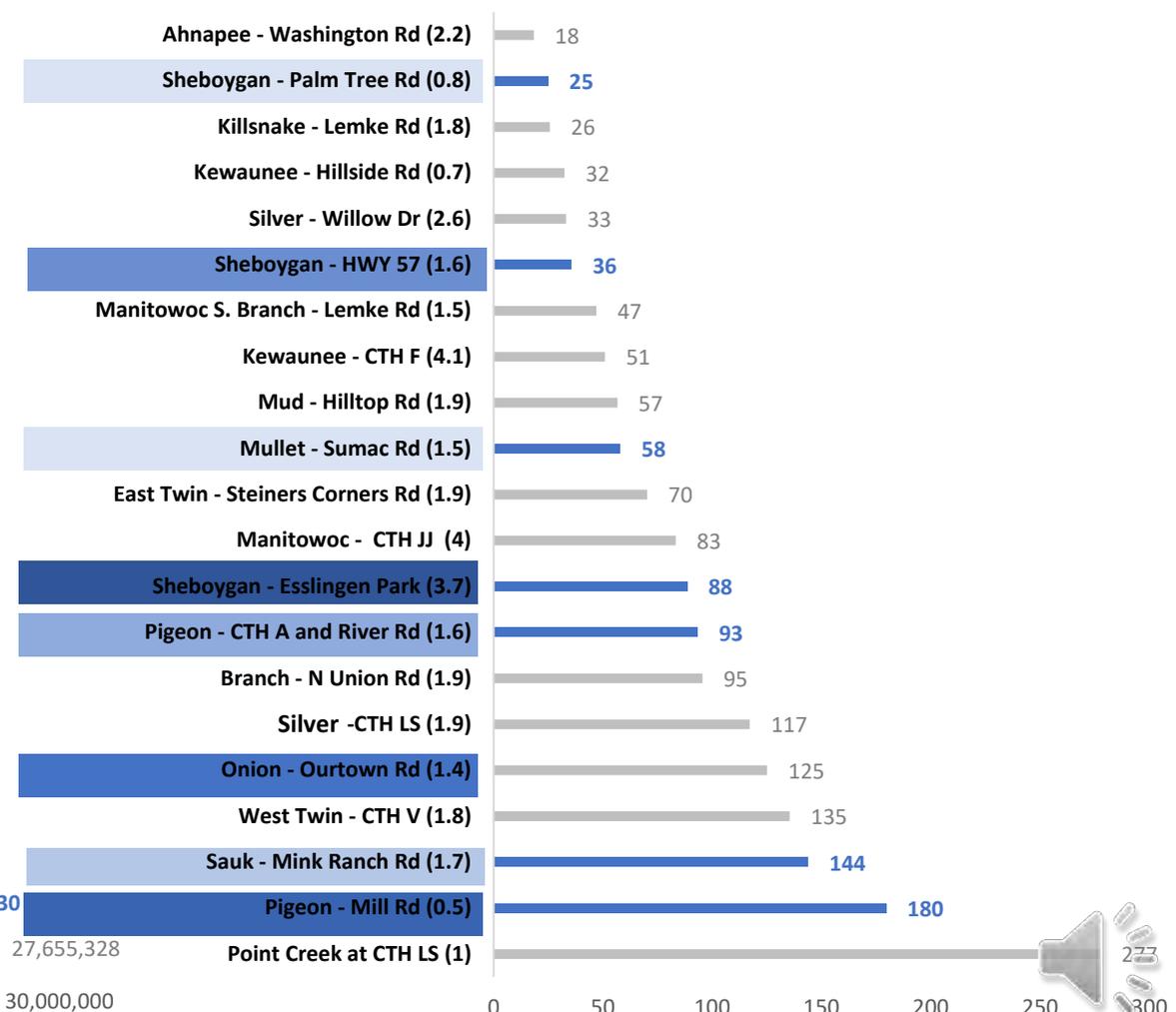


Yearly Total Suspended Solids Load

Average yearly TSS load (lb)



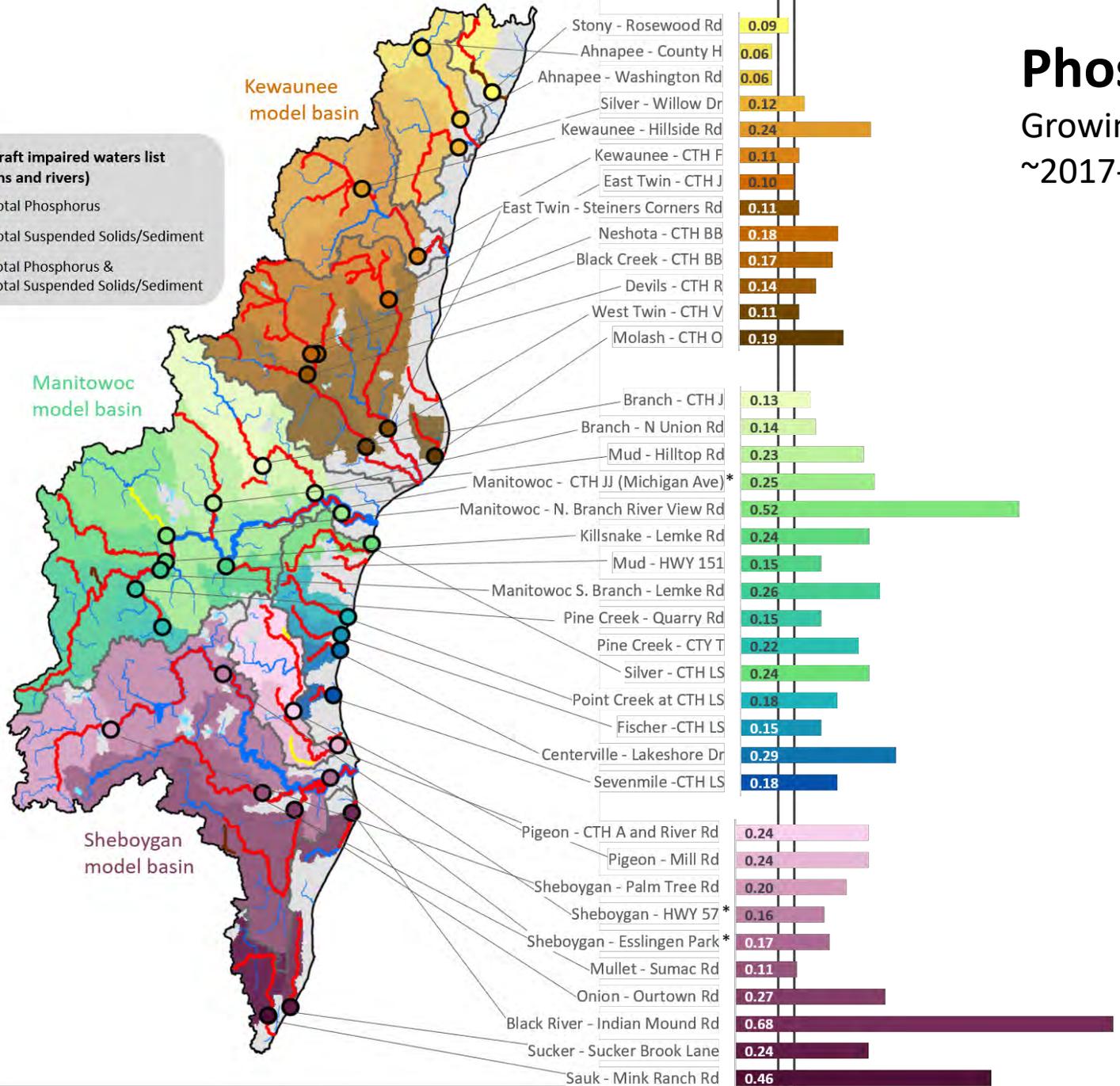
Average yearly TSS load (lb) per acre





2020 draft impaired waters list (streams and rivers)

- Total Phosphorus
- Total Suspended Solids/Sediment
- Total Phosphorus & Total Suspended Solids/Sediment



Phosphorus mg/L

Growing Season Medians ~2017-2019

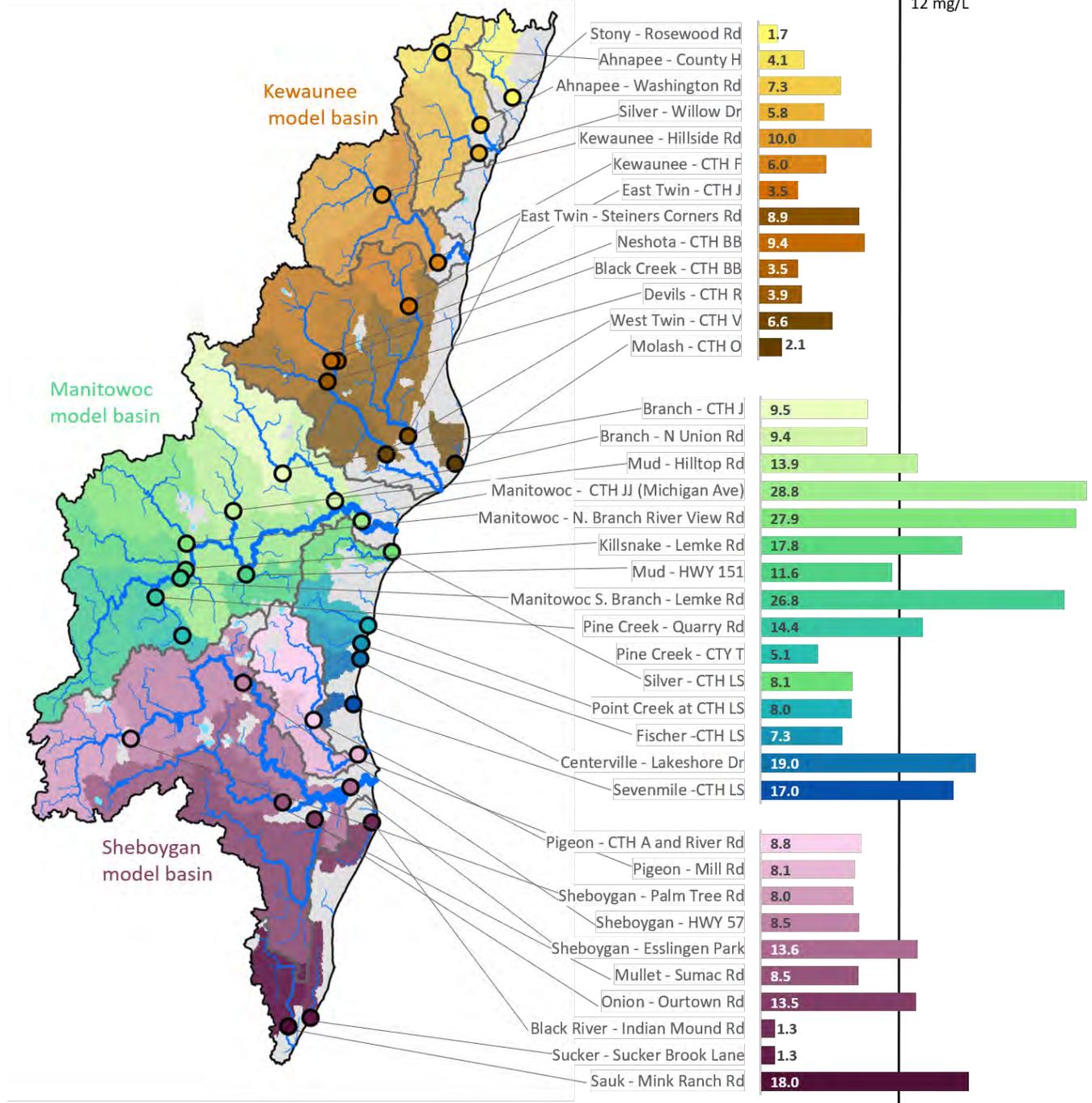




TMDL development criteria
12 mg/L

TSS mg/L

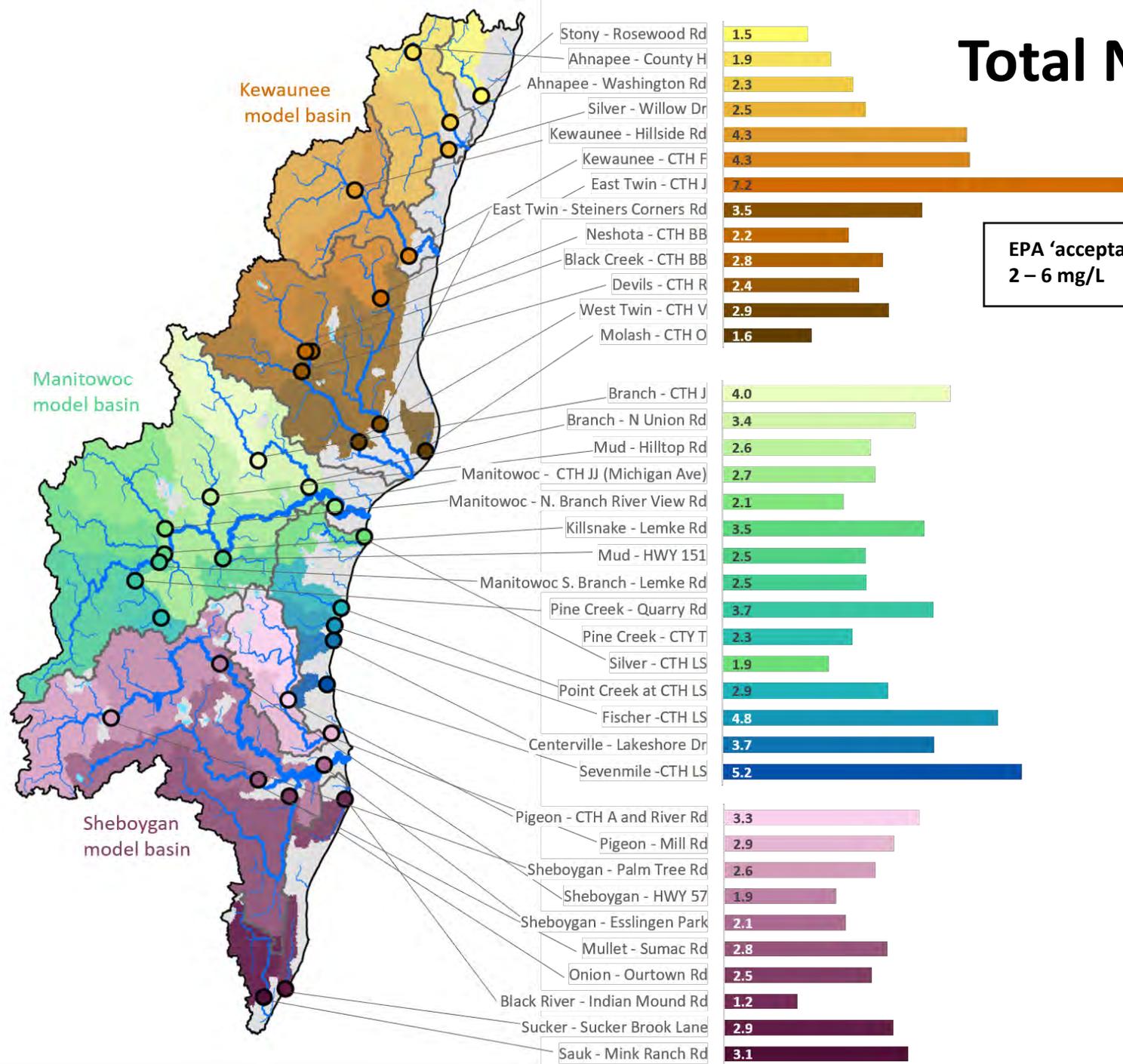
Growing Season Medians ~2017-2019



Total Nitrogen mg/L

Growing Season Medians
~2017-2019

EPA 'acceptable' TN
2 – 6 mg/L



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