

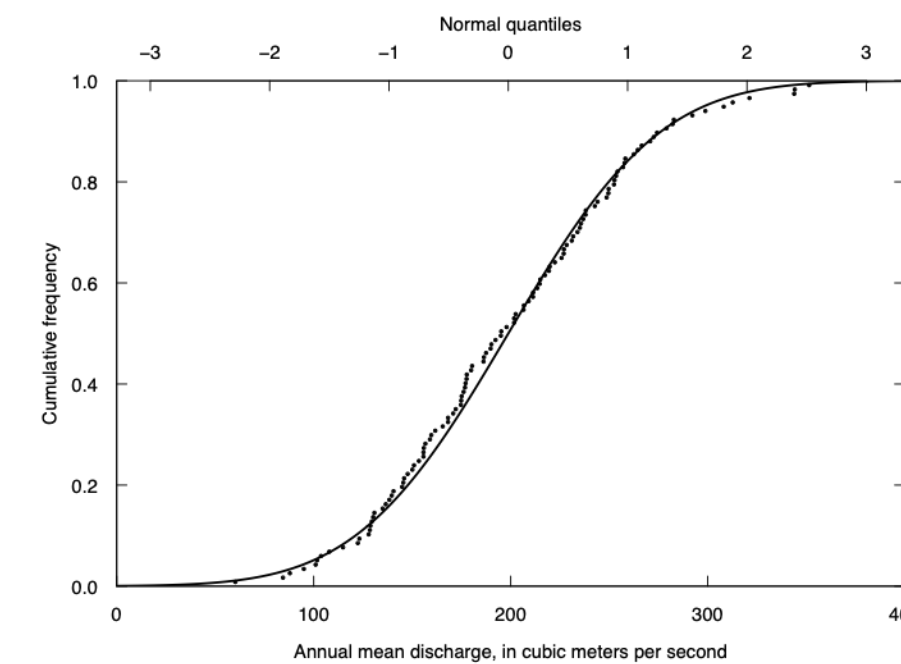
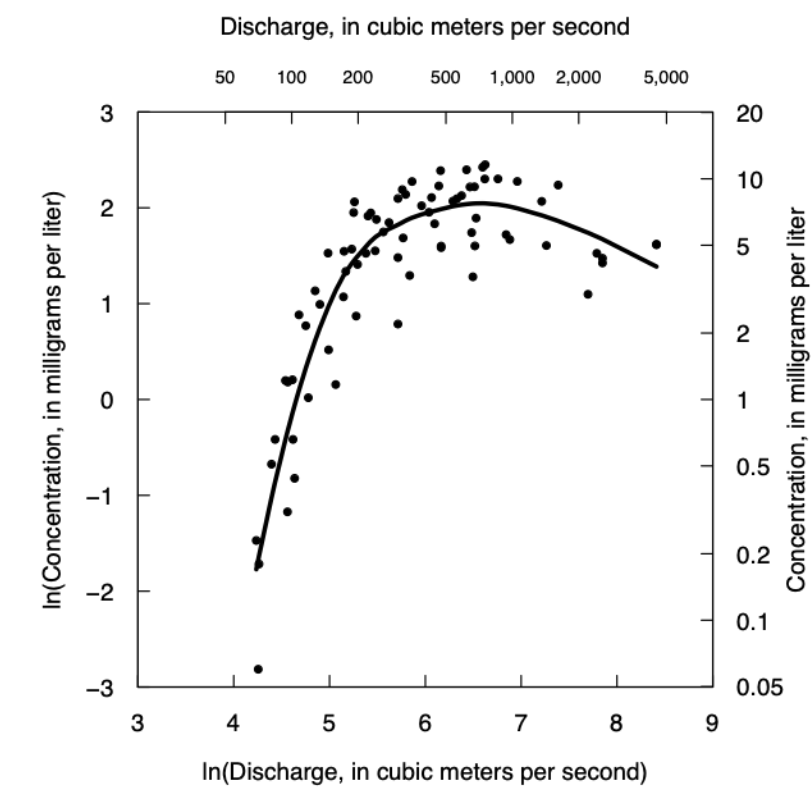
# Quittapahilla Creek nr Bellegrove, P A

## Nutrient & Sediment trends

W.L. Osburn: 2025-08-17

# Statistical Methods in Water Resources

Chapter 3 of  
Section A, Statistical Analysis  
**Book 4, Hydrologic Analysis and Interpretation**



Techniques and Methods 4–A3  
Supersedes USGS Techniques of Water-Resources Investigations, book 4,  
chapter A3

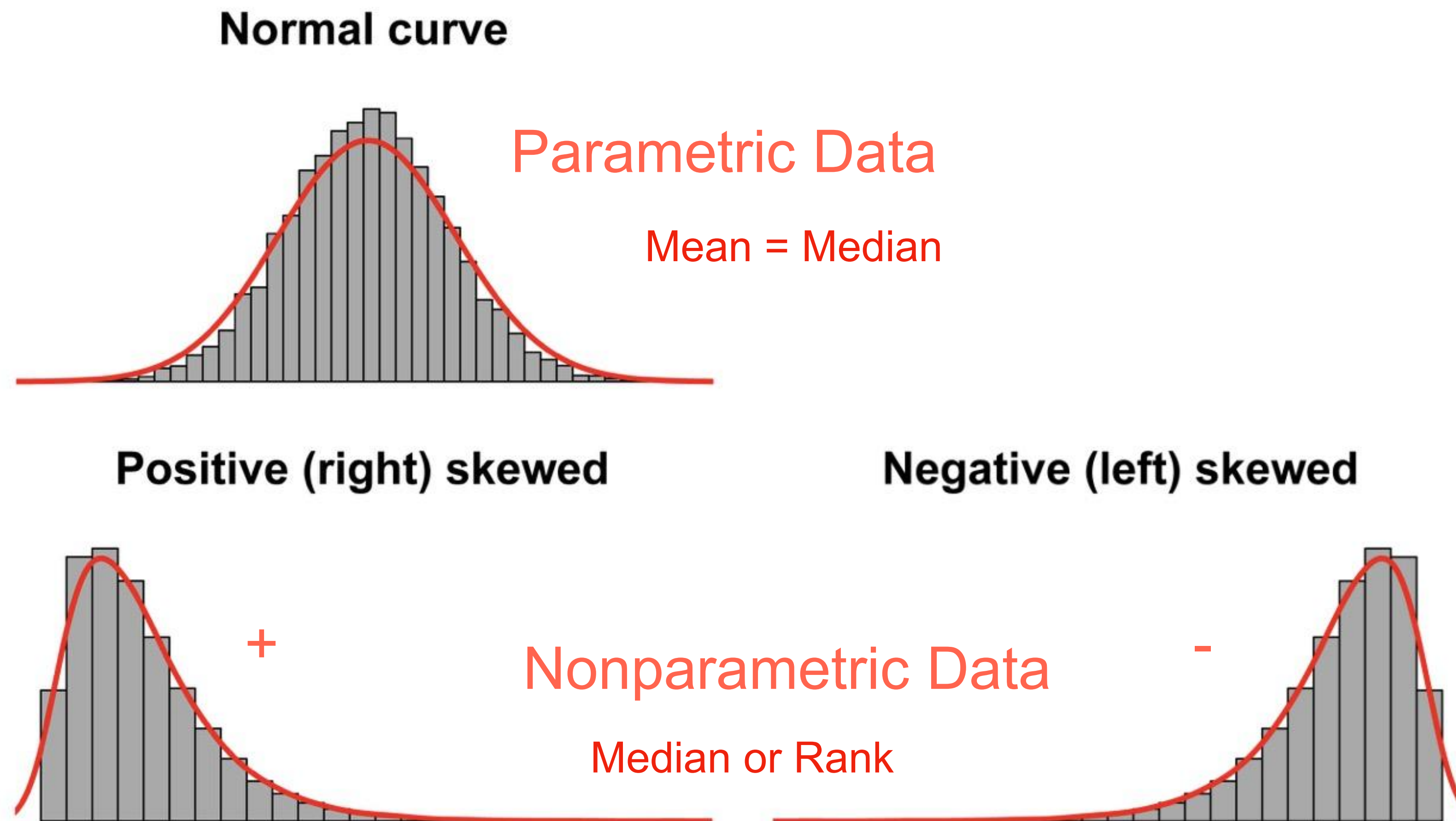
# Analyte Selection

## Trend Analysis Requires Long Terms

- Tried to select the following
- Greater Than 10 yrs sampling (USGS likes 30-40 Yrs +)
- More than 10 samples per year (really wanted 12 +)
- Low missing Months & Quarters (really wanted less than 5%)
- Concentrated on analytes of concern
  - Nutrients & Sediments ~ Total Nitrogen & Phosphorus
  - Conewago Sediments are missing 50% of months over the 2011-2023 period

# Statistical Tests

- Parametric vs Nonparametric

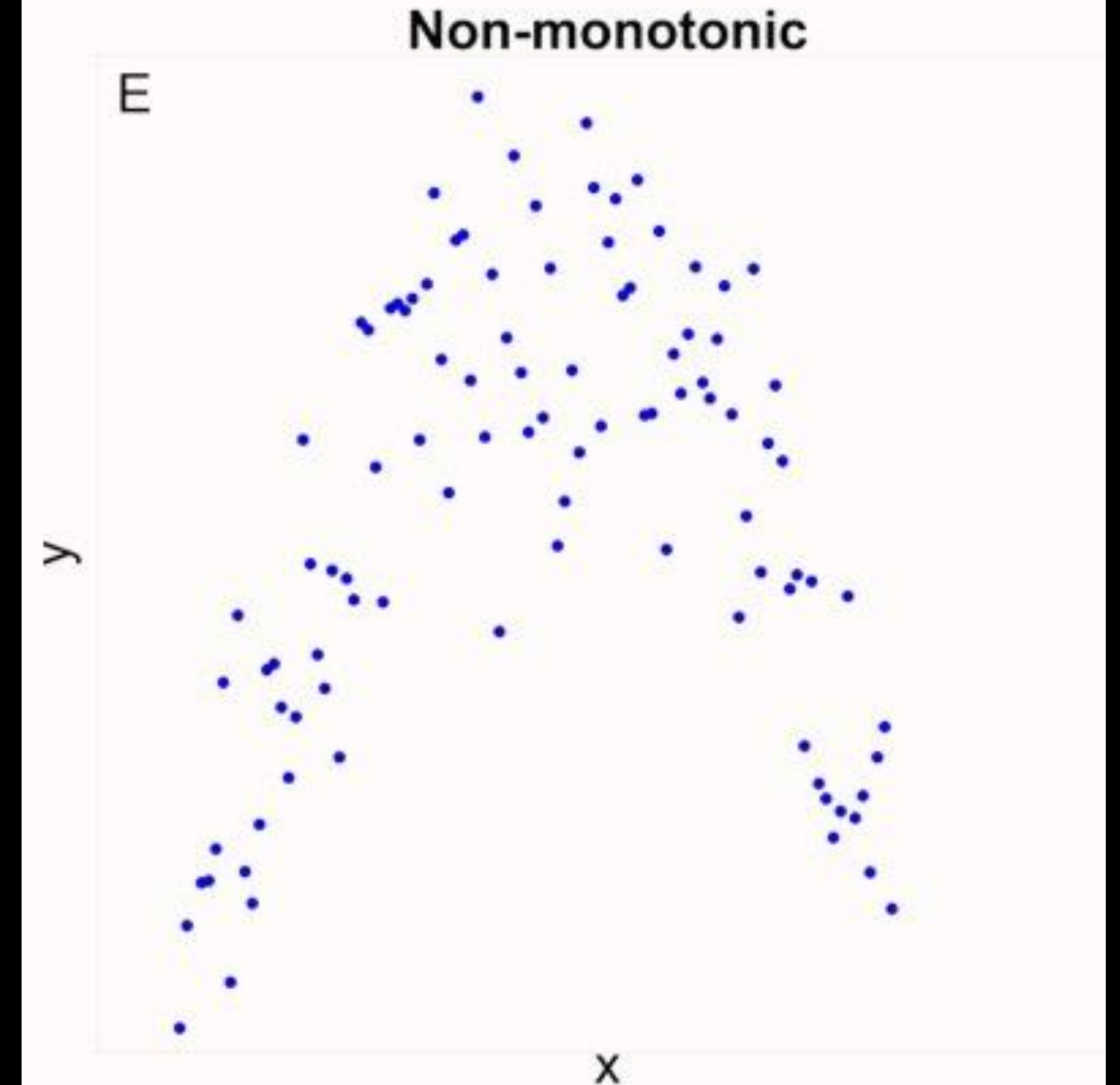
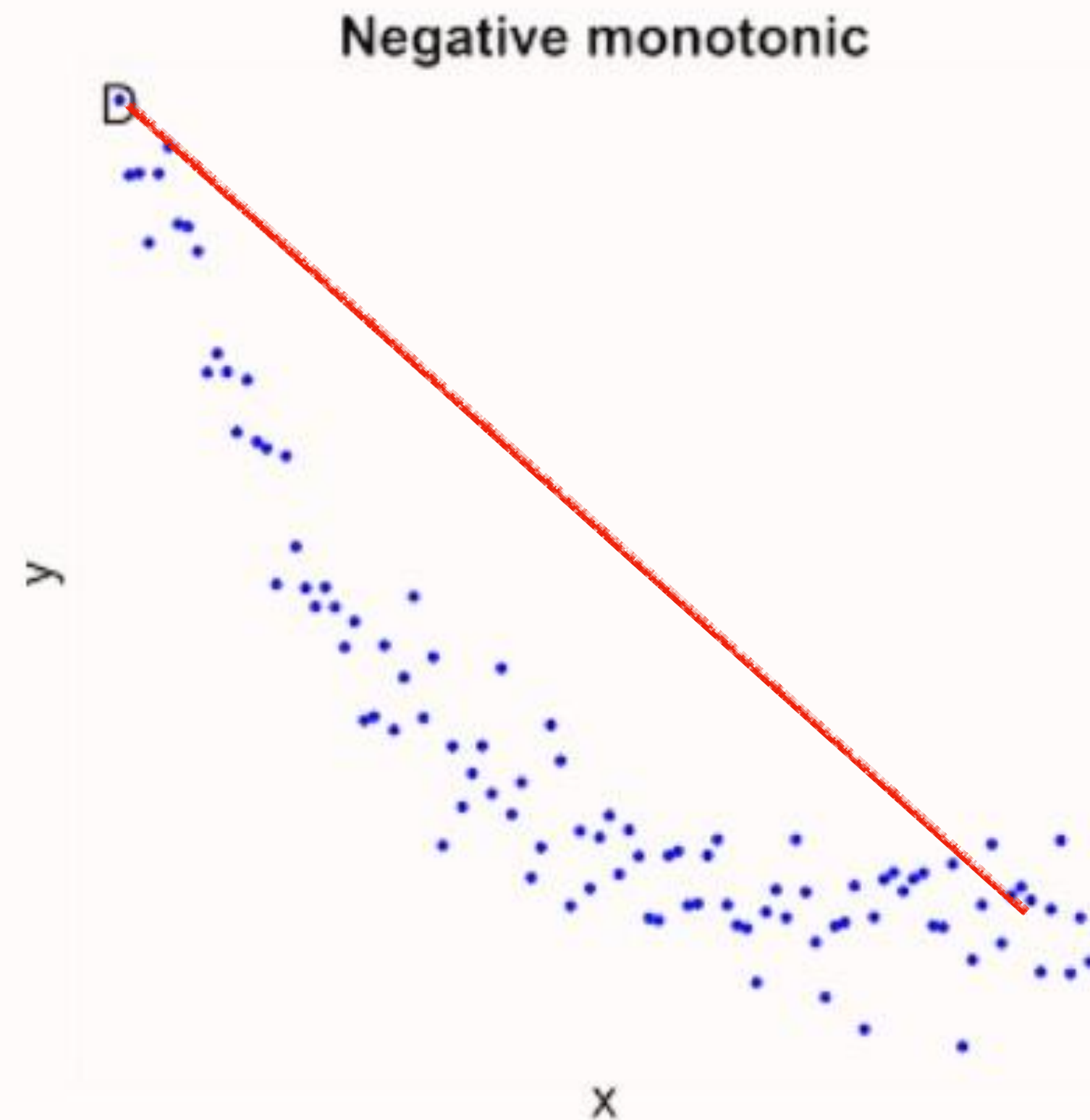
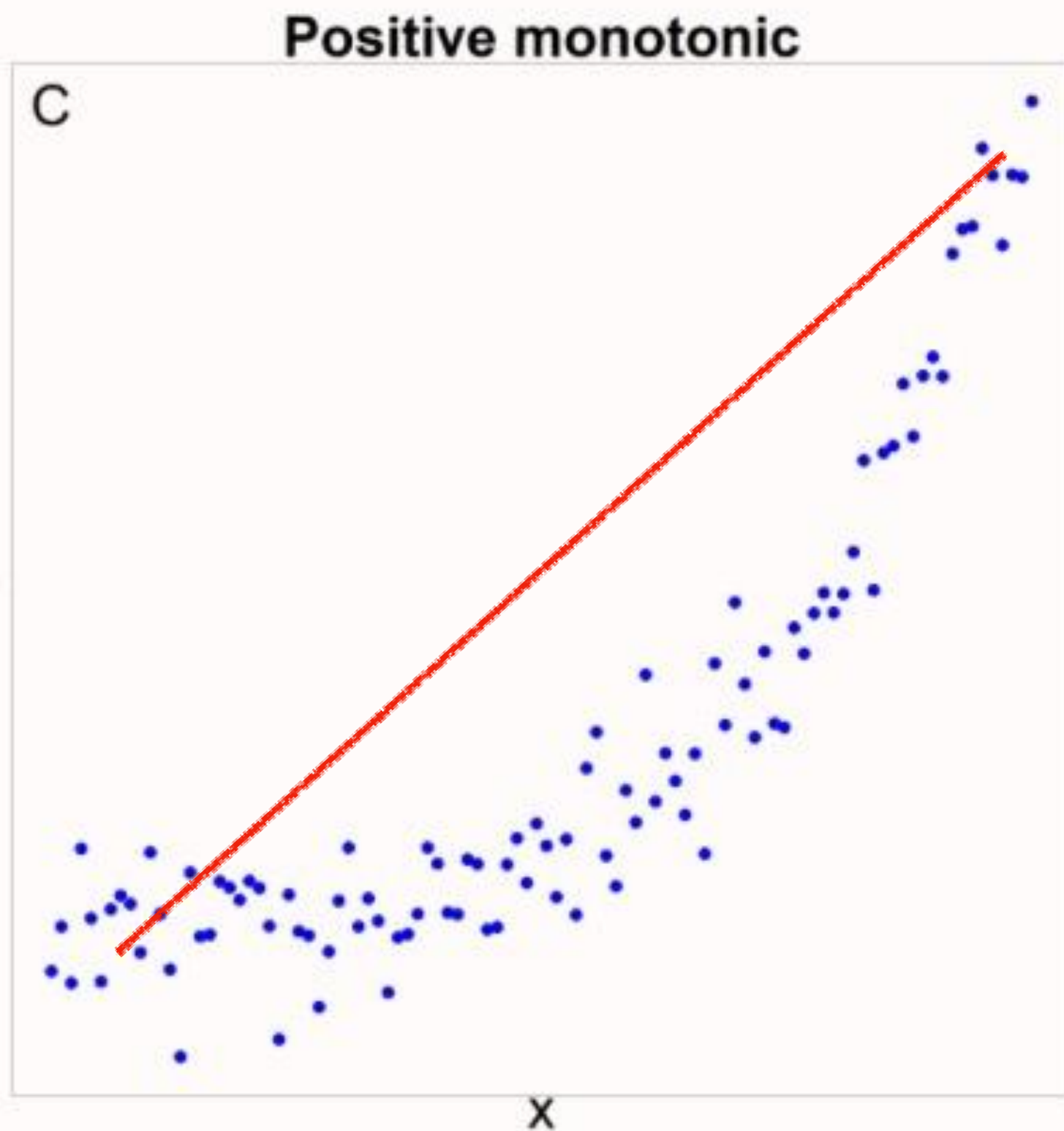


The normal curve is symmetrical around its center. The positively-skewed distribution has a longer, thicker tail to the right. The negatively-skewed distribution has a longer, thicker tail to the left.

# Statistical Testing

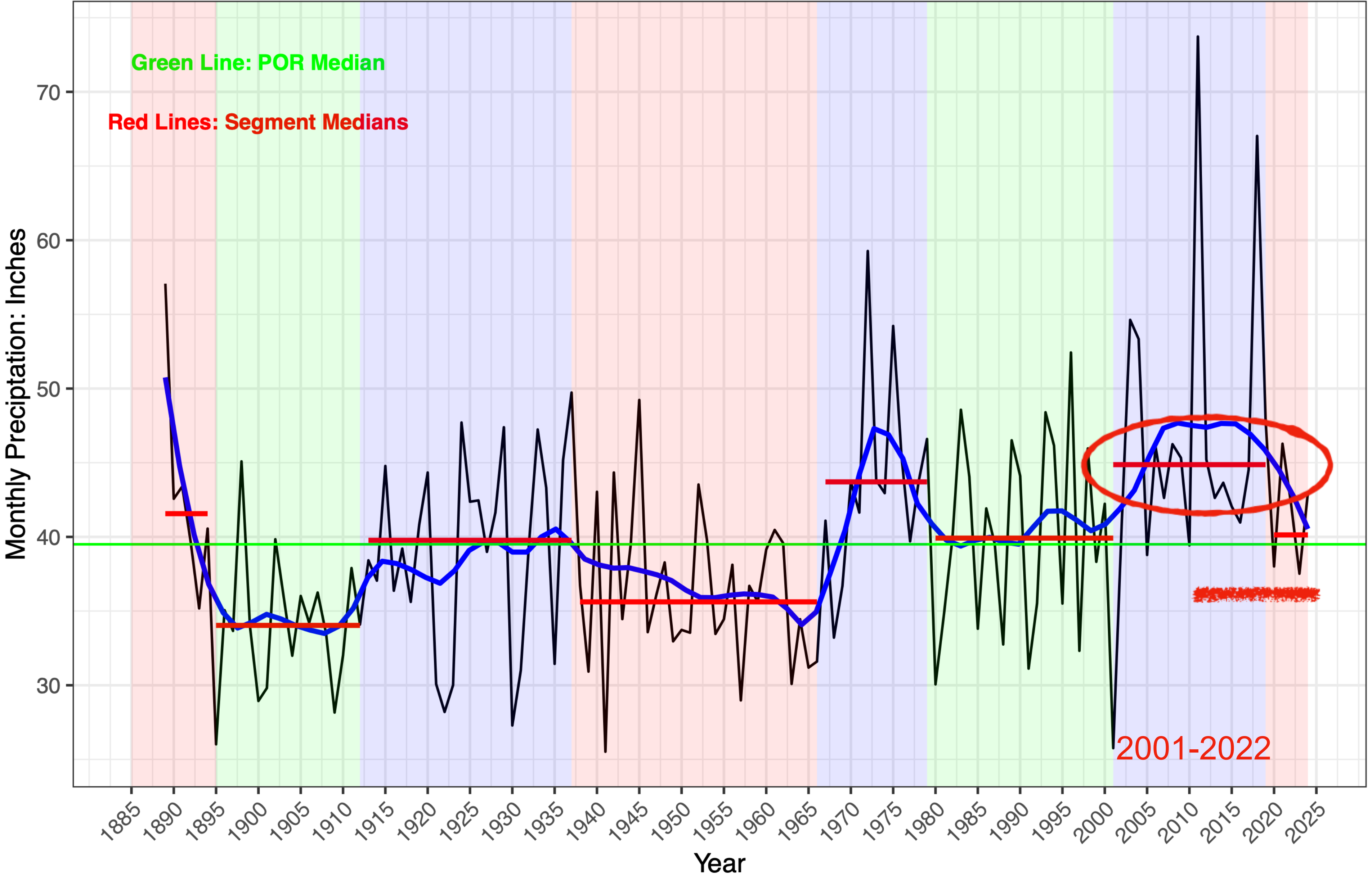
- Used NonParametric Tests
- Mann-Kendall Test: a USGS R Function (**sen**)
- Mann-Kendall Test, Seasonal and Regional Kendall Tests (**rkt**)
- Some considerations/advantages
  - Commonly Used
  - Both test for straight line monotonic trends
  - Both tests utilize close to the same file structure
  - Both tests are more resistant to missing values
  - The **rkt** test can be utilized to compare different stations/regions

# Monotonic vs Non-monotonic



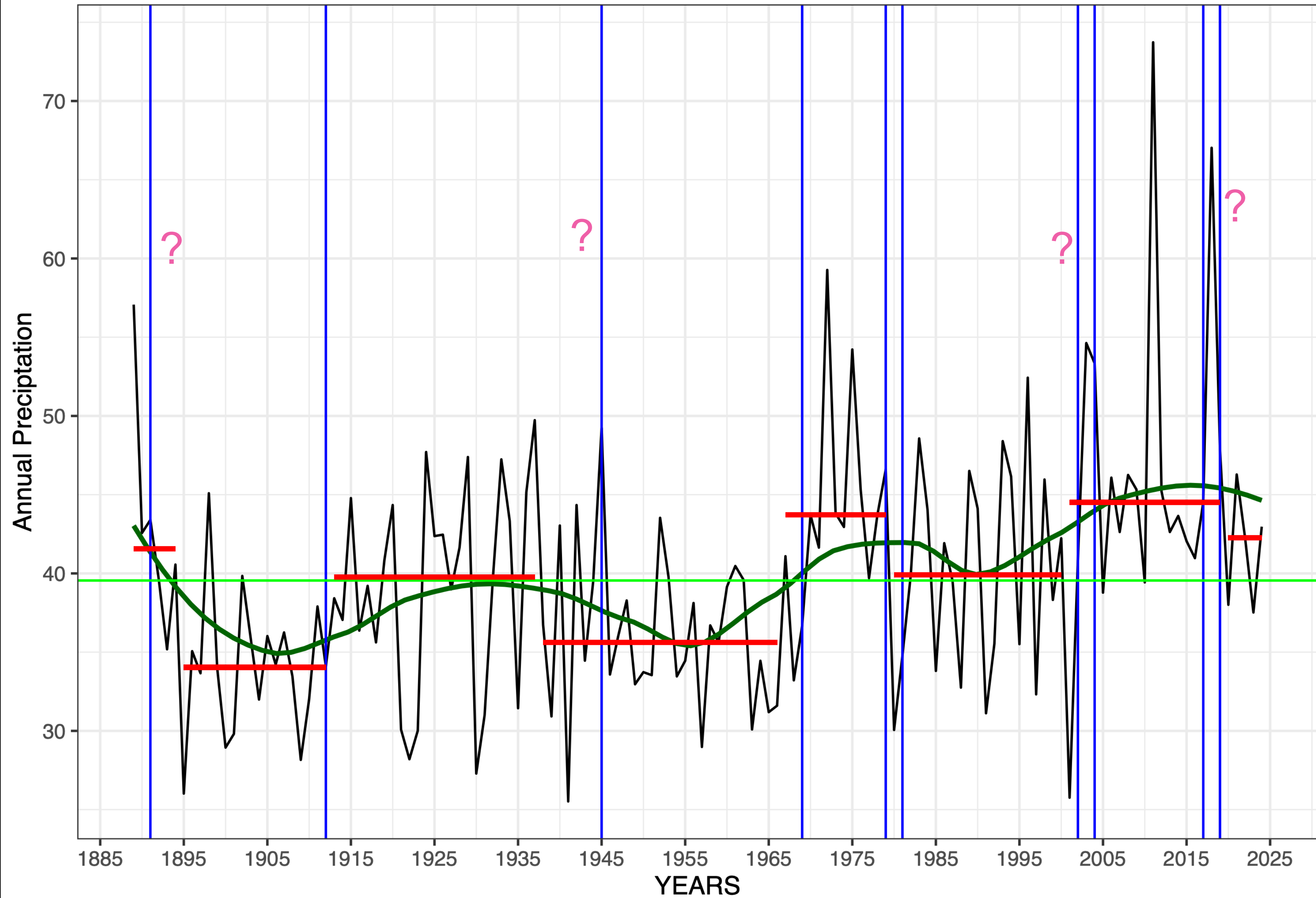
Knowing the shape/behavior of the data is an absolute requirement!

Harrisburg, PA Regional Precipitation  
Annual Precipitation 1889–2023: (134 years)



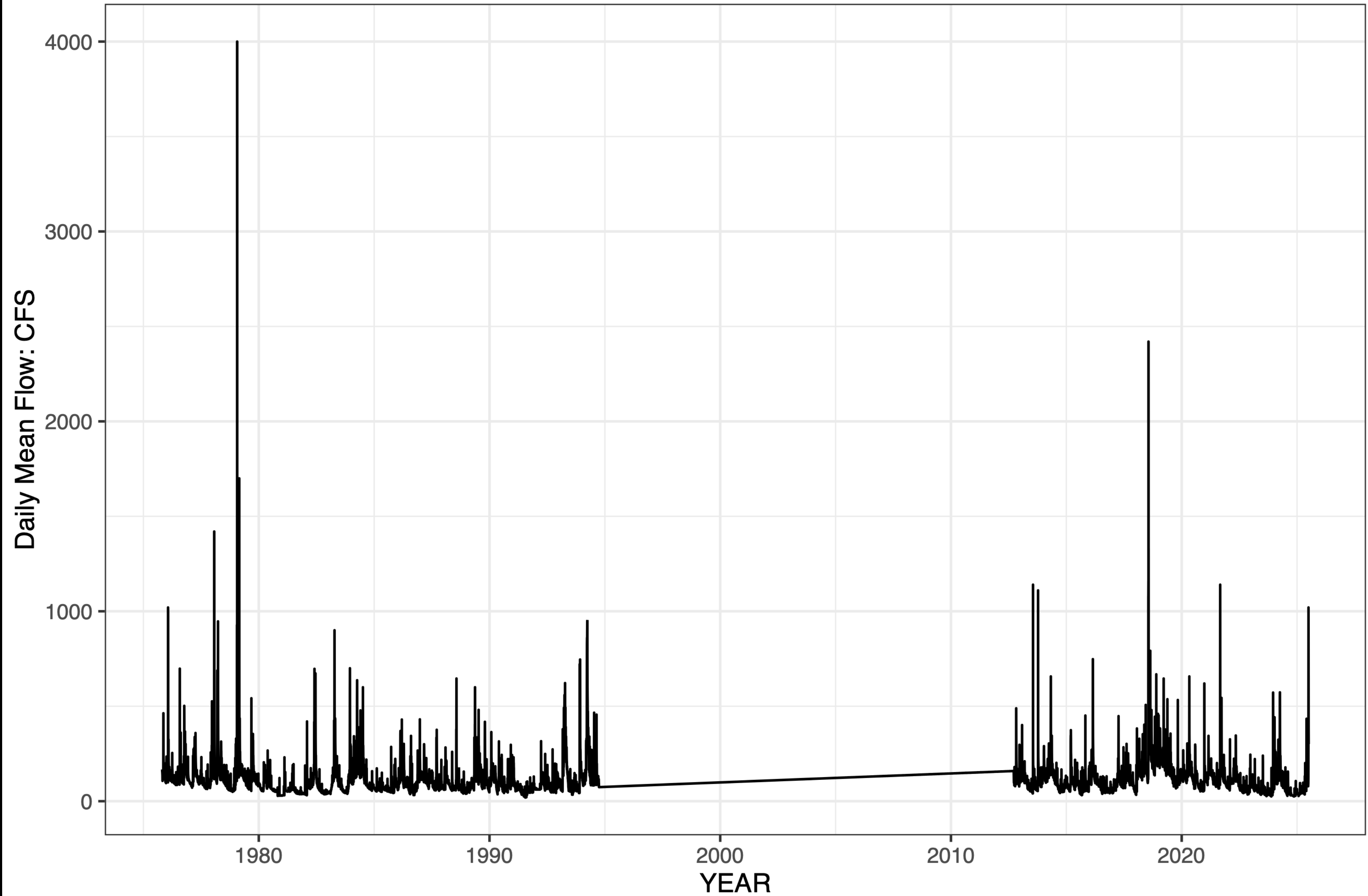
# Harrisburg Annual Rain Change Points in mean (BinSeg with Manual penalty)

Change Points: Blue: Loess Smooth: Dark Green: Red: Visual Median



# Quittapahilla Creek near Bellegrove, PA: USGS-01573160

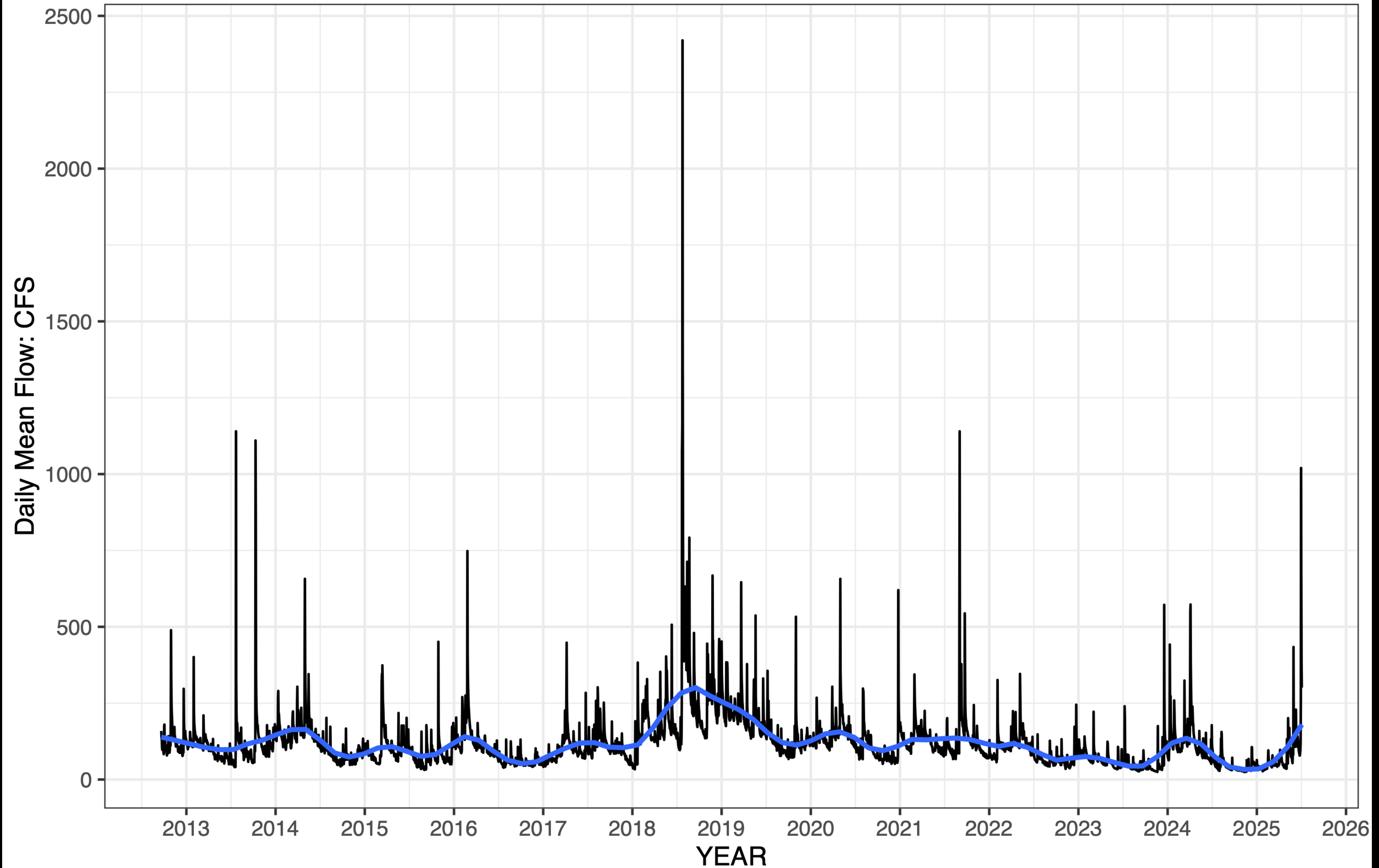
Daily Mean Flow: Units: CFS



SOURCE: NWIS Retrieved: 2025-07-05

# Quittapahilla Creek near Bellegrove, PA: USGS-01573160

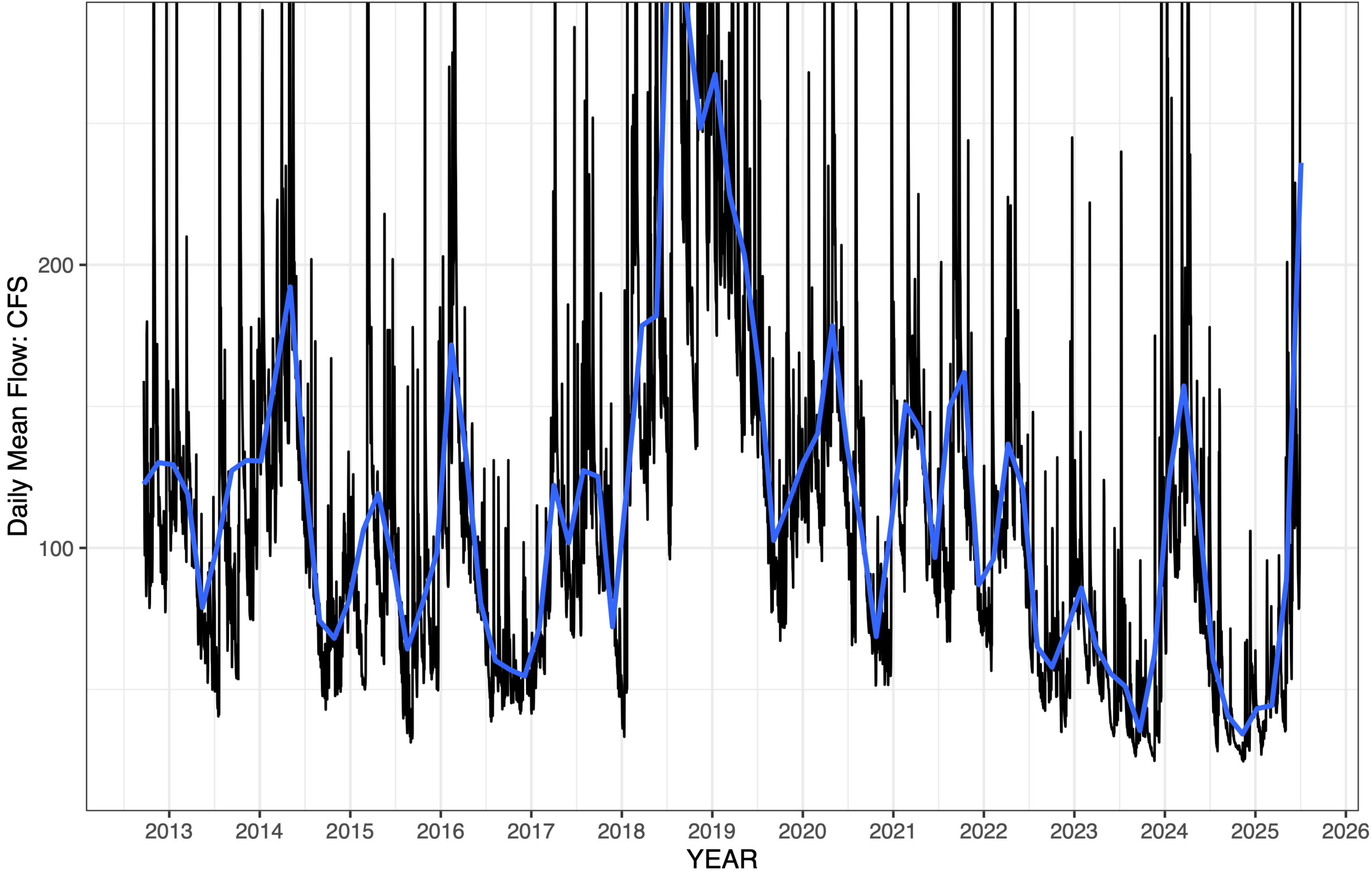
Daily Mean Flow: Units: CFS



SPAN: 0.1: Data Before 2012 Excluded  
SOURCE: NWIS: Retrieved: 2025-07-05

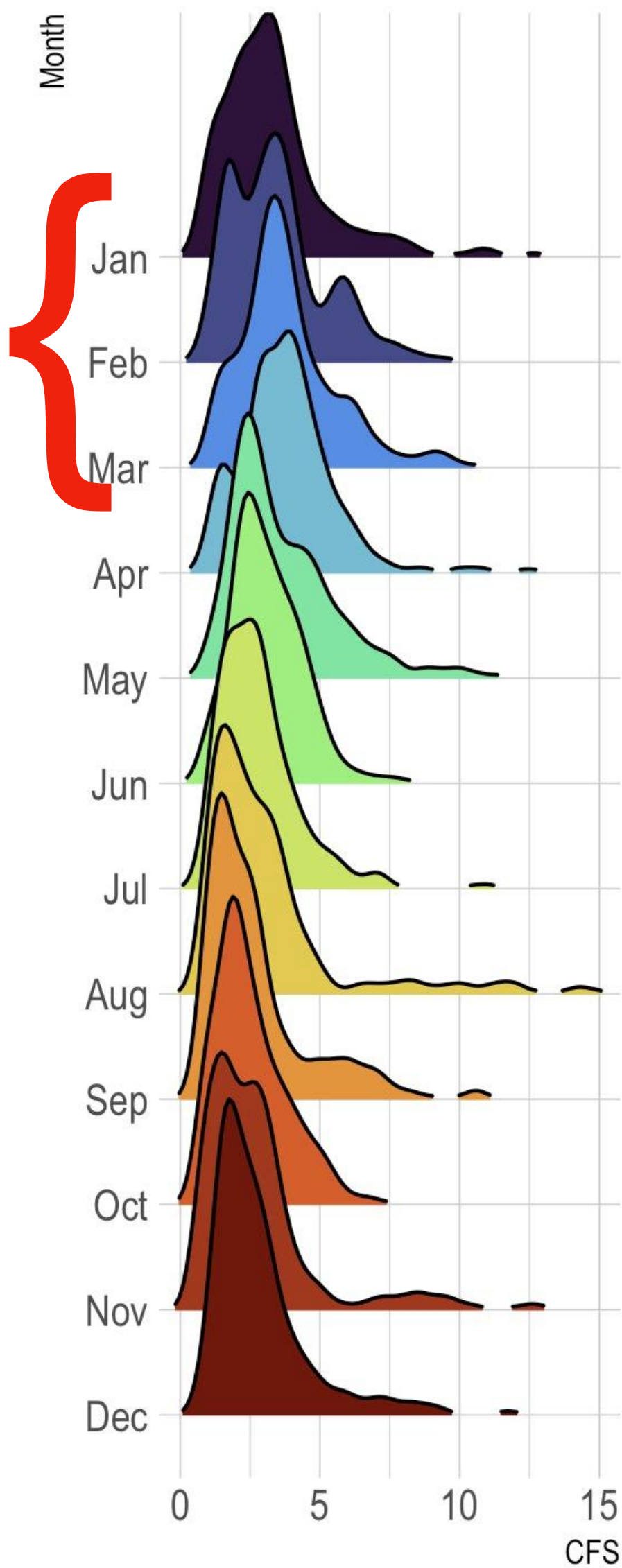
Quittapahilla Creek near Bellegrove, PA: USGS-01573160

Daily Mean Flow: Units: CFS

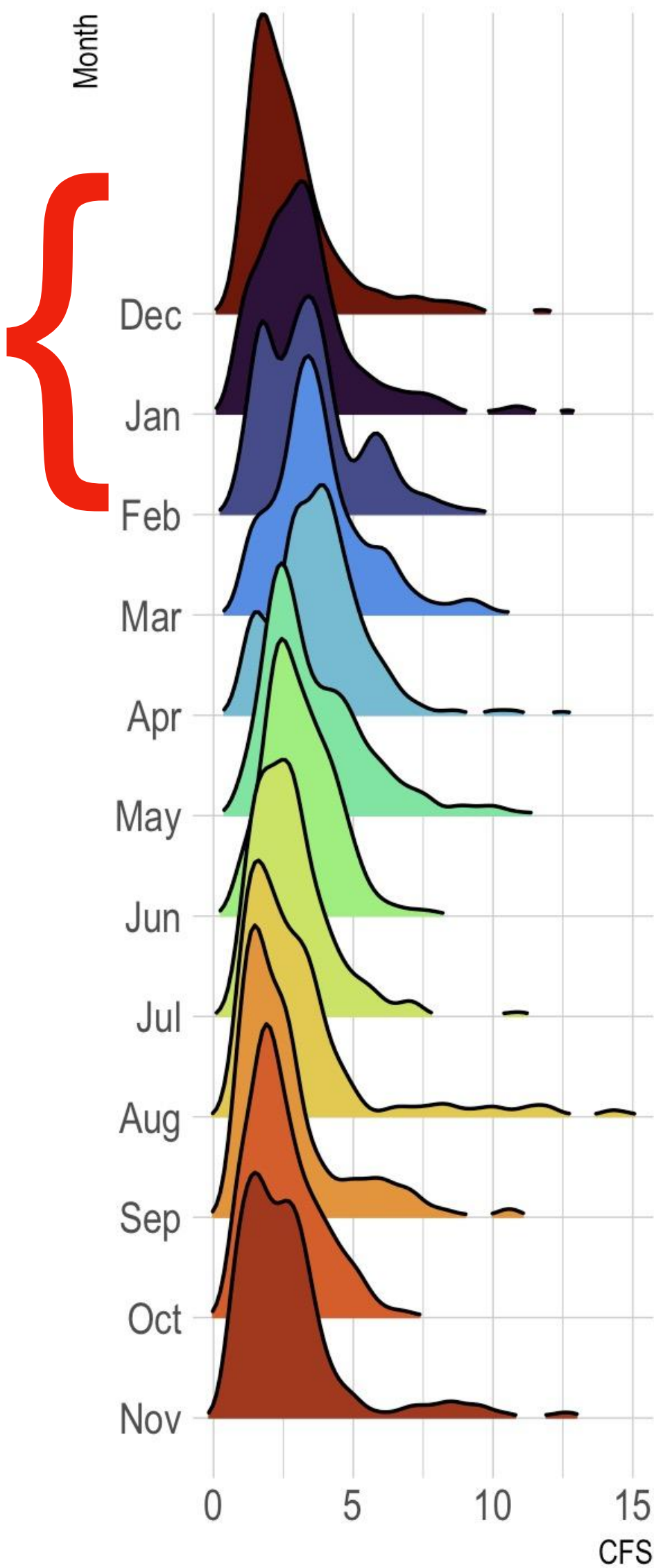


Quittapahilla Creek near Bellegrove, PA: POR: 2012-2025

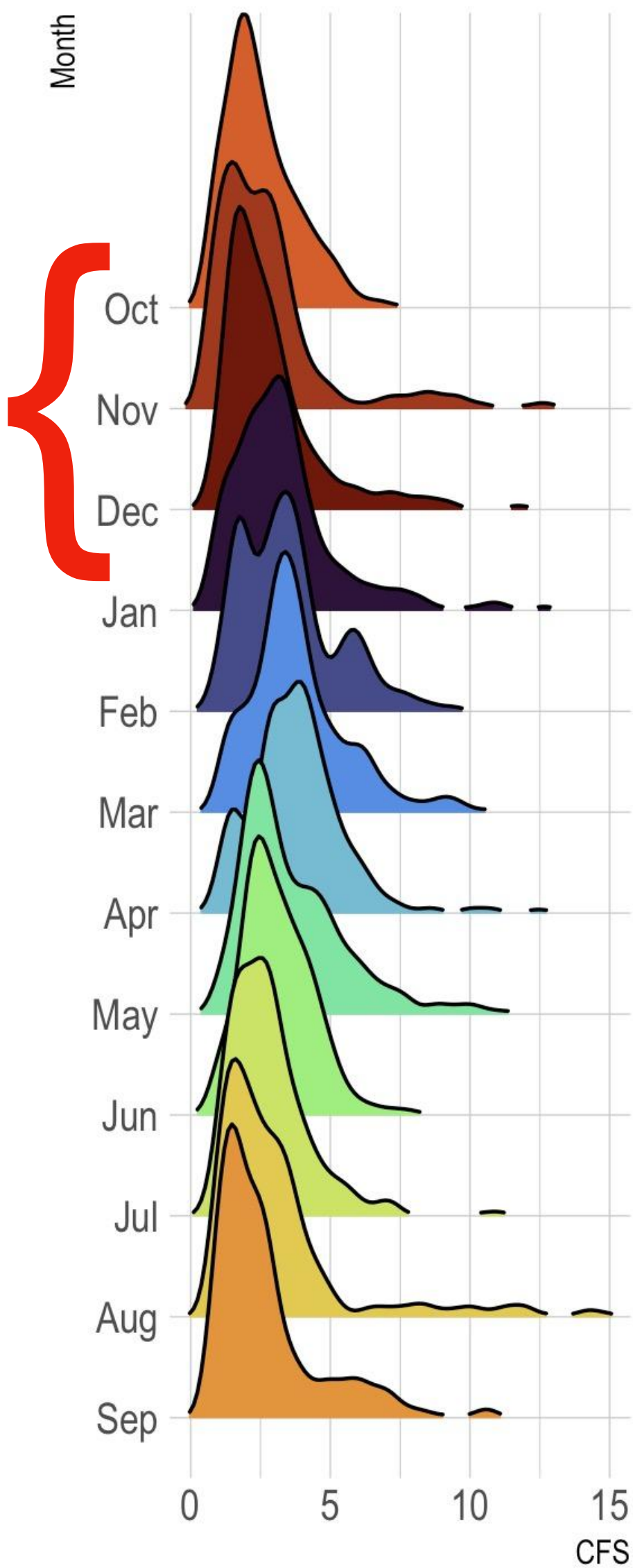
Calendar Year



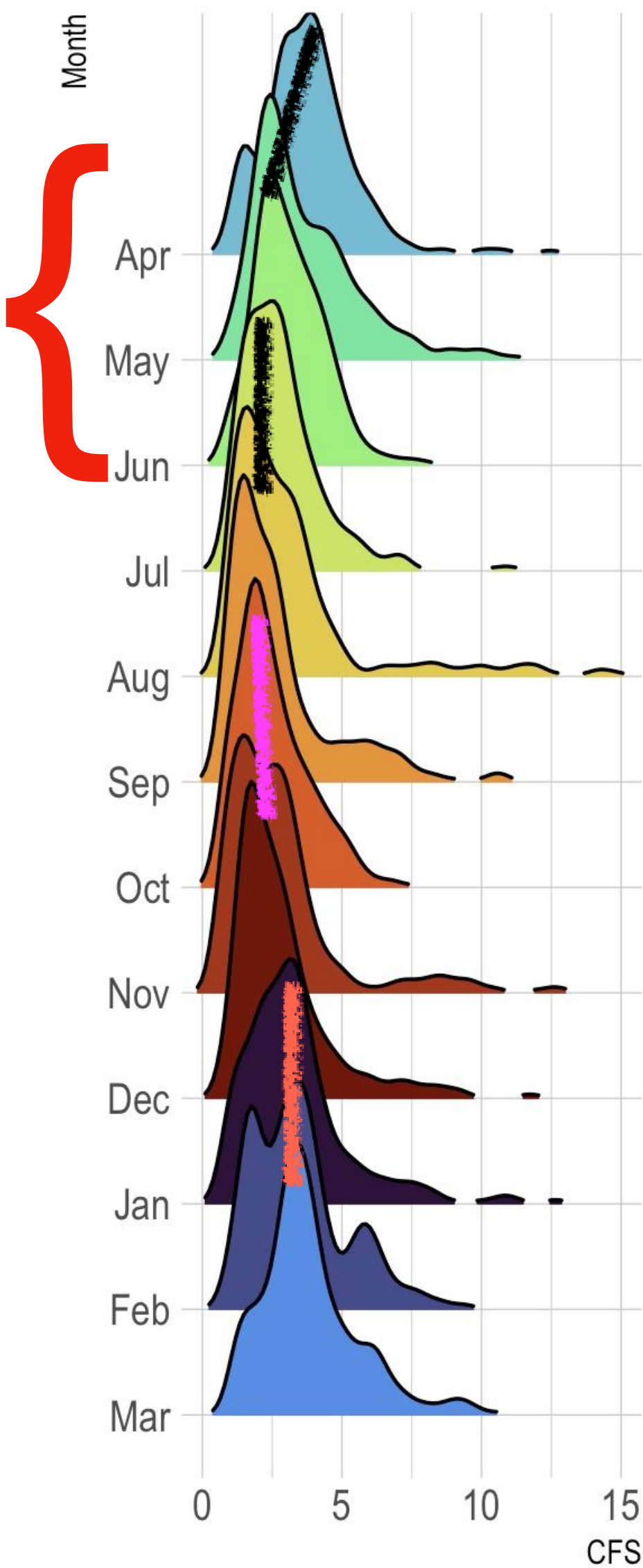
Seasonal Year



Water Year

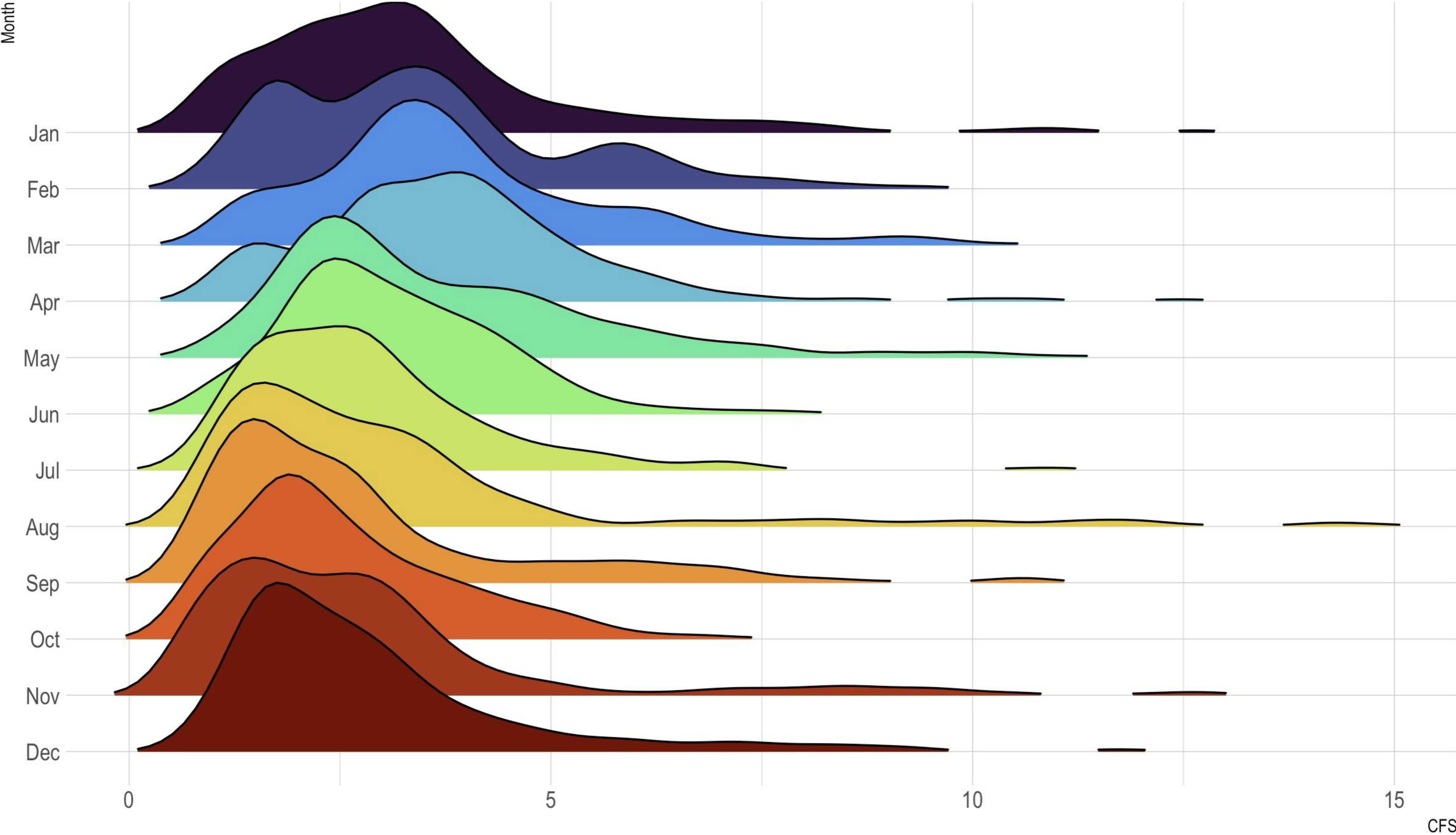


Climate Year



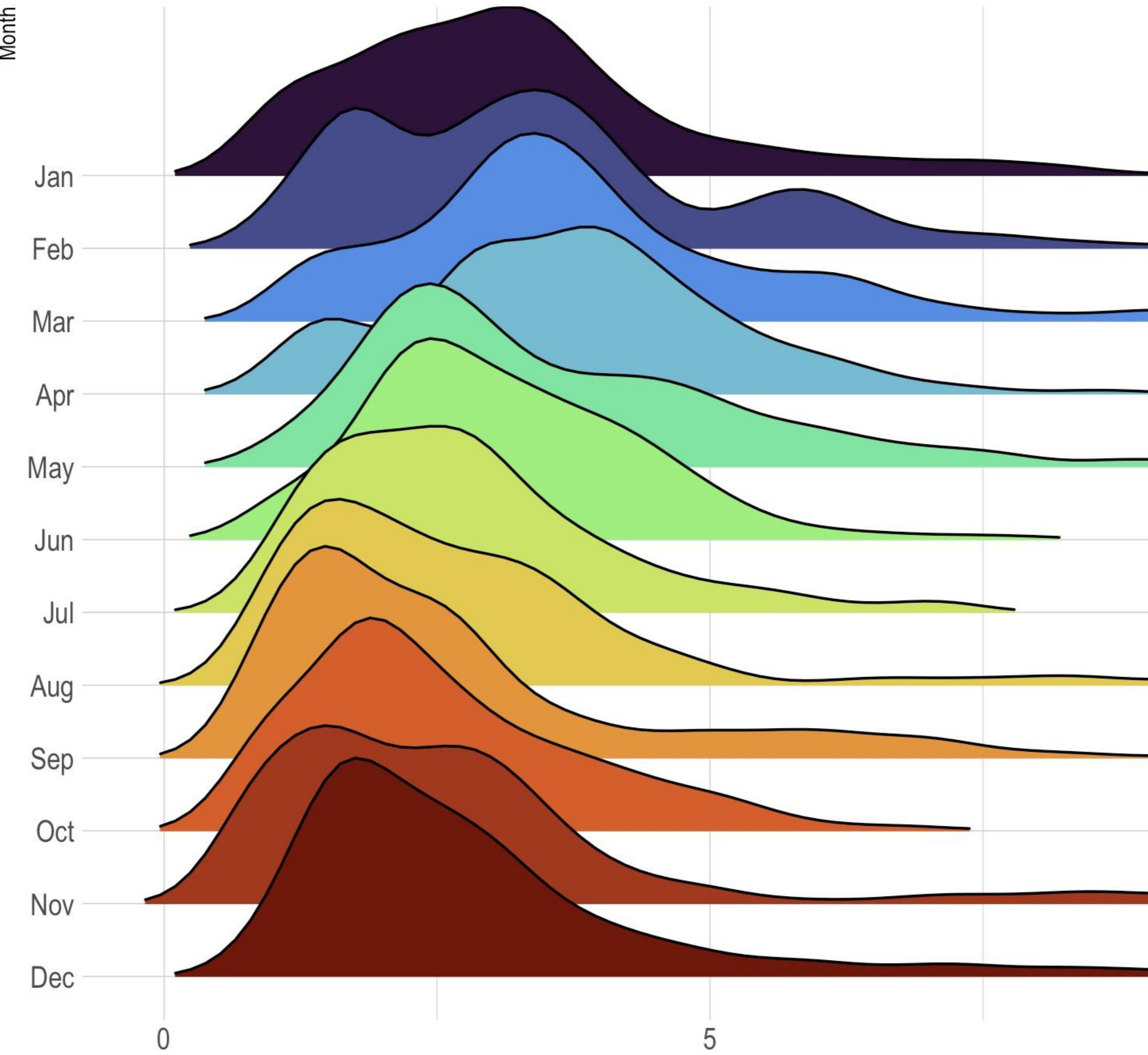
# Quittapahilla Creek near Bellegrove, PA: POR: 2012-2025

Calendar Year



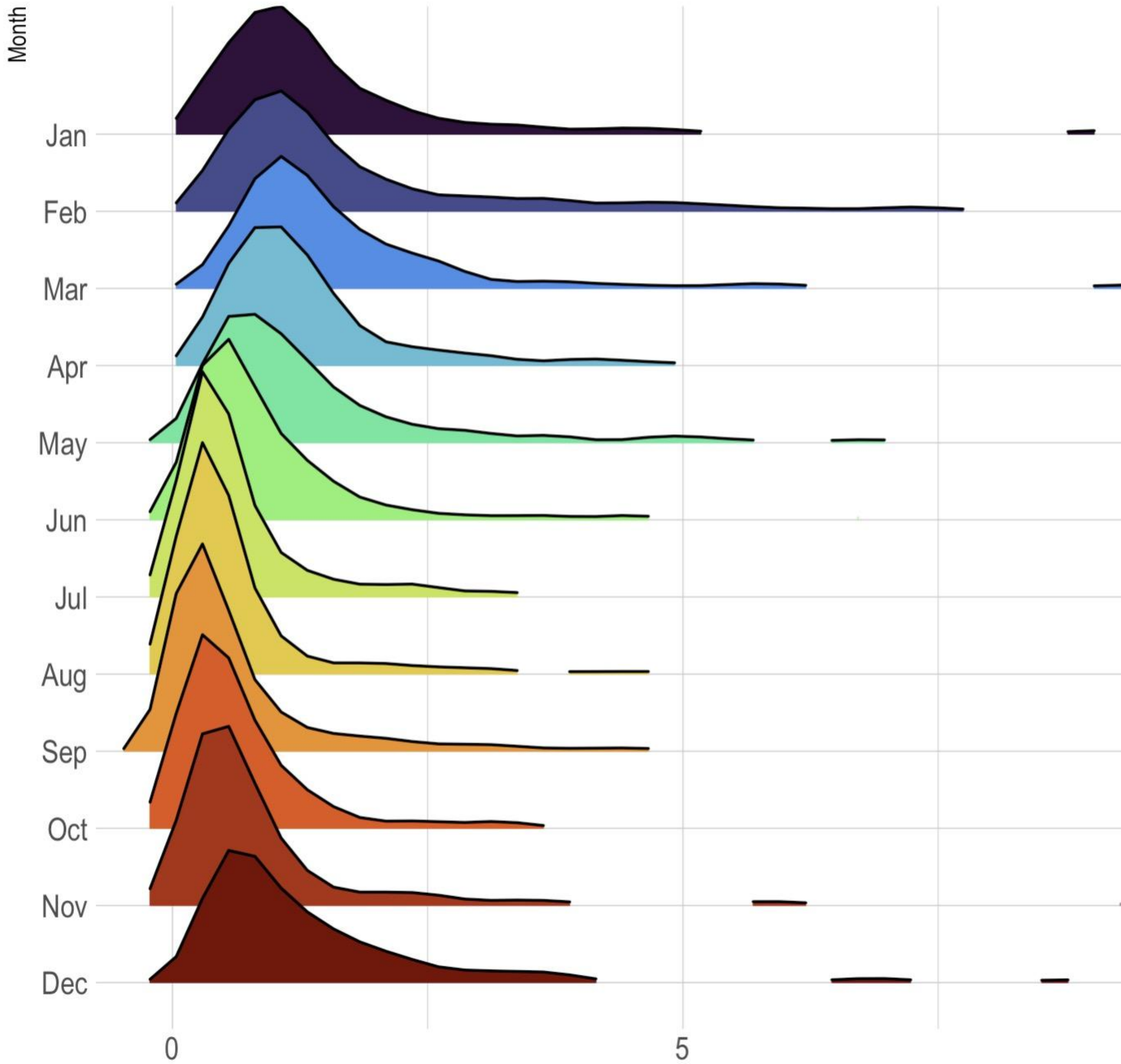
Quittapahilla Creek near Bellegrove, PA: POR: 2012-2025

Calendar Year



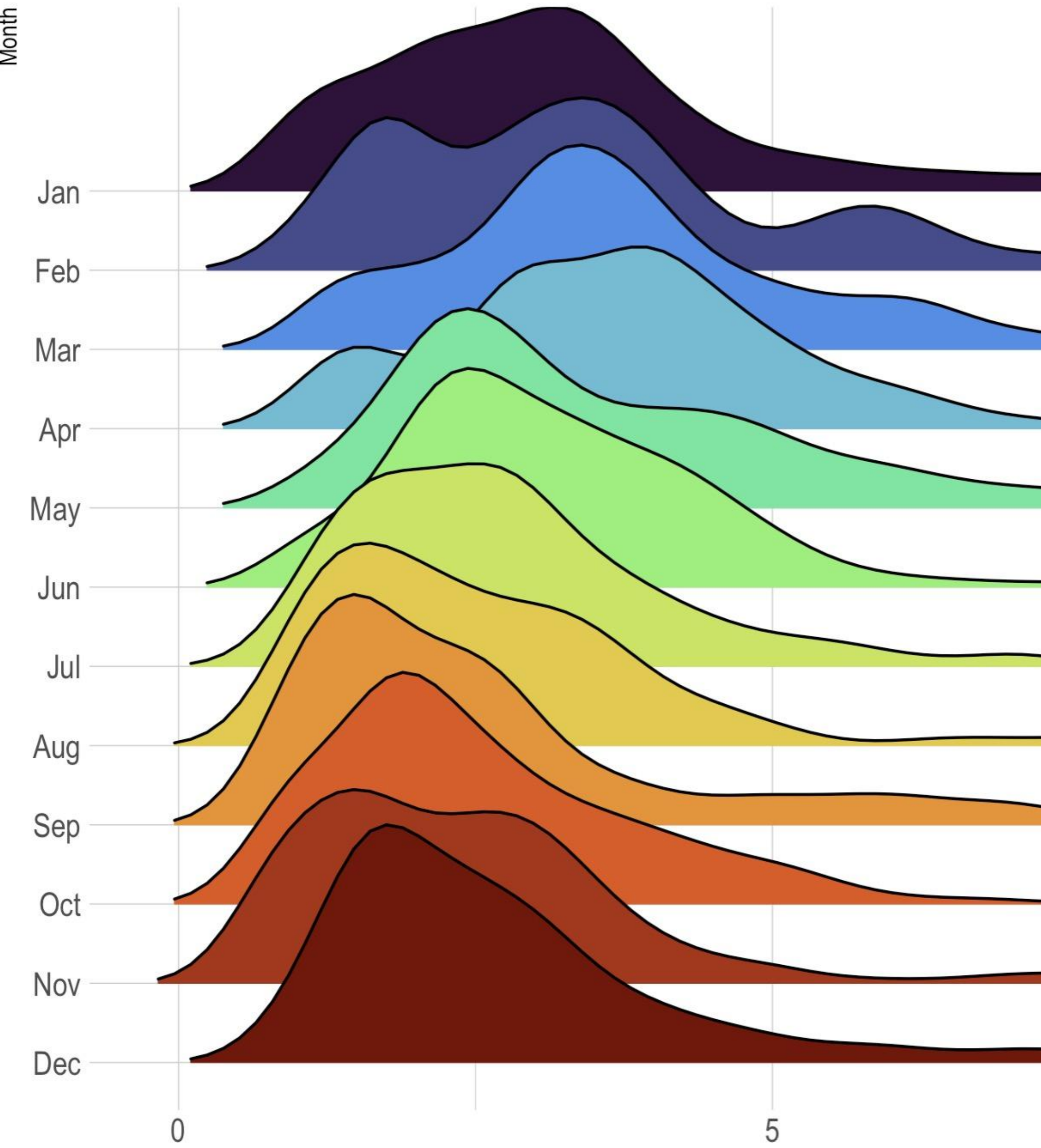
Conewago Creek near Falmouth, PA: POR: 2011-2025

Calendar Year



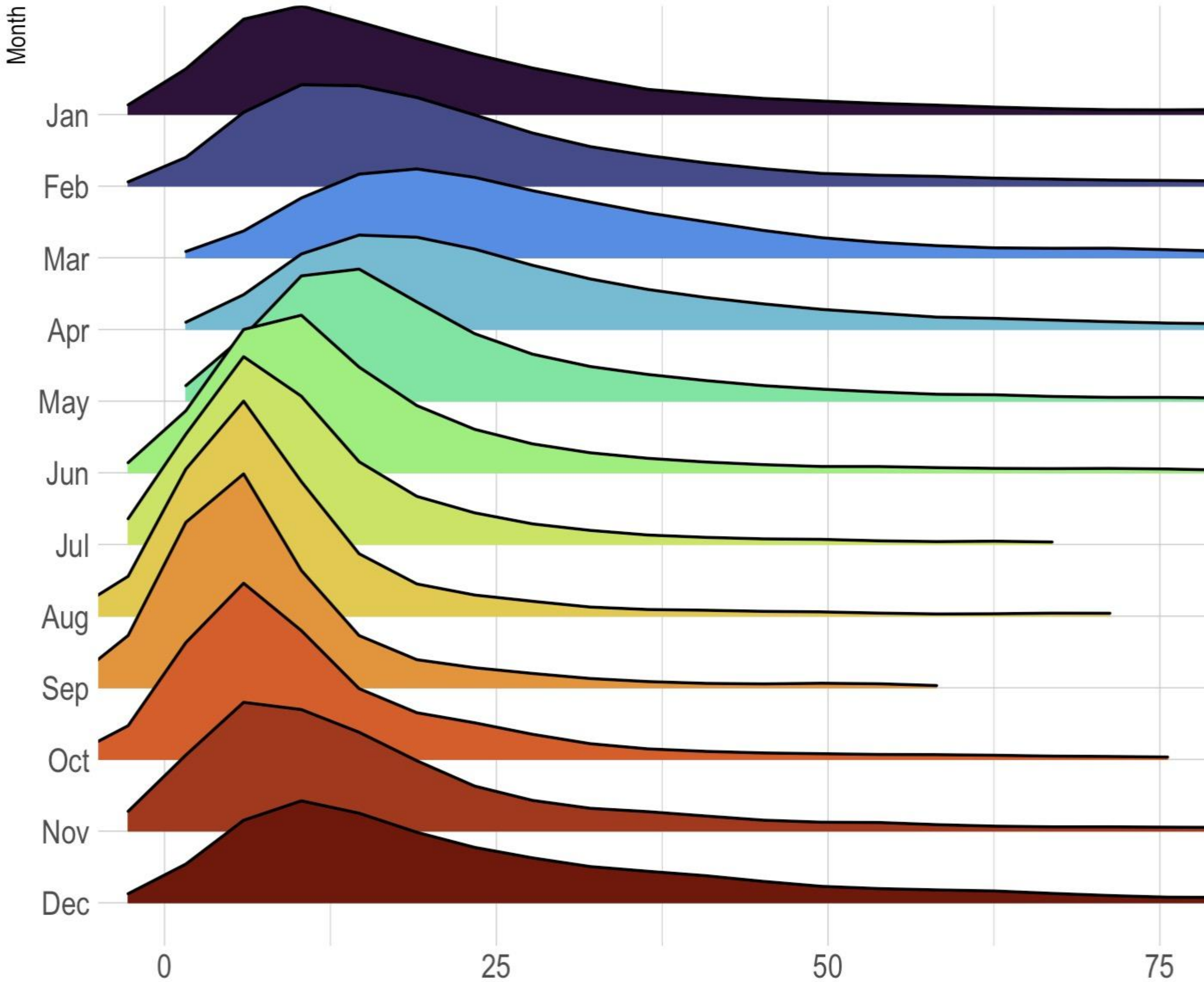
# Quittapahilla Creek near Bellegrove, PA: POR: 2

Calendar Year



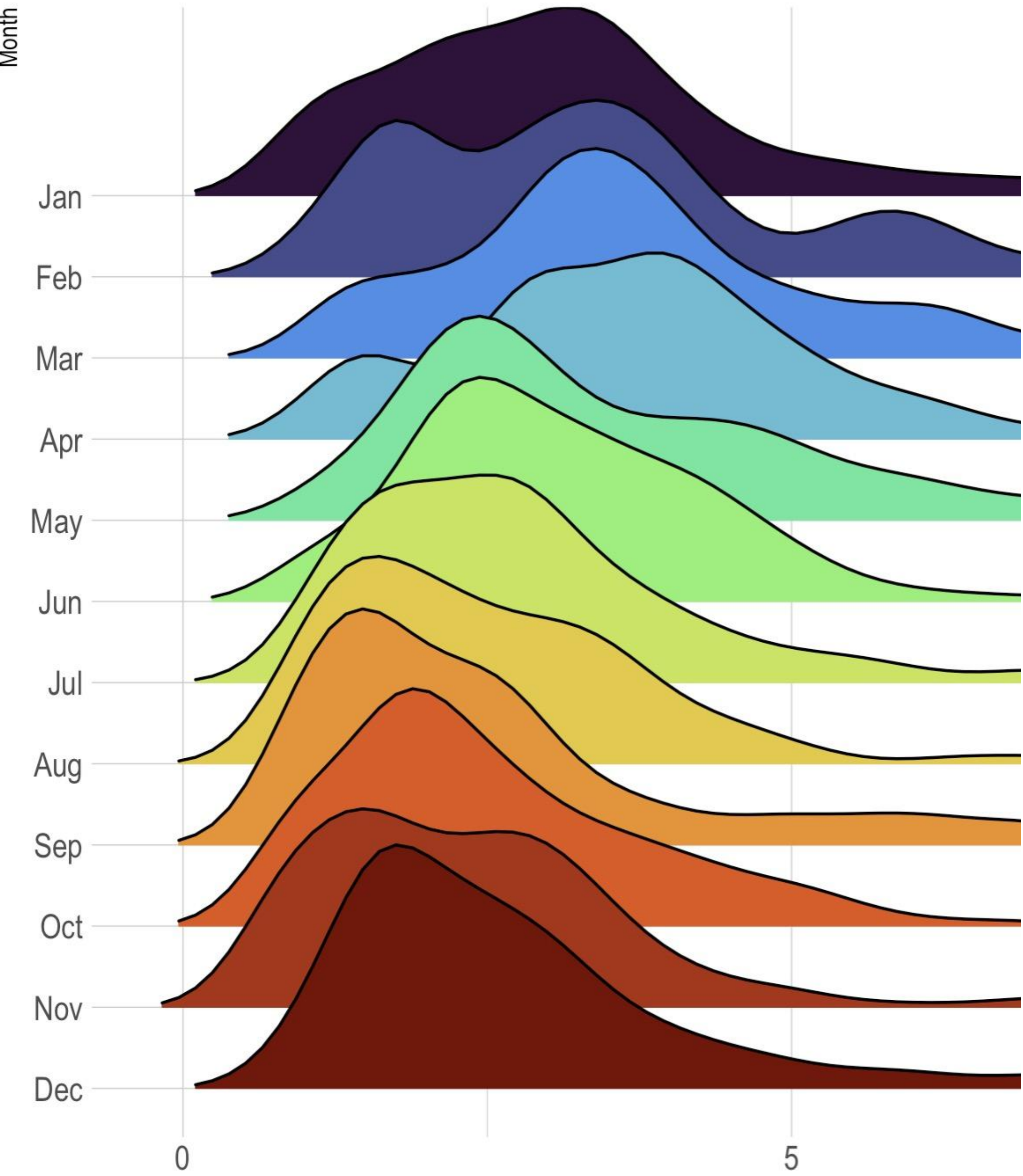
# Swatara Creek near Hershey, PA: POR: 1975-2025

Calendar Year



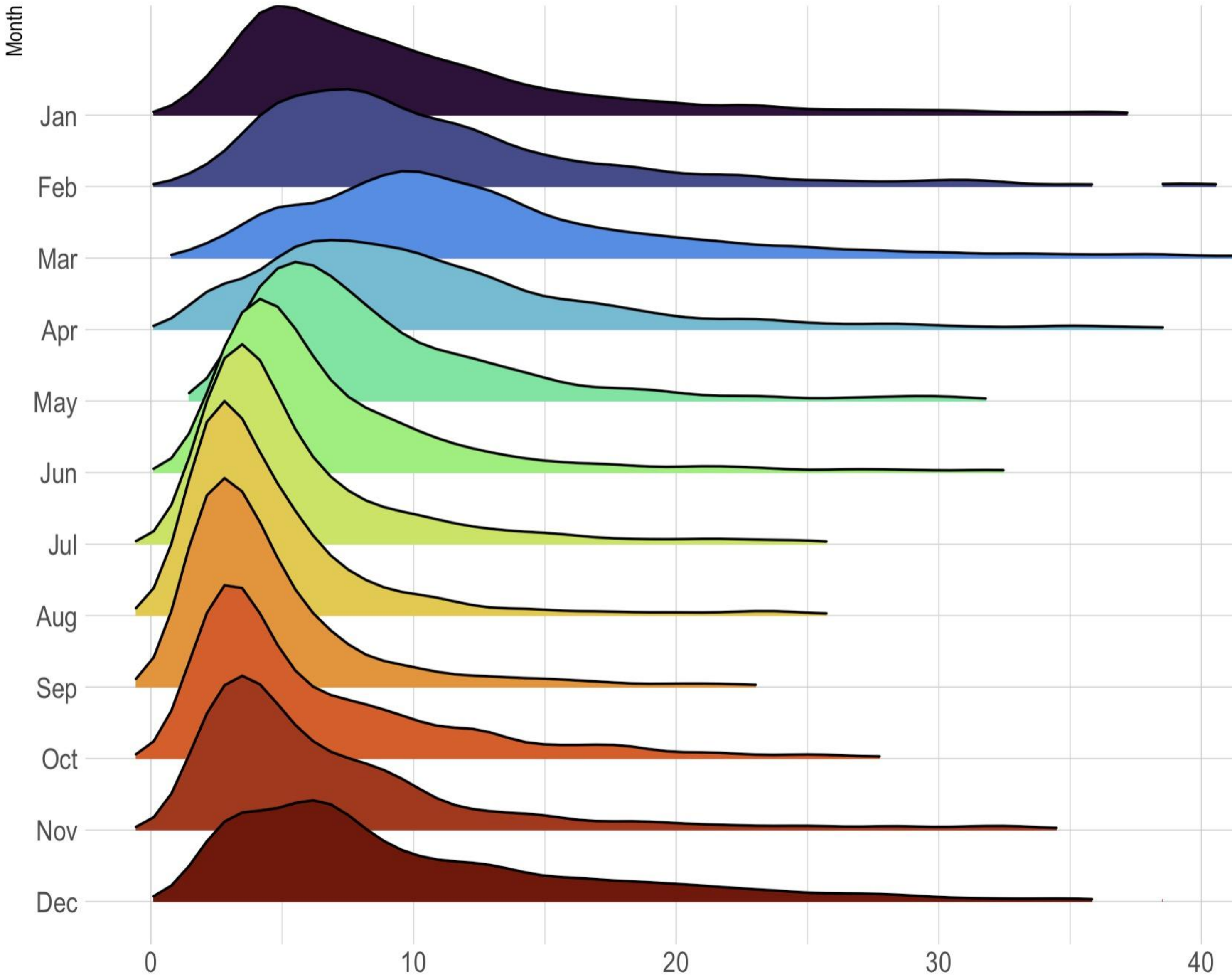
# Quittapahilla Creek near Bellegrove, PA: POR

Calendar Year

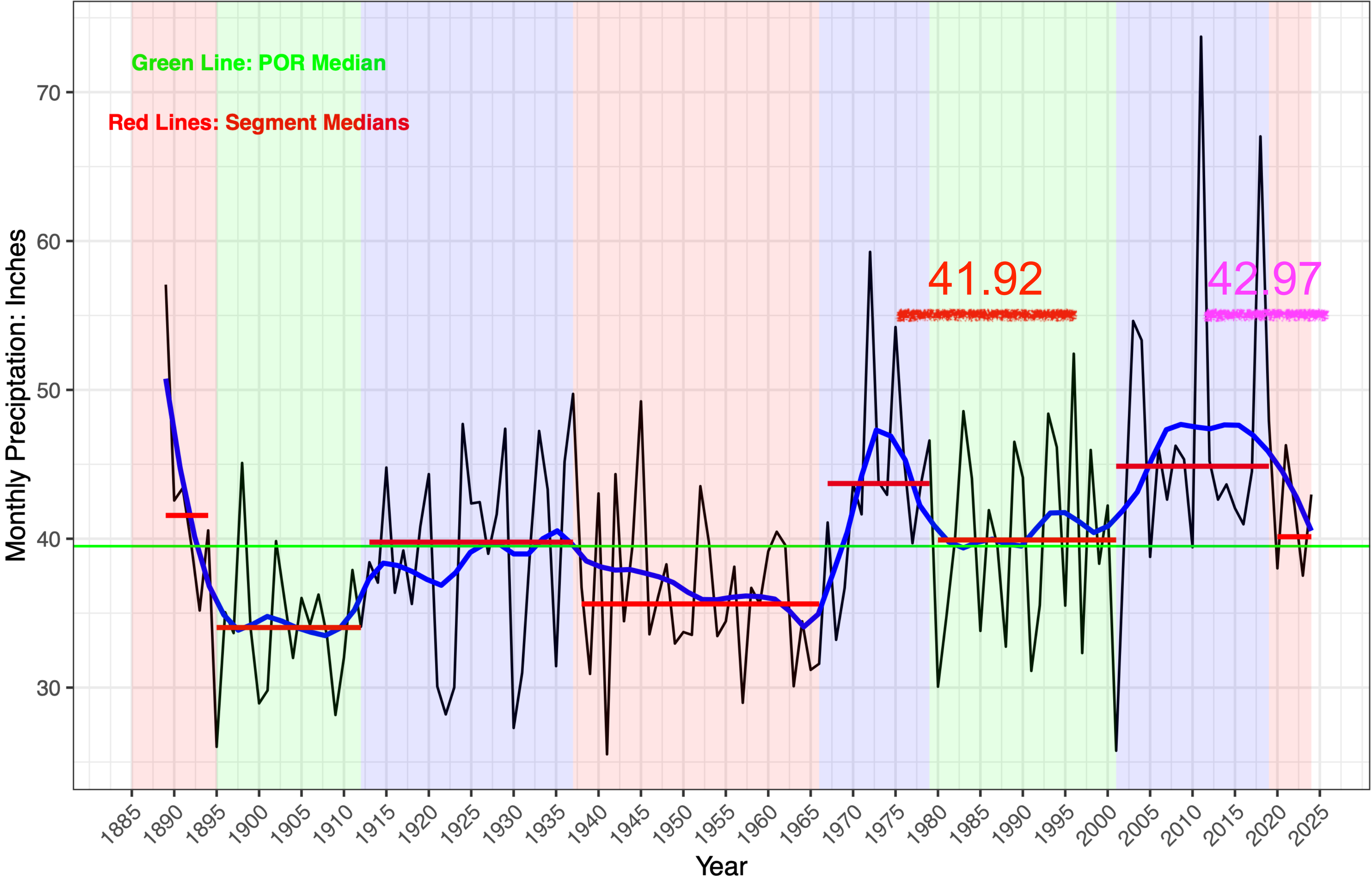


# Tulpehocken Creek near Reading, PA: POR: 1950-2025

Calendar Year



Harrisburg, PA Regional Precipitation  
Annual Precipitation 1889–2023: (134 years)

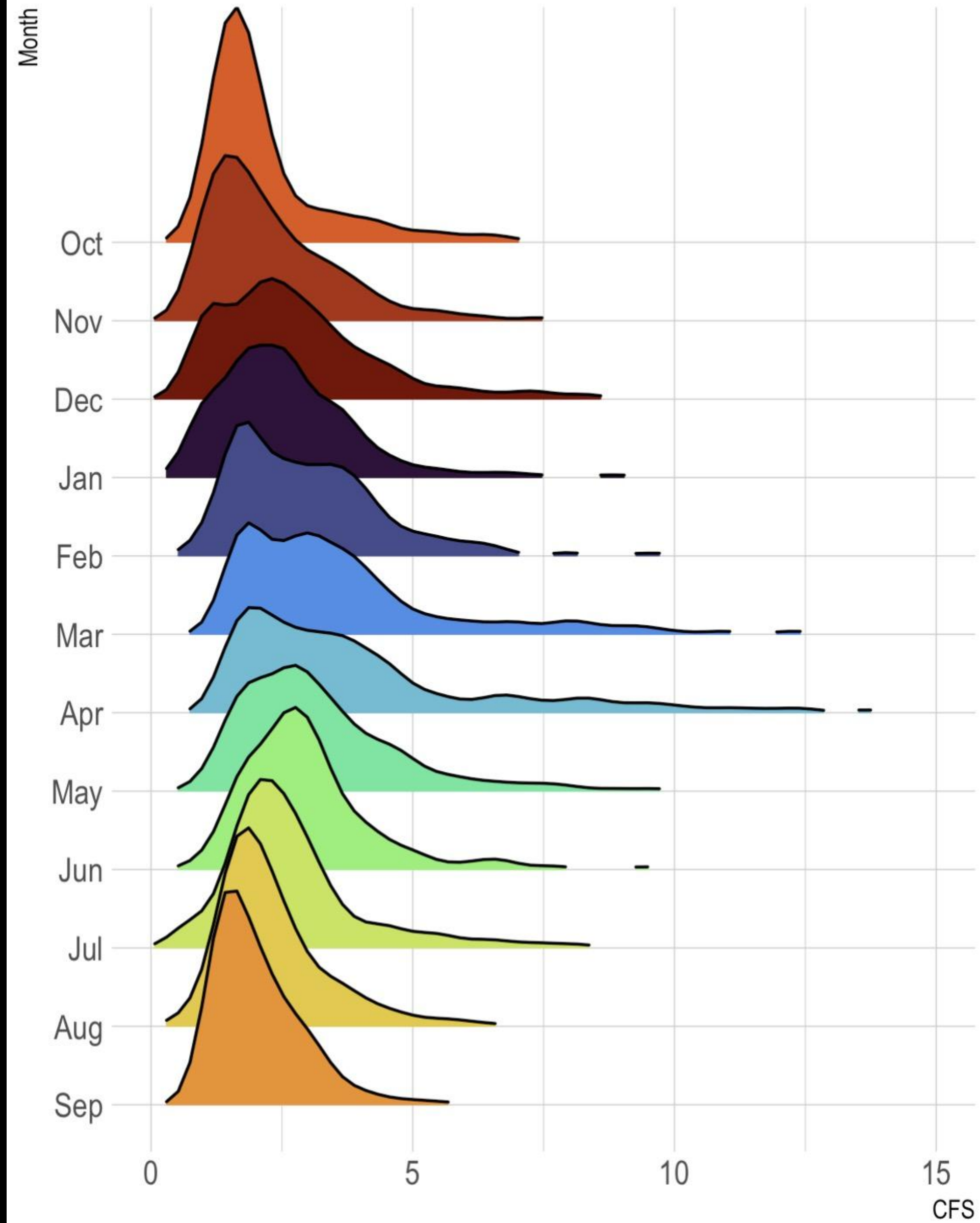


Run: 2025-08-17

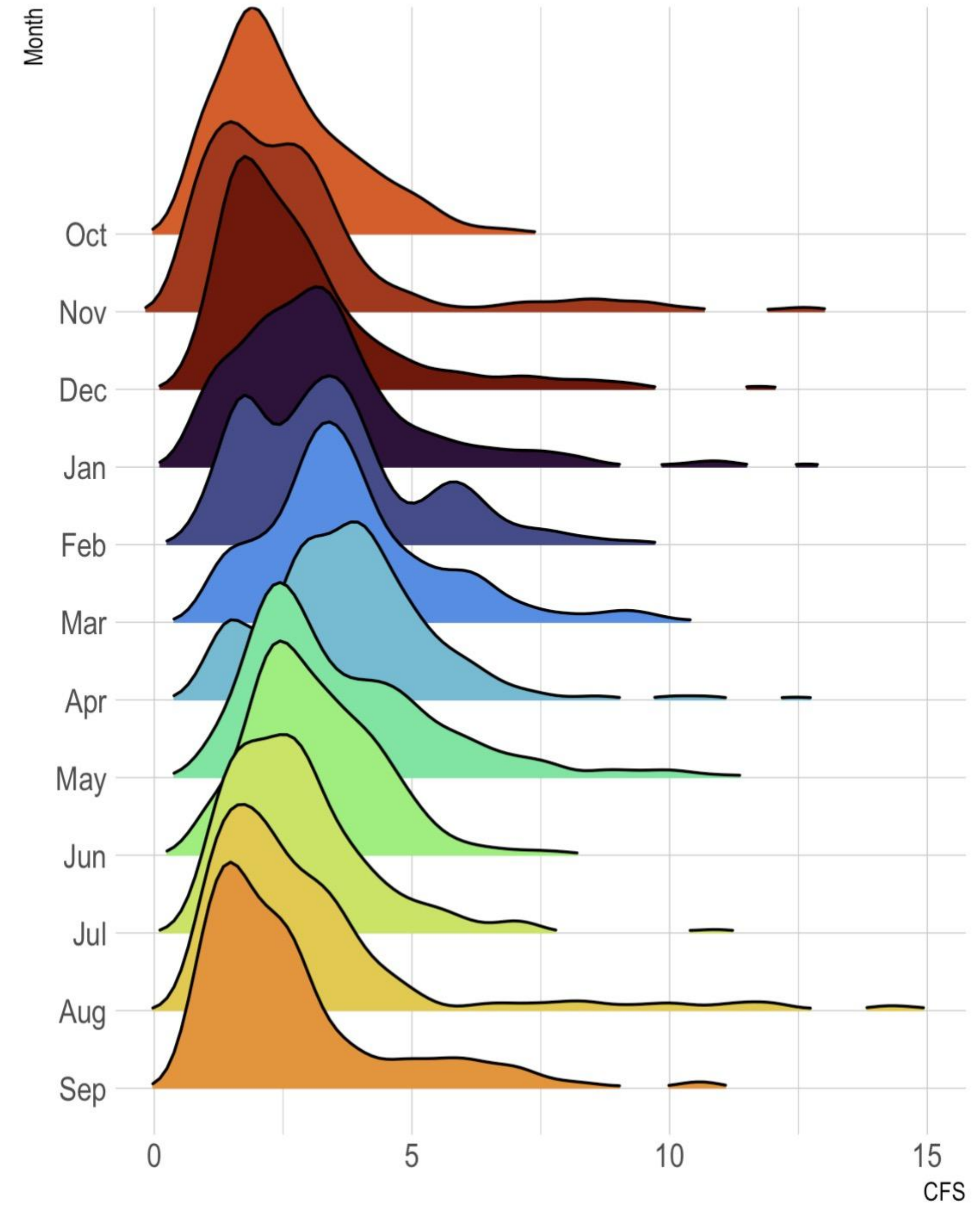
Source: <https://www.weather.gov/wrh/Climate?wfo=ctp> Harrisburg Area

# Quittapahilla Creek near Bellegrove, PA

WaterYear: 1975-1995

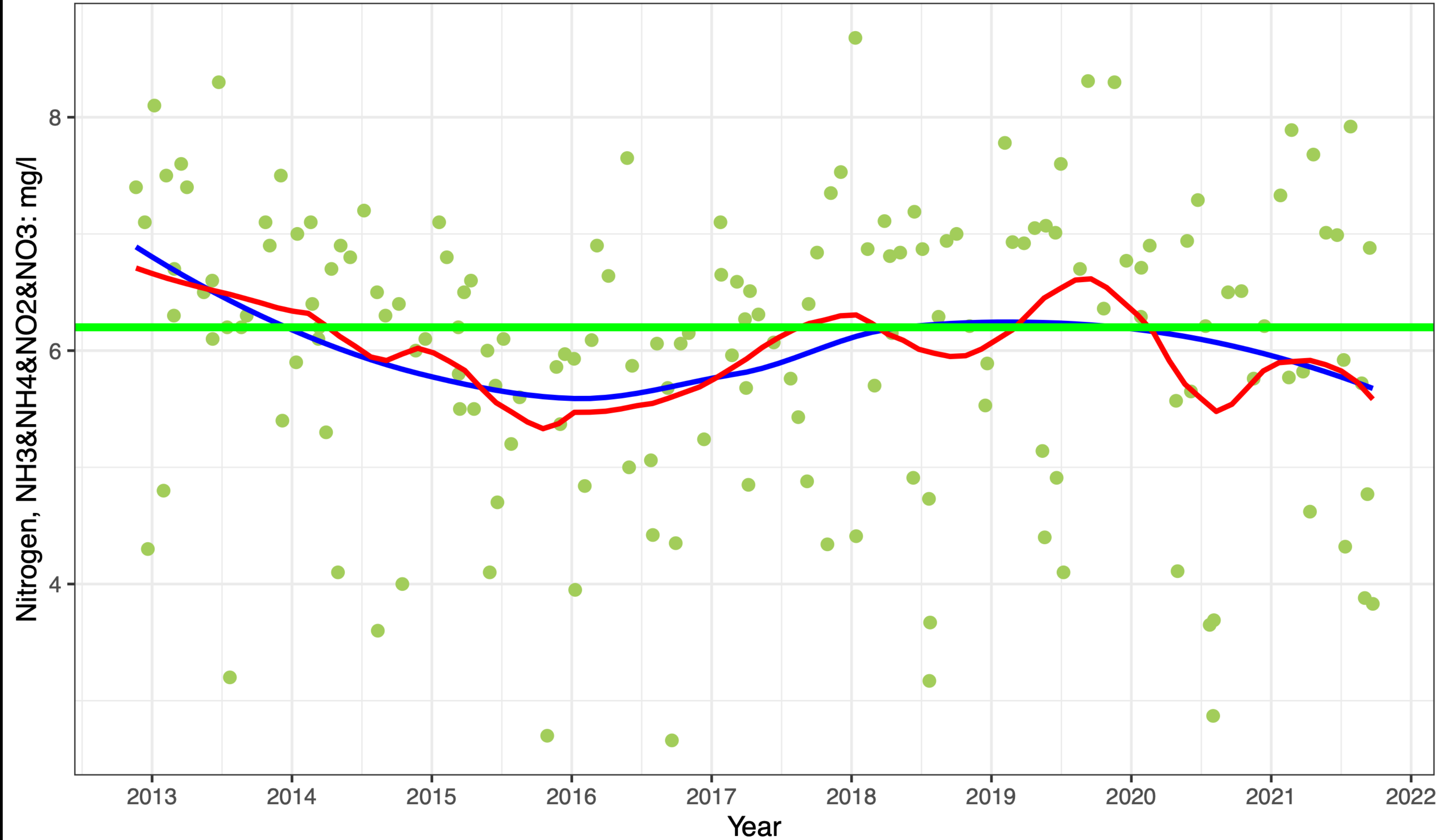


WaterYear: 2012-2025



| Analyte                                                | unit      | Start | End  | Min   | Median | Max    | Samples | Period | Yr_samples |
|--------------------------------------------------------|-----------|-------|------|-------|--------|--------|---------|--------|------------|
| Quittapahilla Creek near Bellegrove, PA: USGS-01573160 |           |       |      |       |        |        |         |        |            |
| Nitrogen, NH3&NH4&NO2&NO3                              | mg/l      | 2012  | 2021 | 2.66  | 6.2    | 8.68   | 164     | 10     | 16.4       |
| Phosphorus                                             | mg/l as P | 2012  | 2023 | 0.02  | 0.1    | 0.60   | 193     | 12     | 16.1       |
| S. Sediment. Con.                                      | %         | 2013  | 2023 | 22.00 | 89.0   | 100.00 | 41      | 11     | 3.7        |
| TN_TP Ratio                                            | Ratio     | 2012  | 2021 | 5.91  | 69.2   | 346.00 | 158     | 10     | 15.8       |

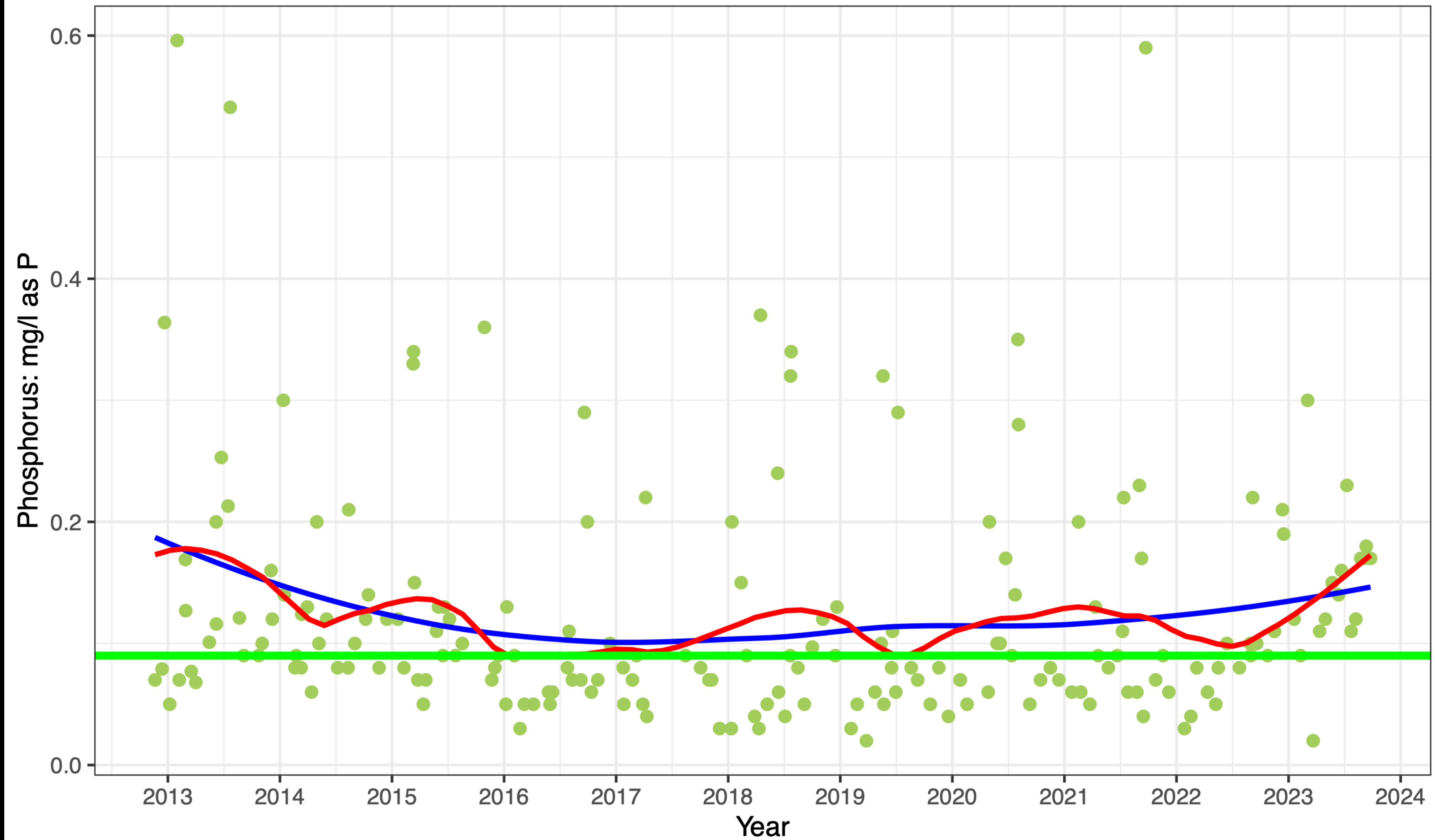
Quittapahilla Creek near Bellegrove, PA: USGS Site: USGS-01573160  
Nitrogen, NH3&NH4&NO2&NO3: Units: mg/l: usgs\_pcode: 00600: CONCENTRATION PLOT



LOESS REGRESSION Span — Span: 0.75 — Span: 0.25

Median: 6.2: GREEN: Data Source: readWQPdata

Phosphorus: Units: mg/l as P: usgs\_pcode: 00665: CONCENTRATION PLOT

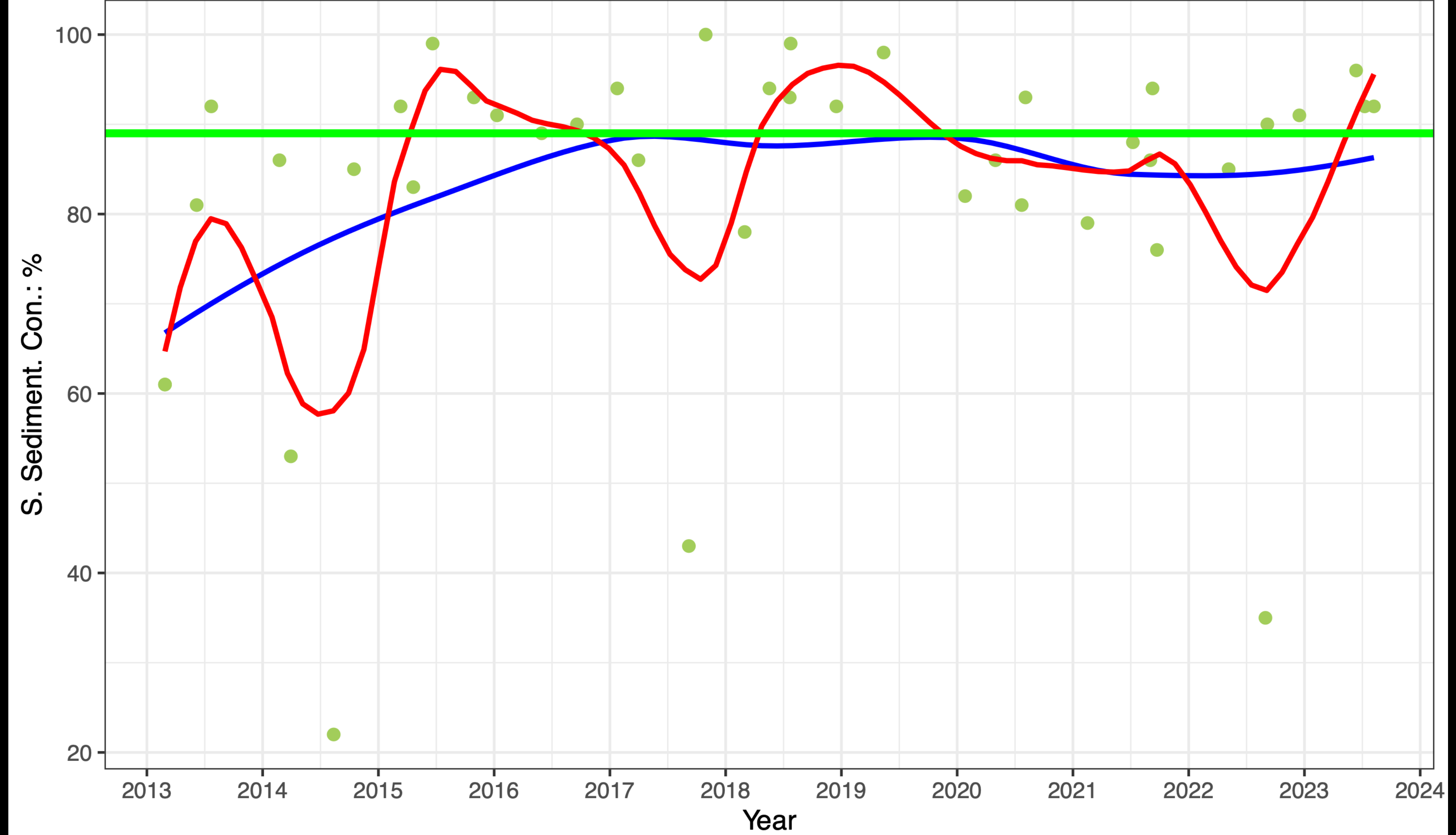


LOESS REGRESSION Span — Span: 0.75 — Span: 0.25

Median: 0.09: GREEN: Data Source: readWQPdata

Quittapahilla Creek near Bellegrove, PA: USGS Site: USGS-01573160

S. Sediment. Con.: Units: %: usgs\_pcode: 70331: CONCENTRATION PLOT

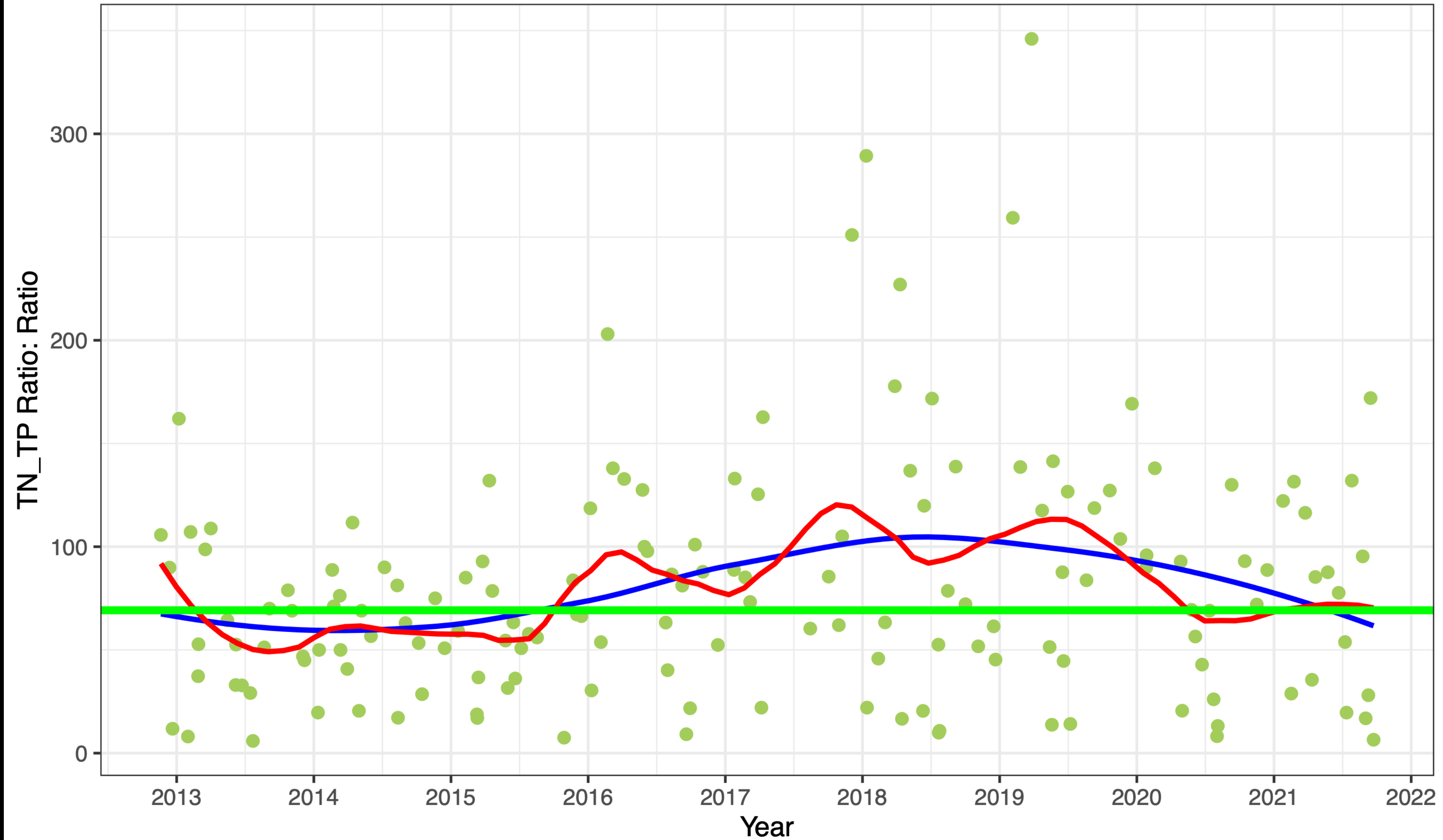


LOESS REGRESSION Span — Span: 0.75 — Span: 0.25

Median: 89: GREEN: Data Source: readWQPdata

# Quittapahilla Creek near Bellegrove, PA: USGS Site: USGS-01573160

TN\_TP Ratio: Units: Ratio: usgs\_pcode: TN\_TP: CONCENTRATION PLOT



LOESS REGRESSION Span — Span: 0.75 — Span: 0.25

Median: 69.2: GREEN: Data Source: readWQPdata

TREND ANALYSIS USING THE LOESS RESIDUALS FLOW-ADJUSTED METHOD

Each Analyte

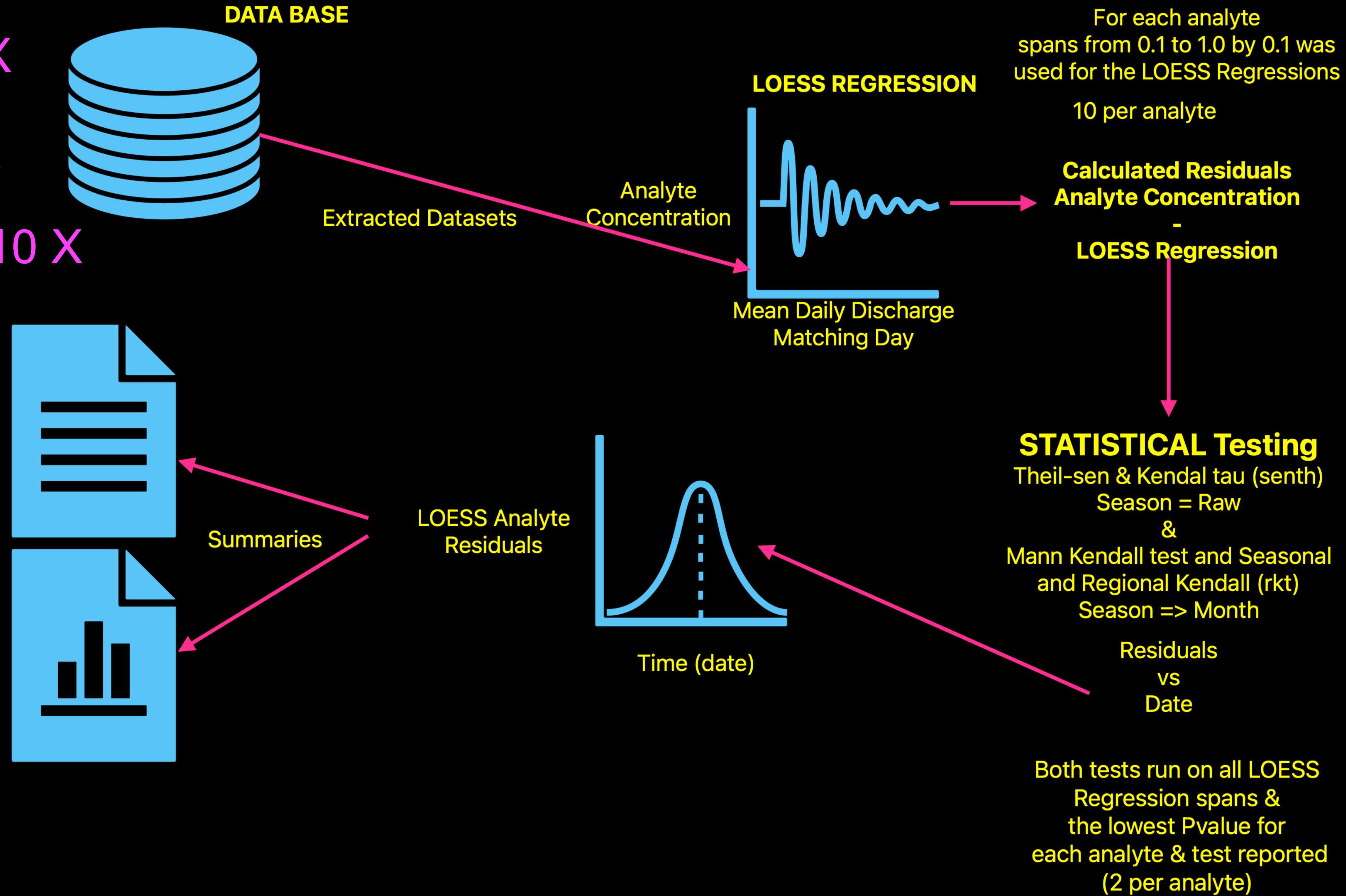
0.2 to 1.0

senh => 5X

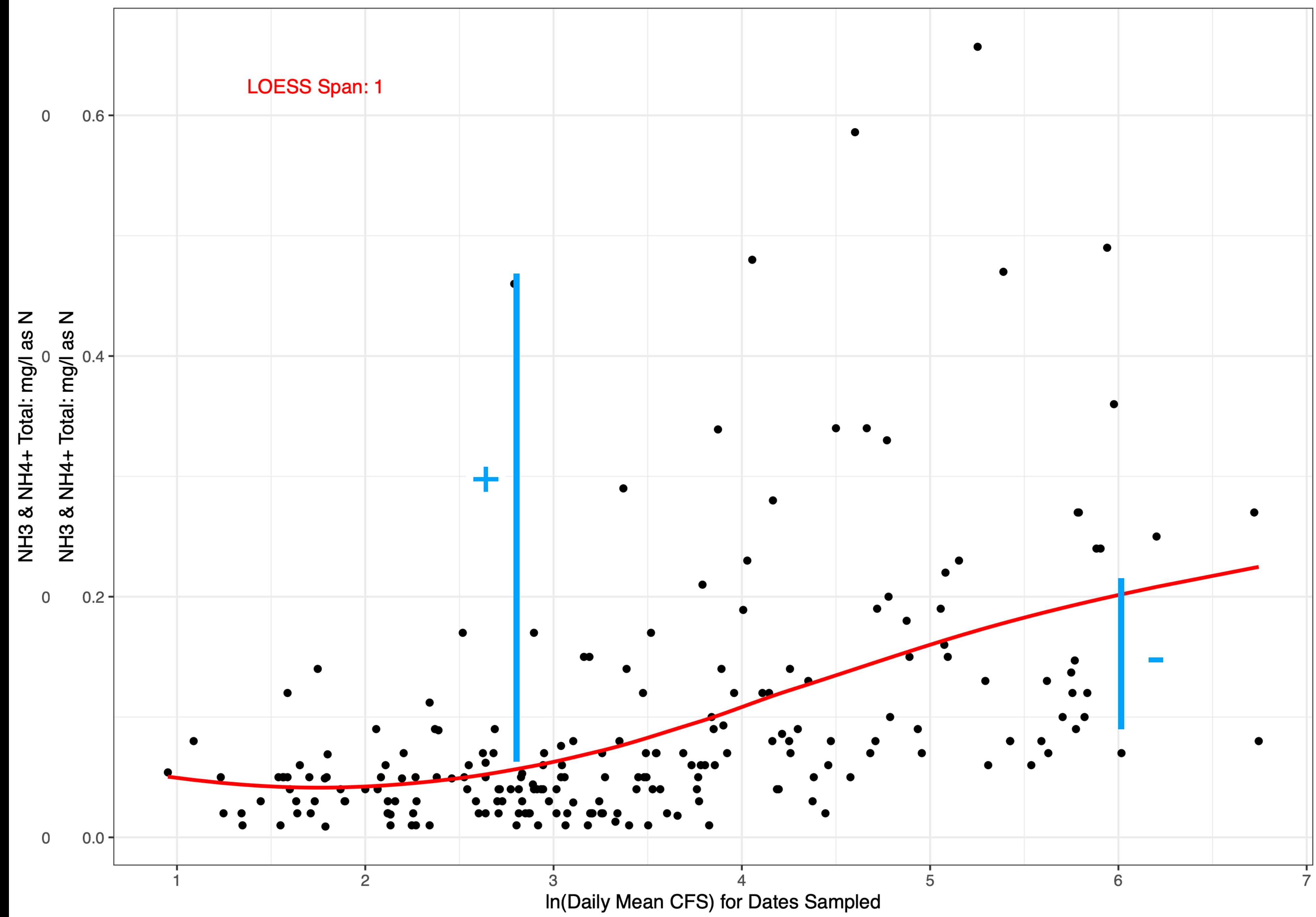
rkt => 5X

Station => 10 X

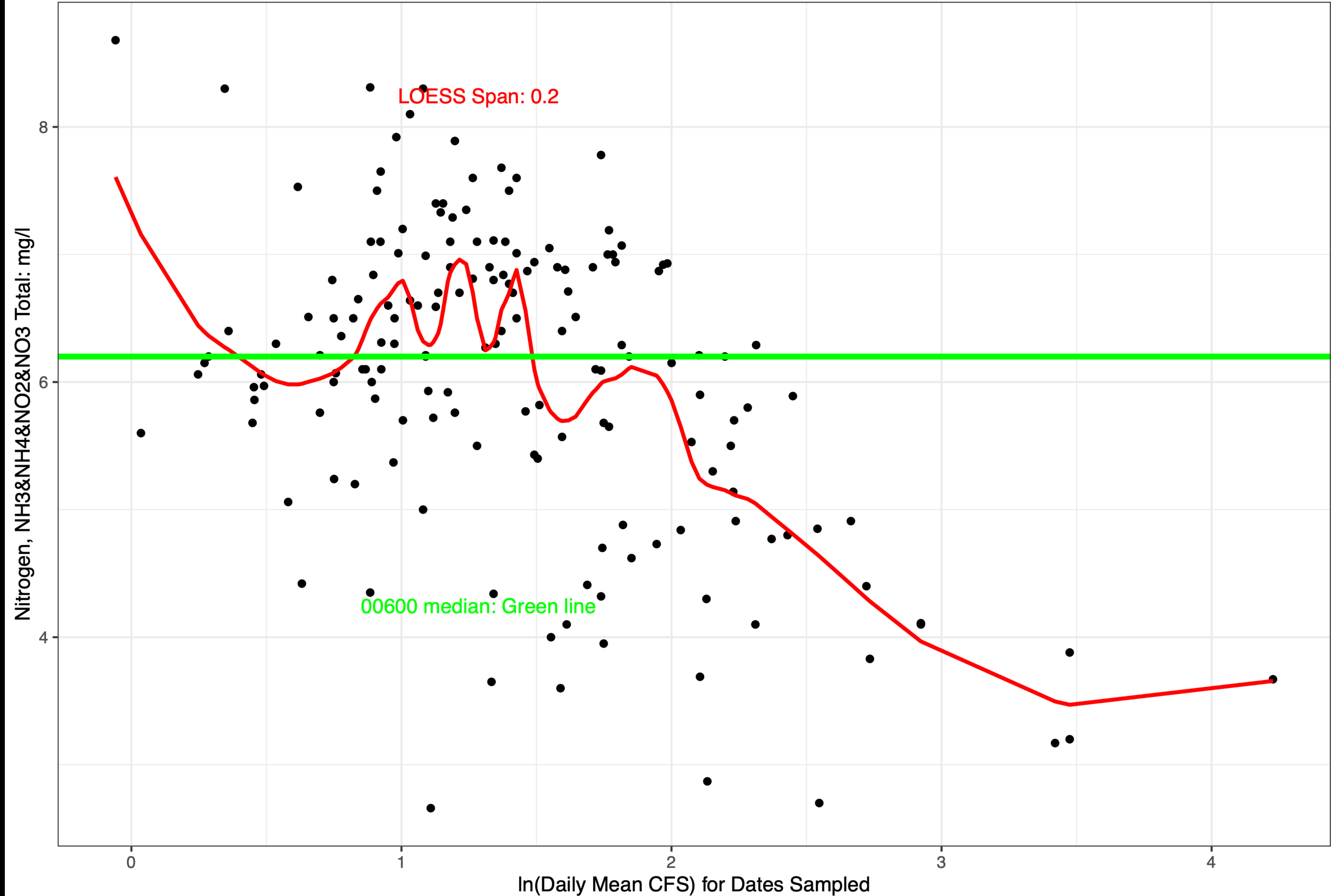
by 0.2



Concentration on ln(Daily Mean CFS) for dates sampled

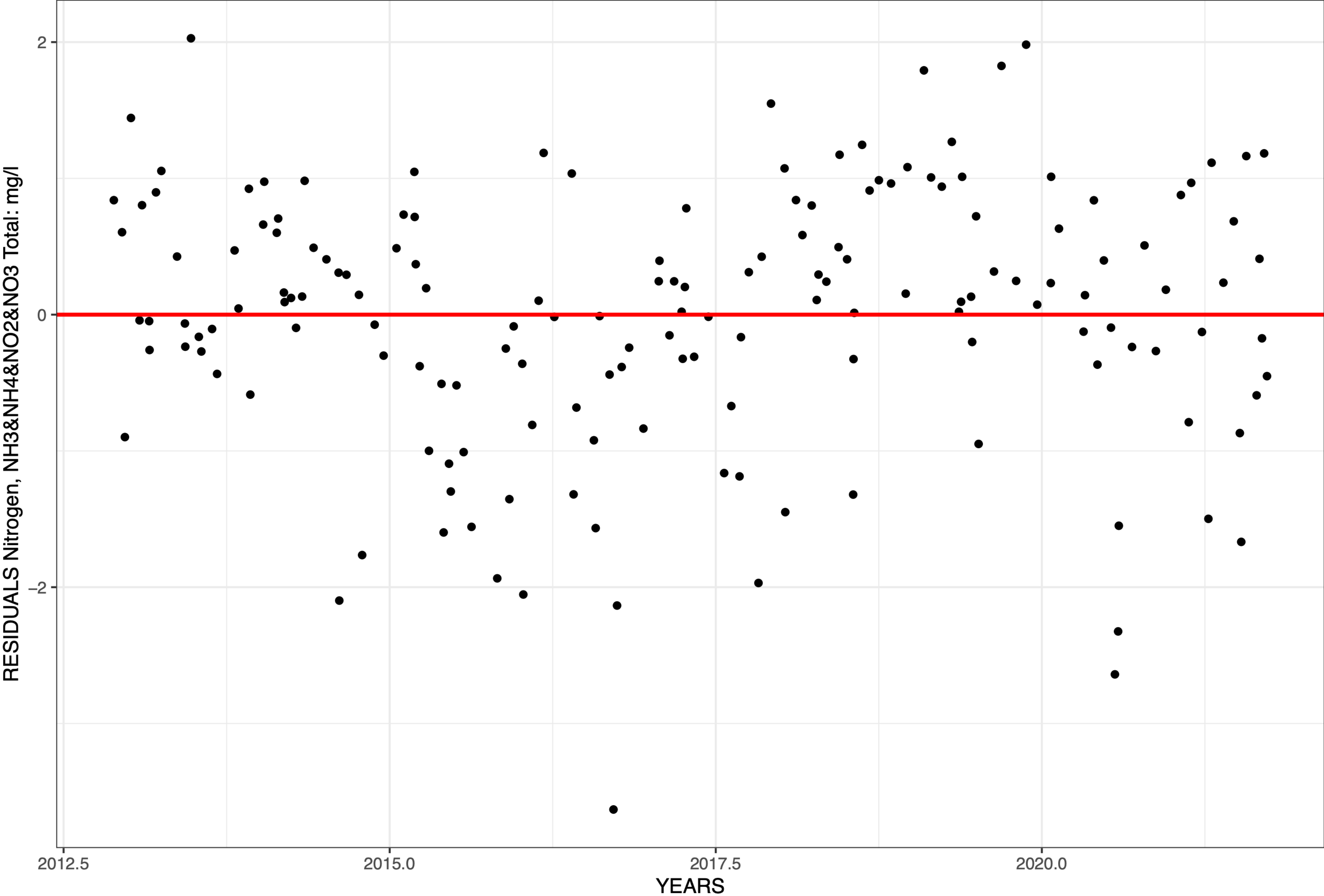


Quittapahilla Creek near Bellegrove, PA: USGS-01573160  
Nitrogen, NH3&NH4&NO2&NO3 Concentration on ln(Daily Mean CFS): LOESS Residuals on Year



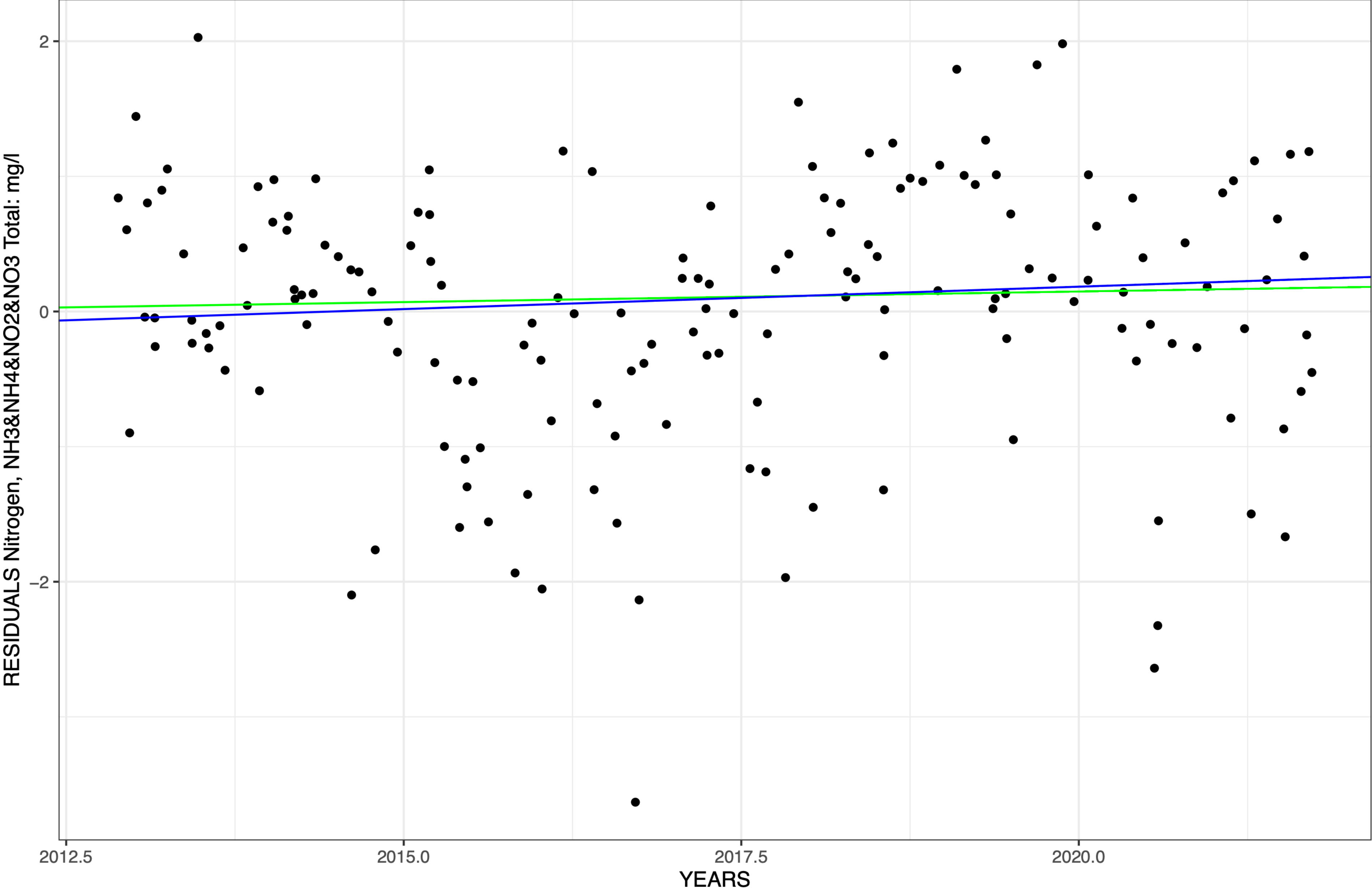
Quittapahilla Creek near Bellegrove, PA: USGS-01573160

Nitrogen, NH3&NH4&NO2&NO3: mg/l Residuals on Year



Quittapahilla Creek near Bellegrove, PA: USGS-01573160

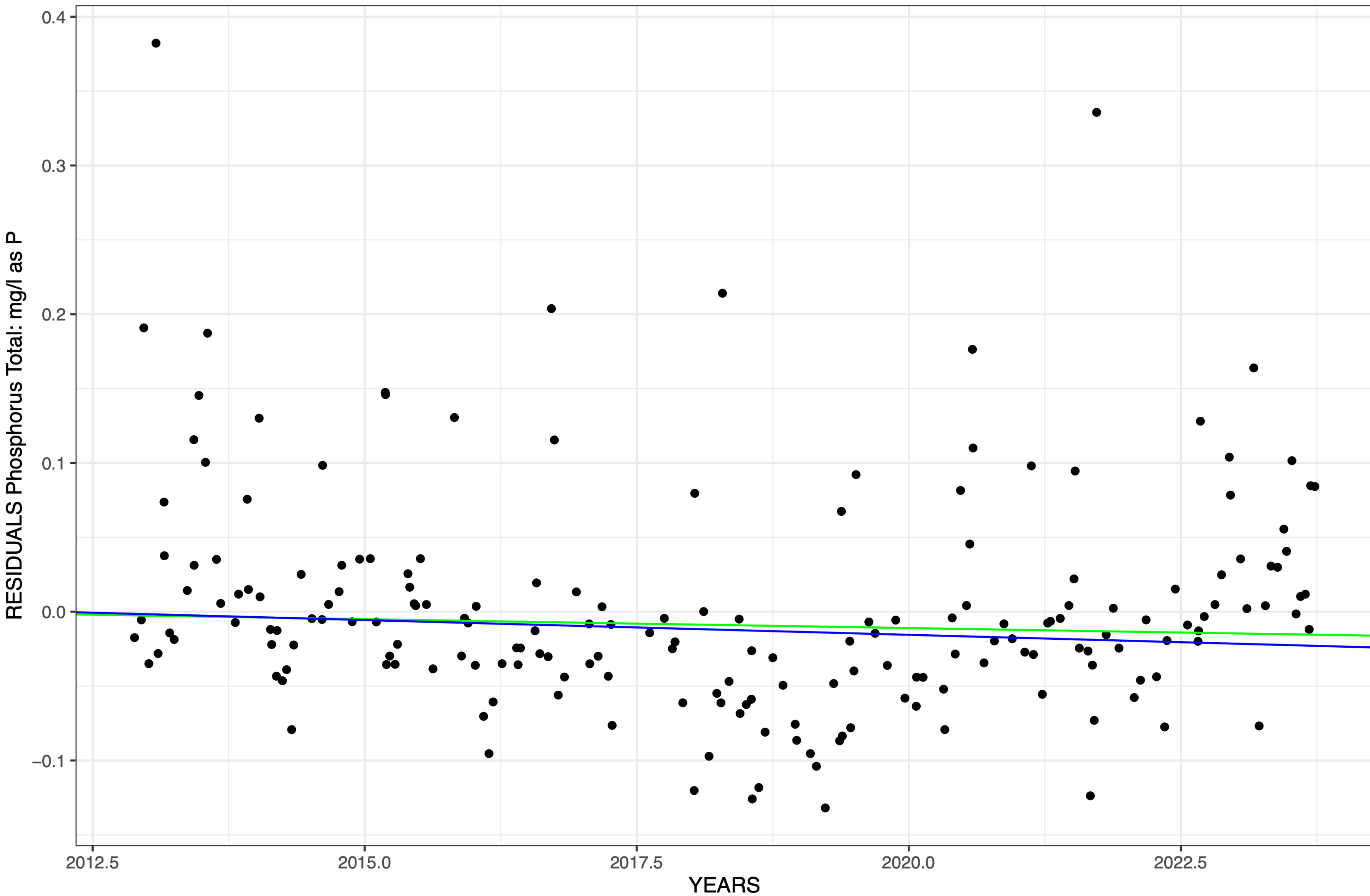
Nitrogen, NH3&NH4&NO2&NO3: mg/l Residuals on Year



TWO SIDED: 95% P\_VALUE 0.05: span: 0.2: Degree: 2: Run: 2025-08-17  
GREEN Test: senh: Intercept: -31.868: Slope: 0.016: p\_value: 0.555: Calendar: raw  
BLUE Test: rkt: Intercept: -67.008: Slope: 0.033: p\_value: 0.17: Calendar: month

Quittapahilla Creek near Belle Grove, PA: USGS-01573160

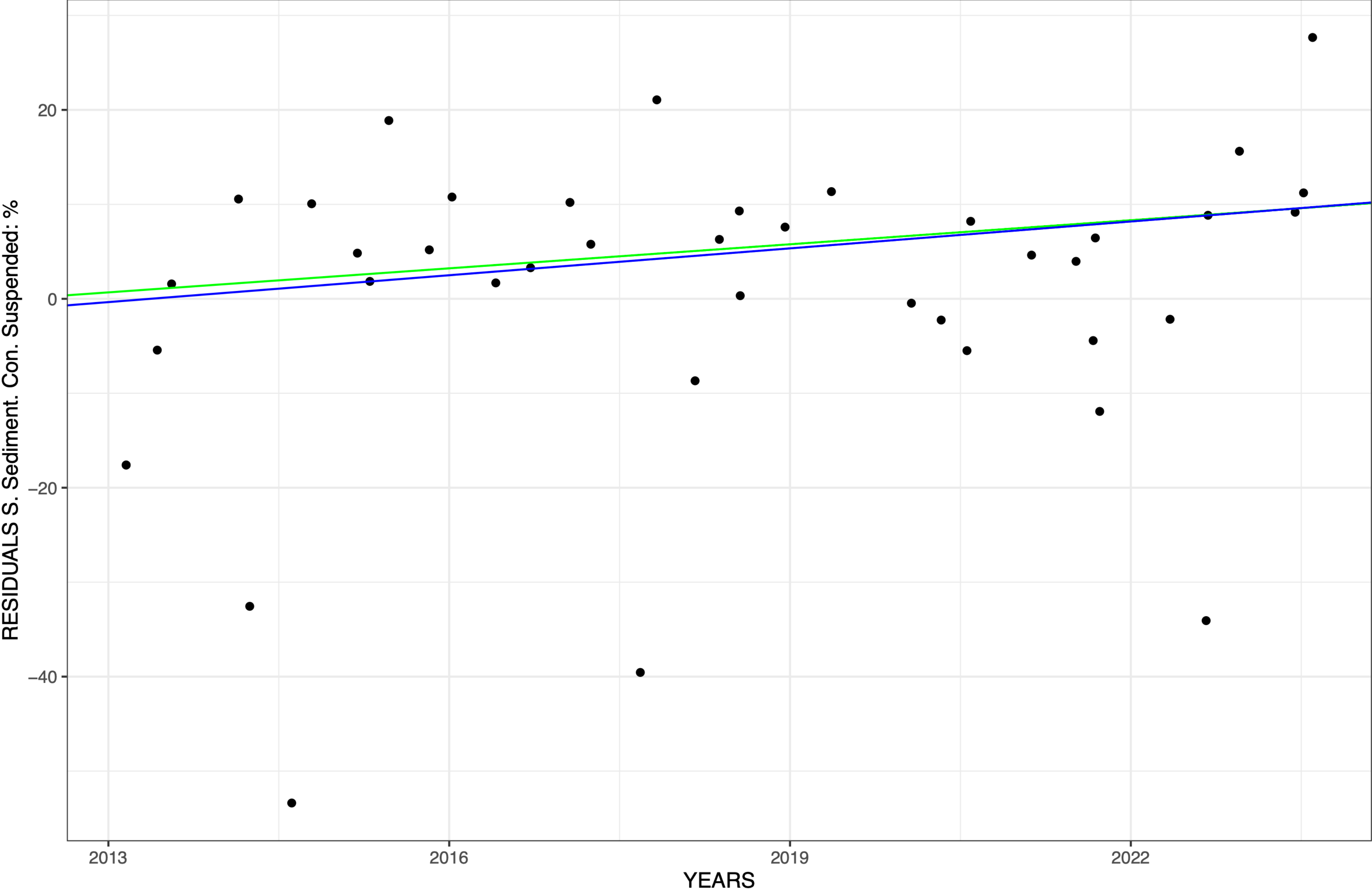
Phosphorus: mg/l as P Residuals on Year



TWO SIDED: 95% P\_VALUE 0.05: span: 1: Degree: 2: Run: 2025-08-17  
GREEN Test: senh: Intercept: 2.409: Slope: -0.001: p\_value: 0.295: Calendar: raw  
BLUE Test: rkt: Intercept: 3.995: Slope: -0.002: p\_value: 0.155: Calendar: month

Quittapahilla Creek near Bellegrove, PA: USGS-01573160

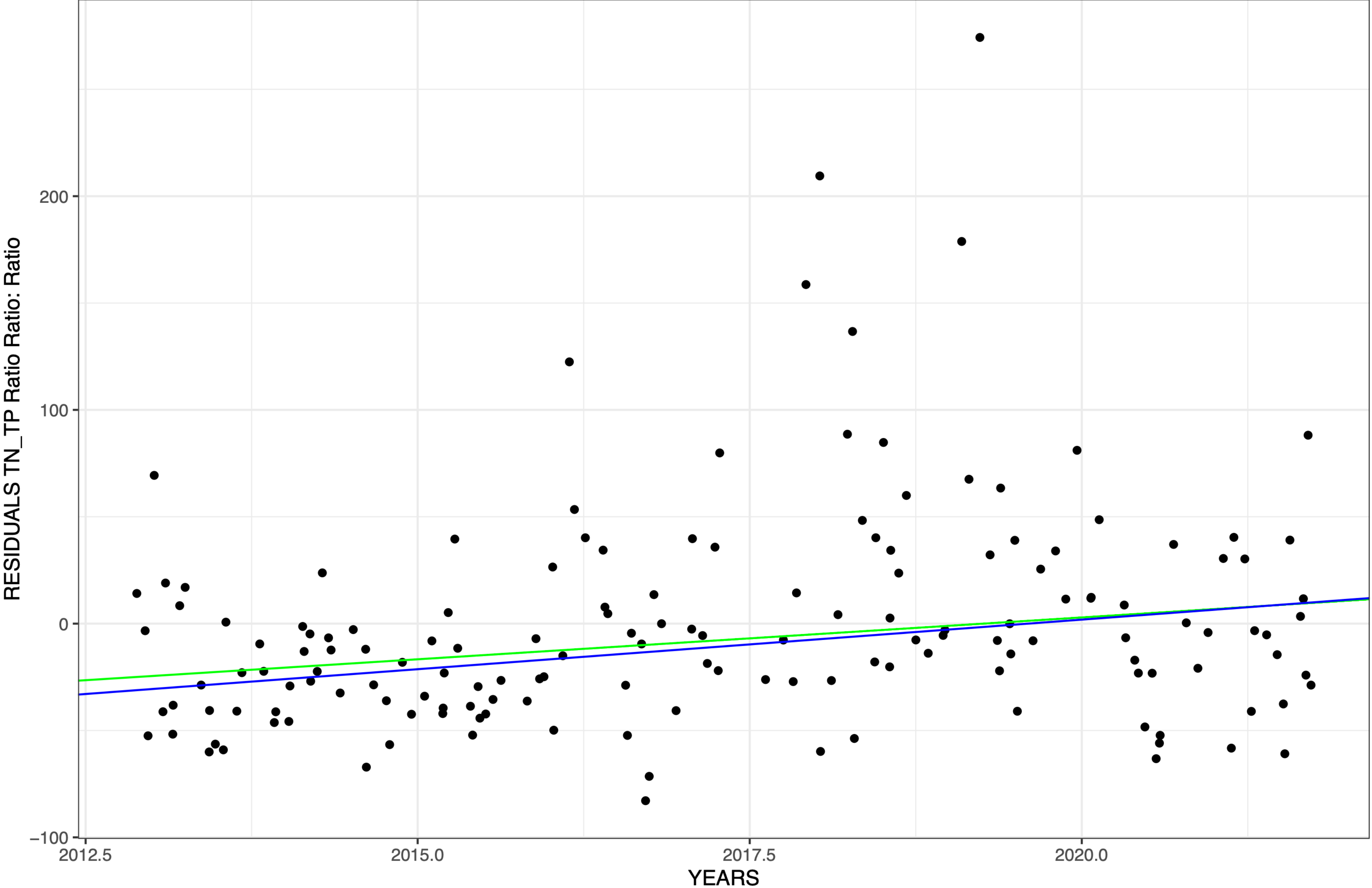
S. Sediment. Con.: % Residuals on Year



TWO SIDED: 95% P\_VALUE 0.05: span: 0.6: Degree: 2: Run: 2025-08-17  
GREEN Test: senh: Intercept: -1711.646: Slope: 0.851: p\_value: 0.106: Calendar: raw  
BLUE Test: rkt: Intercept: -1911.657: Slope: 0.949: p\_value: 0.32: Calendar: month

Quittapahilla Creek near Bellegrove, PA: USGS-01573160

TN\_TP Ratio: Ratio Residuals on Year



TWO SIDED: 95% P\_VALUE 0.05: span: 1: Degree: 2: Run: 2025-08-17  
GREEN Test: senh: Intercept: -7925.616: Slope: 3.925: p\_value: 0: Calendar: raw  
BLUE Test: rkt: Intercept: -9375.504: Slope: 4.642: p\_value: 0: Calendar: month

# LOESS Flow Adjusted Trend Test of Selection Stations & Analytes

Two-sided Theil-sen [senth] & Seasonal Kendall (rkt)

| Analyte                                 | unit      | Test  | Season | Test    | Intercept | Slope   | p_value | Span | CL          |
|-----------------------------------------|-----------|-------|--------|---------|-----------|---------|---------|------|-------------|
| Quittapahilla Creek near Bellegrove, PA |           |       |        |         |           |         |         |      |             |
| Nitrogen, NH3&NH4&NO2&NO3               | mg/l      | rkt   | month  | 2-sided | −67.008   | 0.033   | 0.170   | 0.2  | 90%<=CL<95% |
| Nitrogen, NH3&NH4&NO2&NO3               | mg/l      | senth | raw    | 2-sided | −31.868   | 0.016   | 0.555   | 0.2  | 80%<=CL<90% |
| Phosphorus                              | mg/l as P | rkt   | month  | 2-sided | 3.9946    | −0.0020 | 0.155   | 1.0  | 90%<=CL<95% |
| Phosphorus                              | mg/l as P | senth | raw    | 2-sided | 2.4094    | −0.0012 | 0.295   | 1.0  | 80%<=CL<90% |
| S. Sediment. Con.                       | %         | rkt   | month  | 2-sided | −1,911.7  | 0.95    | 0.320   | 0.6  | 80%<=CL<90% |
| S. Sediment. Con.                       | %         | senth | raw    | 2-sided | −1,711.6  | 0.85    | 0.106   | 0.8  | 90%<=CL<95% |
| TN / TP Ratio                           | NA        | rkt   | month  | 2-sided | −9,375.5  | 4.6     | 0.000   | 1.0  | 95%<=CL     |
| TN / TP Ratio                           | NA        | senth | raw    | 2-sided | −7,925.6  | 3.9     | 0.000   | 0.8  | 95%<=CL     |

Slopes >= 0.05 & <= -0.5 Highlited: LOESS spans of 0.2; 0.4; 0.6; 0.8; 1.0 investigated & min p\_value reported

CHESAPEAKE BAY ACTIVITIES

SCIENCE

# Chesapeake Bay Water-Quality Loads and Trends

ACTIVE

By [Chesapeake Bay Activities](#)

January 1, 2016

<https://www.usgs.gov/centers/chesapeake-bay-activities/science/chesapeake-bay-water>

## Nontidal Monitoring Network Loads and Trends 2023

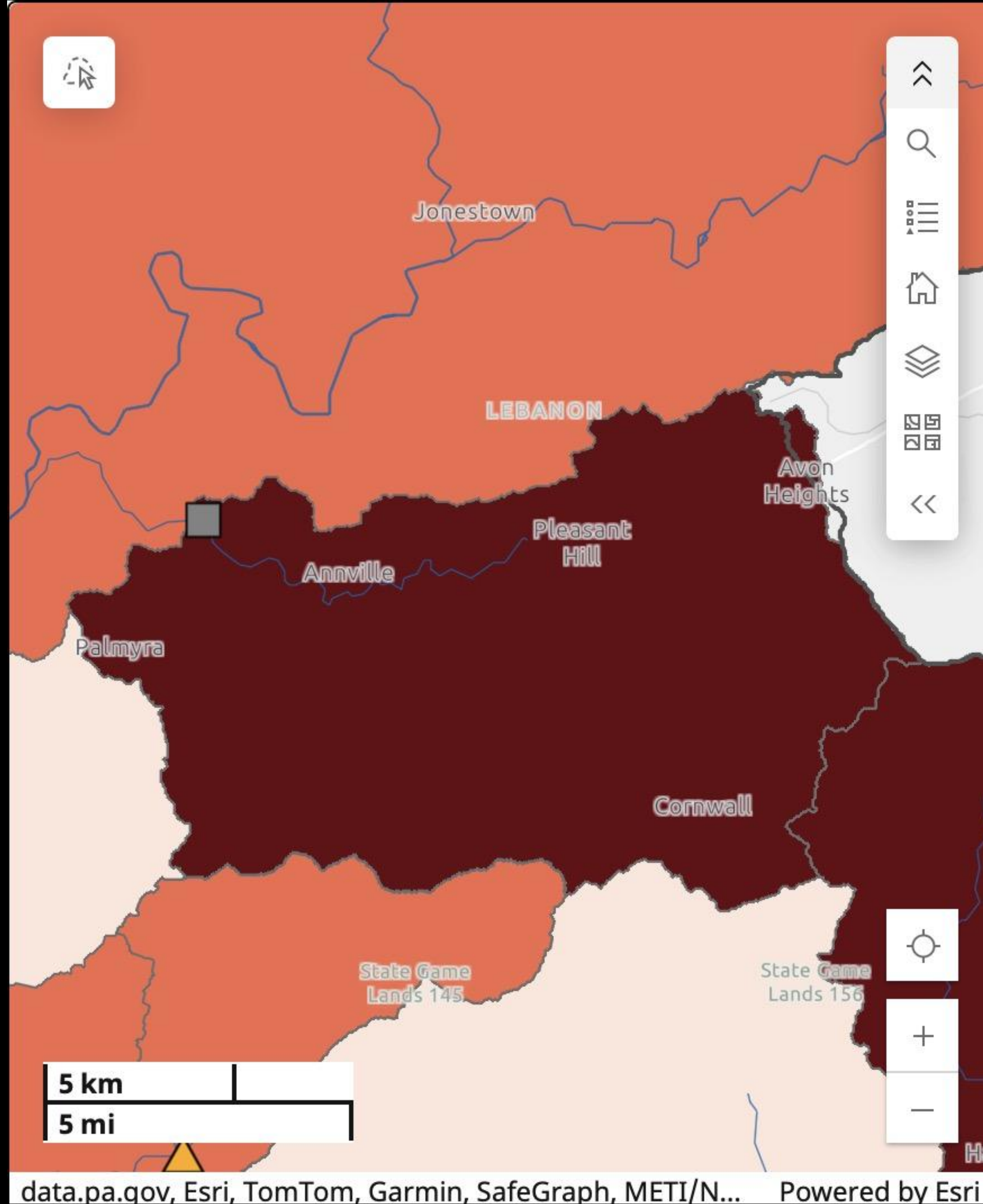
Explore Interactive Maps, View Results, and Query Data

**Total nitrogen trend direction, 2014 to 2023**

- ▲ Degrading
- ▼ Improving
- No Trend

**Total Nitrogen Average Load, in pounds per acre, 2014 to 2023**

- 0.0 to 7.0
- 7.1 to 14.0
- 14.1 to 21.0
- 21.1 to 28.0
- 28.1 to 35.0



**Total phosphorus trend direction, 2014 to 2023**

▲

 Degrading

▼

 Improving

■

 No Trend

**Total phosphorus average load, in pounds per acre, 2014 to 2023**

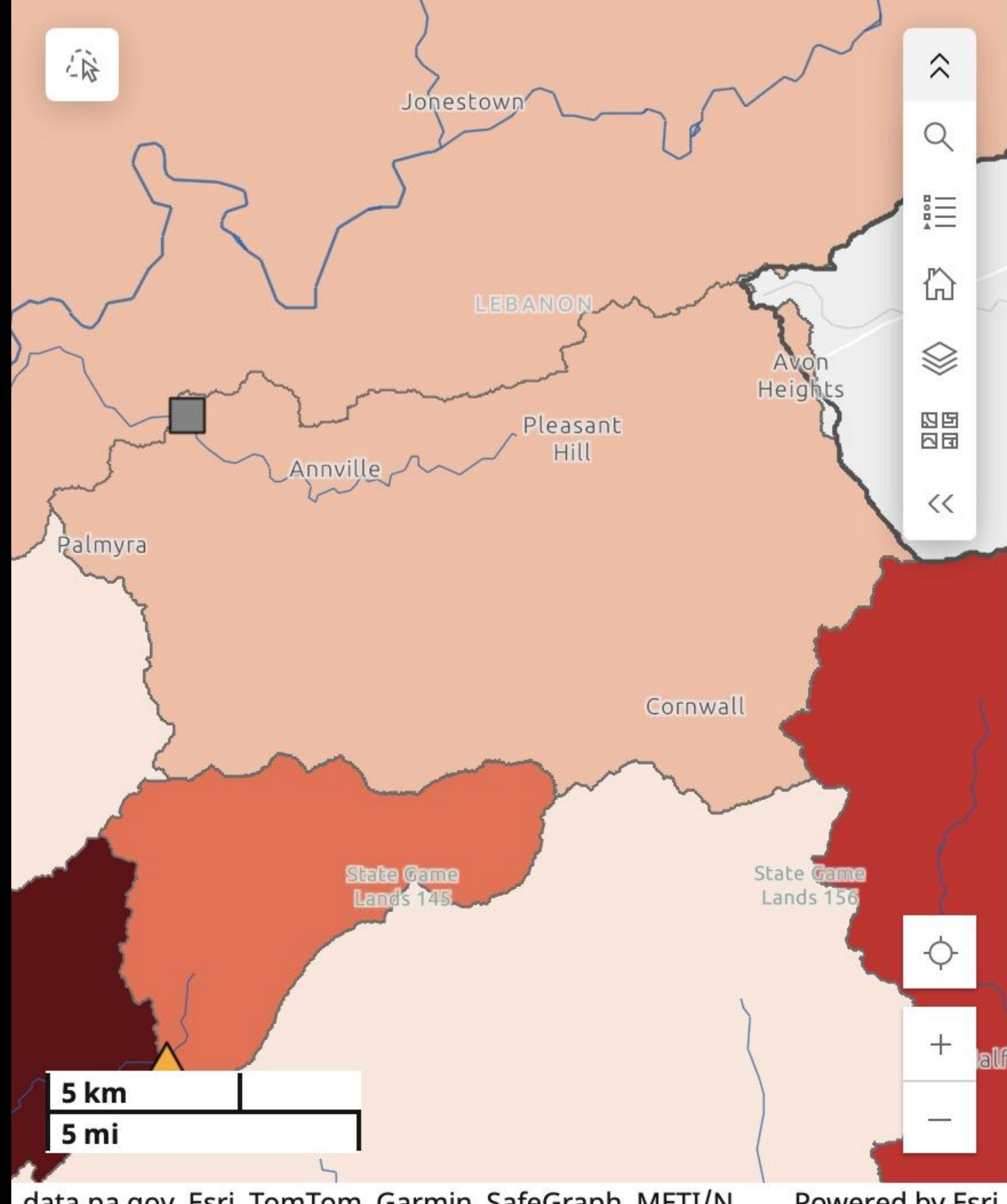
0.00 to 0.35

0.36 to 0.70

0.71 to 1.05

1.06 to 1.40

1.41 to 1.75



Legend

2023

▲ Degrading

▼ Improving

■ No Trend

Suspended sediment average load, in pounds per acre, 2014 to 2023

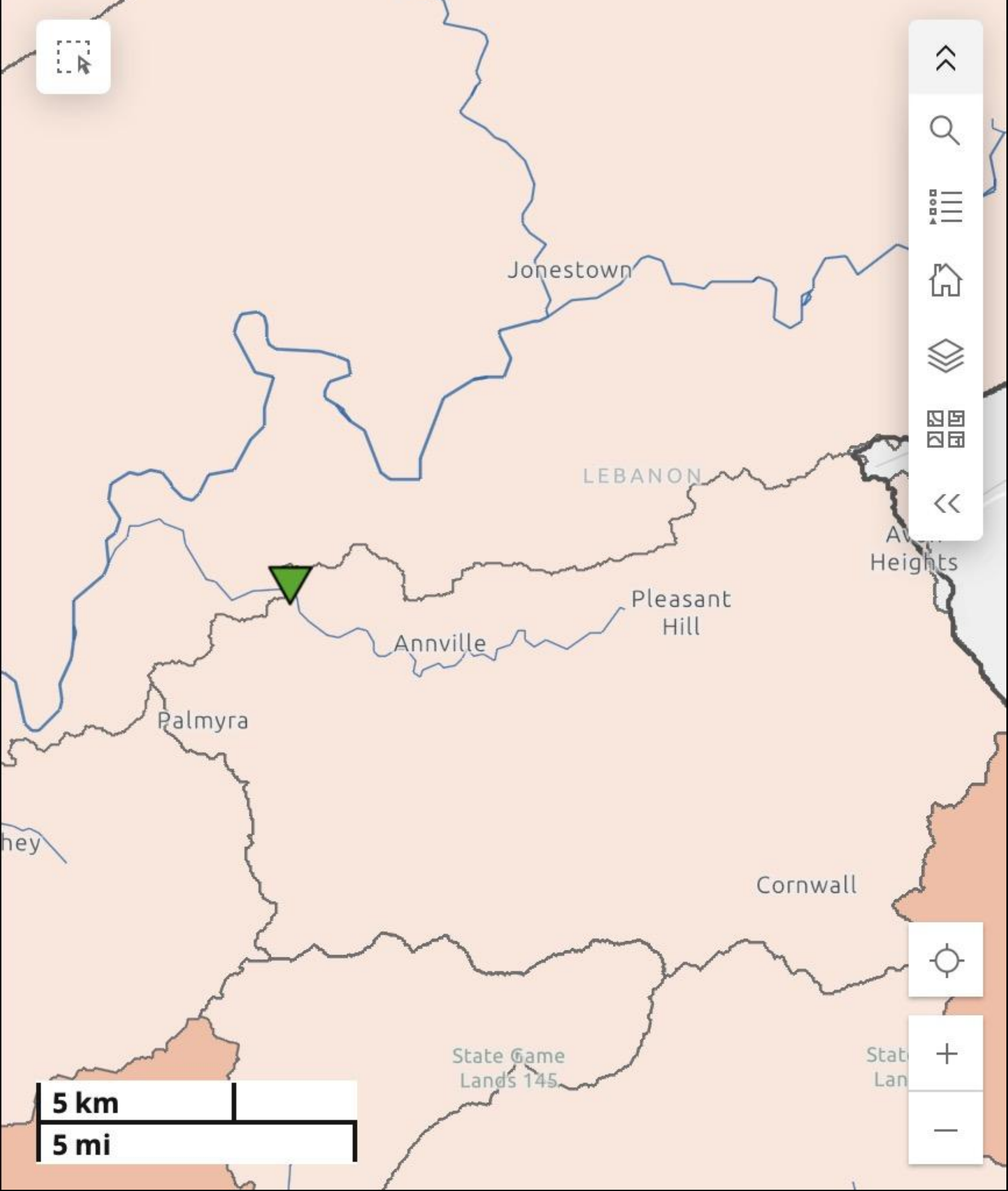
0 to 280

281 to 560

561 to 840

841 to 1,120

1,121 to 1,400

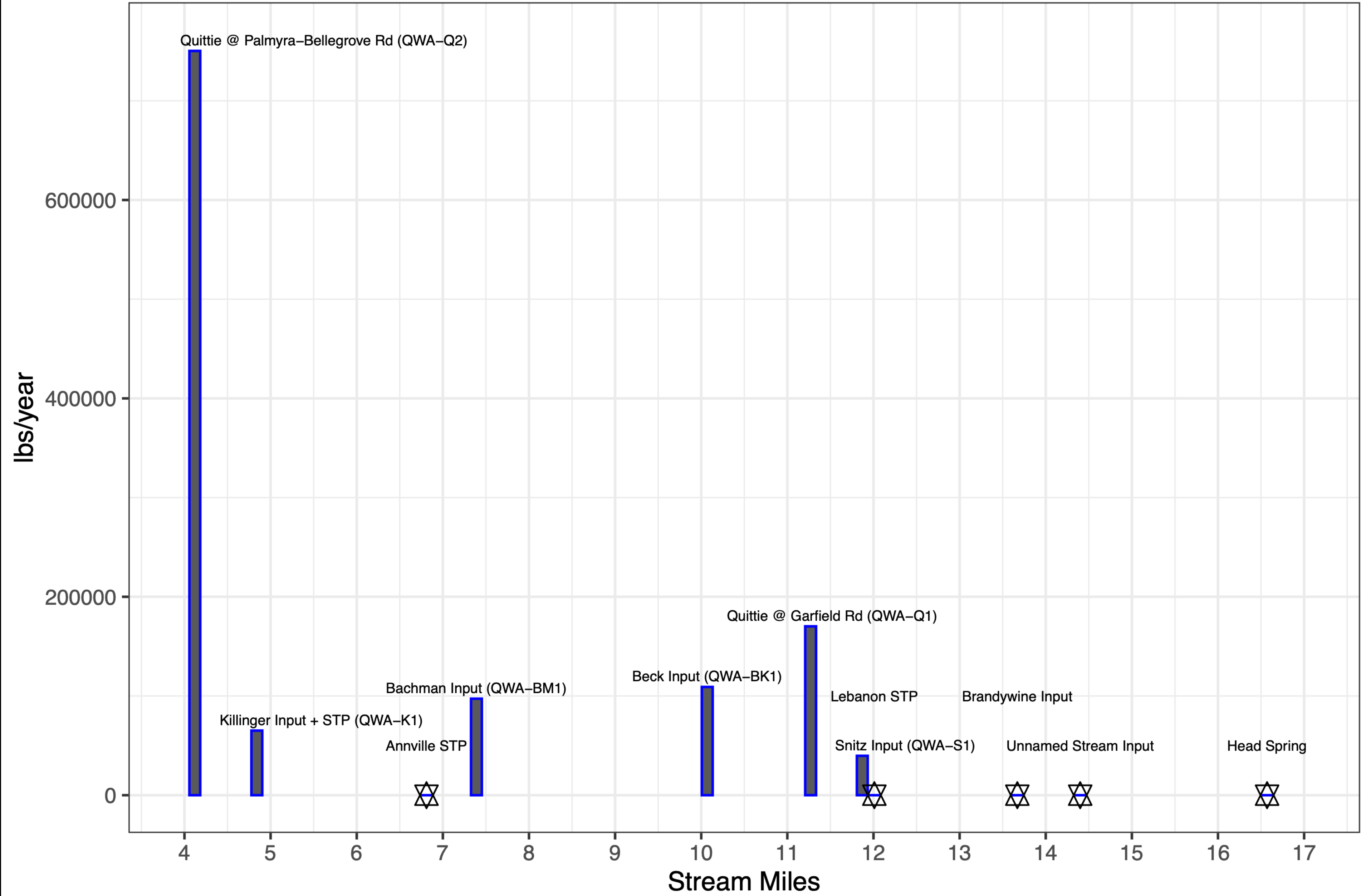


# Quittapahilla Creek nr Bellegrove, P A

| Analyte | WLO | USGS |
|---------|-----|------|
| TN@     |     |      |
| TP      |     |      |
| SS@     |     | ▼    |

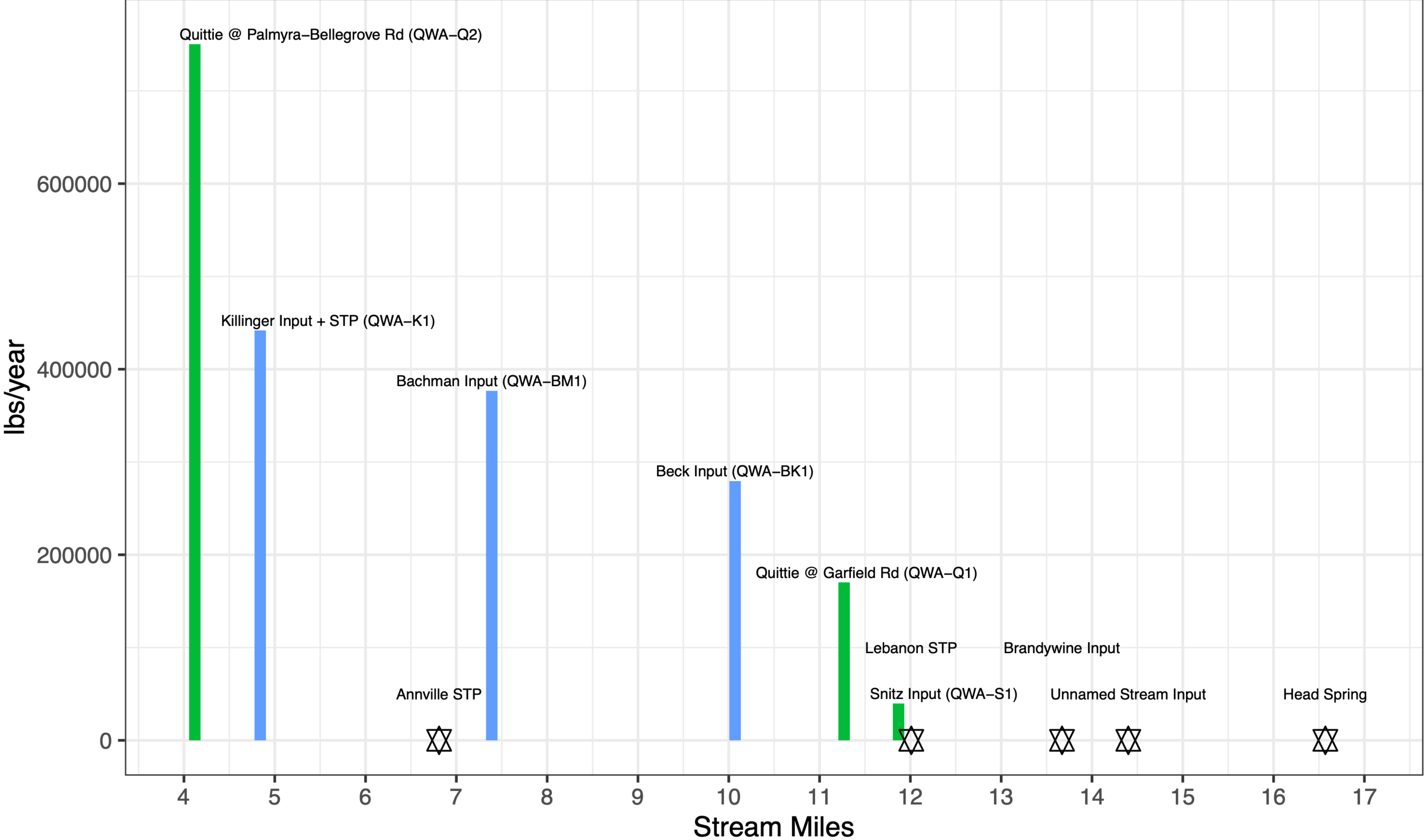
CL @ 95%: Author has 50% SS missing data: USGS 0% SS missing data: NWIS TN ended in 2022

Individual Station's Pollutant Loads for  
Total nitrogen [nitrate + nitrite + ammonia + organic-N], water, unfiltered, milligrams per liter



NOTE: Annville & N. Londerry STP Inputs are not accounted for until QWA-Q2

CUMULATIVE MEAN Quittie Pollutant Loads for  
Total nitrogen [nitrate + nitrite + ammonia + organic-N], water, unfiltered, milligrams per liter



NOTE: Annville & N. Londerry STP Inputs are not accounted for until QWA-Q2

QUESTIONS ?



Nitrogen

