TRENDS OF SEDIMENT AND NUTRIENT LOADS IN INDIANA WATERSHEDS

Component 1 of the Indiana Science Assessment to support the Indiana State Nutrient Reduction Strategy

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Acronyms

Ex	Exports sites
Im	Imports sites
In	Interior sites
EGRET	Exploration and Graphics for RivEr Trends
EPA	Environmental Protection Agency
FSMP	Fixed Station Water Quality Monitoring Program
FWMC	Flow-Weighted Mean Concentration
HTF	Hypoxia Task Force (Gulf of Mexico)
HUC	Hydrologic Unit Code
IANA	Indiana Agriculture Nutrient Alliance
ICP	Indiana Conservation Partnership
IDEM	Indiana Department of Environmental Management
ISDA	Indiana State Department of Agriculture
ISDH	Indiana State Department of Health
NWIS	National Water Information System
SNRS	State Nutrient Reduction Strategy
SSC	Suspended Sediment Concentration
TN	Total Nitrogen
TNC	The Nature Conservancy
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey
WBT	WRTDS Bootstrap Test
WLEB	Western Lake Erie Basin
WQ	Water Quality
WRTDS	Weighted Regressions on Time, Discharge, and Season
WWTP	Wastewater Treatment Plant

A. Introduction

Eutrophication, or nutrient enrichment of waters, is a concern in many parts of the United States. Nutrients are an essential part of the water system for plant and animal life, however when there is an excess of nutrients, such as nitrogen and phosphorus in aquatic ecosystems, there is the potential for water quality impairments such as hazardous algal blooms and oxygen depleted water, called hypoxia. Excess nutrients come from many non-point and point sources including failed septic systems, land-disturbing activities, stormwater runoff from residential areas and agricultural lands, and waste-water treatment plants (WWTPs). To reduce the quantity of nutrients in Indiana's waters, the Indiana State Department of Agriculture (ISDA) and the Indiana Department of Environmental Management (IDEM) in consultation with some members of the Indiana Conservation Partnership (ICP) and other partners in the state, such as the Indiana Agriculture Nutrient Alliance (IANA) and the United States Geological Survey (USGS) have developed the State Nutrient Reduction Strategy (SNRS). (Indiana Conservation Partnership, 2021)

The Indiana Science Assessment was created to help carry out the SNRS. Specifically, it was created to address two critical needs. (Indiana Science Assessment Core Team, 2019)

> **Component 1**: Determine historic and ongoing nutrients loads leaving and entering the state, and by watershed basins used in the State Nutrient Reduction Strategy (Figure 1) and;
>
> **Component 2**: Improve the method to quantify nutrient reductions from conservation practices, including dissolved nutrients, and determine efficiency of agricultural conservation practices in reducing loads.

The first component is the objective of this report.

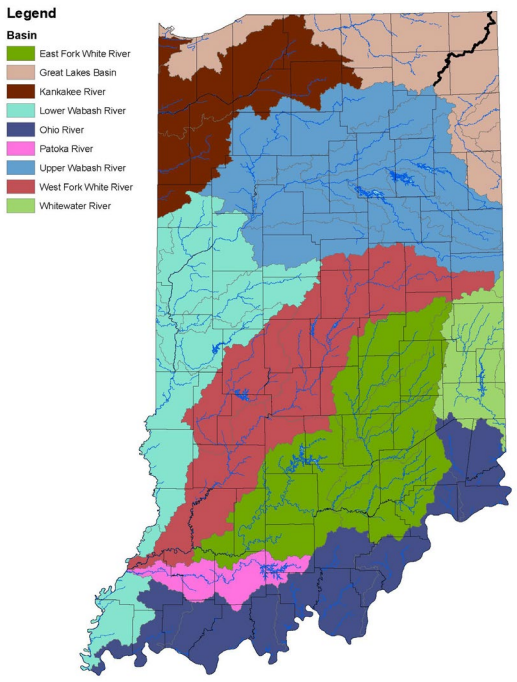

Figure 1 – Indiana's Major River and Lake Basins

The major drainage basins are monitored probabilistically and assessed statistically by IDEM on a nine-year rotating basin schedule to determine if waters are meeting their designated uses and/or water quality standards.

Three water quality constituents were chosen to meet the objectives outlined by Component 1 of the Indiana Science Assessment: total nitrogen, total phosphorus, and total suspended solids. Long term water quality monitoring data from the IDEM Fixed Station network and the USGS stream gaging network were compiled for key locations along the state borders and within each major river basin in the state. Water quality monitoring data was evaluated using the USGS Weighted Regressions on Time, Discharge, and Season (WRTDS) model to determine trends in nitrogen, phosphorus, and sediment loads and concentrations. The time period of data used in this trend analysis is based on the best data that we have available at this time. Originally the desire was to mirror the baseline period of the Gulf of Mexico Hypoxia Task Force (HTF) which is 1980-1996, however this is not possible due to the timeframe of the available data.

Analyzing water quality monitoring information to determine loading and trends within each of the basins in the state will help show the current state of Indiana's water quality and will further help in prioritizing watersheds for more targeted conservation efforts in the future.

Project Objectives

1. Better understand long term trends of water quality related to nutrients entering and exiting the state.
2. Better understand trends of water quality related nutrients within the state.
3. Document the data compilation, processing, and statistical methods used for the project.
4. Document the statewide and basin site-specific trend results.

B. Site Selection

Site selection was based on the goals of this project, within the constraints of approximately collocated IDEM fixed station locations and USGS streamflow gages. To be considered approximately collocated, a fixed station site and a streamflow gage are required to have within 10% drainage area ratios, and discharge data was adjusted by the drainage area ratio. Key locations were chosen within the state's basins, as well as those sites leaving the state and entering the state.

Indiana has three major drainage areas, known as 4-digit HUC[1] watersheds (Figure 2):

- the Mississippi River Basin (shown in blue)
- the Lake Michigan Basin (shown in yellow)
- the Western Lake Erie Basin (shown in green)

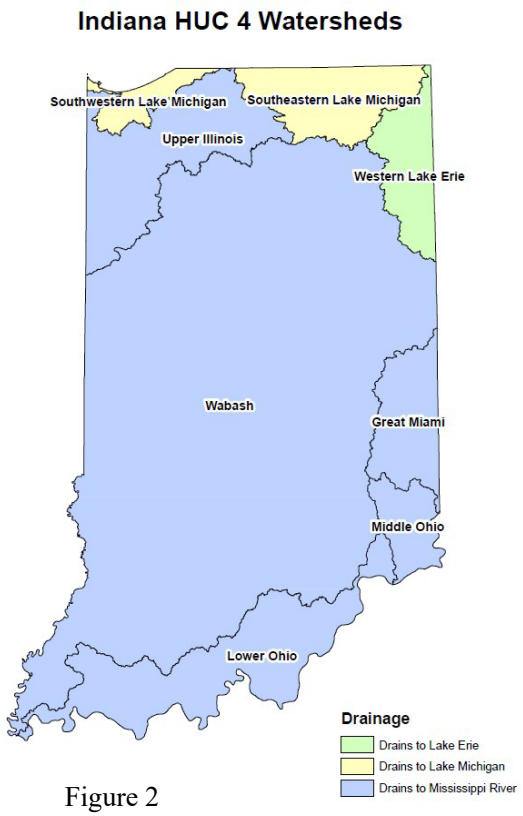

Figure 2

[1] Hydrologic unit codes (HUC) are a way of identifying all of the drainage basins the United State in a nested arrangement from largest (Regions) to smallest (Cataloging Units). The term watershed is often used in place of drainage basin. The smaller the HUC number, the larger the drainage area.

Key site locations were selected as close to the downstream export of each major basin to capture the major exports from each basin. Sites were also selected to capture the exports from basins interior to the state. There are nine site locations or pour points near or at the state border that act as **exports (Ex)**. There are three site locations or pour points that are entering the state of Indiana and are located along the northeast border of Indiana and are referred to as **imports (Im)**. There are eight site locations within the state's major river basins that are referred to as **interior (In)** sites. Refer to Table 1 and Figure 3.

Table 1: List of sites used in analysis

Map ID	USGS Site Name	Sub-Watershed	Type
Mississippi River Basin			
Ex1	Wabash River at New Harmony, IN	Wabash River	Export
Ex2	Kankakee River at Shelby, IN	Kankakee River	Export
Ex3	Whitewater River at Brookville, IN	Whitewater River	Export
Ex4	Iroquois River near Iroquois, IL	Kankakee River	Export
Ex5	Blue River near White Cloud, IN	Ohio River	Export
Im1	Wabash River at Linn Grove, IN	Wabash River	Import
Im2	Mississinewa River near Ridgeville, IN	Wabash River	Import
In1	Wabash River at Riverton, IN	Middle and Lower Wabash	Interior
In2	Wabash River at Lafayette, IN	Upper Wabash	Interior
In3	Wildcat Creek near Lafayette, IN	Middle Wabash	Interior
In4	White River at Petersburg, IN	White River	Interior
In5	East Fork White River at Shoals, IN	East Fork White River	Interior
In6	White River at Newberry, IN	West Fork White River	Interior
In7	Patoka River at Winslow, IN	Patoka River	Interior
Lake Michigan Basin			
Ex6	St. Joseph River at Niles, MI	Lake Michigan	Export
Ex7	Burns Ditch at Portage, IN	Lake Michigan	Export
Ex8	Trail Creek at Michigan City, IN	Lake Michigan	Export
Western Lake Erie Basin			
Ex9	Maumee River at New Haven, IN *(used with SR101 in IN near IN/OH State Line)*	Maumee River	Export
Im3	St Joseph River near Newville IN	St. Joseph River	Import
In8	Maumee River at New Haven, IN	Maumee River	Interior

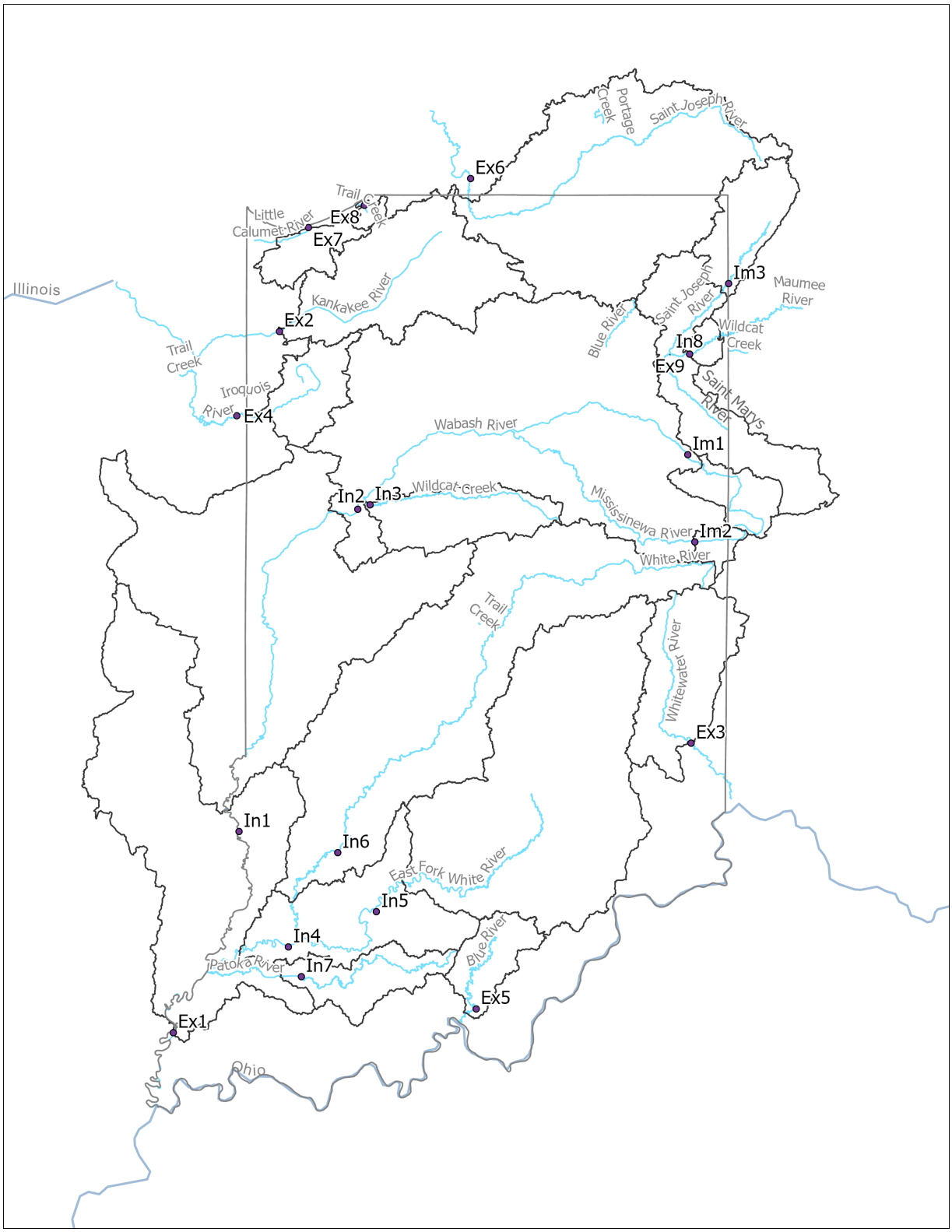

Figure 3 – USGS streamflow gages and associated drainage areas for all sites.

Figure 3 shows the drainage areas for the USGS gages associated with each sampling site, and the drainage area for each watershed.

Selected Gages and Sampling Sites

Mississippi River Basin

The Mississippi River Basin is the largest major basin in Indiana. It drains the majority of the state either to Illinois through the Kankakee River System, into the Ohio River along the southern border of Indiana, or through the Wabash River System. The main rivers that drain Indiana in the Mississippi River Basin are the Wabash River, the Tippecanoe River, the White River, the Kankakee River, the Whitewater, and several smaller tributaries that drain to the Ohio River. This system drains approximately 90% of Indiana's 92 counties and consists of primarily agricultural land with many small towns and some cities located along the rivers. Fourteen sites were selected within the Mississippi River Basin, with five of those fourteen sites measuring loads leaving Indiana to the Mississippi River, two sites coming into Indiana, and seven sites measuring loads within Indiana watersheds (Figure 4).

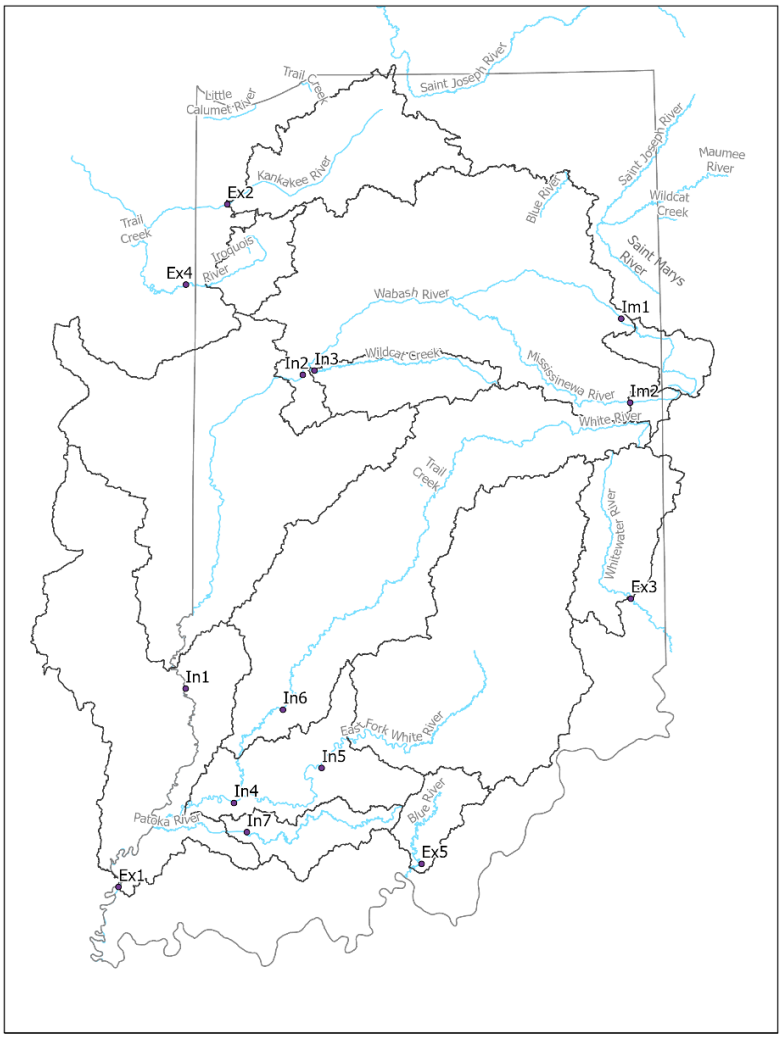

Figure 4 – Selected Sites with USGS streamflow gages and sampling sites and associated drainage areas in the Mississippi River Basin.

Figure 4 shows the sites in the Mississippi River Basin that were selected as potential candidates for trend analysis. Each site, designated by a dot, represents a water chemistry sampling location and associated USGS Streamflow gage. The drainage area for each site is outlined in black.

Lake Michigan Basin

The Lake Michigan Basin includes two noncontiguous watersheds that drain into Lake Michigan along the northern border of the state. It covers all or part of 10 Indiana counties, encompassing approximately 1,416,113 acres. The northwest portion is drained through the Grand Calumet and Little Calumet Rivers, Trail Creek, and Salt Creek and is made up of mostly urban areas. The northeast portion drains to Lake Michigan through the St. Joseph River System (different then the St. Joseph River in the Western Lake Erie Basin area), the Elkhart River, the Little Elkhart River, Pigeon River and Pigeon Creek. It consists of primarily agricultural land with small towns and cities located in the watershed.

Three sites were identified that export into Lake Michigan (Figure 5). Trail Creek at Michigan City had a gap in coverage of discharge data from the mid-1990s to the mid-2000s, and therefore it was not included in the Lake Michigan Basin trend, as later indicated in Section E.

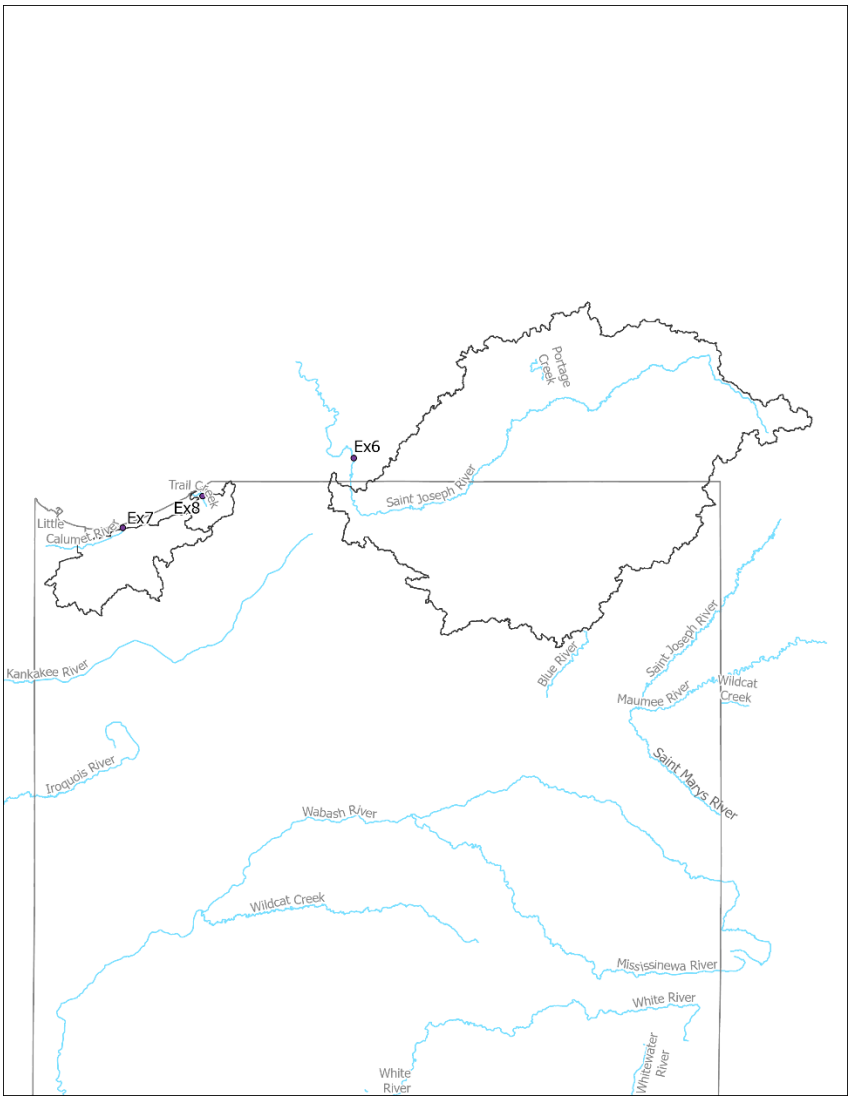

Figure 5 – Selected Sites with USGS streamflow gages and sampling sites and associated drainage areas in the Lake Michigan Basin.

Figure 5 shows the sites in the Lake Michigan Basin that were selected as potential candidates for trend analysis. Each site, designated by a dot, represents a water chemistry sampling location and associated USGS Streamflow gage. The drainage area for each site is outlined in black.

Western Lake Erie Basin

The Western Lake Erie Basin (WLEB) is the smallest of the basins and is located in the northeast part of the state, bordering Ohio and Michigan. It covers all or part of 6 Indiana counties, and approximately 3.5% of Indiana drains to Lake Erie. The main rivers that drain the WLEB area in Indiana are the St. Joseph River, the St. Marys River, and the Upper Maumee River. The St. Joseph River and the St. Marys River enter Indiana from Ohio and then come together in Fort Wayne, IN to form the Maumee River that drains back into and through Ohio and eventually empties into the western basin of Lake Erie at Toledo, Ohio. Three sites were selected for this basin, with one being an export, one being an import, and one being an interior site that measures the impact from Fort Wayne, Indiana. (Figure 6)

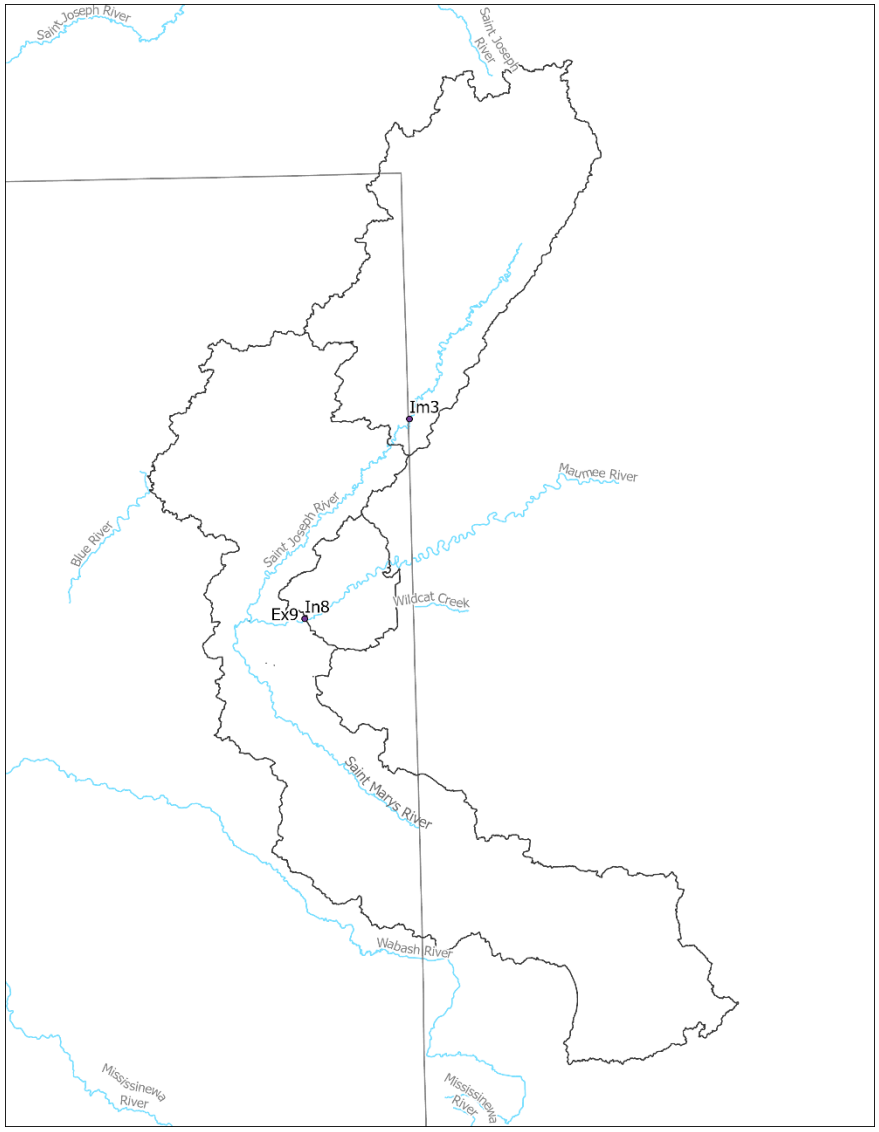

Figure 6 – Selected Sites with USGS streamflow gages and sampling sites and associated drainage areas in the Western Lake Erie Basin.

Figure 6 shows the sites in the Western Lake Erie Basin that were selected as potential candidates for trend analysis. Each site, designated by a dot, represents a water chemistry sampling location and associated USGS Streamflow gage. The drainage area for each site is outlined in black.

C. Methods & Data

Water Quality Data

Water quality data for this project was provided by the Indiana Department of Environmental Management's (IDEM) Fixed Station Water Quality Monitoring Program (FSMP), and the USGS National Water Information System (NWIS).

The Fixed Station Network Monitoring Program was established in 1957 with 49 sites located upstream and downstream of major wastewater treatment outfalls and near drinking water intakes. Since that time, sampling has increased to 165 sites statewide. This program collects monthly water quality samples to provide basic ambient water quality data for assessment of the major rivers of Indiana. This data can be used to determine long-term water quality trends. Using data from 57 of these sites co-located with a USGS stream flow gage, the USGS in 2014 published its *Water Quality in Indiana: Trends in Concentrations of Selected Nutrients, Metals, and Ions in Streams, 2000-2010*. This project analyzes data from the period 1965-2020 and focuses on a subset of 12 of the FSMP close to the state border that represent water flowing out of or into the state. Due to the long running nature of the program various changes and improvement have been made over the years.

Water Quality Constituents

As mentioned before, three water quality constituents were chosen to be analyzed as part of this project: total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS).

Total nitrogen is the sum of total kjeldahl nitrogen (ammonia, organic and reduced nitrogen) and nitrate-nitrite. Total nitrogen can be derived by analyzing for organic nitrogen compounds, free-ammonia, and nitrate-nitrite individually and adding the components together. (US EPA, 2013) Total nitrogen was not measured directly by the Indiana FSMP. Generally total kjeldahl nitrogen and nitrogen nitrate-nitrite were measured. During some timeframes, organic nitrogen compounds, free ammonia, and nitrate-nitrite were measured. For the purposes of this project total nitrogen was calculated by the sum of its constituents. Total nitrogen samples were considered equivalent regardless of the constituents used in their calculation.

Total phosphorus was measured directly by the Indiana FSMP. Water quality data for the Indiana FSMP is analyzed by the Indiana State Department of Health (ISDH) Environmental Lab in accordance with pre-approved test methods. Specific analytical methods can be found in *IDEM's Fixed Station Water Quality Monitoring Program Work Plan*. (Beckman, 2020) Dissolved reactive phosphorus or DRP, which is a part of total phosphorus, was not measured at the sites until recently so it cannot be used in determining a trend.

Total suspended solids (TSS) represent, generally the portion of solids that can be removed by mechanical filtration and are a portion of the total solids in water. Total solids are made up of total suspended solids and total dissolved solids. TSS include a wide variety of materials such as silty soil, organic matter, and sewage or industrial waste. High levels of TSS near agricultural lands can be due to soil loss from erosion.

Streamflow Data

Streamflow data are often correlated with water quality data and must be accounted for during trend analysis. Streamflow data acts as an explanatory variable in the WRTDS model. The USGS National Water Information System (NWIS) is the source of streamflow data for this project. The NWIS contains a database of stream gage data of approximately 1.9 million sites across the country. This data can be accessed via the USGS online portal at https://waterdata.usgs.gov/nwis.

Loads and Concentrations

Load is the amount (mass) of a pollutant that is discharged into a water body during a period of time (i.e. tons of sediment per year). Concentration is the mass of a pollutant in a defined volume of water (for example, milligrams of phosphorus per liter, or PPM). The flow-weighted mean concentration (FWMC) is calculated by dividing the total load over the estimation time period by the total streamflow.

Weighted Regressions on Time, Discharge, and Season (WRTDS) Model

Weighted Regressions on Time, Discharge, and Season (WRTDS) is a statistical method for the analysis of surface water quality datasets. WRTDS was developed by the United States Geological Survey (USGS) to utilize robust long-term water quality monitoring datasets. WRTDS uses the weighted regressions of concentrations of water quality parameters on time, discharge (flow) and season. WRTDS normalizes loads to average flow conditions, providing a trend analysis of flow-normalized loads. It attempts to evaluate changes in nutrient loads and concentrations that are caused by factors other than changes in streamflow, such as land-use, management changes, and hydromodification. The USGS has compared WRTDS favorably to other trend estimation models, and broadly adopted it as the primary model for estimating water quality loads/fluxes. (Hirsch, 2010) Exploration and Graphics for RivEr Trends (EGRET), an R soft software package, was used to aggregate data and apply the WRTDS model.

WRTDS Bootstrap Test (WBT)

There is a degree of uncertainty with the estimates produced by WRTDS; the WRTDS Bootstrap Test (WBT) is used to quantify this uncertainty. Bootstrapping is a common method of describing the uncertainty of complex analysis (like WRTDS) that cannot be done with simple mathematical expressions. Generally, bootstrapping is a method that involves the random resampling of test data and subjecting that resampled data to the analysis. This process is repeated some number of times (default of 100 for WRTDS). A confidence interval is then determined from the upper and lower ends of the distribution of the bootstrapped estimates. A confidence interval is a range of values around an estimated parameter where there is a specified probability that the true value of the parameter falls within it. Confidence intervals are important for hydrologic data in that they provide a level of certainty about a modeled trend. For WRTDS, the 90% confidence interval is computed by interpolating the 5% and 95% quantiles of the cumulative distribution function of the bootstrap estimates. (Robert M. Hirsch ,. S., 2015)

The WRTDS bootstrap test uses the confidence interval to conduct a trend test, to determine the presence and direction of a trend in a dataset. If the change in the lower confidence interval multiplied by the change in the upper confidence interval is greater than zero, than it is concluded that there is a trend. In other words, if the lower bound of the confidence interval and the upper bound of the confidence interval are both increasing or decreasing, a trend is established. The direction of the trend

is based on sign (increasing or decreasing) of the original WRTDS trend. The WBT computes a statistic that is the equivalent of a P-value for determining the strength of evidence of a trend. (This is referred to as p-value). A smaller p-value indicates stronger evidence for the trend. Confidence intervals for WRTDS are calculated via the R-package EGRETci.

A WRTDS model and associated bootstrap test was calculated for each individual gage and sampling site pair. The largest amount of available overlapping water quality and discharge data was used for each analysis. The WBT was conducted for each applicable site from years 2005 to 2015. These years were chosen to capture a period that had overlapping data for the applicable sites, was close to contemporary, and did not include the start or end of the WRTDS trend period.

Data Screening & Criteria

Discharge data was evaluated for all sites to identify any discrepancies that could affect the trend analysis. The discharge data was screened for the following parameters: number of days of discharge data per year available, number of missing days per year, number of consecutive days with missing flow per year, number of days with a negative flow per year, and number of days with no flow per year. If the discharge data from a specific gage did not meet specifications for these parameters, it was not included for analysis.

Data for all water quality constituents was screened to ensure that it met criteria necessary to produce accurate WRTDS model results. Required criteria include: 1) at least quarterly data in the first two years and last two years of the trend period, 2) at least quarterly sampling in at least 70% of all years, 3) availability of suitable daily streamflow for the entire period, 4) 10-14% of samples collected at moderate to high streamflow conditions during each decade, and 5) no more than 50% censored data.

Data was screened for seasonal coverage and across the full range of flow conditions. To ensure seasonal coverage samples were divided by quarter year, all sites had at least quarterly sampling for all constituents. Generally, coverage during high flow conditions is lacking, and can cause underestimation in the WRTDS model. USGS identifies high flow samples by comparing corresponding streamflow with the 85th percentile of flows in that month during the corresponding decade of the trend period. (Oelsner, 2017)

Chemical analysis of environmental samples often can have values that are below the detection abilities of laboratory tests. These results are considered non-detects. EGRET allows a complex censoring scheme for input data that allows a low and high estimate. For non-detects, the laboratory detection was considered the high end and zero the low end. In the case of water quality parameters consisting of more than one analyte, in which a non-detect was observed, the sum of the low and high end of the non-detect was added to the observed value of the other analyte(s).

D. Tables of Site Data

Table 2: General data about each site

Map ID	USGS Gage Site Name	USGS Gage ID	IDEM Station ID	Sub-Watershed	County	Drainage Area Ratio	Type
Ex1	Wabash River at New Harmony, IN	03378500	03377500*	Wabash River	Posey	Collocated	Export
Ex2	Kankakee River at Shelby, IN	05518000	UMK110-0002	Kankakee River	Newton	0.999	Export
Ex3	Whitewater River at Brookville, IN	03276500	GMW080-0001	Whitewater River	Franklin	1.076	Export
Ex4	Iroquois River near Iroquois, IL	05525000	UMI050-0006	Kankakee River	Newton	Collocated	Export
Ex5	Blue River near White Cloud, IN	03303000	OBS150-0008	Lower Ohio	Crawford	1.04	Export
Im1	Wabash River at Linn Grove, IN	03322900	WUW060-0007	Wabash River	Adams	0.952	Import
Im2	Mississinewa River near Ridgeville, IN	03325500	WMI020-0002	Wabash River	Randolph	0.997	Import
In1	Wabash River at Riverton, IN	03342000	WBU-13-0001	Middle and Lower Wabash	Sullivan	0.986	Interior
In2	Wabash River at Lafayette, IN	03335500	WLV030-0003	Upper Wabash	Tippecanoe	1.03	Interior
In3	Wildcat Creek near Lafayette, IN	03335000	WAW050-0005	Upper Wabash	Tippecanoe	1.003	Interior
In4	White River at Petersburg, IN	03374000	WWL100-0005	White River	Gibson	Collocated	Interior
In5	East Fork White River at Shoals, IN	03373500	WEL100-0002	East Fork White River	Lawrence	0.959	Interior
In6	White River at Newberry, IN	03360500	WWL070-0003	West Fork White River	Daviess	Collocated	Interior
In7	Patoka River at Winslow, IN	03376300	WPA060-0002	Patoka River	Pike	1.077	Interior
Ex6	St. Joseph River at Niles, MI	04101500	LMJ240-0024	Lake Michigan	St. Joseph	Collocated	Export
Ex7	Burns Ditch at Portage, IN	04095090	LMG060-0007	Lake Michigan	Porter	0.998	Export
Ex8	Trail Creek at Michigan City, IN	04095300	LMG070-0005	Lake Michigan	LaPorte	1.093	Export
Ex9	Maumee River at New Haven *(used with SR101 in IN near IN/OH State Line)*	04183000	LEM010-0013	Maumee River	Allen	1.005	Export
Im3	St Joseph River near Newville IN	04178000	LEJ060-0006	St. Joseph River	Dekalb	1.064	Import
In8	Maumee River at New Haven, IN	04183000	LEM010-0014	Maumee River	Allen	Collocated	Interior

* 03377500 is a USGS gage site located at Mt. Carmel, IL on the Wabash River that was used for data instead of an IDEM Fixed Station site.

Table 3: Period of available data for each site

Map ID	USGS Gage Name	USGS Gage ID	Available Discharge Data Range	IDEM Station ID	Total Suspended Solids Data Range	Total Phosphorus Data Range	Total Nitrogen Data Range
Ex1	Wabash River at New Harmony, IN	03378500	1938-2020	03377500*	1996-2020†	1996-2020	1996-2020
Ex2	Kankakee River at Shelby, IN	05518000	2015-2020	UMK110-0002	1965-2020	1976-2020	1980-2020
Ex3	Whitewater River at Brookville, IN	03276500	1915-2020	GMW080-0001	1959-1966; 1971-1985; 1996-2020	1971; 1976-1985; 1996-2020	1996-2020
Ex4	Iroquois River near Iroquois, IL	05525000	1999-2020	UMI050-0006	1999-2020	1999-2020	1999-2020
Ex5	Blue River near White Cloud, IN	03303000	1931-2020	OBS150-0008	1999-2020	1999-2020	1999-2020
Im1	Wabash River at Linn Grove, IN	03322900	1964-2020	WUW060-0007	1971-2020	1971; 1979-2020	1980-1986; 2003-2020
Im2	Mississinewa River near Ridgeville, IN	03325500	1946-2017	WMI020-0002	1979-2020	1979-2020	1980-1985; 1998-2020
In1	Wabash River at Riverton, IN	03342000	2011-2020	WBU-13-0001	2011-2020	2011-2020	2011-2020
In2	Wabash River at Lafayette, IN	03335500	1923-2020	WLV030-0003	1973-2020	1973-2020	1980-2020
In3	Wildcat Creek near Lafayette, IN	03335000	1954-2020	WAW050-0005	1965-1966; 1980-2020	1980-2020	1980-1985; 1998-2020
In4	White River at Petersburg, IN	03374000	1959-2020	WWL-10-0006	1959-1964; 1970-2020	1986-2020	1996-2020
In5	East Fork White River at Shoals, IN	03373500	1903-2020	WEL100-0002	1971-2020	1971-2020	1980-2020
In6	White River at Newberry, IN	03360500	1965-2020	WWL070-0003	1965-1966; 1971-2020	1971; 1973-2020	1980-1985; 1996-2020
In7	Patoka River at Winslow, IN	03376300	1963-2020	WPA060-0002	1973-2020	1973-2020	1980-1985; 1996-2020
Ex6	St. Joseph River at Niles, MI	04101500	1980-2020	LMJ240-0024	1965-1966; 1970-2020	1971; 1973-2020	1980-2020
Ex7	Burns Ditch at Portage, IN	04095090	2011-2020	LMG060-0007	1970-2020	1971-2020	1980-2020
Ex8	Trail Creek at Michigan City, IN	04095300	1969-2020	LMG070-0005	1973-2020	1973-2020	1973-1976; 1980-2020
Ex9	Maumee River at New Haven *(used with SR101 in IN near IN/OH State Line)*	04183000	1956-2020	LEM010-0013	1973-2020	1973-2020	1973-1975; 1980-1985; 1989-2020
Im3	St Joseph River near Newville IN	04178000	1946-2020	LEJ060-0006	1999-2020	1999-2020	1999-2020
In8	Maumee River at New Haven, IN	04183000	1956-2020	LEM010-0014	1965-1967; 1971-2020	1973-1974; 1976-2020	1984-2020

* 03377500 is a USGS gage site located at Mt. Carmel, IL on the Wabash River that was used for data instead of an IDEM Fixed Station site.
† For the New Harmony site, USGS measures Suspended Sediment Concentration (SSC) and not Total Suspended Solids (TSS).

E. Basin Results

Basin Trend Results for Statewide Export Sites

Flow normalized loads (referred to as fluxes in WRTDS) and concentrations were calculated annually by the WRTDS model for each site. All the export sites that were identified for each major basin were summed to provide the total load for each corresponding basin for each constituent. The largest period of overlapping data was used for all sites. Individual sites generally have longer trends, and the basin trends are the summation of the individual annual loads from the longer site trends. Ninety five percent confidence level confidence intervals were calculated with the WBT method for each site and treated

the same way as the load/flux trends. To see the trends for TN, TP and TSS for the statewide export sites, refer to the graphs in Figures 7-9 below.

All Sites that export from Indiana to the Mississippi River Basin

The largest period of overlapping data was used for the 5 export sites in the Mississippi River Basin, which was from 2000-2019, to show the flow normalized load/flux trend. The 5 sites are: 1) Ex1 - the Wabash River at New Harmony, IN, 2) Ex2 - the Kankakee River at Shelby, IN, 3) Ex3 - the Whitewater River at Brookville, IN, 4) Ex4 - the Iroquois River near Iroquois, IL, and 5) Ex5 - the Blue River near White Cloud, IN.

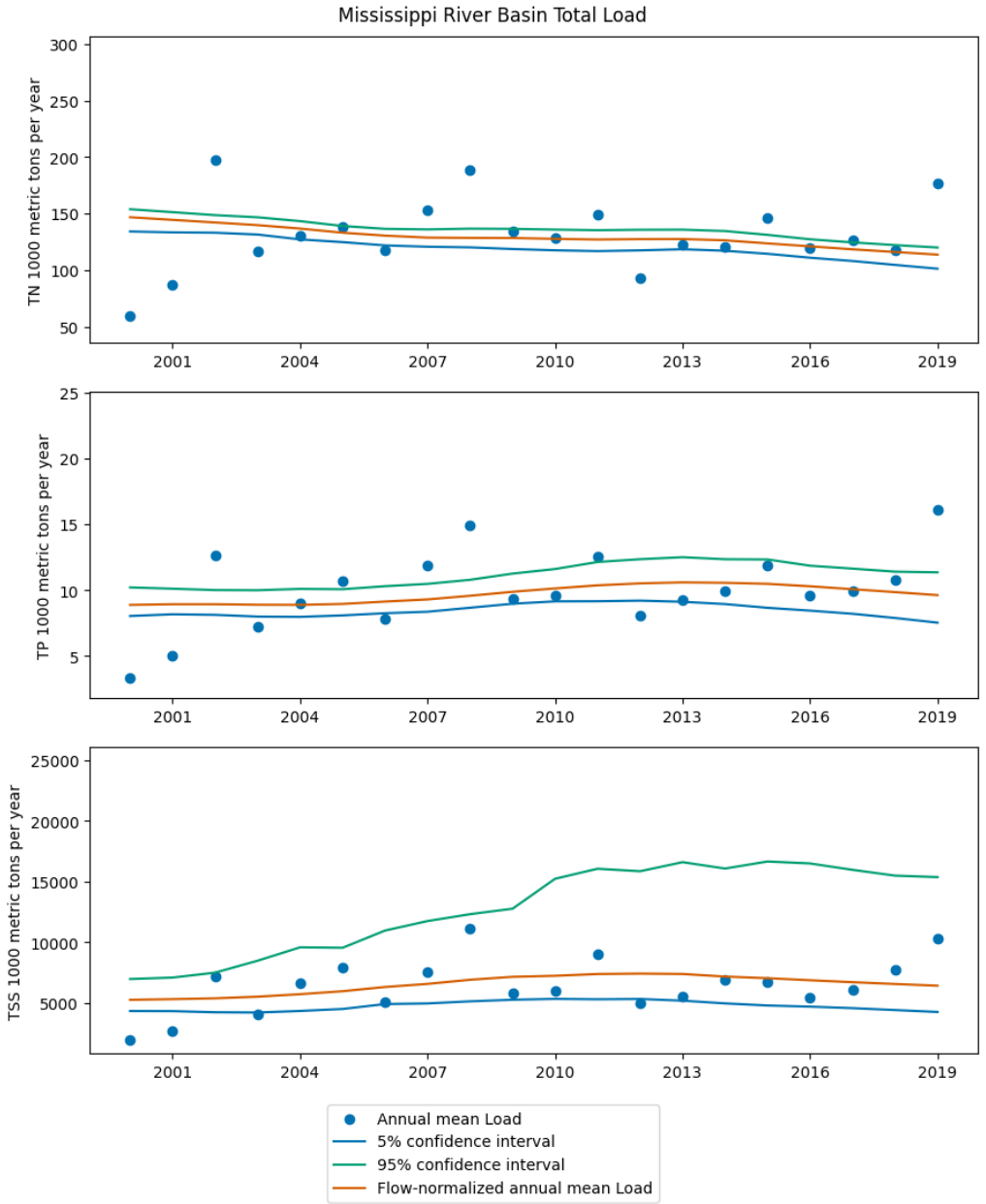

Figure 7: Figure 7 shows the trend in flow normalized load/mean flux combined for the **Mississippi River export sites**. (5 export sites)

All Sites that export from Indiana to Lake Michigan

The largest period of overlapping data was used for the 2 export sites in the Lake Michigan Basin, which was from 1994-2018, to show the flow normalized load/flux trend. The 2 sites are: 1) Ex6 - the St. Joseph River at Niles, MI and 2) Ex7 - Burns Ditch at Portage, IN. As mentioned before on page 10, the Trail Creek site at Michigan City was not used because it had a gap in coverage of discharge data from the mid-1990s to the mid-2000s, and therefore it was not included in the Lake Michigan Basin trend.

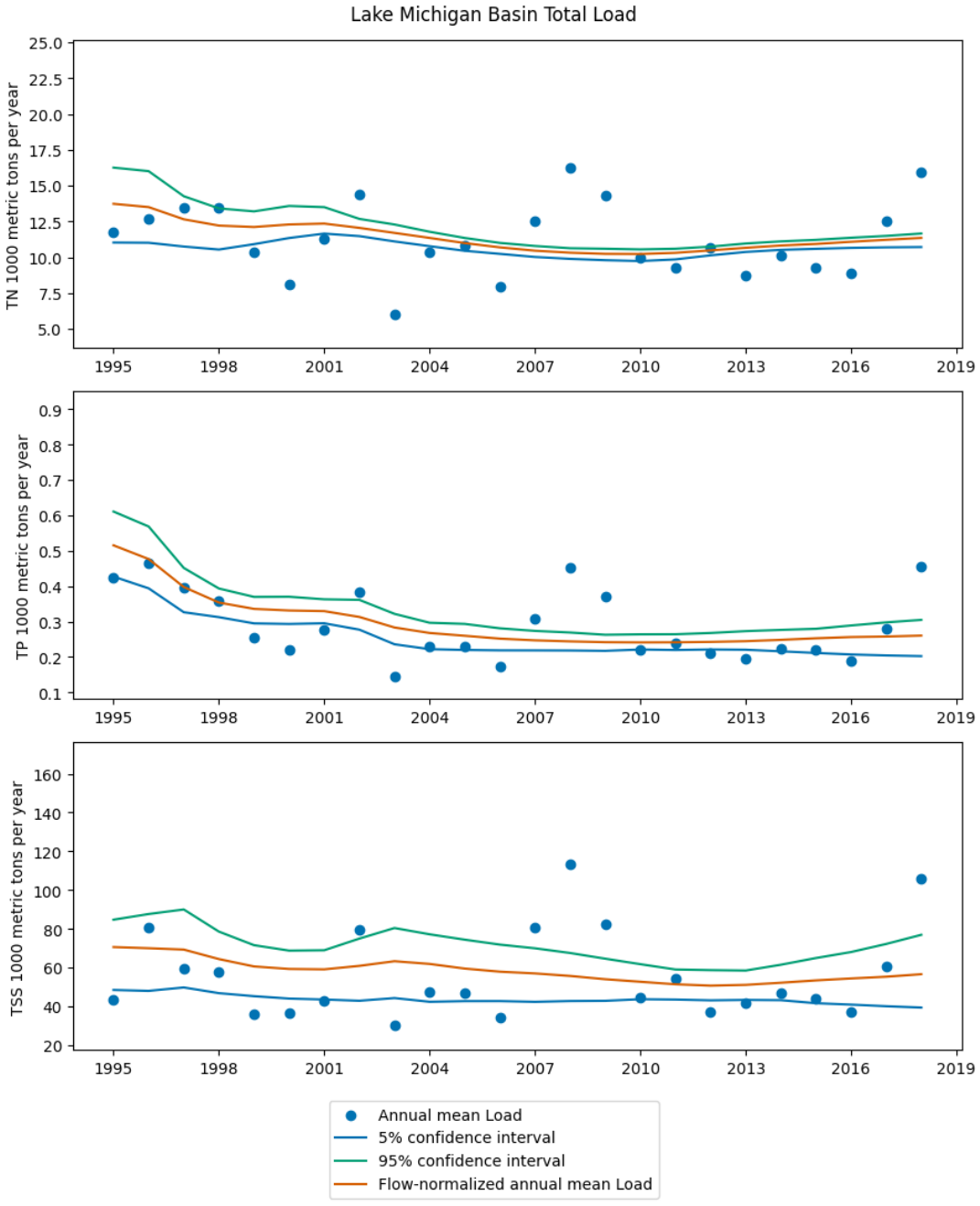

Figure 8: Figure 8 shows the trend in flow normalized load/mean flux combined for the **Lake Michigan Basin** export sites. (2 export sites)

Site that exports from Indiana to Western Lake Erie

There is only one export site in the Western Lake Erie Basin, and the period of data for this export site was from 1967-2017. However, the graphs below showing the flow normalized load/flux trend show results of the data from 1980-2020 so that a more recent trend is shown, and because WRTDS variability in early data did not produce reliable results in terms of the confidence interval being so wide that the estimates are not very meaningful. The IDEM site is on the Maumee River at SR 101 in Indiana near the IN/OH state line (Ex9), and the USGS site used is located on the Maumee River in New Haven, IN.

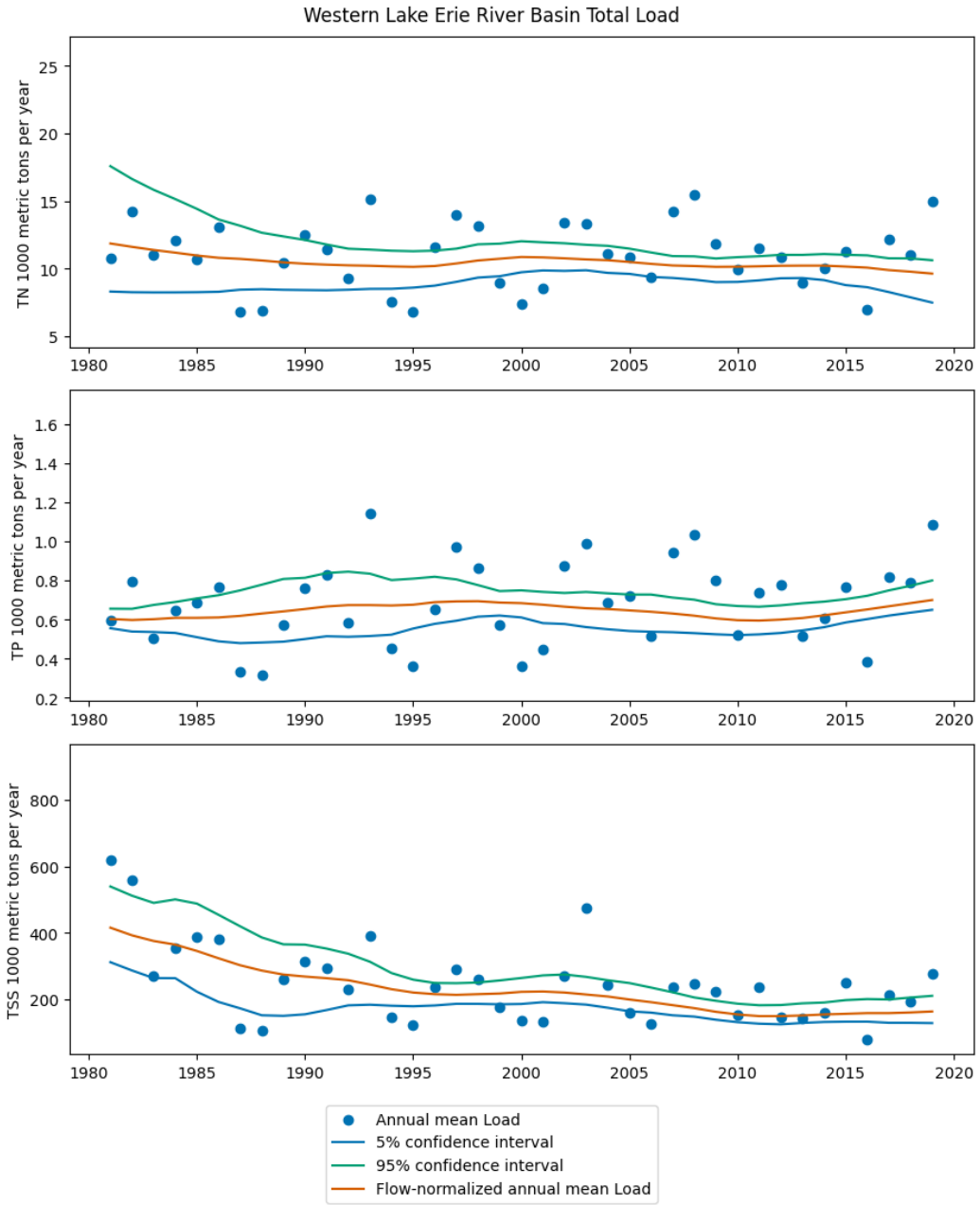

Figure 9: Figure 9 shows the trend in flow normalized load/mean flux for the **Western Lake Erie Basin** export site. (1 export site)

Site Specific Trend Results

Flow normalized loads (referred to as fluxes in WRTDS) and concentrations for each constituent were calculated annually by the WRTDS model for each site. WRTDS results for individual sites for loads and concentrations for each constituent can be found in Appendix A.

WRTDS Bootstrap Test (WBT)

The WBT test was conducted for WRTDS trends for concentration and load/flux for each site, for 2005-2015. This was chosen to give a recent decade long period that does not include the beginning or end of any WRTDS trend periods. Conclusions from the WBT are only applicable over the time they were run, and may not be indicative of the trend over a larger time period. The WBT results can be found in Appendix B.

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APPENDIX A – Individual Site-Specific Trend Results

A. Individual Site-Specific Trend Results

Flow normalized loads (referred to as fluxes in WRTDS) and concentrations for each constituent were calculated annually by the WRTDS model for each individual site identified in the state. Ninety five percent confidence level confidence intervals were calculated with the WBT method for each site and treated the same way as the load and concentration trends. In the graphs shown on the following pages, the first column of graphs shows either the concentrations or the loads for each constituent (TN, TP and TSS) over the life of the entire trend period of data available for each individual site. The second column of graphs shows the concentrations or the loads for each parameter from 2000-2020, using available data, showing a more recent trend.

Additionally, a WRTDS Bootstrap Test (WBT) test was conducted for each site from 2005-2015 to evaluate the trend for that period for both concentration and load (flux) for each constituent. The WBT tests the significance level and confidence intervals for the trend between two years. This can be used to determine the likelihood of whether that trend is increasing or decreasing over the selected interval. The likelihood of an upward or downward trend is lumped into five bins: highly likely, likely, about as likely as not, unlikely, or highly unlikely. The WBT results are included for each site below.

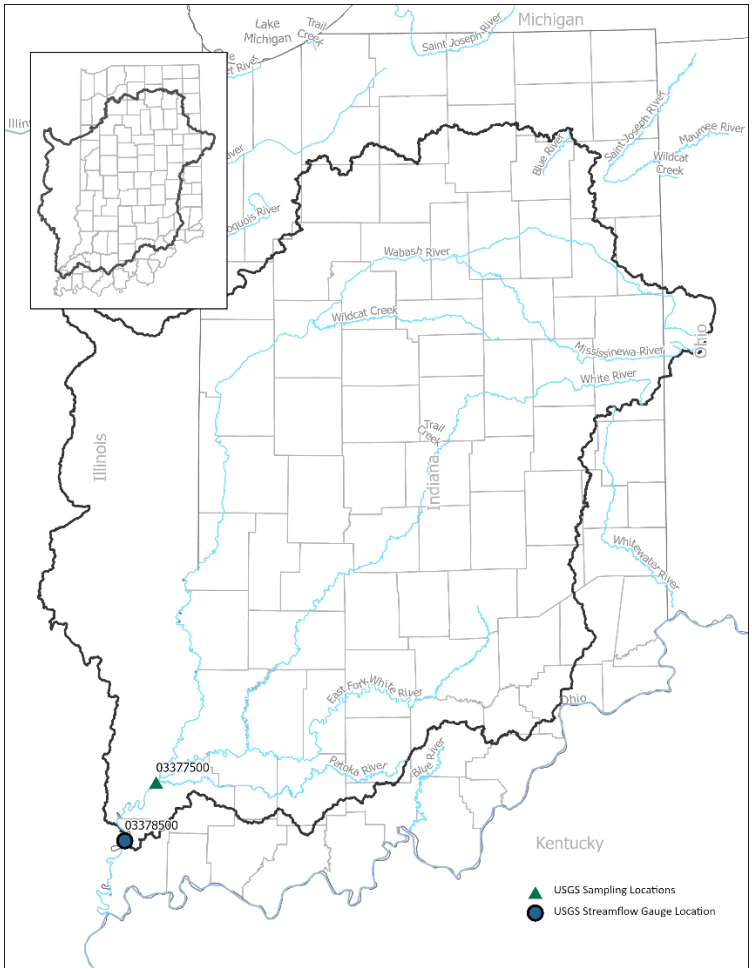
B. Mississippi River Basin

Export Sites

Wabash River at New Harmony, IN (Ex1)

USGS Gage ID 03378500
USGS Gage ID 03377500

The USGS streamgage site #03378500 is located in New Harmony, IN in Posey County in southwest Indiana. The New Harmony USGS location on the Wabash River is the last station on the Wabash River before it flows into the Ohio River, collecting data from the Wabash River watershed as well as the White River Watershed. The USGS streamgage site #03377500 is located on the Wabash River in Mount Carmel, IL in Wabash County in Illinois. It is located upstream of the New Harmony gage location.



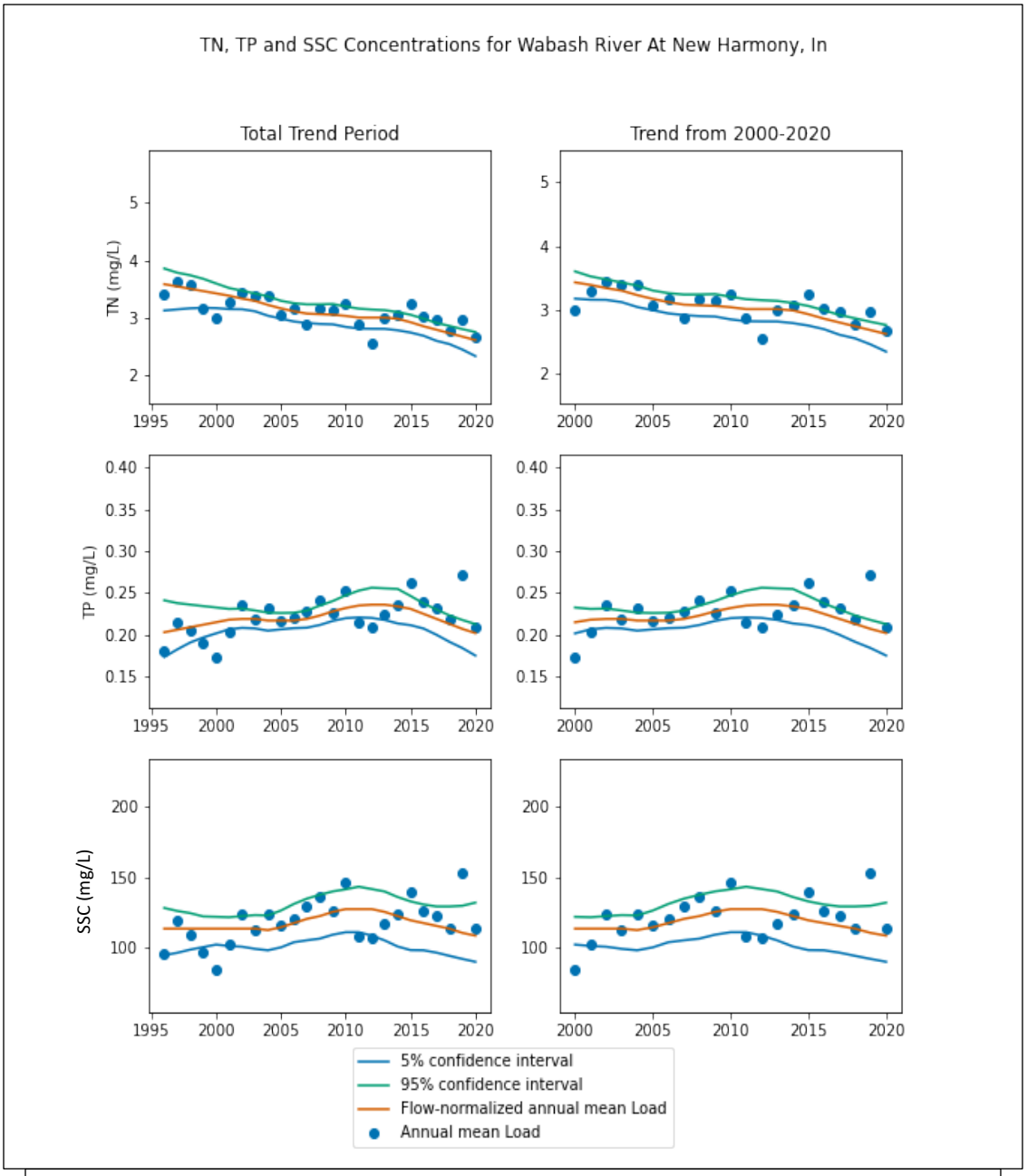


Figure 1A: Figure 1A shows the trend in flow normalized mean concentration and annual mean concentration over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Suspended Sediment Concentration
Upward Trend in Concentration	highly unlikely	likely	about as likely as not
Downward Trend in Concentration	highly likely	unlikely	about as likely as not

Table 1A: WBT descriptive results for concentrations from **2005-2015** for Wabash River at New Harmony, IN (Ex1)

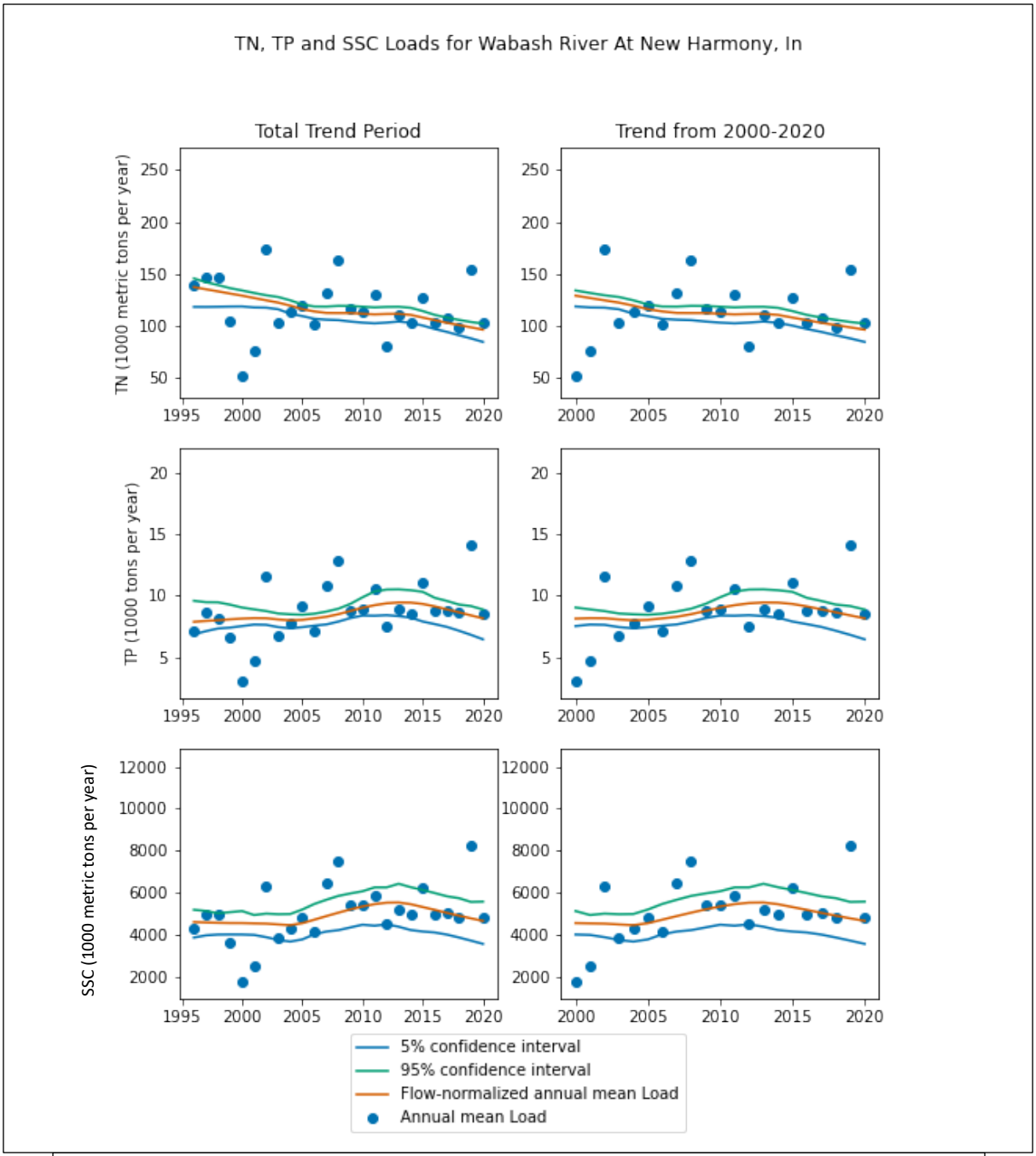


Figure 1B: Figure 1B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

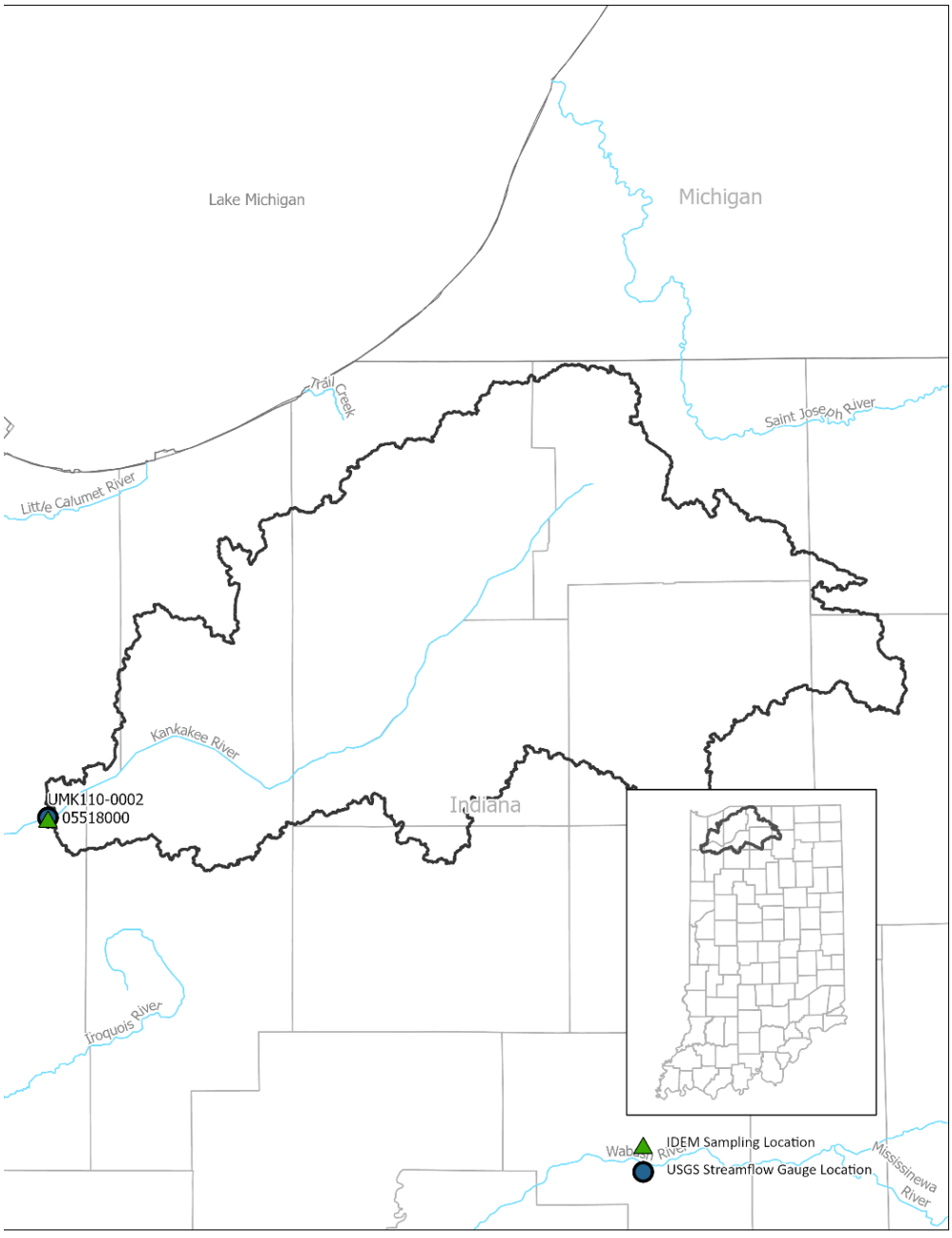
Trend	Total Nitrogen	Total Phosphorus	Suspended Sediment Concentration
Upward Trend in Load	very unlikely	likely	likely
Downward Trend in Load	very likely	unlikely	unlikely

Table 1B: WBT descriptive results for loads from **2005-2015** for Wabash River at New Harmony, IN (Ex1)

Kankakee River at Shelby, IN (Ex2)

USGS Gage ID 05518000 (Supergage)
IDEM station ID UMK110-0002

The USGS supergage site and the IDEM station are co-located at this location, and are located in northern Newton County in northwest Indiana near Shelby, IN. This location captures the Kankakee River exports into Illinois from Indiana. The Kankakee River is located in northwest Indiana and the watershed covers all or part of 11 Indiana counties. The Kankakee River stretches across northwest Indiana for 90 miles starting near South Bend in St. Joseph County flowing to the Illinois State line. The Yellow River and Iroquois Rivers are the important tributaries to the Kankakee River and join up with the river in the state of Illinois.



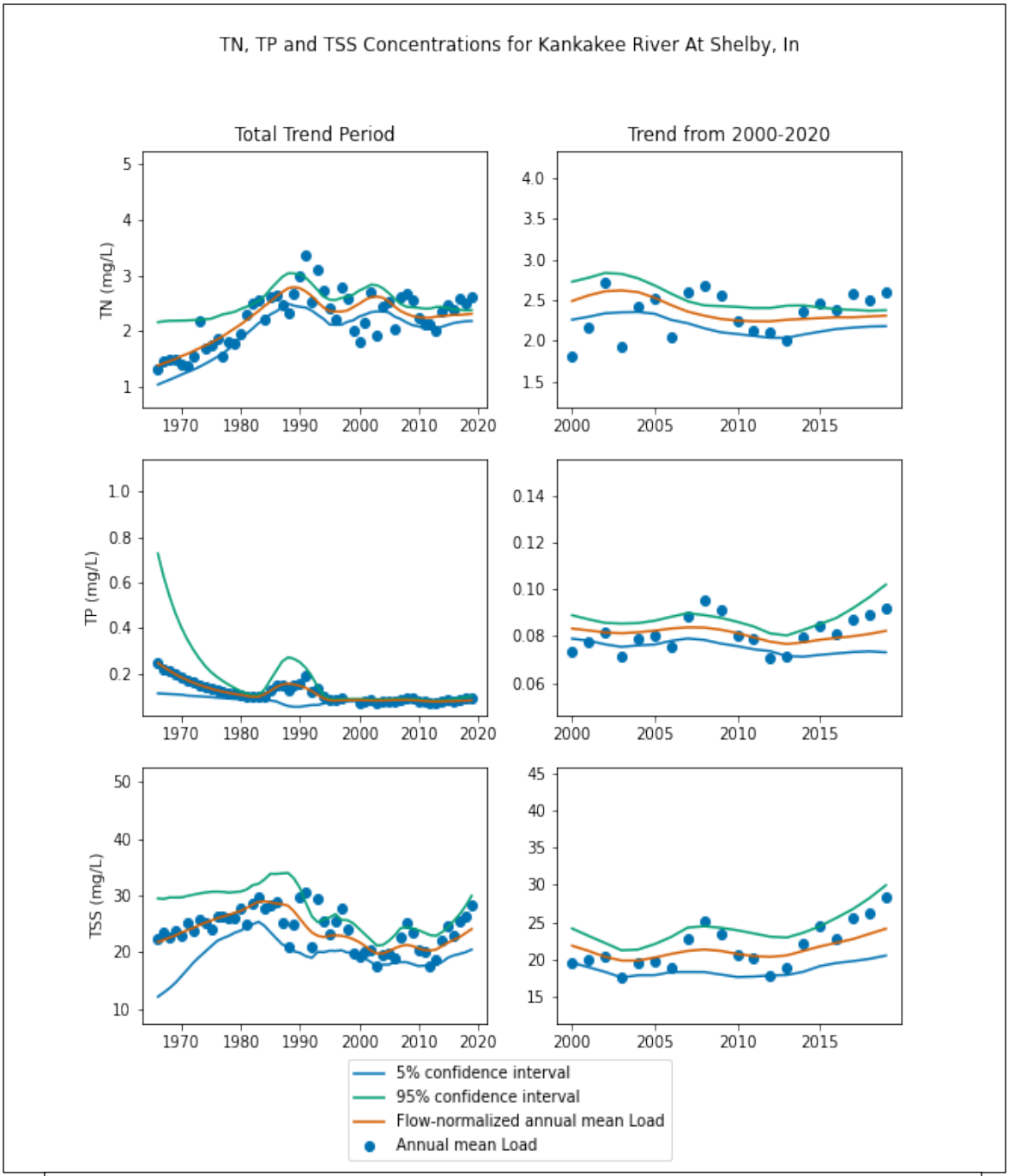


Figure 2A: Figure 2A shows the trend in flow normalized mean concentration, and annual mean concentration over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	unlikely	likely
Downward Trend in Concentration	highly likely	likely	unlikely

Table 2A: WBT descriptive results for concentrations from **2005-2015** for Kankakee River at Shelby, IN (Ex2)

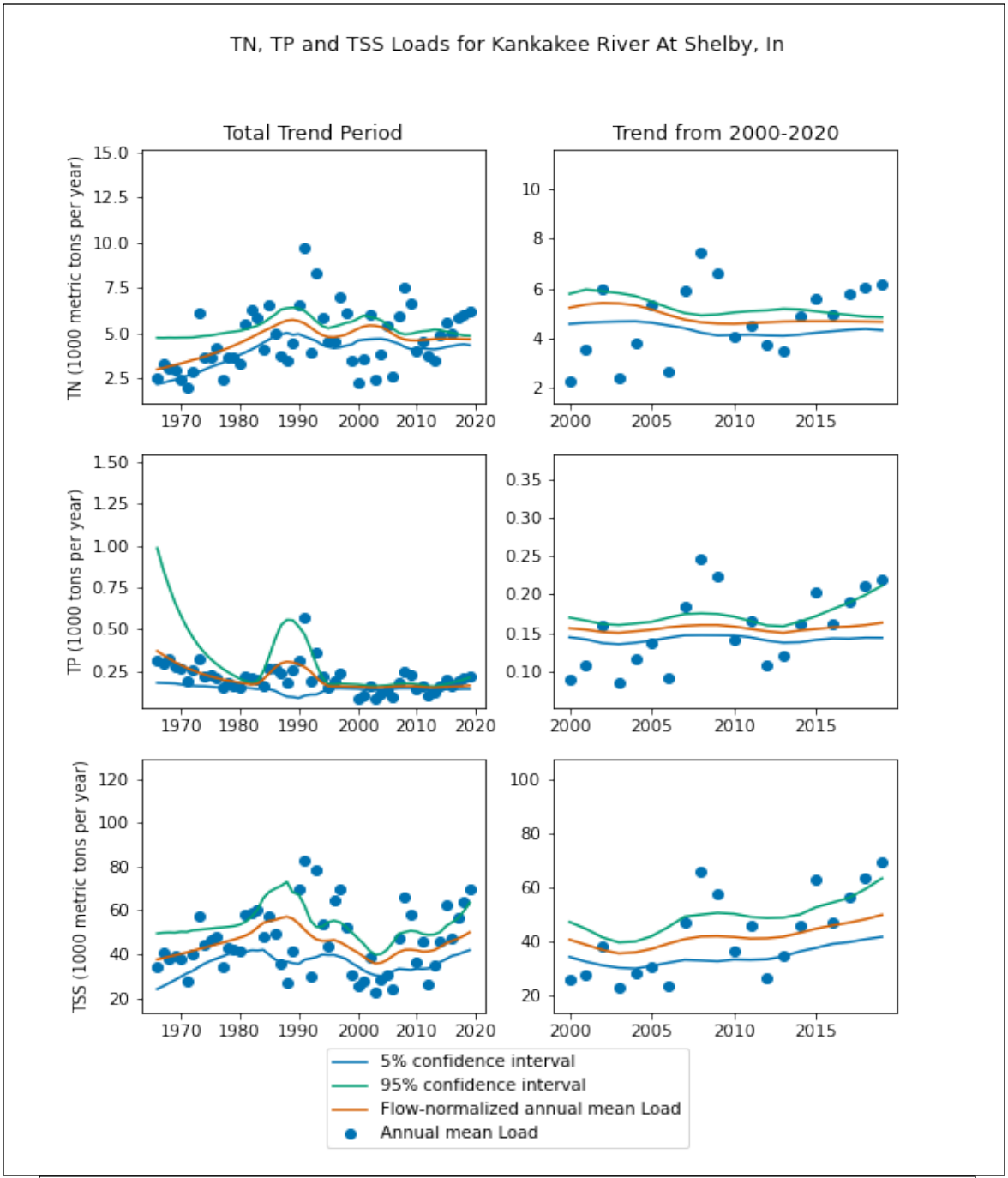


Figure 2B: Figure 2B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

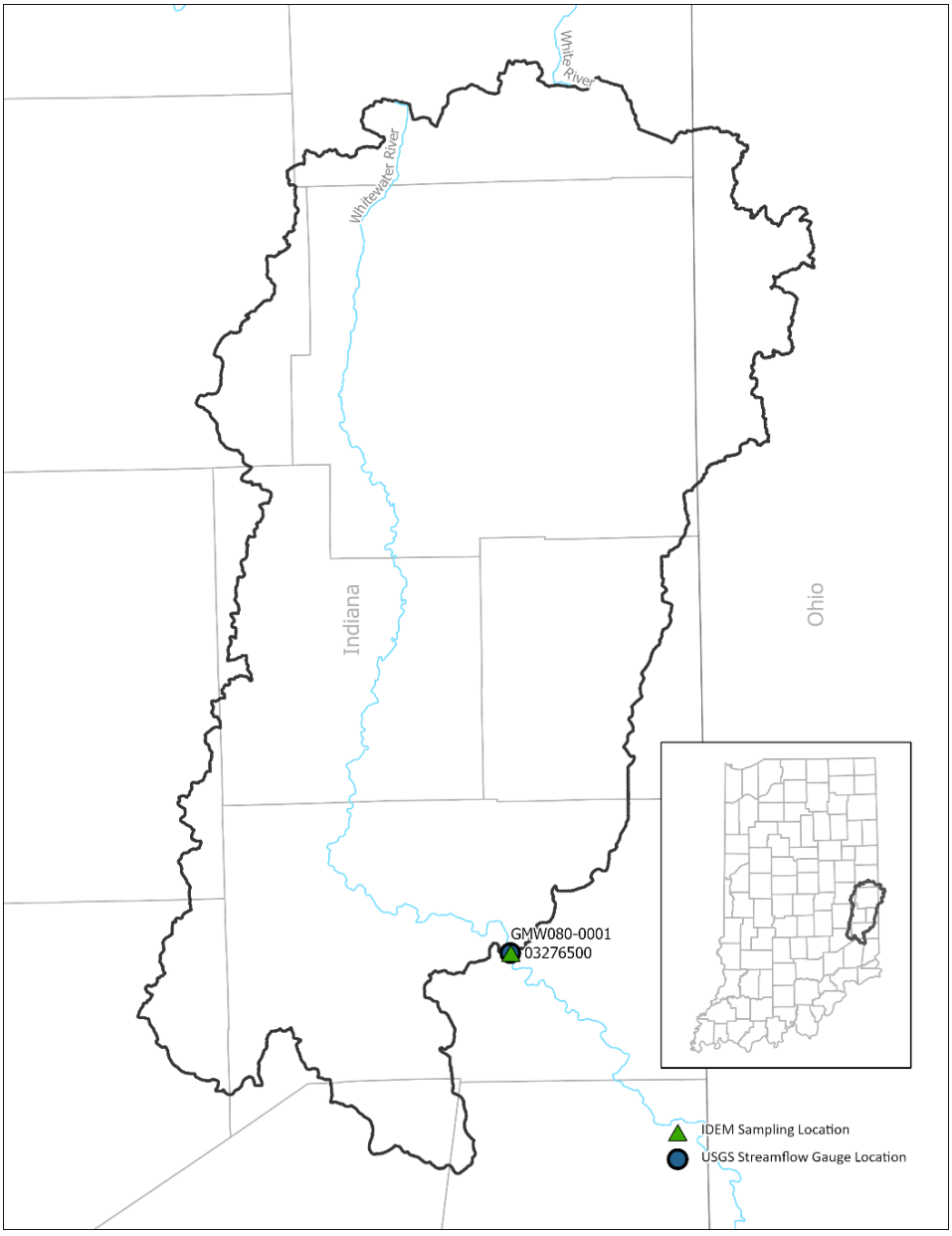
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	very unlikely	about as likely as not	very likely
Downward Trend in Load	very likely	about as likely as not	very unlikely

Table 2B: WBT descriptive results for loads from **2005-2015** for Kankakee River at Shelby, IN (Ex2)

Whitewater River at Brookville, IN (Ex3)

USGS Gage ID 03276500
IDEM station ID GMW080-0001

The USGS streamgage site and the IDEM station are co-located at this location. The sites are located in Franklin County in southeast Indiana near Brookville, IN and downstream of the Brookville Reservoir. This location captures the Whitewater River exports into the state of Ohio and to the Ohio River from Indiana. The Whitewater River rises in southern Randolph and northern Wayne Counties and flows in two main branches which are just 10 miles apart as they flow southward before joining together in Brookville, IN. From the point at which the Whitewater River and the East Fork Whitewater come together, the river flows southeasterly toward the Great Miami River near the Indiana-Ohio state line, which then flows into the Ohio River.



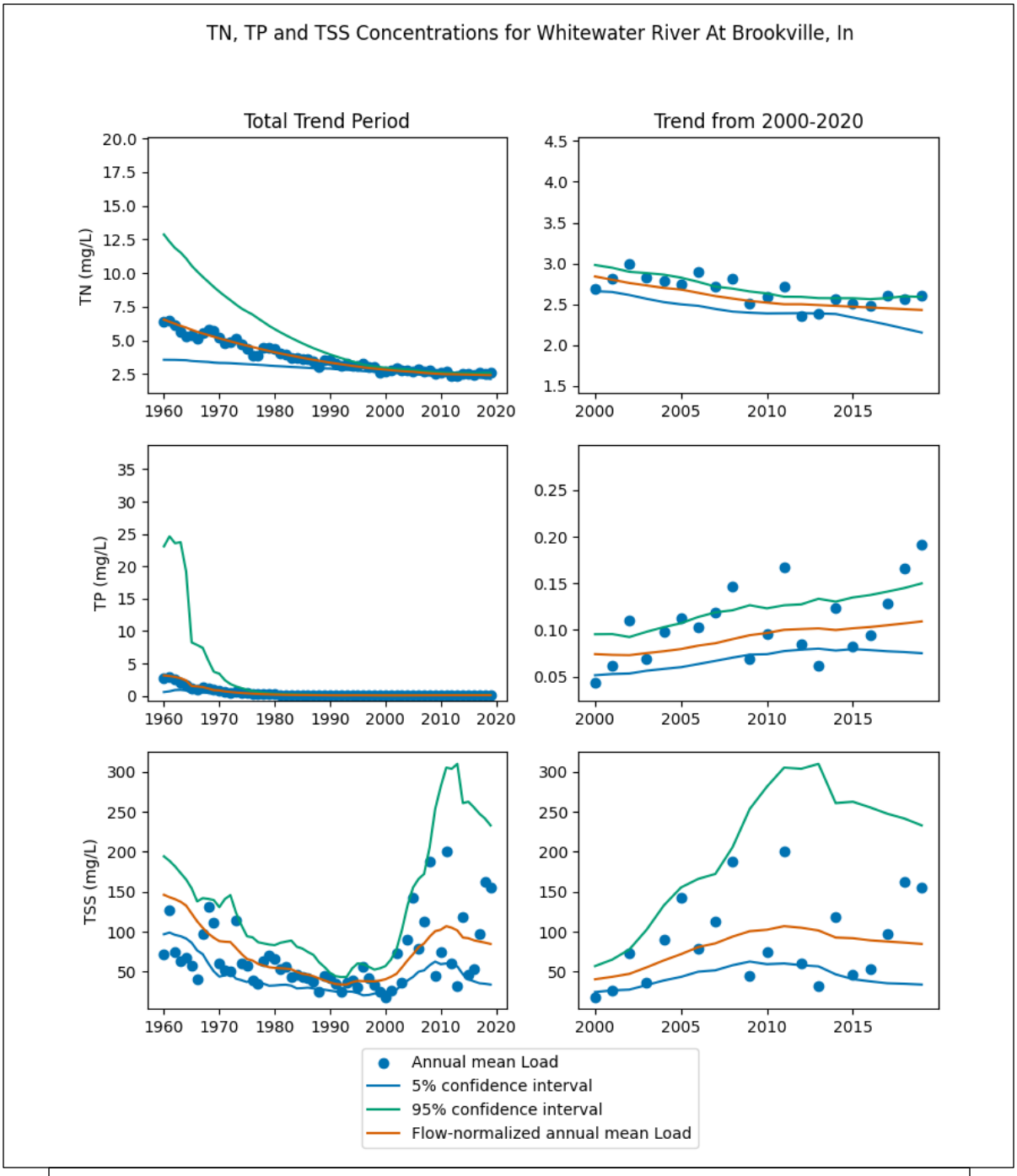


Figure 3A: Figure 3A shows the trend in flow normalized mean concentration, and annual mean concentration over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	very likely	likely
Downward Trend in Concentration	highly likely	very unlikely	unlikely

Table 3A: WBT descriptive results for concentrations from **2005-2015** for Whitewater River at Brookville, IN (Ex3)

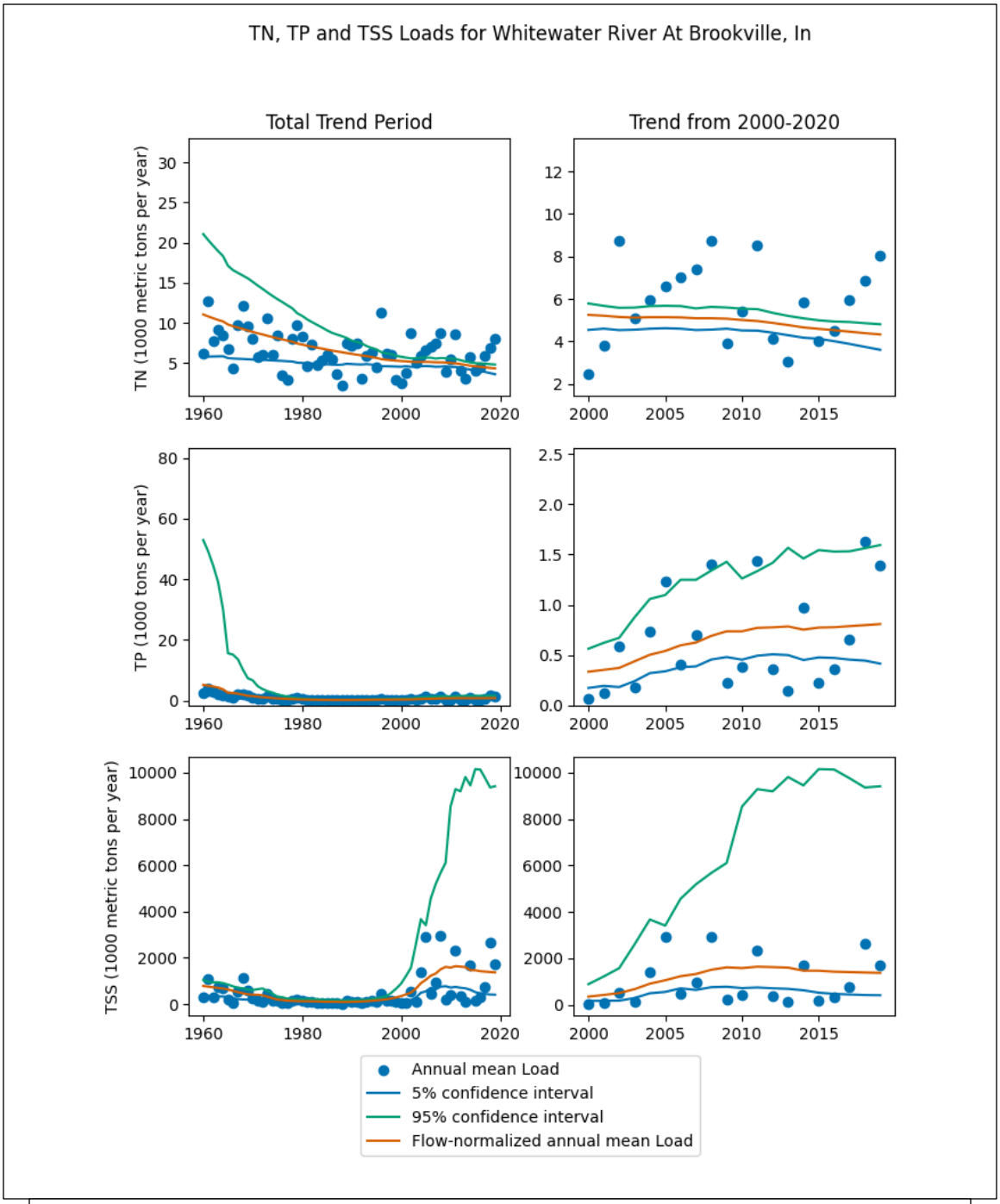


Figure 3B: Figure 3B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

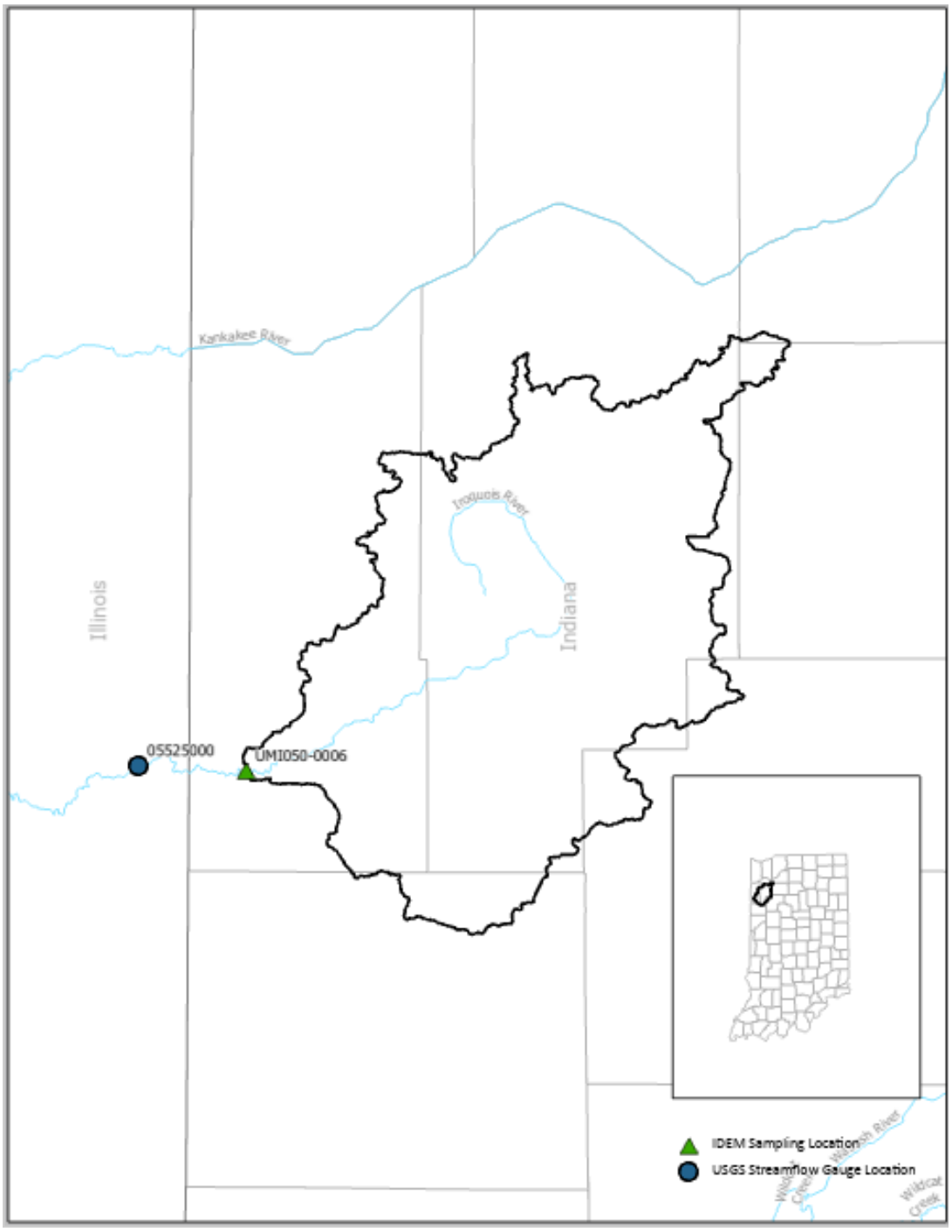
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	very unlikely	likely	likely
Downward Trend in Load	very likely	unlikely	unlikely

Table 3B: WBT descriptive results for loads from **2005-2015** for Whitewater River at Brookville, IN (Ex3)

Iroquois River at Iroquois, IL (Ex4)

USGS Gage ID 05525000
IDEM station ID UMI050-0006

The USGS streamgage is located in Iroquois, IL downstream of the IDEM site which is located in southern Newton County in northwest Indiana. This location captures the Iroquois River exports into Illinois from Indiana. The Iroquois River is a major tributary in the Kankakee River Basin, and it joins up with the Kankakee River in the state of Illinois. The watershed covers parts of 6 Indiana counties.



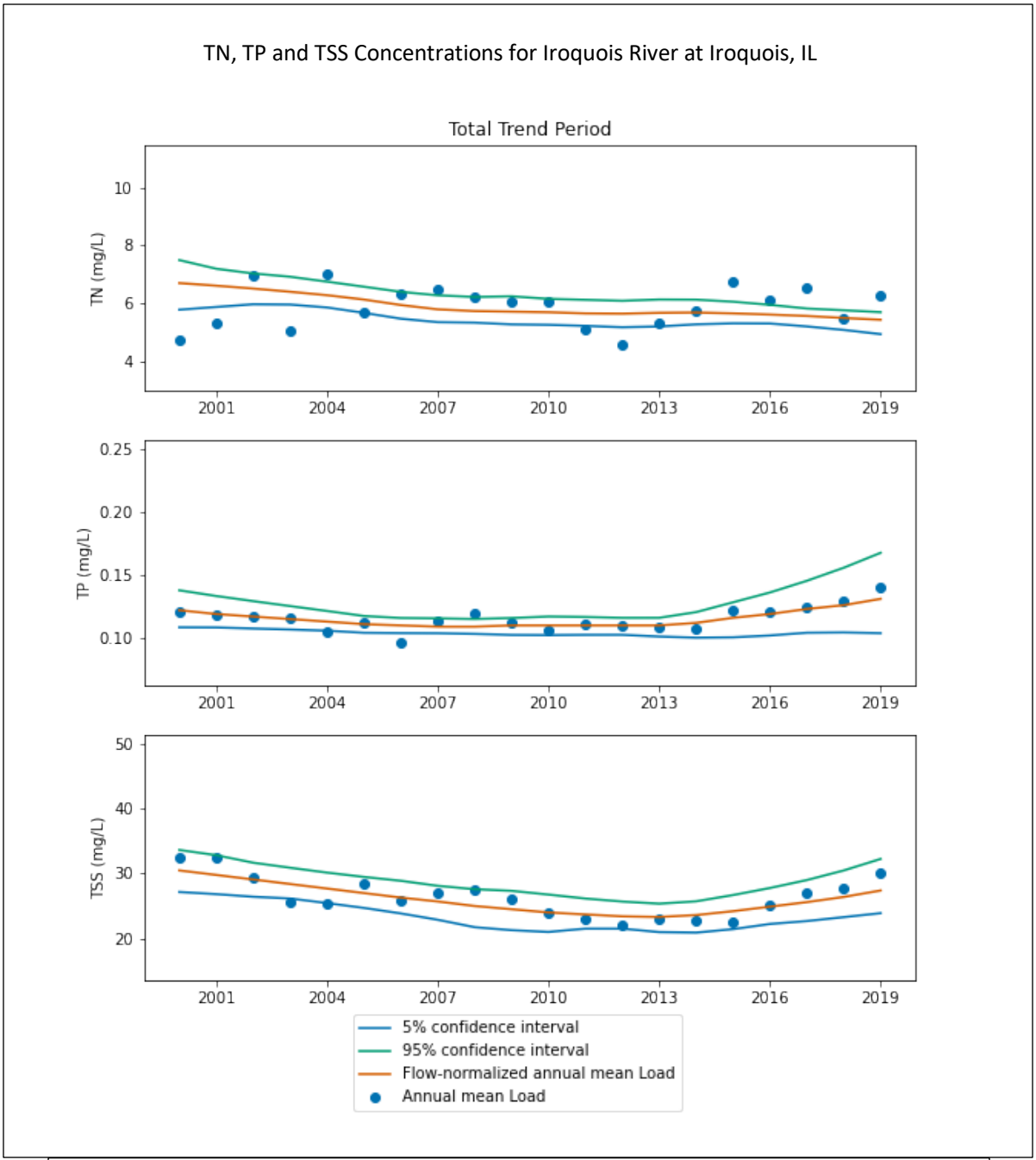


Figure 4A: Figure 4A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, which is the period from 2000 to 2020 and shows a more recent trend.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	about as likely as not	about as likely as not
Downward Trend in Concentration	highly likely	about as likely as not	about as likely as not

Table 4A: WBT descriptive results for concentrations from **2005-2015** for Iroquois River at Iroquois, IL (Ex4)

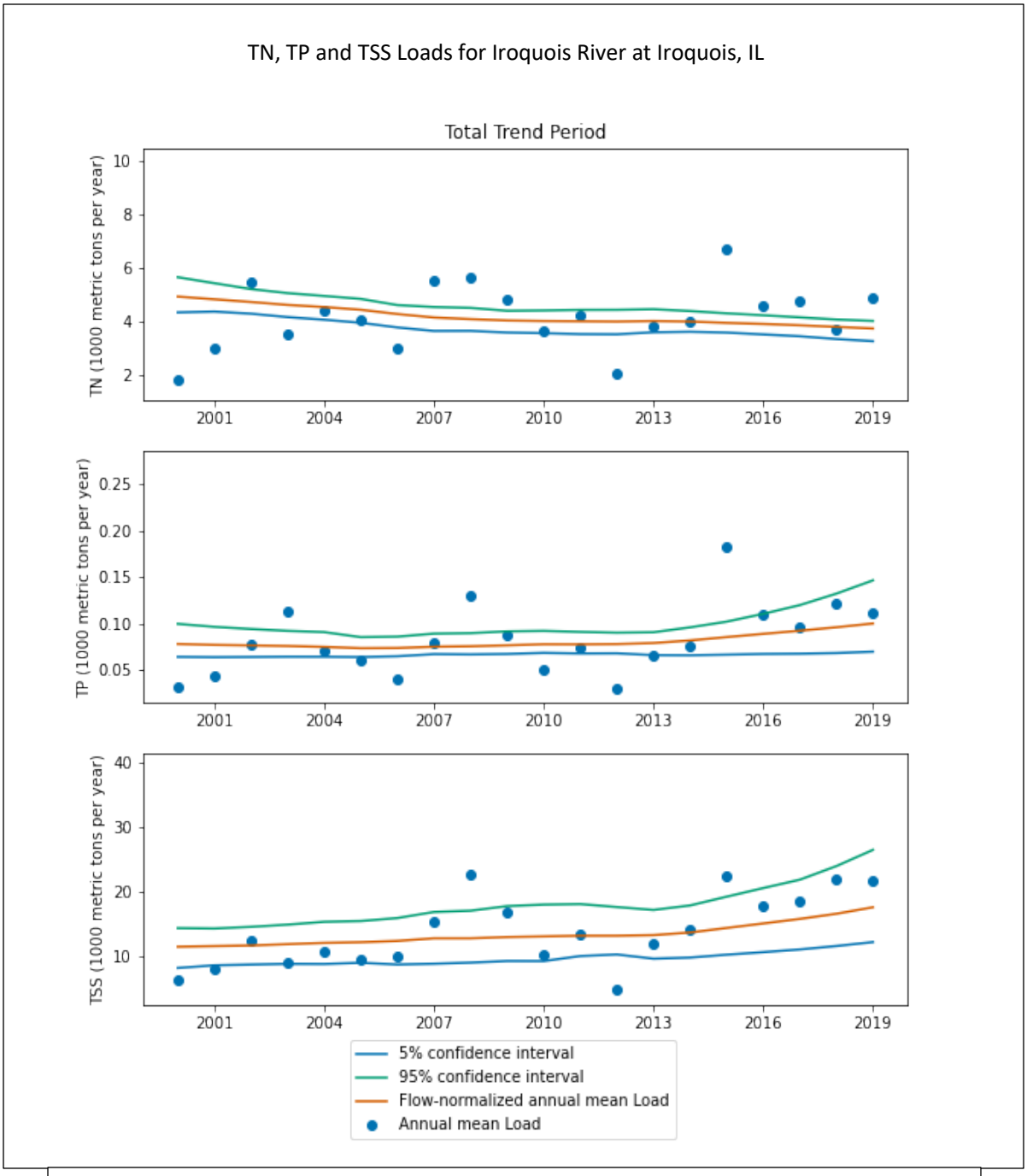


Figure 4B: Figure 4B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, which is the period from 2000 to 2020 and shows a more recent trend.

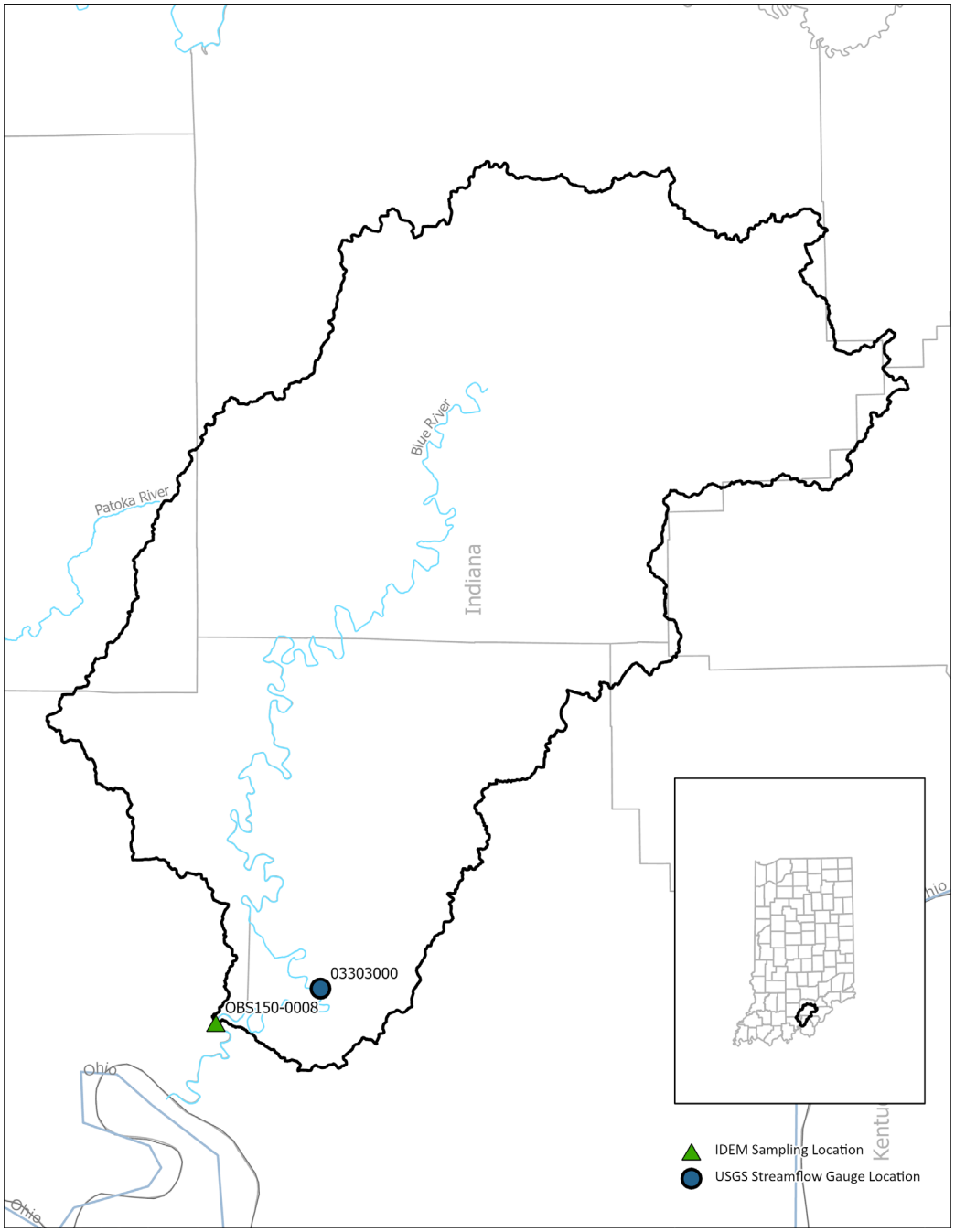
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	very unlikely	likely	likely
Downward Trend in Load	very likely	unlikely	unlikely

Table 4B: WBT descriptive results for loads from **2005-2015** for Iroquois River at Iroquois, IL (Ex4)

Blue River near White Cloud, IN (Ex5)

USGS Gage ID 03303000
IDEM station ID OBS150-0008

The USGS streamgage is located in Harrison County upstream of the IDEM site that is located in Crawford County in southern Indiana. This location captures the Blue River exports to the Ohio River from Indiana. The Blue River originates in Washington County in southern Indiana, and for a portion of its journey to the Ohio River, it forms the boundary between Harrison and Crawford Counties. This area is known for karst (limestone) topography with many sink holes and caves that formed as water dissolved the rock.



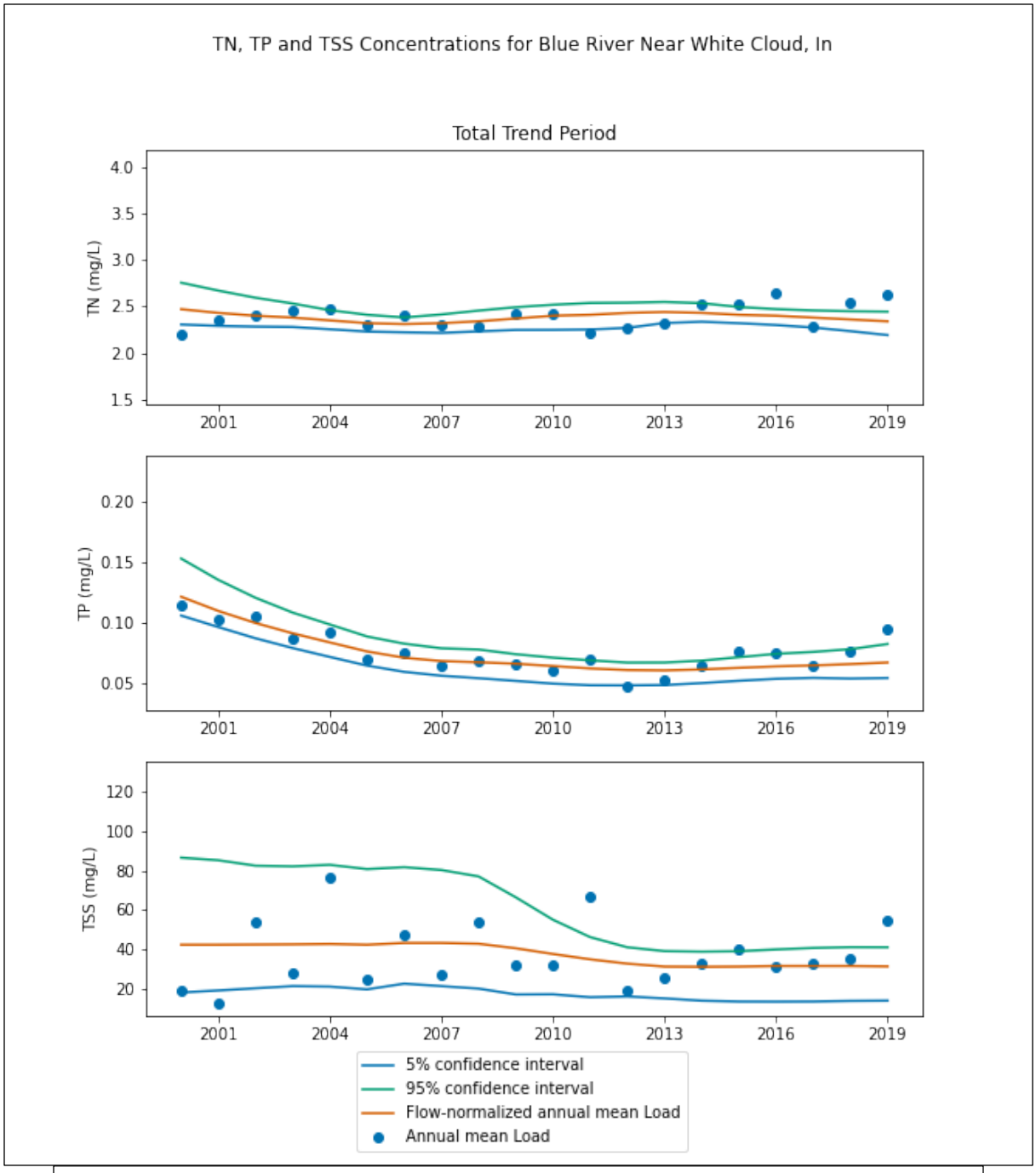


Figure 5A: Figure 5A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, which is the period from 2000 to 2020 and shows a more recent trend.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	likely	highly unlikely	highly unlikely
Downward Trend in Concentration	unlikely	highly likely	highly likely

Table 5A: WBT descriptive results for concentrations from **2005-2015** for Blue River near White Cloud, IN (Ex5)

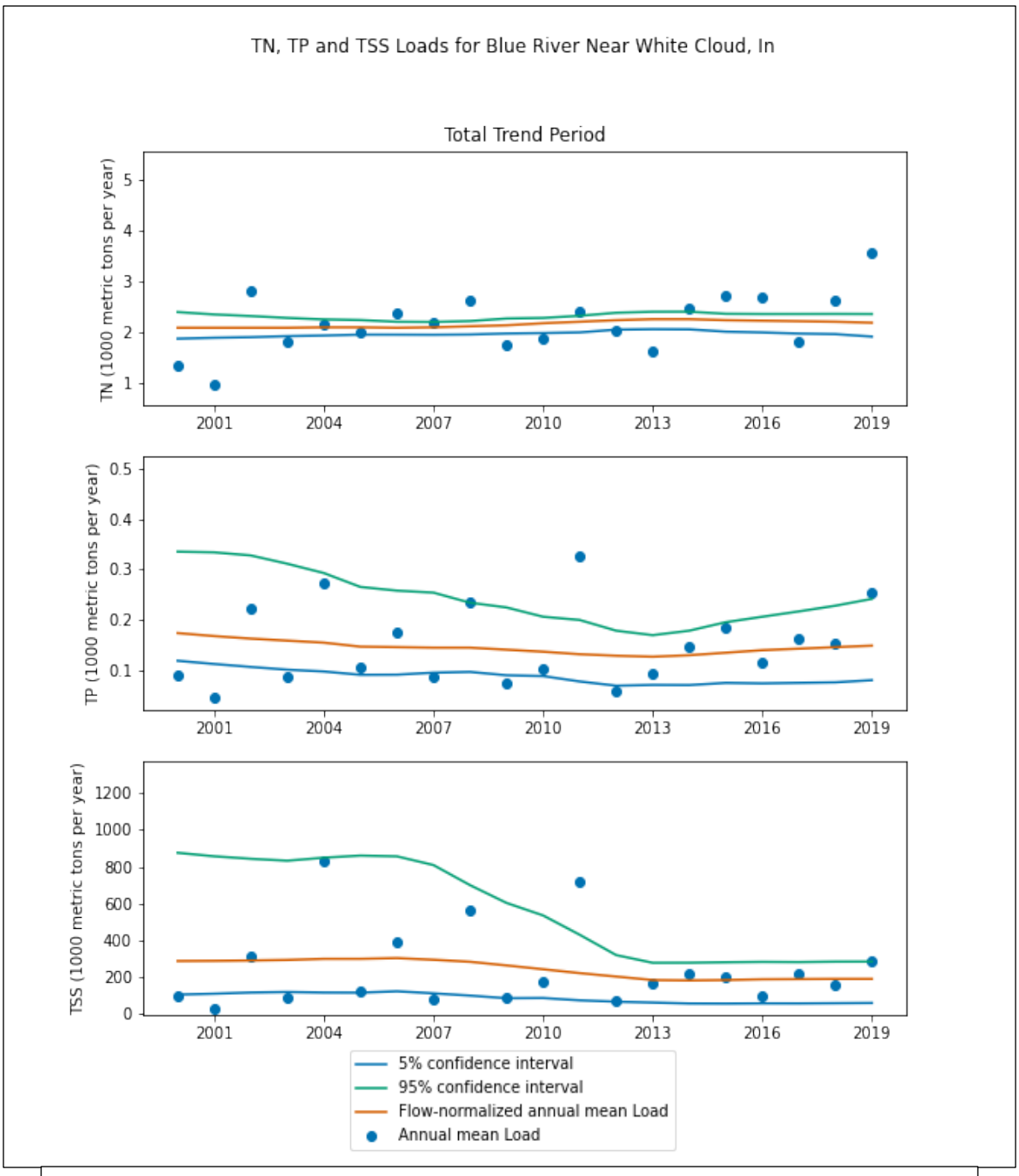


Figure 5B: Figure 5B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, which is the period from 2000 to 2020 and shows a more recent trend.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	likely	unlikely	unlikely
Downward Trend in Load	unlikely	likely	likely

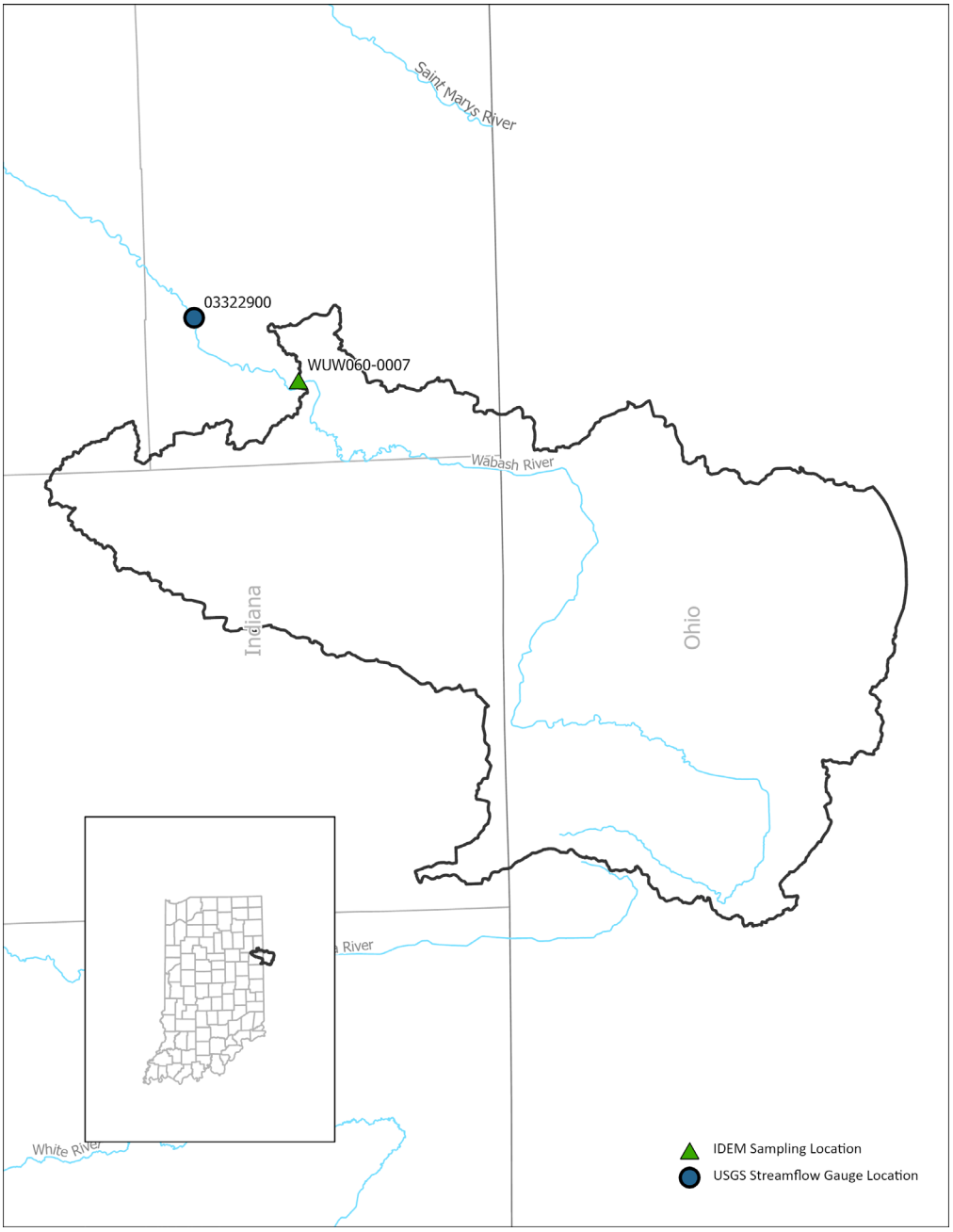
Table 5B: WBT descriptive results for loads from **2005-2015** for Blue River near White Cloud, IN (Ex5)

Import Sites

Wabash River at Linn Grove, IN (Im1)

USGS Gage ID 03322900
IDEM Station ID WUW060-0007

The USGS streamgage site and the IDEM station site are both located in southern Adams County, IN. The USGS site is located downstream of the IDEM site. The watershed covers parts of three counties in Indiana and some land in Ohio. This particular site captures imports into the state as the Wabash River begins in Ohio and flows into Indiana. It is the headwaters of the Wabash River. The river rises in Ohio near Fort Recovery and flows for only thirty miles before it becomes entirely an Indiana river, crossing the border near the town of New Corydon in Jay County.



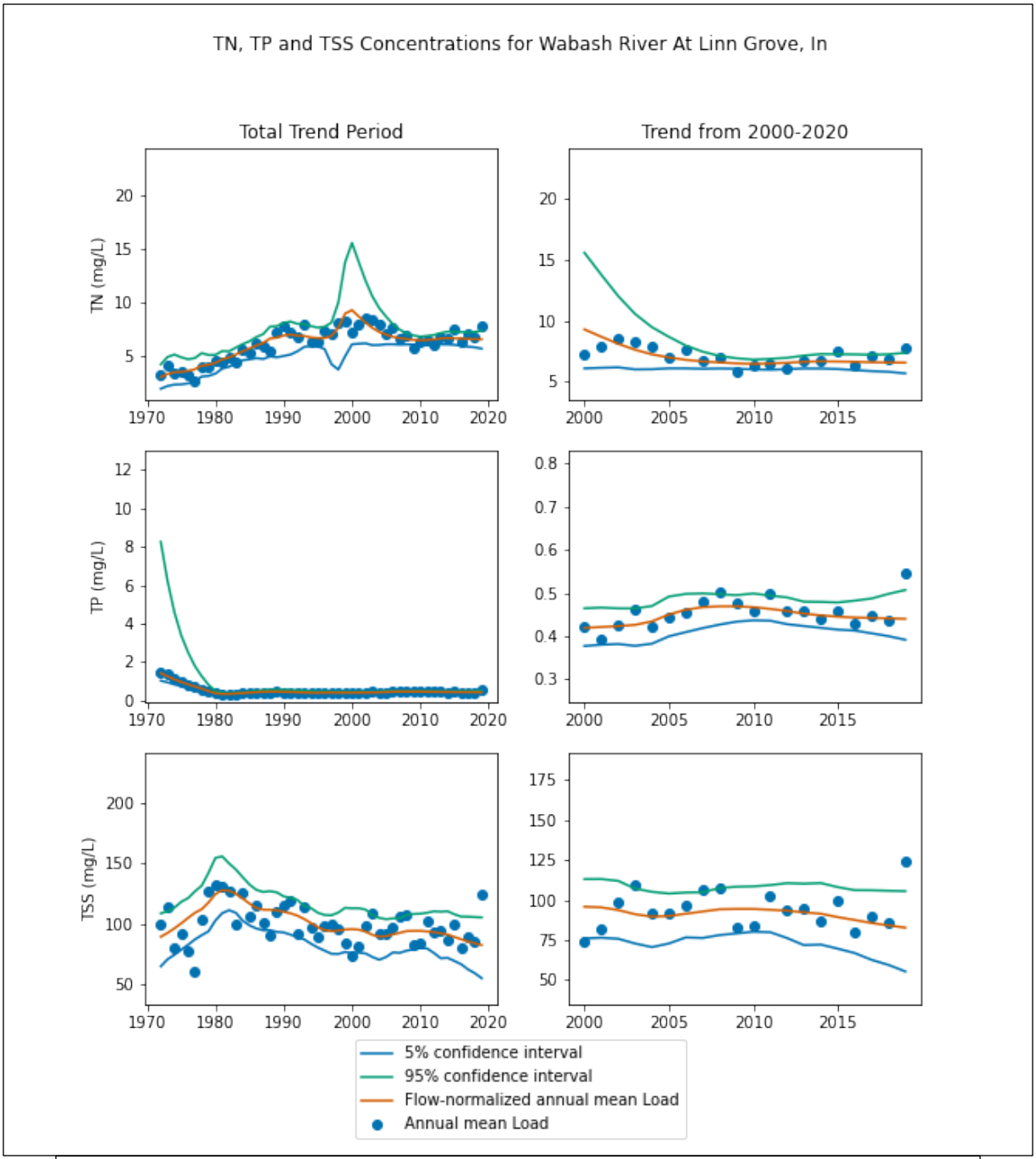


Figure 6A: Figure 6A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	about as likely as not	about as likely as not	about as likely as not
Downward Trend in Concentration	about as likely as not	about as likely as not	about as likely as not

Table 6A: WBT descriptive results for concentrations from **2005-2015** for Wabash River at Linn Grove, IN (Im1)

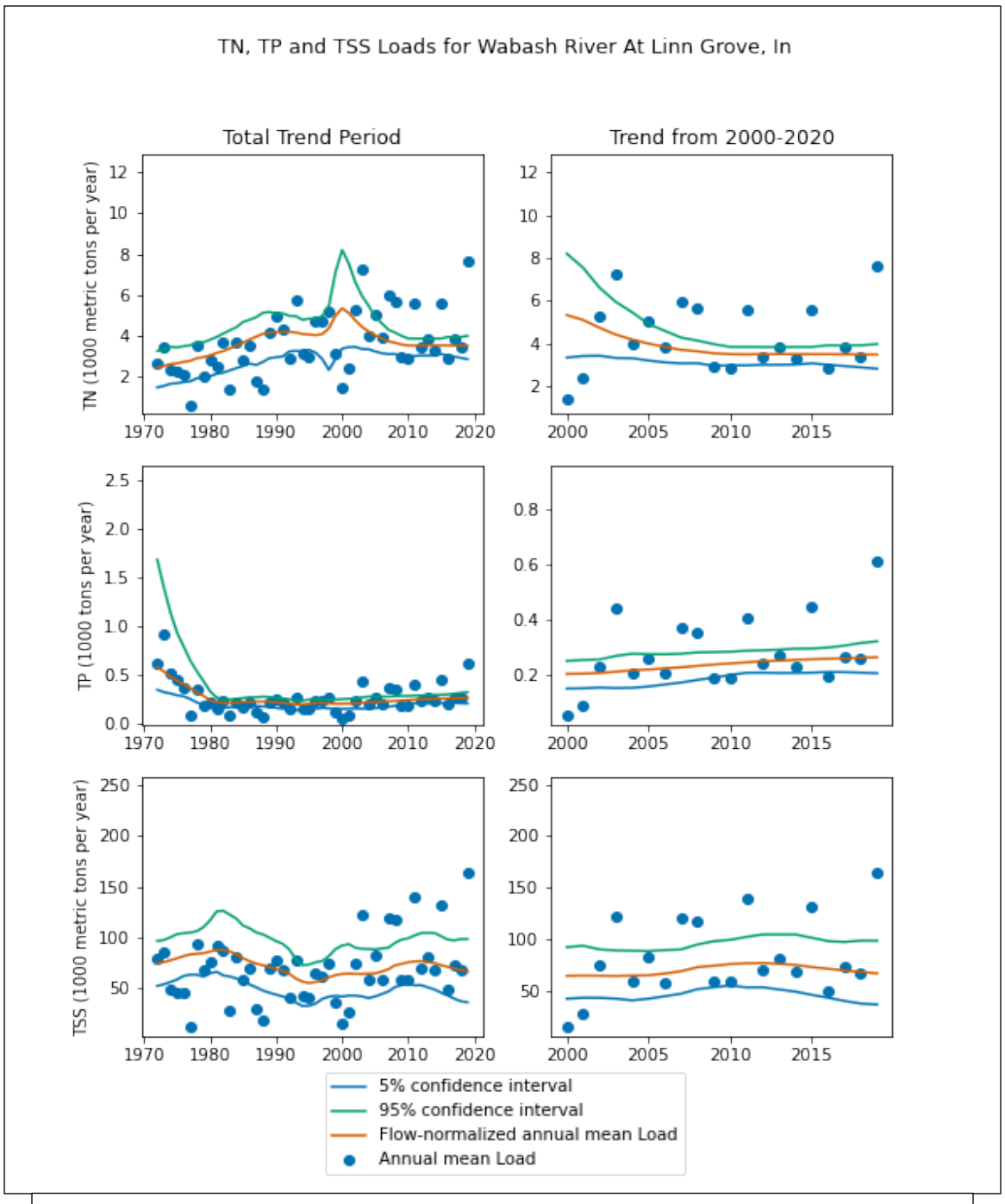


Figure 6B: Figure 6B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

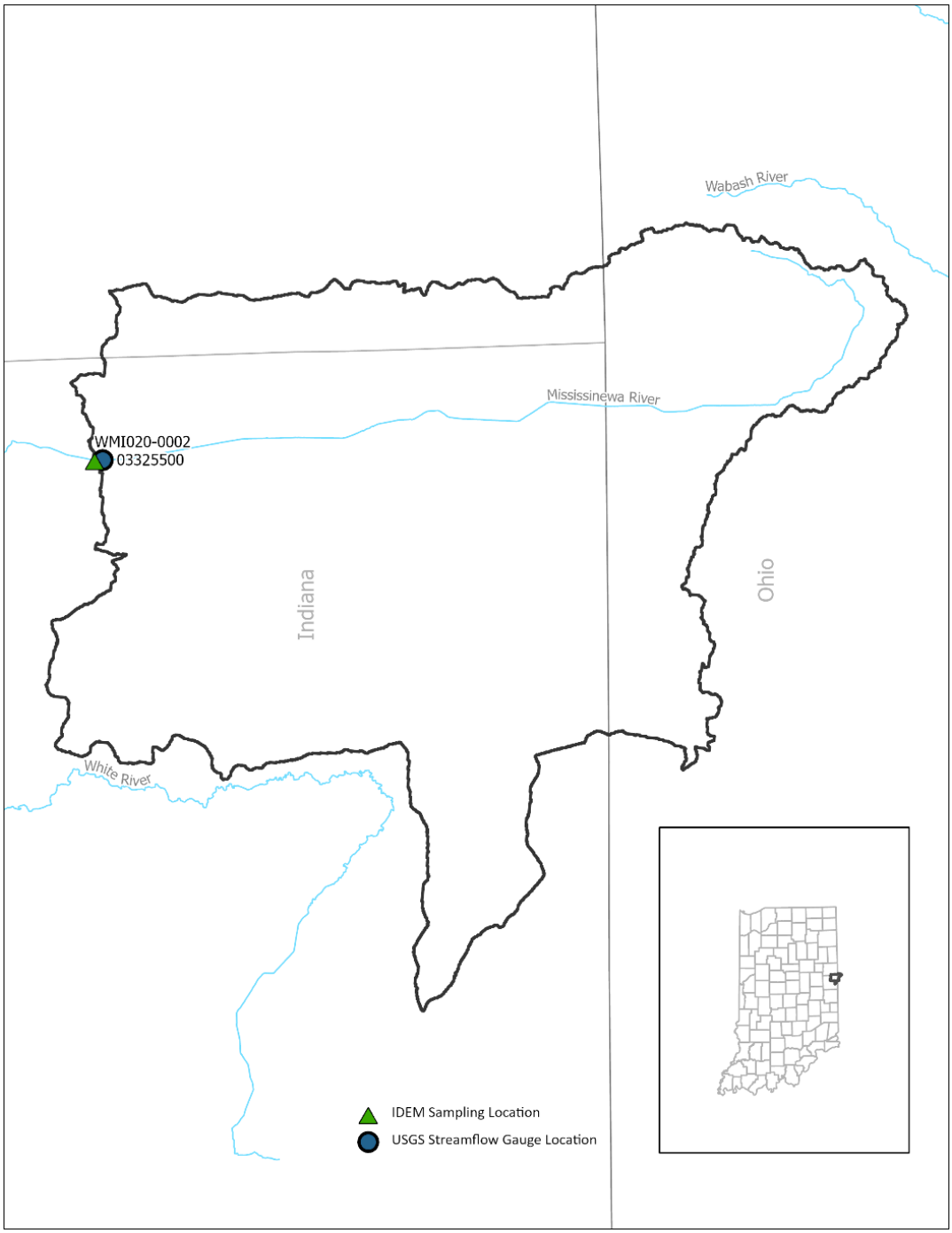
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	unlikely	very likely	likely
Downward Trend in Load	likely	very unlikely	unlikely

Table 6B: WBT descriptive results for loads from **2005-2015** for Wabash River at Linn Grove, IN (Im1)

Mississinewa River near Ridgeville, IN (Im2)

USGS Gage ID 03325500
IDEM station ID WMI020-0002

Both the USGS streamgage and the IDEM site are located in northern Randolph County, IN. The watershed covers parts of two counties in Indiana and some land in Ohio. This particular site captures imports into the state as the Mississinewa River begins in Ohio and flows into Indiana. This is the headwaters of the Mississinewa River which is a tributary to the Wabash River.



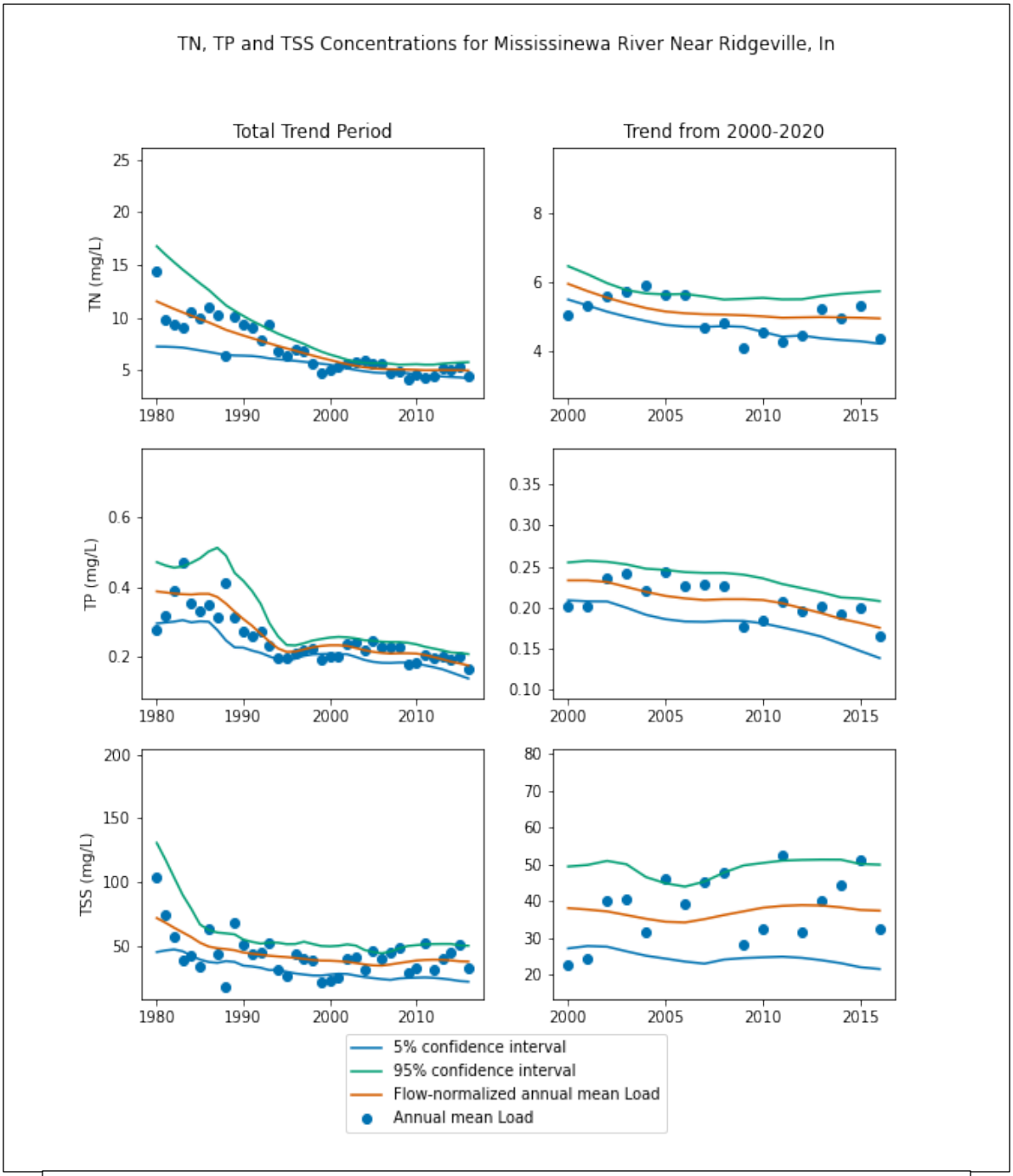


Figure 7A: Figure 7A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	about as likely as not	very unlikely	very unlikely
Downward Trend in Concentration	about as likely as not	very likely	very likely

Table 7A: WBT descriptive results for concentrations from **2005-2015** for Mississinewa River near Ridgeville, IN (Im2)

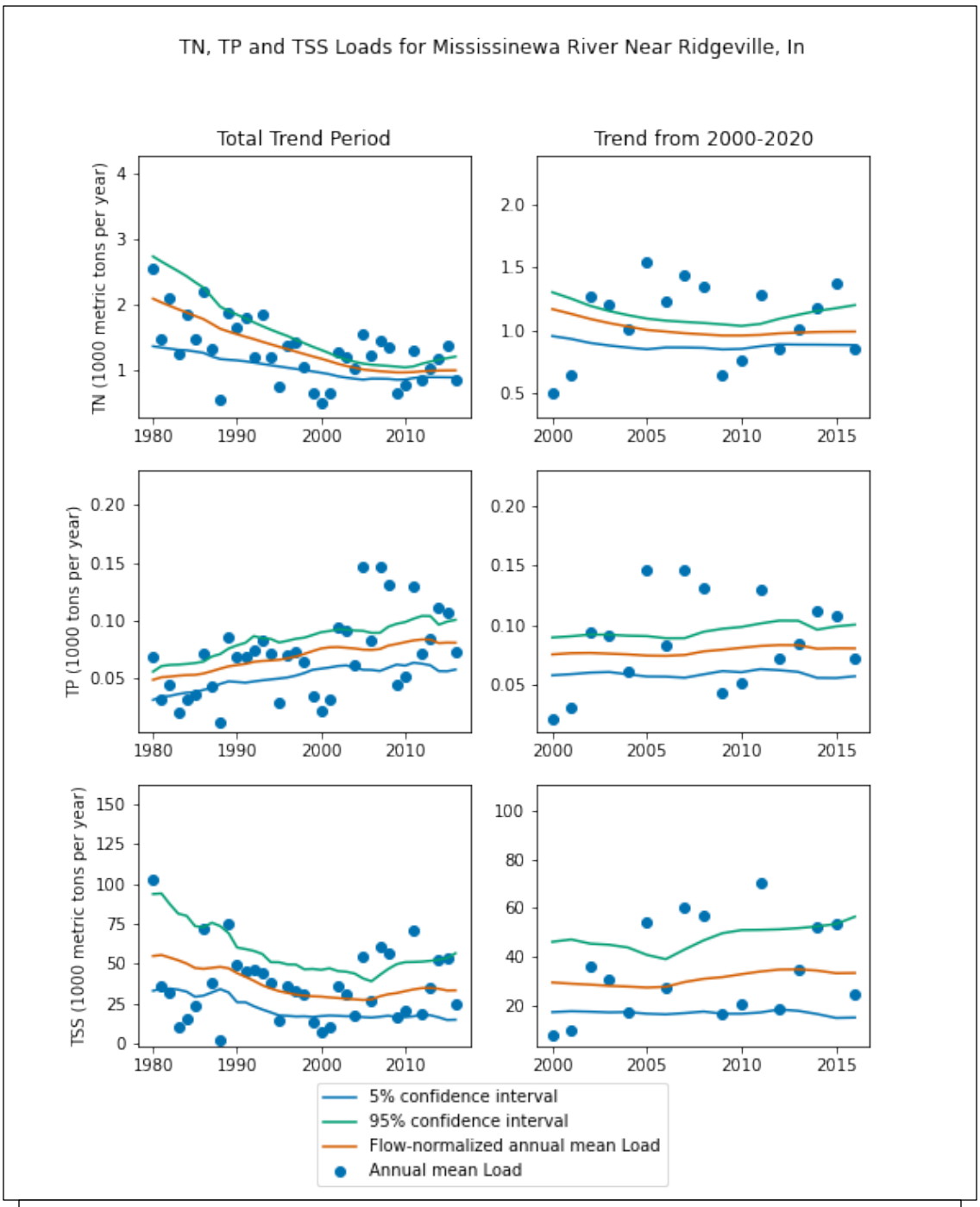


Figure 7B: Figure 7B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	about as likely as not	likely	likely
Downward Trend in Load	about as likely as not	unlikely	unlikely

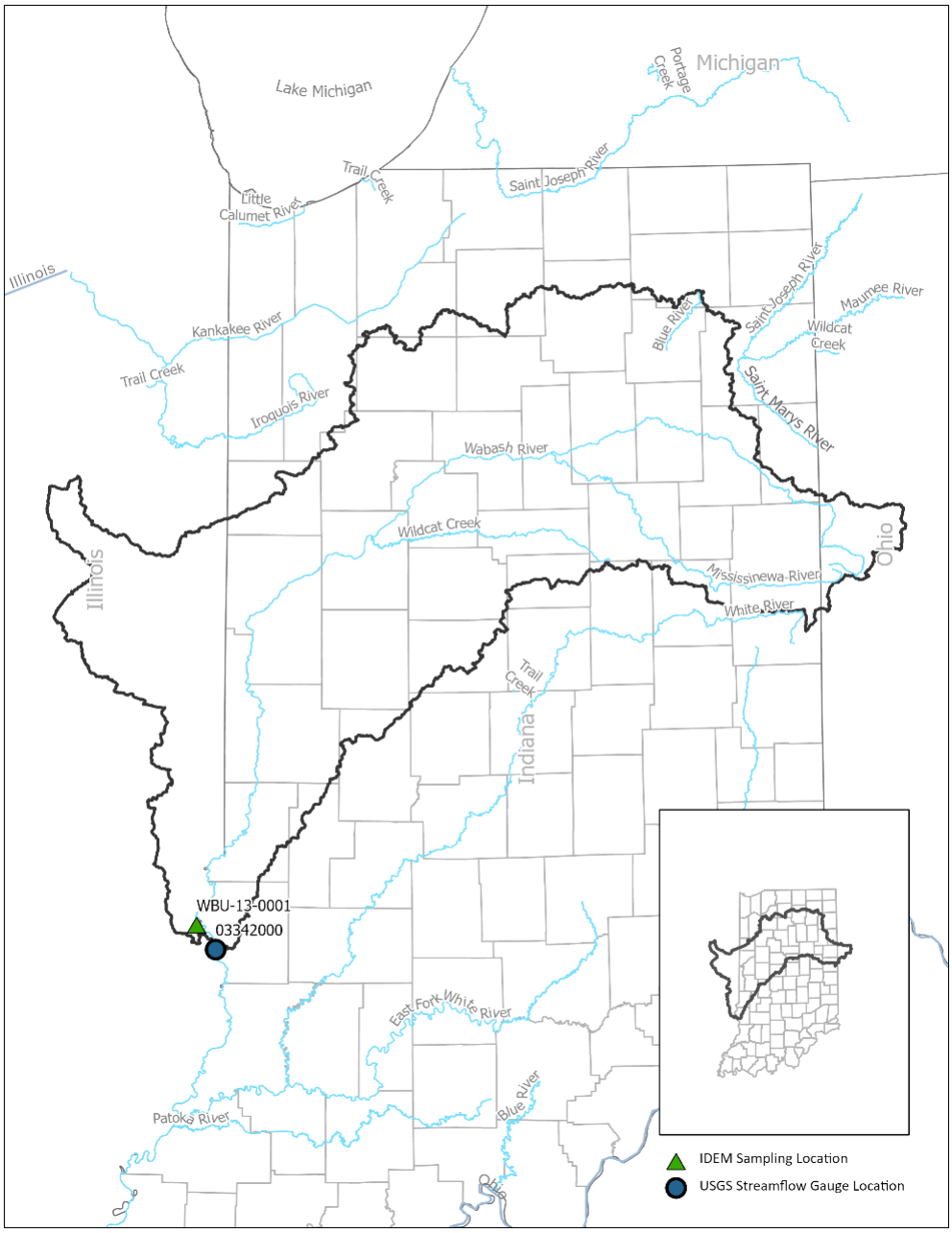
Table 7B: WBT descriptive results for loads from **2005-2015** for Mississinewa River near Ridgeville, IN (Im2)

Interior Sites

Wabash River at Riverton, IN (In1)

USGS Gage ID 03342000
IDEM station ID WBU-13-0001

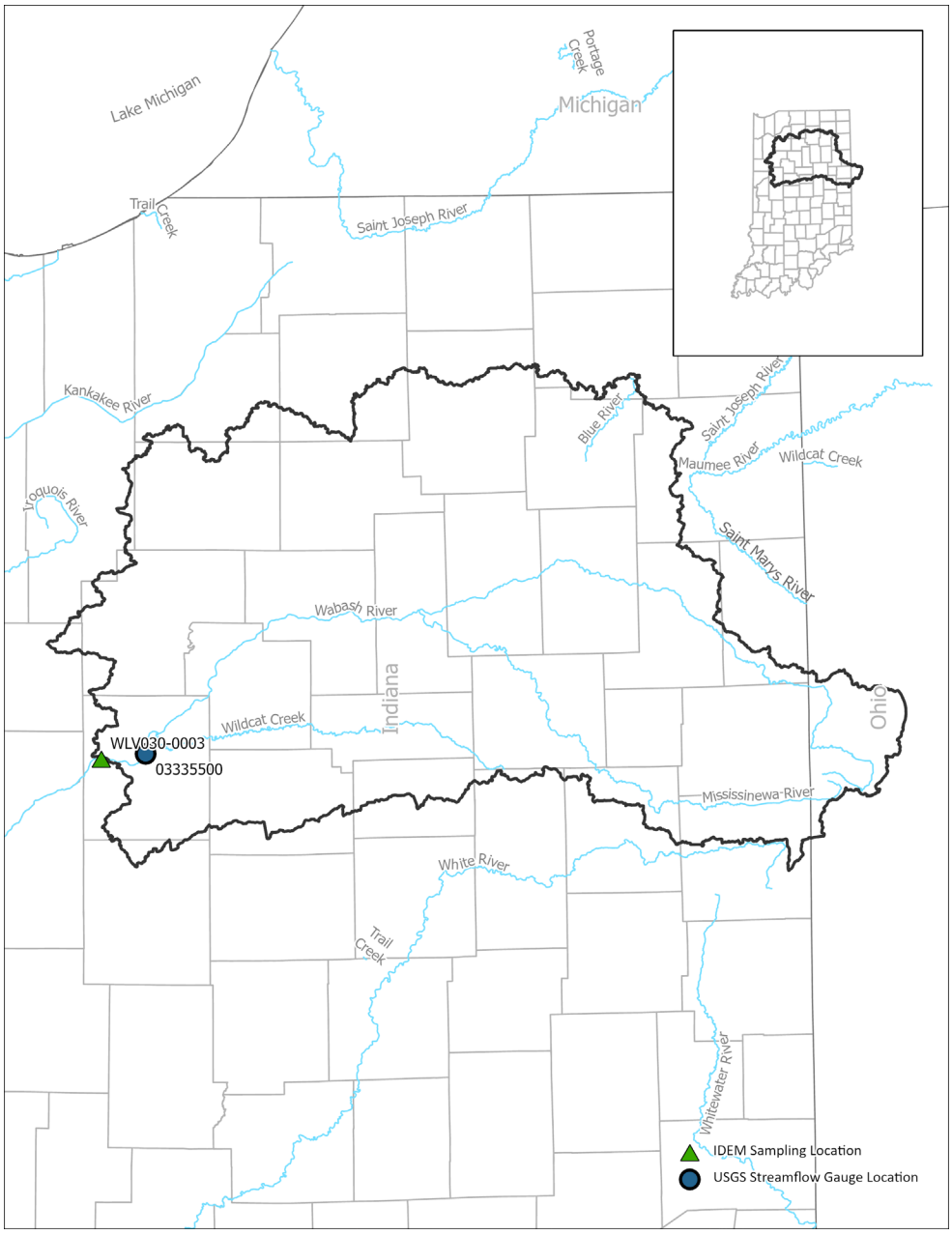
The USGS streamgage site and the IDEM station site are both located in Sullivan County, IN near Riverton, IN. The USGS streamgage site is located downstream of the IDEM site. This particular site captures a large swath of the Wabash River in Indiana before the Patoka and White River confluence, as well as some watershed in Illinois. However, WRTDS analysis was not able to be performed for this site because discharge data was only available from 2011 to present. It is recommended that a minimum of 20 years is needed to accurately assess a trend with WRTDS.



Wabash River at Lafayette, IN (In2)

USGS Gage ID 03335500
IDEM station ID WLV030-0003

The USGS streamgage site and the IDEM station site are both located in Tippecanoe County near Lafayette, IN. The USGS streamgage site is located upstream of the IDEM site. This particular site captures the Upper Wabash watershed influence before the Lower Wabash watershed. The upper portion of the Wabash River flows for hundreds of miles through nine counties before it reaches Lafayette, IN.



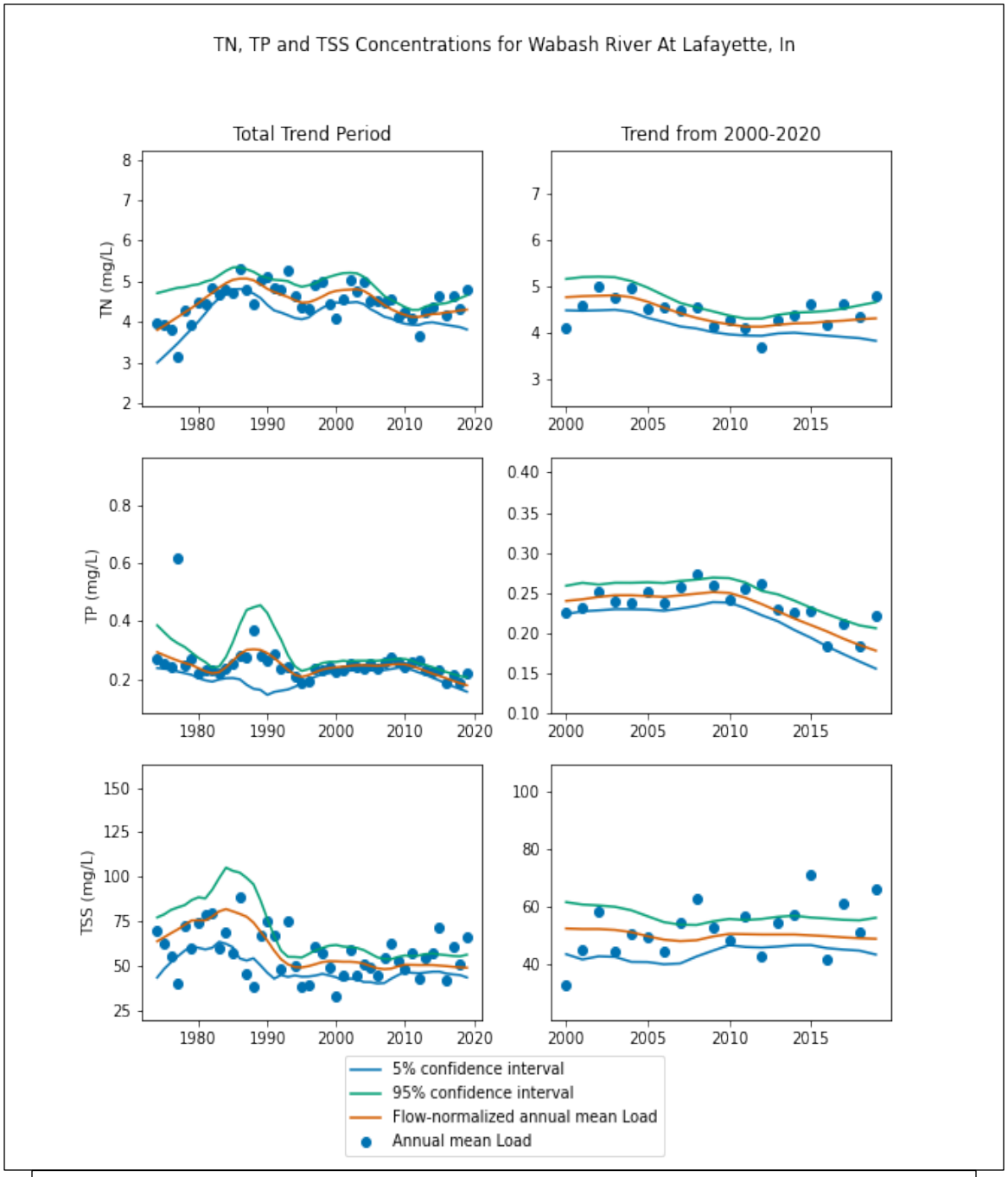


Figure 8A: Figure 8A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	highly unlikely	about as likely as not
Downward Trend in Concentration	highly likely	highly likely	about as likely as not

Table 8A: WBT descriptive results for concentrations from **2005-2015** for Wabash River at Lafayette, IN (In2)

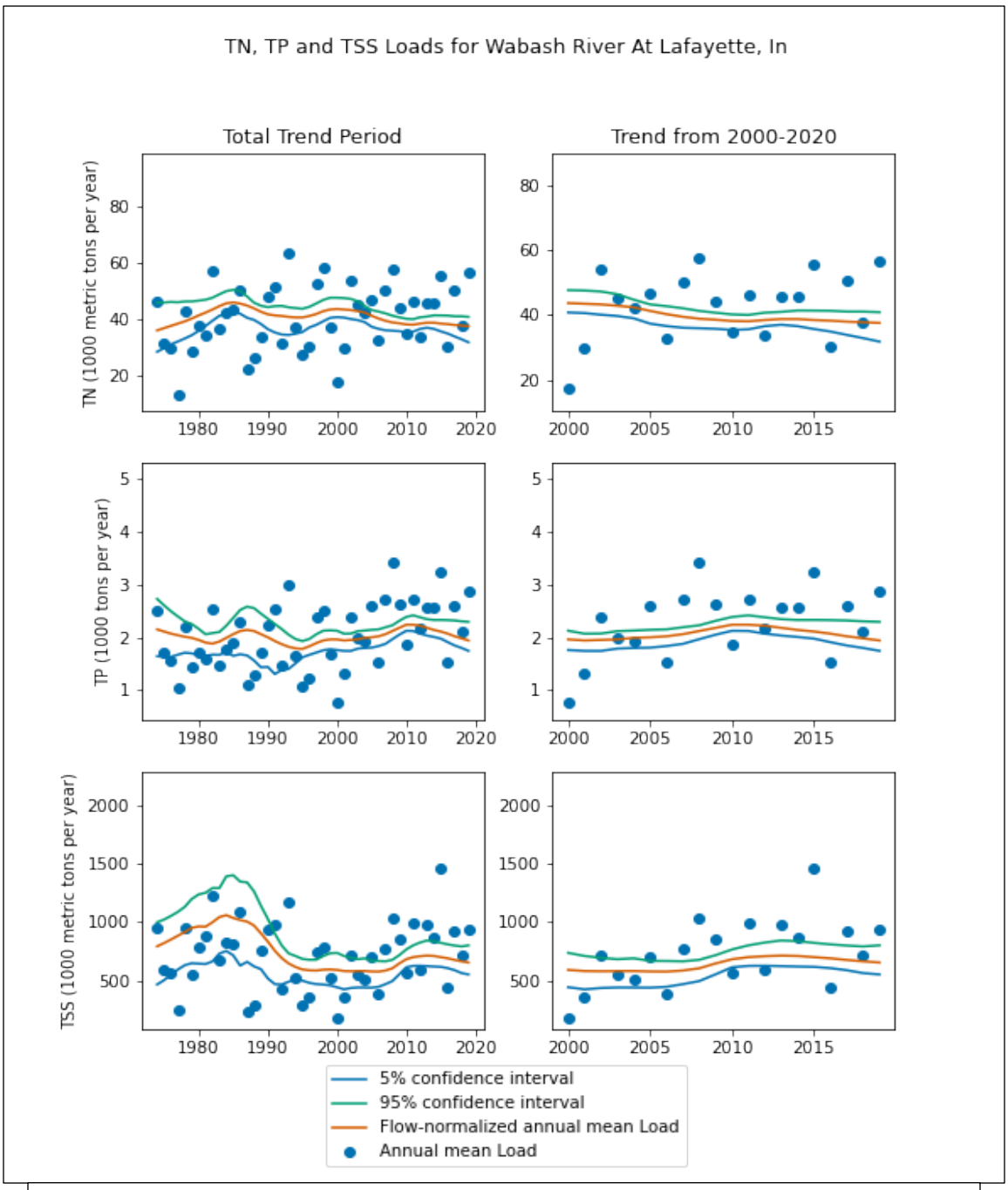


Figure 8B: Figure 8B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

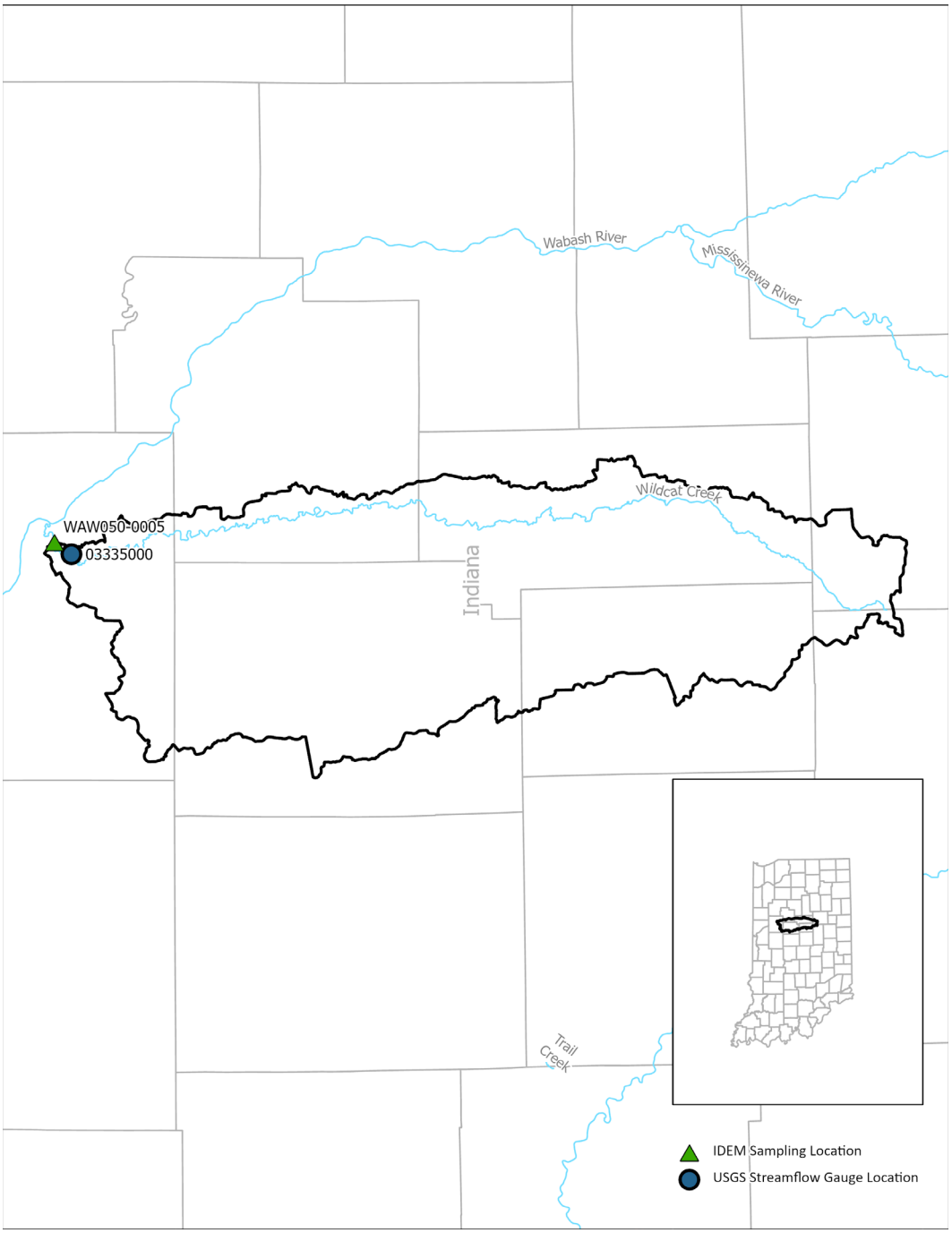
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	highly unlikely	likely	likely
Downward Trend in Load	highly likely	unlikely	unlikely

Table 8B: WBT descriptive results for loads from **2005-2015** for Wabash River at Lafayette, IN (In2)

Wildcat Creek near Lafayette, IN (In3)

USGS Gage ID 03335000
IDEM station ID WAW050-0005

The USGS streamgage site and the IDEM station site are both located in Tippecanoe County north of Lafayette, IN and the USGS streamgage site is located just upstream of the IDEM site. This particular site captures the exports from Wildcat Creek to the Wabash River. The Wildcat Creek originates near the Grant County and Madison County lines, and flows through four counties before meeting up with the Wabash River. The watershed covers parts of seven counties in Indiana.



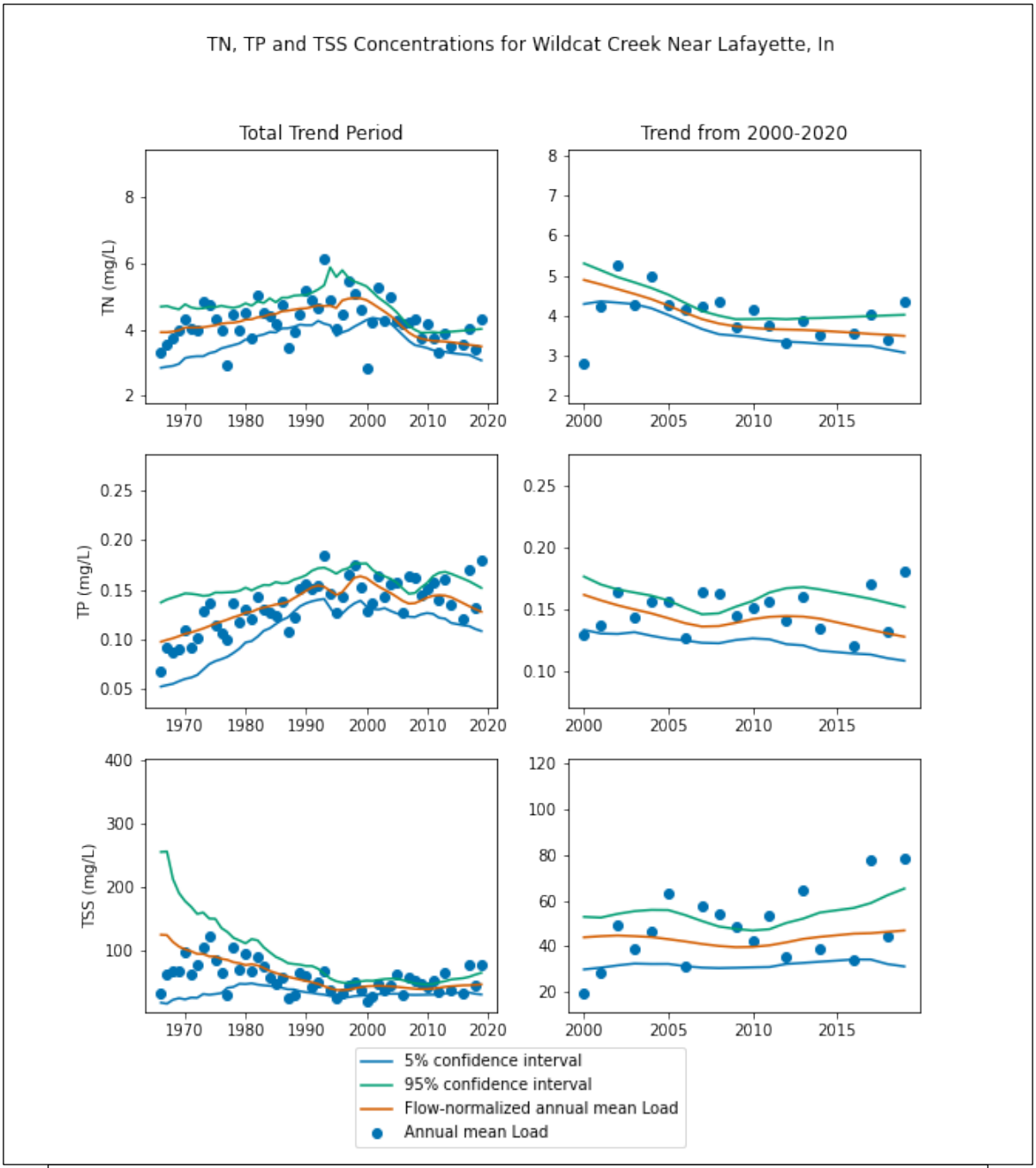


Figure 9A: Figure 9A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	about as likely as not	about as likely as not
Downward Trend in Concentration	highly likely	about as likely as not	about as likely as not

Table 9A: WBT descriptive results for concentrations from **2005-2015** for Wildcat Creek near Lafayette, IN (In3)

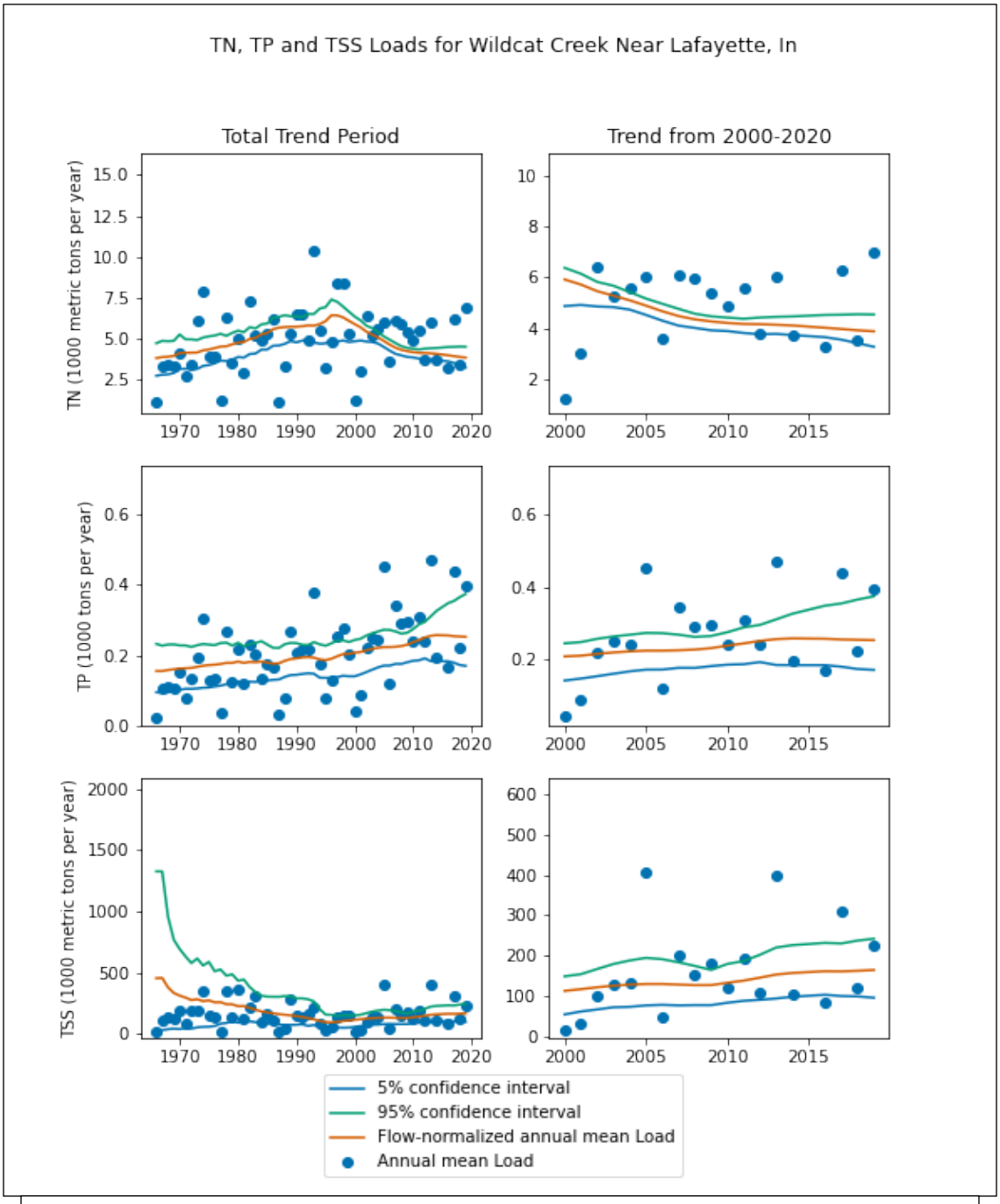


Figure 9B: Figure 9B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

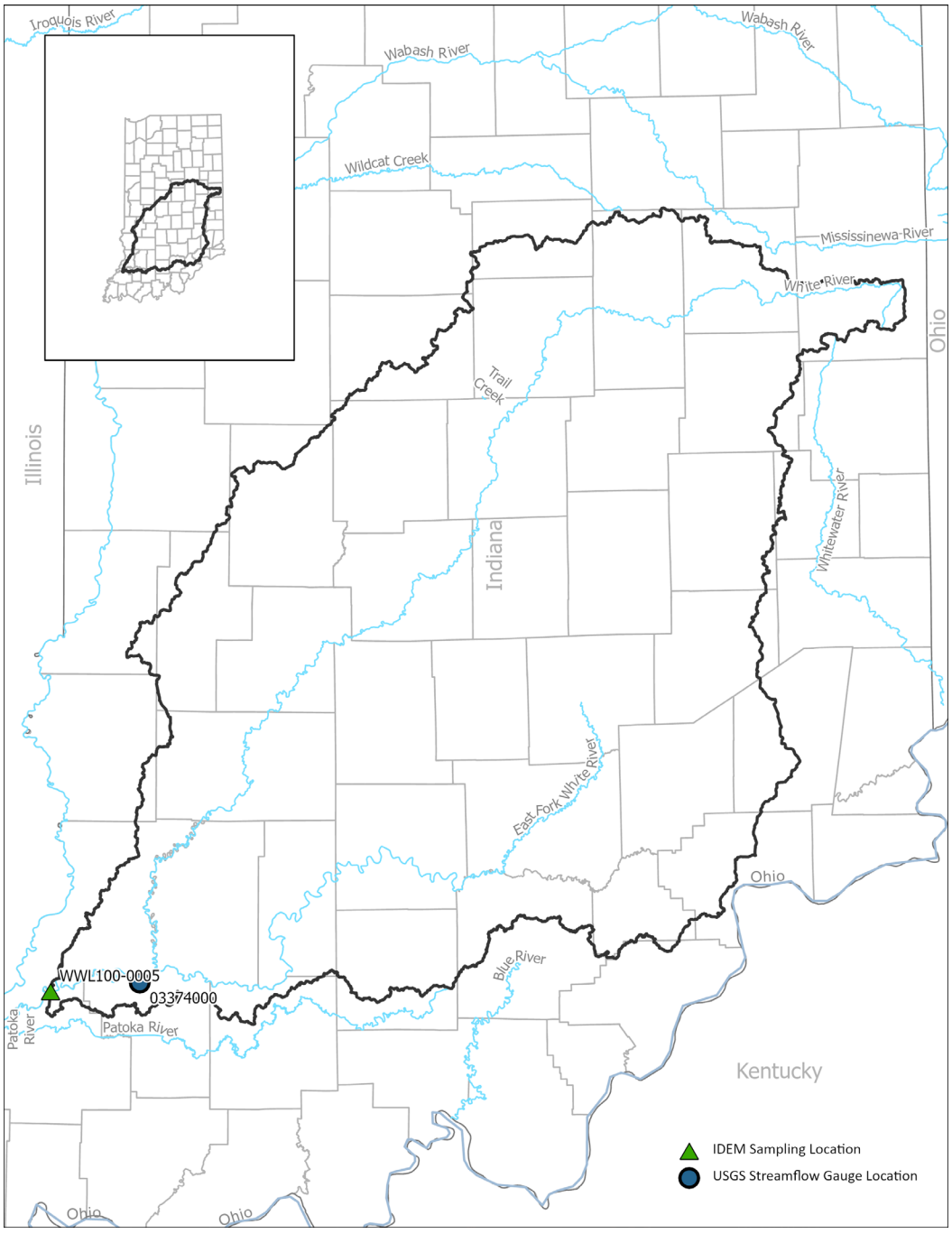
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	highly unlikely	likely	likely
Downward Trend in Load	highly likely	unlikely	unlikely

Table 9B: WBT descriptive results for loads from **2005-2015** for Wildcat Creek near Lafayette, IN (In3)

White River at Petersburg, IN (In4)

USGS Gage ID 03374000 (Supergage)
IDEM station ID WWL100-0005

The USGS supergage is located on the White River near Petersburg in Pike County upstream of the IDEM site that is located in Gibson County in southwest Indiana. This location captures the White River after the confluence of the West Fork White River and the East Fork White River. The White River watershed is made up of two main tributaries, the West Fork White River and the East Fork White River, and it has more than 1,000 miles of waterway. It is the largest tributary to the Wabash River.



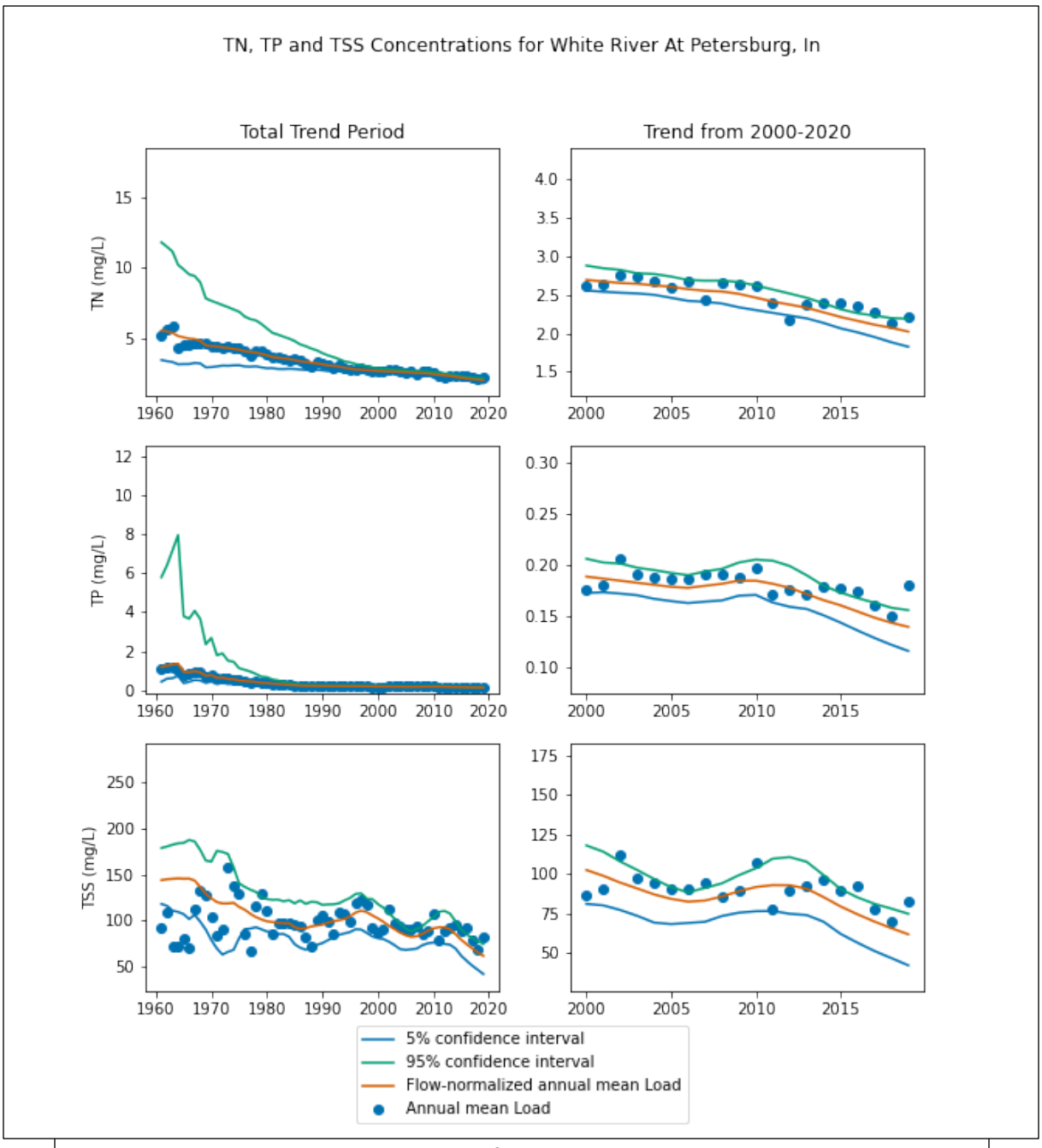


Figure 10A: Figure 10A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	highly unlikely	unlikely
Downward Trend in Concentration	highly likely	highly likely	likely

Table 10A: WBT descriptive results for concentrations from **2005-2015** for White River at Petersburg, IN (In4)

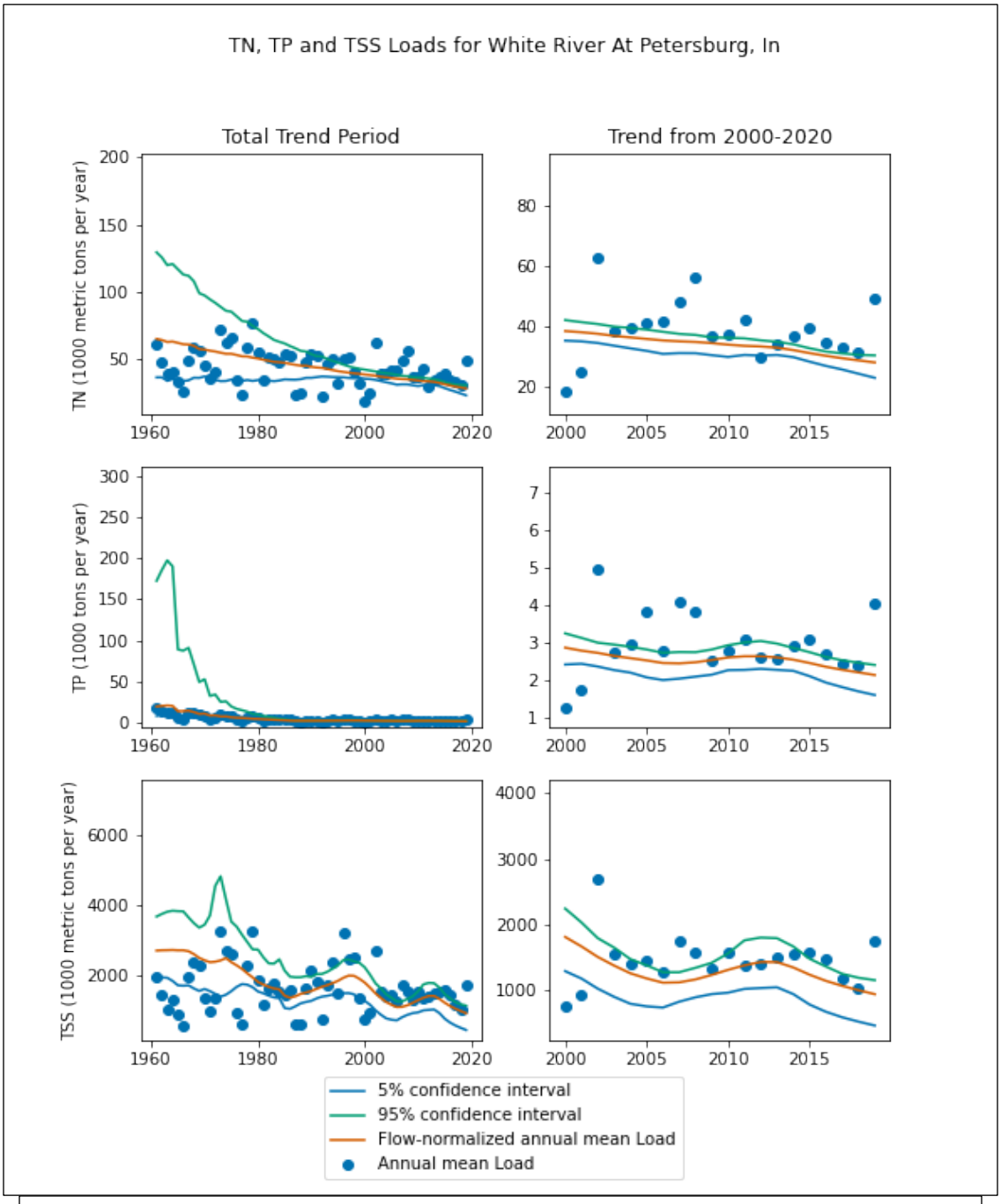


Figure 10B: Figure 10B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

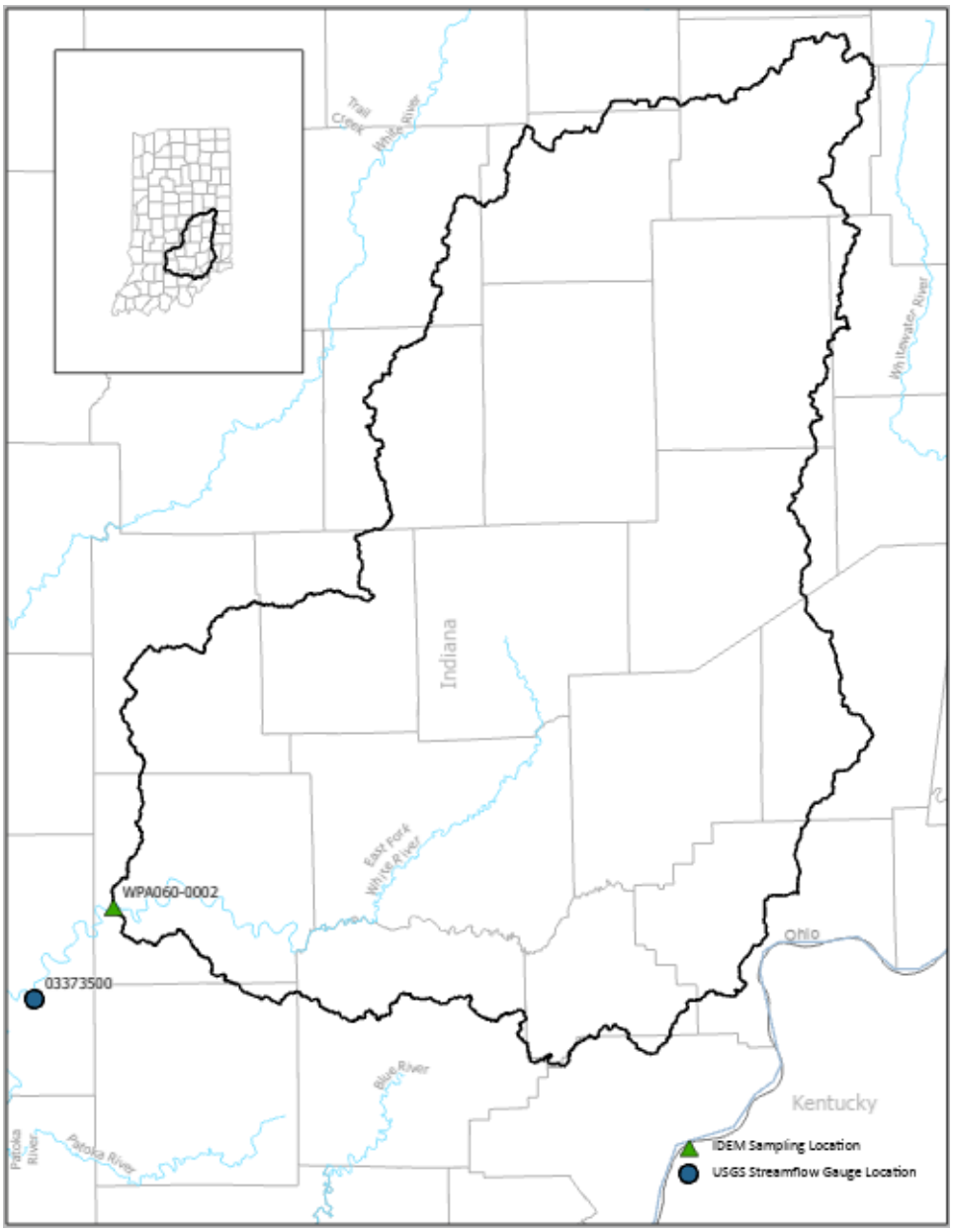
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	highly unlikely	unlikely	about as likely as not
Downward Trend in Load	highly likely	likely	about as likely as not

Table 10B: WBT descriptive results for loads from **2005-2015** for White River at Petersburg, IN (In4)

East Fork White River at Shoals, IN (In5)

USGS Gage ID 03373500
IDEM station ID WEL100-0002

The USGS streamgage is located in central Martin County downstream of the IDEM site that is located in west central Lawrence County in southern Indiana. This location captures the majority of the East Fork White River before its confluence with the West Fork White River. The East Fork White River beings in Bartholomew County in southeastern Indiana and travels approximately 200 miles before meeting up with the West Fork White River near Petersburg, Indiana. Important tributaries to the East Fork White River that help make up the large watershed are the Driftwood and Flatrock Rivers, the Upper East Fork White River, and the Muscatatuk River.



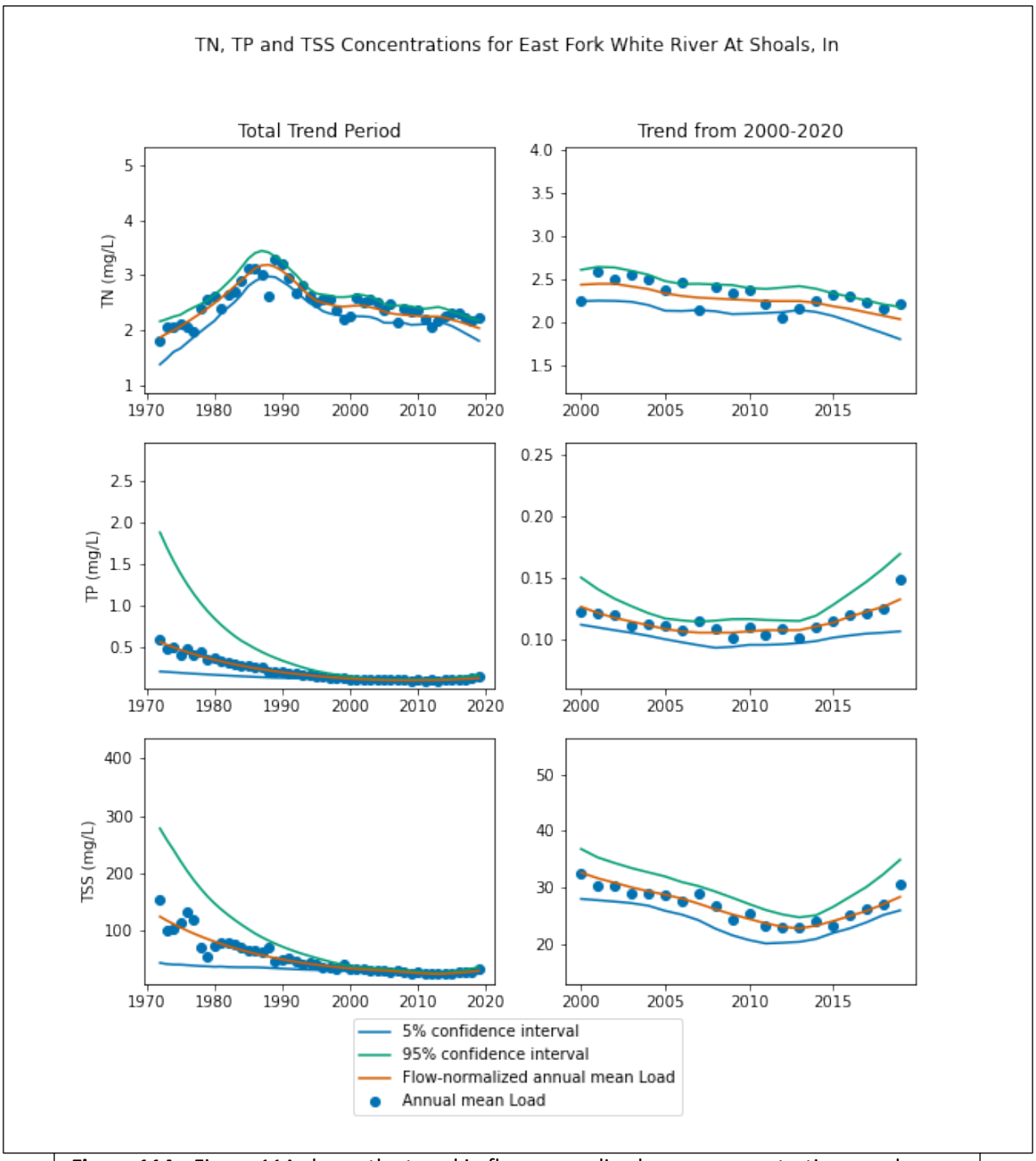


Figure 11A: Figure 11A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	unlikely	likely	likely
Downward Trend in Concentration	likely	unlikely	unlikely

Table 11A: WBT descriptive results for concentrations from **2005-2015** for East Fork White River at Shoals, IN (In5)

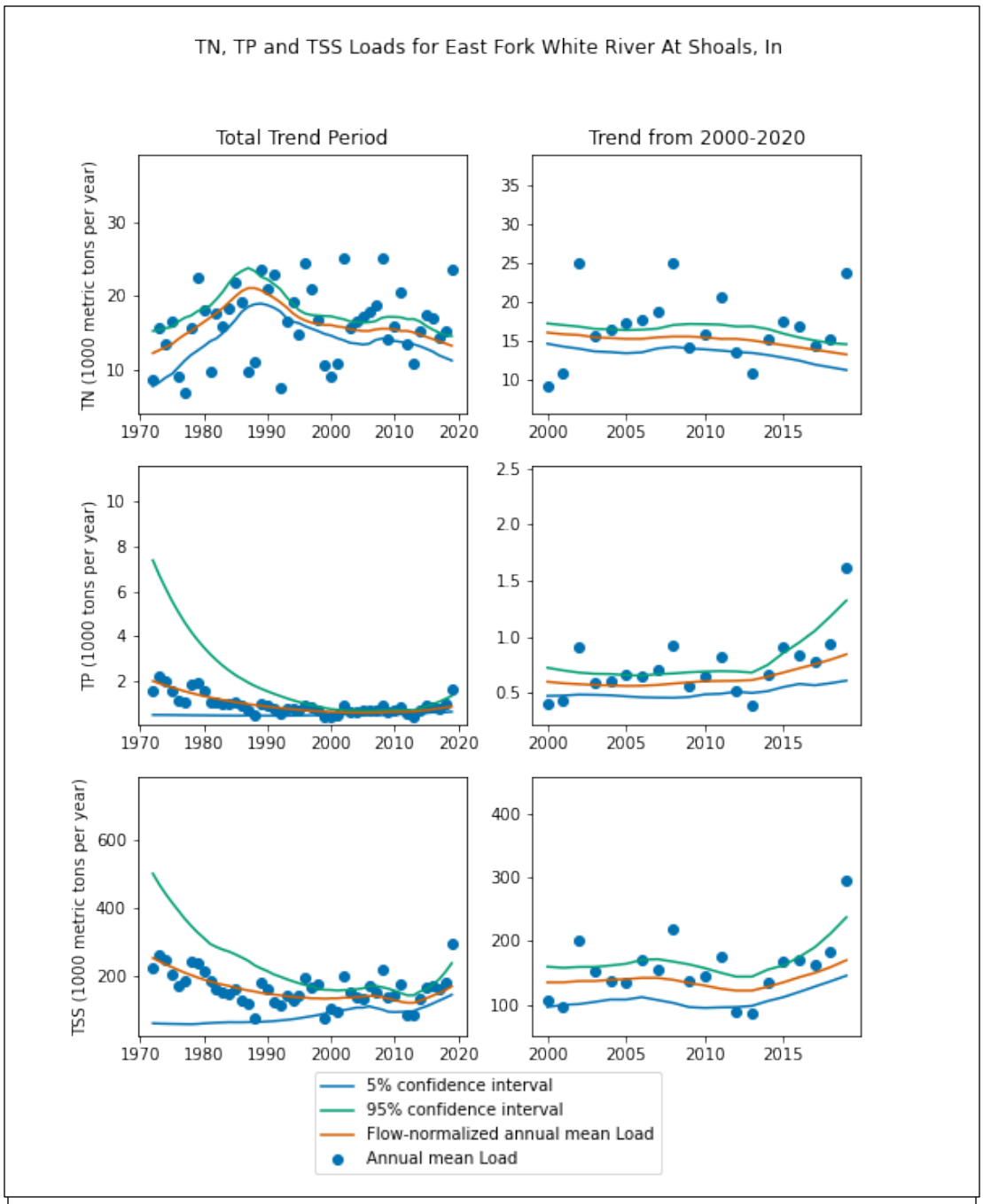


Figure 11B: Figure 11B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

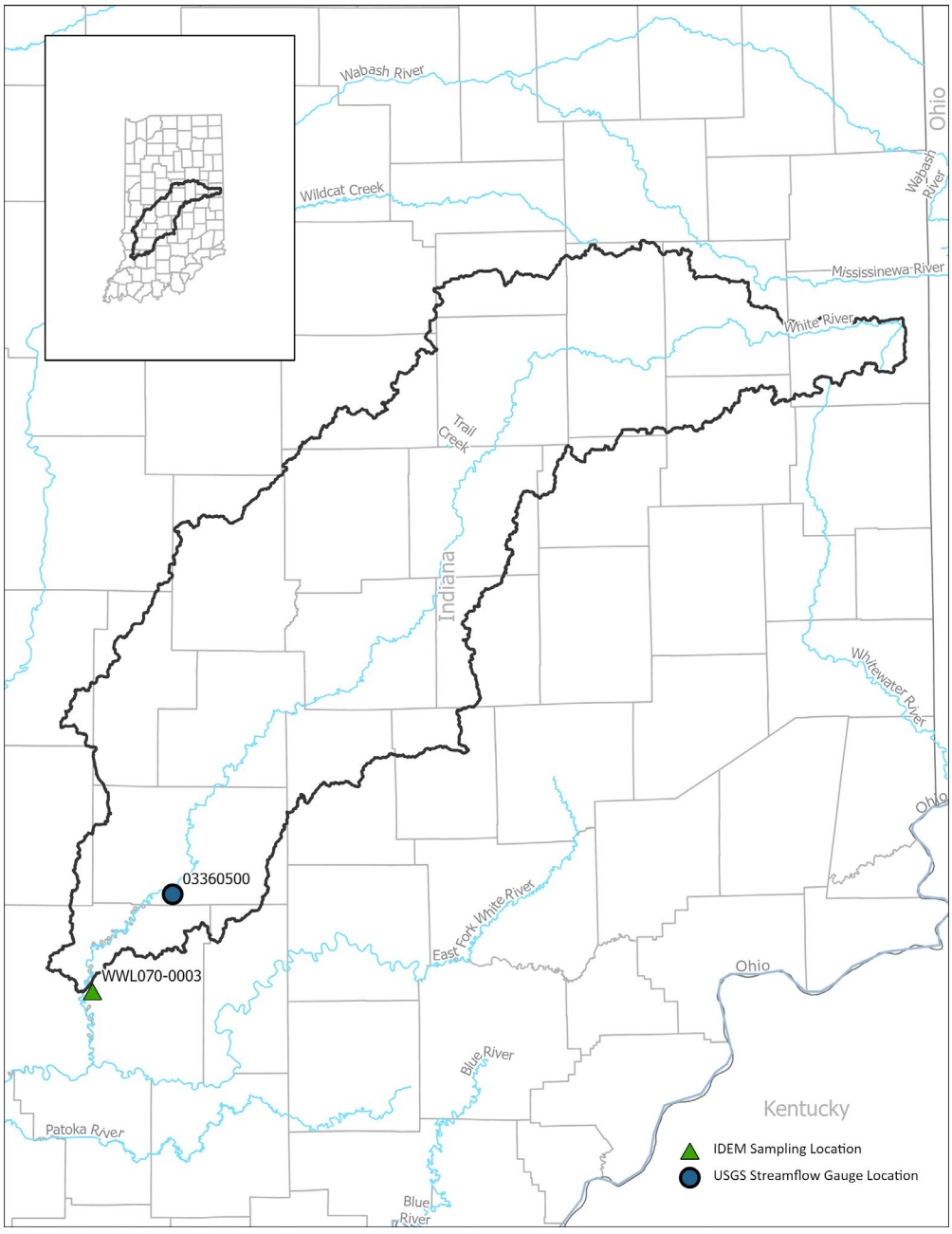
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	unlikely	very likely	very likely
Downward Trend in Load	likely	very unlikely	very unlikely

Table 11B: WBT descriptive results for loads from **2005-2015** for East Fork White River at Shoals, IN (In5)

White River at Newberry, IN (In6)

USGS Gage ID 03360500
IDEM station ID WWL070-0003

The USGS streamgage is located in southern Greene County upstream of the IDEM site that is located in west central Daviess County in southern Indiana. This location captures the West Fork White River after the confluence of the Eel River and before the confluence of the East Fork White River. The West Fork White River originates in Randolph County in east central Indiana and travels through 11 counties before meeting up with the East Fork White River near Petersburg, Indiana. The watershed covers all or parts of 22 Indiana counties.



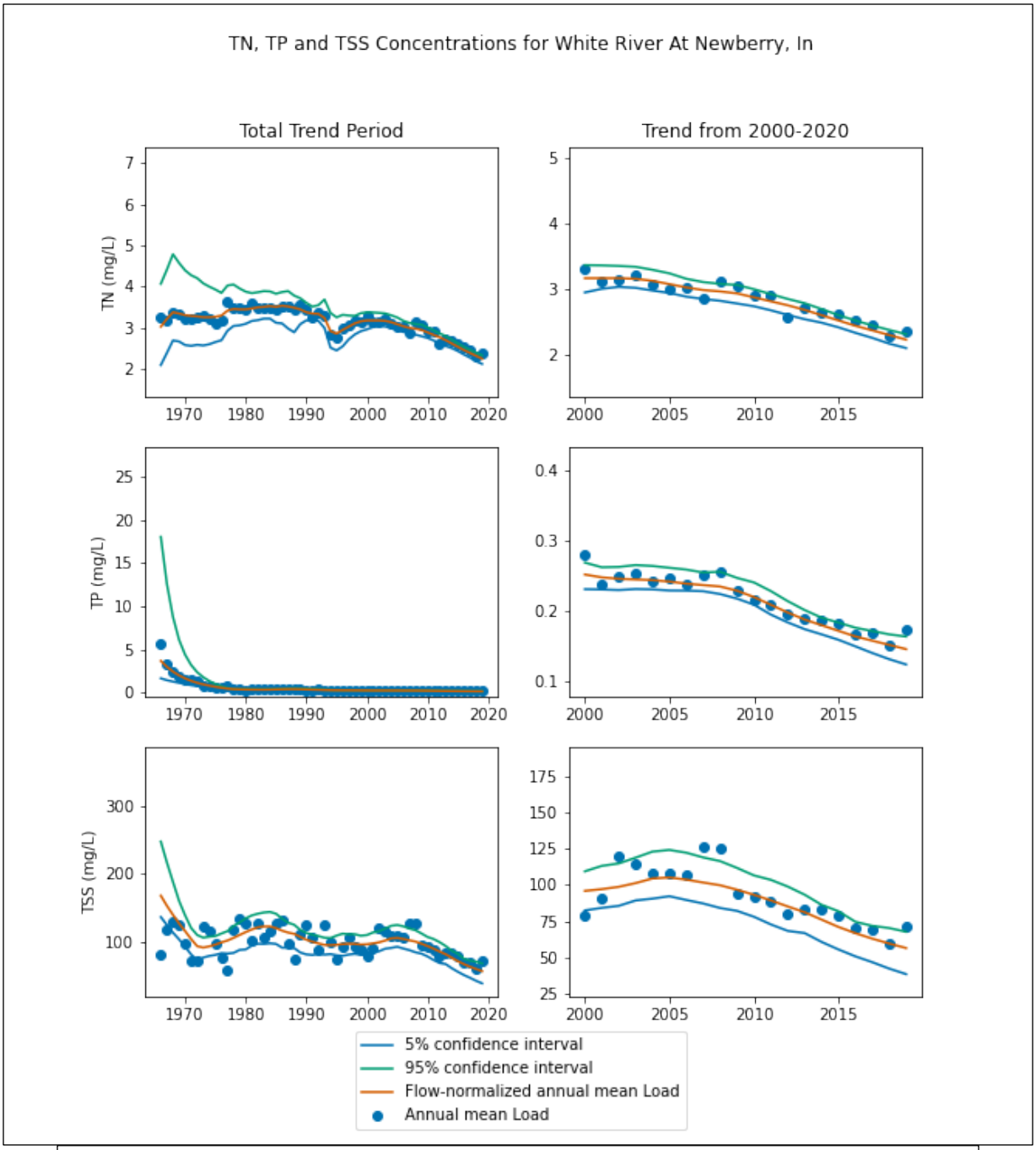


Figure 12A: Figure 12A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	highly unlikely	highly unlikely
Downward Trend in Concentration	highly likely	highly likely	highly likely

Table 12A: WBT descriptive results for concentrations from **2005-2015** for White River at Newberry, IN (In6)

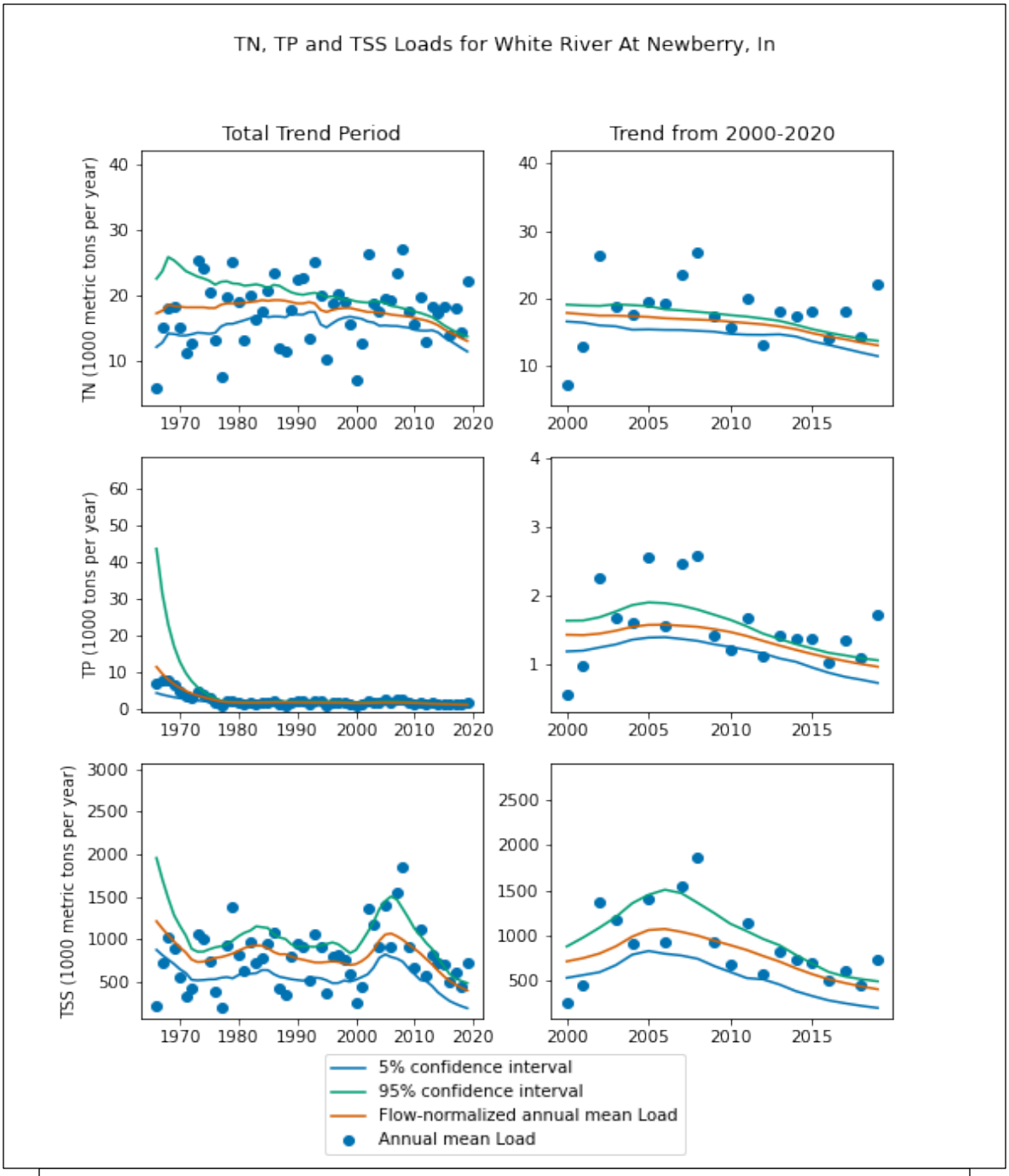


Figure 12B: Figure 12B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

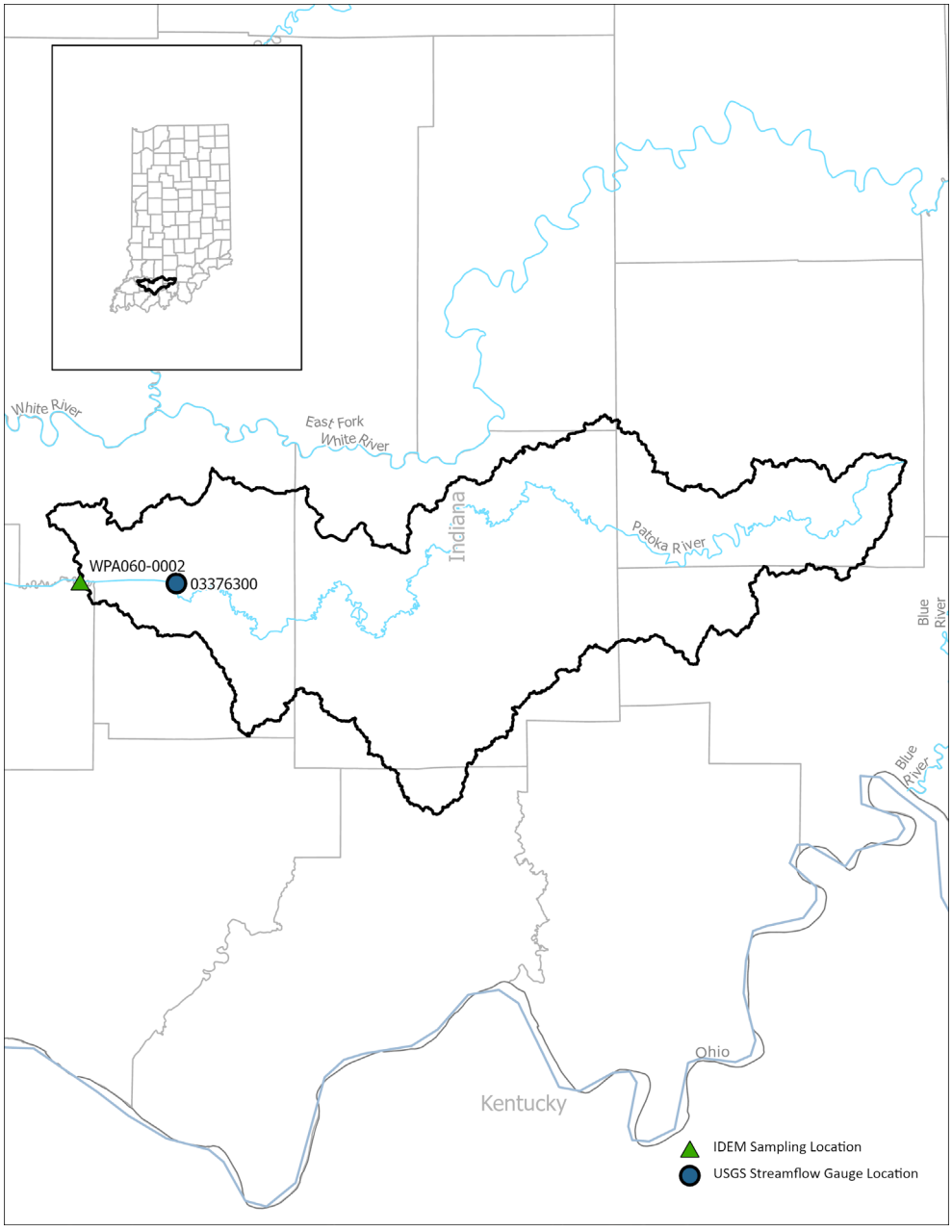
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	highly unlikely	highly unlikely	highly unlikely
Downward Trend in Load	highly likely	highly likely	highly likely

Table 12B: WBT descriptive results for loads from **2005-2015** for White River at Newberry, IN (In6)

Patoka River at Winslow, IN (In7)

USGS Gage ID 03376300
IDEM station ID WPA060-0002

Both the USGS streamgage site and the IDEM station site are located in Pike County in southwestern Indiana. The USGS streamgage site is located upstream of the IDEM site. This location captures the majority of the Patoka River downstream of Patoka Lake, which is located in the headwaters of the Patoka River. This part of the watershed covers all or part of 6 Indiana counties, and is made up of a largely rural areas of forested bottomland and agricultural lands. The entire Patoka River flows approximately 165 miles from Orange County to the Wabash River on the western State border between Indiana and Illinois. The mouth of the Patoka River enters the Wabash River approximately 1 mile downstream (south) from the mouth of the White River.



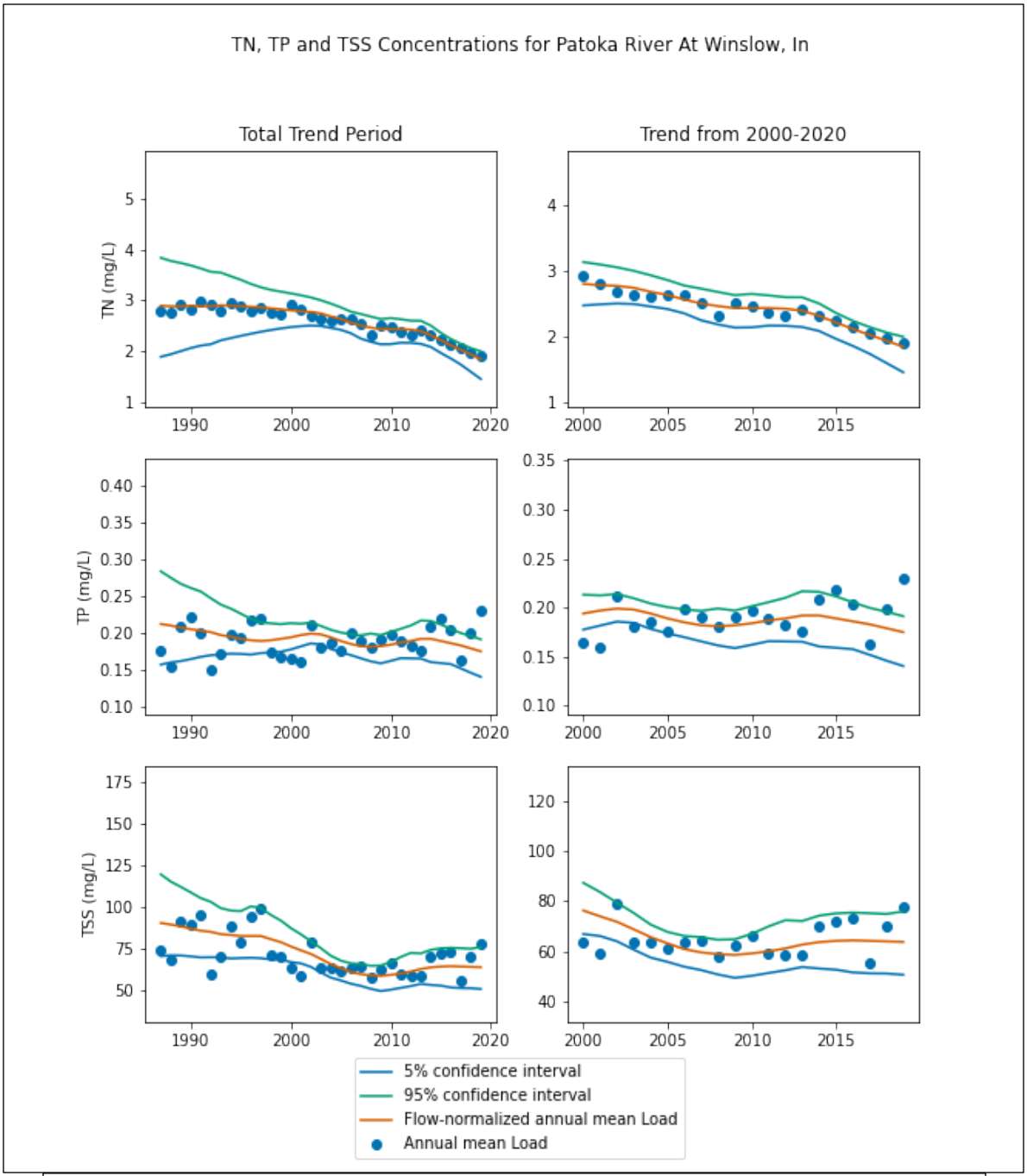


Figure 13A: Figure 13A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	about as likely as not	about as likely as not
Downward Trend in Concentration	highly likely	about as likely as not	about as likely as not

Table 13A: WBT descriptive results for concentrations from **2005-2015** for Patoka River at Winslow, IN (In7)

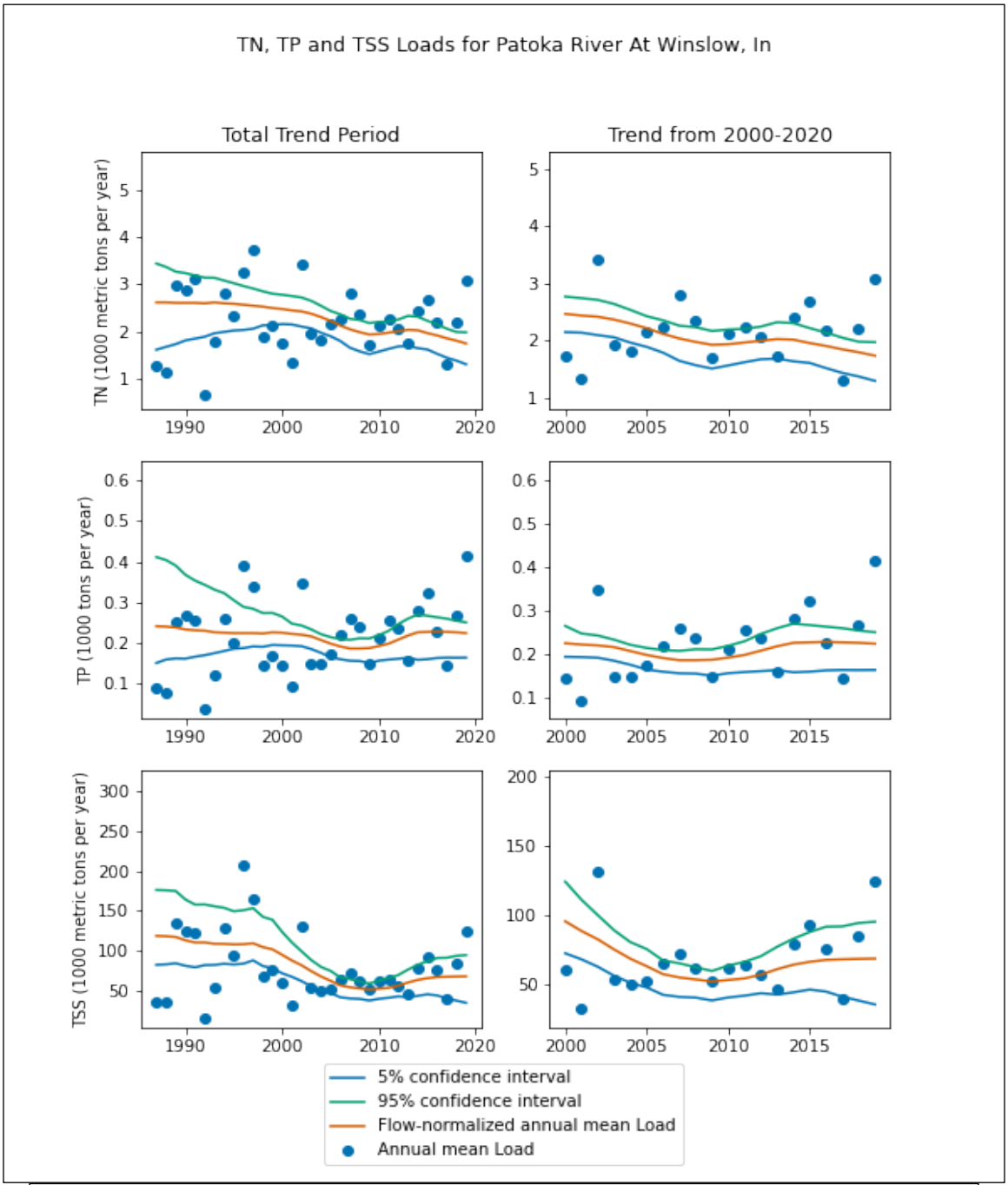


Figure 13B: Figure 13B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	unlikely	likely	about as likely as not
Downward Trend in Load	likely	unlikely	about as likely as not

Table 13B: WBT descriptive results for loads from **2005-2015** for Patoka River at Winslow, IN (In7)

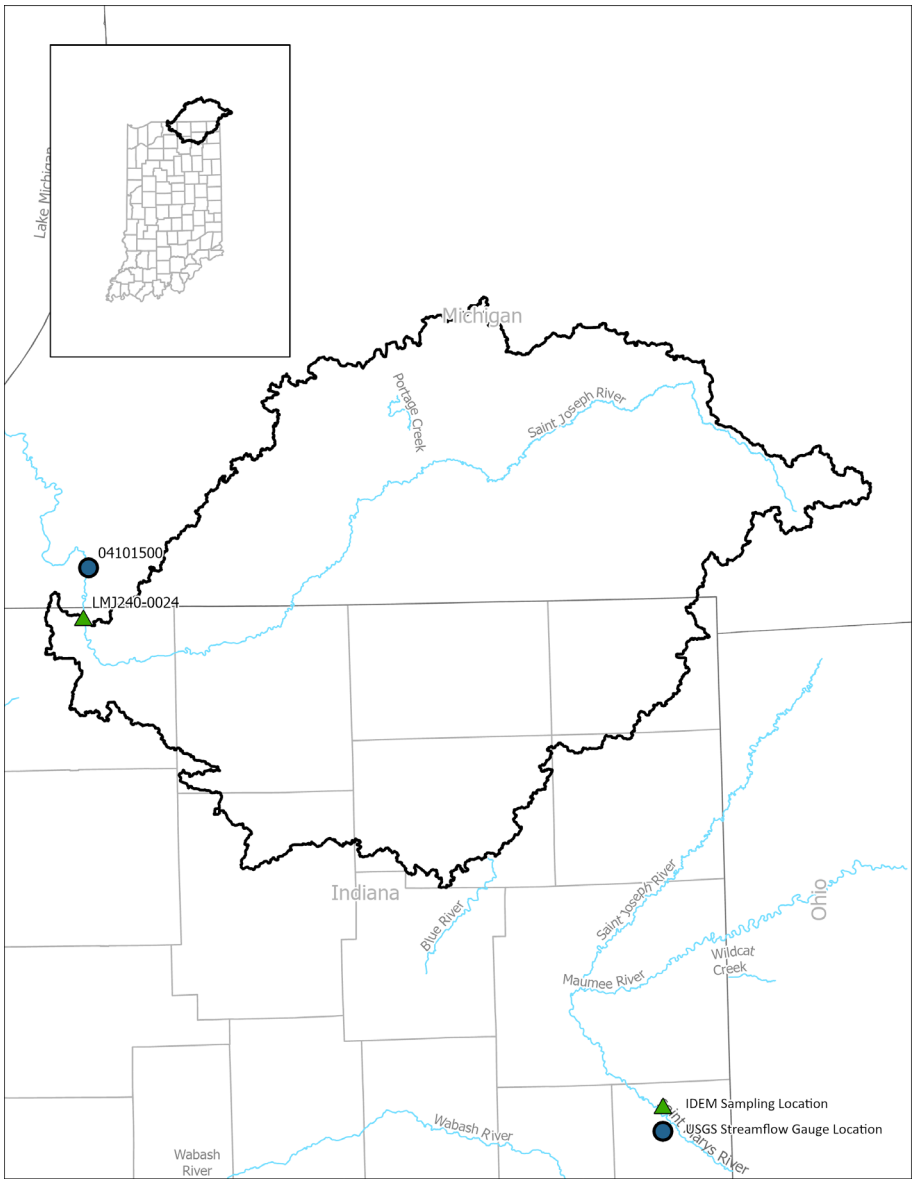
C. Lake Michigan Basin

Export Sites

St. Joseph River at Niles, MI (Ex6)

USGS Gage ID 04101500
IDEM station ID LMJ240-0024

The USGS streamgage site is located in Berrien County, Michigan downstream of the IDEM station site that is located in St. Joseph County in northern Indiana. This location captures the St. Joseph River exports into the state of Michigan and to Lake Michigan from Indiana. The St. Joseph-Lake Michigan watershed is located in southwest Michigan and northeast Indiana. The St. Joseph River begins in Michigan's Hillsdale County at Baw Beese Lake, and flows in a northerly arc before turning south and entering Indiana. The river then flows west through Indiana before making an abrupt turn north in South Bend. It re-enters Michigan between the cities of St. Joseph and Benton Harbor.



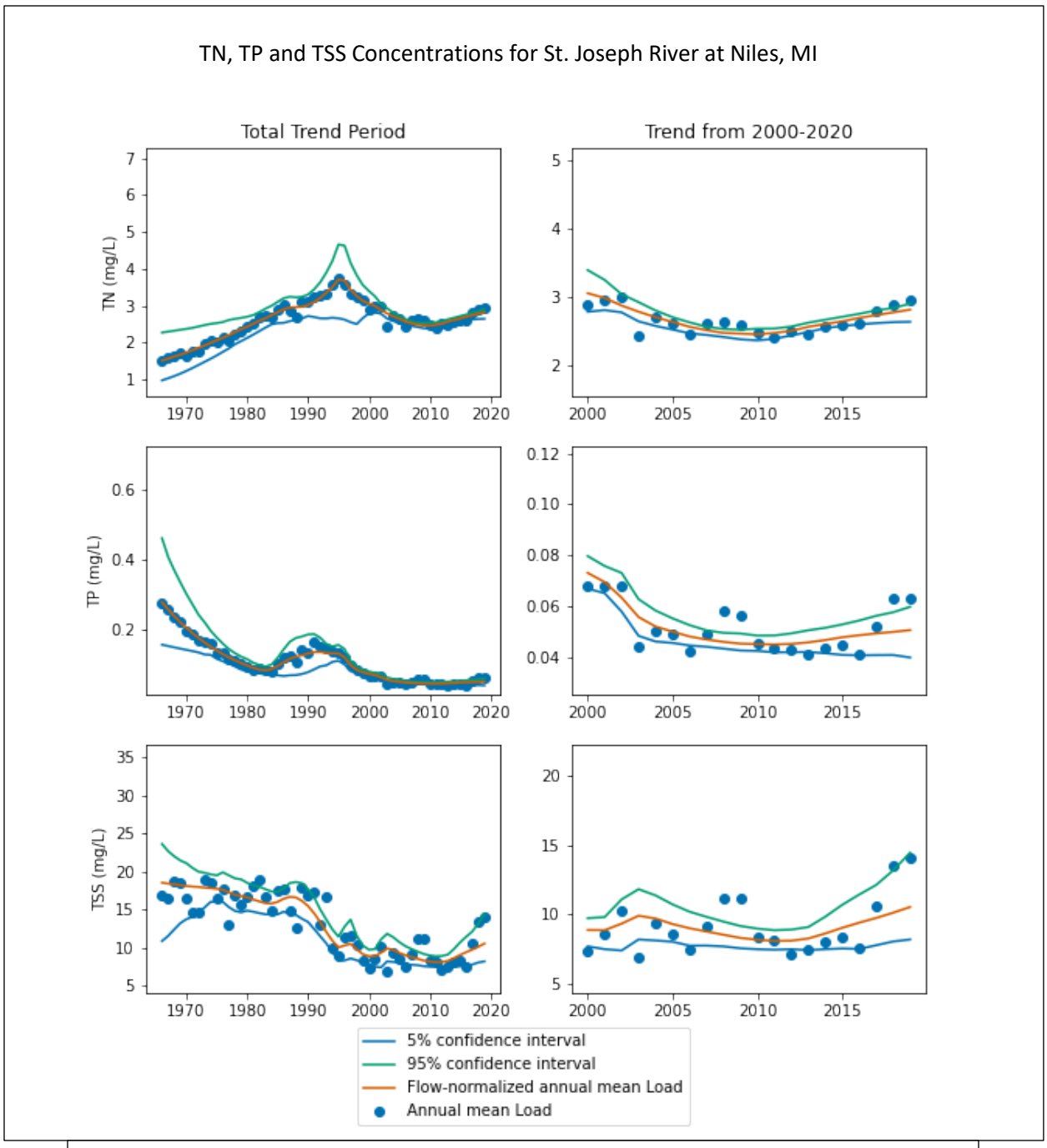


Figure 14A: Figure 14A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	about as likely as not	unlikely	about as likely as not
Downward Trend in Concentration	about as likely as not	likely	about as likely as not

Table 14A: WBT descriptive results for concentrations from **2005-2015** for St. Joseph River at Niles, MI (Ex6)

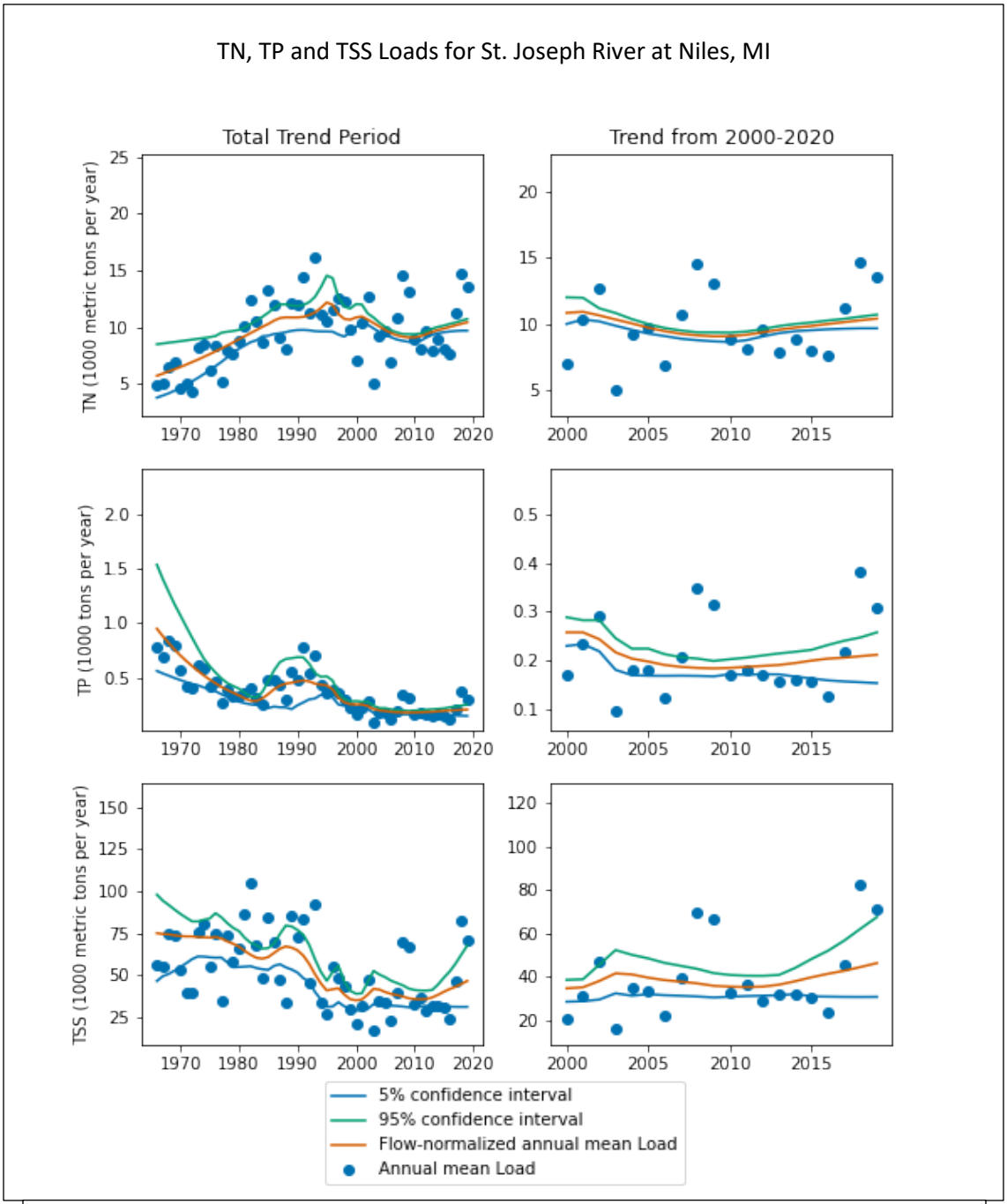


Figure 14B: Figure 14B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

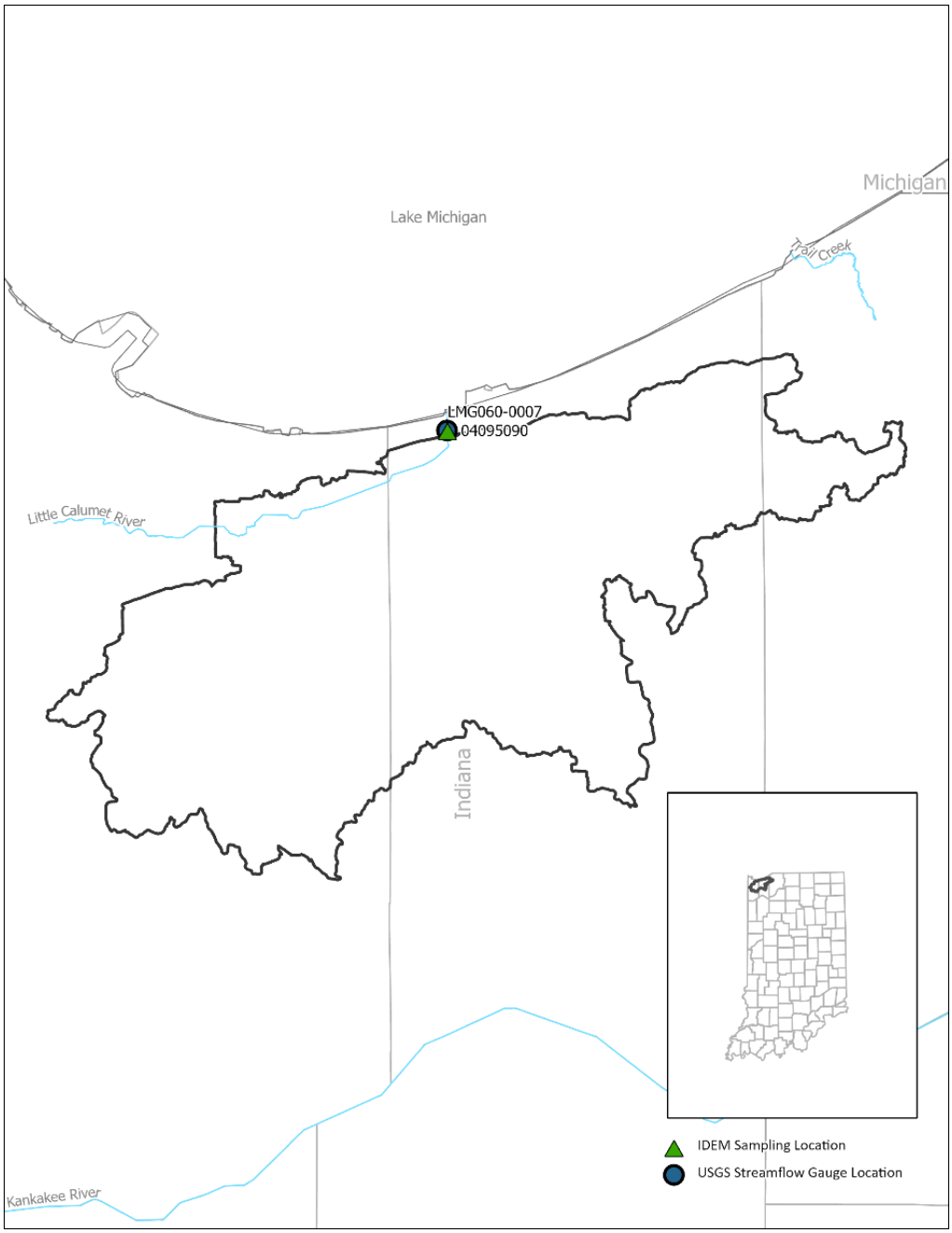
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	about as likely as not	about as likely as not	about as likely as not
Downward Trend in Load	about as likely as not	about as likely as not	about as likely as not

Table 14B: WBT descriptive results for loads from **2005-2015** for St. Joseph River at Niles, MI (Ex6)

Burns Ditch at Portage, IN (Ex7)

USGS Gage ID 04095090
IDEM station ID LMG060-0007

The USGS streamgage site and the IDEM station are co-located at this location. The sites are located in northern Porter County in northwest Indiana in Portage, IN. This location captures Burns Ditch exports to Lake Michigan from Indiana. The Little Calumet River collects it waters from many small streams and drainage ditches in northwestern Indiana before emptying into Lake Michigan via Burns Ditch in Indiana and the Calumet Harbor in Illinois. Most of the Little-Calumet-Galien watershed has been altered from its historic setting. Land use in this watershed is predominatley urban, suburban, and industrial. Some of the land is used for agriculture, while only a remnant of the historic wetlands remains (USEPA 2002).



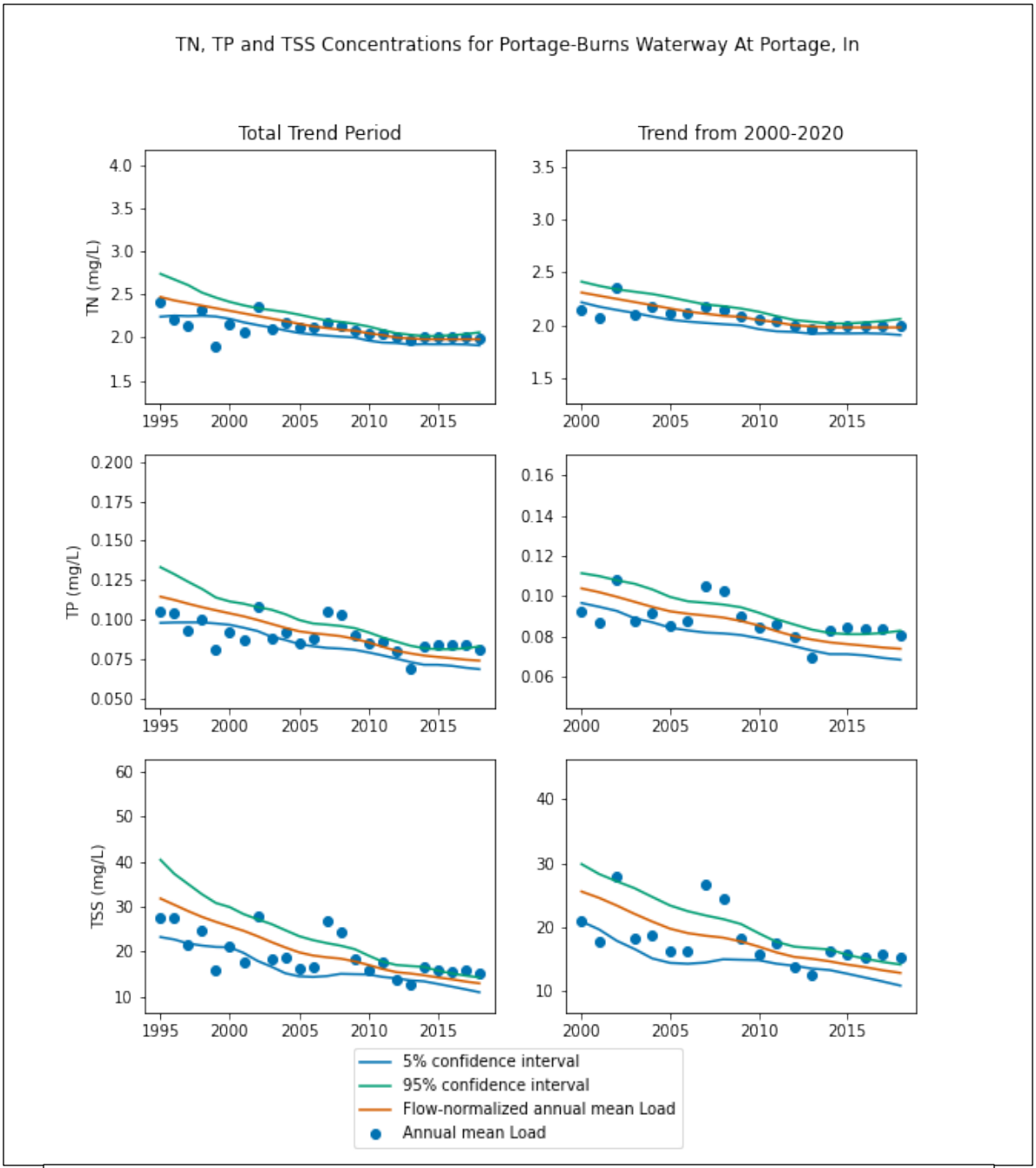


Figure 15A: Figure 15A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	highly unlikely	highly unlikely	highly unlikely
Downward Trend in Concentration	highly likely	highly likely	highly likely

Table 15A: WBT descriptive results for concentrations from **2005-2015** for Portage-Burns Waterway at Portage, IN (Ex7)

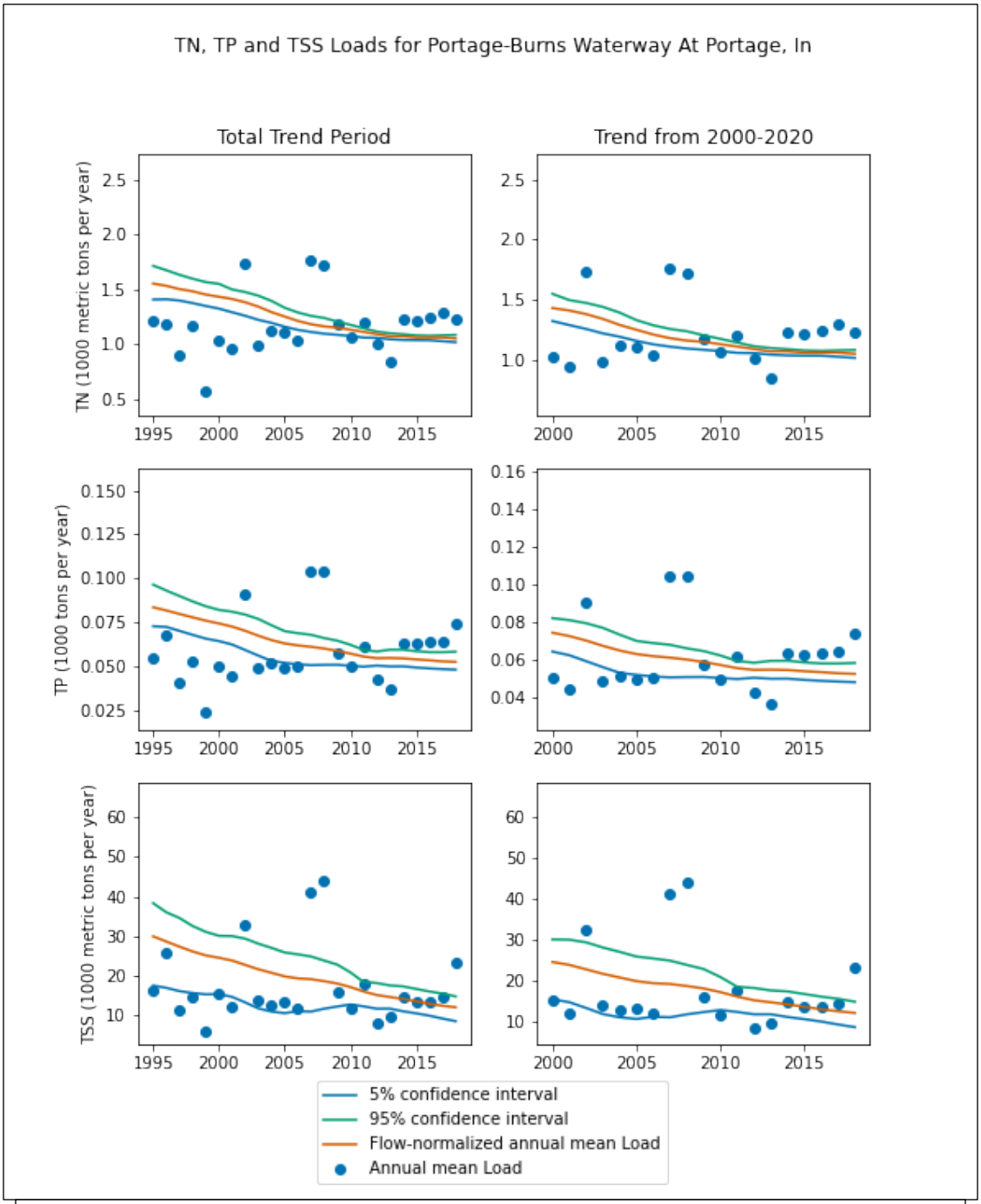


Figure 15B: Figure 15B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

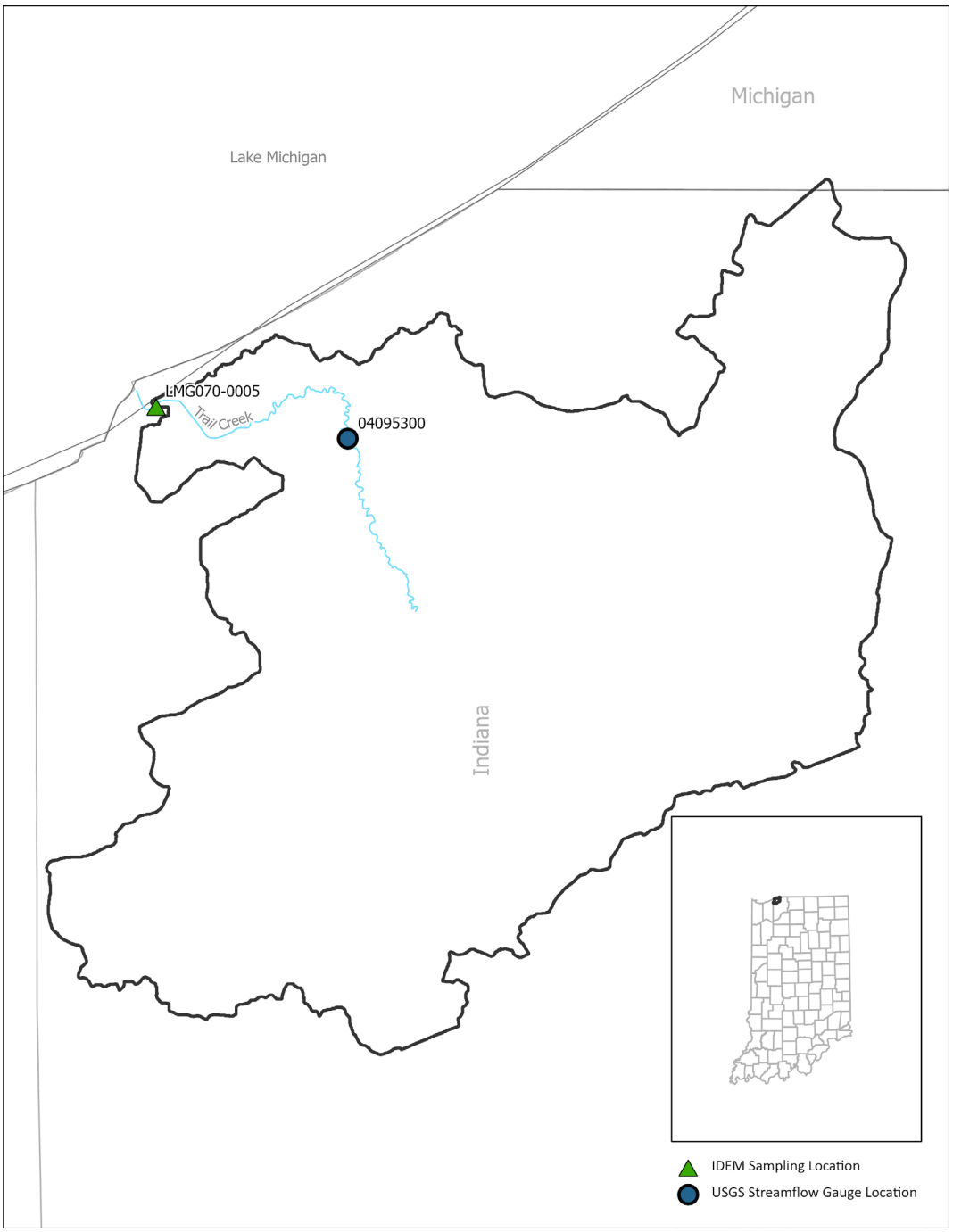
Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	highly unlikely	unlikely	unlikely
Downward Trend in Load	highly likely	likely	likely

Table 15B: WBT descriptive results for loads from **2005-2015** for Portage-Burns Waterway at Portage, IN (Ex7)

Trail Creek at Michigan City, IN (Ex8)

USGS Gage ID 04095300
IDEM station ID LMG070-0005

For this site, the USGS streamgage site and the IDEM site are both located in LaPorte County in northern Indiana in Michigan City. The USGS streamgage site is located upstream of the IDEM site. Unfortunately, the discharge data available from the USGS streamgage site had a gap in coverage of data from the mid-1990s to the mid-2000s, so it was not able to be analyzed for a trend in water quality. This location captures Trail Creek exports into Lake Michigan from Indiana.



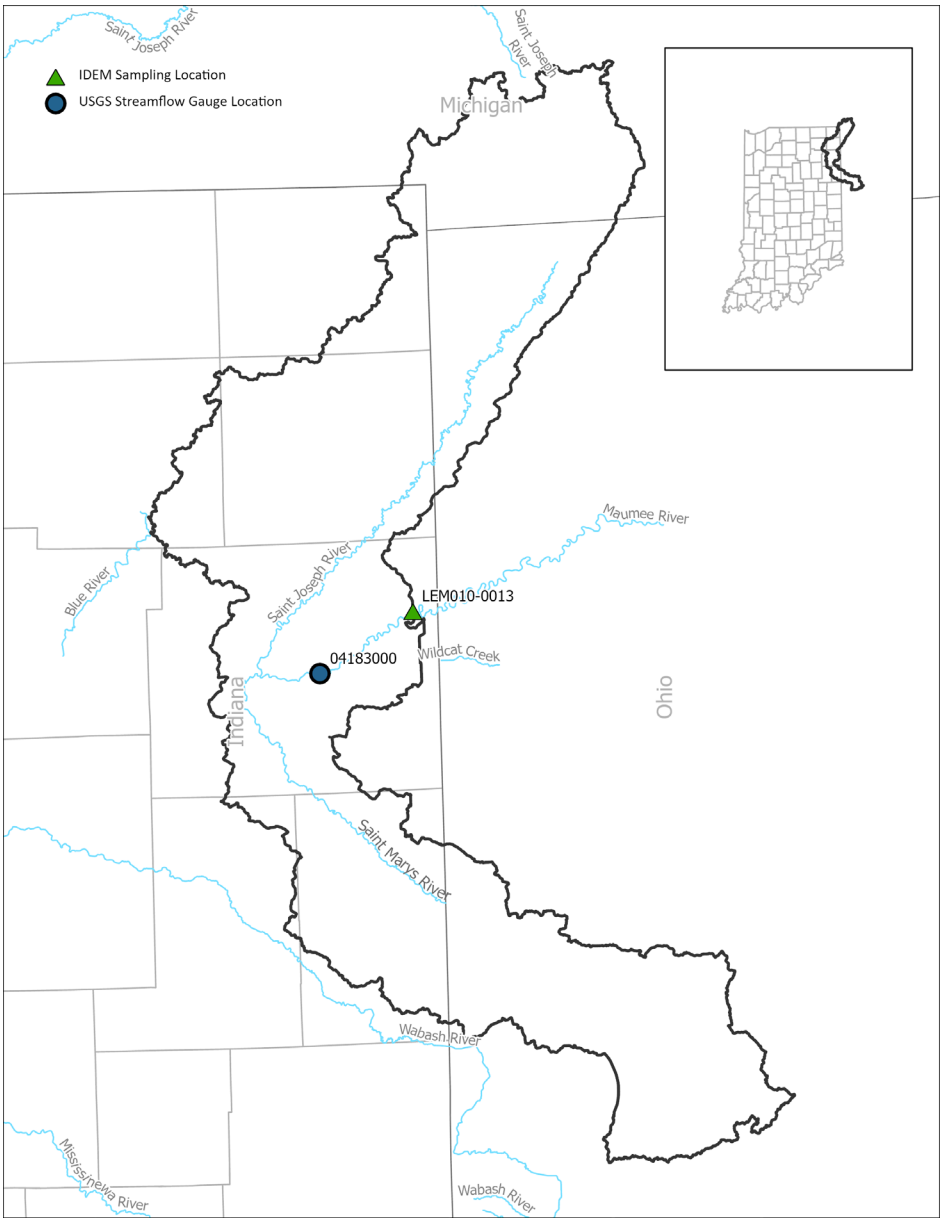
D. Western Lake Erie Basin

Export Site

Maumee River at SR101 in IN near IN/OH State Line (Ex9)

USGS Gage ID 04183000
IDEM station ID LEM010-0013

Both the USGS streamgage site and the IDEM station site are located in Allen County in northeast Indiana, however the USGS streamgage site is located upstream of the IDEM site. This location captures the Maumee River exports into Ohio from Indiana. The watershed covers all or parts of 6 Indiana counties, as well as parts of Michigan and Ohio. The St. Joseph River and the St. Marys River come together in Fort Wayne, Indiana to form the Maumee River that drains to Ohio and eventually empties into the western basin of Lake Erie at Toledo, Ohio.



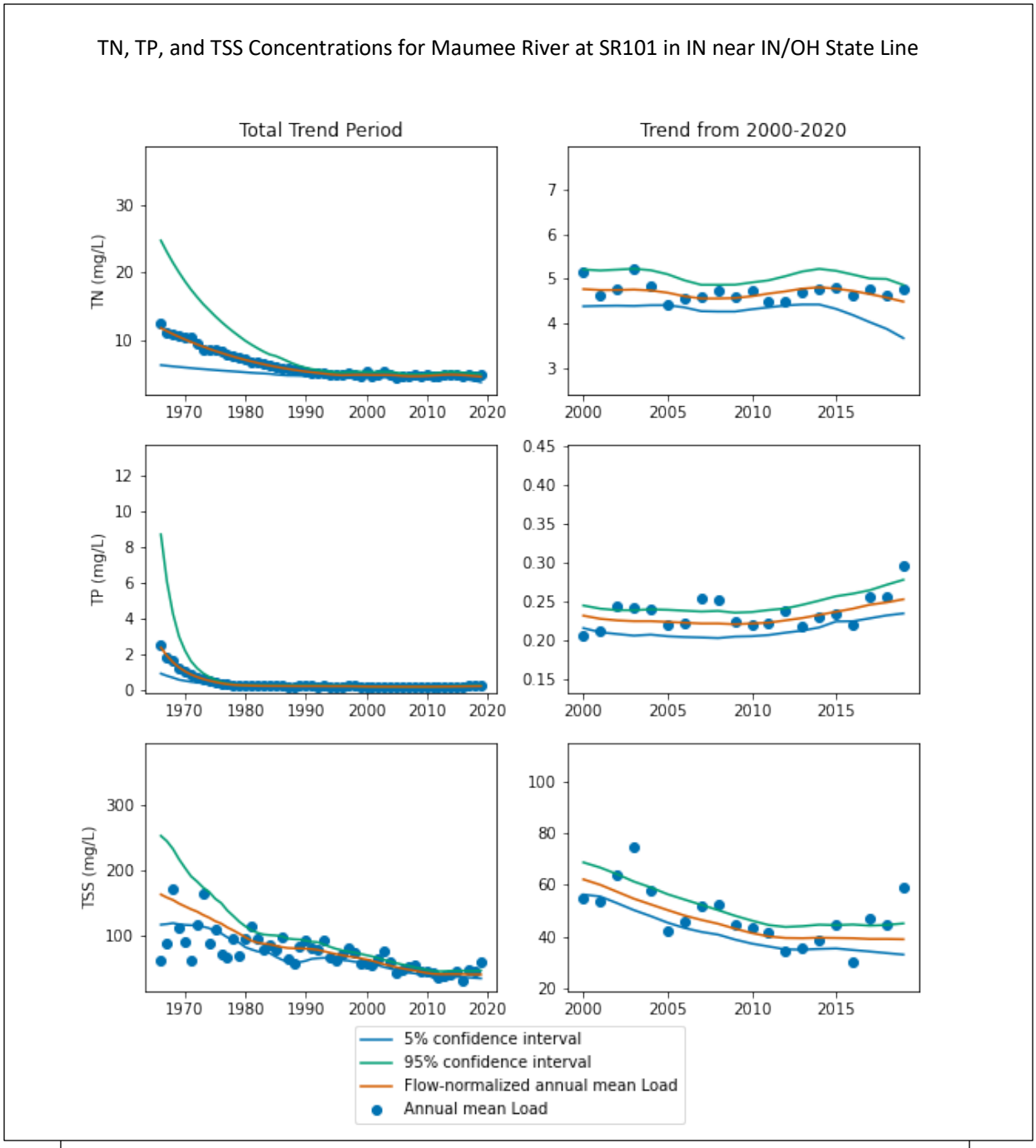


Figure 16A: Figure 16A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	about as likely as not	likely	very unlikely
Downward Trend in Concentration	about as likely as not	very unlikely	very likely

Table 16A: WBT descriptive results for concentrations from **2005-2015** for Maumee River at SR101 near State Line (Ex9)

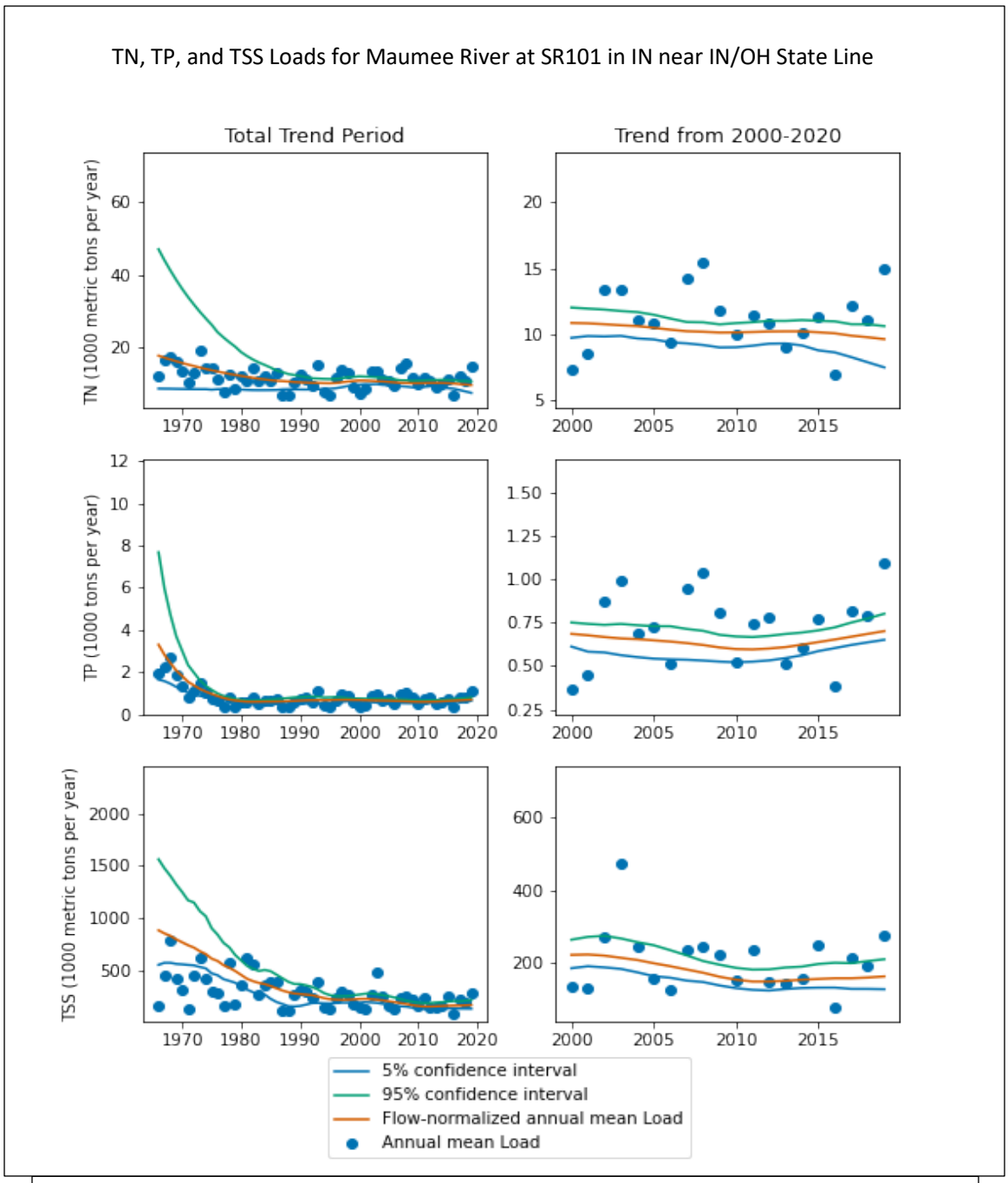


Figure 16B: Figure 16B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	unlikely	about as likely as not	unlikely
Downward Trend in Load	likely	about as likely as not	likely

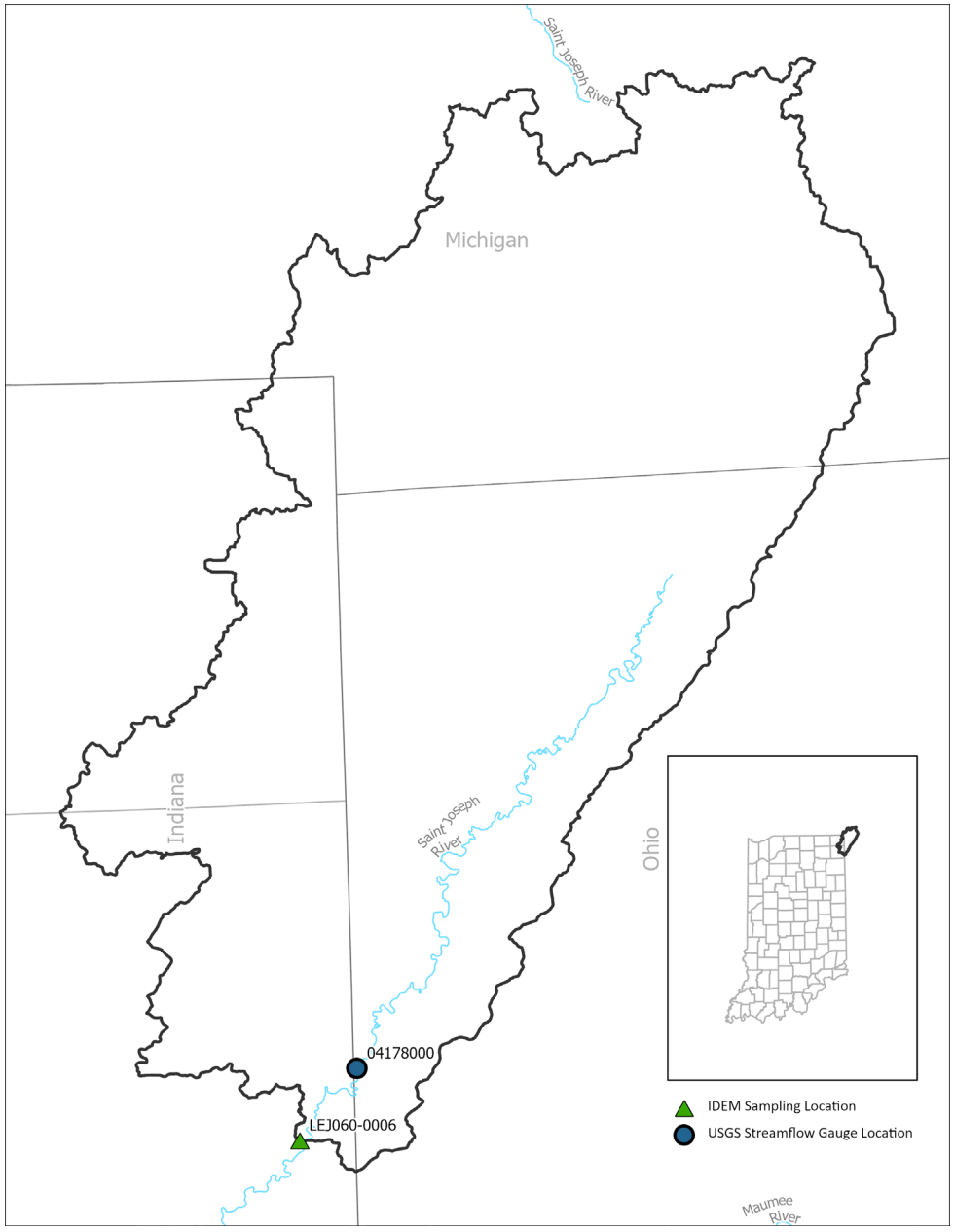
Table 16B: WBT descriptive results for loads from **2005-2015** for Maumee River at SR101 near State Line (Ex9)

Import Site

St. Joseph River near Newville, IN (Im3)

USGS Gage ID 04178000
IDEM station ID LEJ060-0006

The USGS streamgage and the IDEM site are both located in Dekalb County in northeast Indiana near Newville, IN. The USGS streamgage is located upstream of the IDEM site. This particular site is an import into the state as the St. Joseph River originates in Michigan and flows through Ohio before entering into Indiana. The watershed covers parts of Michigan and Ohio and two counties in Indiana. The St. Joseph River and the St. Mary's River come together in Fort Wayne, Indiana to form the Maumee River that drains to Ohio and eventually empties into the western basin of Lake Erie at Toledo, Ohio.



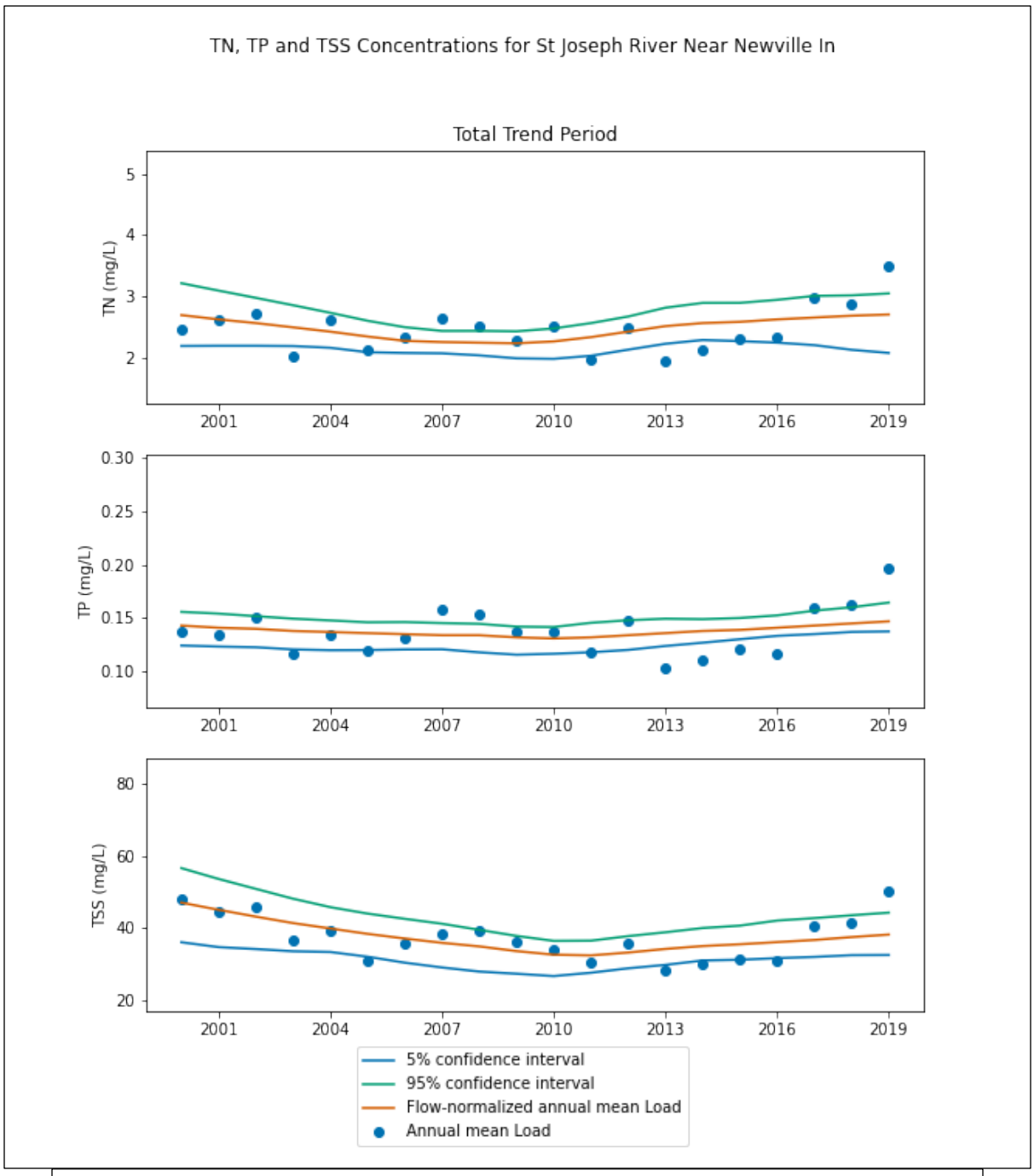


Figure 17A: Figure 17A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, which is the period from 2000 to 2020 and shows a more recent trend.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	likely	likely	about as likely as not
Downward Trend in Concentration	unlikely	unlikely	about as likely as not

Table 17A: WBT descriptive results for concentrations from **2005-2015** for St. Joseph River near Newville, IN (Im3)

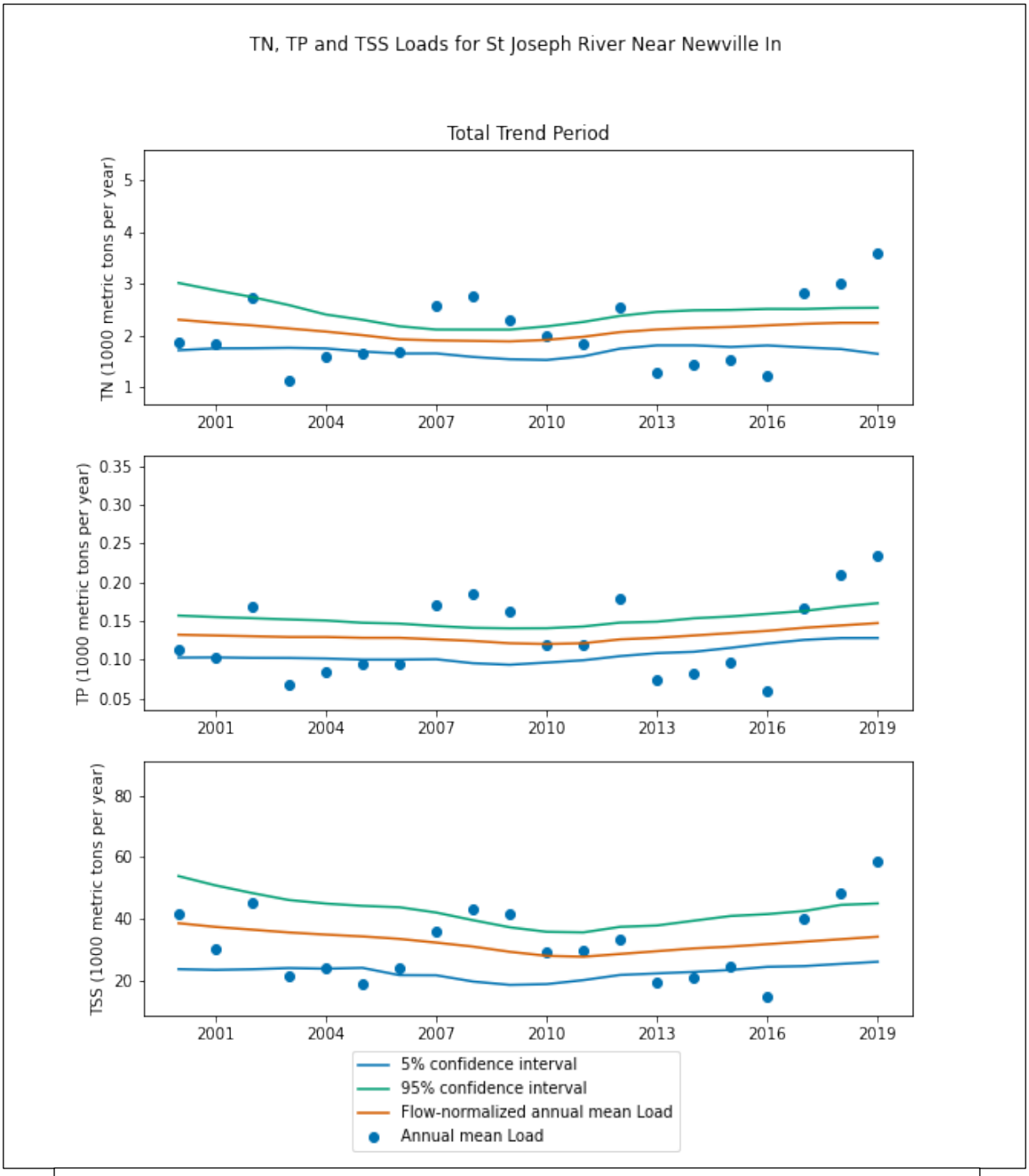


Figure 17B: Figure 17B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, which is the period from 2000 to 2020 and shows a more recent trend.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	likely	likely	about as likely as not
Downward Trend in Load	unlikely	unlikely	about as likely as not

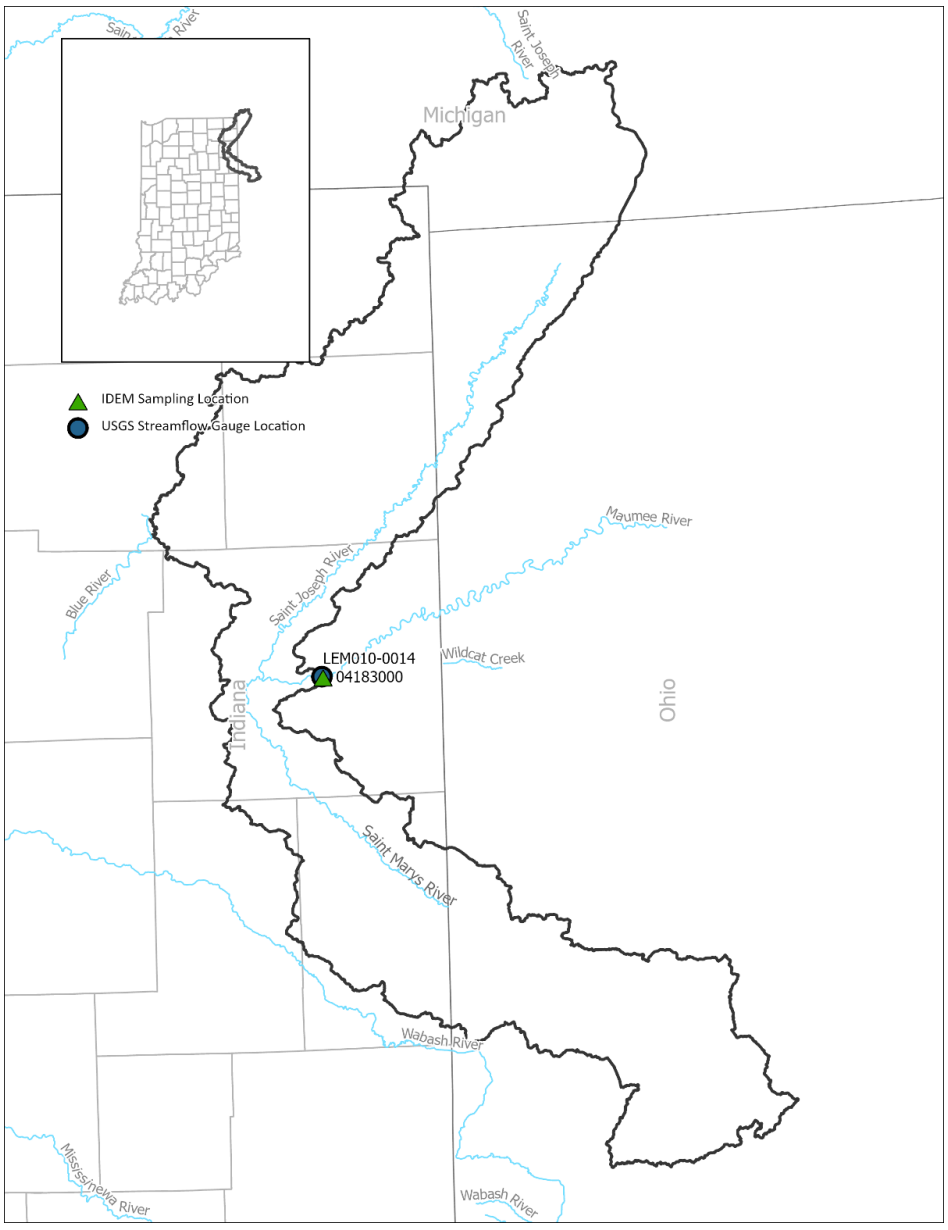
Table 17B: WBT descriptive results for loads from **2005-2015** for St. Joseph River near Newville, IN (Im3)

Interior Site

Maumee River at New Haven, IN (In8)

USGS Gage ID 04183000
IDEM station ID LEM010-0014

The USGS streamgage site and the IDEM station are co-located at this location, and they are located in New Haven, IN in Allen County in northeast Indiana. This location captures the impact of Fort Wayne, Indiana on the Maumee River, as well as the St. Marys River watershed and the St. Joseph River watershed. The watershed covers all or parts of 6 Indiana counties, as well as parts of Michigan and Ohio. The St. Joseph River and the St. Marys River come together in Fort Wayne, Indiana to form the Maumee River that drains to Ohio and eventually empties into the western basin of Lake Erie at Toledo, Ohio.



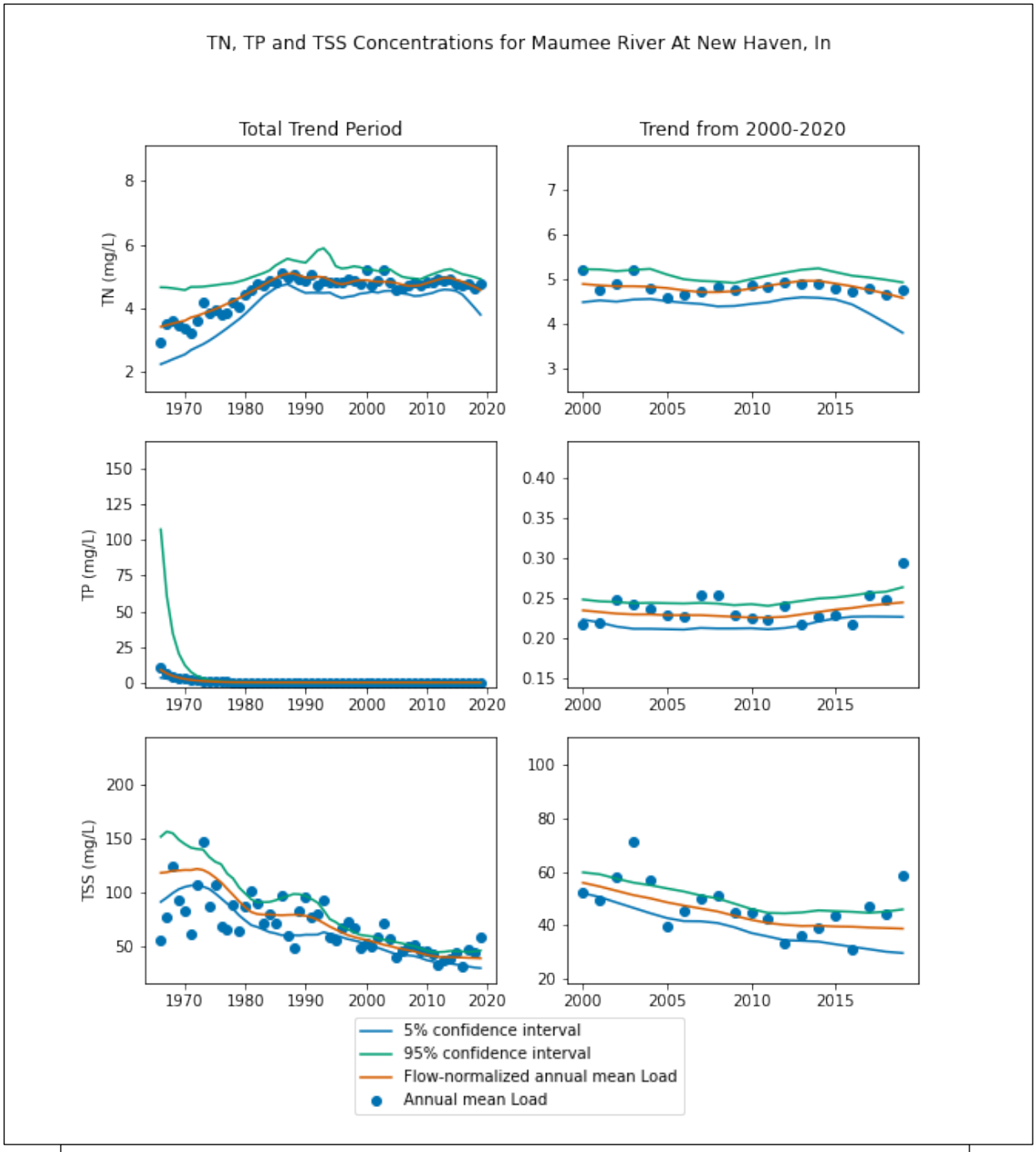


Figure 18A: Figure 18A shows the trend in flow normalized mean concentrations, and annual mean concentrations over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Concentration	about as likely as not	likely	highly unlikely
Downward Trend in Concentration	about as likely as not	unlikely	highly likely

Table 18A: WBT descriptive results for concentrations from **2005-2015** for Maumee River at New Haven, IN (In8)

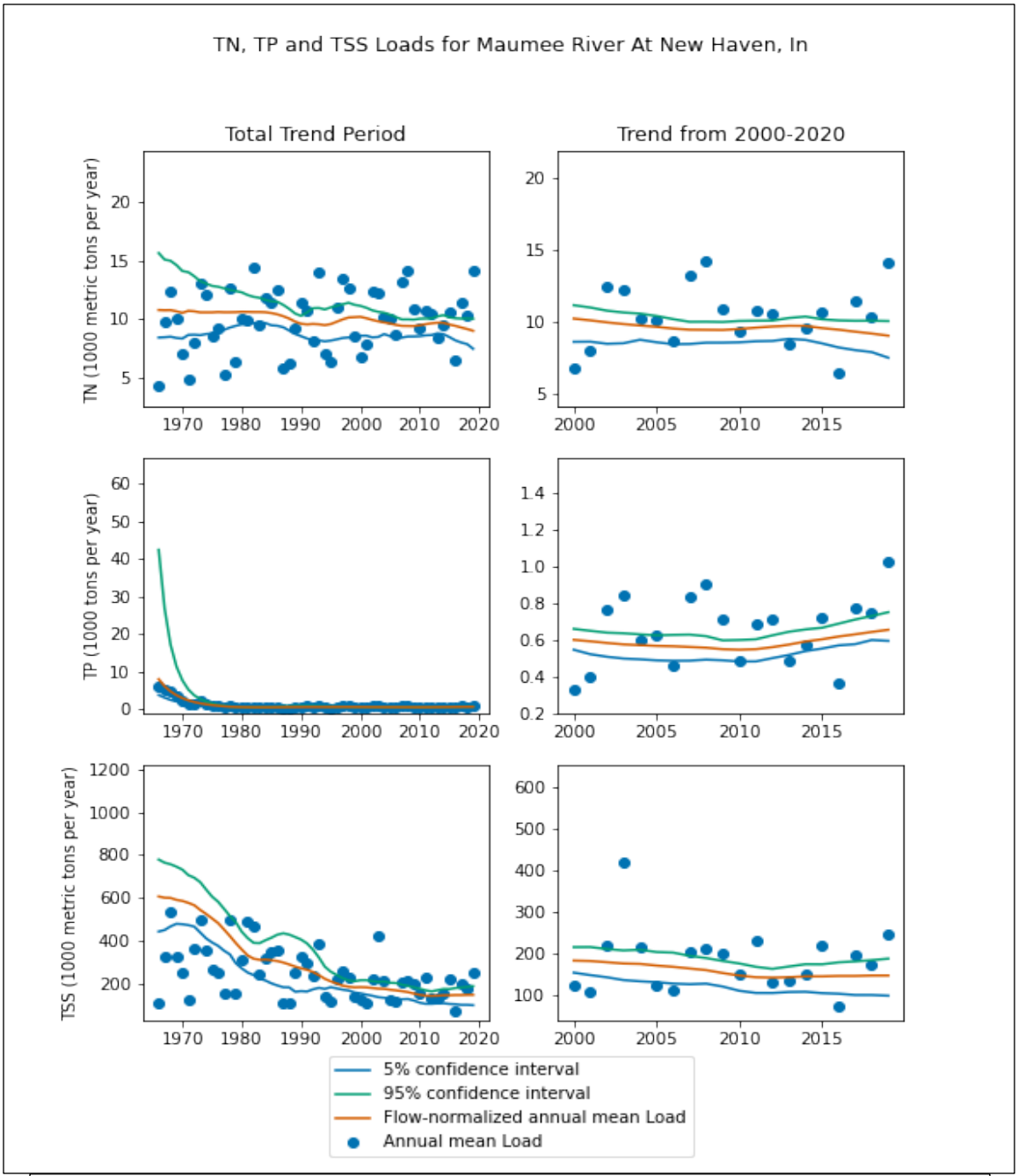


Figure 18B: Figure 18B shows the trend in flow normalized mean loads, and annual mean loads over time for the total trend period of available data for this site, and the trend period from 2000 to 2020, so that a more recent trend is shown.

Trend	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Upward Trend in Load	unlikely	likely	unlikely
Downward Trend in Load	likely	unlikely	likely

Table 18B: WBT descriptive results for loads from **2005-2015** for Maumee River at New Haven, IN (In8)

Appendix B – WRTDS Bootstrap Test Results

USGS Gage Name	P Value Concentration	P Value Flux	Concentration Change	Flux Change	Likelihood Flux is Trending Upward	Likelihood Flux is Trending Downward	Likelihood Concentration is Trending Upward	Likelihood Concentration is Trending Downward
BLUE RIVER NEAR WHITE CLOUD, IN (Ex5)	0.25	0.31	0.0809	0.1289	likely: 0.838	unlikely: 0.162	likely: 0.863	unlikely: 0.137
PORTAGE-BURNS WATERWAY AT PORTAGE, IN (Ex7)	0.05	0.05	-0.175	-0.185	highly unlikely: 0.012	highly likely: 0.988	highly unlikely: 0.0125	highly likely: 0.988
EAST FORK WHITE RIVER AT SHOALS, IN (In5)	0.21	0.34	-0.16	0.9134	unlikely: 0.163	likely: 0.838	unlikely: 0.112	likely: 0.887
IROQUOIS RIVER AT IROQUOIS, IL (Ex4)	0.1	0.14	-0.49	0.4837	very unlikely: 0.068	very likely: 0.931	highly unlikely: 0.049	highly likely: 0.951
KANKAKEE RIVER AT SHELBY, IN (Ex2)	0.078	0.18	-0.26	0.5033	very unlikely: 0.088	very likely: 0.912	highly unlikely: .0294	highly likely: 0.971
MAUMEE RIVER AT NEW HAVEN (used with SR101 Near State Line) (Ex9)	0.96	0.49	0.0606	0.4539	unlikely: 0.237	likely: 0.762	about as likely as not: 0.512	about as likely as not: 0.488
MAUMEE RIVER AT NEW HAVEN, IN (In8)	0.88	0.63	0.0788	0.1514	unlikely: 0.312	likely: 0.688	about as likely as not: 0.562	about as likely as not: 0.438
MISSISSINEWA RIVER NEAR RIDGEVILLE, IN (Im2)	0.81	0.77	-0.179	0.01884	about as likely as not: 0.613	about as likely as not: 0.387	about as likely as not: 0.412	about as likely as not: 0.588
WABASH RIVER AT NEW HARMONY, IN (Ex1)	0.055	0.18	-0.25	-8.391	very unlikely: 0.088	very likely: 0.912	highly unlikely: .0294	highly likely: 0.971
PATOKA RIVER AT WINSLOW, IN (In7)	0.05	0.26	-0.427	0.2799	unlikely: 0.138	likely: 0.863	highly unlikely: .0125	highly likely: 0.988
ST. JOSEPH RIVER NEAR NEWVILLE, IN (Im3)	0.42	0.54	0.222	0.1572	likely: 0.738	unlikely: 0.262	likely: 0.787	unlikely: 0.213
ST. JOSEPH RIVER AT NILES, MI (Ex6)	0.89	0.96	0.0129	0.1021	about as likely as not: 0.512	about as likely as not: 0.488	about as likely as not: 0.438	about as likely as not: 0.562
WABASH RIVER AT LAFAYETTE, IN (In2)	0.071	0.11	-0.456	-2.889	highly unlikely: 0.049	highly likely: 0.951	highly unlikely: .0294	highly likely: 0.971
WABASH RIVER AT LINN GROVE, IN (Im1)	0.79	0.43	-0.333	0.4912	unlikely: 0.212	likely: 0.787	about as likely as not: 0.388	about as likely as not: 0.613
WHITE RIVER AT NEWBERRY, IN (In6)	0.05	0.05	-0.557	-2.433	highly unlikely: 0.012	highly likely: 0.988	highly unlikely: .0125	highly likely: 0.988
WHITE RIVER AT PETERSBURG, IN (In4)	0.039	0.042	-0.385	-4.864	highly unlikely: 0.029	highly likely: 0.971	highly unlikely: 0.0098	highly likely: 0.99
WHITEWATER RIVER AT BROOKVILLE, IN (Ex3)	0.099	0.14	-0.212	0.5352	very unlikely: 0.068	very likely: 0.931	highly unlikely: 0.049	highly likely: 0.951
WILDCAT CREEK NEAR LAFAYETTE, IN (In3)	0.039	0.045	-0.629	0.7861	highly unlikely: 0.029	highly likely: 0.971	highly unlikely: 0.0098	highly likely: 0.99

Table 3: Table 3 shows WRTDS Bootstrap Test results for total nitrogen for 2005 to 2015.

USGS Gage Name	P Value Concentration	P Value Flux	Concentration Change	Flux Change	Likelihood Flux is Trending Upward	Likelihood Flux is Trending Downward	Likelihood Concentration is Trending Upward	Likelihood Concentration is Trending Downward
BLUE RIVER NEAR WHITE CLOUD, IN (Ex5)	0.05	0.52	-0.014	0.01177	unlikely: 0.263	likely: 0.738	highly unlikely: .0125	highly likely: 0.988
PORTAGE-BURNS WATERWAY AT PORTAGE, IN (Ex7)	0.05	0.32	0.0163	9273	unlikely: 0.163	likely: 0.838	highly unlikely: .0125	highly likely: 0.988
EAST FORK WHITE RIVER AT SHOALS, IN (In5)	0.47	0.14	0.00629	0.1694	very likely: 0.931	very unlikely: .0686	likely: 0.775	unlikely: 0.225
IROQUOIS RIVER AT IROQUOIS, IL (Ex4)	0.65	0.41	0.00509	0.01174	likely: 0.787	unlikely: 0.213	about as likely as not: 0.662	about as likely as not: 0.338
KANKAKEE RIVER AT SHELBY, IN (Ex2)	0.47	0.97	0.00348	1821	about as likely as not: 0.512	about as likely as not: 0.488	unlikely: 0.237	likely: 0.762
MAUMEE RIVER AT SR101 NEAR STATE LINE (Ex9)	0.18	0.86	0.013	0.01079	about as likely as not: 0.567	about as likely as not: 0.433	likely: 0.9	very unlikely: 0.1
MAUMEE RIVER AT NEW HAVEN, IN (In8)	0.35	0.21	0.00633	0.03522	likely: 0.887	unlikely: 0.113	likely: 0.838	unlikely: 0.162
MISSISSINEWA RIVER NEAR RIDGEVILLE, IN (Im2)	0.14	0.59	0.0341	0.00575	likely: 0.716	unlikely: 0.284	very unlikely: 0.0686	very likely: 0.931
WABASH RIVER AT NEW HARMONY, IN (Ex1)	0.41	0.28	0.0126	1.241	likely: 0.863	unlikely: 0.137	likely: 0.787	unlikely: 0.213
PATOKA RIVER AT WINSLOW, IN (In7)	0.85	0.37	0.00109	0.02571	likely: 0.812	unlikely: 0.188	about as likely as not: 0.412	about as likely as not: 0.588
ST. JOSEPH RIVER NEAR NEWVILLE, IN (Im3)	0.5	0.53	0.00286	6245	likely: 0.738	unlikely: 0.262	likely: 0.738	unlikely: 0.262
ST. JOSEPH RIVER AT NILES, MI (Ex6)	0.43	0.85	0.00225	2061	about as likely as not: 0.588	about as likely as not: 0.412	unlikely: 0.212	likely: 0.787
WABASH RIVER AT LAFAYETTE, IN (In2)	0.05	0.4	-0.036	0.1042	likely: 0.812	unlikely: 0.188	highly unlikely: .0125	highly likely: 0.988
WABASH RIVER AT LINN GROVE, IN (Im1)	0.98	0.16	0.00627	0.03604	very likely: 0.912	very unlikely: .0882	about as likely as not: 0.5	about as likely as not: 0.5
WHITE RIVER AT NEWBERRY, IN (In6)	0.05	0.05	0.0702	0.4302	highly unlikely: 0.012	highly likely: 0.988	highly unlikely: .0125	highly likely: 0.988
WHITE RIVER AT PETERSBURG, IN (In4)	0.1	0.49	0.0189	0.1024	unlikely: 0.245	likely: 0.755	highly unlikely: 0.049	highly likely: 0.951
WHITEWATER RIVER AT BROOKVILLE, IN (Ex3)	0.15	0.31	0.0226	0.2302	likely: 0.853	unlikely: 0.147	very likely: 0.931	very unlikely: 0.0686
WILDCAT CREEK NEAR LAFAYETTE, IN (In3)	0.9	0.52	894	0.03262	likely: 0.738	unlikely: 0.262	about as likely as not: 0.463	about as likely as not: 0.537

Table 4: Table 4 shows WRTDS Bootstrap Test results for total phosphorus for 2005 to 2015.

USGS Gage Name	P Value Concentration	P Value Flux	Concentration Change	Flux Change	Likelihood Flux is Trending Upward	Likelihood Flux is Trending Downward	Likelihood Concentration is Trending Upward	Likelihood Concentration is Trending Downward
BLUE RIVER NEAR WHITE CLOUD, IN (Ex5)	0.05	0.52	-0.014	0.01177	unlikely: 0.263	likely: 0.738	highly unlikely: .0125	highly likely: 0.988
PORTAGE-BURNS WATERWAY AT PORTAGE, IN (Ex7)	0.05	0.32	0.0163	9273	unlikely: 0.163	likely: 0.838	highly unlikely: 0.0125	highly likely: 0.988
EAST FORK WHITE RIVER AT SHOALS, IN (In5)	0.47	0.14	0.00629	0.1694	very likely: 0.931	very unlikely: .0686	likely: 0.775	unlikely: 0.225
IROQUOIS RIVER AT IROQUOIS, IL (Ex4)	0.65	0.41	0.00509	0.01174	likely: 0.787	unlikely: 0.213	about as likely as not: 0.662	about as likely as not: 0.338
KANKAKEE RIVER AT SHELBY, IN (Ex2)	0.33	0.15	1.67	7.783	very likely: 0.931	very unlikely: 0.0686	likely: 0.833	unlikely: 0.167
MAUMEE RIVER AT SR101 NEAR STATE LINE (Ex9)	0.12	0.29	-10.9	-45.2	unlikely: 0.147	likely: 0.853	very unlikely: .0686	very likely: 0.931
MAUMEE RIVER AT NEW HAVEN, IN (In8)	0.075	0.35	-8.99	-26.2	unlikely: 0.167	likely: 0.833	highly unlikely: .0294	highly likely: 0.971
MISSISSINEWA RIVER NEAR RIDGEVILLE, IN (Im2)	0.14	0.59	0.0341	0.00575	likely: 0.716	unlikely: 0.284	very unlikely: .0686	very likely: 0.931
WABASH RIVER AT NEW HARMONY, IN (Ex1)	0.67	0.41	4.83	756.7	likely: 0.787	unlikely: 0.213	about as likely as not: 0.662	about as likely as not: 0.338
PATOKA RIVER AT WINSLOW, IN (In7)	0.97	0.92	0.523	1.819	about as likely as not: 0.537	about as likely as not: 0.463	about as likely as not: 0.512	about as likely as not: 0.488
ST. JOSEPH RIVER NEAR NEWVILLE, IN (Im3)	0.72	0.88	-2.81	-3.018	about as likely as not: 0.438	about as likely as not: 0.562	about as likely as not: 0.362	about as likely as not: 0.637
ST. JOSEPH RIVER AT NILES, MI (Ex6)	0.65	0.83	-0.219	0.4609	about as likely as not: 0.412	about as likely as not: 0.588	about as likely as not: 0.338	about as likely as not: 0.662
WABASH RIVER AT LAFAYETTE, IN (In2)	0.97	0.27	0.205	119.2	likely: 0.863	unlikely: 0.137	about as likely as not: 0.487	about as likely as not: 0.512
WABASH RIVER AT LINN GROVE, IN (Im1)	0.79	0.53	-1.21	7.606	likely: 0.738	unlikely: 0.262	about as likely as not: 0.613	about as likely as not: 0.387
WHITE RIVER AT NEWBERRY, IN (In6)	0.05	0.05	-34.9	-502.1	highly unlikely: 0.012	highly likely: 0.988	highly unlikely: .0125	highly likely: 0.988
WHITE RIVER AT PETERSBURG, IN (In4)	0.49	0.92	-5.27	30.97	about as likely as not: 0.537	about as likely as not: 0.463	unlikely: 0.237	likely: 0.762
WHITEWATER RIVER AT BROOKVILLE, IN (Ex3)	0.35	0.41	19.8	394.4	likely: 0.787	unlikely: 0.213	likely: 0.812	unlikely: 0.188
WILDCAT CREEK NEAR LAFAYETTE, IN (In3)	0.93	0.57	0.892	24.34	likely: 0.713	unlikely: 0.287	about as likely as not: 0.537	about as likely as not: 0.463

Table 5: Table 5 shows WRTDS Bootstrap Test results for total suspended solids for 2005 to 2015.