Water Quality Trends in Nutrients in New Jersey Streams, Water Years 1971-2016

New Jersey Department of Environmental Protection

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Contents

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Abstract

The New Jersey Department of Environmental Protection's (NJDEP's) Division of Science and Research (DSR) and Bureau of Freshwater & Biological Monitoring (BFBM) collaborated on this study to update a previous report by the United States Geological Survey (USGS) on the trends of water quality parameters measured at stations on streams in New Jersey from water years 1971-2011. This report updates the trends valuated for nutrients with five years of additional data (2012-2016). Trend tests were performed on nitrate plus nitrite as nitrogen, total nitrogen, and total phosphorus at 28 water quality stations. Although the previous report also performed trend analyses on 28 stations, four stations differ between the original report and this update. In this report, water quality trends were assessed at four new stations and four other stations were not assessed because they have been discontinued. Two different statistical methods were utilized to identify trends: Weighted Regressions on Time, Discharge, and Season (WRTDS) and Seasonal Kendall (SK) tests.

Overall, from 1980 to 2016, total nitrogen and total phosphorous concentration decreased at the majority of water quality stations. Total nitrogen concentration statistically increased at three stations and total phosphorous concentration increased at one station. Nitrate plus nitrite trend results were more mixed with some stations exhibiting increasing trends and some decreasing trends from 1980 to 2016. In general, the inclusion of five additional years of data did not have a substantial effect on the long-term trends established in previous reports.

For water years 1980 to 2016, the WRTDS models identified more stations with upward trends (eight stations) than downward trends (four stations) for nitrate plus nitrite (seven stations had no trend, and nine stations were not assessed with WRTDS models). For total nitrogen for water years 1980 to 2016, there were more stations identified with downward trends (eleven

stations) than upward trends (one station; eight stations had no trend, and eight stations did not fulfill the data requirements for WRTDS models). For total phosphorous, there were ten stations with downward trends and one station with an upward trend (seven stations had no trend, and ten stations were not analyzed with WRTDS methods). In general, the trend results of nutrient concentration and those for nutrient flux (upward, downward, no trend) typically matched.

For SK models, for filtered nitrate plus nitrite from water years 1980 to 2016, there were eight stations with downward trends, seven stations with upward trends, and thirteen stations with no trend. For total nitrogen, there were fourteen stations with downward trends, three stations with an upward trend, and eleven stations with no trend. Finally, for total phosphorous, there were downward trends for seventeen stations, upward trends for one station, and no trend for ten stations. All WRTDS and SK trend results for the three parameters at 28 water quality stations during the four different time periods are available in this report and as supplemental digital files.

In addition to the trend analyses, the relationships between nutrient concentrations and percentage of altered land (urban plus agriculture) in each watershed were assessed. The relationship between land use and each of the three nutrients were assessed using Spearman’s rank correlations. In the coastal plain region of New Jersey, nutrient concentrations were positively correlated with increased altered land in the contributing watershed.

Introduction

Since the early 1970s, water quality parameters have been measured at stations on New Jersey streams by the New Jersey Department of Environmental Protection (NJDEP) and the United States Geological Survey (USGS). Most of the water parameters have been collected for the Ambient Surface Water Quality Monitoring Network. However, some water quality parameters have been measured in collaboration with the Delaware River Basin Commission (DRBC). This report aims to improve understanding between changing nutrient concentrations in New Jersey streams. Identification of changing nutrient conditions will aid in assessing the aquatic health of streams and factors leading to nutrient impairments including the development and persistence of harmful algal blooms.

Several previous studies have identified trends in water quality nutrient concentrations and fluxes at water quality stations in New Jersey (Hay and Campbell 1990, Hickman and Barringer 1999, Sprague et al. 2009, Hickman and Gray 2010, Trench et al. 2012, Hickman and Hirsch 2017). Flux is the load per unit time of a water quality parameter carried by a stream. Many of these studies focused on identifying monotonic trends which are an increase or decrease in concentration or flux over the whole period of interest. Most recently, Hickman and Hirsch (2017) assessed water quality trends in New Jersey streams using two different methods (Weighted Regressions on Time, Discharge, and Season, WRTDS, models and seasonal rank-sum tests) for water years 1971 to 2011.

The main objective of this report was to update Hickman and Hirsch's (2017) analysis to include five years of additional data, i.e., 2012 to 2016. Two different types of trend analyses were performed: WRTDS models and Seasonal Kendall (SK) models. The WRTDS models account for discharge, seasonality, and long-term trend, whereas the SK models test for monotonic trends. Both types of trend analyses were conducted on three nutrients (filtered nitrate plus nitrite as nitrogen, total nitrogen, and total phosphorous) at 28 water quality stations (Table 1; Fig. 1). Nitrate plus nitrite as nitrogen is an inorganic component of total nitrogen. Total nitrogen includes nitrate plus nitrite as well as ammonia, organic, and reduced forms of nitrogen. The results from both the WRTDS models and the SK models were compared to each other, and to previous studies conducted on water quality trends in New Jersey streams (Hay and Campbell 1990, Hickman and Barringer 1999, Sprague et al. 2009, Hickman and Gray 2010, Trench et al. 2012, Hickman and Hirsch 2017).

Table 1. Water Quality Stations. The water quality and streamflow data from water years 2012 to 2016 was appended to the original USGS dataset (1971-2011) for the first 28 stations listed below. Hickman and Hirsch (2017) did not analyze four of the stations in this list; however, data were included in the 1971-2011 dataset for these stations (denoted by •). In this report, trend tests were performed on these stations (•), but not on the last four stations which have been discontinued since Hickman and Hirsch 2017 (denoted by *).

#	Station number	Station name
1	01367770	Wallkill River near Sussex, NJ
2	01377000	Hackensack River at Rivervale, NJ
3	01381800	Whippany River near Pine Brook, NJ
4	01382000	Passaic River at Two Bridges, NJ
5	01387500	Ramapo River near Mahwah, NJ
6	01389500	Passaic River at Little Falls, NJ
7	01391500	Saddle River at Lodi, NJ
8	01395000	Rahway River at Rahway, NJ
9	01396660	Mulhockaway Creek at Van Syckel, NJ
10	01398000	Neshanic River at Reaville, NJ
11	01399780	Lamington River at Burnt Mills, NJ
12	01405340	Manalapan Brook at Federal Road near Manalapan, NJ
13	01408500	Toms River near Toms River, NJ
14	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ
15	01409815	West Branch Wading River at Maxwell, NJ
16	01411110	Great Egg Harbor River at Weymouth, NJ
17	01411500	Maurice River at Norma, NJ
18	01412800	Cohansey River at Seeley, NJ
19	01443500	Paulins Kill at Blairstown, NJ
20	01457400	Musconetcong River at Riegelsville, NJ
21	01463500	Delaware River at Trenton, NJ
22	01464515	Doctors Creek at Allentown, NJ
23	01466500	McDonalds Branch in Byrne State Forest, NJ
24	01477120	Raccoon Creek near Swedesboro, NJ
•25	01394500	Rahway River near Springfield, NJ
•26	01409416	Hammonton Creek at Wescoatville, NJ
•27	01410150	East Branch Bass River near New Gretna, NJ
•28	01482500	Salem River at Woodstown, NJ
*29	01403300	Raritan River at Queens Bridge at Bound Brook, NJ
*30	01409500	Batsto River at Batsto, NJ
*31	01443000	Delaware River at Portland, PA
*32	01460820	Delaware River at Lumberville, PA

Fig. 1. Water Quality Stations. Water quality trends were assessed at 28 stations throughout New Jersey. See Table 1 for station names.

In addition to assessing trends in water quality parameters in streams, the second objective was to determine whether relationships existed between nutrient concentrations and the surrounding land use characteristics of the watershed upstream of the sample location. The percentage of land use in each watershed was determined and then the relationship between altered land and each of the nutrient parameter was assessed using Spearman's rank correlation.

Methods

Update of Water Quality Dataset for Water Years 1971-2016

The original water quality dataset was provided by Hickman and Hirsh (2017) to the Bureau of Freshwater & Biological Monitoring (BFBM) by USGS as an Excel spreadsheet. The data included values for the three nutrients reviewed in this analysis (nitrate plus nitrite as nitrogen, total nitrogen, and total phosphorus) along with nine additional parameters for 32 water quality stations from water years 1971 to 2011. Additionally, instantaneous streamflow was included to allow trend tests to account for variations in streamflow. The dataset was updated by BFBM to include data through water year 2016 by following the same guidelines used by Hickman and Hirsch (2017). Values below the reporting limit were incorporated into the WRTDS models for use in the survival analysis which allows for inclusion of censored values, but values below the reporting limit were replaced with one-half of the reporting limit for the SK tests.

Weighted Regressions on Time, Discharge, and Season Trend Test

Trends in concentration and flux of three nutrients (nitrate plus nitrite, total nitrogen, and total phosphorous) were identified using WRTDS models over four time periods: water years 1980-2016, 1980-2011, 2007-2016, and 2012-2016. Originally, WRTDS models were only suggested for stations where a record of daily streamflow (measured or estimated) was available and at least 200 measurements of concentrations existed over a 20-year period (Hirsch et al. 2010). More recent studies have successfully generated WRTDS models with fewer concentration measurements over shorter time frames (Medalie et al. 2012, Hickman and Hirsch 2017). To identify trends using the WRTDS models for a specific parameter at a selected station, the WRTDS model related daily nutrient concentration to year, daily streamflow, and season. For additional details including WRTDS model form, see Hickman and Hirsch (2017). All models were run in program R 3.4.3 using commands from the EGRET and dataRetrieval packages (Hirsch and De Cicco 2015).

Three different scenarios existed for obtaining daily streamflow data for the WRTDS models. Daily streamflow records were available for fourteen of the water quality stations (Table 2). If daily streamflow records were unavailable, streamflow was estimated from stream gages at a nearby station (not necessarily one of the 28 study stations) using either a drainage-area correction (two stations) or Maintenance of Variance Extension 1 (MOVE1; seven stations) when possible (see Appendix 1 of Hickman and Hirsch 2017). For five stations, daily streamflow was unavailable, even at nearby stations. To stay consistent with Hickman and Hirsch (2017), when more than 40% of measured concentrations were censored or the flux bias statistic (which is a measure of WRTDS model fit) was less than -0.20 or greater than 0.20, the results of the WRTDS models were not reported.

Table 2. Sources of Daily Streamflow Data for Weighted Regressions on Time, Discharge, and Season (WRTDS) Models. For the WRTDS models, daily streamflow was either measured or estimated from the record of streamflow at a nearby stream gage with either a drainage-area correction or a Maintenance of Variance Extension 1 (MOVE1) approach. The ratio of drainage area of station to drainage area of stream gage was also included. Table continued on next page.

Station number	Station name	WRTDS Models Reported	Annual Fluxes Reported	Method of Estimation	Stream Gage	Ratio
01367770	Wallkill River near Sussex, NJ	No	No	NA	NA	NA
01377000	Hackensack River at Rivervale, NJ	Yes	Yes	Measured	NA	1
01381800	Whippany River near Pine Brook, NJ	No	No	NA	NA	NA
01382000	Passaic River at Two Bridges, NJ	No	No	NA	NA	NA
01387500	Ramapo River near Mahwah, NJ	Yes	Yes	Measured	NA	1
01389500	Passaic River at Little Falls, NJ	Yes	Yes	Measured	NA	1
01391500	Saddle River at Lodi, NJ	Yes	Yes	Measured	NA	1
01395000	Rahway River at Rahway, NJ	Yes	Yes	Measured	NA	1
01396660	Mulhockaway Creek at Van Syckel, NJ	Yes	Yes	Measured	NA	1
01398000	Neshanic River at Reaville, NJ	Yes	Yes	Measured	NA	1
01399780	Lamington River at Burnt Mills, NJ	Yes	No	Drainage-area correction	North Branch Raritan River near Raritan, NJ (01400000)	0.53
01405340	Manalapan Brook at Federal Road near Manalapan, NJ	Yes	No	MOVE1	Manalapan Brook at Spotswood, NJ (01405400)	0.51
01408500	Toms River near Toms River, NJ	Yes	Yes	Measured	NA	1
01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	Yes	No	MOVE1	Mullica River near Batsto, NJ (01409400)	0.57
01409815	West Branch Wading River at Maxwell, NJ	Yes	No	MOVE1	Oswego River at Harrisville, NJ (01410000)	1.18

Station number	Station name	WRTDS Models Reported	Annual Fluxes Reported	Method of Estimation	Stream Gage	Ratio
01411110	Great Egg Harbor River at Weymouth, NJ	Yes	No	MOVE1	Great Egg Harbor River at Folsom, NJ (01411000)	2.7
01411500	Maurice River at Norma, NJ	Yes	Yes	Measured	NA	NA
01412800	Cohansey River at Seeley, NJ	No	No	NA	NA	NA
01443500	Paulins Kill at Blairstown, NJ	Yes	Yes	Measured	NA	NA
01457400	Musconetcong River at Riegelsville, NJ	Yes	Yes	Drainage-area correction	Musconetcong River near Bloomsbury, NJ (01457000)	1.11
01463500	Delaware River at Trenton, NJ	Yes	Yes	Measured	NA	1
01464515	Doctors Creek at Allentown, NJ	No	No	NA	NA	NA
01466500	McDonalds Branch in Byrne State Forest, NJ	No	No	Measured	NA	1
01477120	Raccoon Creek near Swedesboro, NJ	Yes	Yes	Measured	NA	1
01394500	Rahway River near Springfield, NJ	Yes	Yes	Measured	NA	1
01409416	Hammonton Creek at Wescoatville, NJ	Yes	No	MOVE1	Great Egg Harbor River at Folsom, NJ (01411000)	0.17
01410150	East Branch Bass River near New Gretna, NJ	Yes	No	MOVE1	Westecunk Creek at Stafford Forge, NJ (01409280)	0.51
01482500	Salem River at Woodstown, NJ	Yes	No	MOVE1	Raccoon Creek near Swedesboro, NJ (01477120)	0.54

Furthermore, the annual concentrations, flow-normalized concentrations, fluxes, and flow-normalized fluxes for each water year were determined, and the changes in annual flow-normalized concentrations and fluxes between selected water years were assessed. Annual concentrations and flow-normalized annual concentrations were reported for all water quality stations where streamflow was measured or estimated. Annual fluxes and flow-normalized annual fluxes were reported for the fourteen stations where streamflow was measured. However, annual fluxes and flow-normalized fluxes were only reported at one of the nine stations where streamflow was estimated to stay consistent with Hickman and Hirsch (2017; Table 2). Estimated flow-normalized annual fluxes were generated using the EGRET package in program R (Hirsch and De Cicco 2015).

Changes in flow-normalized annual concentrations and fluxes were determined between water years 1971, 1980, 1990, 2000, 2010, and 2016. When flow-normalized concentrations were unavailable for any of these water years (1971, 1980, 1990, 2000, 2010, and 2016), changes were reported between years with data that were located closest in time to the years of interest (e.g., if data were unavailable for 1971 but were available for 1972, the data from 1972 were utilized). Significant trends were then identified using the WRTDS Bootstrap Test (WBT) found in the EGRETci R package (Hirsch and De Cicco 2016). For this report, the two-way level of significance was set to 0.05 to identify a trend.

Seasonal Kendall Trend Test

Although the WRTDS method was successfully applied to stations with records or estimates of daily streamflow, eight of the 28 water quality stations did not have daily streamflow data available. Thus, the SK tests were also run to identify trends in concentrations over the same four time periods as the WRTDS models. Because these tests do not require records of daily streamflow, the SK tests could be performed on the water quality parameters at all 28 stations.

Basically, a SK test is a nonparametric test for monotonic trends within each season based on Kendall's tau statistic. The seasons were defined as fall (October, November, December), winter (January, February, March), spring (April, May, June), and summer (July, August, September). This test was chosen because it combines the seasonal Kendall's test for trend (Hirsch et al. 1982), a heterogeneity test for trend which tests for trend in any direction in any season (van Belle and Hughes 1984), and an extension allowing for serial dependence in the observations (Hirsch and Slack 1984). The SK tests were performed using the kendallSeasonalTrendTest command from the EnvStats package in R 3.4.3 (Millard 2017).

Land Use Characteristics

Stations included in this study ranged from reference streams with minimal land use impacts throughout the watershed to heavily disturbed watersheds. Some of the streams receive point source discharges and receive water from interbasin transfers. Interbasin transfers are movements of water between watersheds and help maintain reservoir levels during periods of drought and may serve as source water for large water supply utilities. For each water quality station, the land use characteristics of the watershed were assessed to determine whether relationships existed between water quality trends and land use.

Watershed boundaries were delineated using the USGS Streamstats application to facilitate the assessment of upstream contributions to each station (USGS 2018). Land use profiles summarizing the proportion of agriculture, barren land, forest, urban, water, and wetlands were estimated in the drainage basins upstream of each of the 28 water quality stations, and were compiled from the National Land Cover Dataset (NLCD) from 1992 and 2011

(Vogelmann et al. 2001, Homer et al. 2015). This dataset includes a 16-class land cover classification scheme based on a modified system described by Anderson et al. (1976) with a spatial resolution of 30 meters. Individual pixel classification is primarily based on a decision tree analysis of Landsat satellite data. The NCLD was selected to provide a consistent classification scheme for streams where upstream portions of the watershed extend outside the boundary of New Jersey. For each watershed, the percent land cover change was estimated between 1992 and 2011, and the percentage of altered land (agriculture plus urban) was determined using the 2011 NLCD (Homer et al. 2015).

The relationships between altered land from the 2011 NLCD and the median concentration of nitrate plus nitrite, total nitrogen, and total phosphorous were evaluated using nonparametric Spearman rank correlation analysis. Water quality data for each parameter was summarized using all data available from water years 2008 through 2016 (October 2007 – September 2016). This period was chosen to bracket the 2011 NLCD. When concentrations of a parameter were below the reporting level, one half of the detection limit was substituted. Correlation analyses were evaluated across all 28 stations and separately for the stations in two different regions of the state: (1) bedrock and (2) coastal plain. Distinction was made between these two regions because of the different geological compositions and groundwater discharge patterns of the areas. The bedrock region consists of the Northern Piedmont, the Northeastern Highlands, and the Ridge and Valley designations from the Level III Ecoregions utilized by the United States Environmental Protection Agency (US EPA), whereas the coastal plain region includes the Middle Atlantic Coastal Plain and the Atlantic Coastal Pine Barrens designations. Altered land was also related to a multi-parameter rank of water quality at each site. Specifically, each station was ranked based on the concentration of each parameter and then the individual station ranks were averaged to produce a single stations-specific nutrient score.

Results

Weighted Regressions on Time, Discharge, and Season Trend Test

The annual values for each water quality parameter at each water quality station are available in Appendix 1, and the changes between years are available in Appendix 2. The strength of the trend over each of the time periods can be determined by first checking for statistical significance (i.e., ensure that the p-value ≤ 0.05 in Appendix 2) and then examining the change in concentration or flux as percent of first water year. Higher percent changes suggest stronger relationships between nutrient concentration and time.

Moreover, for each water quality parameter at each station of interest, four different plots were generated. The following sample plots are for total nitrogen at the Mullica River station (01409387; Figs. 2-5), and all other plots are available as digital files. First, the concentration of each nutrient was plotted over time for each water quality station with censored values displayed by line segments (Fig. 2). Second, eight-panel plots were developed to determine if there was flux bias with the WRTDS models (Fig. 3). These plots displayed (1) residuals of WRTDS model as a function of model estimates, (2) residuals as function of log of discharge, (3) residuals as function of year, (4) residuals as boxplots per month, (5) sampled day values, sampled day estimates, and all day estimates, (6) scatter plot of observed concentration and estimates for those days with a 1:1 line, (7) log discharge values on all sampled days, log discharge values on all days in periods of record, and (8) scatter plot of observed flux values on all sampled days. Third, the annual mean nutrient concentration was plotted over time (years) with a smoothed line displaying the annual flow-normalized concentrations (Fig. 4). Fourth, the annual flux estimates and the annual flow-normalized flux estimates were displayed over time for each nutrient (Fig. 5).

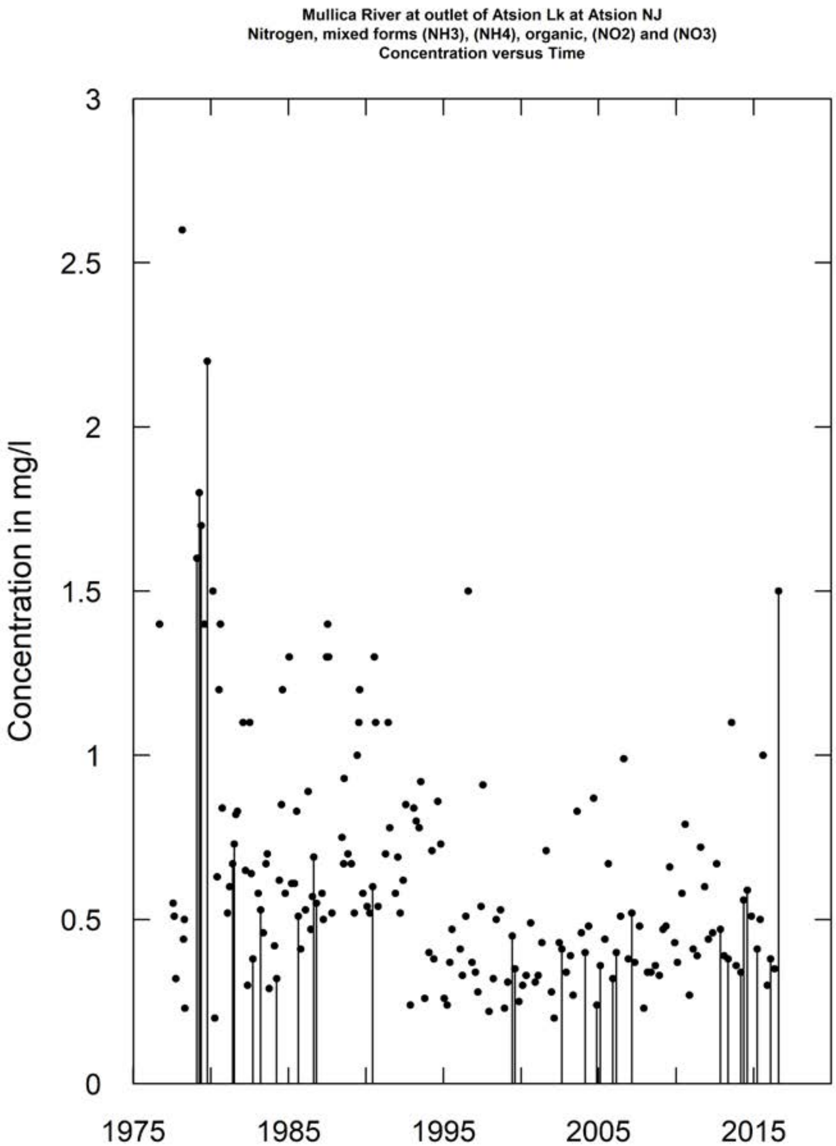

Fig. 2. Nutrient Concentration over Time. For each of the three nutrients (nitrate plus nitrite, total nitrogen, and total phosphorus) and each of the 28 water quality stations, the nutrient concentration over time was plotted. Censored values were displayed by line segments. Plots for all other stations are available digitally.

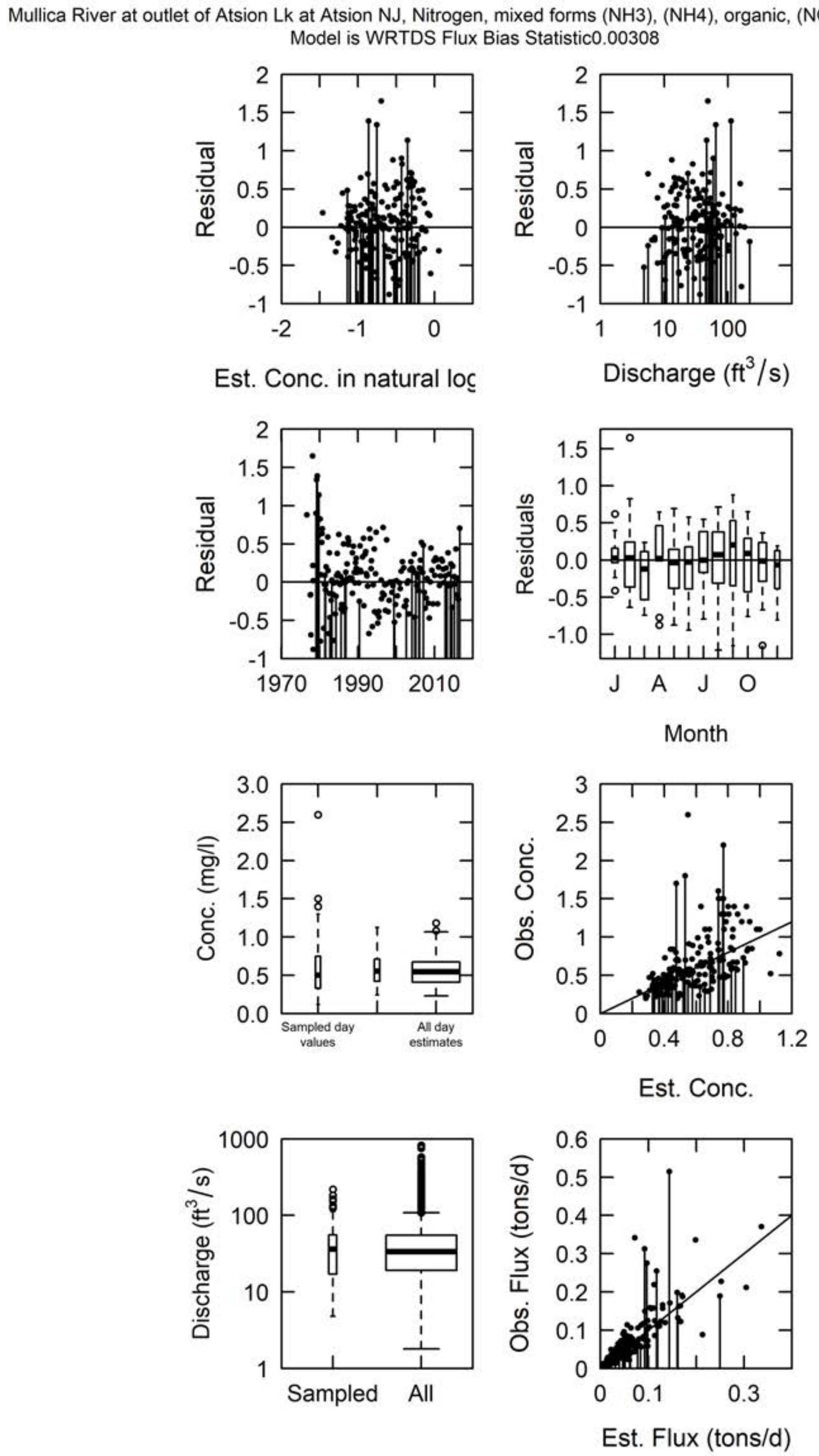

Fig. 3. Flux Bias in WRTDS Models. At each of the water quality stations and for each nutrient, the models were checked for flux bias. Plots for all other stations are available digitally.

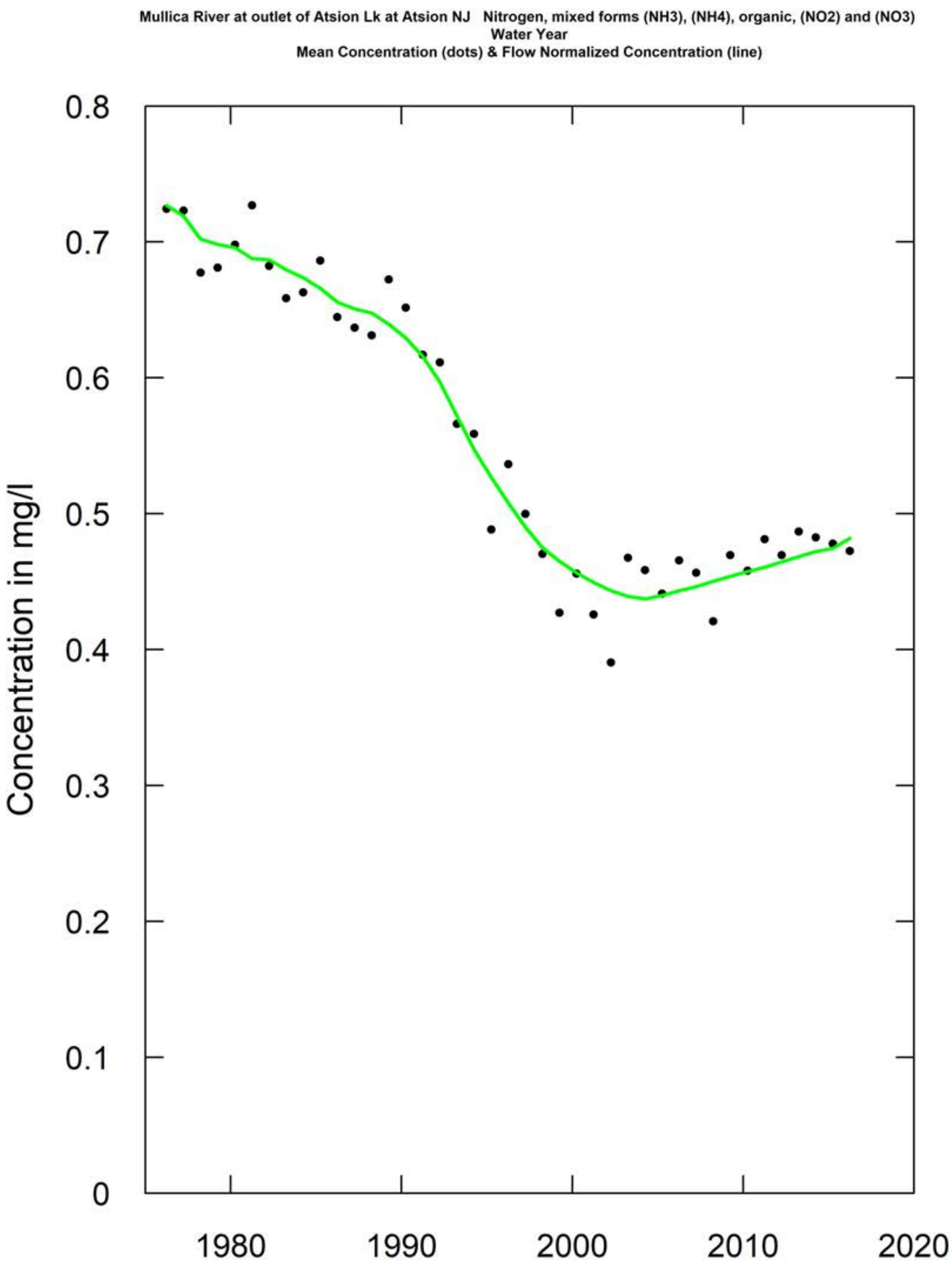

Fig. 4. Annual Mean Nutrient Concentration over Time. The annual mean nutrient concentrations (dots) and the annual flow-normalized concentrations (smoothed line) were plotted over time (years). Plots for all other stations are available digitally.

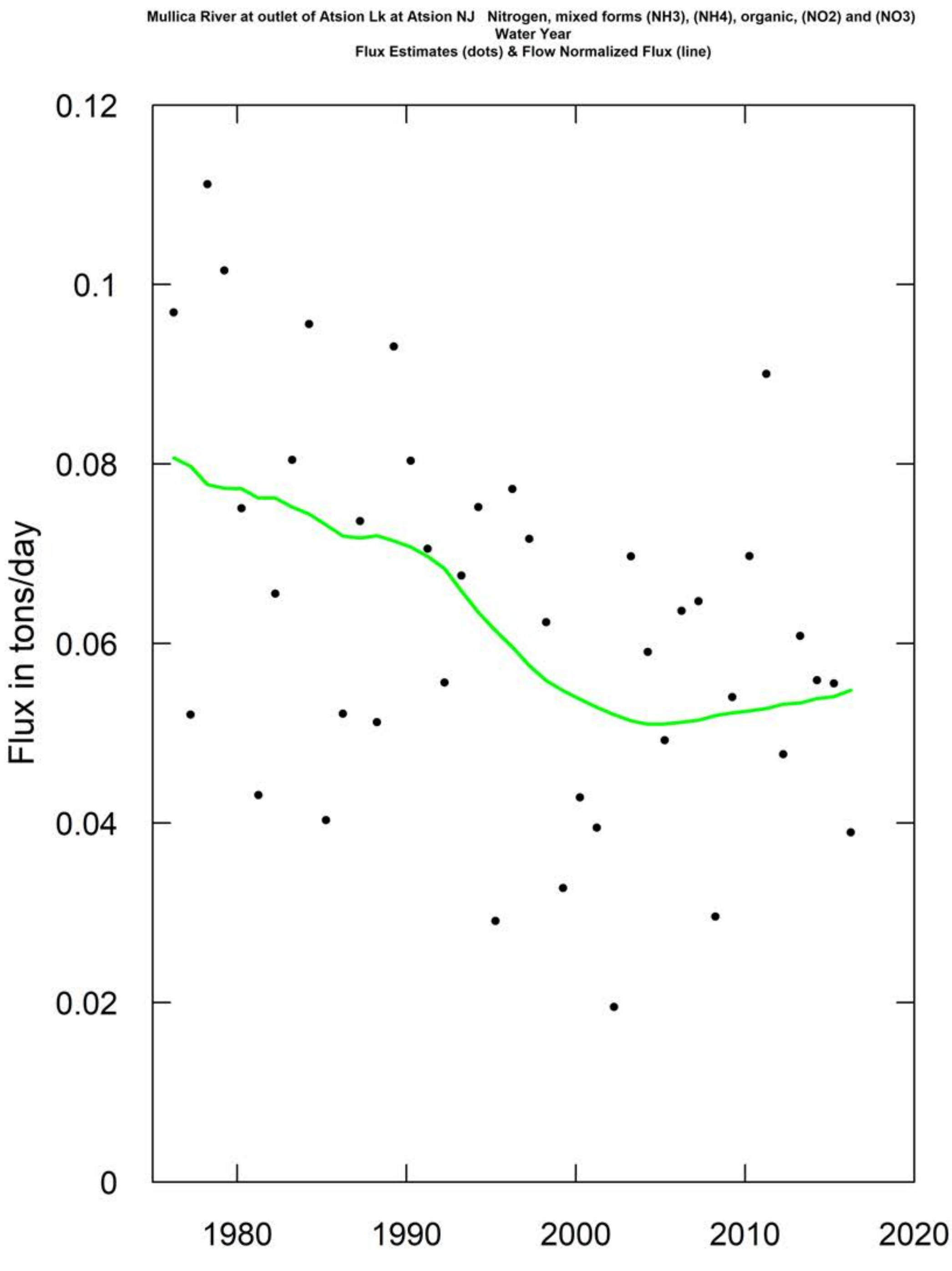

Fig. 5. Annual Flux Estimates over Time. The annual flux estimates (dots) and the annual flow-normalized flux (smoothed line) were plotted over year for each nutrient at each water quality station. Plots for all other stations are available digitally.

In addition to the plots, the general trend (upward; downward; no significant trend, --; or not determined, nd) for each nutrient concentration and flux is reported in Table 3. In the majority of instances, the general trend agreed for both concentration and flux in the same time period. The number of stations with downward, upward, or no trend in concentrations and fluxes of each water quality parameter are given in Table 4. For nitrate plus nitrite, more stations were identified to have upward trends for time periods 1980-2016 and 1980-2011, but more stations had downward trends for 2007-2016 and 2012-2016. Regardless of time period, more stations exhibited downward trends in total nitrogen concentrations and fluxes than upward trends. More stations had downward trends in total phosphorous concentrations and fluxes in 1980-2016 and 1980-2011; however, more stations had upward trends in total phosphorous from 2007-2016 and 2012-2016. Maps were also generated to show the trend results from the WRTDS tests, when available, and trend results from the SK tests when WRTDS results were unavailable (Figs. 6-8).

Table 3. Trend Results from Weighted Regressions on Time, Discharge, and Season (WRTDS) Models. The general trend of three parameters (nitrate plus nitrite, NO23; total nitrogen, TN; and total phosphorous, TP) were described as upward, downward, no significant trend (--), or not determined (nd) over each of four time periods for concentrations and fluxes. Table continued on next three pages.

Parameter	Station number	Station name	Concentrations				Fluxes			
			1980-2016	1980-2011	2007-2016	2012-2016	1980-2016	1980-2011	2007-2016	2012-2016
NO23	01367770	Wallkill River near Sussex, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01377000	Hackensack River at Rivervale, NJ	Downward	Downward	Downward	Downward	Downward	Downward	Downward	Downward
	01381800	Whippany River near Pine Brook, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01382000	Passaic River at Two Bridges, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01387500	Ramapo River near Mahwah, NJ	Upward	Upward	--	--	Upward	Upward	--	--
	01389500	Passaic River at Little Falls, NJ	Upward	Upward	--	--	--	Upward	--	--
	01391500	Saddle River at Lodi, NJ	Upward	Upward	--	--	Upward	Upward	--	--
	01395000	Rahway River at Rahway, NJ	--	--	Downward	Downward	--	--	Downward	Downward
	01396660	Mulhockaway Creek at Van Syckel, NJ	--	Downward	--	Upward	--	--	Upward	Upward
	01398000	Neshanic River at Reaville, NJ	Downward	Downward	--	--	Downward	Downward	--	--
	01399780	Lamington River at Burnt Mills, NJ	Upward	--	--	--	nd	nd	nd	nd
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	--	--	Downward	nd	nd	nd	nd
	01408500	Toms River near Toms River, NJ	Upward	Upward	--	--	Upward	Upward	--	--
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	--	--	--	--	nd	nd	nd	nd
	01409815	West Branch Wading River at Maxwell, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01411110	Great Egg Harbor River at Weymouth, NJ	Upward	Upward	Upward	--	nd	nd	nd	nd
	01411500	Maurice River at Norma, NJ	Upward	Upward	--	--	Upward	Upward	--	--
	01412800	Cohansey River at Seeley, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	Downward	Downward	Downward	Downward	Downward	Downward
	01457400	Musconetcong River at Riegelsville, NJ	Upward	Upward	Upward	--	Upward	Upward	--	--
	01463500	Delaware River at Trenton, NJ	Downward	Downward	--	--	Downward	Downward	--	--
	01464515	Doctors Creek at Allentown, NJ	nd	nd	nd	nd	nd	nd	nd	nd

Parameter	Station number	Station name	Concentrations				Fluxes			
			1980-2016	1980-2011	2007-2016	2012-2016	1980-2016	1980-2011	2007-2016	2012-2016
NO23	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01477120	Raccoon Creek near Swedesboro, NJ	--	--	--	--	--	--	--	--
	01394500	Rahway River near Springfield, NJ	--	--	--	Downward	--	--	--	--
	01409416	Hammonton Creek at Wescoatville, NJ	--	--	--	--	nd	nd	nd	nd
	01410150	East Branch Bass River near New Gretna, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01482500	Salem River at Woodstown, NJ	nd	nd	nd	nd	nd	nd	nd	nd
TN	01367770	Wallkill River near Sussex, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01377000	Hackensack River at Rivervale, NJ	Downward	Downward	Downward	Downward	Downward	Downward	--	Downward
	01381800	Whippany River near Pine Brook, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01382000	Passaic River at Two Bridges, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01387500	Ramapo River near Mahwah, NJ	--	--	--	--	--	--	--	--
	01389500	Passaic River at Little Falls, NJ	Downward	Downward	--	Downward	Downward	Downward	--	--
	01391500	Saddle River at Lodi, NJ	--	--	Downward	Downward	--	--	Downward	Downward
	01395000	Rahway River at Rahway, NJ	Downward	Downward	Downward	Downward	Downward	--	Downward	Downward
	01396660	Mulhockaway Creek at Van Syckel, NJ	Downward	Downward	--	--	Downward	Downward	--	--
	01398000	Neshanic River at Reaville, NJ	Downward	Downward	--	--	Downward	Downward	--	Downward
	01399780	Lamington River at Burnt Mills, NJ	--	--	--	--	nd	nd	nd	nd
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	Downward	Downward	--	--	nd	nd	nd	nd
	01408500	Toms River near Toms River, NJ	Upward	Upward	--	--	Upward	Upward	--	--
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	Downward	Downward	--	--	nd	nd	nd	nd
	01409815	West Branch Wading River at Maxwell, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01411110	Great Egg Harbor River at Weymouth, NJ	--	--	Upward	Upward	nd	nd	nd	nd
	01411500	Maurice River at Norma, NJ	--	--	--	--	--	--	--	--
	01412800	Cohansey River at Seeley, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	Downward	Downward	Downward	Downward	Downward	Downward
	01457400	Musconetcong River at Riegelsville, NJ	--	--	--	--	--	--	--	--
	01463500	Delaware River at Trenton, NJ	Downward	Downward	--	--	Downward	Downward	--	Upward
	01464515	Doctors Creek at Allentown, NJ	nd	nd	nd	nd	nd	nd	nd	nd

Parameter	Station number	Station name	Concentrations				Fluxes			
			1980-2016	1980-2011	2007-2016	2012-2016	1980-2016	1980-2011	2007-2016	2012-2016
TN	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01477120	Raccoon Creek near Swedesboro, NJ	--	--	--	Downward	--	--	--	--
	01394500	Rahway River near Springfield, NJ	Downward	Downward	Downward	Downward	Downward	Downward	Downward	Downward
	01409416	Hammonton Creek at Wescoatville, NJ	Downward	Downward	--	--	nd	nd	nd	nd
	01410150	East Branch Bass River near New Gretna, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01482500	Salem River at Woodstown, NJ	--	--	--	--	nd	nd	nd	nd
TP	01367770	Wallkill River near Sussex, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01377000	Hackensack River at Rivervale, NJ	--	--	--	--	--	--	--	Upward
	01381800	Whippany River near Pine Brook, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01382000	Passaic River at Two Bridges, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01387500	Ramapo River near Mahwah, NJ	--	--	--	--	Upward	Upward	Upward	Upward
	01389500	Passaic River at Little Falls, NJ	Downward	Downward	Downward	Downward	Downward	Downward	Downward	Downward
	01391500	Saddle River at Lodi, NJ	Downward	--	--	--	Downward	Downward	--	--
	01395000	Rahway River at Rahway, NJ	--	--	--	--	--	--	--	Upward
	01396660	Mulhockaway Creek at Van Syckel, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01398000	Neshanic River at Reaville, NJ	--	Downward	--	--	--	--	--	--
	01399780	Lamington River at Burnt Mills, NJ	Downward	Downward	Downward	--	nd	nd	nd	nd
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	--	--	--	nd	nd	nd	nd
	01408500	Toms River near Toms River, NJ	Downward	Downward	--	--	--	Downward	--	--
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	--	--	Upward	Upward	nd	nd	nd	nd
	01409815	West Branch Wading River at Maxwell, NJ	Upward	Upward	--	--	nd	nd	nd	nd
	01411110	Great Egg Harbor River at Weymouth, NJ	Downward	Downward	--	--	nd	nd	nd	nd
	01411500	Maurice River at Norma, NJ	Downward	Downward	Upward	Upward	--	Downward	Upward	Upward
	01412800	Cohansey River at Seeley, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	--	Upward	Downward	Downward	--	Upward
	01457400	Musconetcong River at Riegelsville, NJ	Downward	--	--	--	--	--	--	--
	01463500	Delaware River at Trenton, NJ	Downward	Downward	Upward	Upward	--	--	--	Upward
	01464515	Doctors Creek at Allentown, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	nd	nd	nd	nd	nd	nd	nd

Parameter	Station number	Station name	Concentrations				Fluxes			
			1980-2016	1980-2011	2007-2016	2012-2016	1980-2016	1980-2011	2007-2016	2012-2016
TP	01477120	Raccoon Creek near Swedesboro, NJ	--	--	Downward	Downward	--	--	Downward	--
	01394500	Rahway River near Springfield, NJ	--	Downward	--	--	--	--	--	--
	01409416	Hammonton Creek at Wescoatville, NJ	Downward	Downward	Downward	Downward	nd	nd	nd	nd
	01410150	East Branch Bass River near New Gretna, NJ	nd	nd	nd	nd	nd	nd	nd	nd
	01482500	Salem River at Woodstown, NJ	--	--	--	--	nd	nd	nd	nd

Table 4. Numbers of Water Quality Stations with Trends Identified using Weighted Regression on Time, Discharge, and Season (WRTDS) Models. The number of water quality stations with each trend (downward, upward, no trend) for each time period from the WRTDS models are depicted in this table.

		Concentration			Flux		
Time Period	**Water Quality Parameter**	**Down**	**Up**	**No trend**	**Down**	**Up**	**No trend**
1980 - 2016	Nitrate plus nitrite	4	8	7	4	5	5
	Total nitrogen	11	1	8	8	1	5
	Total phosphorous	10	1	9	3	1	9
1980 - 2011	Nitrate plus nitrite	5	7	7	4	6	4
	Total nitrogen	11	1	8	7	1	6
	Total phosphorous	10	1	9	5	1	7
2007 - 2016	Nitrate plus nitrite	3	2	14	3	1	10
	Total nitrogen	5	1	14	4	0	10
	Total phosphorous	4	3	13	2	2	9
2012 - 2016	Nitrate plus nitrite	5	1	13	3	1	10
	Total nitrogen	7	1	12	6	1	7
	Total phosphorous	3	4	13	1	6	6

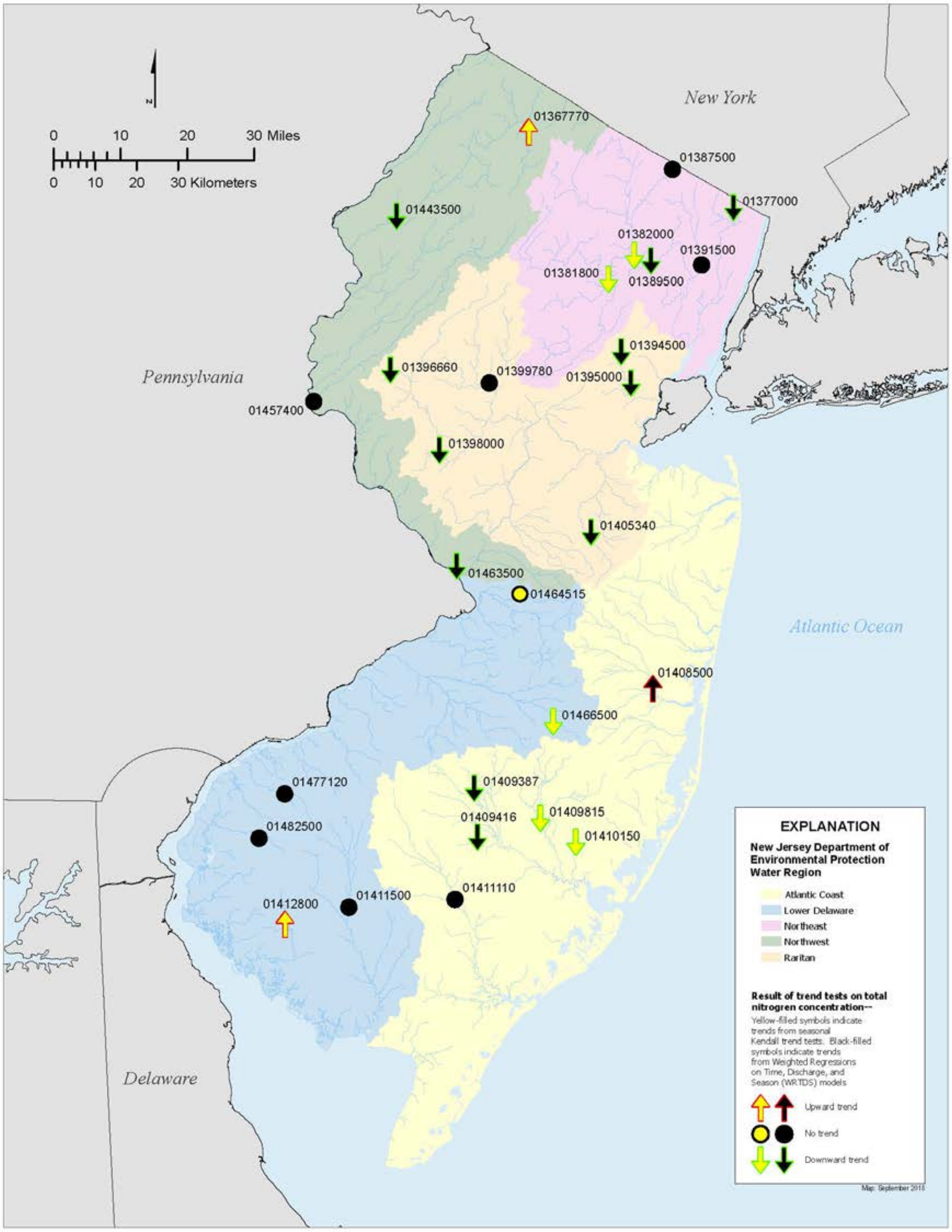

Fig. 6. Total Nitrogen Trends from 1980 to 2016. Total nitrogen trends from WRTDS models were depicted when available, otherwise SK trends were displayed. See Table 1 for station names.

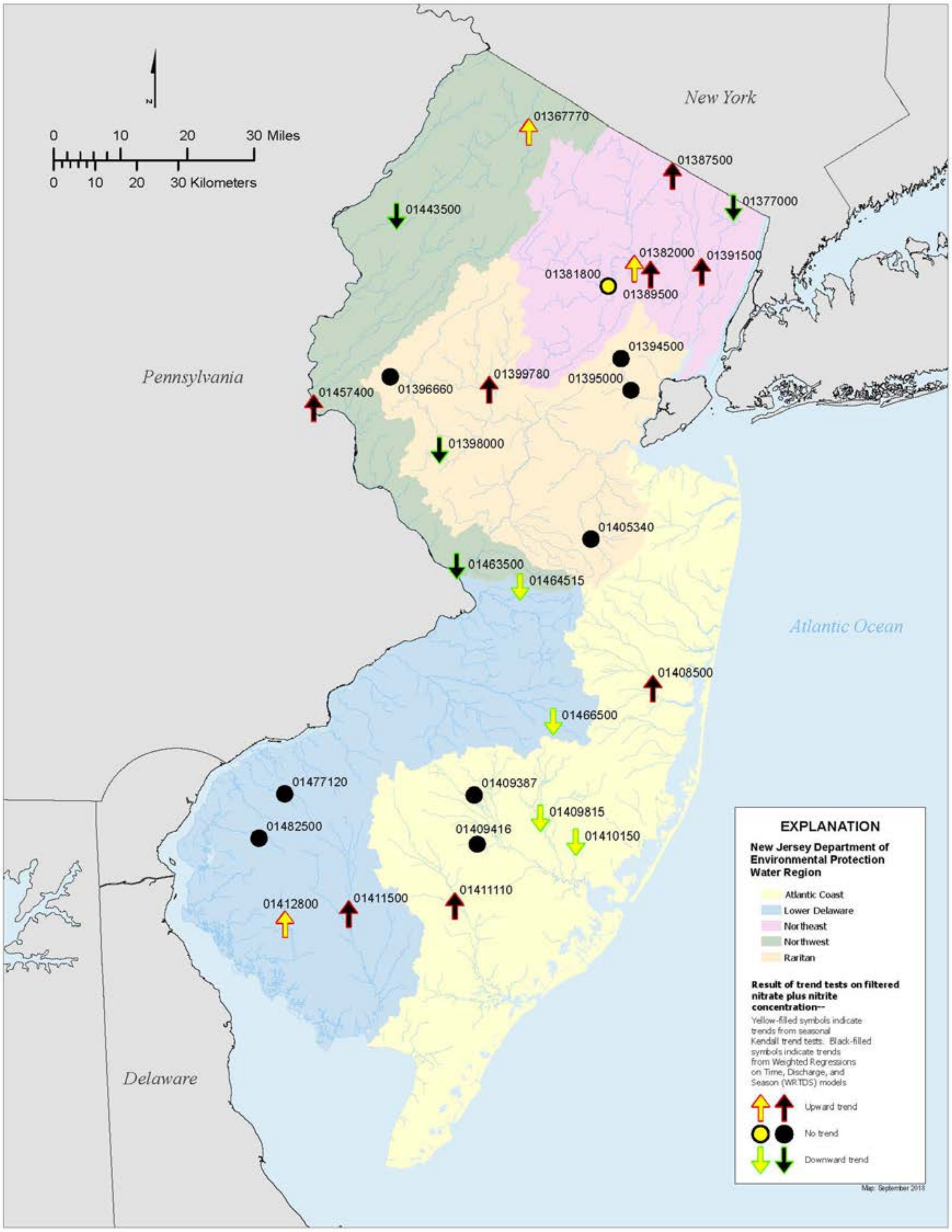

Fig. 7. Nitrate Plus Nitrite Concentration Trends from 1980 to 2016. Nitrate plus nitrite trends from WRTDS models were depicted when available, otherwise SK test results were displayed. See Table 1 for station names.

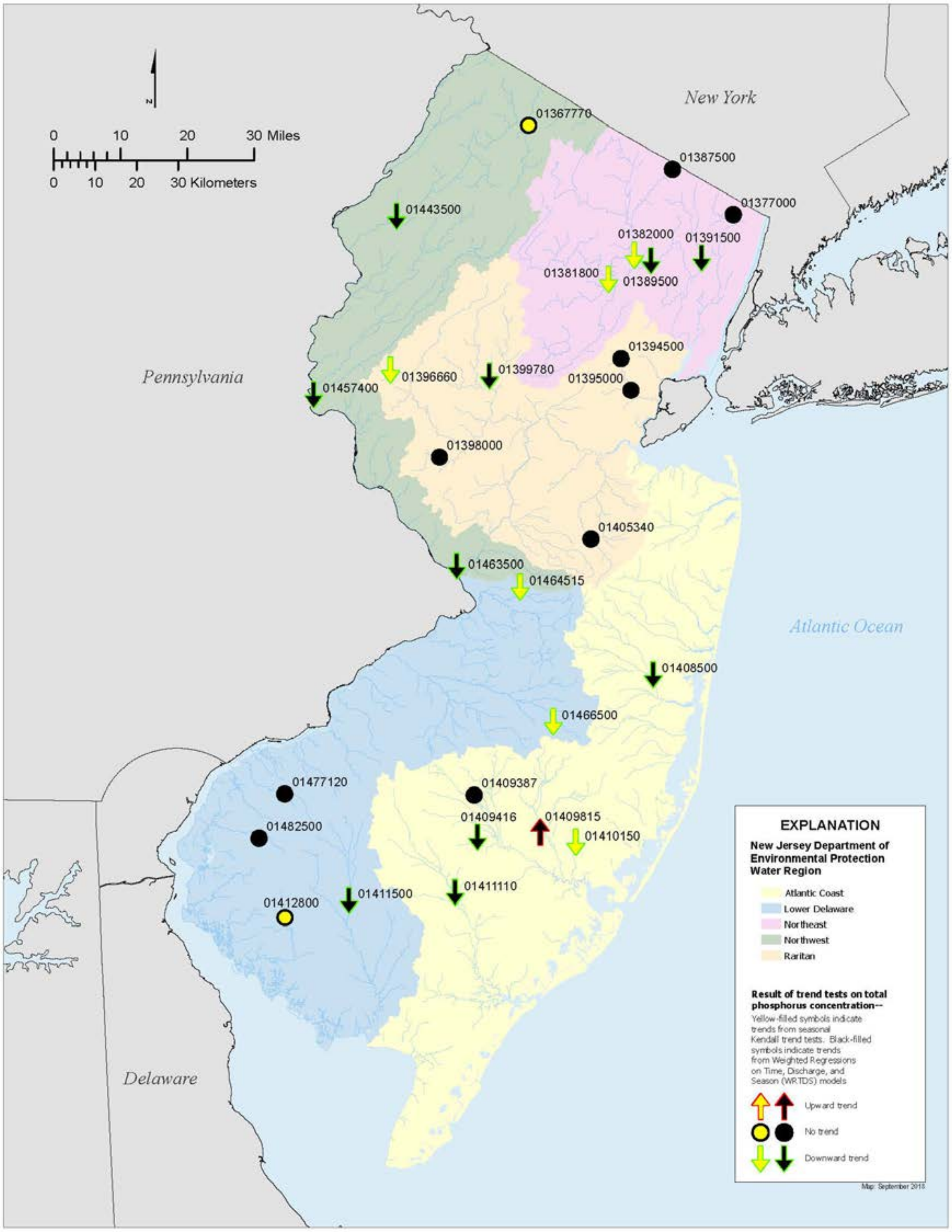

Fig. 8. Total Phosphorous Trends from 1980 to 2016. Total phosphorous trend results from WRTDS models were depicted when available, otherwise SK test results were displayed. See Table 1 for station names.

According to the WRTDS models, from 1980 to 2016, total nitrogen concentration (mg/l; Fig. 9) and flux (tons/day; Fig. 10) increased at only one of the water quality stations (01408500; Toms River near Toms River, NJ; Fig. 6). During the same time frame, nitrate plus nitrite increased at eight water quality stations (Fig. 7). Total phosphorous concentration (Fig. 11) and flux (Fig. 12) also increased at one water quality station from 1980 to 2016 (01409815; West Branch Wading River at Maxwell, NJ; Fig. 8).

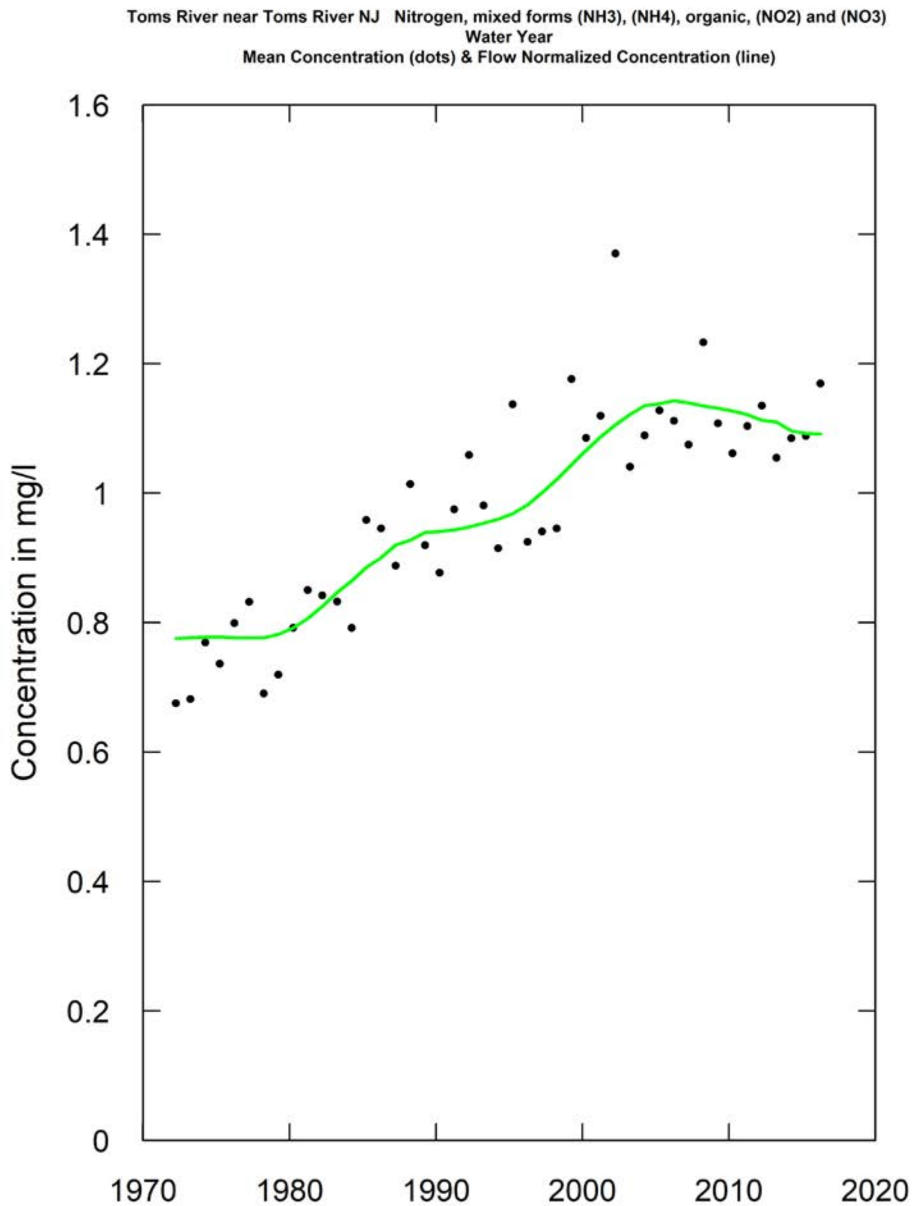

Fig. 9. Concentration of Total Nitrogen at Toms River. The concentration of total nitrogen increased from 1971 to 2016 according to the WRTDS model for the Toms River at Toms River, NJ water quality station (01408500).

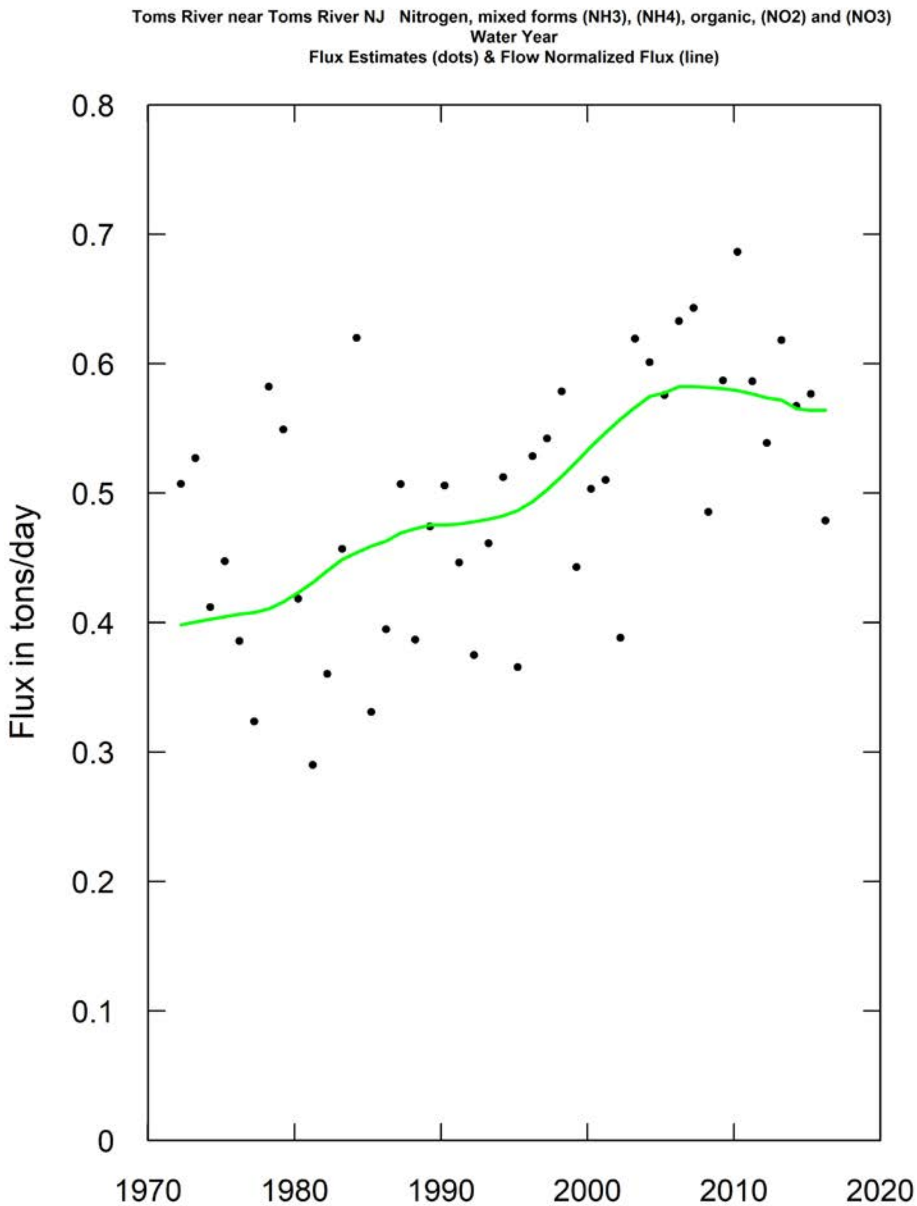

Fig. 10. Flux of Total Nitrogen at Toms River, NJ. The flux of total nitrogen (1971 to 2016) also increased according to the WRTDS model for the water quality station at Toms River at Toms River, NJ (01408500).

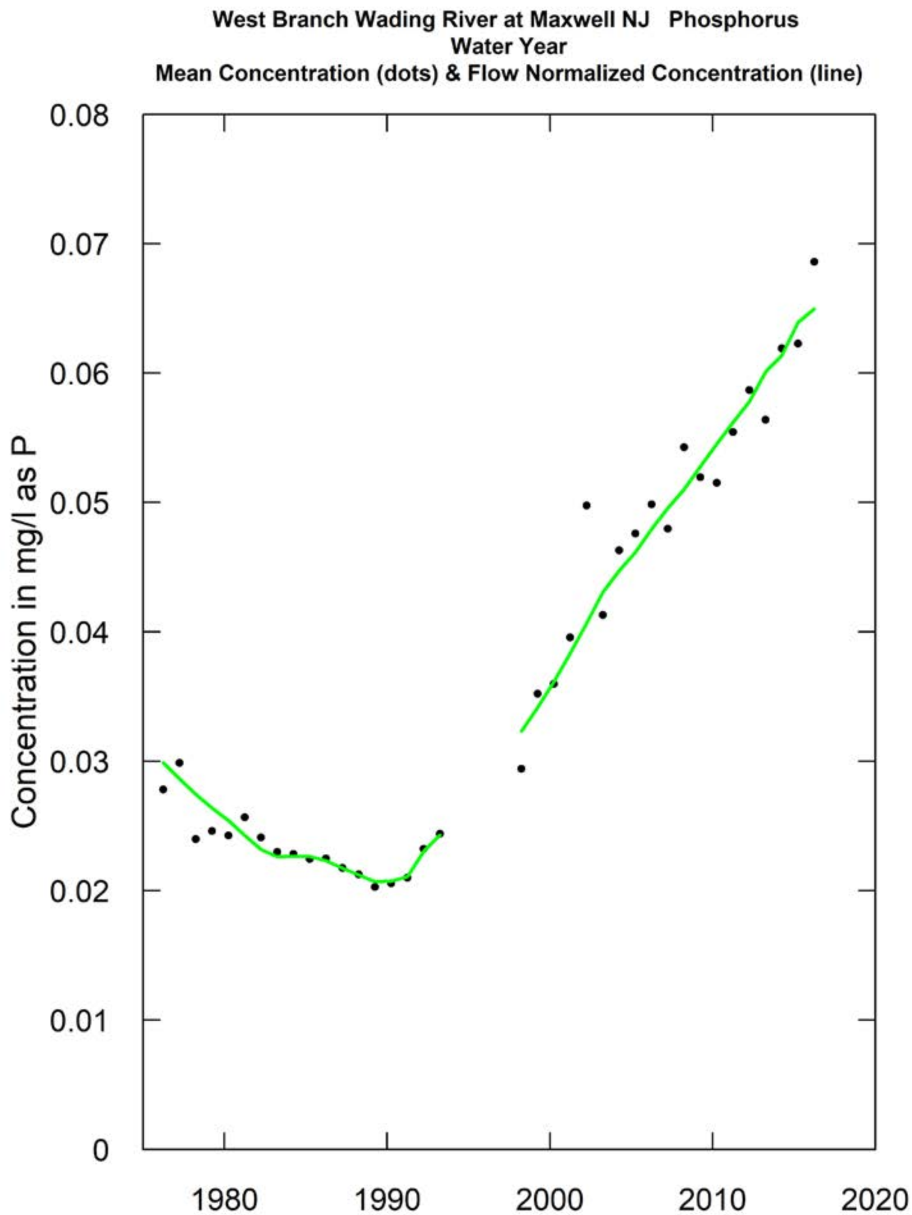

Fig. 11. Concentration of Total Phosphorus at West Branch Wading River. The concentration of total phosphorus increased from 1971 to 2016 according to the WRTDS model for the West Branch Wading River at Maxwell, NJ water quality station (01409815).

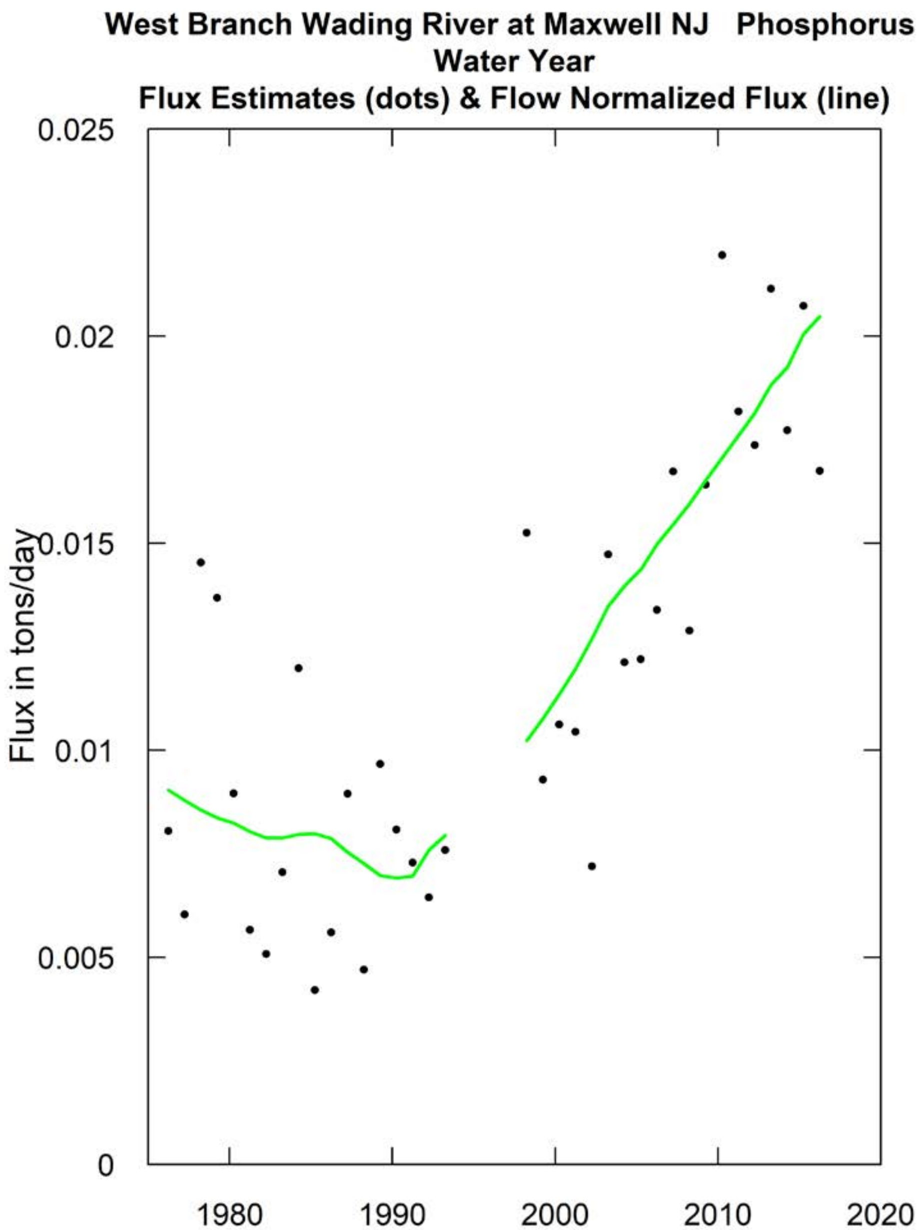

Fig. 12. Flux of Total Phosphorus at West Branch Wading River. The flux of total phosphorus increased (1971 to 2016) according to the WRTDS model for the water quality station at West Branch Wading River at Maxwell, NJ (01409815).

Seasonal Kendall Trend Test

The statistical summary results from the SK models (tau, slopes, intercepts, *p*-values, etc.) are available in Appendix 3 and the nutrient trends are available in Table 5. The correlation coefficient, Kendall's tau, can be used to measure the strength of the association between nutrient concentration and year. The value of Kendall's tau can range from -1 to 1, and the relationship is stronger when tau is closer to -1 and 1 than it is when tau is closer to zero. When tau is negative, it suggests a negative or decreasing relationship between the two variables and vice versa when positive. The strength of the trend over each of the time periods can be determined by first checking for statistical significance (i.e., ensure that the p-value ≤ 0.05 in Appendix 3) and then examining the strength of the correlation. According to the seasonal Kendall trend tests, almost the same number of stations experienced upward and downward trends in nitrate plus nitrite from 1980-2016 and 1980-2011 (Table 6). For the 2007-2016 period, more stations exhibited downward trends than upward trends in nitrate plus nitrite. From 2012-2016, all stations showed non-significant trends in nitrate plus nitrite. More water quality stations experienced a downward trend from 1980-2016 and 1980-2011 than upward trend in total nitrogen. However, the same number of stations exhibited downward and upward trends in total nitrogen concentrations from 2007-2016 and 2012-2016. With regard to total phosphorous, more stations had downward trends from 1980-2016 and 1980-2011. In more recent years (2007-2016 and 2012-2016), more stations had upward trends in total phosphorous.

Table 5. Trend Results from Weighted Regressions on Time, Discharge, and Season (WRTDS) Models and Seasonal Kendall (SK) Tests. The general trend of three parameters (nitrate plus nitrite, total nitrogen, and total phosphorous) were described as upward, downward, no significant trend (--), or not determined (nd) over each of four time periods. When the results of the SK tests and the WRTDS models agreed, trends were highlighted in gray. Table continued on next three pages.

Nutrient	Station ID	Name	WRTDS 1980-2016	SK 1980-2016	WRTDS 1980-2011	SK 1980-2011	WRTDS 2007-2016	SK 2007-2016	WRTDS 2012-2016	SK 2012-2016
NO23	01367770	Wallkill River near Sussex, NJ	nd	Upward	nd	Upward	nd	--	nd	--
	01377000	Hackensack River at Rivervale, NJ	Downward	--	Downward	--	Downward	Downward	Downward	--
	01381800	Whippany River near Pine Brook, NJ	nd	--	nd	--	nd	--	nd	--
	01382000	Passaic River at Two Bridges, NJ	nd	Upward	nd	Upward	nd	--	nd	--
	01387500	Ramapo River near Mahwah, NJ	Upward	--	Upward	--	--	--	--	--
	01389500	Passaic River at Little Falls, NJ	Upward	Upward	Upward	Upward	--	--	--	--
	01391500	Saddle River at Lodi, NJ	Upward	Upward	Upward	Upward	--	--	--	--
	01394500	Rahway River near Springfield, NJ	--	--	--	--	--	--	Downward	--
	01395000	Rahway River at Rahway, NJ	--	--	--	--	Downward	Downward	Downward	--
	01396660	Mulhockaway Creek at Van Syckel, NJ	--	Downward	Downward	Downward	--	--	Upward	--
	01398000	Neshanic River at Reaville, NJ	Downward	--	Downward	--	--	--	--	--
	01399780	Lamington River at Burnt Mills, NJ	Upward	--	--	--	--	--	--	--
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	--	--	--	--	Downward	Downward	--
	01408500	Toms River near Toms River, NJ	Upward	Upward	Upward	Upward	--	--	--	--
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	--	Downward	--	Downward	--	--	--	--
	01409416	Hammonton Creek at Wescoatville, NJ	--	--	--	--	--	--	--	--
	01409815	West Branch Wading River at Maxwell, NJ	nd	Downward	nd	Downward	nd	--	nd	nd
	01410150	East Branch Bass River near New Gretna, NJ	nd	Downward	nd	Downward	nd	--	nd	nd
	01411110	Great Egg Harbor River at Weymouth, NJ	Upward	--	Upward	--	Upward	--	--	--
	01411500	Maurice River at Norma, NJ	Upward	--	Upward	--	--	--	--	--
	01412800	Cohansey River at Seeley, NJ	nd	Upward	nd	Upward	nd	--	nd	--
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	Downward	--	Downward	--	Downward	--
	01457400	Musconetcong River at Riegelsville, NJ	Upward	Upward	Upward	Upward	Upward	Upward	--	--

Nutrient	Station ID	Name	WRTDS 1980-2016	SK 1980-2016	WRTDS 1980-2011	SK 1980-2011	WRTDS 2007-2016	SK 2007-2016	WRTDS 2012-2016	SK 2012-2016
NO23	01463500	Delaware River at Trenton, NJ	Downward	Downward	Downward	Downward	--	--	--	--
	01464515	Doctors Creek at Allentown, NJ	nd	Downward	nd	--	nd	Downward	nd	--
	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	Downward	nd	Downward	nd	Downward	nd	--
	01477120	Raccoon Creek near Swedesboro, NJ	--	--	--	Downward	--	--	--	--
	01482500	Salem River at Woodstown, NJ	--	--	--	--	--	--	--	--
TN	01367770	Wallkill River near Sussex, NJ	nd	Upward	nd	--	nd	Upward	nd	Upward
	01377000	Hackensack River at Rivervale, NJ	Downward	--	Downward	--	Downward	Downward	Downward	--
	01381800	Whippany River near Pine Brook, NJ	nd	Downward	nd	Downward	nd	--	nd	--
	01382000	Passaic River at Two Bridges, NJ	nd	Downward	nd	Downward	nd	--	nd	--
	01387500	Ramapo River near Mahwah, NJ	--	--	--	--	--	--	--	--
	01389500	Passaic River at Little Falls, NJ	Downward	Downward	Downward	Downward	--	--	Downward	--
	01391500	Saddle River at Lodi, NJ	--	--	--	--	Downward	--	Downward	--
	01394500	Rahway River near Springfield, NJ	Downward	Downward	Downward	Downward	Downward	--	Downward	--
	01395000	Rahway River at Rahway, NJ	Downward	--	Downward	--	Downward	Downward	Downward	--
	01396660	Mulhockaway Creek at Van Syckel, NJ	Downward	--	Downward	Downward	--	--	--	--
	01398000	Neshanic River at Reaville, NJ	Downward	--	Downward	--	--	--	--	--
	01399780	Lamington River at Burnt Mills, NJ	--	Downward	--	Downward	--	--	--	--
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	Downward	Downward	Downward	Downward	--	Downward	--	--
	01408500	Toms River near Toms River, NJ	Upward	Upward	Upward	Upward	--	--	--	--
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	Downward	Downward	Downward	Downward	--	--	--	--
	01409416	Hammonton Creek at Wescoatville, NJ	Downward	Downward	Downward	Downward	--	Downward	--	--
	01409815	West Branch Wading River at Maxwell, NJ	nd	Downward	nd	Downward	nd	--	nd	--
	01410150	East Branch Bass River near New Gretna, NJ	nd	Downward	nd	Downward	nd	--	nd	--
	01411110	Great Egg Harbor River at Weymouth, NJ	--	Downward	--	Downward	Upward	--	Upward	--
	01411500	Maurice River at Norma, NJ	--	--	--	--	--	--	--	--
	01412800	Cohansey River at Seeley, NJ	nd	Upward	nd	Upward	nd	--	nd	--
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	Downward	Downward	Downward	Upward	Downward	Downward
	01457400	Musconetcong River at Riegelsville, NJ	--	--	--	--	--	Upward	--	--
	01463500	Delaware River at Trenton, NJ	Downward	Downward	Downward	Downward	--	Upward	--	--

Nutrient	Station ID	Name	WRTDS 1980-2016	SK 1980-2016	WRTDS 1980-2011	SK 1980-2011	WRTDS 2007-2016	SK 2007-2016	WRTDS 2012-2016	SK 2012-2016
TN	01464515	Doctors Creek at Allentown, NJ	nd	--	nd	--	nd	--	nd	--
	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	Downward	nd	Downward	nd	--	nd	--
	01477120	Raccoon Creek near Swedesboro, NJ	--	--	--	--	--	--	Downward	--
	01482500	Salem River at Woodstown, NJ	--	--	--	--	--	--	--	--
TP	01367770	Wallkill River near Sussex, NJ	nd	--	nd	--	nd	--	nd	Upward
	01377000	Hackensack River at Rivervale, NJ	--	--	--	--	--	--	--	--
	01381800	Whippany River near Pine Brook, NJ	nd	Downward	nd	Downward	nd	--	nd	--
	01382000	Passaic River at Two Bridges, NJ	nd	Downward	nd	Downward	nd	--	nd	--
	01387500	Ramapo River near Mahwah, NJ	--	--	--	--	--	--	--	Upward
	01389500	Passaic River at Little Falls, NJ	Downward	Downward	Downward	--	Downward	--	Downward	--
	01391500	Saddle River at Lodi, NJ	Downward	Downward	--	--	--	--	--	--
	01394500	Rahway River near Springfield, NJ	--	--	Downward	--	--	--	--	--
	01395000	Rahway River at Rahway, NJ	--	--	--	--	--	--	--	--
	01396660	Mulhockaway Creek at Van Syckel, NJ	nd	Downward	nd	Downward	nd	Upward	nd	--
	01398000	Neshanic River at Reaville, NJ	--	--	Downward	Downward	--	--	--	--
	01399780	Lamington River at Burnt Mills, NJ	Downward	Downward	Downward	Downward	Downward	--	--	--
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	--	--	--	--	--	--	--
	01408500	Toms River near Toms River, NJ	Downward	Downward	Downward	Downward	--	--	--	--
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	--	Downward	--	Downward	Upward	Upward	Upward	--
	01409416	Hammonton Creek at Wescoatville, NJ	Downward	Downward	Downward	Downward	Downward	Downward	Downward	Downward
	01409815	West Branch Wading River at Maxwell, NJ	Upward	Upward	Upward	Upward	--	--	--	--
	01410150	East Branch Bass River near New Gretna, NJ	nd	Downward	nd	Downward	nd	--	nd	--
	01411110	Great Egg Harbor River at Weymouth, NJ	Downward	Downward	Downward	Downward	--	Upward	--	Upward
	01411500	Maurice River at Norma, NJ	Downward	--	Downward	Downward	Upward	Upward	Upward	--
	01412800	Cohansey River at Seeley, NJ	nd	--	nd	Downward	nd	--	nd	--
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	Downward	Downward	--	Upward	Upward	--
	01457400	Musconetcong River at Riegelsville, NJ	Downward	Downward	--	Downward	--	--	--	--
	01463500	Delaware River at Trenton, NJ	Downward	Downward	Downward	Downward	Upward	Upward	Upward	Upward
	01464515	Doctors Creek at Allentown, NJ	nd	Downward	nd	Downward	nd	--	nd	--

Nutrient	Station ID	Name	WRTDS 1980-2016	SK 1980-2016	WRTDS 1980-2011	SK 1980-2011	WRTDS 2007-2016	SK 2007-2016	WRTDS 2012-2016	SK 2012-2016
TP	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	Downward	nd	Downward	nd	Downward	nd	Downward
	01477120	Raccoon Creek near Swedesboro, NJ	--	Downward	--	--	Downward	--	Downward	--
	01482500	Salem River at Woodstown, NJ	--	--	--	--	--	--	--	--

Table 6. Numbers of Water Quality Stations with Trends Identified using Seasonal Kendall (SK) Models. The number of water quality stations with each trend (downward, upward, no trend) for each time period from the SK tests are depicted in this table.

		Concentration		
Time Period	**Water Quality Parameter**	**Down**	**Up**	**No trend**
1980 - 2016	Nitrate plus nitrite	8	7	13
	Total nitrogen	14	3	11
	Total phosphorous	17	1	10
1980 - 2011	Nitrate plus nitrite	7	7	14
	Total nitrogen	15	2	11
	Total phosphorous	17	1	10
2007 - 2016	Nitrate plus nitrite	5	1	22
	Total nitrogen	4	4	20
	Total phosphorous	2	6	20
2012 - 2016	Nitrate plus nitrite	0	0	26
	Total nitrogen	1	1	26
	Total phosphorous	2	4	22

According to the SK models, two water quality stations exhibited increasing trends in total nitrogen from 1980 to 2016: Wallkill River near Sussex, NJ (01367770; Fig. 13) and Cohansey River at Seeley, NJ (01412800; Fig. 14). Furthermore, nitrate plus nitrite concentration increased at three stations (Fig. 7).

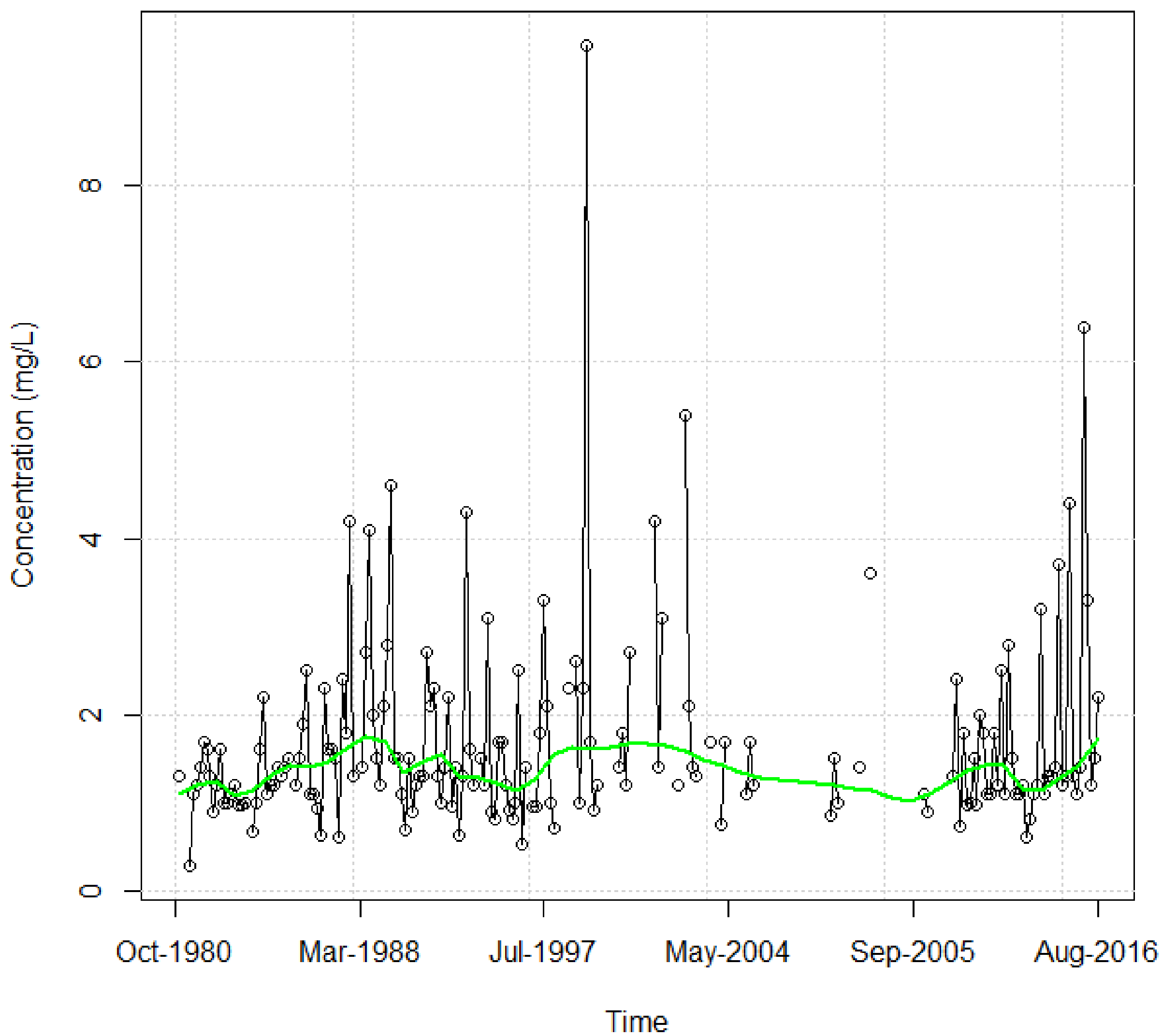

Fig. 13. Total Nitrogen Concentration at Wallkill River. According to a seasonal Kendall trend test, total nitrogen increased over time at the Wallkill River near Sussex, NJ (01367770). Green line shows loess line smoothed with a 10% window.

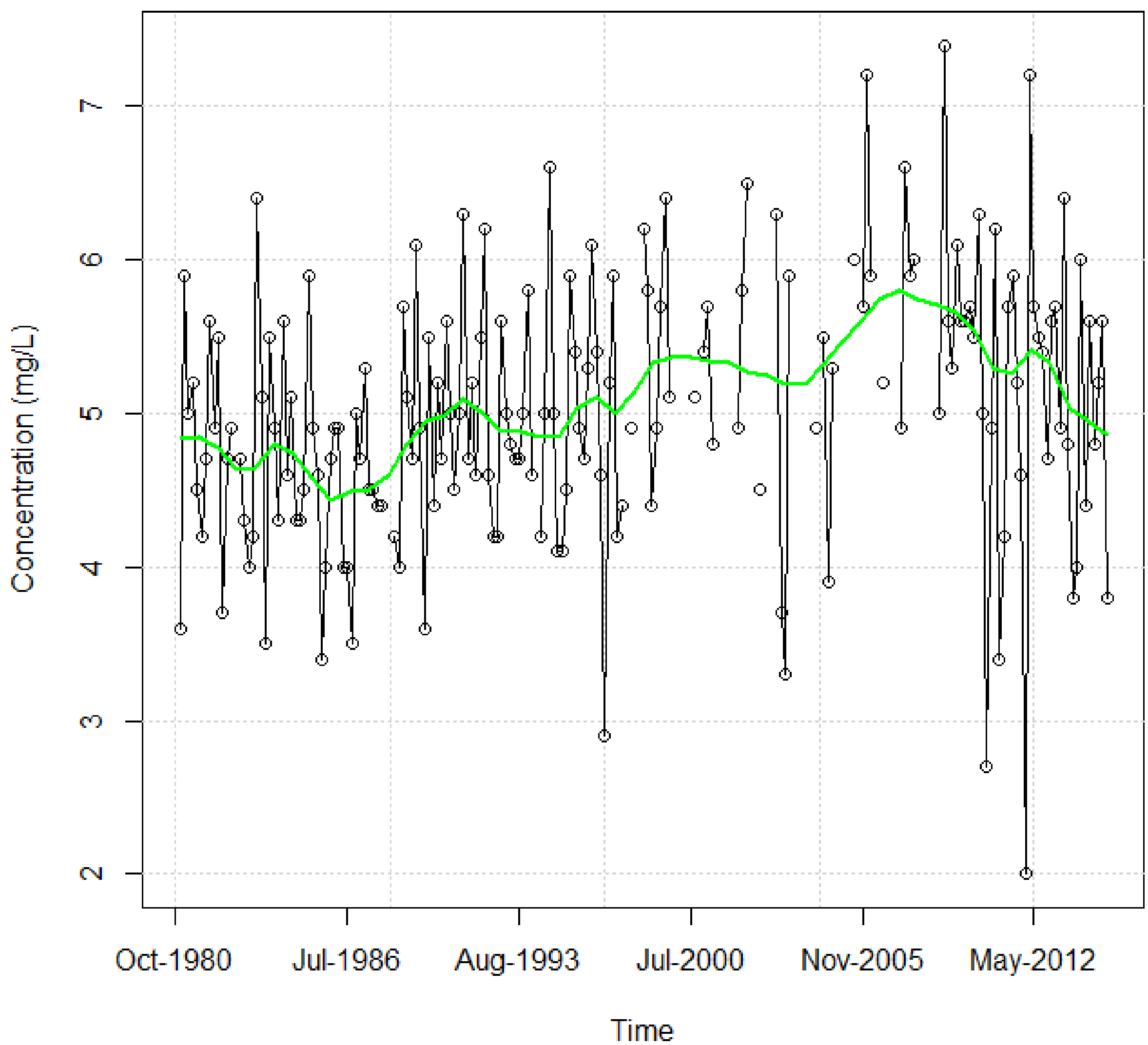

Fig. 14. Total Nitrogen Concentration at Cohansey River. According to a seasonal Kendall trend test, total nitrogen increased over time at the Cohansey River at Seeley, NJ (01412800). Green line displays loess line smoothed with a 10% window.

Land Use Characteristics

The percentages of major land use classes within each watershed during two different years (1992 & 2011) are presented in Table 7. Furthermore, the percent change between 1992 and 2011 was calculated (Table 8). All watersheds, except for one (Saddle River, 01391500), experienced an increase in urban land cover (ranging from 3.3 to 29.2%). On the other hand, 27 watersheds exhibited decreases in agriculture, except for one site where the percentage of agricultural lands increased (West Branch Wading River, 01409815). The water quality station at the West Branch Wading River was also the only site where total phosphorous increased from 1980 to 2016.

Table 7. Land Use Characteristics of Water Quality Stations. The percentage of major land use classes (urban, agriculture, barren, forest, wetlands, and water) within each watershed during two different time frames (1992 & 2011) was estimated from National Land Cover Datasets (NLCD). Table continued on next page.

Station Name	Station ID	1992 Urban	2011 Urban	1992 Agriculture	2011 Agriculture	1992 Barren	2011 Barren	1992 Forest	2011 Forest	1992 Wetlands	2011 Wetlands	1992 Water	2011 Water
Hackensack River at Rivervale, NJ	01377000	58.4	65.1	4.8	0.8	0.1	0.5	27.6	20.2	1.9	6.6	7.2	6.8
Wallkill River near Sussex, NJ	01367770	9.4	19.1	17.9	11.9	0.4	0.6	63.5	48.8	4.7	15.5	4.1	4.1
Whippany River near Pine Brook, NJ	01381800	43.3	53.6	5.5	1.5	0.1	0.2	42.8	26.9	7.0	16.7	1.3	1.1
Passaic River at Two Bridges, NJ	01382000	31.8	41.6	6.3	2.3	0.1	0.4	48.0	34.0	11.3	19.7	2.4	2.1
Ramapo River near Mahwah, NJ	01387500	17.3	22.5	2.5	0.8	0.0	0.1	75.1	66.9	1.8	6.5	3.4	3.2
Passaic River at Little Falls, NJ	01389500	25.4	32.9	4.4	1.4	0.1	0.4	59.0	47.0	7.2	14.8	3.8	3.5
Saddle River at Lodi, NJ	01391500	77.2	75.1	6.0	0.5	0.0	0.0	15.1	14.1	1.4	10.1	0.4	0.3
Rahway River near Springfield, NJ	01394500	65.8	80.5	4.4	0.1	0.0	0.0	28.4	17.1	0.8	1.8	0.5	0.5
Rahway River at Rahway, NJ	01395000	71.8	80.5	4.2	0.1	0.0	0.0	21.4	15.0	2.1	4.0	0.5	0.5
Mulhockaway Creek at Van Syckel, NJ	01396660	2.8	17.3	25.4	22.9	0.1	0.0	69.9	49.2	1.6	10.6	0.1	0.1
Neshanic River at Reaville, NJ	01398000	5.9	24.5	61.0	41.9	0.0	0.1	31.8	28.5	1.3	5.0	0.1	0.0
Lamington River at Burnt Mills, NJ	01399780	8.5	18.5	28.6	24.6	0.2	0.4	57.9	46.7	3.7	8.8	1.1	1.0
Manalapan Brook at Federal Road near Manalapan, NJ	01405340	2.7	32.0	43.6	20.6	0.0	0.3	43.4	25.1	9.8	21.8	0.5	0.2
Toms River near Toms River, NJ	01408500	9.4	28.1	8.3	2.7	4.8	3.8	58.9	38.3	17.6	26.1	1.0	1.0
Mullica River at outlet of Atsion Lk at Atsion, NJ	01409387	8.1	12.9	6.2	4.9	1.3	0.2	60.9	42.9	21.2	37.6	2.4	1.4
Hammonton Creek at Wescoatville, NJ	01409416	14.2	24.8	51.7	46.8	0.0	0.3	27.5	16.3	5.3	10.6	1.3	1.1
West Branch Wading River at Maxwell, NJ	01409815	0.5	3.8	1.7	5.5	2.1	0.2	75.8	52.0	15.0	36.9	4.9	1.6
East Branch Bass River near New Gretna, NJ	01410150	2.1	8.6	0.3	0.0	0.0	0.1	91.6	72.0	5.3	18.5	0.8	0.8

Station Name	Station ID	1992 Urban	2011 Urban	1992 Agriculture	2011 Agriculture	1992 Barren	2011 Barren	1992 Forest	2011 Forest	1992 Wetlands	2011 Wetlands	1992 Water	2011 Water
Great Egg Harbor River at Weymouth, NJ	01411110	11.6	22.5	19.3	14.0	1.8	1.1	52.5	35.1	13.9	26.5	0.9	0.9
Maurice River at Norma, NJ	01411500	13.4	26.0	31.9	22.2	0.3	0.1	43.0	30.1	10.6	20.9	0.8	0.6
Cohansey River at Seeley, NJ	01412800	1.5	8.7	80.7	72.9	0.0	0.1	13.4	9.3	3.9	8.7	0.4	0.3
Paulins Kill at Blairstown, NJ	01443500	5.2	13.4	26.6	21.5	0.4	0.3	59.4	45.8	5.2	15.7	3.2	3.2
Musconetcong River at Riegelsville, NJ	01457400	8.4	19.7	22.2	17.9	0.5	0.5	60.5	49.9	3.7	8.1	4.7	4.0
McDonalds Branch in Byrne State Forest, NJ	01466500	0.0	6.2	0.0	0.0	9.5	0.9	85.1	77.2	5.4	15.7	0.0	0.0
Raccoon Creek near Swedesboro, NJ	01477120	4.2	24.5	64.3	43.7	0.0	0.8	27.1	17.4	4.0	13.5	0.3	0.1
Salem River at Woodstown, NJ	01482500	3.2	10.3	76.9	69.5	0.1	0.0	15.6	8.1	3.1	11.3	1.2	0.8
Doctors Creek at Allentown, NJ	01464515	4.5	17.6	56.7	44.5	0.0	0.4	32.9	24.1	4.9	13.0	1.1	0.5
Delaware River at Trenton, NJ	01463500	3.3	10.8	16.8	14.6	0.4	0.3	74.6	67.7	2.5	4.6	2.4	2.1

Table 8. Percent Change in Land Use from 1992 to 2011. The percentage change (%) in land use for each water quality station was calculated between 1992 and 2011 for each class.

Station Name	Station ID	Urban (%)	Agriculture (%)	Barren (%)	Forest (%)	Wetlands (%)	Water (%)
Hackensack River at Rivervale, NJ	01377000	6.7	-3.9	0.4	-7.4	4.6	-0.4
Wallkill River near Sussex, NJ	01367770	9.7	-6.0	0.2	-14.7	10.8	-0.1
Whippany River near Pine Brook, NJ	01381800	10.3	-4.0	0.2	-15.9	9.7	-0.3
Passaic River at Two Bridges, NJ	01382000	9.7	-4.0	0.2	-14.0	8.3	-0.2
Ramapo River near Mahwah, NJ	01387500	5.3	-1.7	0.1	-8.2	4.8	-0.2
Passaic River at Little Falls, NJ	01389500	7.5	-3.0	0.3	-12.1	7.6	-0.3
Saddle River at Lodi, NJ	01391500	-2.1	-5.5	0.0	-1.0	8.7	-0.1
Rahway River near Springfield, NJ	01394500	14.6	-4.3	0.0	-11.3	1.0	0.0
Rahway River at Rahway, NJ	01395000	8.7	-4.1	0.0	-6.4	1.9	0.0
Mulhockaway Creek at Van Syckel, NJ	01396660	14.4	-2.5	-0.1	-20.7	9.0	-0.1
Neshanic River at Reaville, NJ	01398000	18.6	-19.0	0.1	-3.3	3.8	0.0
Lamington River at Burnt Mills, NJ	01399780	10.0	-4.0	0.2	-11.3	5.1	-0.1
Manalapan Brook at Federal Road near Manalapan, NJ	01405340	29.2	-23.0	0.3	-18.3	12.0	-0.2
Toms River near Toms River, NJ	01408500	18.7	-5.5	-1.0	-20.6	8.5	-0.1
Mullica River at outlet of Atsion Lk at Atsion, NJ	01409387	4.9	-1.3	-1.1	-17.9	16.4	-1.0
Hammonton Creek at Wescoatville, NJ	01409416	10.7	-4.9	0.3	-11.2	5.3	-0.2
West Branch Wading River at Maxwell, NJ	01409815	3.3	3.8	-1.9	-23.8	21.9	-3.3
East Branch Bass River near New Gretna, NJ	01410150	6.5	-0.3	0.1	-19.6	13.2	0.1
Great Egg Harbor River at Weymouth, NJ	01411110	10.9	-5.3	-0.7	-17.4	12.6	0.0
Maurice River at Norma, NJ	01411500	12.6	-9.7	-0.1	-12.8	10.3	-0.2
Cohansey River at Seeley, NJ	01412800	7.2	-7.9	0.0	-4.0	4.8	-0.1
Paulins Kill at Blairstown, NJ	01443500	8.2	-5.1	-0.1	-13.6	10.6	0.0
Musconetcong River at Riegelsville, NJ	01457400	11.2	-4.3	0.0	-10.6	4.4	-0.8
McDonalds Branch in Byrne State Forest, NJ	01466500	6.2	0.0	-8.6	-7.8	10.3	0.0
Raccoon Creek near Swedesboro, NJ	01477120	20.3	-20.6	0.8	-9.8	9.5	-0.2
Salem River at Woodstown, NJ	01482500	7.0	-7.4	-0.1	-7.5	8.2	-0.4
Doctors Creek at Allentown, NJ	01464515	13.1	-12.1	0.3	-8.8	8.1	-0.6
Delaware River at Trenton, NJ	01463500	7.5	-2.2	-0.1	-7.0	2.0	-0.3

The percentage of agriculture and urban land in the watersheds ranged from < 0.5% to 72.9% and 3.8% to 80.5%, respectively, in 2011 (Fig. 15). Altered land which includes the combined total of agriculture and urban areas in a watershed ranged from 6.2% to 81.6%.

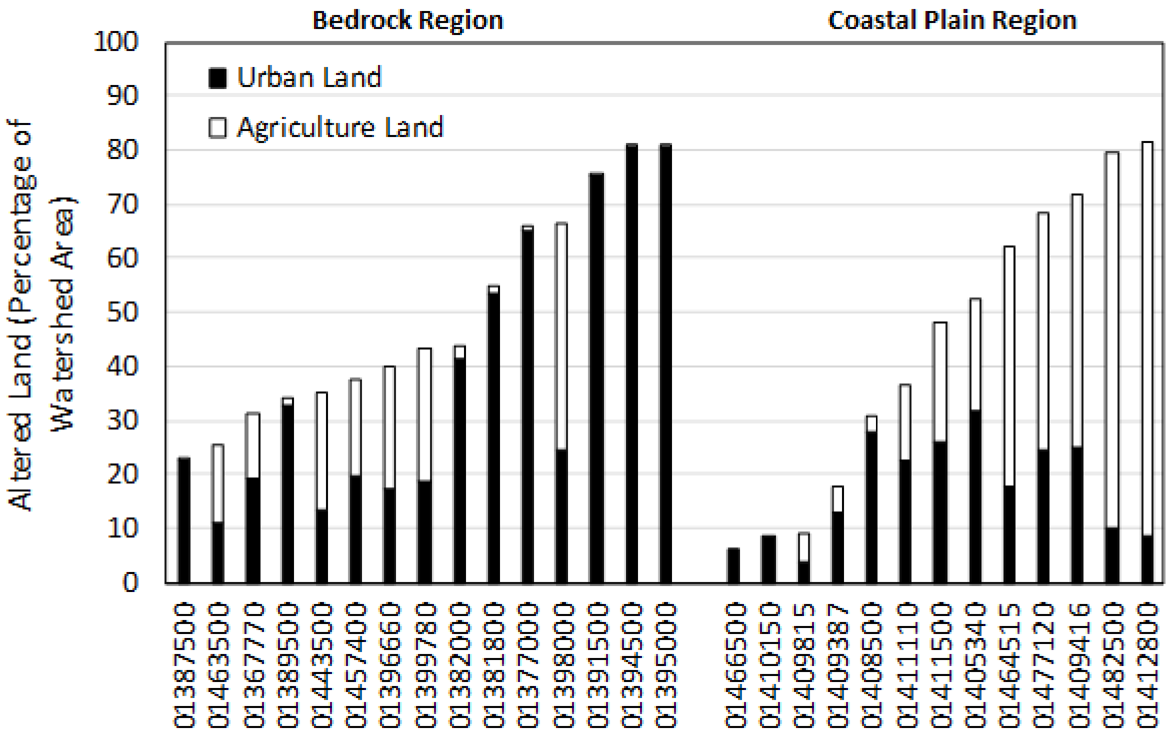

Fig. 15. Altered Land in each Watershed. For water quality station, the percentage of altered land (urban and agriculture combined) was determined in the watershed. Water quality station numbers are depicted on the *x*-axis in order of low to high percentage of altered land in the watershed. See Table 1 for station names.

Significant relationships between altered land and nutrients were identified across the gradient of all 28 sites (Table 9). This pattern was seemingly driven by the strong correlations across the gradient of the 13 sites in the coastal plain where Spearman correlation coefficients exceeded 0.85 for all three nutrient parameters (Fig. 16). The 15 sites in the bedrock region showed no significant relationship between land use and either of the nutrients when evaluated alone. Similar patterns were present for the multi-metric nutrient evaluation where a state-wide relationship existed but was driven by the high correlations in the coastal plain region (Table 10; Fig. 17).

Table 9. Spearman Rank Correlation Summary: Nutrients. Spearman rank correlations were performed for each parameter (nitrate plus nitrite, total nitrogen, and total phosphorous) compared to altered land (urban plus agriculture) for all sites, sites in the bedrock region, and sites in the coastal plain region.

Site	Water Quality Parameter	***n***	**Spearman *r***	***p*-value**
All	Nitrate plus nitrite	28	0.576	0.0013
	Total Nitrogen	28	0.642	0.0002
	Total Phosphorus	28	0.583	0.0011
Bedrock Region	Nitrate plus nitrite	15	0.107	0.7039
	Total Nitrogen	15	0.177	0.5281
	Total Phosphorus	15	0.239	0.3904
Coastal Plain Region	Nitrate plus nitrite	13	0.922	< 0.0001
	Total Nitrogen	13	0.938	< 0.0001
	Total Phosphorus	13	0.852	0.0002

Table 10. Spearman Rank Correlation Summary: Multimetric Rank of each Site. Spearman rank correlations were performed on the multimetric rank of each site compared to altered land (urban plus agriculture) for all sites, sites in the bedrock region, and sites in the coastal plain region.

Sites	***n***	**Spearman *r***	***p*-value**
All	28	0.651	0.0002
Bedrock Region	15	0.204	0.4668
Coastal Plain Region	13	0.962	< 0.0001

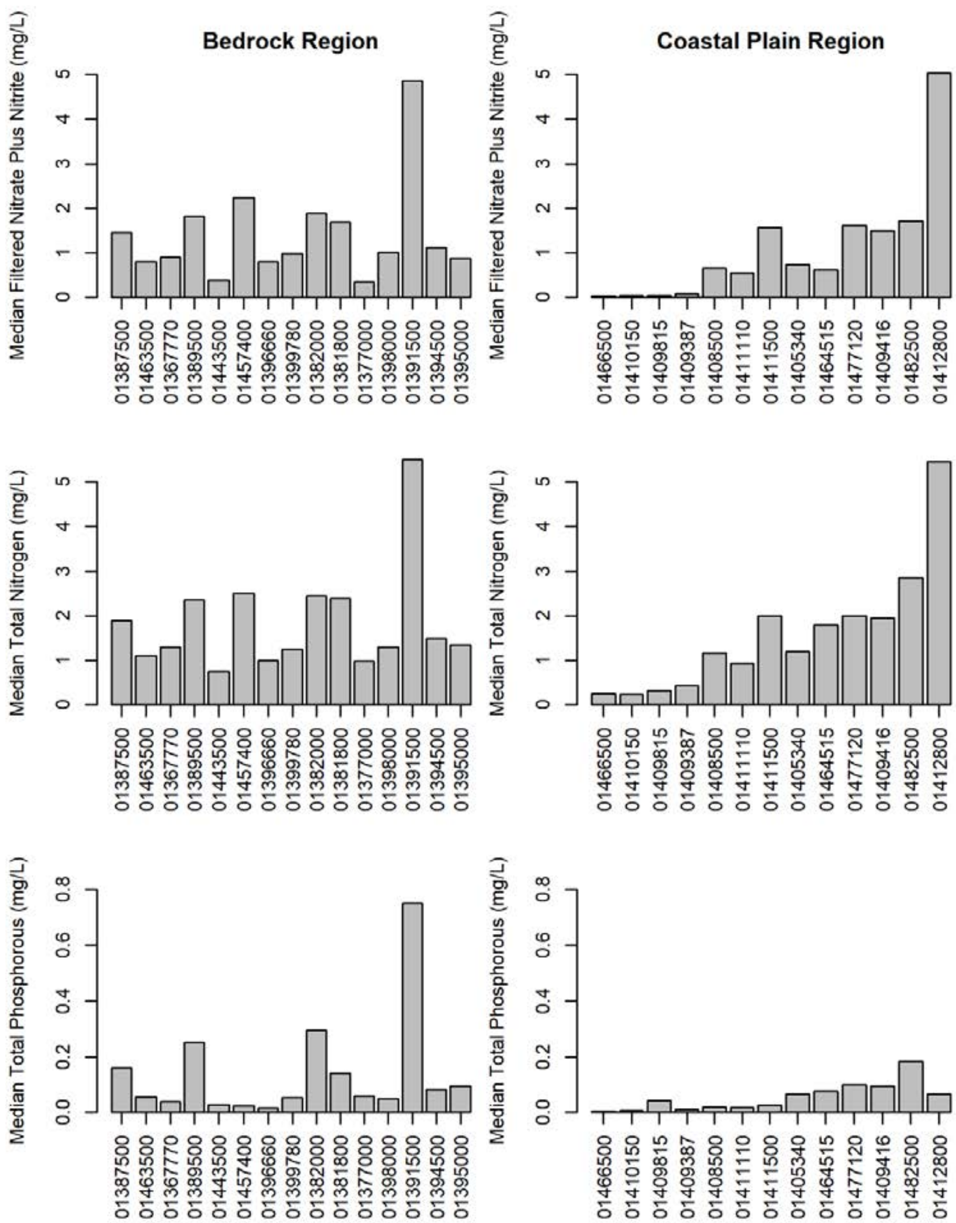

Fig. 16. Water Quality Parameters and Altered Land. The three water quality parameters (nitrate plus nitrite, total nitrogen, and total phosphorous) were compared to the percentage of altered land in each watershed with Spearman rank correlations (Table 9). Significant relationships were found between nutrients and increased altered land (*p*-values < 0.0002) in the Coastal Plain Region (right hand plots). Water quality station IDs are displayed on *x*-axis, and the stations are listed in the order of increasing percentage of altered land. See Table 1 for station names.

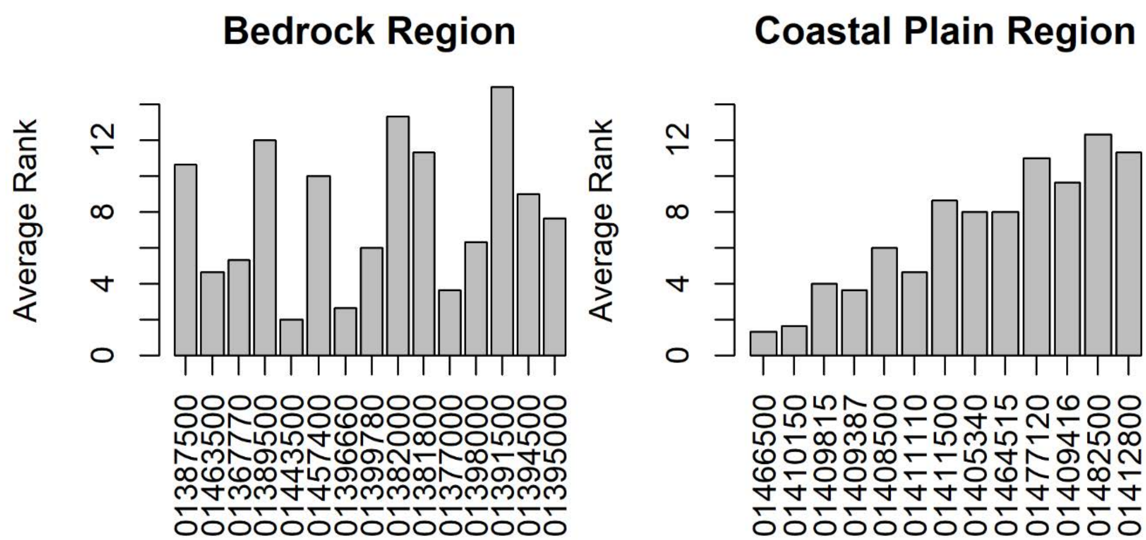

Fig. 17. Multi-Metric Rank and Altered Land. In the coastal plain region, the multi-metric rank of each water quality station increased as the percentage of altered land increased (Spearman rank correlations; *p*-values < 0.0001). Water quality stations are listed along the *x*-axis from low percentage of altered land to high percentage of altered land. See Table 1 for station names.

Discussion

Previously, nutrient trends in New Jersey streams were assessed from 1980-2011 using the WRTDS approach (Hickman and Hirsch 2017) and were analyzed from 1975 to 2003 using coupled water quality and streamflow statistical models (Trench et al. 2012). The results of the WRTDS models for concentrations and fluxes of nutrients over water years 1980 to 2016 often, but not always, agreed with previous studies (Table 11). For example, results for nitrate plus nitrite concentration agreed at seven of the nine stations assessed by all three reports.

Table 11. Results from Weighted Regressions on Time, Discharge, and Season (WRTDS) Models Compared to Previous Studies. Most results agreed with previous studies (Trench et al. 2012, Hickman and Hirsch 2017). Table on next three pages.

Nutrient	Station ID	Station Name	Concentrations: DSR 2019 — Trends in flow-normalized annual concentrations over water years 1980-2016	Concentrations: Hickman and Hirsch 2017 — Trends in flow-normalized annual concentrations over water years 1980-2011	Concentrations: Trench *et al.* 2012 — Trends in flow-adjusted concentrations over water years 1975-2003	Fluxes: DSR 2019 — Trends in flow-normalized fluxes over water years 1980-2016	Fluxes: Hickman and Hirsch 2017 — Trends in flow-normalized fluxes over water years 1980-2011	Fluxes: Trench *et al.* 2012 — Trends in fluxes over water years 1975-2003
NO23	01367770	Wallkill River near Sussex, NJ	nd	nd	nd	nd	nd	nd
	01377000	Hackensack River at Rivervale, NJ	Downward	Downward	Downward	Downward	Downward	Downward
	01381800	Whippany River near Pine Brook, NJ	nd	nd	nd	nd	nd	nd
	01382000	Passaic River at Two Bridges, NJ	nd	nd	nd	nd	nd	nd
	01387500	Ramapo River near Mahwah, NJ	Upward	Upward	Upward	Upward	Upward	Upward
	01389500	Passaic River at Little Falls, NJ	Upward	Upward	Upward	--	--	Upward
	01391500	Saddle River at Lodi, NJ	Upward	Upward	Upward	Upward	Upward	Upward
	01395000	Rahway River at Rahway, NJ	--	--	nd	--	--	nd
	01396660	Mulhockaway Creek at Van Syckel, NJ	--	Downward	nd	--	--	nd
	01398000	Neshanic River at Reaville, NJ	Downward	Downward	nd	Downward	Downward	nd
	01399780	Lamington River at Burnt Mills, NJ	Upward	--	nd	nd	nd	nd
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	--	nd	nd	nd	nd
	01408500	Toms River near Toms River, NJ	Upward	Upward	Upward	Upward	Upward	Upward
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	--	--	nd	nd	nd	nd
	01409815	West Branch Wading River at Maxwell, NJ	nd	nd	nd	nd	nd	nd
	01411110	Great Egg Harbor River at Weymouth, NJ	Upward	--	nd	nd	nd	nd
	01411500	Maurice River at Norma, NJ	Upward	--	--	Upward	--	--
	01412800	Cohansey River at Seeley, NJ	nd	nd	nd	nd	nd	nd
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	--	Downward	Downward	--
	01457400	Musconetcong River at Riegelsville, NJ	Upward	Upward	nd	Upward	Upward	nd
	01463500	Delaware River at Trenton, NJ	Downward	Downward	Downward	Downward	Downward	--

Nutrient	Station ID	Station Name	Concentrations			Fluxes		
			DSR 2019	Hickman and Hirsch 2017	Trench *et al.* 2012	DSR 2019	Hickman and Hirsch 2017	Trench *et al.* 2012
			Trends in flow-normalized annual concentrations over water years 1980-2016	Trends in flow-normalized annual concentrations over water years 1980-2011	Trends in flow-adjusted concentrations over water years 1975-2003	Trends in flow-normalized fluxes over water years 1980-2016	Trends in flow-normalized fluxes over water years 1980-2011	Trends in fluxes over water years 1975-2003
	01464515	Doctors Creek at Allentown, NJ	nd	nd	nd	nd	nd	nd
	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	nd	nd	nd	nd	nd
	01477120	Raccoon Creek near Swedesboro, NJ	--	--	--	--	--	Downward
	01394500	Rahway River near Springfield, NJ	--	nd	nd	--	nd	nd
	01409416	Hammonton Creek at Wescoatville, NJ	--	nd	nd	nd	nd	nd
	01410150	East Branch Bass River near New Gretna, NJ	nd	nd	nd	nd	nd	nd
	01482500	Salem River at Woodstown, NJ	nd	nd	nd	nd	nd	nd
TN	01367770	Wallkill River near Sussex, NJ	nd	nd	nd	nd	nd	nd
	01377000	Hackensack River at Rivervale, NJ	Downward	--	Downward	Downward	--	Downward
	01381800	Whippany River near Pine Brook, NJ	nd	nd	nd	nd	nd	nd
	01382000	Passaic River at Two Bridges, NJ	nd	nd	nd	nd	nd	nd
	01387500	Ramapo River near Mahwah, NJ	--	--	--	--	--	--
	01389500	Passaic River at Little Falls, NJ	Downward	Downward	Downward	Downward	Downward	Downward
	01391500	Saddle River at Lodi, NJ	--	--	Upward	--	--	--
	01395000	Rahway River at Rahway, NJ	Downward	--	nd	Downward	--	nd
	01396660	Mulhockaway Creek at Van Syckel, NJ	Downward	Downward	nd	Downward	Downward	nd
	01398000	Neshanic River at Reaville, NJ	Downward	Downward	nd	Downward	Downward	nd
	01399780	Lamington River at Burnt Mills, NJ	--	--	nd	nd	nd	nd
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	Downward	--	nd	nd	nd	nd
	01408500	Toms River near Toms River, NJ	Upward	Upward	Upward	Upward	Upward	Upward
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	Downward	Downward	nd	nd	nd	nd
	01409815	West Branch Wading River at Maxwell, NJ	nd	nd	nd	nd	nd	nd
	01411110	Great Egg Harbor River at Weymouth, NJ	--	--	nd	nd	nd	nd
	01411500	Maurice River at Norma, NJ	--	--	--	--	--	--

Nutrient	Station ID	Station Name	Concentrations			Fluxes		
			DSR 2019	Hickman and Hirsch 2017	Trench *et al.* 2012	DSR 2019	Hickman and Hirsch 2017	Trench *et al.* 2012
			Trends in flow-normalized annual concentrations over water years 1980-2016	Trends in flow-normalized annual concentrations over water years 1980-2011	Trends in flow-adjusted concentrations over water years 1975-2003	Trends in flow-normalized fluxes over water years 1980-2016	Trends in flow-normalized fluxes over water years 1980-2011	Trends in fluxes over water years 1975-2003
	01412800	Cohansey River at Seeley, NJ	nd	nd	nd	nd	nd	nd
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	Downward	Downward	Downward	--
	01457400	Musconetcong River at Riegelsville, NJ	--	--	nd	--	--	nd
	01463500	Delaware River at Trenton, NJ	Downward	Downward	Downward	Downward	Downward	Downward
	01464515	Doctors Creek at Allentown, NJ	nd	nd	nd	nd	nd	nd
	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	nd	nd	nd	nd	nd
	01477120	Raccoon Creek near Swedesboro, NJ	--	--	--	--	--	--
	01394500	Rahway River near Springfield, NJ	Downward	nd	nd	Downward	nd	nd
	01409416	Hammonton Creek at Wescoatville, NJ	Downward	nd	nd	nd	nd	nd
	01410150	East Branch Bass River near New Gretna, NJ	nd	nd	nd	nd	nd	nd
	01482500	Salem River at Woodstown, NJ	--	nd	nd	nd	nd	nd
TP	01367770	Wallkill River near Sussex, NJ	nd	nd	nd	nd	nd	nd
	01377000	Hackensack River at Rivervale, NJ	--	--	--	--	--	--
	01381800	Whippany River near Pine Brook, NJ	nd	nd	nd	nd	nd	nd
	01382000	Passaic River at Two Bridges, NJ	nd	nd	nd	nd	nd	nd
	01387500	Ramapo River near Mahwah, NJ	--	--	--	Upward	--	--
	01389500	Passaic River at Little Falls, NJ	Downward	Downward	Downward	Downward	Downward	Downward
	01391500	Saddle River at Lodi, NJ	Downward	--	--	Downward	--	--
	01395000	Rahway River at Rahway, NJ	--	--	nd	--	--	nd
	01396660	Mulhockaway Creek at Van Syckel, NJ	nd	nd	nd	nd	nd	nd
	01398000	Neshanic River at Reaville, NJ	--	--	nd	--	--	nd
	01399780	Lamington River at Burnt Mills, NJ	Downward	--	nd	nd	nd	nd
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	--	nd	nd	nd	nd
	01408500	Toms River near Toms River, NJ	Downward	Downward	Downward	--	Downward	Downward

Nutrient	Station ID	Station Name	Concentrations: DSR 2019 — Trends in flow-normalized annual concentrations over water years 1980-2016	Concentrations: Hickman and Hirsch 2017 — Trends in flow-normalized annual concentrations over water years 1980-2011	Concentrations: Trench *et al.* 2012 — Trends in flow-adjusted concentrations over water years 1975-2003	Fluxes: DSR 2019 — Trends in flow-normalized fluxes over water years 1980-2016	Fluxes: Hickman and Hirsch 2017 — Trends in flow-normalized fluxes over water years 1980-2011	Fluxes: Trench *et al.* 2012 — Trends in fluxes over water years 1975-2003
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	--	Downward	nd	nd	nd	nd
	01409815	West Branch Wading River at Maxwell, NJ	Upward	Upward	nd	nd	nd	nd
	01411110	Great Egg Harbor River at Weymouth, NJ	Downward	Downward	nd	nd	nd	nd
	01411500	Maurice River at Norma, NJ	Downward	Downward	Downward	--	Downward	Downward
	01412800	Cohansey River at Seeley, NJ	nd	nd	nd	nd	nd	nd
	01443500	Paulins Kill at Blairstown, NJ	Downward	--	Downward	Downward	--	Downward
	01457400	Musconetcong River at Riegelsville, NJ	Downward	--	nd	--	--	nd
	01463500	Delaware River at Trenton, NJ	Downward	Downward	Downward	--	--	Downward
	01464515	Doctors Creek at Allentown, NJ	nd	nd	nd	nd	nd	nd
	01466500	McDonalds Branch in Byrne State Forest, NJ	nd	nd	nd	nd	nd	nd
	01477120	Raccoon Creek near Swedesboro, NJ	--	nd	Upward	--	nd	--
	01394500	Rahway River near Springfield, NJ	--	nd	nd	--	nd	nd
	01409416	Hammonton Creek at Wescoatville, NJ	Downward	nd	nd	nd	nd	nd
	01410150	East Branch Bass River near New Gretna, NJ	nd	nd	nd	nd	nd	nd
	01482500	Salem River at Woodstown, NJ	--	nd	nd	nd	nd	nd

The SK test results for water years 1980-2016 were compared to previous studies (Table 12) that utilized Tobit Regression (TR) or SK tests to assess nutrient concentrations in NJ streams over various time frames, including 1998-2007 (Hickman and Gray 2010), 1986-1995 (Hickman and Barringer 1999), and 1976-1986 (Hay and Campbell 1990). Over the longer time frame (1980-2016) evaluated in this study, more stations were found to have downward trends in nutrient concentrations than when stations were evaluated previously over shorter time frames. Since the SK and TR tests only look for monotonic trends over the whole study period, the variation in trend results are likely due to differences between the assessed time periods.

Table 12. Results from Seasonal Kendall (SK) Trend Tests Compared to Previous Studies. The SK test results commonly did not align with results from previous studies (Hay and Campbell 1990, Hickman and Barringer 1999, Hickman and Gray 2010). Tobit Regression (TR) and SK tests assess monotonic trends, thus the differences between results likely depend on the different time periods studied. Table continued on next three pages.

			DSR	Hickman and Gray 2010	Hickman and Barringer 1999	Hay and Campbell 1990
Nutrient	**Station ID**	**Station Name**	**SK 1980-2016**	**TR 1998-2007**	**SK or TR 1986-1995**	**SK 1976-1986**
NO23	01367770	Wallkill River near Sussex, NJ	Upward	Downward	--	--
	01377000	Hackensack River at Rivervale, NJ	--	--	--	--
	01381800	Whippany River near Pine Brook, NJ	--	--	Upward	--
	01382000	Passaic River at Two Bridges, NJ	Upward	--	Upward	--
	01387500	Ramapo River near Mahwah, NJ	--	--	--	--
	01389500	Passaic River at Little Falls, NJ	Upward	--	Upward	nd
	01391500	Saddle River at Lodi, NJ	Upward	Upward	Upward	--
	01394500	Rahway River near Springfield, NJ	--	--	--	nd
	01395000	Rahway River at Rahway, NJ	--	--	--	nd
	01396660	Mulhockaway Creek at Van Syckel, NJ	Downward	Upward	--	--
	01398000	Neshanic River at Reaville, NJ	--	--	--	nd
	01399780	Lamington River at Burnt Mills, NJ	--	--	--	--
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	Upward	--	--
	01408500	Toms River near Toms River, NJ	Upward	Upward	Upward	--
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	Downward	--	--	--
	01409416	Hammonton Creek at Wescoatville, NJ	--	Upward	Upward	--
	01409815	West Branch Wading River at Maxwell, NJ	Downward	nd	nd	--
	01410150	East Branch Bass River near New Gretna, NJ	Downward	nd	--	--
	01411110	Great Egg Harbor River at Weymouth, NJ	--	Upward	--	--
	01411500	Maurice River at Norma, NJ	--	Upward	Upward	--
	01412800	Cohansey River at Seeley, NJ	Upward	Upward	Upward	--
	01443500	Paulins Kill at Blairstown, NJ	Downward	--	Downward	--

			DSR	Hickman and Gray 2010	Hickman and Barringer 1999	Hay and Campbell 1990
Nutrient	**Station ID**	**Station Name**	**SK 1980-2016**	**TR 1998-2007**	**SK or TR 1986-1995**	**SK 1976-1986**
	01457400	Musconetcong River at Riegelsville, NJ	Upward	Upward	Upward	--
	01463500	Delaware River at Trenton, NJ	Downward	--	--	--
	01464515	Doctors Creek at Allentown, NJ	Downward	--	--	--
	01466500	McDonalds Branch in Byrne State Forest, NJ	Downward	nd	nd	--
	01477120	Raccoon Creek near Swedesboro, NJ	--	--	--	nd
	01482500	Salem River at Woodstown, NJ	--	--	--	--
TN	01367770	Wallkill River near Sussex, NJ	Upward	--	--	--
	01377000	Hackensack River at Rivervale, NJ	--	--	Downward	--
	01381800	Whippany River near Pine Brook, NJ	Downward	--	Downward	--
	01382000	Passaic River at Two Bridges, NJ	Downward	--	--	--
	01387500	Ramapo River near Mahwah, NJ	--	--	--	--
	01389500	Passaic River at Little Falls, NJ	Downward	Downward	--	nd
	01391500	Saddle River at Lodi, NJ	--	Downward	--	--
	01394500	Rahway River near Springfield, NJ	Downward	--	Downward	nd
	01395000	Rahway River at Rahway, NJ	--	--	Downward	nd
	01396660	Mulhockaway Creek at Van Syckel, NJ	--	--	Downward	--
	01398000	Neshanic River at Reaville, NJ	--	--	--	nd
	01399780	Lamington River at Burnt Mills, NJ	Downward	--	Downward	--
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	Downward	--	Downward	--
	01408500	Toms River near Toms River, NJ	Upward	--	--	Upward
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	Downward	--	Downward	--
	01409416	Hammonton Creek at Wescoatville, NJ	Downward	--	Downward	--
	01409815	West Branch Wading River at Maxwell, NJ	Downward	--	nd	Downward
	01410150	East Branch Bass River near New Gretna, NJ	Downward	--	Downward	--
	01411110	Great Egg Harbor River at Weymouth, NJ	Downward	Upward	Downward	Upward
	01411500	Maurice River at Norma, NJ	--	Upward	--	--
	01412800	Cohansey River at Seeley, NJ	Upward	--	--	Downward
	01443500	Paulins Kill at Blairstown, NJ	Downward	Downward	Downward	--

			DSR	Hickman and Gray 2010	Hickman and Barringer 1999	Hay and Campbell 1990
Nutrient	Station ID	Station Name	SK 1980-2016	TR 1998-2007	SK or TR 1986-1995	SK 1976-1986
	01457400	Musconetcong River at Riegelsville, NJ	--	Downward	--	--
	01463500	Delaware River at Trenton, NJ	Downward	--	Downward	--
	01464515	Doctors Creek at Allentown, NJ	--	--	Downward	--
	01466500	McDonalds Branch in Byrne State Forest, NJ	Downward	--	nd	--
	01477120	Raccoon Creek near Swedesboro, NJ	--	--	Downward	nd
	01482500	Salem River at Woodstown, NJ	--	--	--	--
TP	01367770	Wallkill River near Sussex, NJ	--	--	--	--
	01377000	Hackensack River at Rivervale, NJ	--	--	--	--
	01381800	Whippany River near Pine Brook, NJ	Downward	Downward	Downward	--
	01382000	Passaic River at Two Bridges, NJ	Downward	Downward	--	--
	01387500	Ramapo River near Mahwah, NJ	--	--	--	--
	01389500	Passaic River at Little Falls, NJ	Downward	--	Upward	nd
	01391500	Saddle River at Lodi, NJ	Downward	--	Downward	--
	01394500	Rahway River near Springfield, NJ	--	--	--	nd
	01395000	Rahway River at Rahway, NJ	--	--	--	nd
	01396660	Mulhockaway Creek at Van Syckel, NJ	Downward	--	Downward	Upward
	01398000	Neshanic River at Reaville, NJ	--	--	--	nd
	01399780	Lamington River at Burnt Mills, NJ	Downward	--	--	--
	01405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	--	--	--
	01408500	Toms River near Toms River, NJ	Downward	Downward	--	--
	01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	Downward	--	Downward	--
	01409416	Hammonton Creek at Wescoatville, NJ	Downward	--	Downward	--
	01409815	West Branch Wading River at Maxwell, NJ	Upward	Upward	nd	--
	01410150	East Branch Bass River near New Gretna, NJ	Downward	--	Downward	--
	01411110	Great Egg Harbor River at Weymouth, NJ	Downward	--	Downward	--
	01411500	Maurice River at Norma, NJ	--	--	--	Downward
	01412800	Cohansey River at Seeley, NJ	--	--	Downward	--
	01443500	Paulins Kill at Blairstown, NJ	Downward	--	Downward	--

			DSR	Hickman and Gray 2010	Hickman and Barringer 1999	Hay and Campbell 1990
Nutrient	**Station ID**	**Station Name**	**SK 1980-2016**	**TR 1998-2007**	**SK or TR 1986-1995**	**SK 1976-1986**
	01457400	Musconetcong River at Riegelsville, NJ	Downward	Downward	Downward	--
	01463500	Delaware River at Trenton, NJ	Downward	Downward	--	--
	01464515	Doctors Creek at Allentown, NJ	Downward	--	Downward	--
	01466500	McDonalds Branch in Byrne State Forest, NJ	Downward	nd	nd	--
	01477120	Raccoon Creek near Swedesboro, NJ	Downward	--	--	nd
	01482500	Salem River at Woodstown, NJ	--	--	--	Upward

In many cases, the trends for each nutrient were similar regardless of whether the data were analyzed with the WRTDS models or the SK tests (Table 5). The results from the SK tests and the WRTDS models agreed 42 to 60% of the time depending on water quality parameter and time frame (Fig. 18). Thus, the SK trend test was an appropriate tool for assessing trends in nutrient concentration when data requirements were not met for the WRTDS approach. However, when the data requirements are met, the WRTDS model should be utilized because it also accounts for discharge, which is a critical driver of in-stream water quality conditions. Moreover, the WRTDS method is superior to the SK approach because it does not assume a monotonic change in concentrations over time and it allows for the determination of trends in fluxes.

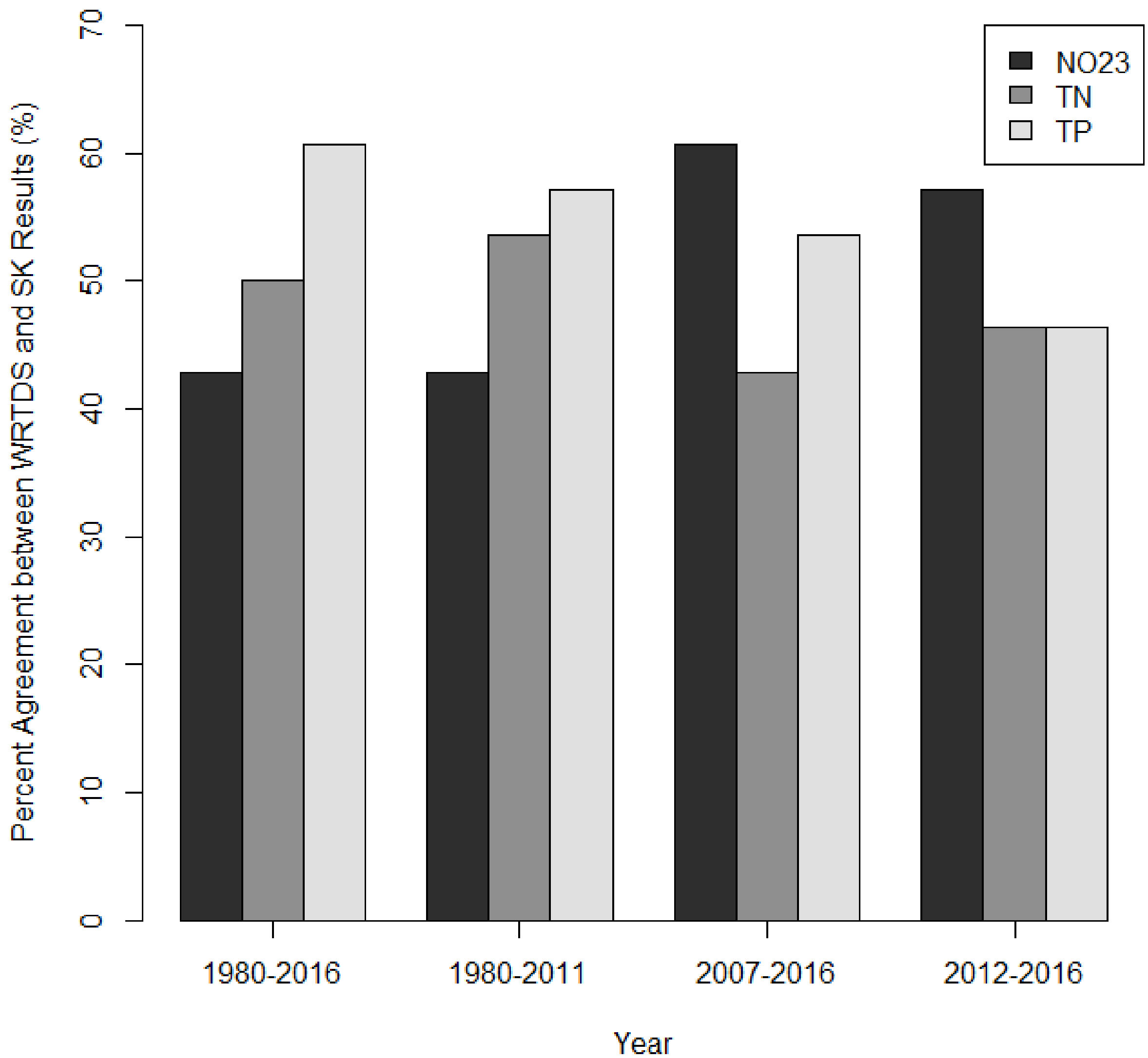

Fig. 18. Percent Agreement between Weighted Regressions on Time, Discharge, and Season (WRTDS) and Seasonal Kendall (SK) Results. The trend results (upward, downward, no trend) from the SK tests and the WRTDS models agreed 42 to 60% of the time depending on water parameter (nitrate plus nitrite, NO23; total nitrogen, TN; or total phosphorous, TP) and time frame.

From 1980 to 2016, total nitrogen concentrations increased at three locations (Wallkill River near Sussex, 01367770; Cohansey River at Seeley, 01412800; Toms River near Toms River, 01408500) and total phosphorous increased at one location (West Branch Wading River at Maxwell, 01409815). These same trends were found from 1980 to 2011, with the exception of total nitrogen at the Wallkill River site which exhibited no trend in the previous report (Hickman and Hirsch 2017). Although the SK test confirmed a statistical significance in increasing total nitrogen at the Wallkill River site, the trend does not appear to be ecologically significant as annual values never exceeded the NJ surface water quality standard on 10 mg/l for nitrate plus nitrite, a major component to total nitrogen (Fig. 13). The same holds true at the Cohansey River site: the trend appears to have increased until around 2007 at which point it decreased (Fig. 14). Both sites had low tau-statistic values (Appendix 3): the value of the tau-statistic for the Wallkill River station was 0.116 and for the Cohansey River station was 0.207. While statistically significant, these low values indicate minimal relation between time and concentration. Furthermore, the SK test only assessed monotonic trend, and thus may have overgeneralized the trend at the Wallkill and Cohansey stations.

In regards to nitrate plus nitrite, the concentration increased over time from 1980 to 2016 at two sites where previously no trend was found (Hickman and Hirsch 2017): Maurice River at Norma (01411500; pg. 164 of Supplemental Figures) and Great Egg Harbor River at Weymouth (01411110; pg. 176 of Supplemental Figures). At both of these stations, recent high concentration measurements likely contributed to this significant trend. In addition, nitrate plus nitrite increased at eight stations in this study and the previous report (Hickman and Hirsch 2017). Moreover, when an increasing trend was determined for total nitrogen at a specific water quality station from 1980 to 2016, this trend was also found for nitrate plus nitrite which was expected because nitrate plus nitrite is most often the largest component of total nitrogen in aquatic systems (Dubrovsky et al. 2010).

During the most recent ten-year period (2007-2016), more stations exhibited increasing total nitrogen and total phosphorous concentrations than compared to the entire study period. In particular, two stations had increases in nitrate plus nitrite, five stations had increases in total nitrogen, and six stations had increases in total phosphorous (Table 5). Some stations, Toms River at Toms River for example, showed increasing nutrient trends since 1980 but when evaluated in the shorter term show no conclusive trends. Although this increase in the number of stations with increasing nutrients in the recent time frame appears concerning, caution should be taken when interpreting these results considering the smaller sample sizes utilized to run the trend analyses.

The New Jersey Surface Water Quality Standards, N.J.A.C. 7:9B, establish the applicable surface water quality standards as follows: the surface water quality criterion for nitrate-nitrogen is 2 mg/l in Pinelands (PL) waters and 10 mg/l for Nitrate (as N) in all other freshwater 2 (FW2) waters statewide. The surface water quality criteria for total phosphorous is 0.1 mg/l in non-tidal FW2 streams (Fig. 19) and 0.05 mg/l in FW2 lakes throughout the State, except for where site-specific criteria have been promulgated at See N.J.A.C. 7:9B-1.14(g). Between 2012 and 2016, the nitrate plus nitrite samples exceeded the standard for nitrate-nitrogen at two water quality stations: Saddle Ridge at Lodi (01391500; 1 exceedance at 10.2 mg/l) and Hammonton Creek at Wescoatville (01409416; 6 exceedances with the maximum at 2.66 mg/l; Table 13). Total phosphorus samples exceeded the standard at more stations (18) than nitrate-nitrogen (2) between 2012 and 2016. The highest total phosphorous exceedance (1.86 mg/l) was recorded at the Saddle Ridge at Lodi station (01391500). The general trend in phosphorus concentrations for all 28 sites reveals that there were seven stations where the loess line exceeded the surface water quality standard of 0.1 mg/L between 2011-2016 (Fig. 19).

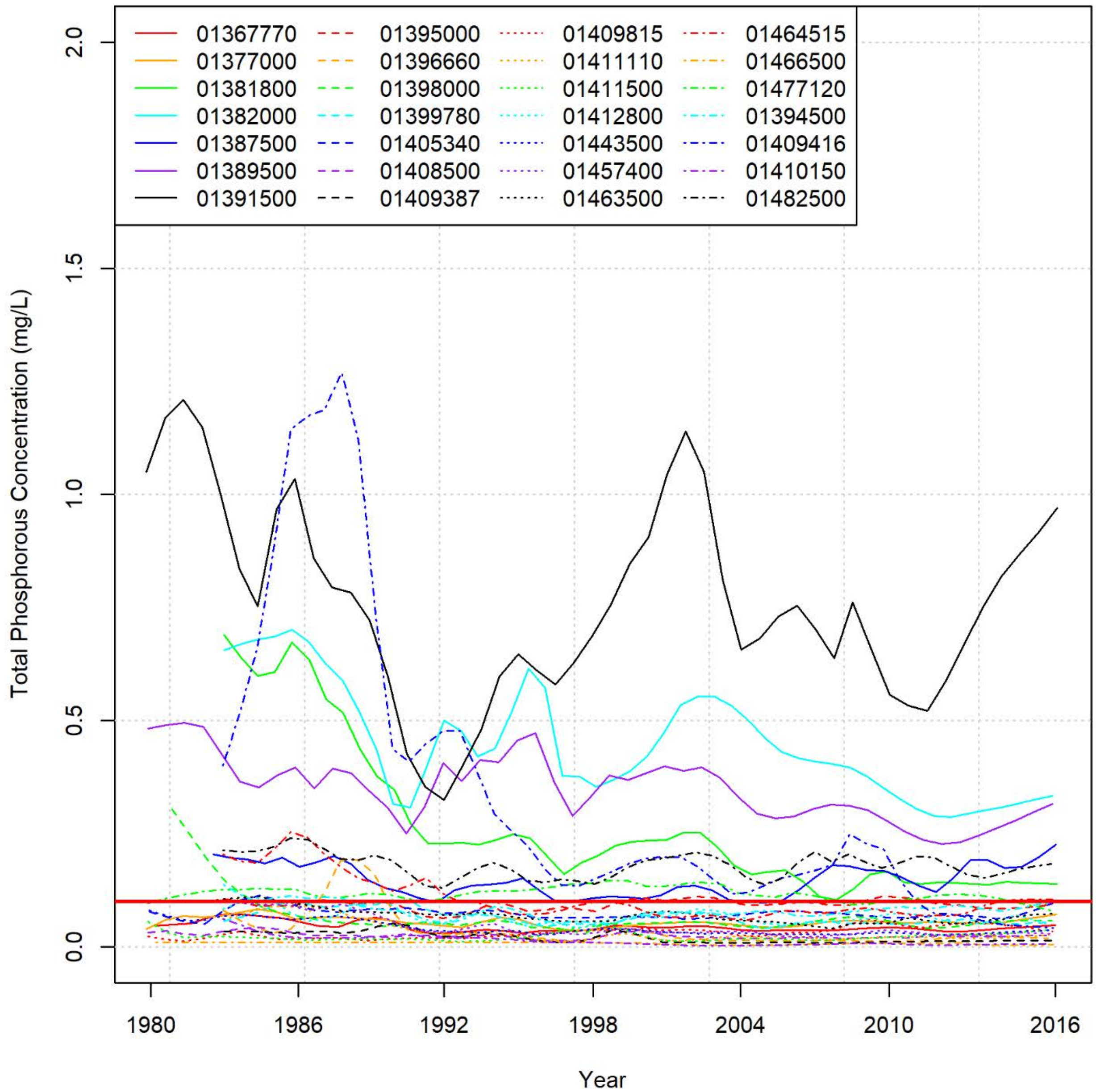

Fig. 19. Total Phosphorous Concentrations at New Jersey Water Quality Stations. After running the seasonal Kendall tests, locally weighted smoothing (Loess) lines were plotted with a 10% window for the total phosphorous concentrations at each of 28 water quality stations. From 2011-2016, there were seven stations where the loess line exceeded the surface water quality standard (SWQS) of 0.1 mg/l (displayed with horizontal red line). Note: The SWQS was amended in April 2019. Although a station exceeds the 0.1 mg/l standard, it may not exceed site-specific criteria developed based on total maximum daily loads (TMDLs).

Table 13. Potential Exceedances of NJ Surface Water Quality Standards. The NJ Surface Water Quality Standard (SWQS) for nitrate-nitrogen is 2 mg/l in the Pinelands and 10 mg/l in other locations. The freshwater (FW2) standard for total phosphorous is 0.1 mg/l; however, this SWQS was amended in April 2019 to recognize that the criterion does not apply to certain waterbodies. Thus, although the TP exceedances listed in this table exceed 0.1 mg/l, they may not exceed the site-specific criteria. Refer to N.J.A.C. 7:9B-1.14(g)3(B)i for locations where the total phosphorus criterion of 0.1 mg/l does not apply. The number of samples that potentially exceeded the standards and the maximum concentration of exceedances between 2012 and 2016 for each station are recorded here. A -- indicates there were no exceedances at the site.

Station ID	Station Name	NO23 Exceedances (#)	Max NO23 (mg/l)	TP Exceedances (#)	Max TP (mg/l)
1367770	Wallkill River near Sussex, NJ	--	--	1	0.12
1377000	Hackensack River at Rivervale, NJ	--	--	--	--
1381800	Whippany River near Pine Brook, NJ	--	--	17	0.25
1382000	Passaic River at Two Bridges, NJ	--	--	19	0.95
1387500	Ramapo River near Mahwah, NJ	--	--	15	0.52
1389500	Passaic River at Little Falls, NJ	--	--	17	0.75
1391500	Saddle River at Lodi, NJ	1	10.70	19	1.86
1394500	Rahway River near Springfield, NJ	--	--	8	0.13
1395000	Rahway River at Rahway, NJ	--	--	7	0.26
1396660	Mulhockaway Creek at Van Syckel, NJ	--	--	--	--
1398000	Neshanic River at Reaville, NJ	--	--	3	0.12
1399780	Lamington River at Burnt Mills, NJ	--	--	2	0.17
1405340	Manalapan Brook at Federal Road near Manalapan, NJ	--	--	6	0.28
1408500	Toms River near Toms River, NJ	--	--	--	--
1409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	--	--	--	--
1409416	Hammonton Creek at Wescoatville, NJ	6	2.66	2	0.12
1409815	West Branch Wading River at Maxwell, NJ	--	--	1	0.11
1410150	East Branch Bass River near New Gretna, NJ	--	--	--	--
1411110	Great Egg Harbor River at Weymouth, NJ	--	--	--	--
1411500	Maurice River at Norma, NJ	--	--	--	--
1412800	Cohansey River at Seeley, NJ	--	--	6	0.30
1443500	Paulins Kill at Blairstown, NJ	--	--	--	--
1457400	Musconetcong River at Riegelsville, NJ	--	--	--	--
1463500	Delaware River at Trenton, NJ	--	--	13	0.20
1464515	Doctors Creek at Allentown, NJ	--	--	6	0.24
1466500	McDonalds Branch in Byrne State Forest, NJ	--	--	--	--
1477120	Raccoon Creek near Swedesboro, NJ	--	--	11	0.26
1482500	Salem River at Woodstown, NJ	--	--	15	0.48

In general, increases in altered lands have been shown to lead to increased nutrients (Jordan et al. 1997, Rhodes et al. 2001, Zampella et al. 2007, Broussard and Turner 2009, Johnson et al. 2009, Clapcott et al. 2012, Stets et al. 2020). This was most evident in the coastal plain region where nutrient concentrations were shown to increase along the watershed disturbance gradient defined by increasing altered land. However, this trend was not found in the bedrock region. The disparity may in part be due to the high groundwater-surface water connectivity in the coastal plain which enables faster and more direct movement of nutrients from the land surface to nearby waterways. The well-drained sandy soils of the coastal plain allow for rapid movement of nutrients from the surface or shallow groundwater to more poorly drained riparian areas adjacent to streams (Jordan et al. 1997, Kauffman et al. 2001). The wetland areas retain the nutrients allowing for greater uptake and denitrification to occur. This process may explain the lower nitrogen concentrations among the least disturbed stations in the coastal plain compared to the least disturbed stations in the bedrock region. Groundwater flow patterns in the bedrock area are typically deeper with preferential flow along geologic fractures and thus may not be as favorable to passage and nutrient uptake through riparian areas. If lands are changed to urban or agriculture, the levels of nutrients will likely change accordingly (i.e., increase), and these changes should be considered by land use planners.

The inclusion of an additional five years of data onto an already long time-series does not appear to substantially change results presented in previous trend reports. However, when these parameters are evaluated over the past five- or ten-years, changes from the long-term relationship are apparent at some sites. As additional data becomes available over time, water quality trends can be assessed at additional stations and for additional parameters where insufficient data currently exists to conduct meaningful trend analyses. We recommend a re-evaluation of these analyses every five years. Water-quality track-down studies could be developed in watersheds with streams showing increasing nutrient levels to locate potential sources. Such analyses should include a focus on the relationship between nutrients and land use changes over time. The Great Egg Harbor River, due to ongoing increases in nitrogen concentrations, and the Wading River, due to increasing phosphorus concentrations, are two sites recommended for further study. Sites could be prioritized by the frequency of exceedance above the surface water quality standards (Table 13) for nitrate-nitrogen and phosphorus.

Conclusion

Although total nitrogen and total phosphorous decreased at the majority of water quality stations in NJ from 1980 to 2016, total nitrogen concentration increased at three stations and total phosphorous concentration increased at one station. The trend results for nitrate plus nitrite concentrations varied with some stations experiencing increasing trends while others experienced decreasing trends from 1980 to 2016. When land use was assessed, nutrient concentrations were positively correlated with increased altered land in the coastal plain region of NJ. The addition of five years of data to the previous analyses by Hickman and Hirsch (2017) did not substantially change the results when looking at the entire time frame (1980-2016). However, when looking at the shorter time frames (5- or 10-years), more water quality stations experienced significant increasing trends in total phosphorous concentration than in nitrate plus nitrite or total nitrogen concentration. This increase in total phosphorous concentration over the recent years may be of interest when examining the aquatic health of streams and in particular, factors leading to the development and continuance of harmful algal blooms.

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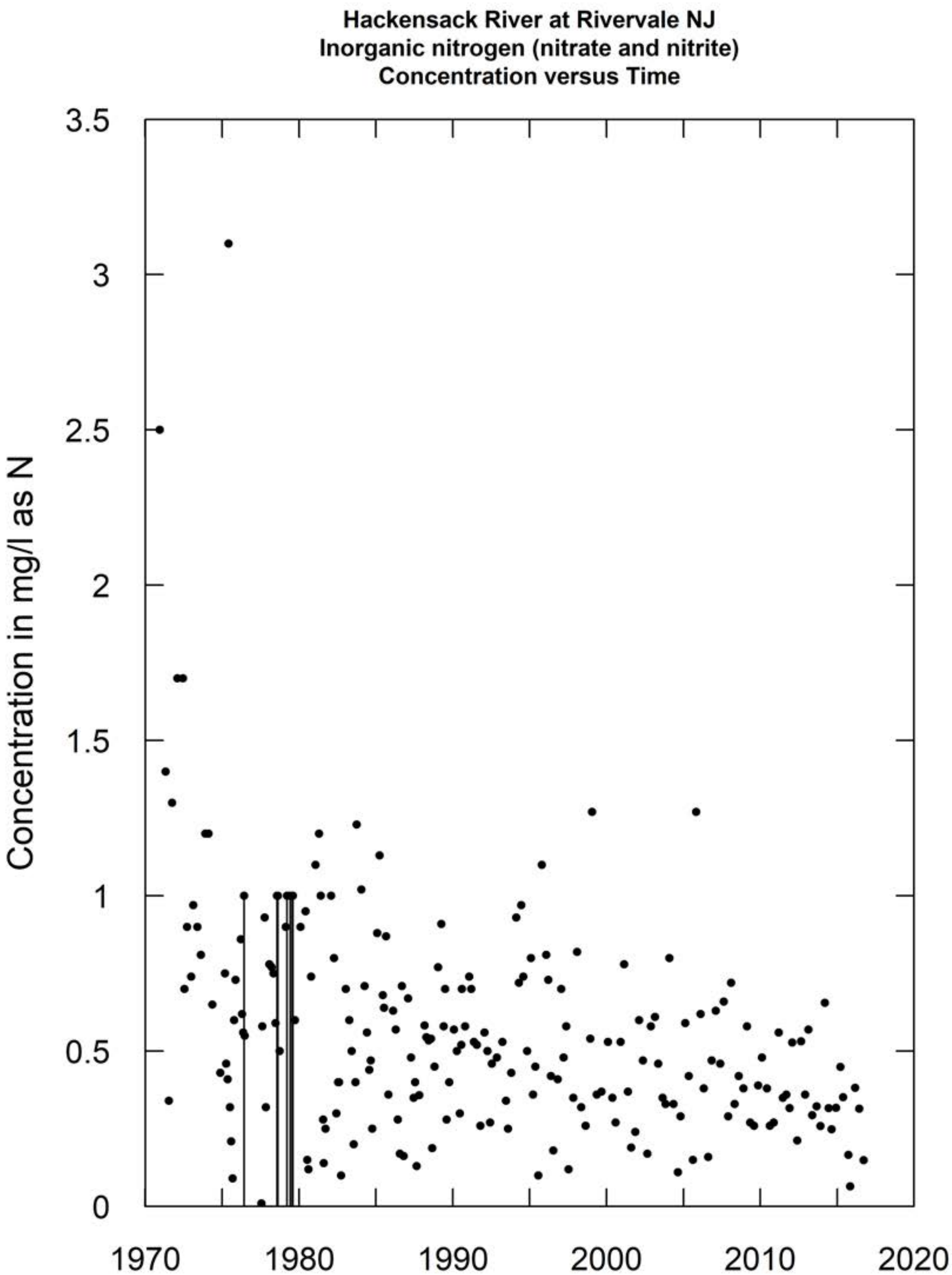
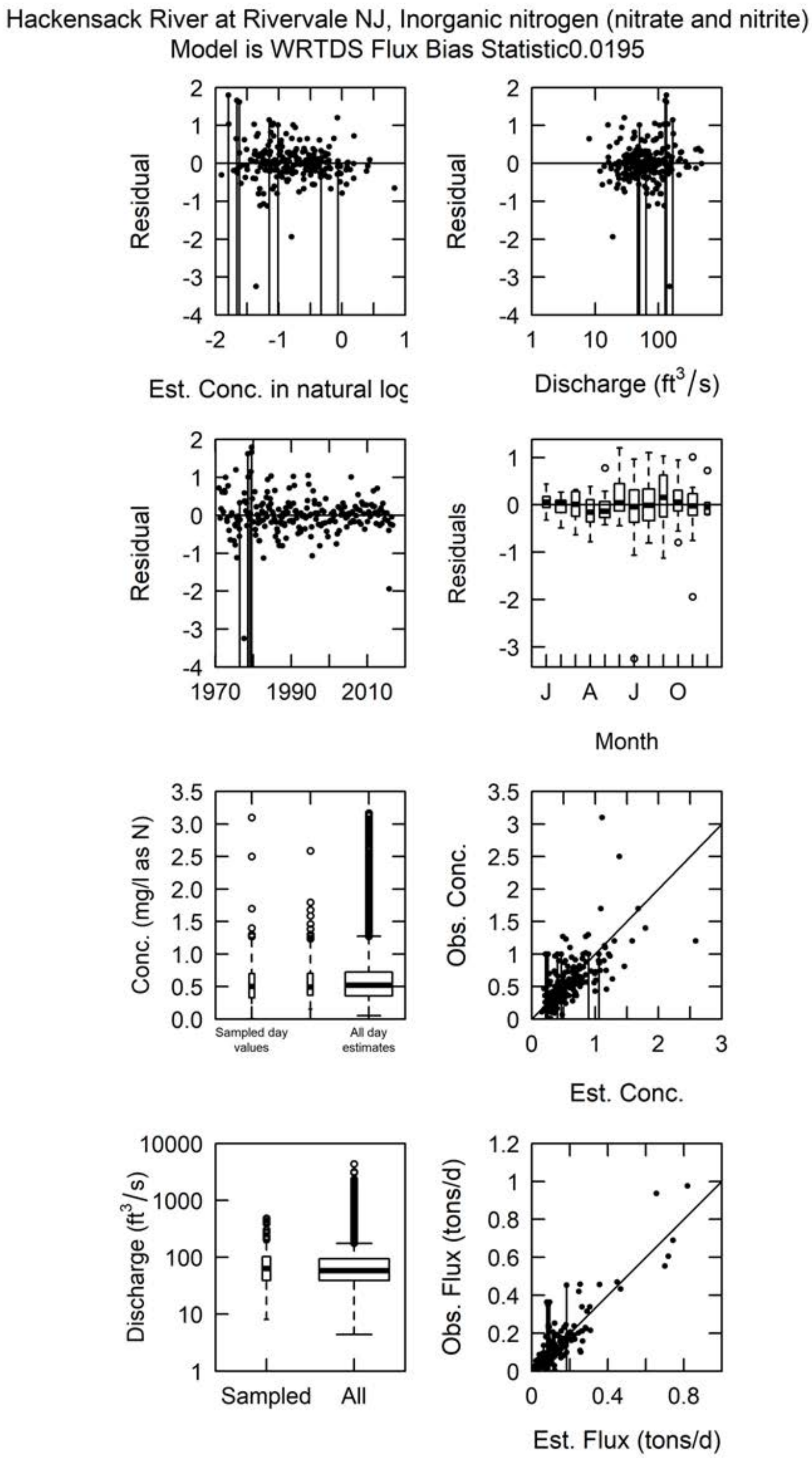
Supplemental Figures

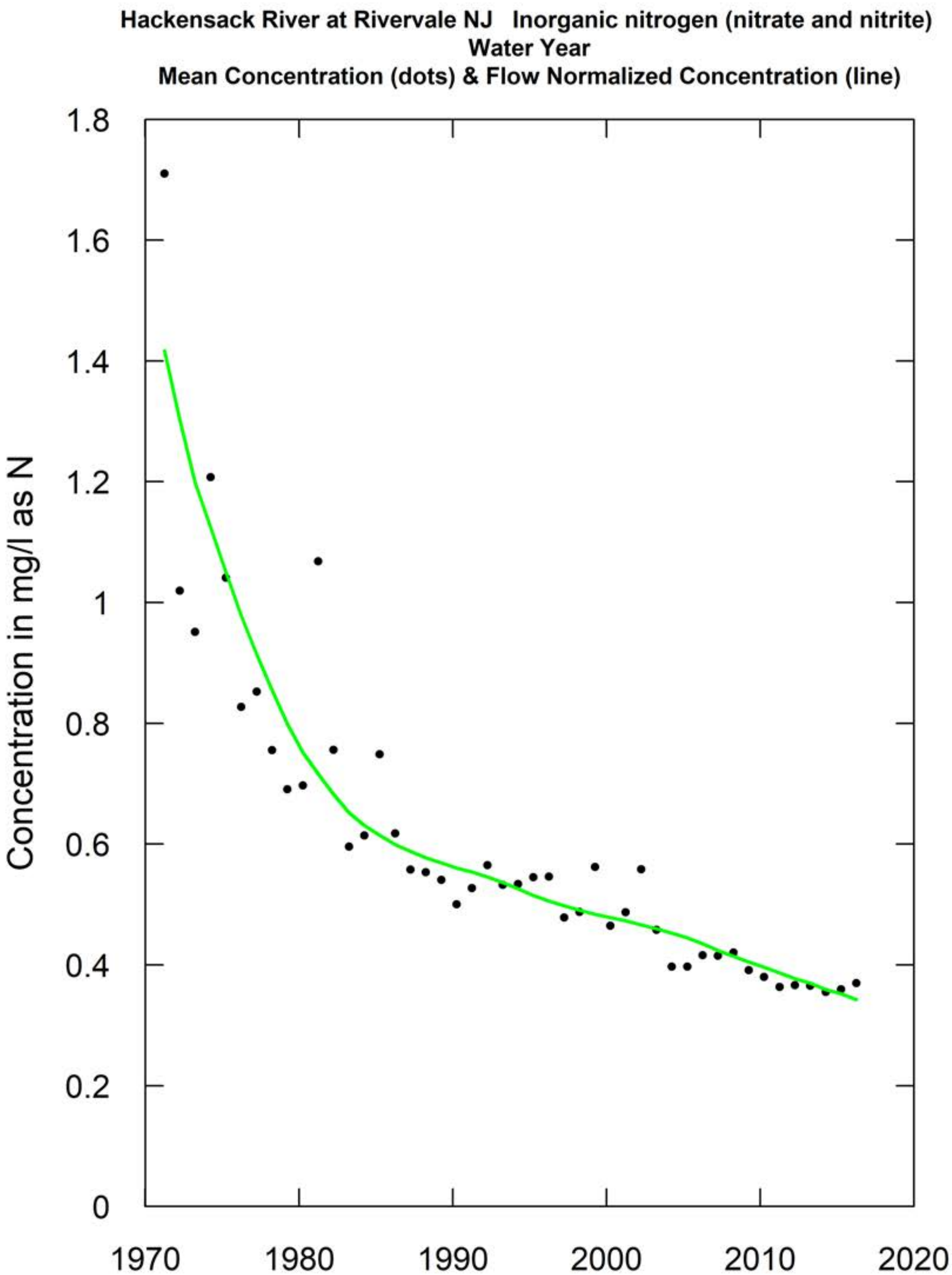
Plots displayed here were produced from Weighted Regressions on Time, Discharge, and Season (WRTDS) models. See Figs. 2-5, for description of the four types of plots for each water quality station and nutrient (filtered nitrate plus nitrite as nitrogen, NO23; total nitrogen, TN; and total phosphorus, TP).

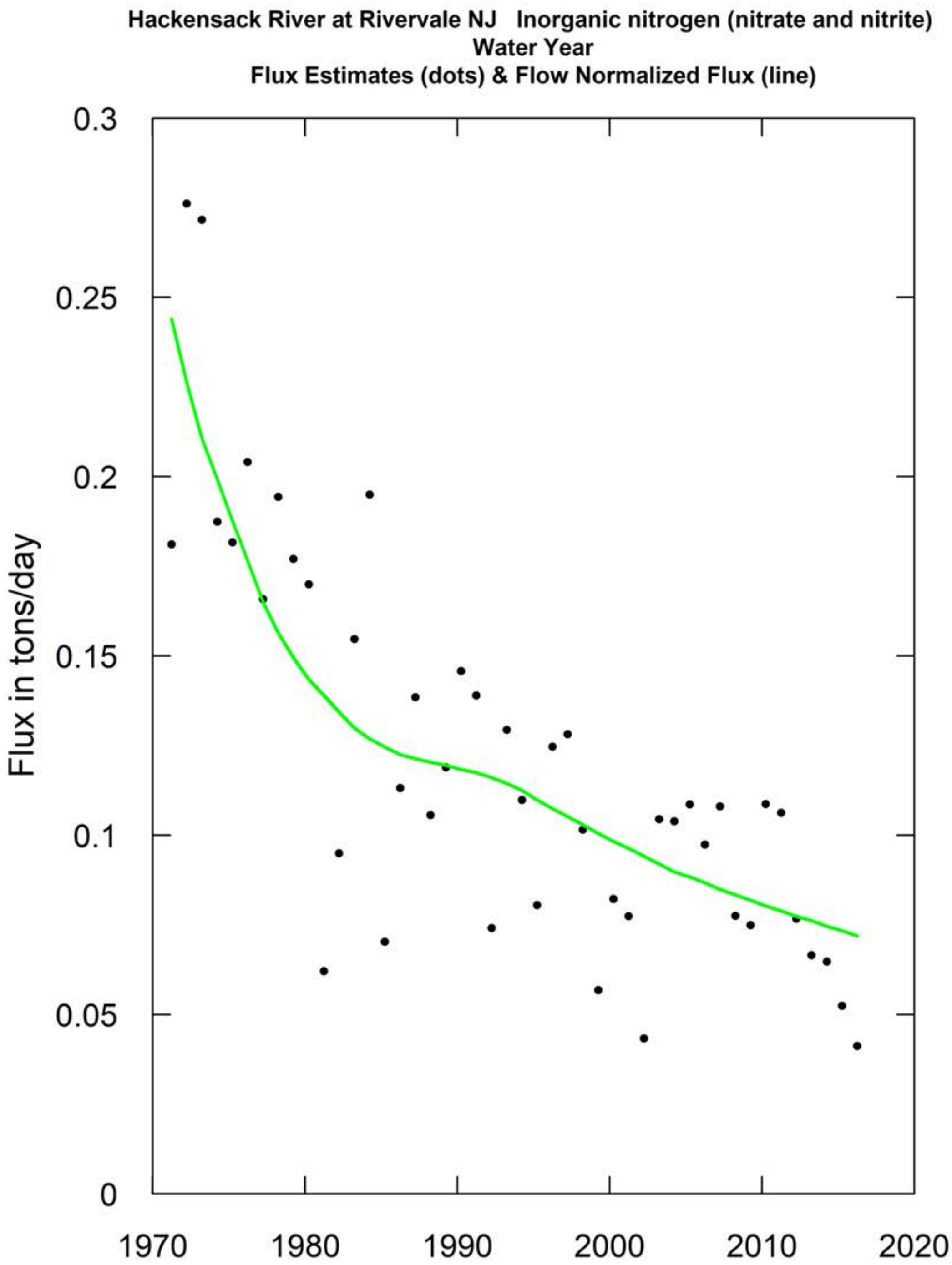
		Page Numbers		
Station ID	Station name	NO23	TN	TP
01377000	Hackensack River at Rivervale, NJ	2-5	6-9	10-13
01387500	Ramapo River near Mahwah, NJ	14-17	18-21	22-25
01389500	Passaic River at Little Falls, NJ	26-29	30-33	34-37
01391500	Saddle River at Lodi, NJ	38-41	42-45	46-49
01394500	Rahway River near Springfield, NJ	50-53	54-57	58-61
01395000	Rahway River at Rahway, NJ	62-65	66-69	70-73
01396660	Mulhockaway Creek at Van Syckel, NJ	74-77	78-81	82-85
01398000	Neshanic River at Reaville, NJ	86-89	90-93	94-97
01399780	Lamington River at Burnt Mills, NJ	98-101	102-105	106-109
01405340	Manalapan Brook at Federal Road near Manalapan, NJ	110-113	114-117	118-121
01408500	Toms River near Toms River, NJ	122-125	126-129	130-133
01409387	Mullica River at outlet of Atsion Lk at Atsion, NJ	134-137	138-141	142-145
01409416	Hammonton Creek at Wescoatville, NJ	146-149	150-153	154-157
01409815	West Branch Wading River at Maxwell, NJ	*	*	158-161
01410150	East Branch Bass River near New Gretna, NJ	*	*	*
01411110	Great Egg Harbor River at Weymouth, NJ	162-165	166-169	170-173
01411500	Maurice River at Norma, NJ	174-177	178-181	182-185
01443500	Paulins Kill at Blairstown, NJ	186-189	190-193	194-197
01457400	Musconetcong River at Riegelsville, NJ	198-201	202-205	206-209
01463500	Delaware River at Trenton, NJ	210-213	214-217	218-221
01466500	McDonalds Branch in Byrne State Forest, NJ	*	*	*
01477120	Raccoon Creek near Swedesboro, NJ	222-225	226-229	230-233
01482500	Salem River at Woodstown, NJ	234-237	238-241	242-245

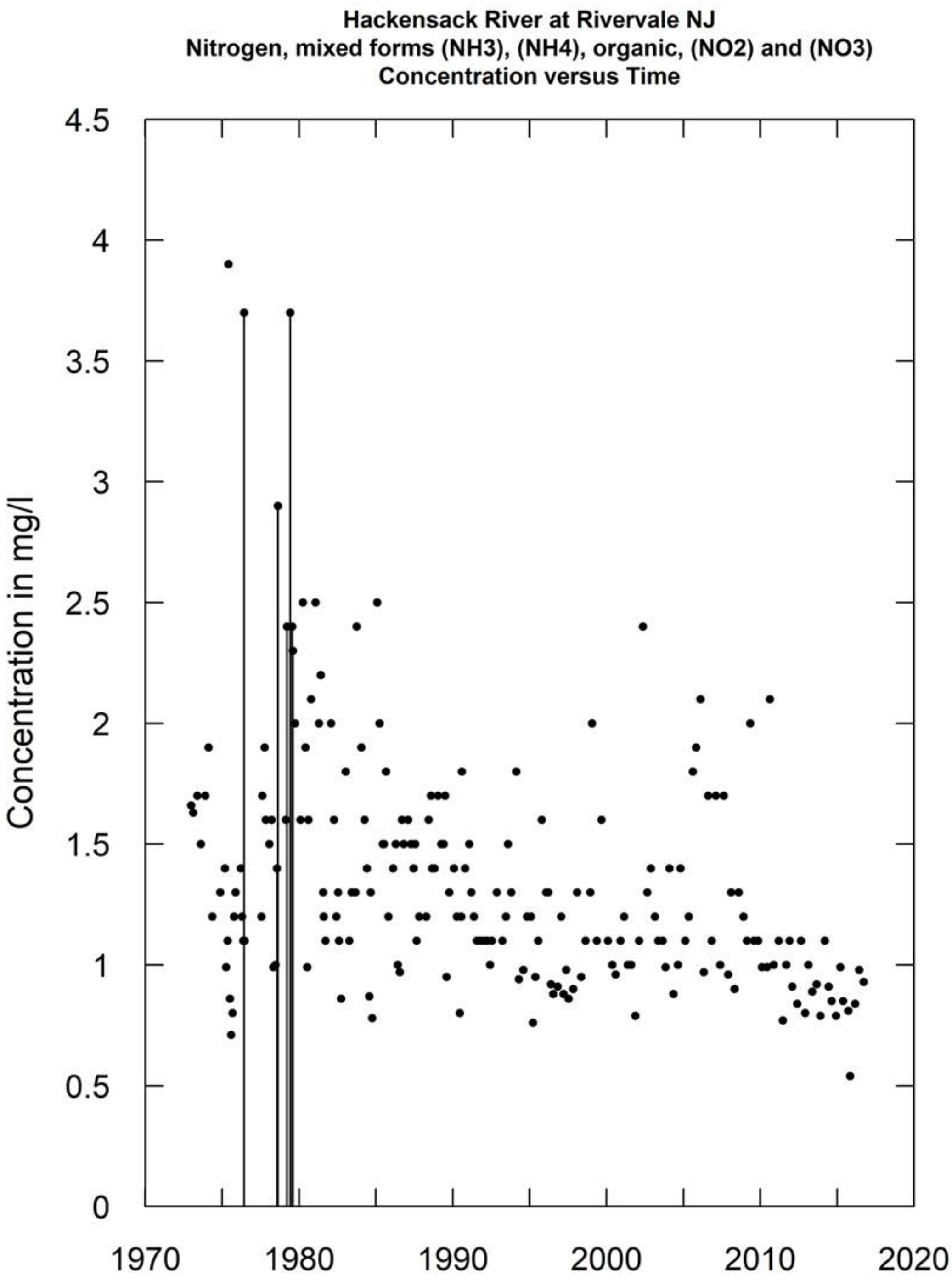
* Too many censored values to produce plots

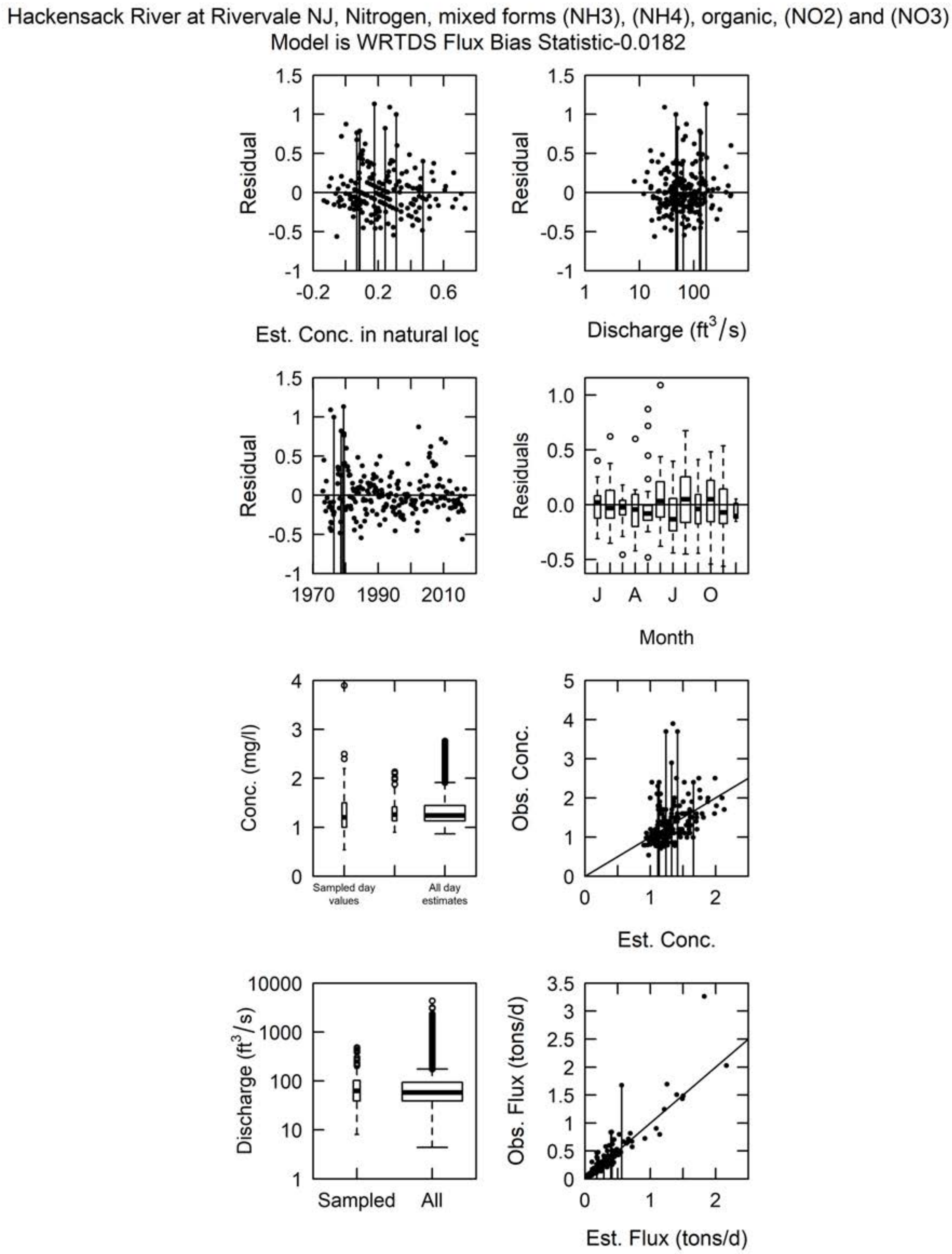

Hackensack River at Rivervale NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
3.5
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

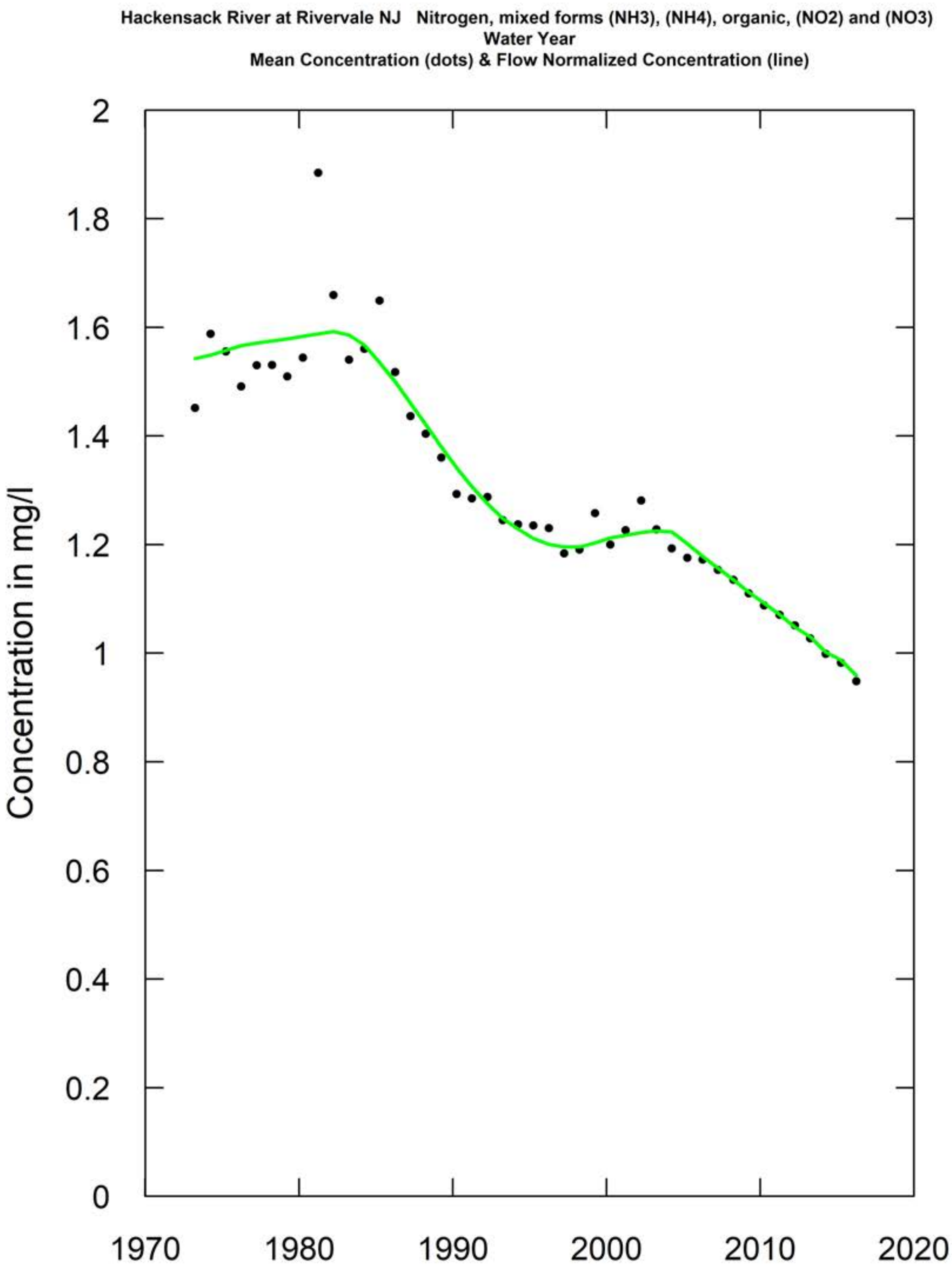

Hackensack River at Rivervale NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0195
Residual
Est. Conc. in natural log
Discharge (ft³/s)
Residual
Residuals
Month
J A J O
1970 1990 2010
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

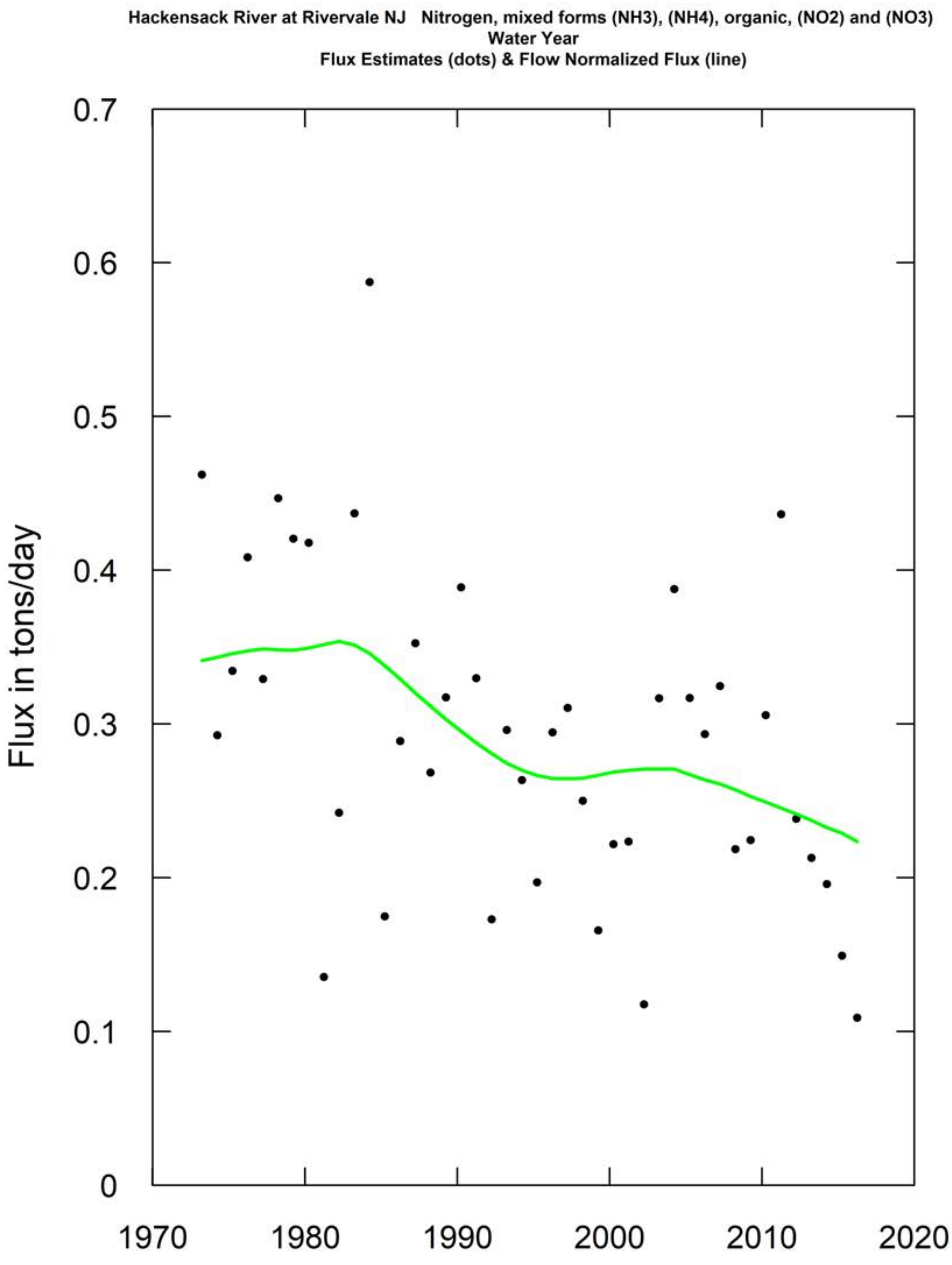

Hackensack River at Rivervale NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

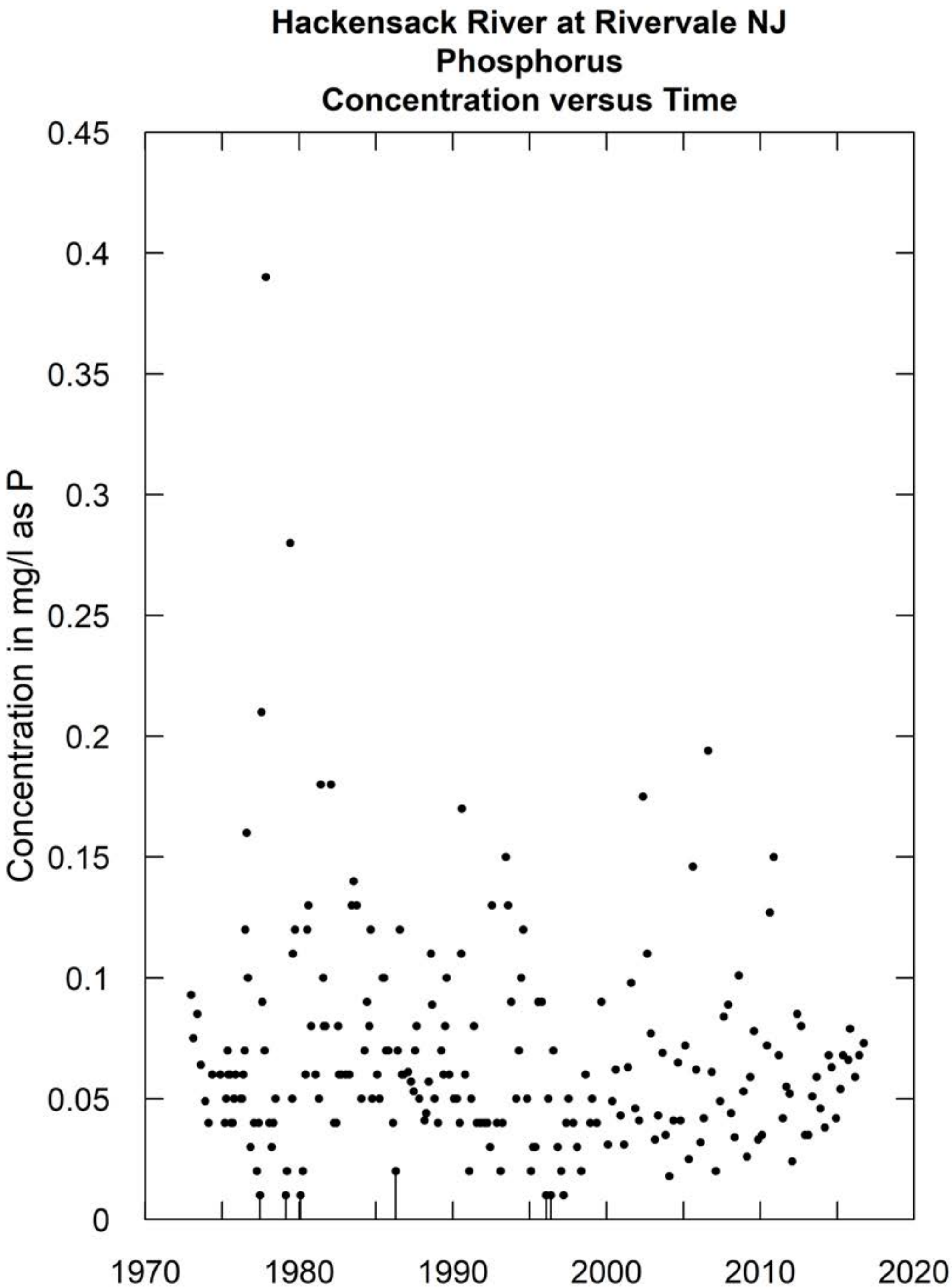

Hackensack River at Rivervale NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

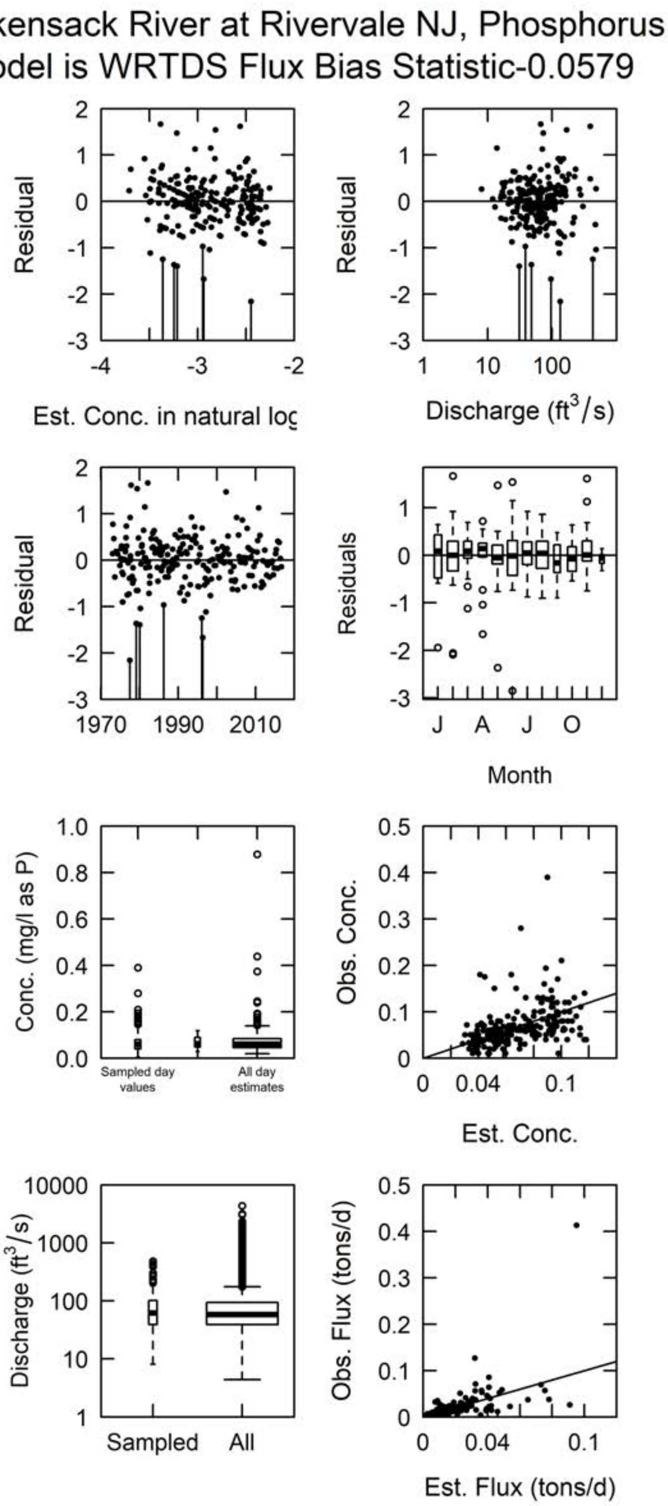

Hackensack River at Rivervale NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
1970
1980
1990
2000
2010
2020

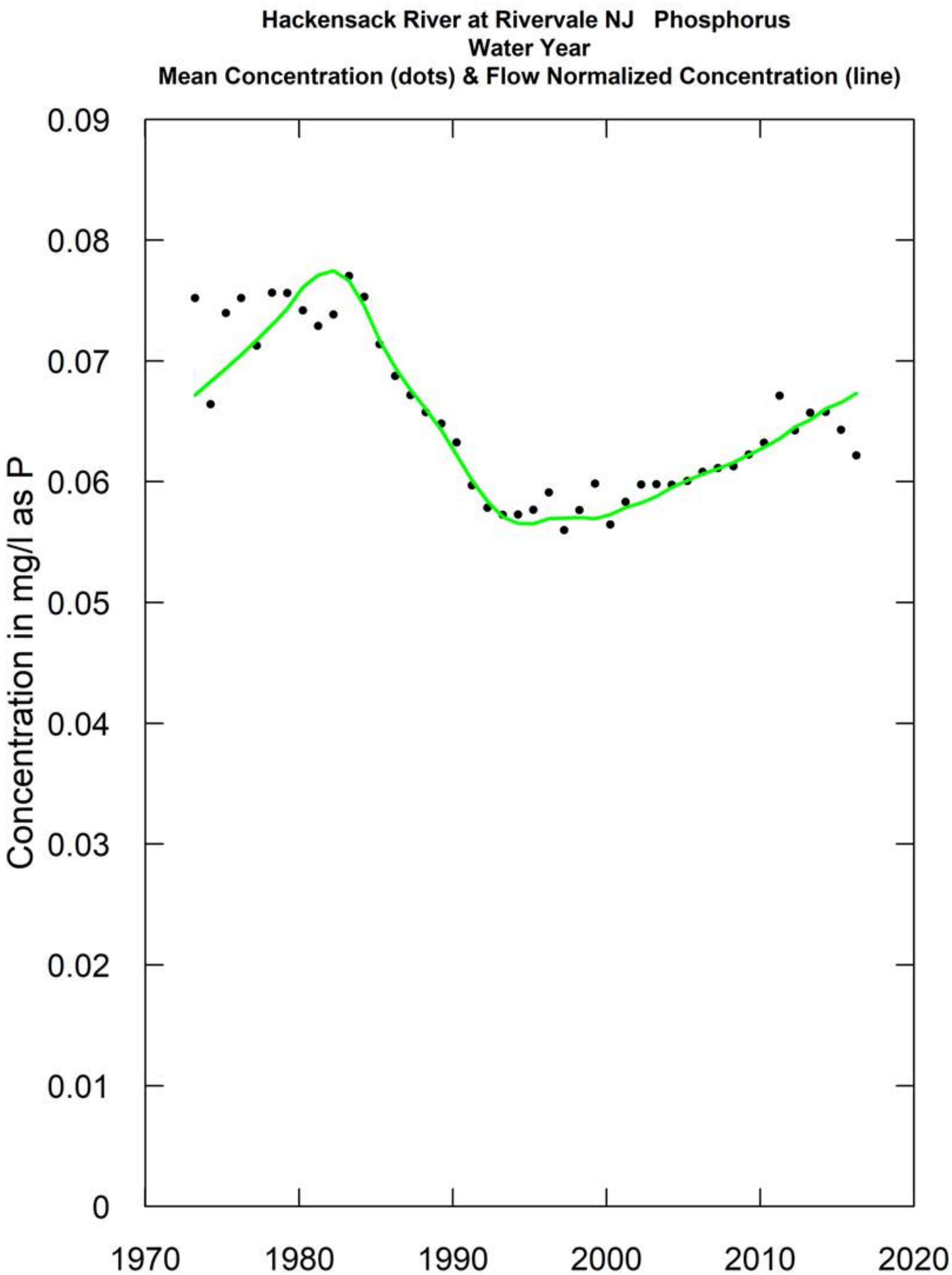

Hackensack River at Rivervale NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic-0.0182
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

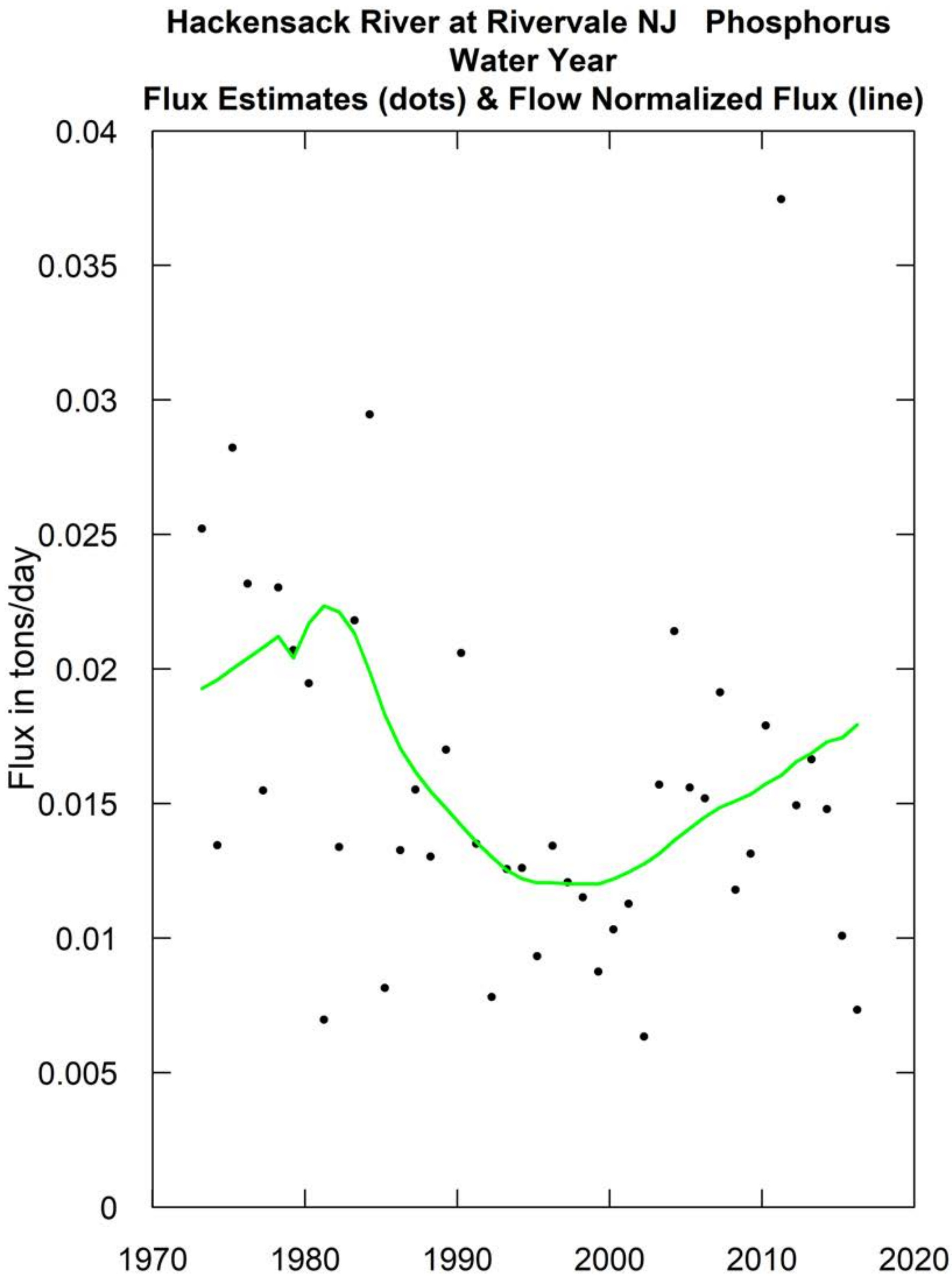

Hackensack River at Rivervale NJ   Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

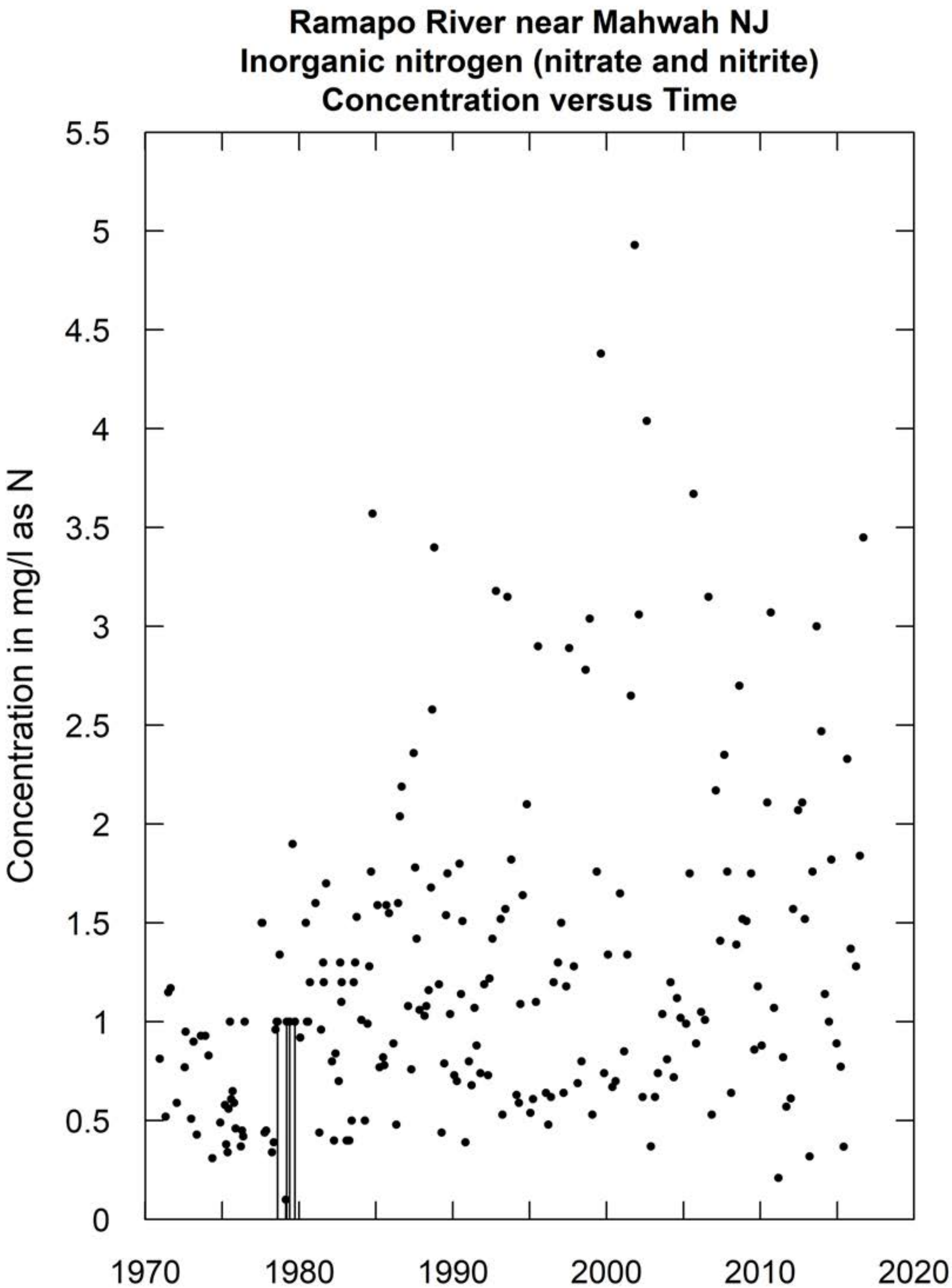

Hackensack River at Rivervale NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1970
1980
1990
2000
2010
2020

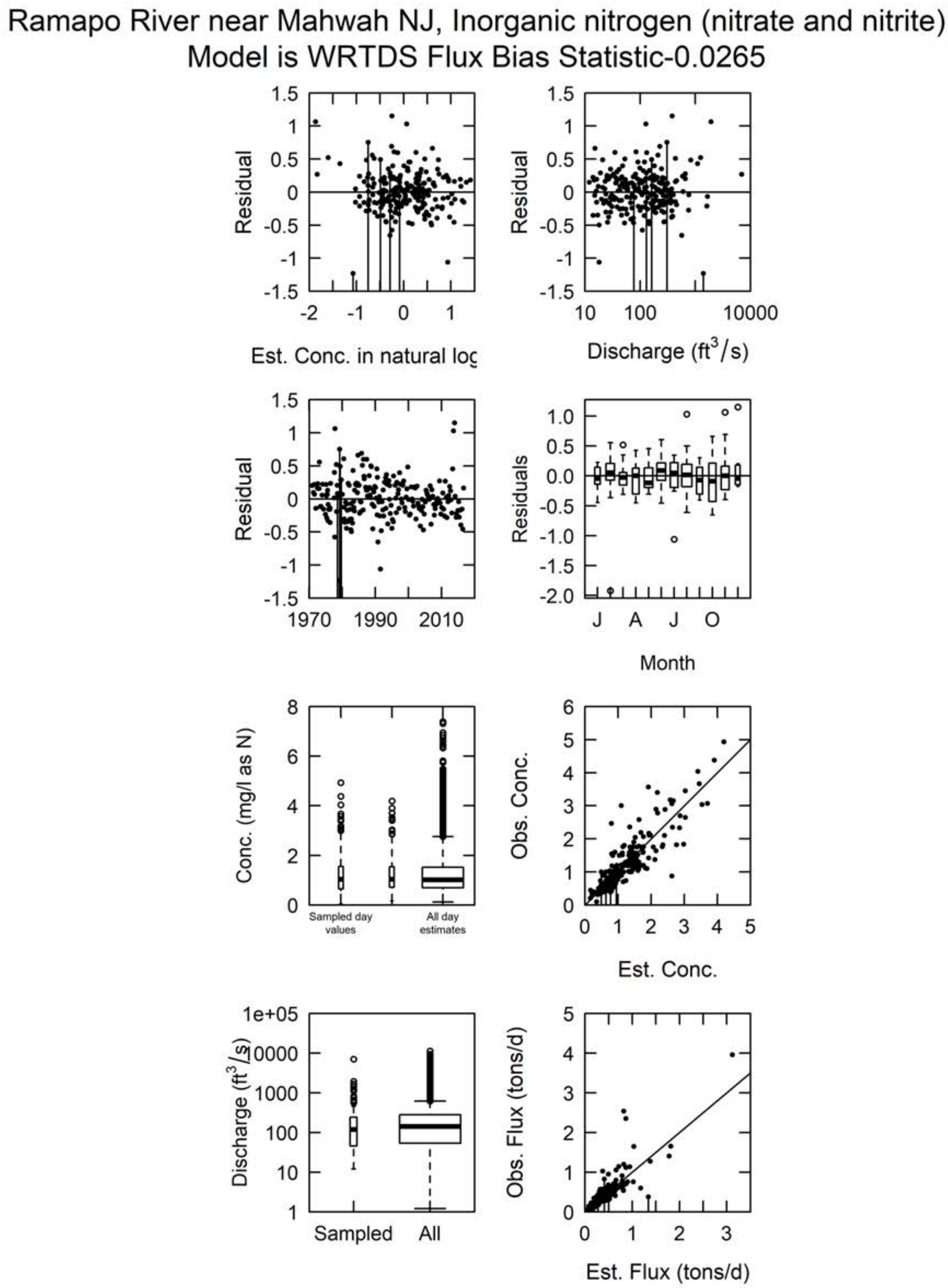

Hackensack River at Rivervale NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

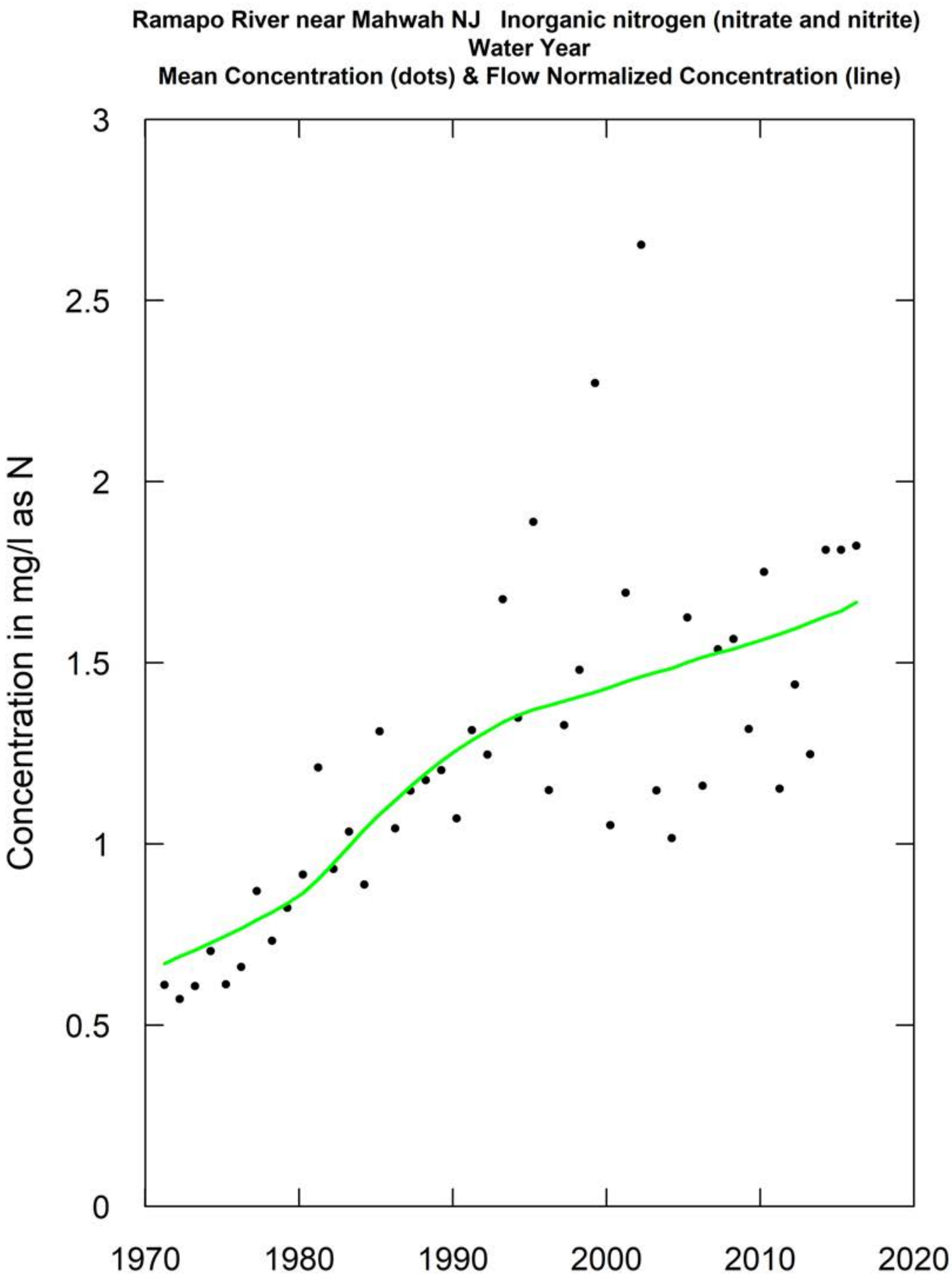

Hackensack River at Rivervale NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.0579
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

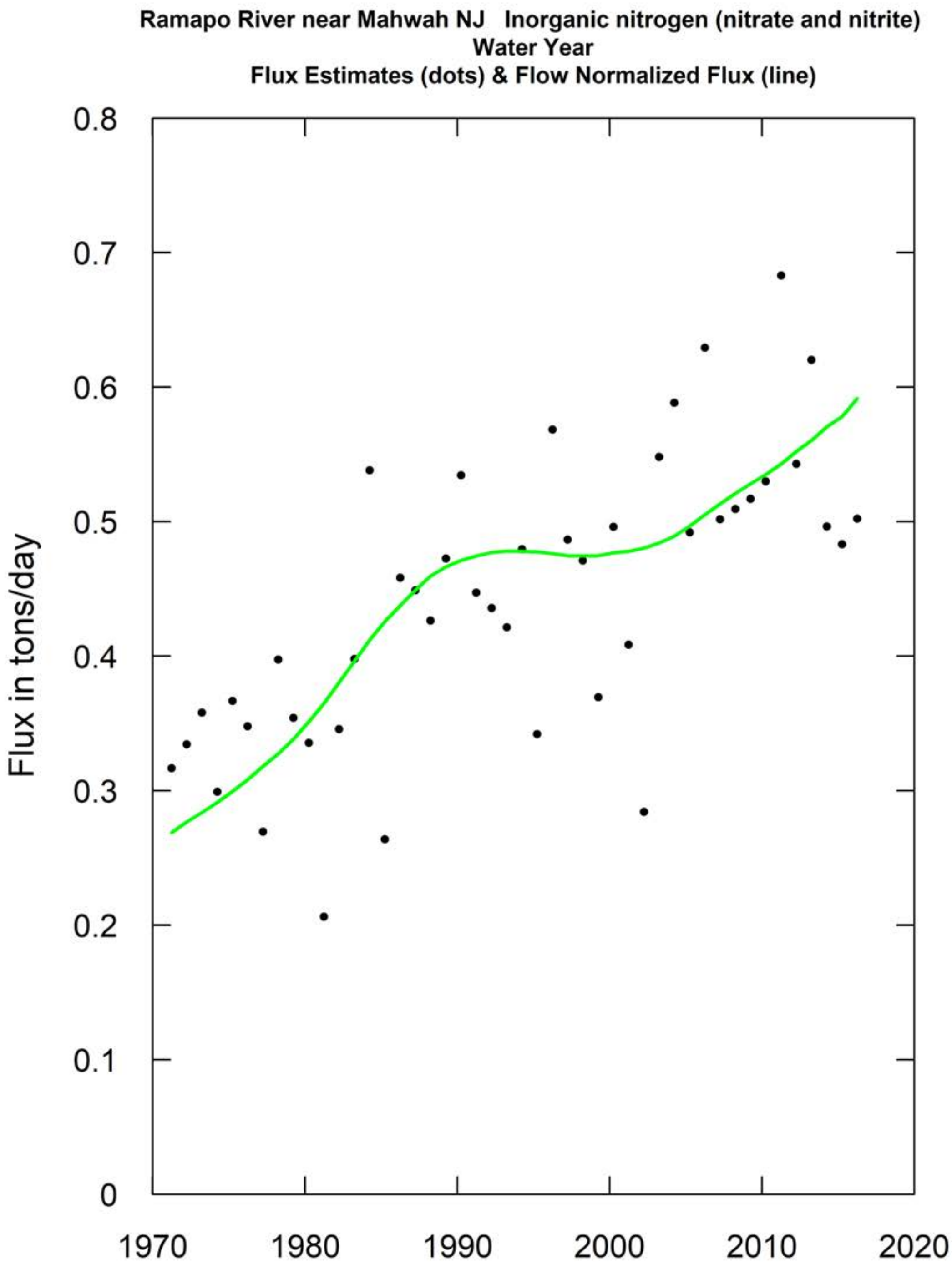

Hackensack River at Rivervale NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1970
1980
1990
2000
2010
2020

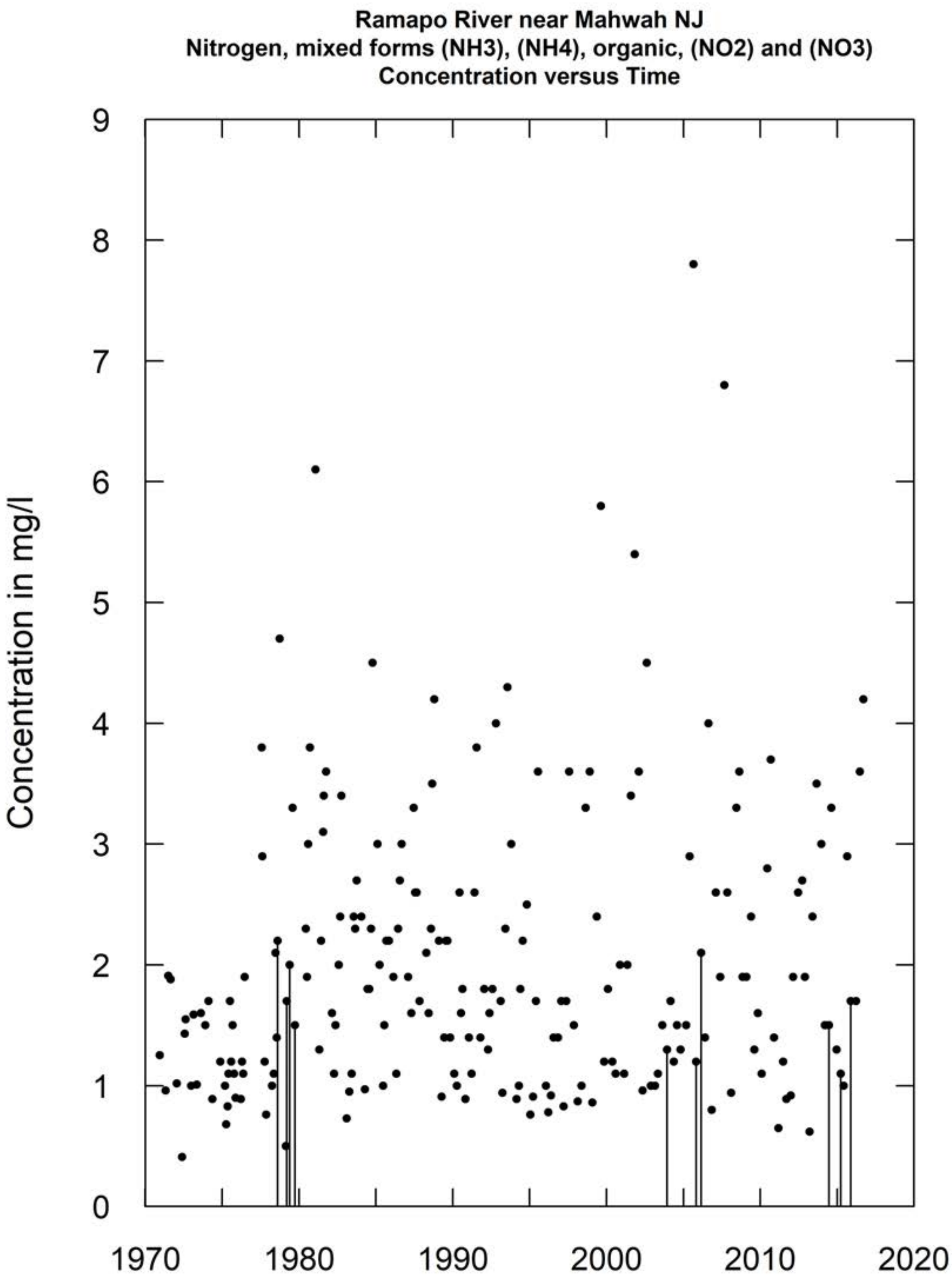

Hackensack River at Rivervale NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1970
1980
1990
2000
2010
2020

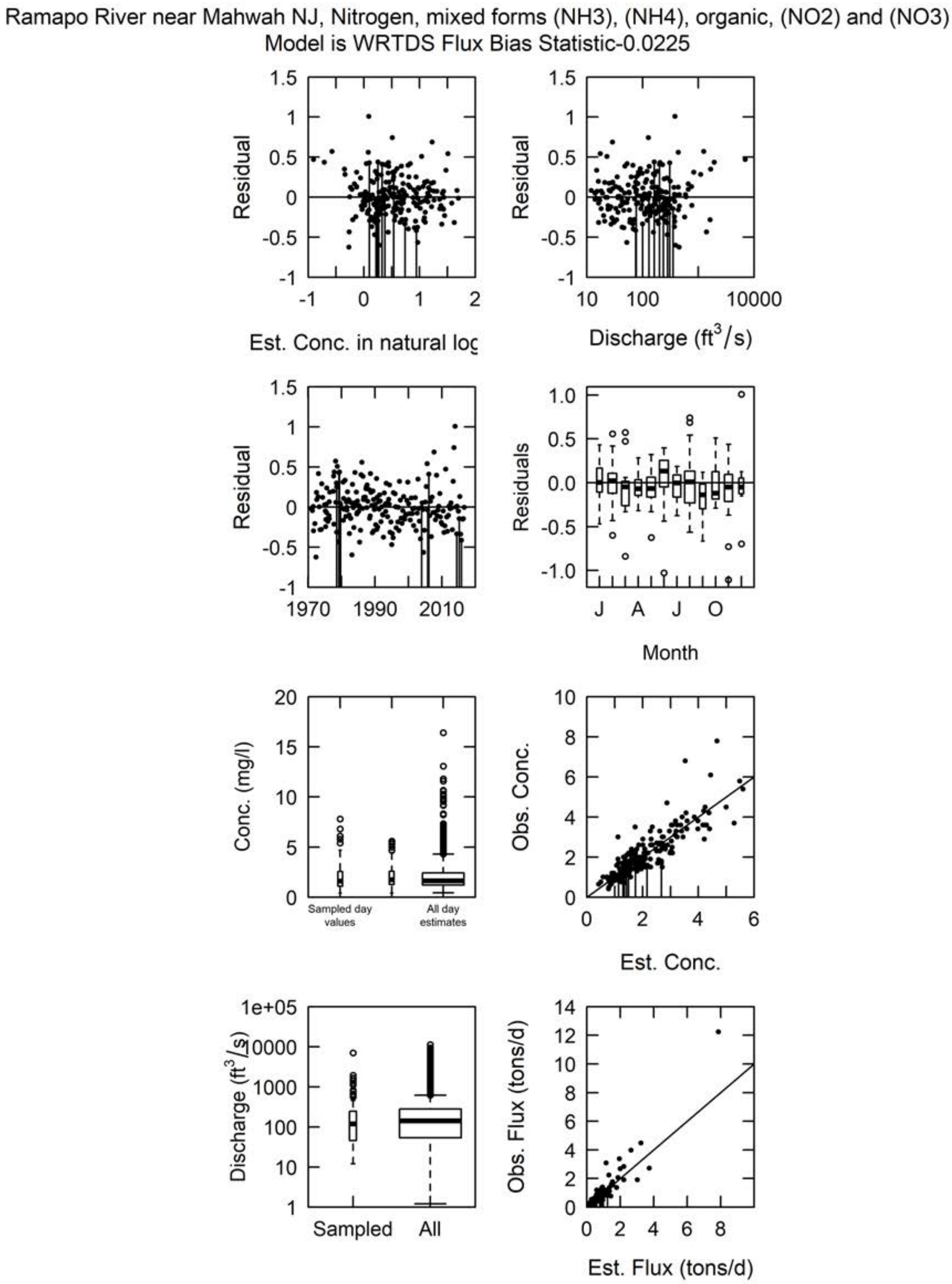

Ramapo River near Mahwah NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020


Ramapo River near Mahwah NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.0265
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

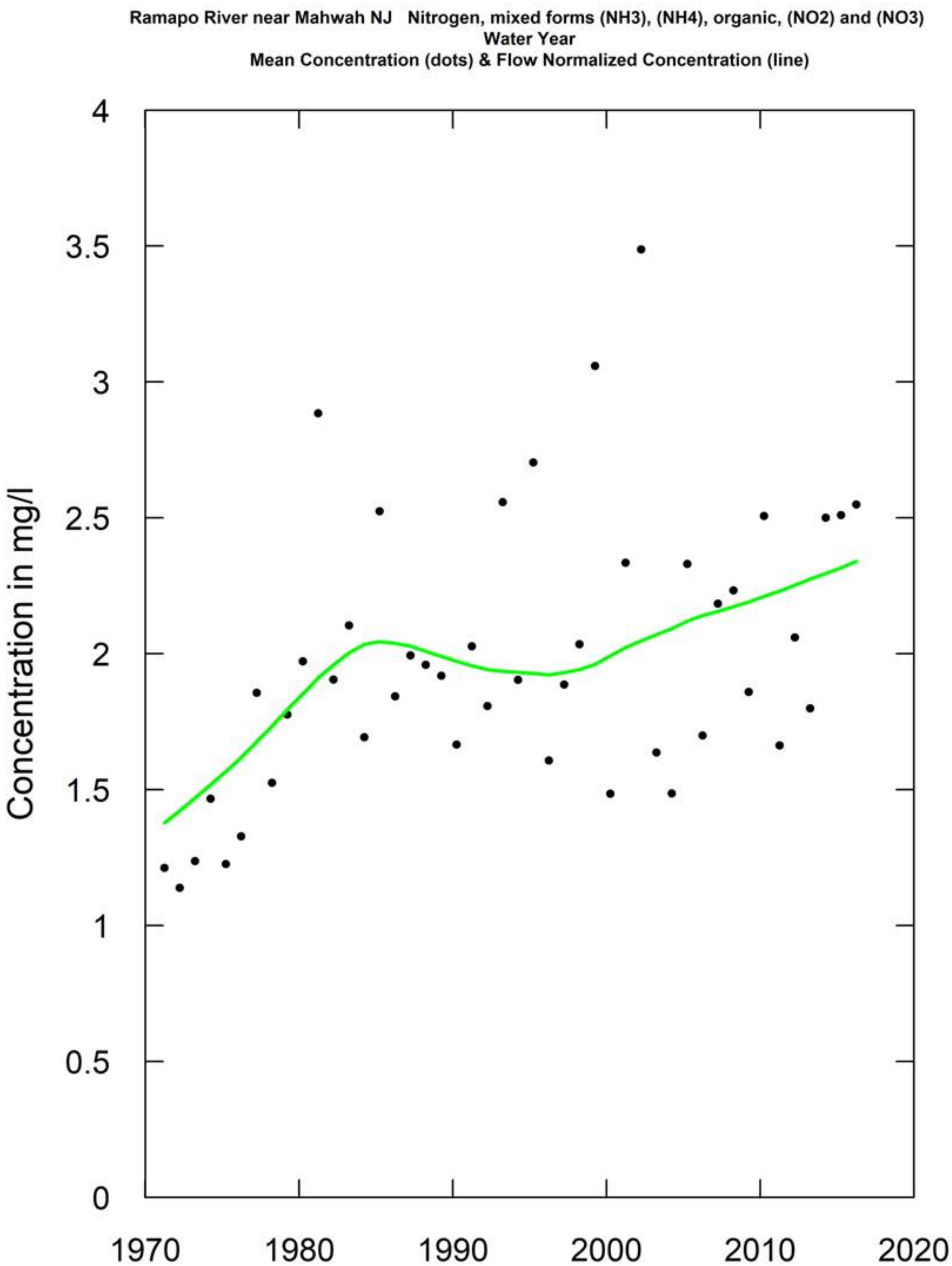

Ramapo River near Mahwah NJ   Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0
0.5
1
1.5
2
2.5
3
1970
1980
1990
2000
2010
2020

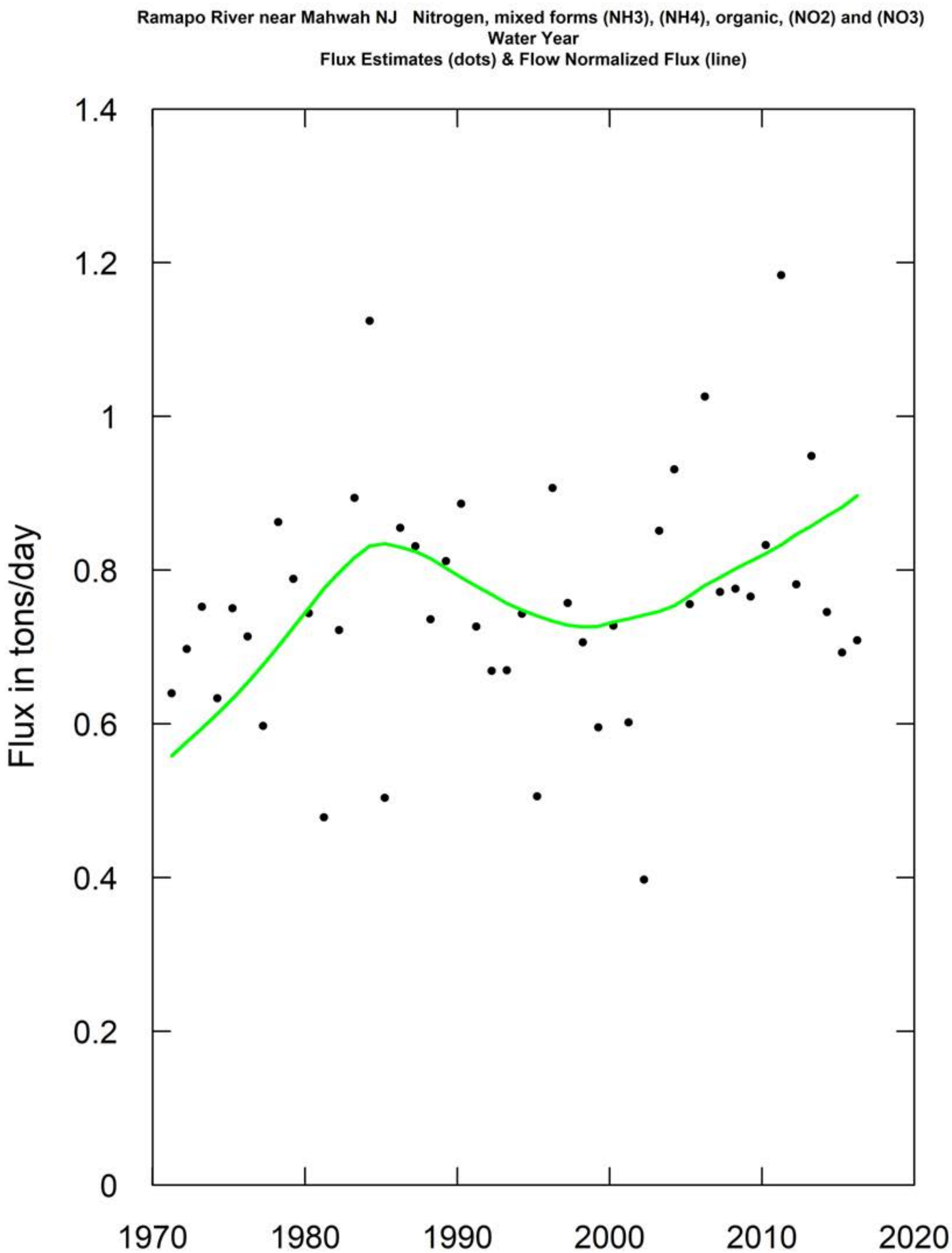

Ramapo River near Mahwah NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1970
1980
1990
2000
2010
2020

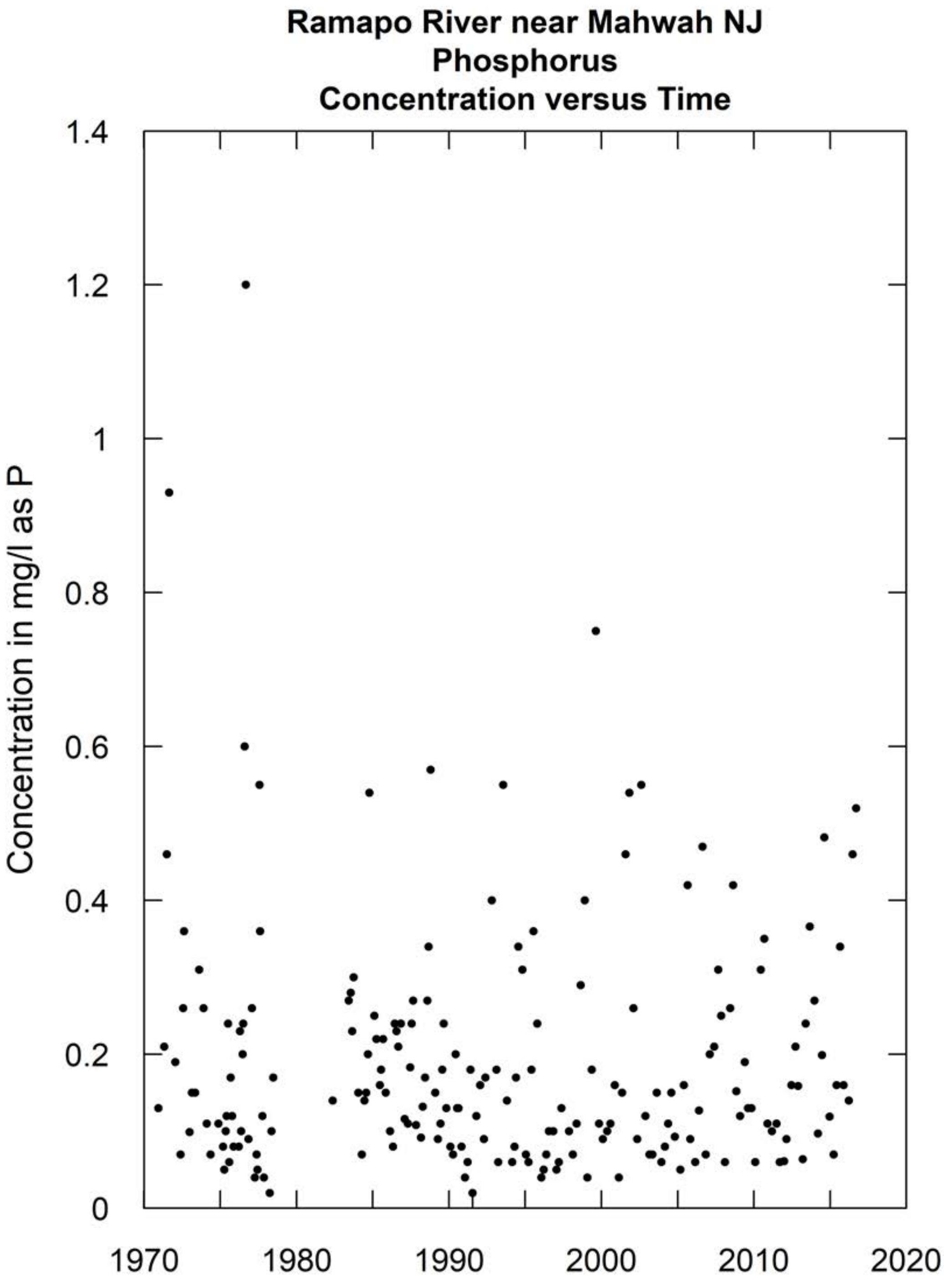

Ramapo River near Mahwah NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
9
8
7
6
5
4
3
2
1
0
1970
1980
1990
2000
2010
2020

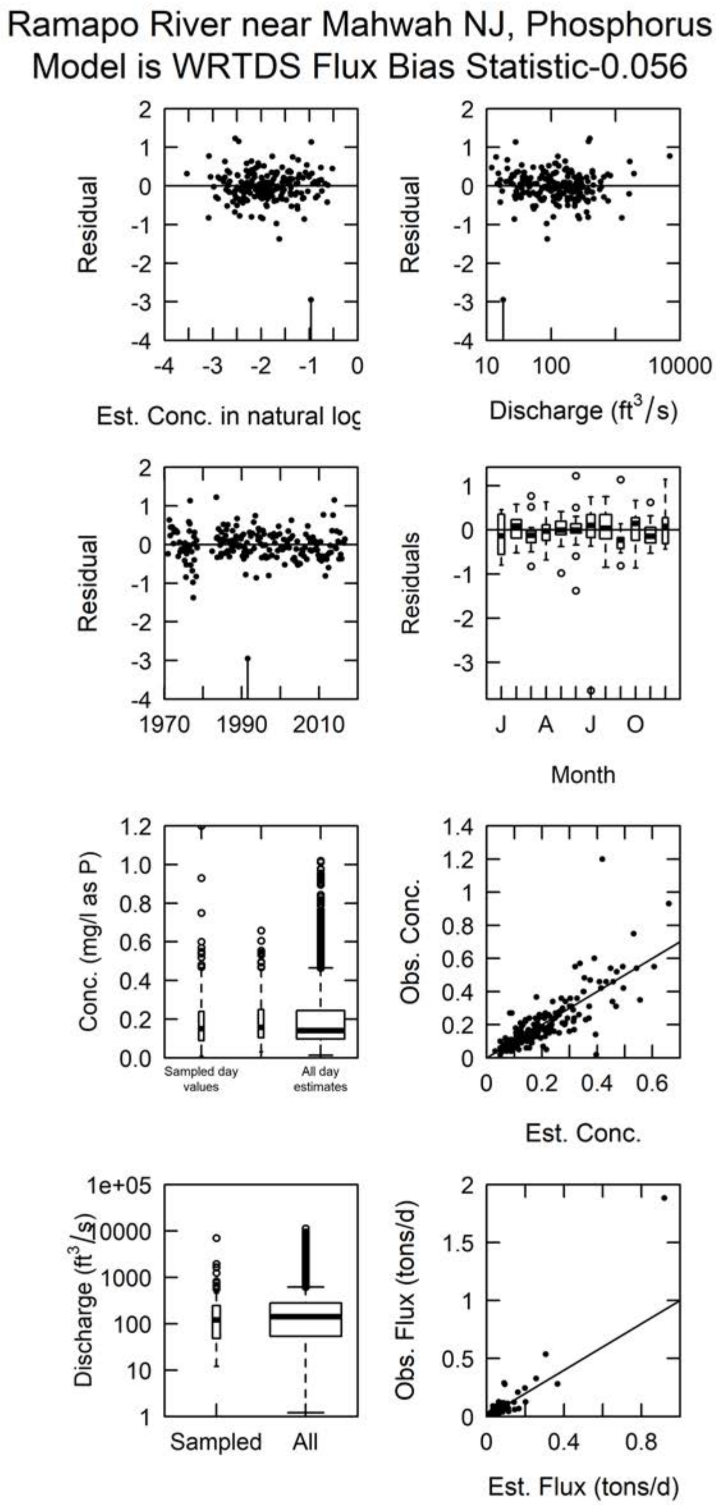


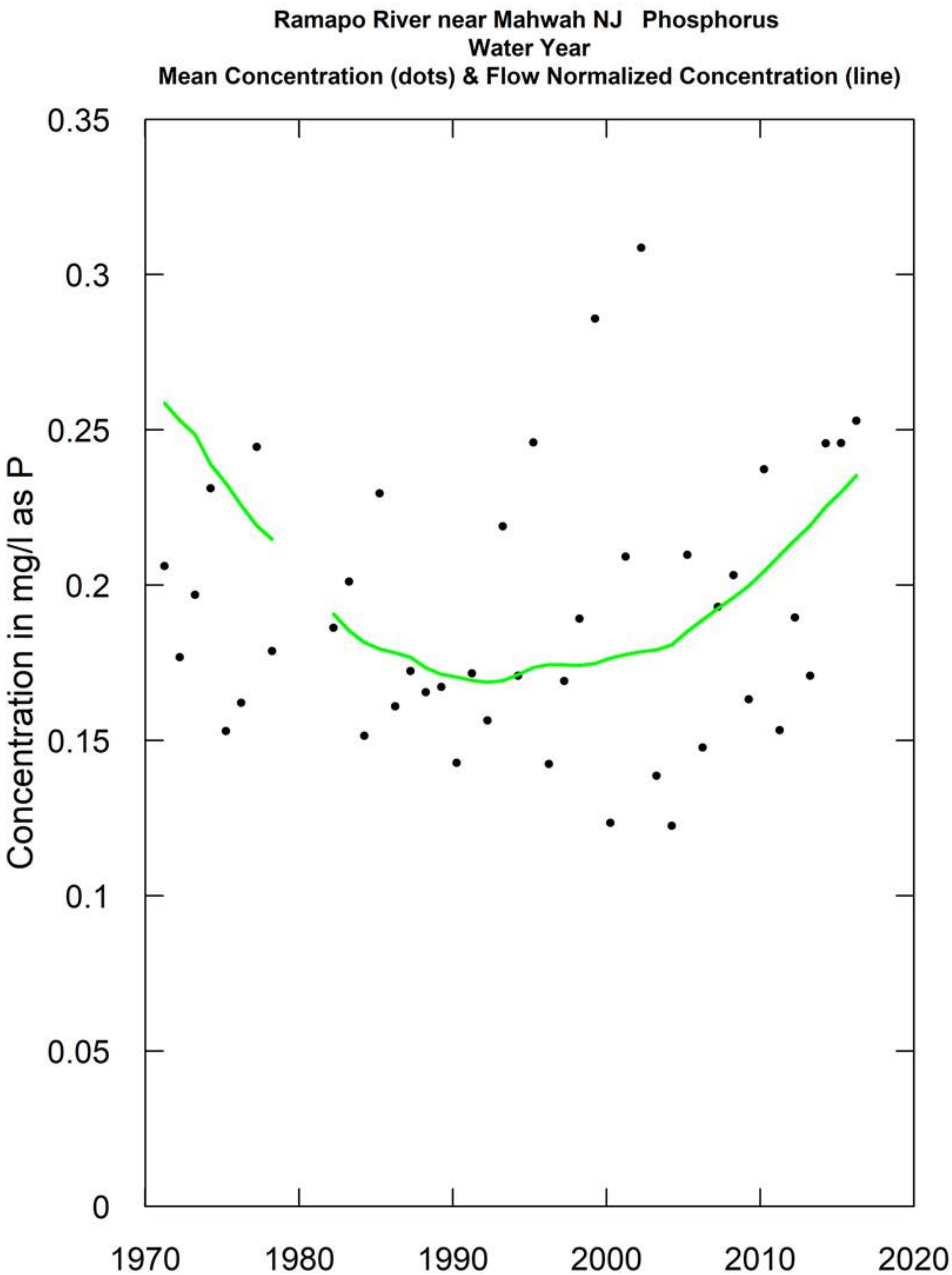
Ramapo River near Mahwah NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic-0.0225
Residual
Est. Conc. in natural log
Discharge (ft3/s)
1970 1990 2010
Residuals
J A J O
Month
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled All
Obs. Flux (tons/d)
Est. Flux (tons/d)

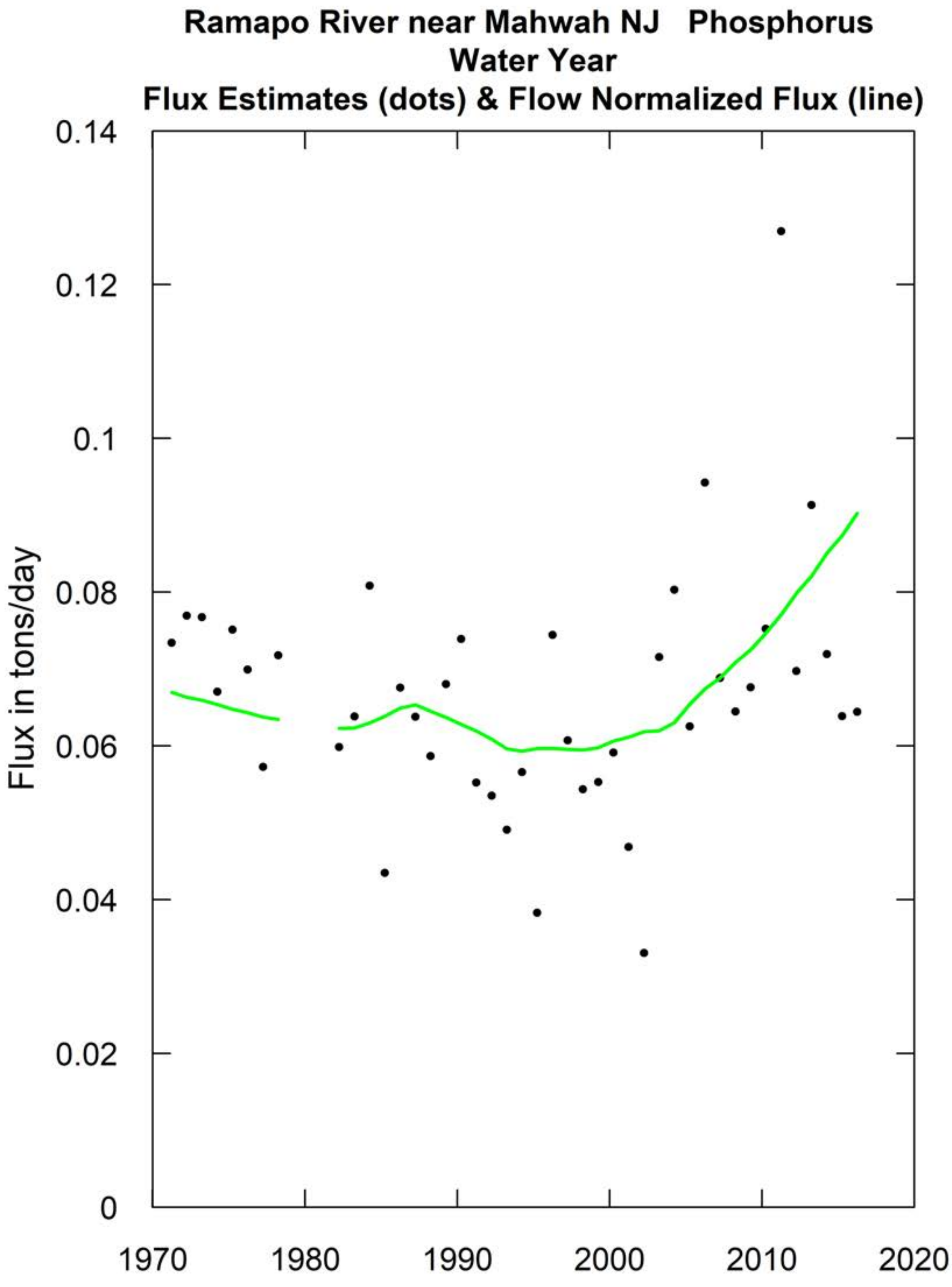

Ramapo River near Mahwah NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

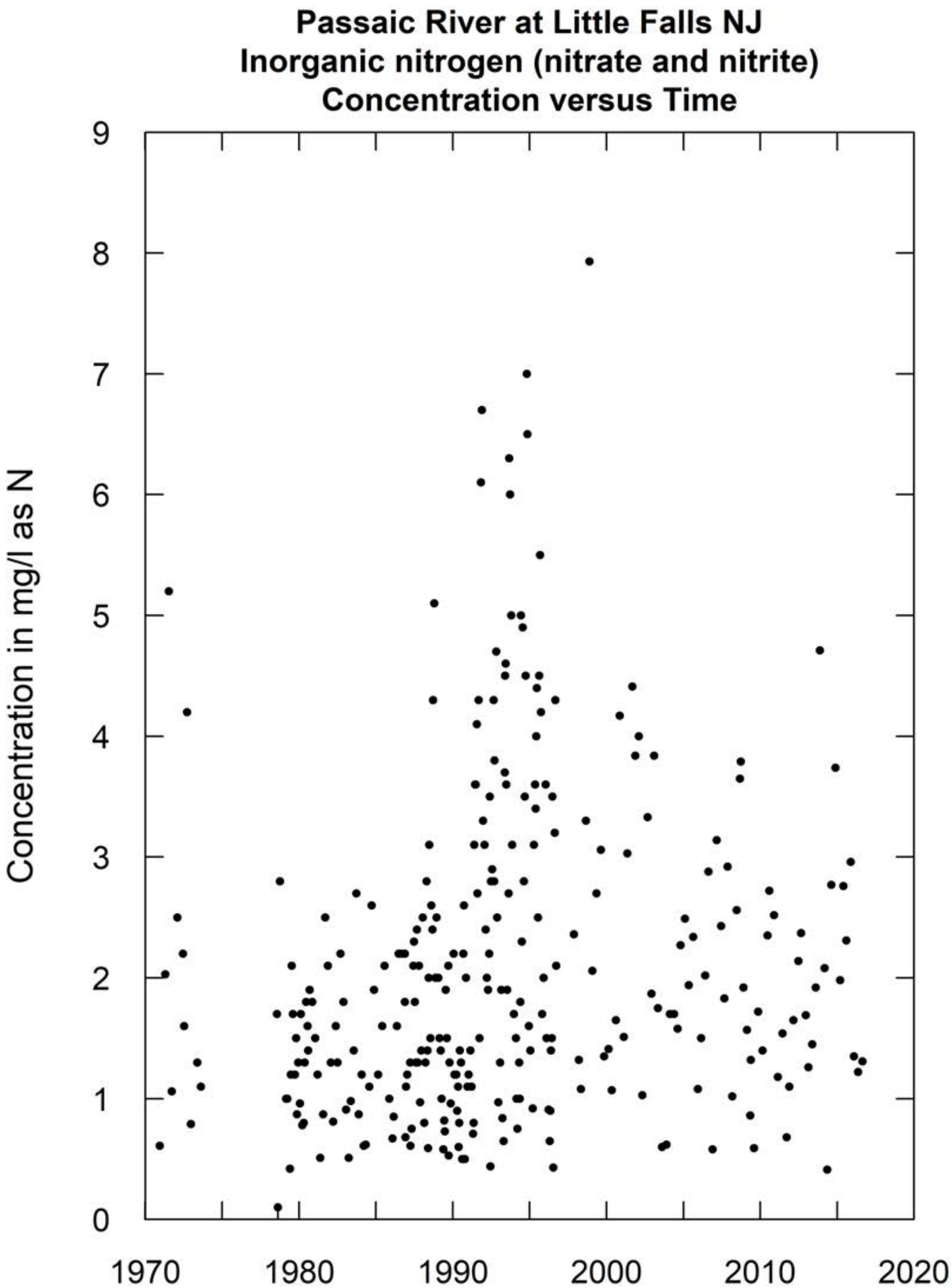

Ramapo River near Mahwah NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

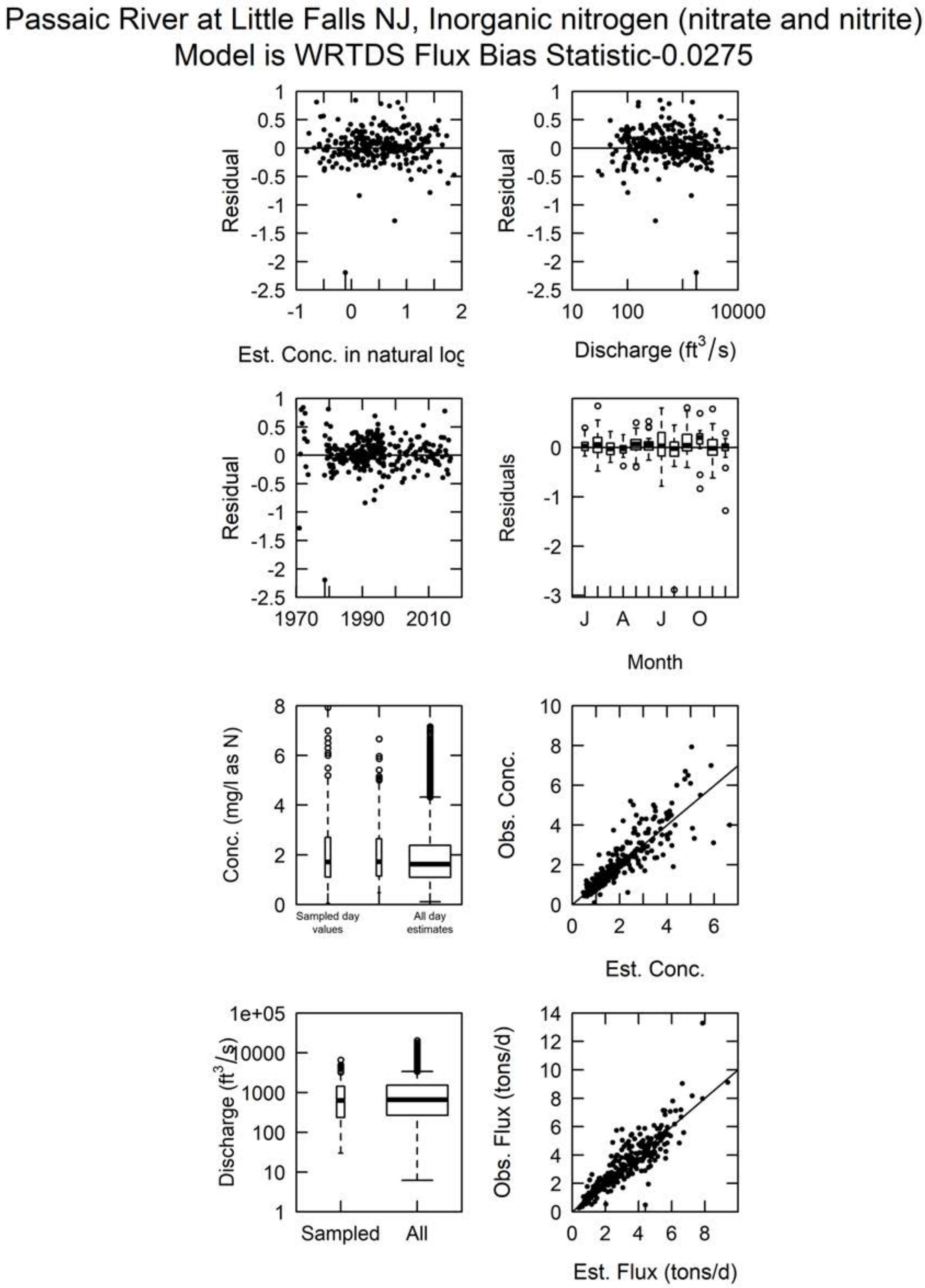

Ramapo River near Mahwah NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1970
1980
1990
2000
2010
2020

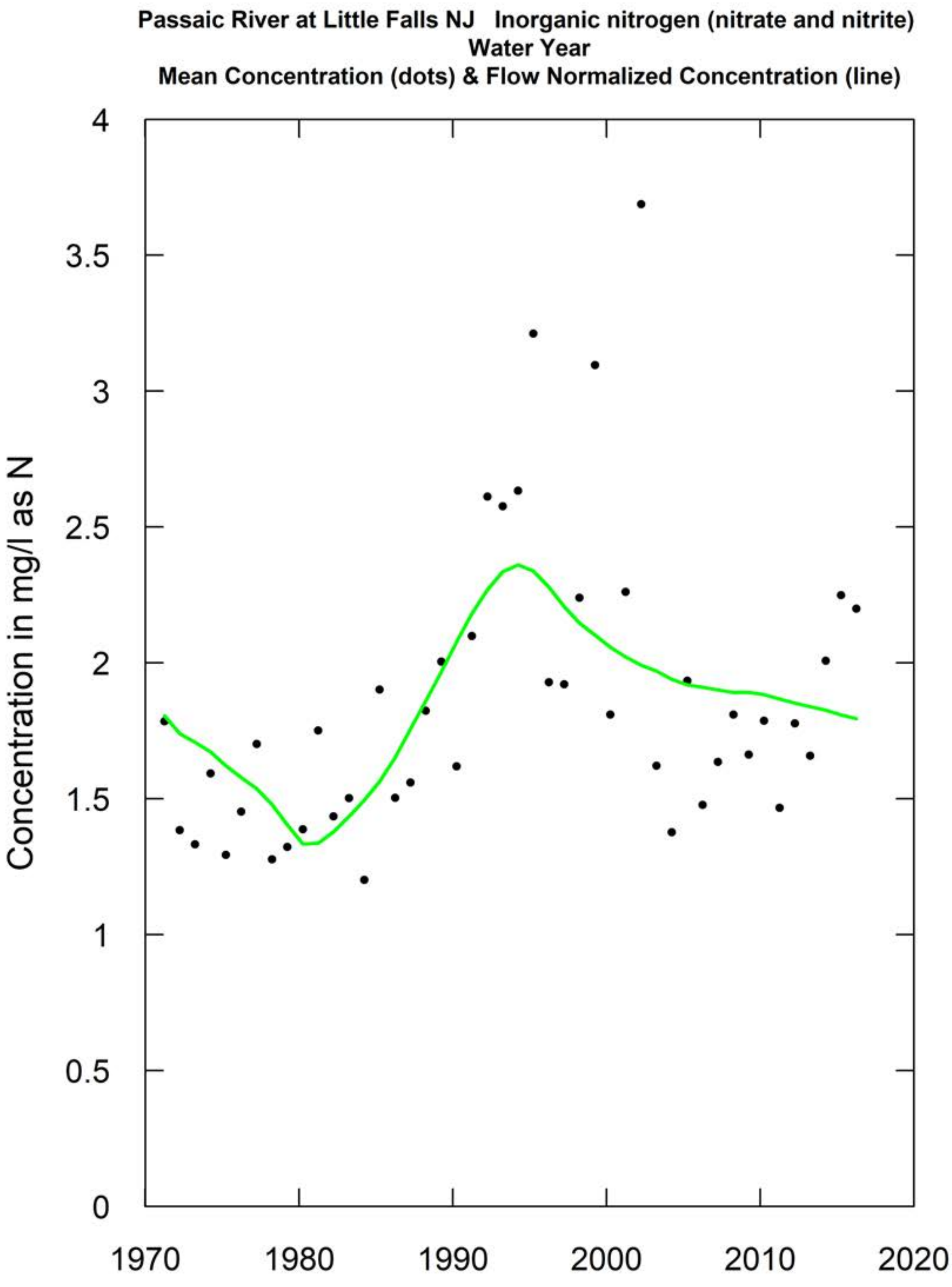

Ramapo River near Mahwah NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.056
Residual
Est. Conc. in natural log
Residual
Discharge (ft³/s)
Residual
Residuals
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

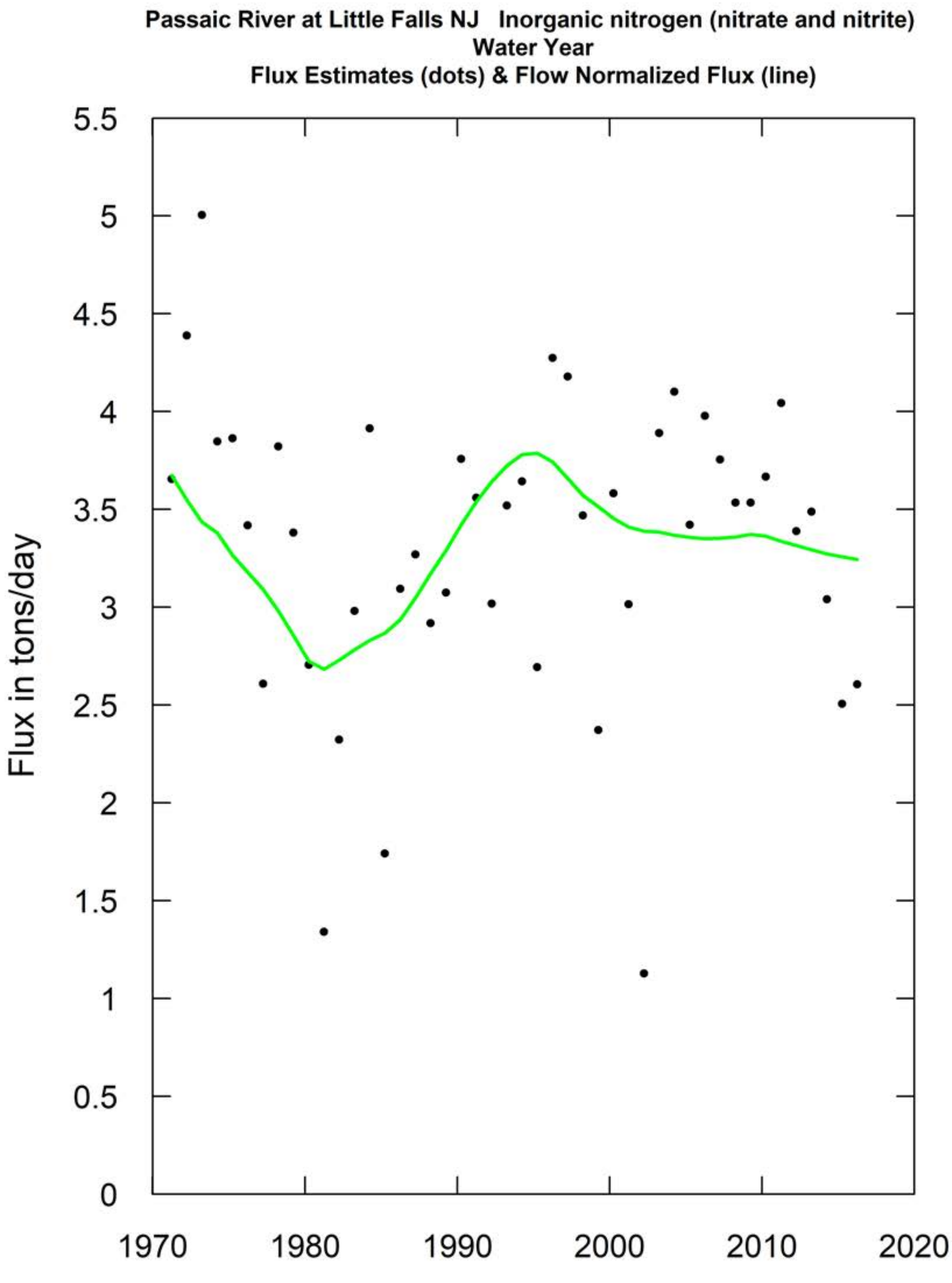

Ramapo River near Mahwah NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

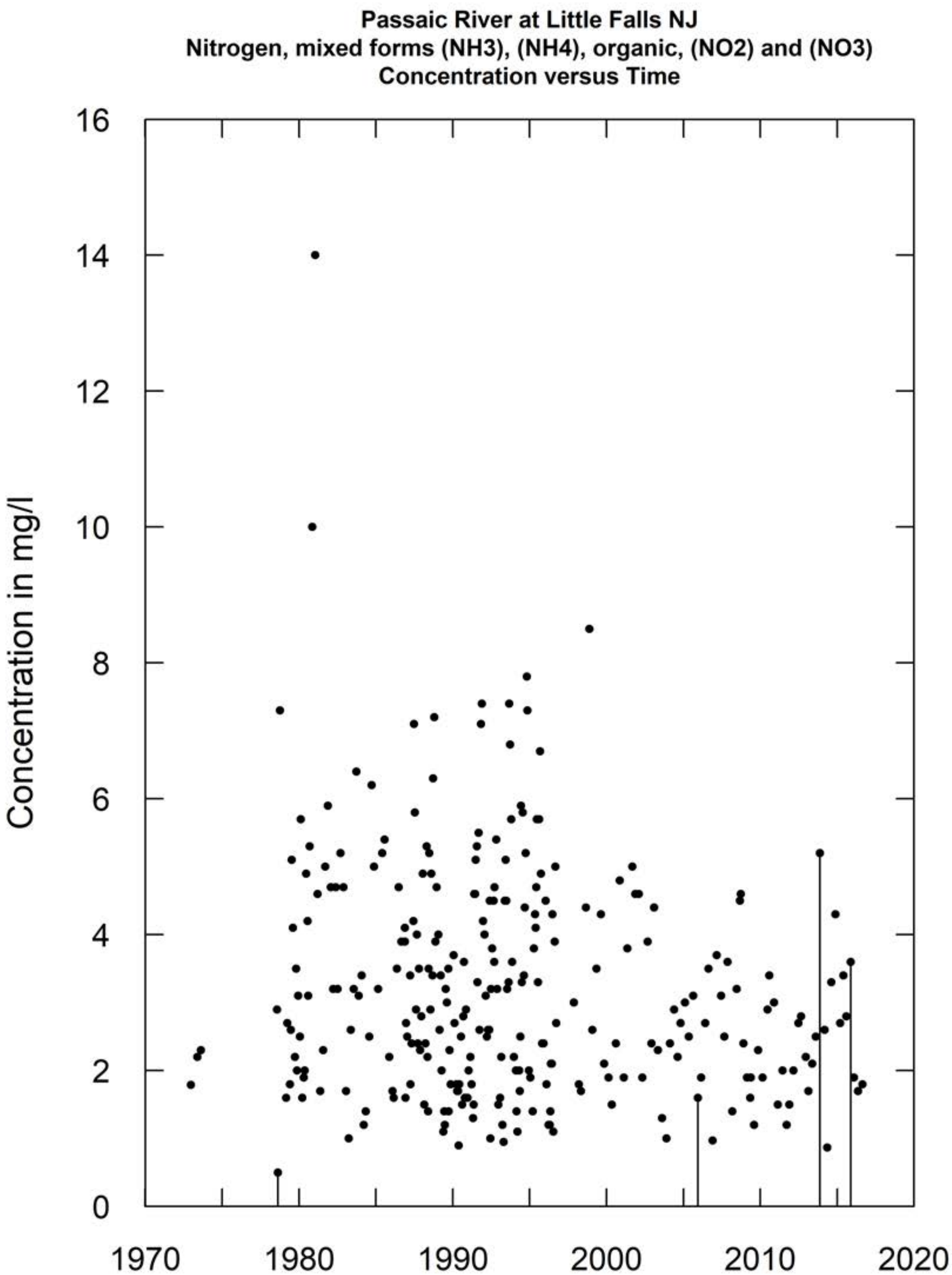

Ramapo River near Mahwah NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1970
1980
1990
2000
2010
2020

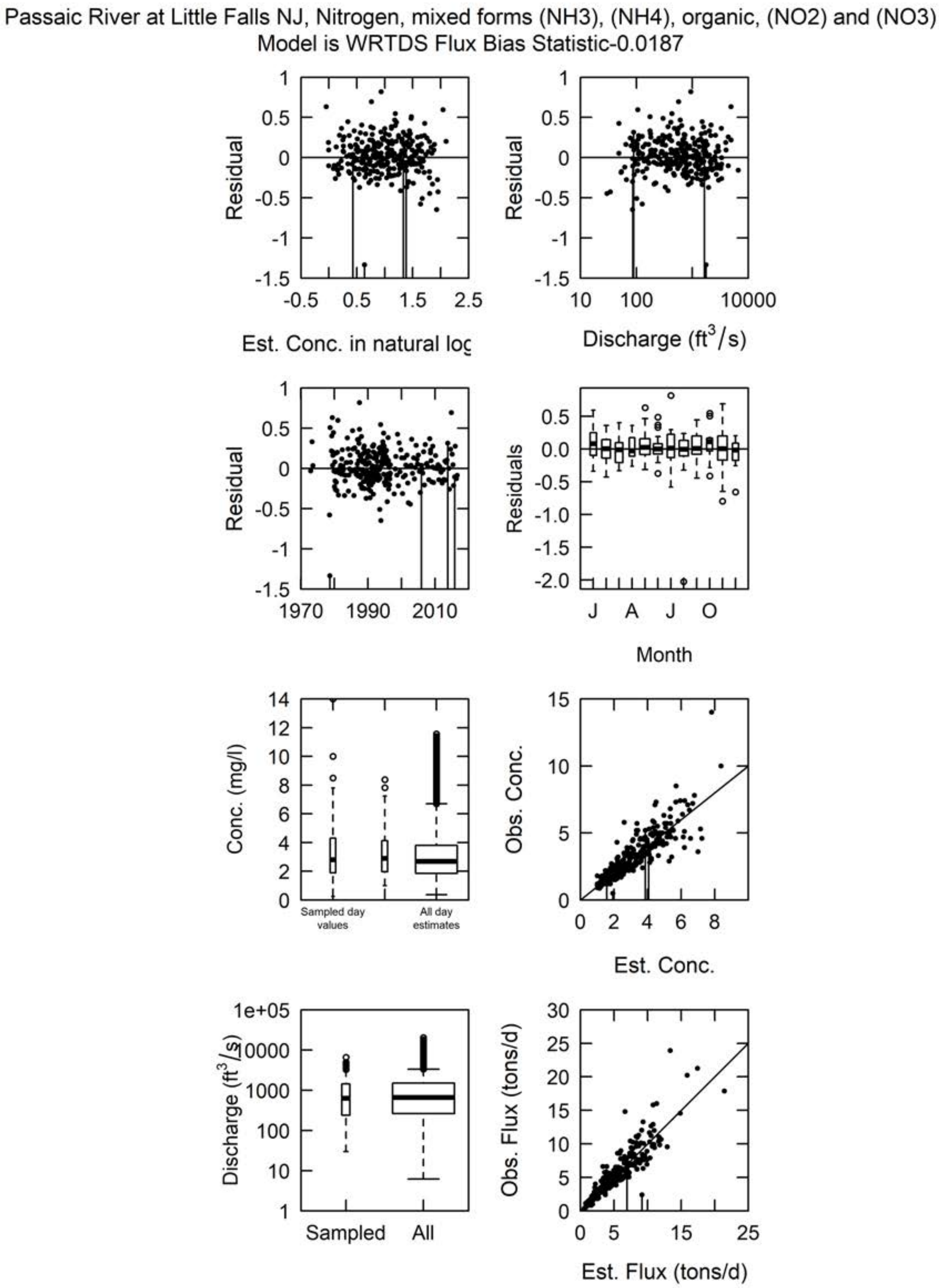

Passaic River at Little Falls NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
0
1
2
3
4
5
6
7
8
9
1970
1980
1990
2000
2010
2020

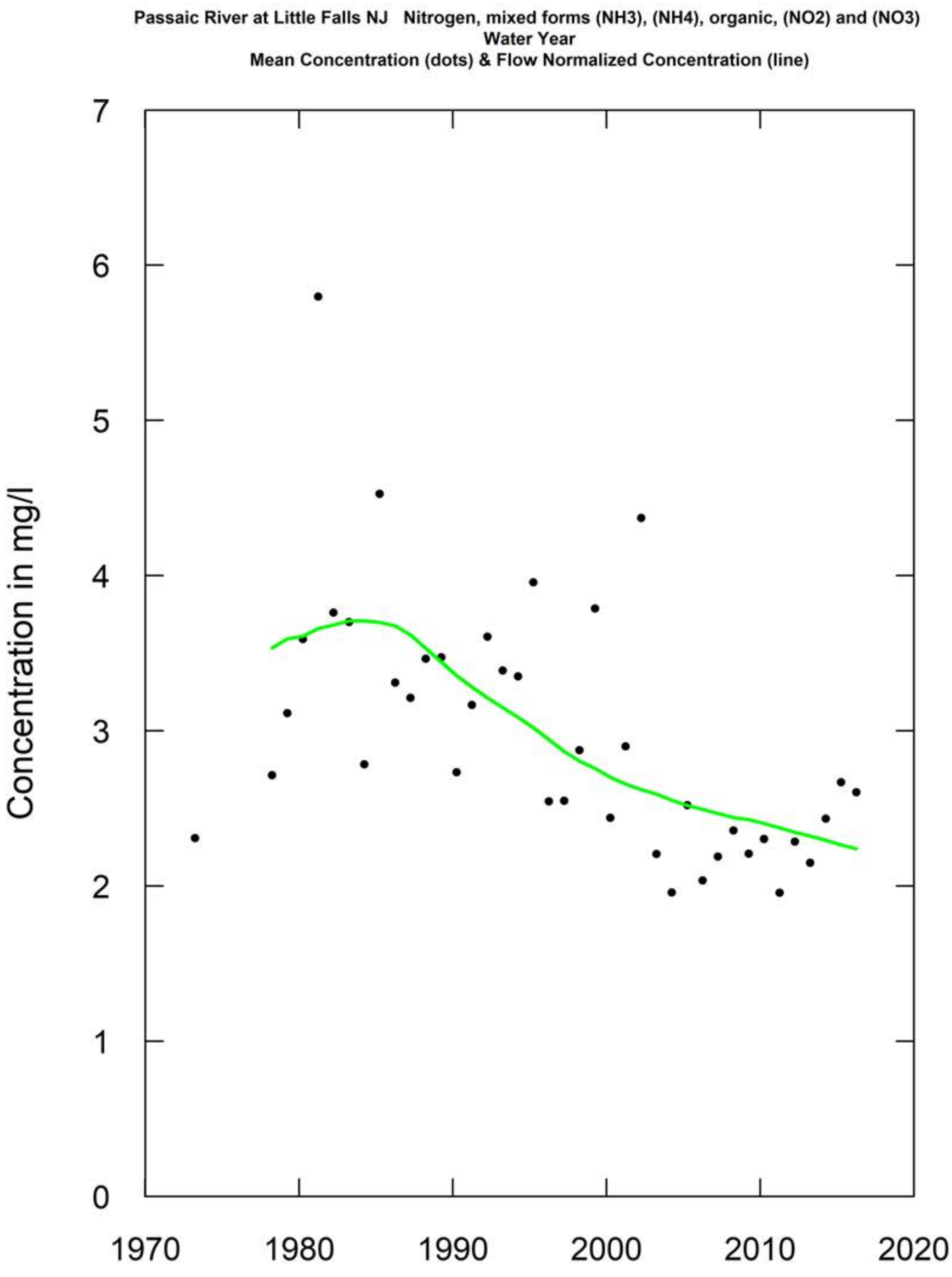

Passaic River at Little Falls NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.0275
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

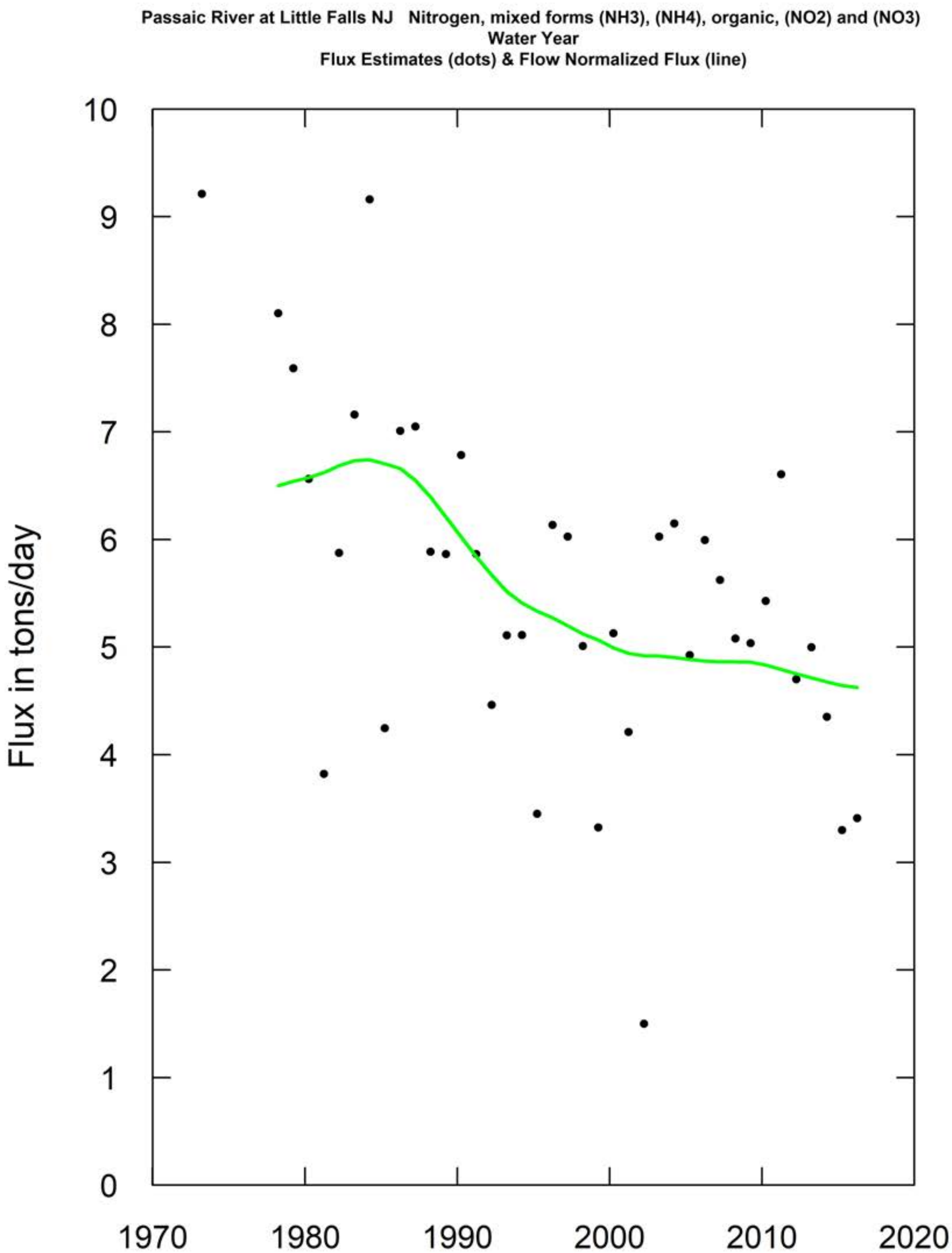

Passaic River at Little Falls NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
4
3.5
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

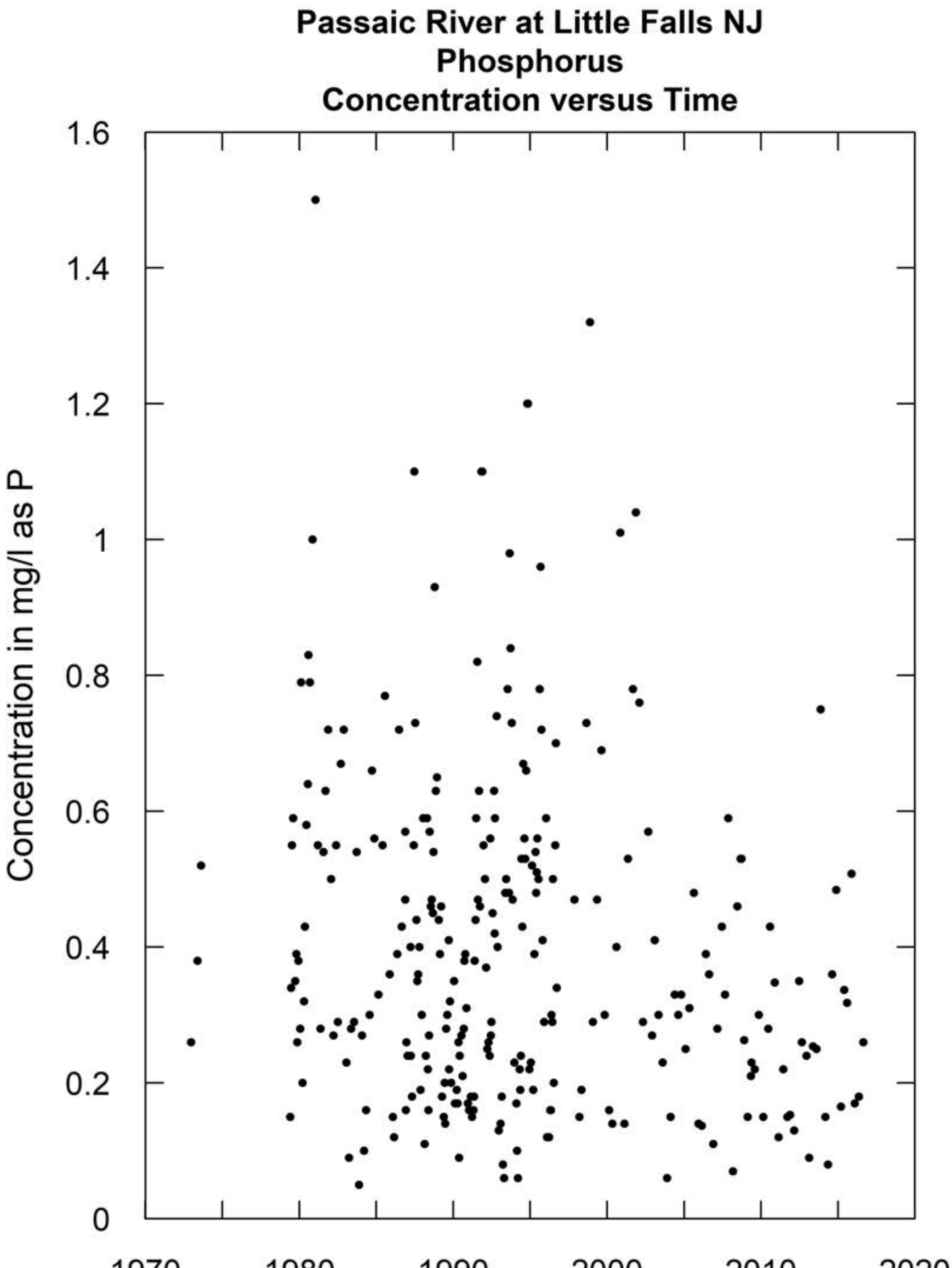

Passaic River at Little Falls NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

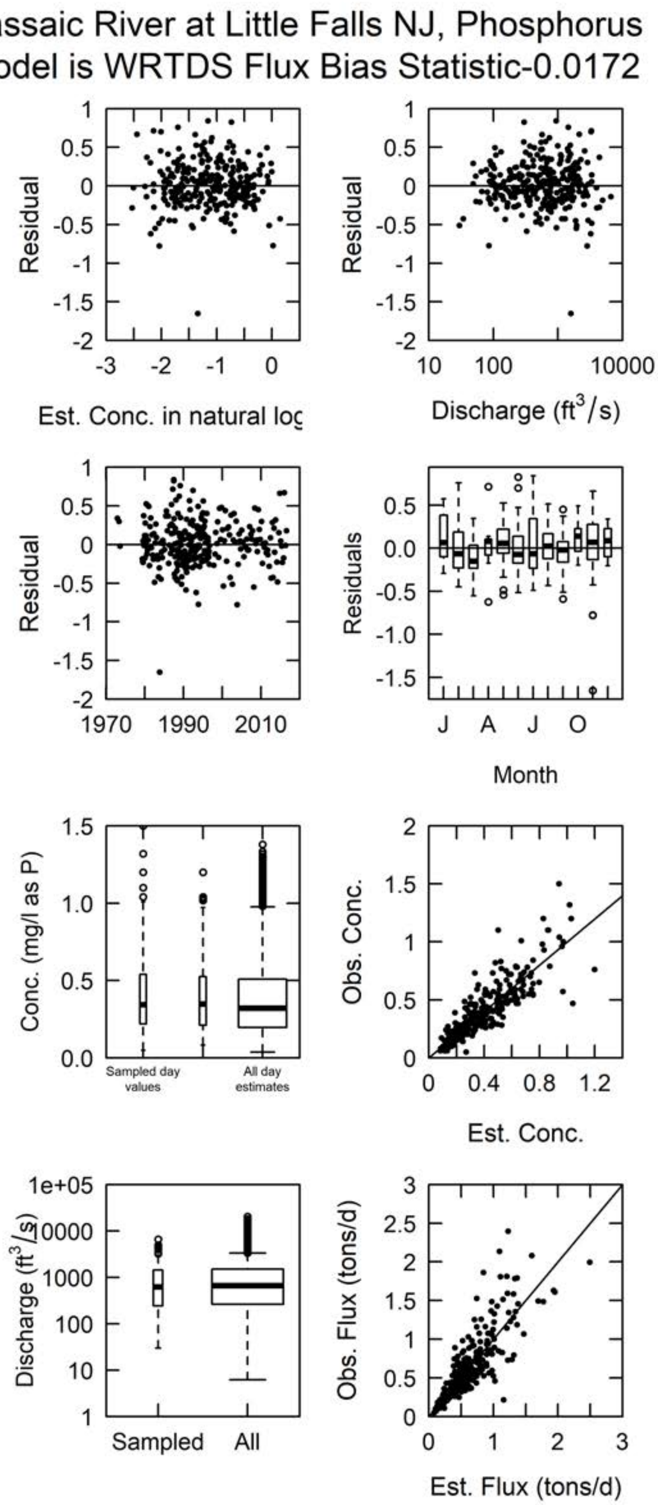

Passaic River at Little Falls NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
2
4
6
8
10
12
14
16
1970
1980
1990
2000
2010
2020

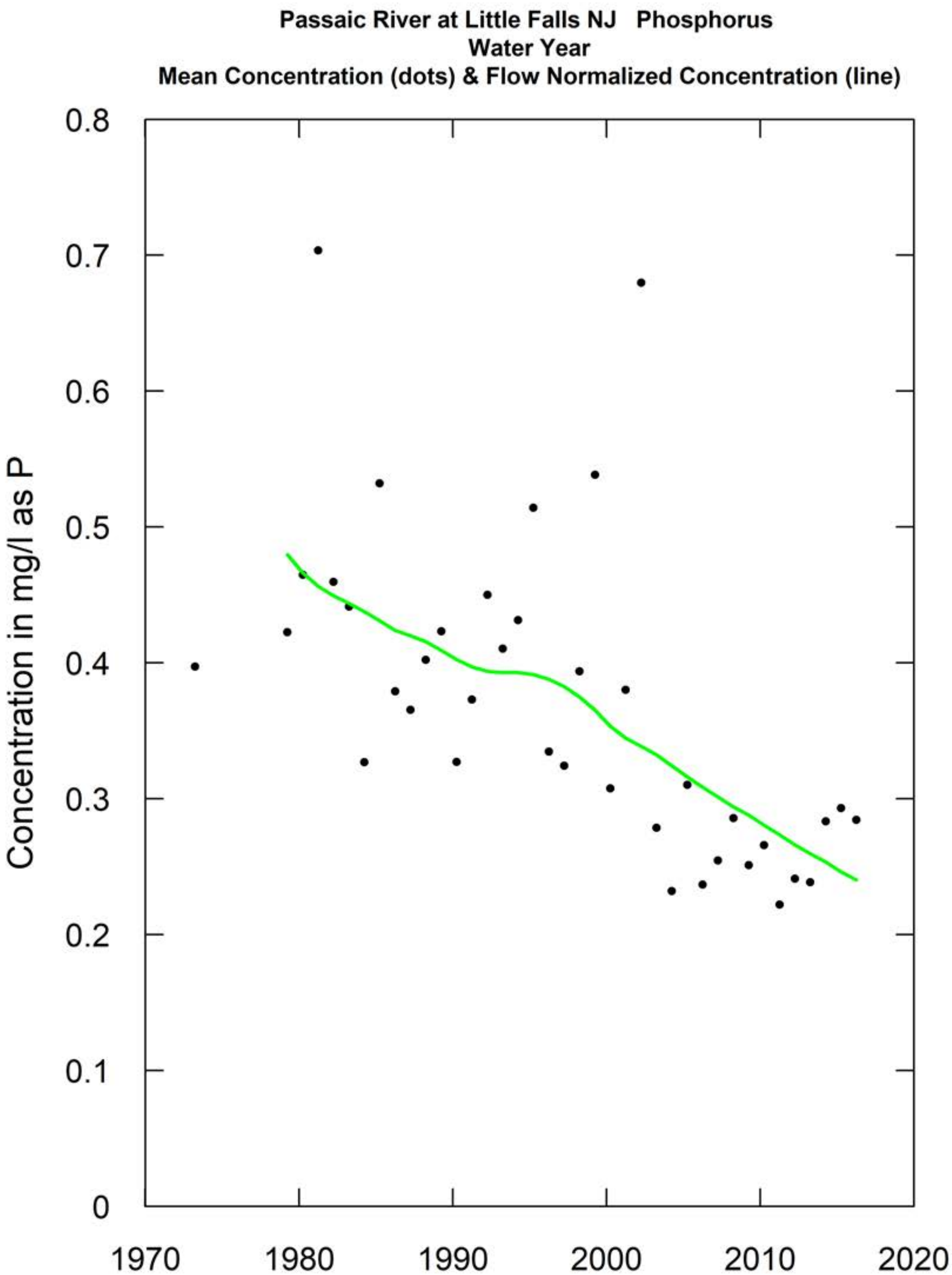

Passaic River at Little Falls NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic-0.0187
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

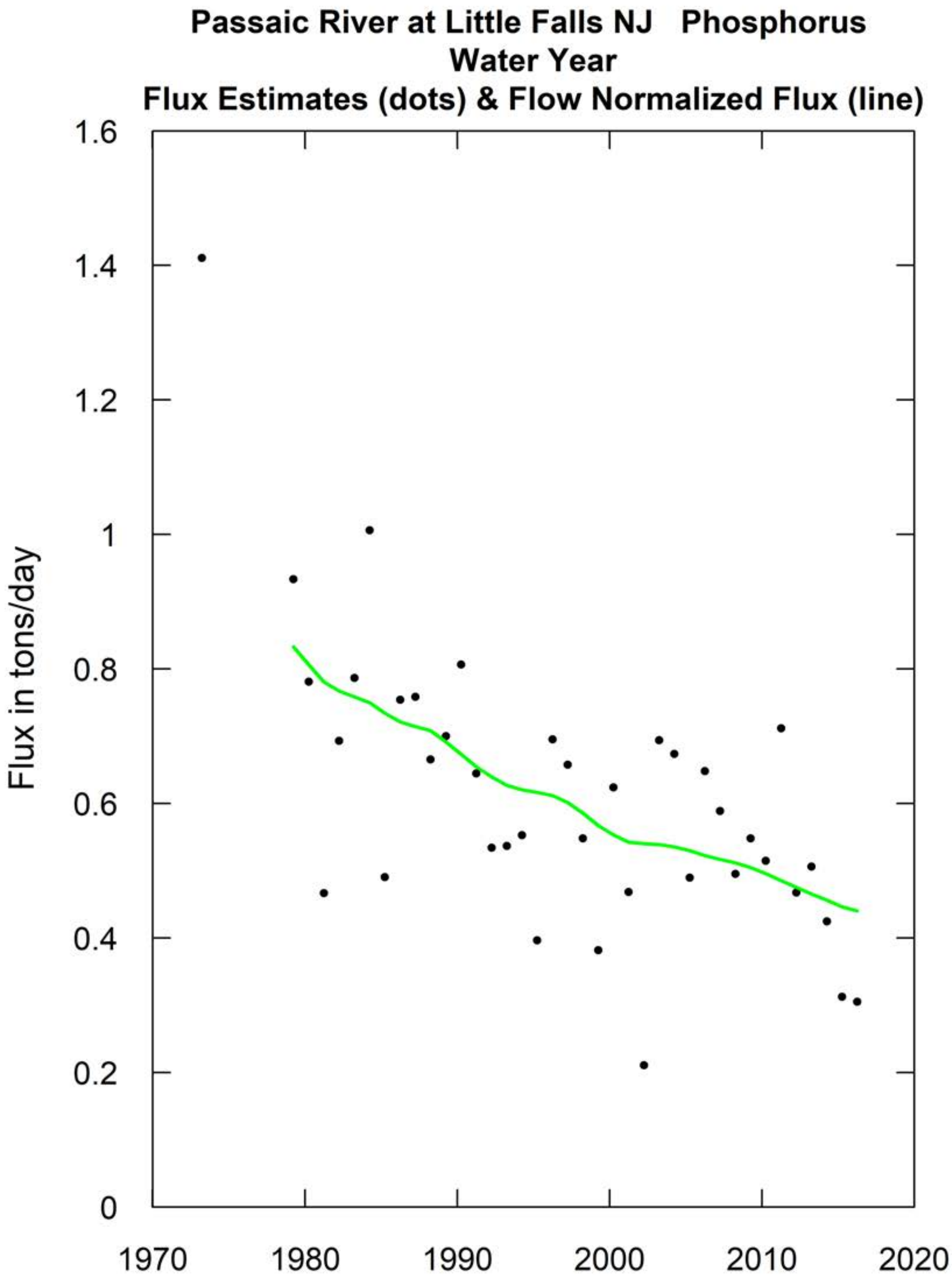

Passaic River at Little Falls NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0
1
2
3
4
5
6
7
1970
1980
1990
2000
2010
2020

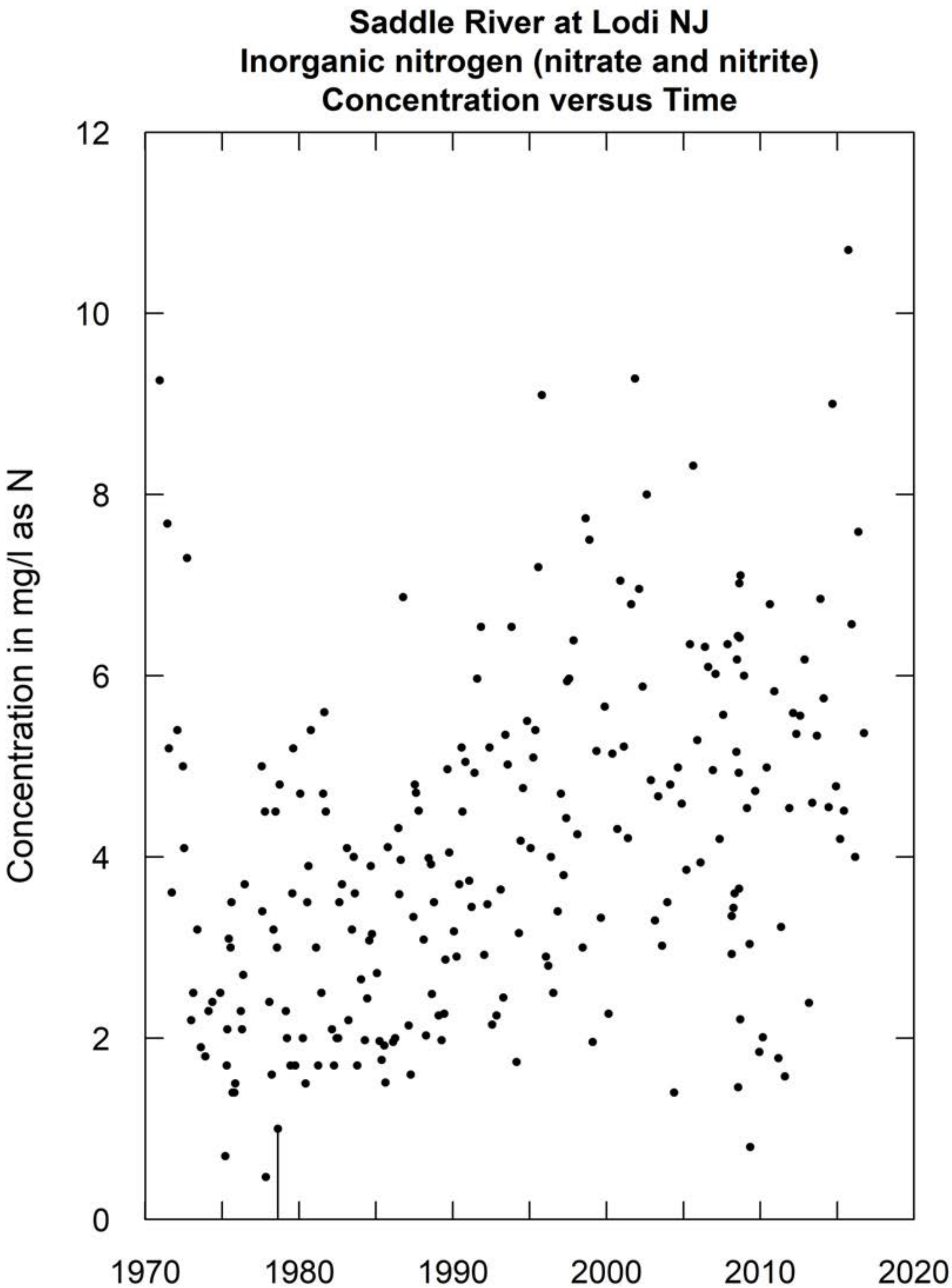

Passaic River at Little Falls NJ   Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0
1
2
3
4
5
6
7
8
9
10
1970
1980
1990
2000
2010
2020

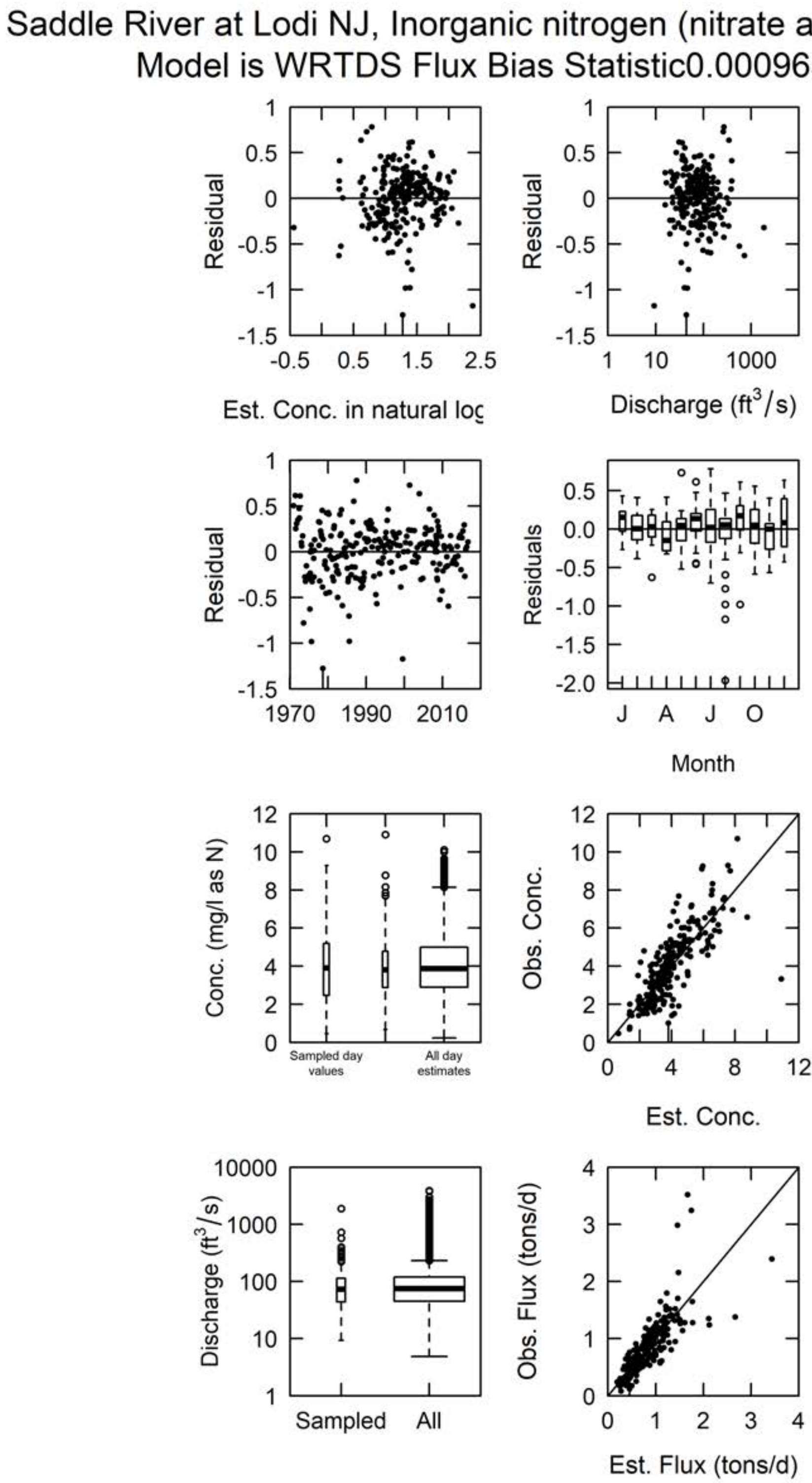

Passaic River at Little Falls NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1970
1980
1990
2000
2010
2020

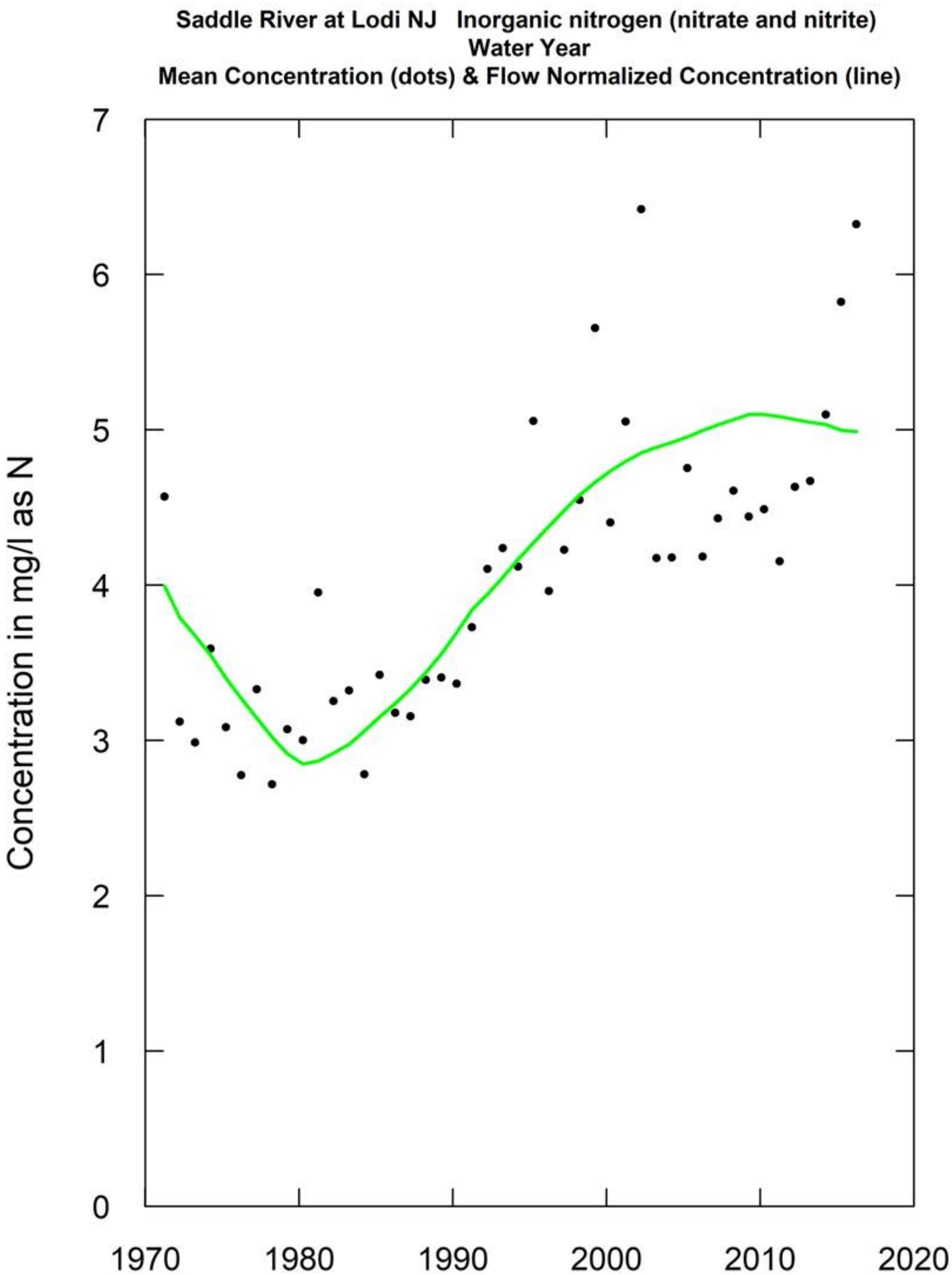

Passaic River at Little Falls NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.0172
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

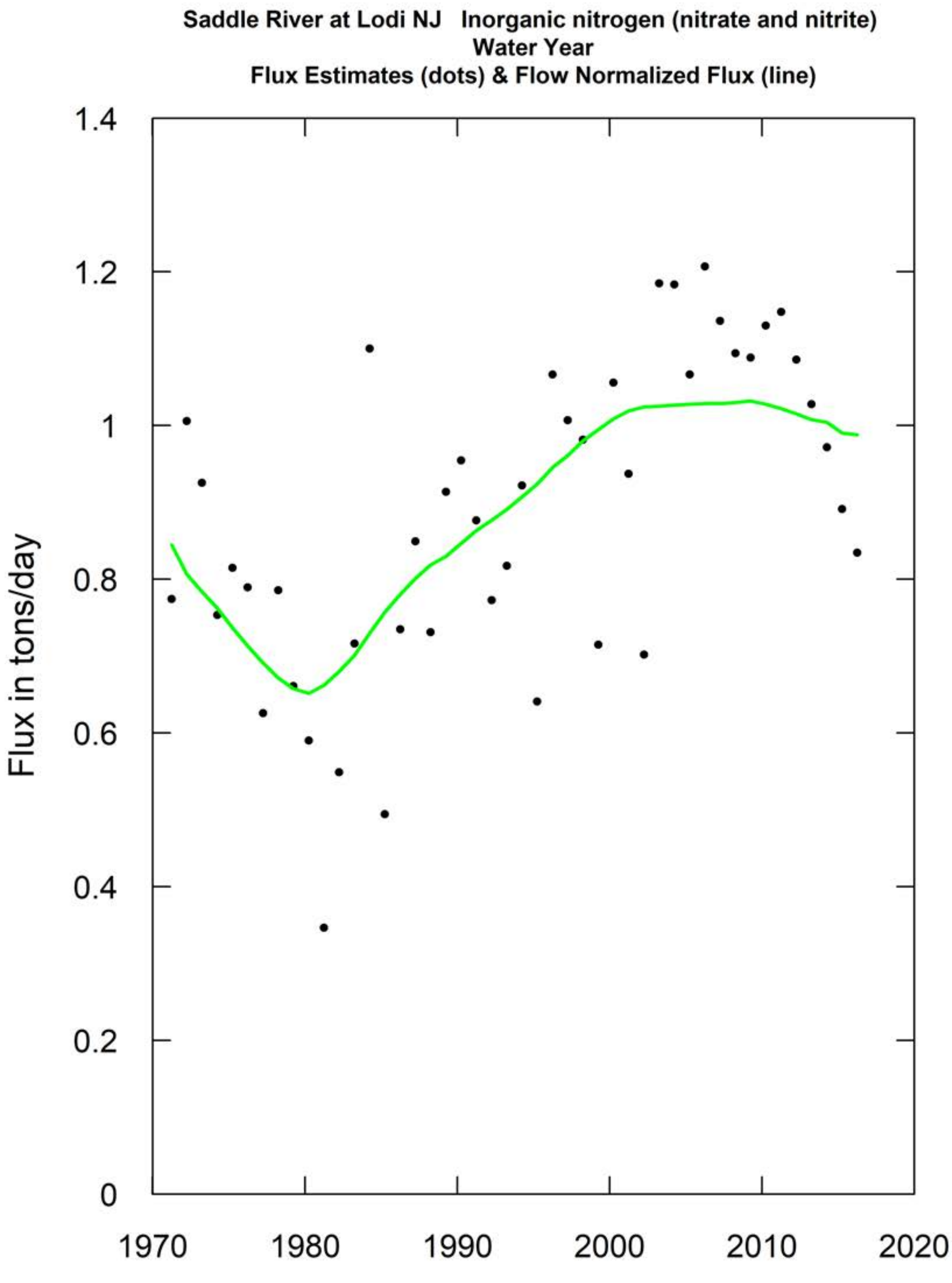

Passaic River at Little Falls NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1970
1980
1990
2000
2010
2020

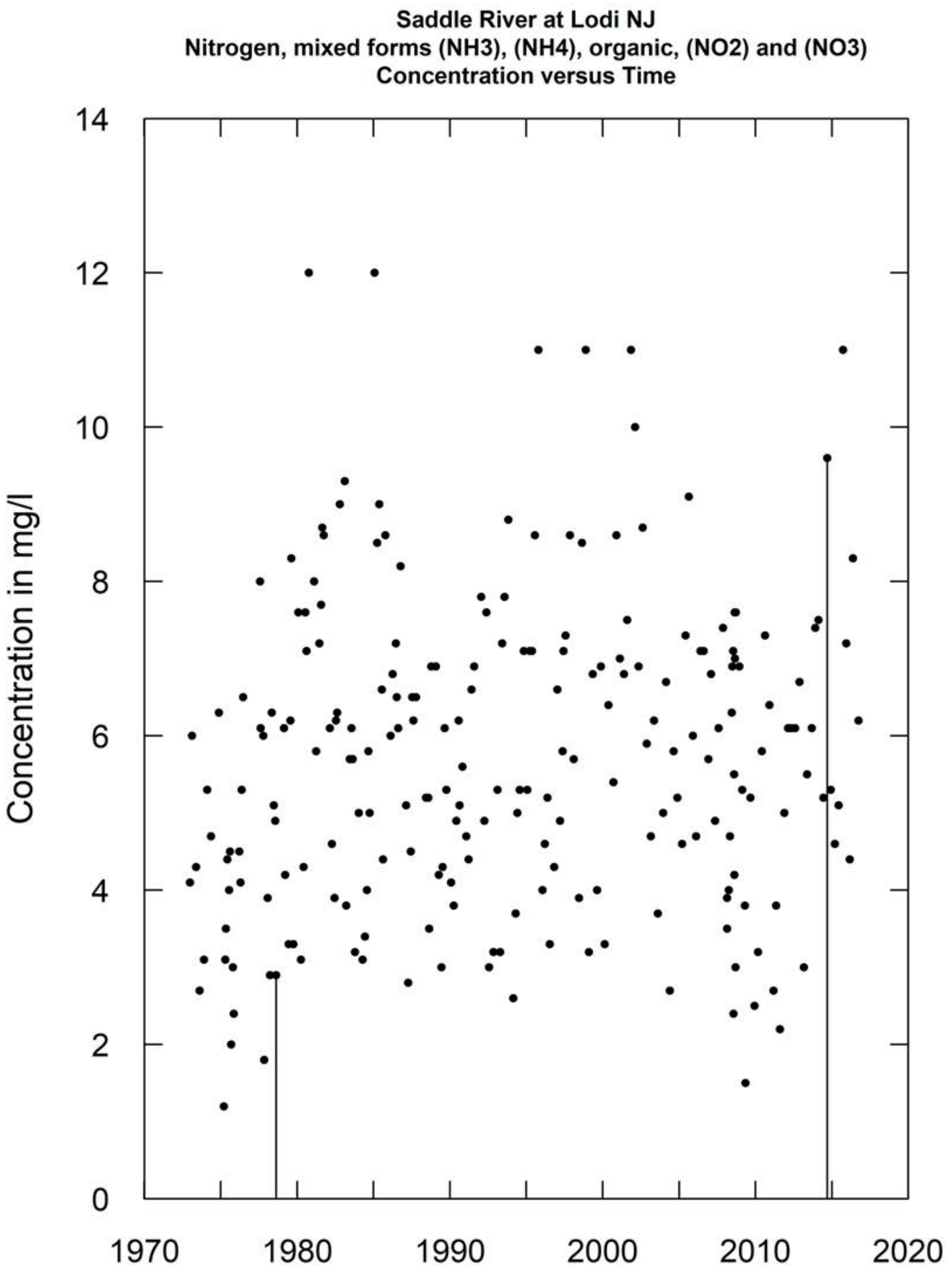

Passaic River at Little Falls NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

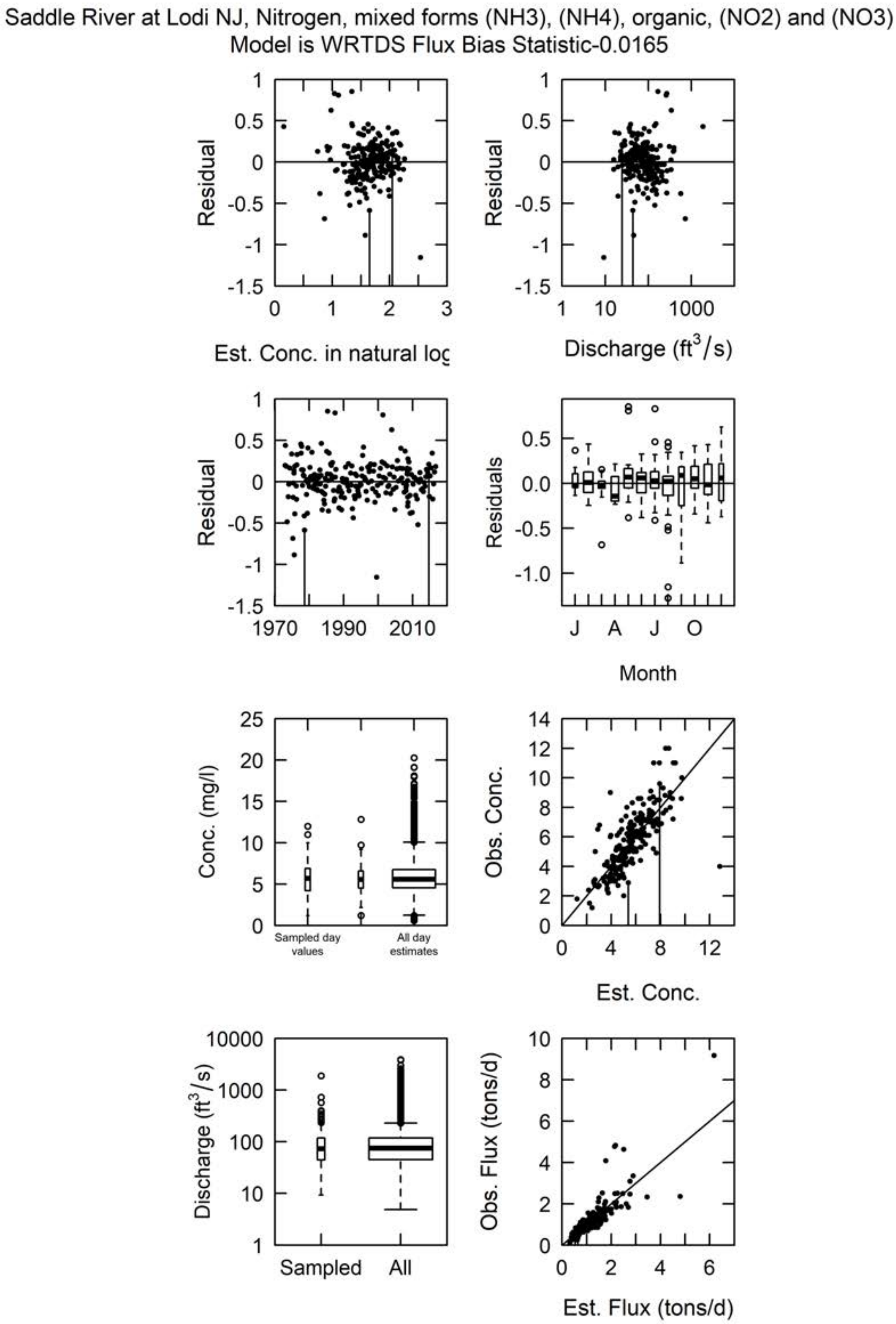

Saddle River at Lodi NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
0
2
4
6
8
10
12
1970
1980
1990
2000
2010
2020


Saddle River at Lodi NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.000965
Residual
Est. Conc. in natural log
Discharge (ft³/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

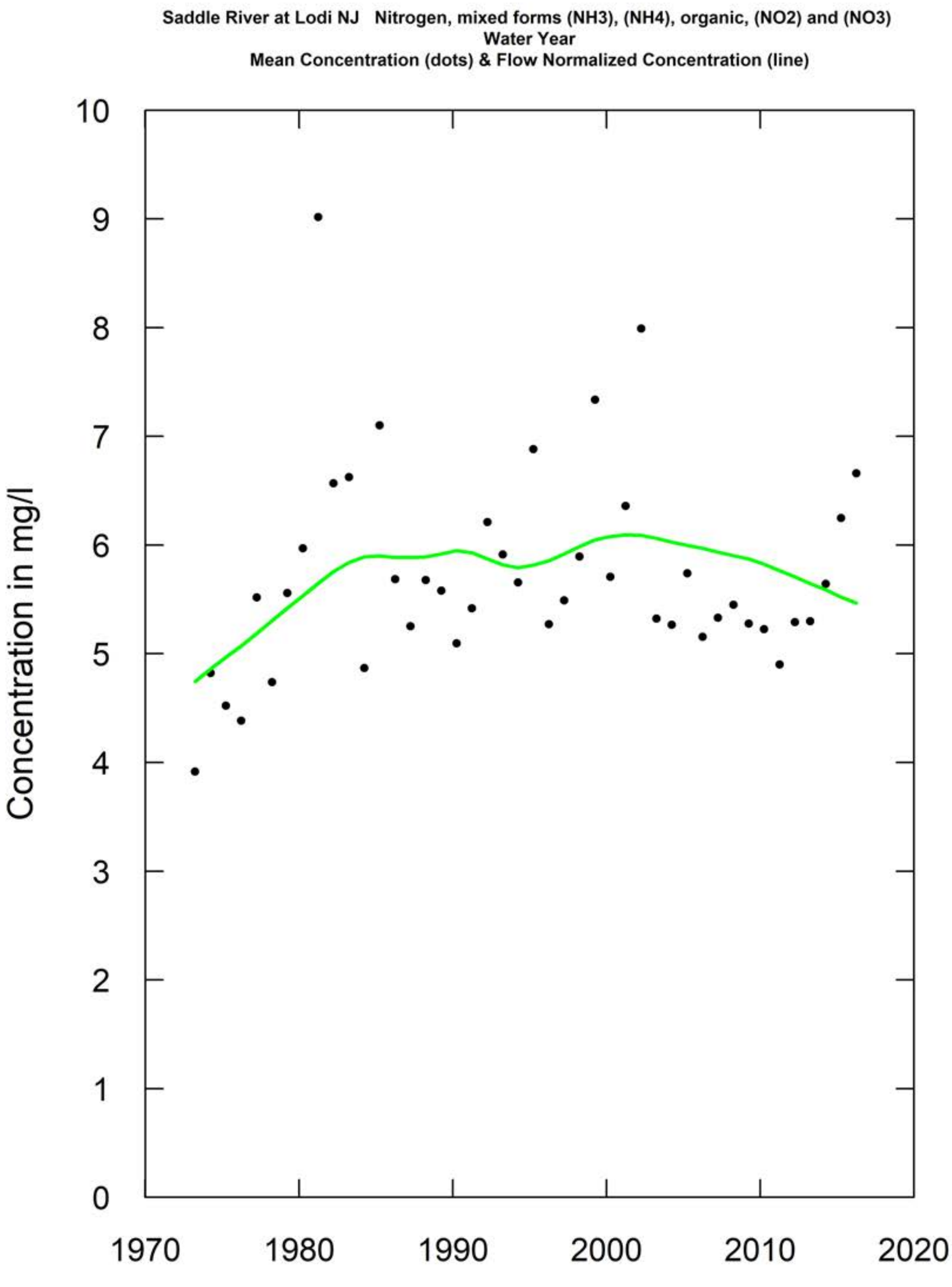

Saddle River at Lodi NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0
1
2
3
4
5
6
7
1970
1980
1990
2000
2010
2020

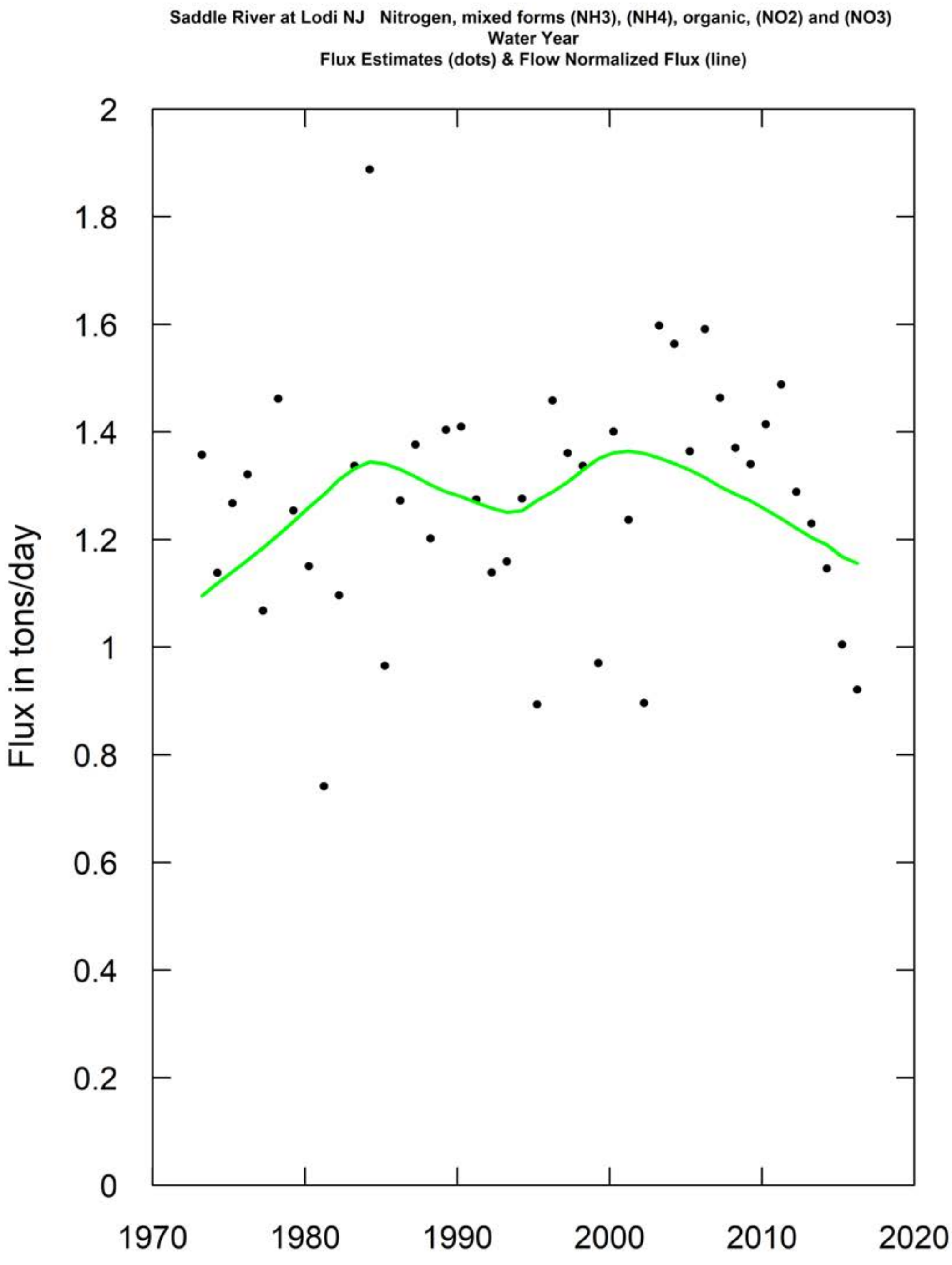

Saddle River at Lodi NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

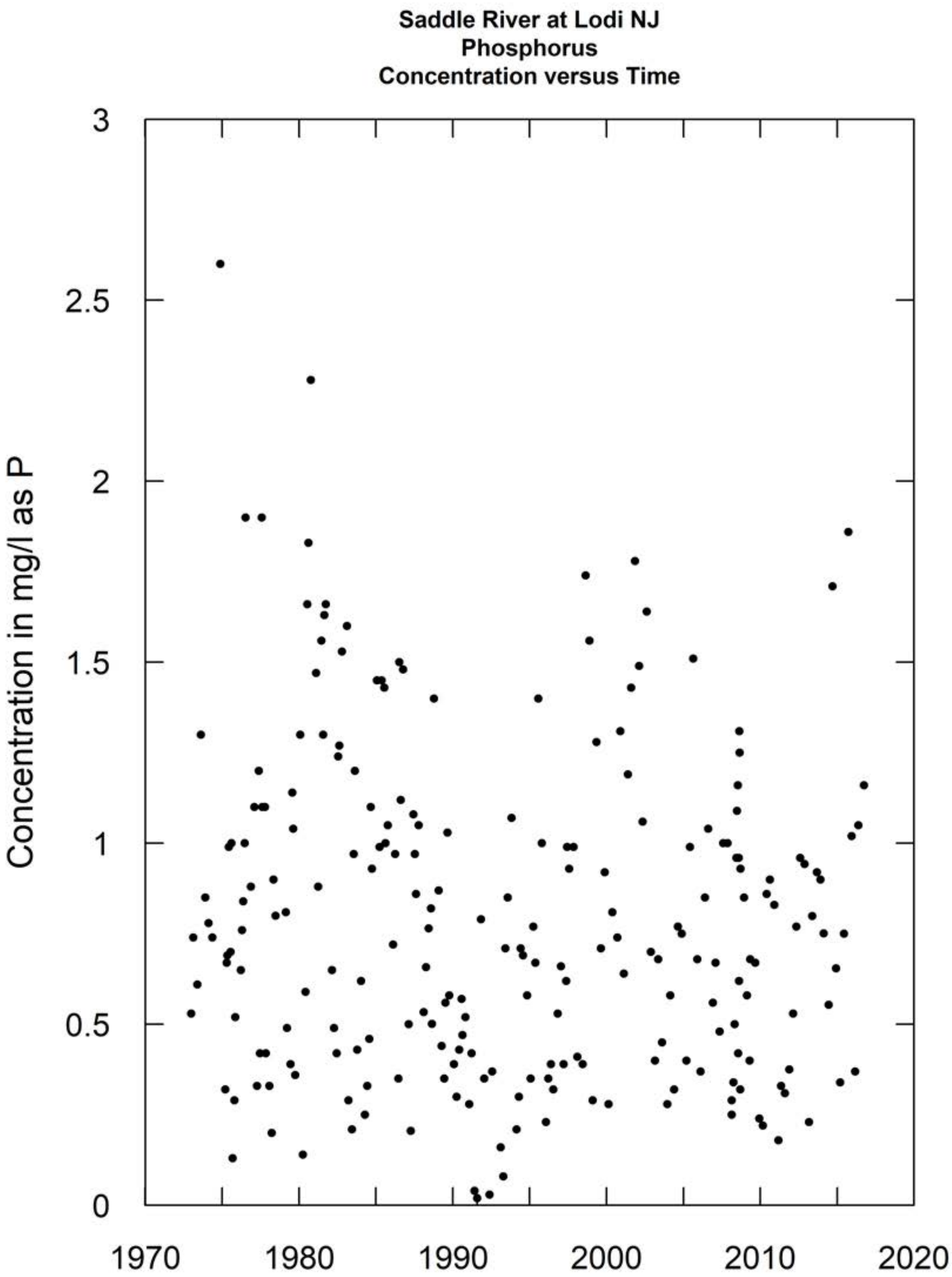

Saddle River at Lodi NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
2
4
6
8
10
12
14
1970
1980
1990
2000
2010
2020

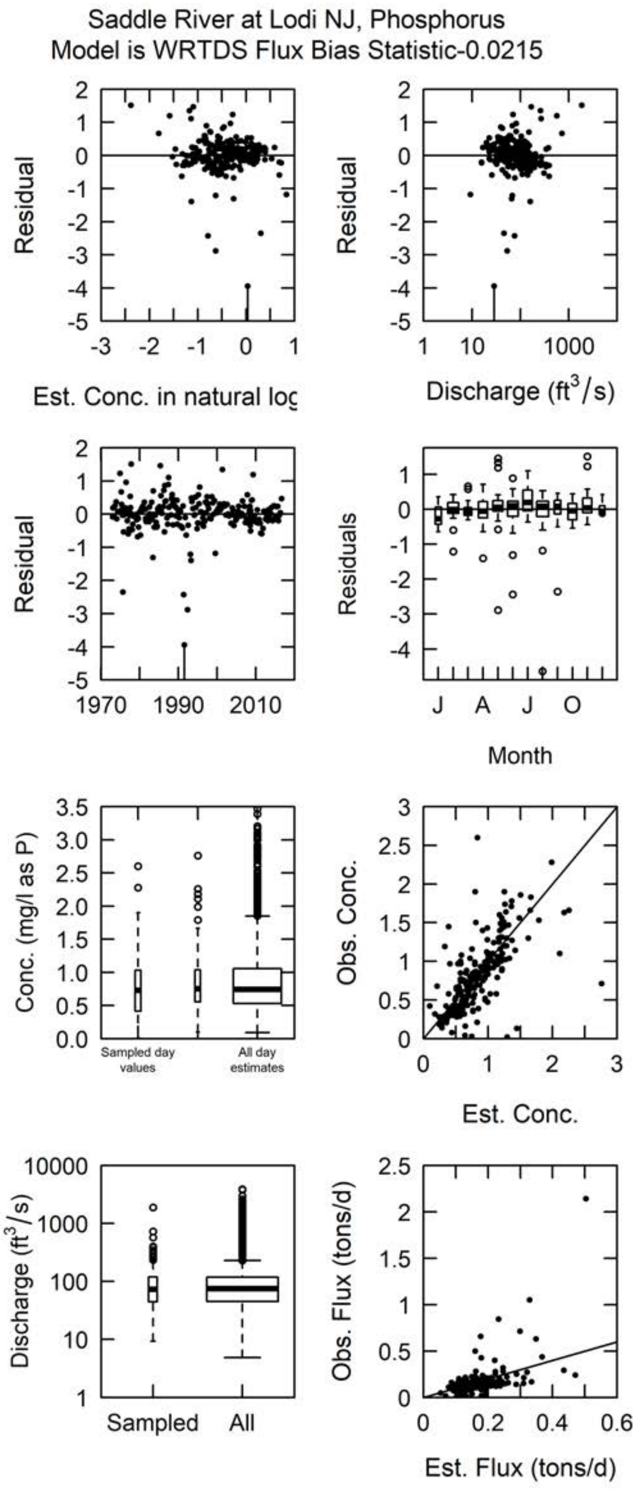


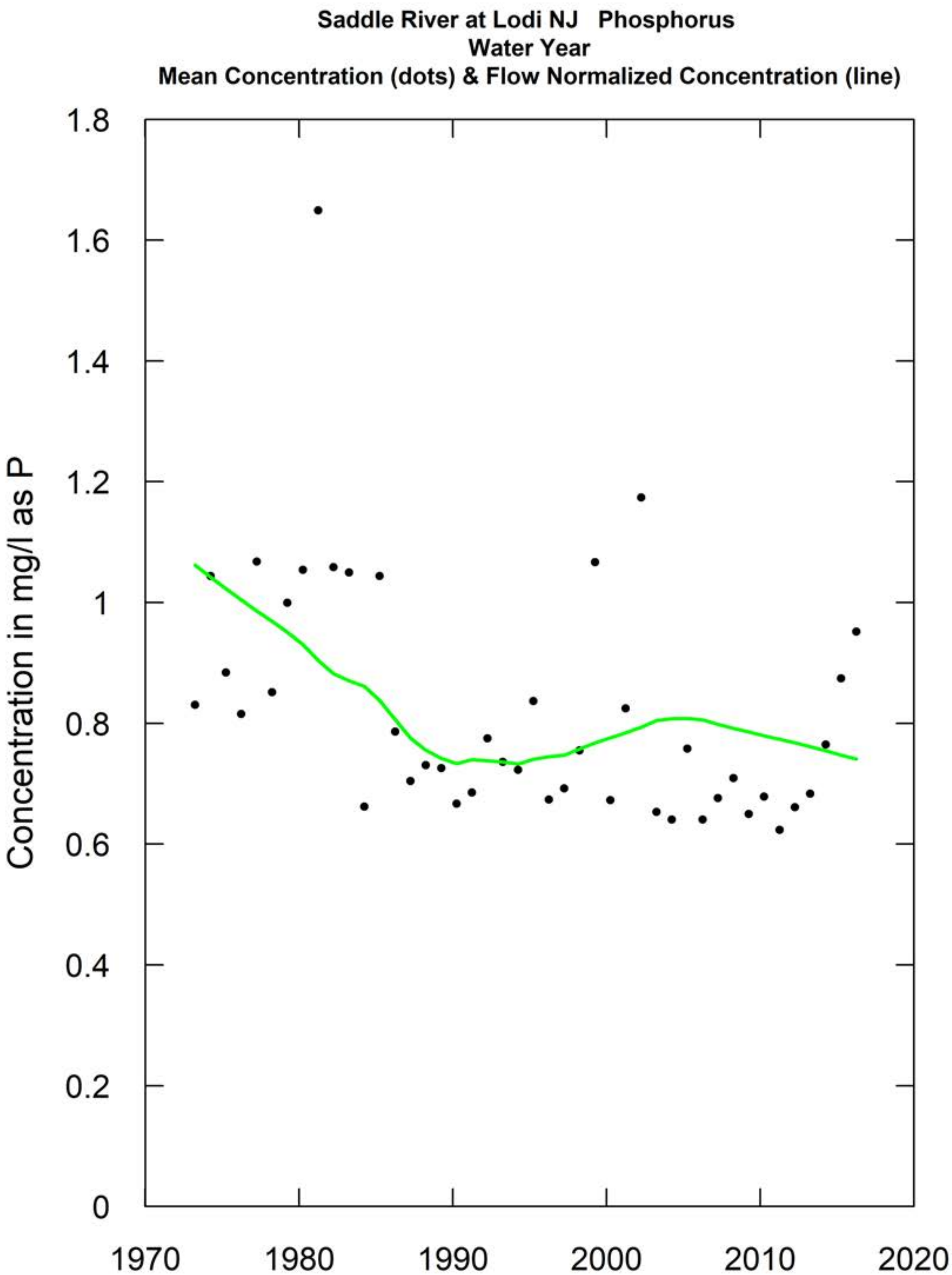
Saddle River at Lodi NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic-0.0165
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

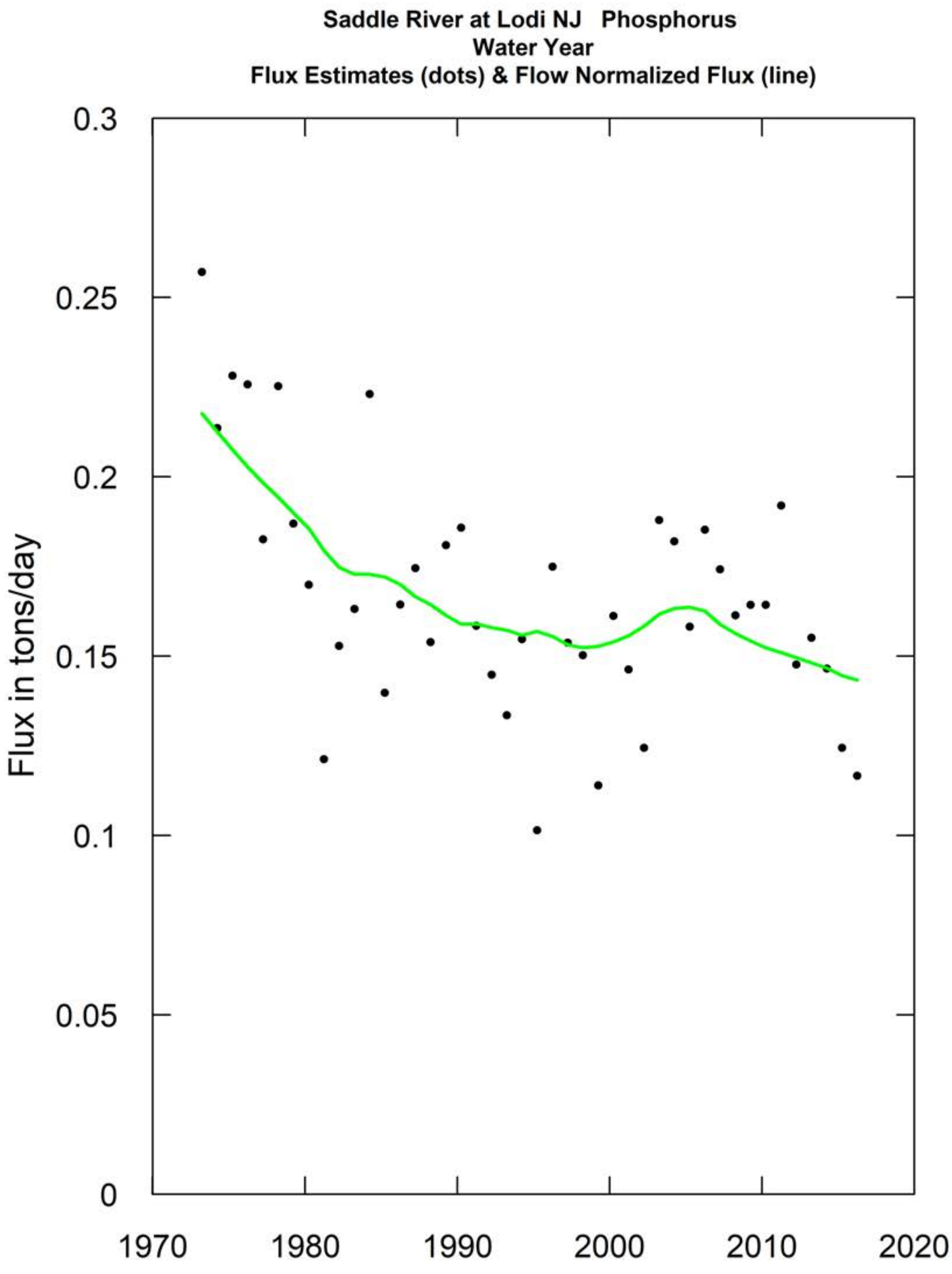

Saddle River at Lodi NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0
1
2
3
4
5
6
7
8
9
10
1970
1980
1990
2000
2010
2020


Saddle River at Lodi NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

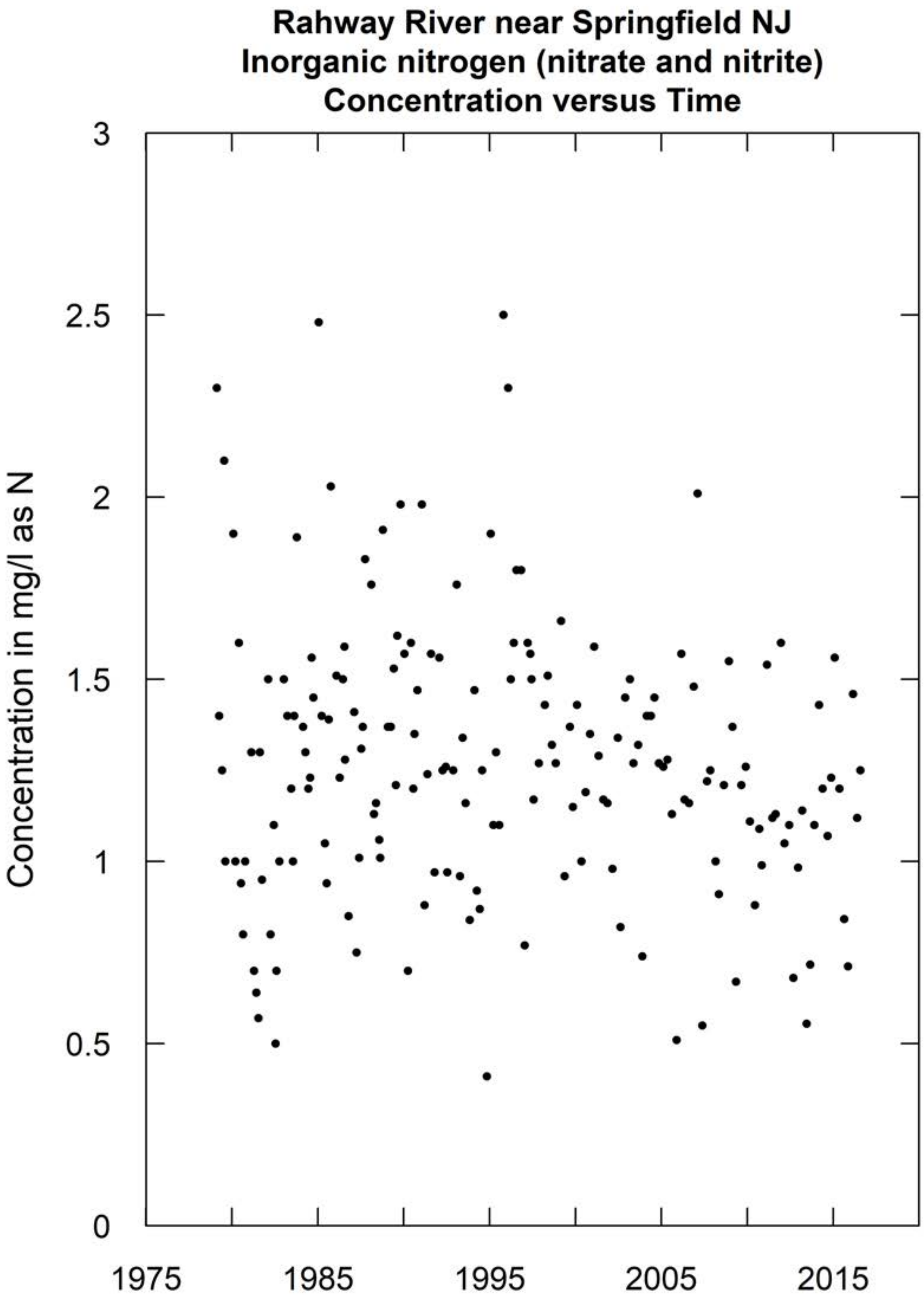

Saddle River at Lodi NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

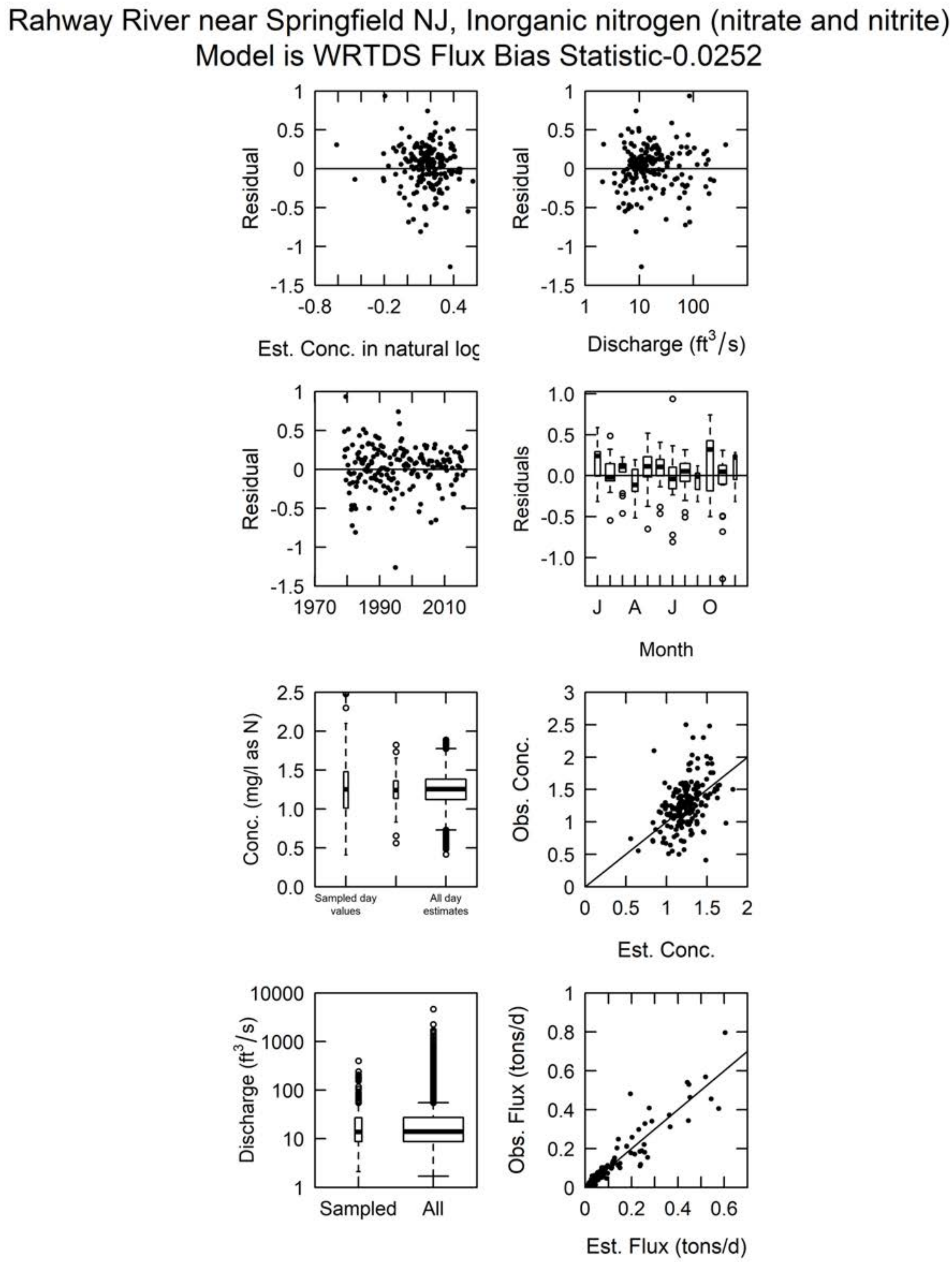

Saddle River at Lodi NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.0215
Residual
Est. Conc. in natural log
Residual
Discharge (ft³/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

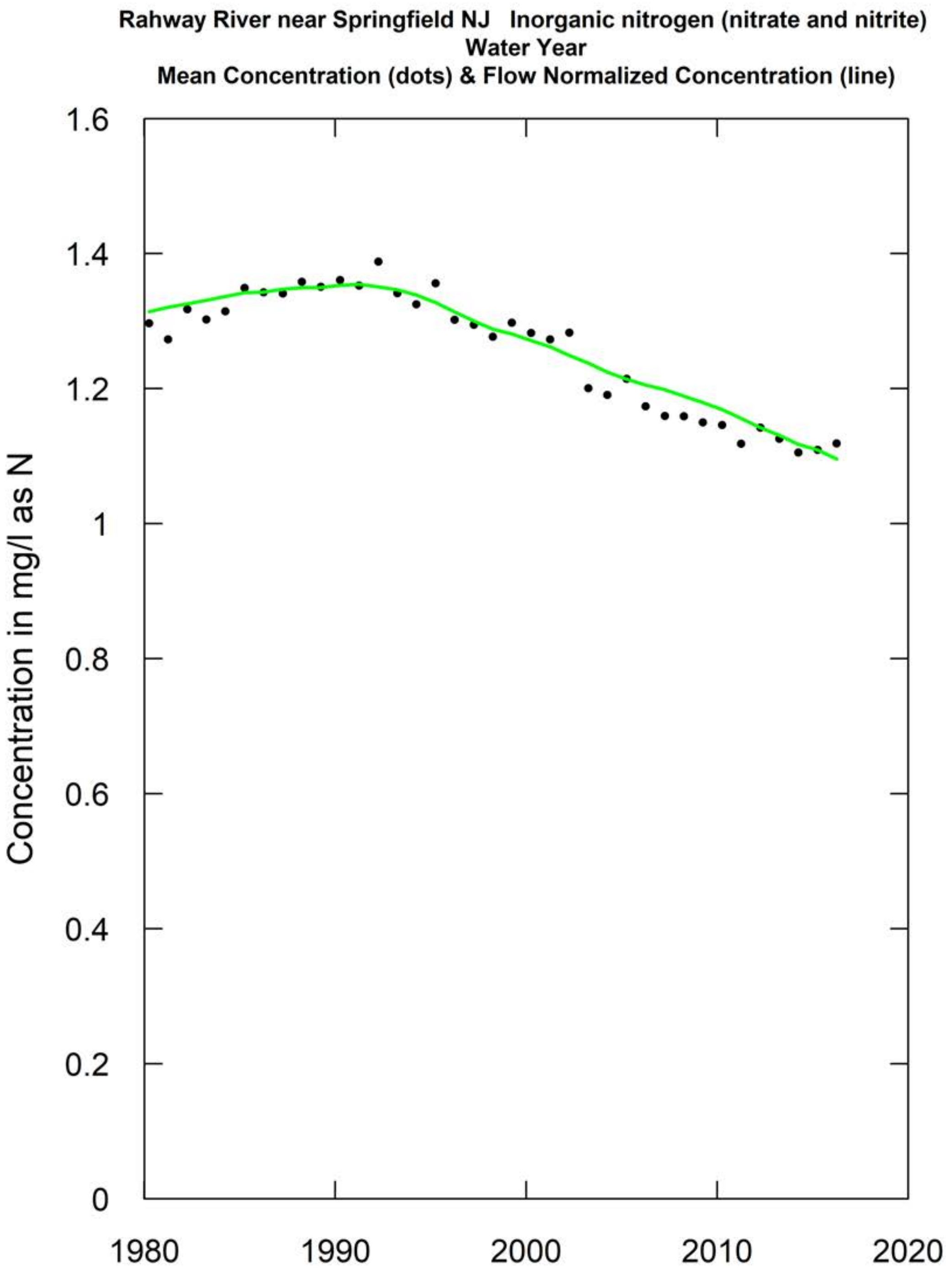

Saddle River at Lodi NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

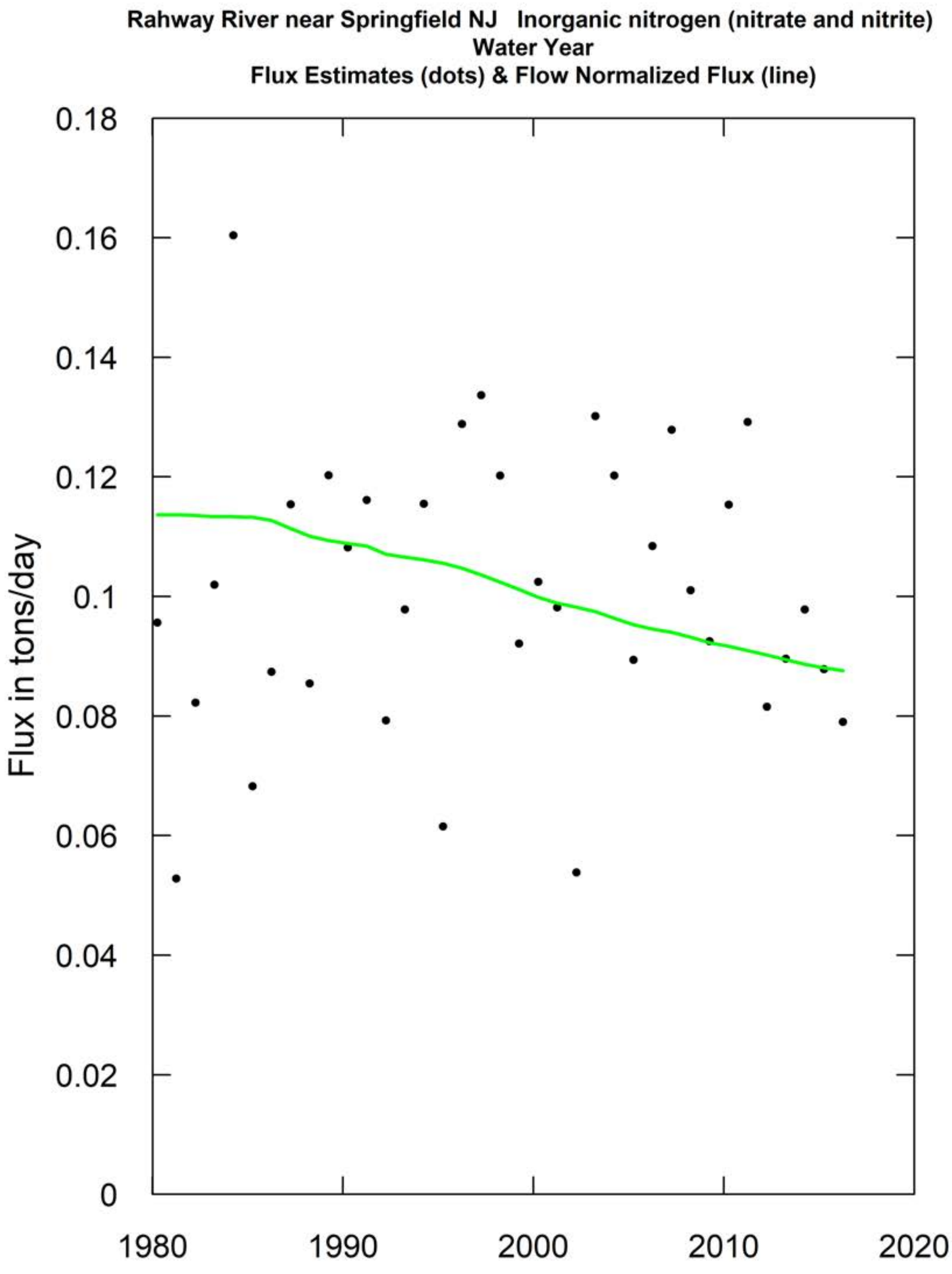


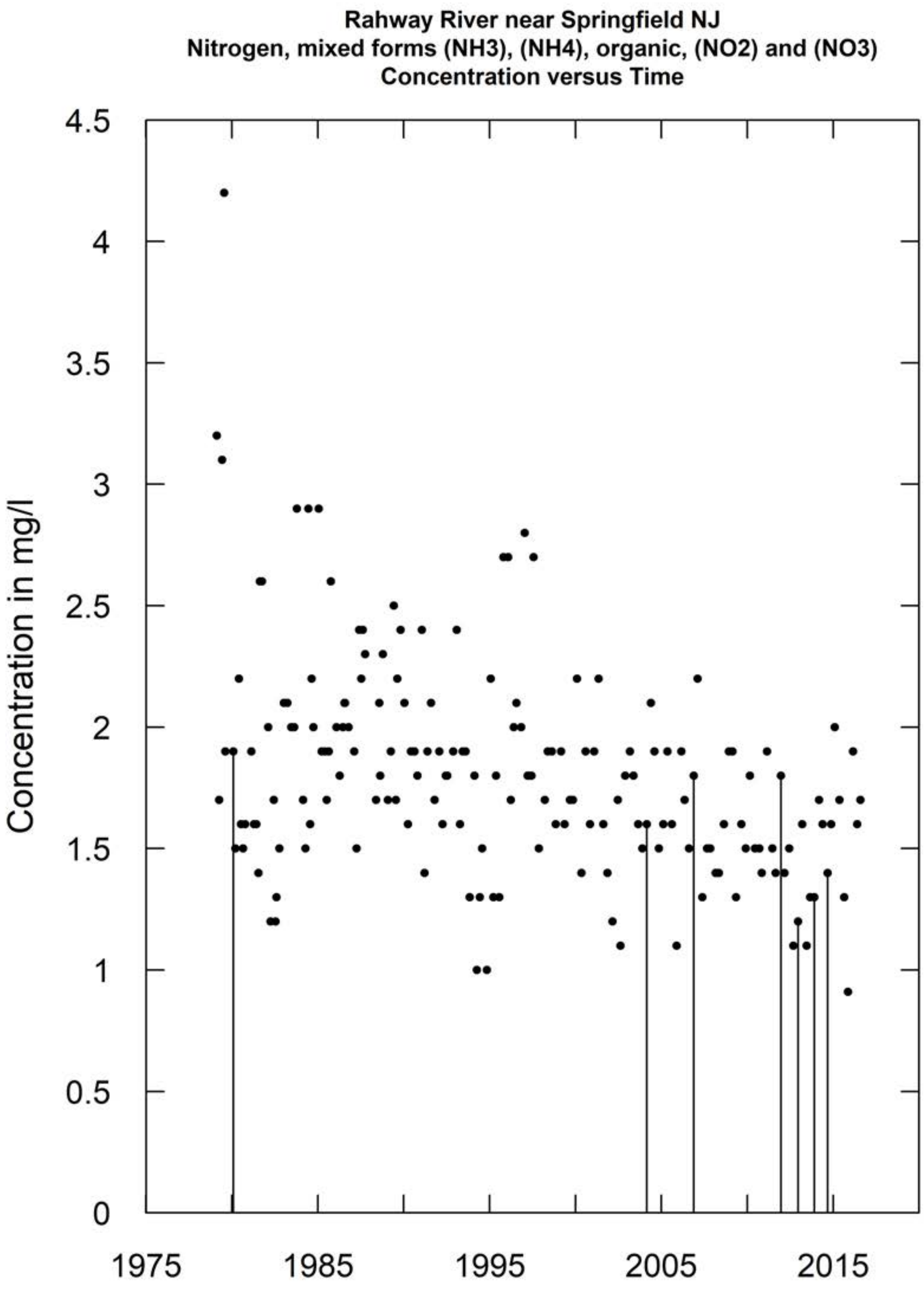
Saddle River at Lodi NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

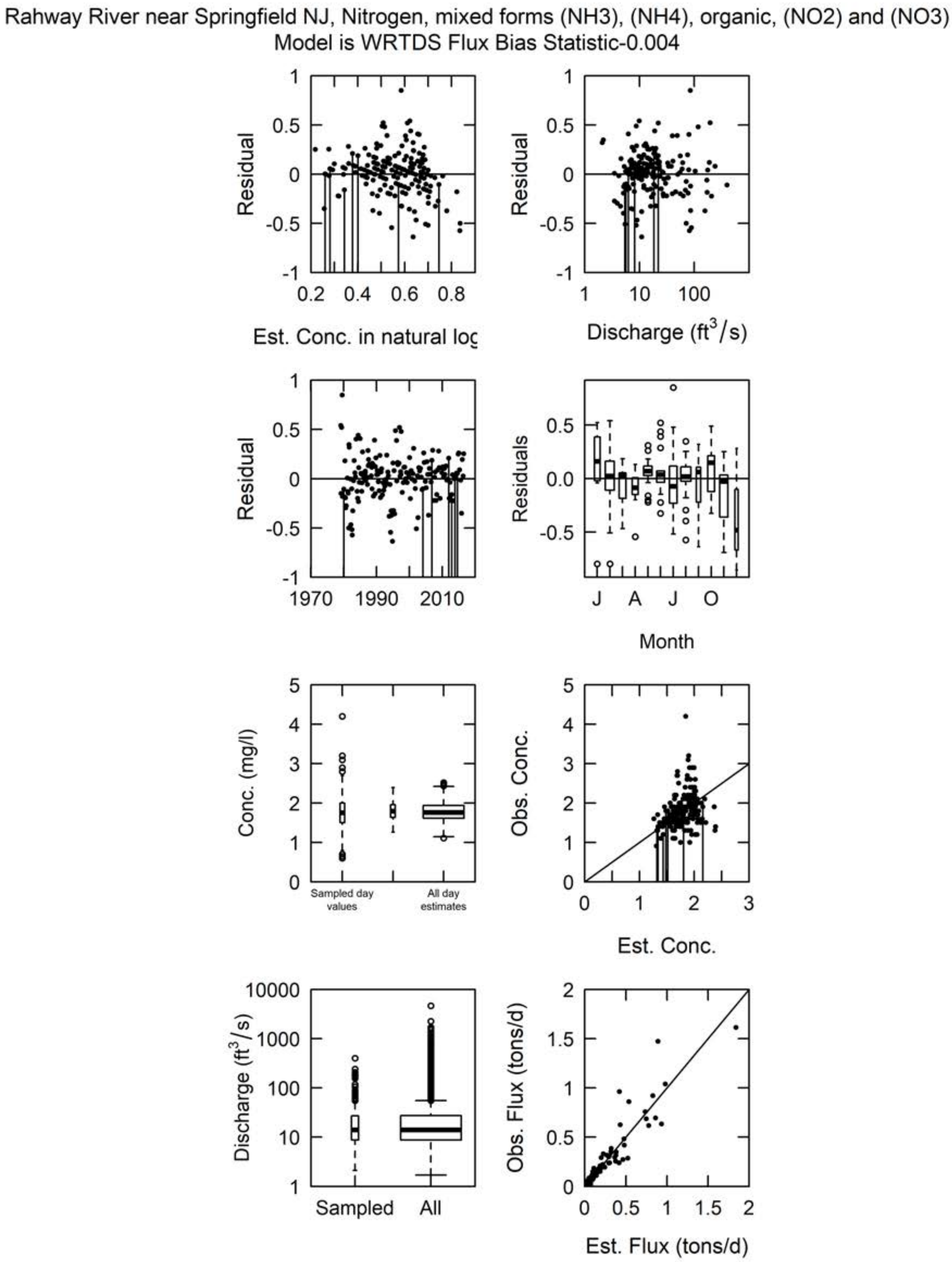

Rahway River near Springfield NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
3
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

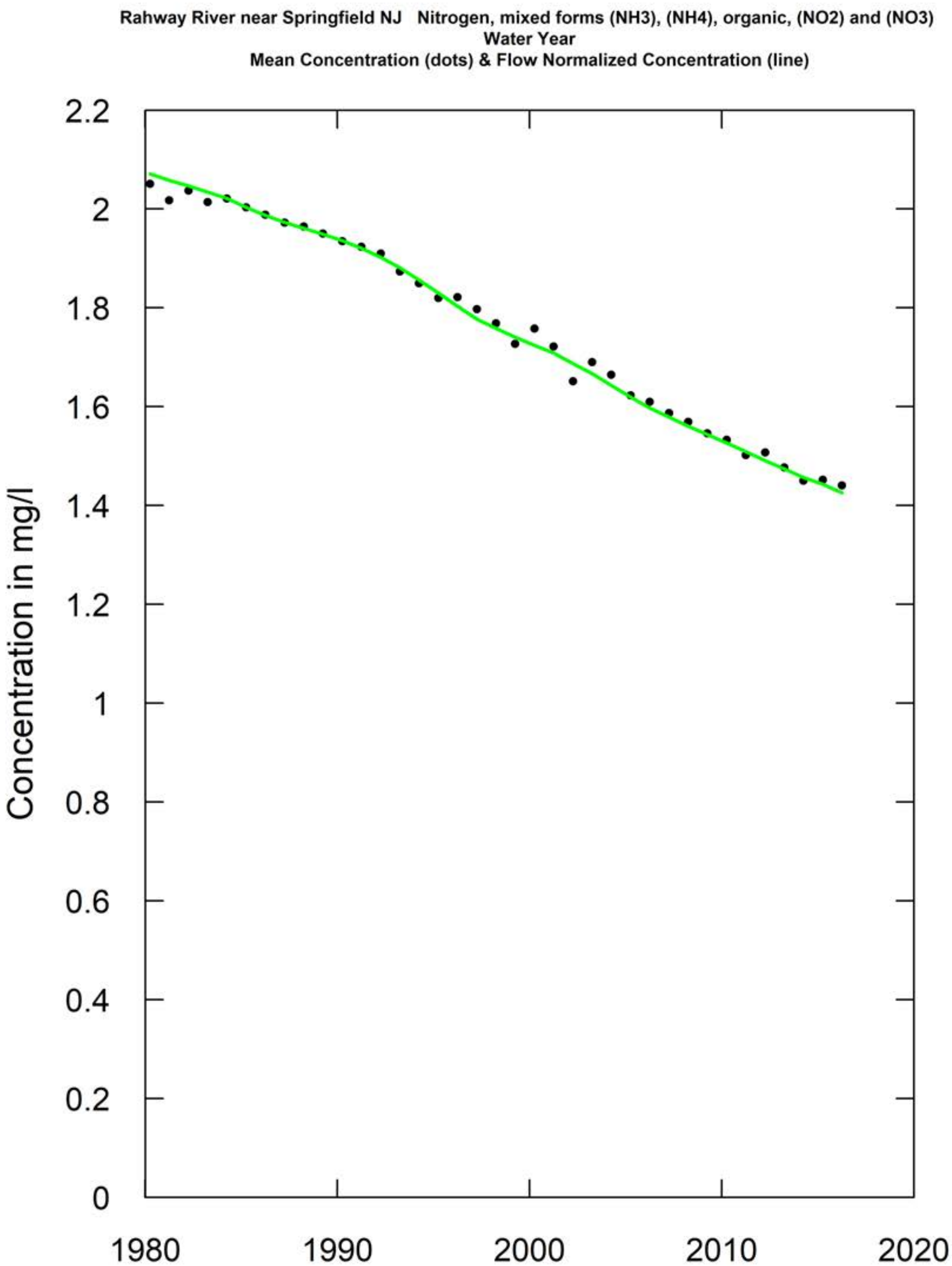

Rahway River near Springfield NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.0252
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)


Rahway River near Springfield NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

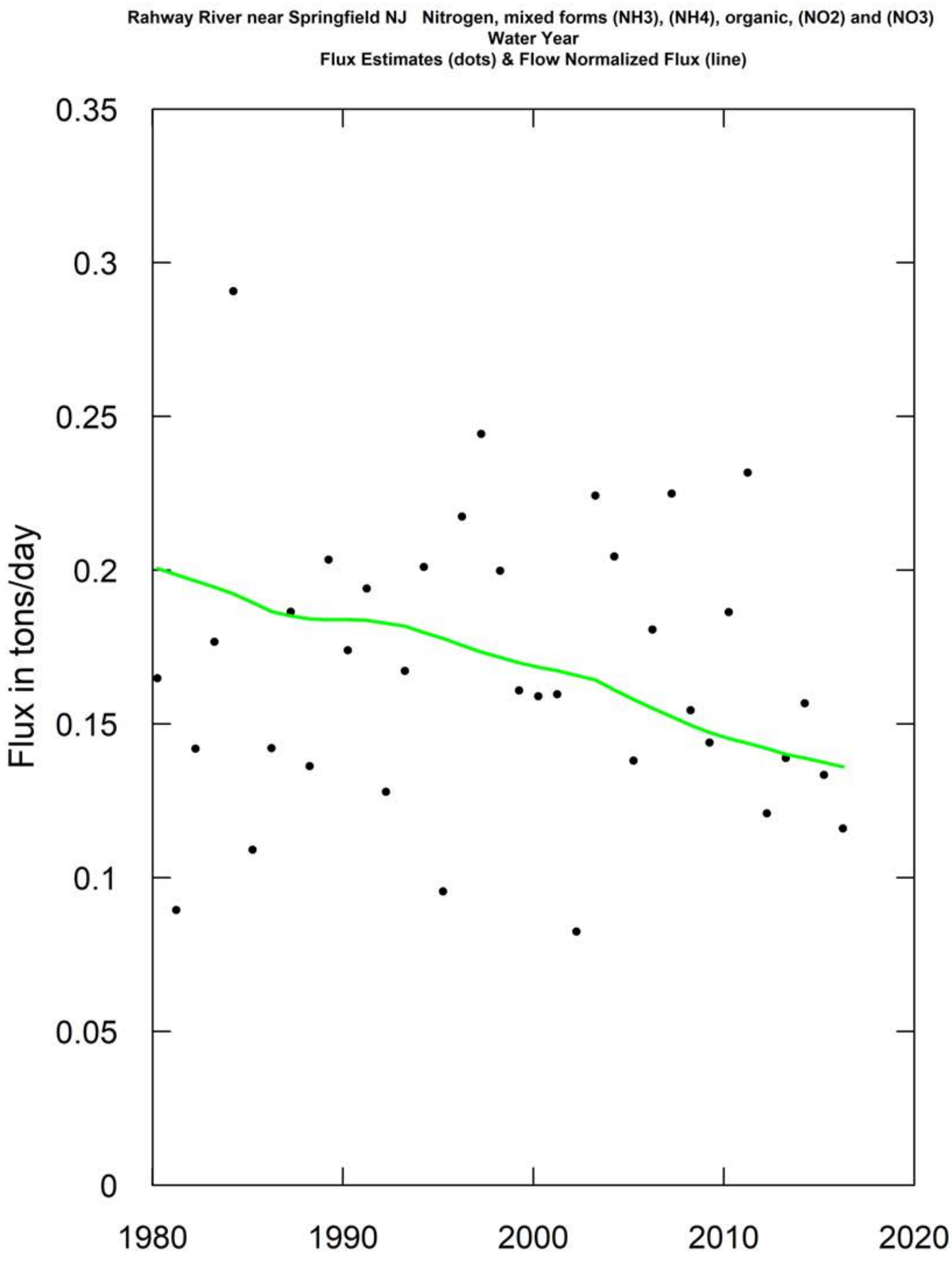

Rahway River near Springfield NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

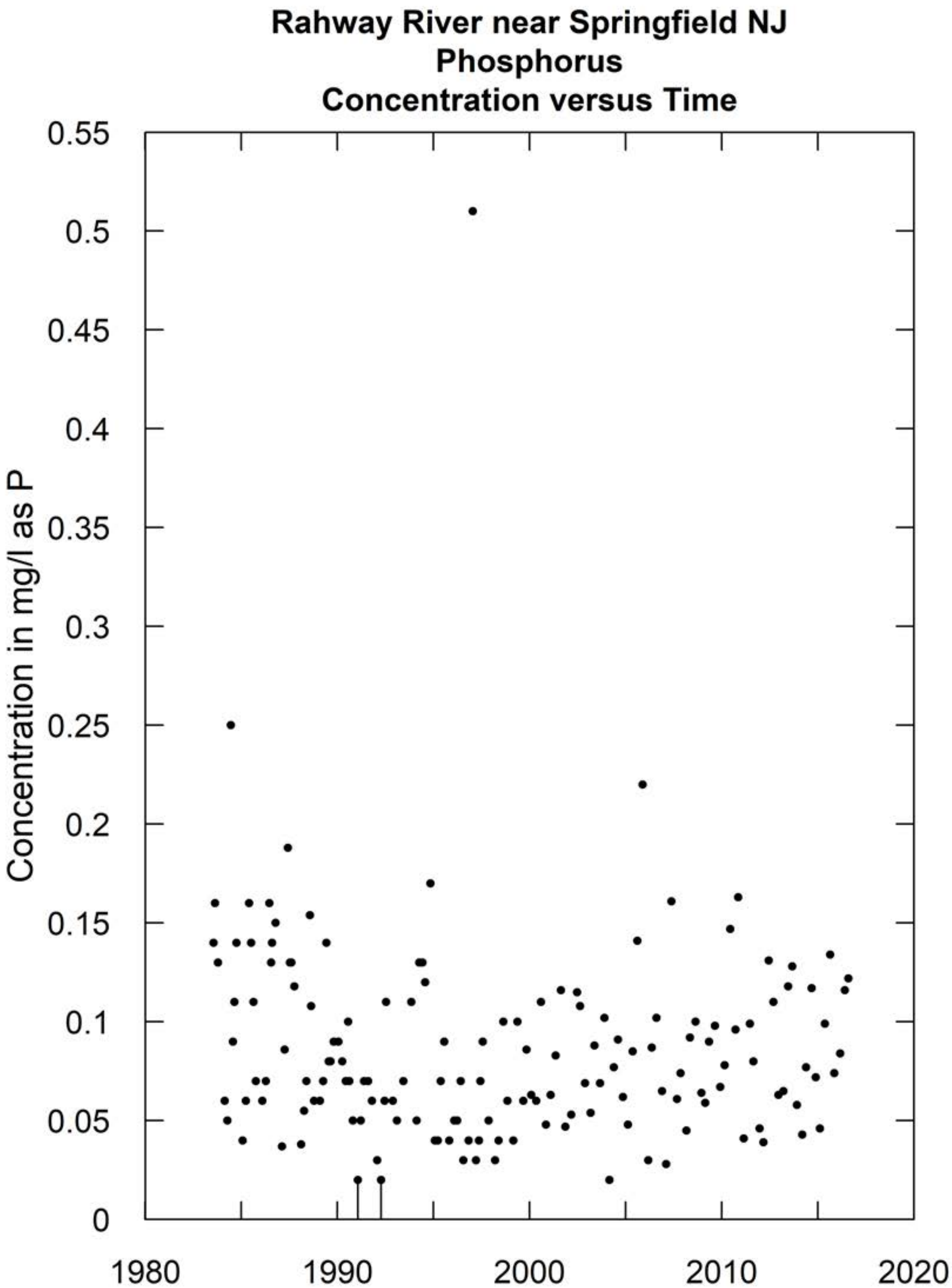

Rahway River near Springfield NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

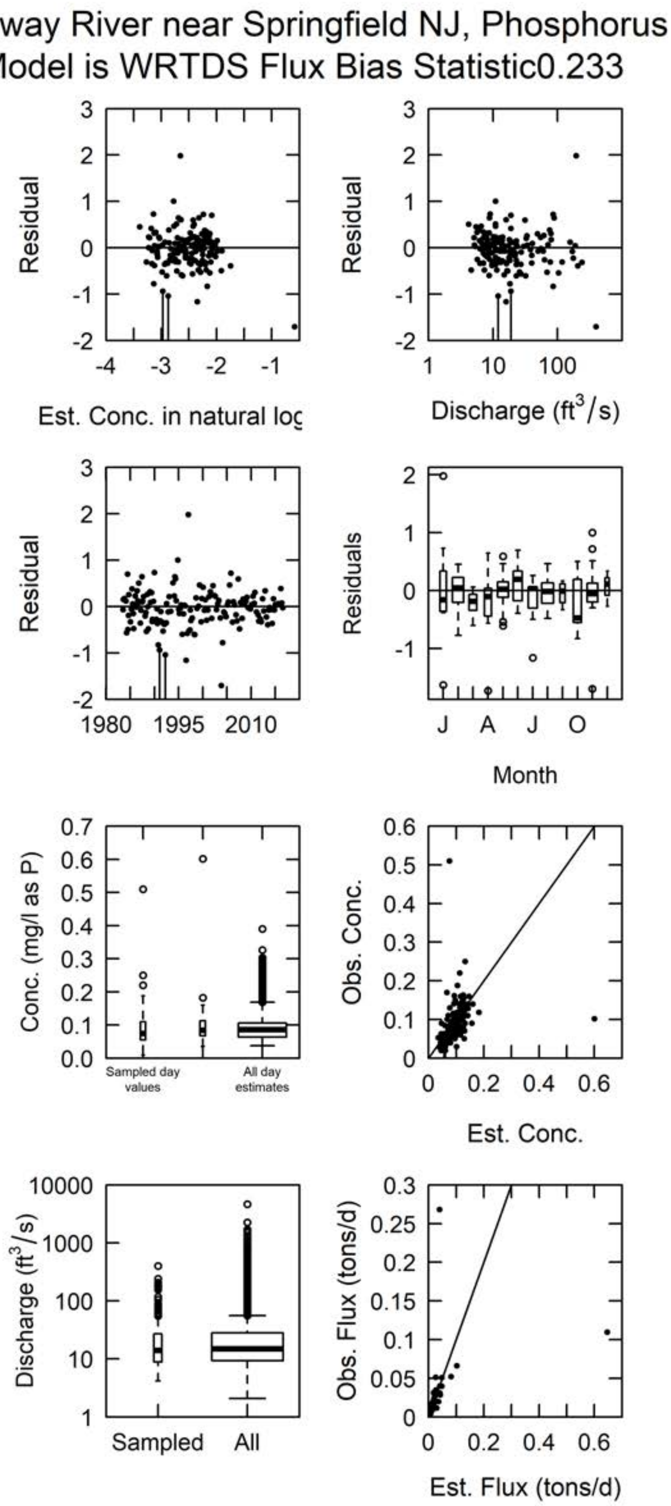

Rahway River near Springfield NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic-0.004
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

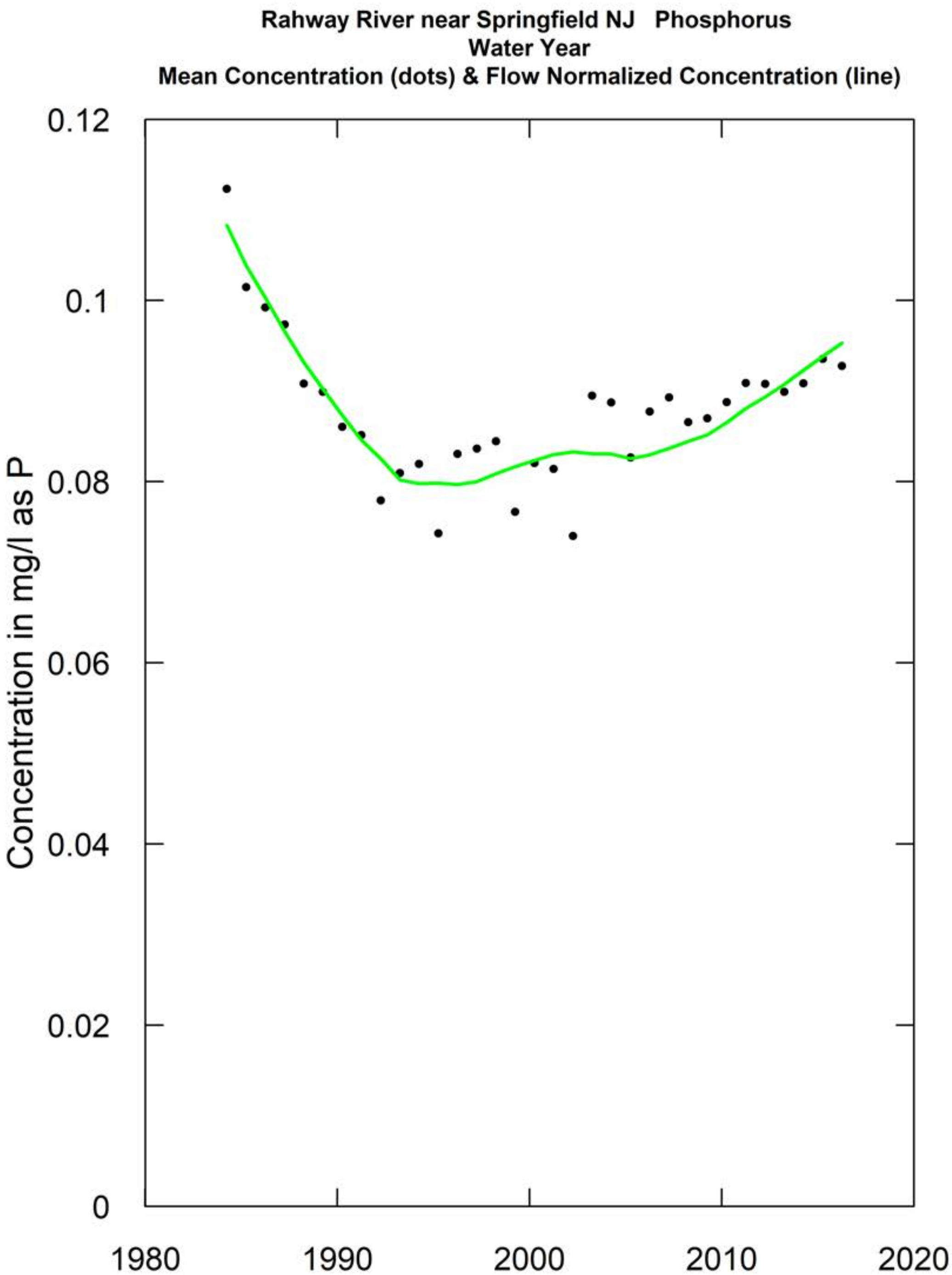


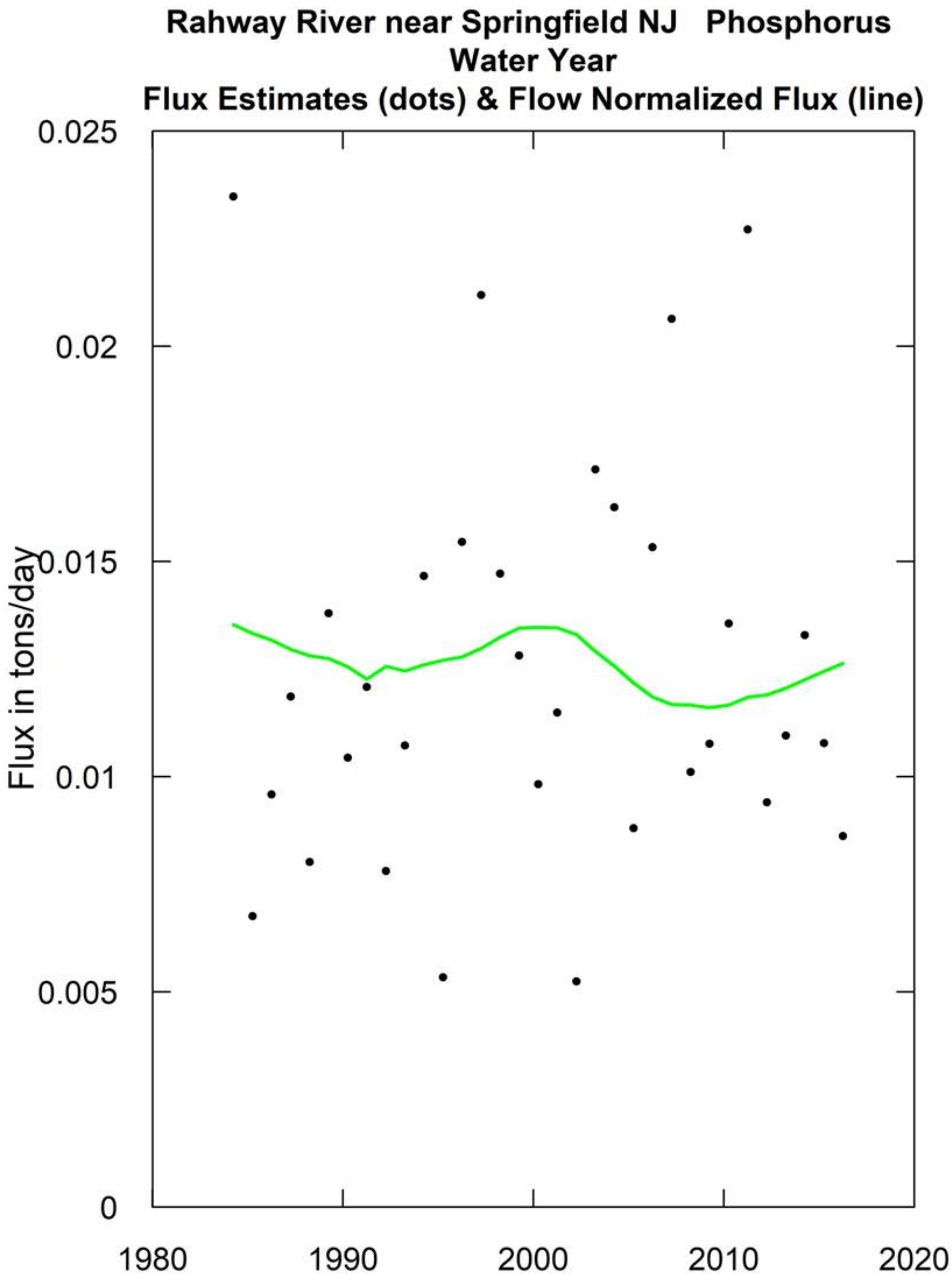
Rahway River near Springfield NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

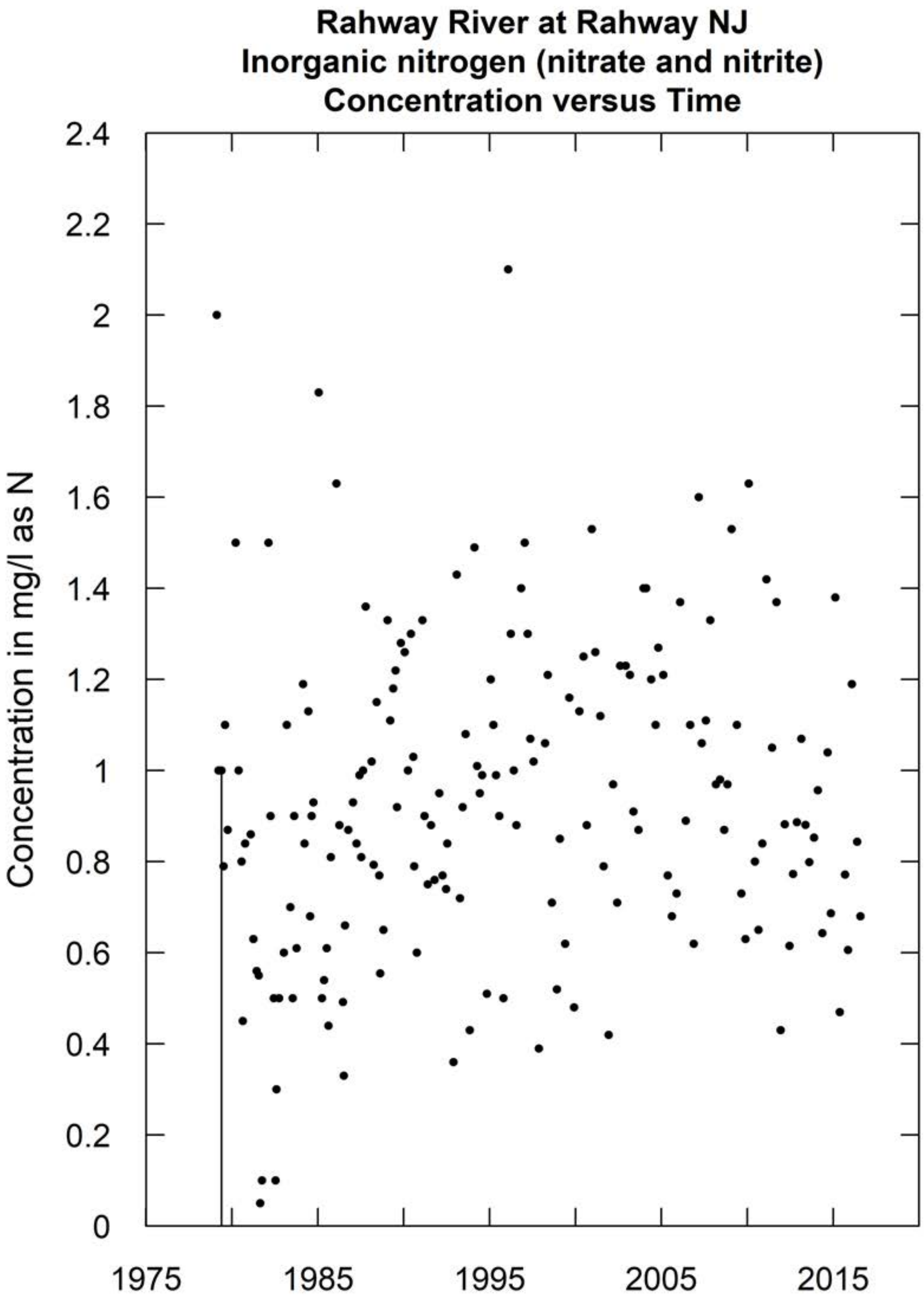

Rahway River near Springfield NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1980
1990
2000
2010
2020

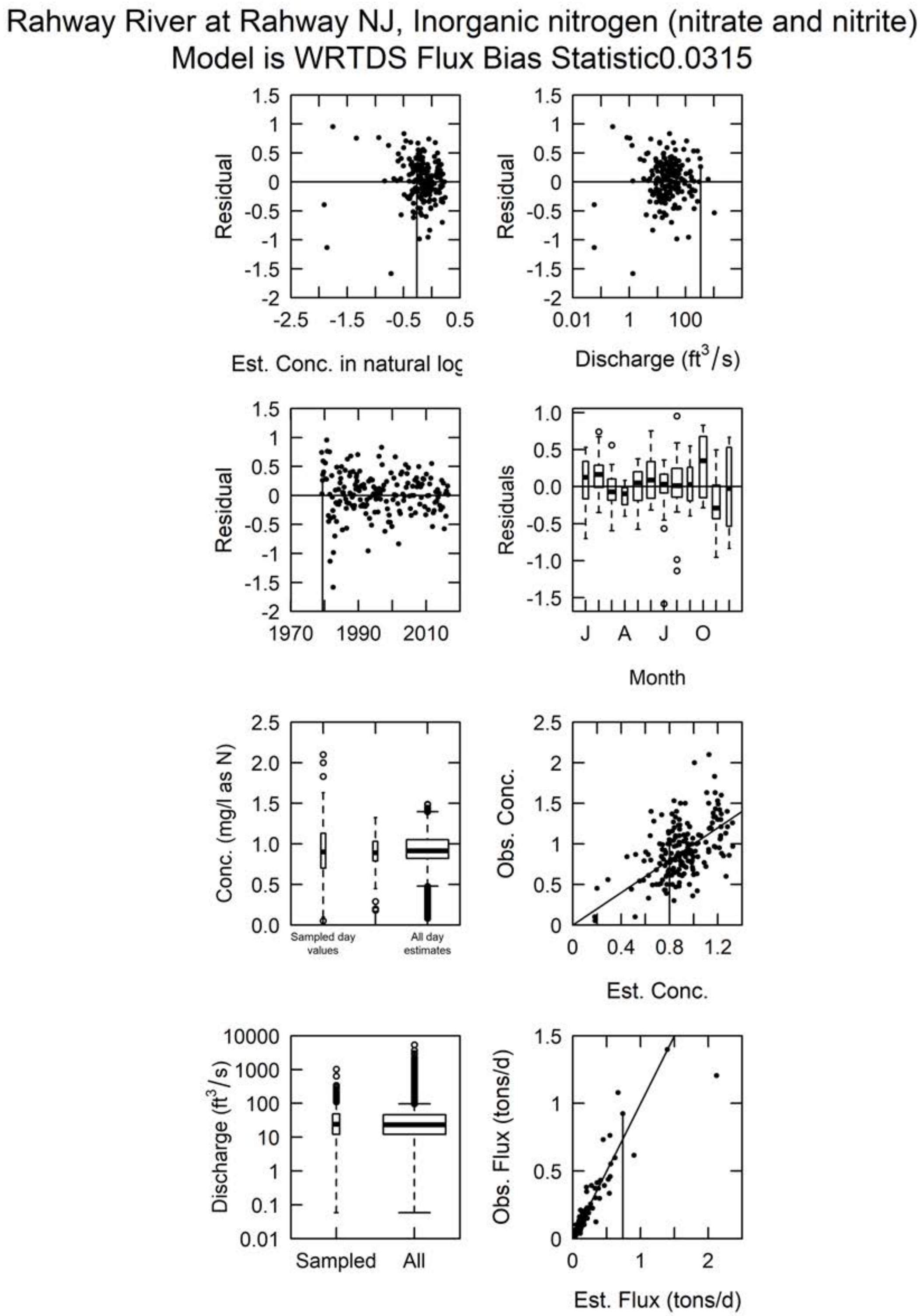

Rahway River near Springfield NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1980
1990
2000
2010
2020

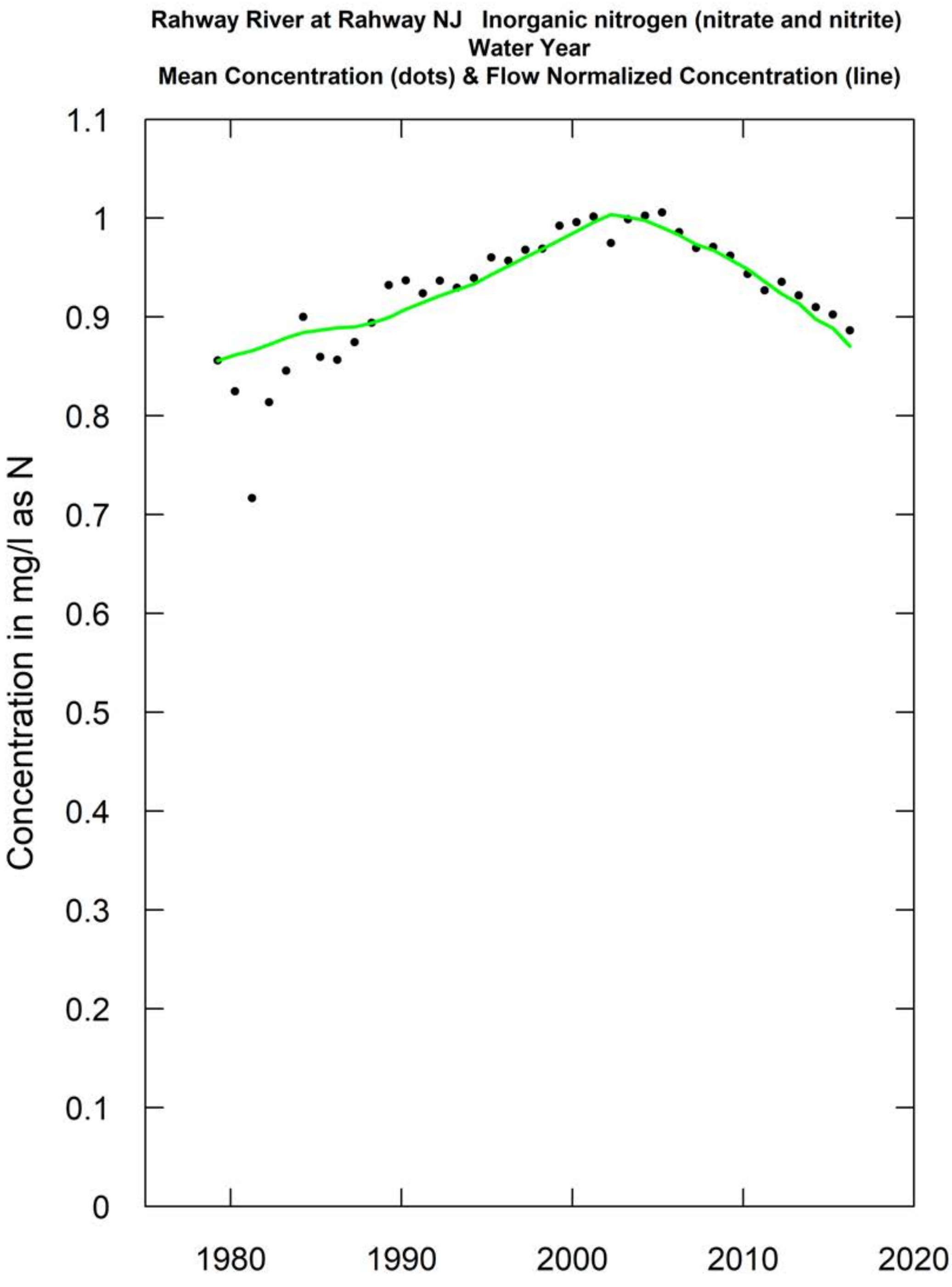

Rahway River near Springfield NJ, Phosphorus
Model is WRTDS Flux Bias Statistic0.233
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

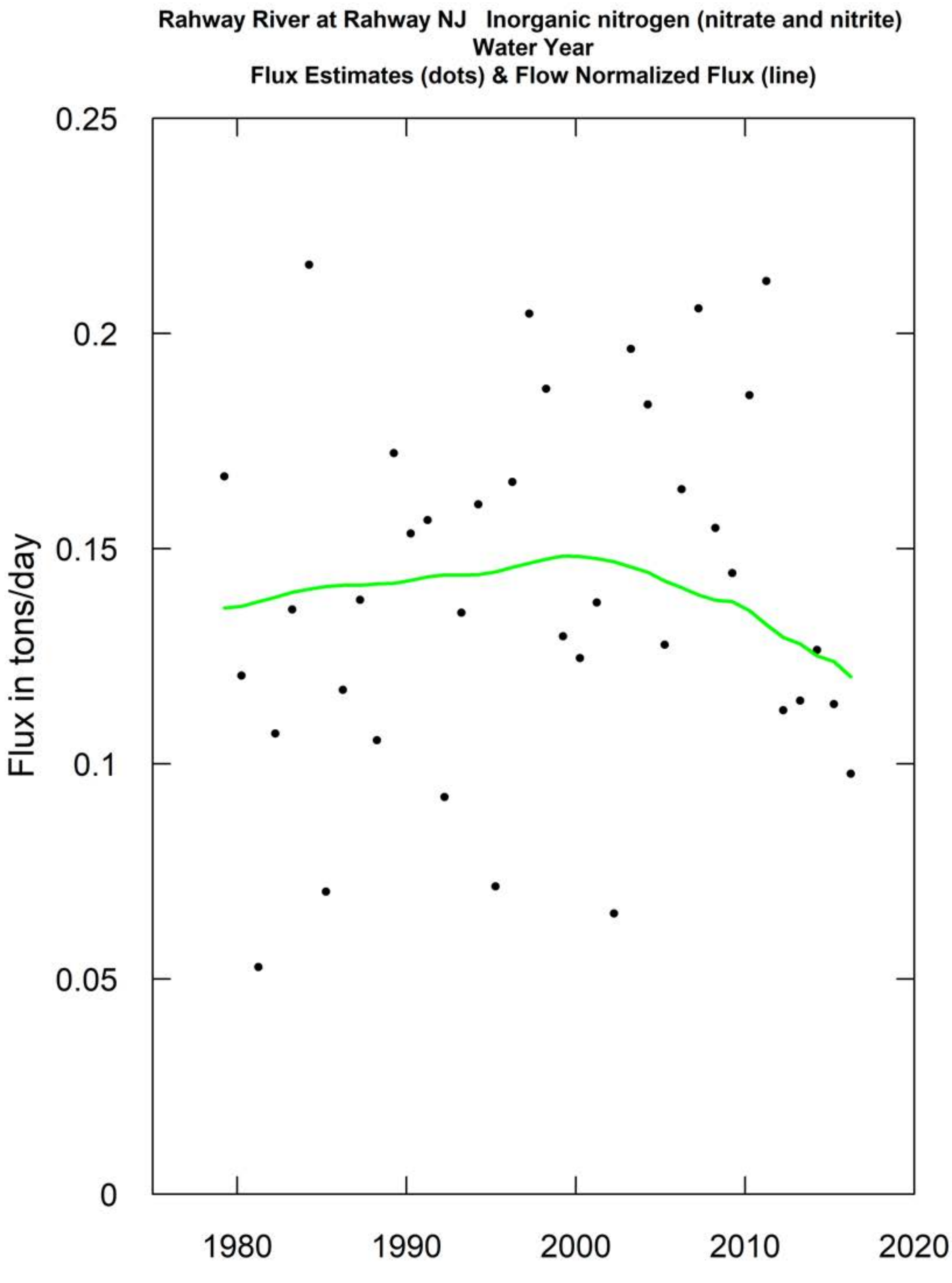

Rahway River near Springfield NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

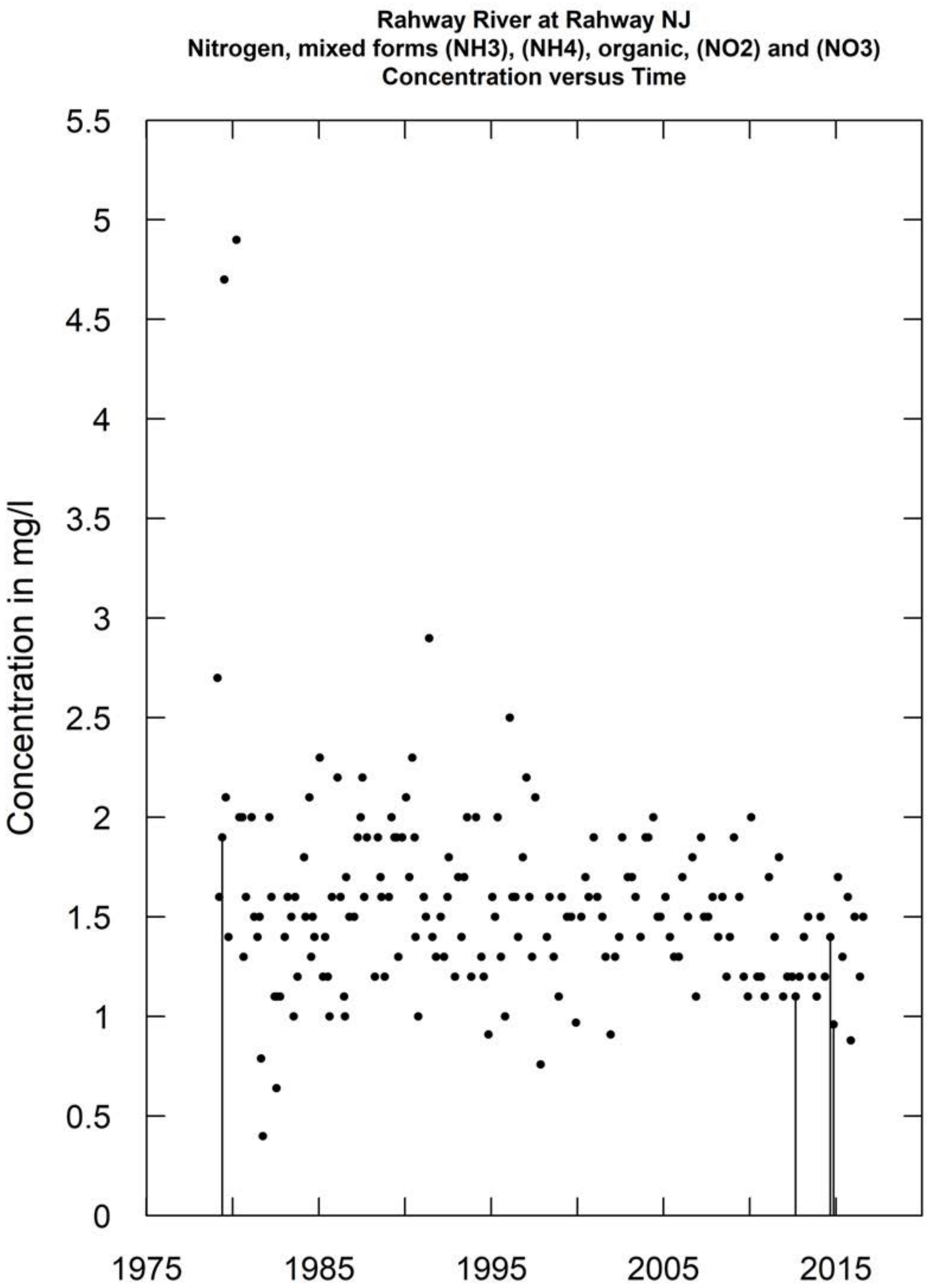

Rahway River near Springfield NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.025
0.02
0.015
0.01
0.005
0
1980
1990
2000
2010
2020

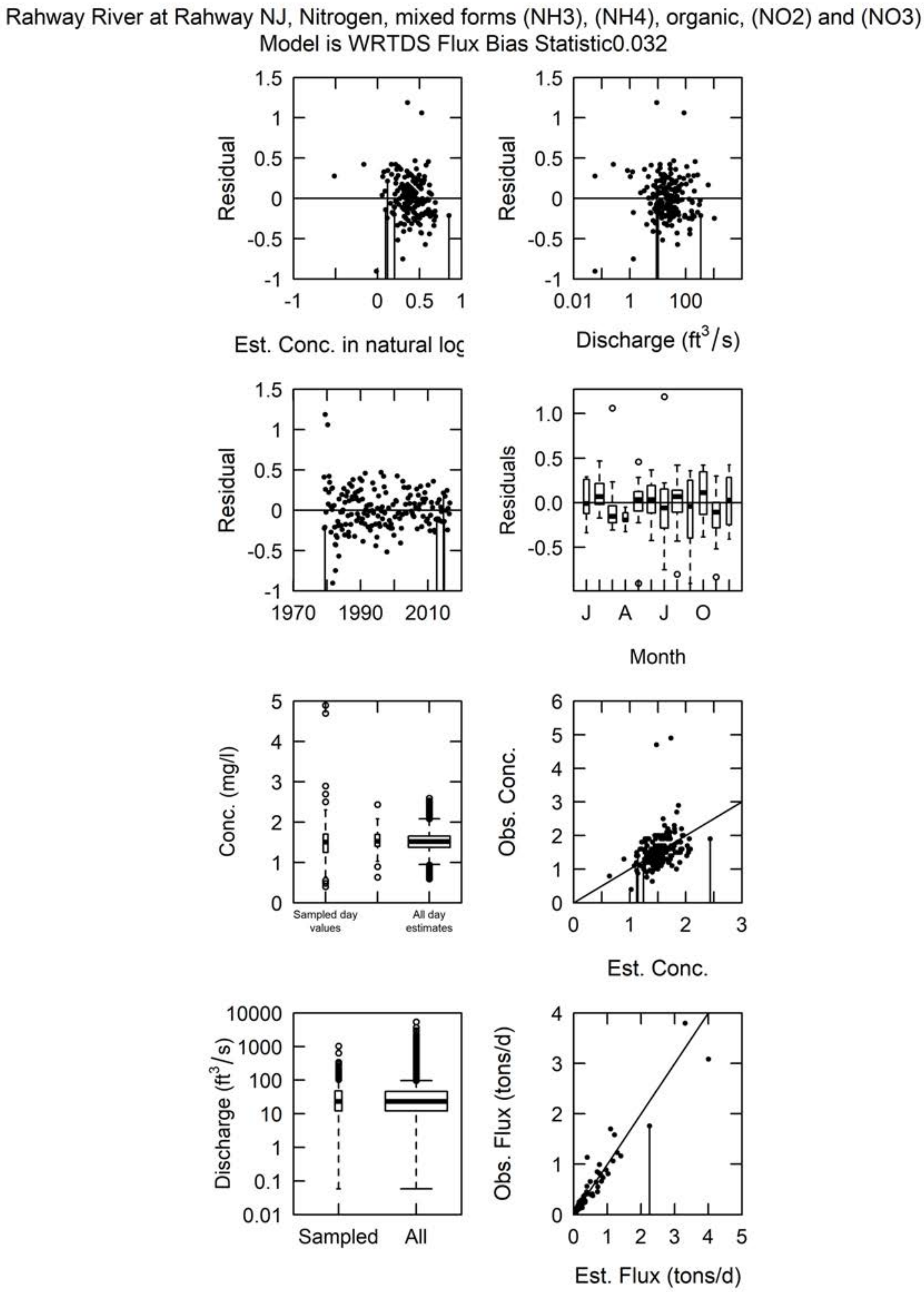

Rahway River at Rahway NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1975
1985
1995
2005
2015

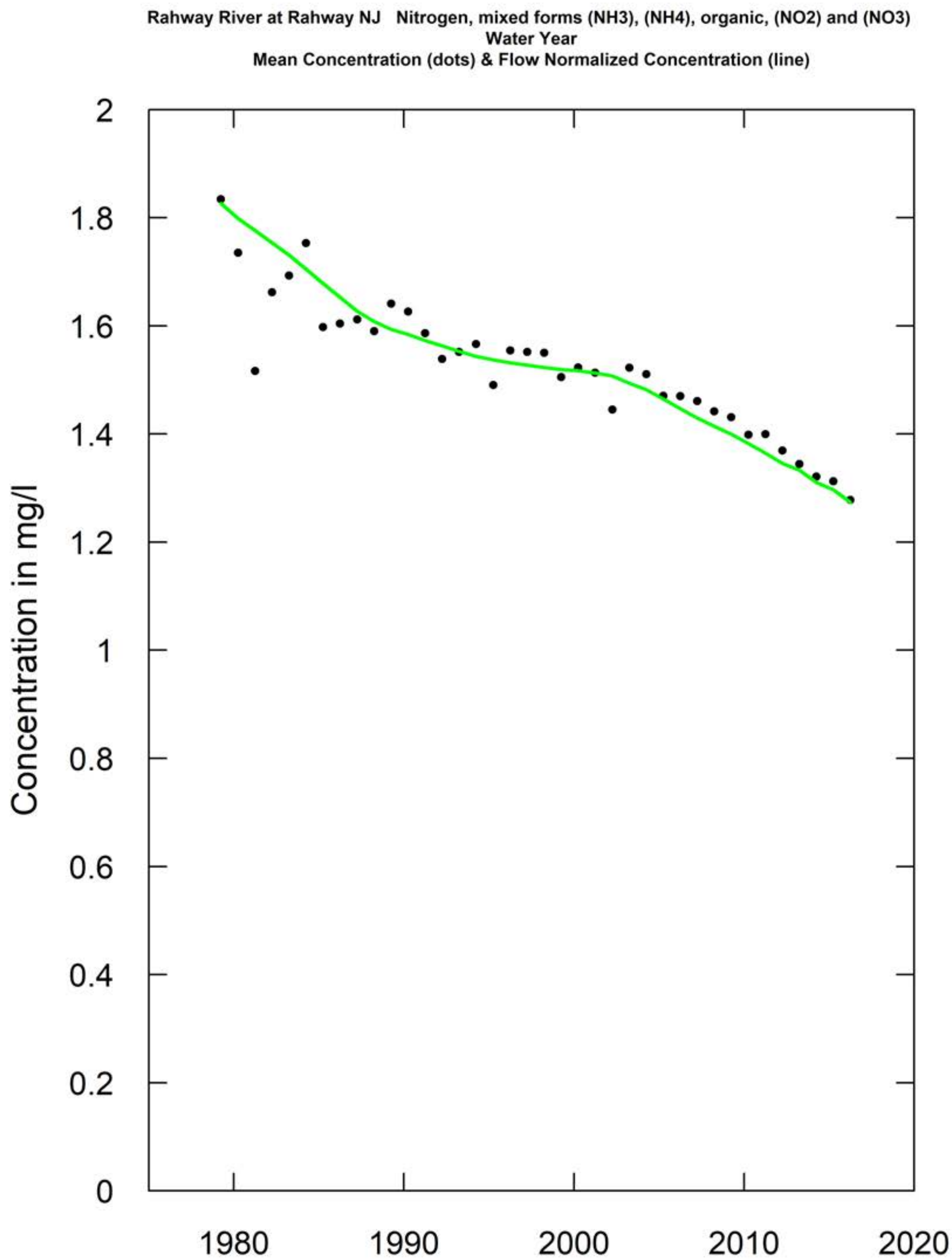

Rahway River at Rahway NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0315
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

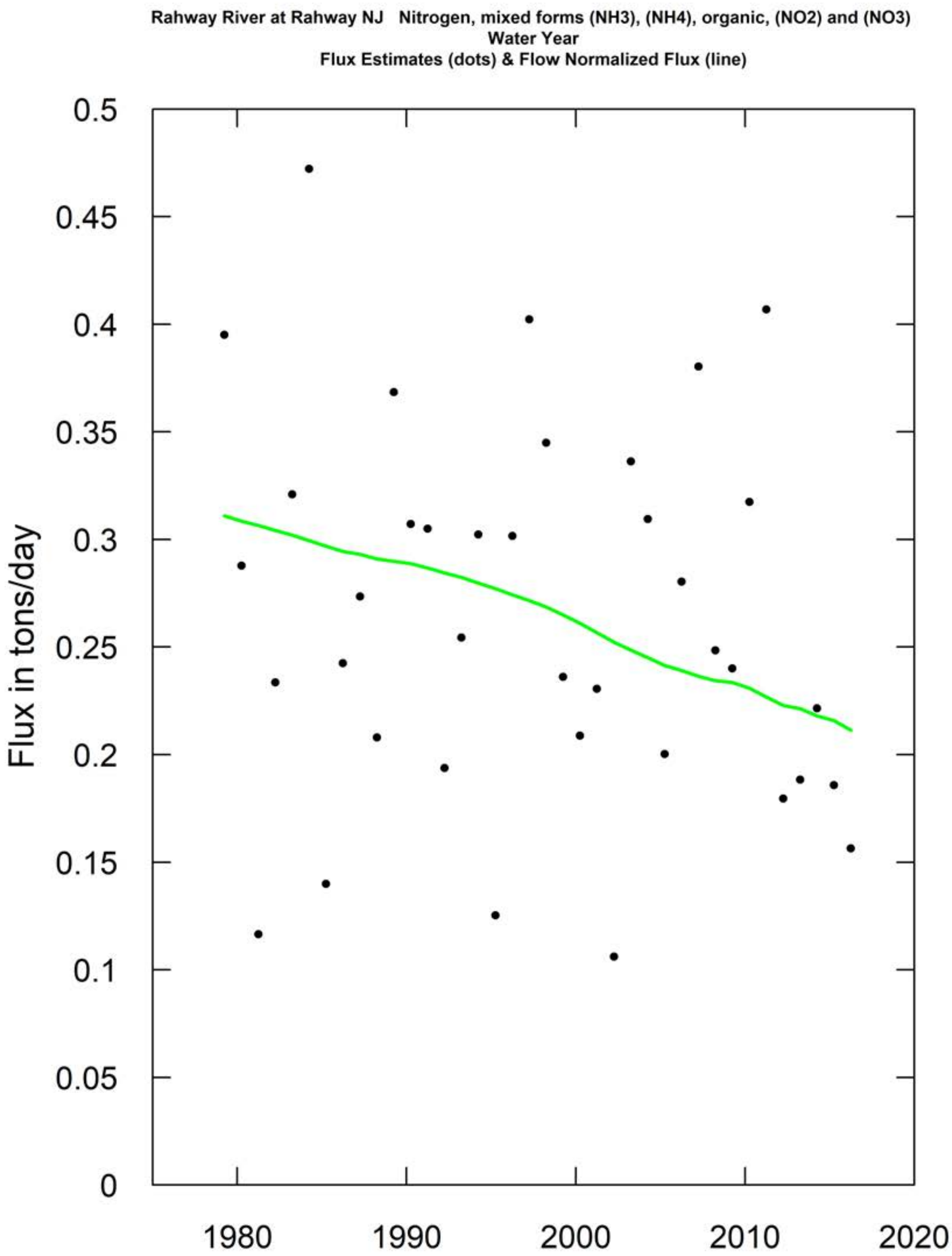

Rahway River at Rahway NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

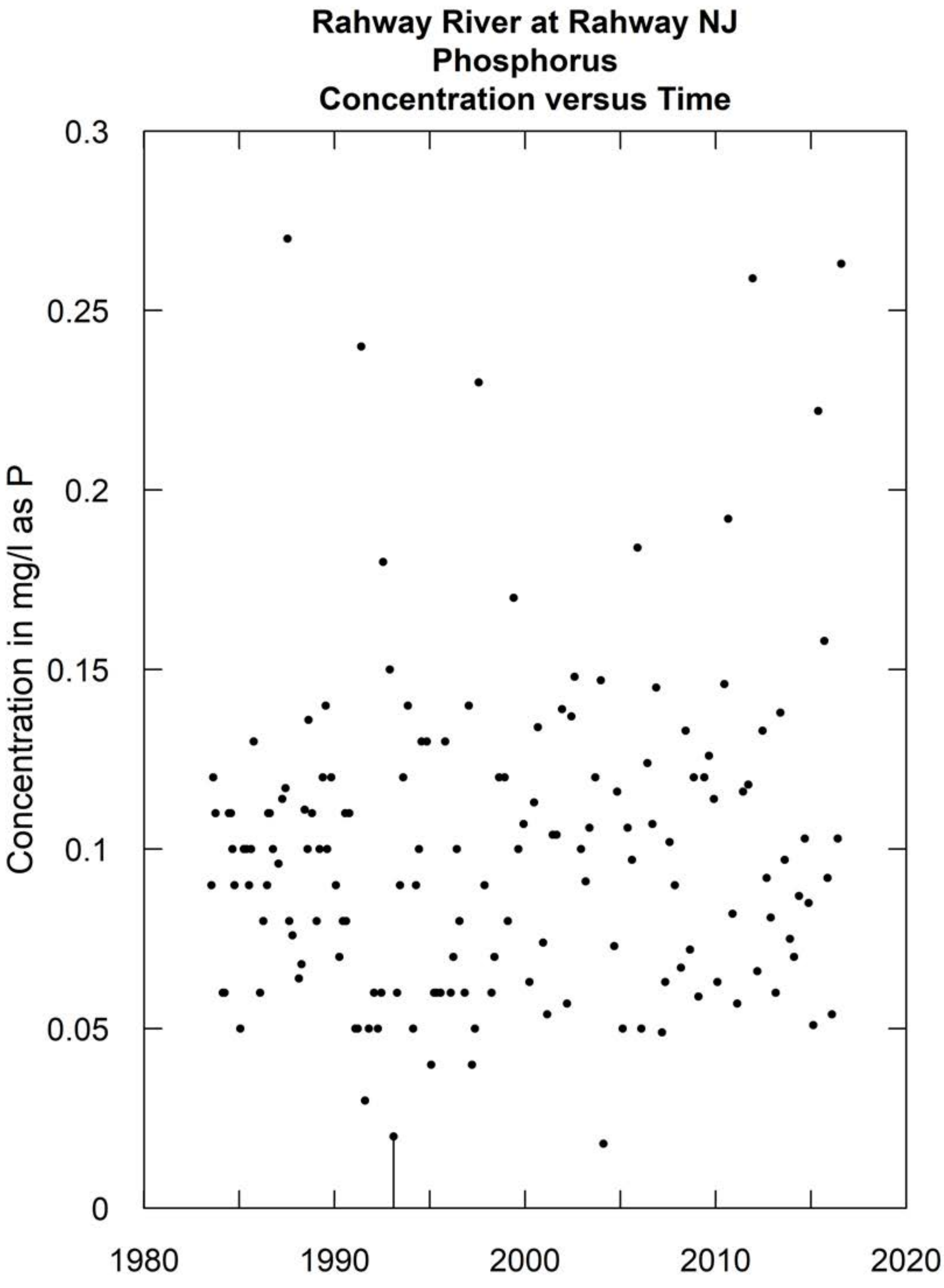

Rahway River at Rahway NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.25
0.2
0.15
0.1
0.05
0
1980
1990
2000
2010
2020

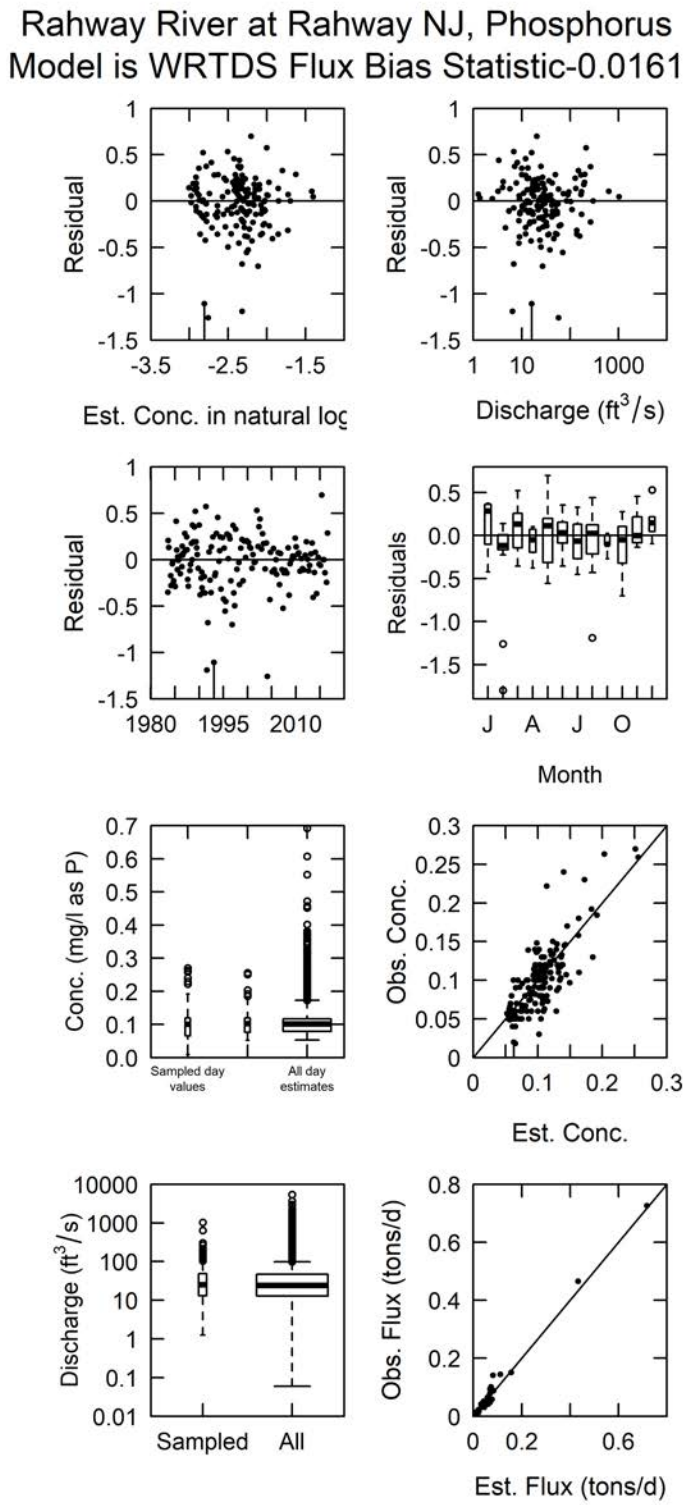

Rahway River at Rahway NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

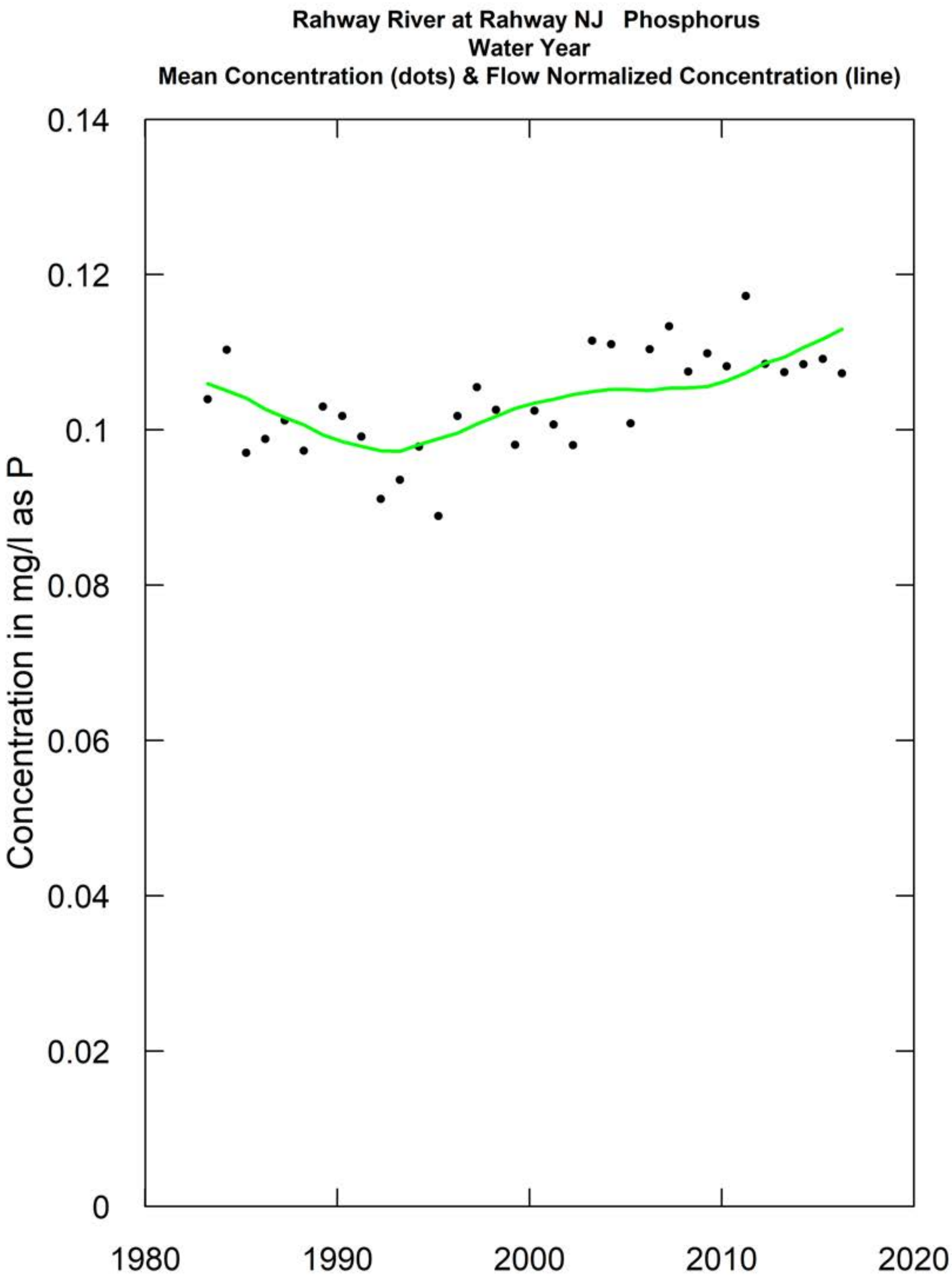

Rahway River at Rahway NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.032
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

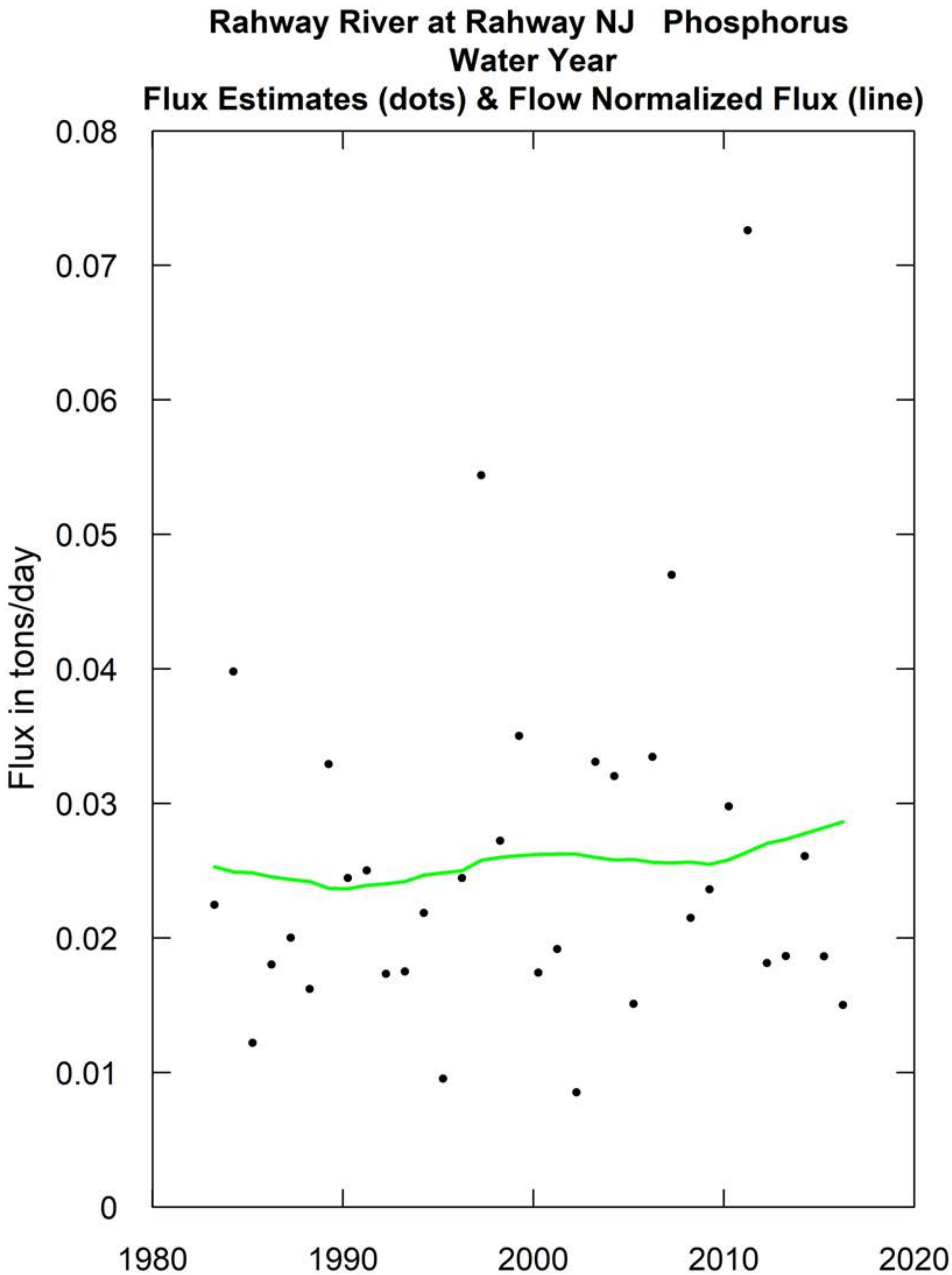

Rahway River at Rahway NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

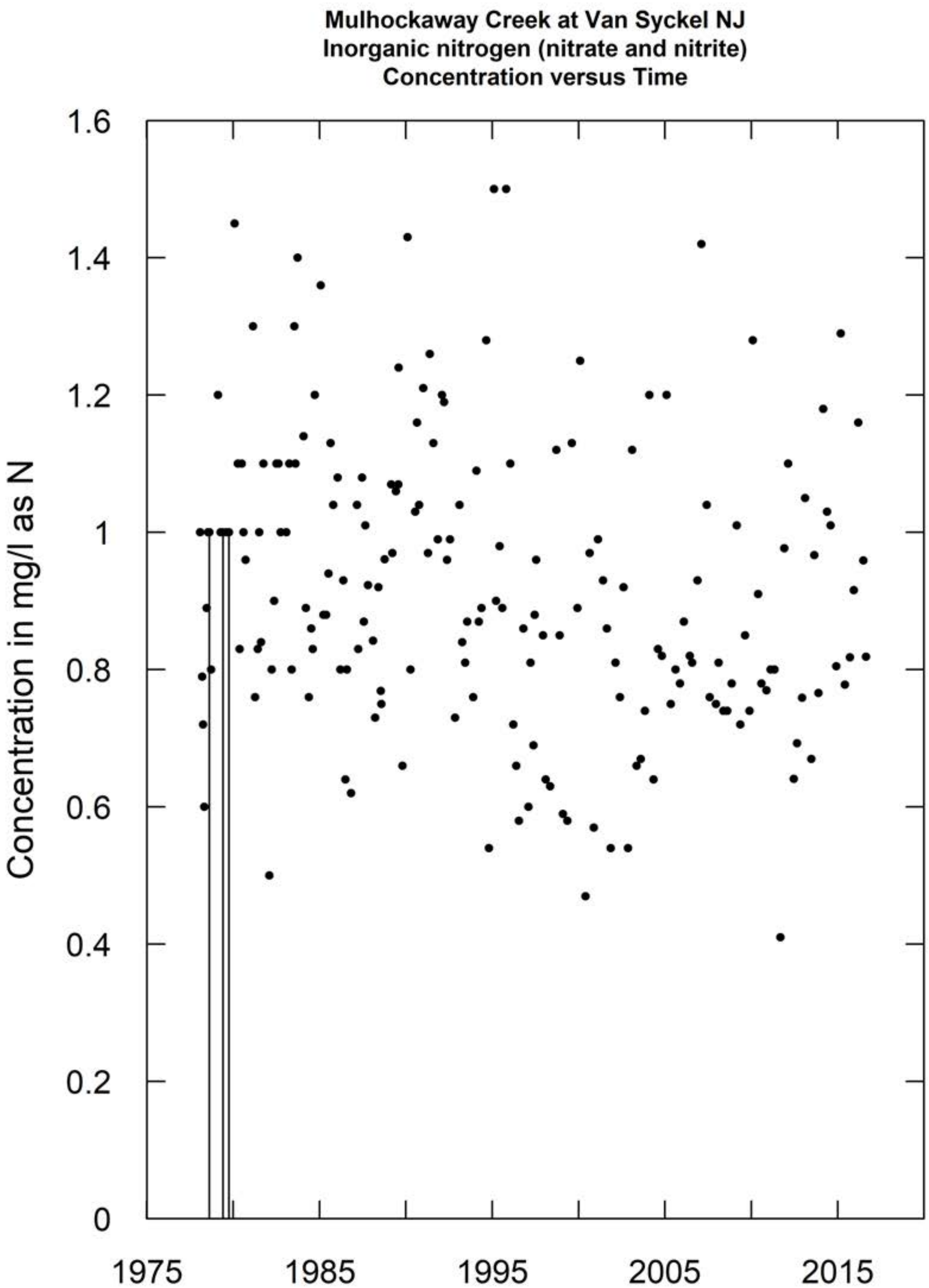

Rahway River at Rahway NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1980
1990
2000
2010
2020

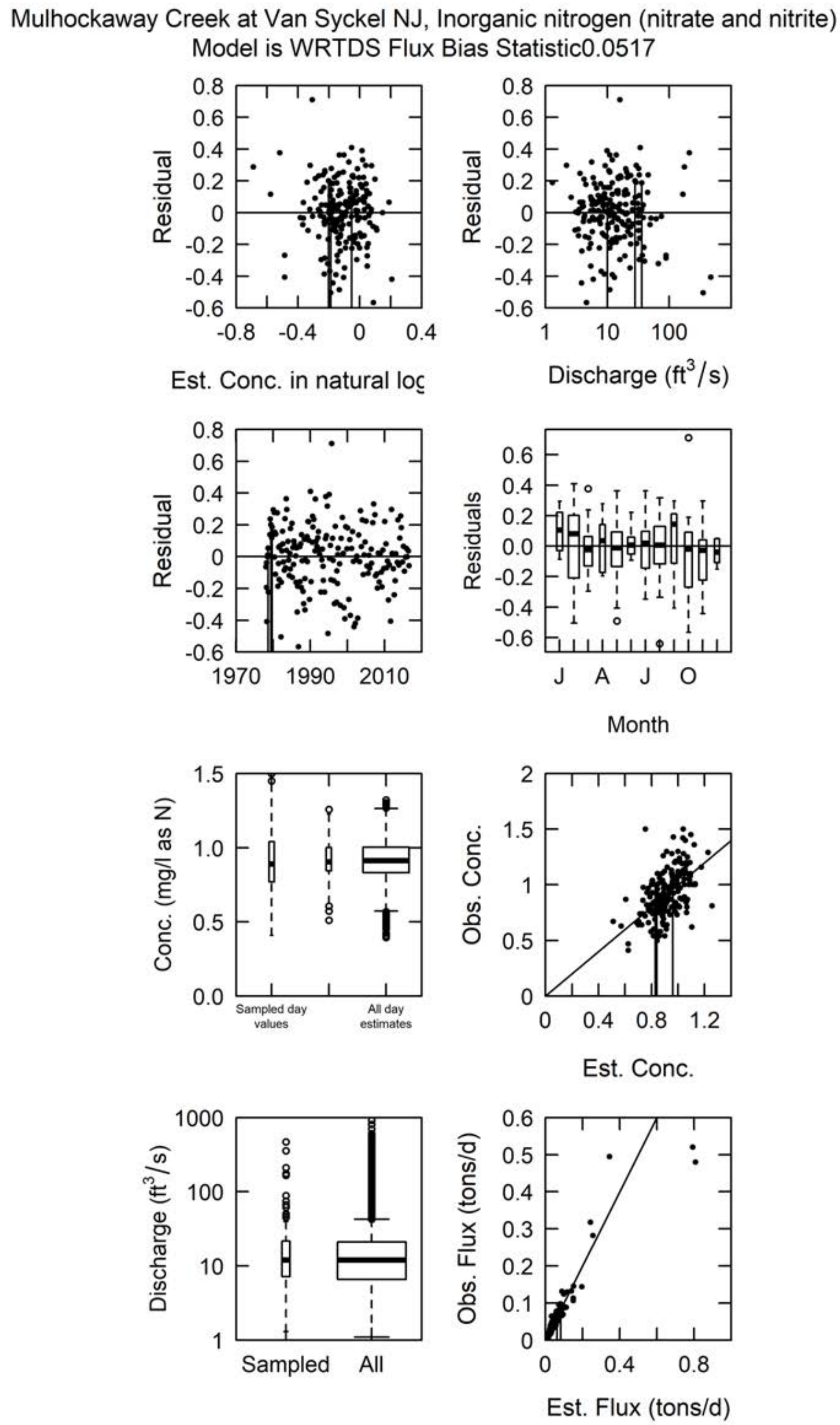

Rahway River at Rahway NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.3
0.25
0.2
0.15
0.1
0.05
0
1980
1990
2000
2010
2020

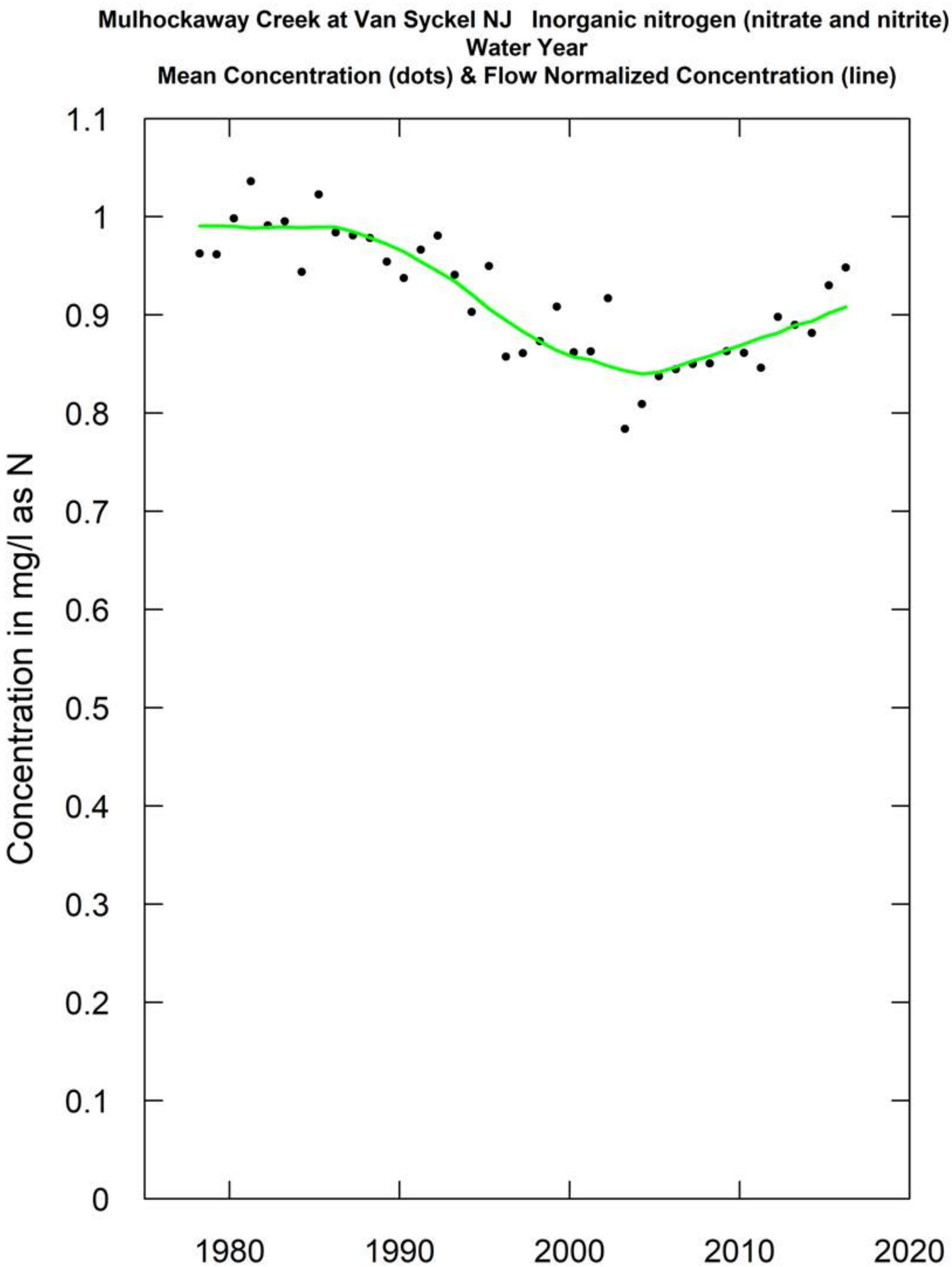

Rahway River at Rahway NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.0161
Residual
Est. Conc. in natural log
Discharge (ft³/s)
Residual
Residuals
Month
J A J O
1980 1995 2010
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

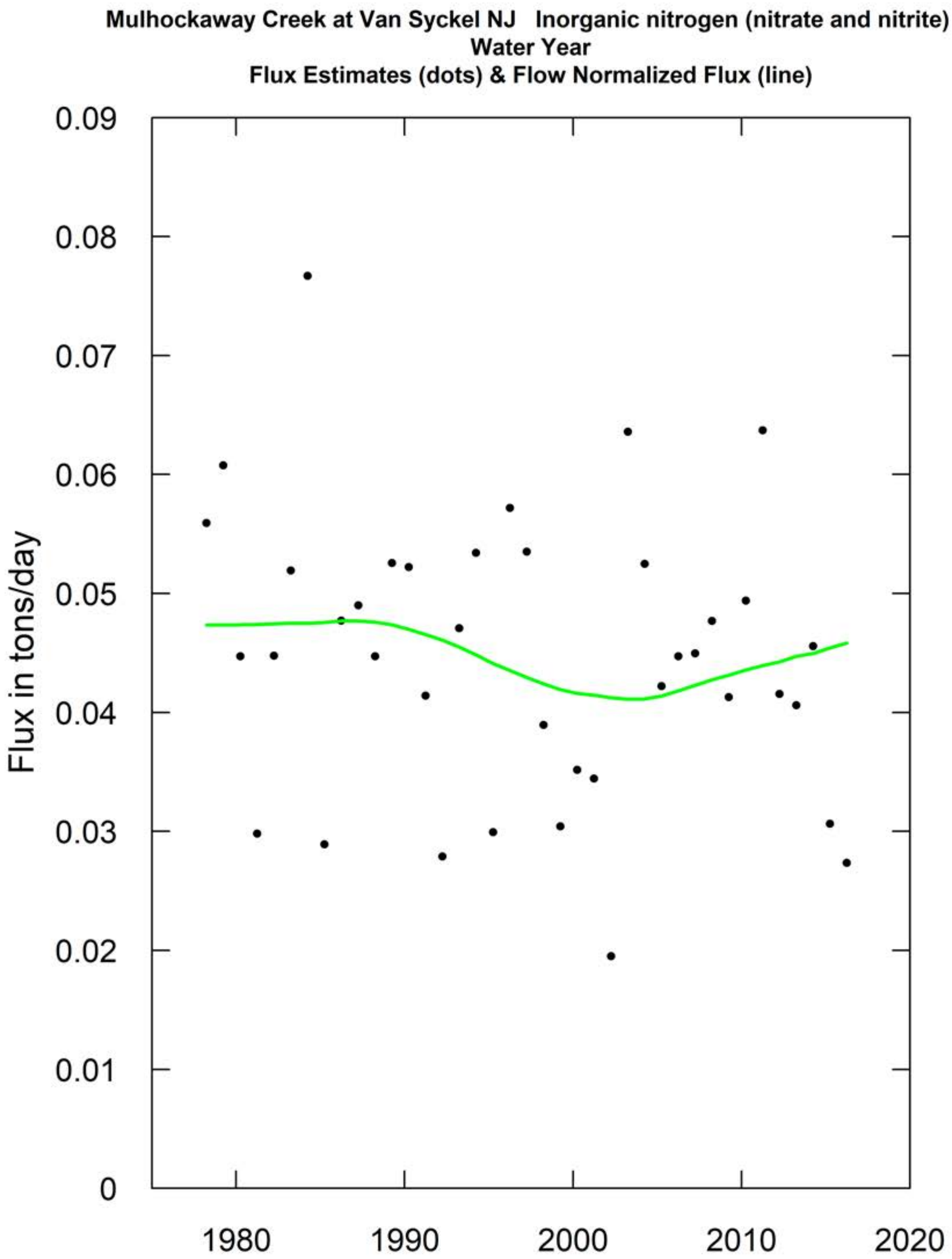

Rahway River at Rahway NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

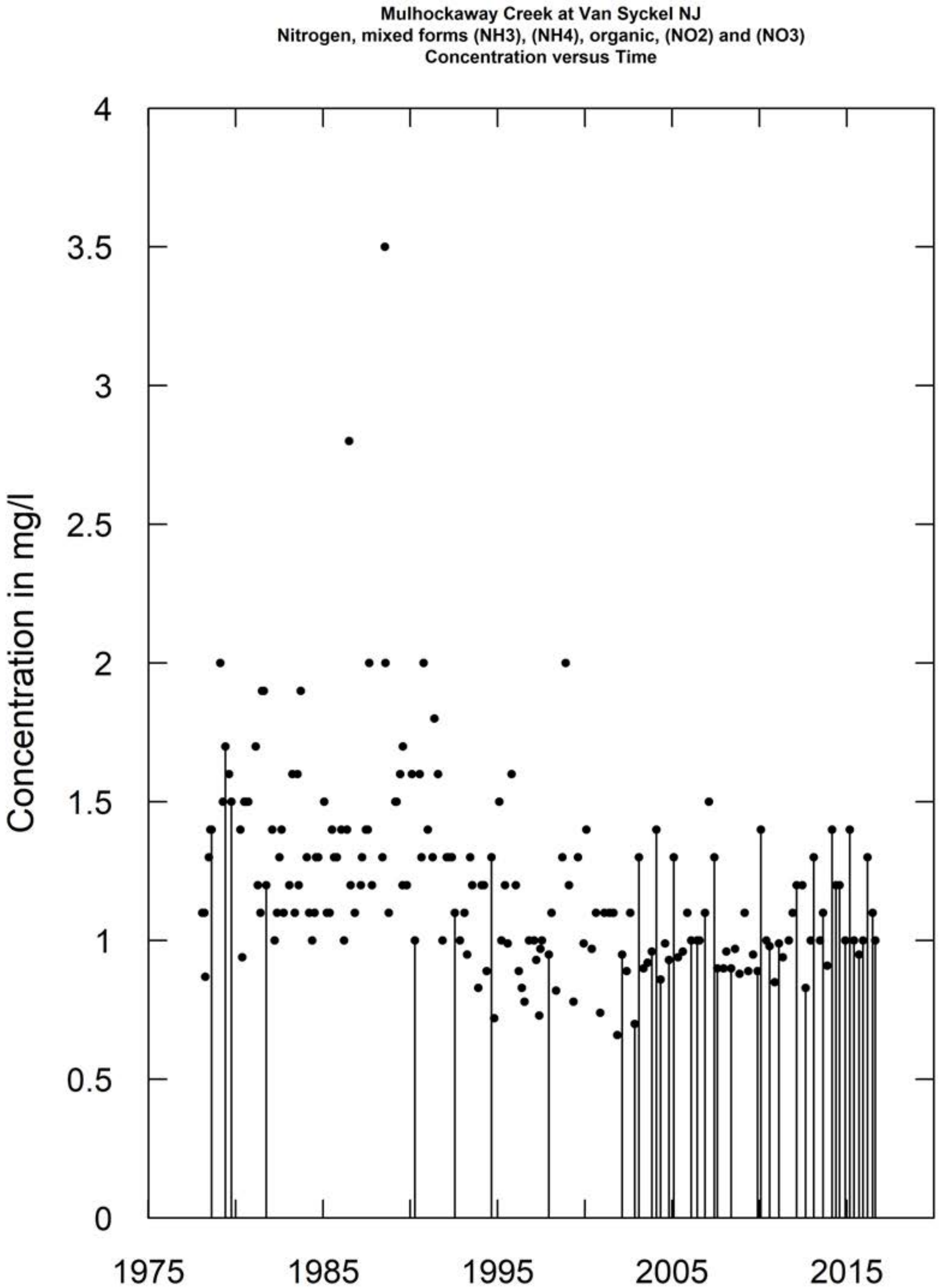

Rahway River at Rahway NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1980
1990
2000
2010
2020

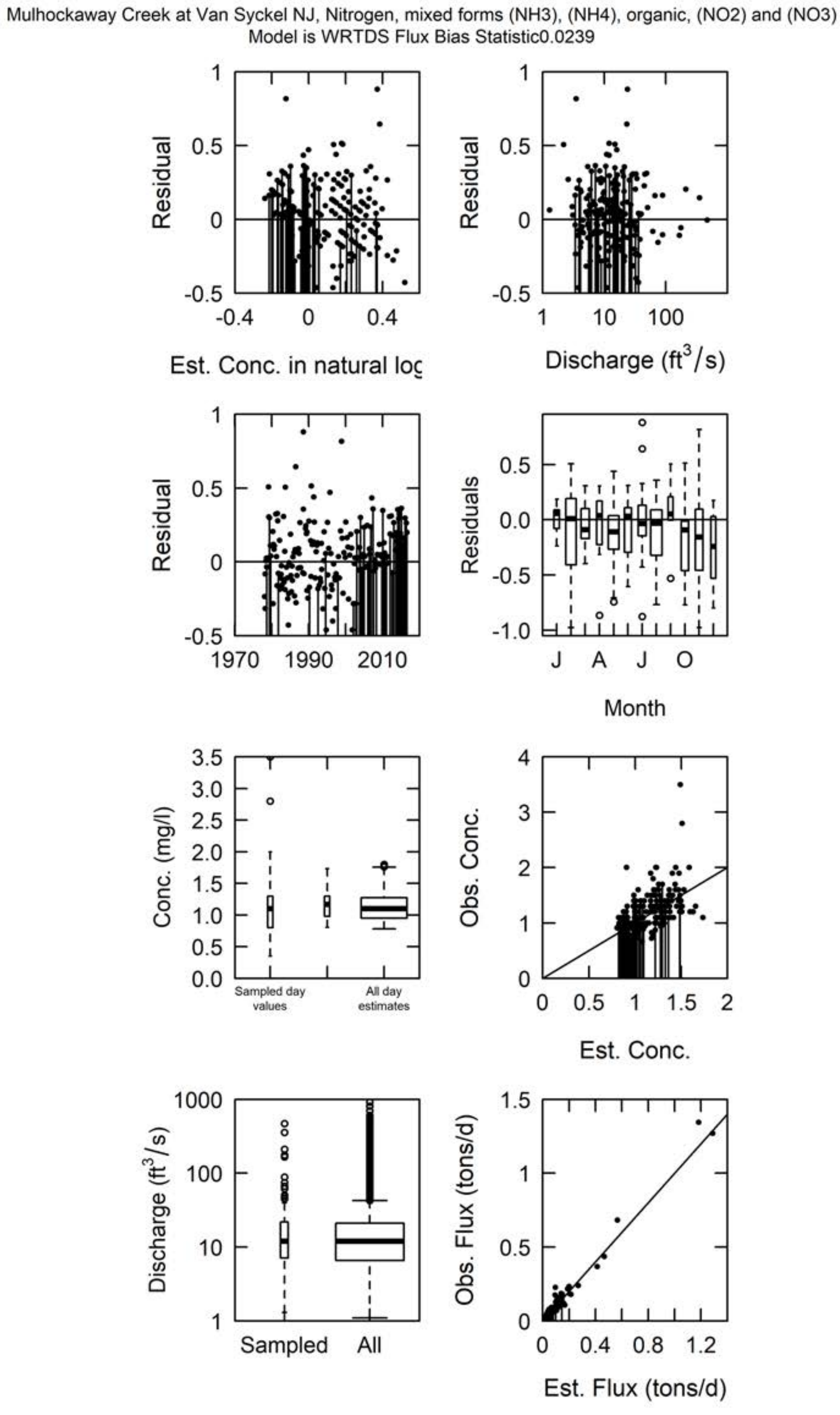

Mulhockaway Creek at Van Syckel NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1975
1985
1995
2005
2015

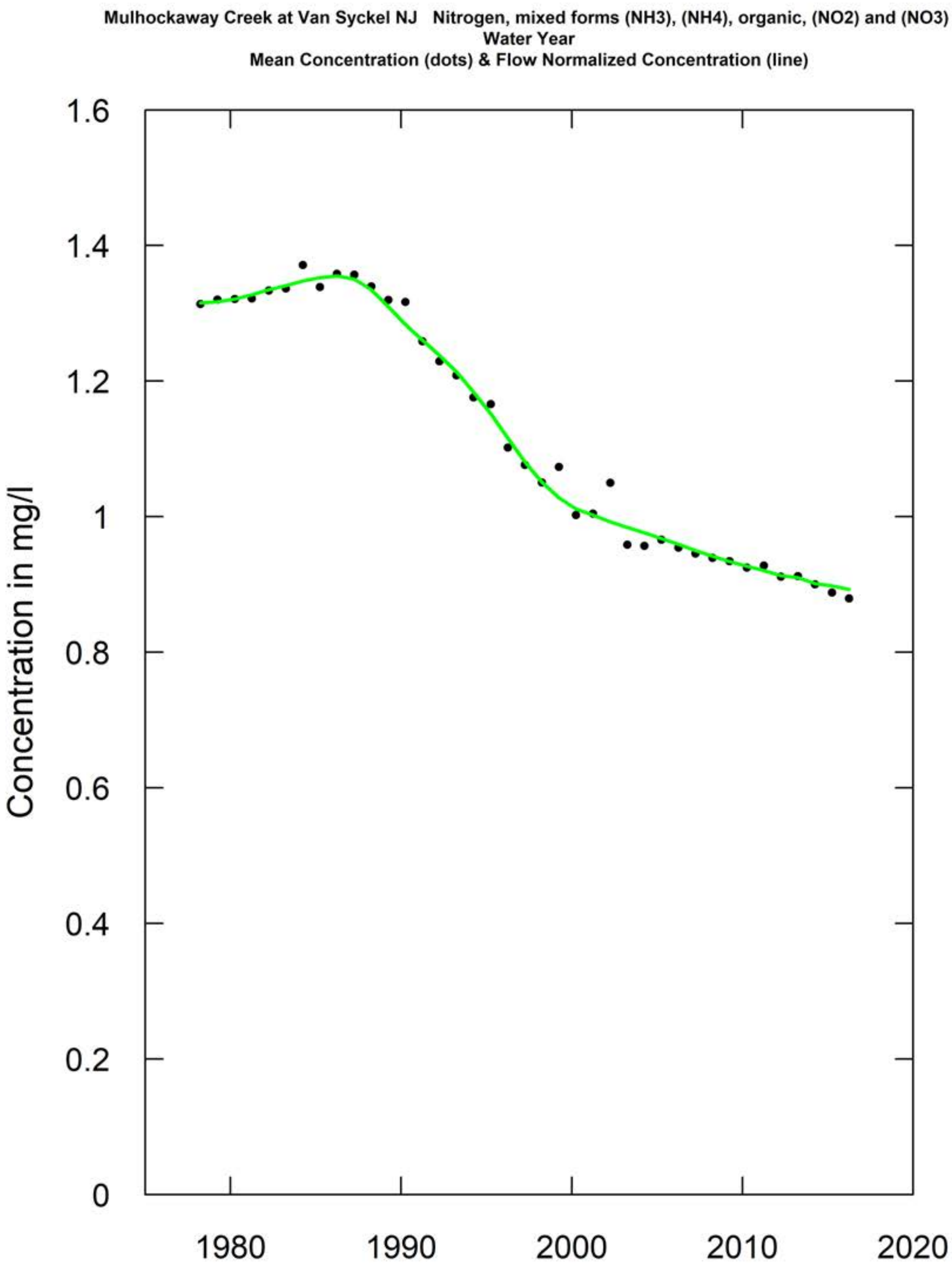

Mulhockaway Creek at Van Syckel NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0517
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
1970 1990 2010
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled All
Obs. Flux (tons/d)
Est. Flux (tons/d)

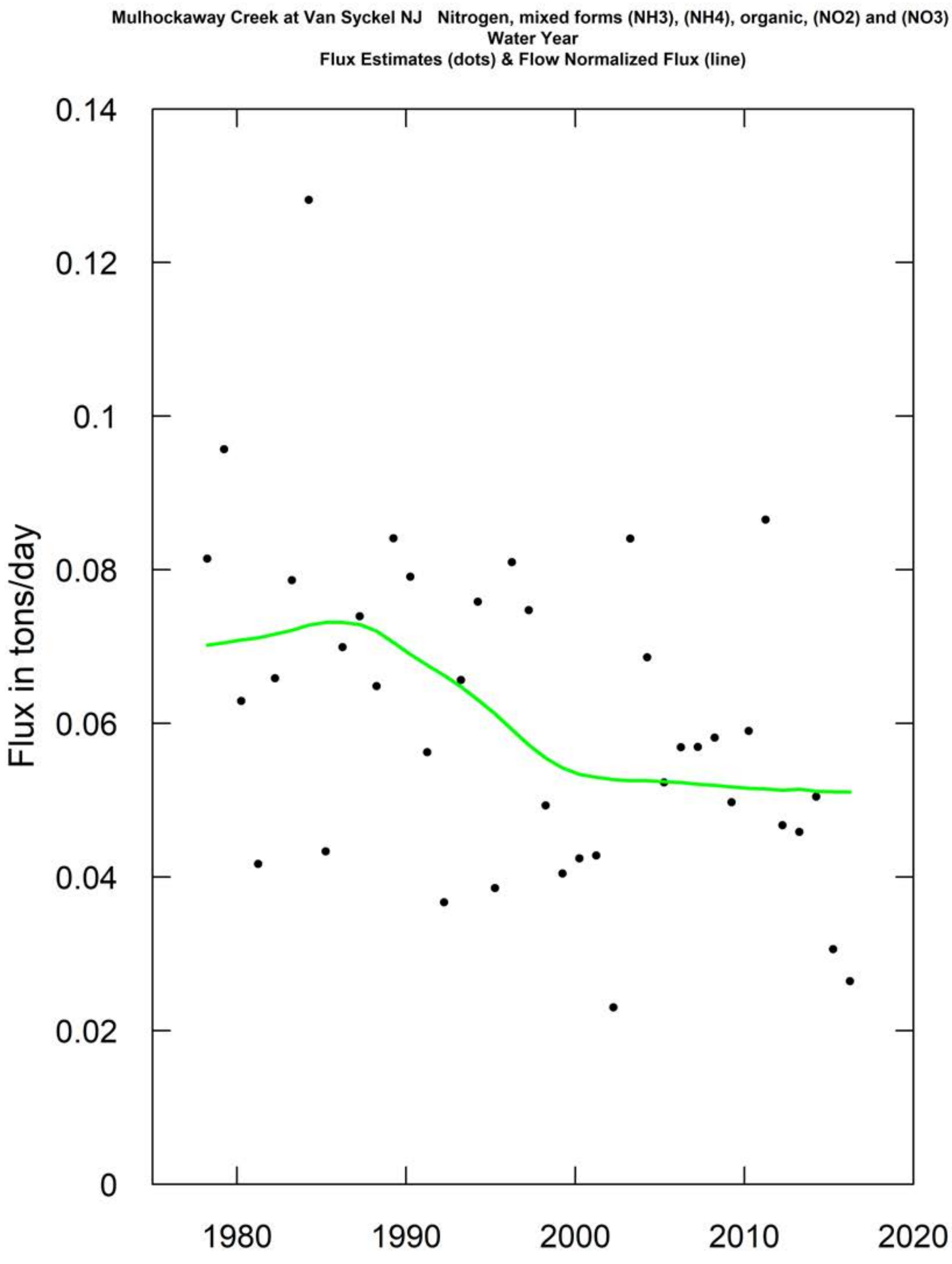

Mulhockaway Creek at Van Syckel NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1980
1990
2000
2010
2020

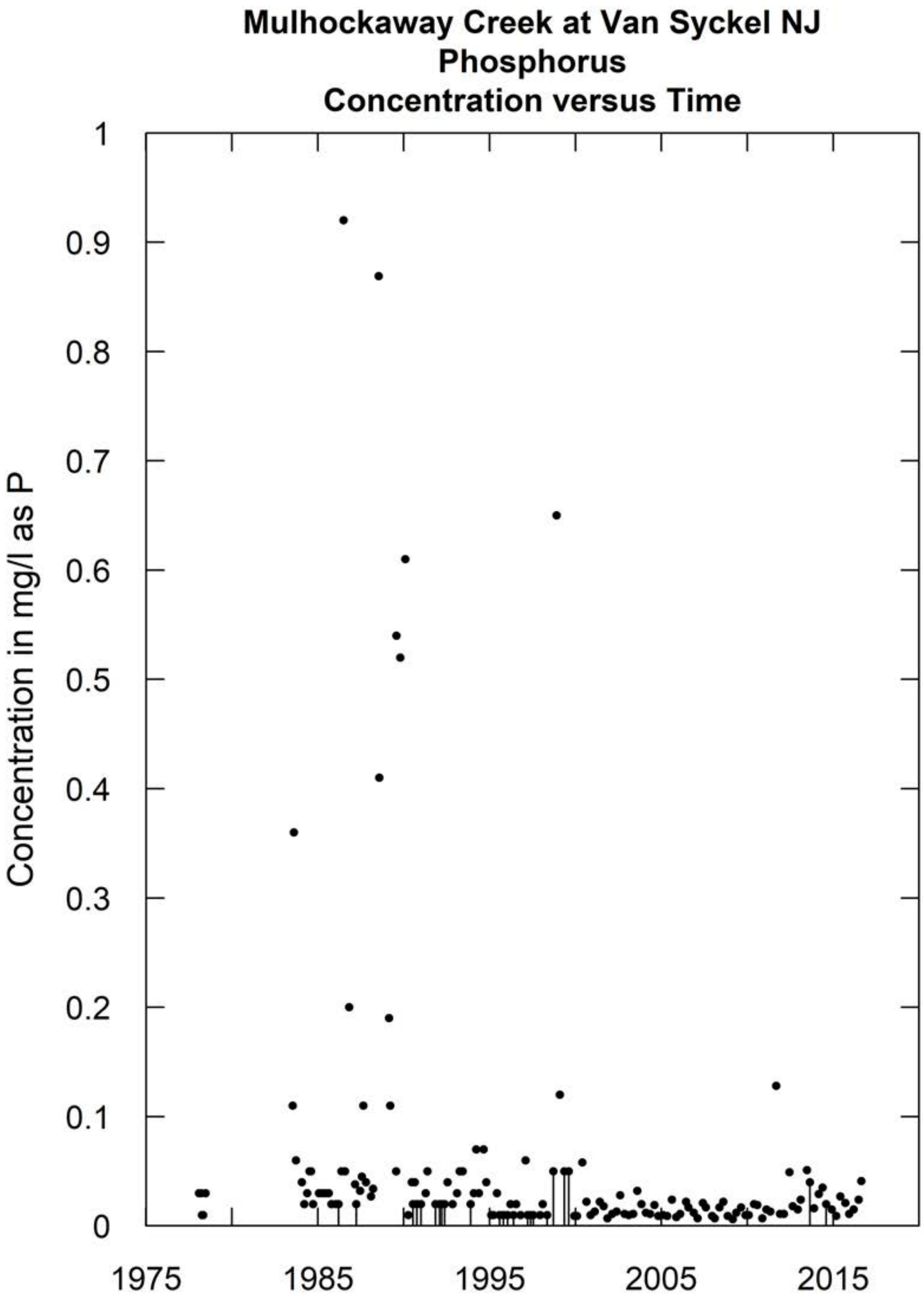

Mulhockaway Creek at Van Syckel NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1980
1990
2000
2010
2020

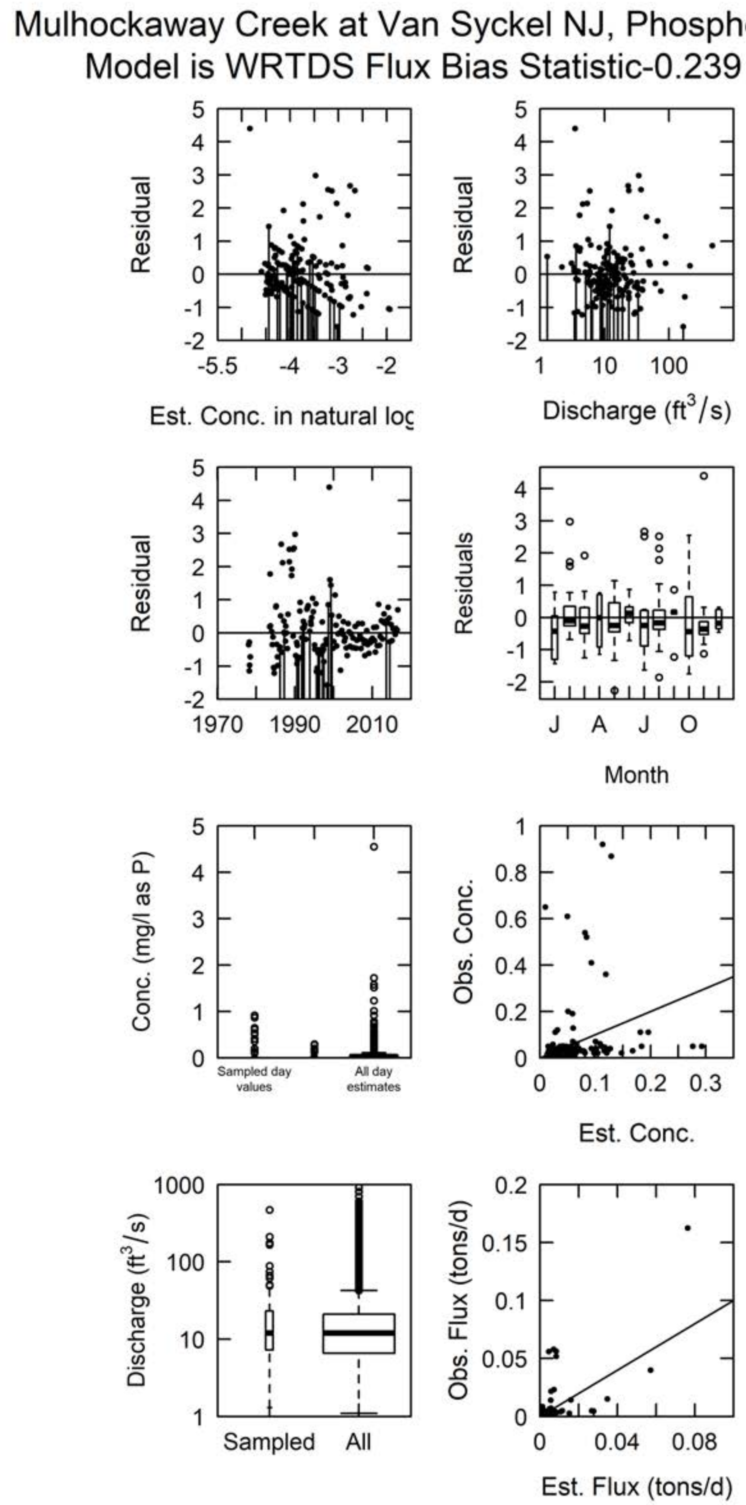

Mulhockaway Creek at Van Syckel NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

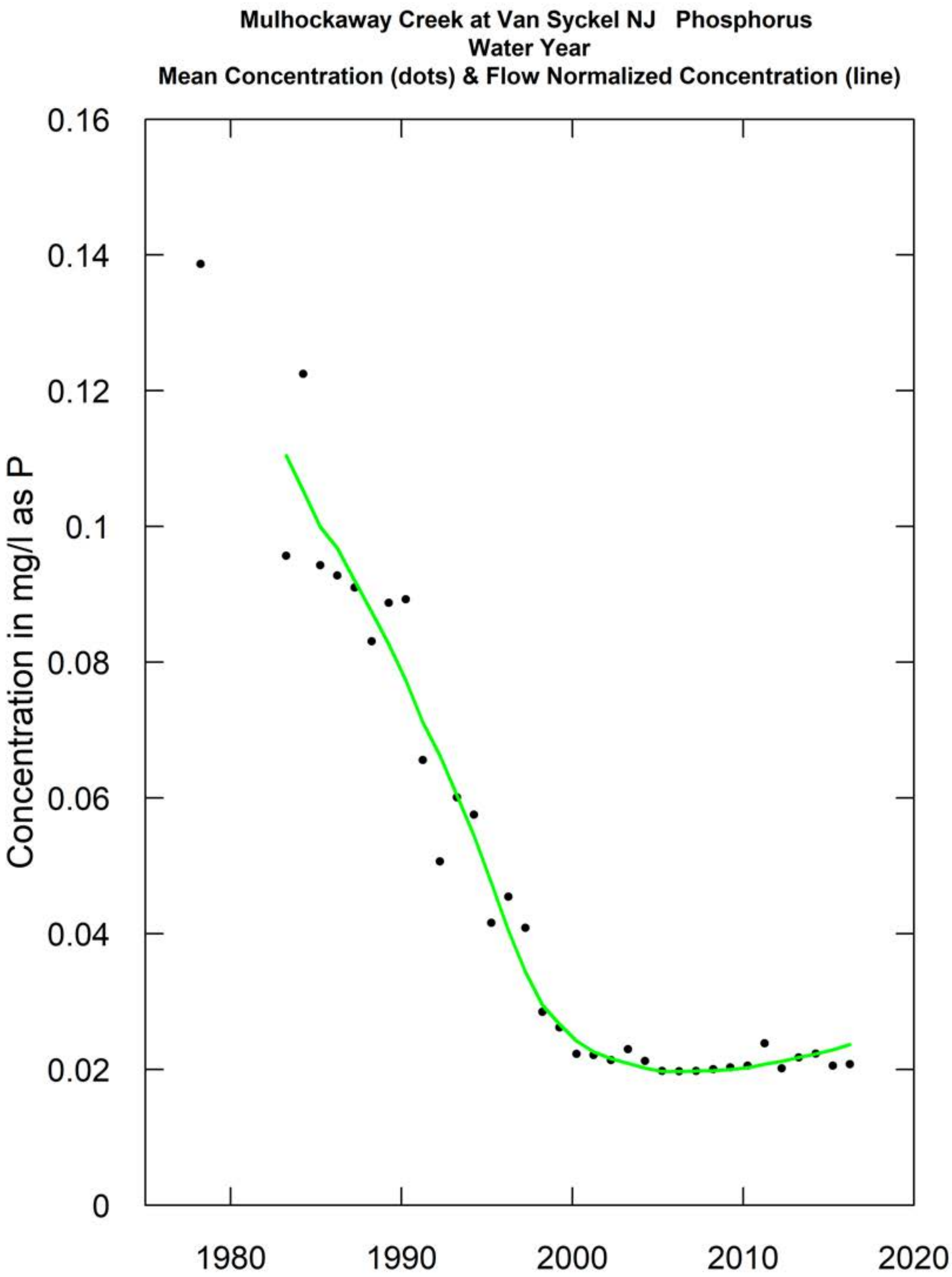

Mulhockaway Creek at Van Syckel NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.0239
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

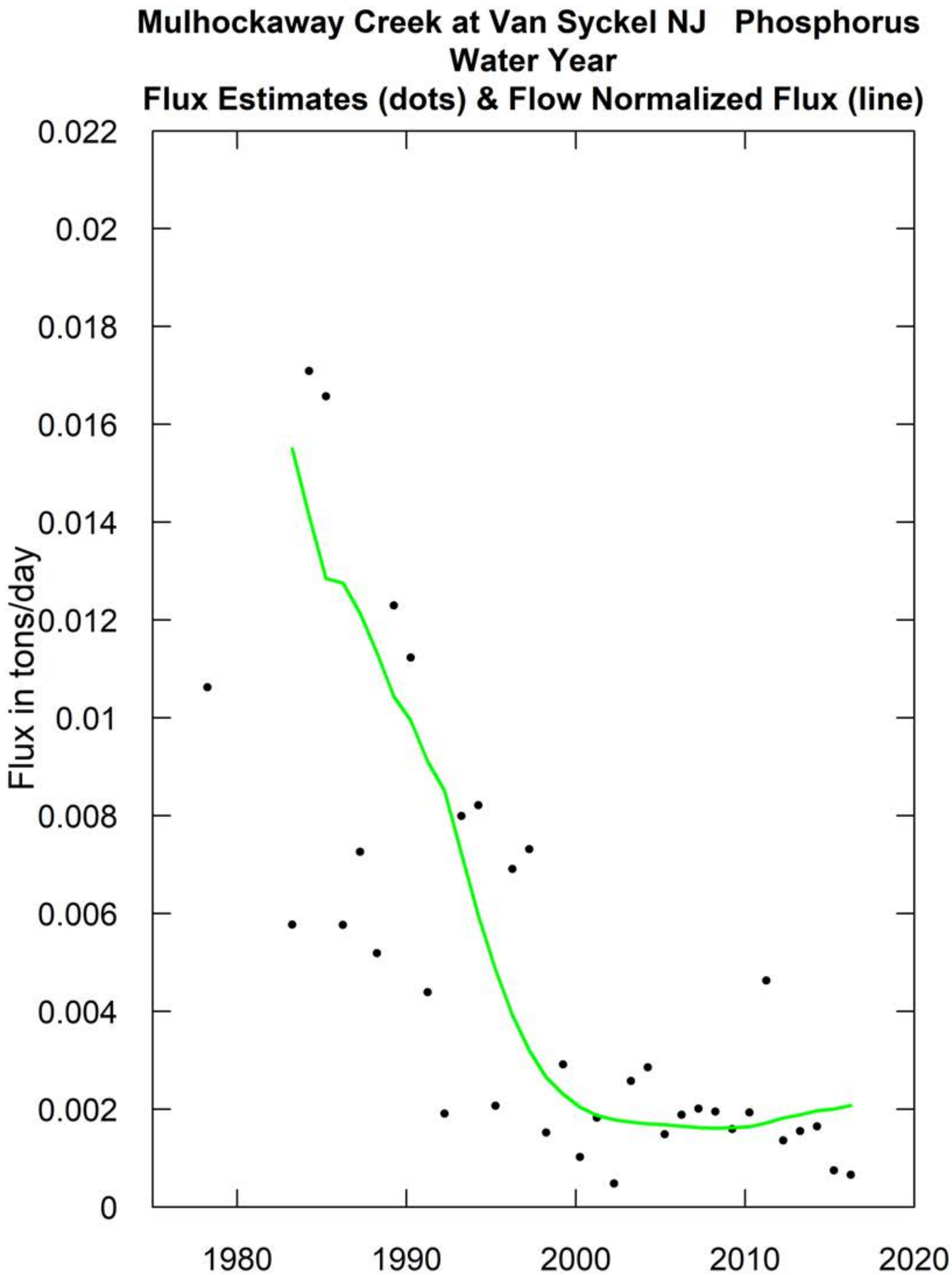

Mulhockaway Creek at Van Syckel NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

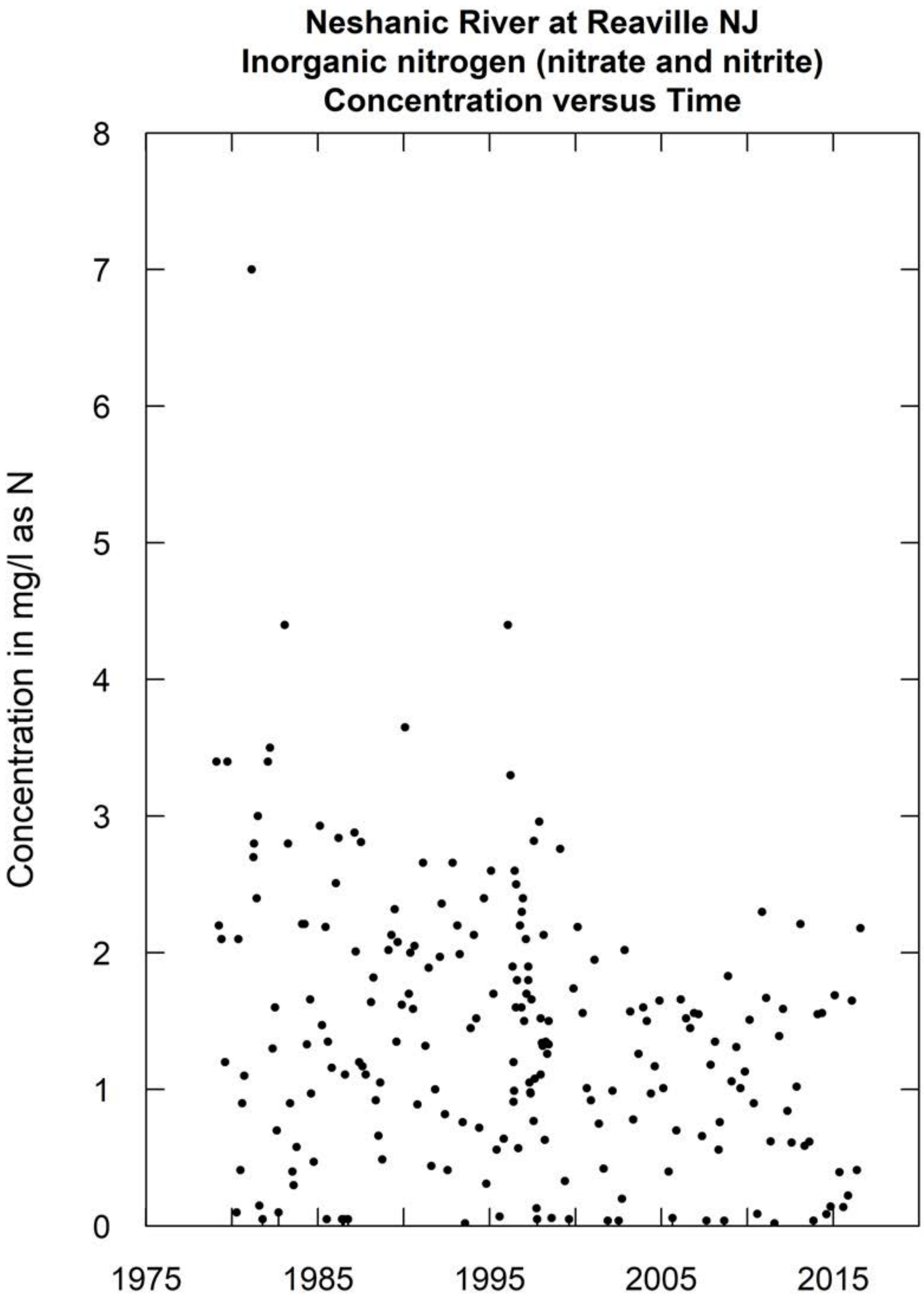

Mulhockaway Creek at Van Syckel NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

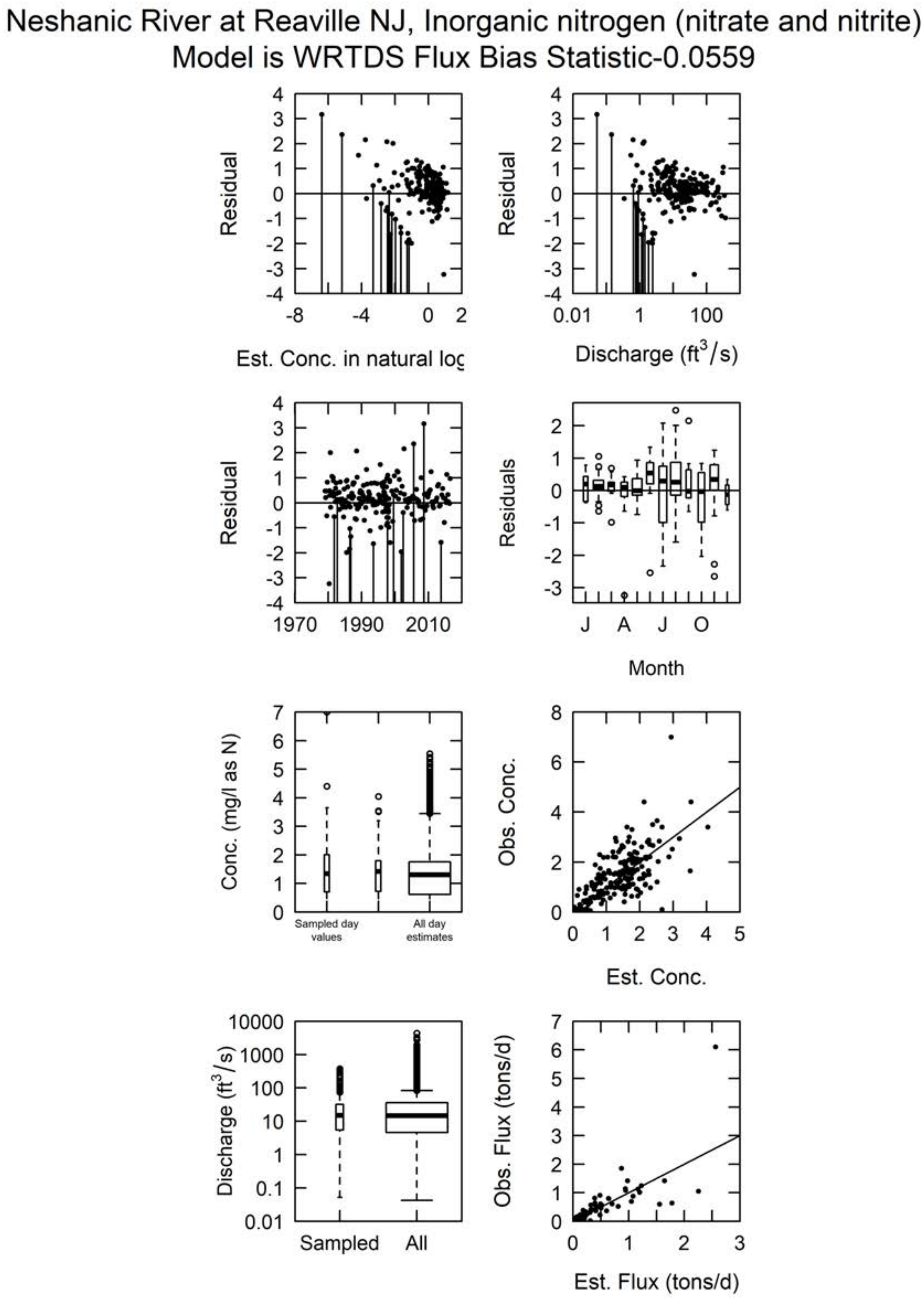

Mulhockaway Creek at Van Syckel NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1975
1985
1995
2005
2015

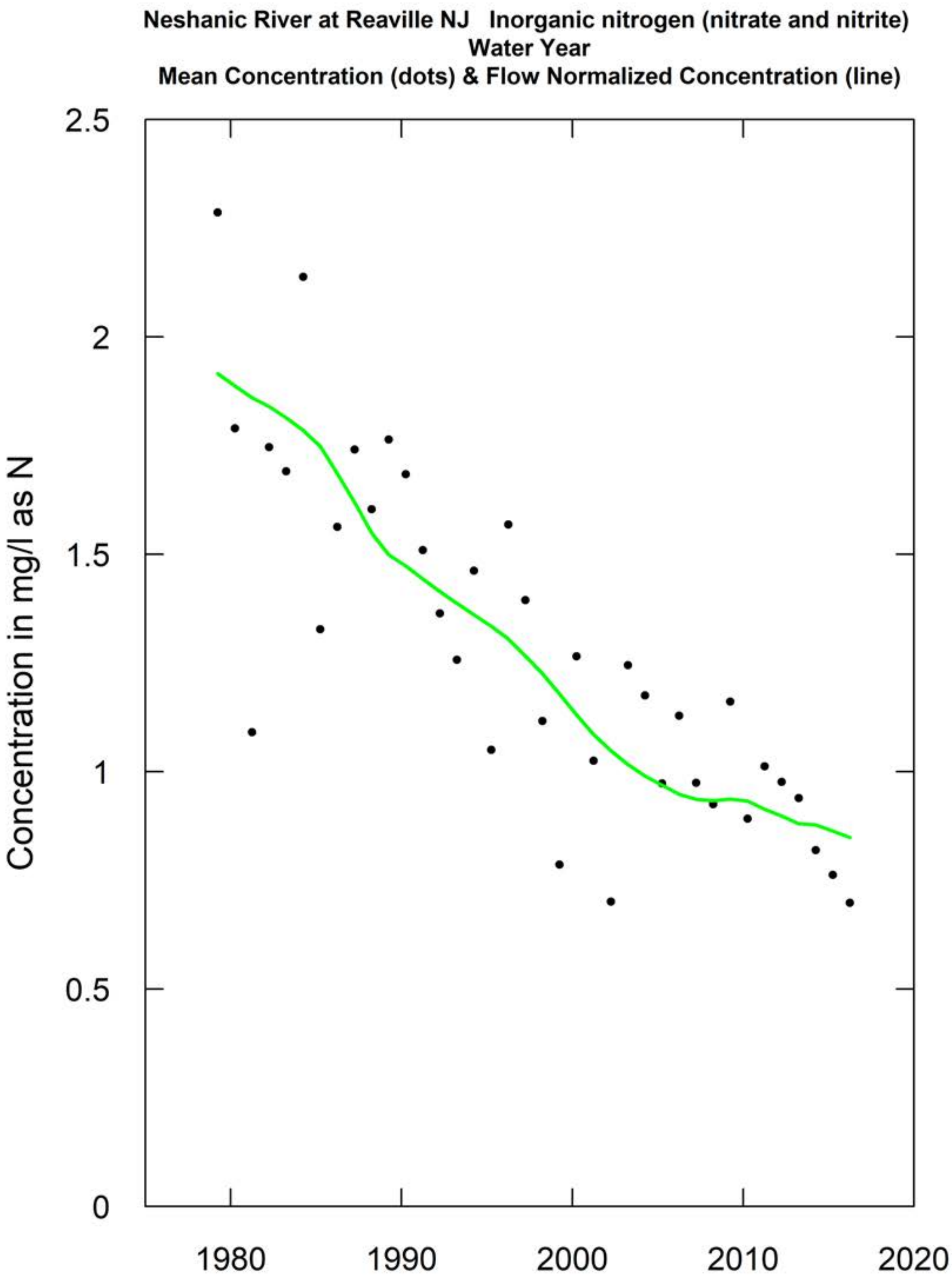

Mulhockaway Creek at Van Syckel NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.239
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

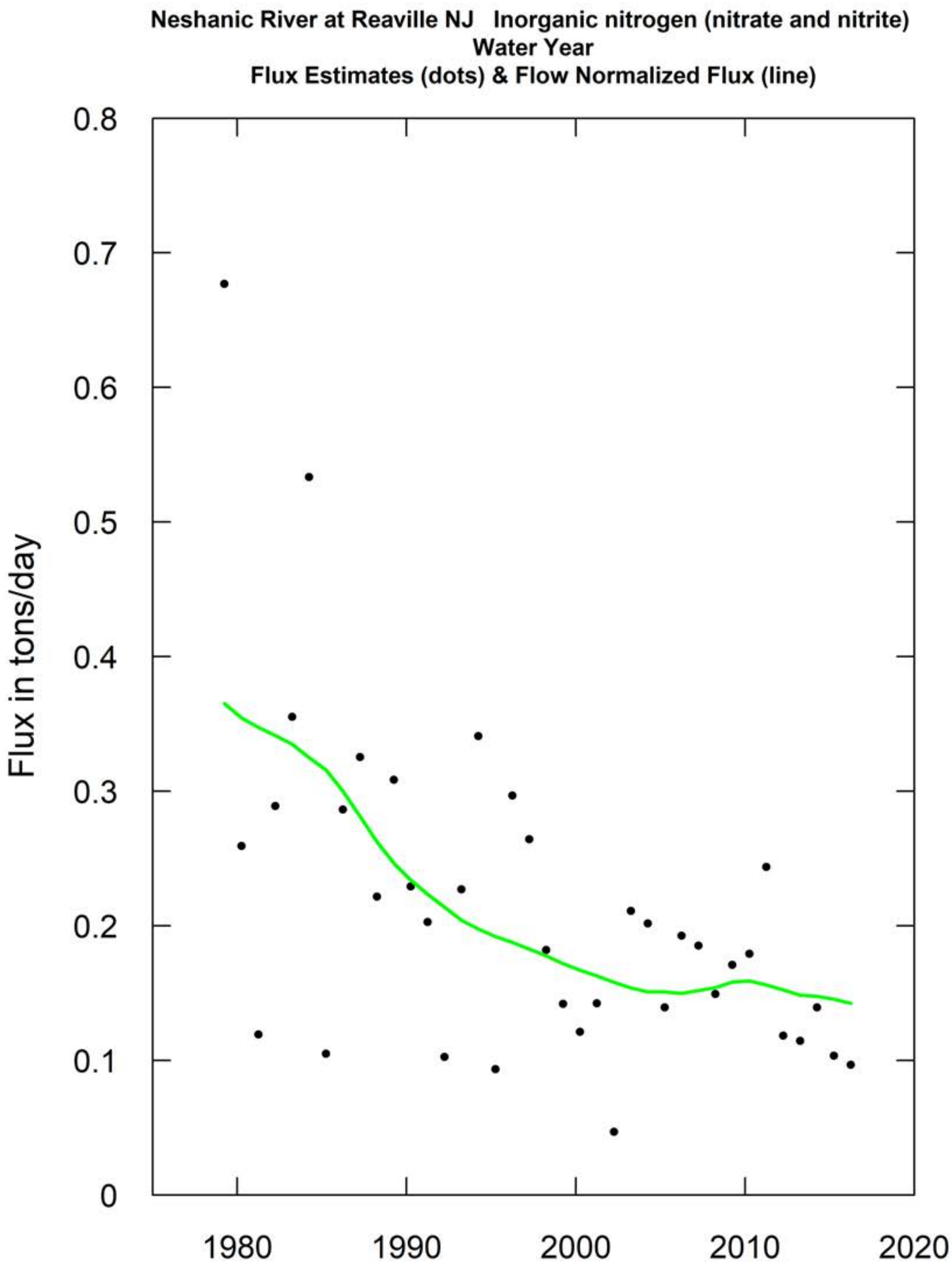

Mulhockaway Creek at Van Syckel NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

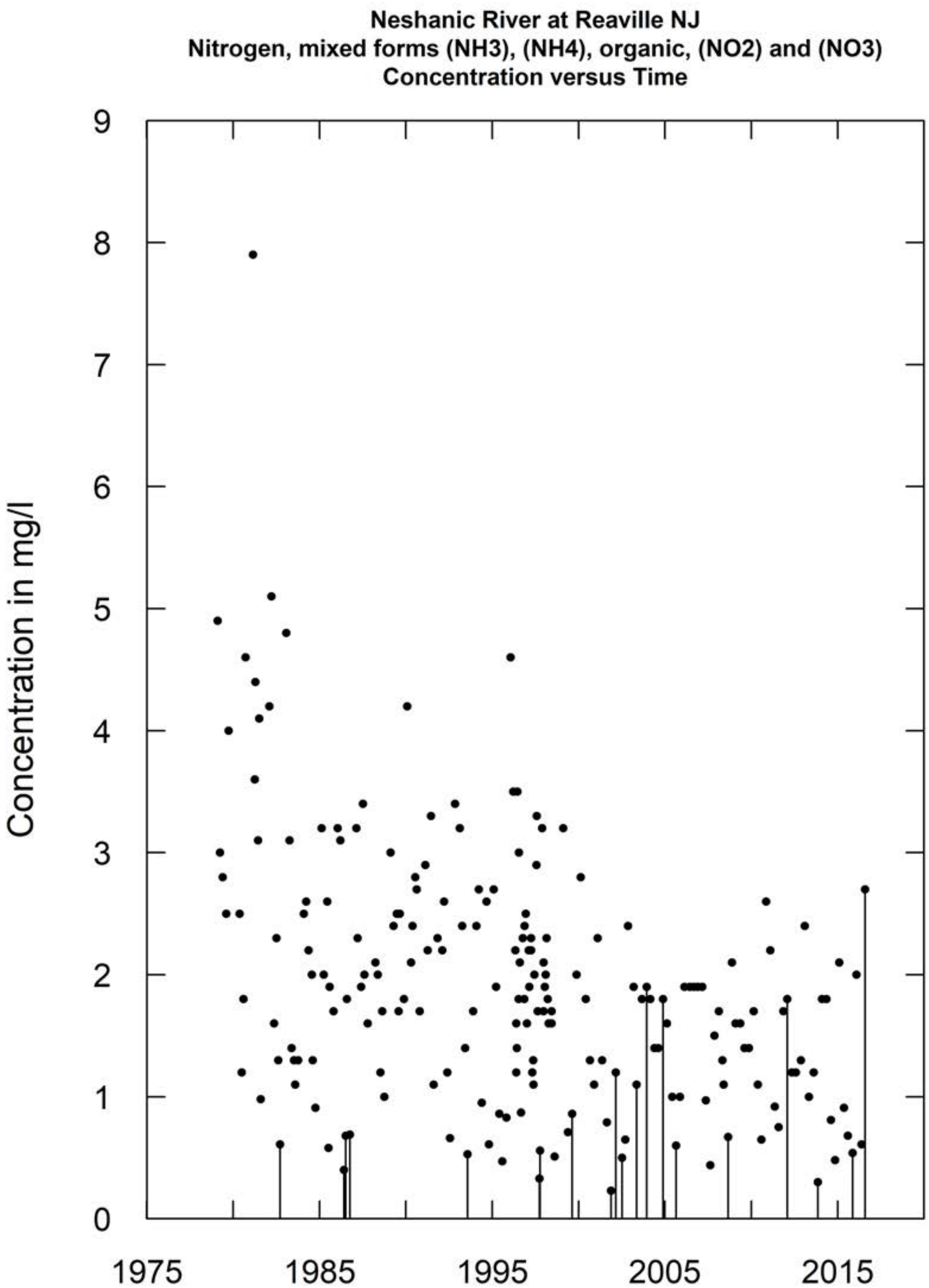

Mulhockaway Creek at Van Syckel NJ   Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.022
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
1980
1990
2000
2010
2020


Neshanic River at Reaville NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
0
1
2
3
4
5
6
7
8
1975
1985
1995
2005
2015

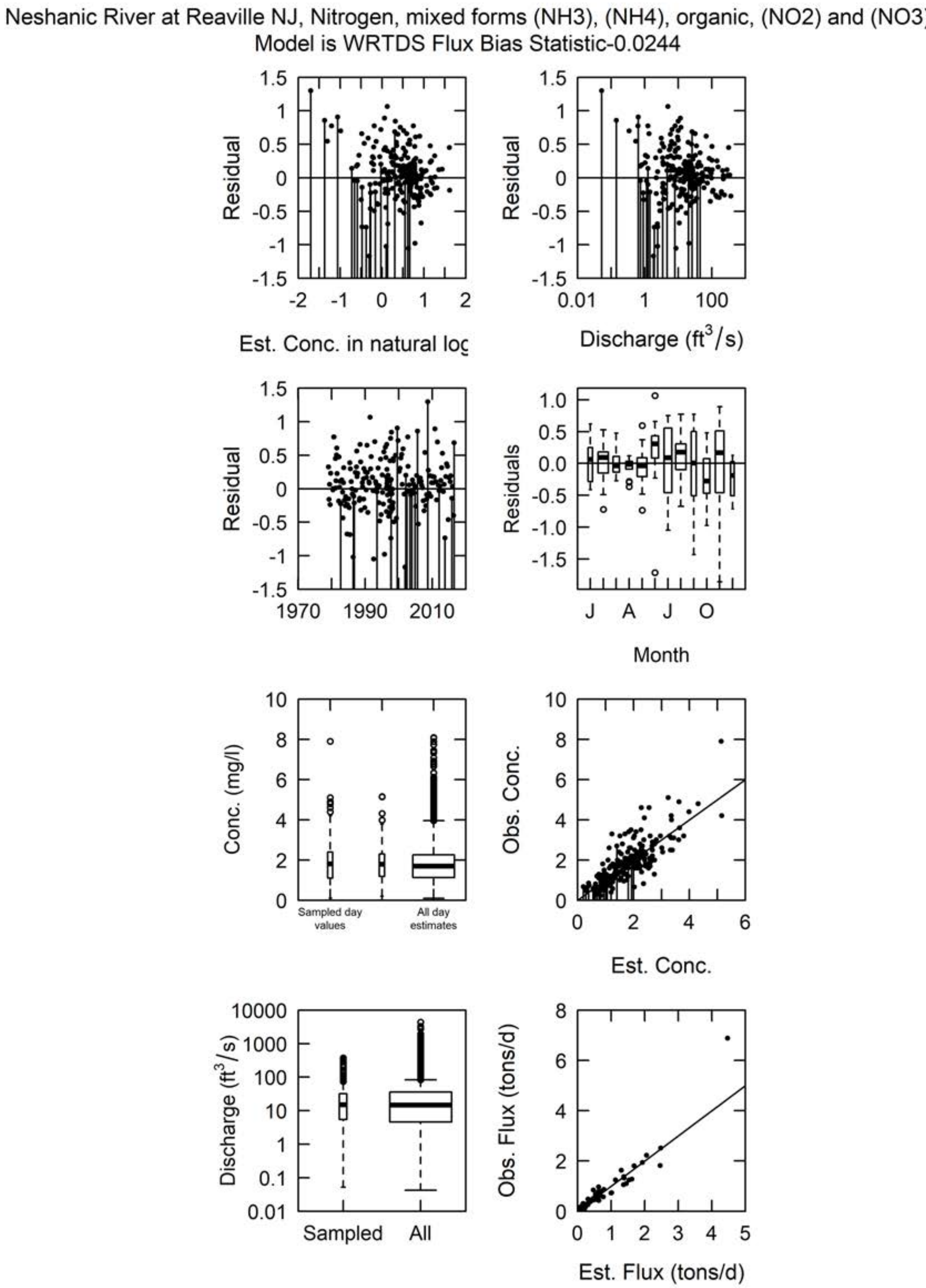

Neshanic River at Reaville NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.0559
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

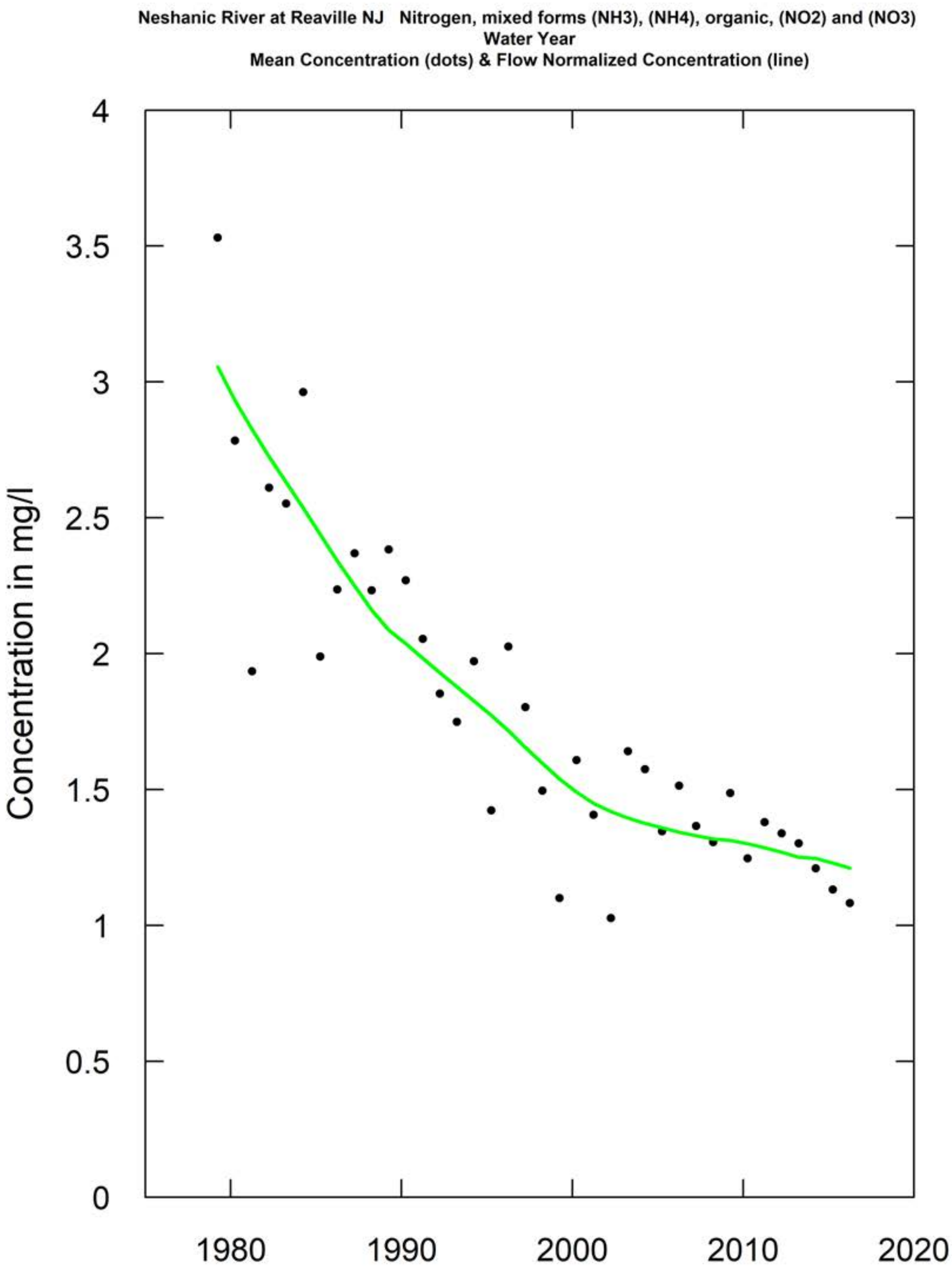

Neshanic River at Reaville NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
2.5
2
1.5
1
0.5
0
1980
1990
2000
2010
2020

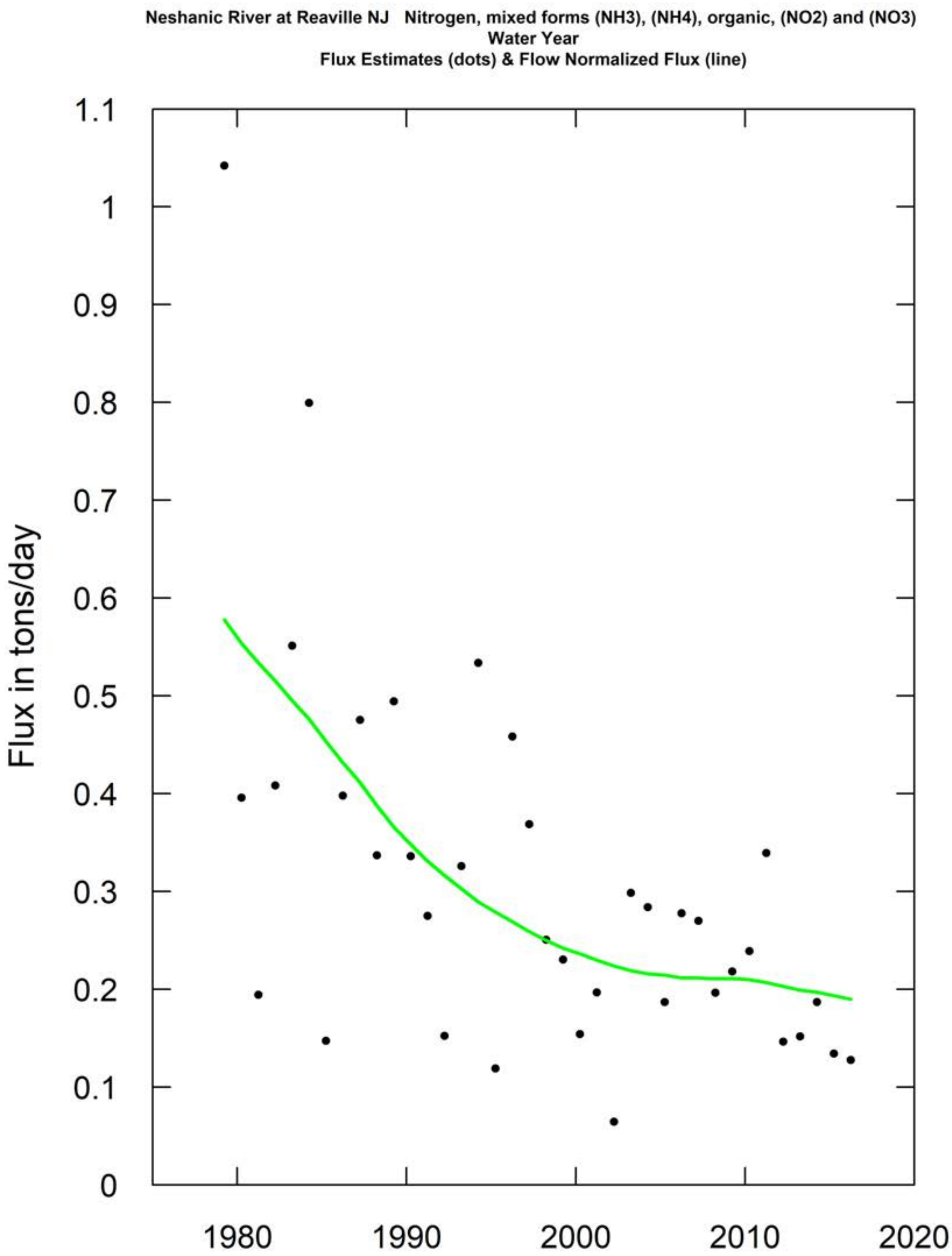

Neshanic River at Reaville NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

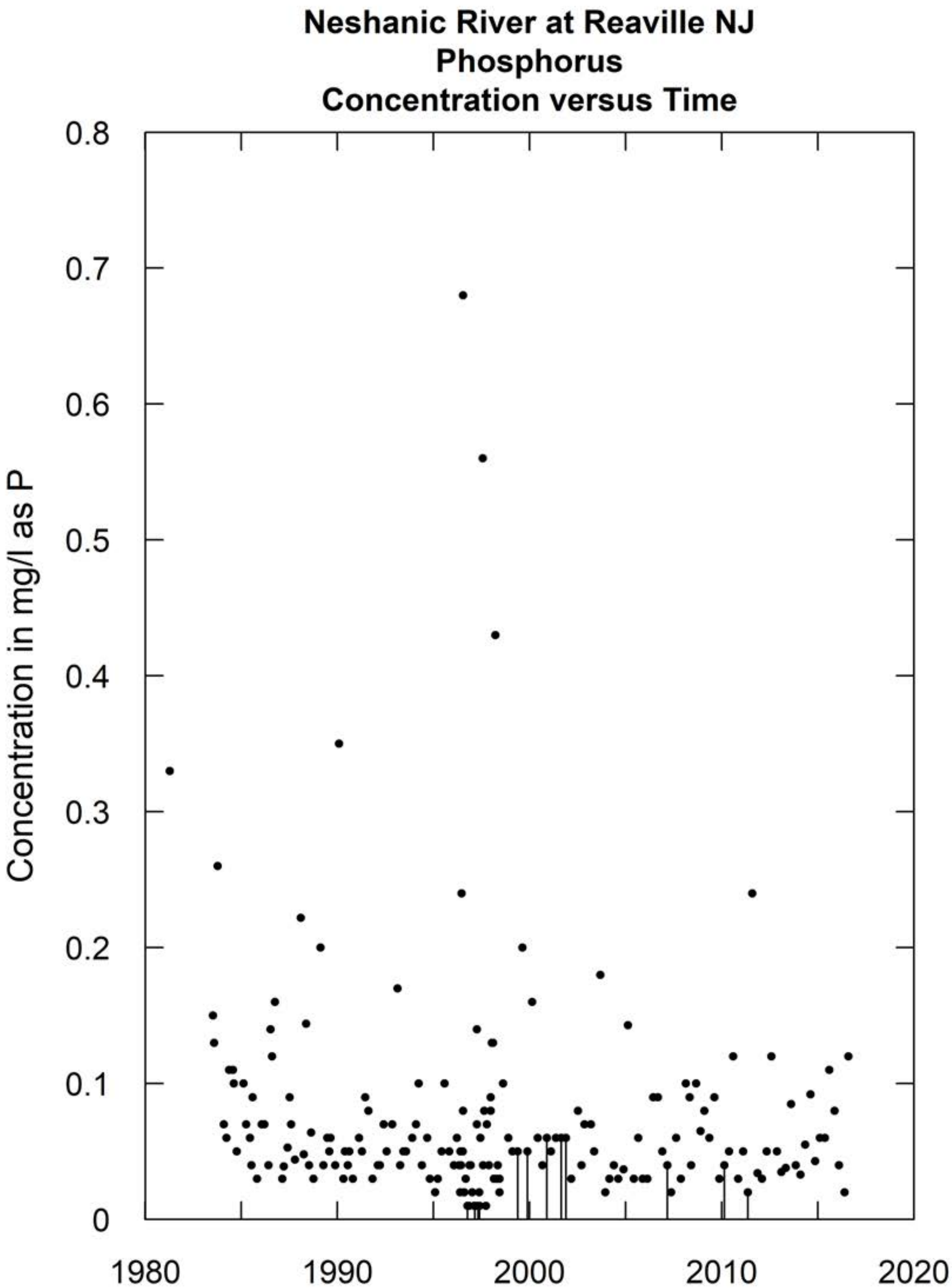


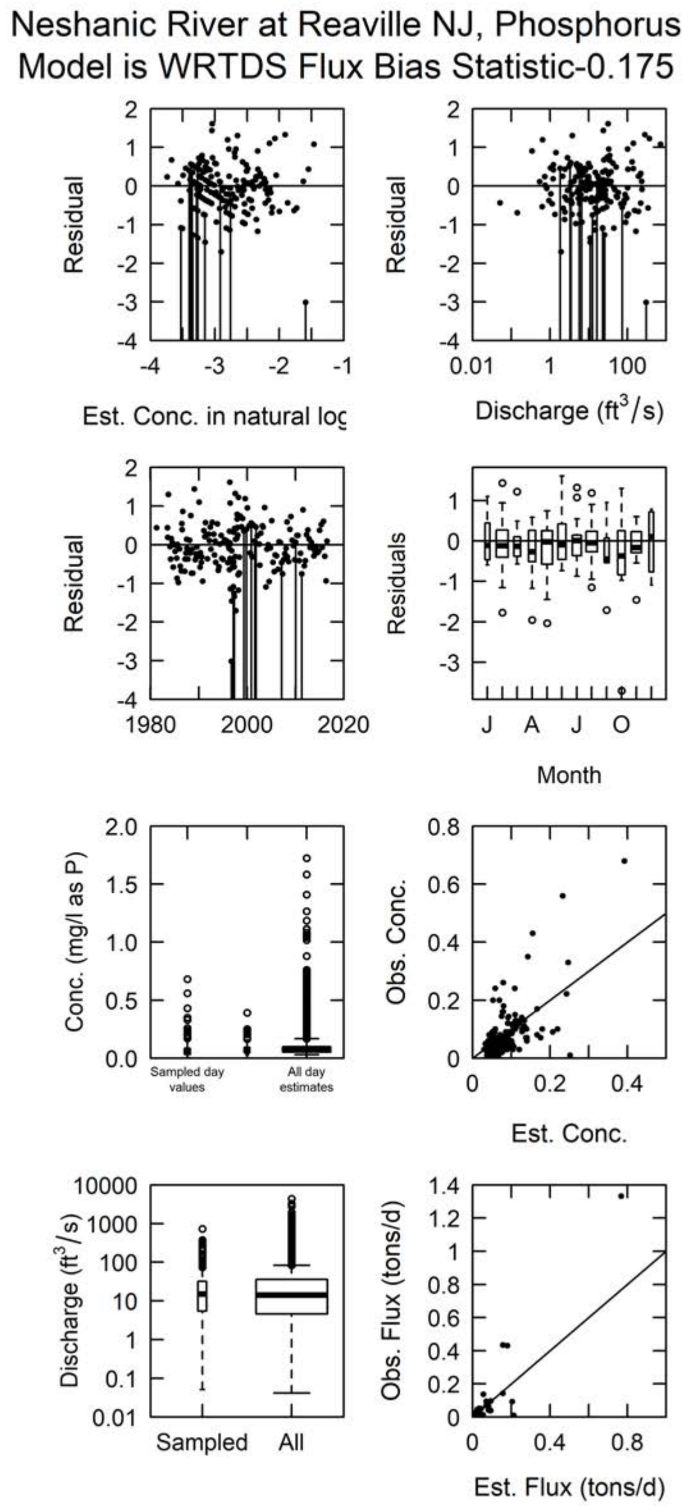
Neshanic River at Reaville NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
1
2
3
4
5
6
7
8
9
1975
1985
1995
2005
2015

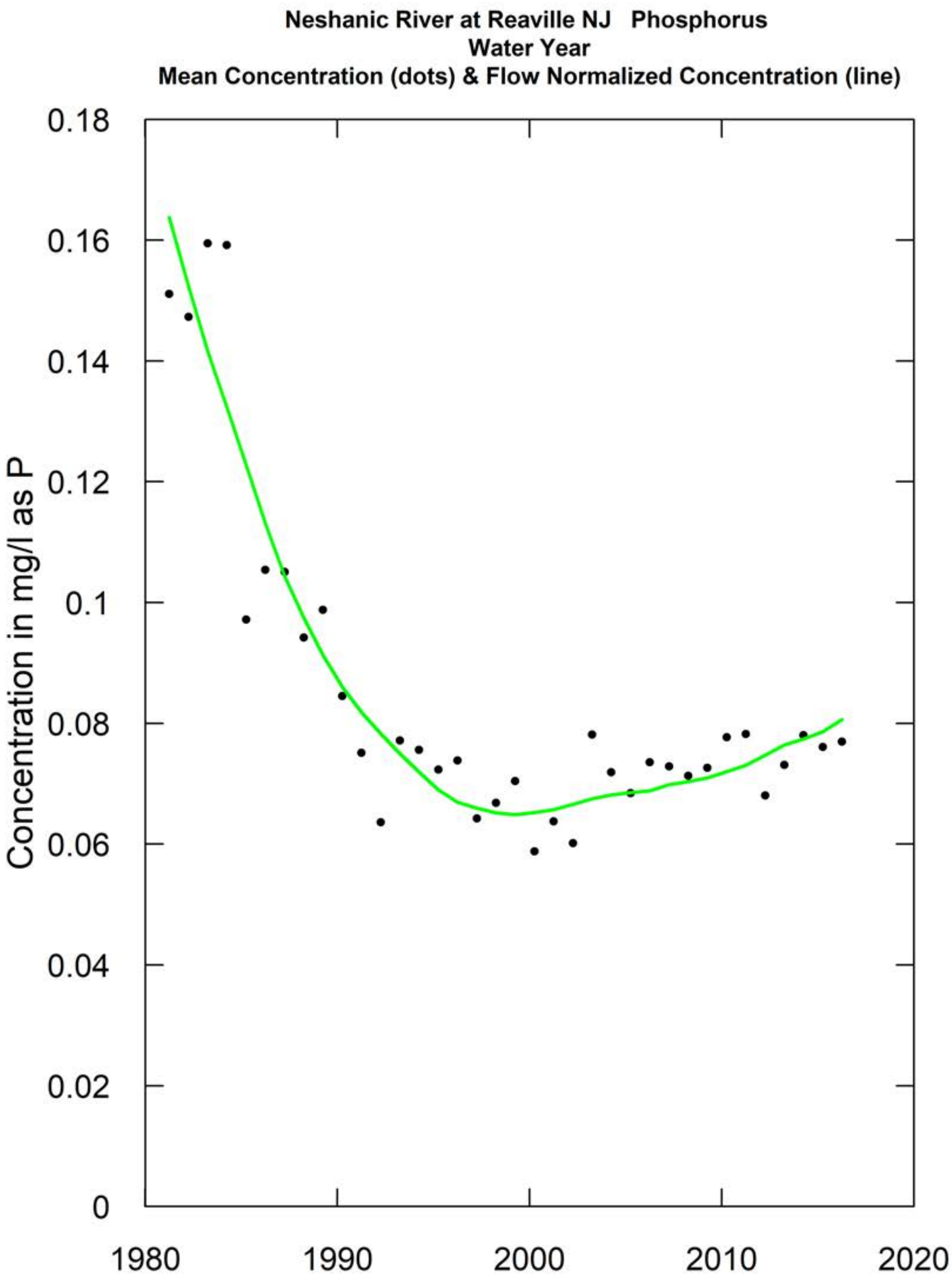

Neshanic River at Reaville NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic-0.0244
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

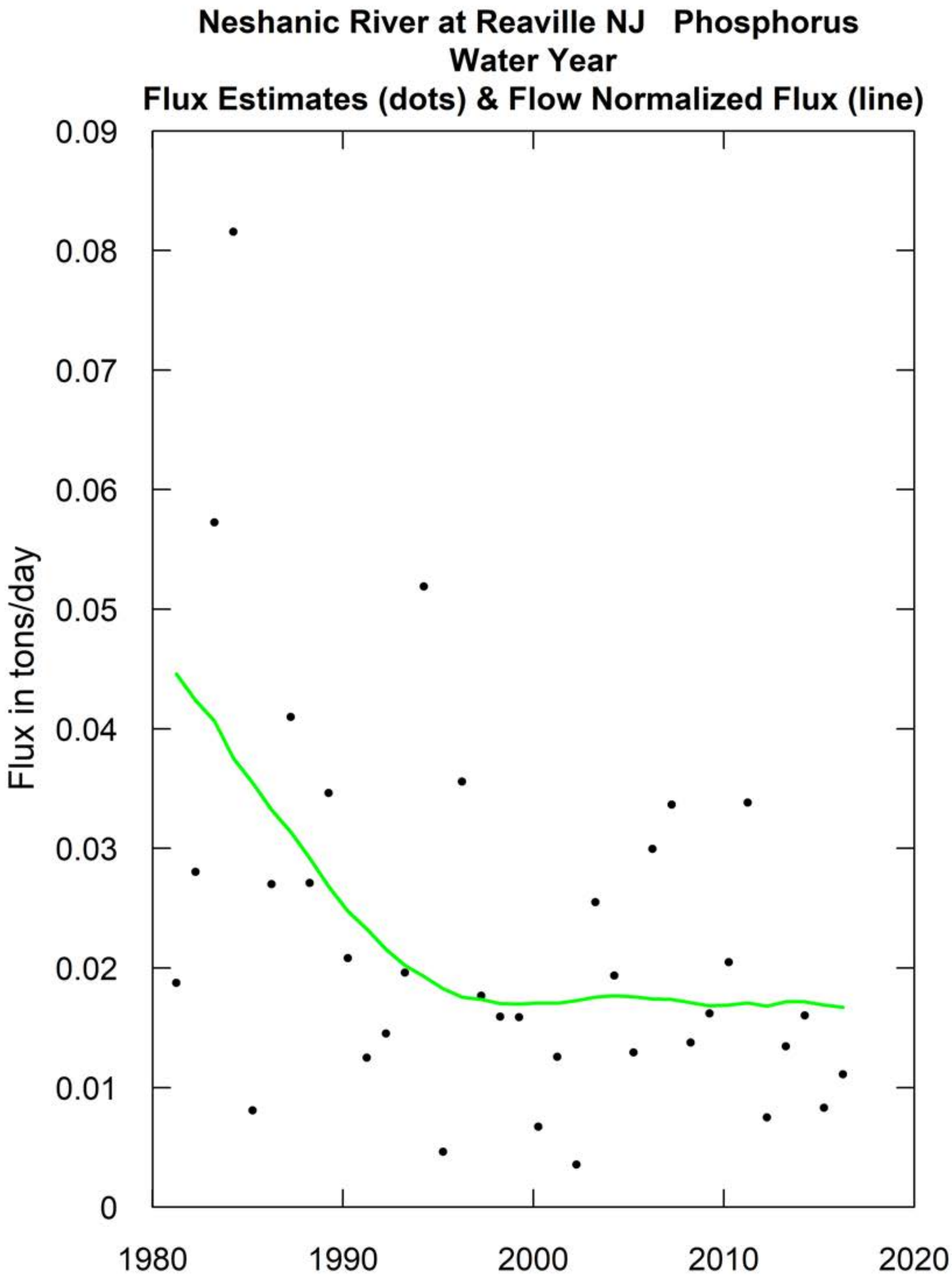

Neshanic River at Reaville NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
1980
1990
2000
2010
2020

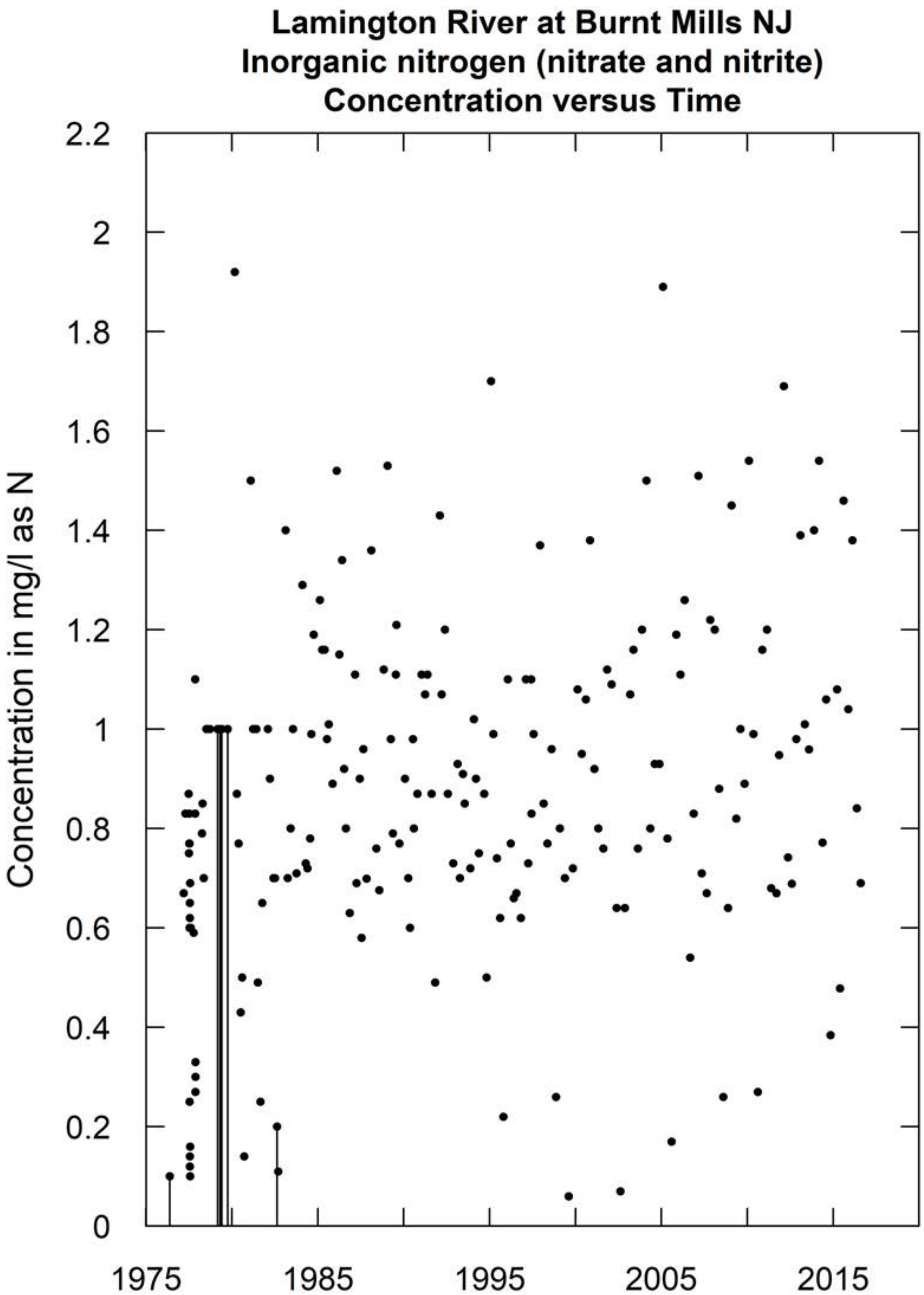

Neshanic River at Reaville NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

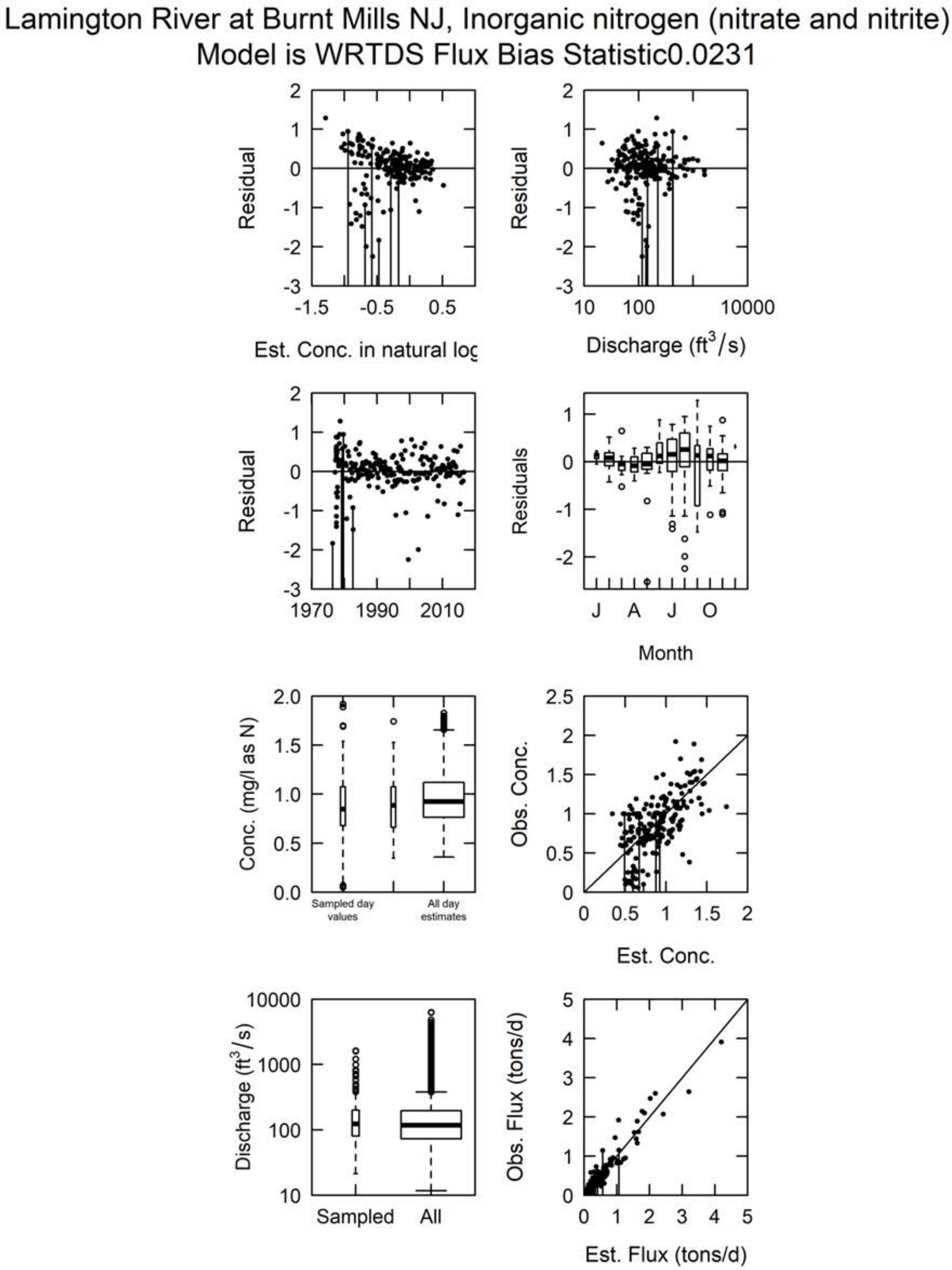

Neshanic River at Reaville NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

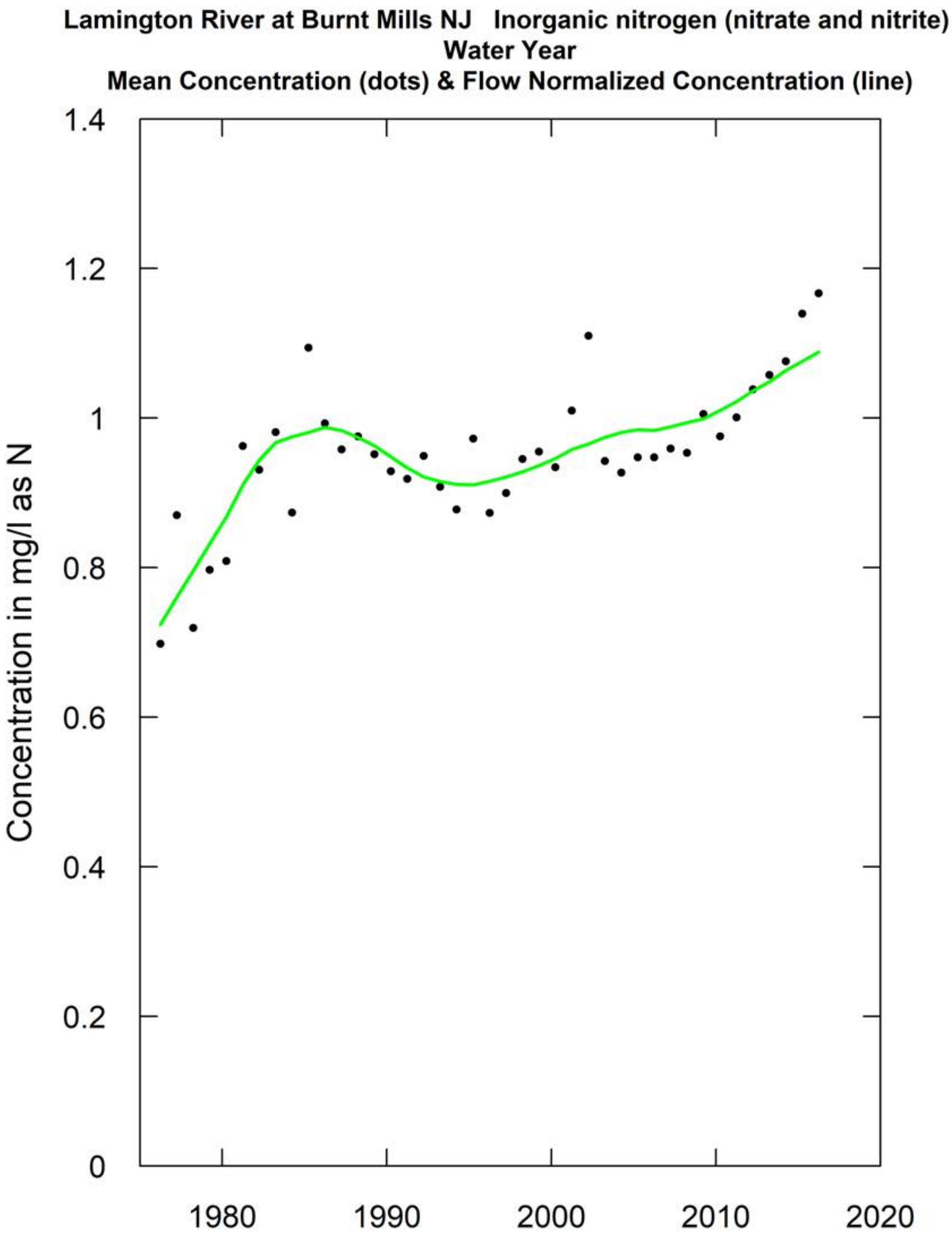

Neshanic River at Reaville NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.175
Residual
Est. Conc. in natural log
Residual
Discharge (ft^3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

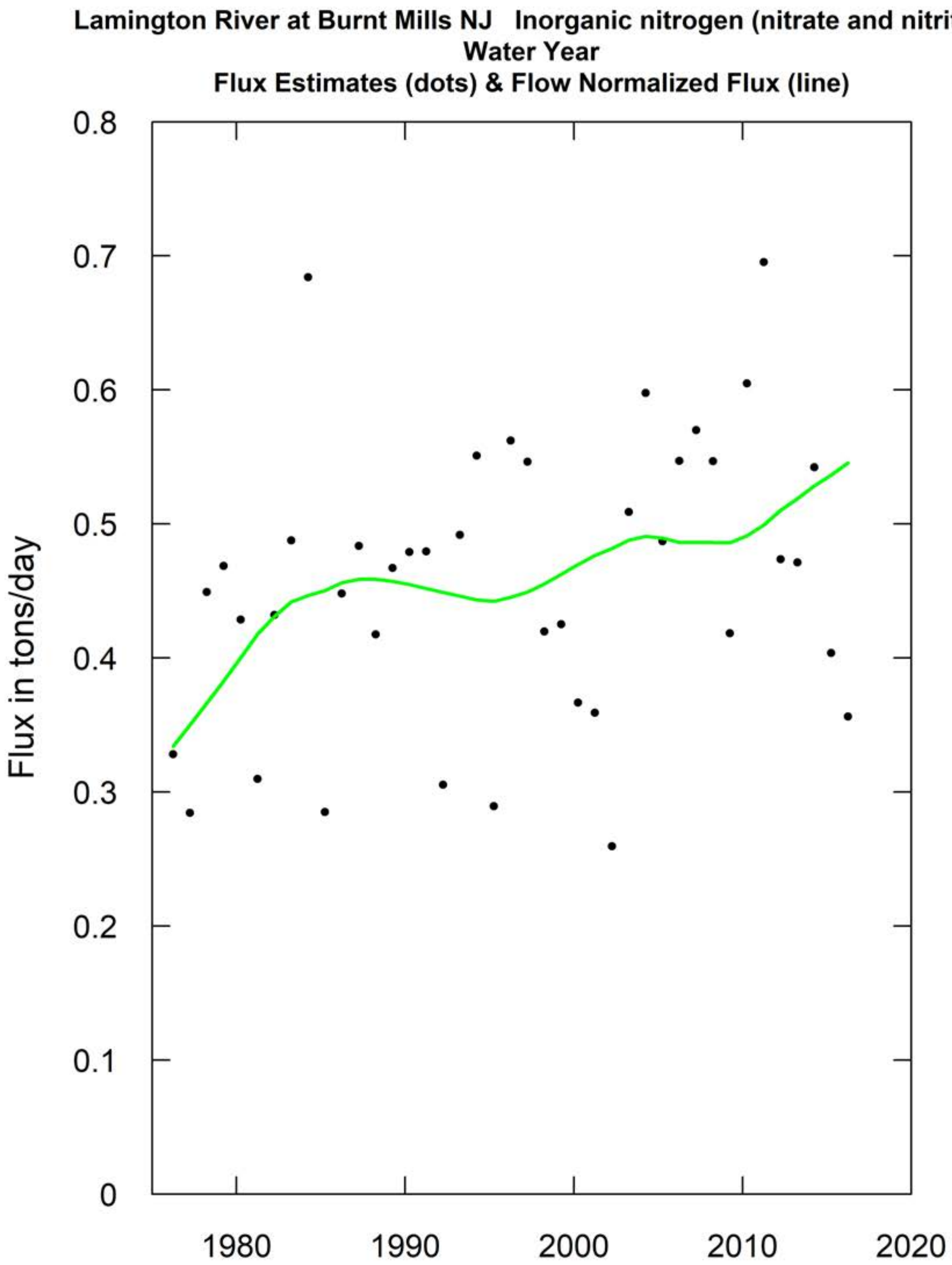

Neshanic River at Reaville NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

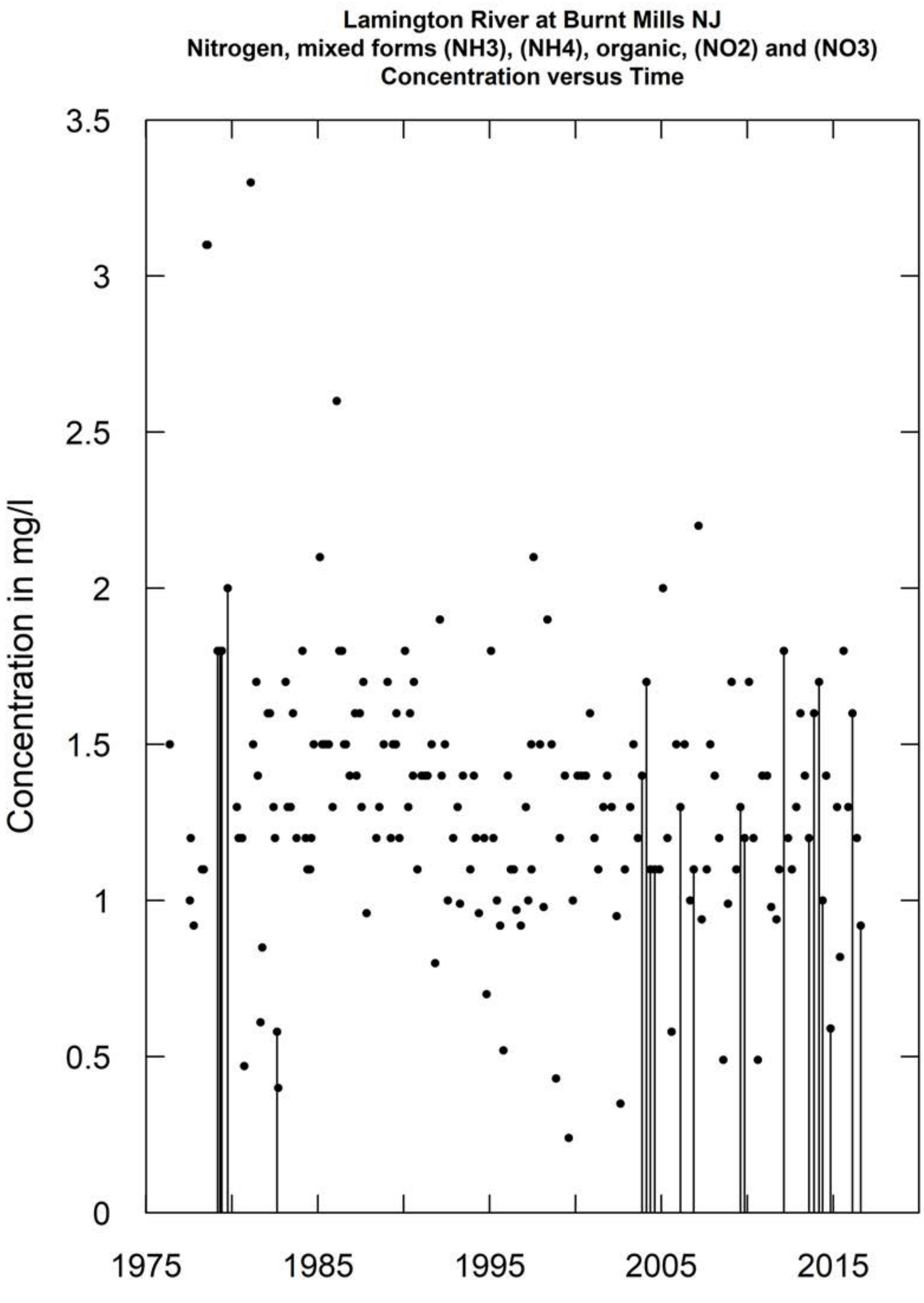

Neshanic River at Reaville NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1980
1990
2000
2010
2020

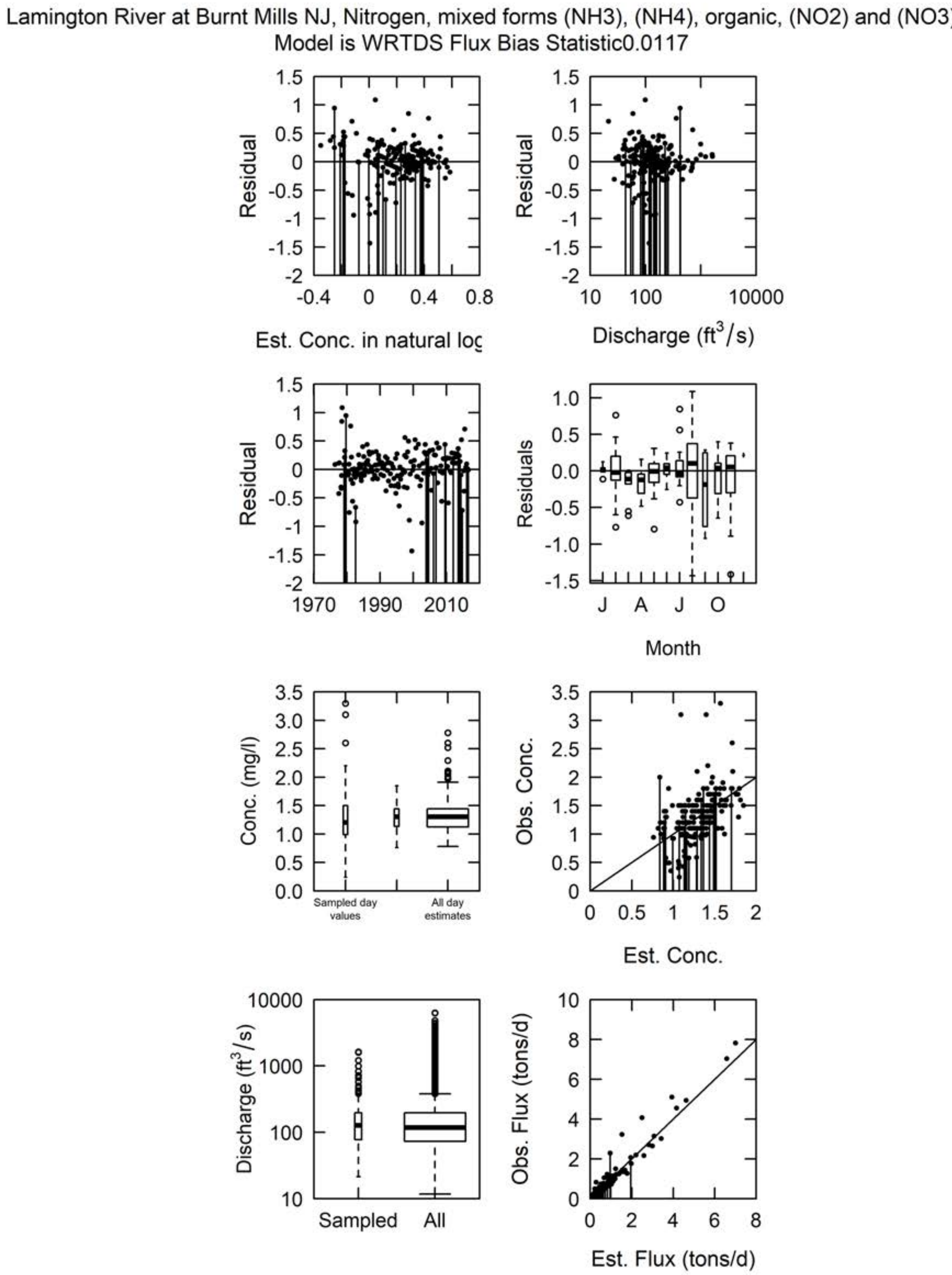

Lamington River at Burnt Mills NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1975
1985
1995
2005
2015

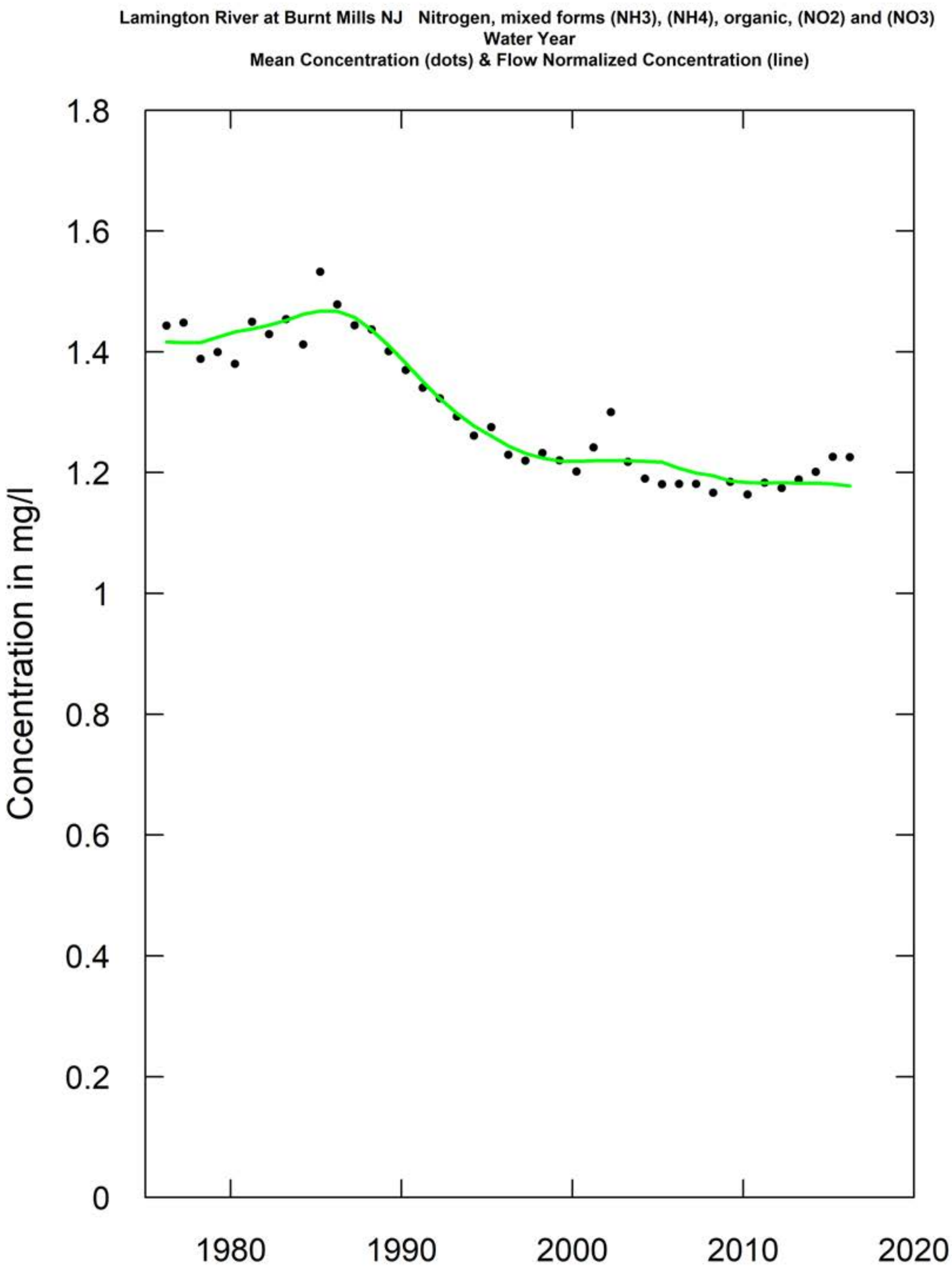

Lamington River at Burnt Mills NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0231
Residual
Est. Conc. in natural log
Residual
Discharge (ft³/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

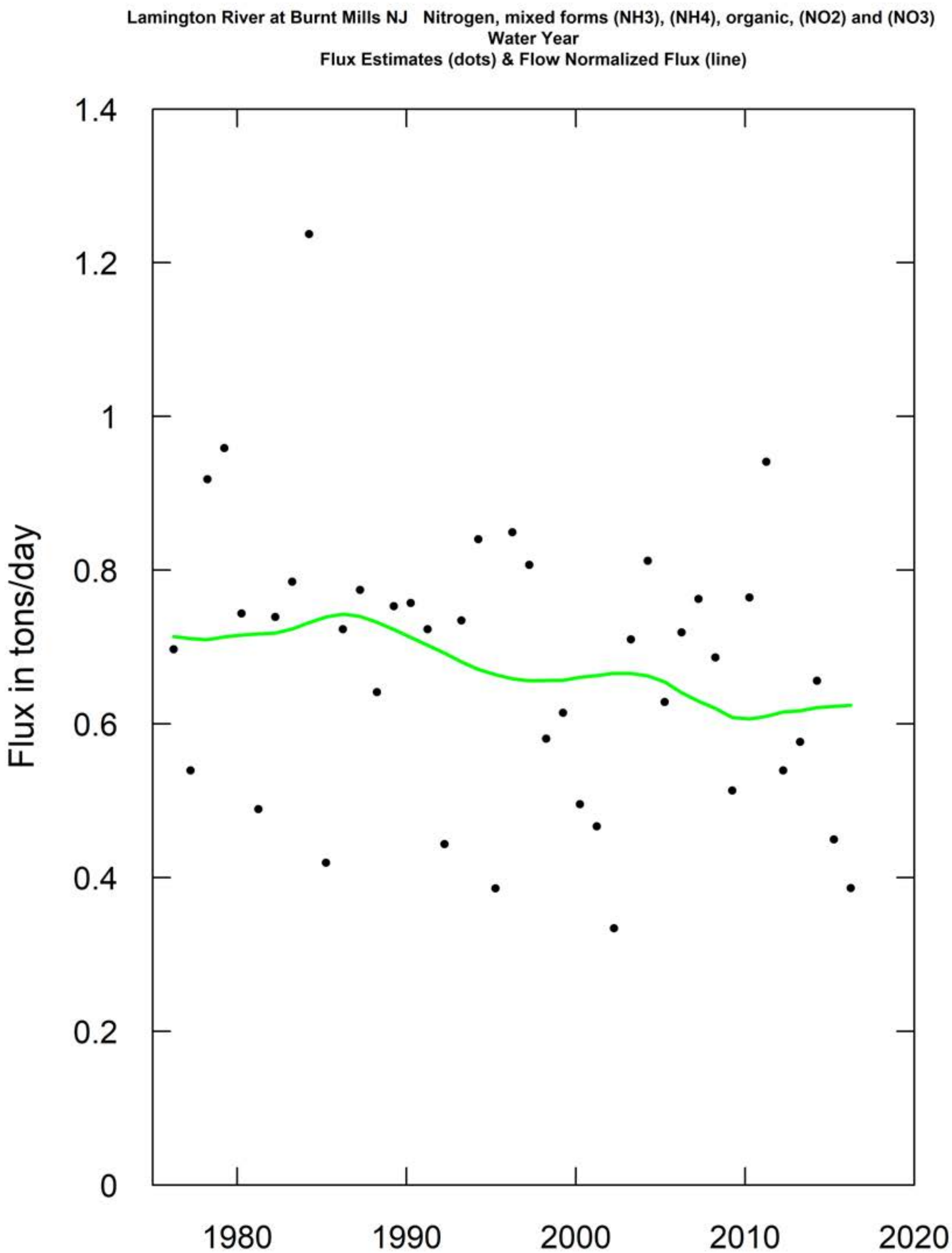

Lamington River at Burnt Mills NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

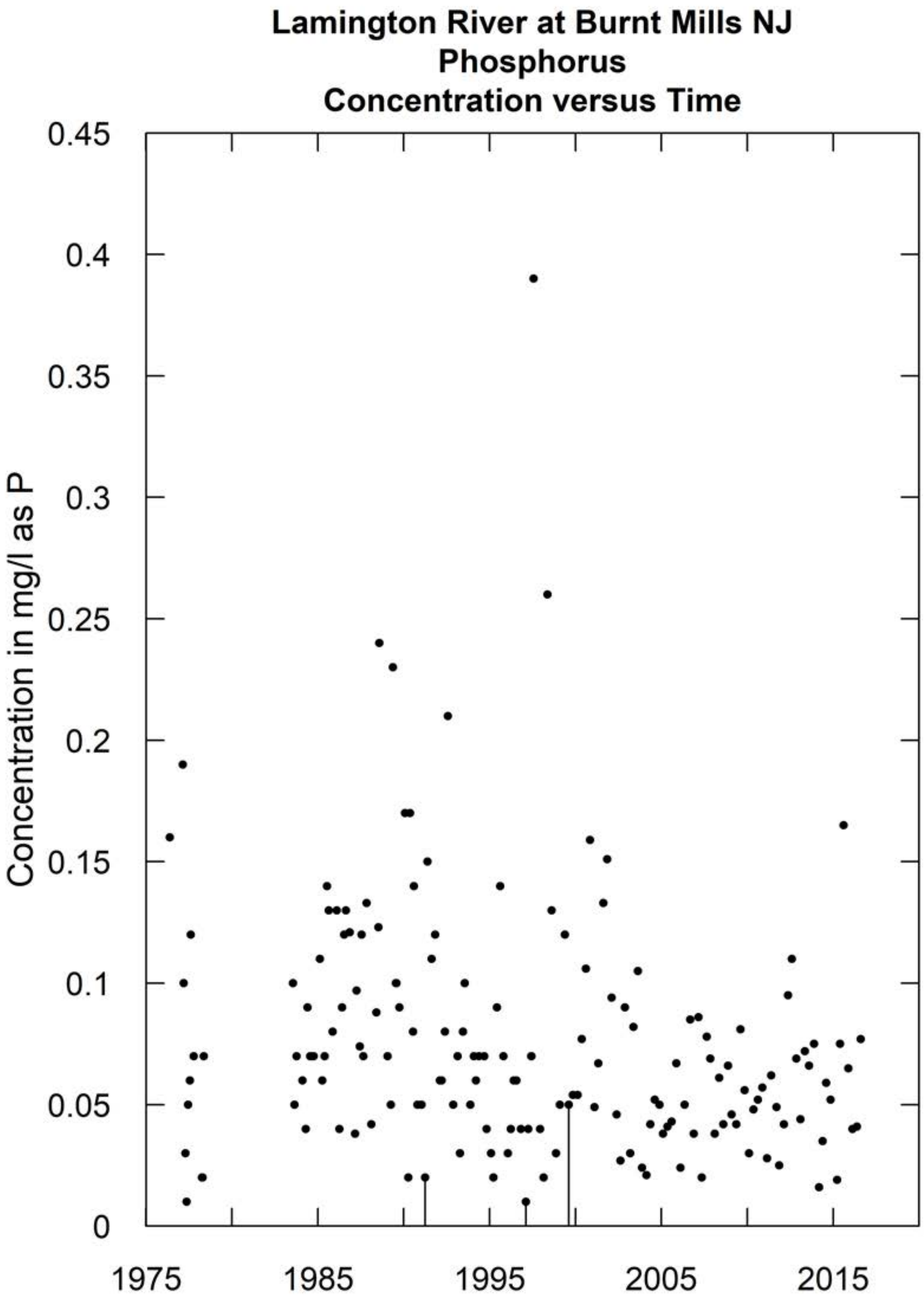

Lamington River at Burnt Mills NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

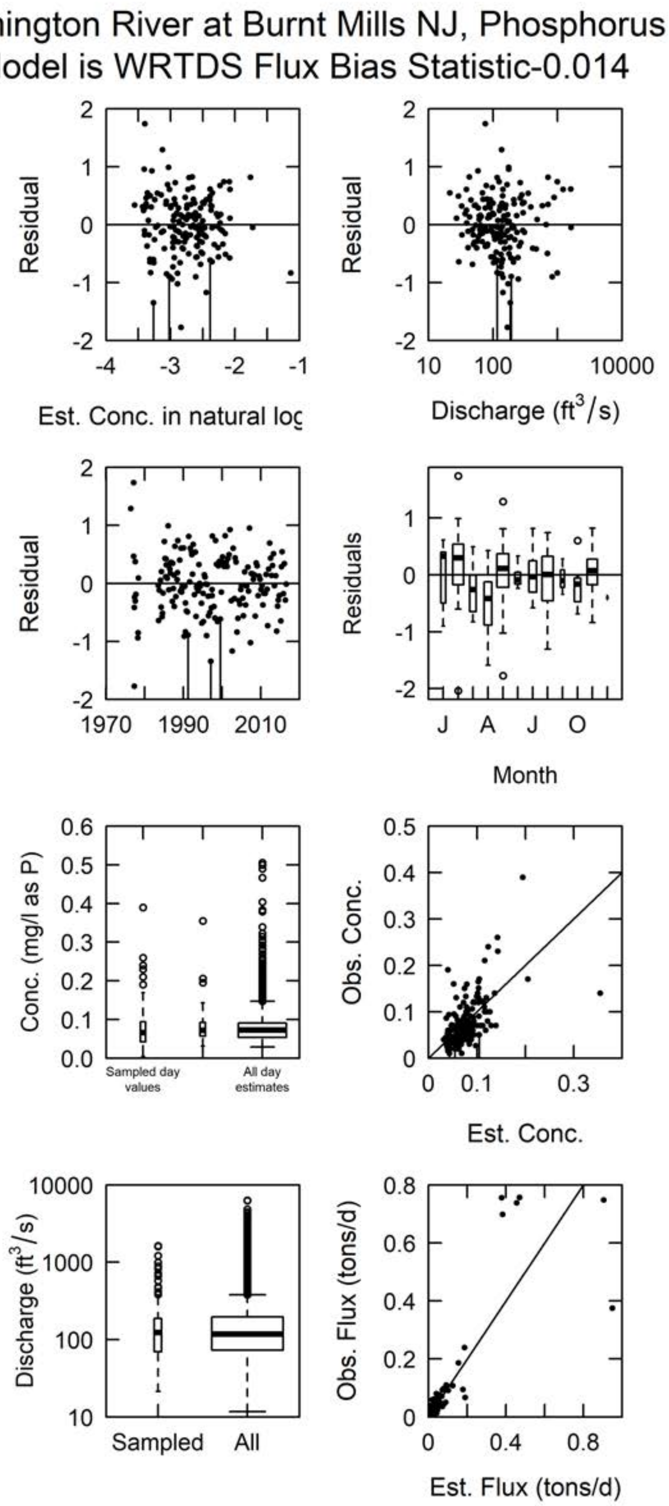

Lamington River at Burnt Mills NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
3.5
3
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

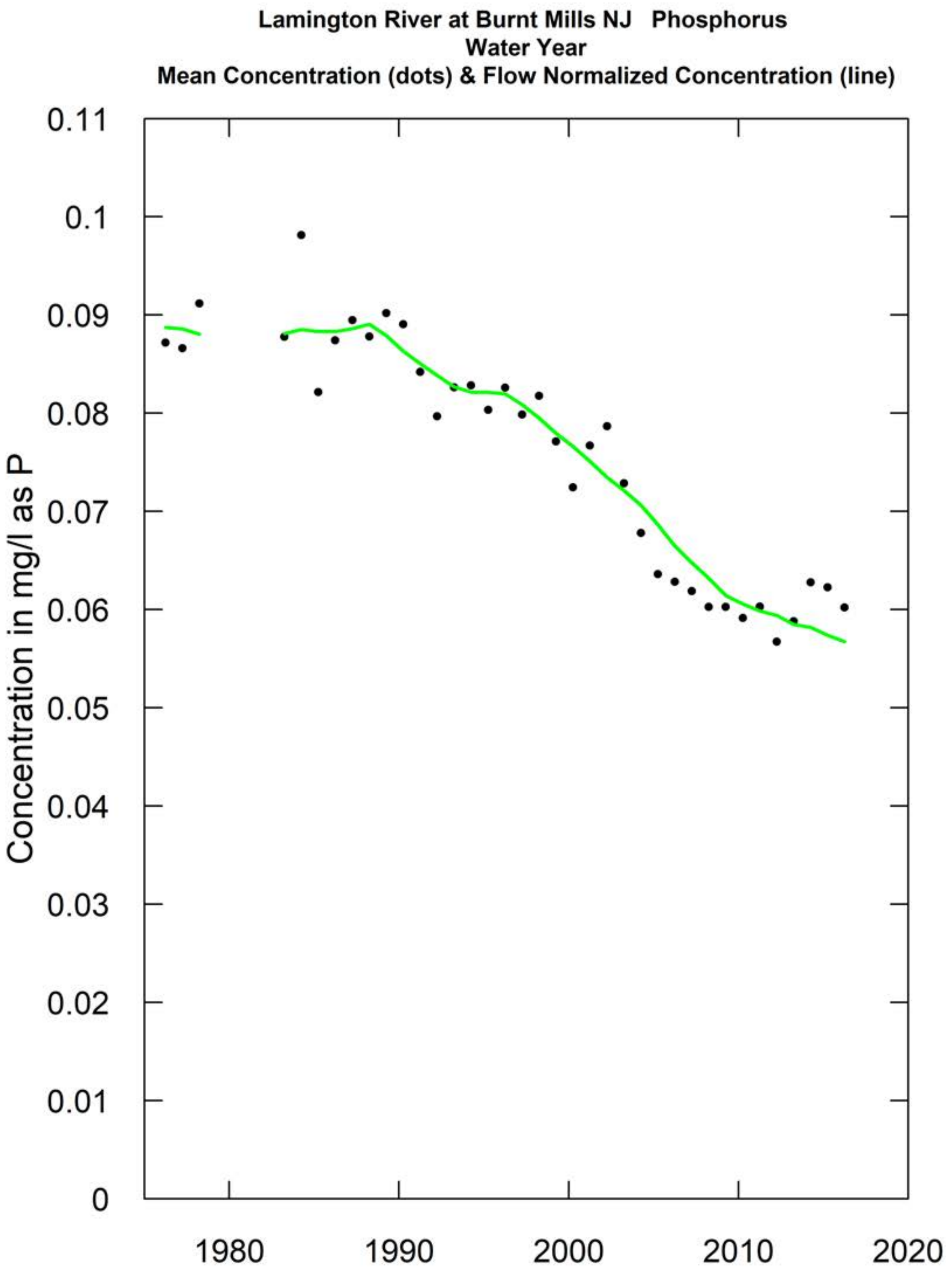

Lamington River at Burnt Mills NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.0117
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

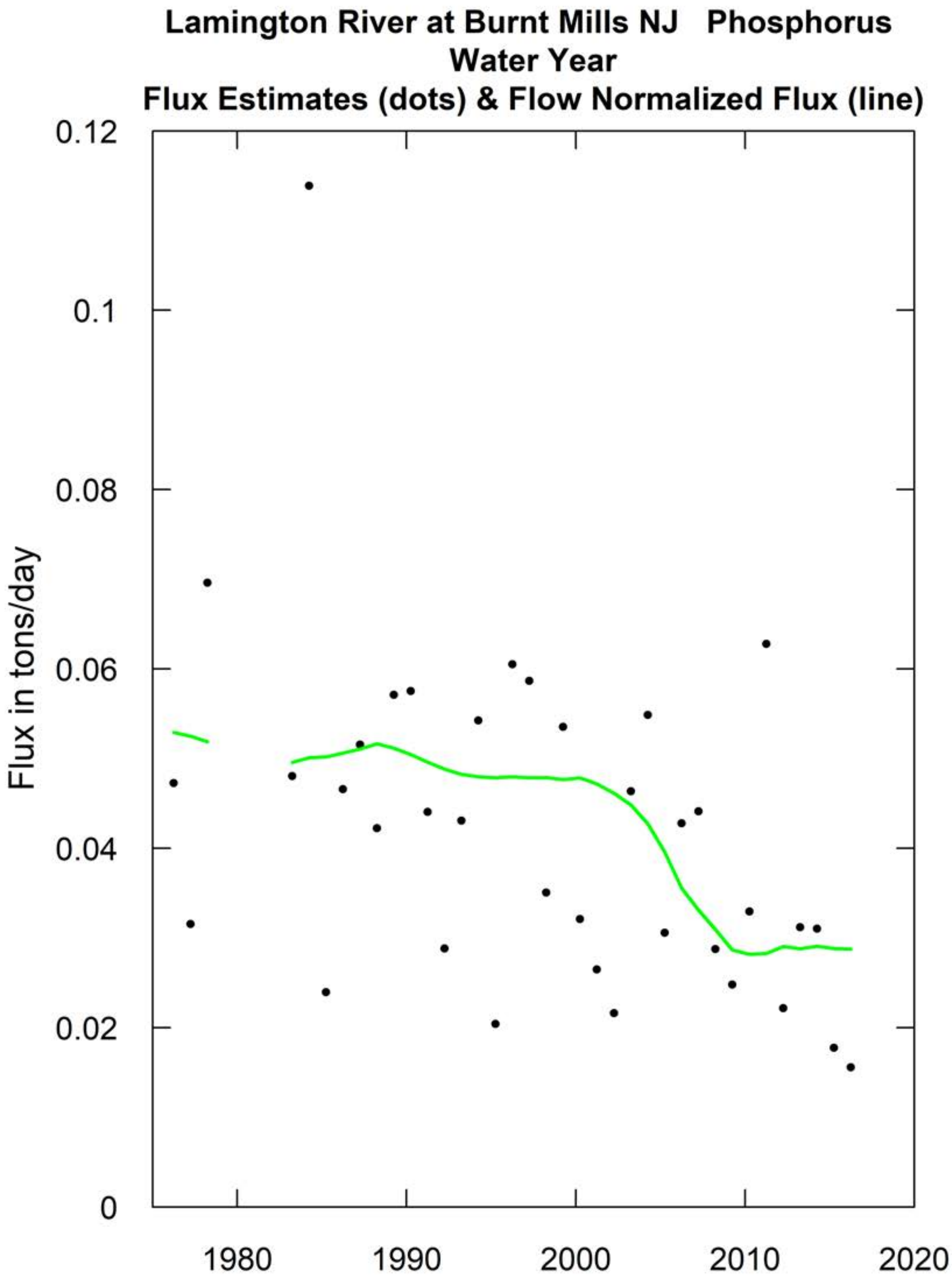

Lamington River at Burnt Mills NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

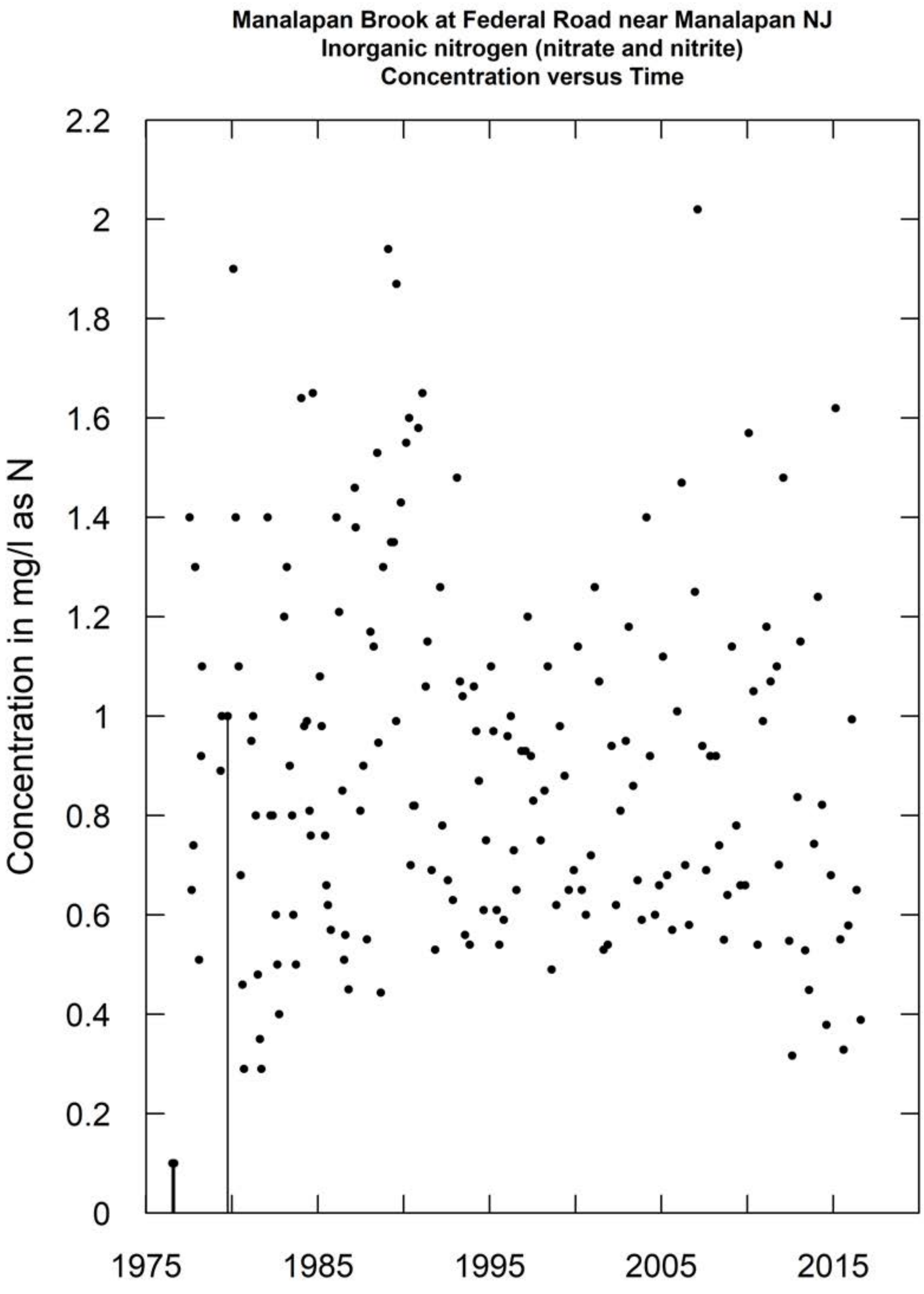

Lamington River at Burnt Mills NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

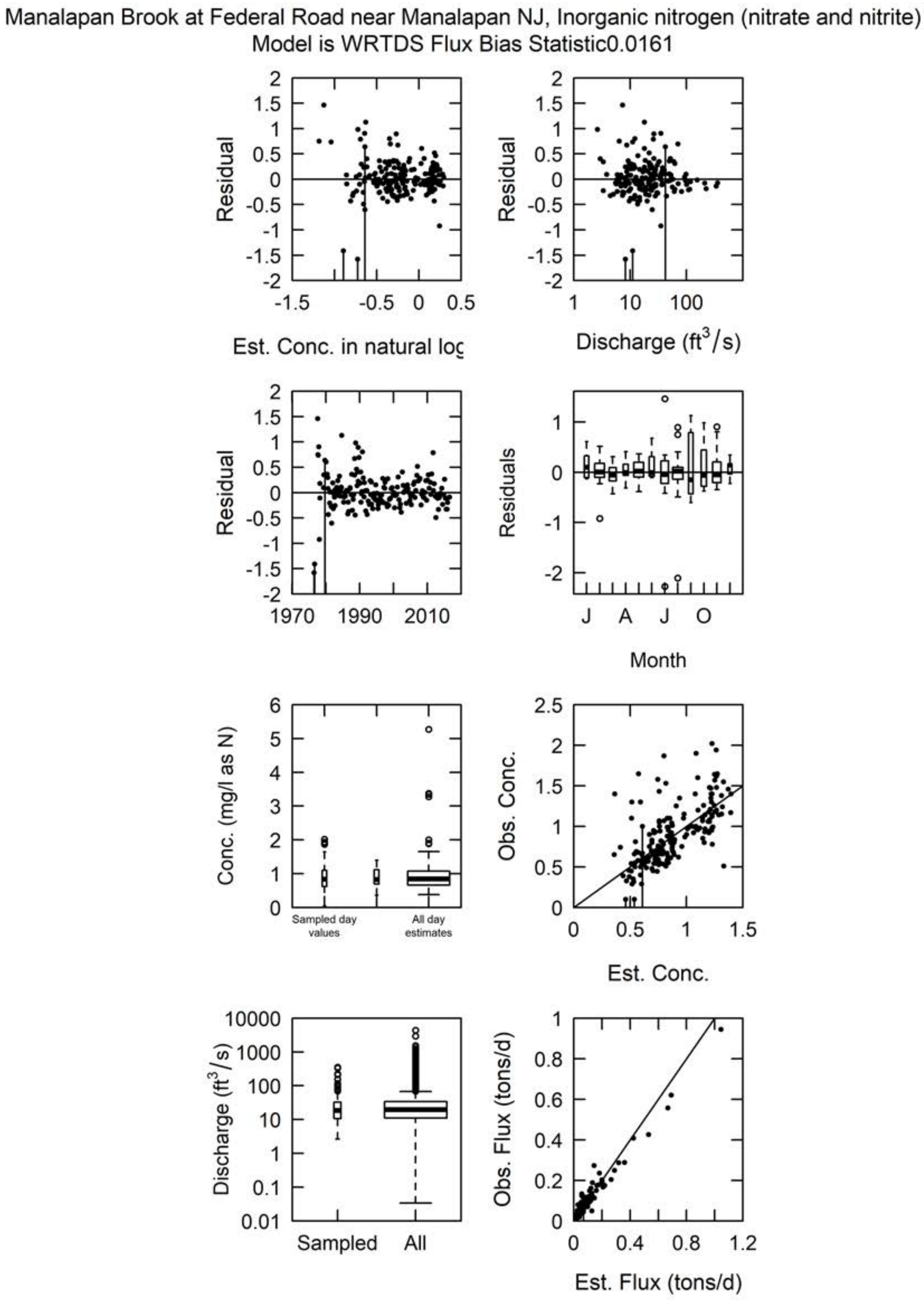

Lamington River at Burnt Mills NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1975
1985
1995
2005
2015

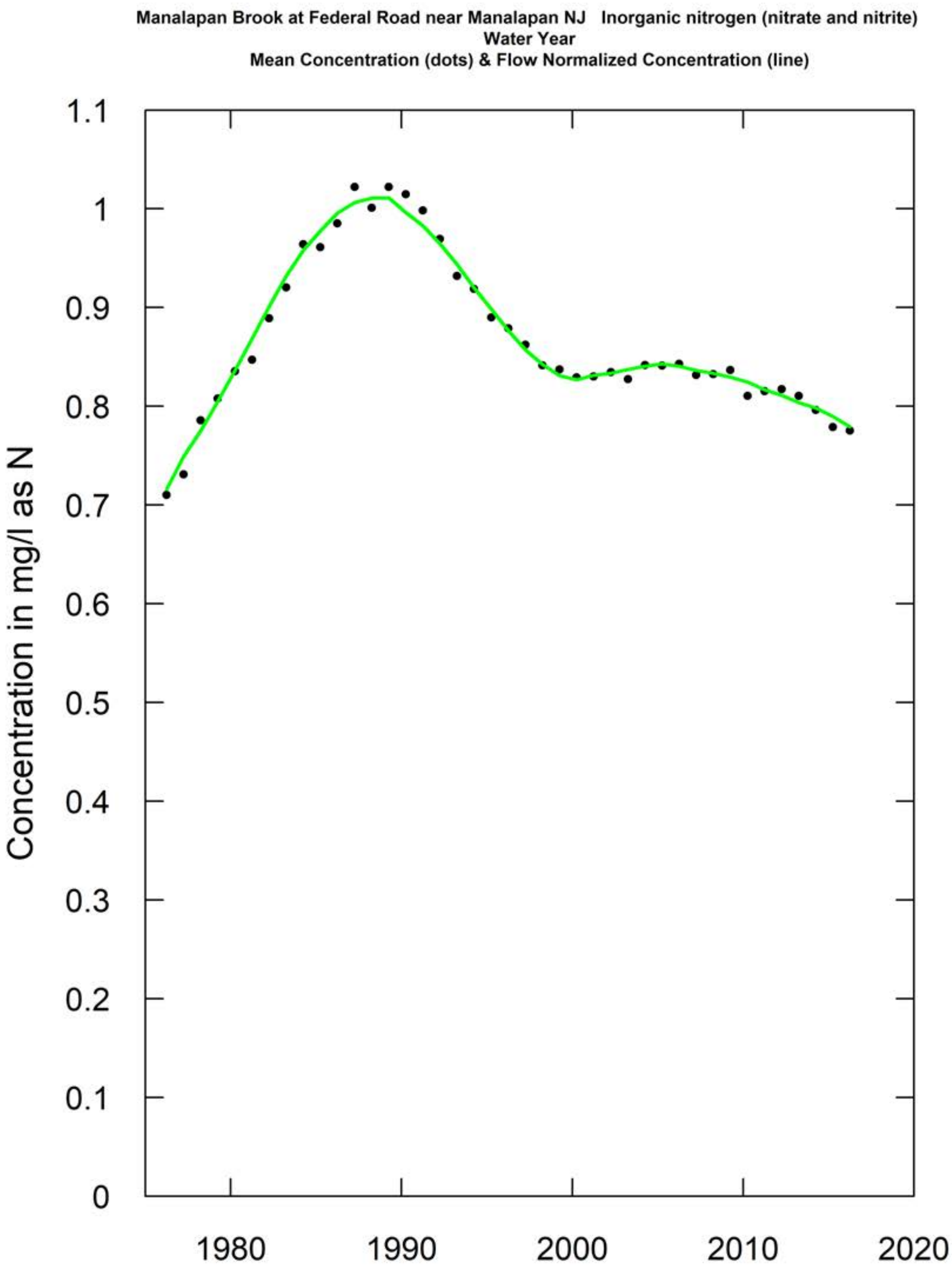

Lamington River at Burnt Mills NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.014
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
1970 1990 2010
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled All
Obs. Flux (tons/d)
Est. Flux (tons/d)


Lamington River at Burnt Mills NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1980
1990
2000
2010
2020

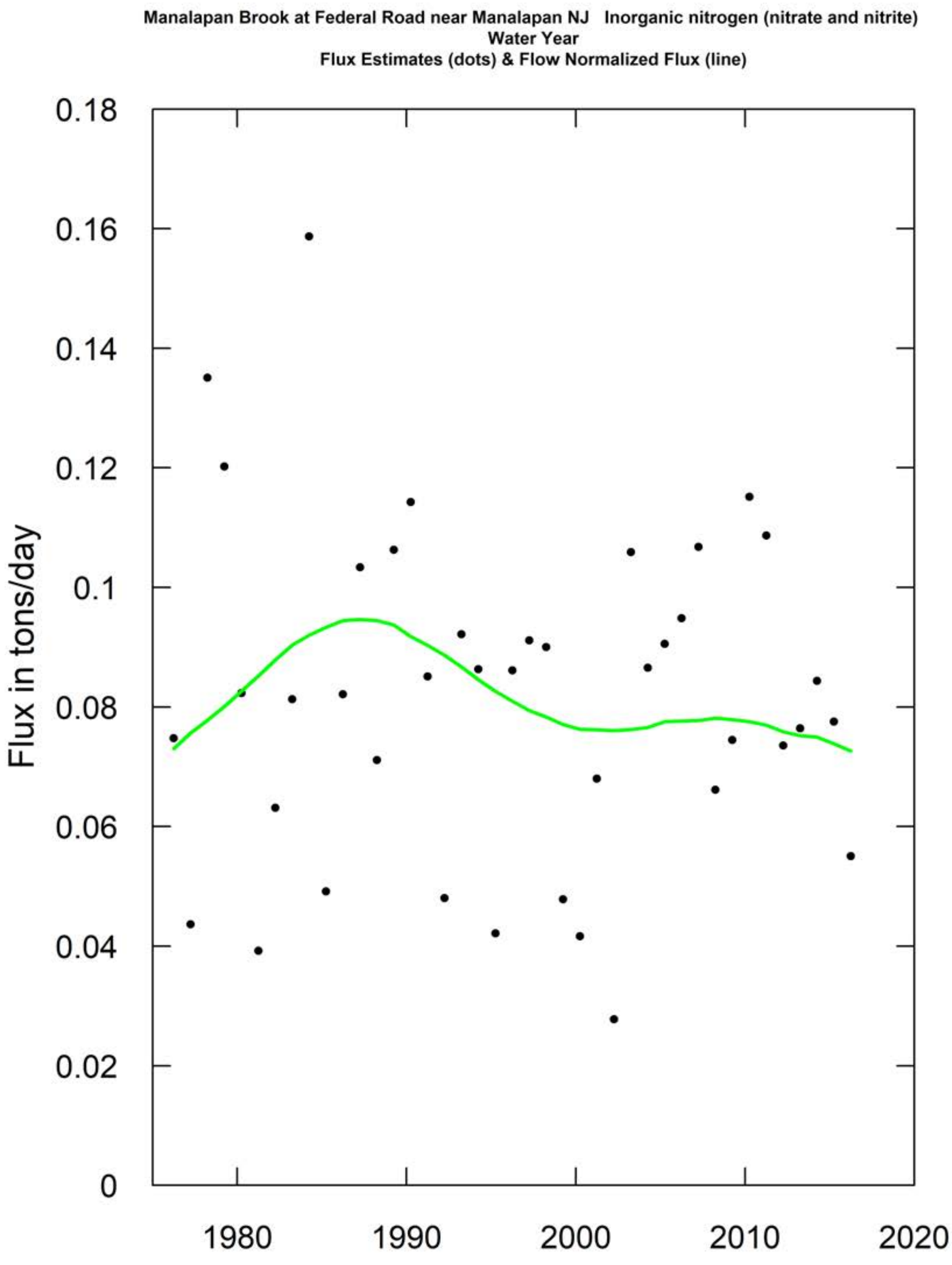

Lamington River at Burnt Mills NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

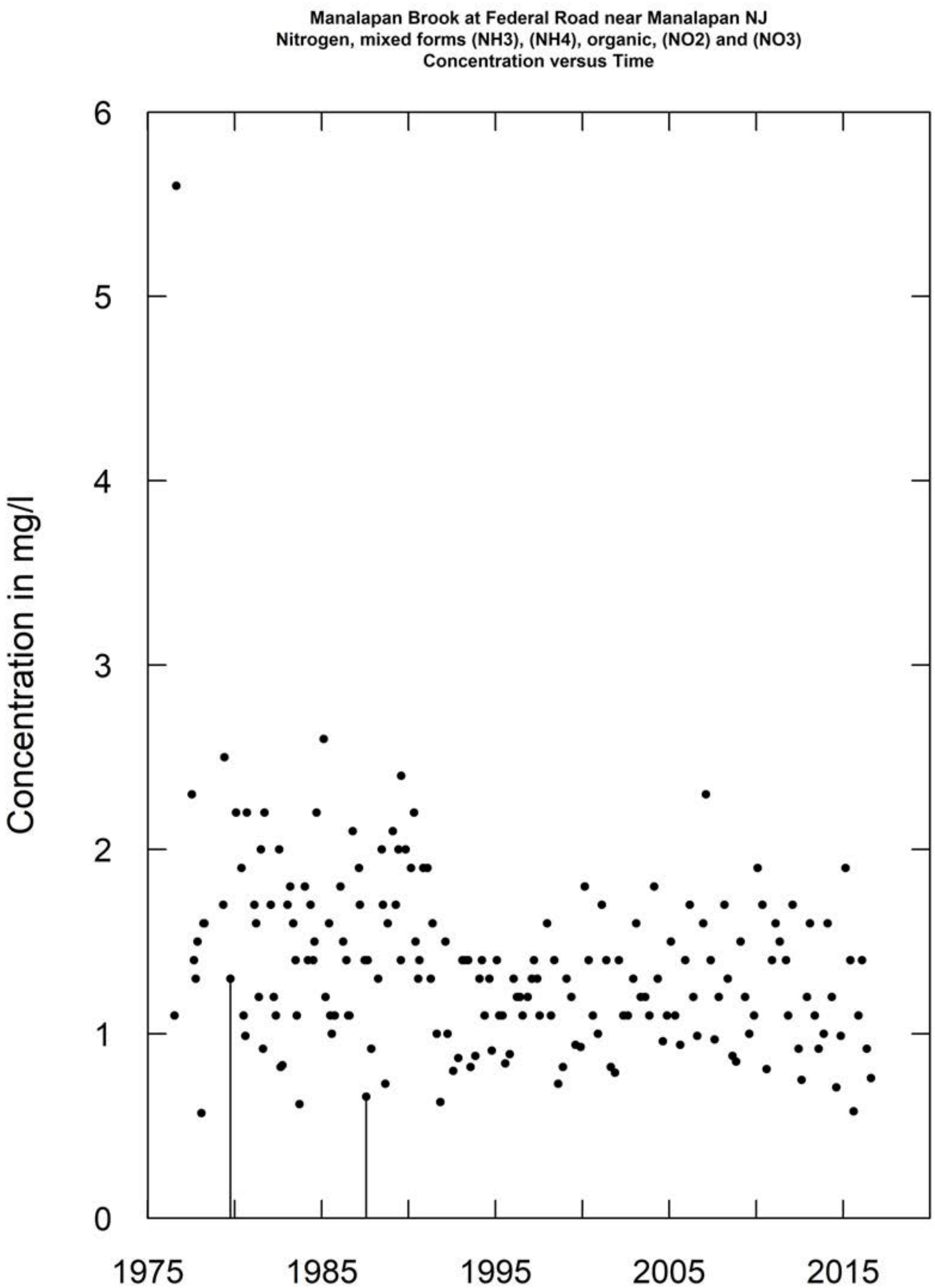

Manalapan Brook at Federal Road near Manalapan NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
1975
1985
1995
2005
2015


Manalapan Brook at Federal Road near Manalapan NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0161
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

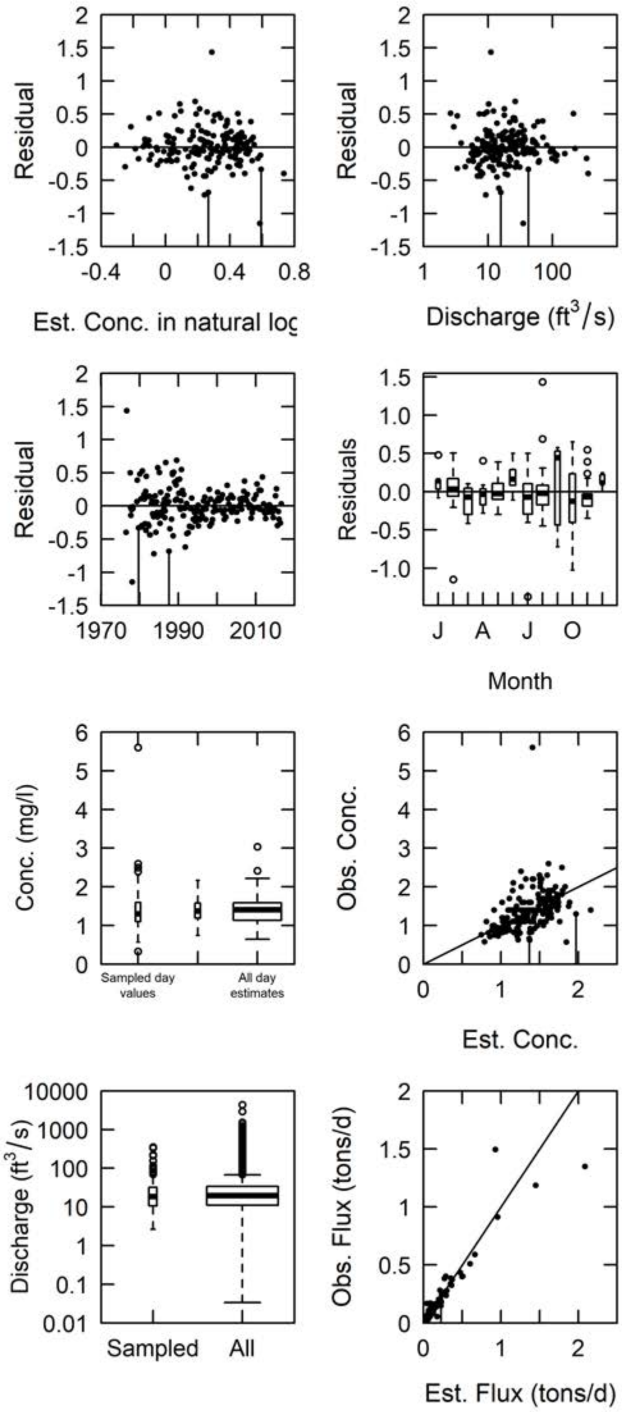


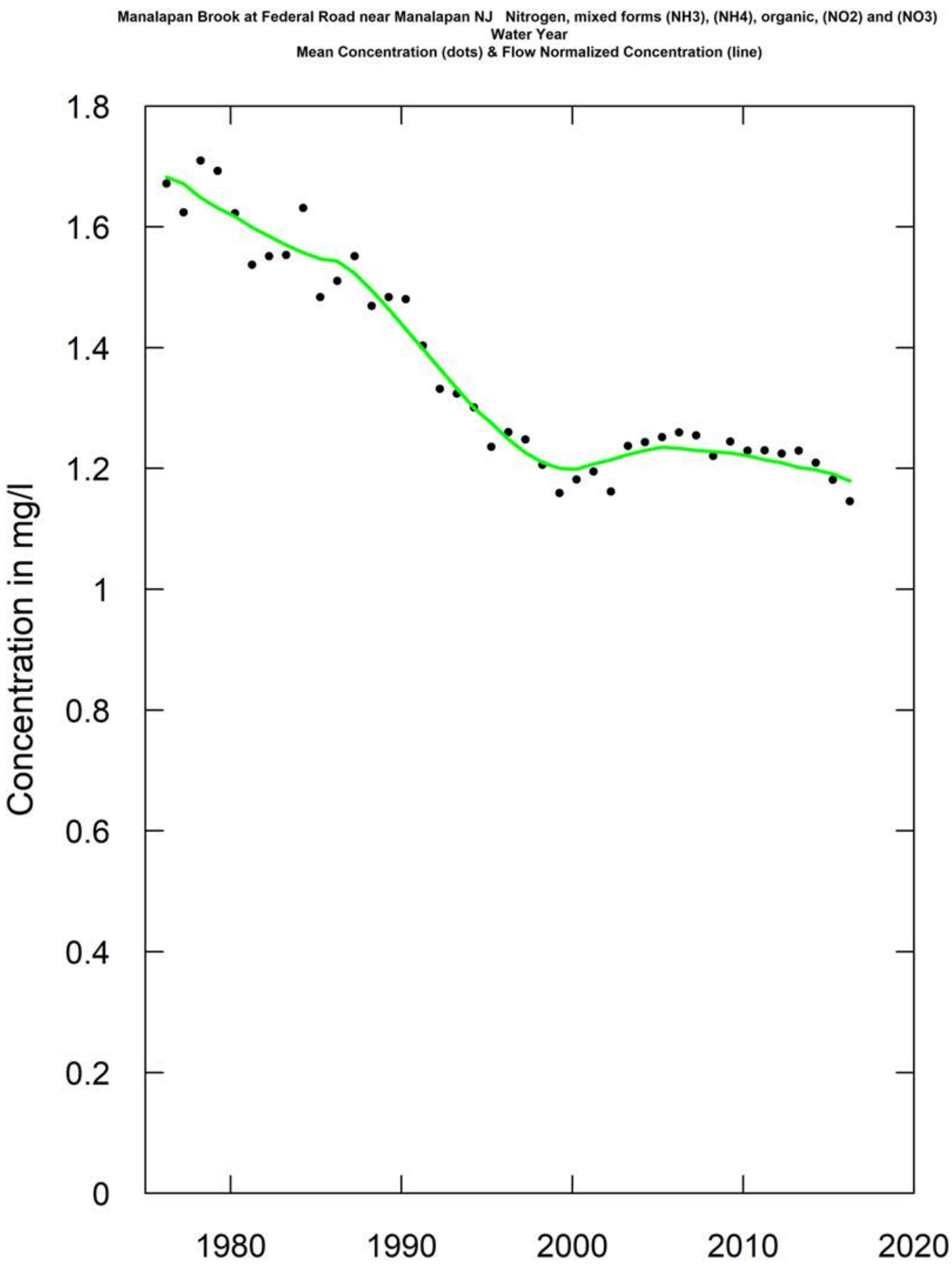
Manalapan Brook at Federal Road near Manalapan NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

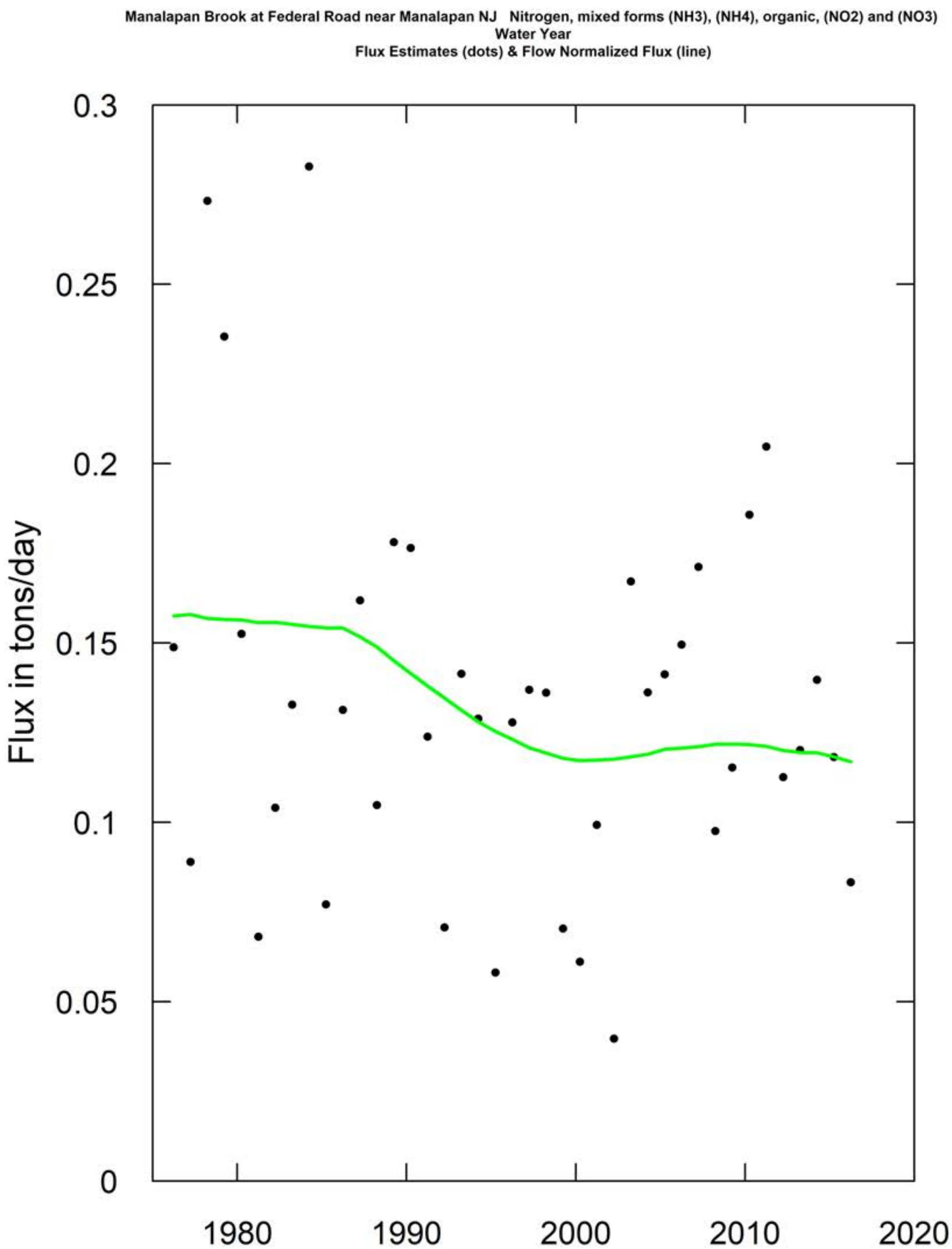

Manalapan Brook at Federal Road near Manalapan NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

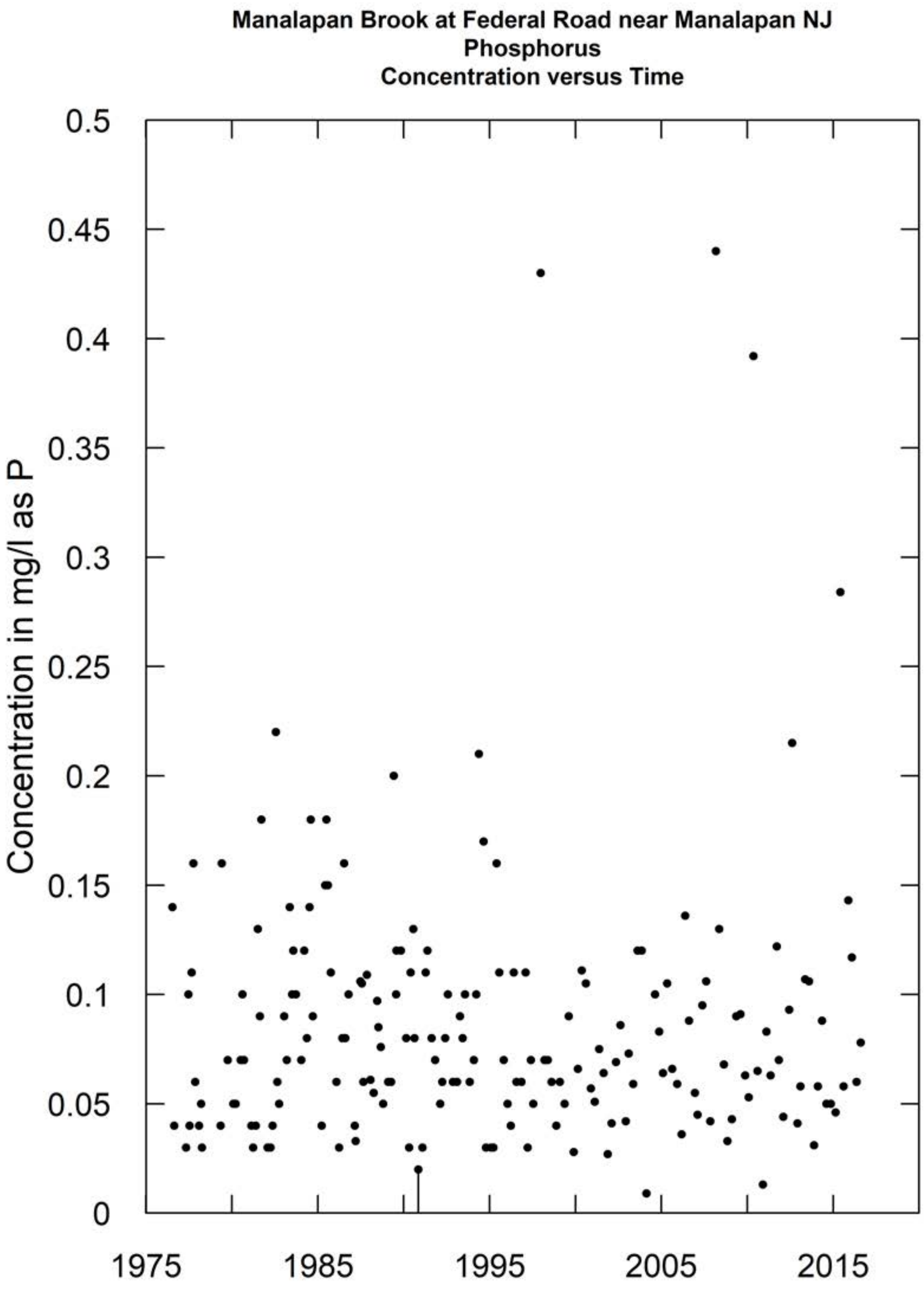

Manalapan Brook at Federal Road near Manalapan NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
1
2
3
4
5
6
1975
1985
1995
2005
2015

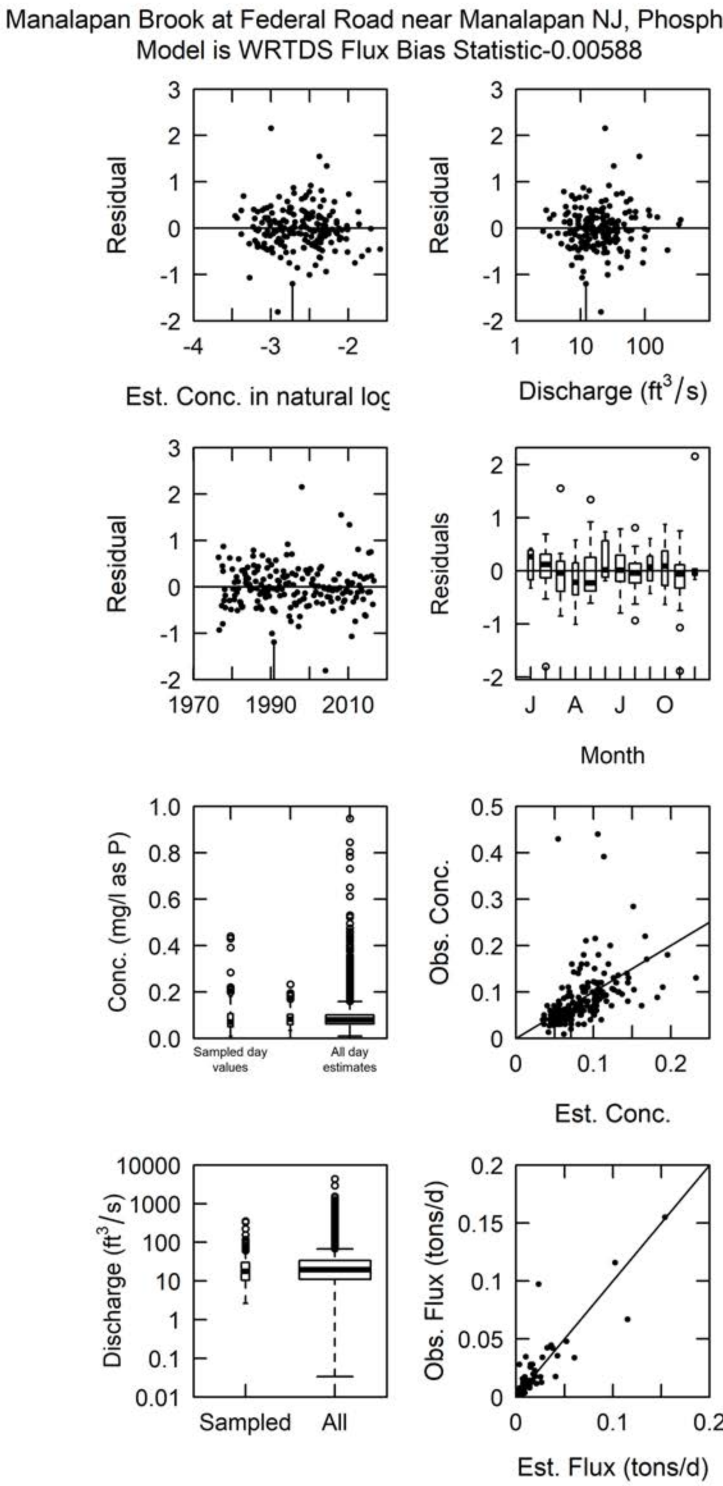
Manalapan Brook at Federal Road near Manalapan NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.0341

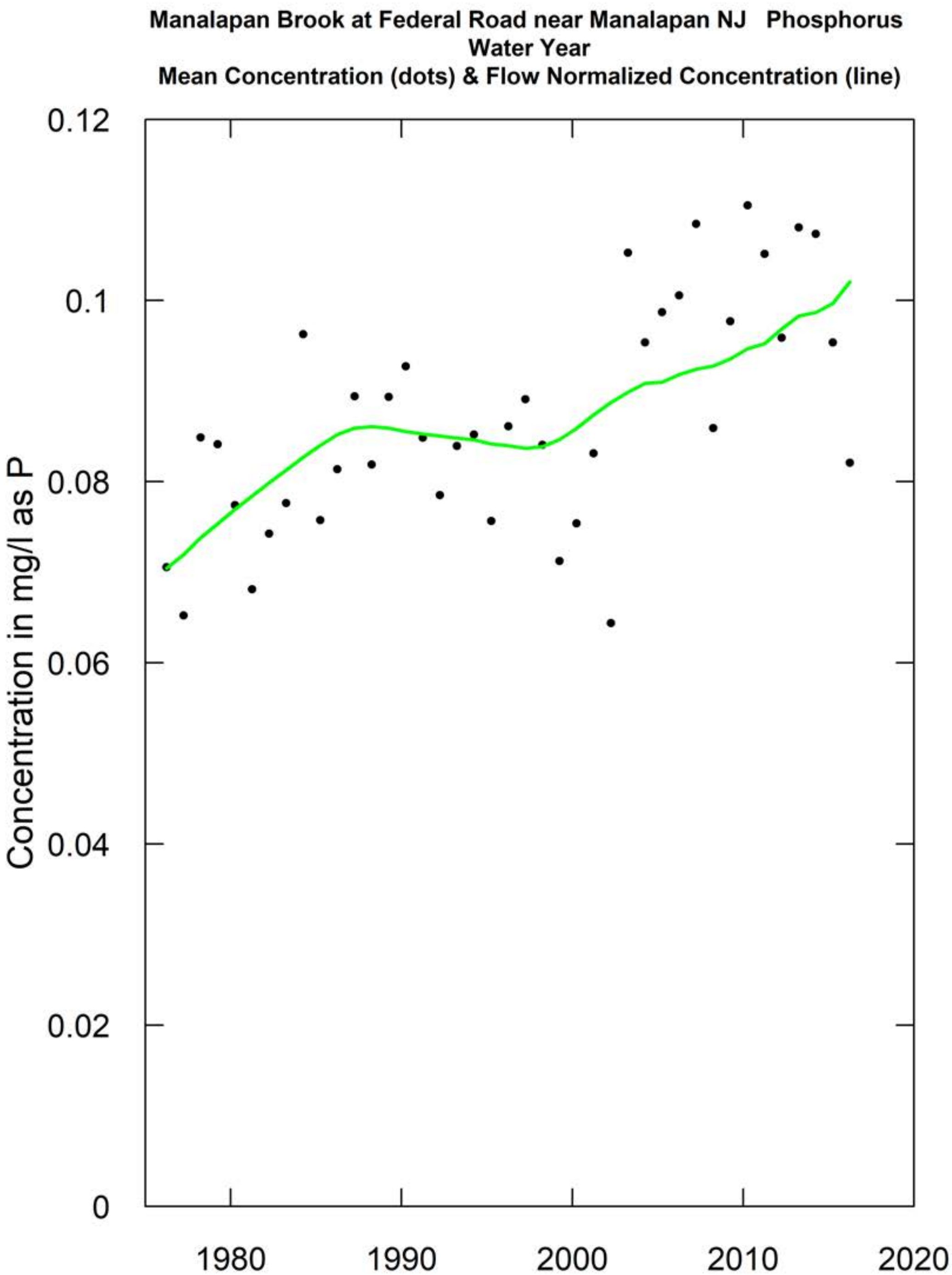


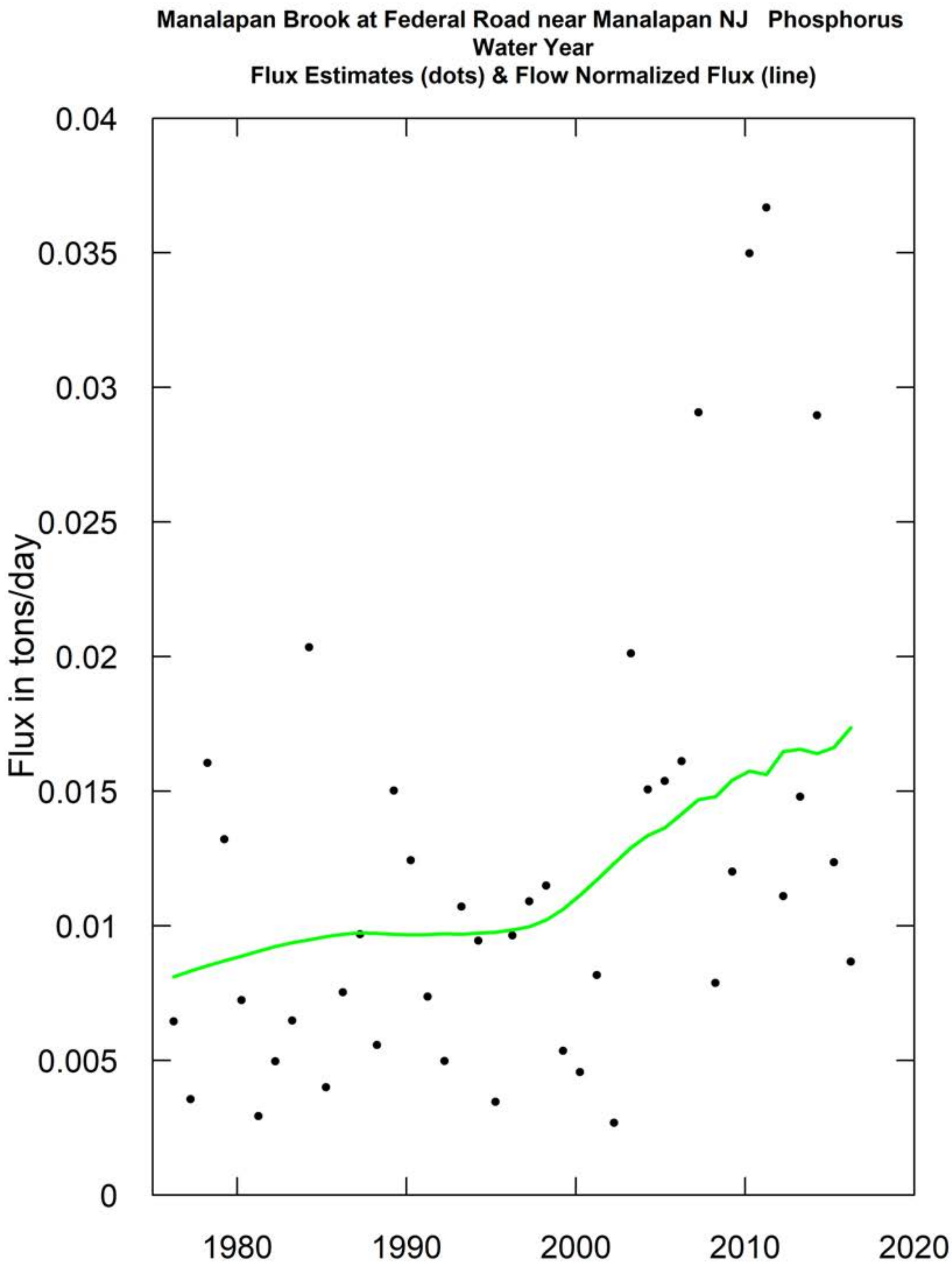

Manalapan Brook at Federal Road near Manalapan NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

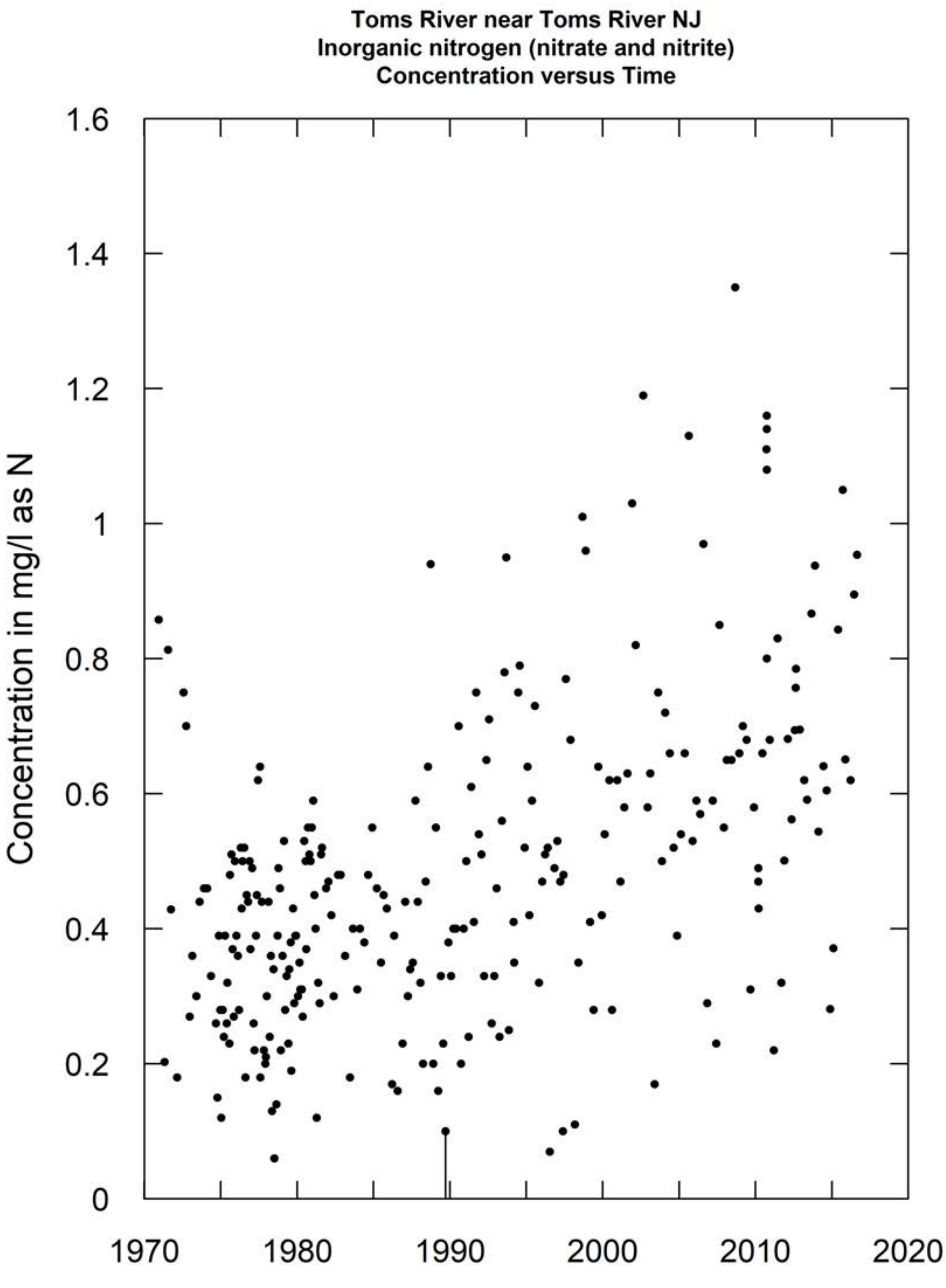

Manalapan Brook at Federal Road near Manalapan NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.3
0.25
0.2
0.15
0.1
0.05
0
1980
1990
2000
2010
2020

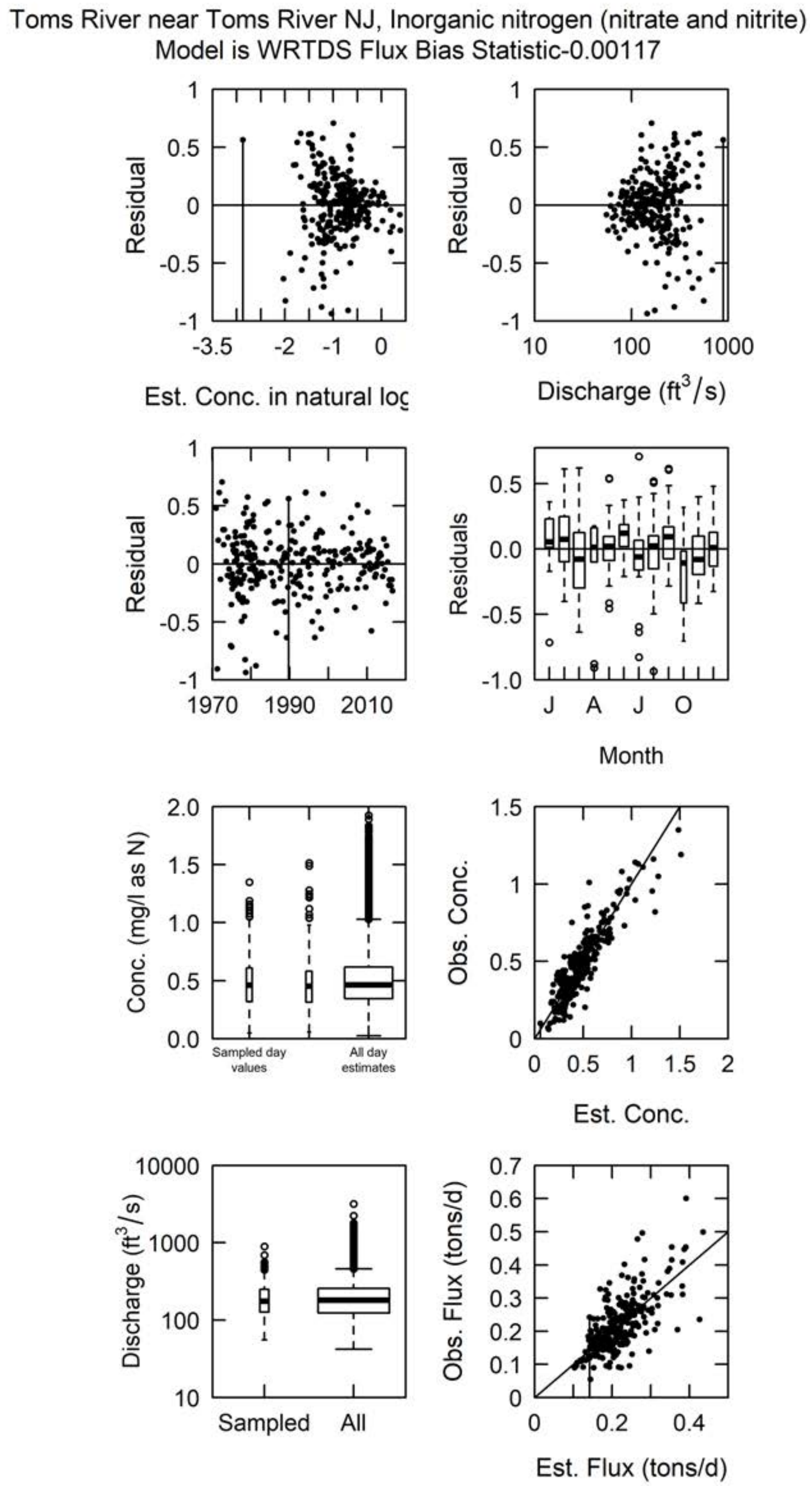

Manalapan Brook at Federal Road near Manalapan NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1975
1985
1995
2005
2015

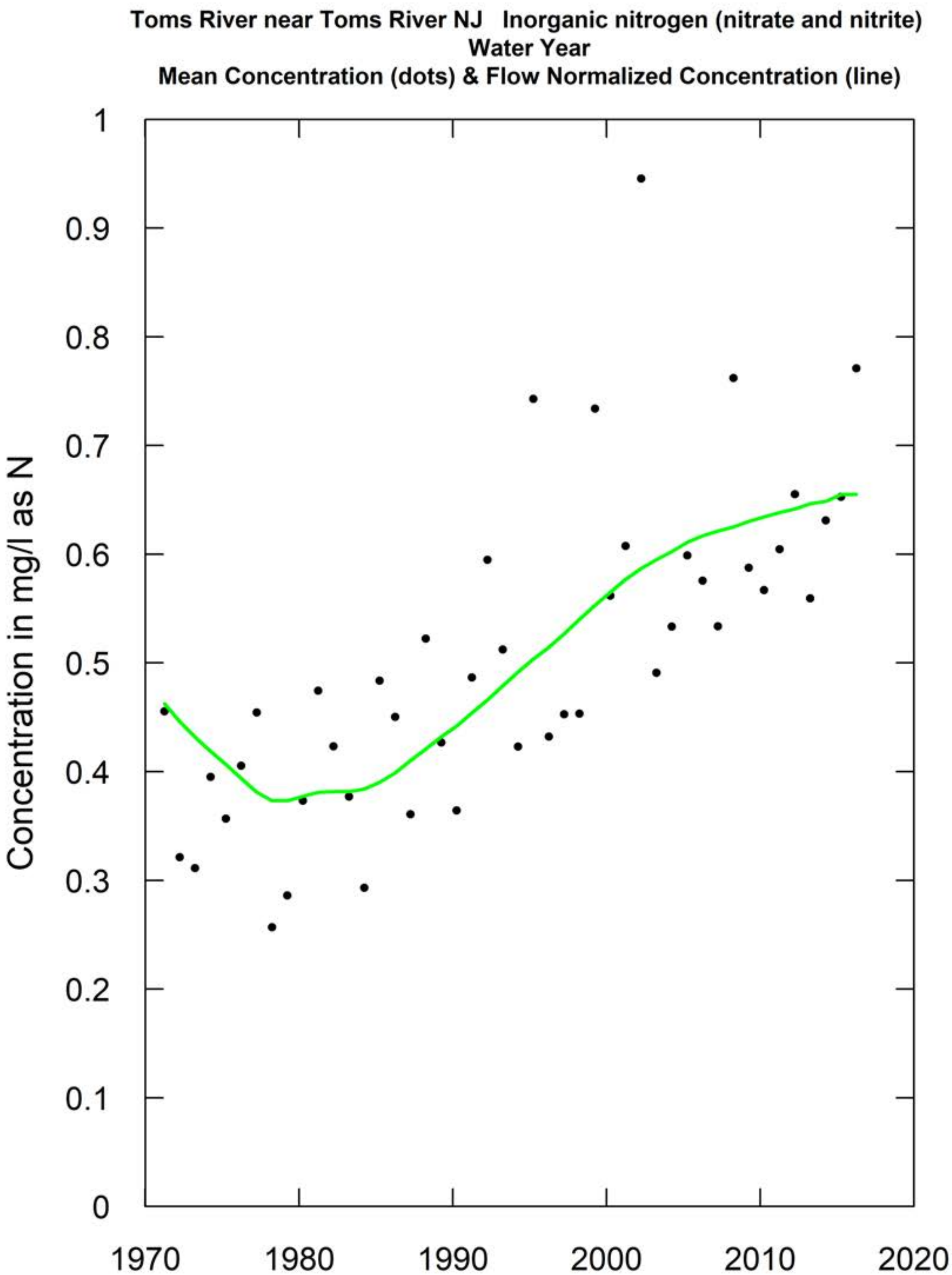

Manalapan Brook at Federal Road near Manalapan NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.00588
Residual
Est. Conc. in natural log
Residual
Discharge (ft³/s)
Residual
Residuals
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

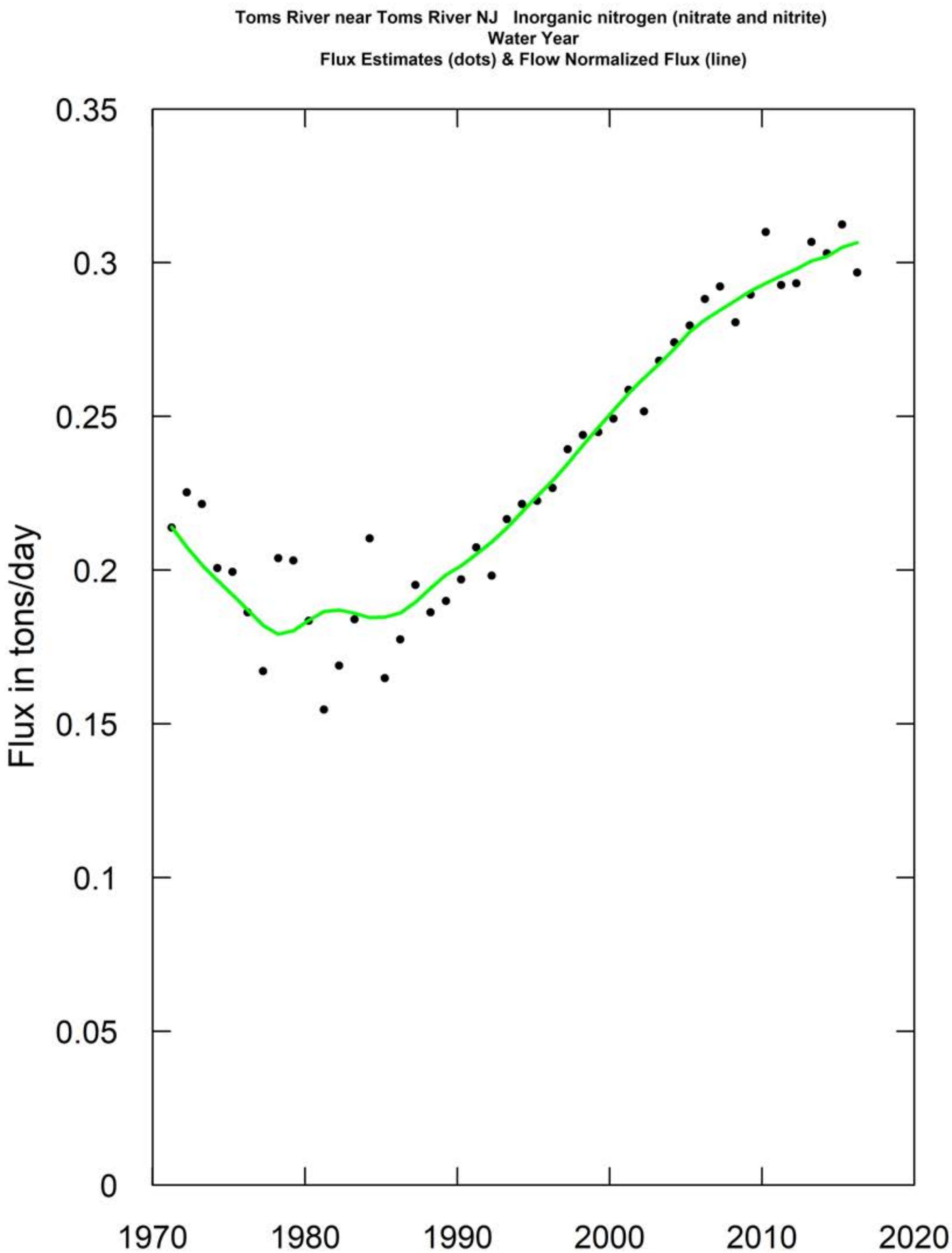

Manalapan Brook at Federal Road near Manalapan NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

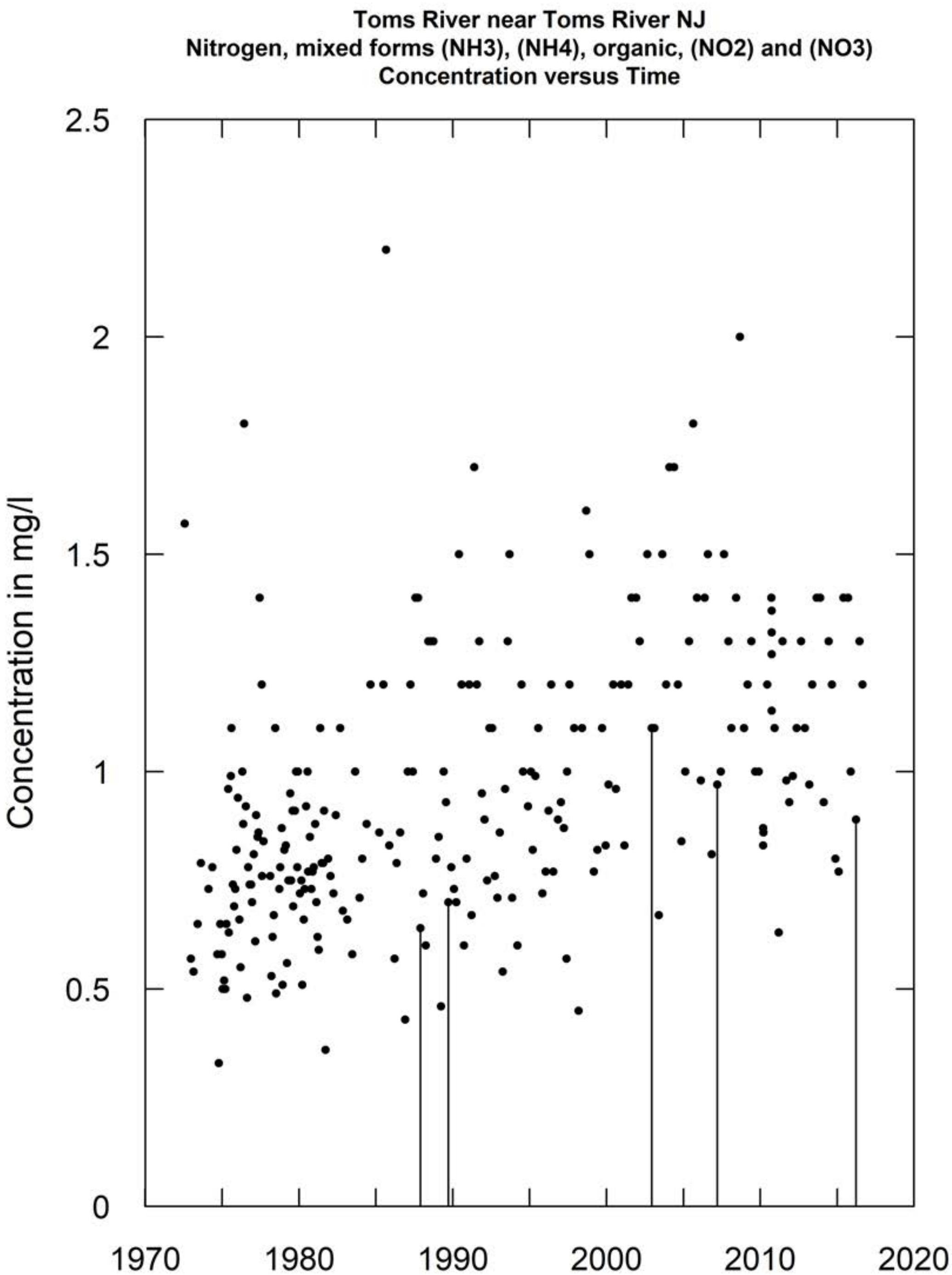

Manalapan Brook at Federal Road near Manalapan NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1980
1990
2000
2010
2020

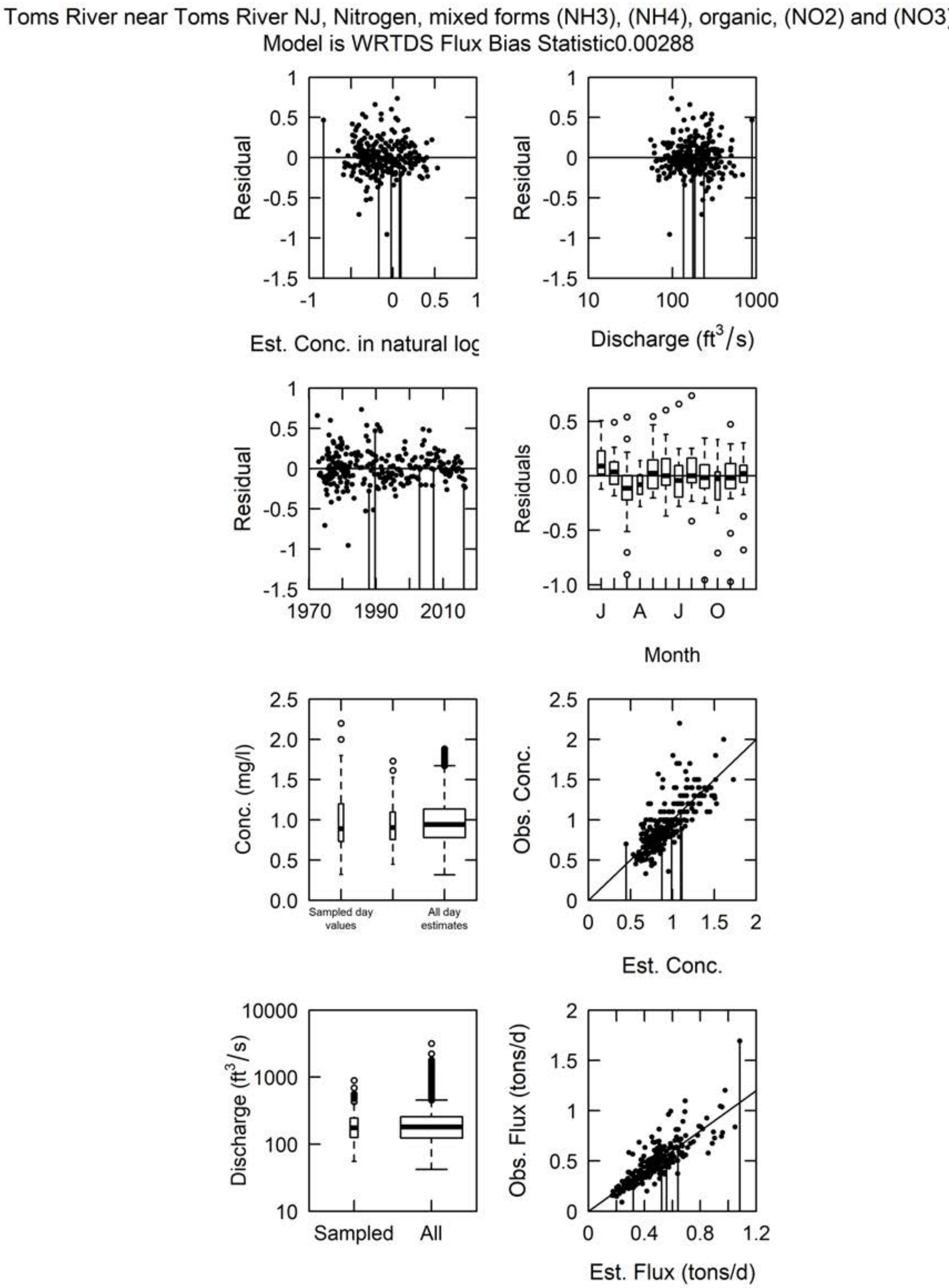

Toms River near Toms River NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1970
1980
1990
2000
2010
2020

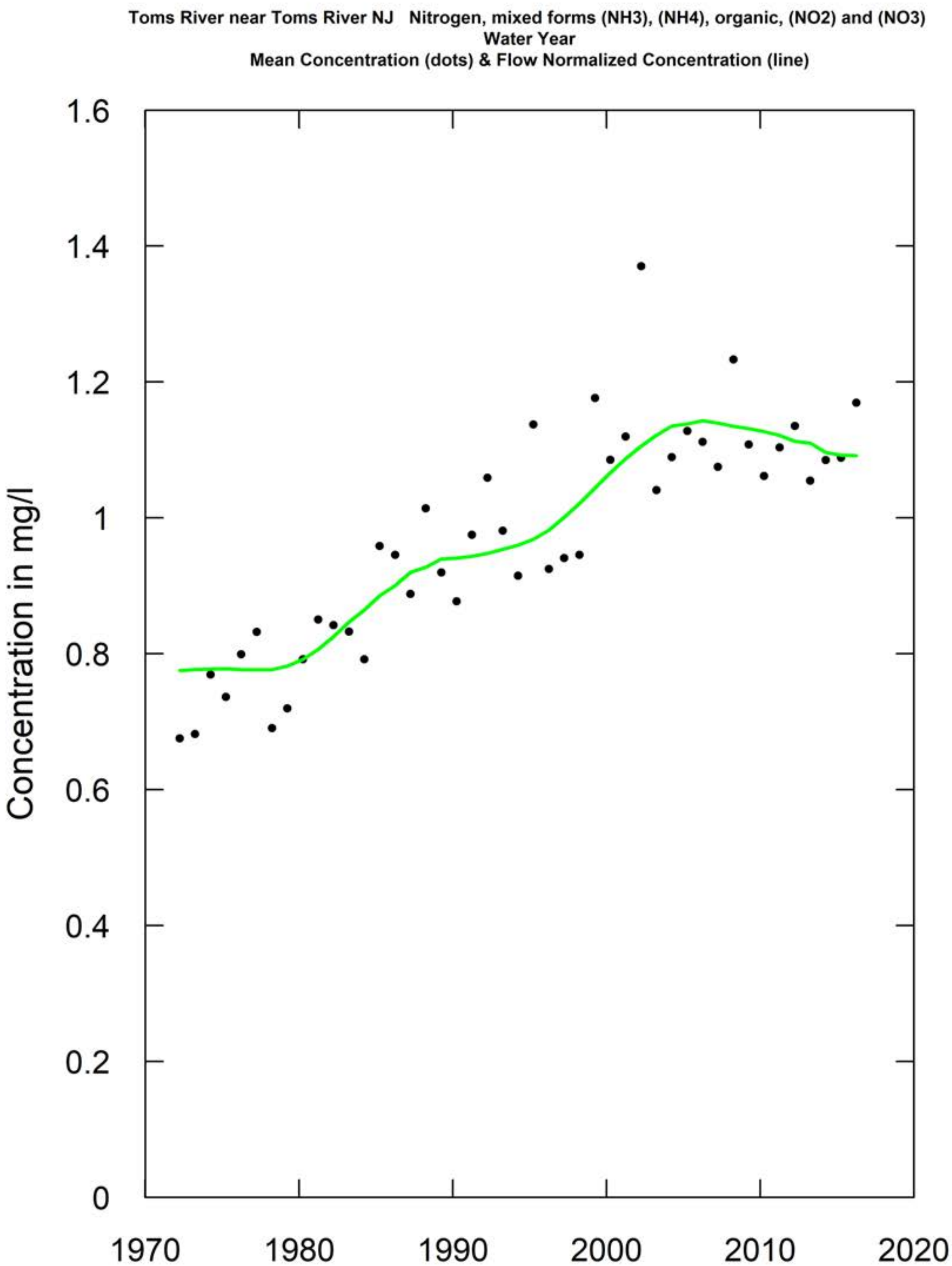

Toms River near Toms River NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.00117
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
1970 1990 2010
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

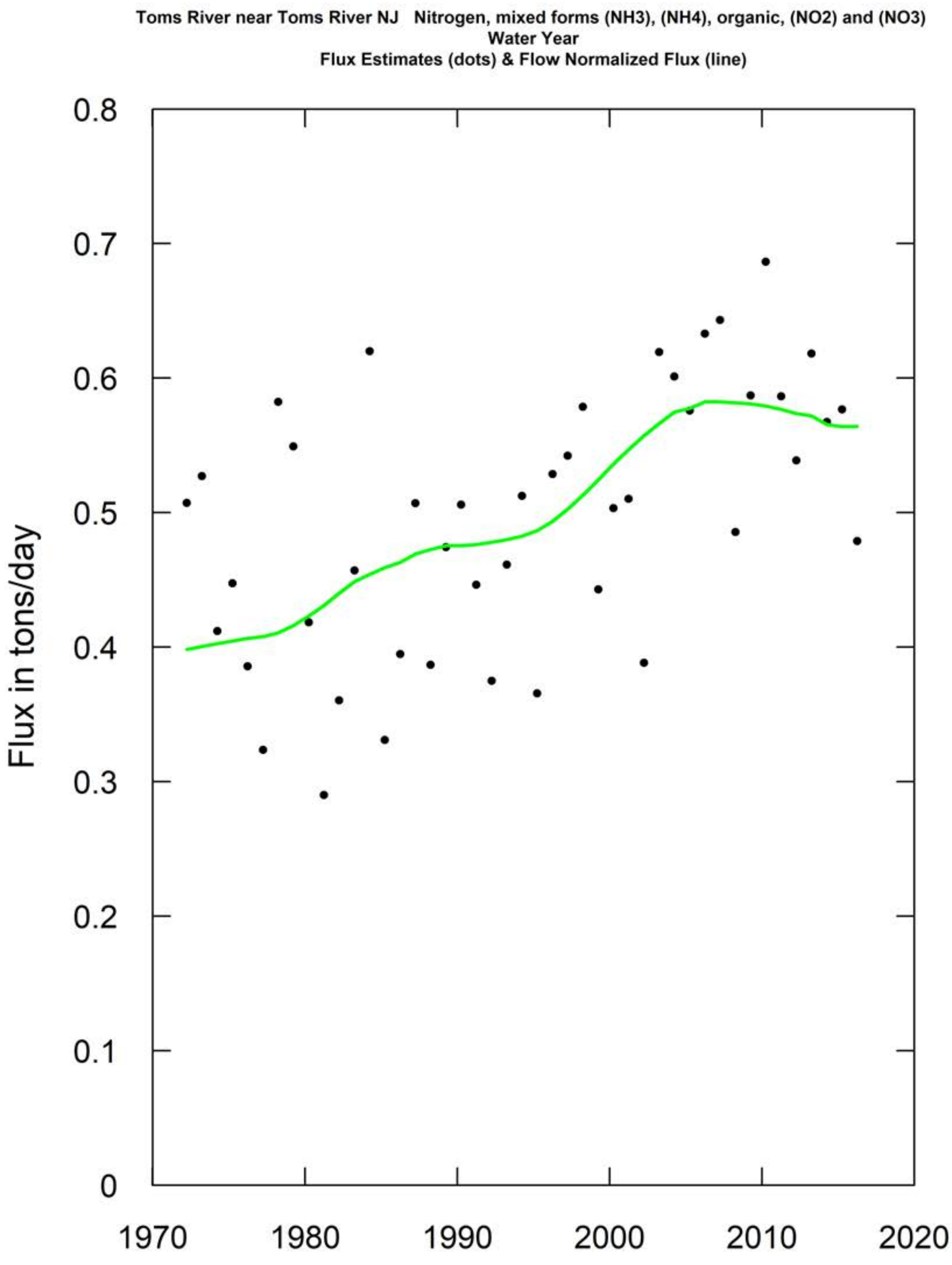

Toms River near Toms River NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1970
1980
1990
2000
2010
2020

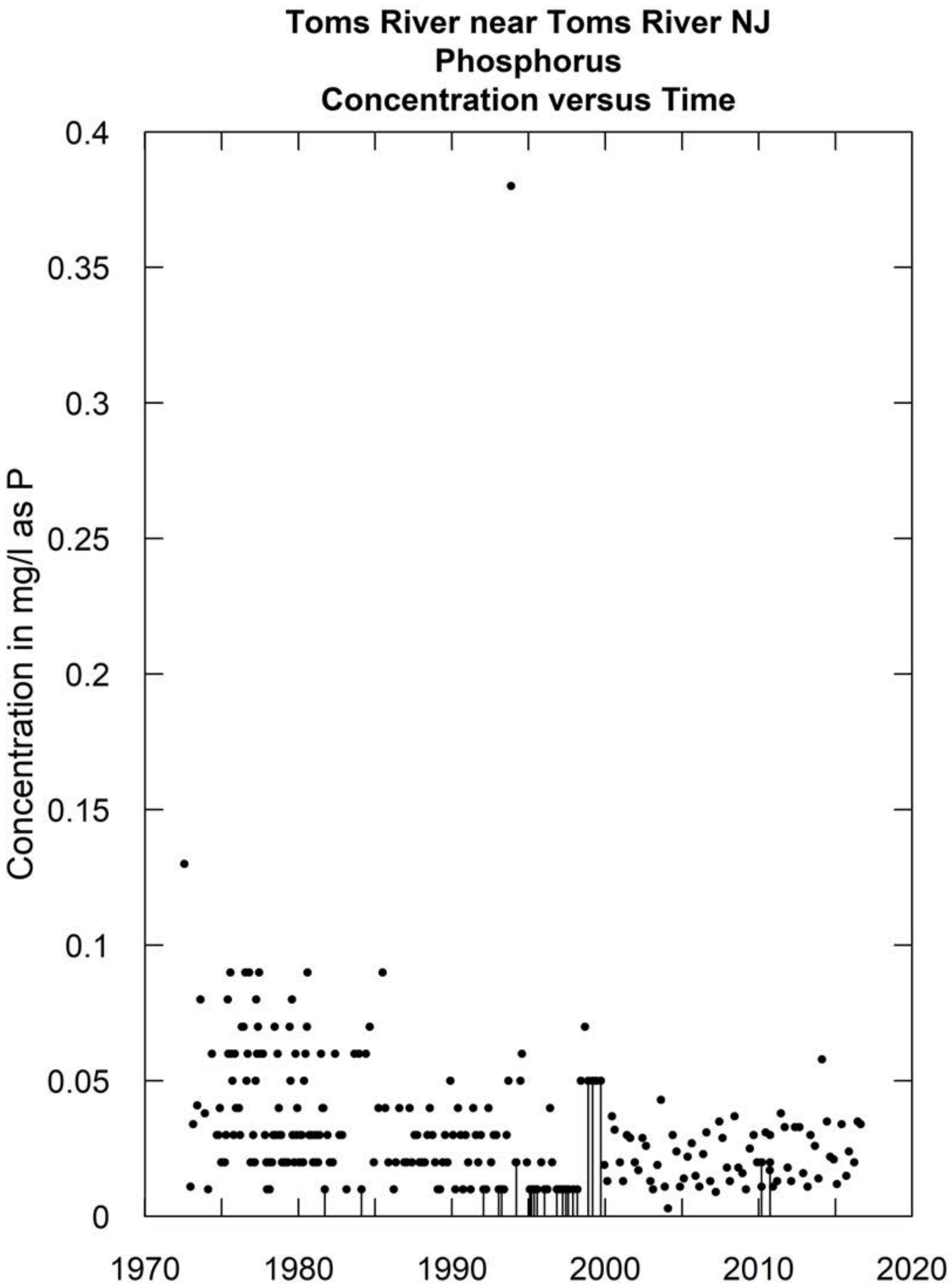

Toms River near Toms River NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

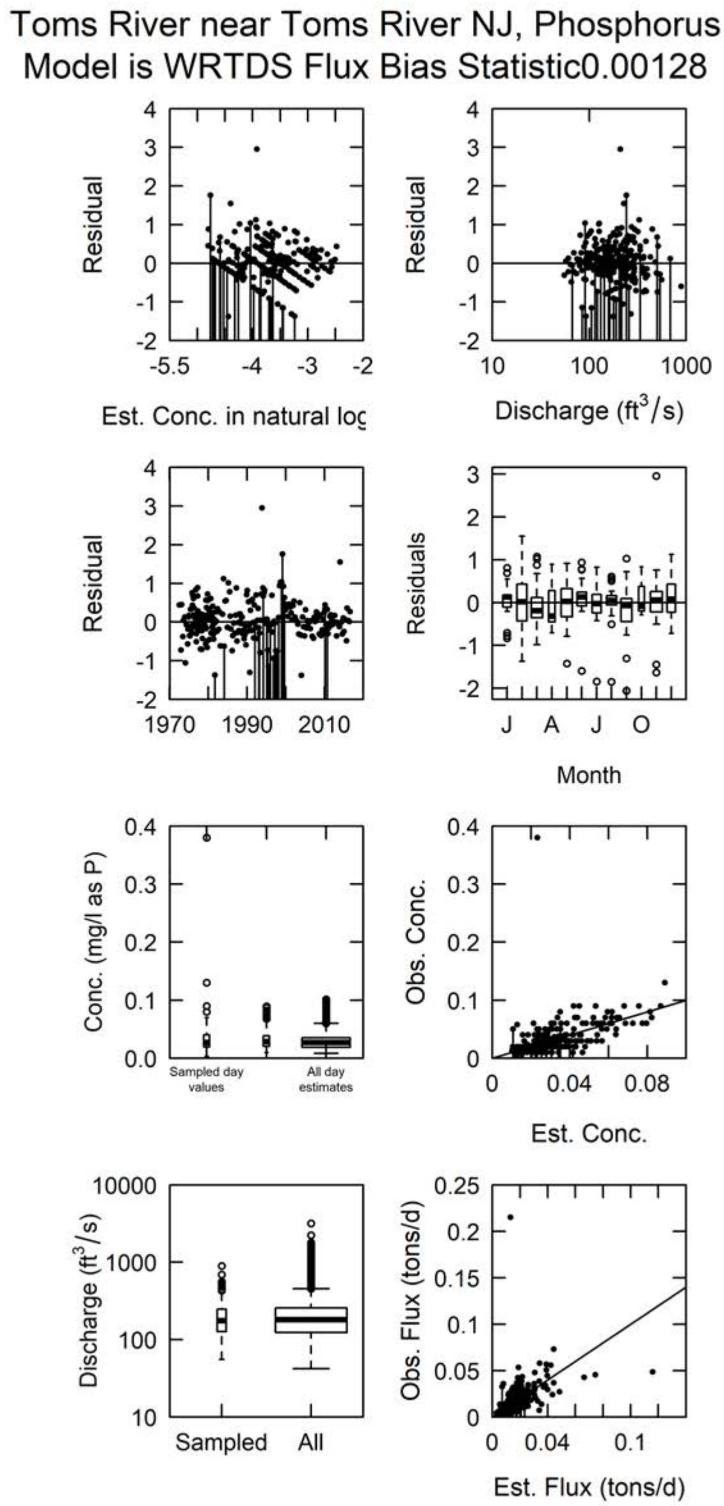

Toms River near Toms River NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

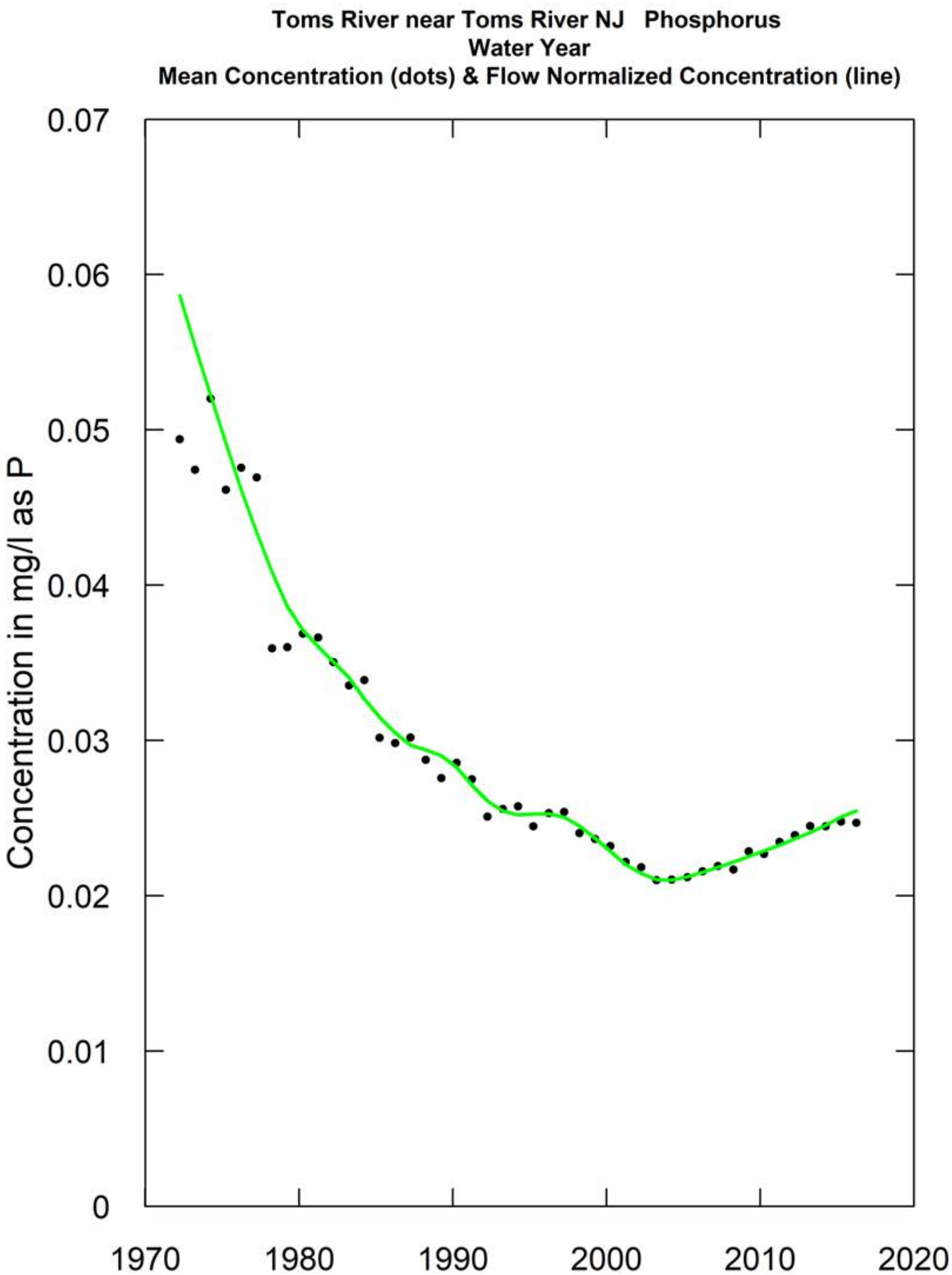

Toms River near Toms River NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.00288
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
Month
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

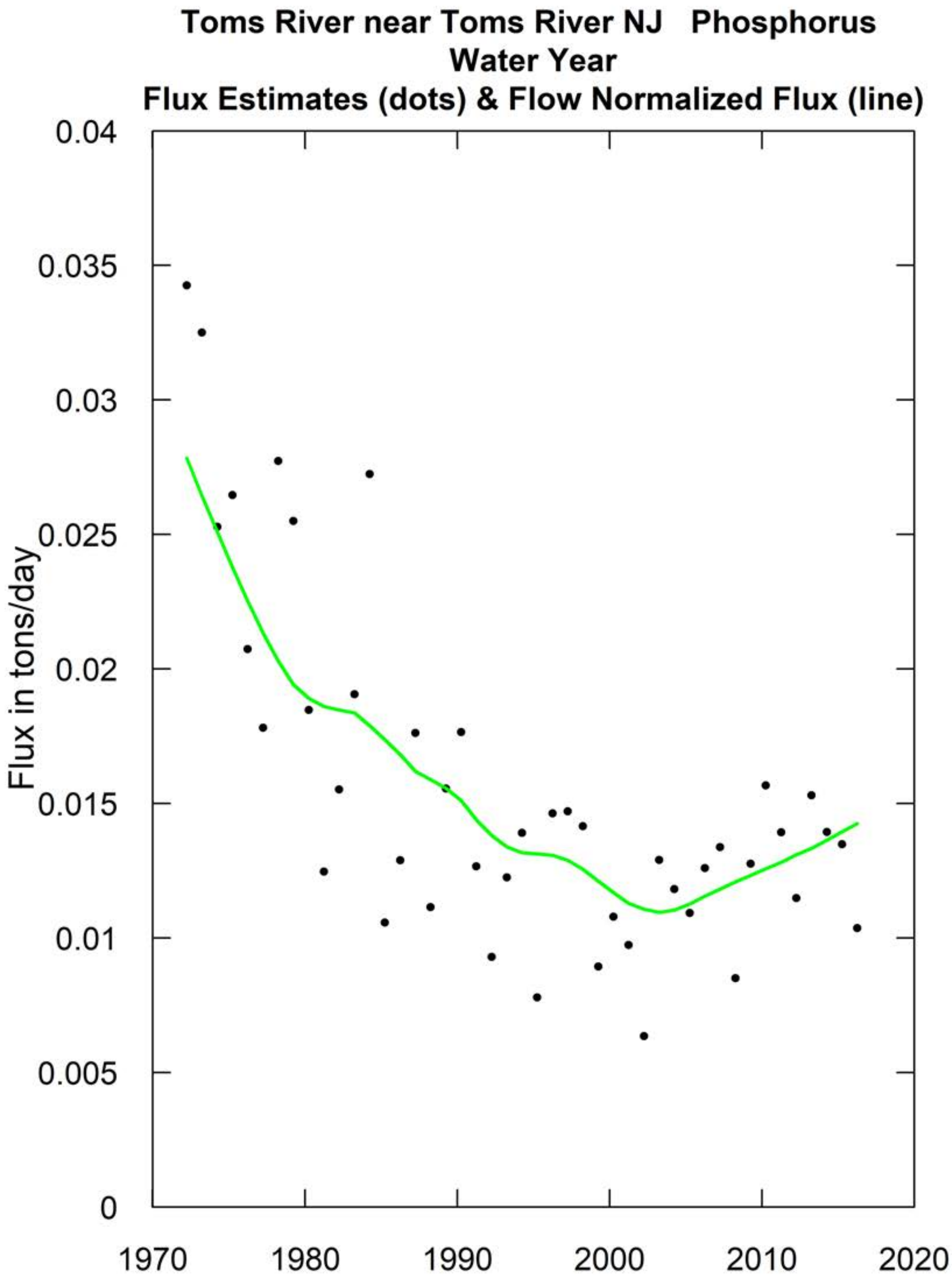

Toms River near Toms River NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

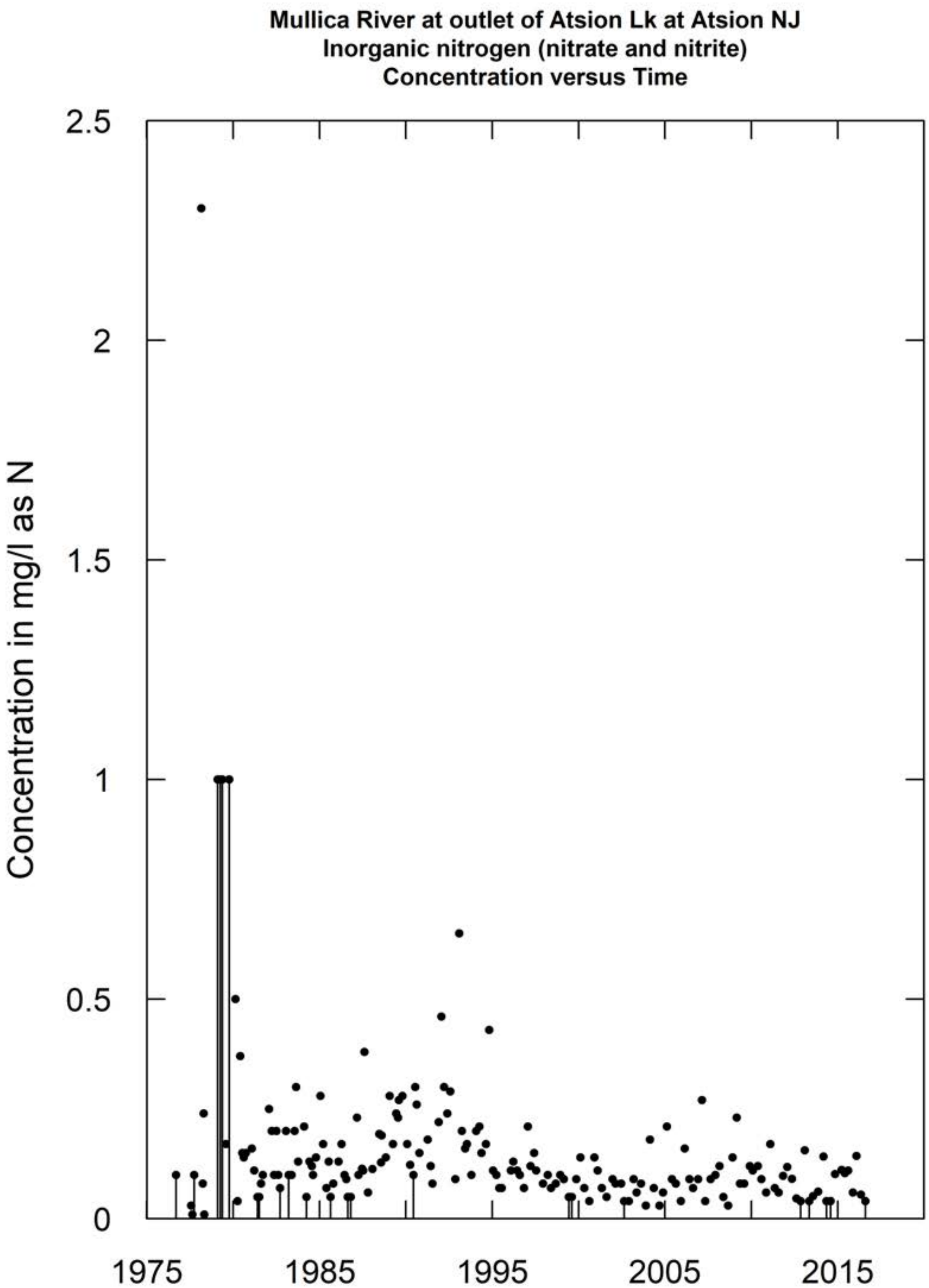

Toms River near Toms River NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1970
1980
1990
2000
2010
2020

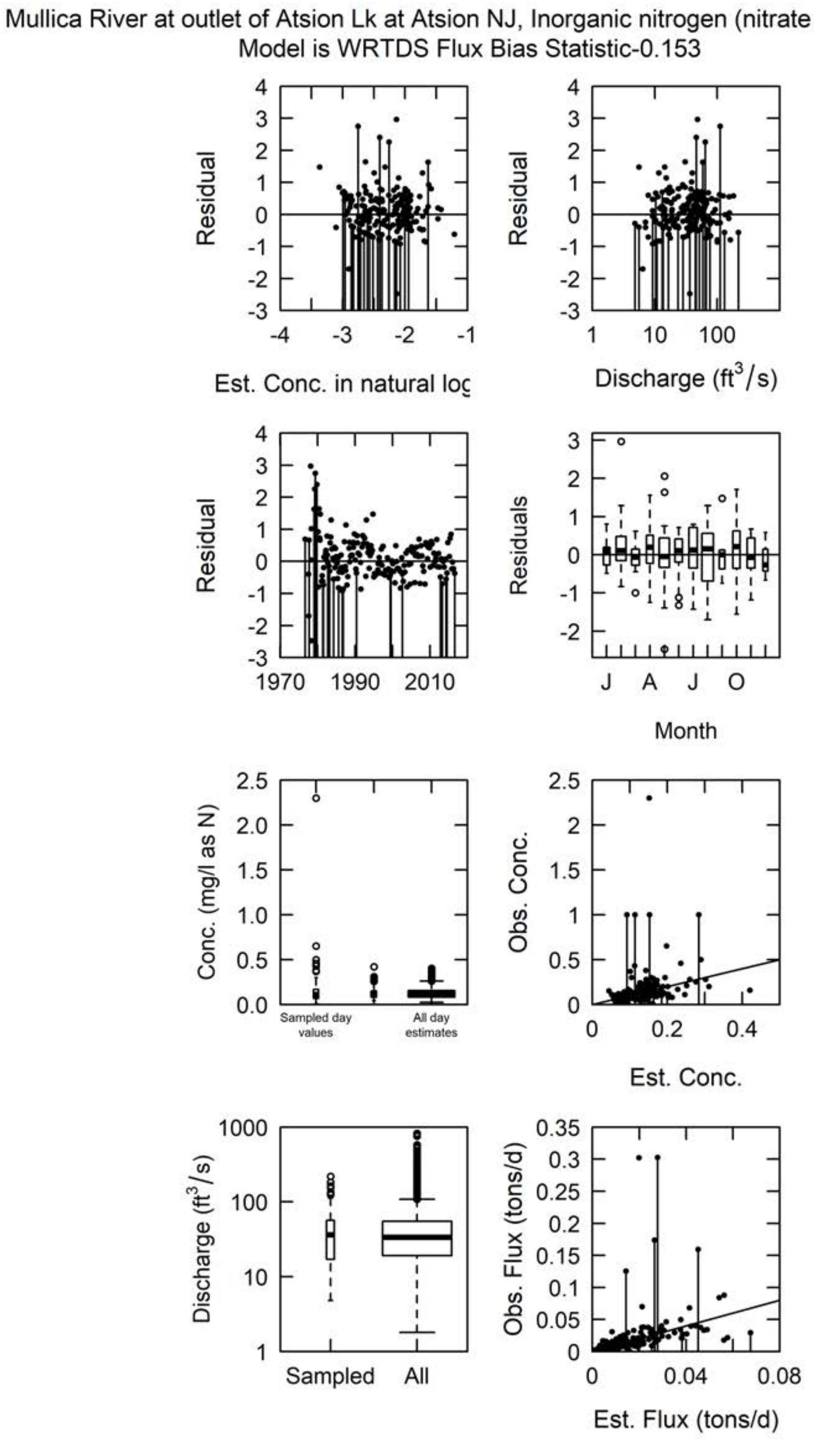

Toms River near Toms River NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020


Toms River near Toms River NJ, Phosphorus
Model is WRTDS Flux Bias Statistic0.00128
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

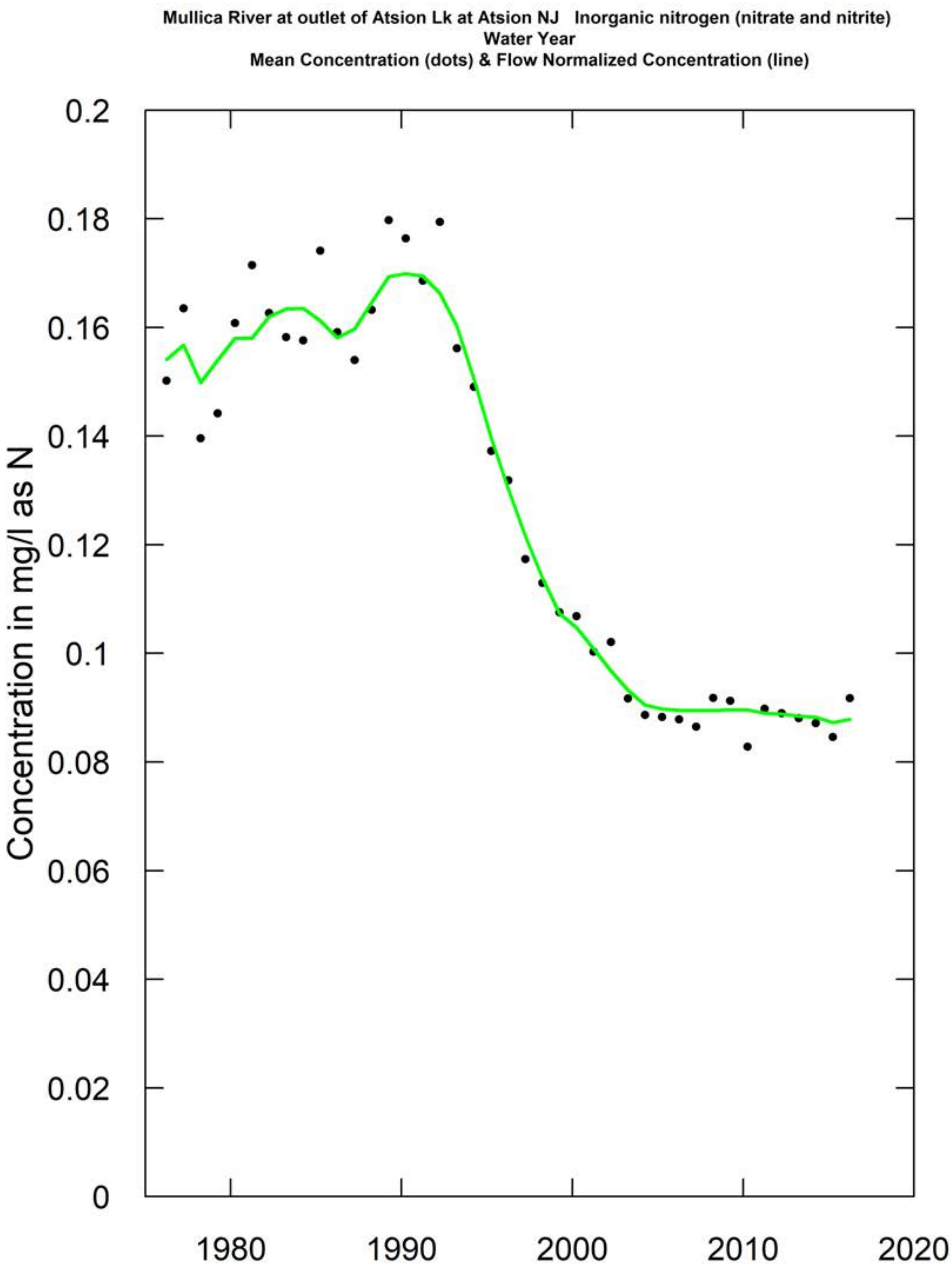

Toms River near Toms River NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1970
1980
1990
2000
2010
2020

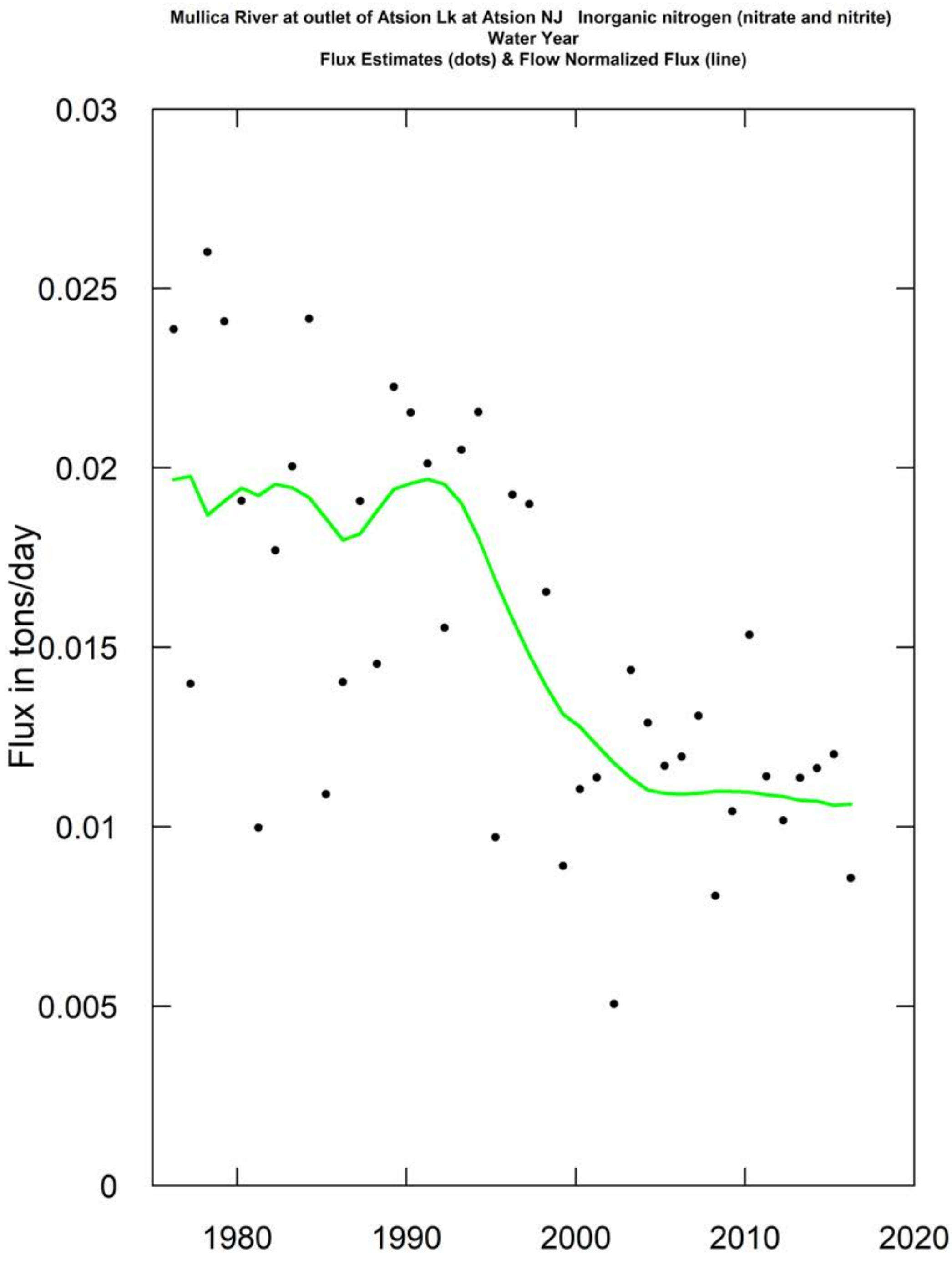

Toms River near Toms River NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1970
1980
1990
2000
2010
2020

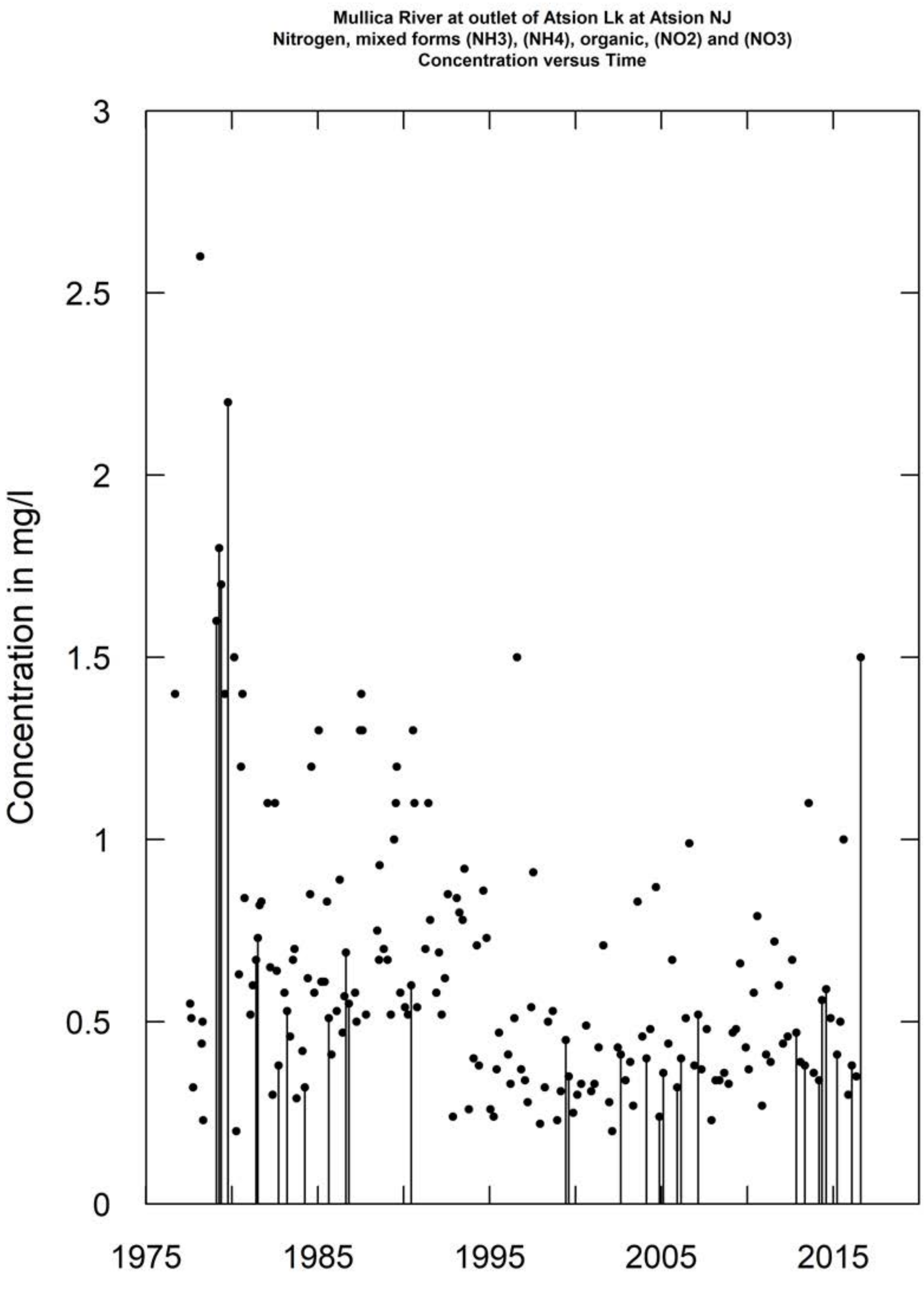

Mullica River at outlet of Atsion Lk at Atsion NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

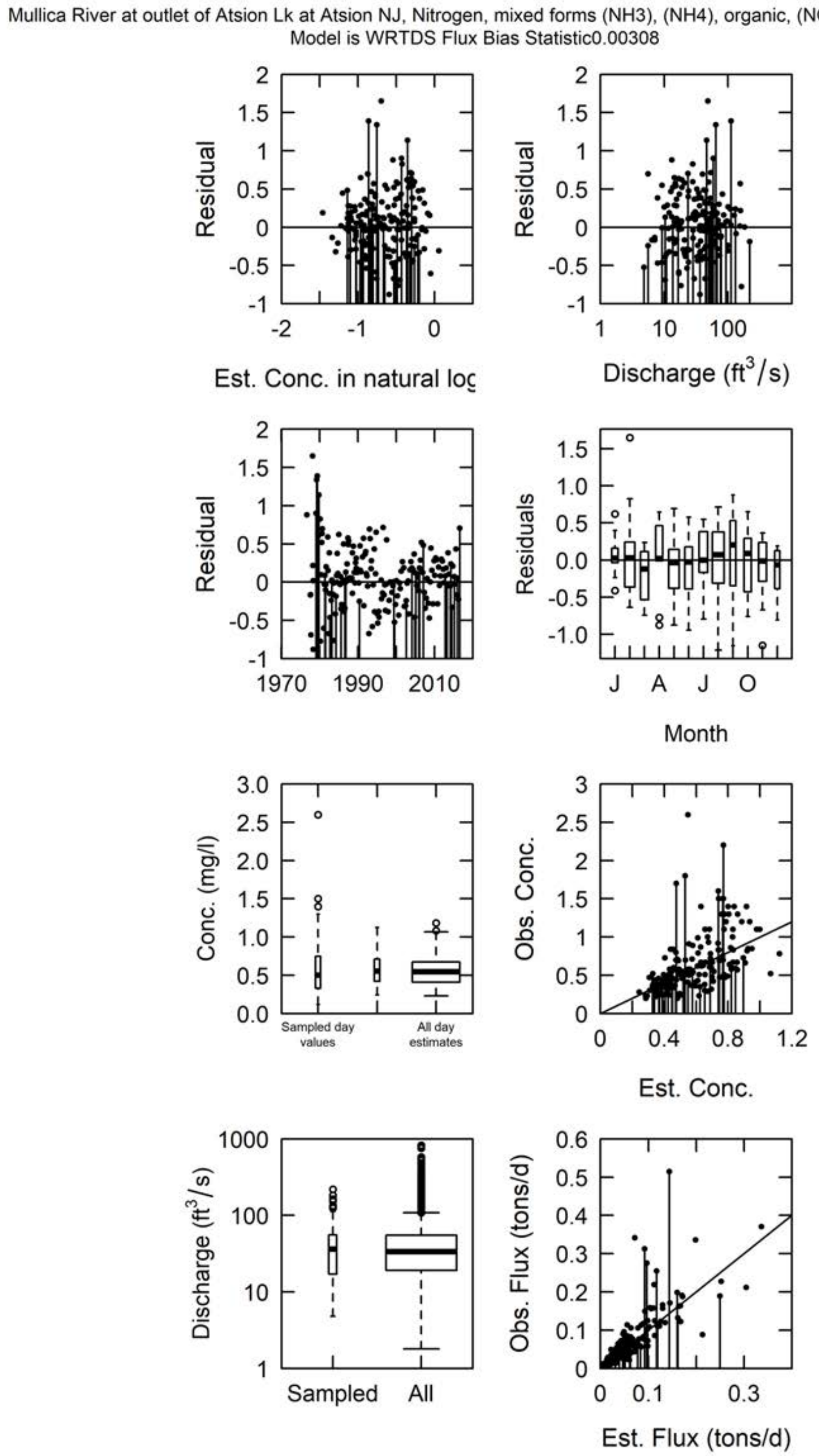


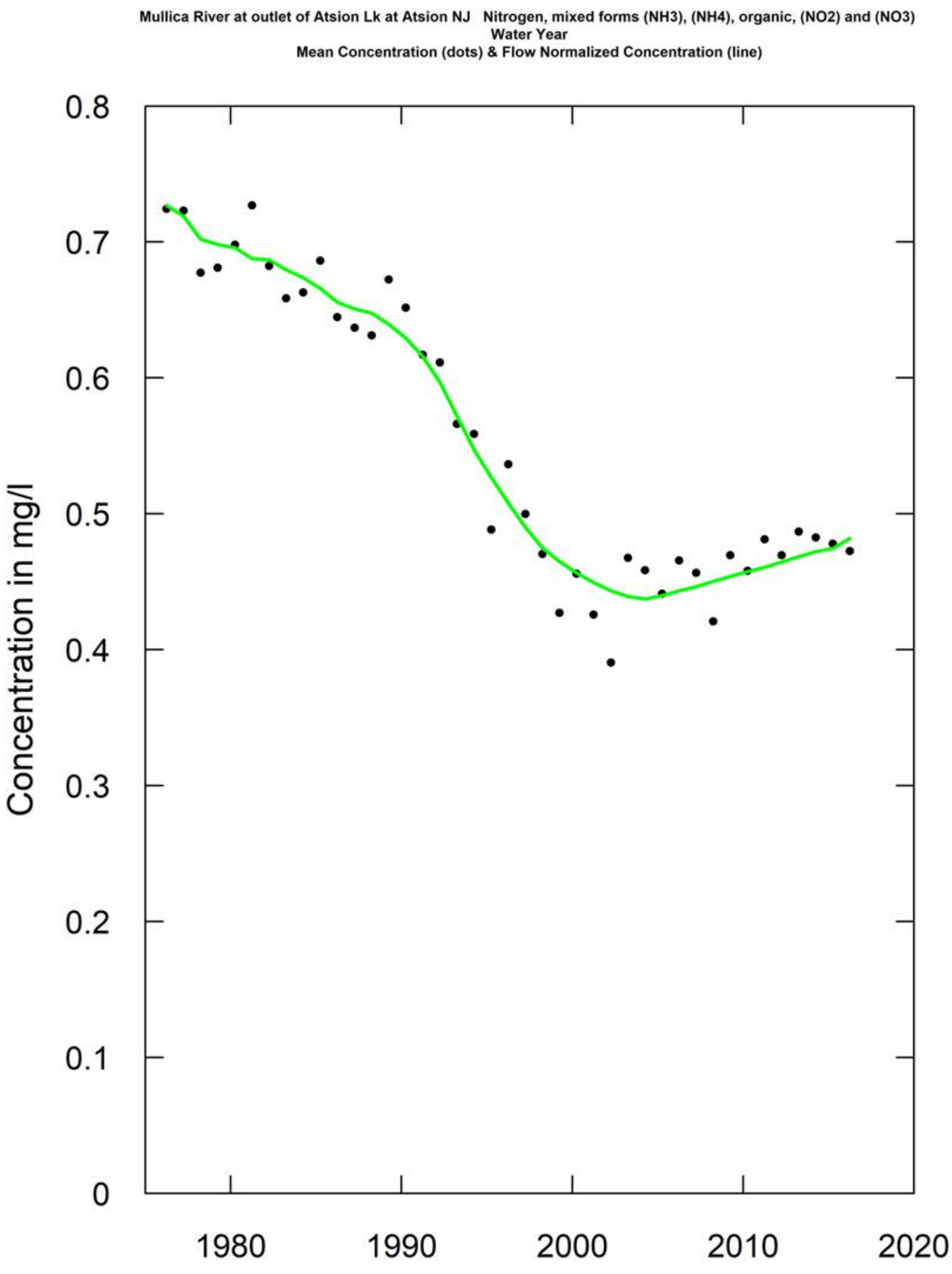
Mullica River at outlet of Atsion Lk at Atsion NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.153
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

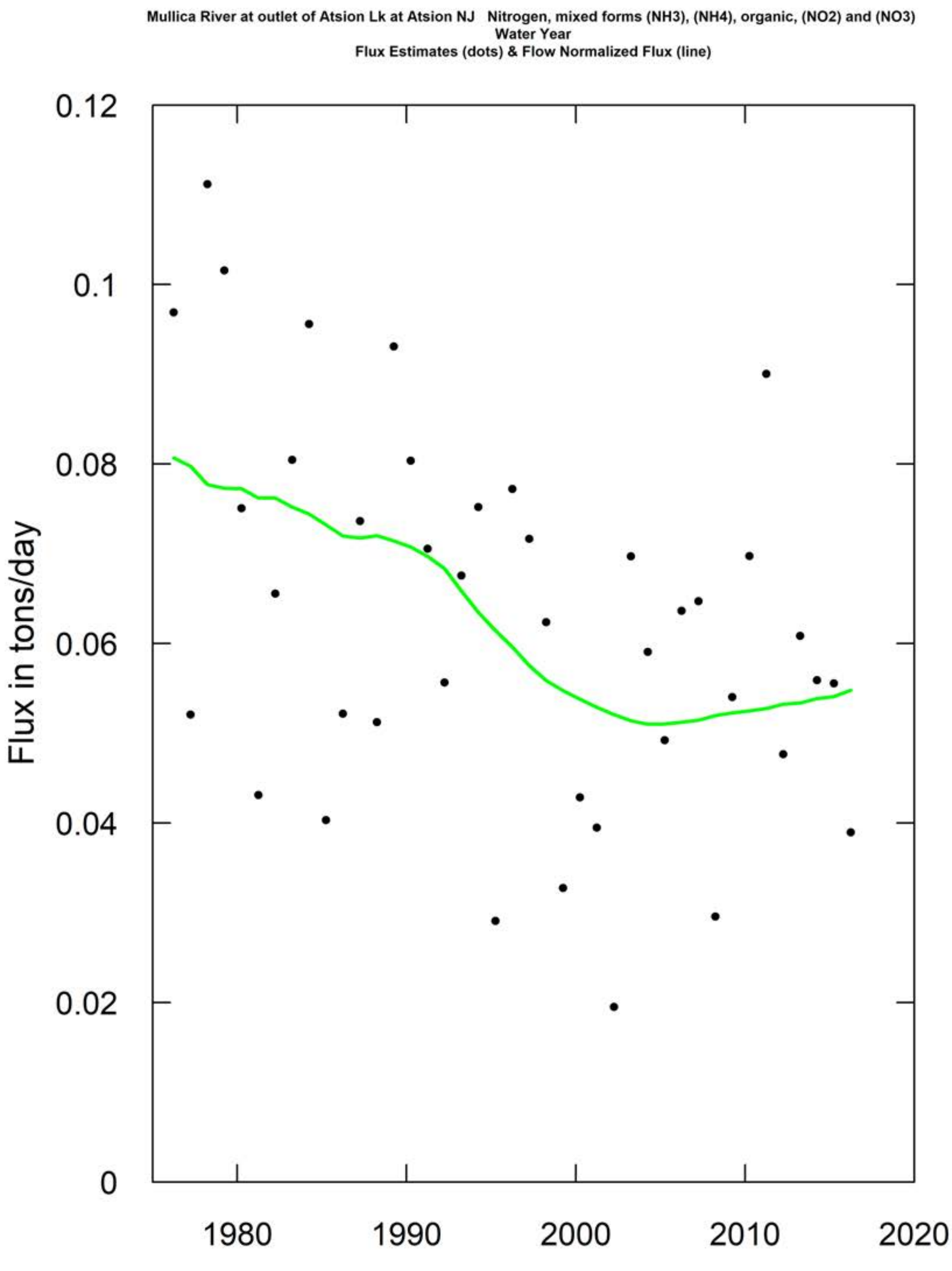

Mullica River at outlet of Atsion Lk at Atsion NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

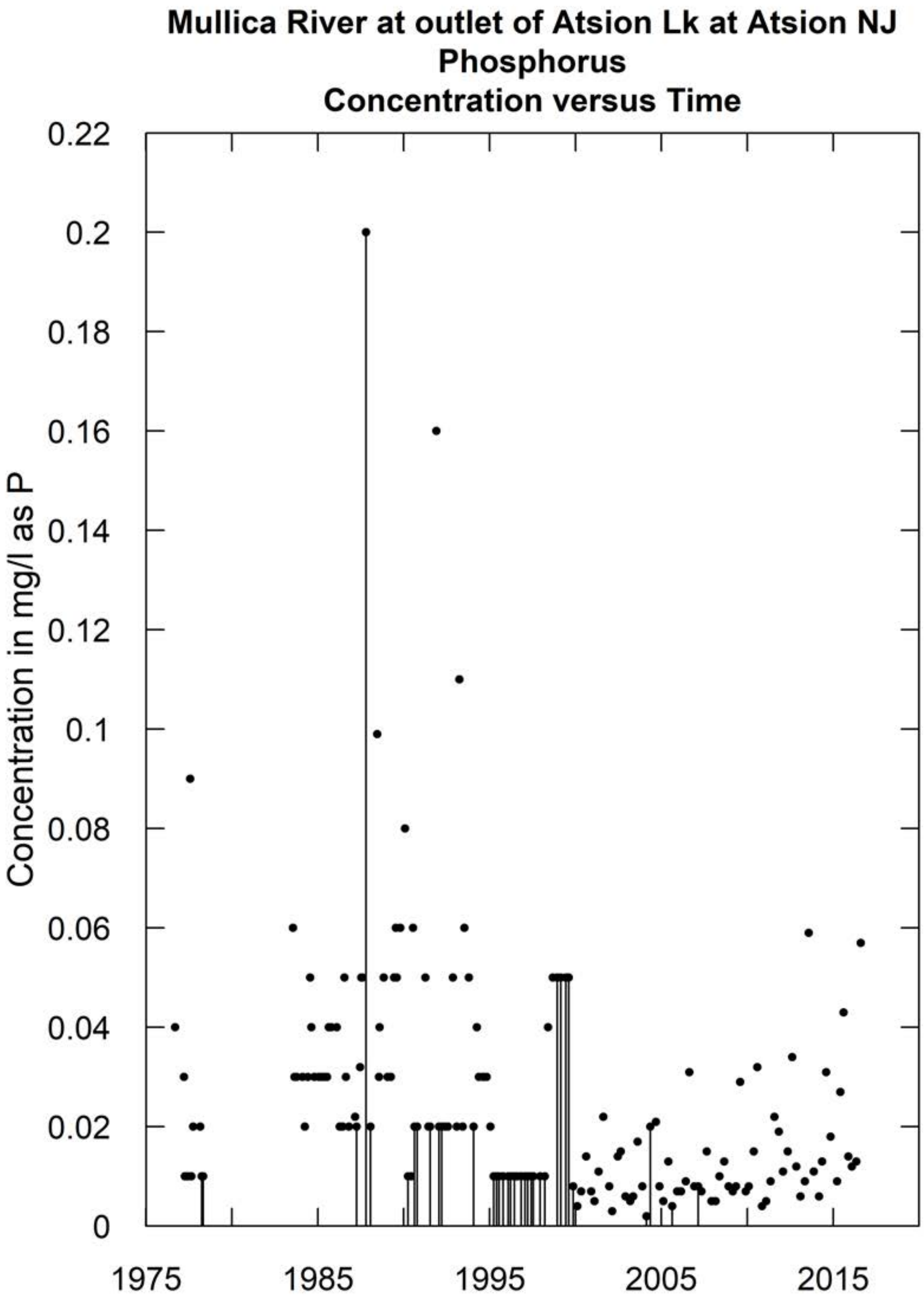

Mullica River at outlet of Atsion Lk at Atsion NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.03
0.025
0.02
0.015
0.01
0.005
0
1980
1990
2000
2010
2020

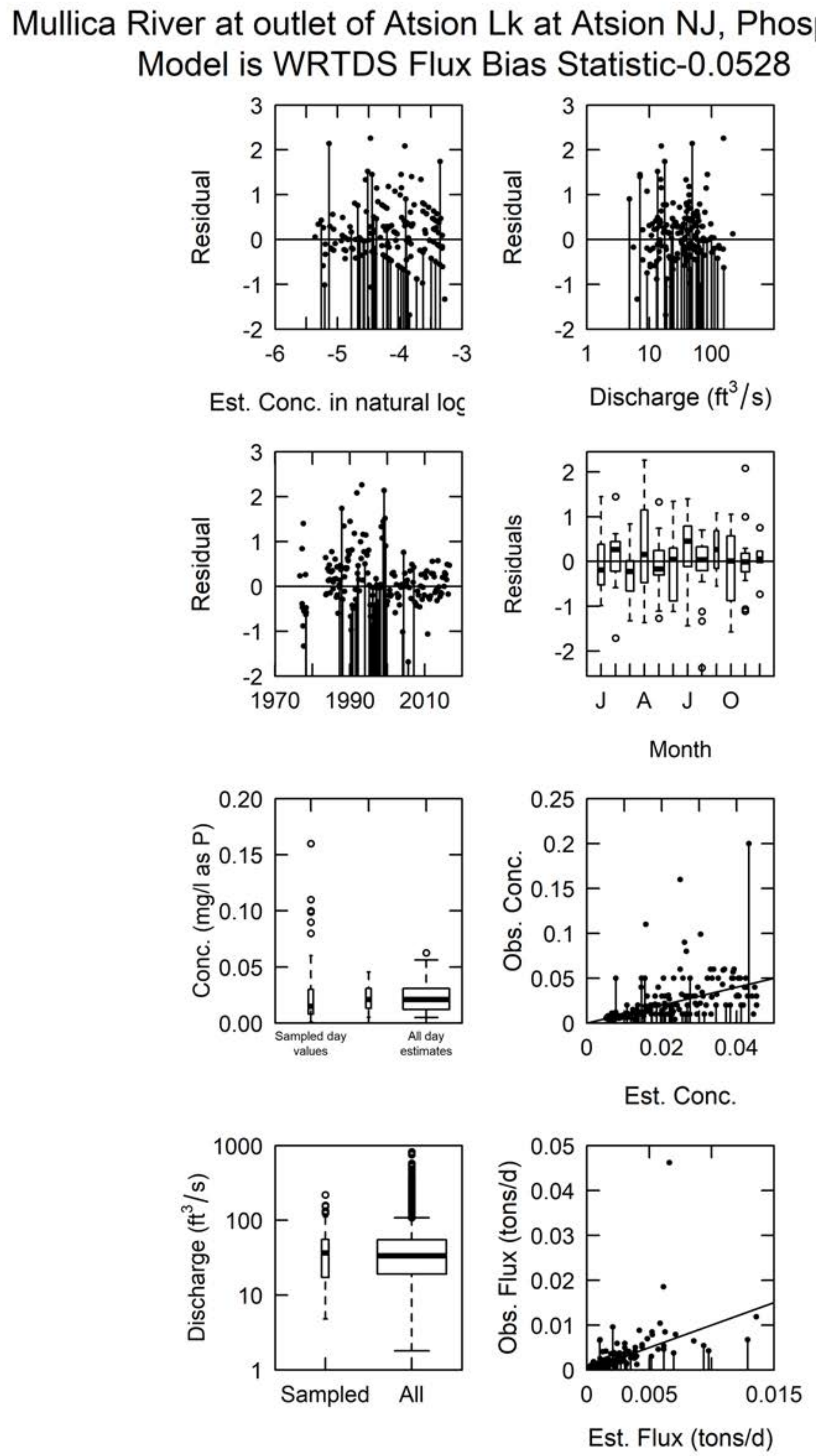

Mullica River at outlet of Atsion Lk at Atsion NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
0.5
1
1.5
2
2.5
3
1975
1985
1995
2005
2015

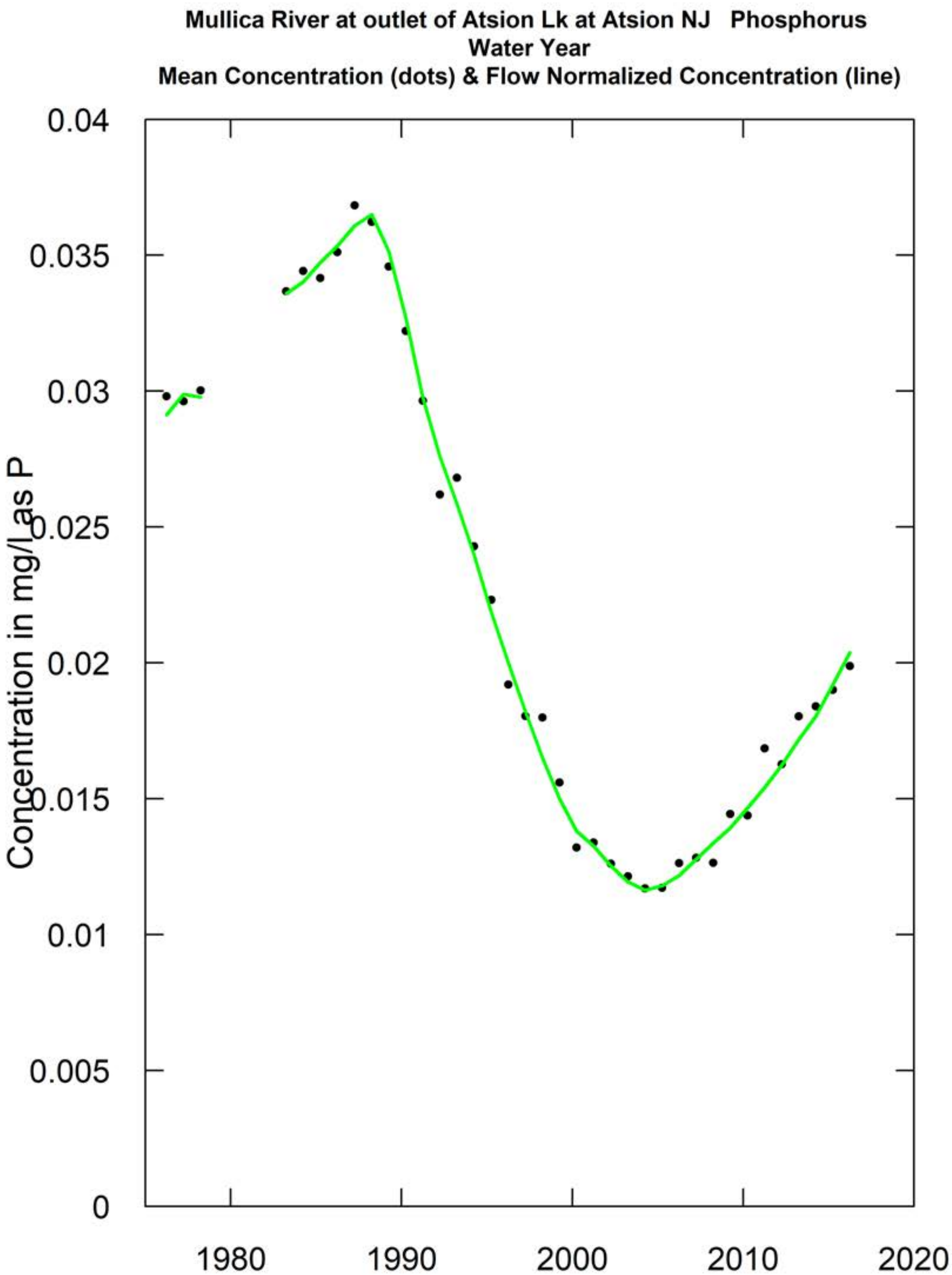

Mullica River at outlet of Atsion Lk at Atsion NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.00308
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

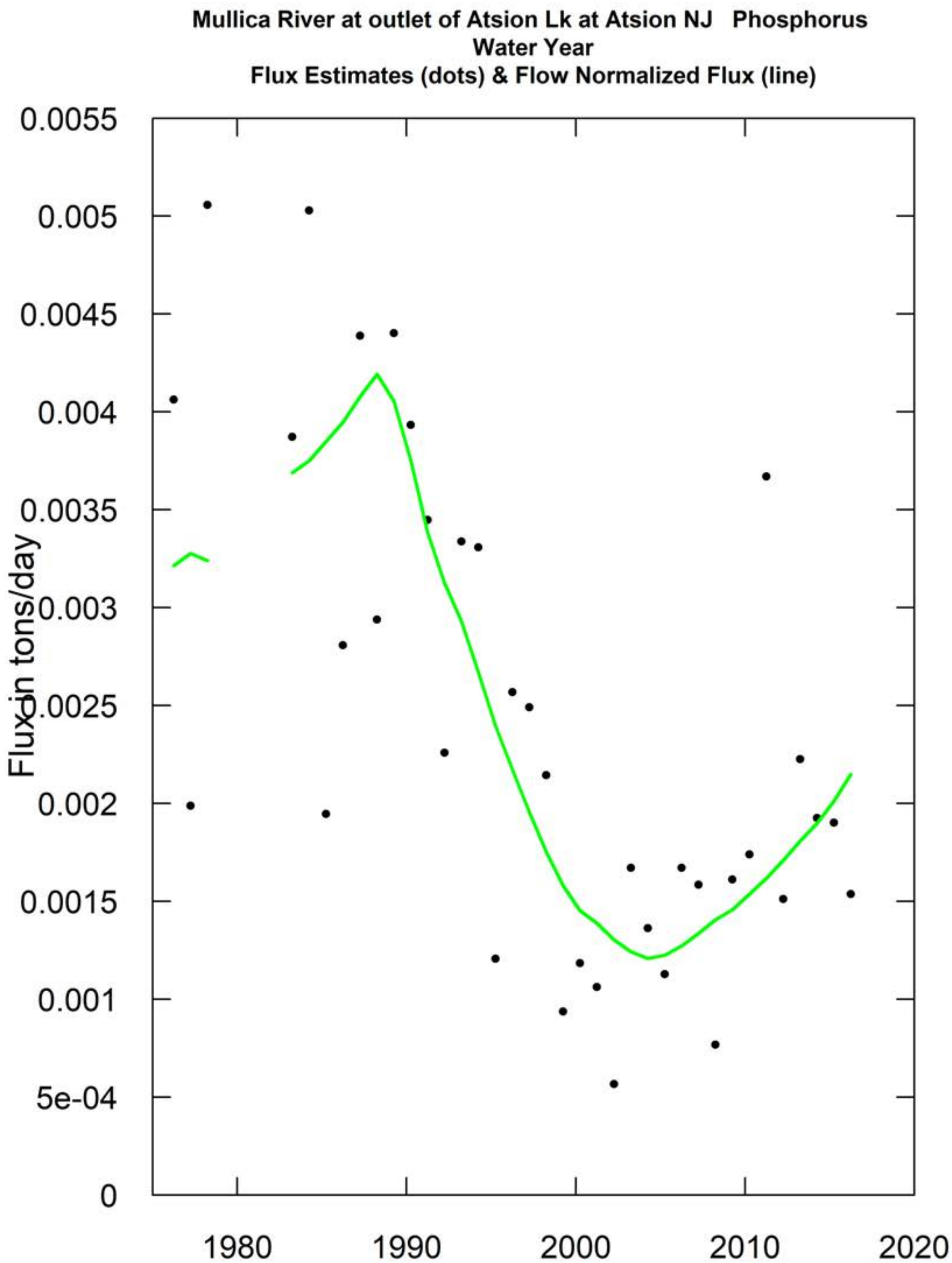

Mullica River at outlet of Atsion Lk at Atsion NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

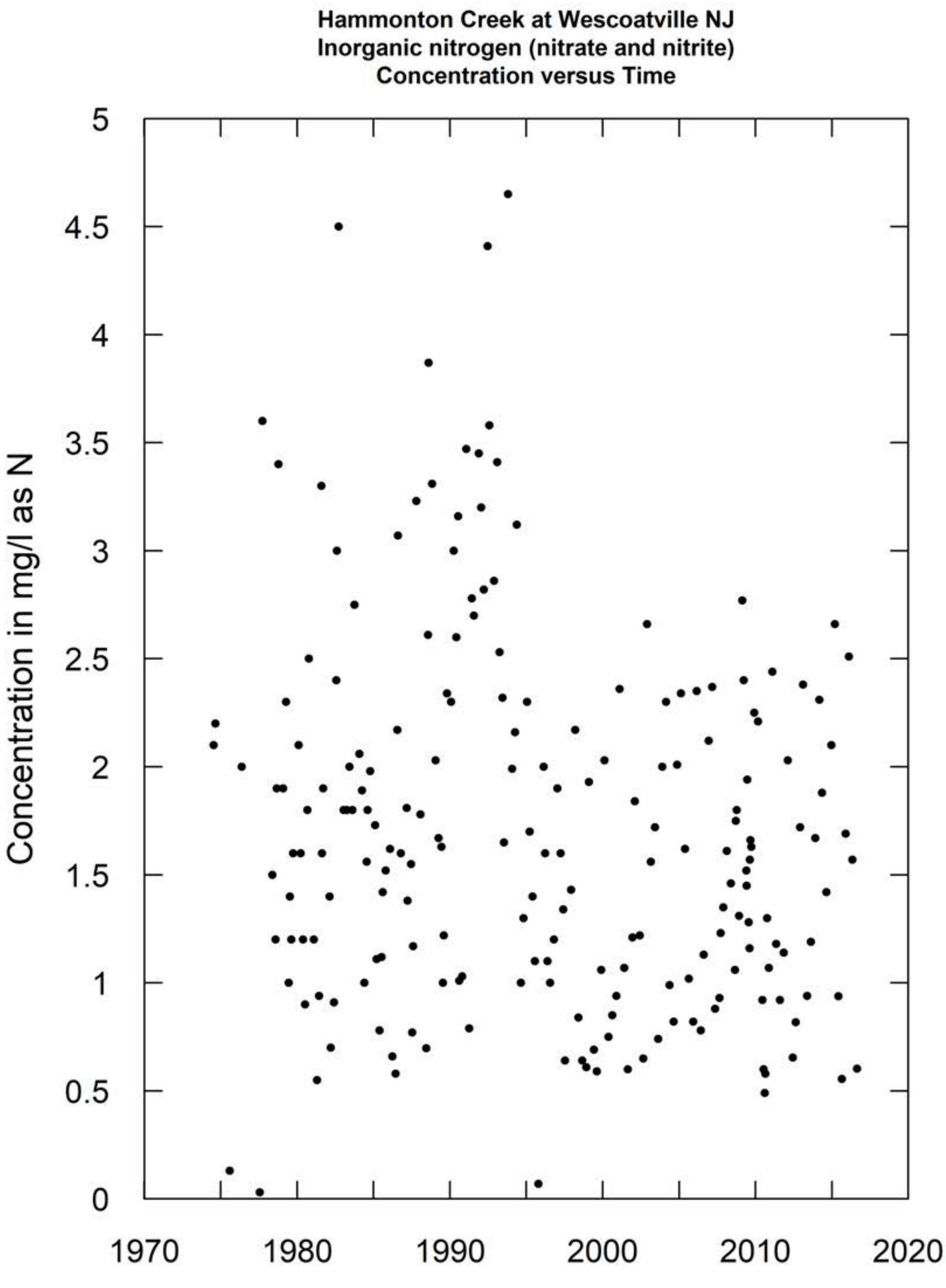

Mullica River at outlet of Atsion Lk at Atsion NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

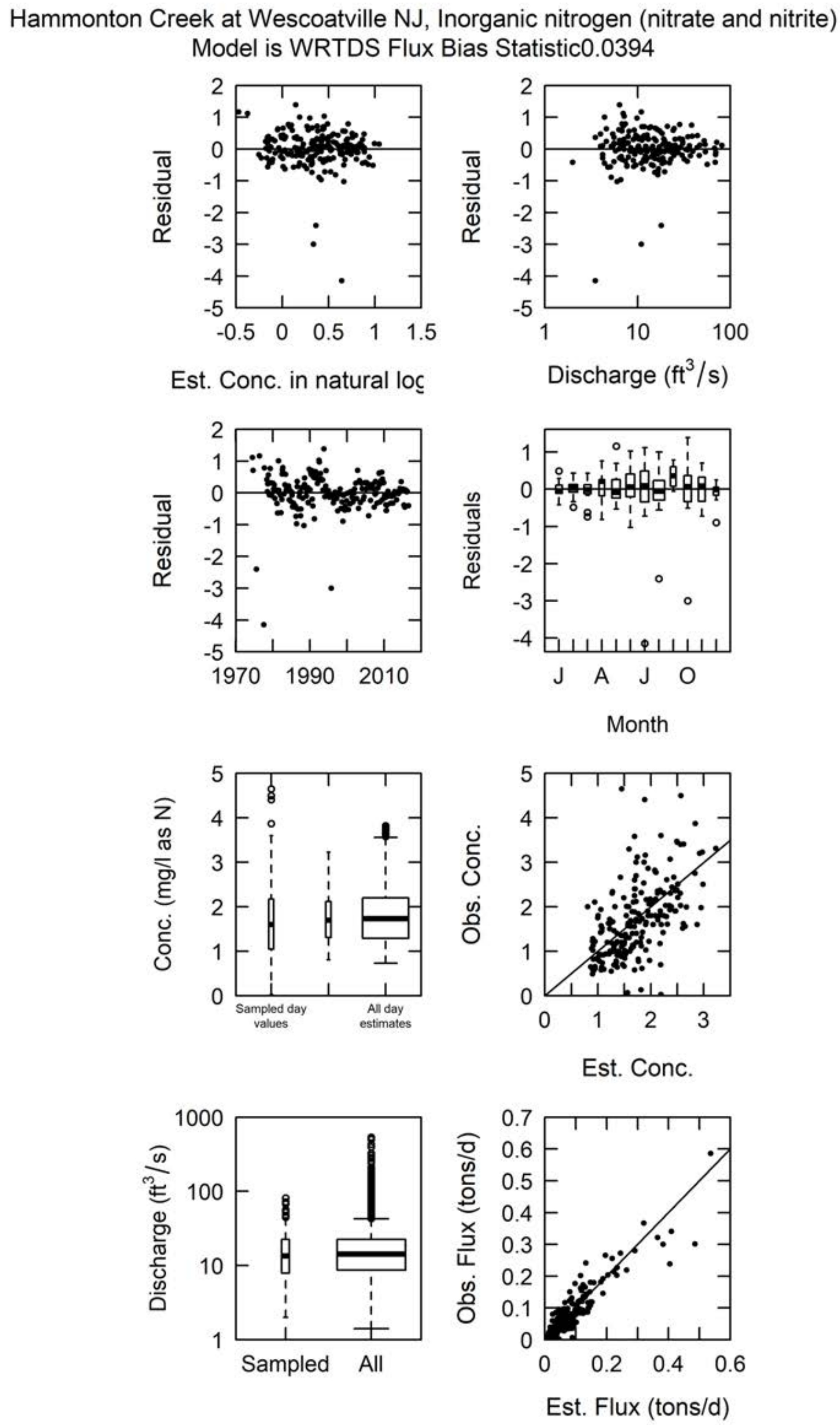

Mullica River at outlet of Atsion Lk at Atsion NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1975
1985
1995
2005
2015


Mullica River at outlet of Atsion Lk at Atsion NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.0528
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
J A J O
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

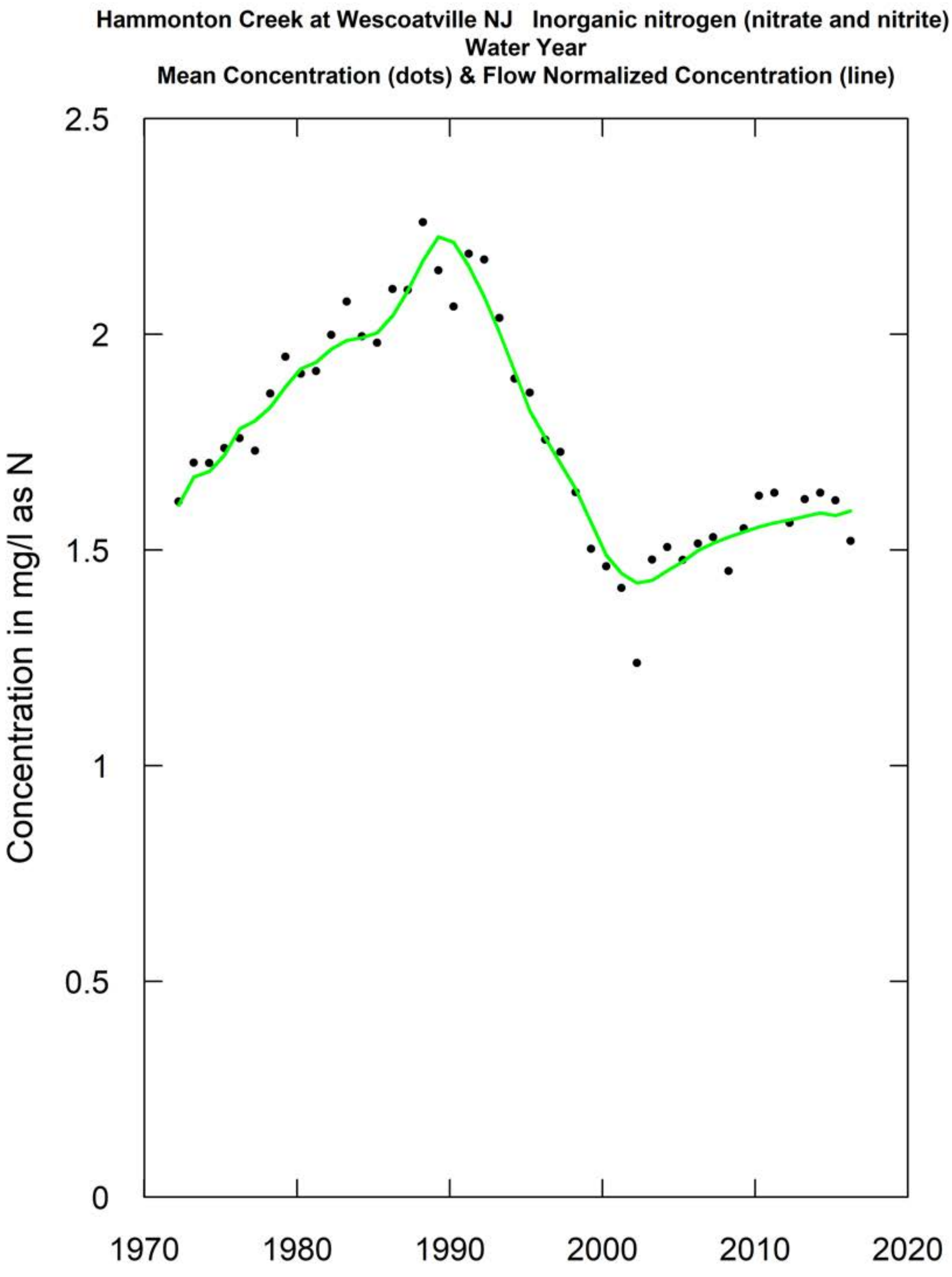

Mullica River at outlet of Atsion Lk at Atsion NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1980
1990
2000
2010
2020

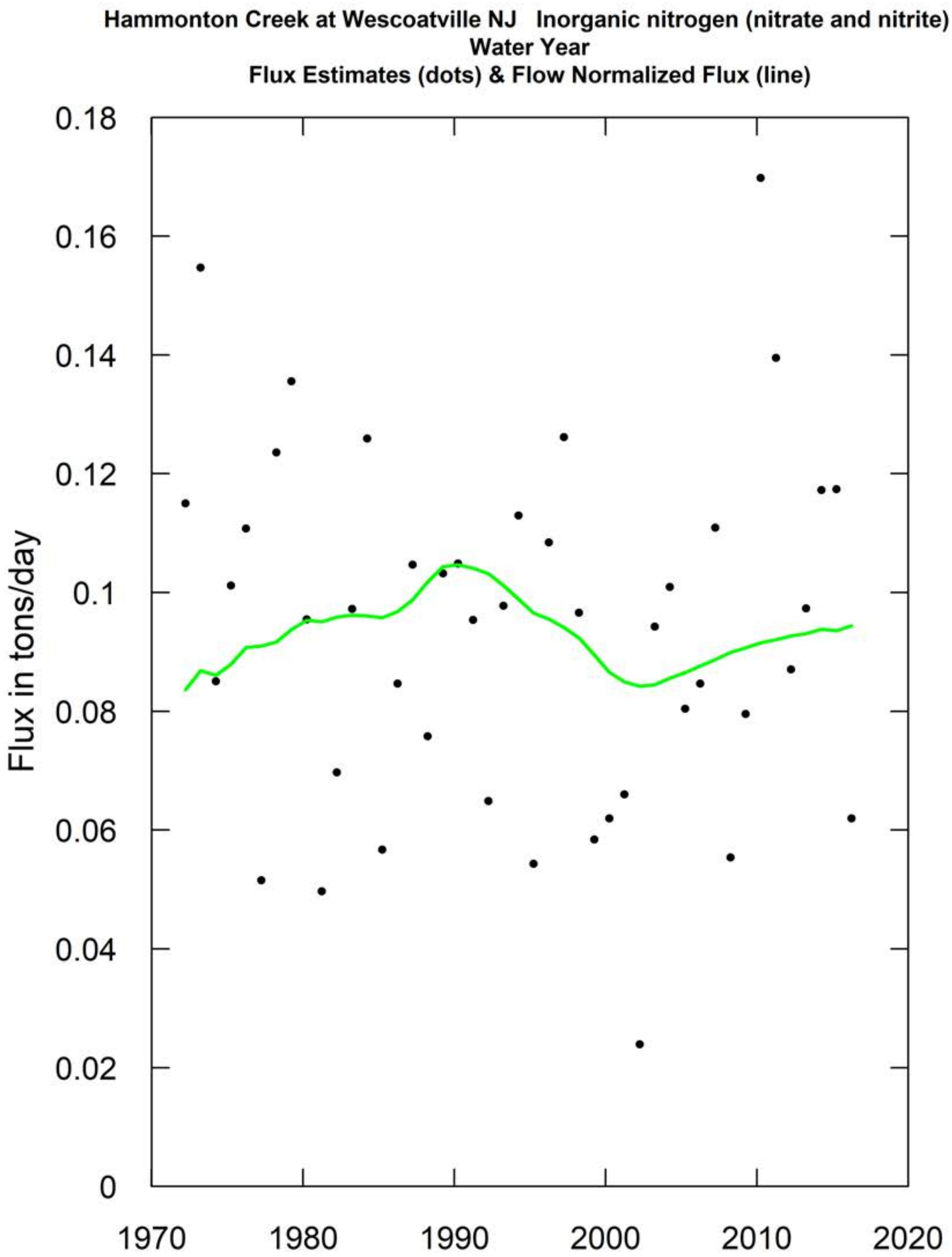

Mullica River at outlet of Atsion Lk at Atsion NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.0055
0.005
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
5e-04
0
1980
1990
2000
2010
2020

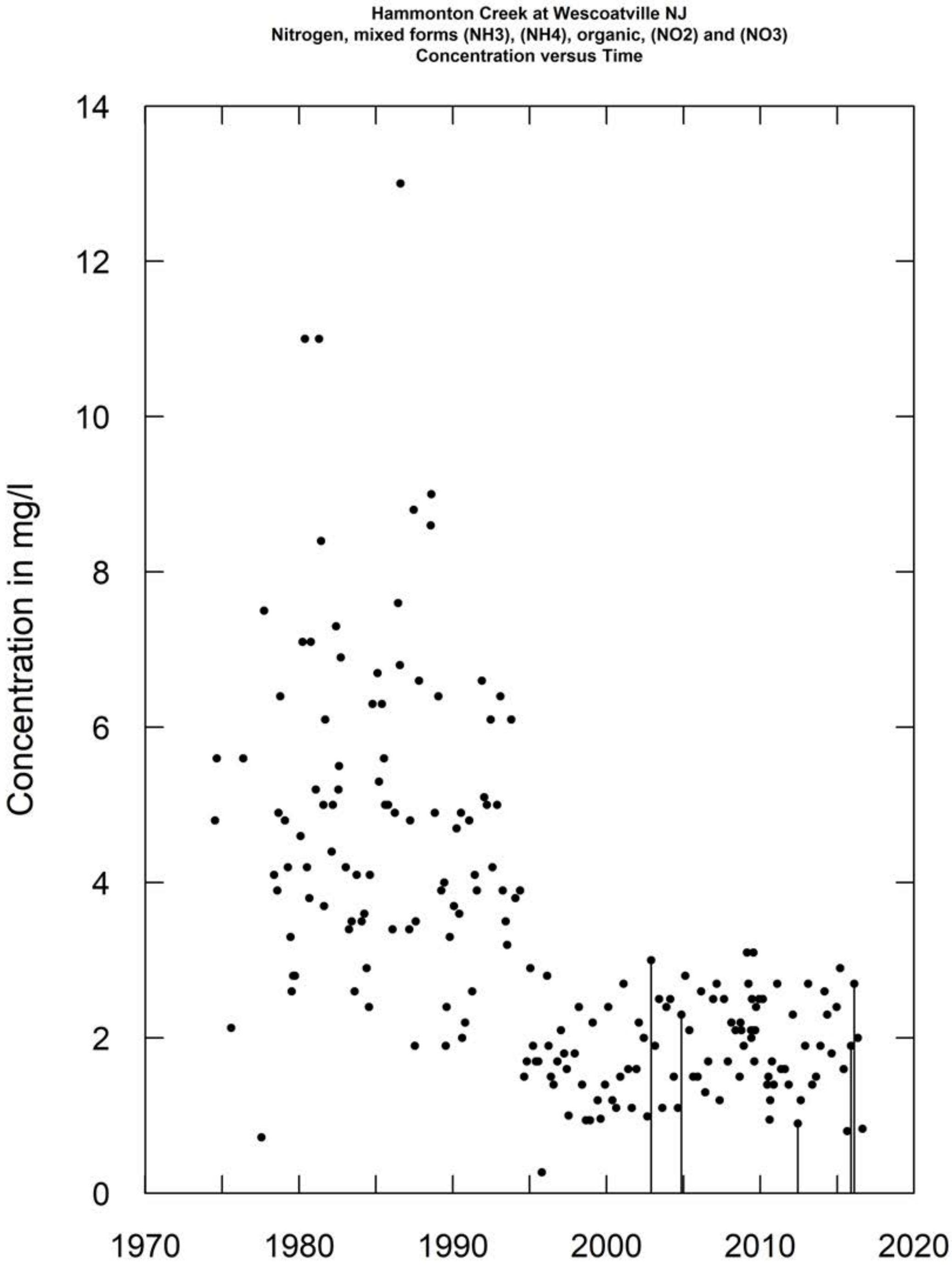

Hammonton Creek at Wescoatville NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

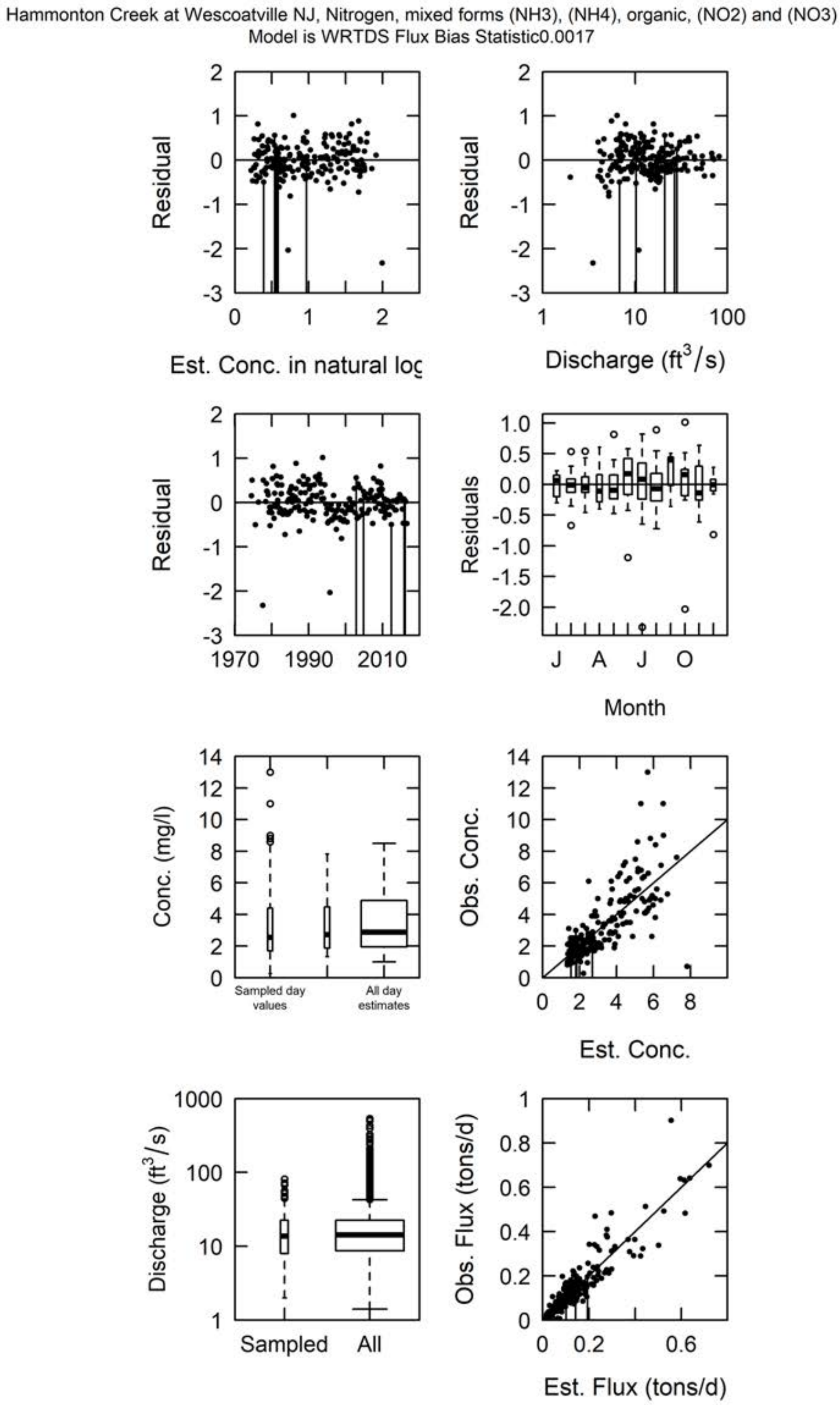


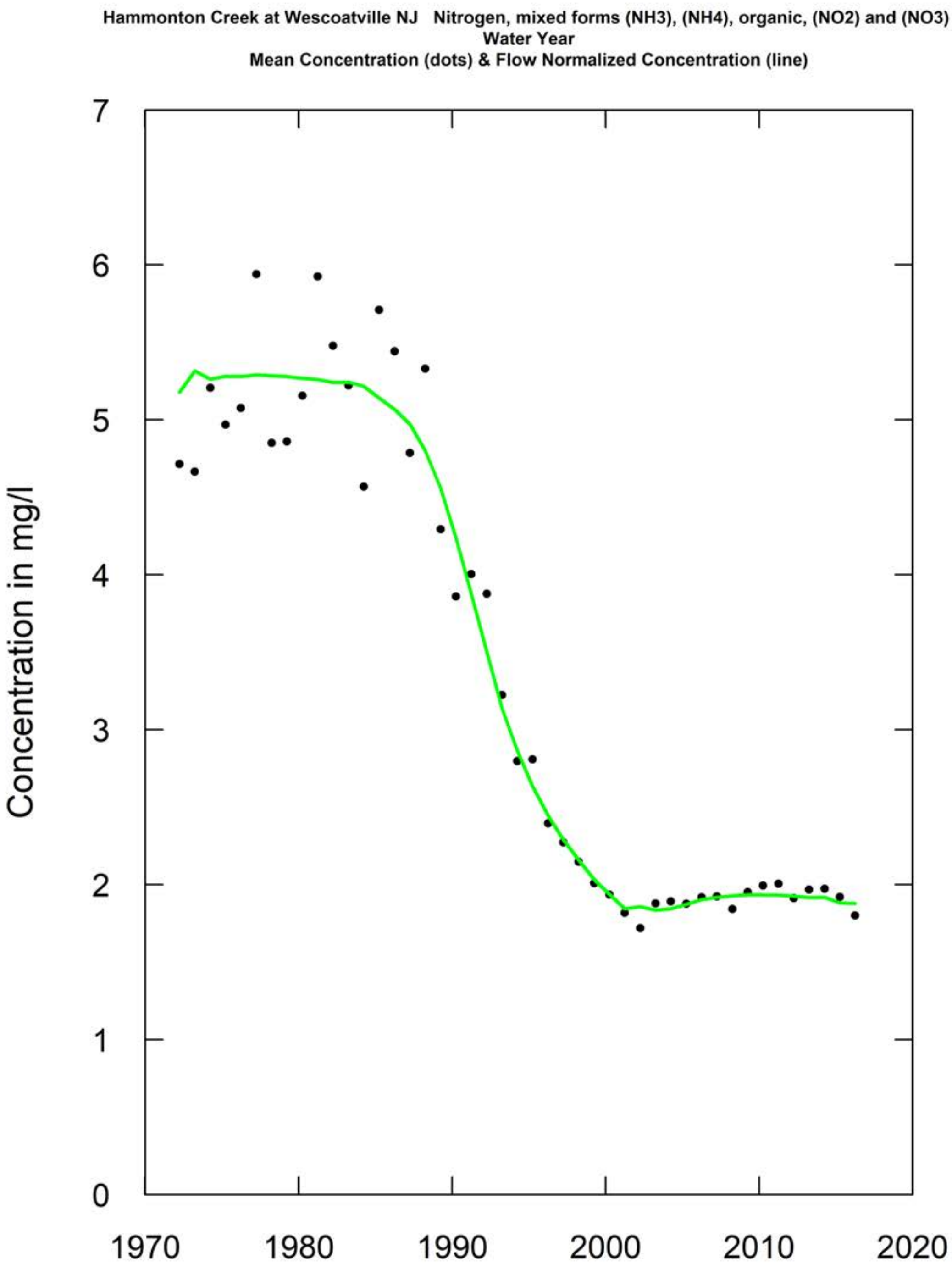
Hammonton Creek at Wescoatville NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0394
Residual
Est. Conc. in natural log
Discharge (ft3/s)
1970 1990 2010
Residuals
J A J O
Month
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

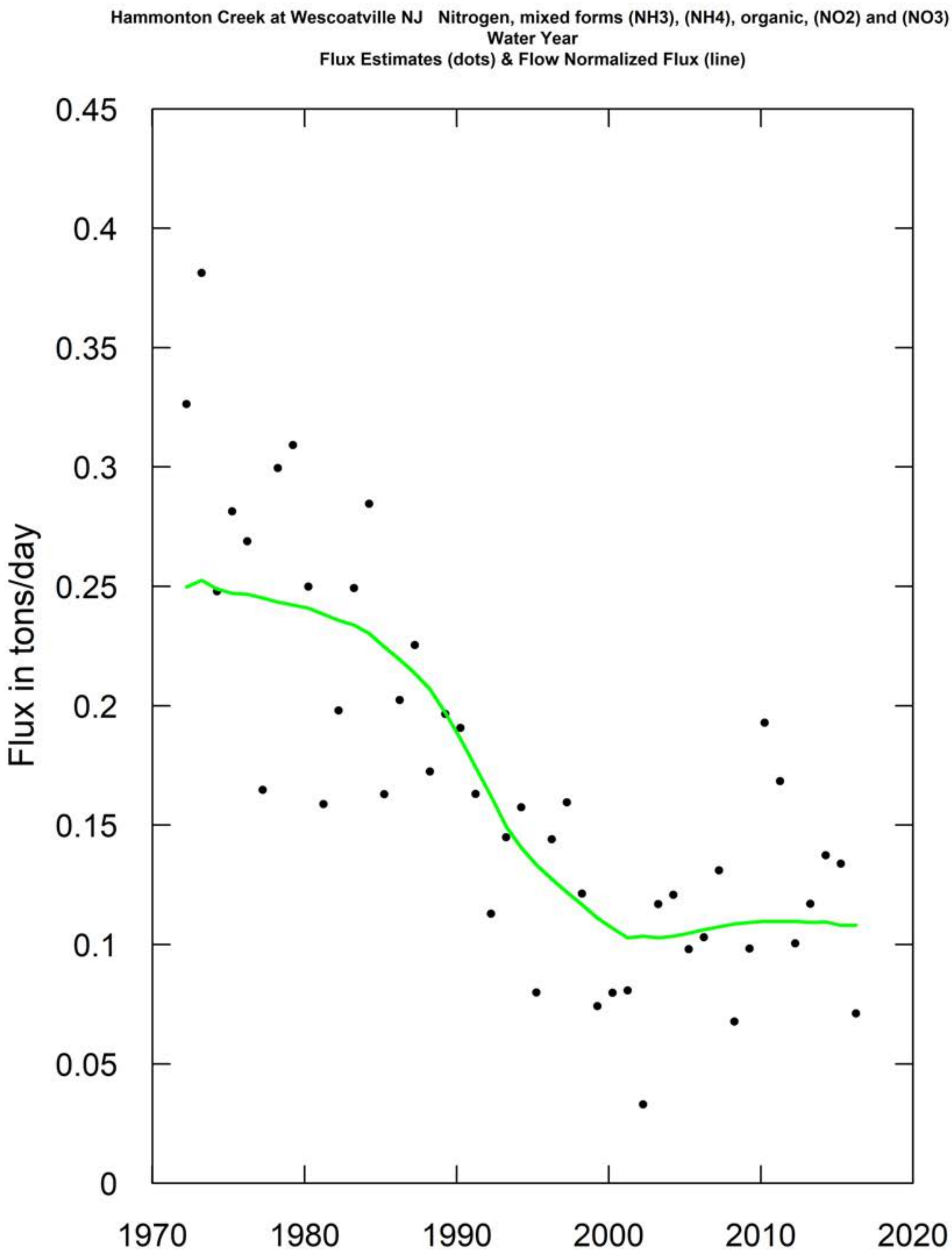

Hammonton Creek at Wescoatville NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

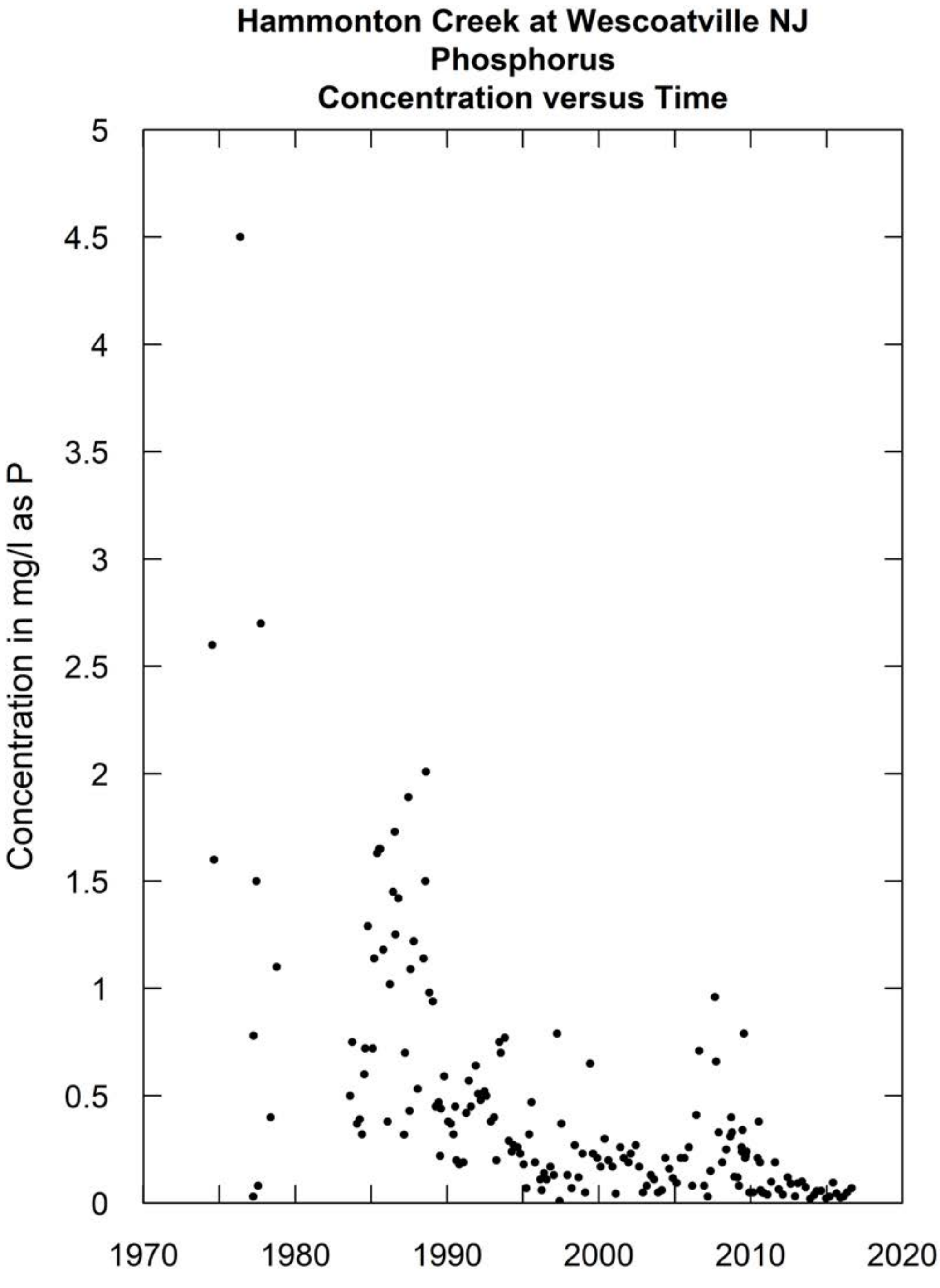

Hammonton Creek at Wescoatville NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1970
1980
1990
2000
2010
2020

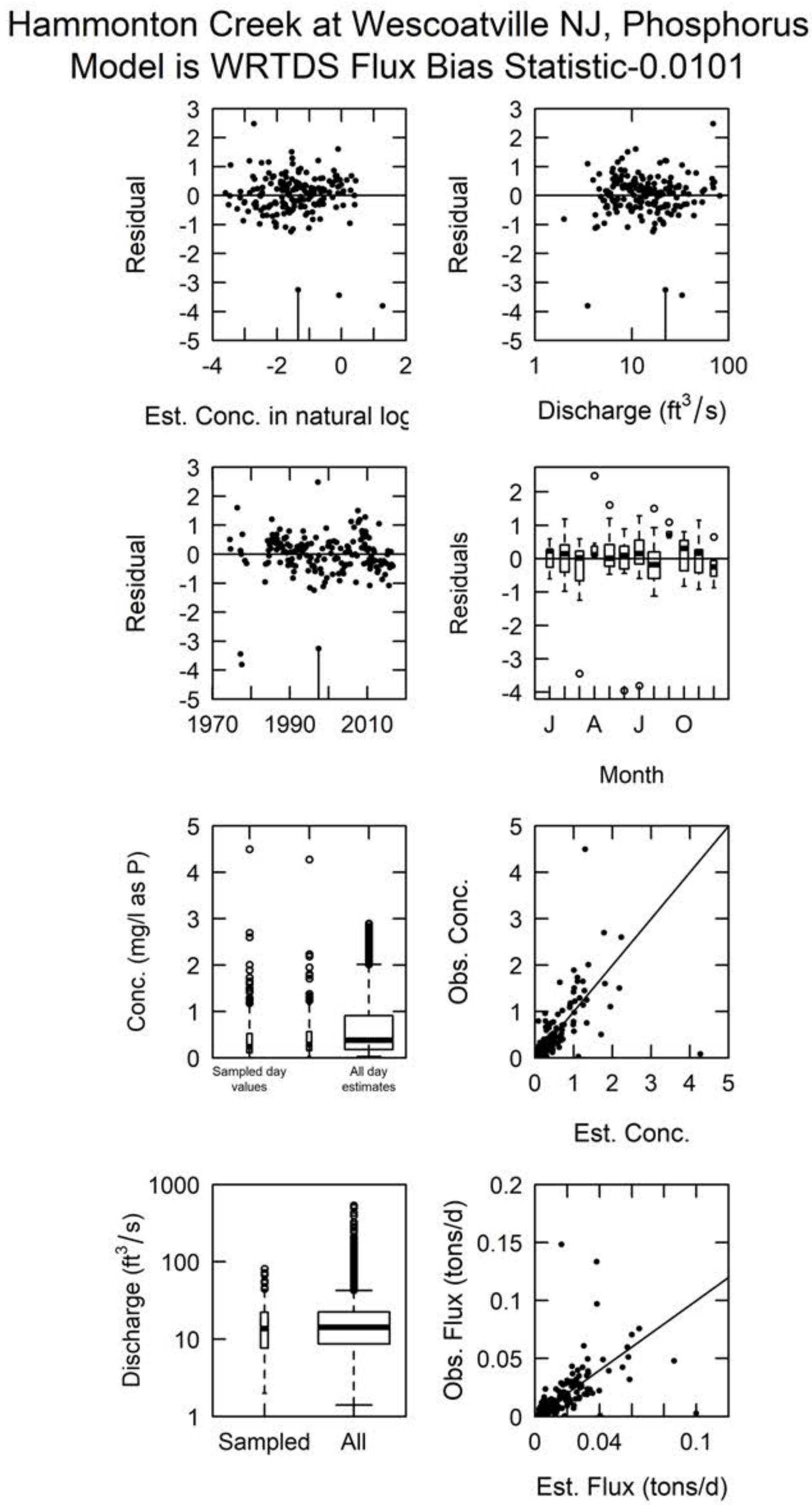

Hammonton Creek at Wescoatville NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
2
4
6
8
10
12
14
1970
1980
1990
2000
2010
2020

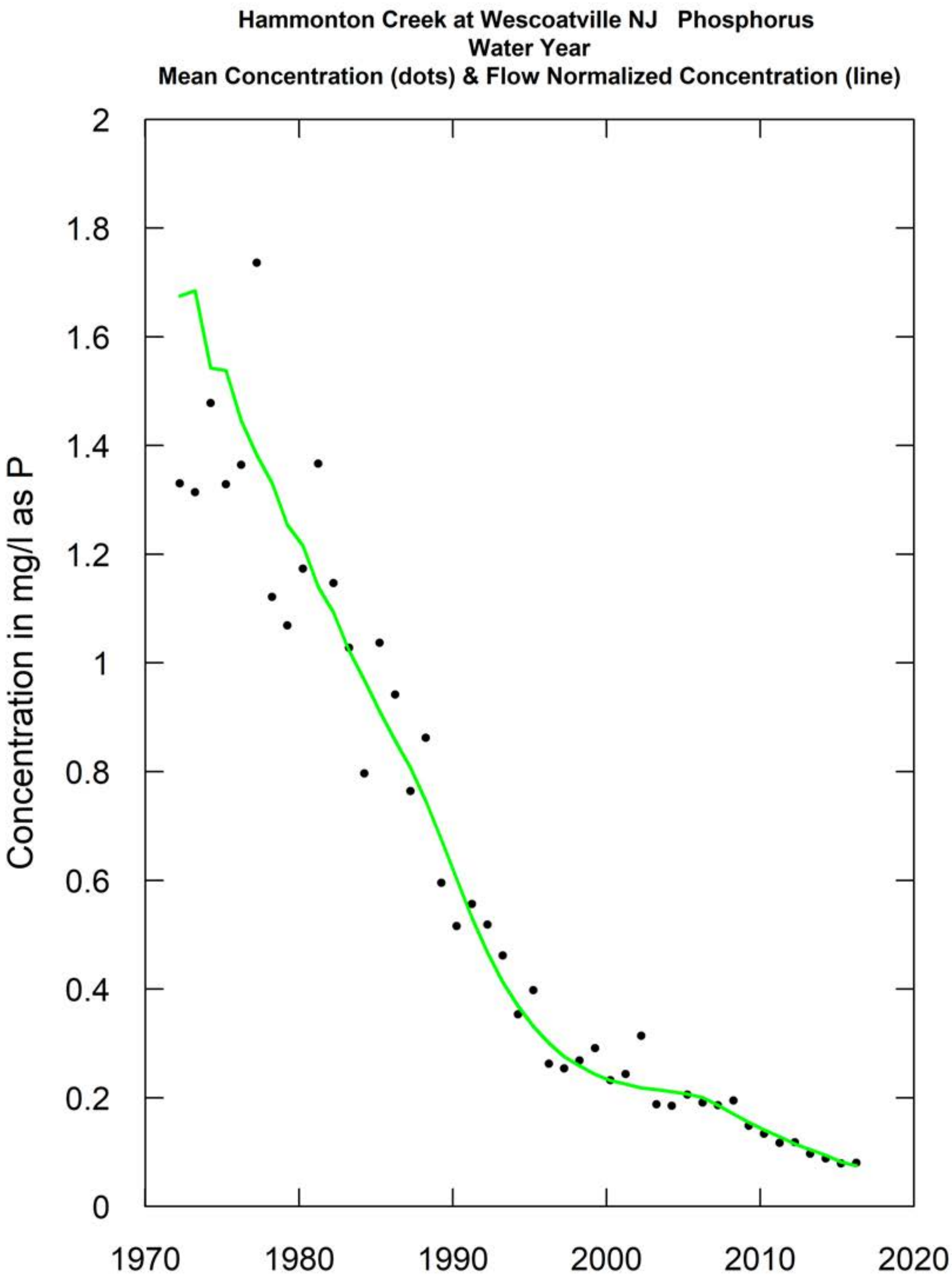

Hammonton Creek at Wescoatville NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.0017
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

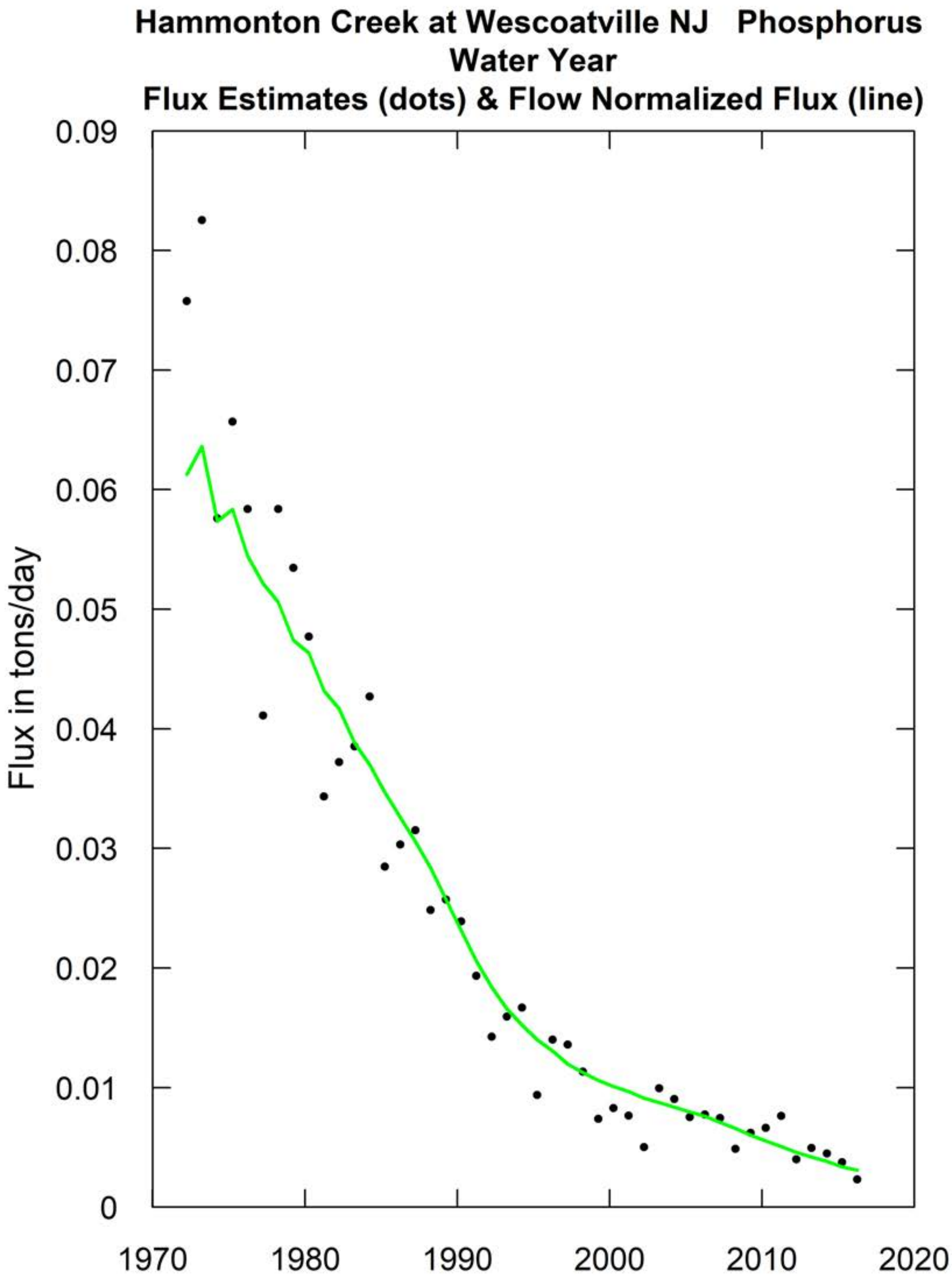

Hammonton Creek at Wescoatville NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0
1
2
3
4
5
6
7
1970
1980
1990
2000
2010
2020

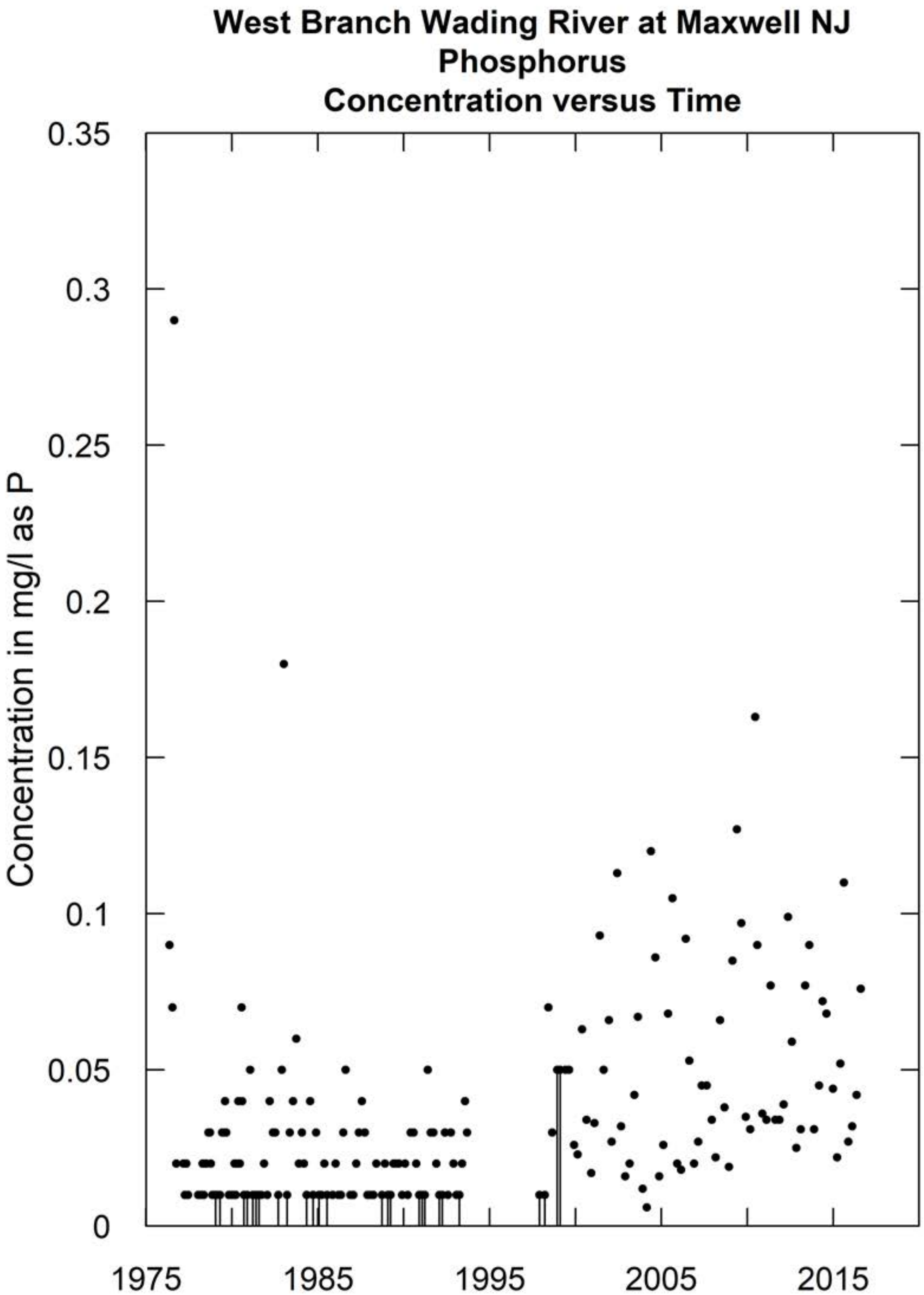

Hammonton Creek at Wescoatville NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

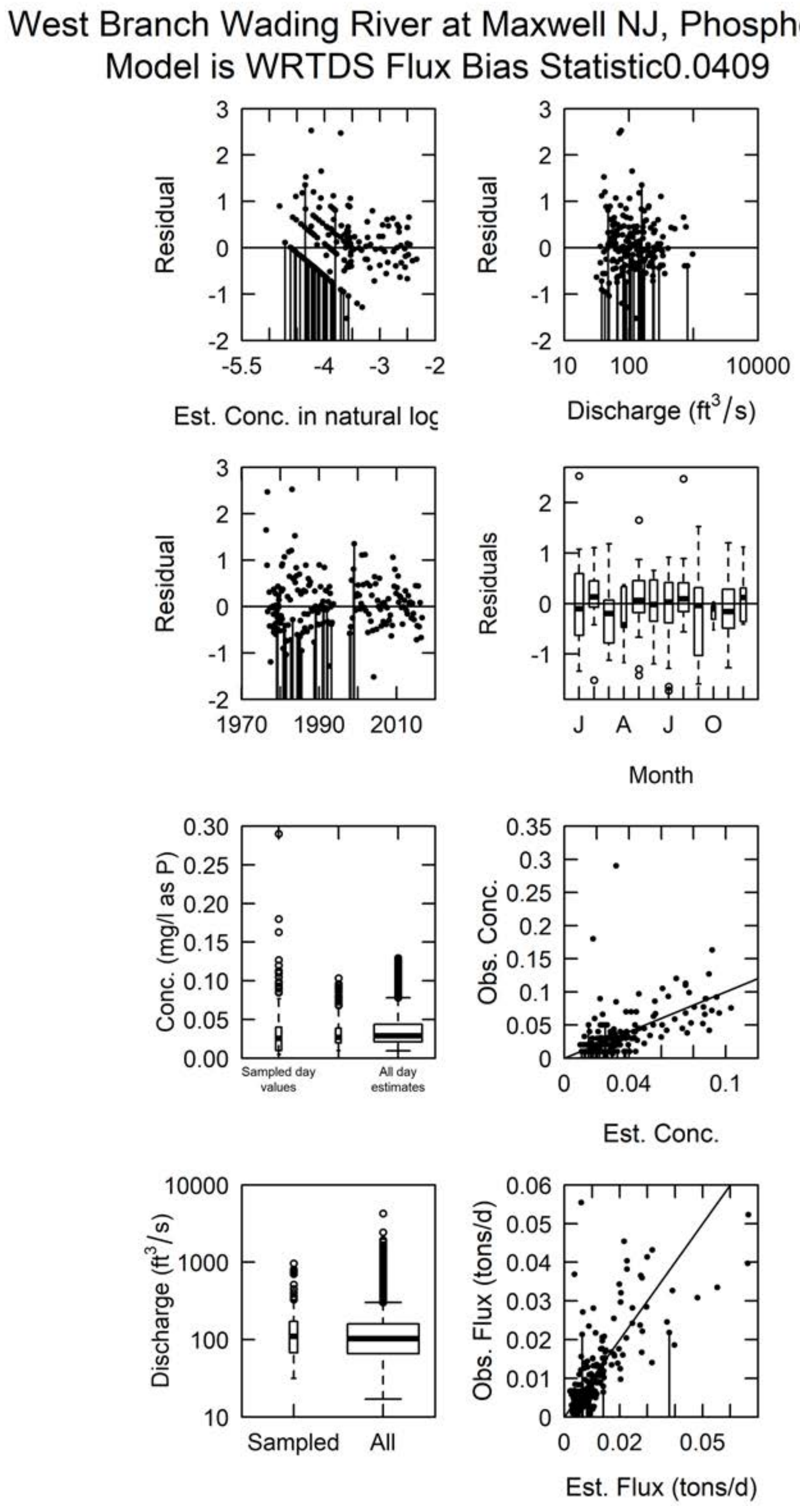

Hammonton Creek at Wescoatville NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

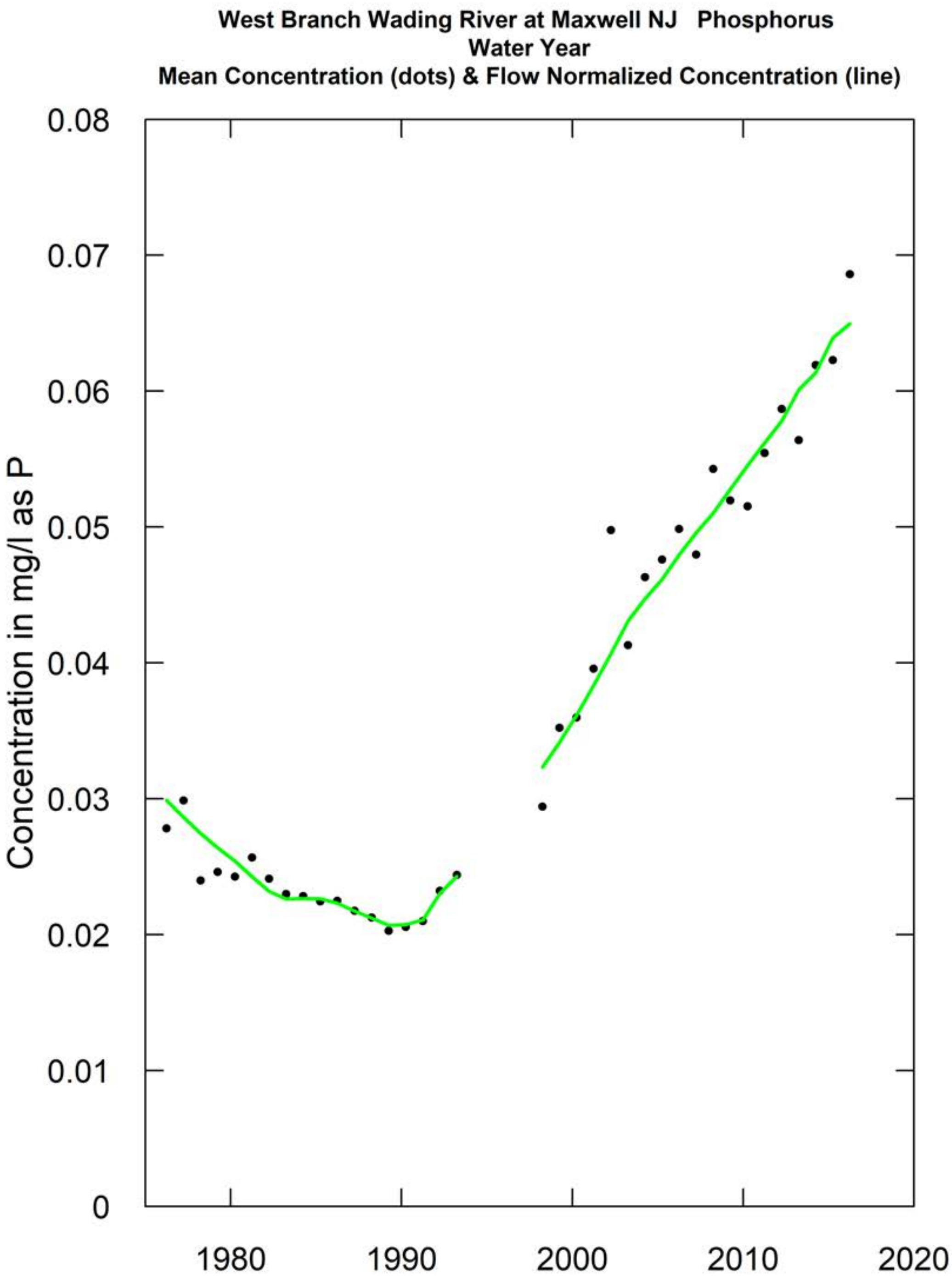

Hammonton Creek at Wescoatville NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.0101
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
1970 1990 2010
Residuals
J A J O
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled All
Obs. Flux (tons/d)
Est. Flux (tons/d)

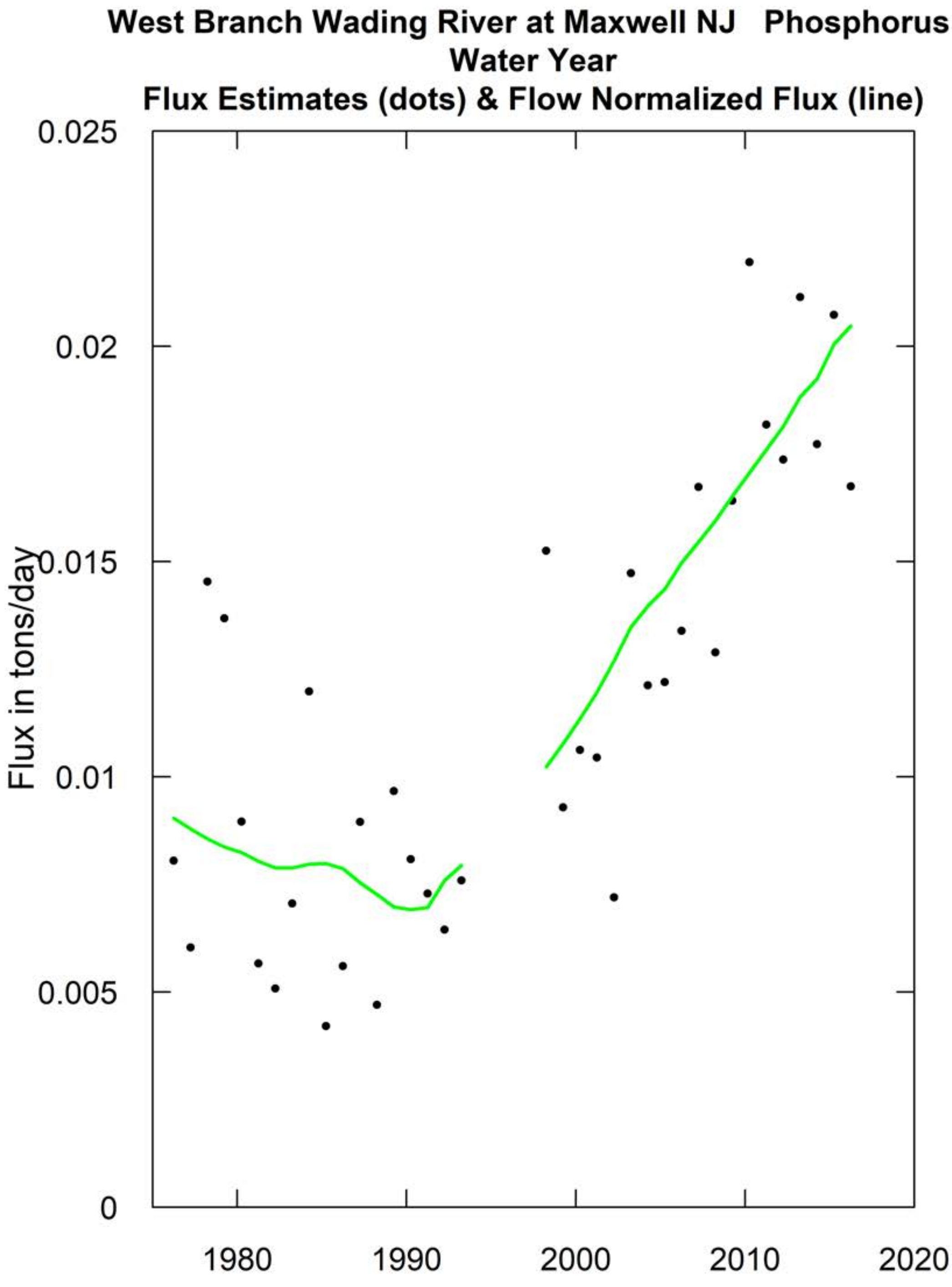

Hammonton Creek at Wescoatville NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

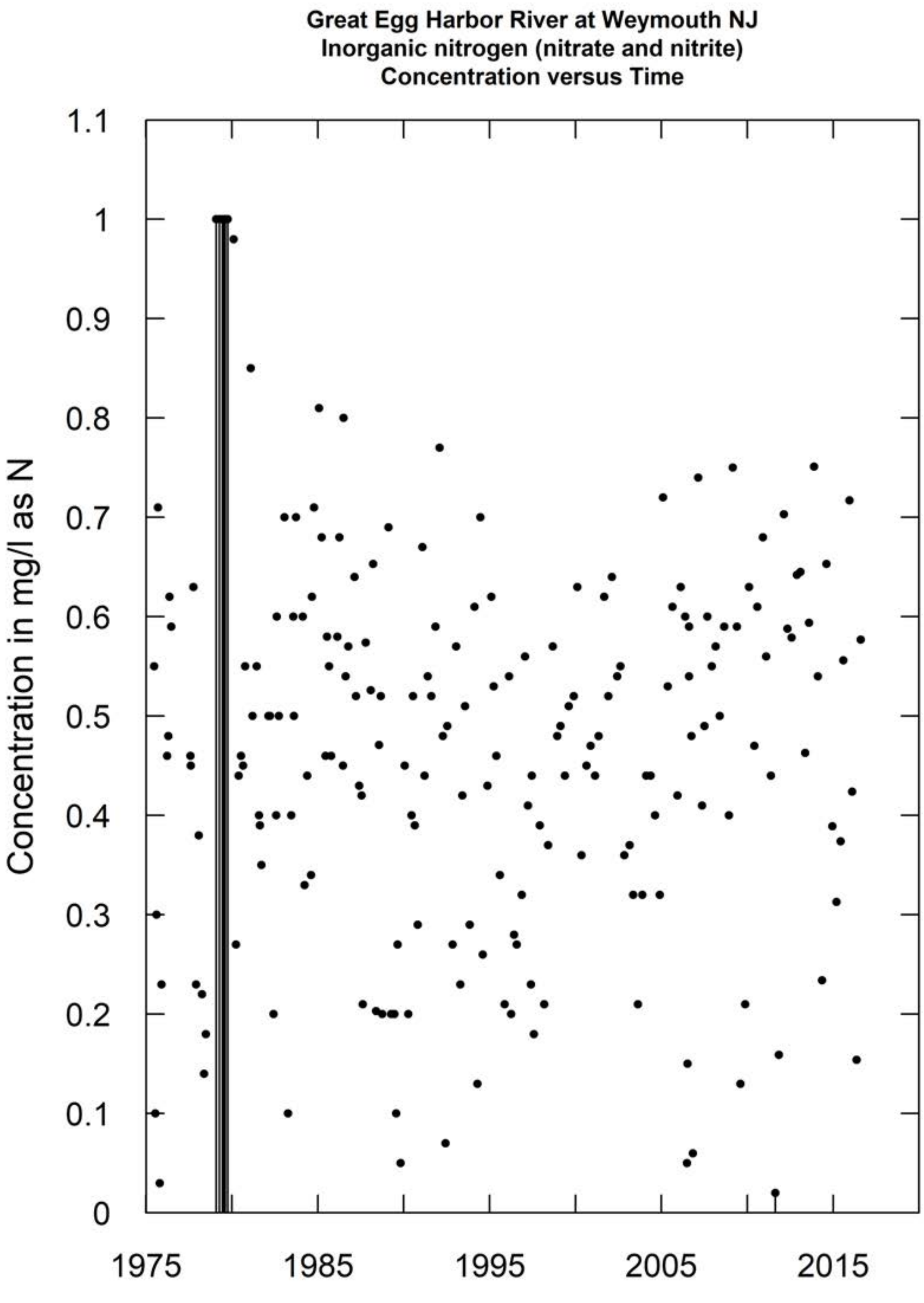

Hammonton Creek at Wescoatville NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1970
1980
1990
2000
2010
2020

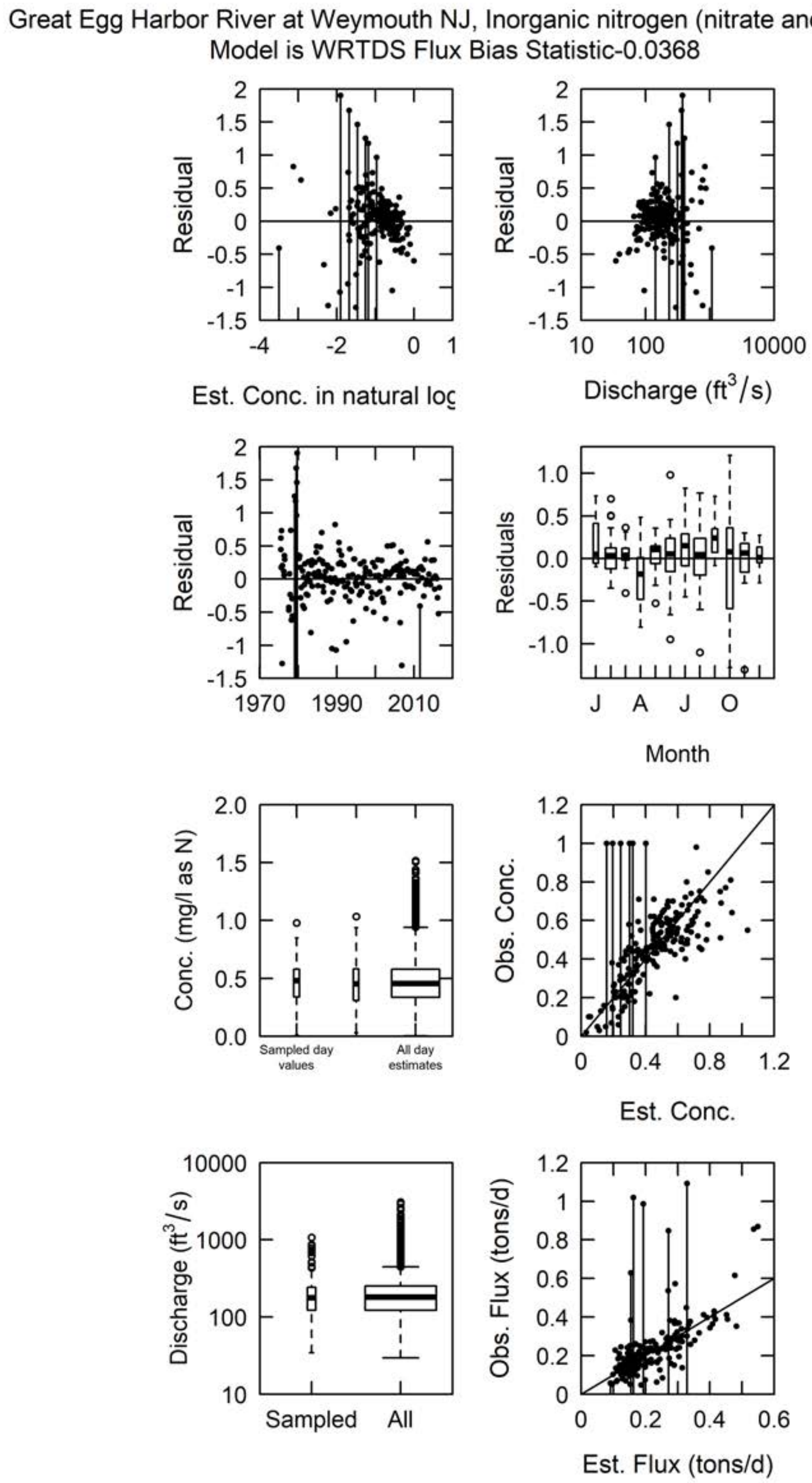

West Branch Wading River at Maxwell NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1975
1985
1995
2005
2015

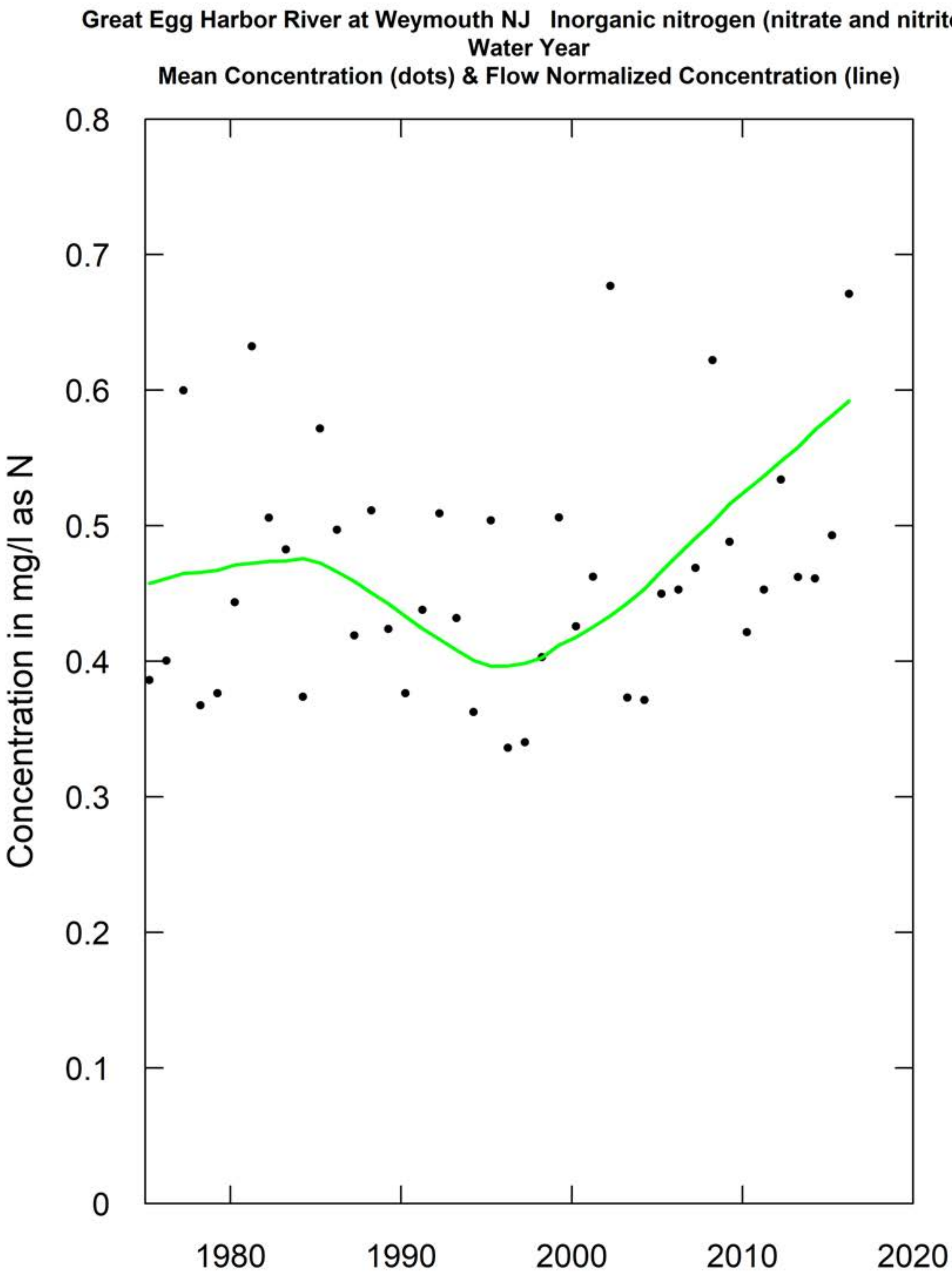

West Branch Wading River at Maxwell NJ, Phosphorus
Model is WRTDS Flux Bias Statistic0.0409
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
Residuals
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

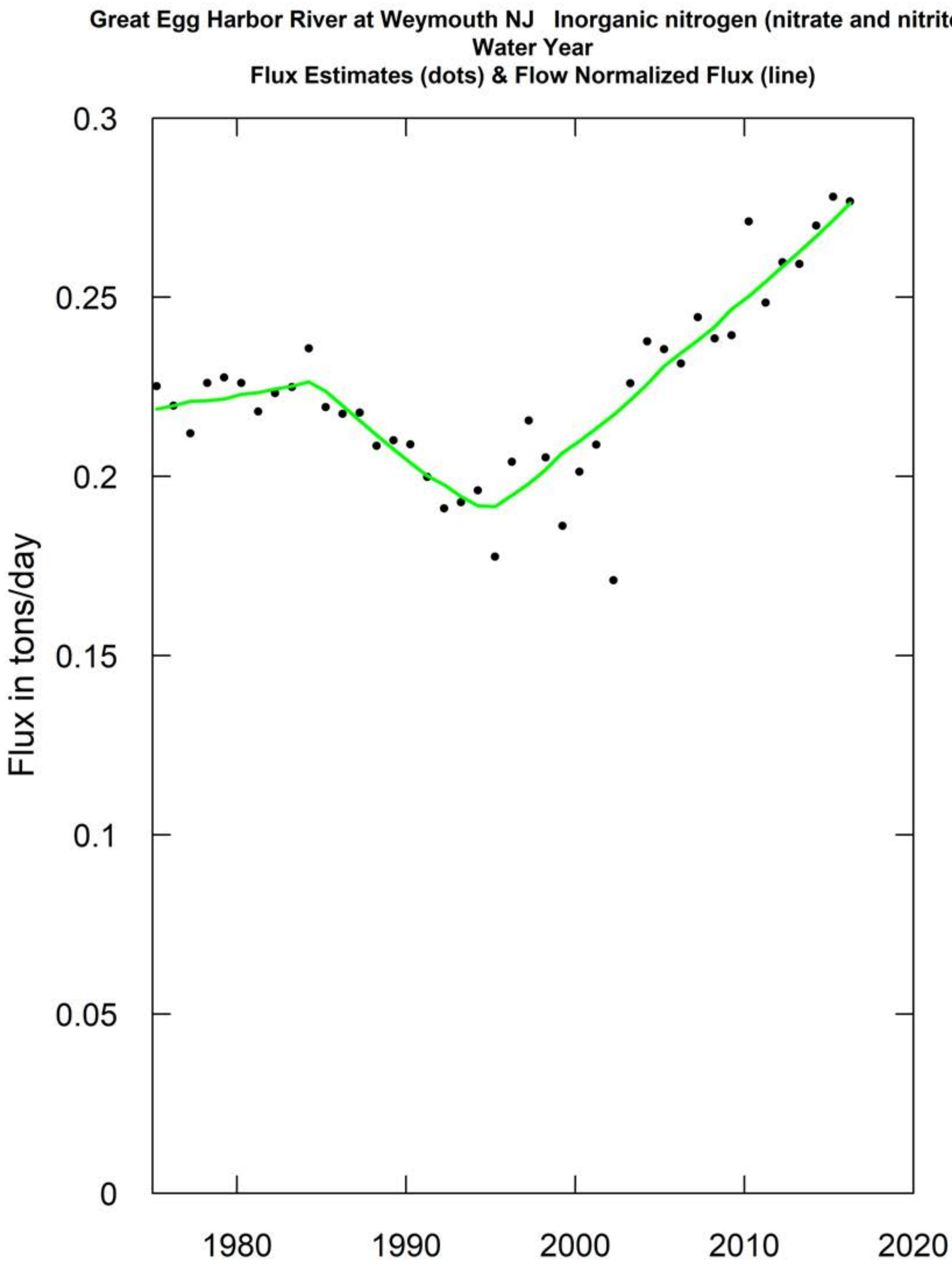

West Branch Wading River at Maxwell NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1980
1990
2000
2010
2020

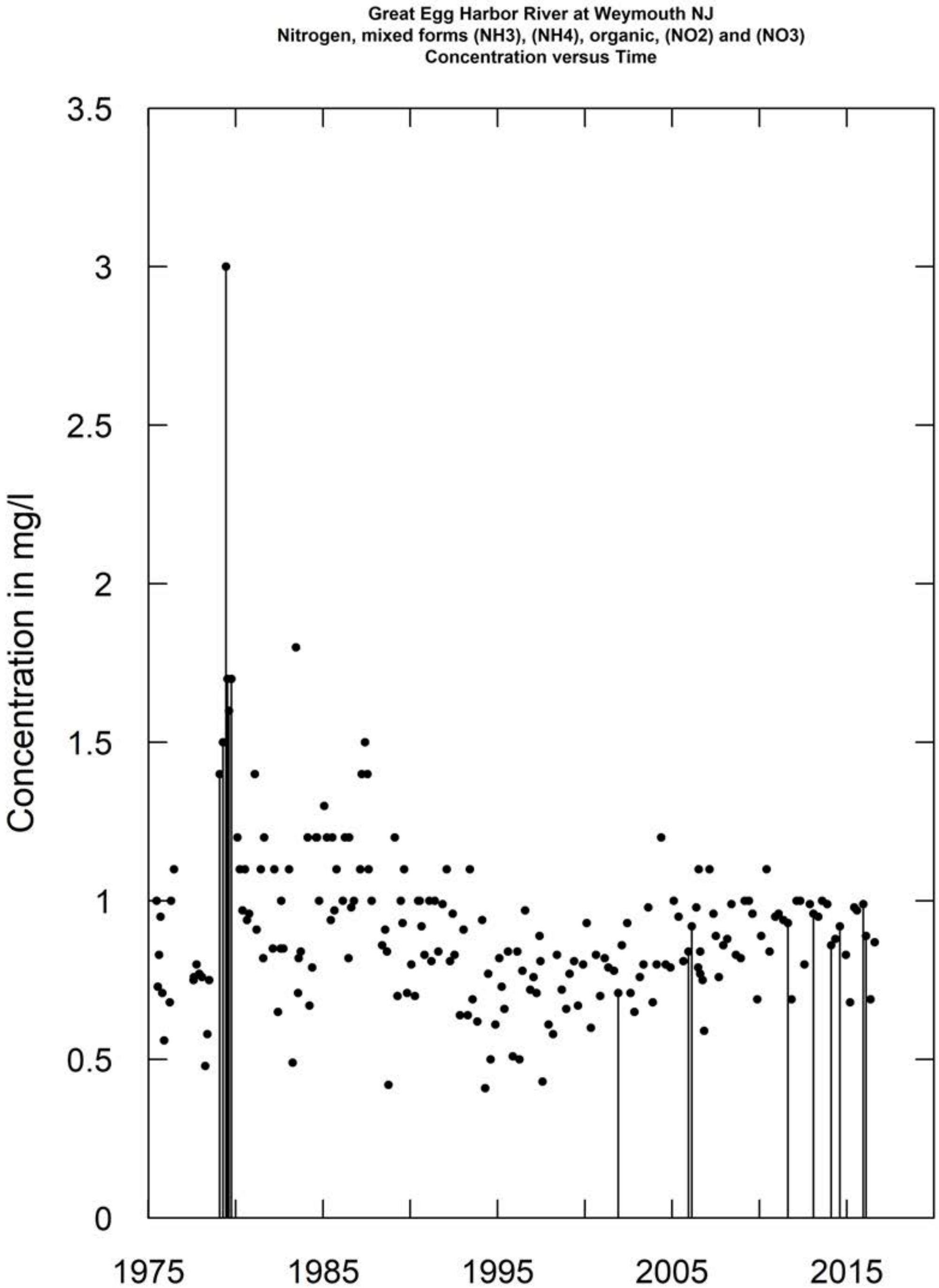

West Branch Wading River at Maxwell NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.025
0.02
0.015
0.01
0.005
0
1980
1990
2000
2010
2020

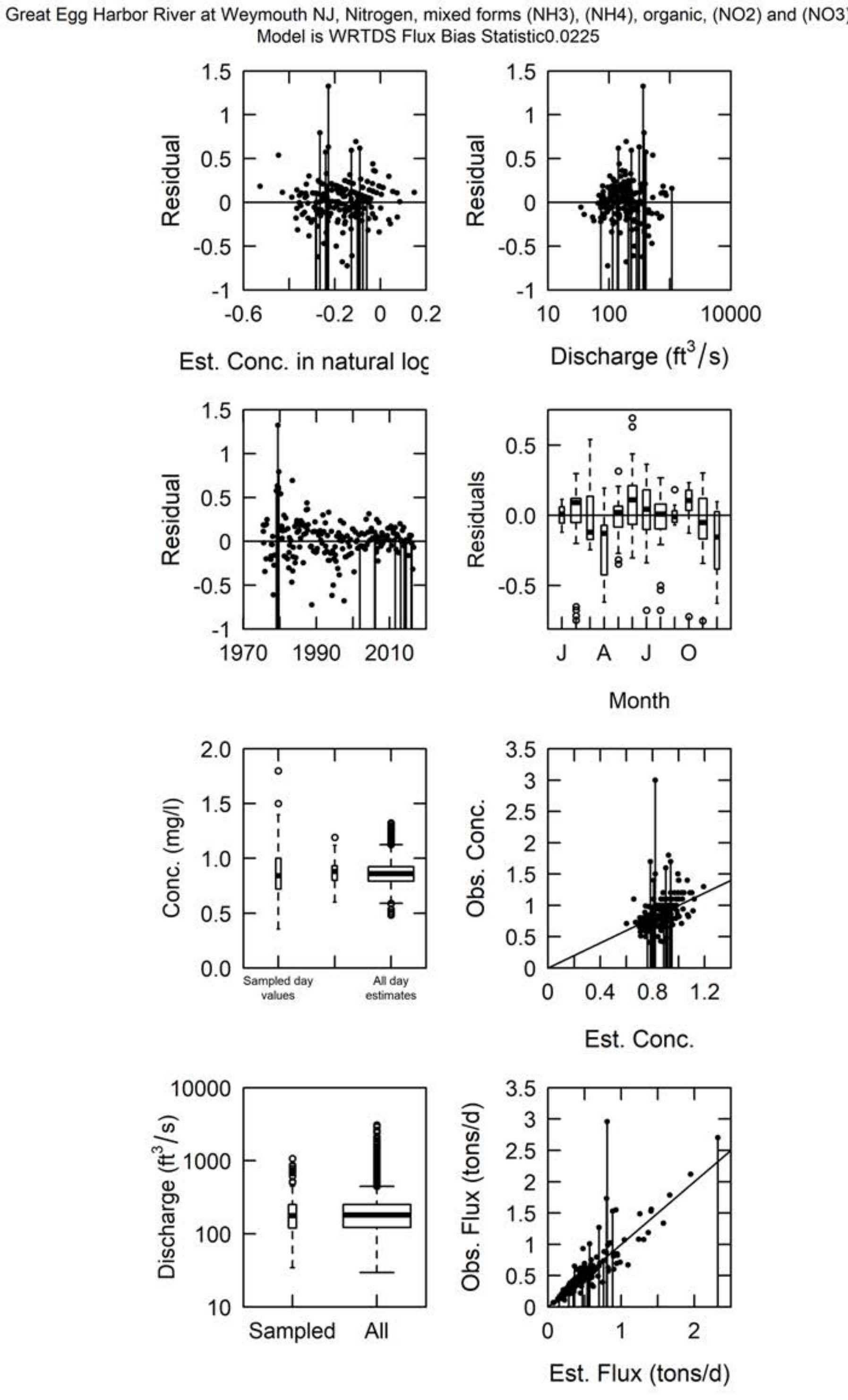

Great Egg Harbor River at Weymouth NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1975
1985
1995
2005
2015


Great Egg Harbor River at Weymouth NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.0368
Residual
Est. Conc. in natural log
Residual
Discharge (ft^3/s)
Residual
Residuals
Month
J
A
J
O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

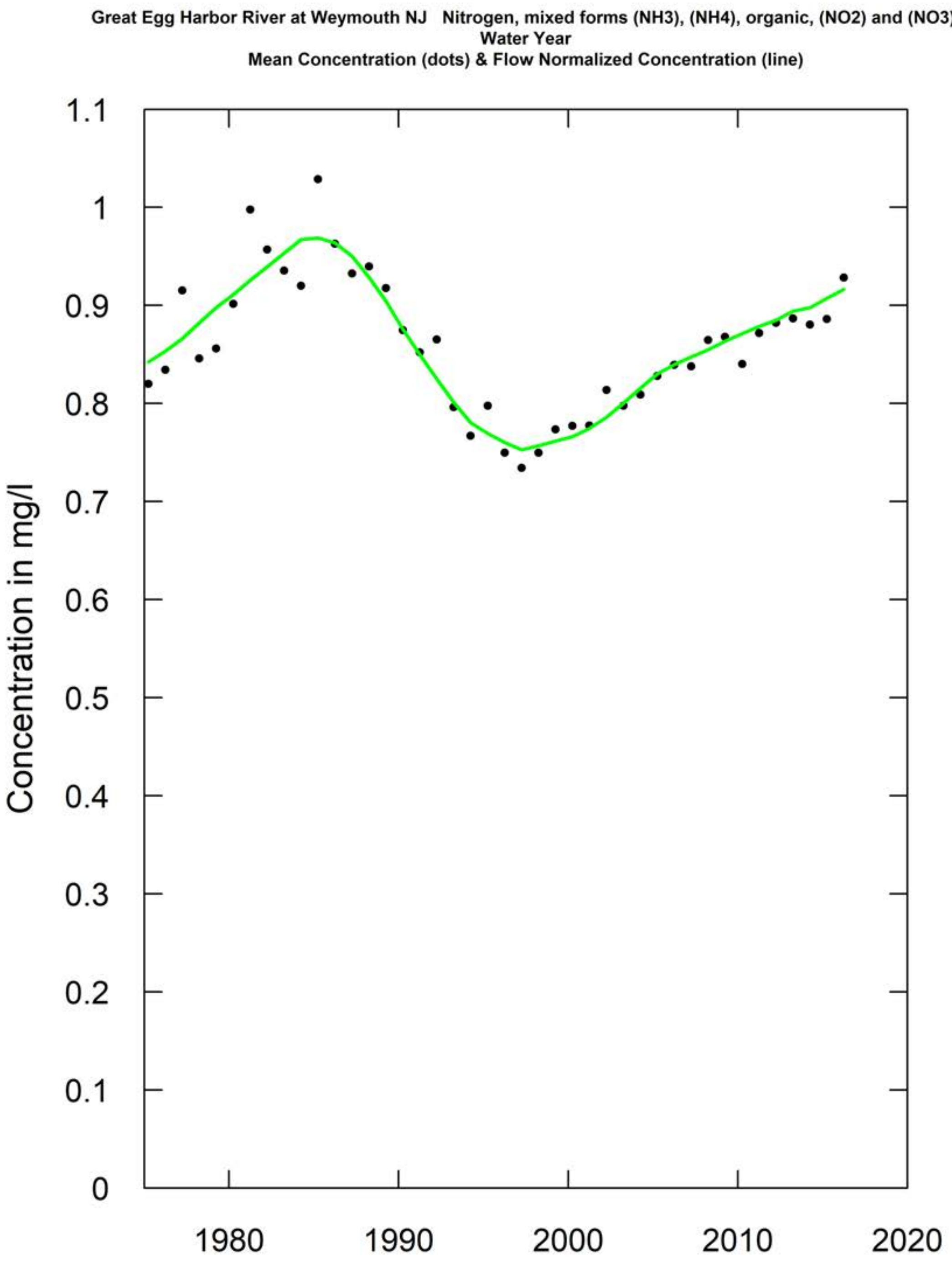

Great Egg Harbor River at Weymouth NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

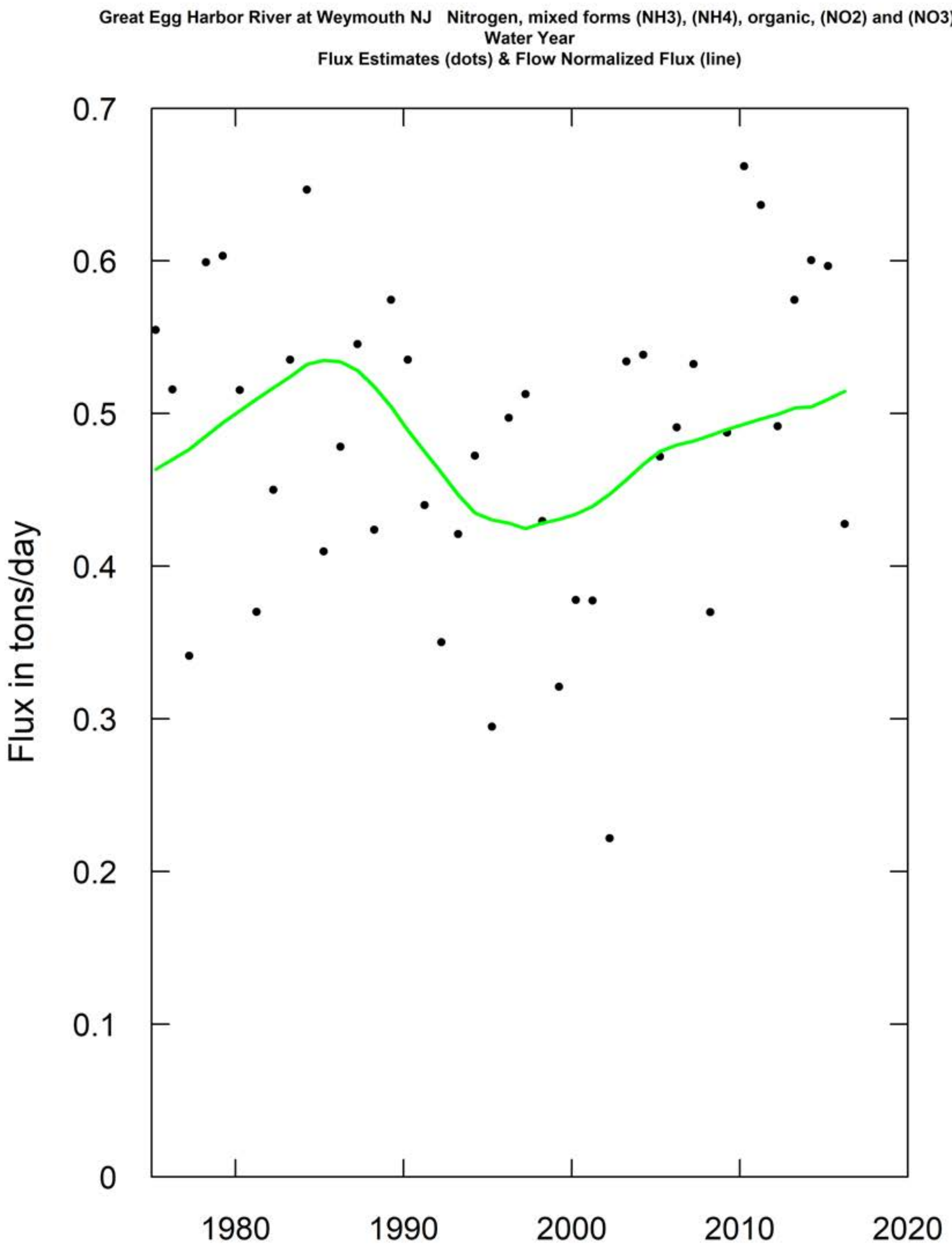

Great Egg Harbor River at Weymouth NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.3
0.25
0.2
0.15
0.1
0.05
0
1980
1990
2000
2010
2020

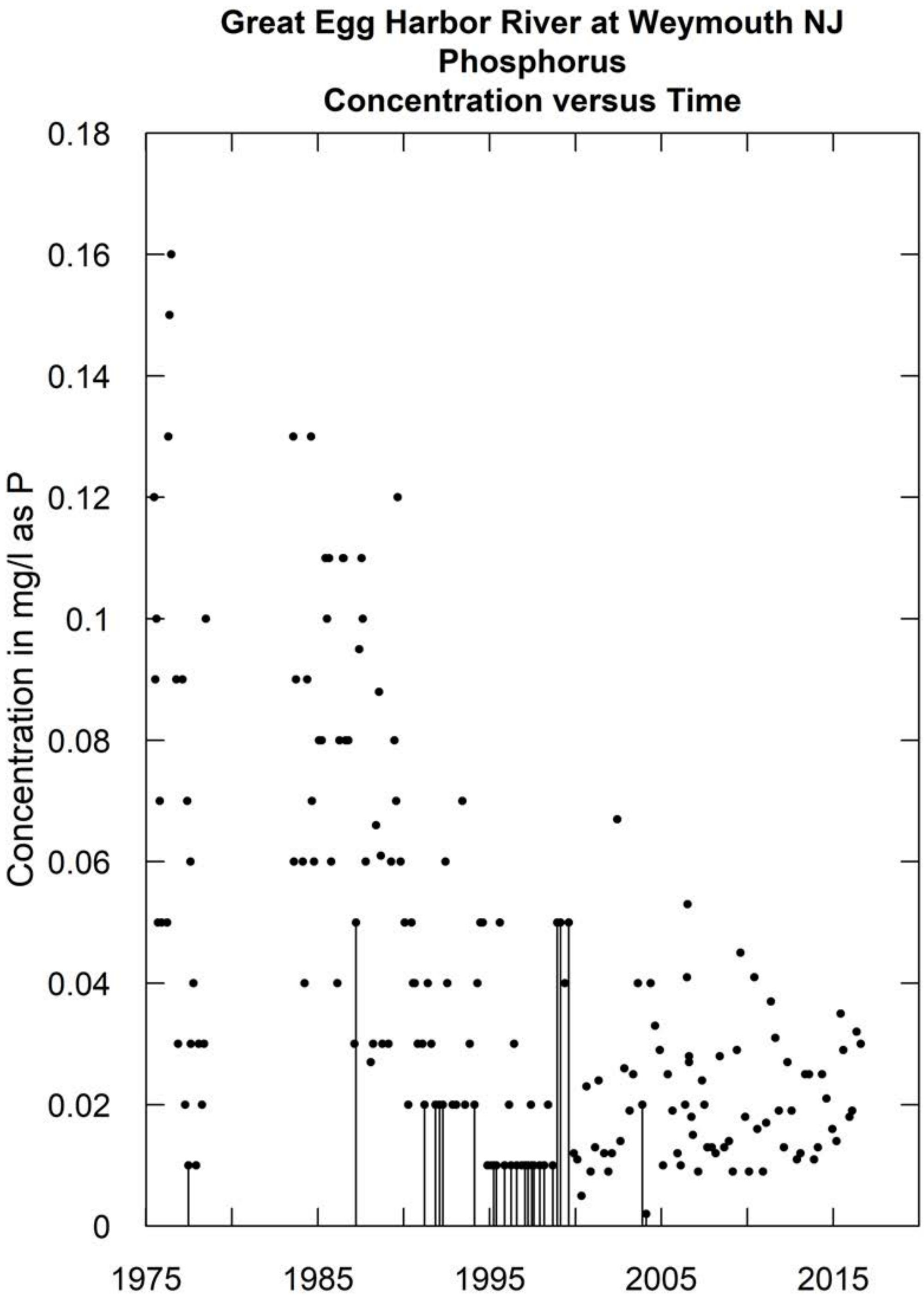

Great Egg Harbor River at Weymouth NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
3.5
3
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

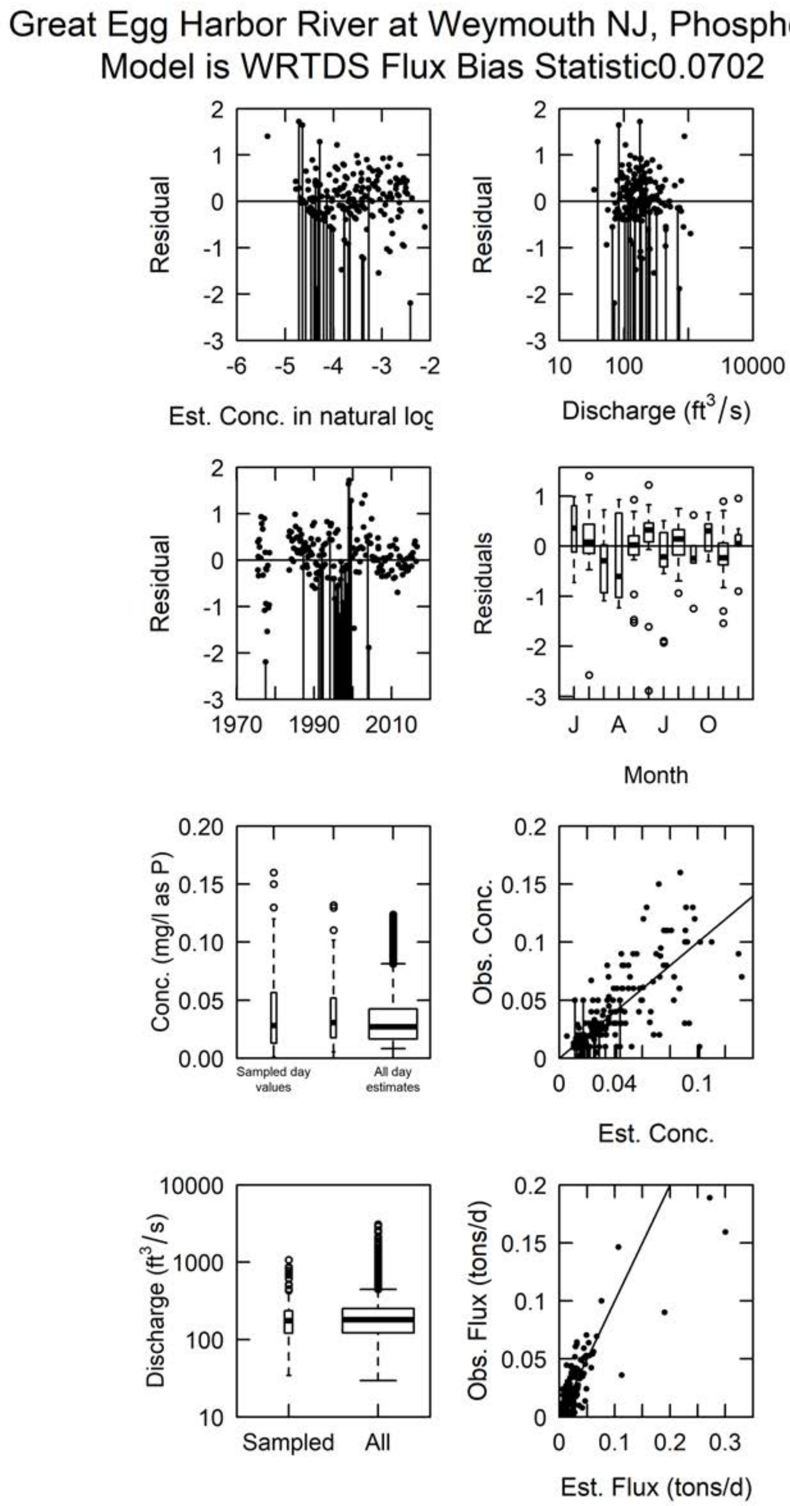


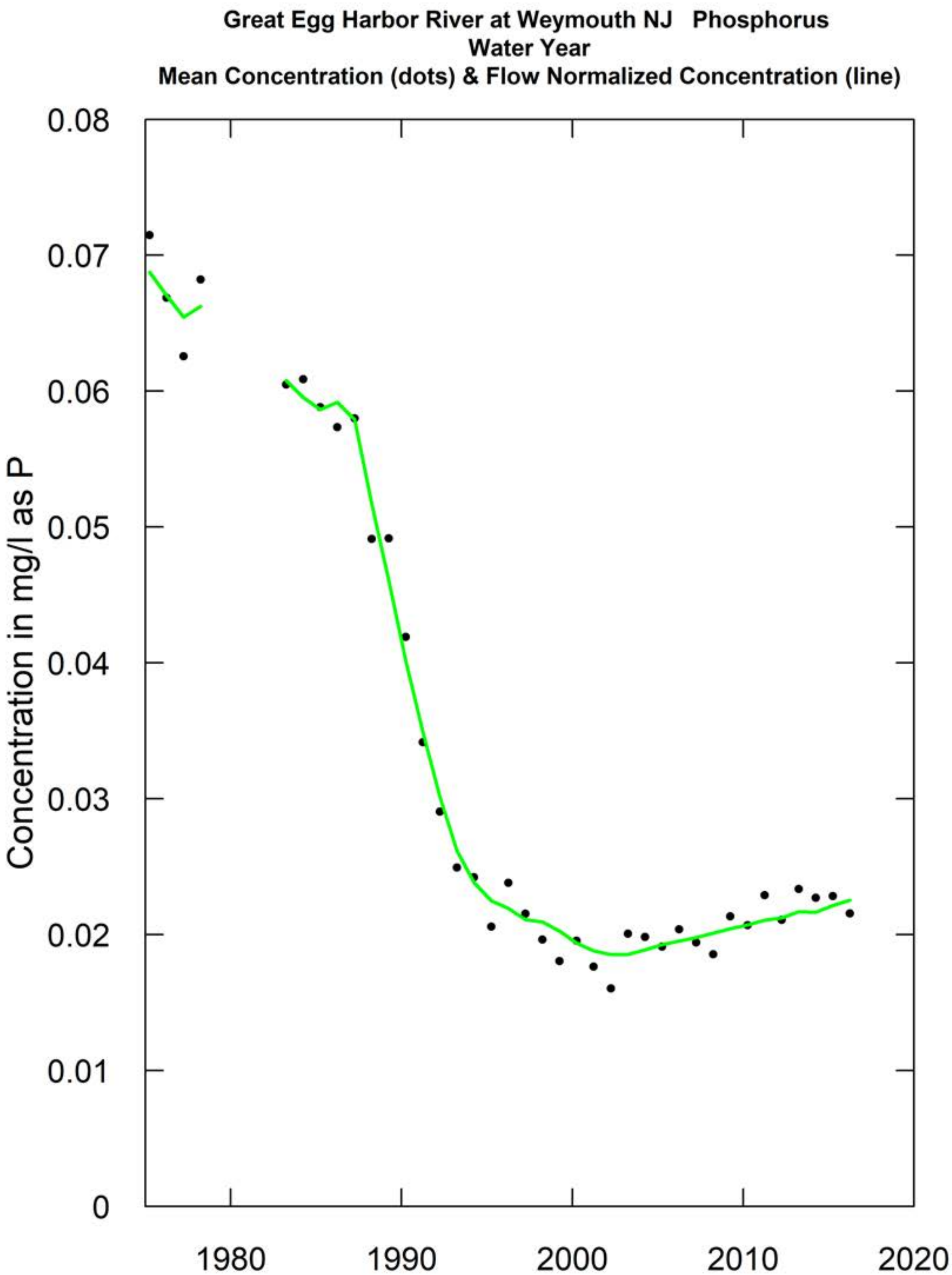
Great Egg Harbor River at Weymouth NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.0225
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

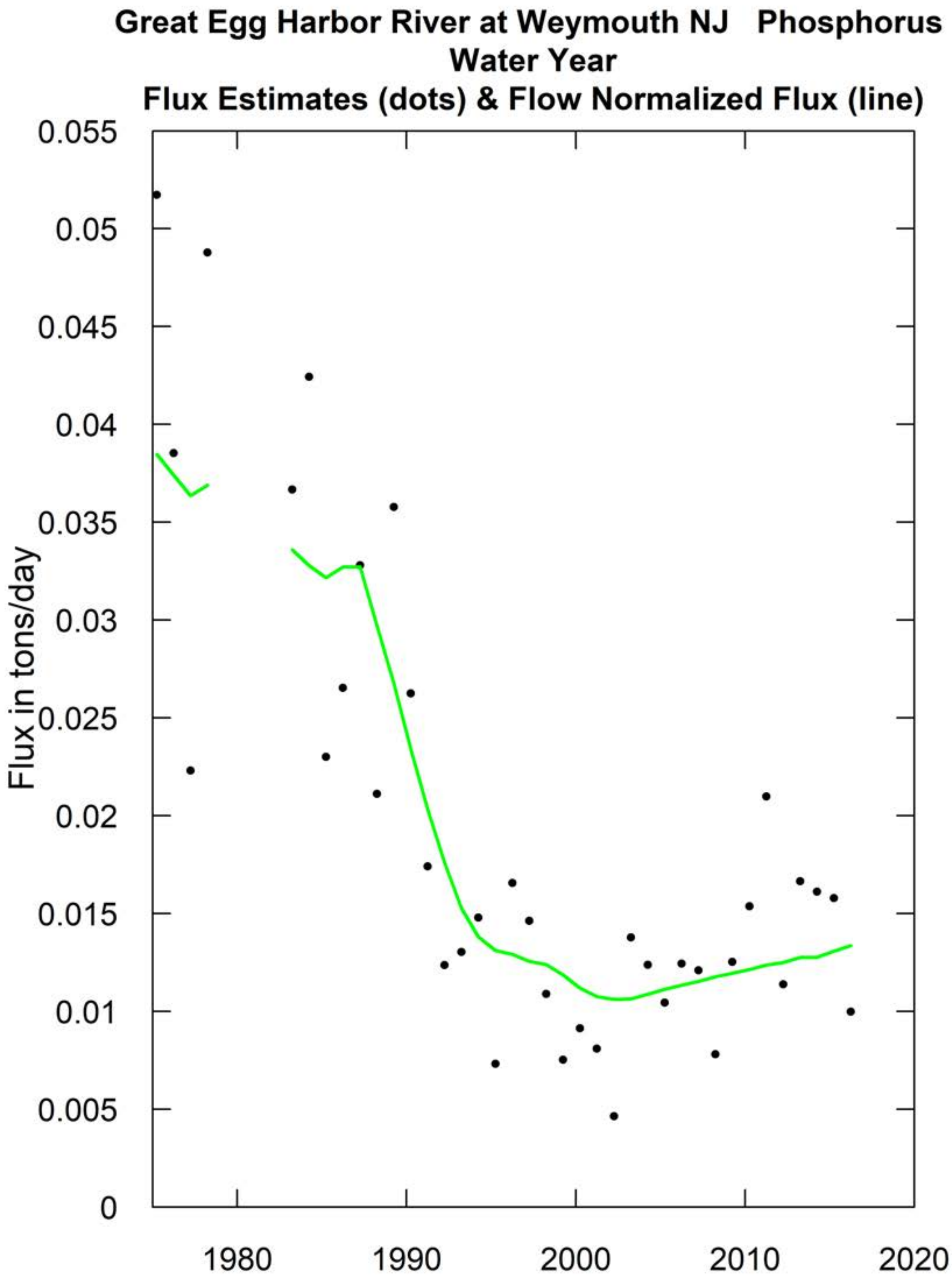

Great Egg Harbor River at Weymouth NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

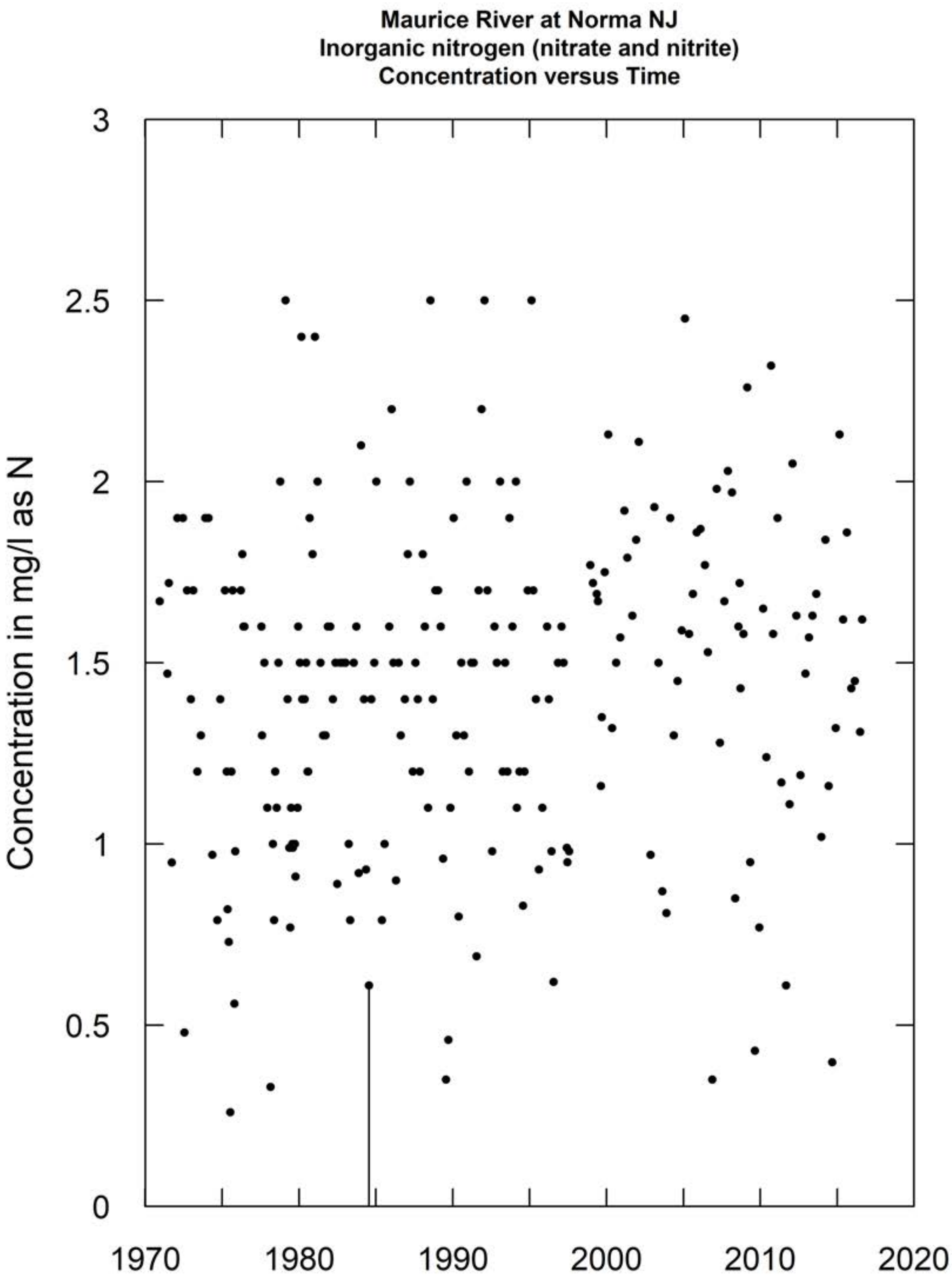

Great Egg Harbor River at Weymouth NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

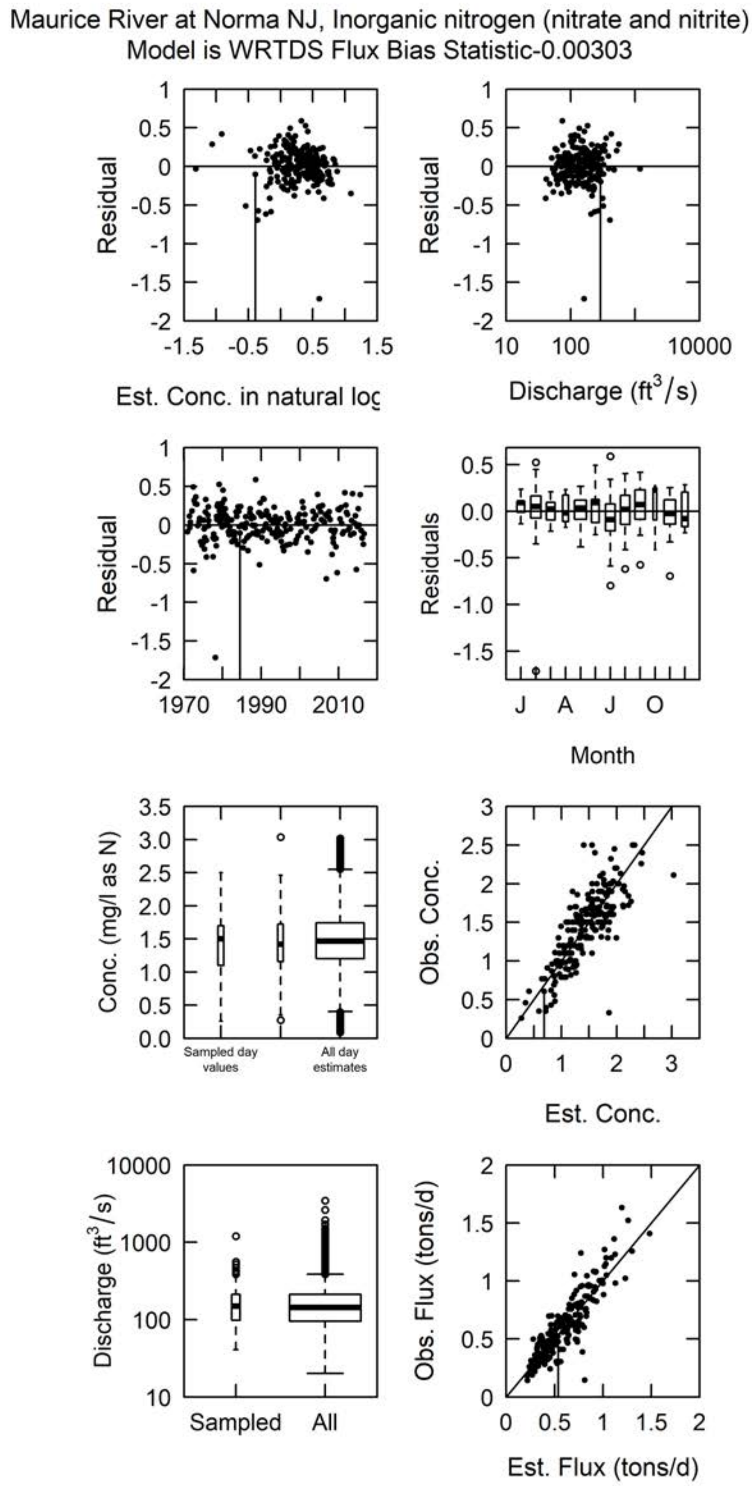

Great Egg Harbor River at Weymouth NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1975
1985
1995
2005
2015


Great Egg Harbor River at Weymouth NJ, Phosphorus
Model is WRTDS Flux Bias Statistic0.0702
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

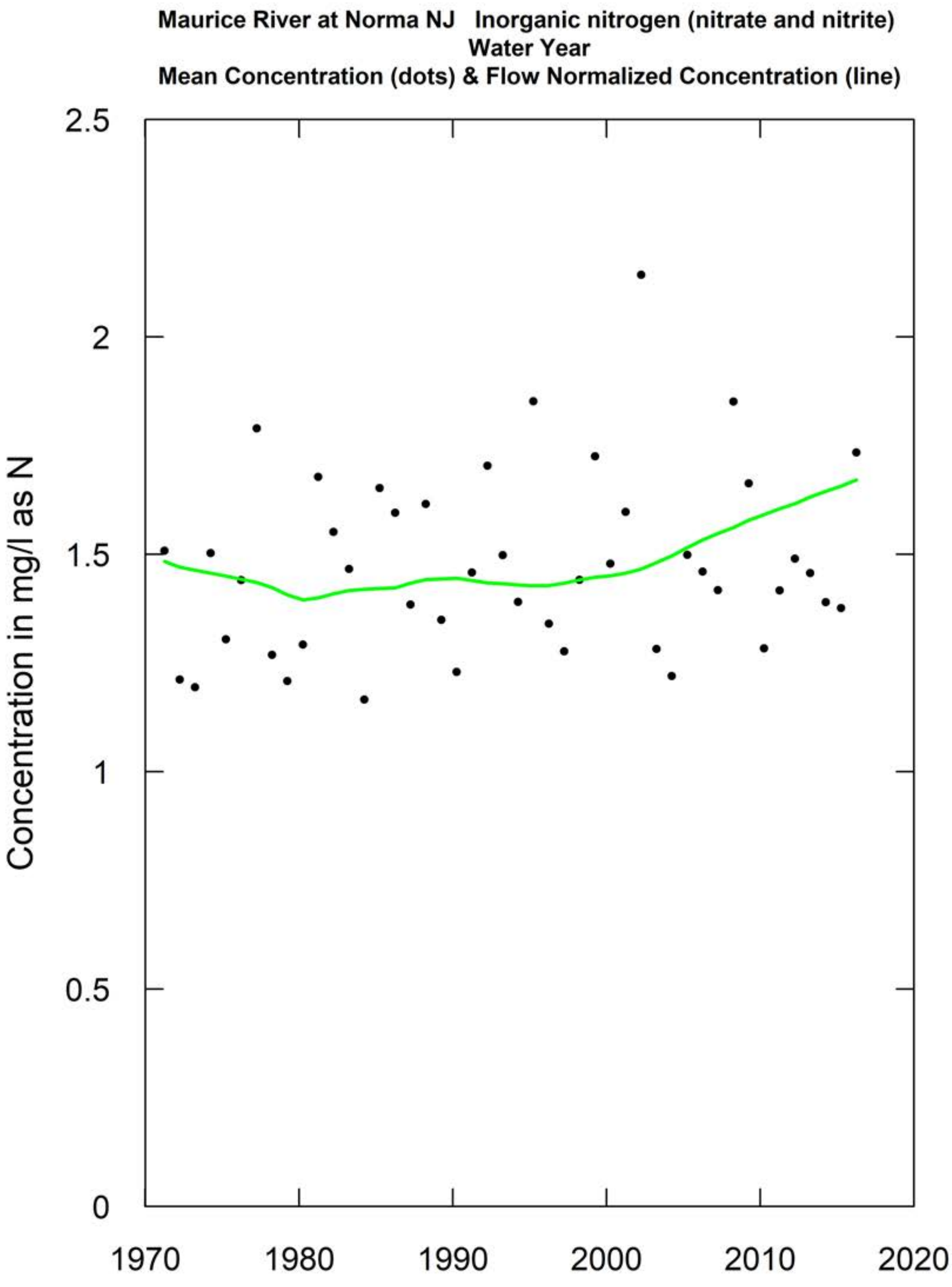

Great Egg Harbor River at Weymouth NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1980
1990
2000
2010
2020

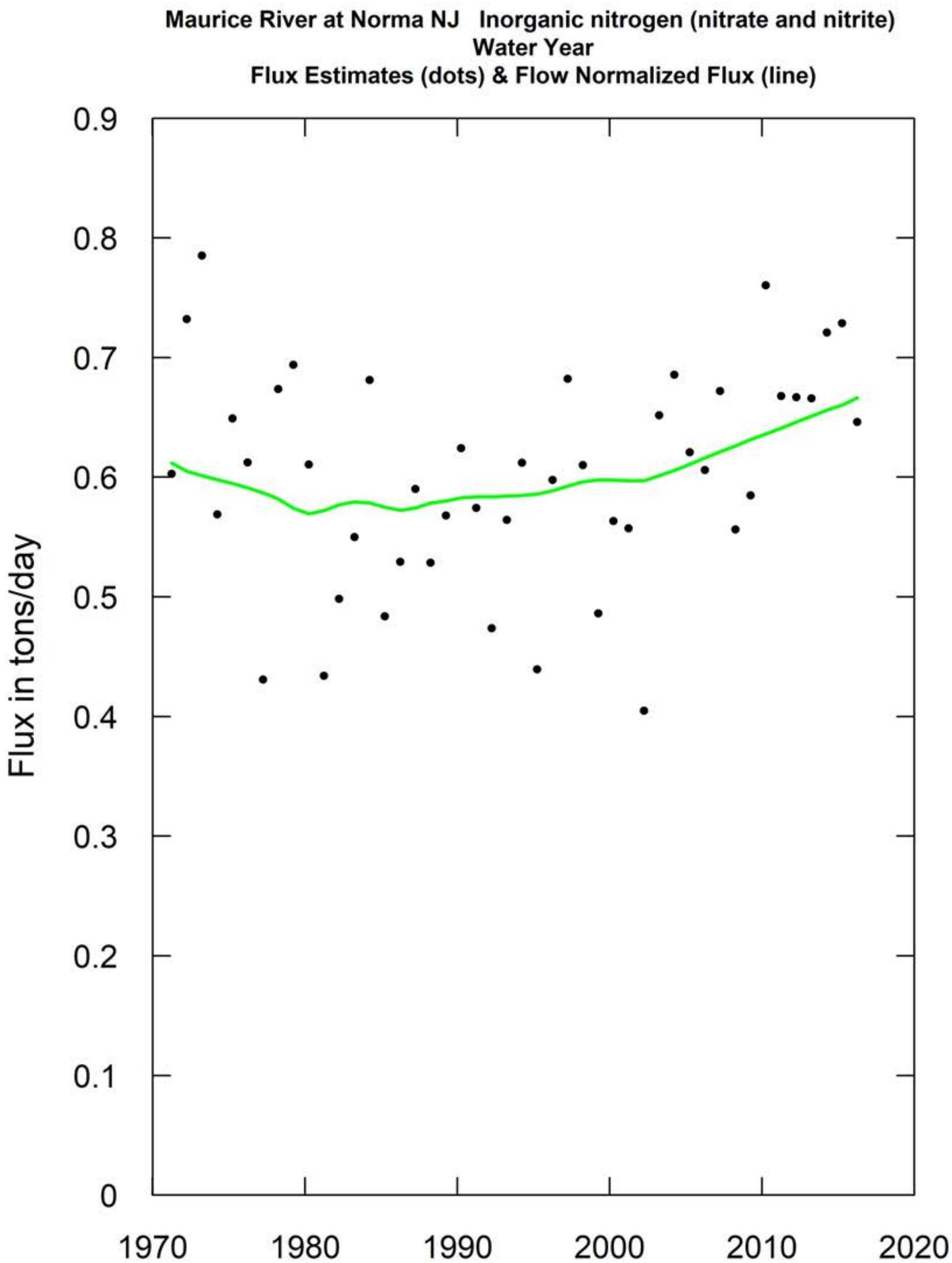

Great Egg Harbor River at Weymouth NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
0.055
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Flux in tons/day
1980
1990
2000
2010
2020

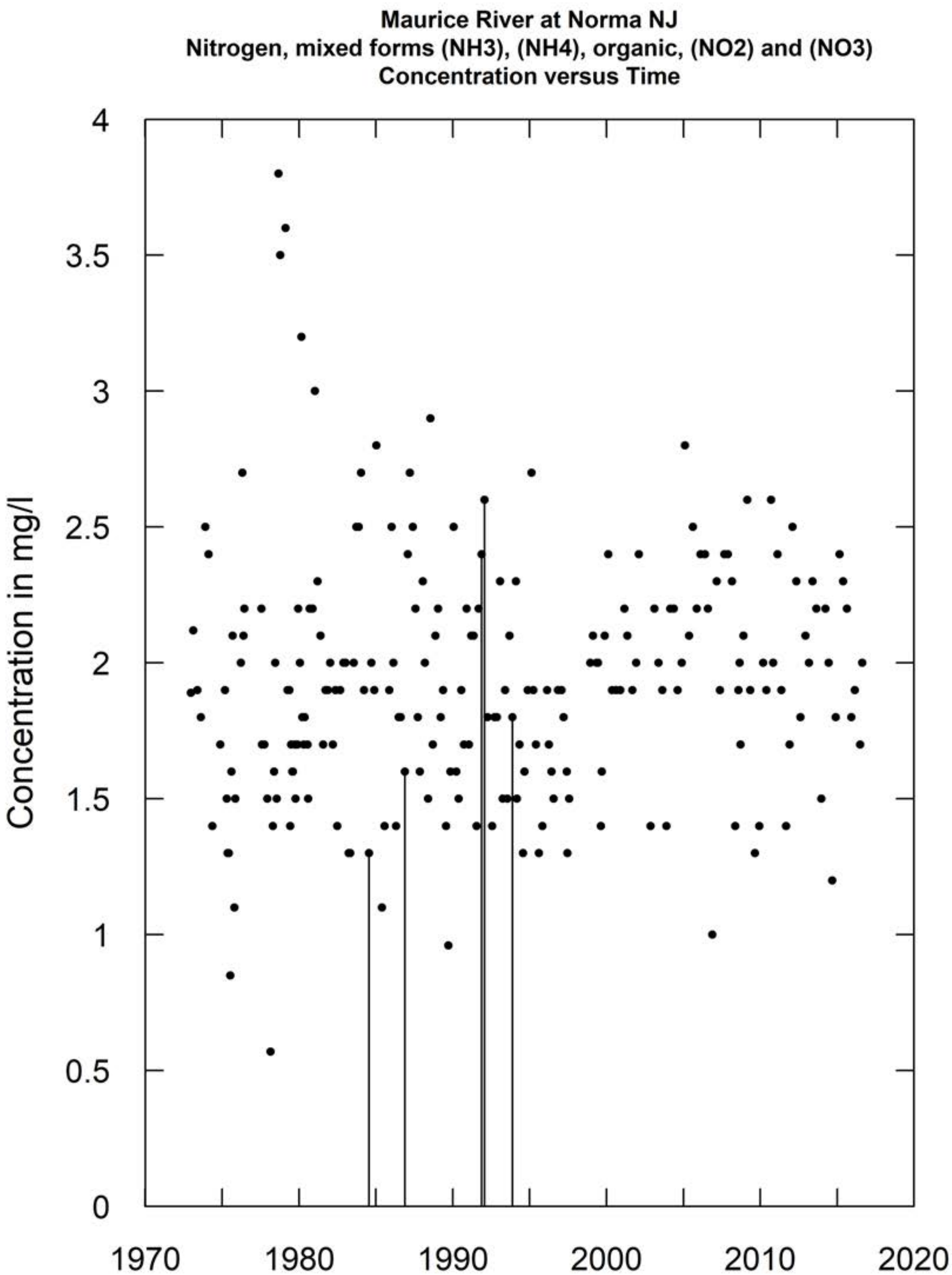

Maurice River at Norma NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
0
0.5
1
1.5
2
2.5
3
1970
1980
1990
2000
2010
2020

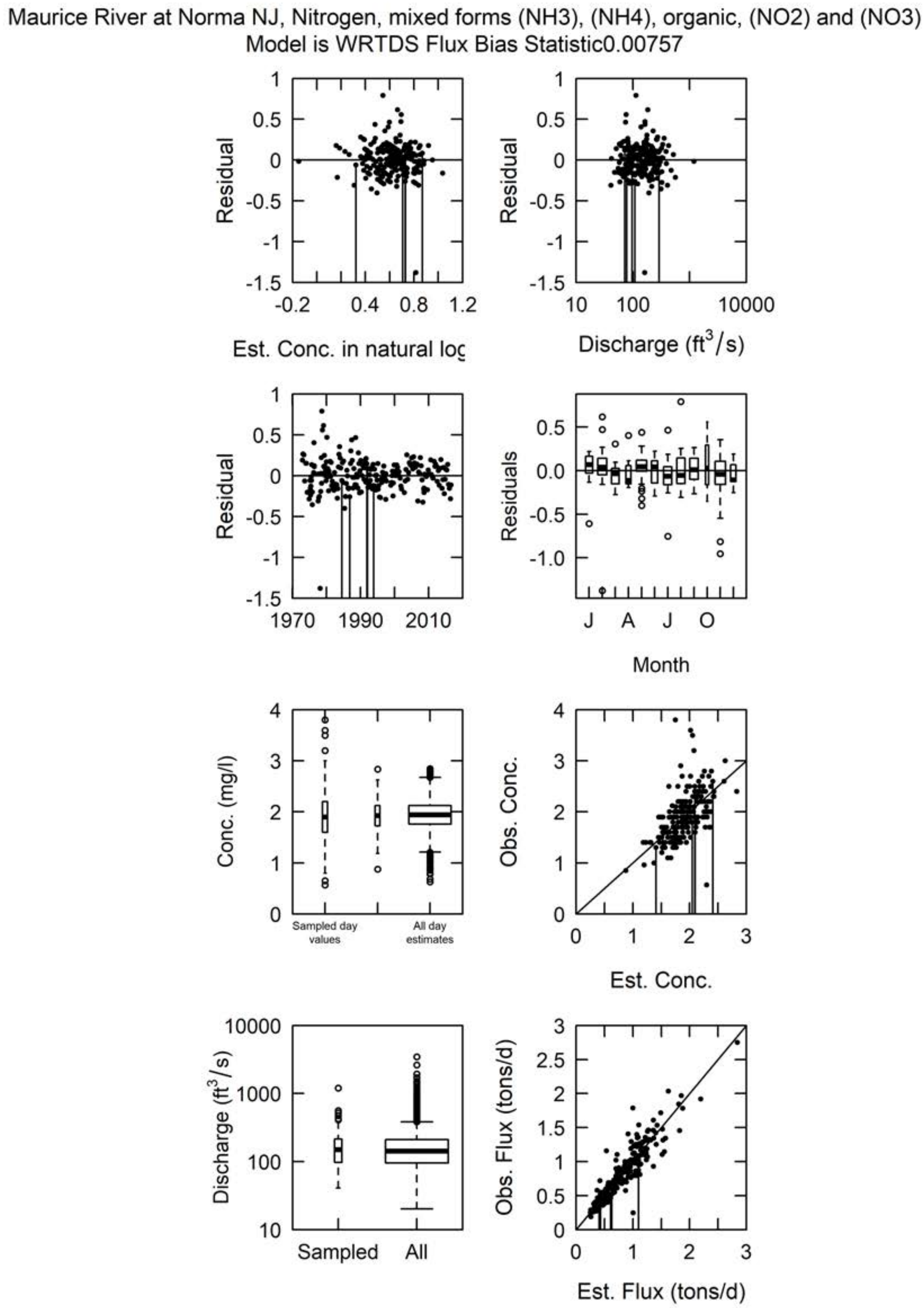


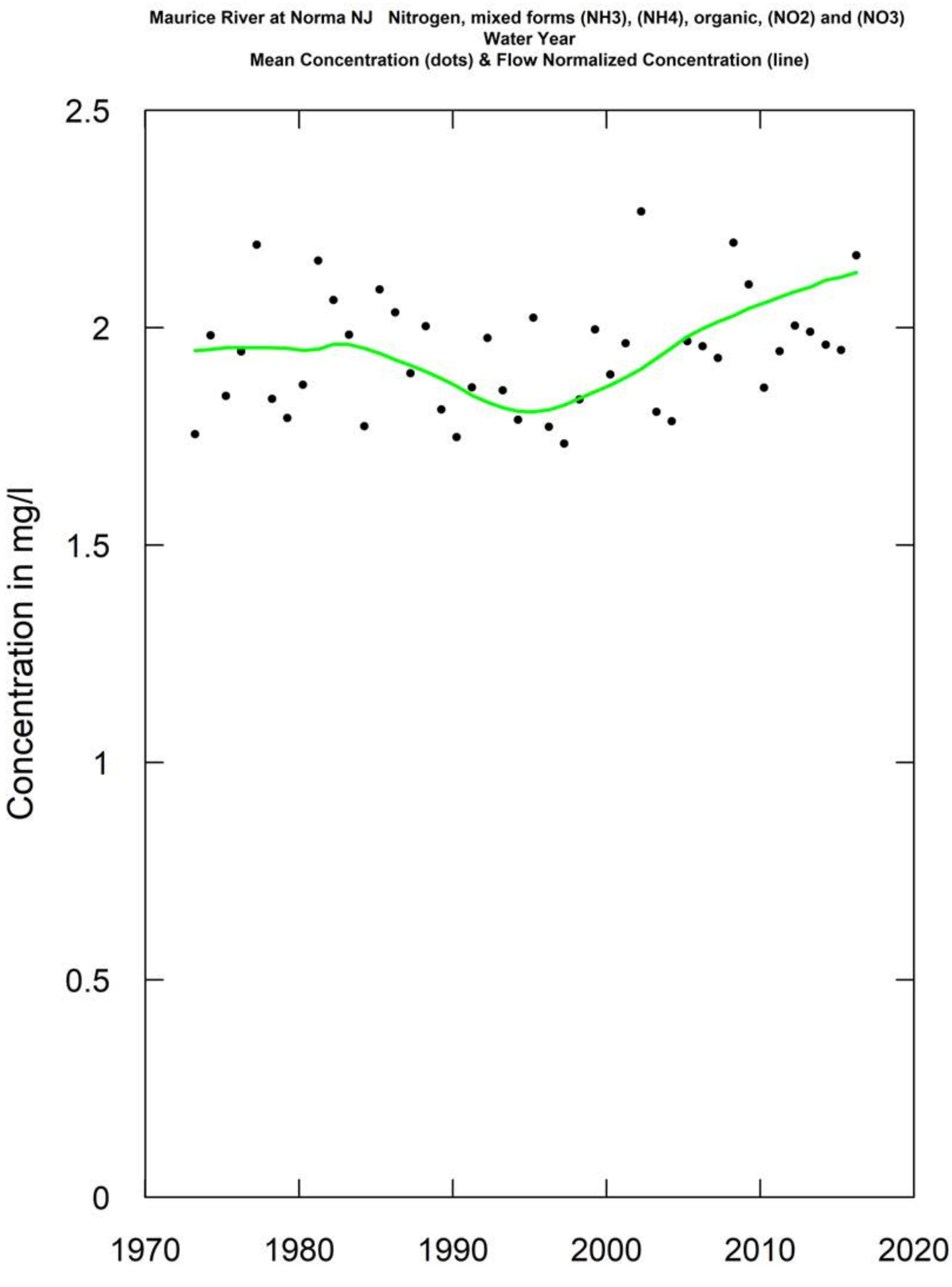
Maurice River at Norma NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.00303
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

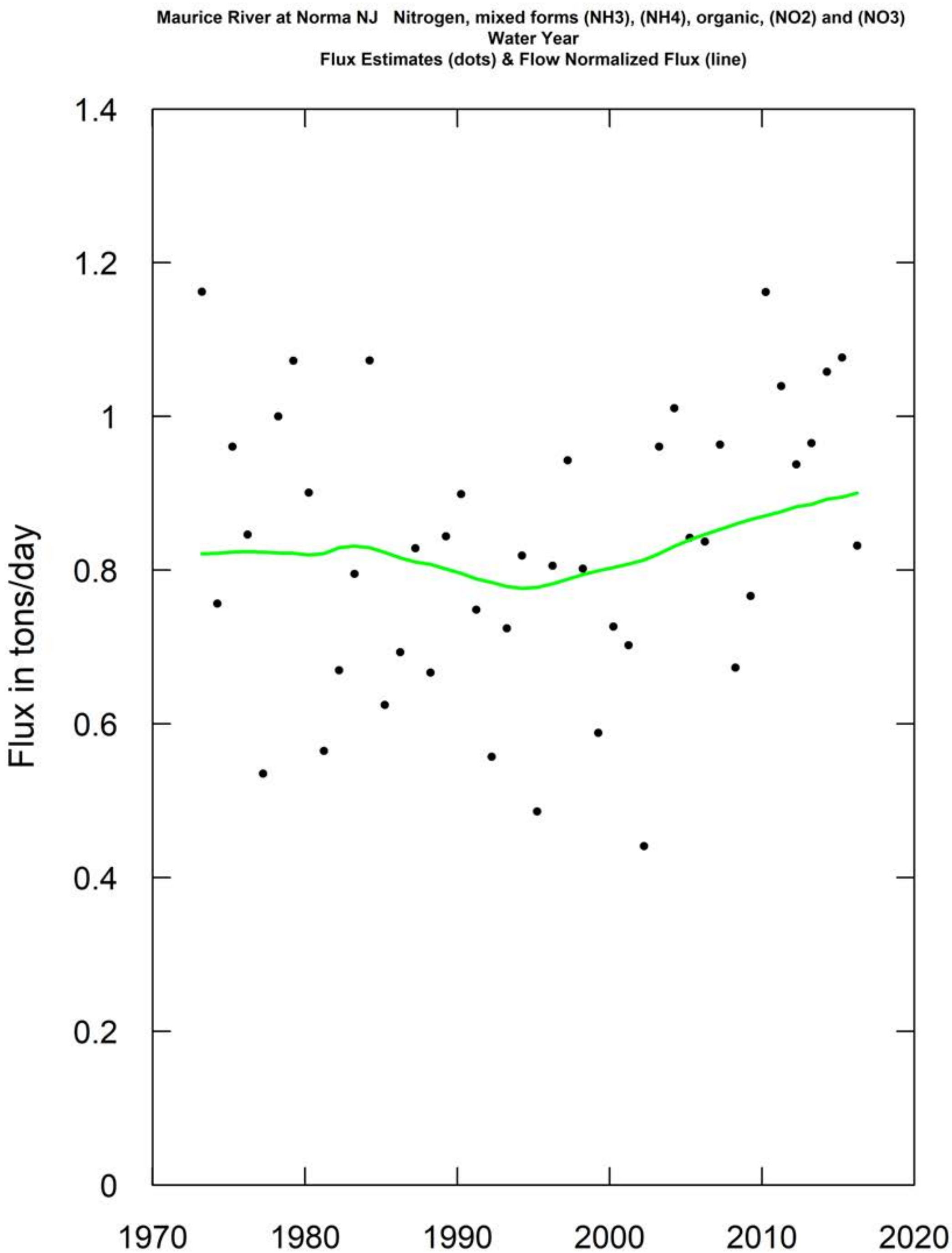

Maurice River at Norma NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

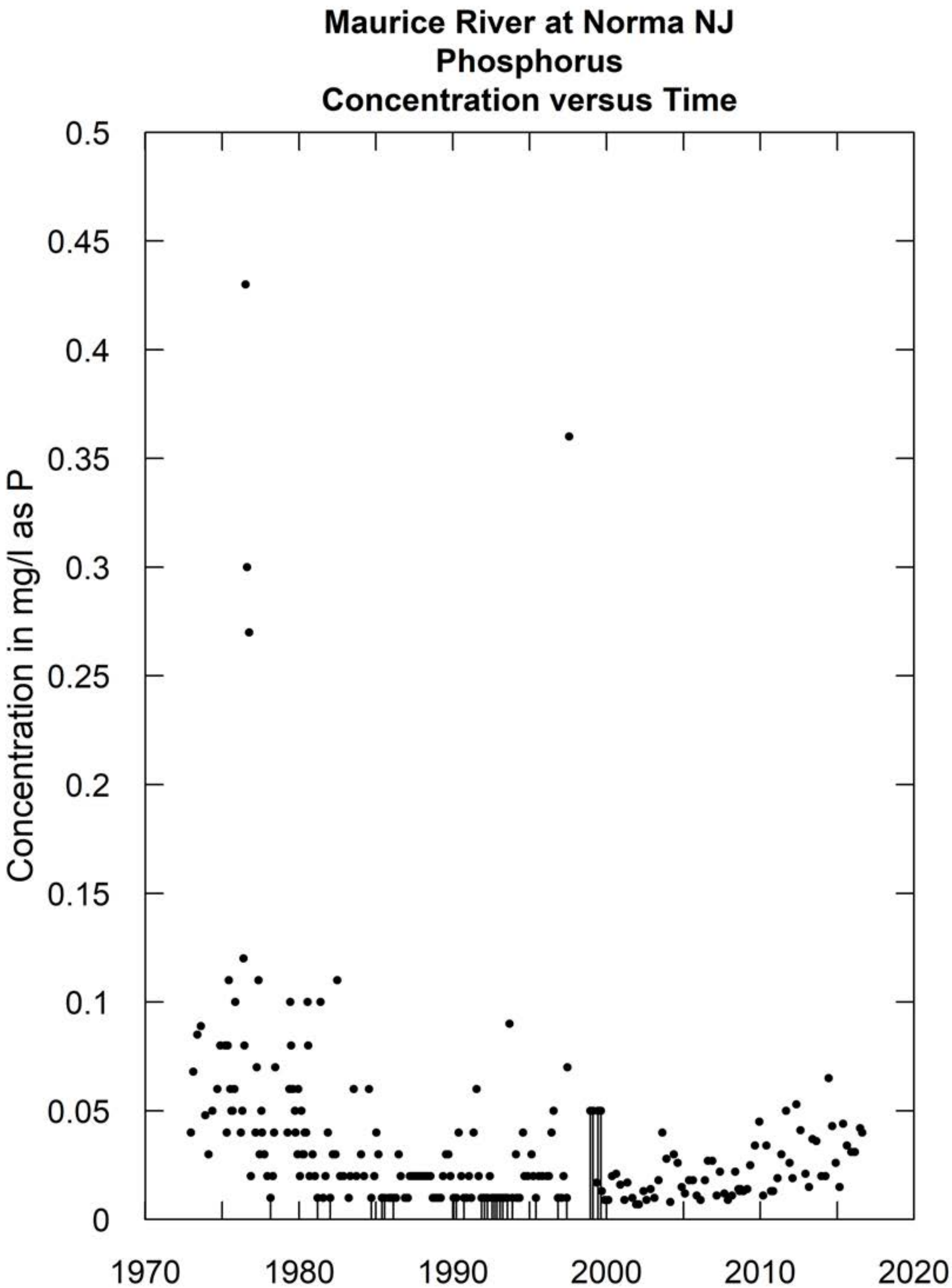

Maurice River at Norma NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1970
1980
1990
2000
2010
2020

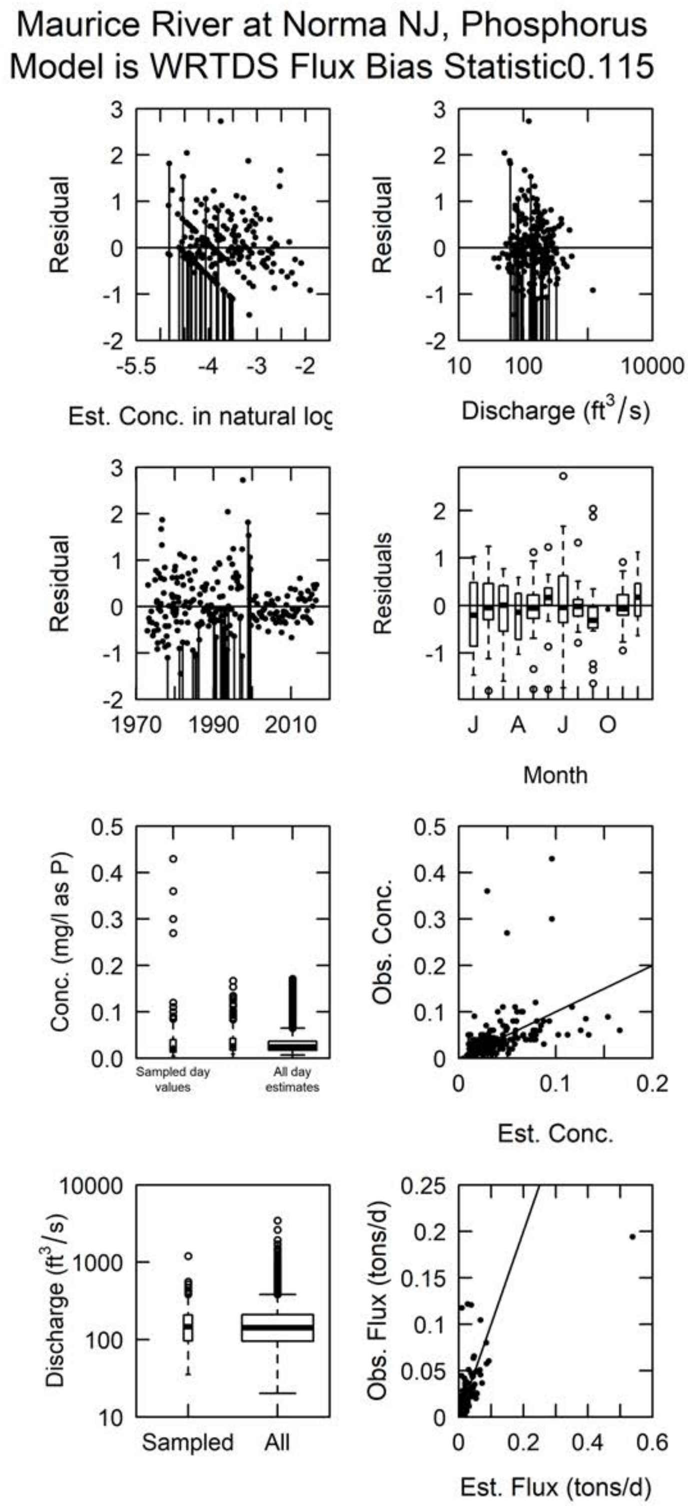

Maurice River at Norma NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
0.5
1
1.5
2
2.5
3
3.5
4
1970
1980
1990
2000
2010
2020


Maurice River at Norma NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.00757
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

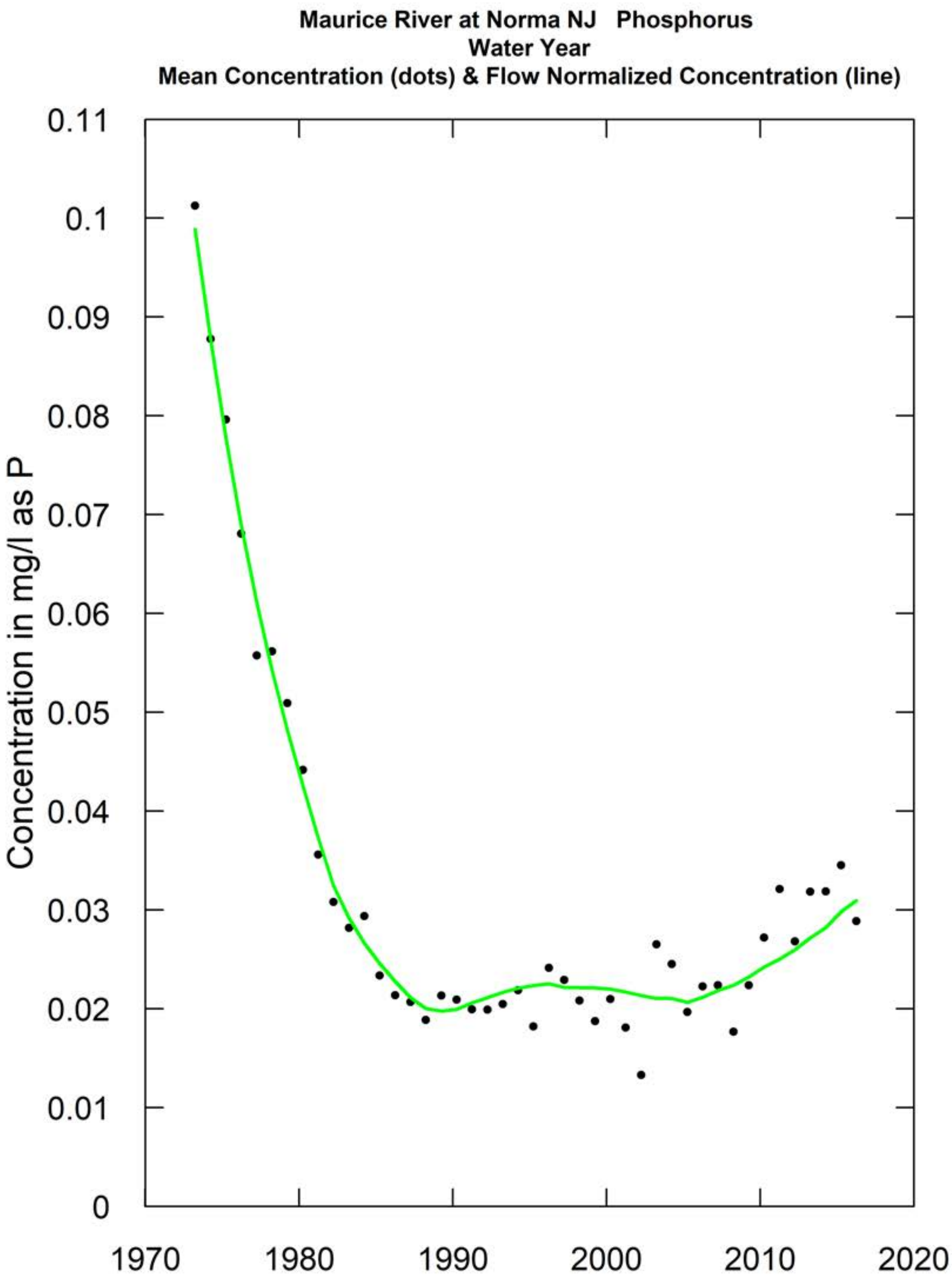

Maurice River at Norma NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

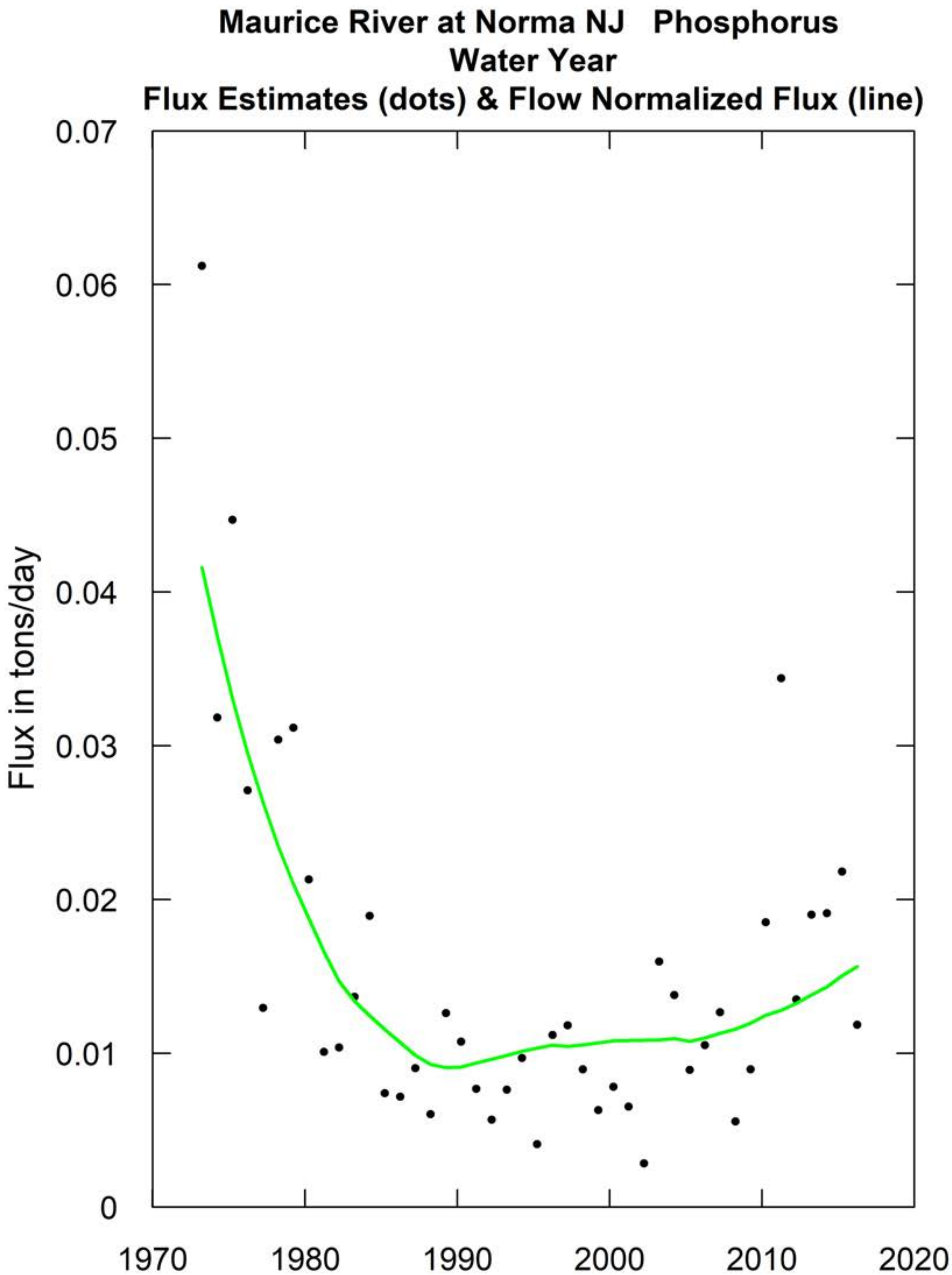

Maurice River at Norma NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

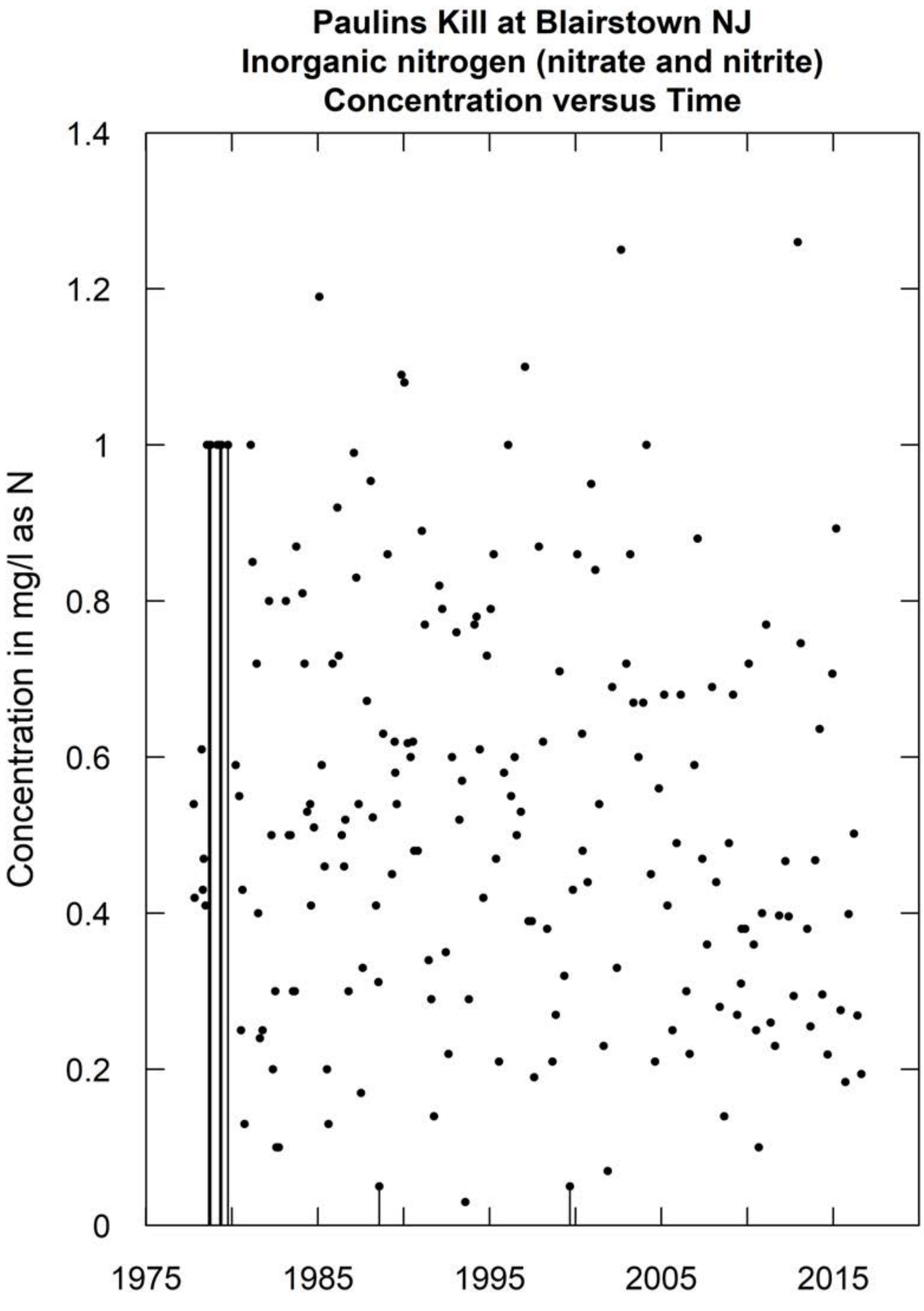

Maurice River at Norma NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

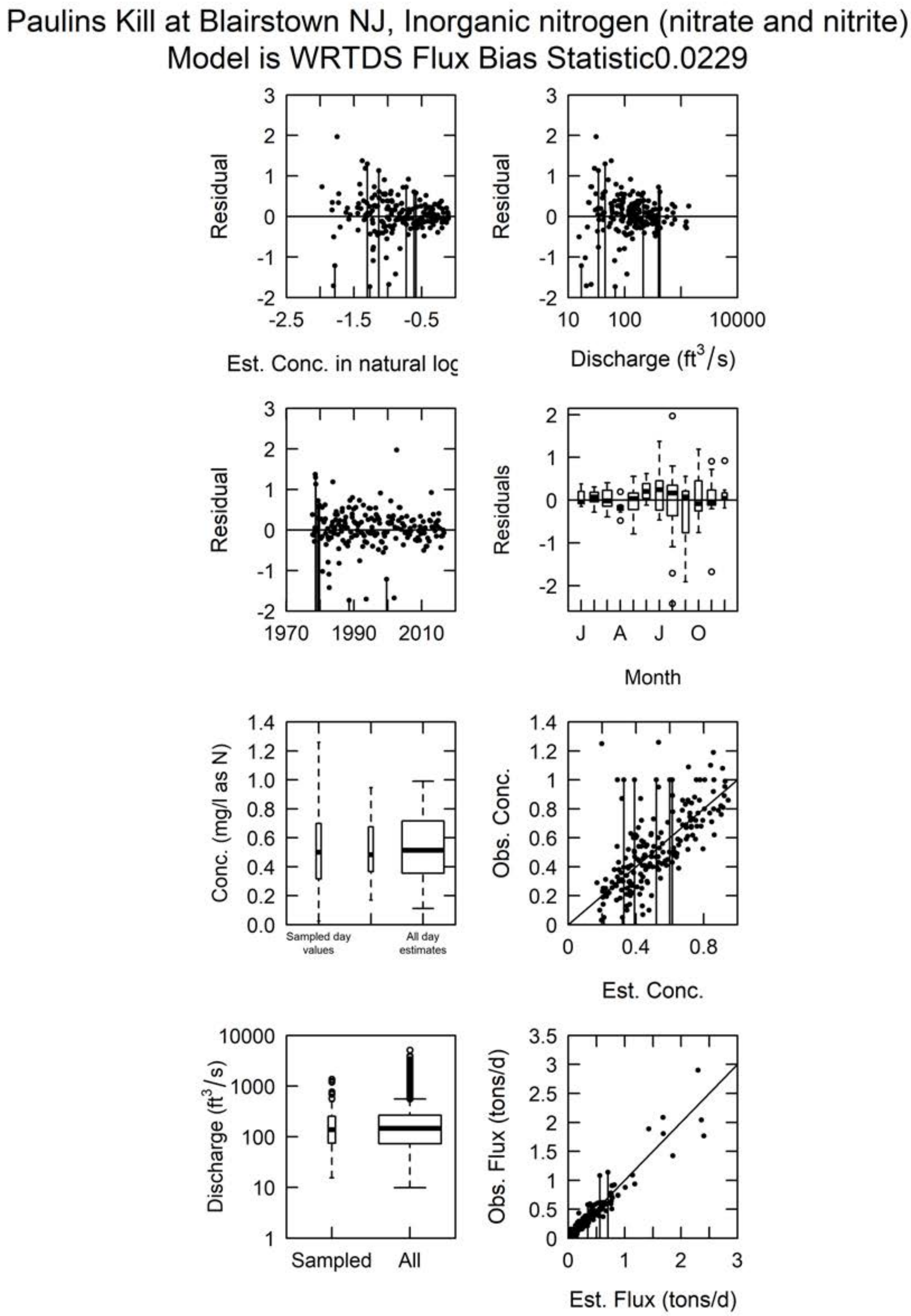


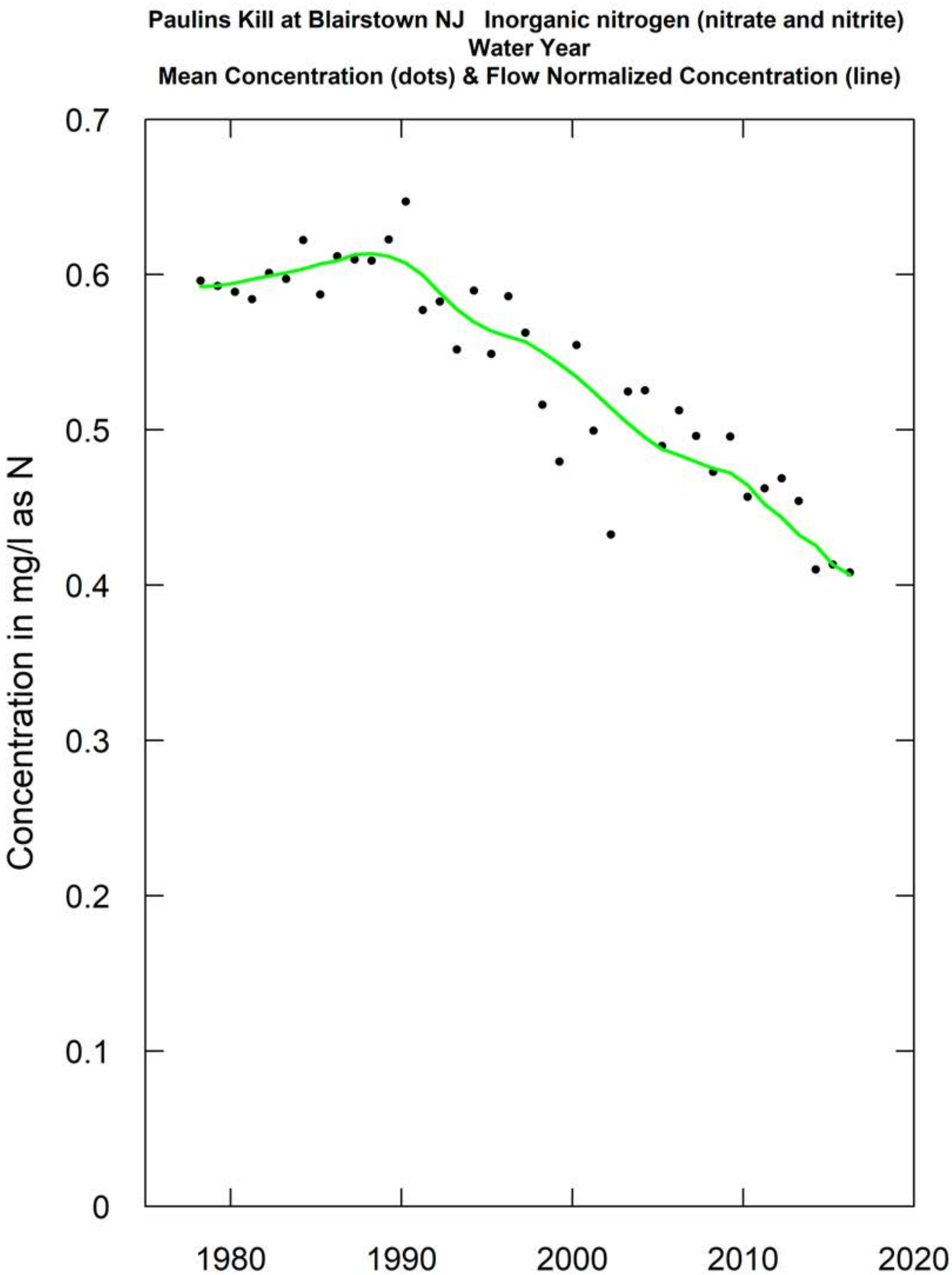
Maurice River at Norma NJ, Phosphorus
Model is WRTDS Flux Bias Statistic0.115
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
Residuals
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

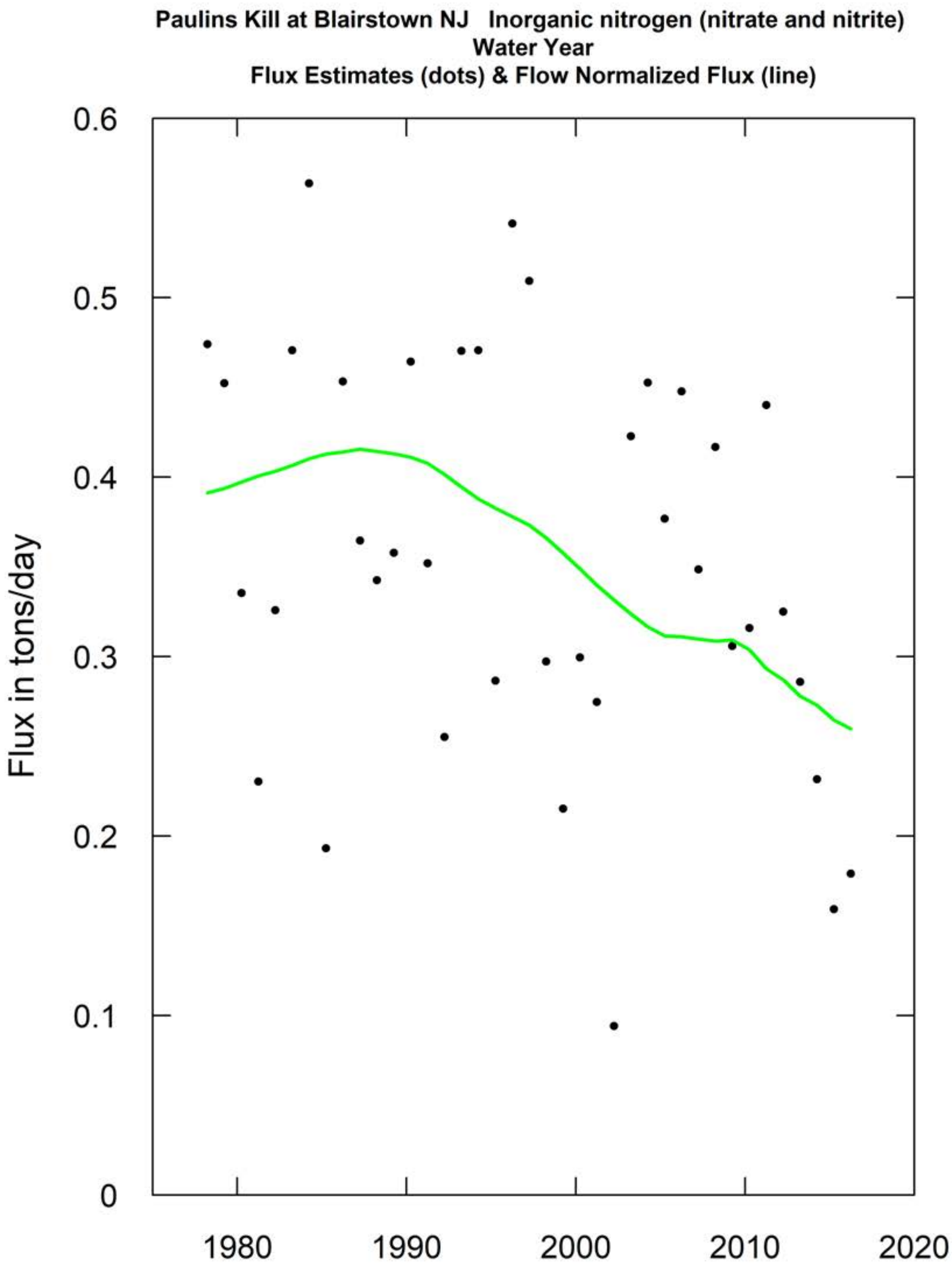

Maurice River at Norma NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1970
1980
1990
2000
2010
2020

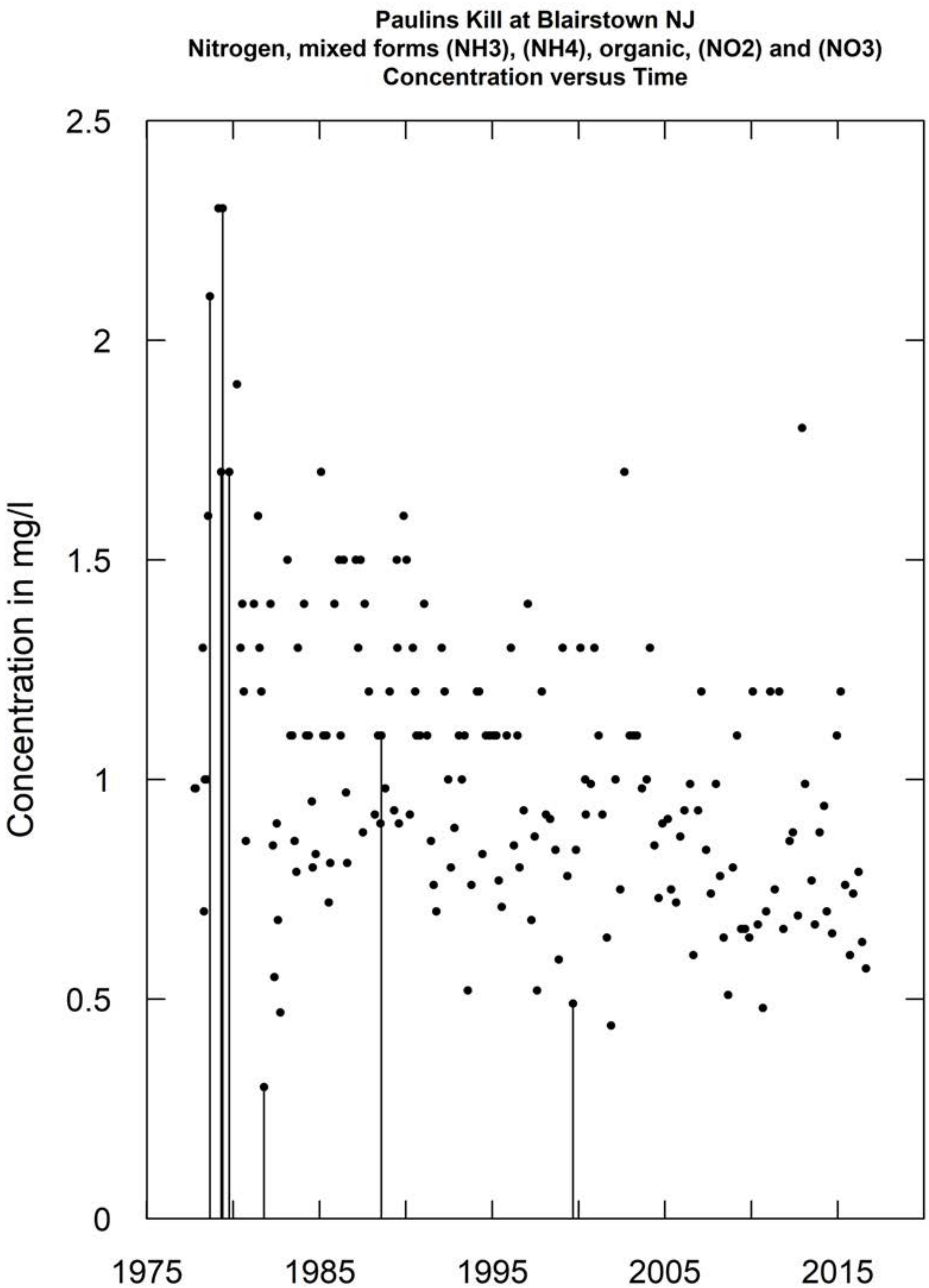

Maurice River at Norma NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1970
1980
1990
2000
2010
2020

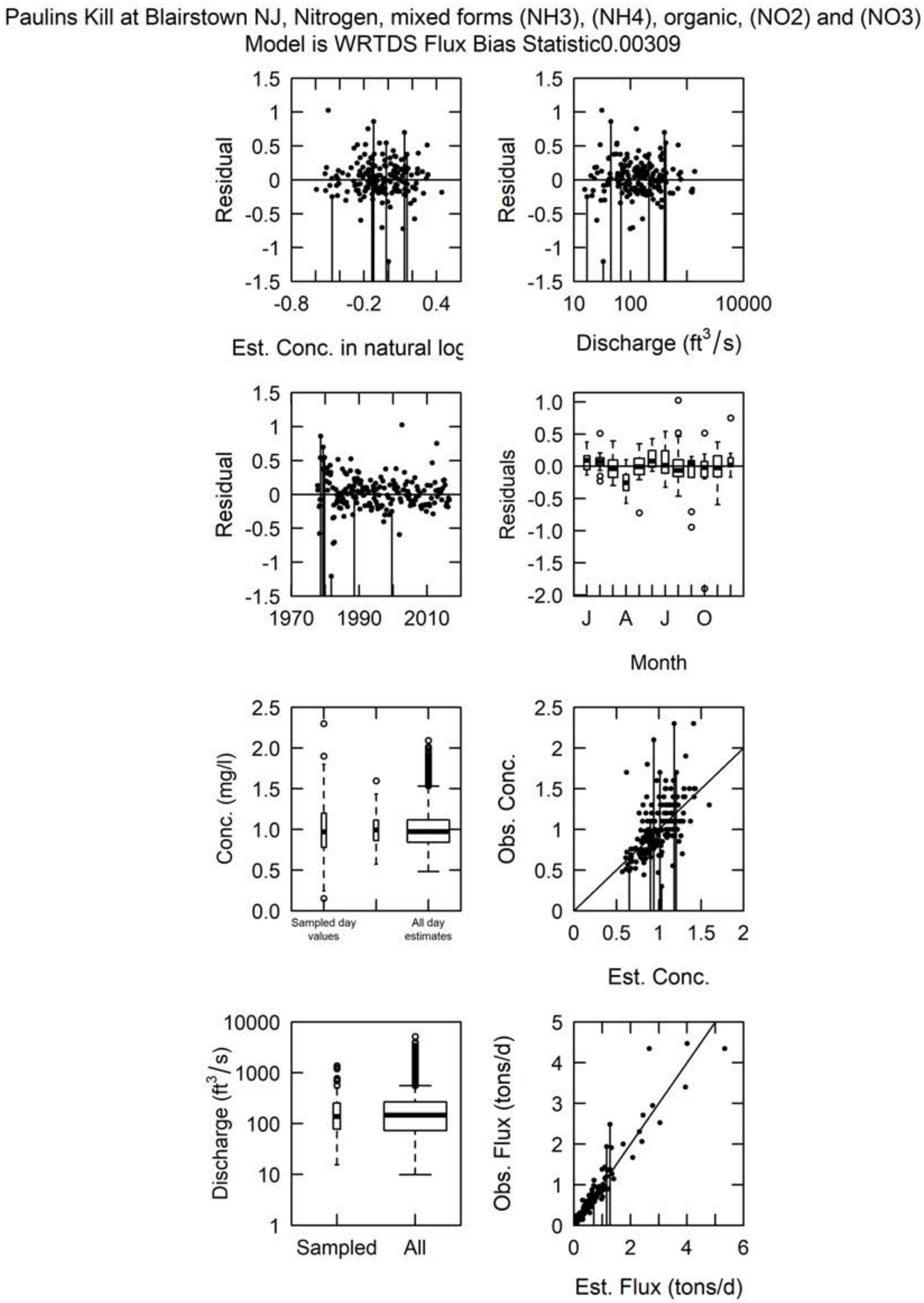

Paulins Kill at Blairstown NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1975
1985
1995
2005
2015

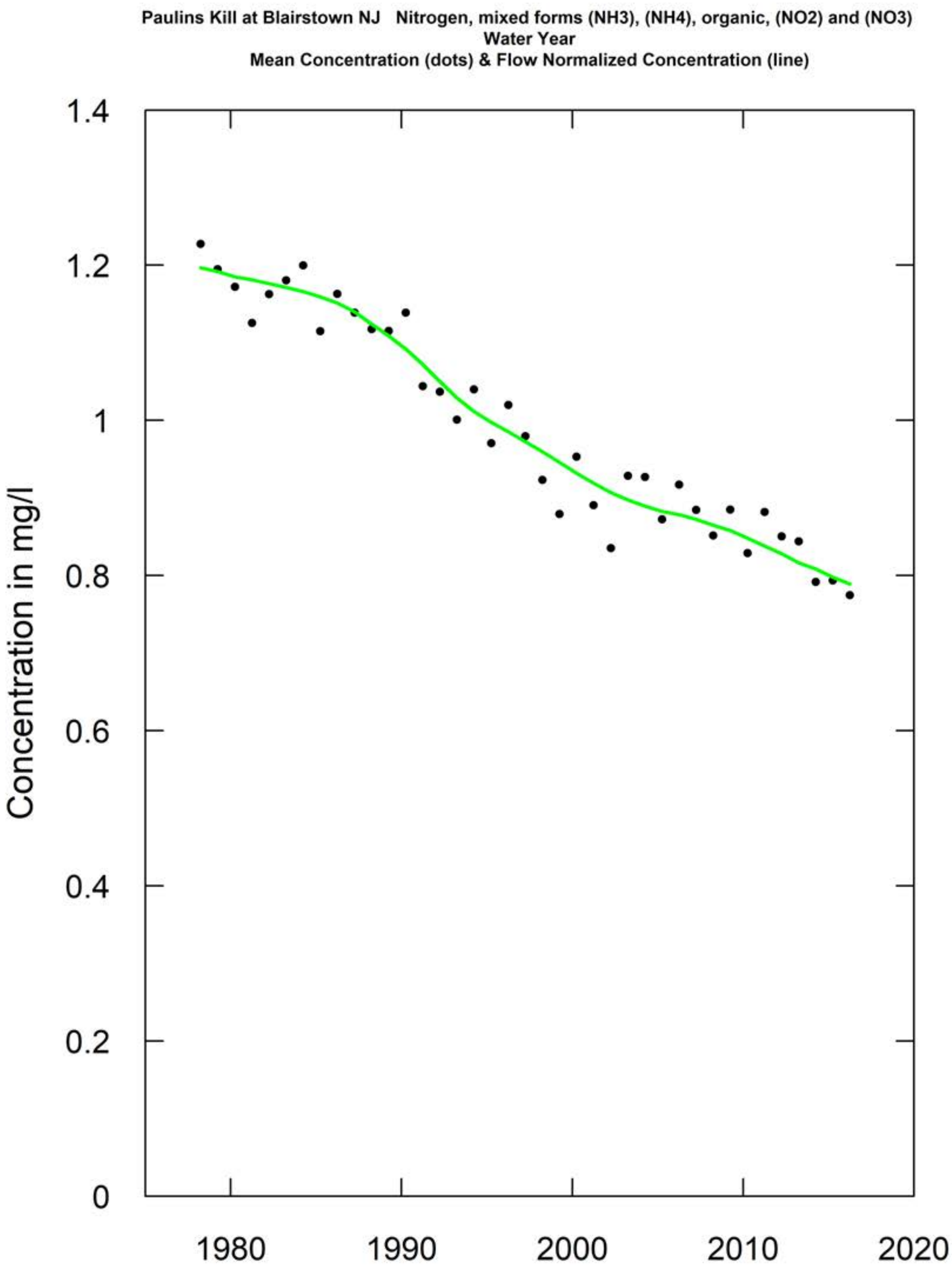

Paulins Kill at Blairstown NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0229
Residual
Est. Conc. in natural log
Residual
Discharge (ft^3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

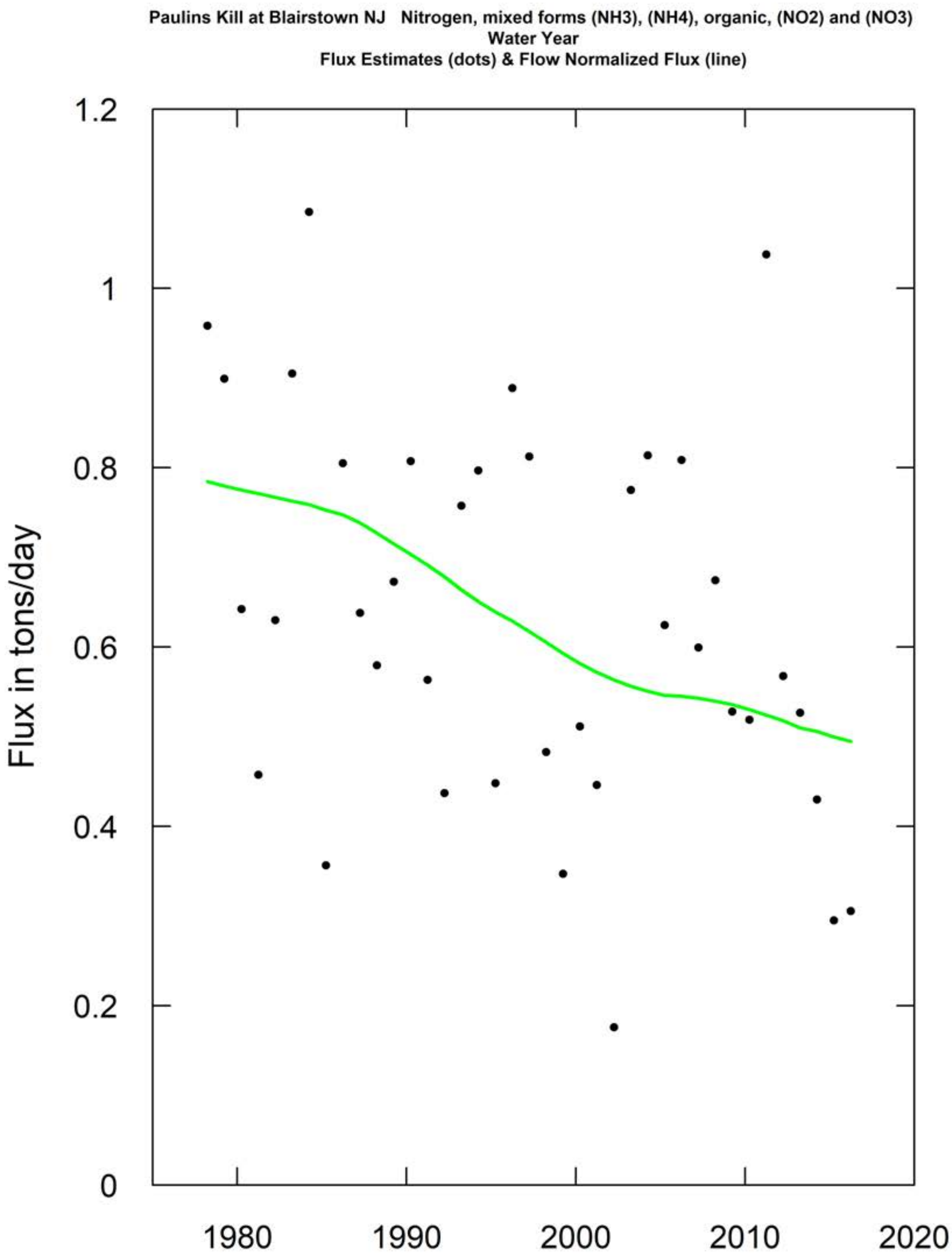

Paulins Kill at Blairstown NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020

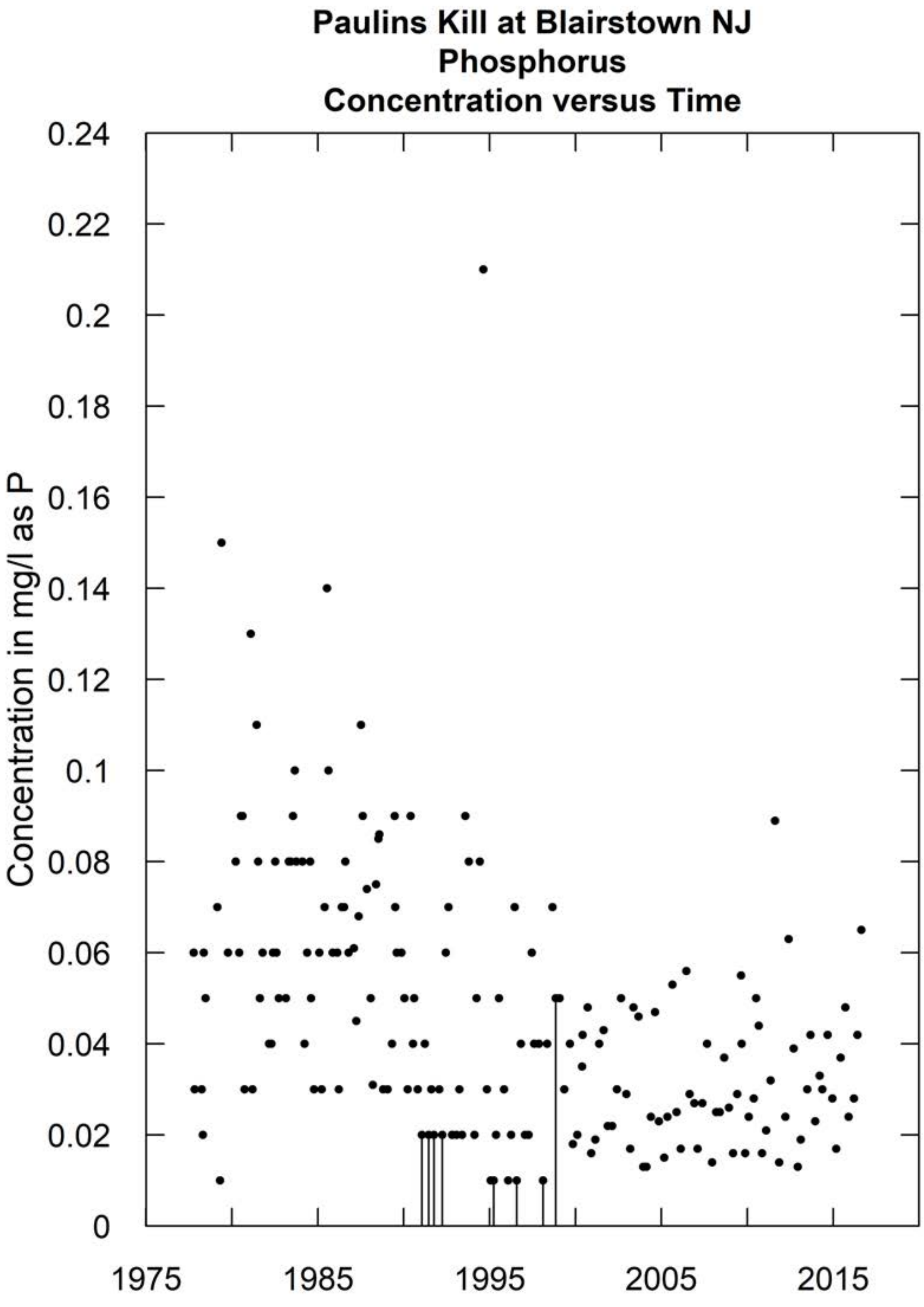

Paulins Kill at Blairstown NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1990
2000
2010
2020


Paulins Kill at Blairstown NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

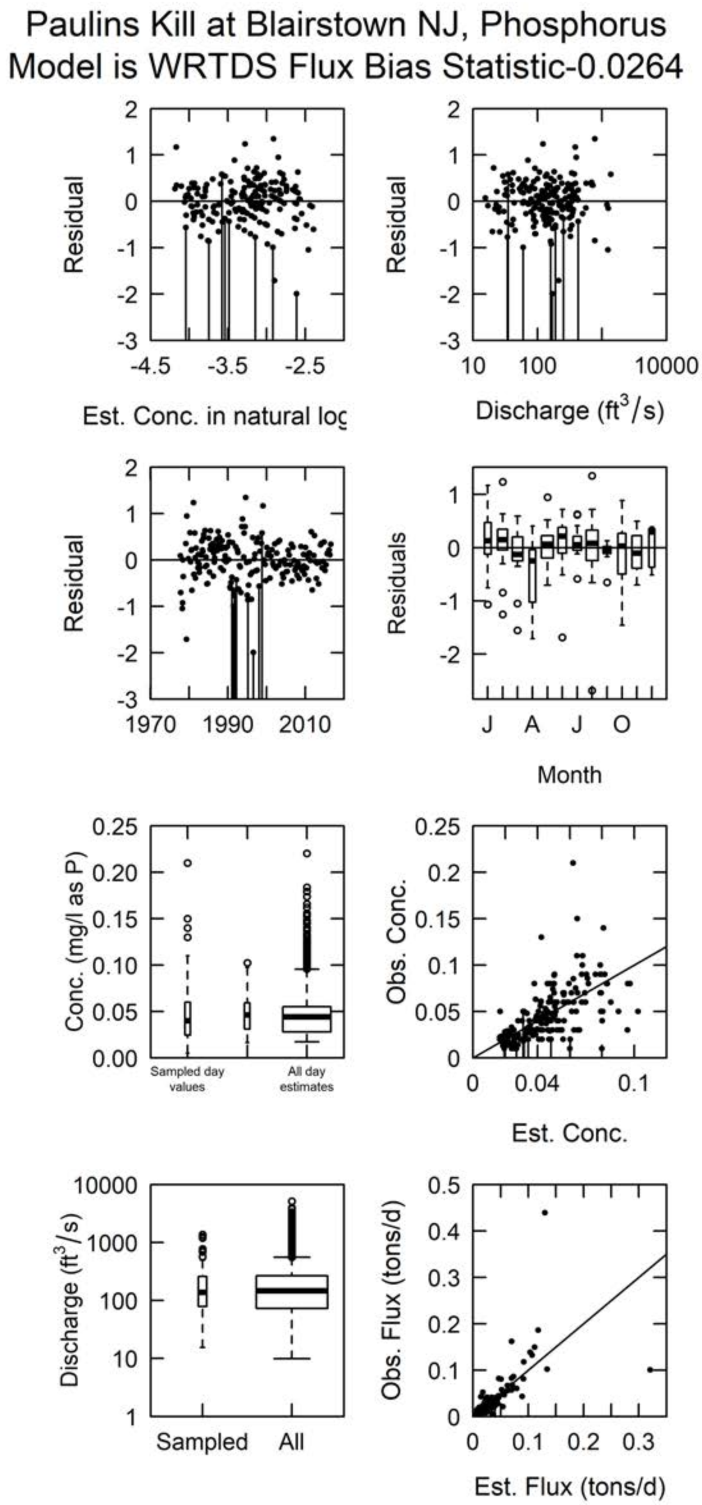

Paulins Kill at Blairstown NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.00309
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

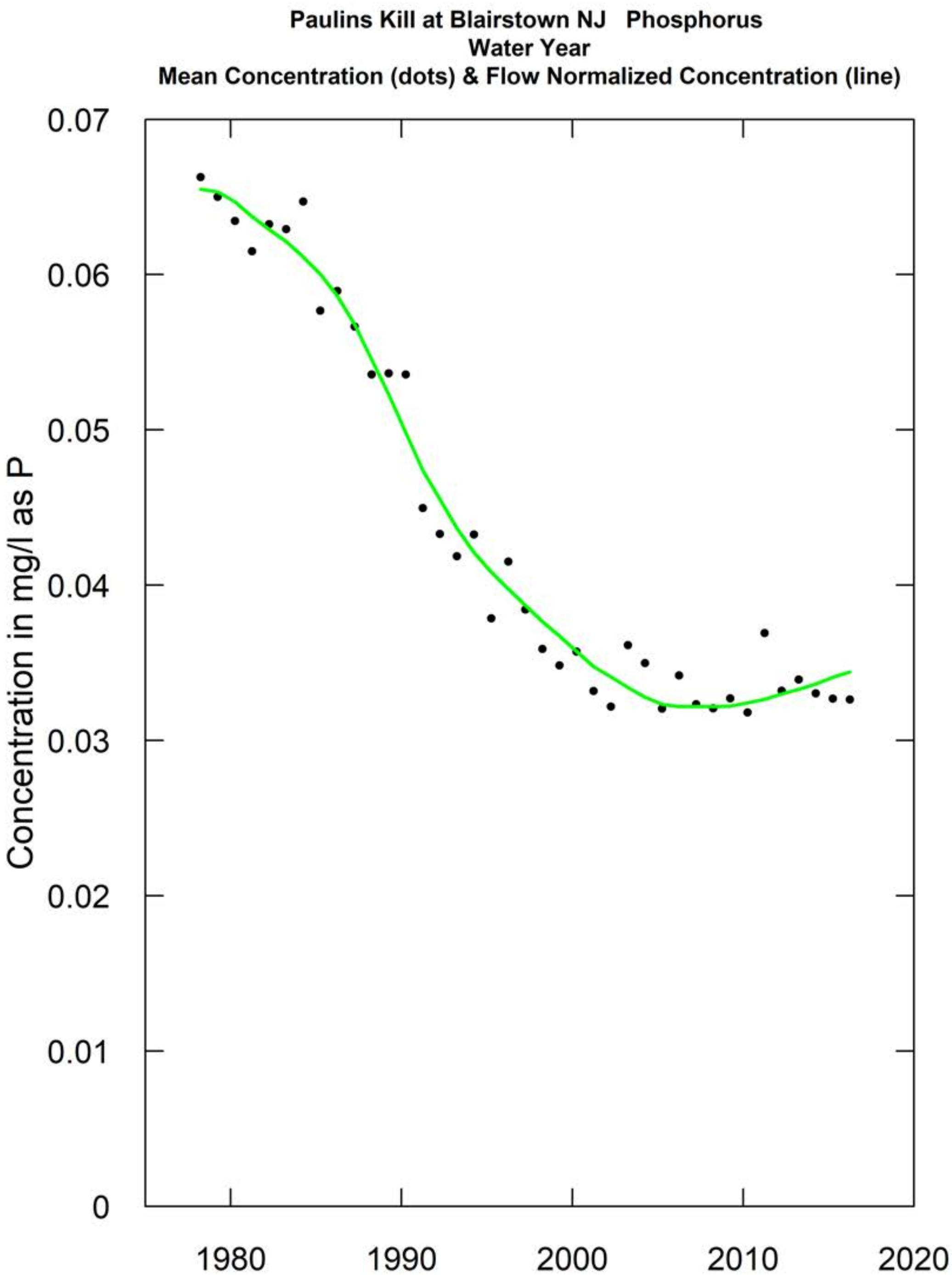

Paulins Kill at Blairstown NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

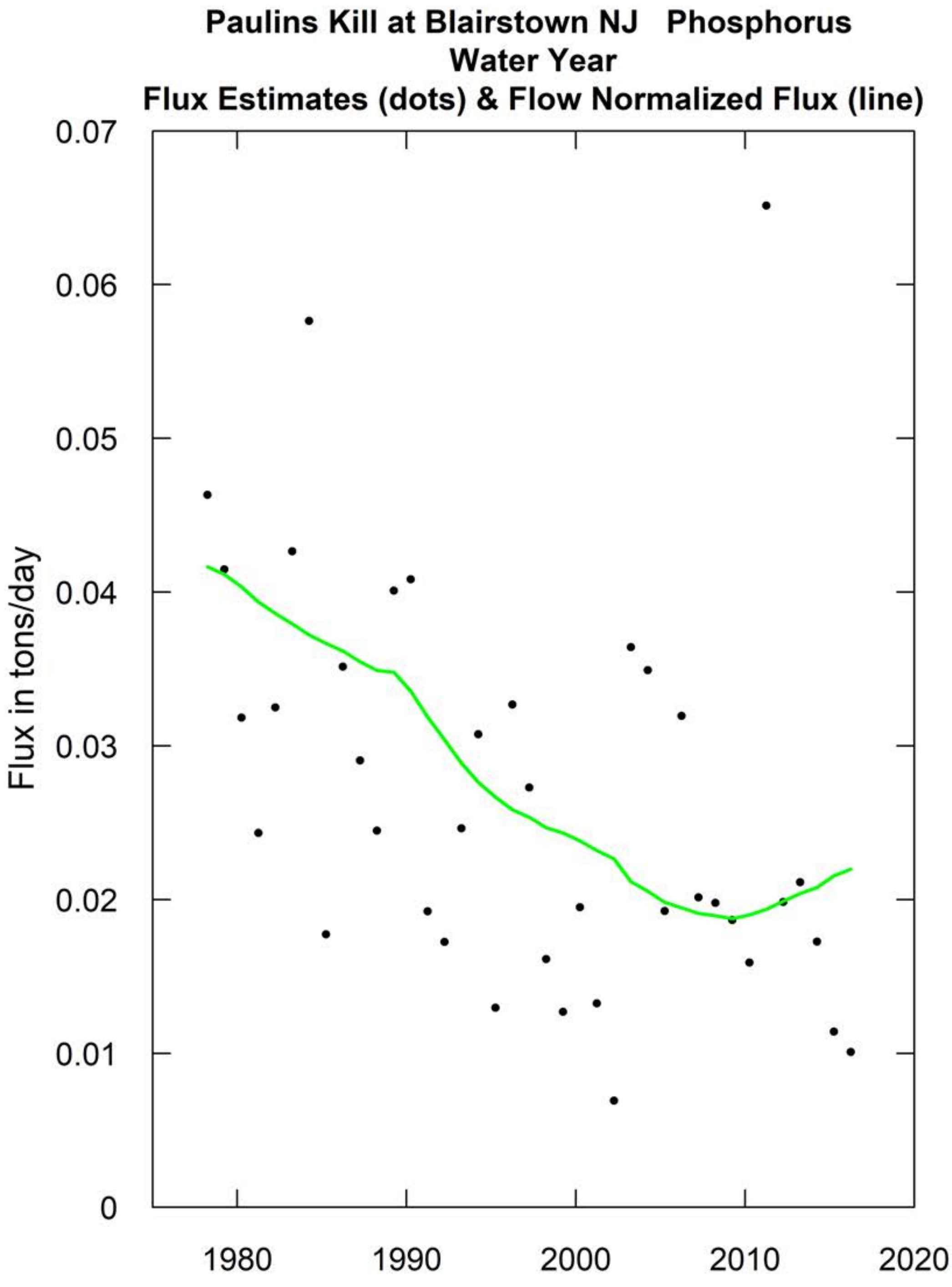

Paulins Kill at Blairstown NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

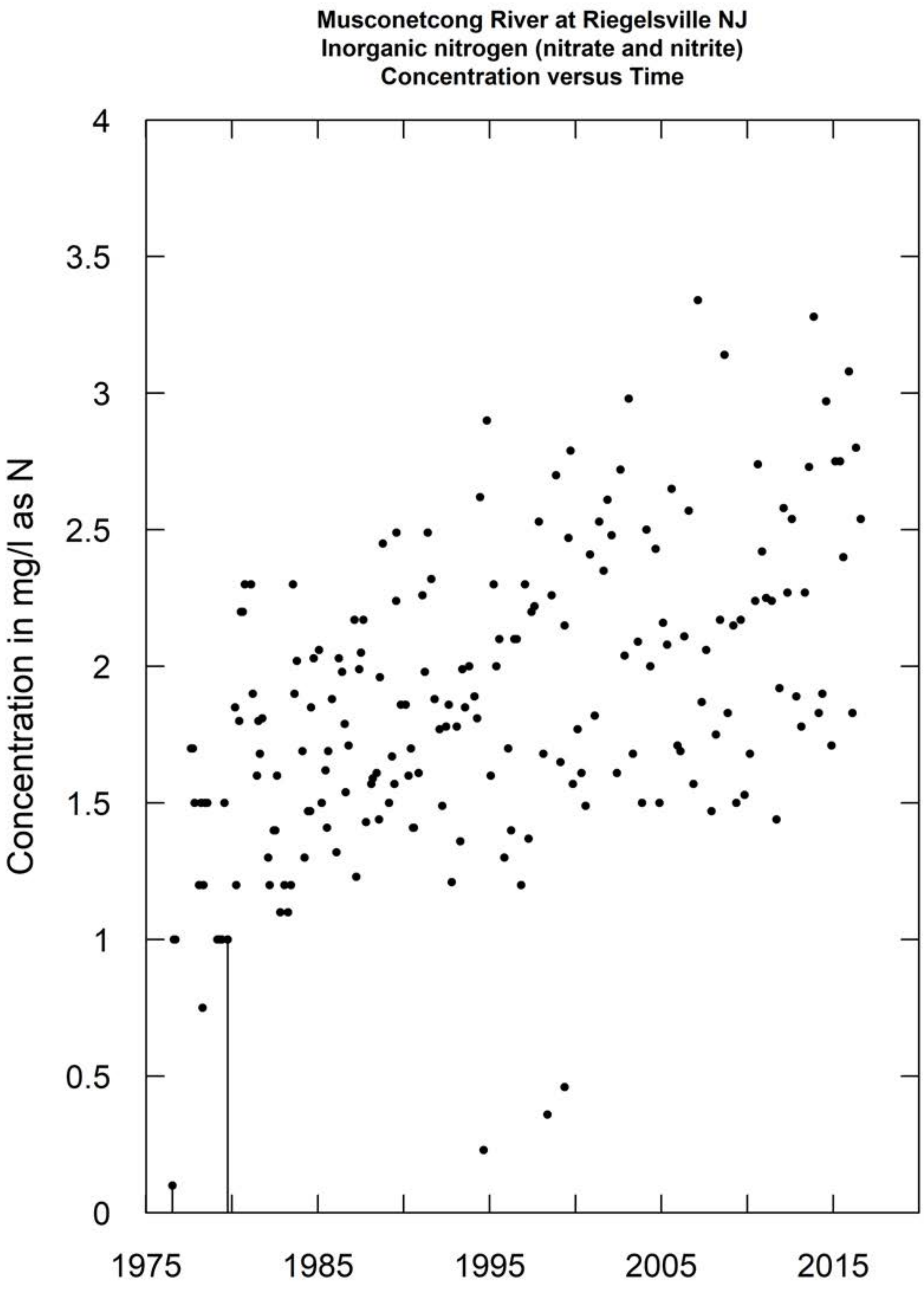


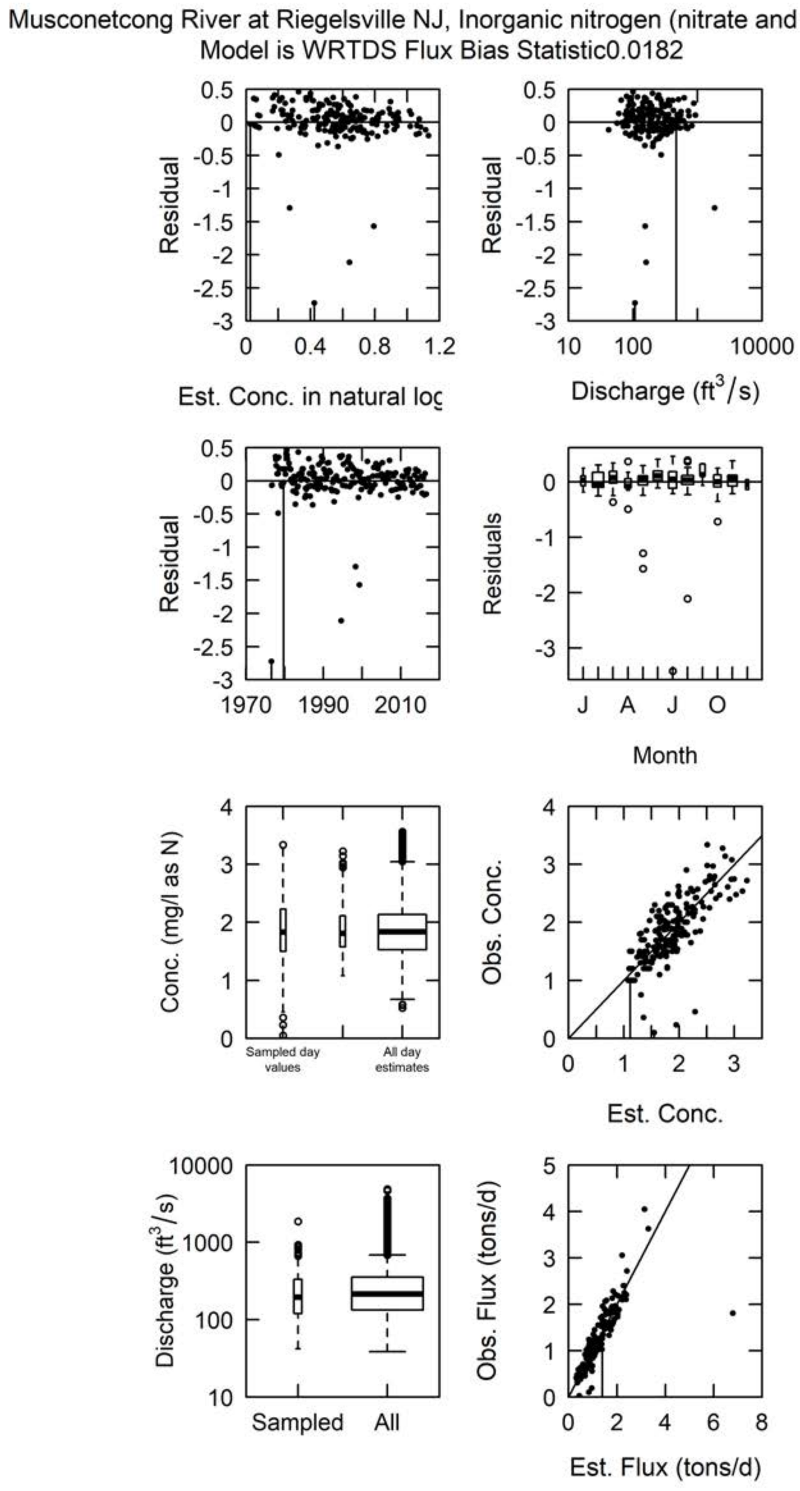
Paulins Kill at Blairstown NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1975
1985
1995
2005
2015

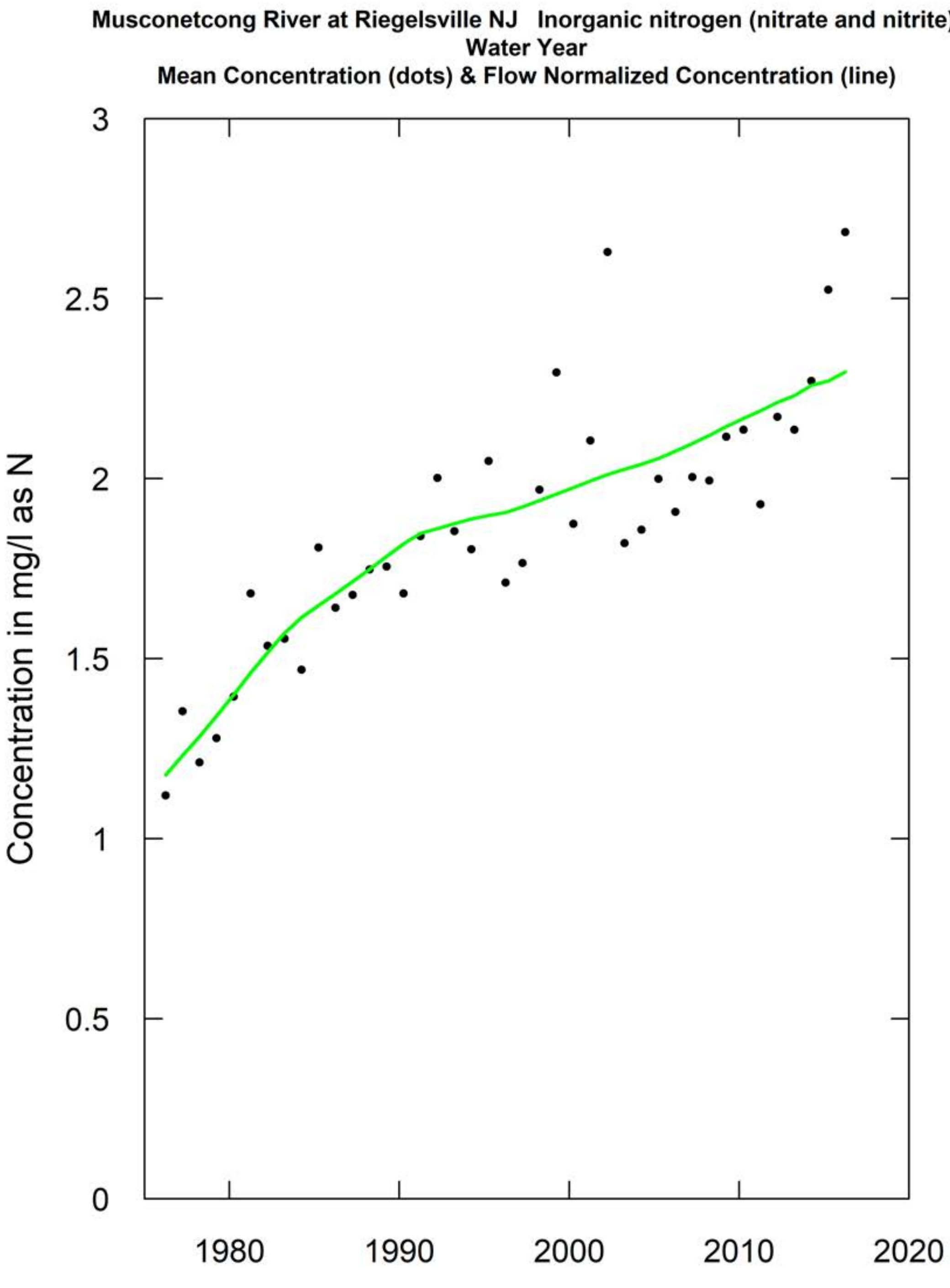

Paulins Kill at Blairstown NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.0264
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
Residuals
Month
J A J O
1970 1990 2010
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

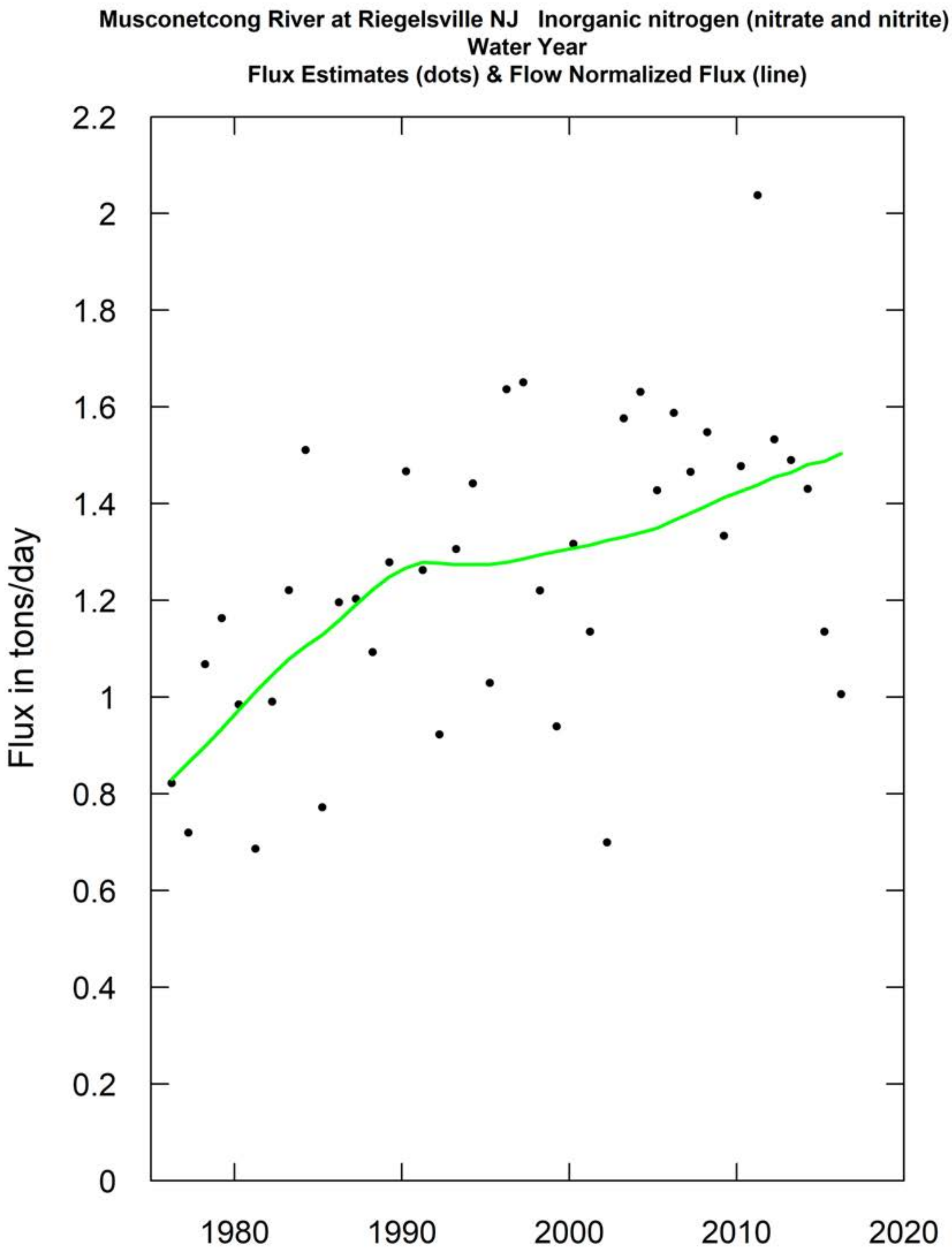

Paulins Kill at Blairstown NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1980
1990
2000
2010
2020

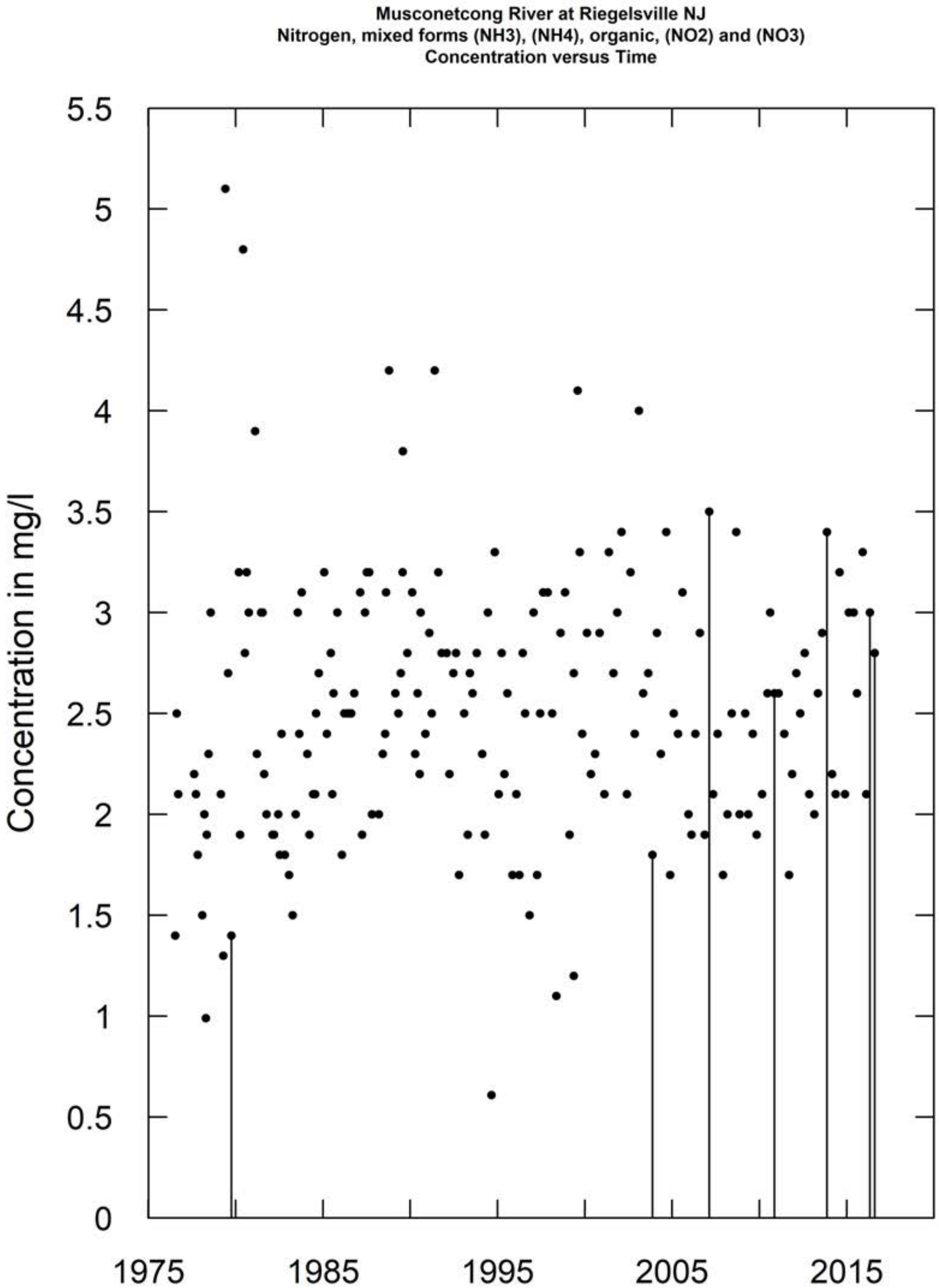

Paulins Kill at Blairstown NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1980
1990
2000
2010
2020

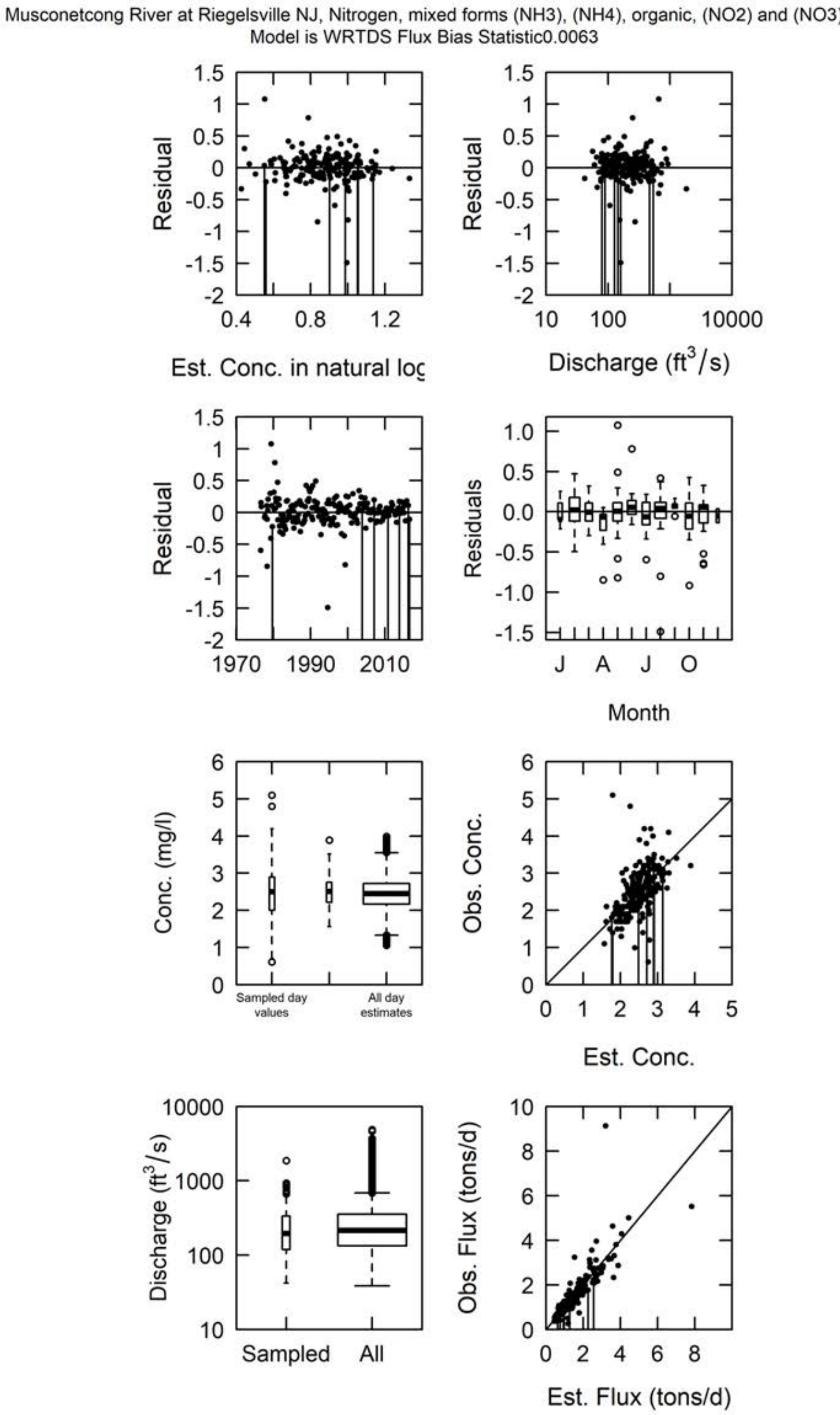

Musconetcong River at Riegelsville NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
4
3.5
3
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015

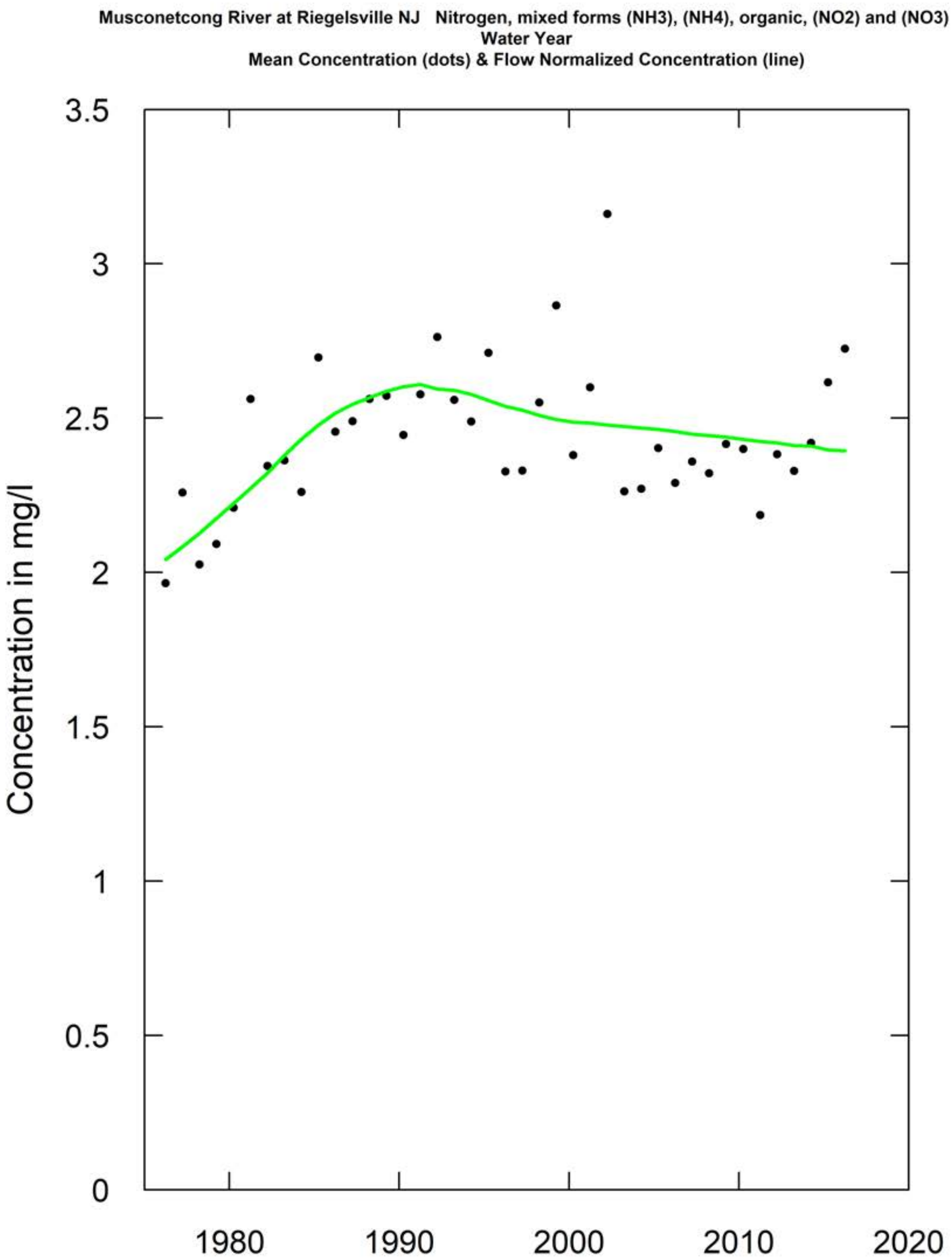

Musconetcong River at Riegelsville NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0182
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

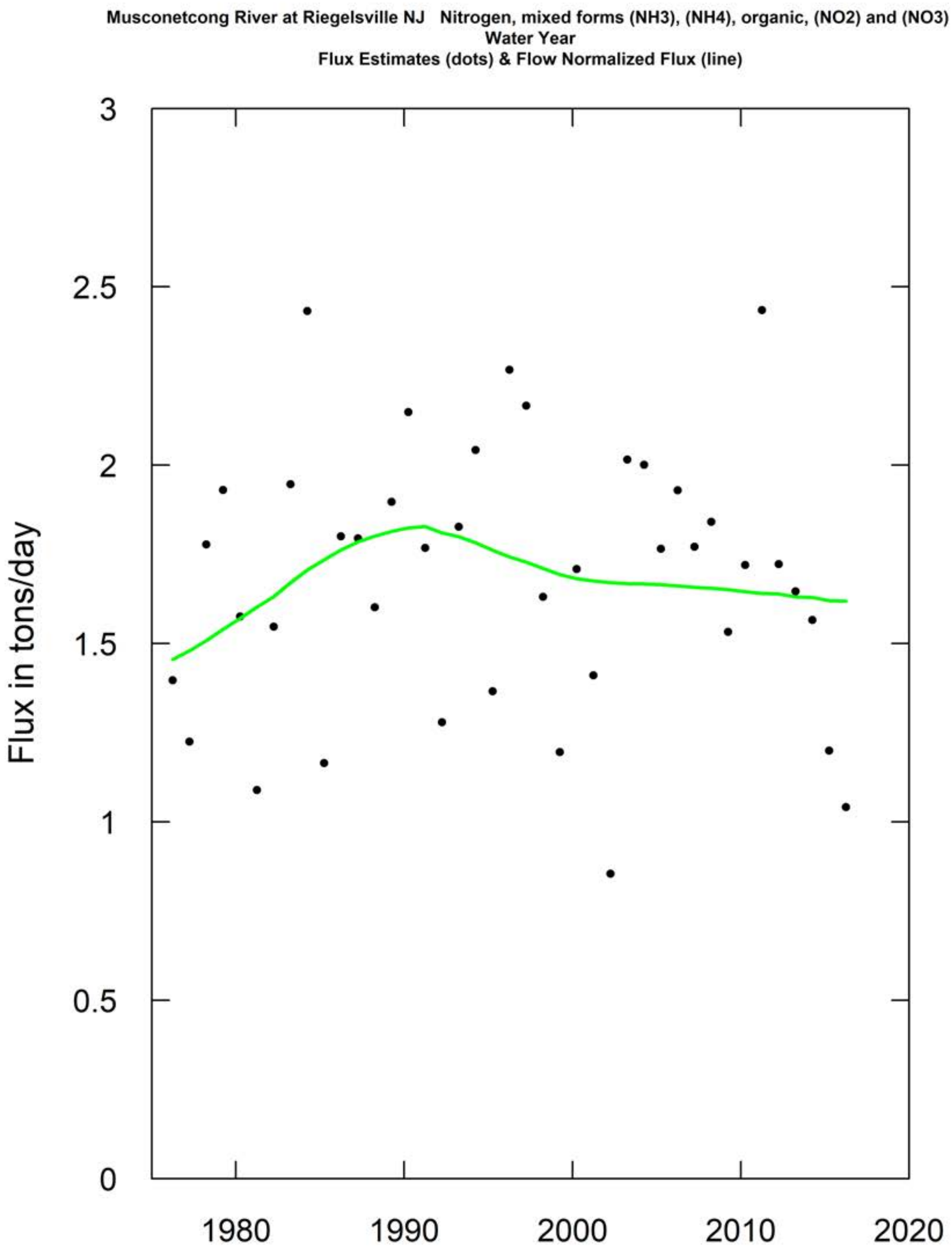

Musconetcong River at Riegelsville NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0
0.5
1
1.5
2
2.5
3
1980
1990
2000
2010
2020

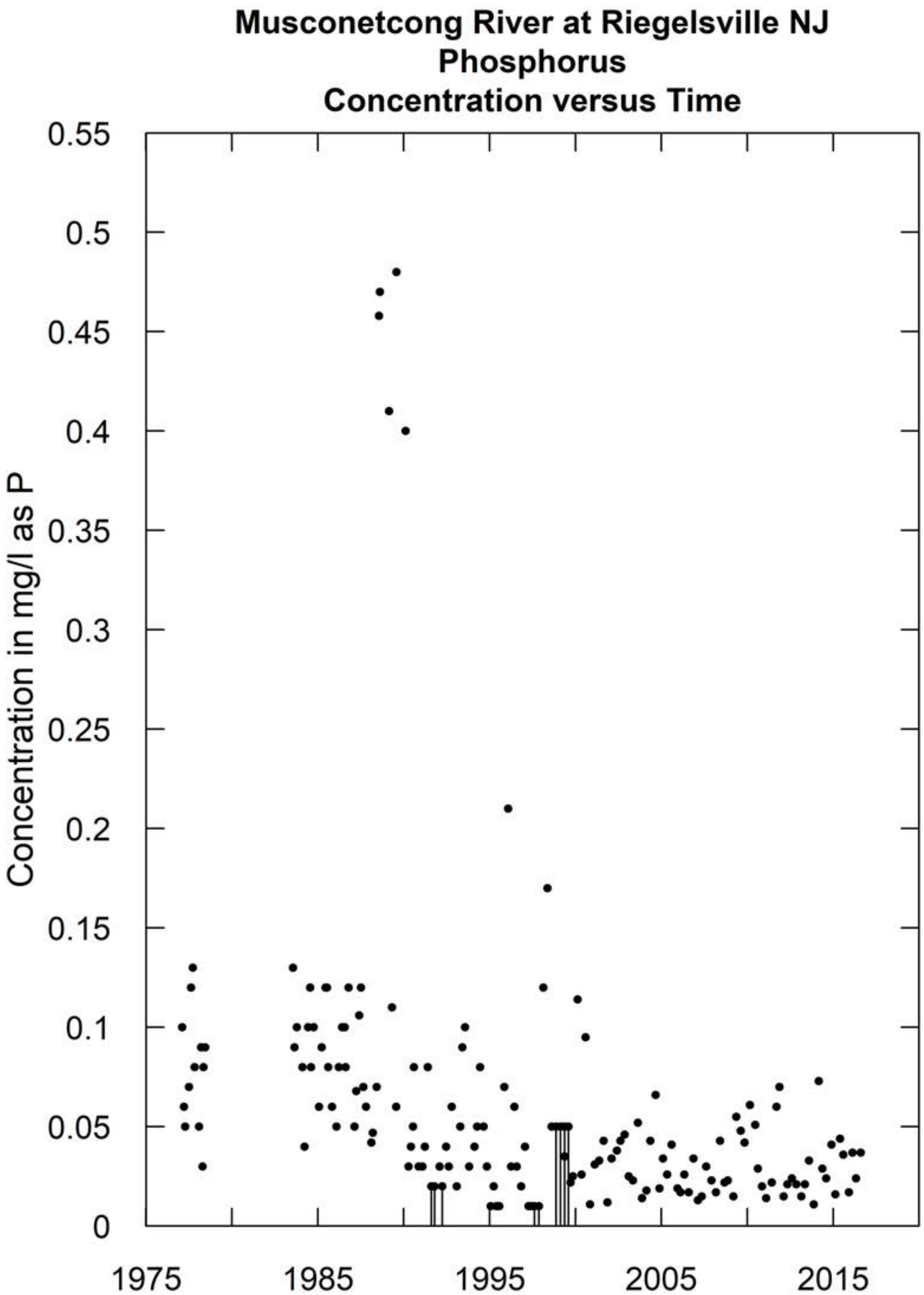

Musconetcong River at Riegelsville NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020

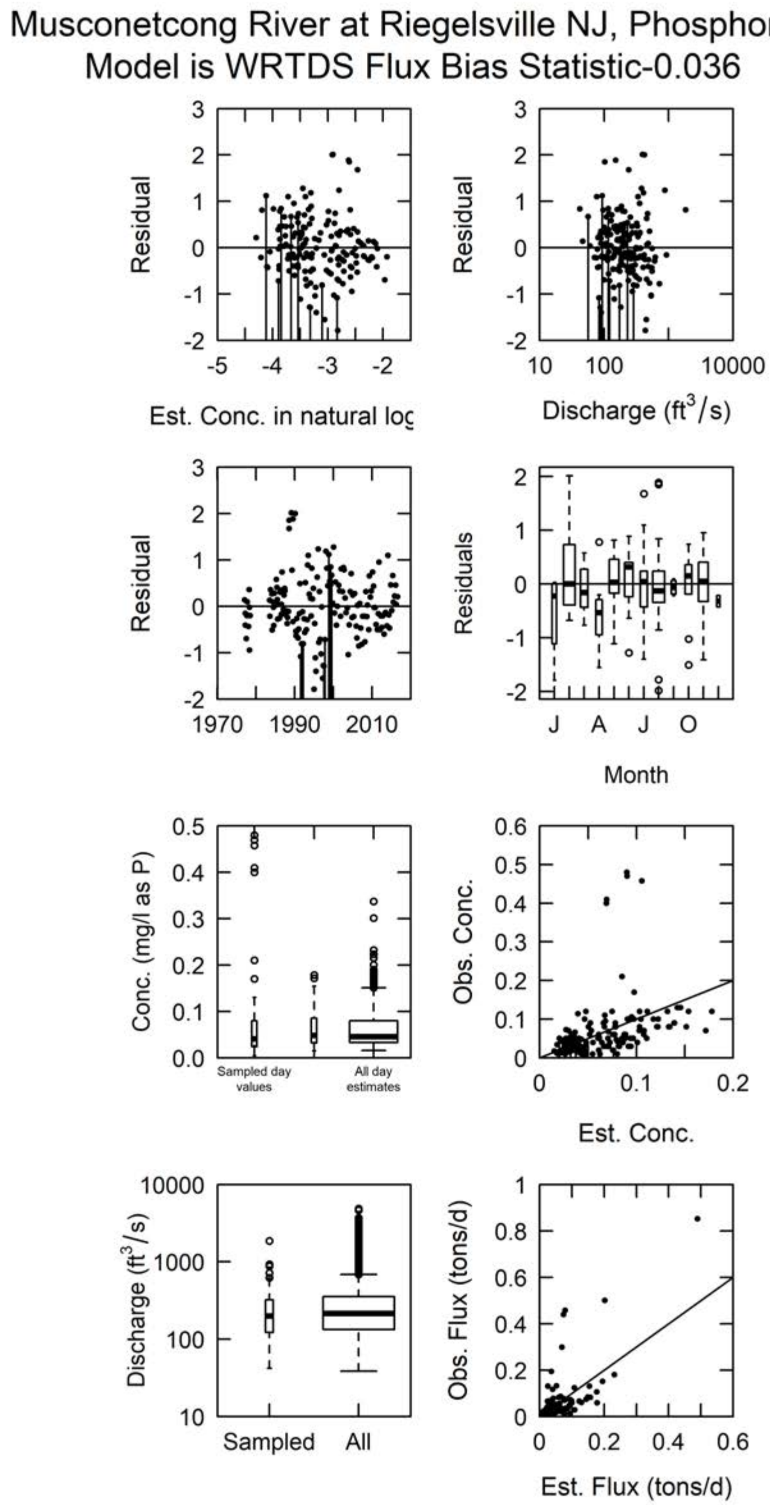

Musconetcong River at Riegelsville NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1975
1985
1995
2005
2015


Musconetcong River at Riegelsville NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.0063
Residual
Est. Conc. in natural log
Residual
Discharge (ft3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

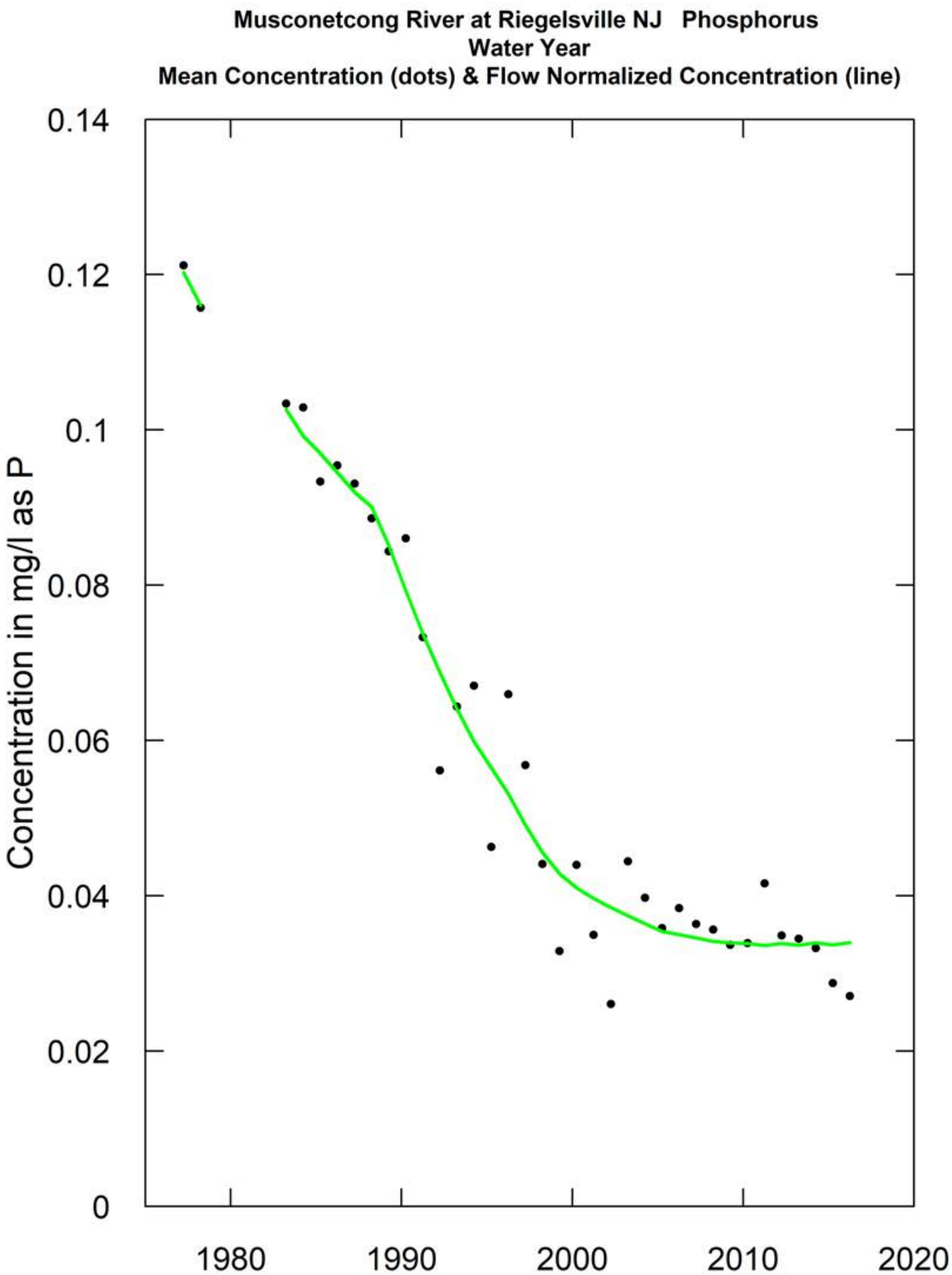

Musconetcong River at Riegelsville NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
3.5
3
2.5
2
1.5
1
0.5
0
1980
1990
2000
2010
2020

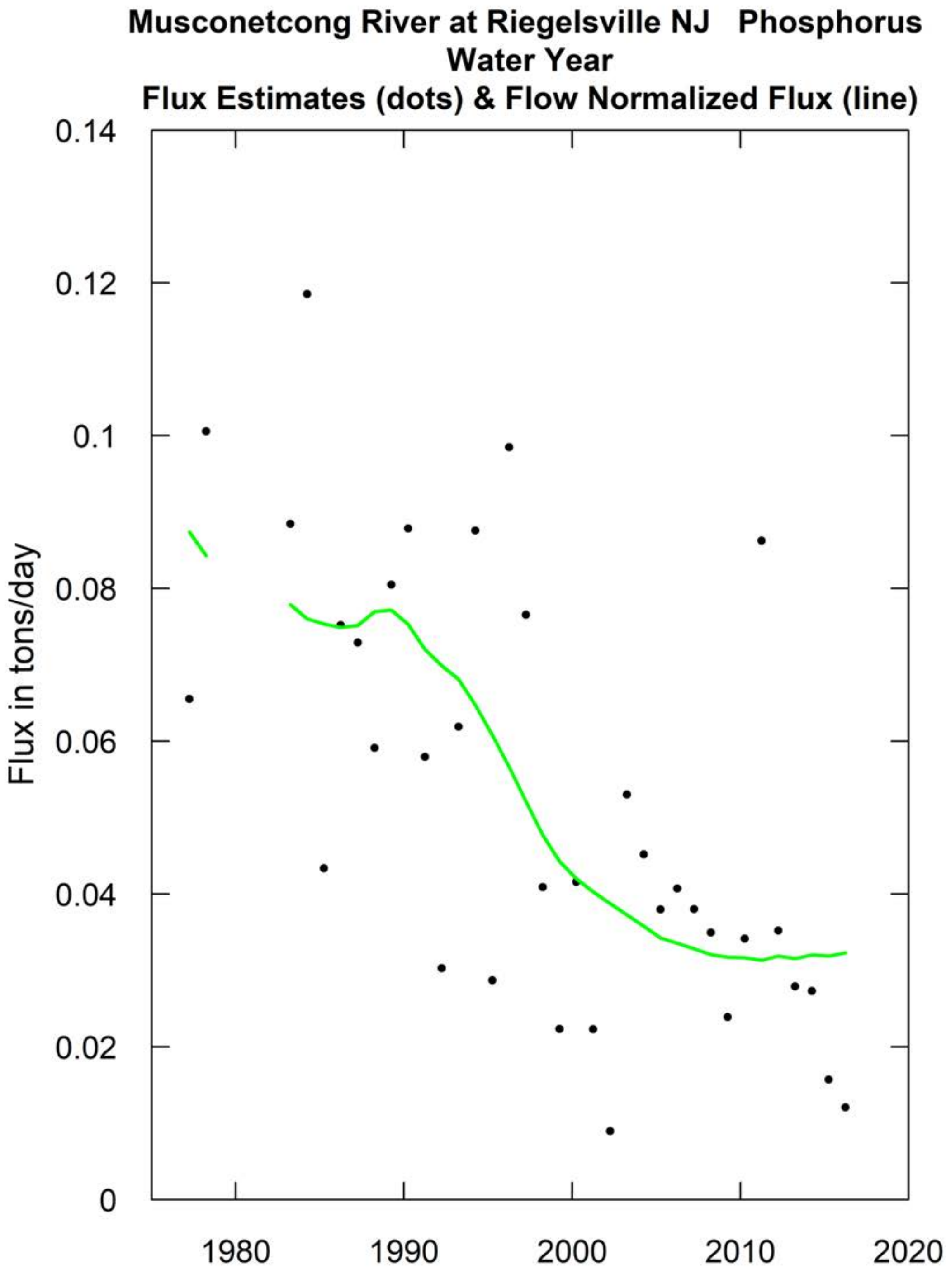

Musconetcong River at Riegelsville NJ   Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
3
2.5
2
1.5
1
0.5
0
1980
1990
2000
2010
2020

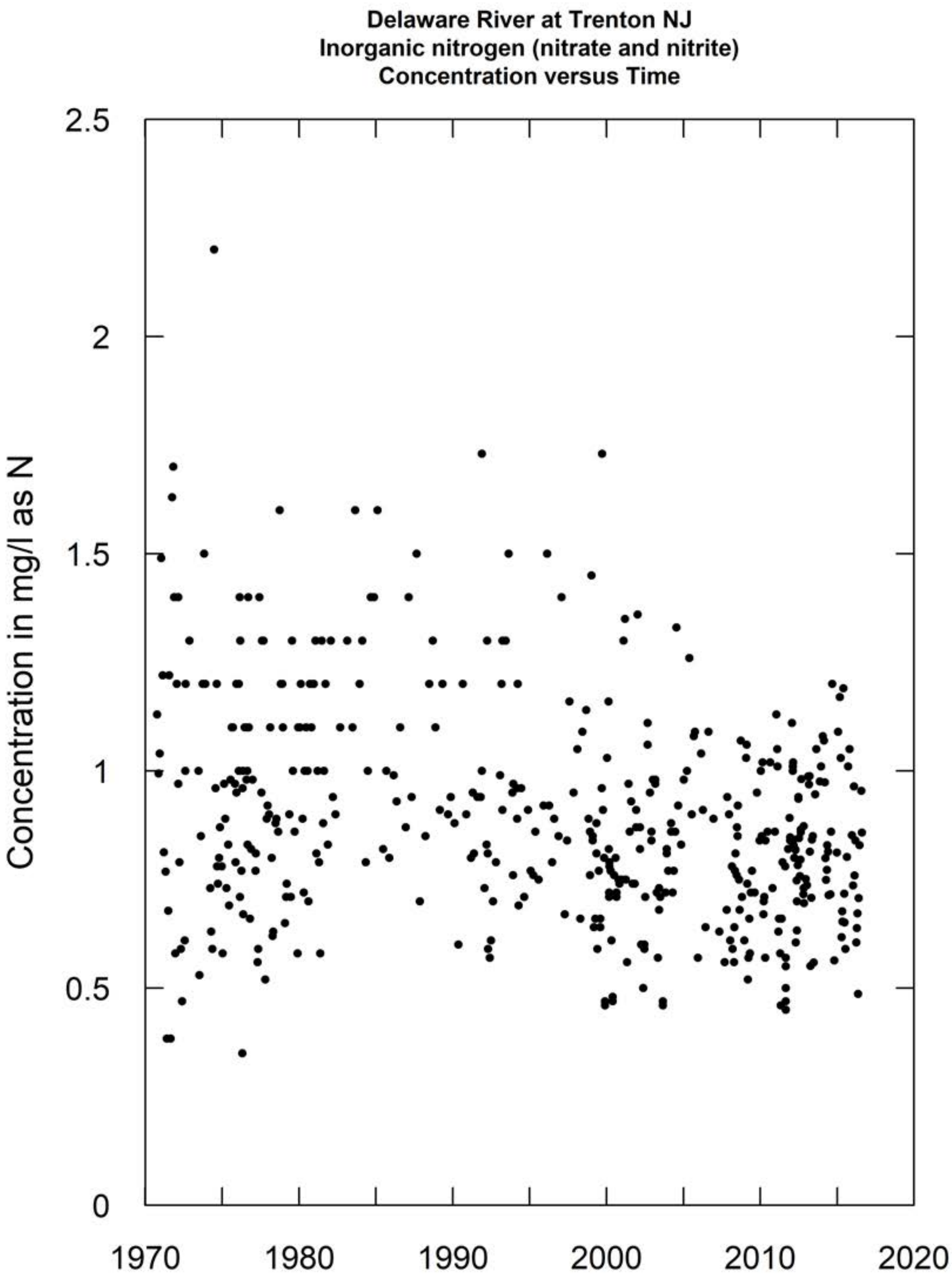

Musconetcong River at Riegelsville NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1975
1985
1995
2005
2015

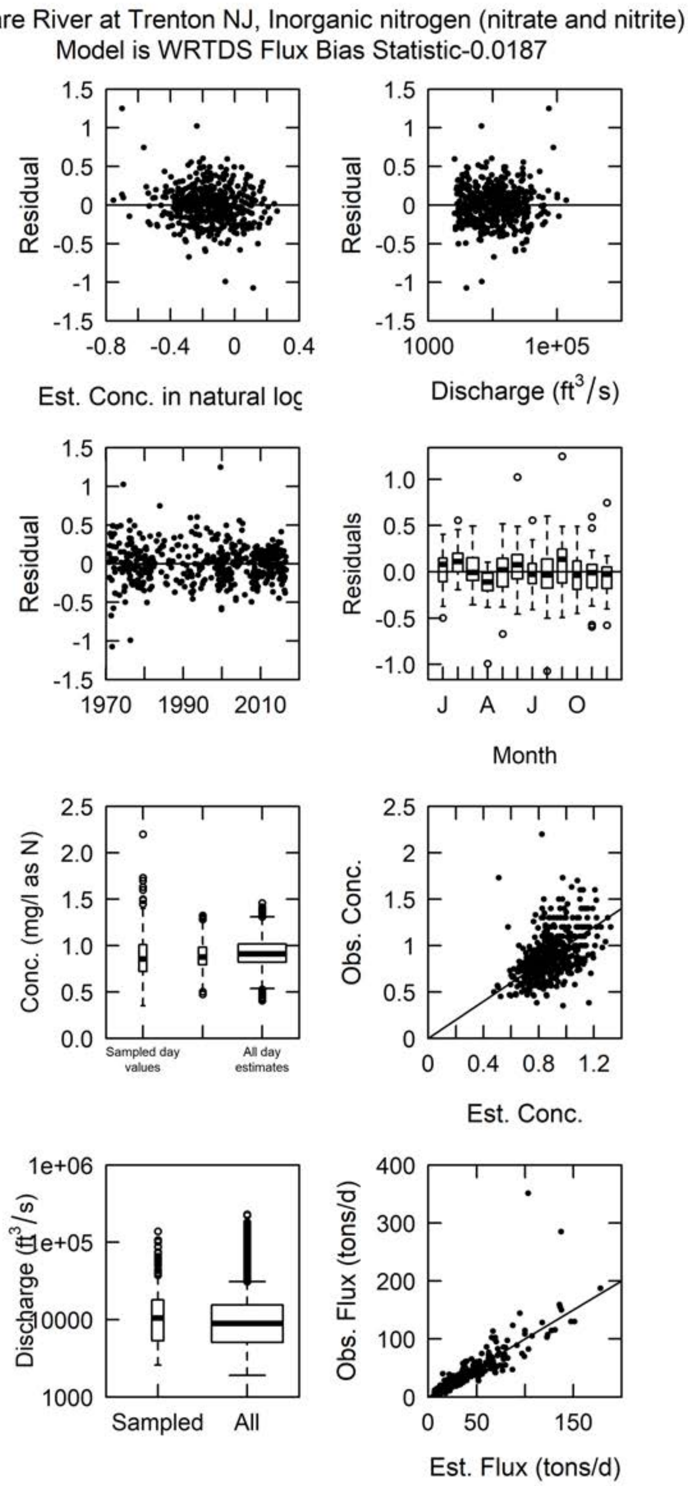


Musconetcong River at Riegelsville NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.036
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
Residual
Residuals
Month
J A J O
1970 1990 2010
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

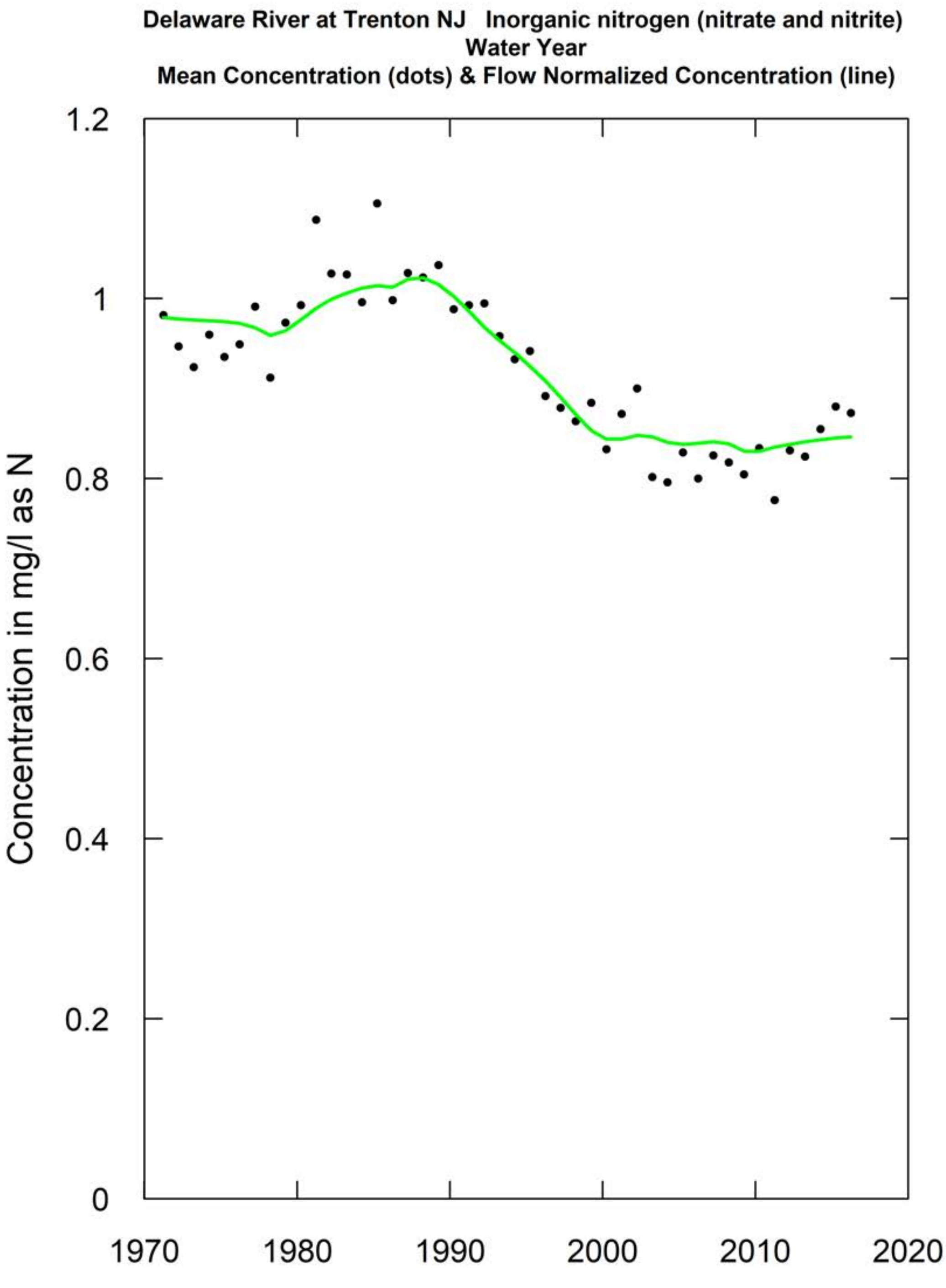

Musconetcong River at Riegelsville NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

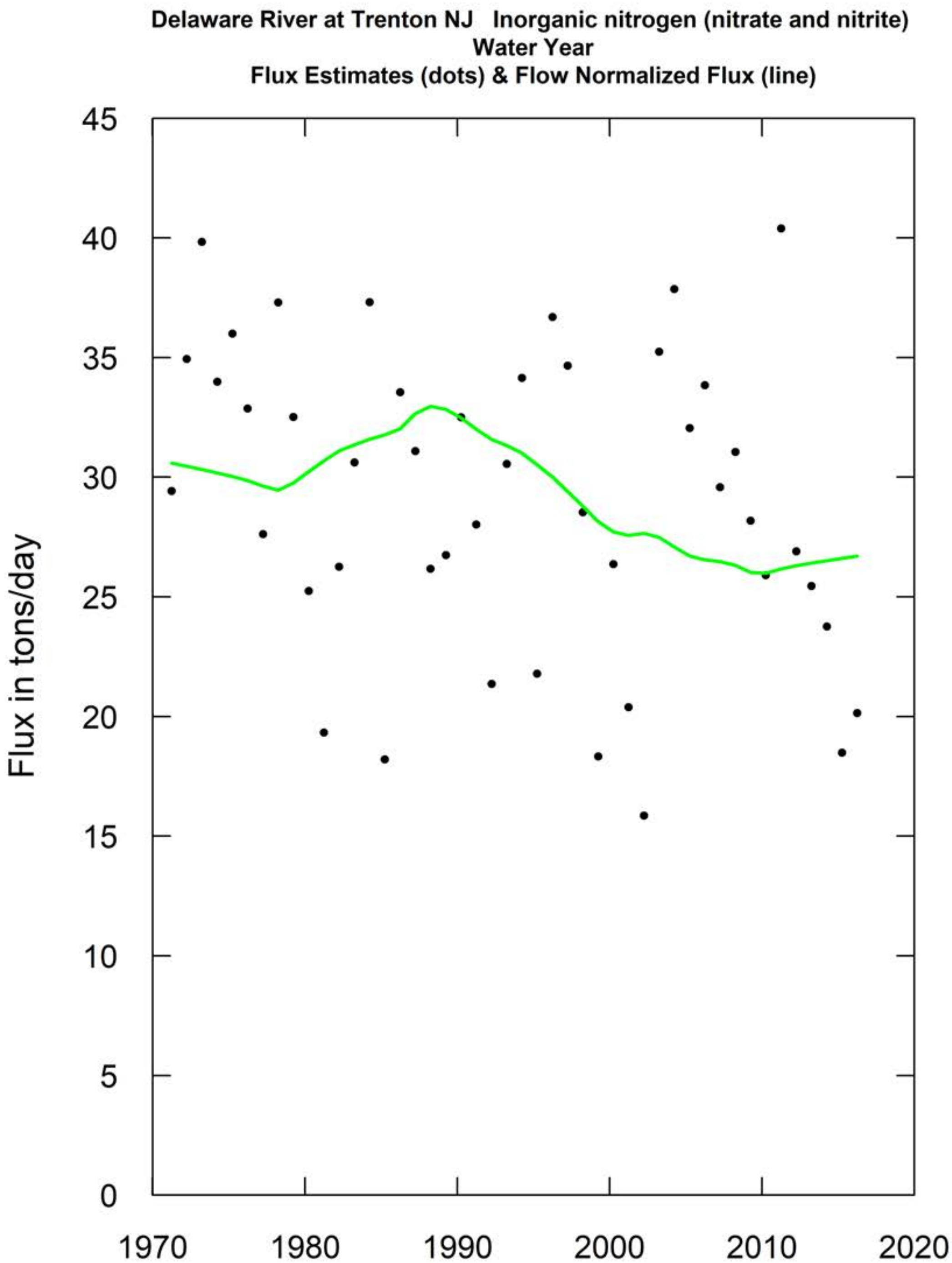

Musconetcong River at Riegelsville NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1980
1990
2000
2010
2020

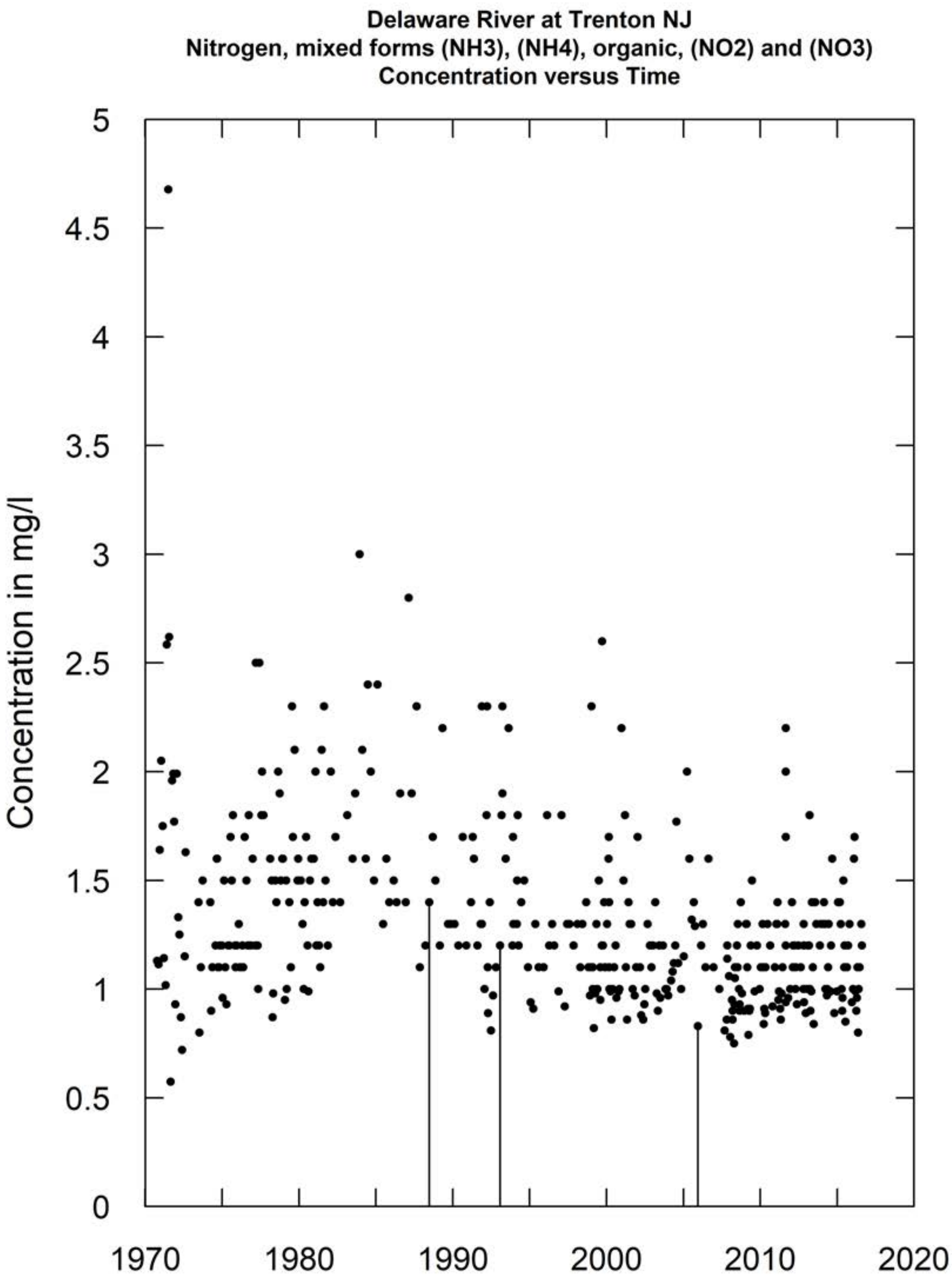

Delaware River at Trenton NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

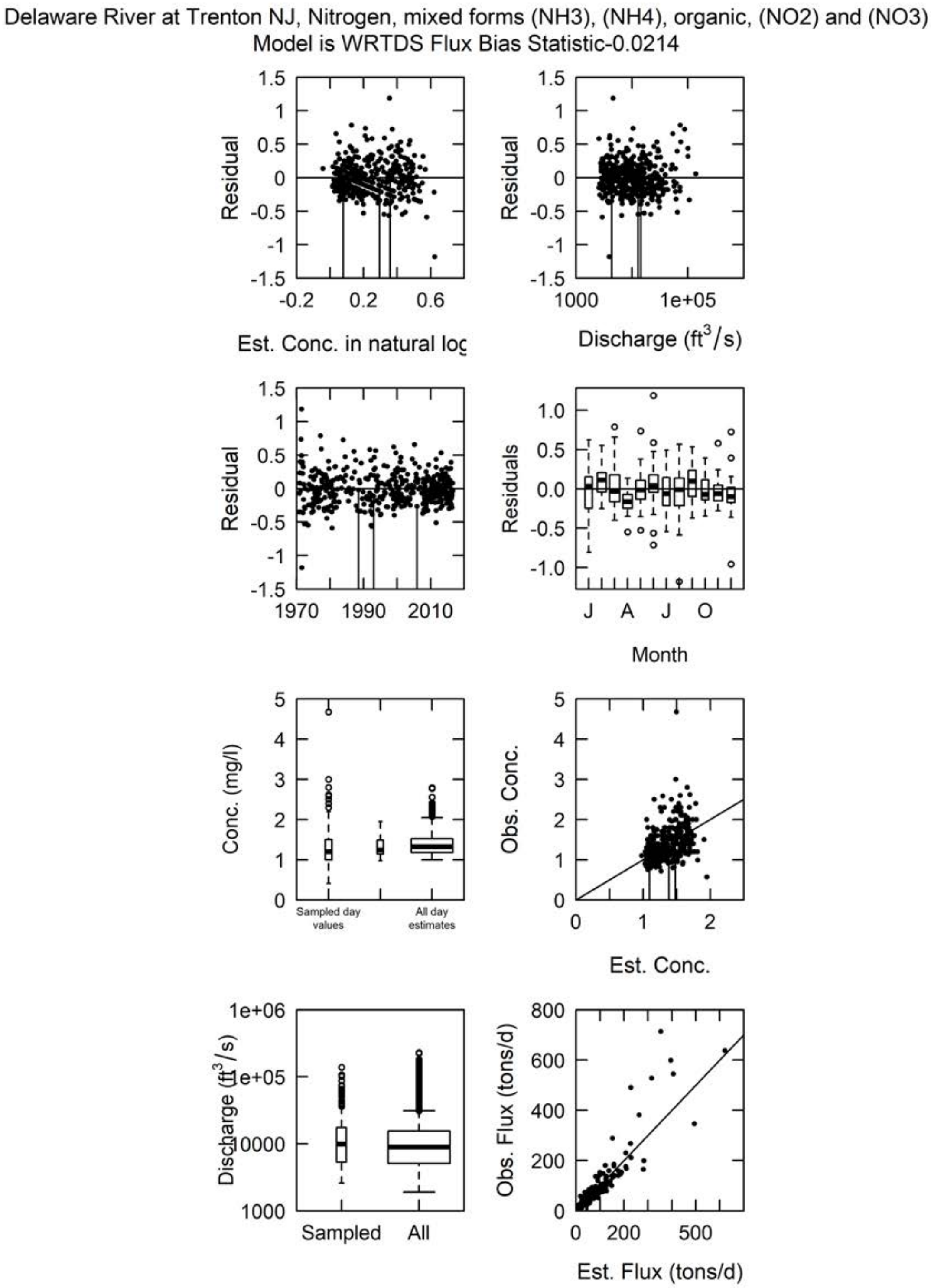


Delaware River at Trenton NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic-0.0187
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

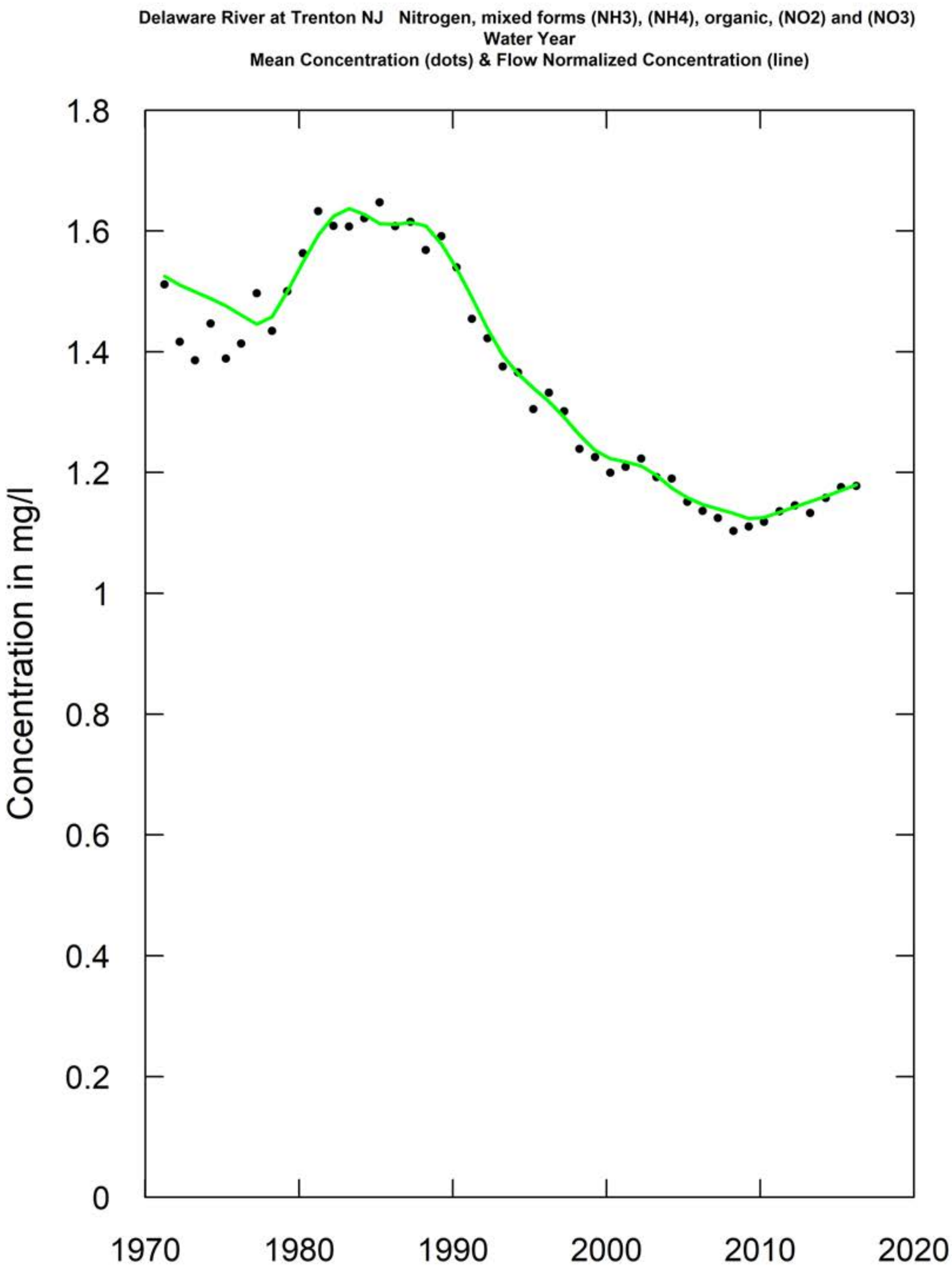

Delaware River at Trenton NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0
0.2
0.4
0.6
0.8
1
1.2
1970
1980
1990
2000
2010
2020

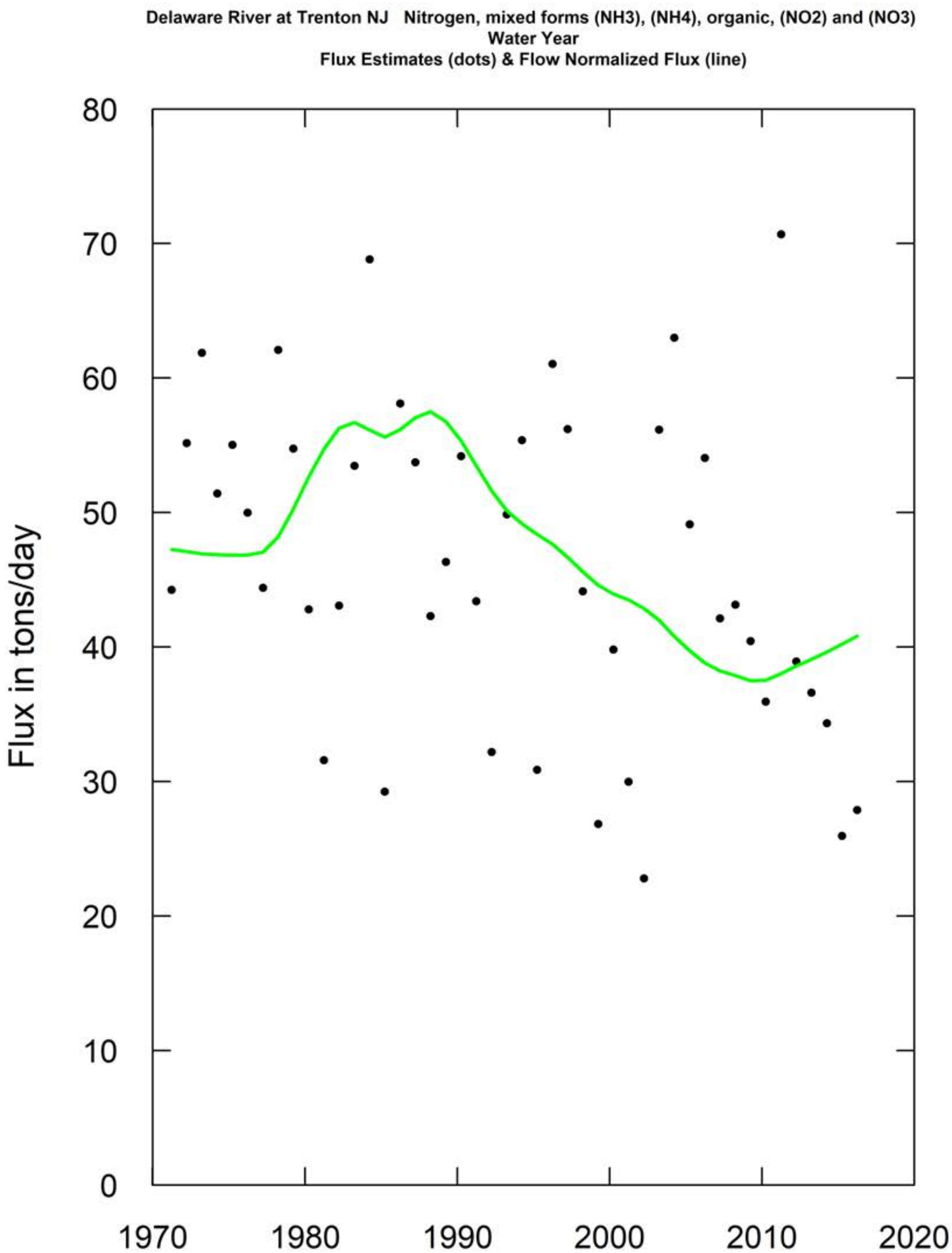

Delaware River at Trenton NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
45
40
35
30
25
20
15
10
5
0
1970
1980
1990
2000
2010
2020

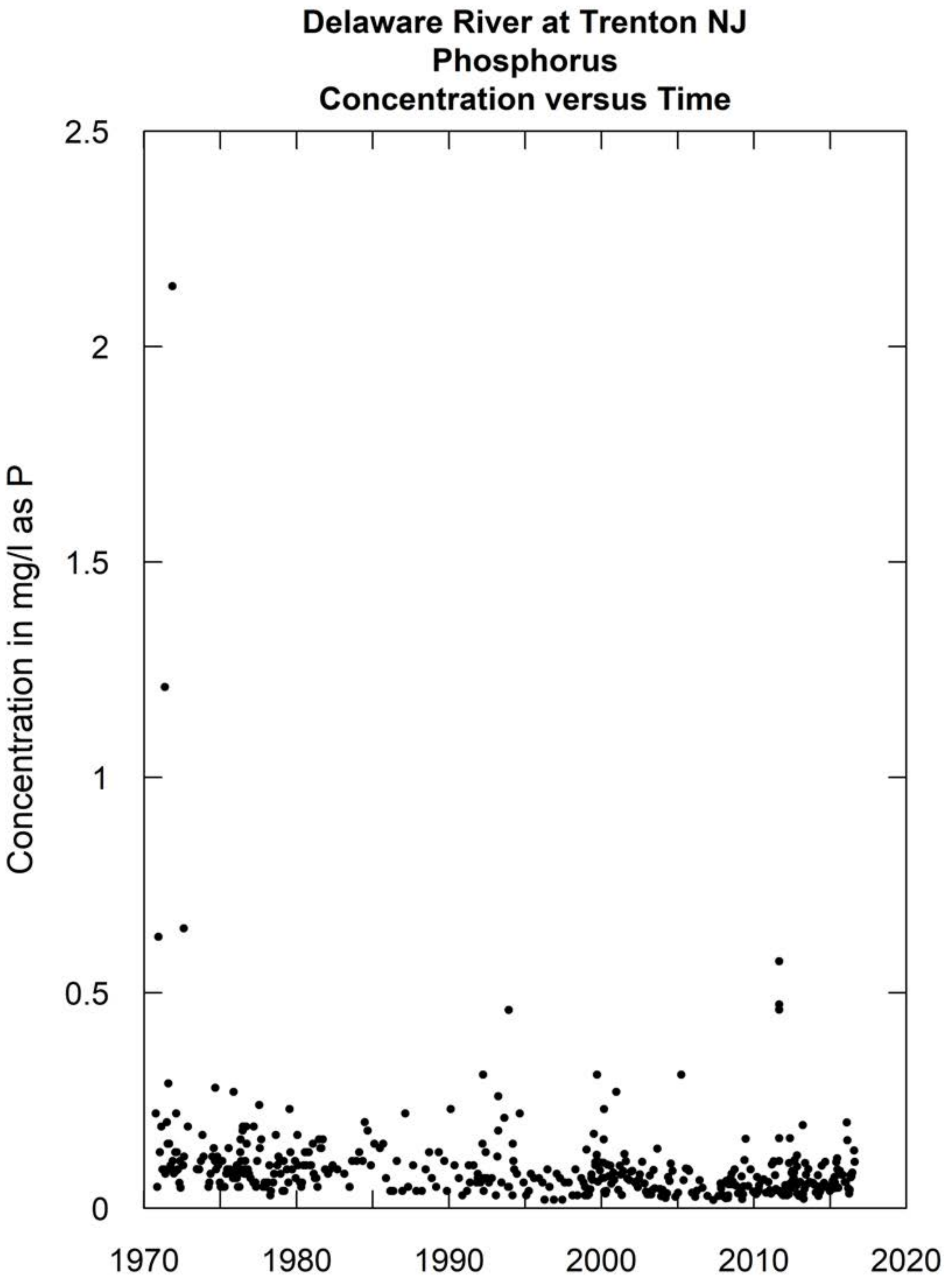

Delaware River at Trenton NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1970
1980
1990
2000
2010
2020

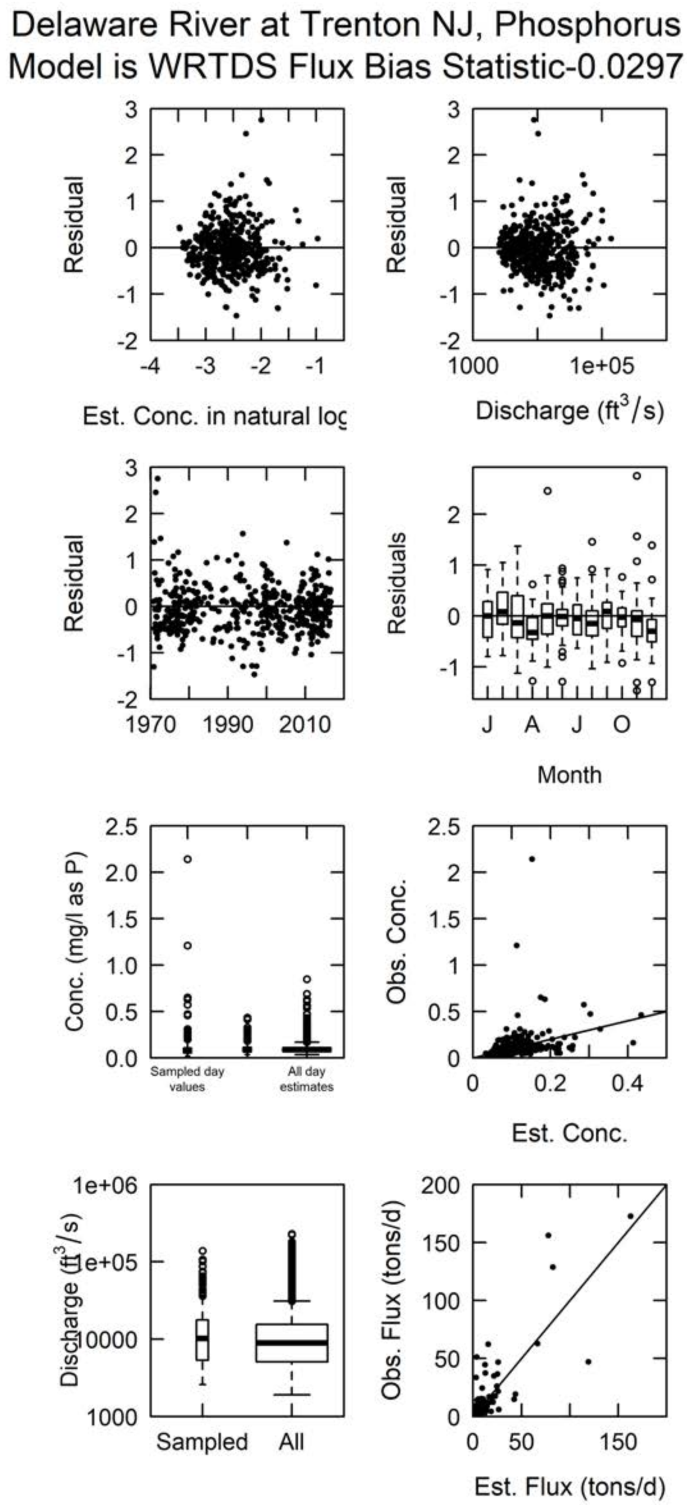


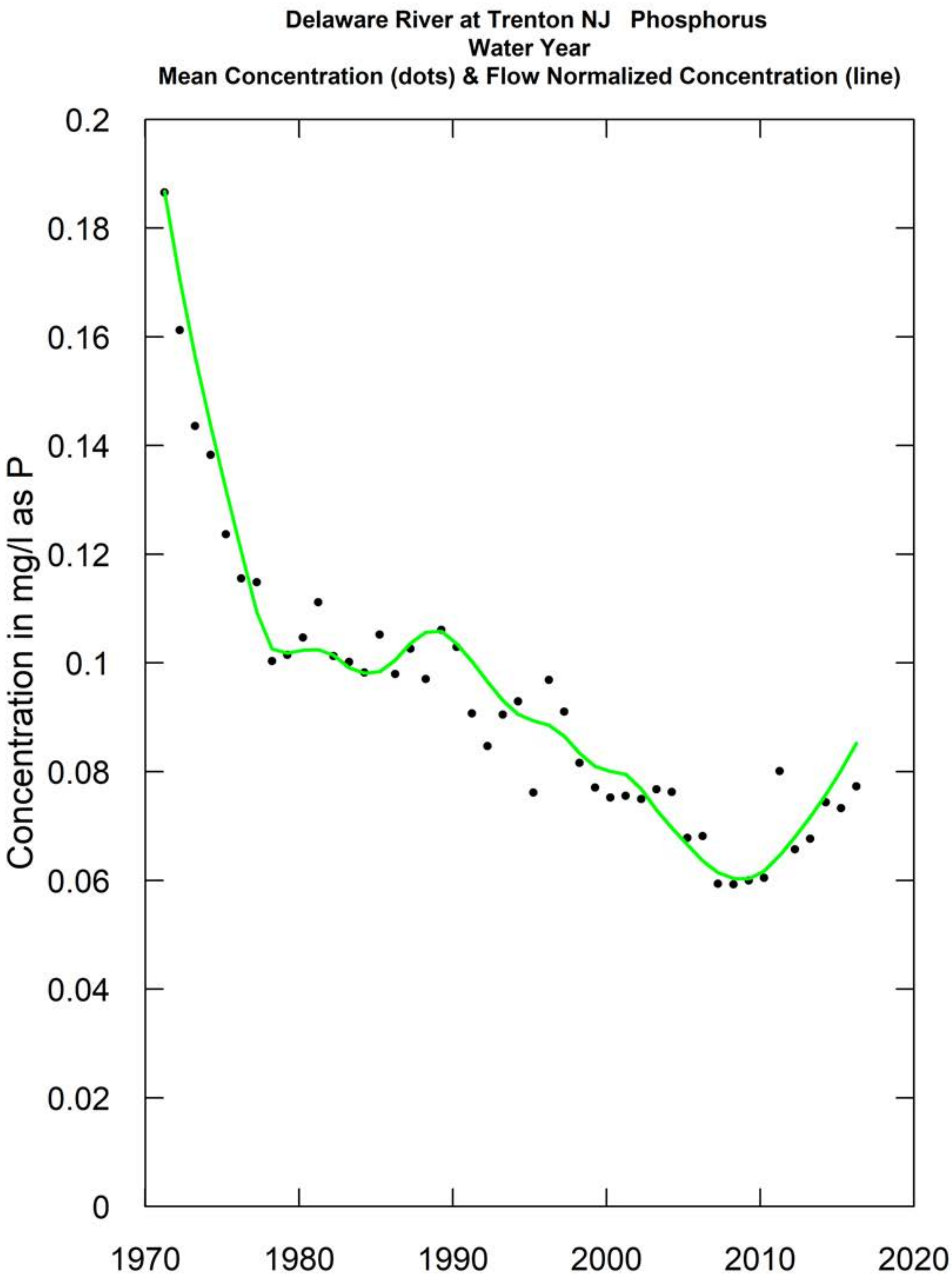
Delaware River at Trenton NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic-0.0214
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

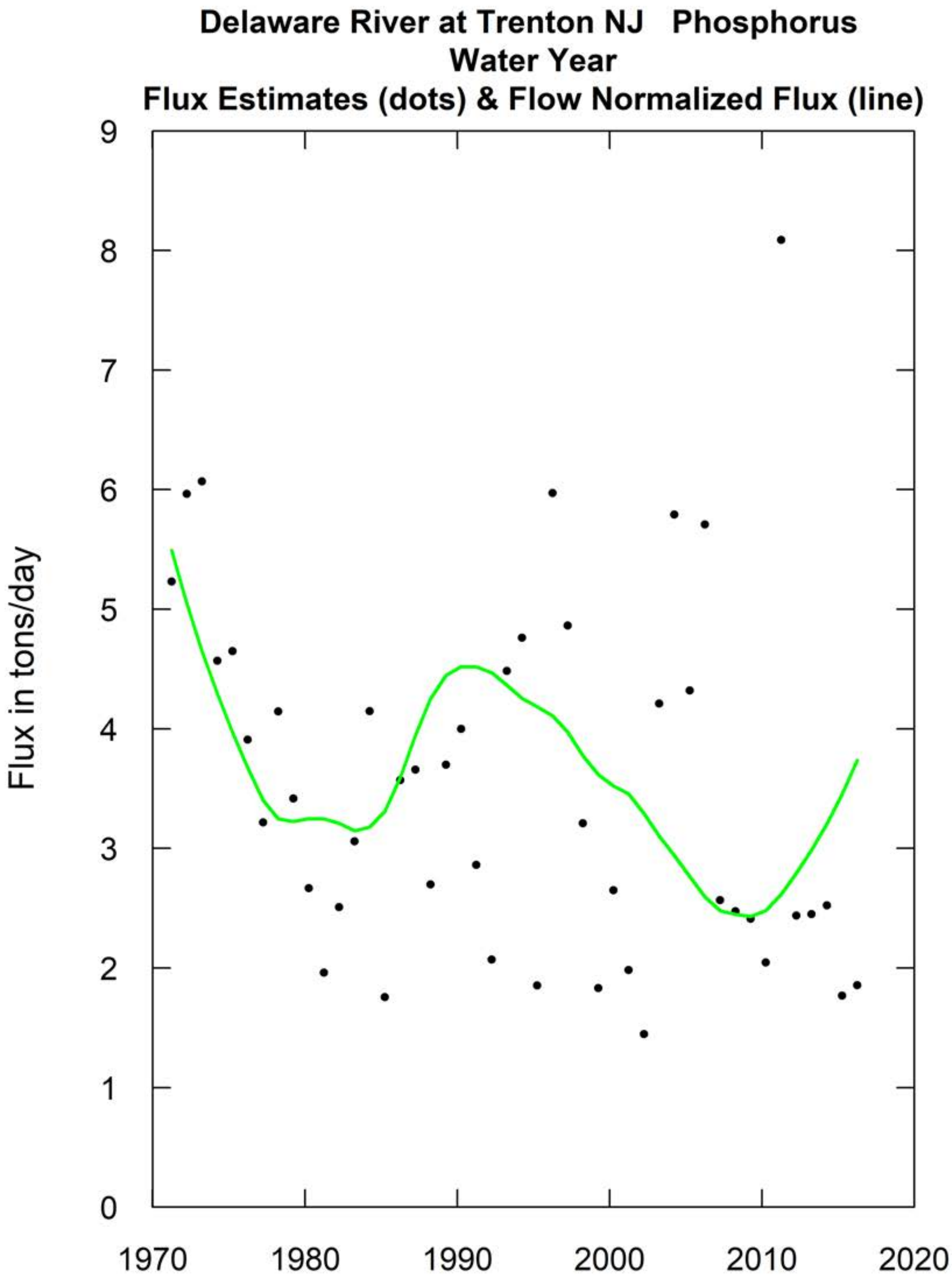

Delaware River at Trenton NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020

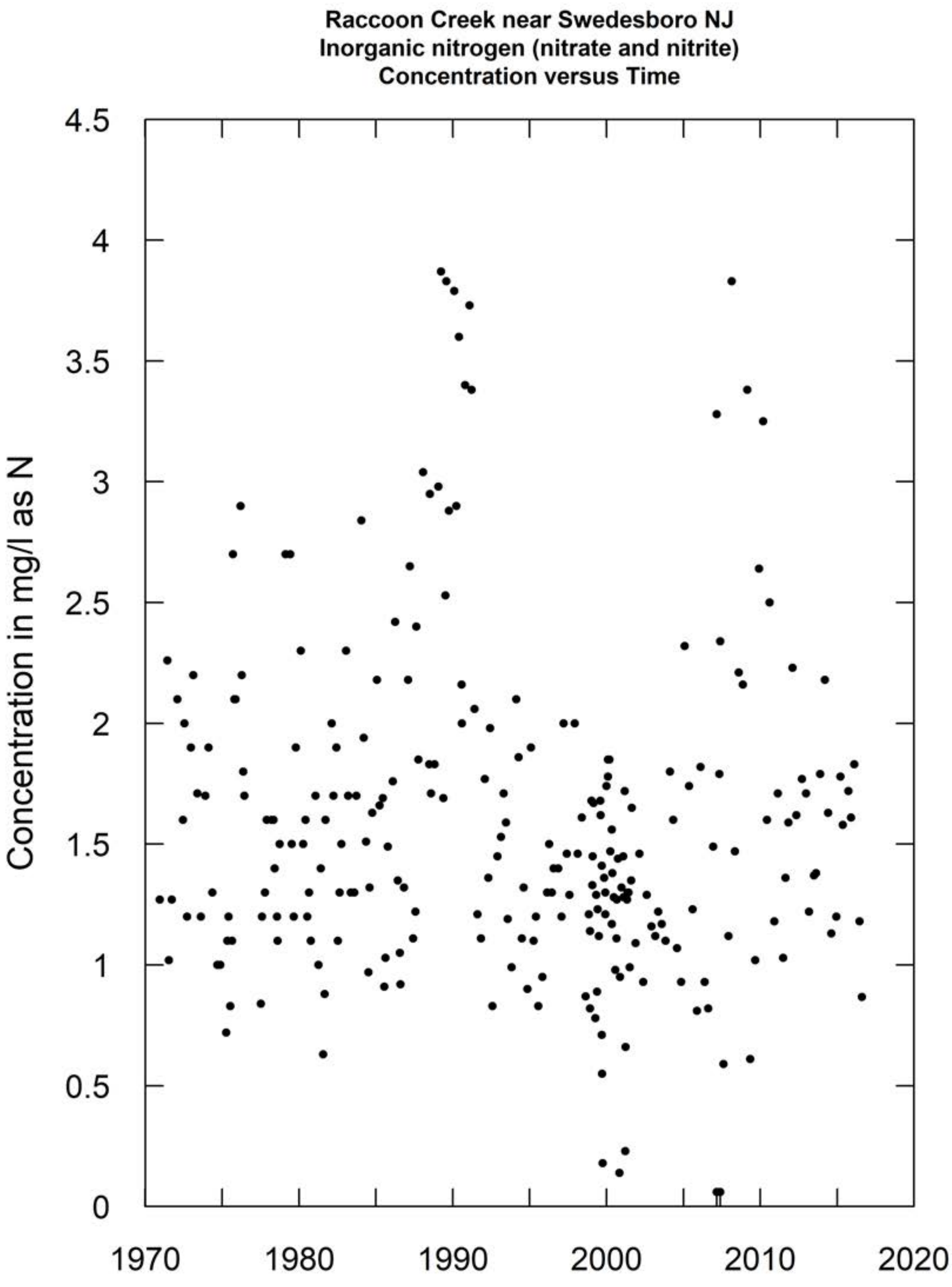

Delaware River at Trenton NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
80
70
60
50
40
30
20
10
0
1970
1980
1990
2000
2010
2020

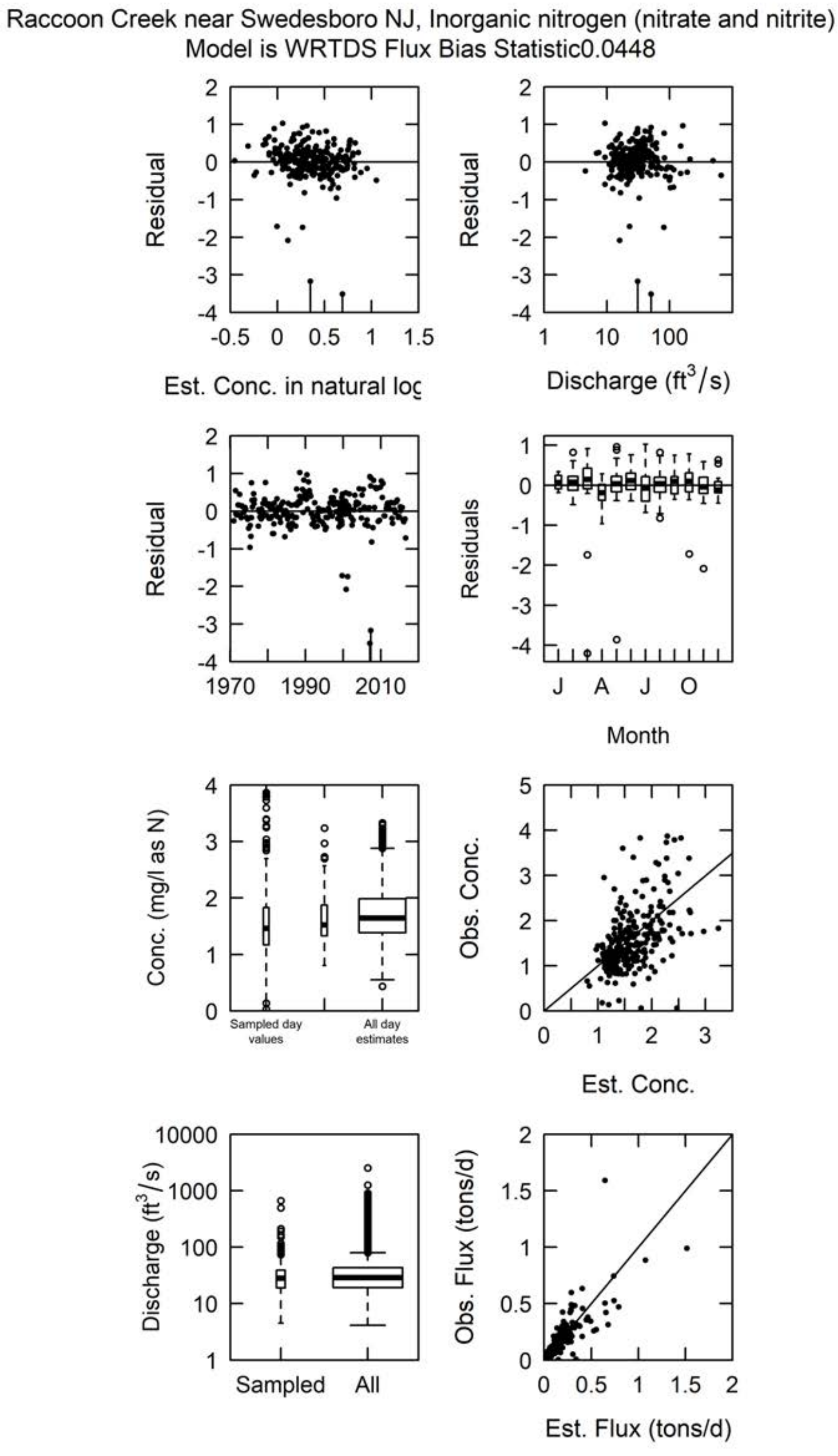

Delaware River at Trenton NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

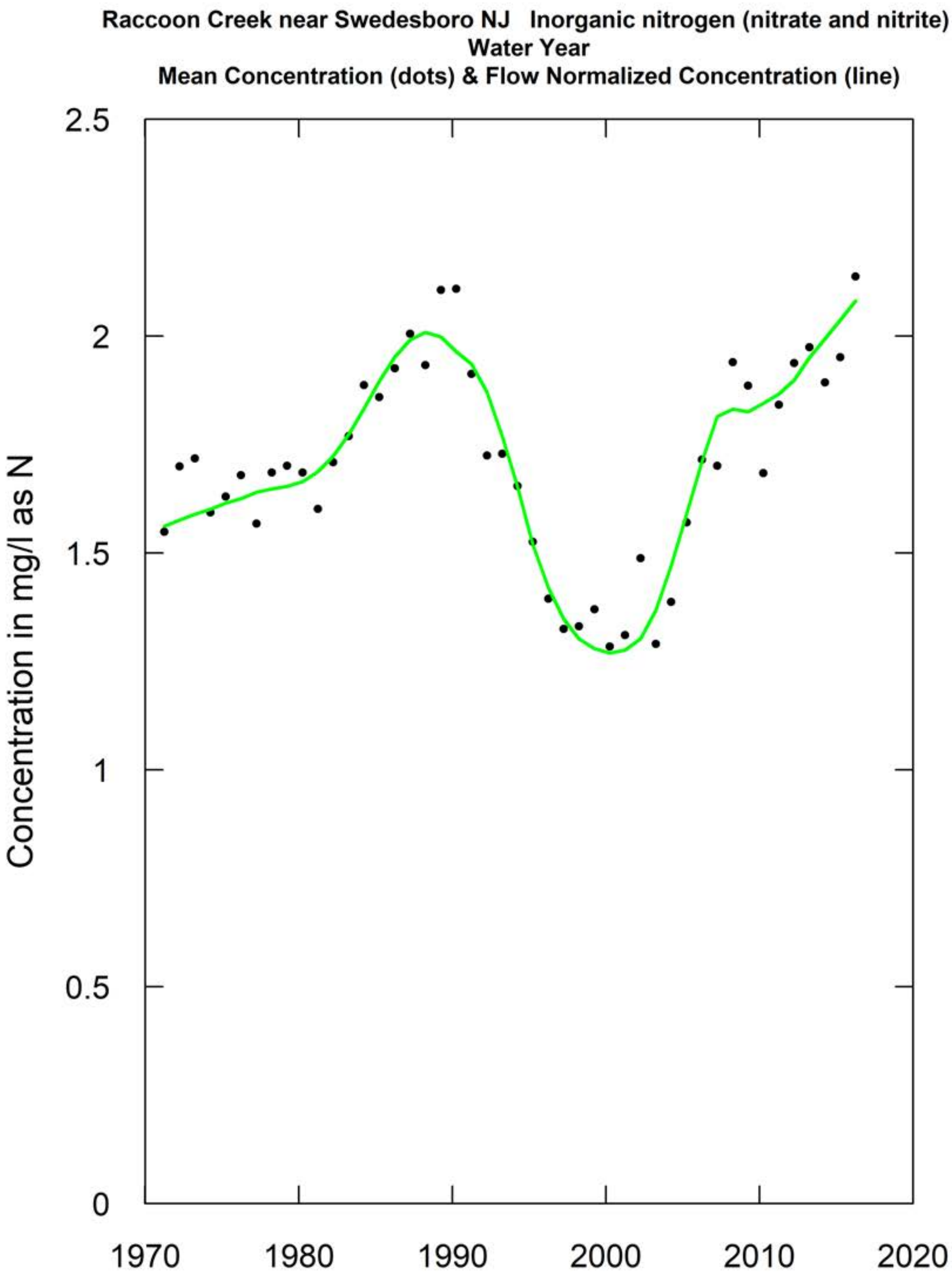

Delaware River at Trenton NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.0297
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

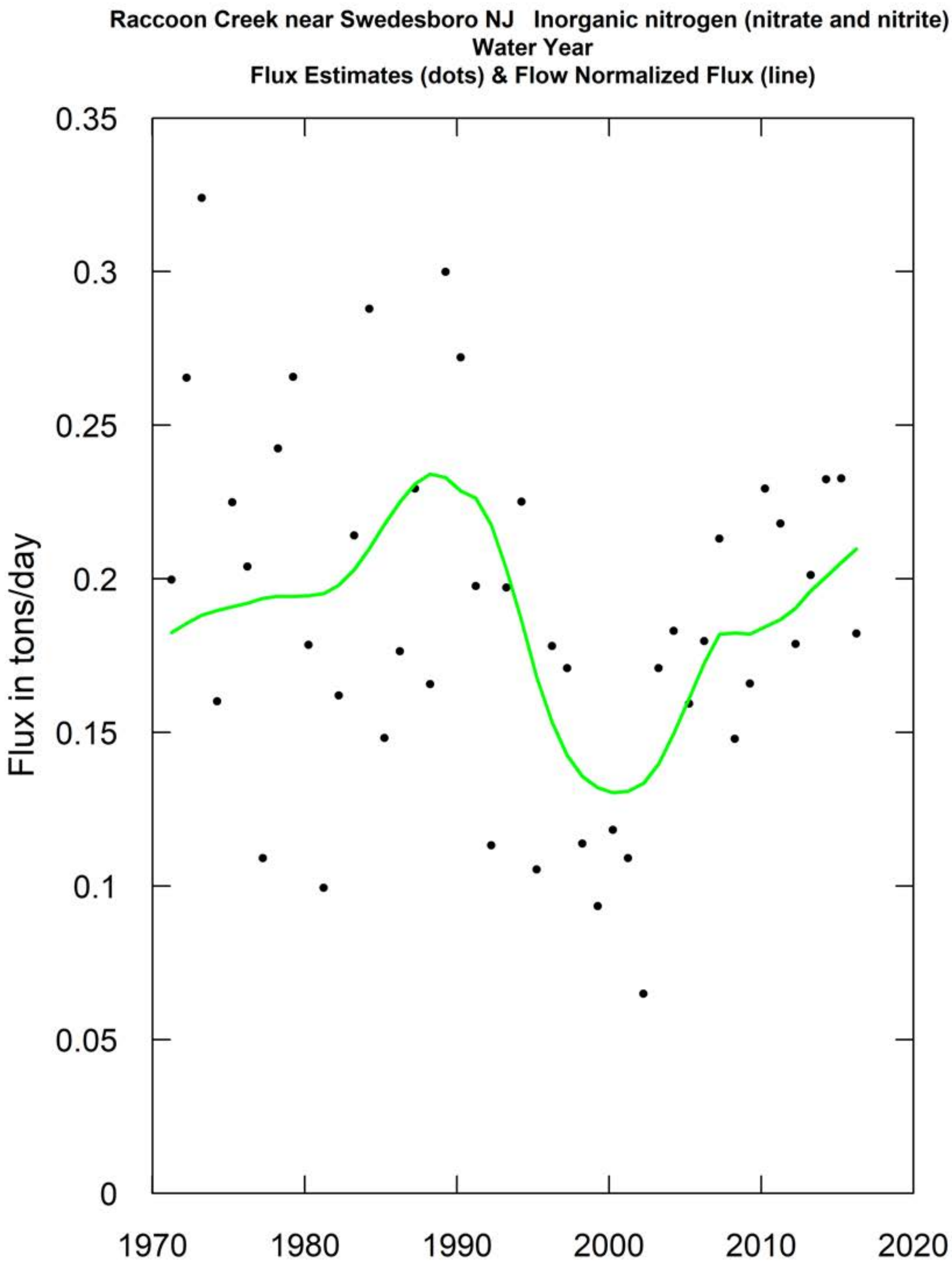

Delaware River at Trenton NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1970
1980
1990
2000
2010
2020

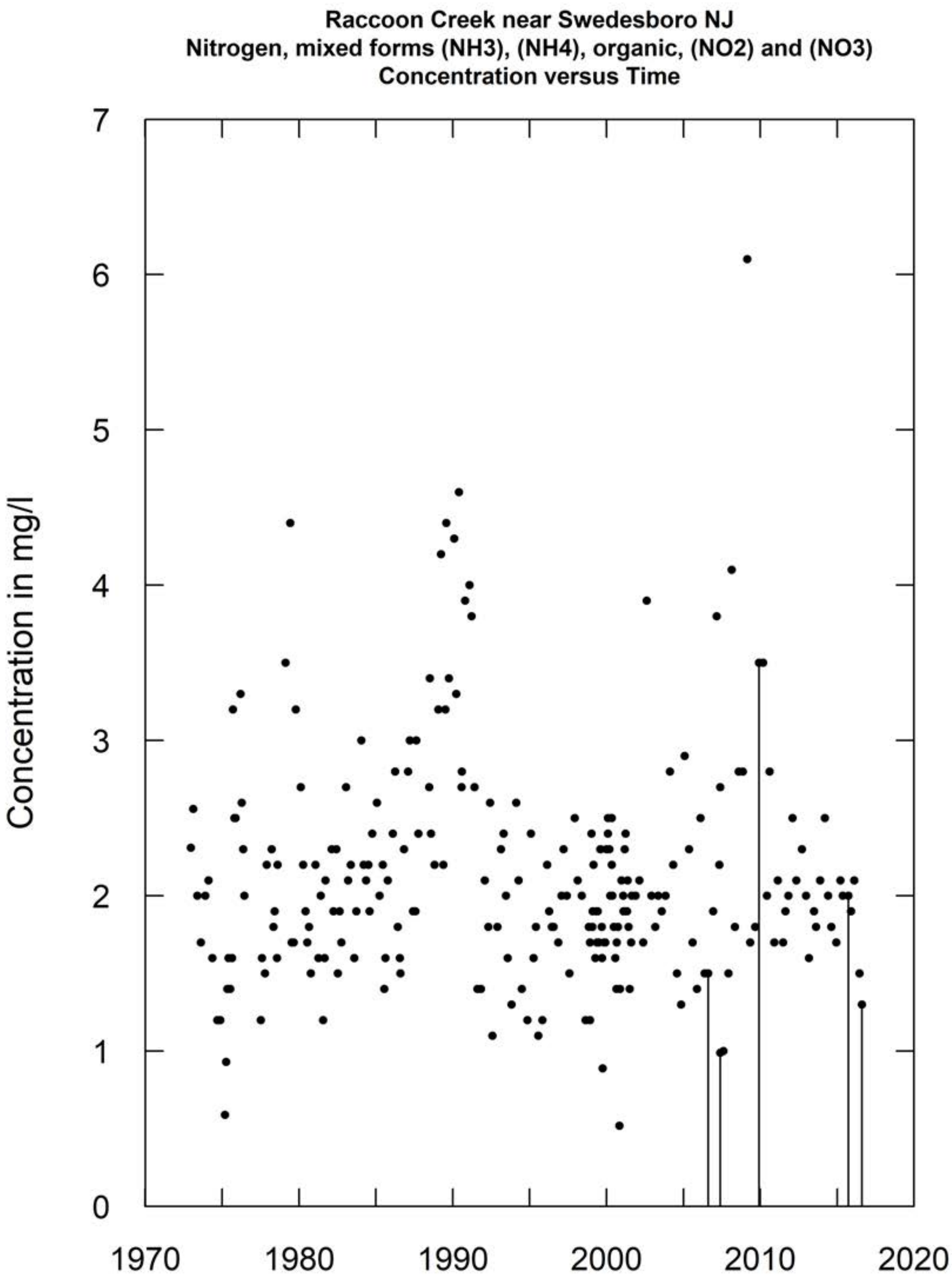

Delaware River at Trenton NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
9
8
7
6
5
4
3
2
1
0
1970
1980
1990
2000
2010
2020


Raccoon Creek near Swedesboro NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
1970
1980
1990
2000
2010
2020

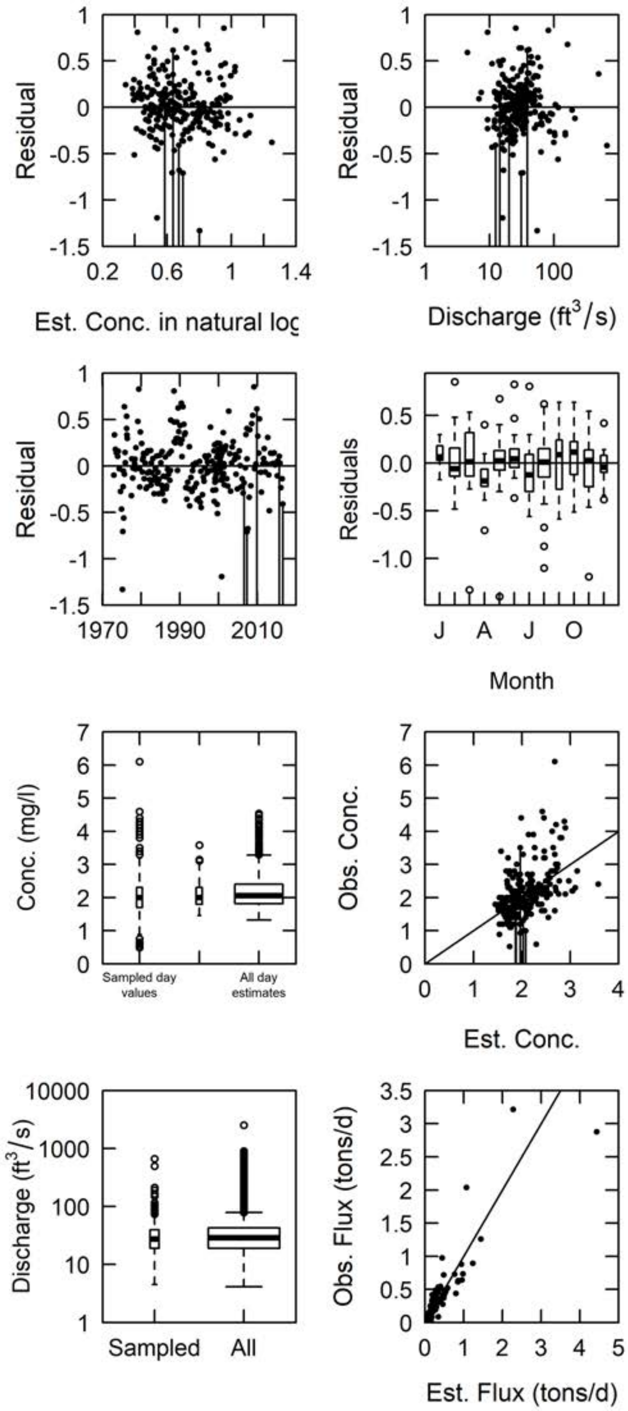

Raccoon Creek near Swedesboro NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.0448
Residual
Est. Conc. in natural log
Residual
Discharge (ft³/s)
Residual
Residuals
Month
J A J O
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

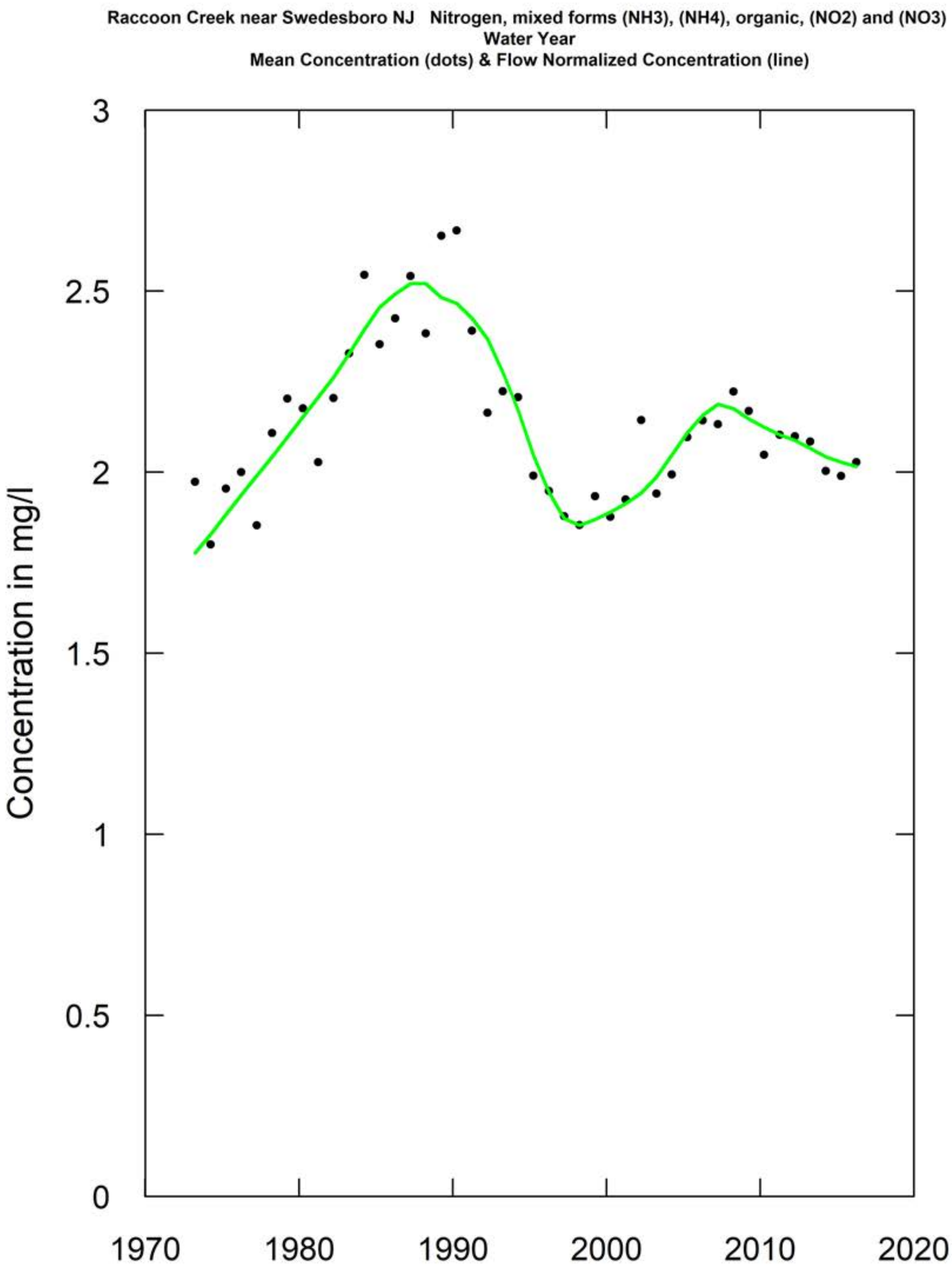

Raccoon Creek near Swedesboro NJ   Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

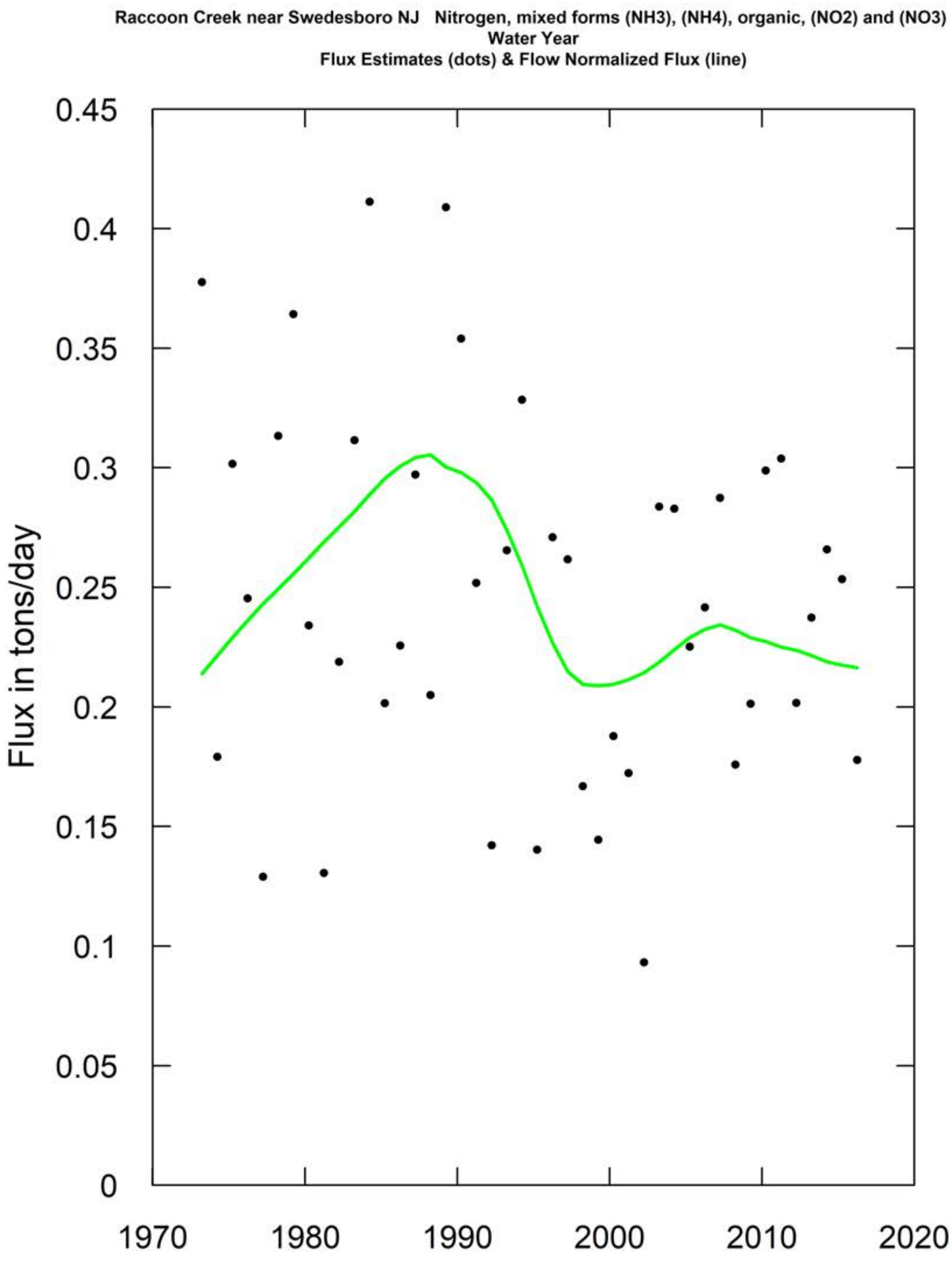

Raccoon Creek near Swedesboro NJ   Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

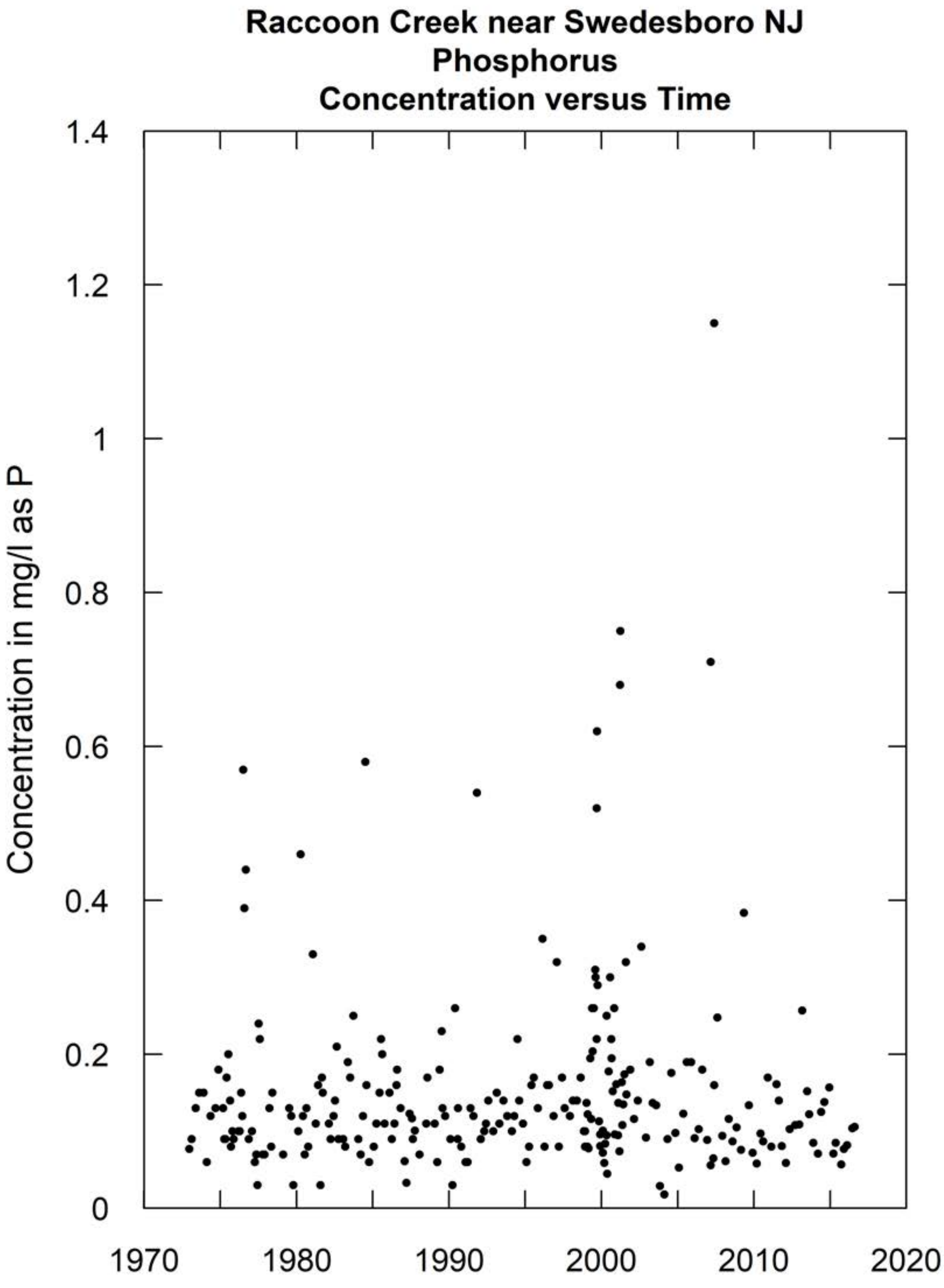

Raccoon Creek near Swedesboro NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
1
2
3
4
5
6
7
1970
1980
1990
2000
2010
2020

Raccoon Creek near Swedesboro NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.00956

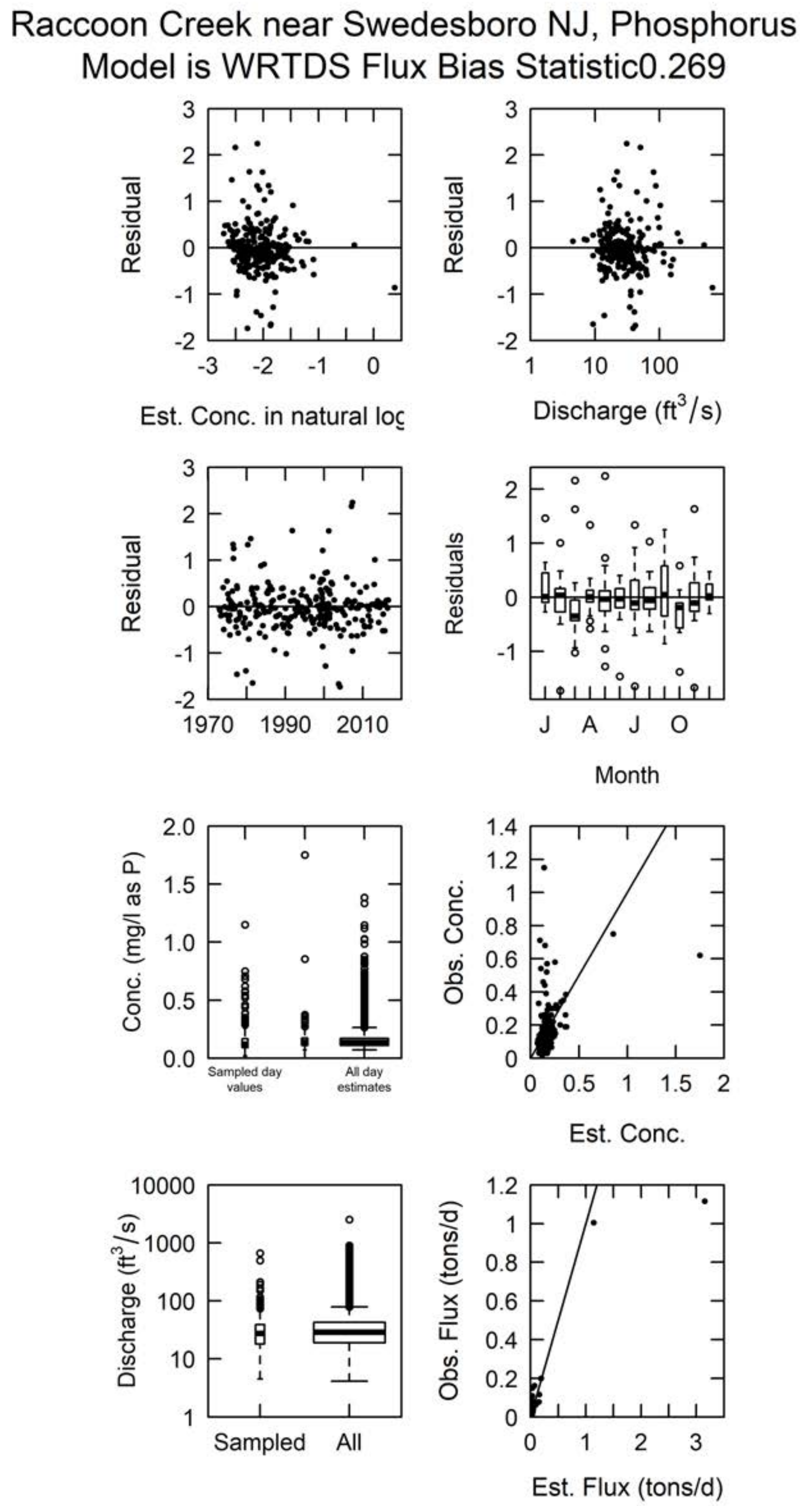


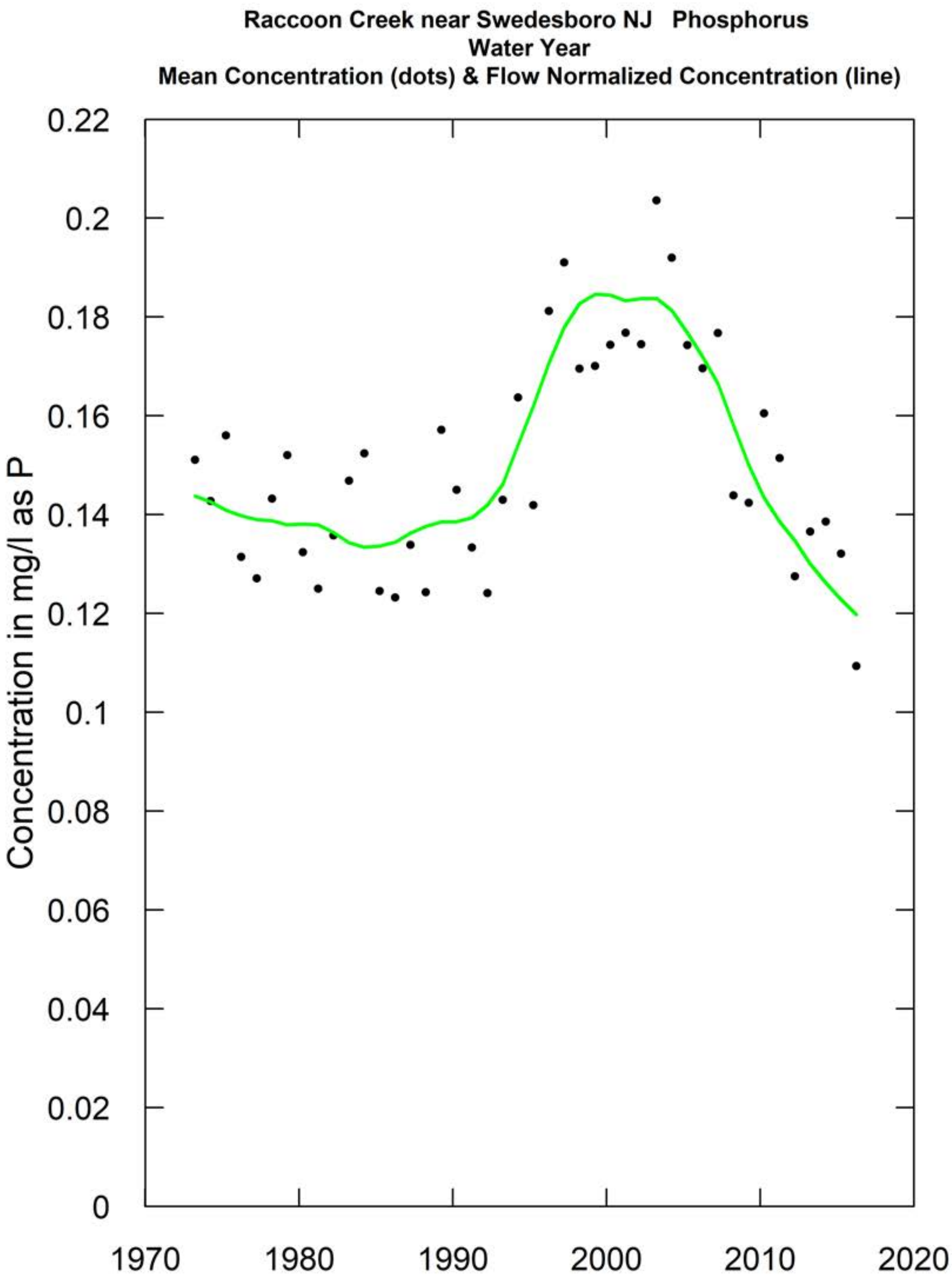

Raccoon Creek near Swedesboro NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
3
2.5
2
1.5
1
0.5
0
1970
1980
1990
2000
2010
2020

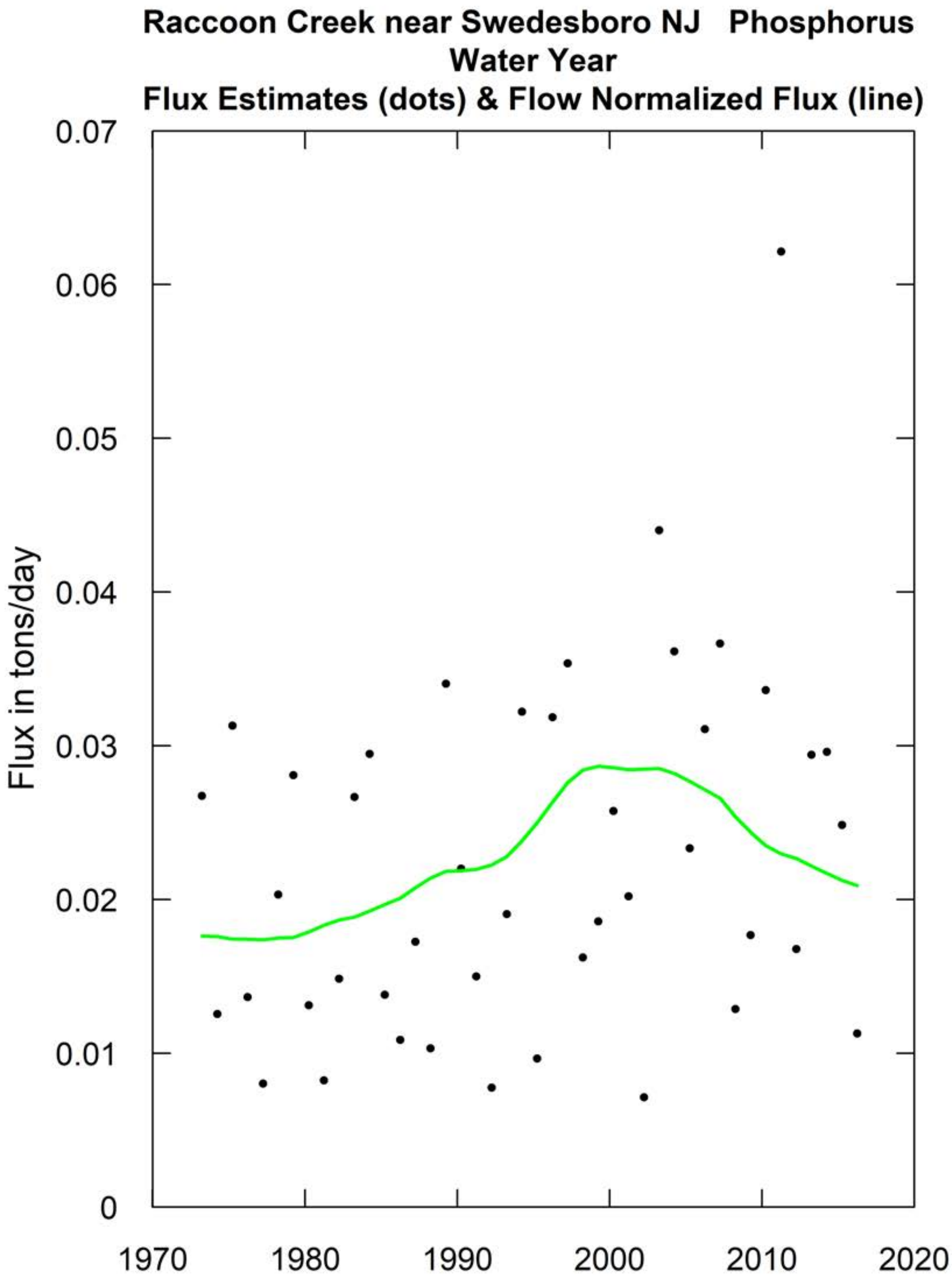

Raccoon Creek near Swedesboro NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

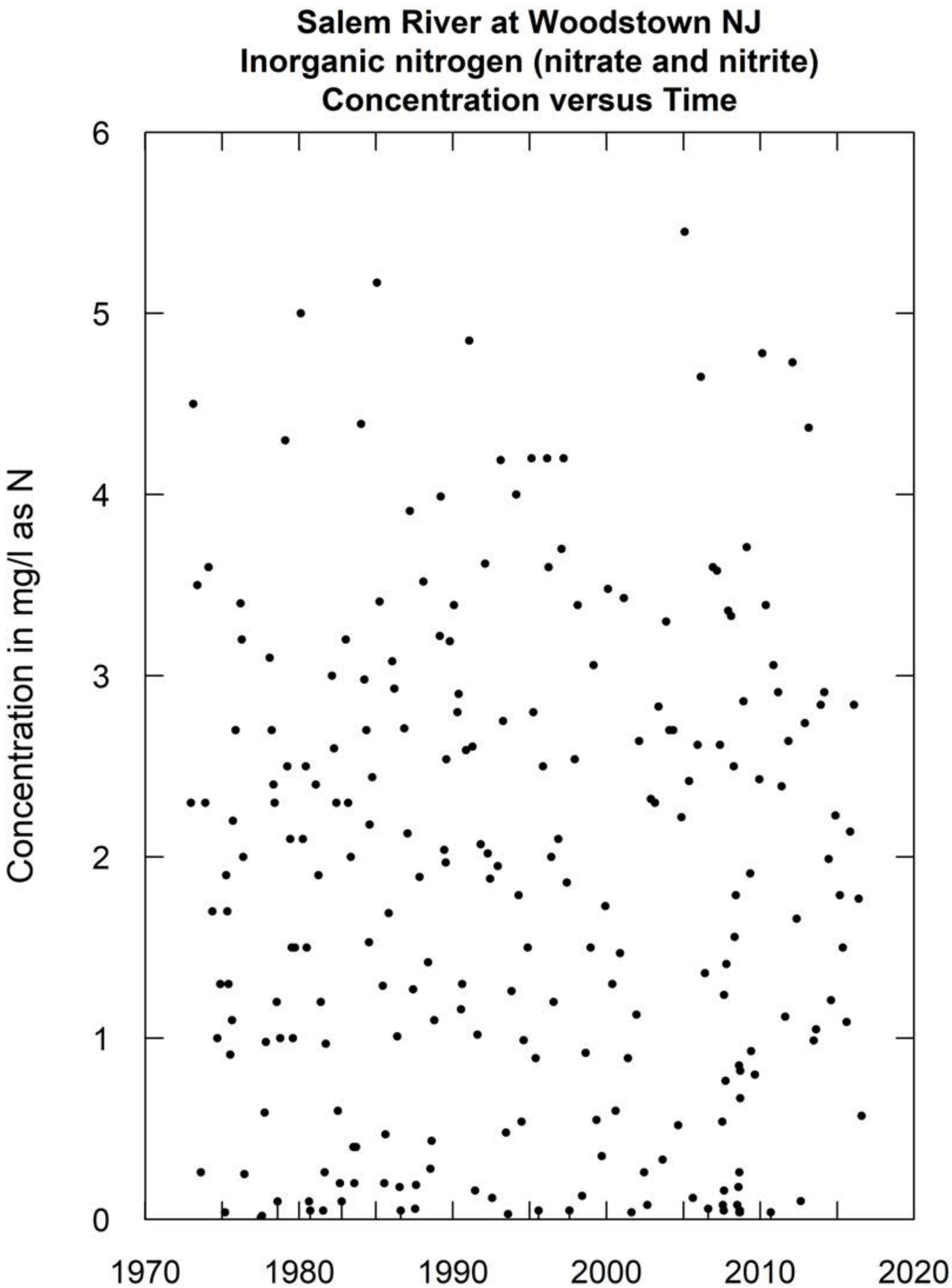


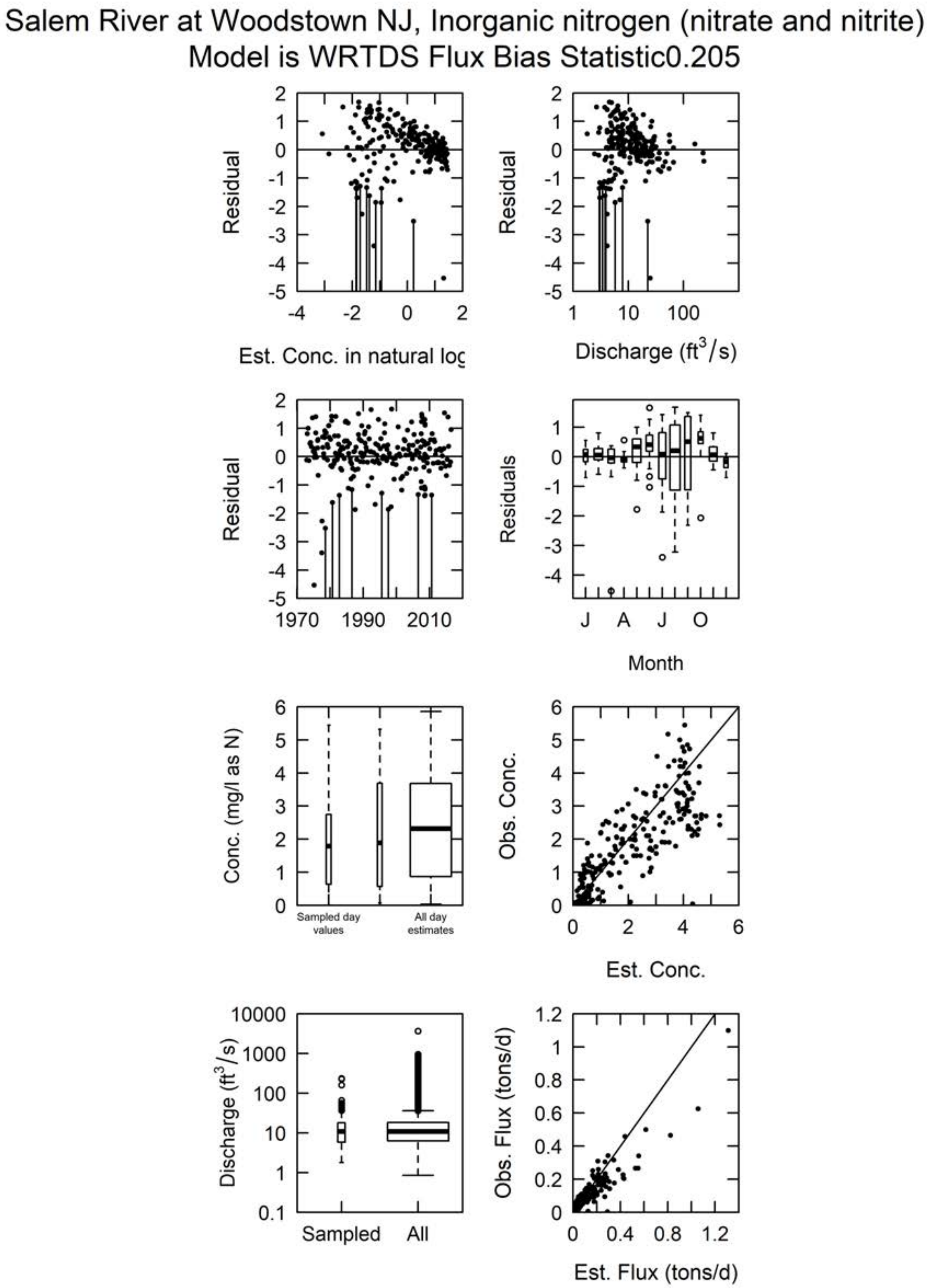
Raccoon Creek near Swedesboro NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1970
1980
1990
2000
2010
2020

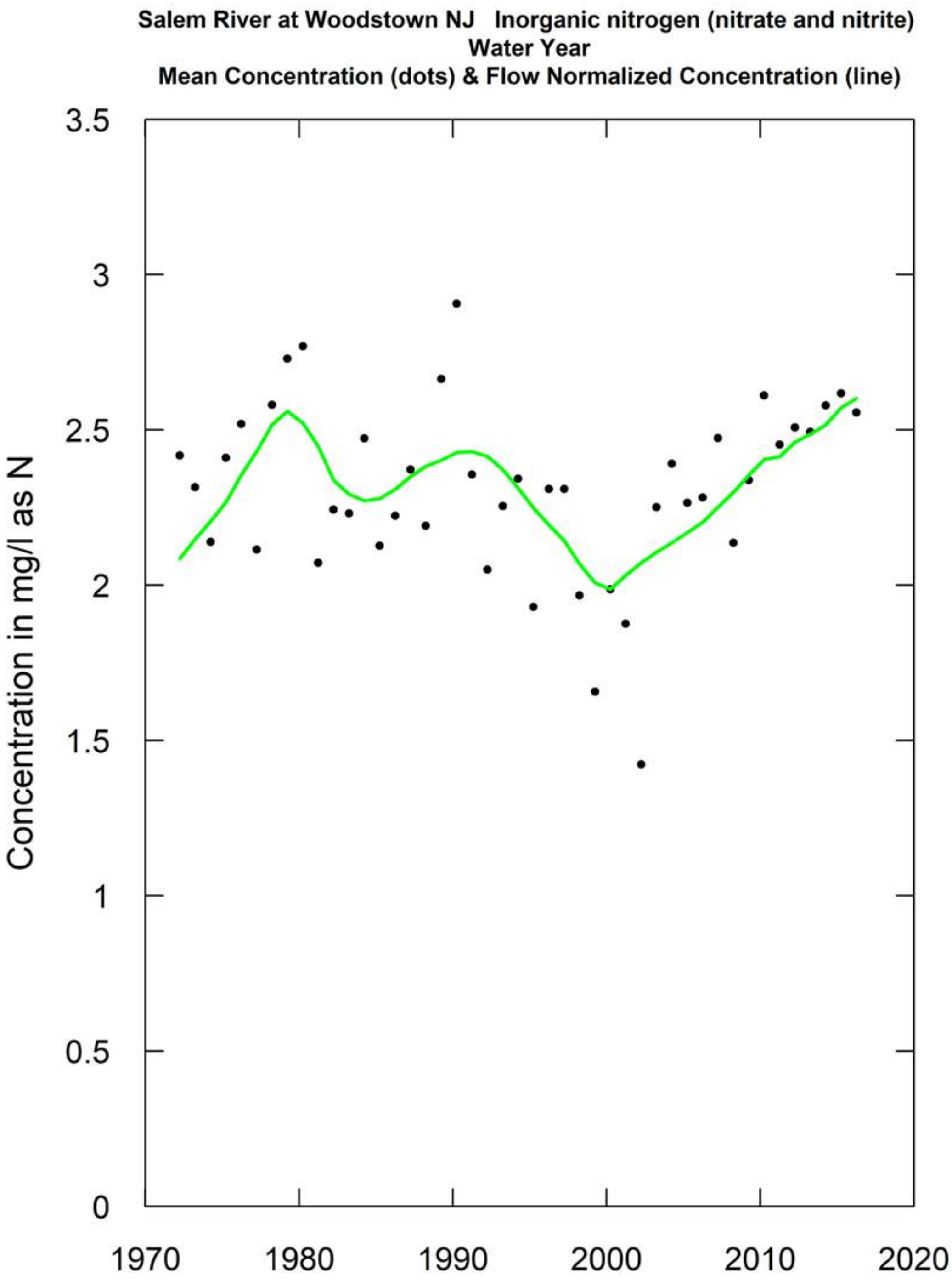

Raccoon Creek near Swedesboro NJ, Phosphorus
Model is WRTDS Flux Bias Statistic0.269
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
Residuals
Month
J A J O
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

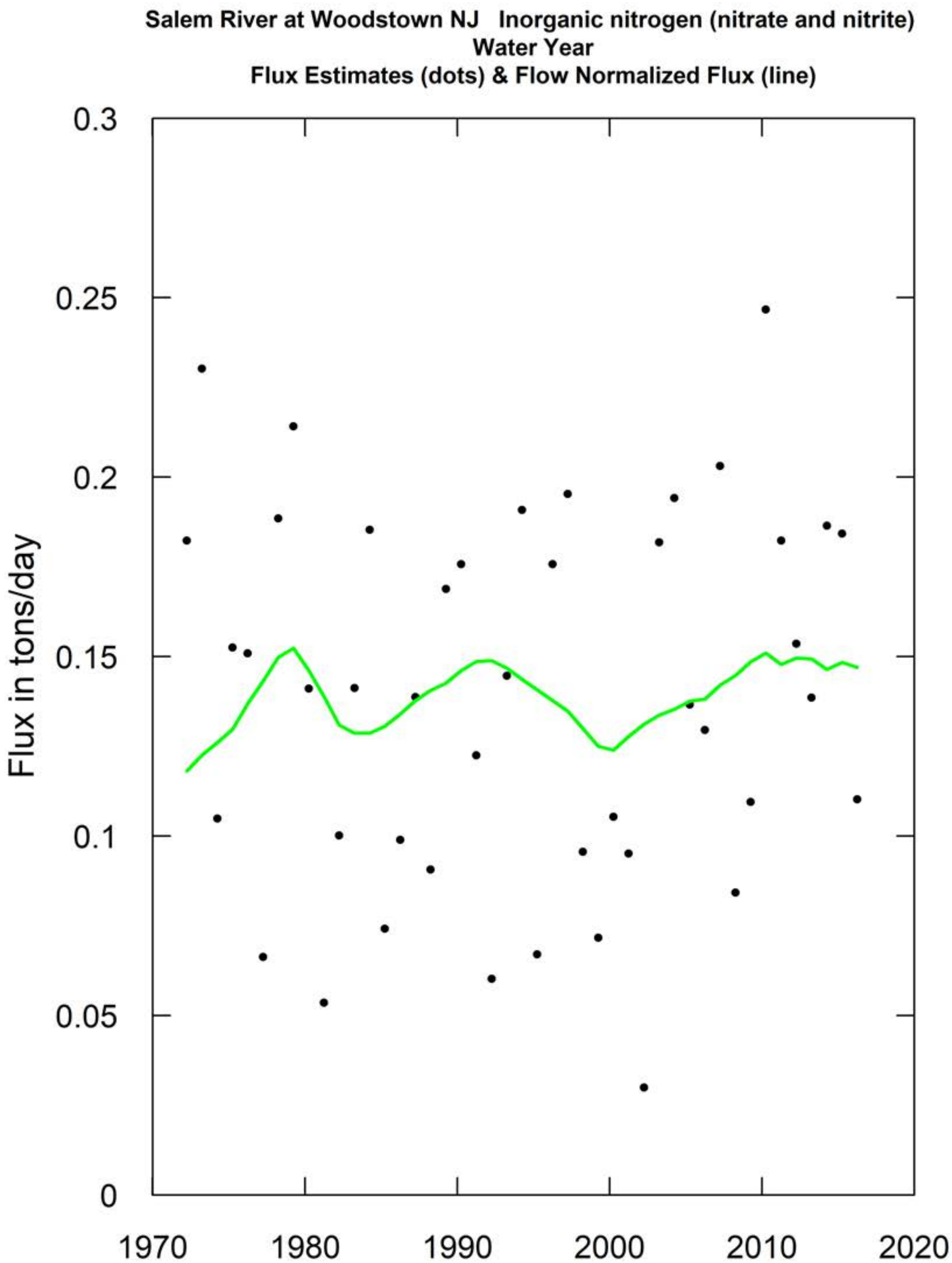

Raccoon Creek near Swedesboro NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1970
1980
1990
2000
2010
2020

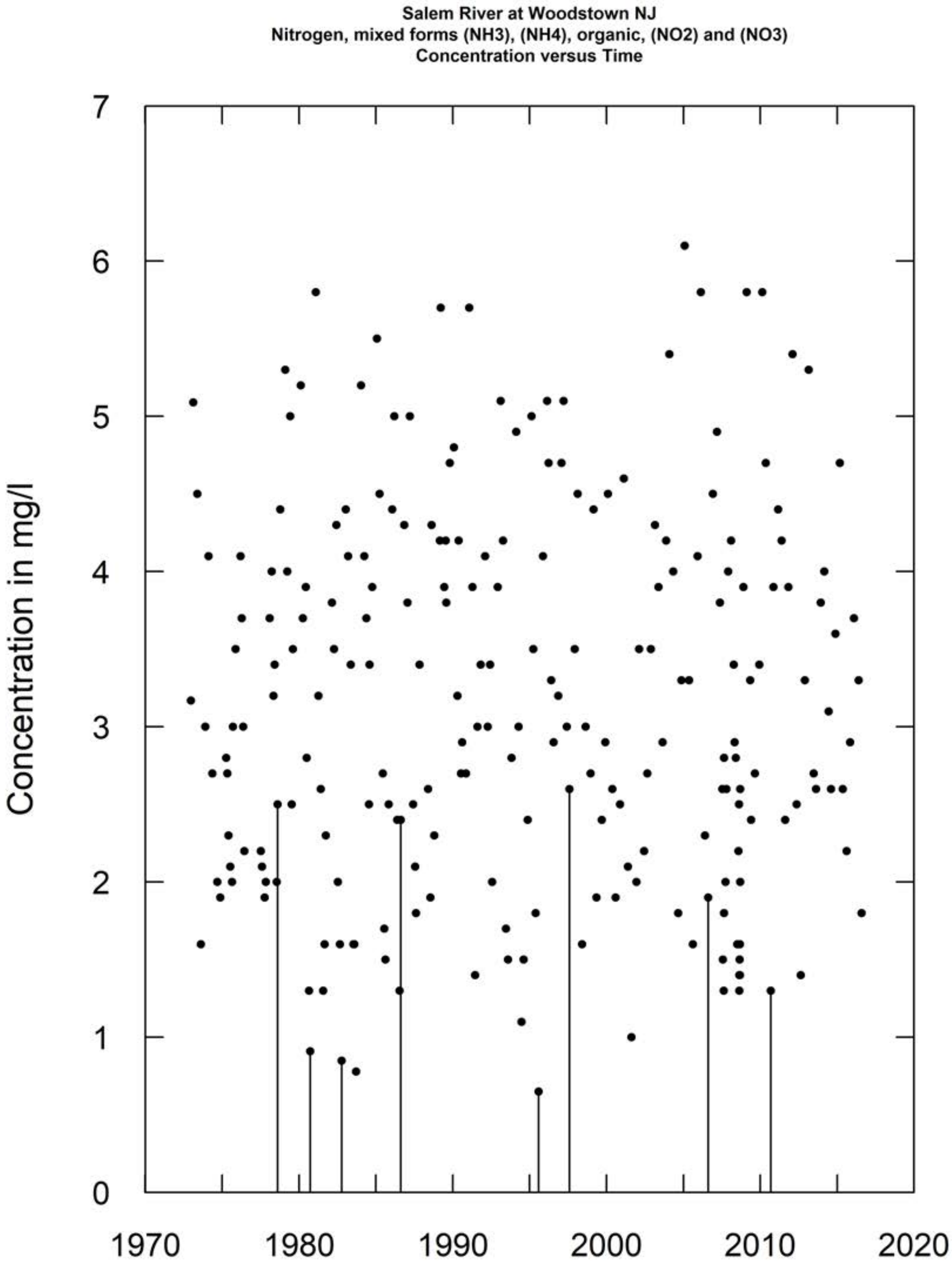

Raccoon Creek near Swedesboro NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1970
1980
1990
2000
2010
2020

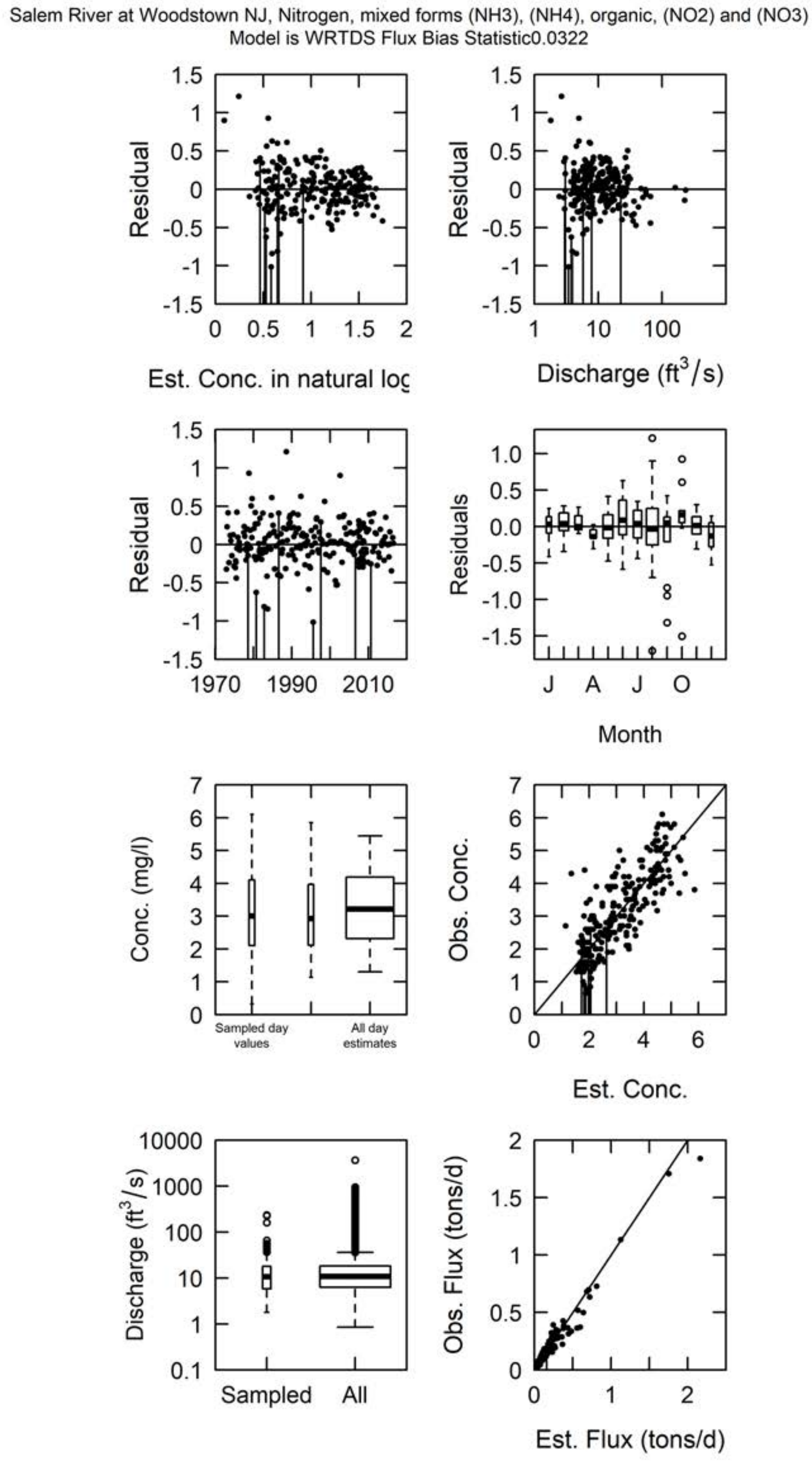

Salem River at Woodstown NJ
Inorganic nitrogen (nitrate and nitrite)
Concentration versus Time
Concentration in mg/l as N
0
1
2
3
4
5
6
1970
1980
1990
2000
2010
2020

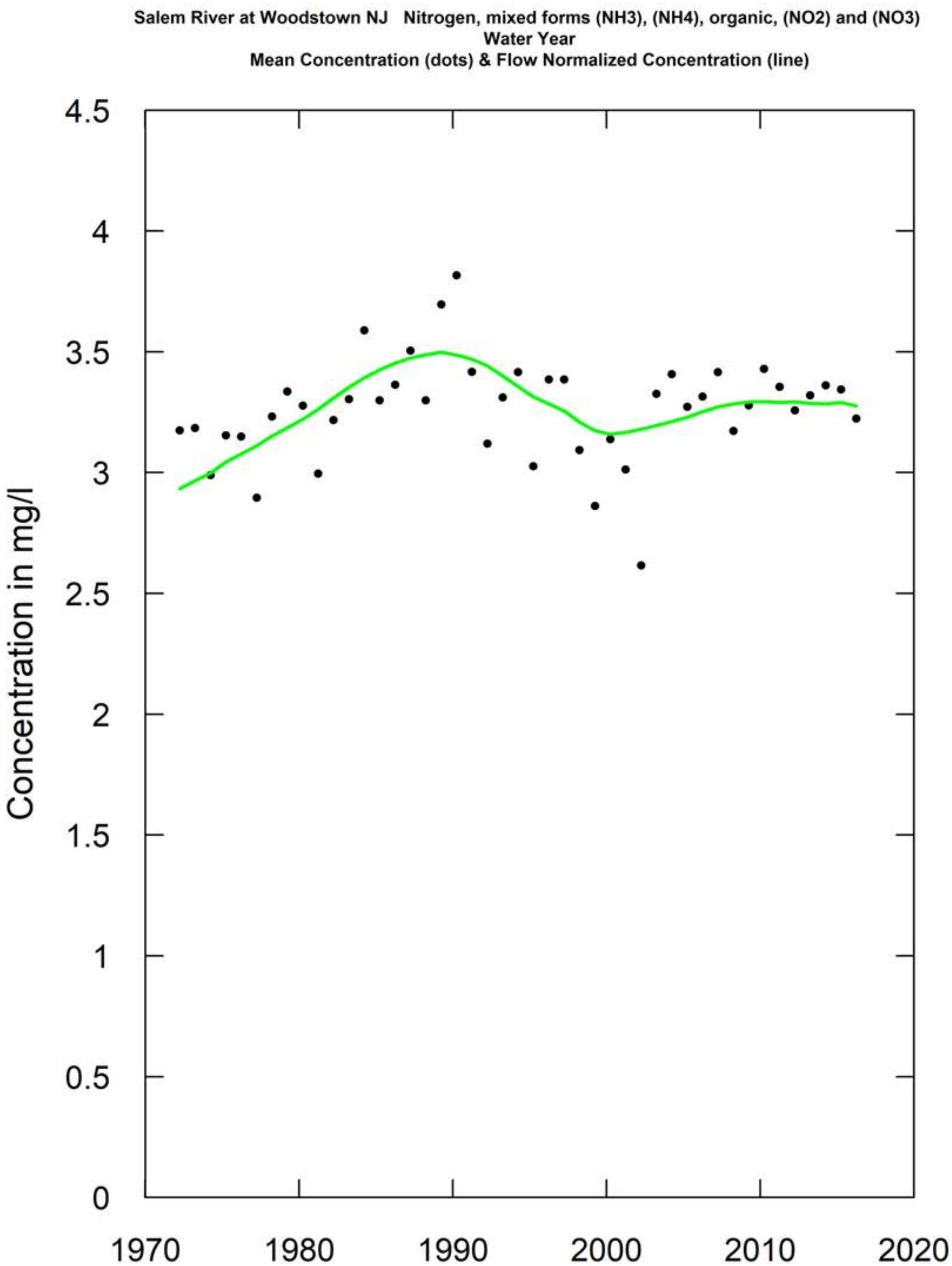

Salem River at Woodstown NJ, Inorganic nitrogen (nitrate and nitrite)
Model is WRTDS Flux Bias Statistic0.205
Residual
Est. Conc. in natural log
Discharge (ft^3/s)
1970
1990
2010
Residuals
J
A
J
O
Month
Conc. (mg/l as N)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft^3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

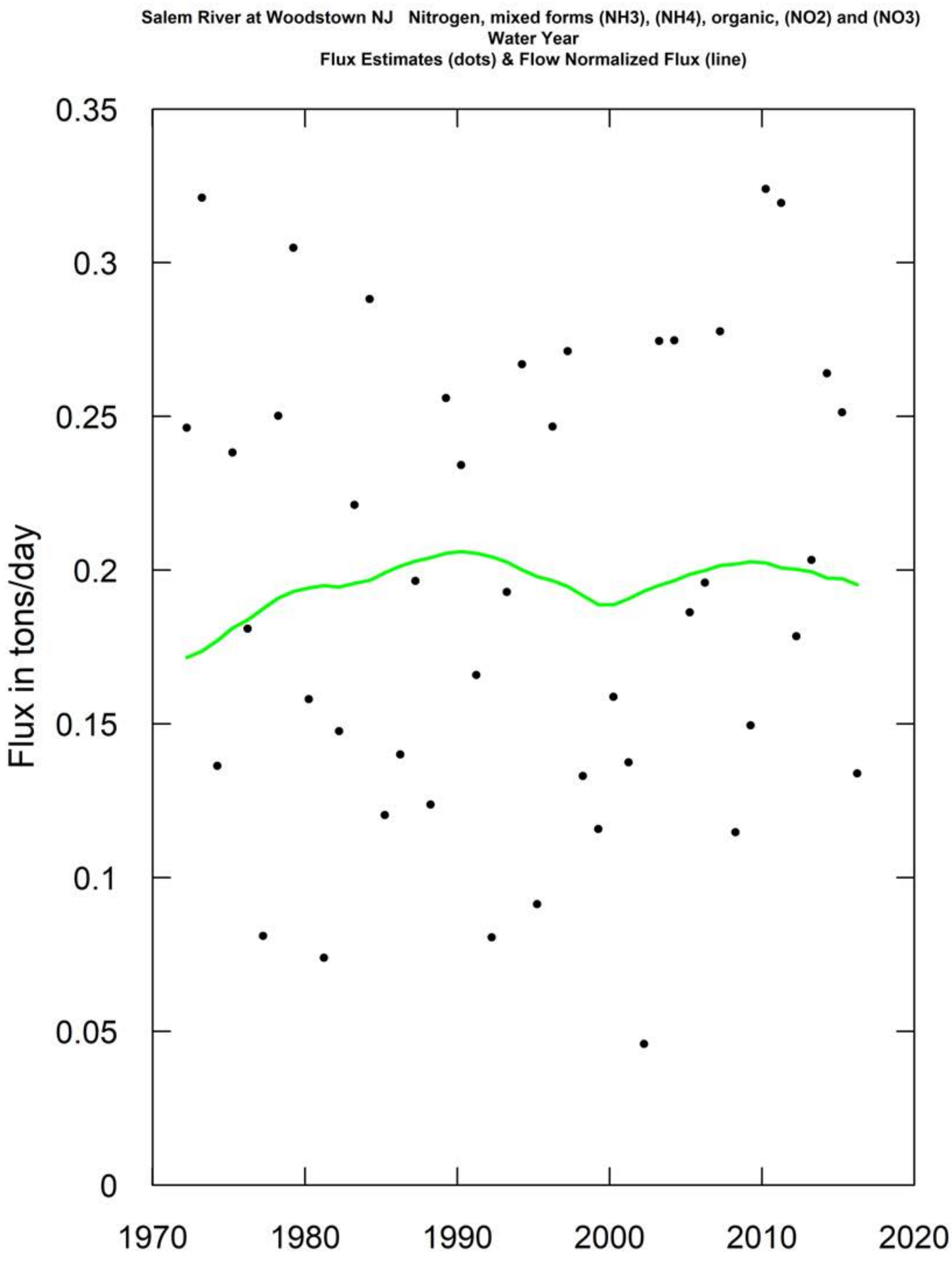

Salem River at Woodstown NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as N
0
0.5
1
1.5
2
2.5
3
3.5
1970
1980
1990
2000
2010
2020

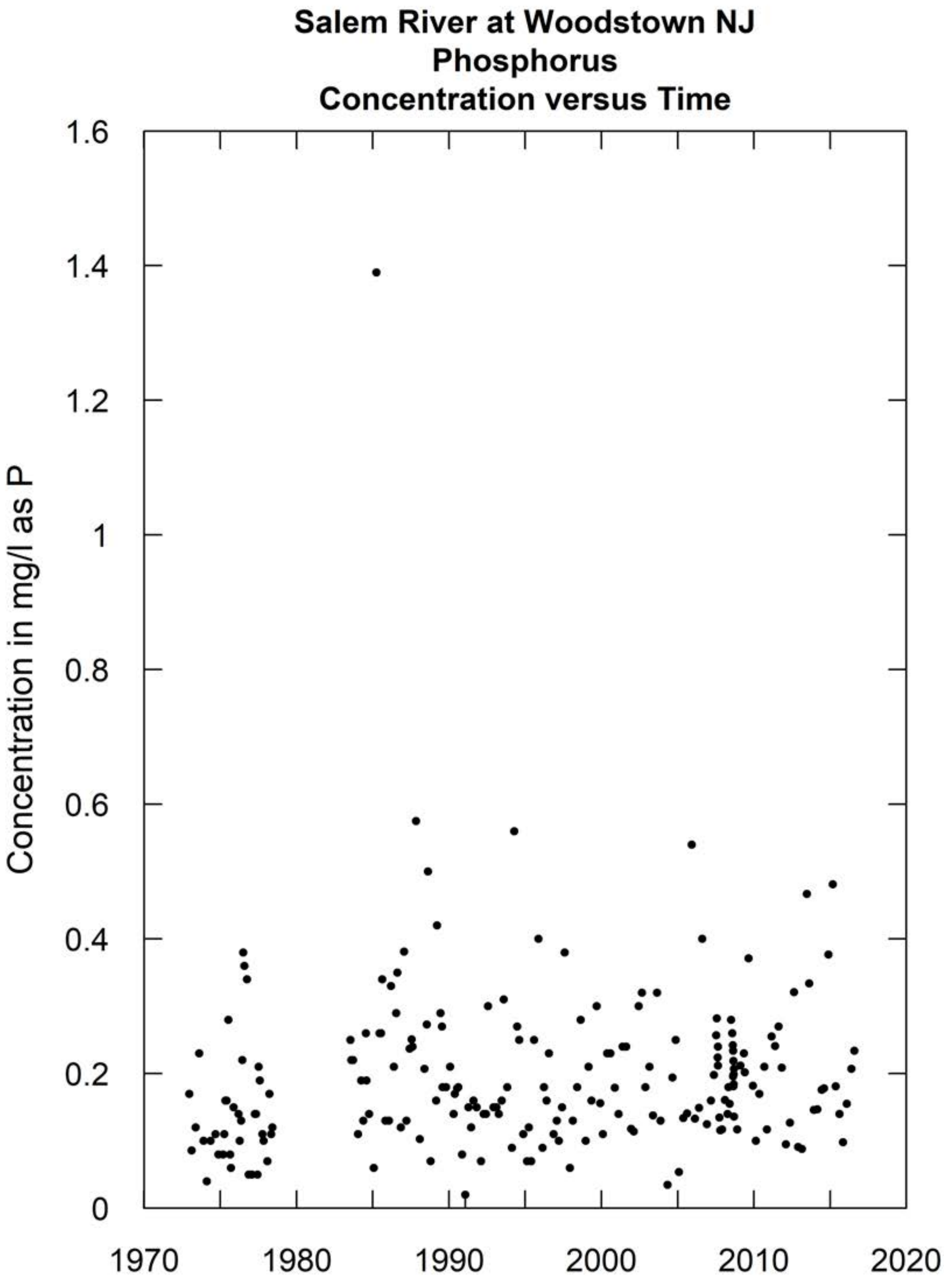

Salem River at Woodstown NJ Inorganic nitrogen (nitrate and nitrite)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020

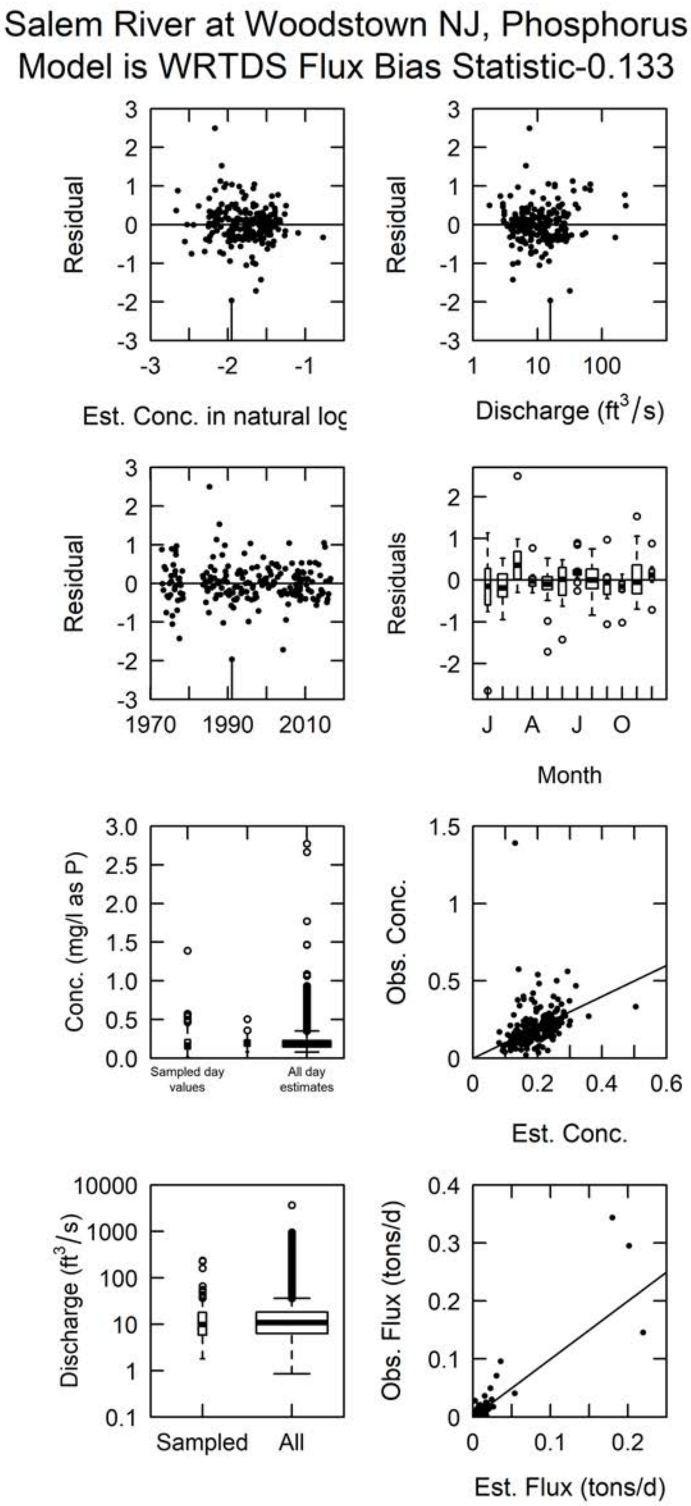

Salem River at Woodstown NJ
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Concentration versus Time
Concentration in mg/l
0
1
2
3
4
5
6
7
1970
1980
1990
2000
2010
2020

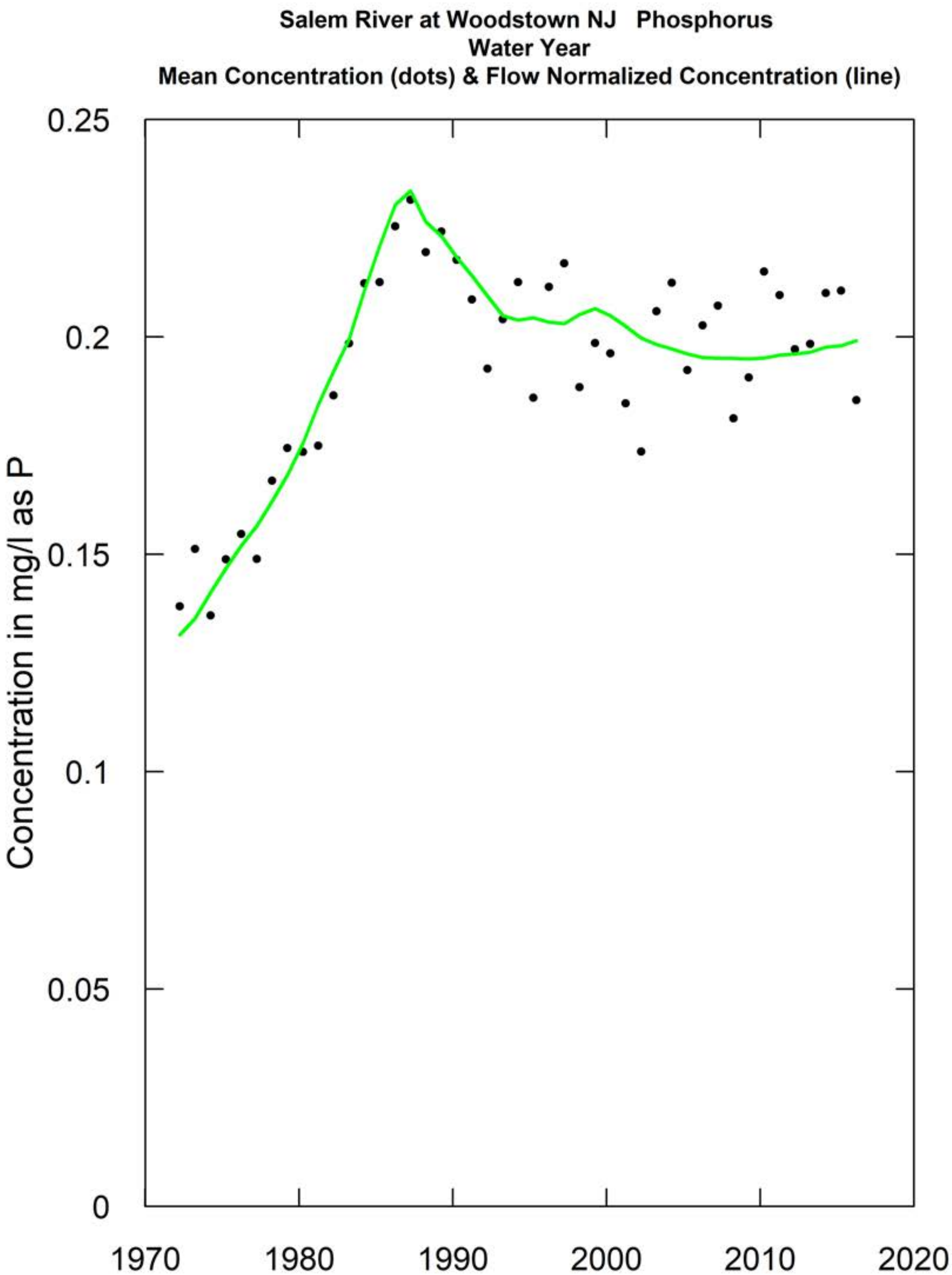

Salem River at Woodstown NJ, Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Model is WRTDS Flux Bias Statistic0.0322
Residual
Est. Conc. in natural log
Discharge (ft3/s)
Residuals
Month
J A J O
Conc. (mg/l)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft3/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)

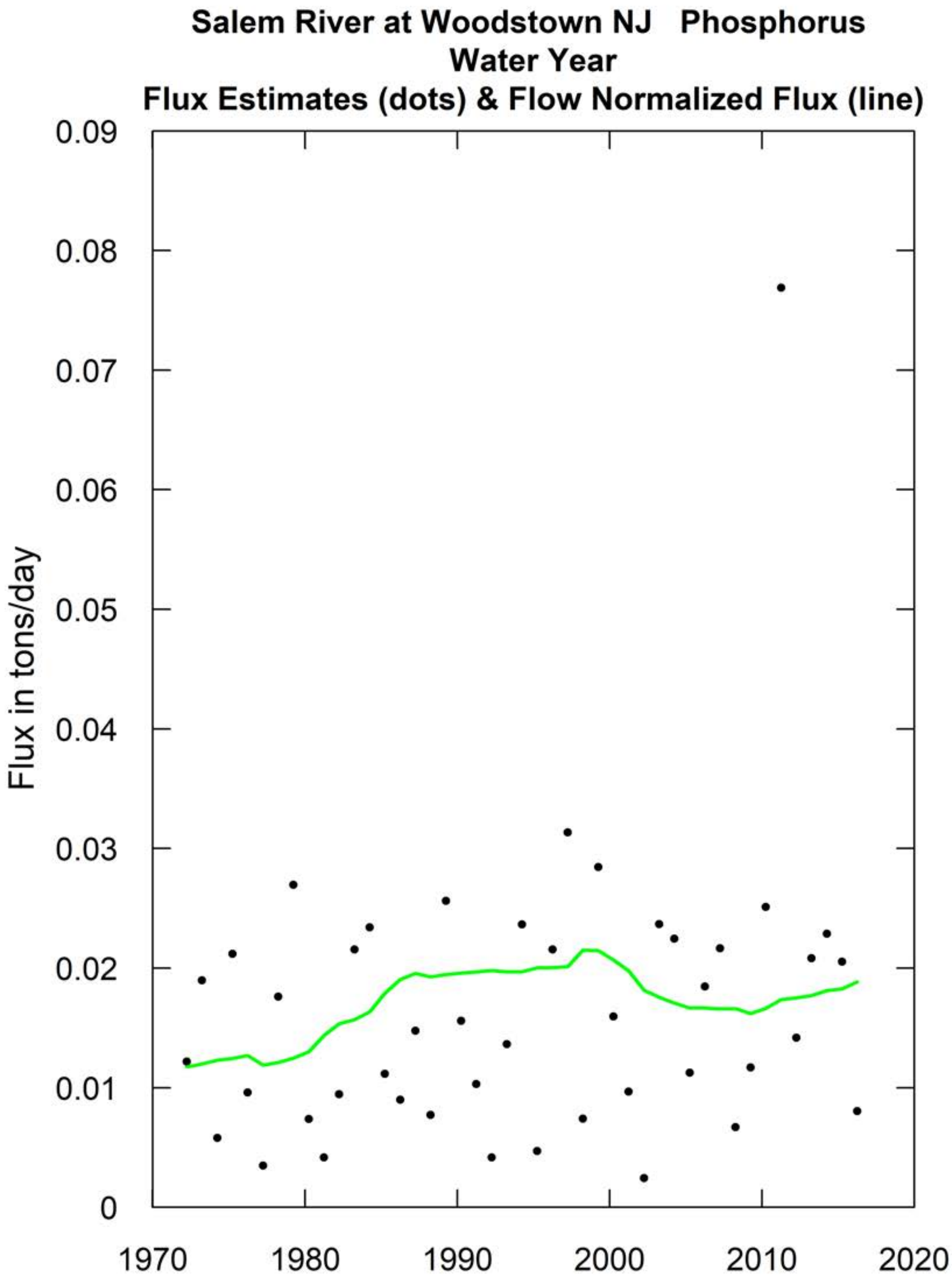

Salem River at Woodstown NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
1970
1980
1990
2000
2010
2020


Salem River at Woodstown NJ Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020


Salem River at Woodstown NJ
Phosphorus
Concentration versus Time
Concentration in mg/l as P
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1970
1980
1990
2000
2010
2020


Salem River at Woodstown NJ, Phosphorus
Model is WRTDS Flux Bias Statistic-0.133
Residual
Est. Conc. in natural log
Discharge (ft³/s)
Residuals
Month
Conc. (mg/l as P)
Sampled day values
All day estimates
Obs. Conc.
Est. Conc.
Discharge (ft³/s)
Sampled
All
Obs. Flux (tons/d)
Est. Flux (tons/d)


Salem River at Woodstown NJ Phosphorus
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l as P
0.25
0.2
0.15
0.1
0.05
0
1970
1980
1990
2000
2010
2020


Salem River at Woodstown NJ Phosphorus
Water Year
Flux Estimates (dots) & Flow Normalized Flux (line)
Flux in tons/day
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1970
1980
1990
2000
2010
2020