2015 NUTRIENTS AND SUSPENDED SEDIMENT IN THE SUSQUEHANNA RIVER BASIN

Publication No. 313 *May 18, 2017*

Kevin H. McGonigal
Environmental Scientist

James P. Shallenberger
Manager, Monitoring & Protection Program

This report is prepared in cooperation with the Pennsylvania Department of Environmental Protection, Bureau of Water Quality Protection, Division of Conservation Districts and Nutrient Management, under Grant ME4100064572.

SRBC
SUSQUEHANNA RIVER
BASIN COMMISSION
NY ■ PA ■ MD ■ USA

The Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact* among the states of Maryland and New York, the Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development, and control of Basin water resources among the public and private sectors.

**Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December 1970); Maryland - Natural Resources Sec. 8-301 (Michie 1974); New York - ECL Sec. 21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).*

This report is available on our web site (www.srbc.net) by selecting Public Information/Technical Reports. For a CD or hard copy, contact the Susquehanna River Basin Commission, 4423 N. Front Street, Harrisburg, Pa. 17110-1788, Phone: (717) 238-0423, Fax: (717) 238-2436, E-mail: srbc@srbc.net.

TABLE OF CONTENTS

SUMMARY 1
KEY FINDINGS 1
BACKGROUND 2
WATER SAMPLE COLLECTION 8
LABORATORY ANALYSIS 9
HYDROLOGIC DATA: PRECIPITATION 10
HYDROLOGIC DATA: DISCHARGE (FLOW) 11
2015 PRECIPITATION AND DISCHARGE 11
DATA REDUCTION 12
    Concentrations, Estimated Loads, and Estimated Yields 13
    Long-Term Mean Ratio 14
    Distributed Targets 15
    Trends 16
    Adjustments for Flow and Season 17
    Colorized Heat Charts 18
2015 RESULTS 23
DISCUSSION 24
DISTRIBUTED LOADS 34
KEY POLLUTANT: SUSPENDED SEDIMENT 38
CONCLUSION 40
REFERENCES 42

FIGURES

Figure 1. Locations of Sampling Sites Within the Susquehanna River Basin 6
Figure 2. Conceptual Storm Hydrograph and Group A and Group B Storm Sampling Targets 8
Figure 3. Precipitation and Average Daily Flow (ADF) Seasonal and Annual Statistics for 2015 and the Approximately 30-year Long-term Mean for Group A NTN Monitoring Stations in the Susquehanna River Basin 12
Figure 4. Comparison of Total Nitrogen Yield (left) and Load (right) for the Marietta and Conestoga Stations 14
Figure 5. 2015 Annual Pollutant Loads and Discharge for Group A NTN Monitoring Stations as Fractions of the Long-Term Mean 15
Figure 6. Annual and Mean Discharge Susquehanna River at Marietta in Cubic Feet/Second (cfs) . 24
Figure 7. Peak Discharge Susquehanna River at Marietta in Cubic Feet/Second (cfs) 24
Figure 8. Annual Pollutant Loads and Peak Annual ADF in Chronological Order from 1999 to 2015 for Marietta Station 25
Figure 9. 2015 and LTM TN, TP, and SS Yields at All Sites in Pounds Per Acre 29
Figure 10. Long-term FNC and FNF Trend Directions at Group A Sites 32
Figure 11. Short-term FNC and FNF Trend Directions at All Sites 33
Figure 12. 2015 and LTM TN, TP, and SS Yields and 2025 Targets at All Sites in Pounds Per Acre 36
Figure 13. Small Tributary Monitoring Locations 40

TABLES

Table 1. Data Collection Sites and Their Drainage Areas and 2000 Land Use Percentages 7
Table 2. Water Quality Parameters, Laboratory Methods, and Detection Limits 10
Table 3. TN, TP, and SS loads (1000’s of pounds) at Towanda, Danville, and Marietta 15
Table 4. 2017 and 2025 Loads (1000’s of lbs) and Yield (lb/ac) Targets, (BayTas 2.0) for the Susquehanna River Basin 16
Table 5. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together .. 19
Table 6. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together .. 20
Table 7. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together .. 21
Table 8. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together .. 22
Table 9. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together .. 23
Table 10. Loads of TN, TP, and SS during Two Four-Year Low Flow Periods at Marietta 25
Table 11. Suspended Sediment Loads at Susquehanna River Sites 26
Table 12. SS Colorized Heat Chart at Danville 27
Table 13. Select Monthly Discharge and Load Ratios 28
Table 14. Flow, TN, TP, and SS Loads (1000’s of pounds) for 2015 and Similar Flow Years 28
Table 15. Monthly Precipitation, Flow, and Suspended Sediment Loads at Marietta 30
Table 16. Short-term Flow Normalized Trend Percent Change at All Sites by Subbasin 31
Table 17. 2015 10-year Average, and 2025 Distributed Loads (1000’s of lbs) for all Sites 35
Table 18. Annual Reductions Needed (1000’s of Pounds) to Attain 2025 Target Levels at All Sites 37
Table 19. Monthly Reductions Needed (1000’s of Pounds) to Attain 2025 Target Levels at Group A Mainstem Susquehanna 37
Table 20. Monthly Reductions Needed (1000’s of Pounds) to Attain 2025 Target Levels at Group A Tributary Sites 38
Table 21. Potential Load Reductions (1000’s of Pounds) in the Lower Susquehanna Subbasin 38

APPENDICES

Appendix A. Summary Statistics 44
Appendix B. Individual Long-Term Site Data 50
Appendix C. Individual Enhanced Site Data 120

SUMMARY

2015 nutrient and suspended sediment (SS) samples were collected at 26 stations across the Susquehanna River Watershed including both monthly and storm samples to fully represent variations in flow. Samples were vertically and horizontally integrated across the water column and composited into one sample to ensure a representative sample was collected. Samples were analyzed for various nitrogen (N) and phosphorus (P) forms, total organic carbon (TOC), total suspended solids (TSS), and SS.

Data were used to calculate nutrient and sediment loads, also called flux or fluxes and Flow Normalized Concentration (FNC) and Flow Normalized Flux (FNF) trends using Weighted Regressions on Time, Discharge, and Season (WRTDS) (Hirsch et al., 2010). Results for annual, seasonal, and monthly loads were reported and compared to long-term means (LTM) to identify changes through time.

2015 was the fourth year of below average flows in the watershed. Additionally, no storms surpassed 200,000 cubic feet per second (cfs) at Marietta with the highest being 173,000 cfs. The average annual peak flow during this sampling program at Marietta is 284,967 cfs, with the highest single peak occurring on September 9, 2011, at 665,000 cfs. 2015 flows ranged from 73 percent of the LTM at Newport to 100 percent of the LTM at Danville. Low flows resulted in nutrient and SS loads being below LTMs at all sites.

LTM TN yields were ranked in decreasing order with the lower Susquehanna Basin having the top eight yield sites. LTM TP yields were highest at Pequea, Conestoga, and Octoraro followed by Wilkes Barre. Highest LTM SS yields were found at Pequea followed by the mainstem Susquehanna sites at Danville, Wilkes Barre, and Towanda.

Long-term trends for TN and TP were all downward at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga. SS was downward at all of those sites except Danville, which had upward trends.

Short-term trends (approximately most recent 10 years) at 22 sites included 17 downward trends for TN and TP and 13 downward trends for SS. The mainstem Susquehanna at Wilkes Barre had upward trends for all three parameters. Five of eight sites in the lower Susquehanna had an upward trend in at least one parameter with Pequea and Swatara both having upward trends in TP and SS.

KEY FINDINGS

- **Hydrology** is the primary near-term driver of Susquehanna River Basin (SRB) pollutant loads – if annual average daily flow (ADF) is below normal, then annual pollutant loads typically are also below normal.
- In 2015, annual pollutant loads were among the smallest since measurements began in the 1980s – annual ADF generally was in the lowest third of recorded observations.
- Long-term seasonal and flow-normalized concentrations showed steep declines overall for nutrients (total nitrogen and total phosphorus) and suspended sediment.
- Based on the recent 10-year period, estimated load and concentration trends generally showed improvements as follows:
    - Upper parts of the SRB especially were substantially improved (-ing) for TN, TP, and SS.
    - Importantly, the TN trend was consistently improving throughout the agro-dominated Lower Subbasin.
    - The magnitude of TP improvement was substantial.

  - SS trends (increase & decrease) were highly variable in distribution and magnitude and there appeared to be no consistent parallel trends between SS and TP.
- Using a simplistic, uniform distribution approach for the Chesapeake Bay Total Maximum Daily Load's (TMDL) targets, the current (2015) basinwide TN load meets the 2025 goal and for all subbasins except the Juniata River; however, based on the most recent 10-year average annual load, no subbasins would fulfill the 2025 goal.
- Using the uniform distribution approach for TMDL targets, the TP and SS loads for the SRB cannot achieve the 2025 targets even when discharge is below long-term normal.
- Strong correlation exists between flow-normalized concentration trends for TN and nitrate (NO_{3-}); i.e., the dominant soluble, bioavailable form of nitrogen.
- Poor correlation exists between flow-normalized concentration trends for TP and orthophosphate (PO_4^{3-}); i.e., the dominant soluble, bioavailable form of phosphorus.

BACKGROUND

By the 1960s and 1970s, scientists began to link nutrient and sediment pollution with a suite of aquatic resource concerns in estuaries, lakes, and rivers worldwide. Nutrient and sediment inputs are essential, natural phenomena in well-functioning aquatic ecosystems. The macronutrients nitrogen (N) and phosphorus (P) are required for the growth and development of all life and the relative timing and availability of one versus the other governs limits on an aquatic ecosystem's primary producers – that is, the photosynthesizing plants that transform solar energy into the "food" that sustains all other life.

Because of their life history traits, simple organisms and especially primary producers are predisposed for rapid population response to the changing availability of a growth-limiting nutrient. Excess nutrient availability commonly stimulates growth of an (over-) abundance of plant biomass that can include phytoplankton, macroalgae, and vascular aquatic plants. Inevitably environmental conditions change and part of the excessively-abundant biomass dies.

The dead biomass fulfills a nutrient limitation for a different community of simple organisms (e.g., bacteria) that can also achieve rapid population growth. The decay of biomass favors oxygen-demanding metabolic processes, and the bacteria community swells to take advantage of its rich nutrient supply. In abrupt fashion, a nutrient-enriched ecosystem can switch from dominance by oxygen-producers to dominance by oxygen-consumers and transform the whole setting into a perilous environment for the broader community that depends on oxygen. The transition from oxygen-rich to oxygen-depleted status also triggers a cascade of geochemical processes that may destabilize certain substances settled in the sediment that were not previously "biologically available," but which transform to acute contaminants in the absence of oxygen.

The preceding paragraph describes some of the simplest effects of the eutrophication process. Eutrophy can and does occur naturally in certain settings, most notably estuaries, lakes, and ponds, for which nutrient inputs through time may outweigh processes that flush, transform, sequester, and otherwise govern their bioavailability. But by far, eutrophication is primarily an outcome of human disturbance.

Similar to nutrients, excess amounts of suspended sediment have negative consequences for aquatic ecosystems. Two of the main damaging effects of excess sediment are increased turbidity – the cloudiness of water caused by particles in suspension, and physical changes to the substrate habitat. Increased turbidity, especially for prolonged durations, interferes with light penetration into the water column which can shift the plant community from rooted macrophytes to phytoplankton and filamentous algae. Increased turbidity also can impact the foraging and predator-avoidance success of sightdependent taxa, interfere with gill-functioning, and diminish the metabolic efficiency of filter-feeding animals. Excess sedimentation restricts the availability of critical substrate habitat types by filling voids; blanketing hard or coarse materials with sand or mud; and, even suffocating eggs/larvae.

By the 1970s, the Chesapeake Bay was exhibiting signs of eutrophication and sediment pollution and the Lower Susquehanna River Subbasin, due to its concentrated mix of agriculture and urban settings, was thought to be a primary source for nutrient and sediment pollution to the Bay.

In 1985, the Susquehanna River Basin Commission (Commission), as part of a joint effort with partners consisting of the United States Geological Survey (USGS), Pennsylvania Department of Environmental Protection (PADEP), and United States Environmental Protection Agency (USEPA) Chesapeake Bay Program Office (CBPO), implemented a rigorous sampling program to measure nutrient and sediment concentrations at strategic locations within the Susquehanna River Basin. Comparable sampling programs also were established in the Bay watershed's other tributary river basins as well as in tidal parts of the Chesapeake Bay estuary.

Initially referred to as the Sediment and Nutrient Monitoring Program (later renamed Sediment and Nutrient Assessment Program, SNAP), the Bay-related pollutant monitoring programs and tidal and non-tidal station networks have undergone periodic adjustments, evolutions, and integrations. Overall monitoring efforts are coordinated by the six Bay State jurisdictions (e.g., NY, PA, MD, WV, VA, DE), the District of Columbia, USEPA, USGS, the Commission, the Delaware River Basin Commission (DRBC), and the Interstate Commission for the Potomac River Basin (ICPRB). In its current configuration, monitoring activities are coordinated and all of the Bay-related monitoring data are coalesced and subjected to integrated analytics by the CBPO.

The overall Bay monitoring network strives for uniformity in site selection criteria, water quality parameters analyzed, and sample/data collection methodology. Specific monitoring station selection criteria include: (i) placement at outlets of major streams considered to reflect strategic value within the particular major watershed to the Bay (e.g., Susquehanna); (ii) areas expected to have the highest pollutant contributions to the Bay; and, (iii) assurance the various conditions in the major watersheds among land use type, physiographic/geologic setting, and watershed size were adequately represented.

Since 1989, the following modifications to the monitoring have occurred within the SRB:

- 1990 – number of stations was reduced from 12 to 6;
- 2004 – 13 stations were added;
- 2005 – 4 stations were added;
- 2012 – 4 stations were added; and,
- 2013 – 1 site was dropped (26 total non-tidal network (NTN) stations).

The current SRB network consists of six mainstem river and 20 tributary stations as depicted in Figure 1. The Susquehanna River Basin NTN configuration includes five stations in New York, 20 in Pennsylvania, and one in Maryland. The individual NTN stations are categorized as either ***long-term*** (e.g., 6 stations established prior to 1990) or ***enhanced*** (e.g., 20 stations established since 2004). Aside from the record period of observation, certain programmatic differences also exist between long-term and enhanced stations in terms of sampling frequency targets and analyzed parameters.

Table 1 lists the individual SRB NTN stations grouped as long-term sites (Group A) and enhanced sites (Group B) along with subbasin, contributing drainage area, co-located USGS gage station number, and the distribution of major land use/land cover classes within the contributing drainage area.

Objectives for the NTN program include:

- Measure instream nutrient and sediment concentrations throughout the watershed, year-round, and across the spectrum of hydrologic conditions;
- Integrate instream quantified pollutant concentration measurements with estimates of flow developed by USGS in order to estimate pollutant loading rates[1] and yields;
- Analyze discharge as well as pollutant concentration and loading estimates for indications of change through time or trend;
- Improve calibration and verification of the Bay partners' watershed models[2]; and,
- Assess factors affecting nutrient and sediment distributions and trends.

The CBPO established the NTN as a fixed-station monitoring program by which gradual responses to actions occurring on the landscape will become detectable through time. Since the 1970s, management strategies have been underway to improve water quality impacted by nutrients and sediment in general and in the Chesapeake Bay specifically, through the following:

- Regulated limits and phase-out of certain P-containing detergents;
- More stringent effluent limits on N and P point-source discharges;
- Adoption of agriculture BMPs that seek to optimize fertilizer application rates and timing to better coincide with site-specific soil conditions and seasonal crop demand;
- Promotion of stormwater BMPs that seek to reduce N, P, and suspended sediment associated with nonpoint pollutant sources; and,
- Dampen the erosive effects to streams caused by intentional routing of stormwater from the developed landscape into local waterways.

It is important to note that comparatively few discrete or instantaneous measurements of pollutant concentration from any year are integrated with USGS' continuous flow data to form the basis that all subsequent concentration, load, and yield estimates are derived from. It is through the long-term accumulation of concentration measurements, using rigorous and consistent protocols, that the CBPO and its partners have developed, calibrated, and refined predictive models of nutrient and sediment dynamics within the Bay watershed.

Given decades of widespread efforts to reduce nutrient and sediment pollution, there is powerful incentive to answer the question; *do instream measurements of pollutants through time indicate conditions are improving?* The answer to this question is sought using statistics; specifically, the mathematics of probability. For a mathematical solution, the question is re-stated; "from a series of pollutant concentration measurements collected over time, do the concentration values generally decrease or increase (e.g., get better or worse)?"

Probability is based on the assumption that with enough random glimpses into the actual distribution of variation in a system, acquired across the system's range of conditions, it is possible to determine whether the actual distribution has changed over time. Moreover, if actual change has occurred, then the average pace of change can be estimated.

Of particular importance from policy and management decision-making perspectives is not just whether instream monitoring is able to accurately detect upward and downward pollutant trends; i.e., systemic water quality changes through time, but also to determine what is driving the change. To have confidence that perceptions of gradual change in water quality indicators are ***more than likely linked*** to a

---

[1] Loading rate = amount or mass of pollutant transported by water in a particular time duration.

[2] A suite of ever-evolving CBPO watershed models are used to inform management strategies.

particular human activity, sources and ranges of natural/existing variation must be known and adjusted for prior to analyses. Hirsch (1988) suggested that five years of monthly data provide the minimum to detect gradual change. Longer as well as more frequent sampling increases the analytical sensitivity to detect smaller changes.

This report contains a summary of estimated nutrient and sediment pollutant loads and yields derived from continuous river flow estimates and pollutant concentrations measured from water samples collected during calendar year 2015 in the SRB. Additionally, the 2015 estimates of pollutant loads and yields are compared to the overall period of record. Both long-term (~30-year) and recent (~last 10 years) datasets are analyzed for trends. Bay-related management milestones set for 2025 within the Chesapeake Bay TMDL are evaluated as measures of existing progress. And we discuss scenarios for achieving 2025 pollutant reduction milestones.

Emphasis in this report is placed on the six Group A long-term monitoring stations. This subset of NTN stations each encompass more than twice the observation period (over 30 years) of monitoring data as compared to the enhanced NTN stations. Additionally, the Group A stations are distributed throughout the Basin in manner that facilitates a generalized, overall understanding of conditions in the primary subbasin regions as well as the mainstem Susquehanna River. Group B stations are discussed in terms of recent trends and management implications. Additionally, a blend of Group A and B stations that are situated at/near the outlets of major subbasins are discussed for their relevance regarding the 2025 milestones.

Nutrient and sediment dynamics instream are governed by precipitation, streamflow, seasonal rhythms – both natural and human, and characteristics of the watershed landscape. Because they are inescapable realities, we are wise to acknowledge that the Laws of Nature operate to establish a balance everywhere on the Earth's surface among Climate, Land Form, and Biotic Community. Moreover, it is important to accept that the pace at which the Laws of Nature achieve balance between Climate, Land Form, and Biotic Community is independent of the desires, intentions, as well as, the Laws of Man.

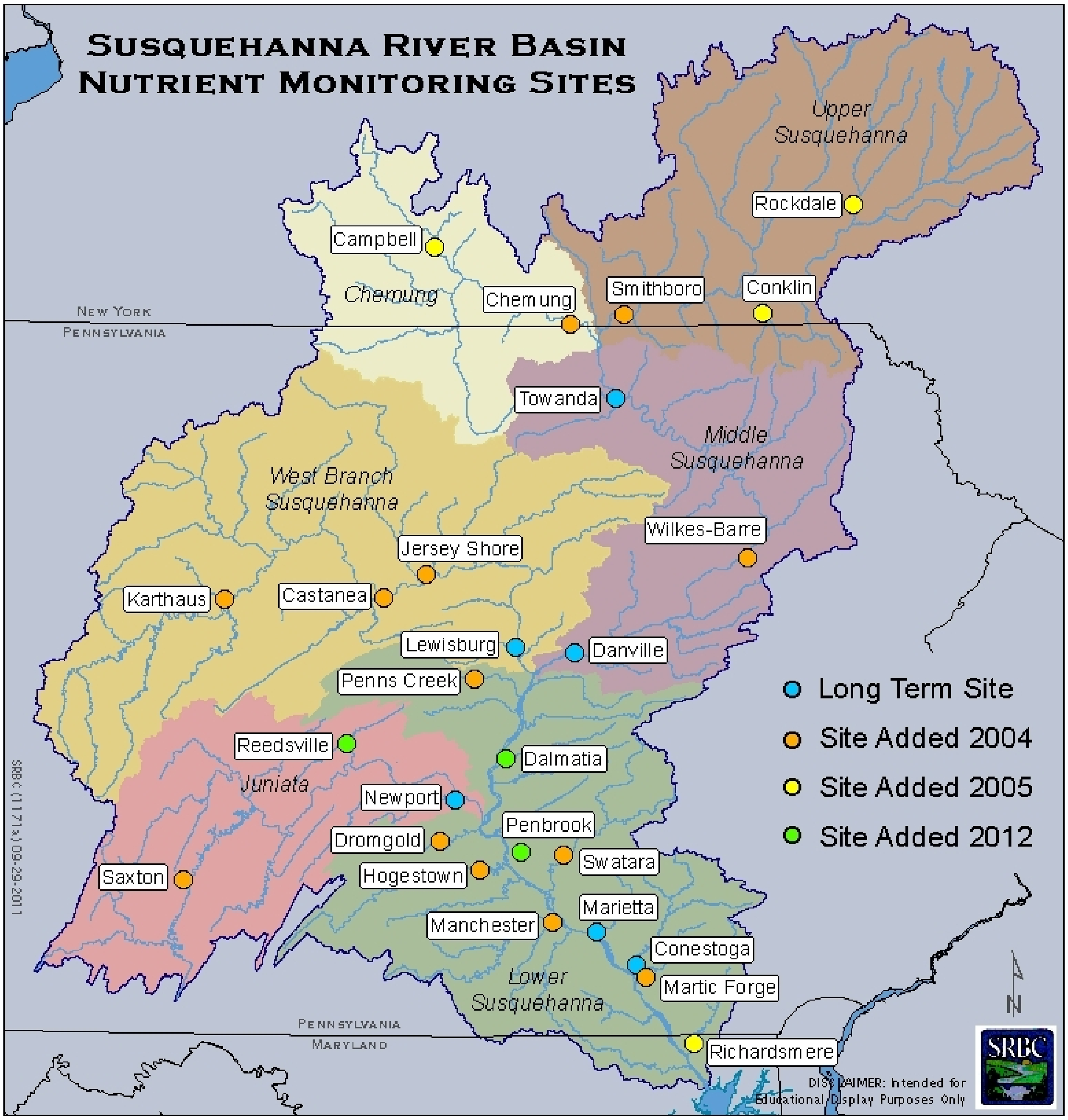


Figure 1. Locations of Sampling Sites Within the Susquehanna River Basin

Table 1. Data Collection Sites and Their Drainage Areas and 2000 Land Use Percentages

Site Location	USGS Site ID	Subbasin	Waterbody	Drainage Area (Sq. Mi.)	Water/ Wetland	Urban	Agricultural			Forest	Other
							Row Crops	Pasture Hay	Total		
Group A: Long-term Sites											
Towanda	01531500	Middle Susquehanna	Susquehanna	7,797	2	5	17	5	22	71	0
Danville	01540500	Middle Susquehanna	Susquehanna	11,220	2	6	16	5	21	70	1
Lewisburg	01553500	W Branch Susquehanna	W Branch Susquehanna	6,847	1	5	8	2	10	84	0
Newport	01567000	Juniata	Juniata	3,354	1	6	14	4	18	74	1
Marietta	01576000	Lower Susquehanna	Susquehanna	25,990	2	7	14	5	19	72	0
Conestoga	01576754	Lower Susquehanna	Conestoga	470	1	24	12	36	48	26	1
Group B: Enhanced Sites											
Rockdale	01502500	Upper Susquehanna	Unadilla	520	3	2	22	6	28	66	1
Conklin	01503000	Upper Susquehanna	Susquehanna	2,232	3	3	18	4	22	71	1
Smithboro	01515000	Upper Susquehanna	Susquehanna	4,631	3	5	17	5	22	70	0
Campbell	01529500	Chemung	Cohocton	470	3	4	13	6	19	74	0
Chemung	01531000	Chemung	Chemung	2,506	2	5	15	5	20	73	0
Wilkes-Barre	01536500	Middle Susquehanna	Susquehanna	9,960	2	6	16	5	21	71	0
Karthaus	01542500	W Branch Susquehanna	W Branch Susquehanna	1,462	1	6	11	1	12	80	1
Castanea	01548085	W Branch Susquehanna	Bald Eagle	420	1	8	11	3	14	76	1
Jersey Shore	01549760	W Branch Susquehanna	W Branch Susquehanna	5,225	1	4	6	1	7	87	1
Saxton	01562000	Juniata	Raystown Branch Juniata	756	< 0.5	6	18	5	23	71	0
Reedsville	01565000	Juniata	Kishacoquillas	164	<0.5	5	20	6	26	67	2
Dalmatia	01555500	Lower Susquehanna	East Mahantango	162	1	6	20	6	26	66	1
Penbrook	01571000	Lower Susquehanna	Paxton	11	<0.5	50	9	11	20	29	1
Penns Creek	01555000	Lower Susquehanna	Penns	301	1	3	16	4	20	75	1
Dromgold	01568000	Lower Susquehanna	Shermans	200	1	4	15	6	21	74	0
Hogestown	01570000	Lower Susquehanna	Conodoguinet	470	1	11	38	6	44	43	1
Hershey	01573560	Lower Susquehanna	Swatara	483	2	14	18	10	28	56	0
Manchester	01574000	Lower Susquehanna	West Conewago	510	2	13	12	36	48	36	1
Martic Forge	01576787	Lower Susquehanna	Pequea	155	1	12	12	48	60	25	2
Richardsmere	01578475	Lower Susquehanna	Octoraro	177	1	10	16	47	63	24	2
Entire Susquehanna River Basin				27,510	2	7	14	7	21	69	1

WATER SAMPLE COLLECTION

Year 2015 monitoring at the six long-term (Table 1, Group A) stations included sampling during monthly base flow conditions, monthly flow-independent conditions, and seasonal storm conditions; an approach that resulted in at least two samples collected per month at each Group A station. In general, flow-independent sampling occurs based on a recurring target date near the 12th of each month; whereas, monthly base flow sampling targets the final week of the month. Maintaining a consistent framework of flow-independent mid-month sample collection greatly facilitates the analytics associated with detecting long-term trends.

Additionally, due to the profound effect high flow events impart on nutrient and sediment loads, each long-term station is targeted for two storms during the spring season and one storm each during summer, fall, and winter. The rationale for extra storm sampling during spring is to ensure representation within the water quality dataset for conditions before and after spring crops are planted. Storm samples were collected at Group A stations during the rising and falling limbs of the hydrograph with targets of three samples each during the rise and fall of stage and one sample as close to the peak as possible (Figure 2).

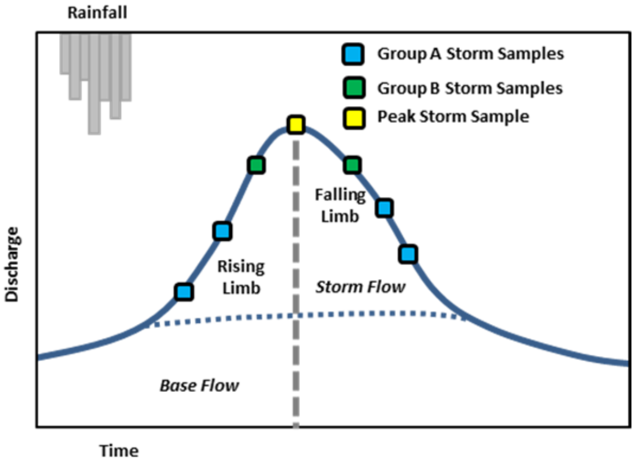


Figure 2. Conceptual Storm Hydrograph and Group A and Group B Storm Sampling Targets (For Group A stations, the goal is to collect all 7 samples. For Group B stations, the goal is to collect the peak and either the rising or falling Group B samples.)

For the enhanced stations (Table 1, Group B), sampling also targets one mid-month, flow-independent sample consistent with provisions of Group A stations. Enhanced stations are not targeted for monthly base flow sampling. Group B stations are targeted for two *storm samples per season*. Storm samples at Group B stations are targeted to sample once during the rising limb and once during the falling limb of the hydrograph and with an added goal that either of the two be as close to the peak as possible. Because some Group B stations are situated on small, flashy watersheds, occasionally, two storm samples per season are obtained from two different storms. In such circumstances, the goal is to sample close to the peak of each storm.

The goal of every collection effort is to obtain a sample representative of the entire water column. Due to variations in stream width, depth, substrate composition, and other obstacles, complete mixing of the stream across its width is not assured; therefore, the sampling protocol necessitates that a series of discrete, depth-integrated samples through the vertical water column are collected at multiple intervals across the stream width. The set of discrete samples is composited into a “churn container” and one representative subsample is drawn from the composite blend for laboratory analyses.

The number of discrete width intervals at each station varied from 3 to 10, depending upon the stream width. Based on USGS depth-integrated sampling methodology at each vertical location, the sampler was lowered at a consistent rate from the top of the water surface to the stream bottom and back to ensure water from the entire vertical column was represented (Myers, 2006). Instream, direct-read water quality indicator sensor measurements (temperature, pH, dissolved oxygen, specific conductance, turbidity) for each vertical subsample are logged electronically and subsequently archived.

Composite blending, subsequent subsampling for laboratory analyses, and sample filtering to quantify soluble forms of N and P all occur on-site at each NTN station.

LABORATORY ANALYSIS

Samples were either hand-delivered or shipped directly to the appropriate laboratory for analyses on the day following collection, except for storm sampling that occurred during weekends. Samples collected on Saturday or Sunday were delivered to the laboratory on the following Monday. Samples collected in Pennsylvania and at the Octoraro Creek site near Richardsmere, Maryland, were delivered to PADEP's Bureau of Laboratories in Harrisburg, Pennsylvania. Samples collected at New York stations were shipped to ALS Environmental Laboratory in Rochester, New York. The schedule of analytical parameters, methodologies, and detection limits are listed in Table 2.

Due to a biased influence of stormflows on sediment concentrations, SS samples were collected during storm events at all stations with the goal of two samples for each event and one event per quarter. Of the two samples per storm, the more sediment-laden sample was analyzed for both sediment concentration and sand/fine particle percentage. The additional sample was submitted for sediment concentration only. Sediment samples were shipped to the USGS sediment laboratory in Louisville, KY, for analysis. Additional SS samples also were collected at all Group A sites as part of each sampling round. These samples were analyzed at the Commission laboratory to quantify sediment concentration only. Laboratory analytical parameters are the same for Group A and Group B stations during sample events except that for Group B stations, SS analyses are only conducted on storm samples.

Year 2015 sample analytical results were compiled and incorporated into the comprehensive SRB-specific NTN database. These data were then made publicly available via the Commission's website as well as provided in electronic format to various partners for use with models and individual analyses.

Table 2. Water Quality Parameters, Laboratory Methods, and Detection Limits

Parameter	Storet	Laboratory	Methodology	Detection Limit (mg/l)	References
Total Ammonia (TNH_3)	610	PADEP	Colorimetry	0.020	USEPA 350.1
		ALS*	Colorimetry	0.010	USEPA 350.1R
Dissolved Ammonia (DNH_3)	608	PADEP	Block Digest, Colorimetry	0.020	USEPA 350.1
		ALS*	Block Digest, Colorimetry	0.010	USEPA 350.1R
Total Nitrogen (TN)	600	PADEP	Persulfate Digestion for TN	0.040	Standard Methods #4500-N_{org}-D
Dissolved Nitrogen (DN)	602	PADEP	Persulfate Digestion	0.040	Standard Methods #4500-N_{org}-D
Total Organic Nitrogen (TON)	605	N/A	TN minus TNH_3 and TNO_x	N/A	N/A
Dissolved Organic Nitrogen (DON)	607	N/A	DN minus DNH_3 and DNO_x	N/A	N/A
Total Kjeldahl Nitrogen (TKN)	625	ALS*	Block Digest, Flow Injection	0.050	USEPA 351.2
Dissolved Kjeldahl Nitrogen (DKN)	623	ALS*	Block Digest, Flow Injection	0.050	USEPA 351.2
Total Nitrite plus Nitrate (TNO_x)	630	PADEP	Cd-reduction, Colorimetry	0.010	USEPA 353.2
		ALS*	Colorimetric by LACHAT	0.002	USEPA 353.2
Dissolved Nitrite plus Nitrate (DNO_x)	631	PADEP	Cd-reduction, Colorimetry	0.010	USEPA 353.2
		ALS*	Colorimetric by LACHAT	0.002	USEPA 353.2
Dissolved Orthophosphate (DOP)	671	PADEP	Colorimetry	0.010	USEPA 365.1
		ALS*	Colorimetric Determination	0.002	USEPA 365.1
Dissolved Phosphorus (DP)	666	PADEP	Block Digest, Colorimetry	0.010	USEPA 365.1
		ALS*	Colorimetric Determination	0.002	USEPA 365.1
Total Phosphorus (TP)	665	PADEP	Persulfate Digest, Colorimetry	0.010	USEPA 365.1
		ALS*	Colorimetric Determination	0.002	USEPA 365.1
Total Organic Carbon (TOC)	680	PADEP	Combustion/Oxidation	0.50	SM 5310D
		ALS*	Chemical Oxidation	0.05	GEN 415.1/9060
Total Suspended Solids (TSS)	530	PADEP	Gravimetric	5.0	USGS I-3765
		ALS*	Residue, non-filterable	1.1	SM2540D
Suspended Sediment Fines	70331	USGS	**		
Suspended Sediment (SS)	80154	SRBC	**		
		USGS	**		

* ALS Environmental, Rochester, N.Y. (New York sites only)
** TWRI Book 3, Chapter C2 and Book 5, Chapter C1, Laboratory Theory and Methods for Sediment Analysis (Guy and others, 1969)

HYDROLOGIC DATA: PRECIPITATION

Setting aside past and current landscape conditions, for any given location, the most significant factor that affects pollutant loads overall is rainfall/precipitation, due to its: (i) short-term episodic effect on above-bank transport processes as well as instream discharge; and, (ii) long-term (e.g., intra-annual seasonal, overall annual, and inter-annual) cumulative effect on hydrologic regime. Regarding episodic events, higher precipitation generally fosters higher pollutant loads in streams (Ott and others, 1991; Takita, 1996, 1998); however, relationships between total precipitation and instream load during a given event are complicated by the intensity of rainfall, the season during which the storm occurs, and antecedent hydrologic conditions.

Precipitation data were obtained from the PRISM Climate Group of Oregon State University's website. Monthly data for each county within the Basin were compiled and weighted by acreage to estimate monthly rainfall amounts across the subbasins of the Susquehanna River Basin.

HYDROLOGIC DATA: DISCHARGE (FLOW)

Discharge (hydrology) is the dominant factor that affects pollutant concentrations measured in time. USGS operates and maintains a national network of stream gages according to rigorous and consistent protocols and standards. USGS stream gages provide a consistent framework for hydrology data and information nationally. Through long-term monitoring periods, USGS establishes and continually refines stage–discharge relationships for most of the stations in its network and all of the NTN stations in the Susquehanna River Basin. Each NTN station is co-located with a USGS gage* that is equipped with an automated electronic pressure sensor for continuous stage monitoring.

> (*Due to the absence of a paired USGS flow gage at Smithboro, the Waverly gage (USGS #01515000) served for flow-based integration with water quality data collected at Smithboro. The Waverly gage is downstream of Smithboro, has a ~3% larger watershed area, and includes the 140-square-mile Cayuta Creek Watershed. The additional watershed area results in an unquantified, yet presumed modest, bias in load and concentration estimates at the Smitboro site.)

A stage–discharge relationship, also called a ratings curve, is an empirically-derived regression model that relates the height of water in a stream channel to the corresponding discharge (or flow) at a specific location. The development of ratings curves requires precise instream measurements of the instantaneous flow through incremental portions across the stream width during a period in which the stream level, or stage, is not changing appreciably. The series of incremental discharge measurements is summed to obtain the discharge through the complete cross-sectional area of the stream width.

Such measurements of total discharge and corresponding water level are repeated at the same location across a range of flow conditions and "best fit" regression models are iteratively fitted to the dataset until a resultant model satisfies confidence bounds consistent with the quality assurance requirements of the program. Continuous instream measurements (CIM) of water level obtained by USGS are input directly into the stage–discharge model to generate an estimate of continuous discharge.

USGS average daily discharge estimates were used to estimate daily pollutant concentration and load estimates throughout the entire period of observation to support trend analyses.

2015 PRECIPITATION AND DISCHARGE

For Year 2015, total precipitation at the six long-term monitoring NTN stations approximated the long-term mean (e.g., total precipitation ranged from 95 to 103 percent of the LTM) for each station. While the overall precipitation for 2015 was comparable to the long-term average, the seasonal patterns differed for all except the Conestoga station. In contrast to the LTM, for five of the stations, the 2015 winter was ~25 percent drier than normal and the spring was > 25 percent wetter.

Figure 3 is a set of charts that summarize Year 2015 seasonal and annual precipitation and discharge at the six Group A stations in comparison to the respective long-term (~30-year) means.

Although 2015 precipitation approximated the ~30-year average, discharge for the year was generally well below the long-term average (for the Danville station, the 2015 ADF equaled the long-term average). Because winter precipitation in 2015 lagged well behind the long-term average, so too did winter discharge. Whereas winter precipitation was approximately 30 percent below normal, discharge was almost 50 percent below normal. Spring discharge in 2015 was close to the long-term average, summer was 25 percent above, and fall was > 35 percent below.

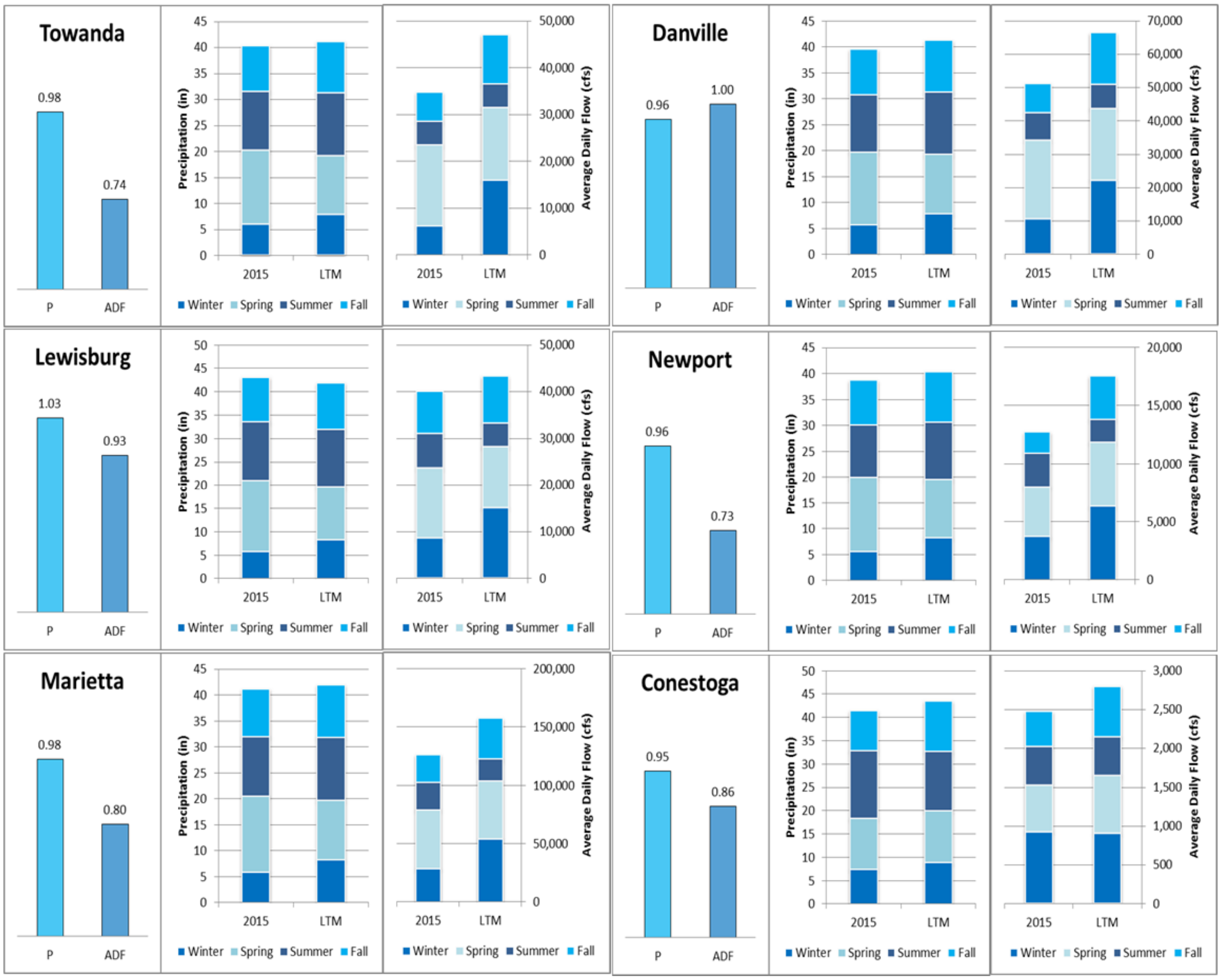


Figure 3. ***Precipitation and Average Daily Flow (ADF) Seasonal and Annual Statistics for 2015 and the Approximately 30-year Long-term Mean for Group A NTN Monitoring Stations in the Susquehanna River Basin***

DATA REDUCTION

Sampling that is conducted according to consistent protocols and frequent intervals supports being aggregated into standard time periods for analyses. For our computational purposes, the Commission retrieves discharge data from USGS that have been reduced from CIM stage measurements to a single average daily flow (ADF) value. For certain purposes, we reduce ADF data to standard time periods by two additional steps: (1) compilation of ADF for all days in each calendar month into a single composite ADF value for each month; and, (2) development of a single composite ADF value for the entire year.

In addition to ADF, we also filter USGS daily ADF data to extract the peak ADF value for each month and/or the entire year (as appropriate). All subsequent analytical approaches are performed using data that were reduced to daily, monthly, seasonal, annual, or long-term averages.

The following section describes the various measurements and estimates related to quantifying instream pollutant mass. It is worthwhile to repeat that relatively few discrete or instantaneous measurements of pollutant concentration are collected annually and integrated with the ADF reduced datasets to form the basis that all subsequent concentration, load, and yield estimates are derived from. It is through the long-term accumulation of many such instantaneous concentration measurements that the CBPO and its partners have developed, calibrated, and refined predictive models of nutrient and sediment dynamics within the Bay watershed.

Concentrations, Estimated Loads, and Estimated Yields

The amount of a substance transported in water can be described in various ways and each of the following is part of the NTN program framework.

Concentration is the amount (or mass) of nutrient and sediment in a specific water sample as quantified by laboratory analyses. Concentration is expressed in units of Mass/Volume. Water conveys substances that are dissolved as well as suspended. It is important to note that measured instream concentrations of a substance, especially during storm events, are comprised of four main components as follows:

i. mass that is part of base flow;
ii. mass transported into the waterway from the landscape by processes during the current storm;
iii. mass that was transported into the waterway before the current storm event; and,
iv. mass that is scoured or eroded from the bed/banks of the waterway by the energetics of the current storm event.

Total Concentration: $C = C_{\text{base flow}} + C_{\text{landscape}} + C_{\text{resuspension}} + C_{\text{erosion}}$

Where C is concentration and subscripts refer to particular components of total concentration. Moreover, the various concentration components can be separated further into dissolved and/or particulate fractions.

It is noteworthy that the NTN program monitoring dataset does not facilitate the decomposition of a measured concentration into the main components listed above, although nutrients are quantified according to dissolved and particulate fractions and various chemical forms. Ultimately, pollutant load-reduction depends on how well the management strategy addresses the dominant component sources of pollutants.

Load (also referred to herein as ***flux***) is the estimated amount of a pollutant transported past a point in a specified time. Load is expressed in units of Mass/Time. At a given station, load is an estimate of the total pollutant mass conveyed from the upstream catchment area.

Yield expresses the estimated load as though the amount of pollutant was uniformly delivered by the contributing catchment area. Yield is expressed in units of Mass/Area-Time. Yield provides a standard means to compare pollutant contributions from catchments of different size and different land use.

Loads and yields represent two common methods for describing instream estimates of nutrients and sediment. Load refers to the total estimated mass of nutrients and sediment carried instream to/through a station; whereas yield represents the estimated load distributed uniformly across the drainage area that contributes to the station.

Figure 4 compares the annual loads and yields through time, respectively, for TN at Marietta and Conestoga. Marietta, with a drainage area of nearly 26,000 mi^2, is the largest station within the SRB NTN; conversely, the drainage area contributed to the Conestoga station (470 mi^2) is 55 times smaller than Marietta.

The distinct magnitude difference between annual TN load estimates for these two stations is entirely a function of their disparate contributing areas. Interestingly, although its drainage area is 55 times larger than the Conestoga station, the annual estimated TN load in 2015 was only around 10 times larger for the Marietta station. As mentioned elsewhere, estimated yield is a useful mechanism to compare pollutant conditions in watersheds with wide disparity in drainage area. So despite its far smaller size, on an acre-for-acre basis, the Conestoga catchment produced greater than five times more TN in 2015 than the Marietta watershed.

This suggests that the same management action applied in both watersheds will show more benefit in the Conestoga watershed. This report shows loads and yields for the constituents listed in Table 2 as computed by WRTDS. 2015 loads and yields are listed in Appendix B for Group A sites. Load analyses also were completed for TN, TP, and TSS/SS for Group B sites, and results are listed in Appendix C. Due to SS only being collected during high flow events at Group B sites, TSS data were substituted when SS data were not available.

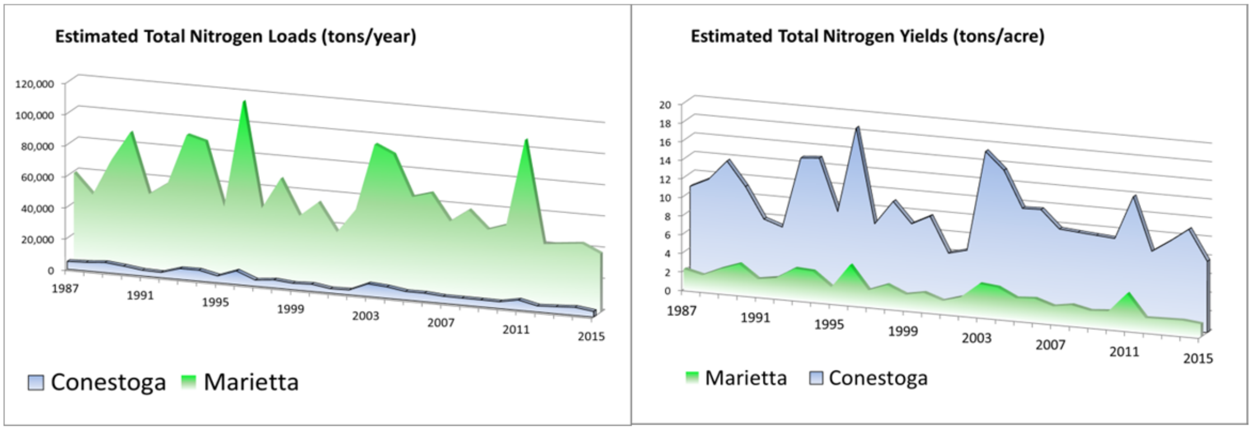


Figure 4. Comparison of Total Nitrogen Yield (left) and Load (right) for the Marietta and Conestoga Stations

Long-Term Mean Ratio

In an attempt to describe annual changes from previous years, 2015 nutrient and SS loads, yields, and concentrations were compared to LTMs. LTM load and discharge ratios (Annual Flow/LTM flow) were calculated for annual, seasonal, and monthly time periods by dividing the 2015 value by the LTM for the same time frame and were reported as a percentage or ratio. Identifying sites where the percentage of LTM for a constituent, termed the load ratio, was different than the corresponding percentage of LTM for discharge, termed the water-discharge ratio or discharge ratio, would suggest areas where improvements or degradations may have occurred for that particular constituent. Likewise, if changes in constituent loads had not occurred during the time frame, the constituent LTM ratio would be near the discharge ratio. Table 3 lists annual TN, TP, and SS loads and concentrations and their respective LTM ratios at Towanda, Danville, and Marietta. Figure 5 graphically displays the Q, TN, TP, and SS LTM ratios at all sites. 2015 flows were below the LTM at all sites ranging from 74 percent at Towanda to 80 percent at Marietta. The corresponding load ratios for all three parameters were well below the discharge ratios, except SS at Danville, where the load and discharge ratios were relatively the same.

Table 3. TN, TP, and SS loads (1000's of pounds) at Towanda, Danville, and Marietta

Parameter	Site	Discharge Ratio	Load	Load % of LTM
Total Nitrogen	Towanda	74%	16,496	61%
	Danville	77%	24,465	59%
	Marietta	80%	75,252	61%
Total Phosphorus	Towanda	74%	1,352	55%
	Danville	77%	1,927	50%
	Marietta	80%	4,303	54%
Suspended Sediment	Towanda	74%	1,445,071	57%
	Danville	77%	2,851,634	75%
	Marietta	80%	2,906,548	47%

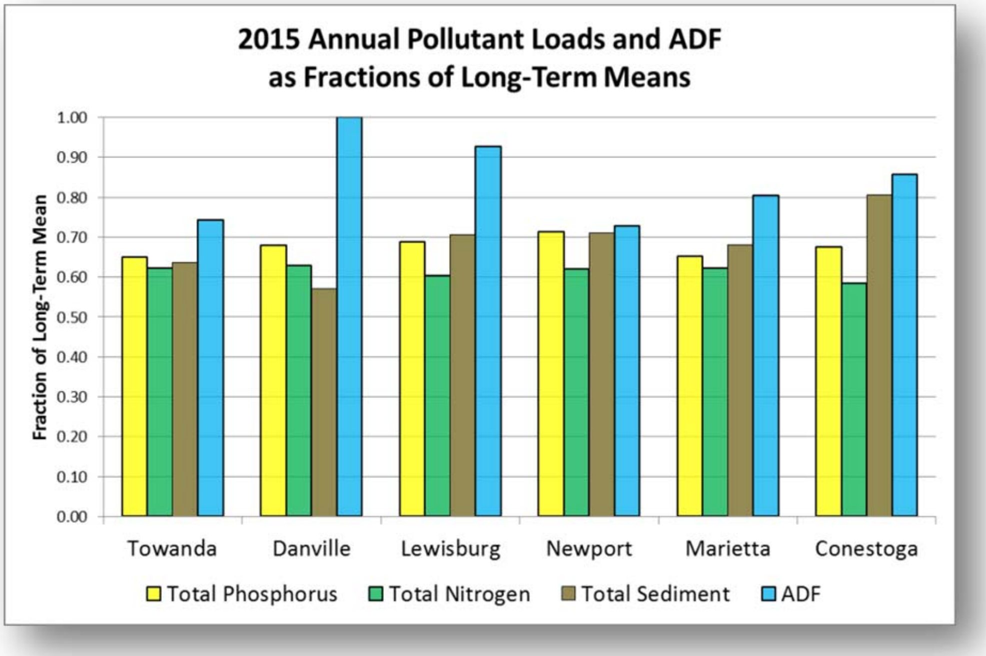


Figure 5. 2015 Annual Pollutant Loads and Discharge for Group A NTN Monitoring Stations as Fractions of the Long-Term Mean

Distributed Targets

A primary objective of the monitoring network of this program is to monitor and assess the progress of management actions towards meeting nutrient and SS targets that have been established to improve the water quality of the Chesapeake Bay. Assessment of progress involves teasing apart multiple confounding factors to arrive at an actual measure of the effects of effort, whether qualitative or quantitative. A critical component of quantifying progress of management actions includes determination of goals and targets. To that extent, this report utilizes the Susquehanna River's TN, TP, and SS targets provided by the Chesapeake Bay TMDL Tracking and Accounting System (BayTas 2.0) to establish reference conditions across the watershed. 2017 and 2025 load targets for TN, TP, and SS for the Susquehanna River Basin are listed in Table 4 along with associated yields. These values represent the actual 2017 and 2025 targets.

The 2025 yields from Table 4 were used at all sites within the watershed to calculate associated loads. As an example, the 2025 TN target of 4.8275191 lbs/acre (rounded to 4.83 in Table 4) for the Susquehanna River at Towanda, with 4,990,080 acres, resulted in a target load of 24,089,706 pounds. Since this process distributes loads across the watershed based solely on acreage, regardless of distance to the Bay and accepted delivery ratios, they no longer represent formally accepted goals. To avoid confusion, while maintaining the ability to make comparisons, these values will be referred to as distributed load and yield targets or 2025 targets. In this report, distributed loads were used as a benchmark for comparing 10-year average historical loads at each site and gauging progress. Distributed loads and yields for Group A sites are listed in Tables 17.

Table 4. 2017 and 2025 Loads (1000's of lbs) and Yield (lb/ac) Targets, (BayTas 2.0) for the Susquehanna River Basin

Site	Acres	Year	TN Load	TN Yield	TP Load	TP Yield	SS Load	SS Yield
Basin	17,599,550	2017	100,202	5.69	4,424	0.251	2,301,459	130.8
		2025	84,962	4.83	3,767	0.216	2,045,365	116.2

Trends

Rivers and streams undergo continuous change because they are part of a dynamic equilibrium system based on an extraordinarily complex, multi-dimensional inter-play that seeks to balance interactions primarily between climate, landscape, and biological community.

Water quality in rivers and streams is prone to substantial short-term and local influence by discharge and season; to longer-term and broad influence by climate cycles and modifications of the landscape; and, for certain of its components, to discrete perturbations from the past that continue to reverberate and manifest as part of the combined water quality spectrum in accordance with the natural laws that govern the system's overall equilibrium.

High discharge affects water quality immediately in numerous ways including: (i) transporting soluble and suspended matter from the landscape to the waterway; (ii) by shifting the mixing proportions of water sources that comprise streamflow; (iii) through dilution; (iv) through abrupt shifts in temperature, dissolved oxygen, and other water quality indicators; (v) by increasing energetics that re-suspend material previously deposited in the stream channel; and, (vi) through erosion/scour of the streambed and banks. Low discharge tends to concentrate soluble substances, reduce oxygen availability, increase clarity and therefore light penetration, and foster a build-up of settled material.

Like discharge, seasonal effects exert influence on water quality measurements. Many seasonal effects combine discharge-related patterns with intra-annual cycles of biological processes. Other seasonal effects reflect rhythms of human activity. In addition to the short-term influences that discharge and season exert on water quality variation, it is important to acknowledge that broad-scale changes/cycles in climate (i.e., mainly evident in temperature and precipitation) and landscape also influence water quality and often do so through signals that tend to be masked by short-term factors.

Water quality trends may occur abruptly, gradually, or not at all. Monitoring before and after conditions for a specific or localized effect can be expected to generate a "step change" signal with sufficient monitoring resolution; whereas, changes at a catchment or watershed scale resulting from: (i) the accumulation of numerous BMPs; (ii) on-going land uses; or, (iii) continual land development are expected to occur gradually in one direction, or *monotonically*.

The NTN monitoring program was designed to amass long-term pollutant concentration measurements from a broadly-distributed, fixed-station network because such design facilitates a probability assessment to detect gradual changes through time on watershed and regional basis. It is also important to recognize that some increasing and decreasing patterns in water quality are not trends and that monotonic trend analysis especially, becomes more effective with longer periods of observation. And, a fully informed understanding of water quality variation must acknowledge that certain contributions to contemporary measurements may be artifacts of the past.

Adjustments for Flow and Season

Because flow and season have significant effects upon instream pollutant concentrations measurements, adjustments that reduce flow/season effects are necessary in order to perform sensitive trend analysis. To adjust a series of water quality observations for flow, each discrete measurement of concentration is plotted against its corresponding estimate of instantaneous discharge and a non-linear regression model is fitted. From the plot of concentration versus discharge, residual values – representative of the data variance, are the differences between each measured and modeled water quality concentration value. The residual values of concentration are then plotted as a time-ordered series and a nonlinear model is fit to the residuals data – this model represents an estimate of flow-normalized concentrations (FNC) across the period of observation.

The Weighted Regression on Time, Discharge, and Season (WRTDS) model, a highly flexible smoothing algorithm developed for use by CBPO (Hirsch et al., 2010), uses daily discharge estimates and measured water quality concentrations to generate estimates of concentration and load (note that WRTDS nomenclature substitutes the term ***flux*** for load) for every non-sampled day throughout the period of record according to the framework described above. The WRTDS model requires a large observational dataset. For each estimation day, the model prescreens all sampled data to select at least 100 samples that satisfy "closeness" according to the following criteria: (i) time; (ii) discharge; and (iii) season.

WRTDS invokes a three-dimensional model applied to the prescreened dataset to generate a water quality concentration for every estimation or model day that is biased and anchored toward previously-observed, similar conditions of discharge at/near the estimation date. Moreover, favorable weighting is applied to more recent rather than more distant observations in the period of observation. WRTDS decomposes each daily concentration estimate in the modeled period into residuals of: (i) time; (ii) discharge; (iii) season; and, (iv) randomization. Mathematical model trend testing then is applied to the randomized decomposed residual to determine within conditions of the model, whether an underlying trend exists.

To adjust for season first requires a definition of season, such as the calendar months or discrete blocks of months. With season defined, the difference between later measurements and all earlier measurements in each season is computed. To each iterative difference, one of three integer values is assigned: -1, 0, or 1 to negative, no, or positive differences, respectively. A seasonal test statistic (S) is computed as the sum of all integers and generally, if S is large and positive, then the later-measured values tended to be larger than the earlier-measured values indicating an upward trend. If the absolute value of S is small, then no trend is indicated. Based on factors specific to the dataset, the seasonal test statistic is compared to standard probability values and a trend decision is rendered with a defined mathematical confidence. The seasonal Kendall test was used to analyze discharge data for trends based on the XLSTAT computational package.

Additionally, WRTDS's estimated daily concentrations are multiplied by the estimated ADF value obtained from USGS gage data to generate a time series of flow-normalized estimated daily loads for the entire modeled period. WRTDS also is used to estimate a "true condition" or non-normalized load by combining the discrete measured concentrations with continuous discharge estimates for the entire period of interest and applying a simple (non-seasonal, non-discharge-weighted) interpolation algorithm to estimate load for the non-quantified periods.

The WRTDS model was used to analyze pollutant concentrations and loads for trends after datasets were normalized for flow and season.

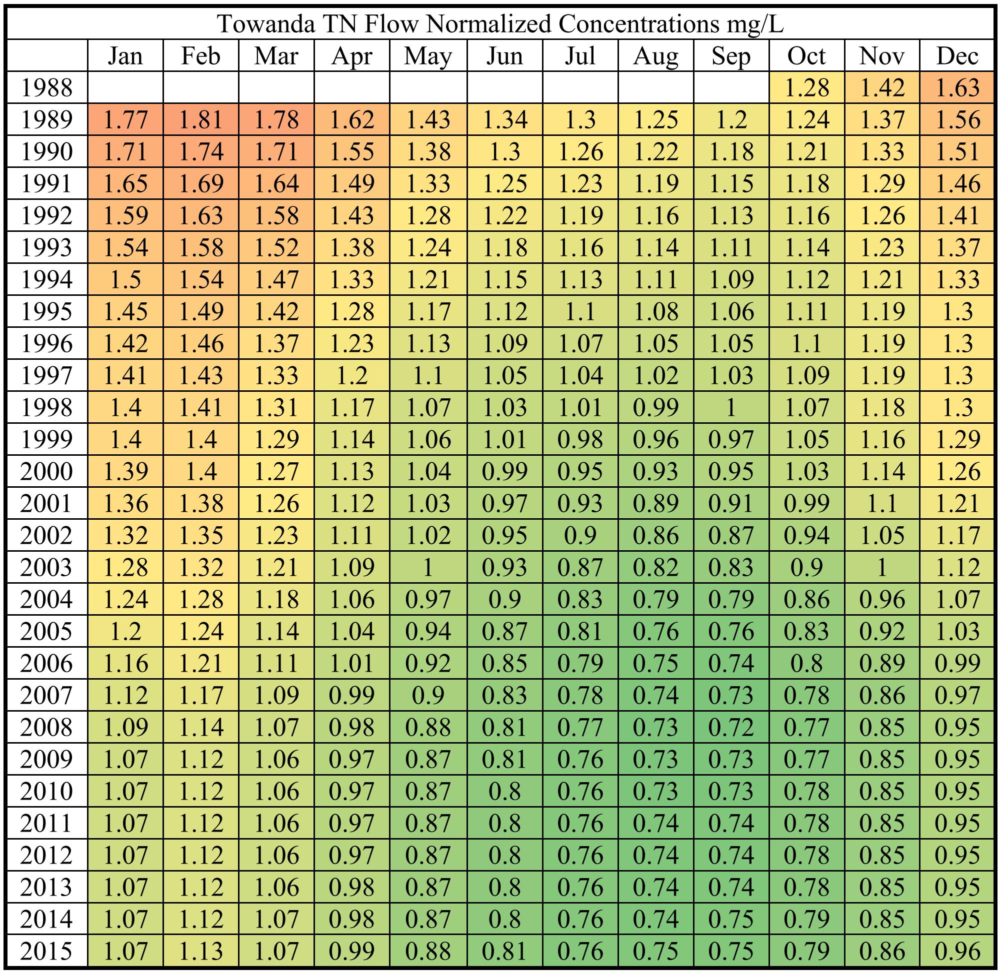
Colorized Heat Charts

The long-term sites present some difficulty in visualizing change within the annual trends due to the duration and extent of sampling that has occurred. One approach to improving visualization involves using Excel's conditional formatting function to colorize monthly data as a group with red set at the highest value, green set at the lowest value, and yellow set at the 50 percentile value. Plotting the data in this fashion allows for comparison of the progression through each year and the progression of each individual month through the years.

This approach works best for FNCs as the variation of concentration from month to month is much less dramatic than the variation in load and subsequent yields, which can mask the monthly changes when looking at only the colorized FNFs. As such, it is critical to couple numerical change data with the colorized change data in order to have a clear picture of the changes that are occurring. Thus, the colorized charts, change, and percent change information must be collectively used to create an accurate picture of how concentrations and yields have changed over the duration of sampling.

Tables 5 through 9 show TN heat charts for Towanda, Danville, Marietta, Lewisburg, and Newport, which were all colorized together. Colorizing these sites together allows visualization of how the sites' TN concentrations interrelate. Of particular interest is the cumulative collection of TN when moving downstream from Towanda to Marietta. Of additional interest is the dominance of green (i.e., low concentrations) in the Lewisburg chart and dominance of red (high concentrations) in the Newport chart. The visualization of Newport having worse TN water quality and Lewisburg having better TN water quality when compared to the Susquehanna mainstem can provide valuable management planning information. Although this visualization presents Newport as the best location for TN practices, it should be noted that Conestoga was not included in the colorization process as the concentrations of TN there are so high that they mask variations in other sites' concentrations. Heat charts for TN, TP, and SS for Group A sites that were individually colorized (i.e., only using data for the individual site), are presented in Appendix B for each individual site.

Table 5. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together



Towanda TN Flow Normalized Concentrations mg/L

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988										1.28	1.42	1.63
1989	1.77	1.81	1.78	1.62	1.43	1.34	1.3	1.25	1.2	1.24	1.37	1.56
1990	1.71	1.74	1.71	1.55	1.38	1.3	1.26	1.22	1.18	1.21	1.33	1.51
1991	1.65	1.69	1.64	1.49	1.33	1.25	1.23	1.19	1.15	1.18	1.29	1.46
1992	1.59	1.63	1.58	1.43	1.28	1.22	1.19	1.16	1.13	1.16	1.26	1.41
1993	1.54	1.58	1.52	1.38	1.24	1.18	1.16	1.14	1.11	1.14	1.23	1.37
1994	1.5	1.54	1.47	1.33	1.21	1.15	1.13	1.11	1.09	1.12	1.21	1.33
1995	1.45	1.49	1.42	1.28	1.17	1.12	1.1	1.08	1.06	1.11	1.19	1.3
1996	1.42	1.46	1.37	1.23	1.13	1.09	1.07	1.05	1.05	1.1	1.19	1.3
1997	1.41	1.43	1.33	1.2	1.1	1.05	1.04	1.02	1.03	1.09	1.19	1.3
1998	1.4	1.41	1.31	1.17	1.07	1.03	1.01	0.99	1	1.07	1.18	1.3
1999	1.4	1.4	1.29	1.14	1.06	1.01	0.98	0.96	0.97	1.05	1.16	1.29
2000	1.39	1.4	1.27	1.13	1.04	0.99	0.95	0.93	0.95	1.03	1.14	1.26
2001	1.36	1.38	1.26	1.12	1.03	0.97	0.93	0.89	0.91	0.99	1.1	1.21
2002	1.32	1.35	1.23	1.11	1.02	0.95	0.9	0.86	0.87	0.94	1.05	1.17
2003	1.28	1.32	1.21	1.09	1	0.93	0.87	0.82	0.83	0.9	1	1.12
2004	1.24	1.28	1.18	1.06	0.97	0.9	0.83	0.79	0.79	0.86	0.96	1.07
2005	1.2	1.24	1.14	1.04	0.94	0.87	0.81	0.76	0.76	0.83	0.92	1.03
2006	1.16	1.21	1.11	1.01	0.92	0.85	0.79	0.75	0.74	0.8	0.89	0.99
2007	1.12	1.17	1.09	0.99	0.9	0.83	0.78	0.74	0.73	0.78	0.86	0.97
2008	1.09	1.14	1.07	0.98	0.88	0.81	0.77	0.73	0.72	0.77	0.85	0.95
2009	1.07	1.12	1.06	0.97	0.87	0.81	0.76	0.73	0.73	0.77	0.85	0.95
2010	1.07	1.12	1.06	0.97	0.87	0.8	0.76	0.73	0.73	0.78	0.85	0.95
2011	1.07	1.12	1.06	0.97	0.87	0.8	0.76	0.74	0.74	0.78	0.85	0.95
2012	1.07	1.12	1.06	0.97	0.87	0.8	0.76	0.74	0.74	0.78	0.85	0.95
2013	1.07	1.12	1.06	0.98	0.87	0.8	0.76	0.74	0.74	0.78	0.85	0.95
2014	1.07	1.12	1.07	0.98	0.87	0.8	0.76	0.74	0.75	0.79	0.85	0.95
2015	1.07	1.13	1.07	0.99	0.88	0.81	0.76	0.75	0.75	0.79	0.86	0.96

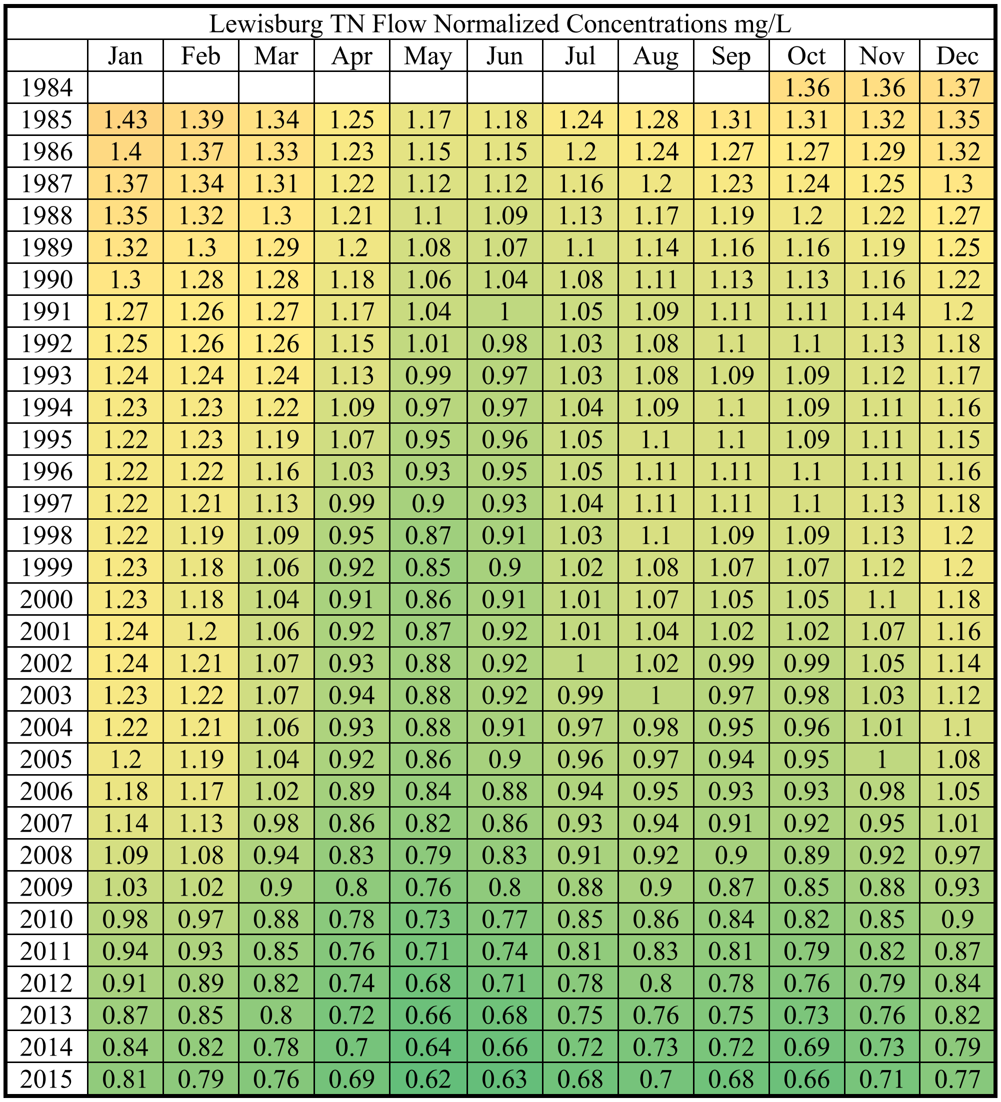
Table 6. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together

Danville TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										1.61	1.74	1.85
1985	1.96	1.97	1.9	1.73	1.51	1.38	1.33	1.34	1.42	1.57	1.69	1.8
1986	1.91	1.92	1.85	1.69	1.47	1.34	1.3	1.31	1.38	1.52	1.64	1.75
1987	1.85	1.86	1.81	1.65	1.43	1.31	1.27	1.28	1.35	1.47	1.58	1.7
1988	1.8	1.8	1.76	1.61	1.39	1.27	1.24	1.25	1.31	1.43	1.53	1.64
1989	1.74	1.75	1.71	1.57	1.35	1.24	1.21	1.22	1.27	1.37	1.47	1.59
1990	1.68	1.69	1.67	1.53	1.3	1.2	1.18	1.19	1.24	1.32	1.41	1.54
1991	1.63	1.64	1.62	1.49	1.26	1.16	1.15	1.18	1.21	1.27	1.36	1.49
1992	1.59	1.6	1.58	1.45	1.23	1.14	1.14	1.16	1.19	1.24	1.32	1.45
1993	1.57	1.58	1.56	1.43	1.22	1.14	1.13	1.15	1.16	1.21	1.29	1.43
1994	1.55	1.57	1.53	1.4	1.2	1.13	1.13	1.14	1.16	1.2	1.29	1.42
1995	1.55	1.57	1.5	1.36	1.18	1.1	1.09	1.1	1.13	1.2	1.29	1.42
1996	1.55	1.56	1.48	1.32	1.14	1.06	1.05	1.06	1.09	1.19	1.3	1.43
1997	1.55	1.56	1.45	1.28	1.11	1.02	1	1.01	1.05	1.17	1.3	1.44
1998	1.55	1.55	1.42	1.25	1.08	0.98	0.95	0.95	1.01	1.15	1.3	1.44
1999	1.55	1.54	1.4	1.22	1.06	0.96	0.91	0.92	0.98	1.12	1.28	1.42
2000	1.53	1.52	1.37	1.2	1.05	0.94	0.88	0.88	0.95	1.1	1.25	1.38
2001	1.49	1.49	1.35	1.18	1.03	0.92	0.86	0.85	0.92	1.05	1.2	1.32
2002	1.43	1.44	1.31	1.16	1.01	0.89	0.83	0.82	0.88	1	1.13	1.26
2003	1.37	1.4	1.27	1.13	0.98	0.87	0.81	0.79	0.84	0.94	1.07	1.19
2004	1.32	1.35	1.23	1.1	0.95	0.85	0.79	0.77	0.8	0.9	1.02	1.14
2005	1.29	1.32	1.2	1.07	0.93	0.83	0.78	0.76	0.79	0.87	0.98	1.11
2006	1.26	1.3	1.18	1.06	0.92	0.82	0.77	0.76	0.77	0.84	0.95	1.08
2007	1.23	1.27	1.16	1.04	0.9	0.81	0.77	0.75	0.76	0.82	0.92	1.05
2008	1.21	1.25	1.14	1.03	0.89	0.8	0.76	0.75	0.75	0.8	0.9	1.04
2009	1.18	1.22	1.13	1.03	0.88	0.79	0.75	0.73	0.73	0.79	0.89	1.03
2010	1.16	1.2	1.13	1.03	0.87	0.78	0.73	0.71	0.72	0.78	0.88	1.02
2011	1.15	1.19	1.13	1.03	0.86	0.77	0.71	0.7	0.7	0.76	0.87	1.01
2012	1.14	1.17	1.13	1.02	0.86	0.75	0.7	0.68	0.69	0.75	0.86	1.01
2013	1.13	1.16	1.13	1.03	0.85	0.74	0.68	0.67	0.68	0.74	0.85	1
2014	1.12	1.16	1.13	1.03	0.85	0.73	0.67	0.65	0.66	0.72	0.84	0.99
2015	1.11	1.15	1.13	1.03	0.84	0.72	0.66	0.64	0.65	0.71	0.83	0.99

Table 7. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together

Marietta TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986										1.77	1.91	2.07
1987	2.02	1.96	2.03	1.96	1.77	1.67	1.65	1.61	1.65	1.73	1.87	2.02
1988	1.99	1.93	1.98	1.91	1.72	1.63	1.6	1.58	1.62	1.69	1.83	1.98
1989	1.95	1.9	1.94	1.86	1.68	1.58	1.56	1.54	1.58	1.65	1.79	1.94
1990	1.91	1.86	1.9	1.81	1.63	1.54	1.52	1.51	1.55	1.62	1.75	1.9
1991	1.88	1.83	1.85	1.76	1.58	1.5	1.49	1.48	1.52	1.59	1.72	1.87
1992	1.85	1.8	1.81	1.71	1.53	1.45	1.45	1.46	1.5	1.57	1.7	1.84
1993	1.84	1.79	1.78	1.66	1.48	1.41	1.42	1.44	1.48	1.54	1.67	1.82
1994	1.83	1.8	1.76	1.61	1.43	1.38	1.41	1.44	1.48	1.54	1.67	1.81
1995	1.84	1.82	1.75	1.58	1.39	1.34	1.39	1.44	1.48	1.55	1.68	1.81
1996	1.84	1.83	1.73	1.53	1.35	1.3	1.37	1.42	1.47	1.57	1.7	1.83
1997	1.84	1.82	1.7	1.49	1.31	1.26	1.33	1.39	1.45	1.58	1.74	1.88
1998	1.85	1.79	1.65	1.45	1.28	1.23	1.29	1.35	1.43	1.58	1.78	1.92
1999	1.87	1.77	1.61	1.41	1.26	1.21	1.26	1.32	1.4	1.58	1.8	1.95
2000	1.88	1.77	1.59	1.41	1.27	1.21	1.25	1.3	1.38	1.58	1.81	1.96
2001	1.88	1.77	1.6	1.42	1.29	1.22	1.24	1.28	1.37	1.56	1.79	1.93
2002	1.85	1.75	1.6	1.43	1.29	1.21	1.22	1.26	1.35	1.53	1.74	1.88
2003	1.81	1.72	1.58	1.43	1.29	1.2	1.2	1.24	1.31	1.48	1.68	1.81
2004	1.75	1.67	1.55	1.41	1.28	1.2	1.19	1.21	1.28	1.43	1.62	1.75
2005	1.7	1.62	1.51	1.4	1.28	1.19	1.18	1.2	1.26	1.39	1.56	1.69
2006	1.64	1.57	1.48	1.38	1.27	1.19	1.18	1.2	1.26	1.37	1.52	1.63
2007	1.6	1.53	1.45	1.35	1.25	1.18	1.18	1.2	1.26	1.36	1.49	1.58
2008	1.56	1.5	1.41	1.32	1.22	1.16	1.16	1.2	1.27	1.35	1.46	1.54
2009	1.52	1.46	1.39	1.3	1.19	1.13	1.14	1.18	1.24	1.32	1.43	1.52
2010	1.49	1.42	1.37	1.29	1.18	1.1	1.1	1.14	1.21	1.29	1.4	1.49
2011	1.45	1.39	1.36	1.28	1.16	1.07	1.07	1.11	1.17	1.25	1.36	1.46
2012	1.42	1.36	1.34	1.26	1.13	1.04	1.04	1.07	1.14	1.22	1.33	1.43
2013	1.39	1.34	1.33	1.25	1.11	1.02	1.01	1.04	1.11	1.19	1.3	1.41
2014	1.37	1.31	1.31	1.24	1.09	0.99	0.98	1.01	1.08	1.16	1.27	1.38
2015	1.34	1.29	1.3	1.22	1.07	0.97	0.95	0.98	1.05	1.13	1.25	1.36

Table 8. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together



Lewisburg TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										1.36	1.36	1.37
1985	1.43	1.39	1.34	1.25	1.17	1.18	1.24	1.28	1.31	1.31	1.32	1.35
1986	1.4	1.37	1.33	1.23	1.15	1.15	1.2	1.24	1.27	1.27	1.29	1.32
1987	1.37	1.34	1.31	1.22	1.12	1.12	1.16	1.2	1.23	1.24	1.25	1.3
1988	1.35	1.32	1.3	1.21	1.1	1.09	1.13	1.17	1.19	1.2	1.22	1.27
1989	1.32	1.3	1.29	1.2	1.08	1.07	1.1	1.14	1.16	1.16	1.19	1.25
1990	1.3	1.28	1.28	1.18	1.06	1.04	1.08	1.11	1.13	1.13	1.16	1.22
1991	1.27	1.26	1.27	1.17	1.04	1	1.05	1.09	1.11	1.11	1.14	1.2
1992	1.25	1.26	1.26	1.15	1.01	0.98	1.03	1.08	1.1	1.1	1.13	1.18
1993	1.24	1.24	1.24	1.13	0.99	0.97	1.03	1.08	1.09	1.09	1.12	1.17
1994	1.23	1.23	1.22	1.09	0.97	0.97	1.04	1.09	1.1	1.09	1.11	1.16
1995	1.22	1.23	1.19	1.07	0.95	0.96	1.05	1.1	1.1	1.09	1.11	1.15
1996	1.22	1.22	1.16	1.03	0.93	0.95	1.05	1.11	1.11	1.1	1.11	1.16
1997	1.22	1.21	1.13	0.99	0.9	0.93	1.04	1.11	1.11	1.1	1.13	1.18
1998	1.22	1.19	1.09	0.95	0.87	0.91	1.03	1.1	1.09	1.09	1.13	1.2
1999	1.23	1.18	1.06	0.92	0.85	0.9	1.02	1.08	1.07	1.07	1.12	1.2
2000	1.23	1.18	1.04	0.91	0.86	0.91	1.01	1.07	1.05	1.05	1.1	1.18
2001	1.24	1.2	1.06	0.92	0.87	0.92	1.01	1.04	1.02	1.02	1.07	1.16
2002	1.24	1.21	1.07	0.93	0.88	0.92	1	1.02	0.99	0.99	1.05	1.14
2003	1.23	1.22	1.07	0.94	0.88	0.92	0.99	1	0.97	0.98	1.03	1.12
2004	1.22	1.21	1.06	0.93	0.88	0.91	0.97	0.98	0.95	0.96	1.01	1.1
2005	1.2	1.19	1.04	0.92	0.86	0.9	0.96	0.97	0.94	0.95	1	1.08
2006	1.18	1.17	1.02	0.89	0.84	0.88	0.94	0.95	0.93	0.93	0.98	1.05
2007	1.14	1.13	0.98	0.86	0.82	0.86	0.93	0.94	0.91	0.92	0.95	1.01
2008	1.09	1.08	0.94	0.83	0.79	0.83	0.91	0.92	0.9	0.89	0.92	0.97
2009	1.03	1.02	0.9	0.8	0.76	0.8	0.88	0.9	0.87	0.85	0.88	0.93
2010	0.98	0.97	0.88	0.78	0.73	0.77	0.85	0.86	0.84	0.82	0.85	0.9
2011	0.94	0.93	0.85	0.76	0.71	0.74	0.81	0.83	0.81	0.79	0.82	0.87
2012	0.91	0.89	0.82	0.74	0.68	0.71	0.78	0.8	0.78	0.76	0.79	0.84
2013	0.87	0.85	0.8	0.72	0.66	0.68	0.75	0.76	0.75	0.73	0.76	0.82
2014	0.84	0.82	0.78	0.7	0.64	0.66	0.72	0.73	0.72	0.69	0.73	0.79
2015	0.81	0.79	0.76	0.69	0.62	0.63	0.68	0.7	0.68	0.66	0.71	0.77

Table 9. Heat Chart of TN When All Group A sites, Except Conestoga, Are Colorized Together

Newport TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										1.91	2.14	2.22
1985	2.08	2.01	2.03	1.95	1.87	1.72	1.6	1.58	1.68	1.84	2.06	2.15
1986	2.01	1.94	1.97	1.9	1.82	1.67	1.55	1.53	1.63	1.78	1.99	2.07
1987	1.95	1.88	1.91	1.85	1.77	1.63	1.52	1.49	1.58	1.72	1.92	2.01
1988	1.88	1.83	1.86	1.8	1.73	1.59	1.49	1.46	1.55	1.67	1.86	1.94
1989	1.82	1.77	1.81	1.76	1.69	1.56	1.46	1.44	1.51	1.62	1.79	1.87
1990	1.76	1.71	1.76	1.71	1.65	1.53	1.44	1.42	1.48	1.57	1.72	1.8
1991	1.69	1.65	1.71	1.67	1.62	1.51	1.43	1.41	1.46	1.52	1.66	1.74
1992	1.63	1.6	1.68	1.65	1.6	1.51	1.44	1.42	1.45	1.5	1.63	1.72
1993	1.65	1.62	1.68	1.64	1.59	1.51	1.46	1.43	1.45	1.5	1.63	1.75
1994	1.71	1.68	1.7	1.63	1.57	1.5	1.47	1.45	1.46	1.51	1.65	1.77
1995	1.74	1.71	1.7	1.6	1.53	1.47	1.45	1.45	1.47	1.52	1.66	1.79
1996	1.75	1.72	1.69	1.58	1.5	1.45	1.43	1.44	1.47	1.54	1.71	1.84
1997	1.78	1.74	1.71	1.59	1.5	1.43	1.4	1.41	1.46	1.56	1.76	1.89
1998	1.81	1.75	1.72	1.6	1.5	1.42	1.38	1.4	1.46	1.58	1.81	1.95
1999	1.86	1.77	1.73	1.61	1.51	1.42	1.38	1.39	1.46	1.61	1.86	2.01
2000	1.9	1.8	1.75	1.63	1.53	1.43	1.38	1.39	1.47	1.63	1.9	2.05
2001	1.93	1.82	1.78	1.66	1.55	1.44	1.38	1.39	1.46	1.63	1.91	2.05
2002	1.93	1.82	1.79	1.68	1.57	1.45	1.37	1.37	1.45	1.61	1.88	2.02
2003	1.9	1.81	1.8	1.68	1.57	1.44	1.36	1.36	1.43	1.58	1.84	1.98
2004	1.87	1.78	1.79	1.68	1.56	1.44	1.35	1.34	1.4	1.55	1.8	1.93
2005	1.83	1.76	1.77	1.66	1.55	1.42	1.34	1.32	1.38	1.52	1.75	1.89
2006	1.8	1.74	1.75	1.65	1.54	1.42	1.33	1.31	1.36	1.49	1.71	1.84
2007	1.77	1.72	1.72	1.63	1.53	1.41	1.33	1.31	1.35	1.46	1.66	1.78
2008	1.74	1.69	1.69	1.6	1.51	1.4	1.32	1.3	1.33	1.43	1.61	1.73
2009	1.7	1.65	1.66	1.58	1.49	1.38	1.32	1.3	1.33	1.41	1.58	1.71
2010	1.67	1.63	1.64	1.56	1.48	1.38	1.32	1.31	1.32	1.39	1.56	1.69
2011	1.65	1.61	1.62	1.55	1.47	1.38	1.32	1.31	1.31	1.38	1.54	1.67
2012	1.63	1.59	1.6	1.53	1.46	1.38	1.33	1.31	1.31	1.37	1.52	1.65
2013	1.62	1.57	1.59	1.52	1.46	1.38	1.33	1.31	1.3	1.36	1.51	1.63
2014	1.6	1.56	1.58	1.51	1.45	1.38	1.33	1.31	1.3	1.35	1.5	1.62
2015	1.58	1.55	1.57	1.51	1.45	1.38	1.33	1.31	1.3	1.35	1.49	1.61

2015 RESULTS

Summary statistics for the laboratory-analyzed water sample concentrations are listed in Appendix A for the 2015 dataset. Summaries of the six long-term monitoring Group A station 2015 pollutant concentrations, loads, and yields are provided in Appendix B. Loading estimates also were completed for 17 of 20 Group B stations, although only for the primary pollutant parameters TN, TP, and TSS/SS. Because of their recent addition to the monitoring network, the Group B NTN stations on Kishacoquillas Creek (Reedsville, PA), East Mahantango Creek (Dalmatia, PA), and Paxton Creek (Penbrook, PA) were excluded from pollutant load estimates. Group B station summary results are provided in Appendix C.

DISCUSSION

Figure 6 shows the annual long-term mean discharge at Marietta and Figure 7 shows the annual peak discharge. 2015 was the fourth year in a row with below long-term mean flow on the heels of 2011, the highest flow year during the sampling program. 2011 also contained the highest event since Hurricane Agnes in 1972. The combination of this flushing event followed by four years of below average flow, provided a unique flow period that likely played a factor in recent Bay improvements including receiving the highest rating for 2016 from the Chesapeake Bay Foundation (CBF, 2016). Peak flows at Marietta during 2012-2015 were all around 200,000 cfs, which is another major factor in the health of the Bay over the past four years. Similar flow conditions occurred from 1999-2002. Figure 8 combines annual peak ADF and pollutant loads for the Marietta station for the years 1999 to 2015; a period that encompassed the maximum peak ADF during the ~ 30-year period of record (2011) as well as the two distinct multi-year periods during which annual peak ADF was below-average. The years 1999 to 2003 and the years 2012 to 2015 marked two periods during which annual peak ADF was below normal for successive years.

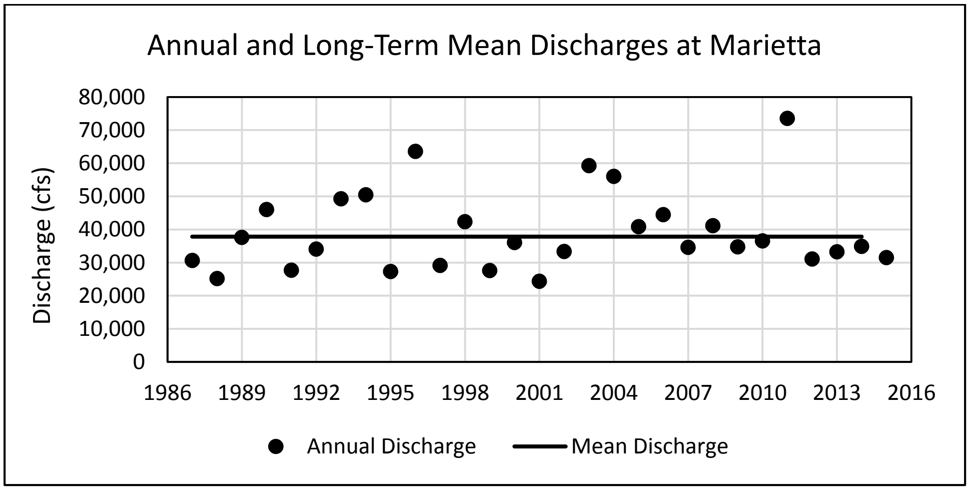


Figure 6. ***Annual and Mean Discharge Susquehanna River at Marietta in Cubic Feet/Second (cfs)***

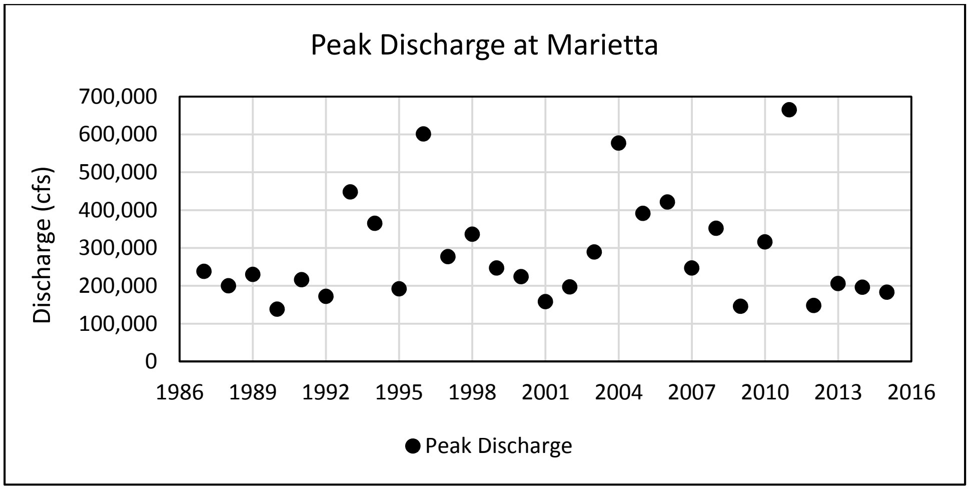


Figure 7. ***Peak Discharge Susquehanna River at Marietta in Cubic Feet/Second (cfs)***

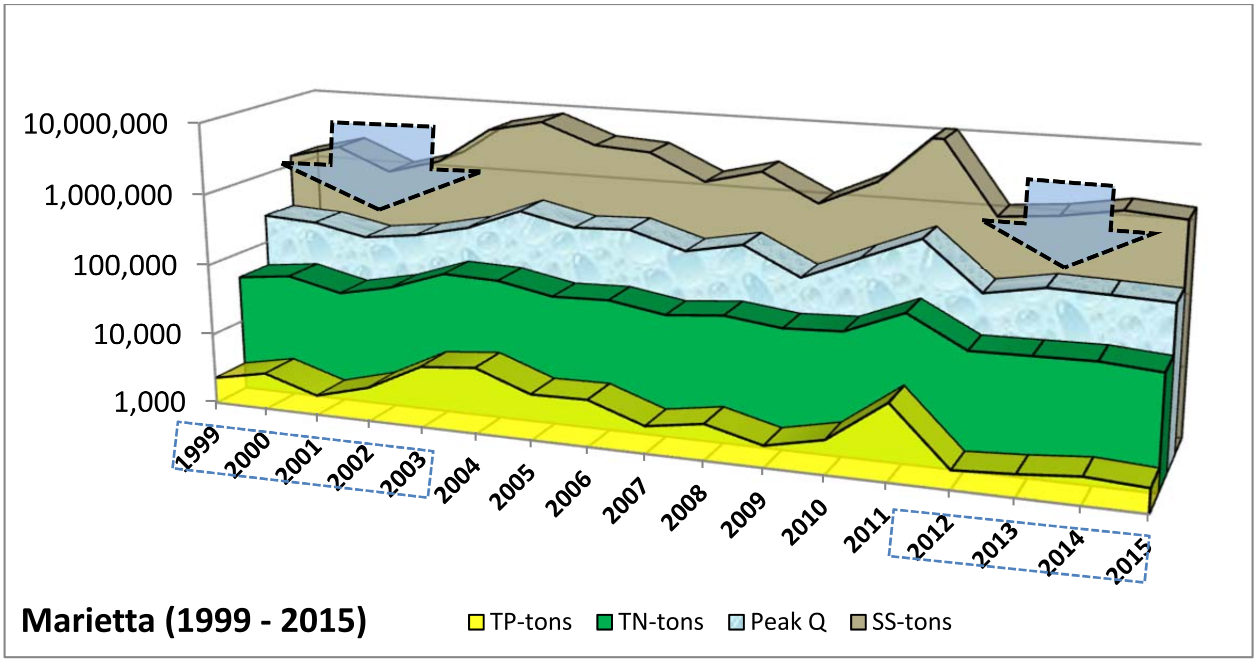


Figure 8. Annual Pollutant Loads and Peak Annual ADF in Chronological Order from 1999 to 2015 for Marietta Station (Blue arrows emphasize the years 1999-2003 and 2012-2015; two periods when successive years exhibited peak annual ADF that were below respective Long-Term Mean values. In 2011, the highest annual peak ADF occurred.)

Table 10 compares the average TN, TP, and SS loads for the two low flow time periods. With more than 10 years between the time periods, there is a large reduction in TN but more modest reductions in TP and SS. Due to the low flows and more specifically, low peak events, all load ratios were well below their respective discharge ratios. The only load ratio that was close to its discharge ratio was SS at Danville. This observation at Danville plays out in several other analyses, suggesting that there may be pockets of sediment that are being re-suspended with each new storm.

Table 10. Loads of TN, TP, and SS during Two Four-Year Low Flow Periods at Marietta

Time Period	Q	Q Ratio	TN	TN LTM Ratio	TP	TP LTM Ratio	SS	SS LTM Ratio
1999-2002 Average	30,331	0.76	93,421	0.75	5,265	0.64	3,083,753	0.48
2012-2015 Average	32,692	0.82	81,625	0.65	4,230	0.51	2,700,198	0.42
Full LTM	40,048	1.00	125,360	1.00	8,226	1.00	6,423,237	1.00

One theory for this increased mass of sediment is the sequence of flooding events that hit New York state in the mid-2000s, which may have started a mass of sediment moving down the Susquehanna. Table 11 shows the SS loads for 2011 through 2015, covering the largest flow year and the subsequent four below-LTM flow years, as well as the 10-year mean. Driven by Tropical Storm Lee in 2011, Wilkes Barre recorded nearly double the sediment load that was found at the downstream sites at Danville and Marietta. Clearly the sediment load settled out somewhere after Wilkes Barre and may be a driving factor for increases in sediment loads at Danville. The data in Table 11 also add some evidence of the difficulty of understanding SS dynamics in the watershed. Whereas TN is more additive going downstream, SS clearly is not, based on the lower SS loads downstream of Wilkes Barre in 2011 and the minimal difference between Danville and Marietta during most years in the table. SS not only responds exponentially to increases in flow, but also clearly has significant deposition and scour dynamics that play out over the long term. The colorized heat chart for SS at Danville in Table 12 implicates April and December as the months driving the increases in SS load, both with greater than 30 percent increase in concentrations since 1984/85. November, January, and March also show increases over the sampling period.

Table 11. Suspended Sediment Loads at Susquehanna River Sites

Site	2011	2012	2013	2014	2015	10 Yr Average
Conklin	2,459,792	127,402	449,567	362,049	343,694	914,517
Smithboro	3,925,325	290,413	863,441	577,420	625,990	1,459,727
Towanda	6,242,339	447,324	1,431,165	1,254,422	1,445,071	2,009,429
Wilkes-Barre	40,443,526	881,210	2,037,201	1,952,209	2,252,242	6,150,431
Danville	23,345,304	1,271,131	2,281,082	2,614,689	2,851,634	4,941,415
Marietta	24,414,848	2,085,604	2,461,776	3,346,865	2,906,548	5,732,748

Table 12. SS Colorized Heat Chart at Danville

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										40.8	39.1	42.1
1985	44.7	32.4	80.4	101.9	58.6	53.3	46.5	43.7	58.1	38.8	37.6	41.0
1986	43.4	31.4	77.6	97.7	55.7	50.2	43.4	40.7	54.6	36.7	36.1	40.0
1987	42.1	30.6	75.1	93.9	53.2	47.3	40.6	37.9	51.5	34.9	34.8	39.0
1988	40.9	30.5	73.1	90.9	51.2	44.9	38.1	35.3	48.7	33.1	33.5	38.1
1989	40.0	29.3	71.3	87.9	48.9	42.3	35.6	33.0	46.3	31.6	32.4	37.4
1990	39.2	28.9	70.1	85.6	47.0	40.0	33.3	30.9	44.2	30.2	31.3	36.8
1991	38.7	28.8	69.7	83.9	45.4	37.9	31.2	28.9	42.6	28.8	30.3	36.5
1992	38.6	29.9	70.5	83.3	44.6	36.5	29.6	27.3	41.2	27.9	30.3	37.3
1993	38.8	29.8	70.3	81.8	43.4	35.3	28.2	26.0	41.4	27.7	30.9	38.5
1994	39.3	30.1	69.5	79.4	41.8	34.6	27.7	25.7	43.1	28.6	32.6	40.4
1995	40.2	30.2	67.4	75.1	39.2	33.8	27.4	25.7	45.3	30.4	35.4	43.6
1996	41.4	30.6	64.0	69.8	36.4	33.1	26.7	25.4	45.6	32.7	38.8	46.9
1997	42.2	28.9	59.4	64.5	33.3	31.6	25.7	24.7	42.1	33.4	40.0	47.1
1998	40.5	26.3	53.9	59.5	31.1	30.0	24.7	23.8	37.1	32.7	38.6	44.4
1999	37.4	23.8	50.1	56.9	29.5	28.6	24.0	23.4	39.7	32.2	36.4	40.6
2000	34.3	22.2	47.7	55.6	28.6	27.5	23.6	23.3	41.0	31.7	34.0	36.6
2001	31.1	19.9	45.6	53.8	27.7	26.0	23.0	22.9	37.8	30.3	31.2	32.8
2002	28.3	18.5	43.9	52.8	27.6	25.5	22.6	22.0	33.7	27.3	27.7	29.4
2003	26.1	17.5	43.3	53.3	28.4	25.8	22.3	20.8	30.4	24.1	24.6	26.6
2004	24.5	17.2	43.4	55.1	29.9	26.6	22.2	19.8	27.9	22.1	22.9	25.1
2005	23.8	16.6	44.6	58.1	31.8	27.7	22.4	19.6	27.0	21.8	23.1	25.7
2006	24.4	17.2	48.1	64.4	35.6	30.5	24.0	20.5	27.8	23.0	25.1	28.4
2007	26.5	18.3	53.2	73.1	40.9	34.5	26.3	21.8	29.0	24.7	28.3	32.9
2008	30.0	20.4	58.9	82.6	46.9	38.9	28.3	22.5	30.0	26.3	32.1	38.5
2009	34.5	21.6	63.8	89.7	50.1	40.6	28.5	22.2	31.6	28.1	35.3	42.9
2010	38.3	23.3	68.4	94.6	50.7	40.3	27.6	21.7	33.3	30.0	38.5	47.1
2011	42.4	25.1	73.6	100.7	52.2	40.9	27.5	21.6	35.3	32.0	42.0	52.0
2012	46.9	27.8	79.7	108.4	54.7	42.4	28.0	22.0	37.6	34.2	45.9	57.3
2013	51.8	29.2	85.9	115.9	57.0	43.9	28.6	22.4	40.1	36.6	50.1	63.1
2014	57.0	31.3	92.5	124.2	59.5	45.6	29.2	22.8	42.8	39.0	54.4	69.2
2015	62.6	33.5	99.3	132.7	61.9	47.3	29.8	23.1	45.6	41.4	58.9	75.4
Change	17.9	1.1	18.9	30.8	3.3	-6.0	-16.7	-20.5	-12.5	0.7	19.8	33.3

Precipitation and subsequent flows are the most significant influence on constituent loads. Table 13 shows how that manifested in 2015 with monthly high and low flow months for the year. Although 2015 was a low flow year, there were elevated flows in March at Conestoga and July at all other sites, where flows were greater than 200 percent of the respective monthly LTM. These high flow months were the largest contributors to the annual loads of TN, TP, and SS. Comparatively, May at Conestoga and September at all other sites was the lowest flow month. As such, it contributed a very small percentage of the TN, TP, and SS loads. Whereas TN tends to respond in a linear fashion to increases in flow, TP and more so SS, respond in a more exponential way as loads increase dramatically under the high flows. Beyond the fact that low flows do not have the erosive capacity of high flows, they also are more likely to be cleaned up by established BMPs as flows are within the design capacity of the BMPs. High flow events have the ability to overwhelm BMPs, which is likely a contributing factor to the exponential-like increases that are found. Additionally, the impacts of storms are enhanced by the management efforts of channeling water to the stream as quickly as possible. Evidence for this effect was presented via the runoff ratio in the 2014 nutrient report. The deposition and scour component previously discussed is a likely factor in the exponential rises seen on the Susquehanna mainstem.

Table 13. Select Monthly Discharge and Load Ratios

Site	July 2015				September 2015			
	Flow	TN	TP	SS	Flow	TN	TP	SS
Towanda	214	195	182	246	22	17	4	1
Danville	242	211	208	414	23	12	3	<1
Marietta	266	234	286	373	32	19	7	2
Lewisburg	333	254	243	456	28	18	3	1
Newport	299	307	240	276	34	23	5	1
Site	**March 2015**				**May 2015**			
Conestoga	155	112	132	99	51	43	19	3

Table 14 shows an annual comparison of 2015 to similar water years. All yearly comparisons suggest solid reductions in TN at all sites. Large reductions in TP and SS were seen at Lewisburg and Conestoga. One caveat for Conestoga is that an automatic sampler was retired in the middle of 2003. During the time that the autosampler was in operation, more samples were collected over each individual storm event and collection protocol was not depth integrated but rather from a pipe on the bottom of the stream. The effects of this collection system are a topic for future analysis.

Table 14. Flow, TN, TP, and SS Loads (1000's of pounds) for 2015 and Similar Flow Years

Site	Year	Q	TN	TP	SS
Towanda	1991	8,403	25,442	1,464	988,185
	2015	8,688	16,496	1,352	1,445,071
Danville	1987	12,884	42,410	2,850	1,949,262
	2015	12,748	24,465	1,927	2,851,634
Marietta	1987	30,634	117,851	6,154	3,794,666
	2012	31,100	81,177	3,690	2,085,604
	2015	31,505	75,252	4,303	2,906,548
Lewisburg	1998	10,331	22,338	1,438	1,863,422
	2008	10,108	18,154	847	602,518
	2015	10,022	14,468	554	513,053
Newport	1988	3,128	11,367	574	245,596
	2000	3,120	10,340	484	191,615
	2015	3,180	9,655	317	200,585
Conestoga	1987	599	9,943	631	295,415
	2000	609	9,151	622	319,802
	2012	605	7,680	329	91,130
	2015	604	7,181	290	63,624

Figure 9 displays the 2015 and LTM TN, TP, and SS yields at all network sites and is sorted by reducing 2015 yields. Using yields in this fashion helps to identify what sites may be the best candidates for BMP implementation. This program has provided long-term data that have consistently placed the lower Susquehanna Basin as the highest producer of TN, TP, and SS. Although these figures are sorted by 2015 data, it is critical to keep the LTM values in mind. This is especially the case due to 2015 being a low flow year and the effects that has on SS. The same charts, sorted by LTM, are displayed in Figure 10.

When looking at the discharge ratios listed on the x-axis, in parentheses, one confounding factor is that a single intense storm event could add a tremendous amount of sediment and yet not have a significant effect on the discharge ratio. Table 15 shows monthly precipitation, flow, and SS loads and yields at Marietta. Whereas the highest monthly rainfall was in June, including the highest daily precipitation, the highest flow was during April, producing 43 percent of the total annual load of SS.

Potential factors include snow melt, ice jam release, and the timing of rainfall. Regarding June, rainfall at the end of the month resulted in discharges that significantly affected July loads. Although three less inches of rainfall fell in July than June, July's flow and SS load was significantly higher.

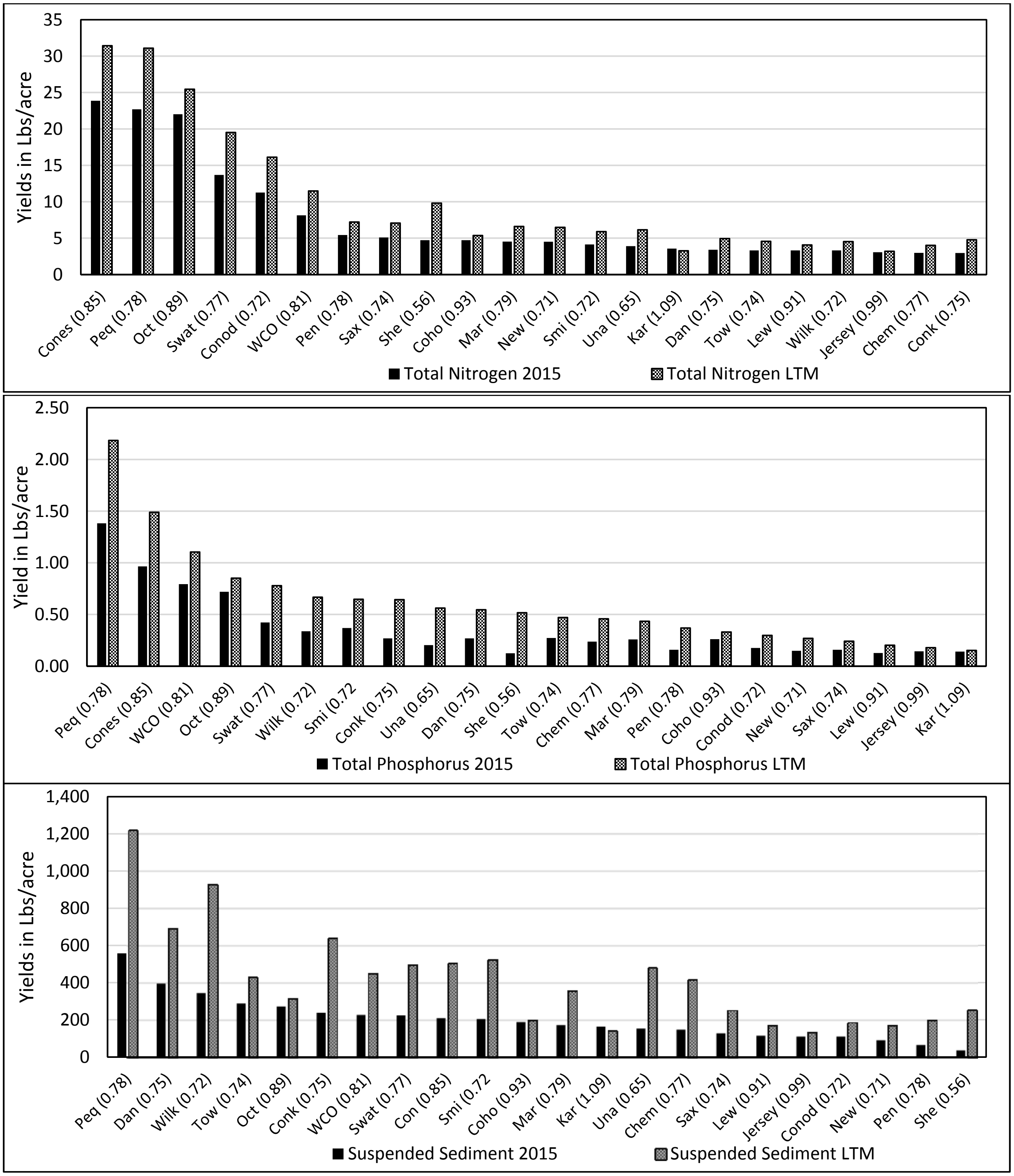


Figure 9. ***2015 and LTM TN, TP, and SS Yields at All Sites in Pounds Per Acre***

Table 15. Monthly Precipitation, Flow, and Suspended Sediment Loads at Marietta

Mon	Precip			Flow		SS		
	Ave	Max	% LTM	2014	% LTM	Load	Yield	% LTM
Jan	1.95	0.59	70%	23,942	51%	50,144	10	7%
Feb	1.55	0.52	71%	11,671	28%	7,062	1.4	3%
Mar	2.39	0.48	74%	48,084	68%	337,456	67.6	34%
Apr	3.96	0.86	114%	92,500	123%	1,258,697	252.2	113%
May	2.46	0.73	64%	24,703	53%	71,531	14.3	14%
Jun	8.19	1.45	196%	35,233	123%	239,070	47.9	80%
Jul	5.09	0.72	127%	51,400	266%	632,177	126.7	373%
Aug	2.74	1.07	71%	11,979	82%	36,084	7.2	25%
Sept	3.62	1.77	85%	6,848	32%	14,253	2.9	2%
Oct	3.31	1.25	90%	13,609	57%	42,476	8.5	14%
Nov	1.97	1.15	60%	24,093	72%	77,029	15.4	20%
Dec	3.9	0.56	125%	33,129	68%	140,569	28.2	25%

By far the best predictor of changes in nutrients and SS are the flow normalized trends produced by WRTDS. Table 16 lists the short-term (~ 10 year) trends for all sites in Flow Normalized Flux (loads). The maps in figures 10 and 11 display the for long-term and short-term trends directions through 2015. Short-term trends were included for the long-term Group A sites to maintain comparability to shorter term datasets and due to the fact that there are multiple inflections in long-term trends. More recent trend magnitudes are less than historical magnitudes. This was in part due to the largest management items that had the most dramatic effect being implemented in the early parts of the long-term dataset. The more recent and subtle trends can get masked in an overall 30-year trend. An additional reason was that when planning the next 10 years of management, it is important to understand the trajectory of the most recent 10 years, which have more impact on the future than previous years.

All Group A sites have strong downward trends for TN and TP. Group B sites, representing the headwaters of many basins, show mixed results for TN, with five upward trends in loads throughout the Basin. Two of the upward trends were at the West Branch sites Karthaus and Jersey Shore, which have the best overall water quality in the watershed. The fact that they have increasing trends in TN raises some concern. Additional sites that show short-term increasing TN trends include Penns Creek, Wilkes Barre, and Cohocton. Increasing trends for TP were focused in the lower subbasin sites including Pequea, Swatara, and West Conewago. Other sites where TP trends are upward include the mainstem Susquehanna at Wilkes Barre and the Raystown Branch of the Juniata River at Saxton.

SS trends showed more inconsistency with nearly half of the sites having upward trends. Towanda, Wilkes Barre, and Danville all have upward short-term trends of increasing magnitude downstream. Although the West Branch sites at Karthaus and Jersey Shore had downward trends in TP, they both have upward trends in SS. Figure 10 lists Karthaus and Jersey Shore as having the lowest yields of all network sites. Thus, they have the least to gain from targeted management action. The simple fact that their TN and SS trends are increasing while TP trends are decreasing does make them good candidates for further investigation. If a shift in trends can be isolated to specific changes in the landscape, the information may prove beneficial for management effort in other watersheds. This same pattern of trend findings and thinking also applies to the Cohocton Watershed. West Conewago and Saxton showed the opposite pattern from the West Branch sites; i.e., upward trends in TP coupled with downward trends in TN and SS.

Considering all analyses completed, SS is quickly becoming the pollutant of concern for management action. Many of these trends show that water quality patterns vary across the watersheds with different areas presenting different opportunities for reductions. Watersheds with upward trends are a vital location for management effort, especially those that are located in high yielding watersheds. Many of these opportunities exist in the lower Susquehanna Watershed, although as the next section will show, they do not represent enough of the problem to meet all long-term goals.

Table 16. Short-term Flow Normalized Trend Percent Change at All Sites by Subbasin

Subbasin	Site	Period	% Change (Upward Trends Shaded)		
			TN	TP	SS
NY Chemung	Cohocton	2005-2015	11	-18	31
	Chemung	2005-2015	-3.4	-21	-28
NY Upper	Unadilla	2005-2015	-2.2	-39	-19
Main-Upper	Conklin	2005-2015	-20	-36	-27
	Smithboro	2004-2015	-11	-24	-39
	Towanda	2005-2015	-5.6	-9	18
Main-Middle	Wilkes Barre	2004-2015	11	19	148
	Danville	2005-2015	-5	-14	153
Main-Lower	Marietta	2005-2015	-14.3	-12	-8.6
W. Branch	Karthaus	2004-2015	3.4	-33	41
	Jersey Shore	2004-2015	1.1	-20	32
	Lewisburg	2005-2015	-20.4	-34	-1.8
Juniata	Saxton	2004-2015	-6.9	19	-33
	Newport	2005-2015	-11.2	-28	-9.1
Lower	Penns Creek	2004-2015	7.3	-25	-17
	Conodoguinet	2004-2015	-8.9	-15	9.3
	Shermans	2004-2015	-9	-23	-47
	Swatara	2004-2015	-18	29	41
	W. Conewago	2004-2015	-19	8.2	-21
	Conestoga	2005-2015	-18.6	-12	-36
	Pequea	2004-2015	-15	18	6.7
	Octoraro	2006-2015	-6.1	-6.3	-3.5

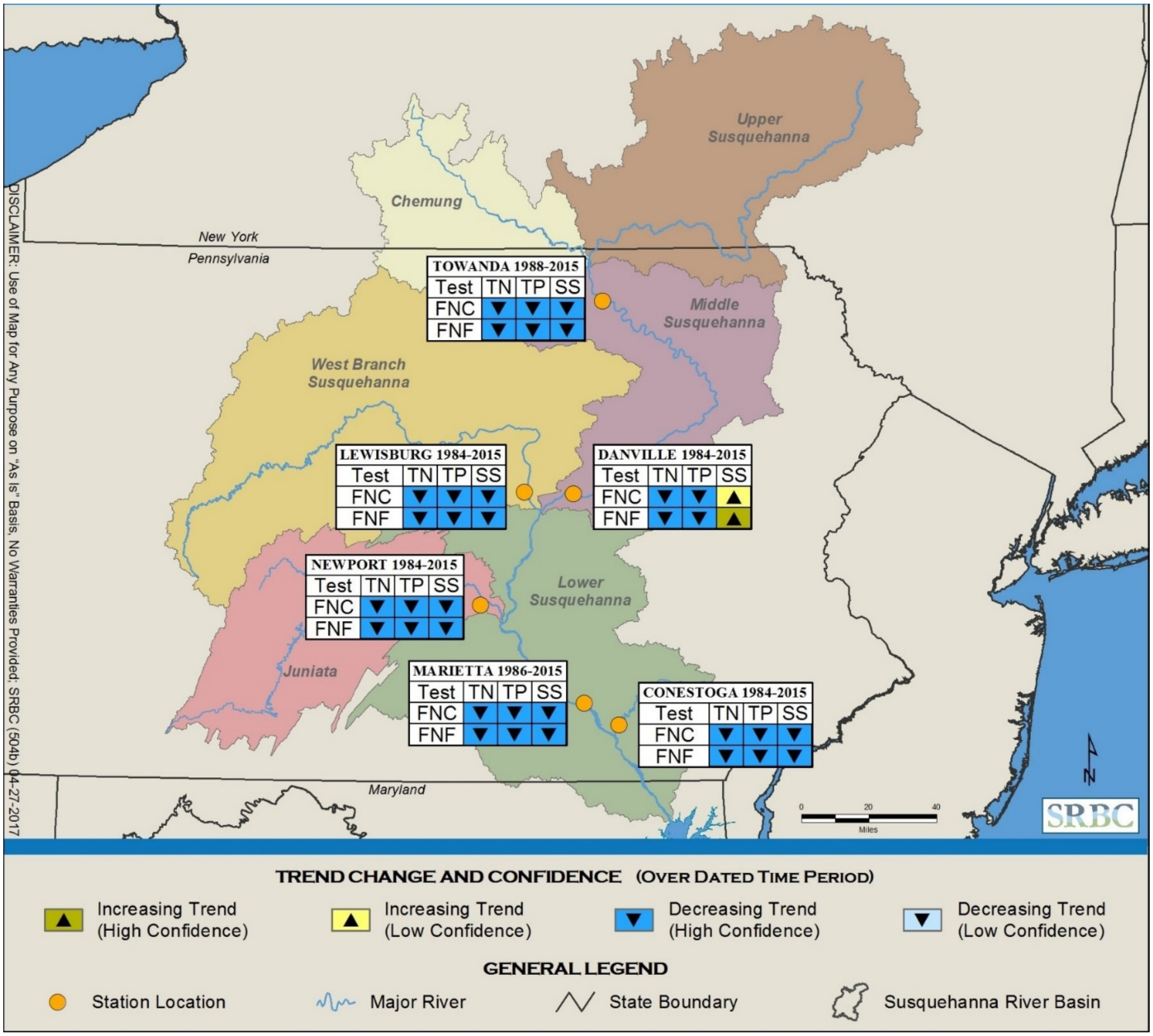


Figure 10. Long-term FNC and FNF Trend Directions at Group A Sites

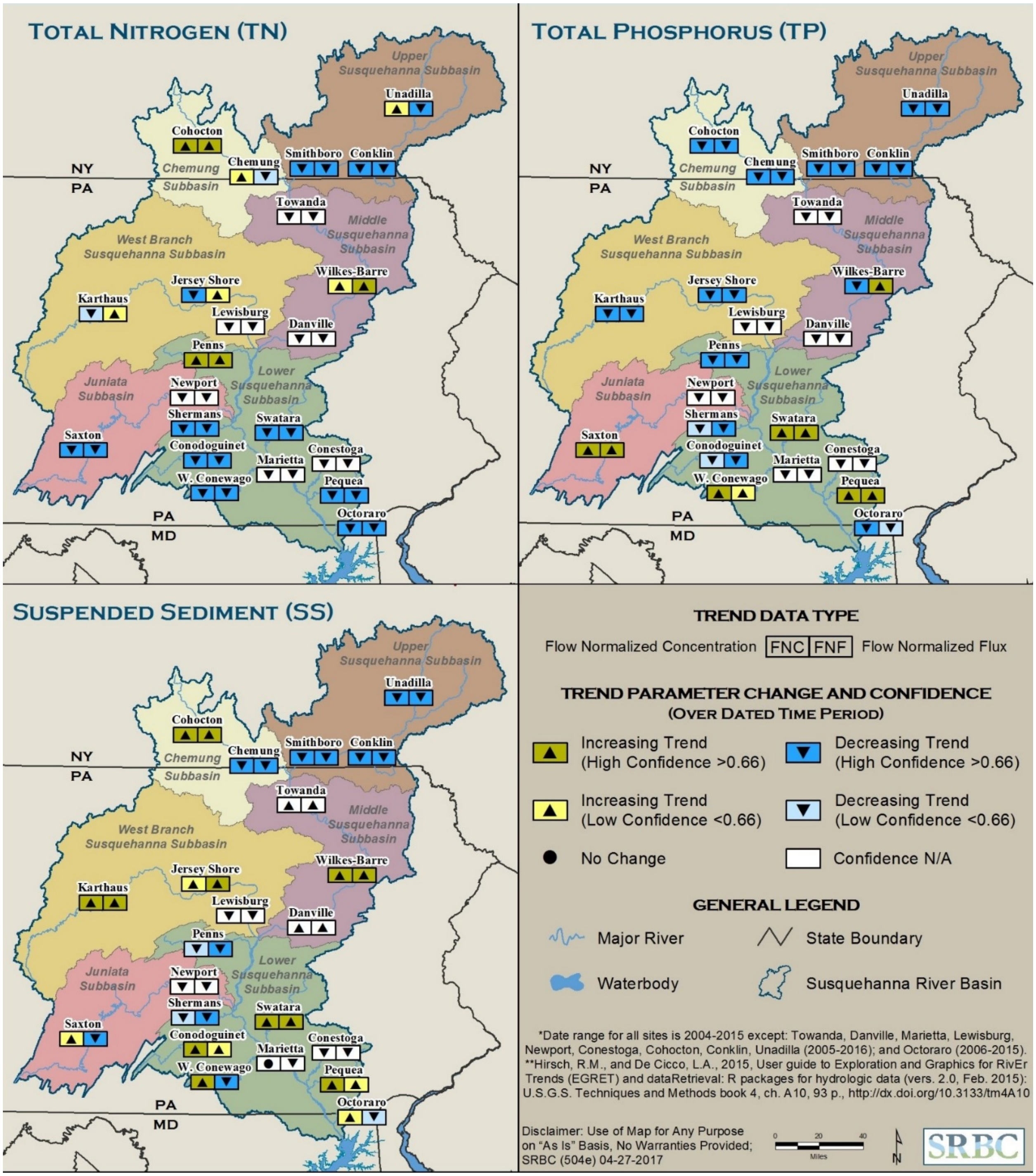


Figure 11. Short-term FNC and FNF Trend Directions at All Sites

DISTRIBUTED LOADS

One of the main goals of this project is to identify watersheds where management efforts should be focused to maximize results. To accomplish that, this report utilized 2025 targets for TN, TP, and SS taken from the Chesapeake Bay TMDL Tracking and Accounting System (BayTas 2.0) and extrapolated them to each site using the overall yield and corresponding loads. Table 17 shows the 2015, 10-year average, and 2025 target loads for TN, TP, and SS at all sites. The 10-year average was used as simply comparing low flow years to the targets can be misleading. As the data show, low flow years come very close to targets, and sometimes below them, simply due to being low flow years. In the current flow pattern, even a three-year average would prevent a solid comparison as the last four years had flows lower than LTMs in the majority of the watershed. Specifically at Marietta, six of the last seven years had annual flows that were below the LTM. In order to compensate for the high number of low flow years, this project used 10 years, which typically added two high flow years to the data. Table 18 quantifies the reductions suggested in Table 10 by subtracting the 10-year mean load for each site from the respective 2025 goal. Although only 10-year average flow conditions are displayed, it is important to note that the largest portion of the reductions to be made occur at flows that are above the LTM. The suggestion being that low flow years are the most likely to attain 2025 targets and that high flow years pose the greatest threat to target attainment.

As can be seen in Tables 17 and 18, nearly all TN 2025 goals were met during 2015, except for the majority of lower Susquehanna sites. Many of these sites are notoriously high in TN as well as TP. When looking at the 10-year average, none of the sites in the lower Susquehanna Basin met their respective TN 2025 targets, while Chemung, Conklin, Towanda, Wilkes Barre, and all three West Branch sites already meet their respective 2025 targets. Of more critical note is that the vast majority of sites fail to meet their SS targets during 2015, a low flow year. Only 2015 SS loads at Jersey Shore, Newport, Penns Creek, Conodoguinet, and Shermans were below the 2025 target. Even with 10 years remaining to meet 2025 goals, the fact that many sites are missing SS targets during a low flow year is a significant concern. When the years of above LTM flow are averaged in, all sites are above their respective 2025 targets and in many cases, the SS target gap is vastly increased, especially for sites on the mainstem of the Susquehanna. TP loads comparisons are similar to the SS comparison. Using 10 years of average loads, only the three West Branch sites have TP loads below 2025 targets.

Table 17. 2015 10-year Average, and 2025 Distributed Loads (1000's of lbs) for all Sites

Subbasin	**Site**	**TN**			**TP**			**SS**		
		2015	**10 Yr Ave**	**2025**	**2015**	**10 Yr Ave**	**2025**	**2015**	**10 Yr Ave**	**2025**
Chemung	Cohocton	1,417	1,617	1,452	78	99	65	57,618	60,487	34,958
	Chemung	4,875	6,370	7,743	388	705	346	247,201	597,649	186,393
Upper	Unadilla	1,296	2,046	1,607	68	187	72	51,756	160,354	38,677
Main-Up	Conklin	4,217	6,830	6,896	382	918	308	343,694	914,517	166,014
	Smithboro	12,489	17,513	14,308	1,116	1,877	639	625,990	1,459,727	344,448
	Towanda	16,496	22,805	24,090	1,352	2,348	1,077	1,445,071	2,146,882	579,932
Main-Mid	Wilkes-Barre	21,477	29,213	30,773	2,192	4,255	1,375	2,252,242	6,150,431	740,813
	Danville	24,465	35,581	34,665	1,927	3,924	1,549	2,851,634	4,976,140	834,530
Main-Low	Marietta	75,252	109,980	80,299	4,303	7,226	3,588	2,906,548	5,944,718	1,933,105
W. Branch	Karthaus	3,164	2,928	4,517	125	132	202	147,958	127,492	108,742
	Jersey Shore	10,260	10,653	16,143	477	584	721	379,499	441,366	388,629
	Lewisburg	14,468	17,789	21,155	554	887	945	513,053	754,912	509,272
Juniata	Saxton	2,459	3,426	2,336	76	119	104	62,754	119,417	56,230
	Newport	9,655	13,926	10,363	317	579	463	200,585	369,831	249,467
Lower	Penns Creek	1,059	1,428	930	31	72	42	13,180	39,094	22,388
	Conodoguinet	3,366	4,809	1,452	52	89	65	33,619	56,018	34,958
	Shermans	568	1,187	618	15	62	28	4,626	30,073	14,876
	Swatara	4,236	6,005	1,492	131	247	67	70,198	157,424	35,925
	W. Conewago	2,662	3,711	1,576	260	367	70	74,911	147,197	37,933
	Conestoga	7,181	9,461	1,452	290	448	65	63,624	152,188	34,958
	Pequea	2,164	2,880	478	132	194	21	53,185	97,937	11,518
	Octoraro	2,664	3,082	547	87	103	24	33,184	38,343	13,165

Figure 12 displays the TN, TP, and SS yields at all sites sorted from high to low by the 10-year means. Included in the figures are the 2025 yield targets, which help to visually identify the sites that offer the most reductions per acre. There are no surprises that the lower basin has the greatest reduction potential per acre for TN and TP. This was the original premise when the program began in the mid-1980s. Of specific note is that four of six mainstem Susquehanna sites made the top five for SS yields. This is another suggestion that SS could be collecting in the mainstem and creeping downstream with each storm event.

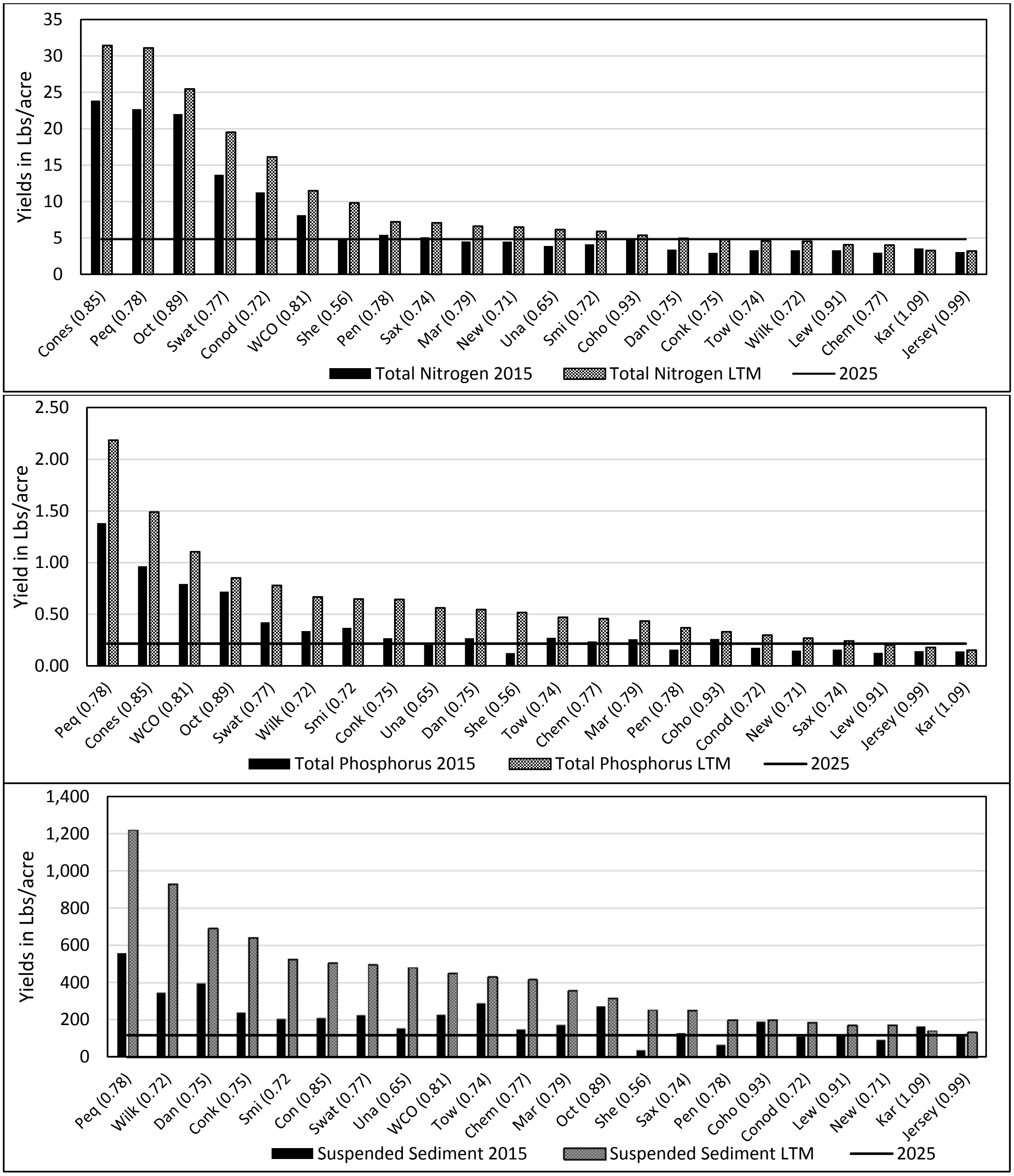


Figure 12. 2015 and LTM TN, TP, and SS Yields and 2025 Targets at All Sites in Pounds Per Acre

Tables 19 and 20 go one step further and look at where the achievable reductions fall during the months of the year. With Conestoga being the exception, most sites are below TN targets during June to October (aka the low flow months) but surpass them in other months, especially March and April during times of likely snowmelt and early spring rainfall. SS follows a similar pattern with March and April delivering the highest loads above targets. Unlike TN, SS for most other months, except August, are also well above targets. Thus, TN appears to be best reduced by focusing effort during spring perhaps with focus on manure management to limit the agricultural sources. SS would also benefit from spring management efforts perhaps including cover crops to help during snowmelt, and reduced tillage to minimize erosion with the increased spring rainfall. SS loads at Lewisburg and Newport were below targets for half of the year including February, June-August, and October-November. The fact that these two major tributaries to the Susquehanna are below targets five more months that the three mainstem Susquehanna sites again implicates issues with legacy sediments in the mainstem.

Table 18. Annual Reductions Needed (1000's of Pounds) to Attain 2025 Target Levels at All Sites (Shaded Areas Represent Upward Trends)

Subbasin	Site	TN		TP		SS	
		Load	Trend	Load	Trend	Load	Trend
Chemung	Cohocton	165	Up	34	Down	25,529	Up
	Chemung	-	Down	359	Down	411,256	Down
Upper	Unadilla	439	Down	115	Down	121,677	Down
Main-Upper	Conklin	-	Down	610	Down	748,504	Down
	Smithboro	3,205	Down	1,238	Down	1,115,279	Down
	Towanda	-	Down	1,271	Down	1,566,951	Up
Main-Middle	Wilkes-Barre	-	Up	2,880	Up	5,409,618	Up
	Danville	916	Down	2,375	Down	4,141,609	Up
Main-Lower	Marietta	29,681	Down	3,638	Down	4,011,612	Down
W. Branch	Karthaus	-	Up	-	Down	18,750	Up
	Jersey Shore	-	Up	-	Down	52,737	Up
	Lewisburg	-	Down	-	Down	245,640	Down
Juniata	Saxton	1,090	Down	14	Up	63,187	Down
	Newport	3,564	Down	116	Down	120,365	Down
Lower	Penns Creek	498	Up	30	Down	16,706	Down
	Conodoguinet	3,357	Down	24	Down	21,060	Up
	Shermans	569	Down	35	Down	15,197	Down
	Swatara	4,513	Down	180	Up	121,499	Up
	West Conewago	2,135	Down	297	Up	109,264	Down
	Conestoga	8,009	Down	383	Down	117,231	Down
	Pequea	2,402	Down	172	Up	86,419	Up
	Octoraro	2,535	Down	79	Down	25,178	Down

Table 19. Monthly Reductions Needed (1000's of Pounds) to Attain 2025 Target Levels at Group A Mainstem Susquehanna

Month	Towanda			Danville			Marietta		
	TN	TP	SS	TN	TP	SS	TN	TP	SS
January	669	107	99,518	1,535	237	245,127	7,364	407	362,079
February	-	17	19,795	106	62	73,037	2,441	61	66,893
March	2,124	334	408,526	3,275	518	798,912	10,687	919	1,014,358
April	1,872	364	492,126	2,975	579	968,743	8,595	840	912,278
May	-	57	65,979	-	117	194,892	2,424	287	280,745
June	-	102	152,904	-	181	271,884	-	112	172,869
July	-	36	60,976	-	63	124,496	-	10	40,090
August	-	-	-	-	-	-	-	-	-
September	-	110	139,282	-	292	983,959	-	584	805,595
October	-	48	50,279	-	89	160,304	-	110	95,107
November	-	34	24,828	-	88	89,170	1,172	103	86,029
December	349	88	65,204	965	195	242,190	6,617	364	282,733

Table 20. Monthly Reductions Needed (1000's of Pounds) to Attain 2025 Target Levels at Group A Tributary Sites

Month	Lewisburg			Newport			Conestoga		
	TN	TP	SS	TN	TP	SS	TN	TP	SS
January	689	22	44,053	888	23	16,472	962	29	8,551
February	-	-	-	325	-	-	804	17	3,407
March	1,273	81	116,342	1,645	86	86,290	1,094	48	20,275
April	581	53	81,139	924	29	24,097	850	34	12,093
May	-	2	10,465	726	31	24,118	613	25	5,704
June	-	-	-	-	-	-	538	39	15,800
July	-	-	-	-	-	-	422	23	3,327
August	-	-	-	-	-	-	276	14	609
September	-	6	55,256	-	1	7,555	402	46	17,251
October	-	-	-	-	-	-	601	54	19,388
November	-	-	-	-	-	-	560	24	5,372
December	400	21	48,769	745	21	14,383	886	30	5,455

Since the lower Susquehanna represents some of the highest yields for TN and TP, Table 21 compares the measured loads to target loads and suggests what level of reductions can be anticipated from efforts in the lower Susquehanna. The measured load is the summation of Marietta, Conestoga, Pequea, and Octoraro and the corresponding 2025 target based on the yields. The second half of the chart shows the amount of reductions that are available at the lower Susquehanna tributaries that are monitored. These sites include site numbers 5-12 shown in Figure 13. Since the sites monitored under this program only represent approximately half of the lower Susquehanna, the loads of the monitored sites were averaged and applied, using yields, to the balance of the lower Susquehanna Watershed that is not monitored. The total lower summation represents the amount of reductions that would be met if all lower Susquehanna watersheds met their 2025 targets. Due to the extremely high levels of nitrogen in the lower Basin, efforts in this subbasin alone would be enough to meet the overall reductions goals for the Susquehanna Watershed (although this does not mean that effort only belongs in the lower Susquehanna). This is not the case for TP and SS. Specifically, the lower Susquehanna watershed can only make up 62 percent and 26 percent of the TP and SS reductions, respectively, needed to meet the Susquehanna's 2025 targets. Thus, focused effort in the lower Susquehanna alone cannot meet the 2025 targets and efforts will need to be applied further up in the watershed including efforts at minimizing the effects of high level storm events that continue to scour the mainstem of the Susquehanna.

Table 21. Potential Load Reductions (1000's of Pounds) in the Lower Susquehanna Subbasin

	Acres	TN	TP	SS
Measured Load	17,154,560	125,482	7,980	6,251,416
2025 Target Load		82,857	3,705	1,993,360
Reductions Needed		42,626	4,275	4,258,056
Potential Lower Susq Reductions	**Acres**	**TN**	**TP**	**SS**
Monitored Sites	1,768,960	24,019	1,200	512,721
Unmonitored Sites*	2,142,080	29,085	1,453	620,867
Total Lower	3,911,040	53,104	2,653	1,133,588

* Estimated using data from monitored sites

KEY POLLUTANT: SUSPENDED SEDIMENT

Considering the assessment of trends herein, SS appears to be the pollutant least susceptible to improvement by the current management strategy. Trends showing increasing SS were widespread throughout the SRB and moreover, SS trends exhibited the largest magnitude increases: ~150 percent at the mainstem Susquehanna River stations of Wilkes Barre and Danville. Of the pollutants of interest, SS in particular, has the most complexity in terms of sources, fate, and transport.

SS does not attenuate in the manner of nutrient drivers of eutrophication. Sediment "pollution" is attenuated by: (i) preventing/minimizing erosion on the landscape; (ii) decoupling pathways between sediment sources on the landscape and entry points to waterways; (iii) stabilizing (or removing) excess sediment accumulations that exist in waterways; and, (iv) dampening shear energies that entrain and/or scour bed and bank materials during high flow episodes. And more so than nutrients, sediment is greatly affected by legacy factors, including factors that readily trace origin to the last continental glacial period. The Commission's characterization of water quality indicator patterns based on CIM dataset analytics demonstrate eco-regional differences, notably, statistically higher stream turbidity profiles for watersheds that drain glaciated portions of the SRB versus unglaciated portions (mdw.srbc.net/remotewaterquality/).

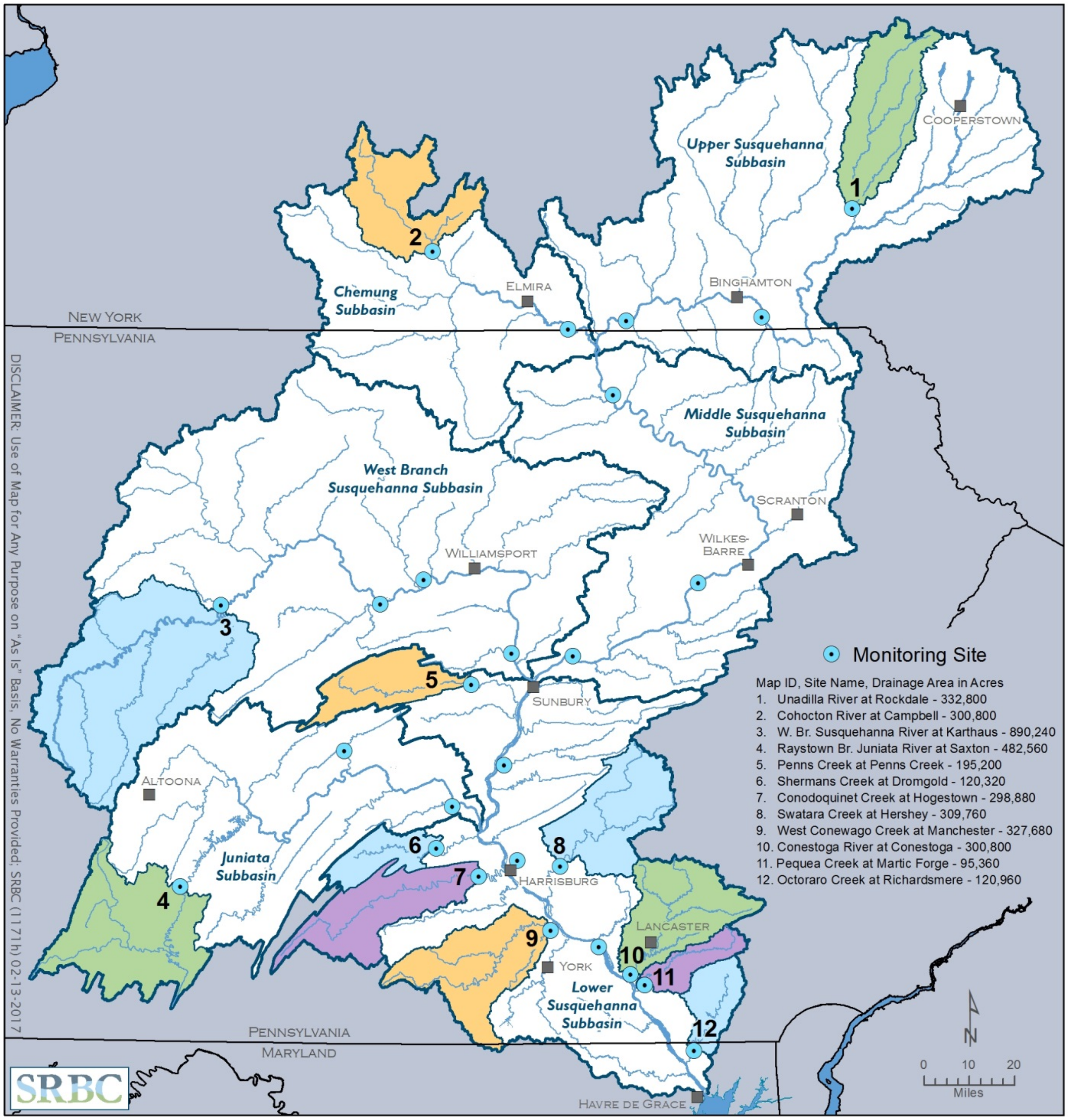


Figure 13. Small Tributary Monitoring Locations

CONCLUSION

Although nutrient and SS conditions continue to show reductions, many factors continue to complicate progress towards 2025 including population growth, development, climate, land use, and hydrology changes. Several issues have been outlined in this report, which inhibit progress towards 2025 with possibly the biggest issue facing water quality being stormwater management. 2015 was the fourth in a string of low flow years and, coupled with effective BMPs across the watershed, has led to the healthiest Bay in years. Low flow years lacking significant storm events are the most significant predictor of a healthy Bay. During low flow periods, established BMPs are fully capable of filtering out nutrients and SS. Inevitably, larger storm events hit, leading to flows that no BMPs can withstand. This means that stormwater management must be a priority for dealing with excessive nutrients and loads as high flow events not only are the largest contributor of loads, but also are inevitable.

This report and previous reports have shown data supporting the concept of anthropomorphic changes to hydrology that have led to flashier storms with higher peaks. Additionally, many BMPs have limited design capacities. Whereas having multiple years of low flow lends itself to cleaner water and a healthier Bay, alterations in the hydrograph based on channeling water as efficiently as possible, coupled with limited capacity BMPs, has led to a more polarized river system. Whereas flows within design capacity have shown dramatic improvements, those outside of it have shown declines. So the problem is how to deal with high precipitation events that are likely have greater impact than before. When considering BMPs, there needs to be an effort made towards those that promote retention of water in the watershed as opposed to channeling it to the nearest stream. Promoting infiltration, restoring floodplains, and implementing conservation buffers and forested stream buffers all lend to the process of reducing runoff and subsequent erosion.

Source reductions of nutrient and sediment also are a critical component towards reaching water quality goals. Although all sectors have a role to play, agriculture likely has the largest. The agricultural community has been pressured extensively to find reductions through more detailed management and a large portion of the farming community has already made great strides towards improving water quality. Perhaps extended effort to locate those who have not had the chance to take advantage of programs that help to implement BMPs on the farm would help to further reduce agricultural sources. Alternatives that make preserving land near streams more profitable could lead to more streambank buffers. Potential SS reductions could be found if conservation plans were written to go beyond accepted soil loss or if extensive focus was placed on crop placement with regard to stream access, field slope, etc.

As critical as source reductions and stormwater management efforts are, so is the recognition and acceptance that all BMPs will inevitably fail. Although installing BMPs that will inevitably fail seems pointless, it becomes more palatable when taken with the data that this program has shown over the past five years. After the largest event to hit the Basin since this program's monitoring began, the Bay survived and thrived to the point of reaching its highest CBF grade in 2016. It is highly likely that the sequence of four years of below LTM flow played a major role in the improvements, especially considering that the same thing has occurred several times in the program's history. The University of Maryland's Center for Environmental Science's Chesapeake Bay Report Card gave the 2015 Bay its third highest rating in 30 years behind 2002 and 1992, both of which were the year after a string of low flow events (University of Maryland Center for Environmental Science, 2017). Although multiple years of below LTM flows clearly play a large role in the Bay's health, a critical point to keep in mind is that the Bay has continually recovered from high flow years, including 1996, 2003, and 2011. Even more uplifting is the Bay's recovery from the largest event to hit the Bay watershed in the program's monitoring history in 2011. The new and clear message is that the Bay can weather high flow events and even thrive in their wake.

REFERENCES

Chesapeake Bay Foundation. 2016. 2016 State of the Bay. http://www.cbf.org/about-the-bay/state-of-the-bay-report-2016 – accessed 3/14/2017.

Chesapeake Bay Program. 2015. Chesapeake Bay TMDL Tracking and Accounting System (BayTAS 2.0) – accessed 11/04/2015.

Cohn, T.A., L.L DeLong, E.J. Gilroy, R.M. Hirsch, and D.E Wells. 1989. Estimating Constituent Loads. *Water Resources Research*, 25(5), pp. 937-942.

Guy, H.P. and V.W. Norman. 1969. Field Methods for Measurement of Fluvial Sediment. U.S. Geological Survey Techniques of Water Resources Investigation, Book 3, Chapter C2 and Book 5, Chapter C1.

Hirsch, R.M., D.L. Moyer, and S.A. Archfield. 2010. Weighted Regressions on Time, Discharge, and Season (WRTDS), with an Application to Chesapeake Bay River Inputs. JAWRA, Volume 46, Issue 5, pp. 857–880.

Langland, M.J., J.D. Bloomquist, L.A. Sprague, and R.E. Edwards. 1999. Trends and Status of Flow, Nutrients, Sediments for Nontidal Sites in the Chesapeake Bay Watershed, 1985-98. U.S. Geological Survey (Open-File Report), 64 pp. (draft).

Lorenz, D. 2012. U.S. Geological Survey. GitHub Repository, https://github.com/dlorenz-usgs.

Jarnagin, S.T. 2007. Historical analysis of the relationship of streamflow flashiness with population density, imperviousness, and percent urban land cover in the Mid-Atlantic region. Internal Report APM 408. U.S. Environmental Protection Agency. Reston, Virginia.

McGonigal, K.M. and J.P. Shallenberger. 2014. 2013 Nutrients and Suspended Sediment in the Susquehanna River Basin. Publication No. 296. Susquehanna River Basin Commission, Harrisburg, Pennsylvania.

Moyer, D.L., R.M. Hirsch, and K.E. Hyer. 2012. Comparison of Two Regression-Based Approaches for Determining Nutrient and Sediment Fluxes and Trends in the Chesapeake Bay Watershed. U.S. Geological Survey (Scientific Investigations Report 2012–5244), 118 pp.

Myers, M.D. 2006. National Field Manual for the Collection of Water-Quality Data. U.S. Geological Survey Techniques of Water Resources Investigation, Book 9, Chapter A4.

Ott, A.N., L.A. Reed, C.S. Takita, R.E. Edwards, and S.W. Bollinger. 1991. Loads and Yields of Nutrient and Suspended Sediment Transported in the Susquehanna River Basin, 1985-89. Publication No. 136. Susquehanna River Basin Commission, Harrisburg, Pennsylvania.

PRISM Climate Group – Oregon State University. 2015. http://prism.oregonstate.edu, created September 1, 2015.

R Core Team. 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Renner, M. and C. Bernhofer. 2011. Long term variability of the annual hydrological regime and sensitivity to temperature phase shifts in Saxony/Germany. Hydrology and Earth System Sciences 15: 1819-1833.

Takita, C.S. 1998. Nutrient and Suspended Sediment Transported in the Susquehanna River Basin, 1994-96, and Loading Trends, Calendar Years 1985-96. Publication No. 194. Susquehanna River Basin Commission, Harrisburg, Pennsylvania.

——. 1996. Nutrient and Suspended Sediment Transported in the Susquehanna River Basin, 1992-93. Publication No. 174. Susquehanna River Basin Commission, Harrisburg, Pennsylvania.

University of Maryland Center for Environmental Science. 2017. Eco Health Report Cards. https://ecoreportcard.org/report-cards/chesapeake-bay/health/.

U.S. Environmental Protection Agency (USEPA). 2010. Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus, and Sediment. EPA Region 3, Region 2, in collaboration with Delaware, the District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia.

U.S. Geological Survey, EGRET. 2014. GitHub Repository, https://github.com/USGS-R/EGRET.

Walter, R.C. and D.J. Merritts. 2008. Natural Streams and the Legacy of Water-Powered Mills. Science, Volume 319. Issue 5861, pp. 299-304.

APPENDIX A

Summary Statistics

Table A1. Temperature, Dissolved Oxygen, Conductivity, and pH Summary Statistics of Samples Collected During 2015

Station	n	Temperature (C°)					Dissolved Oxygen (mg/L)					Conductivity (umhos/cm)					pH (S.U.)				
		Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD
Chemung	24	0.08	25.30	10.68	10.58	8.97	6.63	14.46	11.10	10.81	2.53	184	529	353	360	104	7.6	9.36	8.14	8.23	0.45
Cohocton	20	0.09	23.60	6.26	8.65	8.82	7.12	14.45	11.97	11.70	1.95	193	537	313	336	106	7.38	8.61	7.89	7.95	0.34
Conklin	20	0.01	22.81	6.07	8.18	8.68	7.95	14.27	12.63	11.90	1.83	135	258	179	180	33	7.2	8.7	8	8.02	0.44
Smithboro	31	0.02	24.98	10.39	11.47	8.64	6.85	15.76	10.88	10.69	2.57	133	333	230	242	63	7.52	8.78	7.86	7.99	0.35
Unadilla	16	0.18	22.78	8.36	10.46	8.38	8.12	13.18	11.00	10.96	1.59	175	326	237	242	45	7.54	8.79	8.22	8.22	0.41
Castanea	21	0.58	23.30	7.93	11.58	8.35	8.78	16.55	12.15	11.65	2.40	176	419	350	328	86	7.5	8.33	7.9	7.91	0.22
Conestoga	36	1.56	24.00	12.49	13.15	6.82	6.90	15.57	10.06	10.78	2.03	219	757	607	585	152	7.52	8.66	8.04	8.05	0.28
Dalmatia	20	1.01	20.26	9.19	9.65	7.03	8.31	13.62	11.14	11.04	2.03	139	244	158	173	32	6.8	8.2	7.42	7.41	0.38
Danville	39	0.05	24.95	11.40	11.35	9.12	8.05	16.26	11.19	11.22	2.14	143	436	253	262	78	7.12	9.05	7.67	7.78	0.46
Dromgold	22	0.36	20.97	7.57	10.14	7.16	9.15	15.28	12.87	12.14	1.89	84	232	156	158	38	7.21	8.59	8.11	8.07	0.30
Hershey	21	0.23	22.37	6.38	10.24	7.58	7.35	16.23	11.28	10.87	2.36	206	475	256	300	92	7.22	8.28	7.63	7.68	0.29
Hogestown	20	1.08	22.26	8.44	11.14	6.88	9.14	15.09	12.54	12.25	1.62	292	570	392	408	93	7.61	8.3	7.97	7.97	0.21
Jersey Shore	17	4.79	26.09	16.79	13.56	7.80	8.26	13.41	10.22	10.93	2.02	129	351	221	236	85	7.56	8.19	7.78	7.81	0.19
Karthaus	19	0.17	22.06	7.66	11.15	7.88	7.53	14.56	12.04	11.22	2.23	206	635	353	391	127	6.98	9.1	7.81	7.91	0.52
Lewisburg	37	0.21	27.53	11.70	12.49	8.09	7.81	15.07	10.27	11.03	2.31	85	335	211	211	77	6.92	8.39	7.66	7.69	0.36
Manchester	21	0.00	24.86	11.30	11.01	7.67	5.27	14.89	9.90	10.63	2.74	142	409	295	291	75	7	8.58	7.74	7.72	0.41
Marietta	38	2.15	26.58	13.73	13.68	7.56	7.46	14.05	10.32	10.68	1.62	127	378	239	245	72	7.33	8.82	8.13	8.09	0.40
Martic Forge	21	0.85	22.17	11.00	11.29	6.42	8.74	14.90	10.87	10.95	1.78	145	542	484	431	113	7.45	8.61	7.97	7.97	0.29
Newport	41	0.00	24.12	12.23	11.85	7.93	8.30	17.62	11.40	11.46	2.12	128	341	248	255	56	7.34	8.93	8.07	8.12	0.38
Paxton	21	0.06	20.05	5.51	9.14	6.64	6.20	15.24	10.47	10.48	2.62	443	1239	690	679	172	7.5	8.65	7.73	7.79	0.27
Penns Creek	20	0.00	25.20	12.15	12.14	7.59	9.22	14.85	11.99	11.74	1.98	159	263	223	213	32	7.78	8.85	8.09	8.16	0.32
Reedsville	22	1.00	16.56	6.74	8.53	5.33	10.01	15.18	12.37	12.35	1.68	204	359	245	271	53	7.72	8.46	7.99	8.04	0.23
Saxton	20	0.41	21.37	5.95	8.77	7.37	8.43	14.62	11.95	11.49	2.01	150	488	324	319	94	7.39	8.99	8.09	8.13	0.50
Towanda	37	0.39	24.53	13.41	11.57	8.23	8.21	16.92	10.44	10.99	2.22	125	418	232	247	83	7.33	8.47	7.84	7.85	0.35
Wilkes-Barre	21	0.34	25.10	3.30	8.74	9.12	7.57	15.75	12.60	11.78	2.44	157	451	248	268	81	7.21	8.42	7.61	7.65	0.27
Richardsmere	21	0.76	24.28	11.53	11.02	7.55	8.68	15.24	10.98	11.51	2.10	119	286	264	246	48	7.35	8.77	7.82	7.87	0.40

Table A2. Total Nitrogen Species Summary Statistics of Samples Collected During 2015, in mg/L

Station	n	Total Nitrogen					Total Ammonium					Total Nitrate plus Nitrite					Total Organic Nitrogen				
		Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD
Chemung	23	0.47	2.18	1.04	1.11	0.34	<0.01	0.108	0.029	0.038	0.027	0.340	0.970	0.629	0.629	0.171	0.237	1.660	0.420	0.495	0.303
Cohocton	19	0.90	4.06	1.60	1.73	0.66	<0.01	0.068	0.023	0.027	0.018	0.555	1.600	1.160	1.103	0.326	0.197	2.791	0.402	0.603	0.636
Conklin	18	0.45	1.14	0.61	0.66	0.18	<0.01	0.034	0.013	0.016	0.007	<0.12	0.865	0.310	0.337	0.170	0.154	0.790	0.273	0.312	0.149
Smithboro	24	0.40	1.39	0.92	0.92	0.20	0.007	0.106	0.030	0.035	0.024	0.254	1.080	0.503	0.552	0.188	0.186	0.676	0.358	0.375	0.138
Unadilla	20	0.54	1.43	0.87	0.92	0.24	<0.01	0.093	0.016	0.023	0.019	0.258	1.170	0.577	0.601	0.262	0.144	0.465	0.301	0.300	0.086
Castanea	19	0.76	2.08	1.20	1.21	0.28	0.007	0.069	0.031	0.035	0.020	0.489	1.816	0.950	0.934	0.290	0.023	0.518	0.228	0.243	0.124
Conestoga	30	1.42	8.53	5.44	5.37	1.36	<0.011	1.256	0.070	0.115	0.227	1.155	8.060	4.620	4.661	1.585	0.071	1.805	0.569	0.599	0.356
Dalmatia	18	1.25	7.54	3.87	3.97	1.97	<0.011	0.310	0.025	0.068	0.098	1.006	6.896	3.465	3.400	1.835	0.088	1.782	0.321	0.530	0.476
Danville	33	0.45	1.85	0.84	0.85	0.30	0.007	0.121	0.019	0.027	0.024	0.017	1.388	0.448	0.501	0.319	0.123	0.684	0.289	0.325	0.128
Dromgold	19	0.87	2.40	1.82	1.66	0.54	<0.011	0.144	0.024	0.031	0.030	0.610	1.950	1.316	1.304	0.423	0.076	0.752	0.251	0.325	0.203
Hershey	20	2.06	4.26	3.11	3.11	0.64	<0.011	0.767	0.044	0.084	0.164	1.484	3.682	2.474	2.478	0.639	0.126	1.746	0.396	0.547	0.453
Hogestown	21	2.91	4.68	3.66	3.73	0.58	<0.011	0.144	0.034	0.053	0.049	1.613	4.093	3.372	3.155	0.598	0.105	1.381	0.442	0.524	0.297
Jersey Shore	18	0.39	1.09	0.47	0.54	0.17	<0.011	0.280	0.014	0.032	0.063	0.187	0.635	0.327	0.345	0.105	0.056	0.420	0.165	0.185	0.091
Karthaus	20	0.28	1.06	0.51	0.55	0.18	<0.011	0.085	0.026	0.030	0.018	0.168	0.693	0.307	0.353	0.145	0.048	0.443	0.141	0.168	0.111
Lewisburg	33	0.45	1.77	0.59	0.68	0.25	<0.011	0.061	0.012	0.018	0.011	0.297	0.740	0.436	0.450	0.115	0.056	0.964	0.159	0.209	0.175
Manchester	21	1.00	5.36	2.48	2.35	0.97	<0.011	0.483	0.037	0.081	0.114	0.481	3.296	1.379	1.528	0.683	0.221	1.844	0.587	0.743	0.449
Marietta	33	0.68	2.41	1.02	1.11	0.39	<0.011	0.308	0.024	0.035	0.052	0.344	1.618	0.628	0.716	0.275	0.125	0.735	0.370	0.363	0.145
Martic Forge	19	4.39	9.69	6.16	6.21	1.11	<0.011	1.490	0.040	0.163	0.337	2.049	9.786	5.474	5.173	1.751	0.204	3.940	0.725	0.928	0.842
Newport	29	1.05	3.69	1.55	1.64	0.53	<0.011	0.172	0.020	0.028	0.030	0.831	2.969	1.173	1.229	0.415	0.017	0.792	0.333	0.381	0.180
Paxton	20	0.78	2.34	1.31	1.44	0.55	0.008	0.106	0.020	0.027	0.023	0.525	2.064	0.913	1.097	0.451	0.095	0.704	0.257	0.338	0.173
Penns Creek	18	0.89	1.99	1.43	1.42	0.28	<0.011	0.069	0.025	0.028	0.016	0.768	1.674	1.029	1.086	0.256	0.076	0.670	0.248	0.304	0.175
Reedsville	19	1.66	4.44	2.97	2.93	0.79	<0.011	0.141	0.014	0.029	0.035	1.369	3.953	2.609	2.647	0.711	0.095	1.740	0.335	0.398	0.362
Saxton	19	1.16	2.63	1.97	1.94	0.44	<0.011	0.073	0.021	0.028	0.018	0.787	2.239	1.467	1.517	0.383	0.104	1.202	0.275	0.394	0.288
Towanda	33	0.59	2.02	0.87	0.94	0.29	<0.011	0.235	0.030	0.039	0.041	0.196	1.287	0.475	0.572	0.270	0.131	0.686	0.346	0.332	0.124
Wilkes-Barre	18	0.48	1.63	0.81	0.85	0.28	<0.011	0.182	0.021	0.036	0.042	0.156	1.158	0.370	0.452	0.283	0.146	0.689	0.355	0.368	0.125
Richardsmere	19	4.08	8.36	5.40	5.61	1.12	<0.011	1.633	0.036	0.151	0.367	1.423	7.445	4.459	4.681	1.405	0.385	1.738	0.707	0.782	0.359

Table A3. Dissolved Nitrogen Species Summary Statistics of Samples Collected During 2015, in mg/L

Station	n	Dissolved Nitrogen					Dissolved Ammonium					Dissolved Nitrate plus Nitrite					Dissolved Organic Nitrogen				
		Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD
Chemung	23	0.66	1.43	1.04	1.06	0.20	<0.010	0.107	0.028	0.035	0.027	0.352	0.980	0.658	0.662	0.168	0.208	0.722	0.342	0.367	0.123
Cohocton	19	0.92	1.92	1.64	1.55	0.29	0.006	0.079	0.021	0.027	0.020	0.621	1.590	1.130	1.121	0.303	0.151	0.896	0.402	0.406	0.152
Conklin	18	0.39	1.19	0.63	0.64	0.17	<0.010	0.036	0.014	0.017	0.008	<0.12	0.859	0.308	0.347	0.161	0.150	0.500	0.267	0.274	0.089
Smithboro	24	0.75	1.62	0.90	0.94	0.22	0.009	0.131	0.035	0.040	0.029	0.355	1.080	0.500	0.560	0.190	0.176	0.497	0.350	0.339	0.079
Unadilla	20	0.49	1.52	0.88	0.94	0.29	<0.010	0.088	0.015	0.025	0.023	0.270	1.200	0.583	0.611	0.262	0.172	0.654	0.268	0.305	0.121
Castanea	19	0.73	2.01	1.17	1.13	0.29	0.007	0.070	0.030	0.035	0.020	0.479	1.829	0.944	0.930	0.296	0.021	0.294	0.163	0.164	0.083
Conestoga	30	1.39	8.58	5.27	5.22	1.47	<0.011	1.250	0.062	0.115	0.226	1.161	7.992	4.594	4.635	1.567	0.208	0.903	0.518	0.496	0.162
Dalmatia	18	1.26	7.35	3.74	3.74	1.92	<0.011	0.303	0.018	0.060	0.097	1.003	6.592	3.429	3.365	1.787	0.033	0.740	0.286	0.310	0.164
Danville	33	0.30	1.68	0.71	0.72	0.31	0.007	0.094	0.013	0.022	0.018	0.045	1.359	0.449	0.501	0.314	0.116	0.342	0.190	0.197	0.054
Dromgold	19	0.85	2.20	1.72	1.56	0.48	<0.011	0.143	0.024	0.031	0.030	0.608	1.851	1.312	1.296	0.409	0.017	0.525	0.222	0.233	0.127
Hershey	20	1.86	4.05	2.79	2.87	0.63	<0.011	0.765	0.045	0.084	0.163	1.455	3.684	2.454	2.465	0.641	0.079	0.744	0.276	0.324	0.160
Hogestown	21	2.07	4.42	3.58	3.54	0.59	<0.011	0.147	0.032	0.052	0.048	1.573	4.089	3.364	3.149	0.602	0.118	0.664	0.343	0.338	0.128
Jersey Shore	18	0.38	0.73	0.43	0.47	0.10	<0.011	0.036	0.015	0.018	0.008	0.188	0.638	0.325	0.346	0.106	0.001	0.189	0.105	0.103	0.047
Karthaus	20	0.26	0.87	0.42	0.48	0.16	<0.011	0.089	0.024	0.030	0.018	0.169	0.695	0.310	0.357	0.144	0.029	0.167	0.109	0.101	0.043
Lewisburg	33	0.41	0.87	0.54	0.58	0.12	0.010	0.058	0.012	0.017	0.010	0.296	0.731	0.439	0.449	0.113	0.035	0.210	0.111	0.115	0.047
Manchester	21	0.78	4.50	2.05	2.10	0.83	0.009	0.482	0.041	0.080	0.112	0.484	3.288	1.390	1.530	0.685	0.197	1.005	0.414	0.494	0.233
Marietta	33	0.52	2.05	0.82	0.96	0.34	<0.011	0.310	0.022	0.033	0.052	0.348	1.630	0.650	0.714	0.275	0.052	0.543	0.189	0.214	0.091
Martic Forge	19	3.57	9.78	5.91	5.85	1.37	<0.011	1.456	0.042	0.159	0.329	2.067	9.310	5.387	5.133	1.676	0.157	1.221	0.476	0.554	0.266
Newport	29	0.97	3.50	1.33	1.48	0.48	<0.011	0.180	0.021	0.028	0.031	0.834	2.960	1.175	1.222	0.414	0.001	0.516	0.237	0.233	0.100
Paxton	20	0.75	2.30	1.25	1.37	0.51	0.008	0.103	0.022	0.027	0.023	0.527	2.031	0.913	1.090	0.440	0.092	0.584	0.209	0.259	0.128
Penns Creek	18	0.89	1.92	1.26	1.30	0.25	0.008	0.087	0.025	0.028	0.018	0.781	1.637	1.021	1.080	0.249	0.081	0.385	0.203	0.209	0.087
Reedsville	19	1.59	4.41	2.84	2.88	0.79	<0.011	0.145	0.015	0.029	0.035	1.362	3.939	2.619	2.650	0.702	0.096	1.770	0.231	0.339	0.370
Saxton	19	1.12	2.50	1.75	1.76	0.40	<0.011	0.078	0.022	0.030	0.020	0.794	2.235	1.467	1.519	0.392	0.109	0.311	0.222	0.214	0.063
Towanda	33	0.42	1.81	0.76	0.82	0.30	<0.011	0.255	0.028	0.038	0.045	0.201	1.288	0.469	0.571	0.268	0.101	0.357	0.209	0.208	0.061
Wilkes-Barre	18	0.31	1.53	0.64	0.70	0.30	<0.011	0.179	0.020	0.035	0.041	0.159	1.150	0.363	0.452	0.279	0.109	0.340	0.203	0.214	0.069
Richardsmere	19	3.63	8.11	5.13	5.35	1.15	<0.011	1.679	0.038	0.151	0.378	1.446	7.404	4.441	4.673	1.395	0.210	0.917	0.498	0.530	0.201

Table A4. Phosphorus Species and Total Suspended Solids Summary Statistics of Samples Collected During 2015, in mg/L

Station	**n**	**Total Phosphorus**					**Dissolved Phosphorus**					**Orthophosphorus**					**Total Organic Carbon**				
		Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD
Chemung	23	0.016	0.402	0.039	0.064	0.086	0.008	0.035	0.015	0.016	0.007	<0.001	0.029	0.011	0.013	0.007	2.60	6.20	3.40	3.71	1.01
Cohocton	19	0.008	0.738	0.025	0.081	0.167	0.004	0.068	0.014	0.016	0.014	0.004	0.049	0.008	0.011	0.010	2.30	10.00	3.60	4.45	1.86
Conklin	18	0.011	0.221	0.023	0.045	0.065	0.006	0.040	0.010	0.012	0.008	0.003	0.017	0.006	0.007	0.004	1.50	5.10	2.55	2.78	0.92
Smithboro	24	0.020	0.117	0.032	0.043	0.026	0.009	0.023	0.014	0.015	0.004	<0.001	0.018	0.010	0.010	0.005	1.90	4.20	2.80	2.94	0.61
Unadilla	20	0.011	0.074	0.022	0.027	0.017	0.005	0.022	0.008	0.010	0.005	0.003	0.017	0.006	0.007	0.004	1.50	4.50	2.53	2.76	0.86
Castanea	19	0.013	0.090	0.028	0.035	0.020	0.006	0.026	0.011	0.012	0.006	0.007	0.023	0.010	0.011	0.004	1.26	4.97	1.83	2.32	1.04
Conestoga	30	0.021	0.667	0.188	0.212	0.143	0.011	0.413	0.161	0.158	0.090	0.009	0.713	0.145	0.154	0.128	1.88	16.36	2.67	3.65	2.68
Dalmatia	18	0.019	0.518	0.085	0.134	0.143	0.012	0.166	0.051	0.065	0.043	0.010	0.153	0.043	0.059	0.043	1.63	14.35	2.52	4.06	3.43
Danville	33	0.019	0.136	0.042	0.048	0.027	0.005	0.025	0.012	0.012	0.005	0.003	0.019	0.007	0.008	0.004	1.57	5.20	2.83	2.93	0.87
Dromgold	19	0.011	0.163	0.037	0.057	0.047	0.006	0.095	0.026	0.036	0.027	0.006	0.076	0.021	0.030	0.024	1.13	8.09	2.46	3.36	2.19
Hershey	20	0.019	0.589	0.065	0.126	0.161	0.012	0.246	0.038	0.052	0.053	0.009	0.309	0.031	0.049	0.066	1.39	18.81	2.65	4.30	4.02
Hogestown	21	0.008	0.298	0.032	0.080	0.081	0.005	0.112	0.020	0.033	0.031	0.005	0.098	0.016	0.030	0.030	1.67	12.22	4.23	3.94	2.53
Jersey Shore	18	0.005	0.072	0.013	0.022	0.020	0.002	0.007	0.004	0.005	0.002	0.003	0.008	0.006	0.006	0.002	1.07	3.55	1.54	1.91	0.75
Karthaus	20	0.004	0.084	0.009	0.018	0.022	<0.001	0.011	0.002	0.003	0.002	0.003	8.000	0.006	0.755	2.312	1.00	5.84	1.69	2.14	1.19
Lewisburg	33	0.006	0.190	0.014	0.029	0.036	0.002	0.016	0.005	0.006	0.003	0.003	0.012	0.006	0.006	0.002	1.06	4.30	1.60	1.98	0.90
Manchester	21	0.039	0.783	0.201	0.256	0.228	0.025	0.729	0.127	0.177	0.171	0.015	0.499	0.117	0.150	0.132	2.47	13.67	6.57	6.36	3.27
Marietta	33	0.012	0.237	0.049	0.066	0.055	0.004	0.112	0.012	0.022	0.026	0.002	0.082	0.008	0.016	0.021	1.65	10.55	2.73	3.12	1.57
Martic Forge	19	0.028	2.458	0.198	0.385	0.572	0.015	0.758	0.160	0.215	0.221	0.011	0.751	0.151	0.199	0.208	1.13	18.16	3.10	4.85	4.49
Newport	29	0.010	0.177	0.039	0.051	0.042	0.006	0.087	0.016	0.024	0.020	0.003	0.114	0.013	0.020	0.022	1.81	6.59	2.61	3.07	1.21
Paxton	20	0.003	0.121	0.020	0.036	0.034	0.002	0.053	0.014	0.017	0.012	0.004	0.068	0.014	0.018	0.015	1.35	8.10	2.85	3.50	1.96
Penns Creek	18	0.010	0.160	0.036	0.050	0.043	0.006	0.054	0.017	0.022	0.014	0.006	0.040	0.013	0.017	0.011	1.40	6.95	2.68	3.38	1.70
Reedsville	19	0.017	0.155	0.051	0.058	0.036	0.010	0.092	0.033	0.040	0.023	0.012	0.104	0.030	0.038	0.023	0.97	6.49	1.78	2.66	1.81
Saxton	19	0.007	0.214	0.029	0.049	0.053	0.005	0.052	0.015	0.018	0.013	0.003	0.031	0.011	0.013	0.008	1.74	11.93	2.19	3.56	2.66
Towanda	33	0.013	0.180	0.039	0.049	0.038	0.006	0.089	0.015	0.017	0.014	0.003	0.089	0.010	0.012	0.015	1.79	5.79	2.96	3.15	0.99
Wilkes-Barre	18	0.012	0.171	0.047	0.054	0.036	0.006	0.023	0.013	0.012	0.004	0.003	0.070	0.010	0.012	0.015	1.78	7.41	2.98	3.24	1.24
Richardsmere	19	0.024	0.905	0.100	0.159	0.209	0.014	0.780	0.048	0.127	0.207	0.008	0.670	0.036	0.109	0.180	2.08	15.71	3.31	4.33	3.15

Table A5. ***Flow, Total Organic Carbon, Total Kjeldahl, and Dissolved Kjeldahl Summary Statistics of Samples Collected During 2015, in mg/L***

Station	n	Flow (cfs)					Total Organic Carbon					Total Kjeldahl Nitrogen				
		Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD	Min	Max	Med	Mn	SD
Chemung	23	276	9,380	2,020	3,443	3,164	1.1	254	10.0	31.8	58	1.6	191	8.7	29.5	45
Cohocton	19	76	6,220	444	966	1,419	0.5	1,083	8.2	92.4	261	1.0	655	7.2	58.8	153
Conklin	18	348	20,700	2,395	4,369	5,059	1.3	105	8.5	18.3	29	1.7	237	9.3	24.0	54
Smithboro	24	788	40,600	5,710	9,155	9,425	1.5	53	7.3	12.9	15	2.0	100	10.6	18.5	23
Unadilla	20	118	3,840	787	858	865	1.8	32	8.3	9.7	8	2.1	55	7.0	10.4	12
Castanea	19	-	-	-	-	-	0.9	25	4.2	7.8	8	<5.0	42	6.0	10.2	9
Conestoga	30	235	1,990	607	654	387	0.7	136	6.5	18.2	31	<5.0	255	11.0	30.6	53
Dalmatia	18	25	4,180	152	542	1,024	1.0	643	7.1	65.5	162	<5.0	778	7.0	78.2	186
Danville	33	1,760	54,700	10,900	16,549	14,626	1.9	75	8.8	16.2	18	<5.0	146	18.0	23.6	27
Dromgold	19	33	1,760	165	466	538	2.6	58	8.0	17.3	19	<5.0	62	6.0	14.2	18
Hershey	20	196	6,530	670	1,635	1,770	0.8	193	11.3	33.1	48	<5.0	362	16.0	56.9	95
Hogestown	21	140	5,110	636	1,337	1,517	0.5	429	10.0	54.2	96	<5.0	316	14.0	52.5	81
Jersey Shore	18	2,270	22,500	7,850	10,915	7,814	0.3	47	3.6	9.1	14	<5.0	76	5.0	12.6	18
Karthaus	20	610	11,400	2,060	3,601	3,212	1.1	49	5.1	12.7	14	<5.0	106	6.0	20.5	30
Lewisburg	33	1,830	39,500	11,200	15,031	12,355	0.7	57	4.0	10.2	14	<5.0	154	6.0	18.6	30
Manchester	21	88	5,680	595	1,458	1,737	0.9	219	29.5	44.8	59	<5.0	296	20.0	52.2	76
Marietta	33	4,900	145,000	28,100	42,806	35,055	1.3	175	12.3	25.3	34	<5.0	128	16.0	30.1	32
Martic Forge	19	76	1,240	143	242	285	1.6	653	8.9	64.4	152	<5.0	1,044	20.0	98.4	240
Newport	29	720	34,600	2,700	6,597	7,841	0.7	84	10.1	17.7	20	<5.0	122	13.5	24.8	30
Paxton	20	2	157	8	32	42	0.1	76	2.1	15.4	26	<5.0	88	5.0	19.1	25
Penns Creek	18	88	2,160	345	664	616	0.8	39	9.5	11.5	10	<5.0	72	5.3	13.9	17
Reedsville	19	27	1,080	136	265	289	2.3	43	6.0	12.8	13	<5.0	56	5.0	14.1	14
Saxton	19	128	14,000	641	2,608	4,032	1.5	177	11.0	35.7	53	<5.0	270	8.0	37.8	67
Towanda	33	866	45,700	8,010	12,786	12,065	1.2	151	8.6	19.7	30	<5.0	406	12.0	32.7	71
Wilkes-Barre	18	1,640	53,300	12,050	16,193	15,619	3.4	213	11.4	27.6	50	<5.0	202	17.0	29.0	45
Richardsmere	19	73	1,000	189	274	246	1.5	154	7.1	23.2	40	<5.0	212	10.0	32.5	54

APPENDIX B

Individual Long-Term Site Data

INDIVIDUAL SITES: TOWANDA

Table B1. 2015 Annual and Seasonal Precipitation and Discharge at Towanda

Season	Precipitation (inches)			Discharge (cfs)		
	2015	LTM	LTM Departure	2015	LTM	% LTM
January-March (Winter)	5.97	7.78	-1.18	6,196	15,897	39
April-June (Spring)	14.28	11.41	2.87	17,250	15,480	111
July-September (Summer)	11.32	12.08	-0.76	5,127	4,980	103
October-December (Fall)	8.79	9.90	-1.11	6,218	10,600	59
Annual Total	40.36	41.17	-0.82	8,688	11,709	74

Table B2. 2015 Annual Loads (1000's lbs), Yields (lbs/acre), and Concentrations (mg/L) at Towanda

Parameter	Load	Load % of LTM	Yield	LTM Yield	Ave. Conc.	Conc. % of LTM
TN	16,496	61%	3.31	5.39	0.96	83%
TNO_x	9,525	62%	1.91	3.05	0.56	84%
TON	6,563	62%	1.32	2.11	0.38	84%
TNH_3	776	60%	0.16	0.26	0.05	80%
DN	13,966	61%	2.80	4.58	0.82	82%
DNO_x	9,542	63%	1.91	3.01	0.56	85%
DON	3,945	56%	0.79	1.40	0.23	76%
DNH_3	722	67%	0.14	0.22	0.04	91%
TP	1,352	55%	0.271	0.492	0.079	74%
DP	288	38%	0.058	0.153	0.017	51%
DOP	209	48%	0.042	0.087	0.012	65%
TOC	62,242	73%	12.47	17.01	3.64	99%
SS	1,445,071	57%	289.59	506.12	84.49	77%

Table B3. 2015 Seasonal Loads (1000's lbs) and Yields (lbs/acre) at Towanda

Parameter	Winter		Spring		Summer		Fall	
	Load	Yield	Load	Yield	Load	Yield	Load	Yield
TN	3,280	0.66	8,334	1.67	2,137	0.43	2,745	0.55
TNO_x	2,409	0.48	4,369	0.88	987	0.20	1,760	0.35
TON	757	0.15	3,718	0.75	1,157	0.23	930	0.19
TNH_3	158	0.03	394	0.08	97	0.02	127	0.03
DN	3,082	0.62	6,677	1.34	1,701	0.34	2,505	0.50
DNO_x	2,409	0.48	4,374	0.88	991	0.20	1,767	0.35
DON	575	0.12	2,043	0.41	665	0.13	662	0.13
DNH_3	158	0.03	350	0.07	85	0.02	129	0.03
TP	120	0.024	897	0.180	208	0.042	128	0.026
DP	46	0.009	142	0.028	52	0.010	49	0.010
DOP	34	0.007	103	0.021	37	0.007	35	0.007
TOC	7,383	1.48	34,599	6.93	11,012	2.21	9,248	1.85
SS	50,245	10.07	1,134,356	227.32	204,370	40.96	56,100	11.24

Table B4. 2015 Monthly Average Precipitation (in), High Daily Precipitation During Month (in), Flow (cfs), Loads (1000's lbs), and Yields (lbs/acre) at Towanda

Mon	Precip			Flow		TN			TP			SS		
	Ave	Max	LTM	2015	LTM	Load	Yield	LTM	Load	Yield	LTM	Load	Yield	LTM
Jan	1.72	0.63	68%	7,227	53%	1,275	0.26	42%	46	0.009	18%	15,793	3.2	5%
Feb	2.30	0.54	106%	2,242	19%	462	0.09	19%	9	0.002	6%	525	0.1	1%
Mar	1.95	0.48	64%	8,735	40%	1,543	0.31	33%	65	0.013	17%	33,927	6.8	8%
Apr	4.01	0.68	117%	35,447	141%	5,996	1.20	123%	733	0.147	156%	1,005,217	201.4	161%
May	2.55	0.90	72%	6,464	51%	932	0.19	41%	44	0.009	24%	20,677	4.1	12%
Jun	7.72	1.34	174%	10,199	116%	1,406	0.28	99%	120	0.024	78%	108,462	21.7	77%
Jul	5.20	0.92	129%	11,687	214%	1,708	0.34	195%	185	0.037	182%	197,853	39.6	246%
Aug	2.49	0.92	64%	2,400	57%	291	0.06	43%	17	0.003	21%	5,167	1.0	6%
Sept	3.63	2.26	88%	1,167	22%	139	0.03	17%	6	0.001	4%	1,350	0.3	1%
Oct	2.82	0.98	76%	3,110	44%	405	0.08	33%	19	0.004	16%	6,262	1.3	6%
Nov	2.24	1.60	70%	6,380	61%	875	0.18	46%	41	0.008	24%	17,624	3.5	13%
Dec	3.73	0.51	125%	9,170	67%	1,465	0.29	55%	67	0.013	30%	32,213	6.5	18%

Table B5. Trend Statistics for the Susquehanna River at Towanda, Pa., October 1988 Through September 2015

Towanda	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
FLOW / 60	SMK	-	-	-	0.658	NS	-	-	-
TN / 600	FNC	-0.586	-0.023	-39	<0.05	Down	0.99	HL	Down
	FNF	-7.20	-0.28	-41	<0.05	Down	0.99	HL	Down
TNO_x / 630	FNC	-0.309	-0.012	-37	<0.05	Down	0.99	HL	Down
	FNF	-3.29	-0.13	-36	<0.05	Down	0.99	HL	Down
TON / 605	FNC	-0.202	-0.0078	-37	<0.05	Down	0.99	HL	Down
	FNF	-3.18	-0.12	-43	<0.05	Down	0.99	HL	Down
TNH_3 / 610	FNC	-0.02	-0.00077	-34	0.045	Down	0.98	HL	Down
	FNF	-0.33	-0.013	-40	0.17	NS	0.92	VL	Down
DN / 602	FNC	-0.437	-0.017	-36	<0.05	Down	0.99	HL	Down
	FNF	-5.14	-0.2	-37	<0.05	Down	0.99	HL	Down
DNO_x / 631	FNC	-0.309	-0.012	-37	<0.05	Down	0.99	HL	Down
	FNF	-3.26	-0.13	-36	<0.05	Down	0.99	HL	Down
DON / 607	FNC	-0.095	-0.0037	-29	<0.05	Down	0.99	HL	Down
	FNF	-1.59	-0.061	-39	<0.05	Down	0.99	HL	Down
DNH_3 / 608	FNC	-0.016	-0.00061	-30	0.058	Down	0.97	HL	Down
	FNF	-0.23	-0.0089	-34	0.072	Down	0.97	HL	Down
TP / 665	FNC	-0.034	-0.0013	-39	<0.05	Down	0.97	HL	Down
	FNF	-0.24	-0.0091	-19	0.34	N/A	0.82	L	Down
DP / 666	FNC	-0.028	-0.0011	-62	<0.05	Down	0.99	HL	Down
	FNF	-0.29	-0.011	-61	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	0.0002	<0.0001	2	0.93	NS	0.46	ALAN	UP
	FNF	0.03	0.0012	29	0.38	NS	0.81	L	UP
TOC / 680	FNC	-0.491	-0.019	-14	<0.05	Down	0.99	HL	Down
	FNF	-1.10	-0.042	-2.6	0.72	NS	0.64	ALAN	Down
SSC / 80154	FNC	-4.510	-0.17	-11	0.4	NS	0.79	L	Down
	FNF	-257.4	-9.9	-18	0.44	NS	0.79	L	Down

FNC – Flow Normalized Concentration – mg/L, FNC Slope – mg/L/yr
FNF – Flow Normalized Flux – 10^6 kg/yr, FNF Slope – 10^6 kg/yr/yr
FNC/FNF alpha level – 0.1
SMK – Seasonal Mann-Kendall for flow trends, alpha level – 0.05

NS – Not significant, UP – Increasing trend, DOWN – Decreasing trend

HL – Highly Likely	≥0.95 and ≤1.00
VL – Very Likely	≥0.90 and <0.95
L – Likely	≥0.66 and <0.90
ALAN – About as Likely as Not	>0.33 and <0.66

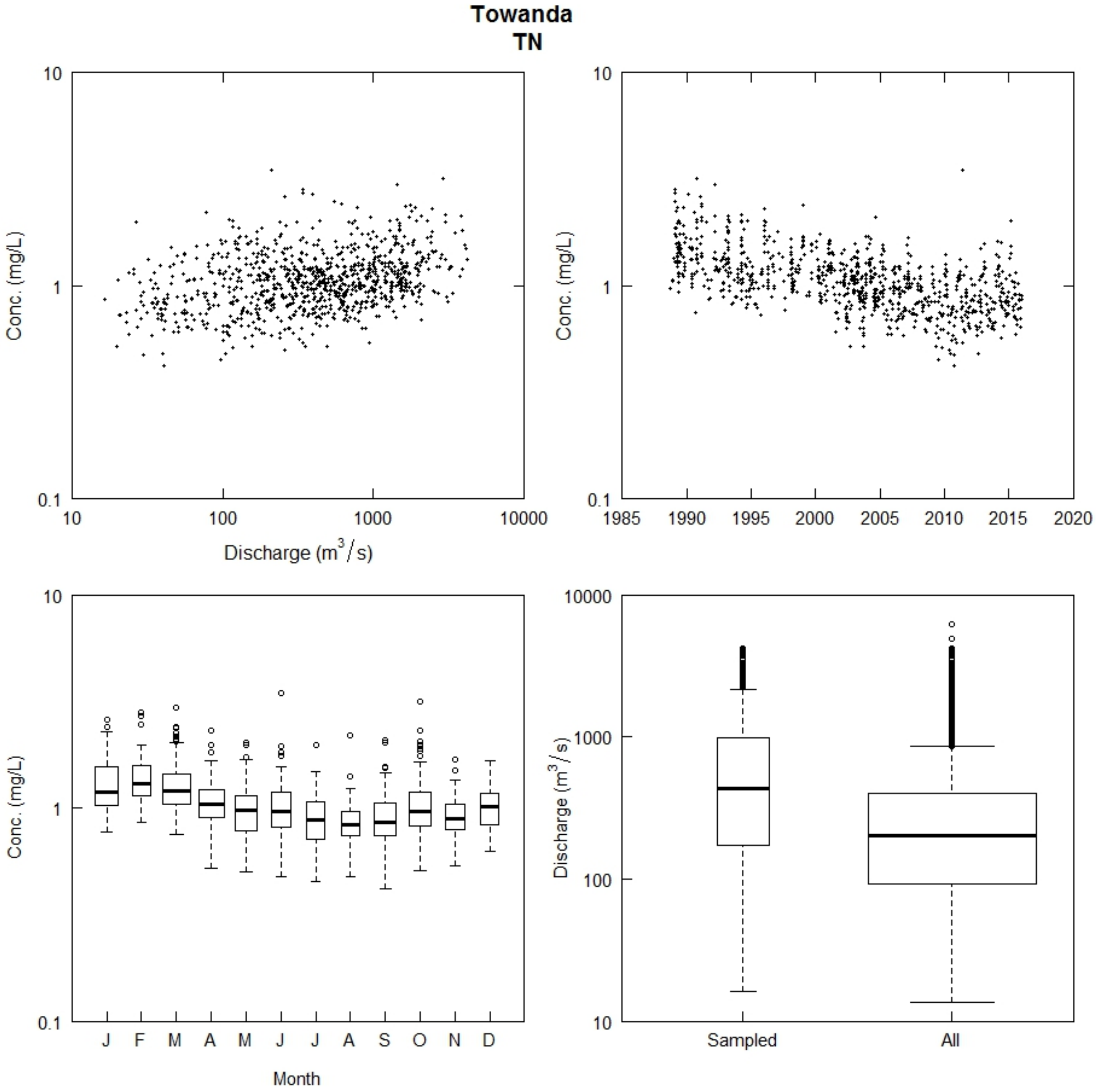


Figure B1. ***WRTDS Plots of Historical Sample Data***

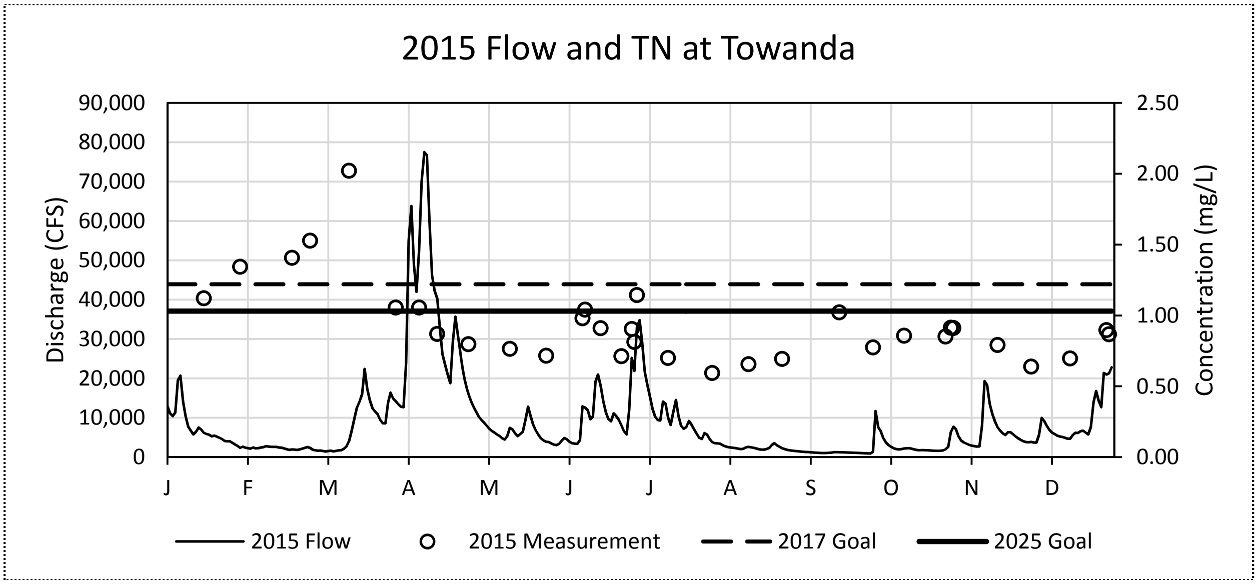


Figure B2. 2015 Daily Average Flow, TN Measurements, 2017 Goal, and 2025 Goal at Towanda

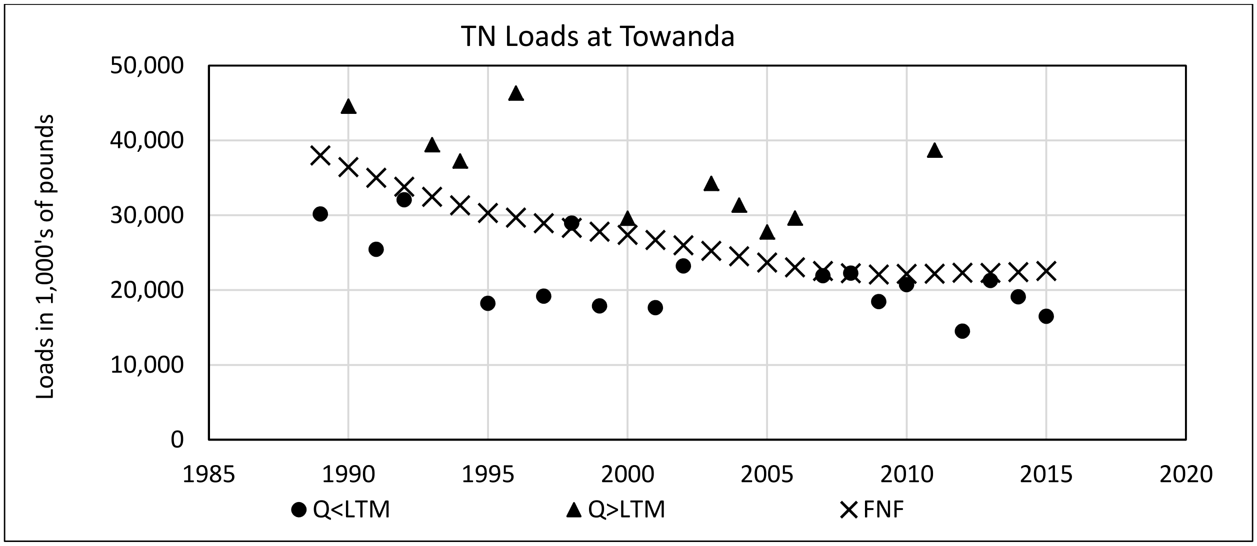


Figure B3. TN Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Towanda

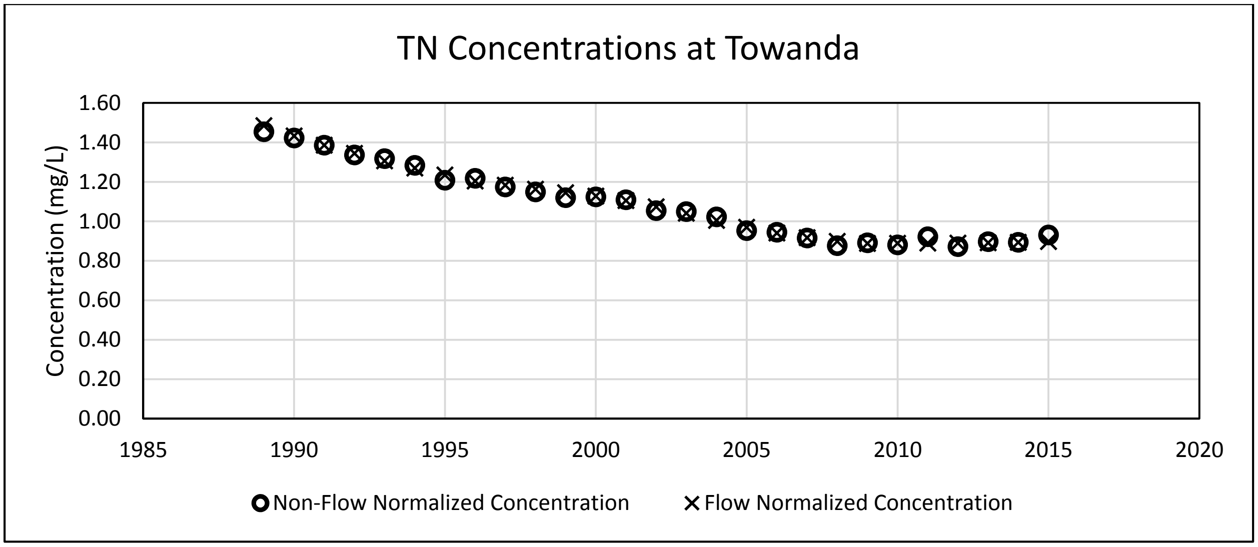


Figure B4. TN Non Flow Normalized and Flow Normalized Concentrations (mg/L) at Towanda

Table B6. Monthly TN Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Towanda	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	7,227	53%	1,275	**2,676**	2,368	2,008	**1.11**	**1.07**	1.22	1.03
February	2,242	19%	462	1,775	2,368	2,008	**1.37**	**1.16**	1.22	1.03
March	8,735	40%	1,543	**4,131**	2,368	2,008	**1.19**	**1.09**	1.22	1.03
April	35,447	141%	**5,996**	**3,879**	2,368	2,008	1.01	0.99	1.22	1.03
May	6,464	51%	932	1,601	2,368	2,008	0.85	0.88	1.22	1.03
June	10,199	116%	1,406	1,262	2,368	2,008	0.83	0.82	1.22	1.03
July	11,687	214%	1,708	921	2,368	2,008	0.84	0.78	1.22	1.03
August	2,400	57%	291	557	2,368	2,008	0.72	0.74	1.22	1.03
September	1,167	22%	139	900	2,368	2,008	0.74	0.75	1.22	1.03
October	3,110	44%	405	1,250	2,368	2,008	0.77	0.79	1.22	1.03
November	6,380	61%	875	1,495	2,368	2,008	0.85	0.85	1.22	1.03
December	9,170	67%	1,465	**2,357**	2,368	2,008	0.95	0.95	1.22	1.03
Annual#	8,688	74%	16,496	22,805	28,411	24,090	0.94	0.91	1.22	1.03

Table B7. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Towanda TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988										1.28	1.42	1.63
1989	1.77	1.81	1.78	1.62	1.43	1.34	1.30	1.25	1.20	1.24	1.37	1.56
1990	1.71	1.74	1.71	1.55	1.38	1.30	1.26	1.22	1.18	1.21	1.33	1.51
1991	1.65	1.69	1.64	1.49	1.33	1.25	1.23	1.19	1.15	1.18	1.29	1.46
1992	1.59	1.63	1.58	1.43	1.28	1.22	1.19	1.16	1.13	1.16	1.26	1.41
1993	1.54	1.58	1.52	1.38	1.24	1.18	1.16	1.14	1.11	1.14	1.23	1.37
1994	1.50	1.54	1.47	1.33	1.21	1.15	1.13	1.11	1.09	1.12	1.21	1.33
1995	1.45	1.49	1.42	1.28	1.17	1.12	1.10	1.08	1.06	1.11	1.19	1.30
1996	1.42	1.46	1.37	1.23	1.13	1.09	1.07	1.05	1.05	1.10	1.19	1.30
1997	1.41	1.43	1.33	1.20	1.10	1.05	1.04	1.02	1.03	1.09	1.19	1.30
1998	1.40	1.41	1.31	1.17	1.07	1.03	1.01	0.99	1.00	1.07	1.18	1.30
1999	1.40	1.40	1.29	1.14	1.06	1.01	0.98	0.96	0.97	1.05	1.16	1.29
2000	1.39	1.40	1.27	1.13	1.04	0.99	0.95	0.93	0.95	1.03	1.14	1.26
2001	1.36	1.38	1.26	1.12	1.03	0.97	0.93	0.89	0.91	0.99	1.10	1.21
2002	1.32	1.35	1.23	1.11	1.02	0.95	0.90	0.86	0.87	0.94	1.05	1.17
2003	1.28	1.32	1.21	1.09	1.00	0.93	0.87	0.82	0.83	0.90	1.00	1.12
2004	1.24	1.28	1.18	1.06	0.97	0.90	0.83	0.79	0.79	0.86	0.96	1.07
2005	1.20	1.24	1.14	1.04	0.94	0.87	0.81	0.76	0.76	0.83	0.92	1.03
2006	1.16	1.21	1.11	1.01	0.92	0.85	0.79	0.75	0.74	0.80	0.89	0.99
2007	1.12	1.17	1.09	0.99	0.90	0.83	0.78	0.74	0.73	0.78	0.86	0.97
2008	1.09	1.14	1.07	0.98	0.88	0.81	0.77	0.73	0.72	0.77	0.85	0.95
2009	1.07	1.12	1.06	0.97	0.87	0.81	0.76	0.73	0.73	0.77	0.85	0.95
2010	1.07	1.12	1.06	0.97	0.87	0.80	0.76	0.73	0.73	0.78	0.85	0.95
2011	1.07	1.12	1.06	0.97	0.87	0.80	0.76	0.74	0.74	0.78	0.85	0.95
2012	1.07	1.12	1.06	0.97	0.87	0.80	0.76	0.74	0.74	0.78	0.85	0.95
2013	1.07	1.12	1.06	0.98	0.87	0.80	0.76	0.74	0.74	0.78	0.85	0.95
2014	1.07	1.12	1.07	0.98	0.87	0.80	0.76	0.74	0.75	0.79	0.85	0.95
2015	1.07	1.13	1.07	0.99	0.88	0.81	0.76	0.75	0.75	0.79	0.86	0.96
Change	-0.70	-0.68	-0.71	-0.63	-0.55	-0.53	-0.54	-0.51	-0.45	-0.49	-0.56	-0.67

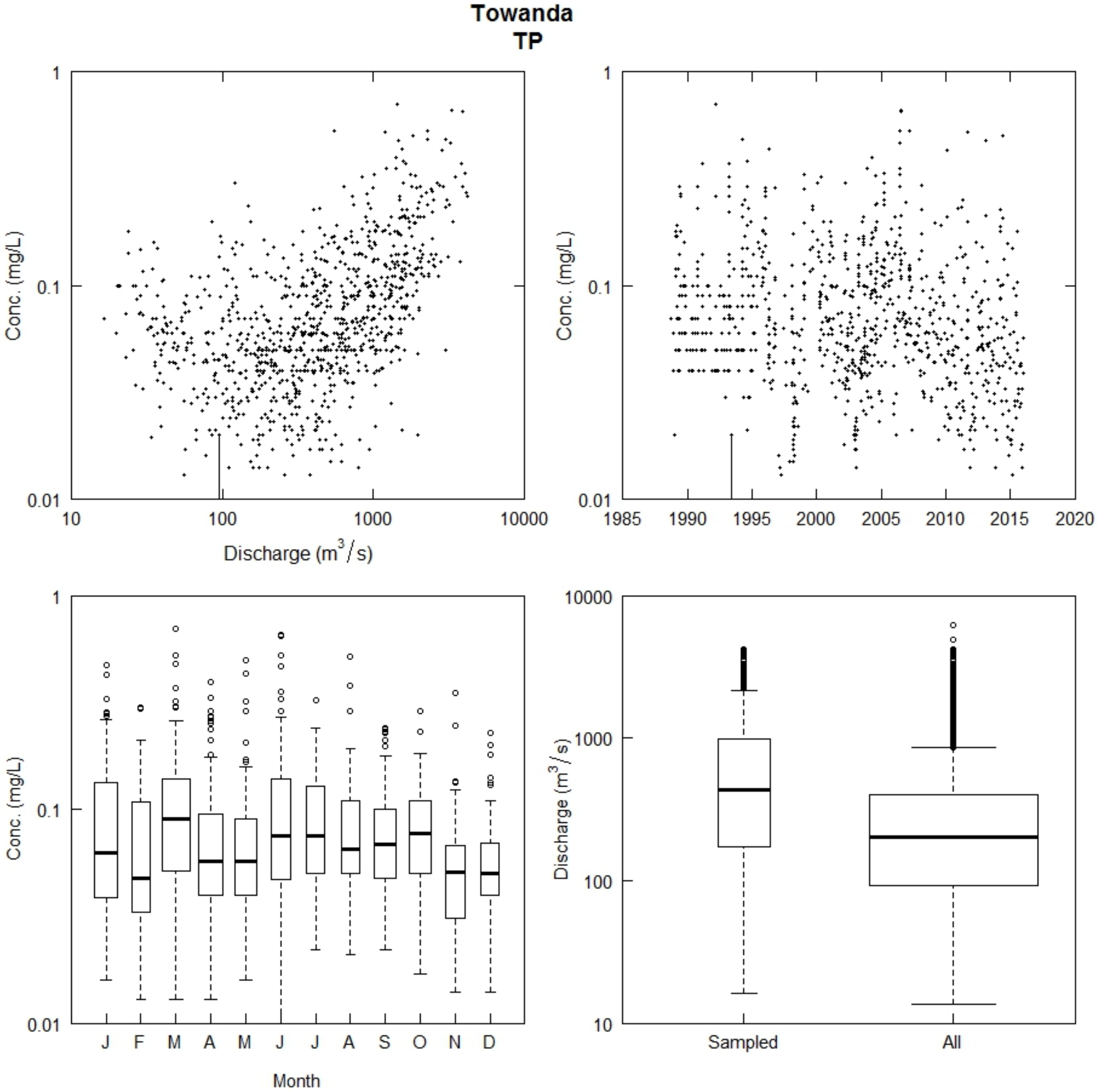


Figure B5. *WRTDS Plots of Historical Sample Data*

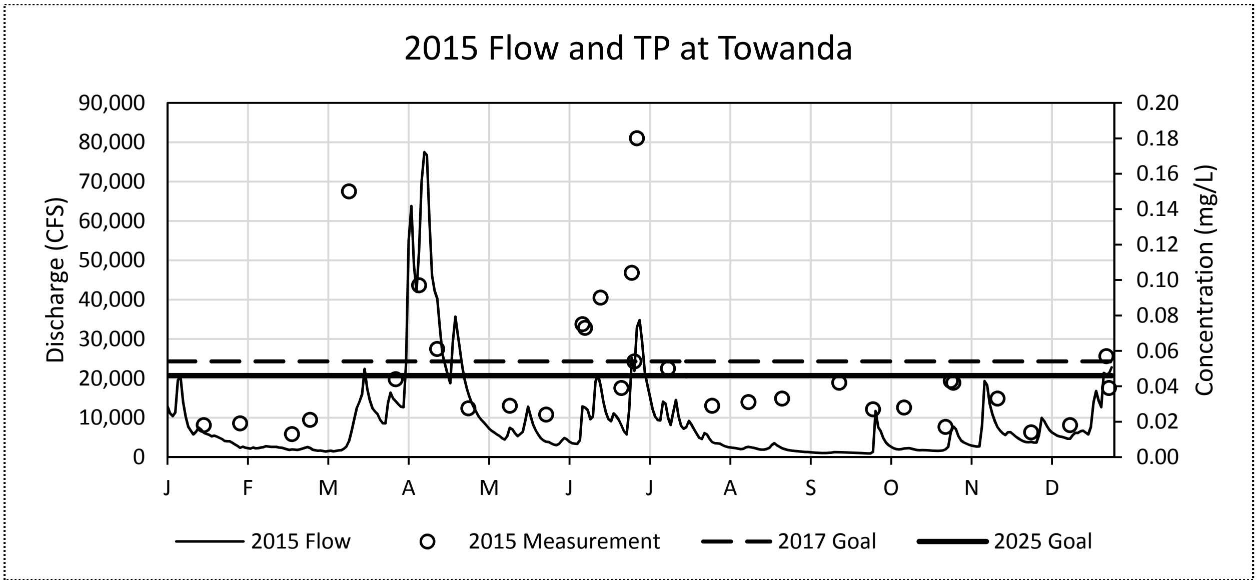


Figure B6. 2015 Daily Average Flow, TP Measurements, 2017 Goal, and 2025 Goal at Towanda

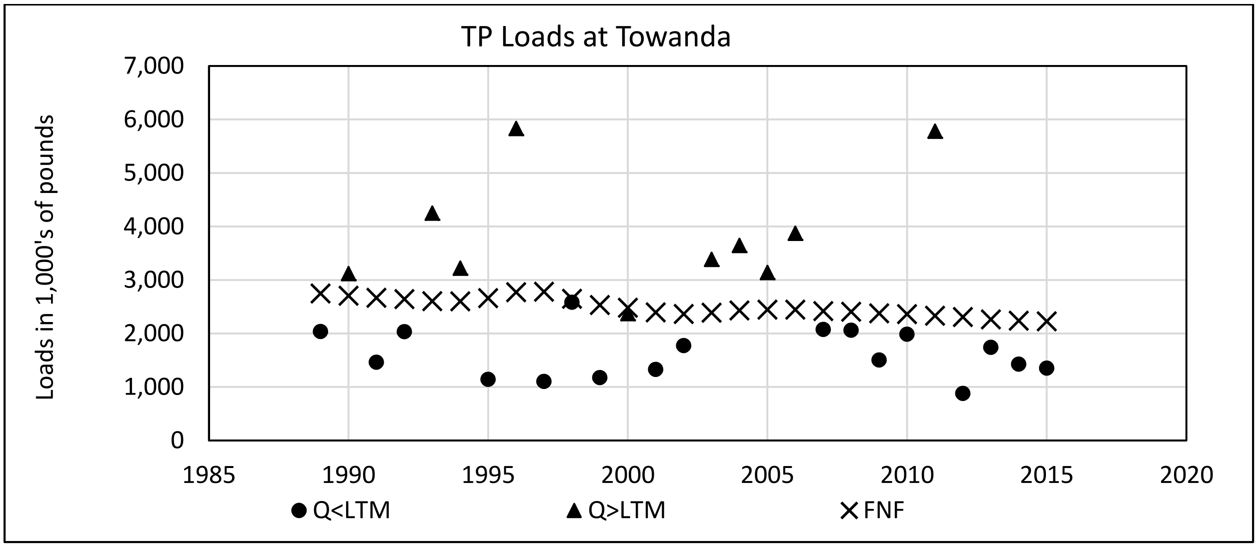


Figure B7. TP Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Towanda

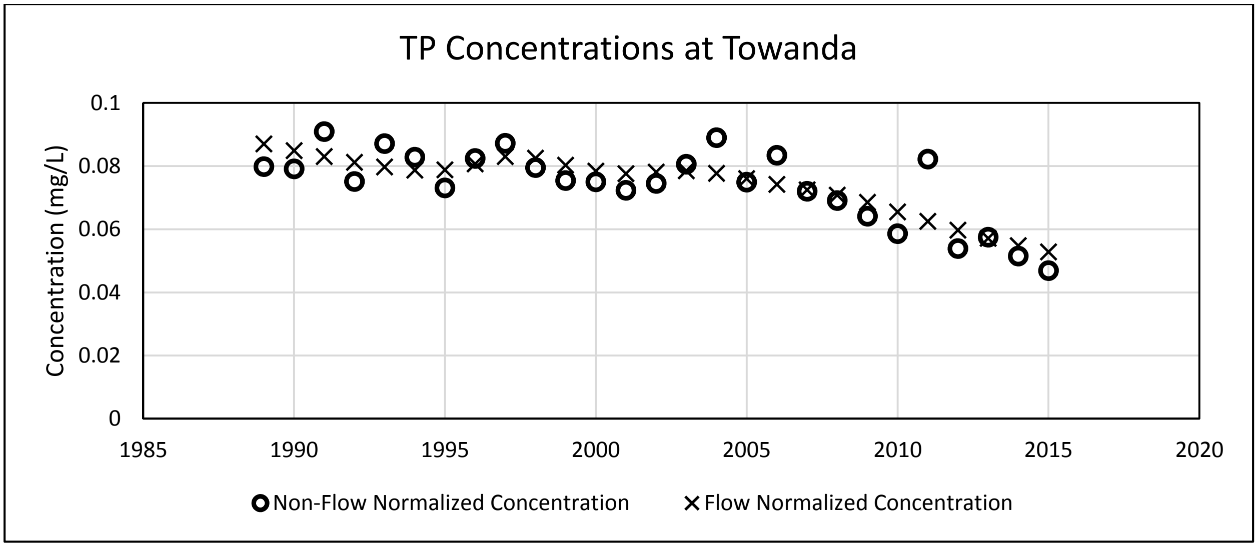


Figure B8. TP Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Towanda

Table B8. Monthly TP Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Towanda	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	7,227	53%	46	**196**	105	90	0.032	**0.054**	0.054	0.046
February	2,242	19%	9	**107**	105	90	0.026	**0.046**	0.054	0.046
March	8,735	40%	65	**424**	105	90	0.038	**0.072**	0.054	0.046
April	35,447	141%	**733**	**453**	105	90	**0.101**	**0.082**	0.054	0.046
May	6,464	51%	44	**147**	105	90	0.039	**0.064**	0.054	0.046
June	10,199	116%	**120**	**192**	105	90	**0.060**	**0.072**	0.054	0.046
July	11,687	214%	**185**	**126**	105	90	**0.075**	**0.075**	0.054	0.046
August	2,400	57%	17	63	105	90	0.041	**0.069**	0.054	0.046
September	1,167	22%	6	**200**	105	90	0.033	**0.067**	0.054	0.046
October	3,110	44%	19	**137**	105	90	0.032	**0.061**	0.054	0.046
November	6,380	61%	41	**124**	105	90	0.034	**0.052**	0.054	0.046
December	9,170	67%	67	**178**	105	90	0.036	**0.055**	0.054	0.046
Annual#	8,688	74%	**1,352**	**2,348**	1,254	1,077	0.046	**0.064**	0.054	0.046

Table B9. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Towanda TP Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988										0.084	0.082	0.088
1989	0.086	0.075	0.090	0.091	0.076	0.085	0.093	0.098	0.095	0.083	0.081	0.086
1990	0.084	0.072	0.087	0.087	0.073	0.082	0.091	0.097	0.095	0.083	0.080	0.084
1991	0.081	0.070	0.084	0.084	0.070	0.080	0.089	0.095	0.094	0.083	0.080	0.083
1992	0.079	0.068	0.080	0.080	0.067	0.077	0.088	0.094	0.094	0.084	0.080	0.082
1993	0.077	0.065	0.077	0.078	0.064	0.075	0.086	0.093	0.094	0.085	0.081	0.081
1994	0.075	0.063	0.075	0.075	0.062	0.074	0.085	0.093	0.095	0.087	0.084	0.082
1995	0.074	0.061	0.072	0.073	0.061	0.074	0.086	0.093	0.097	0.091	0.091	0.087
1996	0.076	0.063	0.071	0.072	0.061	0.075	0.087	0.095	0.099	0.096	0.099	0.095
1997	0.083	0.067	0.072	0.072	0.060	0.073	0.086	0.094	0.098	0.096	0.101	0.098
1998	0.085	0.069	0.072	0.071	0.059	0.070	0.083	0.091	0.094	0.092	0.097	0.094
1999	0.083	0.069	0.072	0.071	0.058	0.068	0.080	0.088	0.091	0.089	0.090	0.086
2000	0.078	0.068	0.072	0.073	0.059	0.067	0.079	0.087	0.091	0.086	0.084	0.079
2001	0.074	0.067	0.074	0.076	0.063	0.070	0.081	0.087	0.090	0.082	0.078	0.074
2002	0.071	0.068	0.077	0.082	0.070	0.075	0.084	0.088	0.088	0.079	0.073	0.070
2003	0.068	0.067	0.080	0.088	0.076	0.080	0.086	0.088	0.086	0.075	0.069	0.066
2004	0.065	0.065	0.081	0.092	0.079	0.083	0.086	0.086	0.084	0.072	0.066	0.062
2005	0.061	0.060	0.079	0.093	0.080	0.084	0.086	0.085	0.082	0.070	0.063	0.059
2006	0.058	0.055	0.077	0.093	0.080	0.085	0.086	0.084	0.081	0.068	0.060	0.057
2007	0.055	0.052	0.075	0.092	0.079	0.084	0.085	0.083	0.079	0.066	0.059	0.057
2008	0.056	0.052	0.074	0.090	0.077	0.082	0.082	0.080	0.076	0.064	0.058	0.058
2009	0.056	0.051	0.072	0.088	0.073	0.077	0.078	0.076	0.071	0.060	0.056	0.057
2010	0.055	0.049	0.071	0.086	0.069	0.073	0.073	0.071	0.065	0.057	0.054	0.055
2011	0.053	0.047	0.070	0.084	0.066	0.069	0.068	0.066	0.061	0.053	0.052	0.054
2012	0.052	0.046	0.068	0.082	0.063	0.065	0.064	0.061	0.057	0.050	0.050	0.052
2013	0.051	0.044	0.067	0.080	0.060	0.062	0.060	0.057	0.053	0.048	0.048	0.051
2014	0.049	0.042	0.066	0.078	0.058	0.059	0.056	0.053	0.049	0.045	0.046	0.050
2015	0.048	0.041	0.065	0.077	0.056	0.056	0.053	0.050	0.046	0.043	0.045	0.049
Change	-0.038	-0.034	-0.026	-0.014	-0.021	-0.029	-0.040	-0.048	-0.049	-0.041	-0.037	-0.039

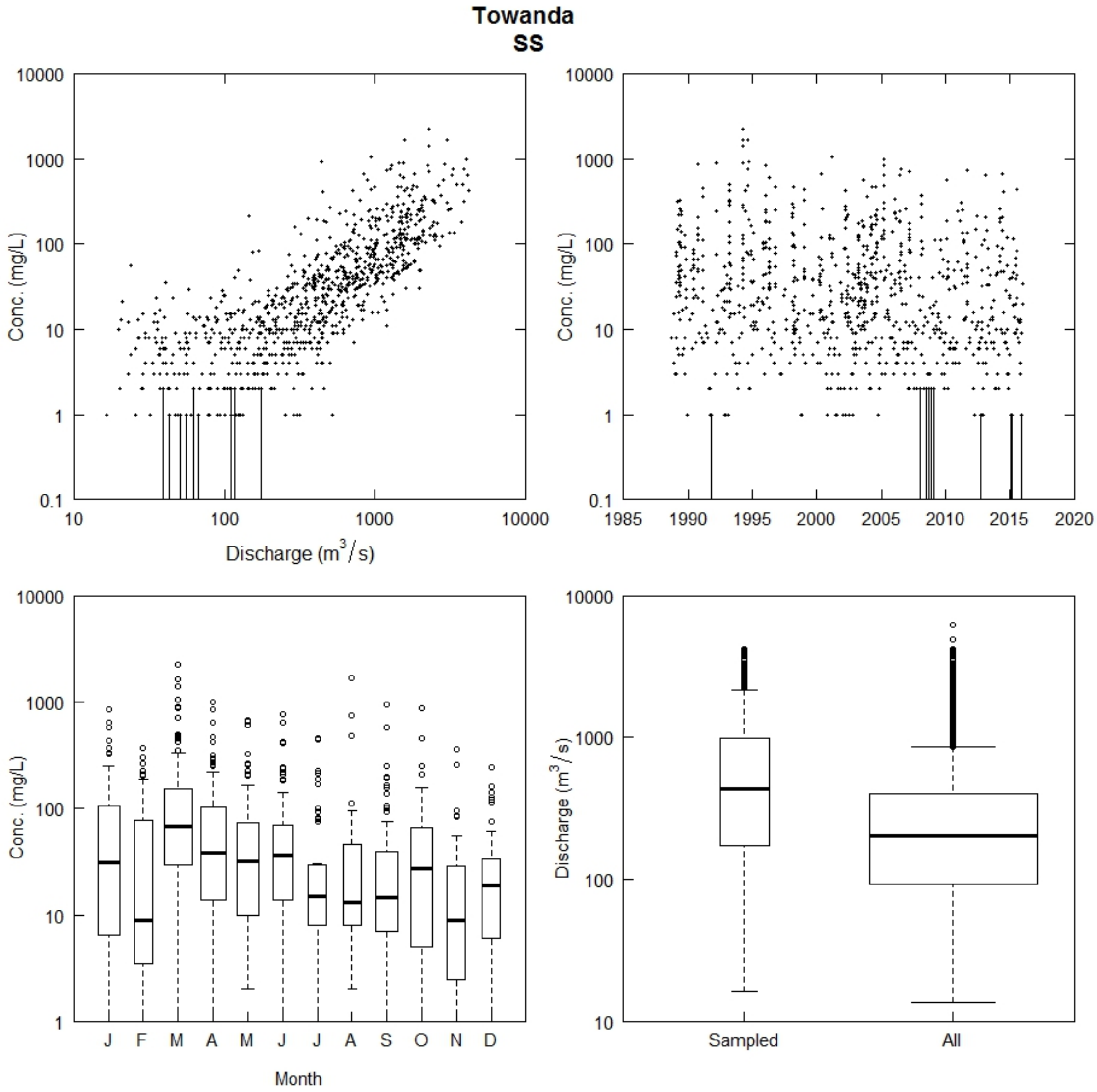


Figure B9. WRTDS Plots of Historical Sample Data

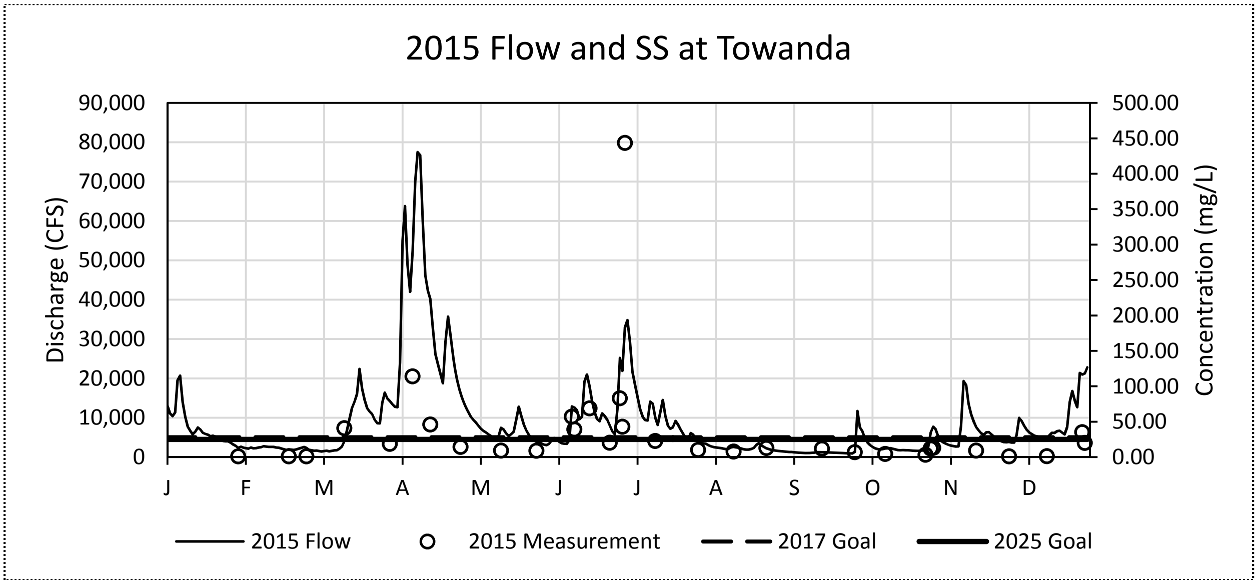


Figure B10. *2015 SS Samples, Daily Average Flow, and Monthly LTM at Towanda*

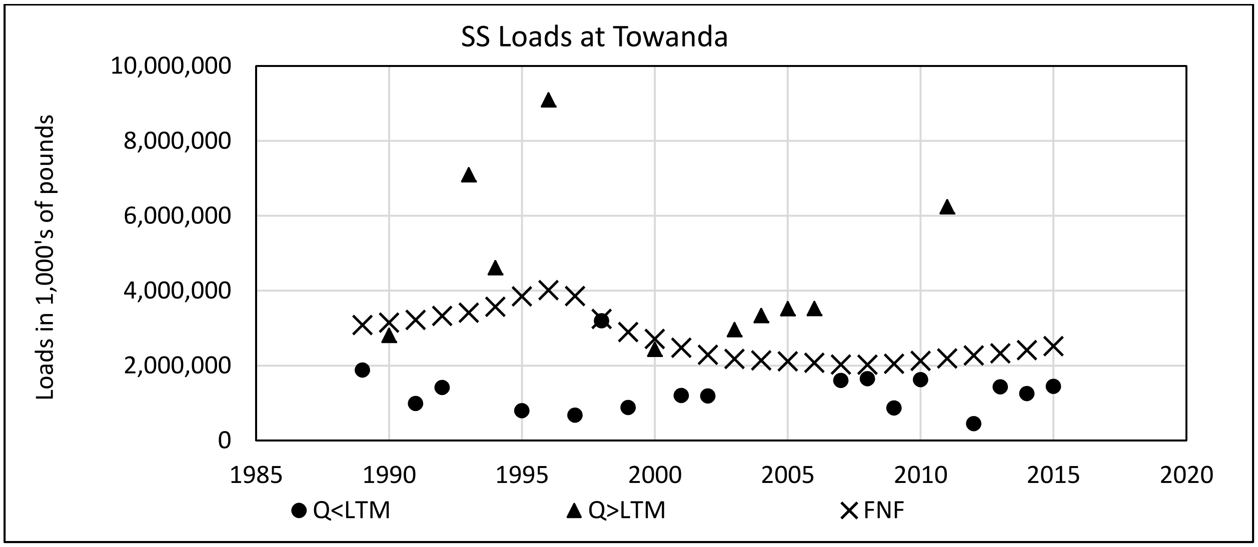


Figure B11. *SS Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Towanda*

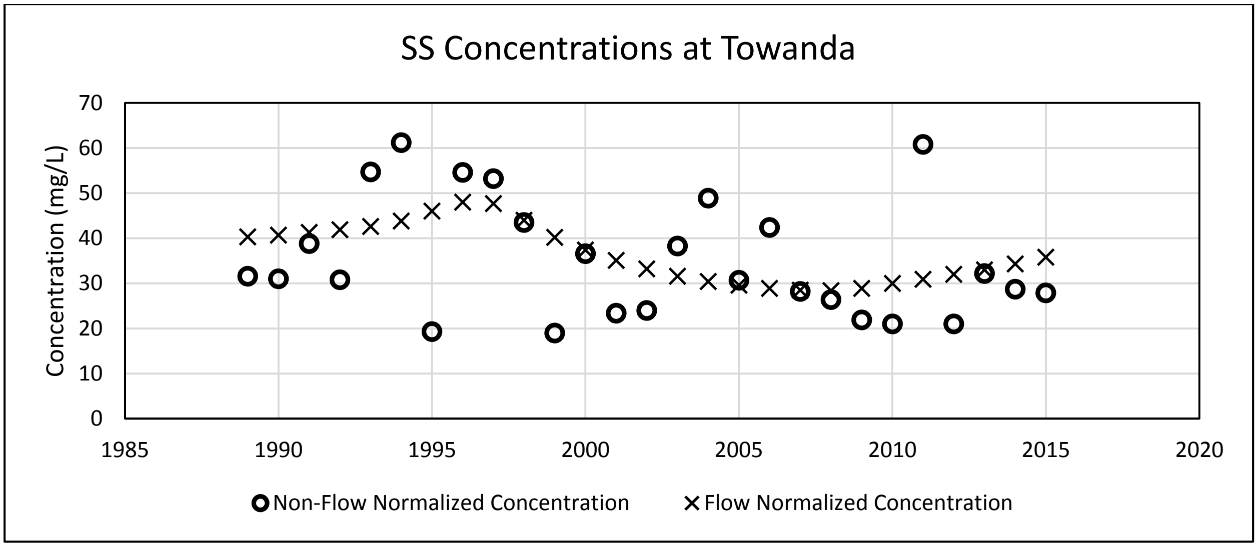


Figure B12. SS Annual Flow Normalized Loads and Concentrations (mg/L) at Towanda

Table B10. Monthly SS Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Towanda	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	7,227	53%	15,793	**147,846**	54,379	48,328	7.9	23.6	28	25
February	2,242	19%	525	**68,122**	54,379	48,328	1.5	14.5	28	25
March	8,735	40%	33,927	**456,853**	54,379	48,328	14.5	**54.4**	28	25
April	35,447	141%	**1,005,217**	**540,454**	54,379	48,328	**125.4**	**66.5**	28	25
May	6,464	51%	20,677	**114,307**	54,379	48,328	16.8	**30.5**	28	25
June	10,199	116%	**108,462**	**201,231**	54,379	48,328	**45.8**	**36.0**	28	25
July	11,687	214%	**197,853**	**109,304**	54,379	48,328	**64.8**	**32.1**	28	25
August	2,400	57%	5,167	35,861	54,379	48,328	12.4	20.0	28	25
September	1,167	22%	1,350	**187,610**	54,379	48,328	7.1	23.5	28	25
October	3,110	44%	6,262	**98,607**	54,379	48,328	7.3	23.6	28	25
November	6,380	61%	17,624	**73,155**	54,379	48,328	10.1	17.9	28	25
December	9,170	67%	32,213	**113,532**	54,379	48,328	12.9	24.2	28	25
Annual#	8,688	74%	**1,445,071**	**2,146,882**	652,543	579,932	**27.2**	**30.6**	28	25

Table B11. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Towanda SS Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988										25.0	26.7	33.9
1989	40.5	27.3	66.7	79.0	38.7	39.0	34.5	32.3	39.6	26.3	27.6	34.5
1990	40.5	27.1	66.0	78.0	38.1	39.1	35.2	33.5	42.5	27.8	28.8	35.4
1991	40.6	26.9	65.4	76.9	37.5	39.2	35.8	34.6	45.7	29.4	30.1	36.4
1992	40.8	27.7	64.8	76.1	37.1	39.5	36.7	35.7	49.0	31.1	31.5	37.6
1993	41.1	26.6	64.5	75.3	36.4	39.4	37.2	36.9	52.9	33.3	33.4	38.9
1994	41.4	26.5	64.5	75.3	36.5	40.1	38.5	38.7	57.9	36.1	36.1	41.0
1995	42.3	26.8	65.4	76.3	37.2	42.1	41.2	41.6	65.8	40.2	40.8	45.6
1996	45.4	29.0	66.5	76.7	37.4	43.0	41.7	41.4	68.2	42.8	45.0	50.4
1997	48.1	28.8	66.2	75.0	35.8	40.7	38.2	37.5	63.6	40.8	44.1	49.9
1998	46.2	27.8	62.4	70.7	33.8	37.0	33.9	32.6	48.1	36.6	40.1	45.4
1999	41.6	25.8	58.4	67.6	32.1	33.4	30.0	28.8	41.8	33.7	36.1	40.4
2000	37.5	24.8	56.0	66.5	31.2	30.8	27.4	26.1	38.6	31.0	32.3	35.6
2001	33.7	22.4	54.2	66.0	31.0	29.4	26.0	24.4	34.5	28.4	28.6	30.9
2002	29.8	20.8	52.4	65.8	31.7	29.3	25.4	23.3	31.0	25.4	24.9	26.7
2003	26.5	19.3	50.8	66.1	32.5	29.7	25.0	22.5	28.7	22.9	22.1	23.6
2004	24.0	18.5	49.5	66.8	33.4	30.4	24.9	21.9	26.9	21.1	20.3	21.6
2005	22.3	16.8	48.6	67.3	33.7	30.6	24.7	21.4	25.7	19.9	19.1	20.5
2006	21.7	16.2	48.0	67.3	33.9	30.8	24.7	21.0	23.8	18.4	18.1	19.9
2007	21.4	15.8	47.5	67.0	34.5	31.3	24.9	20.7	21.7	17.1	17.5	20.0
2008	21.8	16.5	48.0	67.6	35.6	32.2	25.0	20.2	19.9	16.3	17.5	20.8
2009	22.8	16.2	49.0	68.8	36.8	33.2	25.5	20.4	19.6	16.9	18.5	22.3
2010	24.0	16.8	50.6	70.7	38.0	34.3	26.1	21.0	20.0	17.7	19.6	23.5
2011	25.1	17.3	51.9	72.4	39.0	35.1	26.8	21.7	20.5	18.5	20.5	24.7
2012	26.1	18.6	53.5	74.5	40.3	36.3	27.6	22.3	21.0	19.3	21.5	25.9
2013	27.3	18.6	55.0	76.2	41.3	37.2	28.5	23.2	21.7	20.2	22.6	27.3
2014	28.6	19.3	57.0	78.8	42.7	38.5	29.6	24.2	22.5	21.2	23.8	28.9
2015	30.1	20.2	59.4	81.8	44.2	39.9	30.9	25.3	23.4	22.3	25.2	30.6
Change	-10.4	-7.2	-7.2	2.8	5.5	0.9	-3.7	-7.0	-16.2	-2.7	-1.5	-3.3

INDIVIDUAL SITES: DANVILLE

Table B12. 2015 Annual and Seasonal Precipitation and Discharge at Danville

Season	Precipitation (inches)			Discharge (cfs)		
	2015	LTM	LTM Departure	2015	LTM	% LTM
January-March (Winter)	5.74	7.83	-2.09	10,539	22,244	47
April-June (Spring)	14.00	11.42	2.58	23,659	21,470	110
July-September (Summer)	11.01	12.06	-1.05	8,203	7,332	112
October-December (Fall)	8.76	9.91	-1.16	8,663	15,423	56
Annual Total	39.51	41.22	-1.71	12,748	12,748	77

Table B13. 2015 Annual Loads (1000's lbs), Yields (lbs/acre), and Concentrations (mg/L) at Danville

Parameter	Load	Load % of LTM	Yield	LTM Yield	Ave. Conc.	Conc. % of LTM
TN	24,465	59%	4.90	8.36	0.97	76%
TNO$_x$	13,717	58%	2.75	4.70	0.55	76%
TON	9,941	60%	1.99	3.30	0.40	78%
TNH$_3$	947	48%	0.19	0.39	0.04	63%
DN	19,956	58%	4.00	6.92	0.80	75%
DNO$_x$	13,766	58%	2.76	4.72	0.55	76%
DON	5,493	56%	1.10	1.96	0.22	73%
DNH$_3$	854	50%	0.17	0.34	0.03	65%
TP	1,927	50%	0.39	0.78	0.08	65%
DP	349	35%	0.07	0.20	0.01	45%
DOP	233	42%	0.05	0.11	0.01	55%
TOC	86,378	72%	17.31	23.91	3.44	94%
SS	2,851,634	75%	571.46	759.46	113.62	98%

Table B14. 2015 Seasonal Loads (1000's lbs) and Yields (lbs/acre) at Danville

Parameter	Winter		Spring		Summer		Fall	
	Load	Yield	Load	Yield	Load	Yield	Load	Yield
TN	5,614	1.12	11,838	2.37	3,263	0.65	3,751	0.75
TNO$_x$	3,937	0.79	5,878	1.18	1,490	0.30	2,413	0.48
TON	1,368	0.27	5,613	1.12	1,773	0.36	1,186	0.24
TNH$_3$	226	0.05	441	0.09	132	0.03	148	0.03
DN	5,096	1.02	8,888	1.78	2,519	0.50	3,453	0.69
DNO$_x$	3,937	0.79	5,890	1.18	1,491	0.30	2,449	0.49
DON	966	0.19	2,667	0.53	973	0.19	887	0.18
DNH$_3$	212	0.04	395	0.08	110	0.02	138	0.03
TP	217	0.04	1,206	0.24	323	0.06	181	0.04
DP	61	0.01	164	0.03	71	0.01	53	0.01
DOP	41	0.01	111	0.02	48	0.01	34	0.01
TOC	12,394	2.48	45,742	9.17	16,263	3.26	11,979	2.40
SS	141,814	28.42	2,154,464	431.75	436,230	87.42	119,126	23.87

Table B15. 2015 Monthly Average Precipitation (in), High Daily Precipitation During Month (in), Flow (cfs), Loads (1000's lbs), and Yields (lbs/acre) at Danville

Mon	Precip			Flow		TN			TP			SS		
	Ave	Max	% LTM	2014	% LTM	Load	Yield	% LTM	Load	Yield	% LTM	Load	Yield	% LTM
Jan	1.69	0.59	65%	11,429	59%	2,067	0.41	44%	76	0.015	18%	41,505	8.3	12%
Feb	2.05	0.54	95%	5,098	31%	897	0.18	24%	19	0.004	9%	3,203	0.6	2%
Mar	2.00	0.40	65%	14,563	48%	2,650	0.53	37%	122	0.024	20%	97,106	19.5	14%
Apr	4.05	0.88	118%	47,377	139%	8,675	1.74	119%	988	0.198	140%	1,973,558	395.5	229%
May	2.50	0.82	70%	10,115	55%	1,360	0.27	39%	70	0.014	24%	41,553	8.3	16%
Jun	7.46	1.28	170%	13,937	115%	1,803	0.36	89%	148	0.030	64%	139,354	27.9	71%
Jul	4.99	0.89	125%	18,876	242%	2,721	0.55	211%	295	0.059	208%	429,423	86.1	414%
Aug	2.55	0.86	66%	3,664	60%	374	0.07	36%	21	0.004	19%	5,801	1.2	8%
Sept	3.47	2.13	83%	1,865	23%	169	0.03	12%	7	0.001	3%	1,005	0.2	0%
Oct	2.98	1.20	80%	4,066	40%	457	0.09	24%	23	0.005	12%	7,397	1.5	5%
Nov	2.18	1.53	68%	9,617	62%	1,279	0.26	41%	67	0.013	23%	45,838	9.2	24%
Dec	3.60	0.49	121%	12,336	60%	2,014	0.40	45%	91	0.018	24%	65,891	13.2	24%

Table B16. Trend Statistics for the Susquehanna River at Danville, Pa., October 1984 Through September 2015

Danville	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
FLOW / 60	SMK	-	-	-	0.329	NS	-	-	-
TN / 600	FNC	-0.772	-0.026	-47	<0.05	Down	0.99	HL	Down
	FNF	-11.97	-0.4	-44	<0.05	Down	0.99	HL	Down
TNO_x / 630	FNC	-0.305	-0.01	-38	<0.05	Down	0.99	HL	Down
	FNF	-4.21	-0.14	-33	<0.05	Down	0.99	HL	Down
TON / 605	FNC	-0.465	-0.016	-58	<0.05	Down	1.00	HL	Down
	FNF	-8.19	-0.27	-56	0.074	Down	0.97	HL	Down
TNH_3 / 610	FNC	-0.060	-0.002	-64	<0.05	Down	0.99	HL	Down
	FNF	-0.97	-0.032	-62	<0.05	Down	0.99	HL	Down
DN / 602	FNC	-0.576	-0.019	-44	<0.05	Down	0.99	HL	Down
	FNF	-9.16	-0.31	-43	<0.05	Down	0.99	HL	Down
DNO_x / 631	FNC	-0.322	-0.011	-39	<0.05	Down	0.99	HL	Down
	FNF	-4.57	-0.15	-35	<0.05	Down	0.99	HL	Down
DON / 607	FNC	-0.252	-0.0084	-54	<0.05	Down	0.99	HL	Down
	FNF	-4.50	-0.15	-57	<0.05	Down	0.99	HL	Down
DNH_3 / 608	FNC	-0.062	-0.0021	-68	<0.05	Down	0.99	HL	Down
	FNF	-0.98	-0.033	-64	<0.05	Down	0.99	HL	Down
TP / 665	FNC	-0.054	-0.0018	-50	<0.05	Down	0.99	HL	Down
	FNF	-0.55	-0.018	-27	0.063	Down	0.97	HL	Down
DP / 666	FNC	-0.021	-0.00069	-62	<0.05	Down	0.99	HL	Down
	FNF	-0.36	-0.012	-63	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.003	-0.00009	-25	0.47	NS	0.76	L	Down
	FNF	-0.03	-0.001	-17	0.95	NS	0.46	ALAN	Down
TOC / 680	FNC	-1.570	-0.052	-34	<0.05	Down	0.99	HL	Down
	FNF	-17.35	-0.58	-24	<0.05	Down	0.99	HL	Down
SSC / 80154	FNC	4.760	0.16	8.9	0.7	NS	0.64	ALAN	UP
	FNF	917.2	31	40	0.45	NS	0.79	L	UP

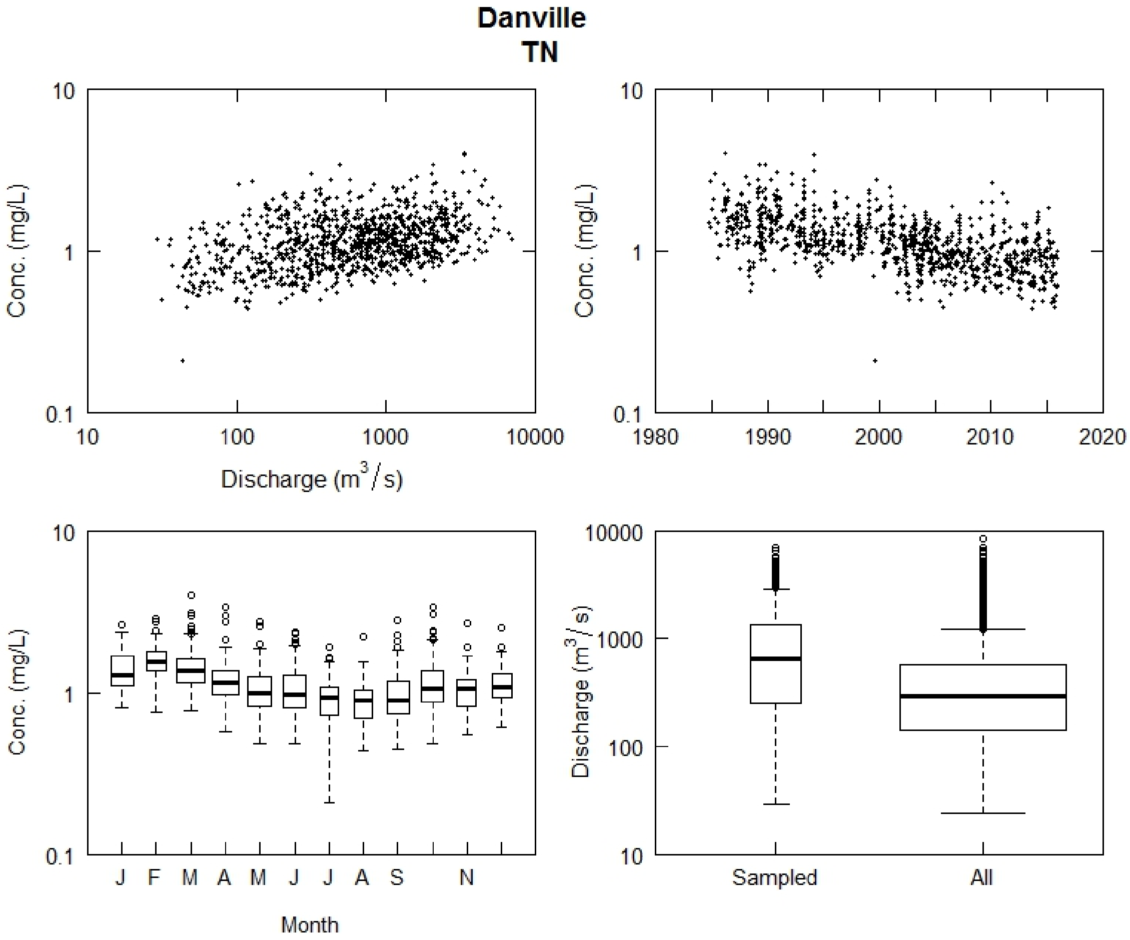


Figure B13. WRTDS Plots of Historical Sample Data

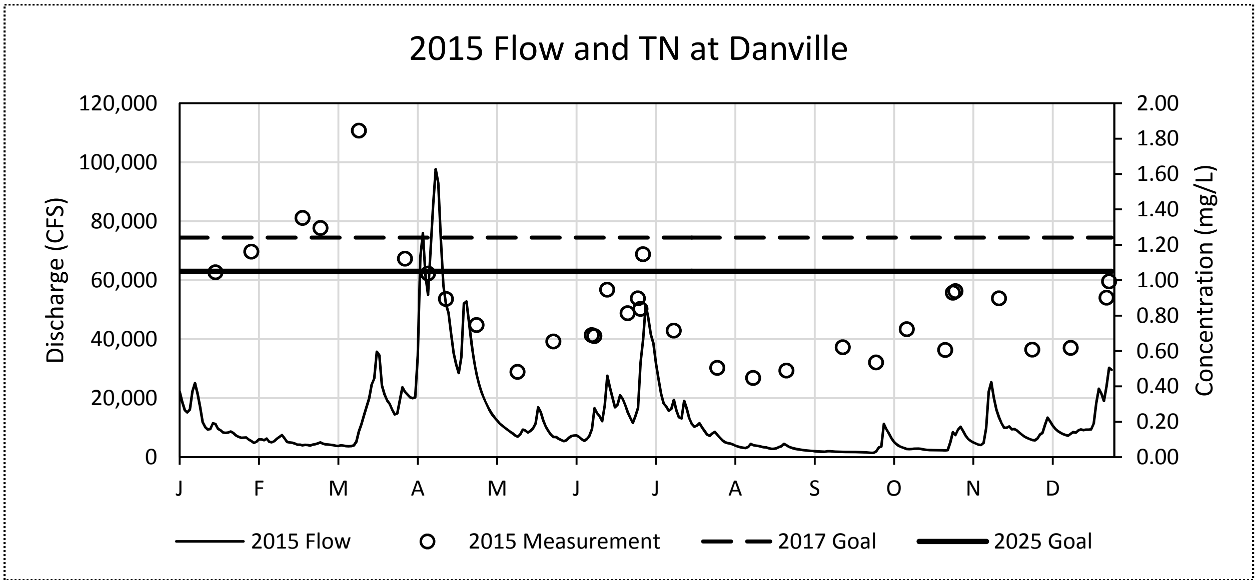


Figure B14. 2015 TN Samples, Daily Average Flow, and Monthly LTM at Danville

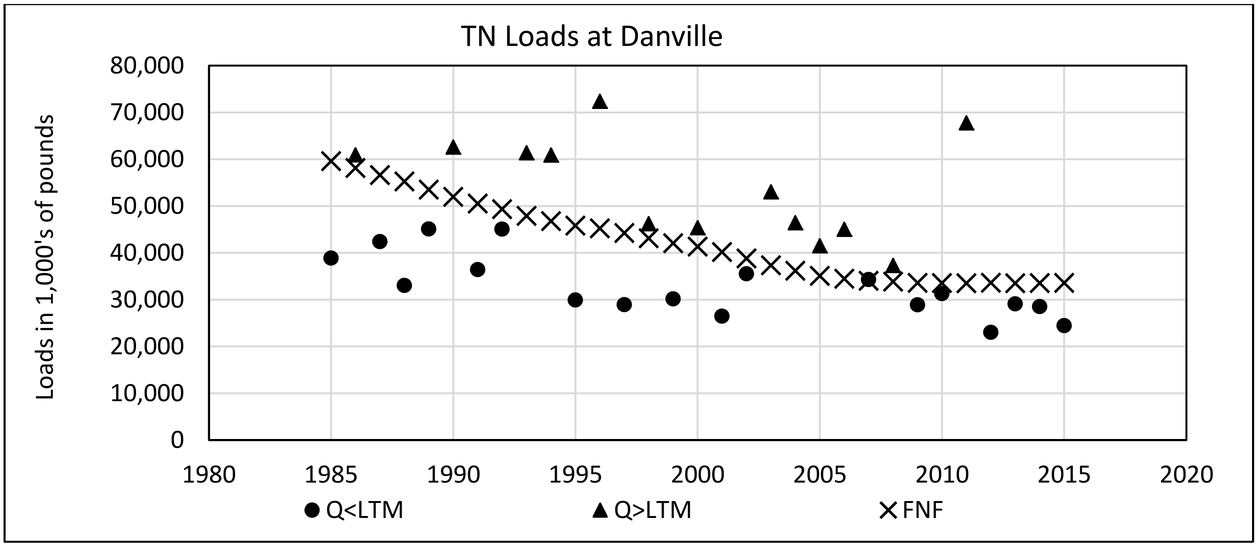


Figure B15. TN Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Danville

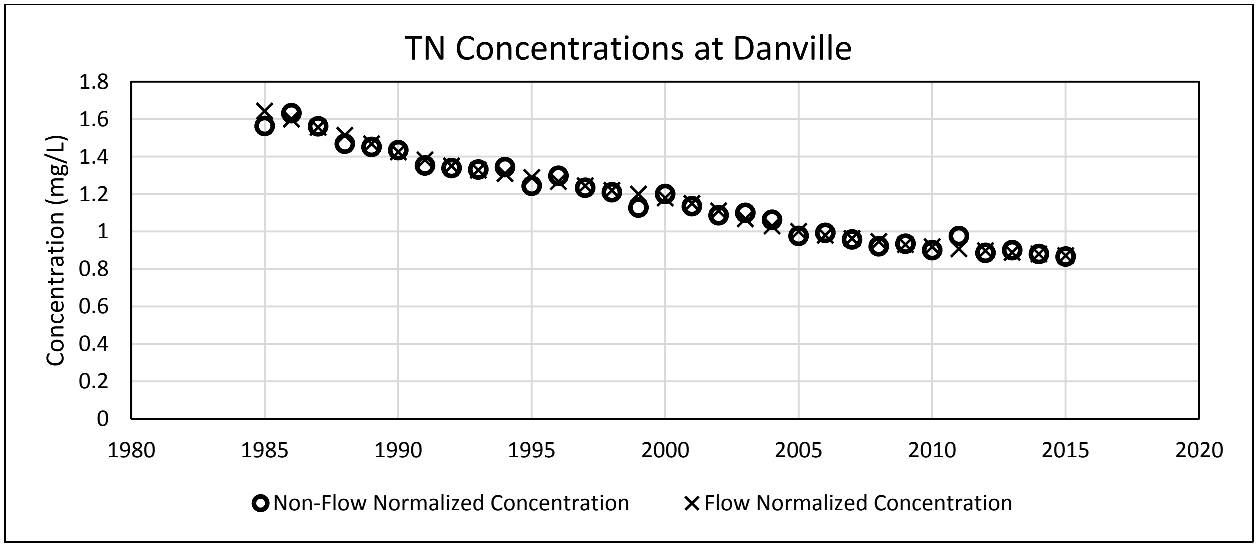


Figure B16. TN Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Danville

Table B17. Monthly TN Load (1000's of pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Danville	**Flow**		**Loads**				**Concentrations**			
	2015	**% LTM**	**2015**	**10 Yr Ave**	**2017**	**2025**	**2015**	**10 Yr Ave**	**2017**	**2025**
January	11,429	59%	2,067	**4,424**	3,407	2,889	**1.09**	**1.15**	1.24	1.05
February	5,098	31%	897	**2,995**	3,407	2,889	**1.17**	**1.21**	1.24	1.05
March	14,563	48%	2,650	**6,163**	3,407	2,889	**1.11**	**1.15**	1.24	1.05
April	47,377	139%	**8,675**	**5,864**	3,407	2,889	**1.09**	1.04	1.24	1.05
May	10,115	55%	1,360	2,546	3,407	2,889	0.79	0.87	1.24	1.05
June	13,937	115%	1,803	1,814	3,407	2,889	0.77	0.79	1.24	1.05
July	18,876	242%	2,721	1,380	3,407	2,889	0.81	0.74	1.24	1.05
August	3,664	60%	374	790	3,407	2,889	0.61	0.72	1.24	1.05
September	1,865	23%	169	1,622	3,407	2,889	0.56	0.72	1.24	1.05
October	4,066	40%	457	1,838	3,407	2,889	0.65	0.79	1.24	1.05
November	9,617	62%	1,279	2,292	3,407	2,889	0.80	0.88	1.24	1.05
December	12,336	60%	2,014	**3,853**	3,407	2,889	0.94	1.02	1.24	1.05
Annual#	12,748	77%	24,465	**35,581**	40,883	34,665	0.86	0.92	1.24	1.05

Table B18. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Danville TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										1.61	1.74	1.85
1985	1.96	1.97	1.90	1.73	1.51	1.38	1.33	1.34	1.42	1.57	1.69	1.80
1986	1.91	1.92	1.85	1.69	1.47	1.34	1.30	1.31	1.38	1.52	1.64	1.75
1987	1.85	1.86	1.81	1.65	1.43	1.31	1.27	1.28	1.35	1.47	1.58	1.70
1988	1.80	1.80	1.76	1.61	1.39	1.27	1.24	1.25	1.31	1.43	1.53	1.64
1989	1.74	1.75	1.71	1.57	1.35	1.24	1.21	1.22	1.27	1.37	1.47	1.59
1990	1.68	1.69	1.67	1.53	1.30	1.20	1.18	1.19	1.24	1.32	1.41	1.54
1991	1.63	1.64	1.62	1.49	1.26	1.16	1.15	1.18	1.21	1.27	1.36	1.49
1992	1.59	1.60	1.58	1.45	1.23	1.14	1.14	1.16	1.19	1.24	1.32	1.45
1993	1.57	1.58	1.56	1.43	1.22	1.14	1.13	1.15	1.16	1.21	1.29	1.43
1994	1.55	1.57	1.53	1.40	1.20	1.13	1.13	1.14	1.16	1.20	1.29	1.42
1995	1.55	1.57	1.50	1.36	1.18	1.10	1.09	1.10	1.13	1.20	1.29	1.42
1996	1.55	1.56	1.48	1.32	1.14	1.06	1.05	1.06	1.09	1.19	1.30	1.43
1997	1.55	1.56	1.45	1.28	1.11	1.02	1.00	1.01	1.05	1.17	1.30	1.44
1998	1.55	1.55	1.42	1.25	1.08	0.98	0.95	0.95	1.01	1.15	1.30	1.44
1999	1.55	1.54	1.40	1.22	1.06	0.96	0.91	0.92	0.98	1.12	1.28	1.42
2000	1.53	1.52	1.37	1.20	1.05	0.94	0.88	0.88	0.95	1.10	1.25	1.38
2001	1.49	1.49	1.35	1.18	1.03	0.92	0.86	0.85	0.92	1.05	1.20	1.32
2002	1.43	1.44	1.31	1.16	1.01	0.89	0.83	0.82	0.88	1.00	1.13	1.26
2003	1.37	1.40	1.27	1.13	0.98	0.87	0.81	0.79	0.84	0.94	1.07	1.19
2004	1.32	1.35	1.23	1.10	0.95	0.85	0.79	0.77	0.80	0.90	1.02	1.14
2005	1.29	1.32	1.20	1.07	0.93	0.83	0.78	0.76	0.79	0.87	0.98	1.11
2006	1.26	1.30	1.18	1.06	0.92	0.82	0.77	0.76	0.77	0.84	0.95	1.08
2007	1.23	1.27	1.16	1.04	0.90	0.81	0.77	0.75	0.76	0.82	0.92	1.05
2008	1.21	1.25	1.14	1.03	0.89	0.80	0.76	0.75	0.75	0.80	0.90	1.04
2009	1.18	1.22	1.13	1.03	0.88	0.79	0.75	0.73	0.73	0.79	0.89	1.03
2010	1.16	1.20	1.13	1.03	0.87	0.78	0.73	0.71	0.72	0.78	0.88	1.02
2011	1.15	1.19	1.13	1.03	0.86	0.77	0.71	0.70	0.70	0.76	0.87	1.01
2012	1.14	1.17	1.13	1.02	0.86	0.75	0.70	0.68	0.69	0.75	0.86	1.01
2013	1.13	1.16	1.13	1.03	0.85	0.74	0.68	0.67	0.68	0.74	0.85	1.00
2014	1.12	1.16	1.13	1.03	0.85	0.73	0.67	0.65	0.66	0.72	0.84	0.99
2015	1.11	1.15	1.13	1.03	0.84	0.72	0.66	0.64	0.65	0.71	0.83	0.99
Change	-0.85	-0.83	-0.77	-0.70	-0.67	-0.66	-0.67	-0.70	-0.77	-0.90	-0.91	-0.86

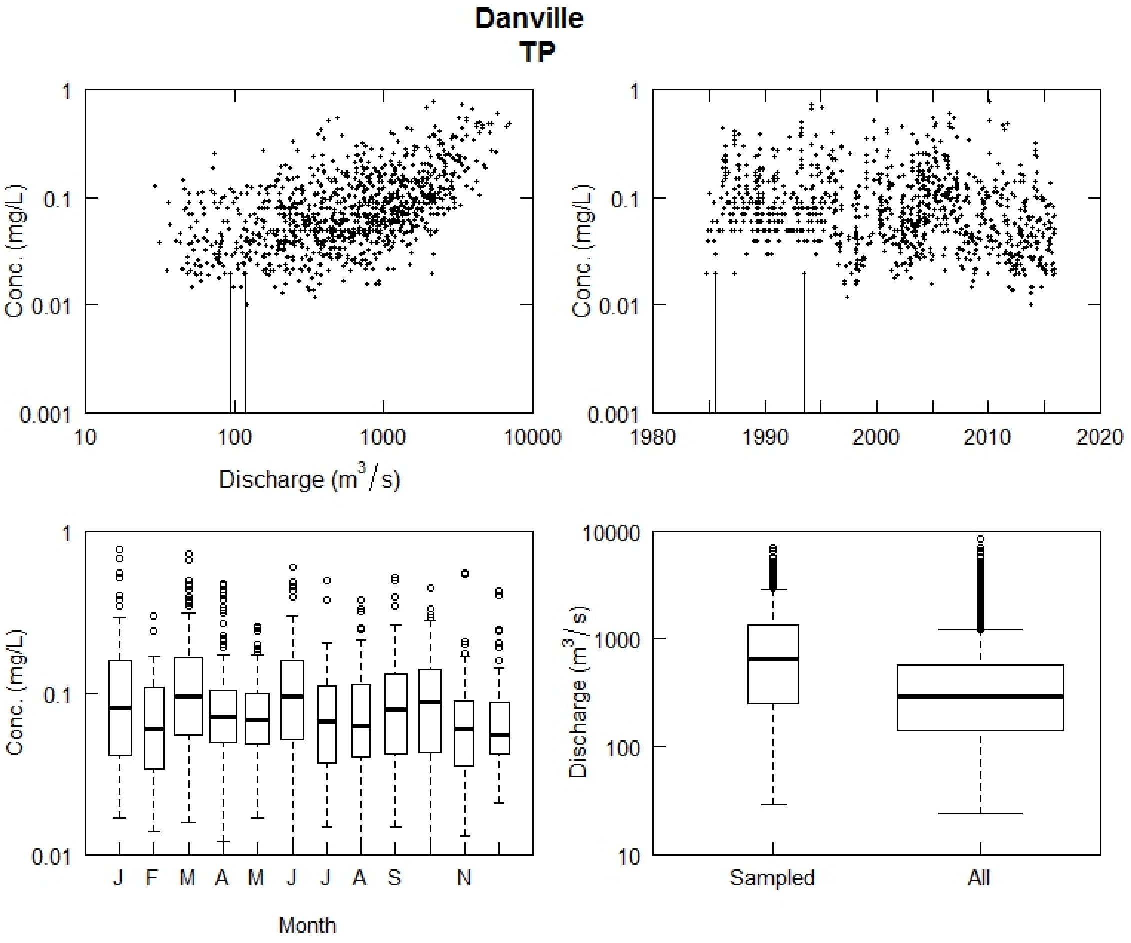


Figure B17. *WRTDS Plots of Historical Sample Data*

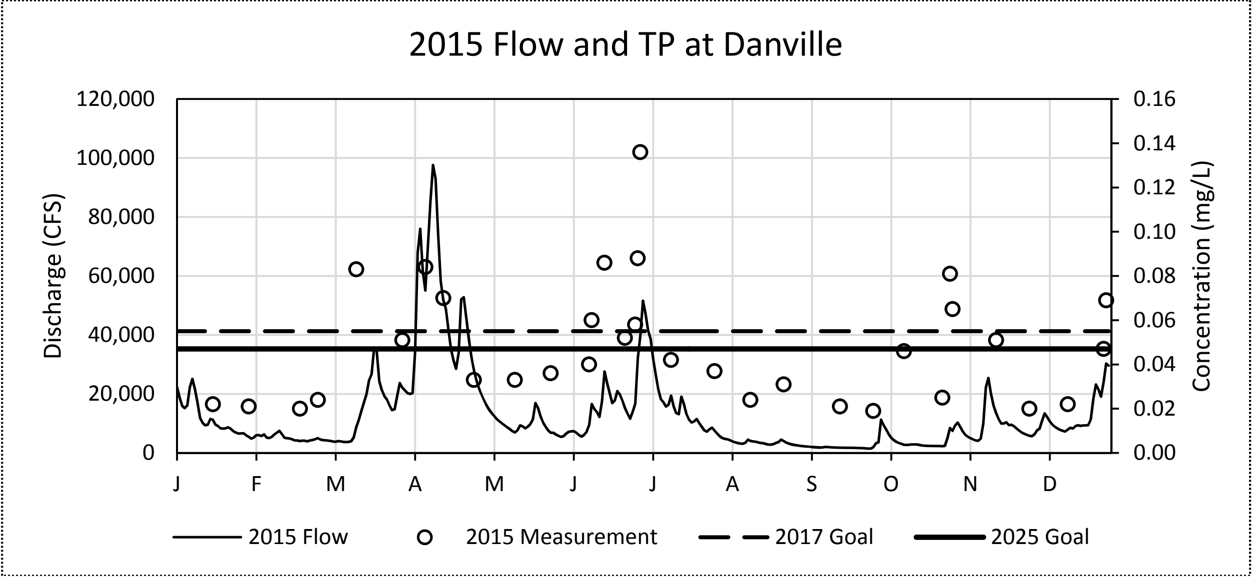


Figure B18. *2015 TP Samples, Daily Average Flow, and Monthly LTM at Towanda*

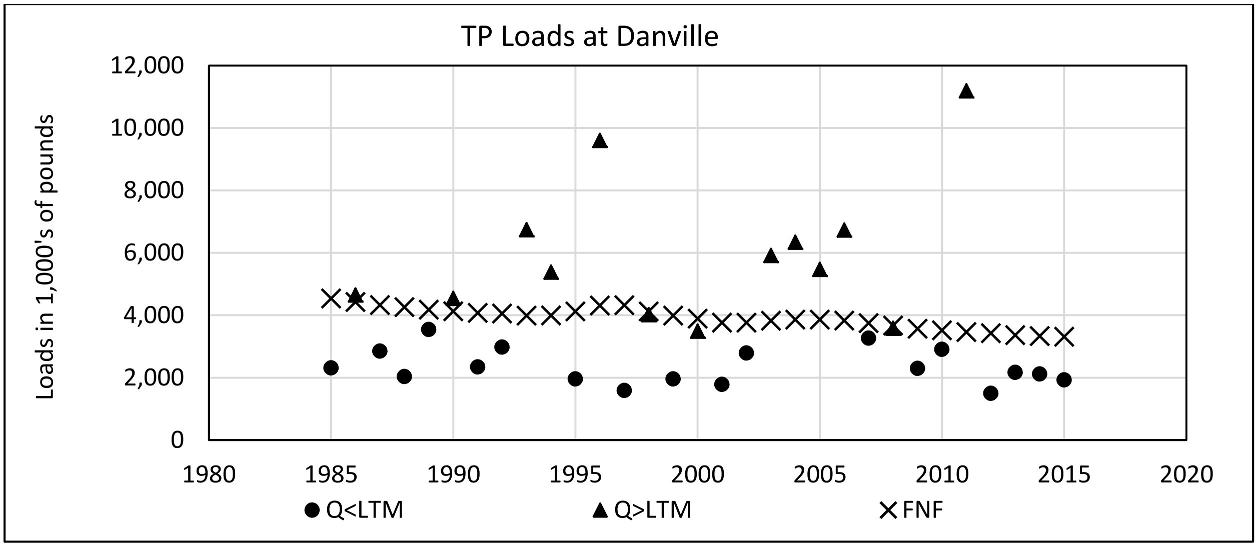


Figure B19. TP Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Danville

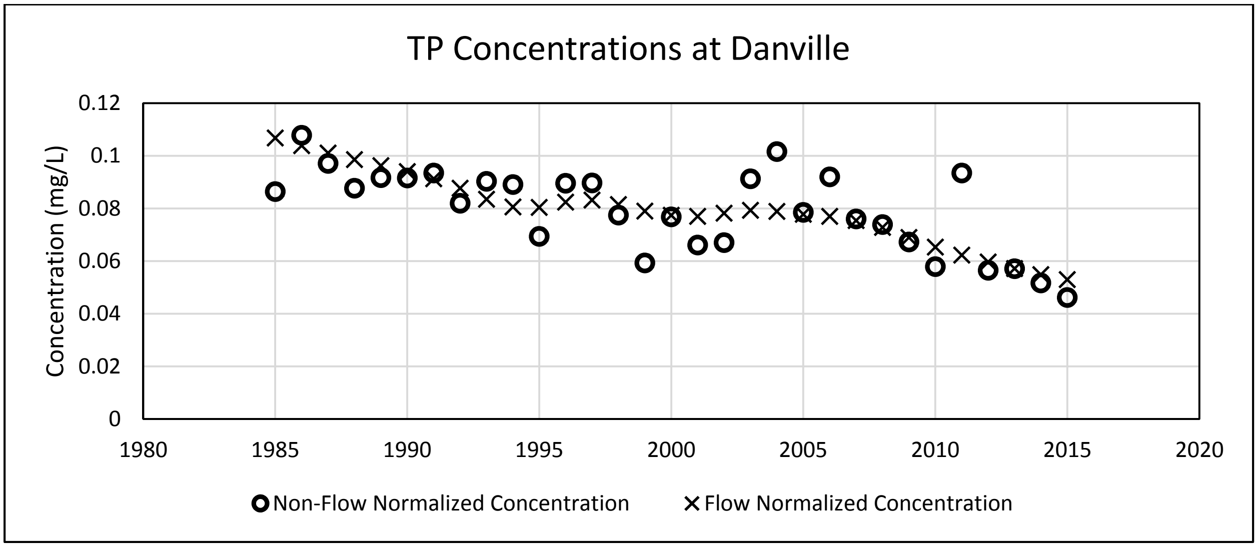


Figure B20. TP Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Danville

Table B19. Monthly TP Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Danville	**Flow**		**Loads**				**Concentrations**			
	2015	**% LTM**	**2015**	**10 Yr Ave**	**2017**	**2025**	**2015**	**10 Yr Ave**	**2017**	**2025**
January	11,429	59%	76	**366**	150	129	0.035	**0.064**	0.055	0.047
February	5,098	31%	19	**191**	150	129	0.024	**0.052**	0.055	0.047
March	14,563	48%	122	**647**	150	129	0.040	**0.078**	0.055	0.047
April	47,377	139%	**988**	**708**	150	129	**0.107**	**0.088**	0.055	0.047
May	10,115	55%	70	**246**	150	129	0.039	**0.068**	0.055	0.047
June	13,937	115%	**148**	**310**	150	129	**0.057**	**0.070**	0.055	0.047
July	18,876	242%	**295**	**192**	150	129	**0.076**	**0.068**	0.055	0.047
August	3,664	60%	21	83	150	129	0.033	**0.060**	0.055	0.047
September	1,865	23%	7	**421**	150	129	0.024	**0.064**	0.055	0.047
October	4,066	40%	23	**218**	150	129	0.029	**0.063**	0.055	0.047
November	9,617	62%	67	**217**	150	129	0.037	**0.061**	0.055	0.047
December	12,336	60%	91	**324**	150	129	0.038	**0.067**	0.055	0.047
Annual#	12,748	77%	**1,927**	**3,924**	1,805	1,549	0.045	**0.067**	0.055	0.047

Table B20. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Danville TP Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										0.099	0.093	0.091
1985	0.089	0.086	0.112	0.126	0.118	0.123	0.121	0.116	0.107	0.098	0.092	0.091
1986	0.088	0.084	0.109	0.120	0.111	0.116	0.116	0.113	0.106	0.097	0.091	0.091
1987	0.087	0.083	0.106	0.116	0.105	0.110	0.111	0.110	0.105	0.096	0.090	0.090
1988	0.087	0.081	0.103	0.112	0.099	0.104	0.107	0.108	0.104	0.095	0.089	0.090
1989	0.086	0.079	0.101	0.108	0.094	0.099	0.103	0.106	0.104	0.094	0.089	0.090
1990	0.086	0.078	0.099	0.104	0.089	0.093	0.099	0.103	0.103	0.093	0.088	0.090
1991	0.086	0.077	0.098	0.101	0.083	0.087	0.092	0.098	0.101	0.092	0.087	0.090
1992	0.085	0.075	0.095	0.096	0.077	0.081	0.086	0.092	0.097	0.089	0.087	0.089
1993	0.082	0.069	0.088	0.089	0.070	0.075	0.081	0.087	0.094	0.087	0.087	0.089
1994	0.078	0.064	0.082	0.083	0.065	0.071	0.078	0.086	0.094	0.089	0.091	0.092
1995	0.079	0.064	0.079	0.080	0.063	0.070	0.077	0.085	0.095	0.094	0.101	0.101
1996	0.085	0.068	0.078	0.079	0.063	0.069	0.075	0.082	0.094	0.098	0.110	0.111
1997	0.090	0.071	0.078	0.077	0.061	0.066	0.071	0.077	0.089	0.096	0.111	0.113
1998	0.092	0.072	0.077	0.076	0.059	0.063	0.066	0.072	0.081	0.090	0.106	0.108
1999	0.090	0.072	0.076	0.075	0.058	0.060	0.064	0.069	0.079	0.086	0.098	0.100
2000	0.086	0.073	0.077	0.077	0.060	0.060	0.064	0.068	0.079	0.082	0.091	0.092
2001	0.083	0.074	0.081	0.080	0.064	0.063	0.066	0.069	0.078	0.080	0.086	0.088
2002	0.082	0.077	0.085	0.086	0.070	0.068	0.069	0.071	0.077	0.077	0.083	0.086
2003	0.081	0.077	0.088	0.092	0.075	0.073	0.072	0.071	0.075	0.074	0.079	0.082
2004	0.078	0.074	0.089	0.095	0.079	0.076	0.074	0.072	0.074	0.072	0.075	0.077
2005	0.073	0.069	0.087	0.096	0.080	0.078	0.076	0.073	0.075	0.070	0.072	0.073
2006	0.069	0.065	0.085	0.097	0.082	0.081	0.079	0.075	0.075	0.068	0.069	0.071
2007	0.066	0.061	0.083	0.096	0.082	0.082	0.079	0.075	0.073	0.067	0.067	0.070
2008	0.064	0.058	0.080	0.093	0.080	0.079	0.076	0.071	0.069	0.063	0.066	0.069
2009	0.062	0.054	0.077	0.091	0.076	0.074	0.069	0.064	0.063	0.059	0.062	0.066
2010	0.059	0.051	0.076	0.089	0.072	0.068	0.063	0.058	0.058	0.056	0.060	0.064
2011	0.058	0.049	0.074	0.088	0.068	0.064	0.058	0.054	0.054	0.053	0.058	0.063
2012	0.056	0.047	0.073	0.086	0.065	0.060	0.054	0.050	0.051	0.050	0.055	0.061
2013	0.055	0.046	0.072	0.084	0.062	0.056	0.050	0.046	0.048	0.048	0.053	0.059
2014	0.054	0.044	0.071	0.083	0.059	0.053	0.046	0.043	0.045	0.045	0.051	0.058
2015	0.053	0.043	0.070	0.082	0.057	0.050	0.043	0.040	0.042	0.043	0.050	0.057
Change	-0.036	-0.044	-0.042	-0.044	-0.061	-0.073	-0.077	-0.075	-0.065	-0.056	-0.043	-0.034

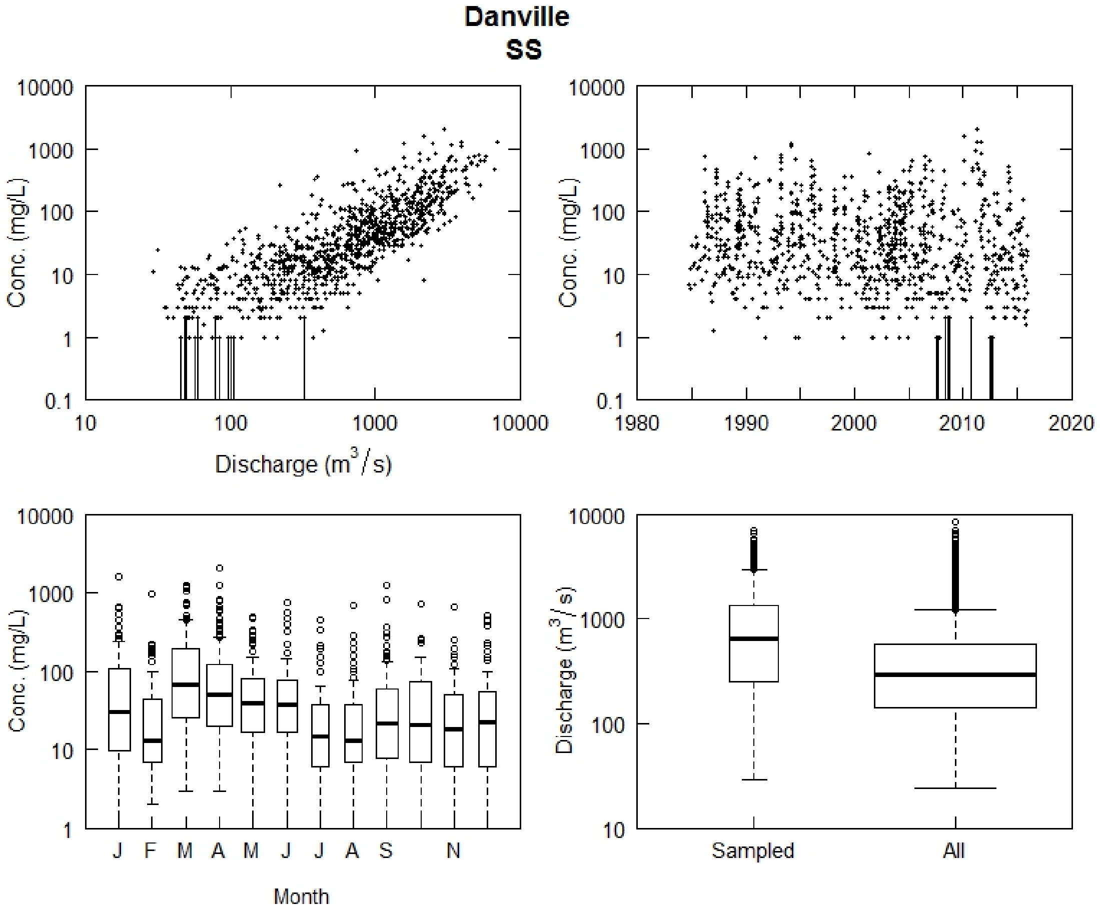


Figure B21.   WRTDS Plots of Historical Sample Data

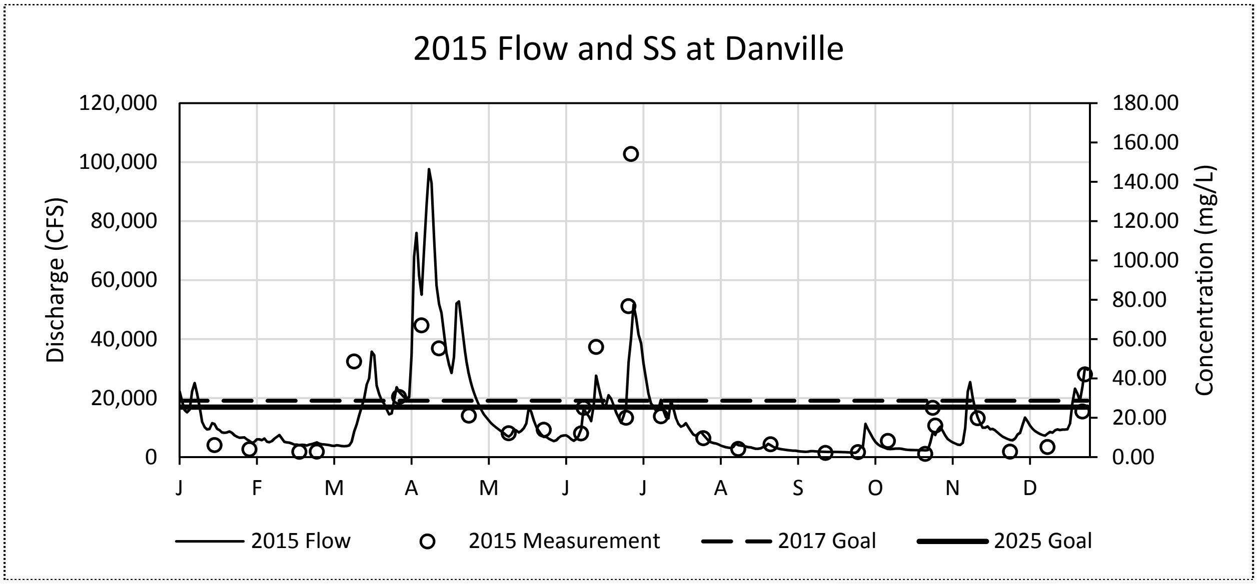


Figure B22.   2015 SS Samples, Daily Average Flow, and Monthly LTM at Towanda

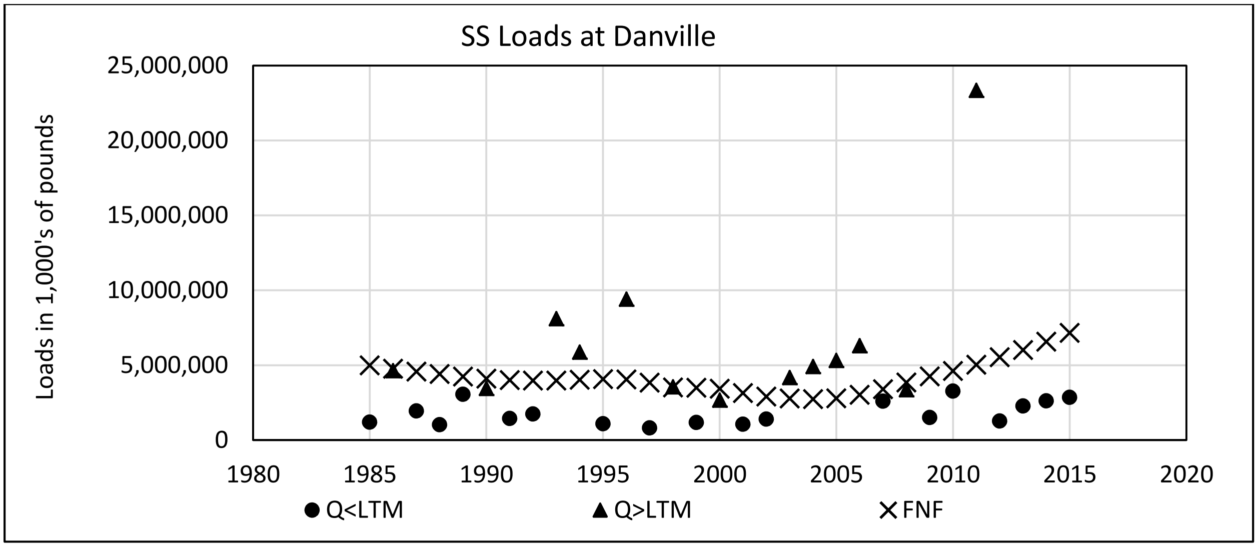


Figure B23. SS Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Danville

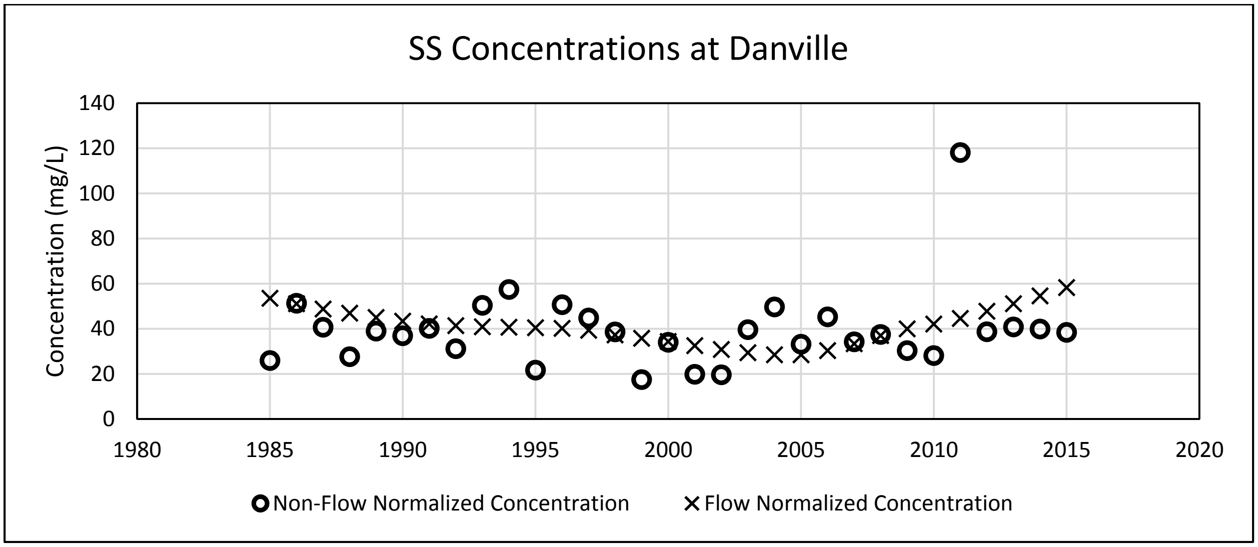


Figure B24. SS Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Danville

Table B21. Monthly SS Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Danville	**Flow**		**Loads**				**Concentrations**			
	2015	**% LTM**	**2015**	**10 Yr Ave**	**2017**	**2025**	**2015**	**10 Yr Ave**	**2017**	**2025**
January	11,429	59%	41,505	**314,671**	78,252	69,544	15.1	**36.2**	29	25
February	5,098	31%	3,203	**142,581**	78,252	69,544	4.0	21.9	29	25
March	14,563	48%	**97,106**	**868,456**	78,252	69,544	**25.5**	**71.5**	29	25
April	47,377	139%	**1,973,558**	**1,038,287**	78,252	69,544	**189.2**	**91.0**	29	25
May	10,115	55%	41,553	**264,436**	78,252	69,544	21.8	**44.2**	29	25
June	13,937	115%	**139,354**	**341,428**	78,252	69,544	**46.3**	**38.7**	29	25
July	18,876	242%	**429,423**	**194,040**	78,252	69,544	**85.1**	**35.4**	29	25
August	3,664	60%	5,801	58,441	78,252	69,544	9.0	20.8	29	25
September	1,865	23%	1,005	**1,053,503**	78,252	69,544	3.3	**49.5**	29	25
October	4,066	40%	7,397	229,848	78,252	69,544	7.0	**37.7**	29	25
November	9,617	62%	45,838	158,714	78,252	69,544	18.9	**29.9**	29	25
December	12,336	60%	65,891	311,734	78,252	69,544	20.8	**46.1**	29	25
Annual#	12,748	77%	**2,851,634**	**4,976,140**	939,019	834,530	**37.2**	**43.6**	29	25

Table B22. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Danville SS Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										40.8	39.1	42.1
1985	44.7	32.4	80.4	101.9	58.6	53.3	46.5	43.7	58.1	38.8	37.6	41.0
1986	43.4	31.4	77.6	97.7	55.7	50.2	43.4	40.7	54.6	36.7	36.1	40.0
1987	42.1	30.6	75.1	93.9	53.2	47.3	40.6	37.9	51.5	34.9	34.8	39.0
1988	40.9	30.5	73.1	90.9	51.2	44.9	38.1	35.3	48.7	33.1	33.5	38.1
1989	40.0	29.3	71.3	87.9	48.9	42.3	35.6	33.0	46.3	31.6	32.4	37.4
1990	39.2	28.9	70.1	85.6	47.0	40.0	33.3	30.9	44.2	30.2	31.3	36.8
1991	38.7	28.8	69.7	83.9	45.4	37.9	31.2	28.9	42.6	28.8	30.3	36.5
1992	38.6	29.9	70.5	83.3	44.6	36.5	29.6	27.3	41.2	27.9	30.3	37.3
1993	38.8	29.8	70.3	81.8	43.4	35.3	28.2	26.0	41.4	27.7	30.9	38.5
1994	39.3	30.1	69.5	79.4	41.8	34.6	27.7	25.7	43.1	28.6	32.6	40.4
1995	40.2	30.2	67.4	75.1	39.2	33.8	27.4	25.7	45.3	30.4	35.4	43.6
1996	41.4	30.6	64.0	69.8	36.4	33.1	26.7	25.4	45.6	32.7	38.8	46.9
1997	42.2	28.9	59.4	64.5	33.3	31.6	25.7	24.7	42.1	33.4	40.0	47.1
1998	40.5	26.3	53.9	59.5	31.1	30.0	24.7	23.8	37.1	32.7	38.6	44.4
1999	37.4	23.8	50.1	56.9	29.5	28.6	24.0	23.4	39.7	32.2	36.4	40.6
2000	34.3	22.2	47.7	55.6	28.6	27.5	23.6	23.3	41.0	31.7	34.0	36.6
2001	31.1	19.9	45.6	53.8	27.7	26.0	23.0	22.9	37.8	30.3	31.2	32.8
2002	28.3	18.5	43.9	52.8	27.6	25.5	22.6	22.0	33.7	27.3	27.7	29.4
2003	26.1	17.5	43.3	53.3	28.4	25.8	22.3	20.8	30.4	24.1	24.6	26.6
2004	24.5	17.2	43.4	55.1	29.9	26.6	22.2	19.8	27.9	22.1	22.9	25.1
2005	23.8	16.6	44.6	58.1	31.8	27.7	22.4	19.6	27.0	21.8	23.1	25.7
2006	24.4	17.2	48.1	64.4	35.6	30.5	24.0	20.5	27.8	23.0	25.1	28.4
2007	26.5	18.3	53.2	73.1	40.9	34.5	26.3	21.8	29.0	24.7	28.3	32.9
2008	30.0	20.4	58.9	82.6	46.9	38.9	28.3	22.5	30.0	26.3	32.1	38.5
2009	34.5	21.6	63.8	89.7	50.1	40.6	28.5	22.2	31.6	28.1	35.3	42.9
2010	38.3	23.3	68.4	94.6	50.7	40.3	27.6	21.7	33.3	30.0	38.5	47.1
2011	42.4	25.1	73.6	100.7	52.2	40.9	27.5	21.6	35.3	32.0	42.0	52.0
2012	46.9	27.8	79.7	108.4	54.7	42.4	28.0	22.0	37.6	34.2	45.9	57.3
2013	51.8	29.2	85.9	115.9	57.0	43.9	28.6	22.4	40.1	36.6	50.1	63.1
2014	57.0	31.3	92.5	124.2	59.5	45.6	29.2	22.8	42.8	39.0	54.4	69.2
2015	62.6	33.5	99.3	132.7	61.9	47.3	29.8	23.1	45.6	41.4	58.9	75.4
Change	17.9	1.1	18.9	30.8	3.3	-6.0	-16.7	-20.5	-12.5	0.7	19.8	33.3

INDIVIDUAL SITES: MARIETTA

Table B23. 2015 Annual and Seasonal Precipitation and Discharge at Marietta

Season	Precipitation (inches)			Discharge (cfs)		
	2015	LTM	LTM Departure	2015	LTM	% LTM
January-March (Winter)	5.89	8.23	-2.34	28,440	53,450	53
April-June (Spring)	14.61	11.48	3.13	50,525	50,182	101
July-September (Summer)	11.45	12.15	-0.70	23,589	18,506	127
October-December (Fall)	9.17	10.10	-0.93	23,605	35,104	67
Annual Total	41.13	41.97	-0.84	31,505	39,213	80

Table B24. 2015 Annual Loads (1000's lbs), Yields (lbs/acre), and Concentrations (mg/L) at Marietta

Parameter	Load	Load % of LTM	Yield	LTM Yield	Ave. Conc.	Conc. % of LTM
TN	75,252	61%	15.08	24.84	1.21	76%
TNO_x	50,724	59%	10.16	17.09	0.82	74%
TON	24,272	68%	4.86	7.12	0.39	85%
TNH_3	2,212	51%	0.44	0.86	0.04	64%
DN	63,799	60%	12.79	21.33	1.03	75%
DNO_x	50,845	60%	10.19	17.04	0.82	74%
DON	11,821	62%	2.37	3.83	0.19	77%
DNH_3	2,003	53%	0.40	0.75	0.03	66%
TP	4,303	54%	0.86	1.61	0.07	67%
DP	1,044	48%	0.21	0.44	0.02	60%
DOP	751	63%	0.15	0.24	0.01	79%
TOC	240,380	93%	48.17	51.87	3.88	116%
SS	2,906,548	47%	582.47	1242.53	46.86	58%

Table B25. 2015 Seasonal Loads (1000's lbs) and Yields (lbs/acre) at Marietta

Parameter	Winter		Spring		Summer		Fall	
	Load	Yield	Load	Yield	Load	Yield	Load	Yield
TN	17,619	3.53	29,782	5.97	13,137	2.63	14,714	2.95
TNO_x	12,726	2.55	19,255	3.86	8,108	1.62	10,635	2.13
TON	4,135	0.83	10,743	2.15	5,438	1.09	3,956	0.79
TNH_3	604	0.12	825	0.17	344	0.07	439	0.09
DN	15,577	3.12	24,074	4.82	10,721	2.15	13,428	2.69
DNO_x	12,726	2.55	19,357	3.88	8,143	1.63	10,619	2.13
DON	2,143	0.43	4,363	0.87	2,729	0.55	2,585	0.52
DNH_3	552	0.11	747	0.15	310	0.06	394	0.08
TP	681	0.14	1,999	0.40	1,012	0.20	611	0.12
DP	175	0.04	372	0.07	257	0.05	239	0.05
DOP	122	0.02	256	0.05	191	0.04	182	0.04
TOC	43,450	8.71	101,108	20.26	55,364	11.09	40,458	8.11
SS	394,662	79.09	1,569,298	314.48	682,514	136.77	260,074	52.12

Table B26. 2015 Monthly Average Precipitation (in), High Daily Precipitation During Month (in), Flow (cfs), Loads (1000's lbs), and Yields (lbs/acre) at Marietta

Mon	Precip			Flow		TN			TP			SS		
	Ave	Max	% LTM	2015	% LTM	Load	Yield	% LTM	Load	Yield	% LTM	Load	Yield	% LTM
Jan	1.95	0.59	70%	23,942	51%	5,164	1.03	36%	142	0.028	17%	50,144	10.0	7%
Feb	1.55	0.52	71%	11,671	28%	2,029	0.41	19%	34	0.007	7%	7,062	1.4	3%
Mar	2.39	0.48	74%	48,084	68%	10,427	2.09	54%	505	0.101	43%	337,456	67.6	34%
Apr	3.96	0.86	114%	92,500	123%	19,643	3.94	104%	1,451	0.291	114%	1,258,697	252.2	113%
May	2.46	0.73	64%	24,703	53%	4,136	0.83	37%	164	0.033	23%	71,531	14.3	14%
Jun	8.19	1.45	196%	35,233	123%	6,003	1.20	98%	384	0.077	87%	239,070	47.9	80%
Jul	5.09	0.72	127%	51,400	266%	10,127	2.03	234%	854	0.171	286%	632,177	126.7	373%
Aug	2.74	1.07	71%	11,979	82%	1,921	0.39	57%	104	0.021	44%	36,084	7.2	25%
Sept	3.62	1.77	85%	6,848	32%	1,089	0.22	19%	53	0.011	7%	14,253	2.9	2%
Oct	3.31	1.25	90%	13,609	57%	2,484	0.50	38%	118	0.024	27%	42,476	8.5	14%
Nov	1.97	1.15	60%	24,093	72%	4,768	0.96	50%	198	0.040	35%	77,029	15.4	20%
Dec	3.90	0.56	125%	33,129	68%	7,462	1.50	51%	296	0.059	36%	140,569	28.2	25%

Table B27. Trend Statistics for the Susquehanna River at Marietta, Pa., October 1986 Through September 2015

Marietta Parameter/code	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
					P-value	Trend	Value	Descriptor	Direction
FLOW / 60	SMK	-	-	-	0.323	NS	-	-	-
TN / 600	FNC	-0.674	-0.024	-37	<0.05	Down	0.99	HL	Down
	FNF	-27.89	-1	-38	<0.05	Down	0.99	HL	Down
TNO_x / 630	FNC	-0.298	-0.011	-27	0.07	Down	0.97	HL	Down
	FNF	-11.90	-0.43	-28	0.058	Down	0.97	HL	Down
TON / 605	FNC	-0.305	-0.011	-46	<0.05	Down	0.99	HL	Down
	FNF	-14.52	-0.52	-49	<0.05	Down	0.99	HL	Down
TNH_3 / 610	FNC	-0.030	-0.0011	-46	<0.05	Down	0.99	HL	Down
	FNF	-1.25	-0.045	-47	<0.05	Down	0.99	HL	Down
DN / 602	FNC	-0.507	-0.018	-33	<0.05	Down	0.99	HL	Down
	FNF	-19.12	-0.68	-33	<0.05	Down	0.99	HL	Down
DNO_x / 631	FNC	-0.293	-0.01	-27	<0.05	Down	0.99	HL	Down
	FNF	-12.18	-0.43	-28	<0.05	Down	0.99	HL	Down
DON / 607	FNC	-0.171	-0.0061	-45	<0.05	Down	0.99	HL	Down
	FNF	-5.88	-0.21	-46	<0.05	Down	0.99	HL	Down
DNH_3 / 608	FNC	-0.030	-0.0011	-49	<0.05	Down	0.99	HL	Down
	FNF	-1.19	-0.042	-48	<0.05	Down	0.99	HL	Down
TP / 665	FNC	-0.041	-0.0015	-42	<0.05	Down	0.99	HL	Down
	FNF	-1.34	-0.048	-30	<0.05	Down	0.99	HL	Down
DP / 666	FNC	-0.021	-0.00073	-54	<0.05	Down	0.99	HL	Down
	FNF	-0.71	-0.025	-53	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	0.005	0.00019	71	0.11	NS	0.95	VL	UP
	FNF	0.23	0.0081	96	<0.05	Up	1.00	HL	UP
TOC / 680	FNC	-0.069	-0.0025	-1.9	0.8	NS	0.61	ALAN	Down
	FNF	2.51	0.09	1.8	0.98	NS	0.51	ALAN	UP
SSC / 80154	FNC	-17.00	-0.61	-35	<0.05	Down	1.00	HL	Down
	FNF	-1405	-50	-35	0.15	NS	0.93	VL	Down

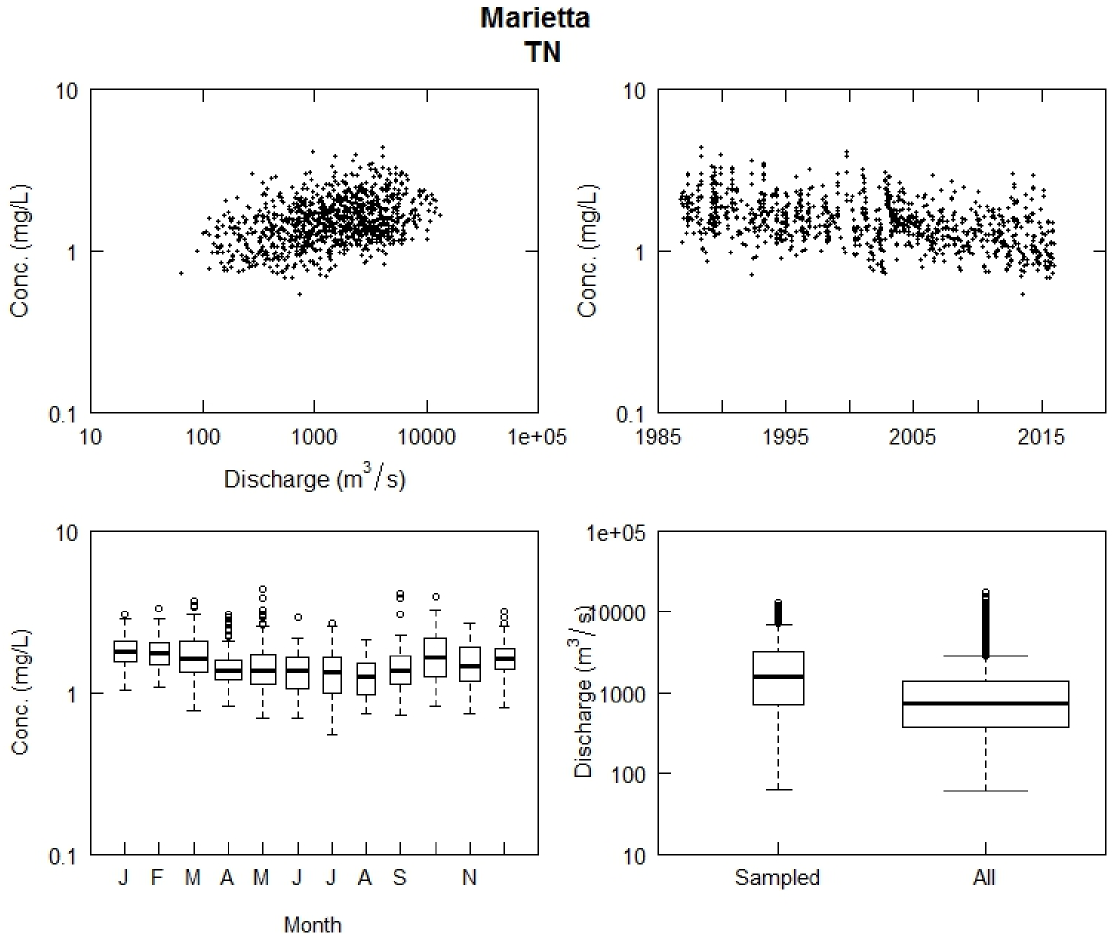


Figure B25. WRTDS Plots of Historical Sample Data

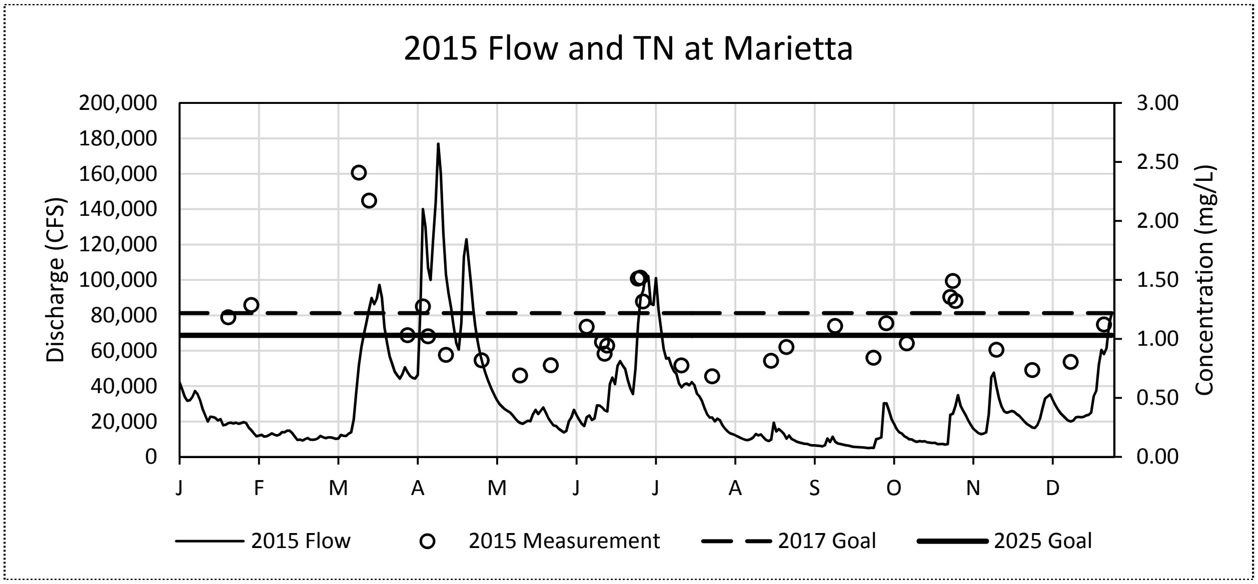


Figure B26. 2015 TN Samples, Daily Average Flow, and Monthly LTM at Marietta

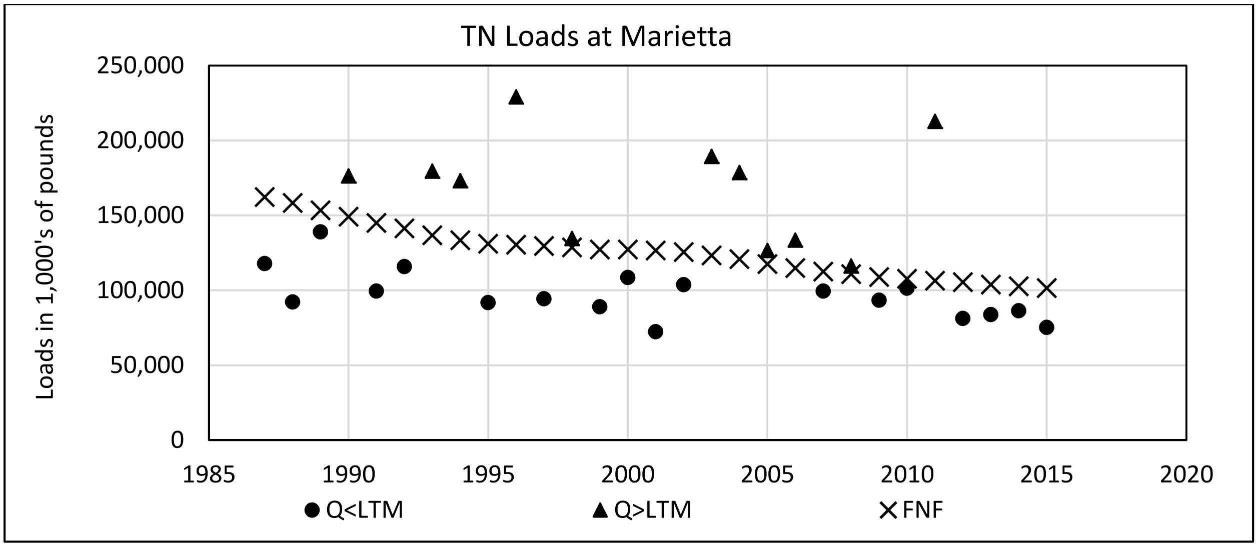


Figure B27. TN Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Marietta

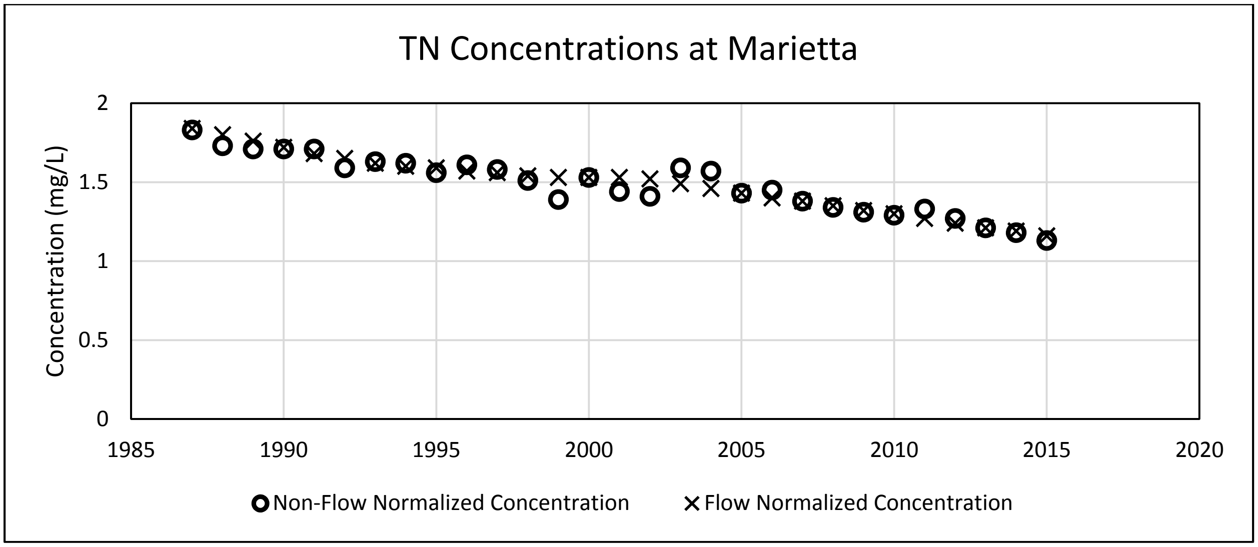


Figure B28. TN Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Marietta

Table B28. Monthly TN Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Marietta	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	23,942	51%	5,164	**14,056**	7,892	6,692	**1.27**	**1.51**	1.22	1.03
February	11,671	28%	2,029	**9,132**	7,892	6,692	**1.15**	**1.42**	1.22	1.03
March	48,084	68%	**10,427**	**17,378**	7,892	6,692	**1.24**	**1.38**	1.22	1.03
April	92,500	123%	**19,643**	**15,287**	7,892	6,692	**1.28**	**1.29**	1.22	1.03
May	24,703	53%	4,136	**9,116**	7,892	6,692	0.99	**1.17**	1.22	1.03
June	35,233	123%	6,003	5,299	7,892	6,692	1.01	**1.09**	1.22	1.03
July	51,400	266%	**10,127**	4,215	7,892	6,692	**1.12**	**1.10**	1.22	1.03
August	11,979	82%	1,921	2,511	7,892	6,692	0.96	**1.11**	1.22	1.03
September	6,848	32%	1,089	5,368	7,892	6,692	0.98	**1.18**	1.22	1.03
October	13,609	57%	2,484	6,446	7,892	6,692	**1.06**	**1.29**	1.22	1.03
November	24,093	72%	4,768	**7,863**	7,892	6,692	**1.20**	**1.40**	1.22	1.03
December	33,129	68%	**7,462**	**13,309**	7,892	6,692	**1.29**	**1.51**	1.22	1.03
Annual#	31,505	80%	75,252	**109,980**	94,702	80,299	**1.13**	**1.29**	1.22	1.03

Table B29. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Marietta TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986										1.77	1.91	2.07
1987	2.02	1.96	2.03	1.96	1.77	1.67	1.65	1.61	1.65	1.73	1.87	2.02
1988	1.99	1.93	1.98	1.91	1.72	1.63	1.60	1.58	1.62	1.69	1.83	1.98
1989	1.95	1.90	1.94	1.86	1.68	1.58	1.56	1.54	1.58	1.65	1.79	1.94
1990	1.91	1.86	1.90	1.81	1.63	1.54	1.52	1.51	1.55	1.62	1.75	1.90
1991	1.88	1.83	1.85	1.76	1.58	1.50	1.49	1.48	1.52	1.59	1.72	1.87
1992	1.85	1.80	1.81	1.71	1.53	1.45	1.45	1.46	1.50	1.57	1.70	1.84
1993	1.84	1.79	1.78	1.66	1.48	1.41	1.42	1.44	1.48	1.54	1.67	1.82
1994	1.83	1.80	1.76	1.61	1.43	1.38	1.41	1.44	1.48	1.54	1.67	1.81
1995	1.84	1.82	1.75	1.58	1.39	1.34	1.39	1.44	1.48	1.55	1.68	1.81
1996	1.84	1.83	1.73	1.53	1.35	1.30	1.37	1.42	1.47	1.57	1.70	1.83
1997	1.84	1.82	1.70	1.49	1.31	1.26	1.33	1.39	1.45	1.58	1.74	1.88
1998	1.85	1.79	1.65	1.45	1.28	1.23	1.29	1.35	1.43	1.58	1.78	1.92
1999	1.87	1.77	1.61	1.41	1.26	1.21	1.26	1.32	1.40	1.58	1.80	1.95
2000	1.88	1.77	1.59	1.41	1.27	1.21	1.25	1.30	1.38	1.58	1.81	1.96
2001	1.88	1.77	1.60	1.42	1.29	1.22	1.24	1.28	1.37	1.56	1.79	1.93
2002	1.85	1.75	1.60	1.43	1.29	1.21	1.22	1.26	1.35	1.53	1.74	1.88
2003	1.81	1.72	1.58	1.43	1.29	1.20	1.20	1.24	1.31	1.48	1.68	1.81
2004	1.75	1.67	1.55	1.41	1.28	1.20	1.19	1.21	1.28	1.43	1.62	1.75
2005	1.70	1.62	1.51	1.40	1.28	1.19	1.18	1.20	1.26	1.39	1.56	1.69
2006	1.64	1.57	1.48	1.38	1.27	1.19	1.18	1.20	1.26	1.37	1.52	1.63
2007	1.60	1.53	1.45	1.35	1.25	1.18	1.18	1.20	1.26	1.36	1.49	1.58
2008	1.56	1.50	1.41	1.32	1.22	1.16	1.16	1.20	1.27	1.35	1.46	1.54
2009	1.52	1.46	1.39	1.30	1.19	1.13	1.14	1.18	1.24	1.32	1.43	1.52
2010	1.49	1.42	1.37	1.29	1.18	1.10	1.10	1.14	1.21	1.29	1.40	1.49
2011	1.45	1.39	1.36	1.28	1.16	1.07	1.07	1.11	1.17	1.25	1.36	1.46
2012	1.42	1.36	1.34	1.26	1.13	1.04	1.04	1.07	1.14	1.22	1.33	1.43
2013	1.39	1.34	1.33	1.25	1.11	1.02	1.01	1.04	1.11	1.19	1.30	1.41
2014	1.37	1.31	1.31	1.24	1.09	0.99	0.98	1.01	1.08	1.16	1.27	1.38
2015	1.34	1.29	1.30	1.22	1.07	0.97	0.95	0.98	1.05	1.13	1.25	1.36
Change	-0.68	-0.67	-0.73	-0.74	-0.70	-0.71	-0.70	-0.63	-0.61	-0.64	-0.66	-0.70

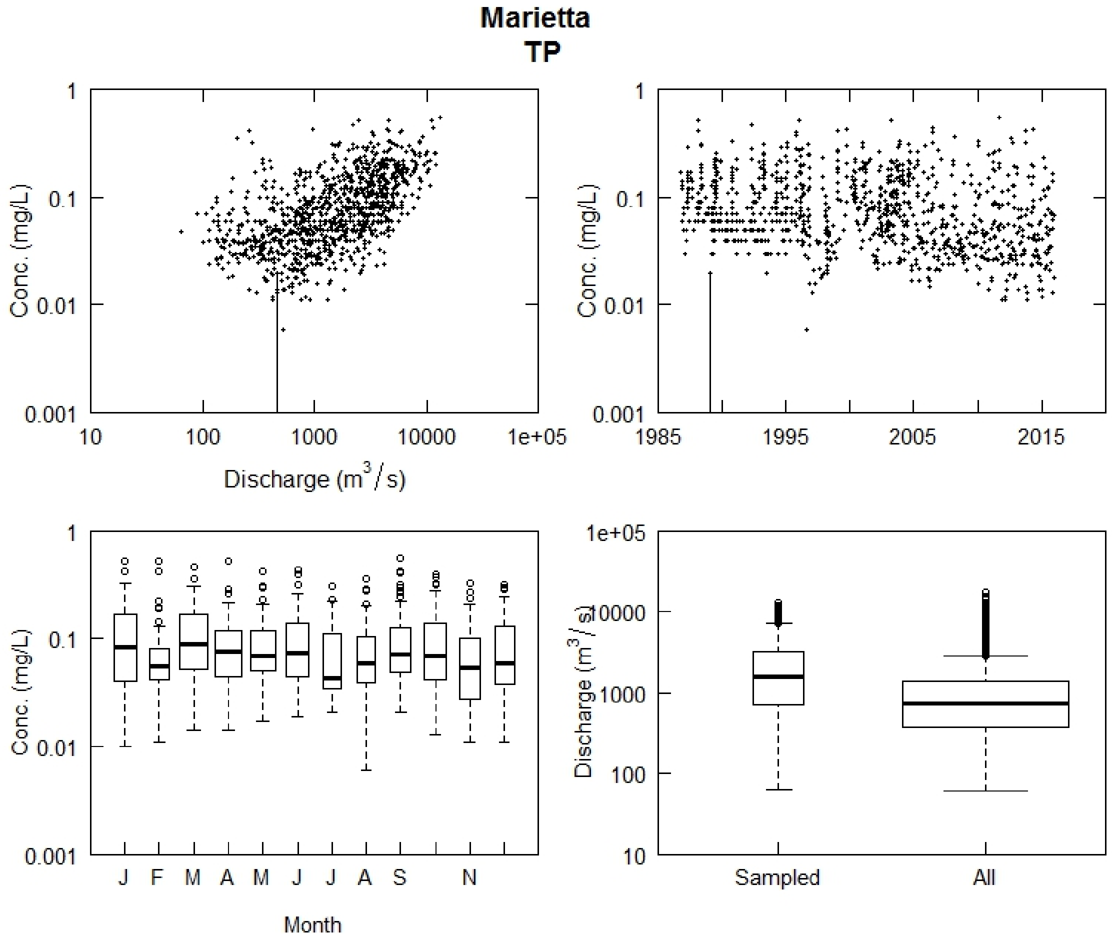


Figure B29. WRTDS Plots of Historical Sample Data

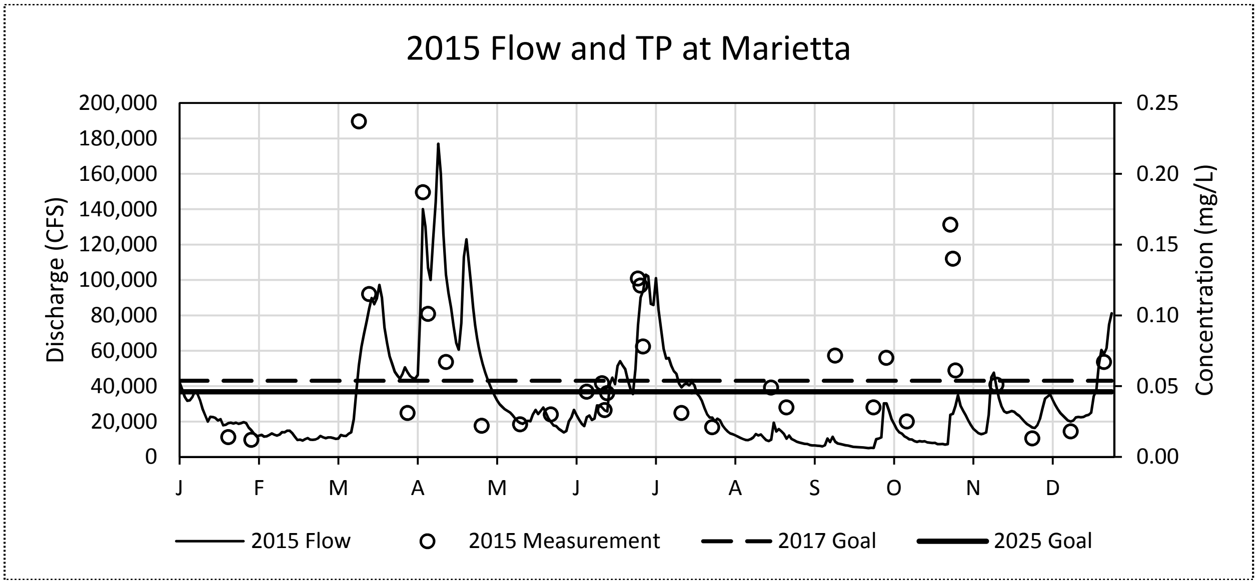


Figure B30. 2015 TP Samples, Daily Average Flow, and Monthly LTM at Marietta

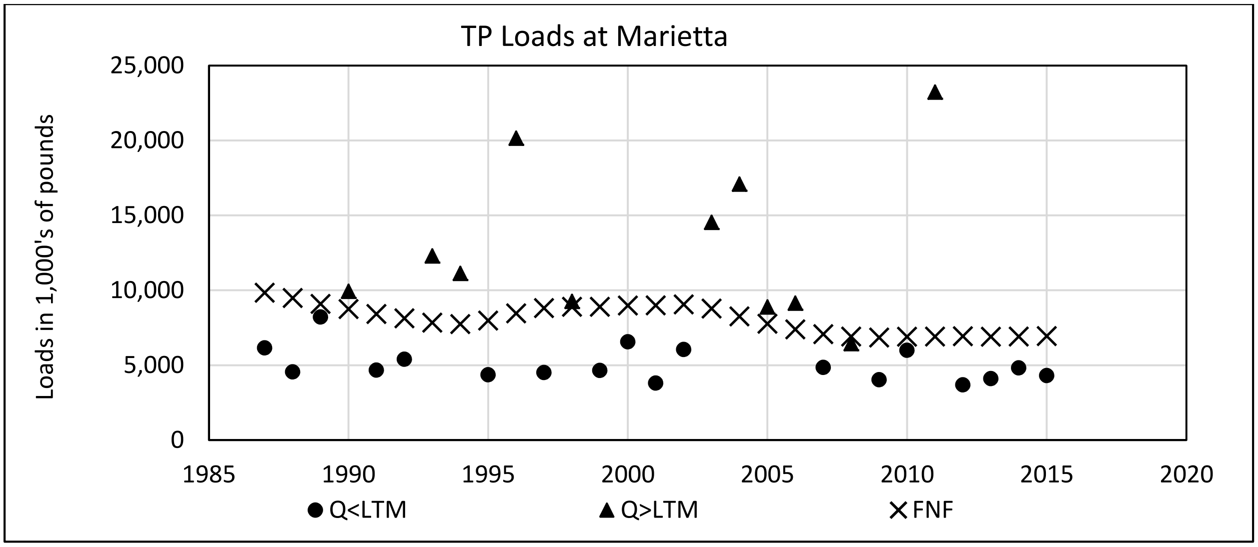


Figure B31.   TP Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Marietta

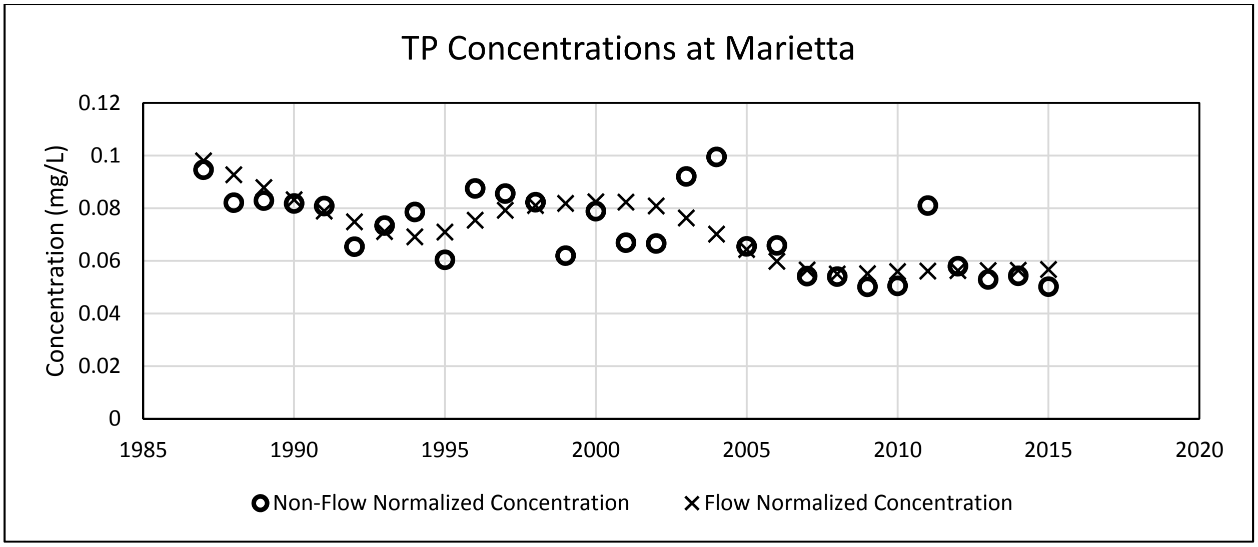


Figure B32.   TP Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Marietta

Table B30. ***Monthly TP Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)***

Marietta	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	23,942	51%	142	**706**	348	299	0.033	**0.053**	0.054	0.046
February	11,671	28%	34	**360**	348	299	0.019	0.040	0.054	0.046
March	48,084	68%	**505**	**1,218**	348	299	**0.049**	**0.064**	0.054	0.046
April	92,500	123%	**1,451**	**1,139**	348	299	**0.087**	**0.068**	0.054	0.046
May	24,703	53%	164	**586**	348	299	0.038	**0.058**	0.054	0.046
June	35,233	123%	**384**	**411**	348	299	**0.057**	**0.054**	0.054	0.046
July	51,400	266%	**854**	**309**	348	299	**0.086**	**0.058**	0.054	0.046
August	11,979	82%	104	138	348	299	**0.052**	**0.054**	0.054	0.046
September	6,848	32%	53	**883**	348	299	**0.048**	**0.064**	0.054	0.046
October	13,609	57%	118	**409**	348	299	**0.047**	**0.059**	0.054	0.046
November	24,093	72%	198	**402**	348	299	**0.048**	**0.053**	0.054	0.046
December	33,129	68%	296	**663**	348	299	**0.047**	**0.058**	0.054	0.046
Annual#	31,505	80%	**4,303**	**7,226**	4,181	3,588	**0.051**	**0.057**	0.054	0.046

Table B31. ***Color Conditioned Heat Chart of Historical Flow Normalized Concentrations***

Marietta TP Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986										0.102	0.090	0.091
1987	0.082	0.072	0.097	0.104	0.099	0.104	0.111	0.111	0.109	0.096	0.087	0.089
1988	0.079	0.069	0.093	0.100	0.093	0.097	0.102	0.103	0.102	0.091	0.084	0.087
1989	0.077	0.067	0.090	0.095	0.087	0.090	0.094	0.095	0.096	0.087	0.081	0.085
1990	0.074	0.064	0.086	0.090	0.082	0.083	0.087	0.088	0.090	0.083	0.078	0.083
1991	0.072	0.062	0.082	0.086	0.077	0.077	0.080	0.081	0.085	0.079	0.076	0.081
1992	0.070	0.059	0.078	0.081	0.072	0.072	0.074	0.075	0.080	0.075	0.074	0.079
1993	0.068	0.057	0.075	0.076	0.067	0.066	0.068	0.069	0.076	0.073	0.073	0.078
1994	0.067	0.056	0.072	0.073	0.064	0.063	0.066	0.068	0.075	0.074	0.075	0.080
1995	0.068	0.057	0.072	0.074	0.066	0.066	0.069	0.070	0.078	0.077	0.081	0.087
1996	0.073	0.061	0.074	0.077	0.071	0.072	0.075	0.075	0.082	0.082	0.088	0.094
1997	0.077	0.064	0.075	0.079	0.074	0.075	0.079	0.078	0.084	0.085	0.092	0.098
1998	0.080	0.065	0.077	0.080	0.075	0.077	0.080	0.078	0.083	0.085	0.092	0.098
1999	0.081	0.067	0.079	0.082	0.076	0.077	0.081	0.079	0.084	0.084	0.090	0.096
2000	0.081	0.069	0.081	0.085	0.078	0.078	0.081	0.079	0.085	0.084	0.088	0.093
2001	0.080	0.069	0.082	0.087	0.079	0.077	0.081	0.080	0.086	0.084	0.086	0.089
2002	0.076	0.066	0.082	0.088	0.079	0.077	0.079	0.077	0.085	0.080	0.080	0.084
2003	0.070	0.061	0.079	0.086	0.076	0.073	0.074	0.072	0.080	0.073	0.072	0.075
2004	0.064	0.055	0.074	0.082	0.072	0.068	0.068	0.065	0.073	0.066	0.064	0.067
2005	0.057	0.048	0.069	0.077	0.067	0.063	0.063	0.060	0.068	0.061	0.059	0.061
2006	0.051	0.043	0.064	0.073	0.063	0.060	0.060	0.057	0.065	0.057	0.054	0.056
2007	0.047	0.039	0.060	0.070	0.061	0.057	0.058	0.056	0.063	0.054	0.051	0.053
2008	0.045	0.037	0.058	0.068	0.059	0.057	0.058	0.057	0.063	0.054	0.051	0.052
2009	0.045	0.037	0.058	0.068	0.059	0.056	0.057	0.058	0.064	0.056	0.052	0.054
2010	0.046	0.039	0.061	0.070	0.059	0.055	0.056	0.057	0.064	0.056	0.053	0.054
2011	0.047	0.040	0.062	0.071	0.059	0.054	0.055	0.057	0.063	0.056	0.053	0.055
2012	0.047	0.041	0.063	0.072	0.059	0.053	0.055	0.056	0.063	0.056	0.054	0.056
2013	0.048	0.042	0.064	0.072	0.058	0.052	0.054	0.056	0.062	0.056	0.054	0.056
2014	0.049	0.043	0.065	0.072	0.058	0.052	0.053	0.056	0.062	0.056	0.054	0.057
2015	0.050	0.044	0.066	0.073	0.058	0.051	0.053	0.055	0.062	0.057	0.055	0.058
Change	-0.032	-0.028	-0.032	-0.031	-0.040	-0.053	-0.059	-0.056	-0.048	-0.045	-0.035	-0.033

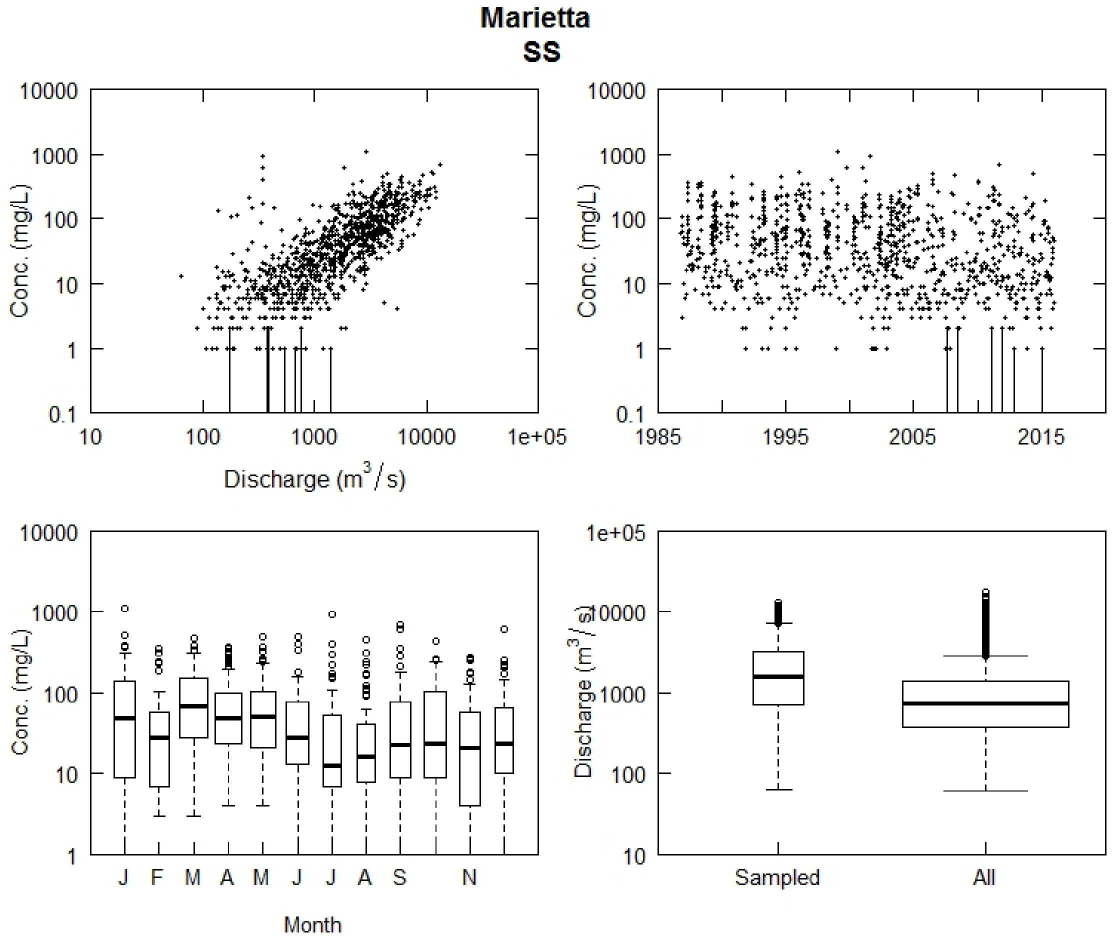


Figure B33. WRTDS Plots of Historical Sample Data

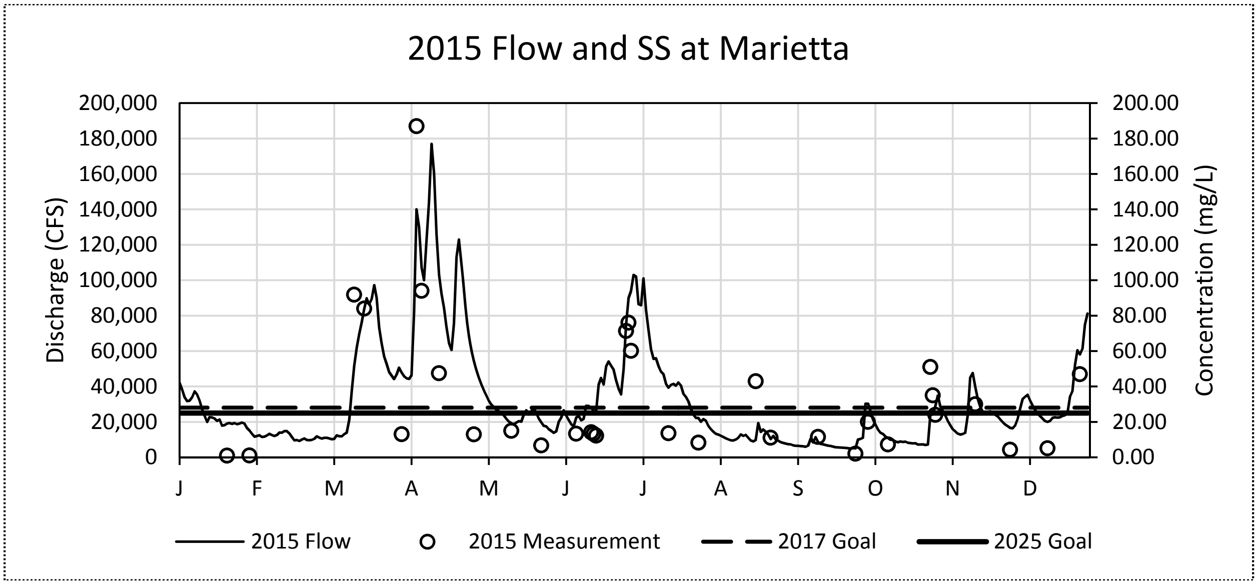


Figure B34. 2015 SS Samples, Daily Average Flow, and Monthly LTM at Marietta

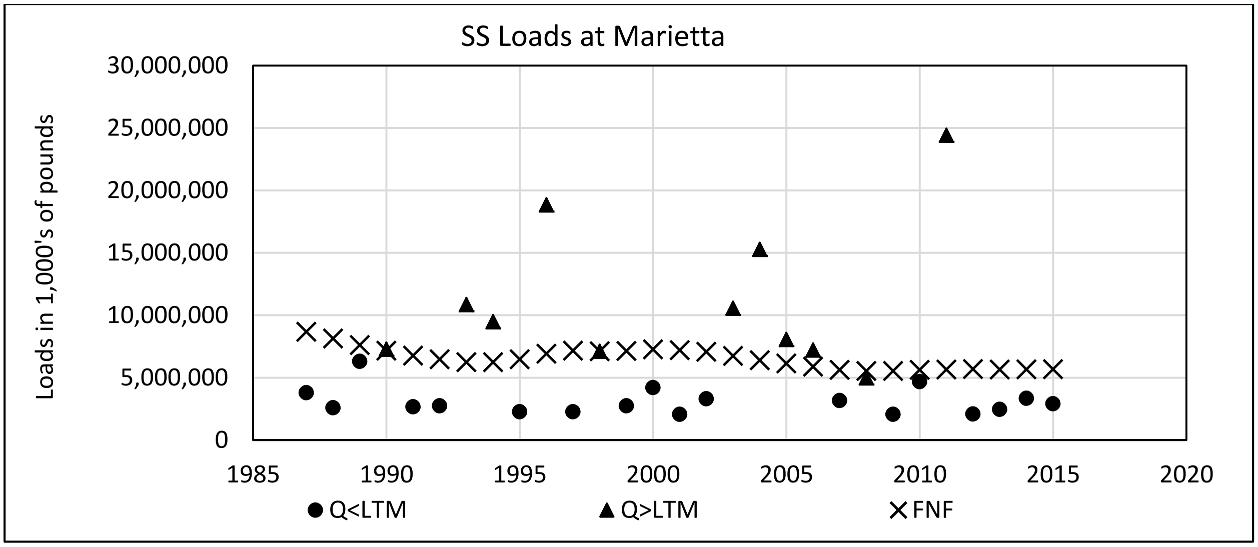


Figure B35. SS Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Marietta

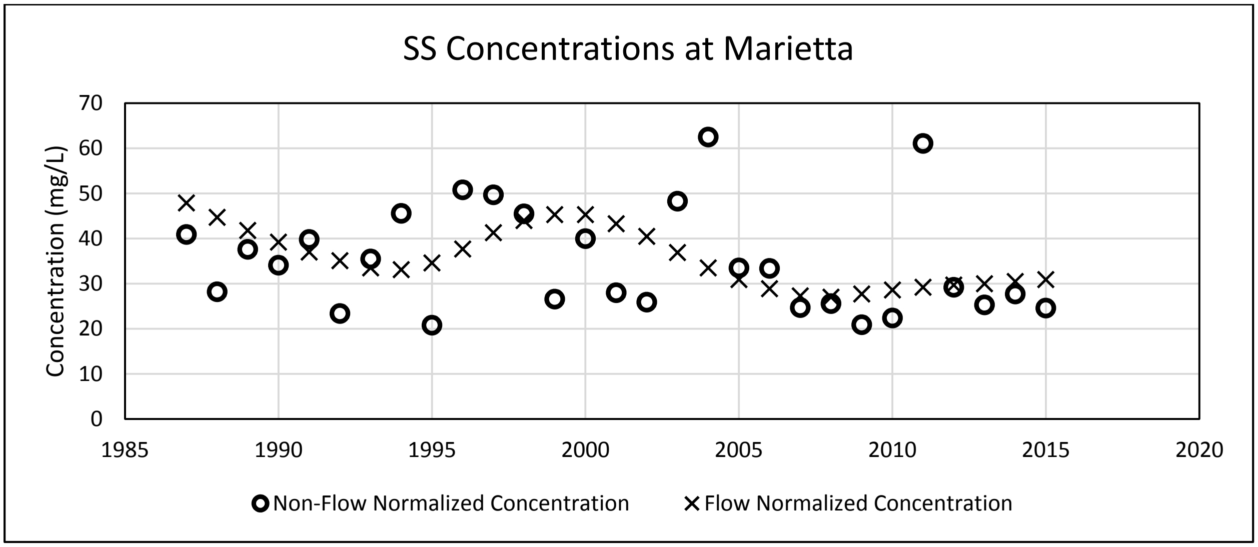


Figure B36. SS Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Marietta

Figure B32. Monthly SS Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Marietta	**Flow**		**Loads**				**Concentrations**			
	2015	**% LTM**	**2015**	**10 Yr Ave**	**2017**	**2025**	**2015**	**10 Yr Ave**	**2017**	**2025**
January	23,942	51%	50,144	**523,171**	181,262	161,092	11.0	**28.9**	28	25
February	11,671	28%	7,062	**227,985**	181,262	161,092	3.9	18.9	28	25
March	48,084	68%	**337,456**	**1,175,450**	181,262	161,092	**29.3**	**46.2**	28	25
April	92,500	123%	**1,258,697**	**1,073,370**	181,262	161,092	**70.9**	**49.0**	28	25
May	24,703	53%	71,531	**441,837**	181,262	161,092	16.0	**33.5**	28	25
June	35,233	123%	**239,070**	**333,961**	181,262	161,092	**32.0**	**25.5**	28	25
July	51,400	266%	**632,177**	**201,182**	181,262	161,092	**57.6**	23.9	28	25
August	11,979	82%	36,084	53,928	181,262	161,092	17.5	16.9	28	25
September	6,848	32%	14,253	**966,687**	181,262	161,092	12.5	**30.5**	28	25
October	13,609	57%	42,476	**256,199**	181,262	161,092	15.1	**25.1**	28	25
November	24,093	72%	77,029	**247,121**	181,262	161,092	17.6	22.7	28	25
December	33,129	68%	140,569	**443,825**	181,262	161,092	19.6	**29.7**	28	25
Annual#	31,505	80%	**2,906,548**	**5,944,718**	2,175,143	1,933,105	**25.3**	**29.2**	28	25

Table B33. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Marietta SS Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986										39.3	40.7	50.4
1987	45.6	33.0	70.5	81.0	56.8	43.5	37.2	32.2	43.9	36.9	38.0	47.1
1988	42.1	31.1	65.6	75.5	53.3	40.7	34.6	29.8	41.8	34.7	35.6	44.0
1989	38.9	28.6	60.9	70.2	49.8	37.9	32.1	27.8	40.1	32.9	33.5	41.4
1990	36.2	26.8	56.7	65.6	46.6	35.5	30.1	26.1	38.7	31.4	31.7	39.1
1991	33.7	25.1	53.0	61.3	43.8	33.4	28.3	24.7	37.7	30.1	30.2	37.0
1992	31.5	23.9	49.6	57.5	41.3	31.7	26.9	23.6	37.3	29.0	28.7	34.9
1993	29.3	22.1	46.2	53.9	39.2	30.4	26.1	23.1	38.2	28.5	27.5	33.0
1994	27.1	20.4	43.1	51.3	38.6	31.8	28.5	25.6	41.5	30.3	28.9	34.0
1995	27.5	20.5	41.9	50.1	39.1	34.3	32.3	29.4	45.8	34.2	33.1	38.4
1996	30.7	23.1	43.4	50.6	40.1	36.9	36.6	34.3	51.1	40.1	39.3	44.9
1997	35.6	25.9	45.6	51.1	40.5	38.7	40.7	38.9	53.8	44.3	44.0	49.9
1998	39.7	28.7	47.6	52.1	41.3	40.7	43.9	41.9	53.0	44.5	44.9	51.0
1999	41.7	30.8	49.7	54.3	42.7	42.4	45.6	43.0	52.5	43.8	44.0	50.1
2000	42.2	32.0	51.7	57.0	43.8	42.4	44.2	40.7	50.8	41.9	42.2	48.2
2001	41.0	31.0	51.9	57.5	43.0	39.6	39.5	35.7	47.7	39.1	39.5	45.5
2002	38.6	29.0	51.0	57.2	41.5	35.9	33.9	30.0	43.8	35.1	35.6	41.8
2003	35.7	26.4	49.6	56.2	39.3	31.8	28.5	24.7	37.9	30.0	30.9	37.2
2004	32.7	24.1	47.5	54.7	37.1	28.8	24.5	21.0	33.3	26.3	27.2	33.1
2005	29.6	21.3	44.9	52.9	35.6	26.6	22.0	18.9	31.6	24.3	24.7	29.9
2006	26.8	18.8	42.4	51.2	34.4	25.3	20.7	17.8	29.9	22.3	22.2	27.0
2007	24.5	16.8	40.0	49.2	33.4	24.8	20.4	17.6	28.5	21.0	21.0	25.7
2008	23.8	16.6	39.3	48.7	33.6	25.5	21.4	18.5	28.3	21.2	21.2	26.1
2009	24.5	17.4	40.5	49.9	34.6	26.2	22.1	19.3	28.5	22.2	22.3	27.3
2010	25.6	19.1	43.0	52.3	35.6	26.3	21.9	19.4	28.2	22.7	23.1	28.3
2011	26.4	20.1	44.5	53.8	36.1	26.3	21.8	19.5	28.0	22.9	23.5	29.0
2012	27.0	21.1	45.7	54.9	36.6	26.5	22.0	19.6	27.7	23.1	23.8	29.4
2013	27.4	21.6	46.5	55.5	36.8	26.5	22.1	19.9	27.7	23.3	24.1	29.8
2014	27.9	22.3	47.5	56.3	37.2	26.6	22.3	20.1	27.6	23.4	24.4	30.3
2015	28.4	23.2	48.6	57.4	37.7	26.8	22.5	20.4	27.5	23.6	24.8	31.0
Change	-17.2	-9.8	-21.9	-23.6	-19.2	-16.6	-14.8	-11.8	-16.4	-15.7	-15.9	-19.4

INDIVIDUAL SITES: LEWISBURG

Table B34. 2015 Annual and Seasonal Precipitation and Discharge at Lewisburg

Season	Precipitation (inches)			Discharge (cfs)		
	2015	LTM	LTM Departure	2015	LTM	% LTM
January-March (Winter)	5.78	8.32	-2.55	8,606	15,027	57
April-June (Spring)	15.19	11.31	3.88	14,964	13,233	113
July-September (Summer)	12.55	12.30	0.25	7,509	5,085	148
October-December (Fall)	9.57	9.97	-0.40	9,033	10,029	90
Annual Total	43.08	41.90	1.18	10,022	10,817	93

Table B35. 2015 Annual Loads (1000's lbs), Yields (lbs/acre), and Concentrations (mg/L) at Lewisburg

Parameter	Load	Load % of LTM	Yield	LTM Yield	Ave. Conc.	Conc. % of LTM
TN	14,468	65%	2.90	4.47	0.73	70%
TNO_x	9,849	69%	1.97	2.84	0.50	75%
TON	4,286	57%	0.86	1.50	0.22	62%
TNH_3	525	55%	0.11	0.19	0.03	59%
DN	12,684	65%	2.54	3.88	0.64	71%
DNO_x	9,860	69%	1.98	2.86	0.50	75%
DON	2,400	51%	0.48	0.94	0.12	55%
DNH_3	501	60%	0.10	0.17	0.03	64%
TP	554	44%	0.11	0.25	0.03	48%
DP	120	28%	0.02	0.09	0.01	30%
DOP	100	47%	0.02	0.04	0.01	51%
TOC	42,414	90%	8.50	9.43	2.15	97%
SS	513,053	42%	102.81	247.17	26.00	45%

Table B36. 2015 Seasonal Loads (1000's lbs) and Yields (lbs/acres) at Lewisburg

Parameter	Winter		Spring		Summer		Fall	
	Load	Yield	Load	Yield	Load	Yield	Load	Yield
TN	3,266	0.65	5,206	1.04	2,621	0.53	3,376	0.68
TNO_x	2,461	0.49	3,431	0.69	1,659	0.33	2,299	0.46
TON	673	0.13	1,709	0.34	947	0.19	956	0.19
TNH_3	126	0.03	183	0.04	96	0.02	120	0.02
DN	2,975	0.60	4,427	0.89	2,276	0.46	3,007	0.60
DNO_x	2,461	0.49	3,438	0.69	1,657	0.33	2,305	0.46
DON	409	0.08	863	0.17	577	0.12	551	0.11
DNH_3	123	0.02	173	0.03	88	0.02	117	0.02
TP	89	0.02	245	0.05	124	0.02	97	0.02
DP	21	0.00	45	0.01	30	0.01	24	0.00
DOP	19	0.00	36	0.01	23	0.00	22	0.00
TOC	6,672	1.34	16,390	3.28	10,162	2.04	9,190	1.84
SS	76,884	15.41	261,935	52.49	106,951	21.43	67,282	13.48

Table B37. 2015 Monthly Average Precipitation (in), High Daily Precipitation During Month (in), Flow (cfs), Loads (1000's lbs), and Yields (lbs/acre) at Lewisburg

Mon	Precip			Flow		TN			TP			SS		
	Ave	Max	% LTM	2014	% LTM	Load	Yield	% LTM	Load	Yield	% LTM	Load	Yield	% LTM
Jan	2.10	0.63	73%	6,009	46%	784	0.16	30%	11	0.002	8%	4,093	0.8	2%
Feb	1.33	0.61	61%	2,990	25%	363	0.07	17%	3	0.001	4%	786	0.2	1%
Mar	2.35	0.65	72%	16,275	82%	2,120	0.42	58%	74	0.015	36%	72,005	14.4	30%
Apr	4.80	0.95	139%	29,000	147%	3,545	0.71	108%	189	0.038	91%	220,912	44.3	86%
May	2.03	0.68	54%	6,138	49%	617	0.12	33%	13	0.003	12%	6,394	1.3	8%
Jun	8.36	1.56	204%	10,049	134%	1,044	0.21	97%	43	0.009	76%	34,629	6.9	129%
Jul	5.77	0.92	142%	17,296	333%	2,076	0.42	254%	111	0.022	243%	101,830	20.4	456%
Aug	3.11	1.48	78%	3,420	79%	375	0.08	54%	9	0.002	23%	4,222	0.8	15%
Sept	3.66	1.53	87%	1,621	28%	170	0.03	18%	3	0.001	3%	899	0.2	1%
Oct	3.49	1.25	101%	5,472	83%	647	0.13	59%	21	0.004	35%	14,914	3.0	39%
Nov	2.02	1.20	60%	8,817	88%	1,034	0.21	60%	28	0.006	31%	17,199	3.4	27%
Dec	4.06	0.56	129%	12,802	95%	1,695	0.34	69%	48	0.010	41%	35,170	7.0	41%

Table B38. Trend Statistics for the West Branch Susquehanna River at Lewisburg, Pa., October 1984 Through September 2015

Lewisburg	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
FLOW / 60	SMK	-	-	-	0.866	NS	-	-	-
TN / 600	FNC	-0.590	-0.02	-45	<0.05	Down	0.99	HL	Down
	FNF	-5.42	-0.18	-42	<0.05	Down	0.99	HL	Down
TNO$_x$ / 630	FNC	-0.224	-0.0075	-31	<0.05	Down	0.99	HL	Down
	FNF	-1.70	-0.056	-26	<0.05	Down	0.99	HL	Down
TON / 605	FNC	-0.358	-0.012	-66	<0.05	Down	0.99	HL	Down
	FNF	-3.76	-0.13	-59	0.059	Down	0.97	HL	Down
TNH$_3$ / 610	FNC	-0.033	-0.0011	-57	<0.05	Down	0.99	HL	Down
	FNF	-0.26	-0.0087	-49	<0.05	Down	0.99	HL	Down
DN / 602	FNC	-0.444	-0.015	-40	<0.05	Down	0.99	HL	Down
	FNF	-4.11	-0.14	-39	<0.05	Down	0.99	HL	Down
DNO$_x$ / 631	FNC	-0.230	-0.0077	-31	<0.05	Down	0.99	HL	Down
	FNF	-1.84	-0.061	-27	<0.05	Down	0.99	HL	Down
DON / 607	FNC	-0.231	-0.0077	-64	<0.05	Down	0.99	HL	Down
	FNF	-2.37	-0.079	-65	<0.05	Down	0.99	HL	Down
DNH$_3$ / 608	FNC	-0.025	-0.00084	-50	<0.05	Down	0.99	HL	Down
	FNF	-0.21	-0.007	-45	<0.05	Down	0.99	HL	Down
TP / 665	FNC	-0.041	-0.0014	-67	<0.025	Down	0.99	HL	Down
	FNF	-0.24	-0.0081	-40	0.057	Down	0.97	HL	Down
DP / 666	FNC	-0.030	-0.001	-83	<0.05	Down	0.99	HL	Down
	FNF	-0.26	-0.0087	-82	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.010	-0.00033	-65	<0.05	Down	0.99	HL	Down
	FNF	-0.03	-0.0012	-42	0.1	NS	0.95	VL	Down
TOC / 680	FNC	-0.498	-0.017	-22	<0.05	Down	0.99	HL	Down
	FNF	-0.07	-0.0023	-0.3	1.0	NS	0.51	ALAN	Down
SSC / 80154	FNC	-5.440	-0.18	-27	0.21	NS	0.89	L	Down
	FNF	-82.0	-2.7	-16	0.69	NS	0.66	L	Down

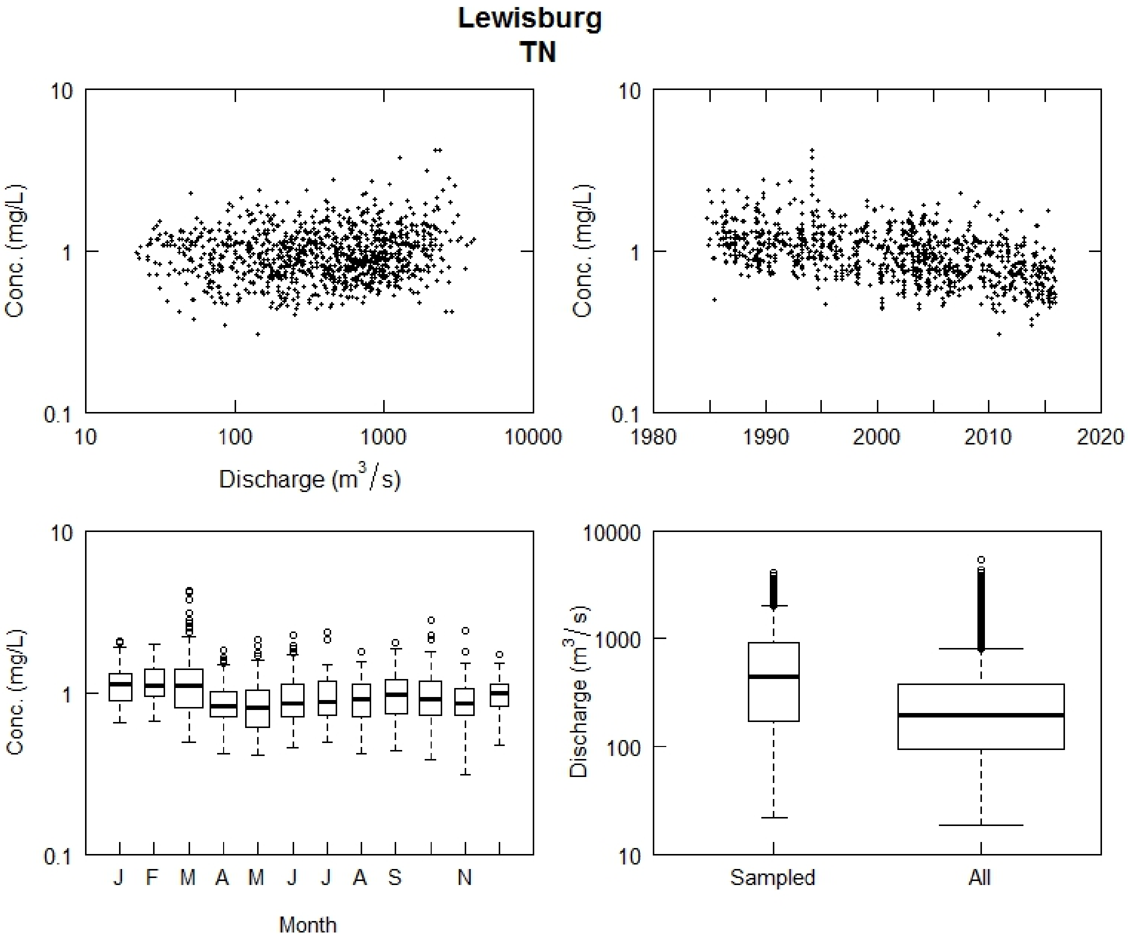


Figure B37. WRTDS Plots of Historical Sample Data

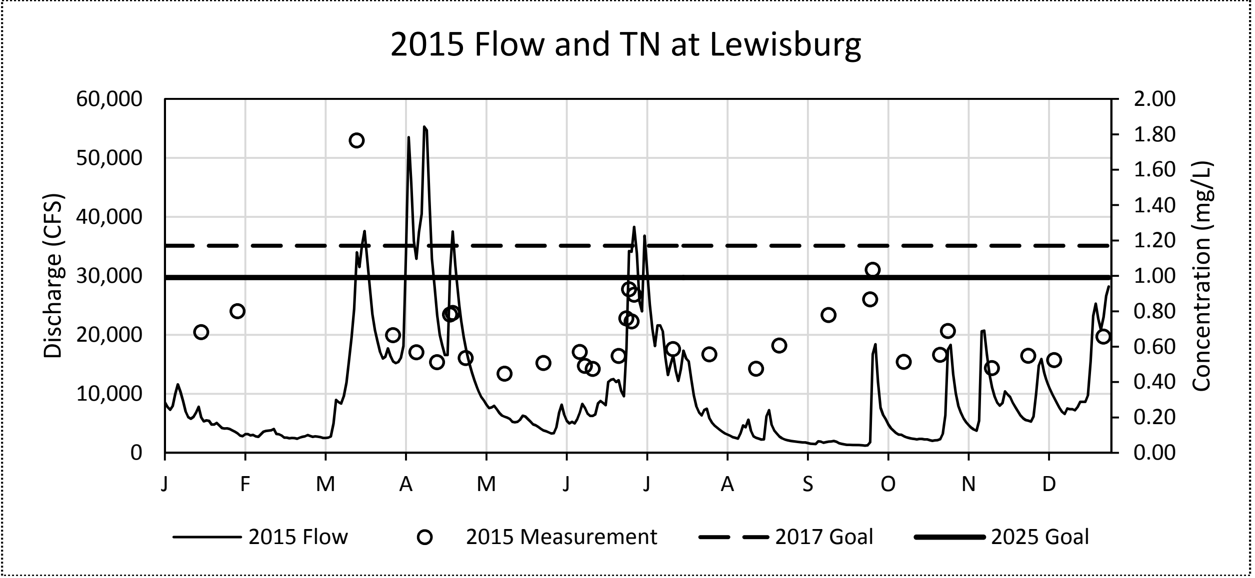


Figure B38. 2015 TN Samples, Daily Average Flow, and Monthly LTM at Lewisburg

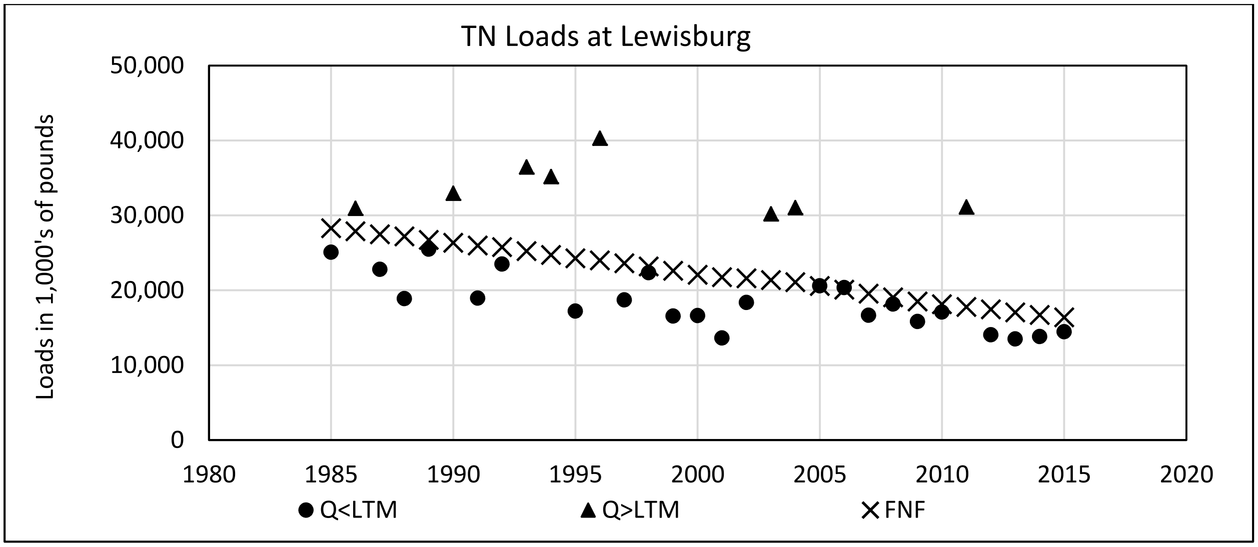


Figure B39. ***TN Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Lewisburg***

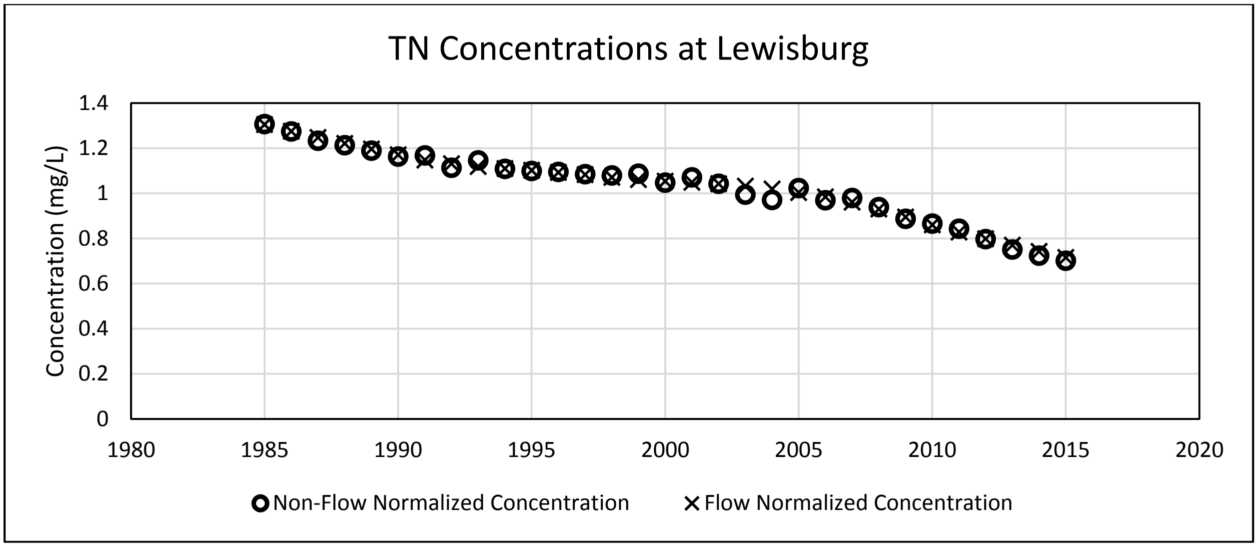


Figure B40. ***TN Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Lewisburg***

Table B39. Monthly TN Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Lewisburg	**Flow**		**Loads**				**Concentrations**			
	2015	**% LTM**	**2015**	**10 Yr Ave**	**2017**	**2025**	**2015**	**10 Yr Ave**	**2017**	**2025**
January	6,009	46%	784	**2,452**	2,079	1,763	0.78	0.97	1.17	0.99
February	2,990	25%	363	1,650	2,079	1,763	0.81	0.98	1.17	0.99
March	16,275	82%	**2,120**	**3,036**	2,079	1,763	0.77	0.90	1.17	0.99
April	29,000	147%	**3,545**	**2,343**	2,079	1,763	0.73	0.81	1.17	0.99
May	6,138	49%	617	1,499	2,079	1,763	0.60	0.75	1.17	0.99
June	10,049	134%	1,044	775	2,079	1,763	0.61	0.78	1.17	0.99
July	17,296	333%	**2,076**	670	2,079	1,763	0.70	0.85	1.17	0.99
August	3,420	79%	375	441	2,079	1,763	0.65	0.85	1.17	0.99
September	1,621	28%	170	659	2,079	1,763	0.65	0.82	1.17	0.99
October	5,472	83%	647	938	2,079	1,763	0.65	0.82	1.17	0.99
November	8,817	88%	1,034	1,164	2,079	1,763	0.70	0.84	1.17	0.99
December	12,802	95%	1,695	**2,163**	2,079	1,763	0.76	0.91	1.17	0.99
Annual#	10,022	93%	14,468	17,789	24,949	21,155	0.70	0.86	1.17	0.99

Table B40. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Lewisburg TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										1.36	1.36	1.37
1985	1.43	1.39	1.34	1.25	1.17	1.18	1.24	1.28	1.31	1.31	1.32	1.35
1986	1.40	1.37	1.33	1.23	1.15	1.15	1.20	1.24	1.27	1.27	1.29	1.32
1987	1.37	1.34	1.31	1.22	1.12	1.12	1.16	1.20	1.23	1.24	1.25	1.30
1988	1.35	1.32	1.30	1.21	1.10	1.09	1.13	1.17	1.19	1.20	1.22	1.27
1989	1.32	1.30	1.29	1.20	1.08	1.07	1.10	1.14	1.16	1.16	1.19	1.25
1990	1.30	1.28	1.28	1.18	1.06	1.04	1.08	1.11	1.13	1.13	1.16	1.22
1991	1.27	1.26	1.27	1.17	1.04	1.00	1.05	1.09	1.11	1.11	1.14	1.20
1992	1.25	1.26	1.26	1.15	1.01	0.98	1.03	1.08	1.10	1.10	1.13	1.18
1993	1.24	1.24	1.24	1.13	0.99	0.97	1.03	1.08	1.09	1.09	1.12	1.17
1994	1.23	1.23	1.22	1.09	0.97	0.97	1.04	1.09	1.10	1.09	1.11	1.16
1995	1.22	1.23	1.19	1.07	0.95	0.96	1.05	1.10	1.10	1.09	1.11	1.15
1996	1.22	1.22	1.16	1.03	0.93	0.95	1.05	1.11	1.11	1.10	1.11	1.16
1997	1.22	1.21	1.13	0.99	0.90	0.93	1.04	1.11	1.11	1.10	1.13	1.18
1998	1.22	1.19	1.09	0.95	0.87	0.91	1.03	1.10	1.09	1.09	1.13	1.20
1999	1.23	1.18	1.06	0.92	0.85	0.90	1.02	1.08	1.07	1.07	1.12	1.20
2000	1.23	1.18	1.04	0.91	0.86	0.91	1.01	1.07	1.05	1.05	1.10	1.18
2001	1.24	1.20	1.06	0.92	0.87	0.92	1.01	1.04	1.02	1.02	1.07	1.16
2002	1.24	1.21	1.07	0.93	0.88	0.92	1.00	1.02	0.99	0.99	1.05	1.14
2003	1.23	1.22	1.07	0.94	0.88	0.92	0.99	1.00	0.97	0.98	1.03	1.12
2004	1.22	1.21	1.06	0.93	0.88	0.91	0.97	0.98	0.95	0.96	1.01	1.10
2005	1.20	1.19	1.04	0.92	0.86	0.90	0.96	0.97	0.94	0.95	1.00	1.08
2006	1.18	1.17	1.02	0.89	0.84	0.88	0.94	0.95	0.93	0.93	0.98	1.05
2007	1.14	1.13	0.98	0.86	0.82	0.86	0.93	0.94	0.91	0.92	0.95	1.01
2008	1.09	1.08	0.94	0.83	0.79	0.83	0.91	0.92	0.90	0.89	0.92	0.97
2009	1.03	1.02	0.90	0.80	0.76	0.80	0.88	0.90	0.87	0.85	0.88	0.93
2010	0.98	0.97	0.88	0.78	0.73	0.77	0.85	0.86	0.84	0.82	0.85	0.90
2011	0.94	0.93	0.85	0.76	0.71	0.74	0.81	0.83	0.81	0.79	0.82	0.87
2012	0.91	0.89	0.82	0.74	0.68	0.71	0.78	0.80	0.78	0.76	0.79	0.84
2013	0.87	0.85	0.80	0.72	0.66	0.68	0.75	0.76	0.75	0.73	0.76	0.82
2014	0.84	0.82	0.78	0.70	0.64	0.66	0.72	0.73	0.72	0.69	0.73	0.79
2015	0.81	0.79	0.76	0.69	0.62	0.63	0.68	0.70	0.68	0.66	0.71	0.77
Change	-0.62	-0.60	-0.58	-0.56	-0.55	-0.55	-0.55	-0.58	-0.62	-0.69	-0.65	-0.60

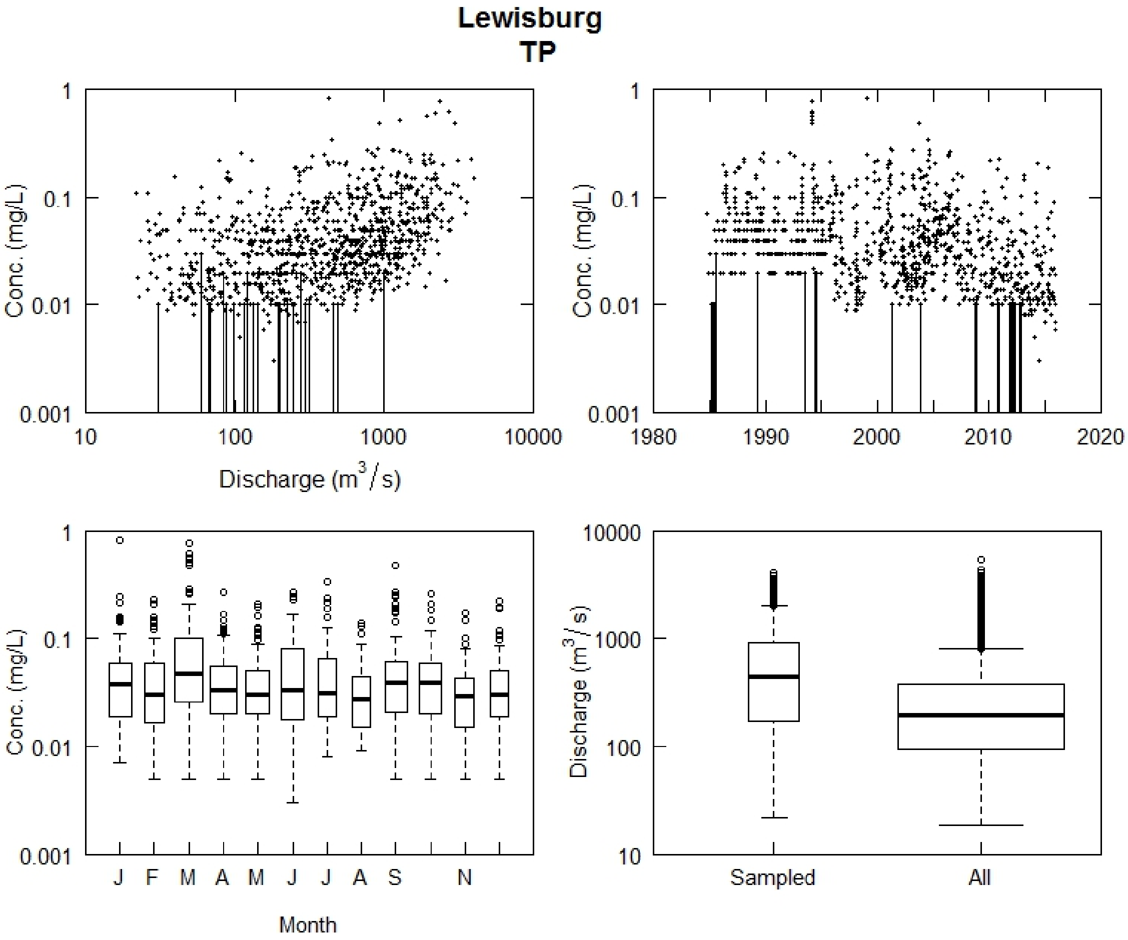


Figure B41. WRTDS Plots of Historical Sample Data

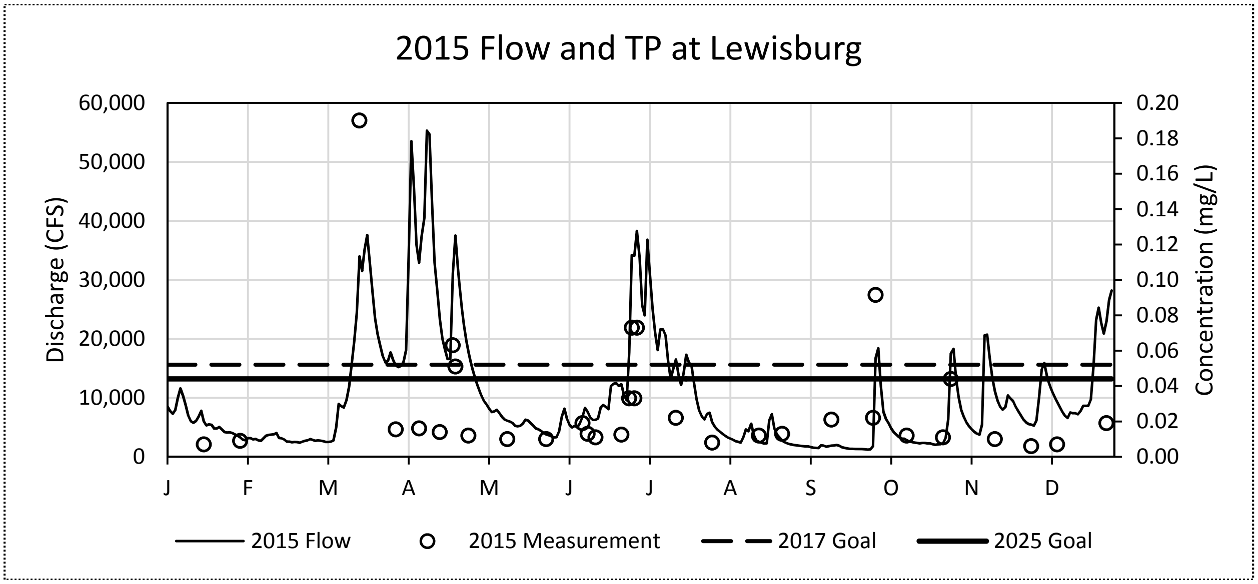


Figure B42. 2015 TP Samples, Daily Average Flow, and Monthly LTM at Lewisburg

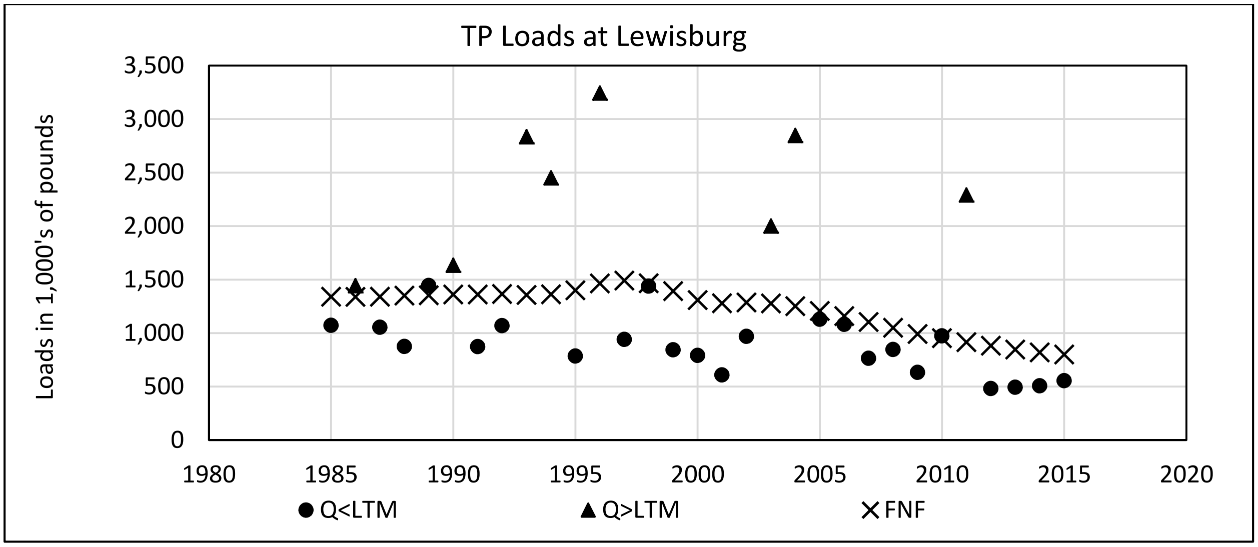


***Figure B43.** TP Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Lewisburg*

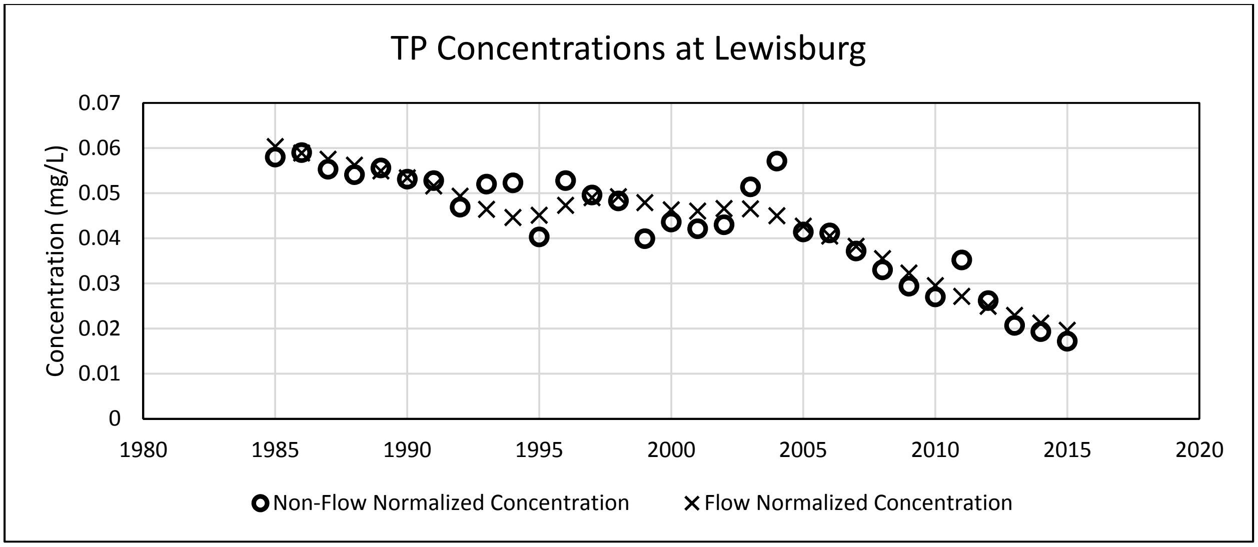


***Figure B44.** TP Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Lewisburg*

Table B41. ***Monthly TP Load (1000's of pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)***

Lewisburg	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	6,009	46%	11	**101**	92	79	0.010	0.027	0.052	0.044
February	2,990	25%	3	57	92	79	0.007	0.024	0.052	0.044
March	16,275	82%	74	**160**	92	79	0.020	0.034	0.052	0.044
April	29,000	147%	**189**	**132**	92	79	0.035	0.035	0.052	0.044
May	6,138	49%	13	**81**	92	79	0.012	0.033	0.052	0.044
June	10,049	134%	43	35	92	79	0.020	0.031	0.052	0.044
July	17,296	333%	**111**	32	92	79	0.033	0.031	0.052	0.044
August	3,420	79%	9	18	92	79	0.016	0.028	0.052	0.044
September	1,621	28%	3	73	92	79	0.012	0.028	0.052	0.044
October	5,472	83%	21	49	92	79	0.016	0.026	0.052	0.044
November	8,817	88%	28	50	92	79	0.017	0.025	0.052	0.044
December	12,802	95%	48	**100**	92	79	0.019	0.028	0.052	0.044
Annual#	10,022	93%	554	887	1,102	945	0.018	0.029	0.052	0.044

Table B42. ***Color Conditioned Heat Chart of Historical Flow Normalized Concentrations***

Lewisburg TP Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										0.065	0.051	0.043
1985	0.042	0.043	0.054	0.060	0.063	0.070	0.076	0.079	0.077	0.064	0.051	0.044
1986	0.043	0.043	0.054	0.059	0.061	0.066	0.071	0.075	0.074	0.063	0.051	0.045
1987	0.044	0.043	0.054	0.059	0.059	0.062	0.068	0.072	0.071	0.061	0.051	0.045
1988	0.044	0.043	0.055	0.059	0.057	0.059	0.064	0.068	0.068	0.059	0.050	0.046
1989	0.044	0.043	0.055	0.058	0.055	0.056	0.060	0.065	0.066	0.058	0.050	0.046
1990	0.045	0.043	0.056	0.058	0.052	0.052	0.056	0.061	0.063	0.057	0.050	0.047
1991	0.045	0.043	0.056	0.057	0.049	0.047	0.051	0.057	0.060	0.055	0.049	0.046
1992	0.045	0.042	0.055	0.055	0.045	0.042	0.046	0.053	0.056	0.052	0.047	0.045
1993	0.043	0.040	0.053	0.052	0.042	0.039	0.043	0.049	0.053	0.049	0.046	0.045
1994	0.042	0.038	0.051	0.049	0.039	0.037	0.041	0.047	0.050	0.049	0.048	0.048
1995	0.045	0.041	0.051	0.049	0.039	0.037	0.040	0.045	0.049	0.050	0.054	0.055
1996	0.053	0.047	0.054	0.050	0.039	0.036	0.039	0.044	0.048	0.052	0.060	0.063
1997	0.060	0.053	0.055	0.049	0.038	0.034	0.037	0.041	0.045	0.051	0.063	0.068
1998	0.067	0.057	0.055	0.047	0.036	0.032	0.035	0.037	0.042	0.049	0.062	0.068
1999	0.067	0.058	0.053	0.045	0.034	0.031	0.033	0.036	0.040	0.047	0.059	0.064
2000	0.064	0.056	0.051	0.042	0.033	0.031	0.033	0.035	0.041	0.046	0.056	0.060
2001	0.059	0.054	0.051	0.044	0.036	0.033	0.035	0.036	0.042	0.046	0.054	0.057
2002	0.056	0.053	0.052	0.047	0.040	0.037	0.037	0.038	0.042	0.045	0.051	0.053
2003	0.052	0.050	0.053	0.050	0.044	0.040	0.040	0.039	0.042	0.042	0.046	0.047
2004	0.046	0.046	0.051	0.051	0.046	0.043	0.042	0.040	0.041	0.039	0.041	0.042
2005	0.040	0.039	0.047	0.050	0.046	0.044	0.043	0.041	0.040	0.036	0.037	0.037
2006	0.034	0.034	0.043	0.047	0.046	0.046	0.045	0.041	0.040	0.034	0.033	0.033
2007	0.030	0.030	0.040	0.045	0.045	0.046	0.045	0.040	0.038	0.032	0.031	0.031
2008	0.028	0.028	0.037	0.042	0.042	0.042	0.041	0.037	0.035	0.029	0.030	0.030
2009	0.027	0.025	0.034	0.038	0.037	0.036	0.036	0.033	0.032	0.027	0.028	0.028
2010	0.025	0.023	0.032	0.035	0.032	0.032	0.031	0.030	0.029	0.026	0.026	0.027
2011	0.024	0.021	0.030	0.032	0.029	0.028	0.028	0.027	0.027	0.024	0.025	0.025
2012	0.022	0.020	0.028	0.030	0.026	0.025	0.025	0.024	0.025	0.022	0.023	0.024
2013	0.021	0.018	0.027	0.028	0.023	0.022	0.022	0.022	0.023	0.020	0.022	0.023
2014	0.020	0.017	0.025	0.026	0.021	0.019	0.020	0.020	0.021	0.019	0.021	0.022
2015	0.019	0.016	0.024	0.024	0.019	0.017	0.018	0.018	0.020	0.018	0.020	0.021
Change	-0.024	-0.028	-0.030	-0.035	-0.044	-0.053	-0.058	-0.061	-0.057	-0.048	-0.032	-0.023

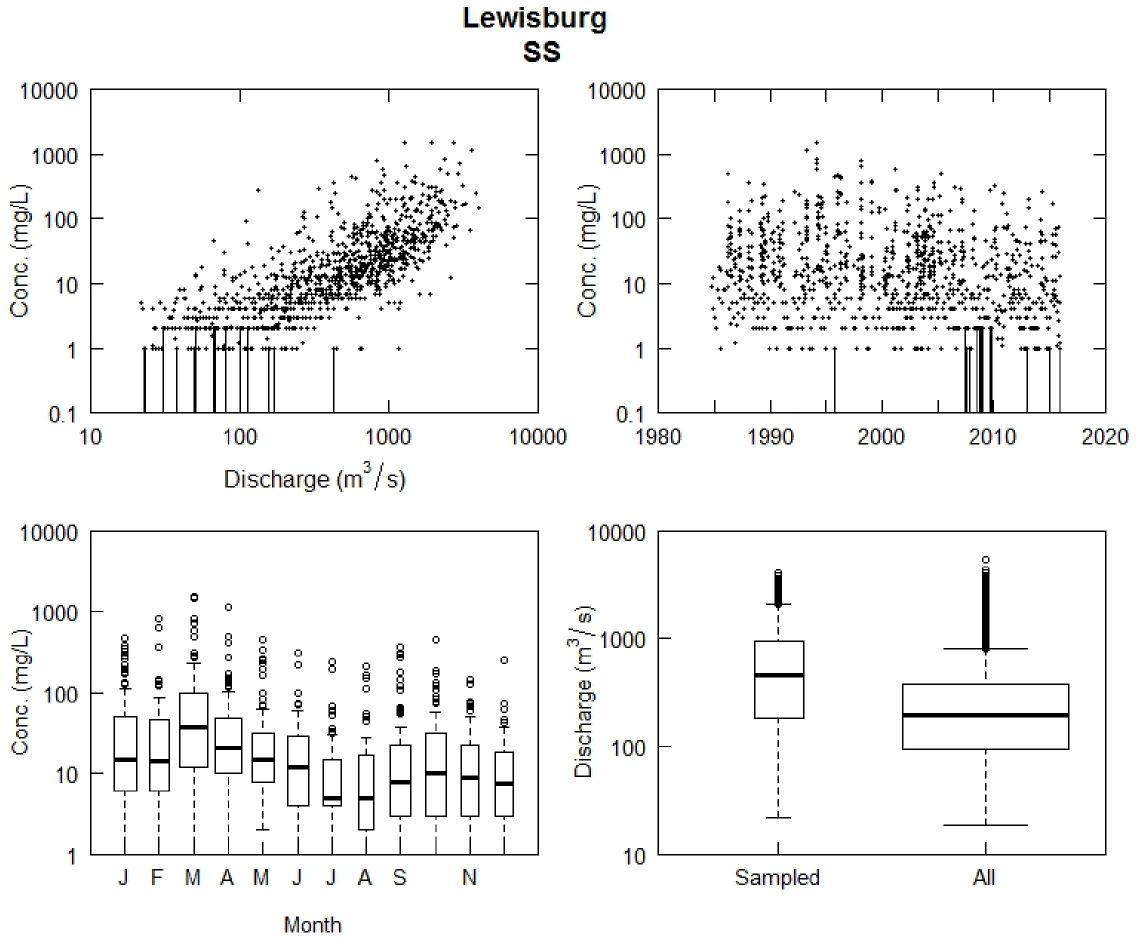


Figure B45. WRTDS Plots of Historical Sample Data

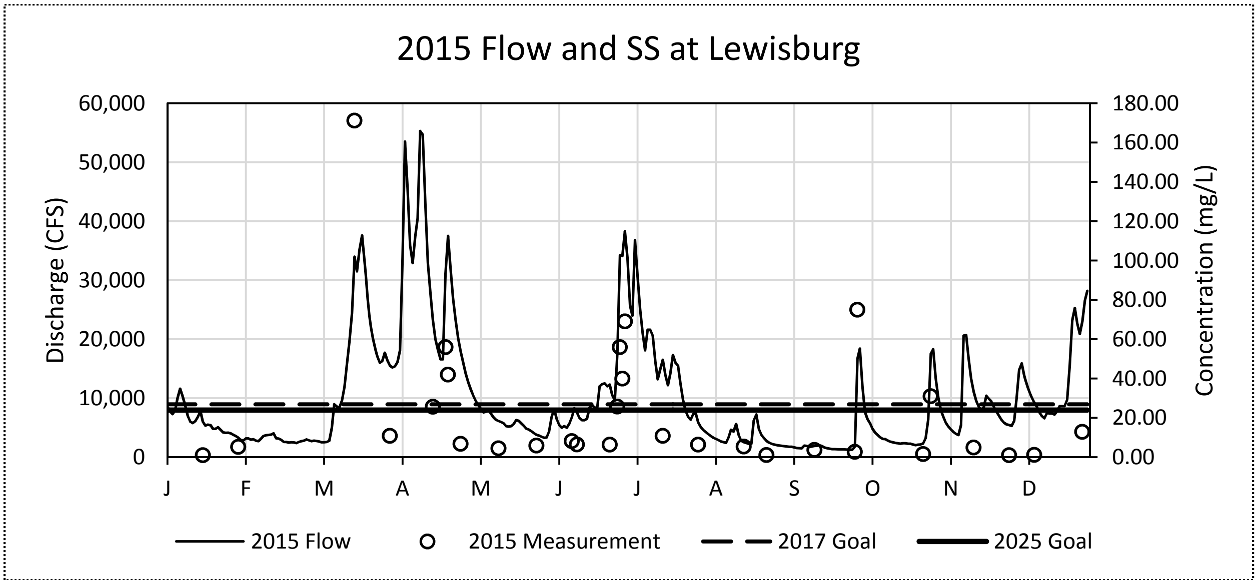


Figure B46. 2015 SS Samples, Daily Average Flow, and Monthly LTM at Lewisburg

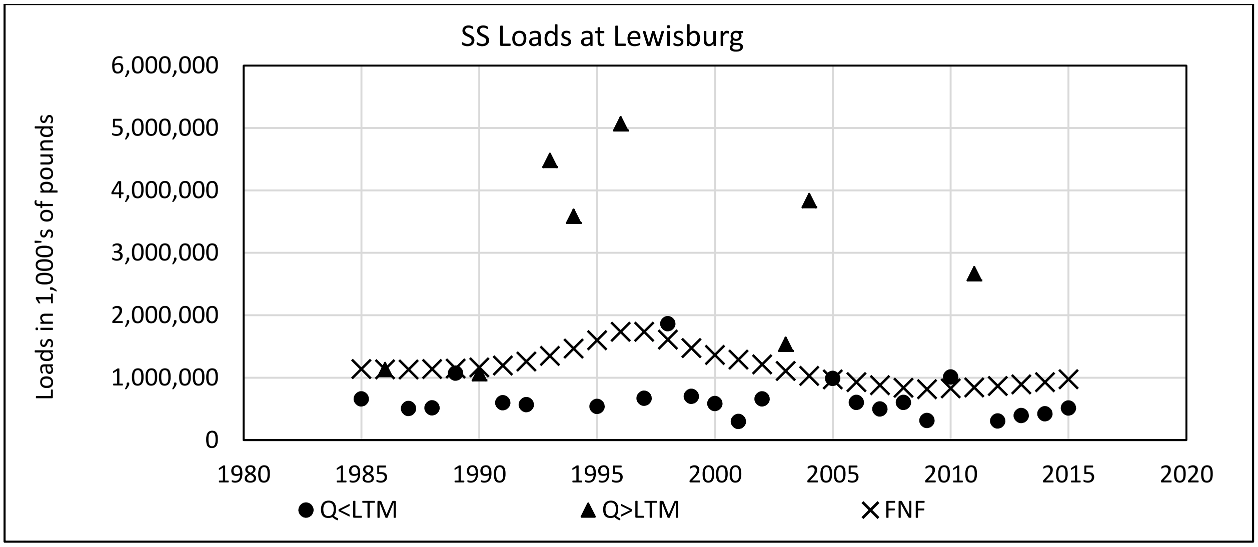


Figure B47. SS Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Lewisburg

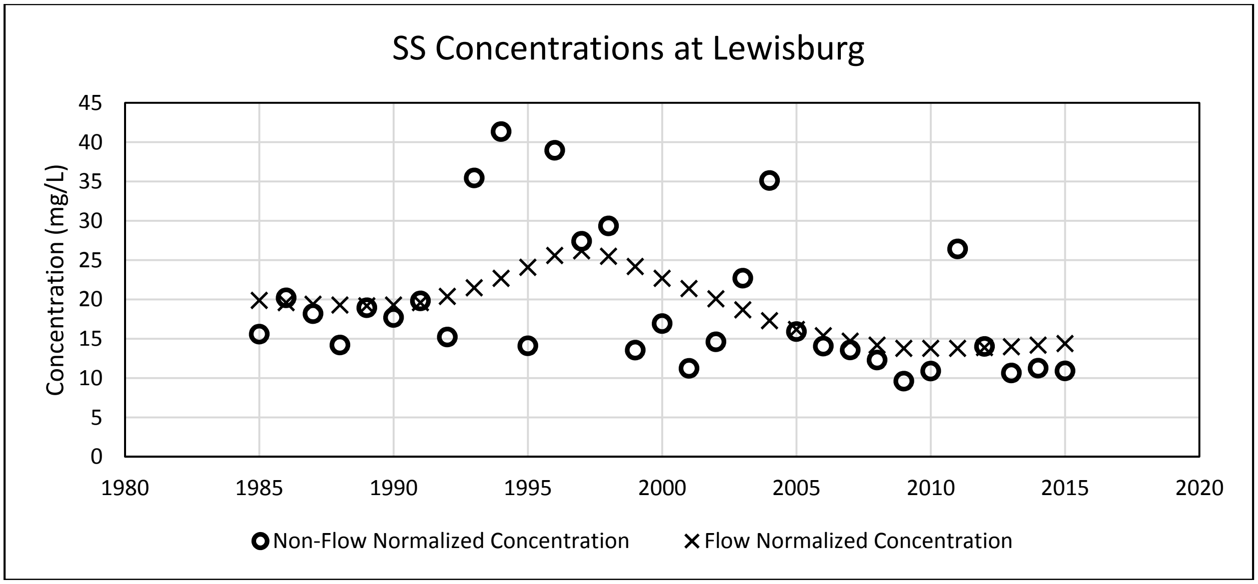


Figure B48. SS Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Lewisburg

Table B43. Monthly SS Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Lewisburg	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	6,009	46%	4,093	**86,492**	47,753	42,439	3.5	15.6	27	24
February	2,990	25%	786	41,069	47,753	42,439	1.7	11.2	27	24
March	16,275	82%	**72,005**	**158,782**	47,753	42,439	17.2	**24.4**	27	24
April	29,000	147%	**220,912**	**123,579**	47,753	42,439	**37.6**	22.4	27	24
May	6,138	49%	6,394	**52,904**	47,753	42,439	5.7	15.0	27	24
June	10,049	134%	34,629	15,632	47,753	42,439	13.1	9.0	27	24
July	17,296	333%	**101,830**	16,637	47,753	42,439	27.7	8.7	27	24
August	3,420	79%	4,222	6,236	47,753	42,439	6.6	6.5	27	24
September	1,621	28%	899	**97,695**	47,753	42,439	3.3	11.6	27	24
October	5,472	83%	14,914	**33,128**	47,753	42,439	8.2	10.7	27	24
November	8,817	88%	17,199	**31,549**	47,753	42,439	9.1	10.0	27	24
December	12,802	95%	35,170	**91,209**	47,753	42,439	11.7	15.7	27	24
Annual#	10,022	93%	**513,053**	**754,912**	573,036	509,272	12.1	13.4	27	24

Table B44. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Lewisburg SS Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										14.0	16.0	20.0
1985	22.9	18.6	36.1	34.4	19.6	13.7	12.8	13.2	17.1	13.5	15.7	19.8
1986	22.8	18.5	36.2	34.6	19.5	13.2	12.3	12.7	16.4	13.1	15.4	19.6
1987	22.6	18.5	36.5	35.0	19.4	12.9	11.8	12.2	15.8	12.7	15.1	19.3
1988	22.5	18.6	36.9	35.5	19.5	12.7	11.5	11.8	15.3	12.4	14.8	19.1
1989	22.4	18.5	37.5	36.3	19.6	12.3	11.1	11.4	14.9	12.1	14.6	18.9
1990	22.4	18.8	38.7	37.5	19.7	12.0	10.8	11.3	14.7	12.1	14.4	18.9
1991	22.6	19.4	40.6	39.3	20.0	11.5	10.5	11.2	14.8	12.2	14.4	18.7
1992	22.5	20.4	43.7	42.6	21.3	11.9	10.8	11.5	14.9	12.3	14.6	18.9
1993	22.8	20.8	47.0	46.7	23.5	13.0	11.4	11.8	15.1	12.4	15.0	19.6
1994	23.7	21.4	50.2	50.1	25.4	14.2	12.5	12.4	15.7	13.0	16.0	21.0
1995	25.8	22.3	53.3	52.4	26.3	15.2	13.5	13.4	16.9	14.3	17.9	23.6
1996	28.9	24.0	56.3	53.2	26.1	15.6	14.2	14.2	18.4	16.1	20.5	27.0
1997	31.9	25.0	57.0	51.2	24.8	15.1	13.8	13.8	17.9	16.5	21.8	28.9
1998	32.2	25.3	54.3	47.4	23.3	14.4	12.8	12.6	16.4	15.8	21.7	29.1
1999	30.9	24.5	49.4	43.0	21.8	13.7	12.0	11.9	16.2	15.4	21.2	28.1
2000	28.8	23.1	43.9	38.4	20.2	13.0	11.4	11.4	16.9	15.3	20.5	26.3
2001	26.3	21.0	39.9	35.8	19.3	12.5	10.9	11.1	17.6	15.0	19.4	24.0
2002	23.6	19.2	36.7	34.1	19.0	12.2	10.5	10.6	17.4	13.9	17.4	21.3
2003	20.9	17.6	33.9	32.6	18.9	12.0	10.1	10.0	16.0	12.0	15.0	18.4
2004	18.5	16.4	31.5	31.4	18.7	11.8	9.7	9.4	15.0	10.8	13.4	16.5
2005	16.7	14.9	29.3	30.1	18.3	11.6	9.4	9.1	14.5	10.3	12.8	15.5
2006	15.6	13.7	27.3	28.3	17.6	11.4	9.3	9.0	14.2	10.1	12.6	15.0
2007	14.7	12.7	25.1	26.2	16.8	11.2	9.2	8.9	13.9	10.0	12.5	14.8
2008	14.3	12.1	23.5	24.5	16.0	10.9	9.1	8.8	13.6	10.0	12.4	14.6
2009	14.1	11.5	22.4	23.3	15.2	10.5	8.9	8.8	13.5	10.2	12.6	14.6
2010	14.0	11.2	22.4	23.1	15.0	10.3	8.9	9.0	13.7	10.5	12.8	14.6
2011	14.0	11.1	22.5	23.1	14.7	10.1	8.9	9.1	13.9	10.7	13.1	14.8
2012	14.2	11.1	22.8	23.1	14.5	10.0	8.9	9.1	14.1	10.9	13.4	15.1
2013	14.5	10.9	23.1	23.1	14.3	9.8	8.9	9.2	14.3	11.1	13.8	15.5
2014	15.0	11.0	23.6	23.4	14.2	9.7	8.9	9.2	14.5	11.3	14.2	15.9
2015	15.6	11.1	24.3	23.8	14.1	9.6	8.8	9.3	14.8	11.5	14.7	16.5
Change	-7.3	-7.5	-11.8	-10.6	-5.5	-4.0	-3.9	-3.9	-2.3	-2.4	-1.3	-3.5

Table B45. 2015 Annual and Seasonal Precipitation and Discharge at Newport

Season	Precipitation (inches)			Discharge (cfs)		
	2015	LTM	LTM Departure	2015	LTM	% LTM
January-March (Winter)	5.62	8.18	-2.56	3,741	6,327	59
April-June (Spring)	14.33	11.33	3.00	4,347	5,547	78
July-September (Summer)	10.14	11.04	-0.90	2,862	2,012	142
October-December (Fall)	8.60	9.85	-1.25	1,793	3,697	49
Annual Total	38.69	40.40	-1.71	3,180	4,383	73

Table B46. 2015 Annual Loads (1000's lbs), Yields (lbs/acre), and Concentrations (mg/L) at Newport

Parameter	Load	Load % of LTM	Yield	LTM Yield	Ave. Conc.	Conc. % of LTM
TN	9,655	62%	1.93	3.12	1.54	86%
TNO_x	7,198	63%	1.44	2.28	1.15	87%
TON	2,442	61%	0.49	0.80	0.39	84%
TNH_3	207	55%	0.04	0.08	0.03	76%
DN	8,761	63%	1.76	2.79	1.40	87%
DNO_x	7,187	64%	1.44	2.25	1.15	88%
DON	1,466	60%	0.29	0.49	0.23	82%
DNH_3	218	66%	0.04	0.07	0.03	91%
TP	317	40%	0.06	0.16	0.05	56%
DP	128	38%	0.03	0.07	0.02	53%
DOP	103	50%	0.02	0.04	0.02	69%
TOC	19,903	66%	3.99	6.00	3.18	92%
SS	200,585	41%	40.20	97.77	32.04	57%

Table B47. 2015 Seasonal Loads (1000's lbs) and Yields (lbs/acre) at Newport

Parameter	Winter		Spring		Summer		Fall	
	Load	Yield	Load	Yield	Load	Yield	Load	Yield
TN	2,841	0.57	3,210	0.64	2,274	0.46	1,329	0.27
TNO_x	2,174	0.44	2,345	0.47	1,618	0.32	1,061	0.21
TON	600	0.12	891	0.18	688	0.14	262	0.05
TNH_3	54	0.01	71	0.01	59	0.01	23	0.00
DN	2,592	0.52	2,850	0.57	2,043	0.41	1,276	0.26
DNO_x	2,174	0.44	2,339	0.47	1,617	0.32	1,058	0.21
DON	345	0.07	484	0.10	423	0.08	214	0.04
DNH_3	62	0.01	75	0.01	59	0.01	21	0.00
TP	72	0.01	119	0.02	101	0.02	25	0.01
DP	25	0.01	44	0.01	46	0.01	12	0.00
DOP	20	0.00	35	0.01	38	0.01	10	0.00
TOC	5,056	1.01	7,057	1.41	5,408	1.08	2,383	0.48
SS	52,557	10.53	82,025	16.44	57,507	11.52	8,495	1.70

Table B48. ***2015 Monthly Average Precipitation (in), High Daily Precipitation During Month (in), Flow (cfs), Loads (1000's lbs), and Yields (lbs/acre) at Newport***

Mon	Precip			Flow		TN			TP			SS		
	Ave	Max	% LTM	2014	% LTM	Load	Yield	% LTM	Load	Yield	% LTM	Load	Yield	% LTM
Jan	1.94	0.51	74%	2,117	41%	529	0.11	31%	6	0.001	8%	1,941	0.4	4%
Feb	1.00	0.45	48%	1,718	34%	360	0.07	25%	3	0.001	7%	1,071	0.2	4%
Mar	2.67	0.71	78%	7,193	84%	1,952	0.39	74%	62	0.013	49%	49,546	9.9	54%
Apr	3.36	1.01	97%	5,811	76%	1,431	0.29	67%	42	0.008	42%	28,752	5.8	45%
May	2.44	0.38	58%	2,613	46%	590	0.12	37%	13	0.003	17%	5,177	1.0	11%
Jun	8.54	1.73	232%	4,675	141%	1,190	0.24	139%	64	0.013	133%	48,096	9.6	185%
Jul	4.85	0.96	135%	6,303	299%	1,785	0.36	307%	87	0.017	240%	55,275	11.1	276%
Aug	2.03	1.16	59%	1,361	95%	322	0.06	87%	10	0.002	44%	1,787	0.4	27%
Sept	3.26	1.00	82%	857	34%	167	0.03	23%	4	0.001	5%	446	0.1	1%
Oct	3.19	0.89	94%	1,073	47%	237	0.05	34%	5	0.001	13%	880	0.2	5%
Nov	1.51	0.62	45%	1,331	37%	296	0.06	26%	4	0.001	8%	849	0.2	2%
Dec	3.90	0.58	126%	2,961	57%	797	0.16	47%	16	0.003	21%	6,766	1.4	16%

Table B49. ***Trend Statistics for the Juniata River at Newport, Pa., October 1984 Through September 2015***

Newport	Trend	Change	Slope	%	Hypothesis Test		Likelihood Test		
Parameter/code	Test			Change	P-value	Trend	Value	Descriptor	Direction
FLOW / 60	SMK	-	-	-	0.531	NS	-	-	-
TN / 600	FNC	-0.446	-0.015	-23	<0.05	Down	0.99	HL	Down
	FNF	-2.30	-0.077	-27	<0.05	Down	0.99	HL	Down
TNO$_x$ / 630	FNC	-0.093	-0.0031	-7.7	0.2	NS	0.91	VL	Down
	FNF	-0.85	-0.028	-16	<0.05	Down	0.99	HL	Down
TON / 605	FNC	-0.346	-0.012	-51	<0.05	Down	0.99	HL	Down
	FNF	-1.56	-0.052	-47	<0.05	Down	0.97	HL	Down
TNH$_3$ / 610	FNC	-0.031	-0.001	-51	<0.05	Down	0.99	HL	Down
	FNF	-0.13	-0.0045	-49	<0.05	Down	0.99	HL	Down
DN / 602	FNC	-0.284	-0.0095	-17	<0.05	Down	0.99	HL	Down
	FNF	-1.57	-0.052	-22	<0.05	Down	0.99	HL	Down
DNO$_x$ / 631	FNC	-0.034	-0.0011	-3	0.64	NS	0.69	L	Down
	FNF	-0.55	-0.018	-11	0.051	Down	0.97	HL	Down
DON / 607	FNC	-0.217	-0.0072	-49	<0.05	Down	0.99	HL	Down
	FNF	-0.96	-0.032	-51	<0.05	Down	0.99	HL	Down
DNH$_3$ / 608	FNC	-0.019	-0.00063	-38	0.072	Down	0.97	HL	Down
	FNF	-0.09	-0.0031	-38	0.2	NS	0.90	L	Down
TP / 665	FNC	-0.064	-0.0021	-62	<0.05	Down	0.99	HL	Down
	FNF	-0.24	-0.0079	-47	<0.05	Down	0.99	HL	Down
DP / 666	FNC	-0.042	-0.0014	-69	<0.05	Down	0.99	HL	Down
	FNF	-0.13	-0.0043	-60	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.029	-0.00097	-66	0.04	Down	0.98	HL	Down
	FNF	-0.07	-0.0022	-49	0.07	Down	0.97	HL	Down
TOC / 680	FNC	-1.800	-0.06	-38	0.051	Down	0.98	HL	Down
	FNF	-7.46	-0.25	-35	0.081	Down	0.96	HL	Down
SSC / 80154	FNC	-15.50	-0.52	-45	0.053	Down	0.97	HL	Down
	FNF	-138.9	-4.6	-39	0.28	NS	0.86	L	Down

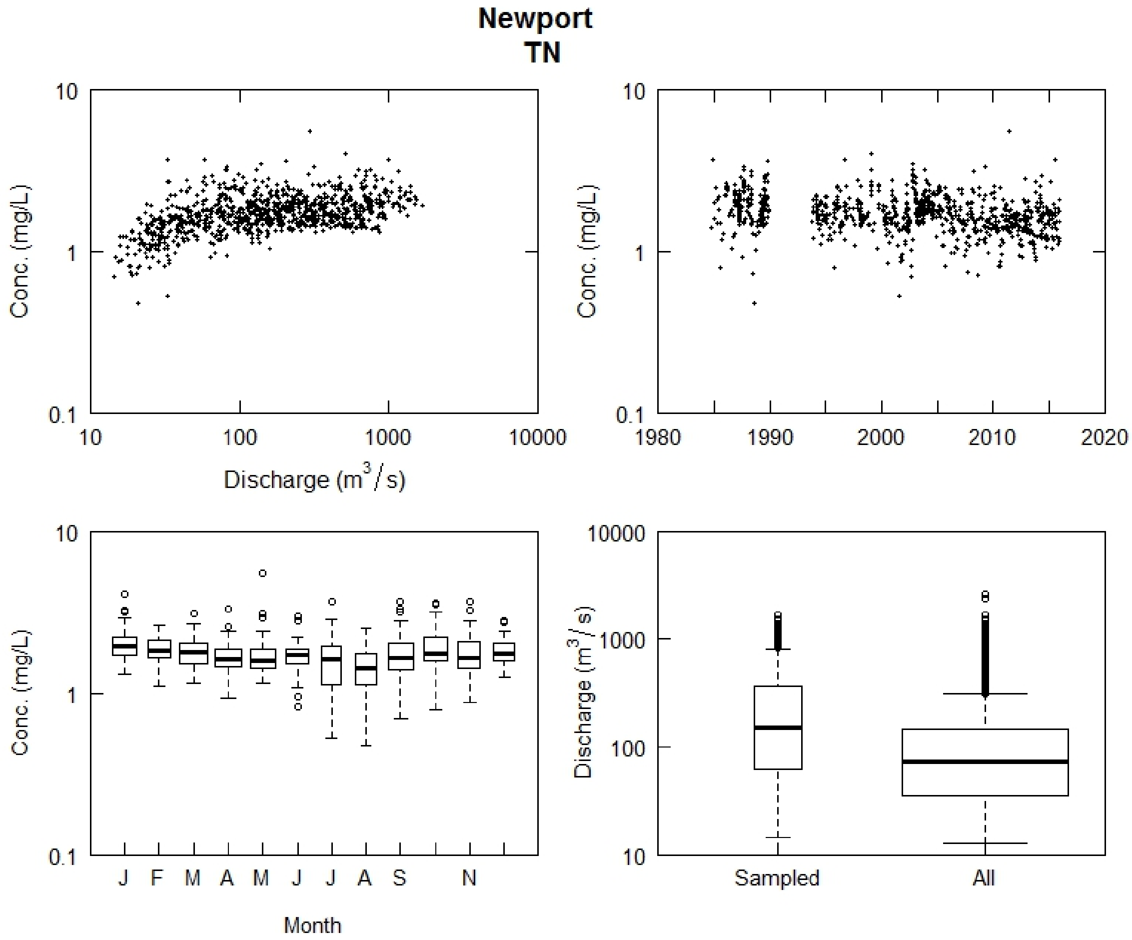


Figure B49. WRTDS Plots of Historical Sample Data

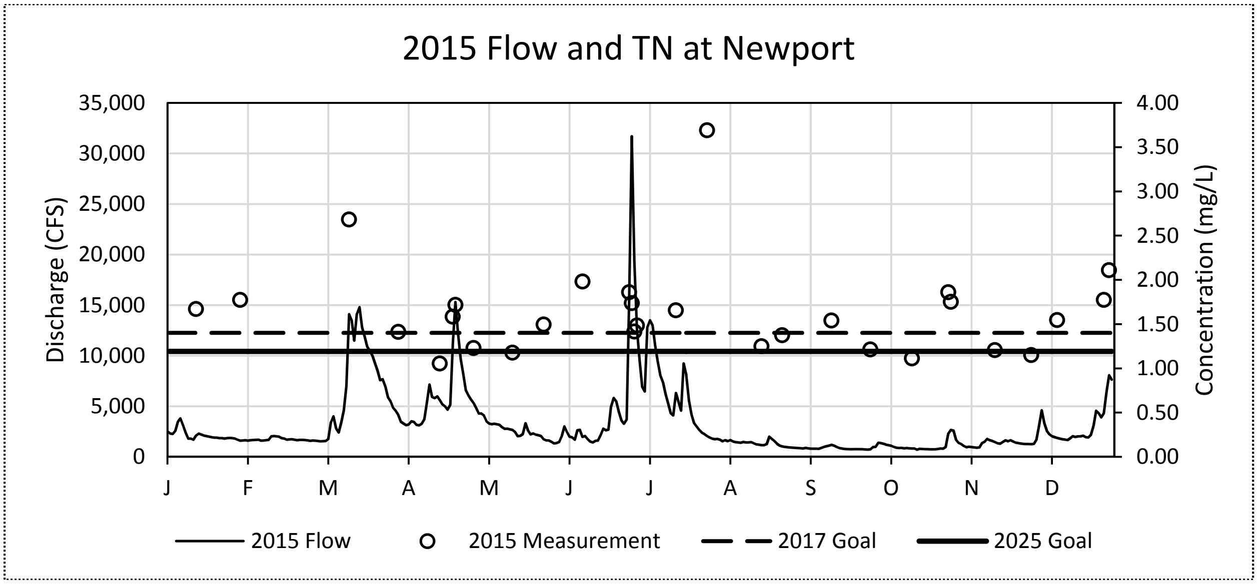


Figure B50. 2015 TN Samples, Daily Average Flow, and Monthly LTM at Newport

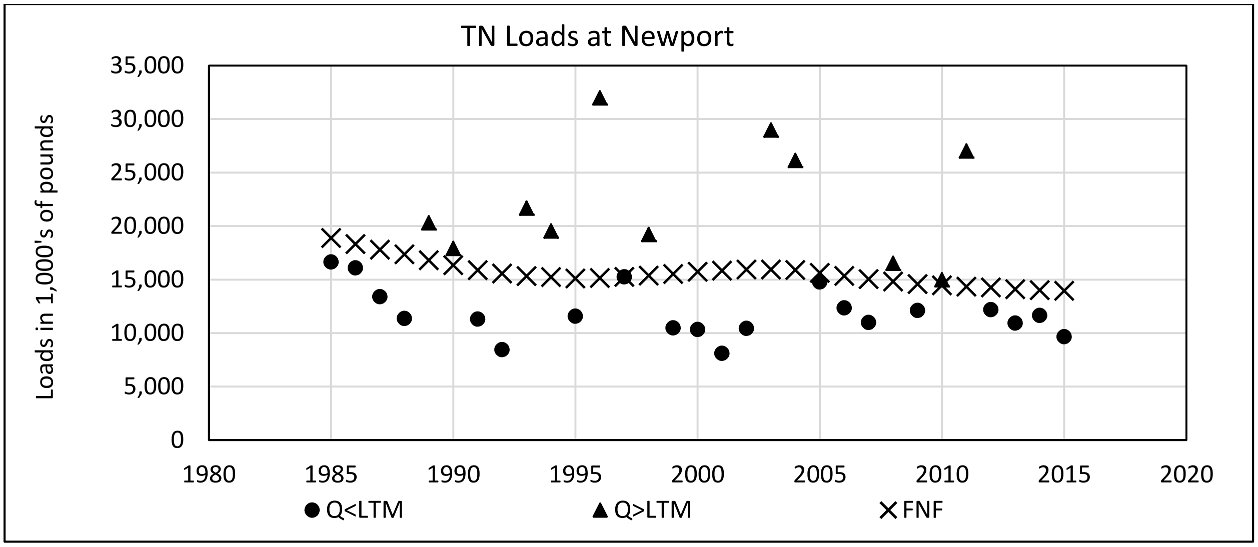


Figure B51. TN Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Newport

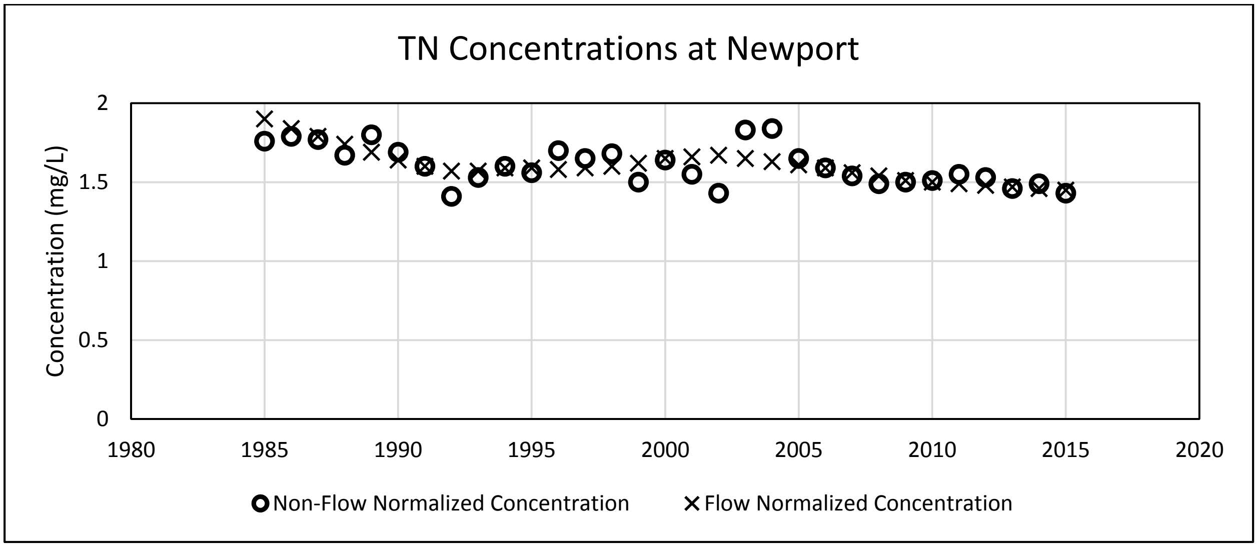


Figure B52. TN Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Newport

Table B50. Monthly TN Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Newport	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	2,117	41%	529	**1,752**	1,018	864	**1.48**	**1.73**	1.40	1.19
February	1,718	34%	360	**1,189**	1,018	864	**1.39**	**1.63**	1.40	1.19
March	7,193	84%	**1,952**	**2,508**	1,018	864	**1.56**	**1.65**	1.40	1.19
April	5,811	76%	**1,431**	**1,787**	1,018	864	**1.49**	**1.56**	1.40	1.19
May	2,613	46%	590	**1,590**	1,018	864	**1.33**	**1.50**	1.40	1.19
June	4,675	141%	**1,190**	776	1,018	864	**1.42**	**1.40**	1.40	1.19
July	6,303	299%	**1,785**	483	1,018	864	**1.67**	**1.34**	1.40	1.19
August	1,361	95%	322	285	1,018	864	**1.40**	**1.29**	1.40	1.19
September	857	34%	167	519	1,018	864	**1.20**	**1.29**	1.40	1.19
October	1,073	47%	237	630	1,018	864	**1.26**	**1.42**	1.40	1.19
November	1,331	37%	296	800	1,018	864	**1.36**	**1.56**	1.40	1.19
December	2,961	57%	797	**1,609**	1,018	864	**1.55**	**1.73**	1.40	1.19
Annual#	3,180	73%	9,655	**13,926**	12,221	10,363	**1.42**	**1.51**	1.40	1.19

Table B51. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Newport TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										1.91	2.14	2.22
1985	2.08	2.01	2.03	1.95	1.87	1.72	1.60	1.58	1.68	1.84	2.06	2.15
1986	2.01	1.94	1.97	1.90	1.82	1.67	1.55	1.53	1.63	1.78	1.99	2.07
1987	1.95	1.88	1.91	1.85	1.77	1.63	1.52	1.49	1.58	1.72	1.92	2.01
1988	1.88	1.83	1.86	1.80	1.73	1.59	1.49	1.46	1.55	1.67	1.86	1.94
1989	1.82	1.77	1.81	1.76	1.69	1.56	1.46	1.44	1.51	1.62	1.79	1.87
1990	1.76	1.71	1.76	1.71	1.65	1.53	1.44	1.42	1.48	1.57	1.72	1.80
1991	1.69	1.65	1.71	1.67	1.62	1.51	1.43	1.41	1.46	1.52	1.66	1.74
1992	1.63	1.60	1.68	1.65	1.60	1.51	1.44	1.42	1.45	1.50	1.63	1.72
1993	1.65	1.62	1.68	1.64	1.59	1.51	1.46	1.43	1.45	1.50	1.63	1.75
1994	1.71	1.68	1.70	1.63	1.57	1.50	1.47	1.45	1.46	1.51	1.65	1.77
1995	1.74	1.71	1.70	1.60	1.53	1.47	1.45	1.45	1.47	1.52	1.66	1.79
1996	1.75	1.72	1.69	1.58	1.50	1.45	1.43	1.44	1.47	1.54	1.71	1.84
1997	1.78	1.74	1.71	1.59	1.50	1.43	1.40	1.41	1.46	1.56	1.76	1.89
1998	1.81	1.75	1.72	1.60	1.50	1.42	1.38	1.40	1.46	1.58	1.81	1.95
1999	1.86	1.77	1.73	1.61	1.51	1.42	1.38	1.39	1.46	1.61	1.86	2.01
2000	1.90	1.80	1.75	1.63	1.53	1.43	1.38	1.39	1.47	1.63	1.90	2.05
2001	1.93	1.82	1.78	1.66	1.55	1.44	1.38	1.39	1.46	1.63	1.91	2.05
2002	1.93	1.82	1.79	1.68	1.57	1.45	1.37	1.37	1.45	1.61	1.88	2.02
2003	1.90	1.81	1.80	1.68	1.57	1.44	1.36	1.36	1.43	1.58	1.84	1.98
2004	1.87	1.78	1.79	1.68	1.56	1.44	1.35	1.34	1.40	1.55	1.80	1.93
2005	1.83	1.76	1.77	1.66	1.55	1.42	1.34	1.32	1.38	1.52	1.75	1.89
2006	1.80	1.74	1.75	1.65	1.54	1.42	1.33	1.31	1.36	1.49	1.71	1.84
2007	1.77	1.72	1.72	1.63	1.53	1.41	1.33	1.31	1.35	1.46	1.66	1.78
2008	1.74	1.69	1.69	1.60	1.51	1.40	1.32	1.30	1.33	1.43	1.61	1.73
2009	1.70	1.65	1.66	1.58	1.49	1.38	1.32	1.30	1.33	1.41	1.58	1.71
2010	1.67	1.63	1.64	1.56	1.48	1.38	1.32	1.31	1.32	1.39	1.56	1.69
2011	1.65	1.61	1.62	1.55	1.47	1.38	1.32	1.31	1.31	1.38	1.54	1.67
2012	1.63	1.59	1.60	1.53	1.46	1.38	1.33	1.31	1.31	1.37	1.52	1.65
2013	1.62	1.57	1.59	1.52	1.46	1.38	1.33	1.31	1.30	1.36	1.51	1.63
2014	1.60	1.56	1.58	1.51	1.45	1.38	1.33	1.31	1.30	1.35	1.50	1.62
2015	1.58	1.55	1.57	1.51	1.45	1.38	1.33	1.31	1.30	1.35	1.49	1.61
Change	-0.50	-0.46	-0.45	-0.45	-0.42	-0.34	-0.27	-0.27	-0.38	-0.56	-0.66	-0.62

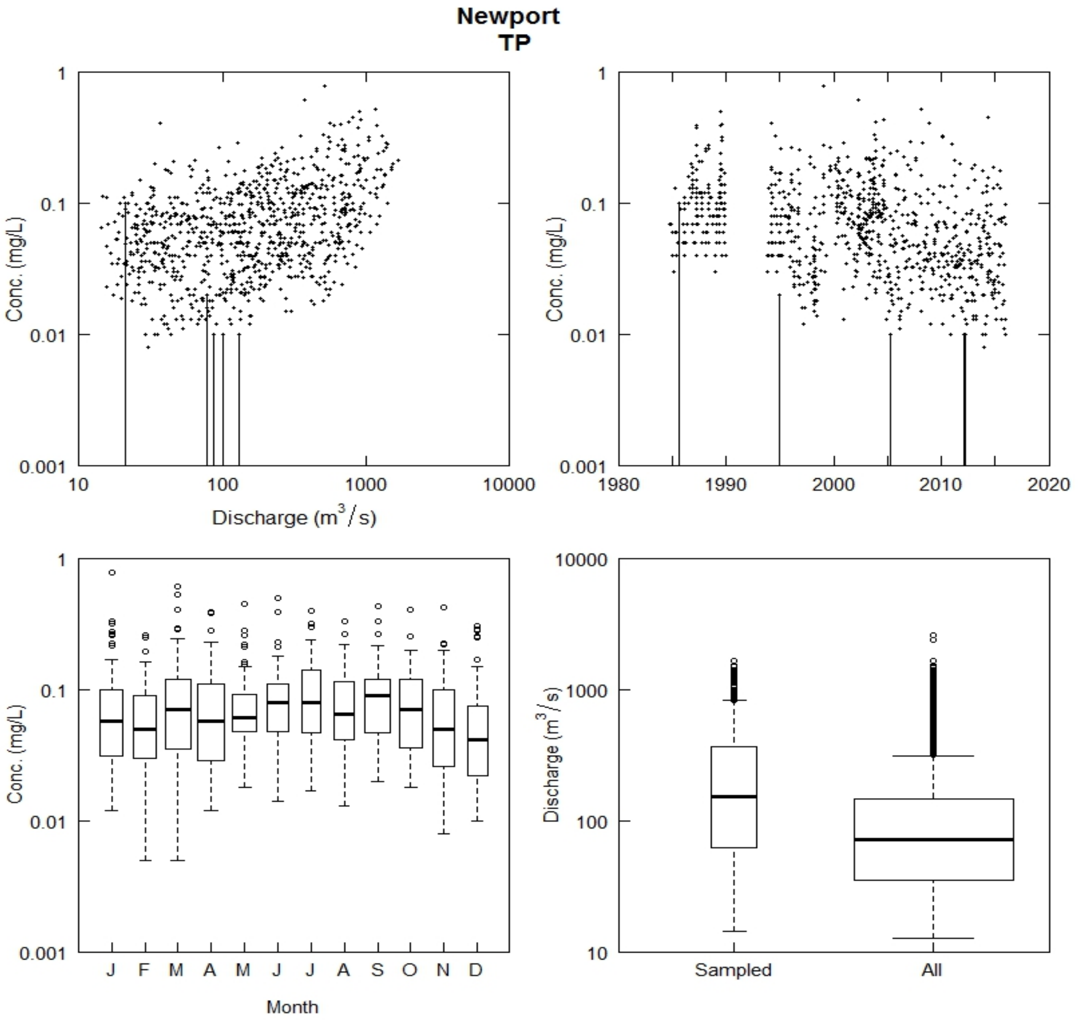


Figure B53. WRTDS Plots of Historical Sample Data

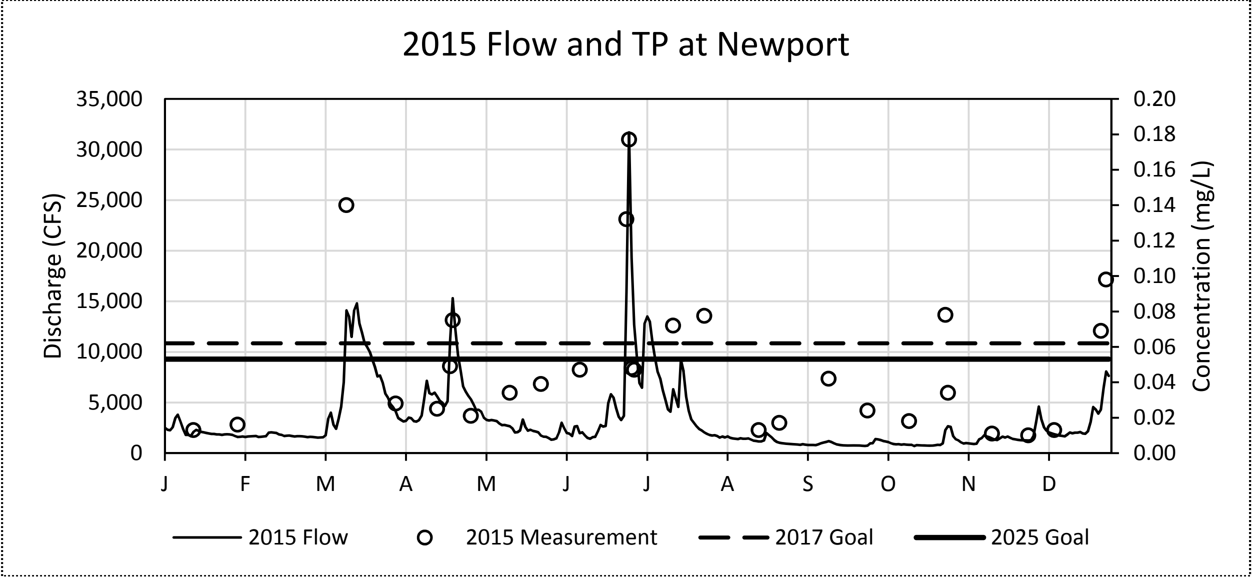


Figure B54. 2015 TP Samples, Daily Average Flow, and Monthly LTM at Newport

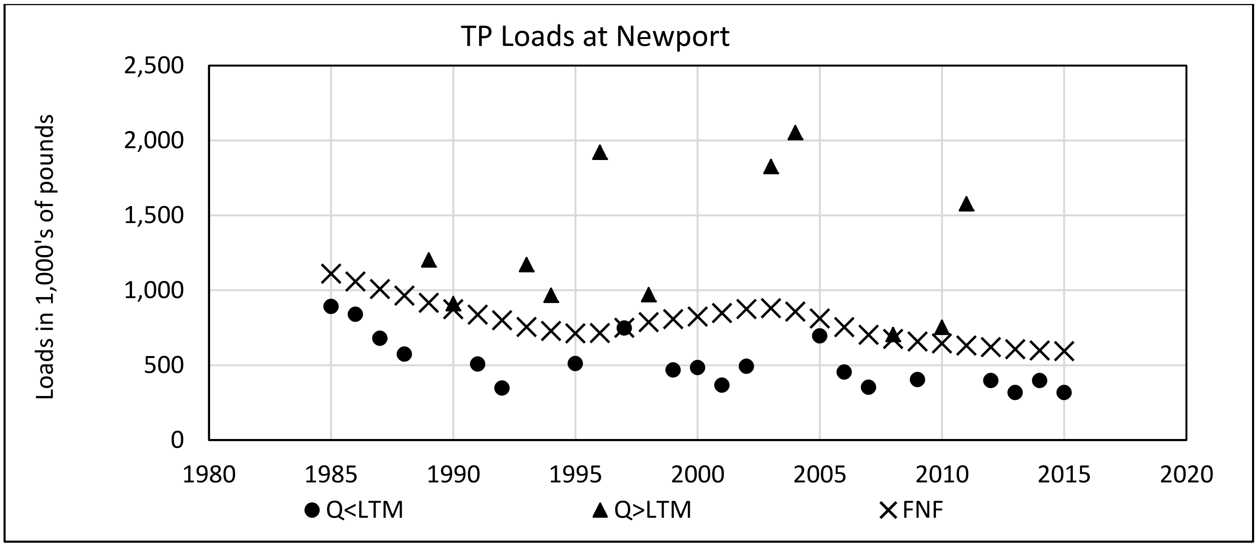


Figure B55. TP Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Newport

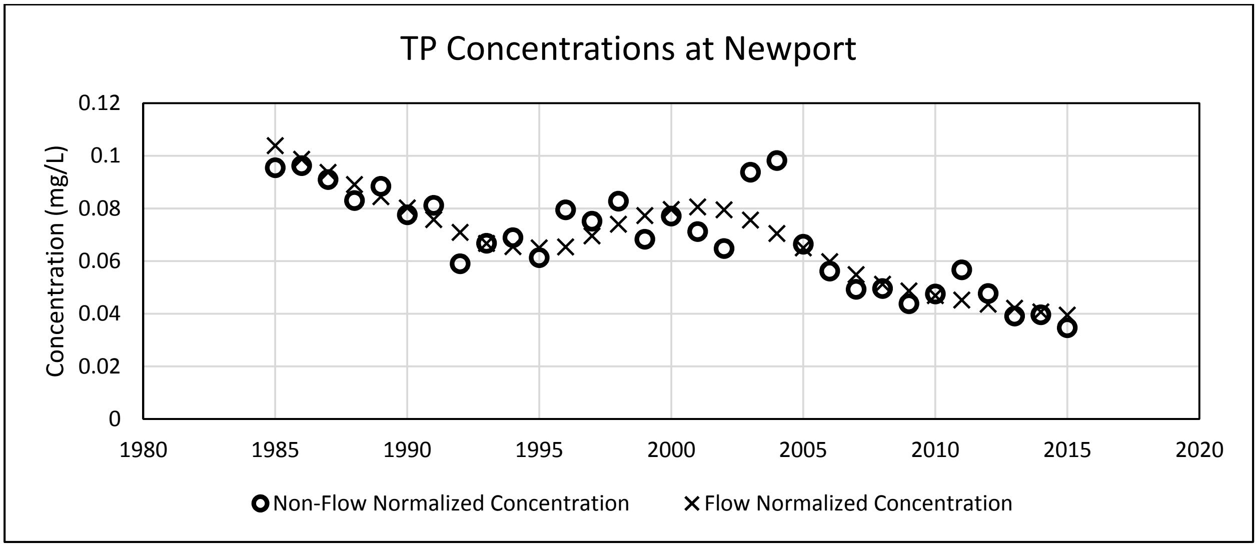


Figure B56. TP Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Newport

Table B52. Monthly TP Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Newport	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	2,117	41%	6	**62**	45	39	0.017	0.040	0.062	0.053
February	1,718	34%	3	31	45	39	0.013	0.031	0.062	0.053
March	7,193	84%	**62**	**125**	45	39	0.040	0.049	0.062	0.053
April	5,811	76%	**42**	**68**	45	39	0.038	0.046	0.062	0.053
May	2,613	46%	13	**69**	45	39	0.030	0.053	0.062	0.053
June	4,675	141%	**64**	34	45	39	0.049	0.053	0.062	0.053
July	6,303	299%	**87**	22	45	39	**0.075**	**0.057**	0.062	0.053
August	1,361	95%	10	12	45	39	0.042	**0.054**	0.062	0.053
September	857	34%	4	39	45	39	0.028	0.052	0.062	0.053
October	1,073	47%	5	27	45	39	0.025	0.046	0.062	0.053
November	1,331	37%	4	31	45	39	0.020	0.039	0.062	0.053
December	2,961	57%	16	**60**	45	39	0.026	0.043	0.062	0.053
Annual#	3,180	73%	317	**579**	540	463	0.034	0.047	0.062	0.053

Table B53. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Newport TP Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										0.113	0.100	0.091
1985	0.078	0.076	0.093	0.099	0.107	0.113	0.122	0.124	0.129	0.107	0.094	0.087
1986	0.075	0.072	0.089	0.095	0.102	0.108	0.116	0.117	0.121	0.100	0.089	0.083
1987	0.071	0.069	0.085	0.090	0.098	0.103	0.110	0.111	0.113	0.094	0.084	0.079
1988	0.068	0.066	0.081	0.087	0.094	0.099	0.105	0.105	0.106	0.088	0.079	0.075
1989	0.065	0.063	0.078	0.083	0.089	0.095	0.100	0.099	0.100	0.083	0.075	0.072
1990	0.062	0.059	0.074	0.078	0.085	0.091	0.096	0.094	0.093	0.077	0.071	0.069
1991	0.059	0.056	0.070	0.074	0.080	0.087	0.091	0.088	0.086	0.072	0.067	0.066
1992	0.057	0.053	0.066	0.068	0.075	0.081	0.084	0.081	0.081	0.069	0.065	0.065
1993	0.055	0.050	0.061	0.062	0.068	0.074	0.077	0.076	0.078	0.069	0.066	0.066
1994	0.057	0.052	0.060	0.059	0.065	0.070	0.073	0.074	0.075	0.068	0.066	0.067
1995	0.058	0.053	0.058	0.058	0.064	0.068	0.071	0.073	0.074	0.067	0.066	0.067
1996	0.057	0.052	0.057	0.057	0.064	0.068	0.073	0.078	0.077	0.070	0.069	0.071
1997	0.061	0.056	0.062	0.062	0.067	0.071	0.078	0.083	0.082	0.075	0.074	0.076
1998	0.067	0.061	0.068	0.067	0.071	0.074	0.081	0.087	0.086	0.078	0.076	0.078
1999	0.070	0.066	0.073	0.071	0.073	0.076	0.084	0.090	0.090	0.081	0.077	0.078
2000	0.072	0.069	0.075	0.074	0.076	0.079	0.087	0.094	0.093	0.082	0.078	0.077
2001	0.071	0.068	0.076	0.076	0.078	0.081	0.090	0.095	0.094	0.081	0.077	0.076
2002	0.067	0.064	0.074	0.076	0.080	0.083	0.090	0.093	0.093	0.078	0.073	0.072
2003	0.061	0.057	0.071	0.072	0.076	0.080	0.087	0.088	0.090	0.074	0.068	0.066
2004	0.056	0.052	0.066	0.067	0.070	0.075	0.082	0.082	0.085	0.070	0.063	0.060
2005	0.051	0.046	0.061	0.061	0.065	0.069	0.076	0.077	0.080	0.065	0.059	0.055
2006	0.046	0.041	0.056	0.056	0.060	0.064	0.070	0.071	0.073	0.059	0.053	0.050
2007	0.042	0.036	0.051	0.051	0.055	0.060	0.066	0.066	0.067	0.054	0.048	0.045
2008	0.038	0.033	0.047	0.048	0.053	0.057	0.063	0.063	0.063	0.050	0.045	0.043
2009	0.036	0.031	0.046	0.047	0.051	0.055	0.059	0.059	0.059	0.047	0.043	0.042
2010	0.035	0.031	0.047	0.047	0.050	0.053	0.056	0.056	0.055	0.044	0.041	0.041
2011	0.035	0.031	0.047	0.047	0.049	0.050	0.053	0.052	0.052	0.041	0.040	0.040
2012	0.035	0.031	0.047	0.046	0.048	0.048	0.050	0.049	0.048	0.039	0.038	0.040
2013	0.034	0.031	0.047	0.046	0.046	0.046	0.047	0.046	0.045	0.037	0.036	0.039
2014	0.034	0.030	0.047	0.045	0.045	0.044	0.045	0.043	0.042	0.035	0.035	0.038
2015	0.033	0.030	0.047	0.045	0.044	0.043	0.042	0.040	0.039	0.033	0.034	0.038
Change	-0.045	-0.045	-0.046	-0.054	-0.062	-0.070	-0.080	-0.084	-0.089	-0.081	-0.066	-0.053

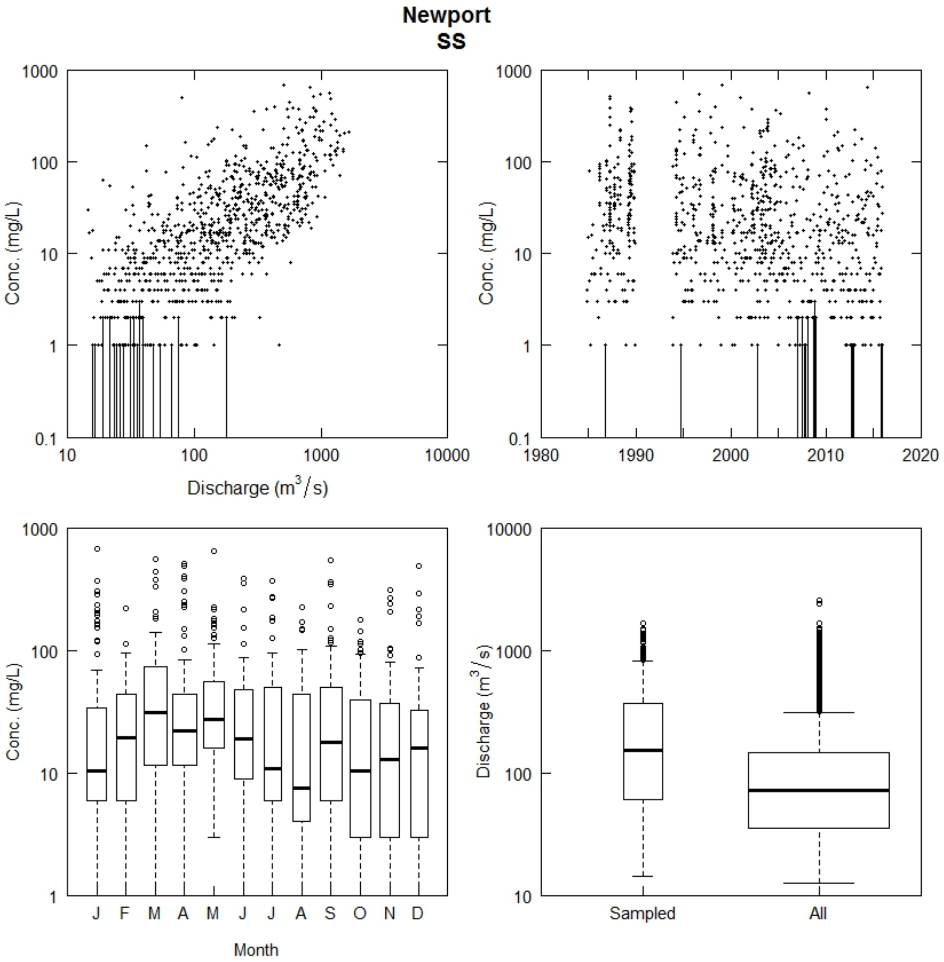


Figure B57. WRTDS Plots of Historical Sample Data

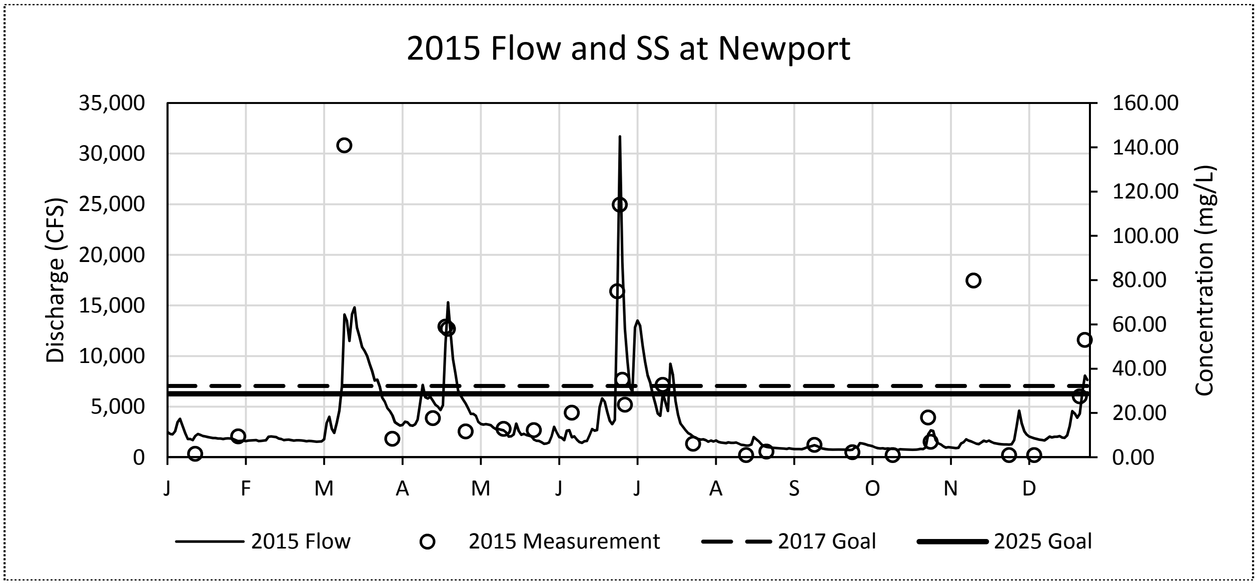


Figure B58. 2015 SS Samples, Daily Average Flow, and Monthly LTM at Newport

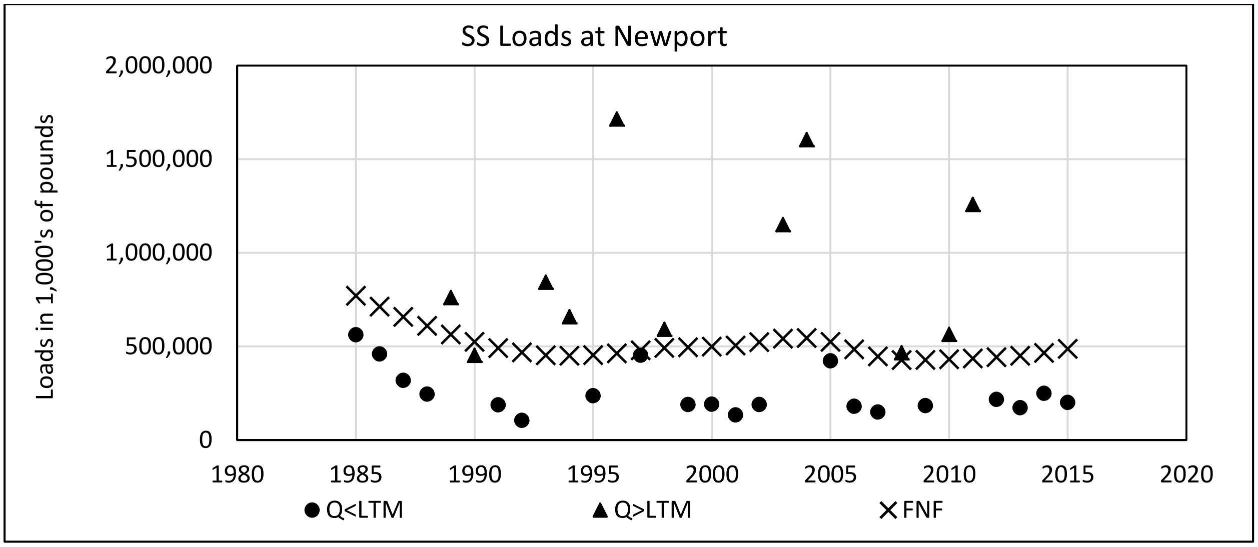


Figure B59. ***SS Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Newport***

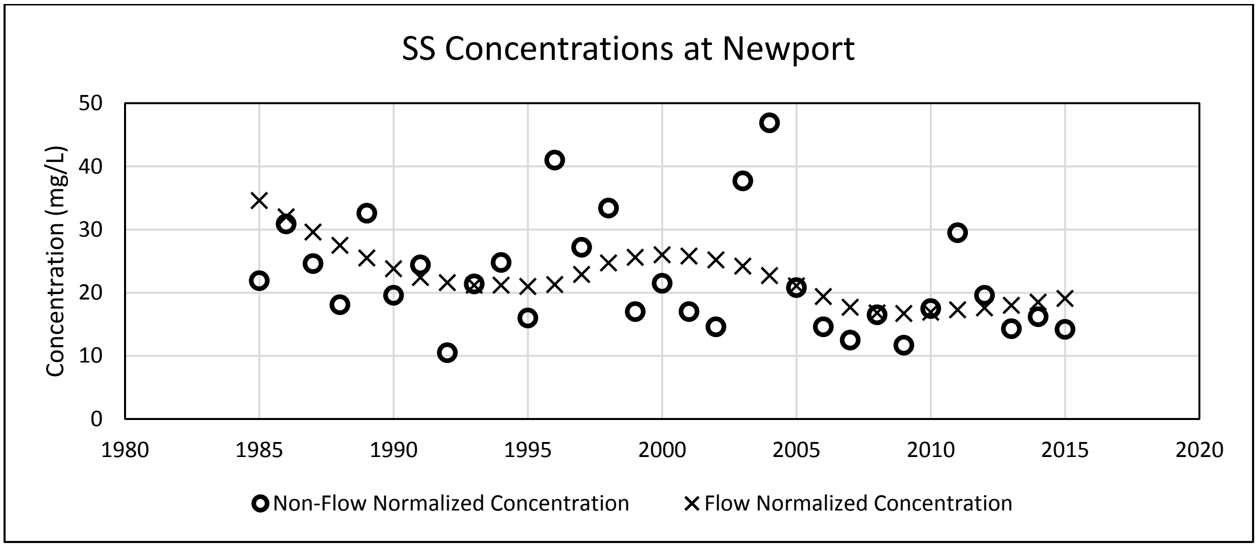
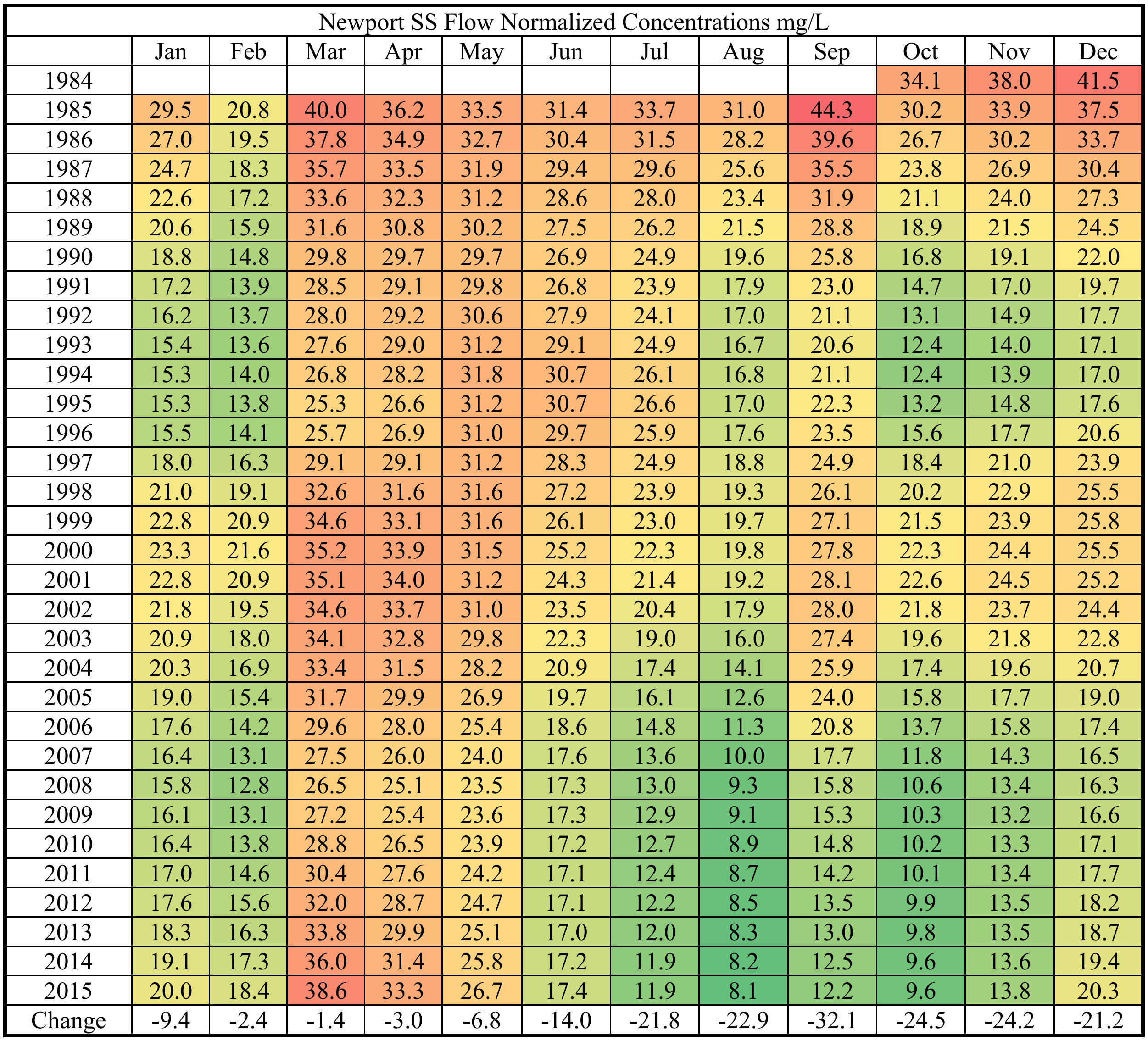


Figure B60. ***SS Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Newport***

Table B54. ***Monthly SS Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)***

Newport	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	2,117	41%	1,941	**37,261**	23,392	20,789	5.1	17.1	32.2	28.6
February	1,718	34%	1,071	16,012	23,392	20,789	4.1	12.1	32.2	28.6
March	7,193	84%	**49,546**	**107,079**	23,392	20,789	**28.8**	**30.7**	32.2	28.6
April	5,811	76%	**28,752**	**44,885**	23,392	20,789	23.2	24.3	32.2	28.6
May	2,613	46%	5,177	**44,907**	23,392	20,789	10.8	25.8	32.2	28.6
June	4,675	141%	**48,096**	17,273	23,392	20,789	23.9	17.1	32.2	28.6
July	6,303	299%	**55,275**	7,846	23,392	20,789	**40.9**	12.2	32.2	28.6
August	1,361	95%	1,787	2,490	23,392	20,789	7.4	7.6	32.2	28.6
September	857	34%	446	**28,344**	23,392	20,789	3.1	11.2	32.2	28.6
October	1,073	47%	880	12,436	23,392	20,789	3.7	10.9	32.2	28.6
November	1,331	37%	849	16,123	23,392	20,789	3.8	11.1	32.2	28.6
December	2,961	57%	6,766	**35,172**	23,392	20,789	9.5	17.8	32.2	28.6
Annual#	3,180	73%	200,585	**369,831**	280,701	249,467	13.7	16.5	32.2	28.6

Table B55. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations



Newport SS Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										34.1	38.0	41.5
1985	29.5	20.8	40.0	36.2	33.5	31.4	33.7	31.0	44.3	30.2	33.9	37.5
1986	27.0	19.5	37.8	34.9	32.7	30.4	31.5	28.2	39.6	26.7	30.2	33.7
1987	24.7	18.3	35.7	33.5	31.9	29.4	29.6	25.6	35.5	23.8	26.9	30.4
1988	22.6	17.2	33.6	32.3	31.2	28.6	28.0	23.4	31.9	21.1	24.0	27.3
1989	20.6	15.9	31.6	30.8	30.2	27.5	26.2	21.5	28.8	18.9	21.5	24.5
1990	18.8	14.8	29.8	29.7	29.7	26.9	24.9	19.6	25.8	16.8	19.1	22.0
1991	17.2	13.9	28.5	29.1	29.8	26.8	23.9	17.9	23.0	14.7	17.0	19.7
1992	16.2	13.7	28.0	29.2	30.6	27.9	24.1	17.0	21.1	13.1	14.9	17.7
1993	15.4	13.6	27.6	29.0	31.2	29.1	24.9	16.7	20.6	12.4	14.0	17.1
1994	15.3	14.0	26.8	28.2	31.8	30.7	26.1	16.8	21.1	12.4	13.9	17.0
1995	15.3	13.8	25.3	26.6	31.2	30.7	26.6	17.0	22.3	13.2	14.8	17.6
1996	15.5	14.1	25.7	26.9	31.0	29.7	25.9	17.6	23.5	15.6	17.7	20.6
1997	18.0	16.3	29.1	29.1	31.2	28.3	24.9	18.8	24.9	18.4	21.0	23.9
1998	21.0	19.1	32.6	31.6	31.6	27.2	23.9	19.3	26.1	20.2	22.9	25.5
1999	22.8	20.9	34.6	33.1	31.6	26.1	23.0	19.7	27.1	21.5	23.9	25.8
2000	23.3	21.6	35.2	33.9	31.5	25.2	22.3	19.8	27.8	22.3	24.4	25.5
2001	22.8	20.9	35.1	34.0	31.2	24.3	21.4	19.2	28.1	22.6	24.5	25.2
2002	21.8	19.5	34.6	33.7	31.0	23.5	20.4	17.9	28.0	21.8	23.7	24.4
2003	20.9	18.0	34.1	32.8	29.8	22.3	19.0	16.0	27.4	19.6	21.8	22.8
2004	20.3	16.9	33.4	31.5	28.2	20.9	17.4	14.1	25.9	17.4	19.6	20.7
2005	19.0	15.4	31.7	29.9	26.9	19.7	16.1	12.6	24.0	15.8	17.7	19.0
2006	17.6	14.2	29.6	28.0	25.4	18.6	14.8	11.3	20.8	13.7	15.8	17.4
2007	16.4	13.1	27.5	26.0	24.0	17.6	13.6	10.0	17.7	11.8	14.3	16.5
2008	15.8	12.8	26.5	25.1	23.5	17.3	13.0	9.3	15.8	10.6	13.4	16.3
2009	16.1	13.1	27.2	25.4	23.6	17.3	12.9	9.1	15.3	10.3	13.2	16.6
2010	16.4	13.8	28.8	26.5	23.9	17.2	12.7	8.9	14.8	10.2	13.3	17.1
2011	17.0	14.6	30.4	27.6	24.2	17.1	12.4	8.7	14.2	10.1	13.4	17.7
2012	17.6	15.6	32.0	28.7	24.7	17.1	12.2	8.5	13.5	9.9	13.5	18.2
2013	18.3	16.3	33.8	29.9	25.1	17.0	12.0	8.3	13.0	9.8	13.5	18.7
2014	19.1	17.3	36.0	31.4	25.8	17.2	11.9	8.2	12.5	9.6	13.6	19.4
2015	20.0	18.4	38.6	33.3	26.7	17.4	11.9	8.1	12.2	9.6	13.8	20.3
Change	-9.4	-2.4	-1.4	-3.0	-6.8	-14.0	-21.8	-22.9	-32.1	-24.5	-24.2	-21.2

Table B56. 2015 Annual and Seasonal Precipitation and Discharge at Conestoga

Season	Precipitation (inches)			Discharge (cfs)		
	2015	LTM	LTM Departure	2015	LTM	% LTM
January-March (Winter)	7.36	8.78	-1.42	925	905	102
April-June (Spring)	10.95	11.13	-0.18	558	739	76
July-September (Summer)	14.56	12.71	1.85	487	487	100
October-December (Fall)	8.58	10.91	-2.33	453	651	70
Annual Total	41.45	43.54	-2.09	604	694	87

Table B57. 2015 Annual Loads (1000's lbs), Yields (lbs/acre), and Concentrations (mg/L) at Conestoga

Parameter	Load	Load % of LTM	Yield	LTM Yield	Ave. Conc.	Conc. % of LTM
TN	7,181	71%	1.44	2.02	6.04	82%
TNO_x	6,374	78%	1.28	1.64	5.36	90%
TON	764	44%	0.15	0.35	0.64	50%
TNH_3	111	49%	0.02	0.05	0.09	57%
DN	6,894	75%	1.38	1.84	5.80	86%
DNO_x	6,383	80%	1.28	1.61	5.37	91%
DON	511	48%	0.10	0.21	0.43	55%
DNH_3	107	51%	0.02	0.04	0.09	59%
TP	290	48%	0.06	0.12	0.24	55%
DP	191	72%	0.04	0.05	0.16	83%
DOP	175	78%	0.04	0.04	0.15	90%
TOC	4,345	59%	0.87	1.48	3.65	68%
SS	63,624	24%	12.75	52.92	53.49	28%

Table B58. 2015 Seasonal Loads (1000's lbs) and Yields (lbs/acre) at Conestoga

Parameter	Winter		Spring		Summer		Fall	
	Load	Yield	Load	Yield	Load	Yield	Load	Yield
TN	2,742	0.55	1,645	0.33	1,342	0.27	1,452	0.29
TNO_x	2,349	0.47	1,492	0.30	1,188	0.24	1,344	0.27
TON	337	0.07	153	0.03	157	0.03	117	0.02
TNH_3	65	0.01	19	0.00	16	0.00	12	0.00
DN	2,575	0.52	1,602	0.32	1,289	0.26	1,429	0.29
DNO_x	2,349	0.47	1,493	0.30	1,191	0.24	1,350	0.27
DON	187	0.04	121	0.02	105	0.02	97	0.02
DNH_3	61	0.01	18	0.00	16	0.00	11	0.00
TP	124	0.02	52	0.01	72	0.01	43	0.01
DP	63	0.01	38	0.01	55	0.01	36	0.01
DOP	57	0.01	35	0.01	51	0.01	32	0.01
TOC	1,944	0.39	848	0.17	904	0.18	648	0.13
SS	43,323	8.68	6,776	1.36	10,084	2.02	3,440	0.69

Table B59. 2015 Monthly Average Precipitation (in), High Daily Precipitation During Month (in), Flow (cfs), Loads (1000's lbs), and Yields (lbs/acre) at Conestoga

Mon	Precip			Flow		TN			TP			SS		
	Ave	Max	% LTM	2014	% LTM	Load	Yield	% LTM	Load	Yield	% LTM	Load	Yield	% LTM
Jan	2.50	0.69	80%	585	73%	694	0.14	64%	13	0.003	23%	1,177	0.2	5%
Feb	0.93	0.40	41%	454	56%	492	0.10	49%	7	0.001	16%	653	0.1	3%
Mar	3.93	0.75	116%	1,690	155%	1,557	0.31	112%	104	0.021	132%	41,493	8.3	99%
Apr	1.95	0.60	61%	704	80%	713	0.14	67%	17	0.003	34%	2,241	0.4	10%
May	1.42	0.44	37%	368	51%	383	0.08	43%	9	0.002	19%	676	0.1	3%
Jun	7.58	1.68	186%	608	98%	549	0.11	80%	25	0.005	51%	3,859	0.8	18%
Jul	6.61	2.99	147%	584	110%	533	0.11	88%	29	0.006	59%	4,181	0.8	18%
Aug	1.50	0.69	45%	359	90%	346	0.07	76%	15	0.003	49%	1,050	0.2	12%
Sept	6.45	2.36	132%	521	97%	464	0.09	84%	28	0.006	52%	4,853	1.0	18%
Oct	3.42	1.17	81%	530	97%	527	0.11	85%	21	0.004	45%	1,671	0.3	10%
Nov	1.19	0.41	35%	301	51%	337	0.07	47%	7	0.001	16%	248	0.0	2%
Dec	3.97	0.75	120%	523	65%	588	0.12	57%	15	0.003	25%	1,521	0.3	7%

Table B60. Trend Statistics for the Conestoga River at Conestoga, Pa., October 1984 Through September 2015

Conestoga	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
FLOW / 60	SMK	-	-	-	0.074	NS	-	-	-
TN / 600	FNC	-2.300	-0.077	-27	<0.05	Down	0.99	HL	Down
	FNF	-1.87	-0.062	-34	<0.05	Down	0.99	HL	Down
TNO_x / 630	FNC	-1.170	-0.039	-17	<0.05	Down	0.99	HL	Down
	FNF	-0.80	-0.027	-20	<0.05	Down	0.99	HL	Down
TON / 605	FNC	-0.844	-0.028	-61	<0.05	Down	0.99	HL	Down
	FNF	-0.89	-0.03	-66	0.061	Down	0.97	HL	Down
TNH_3 / 610	FNC	-0.329	-0.011	-83	<0.05	Down	0.99	HL	Down
	FNF	-0.26	-0.0086	-80	<0.05	Down	0.99	HL	Down
DN / 602	FNC	-1.600	-0.053	-21	<0.05	Down	0.97	HL	Down
	FNF	-1.16	-0.039	-25	<0.05	Down	0.99	HL	Down
DNO_x / 631	FNC	-1.060	-0.035	-16	<0.05	Down	0.99	HL	Down
	FNF	-0.73	-0.024	-19	<0.05	Down	0.99	HL	Down
DON / 607	FNC	-0.345	-0.011	-44	<0.05	Down	0.99	HL	Down
	FNF	-0.26	-0.0085	-48	<0.05	Down	0.99	HL	Down
DNH_3 / 608	FNC	-0.309	-0.01	-83	<0.05	Down	0.99	HL	Down
	FNF	-0.24	-0.0082	-80	<0.05	Down	0.99	HL	Down
TP / 665	FNC	-0.338	-0.011	-62	<0.05	Down	0.99	HL	Down
	FNF	-0.24	-0.0079	-56	0.07	Down	0.97	HL	Down
DP / 666	FNC	-0.186	-0.0062	-54	<0.05	Down	0.99	HL	Down
	FNF	-0.08	-0.0026	-41	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.192	-0.0064	-58	<0.05	Down	1.00	HL	Down
	FNF	-0.06	-0.0021	-38	0.086	Down	0.96	HL	Down
TOC / 680	FNC	-5.650	-0.19	-65	<0.05	Down	0.99	HL	Down
	FNF	-3.94	-0.13	-60	<0.05	Down	0.99	HL	Down
SSC / 80154	FNC	-100.0	-3.3	-79	0.12	NS	0.95	VL	Down
	FNF	-193	-6.4	-78	0.19	NS	0.91	VL	Down

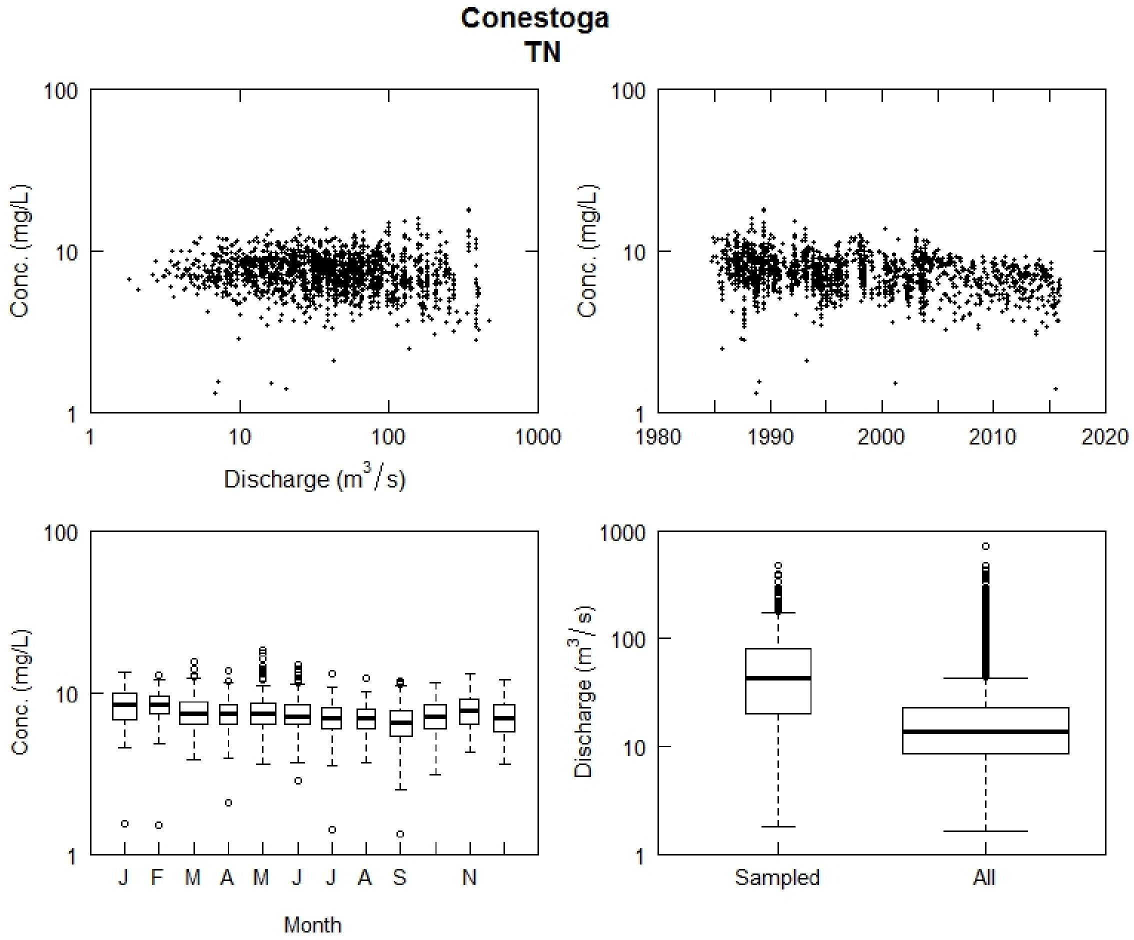


Figure B61. WRTDS Plots of Historical Sample Data

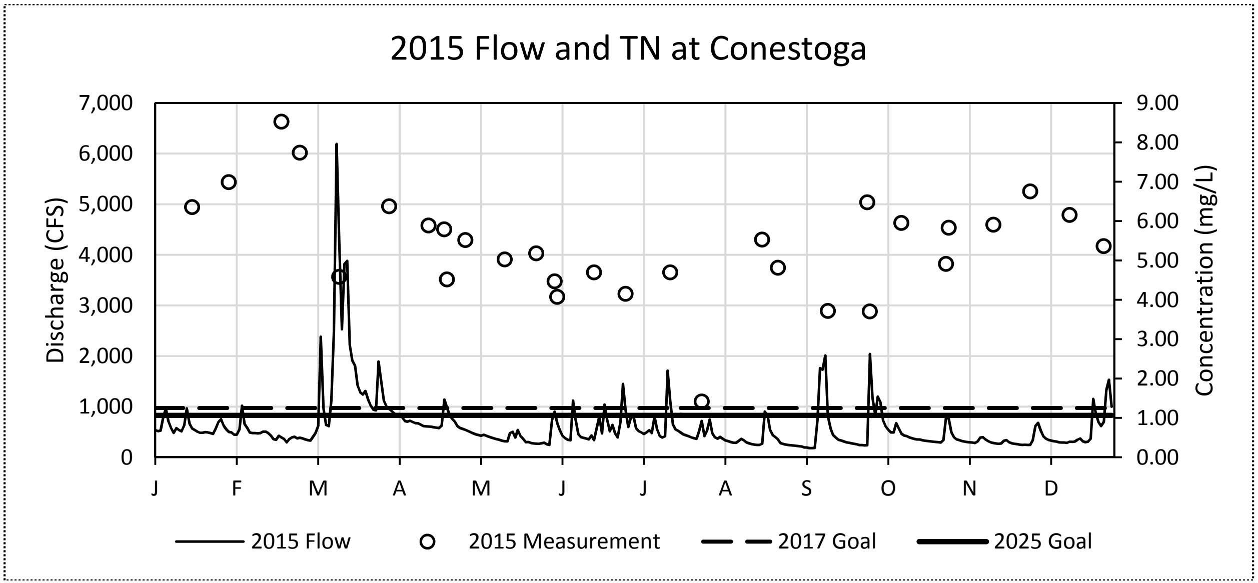


Figure B62. 2015 TN Samples, Daily Average Flow, and Monthly LTM at Conestoga

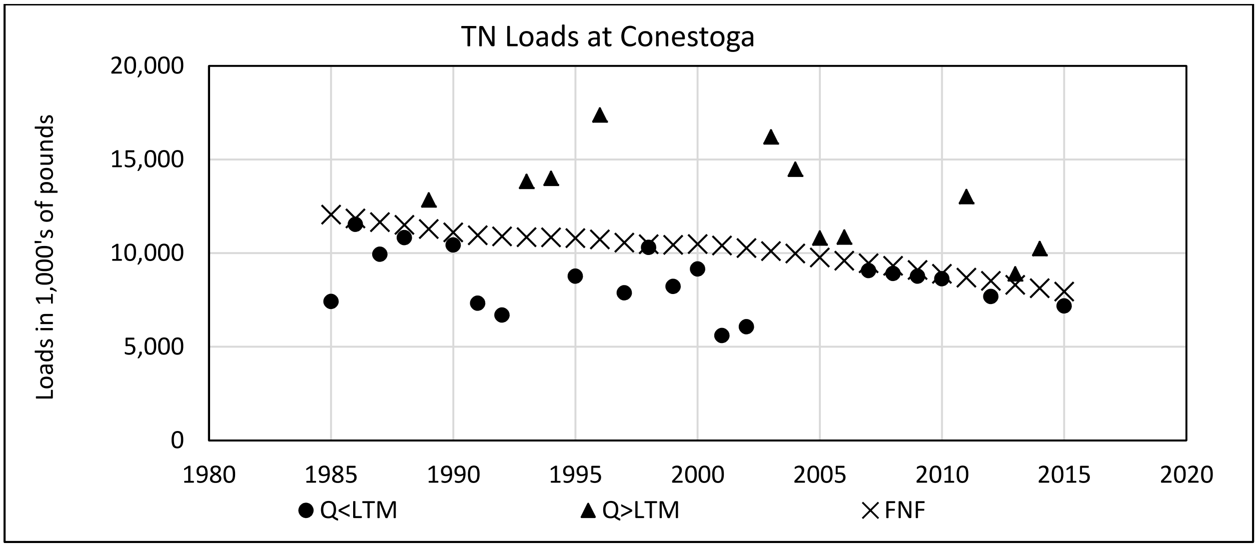


Figure B63. ***TN Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Conestoga***

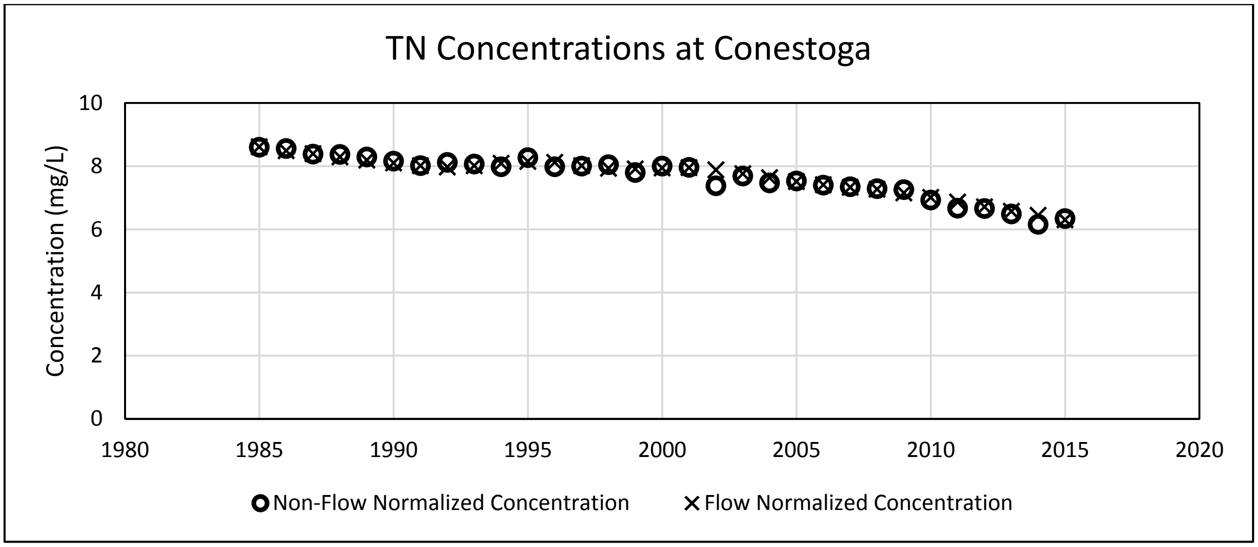


Figure B64. TN Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Conestoga

Table B61. Monthly TN Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Conestoga	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	585	73%	**694**	**1,083**	143	121	**7.13**	**7.78**	1.25	1.06
February	454	56%	**492**	**925**	143	121	**7.21**	**7.61**	1.25	1.06
March	1,690	155%	**1,557**	**1,215**	143	121	**6.00**	**7.04**	1.25	1.06
April	704	80%	**713**	**971**	143	121	**6.28**	**6.78**	1.25	1.06
May	368	51%	**383**	**734**	143	121	**6.23**	**6.54**	1.25	1.06
June	608	98%	**549**	**659**	143	121	**5.67**	**6.31**	1.25	1.06
July	584	110%	**533**	**543**	143	121	**5.53**	**6.29**	1.25	1.06
August	359	90%	**346**	**397**	143	121	**5.86**	**6.43**	1.25	1.06
September	521	97%	**464**	**523**	143	121	**6.00**	**6.53**	1.25	1.06
October	530	97%	**527**	**722**	143	121	**6.12**	**6.70**	1.25	1.06
November	301	51%	**337**	**681**	143	121	**6.95**	**7.26**	1.25	1.06
December	523	65%	**588**	**1,007**	143	121	**6.99**	**7.40**	1.25	1.06
Annual#	604	87%	**7,181**	**9,461**	1,713	1,452	**6.33**	**6.89**	1.25	1.06

Table B62. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Conestoga TN Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										7.89	8.46	9.11
1985	9.73	9.84	9.68	9.23	8.71	8.14	7.67	7.46	7.46	7.80	8.32	8.93
1986	9.53	9.65	9.50	9.10	8.62	8.08	7.64	7.44	7.42	7.71	8.20	8.77
1987	9.34	9.47	9.33	8.97	8.53	8.02	7.61	7.41	7.38	7.64	8.08	8.61
1988	9.17	9.30	9.16	8.83	8.42	7.96	7.57	7.39	7.35	7.57	7.96	8.46
1989	9.00	9.13	9.01	8.72	8.35	7.91	7.55	7.39	7.32	7.49	7.83	8.29
1990	8.81	8.95	8.85	8.60	8.27	7.87	7.54	7.40	7.32	7.42	7.69	8.10
1991	8.59	8.75	8.69	8.50	8.21	7.85	7.55	7.46	7.37	7.42	7.60	7.94
1992	8.42	8.61	8.58	8.42	8.15	7.82	7.58	7.57	7.54	7.55	7.67	7.95
1993	8.41	8.62	8.58	8.41	8.13	7.83	7.64	7.71	7.73	7.74	7.83	8.07
1994	8.49	8.69	8.61	8.41	8.11	7.82	7.66	7.80	7.87	7.90	8.00	8.22
1995	8.58	8.74	8.61	8.41	8.11	7.81	7.66	7.84	7.94	7.98	8.08	8.25
1996	8.53	8.62	8.47	8.26	8.00	7.76	7.66	7.87	7.96	8.01	8.12	8.22
1997	8.36	8.37	8.18	7.97	7.78	7.67	7.65	7.87	7.97	8.07	8.22	8.28
1998	8.29	8.16	7.90	7.66	7.55	7.57	7.64	7.88	7.99	8.15	8.39	8.45
1999	8.33	8.06	7.70	7.41	7.38	7.51	7.65	7.90	8.01	8.24	8.56	8.65
2000	8.45	8.06	7.59	7.29	7.32	7.51	7.67	7.90	7.99	8.30	8.68	8.80
2001	8.56	8.09	7.56	7.25	7.29	7.49	7.62	7.82	7.89	8.24	8.67	8.80
2002	8.56	8.08	7.52	7.22	7.23	7.39	7.49	7.66	7.73	8.08	8.50	8.65
2003	8.49	8.04	7.49	7.18	7.15	7.25	7.32	7.46	7.51	7.86	8.31	8.52
2004	8.43	8.04	7.47	7.15	7.07	7.11	7.14	7.23	7.27	7.62	8.12	8.41
2005	8.41	8.06	7.47	7.12	6.98	6.97	6.95	7.02	7.05	7.40	7.95	8.29
2006	8.38	8.07	7.46	7.10	6.91	6.84	6.79	6.84	6.91	7.26	7.80	8.16
2007	8.33	8.09	7.47	7.11	6.88	6.74	6.66	6.73	6.83	7.18	7.69	8.01
2008	8.24	8.05	7.44	7.12	6.85	6.65	6.57	6.66	6.80	7.11	7.57	7.83
2009	8.04	7.87	7.31	7.03	6.77	6.55	6.47	6.58	6.73	7.01	7.44	7.65
2010	7.85	7.68	7.17	6.91	6.63	6.41	6.33	6.46	6.61	6.89	7.29	7.47
2011	7.66	7.50	7.01	6.76	6.49	6.26	6.18	6.33	6.49	6.76	7.14	7.30
2012	7.48	7.32	6.85	6.61	6.34	6.12	6.05	6.22	6.38	6.64	7.00	7.14
2013	7.31	7.15	6.70	6.47	6.21	5.99	5.93	6.10	6.27	6.52	6.86	6.99
2014	7.14	6.98	6.54	6.32	6.07	5.87	5.82	6.00	6.16	6.40	6.73	6.84
2015	6.98	6.82	6.39	6.18	5.94	5.75	5.71	5.89	6.05	6.29	6.60	6.69
Change	-2.75	-3.02	-3.29	-3.06	-2.77	-2.38	-1.97	-1.57	-1.40	-1.60	-1.86	-2.42

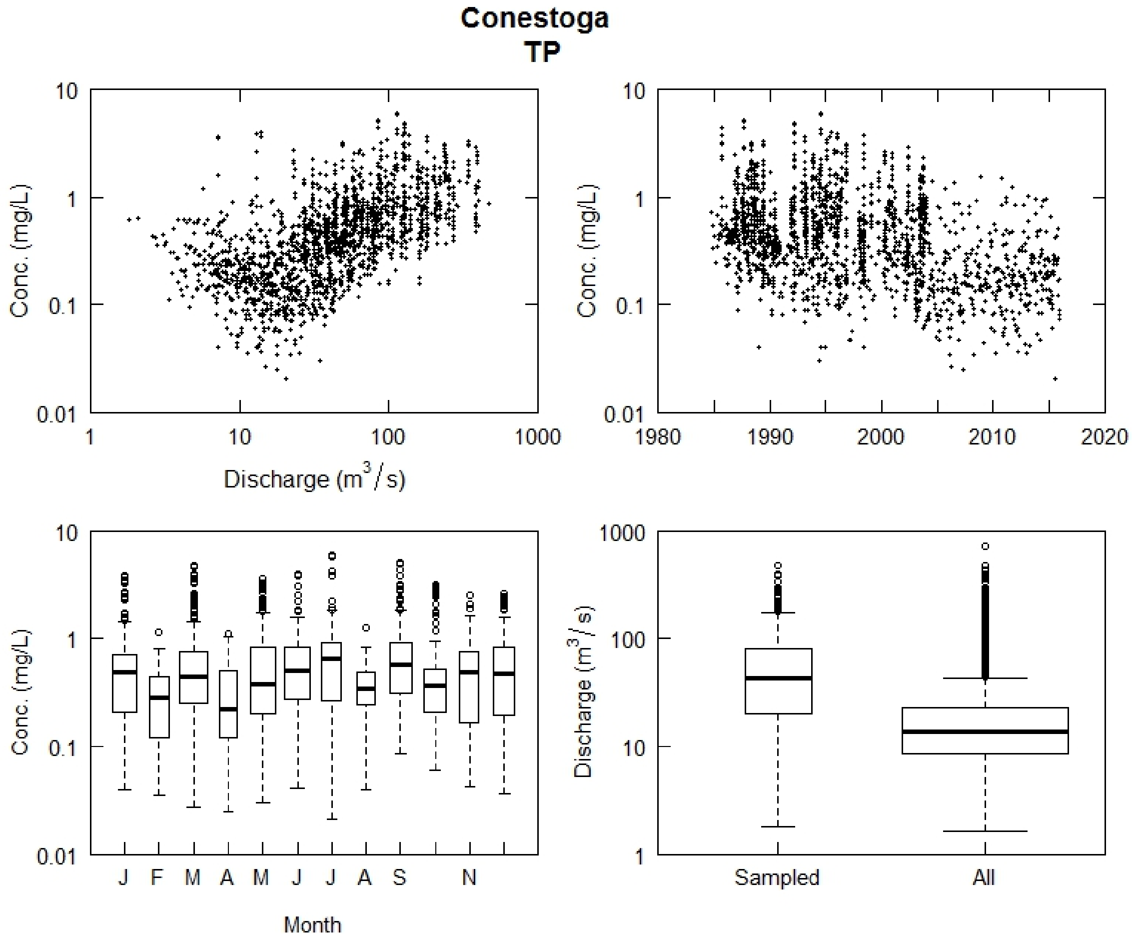


Figure B65. WRTDS Plots of Historical Sample Data

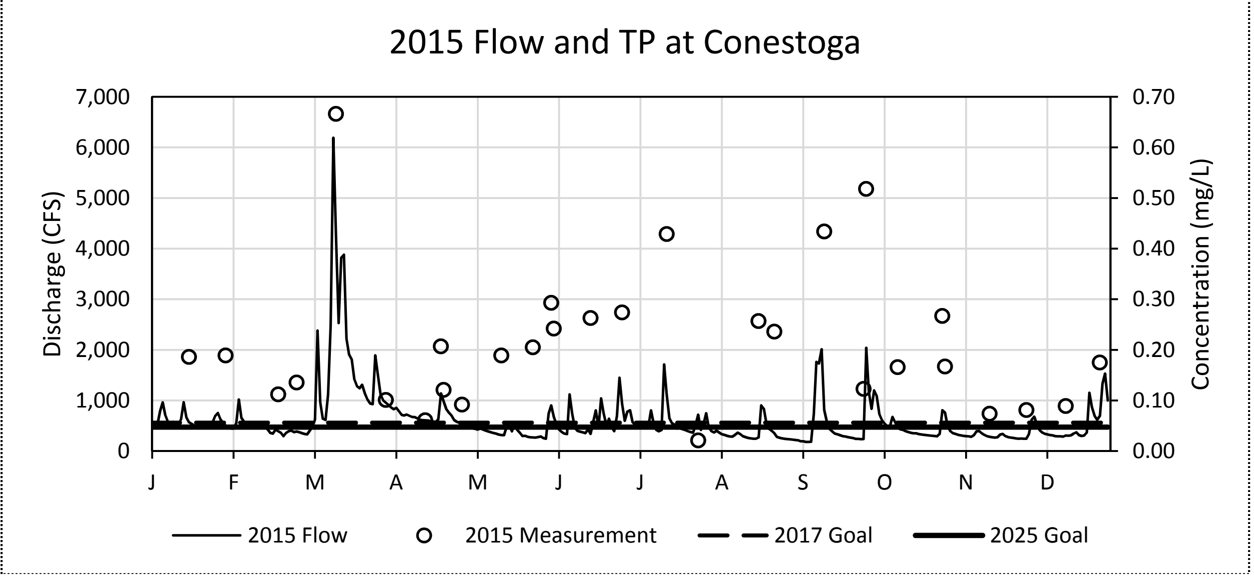


Figure B66. 2015 TP Samples, Daily Average Flow, and Monthly LTM at Conestoga

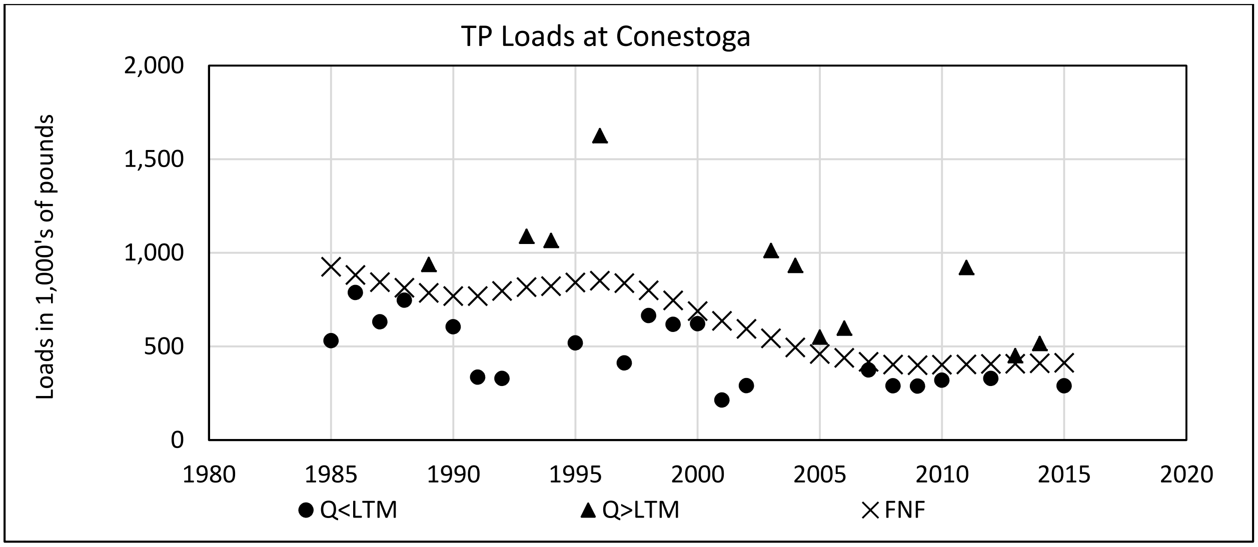


Figure B67. ***TP Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Conestoga***

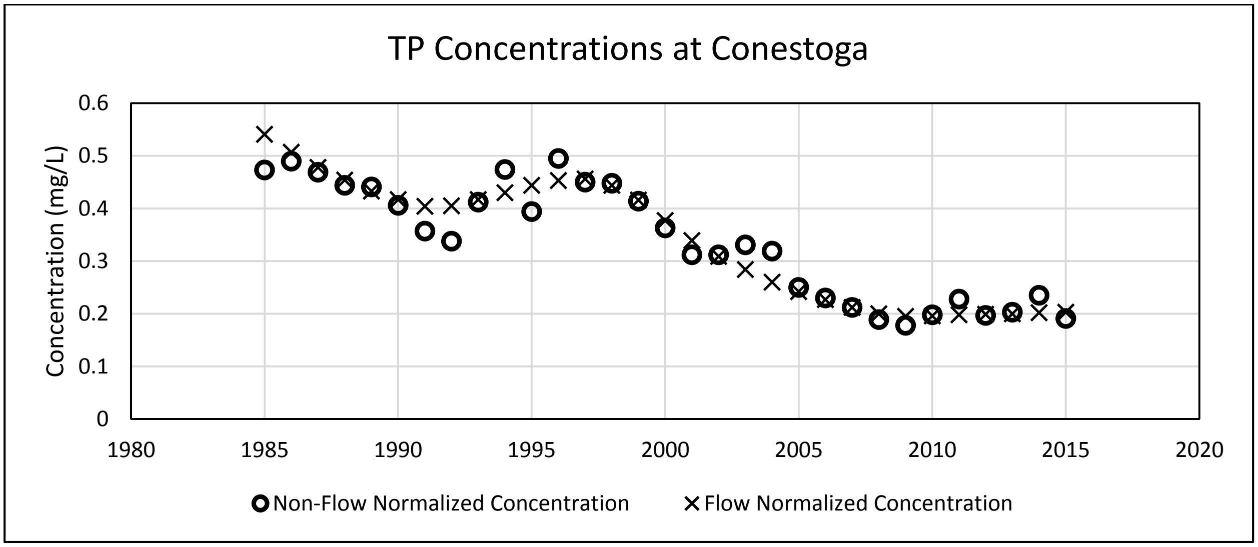


Figure B68. ***TP Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Conestoga***

Table B63. Monthly TP Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Conestoga	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	585	73%	**13**	**34**	6	5	**0.125**	**0.157**	0.056	0.047
February	454	56%	**7**	**22**	6	5	**0.101**	**0.138**	0.056	0.047
March	1,690	155%	**104**	**54**	6	5	**0.250**	**0.178**	0.056	0.047
April	704	80%	**17**	**39**	6	5	**0.148**	**0.181**	0.056	0.047
May	368	51%	**9**	**31**	6	5	**0.152**	**0.196**	0.056	0.047
June	608	98%	**25**	**44**	6	5	**0.233**	**0.241**	0.056	0.047
July	584	110%	**29**	**29**	6	5	**0.273**	**0.266**	0.056	0.047
August	359	90%	**15**	**20**	6	5	**0.246**	**0.256**	0.056	0.047
September	521	97%	**28**	**52**	6	5	**0.248**	**0.261**	0.056	0.047
October	530	97%	**21**	**59**	6	5	**0.211**	**0.242**	0.056	0.047
November	301	51%	**7**	**29**	6	5	**0.143**	**0.187**	0.056	0.047
December	523	65%	**15**	**35**	6	5	**0.146**	**0.185**	0.056	0.047
Annual#	604	87%	**290**	**448**	76	65	**0.190**	**0.207**	0.056	0.047

Table B64. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Conestoga TP Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										0.556	0.503	0.505
1985	0.446	0.414	0.471	0.467	0.537	0.632	0.691	0.655	0.604	0.516	0.471	0.477
1986	0.422	0.392	0.448	0.444	0.507	0.594	0.644	0.606	0.558	0.482	0.443	0.452
1987	0.401	0.373	0.428	0.423	0.482	0.561	0.605	0.563	0.519	0.453	0.419	0.432
1988	0.383	0.356	0.410	0.408	0.463	0.535	0.572	0.527	0.486	0.428	0.400	0.415
1989	0.368	0.342	0.395	0.392	0.443	0.511	0.545	0.497	0.458	0.406	0.383	0.400
1990	0.356	0.332	0.383	0.381	0.430	0.493	0.524	0.472	0.435	0.388	0.370	0.391
1991	0.350	0.327	0.375	0.372	0.418	0.479	0.507	0.452	0.418	0.377	0.370	0.399
1992	0.365	0.340	0.377	0.372	0.415	0.474	0.502	0.444	0.423	0.394	0.407	0.442
1993	0.404	0.367	0.381	0.365	0.403	0.462	0.497	0.441	0.431	0.413	0.445	0.483
1994	0.438	0.388	0.381	0.356	0.392	0.456	0.506	0.451	0.441	0.432	0.477	0.517
1995	0.467	0.405	0.382	0.349	0.385	0.460	0.525	0.467	0.451	0.445	0.495	0.538
1996	0.484	0.412	0.382	0.347	0.385	0.466	0.534	0.479	0.461	0.456	0.505	0.546
1997	0.489	0.416	0.385	0.348	0.385	0.460	0.524	0.480	0.468	0.462	0.500	0.533
1998	0.475	0.407	0.381	0.346	0.375	0.436	0.489	0.460	0.463	0.455	0.475	0.490
1999	0.437	0.379	0.368	0.334	0.349	0.391	0.435	0.427	0.447	0.434	0.429	0.425
2000	0.378	0.335	0.344	0.311	0.314	0.344	0.385	0.395	0.426	0.403	0.373	0.356
2001	0.315	0.288	0.315	0.286	0.285	0.311	0.354	0.373	0.406	0.371	0.326	0.304
2002	0.264	0.245	0.286	0.266	0.268	0.294	0.337	0.357	0.384	0.343	0.294	0.270
2003	0.227	0.211	0.256	0.245	0.253	0.282	0.322	0.338	0.358	0.313	0.265	0.241
2004	0.199	0.184	0.227	0.223	0.238	0.270	0.308	0.319	0.333	0.289	0.243	0.219
2005	0.180	0.165	0.207	0.207	0.224	0.256	0.293	0.300	0.311	0.269	0.225	0.203
2006	0.166	0.153	0.196	0.196	0.213	0.246	0.280	0.282	0.288	0.247	0.207	0.189
2007	0.153	0.139	0.179	0.181	0.201	0.237	0.271	0.268	0.266	0.225	0.190	0.178
2008	0.143	0.128	0.166	0.168	0.191	0.231	0.264	0.257	0.250	0.209	0.178	0.172
2009	0.141	0.127	0.163	0.162	0.186	0.228	0.263	0.256	0.247	0.208	0.177	0.173
2010	0.144	0.130	0.165	0.163	0.187	0.229	0.265	0.258	0.247	0.208	0.179	0.175
2011	0.146	0.133	0.167	0.166	0.189	0.231	0.266	0.258	0.247	0.208	0.180	0.178
2012	0.149	0.136	0.170	0.169	0.192	0.233	0.267	0.258	0.246	0.208	0.181	0.180
2013	0.152	0.138	0.173	0.170	0.192	0.233	0.267	0.258	0.246	0.209	0.182	0.182
2014	0.154	0.141	0.175	0.172	0.194	0.234	0.268	0.258	0.246	0.210	0.184	0.185
2015	0.157	0.144	0.177	0.174	0.195	0.235	0.269	0.259	0.246	0.211	0.186	0.188
Change	-0.289	-0.270	-0.293	-0.293	-0.342	-0.398	-0.422	-0.396	-0.357	-0.345	-0.317	-0.317

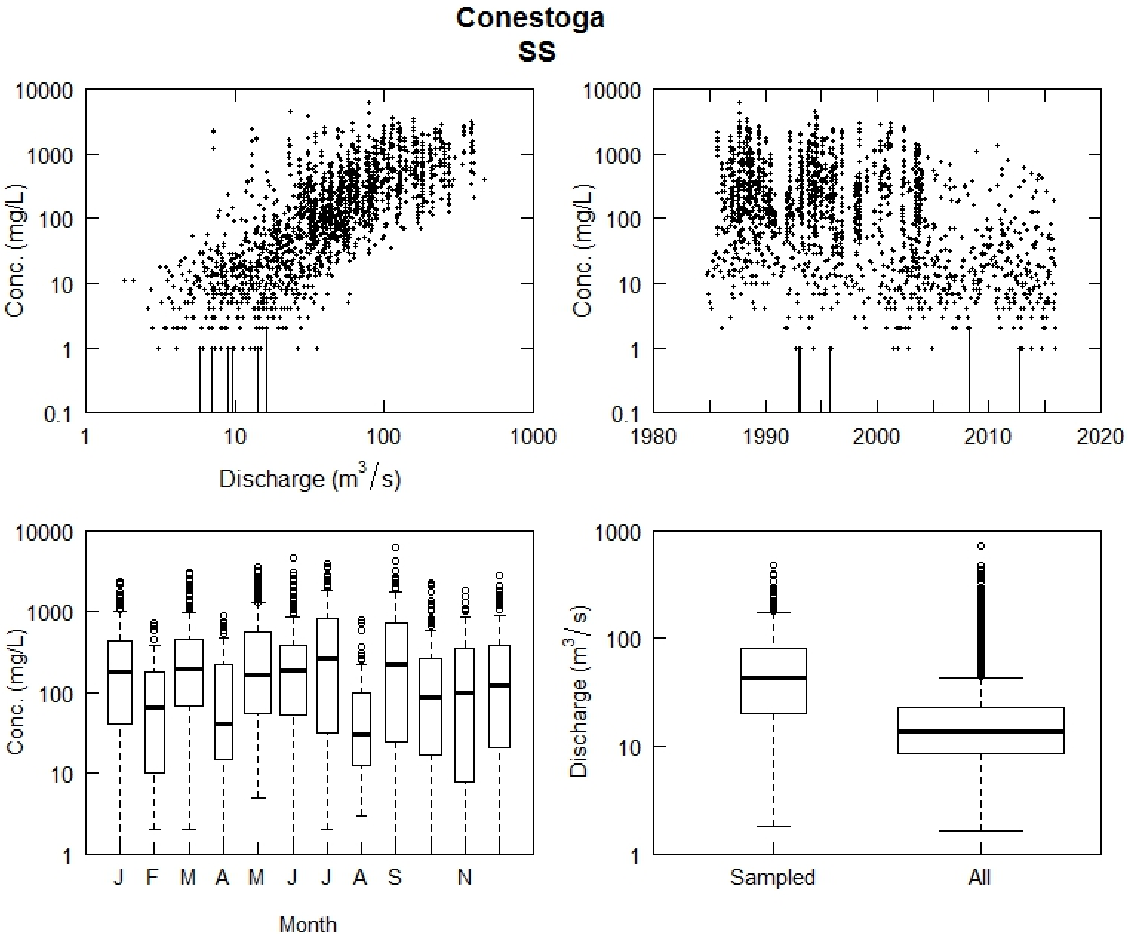


Figure B69. WRTDS Plots of Historical Sample Data

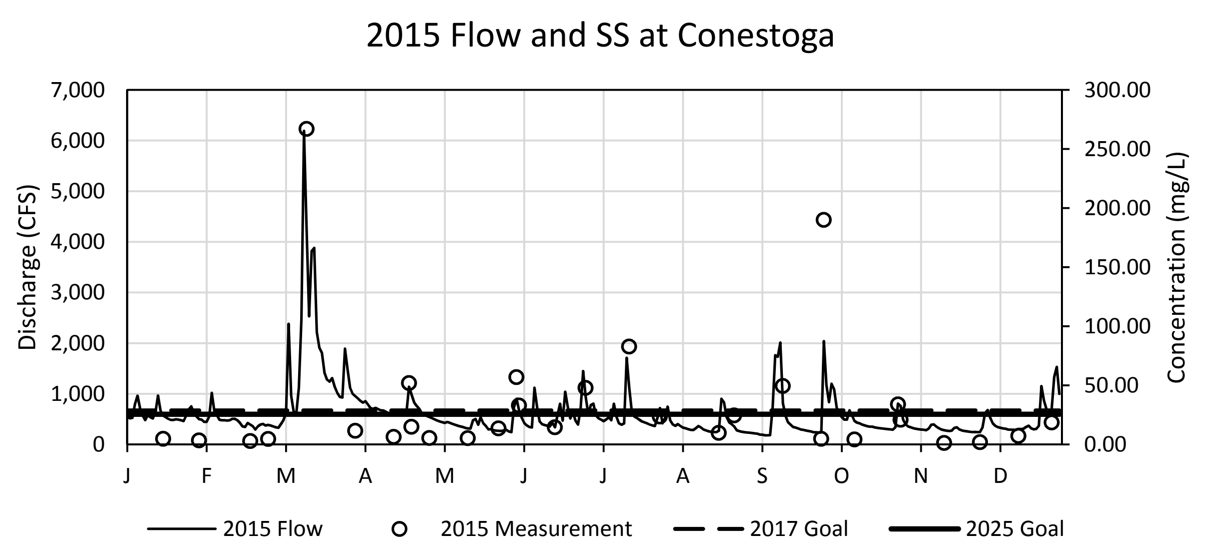


Figure B70. 2015 SS Samples, Daily Average Flow, and Monthly LTM at Conestoga

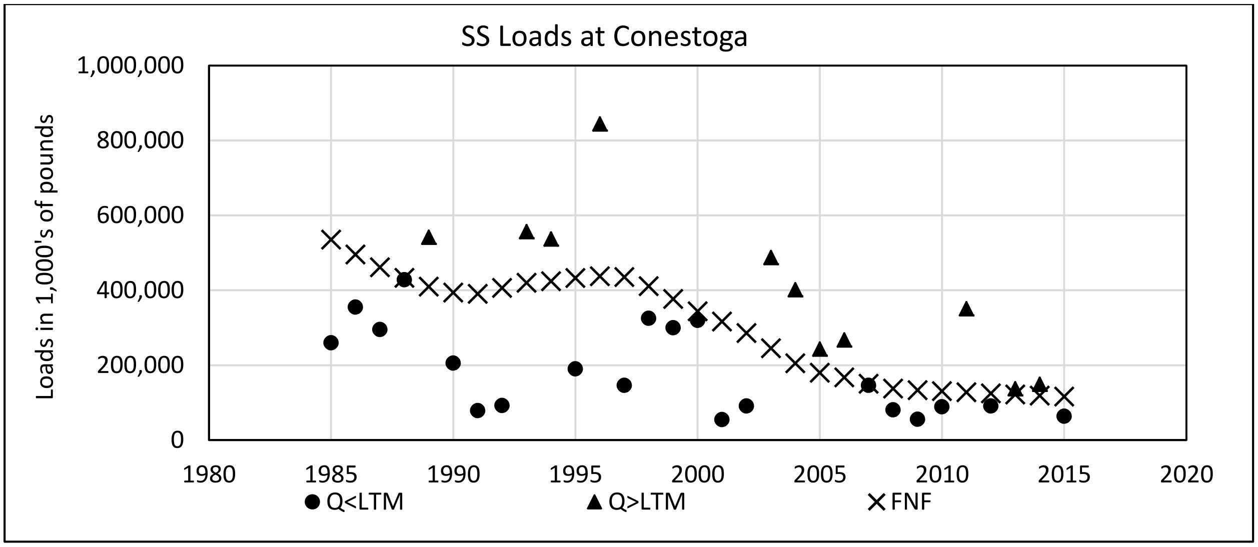


Figure B71. *SS Annual (Above Flow LTM and Below Flow LTM) and Flow Normalized Fluxes (1000's of lbs) at Conestoga*

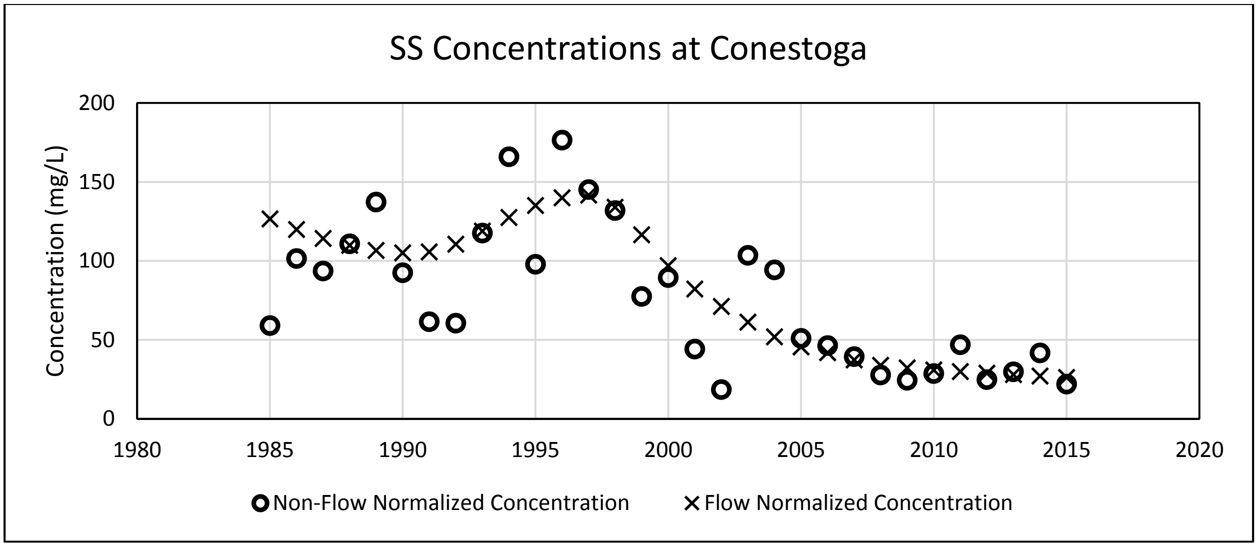


Figure B72. *SS Annual Calculated, Flow Adjusted, and Flow Normalized Concentrations (mg/L) at Conestoga*

Table B65. Monthly SS Load (1000's of Pounds) Comparisons to Targets (Shaded Cells Have Values Above Either 2017, 2025, or Both Targets)

Conestoga	Flow		Loads				Concentrations			
	2015	% LTM	2015	10 Yr Ave	2017	2025	2015	10 Yr Ave	2017	2025
January	585	73%	**1,177**	**11,464**	3,278	2,913	11.2	**33.2**	29	25
February	454	56%	653	**6,320**	3,278	2,913	8.4	**28.6**	29	25
March	1,690	155%	**41,493**	**23,188**	3,278	2,913	**77.9**	**50.0**	29	25
April	704	80%	2,241	**15,006**	3,278	2,913	18.5	**44.8**	29	25
May	368	51%	676	**8,617**	3,278	2,913	10.5	**34.9**	29	25
June	608	98%	**3,859**	**18,713**	3,278	2,913	**30.0**	**41.4**	29	25
July	584	110%	**4,181**	**6,240**	3,278	2,913	**31.7**	**35.9**	29	25
August	359	90%	1,050	**3,522**	3,278	2,913	13.9	21.7	29	25
September	521	97%	**4,853**	**20,164**	3,278	2,913	21.8	**29.4**	29	25
October	530	97%	1,671	**22,301**	3,278	2,913	13.6	**32.9**	29	25
November	301	51%	248	**8,285**	3,278	2,913	5.0	22.9	29	25
December	523	65%	1,521	**8,368**	3,278	2,913	10.8	**30.0**	29	25
Annual#	604	87%	**63,624**	**152,188**	39,335	34,958	21.1	**33.8**	29	25

Table B66. Color Conditioned Heat Chart of Historical Flow Normalized Concentrations

Conestoga SS Flow Normalized Concentrations mg/L												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984										82.0	79.4	115.6
1985	107.0	100.3	185.7	156.7	164.3	174.1	156.3	94.4	99.9	77.9	74.8	107.5
1986	98.6	93.2	171.6	148.9	157.7	167.8	151.0	91.0	95.4	74.4	70.8	100.4
1987	91.3	87.0	159.2	142.1	152.2	162.8	146.9	88.4	91.9	71.5	67.6	94.3
1988	85.1	81.8	149.2	137.7	149.1	159.8	144.3	86.4	89.2	69.3	65.0	89.4
1989	80.1	78.1	140.3	133.2	145.9	157.6	143.4	85.9	87.9	67.9	63.3	85.6
1990	76.8	76.3	134.7	132.0	145.7	157.5	143.9	86.1	87.7	67.1	62.6	83.5
1991	76.1	77.8	133.0	133.8	147.3	159.1	146.6	88.2	90.5	68.1	64.6	86.2
1992	82.4	87.5	139.0	141.0	151.8	163.1	151.9	92.6	97.8	74.3	74.6	99.9
1993	100.5	106.6	148.7	145.4	151.6	163.4	157.0	98.0	104.7	81.0	86.1	117.0
1994	122.1	126.3	157.8	146.5	149.5	164.3	165.7	104.9	107.5	86.4	96.5	134.0
1995	143.1	144.6	166.4	146.2	146.5	165.7	172.9	109.9	108.3	89.9	104.4	148.6
1996	159.1	156.4	175.2	148.3	145.9	164.9	170.5	108.5	106.8	92.4	109.3	159.1
1997	168.8	165.7	186.6	153.2	146.0	158.6	158.5	100.6	101.2	89.0	104.2	155.8
1998	166.9	167.2	193.6	154.1	138.0	138.9	130.6	82.9	87.6	78.5	88.8	133.9
1999	146.7	152.1	189.5	145.6	119.9	110.7	98.0	63.3	72.6	66.3	71.3	106.5
2000	118.3	126.6	175.3	129.2	99.5	86.3	74.3	49.1	60.6	55.5	56.5	84.0
2001	93.4	102.2	157.8	114.4	86.8	74.3	64.1	42.7	54.2	48.4	47.0	69.5
2002	75.4	82.5	137.2	100.7	78.3	67.6	58.6	39.1	49.8	43.4	40.9	58.5
2003	60.9	66.3	115.0	86.8	69.4	60.6	52.7	35.6	44.1	37.9	34.9	48.5
2004	49.4	53.1	93.0	71.9	59.6	53.5	47.2	32.5	39.6	34.2	31.1	42.2
2005	42.6	45.1	78.6	61.5	52.1	47.9	43.3	30.5	37.2	32.3	29.4	39.0
2006	38.7	39.9	70.3	54.9	47.6	44.8	40.9	28.7	34.5	29.9	27.6	36.2
2007	33.9	33.0	57.2	45.8	42.3	42.1	39.3	27.1	31.6	27.3	25.9	34.2
2008	31.3	28.8	48.5	38.8	37.8	39.9	37.9	25.5	29.0	24.9	24.3	33.1
2009	31.0	28.3	46.3	36.0	35.4	38.3	36.9	24.3	27.2	22.8	22.2	30.9
2010	29.7	27.4	45.2	34.8	34.2	37.3	36.1	23.4	26.1	21.5	20.7	29.3
2011	28.5	26.4	44.1	34.0	33.4	36.3	35.1	22.5	25.1	20.5	19.7	28.1
2012	27.6	25.6	43.2	33.5	32.8	35.5	34.0	21.4	23.9	19.4	18.7	27.0
2013	26.8	25.1	42.5	32.8	32.0	34.4	32.8	20.4	22.7	18.4	17.8	25.8
2014	25.9	24.4	41.7	32.2	31.3	33.5	31.6	19.4	21.6	17.5	16.8	24.8
2015	25.0	23.7	40.9	31.6	30.6	32.6	30.5	18.4	20.6	16.6	16.0	23.8
Change	-82.0	-76.6	-144.8	-125.1	-133.7	-141.6	-125.8	-76.0	-79.3	-65.5	-63.4	-91.8

APPENDIX C

Individual Enhanced Site Data

Table C1. Trend Statistics for the Unadilla River at Rockdale, NY, October 2005 Through September 2015

Unadilla	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	0.0269	0.003	3	0.88	NS	0.88	ALAN	Up
	FNF	-0.0207	-0.0023	-2.2	0.57	NS	0.57	L	Down
TNO_x / 630	FNC	0.0647	0.0072	12	0.25	NS	0.89	L	Up
	FNF	0.01218	0.0014	2.3	0.84	NS	0.59	ALAN	Up
TON / 605	FNC	0.0136	0.0015	4.5	0.66	NS	0.662	L	Up
	FNF	-0.0104	-0.0012	-2.6	0.9	NS	0.56	ALAN	Down
TNH_3 / 610	FNC	-0.0126	-0.0014	-33	<0.05	Down	0.98	HL	Down
	FNF	-0.0151	-0.0017	-35	0.13	NS	0.94	VL	Down
DN / 602	FNC	0.0932	0.01	11	0.26	NS	0.86	L	Up
	FNF	-0.0002	-0.00002	-0.021	0.81	NS	0.59	ALAN	Down
DNO_x / 631	FNC	0.0841	0.0093	16	0.35	NS	0.84	L	Up
	FNF	0.0331	0.0037	6.4	0.71	NS	0.64	ALAN	Up
DON / 607	FNC	0.0387	0.0043	16	0.23	NS	0.89	L	Up
	FNF	-0.0165	-0.0018	-6.3	0.47	NS	0.76	L	Down
DNH_3 / 608	FNC	-0.0094	-0.001	-28	0.07	Down	0.97	HL	Down
	FNF	-0.0117	-0.0013	-31	0.23	NS	0.88	L	Down
TP / 665	FNC	-0.0352	-0.0039	-52	<0.05	Down	0.99	HL	Down
	FNF	-0.0434	-0.0048	-39	<0.05	Down	0.99	HL	Down
DP / 666	FNC	-0.0229	-0.0025	-70	<0.05	Down	0.99	HL	Down
	FNF	-0.2877	-0.0032	-71	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.0254	-0.0028	-81	<0.05	Down	0.99	HL	Down
	FNF	-0.0299	-0.0033	-81	<0.05	Down	0.99	HL	Down
TOC / 680	FNC	-0.0674	-0.0075	-2.3	0.69	NS	0.662	L	Down
	FNF	0.1398	0.016	4.4	0.7	NS	0.64	ALAN	Up
SSC-TSS / 80154	FNC	-2.94	-0.33	-12	0.23	NS	0.89	L	Down
	FNF	-15.97	-1.8	-19	0.34	NS	0.84	L	Down

Table C2. Trend Statistics for the Susquehanna River at Conklin, NY, October 2005 Through September 2015

Conklin	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	-0.135	-0.015	-17	<0.05	Down	0.99	HL	Down
	FNF	-0.7105	-0.079	-20	<0.05	Down	0.99	HL	Down
TNO_x / 630	FNC	-0.94	-0.01	-21	<0.05	Down	0.99	HL	Down
	FNF	-0.3619	-0.04	-21	<0.05	Down	0.99	HL	Down
TON / 605	FNC	-0.003	-0.00033	-0.97	0.96	NS	0.51	ALAN	Down
	FNF	-0.1279	-0.014	-8.5	0.88	NS	0.56	ALAN	Down
TNH_3 / 610	FNC	-0.0155	-0.0017	-38	0.07	Down	0.97	HL	Down
	FNF	-0.0592	-0.0066	-34	0.06	Down	0.97	HL	Down
DN / 602	FNC	-0405	-0.0045	-5.8	0.63	NS	0.69	L	Down
	FNF	-0.1314	-0.015	-4.8	0.67	NS	0.66	L	Down
DNO_x / 631	FNC	-0.0663	-0.0074	-16	0.08	Down	0.97	HL	Down
	FNF	-0.2373	-0.026	-14	0.07	Down	0.97	HL	Down
DON / 607	FNC	0.0327	0.0036	14	0.66	NS	0.662	L	Up
	FNF	0.1526	0.017	17	0.84	NS	0.59	ALAN	Up
DNH_3 / 608	FNC	-0.0137	-0.0015	-35	0.17	NS	0.92	VL	Down
	FNF	-0.0497	-0.0055	-31	0.23	NS	0.89	L	Down
TP / 665	FNC	-0.0375	-0.0042	-48	<0.05	Down	0.99	HL	Down
	FNF	-0.1913	-0.021	-36	0.17	NS	0.92	VL	Down
DP / 666	FNC	-0.0297	-0.0033	-72	<0.05	Down	0.99	HL	Down
	FNF	-0.1178	-0.013	-68	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.0302	-0.0034	-83	<0.05	Down	0.99	HL	Down
	FNF	-0.1239	-0.014	-82	<0.05	Down	0.99	HL	Down
TOC / 680	FNC	-0.0346	-0.0038	-1.2	0.96	NS	0.51	ALAN	Down
	FNF	0.636	0.071	5.3	0.41	NS	0.79	L	Up
SSC-TSS / 80154	FNC	-6	-0.67	-19	0.38	NS	0.81	L	Down
	FNF	-126.4	-14	-27	0.48	NS	0.76	L	Down

Table C3. Trend Statistics for the Susquehanna River at Smithboro, NY, October 2004 Through September 2015

Smithboro	**Trend Test**	**Change**	**Slope**	**% Change**	**Hypothesis Test**		**Likelihood Test**		
Parameter/code					**P-value**	**Trend**	**Value**	**Descriptor**	**Direction**
TN / 600	FNC	-0.1	-0.01	-9.9	0.14	NS	0.94	VL	Down
	FNF	-1.006	-0.1	-11	0.2	NS	0.90	L	Down
TNO$_x$ / 630	FNC	-0.0296	-0.003	-5.3	0.42	NS	0.79	L	Down
	FNF	-0.5595	-0.056	-12	0.2	NS	0.89	L	Down
TON / 605	FNC	-0.0297	-0.003	-7.5	0.59	NS	0.71	L	Down
	FNF	-0.098	-0.0098	-2.6	0.95	NS	0.51	ALAN	Down
TNH$_3$ / 610	FNC	-0.0008	-0.00008	-1.7	0.96	NS	0.51	ALAN	Down
	FNF	-0.0575	-0.0057	-13	0.35	NS	0.84	L	Down
DN / 602	FNC	-0.0056	-0.00056	-0.63	0.96	NS	0.51	ALAN	Down
	FNF	-0.3266	-0.033	-4.5	0.44	NS	0.79	L	Down
DNO$_x$ / 631	FNC	-0.0139	-0.0014	-2.5	0.92	NS	0.53	ALAN	Down
	FNF	-0.4047	-0.04	-8.8	0.22	NS	0.90	L	Down
DON / 607	FNC	0.0461	0.0046	17	<0.05	Up	0.99	HL	Up
	FNF	0.1706	0.017	7.3	0.45	NS	0.76	L	Up
DNH$_3$ / 608	FNC	-0.0001	-0.00001	-0.29	0.97	NS	0.51	ALAN	Down
	FNF	-0.001	-0.0001	-0.26	0.98	NS	0.51	ALAN	Down
TP / 665	FNC	-0.0303	-0.003	-36	<0.05	Down	0.99	HL	Down
	FNF	-0.2498	-0.025	-24	0.07	Down	0.97	HL	Down
DP / 666	FNC	-0.0154	-0.0015	-48	0.06	Down	0.97	HL	Down
	FNF	-0.1402	-0.014	-48	<0.05	Down	0.08	HL	Down
DOP / 671	FNC	-0.0156	-0.0016	-60	0.09	Down	0.96	HL	Down
	FNF	-0.1499	-0.015	-62	<0.05	Down	1.00	HL	Down
TOC / 680	FNC	0.0663	0.0066	2.1	0.97	NS	0.51	ALAN	Up
	FNF	2.518	0.25	9.3	0.23	NS	0.89	L	Up
SSC-TSS / 80154	FNC	-7.29	-0.73	-22	0.25	NS	0.88	L	Down
	FNF	-332.3	-33	-39	0.08	Down	0.96	HL	Down

Table C4. Trend Statistics for the Cohocton River at Campbell, NY, October 2005 Through September 2015

Cohocton	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	0.104	0.012	7.3	0.58	NS	0.71	L	Up
	FNF	0.0812	0.009	11	0.17	NS	0.91	VL	Up
TNO_x / 630	FNC	0.097	0.011	10	0.48	NS	0.76	L	Up
	FNF	0.057	0.0063	13	0.26	NS	0.86	L	Up
TON / 605	FNC	0.032	0.0035	7.6	0.21	NS	0.89	L	Up
	FNF	0.0144	0.0016	5.4	0.43	NS	0.79	L	Up
TNH_3 / 610	FNC	-0.018	-0.002	-39	<0.05	Down	0.99	HL	Down
	FNF	-0.0049	-0.00055	-22	0.36	NS	0.81	L	Down
DN / 602	FNC	0.16	0.018	12	0.06	Up	0.97	HL	Up
	FNF	0.0874	0.0097	14	0.06	Up	0.97	HL	Up
DNO_x / 631	FNC	0.135	0.015	14	0.32	NS	0.84	L	Up
	FNF	0.0753	0.0084	18	0.23	NS	0.89	L	Up
DON / 607	FNC	0.0296	0.03	8.1	0.41	NS	0.79	L	Up
	FNF	0.0076	0.0076	4.4	0.74	NS	0.64	ALAN	Up
DNH_3 / 608	FNC	-0.0085	-0.00094	-19	0.43	NS	0.79	L	Down
	FNF	-0.0004	-0.00005	-2.1	0.76	NS	0.61	ALAN	Down
TP / 665	FNC	-0.0268	-0.003	-39	0.04	Down	0.97	HL	Down
	FNF	-0.0092	-0.001	-18	0.39	NS	0.81	L	Down
DP / 666	FNC	-0.027	-0.003	-62	<0.05	Down	0.99	HL	Down
	FNF	-0.0117	-0.0013	-59	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.0258	-0.0029	-70	<0.05	Down	0.99	HL	Down
	FNF	-0.0101	-0.0011	-63	<0.05	Down	0.99	HL	Down
TOC / 680	FNC	-0.187	-0.021	-4.7	0.66	NS	0.66	ALAN	Down
	FNF	0.1166	0.013	5.7	0.59	NS	0.71	L	Up
SSC-TSS / 80154	FNC	4.68	0.52	30	0.43	NS	0.787	L	Up
	FNF	7.747	0.86	31	0.45	NS	0.787	L	Up

Table C5. Trend Statistics for the Chemung River at Chemung, NY, October 2004 Through September 2015

Chemung	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	0.0073	0.00073	0.67	0.8	NS	0.613	ALAN	UP
	FNF	-0.1064	-0.011	-3.4	0.73	NS	0.637	ALAN	Down
TNO$_x$ / 630	FNC	0.026	0.0026	4.1	0.53	NS	0.74	L	Up
	FNF	-0.041	-0.0041	-2.6	0.79	NS	0.61	ALAN	Down
TON / 605	FNC	-0.0027	-0.00027	-0.67	0.89	NS	0.56	ALAN	Down
	FNF	-0.0004	-0.00005	-0.032	0.88	NS	0.56	ALAN	Down
TNH$_3$ / 610	FNC	0.0013	0.00013	4	0.78	NS	0.61	ALAN	Up
	FNF	0.0041	0.00041	3.7	0.83	NS	0.61	ALAN	Up
DN / 602	FNC	-0.143	-0.0014	-1.4	0.77	NS	0.61	ALAN	Down
	FNF	-0.0195	-0.002	-0.75	1.0	NS	0.51	ALAN	Down
DNO$_x$ / 631	FNC	-0.0142	-0.0014	-2.1	0.86	NS	0.56	ALAN	Down
	FNF	-0.0163	-0.0016	-1.0	0.96	NS	0.51	ALAN	Down
DON / 607	FNC	0.0107	0.0011	3.3	0.93	NS	0.54	ALAN	Up
	FNF	0.0159	0.0016	1.9	0.74	NS	0.64	ALAN	Up
DNH$_3$ / 608	FNC	-0.0003	-0.00003	-0.75	0.93	NS	0.54	ALAN	Down
	FNF	0.0034	0.00034	3.2	0.97	NS	0.51	ALAN	Up
TP / 665	FNC	-0.0454	-0.0045	-43	<0.05	Down	0.99	HL	Down
	FNF	-0.0772	-0.0077	-21	0.32	NS	0.84	L	Down
DP / 666	FNC	-0.0327	-0.0033	-57	<0.05	Down	0.99	HL	Down
	FNF	-0.057	-0.0057	-51	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.033	-0.0033	-62	0.073	Down	0.97	HL	Down
	FNF	-0.052	-0.0052	-58	<0.05	Down	0.99	HL	Down
TOC / 680	FNC	0.197	0.02	6.1	0.16	NS	0.92	VL	Up
	FNF	1.018	0.1	11	0.15	NS	0.92	VL	Up
SSC-TSS / 80154	FNC	-7.15	-0.71	-22	0.3	NS	0.84	L	Down
	FNF	-96.99	-9.7	-28	0.27	NS	0.86	L	Down

Table C6. Trend Statistics for the Susquehanna River at Wilkes Barre, Pa., October 2004 Through September 2015

Wilkes Barre	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	0.0054	0.00054	0.61	0.97	NS	0.51	ALAN	Up
	FNF	1.376	0.14	11	0.39	NS	0.81	L	Up
TNO$_x$ / 630	FNC	-0.0152	-0.0015	-3	0.57	NS	0.71	L	Down
	FNF	-0.1858	-0.019	-2.5	0.64	NS	0.69	L	Down
TON / 605	FNC	0.0469	0.0047	14	0.29	NS	0.86	L	Up
	FNF	2.498	0.25	51	0.06	Up	0.97	HL	Up
TNH$_3$ / 610	FNC	-0.0071	-0.00071	-14	0.41	NS	0.79	L	Down
	FNF	0.00099	-0.0001	0.15	0.88	NS	0.56	ALAN	Up
DN / 602	FNC	-0.0313	-0.0031	-4.1	0.5	NS	0.74	L	Down
	FNF	0.2879	0.029	2.7	0.87	NS	0.56	ALAN	Up
DNO$_x$ / 631	FNC	-0.0012	-0.00012	-0.24	0.99	NS	0.51	ALAN	Down
	FNF	-0.0433	-0.0043	-0.59	0.92	NS	0.54	ALAN	Down
DON / 607	FNC	-0.0028	-0.00028	-1.2	0.98	NS	0.51	ALAN	Down
	FNF	0.9876	0.099	35	0.20	NS	0.89	L	Up
DNH$_3$ / 608	FNC	-0.0039	-0.00039	-8.7	0.55	NS	0.74	L	Down
	FNF	0.01827	0.0018	3.1	0.95	NS	0.54	ALAN	Up
TP / 665	FNC	-0.014	-0.0014	-17	0.51	NS	0.74	L	Down
	FNF	0.3681	0.037	19	0.67	NS	0.662	L	Up
DP / 666	FNC	-0.0254	-0.0025	-68	<0.05	Down	0.99	HL	Down
	FNF	-0.3764	-0.038	-66	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.0221	-0.0022	-73	<0.05	Down	0.99	HL	Down
	FNF	-0.3394	-0.034	-70	<0.05	Down	0.99	HL	Down
TOC / 680	FNC	0.0092	0.00092	0.28	0.90	NS	0.54	ALAN	Up
	FNF	8.293	0.83	16	0.60	NS	0.71	L	Up
SSC-TSS / 80154	FNC	37.3	3.7	137	0.27	NS	0.86	L	Up
	FNF	2,540	254	148	0.63	NS	0.69	L	Up

Table C7. Trend Statistics for the West Branch Susquehanna River at Karthaus, Pa., October 2004 Through September 2015

Karthaus	**Trend Test**	**Change**	**Slope**	**% Change**	**Hypothesis Test**		**Likelihood Test**		
Parameter/code					**P-value**	**Trend**	**Value**	**Descriptor**	**Direction**
TN / 600	FNC	-0.0212	-0.0021	-3.8	0.85	NS	0.59	ALAN	Down
	FNF	0.0448	0.0045	3.4	0.79	NS	0.61	ALAN	Up
TNO$_x$ / 630	FNC	-0.0216	-0.0022	-5.6	0.47	NS	0.76	L	Down
	FNF	0.0095	0.00095	1.1	0.93	NS	0.54	ALAN	Up
TON / 605	FNC	-0.0157	-0.0016	-9.9	0.97	NS	0.51	ALAN	Down
	FNF	-0.0159	-0.0016	-3.6	0.87	NS	0.56	ALAN	Down
TNH$_3$ / 610	FNC	-0.0108	-0.0011	-22	<0.05	Down	0.99	HL	Down
	FNF	-0.0155	-0.0016	-15	0.24	NS	0.89	L	Down
DN / 602	FNC	-0.0143	-0.0014	-2.8	0.87	NS	0.56	ALAN	Down
	FNF	-0.0014	-0.00014	-0.12	0.87	NS	0.56	ALAN	Down
DNO$_x$ / 631	FNC	-0.0005	-0.00005	-0.14	0.82	NS	0.59	ALAN	Down
	FNF	0.0355	0.0035	4.2	0.98	NS	0.51	ALAN	Up
DON / 607	FNC	-0.0474	-0.0047	-31	<0.05	Down	0.99	HL	Down
	FNF	-0.1276	-0.013	-35	<0.05	Down	0.99	HL	Down
DNH$_3$ / 608	FNC	-0.0049	-0.00049	-12	0.22	NS	0.90	L	Down
	FNF	-0.0064	-0.00064	-7.2	0.57	NS	0.71	L	Down
TP / 665	FNC	-0.02	-0.002	-61	<0.05	Down	0.99	HL	Down
	FNF	-0.0280	-0.0028	-33	0.21	NS	0.89	L	Down
DP / 666	FNC	-0.0124	-0.0012	-81	N/A	BMDL	N/A	N/A	N/A
	FNF	-0.0185	-0.0019	-73	N/A	BMDL	N/A	N/A	N/A
DOP / 671	FNC	0.003	0.0003	26	N/A	BMDL	N/A	N/A	N/A
	FNF	0.02178	0.0022	129	N/A	BMDL	N/A	N/A	N/A
TOC / 680	FNC	0.125	0.012	7.3	0.4	NS	0.80	L	Up
	FNF	0.7494	0.075	18	0.09	Up	0.96	HL	Up
SSC-TSS / 80154	FNC	3.24	0.32	29	0.64	NS	0.69	L	Up
	FNF	20.38	2	41	0.57	NS	0.71	L	Up

Table C8. Trend Statistics for the West Branch Susquehanna River at Jersey Shore, Pa., October 2004 Through September 2015

Jersey Shore	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	-0.0829	-0.0083	-12	<0.05	Down	0.99	HL	Down
	FNF	0.0556	0.0056	1.1	0.75	NS	0.64	ALAN	Up
TNO_x / 630	FNC	-0.102	-0.01	-19	<0.05	Down	0.99	HL	Down
	FNF	-0.4605	-0.046	-13	0.21	NS	0.89	L	Down
TON / 605	FNC	0.0093	0.00093	5.7	0.60	NS	0.71	L	Up
	FNF	0.2996	0.03	21	0.40	NS	0.79	L	Up
TNH_3 / 610	FNC	0.00136	0.00014	4.5	0.82	NS	0.59	ALAN	Up
	FNF	0.03762	0.0038	17	0.68	NS	0.662	L	Up
DN / 602	FNC	-0.0793	-0.0079	-12	0.28	NS	0.86	L	Down
	FNF	-0.2445	-0.024	-5.6	0.52	NS	0.74	L	Down
DNO_x / 631	FNC	-0.0848	-0.0085	-16	<0.05	Down	0.98	HL	Down
	FNF	-0.3831	-0.038	-11	0.13	NS	0.94	VL	Down
DON / 607	FNC	-0.0282	-0.0028	-16	0.47	NS	0.76	L	Down
	FNF	-0.2834	-0.028	-25	0.37	NS	0.81	L	Down
DNH_3 / 608	FNC	0.00298	0.0003	11	0.60	NS	0.69	L	Up
	FNF	0.02786	0.0028	14	0.54	NS	0.74	L	Up
TP / 665	FNC	-0.0244	-0.0024	-57	<0.05	Down	0.99	HL	Down
	FNF	-0.0687	-0.0069	-20	0.53	NS	0.74	L	Down
DP / 666	FNC	-0.0267	-0.0027	-87	<0.05	Down	0.97	HL	Down
	FNF	-0.1556	-0.016	-85	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0.0197	-0.002	-84	<0.05	Down	0.99	HL	Down
	FNF	-0.1054	-0.011	-79	<0.05	Down	0.99	HL	Down
TOC / 680	FNC	0.12	0.012	7.1	0.53	NS	0.73	L	Up
	FNF	3.766	0.38	28	<0.05	Up	0.97	HL	Up
SSC-TSS / 80154	FNC	1.24	0.12	12	0.72	NS	0.64	ALAN	Up
	FNF	60.56	6.1	32	0.45	NS	0.79	L	Up

Table C9. Trend Statistics for Penns Creek at Penns Creek, Pa., October 2004 Through September 2015

Penns Creek	**Trend Test**	**Change**	**Slope**	**% Change**	**Hypothesis Test**		**Likelihood Test**		
Parameter/code					**P-value**	**Trend**	**Value**	**Descriptor**	**Direction**
TN / 600	FNC	0.0903	0.009	7.1	<0.05	Up	0.99	HL	Up
	FNF	0.0457	0.0046	7.3	<0.05	Up	0.99	HL	Up
TNO_x / 630	FNC	0.132	0.013	14	0.07	Up	0.97	HL	Up
	FNF	0.0251	0.0025	5.3	0.38	NS	0.81	L	Up
TON / 605	FNC	-0.0585	-0.0058	-19	0.44	NS	0.79	L	Down
	FNF	0.0162	0.0016	10	0.54	NS	0.74	L	Up
TNH_3 / 610	FNC	-0.0011	-0.00011	-3.4	0.68	NS	0.662	L	Down
	FNF	-0.0006	-0.00006	-3.6	0.58	NS	0.71	L	Down
DN / 602	FNC	0.0911	0.0091	7.5	<0.05	Up	0.99	HL	Up
	FNF	0.0331	0.0033	5.8	<0.05	Up	0.99	HL	Up
DNO_x / 631	FNC	0.133	0.013	14	<0.05	Up	0.99	HL	Up
	FNF	0.023	0.0023	4.9	0.51	NS	0.74	L	Up
DON / 607	FNC	-0.0518	-0.0052	-22	0.22	NS	0.89	L	Down
	FNF	0.00369	0.00037	3.6	0.74	NS	0.64	ALAN	Up
DNH_3 / 608	FNC	0.0009	-0.00009	3	0.90	NS	0.56	ALAN	Up
	FNF	0.0007	0.00007	4.7	0.92	NS	0,54	ALAN	Up
TP / 665	FNC	-0.0314	-0.0031	-48	<0.05	Down	0.97	HL	Down
	FNF	-0.0102	-0.001	-25	0.21	NS	0.898	L	Down
DP / 666	FNC	-0.0325	-0.0032	-67	<0.05	Down	0.99	HL	Down
	FNF	-0.0133	-0.0013	-54	<0.05	Down	0.99	HL	Down
DOP / 671	FNC	-0,0244	-0.0024	-65	<0.05	Down	0.98	HL	Down
	FNF	-0.0097	-0.0001	-52	0.06	Down	0.97	HL	Down
TOC / 680	FNC	-0.108	-0.011	-3.9	0.70	NS	0.64	ALAN	Down
	FNF	0.2214	0.022	16	0.28	NS	0.86	L	Up
SSC-TSS / 80154	FNC	-1.1	-0.11	-7.9	0.93	NS	0.54	ALAN	Down
	FNF	-3.397	-0.34	-17	0.48	NS	0.76	L	Down

Table C10. Trend Statistics for the Raystown Branch of Juniata River at Saxton, Pa., October 2004 Through September 2015

Saxton	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	-0.0745	-0.0074	-3.6	0.57	NS	0.71	L	Down
	FNF	-0.1136	-0.011	-6.9	0.28	NS	0.86	L	Down
TNO$_x$ / 630	FNC	-0.0829	-0.0083	-4.7	0.47	NS	0.76	L	Down
	FNF	-0.1181	-0.012	-9.2	0.21	NS	0.89	L	Down
TON / 605	FNC	0.0167	0.0017	5.7	0.80	NS	0.59	ALAN	Up
	FNF	0.0413	0.0041	12	0.35	NS	0.81	L	Up
TNH$_3$ / 610	FNC	-0.0004	-0.00004	-1.3	0.80	NS	0.61	ALAN	Down
	FNF	0.0045	0.00045	15	0.36	NS	0.81	L	Up
DN / 602	FNC	-0.049	-0.0049	-2.5	0.64	NS	0.68	L	Down
	FNF	-0.1203	-0.012	-8	0.18	NS	0.91	L	Down
DNO$_x$ / 631	FNC	-0.0689	-0.0069	-3.9	0.54	NS	0.72	L	Down
	FNF	-0.1112	-0.011	-8.7	0.15	NS	0.92	VL	Down
DON / 607	FNC	0.0256	0.0026	12	0.57	NS	0.71	L	Up
	FNF	0.00864	0.00086	4.5	0.94	NS	0.54	ALAN	Up
DNH$_3$ / 608	FNC	0.00523	0.00052	19	0.29	NS	0.86	L	Up
	FNF	0.009	0.0009	35	0.26	NS	0.86	L	Up
TP / 665	FNC	0.00673	0.00067	24	0.06	Up	0.97	HL	Up
	FNF	0.0092	0.00092	19	0.23	NS	0.89	L	Up
DP / 666	FNC	0.0034	0.00034	28	0.22	NS	0.90	L	Up
	FNF	0.00212	0.00021	14	0.47	NS	0.77	L	Up
DOP / 671	FNC	0.00567	0.00057	89	0.23	NS	0.89	L	Up
	FNF	0.00345	0.00034	37	0.38	NS	0.81	L	Up
TOC / 680	FNC	-0.116	-0.012	-4.2	0.89	NS	0.56	ALAN	Down
	FNF	0.3512	0.035	13	0.30	NS	0.84	L	Up
SSC-TSS / 80154	FNC	0.644	0.064	3.7	0.70	NS	0.64	ALAN	Up
	FNF	-23.94	-2.4	-33	0.47	NS	0.76	L	Down

Table C11. Trend Statistics for Shermans Creek at Dromgold, Pa., October 2004 Through September 2015

Shermans	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	-0.21	-0.021	-12	<0.05	Down	0.97	HL	Down
	FNF	-0.0518	-0.0052	-9	0.17	NS	0.91	VL	Down
TNO_x / 630	FNC	-0.189	-0.019	-13	0.07	Down	0.97	HL	Down
	FNF	-0.0255	-0.0025	-5.8	0.42	NS	0.79	L	Down
TON / 605	FNC	-0.0197	-0.002	-7.2	0.83	NS	0.59	ALAN	Down
	FNF	-0.0341	-0.0034	-23	0.65	NS	0.69	L	Down
TNH_3 / 610	FNC	-0.0069	-0.00069	-19	0.24	NS	0.89	L	Down
	FNF	-0.0033	-0.00033	-21	0.43	NS	0.79	L	Down
DN / 602	FNC	-0.19	-0.019	-11	<0.05	Down	0.99	HL	Down
	FNF	-0.0429	-0.0043	-8.1	0.16	NS	0.93	VL	Down
DNO_x / 631	FNC	-0.165	-0.017	-11	<0.05	Down	0.99	HL	Down
	FNF	-0.0182	-0.0018	-4.2	0.51	NS	0.74	L	Down
DON / 607	FNC	-0.0153	-0.0015	-7	0.40	NS	0.79	L	Down
	FNF	-0.0172	-0.0017	-20	0.31	NS	0.84	L	Down
DNH_3 / 608	FNC	-0.002	-0.0002	-6	0.51	NS	0.74	L	Down
	FNF	-0.0018	-0.00018	-12	0.62	NS	0.69	L	Down
TP / 665	FNC	-0.0018	-0.00018	-4.5	0.91	NS	0.54	ALAN	Down
	FNF	-0.0075	-0.00075	-23	0.67	NS	0.662	L	Down
DP / 666	FNC	0.00283	0.00028	12	0.42	NS	0.79	L	Up
	FNF	-0.0007	-0.00007	-4.7	0.83	NS	0.59	ALAN	Down
DOP / 671	FNC	0.0048	0.00048	27	0.09	Up	0.96	HL	Up
	FNF	0.00035	0.00004	3	0.67	NS	0.67	L	Up
TOC / 680	FNC	-0.249	-0.025	-9	0.64	NS	0.69	L	Down
	FNF	-0.0941	-0.0094	-7.8	0.75	NS	0.61	ALAN	Down
SSC-TSS / 80154	FNC	-1.67	-0.17	-14	0.90	NS	0.54	ALAN	Down
	FNF	-9.366	-0.94	-47	0.44	NS	0.79	L	Down

Table C12. Trend Statistics for the Conodoguinet Creek at Hogestown, Pa., October 2004 Through September 2015

Conodoguinet	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	-0.534	-0.053	-12	<0.05	Down	0.99	HL	Down
	FNF	-0.2088	-0.021	-8.9	<0.05	Down	0.99	HL	Down
TNO_x / 630	FNC	-0.631	-0.063	-16	<0.05	Down	0.99	HL	Down
	FNF	-0.2407	-0.024	-12	0.07	Down	0.97	HL	Down
TON / 605	FNC	0.113	0.011	39	<0.05	Up	0.99	HL	Up
	FNF	0.0649	0.0065	29	0.097	Up	0.96	HL	Up
TNH_3 / 610	FNC	-0.0035	-0.00035	-8.8	0.61	NS	0.69	L	Down
	FNF	-0.0016	-0.00016	-5.3	0.68	NS	0.662	L	Down
DN / 602	FNC	-0.576	-0.058	-14	<0.05	Down	0.99	HL	Down
	FNF	-0.2323	-0.023	-10	<0.05	Down	0.99	HL	Down
DNO_x / 631	FNC	-0.566	-0.057	-14	<0.05	Down	0.99	HL	Down
	FNF	-0.2155	-0.022	-11	0.07	Down	0.97	HL	Down
DON / 607	FNC	0.0142	0.0014	4.6	0.69	NS	0.662	L	Up
	FNF	0.0062	0.00062	3.4	0.85	NS	0.56	ALAN	Up
DNH_3 / 608	FNC	0.0016	0.00016	4.4	0.9	NS	0.54	ALAN	Up
	FNF	0.00194	0.00019	7.3	0.71	NS	0.64	ALAN	Up
TP / 665	FNC	-0.0015	-0.00015	-4.1	0.97	NS	0.51	ALAN	Down
	FNF	-0.0067	-0.00067	-15	0.45	NS	0.79	L	Down
DP / 666	FNC	-0.0003	-0.00003	-1.3	0.81	NS	0.59	ALAN	Down
	FNF	-0.0012	-0.00012	-6.9	0.85	NS	0.56	ALAN	Down
DOP / 671	FNC	-0.0001	-0.00001	-0.74	0.94	NS	0.54	ALAN	Down
	FNF	-0.0013	-0.00013	-9.1	0.91	NS	0.54	ALAN	Down
TOC / 680	FNC	-0.262	-0.026	-9.2	0.80	NS	0.59	ALAN	Down
	FNF	-0.1443	-0.014	-6.6	0.94	NS	0.54	ALAN	Down
SSC-TSS / 80154	FNC	4.98	0.5	45	0.34	NS	0.84	L	Up
	FNF	2.327	0.23	9.3	0.75	NS	0.64	ALAN	Up

Table C13. Trend Statistics for the Swatara Creek at Hershey, Pa., October 2004 Through September 2015

Swatara	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	-1.07	-0.11	-24	<0.05	Down	0.99	HL	Down
	FNF	-0.5365	-0.054	-18	<0.05	Down	0.99	HL	Down
TNO_x / 630	FNC	-1.14	-0.11	-27	<0.05	Down	0.99	HL	Down
	FNF	-0.659	-0.066	-24	<0.05	Down	0.99	HL	Down
TON / 605	FNC	0.0264	0.0026	7.5	0.48	NS	0.76	L	Up
	FNF	0.1477	0.015	45	0.40	NS	0.79	L	Up
TNH_3 / 610	FNC	0.0003	0.00003	0.57	0.78	NS	0.61	ALAN	Up
	FNF	0.0253	0.0015	27	0.57	NS	0.71	L	Up
DN / 602	FNC	-1.11	-0.11	-25	<0.05	Down	0.99	HL	Down
	FNF	-0.592	-0.059	-20	<0.05	Down	0.99	HL	Down
DNO_x / 631	FNC	-1.11	-0.11	-27	<0.05	Down	0.99	HL	Down
	FNF	-0.615	-0.062	-23	<0.05	Down	0.99	HL	Down
DON / 607	FNC	-0.0845	-0.0084	-24	0.17	NS	0.92	VL	Down
	FNF	0.0104	0.001	4.3	0.83	NS	0.59	ALAN	Up
DNH_3 / 608	FNC	0.0099	0.00099	19	0.34	NS	0.84	L	Up
	FNF	0.02161	0.0022	41	0.20	NS	0.89	L	Up
TP / 665	FNC	0.0051	0.00051	7.8	0.66	NS	0.662	L	Up
	FNF	0.0286	0.0029	29	0.22	NS	0.89	L	Up
DP / 666	FNC	0.00053	0.00005	1.3	0.87	NS	0.56	ALAN	Up
	FNF	0.0098	0.00098	25	0.23	NS	0.89	L	Up
DOP / 671	FNC	0.00192	0.00019	6	0.41	NS	0.79	L	Up
	FNF	0.00897	0.0009	28	0.38	NS	0.81	L	Up
TOC / 680	FNC	0.191	0.019	7.2	0.52	NS	0.74	L	Up
	FNF	0.6889	0.069	22	0.64	NS	0.69	L	Up
SSC-TSS / 80154	FNC	12.3	1.2	94	0.08	Up	0.96	HL	Up
	FNF	24.56	2.5	41	0.42	NS	0.80	L	Up

Table C14. Trend Statistics for the West Conewago Creek at Manchester, Pa., October 2004 Through September 2015

W. Conewago	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	-0.574	-0.057	-23	<0.05	Down	0.99	HL	Down
	FNF	-0.3696	-0.037	-19	<0.05	Down	0.99	HL	Down
TNO$_x$ / 630	FNC	-0.72	-0.072	-34	<0.05	Down	0.99	HL	Down
	FNF	-0.4298	-0.043	-30	<0.05	Down	0.99	HL	Down
TON / 605	FNC	0.116	0.012	29	<0.05	Up	0.99	HL	Up
	FNF	0.04223	0.0042	9.1	0.61	NS	0.61	ALAN	Up
TNH$_3$ / 610	FNC	0.0086	0.00086	17	0.34	NS	0.82	L	Up
	FNF	0.0195	0.0019	43	0.16	NS	0.92	VL	Up
DN / 602	FNC	-0.619	-0.062	-25	<0.05	Down	0.99	HL	Down
	FNF	-0.3632	-0.036	-21	<0.05	Down	0.99	HL	Down
DNO$_x$ / 631	FNC	-0.664	-0.066	-32	<0.05	Down	0.99	HL	Down
	FNF	-0.3845	-0.038	-28	<0.05	Down	0.99	HL	Down
DON / 607	FNC	0.0185	0.0018	5.2	0.53	NS	0.74	L	Up
	FNF	0.00213	0.00021	0.72	0.91	NS	0.54	ALAN	Up
DNH$_3$ / 608	FNC	0.0143	0.0014	32	0.2	NS	0.90	L	Up
	FNF	0.02192	0.0022	53	0.18	NS	0.91	VL	Up
TP / 665	FNC	0.015	0.0015	12	0.63	NS	0.69	L	Up
	FNF	0.0131	0.0013	8.2	0.83	NS	0.59	ALAN	Up
DP / 666	FNC	0.0093	0.00093	9.5	0.47	NS	0.76	L	Up
	FNF	0.0114	0.0011	13	0.48	NS	0.76	L	Up
DOP / 671	FNC	0.00845	0.00085	10	0.59	NS	0.71	L	Up
	FNF	0.0099	0.00099	13	0.49	NS	0.76	L	Up
TOC / 680	FNC	-0.171	-0.017	-3.6	0.73	NS	0.64	ALAN	Down
	FNF	-0.0669	-0.0067	-1.5	0.91	NS	0.54	ALAN	Down
SSC-TSS / 80154	FNC	3.33	0.33	17	0.57	NS	0.71	L	Up
	FNF	-16.88	-1.7	-21	0.39	NS	0.81	L	Down

Table C15. Trend Statistics for Pequea Creek at Martic Forge, Pa., October 2004 Through September 2015

Pequea Creek	**Trend Test**	**Change**	**Slope**	**% Change**	**Hypothesis Test**		**Likelihood Test**		
Parameter/code					**P-value**	**Trend**	**Value**	**Descriptor**	**Direction**
TN / 600	FNC	-1.33	-0.13	-16	<0.05	Down	0.99	HL	Down
	FNF	-0.2262	-0.023	-15	<0.05	Down	0.99	HL	Down
TNO_x / 630	FNC	-0.874	-0.087	-12	0.09	Down	0.96	HL	Down
	FNF	-0.139	-0.014	-12	0.14	NS	0.93	VL	Down
TON / 605	FNC	-0.589	-0.059	-47	<0.05	Down	0.98	HL	Down
	FNF	-0.1276	-0.013	-40	0.11	NS	0.95	VL	Down
TNH_3 / 610	FNC	0.024	0.0024	38	0.20	NS	0.89	L	Up
	FNF	0.0079	0.00079	38	0.34	NS	0.84	L	Up
DN / 602	FNC	-1.38	-0.14	-17	<0.05	Down	0.99	HL	Down
	FNF	-0.2253	-0.023	-16	<0.05	Down	0.99	HL	Down
DNO_x / 631	FNC	-0.706	-0.071	-10	0.26	NS	0.86	L	Down
	FNF	-0.1139	-0.011	-9.7	0.34	NS	0.84	L	Down
DON / 607	FNC	-0.728	-0.073	-61	<0.05	Down	0.99	HL	Down
	FNF	-0.13	-0.013	-59	<0.05	Down	0.99	HL	Down
DNH_3 / 608	FNC	0.0336	0.0034	58	0.13	NS	0.94	VL	Up
	FNF	0.0102	0.001	54	0.27	NS	0.87	L	Up
TP / 665	FNC	0.0725	0.0072	39	0.33	NS	0.84	L	Up
	FNF	0.0152	0.0015	18	0.53	NS	0.74	L	Up
DP / 666	FNC	0.0592	0.0059	56	<0.05	Up	0.98	HL	Up
	FNF	0.0143	0.0014	43	0.17	NS	0.91	VL	Up
DOP / 671	FNC	0.0612	0.061	66	0.05	Up	0.97	HL	Up
	FNF	0.01679	0.0017	58	0.16	NS	0.92	VL	Up
TOC / 680	FNC	0.0911	0.0091	2.8	0.96	NS	0.51	ALAN	Up
	FNF	0.06776	0.0068	7.2	0.98	NS	0.51	ALAN	Up
SSC-TSS / 80154	FNC	7.32	0.73	16	0.64	NS	0.69	L	Up
	FNF	3.435	0.34	6.7	0.80	NS	0.61	ALAN	Up

Table C16. Trend Statistics for Octoraro at Richardsmere, MD, January 2006 Through September 2015

Octoraro 2006-2015	Trend Test	Change	Slope	% Change	Hypothesis Test		Likelihood Test		
Parameter/code					P-value	Trend	Value	Descriptor	Direction
TN / 600	FNC	-0.0503	-0.063	-7.5	0.08	Down	0.96	HL	Down
	FNF	-0.0873	-0.011	-6.1	0.15	NS	0.93	VL	Down
TNO$_x$ / 630	FNC	-0.31	-0.039	-5.2	0.41	NS	0.79	L	Down
	FNF	-0.0608	-0.0076	-4.9	0.52	NS	0.74	L	Down
TON / 605	FNC	-0.276	-0.034	-35	0.06	Down	0.98	HL	Down
	FNF	-0.0538	-0.0067	-27	0.09	Down	0.96	HL	Down
TNH$_3$ / 610	FNC	-0.0018	-0.00022	-2.3	0.97	NS	0.51	ALAN	Down
	FNF	-0.0012	-0.00015	-4	0.98	NS	0.51	ALAN	Down
DN / 602	FNC	-0.574	-0.072	-8.7	0.07	Down	0.97	HL	Down
	FNF	-0.1021	-0.013	-7.4	0.24	NS	0.88	L	Down
DNO$_x$ / 631	FNC	-0.143	-0.018	-2.5	0.92	NS	0.54	ALAN	Down
	FNF	-0.0316	-0.0039	-2.6	0.78	NS	0.61	ALAN	Down
DON / 607	FNC	-0.325	-0.041	-44	<0.05	Down	0.99	HL	Down
	FNF	-0.071	-0.0089	-42	<0.05	Down	0.99	HL	Down
DNH$_3$ / 608	FNC	0.0037	0.00047	5.3	0.91	NS	0.54	ALAN	Up
	FNF	-0.0002	-0.00003	-0.75	0.63	NS	0.69	L	Down
TP / 665	FNC	-0.0151	-0.0019	-12	0.69	NS	0.662	L	Down
	FNF	-0.0031	-0.00038	-6.3	0.91	NS	0.54	ALAN	Down
DP / 666	FNC	-0.0137	-0.0017	-15	0.57	NS	0.71	L	Down
	FNF	-0.0037	-0.00046	-13	0.68	NS	0.662	L	Down
DOP / 671	FNC	-0.0053	-0.00067	-7.2	0.82	NS	0.59	ALAN	Down
	FNF	-0.0014	-0.00018	-6.4	0.86	NS	0.56	ALAN	Down
TOC / 680	FNC	-0.287	-0.036	-8	0.28	NS	0.86	L	Down
	FNF	-0.0663	-0.0083	-6.5	0.49	NS	0.76	L	Down
SSC-TSS / 80154	FNC	2.17	0.27	14	0.79	NS	0.61	ALAN	Up
	FNF	-0.6325	-0.079	-3.5	0.80	NS	0.59	ALAN	Down

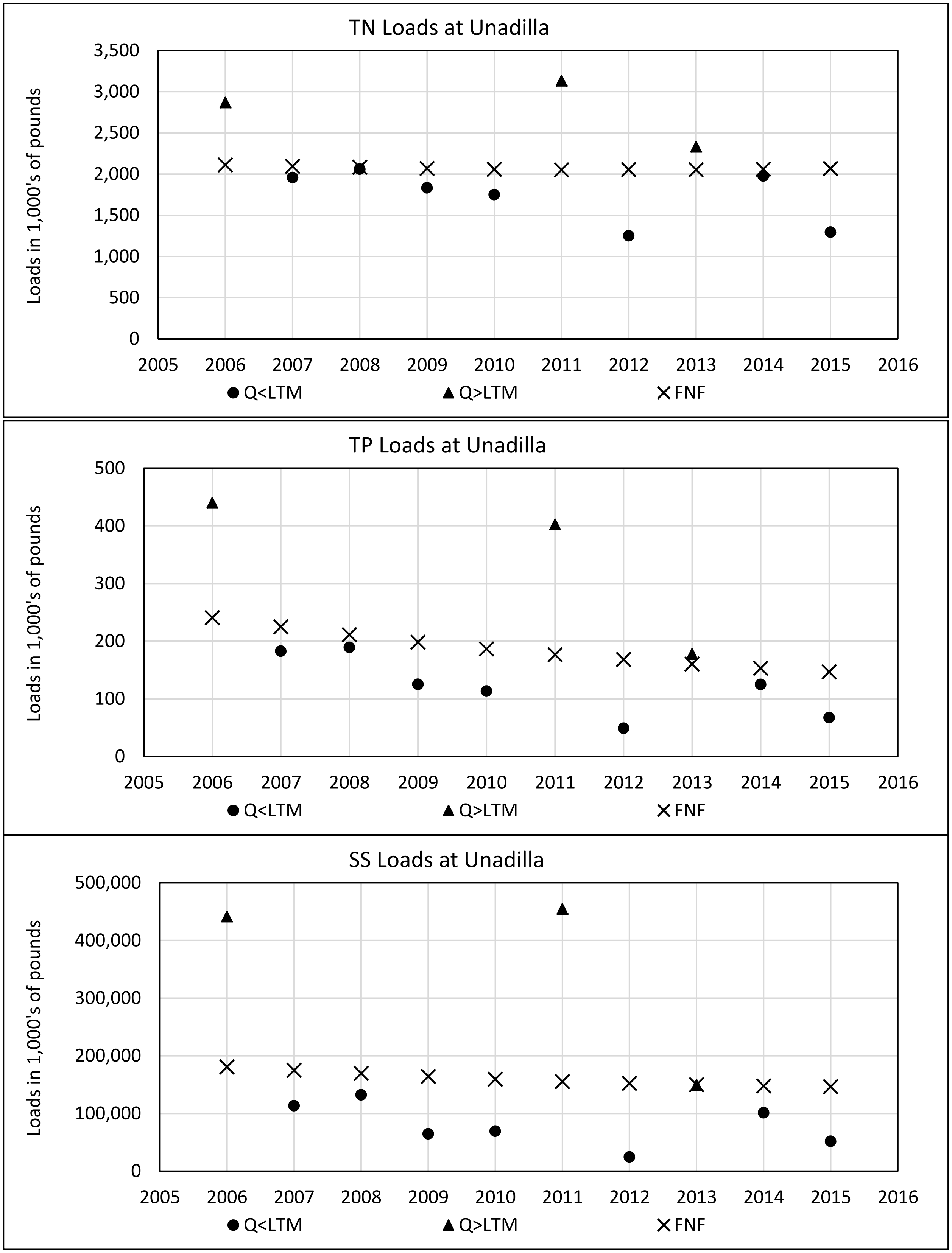


Figure C1.* *TN, TP, and SS Loads at Unadilla

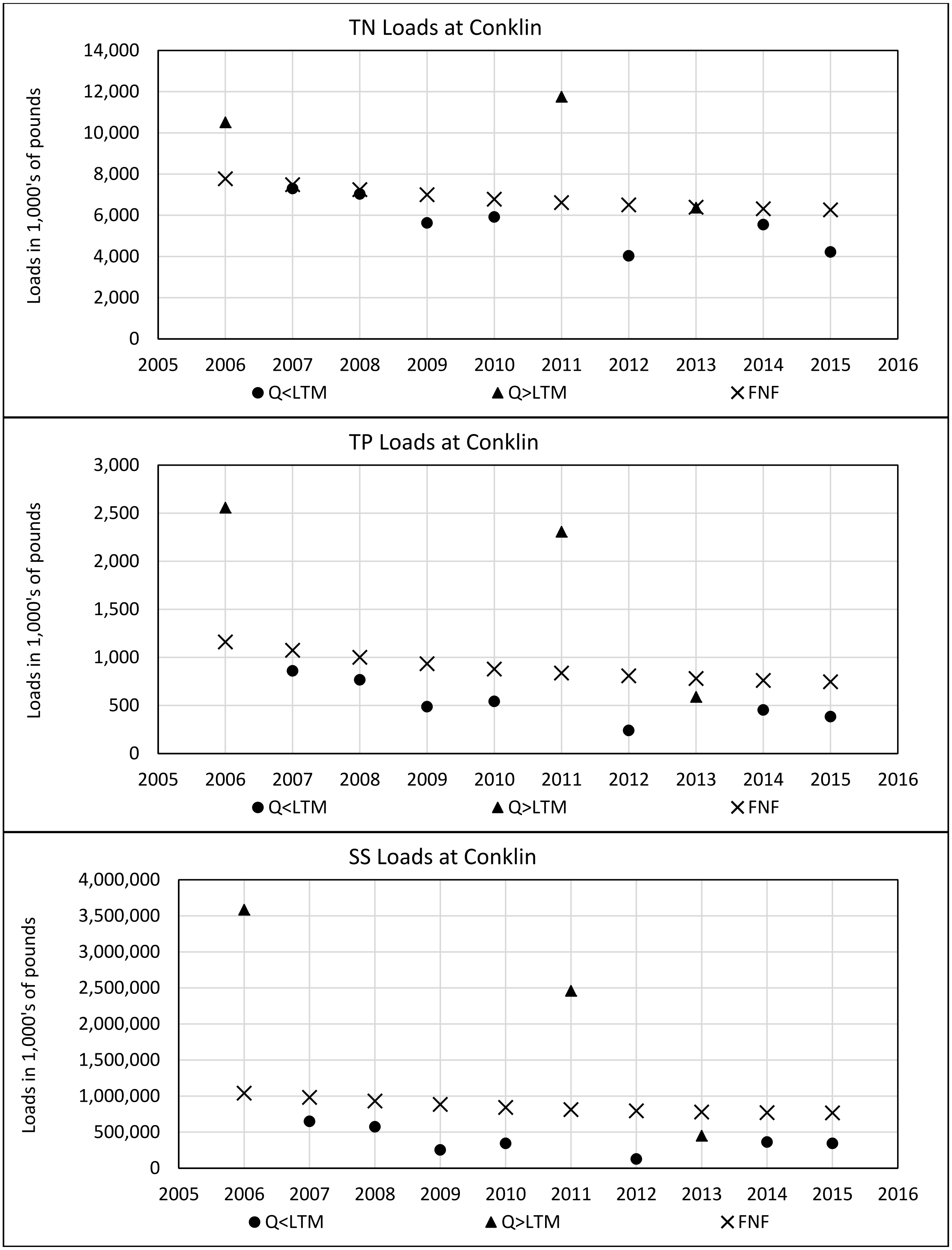


Figure C2. TN, TP, and SS Loads at Conklin

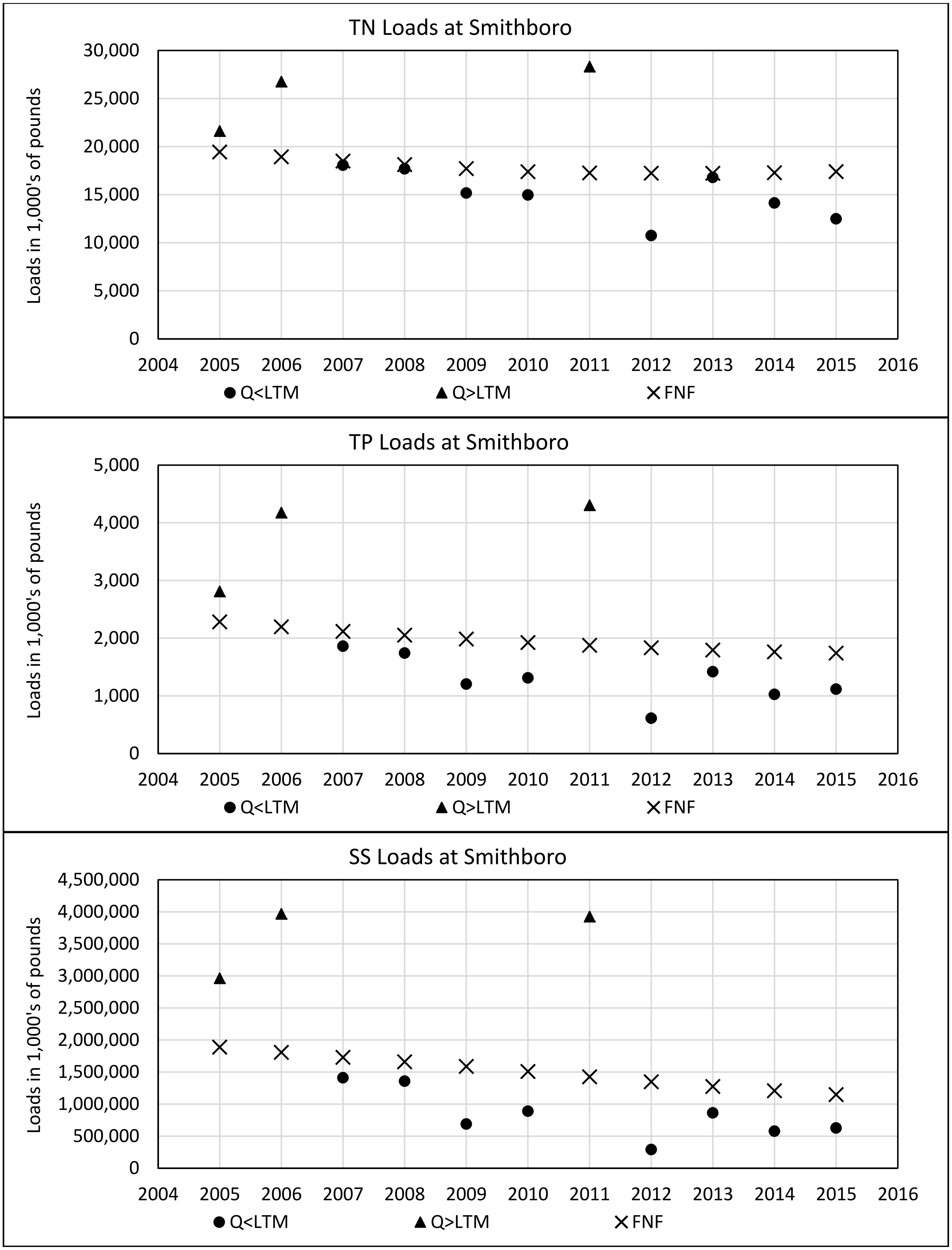


Figure C3. ***TN, TP, and SS Loads at Smithboro***

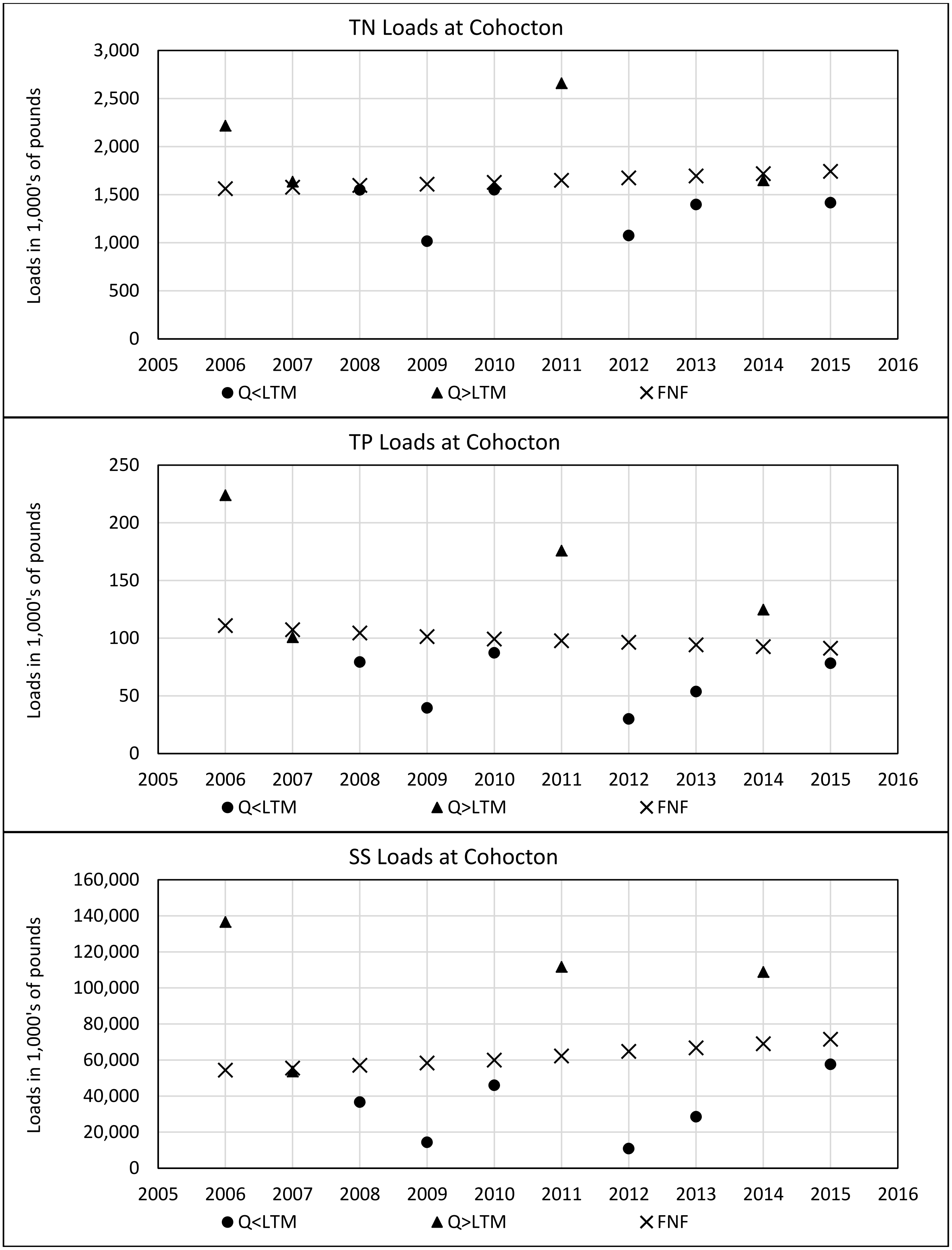


Figure C4. ***TN, TP, and SS Loads at Cohocton***

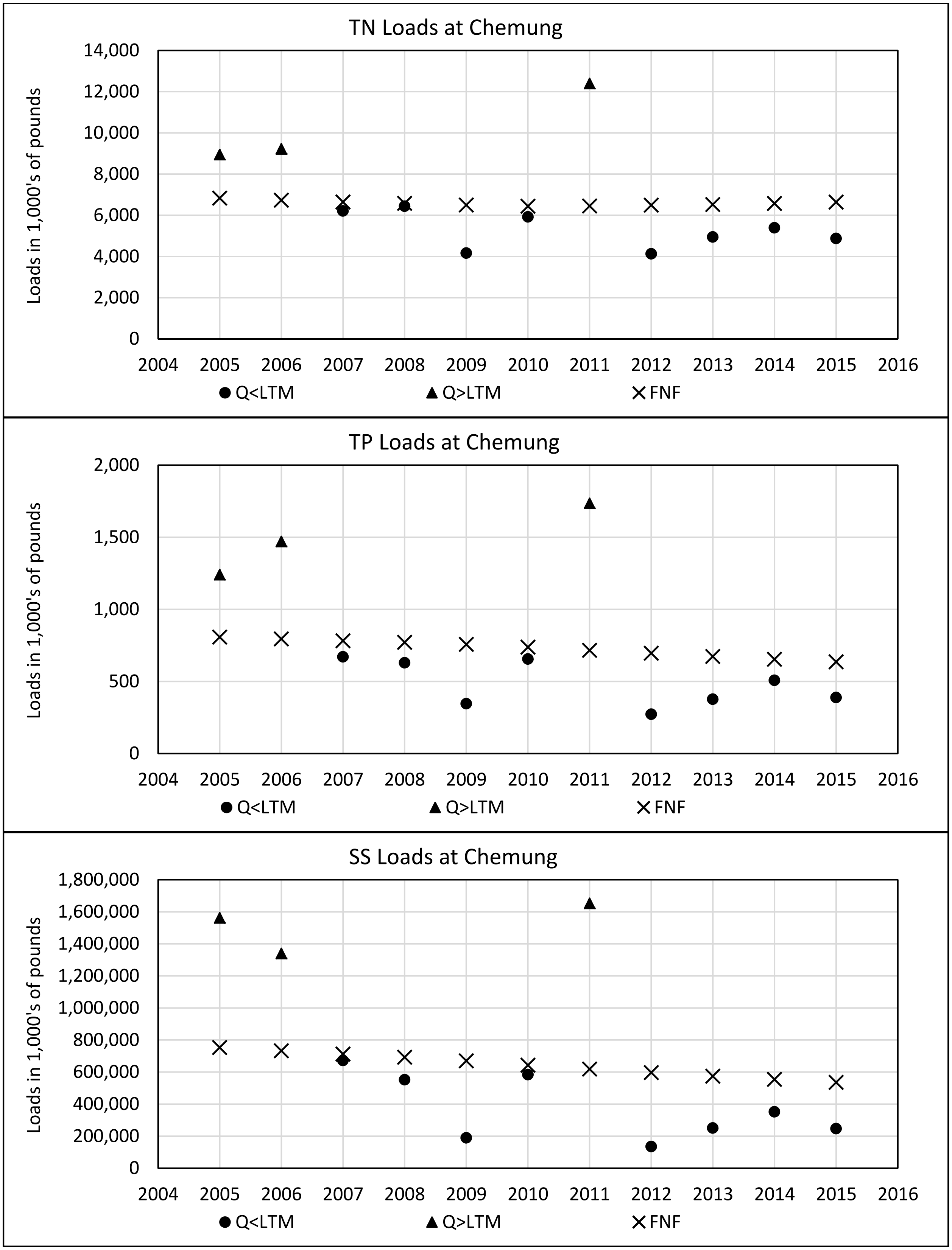


Figure C5. TN, TP, and SS Loads at Chemung

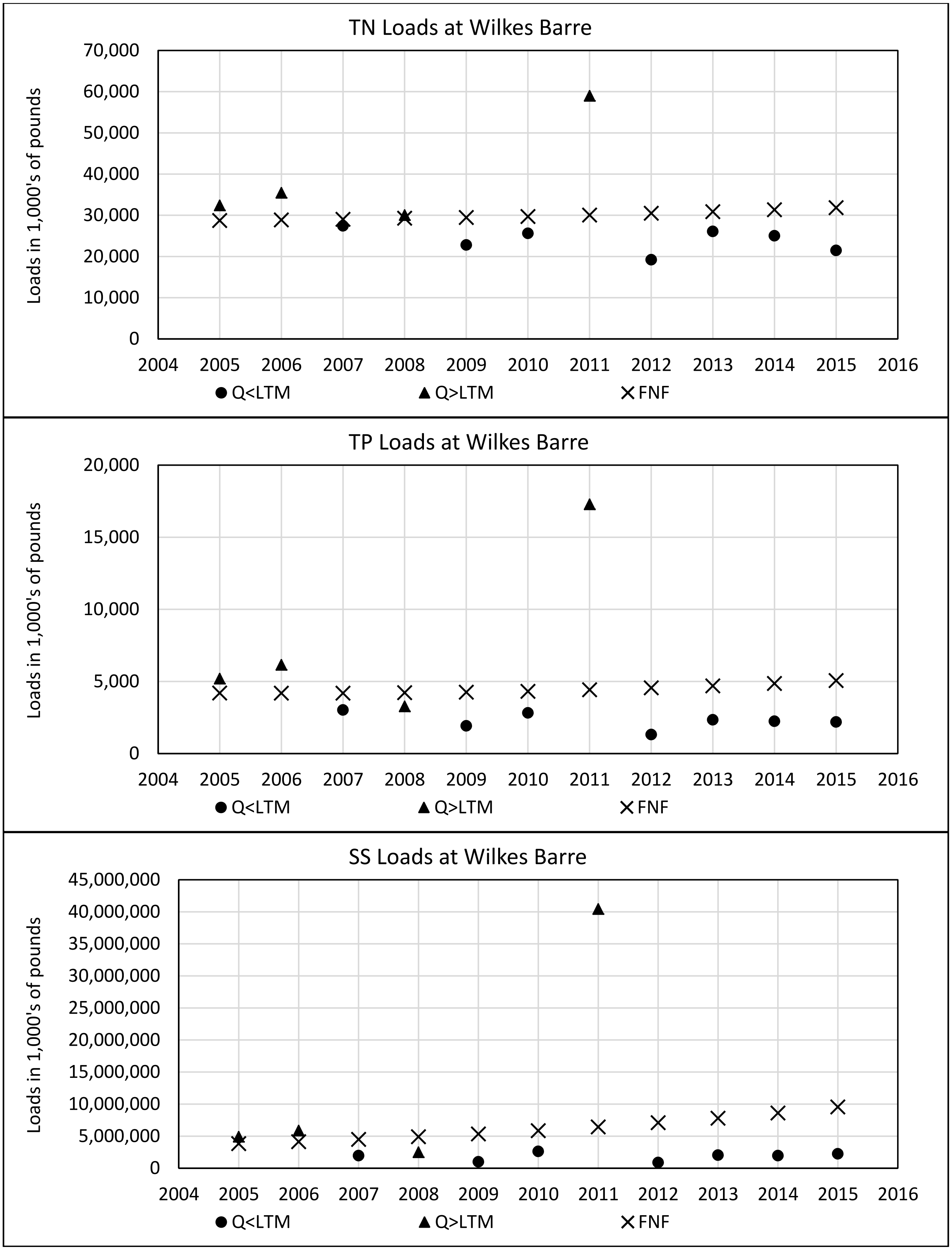


Figure C6. TN, TP, and SS Loads at Wilkes Barre

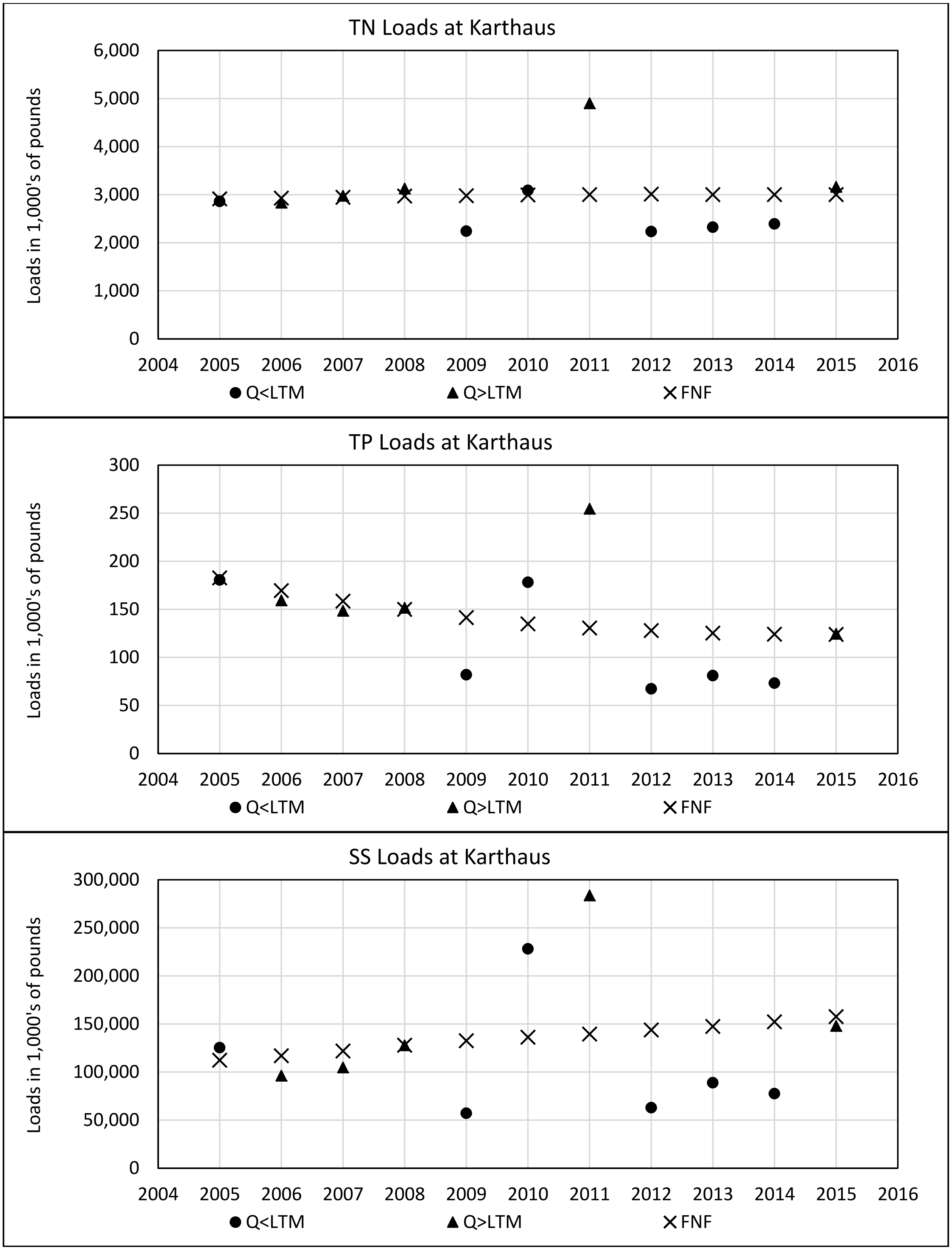


Figure C7.   TN, TP, and SS Loads at Karthaus

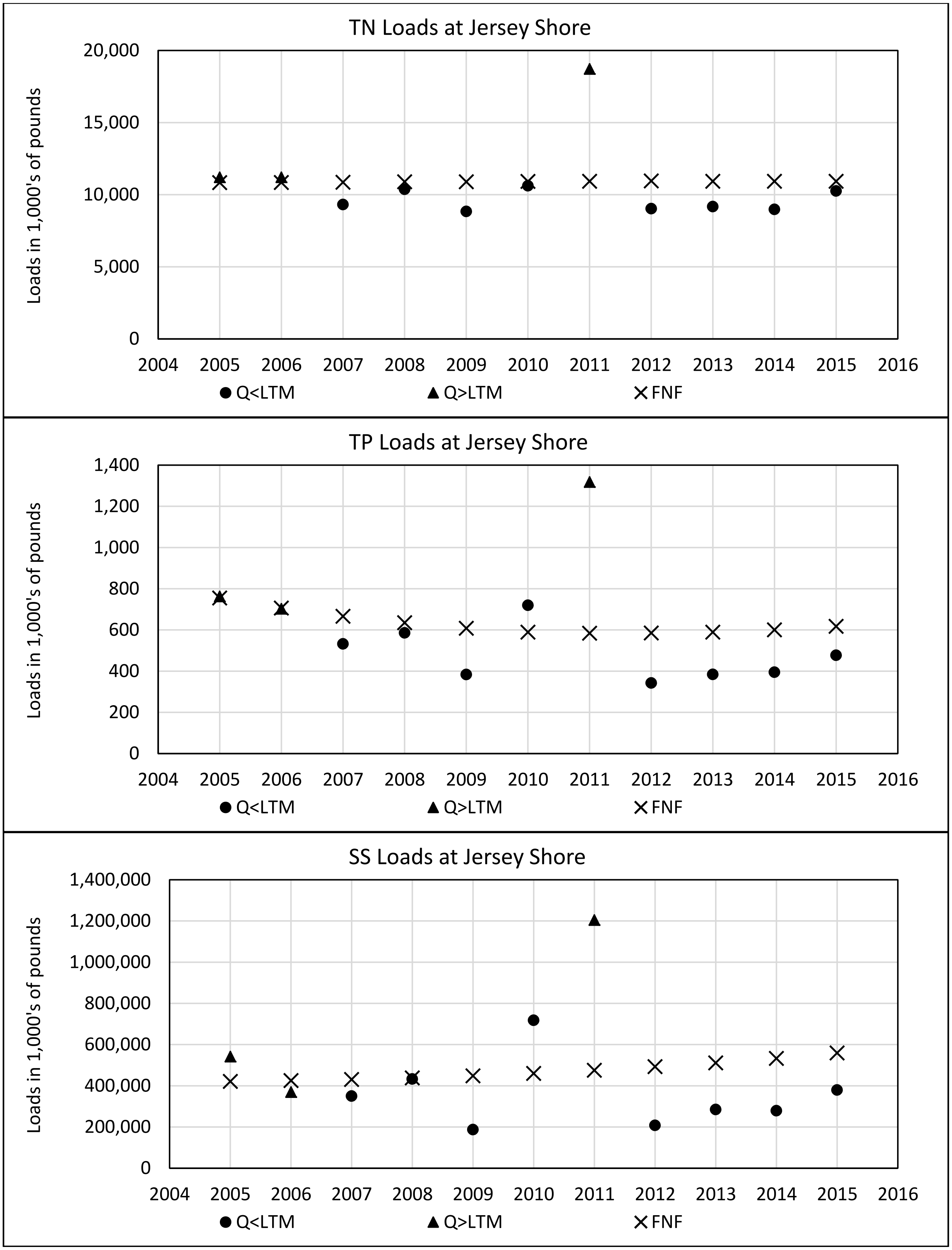


Figure C8. TN, TP, and SS Loads at Jersey Shore

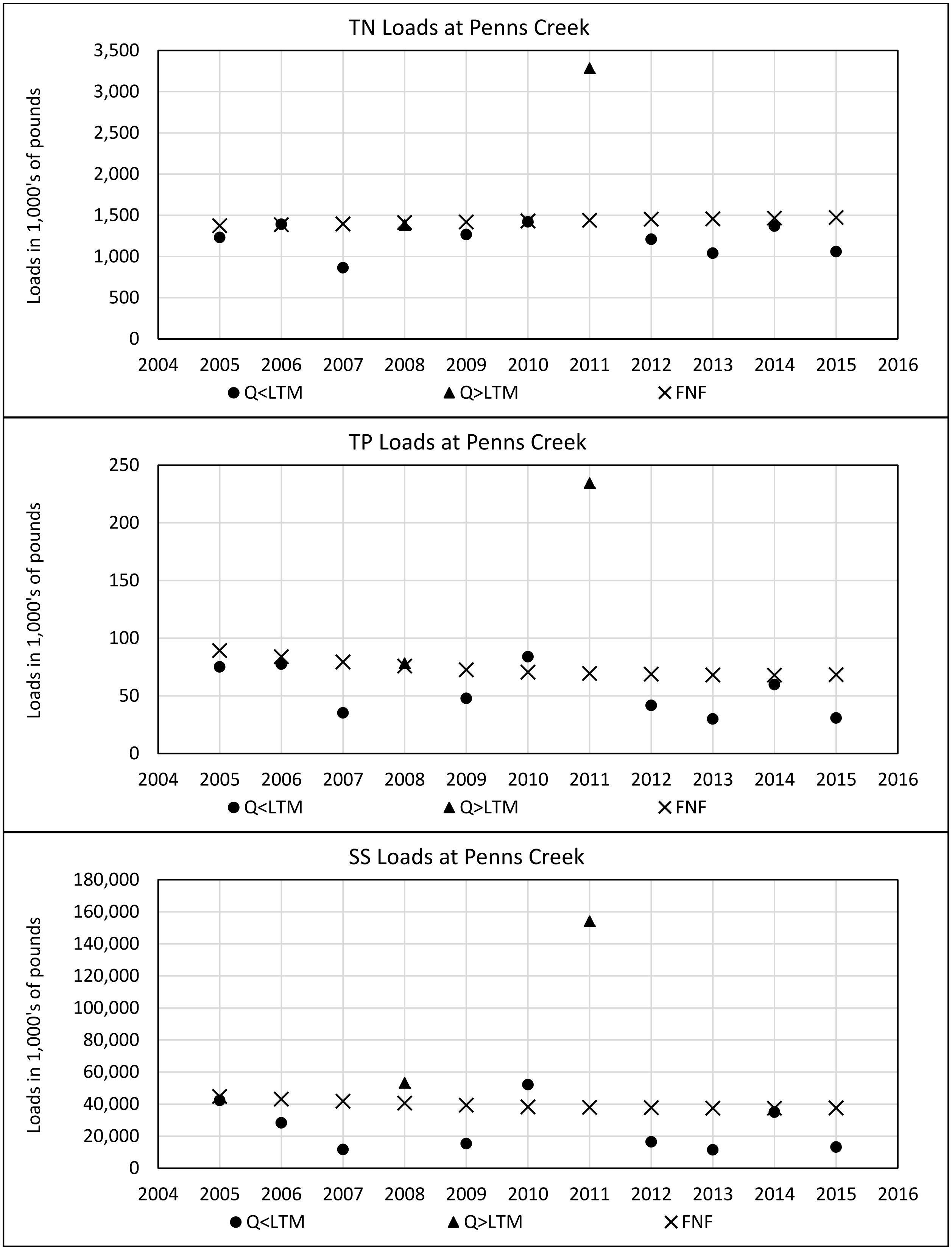


Figure C9. TN, TP, and SS Loads at Penns Creek

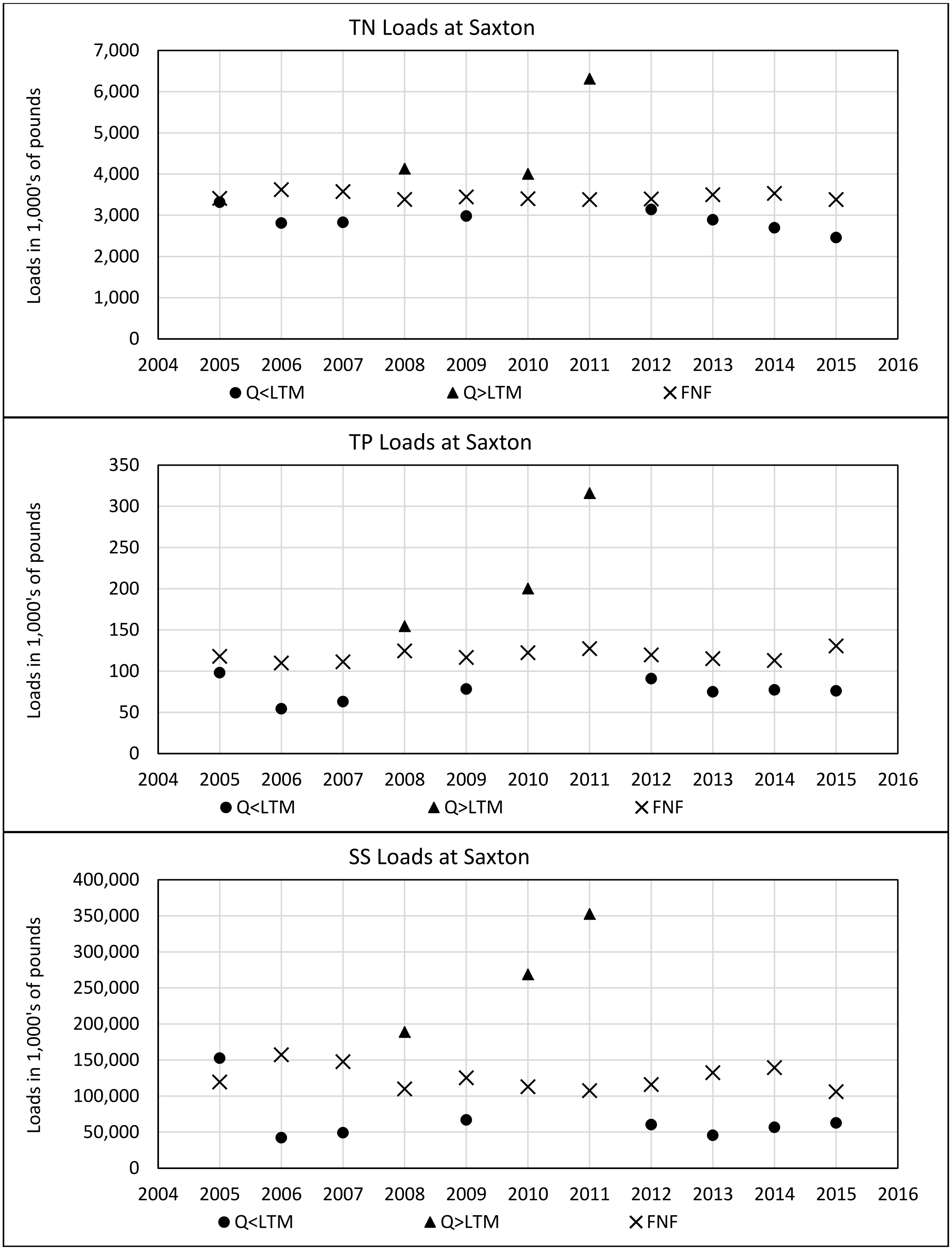


Figure C10. TN, TP, and SS Loads at Saxton

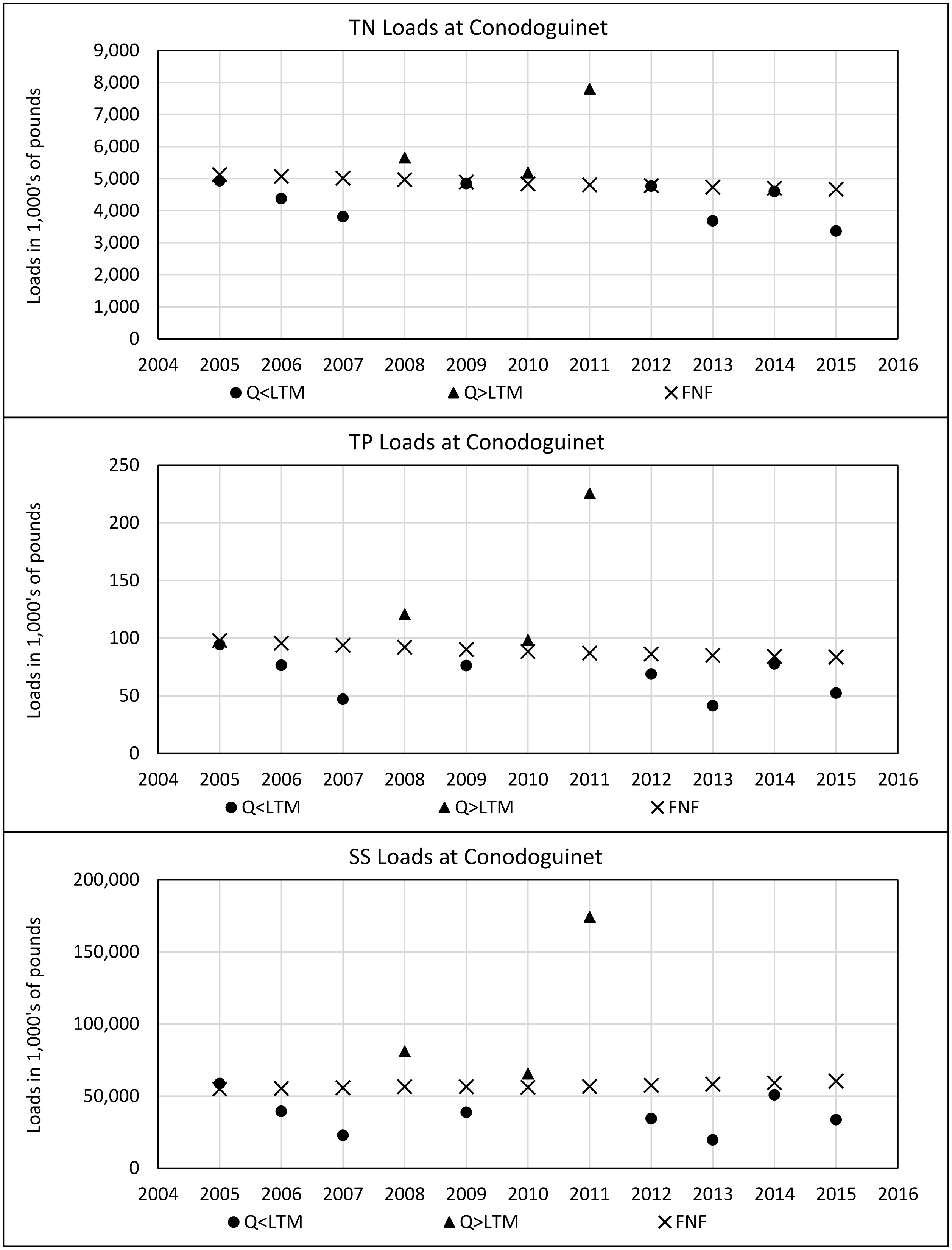


Figure C11. TN, TP, and SS Loads at Conodoguinet

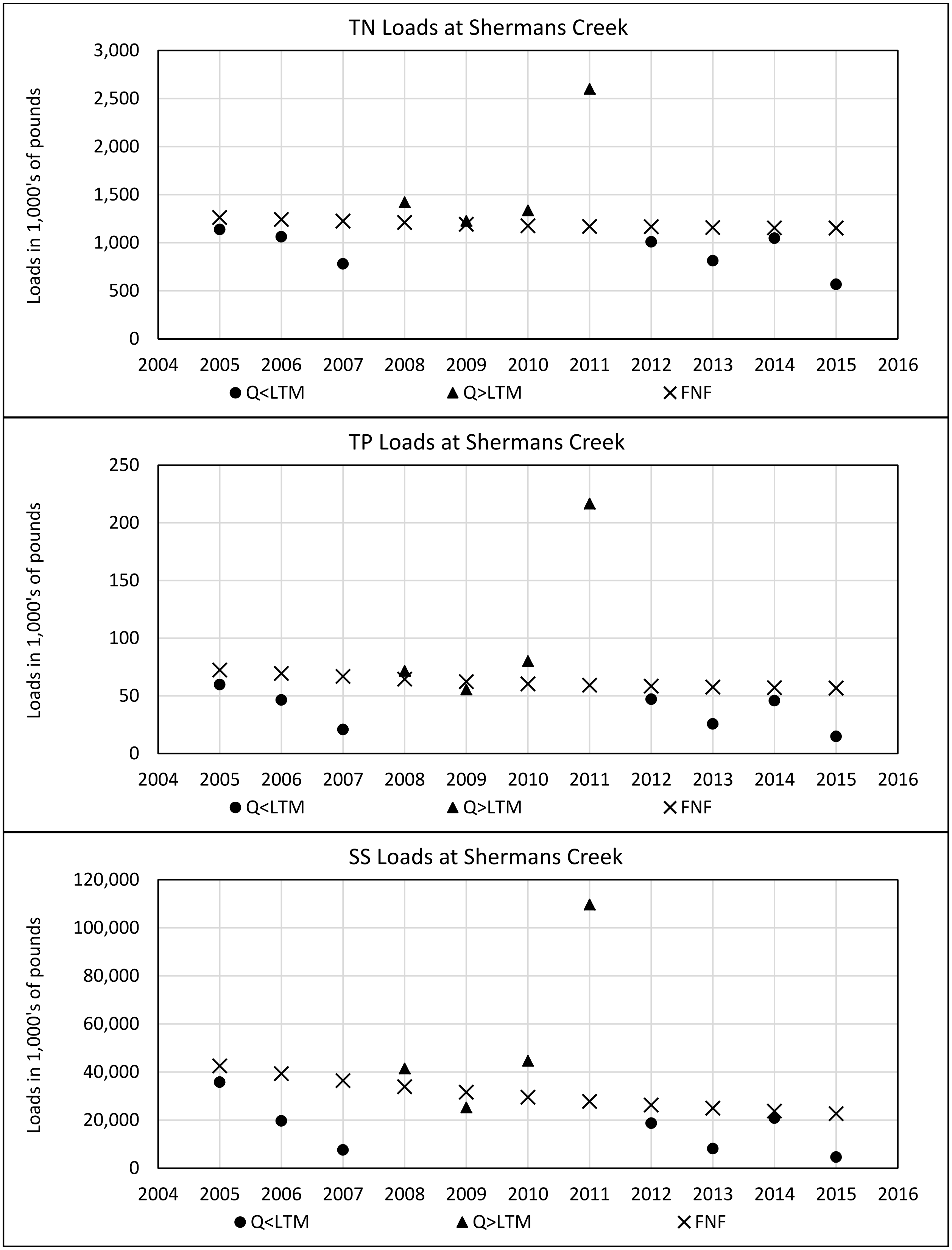


Figure C12.   TN, TP, and SS Loads at Shermans Creek

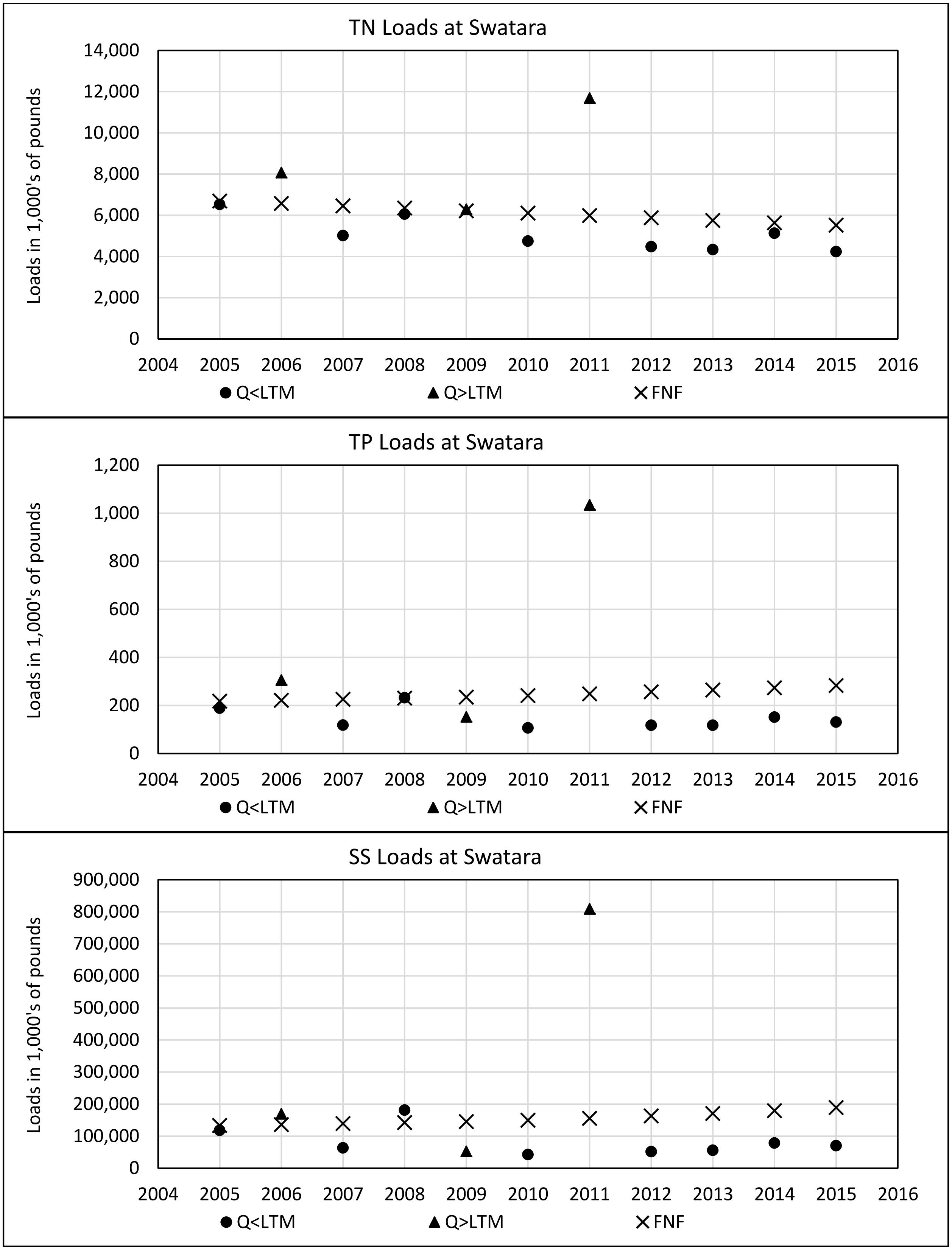


Figure C13. TN, TP, and SS Loads at Swatara

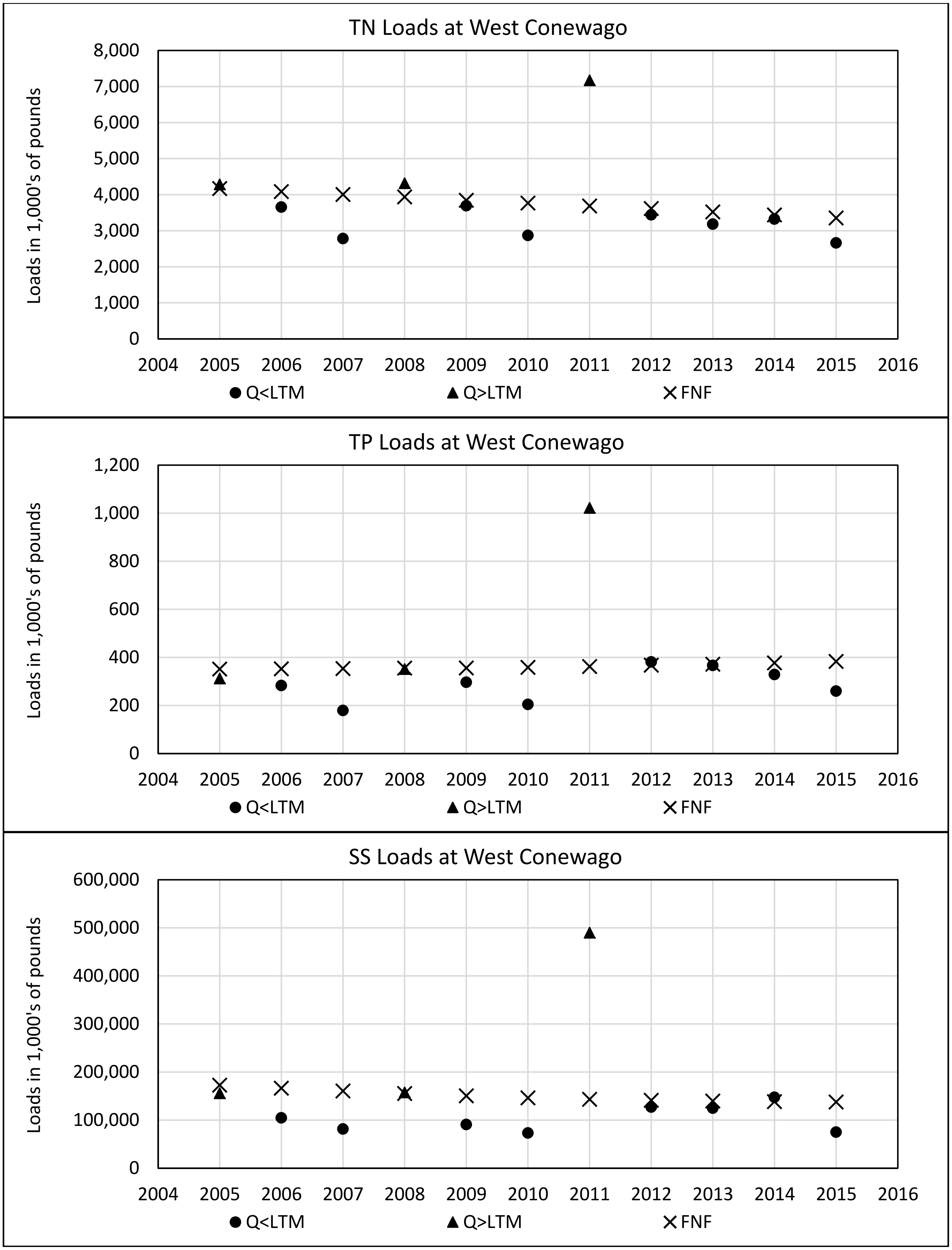


Figure C14. TN, TP, and SS Loads at West Conewago

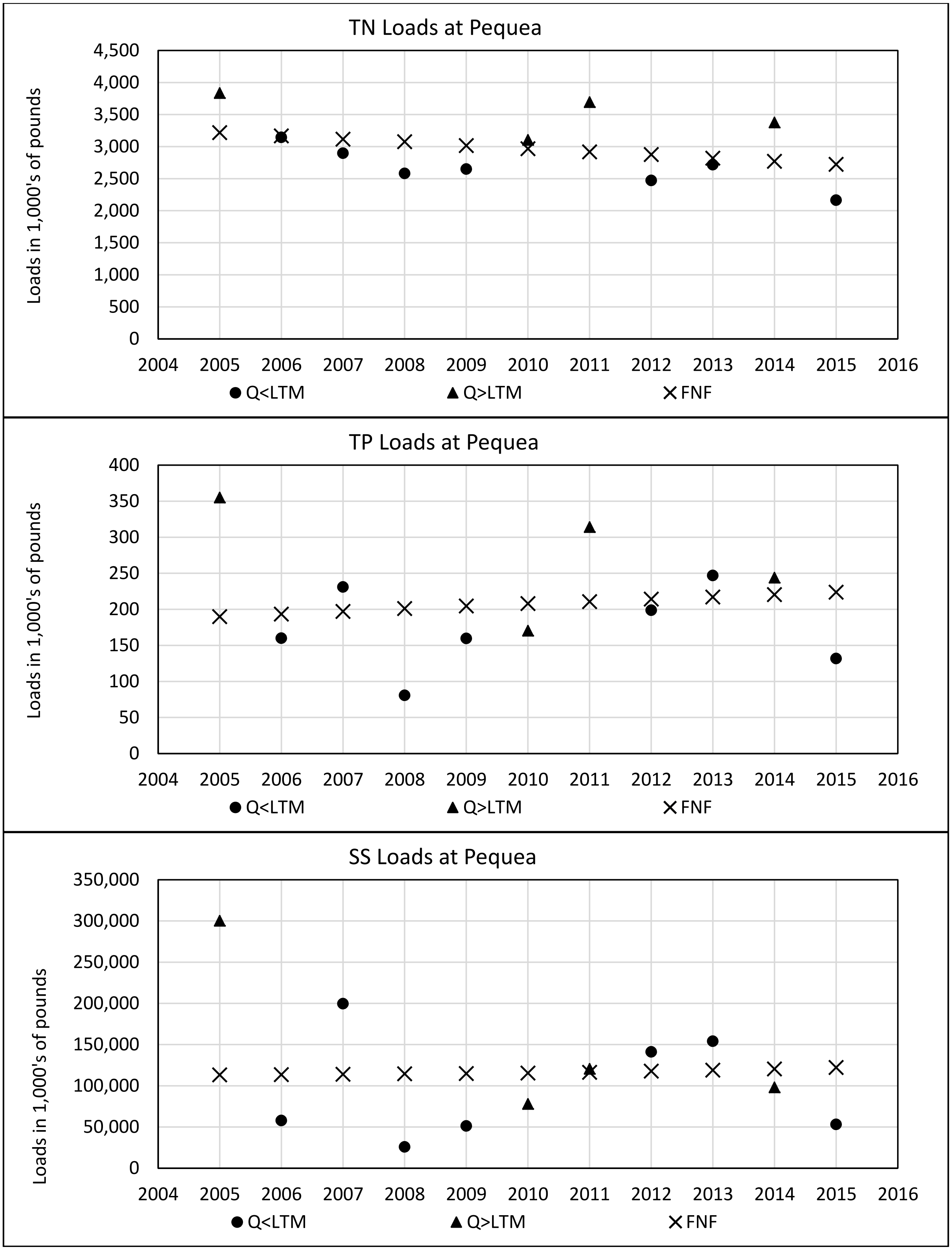


Figure C15. TN, TP, and SS Loads at Pequea

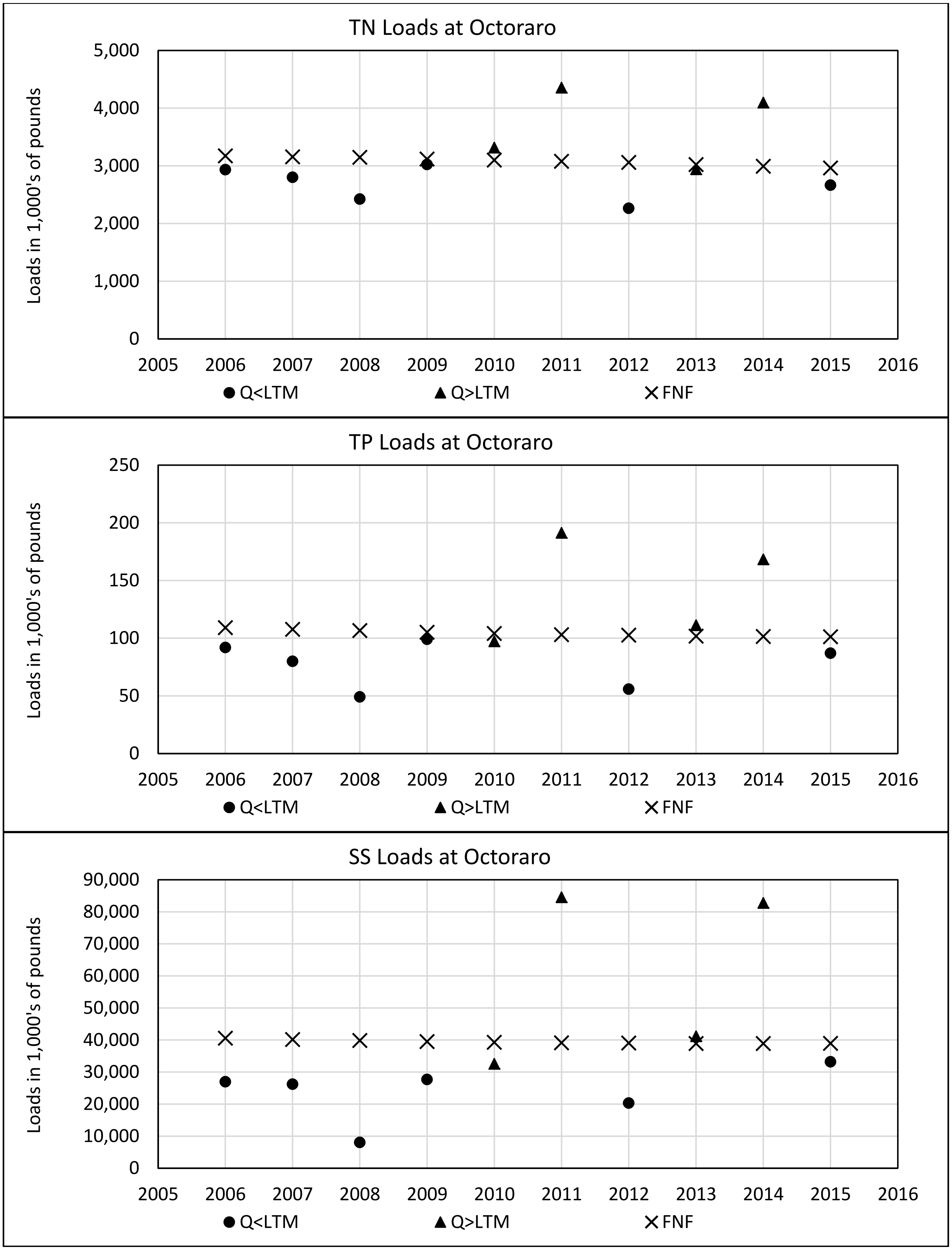


Figure C16. TN, TP, and SS Loads at Octoraro