Historical Chesapeake Bay Stream Water Quality Monitoring Report: An assessment of the overall state of cross-border stream water quality over time at locations both inside and outside of Maryland

Photograph by Laura J. Fabian

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The report below responds to the following request from the Joint Chairman's Report of the 2010 Maryland General Assembly:

> While the streams inside Maryland have been assessed in terms of nutrient and sediment loading, the nutrient and sediment loading at locations outside of Maryland for streams that enter Maryland and empty into the Chesapeake Bay has not been assessed. Therefore, the committees request a report on annual water quality conditions based on numerical results and a relative scale for nutrient and sediment loading or concentrations for streams that both originate outside of Maryland and originate inside of Maryland and that empty into a Maryland tributary of the Chesapeake Bay. The data is to be provided for monitoring locations both inside, and if available, outside of Maryland.

Introduction

The Maryland Department of Natural Resources (DNR) participates in two water quality monitoring programs designed to assess trends and loads in nutrients (nitrogen and phosphorus) and total suspended sediments at cross border stream locations both within and outside of Maryland. DNR in cooperation with the U.S. Geological Survey (USGS) monitors stream water quality and flow at four major Maryland tributaries to the Chesapeake Bay that contribute the largest loads of nutrients and suspended sediments to the Bay through the River Input Monitoring (RIM) Program. The RIM Program was developed in the early 1980s in response to declining water quality and living resources in the Chesapeake Bay. The four RIM Program sites located in Maryland are on the Susquehanna River at Conowingo, Md.; the Potomac River at Chain Bridge, in Washington, D.C.; the Patuxent River near Bowie, Md.; and the Choptank River near Greensboro, Md.. The locations, drainage areas, and station identification numbers of the four RIM Program sites in Maryland that are monitored by the USGS in cooperation with DNR are presented in Table 1. (All tables and figures are presented at the end of this report.)

Four of the nine total RIM Program sites are located in Maryland and contribute approximately 82% of the total flow, 92% of the total nitrogen loads, and 69% of the total phosphorus loads to the Chesapeake Bay (Belval and Sprague, 1999). Nutrient and sediment loads are available from the USGS for Maryland's four RIM Program sites for the 1981 through 2009 time period.
DNR also cooperates with the USGS and state agencies within the Chesapeake Bay watershed (Pennsylvania, Virginia, New York, Delaware, and West Virginia) through the non-tidal network water quality monitoring program. The non-tidal network monitoring program focuses on smaller streams throughout the watershed with the aim of identifying factors affecting nutrient and sediment loads, and estimating nutrient and sediment loads in Maryland's tributary strategy basins.

The non-tidal network consists of 128 sites, 13 of which are located in Maryland and monitored by DNR. The locations, drainage areas, and station identification numbers of Maryland's 13 primary sites are presented in Table 2. There are 15 non-tidal network sites that are located near the Maryland border with an adjoining state that are monitored by Pennsylvania, Delaware, Virginia, or West Virginia, depending on the site's location. The 15 sites, their USGS station identification number, location, and distance relative to the Maryland border are presented in Table 3.

In addition to the RIM Program sites and non-tidal network sites, DNR monitors 55 stations within Maryland through the CORE/Trend monitoring program. Data for many of these sites is available from the mid-1970s through the present. The load sites that are located in Maryland or near its borders appear in Figure 1.

Methods

Monitoring that is conducted at stations that are part of the RIM Program and non-tidal network program is coordinated through the Non-tidal Workgroup, a workgroup of the U.S. Environmental Protection Agency's Chesapeake Bay Program comprised of representatives from the USGS, river basin commissions, and state agencies such as DNR. All participants in these two monitoring programs are required to follow sampling guidelines that were developed by the USGS to ensure that comparable, scientifically accurate, and representative samples are collected at each monitoring site.

Detailed sampling procedures can be found in Chapter V of the *Recommended Guidelines for Sampling and Analysis in the Chesapeake Bay Monitoring Program* (U.S. EPA, 1996), which is available online at www.chesapeakebay.net/committee_analyticalmethodsworkgroup_projects.aspx?menuitem=16701.

After samples results are reported to the agency that collected them, they undergo a series of quality assurance steps before being sent to the USGS for calculating loads and trends. The USGS uses a seven parameter log-linear model to calculate the logarithms of the concentration data. The model uses time, flow, centering variables to improve the precision of the estimates, and the sine and cosine functions to model seasonal effects (Cohn, et al., 1989; Gilroy et al., 1990). A minimum of five years of data are required to accurately calibrate the coefficients for the seven parameter model. A minimum of ten years of data are required to accurately calculate trends.

After daily concentrations are calculated daily flow data are used in a minimum variance unbiased estimator to provide daily loads. Daily load estimates are then averaged for each month to provide monthly loads in kilograms per day.

Results

Total Nitrogen

Flow adjusted trends in total nitrogen are available for 14 sites in Maryland, one site near Washington, D.C., and two sites in Virginia (Table 4). Statistically significant decreasing (improving) trends were detected at 12 sites. One site (Choptank River) had a significant increasing (degrading) trend and four sites had trends that were not statistically significant. The magnitude of the decreasing trends ranged from -9.2% at the Patuxent River near Laurel, Md. to -57.5% at the Patuxent River at Bowie, Md.

Nitrogen loads are available for 21 sites in Maryland, Virginia, West Virginia, and Washington, D.C. There was little change in the order of loads for the major sites from year-to-year. The Susquehanna River at Conowingo, Md. contributes the largest total nitrogen loads at 62% and Mattawoman Creek contributes the smallest loads at less than 1% of the currently measured loads. The total nitrogen loads, their relative percent of the total measured loads, and ranking from highest to lowest are presented in Figure 2.

Total Phosphorus

Flow adjusted trends in total phosphorus are available for 14 sites in Maryland, one site near Washington, DC, and two sites in Virginia (Table 5). Statistically significant decreasing (improving) trends were detected at 13 sites. One site, the Choptank River, had a significant increasing (degrading) trend and two sites had trends that were not statistically significant. The magnitude of the decreasing trends ranged from -31.7% at the Patuxent River near Laurel, Md. to -72.4% at the Patuxent River near Unity, Md.

Phosphorus loads are available for 21 sites in Maryland, Virginia, West Virginia, and Washington, D.C. With the exception of 2003, when total phosphorus loads for the Potomac River in Washington, D.C. exceeded those at the Susquehanna River at Conowingo, Md. there was little change in the ranking of the magnitudes of loads among the larger load sites. The loads for the Potomac exceeded those of the Susquehanna in 2003 because of the rainfall pattern during that year. Two-thousand-three was the wettest year on record in the Maryland area, which would include much of the Potomac River watershed, though not the Susquehanna River watershed, which is mostly in New York and Pennsylvania. The total nitrogen loads, their relative percent of the total measured loads, and ranking from highest to lowest are presented in Figure 3.

Total Suspended Sediments

Trends in total suspended sediments are only available for the four long-term RIM Program sites. Trends were statistically significant and decreasing (improving) at all four sites. The decreases ranged from -20.5 at the Susquehanna River to -64.3% at the Potomac River in Washington, D.C. (Table 6).

Loads are available for the four RIM Program sites and the Mattawoman Creek site. Loads for Mattawoman Creek are only available starting in 2001, so the comparison in Figure 4 does not provide an entirely accurate ranking of the loads. For 1999 through 2009, suspended sediment loads for the Susquehanna River at Conowingo, Md. exceed the other sites. For 2003, loads at the Potomac River site exceed the Susquehanna due to the unusually large amount of rain that fell in the Potomac River watershed as compared to the Susquehanna River watershed.

It is interesting to note that suspended sediment loads for Mattawoman Creek exceed those of the Choptank River for 1999 through 2009 and when the time periods are matched for both stations (2001 through 2009). This finding is important because the size of the watershed and the flow volume of the Choptank River are larger than that of Mattawoman Creek. This indicates that the Mattawoman Creek watershed is generating a large amount of suspended sediment.

Conclusions

Of the nine RIM Program sites located in Maryland and Virginia, the majority of the total nitrogen loads to the Chesapeake Bay come from the Susquehanna River at Conowingo, Md. (67%). The second largest contributor of total nitrogen loads to the Bay is the Potomac River at Washington, D.C. (24%). The James River and Rappahannock River contribute approximately 7% of the load and the remaining sites contribute approximately 3%.

The same four RIM Program sites contribute the majority of the total phosphorus loads to the Chesapeake Bay with the Susquehanna River contributing the most (43%), the Potomac River the second highest (32%), the James River third highest (15%) and the Rappahannock River the fourth highest (6%). The remaining five RIM Program sites contribute approximately 4% of the total phosphorus loads to the Bay.

When total nitrogen loads are compared to sites which are in Maryland or near its borders, the majority of the loads (62%) still come from the Susquehanna River at Conowingo, Md. The second largest total nitrogen load (21%) comes from the Potomac River at Washington, D.C. The remaining total nitrogen loads coming from the other nine monitored streams is smaller than the loads from the Susquehanna River and the Potomac River and ranges from 2.71% at the Monocacy River to 0.11% at Georges Creek.

Similarly, the majority of the total phosphorus loads come from the Susquehanna River and the Potomac River at 47.91% and 31.77%, respectively. Total phosphorus loads from smaller streams in Maryland or near the border with Maryland range from 2.79% for the Monocacy River to 0.10% for Georges Creek and contribute little to the total phosphorus loads.

References

Belval, D.L., and Sprague, L.A., 1999. Monitoring nutrients in the major rivers draining to Chesapeake Bay: U.S. Geological Survey Water-Resources Investigations Report 99-4238, 8 p.

Cohn, T.A., Delong, L.L., Gilroy, E.J., Hirsch, R.M., and Wells, D. 1989. Estimating constituent loads: Water Resources Research, 25 (5), 937-942.

Gilroy, E.J., Hirsch, R.M., and Cohn, T.A. 1990. Mean square error of regression-based constituent transport estimates: Water Resources Research, 276, (9), 2069-2077.

U.S. EPA (U.S. Environmental Protection Agency). 1996 (revised 2008). Recommended Guidelines for Sampling and Analysis in the Chesapeake Bay Monitoring Program. August 1996. EPA 903-R-96-006. Region III Chesapeake Bay Program Office, Annapolis, MD.

Table 1. River input monitoring program sites monitored by USGS in cooperation with DNR.

River	USGS station number	Drainage area (miles^2)	Latitude	Longitude
Susquehanna	01578310	27,100	39°39'28.1"	76°10'28.2"
Potomac	01646580	11,560	38°55'46"	77°07'01"
Patuxent	01594440	348	38°57'21.3"	76°41'37.3"
Choptank	01491000	113	38°59'49.9"	75°47'08.9"

Table 2. Non-tidal network stations monitored by DNR.

Stream	USGS station number	Drainage area (miles^2)	Latitude	Longitude
Antietam Creek	01619500	281	39°26'59.2"	77°43'48.7"
Big Elk Creek	01495000	52.6	39°39'25.4"	75°49'20.5"
Catoctin Creek	01637500	66.9	39°25'38.1"	77°33'22.2
Deer Creek	01580520	164	39°37'02.8"	76°11'30.7"
Georges Creek	01599000	74.2	39°29'38.1"	79°02'40.9"
Gunpowder River	01582500	160	39°32'58.9"	76°38'10.0"
Gwynns Falls	01589300	32.5	39°20'45.2"	76°43'59.5"
Monocacy River	01639000	173	39°40´43.8"	77°14´04.2"
North Branch Patapsco River	01586000	56.6	39°30'13.2"	76°53'05.5"
Patuxent River	01591000	34.8	39°14'17.7"	77°03'20.6"
Tuckahoe Creek	01491500	85.2	38°58'00.5"	75°56'35.0"
Western Branch	01594526	89.7	38°48'51.2"	76°44'55.4"
Wills Creek	01601500	247	39°40'10.6"	78°47'16.9"

Table 3. Non-tidal network sites located in Maryland or near the border with Maryland that are monitored by other states.

Stream	USGS station number	Drainage area (miles^2)	Latitude	Longitude	Distance from border (miles)
Antietam Creek	01619000	93.5	39°42'58.5"	77°36'23.9"	0.3 downstream from PA border (in MD)
Cacapon River	01611500	675	39°34'56"	78°18'36"	4.3 upstream from MD border (in WVA)
Conococheague Creek	01614500	494	39°42'59.0"	77°49'29.2"	2.3 downstream from PA border (in MD)
Licking Creek	01613525	193	39°40'39.7"	78°02'11.5"	4.6 downstream from PA border (in MD)
Marshyhope Creek	01488500	46.8	38°50'58.9"	75°40'23.2"	6.5 upstream from MD border (in DE)
Nanticoke River	01487000	75.4	38°43'42.0"	75°33'42.7"	15.9 upstream from MD border (in DE)
North Fork Shenandoah River	01634000	770	38°58'36"	78°20'11"	60.9 up stream from MD border (in VA)
Octoraro Creek	01578475	177	39°42'24"	76°06'56"	3.2 downstream from PA border (in MD)
Opequon Creek	01616500	273	39°25'25"	77°56'20"	9.2 upstream from MD border (in WVA)
Patterson Creek	01604500	221	39°26'35"	78°49'20"	11.1 upstream from MD border (in WVA)
Sideling Hill Creek	01610155	102	39°38´58.3"	78°20´38.9"	7.6 downstream from PA border (in MD)
South Branch Potomac River	01608500	1,461	39°26'49"	78°39'16"	12.4 upstream from MD border (in WVA)
South Fork Shenandoah River	01631000	1,634	38°54'50"	78°l112'40"	55.7 up stream from MD border (in VA)
Tonoloway Creek	01613095	111	39°42'22.9"	78°09'09.9"	1.2 downstream from PA border (in MD)
Town Creek	01609000	148	39°33'11.6"	78°33'18.0"	17 downstream from PA border (in MD)

Table 4. Flow-adjusted trends in total nitrogen.

USGS station number	Station name	Percent change	p-value
01491000	Choptank River near Greensboro, MD	7.6	0.0228
01578310	Susquehanna River at Conowingo, MD	-26.3	<0.0001
01582500	Gunpowder Falls at Glencoe, MD	NA	0.1459
01586000	North Branch Patapsco River at Cedarhurst, MD	NA	0.7043
01591000	Patuxent River near Unity, MD	NA	0.7043
01592500	Patuxent River near Laurel, MD	-9.2	0.0062
01594440	Patuxent River at Bowie, MD	-57.5	<0.0001
01599000	Georges Creek at Franklin, MD	-43.6	<0.0001
01601500	Wills Creek near Cumberland, MD	-42.3	<0.0001
01614500	Conocheague Creek at Fairview, MD	-12.8	<0.0001
01619500	Antietam Creek near Sharpsburg	-26.5	<0.0001
01631000	South Fork Shenandoah River at Front Royal, VA	-38.2	<0.0001
01634000	North Fork Shenandoah River near Strasburg, VA	NA	0.9278
01637500	Catoctin Creek near Middletown, MD	-30.3	<0.0001
01639000	Monocacy River at Bridgeport, MD	-30	<0.0001
01646580	Potomac River at Chain Bridge, near Washington, DC	-23.2	<0.0001
01651000	North Branch Anacostia River near Hyattsville, MD	-23.8	<0.0001

[1]**NA – not applicable, trend is not significant and percent change is not reported.**

Note: Negative trends show improvements; positive trends indicate degrading water quality.

Table 5. Flow adjusted trends in total phosphorus.

USGS station number	Station name	Percent change	p-value
01491000	Choptank River near Greensboro, MD	44.7	<0.0001
01578310	Susquehanna River at Conowingo, MD	NA	0.1933
01582500	Gunpowder Falls at Glencoe, MD	-46.6	<0.0001
01586000	North Branch Patapsco River at Cedarhurst, MD	-52.7	<0.0001
01591000	Patuxent River near Unity, MD	-72.4	<0.0001
01592500	Patuxent River near Laurel, MD	-31.7	0.0016
01594440	Patuxent River at Bowie, MD	-59.1	<0.0001
01599000	Georges Creek at Franklin, MD	-45.1	<0.0001
01601500	Wills Creek near Cumberland, MD	-42.2	0.0005
01614500	Conocheague Creek at Fairview, MD	-65.2	<0.0001
01619500	Antietam Creek near Sharpsburg	-61	<0.0001
01631000	South Fork Shenandoah River at Front Royal, VA	-32.6	0.0014
01634000	North Fork Shenandoah River near Strasburg, VA	-40.4	<0.0001
01637500	Catoctin Creek near Middletown, MD	-32.6	0.0011
01639000	Monocacy River at Bridgeport, MD	-32.8	<0.0001
01646580	Potomac River at Chain Bridge, near Washington, DC	NA	0.5961
01651000	North Branch Anacostia River near Hyattsville, MD	NA	0.0721

[1]**NA – not applicable, trend is not significant and percent change is not reported.**

Note: Negative trends show improvements; positive trends indicate degrading water quality.

Table 6. Flow adjusted trends in total suspended sediment.

USGS station number	Station name	Percent change	p-value
01491000	Choptank River near Greensboro, MD	-20.5	0.0003
01578310	Susquehanna River at Conowingo, MD	-26.3	<0.0001
01594440	Patuxent River at Bowie, MD	-49.9	<0.0001
01646580	Potomac River at Chain Bridge, near Washington, DC	-64.3	<0.0001

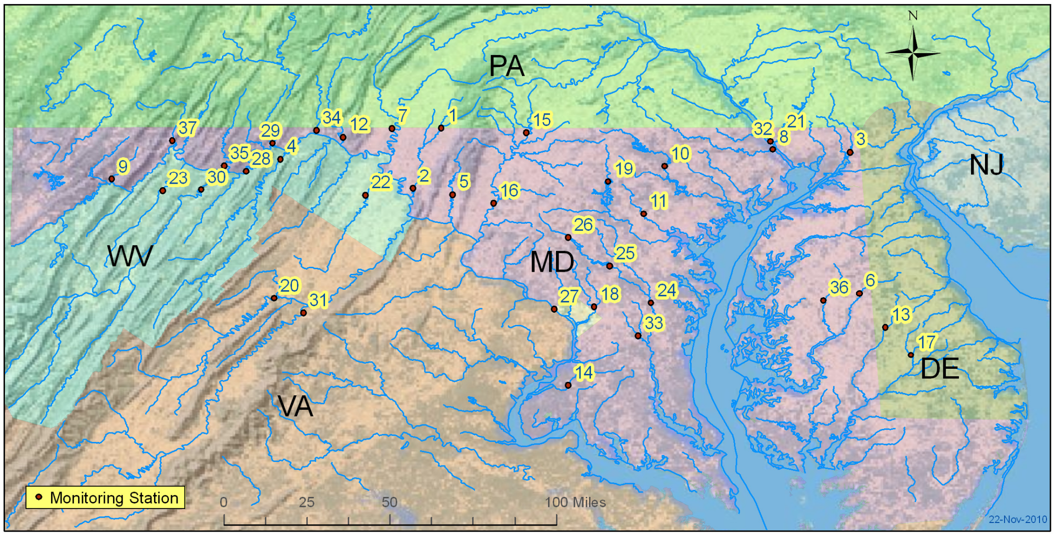

Figure 1. List of load sites monitored in Maryland or near its borders.

Key to Figure 1

Station Map ID	Station name	State[1]	USGS ID
1	Antietam Creek near Waynesboro, PA	PA	01619000
2	Antietam Creek near Sharpsburg, MD	MD	01619500
3	Big Elk Creek near Elkton, MD	MD	01495000
4	Cacapon River near Great Cacapon, WV	WV	01611500
5	Catoctin Creek near Middletown, MD	MD	01637500
6	Choptank River, near Greensboro, MD	MD	01491000
7	Conocheague Creek at Fairview, MD	PA	01614500
8	Deer Creek near Darlington, MD	MD	01580520
9	Georges Creek at Franklin, MD	MD	01599000
10	Gunpowder Falls at Glencoe, MD	MD	01582500
11	Gwynns Falls at Villa Nova, MD	MD	01589300
12	Licking Creek near Pectonville, MD	PA	01613525
13	Marshyhope Creek near Adamsville, DE	DE	01488500
14	Mattawoman Creek near Pomonkey, MD	NA[2]	01658000
15	Monocacy River at Bridgeport, MD	MD	01639000
16	Monocacy River near Frederick, MD	MD	01643000
17	Nanticoke River near Bridgeville, DE	DE	01487000
18	Northwest Branch Anacostia River near Hyattsville, MD[2]	NA[3]	01651000
19	North Branch Patapsco River at Cedarhurst, MD	MD	01586000
20	North Fork Shenandoah River near Strasburg, VA	VA	01634000
21	Octoraro Creek near Richardsmere, MD	PA	01578475
22	Opequon Creek near Martinsburg, WV	WV	01616500
23	Patterson Creek near Headsville, WV	WV	01604500
24	Patuxent River near Bowie, MD	MD	01594440
25	Patuxent River near Laurel, MD	MD	01592500
26	Patuxent River near Unity, MD	MD	01591000
27	Potomac River at Chain Bridge, in Washington, DC	NA[4]	01646580
28	Potomac River at Paw Paw, WV	WV	01610000

Station Map ID	Station name	State[1]	USGS ID
29	Sideling Hill Creek near Bellegrove, MD	PA	01610155
30	South Branch Potomac River near Springfield, WV	WV	01608500
31	South Fork Shenandoah River at Front Royal, VA	VA	01631000
32	Susquehanna River, at Conowingo, MD	MD	01578310
33	Western Branch at Upper Marlboro, MD	MD	01594526
34	Tonoloway Creek near Hancock, MD	PA	01613095
35	Town Creek near Oldtown, MD	PA	01609000
36	Tuckahoe Creek near Ruthsburg, MD	MD	01491500
37	Wills Creek near Cumberland, MD	MD	01601500

1 – State or entity that monitors the site.

2 – Mattawoman Creek is monitored by USGS with support from Charles County.

3 – Northwest Branch Anacostia River is monitored by USGS with support from Montgomery County.

4 – Potomac River at Chain Bridge is monitored by USGS with support from the Maryland Department of Natural Resources.

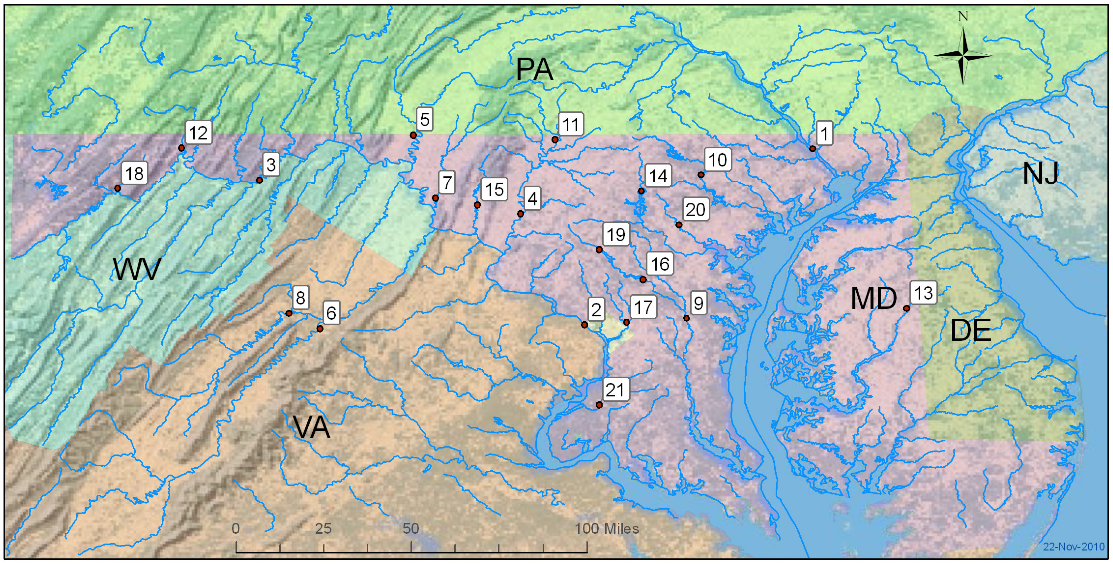

Figure 2. Relative ranking of total nitrogen load sites.

Key to Figure 2 – Average total nitrogen loads for 1999 through 2009.

Ranking	USGS STAID	Station name	Load (kg/day)	Percent of total
1	01578310	Susquehanna River, at Conowingo, MD	155,050	62.48%
2	01646580	Potomac River at Chain Bridge, at Washington, DC	51,396	20.71%
3	01610000	Potomac River at Paw Paw, WV	9,091	3.66%
4	01643000	Monocacy River near Frederick, MD	6,734	2.71%
5	01614500	Conocheague Creek at Fairview, MD	6,534	2.63%
6	01631000	South Fork Shenandoah River at Front Royal, VA	5,038	2.03%
7	01619500	Antietam Creek near Sharpsburg, MD	3,322	1.34%
8	01634000	North Fork Shenandoah River near Strasburg, VA	2,824	1.14%
9	01594440	Patuxent River near Bowie, MD	1,623	0.65%
10	01582500	Gunpowder Falls at Glencoe, MD	1,284	0.52%
11	01639000	Monocacy River at Bridgeport, MD	1,115	0.45%
12	01601500	Wills Creek near Cumberland, MD	989	0.40%
13	01491000	Choptank River, near Greensboro, MD	692	0.28%
14	01586000	North Branch Patapsco River at Cedarhurst, MD	634	0.26%
15	01637500	Catoctin Creek near Middletown, MD	340	0.14%
16	01592500	Patuxent River near Laurel, MD	315	0.13%
17	01651000	North Branch Anacostia River near Hyattsville, MD	292	0.12%
18	01599000	Georges Creek at Franklin, MD	273	0.11%
19	01591000	Patuxent River near Unity, MD	272	0.11%
20	01589300	Gwynns Falls at Villa Nova, MD	185	0.07%
21	01658000	Mattawoman Creek near Pomonkey, MD[1]	167	0.07%

[1]Loads for Mattawoman Creek are for 2001 through 2009.

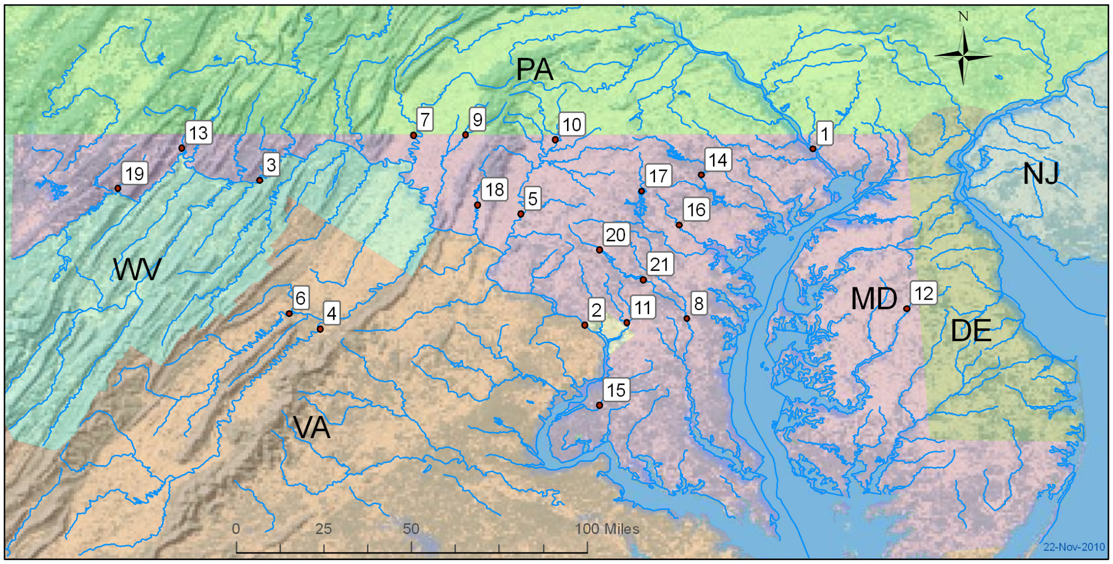

Figure 3. Relative ranking of total phosphorus load sites.

Key to Figure 3 – Average total phosphorus loads for 1999 through 2009.

Ranking	USGS STAID	Station name	Load (kg/day)	Percent of total
1	01578310	Susquehanna River, at Conowingo, MD	5969.37	47.91%
2	01646580	Potomac River at Chain Bridge, at Washington, DC	3958.54	31.77%
3	01610000	Potomac River at Paw Paw, WV	597.92	4.80%
4	01631000	South Fork Shenandoah River at Front Royal, VA	477.51	3.83%
5	01643000	Monocacy River near Frederick, MD	348.12	2.79%
6	01634000	North Fork Shenandoah River near Strasburg, VA	299.3	2.40%
7	01614500	Conocheague Creek at Fairview, MD	209.22	1.68%
8	01594440	Patuxent River near Bowie, MD	136.4	1.09%
9	01619500	Antietam Creek near Sharpsburg, MD	100.06	0.80%
10	01639000	Monocacy River at Bridgeport, MD	77.4	0.62%
11	01651000	North Branch Anacostia River near Hyattsville, MD	62.47	0.50%
12	01491000	Choptank River, near Greensboro, MD	50.28	0.40%
13	01601500	Wills Creek near Cumberland, MD	45.49	0.37%
14	01582500	Gunpowder Falls at Glencoe, MD	21.84	0.18%
15	01658000	Mattawoman Creek near Pomonkey, MD[1]	21.59	0.17%
16	01589300	Gwynns Falls at Villa Nova, MD	19.68	0.16%
17	01586000	North Branch Patapsco River at Cedarhurst, MD	18.88	0.15%
18	01637500	Catoctin Creek near Middletown, MD	16.7	0.13%
19	01599000	Georges Creek at Franklin, MD	12.45	0.10%
20	01591000	Patuxent River near Unity, MD	11.07	0.09%
21	01592500	Patuxent River near Laurel, MD	5.38	0.04%

[1]Loads for Mattawoman Creek are for 2001 through 2009.

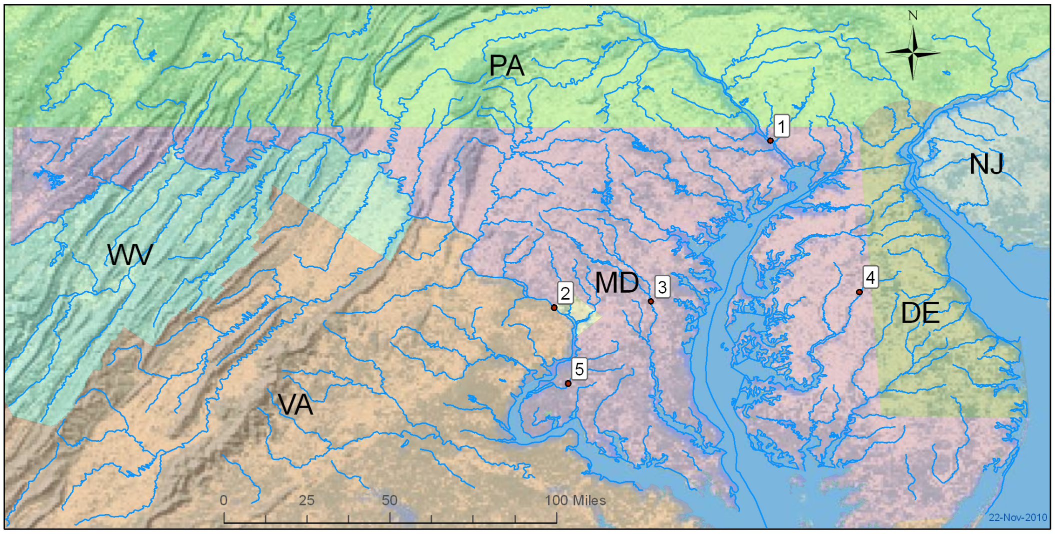

Figure 4. Relative ranking of total suspended sediment load sites.

Key to Figure 4 – Average total suspended sediment loads for 1999 through 2009.

Ranking	USGS STAID	Station name	Load (kg/day)	Percent of total
1	01578310	Susquehanna River, at Conowingo, MD	2612764.58	53.61%
2	01646580	Potomac River at Chain Bridge, at Washington, DC	2169477.10	44.51%
3	01594440	Patuxent River near Bowie, MD	72271.39	1.48%
4	01658000	Mattawoman Creek near Pomonkey, MD[1]	11241.93	0.23%
5	01491000	Choptank River, near Greensboro, MD	8023.97	0.16%

[1]Loads for Mattawoman Creek are for 2001 through 2009.

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Appendix A

Total nitrogen, total phosphorus, total suspended sediment and flow for the load sites in Maryland or near its borders

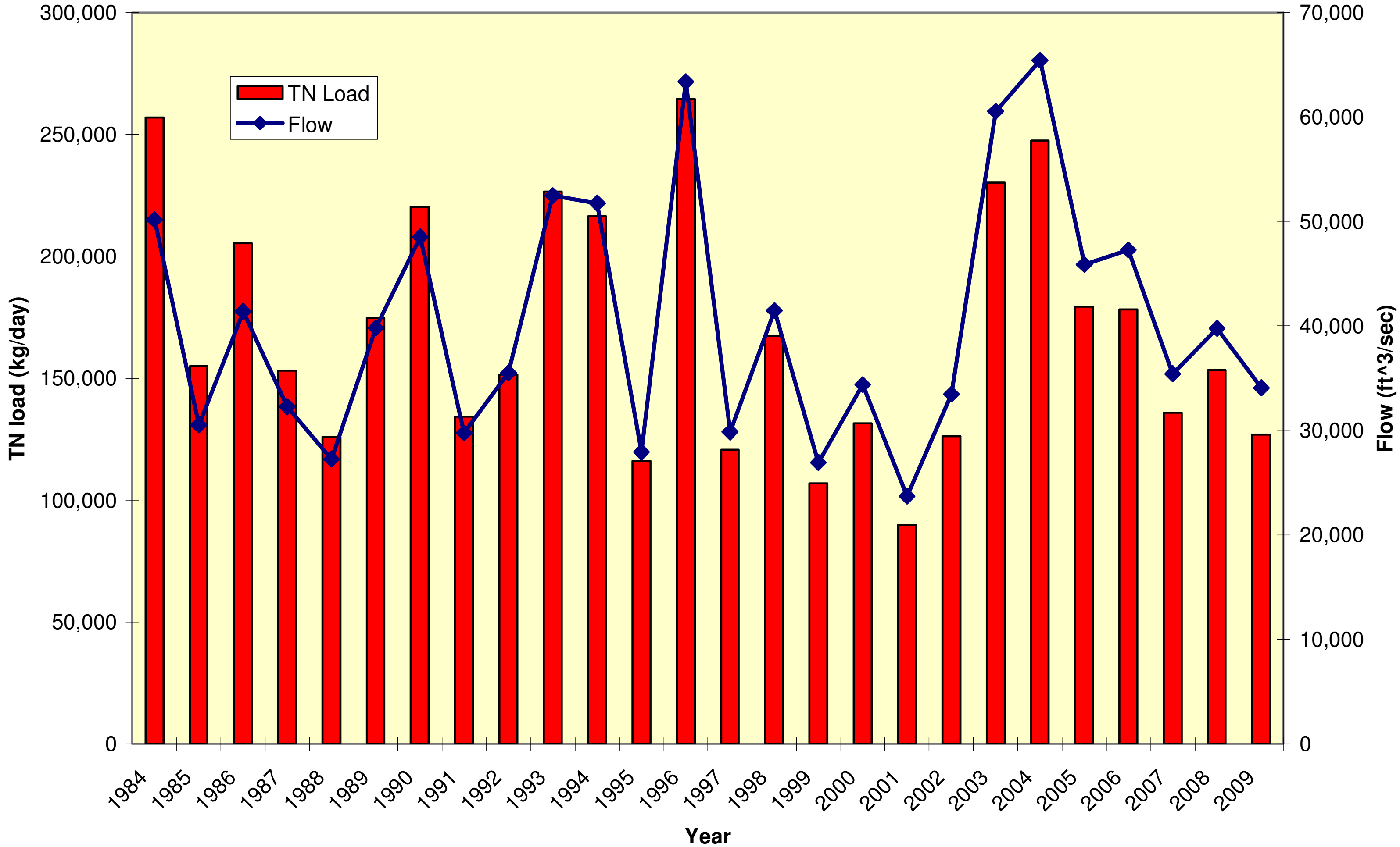


Figure A-1. Total nitrogen loads and flow for the Susquehanna River at Conowingo, MD RIM Program site.

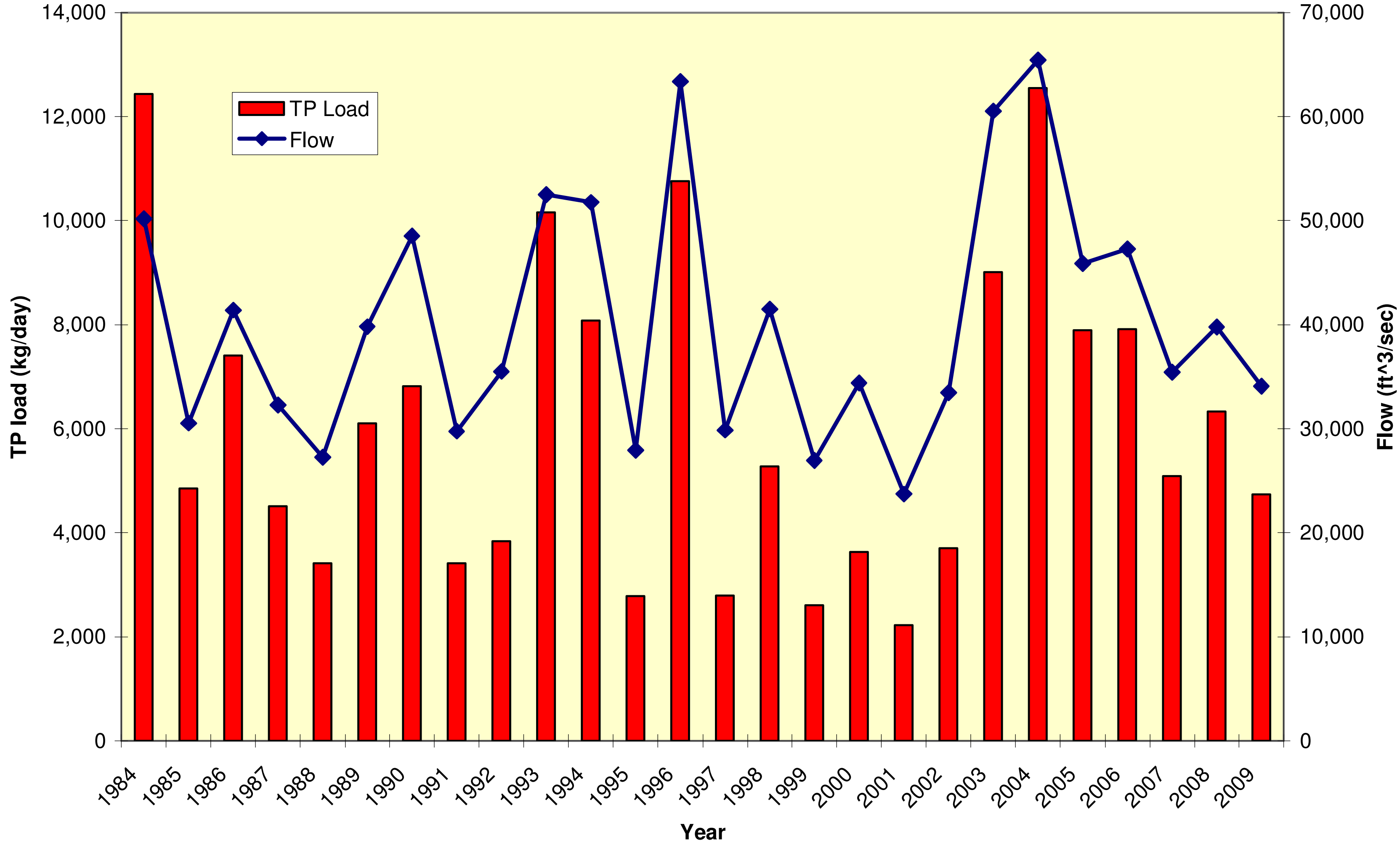


Figure A-2. Total phosphorus loads and flow for the Susquehanna River at Conowingo, MD RIM Program site.

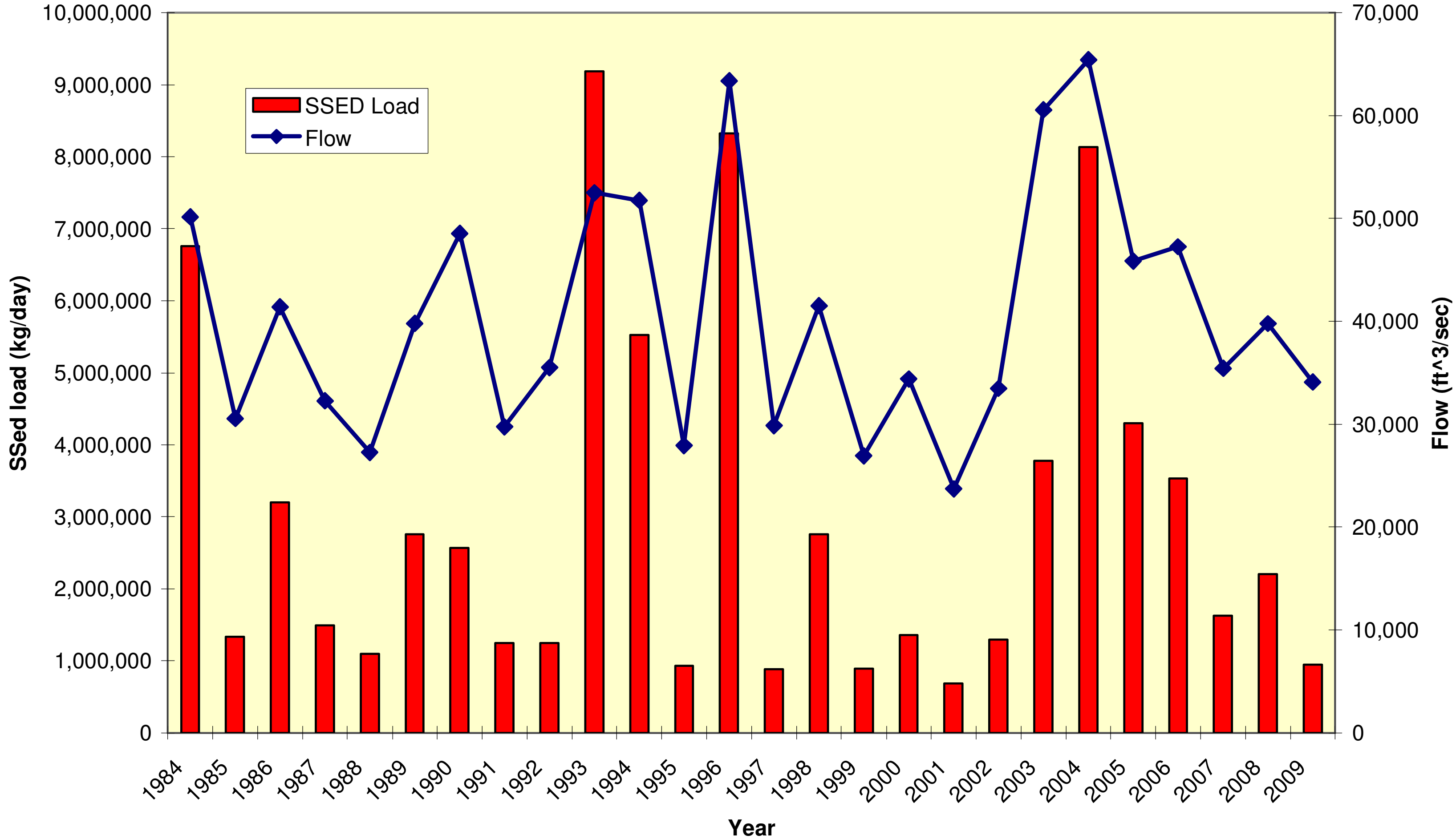


Figure A-3. Total suspended sediment loads and flow for the Susquehanna River at Conowingo, MD RIM Program site.

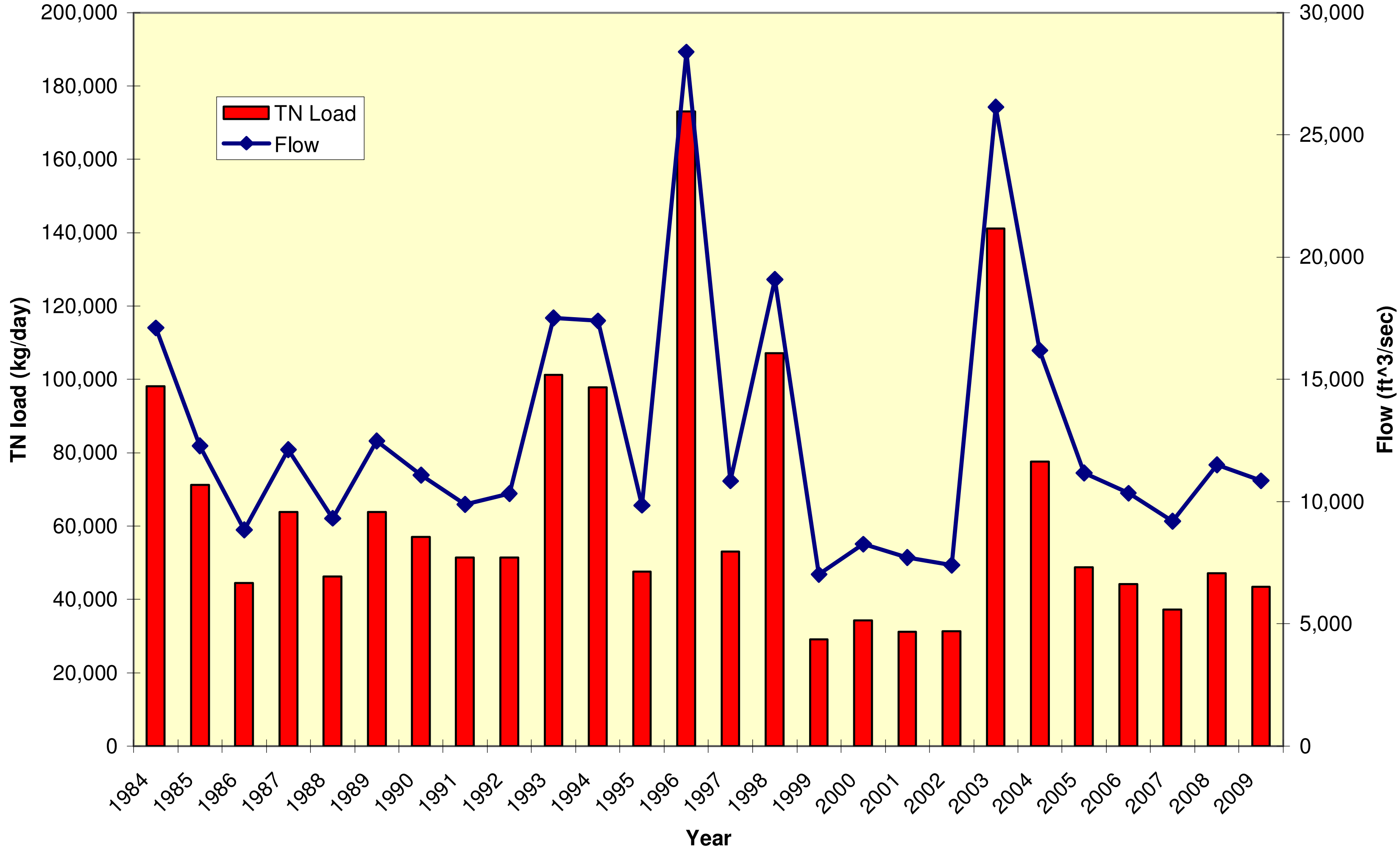


Figure A-4. Total nitrogen loads and flow for the Potomac River at Washington, DC RIM Program site.

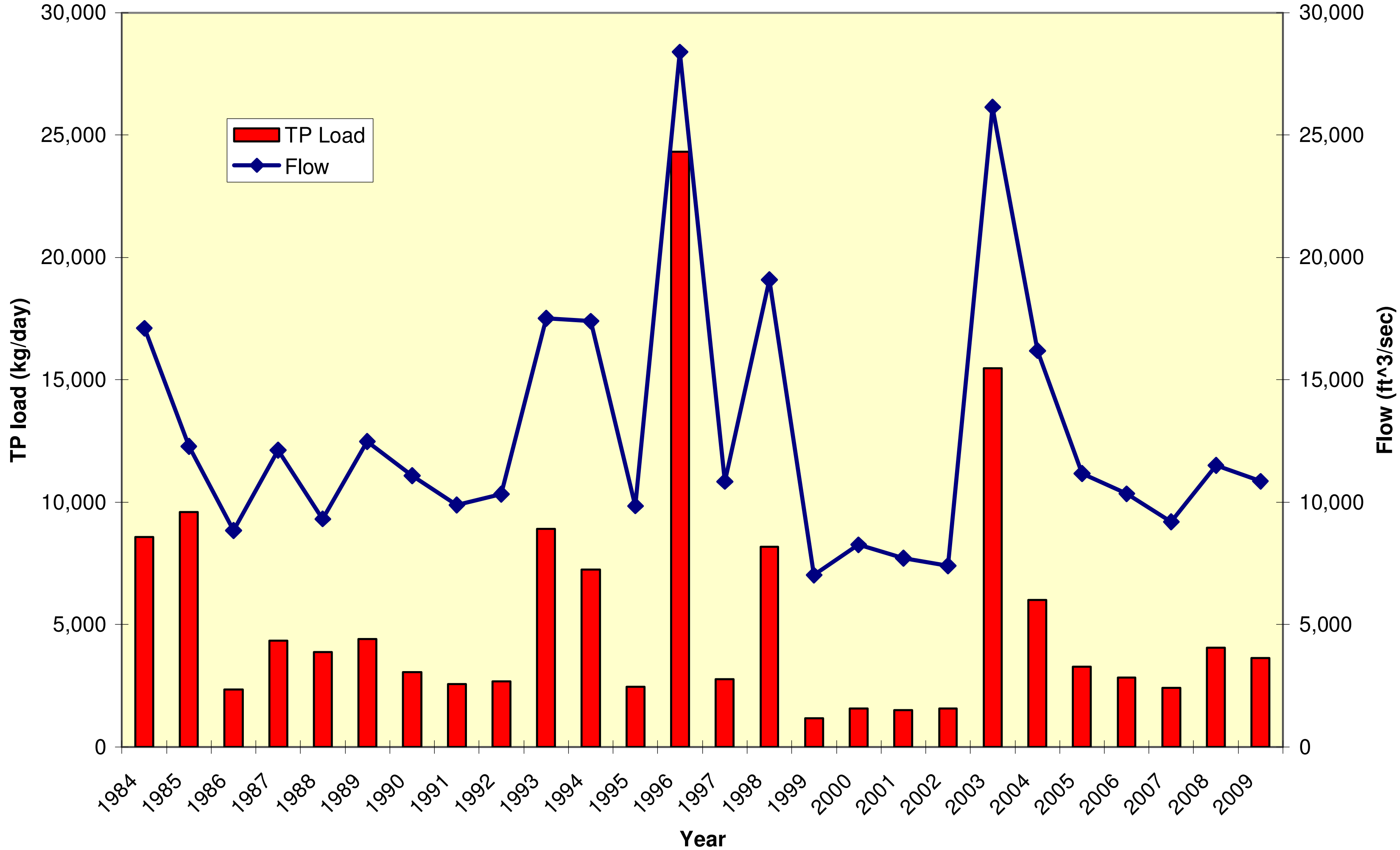


Figure A-5. Total phosphorus loads and flow for the Potomac River at Washington, DC RIM Program site.

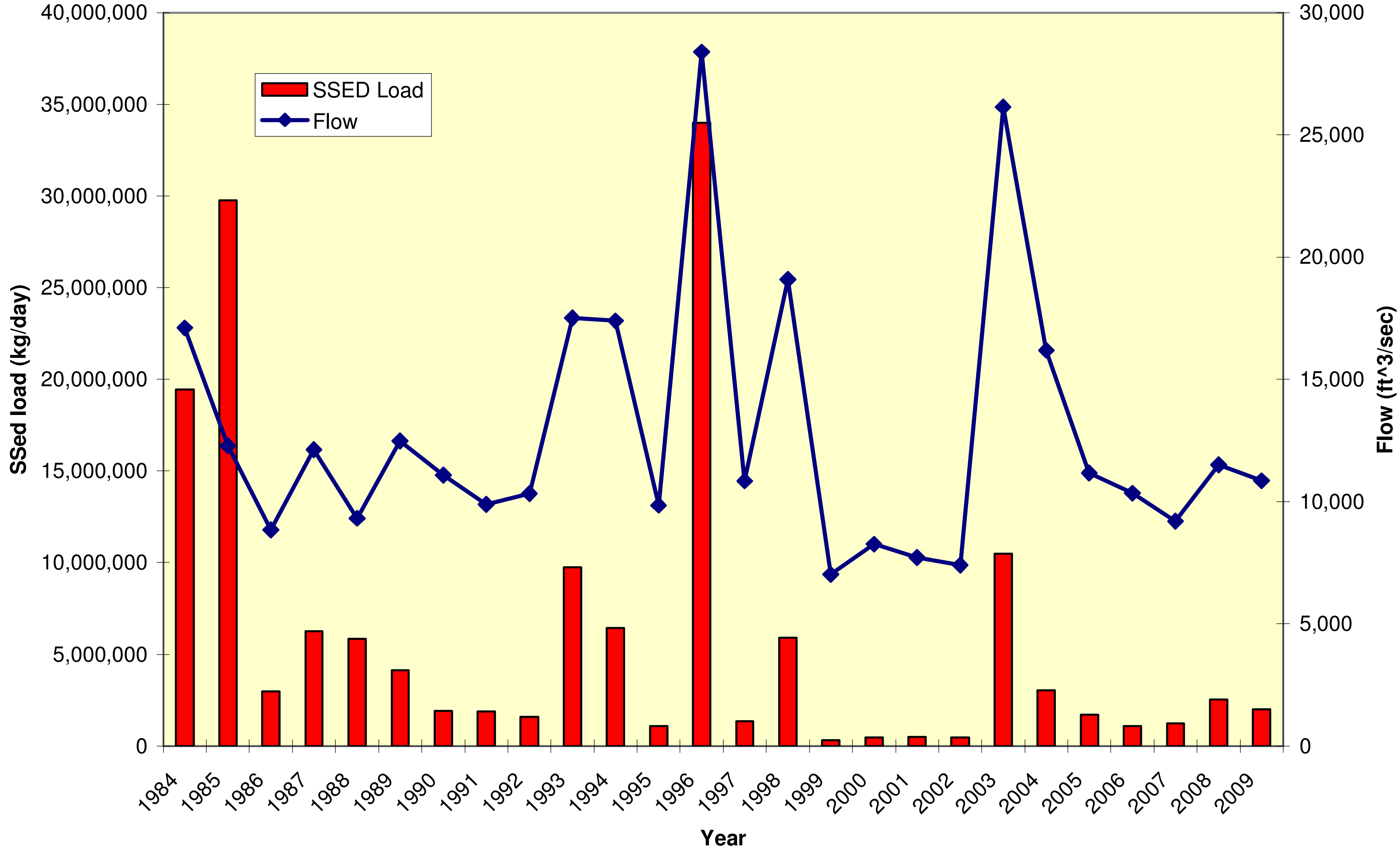


Figure A-6. Total suspended sediment loads and flow for the Potomac River at Washington, DC RIM Program site.

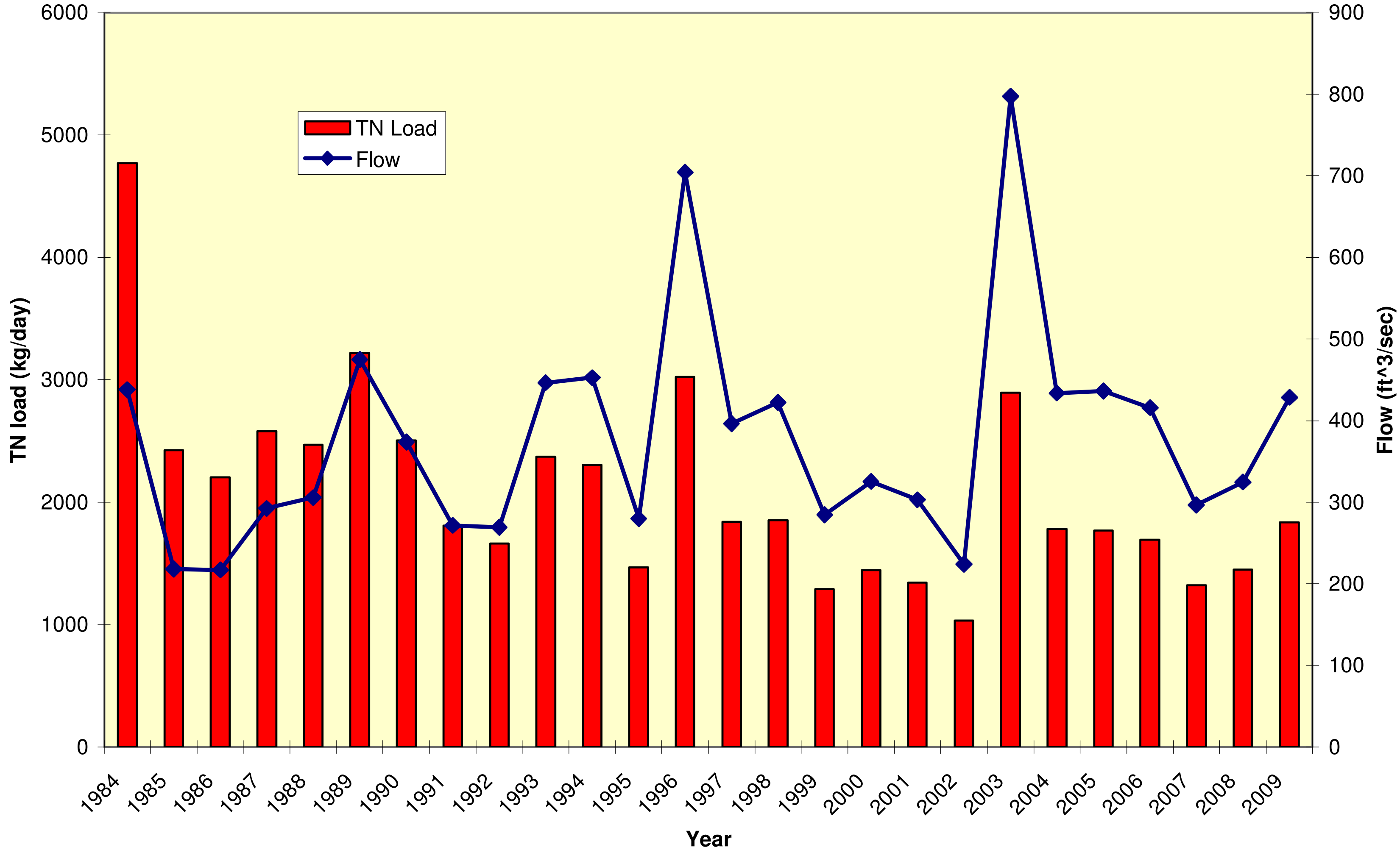


Figure A-7. Total nitrogen loads and flow for the Patuxent River near Bowie, MD RIM Program site.

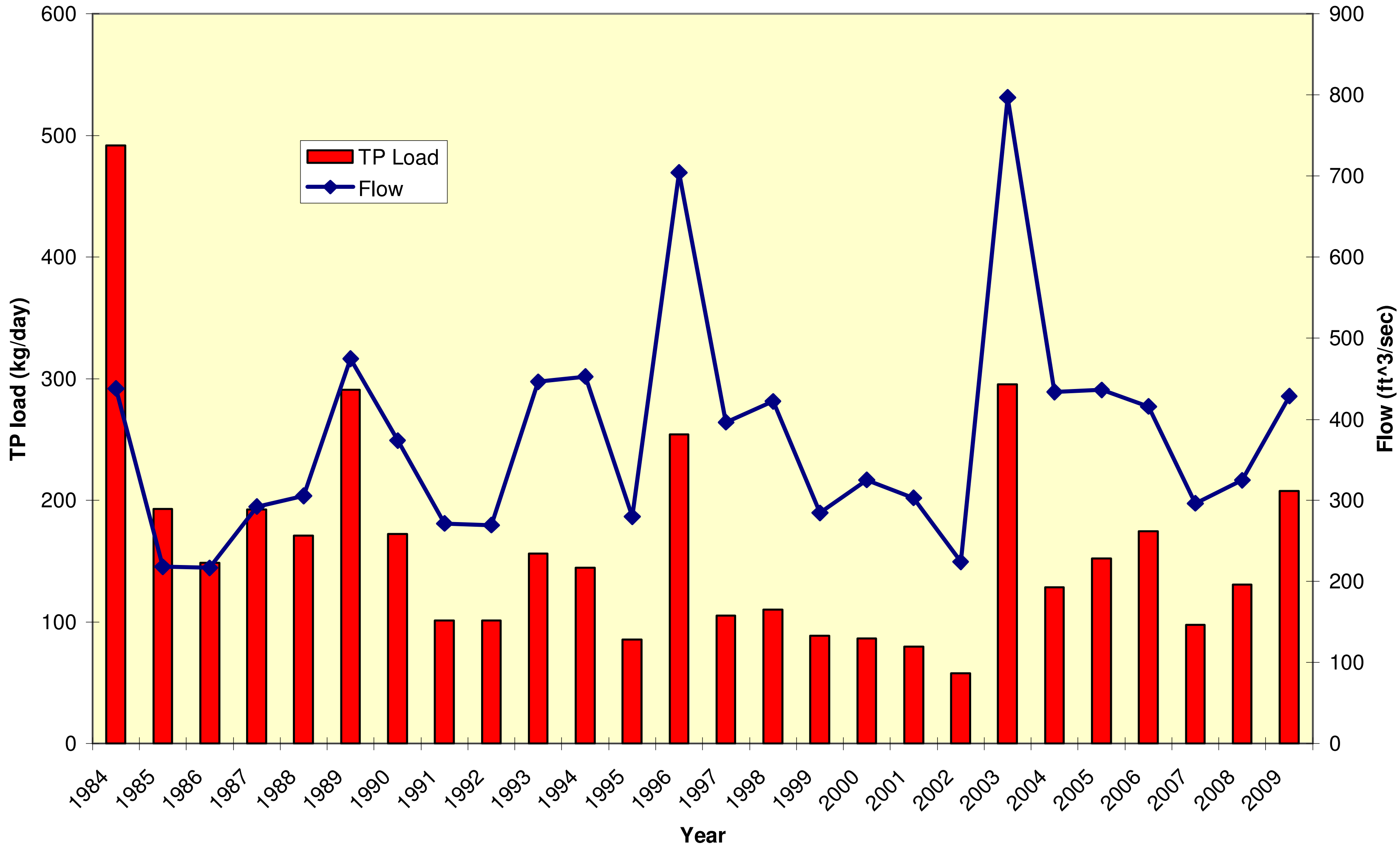


Figure A-8. Total phosphorus loads and flow for the Patuxent River near Bowie, MD RIM Program site.

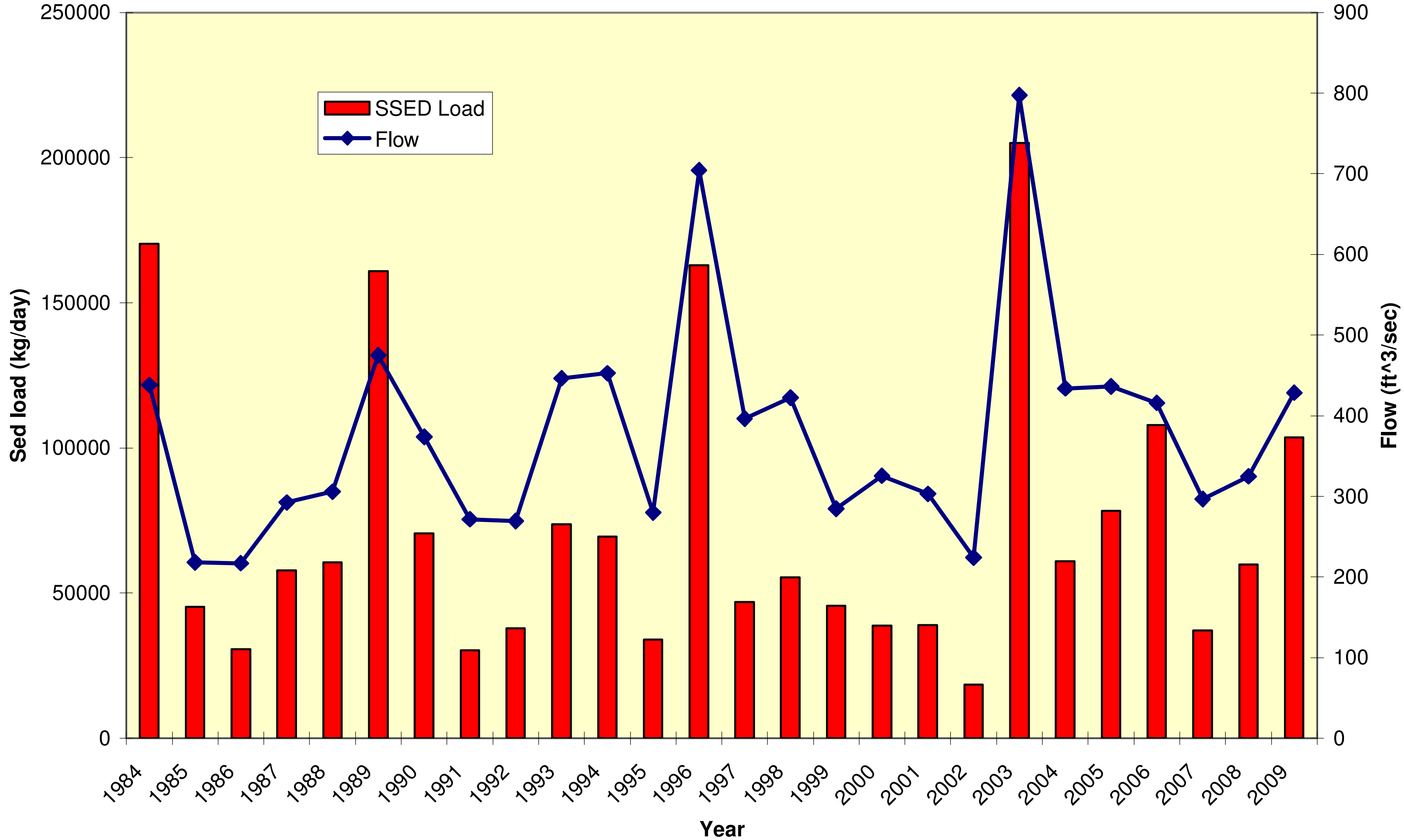


Figure A-9. Total suspended sediment loads and flow for the Patuxent River near Bowie, MD RIM Program site.

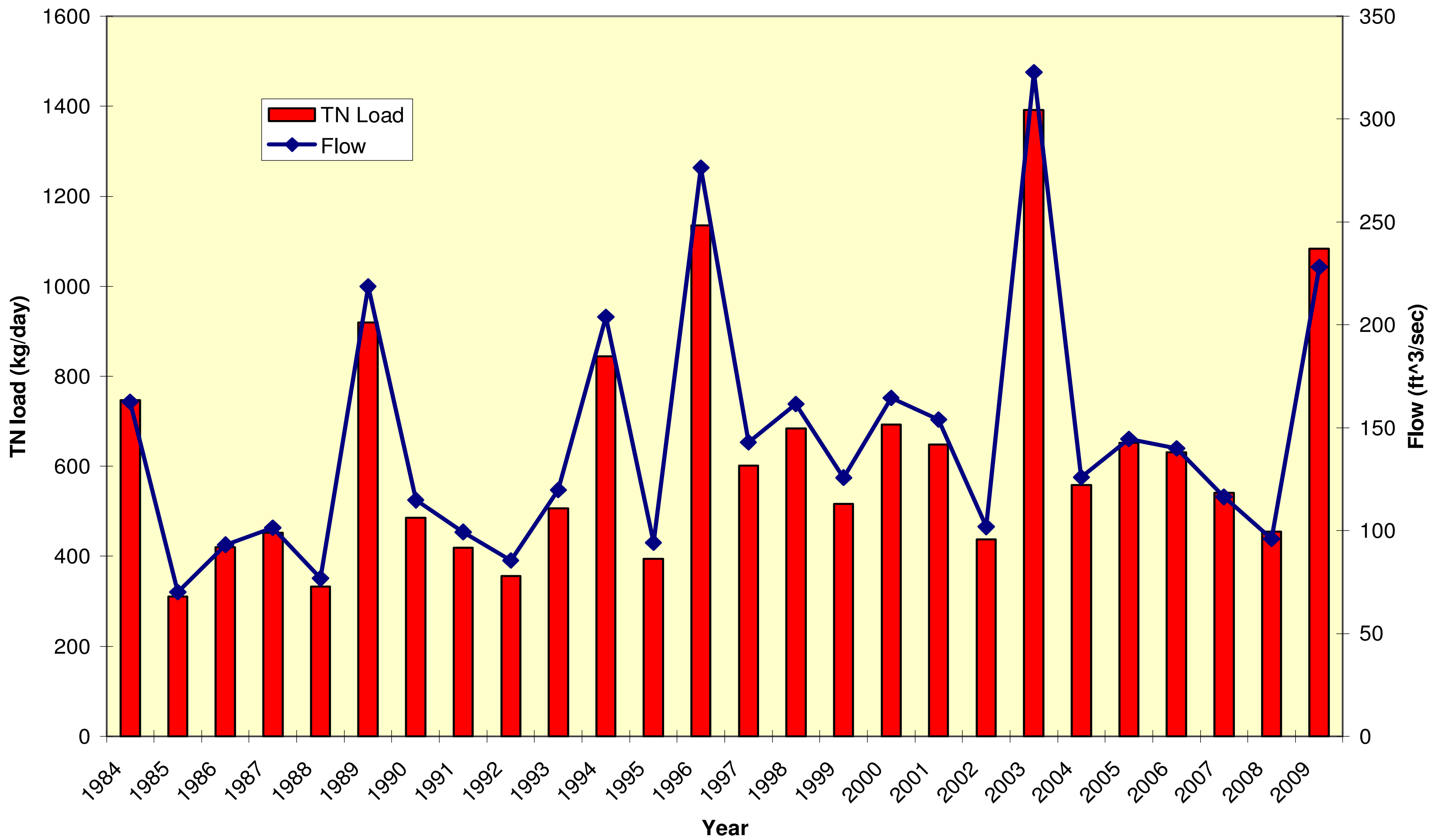
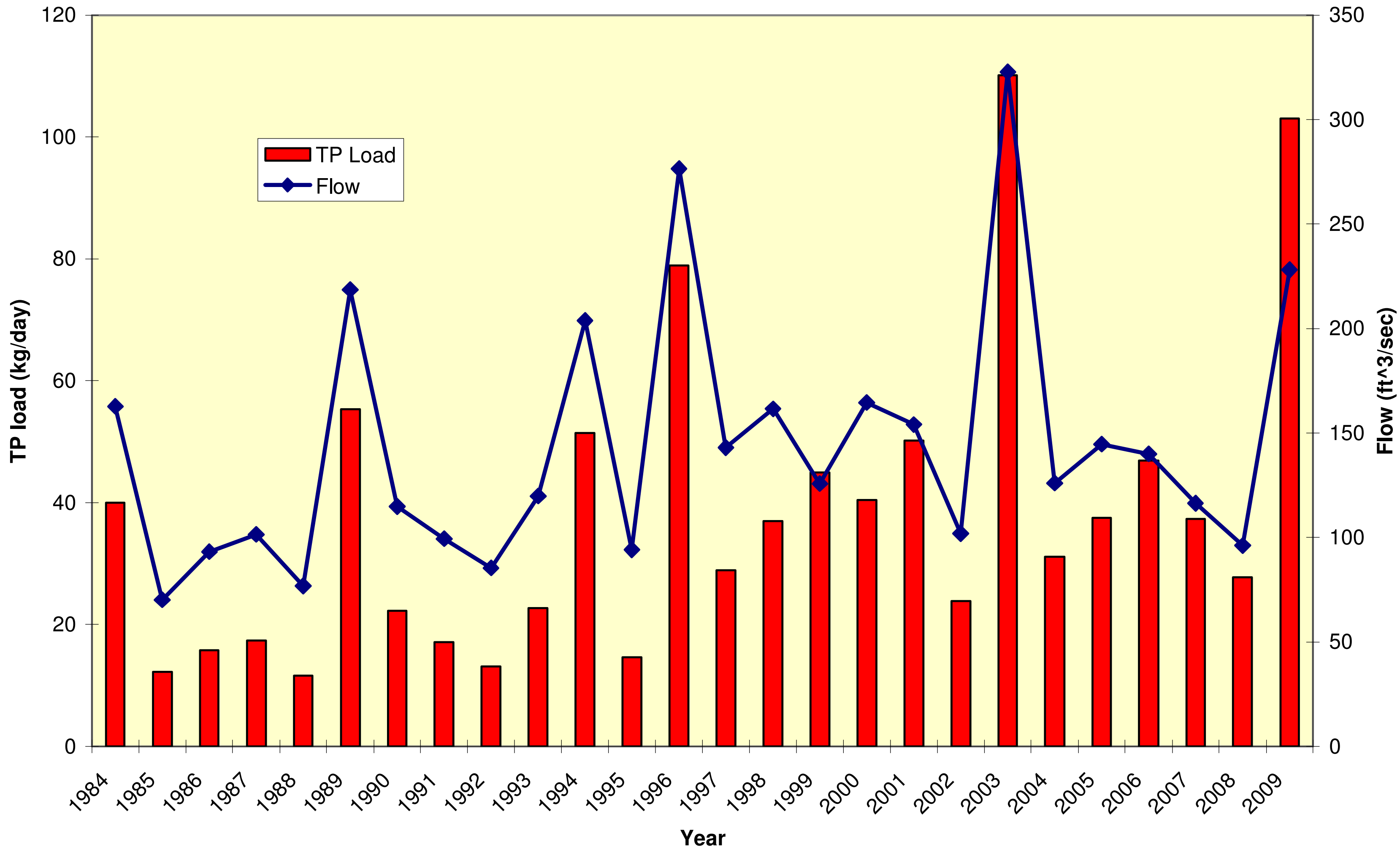


Figure A-10. Total nitrogen loads and flow for the Choptank River near Greensboro, MD RIM Program site.



TP Load
Flow
TP load (kg/day)
Flow (ft^3/sec)
Year
0
20
40
60
80
100
120
0
50
100
150
200
250
300
350
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

Figure A-11. Total phosphorus loads and flow for the Choptank River near Greensboro, MD RIM Program site.

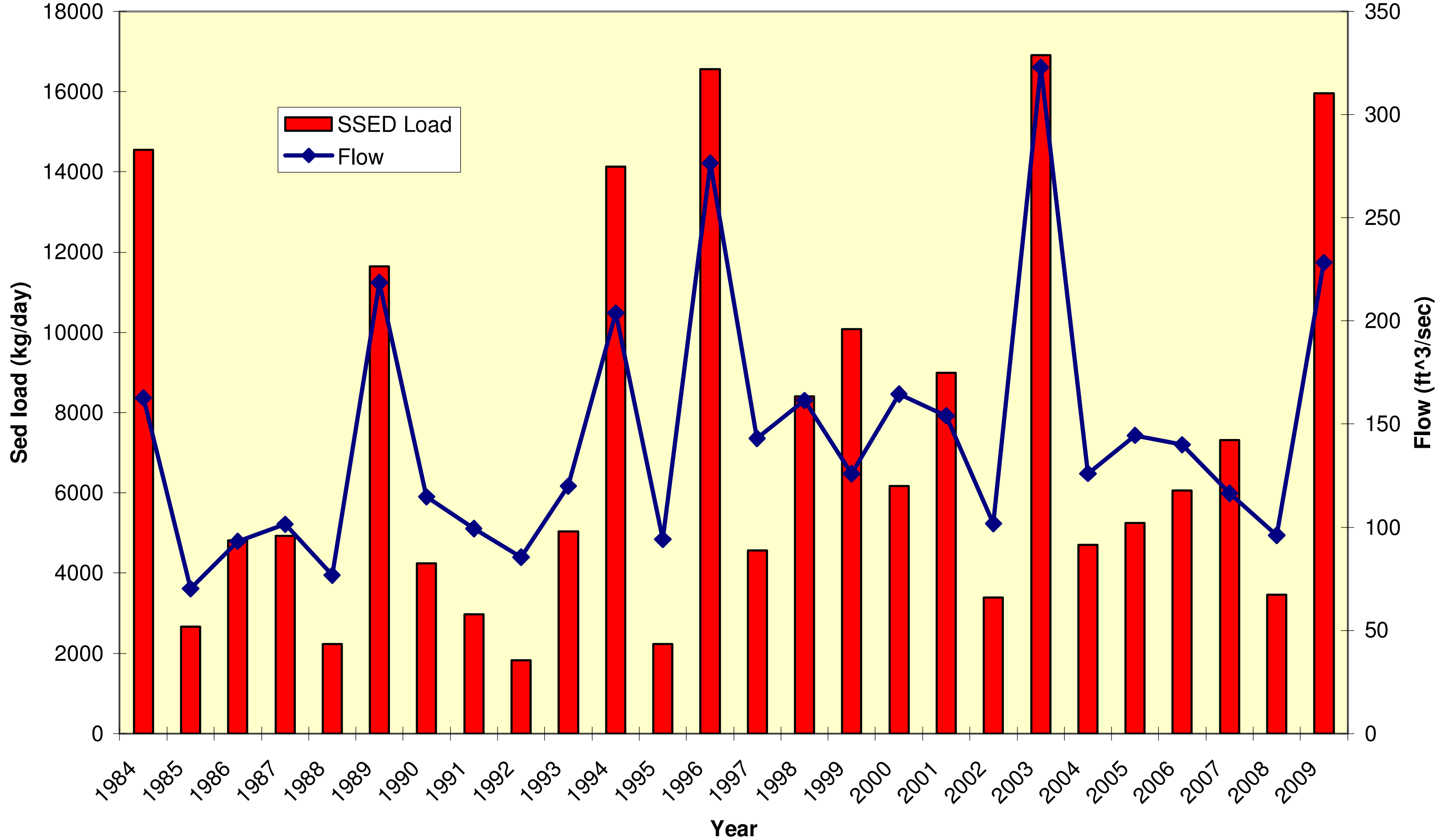


Figure A-12. Total suspended sediment loads and flow for the Choptank River near Greensboro, MD RIM Program site.

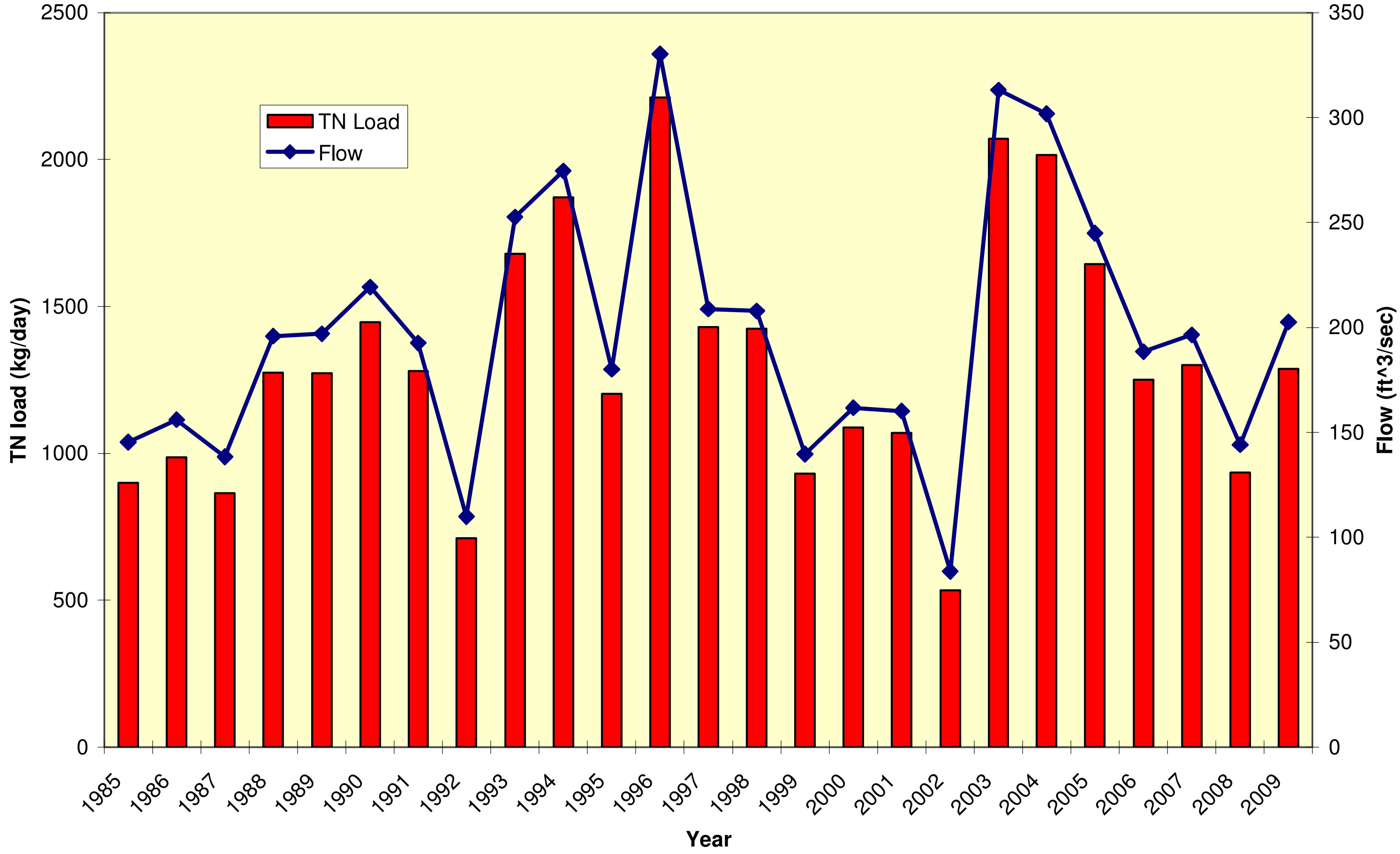


Figure A-13. Total nitrogen loads and flow for the Gunpowder River at Glencoe, MD non-tidal network site.

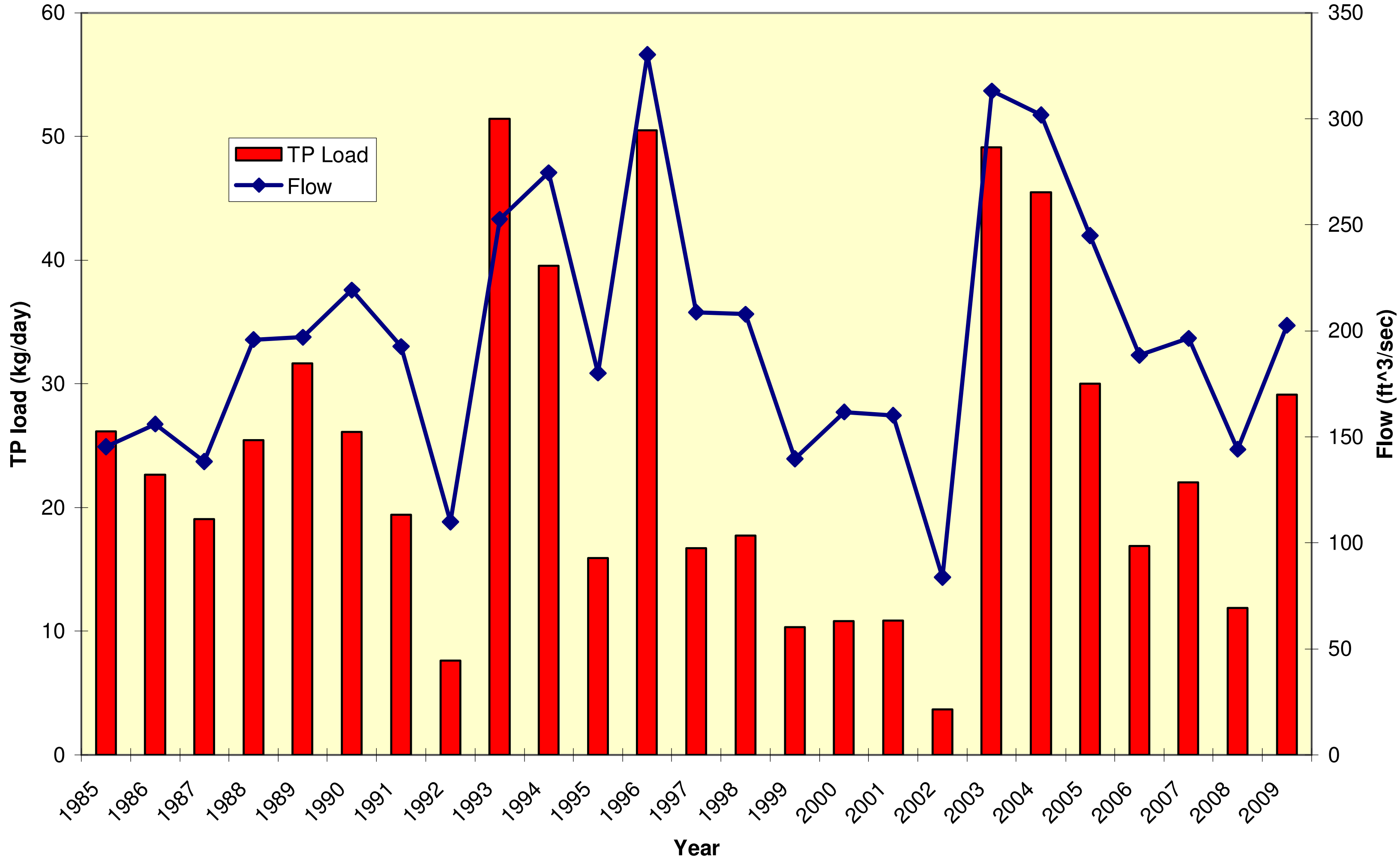


Figure A-14. Total phosphorus loads and flow for the Gunpowder River at Glencoe, MD non-tidal network site.

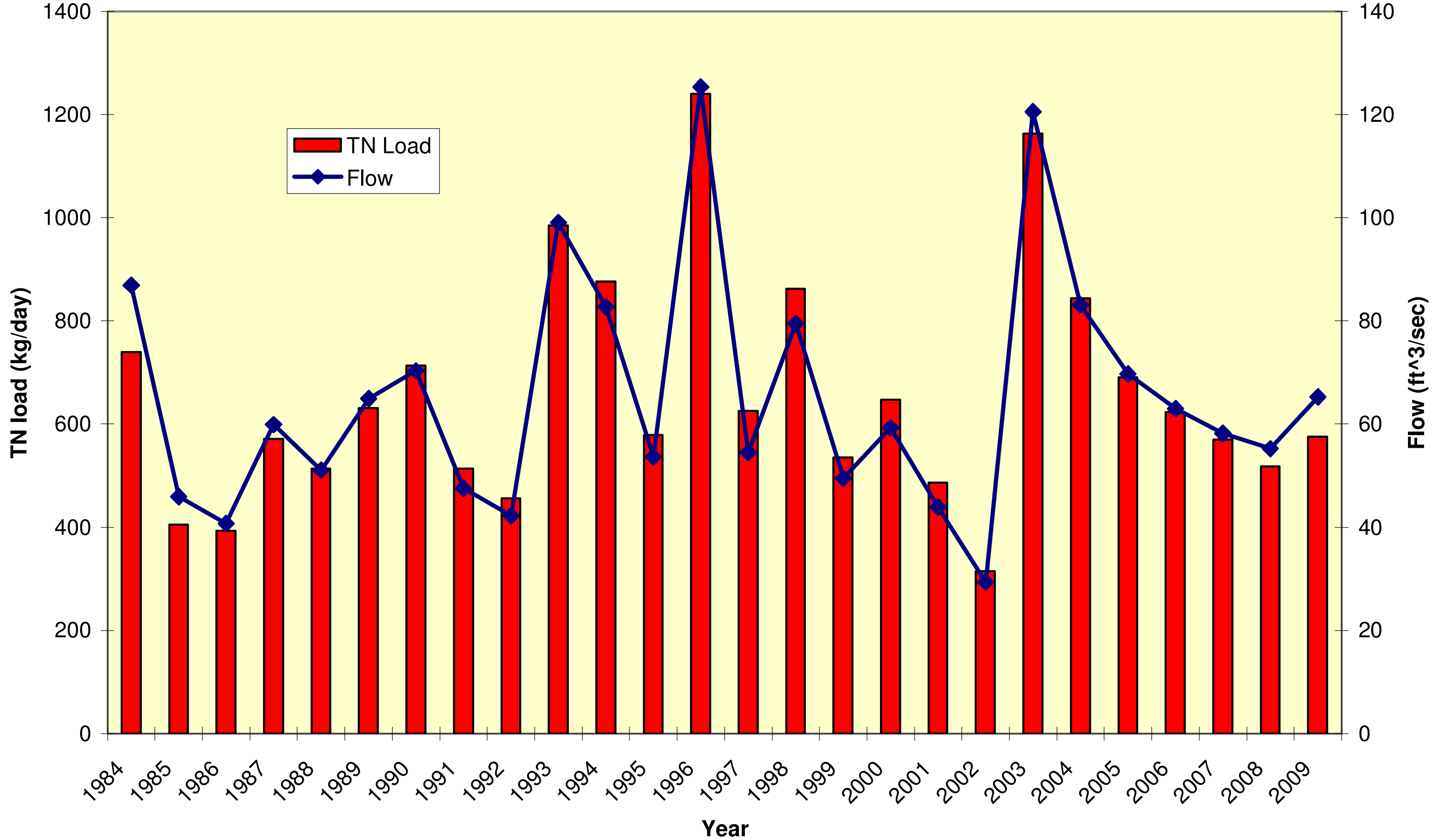


Figure A-15. Total nitrogen loads and flow for the North Branch Patapsco River at Cedarhurst, MD non-tidal network site.

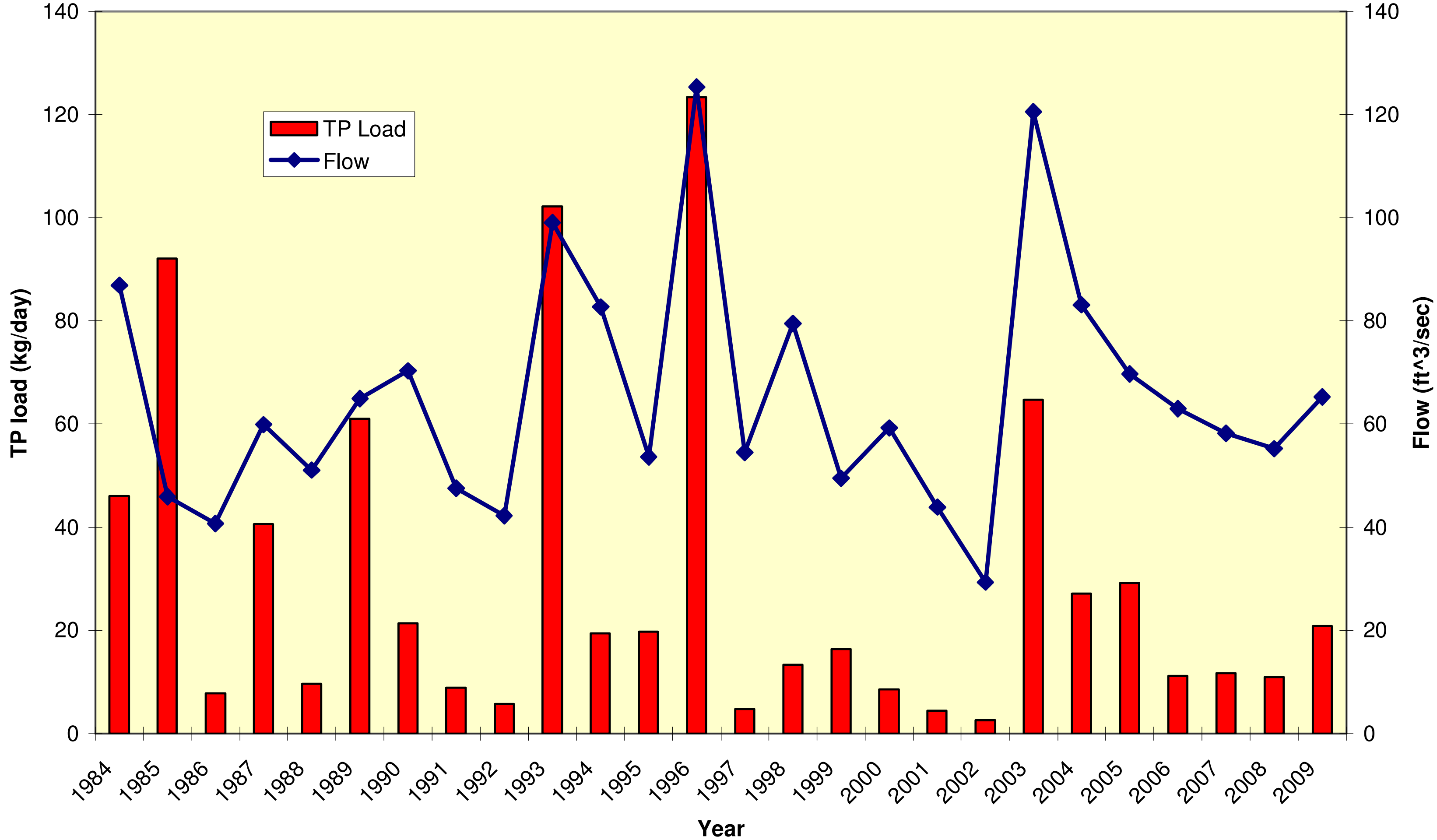


Figure A-16. Total phosphorus loads and flow for the North Branch Patapsco River at Cedarhurst, MD non-tidal network site.

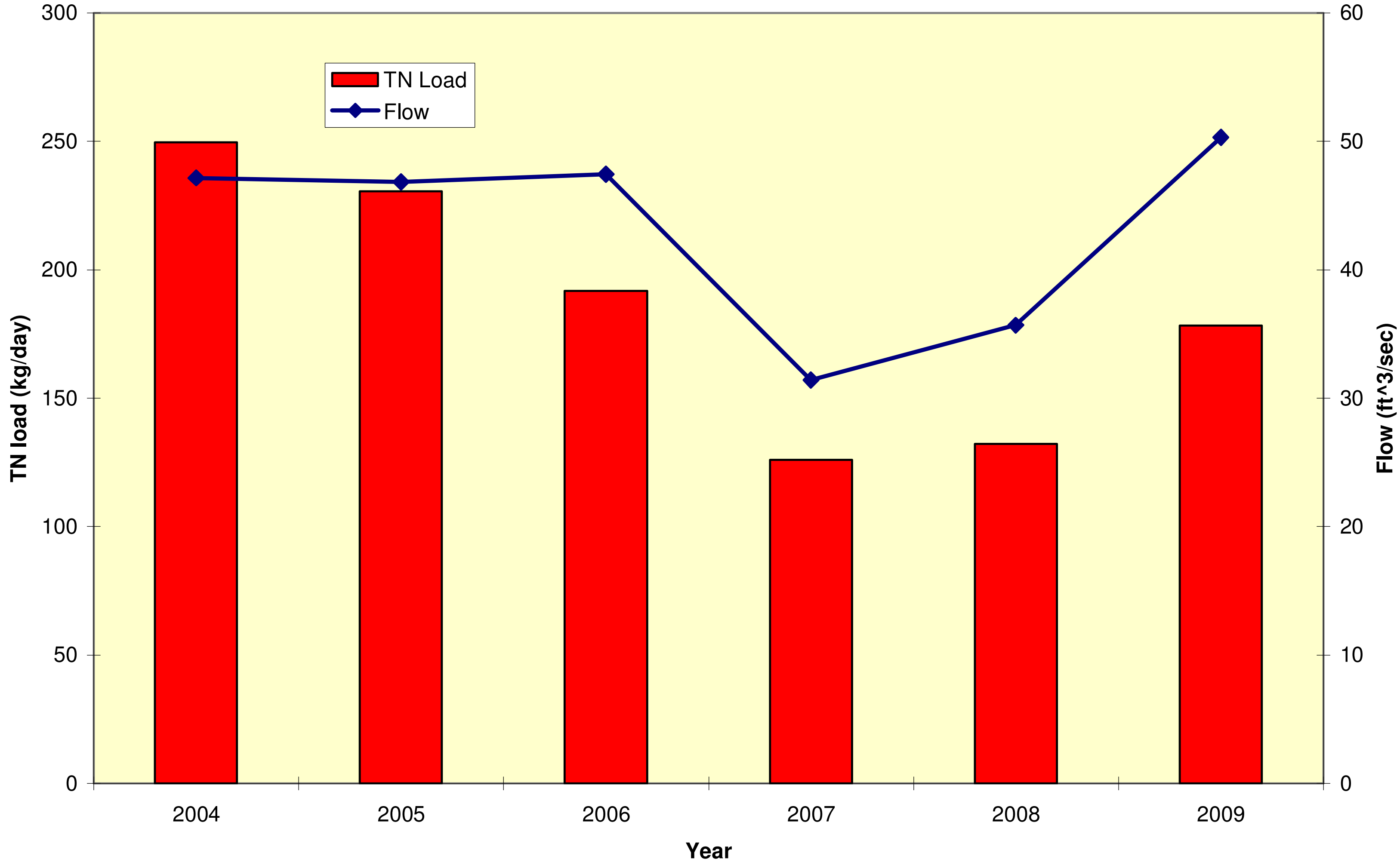


Figure A-17. Total nitrogen loads and flow for the Gwynns Falls at Villa Nova, MD non-tidal network site.

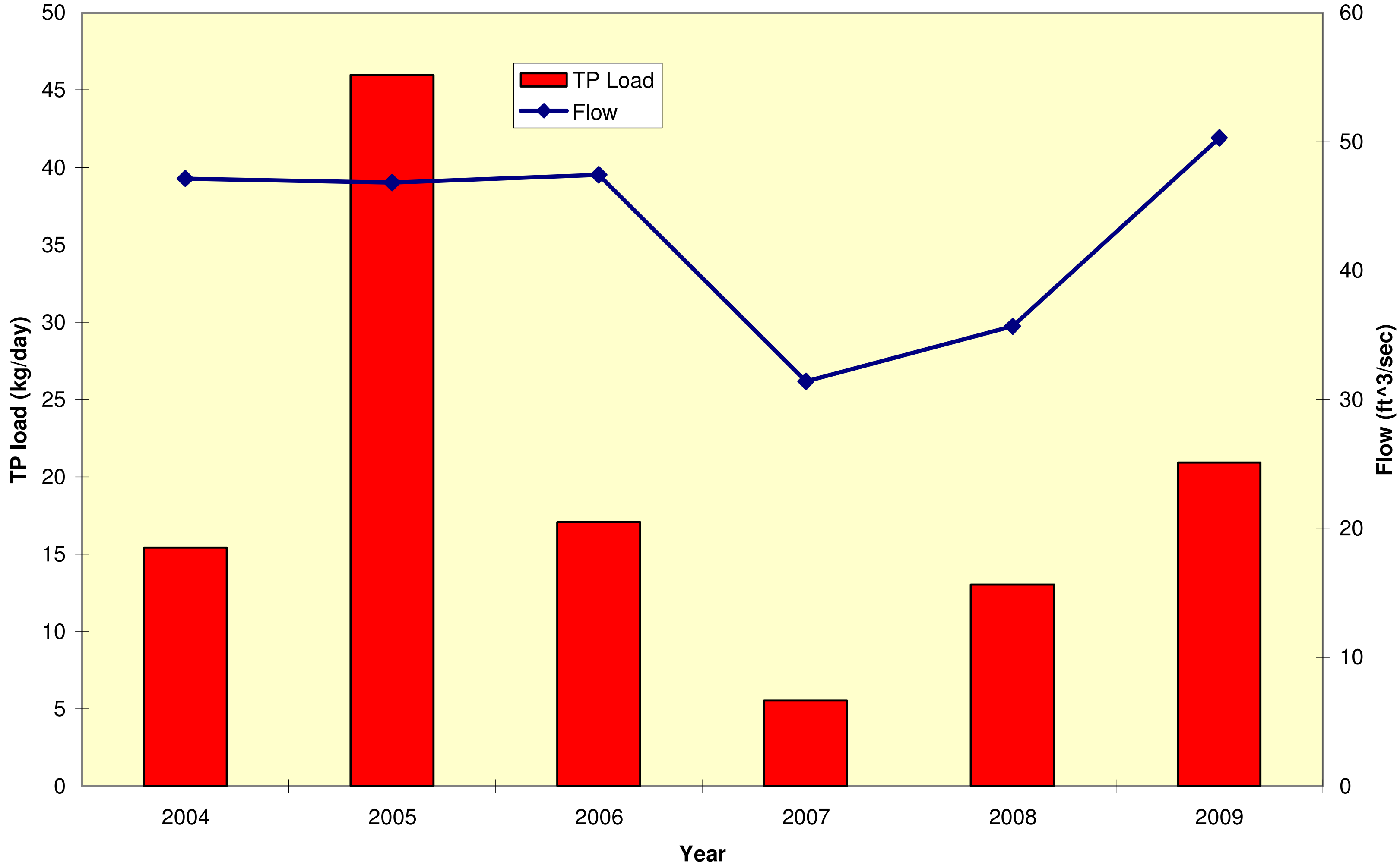


Figure A-18. Total phosphorus loads and flow for the Gwynns Falls at Villa Nova, MD non-tidal network site.

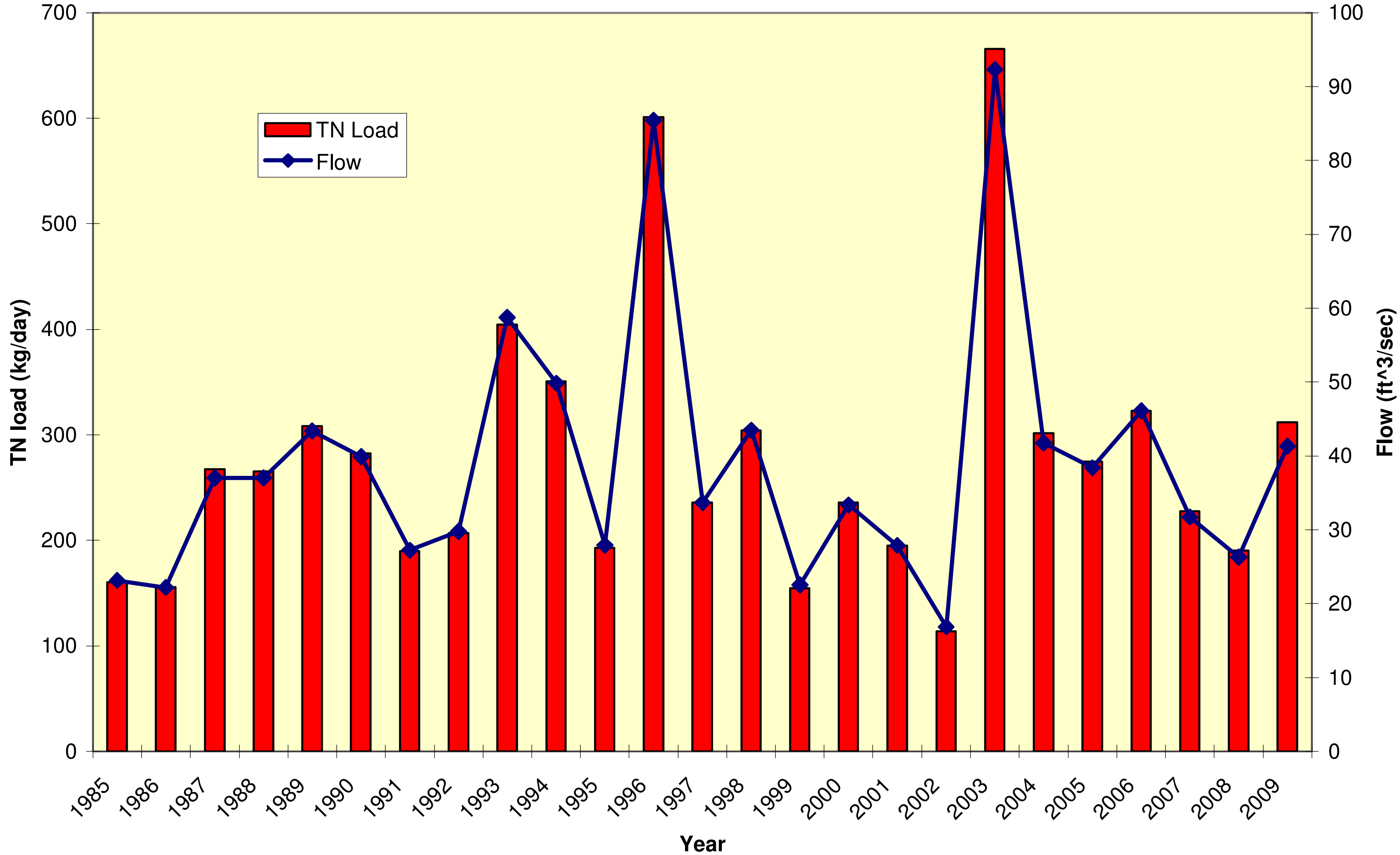


Figure A-19. Total nitrogen loads and flow for the Patuxent River near Unity, MD non-tidal network site.

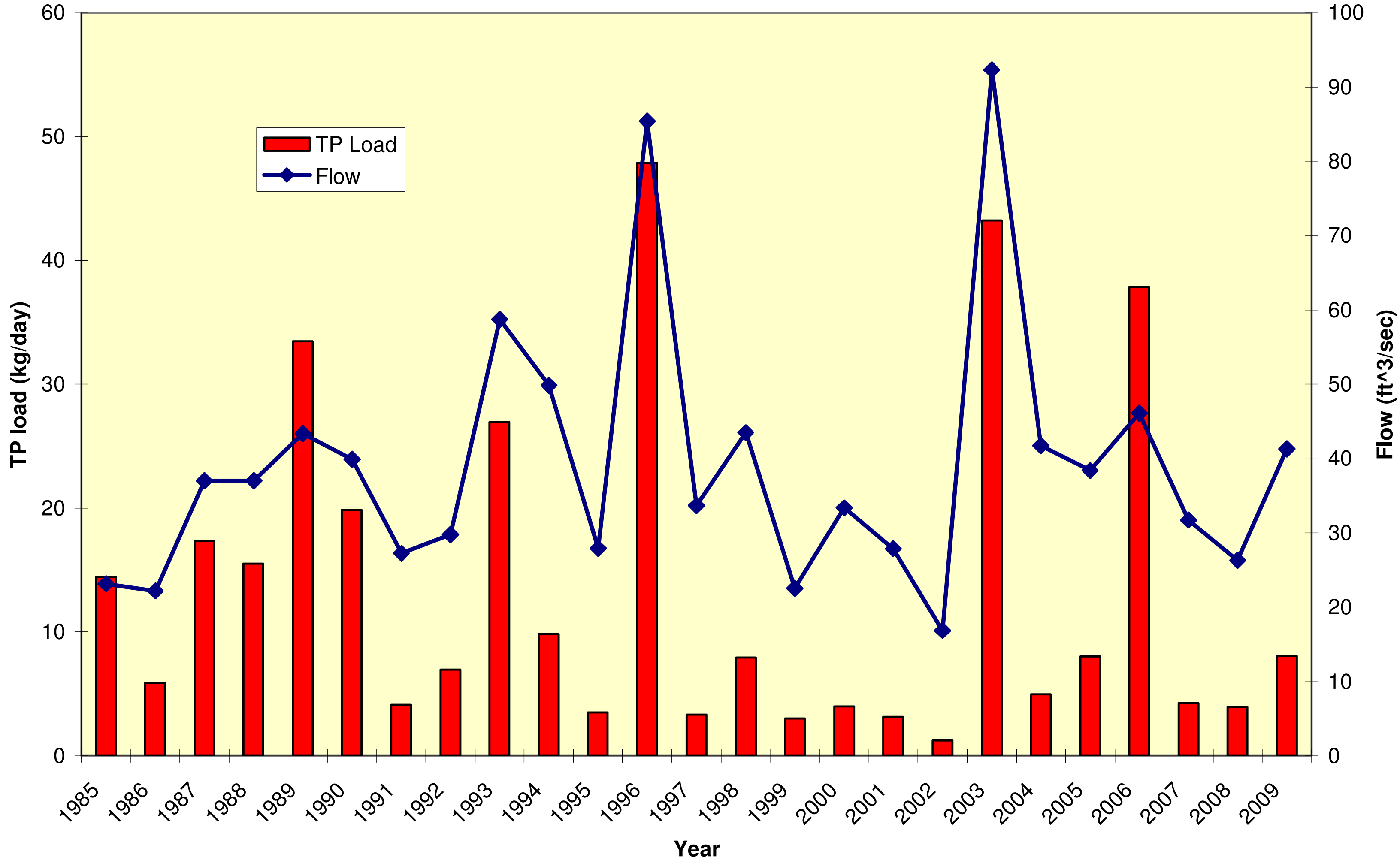


Figure A-20. Total phosphorus loads and flow for the Patuxent River near Unity, MD non-tidal network site.

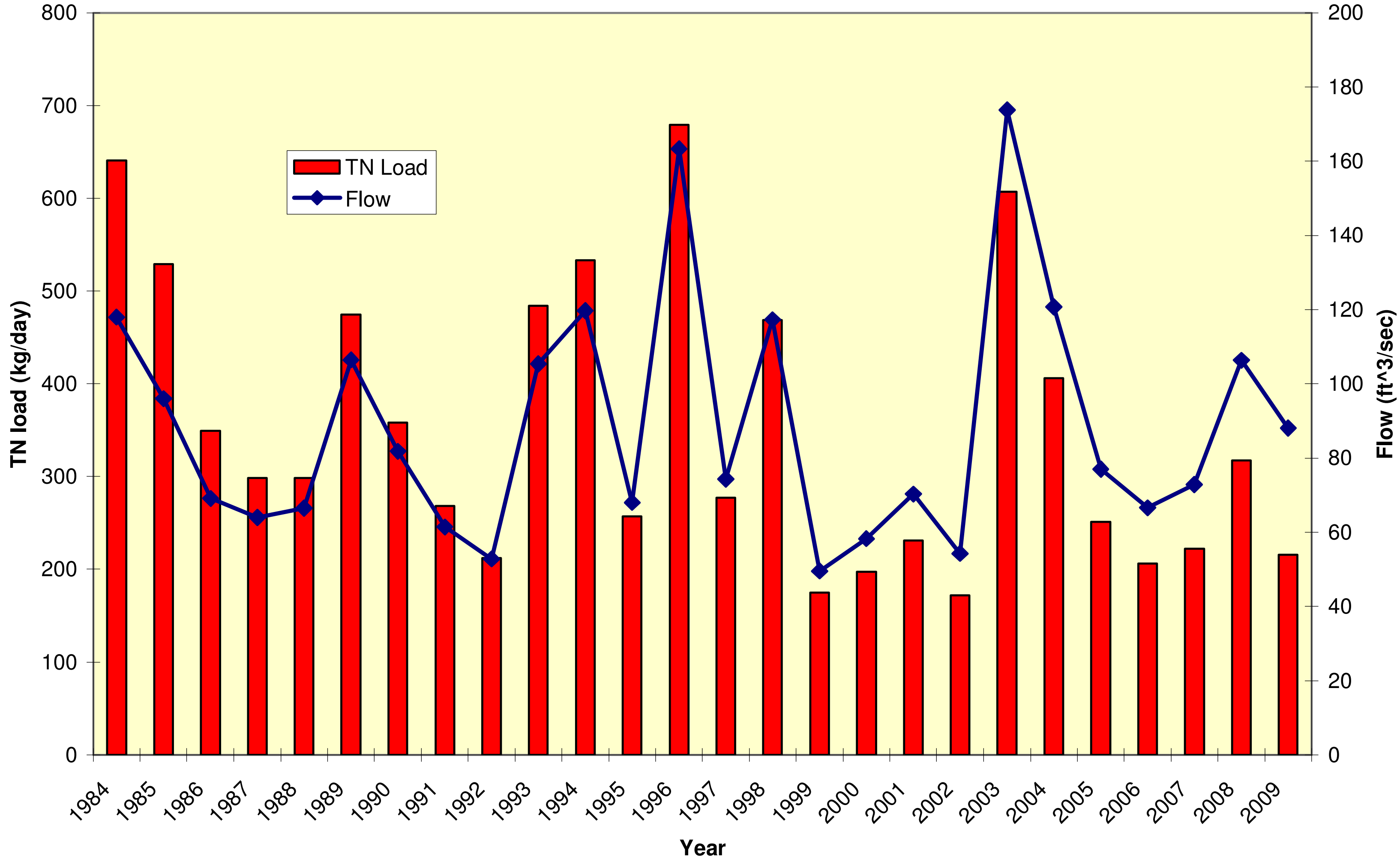


Figure A-21. Total nitrogen loads and flow for the Georges Creek at Franklin, MD non-tidal network site.

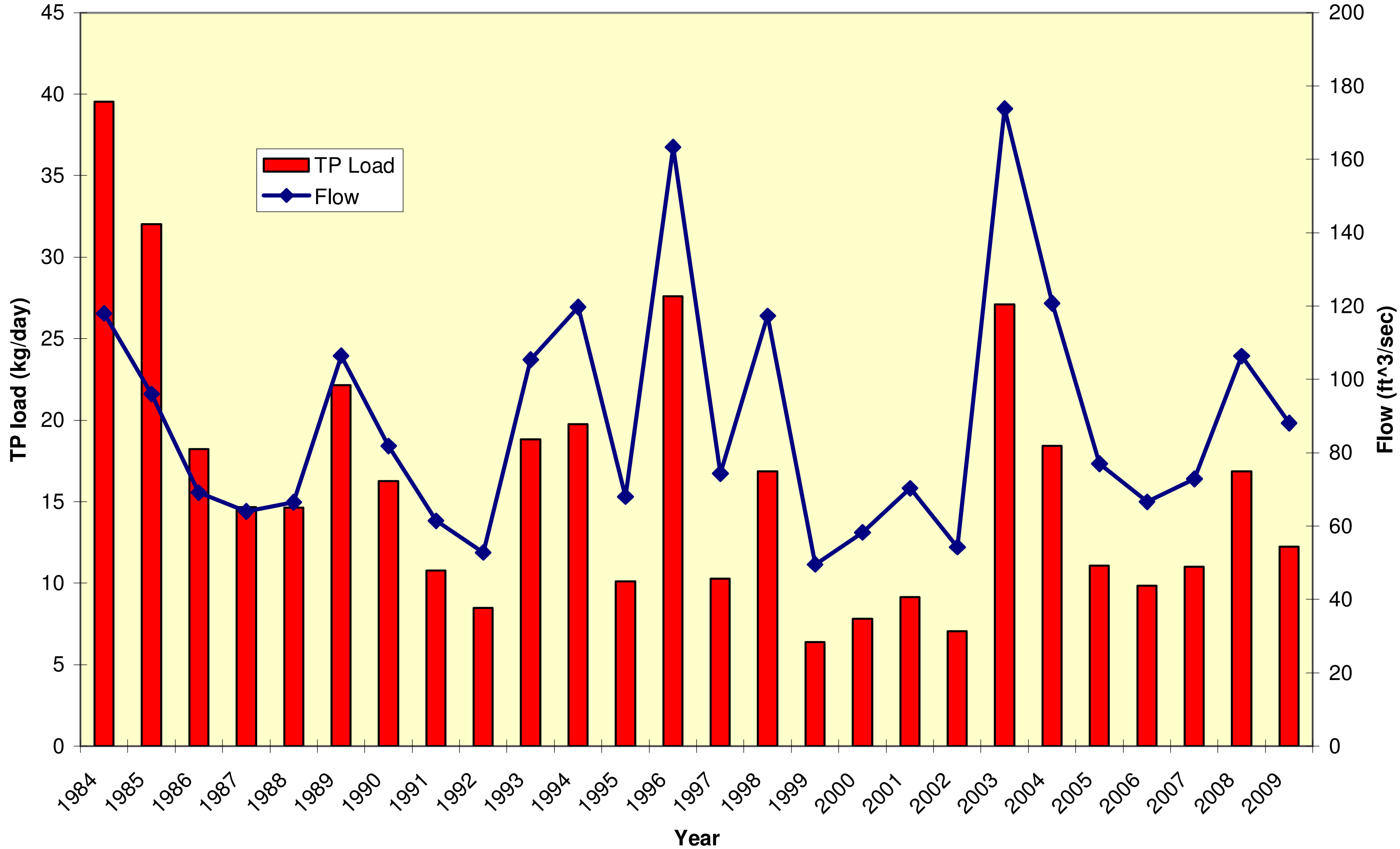


Figure A-22. Total phosphorus loads and flow for the Georges Creek at Franklin, MD non-tidal network site.

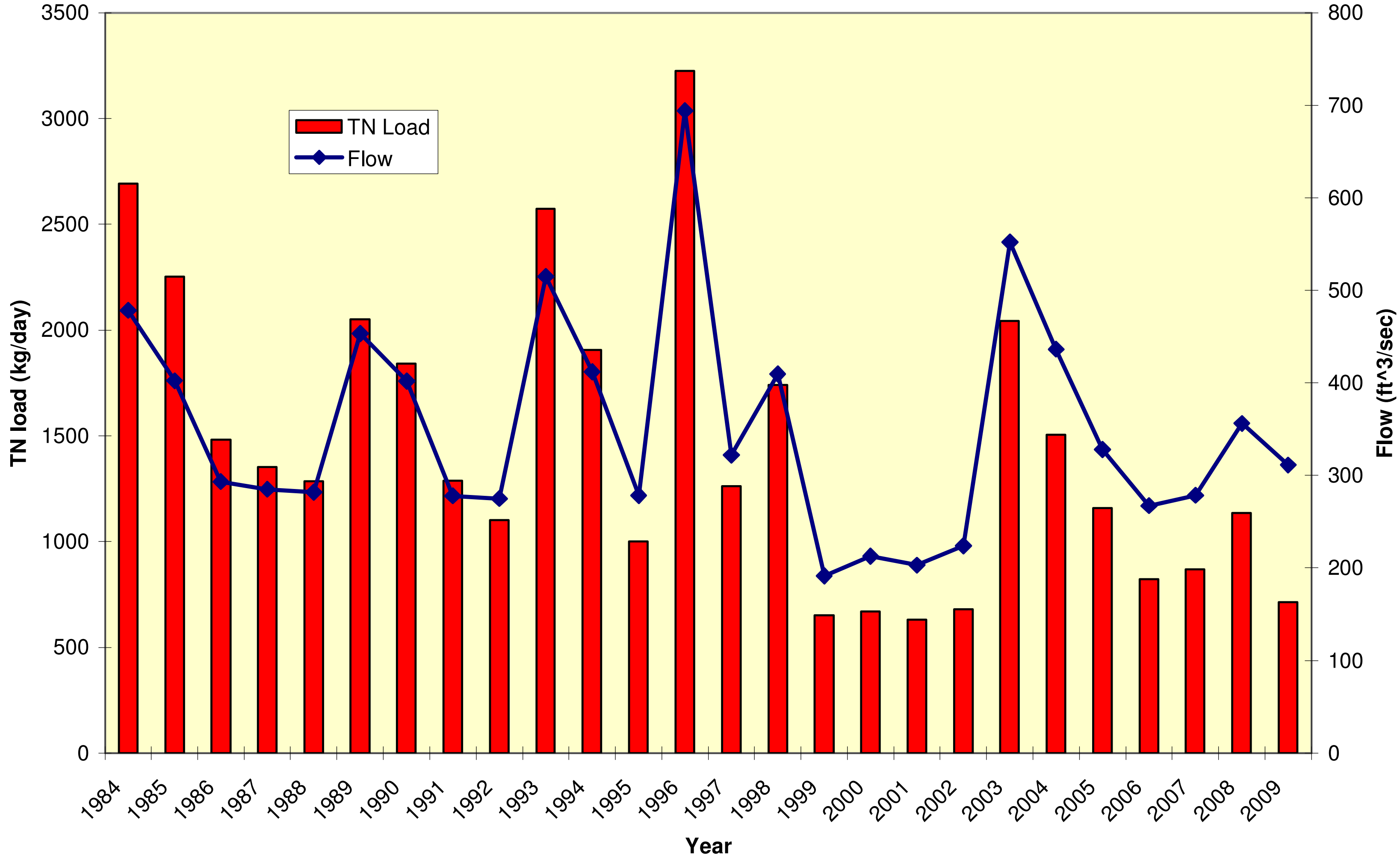


Figure A-23. Total nitrogen loads and flow for the Wills Creek near Cumberland, MD non-tidal network site.

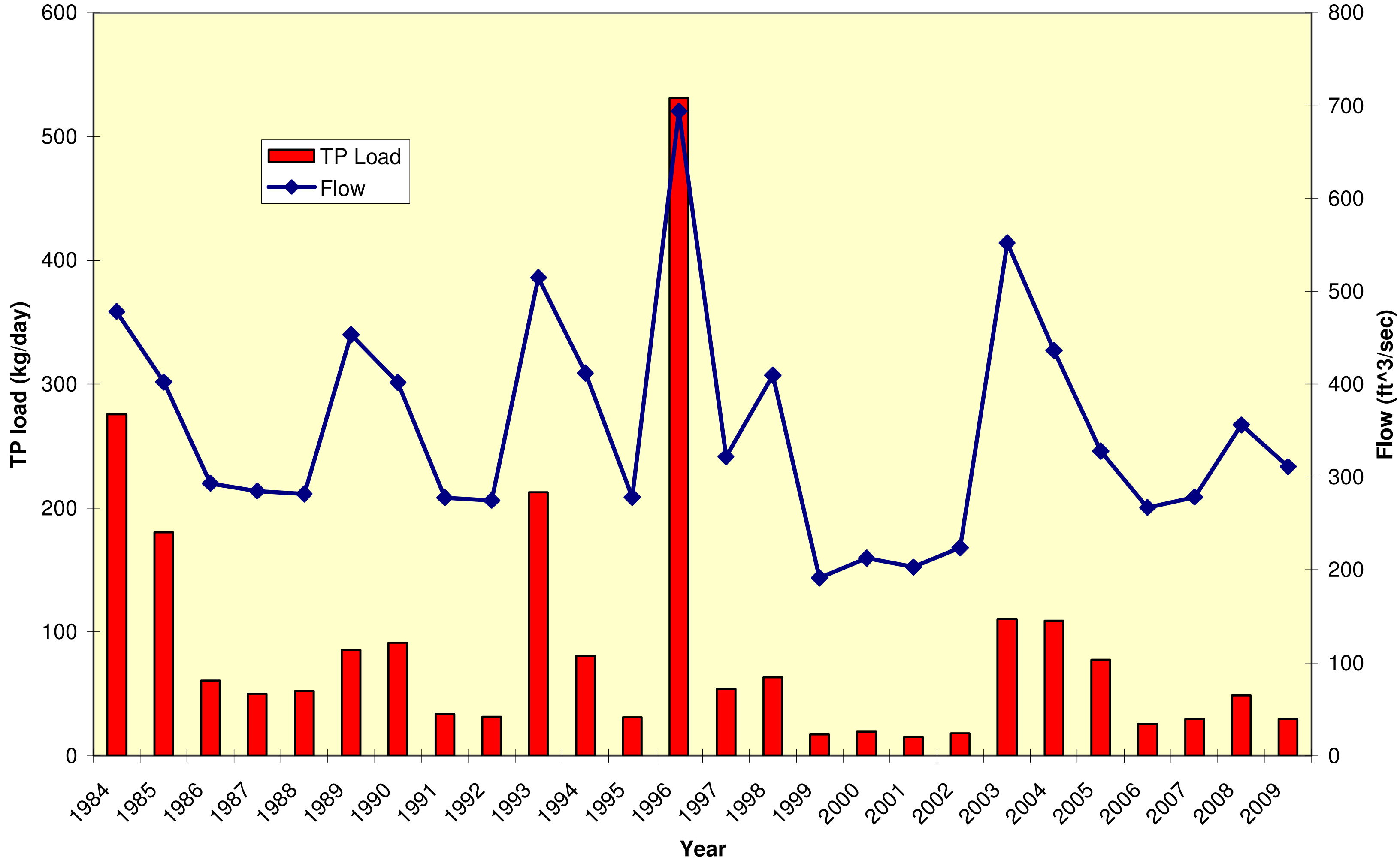


Figure A-24. Total phosphorus loads and flow for the Wills Creek at Cumberland, MD non-tidal network site.

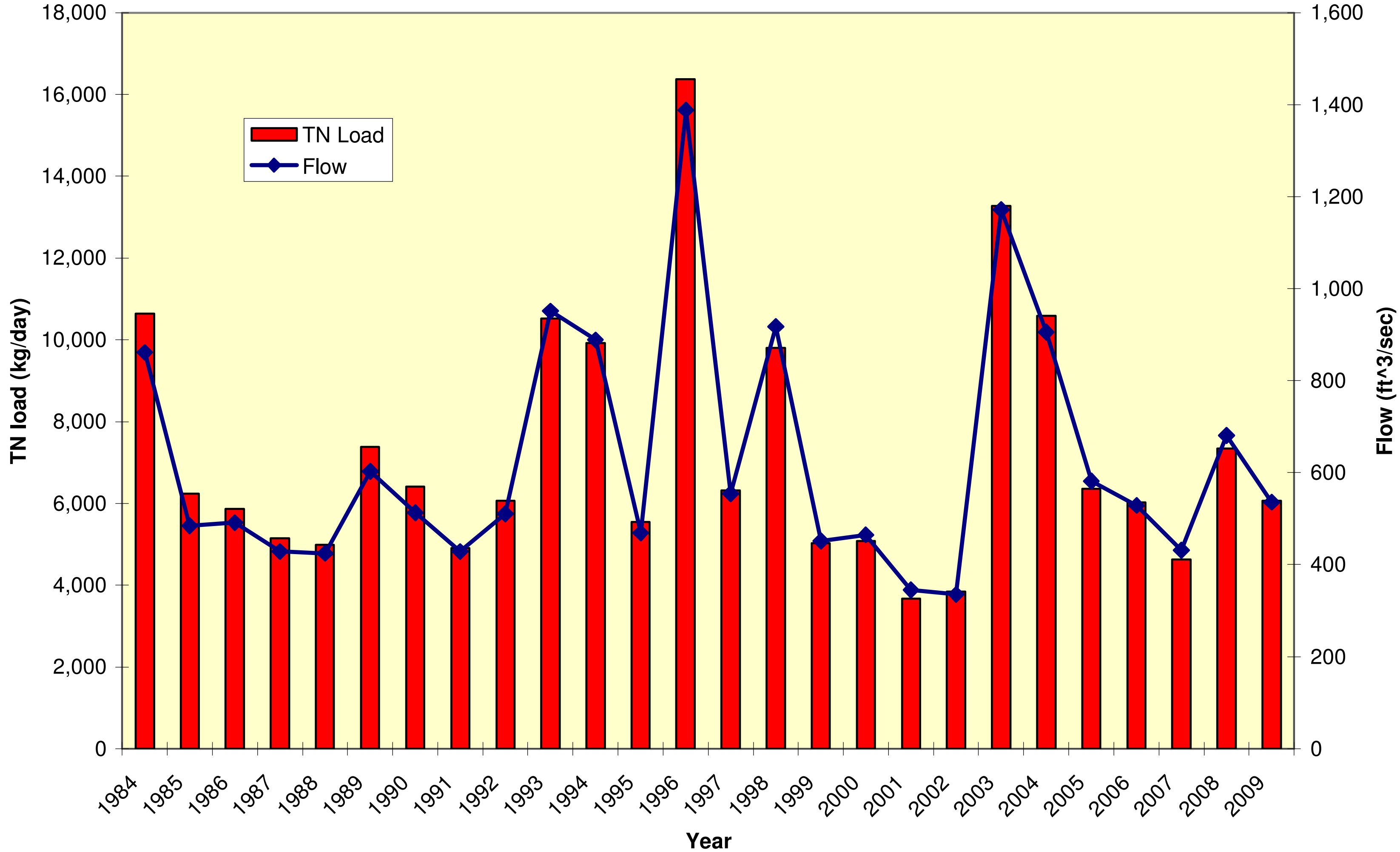


Figure A-25. Total nitrogen loads and flow for the Conococheague Creek at Fairview, MD non-tidal network site.

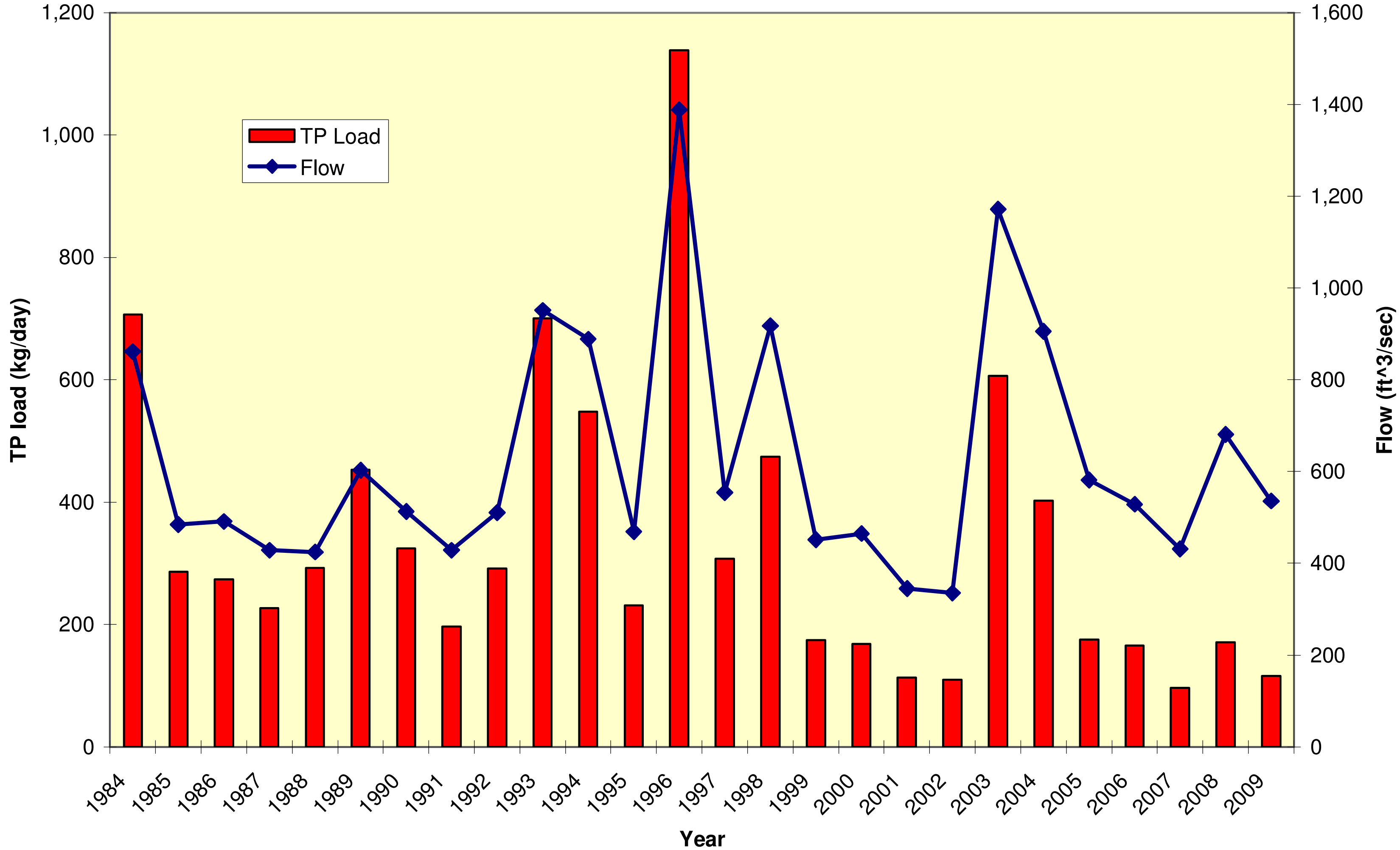


Figure A-26. Total phosphorus loads and flow for the Conococheague Creek at Fairview, MD non-tidal network site.

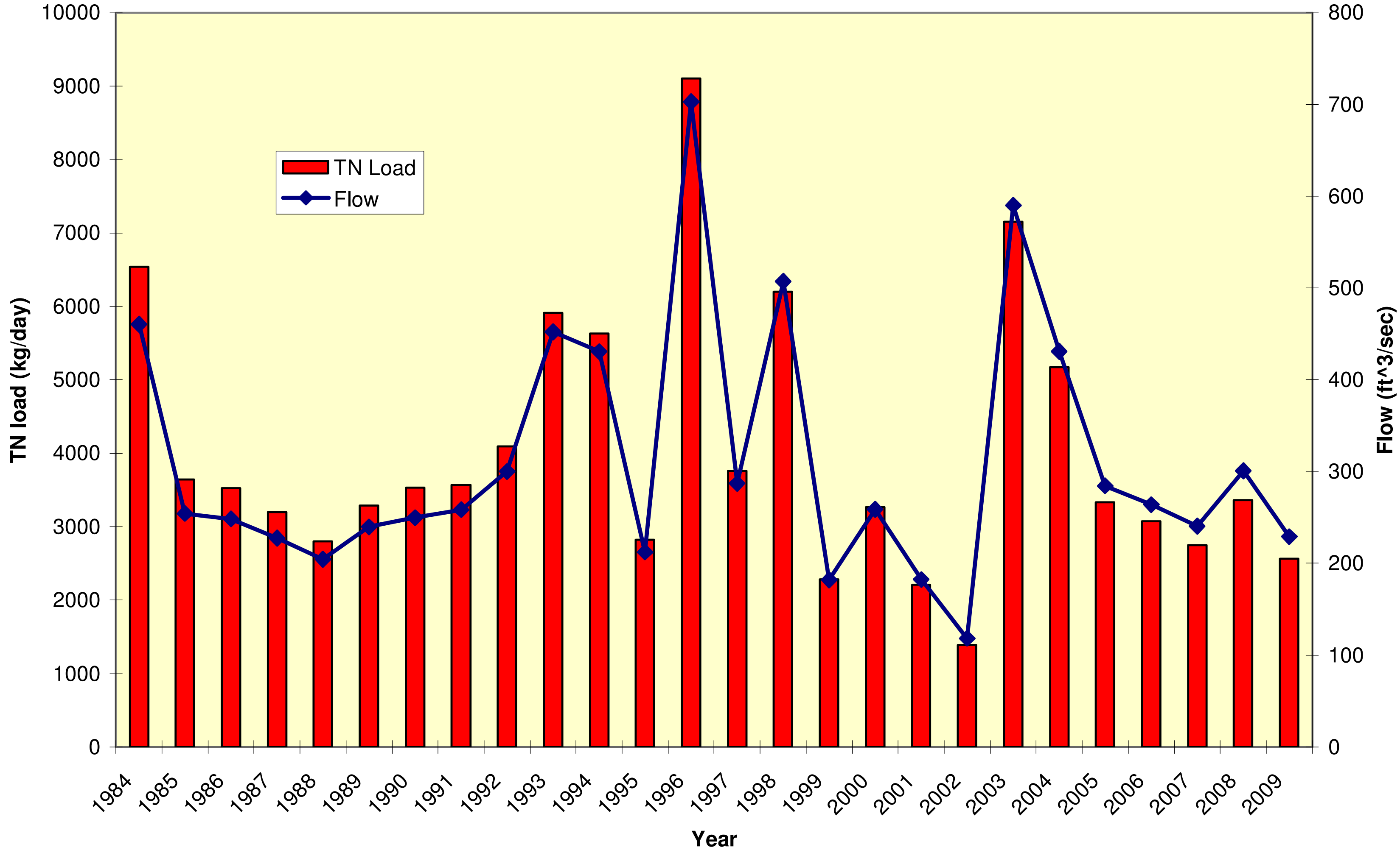


Figure A-27. Total nitrogen loads and flow for the Antietam Creek near Sharpsburg, MD non-tidal network site.

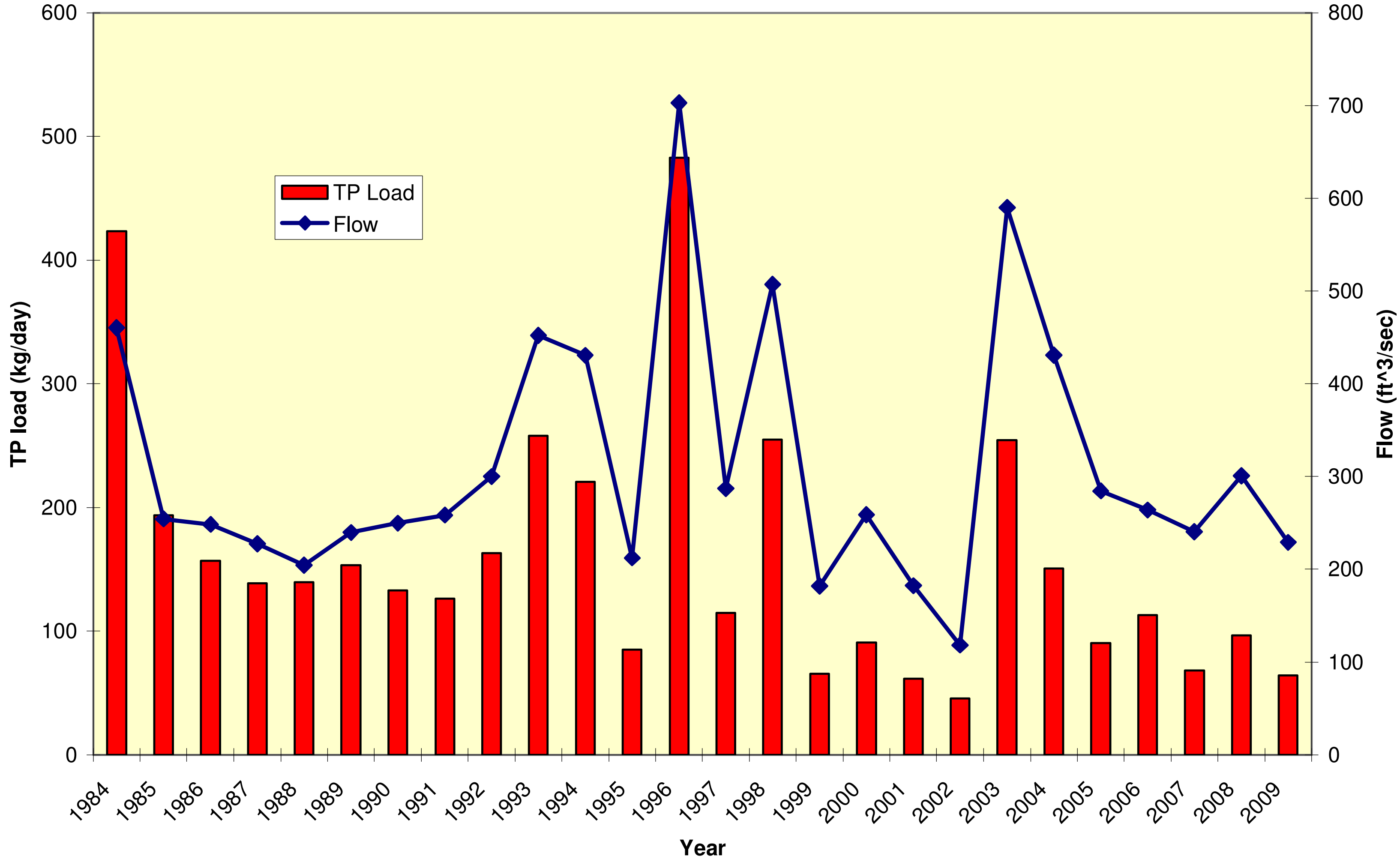


Figure A-28. Total phosphorus loads and flow for the Antietam Creek near Sharpsburg, MD non-tidal network site.

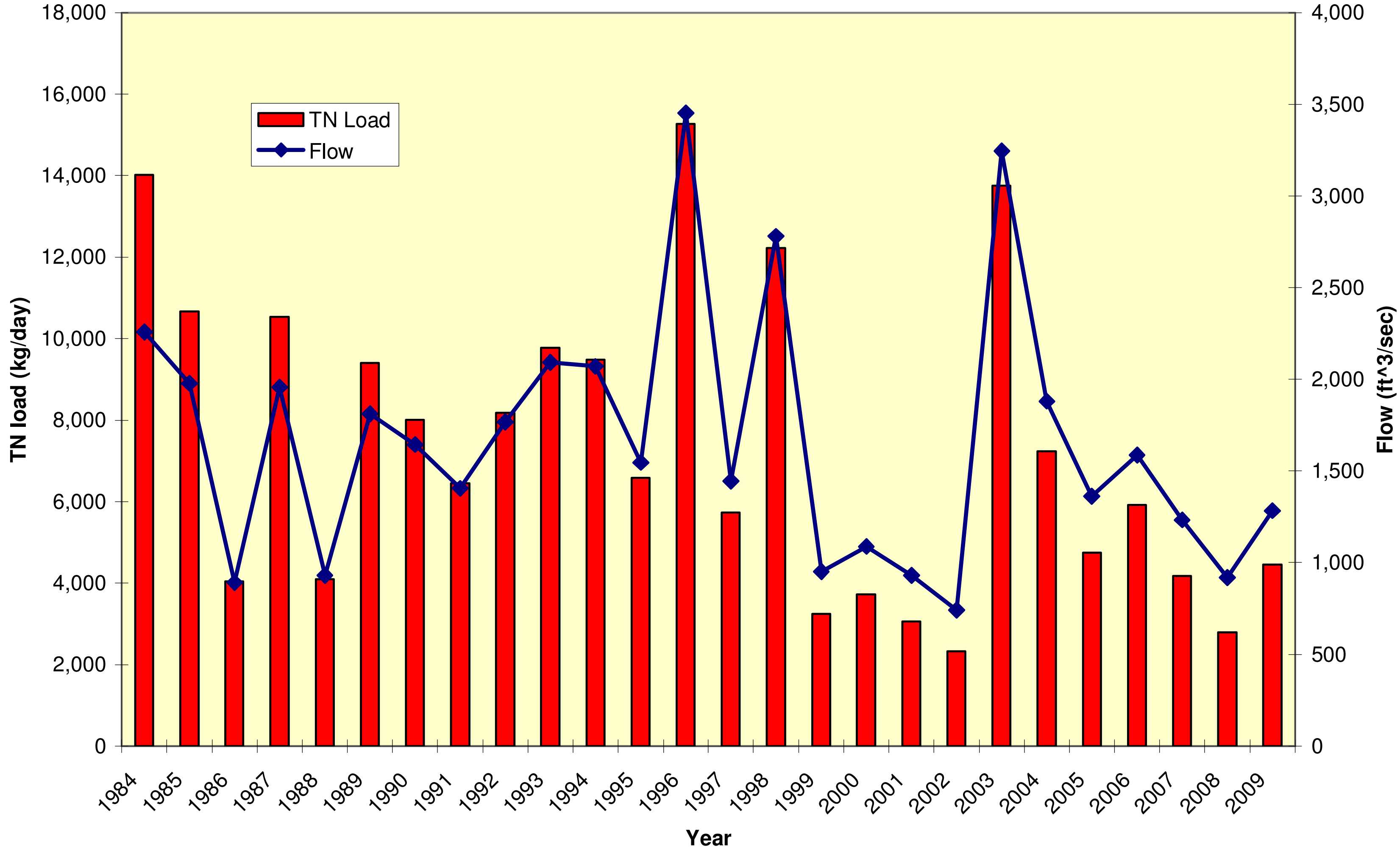


Figure A-29. Total nitrogen loads and flow for the South Fork Shenandoah River at Front Royal, VA non-tidal network site.

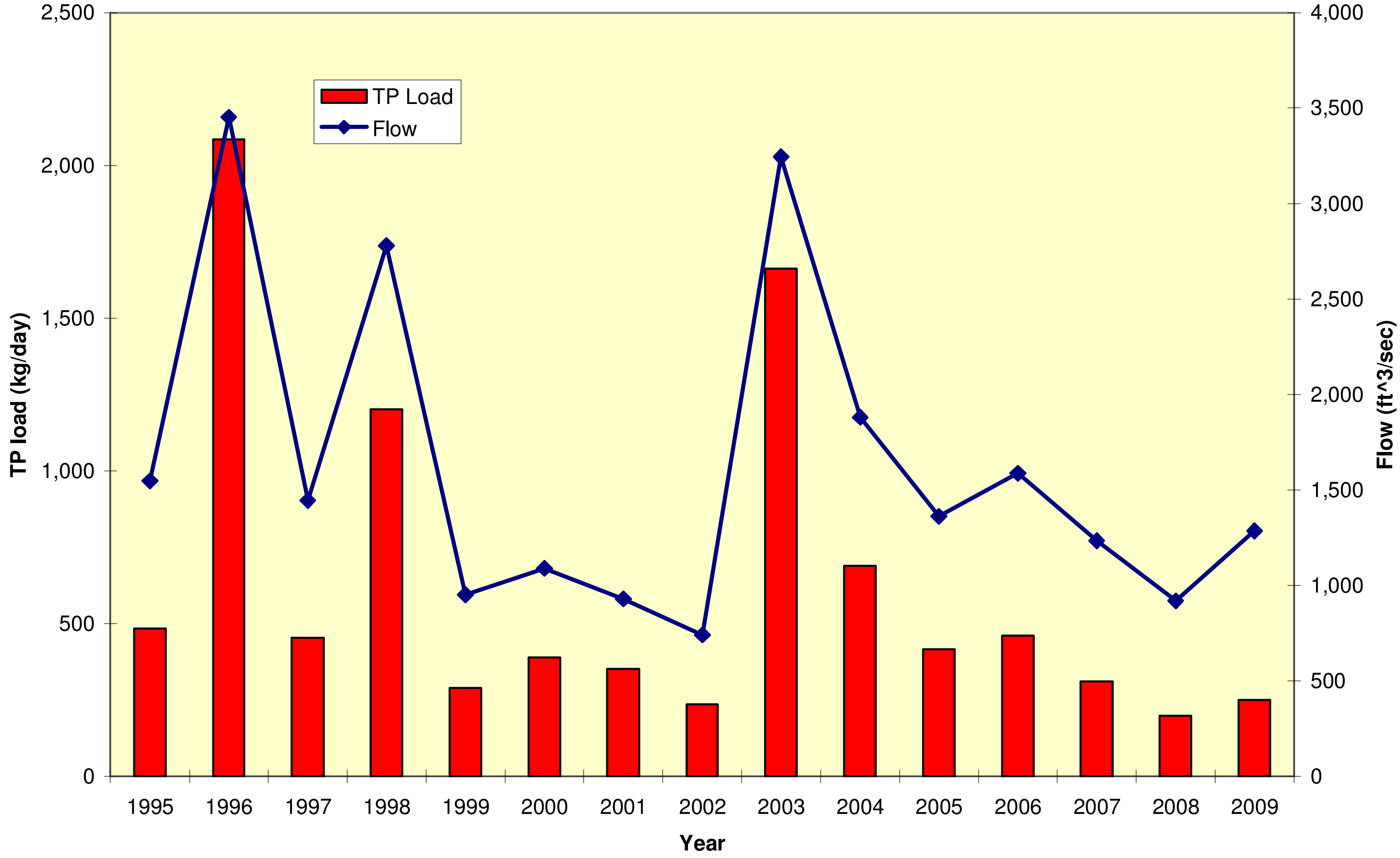


Figure A-30. Total phosphorus loads and flow for the South Fork Shenandoah River at Front Royal, VA non-tidal network site.

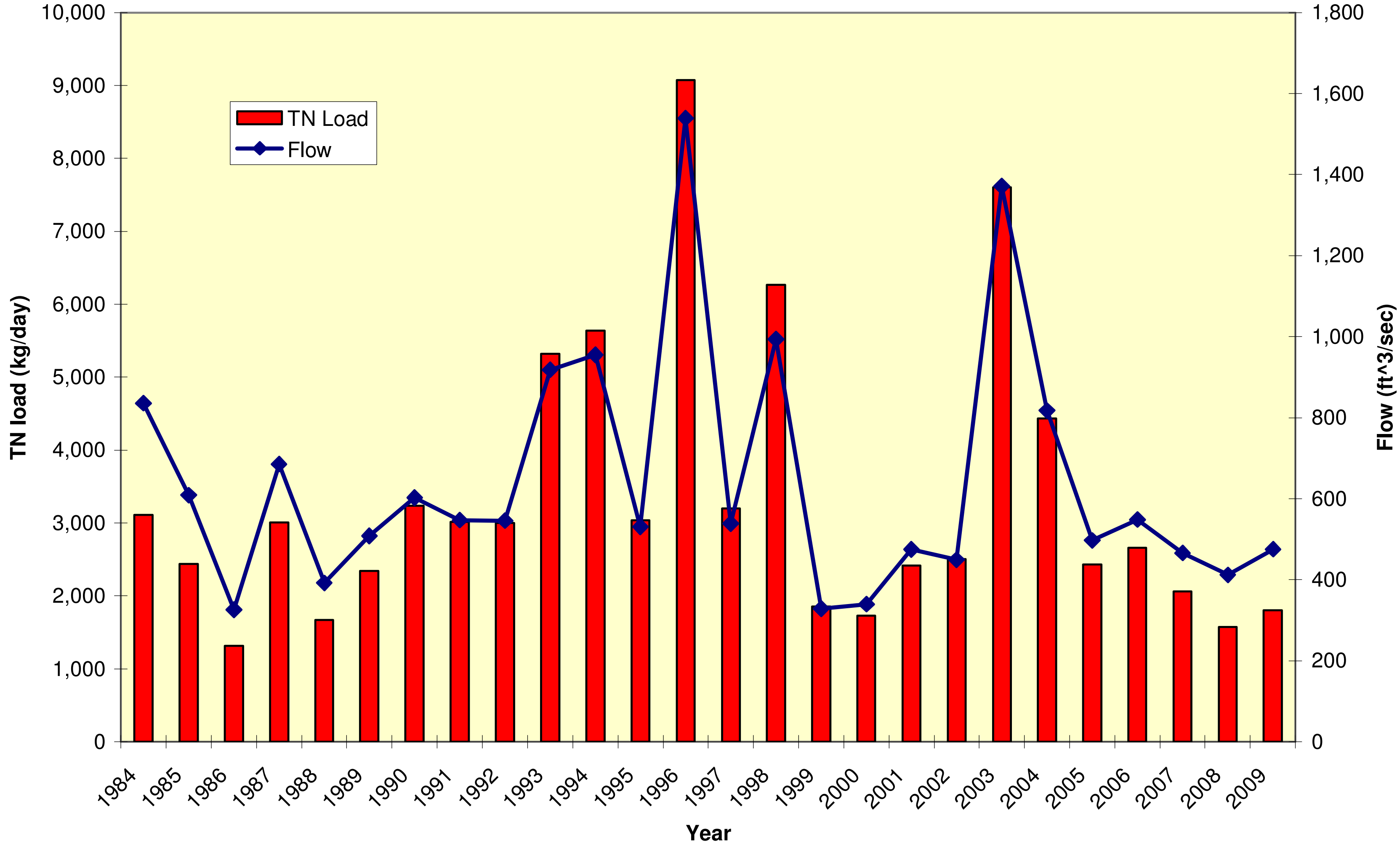


Figure A-31. Total nitrogen loads and flow for the North Fork Shenandoah River near Strasburg, VA non-tidal network site.

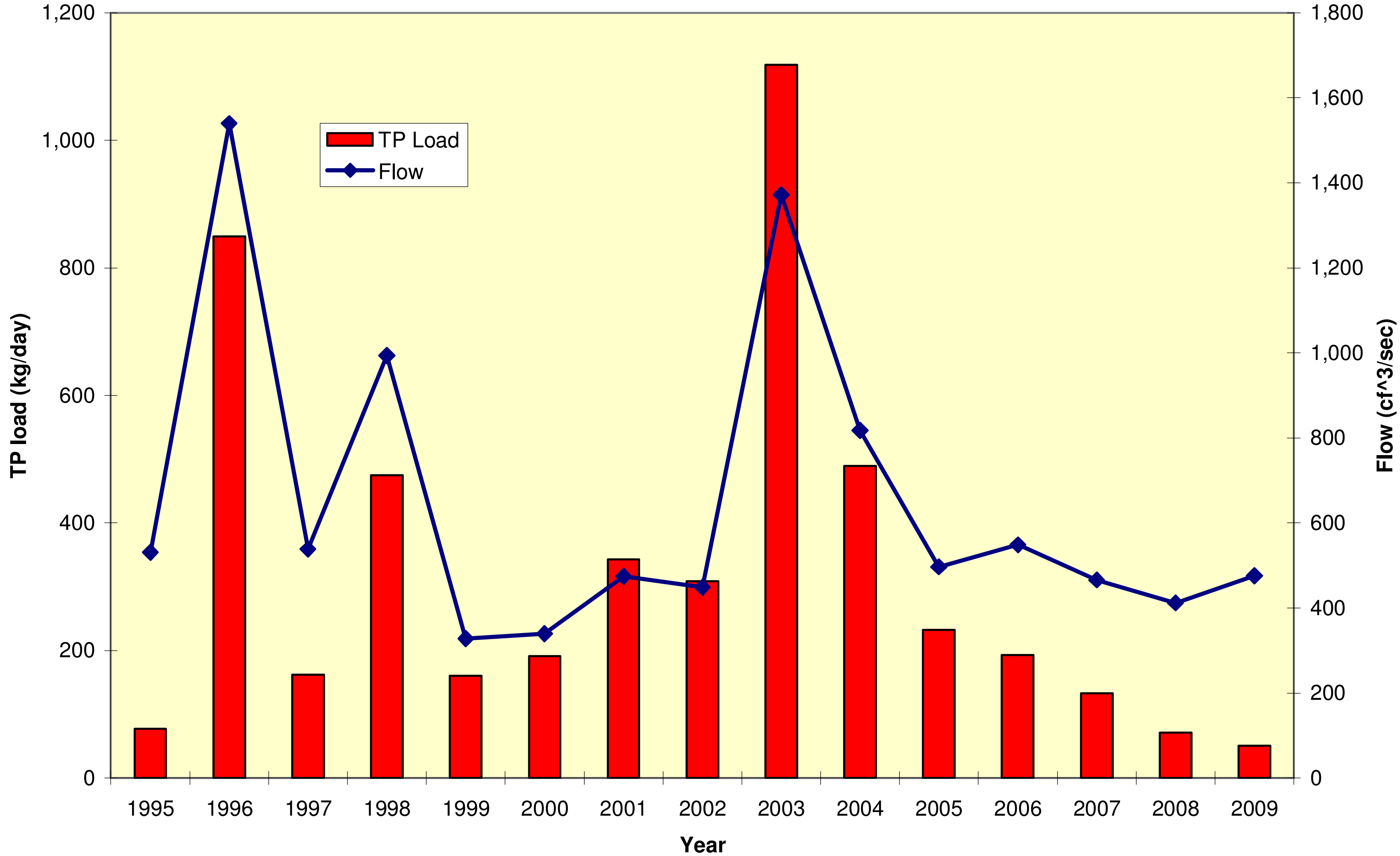


Figure A-32. Total phosphorus loads and flow for the North Fork Shenandoah River near Strasburg, VA non-tidal network site.

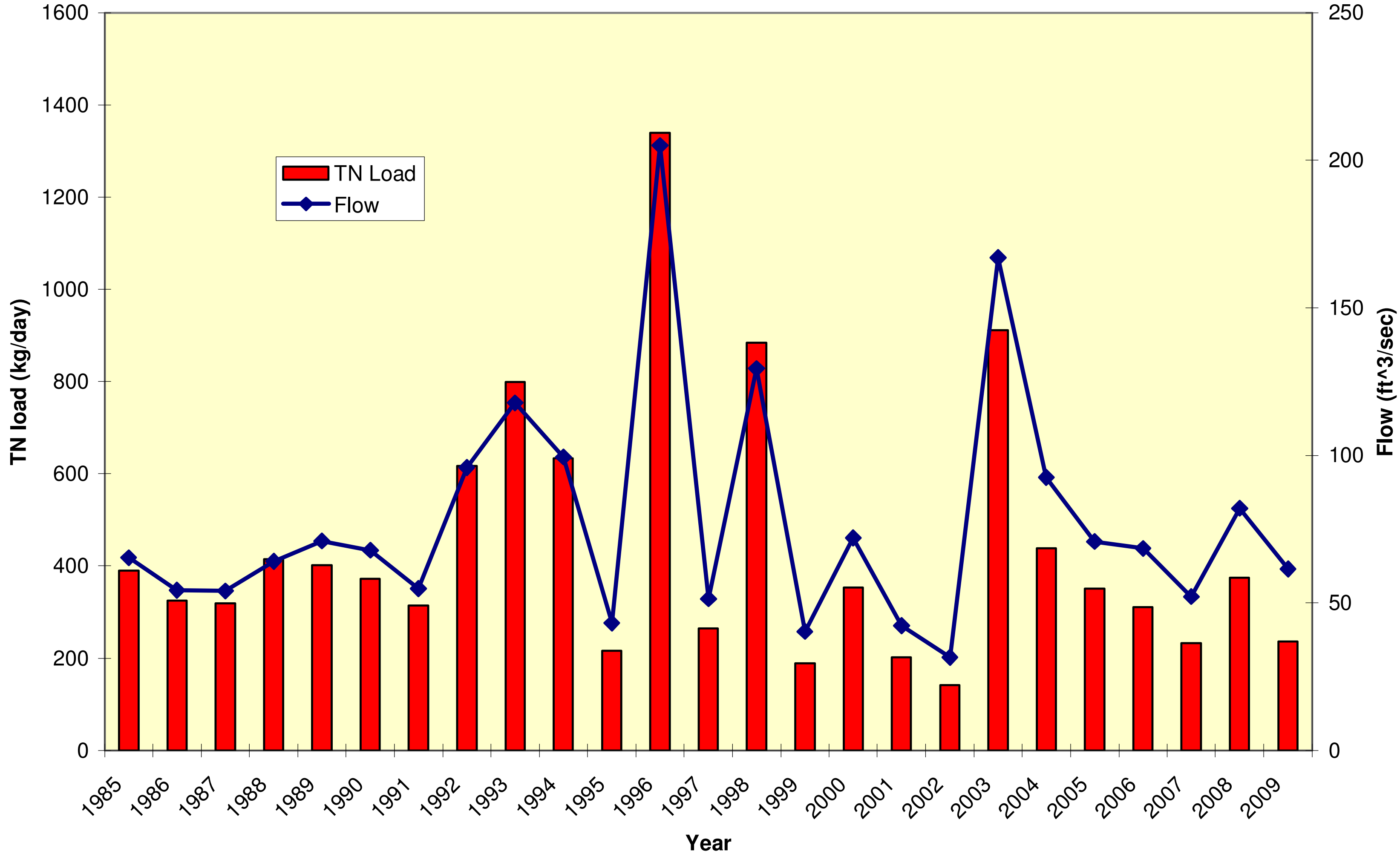


Figure A-33. Total nitrogen load and flow for the Catoctin Creek near Middletown, MD non-tidal network site.

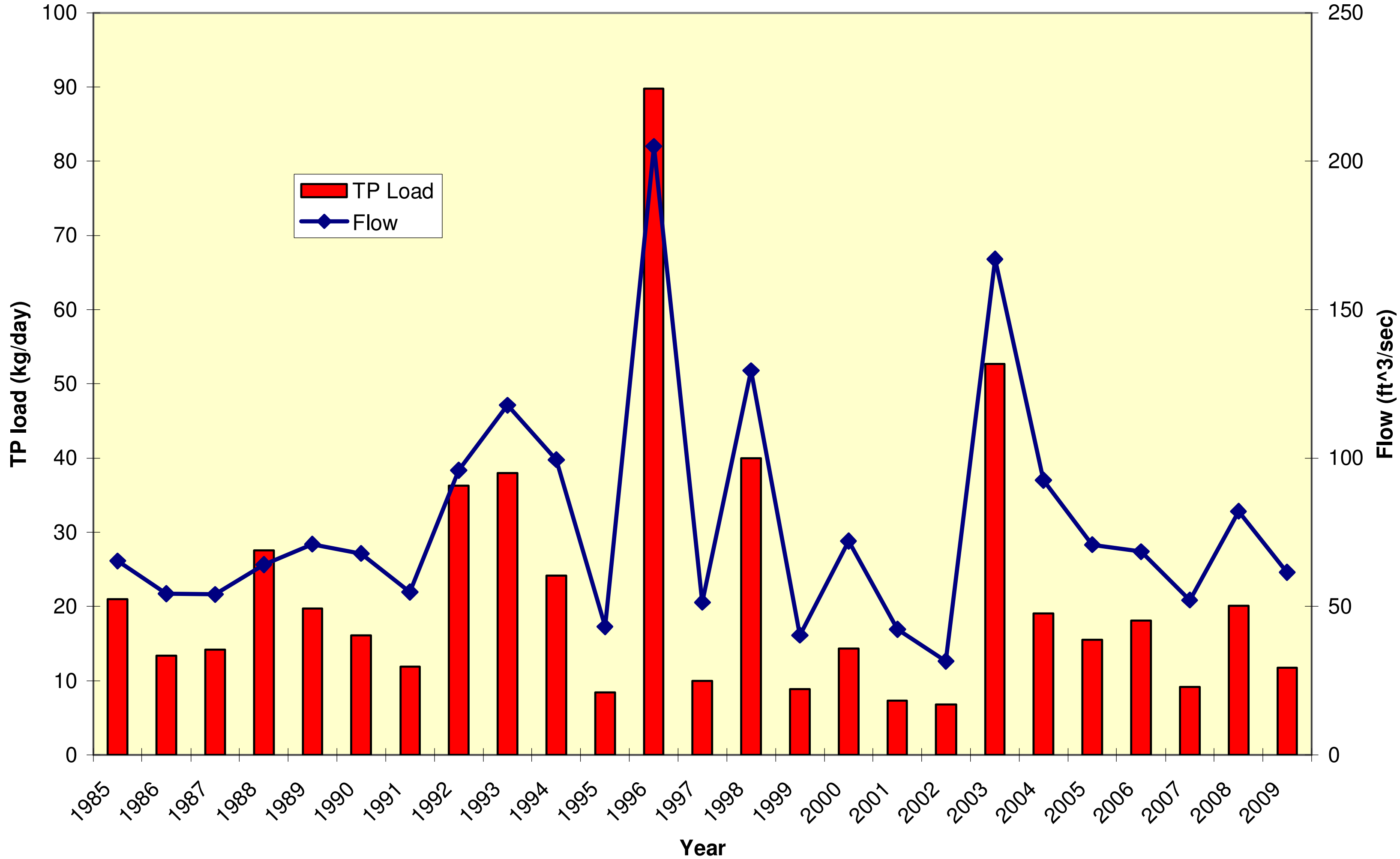


Figure A-34. Total phosphorus load and flow for the Catoctin Creek near Middletown, MD non-tidal network site.

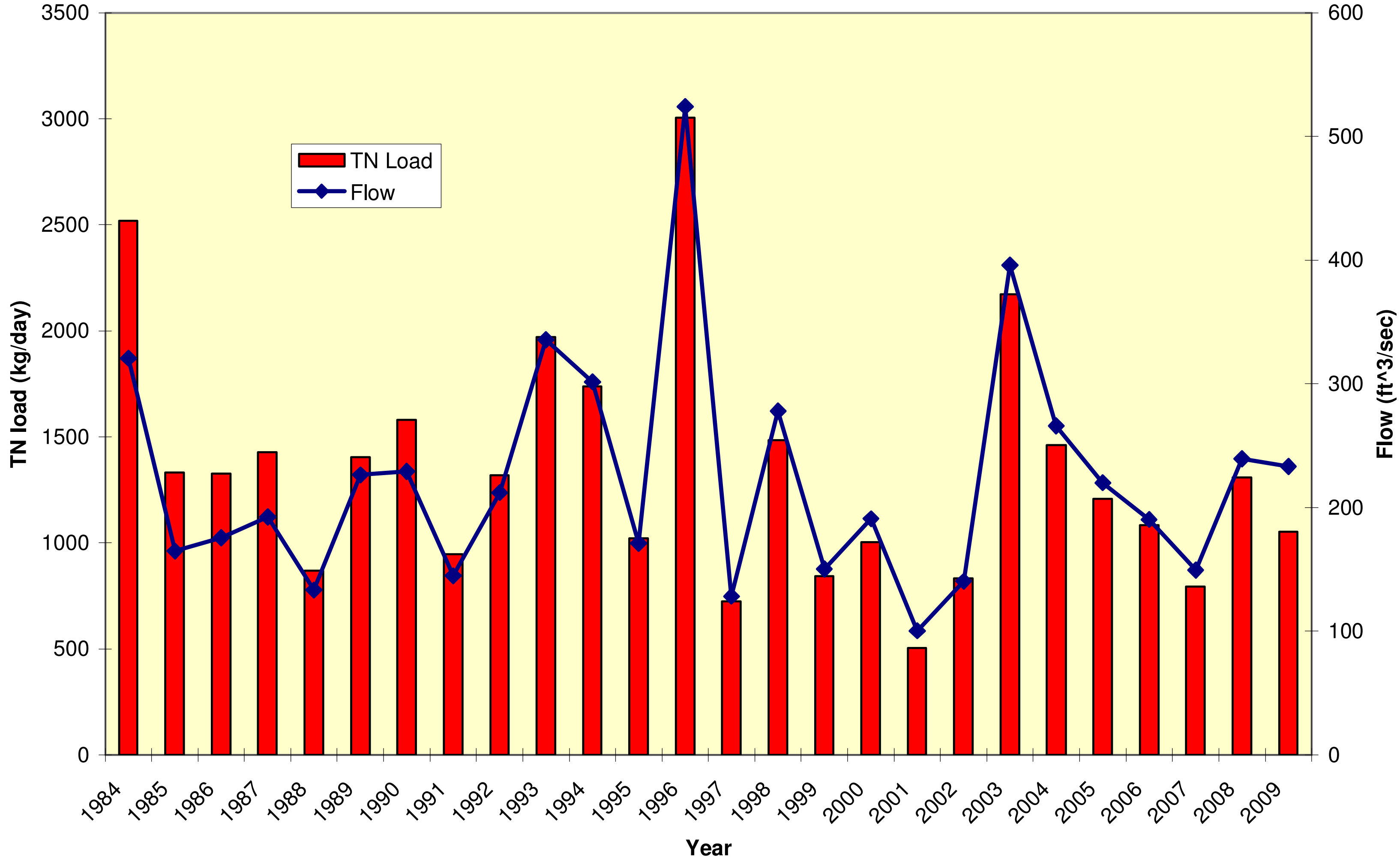


Figure A-35. Total nitrogen load and flow for the Monocacy River near Bridgeport, MD non-tidal network site.

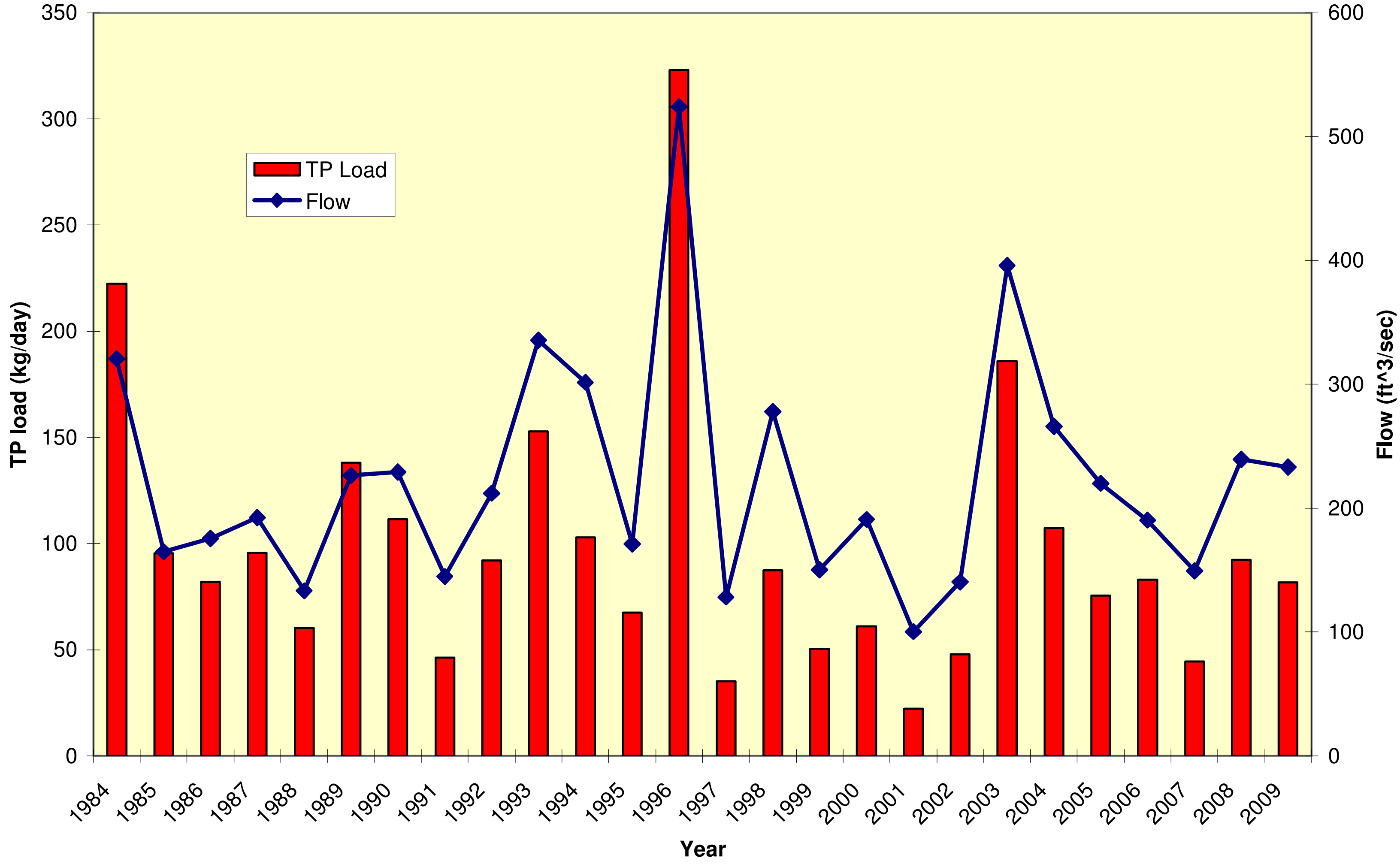


Figure A-36. Total phosphorus load and flow for the Monocacy River near Bridgeport, MD non-tidal network site.

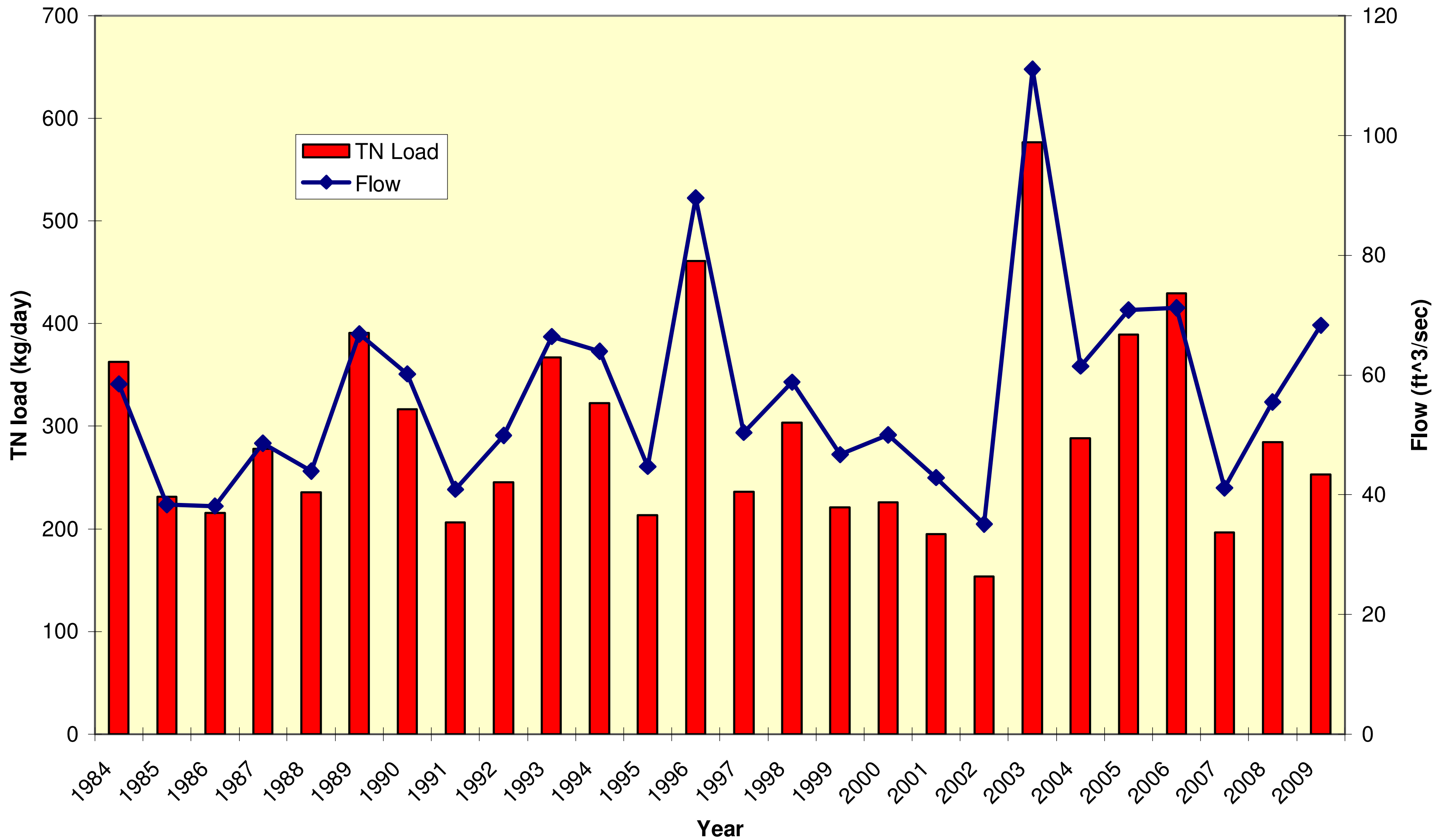


Figure A-37. Total nitrogen load and flow for the North Branch Anacostia River near Hyattsville, MD CORE/Trend site.

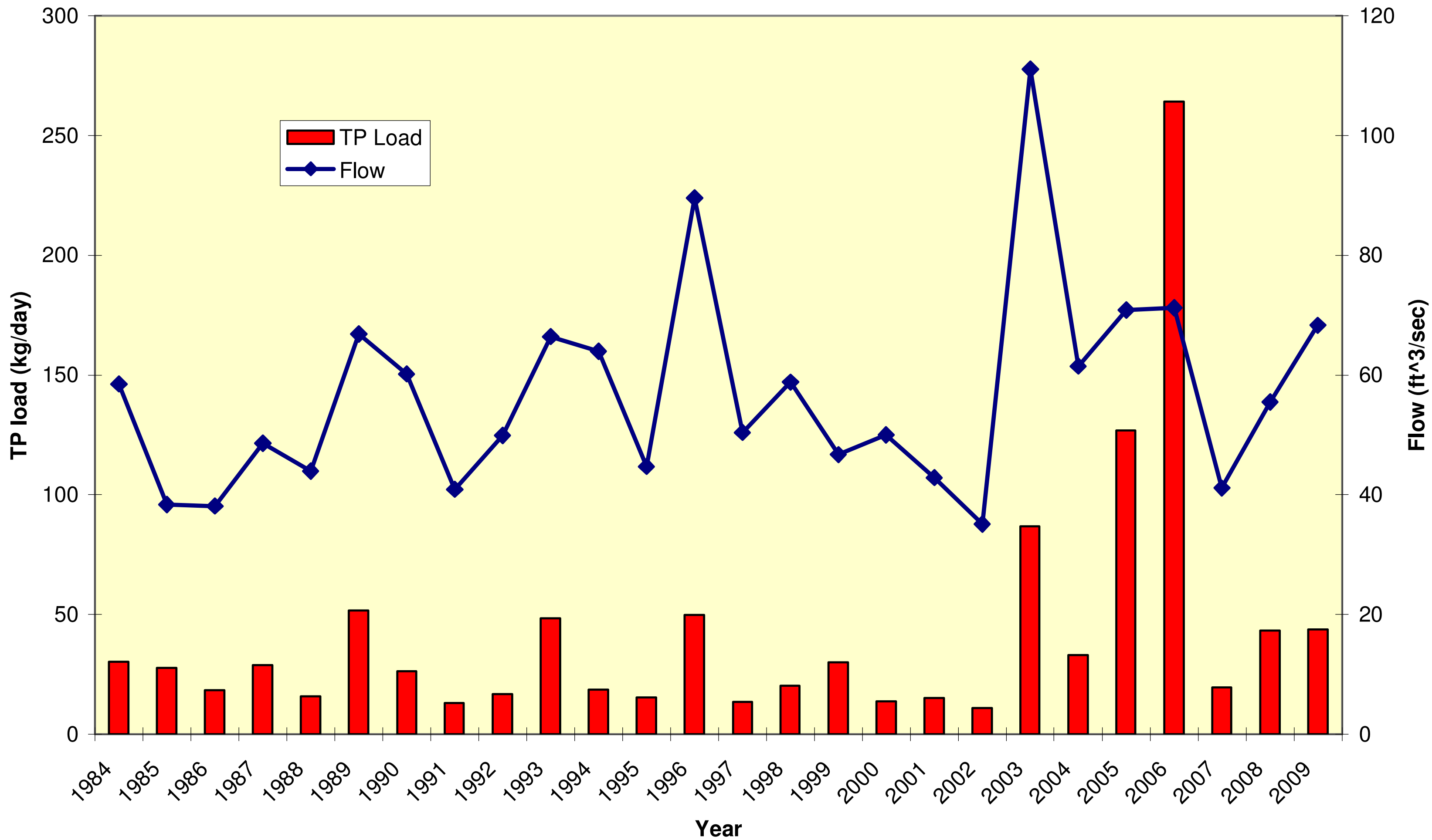


Figure A-38. Total phosphorus load and flow for the North Branch Anacostia River near Hyattsville, MD CORE/Trend site.

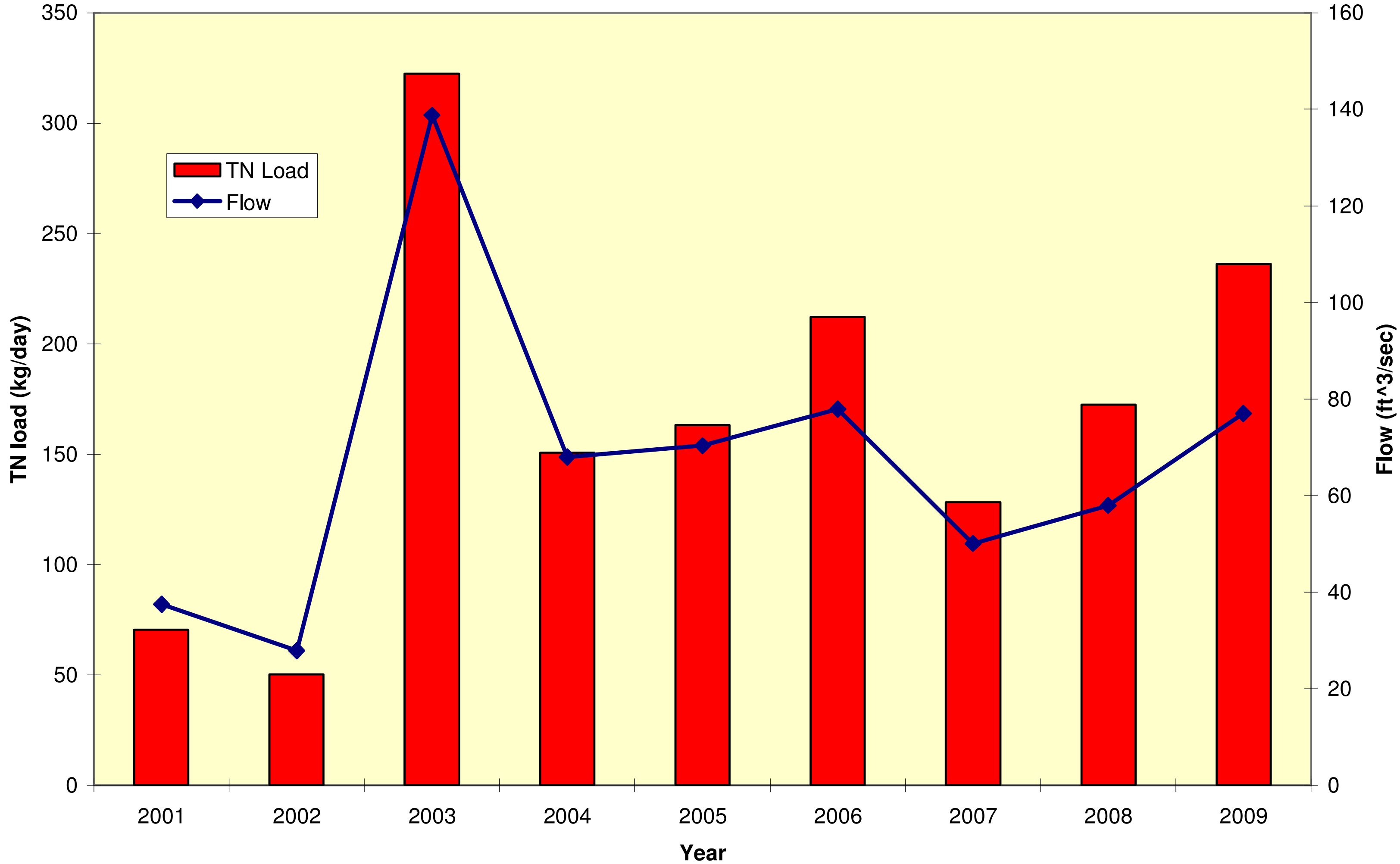


Figure A-39. Total nitrogen load and flow for the Mattawoman Creek near Pomonkey, MD Charles County site.

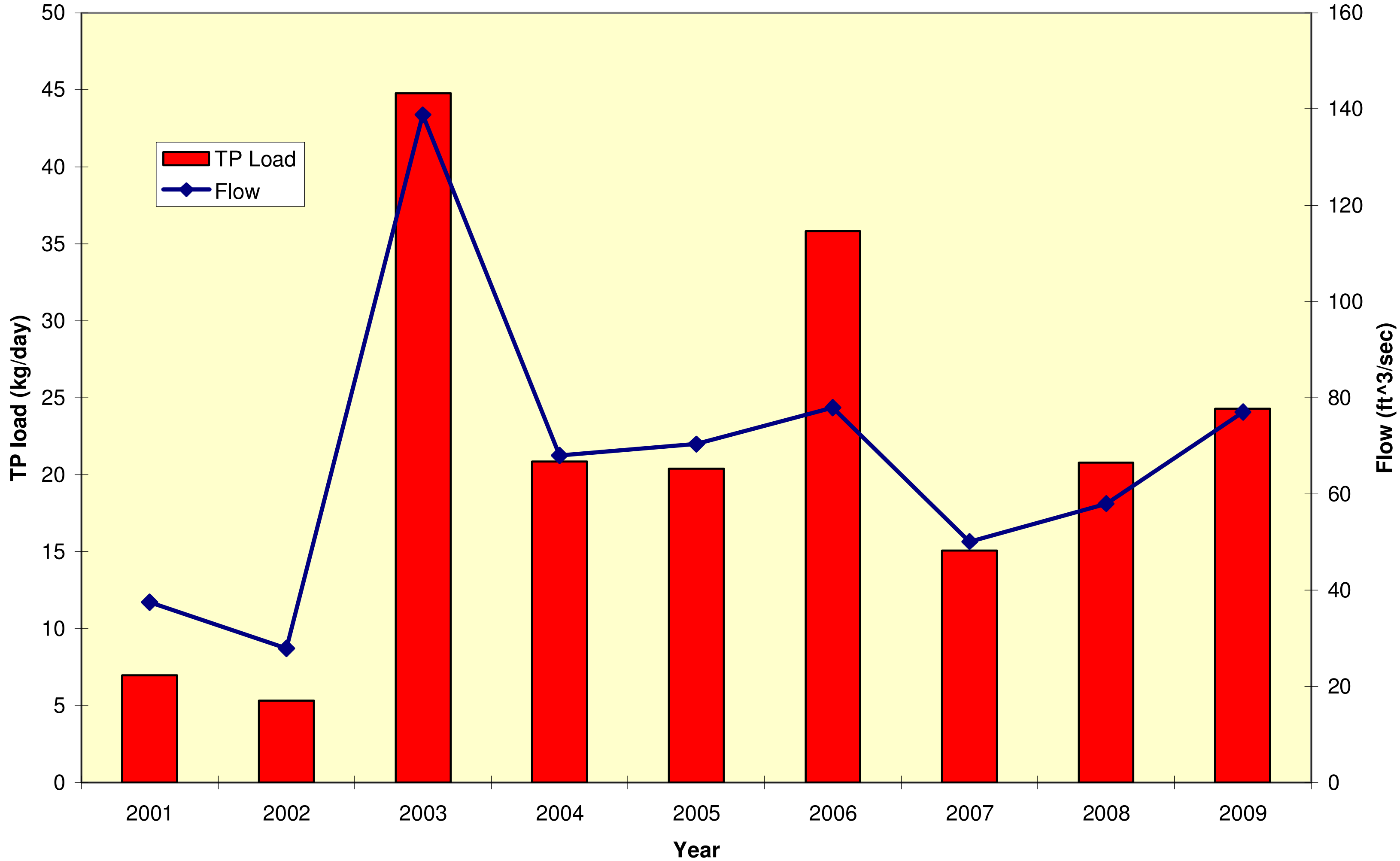


Figure A-40. Total phosphorus load and flow for the Mattawoman Creek near Pomonkey, MD Charles County site.

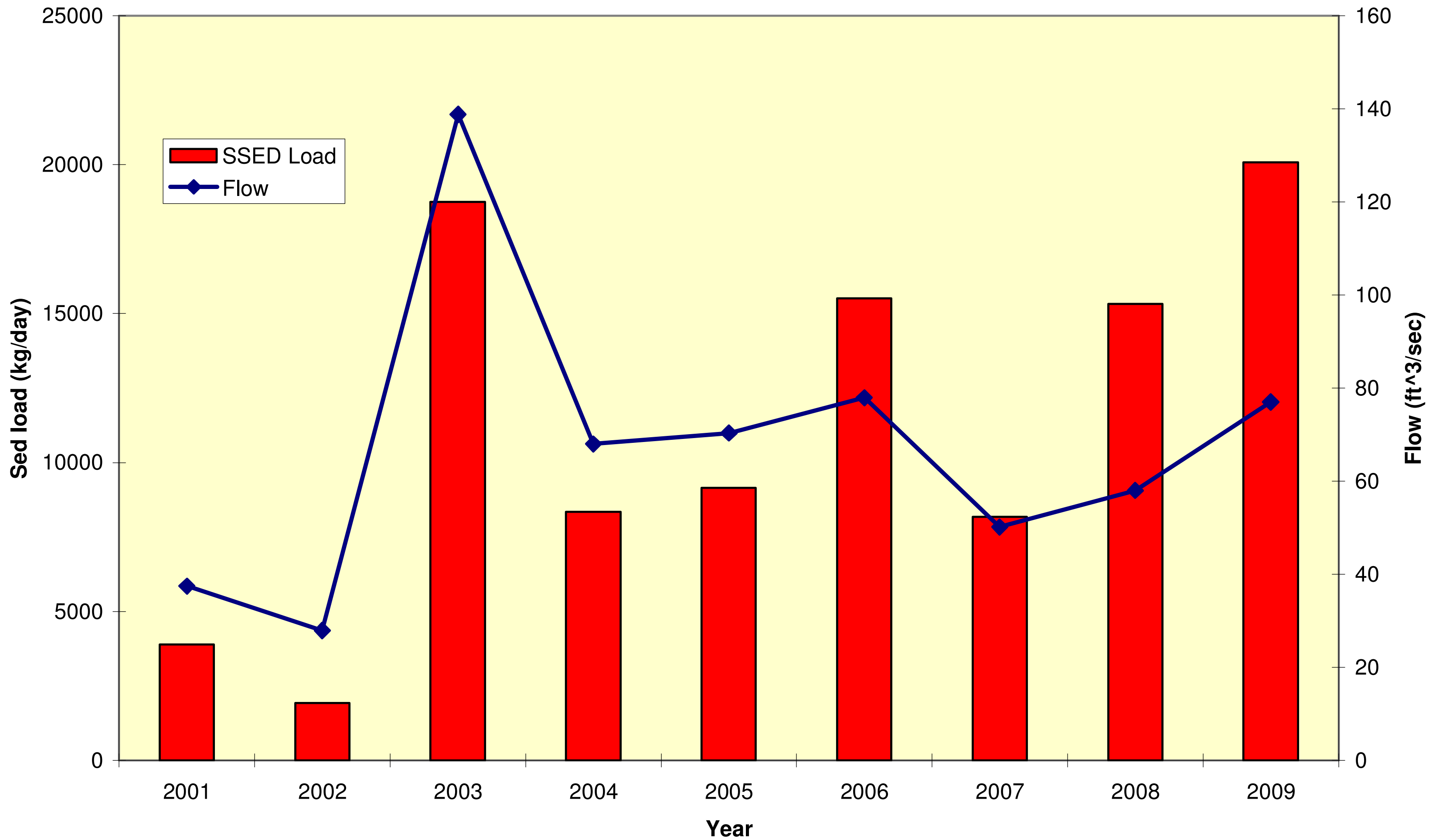


Figure A-41. Total suspended sediment load and flow for the Mattawoman Creek near Pomonkey, MD Charles County site.

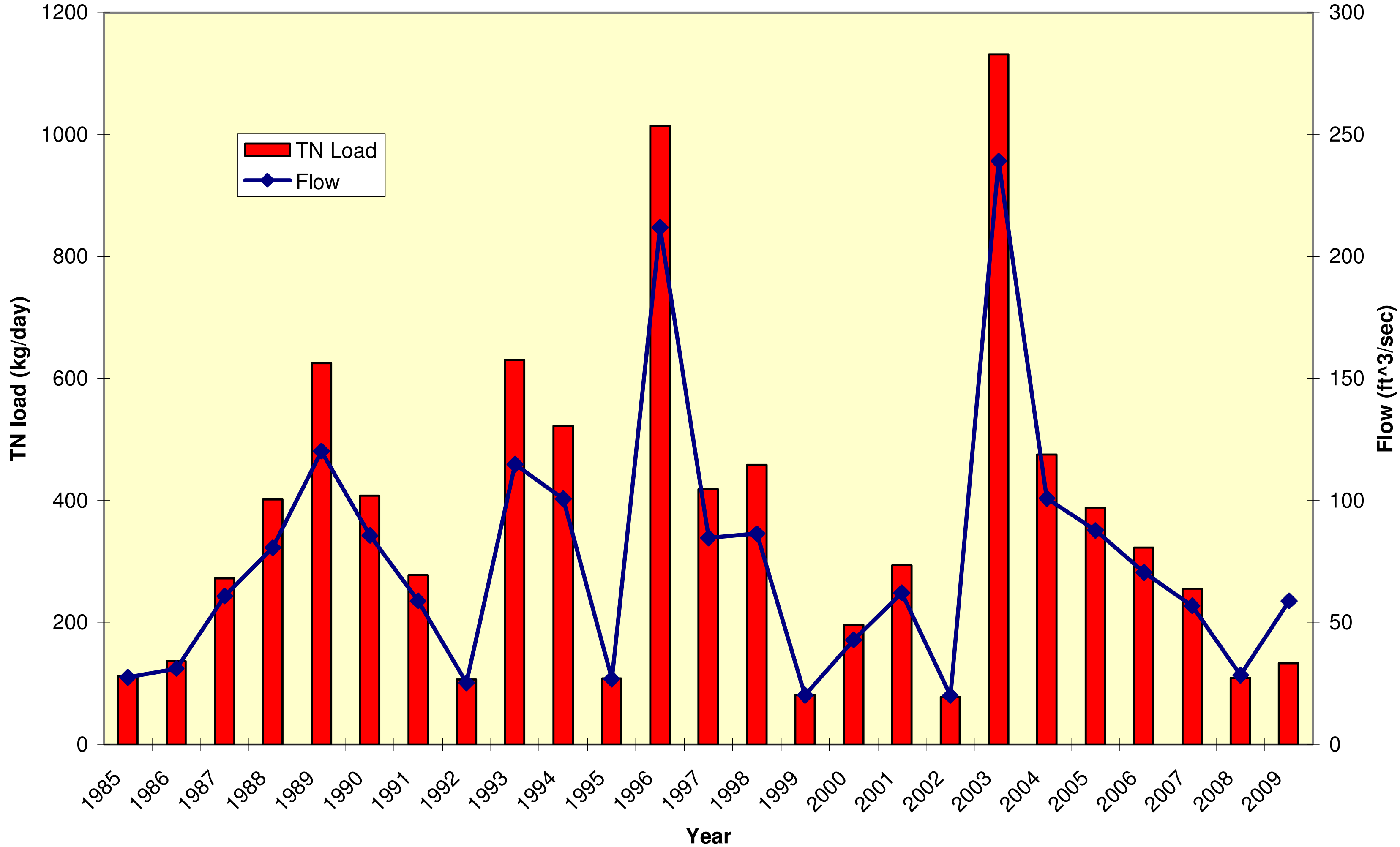


Figure A-42. Total nitrogen load and flow for the Patuxent River near Laurel, MD CORE/Trend site.

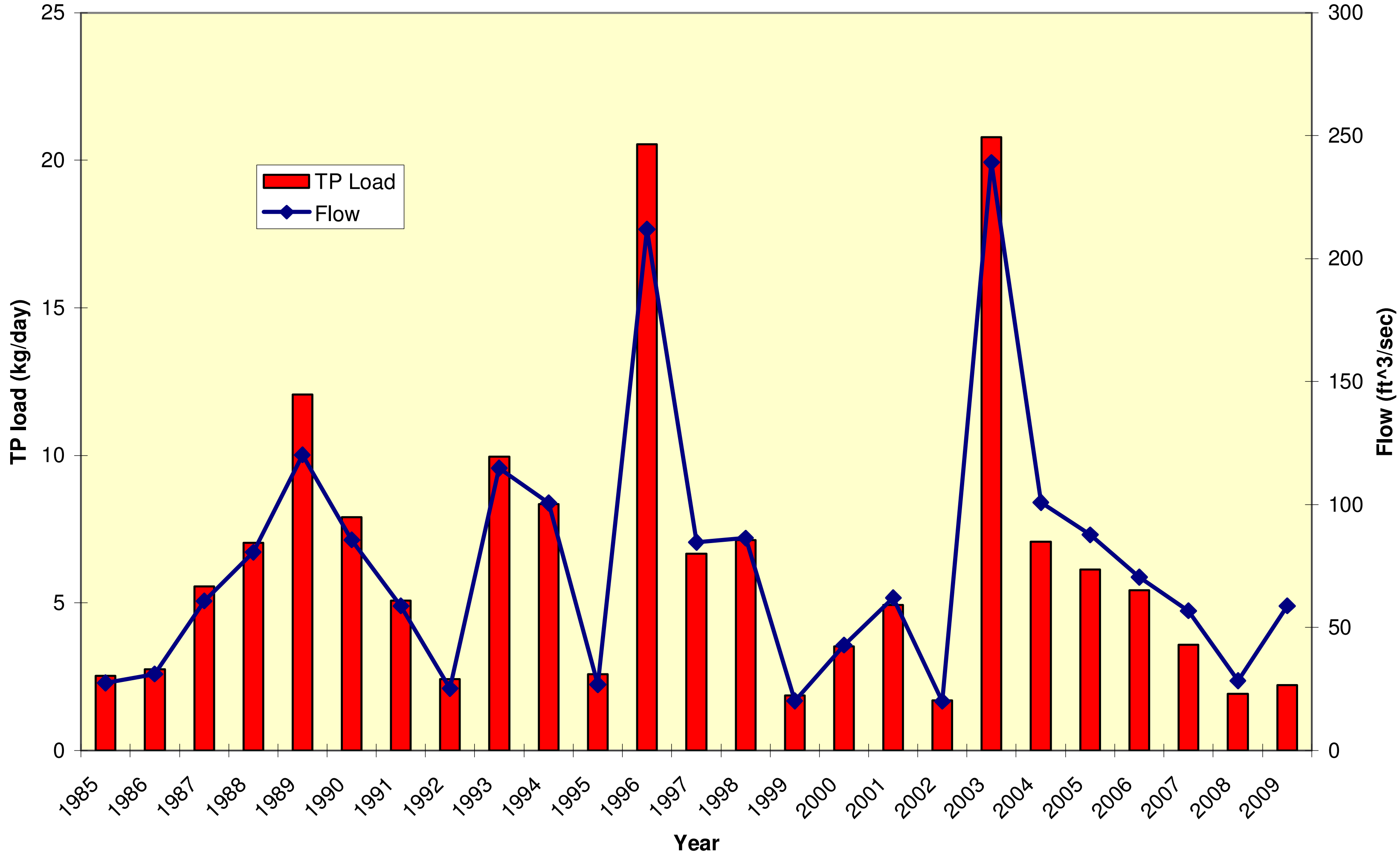


Figure A-43. Total phosphorus load and flow for the Patuxent River near Laurel, MD CORE/Trend site.

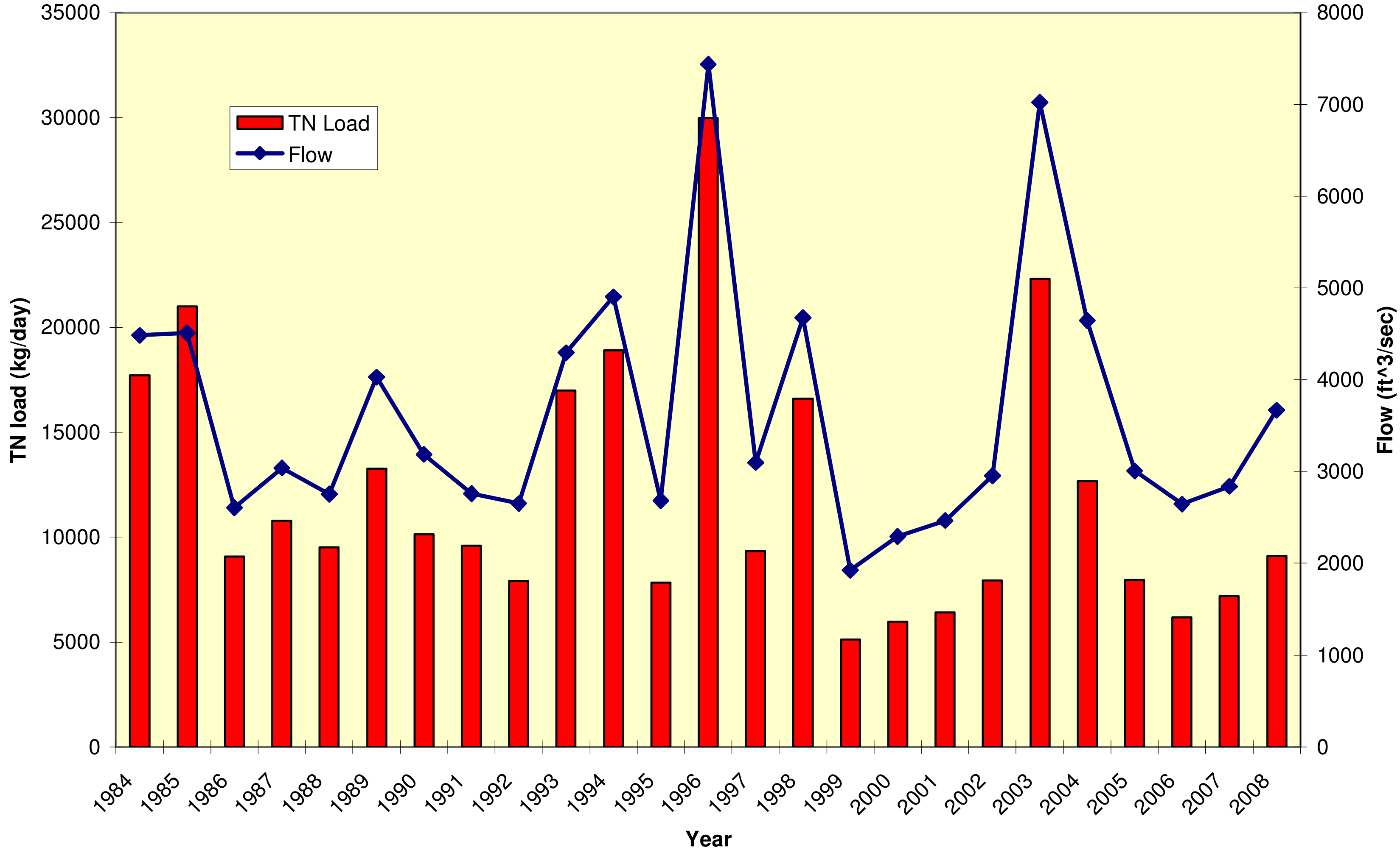


Figure A-44. Total nitrogen load and flow for the Potomac River near Paw Paw, WV CORE/Trend site.

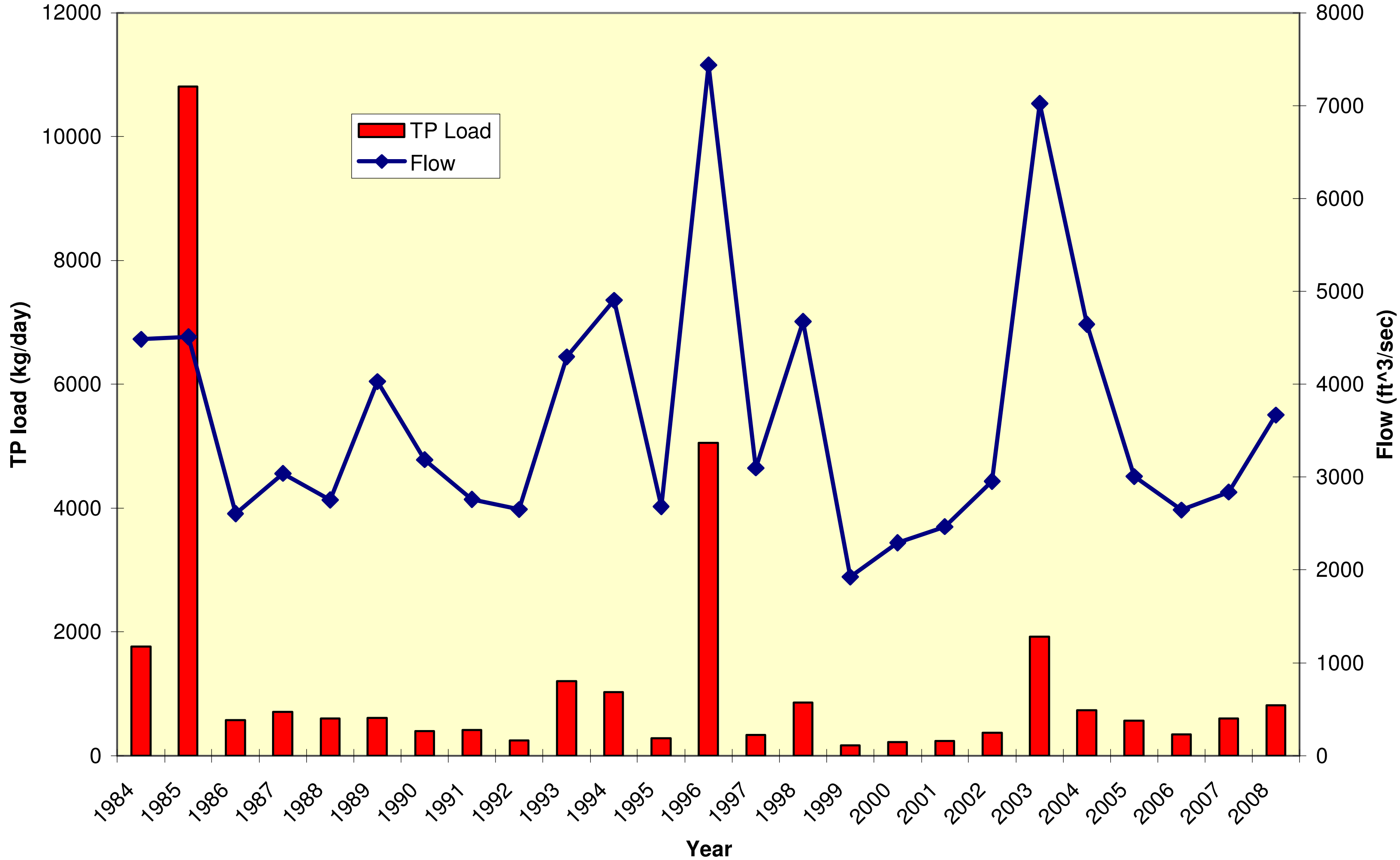


Figure A-45. Total phosphorus load and flow for the Potomac River near Paw Paw, WV CORE/Trend site.

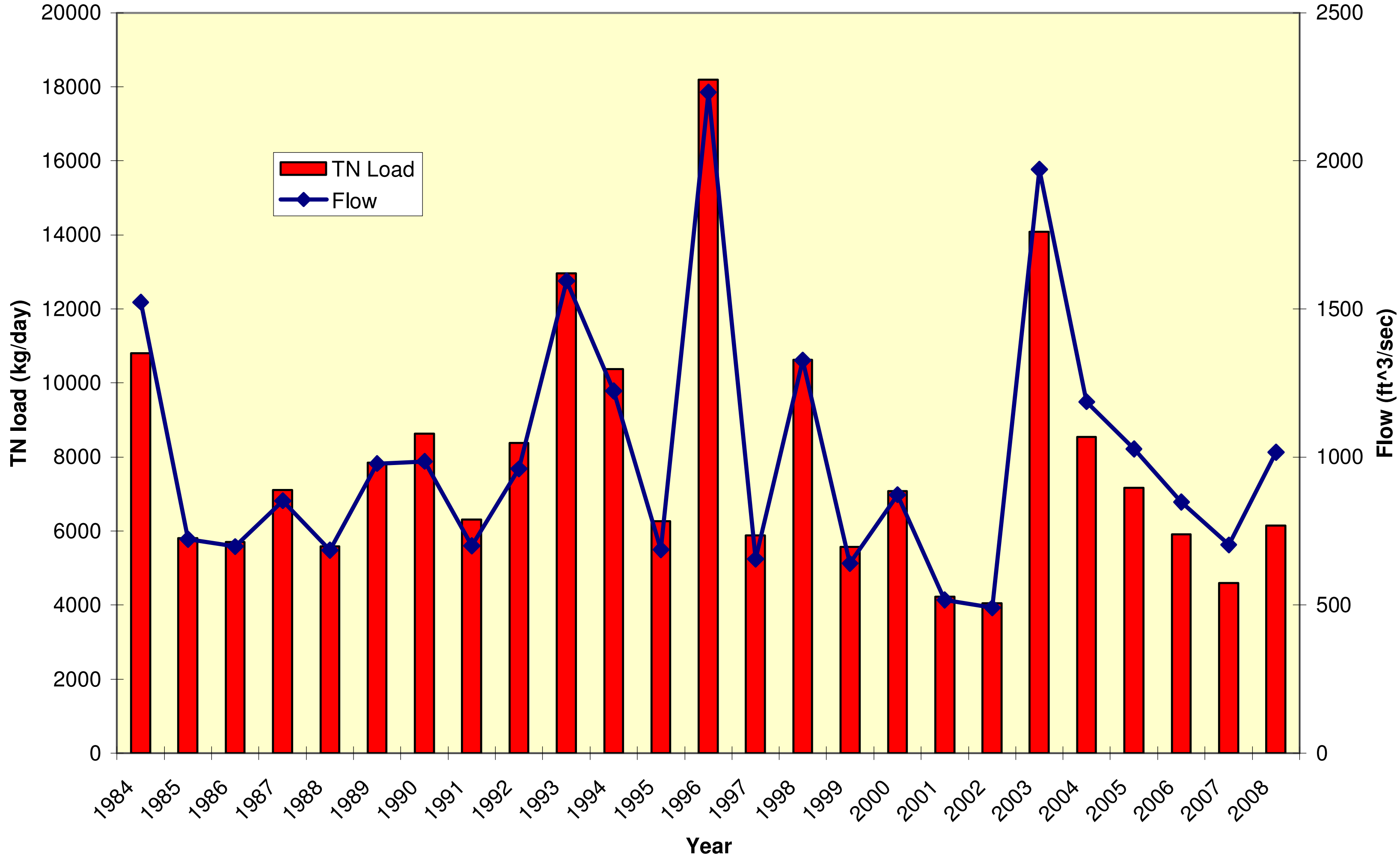


Figure A-46. Total nitrogen load and flow for the Monocacy River near Frederick, MD CORE/Trend site.

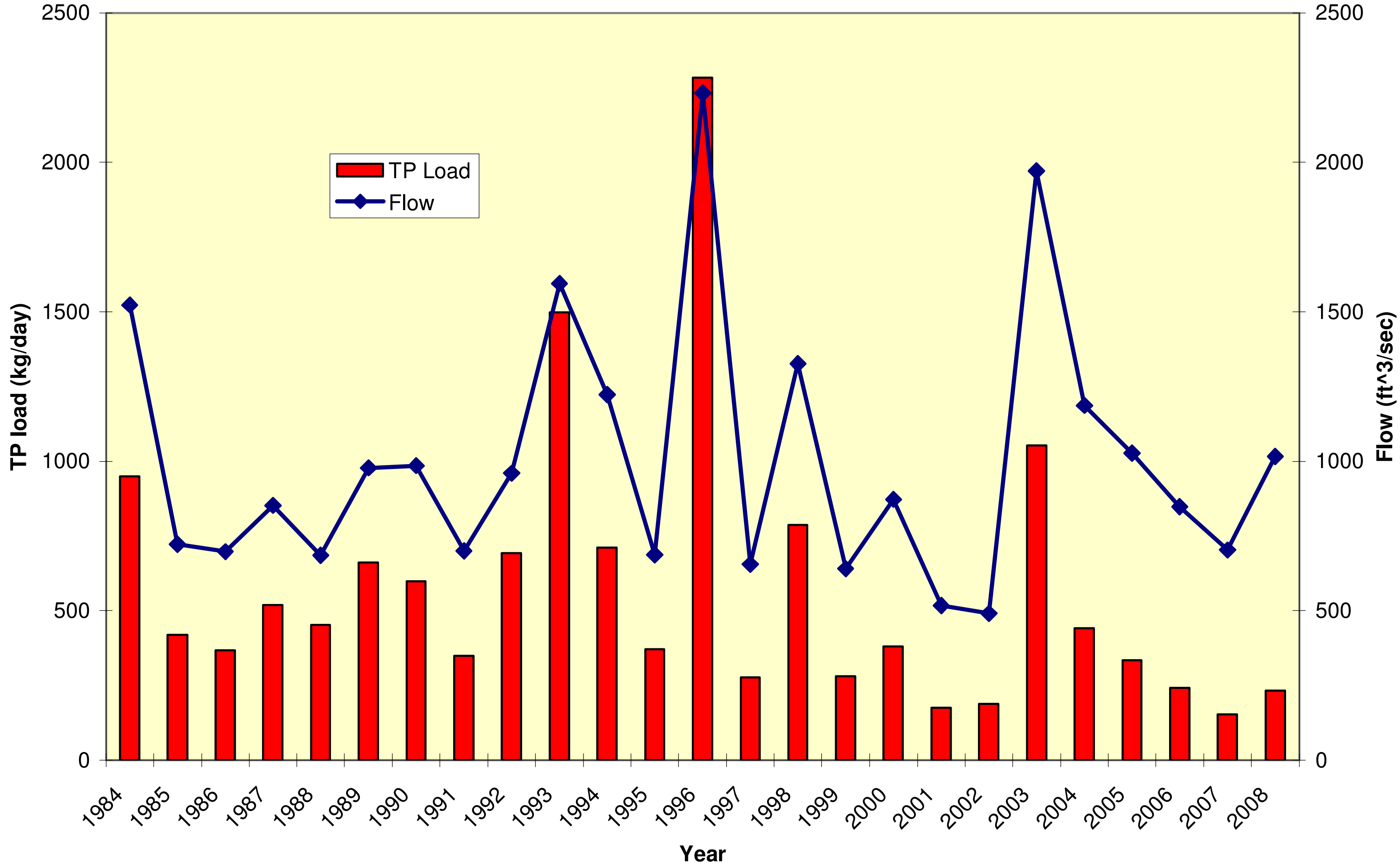


Figure A-47. Total phosphorus load and flow for the Monocacy River near Frederick, MD CORE/Trend site.