SEASONAL WATER DISCHARGES AND NUTRIENT AND SUSPENDED-SEDIMENT LOADS AND YIELDS

Seasonal water discharges and loads of nutrients and SS for calendar year 2001 are listed in Table 18. The calendar year 2001 and long-term seasonal water discharges and loads of TN, TP, and SS are illustrated in Figures 7 through 12.

Seasonal mean water discharges for calendar year 2001 at Towanda, Danville, Lewisburg, Newport, and Marietta were highest in the spring (April-June), followed by winter (January-March), fall (October-December), then summer (July-September). The 2001 seasonal discharges at Conestoga were highest in the winter, followed by spring, summer, and fall. The 2001 seasonal discharges were greater than long-term discharges during the spring at Towanda. The seasonal discharges were smaller than the long-term mean for all seasons at all other sites.

TN consists mostly of the highly soluble nitrite plus nitrate fraction; therefore, the seasonal variation of TN loads for 2001 corresponded with the seasonal variation of water discharges at all sites except at Newport and Lewisburg. Both sites showed the highest discharges during spring, followed by winter, while showing higher concentrations of TN during winter, followed by spring.

The variations in seasonal loads of TP were consistent with seasonal variations of water discharges at all sites, except Newport. Newport had the highest TP load in the spring, followed by winter, summer, and fall, while the discharge was highest in the spring, followed by winter, fall, and summer. TP loads for spring 2001 were greater than the long-term seasonal loads at Towanda, Danville, Newport, and Marietta. All other TP seasonal loads were lower than the corresponding long-term means.

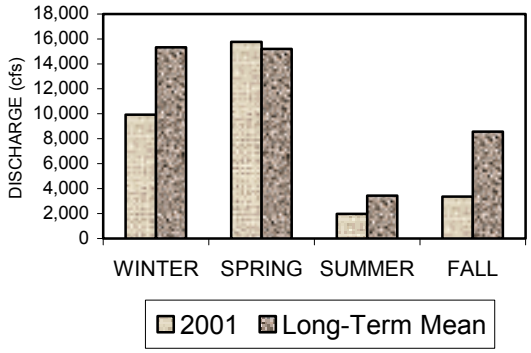
Seasonal variations in SS loads generally corresponded with discharge. The exception was at Newport. The SS load at Newport was highest in the spring, followed by winter, summer, and fall, while the discharge was highest in the spring, followed by winter, fall, and summer. All 2001 SS loads were lower than the seasonal long-term means except for spring at Towanda.

The long-term seasonal water discharges for all sites except Lewisburg are highest in the winter, followed by spring, fall, than summer. The long-term high discharge at Lewisburg was during spring followed by winter. The seasonal variations of the long-term TN loads are consistent with the seasonal discharges, except at Lewisburg. The long-term TP and SS loads in the Susquehanna River at Towanda, Danville, and the Juniata River at Newport show the same seasonal variability. The greatest loads occur in the spring, then in the winter, followed by fall and summer, while the highest discharge occurs in the winter, followed by spring, fall, and summer. TP loads at Conestoga show the same seasonal fluctuations as their respective seasonal discharges.

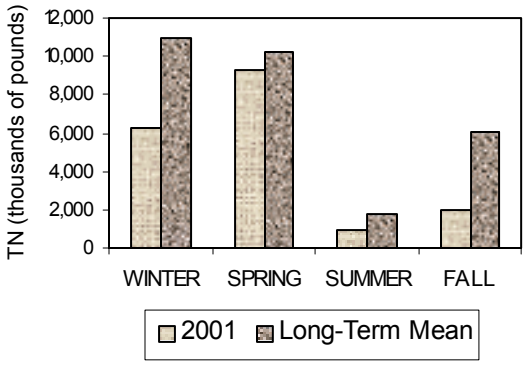
Figures 13 through 15 provide a comparison of the seasonal yields among the monitoring sites for calendar year 2001 and for the long-term seasonal average. The long-term seasonal averages indicate that the Conestoga River at Conestoga has the greatest yields of TN, TP, and SS for all seasons. The long-term TN yields in the Susquehanna River at Towanda, Danville, and Marietta generally increased in the downstream order. The 2001 TN yields for these sites maintained the same pattern during winter, summer, and fall. The West Branch Susquehanna River at Lewisburg, which has the greatest forested area, had the lowest long-term TN yield among the tributary sites. Lewisburg maintained the smallest TN yields among all sites during winter and spring of 2001.

Table 18. Seasonal Mean Water Discharges and Loads of Nutrients and Suspended Sediment, Calendar Year 2001

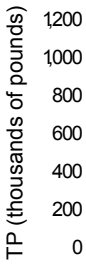
Station	Season	Mean Water Discharge	Total Ammonia as N	Total-Organic Nitrogen as N	Total Nitrite Plus Nitrate as N	Total Nitrogen as N	Dissolved Ortho-phosphate as P	Dissolved Phosphorus as P	Total Phosphorus as P	Dissolved Ammonia as N	Suspended Sediment	Dissolved Nitrogen as N	Dissolved Nitrite Plus Nitrate as N	Dissolved Organic Nitrogen as N	Total Organic Carbon
		cfs	thousands of pounds												
Towanda	Winter	9,929	259.1	2,045	3,901	6,211	255.9	228.2	402.5	327.5	170,359	6,112	3,959	1,807	13,865
	Spring	15,781	384.6	4,415	4,642	9,297	358.7	348.8	1,099.0	410.2	1,102,616	8,193	4,660	3,299	26,876
	Summer	1,978	22.3	573	428	953	92.4	67.2	108.9	26.0	13,055	839	429	427	3,598
	Fall	3,356	79.8	777	1,148	1,999	244.6	152.5	189.0	122.4	21,195	1,980	1,155	694	5,173
Danville	Winter	14,781	406.3	3,054	6,997	10,301	361.8	277.2	585.3	561.4	208,795	10,180	7,107	2,616	18,629
	Spring	20,990	433.0	5,719	7,417	13,212	407.1	366.7	1,289.3	525.1	877,762	11,899	7,459	4,175	32,927
	Summer	3,462	28.5	1,100	800	1,738	74.0	66.4	155.8	36.4	22,120	1,454	803	752	6,161
	Fall	5,223	110.2	1,404	2,096	3,474	226.6	162.8	276.2	167.9	38,226	3,361	2,122	1,173	7,775
Lewisburg	Winter	9,062	332.0	1,635	2,810	4,578	107.7	115.2	277.9	271.3	86,194	4,300	2,812	1,258	8,285
	Spring	10,014	241.0	1,827	2,569	4,462	106.9	104.3	298.3	192.3	107,395	3,993	2,555	1,324	9,992
	Summer	2,476	30.1	539	659	1,183	44.6	39.9	80.0	31.2	13,270	1,048	649	389	3,111
	Fall	5,529	103.0	1,205	1,685	2,973	122.4	120.7	245.2	147.8	46,311	2,676	1,672	880	6,368
Newport	Winter	4,054	46.9	920	2,494	3,524	154.6	132.7	221.4	61.8	80,589	3,352	2,515	755	5,676
	Spring	4,202	49.1	1105	2,283	3,432	184.8	152.7	305.6	71.1	149,541	3,140	2,294	812	6,501
	Summer	883	8.0	283	364	588	46.1	45.1	71.4	12.4	9,730	531	365	211	1,640
	Fall	912	7.8	255	462	695	47.5	49.4	65.5	12.3	5,873	662	467	214	1,539
Marietta	Winter	33,127	829.7	8,599	18,225	27,089	1,452.3	966.3	1,813.1	935.4	786,776	24,951	18,280	5,914	43,722
	Spring	42,905	780.7	13,965	18,856	30,894	2,329.9	1,374.4	3,402.7	850.3	1,948,548	27,395	18,800	8,729	67,466
	Summer	8,382	82.4	3,396	2,742	5,248	463.9	311.9	552.0	106.2	150,945	4,697	2,777	2,273	16,153
	Fall	13,490	312.0	5,081	6,776	11,315	1,136.6	625.8	1,006.3	362.4	285,069	10,364	6,865	3,439	22,488
Conestoga	Winter	635	30.2	487	2,104	2,587	49.7	52.6	122.6	31.5	42,775	2,438	2,092	295	1,456
	Spring	521	19.0	342	1,715	2,003	53.5	46.3	111.8	19.5	35,897	1,896	1,706	193	1,170
	Summer	200	4.4	116	635	737	38.9	30.6	50.2	4.5	6,754	696	636	68	488
	Fall	120	1.7	78	410	502	18.7	18.4	20.8	2.1	630	478	412	54	264



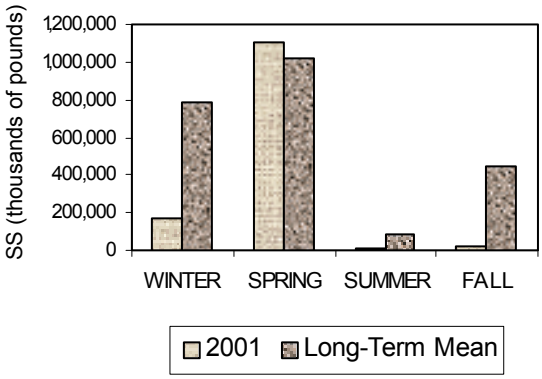
Discharge



Total Nitrogen

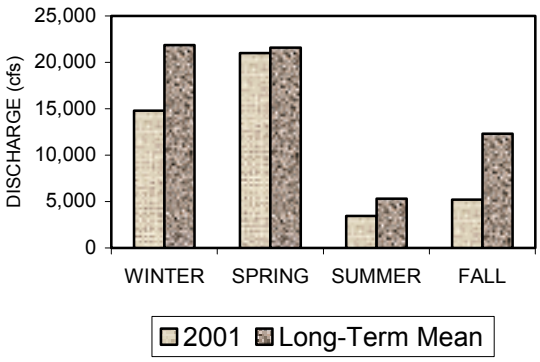


Total Phosphorus

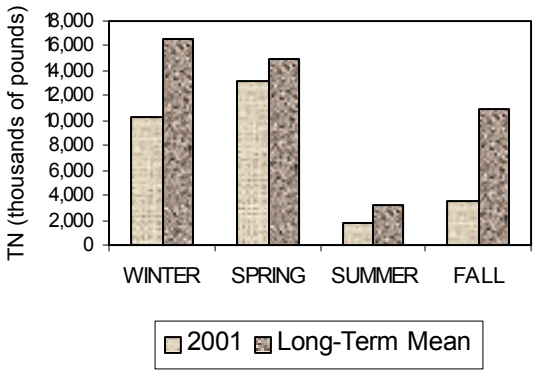


Suspended Sediment

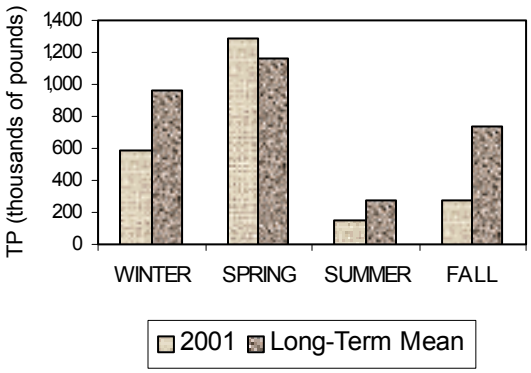
Figure 7. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), and Suspended Sediment (SS) at Towanda, Pa., Calendar Year 2001



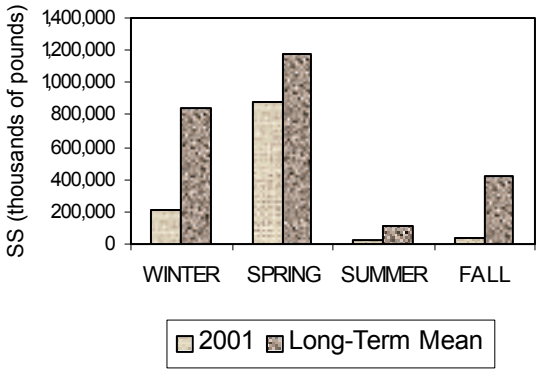
Discharge



Total Nitrogen

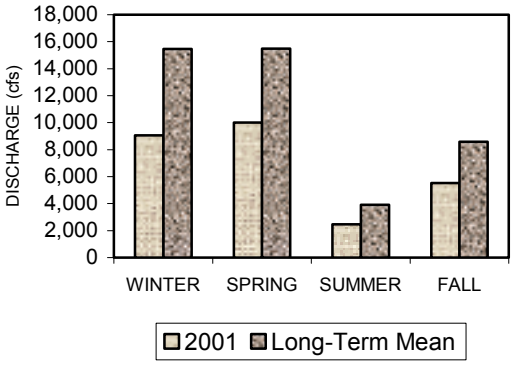


Total Phosphorus

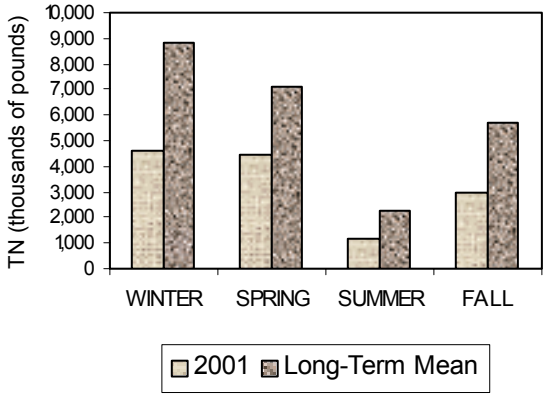


Suspended Sediment

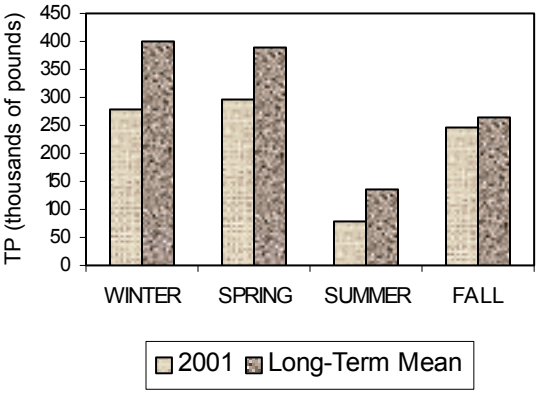
Figure 8. Seasonal Discharges and Loads of Total Nitrogen(TN), Total Phosphorus(TP), and Suspended Sediment (SS) at Danville, Pa., Calendar Year 2001



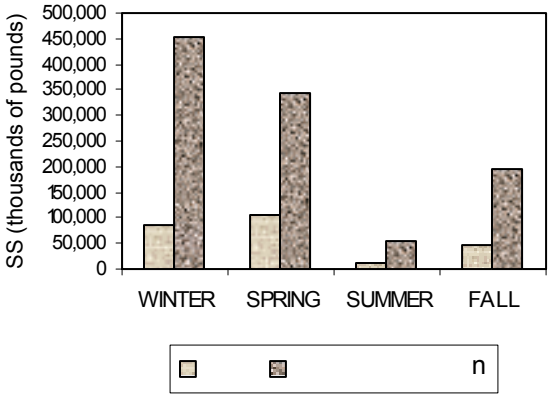
Discharge



Total Nitrogen

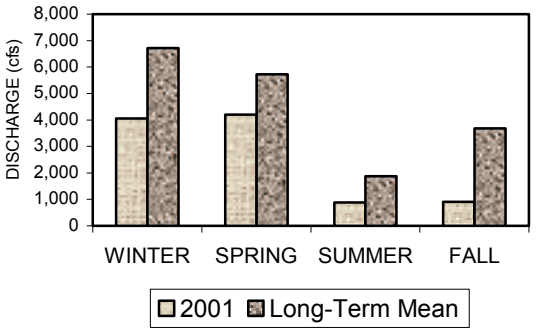


Total Phosphorus

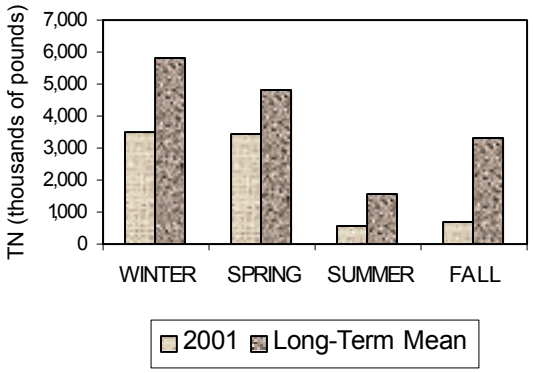


Suspended Sediment

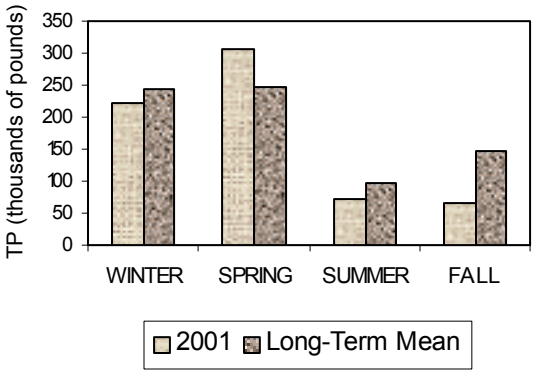
Figure 9. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), and Suspended Sediment (SS) at Lewisburg, Pa., Calendar Year 2001



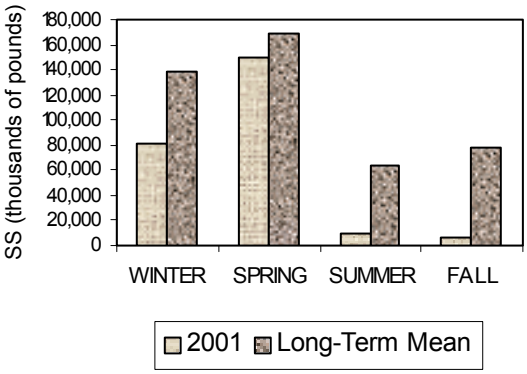
Discharge



Total Nitrogen

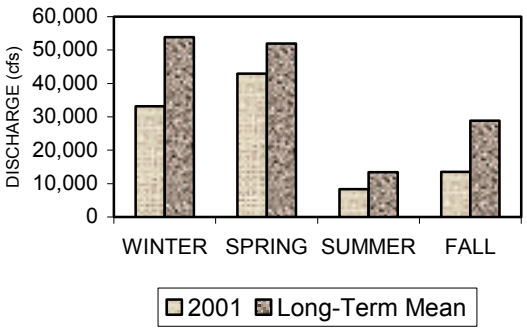


Total Phosphorus

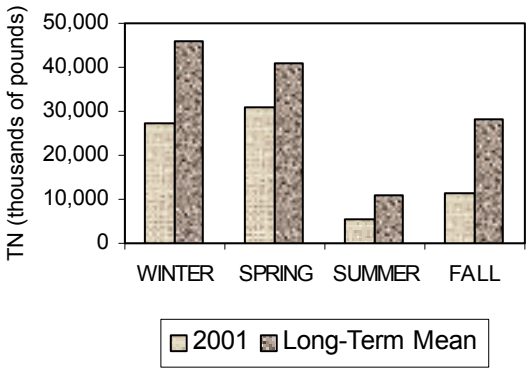


Suspended Sediment

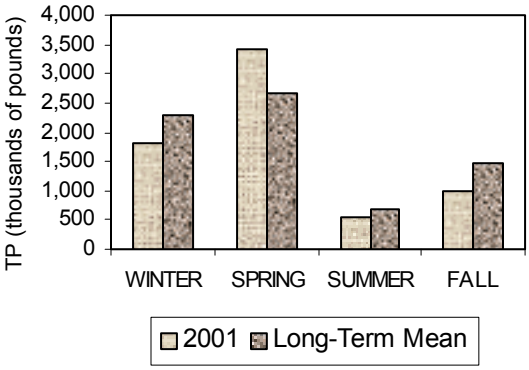
Figure 10. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), and Suspended Sediment (SS) at Newport, Pa., Calendar Year 2001



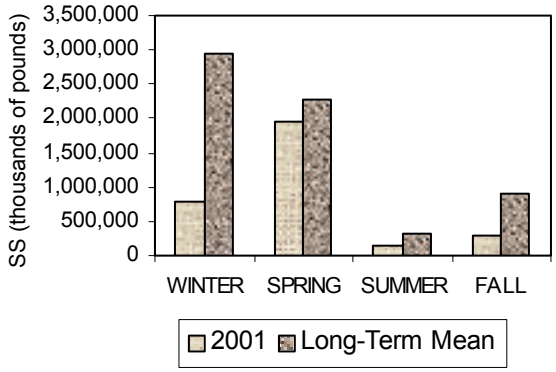
Discharge



Total Nitrogen

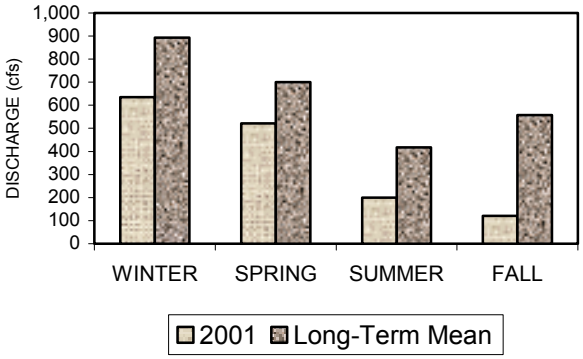


Total Phosphorus

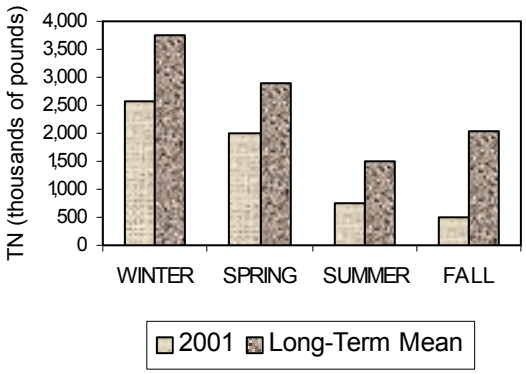


Suspended Sediment

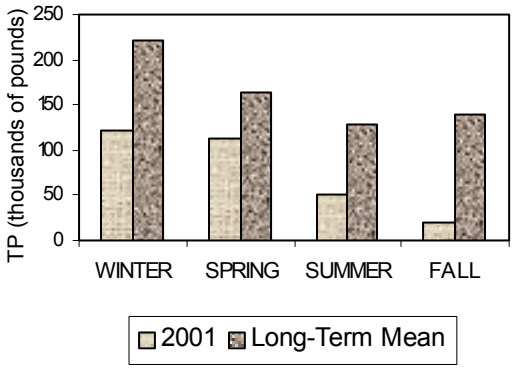
Figure 11. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), and Suspended Sediment (SS) at Marietta, Pa., Calendar Year 2001



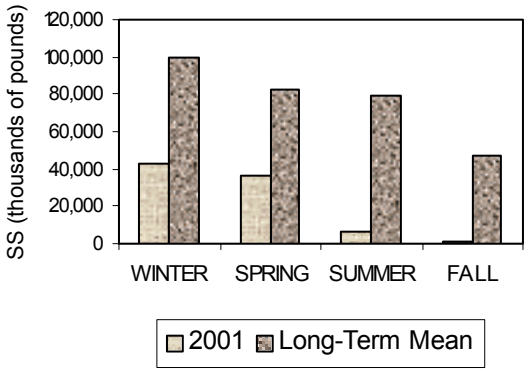
Discharge



Total nitrogen



Total Phosphorus



Suspended Sediment

Figure 12. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), and Suspended Sediment (SS) at Conestoga, Pa., Calendar Year 2001

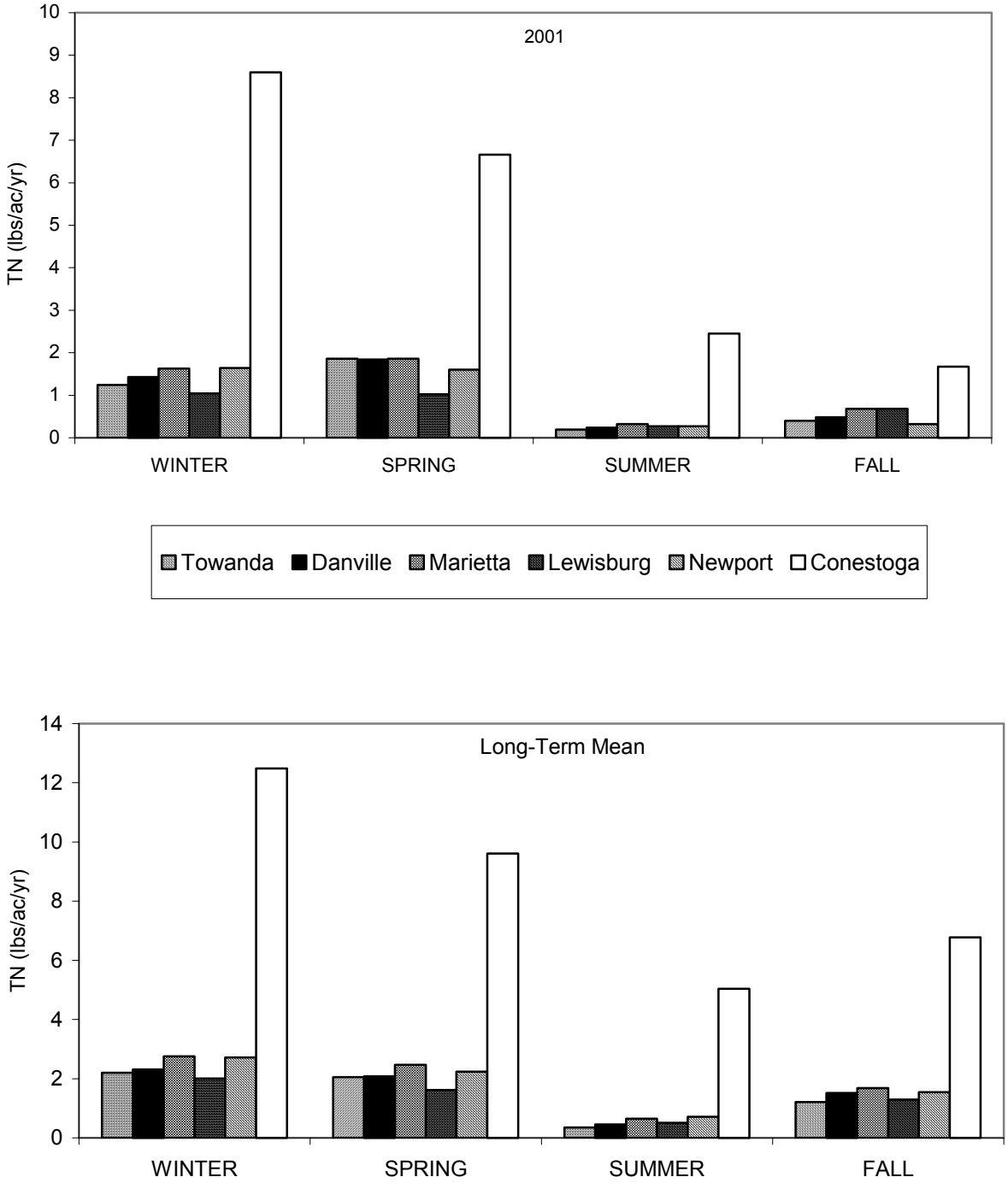
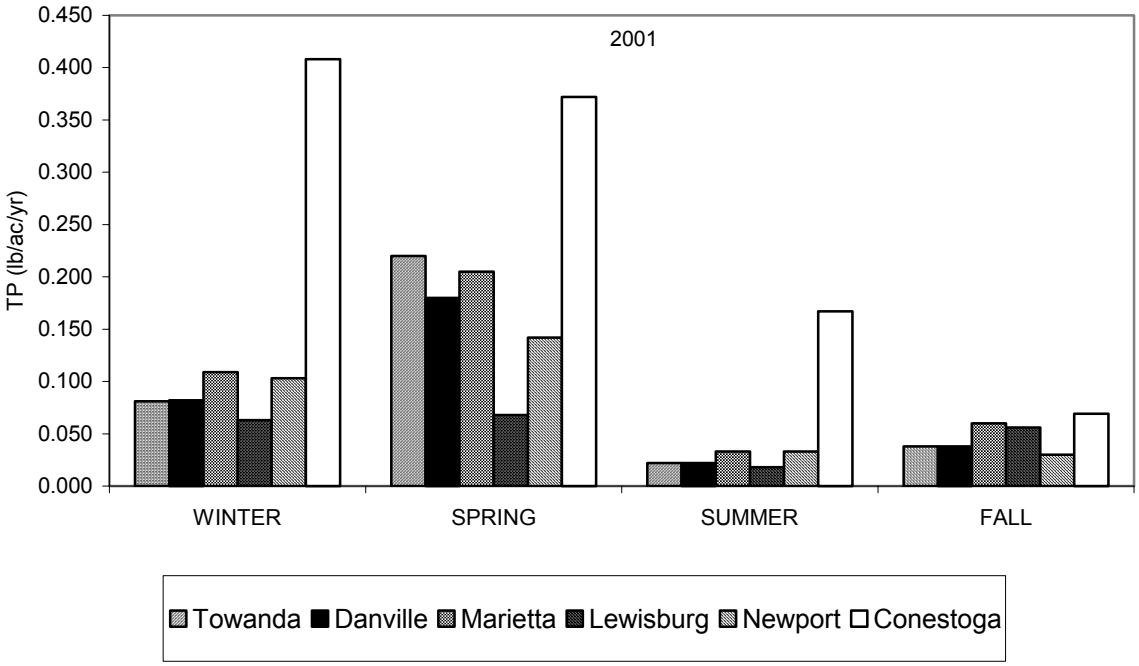


Figure 13. Comparison of Seasonal Yields of Total Nitrogen (TN) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, PA



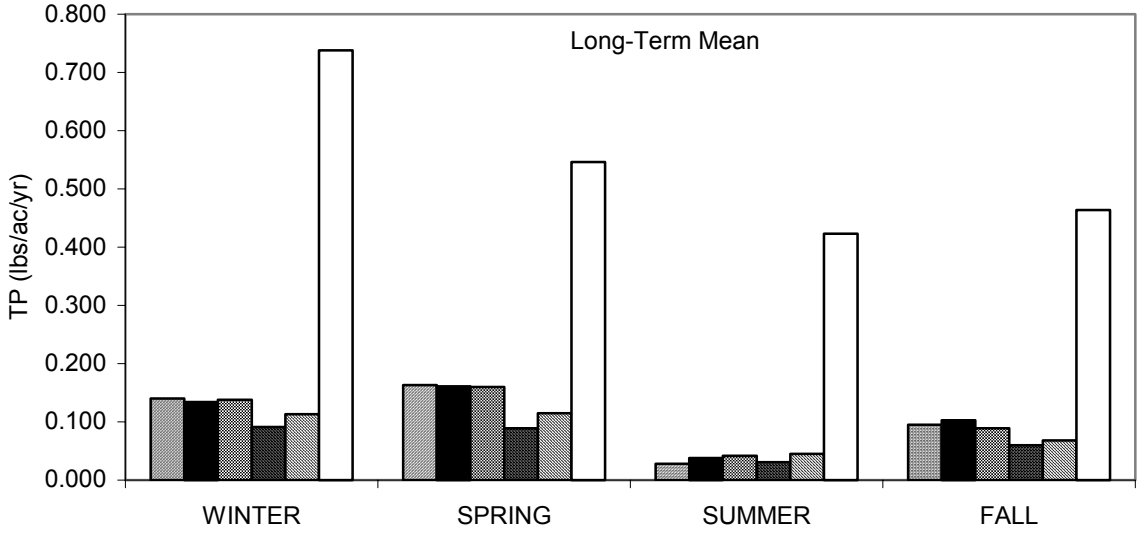


Figure 14. Comparison of Seasonal Yields of Total Phosphorus (TP) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, PA

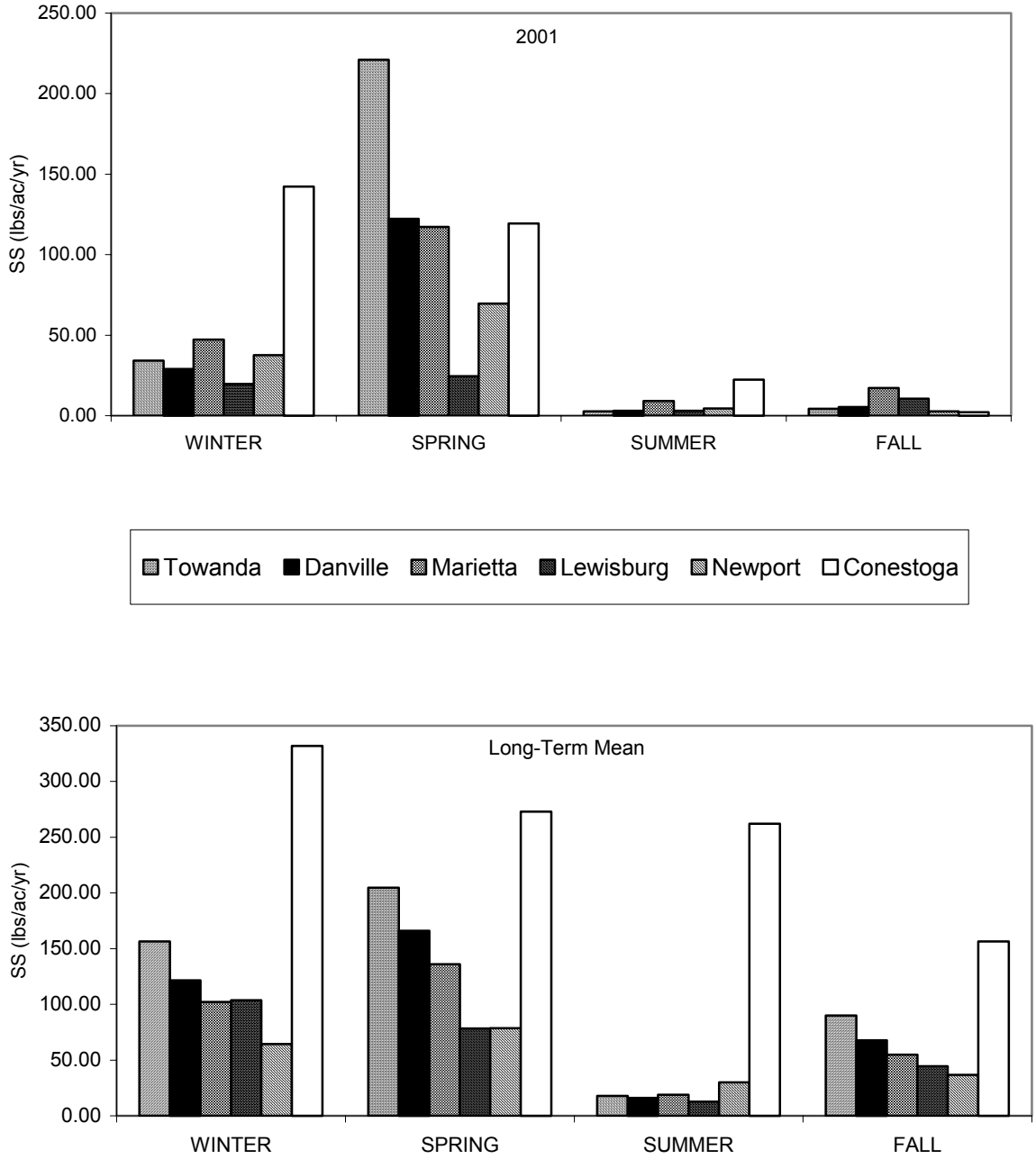


Figure 15. Comparison of Seasonal Yields of Suspended Sediment (SS) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, PA

The long-term TP yields in the Susquehanna River at Towanda, Danville, and Marietta do not show any consistent seasonal pattern among the sites. TP yields among the tributary sites show that Lewisburg had the smallest yield during all seasons. The 2001 TP yields for Towanda, Danville, and Marietta followed the same pattern during the winter, summer, and fall months with Towanda and Danville having similar yields and Marietta slightly higher. The smallest TP yield in 2001 occurred at Lewisburg during winter, spring, and summer. Newport showed the lowest TP yield values during the fall. Conestoga had the highest TP yields for all sites during all seasons.

Long-term SS yields in the Susquehanna River generally decreased in the downstream order with the summer at Marietta as the exception. SS yields among the tributary sites were smallest at Newport in the winter and fall, and at Lewisburg during spring and summer. The 2001 seasonal SS yields did not show any consistent relationships among the sites.

COMPARISON OF THE 2001 LOADS AND YIELDS OF TOTAL NITROGEN, TOTAL PHOSPHORUS, AND SUSPENDED SEDIMENT WITH THE BASELINES

Several studies, Ott and others (1991), Takita and Edwards (1993), and Takita (1998), have shown that annual loads of TN, TP, and SS change with annual fluctuations in water discharge. The annual fluctuations of nutrient and SS loads and water discharge made it difficult to determine whether the changes were related to land use, nutrient availability, or simply annual water discharge. Ott and others (1991) used the functional relationship between annual loads and annual water discharge to provide a method to reduce the variability of loadings due to discharge. This was accomplished by plotting the annual loads or yields against the water-discharge ratio. This water-discharge ratio is the ratio of the annual mean discharge to the long-term mean discharge. Data from the initial 5-year study (1985-89) were used to provide a best-fit linear regression line to be used as the baseline relationship between annual loads and water discharge. It was hypothesized that, as future loads and water-discharge ratios were plotted against the baseline, any significant deviation from the baseline would indicate that some change in the annual load had occurred, and that further evaluations to determine the reason for the change were warranted. The data collected in 2001 were compared with the 1985-89 baseline, where possible. Monitoring at some of the stations was started after 1987; therefore, a baseline was established for the 5-year period following the start of monitoring.

Susquehanna River at Towanda, Pa.

The 5-year baselines for TN, TP, and SS for the Susquehanna River at Towanda are shown in Figure 16 with the 2001 annual yield. Best-fit lines were drawn through the initial 5-year data sets using the following equations:

<u>Total Nitrogen (TN)</u>
TN Yield = 0.7484 + 6.0967x $R^2 = 0.86$

<u>Total Phosphorus (TP)</u>
TP Yield = -0.1419 + 0.4999x $R^2 = 0.52$

<u>Suspended Sediment (SS)</u>
SS Yield = -612.879 + 918.165x $R^2 = 0.43$

Where x = water-discharge ratio and R2 = correlation coefficient

The 2001 TN yield plotted below the 5-year baseline suggesting that the TN load decreased. The TN yield was estimated to be 4.47 lb/ac/yr at a water-discharge ratio of 0.7278 for the initial five years of monitoring, while the yield for 2001 was 3.7 lb/ac/yr at the same discharge ratio. The TP load increased in 2001. The baseline TP yield was 0.22 lb/ac/yr, compared to 0.36 lb/ac/yr for 2001. The SS yields in Figure 16 indicate that there was an increase in yields for 2001. The baseline yield was 55.3 lb/ac/yr, and the yield for 2001 was 261.96 lb/ac/yr.