Table 4. Summary for Annual Precipitation for Selected Areas in the Susquehanna River Basin, Calendar Year 2003

River Location	Season	Calendar Year 2003 Precipitation inches	Average Long-term Precipitation inches	Departure From Long Term inches
Susquehanna River above Towanda, Pa	January-March	6.58	7.94	-1.36
	April-June	8.77	10.02	-1.25
	July-September	15.06	10.25	+4.81
	October-December	9.71	8.73	+0.98
	Yearly Total	**40.12**	**36.94**	**+3.18**
Susquehanna River above Danville, Pa.	January-March	6.13	7.87	-1.74
	April-June	9.13	10.11	-0.99
	July-September	13.97	10.39	+3.58
	October-December	9.43	8.75	+0.68
	Yearly Total	**38.66**	**37.12**	**+1.54**
West Branch Susquehanna River above Lewisburg, Pa.	January-March	8.38	8.87	-0.49
	April-June	11.55	11.43	+0.12
	July-September	21.25	11.61	+9.64
	October-December	12.18	9.44	+2.74
	Yearly Total	**53.36**	**41.35**	**+12.01**
Juniata River above Newport, Pa.	January-March	8.57	8.79	-0.22
	April-June	13.09	11.01	+2.08
	July-September	16.21	10.89	+5.32
	October-December	10.57	9.13	+1.44
	Yearly Total	**48.44**	**39.82**	**+8.62**
Susquehanna River above Marietta, Pa.	January-March	7.99	8.49	-0.50
	April-June	11.68	10.71	+0.97
	July-September	16.21	10.79	+5.42
	October-December	10.88	9.06	+1.81
	Yearly Total	**46.76**	**39.05**	**+7.71**
Conestoga River above Conestoga, Pa.	January-March	10.19	8.57	+1.62
	April-June	14.16	10.85	+3.31
	July-September	16.96	11.79	+5.17
	October-December	14.09	9.50	+4.59
	Yearly Total	**55.40**	**40.71**	**+14.69**

WATER DISCHARGE

Water discharge data were obtained from the USGS and are listed in Table 5. Lewisburg recorded the second highest rainfall for the year but also recorded the lowest percent of flow above the LTM. This could be due to the watershed being mostly forested and thus allowing for less runoff. Water discharges were above the LTM at all sites ranging from 147.3 percent of the LTM at Lewisburg to 176.2 percent at Conestoga. Figure 3 compares the 2003 discharges with the LTM discharges for each site.

ANNUAL NUTRIENT AND SUSPENDED-SEDIMENT LOADS AND YIELDS

Loads and yields represent two methods for describing nutrient and SS amounts within a basin. Loads refer to the actual amount of the constituent being transported in the water column past a given point over a specific duration of time and are expressed in pounds. Yields compare the transported load with the acreage of the watershed and are expressed in lbs/acre. This allows for easy watershed comparisons. This project reports loads and yields for the constituents listed in Table 6 as computed by the Minimum Variance Unbiased Estimator (MVUE) described by Cohn and others (1989). This estimator relates the constituent concentration to water discharge, seasonal effects, and long-term trends, and computes the best-fit regression equation. Daily loads of the constituents were then calculated from the daily mean water discharge records. The loads were reported along with the estimates of accuracy. Tables 7-19 show the loads and yields for the six monitoring stations, as well as an

associated error value. They also show the average annual concentration for each constituent. Comparisons have been made to the LTMs for all constituents. As a general note, nutrient and SS loads increase with increasing discharge.

Table 5. Annual Water Discharge, Calendar Year 2003

Site	Years of Record	Long-term Annual Mean cfs[1]	2003	
			Mean cfs	Percent of LTM[2]
Towanda	90	10,700	16,290	152.2
Danville	99	15,359	24,050	156.6
Lewisburg	64	10,924	16,095	147.3
Newport	104	4,564	8,029	175.9
Marietta	72	37,290	59,234	158.8
Conestoga	19	655	1,154	176.2

[1] Cubic feet per second
[2] Long-Term Mean

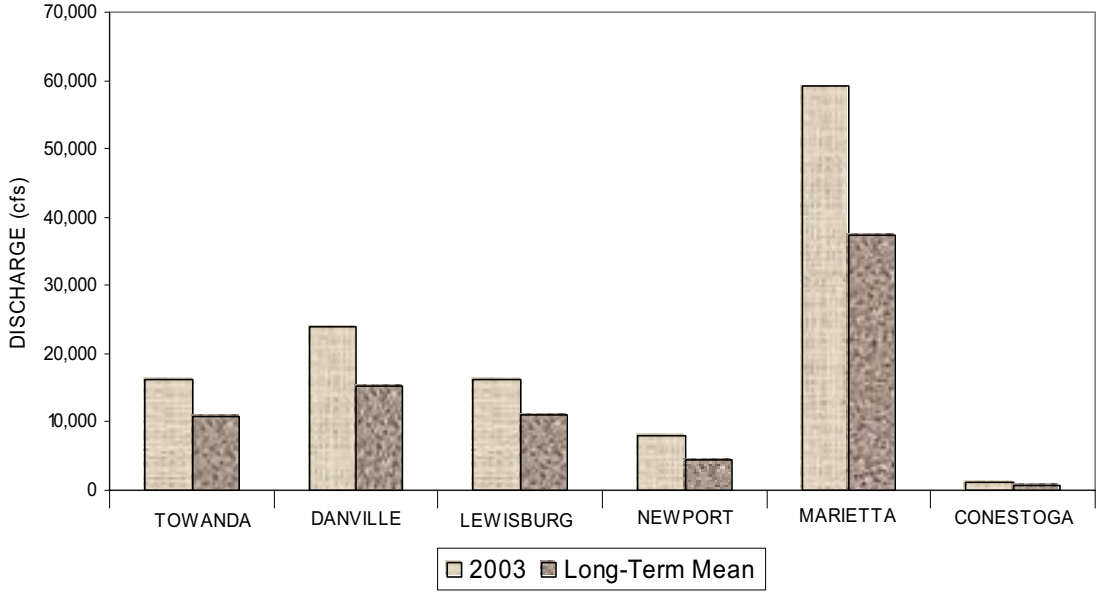

Figure 3. Annual and Long-Term Discharges at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa.

Table 6. List of Analyzed Parameters, Abbreviations, and Storet Codes

Parameter	Abbreviation	Storet Code
Total Nitrogen as N	TN	00600
Dissolved Nitrogen as N	DN	00602
Total Organic Nitrogen as N	TON	00605
Dissolved Organic Nitrogen as N	DON	00607
Total Ammonia as N	TNH_3	00610
Dissolved Ammonia as N	DNH_3	00608
Total Nitrate + Nitrite as N	TNOx	00630
Dissolved Nitrate + Nitrite as N	DNOx	00631
Total Phosphorus as P	TP	00665
Dissolved Phosphorus as P	DP	00666
Dissolved Orthophosphate as P	DOP	00671
Total Organic Carbon	TOC	00680
Suspended Sediment	SS	80154

Table 7. Annual Water Discharges, Annual Loads, Yields, and Average Concentration of Total Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	N Load % of LTM	Prediction Error percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	32,621	113.1	5.4	1.37	1.02	5.78	6.54
Danville	24,050	156.6	50,184	110.4	6.0	1.50	1.06	6.33	6.99
Lewisburg	16,095	147.3	31,644	132.0	7.9	1.12	1.0	5.47	7.22
Newport	8,029	175.9	31,282	194.5	5.1	1.79	1.98	7.49	14.57
Marietta	59,234	158.8	193,078	150.2	6.3	1.75	1.66	7.73	11.61
Conestoga	1,154	176.2	17,139	166.4	5.3	7.98	7.54	34.24	56.98

Table 8. Annual Water Discharges and Annual Loads and Yields of Total Phosphorus, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	P Load % of LTM	Prediction Error percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	2,677	125.2	21.5	0.1015	0.0835	0.428	0.54
Danville	24,050	156.6	4,691	146.5	20.7	0.1059	0.0991	0.446	0.65
Lewisburg	16,095	147.3	1,712	142.2	27.1	0.0560	0.0540	0.275	0.39
Newport	8,029	175.9	1,949	244.8	20.4	0.0886	0.1233	0.371	0.91
Marietta	59,234	158.8	15,013	196.6	19.0	0.1040	0.1287	0.459	0.90
Conestoga	1,154	176.2	1,055	159.1	31.0	0.5139	0.4644	2.202	3.51

Table 9. Annual Water Discharges and Annual Loads and Yields of Total Suspended Sediment, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	SS Load % of LTM	Prediction Error percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	2,399,772	106.4	45.5	107.06	74.83	452.0	480.9
Danville	24,050	156.6	2,855,630	114.4	38.0	82.53	60.31	347.5	397.7
Lewisburg	16,095	147.3	555,487	56.2	63.1	45.98	17.53	225.7	126.8
Newport	8,029	175.9	1,059,614	223.3	46.0	52.82	67.03	221.1	493.6
Marietta	59,234	158.8	8,041,920	151.8	33.9	72.15	68.96	318.4	483.5
Conestoga	1,154	176.2	561,962	179.5	94.1	242.78	247.35	1040.8	1,868.2

Table 10. Annual Water Discharges and Annual Loads and Yields of Total Ammonia, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	1,319	90.0	22.26	0.0688	0.0411	0.29	0.26
Danville	24,050	156.6	2,083	95.0	25.35	0.0721	0.0440	0.30	0.29
Lewisburg	16,095	147.3	1,032	100.0	24.46	0.0480	0.0326	0.24	0.24
Newport	8,029	175.9	587	146.4	25.21	0.0447	0.0371	0.19	0.27
Marietta	59,234	158.8	6,391	142.2	27.91	0.0612	0.0548	0.27	0.38
Conestoga	1,154	176.2	257	90.5	37.54	0.2200	0.1131	0.94	0.86

Table 11. Annual Water Discharges and Annual Loads and Yields of Total NO_{23} Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	22,055	134	7.41	0.7799	0.688	3.29	4.42
Danville	24,050	156.6	33,440	128	6.68	0.8663	0.706	3.65	4.66
Lewisburg	16,095	147.3	23,174	155	6.72	0.6960	0.731	3.42	5.29
Newport	8,029	175.9	25,091	210	5.20	1.3304	1.587	5.57	11.69
Marietta	59,234	158.8	146,915	168	7.02	1.1915	1.260	5.26	8.83
Conestoga	1,154	176.2	14,852	181	6.88	6.37	6.537	27.30	49.37

Table 12. Annual Water Discharges and Annual Loads and Yields of Total Organic Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	10,019	90	11.20	0.53	0.312	2.24	2.01
Danville	24,050	156.6	16,175	922	12.98	0.58	0.342	2.44	2.25
Lewisburg	16,095	147.3	8,894	110	21.23	0.375	0.281	1.84	2.03
Newport	8,029	175.9	6,092	148	14.13	0.458	0.385	1.92	2.84
Marietta	59,234	158.8	35,348	0.88	14.76	0.548	0.303	2.42	2.13
Conestoga	1,154	176.2	2,798	144	25.84	1.51	1.232	6.47	9.3

Table 13. Annual Water Discharges and Annual Loads and Yields of Dissolved Phosphorus, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	905	121	19.03	0.0356	0.0282	0.15	0.18
Danville	24,050	156.6	1,348	151	19.52	0.029	0.0285	0.12	0.19
Lewisburg	16,095	147.3	584	129	19.03	0.021	0.0184	0.10	0.13
Newport	8,029	175.9	905	225	18.22	0.045	0.0573	0.19	0.42
Marietta	59,234	158.8	4,667	192	16.27	0.033	0.0400	0.15	0.28
Conestoga	1,154	176.2	448	172	14.16	0.20	0.1972	0.87	1.49

Table 14. Annual Water Discharges and Annual Loads and Yields of Dissolved Orthophosphate, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	703	1.85	24.10	0.018	0.0219	0.076	0.14
Danville	24,050	156.6	1,004	231	24.25	0.014	0.0212	0.061	0.14
Lewisburg	16,095	147.3	364	2.08	30.20	0.008	0.0115	0.04	0.08
Newport	8,029	175.9	873	288	28.22	0.034	0.0552	0.14	0.41
Marietta	59,234	158.8	4,358	263	24.94	0.023	0.0374	0.10	0.26
Conestoga	1,154	176.2	414	195	19.37	0.16	0.1822	0.70	1.38

Table 15. Annual Water Discharges and Annual Loads and Yields of Dissolved Ammonia, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	1,461	128	19.72	0.054	0.0456	0.23	0.29
Danville	24,050	156.6	2,252	131	19.86	0.057	0.0476	0.24	0.31
Lewisburg	16,095	147.3	1,238	114	18.14	0.05	0.0391	0.25	0.28
Newport	8,029	175.9	612	181	16.70	0.038	0.0387	0.16	0.28
Marietta	59,234	158.8	5,946	151	19.65	0.05	0.0510	0.24	0.36
Conestoga	1,154	176.2	242	124	31.26	0.15	0.1065	0.65	0.29

Table 16. Annual Water Discharges and Annual Loads and Yields of Dissolved Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	30,225	133	5.67	1.08	0.942	4.57	6.06
Danville	24,050	156.6	44,867	123	6.54	1.208	0.948	5.09	6.25
Lewisburg	16,095	147.3	28,206	121	6.57	1.08	0.890	5.32	6.44
Newport	8,029	175.9	28,640	212	4.71	1.50	1.812	6.28	13.34
Marietta	59,234	158.8	173,772	167	6.58	1.42	1.490	6.25	10.45
Conestoga	1,154	176.2	16,363	190	6.14	6.68	7.202	28.65	54.40

Table 17. Annual Water Discharges and Annual Loads and Yields of Dissolved NO_{23} Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	21,878	154	7.38	0.67	0.682	2.85	4.38
Danville	24,050	156.6	33,112	137	6.72	0.80	0.699	3.36	4.61
Lewisburg	16,095	147.3	23,002	145	6.57	0.74	0.726	3.62	5.25
Newport	8,029	175.9	24,956	231	5.21	1.20	1.579	5.03	11.63
Marietta	59,234	158.8	145,701	221	7.16	0.90	1.249	3.97	8.76
Conestoga	1,154	176.2	14,800	199	6.88	5.78	6.514	24.78	49.20

Table 18. Annual Water Discharges and Annual Loads and Yields of Dissolved Organic Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	8,541	104	10.70	0.39	0.266	1.64	1.71
Danville	24,050	156.6	11,893	108	10.76	0.36	0.251	1.54	1.66
Lewisburg	16,095	147.3	5,566	105	15.88	0.25	0.176	1.21	1.27
Newport	8,029	175.9	4,017	142	11.59	0.31	0.254	1.31	1.87
Marietta	59,234	158.8	23,113	80	18.47	0.39	0.198	1.73	1.39
Conestoga	1,154	176.2	2,157	213	25.76	0.79	0.949	3.37	7.17

Table 19. Annual Water Discharges and Annual Loads and Yields of Total Organic Carbon, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	112,146	141	4.45	3.77	3.497	15.91	22.47
Danville	24,050	156.6	166,362	156	4.28	3.52	3.514	14.81	23.17
Lewisburg	16,095	147.3	73,227	169	7.31	2.02	2.311	9.91	16.71
Newport	8,029	175.9	50,402	167	6.68	3.36	3.189	14.06	23.48
Marietta	59,234	158.8	356,712	151	5.10	3.21	3.059	14.17	21.45
Conestoga	1,154	176.2	11,153	137	9.50	6.31	4.909	27.07	37.08

Identifying sites where the percentage of LTM for a constituent was higher than the percentage of LTM for discharge may show potential areas where degradation was occurring for that particular constituent. For example, the flow for 2003 was 175.9 percent of the LTM at Newport while TN was 194.5 percent, TP was 244.8 percent, and SS was 223.3 percent of the long term means. This implies an increase in these constituents that has come from more than increased flow. Newport also showed higher average annual concentrations for TN, TP, and SS during 2003 as compared with the LTMs. As a general note for 2003, when higher percentages of LTM were found, so were higher average concentrations. Marietta showed an increased TP load and concentration value when compared to the LTM. All yield values for 2003 for TN, TP, and SS were higher than the LTMs for all sites except for SS at Lewisburg. Lewisburg also showed a lower average annual concentration as compared to the LTM. The higher yields were most likely due to increased flow during 2003.

While TN was shown to be decreasing at all sites, DN showed higher than LTM values at Newport, Marietta, and Conestoga. Much of this DN value was contained in dissolved NO23 which was higher than the LTM at Newport, Marietta, and Conestoga. Dissolved ammonia was also higher than the LTM at Newport. DP was higher than LTMs at Newport and Marietta and dissolved orthophosphate (DOP) was higher than LTMs at all sites. Dissolved organic nitrogen showed higher than LTMs at Conestoga. Lewisburg was the only site to show higher than LTMs for TOC. This could be due to leaf litter from the mostly forested watershed. Figures 4-6 show loads and yields of TN, TP, and SS in comparison with the LTM for each site.

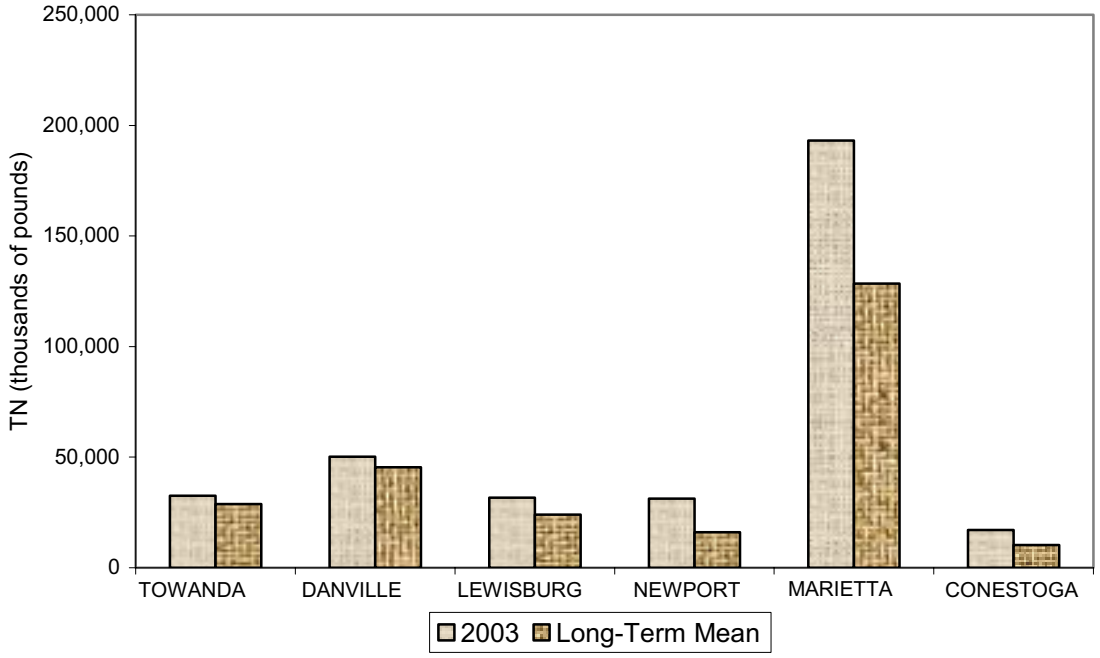

Figure 4A. Annual Loads of Total Nitrogen (TN) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003

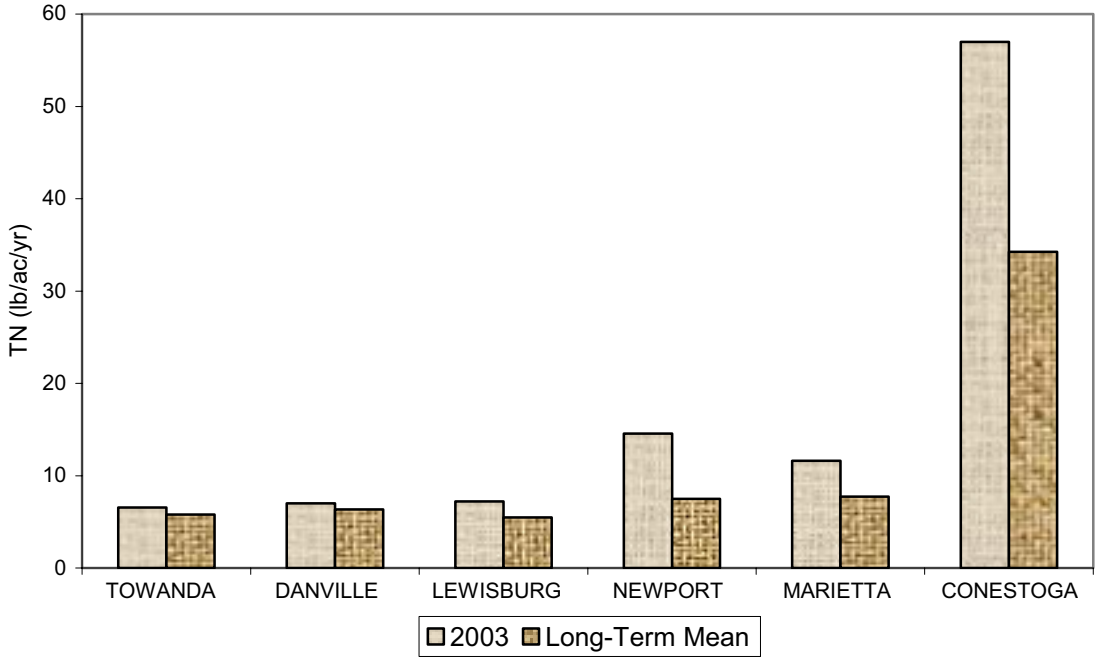

Figure 4B. Total Nitrogen (TN) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003

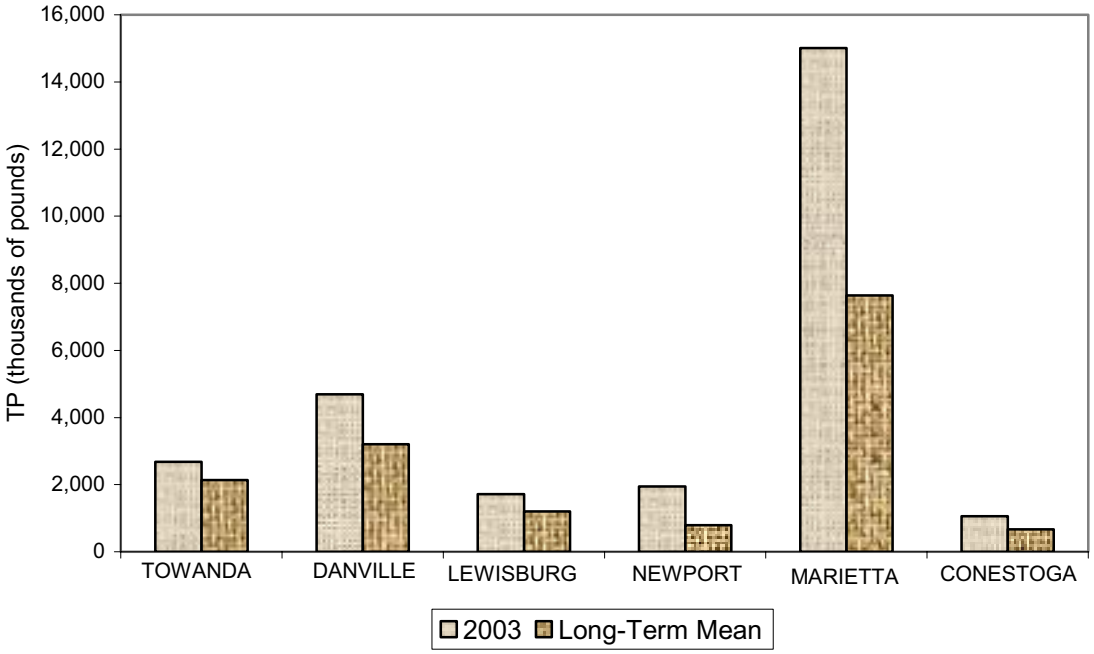

Figure 5A. Annual Loads of Total Phosphorus (TP) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003

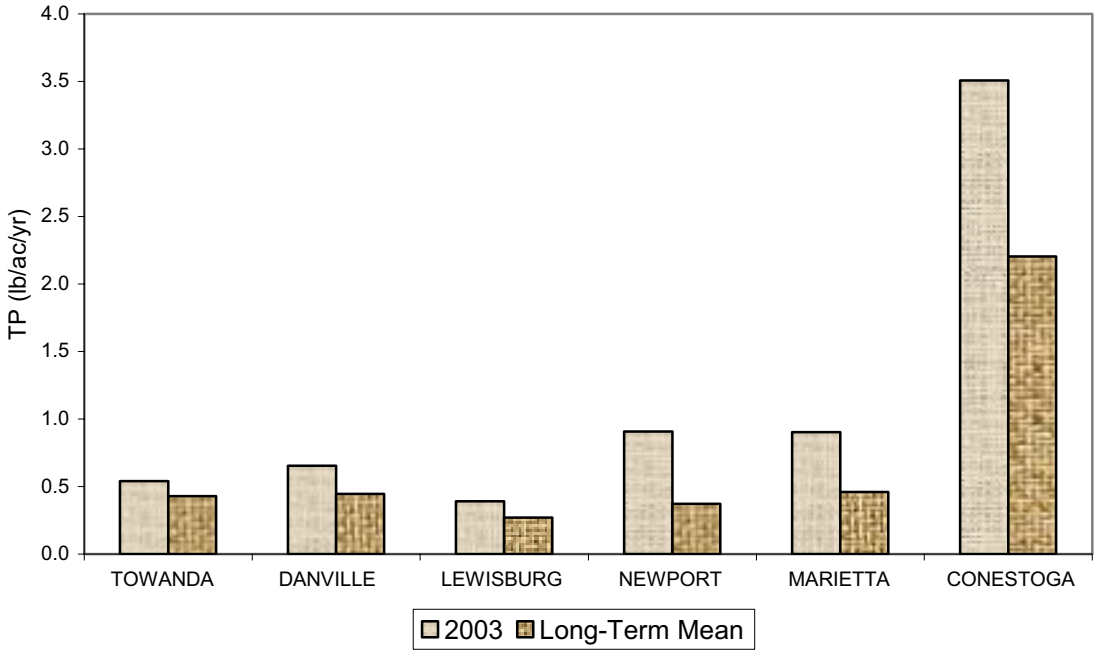

Figure 5B. Total Phosphorus (TP) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003

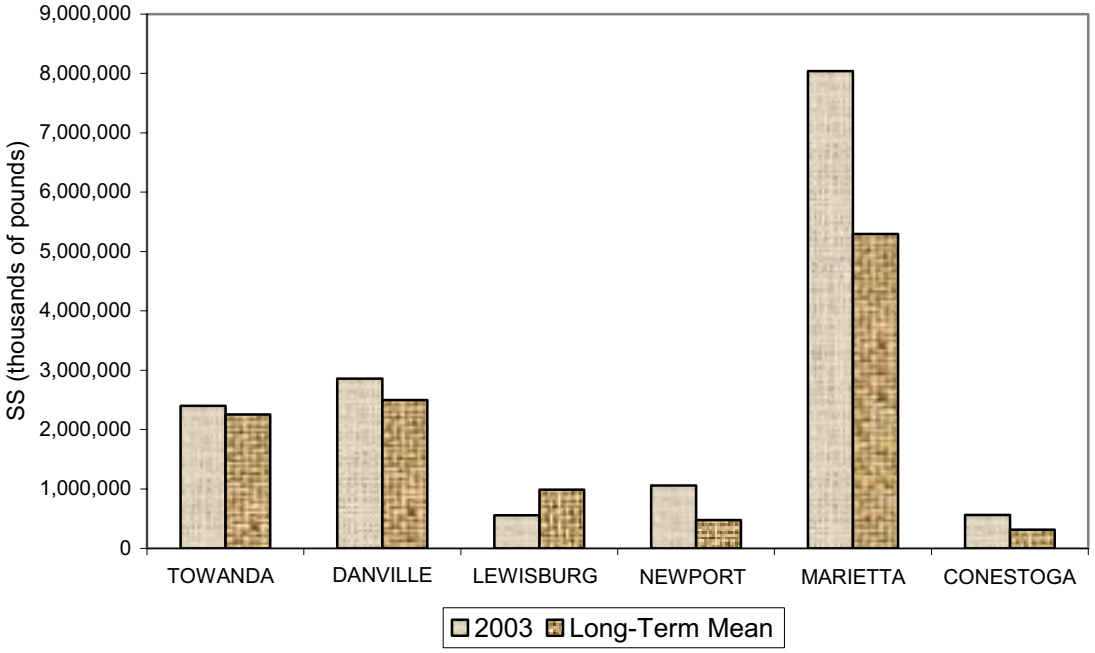

Figure 6A. Annual Loads of Suspended Sediment (SS) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003

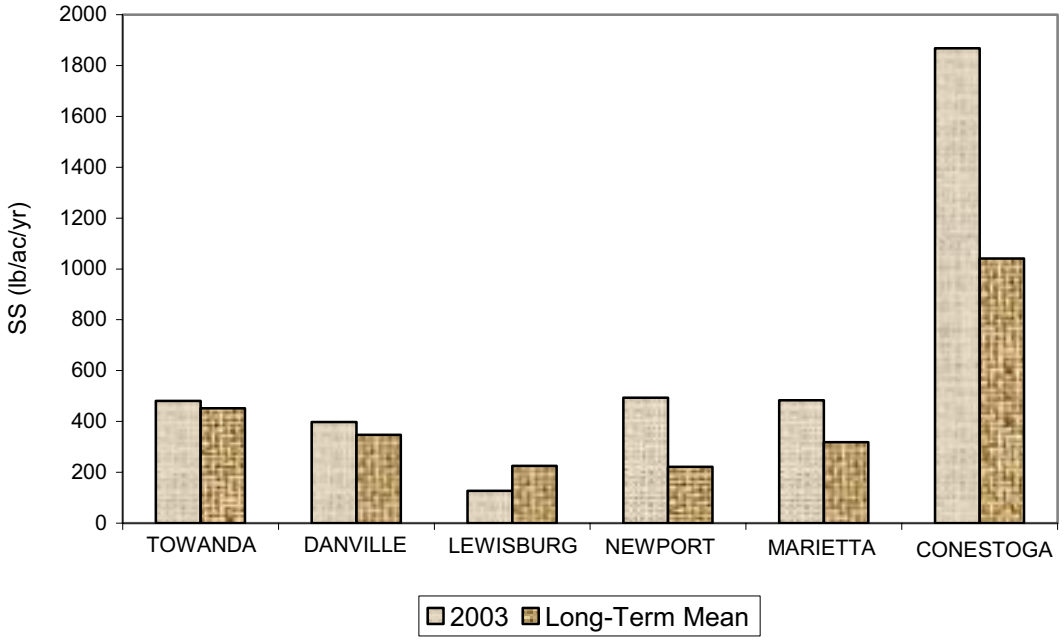

Figure 6B. Suspended Sediment (SS) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003

When looking at constituent loads, it can be difficult to determine whether improvements are being made due to the variations in flow. Because of this, it is useful to compare the loads from years that had similar amounts of flow. Table 20 lists the flow and TN, TP, and SS loads for 1996 and 2003. The fact that constituent loads tend to be higher during higher flow years suggests that the loads for TN, TP, and SS should be higher for all sites except Conestoga during 1996. This was the case for TN, TP, and SS at all sites except Newport, which showed higher percent loads as compared to the 1996 values for TN and TP.

Tables 21–24 show seasonal comparisons of years 1996 and 2003. Newport showed higher percentages than 1996 for TN and TP for all seasons, including doubling the 1996 spring value. SS at Conestoga was four times the 1996 value, while the TP value was only 43.27 percent of the 1996 value. This indicates less sediment bound phosphorous was being transported. Summer sampling results showed increased percentages as compared to 1996 in TP and SS at Towanda, Danville, Conestoga, and Marietta. TN was higher in the fall at Newport, Conestoga, and Marietta.

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

Seasonal loads for all parameters and all sites are listed in Table 25 for loads and Table 26 for percentages (high values in boldface type). For the purposes of this project, January through March is winter, April through June is spring, July through September is summer, and October through December is fall. As a general note, nutrient and SS levels increase with increases in flow. This was observed at all sites for TN except at Towanda. TP, DP and DOP were highest during the fall for all sites except for TP at Conestoga. This matched the highest flow season for Towanda, Danville, Lewisburg, and Marietta.

For Newport, fall was actually the lowest flow season while it was the highest for TP, DP, DOP, and the second highest for TN, DN, total nitrate plus nitrite (TNOx), dissolved nitrate plus nitrite (DNOx), total ammonia (TNH3), dissolved ammonia (DNH3), and TOC. Winter at Newport constituted 36.5 percent of the annual flow and 26.54 percent of the SS annual load while fall represented 13.73 percent of the flow and 24.28 percent of the SS. SS was highest during the winter at Towanda, Danville, Lewisburg, and Marietta even though the season was the second highest for flow at each of the four sites. Conestoga had the highest SS loads during the spring, which was the third highest flow season for the site. Flow at Conestoga for spring was 25.41 percent of the annual flow and 38.26 percent of the annual SS load.

When compared to the seasonal LTMs, Towanda and Danville showed higher than the LTMs for spring flow and lower than the LTMs in TN and TP, with large reductions shown in SS. Spring flows at Lewisburg for 2003 were equal to the LTM while similar reductions in TN, TP, and SS were found at Lewisburg as at the northern sites. Newport showed above LTM values for all seasons for flow, TN, TP, and SS. Marietta had a higher spring flow than the LTM while also showing a lower SS value. Conestoga had all flow values higher than the LTM and a much larger SS value as compared to the LTM during the spring. Figures 7-12 show graphs of discharge, TN, TP and SS as compared to the LTM.

Newport showed an increase in TN yields during the winter and spring when compared to the LTM yields, while Marietta showed higher TN yields in the fall as compared to the LTM yield. Towanda, Danville, and Marietta showed increasing TP yields downstream for 2003, which matched the same trend in LTM yields. Marietta and Newport both showed significant increases in yield values during the summer and fall months as compared to the LTMs. Increases over the LTMs also were apparent during those seasons at all other sites. SS showed a generally decreasing trend in the long term when moving downstream on the Susquehanna. 2003 yields roughly followed the same pattern during winter and fall but showed increasing yields during the spring and summer. When comparing the seasonal percentages, spring had the highest percent of TP, SS, and flow at all sites. Figures 13-16 show the seasonal yields for each site.