DISCUSSION

Precipitation values above the LTM were recorded at all stations during the fall and winter months in 2005. Specifically, precipitation at Towanda was 16.49 inches above the LTM, with the highest rainfall occurring during the fall months and second highest during the winter months. Danville followed the same pattern, with a total of 12.86 inches above the annual LTM. Conestoga was 3.52 inches above the LTM with significant rainfall (7.36 inches above LTM) during the fall months. High precipitation upstream of Towanda, Danville, and Conestoga led to discharges of 112 percent, 115 percent, and 115 percent of the LTM respectively. Newport and Lewisburg both showed discharges lower than their respective LTMs.

Since flow is the most important influence over nutrient and suspended sediment loads, comparing load and flow to the LTM is a good way to find changes in transported load. In making this comparison, the current year's flow divided by the LTM flow is converted to a percentage and compared with the current year's load for a particular constituent divided by the LTM, expressed as a percentage. By comparing percentages of LTMs, the need for units on the values is removed. Thus, a load percentage that is greater than a flow percentage indicates that the increase in constituent load as compared to the LTM is greater than that of the discharge as compared to the LTM.

For example, 2005 average annual discharge at Towanda was 13,230 cfs. Dividing this value by the LTM for annual discharge at Towanda gives 112 percent of the LTM. When doing the same for the TN loads at Towanda during the same time period, it is found that the 2005 TN load was 96.7 percent of the LTM for TN. Thus, although the discharge was higher than the LTM for 2005, the TN was much lower, which indicates possible improvements. This is also apparent when looking at Danville for TN, which shows even greater variance with percent of LTM for discharge at 115 percent and that of TN at 91.1 percent.

In making the above comparison at all sites for TN, reductions were found at all sites except Newport. The same comparison made at Towanda and Danville for TP and SS showed extreme opposite results with percent of LTMs of 132.1 percent and 143.6 percent for TP and 152.9 percent and 143.7 percent for SS, respectively. Using this same approach, increases were found at Lewisburg, Newport, and Marietta for total ammonia. All six sites showed improvements for total organic nitrogen and dissolved nitrate + nitrite. Conestoga recorded substantially higher DON loads at 145 percent of LTM. All other sites were substantially lower than their respective LTMs for DON.

Due to a very high flow event in early April, monthly comparisons of flow, nutrients, and suspended sediment show highs during April for Towanda, Danville, Marietta, and Conestoga, except for TN at Marietta, which was higher during January. Lewisburg and Newport, the most western sites in the watershed, also had high TN values during April, but not as high as during January, when the highest flow, nutrients, and suspended sediment values were recorded for the two sites. When comparing seasonal averages, flow was highest at all sites during the winter. This resulted in the majority of the nutrient and sediment loads being transported during winter, especially at Lewisburg and Newport, which recorded highest loads of all constituents during the winter months. Interestingly, total organic nitrogen, total phosphorus, and suspended sediment all had the highest loads during the spring at Towanda and Danville. Since spring was the time period for the year's highest flow event at Towanda and Danville, this supports the idea that these three parameters were influenced not only by high average flows but more so by single high flow events.

Comparisons with the baselines can be performed in two ways to look for improvements in water quality. The first involves comparing the 2005 yield values to three different baselines. The first baseline uses the first five years of each dataset, the second uses the first half of the dataset, and the third uses the second half of each dataset.

The second comparison is between the first and second half of the datasets and utilizes the entire dataset which reduces any error inherent in using only one year worth of data. Thus, if the baselines created by the second half of the dataset are lower than those created by the first half, there is an indication of improvements.

In comparing 2005 yields to the baselines, Towanda and Danville, showed no substantial improvements when compared to baselines for the second half of each dataset but did show improvements as compared to the first five year and first half of dataset baselines. Comparison of the second half to the first half indicated that concentrations of TN at these sites had been reduced by approximately 2 mg/L. This analysis also indicated major reductions in SS at Towanda. This reduction may not be as dramatic as the plot indicates as the two highest load years for SS (which accounted for 60% of total load for the 8 year period) fell within the first half baseline, skewing the comparison. This same comparison also showed a 2 mg/L reduction at Conestoga. These results indicate that improvements had been made with respect to the earlier years of monitoring, but that, in more recent years, improvements have not been as obvious. Modest improvements are apparent also for TP at these sites, although specific 2005 values were higher than predicted due to the impacts of storms in April. Conestoga, the watershed with the highest percentages of agriculture and urban land uses, showed significant improvements regarding TP and SS.

Although Towanda and Danville both had higher than predicted loads for 2005, all trends for these sites show improving conditions, except DOP, which also was degrading at Newport and Marietta. Additionally, Newport showed degrading trends in TNOx and DNOx. Trends for TN, TP, and SS were improving at all sites, except for TP at Marietta and SS at Lewisburg, which had no significant trends.

When considering one year at a time, it is necessary to look not only at the annual flow but also to pay attention to any single high flow events that may have occurred, as they tend to contribute the most to nutrient and SS loads. Table 38 lists LTM percentages for 1989 through 2005 for flow, TN, TP, and SS at the Susquehanna main stem sites; Towanda, Danville, and Marietta. Q shows the years flow divided by the LTM for all years. Q* shows the highest daily average flow divided by the LTM of each year's high average flow day and is meant to show how the year's highest single flow event compared to those in other years. TN, TP, and SS show the year's load divided by the LTM for all years for that parameter. Of interest is the comparison that can be made between 2005 and 1993. Although values for Towanda and Danville were higher than the LTM for TP and SS during 2005, a comparison to 1993 shows that the 2005 values are not extreme, given the average flow for the year and the daily high event for the year.

Table 39 specifically shows comparisons of April 2005's storm event to other high flow events at Marietta. As a general note, the data indicates that TN may be more dependent upon high average flows, whereas TP and SS appear to be more dependent upon single high flow events. This is seen when comparing years with similar average monthly flows and substantially different sized high flow events. Of interest concerning 2005 is the comparison of the April storm to the storms in March 1998 and May 1989. Both of these storms had lower average monthly flows and high storm flows that were significantly lower than those of the April 2005 storm. Since all of the storms occur during the same time of year, seasonal variation of loads is not an issue. Thus, it would be expected that the April 2005 storm would have the higher loads of TN, TP, and SS. In comparison to the May 1989 storm event, 2005 values for TN, TP, and SS were lower than 1989, despite the substantial difference in flows indicating that there likely have been improvements regarding these parameters. This is also apparent when comparing the TN loads from April of 2005 to March of 1998.

Table 40 compares the results from all analyses using the 2005 data. It is notable that all five ways of analyzing the data showed improvements in TN at Towanda, Danville, and Lewisburg. Towanda and Danville showed

degradations for TP and SS for most analyses except for trends, which were improving for each. This is because the trends analysis takes all years into consideration, blending the current year that was higher than average. Lewisburg, Newport, Marietta, and Conestoga showed improvements for all analyses for SS except for trends in Lewisburg, which were not detected because more than 20 percent of the values were below the method detection limit. Newport, Marietta, and Conestoga showed improvements for all analyses for TP except for trends at Marietta, which were not significant. This is strong evidence that improvements are being made for all parameters at all sites. The only substantial exceptions were Towanda, Danville, and Lewisburg for TP and Towanda and Danville for SS. However, as noted before, these exceptions may be due to the anomalous high flows during April for Towanda and Danville and during January for Lewisburg.

Table 38. Comparison of Percentages of Flows and Loads of Total Nitrogen, Total Phosphorous, and Suspended Sediment for 1989-2005

	Towanda					Danville					Marietta				
Year	Q	Q*	TN	TP	SS	Q	Q*	TN	TP	SS	Q	Q*	TN	TP	SS
1989	86	87	106	83	65	88	87	100	102	111	96	82	103	102	117
1990	121	104	149	126	98	117	92	140	132	114	118	78	134	118	104
1991	72	76	87	56	28	71	70	84	61	41	71	73	75	55	41
1992	99	75	108	82	44	94	68	103	82	50	87	62	89	67	46
1993	116	152	131	180	333	116	147	133	160	294	12	159	132	162	256
1994	119	108	124	130	148	125	109	134	137	170	130	132	129	142	188
1995	60	53	61	45	22	65	55	68	48	26	70	69	68	51	34
1996	144	178	146	191	264	145	162	155	172	217	163	205	168	200	252
1997	68	48	65	45	19	65	46	64	41	19	75	50	69	51	31
1998	99	111	95	95	85	102	109	102	91	83	109	122	102	102	102
1999	63	86	59	45	23	68	87	66	47	26	71	86	65	51	33
2000	111	101	100	98	82	109	101	100	91	73	93	80	82	76	58
2001	67	86	59	53	42	65	77	57	46	31	63	58	54	45	28
2002	93	60	80	69	40	92	66	79	70	42	86	57	77	73	50
2003	139	93	121	129	91	141	102	121	138	109	151	105	146	177	145
2004	130	130	111	135	144	127	162	105	138	155	143	184	139	205	233
2005	113	149	96	137	173	110	158	89	144	138	105	140	103	96	81

Q* equals the high average daily flow during the given year divided by the average of all 17 high average daily flows

Table 39. Storm Events at Marietta with High Daily Average Flow Similar to April 2005 Storm Event

Month of Storm Event	Average Monthly Flow	High Daily Average Flow	Monthly TN	Monthly TP	Monthly SS
January-98	90,668	330,000	29,703,419	2,012,526	1,988,703,397
March-98	99,623	162,000	28,394,908	1,581,592	1,251,858,082
May-89	103,394	223,000	31,865,456	2,688,797	3,650,150,412
March-03	110,171	284,000	30,975,194	2,533,858	2,380,539,985
September-04	110,893	497,000	32,748,690	6,257,286	9,908,945,265
December-96	114,261	259,000	39,493,417	2,899,857	2,879,200,958
January-96	116,852	556,000	40,092,507	4,162,444	6,333,728,265
March-94	142,681	357,000	43,639,904	3,601,068	5,172,513,799
April-94	147,303	248,000	41,387,595	3,315,784	4,335,937,656
April-93	235,133	431,000	68,743,015	7,259,275	12,371,847,860
April-05	108,960	380,000	26,127,702	2,568,258	2,528,153,081

Table 40. Summary of 2005 Data Comparison to Percentage of LTM, Initial 5-Year Baseline, 1st Half of Dataset Baseline, 2nd Half of Dataset Baseline, and Trends in Flow-Adjusted Concentration for Total Nitrogen, Total Phosphorous, and Suspended Sediment

Parameter	Site	LTM %	Baseline 89	Baseline 1st half	Baseline 2nd half	Trend
FLOW	Towanda	Above	N/A	N/A	N/A	NS
	Danville	Above	N/A	N/A	N/A	NS
	Lewisburg	Below	N/A	N/A	N/A	NS
	Newport	Below	N/A	N/A	N/A	NS
	Marietta	Above	N/A	N/A	N/A	NS
	Conestoga	Above	N/A	N/A	N/A	NS
TN	Towanda	IMP	IMP	IMP	IMP	IMP
	Danville	IMP	IMP	IMP	IMP	IMP
	Lewisburg	IMP	IMP	IMP	IMP	IMP
	Newport	IMP	IMP	DEG	DEG	IMP
	Marietta	IMP	IMP	IMP	DEG	IMP
	Conestoga	IMP	IMP	IMP	DEG	IMP
TP	Towanda	DEG	DEG	DEG	DEG	IMP
	Danville	DEG	DEG	DEG	DEG	IMP
	Lewisburg	DEG	IMP	DEG	DEG	IMP
	Newport	IMP	IMP	IMP	IMP	IMP
	Marietta	IMP	IMP	IMP	IMP	NS
	Conestoga	IMP	IMP	IMP	IMP	IMP
SS	Towanda	DEG	DEG	IMP	DEG	IMP
	Danville	DEG	DEG	DEG	DEG	IMP
	Lewisburg	IMP	IMP	IMP	IMP	BMDL
	Newport	IMP	IMP	IMP	IMP	IMP
	Marietta	IMP	IMP	IMP	IMP	IMP
	Conestoga	IMP	IMP	IMP	IMP	IMP

IMP = Improving DEG = Degrading N/A = Not Applicable NS = Not Significant
BMDL = Below Method Detection Limit

Table 41. Summary of 2005 Flow-Adjusted Concentration Trends at All Sites

Parameter	Towanda	Danville	Lewisburg	Newport	Marietta	Conestoga
TN	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING
*TN	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING
DN	IMPROVING	IMPROVING	IMPROVING	NS	IMPROVING	NS
TON	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING
DON	IMPROVING	IMPROVING	IMPROVING	IMPROVING	NS	NS
DNH_3	NS	IMPROVING	NS	IMPROVING	NS	IMPROVING
TNH_3	IMPROVING	BMDL	BMDL	BMDL	IMPROVING	IMPROVING
DKN	IMPROVING	IMPROVING	BMDL	BMDL	IMPROVING	IMPROVING
TKN	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING
TNOx	IMPROVING	IMPROVING	IMPROVING	DEGRADING	IMPROVING	NS
DNOx	IMPROVING	IMPROVING	IMPROVING	DEGRADING	IMPROVING	NS
*DNOx	IMPROVING	IMPROVING	NS	DEGRADING	NS	NS
TP	IMPROVING	IMPROVING	IMPROVING	IMPROVING	NS	IMPROVING
*TP	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING	IMPROVING
DP	IMPROVING	IMPROVING	IMPROVING	IMPROVING	NS	IMPROVING
DOP	DEGRADING	DEGRADING	BMDL	DEGRADING	DEGRADING	IMPROVING
TOC	IMPROVING	IMPROVING	NS	IMPROVING	IMPROVING	IMPROVING
SS	IMPROVING	IMPROVING	BMDL	IMPROVING	IMPROVING	-
*SS	IMPROVING	IMPROVING	NS	IMPROVING	IMPROVING	IMPROVING

* These results were reported by USGS after additional analysis