NUTRIENTS AND SUSPENDED SEDIMENT TRANSPORTED IN THE SUSQUEHANNA RIVER BASIN, 2006, AND TRENDS, JANUARY 1985 THROUGH DECEMBER 2006

Publication No. 252 *December 31, 2007*

Kevin H. McGonigal
Water Quality Program Specialist

Printed on recycled paper.

This report is prepared in cooperation with the Pennsylvania Department of Environmental Protection, Bureau of Water Quality Protection, Division of Conservation Districts and Nutrient Management, under Grant ME4100025873.

SUSQUEHANNA RIVER BASIN COMMISSION

Paul O. Swartz, Executive Director

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

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

This report is available on our website (www.SRBC.net) by selecting Public Information/Technical Reports. For a CD Rom or for a hard copy, contact the Susquehanna River Basin Commission, 1721 N. Front Street, Harrisburg, Pa. 17102-2391, (717) 238-0423, FAX (717) 238-2436, E-mail: srbc@srbc.net.

TABLE OF CONTENTS

FIGURES

TABLES

APPENDIX

NUTRIENTS AND SUSPENDED SEDIMENT TRANSPORTED IN THE SUSQUEHANNA RIVER BASIN, 2006, AND TRENDS, JANUARY 1985 THROUGH DECEMBER 2006

Kevin H. McGonigal
Water Quality Program Specialist

ABSTRACT

Nutrient and suspended-sediment (SS) samples were collected under base flow and stormflow conditions during calendar year 2006 for Group A sites listed in Table 2. Fixed date samples also were collected at these sites. Additionally, fixed date samples were collected during 2006 at Group B sites listed in Table 2. All samples were analyzed for nitrogen and phosphorus species, total organic carbon (TOC), and SS.

Precipitation for 2006 was above average for all Group A sites. Highest departures from the long-term precipitation averages were recorded at Danville, Pa., with 8.39 inches above the long-term mean (LTM). Highest departure above the LTM for discharge was 132 percent of LTM at Danville, which was mostly a result of late June flooding in New York. Lowest departure from the LTM was at Newport, Pa., for both rainfall at 2.17 inches above LTM and for flow at 81 percent of the LTM. Precipitation and flows were above LTM at several sites largely due to high flows caused by Tropical Storm Ernesto during late June and early July.

This report utilizes several methods to compare nutrient and SS loads and yields including: (1) comparison with the LTM; (2) comparison with baseline data; and (3) flow adjusted concentration trend analysis through 2006. Comparison with the LTM showed increases in total phosphorus (TP) and SS for Towanda, Pa., and Danville, and decreases at all other sites except for TP at Lewisburg, Pa., which showed a slight increase. Decreases in total nitrogen (TN) were shown at all sites when compared to the LTMs. Baseline comparisons showed similar results, including increases in TP and SS at both Towanda and Danville and increases in TP at Lewisburg. Baseline comparisons for 2006 TN showed improvements for all sites while Newport, Marietta, and Conestoga, Pa., showed improvements in TP and SS. Comparisons to seasonal baselines indicate that high yields of TP and SS at Towanda and Danville were during the spring and summer months, specifically June and July. Improvements were indicated by winter baseline comparisons at all sites for TN, TP, and SS, except for TP at Lewisburg, which remained unchanged.

2006 trends remained relatively unchanged from 2005 trends as well. Exceptions occurred at Towanda where three trends were no longer found for TP, DP, and TOC. Another trend in DP was lost at Danville, while a downward trend in total ammonia (TNH_3) was gained. Newport lost an upward trend from 2005 to 2006 in total nitrate plus nitrite (TNOx), while Marietta added four new downward trends in 2006, including dissolved organic nitrogen (DON), dissolved ammonia (DNH_3), TP, and dissolved phosphorus (DP). Trends in dissolved orthophosphate (DOP) continue to be degrading at Towanda, Danville, Newport, and Marietta. No significant trends were found for flow.

INTRODUCTION

Nutrients and SS entering the Chesapeake Bay (Bay) from the Susquehanna River Basin contribute to nutrient enrichment problems in the Bay (USEPA, 1982). The Pennsylvania Department of Environmental Protection (PADEP) Bureau of Laboratories, the U.S.

Environmental Protection Agency (USEPA), the U.S. Geological Survey (USGS), and the Susquehanna River Basin Commission (SRBC) conducted a 5-year intensive study at 12 sites from 1985-89 to quantify nutrient and SS transported to the Bay via the Susquehanna River Basin. In 1990, the number of sampling sites was reduced to five long-term monitoring stations. An additional site was included in 1994.

In October 2004, 13 additional sites (two in New York and 11 in Pennsylvania) were added as part of the Chesapeake Bay Program's Non-tidal Water Quality Monitoring Network. In October 2005, four more sites (three in New York and one in Maryland) were added to the existing network. This project involves effort conducted by all six Bay state jurisdictions, the USEPA, USGS, and SRBC to create a uniform non-tidal monitoring network for the entire Bay watershed.

Purpose of Report

The purpose of this report is to present basic information on annual and seasonal loads and yields of nutrients and SS measured during calendar year 2006. Comparisons are made to LTM and to various baselines, including baselines created from the initial five years of data, the first half of the dataset, the second half of the dataset, and those created from the entire dataset for each site. Additionally, seasonal baselines were created using the initial five years of data from each site. Seasonal and annual variations in loads are discussed, as well as the results of flow-adjusted trend analyses for the period January 1985 through December 2006 for various forms of nitrogen and phosphorus, SS, TOC, and water discharge.

DESCRIPTION OF THE SUSQUEHANNA RIVER BASIN

The Susquehanna River (Figure 1) drains an area of 27,510 square miles (Susquehanna River Basin Study Coordination Committee, 1970), and is the largest tributary to the Bay. The Susquehanna River originates in the Appalachian Plateau of southcentral New York, flows into the Valley and Ridge and Piedmont Provinces of Pennsylvania and Maryland, and joins the Bay at Havre de Grace, Md. The climate in the Susquehanna River Basin varies considerably from the low lands adjacent to the Bay in Maryland to the high elevations, above 2,000 feet, of the northern headwaters in central New York State. The annual mean temperature ranges from 53^{o} F (degrees Fahrenheit) near the Pennsylvania-Maryland border to 45^{o} F in the northern part of the basin. Annual precipitation in the basin averages 39.15 inches and is fairly well distributed throughout the year.

Land use in the Susquehanna River Basin, shown in Table 1, is predominantly rural with woodland accounting for 69 percent; agriculture, 21 percent; and urban, seven percent. Woodland occupies the higher elevations of the northern and western parts of the basin and much of the mountain and ridge land in the Juniata and Lower Susquehanna Subbasins. Woods and grasslands occupy areas in the lower part of the basin that are unsuitable for cultivation because the slopes are too steep, the soils are too stony, or the soils are poorly drained. The Lower Susquehanna Subbasin contains the highest density of agriculture operations within the watershed. However, extensive areas are cultivated along the river valleys in southern New York and along the West Branch Susquehanna River from Northumberland, Pa., to Lock Haven, Pa., including the Bald Eagle Creek Valley.

Figure 1. The Susquehanna River Basin, Subbasins, and Population Centers

Table 1. 2000 Land Use Percentages for the Susquehanna River Basin and Selected Tributaries

Site Location	Waterbody	Water/ Wetland	Urban	Agricultural			Forest	Other
				Row Crops	Pasture/Hay	Total		
Original Sites (Group A)								
Towanda	Susquehanna	2	5	17	5	22	71	0
Danville	Susquehanna	2	6	16	5	21	70	1
Lewisburg	West Branch Susquehanna	1	5	8	2	10	84	0
Newport	Juniata	1	6	14	4	18	74	1
Marietta	Susquehanna	2	7	14	5	19	72	0
Conestoga	Conestoga	1	24	12	36	48	26	1
Enhanced Sites (Group B)								
Campbell	Cohocton	3	4	13	6	19	74	0
Rockdale	Unadilla	3	2	22	6	28	66	1
Conklin	Susquehanna	3	3	18	4	22	71	1
Smithboro	Susquehanna	3	5	17	5	22	70	0
Chemung	Chemung	2	5	15	5	20	73	0
Wilkes-Barre	Susquehanna	2	6	16	5	21	71	0
Karthaus	West Branch Susquehanna	1	6	11	1	12	80	1
Castanea	Bald Eagle	1	8	11	3	14	76	1
Jersey Shore	West Branch Susquehanna	1	4	6	1	7	87	1
Penns Creek	Penns	1	3	16	4	20	75	1
Saxton	Raystown Branch Juniata	< 0.5	6	18	5	23	71	0
Dromgold	Shermans	1	4	15	6	21	74	0
Hogestown	Conodoguinet	1	11	38	6	44	43	1
Hershey	Swatara	2	14	18	10	28	56	0
Manchester	West Conewago	2	13	12	36	48	36	1
Martic Forge	Pequea	1	12	12	48	60	25	2
Richardsmere	Octoraro	1	10	16	47	63	24	2
Entire Basin	Susquehanna River Basin	2	7	14	7	21	69	1

Major urban areas in the Lower Susquehanna Subbasin include York, Lancaster, Harrisburg, and Sunbury, Pa. Most of the urban areas in the Upper and Chemung Subbasins are located along river valleys, and they include Binghamton, Elmira, and Corning, N.Y. Urban areas in the Middle Susquehanna include Scranton and Wilkes-Barre, Pa. The major urban areas in the West Branch Susquehanna Subbasin are Williamsport, Renovo, and Clearfield, Pa. Lewistown and Altoona, Pa., are the major urban areas within the Juniata Subbasin.

NUTRIENT MONITORING SITES

Data were collected from six sites on the Susquehanna River, three sites on the West Branch Susquehanna River, and 14 sites on smaller tributaries in the basin. These 23 sites, selected for long-term monitoring of nutrient and SS transport in the basin, are listed in Table 2, and their general locations are shown in Figure 2.

Table 2. Data Collection Sites and Their Drainage Areas

USGS ID Number	Original Sites (Group A)	Subbasin	Short Name	Drainage Area (Sq Mi)
01531500	Susquehanna River at Towanda, Pa.	Middle Susquehanna	Towanda	7,797
01540500	Susquehanna River at Danville, Pa.	Middle Susquehanna	Danville	11,220
01553500	West Branch Susquehanna River at Lewisburg, Pa.	W Branch Susquehanna	Lewisburg	6,847
01567000	Juniata River at Newport, Pa.	Juniata	Newport	3,354
01576000	Susquehanna River at Marietta, Pa.	Lower Susquehanna	Marietta	25,990
01576754	Conestoga River at Conestoga, Pa.	Lower Susquehanna	Conestoga	470
	Enhanced Sites (Group B)			
01502500	Unadilla River at Rockdale, N.Y.	Upper Susquehanna	Rockdale	520
01503000	Susquehanna River at Conklin, N.Y.	Upper Susquehanna	Conklin	2,232
01515000	Susquehanna River at Smithboro, N.Y.	Upper Susquehanna	Smithboro	4,631
01529500	Cohocton River at Campbell, N.Y.	Chemung	Campbell	470
01531000	Chemung River at Chemung, N.Y.	Chemung	Chemung	2,506
01536500	Susquehanna River near Wilkes-Barre, Pa.	Middle Susquehanna	Wilkes-Barre	9,960
01542500	West Branch Susquehanna River near Karthaus, Pa.	W Branch Susquehanna	Karthaus	1,462
01548085	Bald Eagle Creek near Castanea, Pa.	W Branch Susquehanna	Castanea	420
01549760	West Branch Susquehanna River near Jersey Shore, Pa.	W Branch Susquehanna	Jersey Shore	5,225
01555000	Penns Creek at Penns Creek, Pa.	Lower Susquehanna	Penns Creek	301
01562000	Raystown Branch Juniata River at Saxton, Pa.	Juniata	Saxton	756
01568000	Shermans Creek near Dromgold, Pa.	Lower Susquehanna	Dromgold	200
01570000	Conodoguinet Creek near Hogestown, Pa.	Lower Susquehanna	Hogestown	470
01573560	Swatara Creek near Hershey, Pa.	Lower Susquehanna	Hershey	483
01574000	West Conewago Creek near Manchester, Pa.	Lower Susquehanna	Manchester	510
01576787	Pequea Creek near Martic Forge, Pa.	Lower Susquehanna	Pequea	155
01578475	Octoraro Creek at Richardsmere, Md.	Lower Susquehanna	Richardsmere	177

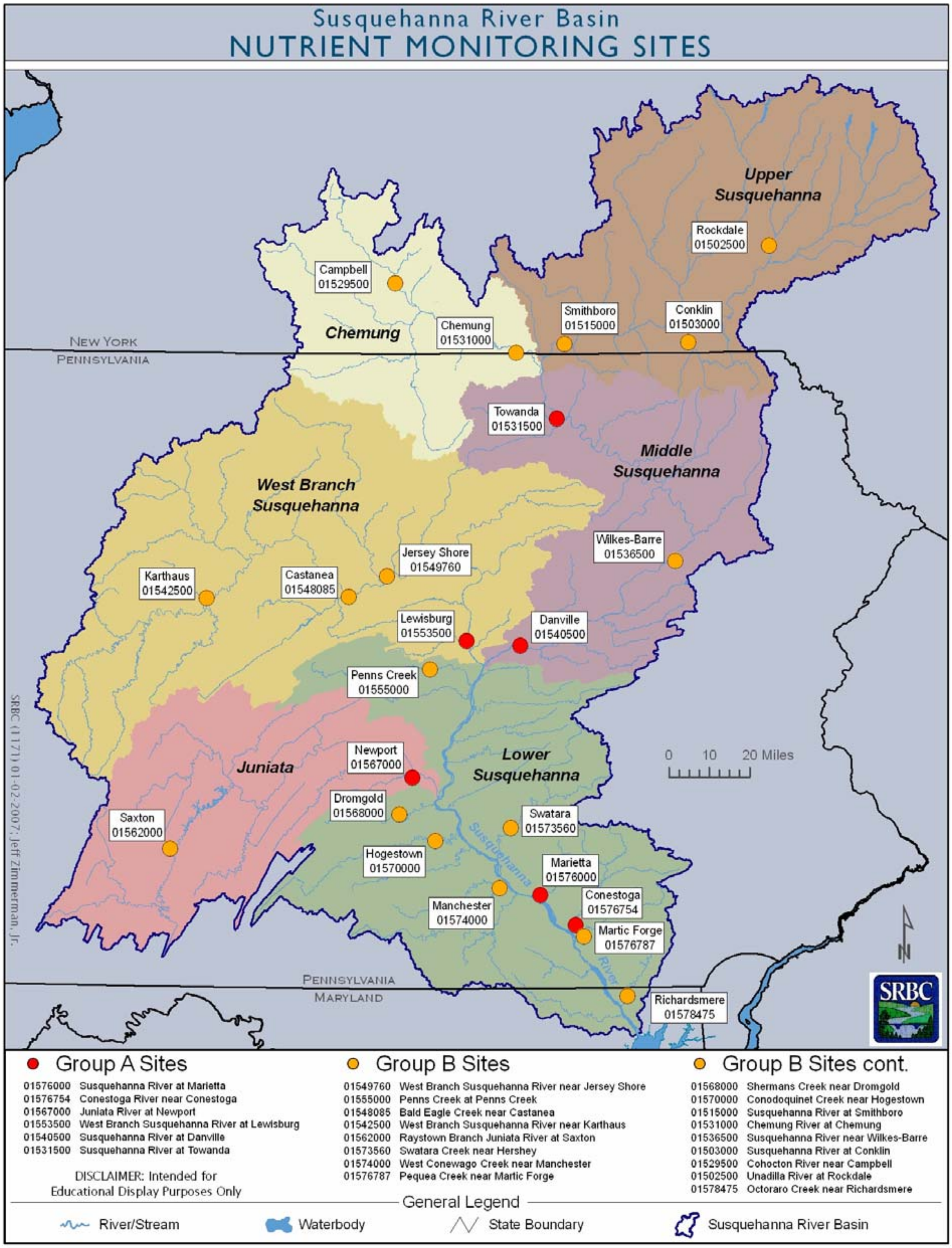


Figure 2. Locations of Sampling Sites Within the Susquehanna River Basin

SAMPLE COLLECTION AND ANALYSIS

Samples were collected to measure nutrient and SS concentrations during various flows in 2006. For Group A sites, two samples were collected per month: one near the twelfth of the month (fixed date sample) and one during monthly base flow conditions. Additionally, at least four high flow events were sampled, targeting one per season. When possible, a second high flow event was sampled after spring planting in the basin. During high flow sampling events, samples were collected daily during the rise and fall of the hydrograph. The goal was to gather a minimum of three samples on the rise and three samples on the fall, with one sample as close to peak flow as possible. Sampling continued until flows returned to pre-storm levels.

For Group B sites, fixed date monthly samples were collected during the middle of each month during 2006. Additionally, two storm samples were collected per quarter at each site. All samples were collected by hand with USGS depth integrating samplers. At each site between three and 10 depth integrated verticals were collected across the water column and then composited to obtain a representative sample of the entire waterbody.

Whole water samples were collected to be analyzed for TN species, TP species, TOC, TSS, and SS. For Group B sites, SS samples were only collected during storm events. Additionally, filtered samples were collected to analyze for dissolved nitrogen (DN) and dissolved phosphorus (DP) species. All Pennsylvania samples were delivered to the PADEP Laboratory in Harrisburg to be analyzed the following workday. SS concentrations for Group A sites were completed at SRBC, while concentrations for Group B sites were analyzed at the USGS sediment laboratory in Louisville, Kentucky. Additionally, one of each of the two storm samples per storm was submitted to the USGS sediment laboratory for analysis of sand/fine content. The parameters and laboratory methods used are listed in Table 3.

Table 3. Water Quality Parameters, Laboratory Methods, and Detection Limits

Parameter	Laboratory	Methodology	Detection Limit (mg/l)	References
Total Ammonia (TNH_3)	PADEP	Colorimetry	0.020	USEPA 350.1
Dissolved Ammonia (DNH_3)	PADEP	Block Digest, Colorimetry	0.020	USEPA 350.1
Total Nitrogen (TN)	PADEP	Persulfate Digestion for TN	0.040	Standard Methods #4500-N_{org}-D
Dissolved Nitrogen (DN)	PADEP	Persulfate Digestion	0.040	Standard Methods #4500-N_{org}-D
Total Kjeldahl Nitrogen (TKN)	PADEP	Block Digest, Flow Injection	0.050	USEPA 351.2
Dissolved Kjeldahl Nitrogen (DKN)	PADEP	Block Digest, Flow Injection	0.050	USEPA 351.2
Total Nitrite plus Nitrate (TNOx)	PADEP	Cd-reduction, Colorimetry	0.010	USEPA 353.2
Dissolved Nitrite plus Nitrate (DNOx)	PADEP	Cd-reduction, Colorimetry	0.010	USEPA 353.2
Dissolved Orthophosphate (DOP)	PADEP	Colorimetry	0.002	USEPA 365.1
Dissolved Phosphorus (DP)	PADEP	Block Digest, Colorimetry	0.010	USEPA 365.1
Total Phosphorus (TP)	PADEP	Persulfate Digest, Colorimetry	0.010	USEPA 365.1
Total Organic Carbon (TOC)	PADEP	Combustion/Oxidation	0.50	SM 5310D
Suspended Sediment (Fines)	USGS	**		
Suspended Sediment (Sand)	USGS	**		
Suspended Sediment (Total)	SRBC	**		
	USGS	**		

** TWRI Book 3, Chapter C2 and Book 5, Chapter C1, Laboratory Theory and Methods for Sediment Analysis (Guy and others, 1969)

PRECIPITATION

Precipitation data were obtained from long-term monitoring stations operated by the U.S. Department of Commerce. The data are published as Climatological Data–Pennsylvania, and as Climatological Data–New York by the National Oceanic and Atmospheric Administration (NOAA) at the National Climatic Data Center in Asheville, North Carolina. Quarterly and annual data from these sources were compiled across the subbasins of the Susquehanna River Basin and are reported in Table 4 for Group A sites.

Table 4. Summary for Annual Precipitation for Selected Areas in the Susquehanna River Basin, Calendar Year 2006

River Location	Season	Calendar Year 2006 Precipitation inches	Average Long-term Precipitation inches	Departure From Long-term inches
Susquehanna River above Towanda, Pa.	January-March	7.09	7.45	-0.36
	April-June	14.07	10.69	+3.38
	July-September	13.75	11.33	+2.42
	October-December	11.29	9.09	+2.20
	Yearly Total	46.20	38.56	+7.64
Susquehanna River above Danville, Pa.	January-March	7.21	7.49	-0.28
	April-June	14.48	10.73	+3.75
	July-September	13.76	11.51	+2.25
	October-December	11.18	9.15	+2.03
	Yearly Total	46.63	38.88	+7.75
West Branch Susquehanna River above Lewisburg, Pa.	January-March	7.35	8.23	-0.88
	April-June	13.45	11.03	+2.42
	July-September	14.81	12.49	+2.32
	October-December	10.28	9.58	+0.70
	Yearly Total	45.89	41.33	+4.56
Juniata River above Newport, Pa.	January-March	6.02	7.73	-1.71
	April-June	11.85	9.47	+2.38
	July-September	10.87	10.01	+0.86
	October-December	9.54	8.89	+0.65
	Yearly Total	38.28	36.10	+2.18
Susquehanna River above Marietta, Pa.	January-March	7.15	8.11	-0.96
	April-June	14.55	10.70	+3.85
	July-September	12.91	11.63	+1.28
	October-December	10.77	9.34	+1.43
	Yearly Total	45.38	39.78	+5.60
Conestoga River above Conestoga, Pa.	January-March	7.12	8.90	-1.78
	April-June	16.23	10.46	+5.77
	July-September	11.78	12.64	-0.86
	October-December	11.70	10.42	+1.28
	Yearly Total	46.83	42.42	+4.41

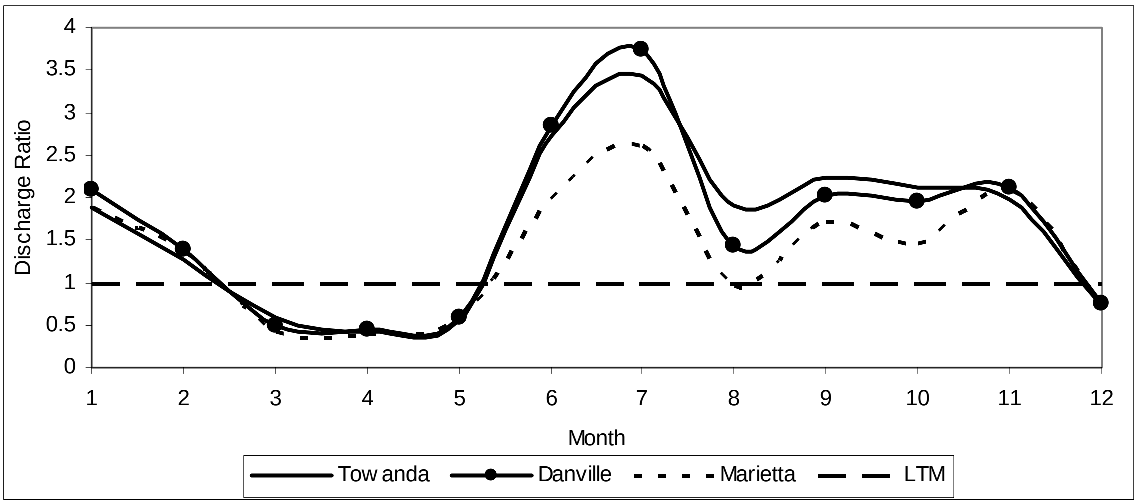
WATER DISCHARGE

Water discharge data were obtained from the USGS and are listed in Table 5. Monthly water discharge ratios are plotted in Figure 3 for all sites. The water discharge ratio is the actual flow for the time period divided by the LTM for the same time period. Thus, a value of one equals the 2006 flow being the same as the LTM, while a value of three equals the 2006 flow being three times the volume of the LTM. Two major discharge events occurred in 2006, including Tropical Storms Ernesto and Alberto, leading to annual water discharges that were above the LTM for all sites except Lewisburg and Newport. Figure 3 shows these effects for June, in which flows ranged from 2.5 times the LTM at Conestoga and Marietta to 3.5 times the LTM at Towanda and Danville. High flows at Towanda and Danville were a result of the dramatic flooding in New York, resulting in massive loadings of TP and SS at these sites. Alberto's affects were most apparent at Conestoga during November, as can be seen at the bottom of Figure 3.

Table 5. Annual Water Discharge, Calendar Year 2006

Site	Years of Record	Long-term Annual Mean cfs[1]	2006	
			Mean cfs	Percent of LTM[2]
Towanda	18	11,899	15,404	129
Danville	22	16,511	21,856	132
Lewisburg	22	10,966	10,800	98
Newport	22	4,428	3,581	81
Marietta	20	39,255	44,624	114
Conestoga	22	680	802	118

[1] Cubic feet per second [2] Long-term mean



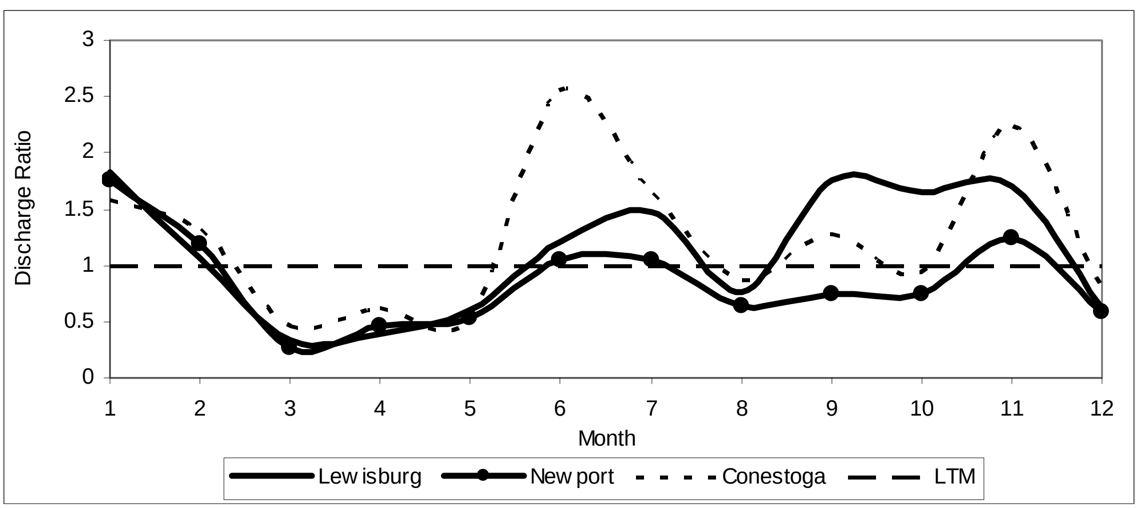


Figure 3. Discharge Ratios for Long-term Sites, Susquehanna Mainstem Sites (top) and Tributaries (bottom)

2006 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 (ESTIMATOR) 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 then were calculated from the daily mean water discharge records. The loads were reported along with the estimates of accuracy.

Identifying sites where the percentage of LTM for a constituent was different than the percentage of LTM for discharge may show potential areas where improvements or degradations have occurred for that particular constituent. One item to note is that nutrients and SS increase with increased flow (Ott and others, 1991; Takita, 1996, 1998). This increase, however, is not as linear at higher flows as at lower ones. Individual high flow events, such as Ernesto in New York, tend to produce higher loads, especially for TP and SS, than would be predicted by a simple comparison with the LTM.

Tables 7-19 show the loads and yields for the Group A 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. Seasonal loads and yields for all parameters and all sites are listed in Table 20 for loads and Table 21 for yields. 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. Monthly loads and yields for TN, TP, and SS at all long-term sites are listed in Tables 22 and 23.

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

Parameter	Abbreviation	STORET Code
Discharge	Q	00060
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 (fine)	SSF	70331
Suspended sediment (sand)	SSS	70335
Suspended Sediment (total)	SS	80154

Table 7. Annual Water Discharges, Annual Loads, Yields, and Average Concentration of Total Nitrogen, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	28,333	98.8	3.0	0.93	1.22	5.68	5.75
Danville	21,856	132.4	41,578	93.0	3.4	0.97	1.37	5.79	6.22
Lewisburg	10,800	98.5	18,568	77.4	4.3	0.87	1.11	4.24	5.47
Newport	3,581	80.9	12,865	78.5	3.1	1.83	1.88	6.00	7.63
Marietta	44,624	113.7	130,166	97.5	4.0	1.48	1.73	7.83	8.02
Conestoga	802	117.9	12,022	111.3	3.2	7.61	8.07	40.00	35.90

Table 8. Annual Water Discharges and Annual Loads and Yields of Total Phosphorus, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	4,129	163.2	9.9	0.136	0.105	0.83	0.49
Danville	21,856	132.4	7,856	206.2	11.2	0.183	0.117	1.09	0.53
Lewisburg	10,800	98.5	1,466	106.5	12.2	0.069	0.064	0.33	0.31
Newport	3,581	80.9	301	37.6	10.0	0.043	0.092	0.14	0.37
Marietta	44,624	113.7	6,281	78.9	9.5	0.072	0.103	0.38	0.48
Conestoga	802	117.9	431	64.1	10.8	0.273	0.503	1.43	2.24

Table 9. Annual Water Discharges and Annual Loads and Yields of Total Suspended Sediment, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	6,906,798	201.8	18.4	228.2	146.1	1,384	686
Danville	21,856	132.4	9,793,449	282.4	17.1	227.6	106.6	1,364	483
Lewisburg	10,800	98.5	455,030	36.3	21.4	21.4	58.0	104	286
Newport	3,581	80.9	120,308	23.8	16.4	17.1	58.0	56	235
Marietta	44,624	113.7	6,426,641	87.4	20.2	73.2	95.1	386	442
Conestoga	802	117.9	236,195	63.8	22.3	149.6	276.4	785	1,231

Table 10. Annual Water Discharges and Annual Loads and Yields of Total Ammonia, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	1,722	117.2	11.9	0.06	0.06	0.35	0.29
Danville	21,856	132.4	2,723	121.2	13.2	0.06	0.07	0.38	0.31
Lewisburg	10,800	98.5	1,141	101.5	13.0	0.05	0.05	0.26	0.26
Newport	3,581	80.9	385	99.3	14.0	0.06	0.04	0.18	0.18
Marietta	44,624	113.7	6,362	129.7	13.9	0.07	0.06	0.38	0.29
Conestoga	802	117.9	139	54.4	14.9	0.09	0.19	0.46	0.85

Table 11. Annual Water Discharges and Annual Loads and Yields of Total NOx Nitrogen, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	17,220	102.5	3.6	0.57	0.72	3.45	3.37
Danville	21,856	132.4	24,640	94.6	3.7	0.57	0.80	3.43	3.63
Lewisburg	10,800	98.5	14,020	91.6	4.0	0.66	0.71	3.20	3.50
Newport	3,581	80.9	11,086	90.0	3.3	1.57	1.41	5.17	5.74
Marietta	44,624	113.7	101,623	109.0	4.6	1.16	1.21	6.11	5.61
Conestoga	802	117.9	10,293	120.3	4.5	6.52	6.39	34.22	28.44

Table 12. Annual Water Discharges and Annual Loads and Yields of Total Organic Nitrogen, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	9,994	93.9	7.0	0.33	0.45	2.00	2.13
Danville	21,856	132.4	15,092	91.1	7.2	0.35	0.51	2.10	2.31
Lewisburg	10,800	98.5	3,926	49.9	11.2	0.18	0.36	0.90	1.80
Newport	3,581	80.9	1,863	46.9	11.2	0.26	0.46	0.87	1.85
Marietta	44,624	113.7	26,534	62.8	9.0	0.30	0.55	1.60	2.54
Conestoga	802	117.9	2,060	95.6	11.2	1.30	1.61	6.85	7.17

Table 13. Annual Water Discharges and Annual Loads and Yields of Dissolved Phosphorus, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	1,578	183.0	10.2	0.052	0.037	0.32	0.17
Danville	21,856	132.4	2,978	262.0	11.3	0.069	0.035	0.42	0.16
Lewisburg	10,800	98.5	816	152.6	11.4	0.038	0.025	0.19	0.12
Newport	3,581	80.9	182	46.5	9.8	0.026	0.045	0.09	0.18
Marietta	44,624	113.7	1,575	62.5	9.2	0.018	0.033	0.09	0.15
Conestoga	802	117.9	181	68.2	7.3	0.115	0.198	0.60	0.88

Table 14. Annual Water Discharges and Annual Loads and Yields of Dissolved Orthophosphate, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	1,273	286.7	11.3	0.042	0.019	0.26	0.09
Danville	21,856	132.4	2,574	447.3	12.5	0.060	0.018	0.36	0.08
Lewisburg	10,800	98.5	769	323.0	14.7	0.036	0.011	0.18	0.05
Newport	3,581	80.9	157	70.5	11.1	0.022	0.025	0.07	0.10
Marietta	44,624	113.7	1,230	94.2	10.9	0.014	0.017	0.07	0.08
Conestoga	802	117.9	166	78.3	7.6	0.105	0.159	0.55	0.71

Table 15. Annual Water Discharges and Annual Loads and Yields of Dissolved Ammonia, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	1,412	121.7	8.9	0.05	0.05	0.28	0.23
Danville	21,856	132.4	2,227	117.6	9.5	0.05	0.06	0.31	0.26
Lewisburg	10,800	98.5	943	98.8	8.7	0.04	0.04	0.22	0.22
Newport	3,581	80.9	287	86.7	8.4	0.04	0.04	0.13	0.15
Marietta	44,624	113.7	4,744	116.9	10.1	0.05	0.05	0.29	0.24
Conestoga	802	117.9	125	55.0	12.8	0.08	0.17	0.42	0.76

Table 16. Annual Water Discharges and Annual Loads and Yields of Dissolved Nitrogen, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	22,657	91.0	3.4	0.75	1.06	4.54	4.99
Danville	21,856	132.4	33,355	87.8	3.5	0.78	1.17	4.65	5.29
Lewisburg	10,800	98.5	16,478	78.0	4.0	0.78	0.98	3.76	4.82
Newport	3,581	80.9	12,035	80.7	2.9	1.71	1.71	5.61	6.95
Marietta	44,624	113.7	114,147	98.3	4.2	1.30	1.50	6.86	6.98
Conestoga	802	117.9	11,646	119.0	3.6	7.38	7.31	38.72	32.43

Table 17. Annual Water Discharges and Annual Loads and Yields of Dissolved NOx Nitrogen, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	16,664	100.0	3.8	0.55	0.71	3.34	3.34
Danville	21,856	132.4	24,258	93.9	3.7	0.56	0.79	3.38	3.60
Lewisburg	10,800	98.5	13,835	91.3	4.0	0.65	0.70	3.16	3.46
Newport	3,581	80.9	10,918	89.5	3.3	1.55	1.40	5.09	5.68
Marietta	44,624	113.7	99,228	107.6	4.7	1.13	1.19	5.97	5.55
Conestoga	802	117.9	10,272	123.4	4.6	6.51	6.21	34.15	27.67

Table 18. Annual Water Discharges and Annual Loads and Yields of Dissolved Organic Nitrogen, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	5,590	76.2	6.9	0.18	0.31	1.12	1.47
Danville	21,856	132.4	7,167	69.1	7.7	0.17	0.32	1.00	1.44
Lewisburg	10,800	98.5	2,775	51.2	9.9	0.13	0.25	0.63	1.24
Newport	3,581	80.9	1,242	46.6	11.0	0.18	0.31	0.58	1.24
Marietta	44,624	113.7	13,509	48.4	10.6	0.15	0.36	0.81	1.68
Conestoga	802	117.9	1,939	146.7	10.8	1.23	0.99	6.45	4.39

Table 19. Annual Water Discharges and Annual Loads and Yields of Total Organic Carbon, Calendar Year 2006

Site	2006 Discharge cfs	Discharge % of LTM	2006 Load thousands of lbs	Load % of LTM	Prediction Error %	2006 Ave. Conc. mg/l	LTM Conc. mg/l	2006 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,404	129.4	123,583	146.6	2.8	4.08	3.60	24.77	16.89
Danville	21,856	132.4	174,979	150.8	2.8	4.07	3.57	24.37	16.16
Lewisburg	10,800	98.5	44,903	97.5	4.0	2.11	2.13	10.25	10.51
Newport	3,581	80.9	19,658	68.8	4.5	2.79	3.28	9.16	13.32
Marietta	44,624	113.7	276,431	114.3	3.8	3.15	3.13	16.62	14.55
Conestoga	802	117.9	6,842	90.0	5.3	4.33	5.68	22.75	25.28

Table 20. Seasonal Mean Water Discharges and Loads of Nutrients and Suspended Sediment, Calendar Year 2006

Station	Season	Mean Q cfs	TN	DN	NH_3	DNH_3	TON	DON	TNOx	DNOx	TP	DP	DOP	TOC	SS
			Thousands of pounds												
Towanda	Winter	18,351	9,671	8,274	601	492	2,338	1,577	6,770	6,606	800	388	327	26,720	468,516
	Spring	14,860	6,390	4,774	318	277	3,177	1,490	3,393	3,266	1,421	374	295	33,143	4,351,597
	Summer	12,453	4,919	3,716	264	229	2,264	1,215	2,498	2,400	931	363	282	31,050	1,218,108
	Fall	15,952	7,353	5,893	539	414	2,215	1,308	4,559	4,392	976	453	368	32,670	868,577
Danville	Winter	26,286	14,465	12,689	1,024	816	3,534	2,127	9,905	9,797	1,593	799	693	37,902	637,758
	Spring	20,780	8,869	6,432	476	413	4,965	1,834	4,384	4,291	2,595	640	529	48,084	6,258,484
	Summer	17,197	6,899	5,039	362	327	3,315	1,456	3,372	3,296	1,650	604	520	42,182	1,696,086
	Fall	23,163	11,345	9,196	861	671	3,277	1,750	6,980	6,875	2,017	934	830	46,812	1,201,122
Lewisburg	Winter	14,651	7,112	6,416	467	375	1,452	1,042	5,429	5,379	477	239	207	13,195	145,322
	Spring	8,219	3,197	2,879	157	150	734	532	2,325	2,286	222	148	136	7,431	54,602
	Summer	7,502	2,730	2,360	130	122	635	436	1,990	1,952	254	155	155	9,166	72,534
	Fall	12,828	5,530	4,823	387	296	1,105	766	4,275	4,219	513	274	272	15,110	182,571
Newport	Winter	6,107	5,875	5,496	146	113	800	514	5,125	5,064	128	70	60	7,688	55,395
	Spring	3,326	2,534	2,359	89	67	445	293	2,113	2,075	67	39	32	4,367	29,757
	Summer	1,729	1,329	1,230	55	39	240	169	1,074	1,051	42	29	25	2,845	11,960
	Fall	3,161	3,128	2,950	96	68	379	267	2,774	2,728	64	44	39	4,759	23,196
Marietta	Winter	58,806	46,488	42,306	2,440	1,817	7,576	4,608	38,183	37,358	1,672	495	387	73,060	916,791
	Spring	38,825	23,019	19,323	960	794	6,681	2,937	16,660	16,236	1,795	315	237	62,603	3,311,798
	Summer	33,643	21,918	18,257	851	687	5,589	2,531	15,740	15,337	1,298	358	272	63,151	1,119,974
	Fall	47,223	38,741	34,260	2,112	1,446	6,689	3,433	31,040	30,297	1,517	441	334	77,617	1,078,079
Conestoga	Winter	949	3,794	3,677	40	38	608	641	3,148	3,107	62	37	32	1,660	18,704
	Spring	828	2,585	2,394	46	38	624	447	2,099	2,042	243	62	57	2,387	179,068
	Summer	618	2,380	2,391	17	16	281	306	2,256	2,183	45	35	33	1,164	10,162
	Fall	814	3,263	3,184	37	34	546	545	2,789	2,702	81	48	44	1,630	28,261

Table 21. Seasonal Mean Water Discharges and Yields of Nutrients and Suspended Sediment, Calendar Year 2006

Station	Season	Mean Q cfs	TN	DN	NH_3	DNH_3	TON	DON	TNOx	DNOx	TP	DP	DOP	TOC	SS
			lbs/acre												
Towanda	Winter	18,351	1.94	1.66	0.12	0.10	0.47	0.32	1.36	1.32	0.160	0.078	0.066	5.4	94
	Spring	14,860	1.28	0.96	0.06	0.06	0.64	0.30	0.68	0.65	0.285	0.075	0.059	6.6	872
	Summer	12,453	0.99	0.74	0.05	0.05	0.45	0.24	0.50	0.48	0.187	0.073	0.057	6.2	244
	Fall	15,952	1.47	1.18	0.11	0.08	0.44	0.26	0.91	0.88	0.196	0.091	0.074	6.5	174
Danville	Winter	26,286	2.01	1.77	0.14	0.11	0.49	0.30	1.38	1.36	0.222	0.111	0.097	5.3	89
	Spring	20,780	1.24	0.90	0.07	0.06	0.69	0.26	0.61	0.60	0.361	0.089	0.074	6.7	872
	Summer	17,197	0.96	0.70	0.05	0.05	0.46	0.20	0.47	0.46	0.230	0.084	0.072	5.9	236
	Fall	23,163	1.58	1.28	0.12	0.09	0.46	0.24	0.97	0.96	0.281	0.130	0.116	6.5	167
Lewisburg	Winter	14,651	1.62	1.46	0.11	0.09	0.33	0.24	1.24	1.23	0.109	0.055	0.047	3.0	33
	Spring	8,219	0.73	0.66	0.04	0.03	0.17	0.12	0.53	0.52	0.051	0.034	0.031	1.7	12
	Summer	7,502	0.62	0.54	0.03	0.03	0.14	0.10	0.45	0.45	0.058	0.035	0.035	2.1	17
	Fall	12,828	1.26	1.10	0.09	0.07	0.25	0.17	0.98	0.96	0.117	0.063	0.062	3.4	42
Newport	Winter	6,107	2.74	2.56	0.07	0.05	0.37	0.24	2.39	2.36	0.060	0.033	0.028	3.6	26
	Spring	3,326	1.18	1.10	0.04	0.03	0.21	0.14	0.98	0.97	0.031	0.018	0.015	2.0	14
	Summer	1,729	0.62	0.57	0.03	0.02	0.11	0.08	0.50	0.49	0.020	0.014	0.012	1.3	6
	Fall	3,161	1.46	1.37	0.04	0.03	0.18	0.12	1.29	1.27	0.030	0.020	0.018	2.2	11
Marietta	Winter	58,806	2.79	2.54	0.15	0.11	0.46	0.28	2.30	2.25	0.101	0.030	0.023	4.4	55
	Spring	38,825	1.38	1.16	0.06	0.05	0.40	0.18	1.00	0.98	0.108	0.019	0.014	3.8	199
	Summer	33,643	1.32	1.10	0.05	0.04	0.34	0.15	0.95	0.92	0.078	0.022	0.016	3.8	67
	Fall	47,223	2.33	2.06	0.13	0.09	0.40	0.21	1.87	1.82	0.091	0.027	0.020	4.7	65
Conestoga	Winter	949	12.61	12.22	0.13	0.13	2.02	2.13	10.47	10.33	0.206	0.123	0.106	5.5	62
	Spring	828	8.59	7.96	0.15	0.13	2.07	1.49	6.98	6.79	0.808	0.206	0.189	7.9	595
	Summer	618	7.91	7.95	0.06	0.05	0.93	1.02	7.50	7.26	0.150	0.116	0.110	3.9	34
	Fall	814	10.85	10.59	0.12	0.11	1.82	1.81	9.27	8.98	0.269	0.160	0.146	5.4	94

Table 22. 2006 Monthly Flow in CFS and TN, TP, and SS in Thousands of Pounds

Station	Parameter	January	February	March	April	May	June	July	August	September	October	November	December	Annual#
Towanda	Q	26,706	16,111	12,235	11,295	7,620	25,666	18,597	8,121	10,641	14,900	22,957	10,000	15,404
	TN	4,919	2,637	2,115	1,735	1,109	3,546	2,489	1,055	1,375	2,186	3,525	1,642	28,333
	TP	465	183	152	130	87	1,205	541	168	223	327	533	116	4,130
	SS	330,365	73,545	64,605	43,173	19,501	4,288,923	929,019	117,368	171,721	254,137	585,638	28,803	6,906,798
Danville	Q	40,332	23,946	14,579	15,356	10,926	36,057	28,328	8,739	14,524	19,123	35,260	15,105	21,856
	TN	7,890	4,072	2,504	2,323	1,541	5,006	3,858	1,118	1,923	2,946	5,808	2,591	41,580
	TP	1,004	385	204	217	141	2,237	1,104	180	366	548	1,207	261	7,854
	SS	480,505	112,986	44,267	51,704	22,514	6,184,266	1,461,343	61,837	172,905	270,999	879,679	50,444	9,793,449
Lewisburg	Q	24,413	13,060	6,481	7,902	7,184	9,571	7,648	3,603	11,254	11,135	19,274	8,074	10,800
	TN	4,079	1,972	1,061	1,113	964	1,120	915	471	1,344	1,533	2,699	1,299	18,570
	TP	311	116	51	62	58	102	73	38	142	151	281	81	1,466
	SS	112,313	26,090	6,919	9,974	8,910	35,718	14,344	7,780	50,410	49,653	120,002	12,917	455,030
Newport	Q	9,660	6,398	2,264	3,699	2,819	3,460	2,260	962	1,964	1,649	4,887	2,946	3,581
	TN	3,403	1,883	589	952	705	877	574	208	546	485	1,678	964	12,864
	TP	82	37	9	20	16	31	18	7	18	11	39	14	302
	SS	39,301	14,534	1,560	6,893	3,985	18,879	5,003	1,076	5,881	2,206	17,953	3,037	120,308
Marietta	Q	90,187	58,107	28,123	31,860	25,994	58,620	50,535	14,456	35,937	34,535	74,047	33,087	44,624
	TN	26,028	14,025	6,435	6,524	5,140	11,355	10,582	2,930	8,406	9,217	20,435	9,088	130,165
	TP	1,103	433	136	171	137	1,486	772	103	423	354	984	179	6,281
	SS	681,939	197,220	37,632	58,728	39,737	3,213,333	821,131	32,178	266,665	186,741	837,500	53,838	6,426,642
Conestoga	Q	1,275	1,081	491	534	373	1,578	889	343	622	449	1,385	608	802
	TN	1,745	1,349	700	695	501	1,389	1,122	459	799	632	1,723	909	12,023
	TP	35	21	7	9	5	229	22	7	17	10	62	9	433
	SS	11,356	6,362	985	2,316	678	176,074	5,844	694	3,623	1,423	25,481	1,357	236,193

Annual flow is average for the year; Annual loads are total for the year

Table 23. 2006 Monthly Flow in CFS and TN, TP, and SS Yields in lbs/acre

Station	Parameter	January	February	March	April	May	June	July	August	September	October	November	December	Annual#
Towanda	Q	26,706	16,111	12,235	11,295	7,620	25,666	18,597	8,121	10,641	14,900	22,957	10,000	15,404
	TN	0.99	0.53	0.42	0.35	0.22	0.71	0.50	0.21	0.28	0.44	0.71	0.33	5.69
	TP	0.093	0.037	0.030	0.026	0.017	0.241	0.108	0.034	0.045	0.066	0.107	0.023	0.827
	SS	66.2	14.7	12.9	8.7	3.9	859.5	186.2	23.5	34.4	50.9	117.4	5.8	1,384.1
Danville	Q	40,332	23,946	14,579	15,356	10,926	36,057	28,328	8,739	14,524	19,123	35,260	15,105	21,856
	TN	1.10	0.57	0.35	0.32	0.21	0.70	0.54	0.16	0.27	0.41	0.81	0.36	5.80
	TP	0.140	0.054	0.028	0.030	0.020	0.312	0.154	0.025	0.051	0.076	0.168	0.036	1.094
	SS	66.9	15.7	6.2	7.2	3.1	861.2	203.5	8.6	24.1	37.7	122.5	7.0	1,363.7
Lewisburg	Q	24,413	13,060	6,481	7,902	7,184	9,571	7,648	3,603	11,254	11,135	19,274	8,074	10,800
	TN	0.93	0.45	0.24	0.25	0.22	0.26	0.21	0.11	0.31	0.35	0.62	0.30	4.25
	TP	0.071	0.026	0.012	0.014	0.013	0.023	0.017	0.009	0.032	0.034	0.064	0.018	0.333
	SS	25.6	6.0	1.6	2.3	2.0	8.2	3.3	1.8	11.5	11.3	27.4	2.9	103.9
Newport	Q	9,660	6,398	2,264	3,699	2,819	3,460	2,260	962	1,964	1,649	4,887	2,946	3,581
	TN	1.59	0.88	0.27	0.44	0.33	0.41	0.27	0.10	0.25	0.23	0.78	0.45	6.00
	TP	0.038	0.017	0.004	0.009	0.007	0.014	0.008	0.003	0.008	0.005	0.018	0.007	0.138
	SS	18.3	6.8	0.7	3.2	1.9	8.8	2.3	0.5	2.7	1.0	8.4	1.4	56.0
Marietta	Q	90,187	58,107	28,123	31,860	25,994	58,620	50,535	14,456	35,937	34,535	74,047	33,087	44,624
	TN	1.56	0.84	0.39	0.39	0.31	0.68	0.64	0.18	0.51	0.55	1.23	0.55	7.83
	TP	0.066	0.026	0.008	0.010	0.008	0.089	0.046	0.006	0.025	0.021	0.059	0.011	0.375
	SS	41.0	11.9	2.3	3.5	2.4	193.2	49.4	1.9	16.0	11.2	50.3	3.2	386.3
Conestoga	Q	1,275	1,081	491	534	373	1,578	889	343	622	449	1,385	608	802
	TN	5.80	4.48	2.33	2.31	1.67	4.62	3.73	1.53	2.66	2.10	5.73	3.02	39.98
	TP	0.116	0.070	0.023	0.030	0.017	0.761	0.073	0.023	0.057	0.033	0.206	0.030	1.439
	SS	37.8	21.2	3.3	7.7	2.3	585.4	19.4	2.3	12.0	4.7	84.7	4.5	785.3

Annual flow is average for the year

2006 SUMMARY STATISTICS AT ALL SITES

As sampling at group B stations began fairly recently, there were not enough data to complete loads or trends analyses. Therefore, summary statistics have been calculated for these sites, as well as the long term sites for comparison. Summary statistics are listed in Table 24 and include minimum, maximum, median, mean, and standard deviation values. Table 25 lists annual mean values of all parameters. Table 26 lists seasonal mean values for TN, TP, and TSS at all sites.

Table 24. Enhanced Monitoring Station Concentration Summary Statistics for 2006 in mg/L

Station	Minimum Value			Maximum Value			Median Value			Mean Value			Standard Deviation		
	TN	TP	TSS	TN	TP	TSS	TN	TP	TSS	TN	TP	TSS	TN	TP	TSS
Original Sites (Group A)															
Towanda *	0.58	0.020	3	1.23	0.657	764	0.93	0.110	39	0.92	0.162	119	0.18	0.153	187
Danville *	0.54	0.021	4	1.88	0.599	762	0.95	0.112	31	0.96	0.180	113	0.24	0.160	184
Lewisburg *	0.55	0.012	1	1.52	0.268	310	0.76	0.052	8	0.83	0.064	24	0.24	0.045	53
Newport *	0.98	0.011	1	2.42	0.228	153	1.67	0.047	15	1.63	0.062	27	0.37	0.053	38
Marietta *	0.87	0.015	3	2.93	0.438	493	1.28	0.051	23	1.34	0.098	78	0.38	0.107	121
Conestoga *	3.72	0.027	2	9.65	1.352	699	7.36	0.140	13	7.21	0.254	84	1.70	0.296	157
Enhanced Sites (Groups B)															
Unadilla *	0.70	0.030	2	1.38	1.801	486	0.90	0.077	9	0.95	0.113	61	0.21	0.084	127
Conklin *	0.52	0.029	4	1.77	0.444	747	0.83	0.089	18	0.92	0.128	99	0.32	0.109	188
Smithboro *	0.75	0.025	3	1.78	0.736	697	1.02	0.103	63	1.13	0.186	200	0.33	0.206	279
Cohocton *	1.19	0.020	1	1.84	0.317	170	1.40	0.065	8	1.44	0.095	32	0.22	0.077	48
Chemung *	0.64	0.026	2	2.16	0.753	891	1.03	0.084	20	1.13	0.179	169	0.41	0.211	308
Wilkes-Barre	0.40	0.025	2	1.42	0.635	936	0.85	0.078	22	0.87	0.149	113	0.23	0.171	248
Karthaus	0.21	0.013	2	0.82	0.105	88	0.56	0.049	10	0.56	0.052	19	0.17	0.027	22
Castanea	1.11	0.015	2	1.83	0.102	96	1.47	0.049	3	1.48	0.054	15	0.22	0.031	24
Jersey Shore	0.35	0.013	2	0.78	0.245	42	0.58	0.051	4	0.58	0.058	4	0.12	0.051	13
Penns Creek	0.75	0.013	2	2.10	0.257	116	1.50	0.067	4	1.40	0.100	24	0.40	0.081	38
Saxton	1.17	0.010	2	2.25	0.126	94	1.99	0.023	6	1.86	0.042	23	0.34	0.037	34
Dromgold	1.10	0.012	2	3.89	0.215	114	1.93	0.027	4	1.88	0.073	21	0.64	0.077	31
Hogestown	1.75	0.011	2	5.60	0.257	138	3.80	0.027	4	3.87	0.068	23	0.93	0.077	39
Hershey	2.44	0.013	2	5.80	0.495	310	3.55	0.065	3	3.37	0.115	46	0.82	0.121	76
Manchester	1.19	0.036	2	4.57	0.602	276	2.55	0.146	9	2.64	0.218	55	1.01	0.201	92
Martic Forge	4.76	0.022	2	9.69	2.175	1,092	7.94	0.120	17	7.74	0.452	213	1.46	0.677	379
Octoraro	4.41	0.037	2	8.99	0.829	528	6.06	0.079	3	6.43	0.183	45	1.27	0.212	131

* Suspended-sediment concentrations were substituted for total suspended solids (TSS) at these sites as there were more data points available

Table 25. Enhanced Monitoring Station Average Concentration Data for 2006

Station	Flow cfs	Temp C°	Cond umhos/cm	pH S.U.	TN	DN	TNH_4	DNH_4	TNOx	DNOx	TP	DP	DOP	TOC	TSS
					mg/L										
Original Sites (Group A)															
Towanda *	33,124	12.2	186	7.17	0.92	0.76	0.05	0.04	0.52	0.50	0.162	0.074	0.061	4.58	119
Danville *	49,771	12.5	201	7.09	0.96	0.75	0.05	0.04	0.52	0.51	0.178	0.079	0.067	4.60	112
Lewisburg *	19,117	12.5	162	6.91	0.82	0.74	0.04	0.04	0.57	0.56	0.064	0.039	0.032	2.46	24
Newport *	6,487	14.6	221	8.02	1.63	1.51	0.04	0.04	1.28	1.27	0.062	0.035	0.027	3.50	27
Marietta *	86,822	14.5	187	7.51	1.34	1.13	0.05	0.04	0.93	0.91	0.098	0.024	0.018	3.87	78
Conestoga *	2,245	15.6	494	7.98	7.21	6.96	0.07	0.06	6.35	6.09	0.255	0.140	0.125	5.04	84
Enhanced Sites (Group B)															
Unadilla *	2,151	10.6	226	7.35	0.95	0.87	0.03	0.03	0.58	0.58	0.113	0.070	0.068	2.99	61
Conklin *	7,361	11.4	174	7.40	0.92	0.75	0.03	0.03	0.47	0.42	0.128	0.056	0.051	3.15	99
Smithboro *	25,970	11.9	201	7.34	1.13	0.87	0.04	0.04	0.53	0.54	0.186	0.070	0.053	3.55	183
Cohocton *	880	12.1	437	7.72	1.44	1.38	0.37	0.33	0.96	0.96	0.095	0.051	0.047	4.31	32
Chemung *	5,738	10.4	296	7.60	1.13	0.93	0.03	0.03	0.56	0.59	0.179	0.061	0.043	3.50	169
Wilkes-Barre	35,938	13.0	213	7.15	0.87	0.69	0.04	0.03	0.47	0.46	0.149	0.049	0.040	4.49	113
Karthaus	3,424	12.9	340	6.39	0.56	0.49	0.05	0.04	0.34	0.34	0.052	0.019	0.016	1.90	19
Castanea	-	13.0	262	7.33	1.48	1.42	0.03	0.03	1.24	1.24	0.054	0.033	0.029	2.20	15
Jersey Shore	13,202	13.8	191	6.82	0.58	0.52	0.03	0.03	0.41	0.39	0.058	0.040	0.035	1.87	12
Penns Creek	1,154	12.6	177	7.66	1.40	1.28	0.04	0.03	1.04	1.04	0.100	0.060	0.051	3.72	24
Saxton	2,034	13.7	234	7.70	1.86	1.80	0.04	0.04	1.56	1.54	0.041	0.033	0.024	3.36	23
Dromgold	1,070	13.9	157	7.55	1.88	1.80	0.05	0.04	1.51	1.47	0.073	0.044	0.035	4.36	21
Hogestown	1,191	16.0	358	7.89	3.87	3.78	0.04	0.04	3.44	3.39	0.068	0.032	0.027	3.90	23
Hershey	4,367	14.8	232	7.43	3.67	3.54	0.06	0.05	3.25	3.17	0.115	0.053	0.044	4.27	46
Manchester	2,998	16.4	237	7.80	2.64	2.44	0.05	0.05	2.08	1.94	0.218	0.139	0.122	6.85	55
Martic Forge	469	14.6	397	7.90	7.74	7.26	0.10	0.10	6.32	6.16	0.452	0.174	0.159	6.03	213
Octoraro	472	16.6	224	7.98	6.43	6.23	0.08	0.07	5.60	5.30	0.183	0.108	0.084	3.34	45

* Suspended-sediment concentrations were substituted for total suspended solids (TSS) at these sites as there were more data points available

Table 26. Enhanced Monitoring Station Average Seasonal Concentration Data for 2006 in mg/L

Station	Winter				Spring				Summer				Fall			
	Flow	TN	TP	TSS	Flow	TN	TP	TSS	Flow	TN	TP	TSS	Flow	TN	TP	TSS
	cfs	mg/L			cfs	mg/L			cfs	mg/L			cfs	mg/L		
Original Sites (Group A)																
Towanda *	33,304	1.04	0.103	103	40,865	0.90	0.279	214	28,412	0.88	0.117	49	25,052	0.86	0.091	50
Danville *	46,328	0.99	0.104	65	60,727	0.97	0.218	170	46,222	0.87	0.165	90	40,857	0.97	0.232	109
Lewisburg *	25,593	0.90	0.040	26	15,566	0.82	0.090	36	8,680	0.64	0.060	6	23,002	0.86	0.600	14
Newport *	9,450	1.82	0.043	24	7,013	1.56	0.088	46	1,333	1.32	0.055	10	3,142	1.71	0.066	24
Marietta *	98,806	1.38	0.068	44	117,490	1.45	0.155	153	46,909	1.12	0.066	34	67,128	1.36	0.086	61
Conestoga *	1,149	8.30	0.142	48	4,393	5.65	0.420	170	685	7.84	0.205	42	2,387	7.11	0.247	60
Enhanced Sites (Group B)																
Unadilla *	943	1.13	0.076	6	1,465	0.89	0.101	109	1,511	0.95	0.094	32	3,945	0.89	0.157	53
Conklin *	3,690	1.03	0.056	7	7,512	1.00	0.163	176	5,463	0.91	0.149	58	10,337	0.79	0.119	93
Smithboro *	10,234	1.21	0.134	6	32,179	1.18	0.251	467	14,926	1.06	0.106	14	34,589	1.06	0.189	155
Cohocton *	867	1.67	0.045	11	706	1.36	0.107	33	569	1.46	0.159	62	1,249	1.36	0.073	23
Chemung *	3,847	1.13	0.057	11	5,316	1.14	0.204	333	730	0.92	0.092	15	10,294	1.21	0.278	163
Wilkes-Barre	16,900	1.01	0.033	6	46,350	0.78	0.182	146	31,791	0.85	0.161	44	41,281	0.88	0.179	190
Karthaus	5,438	0.68	0.044	20	2,578	0.54	0.047	25	903	0.41	0.052	9	3,769	0.54	0.063	17
Castanea	-	1.46	0.025	3	-	1.45	0.062	19	-	1.70	0.082	2	-	1.43	0.046	24
Jersey Shore	11,227	0.61	0.026	18	11,538	0.55	0.079	14	3,562	0.59	0.069	3	20,673	0.60	0.047	11
Penns Creek	1,522	1.58	0.065	26	1,254	1.25	0.120	33	300	1.10	0.065	3	1,183	1.58	0.130	23
Saxton	4,544	2.07	0.045	26	1,088	1.63	0.058	38	182	1.78	0.022	6	440	1.90	0.025	5
Dromgold	921	2.54	0.075	2	1,978	1.73	0.110	38	107	1.47	0.023	2	767	1.70	0.061	767
Hogestown	680	3.64	0.038	9	2,028	3.28	0.120	42	306	5.01	0.027	4	1,053	4.02	0.052	20
Hershey	1,860	3.84	0.077	40	8,888	3.16	0.170	78	582	4.70	0.059	4	2,815	3.60	0.110	31
Manchester	625	3.35	0.073	7	5,032	2.93	0.295	101	156	1.53	0.125	6	3,273	2.56	0.261	58
Martic Forge	346	9.16	0.218	106	1,185	6.62	0.736	420	121	8.09	0.118	17	331	7.22	0.603	232
Octoraro	193	8.35	0.104	3	856	5.55	0.321	108	109	5.67	0.072	6	475	6.44	0.186	31

* Suspended-sediment concentrations were substituted for total suspended solids (TSS) at these sites as there were more data points available

COMPARISON OF THE 2006 LOADS AND YIELDS OF TOTAL NITROGEN, TOTAL PHOSPHORUS, AND SUSPENDED SEDIMENT WITH THE BASELINES

Annual fluctuations of nutrient and SS loads and water discharge create difficulties in determining whether the changes observed were related to land use, nutrient availability, or simply annual water discharge. Ott and others (1991) used the 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 yields against the water-discharge ratio. This water-discharge ratio is the ratio of the annual mean discharge to the LTM discharge. Data from the initial five year study (1985-89) were used to provide a best-fit linear regression line to be used as the baseline relationship between annual yields and water discharge. It was hypothesized that, as future yields and water-discharge ratios were plotted against the baseline, any significant deviation from the baseline would indicate that some change in the annual yield had occurred, and that further evaluations to determine the reason for the change were warranted.

Several different baselines were developed for this report. The data collected in 2006 were compared with the 1985-89 baselines, where possible. Monitoring at some of the stations was started after 1987; therefore, a baseline was established for the five year period following the start of monitoring. Additionally, annual 2006 yield values were plotted against baselines developed from the first half of the dataset, the second half of the data set, and the entire dataset. The results of these analyses are shown in Table 27. The R^2 value represents the strength of the correlation that each specific regression shows, with an R^2 of one meaning that there is perfect correlation between the two variables–flow and the individual parameter. The closer the R^2 is to a value of one, the better the regression line is for accurately using one variable (flow) to predict the other. R^2 values less than 0.5 have poor predictive value (< 50 percent) and have been noted with an asterisk (*) in Tables 27 and 28. The Y' value is the yield value that the regression line predicts for 2006. The Y corresponds to the actual 2006 yield. R^2 values for TN tend to be close to one as the relationship between TN and flow is very consistent through various ranges of flows. R^2 values for TP and SS tend to vary more, especially towards higher flows. Thus, when regression graphs include high flow events, the resulting correlation tends to be less perfect. This is an indication that single high flow events, and not necessarily a high flow year, are the highest contributors to high loads in TP and SS. As has been evident in the last few years, the high loads that have occurred at Towanda and Danville can be linked directly to high flow events, specifically Tropical Storm Ernesto in 2006 and Hurricane Ivan in 2004. Seasonal baselines also were found for the initial five years of data at each site. Figure 28 compares these baselines to the 2006 seasonal yields.

Table 27. Comparison of 2006 TN, TP, and SS Yields with Baseline Yields at Towanda, Pa.

Site/Parameter/Discharge Ratio			Initial Baseline		First Half Baseline		Full Baseline		Second Half Baseline		2006
			R^2	Y'	R^2	Y'	R^2	Y'	R^2	Y'	Y
Towanda	TN	1.31	0.81	8.58	0.87	8.15	0.75	7.34	0.93	6.48	5.68
	TP	1.31	0.75	0.78	0.87	0.78	0.84	0.73	0.87	0.67	0.83
	SS	1.31	0.46*	982	0.65	1,341	0.55	1,069	0.61	788	1,384
Danville	TN	1.33	0.99	10.50	0.86	8.94	0.68	7.91	0.83	7.34	5.79
	TP	1.33	0.91	0.80	0.84	0.80	0.81	0.78	0.85	0.76	1.09
	SS	1.33	0.99	926	0.70	649	0.72	699	0.74	714	1,364
Lewisburg	TN	0.98	0.83	6.20	0.91	5.78	0.83	5.43	0.95	4.90	4.24
	TP	0.98	0.86	0.30	0.82	0.32	0.87	0.30	0.91	0.29	0.33
	SS	0.98	0.75	238	0.71	204	0.41*	227	0.44*	253	104
Newport	TN	0.79	0.85	6.60	0.86	6.24	0.97	6.01	1.00	5.80	5.99
	TP	0.79	0.93	0.33	0.81	0.31	0.83	0.28	0.86	0.25	0.14
	SS	0.79	0.94	172	0.68	150	0.83	140	0.86	135	56
Marietta	TN	1.14	1.00	10.53	0.94	9.75	0.94	10.67	0.99	8.58	7.83
	TP	1.14	0.96	0.54	0.93	0.57	0.92	0.60	0.93	0.61	0.38
	SS	1.14	0.63	451	0.79	474	0.77	591	0.80	641	386
Conestoga	TN	1.31	1.00	45.25	0.97	43.06	0.96	41.40	0.97	40.45	39.97
	TP	1.31	0.30*	2.75	0.70	3.00	0.67	2.77	0.70	2.60	1.43
	SS	1.31	0.92	1,875	0.83	1,892	0.61	1,600	0.56	1,458	785

R^2 = correlation coefficient
* indicates a R^2 that is low and thus is less accurate at predicting Y

Table 28. Comparison of 2006 Seasonal TN, TP, and SS Yields with Baseline Yields at Towanda, Pa.

Site/Parameter		Winter				Spring				Summer				Fall			
		Q	R^2	Y'	Y06	Q	R^2	Y'	Y06	Q	R^2	Y'	Y06	Q	R^2	Y'	Y06
Towanda	TN	1.15	0.94	2.87	1.94	0.91	0.94	2.04	1.28	2.59	0.99	1.41	0.99	1.48	0.98	2.33	1.47
	TP	1.15	0.63	0.17	0.16	0.91	0.93	0.14	0.28	2.59	0.98	0.11	0.19	1.48	0.96	0.21	0.20
	SS	1.15	0.06*	130	94	0.91	0.92	157	872	2.59	0.94	65	244	1.48	0.85	210	174
Danville	TN	1.20	1.00	3.36	2.01	0.94	1.00	2.30	1.24	2.48	1.00	1.74	0.96	1.49	1.00	2.97	1.58
	TP	1.20	0.97	0.25	0.22	0.94	0.99	0.17	0.36	2.48	0.83	0.15	0.23	1.49	0.98	0.22	0.28
	SS	1.20	0.89	332	89	0.94	0.98	419	872	2.48	0.73	75	236	1.49	0.95	159	167
Lewisburg	TN	0.98	0.98	2.34	1.62	0.62	0.98	1.22	0.73	1.38	0.99	0.89	0.62	1.24	0.99	1.91	1.26
	TP	0.98	0.98	0.11	0.11	0.62	1.00	0.06	0.05	1.38	0.80	0.05	0.06	1.24	0.97	0.09	0.12
	SS	0.98	0.91	94	33	0.62	0.96	13	12	1.38	0.40*	15	17	1.24	0.91	59	42
Newport	TN	0.94	0.95	2.90	2.74	0.61	0.98	1.50	1.18	0.83	1.00	0.74	0.62	0.84	0.99	1.65	1.46
	TP	0.94	0.93	0.13	0.06	0.61	0.99	0.08	0.03	0.83	1.00	0.05	0.02	0.84	0.97	0.08	0.03
	SS	0.94	0.94	77	26	0.61	0.95	22	14	0.83	1.00	32	6	0.84	0.86	42	11
Marietta	TN	1.10	0.99	3.48	2.79	0.76	0.99	2.02	1.38	1.83	0.99	1.80	1.32	1.34	1.00	3.07	2.33
	TP	1.10	0.93	0.15	0.10	0.76	0.91	0.11	0.11	1.83	0.92	0.10	0.08	1.34	1.00	0.19	0.09
	SS	1.10	0.94	84	55	0.76	0.90	96	199	1.83	0.87	66	67	1.34	0.98	139	65
Conestoga	TN	1.05	0.99	14.02	12.61	1.13	1.00	11.84	8.59	1.30	0.98	7.94	7.91	1.29	0.99	11.04	10.85
	TP	1.05	0.43*	0.86	0.21	1.13	0.99	0.79	0.81	1.30	0.11*	0.80	0.15	1.29	0.80	0.88	0.27
	SS	1.05	0.15*	270	62	1.13	0.97	596	595	1.30	0.11*	717	34	1.29	0.92	262	94

Q = discharge ratio
R^2 = correlation coefficient
* indicates a R^2 that is low and thus is less accurate at predicting Y

DISCHARGE, NUTRIENT, AND SUSPENDED-SEDIMENT TRENDS

Trend analyses of water quality and flow data collected at the six Group A monitoring sites were completed for the period January 1985 through December 2006. FAC trends were estimated based on the USGS water year, October 1 to September 30, using the USGS 7-parameter, log-linear regression model (ESTIMATOR) developed by Cohn and others (1989) and described in Langland and others (1999). This estimator relates the constituent concentration to water discharge, seasonal effects, and long-term trends, and computes the best-fit regression equation. These tests were used to estimate the direction and magnitude of trends for discharge, SS, TOC, and several forms of nitrogen and phosphorus. Slope, p-value and sigma (error) values are taken from the DECTIME variable of the ESTIMATOR output. These values are then used to calculate flow adjusted trends using the following equations:

Trend =
100*(exp(Slope *(end yr – begin yr)) – 1)

Trend minimum =
100*(exp((Slope – (1.96*sigma)) *(end yr – begin yr)) – 1)

Trend maximum =
100*(exp((Slope + (1.96*sigma)) *(end yr – begin yr)) – 1)

The computer application S-Plus with the USGS ESTREND library addition was used to conduct Seasonal Kendall trend analysis on flows (Shertz and others, 1991). Results were reported for monthly mean discharge (FLOW) and FAC. Trends in FLOW indicate the natural changes in hydrology. Changes in flow and the cumulative sources of flow (base flow and overland runoff) affect the observed concentrations and the estimated loads of nutrients and SS. The FAC is the concentration after the effects of flow are removed from the concentration time series. Trends in FAC indicate that changes have occurred in the processes that deliver constituents to the stream system. After the effects of flow are removed, this is the concentration that relates to the effects of nutrient-reduction activities and other actions taking place in the watershed. A description of the methodology is included in Langland and others (1999).

Trend results for each monitoring site are presented in Tables 29 through 34. Each table lists the results for flow, the various nitrogen and phosphorus species, TOC, and SS. The level of significance was set by a p-value of 0.05 for FAC (Langland and others, 1999). The magnitude of the slope incorporates a confidence interval and was reported as a range (minimum and maximum). The slope direction was reported as not significant (NS) or, when significant, as down for improving trends and up for degrading trends. When a time series had greater than 20 percent of its observations below the method detection level (BMDL), a trend analysis could not be completed.

Table 29. Trend Statistics for the Susquehanna River at Towanda, Pa., January 1989 Through December 2006

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	109.76	0.3365	-	-	-	NS
TN	600	FAC	-0.0251	<0.0001	-39.85	-36.35	-32.66	DOWN
DN	602	FAC	-0.0227	<0.0001	-37.41	-33.54	-29.43	DOWN
TON	605	FAC	-0.0315	<0.0001	-50.04	-43.28	-35.60	DOWN
DON	607	FAC	-0.0245	<0.0001	-43.53	-35.66	-26.69	DOWN
DNH_3	608	FAC	-0.0076	0.0775	-25.06	-12.79	1.50	NS
TNH_3	610	FAC	-0.0283	<0.0001	-49.45	-39.91	-28.58	DOWN
DKN	623	FAC	-0.0313	<0.0001	-50.22	-43.07	-34.91	DOWN
TKN	625	FAC	-0.0311	<0.0001	-49.50	-42.87	-35.36	DOWN
TNOx	630	FAC	-0.0193	<0.0001	-33.93	-29.35	-24.45	DOWN
DNOx	631	FAC	-0.0201	<0.0001	-35.10	-30.36	-25.27	DOWN
TP	665	FAC	-0.0005	0.9038	-14.54	-0.90	14.93	NS
DP	666	FAC	-0.0057	0.1704	-22.18	-9.75	4.66	NS
DOP	671	FAC	0.1100	<0.0001	475.85	624.27	810.95	UP
TOC	680	FAC	-0.0031	0.0509	-10.62	-5.43	0.06	NS
SS	80154	FAC	-0.0191	0.0042	-44.02	-29.09	-10.19	DOWN

Table 30. Trend Statistics for the Susquehanna River at Danville, Pa., January 1985 Through December 2006

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	134.43	0.2180	-	-	-	NS
TN	600	FAC	-0.0258	<0.0001	-46.63	-43.31	-39.78	DOWN
DN	602	FAC	-0.0211	<0.0001	-41.07	-37.14	-32.94	DOWN
TON	605	FAC	-0.0352	<0.0001	-59.50	-53.90	-47.54	DOWN
DON	607	FAC	-0.0256	<0.0001	-49.54	-43.06	-35.75	DOWN
DNH_3	608	FAC	-0.0211	<0.0001	-46.17	-37.14	-26.58	DOWN
TNH_3	610	FAC	-0.0360	<0.0001	-61.72	-54.71	-46.41	DOWN
DKN	623	FAC	-0.0346	<0.0001	-59.13	-53.29	-46.61	DOWN
TKN	625	FAC	-0.0360	<0.0001	-59.68	-54.71	-49.11	DOWN
TNOx	630	FAC	-0.0160	<0.0001	-34.08	-29.67	-24.97	DOWN
DNOx	631	FAC	-0.0162	<0.0001	-34.37	-29.98	-25.30	DOWN
TP	665	FAC	-0.0128	0.0002	-34.83	-24.54	-12.63	DOWN
DP	666	FAC	-0.0021	0.5705	-18.60	-4.51	12.00	NS
DOP	671	FAC	0.1018	<0.0001	647.13	838.96	1080.04	UP
TOC	680	FAC	-0.0097	<0.0001	-23.62	-19.22	-14.56	DOWN
SS	80154	FAC	-0.0393	<0.0001	-65.31	-57.88	-48.86	DOWN

Table 31. Trend Statistics for the West Branch Susquehanna River at Lewisburg, Pa., January 1985 Through December 2006

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	5.47	0.9492	-	-	-	NS
TN	600	FAC	-0.0167	<0.0001	-35.64	-30.75	-25.48	DOWN
DN	602	FAC	-0.0138	<0.0001	-30.51	-26.18	-21.60	DOWN
TON	605	FAC	-0.0336	<0.0001	-59.47	-52.25	-43.75	DOWN
DON	607	FAC	-0.0273	<0.0001	-52.01	-45.15	-37.31	DOWN
DNH_3	608	FAC	-0.0050	0.1533	-23.30	-10.42	4.63	NS
TNH_3	610	FAC	-0.0214	<0.0001	-47.89	-37.55	-25.15	BMDL
DKN	623	FAC	-0.0383	<0.0001	-63.61	-56.94	-49.06	BMDL
TKN	625	FAC	-0.0332	<0.0001	-58.75	-51.83	-43.74	DOWN
TNOx	630	FAC	-0.0051	0.0008	-16.21	-10.61	-4.64	DOWN
DNOx	631	FAC	-0.0049	0.0012	-15.84	-10.22	-4.22	DOWN
TP	665	FAC	-0.0157	0.0001	-40.68	-29.21	-15.52	DOWN
DP	666	FAC	-0.0222	<0.0001	-47.69	-38.64	-28.03	DOWN
DOP	671	FAC	0.0841	<0.0001	393.22	536.11	720.39	BMDL
TOC	680	FAC	0.0018	0.3234	-4.14	4.04	12.92	NS
SS	80154	FAC	-0.0449	<0.0001	-71.74	-62.76	-50.93	BMDL

Table 32. Trend Statistics for the Juniata River at Newport, Pa., January 1989 Through December 2006

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	15.26	0.5967	-	-	-	NS
TN	600	FAC	-0.0051	<0.0001	-15.12	-10.61	-5.87	DOWN
DN	602	FAC	-0.0022	0.0453	-9.14	-4.72	-0.10	DOWN
TON	605	FAC	-0.0279	<0.0001	-53.45	-45.87	-37.05	DOWN
DON	607	FAC	-0.0206	<0.0001	-44.15	-36.44	-27.66	DOWN
DNH_3	608	FAC	-0.0129	0.0002	-34.98	-24.71	-12.82	DOWN
TNH_3	610	FAC	-0.0239	<0.0001	-50.47	-40.89	-29.46	BMDL
DKN	623	FAC	-0.0342	<0.0001	-60.17	-52.88	-44.25	BMDL
TKN	625	FAC	-0.0265	<0.0001	-51.79	-44.18	-35.36	DOWN
TNOx	630	FAC	0.0023	0.0598	-0.11	5.19	10.78	NS
DNOx	631	FAC	0.0029	0.0148	1.21	6.59	12.25	UP
TP	665	FAC	-0.0202	<0.0001	-44.86	-35.88	-25.43	DOWN
DP	666	FAC	-0.0168	<0.0001	-40.58	-30.90	-19.64	DOWN
DOP	671	FAC	0.0587	<0.0001	179.65	263.79	373.24	UP
TOC	680	FAC	-0.0118	<0.0001	-29.24	-22.86	-15.92	DOWN
SS	80154	FAC	-0.0195	0.0004	-48.63	-34.88	-17.46	DOWN

Table 33. Trend Statistics for the Susquehanna River at Marietta, Pa., January 1987 Through December 2006

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	-16.27	0.9811	-	-	-	NS
TN	600	FAC	-0.0144	<0.0001	-28.36	-25.02	-21.54	DOWN
DN	602	FAC	-0.0094	<0.0001	-22.18	-17.14	-11.78	DOWN
TON	605	FAC	-0.0301	<0.0001	-53.36	-45.23	-35.68	DOWN
DON	607	FAC	-0.0138	0.0030	-36.89	-24.12	-8.77	DOWN
DNH_3	608	FAC	-0.0086	0.0172	-26.88	-15.80	-3.04	DOWN
TNH_3	610	FAC	-0.0191	<0.0001	-41.88	-31.75	-19.85	DOWN
DKN	623	FAC	-0.0288	<0.0001	-51.76	-43.79	-34.50	DOWN
TKN	625	FAC	-0.0300	<0.0001	-51.78	-45.12	-37.54	DOWN
TNOx	630	FAC	-0.0050	0.0041	-15.35	-9.52	-3.28	DOWN
DNOx	631	FAC	-0.0052	0.0033	-16.02	-9.88	-3.29	DOWN
TP	665	FAC	-0.0089	0.0100	-27.04	-16.31	-4.00	DOWN
DP	666	FAC	-0.0080	0.0212	-25.71	-14.79	-2.25	DOWN
DOP	671	FAC	0.1236	<0.0001	825.39	1,084.61	1,416.45	UP
TOC	680	FAC	-0.0065	<0.0001	-17.20	-12.19	-6.87	DOWN
SS	80154	FAC	-0.0265	<0.0001	-52.37	-41.14	-27.26	DOWN

Table 34. Trend Statistics for the Conestoga River at Conestoga, Pa., January 1985 Through December 2006

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	3.14	0.6444	-	-	-	NS
TN	600	FAC	-0.0088	<0.0001	-21.42	-17.60	-13.60	DOWN
DN	602	FAC	0.0009	0.3917	-2.73	2.00	6.95	NS
TON	605	FAC	-0.0252	<0.0001	-49.53	-42.56	-34.63	DOWN
DON	607	FAC	0.0030	0.3178	-6.14	6.82	21.57	NS
DNH_3	608	FAC	-0.0632	<0.0001	-78.68	-75.10	-70.92	DOWN
TNH_3	610	FAC	-0.0693	<0.0001	-81.44	-78.23	-74.46	DOWN
DKN	623	FAC	-0.0128	<0.0001	-32.84	-24.54	-15.23	DOWN
TKN	625	FAC	-0.0323	<0.0001	-56.45	-50.87	-44.56	DOWN
TNOx	630	FAC	0.0018	0.1972	-2.06	4.04	10.51	NS
DNOx	631	FAC	0.0027	0.0490	-0.10	6.12	12.72	NS
TP	665	FAC	-0.0289	<0.0001	-53.47	-47.05	-39.74	DOWN
DP	666	FAC	-0.0253	<0.0001	-47.42	-42.68	-37.52	DOWN
DOP	671	FAC	-0.0107	0.0002	-29.96	-20.97	-10.83	DOWN
TOC	680	FAC	-0.0295	<0.0001	-52.06	-47.74	-43.04	DOWN
SS	80154	FAC	-0.0484	<0.0001	-71.85	-65.52	-57.77	DOWN

DISCUSSION

Nutrient and sediment loads for 2006 were influenced greatly by individual high flow events. In late June and early July, Tropical Storm Ernesto caused significant flooding in the northern portion of the basin. Figure 3 shows that high flows were recorded at Towanda and Danville, as well as at Conestoga in the southern basin area. Monthly flows ranged from 250 percent of the LTM at Conestoga to more than 350 percent of the LTM flow at Danville. These high flows produced large loads of TP and SS. Annual flows for the basin ranged from 81 percent of the LTM at Newport to 129 percent and 132 percent of the LTM at Towanda and Danville, respectively. Whereas TN loads were below LTM at theses sites, TP and SS loads were much higher at both Towanda and Danville. The southern sites, which were not affected as dramatically by Ernesto, had TP and SS loads that were well below the LTMs, including both Marietta and Newport. Conestoga showed similar results even though Ernesto did produce high flows in the watershed. Lewisburg had higher than LTM loads of TP and lower than LTM loads of SS. This is the opposite of what is expected, as usually TP and SS are positively correlated. These results may be due to the highly forested watershed nature of the West Branch Susquehanna Subbasin. Interestingly, TNH_3 and DNH_3 loads were higher than the LTMs for the three sites that had the lowest annual percentage of LTM for flow–Lewisburg, Newport, and Marietta–while Towanda and Danville had lower than the LTM loads of TNH_3 compared with higher than LTM flow values. The northern three sites, Towanda, Danville, and Lewisburg, showed dramatically higher loads of DP and DOP as compared to the LTMs. This is opposed to the three southern sites, which reported lower values for both when compared to their respective LTMs. TON loads were lower than the LTM for all sites.

Closer inspection of the loads at the seasonal level suggest that nearly all fractions of nitrogen, including TN, DN, TNH_3, DNH_3, DON, TNOx, and DNOx, had highest loads corresponding to the highest flow season during 2006, which was winter for all sites. At Towanda and Danville, TON, TP, TOC, and SS all had highest load values during the spring, which caught the beginning of Tropical Storm Ernesto. Conestoga showed the same pattern for all of these constituents, as well as TNH_3, DP, and DOP, which were highest during spring. This provides substantial evidence that whereas nitrogen tends to have the highest loads during extended periods of high flow, phosphorus, sediment, TOC, and TON tend to have their highest loads during very high individual peak flow events. This also can be seen upon closer inspection of Danville during the June 2006 and April 2005 storm events shown in Table 35.

Table 35. High Flow Events at Towanda and Danville, 2004-2006

Date	Peak Q	Daily Ave	Monthly Q	TN	TP	SS
Susquehanna River at Towanda						
Sep-04	154,000	127,000	27,943	4,122,557	1,157,923	3,274,241,652
Apr-05	162,000	146,000	37,744	6,612,034	1,254,475	2,861,470,602
Jun-06	141,000	138,000	25,666	3,545,918	1,204,632	4,288,922,530
Susquehanna River at Danville						
Sep-04	220,000	205,000	40,628	6,420,878	2,013,116	4,481,046,982
Apr-05	202,000	199,000	54,717	9,726,602	1,925,590	2,339,994,129
Jun-06	260,000	264,000	36,057	5,005,701	2,237,289	6,184,266,179

It has been well established that nutrient and sediment loads increase with increasing flow, but a closer look at these storms shows that high flows have an even more specific impact on loads when considering single high flow events. The April 2005 storm event had higher monthly average flow than the June 2006 storm event, whereas it had much lower values of instantaneous peak flow and peak average daily flow. The April storm, however, produced a much larger amount of TN while producing much lower loads of TP and SS. This suggests that consistent high flows produce higher amounts of TN, while single high flow events are the major producers of TP and SS. This makes sense as high flows produce higher energy waters that can erode soil and TP along with it.

This type of comparison also can be made comparing June 2006 and January 2006 for Marietta from Table 22. Monthly average flows were 58,620 cfs and 90,187 cfs for June and January, respectively. January had approximately 230 percent the TN load, 74 percent of the TP load, and 21 percent of the SS load as compared to June's loads. Some of this can be accounted for by seasonal variation of temperature, such as frozen versus thawed ground, but the numbers still suggest that TN is dependent upon high average flows, whereas TP, and more so SS, are dependent upon high peak flows. Another interesting comparison is between the high and low monthly loads at Danville. By dividing the highest monthly value of a parameter by the lowest monthly value of the same parameter, a measure of the range of the loads is obtained. At Danville, the differences between the high and low monthly values for the year were 706 percent for TN, 1,586 percent for TP, and 27,469 percent for SS. This means that the highest monthly load of TN was 706 times the size of the lowest monthly value, while the highest SS monthly load was 27,469 times the size of the lowest monthly load for SS. Clearly, there is a vast difference between TN and SS reactions to flow.

Considering that high flow affects these constituents differently, it would seem that managerial approaches to reducing TN and SS need to focus on different types of flows. Nutrient management practices that focus on nutrient reduction would be the best management practices for reducing TN whereas management practices that soften the surge of a fast and high hydrograph stage would be most effective at curbing SS. TP could be reduced by applying both nutrient reduction and flow amelioration techniques as reductions in SS also would result in reductions in TP.

Yields for 2006 at each site were compared with several different baselines, including an initial five year baseline, a baseline created from the first half of the site's dataset, one from the second half of the dataset, and one from the entire dataset. These comparisons indicated that 2006 yields for TP and SS at Towanda and Danville were higher than all the baselines predicted they should be for the given flow. Additionally, TP was higher at Lewisburg for all baseline comparisons. These values were due mostly to the high flows recorded in June 2006 when the majority of the loads of TP and SS were transported at these sites. This can be seen in Table 27, which compares seasonal yields with the initial five year baselines. Both spring and summer yields at Towanda and Danville were above the baselines. As mentioned before, the high flows from Tropical Storm Ernesto were spread over the end of June and beginning of July and, thus, likely accounted for the majority of these results.

Flows during the summer season are generally the lowest of the year. For 2006, however, flows were above the LTM at all sites except Newport, which was 83 percent of the LTM. Danville and Towanda had flows that were 248 percent and 259 percent of the LTM, respectively. Seasonal comparison with the initial baselines showed dramatic decreases in winter yields for SS. Additionally, dramatic reductions were found at Conestoga for both TP and SS during all seasons except spring. Interestingly, this was the time of highest flow at Conestoga, but still the SS yields compared with those predicted by the baselines, with the TP values being slightly higher. Given that the Conestoga River watershed is an area of high agricultural activity, this may be an indication of the success of erosion reducing management strategies. Large reductions also were implied by the baselines comparison of 2006 fall yields of TP and SS at Marietta and Newport.

The majority of the trends for 2006 remained unchanged from 2005. Specifically, Lewisburg and Conestoga recorded no changes from 2005 trends. Downward trends for TN, TP, and SS occurred at Conestoga, while TN and TP have downward trends at Lewisburg. Several trends that existed for the datasets from the beginning of monitoring at each site through 2005 were not found when analyzed through 2006. At Towanda, no trends were found for TP, DP, and TOC. The Danville 2005 downward trend in DP changed to a NS trend in 2006, while a new downward trend appeared for TNH_3, which previously did not show a trend due to greater than 20 percent of the values being BMDL. A 2005 degrading trend for TNOx changed to NS at Newport, while Marietta showed four new downward trends for DON, DNH_3, TP, and DP. Additionally, DOP has continued to show an increasing trend at all sites except for Conestoga, which has a downward trend, and Lewisburg, which had no trend due to greater than 20 percent of the data being BMDL.

Appendix A shows a graph of annual loads for all years for each parameter. Additionally, the LTM for each constituent load for all years is shown by a dotted line, and annual flow for each year is shown by a solid line with triangles. The graphs have been depicted so that improvements can be found by looking for a separation between the flow and loads plots. Such improvements can be seen when looking at the TN plots for Towanda and Danville, Figures 1 and 2, respectively. The graphs show the flow line at the top of the loads bars for the beginning years of the graph. In later years, they show that the loads have separated from the associated annual flows. Although this is a vague comparison, it does show valuable information implying that TN levels have decreased. In fact, all forms of nitrogen appear to have been reduced at both Towanda and Danville. Additionally, DON and TON have decreased over the given time periods at all sites except for DON at Conestoga, which has been increasing. These graphs indicate that all forms of phosphorus have either not changed or, as in the case of DOP, have increased at all sites except for Conestoga, which was the only site that indicated reductions in all forms of phosphorus as well as SS and TOC. Other common changes included decreasing loads of TNH_3 and DNH_3 at all sites except for Marietta, with improvements only in TON and DON over the time period. Towanda and Danville both show increases in SS loads over the past three years. However, this was mostly due to high peak flow events that occurred during each of the three years at these sites. Probably the most visually dramatic changes were shown for DOP. All sites except for Conestoga seem to show dramatic increases in DOP through the later years of each dataset.

When comparing the annual loads of TP and SS to the LTMs and flow, 2006 marks the third year in a row that both Towanda and Danville had increasing loads for both. Although each one of these years had a single high flow event that contributed a majority of the loads of these two constituents, the fact that this occurred three years in a row also has led to the loss of previous downward trends in TP and DP for Towanda and DP for Danville. Interestingly, although these are two of the three mainstem sites, the third and downstream site at Marietta has recorded new improving trends for both TP and DP through 2006. DOP also has continued to show degradations during the past several years with degrading trends continuing to show at four of the six sites, including Towanda, Danville, Newport, and Marietta. Improving conditions continue for TN at all six sites, regardless of the single high flow events that have been occurring in the northern basin.

REFERENCES

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

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

Langland, M.J. 2000. "Delivery of Sediment and Nutrients in the Susquehanna, History, and Patterns." The Impact of Susquehanna Sediments on the Chesapeake Bay, Chesapeake Bay Program Scientific and Technical Advisory Committee Workshop Report.

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

Ott, A.N., L.A. Reed, C.S. Takita, R.E. Edwards, and S.W. Bollinger. 1991. Loads and Yields of Nutrient and Suspended Sediment Transported in the Susquehanna River Basin, 1985-89. Susquehanna River Basin Commission (Publication No. 136), 254 pp.

Schertz, T.L., R.B. Alexander, and D.J. Ohe. 1991. The computer program EStimate TREND (ESTREND), a system for the detection of trends in water-quality data: U.S. Geological Survey Water-Resources Investigations Report 91-4040, 63 pp.

Susquehanna River Basin Study Coordination Committee. 1970. Susquehanna River Basin Study, 156 pp.

Takita, C.S. 1996. Nutrient and Suspended Sediment Transported in the Susquehanna River Basin, 1992-93. Susquehanna River Basin Commission (Publication No. 174), 51 pp.

——. 1998. Nutrient and Suspended Sediment Transported in the Susquehanna River Basin, 1994-96, and Loading Trends, Calendar Years 1985-96. Susquehanna River Basin Commission (Publication No. 194), 72 pp.

Takita, C.S., and R.E. Edwards. 1993. Nutrient and Suspended Sediment Transported in the Susquehanna River Basin, 1990-91. Susquehanna River Basin Commission (Publication No. 150), 57 pp.

U.S. Environmental Protection Agency (USEPA). 1982. Chesapeake Bay Program Technical Studies: A Synthesis, 634 pp.

Appendix A

Annual Loads of All Parameters

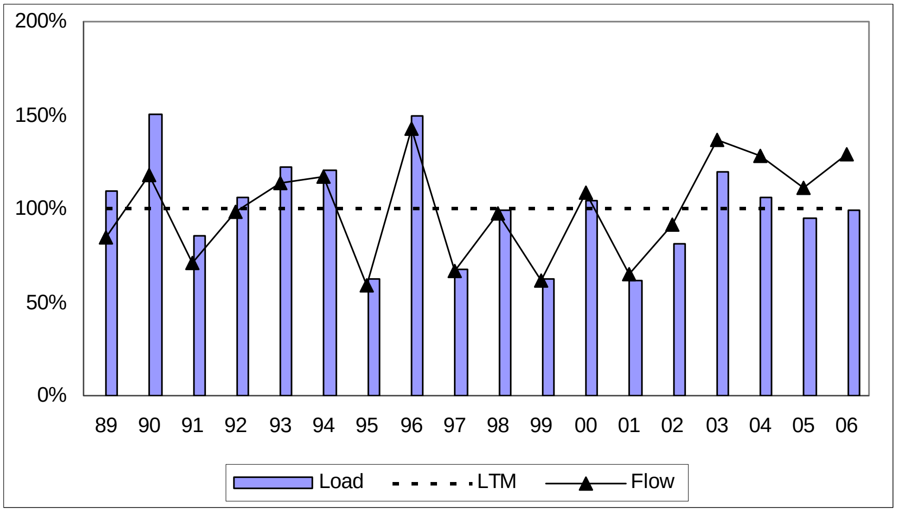


Figure 1. Ratio of Annual to LTM flow and TN loads at Towanda

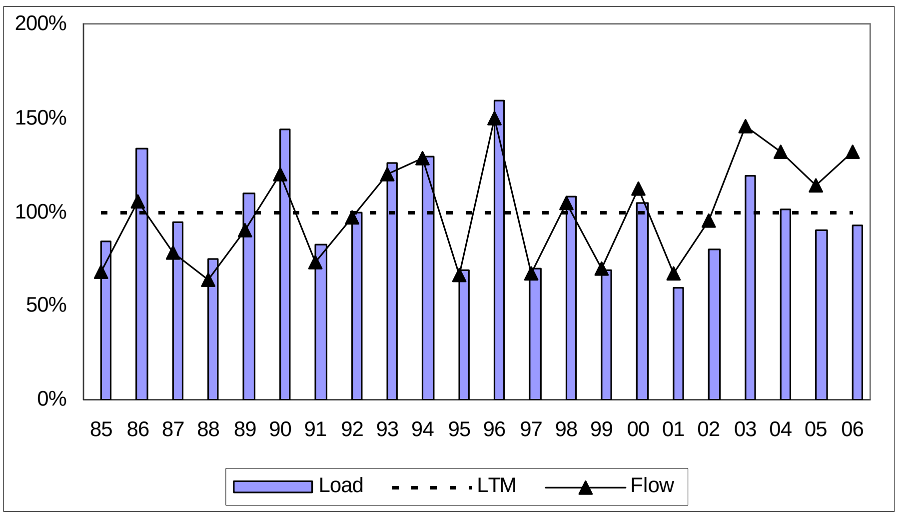


Figure 2. Ratio of Annual to LTM flow and TN loads at Danville

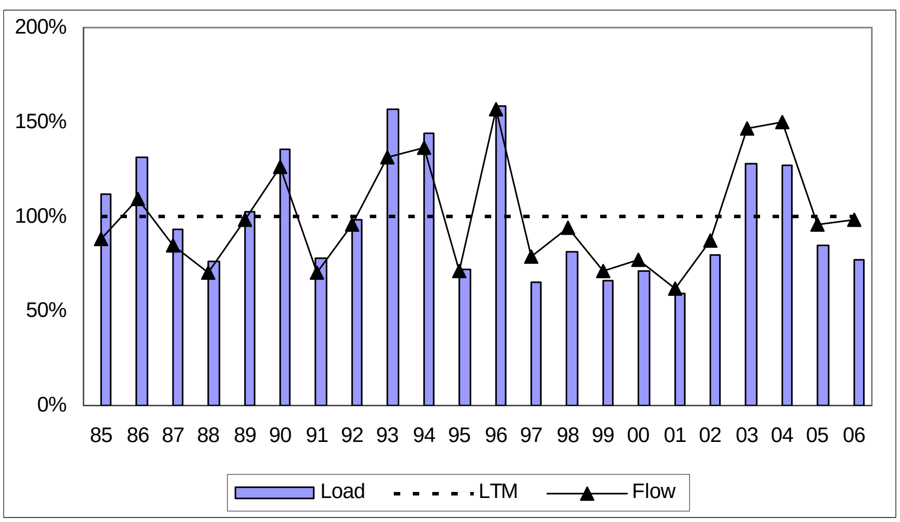


Figure 3. Ratio of Annual to LTM flow and TN loads at Lewisburg

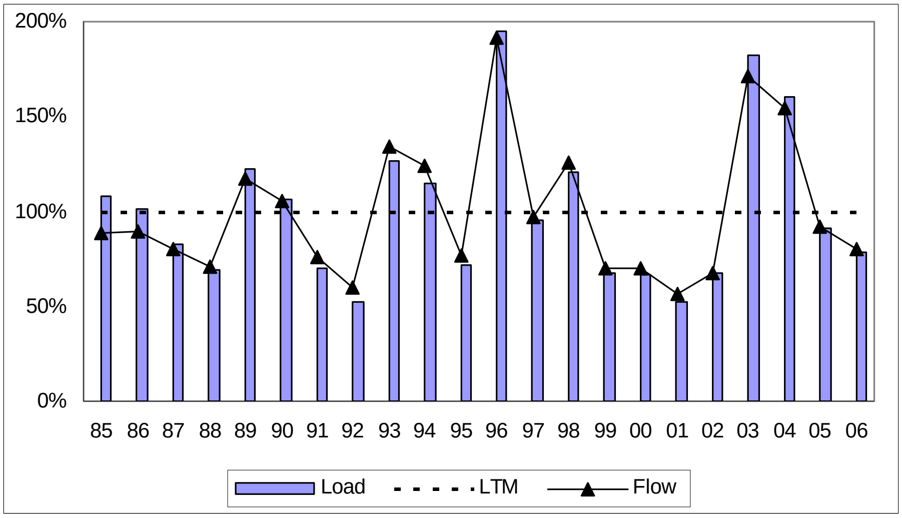


Figure 4. Ratio of Annual to LTM flow and TN loads at Newport

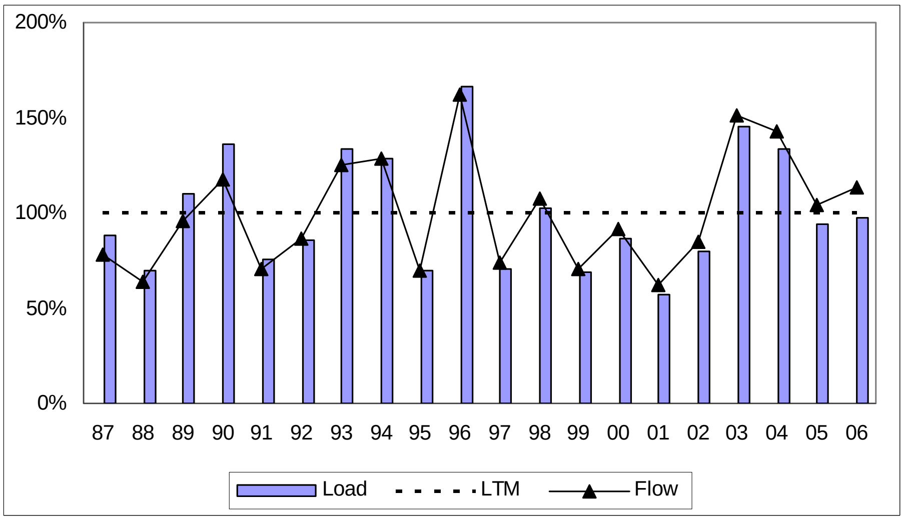


Figure 5. Ratio of Annual to LTM flow and TN loads at Marietta

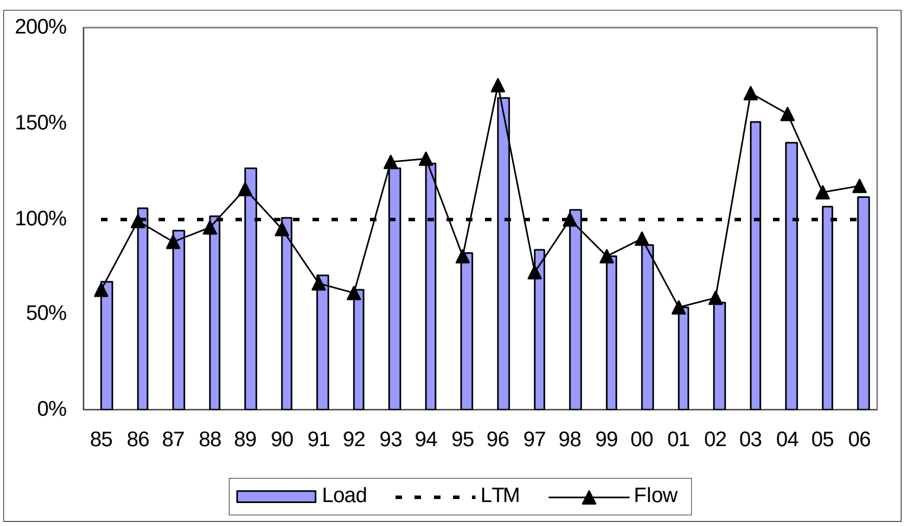


Figure 6. Ratio of Annual to LTM flow and TN loads at Conestoga

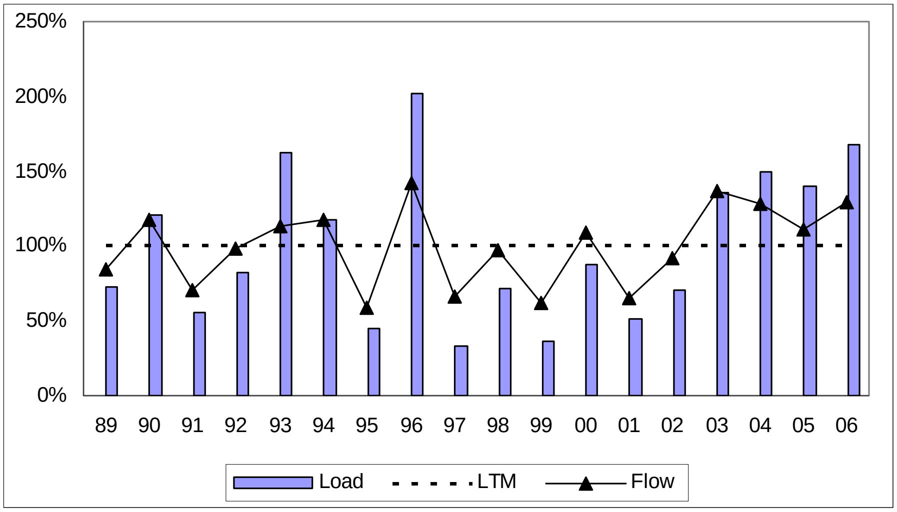


Figure 7. Ratio of Annual to LTM flow and TP loads at Towanda

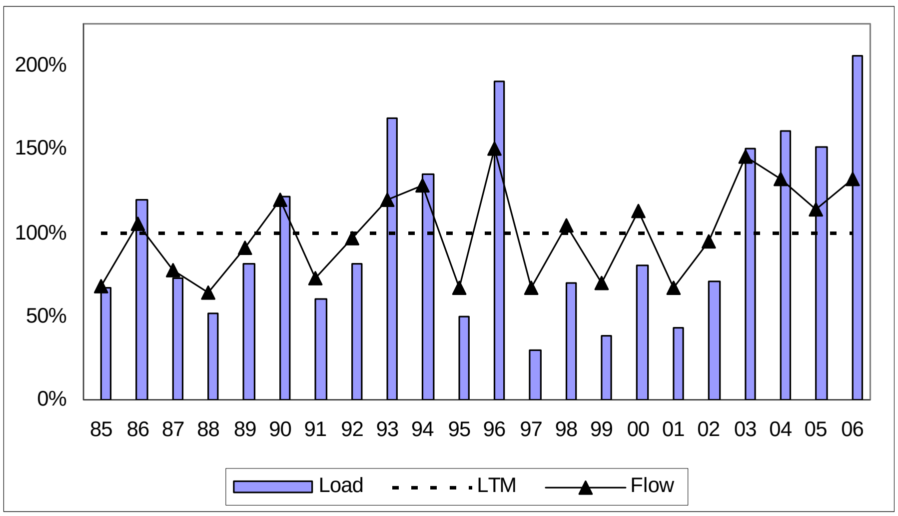


Figure 8. Ratio of Annual to LTM flow and TP loads at Danville

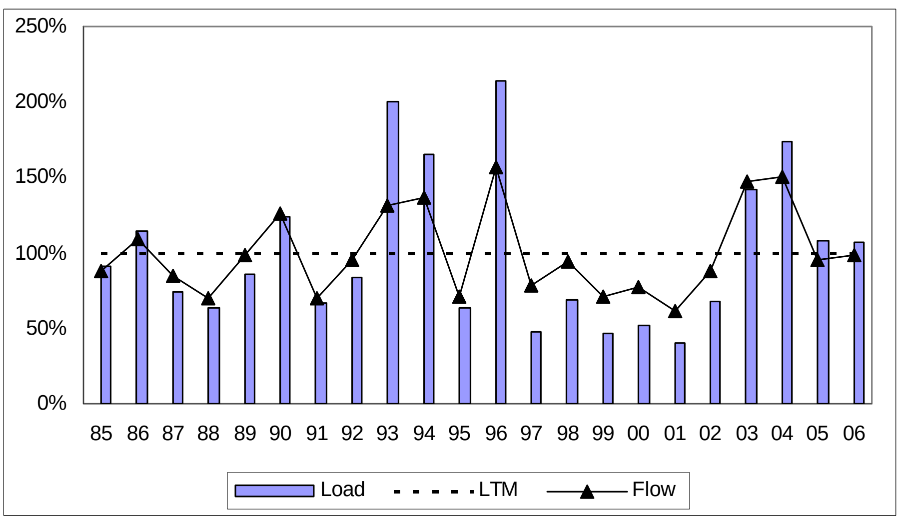


Figure 9. Ratio of Annual to LTM flow and TP loads at Lewisburg

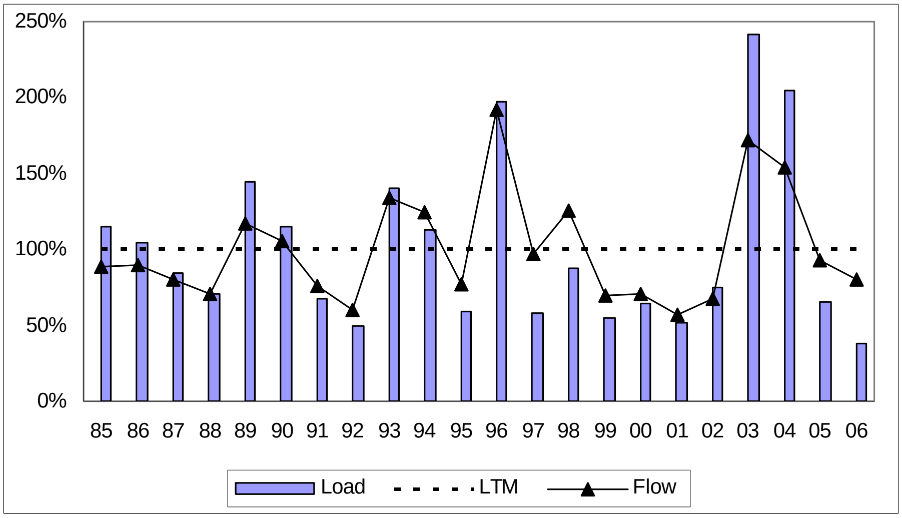


Figure 10. Ratio of Annual to LTM flow and TP loads at Newport

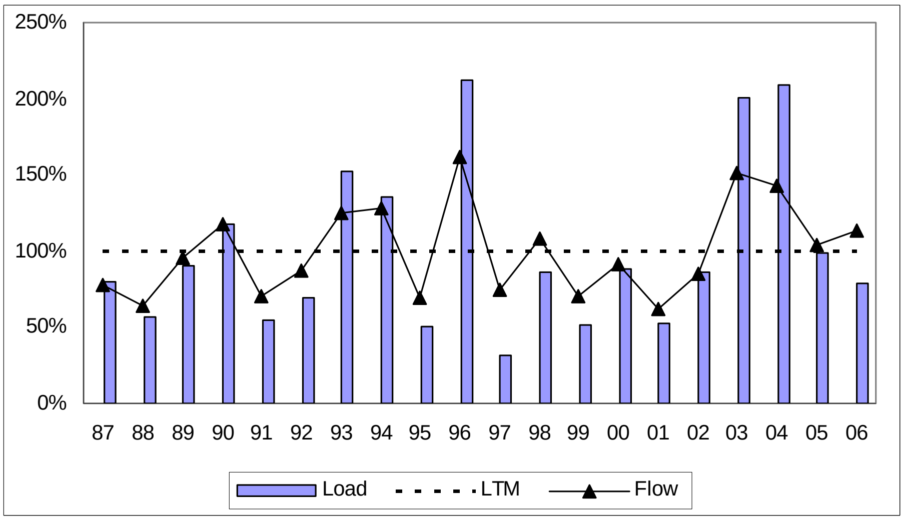


Figure 11. Ratio of Annual to LTM flow and TP loads at Marietta

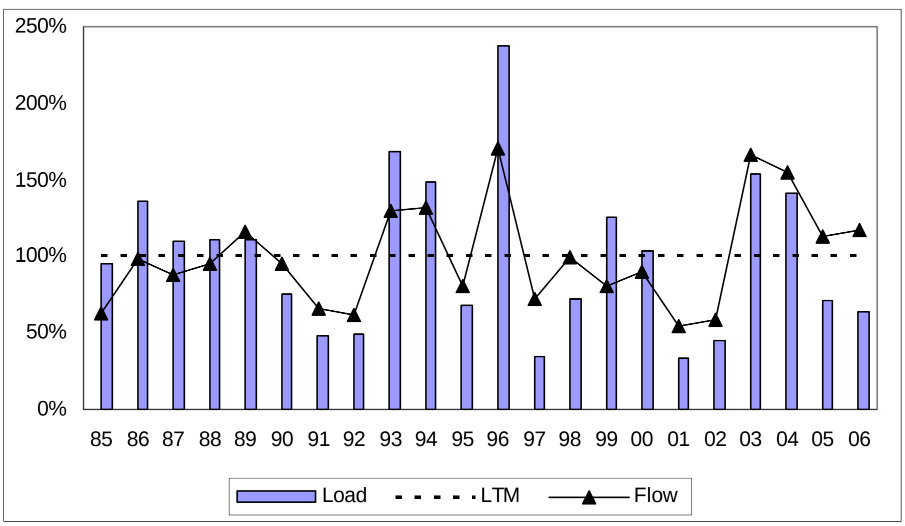


Figure 12. Ratio of Annual to LTM flow and TP loads at Conestoga

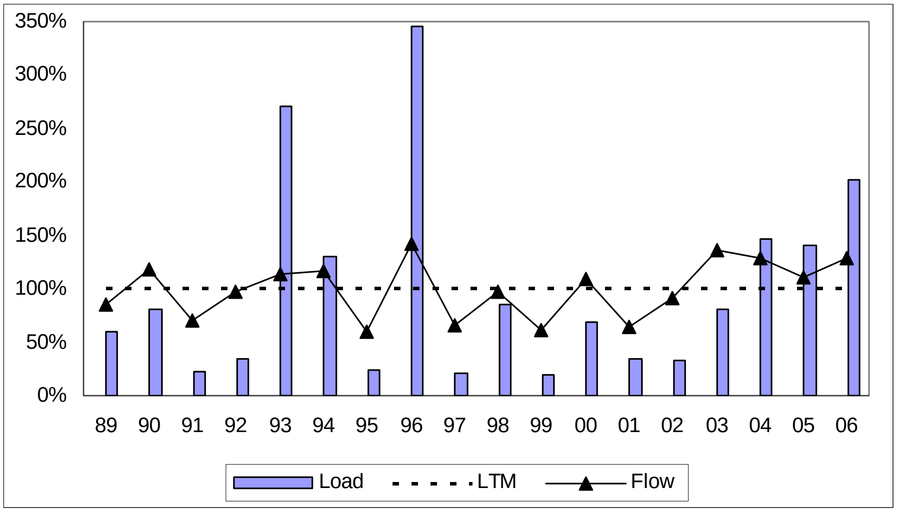


Figure 13. Ratio of Annual to LTM flow and SS loads at Towanda

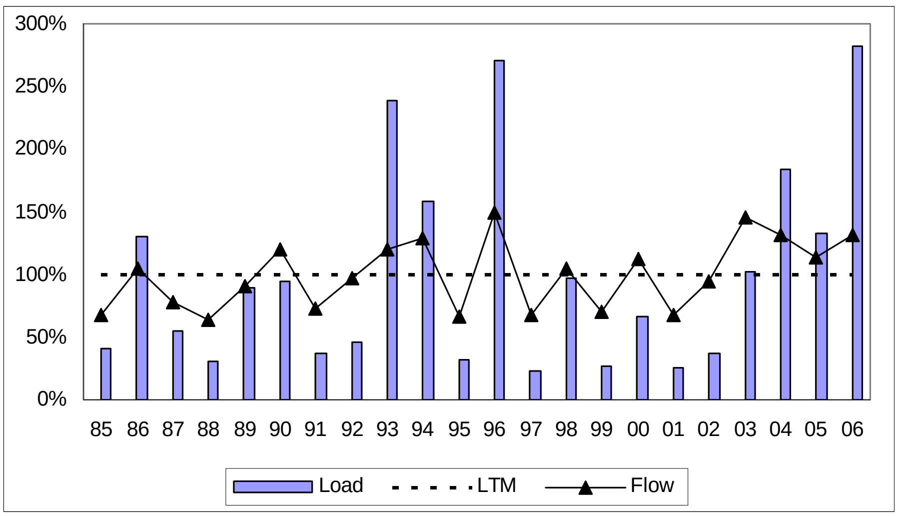


Figure 14. Ratio of Annual to LTM flow and SS loads at Danville

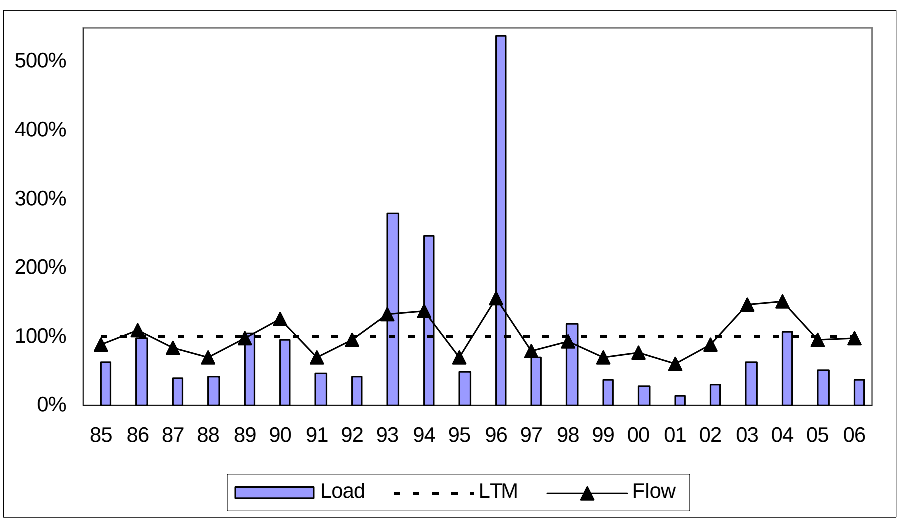


Figure 15. Ratio of Annual to LTM flow and SS loads at Lewisburg

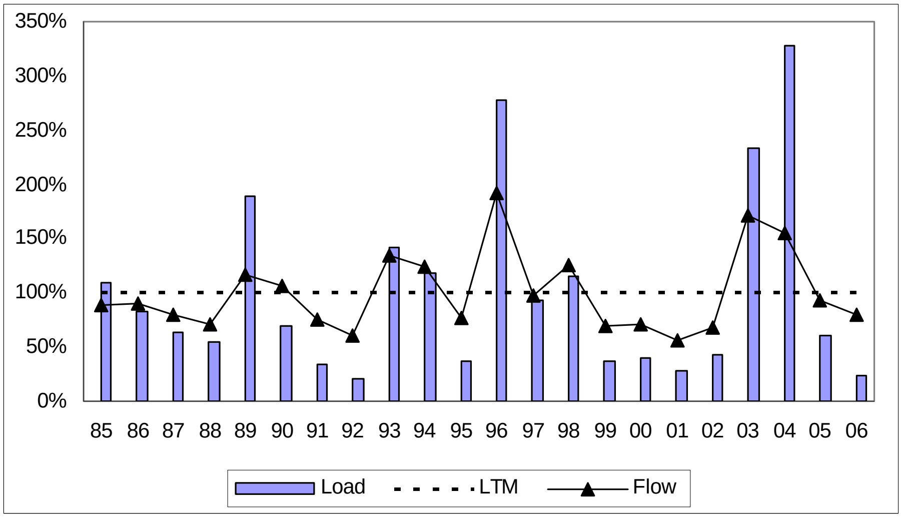


Figure 16. Ratio of Annual to LTM flow and SS loads at Newport

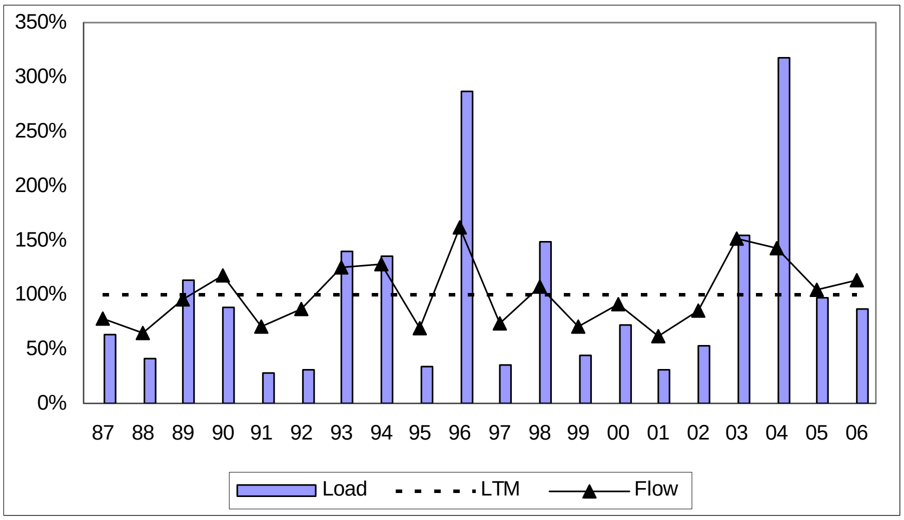


Figure 17. Ratio of Annual to LTM flow and SS loads at Marietta

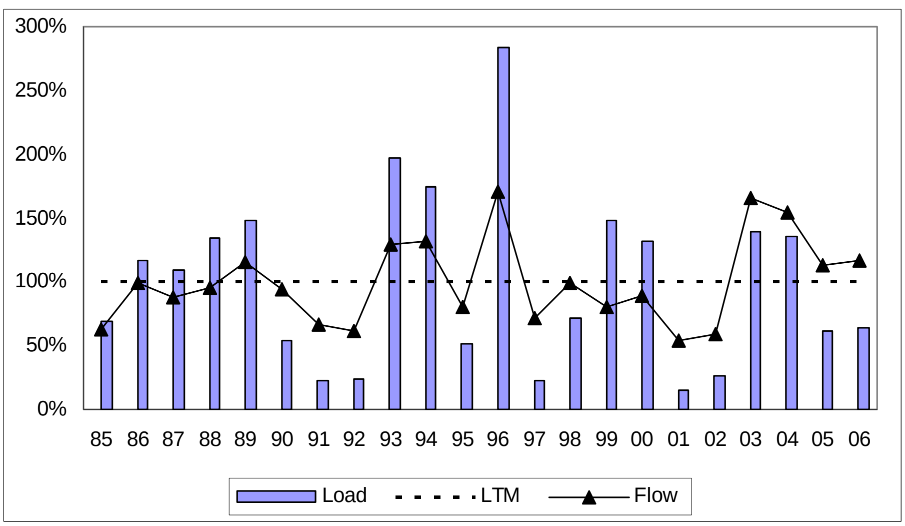


Figure 18. Ratio of Annual to LTM flow and SS loads at Conestoga

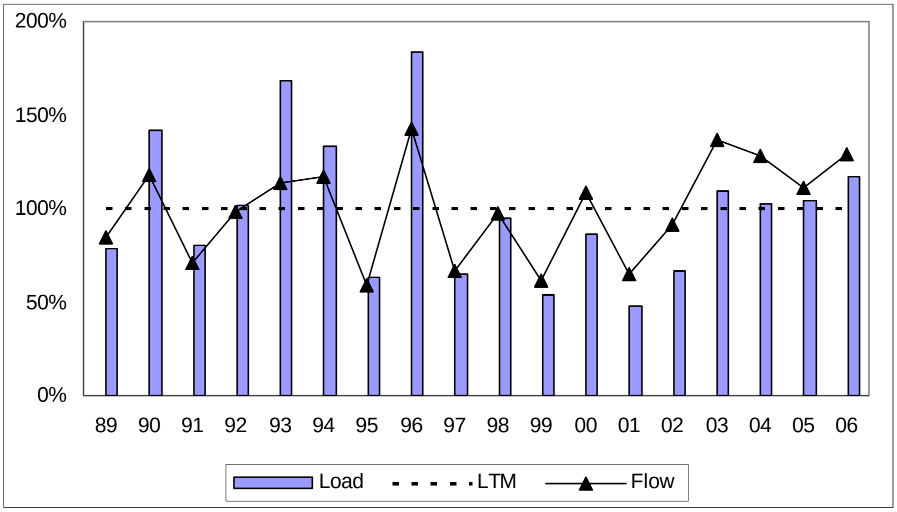


Figure 19. Ratio of Annual to LTM flow and TNH_3 loads at Towanda

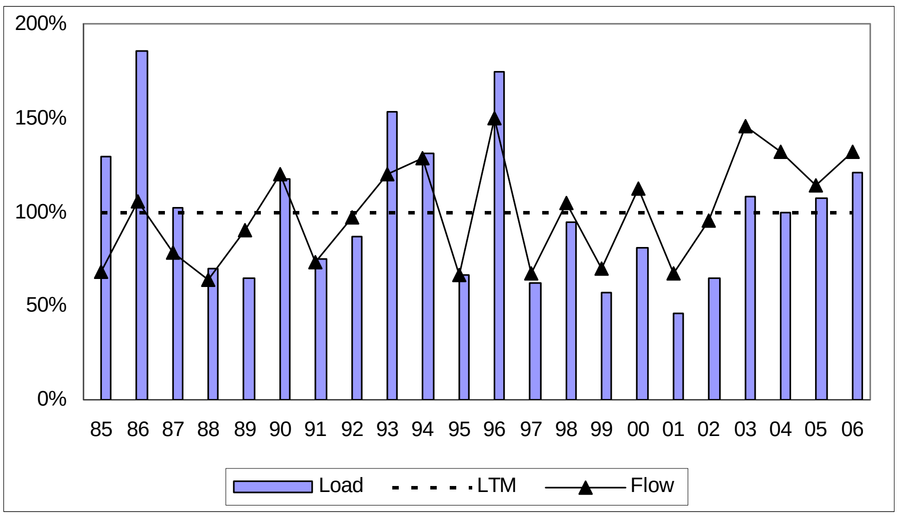


Figure 20. Ratio of Annual to LTM flow and TNH_3 loads at Danville

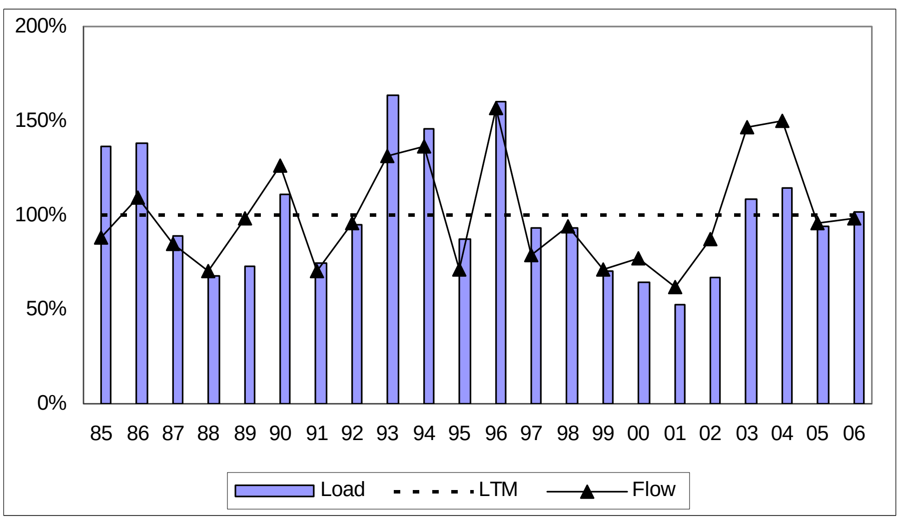


Figure 21. Ratio of Annual to LTM flow and TNH_3 loads at Lewisburg

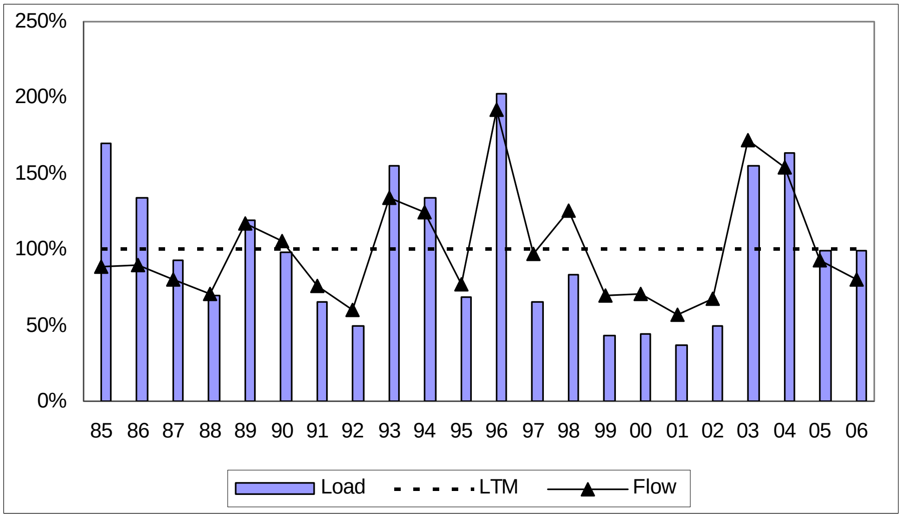


Figure 22. Ratio of Annual to LTM flow and TNH_3 loads at Newport

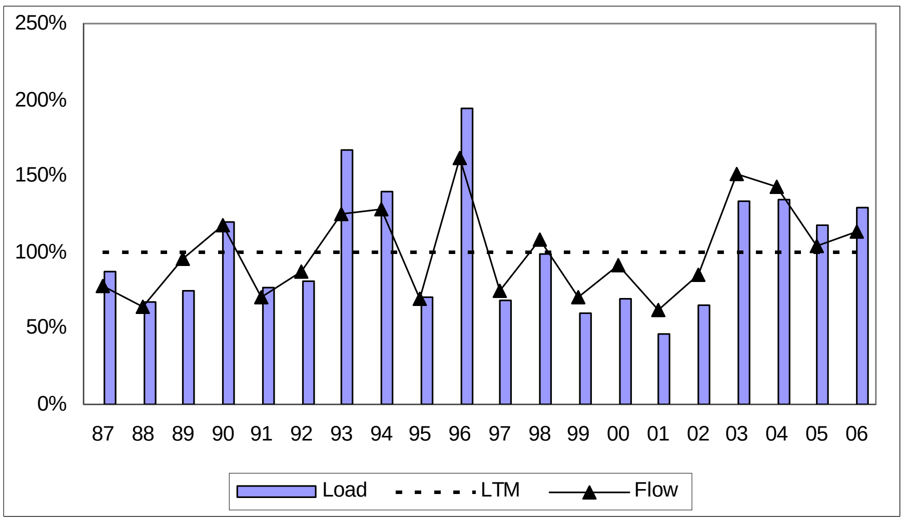


Figure 23. Ratio of Annual to LTM flow and TNH_3 loads at Marietta

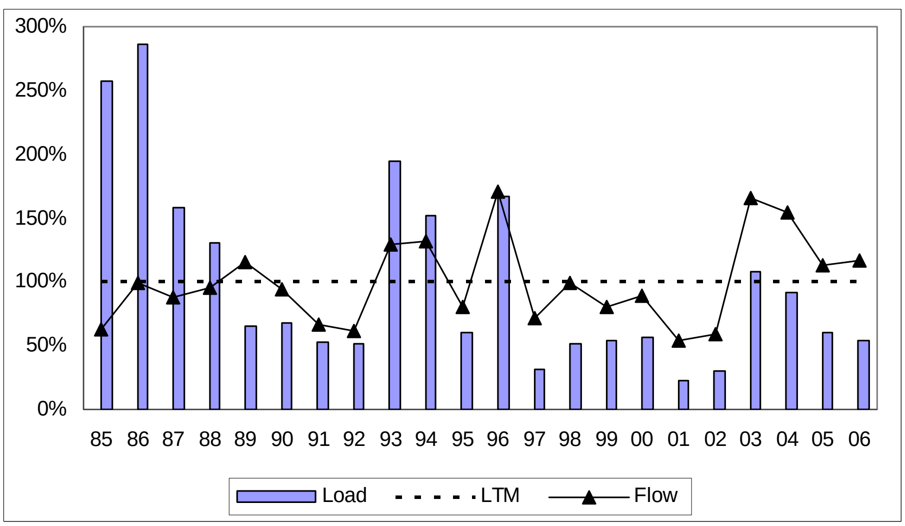


Figure 24. Ratio of Annual to LTM flow and TNH_3 loads at Conestoga

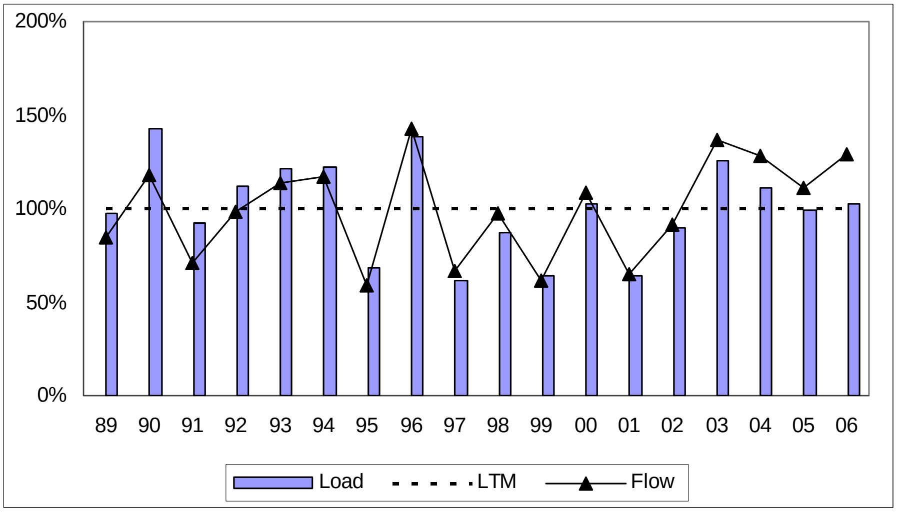


Figure 25. Ratio of Annual to LTM flow and TNOx loads at Towanda

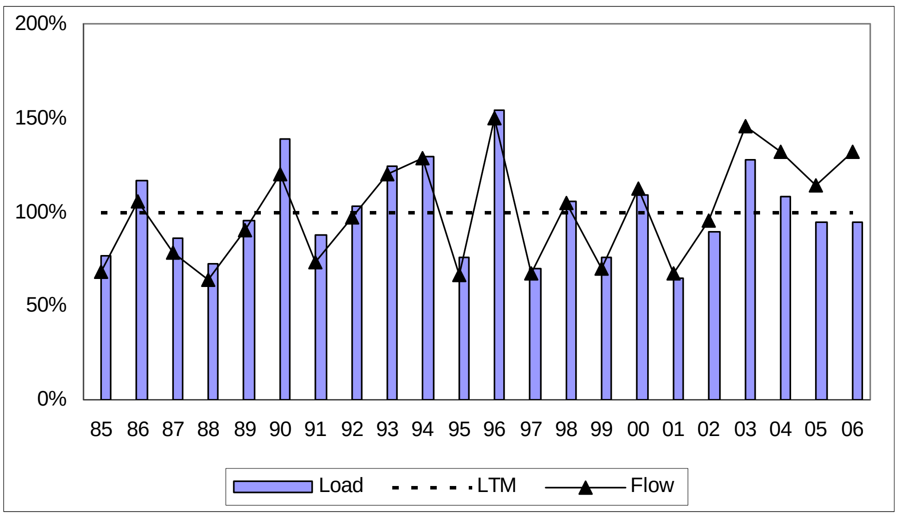


Figure 26. Ratio of Annual to LTM flow and TNOx loads at Danville

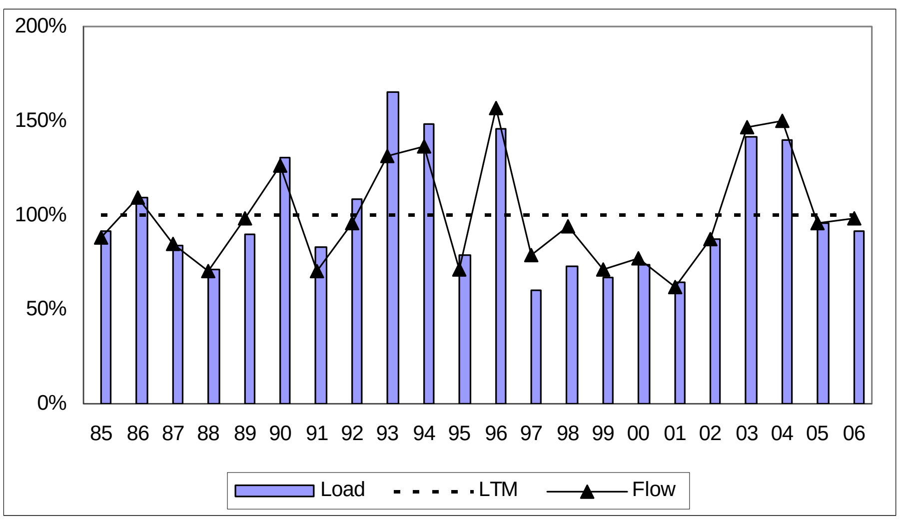


Figure 27. Ratio of Annual to LTM flow and TNOx loads at Lewisburg

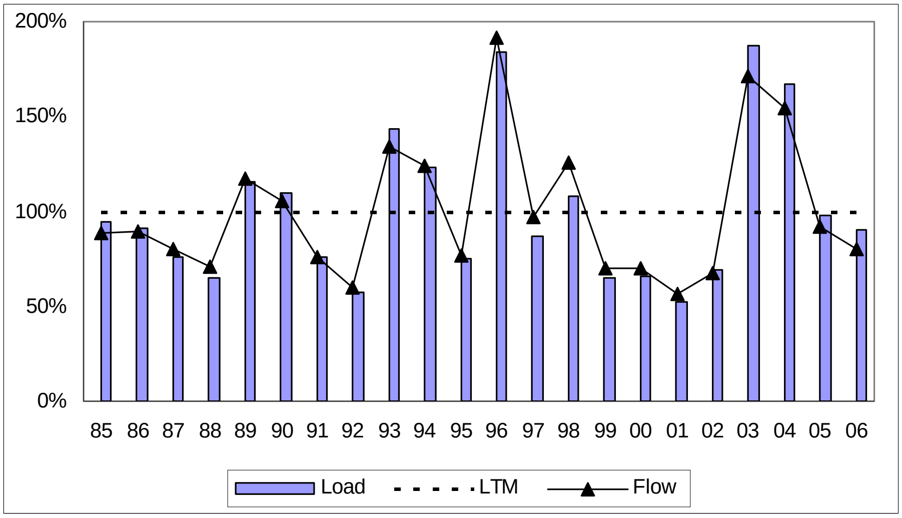


Figure 28. Ratio of Annual to LTM flow and TNOx loads at Newport

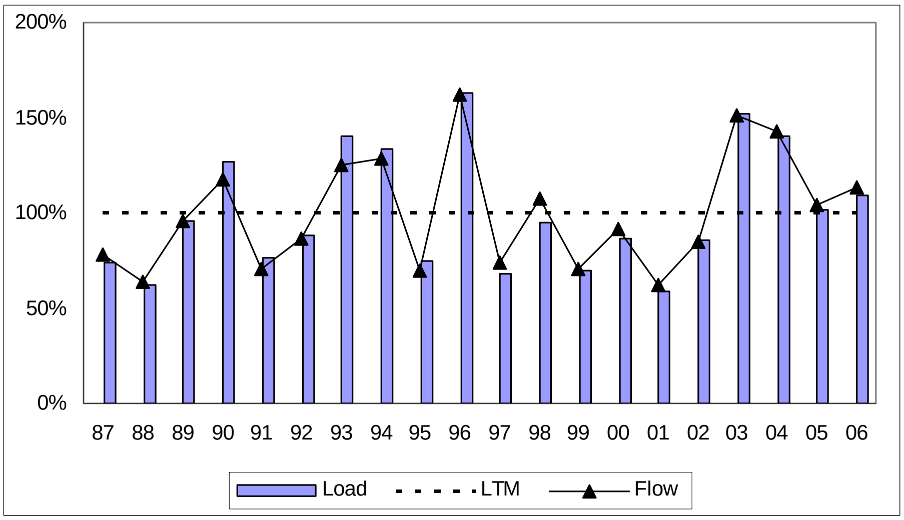


Figure 29. Ratio of Annual to LTM flow and TNOx loads at Marietta

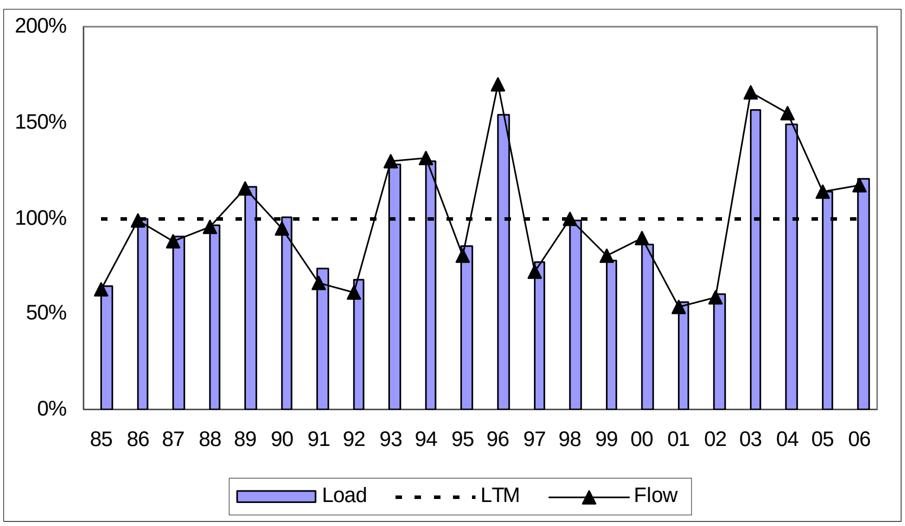


Figure 30. Ratio of Annual to LTM flow and TNOx loads at Conestoga

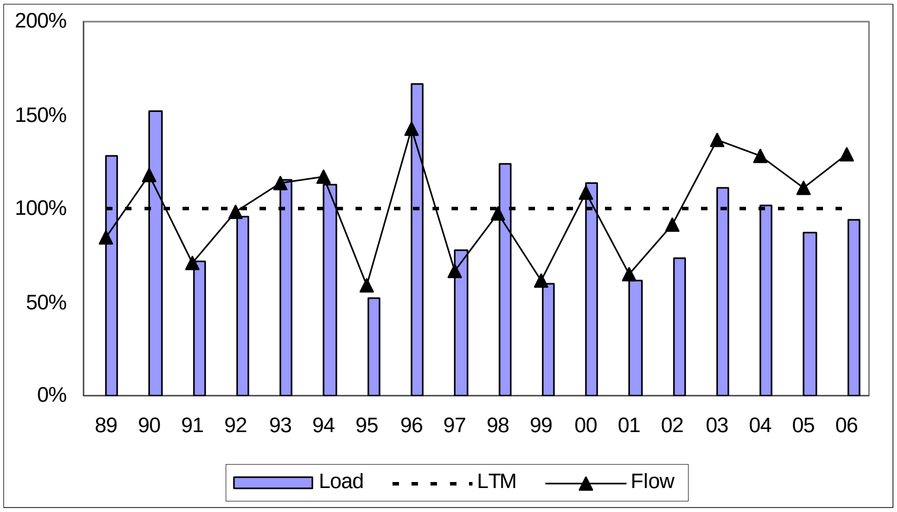


Figure 31. Ratio of Annual to LTM flow and TON loads at Towanda

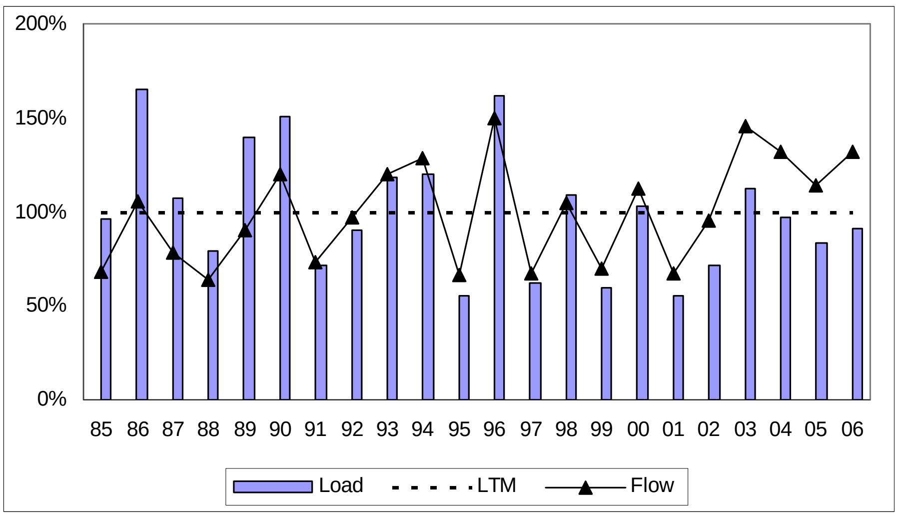


Figure 32. Ratio of Annual to LTM flow and TON loads at Danville

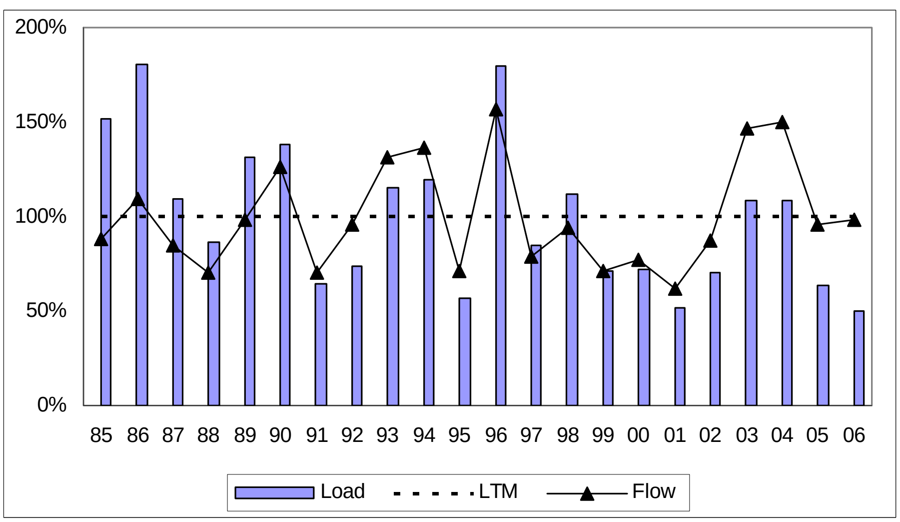


Figure 33. Ratio of Annual to LTM flow and TON loads at Lewisburg

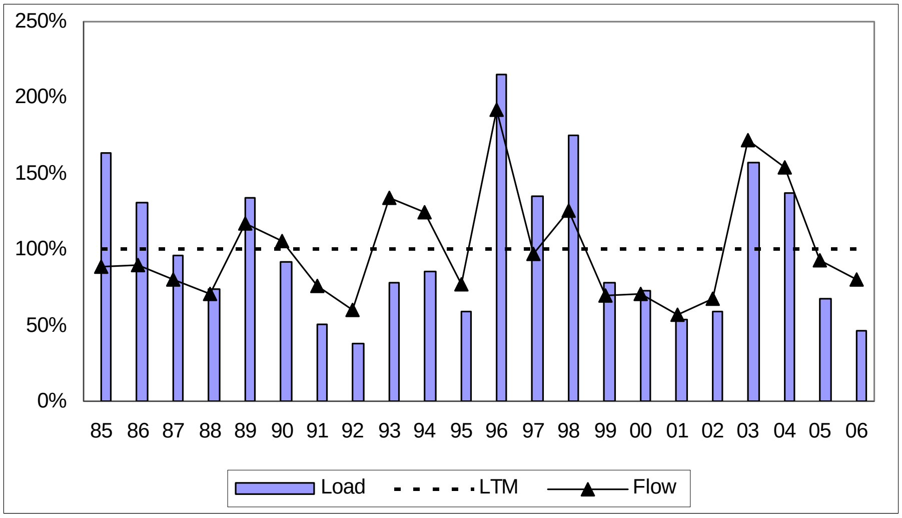


Figure 34. Ratio of Annual to LTM flow and TON loads at Newport

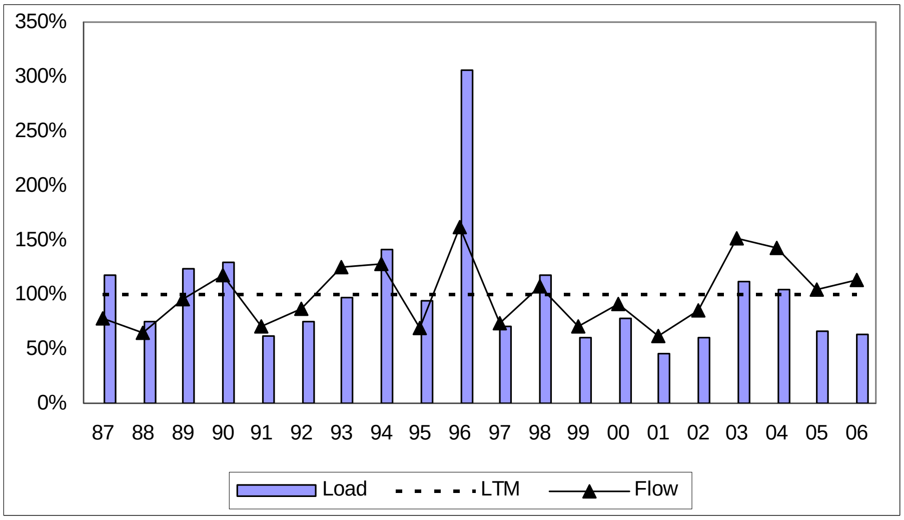


Figure 35. Ratio of Annual to LTM flow and TON loads at Marietta

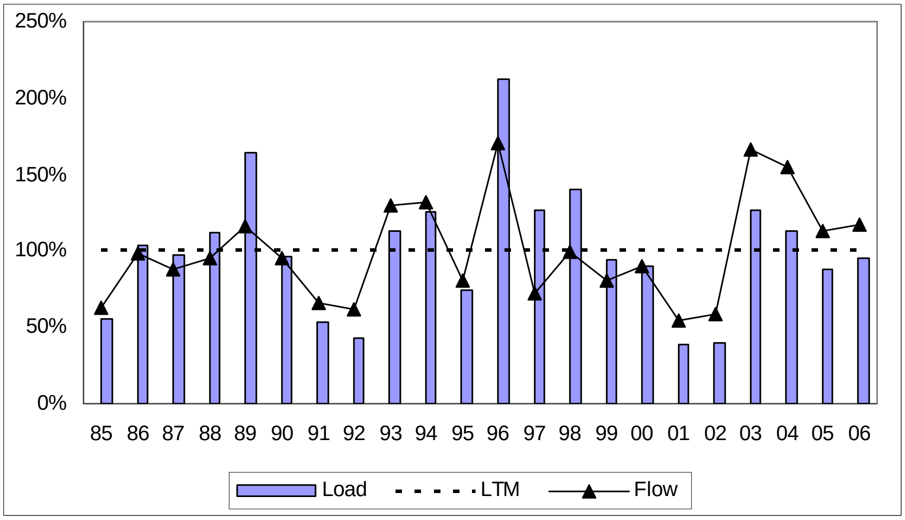


Figure 36. Ratio of Annual to LTM flow and TON loads at Conestoga

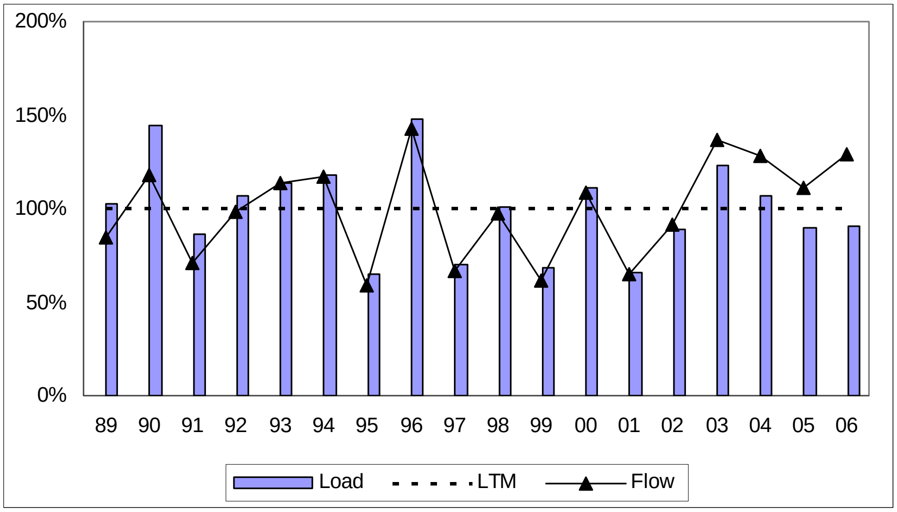


Figure 37. Ratio of Annual to LTM flow and DN loads at Towanda

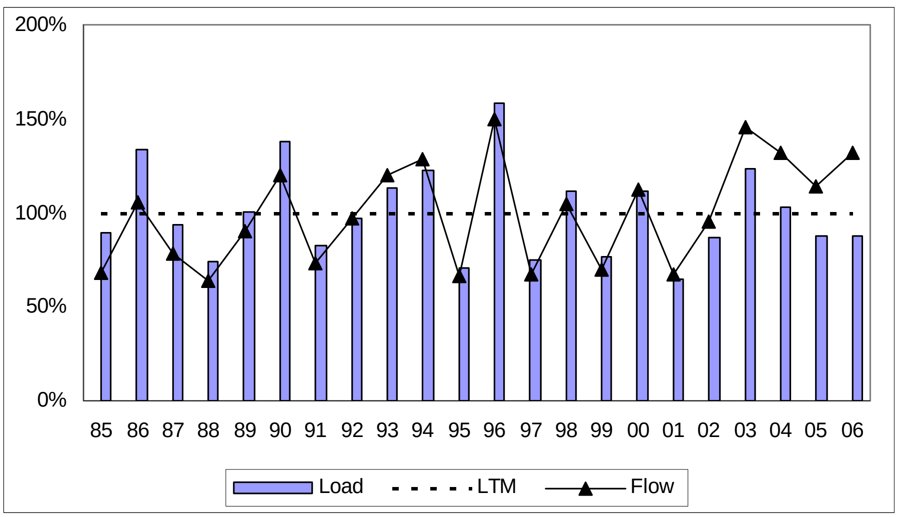


Figure 38. Ratio of Annual to LTM flow and DN loads at Danville

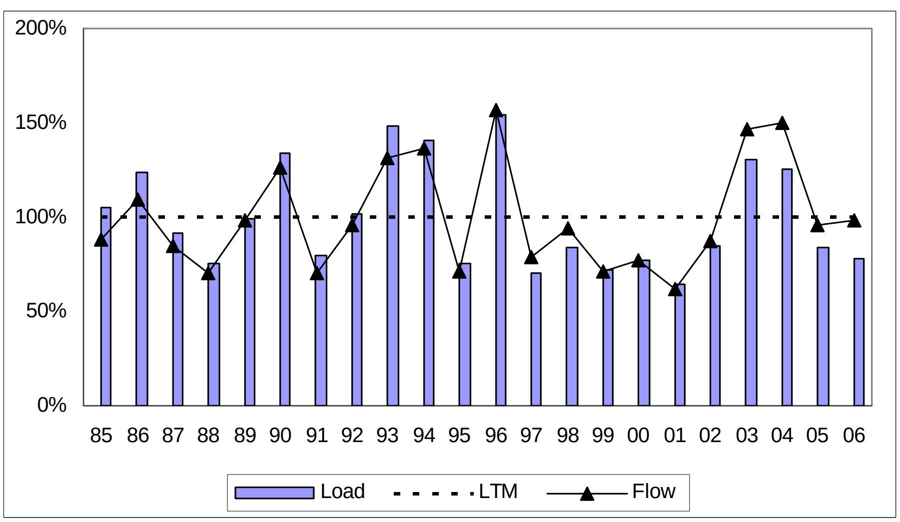


Figure 39. Ratio of Annual to LTM flow and DN loads at Lewisburg

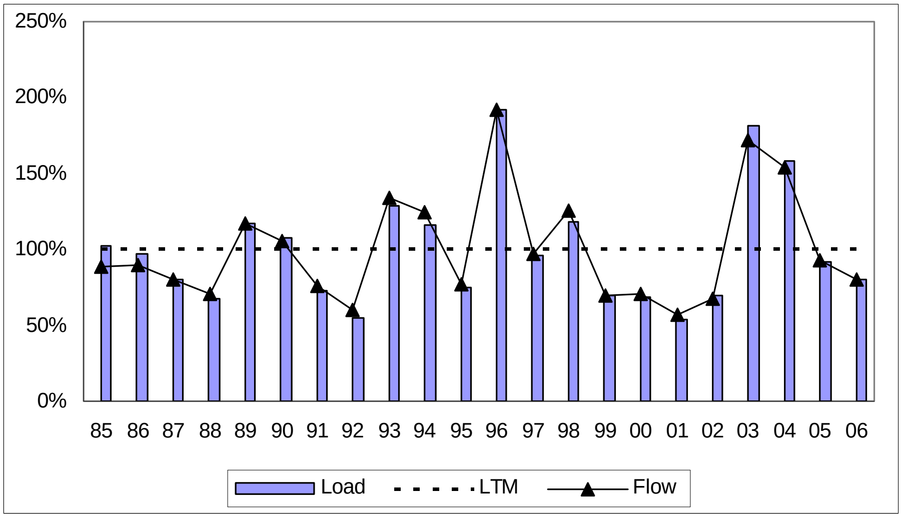


Figure 40. Ratio of Annual to LTM flow and DN loads at Newport

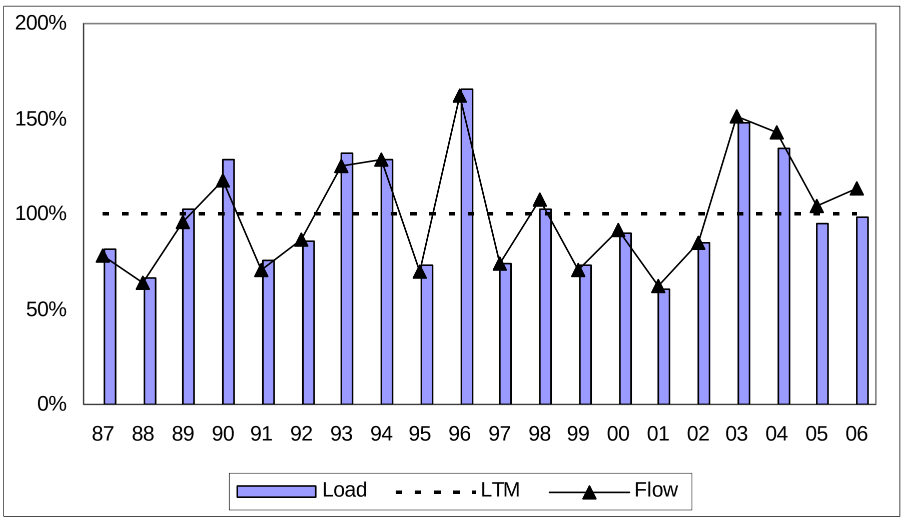


Figure 41. Ratio of Annual to LTM flow and DN loads at Marietta

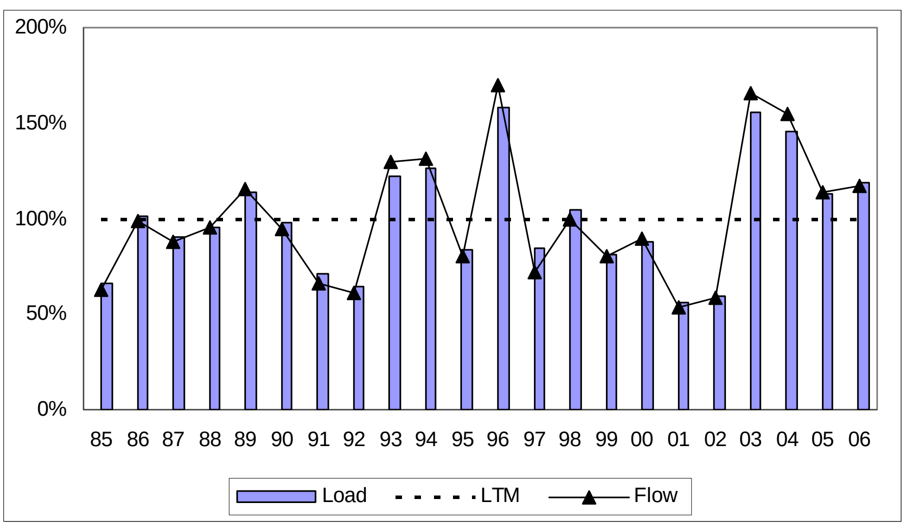


Figure 42. Ratio of Annual to LTM flow and DN loads at Conestoga

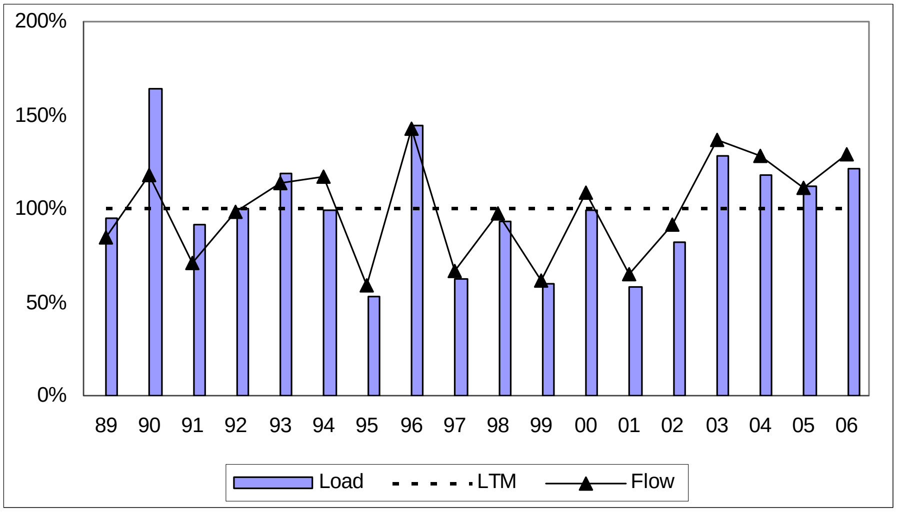


Figure 43. Ratio of Annual to LTM flow and DNH_3 loads at Towanda

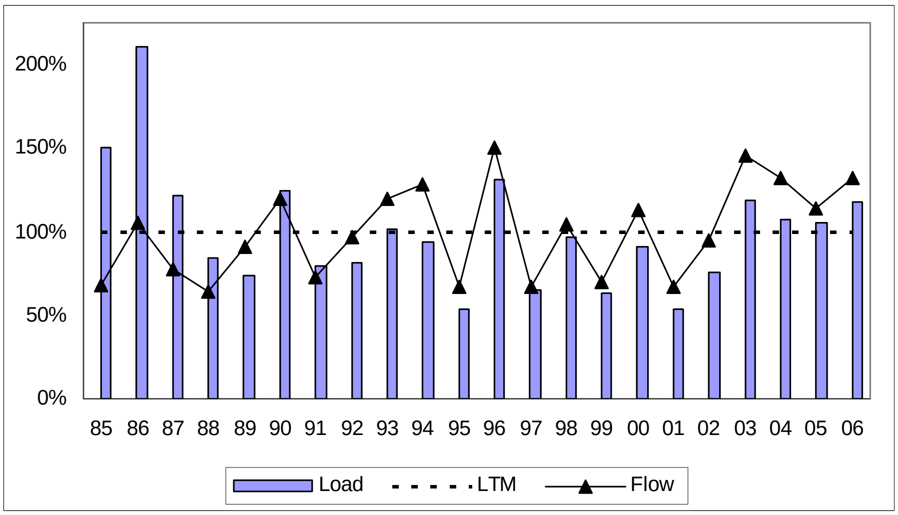


Figure 44. Ratio of Annual to LTM flow and DNH_3 loads at Danville

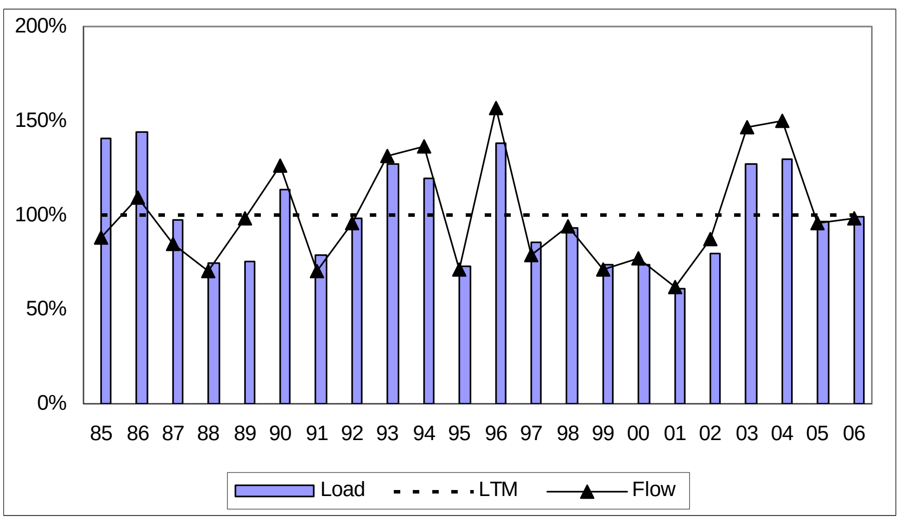


Figure 45. Ratio of Annual to LTM flow and DNH_3 loads at Lewisburg

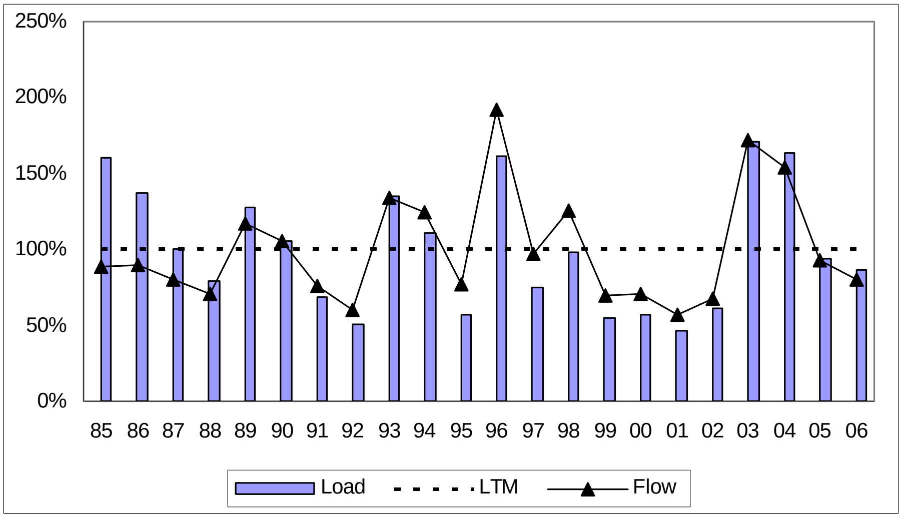


Figure 46. Ratio of Annual to LTM flow and DNH_3 loads at Newport

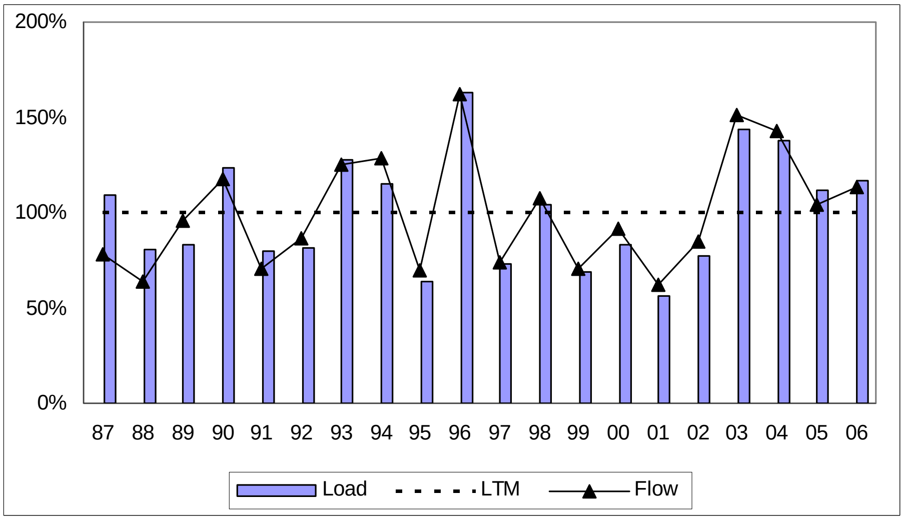


Figure 47. Ratio of Annual to LTM flow and DNH_3 loads at Marietta

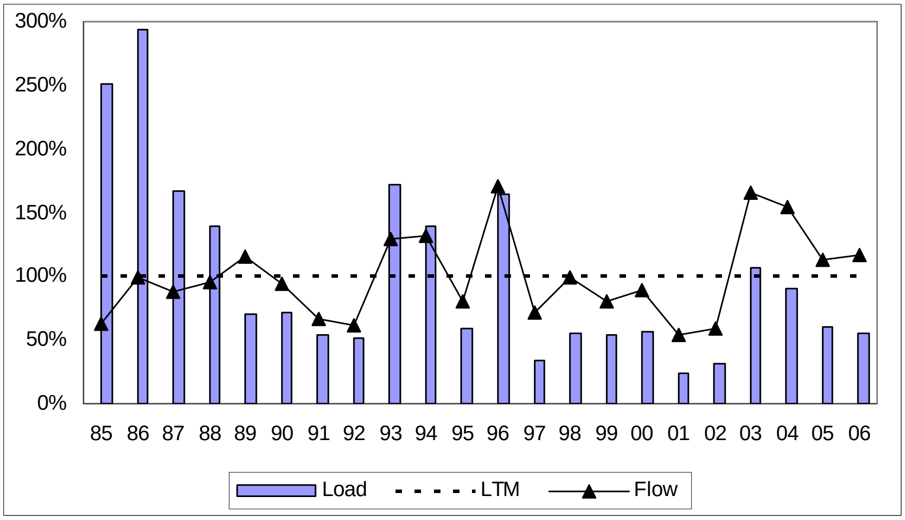


Figure 48. Ratio of Annual to LTM flow and DNH_3 loads at Conestoga

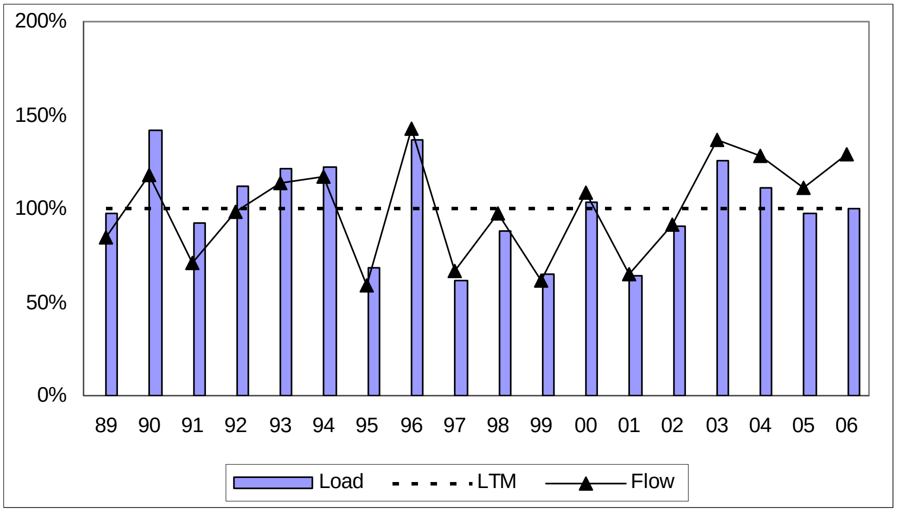


Figure 49. Ratio of Annual to LTM flow and DNOx loads at Towanda

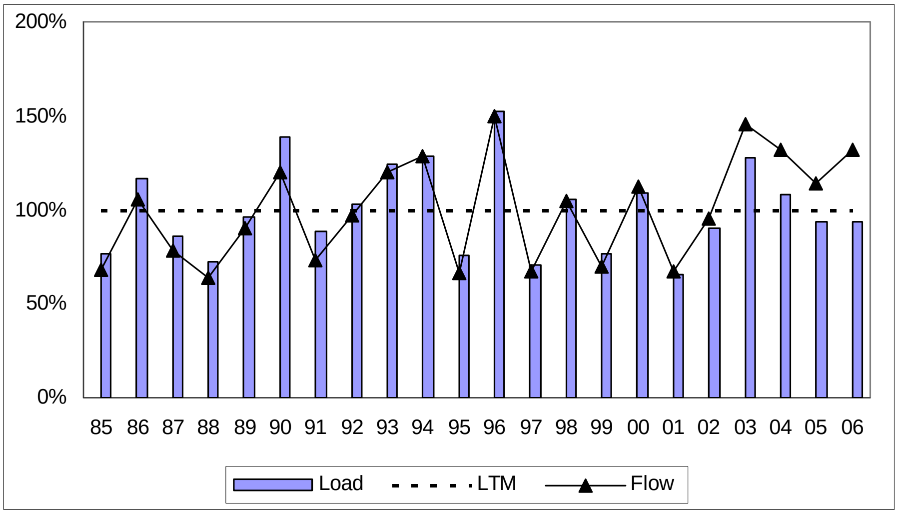


Figure 50. Ratio of Annual to LTM flow and DNOx loads at Danville

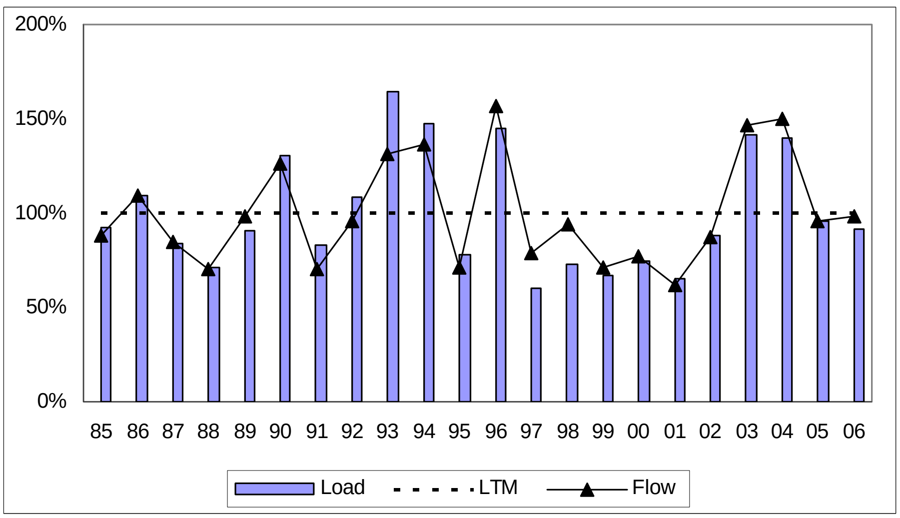


Figure 51. Ratio of Annual to LTM flow and DNOx loads at Lewisburg

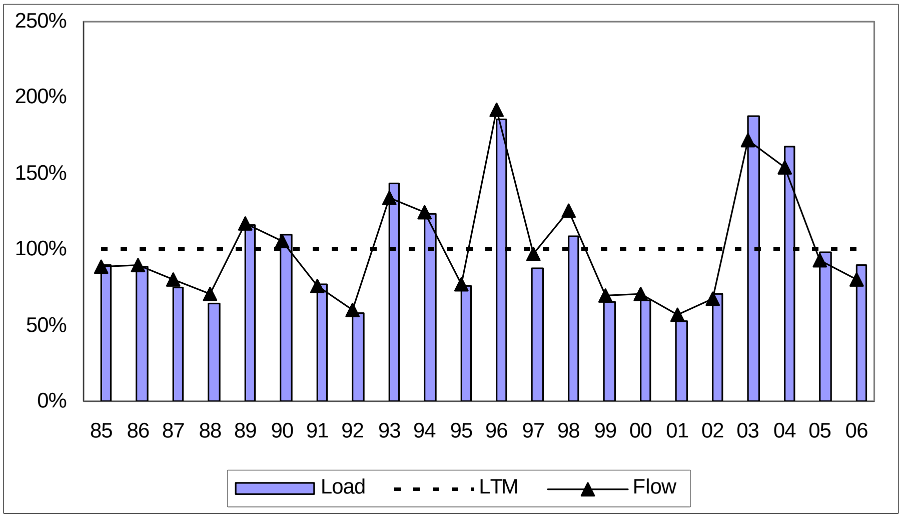


Figure 52. Ratio of Annual to LTM flow and DNOx loads at Newport

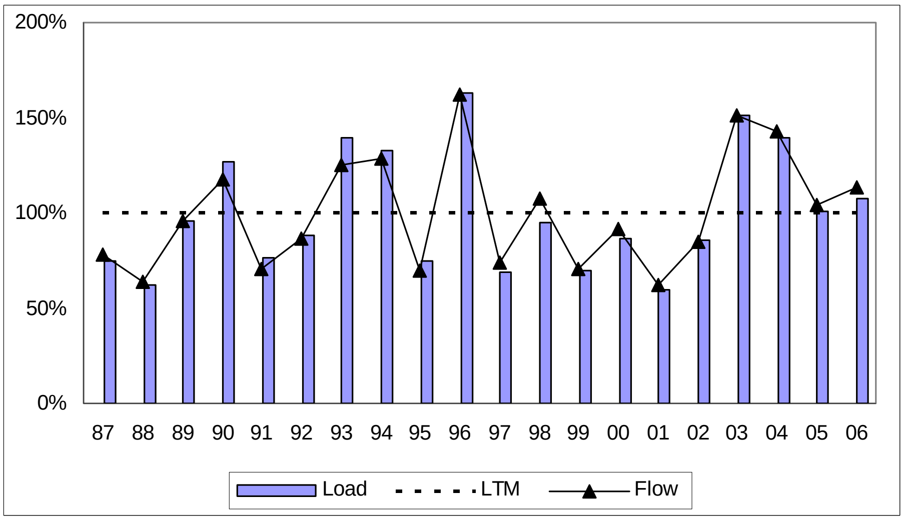


Figure 53. Ratio of Annual to LTM flow and DNOx loads at Marietta

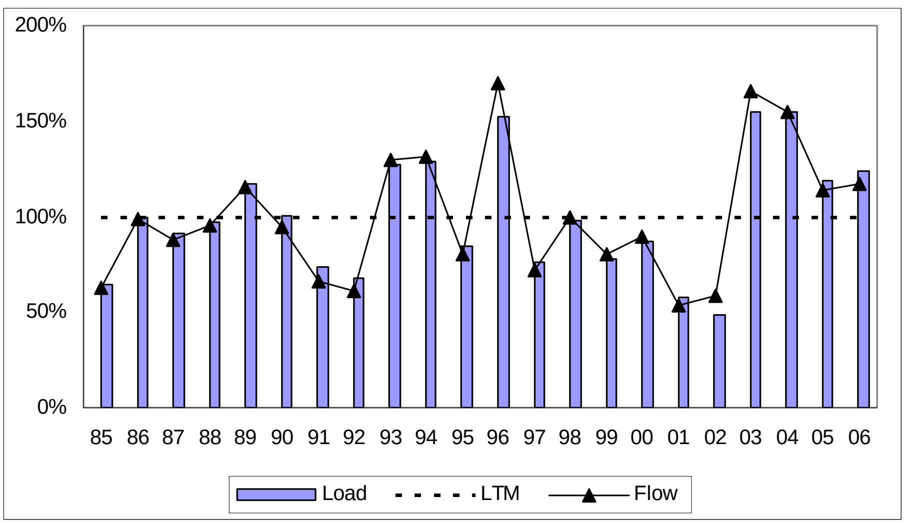


Figure 54. Ratio of Annual to LTM flow and DNOx loads at Conestoga

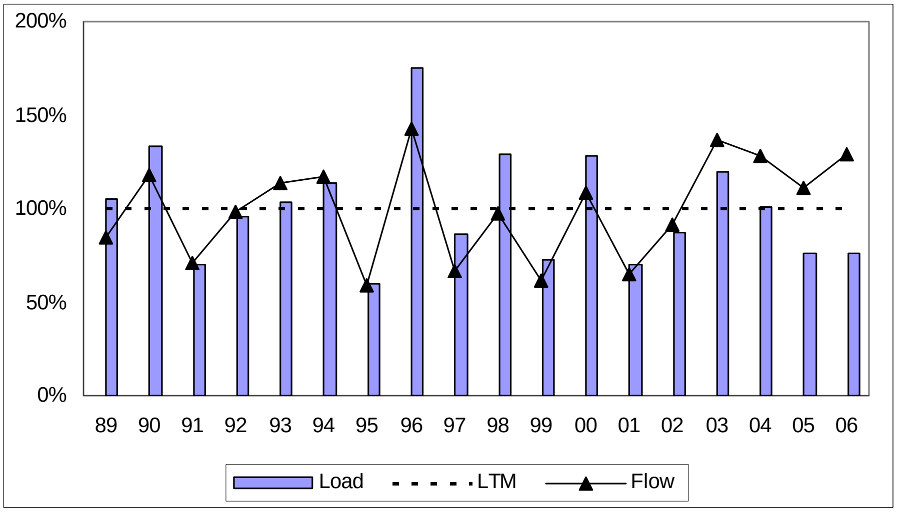


Figure 55. Ratio of Annual to LTM flow and DON loads at Towanda

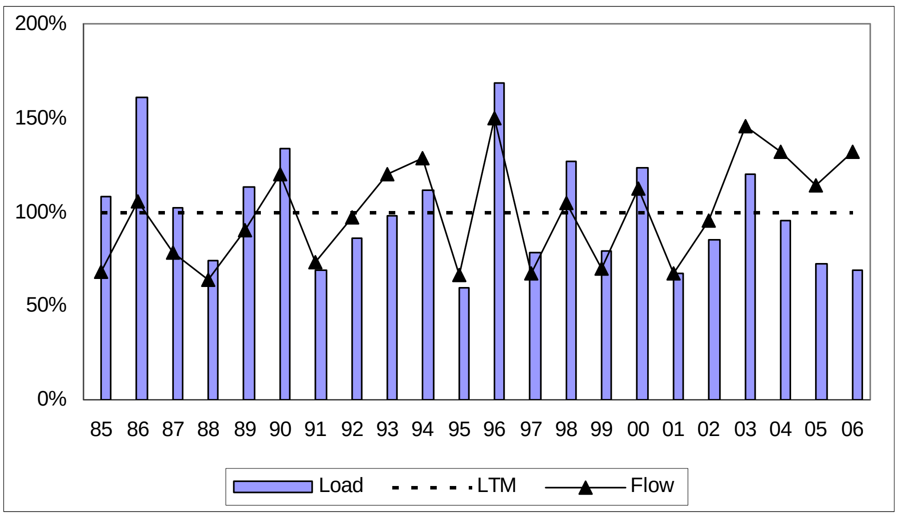


Figure 56. Ratio of Annual to LTM flow and DON loads at Danville

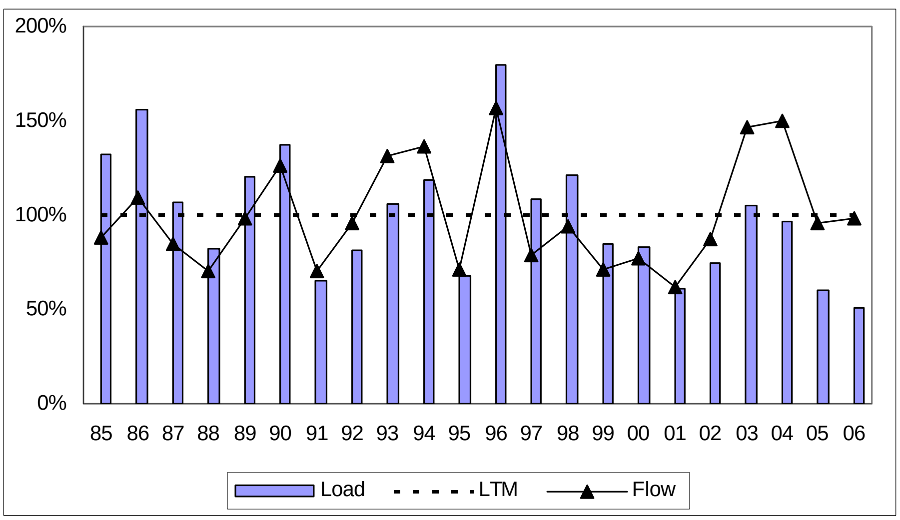


Figure 57. Ratio of Annual to LTM flow and DON loads at Lewisburg

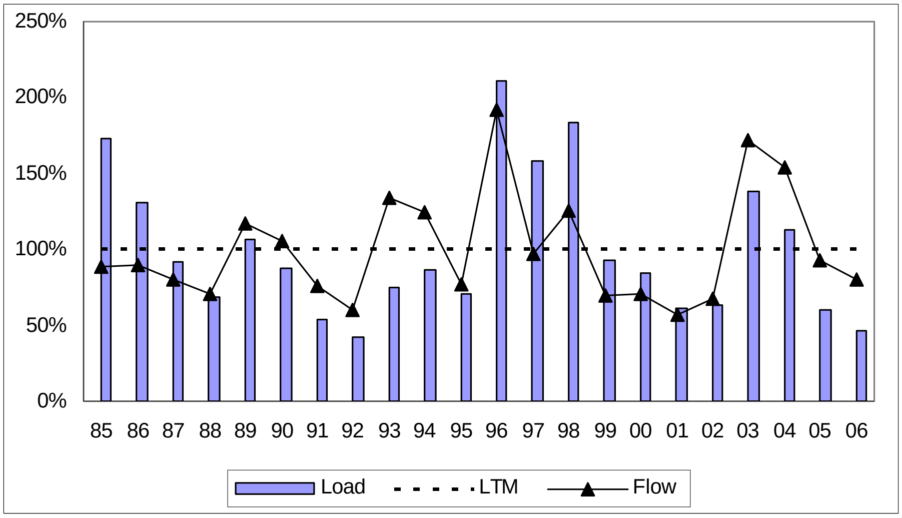


Figure 58. Ratio of Annual to LTM flow and DON loads at Newport

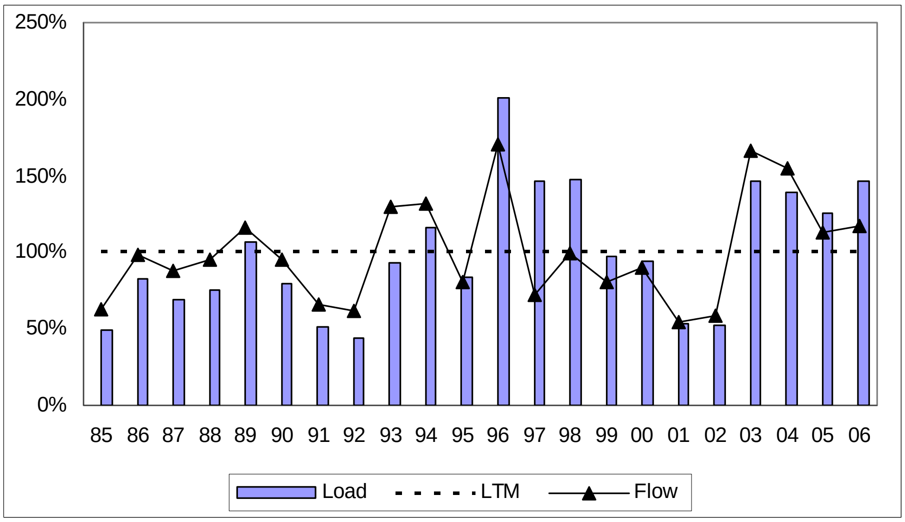


Figure 59. Ratio of Annual to LTM flow and DON loads at Marietta

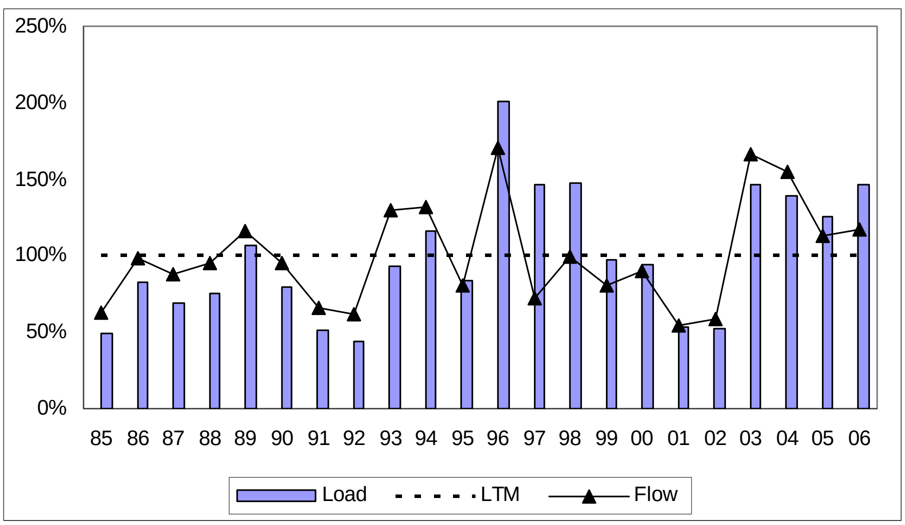


Figure 60. Ratio of Annual to LTM flow and DON loads at Conestoga

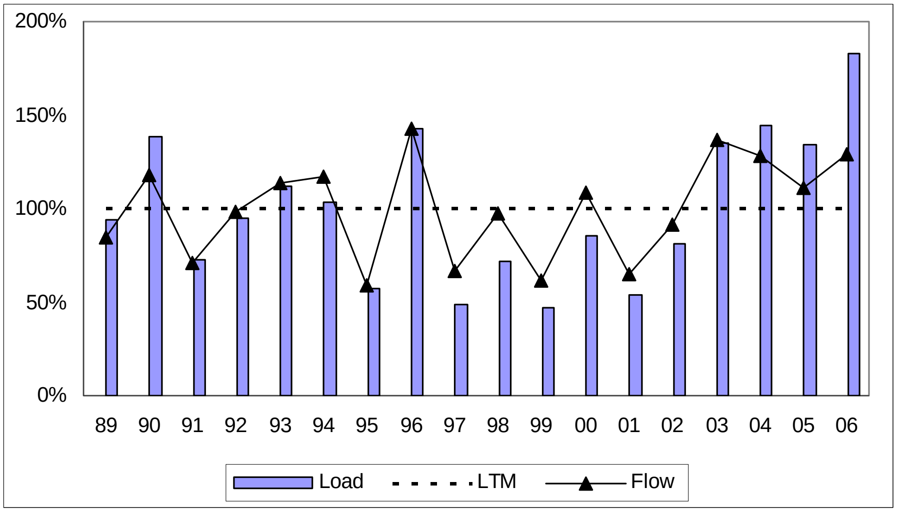


Figure 61. Ratio of Annual to LTM flow and DP loads at Towanda

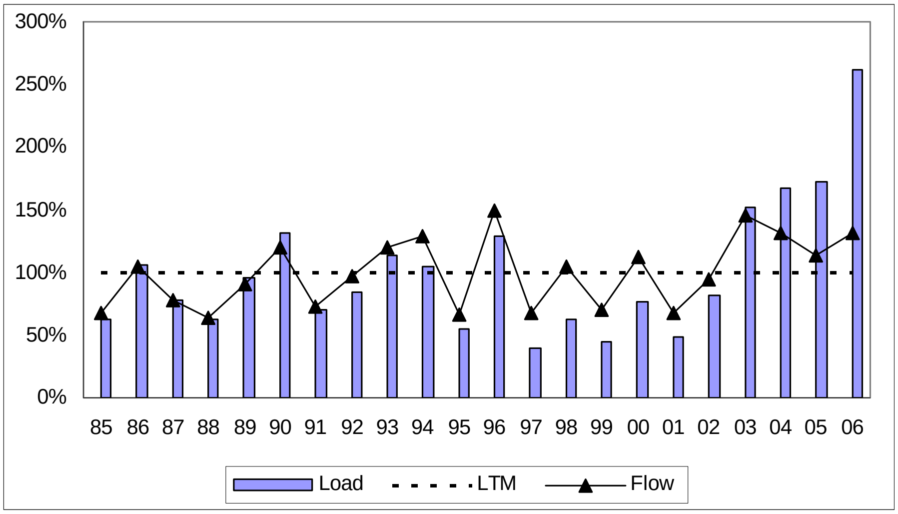


Figure 62. Ratio of Annual to LTM flow and DP loads at Danville

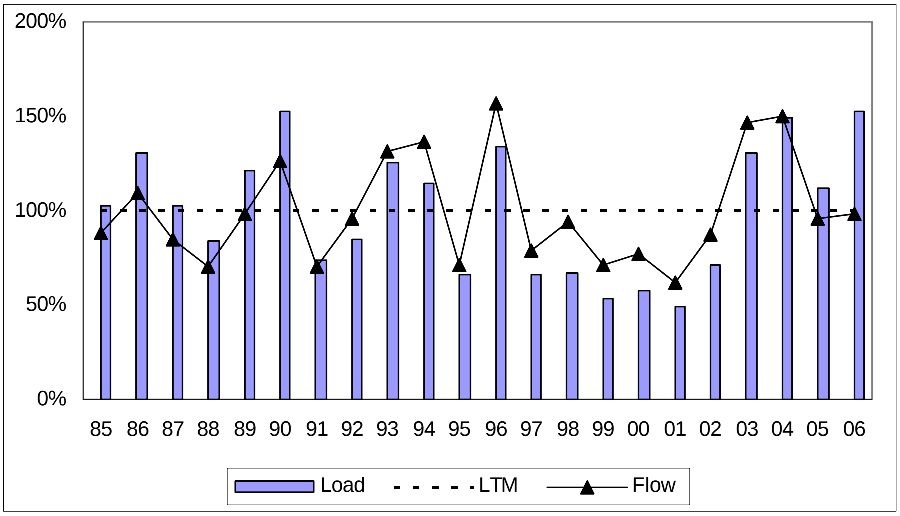


Figure 63. Ratio of Annual to LTM flow and DP loads at Lewisburg

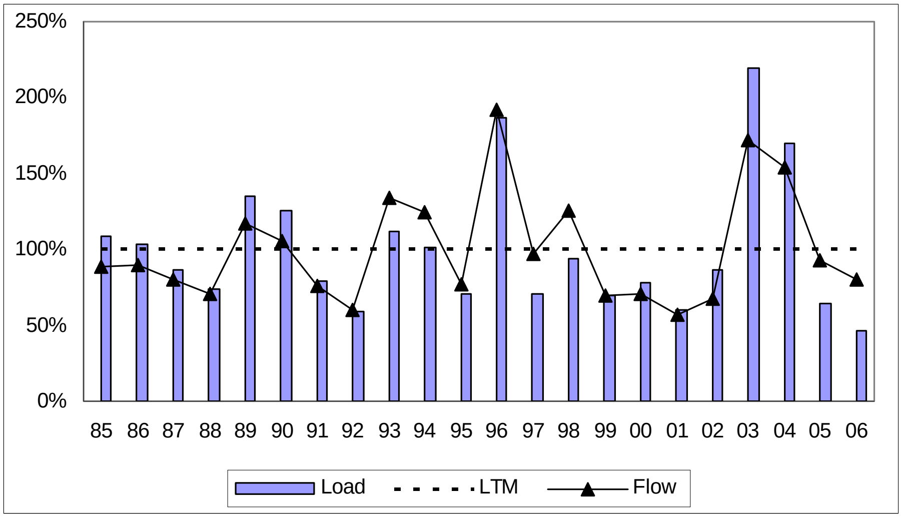


Figure 64. Ratio of Annual to LTM flow and DP loads at Newport

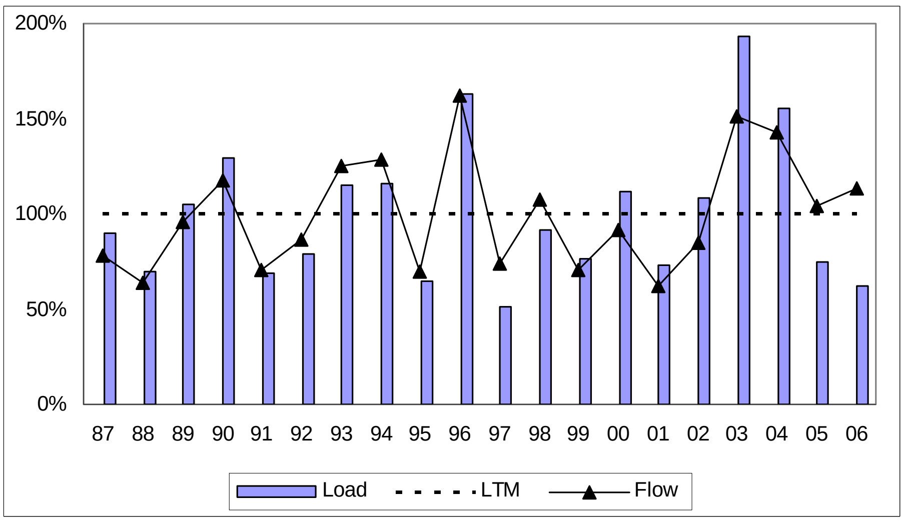


Figure 65. Ratio of Annual to LTM flow and DP loads at Marietta

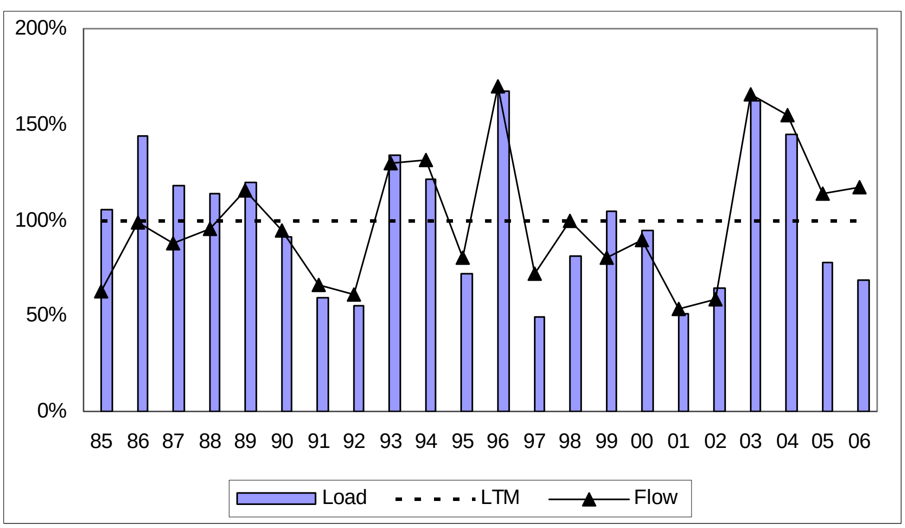


Figure 66. Ratio of Annual to LTM flow and DP loads at Conestoga

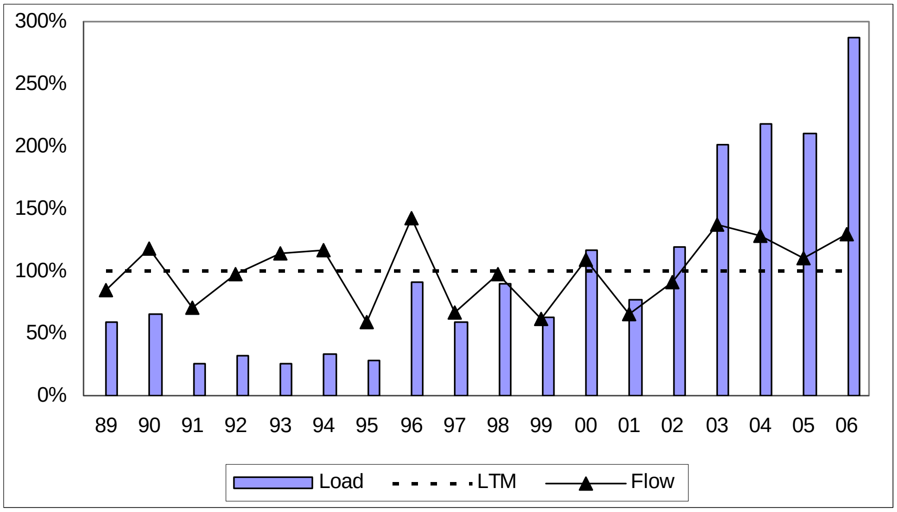


Figure 67. Ratio of Annual to LTM flow and DOP loads at Towanda

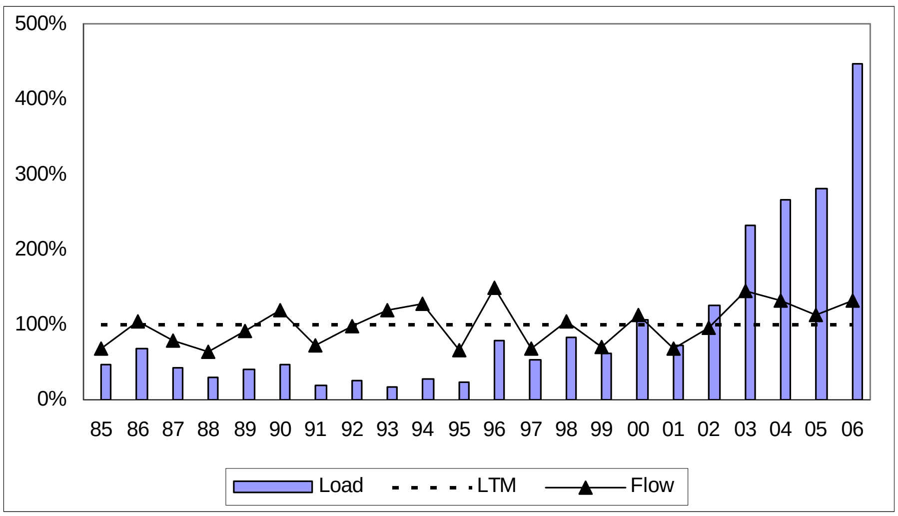


Figure 68. Ratio of Annual to LTM flow and DOP loads at Danville

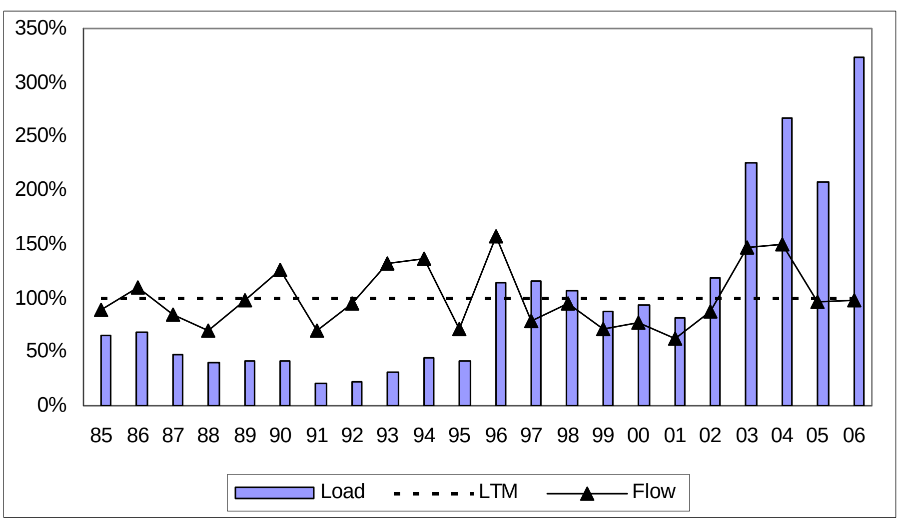


Figure 69. Ratio of Annual to LTM flow and DOP loads at Lewisburg

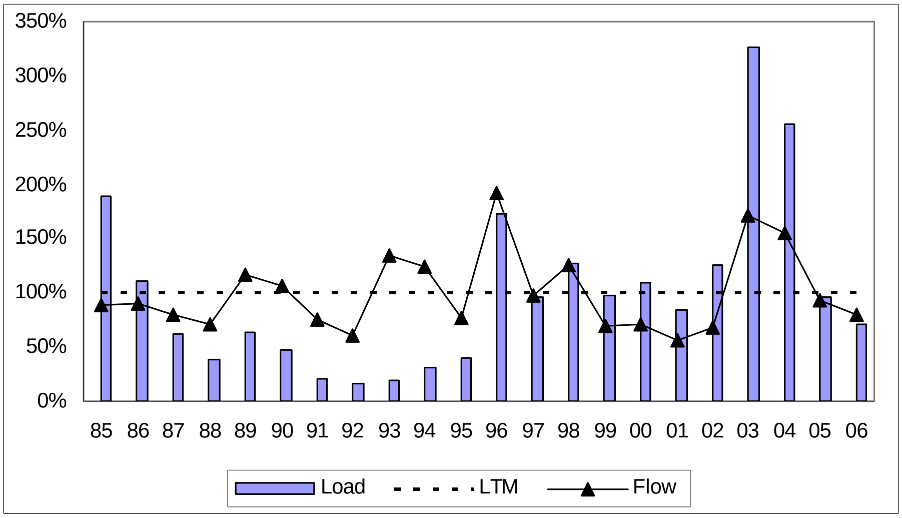


Figure 70. Ratio of Annual to LTM flow and DOP loads at Newport

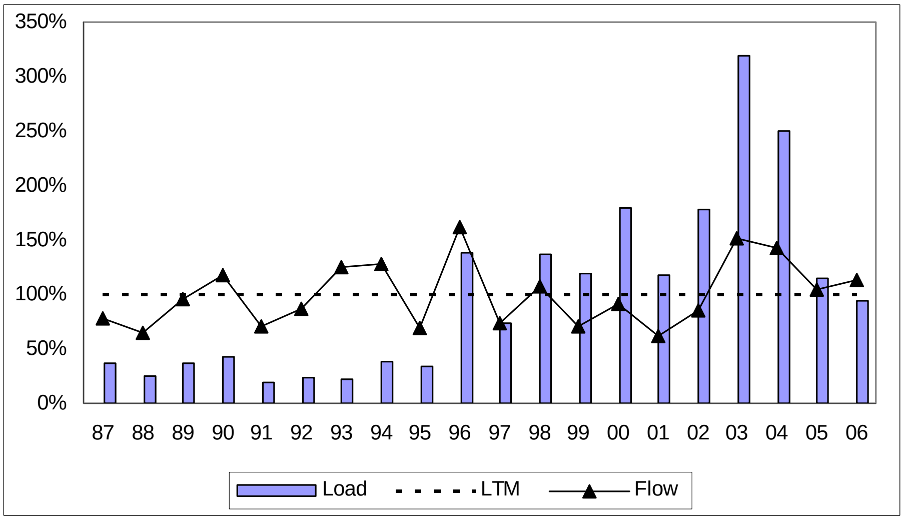


Figure 71. Ratio of Annual to LTM flow and DOP loads at Marietta

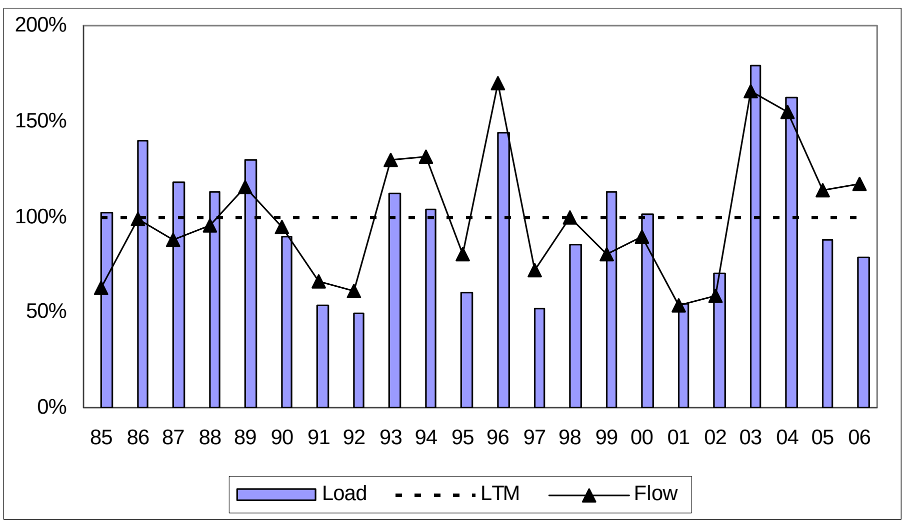


Figure 72. Ratio of Annual to LTM flow and DOP loads at Conestoga

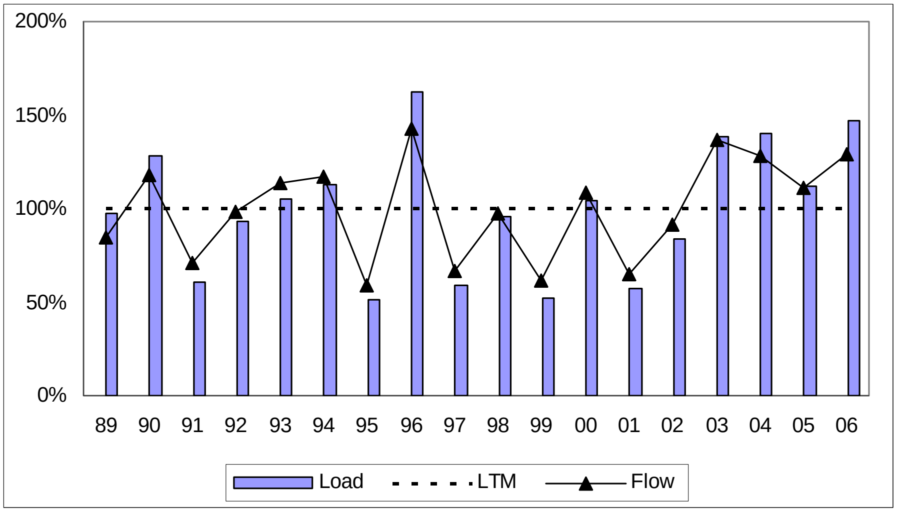


Figure 73. Ratio of Annual to LTM flow and TOC loads at Towanda

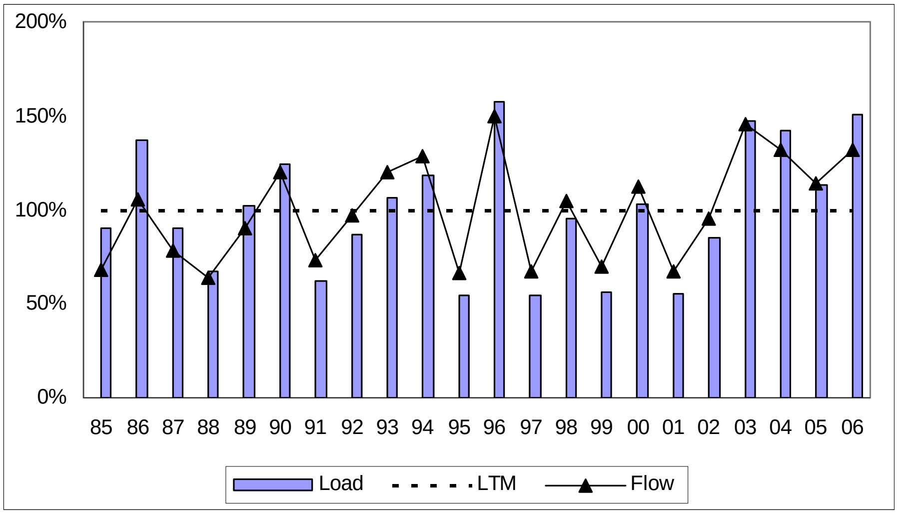


Figure 74. Ratio of Annual to LTM flow and TOC loads at Danville

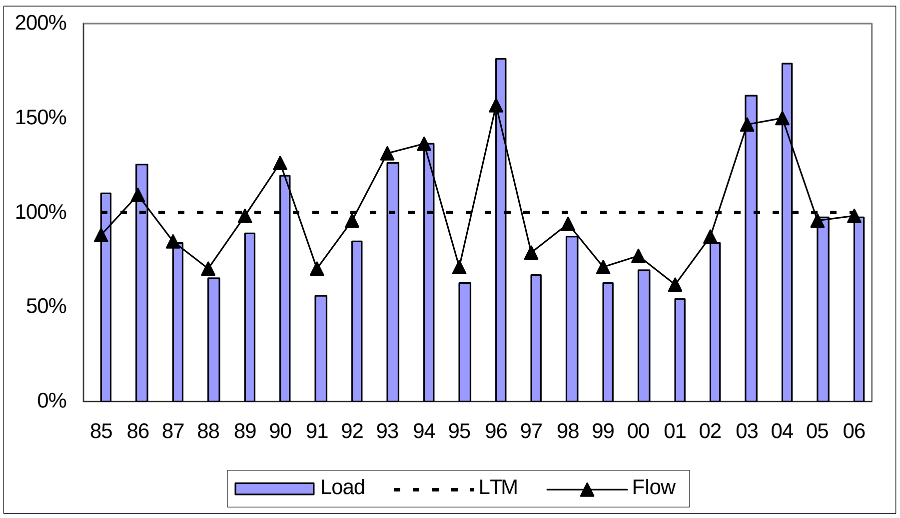


Figure 75. Ratio of Annual to LTM flow and TOC loads at Lewisburg

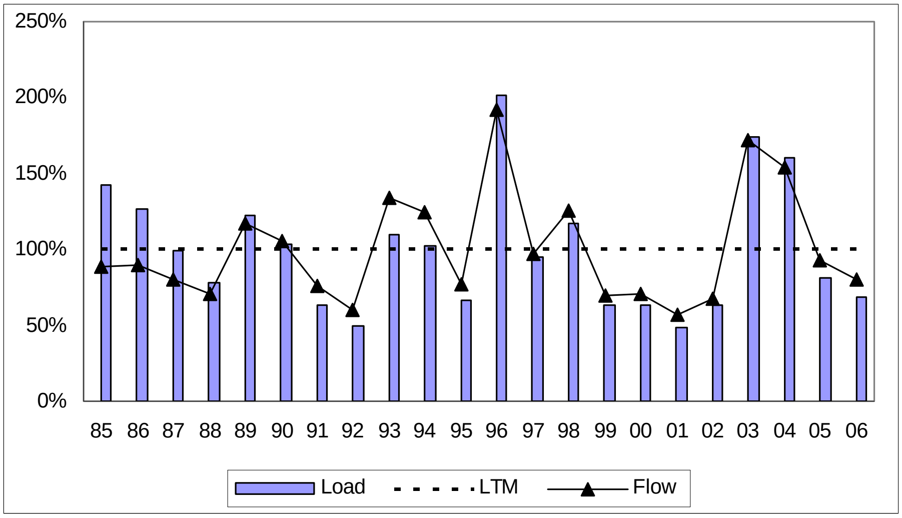


Figure 76. Ratio of Annual to LTM flow and TOC loads at Newport

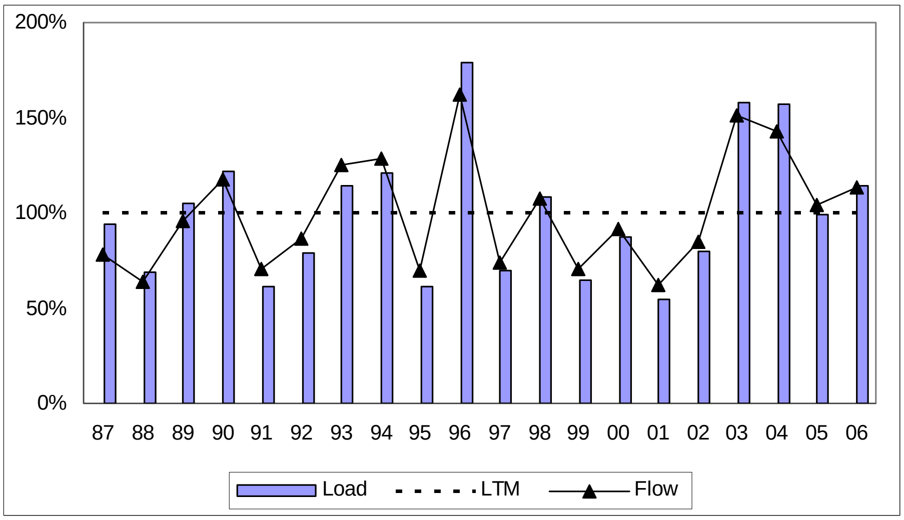


Figure 77. Ratio of Annual to LTM flow and TOC loads at Marietta

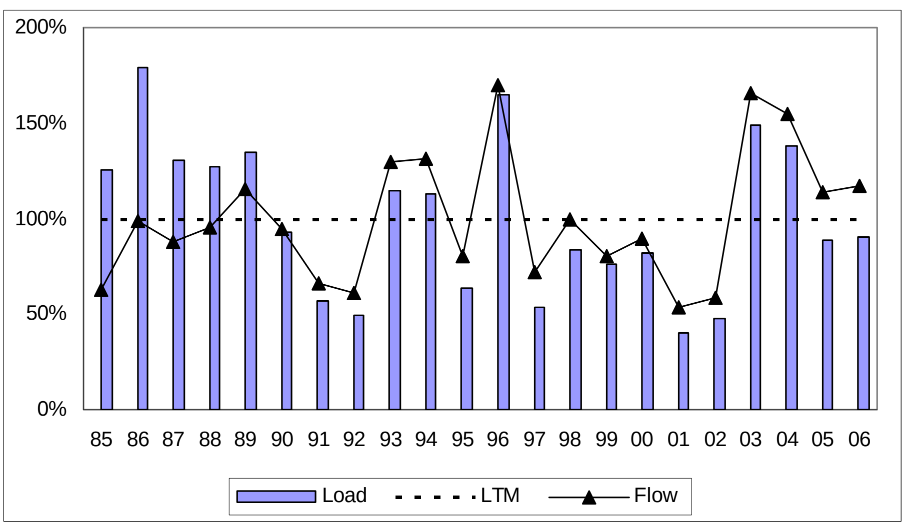


Figure 78. Ratio of Annual to LTM flow and TOC loads at Conestoga