

## **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 2005. FAC trends were estimated 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. Trends in FAC are directly taken from ESTIMATOR output. Trends in flow are calculated by using the Seasonal Kendall (SK) trend test within S-Plus, including the USGS ESTREND library addition (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 32 through 37. Each table lists the results for flow, the various nitrogen and phosphorus species, TOC, and SS. The level of significance is set at the p-value of 0.05 for FAC (Langland and others, 1999). The magnitude of the slope incorporates a confidence interval and is reported as a range (minimum and maximum). The slope direction is reported as not significant (NS) or, when significant, as improving or degrading. 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. Additional results from USGS are listed for TN, TNOx, TP, and SS for all sites. Due to model related issues only, the USGS trend value is given for SS at Conestoga.

**Table 32. Trend Statistics for the Susquehanna River at Towanda, Pa., January 1989 Through December 2005**

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	66.208	0.519	-	-	-	NS
TN	600	FAC		<0.0001	-39	-35	-31	IMPROVING
*TN	600	*FAC	-0.4586	<0.0001	-41	-37	-32	IMPROVING
DN	602	FAC		<0.0001	-35	-31	-26	IMPROVING
TON	605	FAC		<0.0001	-54	-46	-38	IMPROVING
DON	607	FAC		<0.0001	-41	-31	-18	IMPROVING
DNH <sub>3</sub>	608	FAC		0.088	-27	-13	2	NS
TNH <sub>3</sub>	610	FAC		<0.0001	-51	-41	-29	IMPROVING
DKN	623	FAC		<0.0001	-51	-44	-34	IMPROVING
TKN	625	FAC		<0.0001	-50	-43	-36	IMPROVING
TNOx	630	FAC		<0.0001	-37	-31	-25	IMPROVING
DNOx	631	FAC		<0.0001	-37	-32	-26	IMPROVING
*DNOx	631	*FAC	-0.4252	<0.0001	-47	-35	-20	IMPROVING
TP	665	FAC		0.0457	-26	-14	0	IMPROVING
*TP	665	*FAC	-0.3862	<0.0001	-42	-32	-21	IMPROVING
DP	666	FAC		0.0003	-34	-24	-12	IMPROVING
DOP	671	FAC		<0.0001	376	500	658	DEGRADING
TOC	680	FAC		0.0001	-15	-10	-5	IMPROVING
SS	80154	FAC		0.0029	-46	-31	-12	IMPROVING
*SS	80154	*FAC	-0.2431	0.0447	-38	-21	-0.01	IMPROVING

\* These results were reported by USGS after additional analysis

**Table 33. Trend Statistics for the Susquehanna River at Danville, Pa., January 1985 Through December 2005**

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	134.434	0.265	-	-	-	NS
TN	600	FAC		<0.0001	-45	-41	-37	IMPROVING
*TN	600	*FAC	-0.464	<0.0001	-41	-37	-33	IMPROVING
DN	602	FAC		<0.0001	-38	-34	-29	IMPROVING
TON	605	FAC		<0.0001	-60	-54	-47	IMPROVING
DON	607	FAC		<0.0001	-51	-44	-36	IMPROVING
DNH <sub>3</sub>	608	FAC		<0.0001	-48	-38	-27	IMPROVING
TNH <sub>3</sub>	610	FAC		<0.0001	-62	-55	-46	BMDL
DKN	623	FAC		<0.0001	-57	-50	-43	IMPROVING
TKN	625	FAC		<0.0001	-58	-53	-47	IMPROVING
TNOx	630	FAC		<0.0001	-35	-30	-24	IMPROVING
DNOx	631	FAC		<0.0001	-36	-30	-35	IMPROVING
*DNOx	631	*FAC	-0.3578	<0.0001	-38	-30	-21	IMPROVING
TP	665	FAC		<0.0001	-42	-33	-22	IMPROVING
*TP	665	*FAC	-0.4942	<0.0001	-47	-39	-30	IMPROVING
DP	666	FAC		0.0005	-35	-24	-11	IMPROVING
DOP	671	FAC		<0.0001	467	619	813	DEGRADING
TOC	680	FAC		<0.0001	-26	-22	-17	IMPROVING
SS	80154	FAC		<0.0001	-68	-60	-51	IMPROVING
*SS	80154	*FAC	-0.54	<0.0001	-51	-42	-31	IMPROVING

\* These results were reported by USGS after additional analysis

**Table 34. Trend Statistics for the West Branch Susquehanna River at Lewisburg, Pa., January 1985 Through December 2005**

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	13.932	0.908	-	-	-	NS
TN	600	FAC		<0.0001	-33	-28	-23	IMPROVING
*TN	600	*FAC	-0.2438	<0.0001	-27	-22	-16	IMPROVING
DN	602	FAC		<0.0001	-28	-23	-18	IMPROVING
TON	605	FAC		<0.0001	-61	-54	-45	IMPROVING
DON	607	FAC		<0.0001	-53	-45	-36	IMPROVING
DNH <sub>3</sub>	608	FAC		0.3639	-21	-7	9	NS
TNH <sub>3</sub>	610	FAC		<0.0001	-47	-35	-21	BMDL
DKN	623	FAC		<0.0001	-59	-51	-42	BMDL
TKN	625	FAC		<0.0001	-57	-49	-40	IMPROVING
TNOx	630	FAC		0.0167	-14	-8	-2	IMPROVING
DNOx	631	FAC		0.0195	-14	-8	-1	IMPROVING
*DNOx	631	*FAC	0.0075	0.8502	-7	0.4	9	NS
TP	665	FAC		<0.0001	-46	-35	-22	IMPROVING
*TP	665	*FAC	-0.6246	<0.0001	-55	-46	-36	IMPROVING
DP	666	FAC		<0.0001	-55	-47	-38	IMPROVING
DOP	671	FAC		<0.0001	307	432	595	BMDL
TOC	680	FAC		0.8116	-7	1	10	NS
SS	80154	FAC		<0.0001	-73	-64	-53	BMDL
*SS	80154	*FAC	-0.0864	0.4518	-27	-8	15	NS

\* These results were reported by USGS after additional analysis

**Table 35. Trend Statistics for the Juniata River at Newport, Pa., January 1985 Through December 2005**

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	20.264	0.461	-	-	-	NS
TN	600	FAC		0.0001	-14	-9	-5	IMPROVING
*TN	600	*FAC	-0.1102	0.0001	-15	-11	-6	IMPROVING
DN	602	FAC		0.1073	-8	-4	1	NS
TON	605	FAC		<0.0001	-53	-45	-36	IMPROVING
DON	607	FAC		<0.0001	-48	-40	-30	IMPROVING
DNH <sub>3</sub>	608	FAC		0.001	-36	-24	-10	IMPROVING
TNH <sub>3</sub>	610	FAC		<0.0001	-52	-42	-29	BMDL
DKN	623	FAC		<0.0001	-57	-49	-40	BMDL
TKN	625	FAC		<0.0001	-49	-41	-32	IMPROVING
TNOx	630	FAC		0.032	0	6	12	DEGRADING
DNOx	631	FAC		0.0065	2	7	13	DEGRADING
*DNOx	631	*FAC	0.0973	0.0369	0	10	20	DEGRADING
TP	665	FAC		<0.0001	-40	-30	-19	IMPROVING
*TP	665	*FAC	-0.461	<0.0001	-47	-38	-26	IMPROVING
DP	666	FAC		0.0001	-37	-26	-14	IMPROVING
DOP	671	FAC		<0.0001	197	286	403	DEGRADING
TOC	680	FAC		<0.0001	-31	-25	-18	IMPROVING
SS	80154	FAC		0.0015	-46	-32	-14	IMPROVING
*SS	80154	*FAC	-0.5778	0.0002	-59	-45	-25	IMPROVING

\* These results were reported by USGS after additional analysis

**Table 36. Trend Statistics for the Susquehanna River at Marietta, Pa., January 1987 Through December 2005**

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	-85.645	0.7511	-	-	-	NS
TN	600	FAC		<0.0001	-28	-23	-17	IMPROVING
*TN	600	*FAC	-0.1649	<0.0001	-21	-15	-9	IMPROVING
DN	602	FAC		<0.0001	-19	-13	-7	IMPROVING
TON	605	FAC		<0.0001	-48	-39	-28	IMPROVING
DON	607	FAC		0.2436	-28	-11	9	NS
DNH <sub>3</sub>	608	FAC		0.0626	-27	-14	1	NS
TNH <sub>3</sub>	610	FAC		<0.0001	-43	-32	-18	IMPROVING
DKN	623	FAC		<0.0001	-44	-35	-25	IMPROVING
TKN	625	FAC		<0.0001	-48	-41	-32	IMPROVING
TNOx	630	FAC		0.0187	-16	-9	-2	IMPROVING
DNOx	631	FAC		0.0186	-16	-9	-1	IMPROVING
*DNOx	631	*FAC	0.0451	0.5205	-9	5	10	NS
TP	665	FAC		0.1802	-21	-9	5	NS
*TP	665	*FAC	-0.2788	<0.0001	-34	-25	-14	IMPROVING
DP	666	FAC		0.2883	-20	-7	7	NS
DOP	671	FAC		<0.0001	923	1218	1598	DEGRADING
TOC	680	FAC		<0.0001	-18	-12	-7	IMPROVING
SS	80154	FAC		0.0001	-48	-35	-20	IMPROVING
*SS	80154	*FAC	-0.3225	0.0017	-41	-28	-11	IMPROVING

\* These results were reported by USGS after additional analysis

**Table 37. Trend Statistics for the Conestoga River at Conestoga, Pa., January 1985 Through December 2005**

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	3.7705	0.508	-	-	-	NS
TN	600	FAC		<0.0001	-22	-18	-14	IMPROVING
*TN	600	*FAC	-0.2069	<0.0001	-22	-19	-15	IMPROVING
DN	602	FAC		0.4919	-3	2	6	NS
TON	605	FAC		<0.0001	-50	-43	-35	IMPROVING
DON	607	FAC		0.5953	-9	4	18	NS
DNH <sub>3</sub>	608	FAC		<0.0001	-77	-73	-69	IMPROVING
TNH <sub>3</sub>	610	FAC		<0.0001	-79	-76	-72	IMPROVING
DKN	623	FAC		<0.0001	-35	-27	-18	IMPROVING
TKN	625	FAC		<0.0001	-56	-50	-44	IMPROVING
TNOx	630	FAC		0.2314	-3	4	10	NS
DNOx	631	FAC		0.0801	-1	6	12	NS
*DNOx	631	*FAC	0.0751	0.055	-0.2	8	16	NS
TP	665	FAC		<0.0001	-48	-41	-33	IMPROVING
*TP	665	*FAC	-0.5665	<0.0001	-50	-43	-36	IMPROVING
DP	666	FAC		<0.0001	-44	-39	-34	IMPROVING
DOP	671	FAC		0.003	-26	-17	-6	IMPROVING
TOC	680	FAC		<0.0001	-51	-47	-42	IMPROVING
SS	80154	FAC		-	-	-	-	-
*SS	80154	*FAC	-0.9426	<0.0001	-69	-60.7	-51.7	IMPROVING

\* These results were reported by USGS after additional analysis