



PRELIMINARY ASSESSMENT OF ANNUAL NUTRIENT LOADS TO THE MURDERKILL ESTUARY, DELAWARE: WATERSHED, WASTEWATER, AND ATMOSPHERIC CONTRIBUTIONS.



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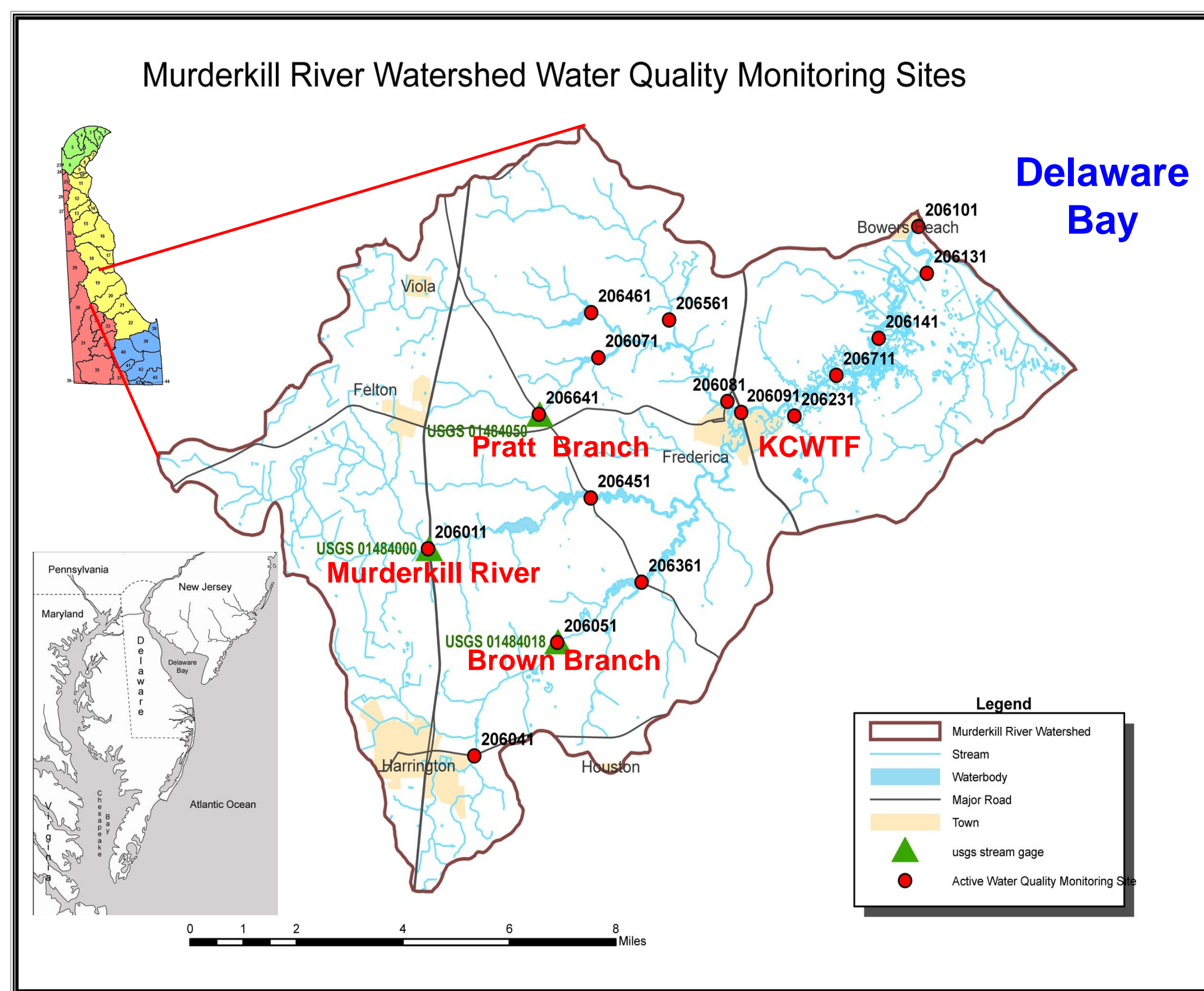
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ABSTRACT

Nutrient budgets are an essential tool for the management of estuarine eutrophication and serve to direct managers toward the most efficient and cost effective mitigation strategies. As part of a comprehensive study of nutrient cycling in the Murderkill Estuary funded by the Kent County Levy Court (Delaware), we have used existing and new monitoring data to determine nitrate (NO_3^-), total ammonium (NH_4^+), total dissolved nitrogen (TDN), soluble reactive phosphorus (SRP $\approx \text{PO}_4^{3-}$) and total dissolved P (TDP) loads from the upland watershed, the Kent County Wastewater Treatment Facility (KCWTF), and the atmosphere to the Murderkill Estuary, a tributary to Delaware Bay.

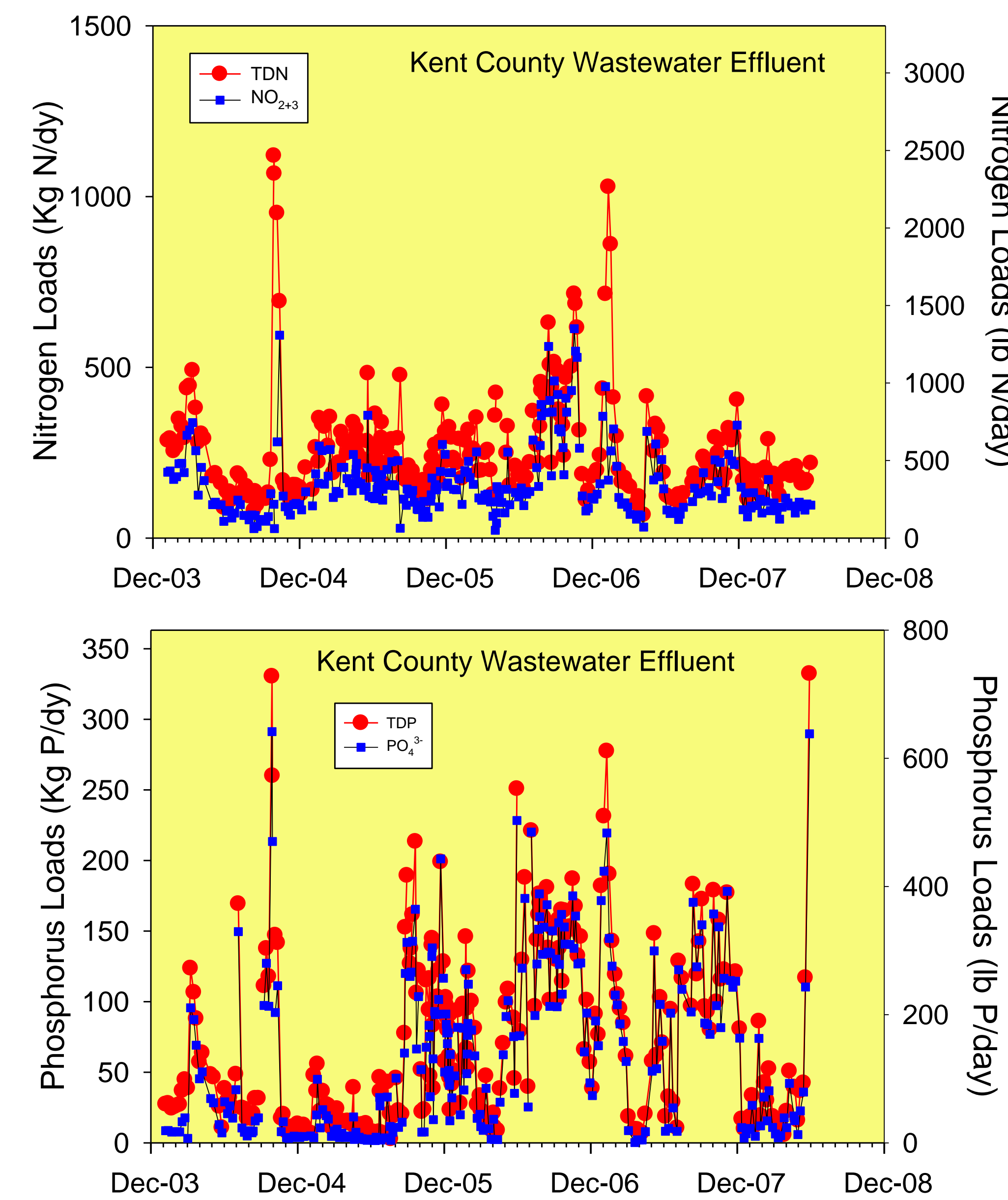
Total loads of NO_3^- , NH_4^+ , TDN, PO_4^{3-} , and TDP to the Murderkill Estuary average 356,000, 38500, and 497,000, 27,400, and 40,600 kg/day, respectively. The watershed is responsible for 82% of the total NO_3^- load, 62% of the total NH_4^+ load, 79% of the TDN load, 15% of the PO_4^{3-} and 32% of the TDP load. The KCWTF is responsible for 17% of the total NO_3^- load, 28% of the total NH_4^+ load, 19% of the TDN load, but 85% of the PO_4^{3-} and 67% of the TDP load to the Murderkill Estuary.

These preliminary results suggest that the most efficient strategy for reducing the impact of nutrient loads on the Murderkill estuary should focus on mitigating N loads from the watershed and P loads from the KCWTF.



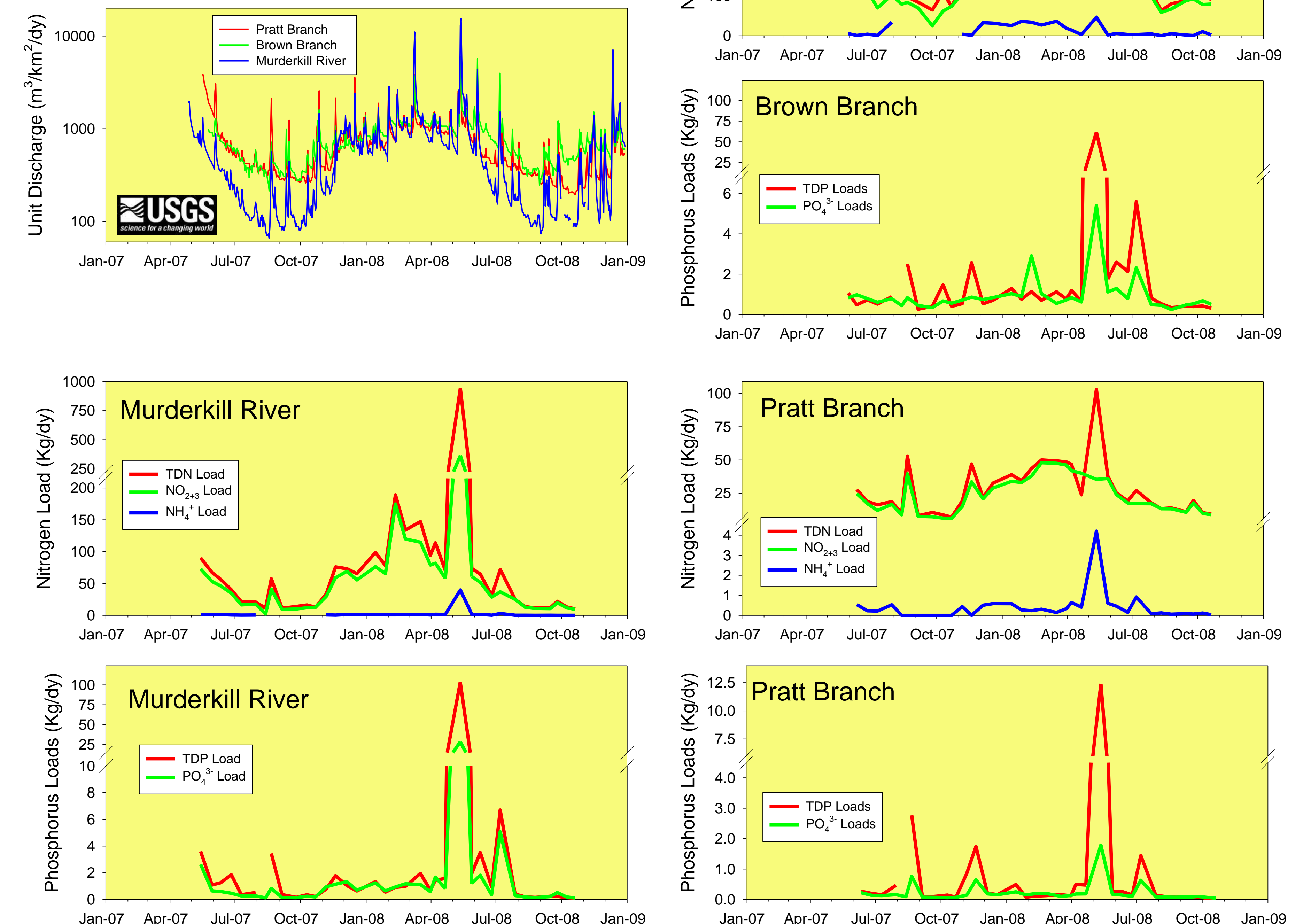
Nitrogen and Phosphorus Loads from the Kent County Wastewater Treatment Facility (KCWTF), Frederica, DE

(Data Provided by the Kent County Engineering Department)



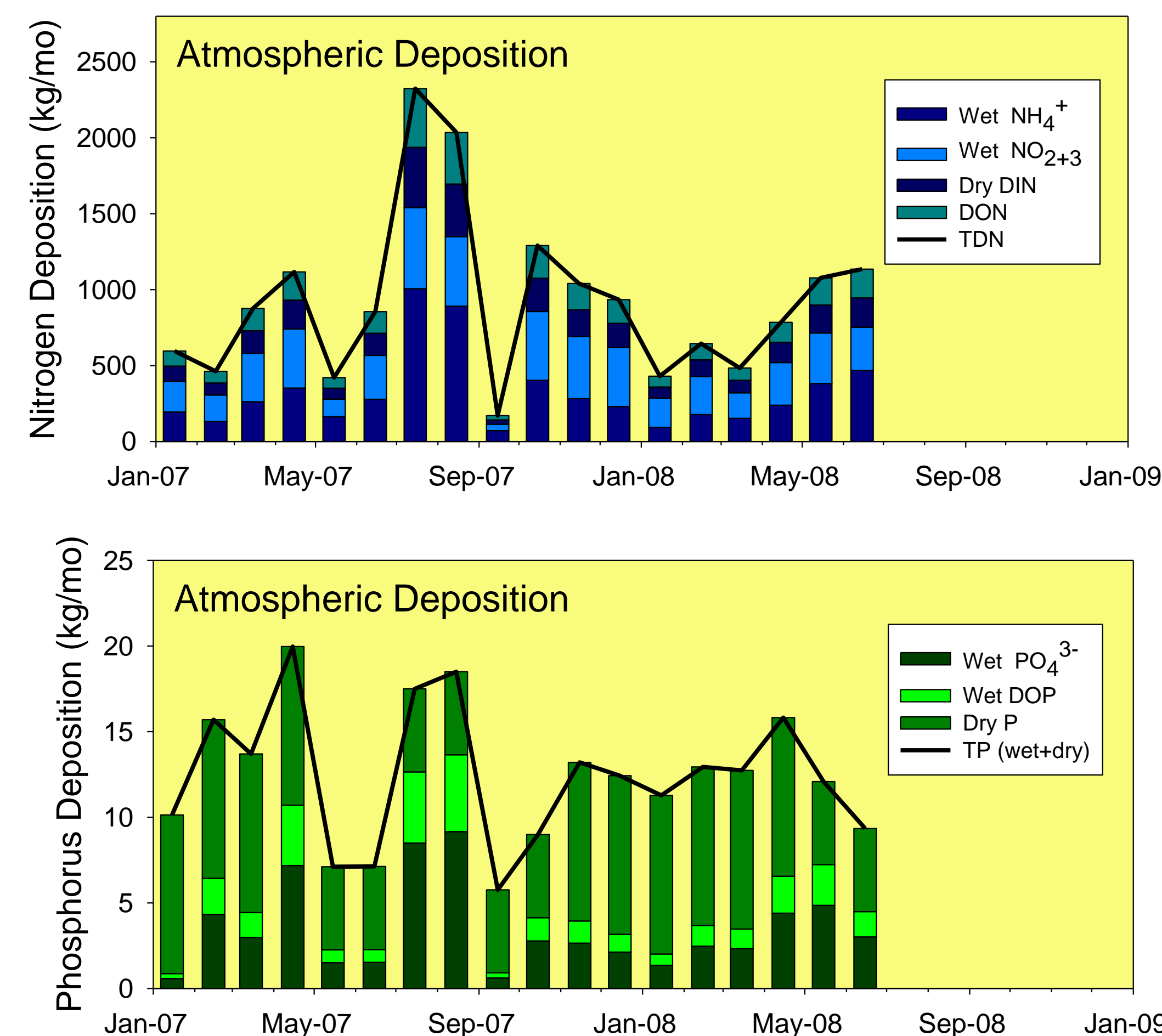
Loads Determined at Three Watershed Gauging Stations

Data provided by USGS (Discharge) and DNREC (Nutrient Concentrations)
Note: A major storm in early May, 2008, had a significant impact on annual loads.



Atmospheric Deposition to the Murderkill Estuary and Associated Salt Marshes

Wet deposition of nitrate+nitrite, ammonium, and orthophosphate was measured at the NADP-AIRMoN site at Cape Henlopen (DE02; nadp.sws.uiuc.edu/sites/siteinfo.asp?id=DE02&net=AIRMoN), 45km southeast of the Murderkill Estuary. Atmospheric deposition rates were determined for the period of January 2007 to June 2008, the period for which data is currently available. To calculate total nitrogen deposition, dry deposition of nitrate and ammonium were assumed to be approximately 25% of wet deposition and deposition of DON is assumed to 25% of total DIN (wet + dry) deposition. These components were summed to yield TDN fluxes. To calculate total wet phosphorus deposition, DOP deposition was taken to average 49% of dry deposition based on analyses completed in 2002 (Volk et al., submitted). Based on measurements made in 1986 (Wolff et al., 1987), dry phosphorus deposition was estimated to be 0.65 mg P/m²/mo during summer months (May-October) and 0.34 mg P/m²/mo during winter months (November-April). Dry deposition is included in the estimates of total phosphorus deposition, even though it is likely that a substantial fraction of this component of atmospheric deposition may not be soluble or bioavailable.



Summary of N and P Loads to the Murderkill Estuary

Source	Unit	Watershed	Atmosphere	KCWTF	Total
Period of Analysis					
		May 2007 - Oct. 2008	2007 - May 2008	2004 to May 2008	
NH_4^+	kg/yr	23700	4200	10600	38500
	(\pm kg/yr)	18800	100	5800	19700
	% of Total	62%	11%	28%	100%
NO_{2+3}	kg/yr	293000	3700	59700	356000
	(\pm kg/yr)	65900	100	12200	67100
	% of Total	82%	1%	17%	100%
TDN (wet+dry)	kg/yr	391000	12000	94800	497000
	(\pm kg/yr)	67000	300	14600	69000
	% of Total	79%	2%	19%	100%
PO_4^{3-}	kg/yr	4190	40	23100	27400
	(\pm kg/yr)	1120	2	9500	9500
	% of Total	15%	< 1%	85%	100%
TDP (wet+dry)	kg/yr	13100	150	27300	40600
	(\pm kg/yr)	2000	3	9100	9300
	% of Total	32%	< 1%	67%	100%

Summary

These preliminary results suggest that eutrophication in the Murderkill Estuary can be best mitigated by a two-pronged management strategy: (1) nitrogen mitigation should focus on the watershed (the dominant source of this nutrient to the estuary); and (2) phosphorus mitigation should focus on the KCWTF (the dominant source of this nutrient to estuary). Reductions of N loads from the KCWTF and P loads from the watershed will likely have lesser impact on the symptoms of eutrophication in these waters.



This research and collaborations with other scientists of the Murderkill Estuary Working Group were supported by the Kent County Levy Court (Delaware), the Delaware Department of Natural Resources and Environmental Control (DNREC), and the NOAA Air Resources Laboratory (NADP-AIRMoN Program). This work would not have been possible without the support and assistance of Hans Medlarz and James Newton (Kent County Engineering Department), Andrew Thuman (HydroQual, Inc.), Holly Weyers and Anthony Tallman (US Geological Survey, Dover), David McQuaid, Ben Pressley, and Xia Xie (DNREC). MAD was supported by a fellowship from the Université de Perpignan.