Results/Discussion

Water quality, biological (macroinvertebrate), and habitat site conditions for each sampling site in 2005 throughout the Lower Susquehanna Subbasin are depicted in Figure 4. Only one site, SHRM 2.0, located at the mouth of Sherman Creek demonstrated the best overall conditions in each category with nonimpaired macroinvertebrates, "higher" water quality, and excellent habitat. Furthermore, only six stations did not exceed water quality levels of concern and received a "higher" water quality condition rating. Those sites were NMHT 0.0, SHRM 2.0, SWAT 39.0, SWAT 56.0, SUSQ 122.0, and WICO 0.3. The low number of "higher" water quality ratings was mostly due to the widespread high nitrogen levels. There were 82 sites (84.5 percent) that exceeded the total nitrogen level of concern. Seventy-five stations slightly exceeded levels of concern and received a "middle" water quality designation, and 16 received a "lower" quality designation. Nonimpaired biological conditions were determined at 41 stations (43 percent), slightly impaired conditions were found at 32 sites (33 percent), moderately impaired conditions were found at 21 sites (22 percent), and severely impaired conditions were discovered at two sites (2 percent). Habitat conditions were excellent at 30 sites (33 percent), supporting at 51 sites (56 percent), and partially supporting at 10 sites (11 percent). One site, BERM 11.0, was not sampled for macroinvertebrates due to lack of available riffle/run habitat, and the river sites were not rated for habitat conditions.

In addition to 84.5 percent of the samples exceeding levels of concern for total nitrogen, other nutrient parameters were exceeded in many of the samples. The five parameters with the highest number of values exceeding levels of concern were: total nitrogen, total nitrate-n (70), total orthophosphate (34), total phosphorus (29), and total sodium (21) (Table 4). The values set for total nitrogen and total nitrate-n (1.0 mg/l) were based on natural background conditions; therefore, values higher than 1.0 mg/l indicate the potential presence of nitrogen sources in the watershed (U.S. Geological Survey, 1999). The highest number of parameters to be exceeded at a site was seven at MILL 0.3. There were five sites where six parameters were exceeded, including ARMS 0.1, CNTG 0.9, CODO 0.6, LCHQ 0.4, and SHAM 2.7 (Table 4).

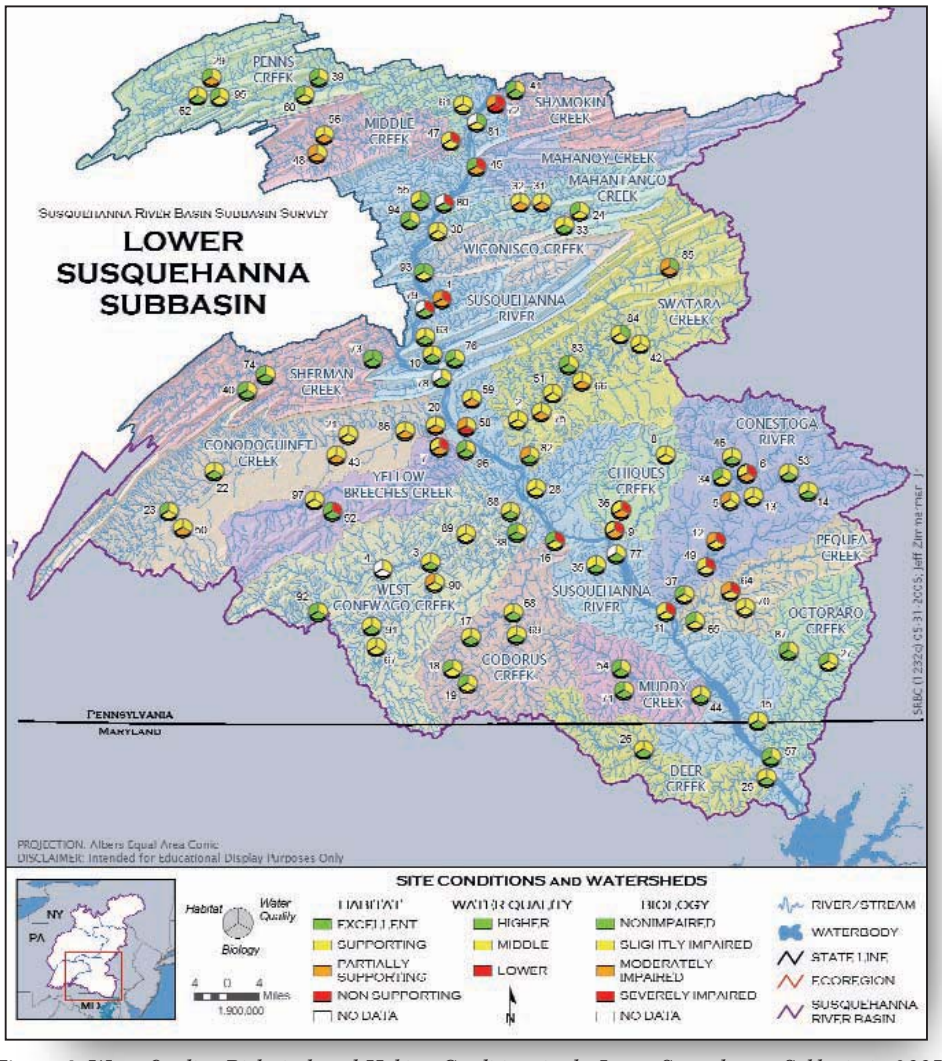

Figure 4. *Water Quality, Biological, and Habitat Conditions in the Lower Susquehanna Subbasin in 2005*

The high level of nutrients corresponds to the prevalence of cultivated land in the Lower Susquehanna Subbasin. The highest level of total nitrogen was 11.37 mg/l measured at LCHQ 0.4 on Little Chiques Creek. Total phosphorus and orthophosphate values were exceeded 29 and 34 times, respectively (Table 4). Orthophosphate and phosphorus can be indicators of wastewater and septic systems, detergents, chemical fertilizers, animal waste, some industrial discharges, and soil erosion. Sodium values were high at 21 of the sites, with the highest being 80.5 mg/l at MILL 0.3 (Table 4). As many of these sites were urban or suburban, the high sodium levels may have been due to road runoff. Abandoned mine lands were located in only a small section of the subbasin, and the associated water chemistry impacts were noted only in SHAM 2.7, SUSQ 94.0, SUSQ 106.0, MHNY 0.3, and possibly EPIN 0.1, EPIN 12.7, and SWAT 56.0.

Section 303(d) of the Clean Water Act requires a Total Maximum Daily Load (TMDL) to be developed for any waterbody designated as impaired, or not meeting the state water quality standards or its designated use. Streams in Pennsylvania are being assessed as part of the State Surface Waters Assessment Program,

Table 4. *Lower Susquehanna River Subbasin Sites with Water Quality Values Exceeding Levels of Concern*

StationID	Lab Alkalinity	Calcium T	Hardness T	Iron T	Magnesium T	Manganese T	Nitrate-N T	Nitrite-N T	Nitrogen TOT	Phos T Ortho	Phosphorus T	Sodium T	Sulfate T	T Susp Solid	Acidity	Specific Cond.	Water Temp.	TOTAL
ARMS 0.1	17.8						1.1		1.4		0.572			**204**			25.6	6
BEAV 0.6							1.29		1.45			30.6						3
BERM 1.2									1.24	0.058							25.6	3
BERM 11.0							1.55		1.74									2
CCLC 0.4							7.48		7.88	0.137	0.147	23.3						5
CCLC 12.2							7.43		7.96	0.241	0.292	45.4						5
CEDR 0.1		**103**	318				3.05		3			39.1						5
CHIQ 20.0							3.81		4.26	0.075								3
CHIQ 3.0							11		11	0.068		33.6						4
CLRK 3.8	10.8																	1
CNTG 0.9							8.18		8.47	0.175	0.192	41.7					25.3	6
CNTG 22.6							8.61		8.7	0.131	0.138	30.1						5
CNTG 32.7							7.54		7.76	0.075								3
CNTG 43.9							6.18		6.31	0.056								3
CNWG 1.8							8.58	0.07	8.91	0.079	0.102							5
CODO 0.6							4.51	0.09	4.78	0.111	0.132	59.8						6
CODO 22.4							4.54		4.48	0.14	0.155							4
CODO 33.0							3.28		3.28									2
CODO 34.1							5.39		5.14									2
CONO 1.3							3.93		4.18								26.3	3
CONO 28.8							3.98		4.42								27.1	3
CONO 51.8							4.41		4.64								25.7	3
CONO 66.0							4.59		4.75									2
DEEP 1.2	11						1.23		1.49									3
DEER 1.2							3.72		3.7									2
DEER 30.1							4.43		4.43									2
EBOC 5.3							9.41		9.38	0.059								3
ECON 0.0							4.23		4.24									2
ELKN 0.1							2.55		2.75									2
EMAH 0.2							1.9		2.28	**0.445**	0.573						**27.3**	5
EMAH 17.1							3.5		3.85									2
EPIN 0.1	13.6								1.08									2
EPIN 12.7	13.4																	1
HAMM 0.2							5.85		6.08									2
KRTZ 1.5							5.56	0.07	5.91									3
LCHQ 0.4							**11.2**		**11.37**	0.073	0.114	27.1		28				6
LCNT 1.7							9.66		9.51									2
LCON 1.5							4.54		4.85	0.255	0.267	21.9						5
LRLN 0.8	9.4										0.192							2
LRLS 0.5	7.8																	1
LSHM 0.8							1.71		1.85									2
LSWT 0.6							7.46	**0.13**	7.67									3
LTRT 0.1							5.65		5.74									2
MDDY 3.3							5.36		5.32									2
MHNY 0.3			**356**	740	**47.3**	1710							**304**					5
MIDD 0.2							8.41		8.74									2
MIDL 0.7							1.12		1.51		**0.902**	44.2						4
MIDL 24.7											0.349							1
MILL 0.3							6.53		6.86	0.22	0.237	**80.5**				**940**	25.1	7
MISP 0.5							6.46		6.65									2
MNDA 0.1									1.01	0.075								2
MNTN 3.0				**2789**					1.12					118				3
MUDD 0.2							3.51		3.97	0.118	0.139	29.6						5
NBMY 0.0							5.1		4.9									2
NMID 0.7									1.35		0.185							2
OCTO 1.0							4.65		4.86	0.289	0.305							4
PAXT 0.5							1.19		1.6	0.069		39.8						4
PAXT 8.4												30.7						1
PENN 30.0							1.15		1.62		0.209							3
PENN 5.0									1.3		0.194						25.1	3
PENN 50.6							2.2		2.75	0.115	0.366							4
POWL 0.1	14.6						1.25		1.39									3
PQEA 15.2							8.65		8.85	0.133	0.187			42				5
PQEA 3.3							7.27		7.54	0.146	0.169							4
QUIT 0.3							9.39		9.96	0.101	0.119							4
SBCC 1.2							3.78		4.04	0.083								3
SBCD 0.4							4.18		4.2									2
SBCD 3.6							4.96		4.95	0.05								3
SBEV 2.5							6.62		6.92									2
SBMY 0.0							6.33		6.16									2
SHAM 2.7	**2.6**			1630		**2420**			1.82	0.082	0.17							6
SHRM 27.5							1.52		1.68									2
SPRG 0.0							6.33		6.6									2
STON 0.4	12.8																	1
SUSQ 106.0												23.1				883		2
SUSQ 44.5									1.3			22.6					26.9	3
SUSQ 77.0									1.21			20						2
SUSQ 94.0									1.72			22.5				822	25.3	4
SWAT 2.3							5.26		5.68	0.113	0.13	22.4						5
SWAT 21.7							2.55		2.69									2
TRDL 0.0							5.04		5.06			20.6			**22**			4
WBOC 4.3							10.1		9.8	0.11	0.111							4
WCON 2.9							2.88		3.17	0.126	0.134							4
WCON 20.4							2.26		2.62	0.06								3
WCON 35.5							1.72		2.12	0.153	0.158						26	5
WCON 56.3									1.09	0.08								2
WCON 66.5									1.03									1
WMHT 2.2							1.25		1.42									2
WPIN 0.8							1.43		1.49					44				3
YLBR 3.4							2.22		2.32									2
YLBR 35.7							1.39		1.53									2
TOTAL	10	1	2	3	1	2	70	4	82	34	29	21	1	5	1	3	12	

and if found to be impaired, a TMDL is calculated for the watershed. In Maryland, the Maryland Department of Natural Resources is performing assessments through its Maryland Biological Stream Surveys and Unified Watershed Assessment programs. Some of the watersheds in the Lower Susquehanna Subbasin have been rated impaired and, subsequently, will require a TMDL. Tables 5 and 6 identify those watersheds that have been found to be impaired, their impairment causes, the dates sampled, and Lower Susquehanna Subbasin Survey stations located in impaired sections. More information on the Pennsylvania and Maryland TMDL programs are available respectively at: *http://www.dep.state.pa.us/watermanagement_apps/tmdl/default.asp* and *http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/index.asp.*

Table 5. *Lower Susquehanna River Subbasin Survey Streams Identified as Impaired Streams Requiring a TMDL on PADEP's 2004 Integrated List of All Waters*

PA State WaterPlan	Watersheds	Major Sources of Impairment	Stations in Impaired Sections
6C	Armstrong Creek	Agriculture/Siltation:1998 Removal of Vegetation/Siltation:1998	
7K	Big Beaver Creek	Agriculture/Nutrients,Organic Enrichment Low DO,Siltation:2004	
7E	Cedar Run	Natural Sources/Siltation:1998 Source Unknown/Nutrients:1998 Urban Runoff/Storm Sewers/Nutrients,Siltation:1998 Source Unknown/Cause Unknown:1998 Agriculture/Nutrients,Siltation:1998	
7G	Chiques Creek	Agriculture/Nutrients,Siltation:1996,1998	CHIQ 3.0
7G	Chiques Creek	Urban Runoff/Storm Sewers/Cause Unknown:1998	
7J	Cocalico Creek	Crop Related Agric/Nutrients:2002 Grazing Related Agric/Siltation:2002 Urban Runoff/Storm Sewers/Cause Unknown,Nutrients,Siltation:2002 Agriculture/NutrientsSiltation:2002 Small Residential Runoff/Nutrients:2002 Road Runoff/Siltation:2002	CCLC 0.4, CCLC 12.2
7H	Codorus Creek	Urban Runoff/Storm Sewers/Unknown Toxicity, Excessive Algal Growth,Siltation:2004 Industrial Point Source/Color,DO,BOD,Thermal Modifications, Suspended Solids:1996, 2002 Agriculture/Siltation,Excessive Algal Growth,Nutrients:2004	CODO 0.6, CODO 22.4
7J	Conestoga River	Source Unknown/Mercury:2002 Municipal Point Source/Chlorine:2002 Agriculture/Organic Enrichment Low D.O.,Nutrients:1996,2002 Small Residential Runoff/Siltation,Nutrients:2002 Upstream Impoundment/Siltation:2002 Crop Related Agric/Nutrients:2002 Grazing Related Agric/Siltation,Nutrients,Organic Enrichment Low D.O.:2002 Surface Mining/Siltation:2002 Other/Organic Enrichment Low D.O.,Nutrients:1996 Golf Courses/Nutrients:2002 Channelization/Siltation:2002 Removal of Vegetation/Siltation:2002 Urban Runoff/Storm Sewers/Siltation:2002	CNTG 22.6, CNTG 43.9
7G	Conewago Creek	Agriculture/Nutrients,Siltation:1996,1998 Municipal Point Source/Organic Enrichment,Low DO,Suspended Solids:1996,1998	ECON 0.0
7G	Conewago Creek	Agriculture/Suspended Solids:1998	ECON 0.0
7F	Conewago Creek	Source Unknown/Mercury:2002	WCON 2.9
7B	Conodoquinet Creek	Agriculture/Siltation:1998	
7B	Conodoquinet Creek	Combined Sewer Overflow/Organic Enrichment Low DO:2002 Urban Runoff/Storm Sewers/Nutrients,Suspended Solids:1998,2004 Source Unknown/Cause Unknown:1998 Agriculture/Suspended Solids,Nutrients:1998,2002	CONO 66.0, CONO 51.8, CONO 28.8
7K	Conowingo Creek	Agriculture/Nutrients,Suspended Solids:1996 Crop Related Agriculture/Siltation, Organic Enrichment/Low DO, Nutrients:2004 Grazing Related Agriculture/Organic Enrichment/Low DO,Nutrients:2004 Agriculture/Organic Enrichment Low DO, Nutrients,Siltation:2004	CNWG 1.8
6C	Deep Creek	Source Unknown/Siltation:1998 Agriculture/Siltation:1998	
7K	East Branch Octoraro Creek	Agriculture/Siltation,Nutrients:2002	
6A	Elk Creek	Animal Feeding Ag/Siltation,Nutrients:2005	
7J	Hammer Creek	Crop Related Agric/Siltation,Nutrients:2002 Grazing Related Agric/Siltation,Nutrients:2002	HAMM 0.2
7I	Kreutz Creek	Removal of Vegetation/Siltation:2002 Road Runoff/Siltation:2002 Urban Runoff/Storm Sewers/Siltation:2002	
7A	Laurel Run	Atmospheric Deposition/Metals:1998	
7G	Little Chiques Creek	Agriculture/Nutrients,Siltation:1998 Urban Runoff/Storm Sewers/Siltation:1998 On site Wastewater/Organic Enrichment/Low D.O.:1998	LCHQ 0.4
7J	Little Conestoga Creek	Grazing Related Agric/Siltation,Nutrients:2002 Urban Runoff/Storm Sewers/Cause Unknown:2002 Crop Related Agric/Nutrients,Siltation:2002 Erosion from Derelict Land/Siltation,Cause Unknown:2002	
6B	Little Shamokin Creek	Agriculture/Siltation,Organic Enrichment Low DO:2002 Grazing Related Ag/Siltation, Organic Enrichment Low DO:2002	
7D	Little Swatara Creek	Agriculture/Nutrients,Siltation:1998 Urban Runoff/Storm Sewers/Siltation:1998 On site Wastewater/Organic Enrichment/Low D.O.:1998	
6B	Mahanoy Creek	AMD/Metals,pH,Siltation:1996,2002 Crop Related Ag/Siltation:2002 Atmospheric Deposition/pH:2002	MHNY 0.3

6C	Mahantango Creek	Agriculture/Siltation:1998 Removal of Vegetation/Siltation:1998 Road Runoff/Siltation:1998 Silvaculture/Siltation:1998	
7C	Manada Creek	Source Unknown/Pathogens:2004	MNDA 0.1
7D	Manada Creek	Road Runoff/Siltation:2002 Municipal Point Source/Nutrients:2002	MNDA 0.1
6A	Middle Creek	Source Unknown/Mercury:2002 Grazing Related Ag/Siltation:2002 Atmospheric Deposition/pH:2002	
7B	Middle Spring Run	Agriculture/Suspended Solids:1996 Urban Runoff/Storm Sewers/Suspended Solids:1996	MISP 0.5
7J	Mill Creek	Industrial Point Source/Salinity,TDS,Chlorides:1996	
7J	Mill Creek	Agriculture/Siltation,Nutrients,Suspended Solids:1996,2002 Land Development/Siltation:2002 Crop Related Agric/Nutrients:2002 Grazing Related Agric/Siltation,Nutrients:2002	
7E	Mountain Creek	Atmospheric Deposition/pH:1998	
7J	Muddy Creek	Crop Related Agric/Siltation,Nutrients:2002 Agriculture/Siltation,Nutrients:2002	
6C	North Branch Mahantango Creek	Agriculture/Siltation:1998	
7C	Paxton Creek	Agriculture/Nutrients,Siltation:1996,1998 Combined Sewer Overflow/Organic Enrichment/Low D.O.:1996 Urban Runoff/Storm Sewers/Suspended Solids,Nutrients,Cause Unknown,Siltation:1998,2004 Construction/Siltation:1998	PAXT 0.5
6A	Penns Creek	Source Unknown/Mercury:2002 Crop Related Ag/Siltation:2002 Small Residential Runoff/Siltation:2002	
7K	Pequea Creek	Agriculture/Nutrients,Organic Enrichment Low DO, Siltation:1996,2002,2004	
7K	Pequea Creek	Agriculture/Organic Enrichment Low D.O.,Siltation:2002,2004	
6A	Pine Creek	Grazing Related Ag/Siltation:2002	
6C	Pine Creek	Agriculture/Siltation:1998 AMD/Metals,Siltation:1996,1998 Source Unknown/Siltation:1998	EPIN 0.1 EPIN 12.7
6C	Powell Creek	Agriculture/Siltation:1998 Removal of Vegetation/Siltation:1998	
7D	Quittapahilla Creek	Agriculture/Siltation:2002	QUIT 0.3
6B	Shamokin Creek	Abandoned Mine Drainage/Metals,Siltation,pH:1996, 2004	SHAM 2.7
6B	Shamokin Creek	AMD/Siltation,Metals:2004 Urban Runoff/Storm Sewer/Siltation:2004 Road Runoff/Siltation:2004	SHAM 2.7
7A	Sherman Creek	Grazing Related Ag/Nutrients,Siltation:2002 Crop Related Ag/Siltation:2002 Removal of Vegetation/Siltation:2002	
7H	South Branch Codorus Creek	Agriculture/Nutrients,Suspended Solids:1996 Urban Runoff/Storm Sewers/Siltation:2002	SBCD 0.4 SBCD 3.6
7F	South Branch Conewago Creek	Agriculture/Siltation:2004	
7D	Spring Creek	Other/Suspended Solids:1998 Urban Runoff/Storm Sewers/Suspended Solids,Siltation:1998 Agriculture/Siltation,Organic Enrichment Low D.O.:1998 Municipal Point Source/Cause Unknown:1998	SPRG 0.0
7D	Swatara Creek	AMD/Metals:1996 Agriculture/DO,BOD:1996	SWAT 56.0
7D	Swatara Creek	Abandoned Mine Drainage/pH,Metals,Suspended Solids:1998,2002 Agriculture/Siltation:1998,2002 Other/Siltation:1998 Construction/Siltation:1998 Urban Runoff/Storm Sewers/Siltation:1998 Crop Related Agric/Siltation,Nutrients:2002	SWAT 56.0
7B	Trindle Spring Run	Construction,Agriculture/Siltation:1998 Land Disposal/Priority Organics:1998	TRDL 0.0
7B	Trindle Spring Run	Source Unknown/PCB:2002 Land Disposal/Priority Organics:1998 Urban Runoff/Storm Sewers/Cause Unknown:1998	TRDL 0.0
6C	West Branch Mahantango Creek	Agriculture/Siltation:1998	
7K	West Branch Octoraro Creek	Agriculture/Siltation,Nutrients:2002	
6C	Wiconisco Creek	AMD/Metals,pH,Siltation:1996,2002 Crop Related Ag/Siltation:2002 Source Unknown/Cause Unknown:2002 Removal of Vegetation/Siltation:2002 Small Residential Runoff/Nutrients:2002 Grazing Related Ag/Siltation:2002	
7E	Yellow Breeches Creek	Industrial Point Source/PCB:2002 Industrial Point Source/Organic Enrichment Low D.O.:2004 Urban Runoff/Storm Sewers/Siltation:1998 Agriculture/Siltation,Organic Enrichment Low D.O.,Nutrients:1998 Construction/Organic Enrichment Low D.O.,Siltation:1998 Source Unknown/Siltation:1998	