Susquehanna River Basin Commission

Middle Susquehanna Subbasin Year-1 Survey

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The Susquehanna River Basin Commission (SRBC) conducted a water quality and biological survey of the Middle Susquehanna Subbasin from June to October 2008. This survey is part of SRBC's Subbasin Survey Program, which is funded in part by the United States Environmental Protection Agency (USEPA). The Subbasin Survey Program consists of two-year assessments in each of the six major subbasins (Figure 1) on a rotating schedule. This report summarizes the Year-1 survey, which consists of point-in-time water chemistry, macroinvertebrate, and habitat data collection and assessment of the major tributaries and areas of interest throughout the Middle Susquehanna Subbasin. The Year-2 survey will be conducted in the Lackawanna River Watershed over a one-year period beginning in spring 2009, focusing on combined sewer overflow (CSO) system impacts. Previous SRBC surveys of the Middle Susquehanna Subbasin were conducted in 1984 (Malione et al., 1984), 1993 (Water Quality and Monitoring Programs Division, 1997), and 2001 (LeFevre, 2002).

DESCRIPTION of the Middle Susquehanna Subbasin

The Middle Susquehanna Subbasin drains an area of approximately 3,700 square miles in northeast Pennsylvania from Ulster to Sunbury, Pa., which includes portions of Bradford, Carbon, Columbia, Lackawanna, Luzerne, Lycoming, Montour, Northumberland, Schuylkill, Sullivan, Susquehanna, Tioga, Wayne, and Wyoming counties. Land use in the Middle Susquehanna Subbasin consists of forested, agricultural, urban, abandoned mine drainage (AMD), and other resource extraction areas (Figure 2). The major urban centers in this area are Scranton and Wilkes-Barre, Pa. Along the eastern portion of this subbasin in the Lackawanna and Wyoming Valleys is an extensive section of abandoned mine lands (Figure 2). This area was heavily mined and the communities still deal with the industry remnants, such as coal slag piles, abandoned mines, and AMD. The subbasin boundaries contain three different ecoregions:

Northern Appalachian Plateau and Uplands

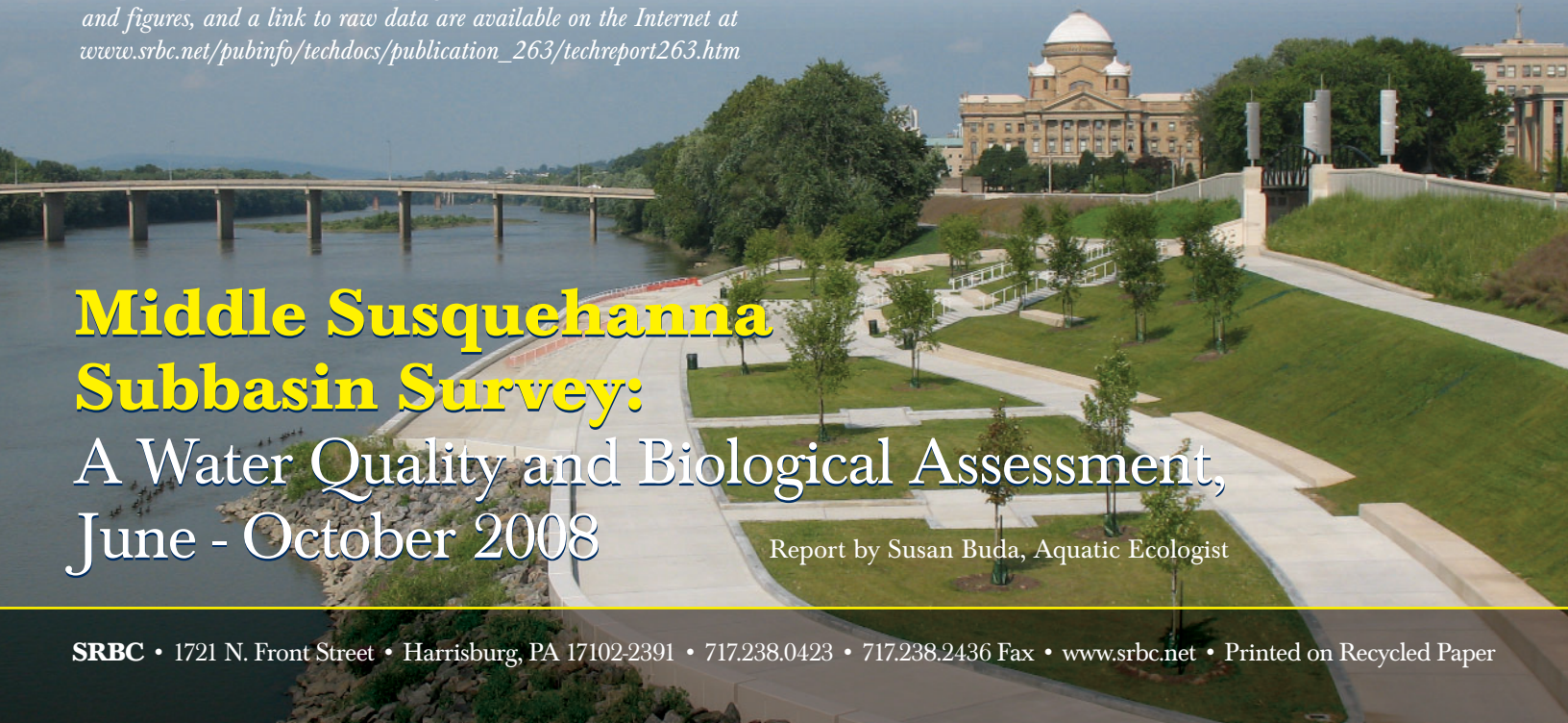
North Central Appalachians

Central Appalachian Ridges and Valleys (Omernick, 1987).

METHODS USED in 2008 Middle Susquehanna Subbasin Survey

From June to October 2008, SRBC staff collected samples from 89 stream sites throughout the Middle Susquehanna Subbasin. In June 2009, SRBC staff collected three additional samples from a few streams that were not able to be sampled in 2008. The appendix contains a sample site list with the sample site number, station name (designated by approximate stream mile), sample location description, county, latitude and longitude, ecoregion, and drainage size. Numerous sites listed in the appendix were unable to be sampled in 2008 due to

This report and detailed sampling methods, additional tables and figures, and a link to raw data are available on the Internet at www.srbc.net/pubinfo/techdocs/publication_263/techreport263.htm



The River Common at Wilkes-Barre, Pa.

Middle Susquehanna Subbasin Survey: A Water Quality and Biological Assessment, June - October 2008

Report by Susan Buda, Aquatic Ecologist

Figure 1. *The Susquehanna Subbasins*

dry stream conditions and other field sampling difficulties encountered, such as lack of access. These sites are marked in the appendix with an asterisk. HICK 0.5, LNSK 0.1, and LNSK 5.7 were sampled in 2009 and are marked by two asterisks. The drainage size designation was based on drainage areas, which were divided into small (<100 square miles), medium (100 - 500 square miles), and large (>500 square miles).

Staff sampled the Middle Susquehanna Subbasin Survey sites once during the Year-1 effort to provide a point-in-time picture of stream characteristics throughout the whole subbasin. Water quality was assessed by examining field and laboratory parameters that included nutrients, major ions, and metals. A list of field and laboratory parameters and their units is found in Table 1. Staff compared the data collected to water chemistry levels of concern based on current state and federal regulations, background levels of stream chemistry, or references for approximate tolerances of aquatic life (Table 2).

Staff collected macroinvertebrate samples and conducted habitat assessments using a slightly modified version of USEPA's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (RBP III) (Barbour and others, 1999). Detailed sampling methods, additional tables and figures, and a link to the raw data can be found on SRBC's web site at www.srbc.net/pubinfo/techdocs/publication_263/techreport263.htm.

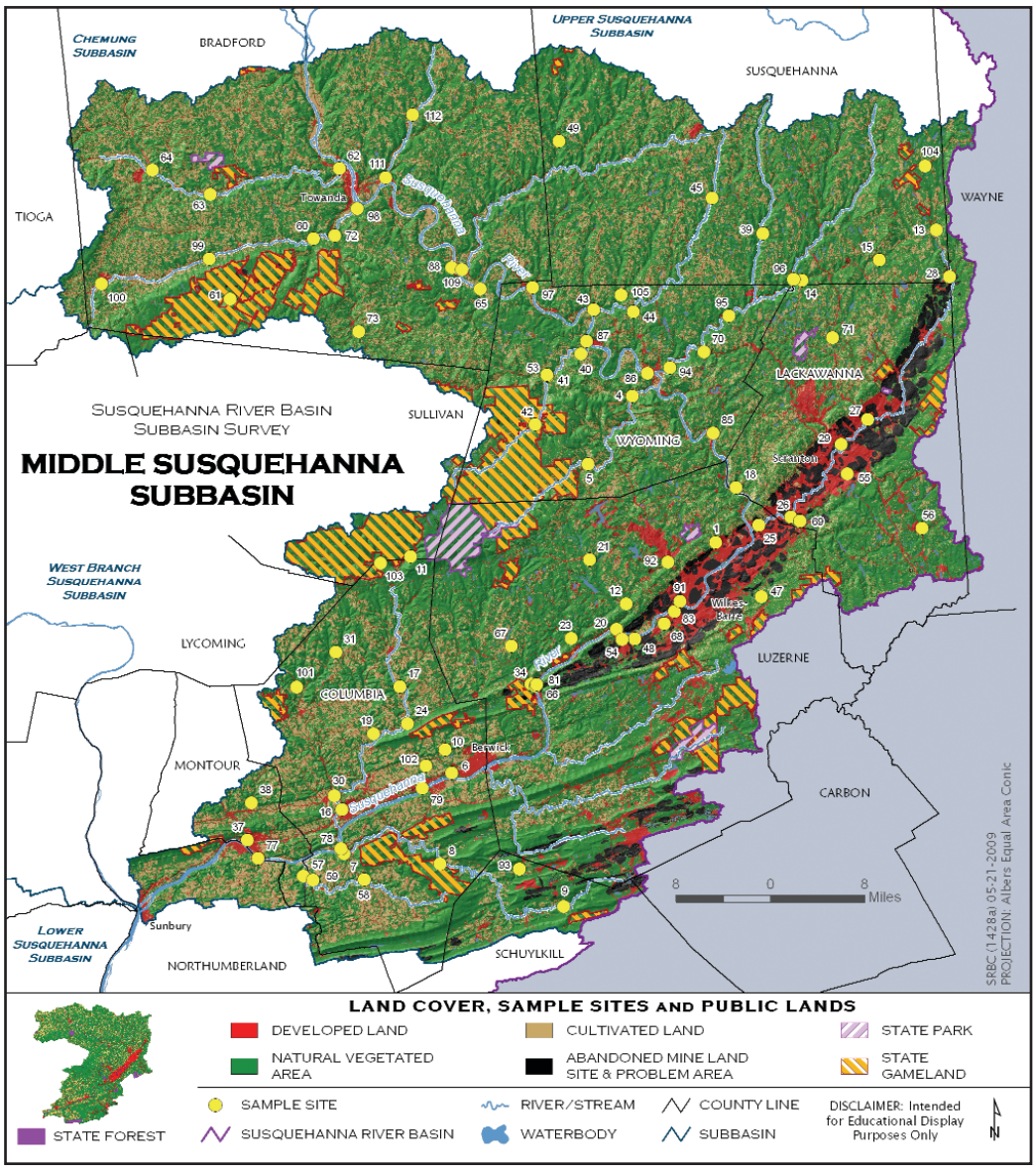


Figure 2. *Land Cover, Sample Sites, and Public Lands in the Middle Susquehanna Subbasin*

Table 1. *Water Quality Parameters Sampled in the Middle Susquehanna Subbasin Survey*

Field Parameters	
Flow, instantaneous cfs[a]	Conductivity, µmhos/cm[c]
Temperature, °C	Alkalinity, mg/l
pH	Acidity, mg/l
Dissolved Oxygen, mg/l[b]	

Laboratory Analysis	
Alkalinity, mg/l	Total Magnesium, mg/l
Total Suspended Solids, mg/l	Total Sodium, mg/l
Total Nitrogen, mg/l	Chloride, mg/l
Nitrite - N, mg/l	Sulfate - IC, mg/l
Nitrate - N, mg/l	Total Iron, µg/l[e]
Turbidity, NTU[d]	Total Manganese, µg/l
Total Organic Carbon, mg/l	Total Aluminum, µg/l
Total Hardness, mg/l	Total Phosphorus, mg/l
Total Calcium, mg/l	Total Orthophosphate, mg/l

[a] cfs = cubic feet per second
[b] mg/l = milligram per liter
[c] µmhos/cm = micromhos per centimeter
[d] NTU = nephelometric turbidity units
[e] µg/l = micrograms per liter

SRBC staff collecting macroinvertebrate samples.

Table 2. *Water Quality Levels of Concern and References*

Parameters	Limit	Reference Code
Temperature	>25 °C	a,f
D.O.	<5 mg/l	a,g,i
Conductivity	>800 µmhos/cm	d
pH	<5.0	c,f,g
Acidity	>20 mg/l	m
Alkalinity	<20 mg/l	a,g
TSS	>25 mg/l	h
Nitrogen*	>1.0 mg/l	j
Nitrite-N	>0.5 mg/l	f,i
Nitrate-N*	>0.6 mg/l	j,k
Turbidity	>150 NTU	h
Phosphorus	>0.1 mg/l	e,j,k
Orthophosphate	>0.05 mg/l	l,j,k
TOC	>10 mg/l	b
Hardness	>300 mg/l	e
Calcium	>100 mg/l	m
Magnesium	>35 mg/l	l,i
Sodium	>20 mg/l	i
Chloride	>250 mg/l	a,i
Sulfate	>250 mg/l	a,i
Iron	>1,500 µg/l	a
Manganese	>1,000 µg/l	a
Aluminum	>750 µg/l	n,c
	>200 µg/l, pH <5.0	

Reference Code & References

a. http://www.pacode.com/secure/data/025/chapter93/s93.7.html
b. Hem (1970) - http://water.usgs.gov/pubs/wsp/wsp2254/
c. Gagen and Sharpe (1987) and Baker and Schofield (1982)
d. http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm
e. http://www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm
f. http://www.hach.com/h2ou/h2wtrqual.htm
g. http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/pondstream.pdf
h. http://www.epa.gov/waterscience/criteria/sediment/appendix3.pdf
i. http://www.dec.ny.gov/regs/4590.html
j.* http://water.usgs.gov/pubs/circ/circ1225/images/table.html
k. http://pubs.usgs.gov/circ/circ1136/
l. http://www.epa.gov/waterscience/criteria/goldbook.pdf
m. based on archived data at SRBC
n. http://www.epa.gov/waterscience/criteria/wqctable/

** Background levels for natural streams*

Water quality, biological (macroinvertebrate) community, and habitat conditions for each sampling site in 2008 throughout the Middle Susquehanna Subbasin are depicted in Figure 3. Six sites demonstrated the best overall conditions in each category with nonimpaired macroinvertebrates, "higher" water quality, and excellent habitat. Those six sites were ETNK 10.0, LAWR 35.2, SGRR 0.4, STWN 0.1, TUNK 1.8, and TUNK 11.9. Forty sites (43 percent) had "higher" water quality, 45 sites (49 percent) had "middle" water quality, and seven sites (8 percent) had "lower" water quality conditions. Thirty-one sites (34 percent) had nonimpaired, 37 sites (40 percent) had slightly impaired, 20 sites (22 percent) had moderately impaired, and four sites (4 percent) had severely impaired biological conditions. Forty sites (43 percent) had excellent habitat, 45 sites (49 percent) had supporting habitat, six sites (7 percent) had partially supporting habitat, and one (1 percent) had nonsupporting habitat conditions.

The parameters that exceeded levels of concern at the largest number of sites were total sodium (23), alkalinity (20), nitrogen (15), nitrates (14), orthophosphate (11), and phosphorus (10) (Table 3). Sodium and total suspended solids were not sampled at 16 sites due to sampling error; therefore, the number of sites exceeding levels of concern may have been higher. The highest number of levels of concern exceeded at a single site was 11, occurring at the Lackawanna River (LAWR 0.8). Newport Creek (NWPT 0.5) had the second highest number of levels of concern exceeded with ten. The highest or lowest value for each parameter is printed in bold in Table 3. NWPT 0.5 had the highest levels of calcium (138 mg/l), hardness (676 mg/l), iron (22,500 µg/l), magnesium (80.3 mg/l), manganese (4,730 µg/l), sulfate (667 mg/l), acidity (52 mg/l), and conductivity (1,400 µmhos/cm). The highest level of aluminum was on Little Nescopeck Creek (LNSK 0.1) with a value of 4,225 µg/l, and this site had the lowest value of alkalinity at zero mg/l. Catawissa Creek (CATW 33.2) also had high aluminum levels with a value of 3,660 µg/l, and an alkalinity value of zero mg/l. These two sites, LNSK 0.1 and CATW 33.2, had the lowest pH values at 4.5 and 4.0, respectively. Nutrients and sodium were highest at Leggetts Creek with 6.3 mg/l of nitrate, 6.87 mg/l of total nitrogen, 1.998 mg/l of orthophosphate, 2.228 mg/l of total phosphorus, and 84.3 mg/l of sodium. The highest temperature was recorded on Catawissa Creek (CATW 0.5) with a value of 26.9 degrees Celsius, and the highest total suspended solids value was at LNSK 0.1 at 26 mg/l (Table 3).

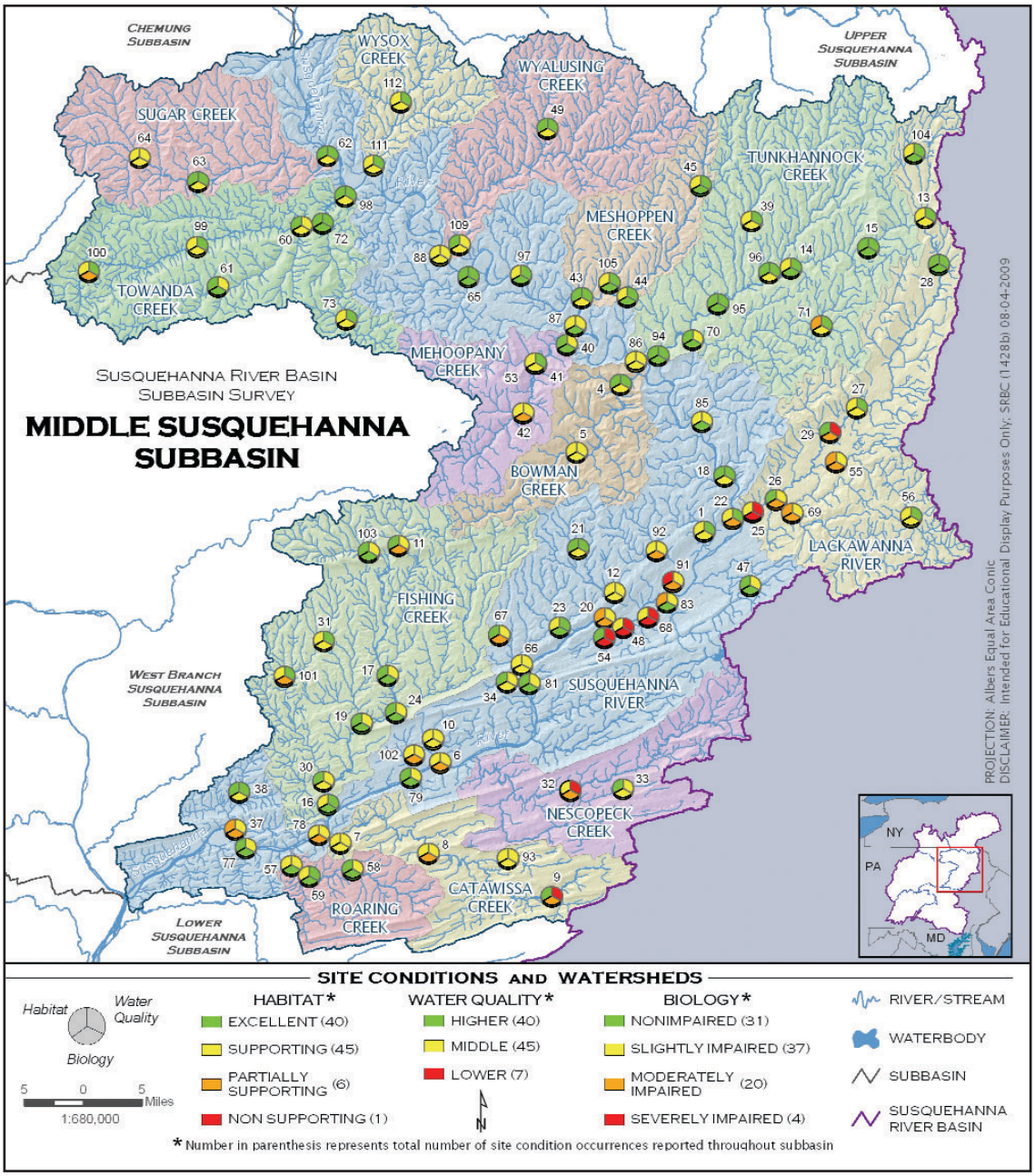


Figure 3.
Water Quality, Biological, and Habitat Conditions in the Middle Susquehanna Subbasin in 2008

Table 3. *Middle Susquehanna Subbasin Sites with Water Quality Values Exceeding Levels of Concern*

Site #	Station Name	Date	Time	Alkalinity < 20 mg/l	*Al > 750 ug/l	Ca > 100 mg/l	Hardness > 300mg/l	Fe > 1,500 ug/l	Mg > 35 mg/l	Mn > 1,000 ug/l	Nitrate > 0.6 mg/l	Nitrogen > 1.0 mg/l	OrthoP > 0.05 mg/l	Phosphorus > 0.1 mg/l	Sodium > 20 mg/l	Sulfate > 250 mg/l	TSS > 25 mg/l	Acidity > 20 mg/l	pH < 5.0	Conductivity > 800 umhos/cm	Temp > 25° C	# Exceeds
5	BOWM013.1	06-18-2008	15:30	8																		1
6	BRIR000.4	07-10-2008	09:00								1.62	1.88										2
7	CATW000.5	07-16-2008	18:00	5.6																	**26.9**	2
8	CATW014.6	07-17-2008	11:30	3																		1
9	CATW033.2	07-17-2008	14:00	**0**	3660					1295								28	**4**			5
10	EBRR004.9	07-10-2008	09:30								1.1	1.22										2
11	EFSH003.4	07-23-2008	12:10	3																		1
12	EHRV000.1	07-09-2008	10:30								1.05	1.24	0.344	0.366								4
17	FISH019.5	07-29-2008	11:20	9.2																		1
19	GREN001.1	07-29-2008	13:45								1.22	4.38										2
20	HARV000.1	07-09-2008	09:30										0.054									1
24	HUNT000.3	07-29-2008	12:20	13.8																		1
25	LAWR000.8	06-26-2008	13:30				305	12500	40.2	1210	1.74	2.15	0.071	0.329	38.4			26		817		11
26	LAWR004.2	06-25-2008	15:30								3.12	3.71	0.423	0.507	30.3							5
29	LEGT000.1	06-25-2008	14:30								**6.3**	**6.87**	**1.998**	**2.228**	**84.3**					810		6
30	LFSH000.1	07-29-2008	15:00																		25.3	1
32	LNSK000.1	06-23-2009	17:00	**0**	**4225**			1624	41	2428						254	**26**		4.55			8
33	LNSK005.7	06-23-2009	15:20	11.8																		1
34	LSHK000.1	07-09-2008	13:30	10.6																		1
37	MAHO001.4	07-10-2008	11:45								1.26	1.64	0.087	0.111	23.5						26.1	6
40	MEHO001.5	06-23-2008	15:30	13.8																		1
41	MEHO006.4	06-23-2008	13:00	4.2																		1
42	MEHO011.2	06-23-2008	12:00	2.2																		1
47	MILL006.7	07-09-2008	08:00	10											20.6							2
48	NANT000.4	07-08-2008	14:00		1300	113	507	7300	54.5	3480					43.9	436				1148		9
54	NWPT000.5	07-08-2008	15:00			**138**	**676**	**22500**	**80.3**	**4730**		1.08			42.1	**667**		**52**		**1400**		10
55	RORB003.0	06-26-2008	10:00												32.5							1
57	RORC001.7	07-17-2008	08:30								0.85											1
58	RORC010.9	07-17-2008	10:30								1.44	1.59										2
60	SCHR000.2	06-17-2008	13:30	6																		1
61	SCHR011.7	06-17-2008	12:00	6																		1
64	SGRC022.1	07-15-2008	08:30									1.45	0.247	0.343								3
66	SHIK000.1	07-09-2008	12:30	12.2																		1
67	SHIK004.6	07-09-2008	14:15	14.6																		1
68	SOLO000.9	06-19-2008	11:30					21400	49.1	2660		1.02				360				1146		6
69	SPRB001.9	06-26-2008	12:30	11											24.4							2
70	STNK000.5	06-24-2008	15:30												23.3							1
77	SUSQ138.0	10-21-2008	14:00												31.6							1
78	SUSQ146.4	10-21-2008	10:30										0.08	0.117	33.2							3
79	SUSQ155.9	10-20-2008	14:00										0.071	0.103	32.9							3
81	SUSQ172.8	10-20-2008	11:30												33.8							1
83	SUSQ187.5	10-02-2008	13:00												28.4							1
85	SUSQ209.1	10-02-2008	09:30												26.3							1
86	SUSQ220.6	10-01-2008	16:00												26							1
87	SUSQ231.8	10-01-2008	13:30												28.4							1
88	SUSQ253.7	10-01-2008	10:30												30.9							1
91	TOBY000.2	07-08-2008	12:30								0.99	1.17			32.2							3
92	TOBY005.1	07-08-2008	11:00								0.67				35.8							2
93	TOMH003.2	07-17-2008	13:00										0.229	0.311	26.3							3
102	WBRR003.2	07-10-2008	10:30								2.04	2.3										2
103	WFSH003.2	07-23-2008	09:40	4.6																		1
109	WYAL000.4	07-16-2008	09:30								2.98	3.22	0.137	0.174	22							5
			# Exceeds	20	3	2	3	5	5	6	14	15	11	10	23	4	1	3	2	5	3	

*Al >750 ug/l for all waters and >200 ug/l for waters with pH < 5.2.

Endless Mountain Region Watersheds

The watersheds discussed in this region are located in the northern portion of the Middle Susquehanna Subbasin and include Sugar Creek, Towanda Creek, Wysox Creek, Wyalusing Creek, Sugar Run, Tuscarora Creek, Meshoppen Creek, Mehoopany Creek, Tunkhannock Creek, Bowman Creek, and Gardner Creek. The Endless Mountain Region is mostly in the Northern Appalachian Plateau and Uplands Ecoregion and is characterized by rolling hills of agricultural and forested lands. Urban areas are few and small with the largest town being Towanda, Pa. The stream conditions and habitat in this region are mostly good quality.

This region had five sites with the best overall conditions of nonimpaired biology, "higher" water quality, and excellent habitat. These sites were located in Tunkhannock Creek, Towanda Creek, and Sugar Run Watersheds. Thirty-five sites were sampled in this region and 13 had nonimpaired biological conditions, 26 had "higher" water quality conditions, and 19 had excellent habitat conditions. The sites that had nonimpaired biological conditions were mostly located in Tunkhannock Creek, Towanda Creek, Sugar Run, Meshoppen Creek, Mehoopany Creek, and Tuscarora Creek Watersheds. The worst biological conditions consisted of two moderately impaired sites located in the headwaters of Mehoopany and Towanda Creeks.

Water quality values that exceeded levels of concern included alkalinity, sodium, total nitrogen, total nitrate, total phosphorus, and total orthophosphate. Alkalinity was low at many sites on Mehoopany, Schrader, and Bowman Creeks and nitrogen and phosphorus levels were elevated on Wyalusing and Sugar Creeks. Wyalusing Creek and South Branch Tunkhannock Creek also had slightly elevated sodium. Most of the sites where sodium and total suspended solids values were not measured due to sampling error were in this region on Towanda, Schrader, Meshoppen, Bowman, and Gardner Creeks. Some of the habitat problems noted at a few sites concerned condition of banks, frequency of riffles, and lack of naturally vegetated riparian areas. One site was rated partially supporting in habitat condition and that site was South Branch Tunkhannock Creek downstream of Route 81.

Bowman Creek located in Wyoming County.

Wyoming Valley (Scranton and Wilkes-Barre) Region Watersheds

The watersheds sampled during this survey that flow into the Wyoming Valley include Lackawanna River, Hicks Creek, Abrahams Creek, Mill Creek, Toby Creek, Solomons Creek, Nanticoke Creek, and Newport Creek. The Wyoming Valley area is located in the North Central Appalachians Ecoregion and is characterized by a legacy of AMD and dense urban development (Figure 2). These urban areas are located in and around Scranton and Wilkes-Barre, Pa.

The best overall conditions in biology, water quality, and habitat in the Wyoming Valley Region were found only at one site in the headwaters of the Lackawanna River (LAWR 35.2). Eighteen sites were sampled in this region and only three of those sites had nonimpaired biological conditions. Two of those sites were in the headwaters of the Lackawanna River and the other one was MILL 6.7. Seven sites had "higher" water quality, and five sites had excellent habitat conditions. Four sites had severely impaired conditions including Lackawanna River at the mouth, Nanticoke Creek, Newport Creek, and Solomons Creek, all of which were impaired by AMD. Five sites had "lower" water quality and six sites had "middle" water quality mostly due to AMD pollutants such as elevated metals and urban pollutants such as elevated nutrients and sodium. Newport Creek had the highest levels of iron, manganese, and sulfates (common pollutants in AMD) while Leggetts Creek, located downstream of a wastewater treatment plant in an urban area, had the highest level of nutrients and sodium (Table 3). Other sites with elevated nutrients and sodium were LAWR 4.2, LAWR 0.8, TOBY 5.1, and TOBY 0.2. Spring Brook and Mill Creek had low levels of alkalinity and elevated sodium. Habitat issues in this region mostly concerned poor condition of banks, lack of naturally vegetated riparian zones, embeddedness, and sediment deposition. The worst habitat conditions were at TOBY 0.2, which had nonsupporting habitat due to a lot of sediment deposition, poor condition of banks, embeddedness, lack of riffles, poor epifaunal substrate, and deficient instream cover habitat.

> *"The best overall conditions in biology, water quality, and habitat in the Wyoming Valley Region were found only at one site in the headwaters of the Lackawanna River."*

AMD-impacted Solomons Creek.

Watersheds from West Nanticoke to Sunbury, Pa.

The watersheds sampled during this survey that enter the Susquehanna River between West Nanticoke and Sunbury, Pa., include Harveys Creek, Hunlock Creek, Shickshinny Creek, Little Nescopeck Creek, Briar Creek, Catawissa Creek, Fishing Creek, Mahoning Creek, and Roaring Creek. This section of the Middle Susquehanna Subbasin is located in the North Central Appalachians Ecoregion and the Central Appalachian Ridges and Valleys Ecoregion. The ridge and valley region is characterized by almost parallel ridges and valleys formed by folding and faulting events. The streams in this area may be influenced by springs and caves. Cultivated agriculture lands are more common in this ridge and valley area (Figure 2). Abandoned mine lands and some urban areas also impact this section from West Nanticoke to Sunbury, Pa.

There were no sites in this section that had the best overall conditions in biology, water quality, and habitat. Of the 30 sites sampled, nine sites had nonimpaired biological conditions, seven sites had "higher" water quality, and 13 sites had excellent habitat conditions. No sites had severely impaired conditions; however, 10 sites had moderately impaired conditions. The sites that had the best biological conditions were located in Fishing Creek, Roaring Creek, and Hunlock Creek Watersheds.

Twenty-three sites exceeded water quality levels of concern. Many of the sites had low alkalinity, such as East Branch Fishing Creek, West Branch Fishing Creek, Fishing Creek, Huntingdon Creek (Fishing Creek Watershed), Shickshinny Creek, Little Shickshinny Creek, Little Nescopeck Creek, and Catawissa Creek. Little Nescopeck and Catawissa Creeks also displayed impacts of AMD with high metals, particularly aluminum. LNSK 0.1 had the highest aluminum value in the survey (Table 3). High nutrient conditions were found on numerous streams such as Harveys Creek, East Fork Harveys Creek, Mahoning Creek, Briar Creek, West Branch Briar Creek, East Branch Briar Creek, Green Creek (Fishing Creek Watershed), Roaring Creek, and Tomhicken Creek (Catawissa Creek). No sites had nonsupporting habitat and only two sites had partially supporting habitat (HARV 0.1 and MAHO 1.4). Most of the habitat issues included poor condition of banks, lack of naturally vegetated riparian zones, channel alteration, infrequent riffles, low channel flow, and lack of diversity in velocity and depth.

Susquehanna River Mainstem

The Susquehanna River meanders through the Middle Susquehanna Subbasin from Towanda to Sunbury, Pa., and passes through the Northern Appalachian Plateau and Uplands, North Central Appalachians, and Central Appalachian Ridges and Valleys ecoregions. No sites sampled on the Susquehanna River during this 2008 subbasin survey had overall best biological, water quality, and habitat conditions. Of the nine sites sampled on the river, six sites had nonimpaired conditions; however, no sites had "higher" water quality. All the sites had "middle" water quality. Most of the habitat conditions were supporting or excellent.

The six nonimpaired sites were SUSQ 138 (just upstream of Danville), SUSQ 155.9 (Mifflinville), SUSQ 172.8 (upstream of Shickshinny), SUSQ 187.5 (Wilkes-Barre), SUSQ 209.1 (West Falls), and SUSQ 231.8 (North Mehoopany). None of the river sites had severely impaired conditions, but one of them had moderately impaired conditions. This site was located in Bloomsburg, Pa. (SUSQ 146.4). All the sites on the river exceeded the sodium level of concern of 20 mg/l. The highest sodium level was 33.8 mg/l at the site located upstream of Shickshinny, Pa. Two river sites also had elevated total phosphorus and orthophosphate. Those sites were located at Mifflinville and Bloomsburg, Pa. The habitat was rated excellent at three of the nonimpaired sites in Danville, Mifflinville, and north of Shickshinny, Pa. There were no sites with nonsupporting habitat and only one site had partially supporting habitat. This site was located in Wilkes-Barre, Pa., and scored low in the habitat assessment on sediment deposition, channel alteration, channel sinuosity, condition of banks, vegetative protective cover, and riparian vegetative zone width.

Hunlock Creek located in Luzerne County.

Comparison of 2008 and 2001 Data

A comparison of the current 2008 data and historical 2001 data showed mostly similar conditions. The results for the biological, water quality, and habitat conditions in the 2001 Middle Susquehanna Subbasin Survey (LeFevre, 2002) are depicted in Figure 4. There were 106 sites sampled during the 2001 survey; however, two sites (HNT 5.0 and UNTA 0.1) were removed from the list for 2008 and are not included in this report. The methods from 2001 to 2008 were very similar except for the water quality analysis methods. Therefore, the water quality analysis was repeated using current methods for the 2001 data in order to compare it to the 2008 data.

A comparison of Figures 3 and 4 indicates that the conditions in 2001 and 2008 have remained relatively the same with mostly green colors (nonimpaired, "higher", and excellent conditions) located in the northern portion and mostly red colors (severely impaired, "lower", and nonsupporting conditions) located in the Wyoming Valley (eastern) portion of the subbasin. Figures 5 and 6 show similar percent composition of biological conditions in 2001 and 2008. In 2001, 27 percent of the sites had nonimpaired, 48 percent had slightly impaired, 17 percent had moderately impaired, and 8 percent had severely impaired conditions (Figure 5). In 2008, 34 percent had nonimpaired, 40 percent had slightly impaired, 22 percent had moderately impaired, and 4 percent had severely impaired conditions (Figure 6). Four sites had the best overall conditions for biology, water quality, and habitat in both 2001 and 2008.

Those sites were in the Tunkhannock Creek, Towanda Creek, and Sugar Run Watersheds (ETNK 10.0, TUNK 11.9, STWN 0.1, and SGRR 0.4).

Individual watersheds that may indicate slight improvement or degradation from 2001 to 2008 include Catawissa Creek (improvement) and Mahoning Creek (degradation). Individual sites that had a large change in condition category from 2001 to 2008 were HARV 0.1, STNK 16.3, WBRN 0.7, and WLWR 5.2. HARV 0.1 degraded from nonimpaired to moderately impaired in biological condition and from excellent to partially supporting in habitat condition. Orthophosphate values at this site exceeded levels of concern in 2001 and 2008. STNK 16.3 degraded from excellent to partially supporting habitat conditions, mostly due to large sediment deposition noted in 2008. WBRN 0.7 degraded from nonimpaired to moderately impaired in biological condition. This site is located in the headwaters of Fishing Creek, where atmospheric deposition impacts have been of concern. A comparison of the macroinvertebrate community from 2001 and 2008 data indicates a decrease in mayflies and variety of caddisflies. WLWR 5.2 improved from moderately impaired to nonimpaired with an increase of mayflies, stoneflies, and caddisflies.

Table 4 shows a comparison of the number of parameter values that exceeded levels of concern and the percentage of the total number of sites sampled in both 2001 and 2008. These numbers were very similar for most parameters in both years, except for nitrogen, nitrate, and dissolved oxygen, which were higher in 2001, and total phosphorus, which was slightly higher in 2008. The parameters that had the highest

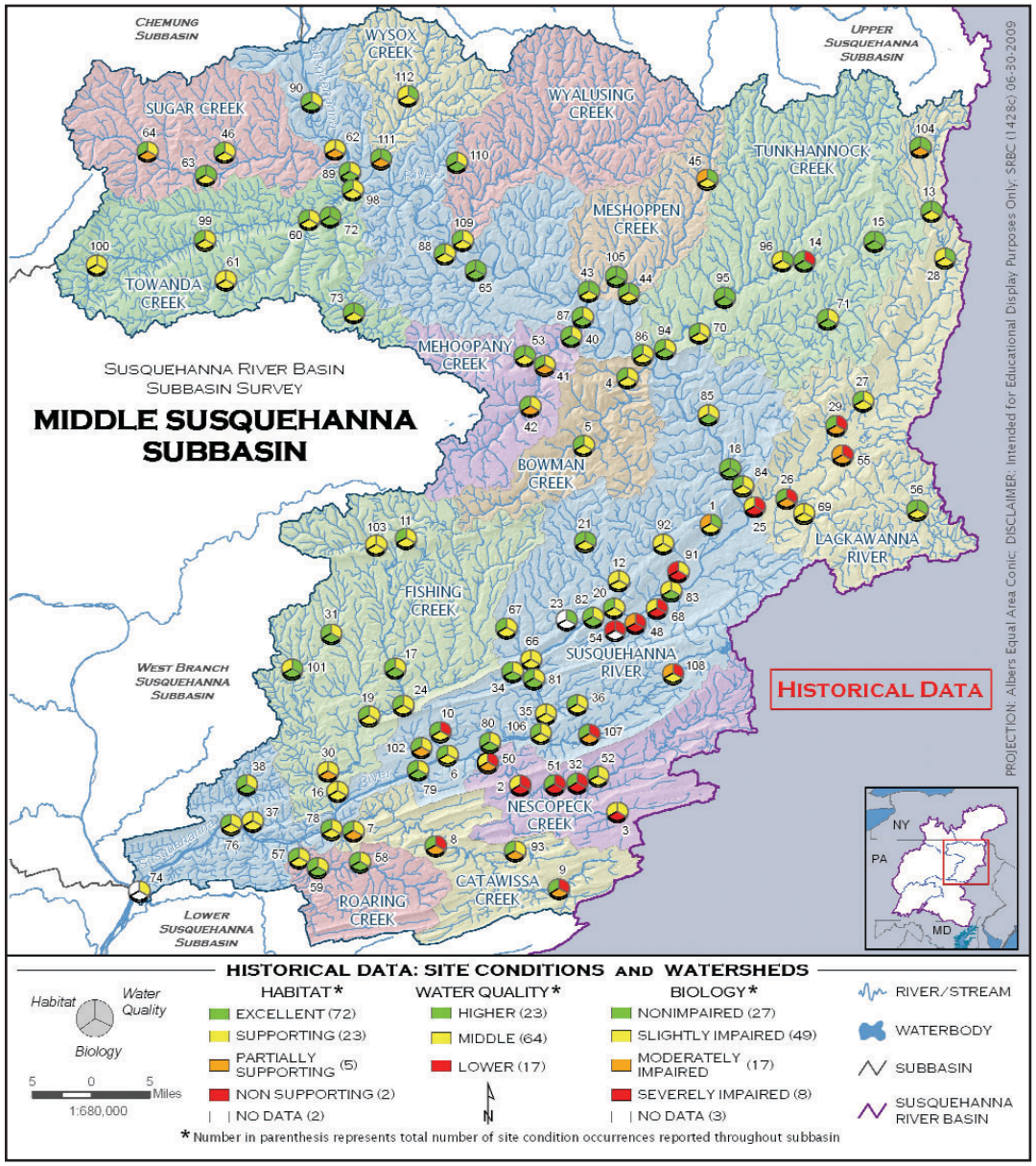


Figure 4. *Water Quality, Biological, and Habitat Conditions in the Middle Susquehanna Subbasin in 2001*

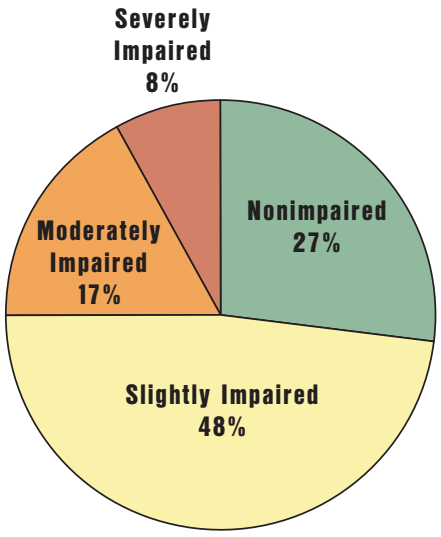


Figure 5.
Summary of Biological Conditions in the Middle Susquehanna Subbasin in 2001

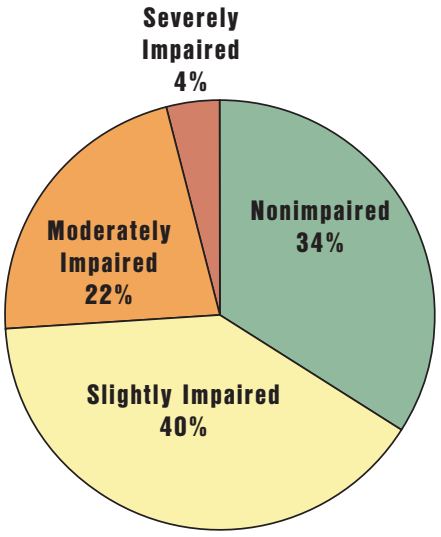


Figure 6.
Summary of Biological Conditions in the Middle Susquehanna Subbasin in 2008

number of sites exceeding levels of concern were similar in both years. These parameters were alkalinity, nitrate, nitrogen, and sodium. In 2001, alkalinity and nitrate had the highest number of sites (25), and sodium and nitrogen were close with 24 and 23 sites, respectively. The parameter to exceed levels of concern the most in 2008 was sodium (23), with alkalinity (20), nitrogen (15), and nitrate (14) being high also. The largest difference in percentage of sites between years was total nitrate, nitrogen, and phosphorus, with total nitrate and nitrogen being higher in 2001 and total phosphorus being higher in 2008.

Many of the sites had the same parameters that exceeded levels of concern in both 2001 and 2008. Also, the sites that had the overall highest or lowest values in certain parameters were the same in both years. Newport Creek had the highest values of typical AMD parameters, such as iron, manganese, and sulfate, and Little Nescopeck Creek had the highest aluminum value, lowest alkalinity, and the same pH value in 2001 and 2008. Leggetts Creek had excessively high values in nutrients and sodium in 2001, with little to no overall improvement in 2008. This site (LEGT 0.1) had the overall highest nutrient and sodium values in both surveys. Many of the Susquehanna River mainstem sites exceeded levels of concern for sodium values in both 2001 and 2008.

CONCLUSIONS

Overall, the majority of the streams in the Middle Susquehanna Subbasin were good with nonimpaired and slightly impaired ratings assigned to 74 percent of the sites sampled. There were also numerous extremely degraded streams, mostly impacted by AMD. Figures 3 and 4, which display the 2008 and historical condition categories, show that the most impaired stream sites were located in the AMD and urban land use areas on Figure 2. The watersheds most impacted by AMD were Newport Creek, Nanticoke Creek, Solomons Creek, Lackawanna River, and Catawissa Creek. Streams that were impacted by urban land use were Leggetts Creek, Lackawanna River, Sugar Creek headwaters, and Mahoning Creek. Agriculture land use was located throughout the subbasin, but was more prevalent in the southern end. Not many or severe impacts from agriculture were noted. Streams that may experience slight agricultural impacts include Wyalusing Creek, Green Creek, Briar Creek (east and west branches), Mahoning Creek, and Sugar Creek headwaters. Another pollution concern in this subbasin is acidic atmospheric deposition. Numerous stream sites had low alkalinity as the only water quality parameter that exceeded levels of concern. Many of these sites drain the same area of North Mountain and Huntingdon Mountain located near the intersections of Sullivan, Columbia, Luzerne, and Wyoming Counties. This area has waters that have been designated by the Department of Environmental Protection as potentially impacted by atmospheric deposition, including East Branch Fishing Creek. The watersheds in this survey that had low alkalinity and are located in this area include headwaters of Fishing Creek, Mehoopany Creek, Bowman Creek, and Shickshinny Creek. East Branch Briar Creek and Hunlock Creek, which are also in this area, had lower alkalinity; however, it was not lower than 20 mg/l. East Branch Fishing Creek and West Branch Fishing Creek also had elevated aluminum (higher than 200 µg/l) at the time of sampling, which is another indication of acidic atmospheric deposition influence. Schrader Creek also had low alkalinity and was located in an area of atmospheric deposition concerns.

The watersheds in the northern portion of the Middle Susquehanna Subbasin (Endless Mountain Region) appeared to be healthier, in general, then the ones in the lower portion, which was also noted in the 2001 survey. The watersheds with the majority of the best overall conditions were Tunkhannock Creek, Towanda Creek, and Sugar Run Watersheds. Other watersheds showing mostly nonimpaired conditions included Meshoppen, Hunlock, Fishing, and Roaring Creek Watersheds. Lackawanna River headwaters had good water quality; however, it was extremely degraded toward the mouth. Each ecoregion and drainage size category reference site used for the biological analysis included STNK 0.5, WMSH 1.2, TUNK 1.8, WLWR 5.2, HUNT 0.3, SBRC 0.5, and SUSQ 209.1. The sites with the best habitat scores in each reference category included TUNK 20.3, ETNK 10.0, SCHR 0.2, SCHR 11.7, HUNT 0.3, LFSH 0.1, and SUSQ 138. The most degraded watersheds in this survey were Newport Creek, Nanticoke Creek, Lackawanna River, and Solomons Creek. Other watersheds that showed some degraded conditions included Catawissa Creek, Leggetts Creek, Briar Creek, Toby Creek, Little Nescopeck Creek, Mahoning Creek, and Harveys Creek.

The results of this report were similar to those found in the 2001 Middle Susquehanna Subbasin Survey (LeFevre, 2002). Similar biological condition categories were obtained in both years and similar parameters exceeded levels of concern on the same streams. The watersheds that were identified as being the most severely degraded in 2001 (Lackawanna River, Solomons Creek, Nanticoke Creek, Newport Creek, Nescopeck Creek, and Catawissa Creek) were still degraded in 2008 (except data for Nescopeck Creek was limited to Little Nescopeck Creek in 2008). Similar watersheds that were identified as healthy in 2001 were still healthy in 2008, such as Towanda, Meshoppen, Tunkhannock, Fishing, Roaring, Mehoopany, and Bowman Creeks.

SRBC staff is conducting the Middle Susquehanna Subbasin Survey Year-2 assessment of the Lackawanna Creek Watershed, focusing on CSO systems and untreated sewage impacts. CSO systems are antiquated sewer and stormwater runoff collection infrastructure that release untreated sewage to streams when capacity is exceeded. The Lackawanna River Watershed study will include water sampling in the mainstem and tributary waters during low flow and high flow (storm events), and macroinvertebrate community assessments.

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Appendix

Site #	Station Name	Location Description	County	Latitude	Longitude	Ecoregion	Drainage Size
1	ABRA002.9	Abrahams Creek along 8th Avenue near West Wyoming	Luzerne	41.32583	-75.85167	62	SMALL
2	* BLAK000.1	Black Creek above SR 3016 bridge upstream of Nescopeck Creek confluence	Luzerne	41.0075	-76.16722	67	SMALL
3	* BLAK015.0	Black Creek upstream of SR 93 bridge outside Hazleton	Luzerne	40.97361	-76.01028	62	SMALL
4	BOWM002.5	Bowman Creek downstream of SR 3003 bridge above Tunkhannock	Wyoming	41.50722	-75.985	62	MEDIUM
5	BOWM013.1	Bowman Creek upstream of Market Street Bridge in Noxen	Wyoming	41.42444	-76.05806	62	SMALL
6	BRIR000.4	Briar Creek downstream of Rt. 11 bridge	Columbia	41.04556	-76.285	67	SMALL
7	CATW000.5	Catawissa Creek next to park area near old railroad bridge piers	Columbia	40.9475	-76.46139	67	MEDIUM
8	CATW014.6	Catawissa Creek upstream of T367 bridge	Columbia	40.93417	-76.30528	67	MEDIUM
9	CATW033.2	Catawissa Creek upstream of T818 bridge	Schuylkill	40.88	-76.10611	62	SMALL
10	EBRR004.9	East Branch Briar Creek along SR 1014 above lake	Columbia	41.07444	-76.29611	67	SMALL
11	EFSH003.4	East Fishing Creek above bridge near Jamison City at gamelands	Columbia	41.31222	-76.34972	62	SMALL
12	EHRV000.1	East Fork Harveys Creek upstream of Rt. 29 bridge	Luzerne	41.25194	-75.99861	62	SMALL
13	ELWR000.1	East Branch Lackawanna River upstream of SR 171 bridge and Stillwater Lake	Susquehanna	41.70611	-75.4825	62	SMALL
14	ETNK001.0	East Branch Tunkhannock Creek near Rt. 407 bridge	Susquehanna	41.64694	-75.70417	60	SMALL
15	ETNK010.0	East Branch Tunkhannock Creek upstream of SR 2014 bridge	Susquehanna	41.67056	-75.57722	60	SMALL
16	FISH002.2	Fishing Creek at Bloom Street/Creek Road bridge in Bloomsburg	Columbia	41.00194	-76.46389	67	MEDIUM
17	FISH019.5	Fishing Creek upstream of Rt. 487 bridge	Columbia	41.15278	-76.36889	67	MEDIUM
18	GARD000.4	Gardner Creek above SR 3005 bridge	Lackawanna	41.39306	-75.8175	62	SMALL
19	GREN001.1	Green Creek 1/2 mile upstream of bridge on SR 4020	Columbia	41.09444	-76.41194	67	SMALL
20	HARV000.1	Harveys Creek downstream of Rt. 11 bridge, upstream of railroad bridge	Luzerne	41.22083	-76.01528	62	SMALL
21	HARV008.9	Harveys Creek adjacent to Rt. 118 below LR 802	Luzerne	41.30667	-76.0575	62	SMALL
22	** HICK000.5	Hicks Creek immediately upstream of Rt. 92 bridge in West Pittston	Luzerne	41.34111	-75.805	62	SMALL
23	HUNL001.7	Hunlock Creek upstream of Hunlock Fire Station	Luzerne	41.21028	-76.08889	62	SMALL
24	HUNT000.3	Huntingdon Creek adjacent to SR1021 on fishing accesible land.	Columbia	41.10694	-76.35639	67	MEDIUM
25	LAWR000.8	Lackawanna River at SR 2033 bridge near Duryea	Luzerne	41.34667	-75.78028	62	MEDIUM
26	LAWR004.2	Lackawanna River upstream of 3rd Street/Moosic Road bridge	Susquehanna	41.35611	-75.72778	62	MEDIUM
27	LAWR017.9	Lackawanna River at Rt. 347 bridge along River Road in Olyphant Borough	Lackawanna	41.47444	-75.6	62	MEDIUM
28	LAWR035.2	Lackawanna River upstream of SR 247 bridge near Forest City	Wayne	41.64861	-75.46194	62	SMALL
29	LEGT000.1	Leggetts Creek 0.5 miles downstream of South Abington/Clarks Summit Joint STP & WTP along Rt. 11/6	Lackawanna	41.44472	-75.64444	62	SMALL
30	LFSH000.1	Little Fishing Creek near mouth	Columbia	41.01889	-76.47639	67	SMALL
31	LFSH015.9	Little Fishing Creek at Arden Hill Road covered bridge (fishing permitted section)	Columbia	41.19556	-76.47278	62	SMALL
32	** LNSK000.1	Little Nescopeck Creek near confluence with Nescopeck Creek	Luzerne	41.00944	-76.07444	62	SMALL
33	** LNSK005.7	Little Nescopeck Creek upstream T335 bridge near Kis-Lyn	Luzerne	41.0109	-75.9891	62	SMALL
34	LSHK000.1	Little Shickshinny Creek near mouth at turnaround at end of Glen Road	Luzerne	41.15417	-76.155	62	SMALL
35	* LWWP000.5	Little Wapwallopen Creek upstream of Route 239 bridge	Luzerne	41.095	-76.61806	67	SMALL
36	* LWWP004.5	Little Wapwallopen Creek upstream of T392 bridge	Luzerne	41.10611	-76.07306	67	SMALL
37	MAHO001.4	Mahoning Creek at Rt. 11 bridge, adjacent to Rt. 54 in Danville	Montour	40.965	-76.61806	67	SMALL
38	MAHO005.9	Mahoning Creek upstream of Rt. 642 bridge near Green Ave.	Montour	41.01056	-76.61139	67	SMALL
39	MART006.5	Martins Creek at Rt. 167 bridge near Hope Bottom	Susquehanna	41.7055	-75.7674	60	SMALL

Appendix *continued*

Site #	Station Name	Location Description	County	Latitude	Longitude	Ecoregion	Drainage Size
40	MEHO001.5	Mehoopany Creek at SR 87 bridge near mouth	Wyoming	41.56	-76.06778	62	MEDIUM
41	MEHO006.4	Mehoopany Creek upstream of confluence with West Branch Mehoopany Creek at SR 87 bridge	Wyoming	41.53361	-76.12306	62	SMALL
42	MEHO011.2	Mehoopany Creek at SR 3001 bridge upstream of Kasson Brook	Wyoming	41.47333	-76.14444	62	SMALL
43	MESH000.2	Meshoppen Creek near mouth upstream of Bedrock Gorge Recreation Area	Wyoming	41.61389	-76.04667	60	MEDIUM
44	MESH004.6	Meshoppen Creek upstream of SR 4019 bridge	Wyoming	41.61111	-75.98139	60	SMALL
45	MESH020.6	Meshoppen Creek upstream of SR 2024 bridge	Susquehanna	41.75	-75.85028	60	SMALL
46	*MILL001.7	Mill Creek upstream of first bridge on Stream Hollow Drive	Bradford	41.7879	-76.6428	62	SMALL
47	MILL006.7	Mill Creek about 1/4 mile downstream from powerline crossing along SR 2039	Luzerne	41.25806	-75.77806	62	SMALL
48	NANT000.4	Nanticoke Creek upstream of San Souci Expressway near Nanticoke, upstream of Wyoming Valley Sanitary Authority building	Luzerne	41.20861	-75.98556	62	SMALL
49	NBWC002.8	North Branch Wyalusing Creek upstream of Gaylord Creek, at Rt. 858 bridge	Susquehanna	41.82194	-76.10028	60	SMALL
50	*NESK001.1	Nescopeck Creek upstream of Rt. 339 bridge, downstream of SR 4092 bridge	Luzerne	41.04361	-76.22222	67	MEDIUM
51	*NESK014.7	Nescopeck Creek upstream of bridge on TR 338	Luzerne	41.00778	-76.10139	62	MEDIUM
52	*NESK019.1	Nescopeck Creek upstream of Little Nescopeck Creek above TR 342	Luzerne	41.01722	-76.05083	62	SMALL
53	NMH0000.1	North Branch Mehoopany Creek 1/4 mile downstream of SR 3001 bridge	Wyoming	41.53444	-76.12417	62	SMALL
54	NWPT000.5	Newport Creek upstream of railroad bridge near Weis Market in Nanticoke	Luzerne	41.20778	-76.00639	62	SMALL
55	RORB003.0	Roaring Brook upstream of Ash Street Bridge in Scranton	Lackawanna	41.40833	-75.63528	62	SMALL
56	RORB014.2	Roaring Brook upstream of SR 2005 bridge, upstream of Bear Brook	Lackawanna	41.33972	-75.51444	62	SMALL
57	RORC001.7	Roaring Creek along T 313 upstream of dwellings	Montour	40.92028	-76.52722	67	MEDIUM
58	RORC010.9	Roaring Creek upstream of Rt. 42 bridge at Queen City	Columbia	40.915	-76.42861	67	SMALL
59	SBRC000.5	South Branch Roaring Creek at Krick Road bridge off Rt. 487	Columbia	40.915	-76.51167	67	SMALL
60	SCHR000.2	Schrader Creek at bridge in Powell	Bradford	41.70472	-76.505	62	MEDIUM
61	SCHR011.7	Schrader Creek at old railroad grade at Laquin	Bradford	41.63083	-76.6425	62	SMALL
62	SGRC000.7	Sugar Creek upstream of old railroad bridge at dead end off Rt. 6	Bradford	41.79083	-76.46167	60	MEDIUM
63	SGRC015.9	Sugar Creek downstream of SR 3019 bridge at West Burlington	Bradford	41.75972	-76.67389	60	MEDIUM
64	SGRC022.1	Sugar Creek upstream of Rt. 6 bridge below Troy	Bradford	41.78944	-76.76972	60	SMALL
65	SGRR000.4	Sugar Run upstream of SR 2002 bridge	Bradford	41.64083	-76.23222	60	SMALL
66	SHIK000.1	Shickshinny Creek near mouth downstream of channelized section	Luzerne	41.15167	-76.14778	62	SMALL
67	SHIK004.6	Shickshinny Creek downstream of SR 4007 bridge	Luzerne	41.20111	-76.18694	62	SMALL
68	SOL0000.9	Solomons Creek 1/8 mile downstream of Breaker Road Bridge	Luzerne	41.22667	-75.93667	62	SMALL
69	SPRB001.9	Spring Brook 1/8 mile upstream of Rt. 502 and downstream of Rt. 9 bridges	Luzerne	41.35056	-75.71333	62	SMALL
70	STNK000.5	South Branch Tunkhannock Creek along Spur Road off Rt. 6 near Bardwell	Wyoming	41.56083	-75.86639	60	MEDIUM
71	STNK016.3	South Branch Tunkhannock Creek downstream of SR 4003 and Rt. 81 bridges near Jordan Hollow	Lackawanna	41.57556	-76.65556	60	SMALL
72	STWN000.1	South Branch Towanda Creek near mouth	Bradford	41.70806	-76.47028	60	SMALL
73	STWN009.5	South Branch Towanda Creek upstream of Beech Creek Road bridge at Monroe Township Building	Bradford	41.59	-76.43222	60	SMALL
74	*SUSQ126.3	Susquehanna River at Rt. 147 bridge between Northumberland and Packers Islands	Northumberland	40.88028	-76.78667	River	LARGE
75	*SUSQ126.4	Susquehanna River at Rt. 147 bridge between Packers Island and Sunbury	Northumberland	40.88722	-76.78944	River	LARGE
76	*SUSQ136.8	Susquehanna River about 1/2 mile downstream of Rt. 54 bridge, upstream of Merck discharge	Northumberland	40.96222	-76.6325	River	LARGE
77	SUSQ138.0	Susquehanna River at Fish and Boat access near Danville	Northumberland	40.94222	-76.60111	River	LARGE
78	SUSQ146.4	Susquehanna River at Fish and Boat access in Bloomsburg	Columbia	40.95389	-76.46583	River	LARGE
79	SUSQ155.9	Susquehanna River downstream of boat ramp at park access in Mifflinville	Columbia	41.02722	-76.33306	River	LARGE
80	*SUSQ162.2	Susquehanna River upstream of Rt. 93 bridge near Berwick	Luzerne	41.0544	-76.22167	River	LARGE
81	SUSQ172.8	Susquehanna River upstream of Shickshinny Creek about one mile downstream of Retreat bridge	Luzerne	41.15333	-76.14611	River	LARGE
82	*SUSQ181.4	Susquehanna River upstream of Harveys Creek near West Nanticoke	Luzerne	41.21944	-76.01528	River	LARGE
83	SUSQ187.5	Susquehanna River upstream of Pierce Street bridge in Kingston	Luzerne	41.24194	-75.92	River	LARGE
84	*SUSQ201.8	Susquehanna River downstream of powerline crossing, near Stanton Station	Luzerne	41.38028	-75.79861	River	LARGE
85	SUSQ209.1	Susquehanna River at Fish and Boat access in West Falls	Wyoming	41.46028	-75.85333	River	LARGE
86	SUSQ220.6	Susquehanna River at Fish and Boat access in Tunkhannock	Wyoming	41.53528	-75.95972	River	LARGE
87	SUSQ231.8	Susquehanna River downstream of Rt. 87 bridge at boat access in North Mehoopany	Wyoming	41.57556	-76.05861	River	LARGE
88	SUSQ253.7	Susquehanna River at boat access near Terrytown	Bradford	41.66778	-76.27833	River	LARGE
89	*SUSQ272.7	Susquehanna River upstream of Rt. 6 bridge at Towanda	Bradford	41.76306	-76.4375	River	LARGE
90	*SUSQ280.6	Susquehanna River upstream of Ulster	Bradford	41.84917	-76.49694	River	LARGE
91	TOBY000.2	Toby Creek upstream of Rt. 11 bridge at Edwardsville	Luzerne	41.25389	-75.91111	62	SMALL
92	TOBY005.1	Toby Creek upstream of Carveton Road	Luzerne	41.3025	-75.93	62	SMALL
93	TOMH003.2	Tomhicken Creek upstream of T706 bridge (Croll Road)	Schuylkill	40.92694	-76.17667	62	SMALL
94	TUNK001.8	Tunkhannock Creek at Rt. 6 bridge near golf course	Wyoming	41.54194	-75.92306	62	LARGE
95	TUNK011.9	Tunkhannock Creek about ? mile downstream of SR 1029 bridge	Wyoming	41.60444	-75.82472	60	MEDIUM
96	TUNK020.3	Tunkhannock Creek upstream of Rt. 374 bridge	Susquehanna	41.64806	-75.71806	60	MEDIUM
97	TUSC000.5	Tuscarora Creek upstream of Rt. 6 bridge near Laceyville	Wyoming	41.6421	-76.1463	60	SMALL
98	TWND000.7	Towanda Creek upstream of bridge at airport near Towanda	Bradford	41.74111	-76.43278	60	MEDIUM
99	TWND016.9	Towanda Creek at closed bridge at Woodruff Corners	Bradford	41.68028	-76.67611	60	SMALL
100	TWND027.3	Towanda Creek upstream of Rt. 154 bridge at Canton	Bradford	41.64972	-76.85361	60	SMALL
101	WBRN000.7	West Branch Little Fishing Creek above bridge near Rt. 442 covered bridge	Columbia	41.1525	-76.53667	62	SMALL
102	WBRR003.2	West Branch Briar Creek at Fowlersville Bridge	Columbia	41.055	-76.3275	67	SMALL
103	WFSH003.2	West Branch Fishing Creek at SR 4049 bridge upstream of Central	Columbia	41.30444	-76.39861	62	SMALL
104	WLWR005.2	West Branch Lackawanna River upstream of SR 2046 bridge near Burnwood	Susquehanna	41.785	-75.49944	62	SMALL
105	WMSH001.2	West Branch Meshoppen Creek at T502 bridge, downstream of two tributaries	Wyoming	41.63167	-76.00139	60	SMALL
106	*WWLP000.2	Wapwallopen Creek downstream of Rt. 239 bridge near mouth	Luzerne	41.07111	-76.13306	67	SMALL
107	*WWLP006.5	Wapwallopen Creek upstream of T392 bridge	Luzerne	41.06944	-76.05389	62	SMALL
108	*WWLP017.0	Wapwallopen Creek below SR 2042 bridge	Luzerne	41.14278	-75.91667	62	SMALL
109	WYAL000.4	Wyalusing Creek upstream of Rt. 6 bridge	Bradford	41.665	-76.26167	60	MEDIUM
110	*WYAL014.6	Wyalusing Creek downstream of SR 1075 bridge	Bradford	41.77389	-76.26139	60	MEDIUM
111	WYSX000.4	Wysox Creek upstream Rt. 6 bridge east of Wysox	Bradford	41.77917	-76.38611	60	MEDIUM
112	WYSX006.5	Wysox Creek at Water Street Bridge in Rome	Bradford	41.85611	-76.34083	60	SMALL

*Sites that were not sampled in 2008 Sites sampled in 2001 are in bold text **HICK 0.5, LNSK 0.1, and LNSK 5.7 were sampled in 2009