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2010 Susquehanna Large River Assessment Project

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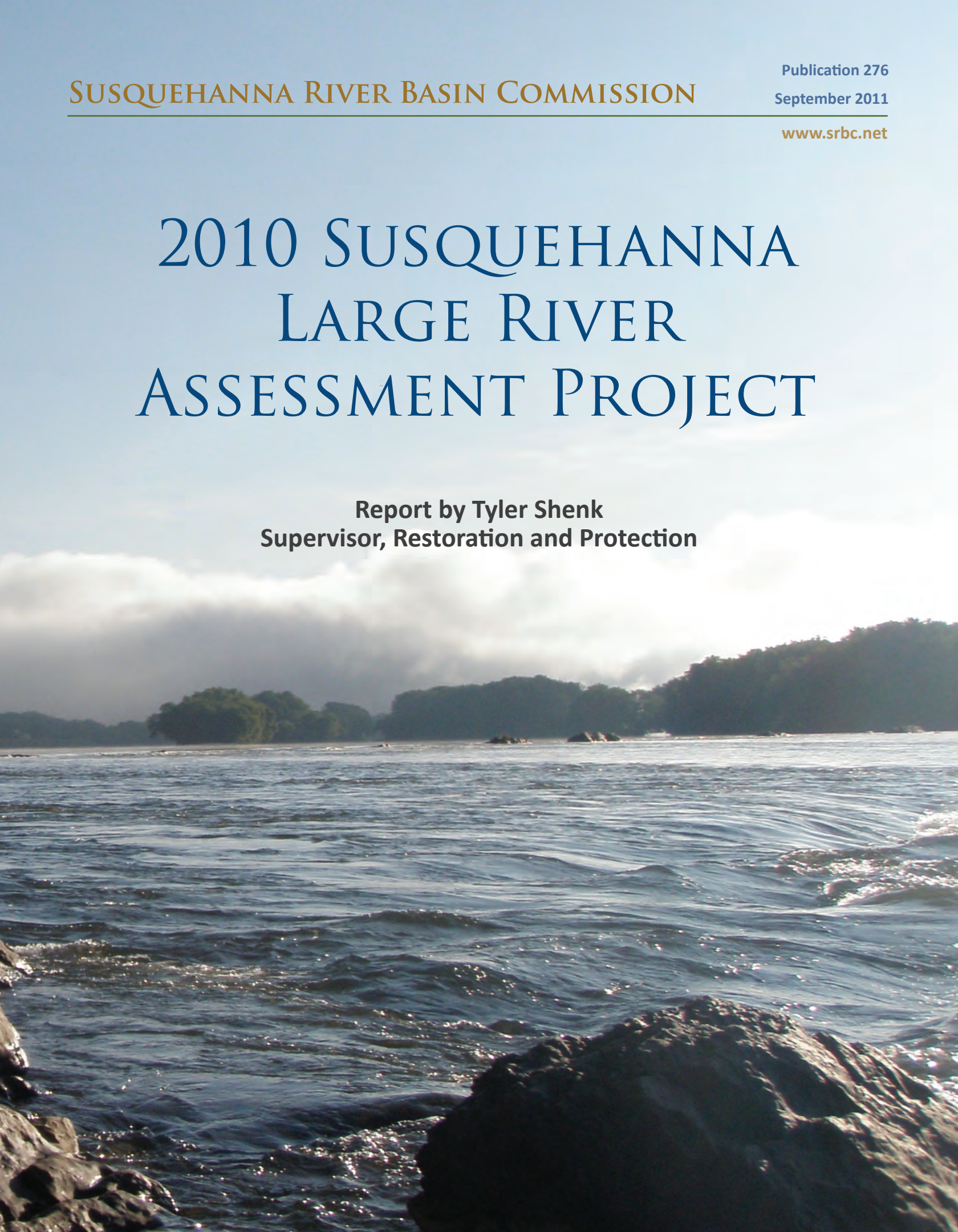

Abstract

Historically, only a few studies were ever conducted to evaluate the condition of large river systems. In recent years, however, that has changed in light of new and expanded methods expressly designed to allow for large river assessments. Many federal, state, and local entities that are interested in the role of larger rivers on industry, power generation, drinking water supply, recreation, and other issues are now able to bring focus to larger river systems. In particular, for the past eight years, the Susquehanna River Basin Commission (SRBC) has been applying expanded technology and methods to monitor the mainstem Susquehanna River.

SRBC conducted a pilot study in 2002 to determine appropriate methods for biologically assessing the large rivers of the Susquehanna River Basin (basin). Based on the results of that study, SRBC determined at that time a combination of rock basket samplers and traditional Rapid Bioassessment Protocol (RBP) methods was the most efficient and consistent collection method to sample the Susquehanna River. These methods were implemented in the 2005 Susquehanna Large River Assessment Project (Hoffman, 2006) at 25 stations on the mainstem Susquehanna River and at the mouths of its major tributaries: the West Branch Susquehanna River, the Juniata River, and the Chemung River.

The U.S. Environmental Protection Agency (USEPA) has developed a field operations manual for the National River and Stream Assessment (NRSA), detailing data collection methods for both wadeable and nonwadeable streams (USEPA, 2008). In 2007, SRBC adapted this protocol for the 25 stations previously sampled. In late summer 2008, SRBC staff collected data at 17 of the same 25 original stations following the NRSA protocols. In 2009, high flows greatly limited SRBC's sampling opportunities. Given the high-flow restrictions, SRBC staff chose to collect data only at the eight stations that were not sampled in 2008, ensuring that all 25 original stations would be covered over the 2008 to 2009 period. In 2010, 16 of the 25 sites were sampled in late summer.

Composite benthic macroinvertebrate samples were collected at each station from three D-frame net sweeps at each of ten transects. Field and laboratory water quality samples and overall observations also were collected at each site.

Three of the sites were designated as nonimpaired, nine sites were slightly impaired, and four sites were moderately impaired. Only 3.6 percent (14 of 384) of the water quality values exceeded their respective limits, indicating fairly good water quality in the Susquehanna River.

SRBC plans to continue using the adapted NRSA nonwadeable river protocols in future assessments. Fish collection has also been added to the protocol for field efforts starting in 2011, and SRBC plans to develop protocols to properly assess the reservoirs in the lower reach of the Susquehanna River.

Introduction

SRBC has been performing biological assessments throughout the basin since the late 1970s. When USEPA introduced the first version of the RBP manual (Plafkin and others, 1989), SRBC adopted those methods for use in its interstate stream monitoring program and its rotating subbasin surveys. However, neither the previous nor current RBP methods (Barbour and others, 1999) used by SRBC in the aforementioned surveys accurately depicted the biological integrity of the basin's large rivers: the mainstem Susquehanna, Chemung, West Branch Susquehanna, and Juniata Rivers. Thus, in 2002, SRBC initiated a pilot project to determine proper methods of biologically assessing the large rivers in the basin. From this pilot project, staff determined that a combination of rock-filled basket samplers and traditional RBP methods was the most effective and consistent collection method for sampling the Susquehanna River (Hoffman, 2003).

"Three of the sites were designated as nonimpaired, nine sites were slightly impaired, and four sites were moderately impaired. Only 3.6 percent (14 of 384) of the water quality values exceeded their respective limits, indicating fairly good water quality in the Susquehanna River."

Susquehanna River at Columbia, Pa.

In summer 2005, SRBC staff collected biological and water quality data at 25 stations on the mainstem Susquehanna River and at the mouth of its major tributaries using the methodology previously described. In 2007, staff changed the methodology to mimic the methods drafted by USEPA for NRSA (USEPA, 2008). These methods have been used for the past four years.

Although the NRSA data collection includes fish, physical habitat, toxicology, and other parameters in addition to benthic macroinvertebrates, SRBC staff chose to focus efforts on benthic macroinvertebrate sampling. Benthic macroinvertebrates were used to assess biological conditions for several reasons. Benthic macroinvertebrates are sensitive to a wide range of stressors, have a wide range of documented pollution tolerances, and are found in a wide variety of habitats throughout lotic systems (Flotemersch and others, 2001a). Additionally, SRBC has background macroinvertebrate data from various sites on the large rivers of the basin from subbasin surveys and interstate streams monitoring, as well as the previous river assessment studies.

Geography

The Susquehanna River Basin is the largest river basin on the east coast of the United States, draining 27,510 square miles. The Susquehanna River originates at Otsego Lake in Cooperstown, N.Y., and flows 444 miles through New York, Pennsylvania, and Maryland to the Chesapeake Bay at Havre de Grace, Md.

This year's Large River Assessment stretched from Sidney, N.Y., to Danville, Pa., and encompassed a total of 16 stations: six in the Upper Susquehanna Subbasin, seven in the Middle Susquehanna Subbasin, one on the Chemung River, one on the Juniata River, and one on the West Branch Susquehanna River (Figure 1). Downstream of Harrisburg, Pa., the river flows through a series of dams and reservoirs, which this protocol is not designed to assess.

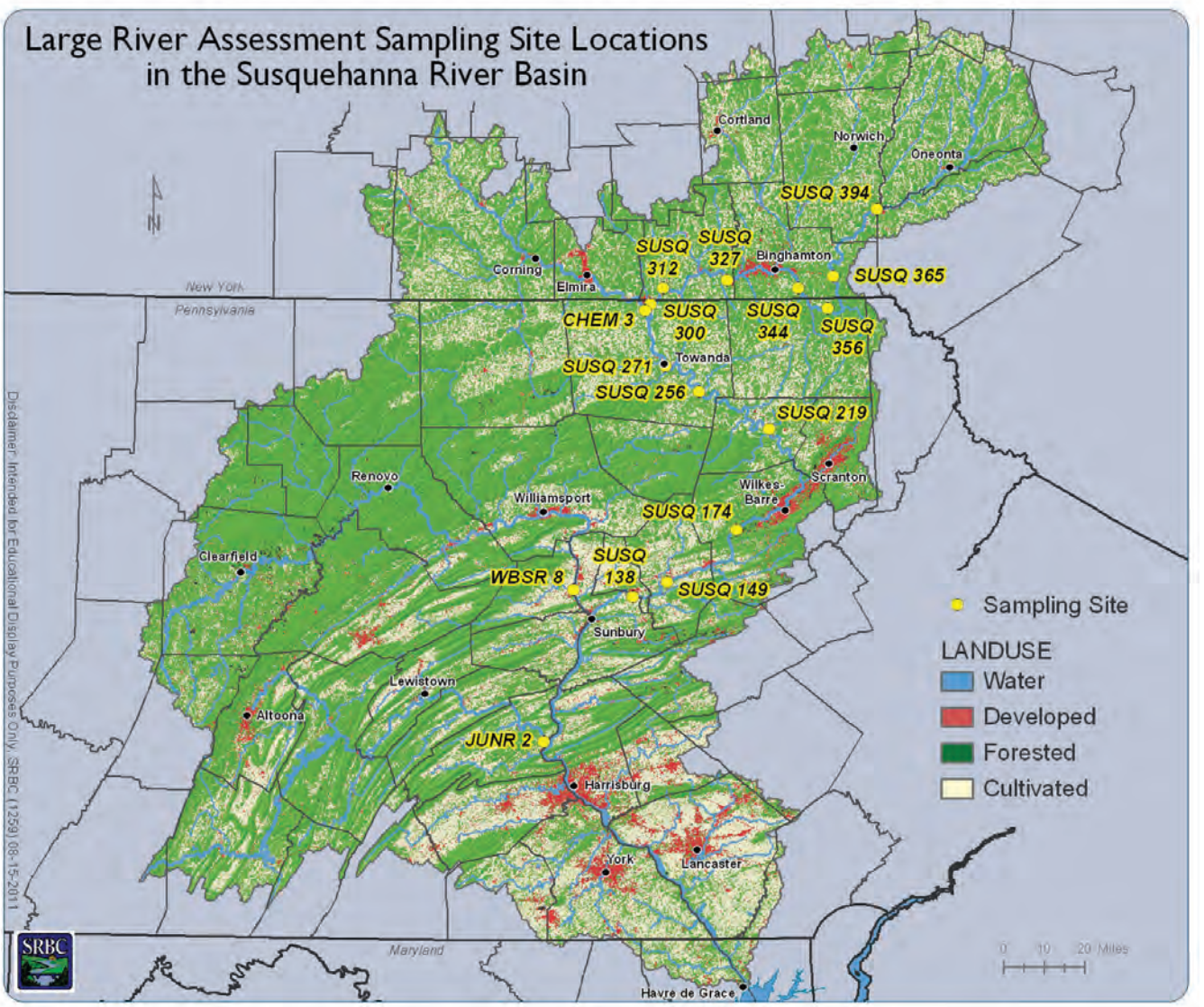

Figure 1. Susquehanna River Site Locations

Methods

Data Collection

In September 2010, SRBC staff collected macroinvertebrate samples using D-frame nets on the mainstem Susquehanna River from Sidney, N.Y., to Danville, Pa., and at the mouth of the Chemung River, Juniata River, and West Branch Susquehanna River. Field chemistry measurements were taken at each site, and chemical water quality samples also were collected for laboratory analysis. Macroinvertebrate samples were labeled with the site number, the date, and the number of bottles used.

A list of laboratory parameters is located in Table 2. Laboratory samples consisted of one 500-ml bottle of raw water, one 250-ml bottle preserved with nitric acid for metal analysis, and one 250-ml bottle preserved with H_2SO_4 for nutrient analysis. Samples were iced and sent for analysis to the Pennsylvania Department of Environmental Protection, Bureau of Laboratories, Harrisburg, Pa.

Table 2. Parameters for Laboratory Analysis

Parameter	
Alkalinity, mg/l[a]	Total Suspended Solids, mg/l
Total Nitrogen, mg/l	Total Sodium, mg/l
Total Nitrite, mg/l	Total Chloride, mg/l
Total Nitrate, mg/l	Total Sulfate, mg/l
Total Phosphorus, mg/l	Total Iron, µg/l[b]
Total Orthophosphate, mg/l	Total Manganese, µg/l
Total Organic Carbon, mg/l	Total Aluminum, µg/l
Total Hardness, mg/l	Turbidity, NTU[c]
Total Magnesium, mg/l	Total Calcium, mg/l

[a] mg/l = milligrams per liter
[b] µg/ micrograms per liter
[c] nephelometric turbidity units

Chemical water quality

Water samples were collected at each sampling site with a depth-integrated sampler to measure nutrient and metal concentrations in the river. Field water quality measurements included water temperature, dissolved oxygen, conductivity, and pH. All field measurements were collected instream with a YSI 6820-V2 meter that was calibrated everyday.

Macroinvertebrates

Ten equidistant transects were established along a one-kilometer sampling reach at each of the sites. Each transect was located along alternating banks; for example, transects two, four, six, eight, and ten were located on the right bank, while transects one, three, five, seven, and nine were located on the left bank. To collect benthic macroinvertebrates (organisms that live on the stream bottom, including aquatic insects, crayfish, clams, snails, and worms), staff used a D-frame net with 500-µm mesh to collect three samples within a 10-meter area surrounding each transect, to a depth of 0.5 meters. Samples were taken from multiple habitats, including bottom substrate, woody debris, undercut banks, and macrophytes. A total of 30 samples were then composited into a single

Table 1. Susquehanna River Station Locations

Station Number	County/State	USGS Quad	Latitude	Longitude	Site Description
SUSQ 394	Chenango/N.Y.	Sidney, N.Y.	42.3113	-75.4199	Susquehanna River at Sidney, N.Y.
SUSQ 365	Broome/N.Y.	Windsor, N.Y.	42.0747	-75.6351	Susquehanna River at Windsor, N.Y.
SUSQ 356	Susquehanna/Pa.	Great Bend, Pa.	41.9612	-75.662	Susquehanna River near Oakland, Pa.
SUSQ 344	Broome/N.Y.	Binghamton East, N.Y.	42.0347	-75.8017	Susquehanna River at Kirkwood, N.Y.
SUSQ 327	Tioga/N.Y.	Apalachin, N.Y.	42.0653	-76.1426	Susquehanna River near Apalachin, N.Y.
SUSQ 312	Tioga/N.Y.	Barton, N.Y.	42.04	-76.4464	Susquehanna River near Nichols, N.Y.
SUSQ 300	Bradford/Pa.	Sayre, Pa.	41.9819	-76.5065	Susquehanna River near Sayre, Pa.
SUSQ 271	Bradford/Pa.	Towanda, Pa.	41.7627	-76.4393	Susquehanna River at Towanda, Pa.
SUSQ 256	Bradford/Pa.	Wyalusing, Pa.	41.6705	-76.2786	Susquehanna River at Wyalusing, Pa.
SUSQ 219	Wyoming/Pa.	Tunkhannock, Pa.	41.5351	-75.9502	Susquehanna River at Tunkhannock, Pa.
SUSQ 174	Luzerne/Pa.	Nanticoke, Pa.	41.1774	-76.1085	Susquehanna River near Shickshinny, Pa.
SUSQ 149	Columbia/Pa.	Catawissa, Pa.	40.9935	-76.4369	Susquehanna River near Bloomsburg, Pa.
SUSQ 138	Northumberland/Pa.	Danville, Pa.	40.9422	-76.6011	Susquehanna River near Danville, Pa.
JUNR 2	Perry/Pa.	Duncannon, Pa.	40.4258	-77.0159	Juniata River at Amity Hall, Pa.
CHEM 3	Bradford/Pa.	Sayre, Pa.	41.9607	-76.5324	Chemung River at Athens, Pa.
WBSR 8	Northumberland/Pa.	Lewisburg, Pa.	40.9679	-76.8797	W. Branch Susquehanna River at Lewisburg, Pa.

sample, which was preserved in the field in 95-percent denatured ethyl alcohol. After sampling was completed at a given site, all equipment that came in contact with the sample was examined carefully, picked free of algae or debris, rinsed thoroughly and sprayed with 10-percent bleach solution before sampling at the next site. Additional organisms that were found on examination were placed into the sample containers.

Subsampling and sorting procedures were based on the 1999 RBP document (Barbour and others, 1999). In the laboratory, composite samples were sorted into 300-organism subsamples, when possible, using a gridded pan and a random numbers table. The organisms contained in the subsamples were identified to genus (except Chironomidae and Oligochaeta) when possible and enumerated.

Data Analysis

Chemical water quality

Chemical water quality was assessed by examining field and laboratory parameters. Limit values are listed for each parameter based on current state and federal regulations or references for aquatic life tolerances (Table 3, Buda, 2008).

SRBC staff collects macroinvertebrates.

Susquehanna River at McKees Half Falls, Snyder County, Pa.

Table 3. Chemical Water Quality

Water Quality - Standards			
Parameter	**Limit**	**Reference Code**	**Reference**
Temperature	> 30.5 ºC	a	a. http://www.pacode.com/secure/data/025/chapter93/s93.7.html b. http://www.pacode.com/secure/data/025/chapter93/s93.8c.html c. http://www.dec.ny.gov/regs/4590.html#16132
Dissolved Oxygen	< 4 mg/l	a	
pH	< 6.0	a	
Alkalinity	< 20 mg/l	a	
Total Ammonia	based on pH & temperature	a	
Total Chloride	> 250 mg/l	a	
Total Sulfate	> 250 mg/l	a	
Total Iron	> 1.5mg/l	a	
Total Manganese	> 1 mg/l	a	
Total Aluminum	> 750 µg/l	b	
Total Magnesium	> 35 mg/l	c	
Total Sodium	> 20 mg/l	c	
Water Quality- Recommended Life Tolerances and Background Levels			
Parameter	**Limit**	**Reference Code**	**Reference**
Conductivity	> 800 µmhos/cm	d	d. http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm e. http://www.dec.ny.gov/regs/4590.html#16132 f. http://water.usgs.gov/pubs/circ/circ1225/images/table.html g. http://www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm h. Hem (1970)
Total Dissolved Solids	> 500 mg/l	e	
Total Nitrogen	> 1 mg/l	f	
Total Nitrite	> 1 mg/l	e	
Total Nitrate	> 0.6 mg/l	f	
Total Phosphorus	> 0.1 mg/l	g	
Total Organic Carbon	> 10 mg/l	h	
Total Hardness	> 300 mg/l	g	
Total Orthophosphate	> 0.02 mg/l	f	

Macroinvertebrate analysis

A series of macroinvertebrate metrics was calculated for each sample, and assessments of the sites were performed. Benthic macroinvertebrate samples were assessed using procedures described by Barbour and others (1999), Klemm and others (1990), and Plafkin and others (1989). Using these methods, staff calculated a series of biological indexes for each station. The metrics used in this survey are summarized in Table 4. Metric 2 (Shannon-Wiener Diversity Index) followed the methods described in Klemm and others (1990), and all other metrics were derived from Barbour and others (1999).

A reference condition approach was used to determine impairment levels for each site. One reference site was chosen from the sites sampled on the basis of macroinvertebrate metrics and water quality to represent the best combination of conditions. The 300-organism subsample data were used to generate scores for each of the seven metrics at each site. Scores for metrics 1-4 were converted to a biological condition score, based on the percent similarity of the site's metric score relative to the metric score at the chosen reference site. Scores for metrics 5-7 were based on set scoring criteria developed for the percentages (Plafkin and others, 1989; Ohio Environmental Protection Agency, 1987). The sum of the biological condition scores constituted the total biological score for the sample, and total biological scores were used to assign each sample to a biological condition category (Table 5).

Table 4. Summary of Metrics Used to Evaluate the Overall Biological Integrity of River Benthic Macroinvertebrate Communities

Metric	Description
1. Taxonomic Richness (a)	The total number of taxa present in the 300-organism subsample. Number decreases with increasing disturbance or stress.
2. Shannon-Wiener Diversity Index (b)	A measure of biological community complexity based on number of equally or nearly equally abundant taxa in the community. Index value decreases with increasing stress.
3. Hilsenhoff Biotic Index (a)	A measure of the organic pollution tolerance of a benthic macroinvertebrate community. Index value increases with increasing stress.
4. EPT Index (a)	The total number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa present in the 300-organism subsample. The index decreases with increasing stress.
5. Percent Ephemeroptera (a)	The percentage of Ephemeroptera in a 300-organism subsample. Percentage decreases with increasing stress.
6. Percent Dominant Taxa (a)	A measure of community balance at the lowest positive taxonomic level. Percentage increases with increasing stress.
7. Percent Chironomidae (a)	The percentage of Chironomidae in a 300-organism subsample. Percentage increases with increasing stress.

Sources: (a) Barbour and others, 1999
(b) Klemm and others, 1990

The EPT Index

The abundance of macroinvertebrates belonging to the orders Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) constitute the EPT Index of a stream. Since these orders of macroinvertebrates are highly sensitive to pollution, they are often used as water quality indicators. Their presence indicates a high quality of water, while their absence suggests water may be polluted. The EPT Index is calculated as the sum of the number of Ephemeroptera, Plecoptera, and Trichoptera divided by the total number of midges. Midges (Diptera: Chironomidae) are a species of fly that are present in large numbers in nearly all streams.

Photos credit: David H. Funk

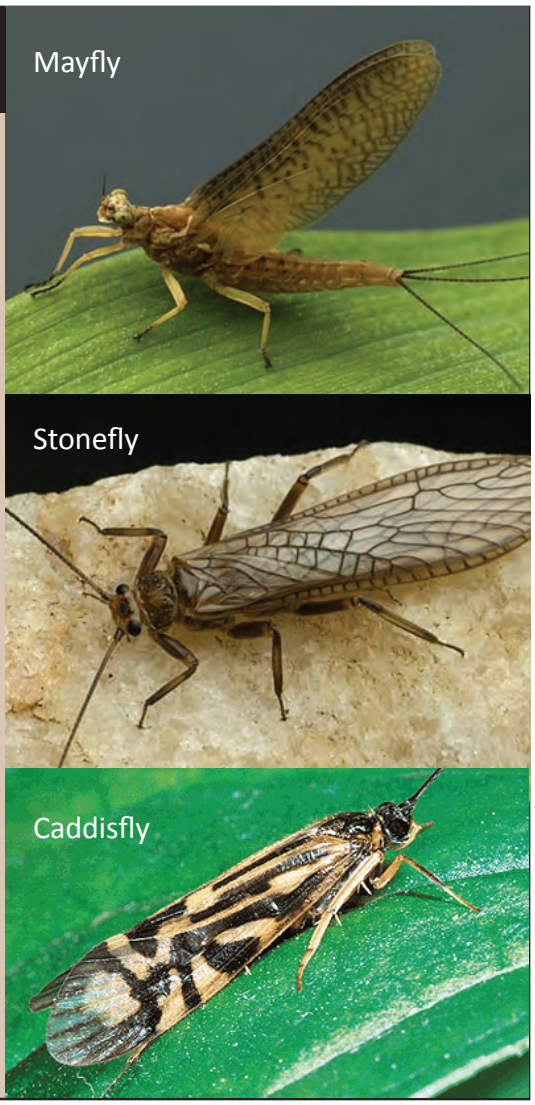

Table 5. Summary of Criteria Used to Classify the Biological Conditions of Sample Sites

SAMPLING AND ANALYSIS

TOTAL BIOLOGICAL SCORE DETERMINATION				
Metric	**Biological Condition Scoring Criteria**			
	6	**4**	**2**	**0**
1. Taxonomic Richness (a)	> 80%	79-60%	59-40%	< 40%
2. Shannon Diversity Index (a)	> 75%	74-50%	49-25%	< 25%
3. Hilsenhoff Biotic Index (b)	> 85%	84-70%	69-50%	< 50%
4. EPT Index (a)	> 90%	89-80%	79-70%	< 70%
5. Percent Ephemeroptera (c)	> 25%	10-25%	1-9%	< 1%
6. Percent Dominant Taxa (c)	< 20%	20-30%	31-40%	> 40%
7. Percent Chironomidae (c)	< 5%	5-20%	21-35%	> 35%
Total Biological Score (d)				

(a) Score is study site value/reference site value X 100
(b) Score is reference site value/study site value X 100
(c) Scoring Criteria evaluate actual percentage contribution, not percent comparability to the reference station
(d) Total Biological Score = the sum of Biological Condition Scores assigned to each metric
(e) Values obtained that are intermediate to the indicated ranges will require subjective judgment as to the correct placement into a biological condition category

BIOASSESSMENT	
Percent Comparability of Study and Reference Condition Total Biological Scores (e)	**Biological Condition Category**
> 83%	Nonimpaired
79-54	Slightly Impaired
50-21	Moderately Impaired
< 17%	Severely Impaired

RESULTS

Water Quality

In September 2010, the water quality at most of the sampling sites met water quality standards. Only 3.4 percent (13 of 384) of water quality values exceeded their respective limits. The majority of the exceedances were for total sodium. Exceedances are summarized in Table 6 and Figure 2.

Table 6. Number of Exceeds per Parameter

Parameter	Limit	Number of Exceedances
Total Sodium	> 20 mg/l	10
Total Orthophosphate	> 0.02 mg/l	2
Total Phosphorus	> 0.1 mg/l	1

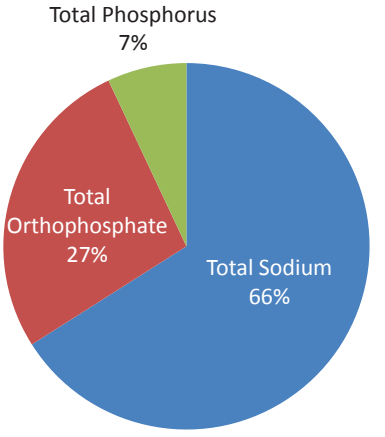

Figure 2. Parameters Exceeding Water Quality Standards or Recommended Life Tolerances

Biological Conditions

Biological conditions are summarized in Figure 3. Nonimpaired biological conditions were found at three of the 16 sites (19 percent), slightly impaired conditions were found at nine sites (56 percent), and moderately impaired conditions were found at four sites (25 percent). No sites were rated as severely impaired.

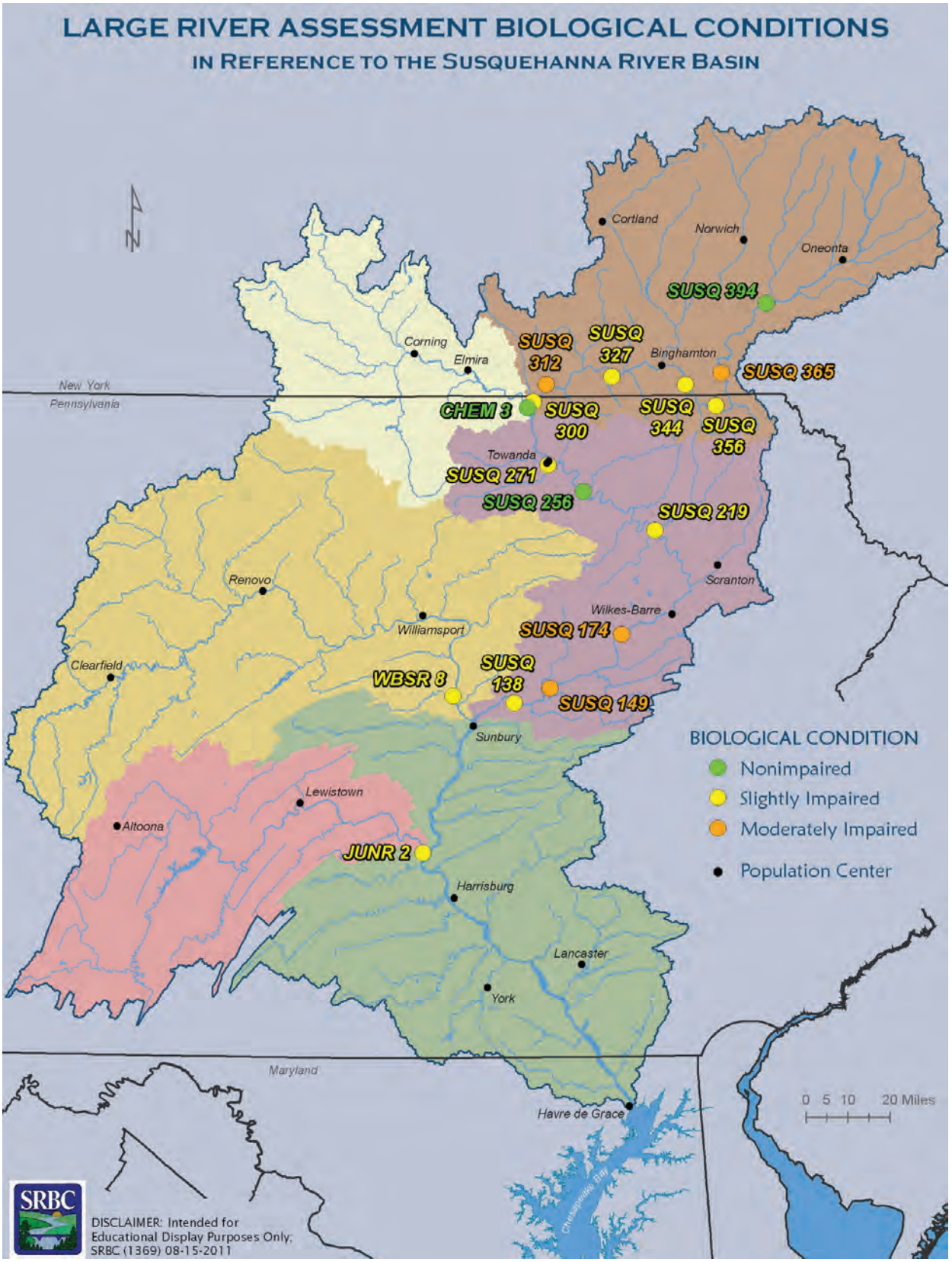

Figure 3. Biological Conditions in 2009

Discussion

Water Quality

The assessments conducted during the 2010 Large River Project, when compared to the results of the 2009 Large River Assessment Project (Shenk, 2010), 2008 Large River Assessment Project (Shenk, 2009), 2007 Large River Assessment Project (Hoffman, 2008), Upper Susquehanna Subbasin Survey (Buda, 2008), and Middle Susquehanna Subbasin Survey (Buda, 2009), show that most of the water quality parameters in the mainstem of the Susquehanna River and the mouths of most of its larger tributaries are below established water quality standards or recommended life tolerances. Total sodium is the parameter that exceeded its limit most often. Total orthophosphate and total phosphorus each exceeded their respective limits at least at one site. Even with these exceedances, the data analysis shows that the river from Sidney, N.Y., to Danville, Pa., has fairly good water quality.

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Macroinvertebrate Communities

The Upper Susquehanna River starts at Otsego Lake in Cooperstown, N.Y., and continues to the confluence with the Chemung River in Sayre, Pa. This is a fairly rural area that mostly consists of forest and agricultural land, with the exception of one large population center, Binghamton, N.Y. Six of the 16 sites that were sampled in 2010 were in the Upper Susquehanna River area.

The most upstream site sampled was at Sidney, N.Y. (SUSQ 394), approximately 50 miles downstream of Otsego Lake. This site was rated nonimpaired with the highest number of species collected, highest percent of Ephemeroptera, and highest number of EPT taxa of all the sites in the 2010 assessment. The site at Windsor, N.Y. (SUSQ365), was rated moderately impaired due to its low number of EPT taxa and to dominance by freshwater snails (not a negative in itself but dominance by one taxa in the macroinvertebrate community can indicate stressed conditions). The Susquehanna River flows into Pennsylvania for approximately 15 miles before it flows north back into New York. This stretch includes the site at Great Bend, Pa. (SUSQ356), which was rated as slightly impaired. This site had a high rating in species richness, Hilsenhoff Biotic Index, and percent Chironomidae but scored low in percent dominant taxa and EPT taxa.

SUSQ394, approximately 50 miles downstream of Otsego Lake, was rated nonimpaired with the highest number of species collected, highest percent of Ephemeroptera, and highest number of EPT taxa of all the sites in the 2010 assessment.

The first site as the river flows back into New York is located near Kirkwood (SUSQ344). This site is rated as slightly impaired due to its very poor rating in percent dominant taxa, due to the very high percentage of Elmidae and number of EPT taxa. The site near Apalachin (SUSQ327) is located just downstream of the city of Binghamton and a large tributary in the Chenango River. The site was rated as slightly impaired with good rating in taxonomic richness and Shannon-Wiener Diversity Index but very poor in number of EPT taxa. SUSQ312 is located near Nichols, N.Y., and rated as moderately impaired. This site scored the lowest of all sites collected in the 2010 collection year, without any metric receiving high ratings, and low ratings in four of the seven metrics. Future monitoring of this site will be helpful because in 2007 and 2009, this site was rated as one of the top sites. SUSQ300, near Sayre, Pa., is the last site in the Upper Susquehanna Subbasin. This site was moderately impaired with the only low rating in percent dominant taxa once again due to the high number of Elmidae found in the sample.

Rated as moderately impaired, SUSQ312 (near Nichols, N.Y.), scored the lowest of all sites collected in the 2010 collection year.

Just downstream of SUSQ300 is the confluence of the Chemung River and Susquehanna River. The Chemung Subbasin drains approximately 2,604 square miles of New York and

Susquehanna River near Apalachin, Tioga County, N.Y.

Pennsylvania. The primary land uses in the subbasin are naturally vegetated areas and cultivated land. For this study, there is one site (CHEM3) in the Chemung Subbasin located in Athens, Pa., approximately three miles from the mouth. This site was nonimpaired with high ratings in all categories.

The Middle Susquehanna Subbasin encompasses the stretch of the Susquehanna River from the confluence with the Chemung River, in Athens, Pa., to the confluence with the West Branch of the Susquehanna River, in Sunbury, Pa. The Middle Susquehanna Subbasin drains approximately 3,700 square miles with main land uses of forested, agricultural, urban, and abandoned mine drainage (AMD) areas. The most upstream site in the Middle Susquehanna Subbasin is located in Towanda, Pa. (SUSQ271). This site was rated as slightly impaired due to the low rating in number of EPT taxa and percent Chironomidae. Site SUSQ256, located near Wyalusing, Pa., was nonimpaired and as in years past, continued to be one of the higher rated sites. The site near Tunkhannock, Pa. (SUSQ219), was slightly impaired with low ratings in EPT taxa and percent Chironomidae.

The Middle Susquehanna River flows through the two main urban centers of Scranton and Wilkes-Barre before the next site near Shickshinny (SUSQ174). This site, as in years past, scored as one of the lowest for 2010 and was moderately impaired. It received low rating in most categories, especially the number of EPT taxa and percent dominant taxa, with its only higher rating coming from percent Chironomidae. The next site downstream, SUSQ149 located near Bloomsburg, Pa., continued the moderately impaired trend from upstream as well, with very similar ratings. These chronically low scores could be attributed to any number of factors from the urban areas to the AMD impacts that are also located in the Middle Susquehanna Subbasin. Site SUSQ138, located near Danville, Pa., is the last site in the Middle Susquehanna Subbasin. With only low ratings in percent dominant taxa and number of EPT taxa as in upstream sites, it was rated as only slightly impaired.

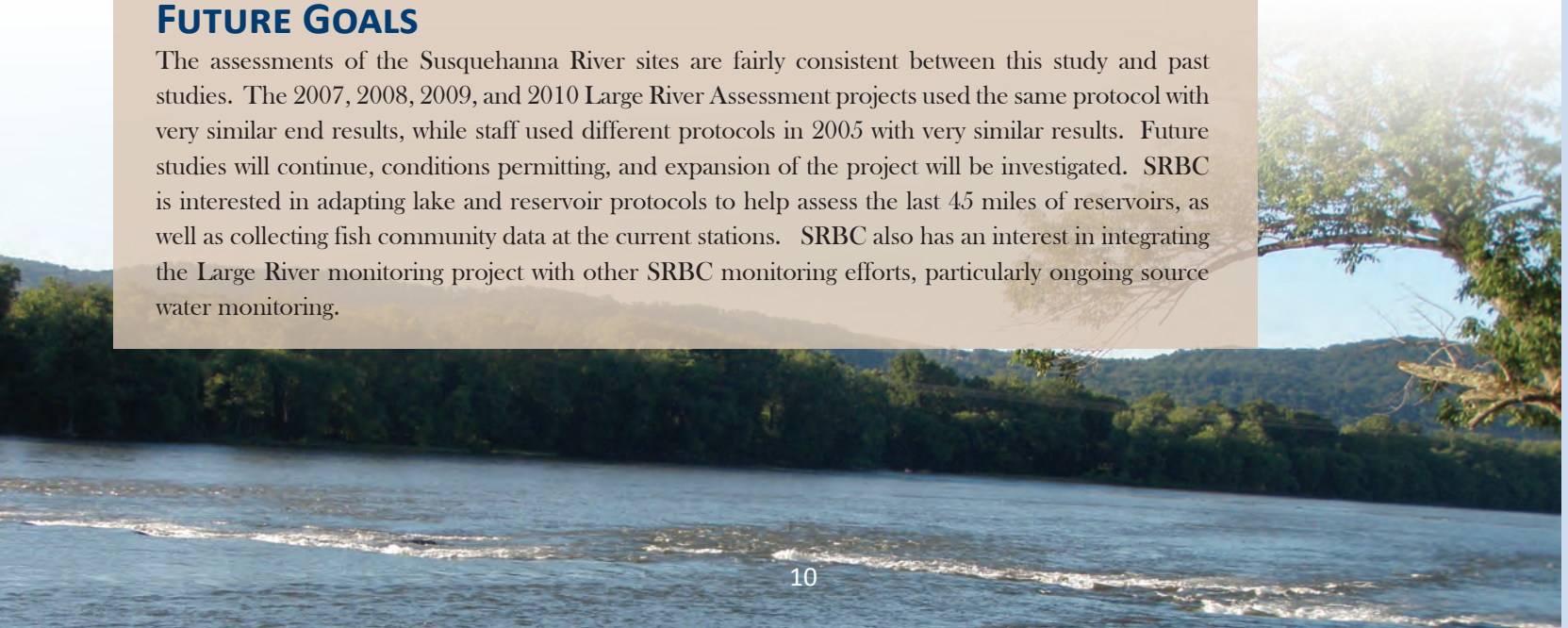
The chronically low scores (in the Middle Susquehanna River) could be attributed to any number of factors from the urban areas to the AMD impacts that are also located in the Middle Susquehanna Subbasin.

In the 2010 study, there were two other sites sampled. The first was at the mouth of the West Branch Susquehanna River (WBSR8). The West Branch Susquehanna drains approximately 6,982 square miles from Carrolltown to Northumberland, Pa. Agricultural lands are most abundant near the mouth in the southeastern area, and the few urban areas are mostly small in size. Resource extraction is prominent in the subbasin with AMD severely impacting many streams. WBSR8 was slightly impaired, with a very low rating in EPT taxa but a high rating in Hilsenhoff Biotic Index.

The Juniata River is the last large tributary to the Susquehanna River. The Juniata Subbasin drains approximately 3,400 square miles from west of Bedford to Duncannon, Pa. The mixed land use in the Juniata Subbasin primarily includes forested areas concentrated on the ridges, with agricultural and urban areas in the valleys. One site (JUNR2), located near Amity Hall and just upstream from the mouth, was sampled for this project. This site was rated as slightly impaired, only scoring high in Shannon-Wiener diversity and taxonomic richness, and scoring moderately in the other remaining categories.

Future Goals

The assessments of the Susquehanna River sites are fairly consistent between this study and past studies. The 2007, 2008, 2009, and 2010 Large River Assessment projects used the same protocol with very similar end results, while staff used different protocols in 2005 with very similar results. Future studies will continue, conditions permitting, and expansion of the project will be investigated. SRBC is interested in adapting lake and reservoir protocols to help assess the last 45 miles of reservoirs, as well as collecting fish community data at the current stations. SRBC also has an interest in integrating the Large River monitoring project with other SRBC monitoring efforts, particularly ongoing source water monitoring.



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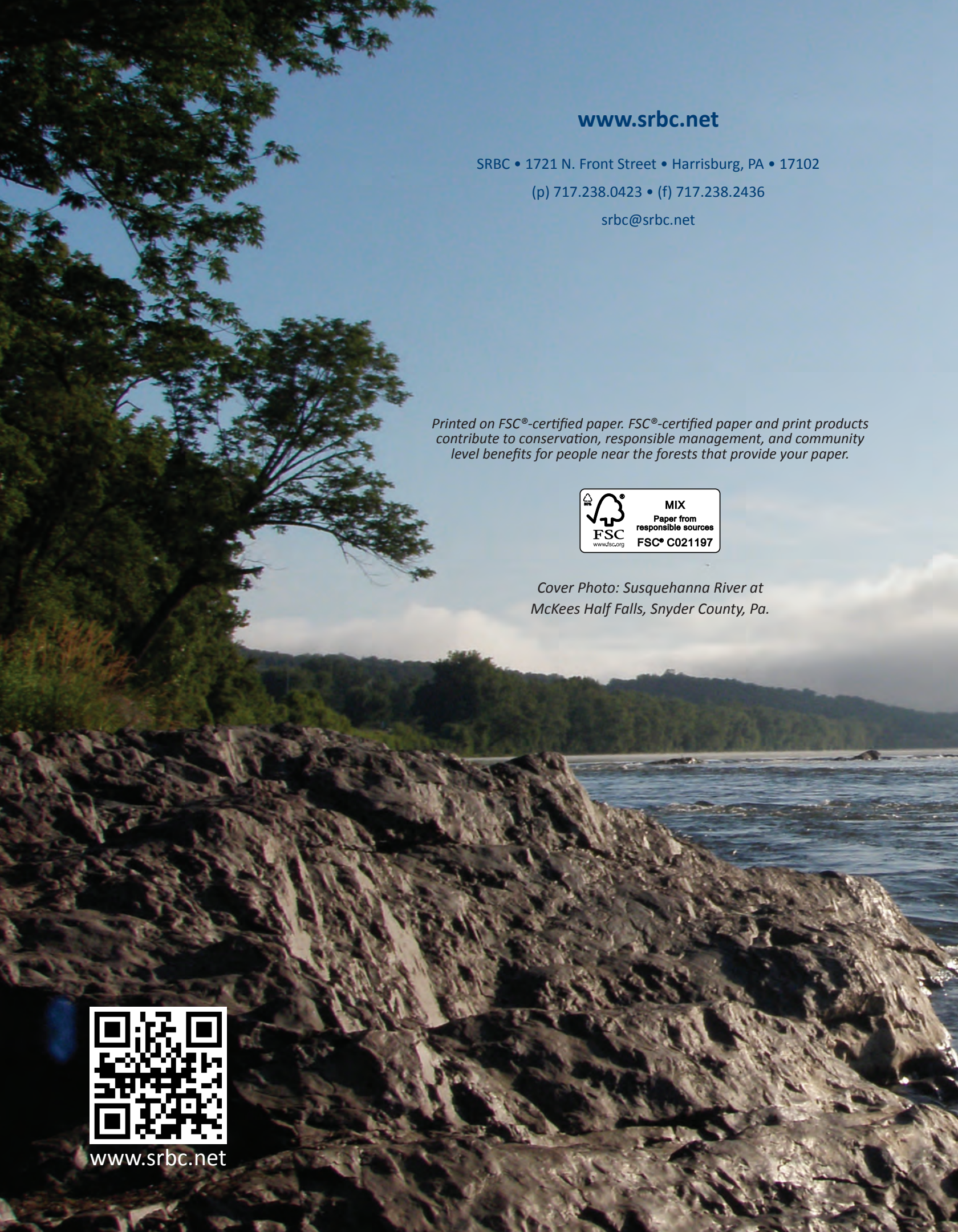

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