MIDDLE SUSQUEHANNA SUBBASIN YEAR-1 SURVEY: A WATER QUALITY AND BIOLOGICAL ASSESSMENT, APRIL THROUGH OCTOBER 2014

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INTRODUCTION

The Susquehanna River Basin Commission (SRBC) assessed the Middle Susquehanna River Subbasin from April through October 2014. SRBC conducted this assessment through the Subbasin Survey Program, funded in part through the United States Environmental Protection Agency (USEPA). This program consists of two-year assessments in each of the six major subbasins comprising the Susquehanna River Basin (Figure 1) on a rotating schedule. The Year-1 survey provides a snapshot assessment of water quality, habitat, and macroinvertebrate communities at both targeted sites along major tributaries and other areas of interest as well as at randomly chosen sites throughout a selected subbasin. In 2014, SRBC sampled 67 sites in the Middle Susquehanna River Subbasin as part of the Year-1 program. SRBC previously conducted similar surveys of the Middle Susquehanna River Subbasin in 1984 (Malione et al., 1984), 1993 (Water Quality and Monitoring Programs Division, 1997), 2001 (LeFevre, 2002), and 2008 (Buda, 2009). This report contains the results from the 2014 study and a comparative analysis of data at 20 sites that have been sampled in previous years.

The associated Year-2 survey, which is designed to be a more focused, in-depth study of a specific area or issue, is focusing on refining the correlation between suspended sediment and turbidity at five study watersheds located in the Middle Subbasin. Sediment loading is a high-profile issue within the basin, especially in relation to the Chesapeake Bay and the maximum sediment retention capacity of reservoirs on the lower stretch of the river. Data collection for the Middle Susquehanna Year-2 survey occurred throughout the 2015 calendar year.

Subbasin survey information is used by SRBC staff and others to:

- evaluate the chemical, biological, and habitat conditions of streams in the basin;
- identify major sources of pollution;
- identify high quality sections of streams that need to be protected;
- maintain a database that can be used to document changes in stream quality over time;
- review projects affecting water quality in the basin; and
- identify areas for more intensive study.

Description of the Middle Susquehanna River Subbasin

The Middle Susquehanna River Subbasin drains about 3,770 square miles of northeastern Pennsylvania, flowing from the town of Athens to the city of Sunbury. Numerous small watersheds as well as 13 larger watersheds feed into the Middle Susquehanna River, including Bowman, Catawissa, Fishing, Mehoopany, Meshoppen, Nescopeck, Roaring, Sugar, Towanda, Tunkhannock, Wyalusing, and Wysox Creeks and the Lackawanna River. The Middle Susquehanna River Subbasin covers parts of 14 counties throughout Pennsylvania, including Bradford, Carbon, Columbia, Lackawanna, Luzerne, Lycoming, Montour, Northumberland, Schuylkill, Sullivan, Susquehanna, Tioga, Wayne, and Wyoming Counties. Major population centers include Scranton, Sunbury, Towanda, and Wilkes-Barre (Figure 2).

Three Level III ecoregions overlap with the Middle Susquehanna subbasin (Figure 2):

- Ecoregion 60: Northern Appalachian Plateau and Uplands (NAPU) (58 percent)
- Ecoregion 67: Central Appalachian Ridges and Valleys (RV) (32 percent)
- Ecoregion 62: North Central Appalachians (NCA) (10 percent)

Figure 3 illustrates the land use coverage in the Middle Susquehanna subbasin. Most of the subbasin is covered by natural vegetated areas, followed by cultivated land and developed areas. Heavily mined anthracite coal lands are concentrated along the eastern portion of this subbasin in the Lackawanna and Wyoming Valleys and in the southern portion around Hazleton. The communities in these areas continue to deal with the remnants of the industry, such as coal slag piles, abandoned mines, and mine drainage.

Figure 1. Six Major Subbasins of the Susquehanna River

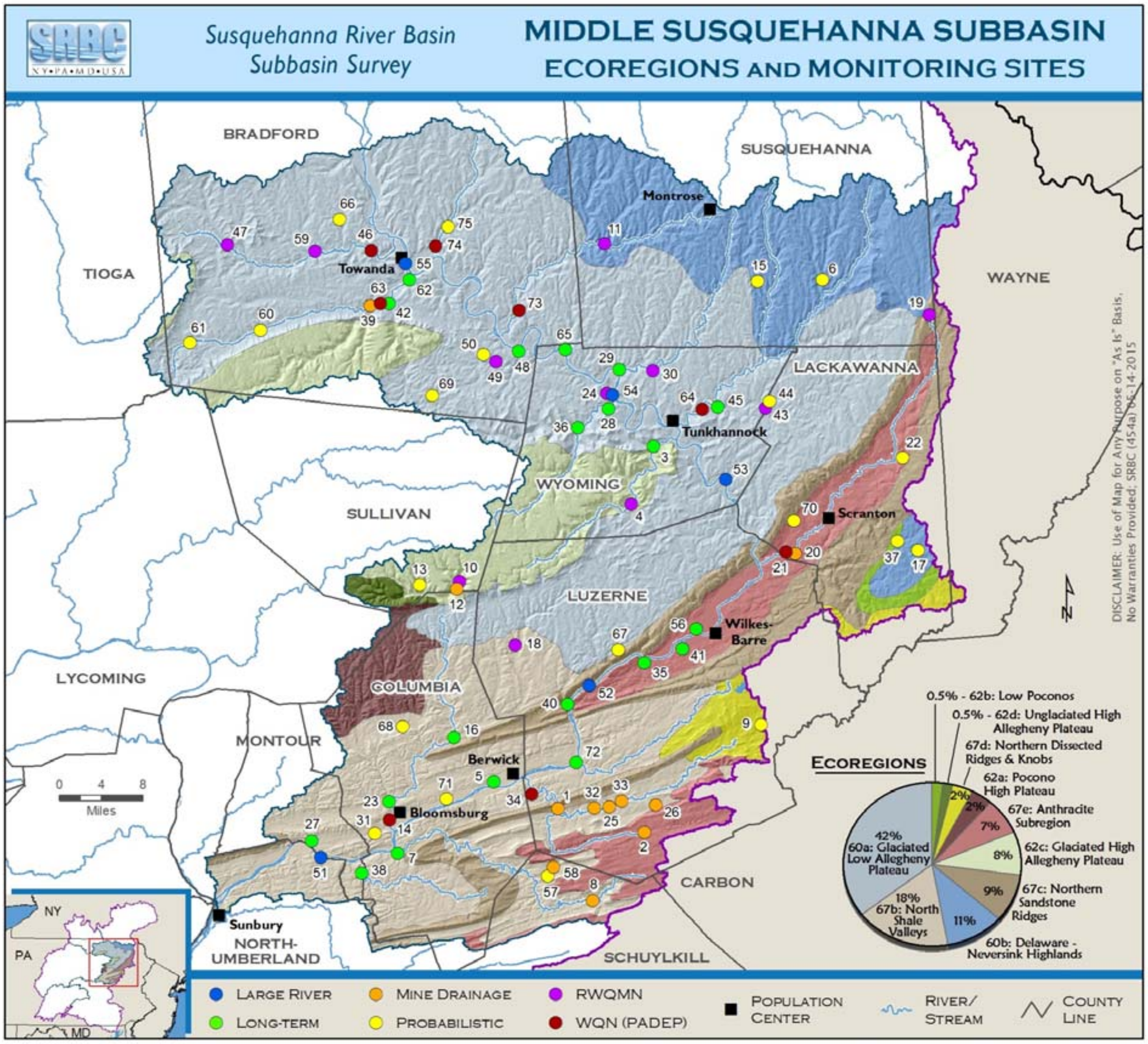


Figure 2. Middle Susquehanna Subbasin Ecoregions and Monitoring Sites

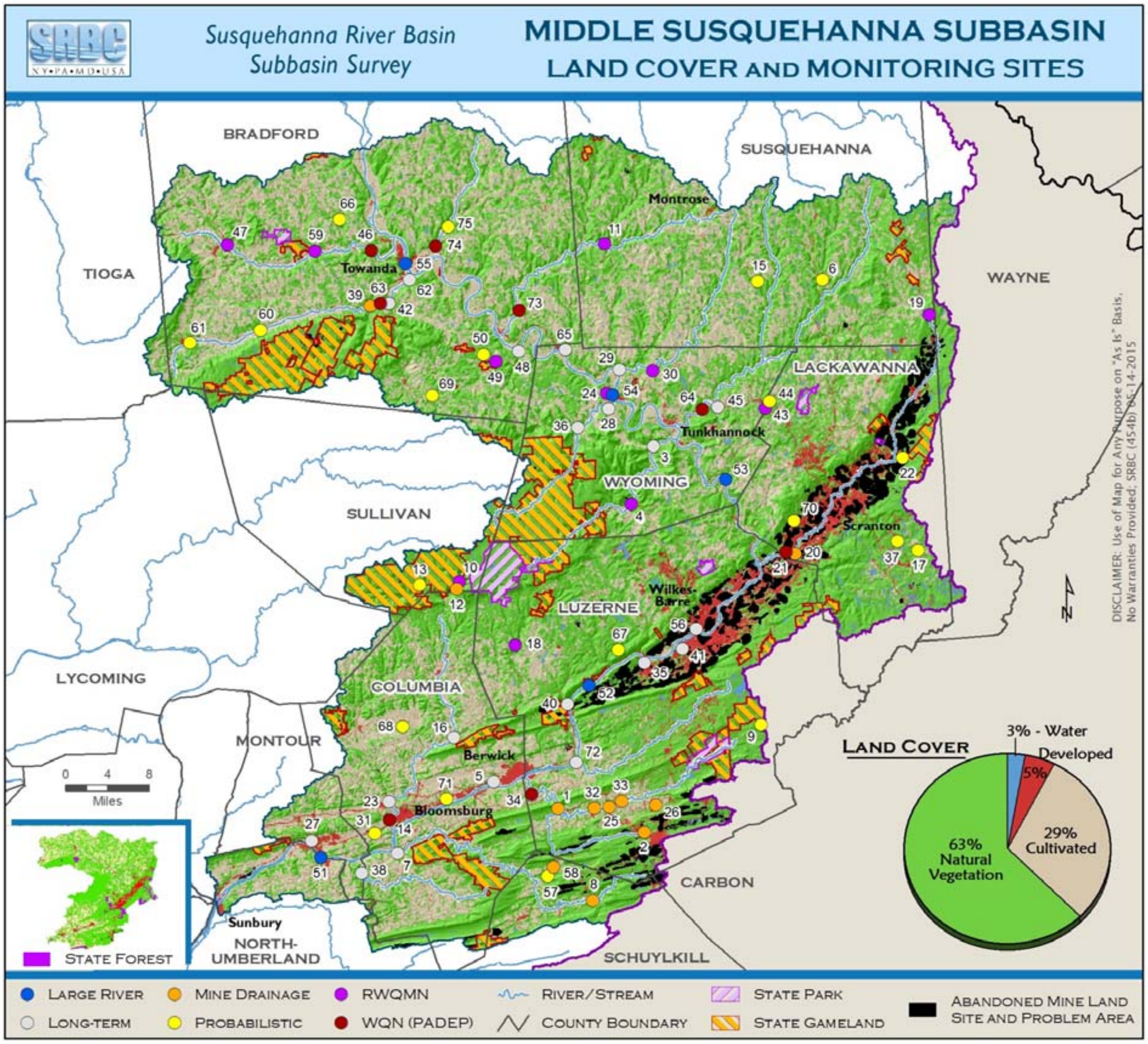


Figure 3.   Middle Susquehanna Subbasin Land Cover and Monitoring Sites

Ongoing Monitoring in the Subbasin

The Pennsylvania Department of Environmental Protection (PADEP) has a fixed, statewide Water Quality Network (WQN) designed in part to assess surface water quality in Pennsylvania. Eight WQN sites are located within the Middle Susquehanna subbasin at the mouths of Fishing, Nescopeck, Sugar, Towanda, Tunkhannock, Wyalusing, and Wysox Creeks, as well as at the mouth of the Lackawanna River. Biological sampling and extensive water chemistry sampling occur routinely at the WQN sites. In this subbasin, sampling at the newest WQN site has been occurring for five years, while sampling at several WQN sites has been occurring for over 50 years.

SRBC currently is engaged in five key monitoring and protection programs in the Middle Susquehanna subbasin:

- Sediment and Nutrient Assessment Program (SNAP);
- Early Warning System Program (EWS);
- Large River Assessment Project (Large Rivers);
- Remote Water Quality Monitoring Network (RWQMN); and
- Flow Monitoring Network (FMN).

Sediment and Nutrient Assessment Program

SRBC conducts the Sediment and Nutrient Assessment Program (SNAP) as part of the Chesapeake Bay Restoration Program. In the Middle Susquehanna subbasin, routine monthly and storm sampling of nutrients and sediment occurs at sites on the Susquehanna River at Towanda, Wilkes-Barre, and Danville, Pa. Data have been collected at Danville since 1984, Towanda since 1988, and Wilkes-Barre since 2004. The SNAP data are used to calculate nutrient and sediment loads, analyze trends, and calibrate watershed models. The data, annual reports, and additional project information can be found at www.srbc.net/programs/CBP/nutrientprogram.htm.

Early Warning System

SRBC established the Early Warning System (EWS) program in 2003 in Pennsylvania to inform public water suppliers that have intakes on the Susquehanna River about potential contaminant threats. In 2006, SRBC expanded the system into the New York portion of the basin. Currently, the EWS helps protect the public drinking water supplies that serve about 700,000 people and provides data to suppliers for improving day-to-day treatment options. The EWS provides a monitoring network that helps minimize the impact from contaminant spills and helps ensure that the public has a safe water supply. The only EWS site in the Middle Susquehanna subbasin is located at Danville, Pa. (SUSQ 138). More information on the EWS program is available at www.srbc.net/drinkingwater/index.htm.

Large River Assessment Project

Many federal, state, and local entities are interested in the role of large rivers on industry, power generation, drinking water supply, recreation, and other issues. Since 2002, SRBC has been collecting water chemistry and macroinvertebrate data at 25 sites on the Susquehanna River and its major tributaries—the West Branch Susquehanna River, the Juniata River, and the Chemung River—as part of the Large River Assessment Project (Large Rivers). Five of these sites are located in the Middle Susquehanna subbasin and were sampled in 2014 as part of the Large Rivers project. These sites are located on the Susquehanna River near Towanda, Meshoppen, Falls, Glen Lyon, and Danville, Pa. A report detailing sampling from 2011-2012 can be found at http://www.srbc.net/pubinfo/techdocs/Publication_289/techreport289.htm. The most recent report detailing sampling from 2013-2014 will be published in December 2015.

Remote Water Quality Monitoring Network

In January 2010, SRBC initiated the Remote Water Quality Monitoring Network (RWQMN), which continuously measures and reports water quality conditions of smaller rivers and streams located in northern tier Pennsylvania and southern tier New York. Some RWQMN stations are located in areas where natural gas drilling in the Marcellus Shale is most active, while other stations are located in areas where no drilling activities are planned to enable collection of baseline and control data. In addition to continuous data, quarterly water quality grab samples and annual biological surveys are conducted. These data help SRBC track existing water quality conditions and provide an early detection opportunity for any changes on an ongoing, real-time basis.

Approximately 60 stations are located throughout the Basin. Eleven of those stations are located in the Middle Susquehanna subbasin, including stations on Bowman, East Branch Fishing, East Branch Wyalusing, Kitchen Creek, Little Mehoopany, Meshoppen, South Branch Tunkhannock, Sugar, and Tomjack Creeks as well as on Sugar Run and the Lackawanna River. SRBC sampled all of these RWQMN stations as part of the Year-1 survey. Reports are issued annually, and the most recent report published in June 2015 can be found at http://mdw.srbc.net/remotewaterquality/assets/downloads/pdf/RWQMN_datareport_2010-2013.PDF. More information on the RWQMN program is available at mdw.srbc.net/remotewaterquality/.

Flow Monitoring Network

Guided by results from the Low Flow Pilot Study conducted by SRBC from 2010 to 2012, SRBC established a basin-wide Flow Monitoring Network (FMN) in 2012. The purpose of the FMN is to document stream discharge, physical habitat, water quality, and fish and benthic macroinvertebrate communities during the natural low flow period (June 1 through September 30; DePhilip and Moberg, 2010). Data collected from the FMN stations will be used to identify, characterize, and compare water quality, habitat, and biological communities (both benthic macroinvertebrates and fish) associated with varying flows. Two of the FMN stations are co-located with RWQMN stations in the Middle Susquehanna subbasin on South Branch Tunkhannock and Little Mehoopany Creeks. More information on the FMN can be found at www.srbc.net/programs/fmn.htm.

METHODS USED IN THE 2014 SUBBASIN SURVEY

Survey Design

Past Year-1 surveys relied on data collected from sites located at convenient stream access points, such as road crossings, which afford easy access but often provide less than ideal conditions for aquatic life. Sampling at less ideal locations can result in data reflecting the local physical and biological conditions of the sampling site and not of the stream in general. Because the locations of these sites were specifically targeted and not randomly chosen, data collected at these locations can only be applied to these sites and cannot be extrapolated to document conditions in the subbasin as a whole. Therefore, data collected at these locations are limited in utility.

Recognizing this limitation, SRBC modified the Year-1 survey design by including probabilistic sampling. The inclusion of probabilistic sampling allows for an unbiased, statistically sound method for assessing streams across a subbasin (Herlihy et al., 2000). As a result, beginning with the 2014 Middle Susquehanna subbasin rotation, the new Year-1 survey design involves collection of data from three categories of sites:

- **Long-term sites**, which are a subset of the pre-established sites sampled in previous Year-1 surveys;
- **Probabilistic sites**, which are randomly selected through a computer program; and
- **Other sites**, which are sampled as part of other projects.

A total of 75 sites were included as part of this new survey design and are listed and categorized in the Appendix and described in the following sections. Sixty-seven of these sites were sampled directly by SRBC. This revised survey design was incorporated to allow for more robust data analysis and leveraging of other on-going efforts. Through this new survey design, SRBC will continue to track water quality issues throughout the subbasin while allowing generalizations to be made about overall water quality within the subbasin.

Long-term Sites

Past Year-1 surveys within the Middle Susquehanna subbasin involved sampling at 112 pre-established sites. SRBC reviewed the locations of these sites in conjunction with the locations of established WQN and RWQMN sites to identify potential long-term station locations. Twenty of the original 112 sites were designated as long-term sites and fill spatial gaps in the subbasin where WQN and RWQMN stations were absent. These sites are mostly located at the mouths of major tributaries and will help characterize the water quality of streams entering larger systems. Analysis of data collected at long-term sites allows water quality patterns to be tracked through time.

Probabilistic Sites

Randomly chosen sites on streams in the subbasin were selected using a Generalized Random Tessellation Stratified (GRTS) design, which is recommended by the USEPA for probabilistic site selection (USEPA, 2008). The GRTS site selection process was completed using the spatial survey design and analysis (spsurvey) package (Kincaid and Olsen, 2012) and R software. Subbasin streams were assigned to one of two stream size classes—'small' for stream orders 2 and 3 and 'large' for stream orders 4 through 6. Streams of stream order 1 were excluded because of the potential for intermittent flow, and streams of stream order 7 or 8 were excluded to keep analysis focused on wadeable streams and rivers. In addition, Susquehanna River mainstem sampling occurs as part of SRBC's Large River Assessment Project.

A stratified, unequal probability GRTS design was then used to select sites. Level III ecoregion (Omernik, 1987) was used as the strata variable, and the number of sites was distributed based on the proportion of land area in each of the three ecoregions present in the Middle Susquehanna subbasin. Within ecoregions, sites were given an unequal probability of being located in each size class (small or large) based on the proportion of stream miles in each size class within the Middle subbasin.

Through this approach, 20 sites were randomly selected throughout the subbasin, using a stratified, unequal probability design based on ecoregion and placing weights on stream segments using stream order. Twenty additional oversample sites were selected for each ecoregion as replacement sampling locations in the event that the original sites were not accessible. Analysis of data collected from probabilistic sites allows for the extrapolation of water quality conditions at these sites to ecoregion-specific water quality conditions of streams of similar size.

Other Sites

In 2014, SRBC sampled water chemistry and macroinvertebrates at five sites in the Middle Susquehanna subbasin as part of the Large Rivers project and 11 sites as part of the RWQMN project. Eleven other sites that were historically sampled as part of the Year-1 survey were sampled to provide data to SRBC's Mine Drainage Program. In 2014, eight WQN sites were sampled by PADEP. Data collected at these 35 additional sites were used to various degrees as part of this Year-1 survey analysis.

Data Collection

SRBC made a concerted effort to sample as many sites as possible by the end of May 2014, which marked the end of the winter/spring index period identified in PADEP's Index of Biotic Integrity for Benthic Macroinvertebrate Communities in Pennsylvania's Wadeable, Freestone, Riffle-Run Streams (PADEP, 2013). High quality (HQ) or Exceptional Value (EV) streams can only be analyzed using this IBI if sites are sampled during the November to May index period. All HQ and EV streams were sampled by the first week of May 2014. SRBC conducted sampling at most other sites in April or May 2014, but a few long-term and probabilistic sites could not be sampled until the first week of June 2014 because of prohibitive scheduling and weather conditions. However, all sites were evaluated under the same index period since cooler spring weather persisted into June 2014. Large Rivers data were collected in October and November 2014, when flows were low and access to these larger systems was easier. Water chemistry collected by PADEP at WQN sites in April 2014 was included as part of this survey.

Water Quality and Discharge

During each site visit, SRBC staff measured instream field chemistry while collecting water samples for laboratory analysis of parameters listed in Table 1. This parameter list includes indicators of hydraulic fracturing activities (i.e., bromide, barium, lithium, strontium, and gross alpha and beta radioactive nuclides). SRBC staff measured all field chemistry parameters (i.e., temperature, conductivity, pH, and dissolved oxygen) simultaneously using a multi-meter YSI sonde. The probes of all meters were rinsed with distilled water and sample water prior to collecting water quality data and were calibrated as detailed in the Quality Assurance Project Plan (QAPP). Water chemistry samples were collected using depth-integrated water sampling methods (Guy and Norman, 1969), placed on ice, and delivered to ALS Environmental, Inc., in Middletown, Pa., for analysis. Suspended sediment samples were collected simultaneously and were returned to the SRBC lab for analysis.

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

Field Parameters	
Flow (instantaneous cfs)	Conductivity (µmhos/cm)
Temperature (°C)	Dissolved Oxygen (mg/l)
pH	
Laboratory Analysis	
Alkalinity (mg/l)	Hot acidity (mg/l)
Total Dissolved Solids (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 (mg/l)
Nitrate-N (mg/l)	Total Iron (mg/l)
Turbidity (NTU)	Total Manganese (mg/l)
Total Organic Carbon (mg/l)	Total Aluminum (mg/l)
Total Hardness (mg/l)	Total Phosphorus (mg/l)
Total Calcium (mg/l)	Total Orthophosphate (mg/l)
Total Bromide (mg/l)*	Total Barium (mg/l)*
Total Strontium (mg/l)*	Total Lithium (mg/l)*
Gross Beta (pCi/l)*	Gross Alpha (pCi/l)*
Suspended sediment	

cfs = cubic feet per second
µmhos/cm = micromhos per centimeter
pCi/l = picoCuries per liter
*only at select sites
mg/l = milligram per liter
NTU = nephelometric turbidity units

Discharges at sites near USGS gaging stations were obtained from the USGS database. At other stations, discharge measurements were made at the time of water sampling by staff using a FlowTracker and standard USGS procedures (Buchanan and Somers, 1969). Discharge was not measured during high flows deemed unsafe or when the transect area was otherwise not wadeable.

Macroinvertebrates

SRBC staff sampled the benthic macroinvertebrate community at probabilistic, long-term, RWQMN, and mine drainage sites according to PADEP IBI protocols (PADEP, 2013). Benthic macroinvertebrates are organisms that live on the stream bottom, including aquatic insects, crayfish, clams, snails, and worms. At each site, staff identified a 100-meter reach containing riffle-run or best available habitat for macroinvertebrate sampling. Six D-frame (500-micron mesh net) samples were collected from representative riffle-run habitats along the reach by allowing the dislodged material loosened through disturbance of the substrate to flow downstream into the net. SRBC staff composited these six D-frame samples into one sample, which was preserved in 95-percent denatured ethyl alcohol and returned to SRBC's lab for processing. Each sample was subsampled by a contractor biologist who picked 200 (± 20 percent) organisms from the sample. Each organism was identified to genus when possible, except for midges, which were identified to family, and worms, which were identified to class.

Large River macroinvertebrate samples were excluded from this analysis because the reach size and collection methodology were different. PADEP also collected macroinvertebrates at the WQN sites, but the macroinvertebrate data were not available for incorporation into this report because of contractor delays.

Habitat

At each site visit, SRBC staff evaluated habitat conditions at probabilistic, long-term, RWQMN, and mine drainage sites using a modified version of RBP III (Plafkin and others, 1989; Barbour and others, 1999), which rates 11 physical stream characteristics pertaining to substrate, pool and riffle composition, shape of the channel, conditions of the banks, and the riparian zone on a scale of 0-20 (20 being optimal). Staff also noted additional information regarding recent precipitation events, substrate material composition, surrounding land use, other relevant features in the watershed, and the presence of common terrestrial and aquatic invasive species at the site and surrounding area.

Habitat was evaluated at Large River sites but was not included in this analysis because a non-wadeable river ecosystem is not directly comparable to the other wadeable sites.

Data Analysis

Water Quality

SRBC assessed water quality by examining field and laboratory results and comparing the results to water quality levels of concern based on current state and federal regulations and recommendations, background levels for unaffected streams, or references for approximate tolerances of aquatic life (Table 2). For each site, SRBC compared the difference between each measured result and the corresponding level of concern value from Table 2 (LeFevre, 2005). If the measured value exceeded the level of concern value, the difference between the two was recorded. If the measured value did not exceed the level of concern value, the difference was recorded as zero. An average of all the recorded differences for each site was calculated. Each site was then assigned to a Water Quality Class (WQC), listed below in order from highest to lowest water quality, based on the final score:

- **WQC I**: no parameters exceeded limits (score of zero);
- **WQC II**: some parameters slightly exceeded limits (score between zero and 0.33);
- **WQC III**: either many parameters exceeded limits or some parameters moderately exceeded limits (score between 0.33 and 0.66);
- **WQC IV**: either several parameters moderately exceeded limits, or some parameters severely exceeded limits (score between 0.66 and one); and
- **WQC V**: many parameters greatly exceeded limits (score greater than one).

Habitat

In past Year-1 survey reports, SRBC used a combination of ecoregions and drainage area sizes to assign reference categories for habitat data analysis. As previously discussed, this subbasin spans three ecoregions. SRBC has developed a standardized classification system of six Aquatic Resource Classes (ARCs) based on drainage area size to which each stream and river in the basin can be assigned (SRBC, 2012). Three habitat reference categories were then derived for this analysis based on stream ARCs sampled in the survey:

- Headwaters and creeks—ARC 1 (≤ 10 sq mi) and ARC 2 (10-50 sq mi);
- Small and medium rivers—ARC 3 (50-200 sq mi) and ARC 4 (200-1000 sq mi); and
- Medium and large rivers—ARC 5 (1000-5000 sq mi) and ARC 6 (≥5000 sq mi).

Sites were sorted first by ecoregion and then again by habitat reference category, based on total RBP habitat score. Sites with the highest habitat condition score within each sorted category were considered habitat reference sites. A comparative percentage score was then calculated for each site, and a habitat rating of Excellent, Supporting, Partially Supporting, or Nonsupporting was assigned to each site based on RBP III methods (Plafkin and others, 1989; Barbour and others, 1999).

Table 2. Water Quality Standards and Recommendations

Parameters	Limits	Reference Code	Reference
Based on water quality standards:			
Alkalinity	≥ 20 mg/l	a	a. *www.pacode.com/secure/data/025/chapter93/s93.7.html*
Dissolved Oxygen	≥ 4 mg/l	a	b. *water.epa.gov/drink/contaminants/index.cfm*
Gross Alpha	< 15 pCi/l	b	c. *www.pacode.com/secure/data/025/chapter93/s93.8.html*
Gross Beta	4 millirems/yr	b	d. *www.dec.ny.gov/regs/4590.html#16132*
pH	≥ 6.0 and ≤ 9.0	a	e. *www.pabulletin.com/secure/data/vol42/42-27/1292.html*
Temperature	≤ 30.5 ºC	a	f. *www.dsd.state.md.us/comar/comarhtml/26/26.08.02.03-3.htm*
Total Aluminum	≤ 0.75 mg/l	c	g. Based on archived data at SRBC
Total Barium	< 2.0 mg/l	b	h. *www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm*
Total Chloride	≤ 250 mg/l	a	i. *wilkes.edu/include/waterresearch/pdfs/waterbooklet070610.pdf*
Total Dissolved Solids	≤ 500 mg/l	d	j. *www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm*
Total Iron	≤ 1.5 mg/l	a	k. *www.vdh.virginia.gov/Epidemiology/dee/PublicHealthToxicology/documents/pdf/factsheets/Lithium2014.pdf*
Total Magnesium	≤ 35 mg/l	d	l. *water.usgs.gov/pubs/circ/circ1225/images/table.html*
Total Manganese	≤ 1.0 mg/l	a	m. Hem (1970)
Total Sodium	≤ 20 mg/l	d	
Total Strontium	< 4.0 mg/l	e	
Total Sulfate	≤ 250 mg/l	a	
Total Suspended Solids	≤ 25 mg/l	a	
Turbidity	≤ 50 NTU	f	
Other background levels, aquatic life tolerances, or recommendations:			
Acidity	≤ 20 mg/l	g	
Calcium	≤ 100 mg/l	g	
Conductivity	≤ 800 µmhos/cm	h	
Total Bromide	< 0.05 mg/l	i	
Total Hardness	≤ 300 mg/l	j	
Total Lithium	< 0.7 mg/l	k	
Total Nitrate	≤ 0.6 mg/l	l	
Total Nitrite	≤ 1 mg/l	d	
Total Nitrogen	≤ 1 mg/l	l	
Total Organic Carbon	≤ 10 mg/l	m	
Total Orthophosphate	≤ 0.02 mg/l	l	
Total Phosphorus	≤ 0.1 mg/l	j	

Macroinvertebrates

In past Year-1 reports, SRBC analyzed macroinvertebrate data using biological reference categories and reference sites, which were based on the best macroinvertebrate community observed during sampling rather than true reference conditions. SRBC is now analyzing macroinvertebrate data using the PADEP IBI. Use of a multi-metric index allows for standardized comparison of data from a study site against a large pool of fixed, established reference sites.

To calculate a PADEP IBI score at a site, the taxonomic composition of each 200-count, largely genus-level macroinvertebrate subsample was reduced to six metrics, including total taxa richness, total Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness, Beck's Index (version 3), Shannon Diversity, Hilsenhoff Biotic Index, and percent sensitive individuals. These metrics were standardized and used to calculate an index score for each site. This index score was then cross-referenced to determine whether the site is attaining its designated use ('Attaining') or is impaired ('Impaired'). SRBC also used a Severely Impaired determination, which is not officially recognized as part of the IBI, but the term is unofficially used when the benthic macroinvertebrate community at a site is so adversely affected that the sample does not yield the minimum required number of macroinvertebrates for IBI calculation (Dustin Shull, personal communication). This approach allows Year-1 data analysis to align with PADEP regulatory determination of designated use impairment.

RESULTS/DISCUSSION

Total Maximum Daily Loads

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. In Pennsylvania, PADEP assesses streams as part of the Statewide Surface Waters Assessment Program. If PADEP determines a stream to be impaired, a TMDL may be established for the corresponding watershed. These impaired streams are listed in the Pennsylvania Integrated Report, which is updated every two years and was most recently updated in 2014 (PADEP, 2014).

Since the last Middle subbasin survey was completed in 2008, about 165 stream miles on about 40 individual streams were listed as impaired and requiring the development of a TMDL. Most of these stream miles (53 percent) were newly listed for aquatic life impairment with leading causes including low pH from atmospheric deposition and siltation from mine drainage, urban runoff, or storm sewers. About 42 percent of these stream miles were newly listed for recreational impairments caused by pathogens from unknown or identified urban sources. Towanda Creek was the only stream newly listed for fish consumption in the subbasin caused by mercury from an unknown source.

Since the last Middle Year-1 survey, TMDLs were developed for about 182 stream miles on over 50 subbasin streams that were previously listed for aquatic life impairment. None of these stream miles were sampled as part of this study. Fifty percent of these stream miles were impaired from low pH, high metals, or a combination of the two as a result of mine drainage or atmospheric deposition. The remaining stream miles were impaired by siltation from agricultural, urban runoff, and storm sewers.

Forty percent of the sites sampled by SRBC in 2014 are on stream segments currently listed as impaired in the 2014 Integrated Report, with the vast majority of those sites impaired for aquatic life, largely by mine drainage sources. Five sites, mostly on the Susquehanna River mainstem, are listed for fish consumption. Three sites are listed for recreational impairment, two of which are located near each other on South Branch Tunkhannock Creek.

Four other sets of sites are paired on the same stream. Two sites on Towanda Creek (WQN 318 and TWND 0.7) are listed for fish consumption impairment from mercury from an unknown source. The remaining sites are listed for aquatic life impairment. Tomhicken Creek (TOMH 1.4 and TOMH 3.2) is affected by low pH and Nescopeck Creek (WQN 308 and NESK 14.7) is affected by low pH and elevated metals from a mine drainage source. East Branch Fishing Creek (EBFC 4.1 and EFSH 3.4) is listed for low pH and elevated metals from acid deposition.

2014 Results

General Findings

Figure 4 illustrates the ratings for water quality, habitat, and biology at each of the 75 sites included in this survey. Most of the sites with the poorest water quality and impaired biology were located in the southern third of the subbasin, which drains developed areas and mine lands. The northern half of the subbasin, which is also more forested (Figure 3), consistently contained sites with better water quality and streams attaining designated use.

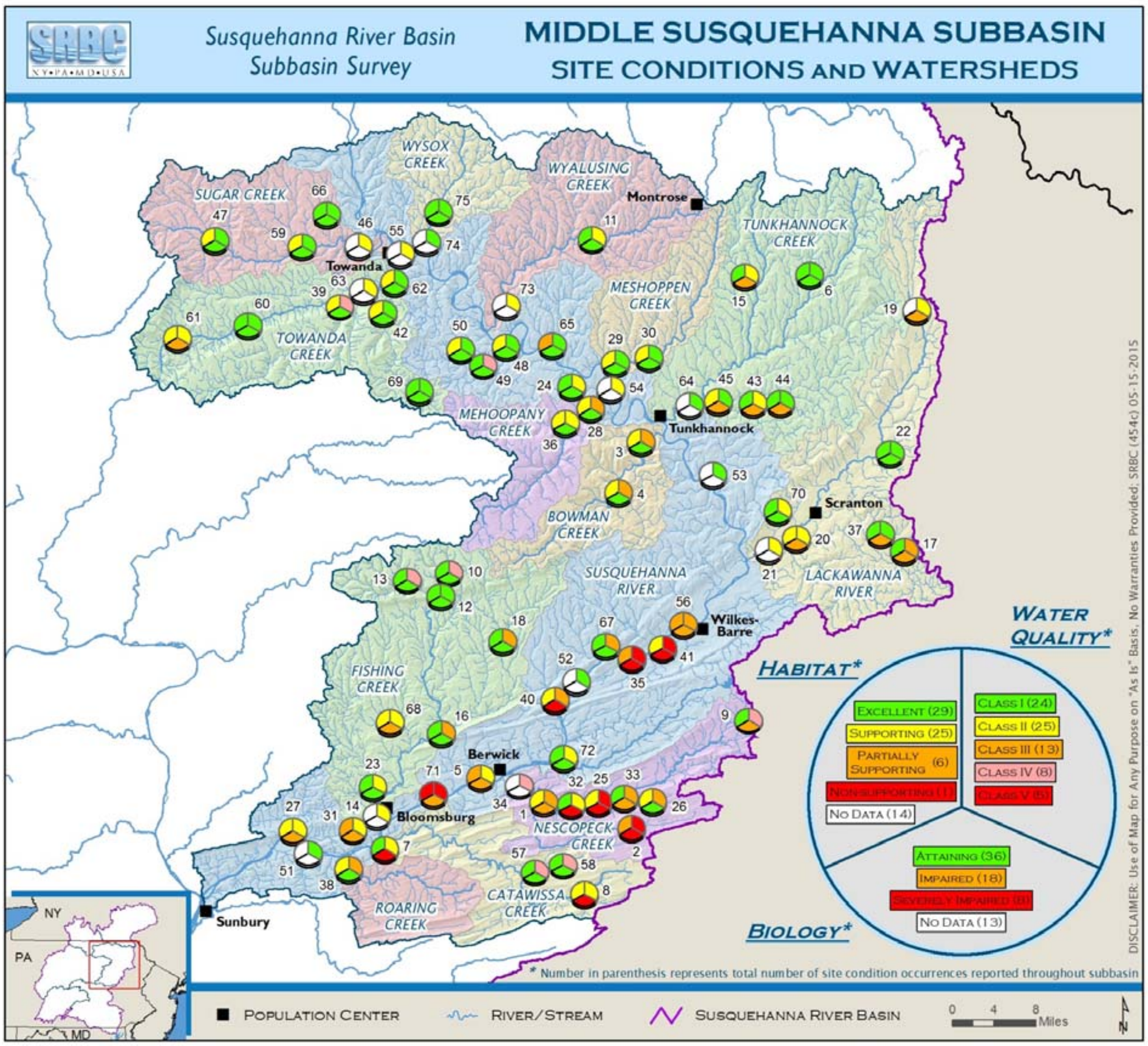


Figure 4. Middle Susquehanna Subbasin Site Conditions and Watersheds

Table 3 summarizes the water quality, habitat, and biological ratings for all sites sampled in 2014 that have complete datasets. In general, Water Quality Class I sites with Excellent or Supporting habitat had good benthic communities resulting in Attaining status. As water quality and habitat ratings decreased, fewer Attaining sites were documented, although not necessarily in a predictable manner. As expected, the poorest water quality and habitat were most often associated with Impaired or Severely Impaired sites.

A correlation matrix (Pearson's r) was developed to look at relationships between IBI scores, habitat scores, water quality scores, drainage area, and land use variables (Table 4), with significant results flagged ($\alpha = 0.05$) and discussed here. Habitat and IBI scores were not correlated with each other and were not correlated with the drainage area of the stream. The categorical nature of stream order or ARC excluded those metrics from correlation analysis.

Habitat scores had a positive relationship with both percent forest cover and percent total stable vegetation and a negative relationship with percent agriculture and percent developed land. IBI scores were positively related to percent total stable vegetation and negatively related to percent developed land use and percent barren/extractive land use.

Water Quality Class is a categorical variable and thereby cannot be included in the correlation matrix. Instead, the raw water quality score used to assign a Water Quality Class was included. Raw water quality score was positively related to percent barren/extractive land use, which was the only land use to show a correlation with raw water quality score. Raw water quality score had a negative relationship with IBI score, indicating the presence of more impaired biological communities with worsening water quality.

Table 3. Matrix of Water Quality, Habitat, and Biological Ratings at Middle Susquehanna Subbasin Sites in 2014

Habitat Rating	Class I (Excellent)	Class II	Class III	Class IV	Class V (Poor)
Nonsupporting					USUS 0.5*
Partially Supporting	TUSC 0.5	BRIR 0.4 CATW 0.5 MNTR 1.8*	TOBY 0.2		NWPT 0.5 BLAK 15.0
Supporting	MESH 0.2 MESH 4.5 SGRR 0.4 STNK 0.5 STWN 0.1 SUGR 22.1 SUGR 6.5* TOMJ 0.4 TWND 0.7	MAHO 1.4 CATW 33.2 LAWR 4.2 NMHO 0.1 TOWA 26.1* UMDR 0.2*	BOWM 2.5 BLAK 0.1 BOWM 10.8 LNSK 5.7 MEHO 1.5 RORC 1.7 SHIK 0.1	SCHR 0.2	SOLO 0.9 LNSK 0.1
Excellent	BTLR 0.6* EFSH 3.4 LRLR 1.0* RORB 11.4* SBTK 8.0* TOWA 18.1* UTBR 0.5* UTST 0.4* WYSX 3.3*	LFSH 0.1 EBWC 0.1 HBTM 2.2* LMEH 0.8 NESK 14.7 SBTK 7.1 UNJN 0.1* WWLP 0.2	HUNT 0.3 KELM 1.3* KTCH 0.5 NESK 19.1 UTHN 1.9*	CREA 4.5* EBFC 4.1 ELKR 1.2* SUGR 2.6 TOMH 1.4* TOMH 3.2	

IDEAL CONDITIONS

Water Quality Rating

Attaining sites
Impaired sites
Severely Impaired sites
*probabilistic sites

LACK 41.8 is not included above because habitat data are missing

Table 4. Correlation Matrix (Pearson's r) for all 2014 Middle Susquehanna Subbasin Sites with Complete Datasets

	Habitat	*IBI*	*DA*	*ARC*	*Stream order*	*% Forest*	*% Ag*	*% Developed*	*% Barren/Extractive*	*Total Stable Vegetation*	*Cultivated Crop*
IBI	0.249										
DA	-0.197	0.145									
% Forest	0.468	0.106	0.022	0.016	-0.032						
% Agriculture	-0.307	0.114	-0.016	-0.001	0.075	-0.918					
% Developed	-0.426	-0.607	0.019	0.030	-0.050	0.218	-0.142				
% Barren/Extractive	-0.230	-0.381	-0.129	-0.085	-0.150	0.154	-0.351	0.344			
% Total Stable Vegetation	0.454	0.278	0.034	0.017	0.037	0.772	-0.626	-0.401	-0.113		
% Cultivated Crop	-0.226	0.106	-0.018	-0.021	0.021	-0.746	0.818	-0.155	-0.277	-0.819	
Raw WQ score	-0.245	-0.262	-0.093	-0.042	-0.086	0.064	-0.173	0.167	0.553	-0.051	-0.055

positive correlation: α = 0.05
negative correlation: α = 0.05

Water quality

Sixty percent of the non-mainstem sites sampled by SRBC in 2014 were categorized as Water Quality Class I or II. This majority was largely comprised of probabilistic, RWQMN, and long-term sites (Figure 5). Nineteen percent of sites were categorized in lowest Water Quality Class IV or V, with mine drainage sites as the largest proportion of these sites. While not illustrated in Figure 5, mainstem Susquehanna sites were classified as either Class I or II. Most of the WQN sites were classified as Class II, with some Class I, and one Class IV (on Nescopeck Creek).

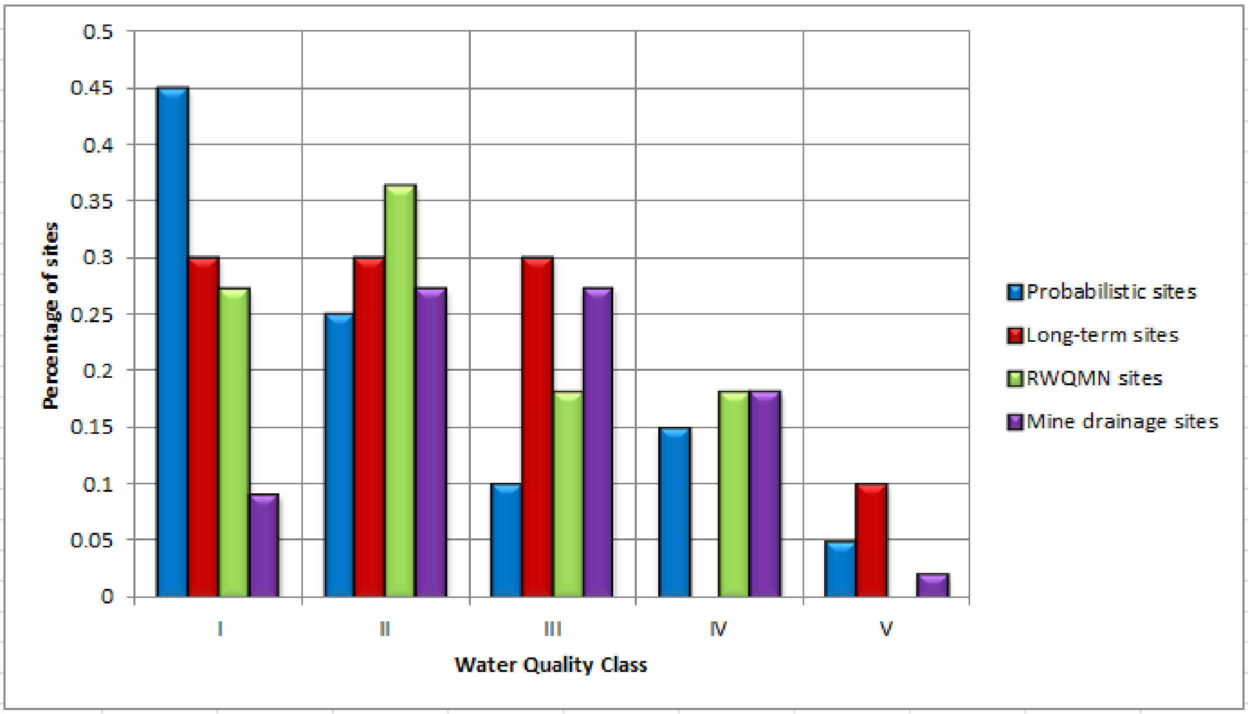


Figure 5. Water Quality Classifications for Sites Sampled in the Middle Susquehanna Subbasin in 2014

Table 5 details which parameters exceed levels of concerns at all Class II through V sites. Alkalinity levels were low at 39 percent of sites, with the lowest levels observed at the RWQMN site on East Branch Fishing Creek (EBFC 4.1) and the probabilistic site on Elk Run (ELKR 1.2) (1 mg/l). Some streams can have naturally low alkalinity and pH, a characteristic that could be stated about the vast majority of these sites since the hallmark elevated parameters associated with acid deposition or mine drainage are lacking. The biological communities at these two sites are both Attaining.

Table 5. Middle Susquehanna Subbasin Sites with 2014 Water Quality Values Exceeding Levels of Concern

Site Type	Site Name	Alkalinity mg/l	Calcium mg/l	Hardness mg/l	Magnesium mg/l	Manganese mg/l	Nitrate-N mg/l	Total Nitrogen mg/l	Total Orthophosphate mg/l	Total Phosphorus mg/l	Total Sodium mg/l	TDS mg/l	Turbidity NTU	Sulfate mg/l	pH	Specific Conductance umhos/cm	Total Aluminum mg/l	Total Iron mg/l	TOTAL
Long-term Sites	BOWM 2.5	12																	1
	BRIR 0.4						1.6	1.6											2
	CATW 0.5						0.66												1
	HUNT 0.3	8																	1
	LFSH 0.1	16					1.1	1.1											3
	MAHO 1.4						1.7	1.7	0.025										3
	MEHO 1.5	9																	1
	NMHO 0.1	17																	1
	NWPT 0.5		127	558	58.6	3.4		1.5			52.4	1110	78.3	649		1365		34.8	11
	RORC 1.7	12					1.8	1.8											3
	SHIK 0.1	11																	1
	SOLO 0.9					1.7					43.1	562						15.1	4
	TOBY 0.2										30.6								1
	WWLP 0.2	15					0.73		0.023										3
Probabilistic Sites	CREA 4.5	3													5.8				2
	ELKR 1.2	1						2.9											2
	HBTM 2.2							1.47											1
	KELM 1.3	13																	1
	MNTR 1.8						0.92												1
	TOMH 1.4	8									25								2
	TOWA 26.1						0.81		0.057										2
	UMDR 0.2						1.5	1.5											2
	UNJN 0.1														5.65				1
	USUS 0.5						4.2	5.7	0.6	0.74	32.7								5
	UTHN 1.9	9																	1
Large River sites	SUSQ 231						0.64												1
	SUSQ 271						0.6												1
Mine Drainage Sites	BLAK 0.1	16					0.99	2.49	0.026		23.6								5
	BLAK 15.0	5									41.2								2
	CATW 33.2														5.04		1.3		2
	LAWR 4.2	16					1.1	1.1	0.061		20.9								5
	LNSK 0.1				38	2.3					21.3			266	4.89		4.3		6
	LNSK 5.7	10									20.1								2
	NESK 14.7														5.65		1.8		2
	NESK 19.1	6																	1
	SCHR 0.2	5																	1
	TOMH 3.2	6									25.6								2
RWQMN Sites	BOWM 10.8	5																	1
	EBFC 4.1	1													5.64				2
	EBWC 0.1	18																	1
	KTCH 0.5	2																	1
	LACK	13																	1
	LMEH 0.8							1.25											1
	SBTK 7.1							1.49			21.9								2

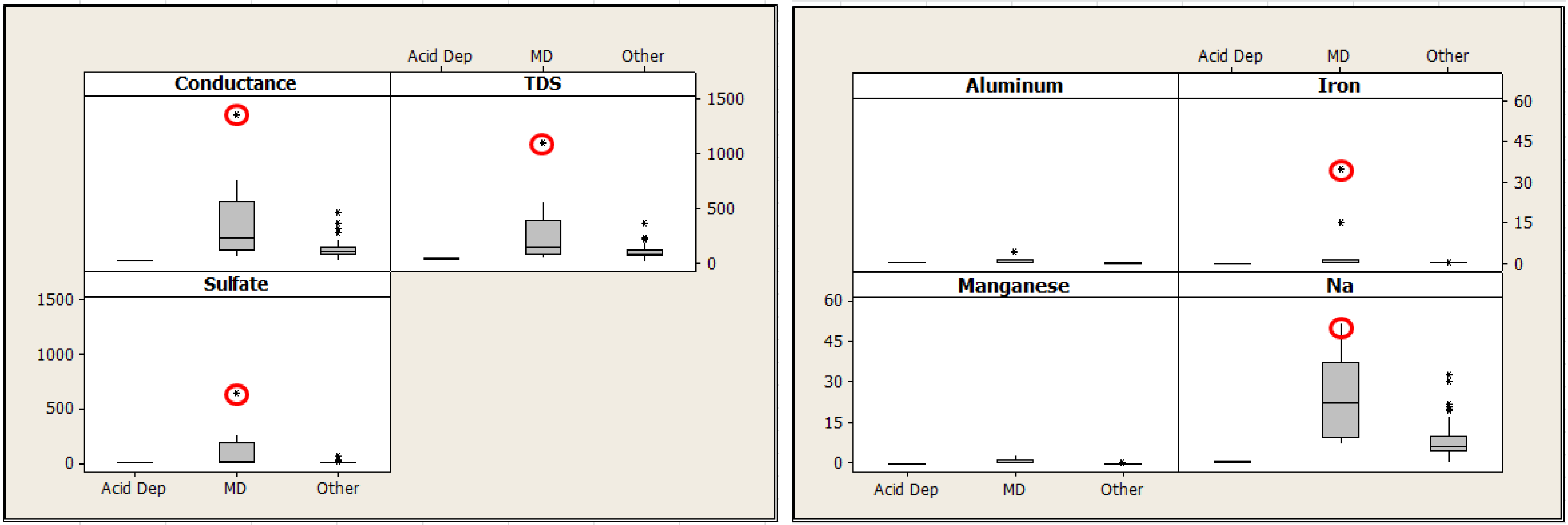
Site Type	Site Name	Alkalinity mg/l	Calcium mg/l	Hardness mg/l	Magnesium mg/l	Manganese mg/l	Nitrate-N mg/l	Total Nitrogen mg/l	Total Orthophosphate mg/l	Total Phosphorus mg/l	Total Sodium mg/l	TDS mg/l	Turbidity NTU	Sulfate mg/l	pH	Specific Conductance umhos/cm	Total Aluminum mg/l	Total Iron mg/l	TOTAL
	SUGR 2.6							1.31											**1**
PADEP Sites	WQN 308 (PADEP)						1.86	1.94											**2**
	WQN 309 (PADEP)	2.8					0.73	1.05									1.044		**4**
	WQN 313 (PADEP)	17.8					0.84	1.08	0.035		20.1								**5**
	WQN 318 (PADEP)	15.4							0.02										**2**
	WQN 333 (PADEP)																0.864	1.587	**2**
	WQN 334 (PADEP)	17.8																	**1**
	TOTAL	**29**	**1**	**1**	**2**	**3**	**17**	**17**	**8**	**1**	**13**	**2**	**1**	**2**	**6**	**1**	**5**	**3**	
	% of sites *	**39%**	**1%**	**1%**	**3%**	**4%**	**23%**	**23%**	**11%**	**1%**	**17%**	**3%**	**1%**	**3%**	**8%**	**1%**	**7%**	**4%**	

Red bolded values were the most extreme values for that parameter measured during this study.

Total nitrogen and total nitrate were both elevated at 23 percent of all sites, but neither parameter was elevated at the same site. The highest levels of total nitrogen (5.7 mg/l) and total nitrate (4.2 mg/l) were observed at the probabilistic site on the unnamed tributary to the Susquehanna River (USUS 0.5). This site, which is located downstream of residential and agricultural land use, also had the highest orthophosphate level (0.6 mg/l) and the only elevated total phosphorus level (0.74 mg/l). USUS 0.5 also had an Impaired biological community from lack of EPT and other sensitive organisms, dominance of midges, and Nonsupporting habitat. Orthophosphate was elevated at 11 percent of sites.

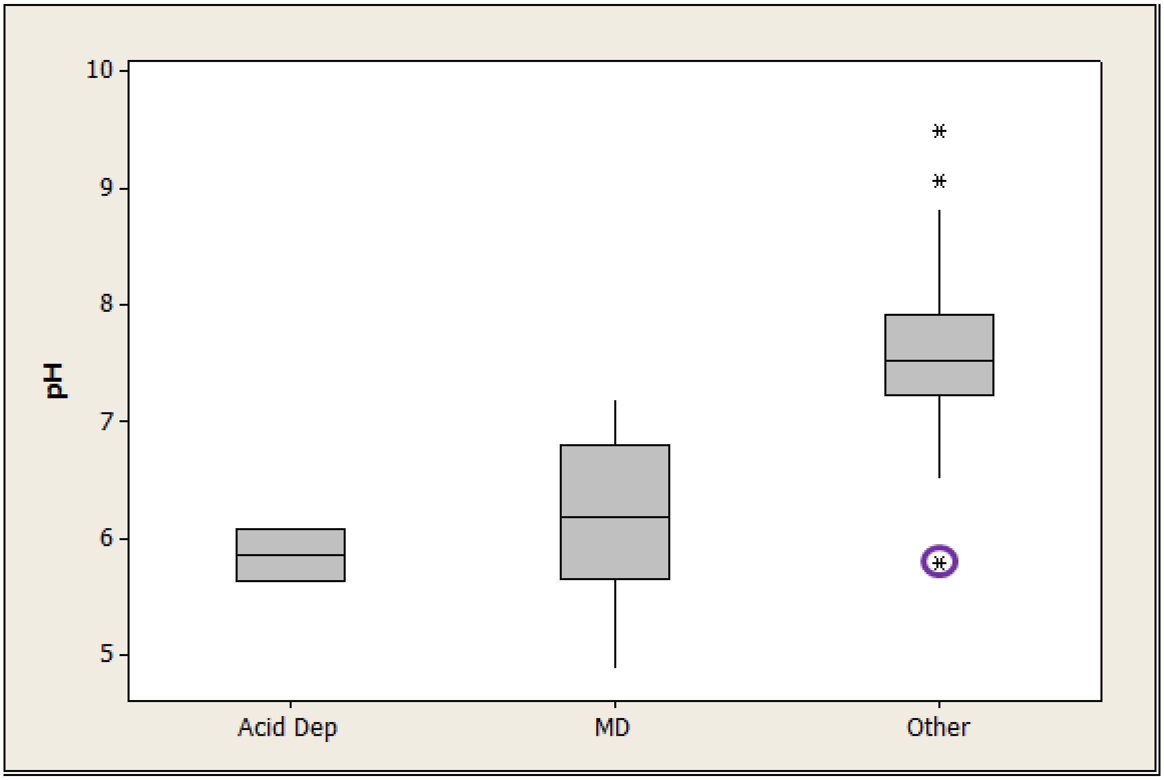
Not surprisingly, sites listed for mine drainage issues predominantly experienced the most elevated sodium, manganese, TDS, sulfate, conductance, iron, and aluminum levels (Figures 6 and 7). Elevated total sodium was found at 17 percent of sites, with the highest level occurring at the long-term site on Newport Creek (NWPT 0.5). This particular site also had the highest levels of calcium, hardness, magnesium, manganese, TDS, turbidity, sulfate, specific conductance, and iron (highlighted in red). Newport Creek is listed for aquatic life impairment for depressed pH from mine drainage (although depressed pH was not observed during the site visit), and the benthic community here received an appropriate Severely Impaired rating. Figure 8 illustrates the lower pH levels of sites affected by acid deposition and mine drainage compared to other study sites. Creasy Creek (CREA 4.5) was an outlier among the other study sites with a low alkalinity and low pH of 5.8.

One Large River site only had a slightly elevated total nitrate level (Susquehanna River at Meshoppen at 0.64 mg/l). Elevated nutrients and sodium, as well as low pH and alkalinity, occurred at probabilistic sites. In addition to low alkalinity, elevated nutrients and mine drainage parameters were documented at long-term sites.



Newport Creek (NWPT 0.5)
"Acid Dep" and "MD" site categories include sites on segments listed in 2014 Integrated Report as having aquatic life impairments from these sources.
"Other" site category includes sites on segments listed in 2014 Integrated Report as having impairments from other sources or are not listed at all.

Figures 6 and 7. Boxplots of Select Water Quality Parameter Concentrations (mg/l) Measured During the 2014 Middle Susquehanna Subbasin Survey



Creasy Creek (CREA 4.5)

"Acid Dep" and "MD" site categories include sites on segments listed in 2014 Integrated Report as having aquatic life impairments from these sources.

"Other" site category includes sites on segments listed in 2014 Integrated Report as having impairments from other sources or are not listed at all.

Figure 8. Boxplots of pH Across Different Site Categories Investigated during the 2014 Middle Susquehanna Subbasin Survey

Elevated calcium, hardness, magnesium, manganese, TDS, turbidity, sulfate, specific conductance, aluminum, and iron, as well as depressed pH, were all found at a small fraction of sites. No elevated levels of unconventional drilling activity indicators—barium, bromide, lithium, strontium, or gross alpha or beta—were measured at any of the RWQMN sites. RWQMN sites experienced issues with alkalinity, total nitrogen, and occasionally sodium and pH. These patterns are similar to historic data from the RWQMN sites, with the exception of total nitrogen, which is not routinely monitored for this project.

Habitat

The vast majority of non-mainstem sites sampled by SRBC had either Excellent or Supporting habitat. Most of the Excellent habitat was found at probabilistic and RWQMN sites (Figure 9). While most of the RWQMN and probabilistic sites are located in smaller watersheds (64 percent of RWQMN and 85 percent of probabilistic are ARC 1 or 2), habitat scores were not significantly correlated with drainage area (Table 4; $\alpha = 0.05$).

Most of the Supporting habitat was found at long-term sites. Slight degradations to habitat are not surprising at long-term sites since most of these sites are located at the mouths of tributaries where the stream systems are larger and may have less flow regime variability. Most mine drainage sites had Supporting habitat, but many also had Excellent habitat.

Partially Supporting habitat was found within all site categories except for RWQMN sites, and the only site with Nonsupporting habitat was probabilistic site USUS 0.5 on an unnamed tributary to the Susquehanna River. USUS 0.5 was a small stream resembling a drainage ditch with slow-moving water and a muddy bottom. Major habitat issues contributing to lower habitat ratings included compromised streambank stability and vegetation, substrate quality, and uniform flow regime.

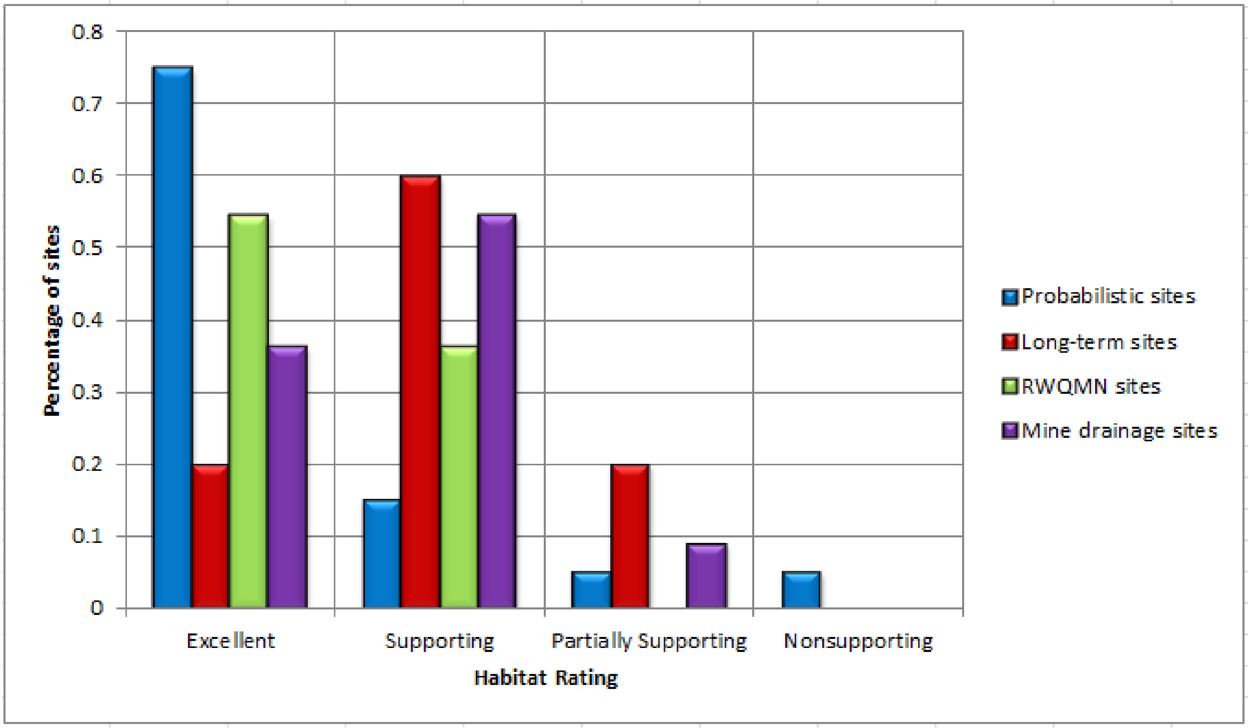


Figure 9. Habitat Ratings for Sites Sampled in the Middle Susquehanna Subbasin in 2014 (Data Missing for One RWQMN Site)

<u>Biology</u>

PADEP IBI scores were calculated for each of the probabilistic, long-term, and RWQMN sites. Figure 10 shows that the vast majority of the benthic macroinvertebrate communities at sites evaluated using the PADEP IBI were Attaining. Fifty percent of probabilistic sites, 60 percent of long-term sites, and 82 percent of RWQMN sites scored as Attaining. Impaired ratings occurred at 18 to 50 percent of sites. Severely impaired communities were found at 20 percent of long-term sites and 36 percent of mine drainage sites. No severely impaired communities were observed at probabilistic or RWQMN sites.

Non-metric multidimensional scaling (NMDS) using Bray-Curtis dissimilarity (Bray and Curtis, 1957) was used to visually examine relative similarity of macroinvertebrate communities between stations. Sites that plot distantly from one another may have few taxa in common, or abundances of shared taxa may differ substantially. Samples plotting close together have more shared taxa with similar abundances. The PRIMER v7 software package was used to complete NMDS ordination (Clarke and Warwick, 2001).

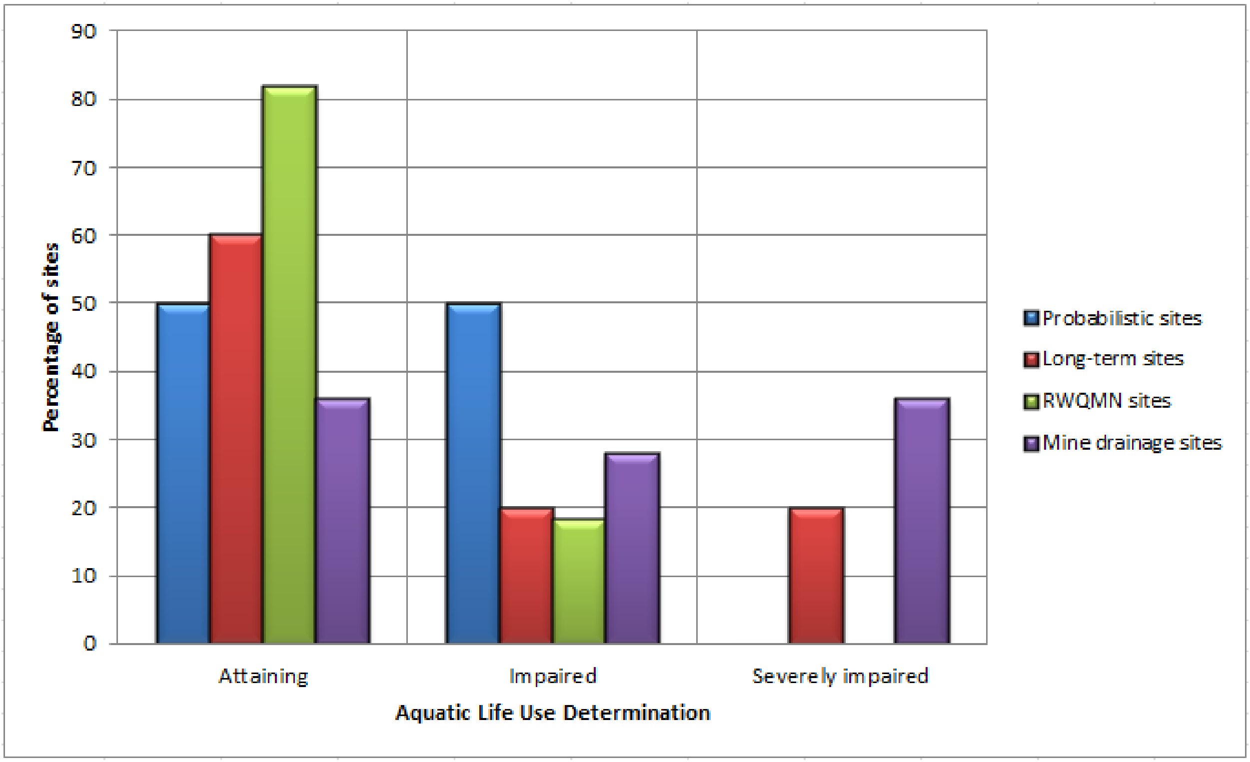


Figure 10. Aquatic Life Use Determinations for Sampled Sites in the Middle Susquehanna Subbasin in 2014

NMDS analysis reveals the biological communities have degrees of similarity among groupings but grouped most definitively when plotting by biological impairment (Figure 11). In general, sites that plotted towards the right had drastically different communities that yielded Severely Impaired site ratings. One outlier on this graph is the Impaired site on Black Creek (BLAK 0.1), which grouped differently than the rest of the Impaired sites because of the dominance of the tolerant mayfly *Baetis*.

Many of these sites are Impaired because of a lack of EPT organisms, lack of diversity, and/or a dominance of organisms, especially if those organisms are pollution-tolerant. A few sites located on Towanda Creek (TOWA 26.1), Kellum Creek (KELM 1.3), and Creasy Creek (CREA 4.5) had communities dominated by larval Simuliidae which affected IBI scores negatively. The site on Toby Creek (TOBY 0.2) and Black Creek (BLAK 0.1, previously mentioned) were Impaired because the dominance of mayflies *Baetis* and *Acentrella* resulted in a low diversity of organisms. Many of the Impaired or Severely Impaired sites are listed in the 2014 Integrated Report for TMDL development. Some sites that are currently listed as Impaired for aquatic life were assessed as Attaining in this study, including sites on East Branch Fishing Creek (EBFC 4.1 and EFSH 3.4), Tomhicken Creek (TOMH 1.4 and 3.2), Laurel Run (LRLR 1.0), an unnamed tributary to St. John's Creek (UNJN 0.1), and Wysox Creek (WYSX 3.3).

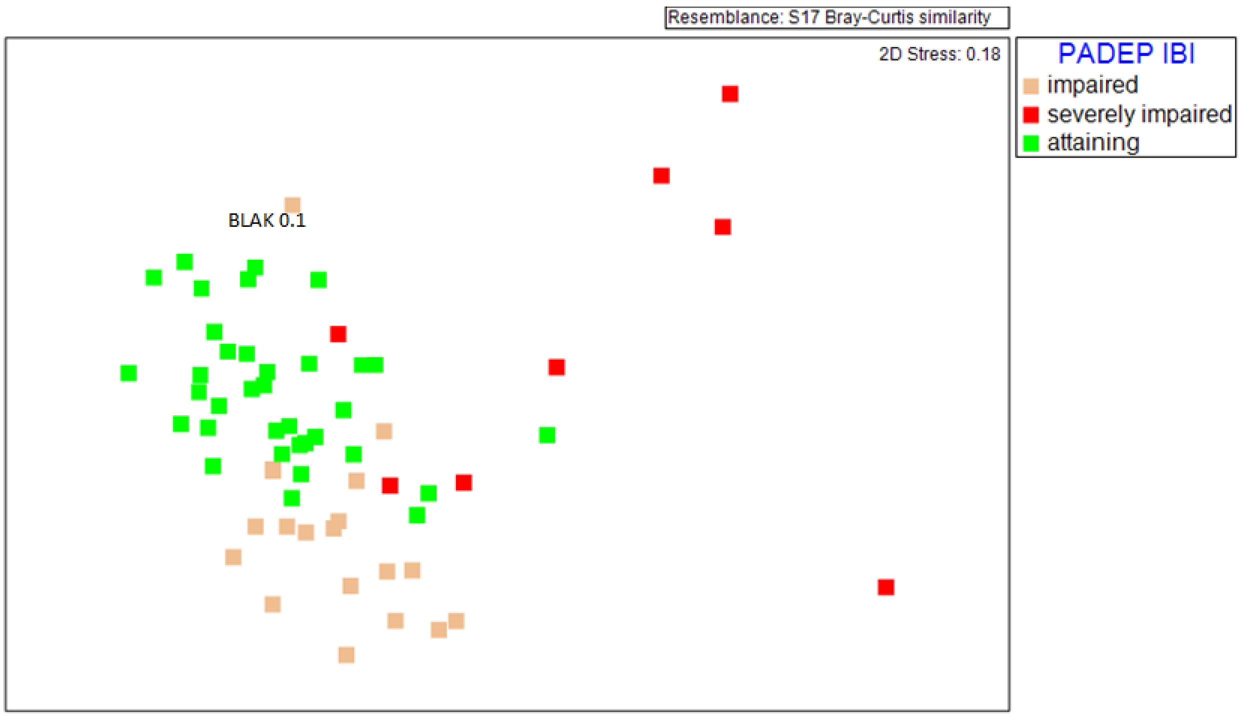


Figure 11. NMDS Plot for Middle Susquehanna Subbasin Sites (2014) by PADEP IBI Rating

Site Categories

Large River Sites

Five of the basinwide Large River sites are located in the Middle Susquehanna subbasin and were sampled in Fall 2014. Water chemistry parameters at all five of these sites fell within acceptable limits based on Table 1 standards, with the exception of slightly elevated total nitrate (0.64 mg/l) at Susquehanna River at Meshoppen, Pa. In general, total alkalinity and total dissolved solids decreased moving downstream. Dissolved oxygen, bromide, chloride, hardness, magnesium, manganese, sodium, and sulfate tended to increase moving downstream, but none of these parameters exceeded acceptable limits.

Continuous measurements for dissolved oxygen, pH, temperature, conductivity, and turbidity have been taken at the Danville site (SUSQ 138) since 2005. This site is the most downstream large river site in the Middle Susquehanna subbasin. From July through October

2014, dissolved oxygen ranged from 6 to 11.2 mg/l with an average of 8.22 mg/l. Measurements for pH ranged from 6.89 to 8.87 with a median value of 7.97. Water temperature ranged from 11.02 to 27.86 °C with an average of 22.54 °C. Conductivity ranged from 217 to 431 µmhos/cm with an average of 329 µmhos/cm. Turbidity ranged from 0 to 45.1 NTU, with an average of 2.6 NTU.

Since the benthic communities at the Large River sites were sampled using a different method, the PADEP IBI could not be applied to assess the level of biological impairment. However, the communities at four of the five sites were dominated by midges, lacked EPT taxa, and/or were low in overall diversity. The site on the Susquehanna River at Falls, Pa., was the only Large River site to have a healthier benthic community with more overall diversity and a higher percentage of pollution sensitive organisms than the other four sites.

<u>RWQMN Sites</u>

Eleven of the 59 RWQMN sites are located within the Middle Susquehanna subbasin. A report analyzing water quality (both continuous and grab samples) and biology at the RWQMN sites was published in June 2015. Nine of the 11 sites were Attaining, and two sites on the Lackawanna River (LACK 41.8) and Sugar Creek (SUGR 22.1) were Impaired. For the most part, these assessment determinations were consistent with determinations made from routine data collected in October 2014. The one RWQMN site listed for aquatic life impairment, EBFC 4.1 on East Branch Fishing Creek, was assessed as Attaining in this study. However, streams listed for acid deposition such as EBFC 4.1 frequently demonstrate seasonal impairment patterns. The next in-depth RWQMN report is expected to be released in Spring 2016.

<u>Mine Drainage Sites</u>

These 11 sites were chosen to monitor mine drainage pollution within the subbasin. Most of these sites have either Supporting or Excellent habitat, but water quality tends to be poor, resulting from elevated parameters indicative of mine drainage pollution. Not surprisingly, many of these sites are located on streams listed for aquatic life impairment, and results from this study indicate that the aquatic life in these streams continue to be impaired.

Long-term Sites

The majority (12) of long-term sites were on stream segments designated as cold water fisheries (CWF), followed by four segments as trout stocked fisheries (TSF), three segments as warm water fisheries (WWF), and one segment as high quality-cold water fisheries (HQ-CWF). Eight of these streams support naturally reproducing trout populations. Four of these stream segments are listed for impairments, with three sites being listed for aquatic life impairments with mine drainage as a partial or sole source. The fourth stream segment (TWND 0.7 on Towanda Creek) is listed for fish consumption issues from mercury.

Water quality data collected from the past three Year-1 surveys were reviewed for the 20 long-term sites. Six sites had no elevated water chemistry parameters in any of the surveys—Meshoppen Creek (MESH 0.2), Sugar Run Creek (SGRR 0.4), South Branch Tunkhannock Creek (STNK 0.5), South Branch Towanda Creek (STWN 0.1), Tuscarora Creek (TUSC 0.5), and Towanda Creek (TWND 0.7)—and one site only had one elevated parameter in 2014 (NMHO 0.1 on North Branch Mehoopany Creek).

Thirteen of these sites had parameters that were elevated at least twice during these surveys. Nutrients were the most consistently elevated category of parameters through time. Seven of the long-term sites had documented chronic issues with nitrate and/or total nitrogen—Briar Creek (BRIR 0.4), Little Fishing Creek (LFSH 0.1), Mahoning Creek (MAHO 1.4), Newport Creek (NWPT 0.1), Roaring Creek (RORC 1.7), Toby Creek (TOBY 0.2), and Wapwallopen Creek (WWLP 0.2). Nitrate has ranged from 0.66 to 2.89 mg/l, while total nitrogen ranged from 1.02 to 2.99 mg/l. Consistent orthophosphate issues were documented only at MAHO 1.4 and WWLP 0.2 with a range of 0.023 to 0.357 mg/l.

Other consistent issues are related to the history of mine activity in the area and involve elevated levels of several associated parameters. Three long-term sites on Catawissa Creek (CATW 0.5), Newport Creek (NWPT 0.5), and Solomons Creek (SOLO 0.9) are listed for impairment of aquatic life with a mine drainage source. CATW 0.5 showed no consistent issues with mine drainage parameters, while SOLO 0.9 had chronically elevated manganese and iron. The site on Newport Creek (NWPT 0.5), however, had nine parameters that were consistently elevated, including calcium (ranging from 127 to 162 mg/l), hardness (558 to 744 mg/l), magnesium (58.6 to 82.3 mg/l), manganese (3.4 to 5.23 mg/l), sodium (42.1 to 58.6 mg/l), iron (22.5 to 57.5 mg/l), sulfate (649 to 827 mg/l), and specific conductance (1365 to 1538 umhos/cm). This site also emanated a strong sulfur smell and was layered with orange and white mucky sediment.

Sites on Huntingdon Creek (HUNT 0.3) and Mehoopany Creek (MEHO 1.5) consistently had low alkalinity levels, ranging from 3.4 to 18.2 mg/l. In addition to NWPT 0.5, the site on Toby Creek (TOBY 0.2) was the only other long-term site to demonstrate consistently elevated sodium levels.

Table 6 shows a comparison of ratings derived from the past three Year-1 surveys. Fifty percent of the long-term sites were categorized in the same Water Quality Class each survey. Four sites on Meshoppen Creek (MESH 0.2), Sugar Run Creek (SGRR 0.4), South Branch Towanda Creek (STWN 0.1), and Tuscarora Creek (TUSC 0.5) were Class I each of the survey years. The two sites on Newport Creek (NWPT 0.5) and Solomons Creek (SOLO 0.9) were consistently Class V streams. The remaining sites fluctuated in Water Quality Class designations.

2001 and 2008 habitat ratings could not be directly compared to 2014 ratings since different sites were used in the 2014 study, thereby shifting the reference condition determination methods. However, review of the habitat ratings through the three surveys indicates 75 percent of the sites had either Excellent or Supporting ratings consistently through the surveys. Compromised habitat conditions (Partially Supporting or Nonsupporting designations) were observed at the remaining five sites at least once over during the three surveys.

Table 6. Comparison of Ratings for Middle Susquehanna Subbasin Long-term Sites (2001, 2008, and 2014 Data)

Site	Ecoregion	Water Chemistry			Habitat			Biology	
		2014	2008	2001	2014	2008[b]	2001[b]	2014	2008
BOWM 2.5	NAPU	Class III	Class I	Class II	Supporting	Excellent	Excellent	Attaining	[a]
BRIR 0.4	NLV	Class II	Class III	Class II	Partially Supporting	Supporting	Excellent	Impaired	Impaired
CATW 0.5	NLV	Class II	Class IV	Class IV	Excellent	Supporting	Excellent	Severely Impaired	Impaired
HUNT 0.3	NLV	Class III	Class II	Class II	Excellent	Excellent	Excellent	Attaining	Attaining
LFSH 0.1	NLV	Class II	Class II	Class II	Excellent	Excellent	Supporting	Attaining	Impaired
MAHO 1.4	NLV	Class II	Class II	Class II	Supporting	Partially Supporting	Supporting	Impaired	Impaired
MEHO 1.5	NAPU	Class III	Class II	Class II	Supporting	Excellent	Excellent	Attaining	Attaining
MESH 0.2	NAPU	Class I	Class I	Class I	Supporting	Excellent	Excellent	Attaining	Impaired
NMHO 0.1	NAPU	Class II	Class I	Class I	Supporting	Supporting	Excellent	Attaining	Attaining
NWPT 0.5	NLV	Class V	Class V	Class V	Partially Supporting	Excellent	Nonsupporting	Severely Impaired	Severely Impaired
RORC 1.7	NLV	Class III	Class II	Class IV	Supporting	Supporting	Excellent	Attaining	Impaired
SGRR 0.4	NAPU	Class I	Class I	Class I	Supporting	Excellent	Excellent	Attaining	Attaining
SHIK 0.1	Ridge	Class III	Class III	Class III	Supporting	Supporting	Supporting	Severely Impaired	Impaired
SOLO 0.9	NLV	Class V	Class V	Class V	Supporting	Supporting	Supporting	Severely Impaired	Severely Impaired
STNK 0.5	NAPU	Class I	Class II	Class II	Supporting	Excellent	Excellent	Impaired	Impaired
STWN 0.1	NAPU	Class I	Class I	Class I	Supporting	Excellent	Excellent	Attaining	Attaining
TOBY 0.2	NLV	Class III	Class III	Class III	Partially Supporting	Nonsupporting	Nonsupporting	Impaired	Severely Impaired
TUSC 0.5	NAPU	Class I	Class I	N/A	Partially Supporting	Supporting	N/A	Attaining	Impaired
TWND 0.7	NAPU	Class I	Class I	Class II	Supporting	Excellent	Excellent	Attaining	Attaining
WWLP 0.2	NLV	Class II	N/A	Class II	Excellent	N/A	Excellent	Attaining	[a]

[a] Cannot assess because site was either not sampled or sampled during the wrong index period.

[b] 2001 and 2008 habitat ratings are not directly comparable to 2014 ratings because different reference sites were used.

Biological data collected in 2001 could not be used to calculate PADEP IBI scores because the subsample size used in 2001 was too small. PADEP IBI assessments could not be performed for 2008 data for two long-term sites because samples were either not collected or were collected in the wrong index period. Review of the PADEP IBI scores for the remaining sites indicates that 78 percent of sites were rated consistently over the past two surveys, with most of those sites Attaining. Three sites alternated between Severely Impaired and Impaired. Four sites moved from Impaired in 2008 to Attaining in 2014—Little Fishing Creek (LFSH 0.1), Meshoppen Creek (MESH 0.2), Roaring Creek (RORC 1.7), and Tuscarora Creek (TUSC 0.5).

Probabilistic Sites and Overall Subbasin Conditions

The process of choosing 20 probabilistic sites involved stratifying sites by ecoregion and giving unequal probability of being selected based on stream order (‘small’ streams of stream orders 2 and 3 and ‘large’ streams of stream orders 4 through 6.) Consequently, the number of sites sampled in each ecoregion was based on the proportion of the ecoregion within the subbasin as well as the proportion of stream sizes within the subbasin. The results within each ecoregion can be extrapolated to streams within that ecoregion within the subbasin.

Only two sites on small streams were sampled in Ecoregion 62 (NCA) since the ecoregion comprises a small portion (10 percent) of the Middle Subbasin. Figures 12 through 14 suggest that small streams within this ecoregion have excellent habitat, poorer water quality (WQN IV), and inconsistently attain aquatic life use. Poorer water quality can be attributed to low alkalinity, high total nitrogen, and low pH values.

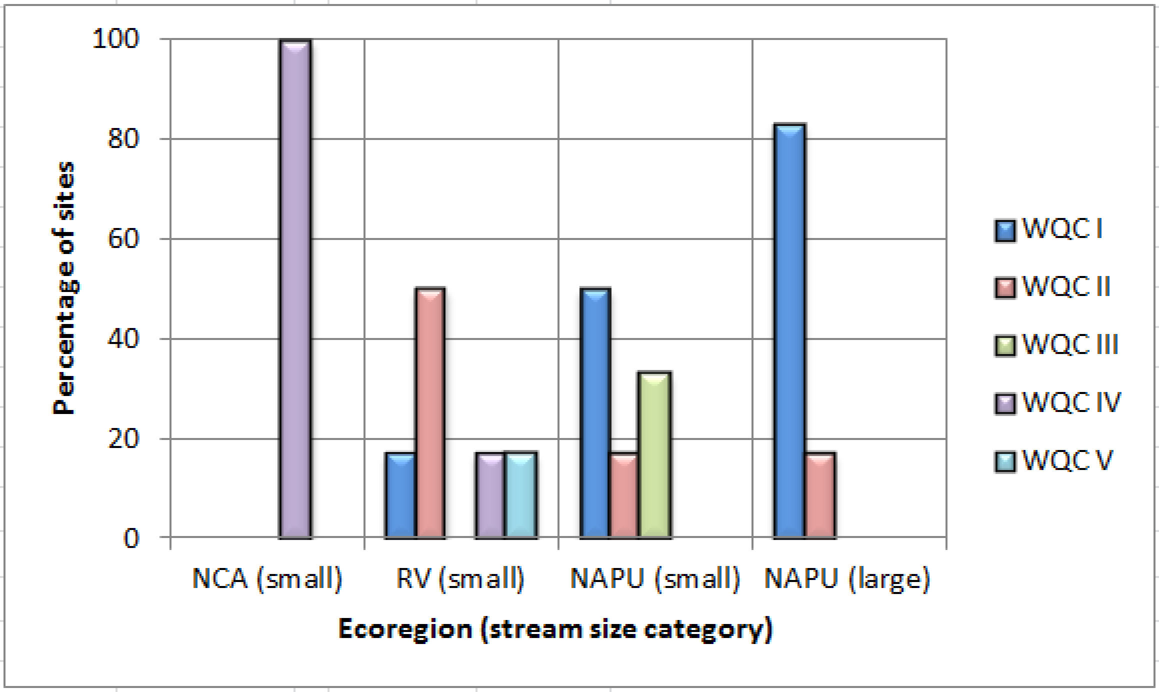


Figure 12. 2015 Water Quality Category Classifications for Streams in Ecoregions in the Middle Susquehanna Subbasin

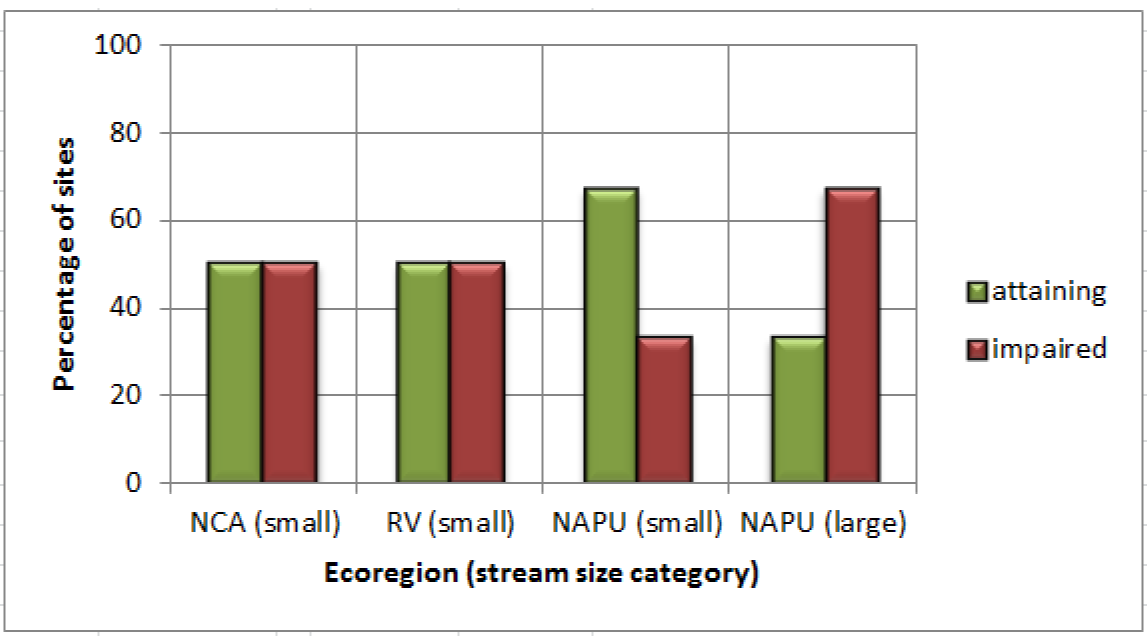


Figure 13. 2015 Aquatic Life Use Determinations for Streams in Ecoregions in the Middle Susquehanna Subbasin

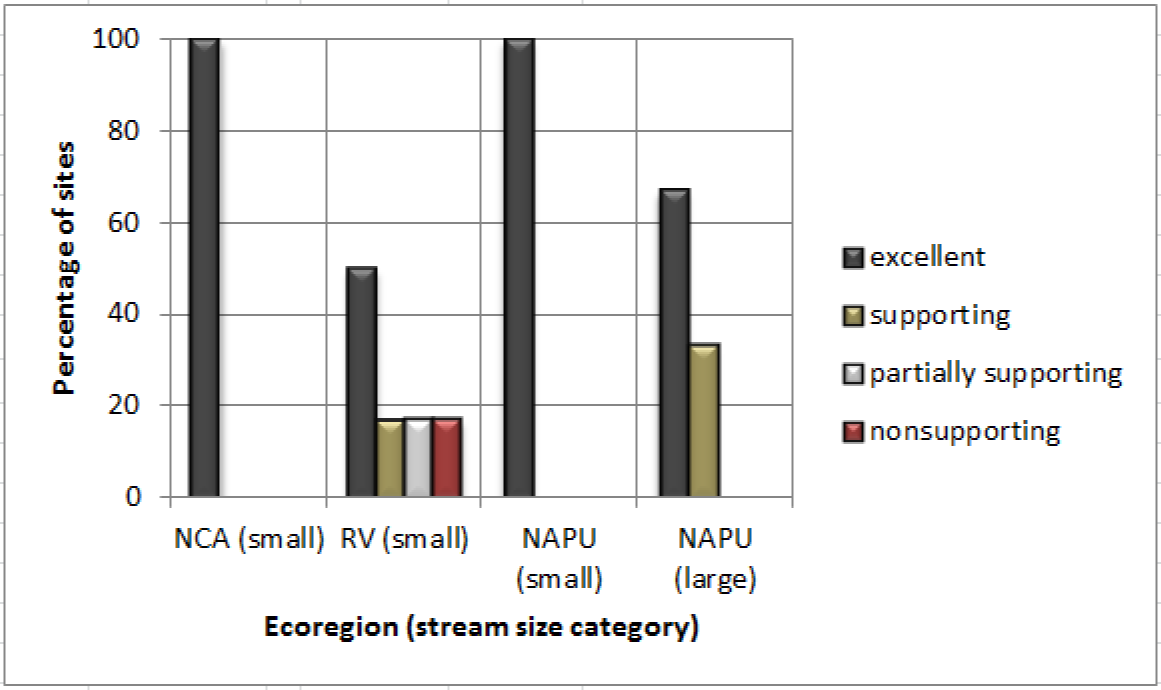


Figure 14. 2015 Habitat Ratings for Streams in Ecoregions in the Middle Susquehanna Subbasin

Six sites on small streams were sampled in Ecoregion 67 (Ridge and Valley), most of which were listed in the 2014 Integrated Report for aquatic life impairments resulting either from mine drainage or agriculture. Results suggest that about 50 percent of the streams in this ecoregion have excellent habitat, while supporting, partially supporting, and nonsupporting habitat is found equally distributed at the remainder of the streams within this ecoregion. Fifty percent of the streams in this ecoregion attain designated use and have good water quality (WQC II). The remainder of the streams range from having excellent (WQC I) or poorer (WQC IV or V) water quality. Results suggest impacted streams have elevated nutrients (nitrate, total nitrogen, orthophosphate, total phosphorus) as well as elevated sodium. Some streams also have low pH and low alkalinity.

Twelve sites were sampled in Ecoregion 60 (NAPU), which has the most coverage over the subbasin. These sites were split evenly between small and large streams, with agriculture as the only source listed for aquatic life impairment. Results indicate all small streams in this ecoregion have excellent habitat, and about two-thirds of these streams have good water quality (WQC I or II). Similarly, two-thirds of the small streams also attain aquatic life designated use.

Two-thirds of large streams in this ecoregion have excellent habitat, and the remainder have supporting habitat. However, despite good habitat ratings and good water quality (WQC I or II), only one-third of these large streams attain aquatic life designated use. Water quality issues in this ecoregion appear to be limited to low alkalinity and elevated nitrate or orthophosphorus.

Generally, about half of the streams within each of the three ecoregions in the Middle subbasin are biologically impaired. IBI scores were most affected by the dominance of midges or other taxa that may be tolerant to pollution and/or compromised substrate conditions, a lack of EPT taxa, and a lack of overall diversity. Habitat quality is generally good across the subbasin but is consistently better in the NCA and NAPU ecoregions compared to the RV ecoregion. Habitat impairment across these sites was largely caused by homogenous flow regimes, siltation, embeddedness, and compromised bank stability and vegetation quality. The NAPU ecoregion also has consistently better water quality than the other two ecoregions. Low pH, low alkalinity, and elevated nutrients are found in all three ecoregions.

The water quality, habitat, and biological ratings are reflective of the agricultural land use, developed land use, and legacy mine drainage effects throughout the subbasin. These land uses cause flow alterations, siltation, and landscape changes that affect the quality of the riparian and instream habitat as well as contribute contaminants that directly affect the biological communities in the streams.

Review of the 2014 Integrated Report indicates that atmospheric deposition is another cause of impairment within the Middle Susquehanna subbasin, but none of the probabilistic sites selected for this study were listed for atmospheric deposition. While financial constraints limited this round of probabilistic sampling to only 20 sites, increasing the number of probabilistic sites within a subbasin would likely increase chances of capturing more variance in stream characteristics and conditions, thereby increasing the statistical power of the method to extrapolate conditions at probabilistic sites to the overall conditions within the subbasin.

Conclusions

With the execution of a new study design and more rigorous analysis, results from the Year-1 survey are more robust than in the past. The incorporation of probabilistic sites allows for a generalization of water quality conditions across the subbasin as a whole. Three surveys across 13 years at long-term sites allow for some analysis of patterns. Reviewing results at targeted monitoring sites such as RWQMN and mine drainage sites enables tracking of specific impacts.

As with all Subbasin Year-1 assessments, these results were based on a one-time sampling event and are meant to provide an overview of subbasin conditions at that point in time. Several of the sites included in this report are sampled more frequently as part of other SRBC projects (RWQMN, FMN, Large Rivers) or by other agencies (WQN), and a more thorough review of conditions and trends at these sites are covered in corresponding project or agency reports. However, the Year-1 results at these sites fall within the range of results observed at these sites in the past.

Based on data collected at 20 probabilistic sites, the majority of 2^{nd} to 5^{th} order streams in the Middle Susquehanna subbasin have good water quality and suitable habitat, and half attain designated uses established by PADEP. Impairment at streams appears linked to nutrients as well as developed land use and mine drainage. Additional probabilistic sampling during the next rotational survey scheduled for 2020 will provide more information.

Sixty percent of the 20 long-term sites were attaining designated uses established by PADEP, indicating overall good conditions throughout the subbasin.

A little over a third of the sites sampled by SRBC in this study are on stream segments listed in the 2014 Integrated Report. Most of these stream segments are listed for aquatic life impairment largely from mine drainage effects, but there are also impairments caused by acid deposition, agricultural practices, and urbanization. Most of the segments sampled on the mainstem Susquehanna River are listed for fish consumption caused by mercury and PCBs. Some other stream segments are listed for recreational impairments resulting from pathogens from unknown or urban sources. These different causes and sources result in deteriorated habitat or water quality pollution that can individually or synergistically affect the biological communities that live in the receiving streams.

This survey revealed that habitat was compromised by direct siltation as well as flow alterations leading to sedimentation and embeddedness issues. Compromised riparian conditions caused by development can result in increased streambank erosion and subsequent sedimentation in downstream reaches, affect the temperature of the stream and associated dissolved oxygen levels, and reduce the input of organic material into the stream that organisms require as a food source. Degraded instream conditions provide less varied habitat to support a diversity of macroinvertebrates and can allow pollution-tolerant and adaptable species to dominate the community.

Elevated sodium and nutrients (mostly nitrate and total nitrogen) as well as depressed alkalinity and pH were the most widespread water quality issues in the subbasin. Sites directly affected by mine drainage experienced many issues including elevated metals, sulfate, and dissolved solids. No parameters indicative of unconventional gas drilling were found to be elevated at RWQMN sites neither during the course of this survey nor during the span of more comprehensive project monitoring.

In addition to habitat changes, chemical pollution can also directly affect the macroinvertebrate assemblage. Chemical pollution can have both acute and chronic effects that can range from shifts in community structure to inability to support any aquatic life. Either way, changes in macroinvertebrate communities can affect the food web and the efficiency of energy processing within the stream.

Some of the highest quality long-term streams tracked in this survey include Bowman Creek, (BOWM 2.5), Huntingdon Creek (HUNT 0.3), Mehoopany Creek (MEHO 1.5), North Branch Mehoopany Creek (NMHO 0.1), Sugar Run Creek (SGRR 0.4), South Branch Towanda Creek (STWN 0.1), Towanda Creek (TWND 0.7), and Wapwallopen Creek (WWLP 0.2).

Long-term sites with poorer quality include Newport Creek (NWPT 0.5), Solomons Creek (SOLO 0.9), Catawissa Creek (CATW 0.5), Shickshinny Creek (SHIK 0.1), and Toby Creek (TOBY 0.2). Newport, Solomons, and Catawissa Creeks all are heavily affected by mine drainage. Shickshinny and Toby Creeks are both located in more developed settings, where channelization and riparian alterations have disturbed habitat and the natural flow regime, and water quality issues such as high sodium and heavy algae growth are seen.

Efforts should be made to restore the most degraded watersheds and protect the higher quality ones within this subbasin. Low impact development, incorporating groundwater recharge areas, and eliminating combined sewer overflows can help minimize urban stormwater problems. Both the Center for Watershed Protection's Urban Subwatershed Restoration Manual series (www.cwp.org) and the PADEP's Pennsylvania Stormwater Best Management Practices Manual (PADEP, 2006) provide more information on remediating urban pollution.

Staff with the Mine Drainage Program at SRBC work with other agencies and organizations such as PADEP and Eastern Pennsylvania Coalition for Abandoned Mine Reclamation (EPCAMR) to assess and restore mine lands. These efforts include designing and constructing mine drainage treatment and mine land restoration projects throughout the Susquehanna Basin (http://www.srbc.net/programs/minedrainage.htm). The Mine Drainage Portal provides public access to water quality data compiled during assessment and tracking efforts (http://mdw.srbc.net/minedrainageviewer).

Information on agricultural best management practices and other conservation methods to limit the impacts associated with farming operations can be obtained from county conservation district offices (www.pacd.org and www.nyacd.org/districts.html).

The next Year-1 subbasin survey for the Middle Susquehanna subbasin is scheduled to take place in 2020. The Middle Susquehanna Year-2 study, taking place during the 2015 calendar year, is focusing on refining the correlation between suspended sediment and turbidity at five study watersheds located in the Middle Subbasin. A final report on the Year-2 study will be available in December 2016.

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APPENDIX

Sample Site #	Site Name	Location Description	Site Category	PADEP Chp 93 Designated Use	County	Latitude	Longitude	Ecoregion III	Drainage (sq mi)	Stream Order	ARC
1	BLAK 0.1	Black Creek above SR 3016 bridge upstream of Nescopeck Creek confluence	Mine drainage	CWF	Luzerne	41.0075	-76.16722	RV	61.8	4	3
2	BLAK 15.0	Black Creek upstream of SR 93 bridge outside Hazleton	Mine drainage	CWF	Luzerne	40.97361	-76.01028	RV	20.6	3	2
3	BOWM 2.5	Bowman Creek downstream of SR 3003 bridge above Tunkhannock	Long-term	HQ-CWF	Wyoming	41.50722	-75.985	NAPU	114.2	4	3
4	BOWM 10.8	Bowman Creek at State Road 29	RWQMN	HQ-CWF	Wyoming	41.427247	-76.027558	NCA	38.5	4	2
5	BRIR 0.4	Briar Creek downstream of Rt. 11 bridge	Long-term	CWF	Columbia	41.04556	-76.285	RV	32.25	4	2
6	BTLR 0.6	Butler Creek below foot bridge	Probabilistic	CWF	Susquehanna	41.73499	-75.669789	NAPU	20.74	3	2
7	CATW 0.5	Catawissa Creek next to park area near old railroad bridge piers	Long-term	TSF	Columbia	40.9475	-76.46139	RV	152.5	4	3
8	CATW 33.2	Catawissa Creek upstream of T818 bridge	Mine drainage	CWF	Schuylkill	40.88	-76.10611	RV	22.8	4	2
9	CREA 4.5	Creasy Creek upstream of culvert at rails to trails crossing	Probabilistic	CWF	Luzerne	41.12019	-75.794205	NCA	0.71	2	1
10	EBFC 4.1	East Branch Fishing Creek in state gamelands	RWQMN	HQ-CWF	Sullivan	41.322608	-76.34434	NCA	12.55	4	2
11	EBWC 0.1	East Branch Wyalusing Creek upstream of Route 367 bridge	RWQMN	CWF	Susquehanna	41.788321	-76.071108	NAPU	69.3	4	3
12	EFSH 3.4	East Fishing Creek above bridge near Jamison City at gamelands	Mine drainage	HQ-CWF	Columbia	41.31222	-76.34972	NCA	14.6	4	2
13	ELKR 1.2	Elk Run 800m up from cabin	Probabilistic	EV	Sullivan	41.318721	-76.417134	NCA	4.88	2	1
14	WQN 308	Fishing Creek near Bloomsburg, Pa.	WQN (PADEP)	WWF	Columbia	40.99350	-76.47560	RV	379.13	6	4
15	HBTM 2.2	Hop Bottom Creek across from pulloff area	Probabilistic	CWF	Susquehanna	41.733826	-75.789556	NAPU	14.3	3	2
16	HUNT 0.3	Huntingdon Creek adjacent to SR1021 on fishing accessible land	Long-term	TSF	Columbia	41.10694	-76.35639	RV	113.3	5	3
17	KELM 1.3	Kellum Creek behind horse farm	Probabilistic	HQ-CWF	Lackawanna	41.35802	-75.501545	NAPU	1.67	3	1
18	KTCH 0.5	Kitchen Creek near mouth on Bethel Hill Road	RWQMN	HQ-CWF	Luzerne	41.233657	-76.242822	RV	20.1	4	2
19	LACK 41.8	Lackawanna River along Stillwater Dam Road	RWQMN	HQ-CWF	Susquehanna	41.683305	-75.473242	RV	38	4	2
20	LAWR 4.2	Lackawanna River upstream of 3rd Street/Moosic Road bridge	Mine drainage	WWF	Susquehanna	41.35611	-75.72778	RV	253.5	5	4
21	WQN 313	Lackawanna River at Main Street bridge near Old Forge, Pa.	WQN (PADEP)	CWF	Lackawanna	41.35845	-75.74404	NCA	335.54	5	4
22	LRLR 1.0	Laurel Run downhill from pulloff, below large plunge pool	Probabilistic	CWF	Lackawanna	41.486397	-75.52667	RV	2.33	2	1
23	LFSH 0.1	Little Fishing Creek near mouth	Long-term	CWF	Columbia	41.01889	-76.47639	RV	68.2	4	3
24	LMEH 0.8	Little Mehoopany Creek off Scottville Road, near Mehoopany Elementary	RWQMN	CWF	Wyoming	41.58154	-76.0698	NAPU	11	2	2

Sample Site #	Site Name	Location Description	Site Category	PADEP Chp 93 Designated Use	County	Latitude	Longitude	Ecoregion III	Drainage (sq mi)	Stream Order	ARC
25	LNSK 0.1	Little Nescopeck Creek near confluence with Nescopeck Creek	Mine drainage	CWF	Luzerne	41.00944	-76.07444	RV	14	3	2
26	LNSK 5.7	Little Nescopeck Creek upstream T335 bridge near Kis-Lyn	Mine drainage	CWF	Luzerne	41.0109	-75.9891	RV	3.9	2	1
27	MAHO 1.4	Mahoning Creek at Rt. 11 bridge, adjacent to Rt. 54 in Danville	Long-term	WWF	Montour	40.965	-76.61806	RV	31.7	4	2
28	MEHO 1.5	Mehoopany Creek at SR 87 bridge near mouth	Long-term	CWF	Wyoming	41.56	-76.06778	NAPU	121.7	4	3
29	MESH 0.2	Meshoppen Creek near mouth upstream of Bedrock Gorge Recreation Area	Long-term	CWF	Wyoming	41.61389	-76.04667	NAPU	100.2	5	3
30	MESH 4.5	Meshoppen Creek near Lemon Creek Rd and Meshoppen Creek Rd intersection	RWQMN	CWF	Wyoming	41.61164	-75.984739	NAPU	51.9	4	3
31	MNTR 1.8	Montour Run 100 meters off land between two wetlands	Probabilistic	CWF	Columbia	40.974585	-76.50222	RV	3.13	3	1
32	NESK 14.7	Nescopeck Creek upstream of bridge on TR 338	Mine drainage	TSF	Luzerne	41.00778	-76.10139	RV	82.7	4	3
33	NESK 19.1	Nescopeck Creek upstream of Little Nescopeck Creek above TR 342	Mine drainage	TSF	Luzerne	41.01722	-76.05083	RV	60	4	3
34	WQN 309	Nescopeck Creek near Broad Street bridge	WQN (PADEP)	TSF	Luzerne	41.02771	-76.21478	RV	171.28	5	3
35	NWPT 0.5	Newport Creek upstream of railroad bridge near Weis Market in Nanticoke	Long-term	CWF	Luzerne	41.20778	-76.00639	RV	13.3	3	2
36	NMHO 0.1	North Branch Mehoopany Creek ¼ mile downstream of SR 3001 bridge	Long-term	CWF	Wyoming	41.53444	-76.12417	NAPU	39.9	3	2
37	RORB 11.4	Roaring Brook 500 yards downstream of reservoir	Probabilistic	CWF	Lackawanna	41.370788	-75.539393	NAPU	35.46	4	2
38	RORC 1.7	Roaring Creek along T 313 upstream of dwellings	Long-term	TSF	Montour	40.92028	-76.52722	RV	86.6	5	3
39	SCHR 0.2	Schrader Creek at bridge in Powell	Mine drainage	HQ-CWF	Bradford	41.70472	-76.505	NAPU	82.1	4	3
40	SHIK 0.1	Shickshinny Creek near mouth downstream of channelized section	Long-term	CWF	Luzerne	41.15167	-76.14778	RV	35	3	2
41	SOLO 0.9	Solomons Creek 1/8 mile downstream of Breaker Road Bridge	Long-term	CWF	Luzerne	41.22667	-75.93667	RV	17.6	3	2
42	STWN 0.1	South Branch Towanda Creek near mouth	Long-term	CWF	Bradford	41.70806	-76.47028	NAPU	48.9	4	2
43	SBTK 7.1	South Branch Tunkhannock Creek off Regina Way at Keystone College	RWQMN	TSF	Wyoming	41.557825	-75.777879	NAPU	70.5	4	3
44	SBTK 8.0	South Branch Tunkhannock Creek at edge of mowed lawn near pavilion	Probabilistic	TSF	Lackawanna	41.567	-75.770343	NAPU	52.64	4	3
45	STNK 0.5	South Branch Tunkhannock Creek along Spur Road off Rt. 6 near Bardwell	Long-term	TSF	Wyoming	41.56083	-75.86639	NAPU	97.5	4	3
46	WQN 333	Sugar Creek near Pine Valley Road bridge	WQN (PADEP)	WWF	Bradford	41.78131	-76.50258	NAPU	183.78	4	3
47	SUGR 22.1	Sugar Creek on Route 6	RWQMN	TSF	Bradford	41.789737	-76.768352	NAPU	56	4	3
48	SGRR 0.4	Sugar Run Creek upstream of SR 2002 bridge	Long-term	CWF	Bradford	41.64083	-76.23222	NAPU	56.7	5	3
49	SUGR 2.6	Sugar Run at bridge on Fisk Road in State Gamelands #172	RWQMN	CWF	Bradford	41.626436	-76.274356	NAPU	33.5	4	2

Sample Site #	Site Name	Location Description	Site Category	PADEP Chp 93 Designated Use	County	Latitude	Longitude	Ecoregion III	Drainage (sq mi)	Stream Order	ARC
50	SUGR 6.5	Sugar Run directly upstream of confluence with tributary	Probabilistic	CWF	Bradford	41.636611	-76.297303	NAPU	29.56	4	3
51	SUSQ 138	Susquehanna River near Danville, Pa.	Large Rivers	WWF	Montour/NU	40.94214	-76.60111	RV	11228.39	8	6
52	SUSQ 174	Susquehanna River near Glen Lyon, Pa.	Large Rivers	WWF	Luzerne	41.17740	-76.10850	NCA	10156.82	8	6
53	SUSQ 207	Susquehanna River near Falls, Pa.	Large Rivers	WWF	Wyoming	41.46028	-75.85333	NAPU	9462.06	8	6
54	SUSQ 231	Susquehanna River near Meshoppen, Pa.	Large Rivers	WWF	Wyoming	41.57847	-76.05923	NAPU	8740.06	8	6
55	SUSQ 271	Susquehanna River near Towanda, Pa.	Large Rivers	WWF	Bradford	41.76270	-76.43930	NAPU	7792.47	8	6
56	TOBY 0.2	Toby Creek upstream of Rt. 11 bridge at Edwardsville	Long-term	WWF	Luzerne	41.25389	-75.91111	RV	34.3	4	2
57	TOMH 1.4	Tomhicken Creek above campground, below plunge pool	Probabilistic	CWF	Schuylkill	40.914024	-76.187563	RV	18.94	3	2
58	TOMH 3.2	Tomhicken Creek upstream of T706 bridge (Croll Road)	Mine drainage	CWF	Schuylkill	40.92694	-76.17667	RV	17	3	2
59	TOMJ 0.4	Tomjack Creek upstream of Route 6 and Berwick Turnpike Road intersection	RWQMN	TSF	Bradford	41.781321	-76.607231	NAPU	27	3	2
60	TOWA 18.1	Towanda Creek above Mill Road bridge	Probabilistic	TSF	Bradford	41.672242	-76.707794	NAPU	65.87	5	3
61	TOWA 26.1	Towanda Creek off Rt 3008	Probabilistic	TSF	Bradford	41.65497	-76.838052	NAPU	22.26	4	2
62	TWND 0.7	Towanda Creek upstream of bridge at airport near Towanda	Long-term	WWF	Bradford	41.74111	-76.43278	NAPU	277	5	4
63	WQN 318	Towanda Creek near Monroe, Pa.	WQN (PADEP)	TSF	Bradford	41.70820	-76.48630	NAPU	216.19	5	4
64	WQN 317	Tunkhannock Creek near Route 6 bridge	WQN (PADEP)	TSF	Wyoming	41.55725	-75.89443	NAPU	393.27	5	4
65	TUSC 0.5	Tuscarora Creek upstream of Rt. 6 bridge near Laceyville, Pa.	Long-term	CWF	Wyoming	41.6421	-76.1463	NAPU	38.8	4	2
66	UTBR 0.5	Unnamed tributary to Browns Creek 300 yards upstream of tributary confluence	Probabilistic	WWF	Bradford	41.82513	-76.561385	NAPU	2.63	2	1
67	UTHN 1.9	Unnamed tributary to Hunlock Creek upstream of bridge	Probabilistic	CWF	Luzerne	41.226071	-76.054267	NAPU	6.22	2	1
68	UMDR 0.2	Unnamed tributary to Mud Run off Utt Road	Probabilistic	TSF	Columbia	41.12296	-76.450213	RV	3.45	2	1
69	UTST 0.4	Unnamed tributary to South Branch Towanda Cr downstream of rock wall	Probabilistic	CWF	Bradford	41.580137	-76.39217	NAPU	0.42	2	1
70	UNJN 0.1	Unnamed tributary to St. Johns Creek downstream of Ransom Road bridge	Probabilistic	CWF	Lackawanna	41.401974	-75.729207	RV	0.72	2	1
71	USUS 0.5	Unnamed tributary to Susquehanna River at end of cul de sac	Probabilistic	CWF	Columbia	41.022648	-76.371733	RV	1.08	2	1
72	WWLP 0.2	Wapwallopen Creek downstream of Rt. 239 bridge near mouth	Long-term	CWF	Luzerne	41.07111	-76.13306	RV	53.2	3	3
73	WQN 334	Wyalusing Creek near Route 706 bridge	WQN (PADEP)	WWF	Bradford	41.69740	-76.23060	NAPU	211.24	5	4
74	WQN 342	Wysox Creek upstream of Route 6 bridge	WQN (PADEP)	CWF	Bradford	41.78670	-76.38328	NAPU	99.6	5	3

Sample Site #	Site Name	Location Description	Site Category	PADEP Chp 93 Designated Use	County	Latitude	Longitude	Ecoregion III	Drainage (sq mi)	Stream Order	ARC
75	WYSX 3.3	Wysox Creek upstream 100 yards from tributary	Probabilistic	CWF	Bradford	41.813815	-76.360586	NAPU	89.65	5	3