Susquehanna River Basin Commission

Lower Susquehanna River Subbasin Year-2 Focused Watershed Study

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A Water Quality and Biological Assessment of the Lower Reservoirs of the Susquehanna River

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Introduction

The Susquehanna River Basin Commission (SRBC) completed a water quality and biological assessment in the lower reservoirs of the Susquehanna River from April-October 2012, as part of the Lower Susquehanna Subbasin Survey Year-2 project (Figure 1). This project was an exploratory pilot study representing the first focused, extensive monitoring effort by SRBC on this portion of the river. The lower reservoirs are located in the final 45 miles of the Susquehanna River before its confluence with the Chesapeake Bay. Three large hydroelectric dam facilities within this reach of river create the three main reservoirs. The objectives of this project were to assess current chemical and biological conditions within the reservoirs while also exploring a variety of assessment methodologies with which to incorporate routine monitoring of the reservoirs into SRBC's on-going monitoring program.

The Subbasin Survey Program is one of SRBC's longest standing monitoring programs, ongoing since the mid-1980s, and is funded by the United States Environmental Protection Agency (USEPA). This program consists of two-year assessments in each of the six major subbasins of the Susquehanna River Basin on a rotating basis. The Year-1 studies involve broad-brush, one-time sampling efforts of about 100 stream sites to assess water quality, macroinvertebrate communities, and physical habitat throughout an entire subbasin. SRBC conducted the Lower Susquehanna Year-1 study from April-July 2011 (Campbell, 2012). The Year-2 studies focus on a particular region or smaller watershed within the major subbasin and typically seek to address one specific issue or topic. Each Year-2 sampling plan is tailored for the individual needs or concerns of the chosen watershed or region and sampled accordingly so a more detailed, focused evaluation can be made. More information on SRBC's Subbasin Survey Program is available at *www.srbc.net/programs/monitoringprotection.htm*, and technical reports are available in hard copy from SRBC or online at *www.srbc.net/pubinfo/techdocs/Publications/techreports.htm*.

Figure 1. Location of the Lower Reservoir Section of the Susquehanna River within the Susquehanna River Basin

Study Area Description

The Lower Susquehanna River Subbasin is a very diverse watershed. It drains a mixture of both rural and urban land comprising nearly 6,000 square miles of central Pennsylvania and northern Maryland, from Sunbury, Pa., to the mouth of the Susquehanna River in Havre de Grace, Md. The Lower Susquehanna River Subbasin includes the urban areas of Harrisburg, York, and Lancaster, Pa., and more than a million acres of agricultural land spread throughout much of the subbasin.

Three individual reservoirs are formed by the three hydroelectric dams within the lower 45 miles of the Susquehanna River. All three reservoirs serve as drinking water supplies and are also used heavily for recreational activities.

The most upstream reservoir, Lake Clarke, begins around the Route 30 bridge in Columbia, Pa., and is formed by the Safe Harbor Dam (Figure 2). This dam and the accompanying hydroelectric power station, which is located just above the confluence of the Conestoga River, were completed in 1931 and further expanded in the 1980s. Lake Clarke is approximately 10 miles long and is relatively shallow, with numerous rock outcroppings and small islands. The middle and smallest reservoir, Lake Aldred, is formed by Holtwood Dam and is about seven miles in length. Holtwood Dam is the oldest of the three dams and was completed in 1910. Both Lake Clarke and Lake Aldred were historically dredged for anthracite coal silt that had washed down from upstream coal mining activities and was then used in the power stations from the 1920s-1950s.

The third and largest reservoir is the interstate Conowingo Pond, a 15-mile-long pool created by the Conowingo Dam and situated in both Maryland and Pennsylvania. The Conowingo Dam is one of the largest non-federal dams in the country and was completed in 1928. This dam is located in Maryland, five miles south of the Pennsylvania border, and also serves as the U.S. Route 1 bridge across the Susquehanna River. In addition, within the upper portion of Conowingo Pond is Muddy Run Pumped Storage Facility, which pumps water from Conowingo Pond up into Muddy Run reservoir during off-peak hours and releases the water through turbines during times of high demand to generate electricity.

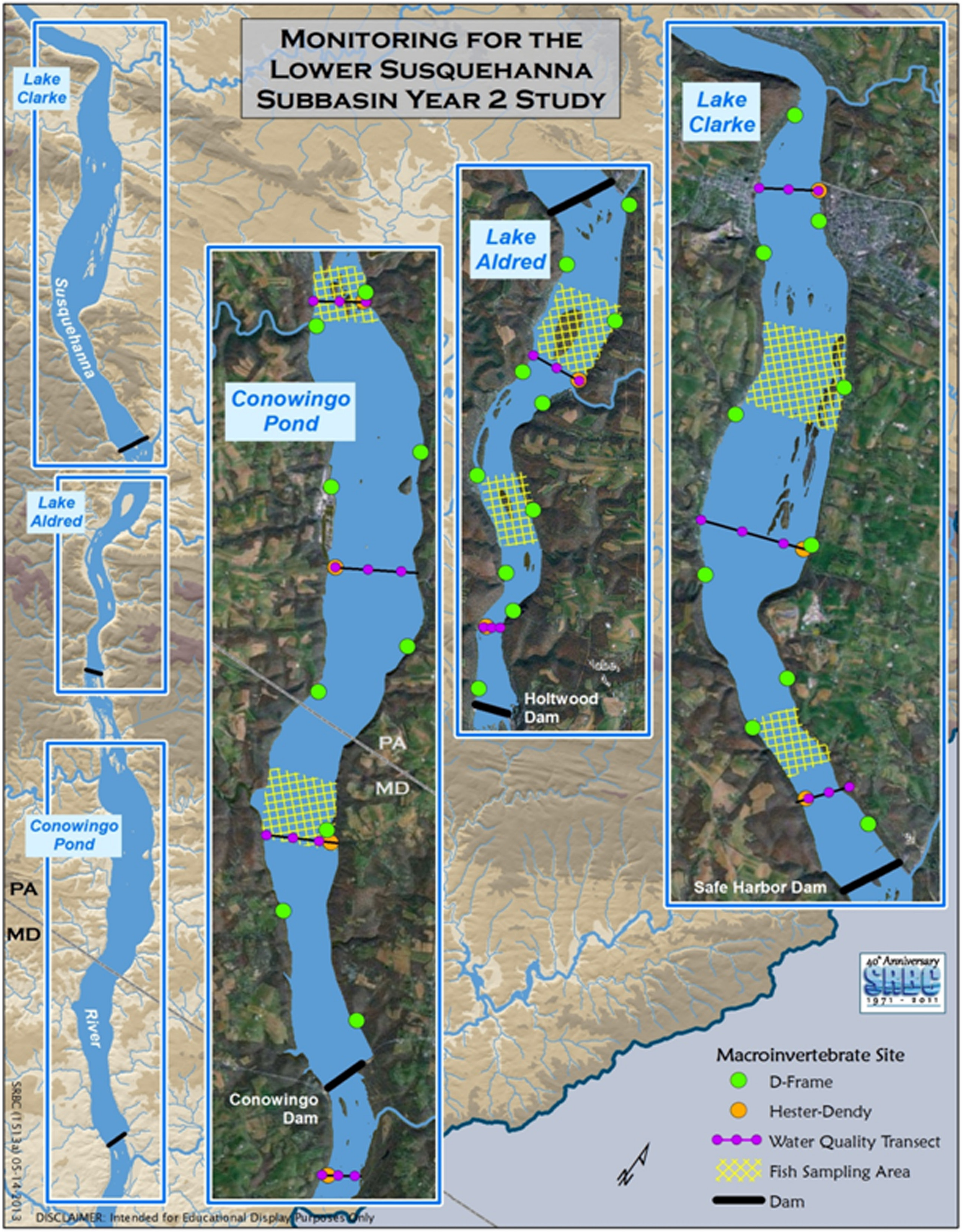

Figure 2. Sampling Locations within the Lower Reservoirs

The Lower Susquehanna Reservoir system was chosen as the focus of the Lower Susquehanna Subbasin Year-2 Survey for a variety of reasons. Since 2002, SRBC has been exploring methods and protocols to best monitor water quality and biological conditions in the mainstem Susquehanna River. The Large River Assessment Project was established in 2005 and has been completed annually when flows permit. More information and the most recent report for the Large River Assessment Project can be found by following the link at *www.srbc.net/programs/monitoringprotection.htm*. Despite the importance of this project, it addresses only the free-flowing portion of the Susquehanna River and its large tributaries, with the most downstream site located at the top of the first reservoir, Lake Clarke. SRBC has been involved in numerous other activities that pertain to various aspects of the lower reservoir system, including the Lower Susquehanna Initiative, Source Water Protection, fish passage issues, and the Early Warning System (EWS).

The Lower Susquehanna Initiative is a collaborative effort between numerous agencies and stakeholders to address flow needs and consumptive use mitigation within the lower 55 miles of river. For many years, staff has been actively involved in fish passage issues related to the hydroelectric dams and their respective Federal Energy Regulatory Commission (FERC) permit relicensing procedures. Because the lower reservoirs function as part of a large power generation process and also provide drinking water to many central Pennsylvania residents, SRBC has been involved with two projects that focus on the protection of drinking water supplies. The Source Water Protection project, completed in 2013, identified sources of potential drinking water contamination within various zones of influence to the water suppliers in the Lower Susquehanna Subbasin. Each individual report also provided management options to protect or restore source water supplies. The EWS program, established in 2003, provides real-time water quality measurements above water supply intakes to alert water suppliers of potential contaminant threats to drinking water before the contaminants reach the actual intakes. Two of the seven EWS stations are located in the lower reservoirs: one near Columbia, Pa., and one near the Pennsylvania/Maryland border. In addition, while there are some monitoring data available on these reservoirs pertaining to the FERC licensing requirements of the individual hydroelectric facility, these data are typically just collected around the dam area and do not include the reservoir as a whole. Previous bathymetric measurements done in the lower reservoirs by the U.S. Geological Survey (USGS) were used as a reference for site selection and for logistical planning purposes (Langland, 2009).

Despite all these other activities in the Lower Reservoir System, until this pilot study, SRBC had largely bypassed this lower 45-mile stretch of the river with regard to the agency's monitoring activities. This gap was due primarily to the immense complexities of the reservoir system resulting from the hydroelectric facilities and the inherent modifications to sampling protocol that monitoring this reach of river would entail.

Lake Clarke in Pennsylvania is a man-made lake along the Susquehanna River formed by the Safe Harbor Dam, a public works project of the 1930s Great Depression.
Photo credit: Susquehanna Yacht Club.

The Holtwood Dam creates Lake Aldred, the smallest of the three lower Susquehanna River reservoirs.

Looking upstream along the Susquehanna River at the Conowingo Dam and Conowingo Pond.
Photo credit: Jane Thomas, IAN Image Library (ian.umces.edu/imagelibrary/).

Methods

Water Quality

Sampling was conducted in the reservoirs between April and October 2012. Figure 2 shows the locations of the various types of sampling. Seasonal water quality samples were taken in April, August, and October at nine transects throughout the reach. At each transect, a separate depth-integrated sample was taken at each bank and at mid-channel. The sample was gathered using multiple pulls of a VanDorn water sampler, which allows for water to be taken at specific depths. Water was collected at meter intervals throughout the water column at each location and composited. All three samples (right, left, and middle) for each transect were submitted to the lab individually for chemical analysis, including chlorophyll *a* analysis. In addition, a multi-meter sonde was used to collect field parameters in-situ at each location. At the mid-channel sampling location (or whichever sampling location along the transect was deepest), a vertical profile of field chemistry parameters was recorded to document the extent of vertical mixing within the water column. Table 1 explains the general location of each of the nine water quality transects.

Table 1. Locations of Water Quality Transects

River Mile	Location	Mid-channel Latitude	Mid-channel Longitude
SUSQ 44.0	Upstream section of Lake Clarke	40.032156	76.520147
SUSQ 38.0	Mid-section of Lake Clarke	39.963622	76.470861
SUSQ 34.0	Downstream section of Lake Clarke	39.929525	76.419986
SUSQ 30.0	Upstream section of Lake Aldred	39.889961	76.372872
SUSQ 26.0	Downstream section of Lake Aldred	39.839425	76.347603
SUSQ 22.0	Upstream section of Conowingo Pond	39.795458	76.293983
SUSQ 18.0	Mid-section of Conowingo Pond	39.747336	76.241156
SUSQ 14.0	Downstream section of Conowingo Pond	39.691858	76.215058
SUSQ 7.0	Below Conowingo Dam	39.605978	76.127972

SRBC staff collected water samples using a VanDorn sampler which allows for water to be taken at specific depths.

Macroinvertebrates

In early August, 11 Hester-Dendy (H-D) samplers were deployed and left out for eight weeks to allow for macroinvertebrate colonization. Each H-D sampler contained a cluster of five individual units that each had eight, 3" x 3" plates spaced at various increments all attached to a central eye bolt (Figure 3). In total, each sampler had 720 square inches of artificial substrate surface area to be colonized. One H-D sampler (Figure 3) was set out at each of the nine transects on whichever bank was more

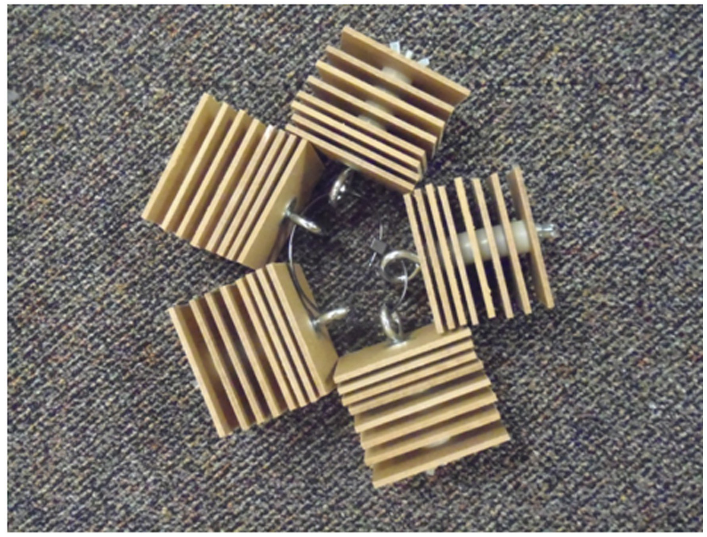

Figure 3. Picture of Hester-Dendy Sampler

suitable. Each sampler as shown in Figure 3 was attached to a bucket of concrete, and a small float was secured to apparatus using paracord to improve ease of recovery. Two replicates were also deployed to assess community differences between left and right bank samples and in side-by-side samples. When the samplers were retrieved in early October, an additional macroinvertebrate sample was taken for each reservoir by compositing ten D-frame net kicks spaced evenly around the shoreline. A general assessment of physical habitat and substrate was completed along the shoreline at every transect in each reservoir. The protocols for the multi-habitat composite macroinvertebrate collection and the physical habitat assessment along the shoreline were patterned after USEPA's National Lake Survey protocol (USEPA, 2012).

Macroinvertebrates from H-D samplers were subsampled to 200 individuals and identified to genus, and D-frame-composited samples from each reservoir were subsampled to 500 individuals and also identified to genus. Typically, SRBC does not identify the family Chironomidae to genus, but in reservoir and lake systems, Chironomidae genera often make up a large percentage of the sample. Therefore, to more accurately assess differences between reservoirs and better characterize the macroinvertebrate community, Chironomidae were identified to genus level for this project.

Fish

Fish sampling was completed in early September using a combination of benthic trawling and boat electroshocking. Boat electroshocking was completed in the late afternoon and evening along representative, fishable shoreline habitat in each reservoir as well as below Conowingo Dam. All shocked fish were captured with dip nets and put into a live well in the boat until the whole reach was sampled. Fish were identified in the field when possible and returned immediately to the river. In addition, lengths and weights for all game fish were recorded, and any deformities, erosions, lesions, or tumors (DELTs) were noted. Trawling was done in two-minute increments at two to four locations in each reservoir, and fish were also field identified when possible.

A combination of benthic trawling and boat electroshocking was used to sample fish at all three reservoirs. SRBC staff used dip nets to collect shocked fish, which were identified in the field when possible and returned to the river.

Data Analysis

Water quality data results were compared to state water quality standards or general levels of concerns (Table 2).

Table 2. Water Quality Standards and Levels of Concern

Parameters	Limits	Reference Code	Reference
Based on state water quality standards:			
Temperature	> 30.5ºC	a	a. www.pacode.com/secure/data/025/chapter93/s93.7.html b. www.pacode.com/secure/data/025/chapter93/s93.8c.html c. www.dec.ny.gov/regs/4590.html#16132 d. www.dsd.state.md.us/comar/comarhtml/26/26.08.02.03-3.htm e. www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm f. water.usgs.gov/pubs/circ/circ1225/images/table.html g. www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm h. Hem (1970) i. Based on archived data at SRBC
Dissolved Oxygen	< 4 mg/l	a	
pH	< 6.0	a	
Alkalinity	< 20 mg/l	a	
Total Chloride	> 250 mg/l	a	
Total Dissolved Solids	> 500 mg/l	c	
Total Sulfate	> 250 mg/l	a	
Total Iron	> 1500 µg/l	a	
Total Manganese	> 1000 µg/l	a	
Total Aluminum	> 750 µg/l	b	
Total Magnesium	> 35 mg/l	c	
Total Sodium	> 20 mg/l	c	
Total Suspended Solids	> 25 mg/l	a	
Turbidity	> 50 NTU	d	
Based on background levels or aquatic life tolerances:			
Conductivity	> 800 µS/cm	e	
Total Nitrogen	> 1 mg/l	f	
Total Nitrate	> 0.6 mg/l	f	
Total Nitrite	> 1 mg/l	c	
Total Phosphorus	> 0.1 mg/l	g	
Total Orthophosphate	> 0.02 mg/l	f	
Total Organic Carbon	> 10 mg/l	h	
Total Hardness	> 300 mg/l	g	
Biological Oxygen Demand	> 10 mg/l	h	
Dissolved Organic Carbon	> 10 mg/l	h	
Total Organic Carbon	>10 mg/l	h	
Ammonia	> 0.1 mg/l	f	
Acidity	> 20 mg/l	i	
Calcium	> 100 mg/l	i	

Macroinvertebrate and fish data were used to calculate a variety of metrics, which are used to summarize community characteristics. Bray-Curtis similarity indices were used to compare macroinvertebrate community data from H-D samplers throughout the three reservoirs and to compare the results from these samplers with the composited D-frame samples from each reservoir. Fish and macroinvertebrate metrics were taken primarily from Barbour and others (1999), Pennsylvania Department of Environmental Protection (PADEP) Index of Biotic Integrity for Benthic Macroinvertebrate Communities (PADEP, 2013), and the Ohio River Valley Water Sanitation Commission (ORSANCO) fish index of biotic integrity (ORFin) (Emery and others, 2003). Catch per unit effort (CPUE) was calculated for each fishing location as well as an overall CPUE estimate for smallmouth bass. Smallmouth bass are of special interest not only because they are the prized sport fish of the Susquehanna River, but also because there have been a series of disease outbreaks and die-offs of smallmouth bass in recent years, especially in the lower Susquehanna River.

SRBC staff processed fish sampled in each reservoir. Lengths and weights for all game fish were recorded, and any deformities, erosions, lesions, or tumors (DELTs) were noted.

Results/Discussion

Water Quality

The evaluation of water quality in reservoirs is partially dependent on whether they are considered to be functioning more as rivers or lakes. The reservoirs in the lower Susquehanna River seem to be functioning as a hybrid. In river systems, nitrogen is more frequently the nutrient of concern, but in lakes, phosphorus tends to be more of a problem. In Pennsylvania, one of the main criteria to be considered a lake is a 14-day residence time (*www.pacode.com/secure/data/025/chapter96/chap96toc.html*). The three reservoirs in the Susquehanna River do not always meet this criteria, but they also do not function like a typical river system either given the three large hydroelectric facilities and the constant manipulation of flow that their operations necessitate. Additionally, in most lakes there is some vertical stratification throughout the water column. Typically, even in lakes only a few meters deep, temperature and dissolved oxygen decrease rapidly at a certain depth, called the thermocline, and the difference in temperature keeps the colder water below separated from the warmer water on top. No vertical stratification was seen in any of the three reservoirs, even in depths of up to 30 meters. All the water in these reservoirs seems to be extremely well-mixed.

Nutrients were the biggest water quality concern throughout the study area, with no other parameter consistently exceeding water quality standards or levels of concern. Using the normal criteria for rivers, total nitrate exceeded background (0.6 mg/l) concentration in 99 percent of the samples collected. Much of the total nitrogen in the Susquehanna River is in the form of nitrate and, as a result, total nitrogen exceeded background (1.0 mg/l) concentration in approximately half of the samples collected. In a few cases, a majority of the total nitrogen was in the form of Total Kjeldahl Nitrogen (TKN), but there was no consistent spatial or temporal pattern to these occurrences. Total phosphorus exceeded the natural background (0.1 mg/l) concentration of rivers and streams in less than 10 percent of the samples collected.

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In typical lakes, total phosphorus and chlorophyll *a* are two primary characteristics indicative of trophic status. Trophic status is simply a categorization of the degree of biological productivity in a lake and ranges from oligotrophic (low productivity) to hyper-eutrophic (extremely productive). Highly productive lakes, while they can support a strong aquatic ecosystem, can also be characterized by algal blooms, oxygen depletion, fish kills, and negative impacts on recreational opportunities. Reservoirs, like those in the lower Susquehanna River, can function a little differently than typical lakes because of the shorter residence time but can fall into similar trophic categories. In about 10 percent of the samples taken over the three sampling rounds, total phosphorus and chlorophyll *a* concentrations exceeded the standards for a eutrophic lake. A eutrophic lake is typically characterized by chlorophyll *a* concentrations greater than 15 µg/l and total phosphorus concentrations between 30-50 µg/l. Eutrophic conditions in the Susquehanna River have possible implications for degraded water quality related to drinking water treatment, recreation, and maintenance of a strong fishery presence.

Another tool to evaluate the condition of lakes as well as their use attainment, which is used by PADEP and many other agencies, is Carlson's trophic status indices (TSIs) (Carlson, 1977). A TSI of 50 represents the threshold value for eutrophic conditions. Generally, a TSI value greater than 65 indicates problems and probable impairments (PADEP, 2009). While the interpretation of these TSI values should be used with caution in reservoirs like those on the lower Susquehanna where flows and water levels fluctuate greatly depending on the demand for power generation, the TSIs for chlorophyll *a*, total phosphorus, and total nitrogen can provide some additional insight into the water quality of these reservoirs. The TSI for total phosphorus exceeded 65 for every water sample taken in the lower reservoirs in all three seasons. The TSI for total nitrogen was greater than 65 in about 10 percent of the samples, and the TSI for chlorophyll *a* did not exceed 65 in any of the samples.

There can be a discrepancy in how to evaluate nutrient impairment in these types of reservoirs that have relatively short residence times, are not stratified, and have a large variability in water level throughout the day, yet cannot be classified as run-of-the-river pools because of the presence of the large dams. When using typical lake standards (>30 ug/l), phosphorus is clearly the most significant nutrient problem in all three reservoirs. When using the background level for rivers and streams (100 ug/l), total phosphorus exceeds that level less than 10 percent of the time.

Macroinvertebrates

Macroinvertebrate communities in the lower reservoirs were assessed using two different methods — composites of multi-habitat kicks from each reservoir and deployment of artificial substrate samplers (H-D samplers). Over the past few years, USEPA has been working on validating and improving upon a Lake Macroinvertebrate Integrity Index (LMII) that was originally developed for lakes in New Jersey (North, 2009). Although field collection methods used to develop the LMII were different than what was used in this study, many of the metrics used in the LMII are applicable to the lower reservoirs and were used additionally in the overall analysis, including number of Diptera taxa, percent Chironomidae individuals, percent Oligochaetes/leeches, percent collector/gatherer taxa, and Hilsenhoff Biotic Index (HBI). Prior to this project, there were very little macroinvertebrate data available for this section of the Susquehanna River.

In general, the multi-habitat composite samples yielded more taxa, more Ephemeroptera, Plecoptera, Trichoptera (EPT)

Artificial substrate samplers (H-D samplers) were deployed at specific locations within each reservoir and allowed to colonize for eight weeks to assess macroinvertebrate communities.

taxa, better Hilsenhoff scores, and a lower percentage of Chironomidae than the H-D samples. While more than 75 taxa were found throughout the study area, multi-habitat samples were comprised of 26-36 taxa, and H-D samples had far fewer, ranging from 3-22 taxa. Multi-habitat samples from each reservoir were collected from snags, woody debris, sand, small gravel, boulders, and muck. Fifteen EPT taxa were collected in these samples, including seven mayfly genera, one stonefly genera, and seven caddisfly genera. These samples were dominated by the mayfly genera *Brachycercus* (Caenidae), which is well suited to slow-moving rivers where fine sediment is the dominant substrate. The average Hilsenhoff score for the multi-habitat samples was 4.5 compared to 7.1 in the H-D samples. All samples, regardless of sample collection methods, were comprised of at least 60 percent collector/gatherer genera. Taxa classified in this functional feeding group primarily collect fine particulate organic matter from the river bottom. The expected response in typical lakes is a decrease in percentage of collector/gatherer taxa with increasing stress (North, 2009). Chironomidae genera are commonly the most frequently found taxa in lakes and reservoirs, and the samples collected in the lower Susquehanna River were no exception. In all the H-D samples, Chironomidae genera made up from 59-99 percent of the sample, comprised of 25 genera. Table 3 gives a general comparative summary of key macroinvertebrate metrics for both the multi-habitat sampling and the H-D samplers in each reservoir.

One interesting pattern that emerged from the H-D data was the greater similarity of assemblages from the lower transects in each reservoir than among all samples within the same reservoir. Additionally, at the sampling transect where an H-D was placed on each bank along the transect, macroinvertebrate communities were quite similar. This similarity suggests that perhaps macroinvertebrate assemblages in these reservoirs may

Table 3. Comparison of Select Macroinvertebrate Metrics by Reservoir

Summary of Macroinvertebrate Data for each Reservoir

MULTI-HABITAT (500-count subsample)

	Lake Clarke	Lake Aldred	Conowingo Pond
Taxa Richness	36	32	26
EPT Taxa	4	7	4
Hilsenhoff Biotic Index	5.63	4.54	3.51
Chironomidae Taxa	12	6	9
% Chironomidae	17.1	5.6	10.4
% Dominant Taxa	42.1	40.8	40.6

HESTER-DENDY SAMPLERS (200-count subsample)

	Lake Clarke		Lake Aldred		Conowingo Pond		
	top	bottom	top	bottom	top	mid	bottom
Taxa Richness	22	11	11	5	18	5	15
EPT Taxa	4	0	2	0	4	0	6
Hilsenhoff Biotic Index	5.94	7.54	7.69	7.99	6.42	7.79	6.34
Chironomidae Taxa	11	9	5	3	10	3	5
% Chironomidae	59.1	99.1	87.8	99.0	58.4	97.3	62.2
% Dominant Taxa	17.5	80.1	83.8	98.1	37.8	96.4	57.6

be more dependent on local habitat and flow patterns than on potential water quality issues associated with the shoreline where they live. For example, the macroinvertebrate community in the lower Conowingo Pond (RM 14) was more similar to the macroinvertebrate community in the lower portion of Lake Aldred (RM 26) than it was to the assemblage in the same reservoir just four miles upstream at RM 18.

Fish

Fish were collected at paired 500-meter reaches within each reservoir using a boat electroshocker. Complex, structured fish habitat was scarce throughout the study area and was limited primarily to shorelines or in and around islands. Fluctuating river levels are a significant issue for fish populations in the lower reservoirs of the Susquehanna River. The constant but inconsistent rise and fall of river levels greatly compromises the persistent shallow, near-shore habitat necessary for juvenile life stages of many fish species.

Twenty-nine unique species were detected across all sites, and the fish community was dominated by tolerant species (Table 4). The most abundant fish species was gizzard shad. Smallmouth bass are the most prominent game fish in the Susquehanna River. Historic catch per unit effort (CPUE) for smallmouth for the lower river is about 75 fish per hour, although CPUE catch rates in the lower reaches of the Susquehanna River have been dropping over the last number of years (PFBC, 2010). During this study, CPUE for smallmouth bass (age >1) in the lower reservoirs was under 10 fish per hour. The overall percentage of fish with DELTs was 13 percent, and melanosis was not observed in any fish. The highest percentage of DELTs were found in smallmouth bass in Lake Clarke, which also had the highest CPUE for smallmouth bass.

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In recent years, the spread of the invasive flathead catfish has been widespread throughout the lower Susquehanna River. Although there were no discernible spatial trends with populations of the native channel catfish, compared to flathead catfish, the overall catch ratio was approximately 4:1. Flathead catfish were outnumbered by channel catfish everywhere except Conowingo Pond, where the ratio of flathead to channel catfish was 10:1. Table 5 is a comparative summary of key data results for the overall fish survey as well as each individual fish survey area. Additionally, mimic shiner, which were first found in the Susquehanna River drainage in 1977, are widely distributed throughout the lower river. Below Conowingo Dam, numerous fish species were collected that were not seen

Carp was among 29 species of fish detected across all sites. Tolerant species, such as gizzard shad and carp, dominated the fish communities.

Table 4. List and Location of Fish Species Collected in Order of Abundance					
Common name	Scientific Name	Lake Clarke	Lake Aldred	Conowingo Pond	Below Conowingo Dam
gizzard shad	*Dorosoma cepedianum*	X	X	X	X
comely shiner	*Notropis amoenus*	X	X	X	X
bluegill	*Lepomis macrochirus*	X	X	X	X
channel catfish	*Ictalurus punctatus*	X	X	X	X
spottail shiner	*Notropis hudsonius*	X	X	X	X
common carp	*Cyprinus carpio*	X	X	X	X
spotfin shiner	*Cyprinella spiloptera*	X	X	X	X
smallmouth bass	*Micropterus dolomieu*	X	X	X	X
bluntnose minnow	*Pimephales notatus*	X	X	X	X
walleye	*Sander vitreus*	X	X		
flathead catfish	*Pylodictis olivaris*	X	X	X	X
mimic shiner	*Notropis volucellus*	X	X	X	X
green sunfish	*Lepomis cyanellus*	X	X	X	X
shorthead redhorse	*Moxostoma macrolepidotum*	X	X		X
largemouth bass	*Micropterus salmoides*	X		X	X
yellow perch	*Perca flavescens*	X	X	X	X
rock bass	*Ambloplites rupestris*	X	X		X
white sucker	*Catostomus commersoni*	X		X	
northern hog sucker	*Hypentelium nigricans*	X	X		
Chesapeake logperch	*Percina bimaculata*			X	X
American eel	*Anguilla rostrata*				X
tessellated darter	*Etheostoma olmstedi*	X			X
white perch	*Morone americana*				X
banded killifish	*Fundulus diaphanous*				X
rosyface shiner	*Notropis rubellus*				X
quillback	*Carpiodes cyprinus*	X	X		
striped bass	*Morone saxatilis*				X
pumpkinseed	*Lepomis gibbosus*		X		X
inland silverside	*Menidia beryillna*				X

within any of the three reservoirs including American eel, banded killifish, inland silverside, and striped bass.

Historically, before the construction of dams on the Susquehanna River, migratory fish species such as American shad (*Alosa sapidissima*) and American eel were common throughout the Susquehanna River (*www.fws.gov/chesapeakebay/shad.htm*). Even with the presence of alternate fish passage methods, such as fish lifts and fish ladders, the populations of these migratory fish above Conowingo Dam have greatly declined over the years. American shad were not captured during this pilot study period. Reasons for this likely include the rarity of American shad above Conowingo Dam and the time of year sampling was completed. Sampling was done in September, and a typical shad run up the river is from April to June. American eels were only found below Conowingo Dam.

The Chesapeake logperch was recently recognized as a distinct and valid species with a limited global distribution restricted to the Chesapeake Bay Watershed (Near, 2008). In Pennsylvania, the Chesapeake logperch is currently known to exist only in Conowingo Pond, a few of its tributaries in Lancaster and York counties, and in Octoraro Creek Watershed in Chester and Lancaster counties. The Chesapeake logperch only occurs

The Chesapeake logperch (*Percina bimaculata*) was recently recognized as a distinct and valid species with a limited global distribution restricted to the Chesapeake Bay Watershed.

Table 5. Comparison of Select Fisheries Statistics for Each Survey Area				
Survey Area	**Smallmouth Bass CPUE (fish/hr)**	**Smallmouth Bass DELT prevalence**	**Flathead: Channel Catfish Ratio**	**Total Richness**
Lake Clarke	11.20	23%	1:5	21
Lake Aldred	10.96	9%	1:16	19
Conowingo Pond	9.31	8%	10:1	16
Below Conowingo Dam	2.98	0%	1:16	25
Total	**9.2**	**13%**	**1:13**	**29**

in approximately 30 combined stream and river miles within Pennsylvania. Historically, *P. bimaculata* was found as far north as what is now the upper reaches of Lake Clarke, but no recent surveys have shown any individuals upstream of Holtwood Dam. SRBC staff collected seven individuals with boat electrofishing below Conowingo Dam and one individual in the upper reaches of Conowingo Pond using backpack electroshocking. Electric trawling and backpack shocking are likely the more effective ways of surveying specifically for Chesapeake logperch, but this type of species-specific sampling was beyond the scope of this study.

Benthic trawling, using a Herzog-mini-Missouri trawl, was piloted as a means of fish collection in the Susquehanna River during this study. Results were marginal, and techniques and protocols may need to be re-evaluated before benthic trawling can become a practical component of SRBC's fish collection methods. This re-evaluation would likely include electrifying the trawl to increase the efficiency of benthic fish species collection. A more detailed discussion of water quality, biological, and habitat conditions in each individual reservoir can be found below.

Benthic trawling was piloted as a means of fish collection in the Susquehanna River during this study. Results were marginal. Trawling techniques and protocols may need to be re-evaluated before benthic trawling can become a practical component of SRBC's fish collection methods.

Lake Clarke

Water Quality

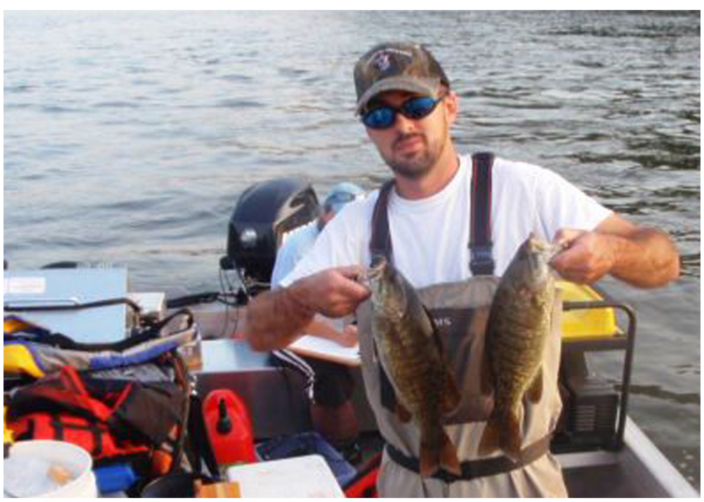
Lake Clarke is the uppermost reservoir in the lower reservoir system and is created by the Safe Harbor hydroelectric dam. The transition between free-flowing river and reservoir occurs around the Wrightsville Route 462 bridge where the river is a mile wide and only a few feet deep. Lake Clarke is generally the widest and most shallow of the three reservoirs. The major streams that flow into Lake Clarke are Kreutz Creek, Cabin Creek, and Fishing Creek. Lake Clarke depths were typically about 1.5 meters deep at the top transect (river mile (RM) 44), from three to five meters deep at RM 38, and about 9 meters deep at the lowest transect (RM 34). Vertical profiles at these transects revealed total mixing of the water and no vertical stratification. There was less than 0.4°C temperature change and a 0.2 mg/l change in dissolved oxygen concentration from surface level to bottom at nine meters deep in lower Lake Clarke. Specific conductivity ranged from 250-400 uS/cm throughout the reservoir, with the highest values in the summer and the lowest in the spring.

General water quality in Lake Clarke was fair with total nitrogen being the most frequent parameter to exceed water quality levels of concern. Ammonia, which is a fraction of the total nitrogen value, exceeded water quality standards twice in October and once in April in the lower portion of Lake Clarke. Total nitrate, typically the largest fraction of total nitrogen in the Susquehanna River Basin, exceeded the water quality level of concern of 0.6 mg/l in 96 percent of samples taken in Lake

Clarke. TKN was typically below detection limits throughout the reservoir system, but at the two sites with the highest total nitrogen in Lake Clarke, both along RM 38 transect (center and east shore), TKN made up half of the total nitrogen concentration. TKN is a measure of the organic nitrogen in the water. This transect was about one mile downstream of a large wastewater discharge on the eastern shore. In wastewater, nitrogen is primarily found in this form, and in freshwater, TKN can be an indicator of untreated or partially treated wastewater from sewage treatment plants. Total phosphorus only exceeded the water quality level of concern one time, but in general, higher total phosphorus concentrations were found in the fall. In Pennsylvania, there are currently no numeric water quality standards for nitrogen or phosphorus, so the levels of concern are based on guidelines published by the USGS for rivers and streams documenting background levels of nitrogen and phosphorus above which is likely anthropogenically derived (USGS, 1999). Water temperature in August was just below or right at the water quality standard for a warm water fishery of 30°C (86°F) at each transect in Lake Clarke.

Macroinvertebrates

The composite macroinvertebrate sample from the ten D-frame kicknet samples around the shorelines of Lake Clarke yielded 36 taxa, including 12 genera of Chironomidae and 4 Ephemeroptera, Plecoptera, and Trichoptera (EPT) genera, making Lake Clarke the most diverse of the three reservoirs. The Hilsenhoff Biotic Index (which is indicative of the degree to which the macroinvertebrate community is comprised of organisms that are tolerant of organic pollution) for Lake Clarke was the highest of all three reservoirs. This indicates the presence of a higher proportion of pollution-tolerant taxa in Lake Clarke. Within the multi-habitat sample from Lake Clarke, greater than 40 percent of the individuals were either Chironomidae, Oligocheates, or leeches. However, the dominant taxon (42 percent) was the mayfly *Brachycercus*, which is not surprising as it favors slow, warm rivers or lakes and is tolerant of siltation.



SRBC staff holds smallmouth bass, the most prominent game fish in the Susquehanna River. Historic catch per unit effort (CPUE) for smallmouth for the lower river is about 75 fish per hour, although CPUE catch rates in the lower reaches of the Susquehanna River have been dropping. During this study, CPUE for smallmouth bass (age >1) in the lower reservoirs was under 10 fish per hour.

Two H-D samplers were retrieved from Lake Clarke at RM 44 and RM 34 (a third was lost from RM 38) and yielded very different macroinvertebrate communities. In fact, Bray-Curtis similarity analysis indicated that these two communities were only 4 percent similar. The sample at RM 44, at the top of Lake Clarke, had fewer individuals but double the number of taxa (22) and also supported four EPT genera. It was also very close to the free-flowing portion of the river, which may explain the higher diversity. The sample from the downstream transect of Lake Clarke, RM 34, was almost entirely comprised of Chironomid genera (99 percent), only had 11 taxa, and had no EPT taxa. The macroinvertebrate taxa indicate that this downstream portion of Lake Clarke is likely functioning like a lake. When comparing the similarity of Lake Clarke's multi-habitat sample to its artificial substrate samples in Lake Clarke using Jaccards similarity index (which takes into account only taxa presence/absence, due to the difference in subsampling count within the two samples), the highest similarity was only about 20 percent.

Fish

Two sections of Lake Clarke were sampled for fish. The first sampling area in the lower portion of Lake Clarke, around RM 33, was a paired shoreline sample of 500 meters along each bank. Fifteen total species were found within these paired reaches, with the eastern shoreline accounting for a majority of those taxa. However, more than 90 percent of the individuals collected with this sampling area were gizzard shad or Cyprinid (minnow) species. This is likely a function of poor habitat quality along shorelines, as both were primarily muck and sand. Additionally, along the eastern shore in lower Lake Clarke, the river bank is very steep and unfavorable for fish sampling, as a railroad track is the only thing between the river and a large cliff face.

The second fish sampling area was in the middle of Lake Clarke, at RM 36, and also included a paired shoreline sample of 500 meters along each bank. Twenty-four taxa were collected within this sampling reach, which also had the highest proportion of top predators of any of the sampling reaches in the study area. The greatest number of walleye was collected in the upper reaches of Lake Clarke. Shoreline habitat in this reach was a little more complex and included some boulders and woody debris as well as some man-made structures like docks and piers. The western shoreline of the lower section of Lake Clarke is largely undeveloped. However, the shoreline of upper Lake Clarke is more than 50 percent developed along both sides of the river.

Lake Aldred

Water Quality

Lake Aldred is the middle reservoir and is also the smallest and most narrow. It is formed by the Holtwood hydroelectric dam and drains major streams such as Conestoga River, Pequea Creek, and Otter Creek. There were two water quality transects in Lake Aldred, one near the top just upstream of the confluence of Pequea Creek, and one in the lower portion about a mile upstream of Holtwood Dam. Water depths along the transects in Lake Aldred reached depths of greater than 10 meters, but field chemistry profiles again revealed no vertical stratification. Temperature varied up to 0.6°C from surface to bottom and, similarly, there was only about 0.5 mg/l difference in dissolved oxygen from top to bottom. Conductivity was consistently between 260 - 360 uS/cm throughout this reservoir.

General water chemistry in Lake Aldred was fair, with nitrogen again as the parameter exceeding water quality levels of concern most frequently. Total nitrogen exceeded 1.0 mg/l in 40 percent of the samples taken in this reservoir, with most of that nitrogen in the form of nitrate. Total nitrate exceeded 0.6 mg/l in every sample taken in Lake Aldred. In addition, the highest concentration of TKN (2.7 mg/l) was found along the RM 26 transect on the western shore in April. TKN was also detected at this same location in October but at a lower concentration. In both cases, TKN made up at least half of the total nitrogen in the water sample, which is not surprising since there is a wastewater discharge about two miles upstream of this transect along the western shore.

Total phosphorus concentrations were the highest, on average, in Lake Aldred compared to either of the other two reservoirs. The higher nutrient concentrations in Lake Aldred are not surprising as two heavily agricultural watersheds, Conestoga River and Pequea Creek, empty into Lake Aldred. Water temperature in Lake Aldred stayed under 30°C during the summer months, possibly due to this reservoir being more narrow and shaded than either Lake Clarke or Conowingo Pond.

Macroinvertebrates

The composite macroinvertebrate sample for Lake Aldred consisted of 32 taxa, including six Chironomid genera and seven EPT taxa. However, Chironomids made up only about 5 percent of the sample. The Hilsenhoff Biotic Index score for Lake Aldred was 4.54, indicating the presence of fewer pollution tolerant taxa than in Lake Clarke. The dominant taxon in Lake Aldred was also the mayfly *Brachycercus*, in similar abundances as it was in Lake Clarke (~40 percent). Using the Bray-Curtis similarity index, the composite samples from Lake Clarke and Lake Aldred were quite similar with a similarity of 64 percent. The amphipod genus *Gammarus* also made up about one-fifth of the multi-habitat sample in Lake Aldred.

H-D samplers were retrieved from both transects in Lake Aldred, and the side-by-side replicate of the artificial substrate was done at the upper transect. The goal of the side-by-side H-D samplers was to document variation within samplers at the same location. The side-by-side replicates showed 84 percent similarity, which was primarily a reflection of the extreme dominance of one genus of Chironomidae (*Dicrotendipes*) at 84 and 99 percent. One of the samplers had 11 taxa and the other had three, but other than the *Dicrotendipes*, no taxa were represented in large numbers. The other H-D sampler in Lake Aldred (located at RM 30) had very similar results to both replicate samplers (87 and 96 percent similarity), with 99 percent *Dicrotendipes* and very few other taxa.

Fish

Lake Aldred was dominated by gizzard shad, in the lower reaches particularly, as they accounted for greater than 85 percent of the fish collected. Nineteen species were collected at the lower sampling reach (RM 26), with 11 species representing native taxa. The western shoreline held more favorable fish habitat as there were more complex structures like woody debris, live trees, and overhanging vegetation. The upper fishing reach in Lake Aldred was the least productive of all the sampling reaches with only four taxa collected. Water depth greater than 3 meters along the shoreline and very poor habitat were likely the major factors driving the lack of fish capture. Shoreline habitat directly adjacent to Lake Aldred is largely undeveloped, although much of the surrounding lands within one mile of the river are agricultural. Shoreline substrate along most of Lake Aldred is muck and fine sediment. Railroad tracks follow the river along much of the eastern shoreline of the reservoir, and portions of the river bank in that reach are reinforced with large boulder rip rap, creating a steep bank drop-off. Not including the gizzard shad, Lake Aldred had the lowest CPUE of all three of the reservoirs.

One interesting pattern that emerged from the H-D data was the greater similarity of macroinvertebrate assemblages from the lower transects in each reservoir than among all samples within the same reservoir. This similarity suggests that macroinvertebrate communities may be more dependent on local habitat and flow patterns than on potential water quality issues associated with the shoreline where they live.

Conowingo Pond

Water Quality

Conowingo Pond is the largest of the three reservoirs in the Lower Susquehanna reservoir system, measuring nearly 14 miles in length and stretching over a mile wide in some places. There were three water quality transects in Conowingo Pond: one below the Muddy Run Pumped Storage Facility (RM 22), one below Peach Bottom Nuclear Power Plant (RM 18), and one about three miles upstream of Conowingo Dam (RM 14). Vertical profiles in Conowingo Pond revealed similar results to the other two reservoirs. There was no vertical stratification even in the deepest parts of Conowingo Pond. At 20 meters deep at RM 22, the temperature changed 0.02°C between the surface and the bottom, and dissolved oxygen decreased just 0.7 mg/l. At the most downstream point just above Conowingo Dam at depths of 10 meters, temperature and dissolved oxygen were also very stable with changes of only 0.37°C and 0.26 mg/l, respectively.

General water quality in Conowingo Pond was similar to the other two reservoirs, with nitrogen being the most frequent parameter to exceed water quality levels of concern. Total nitrogen exceeded 1.0 mg/l in half of the samples, and again a majority of the nitrogen was in the form of nitrate, as nitrate exceeded background levels in 100 percent of the samples taken in Conowingo Pond. TKN was only detected in one sample in August within Conowingo Pond. Water temperatures topped 30°C at both transects (RM 18 and RM 14) downstream of Peach Bottom Nuclear Power Plant. Higher temperatures are not unexpected as the discharge from the cooling towers at this facility can be greater than 33°C. Conowingo Pond also had the highest average chlorophyll *a* concentrations with a maximum of 25.6 ug/l. Conductivity was consistently between 250-360 uS/cm. Total suspended solids (TSS) were above levels of concern (15 mg/l) at nearly all Conowingo Pond sites during April sampling. Depending on the timing of sampling with the timing of operations at Muddy Run Pumped Storage Facility, high TSS would not be unusual as sediment is naturally re-suspended when water is pumped up into the storage reservoir or when it is released back into the river.

Macroinvertebrates

The composite macroinvertebrate sample from Conowingo Pond had the fewest taxa (26) of the three reservoirs but showed the best Hilsenhoff score, indicating a higher proportion of taxa that are less tolerant of organic pollution. As in the other two reservoirs, the dominant taxa was the mayfly genus *Brachycercus* in similar proportions (40 percent of sample) as it was found in the two other reservoirs. Again, it cannot be considered unusual to find this mayfly in this type of river reservoir environment, as it prefers slow moving, warmer waters and is suited to depositional sediment habitat. One unusual macroinvertebrate taxa that was found in the multi-habitat sample for Conowingo Pond, as well as two of the H-D samplers, is the mayfly genus *Rhithrogena*. This genus is very intolerant to organic pollution, noted by a Hilsenhoff score of zero, and is often found in fast moving, clear clean streams, but comprised nearly 20 percent of the multi-habitat sample in Conowingo Pond.

A second type of duplicate sample using the H-D samplers was taken in Conowingo Pond. At the transect at RM 14, near the bottom of Conowingo Pond, one H-D sampler was deployed on the western shore and another was deployed on the eastern shore. These samples yielded very similar metric scores, nearly identical taxa richness, Hilsenhoff Biotic Index scores, number of EPT taxa, percent Chironomid individuals,

Below Conowingo Dam

and number of Chironomid genera—which is interesting to note as the samplers were nearly a mile apart on opposite banks of the Conowingo Pond. The macroinvertebrate communities from the other H-D samplers in Conowingo Pond were much different. The sample from mid-pond at RM 18 was dominated by Chironomids and contained no EPT taxa at all. The H-D sample at the upper transect, RM 22, had the most taxa, although many were Chironomid genera, but was also heavily comprised of the amphipod *Gammarus*.

Fish

Two reaches were fished in Conowingo Pond. One reach included paired shoreline reaches around RM 14, in the lower portion of the reservoir. The other reach involved an equivalent amount of effort in and around the cluster of small islands and outcroppings just downstream (RM 22) of the Muddy Run Pumped Storage Facility near the top of Conowingo Pond. Eight species were collected in the lower sampling reaches, with gizzard shad once again dominating the population. The western shore was the more productive side of the river with seven of the eight taxa occurring there.

The upper site around the islands was more productive due to better and more structured fish habitat and outcroppings, with 15 species collected, including 10 native species. One Chesapeake logperch was collected in Conowingo Pond. Flow fluctuations resulting from the Muddy Run Facility prevented a more thorough sampling effort of this complex habitat because of limited boat maneuverability.

Habitat along the shoreline of Conowingo Pond is quite varied, as much of the surrounding area is agricultural but not all right up to the river's edge. There is relatively undeveloped shoreline along both banks of the extreme lower portion of the Pond. Shoreline substrate is predominantly muck, boulders, and woody debris. Muddy Run Pumped Storage Facility and Peach Bottom Nuclear Power Generation Plant are also both right on the shoreline of Conowingo Pond.

Below Conowingo Dam

The final water quality transect was located about three miles downstream of the Conowingo Dam and seven miles upstream of the confluence of the Susquehanna River with the Chesapeake Bay. This section of river is free-flowing but heavily dependent on the power-generating activities of Conowingo Dam. Flows can fluctuate tens of thousands of cubic feet per second and six to ten feet in depth numerous times a day based on power generation needs (Figure 4).

Sampling was timed to correspond as best as possible with lower flows and water depths to avoid safety concerns related to rapidly increasing flows. Water quality at this site was fairly good, with nitrogen, exclusively in the form of nitrate, being the only parameter to exceed water quality background levels.

Water temperatures may fluctuate often due to the large undulations in flow, but during the sampling, all water temperatures were below 30°C. Water depths during sampling were between one and two meters.

No macroinvertebrates were collected below Conowingo Dam, as the substrate is primarily boulder and bedrock due to the scouring effect of the repeated rapidly rising flows. Additionally, the H-D sampler placed at the water quality sampling transect below the dam was washed away in the high flows.

Fish sampling was also planned to correspond with anticipated lower flows in the early evening hours. The Spencer Island Complex is

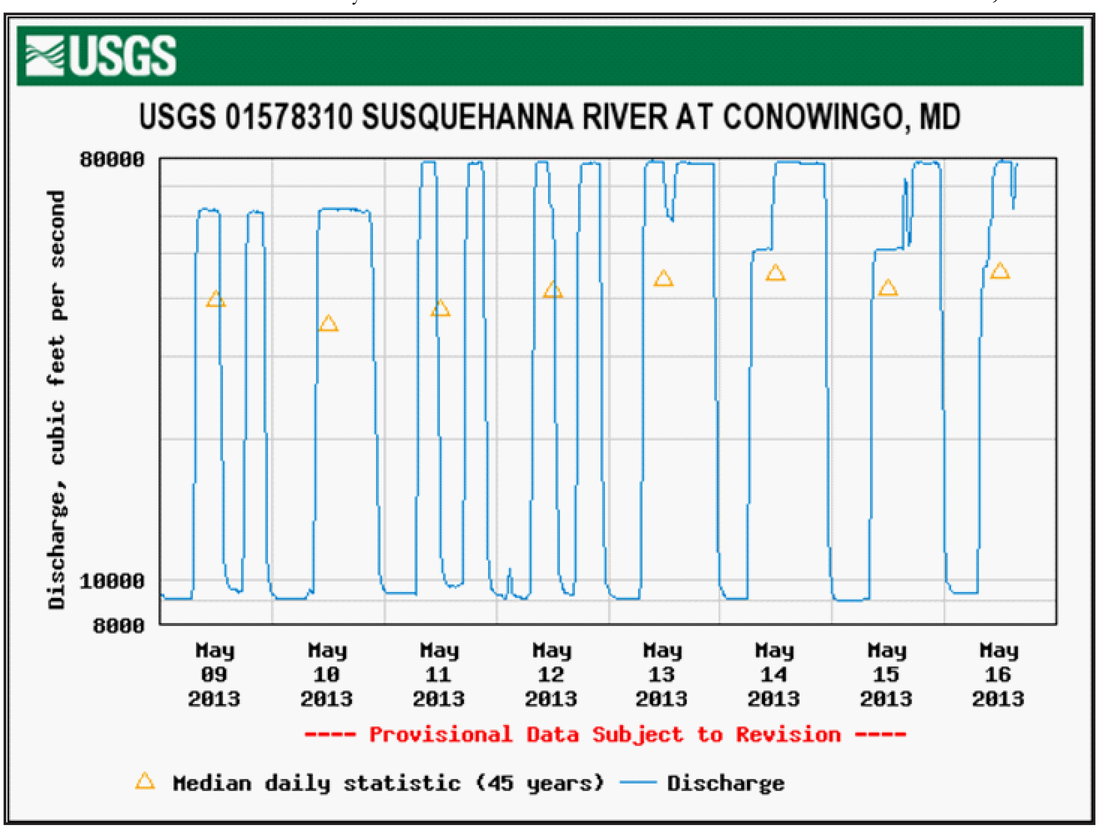


Figure 4. Example of Large Fluctuations in Flow on the Susquehanna River due to Power Generation

a group of islands and large rock outcroppings around RM 7 that was used as the fish sampling area for below Conowingo Dam. Twenty-two species were collected in this sampling reach, including 15 native taxa. Only 10 percent of the sample was comprised of top predator fish species. Habitat below Conowingo Dam is very diverse. Directly below the dam, particularly along the eastern shoreline, constant scour action from dam releases has washed out all small substrate and left nothing but bedrock. Farther downstream where sampling was completed, a mixture of very large boulders and small islands was located in the channel, and muck and small boulders existed along the shorelines.

Challenges and Lessons Learned

One of the biggest challenges encountered throughout this pilot study, which also significantly complicated and hindered monitoring efforts, was the rapidly fluctuating river levels in each of the reservoirs. While it is well-known that these river level fluctuations occur and are an unavoidable by-product of hydroelectric power generation, they appear to be having an observable, negative impact on the ecology of the three lower reservoirs in the Susquehanna River. Because of the lack of any USGS gaging stations between Marietta and Conowingo Dam, the magnitude and frequency of flow fluctuations were not able to be characterized for this study. SRBC staff observed two- to three-foot changes in river levels in just a few hours. Not only do these rapid, unpredictable changes make sampling very difficult, but they also result in the degradation of critical ecosystem habitat areas along the shorelines. Where the river is not steeply sloped, these shoreline areas are likely submerged and exposed multiple times during the day, which limits their capacity to continually support aquatic life and compromises critical habitat. This lack of persistent shallow, near-shore habitat can be ecologically detrimental.

A multi-parameter sonde was deployed for two weeks in Lake Aldred in September to document some continuous water quality conditions for temperature, conductivity, pH, dissolved oxygen, and chlorophyll *a*. The sonde was placed and secured in water about one meter deep and 10-15 meters from the bank, and upon SRBC's return visit two weeks later, it was out of water in a mudflat. In reviewing the sonde data, it is clear that dewatering of these shoreline areas happens frequently, but there is no regular pattern (Figure 5). A conductivity reading at or near zero indicates that the sonde is partially or fully out of water. In this two-week period in September, this shoreline habitat was out of water eight different times. However, because power generation is an on-demand type of industry, there are few alternatives to minimizing these rapidly changing flow regimes within this portion of the river. The hydroelectric facilities are operating within the boundaries of their FERC licensing agreements, which require the maintenance of a minimum flow and pool level at all times.

Marginal to poor fish habitat exists throughout most of the reservoir system, at least in areas that can be sampled using an electroshocking boat. Much of the substrate is covered by varying layers of sediment and organic detritus. Depths are highly variable throughout the river, and it is not uncommon to go from 10 meters to one meter of depth while traveling only a few feet on the surface. Numerous bedrock and boulder outcroppings may or may not be exposed depending on the current river level. Few of these obstructions are marked and are significant hazards to navigation. Sampling around Muddy Run Pumped Storage Facility is a challenge as the river flow is drawn upstream during pumping operations as the storage reservoir is being filled.

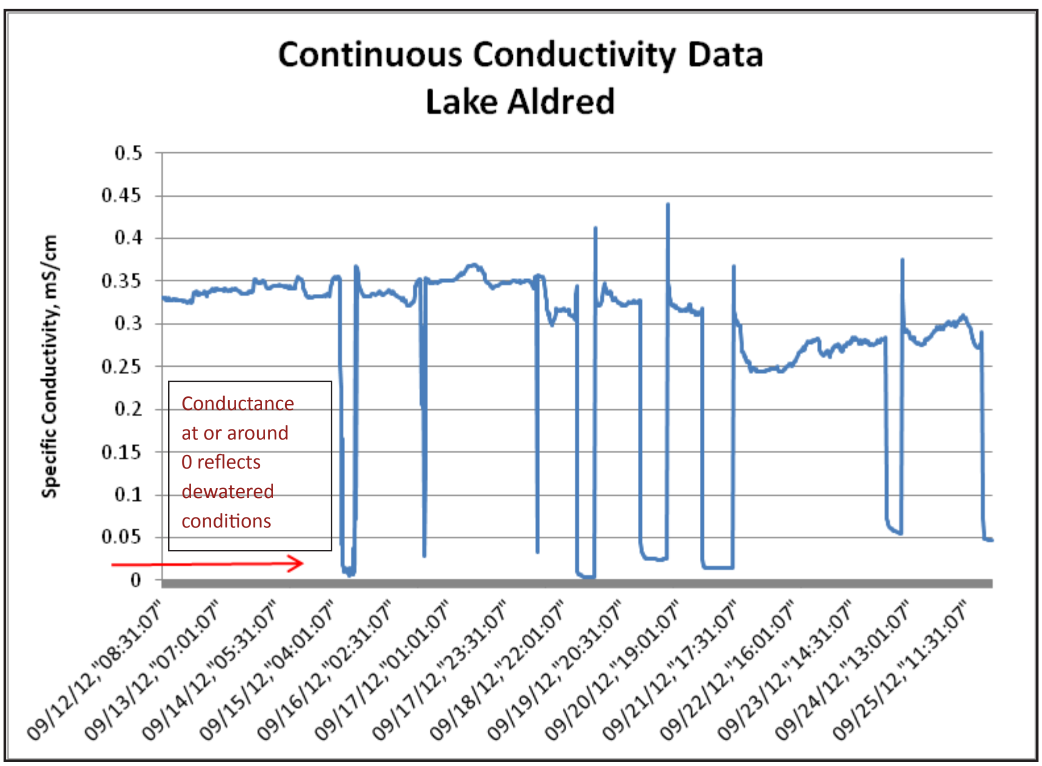


Figure 5. Example of Fluctuating Flows in Lake Aldred Leaving Shorelines Exposed

Conclusions

Water chemistry in the lower reservoirs was characterized by nearly complete vertical mixing as water temperature and dissolved oxygen values between surface and bottom readings revealed very little change. The biggest water quality concerns were nitrogen and phosphorus concentrations throughout the reservoirs. The hybrid nature between free-flowing river and impoundment of the Susquehanna River in this reach leads to difficulty in assessing its water quality status. Based on standards for lakes, the portions of each reservoir could be considered eutrophic given the phosphorus concentrations and low water clarity. However, when considered a typical river, nitrogen is of far greater concern than phosphorus, with concentrations over 3 mg/l in some locations. In either case, nutrient inputs from surrounding land uses into the river are the main water quality issue in the lower reservoirs. The origin of excess nutrients into the river are likely a combination of both point and non-point sources, including but not limited to, wastewater dischargers and agriculture. Macroinvertebrate data collected during this project are some of the only recent data of its kind for the reservoirs and may prove crucial in ongoing discussions about river health. Fish community data collected provided significant data on species presence, abundance and distribution, as well as data for the invasive flathead catfish, the catadromous American eel, and Pennsylvania-threatened Chesapeake logperch. Catch rate and overall health condition of smallmouth bass, a declining species of recent concern within the Susquehanna River Watershed, was also documented.

The lower reservoirs in the last 45-mile reach of the Susquehanna River comprise a complex system of waterways in an already unusual river system. By successfully completing this pilot study, SRBC better understands how these reservoirs function and what their biological communities include. This pilot study also provides excellent baseline data from which to plan future monitoring efforts. The use of new methods and protocols, some more successful than others, has expanded SRBC's monitoring capabilities and allowed for a more diverse monitoring and assessment program. SRBC will begin to incorporate the data gathered and the effective approaches used in this pilot study into a more routine monitoring effort on the lower reservoirs. Plans are underway for the existing Large River Assessment Project to be expanded to include a monitoring component in the lower reservoirs in addition to the free-flowing portions of the river throughout the basin. Lessons learned and data collected from this pilot study will be invaluable moving forward.

Below Conowingo Dam

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Reservoir Facts

Lake Clarke and Lake Aldred reservoirs have reached their capacity to store sediments and generally no longer trap nutrients and sediments. Conowingo Pond has not reached storage capacity, however, and is currently trapping about 70 percent of the suspended-sediment load, 2 percent of the total-nitrogen load, and 40 percent of the total-phosphorus load that would otherwise be discharged to the Chesapeake Bay (Ott and others, 1991). (USGS fact sheet)

The Safe Harbor Dam and the accompanying hydroelectric power station, which is located just above the confluence of the Conestoga River, were completed in 1931 and further expanded in the 1980s.

Holtwood Dam is the oldest of the lowest three dams on the Susquehanna River and was completed in 1910.

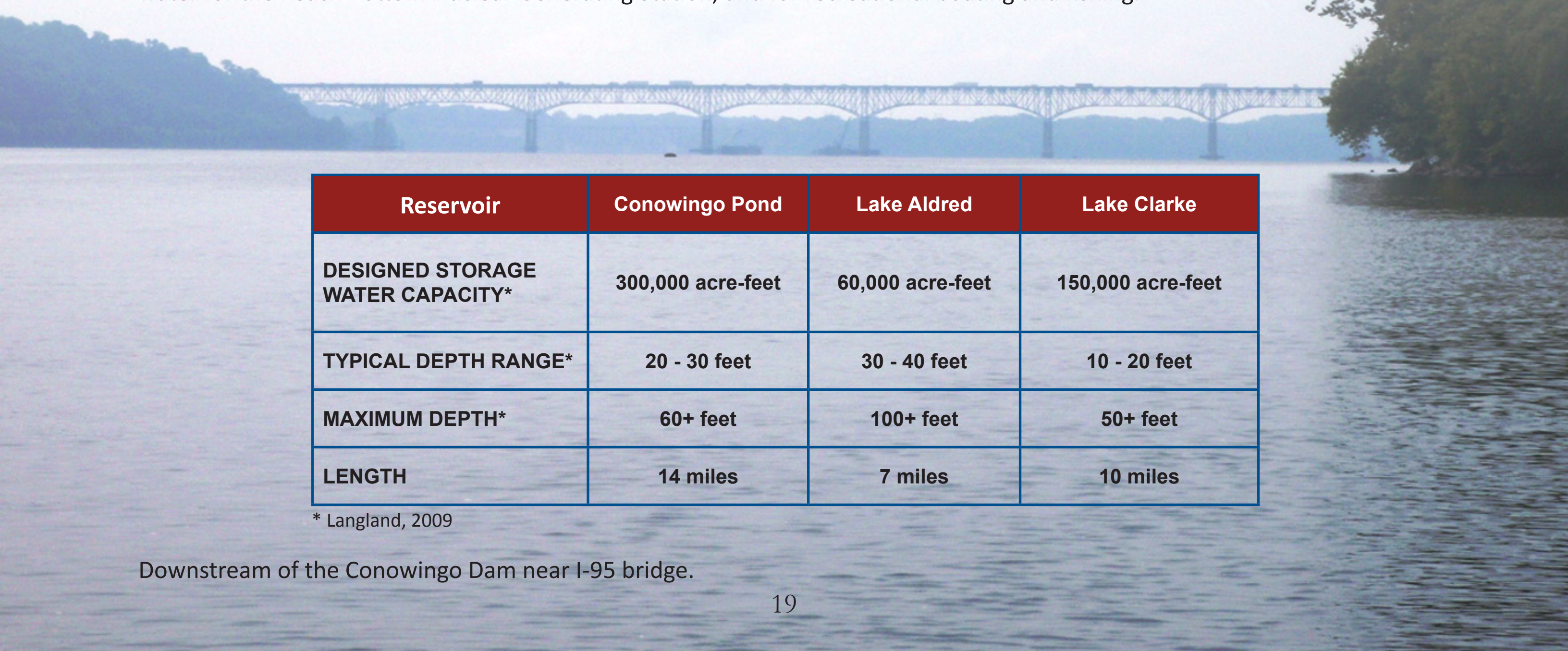
The Conowingo Dam is one of the largest non-federal dams in the country and was completed in 1928. This dam is located in Maryland, five miles south of the Pennsylvania border, and also serves as the U.S. Route 1 bridge across the Susquehanna River.

Both Lake Clarke and Lake Aldred were historically dredged for anthracite coal silt that had washed down from upstream coal mining activities and was used in the power stations from the 1920s-1950s.

The Conowingo Dam is now operated by the Susquehanna Electric Company, part of Exelon Power Corporation. The current Federal Energy Regulatory Commission license for the dam, which may be renewed, was issued in 1980 and expires on September 1, 2014.

During Hurricane Agnes, in 1972, all 53 flood gates of the Conowingo Dam were opened, for only the second time in the dam's history. Waters rose during the early morning hours of June 24th within 5 feet of topping the dam (a record crest of 111.5 ft.), three feet above the normal level for the entire 14-mile (23 km) long Conowingo Pond. The flow sensor in the dam recorded its record discharge of 1,130,000 cu ft/s, and the stream height gauge, at the dam's downstream side, registered a record 36.85 feet. On January 20, 1996, the gauge recorded its second-highest recorded crest of 34.18 feet.

Conowingo Pond is used as a drinking water supply for Baltimore and the Chester Water Authority, as cooling water for the Peach Bottom Nuclear Generating Station, and for recreational boating and fishing.



Reservoir	Conowingo Pond	Lake Aldred	Lake Clarke
DESIGNED STORAGE WATER CAPACITY*	300,000 acre-feet	60,000 acre-feet	150,000 acre-feet
TYPICAL DEPTH RANGE*	20 - 30 feet	30 - 40 feet	10 - 20 feet
MAXIMUM DEPTH*	60+ feet	100+ feet	50+ feet
LENGTH	14 miles	7 miles	10 miles

* Langland, 2009

Downstream of the Conowingo Dam near I-95 bridge.

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Above: Chickies Rock, Lancaster County, Pa., upstream of Columbia, Pa.

Cover Photo: A boat heads north across Lake Clarke and the Conejohela Flats on the Susquehanna River. *Photo Credit: Casey Kreider*