Large River Monitoring Project

Lower Susquehanna River System
Interim Technical Summary (2021/Year 3)

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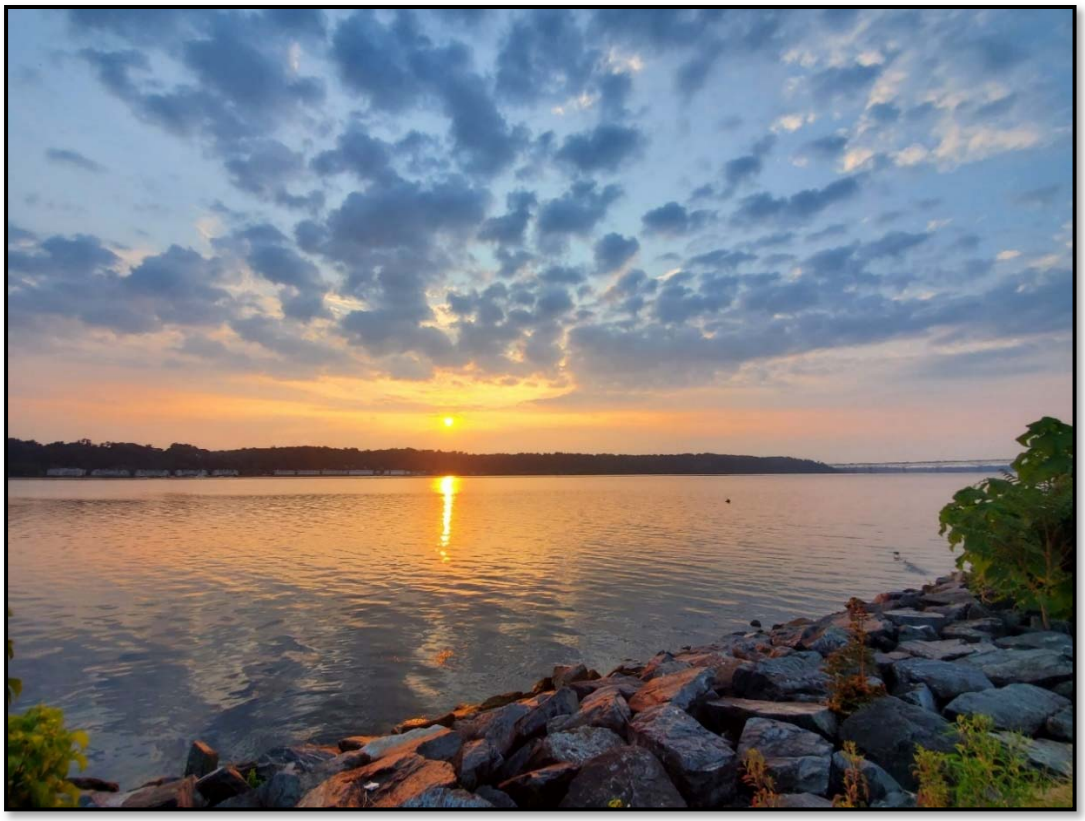

Susquehanna River at Lapidum, Maryland (SUSQ 7)

SRBC
SUSQUEHANNA RIVER BASIN COMMISSION
NY ▪ PA ▪ MD ▪ USA

INTRODUCTION AND BACKGROUND

The Susquehanna River is the longest river on the East Coast of the United States, flowing 444 miles from Cooperstown, NY, to Havre de Grace, MD. The Susquehanna River Basin Commission (Commission) has been monitoring the Susquehanna River and its tributaries through the Large Rivers monitoring program since 2007. Prior studies have focused on basin-wide water quality and biological conditions (2007-2013) and geographically underrepresented areas (2016-2018).

The final 70 miles of the river (Lower Susquehanna River) is a unique transitional system, where the Susquehanna River leaves the Ridge and Valley ecosystem and enters the Piedmont ecoregion before flowing into the Chesapeake Bay. This Lower Susquehanna River system is affected by numerous anthropogenic activities including the presence of four man-made impoundments created by major hydroelectric dams (Figure 1):

1. Lake Frederick created by York Haven Hydroelectric Dam
2. Lake Clarke created by Safe Harbor Dam
3. Lake Aldred created by Holtwood Dam
4. Conowingo Pond created by Conowingo Hydroelectric Plant (furthest downstream)

The lower river system also contains five other power generation facilities: Three Mile Island Nuclear Generating Station (TMI) (now decommissioned), the coal-fired Brunner Island Steam Electric Station, Old Dominion Electric Cooperative Wildcat Point natural gas power plant, Peach Bottom Atomic Power Station, and Muddy Run Pumped Storage Facility.

With partial funding support from the U.S. Environmental Protection Agency (USEPA) through a Water Pollution Control (Section 106) grant, the Commission initiated the current Lower Susquehanna River monitoring project, which is a three-year study (2020 through 2022) focusing on the Lower Susquehanna River system between Harrisburg, PA, and Havre de Grace, MD (Figure 2). The Commission previously collected data in this portion of the river system in 2012 and 2014. This current project complements ongoing studies on the Susquehanna River currently being conducted by the Pennsylvania Department of Environmental Protection (PADEP) and the Commission. Other resource agencies are interested in the results of this project, including the Pennsylvania Fish and Boat Commission (PFBC), Maryland Department of the Environment (MDE), United States Geological Survey (USGS), United States Fish and Wildlife Service (USFWS), and USEPA.

This report has two purposes:

1. To outline the summary of sampling efforts conducted in 2021, and
2. To present the data collected during these sampling efforts. A report summarizing the data collected during the study's three-year span will be completed in November 2023.

Figure 1. Lower Susquehanna River Study Area within the Susquehanna River Basin

STUDY AREA

The Commission sampled at 16 transects along the Lower Susquehanna River (Figure 2; Appendix A). These sampling transects are labeled by river mile moving upstream from the confluence of the Susquehanna River with the Chesapeake Bay, so sampling transects with higher numbers are located farther upstream from the confluence.

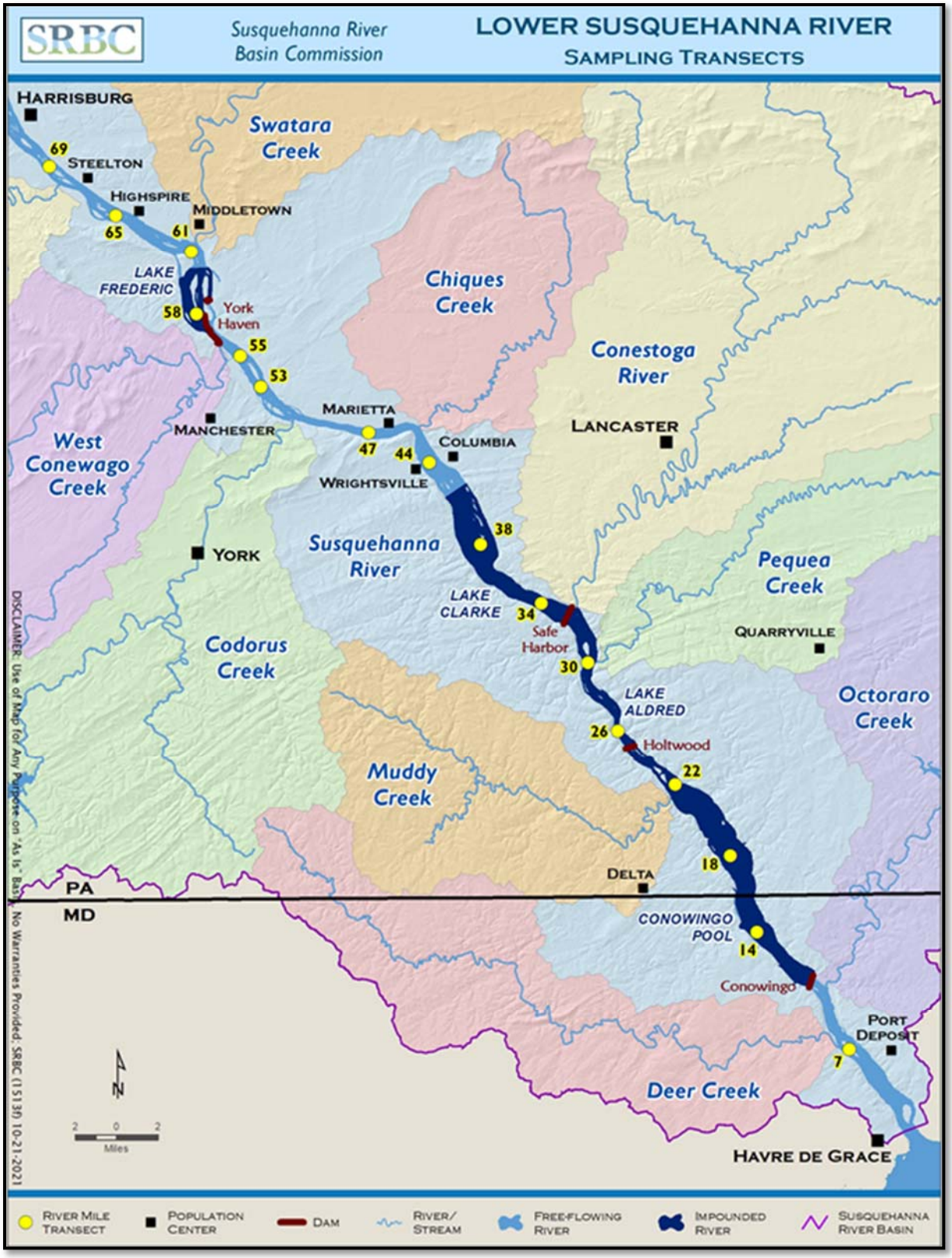

Figure 2. Lower Susquehanna River Study Area Within the Susquehanna River Basin

METHODS

Commission field crews followed the field methods outlined in the USEPA-approved Quality Assurance Work Plan (SRBC, 2021). Sampling occurred in August and September 2021 and included collection of macroinvertebrates, fish, and water samples, as well as assessments of instream characteristics (Appendix B).

Fish were collected by a combination of boat electrofishing and benthic trawling. All fish identification was conducted by Aaron Henning, Certified Fisheries Professional. Macroinvertebrates were collected using two different methods, depending if the transect was impounded (Hester-Dendy artificial substrates) or free-flowing (500-micron D-frame net). Macroinvertebrates were identified by Jeff Erikson, Associate Professor of Biology at Messiah University.

Water quality measurements of dissolved oxygen, turbidity, temperature, specific conductance, and pH were recorded using a field meter along both banks and at the channel midpoint. At impounded transects, a vertical profile was developed by taking these measurements at 1-m increments with a Van Dorn sampler (Figure 3). Water samples were sent to Pace Analytical for analysis of aluminum, iron, manganese, nitrate, orthophosphorus, phosphorus, total organic carbon, chloride, sodium, sulfate, turbidity, total dissolved solids, and total suspended solids.

Figure 3. SRBC Staff Using a Van Dorn Sampler to Collect a Depth-integrated Sample

RESULTS

Fish

Fish community data were successfully collected at 15 of 16 sites (Appendix C). SUSQ 14 was not sampled due to an equipment malfunction. Across all sites, 42 unique fish species were detected. Site level species richness was variable across sites, ranging from 9 to 22 with a mean of 16.4 species per site. Overall abundance ranged from 84 to 1993 with a mean value of 730. Three species were ubiquitous across sites: bluegill, smallmouth bass, and spotfin shiner. Numerically, the nonnative mimic shiner was most abundant throughout the study reach accounting for 41% of all individuals collected and present at 11 of 15 sites.

Multiple species of note were encountered during the monitoring effort including the Chesapeake logperch and American eel. Chesapeake logperch are listed as threatened in Pennsylvania and Maryland and have a narrow geographic range centered on the Lower Susquehanna River. American eel are the focus of an ongoing restoration in the Basin and have a Susquehanna population supported entirely by trapping and trucking the animals around the hydroelectric dams. American eel were documented at four locations in the study area – upstream, downstream, and within the reservoir complex. Chesapeake logperch were encountered at three sites within their known distribution.

No invasive Northern Snakehead or Blue catfish were detected during the fish surveys. Extant reproducing populations of both species are known to presently exist below Conowingo Dam but neither was present in the sample collected from SUSQ 7. Flathead catfish, another non-native, recently introduced invasive species was present at 9 of 15 sites sampled. Two species of migratory fish were present during the survey. American eel were present at SUSQ 7, SUSQ 22, SUSQ 61, and SUSQ 69. A single juvenile American shad was collected at SUSQ 65, providing evidence of natural reproduction from the current trap and transport restoration effort.

Macroinvertebrates

Macroinvertebrate samples were successfully collected from 14 of 16 total sites (Figure 4). All eight free-flowing locations were sampled between August 3 and August 17. The macroinvertebrate data were analyzed with the PADEP Multimetric Index for Large Semi-wadeable Rivers (PADEP, 2018). The Summer SWMMI scores from these free-flowing locations range from 3.1 at SUSQ 7 to 81.4 along SUSQ 69 (Appendix D).

Hester-Dendy samplers were deployed on August 1, and retrieval attempts were made on October 6. Samplers were retrieved from 6 of 8 impounded sites on October 6. The Hester-Dendy samplers placed at SUSQ 22 and SUSQ 34, including the duplicate samplers set at SUSQ 34, were never recovered.

Figure 4. SRBC Staff Utilizing Habitat-specific Methodology to Collect Macroinvertebrates (A D-frame net (left) is used in a riffle at SUSQ 44 and a Hester-Dendy passive sampler (right) is set at SUSQ 22.)

Water Quality

Water quality data were analyzed by using the Commission's Water Quality Index (Berry, 2020) to provide a simple units less measure the overall condition or quality of individual water samples relative to all other water samples collected from within the basin at waterbodies of similar size. The watershed size adjusted scores allow for interpretation based on a 0-100 (worst to best). Scores below 31 indicate 'very poor' quality while scores above 85 suggest 'very good' quality.

As previously shown in prior monitoring efforts, the water quality characteristics of the Susquehanna River showed considerable variation within a relatively narrow geographic reach. This variation effectively disappeared as the river becomes impounded in the vicinity of river mile 40 where the influence of Safe Harbor Dam is realized. Most WQI scores ranged from 30-70, and overall WQI scores trended lower as sampling progressed downstream (Figure 5). The left bank of the river generally experienced the lowest WQI scores until river mile 22, while the left bank had the highest WQI scores.

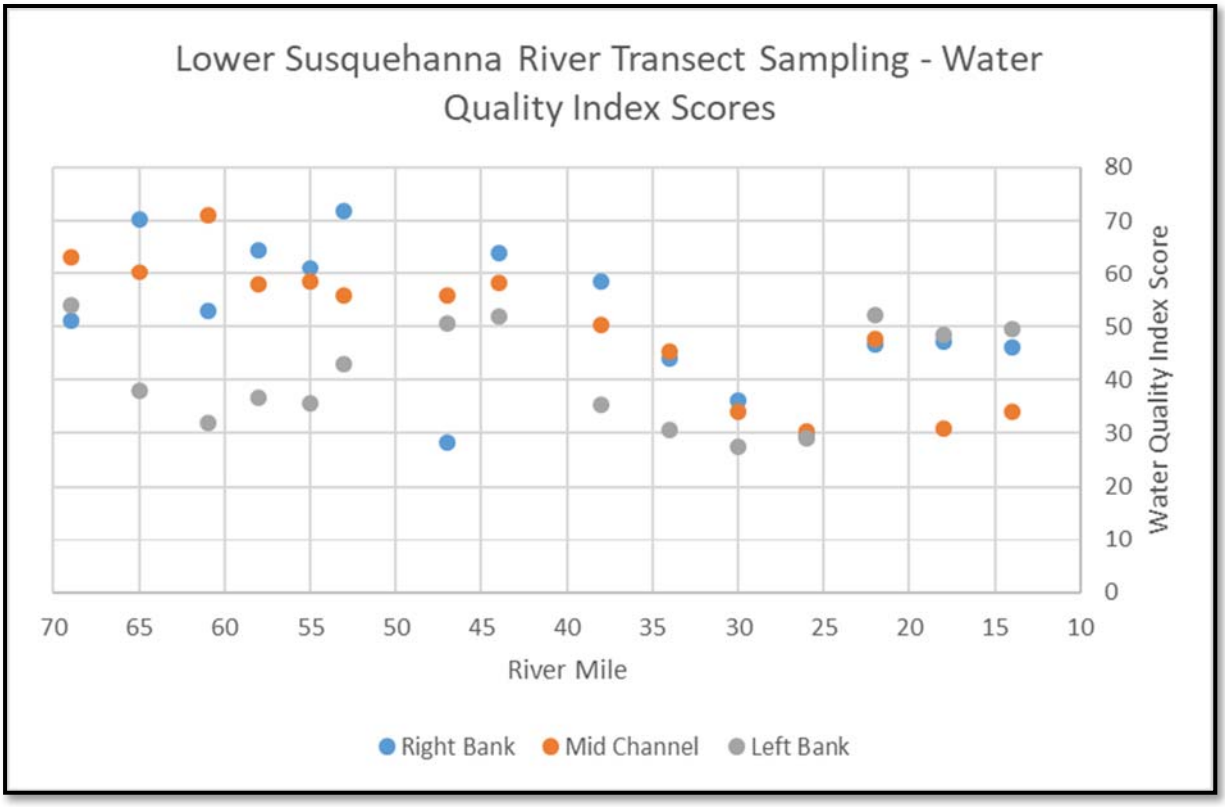

Figure 5. Water Quality Index (WQI) scores from 2021 Large River sampling (Left Bank (grey), Mid Channel (orange) and Right bank (blue) samples)

Habitat Conditions

Instream and riparian habitat varied dramatically through the survey reach. Upriver free-flowing sites were generally shallower, provided more varied and complex substrates, and possessed greater microhabitats than the impounded sites. Free-flowing sites generally had water depths of 1–1.5 meters at the time of sampling. Impounded sites depths ranged from 1–38 meters and exhibited a great deal of variability at individual locations within specific reservoirs.

The upstream most impounded site, SUSQ 58, seldom exceeded 2 meters in depth. The remaining impounded sites lie behind much larger dams and typically have mid channel depths of 5 – 10 meters. Within the impoundments, the west bank (right descending) typically was much steeper, often a bedrock or boulder ledge with depths of 5-7 meters just 10 meters from shore. Conversely, the eastern bank (left descending) is typically shallower at 1-2 meters deep at 10 meters from shoreline with <1 meter depth extending hundreds of meters in river. At SUSQ 38, the upstream most-impounded site created by Safe Harbor Dam, the river is 2,500 meters wide but shallow, non-boatable (>0.3 meters) conditions persist over 1200 meters from the eastern bank.

DISCUSSION

The Lower Susquehanna River is a truly unique system within the study area. The complex reservoir system provides water supplies for drinking water, power generation, and human recreation. The complexity and inherent difficulty of monitoring such a diverse range of conditions was a persistent challenge throughout the study. Reservoir elevations are generally maintained at a steady state through the summer boating season (May-September) but dam operators are allowed greater pond level control following Labor Day. Likewise, power generation through turbine discharges at all four dams is variable and dependent upon time of year, time of day, and incoming river flow. These operations have the ability to influence river flow, turbulence, and turbidity at downstream locations. Additionally, along the eastern bank at river mile 22, lies the Muddy Run Pumped Storage Project (MRPSP), an 800 megawatt pumped storage facility with a hydraulic capacity of 32,000 cfs which typically discharges and recharges on a daily interval, utilizing the Susquehanna River for source water.

During the 2021 sampling period (August–September), river flow was slightly above median conditions for much of August when the majority of samples were collected (Figure 6). A large basin-wide precipitation event in early September caused minor flowing and raised river level significantly above normal for the remainder of the month. Stable, yet sufficient enough river flows to provide safe boating depth were critical to completing the monitoring. Deployment of Hester-Dendy samplers proved difficult with multiple samplers being lost to high flows or theft/vandalism. Hester-Dendys must also be deployed at a sufficient water depth to anticipate possible desiccation from river level fluctuations caused by hydroelectric project operations. Typically Hester-Dendy samplers were deployed in at least 2 m of water to prevent desiccation from drawdowns.

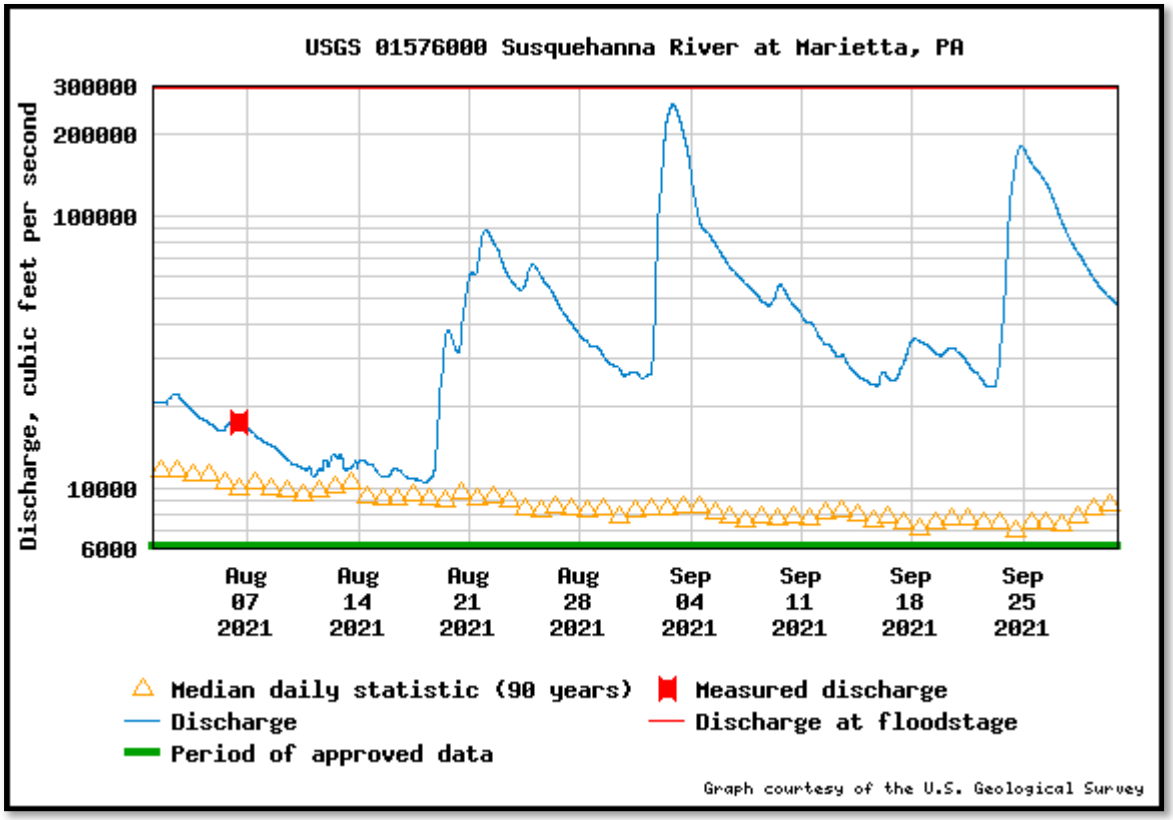

Figure 6. Discharge at USGS Gage at Marietta, PA, For the Study Period

NEXT STEPS

A full technical report summarizing the entirety of the three-year monitoring effort from 2020-2022 will be published in November 2023. Data collected from the project will be shared with fellow resource agencies to support and inform management practices within the Lower Susquehanna Watershed.

REFERENCES

Berry, J., L. Steffy, and M. Shank. 2020. Development of a Water Quality Index (WQI) For the Susquehanna River Basin. Susquehanna River Basin Commission Publication No. 322. Harrisburg, Pennsylvania.

Pennsylvania Department of Environmental Protection. 2018. A Benthic Macroinvertebrate Multimetric Index for Large Semi-Wadeable Rivers: Technical Report. Office of Water Programs, Bureau of Clean Water. Harrisburg, Pennsylvania.

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APPENDIX A:
Sampling Transect Locations

Alias	River Mile	Site Description	Latitude	Longitude	State	Flow Condition	Macros	Fish	Water Quality
SUSQ 69	69	Redbuds Island, upstream New Cumberland, PA	40.239117°	-76.867379°	PA	Free Flowing	D-frame	-	Yes
SUSQ 65	65	Turnpike Bridge, Highspire, PA	40.204377°	-76.806124°	PA	Free Flowing	D-frame	Yes	Yes
SUSQ 61	61	Poplar Island, Royalton, PA	40.178451°	-76.736614°	PA	Free Flowing	D-frame	-	Yes
SUSQ 58	58	South end of Shelley Island, Falmouth, PA	40.134320°	-76.732187°	PA	Impounded	Hester-Dendy	Yes	Yes
SUSQ 55	55	Islands upstream of Brunner Island, York Haven, PA	40.104693°	-76.691793°	PA	Free Flowing	D-frame	-	Yes
SUSQ 53	53	South end Haldeman Island. Bainbridge, PA	40.082840°	-76.673240°	PA	Free Flowing	D-frame	Yes	Yes
SUSQ 47	47	North Accomac, Wrightsville, PA	40.050150°	-76.574510°	PA	Free Flowing	D-frame	Yes	Yes
SUSQ 44	44	Old bridge piers, Columbia, PA	40.028887°	-76.518915°	PA	Free Flowing	D-frame	Yes	Yes
SUSQ 38	38	South end island complex upstream of Turkey Hill, Washington Boro, PA	39.970419°	-76.471952°	PA	Impounded	Hester-Dendy	Yes	Yes
SUSQ 34	34	South Highville, Township of Manor,York Haven, PA	39.928689°	-76.416890°	PA	Impounded	Hester-Dendy	Yes	Yes
SUSQ 30	30	South end Weise Island, Pequea, PA	39.886788°	-76.374618°	PA	Impounded	Hester-Dendy	Yes	Yes
SUSQ 26	26	South of the pinnacle, dam warning sign, Holtwood, PA	39.838423°	-76.347629°	PA	Impounded	-	Yes	Yes
SUSQ 22	22	North end Hennery Island, Drumore, PA	39.799696°	-76.295614°	PA	Impounded	Hester-Dendy	Yes	Yes
SUSQ 18	18	Downstream of Peach Bottom Atomic discharge, Peach Bottom, PA	39.749617°	-76.245526°	PA	Impounded	-	Yes	Yes
SUSQ 14	14	Downstream mouth of Broad Creek, Darlington, MD	39.695515°	-76.221853°	MD	Impounded	-	Yes	Yes
SUSQ 7	7	Robert/Wood Island complex, Susquehanna State Park, Havre De Grace, MD	39.611933°	-76.138724°	MD	Free Flowing	D-frame	-	Yes

APPENDIX B:
Summary of Monitoring Parameters Collected Throughout 2021 Study Period

Site	Flow Condition	Water Quality	Fish	Habitat	Macros	HD set	HD pulled
SUSQ 69	Free Flowing	8/11/2021	8/11/2021	8/11/2021	8/11/2021	NA	NA
SUSQ 65	Free Flowing	8/3/2021	8/3/2021	8/3/2021	8/3/2021	NA	NA
SUSQ 61	Free Flowing	8/17/2021	8/17/2021	8/17/2021	8/17/2021	NA	NA
SUSQ 58	Impounded	9/14/2021	9/14/2021	9/14/2021	NA	8/1/2021	10/6/2021
SUSQ 53	Free Flowing	8/17/2021	8/17/2021	8/17/2021	8/17/2021	NA	NA
SUSQ 51	Free Flowing	8/3/2021	8/3/2021	8/3/2021	8/3/2021	NA	NA
SUSQ 47	Free Flowing	8/4/2021	8/4/2021	8/4/2021	8/4/2021	NA	NA
SUSQ 44	Free Flowing	8/4/2021	8/4/2021	8/4/2021	8/4/2021	NA	NA
SUSQ 38	Impounded	9/30/2021	9/30/2021	9/30/2021	NA	8/1/2021	9/30/2021
SUSQ 34	Impounded	9/30/2021	9/30/2021	9/30/2021	NA	8/1/2021	LOST
SUSQ 30	Impounded	8/31/2021	8/31/2021	8/31/2021	NA	8/1/2021	10/6/2021
SUSQ 26	Impounded	8/31/2021	8/31/2021	8/31/2021	NA	8/1/2021	10/6/2021
SUSQ 22	Impounded	8/10/2021	8/10/2021	8/10/2021	NA	8/1/2021	LOST
SUSQ 18	Impounded	8/9/2021	8/9/2021	8/9/2021	NA	8/1/2021	10/6/2021
SUSQ 14	Impounded	8/9/2021	NA	8/9/2021	NA	8/1/2021	10/6/2021
SUSQ 7	Free Flowing	8/10/2021	8/10/2021	8/10/2021	8/10/2021	NA	NA

APPENDIX C:
Fish Species Collected in the Lower Susquehanna River System (August through October 2022)

Genus and Species	Common name	SUSQ 7	SUSQ 18	SUSQ 22	SUSQ 26	SUSQ 30	SUSQ 34	SUSQ 38	SUSQ 44	SUSQ 47	SUSQ 53	SUSQ 55	SUSQ 58	SUSQ 61	SUSQ 65	SUSQ 69
Anguilla rostrata	American eel	X	-	X	-	-	-	-	-	-	-	-	-	X	-	X
Fundulus diaphanus	Eastern Banded Killifish	-	-	-	-	X	X	-	-	-	X	-	X	-	X	-
Alosa sapidissima	American Shad	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Dorosoma cepedianum	Gizzard Shad	-	X	X	X	X	X	X	-	X	X	-	X	-	X	-
Carpiodes cyprinus	Quillback	-	-	X	-	-	-	-	-	-	X	-	-	-	-	-
Catostomus commersonii	White Sucker	-	X	-	-	-	-	-	X	-	X	-	-	-	X	-
Hypentelium nigricans	Northern Hog Sucker	-	-	X	-	-	-	-	X	X	X	-	X	X	X	X
Moxostoma macrolepidotum	Shorthead Redhorse	X	-	X	X	X	X	X	X	X	X	X	X	X	-	X
Cyprinella spiloptera	Spotfin Shiner	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyprinus carpio	Common Carp	X	X	-	X	-	X	X	X	X	X	X	X	-	X	-
Luxilus cornutus	Common Shiner	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Nocomis micropogon	River Chub	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X
Notemigonus crysoleucas	Golden Shiner	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Notropis amoenus	Comely Shiner	X	-	X	X	X	X	X	X	X	X	-	-	-	-	-
Notropis hudsonius	Spottail Shiner	X	-	X	X	X	X	-	X	X	X	-	X	X	X	X
Notropis rubellus	Rosyface Shiner	-	-	X	-	-	X	-	-	-	-	X	X	X	X	X
Notropis volucellus	Mimic Shiner	-	-	X	X	X	X	-	X	X	X	X	-	X	X	X
Pimephales notatus	Bluntnose Minnow	-	X	X	X	X	X	-	-	X	X	-	X	X	X	X
Semotilus corporalis	Fallfish	-	-	-	-	-	X	-	-	-	-	-	X	X	-	-
Ambloplites rupestris	Rock Bass	-	-	-	-	-	-	-	X	X	-	-	X	X	-	X
Lepomis auritus	Redbreast Sunfish	-	-	-	-	-	-	-	-	X	-	-	X	X	X	-
Lepomis cyanellus	Green Sunfish	X	X	X	X	X	X	X	X	X	X	-	X	-	X	X
Lepomis gibbosus	Pumpkinseed	X	X	-	X	-	-	-	X	X	X	-	X	-	-	-
Lepomis macrochirus	Bluegill	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Micropterus dolomieu	Smallmouth Bass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Micropterus salmoides	Largemouth Bass	X	X	X	-	-	-	-	-	-	X	X	X	-	-	-
Pomoxis annularis	White Crappie	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Pomoxis nigromaculatus	Black Crappie	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-
Morone americana	White Perch	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Morone saxatilis	Striped Bass	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Etheostoma blennioides	Greenside Darter	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-
Etheostoma olmstedi	Tessellated Darter	X	X	-	-	X	-	-	-	-	X	-	X	-	X	X
Etheostoma zonale	Banded Darter	-	-	-	X	-	-	-	-	X	-	-	-	-	-	X
Perca flavescens	Yellow Perch	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Percina bimaculata	Cheseapeake Logperch	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-
Percina peltata	Shield Darter	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
Sander vitreus	Walleye	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-
Esox masquinongy	Muskellunge	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Esox lucius masquinongy (hybrid)	Tiger Muskellunge	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
Ameiurus natalis	Yellow Bullhead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Ictalurus punctatus	Channel Catfish	X	-	-	X	X	X	X	X	X	X	X	X	X	X	X
Pylodictis olivaris	Flathead Catfish	-	-	X	X	X	-	-	X	X	X	X	X	X	-	X

APPENDIX D:
Summer SWMMI Scores for D-frame Samples Collected in August and September 2021

Site	Summer SWMMI
SUSQ 7	3.1
SUSQ 14	30.1
SUSQ 18	27.1
SUSQ 26	27.7
SUSQ 30	18.0
SUSQ 38	24.7
SUSQ 44A	53.4
SUSQ 44B	69.6
SUSQ 44C	40.1
SUSQ 44 A-D	47.1
SUSQ 44 B-D	58.6
SUSQ 44 C-D	47.6
SUSQ 47A	45.5
SUSQ 47B	75.1
SUSQ 47C	73.9
SUSQ 53A	71.7
SUSQ 53B	36.3
SUSQ 53C	47.2
SUSQ 55A	48.1
SUSQ 55B	60.6
SUSQ 55C	64.3
SUSQ 58	18.7
SUSQ 61A	42.1
SUSQ 61B	45.9
SUSQ 61C	62.1
SUSQ 65A	42.8
SUSQ 65B	35.5
SUSQ 65C	27.8
SUSQ 69A	47.5
SUSQ 69B	81.4
SUSQ 69C	27.7