

**SUMMARY OF OPERATIONS AT THE
HOLTWOOD FISH PASSAGE FACILITY
SPRING AND FALL, 2017**

November 2017

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HOLTWOOD FISH PASSAGE FACILITY
SPRING AND FALL, 2017**

Prepared for

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EXECUTIVE SUMMARY

Per the settlement agreement for the Holtwood Redevelopment Project, 2017 marks the third year of fish passage operations for both resident and migratory fish species. The Holtwood fish passage facility commenced resident fish passage operations on April 13, 2017 for six hours per day (river flow permitting), switching to ten hour days of operation when a sufficient number of American Shad were passed at Conowingo Dam or observed in the catch, then back to the six hour operating schedule for resident fish passage after the official end of the American Shad season (per concurrence with Resource Agencies) until June 30. The fall season component of resident fish passage was conducted operating only the tailrace lift in 2017 due to extensive repairs to the spillway lift stemming from a malfunction of the spillway hopper/hoist system on May 24, 2017. The settlement agreement also allows Holtwood to suspend fish passage operations when river flows are $\geq 100,000$ cfs during any fish passage season.

We were unable to start spring fish passage operations prior to April 13 due to river flows exceeding 100,000 cfs. We operated in resident fish passage mode from April 13 to 17, switching to migratory fish passage mode on April 18 due to the increased passage of American Shad at Conowingo (423 on April 17). Migratory fish passage operations were interrupted due to high river flows on April 24 and May 6 through 11. Migratory fish passage operations ended on June 7, with agency concurrence, due to increasing water temperatures and low numbers of shad in the daily passage counts. Resident fish passage operations resumed on June 8 but were quickly suspended per Resource Agency request on June 9, (21 days before scheduled end date of June 30), due to the passage of a Northern snakehead at the Conowingo East Fish Lift into Conowingo Pond on May 20. Spillway lift operations were suspended on May 24 stemming from a malfunction of the hopper and hopper hoist which caused extensive damage to the hopper travel guide beams. The facility operated a total of 51 days between April 13 and June 9, 2017, (Tailrace = 51 days; Spillway = 35 days). Fall fish passage operation was conducted solely with the tailrace fish lift due to the extensive repairs resulting from the spillway malfunction listed previously. This fish passage season marks the twenty-first year of operation at Holtwood.

During the American Shad passage season (44 days of operation from April 18 to June 7), the lifts passed 162,843 fish of 23 taxa and 1 hybrid. Gizzard shad dominated the catch, and comprised 93% of the total fish collected and passed. American Shad and two (2) Alewife represented the *Alosa* species collected and passed at Holtwood in 2017. A total of 3,171 American Shad were passed by the Holtwood fishway in 2017 (3,169 during the “official” shad passage season, with 2 American Shad passed during resident fish passage operations).

The 2017 American Shad passage rate at Holtwood (19.5% of American Shad passing Conowingo passed Holtwood) was the seventh lowest rate observed since operations commenced in 1997. The American Shad passage season at Holtwood appeared to be hampered by the higher river flows experienced and the limited functionality of tailrace entrance Gate A during the spring season.

During spring, 2017, resident fish passage operations were limited to 5 days in April due to high river flows during the first two weeks of the month and only 2 days in June due to the requested shutdown of the facility by the Resource Agencies. The facility operated 6 hours per day from 0900 to 1500 hrs per the settlement agreement. A total of 3,315 fish of 11 taxa was collected and passed during resident fish passage operations this spring. We compared the passage of 7 resident species (smallmouth bass, walleye, channel catfish, shorthead redhorse, quillback, carp, and gizzard shad) passed during resident passage periods to passage of those same species during the migratory passage season. During spring, 2017, 96% or more of the total resident fish observed were passed during the American Shad migratory fish passage season.

Fall resident fish passage operations were conducted using the tailrace fish lift only in 2017 due to the spillway fish lift equipment failures described previously. During 32 days of operation, a total of 17,038 fish comprised of 11 species were passed. Minnow species and gizzard shad accounted for nearly 99% of the total catch. It is anticipated that all repairs to the spillway fish lift will be completed before commencement of fish passage operations on April 1, 2018.

This year was the twenty-first year of fish passage operations at the Holtwood fish passage facility. Future operation of the fishway will build on these past years of operation as we continue to refine operations due to modifications made to the fishway and the overall area as part of the redevelopment of the Holtwood Hydroelectric Project.

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1.0 INTRODUCTION

On June 1, 1993 representatives of PPL, two other upstream utilities, various state and federal resource agencies, and two sportsmen clubs signed the 1993 Susquehanna River Fish Passage Settlement Agreement. This agreement committed the Holtwood Hydroelectric Project (now owned and operated by Brookfield Renewable Energy Group) and the two other upstream hydroelectric projects to provide migratory fish passage at their facilities by the spring of 2000. A major element of this agreement was for PPL, the owner/operator of Holtwood at that time, to construct and place a fishway into operation by April 1, 1997. PPL started construction on the fishway in April 1995, and met the spring 1997 operational target. The upstream passage facility consisting of a tailrace and spillway lift has been successfully operated each spring since 1997, as well as in fall, 2014 and 2015. This year marked the twenty-first operational season.

Objectives of 2017 upstream fishway operation were to (1) monitor and maximize passage of migratory fishes through the fishway; (2) minimize interruptions to fish passage operations due to equipment breakdowns or malfunctions and (3) continue resident fish passage operations in spring and fall per the redevelopment settlement agreement.

2.0 HOLTWOOD OPERATION

2.1 Project Operation

Holtwood, built in 1910, is situated on the Susquehanna River (river mile 24) in Lancaster and York counties, Pennsylvania (see figure in Normandeau Associates, Inc. 1998). It is the second upstream hydroelectric facility on the river. The project now consists of a concrete gravity overflow dam 2,392 ft long by 55 ft high, the legacy powerhouse with ten turbine units having a combined generating capacity of 107 MW, the new powerhouse containing 2 large Kaplan turbines (100 MW capacity) and a reservoir (Lake Aldred) of 2,400 acres surface area. Each legacy unit is capable of passing approximately 3,000 cfs with each Kaplan turbine passing approximately 15,000 cfs. Spills occur at the project when river flow or project inflow exceeds the station hydraulic capacity of approximately 62,000 cfs.

Hydraulic conditions in the Holtwood spillway are controlled by numerous factors that change hourly, daily and throughout the fishway operating season. The primary factors are natural river flows, operation of the power station, operation of the Obermeyer gates controlling flow into Piney channel, and operation of the Safe Harbor Hydroelectric Project.

In 2017, all Obermeyer gates were operable. Operations began at the Holtwood Fish Lift facility on April 13, 2017 to initiate passage of resident fish species prior to passage of American Shad at Conowingo Dam (Table 1). We were unable to start operations on April 1 due to high river flows in excess of 100,000 cfs from April 1 through 12. American Shad passage operations at Holtwood (10-hr days) were initiated on April 18, one day after the Conowingo East fish lift passed 423 American Shad. River flows greater than 100,000 cfs occurred on April 24 and from May 6 through 11 during fish passage operations in 2017, resulting in the suspension of passage operations on these dates, and may have impacted American Shad passage this year at Holtwood (Table 1). Spill at the project occurred on 15 of the 51 days (29% of the season) this spring. In 2017, passage operations for migratory fish (American Shad, etc.) ended on June 7, with agency concurrence, due to increasing water temperatures and low American Shad passage. Spring passage operations for resident fish species ended on June 9 instead of the scheduled termination on June 30, due to a request from the Resource Agencies stemming from the passage of a Northern snakehead into Conowingo Pond by the Conowingo East Fish Lift on May 20. A major mechanical malfunction of the spillway hopper hoist system occurred on May 24, preventing continued use of the spillway lift for the remainder of the

spring and the entire fall resident fish passage season. Tailrace Entrance Gate A, which malfunctioned during pre-season testing operations and was in the full-open position for most of the spring season, was repaired on June 1 and was functional for the remainder of the spring and entire fall resident fish passage season. Operations during the fall resident fish passage season were limited to the use of the tailrace fish lift only as the spillway lift was undergoing substantial repair work. We anticipate functionality of the entire Holtwood fish lift facility in spring, 2018.

2.2 Fishway Design and Operation

2.2.1 Fishway Design

The Holtwood fishway is sized to pass a design population of 2.7 million American Shad and 10 million river herring. The design incorporates numerous criteria established by the USFWS and state resource agencies. Physical design parameters for the fishway are given in Normandeau Associates, Inc. (1998).

The fish passage facility at Holtwood is comprised of a tailrace and spillway lift (see figure in Normandeau Associates, Inc. 1998). The tailrace lift has two entrances (gates A and B) and the spillway lift has one entrance (gate C). Each lift has its own fish handling system that includes a mechanically operated crowder, picket screen(s), hopper, and hopper trough gate. Fishes captured in the lifts are sluiced into one trough through which the fish swim into Lake Aldred. Attraction flows, throughout the entire facility, are supplied via a piping system and five diffusers that are gravity fed from two trough intakes and the additional attraction water pipe. Generally, water conveyance and attraction flow is controlled by regulating the three entrance gates and eight motor-operated valves. Fish that enter the tailrace and/or spillway entrances are attracted by water flow into the mechanically operated crowder chambers. Once inside, fish are crowded into the hoppers (6,700 gal capacity). Fish are then lifted in the hoppers and sluiced into the trough. Fish swim upstream through the trough past a counting facility and into the forebay through a 14 ft wide fish lift exit gate.

In 2017, all four Obermeyer gate sections were available for operation. Obermeyer gate sections 2 and 3 were installed and tested during fall, 2015. Generally, the Obermeyer gates were in the closed (up) position during fish passage operations excepting those times when the river flow approached and exceeded 100,000 cfs.

Design guidelines for fishway operation include seven entrance combinations. These are: (1) entrances A, B, and C; (2) entrances A and B; (3) entrances A and C; (4) entrances B and C; (5) entrance A only; (6) entrance B only; and (7) entrance C only. Completion of the attraction water system after the 1997 season resulted in the drafting of operating protocols and guidelines that are flexible and utilize experience gained during previous years of fish lift operation. In 2014, after installation of the additional attraction water supply pipe and valve (MOV 8), a new operating matrix was developed, but testing and fine-tuning of the matrix continues. The following gate combinations were utilized in spring, 2017: entrances A, B, and C (2 days); entrances A and C (33 days); entrances A and B (10 days); entrance B only (5 days); and entrance A only (1 day).

2.2.2 Fishway Operation

Daily operation of the Holtwood fishway was based on the American Shad catch, and managed to maximize that catch. Pre-season equipment preparations began in March, and were completed before season start-up. During pre-season testing, entrance Gate A malfunctioned and fell to its lowermost position due to failure of the split nuts. Entrance Gate A remained in the full-open position for most of the season as consistent high river flow prevented the repair crew and dive team to initiate and

complete repairs until June 1. In 2017, Gate C was fully operational during the spring fish passage season.

Per the Holtwood redevelopment settlement agreement, the fish passage facility was scheduled to operate daily this spring from April 1 to June 30 for passage of both resident and migratory fish species and again in fall (5 days per week; 6 hours per day) from September 1 through October 15 for passage of resident fish species. Fish passage operations were to be suspended when river flows exceeded 100,000 cfs and resumed when flows fell below 100,000 cfs.

Holtwood fish passage operations in spring, 2017 commenced on April 13 and ended on June 9 (total days of operation = 51). The migratory fish passage season (based on presence of American Shad in the catch) ran from April 18 to June 7 (44 days of operation). Spillway and tailrace lift operations ended on May 24 and June 9, respectively due to two issues; a major mechanical failure of the spillway hopper hoist system and the Resource Agency request to terminate fish passage operations due to the passage of a Northern snakehead into Conowingo Pond by the Conowingo East Fish Lift on May 20.

During the spring fish passage season, the tailrace lift operated on 51 days while the spillway lift operated on 35 days. Resident fish passage operational hours were 0900 to 1500 hrs in spring, 2017, and we operated from 0800 to 1800 hrs during the migratory fish passage season per the redevelopment settlement agreement. Fall 2017 resident fish passage operations were conducted with only the use of the tailrace fish lift as extensive repairs were being conducted on the spillway lift to ensure availability of the entire fish passage facility in spring, 2018.

Operation of the Holtwood fishway followed methods established during the 1997 and 1998 spring fish migration seasons. A three person staff consisting of a lift operator, a supervising biologist, and biological technician manned the facility daily. A detailed description of the fishway's major components and their operation are found in the 1997 and 1998 summary reports (Normandeau Associates, Inc. 1998 and 1999).

2.3 Fish Counts

Fish passing the counting window are identified to species and counted/estimated by a biologist or biological technician. The counting area is located immediately downstream of the main attraction water supply area in the trough. As fish swim upstream and approach the counting area, they are directed by a series of fixed screens to swim up and through a 3 ft wide, 12 ft long channel on the west side of the trough. The channel is adjacent to a 4 ft by 10 ft window located in the counting room where fish are identified and counted. Passage from the fishway is controlled by one set of gates located just downstream of the viewing window. During the day, fish passage is controlled by the technician who opens/closes the set of gates downstream of the viewing window. At night, fish are denied passage from the fishway by closing these gates. When necessary, flow is maintained through the exit channel to ensure that adequate water quality exists for fish held overnight.

Fish passage data is handled by a single system that records and processes the data. The data (species and numbers passed) is recorded on a worksheet by the biologist or biological technician as fish pass the viewing window. At the end of each hour, fish passage data is entered into a Microsoft Excel spreadsheet and saved. Data processing and reporting is PC-based and accomplished by program scripts, or macros, created within Microsoft Excel spreadsheet software.

At day's end, the data is checked and verified by the biologist or biological technician. After data verification is completed, a daily summary of fish passage is produced and distributed to plant personnel. Each day's data is backed up to a flash drive and stored on-site. Daily reports and weekly summaries of fish passage numbers are electronically distributed to members of the Holtwood FPTAC and other co-operators.

3.0 MIGRATORY FISH PASSAGE RESULTS

3.1 Relative Abundance

The diversity and abundance of fishes collected and passed daily in the Holtwood fishway during the spring 2017 migratory fish passage period (April 18 to June 7) is presented in Table 2. A total of 162,843 fish of 23 taxa plus one hybrid passed upstream into Lake Aldred. Gizzard shad (151,902), American Shad (3,169), smallmouth bass (2,888), shorthead redhorse (1,786), and walleye (1,564), comprised 99% of all fishes passed. Other abundant fishes passed included channel catfish (867), and carp (442). The peak one-day passage of all species occurred on May 1, when 12,034 fish were passed, comprised mostly of gizzard shad (11,136), shorthead redhorse (374), and smallmouth bass (279).

3.2 American Shad Passage

A total of 3,169 American Shad were passed in 44 days at Holtwood during the 2017 official migratory fish passage season (April 18 to June 7); 1,411 American Shad passed in the tailrace lift while the spillway lift accounted for 1,758 American Shad (Table 3). One (1) additional American Shad was passed prior to the start of the migratory fish passage season along with 1 shad passed after the migratory season for an overall passage total of 3,171 American Shad. Collection and passage of shad varied daily with 90% of the overall total shad (2,899) passed by May 27 (Figures 1 and 2). The highest daily American Shad catch occurred on May 21 when 377 shad moved upstream during 9.9 hours of operation. On a daily basis, overall shad passage was consistent through the fishway between 0800 hrs and 1759 hrs, with the highest hour of shad passage occurring from 0900 to 0959 hrs (Table 4). Migratory fish passage operations were conducted at average water temperatures ranging from 56.9°F to 71.5°F and river flows between 28,300 and 105,000 cfs. Spillage occurred on 9 days during the spring migratory season and on 15 of the 51 days that the facility operated in 2017. River water temperatures did not reach 70°F until May 24 and river flows were generally higher than the flows experienced in 2015 and 2016.

The capture of American Shad at the fishway in 2017 occurred over a relatively broad range of station operation and discharge conditions this spring (Table 1). Shad were attracted to the tailrace lift at tailrace water elevations ranging from 110 ft. to 119 ft. Tailrace elevations correspond to unit operation, which varies due to river flow and power demand. Spillway lift operation now occurs with Unit #1 discharging into the spillway and with the use of the additional attraction water supply pipe, simultaneous operation of both the spillway and tailrace fish lifts is now and will continue to be a common occurrence.

Passage of American Shad into Lake Aldred occurred at Holtwood forebay elevations ranging from 164 ft. to 170 ft. (Table 1). A Forebay elevation of 170 or higher was observed during migratory fish passage operations for nearly 30% of the season (13 of 44 days). Spillage was a common occurrence at Holtwood during the 2017 migratory fish passage season, particularly during early and mid-May, which has historically been a period of strong migration and passage for American Shad.

The hourly passage numbers of American Shad at Holtwood are provided in Table 4. American Shad passage was consistent throughout the day, but strongest from 0900 hrs to 0959 hrs. The highest number of American Shad passed in one hour (63) occurred from 1200 to 1259 hrs on May 24.

Each year, we attempt to qualitatively assess the relative number of shad using the tailrace and spillway lifts by viewing each hopper of fish and estimating the number of shad in each lift as they are sluiced into the trough. We summarized this information by lift, and applied results to the daily shad passage count. We determined the number of shad captured by each lift and/or the percentage of

daily passage that was attributable to each lift. Based on this assessment, 1,413 and 1,758 shad were captured in the tailrace and spillway lifts over the total operating period in spring, 2017, respectively (Table 3). The percentage of American Shad passed by the spillway lift in recent years continues to be higher than those years of operation prior to the modifications made in the Piney Channel during redevelopment activities.

3.3 Other Alosids

In addition to the 3,171 American Shad passed in 2017, two alewife were also passed at Holtwood this season.

3.4 Maryland DNR tag-recapture

For most of the spring migratory fish passage season, water clarity was adequate, with visibility at the viewing window generally ranging from 18 to 24 inches. The viewing technicians identified 5 American Shad with attached Maryland DNR floy tags in 2017. Four of the 5 floy tags were yellow, from this year's tagging efforts downstream of Conowingo Dam, with 1 orange tag observed from tagging efforts in 2016. All floy tags were observed between April 29 and May 30.

3.5 American Shad Passage Evaluation

In spring 2017, our fishway evaluation efforts focused on maximizing the passage of American Shad at both the tailrace and spillway lifts with minimal interruptions to passage operations due to equipment breakdowns or malfunctions. However, during preseason testing, the split nuts on entrance Gate A failed, and the gate fell to its lowermost position (full open). With Gate A in the full open position, we were unable to create an effective attraction flow. This situation, along with the higher river flows observed this spring, may have impacted the American Shad catch from the tailrace fish lift. Both spillway and tailrace lift operations ended prematurely on May 24 and June 9, respectively due to two issues; a major mechanical failure of the spillway hopper hoist system and the Resource Agency request to terminate fish passage operations due to the passage of a Northern snakehead into Conowingo Pond by the Conowingo East Fish Lift on May 20.

We were unable to start spring fish passage operations prior to April 13 due to river flows exceeding 100,000 cfs. We operated in resident fish passage mode from April 13 to 17, switching to migratory fish passage mode on April 18 due to the increased passage of American Shad at Conowingo (423 on April 17). Migratory fish passage operations were interrupted due to high river flows on April 24 and May 6 through 11. During the spring fish passage season, the tailrace lift operated on 51 days while the spillway lift operated on 35 days.

We present a summary of American Shad passage at three river flow ranges in Table 5. A low, stable, river flow appears to be critical for enhancing American Shad passage rates. We documented 48% of American Shad passed at river flows less than 40,000 cfs, with 45% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. During migratory fish passage operations in 2017, river flows ranged from 28,300 cfs to 105,000 cfs; a much high range of flows than observed in 2015 and 2016.

The 2017 American Shad passage rate at Holtwood (19.5% of American Shad passing Conowingo passed Holtwood) was the seventh lowest rate observed since operations commenced in 1997 and well below the historical average observed from Holtwood since 1997 (Table 6). The American Shad passage season at Holtwood appeared to be hampered by the higher river flows experienced during the spring season.

We seek to optimize future migratory fish passage operations by utilizing knowledge gained through these twenty one years of operation. Debugging of the fishway occurred as needed throughout the season, and operation was modified based on conditions encountered on a daily basis.

4.0 RESIDENT FISH PASSAGE

4.1 Spring

During spring, 2017, resident fish passage operations were limited to 5 days in April due to high river flows during the first two weeks of the month and only 2 days in June due to the requested shutdown of the facility by the Resource Agencies. The facility operated 6 hours per day from 0900 to 1500 hrs per the settlement agreement. A total of 3,315 fish of 11 taxa was collected and passed during resident fish passage operations this spring (Table 7). We compared the passage of 7 resident species (smallmouth bass, walleye, channel catfish, shorthead redhorse, quillback, carp, and gizzard shad) passed during resident passage periods to passage of those same species during the migratory passage season (Table 8). During spring, 2017, 96% or more of the total resident fish observed were passed during the migratory fish passage season.

4.2 Fall

Fall resident fish passage operations were conducted using the tailrace fish lift only in 2017 due to the spillway fish lift equipment failures described previously (Table 9). During 32 days of operation, a total of 17,038 fish comprised of 11 species were passed (Table 10). Minnow species and gizzard shad accounted for nearly 99% of the total catch. It is anticipated that all repairs to the spillway fish lift will be completed before commencement of fish passage operations on April 1, 2018.

5.0 RECOMMENDATIONS

- 1) Continue to improve the current maintenance program to identify additional equipment maintenance inspection and testing activities to reduce in-season disruptions to operation. Unusual conditions, (e.g. severe flood events and additional operating requirements) require a more thorough review of the impacts to the equipment.
- 2) Operate the fishway at Holtwood Dam under annual operational guidelines developed and approved by the HFPTAC. Fishway operation should adhere to these guidelines; however, personnel must retain the ability to make “on-the-spot” modifications to maximize fishway performance.
- 3) Continue, as a routine part of fishway operation, a maintenance program that includes periodic scheduled drawdowns and cleaning of the exit channel as necessary, inspections of picket screens, and daily checks of crowder and hopper doors. Routine maintenance activities minimize disruption of fishway operation.
- 4) Implement protocols/guidelines to spill trash through gates 7 and 9 or the Obermeyer gate adjacent to the fish trough exit. This should be done on an as needed basis prior to or after daily scheduled fishway operations.

6.0 LITERATURE CITED

Normandeau Associates, Inc. 1998. Summary of operation at the Holtwood Fish Passage Facility in 1997. Report prepared for PPL, Inc., Allentown, PA.

Normandeau Associates, Inc. 1999. Summary of the operation at the Holtwood Fish Passage Facility in 1998. Report prepared for PPL, Inc., Allentown, PA.

TABLES AND FIGURES

Summary of daily average river flow, water temperature, unit operation, fishway weir gate operation, and project water elevations during operation of the Holtwood fish passage facility in spring, 2017.

Date	River Flow	Ave. Water	Secchi	Total #	Weir Gate Operation			Elevation (ft)		
	(cfs)	Temp. (°F)	(in)	of Units	A*	B	C*	Forebay	Tailrace	Spillway
13 Apr	86,100	53.3	10	12	X		X	170	119	126
14 Apr	73,800	55.1	10	12	X		X	170	118	121
15 Apr	64,400	56.3	16	12	X		X	169	117	119
16 Apr	57,400	58.1	18	12	X		X	168	117	119
17 Apr	51,100	59.9	20	12	X		X	168	116	119
18 Apr	46,700	61.0	20	11	X		X	169	115	119
19 Apr	43,200	62.1	22	11	X		X	168	115	120
20 Apr	40,500	62.9	22	11	X		X	167.5	115	119
21 Apr	38,700	63.3	22	11	X		X	167	115	118.5
22 Apr	48,300	63.9	20	11	X		X	167	116	119
23 Apr	105,000	61.8	18-12	12	X		X	170	119	128
24 Apr	110,000	61.3	} No operation due to River Flow ≥ 100,000 cfs							
25 Apr	88,400	58.8	8-10	12	X		X	170	119	129
26 Apr	71,300	58.3	6-8	12	X		X	170	118	120
27 Apr	60,200	58.5	12-16	12	X		X	168	118	118
28 Apr	51,800	60.5	18	12	X		X	167	117	119
29 Apr	47,200	62.4	18-20	11	X		X	166	116	119
30 Apr	46,000	64.0	18-20	11	X	X	X	169	114	120
1 May	44,200	66.6	18-20	12	X	X	X	167	116	119
2 May	40,900	68.1	18-20	8	X		X	164	114	119
3 May	66,800	68.1	20	12	X		X	164	116	119
4 May	83,600	66.5	15	12	X		X	170	118	126
5 May	84,300	64.4	6-8	12	X		X	170	119	128.5
6 May	107,000	62.2	} No operation due to River Flow ≥ 100,000 cfs							
7 May	156,000	59.8	} No operation due to River Flow ≥ 100,000 cfs							
8 May	178,000	56.9	} No operation due to River Flow ≥ 100,000 cfs							
9 May	165,000	55.3	} No operation due to River Flow ≥ 100,000 cfs							
10 May	133,000	56.0	} No operation due to River Flow ≥ 100,000 cfs							
11 May	106,000	56.3	} No operation due to River Flow ≥ 100,000 cfs							
12 May	88,000	56.9	6-8	12	X		X	170	119	127
13 May	76,200	56.3	15	12	X		X	170	118	123
14 May	68,200	57.0	18	12	X		X	170	118	120
15 May	63,200	57.7	20	12	X		X	169	117.5	119
16 May	58,900	60.2	20	12	X		X	169	117	119

Table 1

Continued.

Date	River Flow	Water	Secchi	Total #	Weir Gate Operation			Elevation (ft)		
	(cfs)	Temp. (°F)	(in)	of Units	A*	B	C*	Forebay	Tailrace	Spillway
17 May	54,400	61.5	18	12	X		X	169	118	120
18 May	49,900	65.7	22	11	X		X	168	117	119
19 May	44,500	68.3	18	10	X		X	169	116	119
20 May	39,800	68.0	24	11	X		X	169	114	119
21 May	35,800	68.8	24	8	X		X	169	112	118
22 May	32,900	69.1	24	8	X		X	164	113.5	118
23 May	30,600	69.9	28	8	X		X	164	112	118
24 May	28,300	70.3	22	7	X		X	169	110	120
25 May	27,000	69.2	22	7	X			169	111	118
26 May	27,300	69.5	22	8	X	X		168	113	118
27 May	29,100	68.2	22	6		X		170	111	118.5
28 May	31,900	69.1	24	11		X		169	114.5	118.5
29 May	32,400	69.0	24	11		X		169	113	119.5
30 May	33,200	68.4	24	8		X		169	114	119
31 May	40,200	69.8	24	12		X		169	114	119
1 Jun	63,600	70.9	24	12	X	X		170	117.5	119
2 Jun	71,600	70.2	24	12	X	X		170.5	119	126
3 Jun	68,700	70.7	24	12	X	X		170	117	125
4 Jun	59,900	71.4	24	12	X	X		170	118.5	119
5 Jun	50,000	71.5	24	12	X	X		169	117	119
6 Jun	42,700	70.2	24	9	X	X		169	114	120
7 Jun	38,500	70.0	18	10	X	X		169	115	119
8 Jun	41,300	70.2	20	10	X	X		169	115	118.5
9 Jun	56,200	70.5	20	12	X	X		168.5	118	119

*: Entrance Gate A in full-open position until repair on June 1, 2017

: Spillway Lift not operated from May 25 through season end due to hopper malfunction on May 24

Table 2

Summary of daily fish passage at Holtwood during the American shad passage season (18 Apr-7 June) in spring, 2017.

<i>Date</i>	4/18	4/19	4/20	4/21	4/22	4/23	4/24	4/25	4/26	4/27
<i>Hours of Operation- Tailrace:</i>	7.8	9.8	9.8	9.8	9.7	7.7		9.6	9.7	9.7
<i>Number of Lifts - Tailrace</i>	12	11	14	13	14	8		10	11	9
<i>Hours of Operation - Spillway:</i>	7.8	9.6	9.7	9.7	9.6	3.1		5.3	9.6	9.6
<i>Number of Lifts -Spillway:</i>	13	16	14	13	15	4		5	14	11
<i>Water Temperature (F)</i>	61.0	62.1	62.9	63.3	63.9	61.8	61.3	58.8	58.3	58.5
AMERICAN SHAD	80	121	255	114	97	16		2	3	6
HICKORY SHAD	0	0	0	0	0	0		0	0	0
BLUEBACK HERRING	0	0	0	0	0	0		0	0	0
ALEWIFE	0	0	2	0	0	0		0	0	0
GIZZARD SHAD	5,690	4,742	5,655	4,377	2,564	2,239		4,252	1,782	2,810
AMERICAN EEL	0	0	0	0	0	0		0	0	0
SEA LAMPREY	0	0	0	0	1	0		0	0	0
BROWN TROUT	0	0	0	0	0	0		0	0	0
RAINBOW TROUT	0	0	2	0	0	0		0	0	0
MUSKELLUNGE	0	0	0	1	0	0		0	1	0
CARP	0	22	3	51	1	2		1	9	1
QUILLBACK	1	0	0	0	0	0		0	0	0
WHITE SUCKER	0	0	0	0	0	0		0	0	0
SHORTHEAD REDHORSE	146	62	26	10	14	62		2	21	18
CHANNEL CATFISH	3	2	10	5	4	11		1	7	0
FLATHEAD CATFISH	0	0	0	0	0	0		1	1	0
WHITE PERCH	0	0	1	0	1	0		0	0	0
STRIPED BASS	0	0	0	0	0	0		0	0	0
ROCK BASS	2	0	1	0	0	1		0	0	0
PUMPKINSEED	0	0	0	0	0	0		0	0	0
BLUEGILL	0	1	0	0	0	0		0	0	0
SMALLMOUTH BASS	368	97	57	40	106	32		9	4	9
LARGEMOUTH BASS	4	1	0	0	0	0		0	0	0
WHITE CRAPPIE	0	0	0	0	0	0		0	0	0
BLACK CRAPPIE	0	0	1	1	1	0		0	0	0
WALLEYE	44	36	26	13	17	30		7	9	5
TIGER MUSKIE	0	0	0	0	1	0		0	0	0
<i>Daily Totals</i>	6,338	5,084	6,039	4,612	2,807	2,393	0	4,275	1,837	2,849

Table 2 (Continued)

<i>Date</i>	4/28	4/29	4/30	5/1	5/2	5/3	5/4	5/5	5/6	5/7
<i>Hours of Operation- Tailrace:</i>	9.6	9.6	9.6	9.5	9.6	9.6	9.7	9.6		
<i>Number of Lifts - Tailrace</i>	12	12	15	15	11	11	12	11		
<i>Hours of Operation - Spillway:</i>	9.5	9.7	9.7	9.5	9.6	9.7	9.5	7.0		
<i>Number of Lifts -Spillway:</i>	13	12	11	15	11	15	7	5		
<i>Water Temperature (F)</i>	60.5	62.4	64.0	66.6	68.1	68.1	66.5	64.4	62.2	59.8
AMERICAN SHAD	4	82	65	76	52	127	23	3		
HICKORY SHAD	0	0	0	0	0	0	0	0		
BLUEBACK HERRING	0	0	0	0	0	0	0	0		
ALEWIFE	0	0	0	0	0	0	0	0		
GIZZARD SHAD	3,151	6,309	9,126	11,136	5,151	4,805	5,767	1,505		
AMERICAN EEL	0	0	0	0	0	0	0	0		
SEA LAMPREY	0	0	0	0	0	0	0	0		
BROWN TROUT	0	1	0	0	0	0	0	3		
RAINBOW TROUT	0	0	1	0	0	0	0	0		
MUSKELLUNGE	0	0	0	0	0	0	1	0		
CARP	34	120	42	23	43	9	15	2		
QUILLBACK	1	0	16	2	1	0	3	2		
WHITE SUCKER	0	10	0	0	0	0	0	0		
SHORTHEAD REDHORSE	99	114	360	374	49	47	58	4		
CHANNEL CATFISH	3	4	8	29	11	15	39	41		
FLATHEAD CATFISH	0	0	2	0	0	0	1	5		
WHITE PERCH	1	0	0	1	0	0	2	0		
STRIPED BASS	0	0	0	0	0	0	0	0		
ROCK BASS	0	1	0	1	1	0	1	0		
PUMPKINSEED	0	0	0	0	0	0	0	0		
BLUEGILL	1	0	2	2	1	0	0	0		
SMALLMOUTH BASS	172	373	210	279	42	21	17	4		
LARGEMOUTH BASS	1	10	0	1	0	0	0	0		
WHITE CRAPPIE	0	0	0	0	2	0	0	0		
BLACK CRAPPIE	0	0	0	0	0	0	0	0		
WALLEYE	33	40	54	110	6	18	53	1		
TIGER MUSKIE	0	0	0	0	0	0	0	0		
<i>Daily Totals</i>	3,500	7,064	9,886	12,034	5,359	5,042	5,980	1,570	0	0

Table 2 (Continued)

<i>Date</i>	5/8	5/9	5/10	5/11	5/12	5/13	5/14	5/15	5/16	5/17
<i>Hours of Operation- Tailrace:</i>					9.7	9.7	9.7	9.6	9.6	9.6
<i>Number of Lifts - Tailrace</i>					10	10	11	11	11	12
<i>Hours of Operation - Spillway:</i>					9.6	9.6	9.6	9.7	9.7	9.7
<i>Number of Lifts -Spillway:</i>					10	8	12	11	11	17
<i>Water Temperature (F)</i>	56.9	55.3	56.0	56.3	56.9	56.3	57.0	57.7	60.2	61.5
AMERICAN SHAD					0	3	5	5	41	152
HICKORY SHAD					0	0	0	0	0	0
BLUEBACK HERRING					0	0	0	0	0	0
ALEWIFE					0	0	0	0	0	0
GIZZARD SHAD					643	389	345	915	1,448	2,788
AMERICAN EEL					0	0	0	0	0	0
SEA LAMPREY					0	0	0	0	0	0
BROWN TROUT					0	0	0	1	0	0
RAINBOW TROUT					0	0	0	0	1	1
MUSKELLUNGE					0	0	0	0	0	0
CARP					0	0	0	0	0	0
QUILLBACK					0	0	1	0	0	0
WHITE SUCKER					0	0	0	0	0	0
SHORTHEAD REDHORSE					1	3	25	20	18	50
CHANNEL CATFISH					8	1	3	1	1	4
FLATHEAD CATFISH					0	0	0	1	0	0
WHITE PERCH					0	0	0	0	0	0
STRIPED BASS					0	0	0	0	0	0
ROCK BASS					0	0	0	0	0	0
PUMPKINSEED					0	0	0	0	0	0
BLUEGILL					0	0	0	0	0	0
SMALLMOUTH BASS					7	18	8	14	39	93
LARGEMOUTH BASS					0	0	0	0	0	1
WHITE CRAPPIE					0	0	0	0	0	0
BLACK CRAPPIE					0	0	0	0	0	0
WALLEYE					1	4	11	3	25	105
TIGER MUSKIE					0	0	0	0	0	0
<i>Daily Totals</i>	0	0	0	0	660	418	398	960	1,573	3,194

Table 2 (Continued)

<i>Date</i>	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28
<i>Hours of Operation- Tailrace:</i>	9.6	9.5	9.6	9.9	3.8	8.5	9.6	9.7	4.2	10.1	9.6
<i>Number of Lifts - Tailrace</i>	14	13	16	14	6	10	14	13	6	16	17
<i>Hours of Operation - Spillway:</i>	9.8	9.7	9.5	9.9	9.7	9.6	4.5	0.0	0.0	0.0	0.0
<i>Number of Lifts -Spillway:</i>	14	8	14	14	15	13	7	0	0	0	0
<i>Water Temperature (F)</i>	65.7	68.3	68.0	68.8	69.1	69.9	70.3	69.2	69.5	68.2	69.1
AMERICAN SHAD	246	119	240	377	69	32	249	37	86	111	142
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	6,037	6,249	5,584	4,149	2,547	2,594	6,173	1,438	809	1,809	4,571
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	1	1	0	0	0	0	0	0	0
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	1	0	0	0	0	0	0	0
MUSKELLUNGE	0	1	0	0	0	0	0	0	0	0	0
CARP	5	1	5	11	1	0	3	0	0	0	3
QUILLBACK	0	2	7	2	0	1	0	0	0	0	0
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE	72	41	16	25	4	3	5	0	0	1	3
CHANNEL CATFISH	2	12	40	16	1	12	32	5	0	17	6
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0
WHITE PERCH	0	0	0	0	0	0	6	4	0	0	3
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0
ROCK BASS	1	0	5	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	1	0	0	0	0	0	0	0	0
BLUEGILL	2	6	8	6	0	0	4	3	0	1	2
SMALLMOUTH BASS	150	152	245	155	15	4	20	3	0	19	21
LARGEMOUTH BASS	1	3	0	0	0	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	1	0	0	0	0
BLACK CRAPPIE	0	0	0	1	0	0	0	0	0	0	0
WALLEYE	73	110	205	150	24	17	37	30	9	26	17
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0	0
<i>Daily Totals</i>	6,589	6,696	6,357	4,894	2,661	2,663	6,530	1,520	904	1,984	4,768

Table 2 (Continued)

<i>Date</i>	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5	6/6	6/7	<i>Season Totals</i>
<i>Hours of Operation- Tailrace:</i>	9.6	9.7	9.6	9.6	9.6	9.7	9.6	9.8	9.6	9.7	408.9
<i>Number of Lifts - Tailrace</i>	16	16	15	14	14	14	13	13	16	11	547
<i>Hours of Operation - Spillway:</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	268.8
<i>Number of Lifts -Spillway:</i>	0	0	0	0	0	0	0	0	0	0	348
<i>Water Temperature (F)</i>	69.0	68.4	68.4	70.9	70.2	70.7	71.4	71.5	70.2	70.0	
AMERICAN SHAD	36	20	33	18	5	7	2	2	3	3	3,169
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0	0	0	0	2
GIZZARD SHAD	1,715	652	1,695	3,113	2,505	6,259	2,830	1,779	1,186	619	151,902
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	1	0	0	0	0	0	0	0	4
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	5
RAINBOW TROUT	0	0	0	1	0	1	0	0	0	0	8
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	4
CARP	0	0	1	5	8	8	10	1	2	0	442
QUILLBACK	0	0	1	1	0	8	0	2	0	0	51
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	10
SHORTHEAD REDHORSE	2	2	8	6	1	6	0	1	7	0	1,786
CHANNEL CATFISH	5	14	25	36	233	76	44	18	50	12	867
FLATHEAD CATFISH	0	0	0	0	0	0	1	0	0	0	12
WHITE PERCH	0	0	0	3	0	0	0	0	0	0	22
STRIPED BASS	0	0	0	1	0	1	0	0	0	0	2
ROCK BASS	1	1	1	0	1	0	0	0	0	0	18
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0	1
BLUEGILL	2	1	2	2	0	1	1	2	1	2	53
SMALLMOUTH BASS	10	8	8	7	10	31	3	1	3	4	2,888
LARGEMOUTH BASS	0	0	0	0	0	1	0	0	1	0	24
WHITE CRAPPIE	0	0	1	0	0	0	0	0	0	0	4
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0	4
WALLEYE	39	58	24	21	26	14	14	11	3	5	1,564
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0	1
<i>Daily Totals</i>	1,810	756	1,800	3,214	2,789	6,413	2,905	1,817	1,256	645	162,843

No Operation: River Flow \geq 100,000cfs

Table 3

Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2017.

Date	Shad Catch	Number Collected		Percent Collected	
		Tailrace	Spillway	Tailrace	Spillway
13-Apr	0	0	0		
14-Apr	0	0	0		
15-Apr	0	0	0		
16-Apr	0	0	0		
17-Apr	1	1	0	100%	0%
18-Apr	80	4	76	5%	95%
19-Apr	121	54	67	45%	55%
20-Apr	255	76	179	30%	70%
21-Apr	114	46	68	40%	60%
22-Apr	97	49	48	51%	49%
23-Apr	16	16	0	100%	0%
25-Apr	2	2	0	100%	0%
26-Apr	3	0	3	0%	100%
27-Apr	6	3	3	50%	50%
28-Apr	4	0	4	0%	100%
29-Apr	82	41	41	50%	50%
30-Apr	65	13	52	20%	80%
1-May	76	30	46	39%	61%
2-May	52	3	49	6%	94%
3-May	127	13	114	10%	90%
4-May	23	18	5	78%	22%
5-May	3	3	0	100%	0%
12-May	0	0	0		
13-May	3	1	2	33%	67%
14-May	5	0	5	0%	100%
15-May	5	0	5	0%	100%
16-May	41	1	40	2%	98%
17-May	152	8	144	5%	95%
18-May	246	74	172	30%	70%
19-May	119	48	71	40%	60%
20-May	240	120	120	50%	50%
21-May	377	151	226	40%	60%
22-May	69	4	65	6%	94%
23-May	32	16	16	50%	50%
24-May	249	112	137	45%	55%
25-May	37	37	0	100%	0%
26-May	86	86	0	100%	0%
27-May	111	111	0	100%	0%
28-May	142	142	0	100%	0%
29-May	36	36	0	100%	0%
30-May	20	20	0	100%	0%
31-May	33	33	0	100%	0%
1-Jun	18	18	0	100%	0%
2-Jun	5	5	0	100%	0%
3-Jun	7	7	0	100%	0%
4-Jun	2	2	0	100%	0%
5-Jun	2	2	0	100%	0%
6-Jun	3	3	0	100%	0%
7-Jun	3	3	0	100%	0%
8-Jun	1	1	0	100%	0%
9-Jun	0	0	0		
Am. Shad Season	3,169	1,411	1,758	45%	55%
Total	3,171	1,413	1,758	45%	55%

Table 4

Hourly summary of American shad passage at the Holtwood fish passage facility in 2017 (17 April - 8 June).

DATE	4/17	4/18	4/19	4/20	4/21	4/22	4/23	4/24	4/25	4/26	4/27	4/28	4/29	4/30
Viewing Time (Start)	9:00	9:00	8:00	8:00	8:00	8:00	8:00		8:00	8:00	8:00	8:00	8:00	8:00
Viewing Time (End)	15:00	17:00	18:00	18:00	18:00	18:00	16:00		18:00	18:00	18:00	18:00	18:00	18:00
Viewing Time (hrs)	6.0	8.0	10.0	10.0	10.0	10.0	8.0	0.0	10.0	10.0	10.0	10.0	10.0	10.0
Water Temp.(°F)	59.9	61.0	62.1	62.9	63.3	63.9	61.8	61.3	58.8	58.3	58.5	60.5	62.4	64.0
Military Time (hrs)														
0600 to 0659														
0700 to 0759														
0800 to 0859			7	30	0	3	3		2	0	0	0	6	5
0900 to 0959	0	12	20	37	6	24	5		0	0	1	2	7	5
1000 to 1059	0	10	12	24	7	34	1		0	0	1	0	5	10
1100 to 1159	0	7	3	27	2	6	0		0	0	0	0	5	9
1200 to 1259	1	14	9	16	5	2	0		0	0	0	0	1	3
1300 to 1359	0	15	19	37	10	10	1		0	0	1	0	13	13
1400 to 1459	0	7	15	7	28	6	5		0	3	0	0	12	13
1500 to 1559		8	20	25	20	4	1		0	0	1	0	7	6
1600 to 1659		7	8	19	22	4			0	0	1	0	15	1
1700 to 1759			8	33	14	4			0	0	1	2	11	0
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	1	80	121	255	114	97	16	0	2	3	6	4	82	65

DATE	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14
Viewing Time (Start)	8:00	8:00	8:00	8:00	8:00							8:00	8:00	8:00
Viewing Time (End)	18:00	18:00	18:00	18:00	18:00							18:00	18:00	18:00
Viewing Time (hrs)	10.0	10.0	10.0	10.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	10.0	10.0
Water Temp.(°F)	66.6	68.1	68.1	66.5	64.4	62.2	59.8	56.9	55.3	56.0	56.3	56.9	56.3	57.0
Military Time (hrs)														
0600 to 0659														
0700 to 0759														
0800 to 0859	1	0	2	4	0							0	0	1
0900 to 0959	3	2	9	1	2							0	0	0
1000 to 1059	4	6	6	5	0							0	0	0
1100 to 1159	2	9	6	6	0							0	1	0
1200 to 1259	3	3	37	1	0							0	1	0
1300 to 1359	9	5	9	0	0							0	0	0
1400 to 1459	16	4	19	0	0							0	0	3
1500 to 1559	12	14	25	1	0							0	0	0
1600 to 1659	11	5	9	2	0							0	1	1
1700 to 1759	15	4	5	3	1							0	0	0
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	76	52	127	23	3	0	0	0	0	0	0	0	3	5

Table 4 (Continued)

DATE	5/15	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28
Viewing Time (Start)	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	14:30	8:00	8:00
Viewing Time (End)	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00
Viewing Time (hrs)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	3.5	10.0	10.0
Water Temp.(°F)	57.7	60.2	61.5	65.7	68.3	68.0	68.8	69.1	69.9	70.3	69.2	69.5	68.2	69.1
Military Time (hrs)														
0600 to 0659														
0700 to 0759														
0800 to 0859	0	0	24	53	15	25	82	0	2	42	0		22	9
0900 to 0959	3	6	21	51	0	18	77	21	12	43	1		15	16
1000 to 1059	0	3	14	39	0	26	63	15	5	36	1		4	5
1100 to 1159	1	7	27	21	0	27	32	13	6	28	2		8	4
1200 to 1259	0	7	23	17	51	23	45	1	4	63	3		23	12
1300 to 1359	0	4	16	10	16	42	25	10	3	17	8		8	24
1400 to 1459	0	4	9	13	9	20	11	8	0	5	3	0	17	22
1500 to 1559	0	2	6	8	10	17	25	0	0	14	8	11	3	22
1600 to 1659	0	5	4	18	6	24	11	1	0	1	3	41	6	12
1700 to 1759	1	3	8	16	12	18	6	0	0	0	8	34	5	16
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	5	41	152	246	119	240	377	69	32	249	37	86	111	142

DATE	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8	Season Totals
Viewing Time (Start)	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	9:00	
Viewing Time (End)	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	15:00	
Viewing Time (hrs)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	6.0	441.5
Water Temp.(°F)	69.0	68.4	69.8	70.9	70.2	70.7	71.4	71.5	70.2	70.0	70.2	
Military Time (hrs)												
0600 to 0659												0
0700 to 0759												0
0800 to 0859	10	2	3	2	0	0	0	0	0	0		355
0900 to 0959	1	3	1	2	1	0	0	1	0	0	0	429
1000 to 1059	0	3	2	3	0	0	0	0	1	0	0	345
1100 to 1159	3	6	1	1	2	0	1	0	1	1	0	275
1200 to 1259	0	2	9	1	0	3	0	0	0	1	0	384
1300 to 1359	1	0	0	2	1	1	0	1	1	1	1	334
1400 to 1459	9	1	2	0	0	2	1	0	0	0	0	274
1500 to 1559	6	1	1	2	0	0	0	0	0	0	0	280
1600 to 1659	1	1	10	3	1	1	0	0	0	0	0	255
1700 to 1759	5	1	4	2	0	0	0	0	0	0	0	240
1800 to 1859												0
1900 to 1959												0
2000 to 2059												0
Total	36	20	33	18	5	7	2	2	3	3	1	3171

Indicates American Shad passed during resident fish passage operations.
 Indicates No Operation due to River Flow ≥ 100,000 cfs

Table 5

Holtwood fishway summary table evaluating American shad passage at three river flow ranges (1997-2017).

	1997	1998*	1999	2000*	2001	2002*	2003*	2004*	2005	2006	2007
Migration season start date	18 Apr	27 Apr	25 Apr	06 May	27 Apr	15 Apr	28 Apr	26 Apr	27 Apr	11 Apr	01 May
Migration season end date	14 Jun	12 Jun	03 Jun	14 Jun	08 Jun	07 Jun	02 Jun	03 Jun	10 Jun	06 Jun	04 Jun
Season duration (days)	58	47	40	40	43	55	36	39	45	57	35
Number of days of operation	55	41	40	36	42	35	34	39	36	57	35
Am. shad season total (Conowingo)	90,971	39,904	69,712	153,546	193,574	108,001	125,135	109,360	68,926	56,899	25,464
Am. shad season total (Holtwood)	28,063	8,235	34,702	29,421	109,976	17,522	25,254	3,428	34,189	35,968	10,338
River flow \leq40,000 cfs											
Number of days	48	22	34	19	40	19	15	2	33	48	27
Percent of season	87%	54%	85%	53%	95%	54%	44%	5%	92%	84%	77%
No. of Am. shad passed	26,201	7,512	34,069	19,712	109,342	10,322	20,229	2	34,060	35,302	9,549
Daily ave. of Am. shad passed	546	341	1,002	1,037	2,733	543	1,348	1	1,032	735	354
Percent of total passage	93%	91%	98%	67%	99%	59%	80%	0%	99.6%	98.1%	92.3%
River flow 40,001 to 60,000 cfs											
Number of days	7	2	6	12	2	14	18	20	3	5	8
Percent of season	13%	5%	15%	33%	5%	40%	53%	51.3%	8%	9%	23%
No. of Am. shad passed	1,862	230	633	9,536	634	7,029	5,019	1,943	129	566	789
Daily ave. of Am. shad passed	266	115	106	795	317	502	279	97	43	113	99
Percent of Total Passage	7%	3%	2%	32%	1%	40%	19.8%	56.7%	0.4%	1.6%	7.6%
River flow >60,000 cfs											
Number of days	0	17	0	5	0	2	1	17	0	4	0
Percent of season	0%	41%	0%	14%	0%	6%	3%	43.6%	0%	7%	0%
No. of Am. shad passed	0	493	0	173	0	171	6	1,483	0	100	0
Daily ave. of Am. shad passed	0	29	0	35	0	86	6	87	0	25	0
Percent of total passage	0%	6%	0%	1%	0%	1%	0.02%	43.3%	0.0%	0.3%	0.0%

* Denotes seasons of high river flow or frequent spillage.

Table 5 (continued)

Holtwood fishway summary table evaluating American shad passage at three river flow ranges (1997-2017).

	2008*	2009*	2010	2011*	2012	2013	2014*	2015	2016	2017*
Migration season start date	21 Apr	03 May	21 Apr	20 May	07 Apr	29-Apr	27-Apr	1-May	21-Apr	18-Apr
Migration season end date	09 Jun	07 Jun	09 Jun	05 Jun	05 Jun	5-Jun	8-Jun	2-Jun	8-Jun	7-Jun
Season duration (days)	50	36	50	17	60	38	43	33	49	51
Number of days of operation	49	36	48	10	58	38	37	33	49	44
Am. shad season total (Conowingo)	19,914	29,272	37,757	20,571	22,143	12,733	10,425	8,341	14,276	16,248
Am. shad season total (Holtwood)	2,795	10,896	16,472	21	4,238	2,503	2,589	5,286	6,696	3,169
River flow ≤40,000 cfs										
Number of days	20	20	40	0	31	34	16	31	42	13
Percent of season	40%	56%	83%	0%	53%	89%	37%	94%	86%	29%
No. of Am. shad passed	2,242	8,939	15,606	0	3260	2,355	2248	5203	6,071	1,516
Daily ave. of Am. shad passed	112	447	372	0	105	70	141	168	144	117
Percent of total passage	80.2%	82%	95%	0%	77%	94%	87%	98%	91%	48%
River flow 40,001 to 60,000 cfs										
Number of days	22	14	8	2	18	4	12	2	7	17
Percent of season	44%	39%	17%	12%	30.0%	11%	28%	6%	14%	39%
No. of Am. shad passed	533	1,846	866	0	967	148	314	83	625	1,430
Daily ave. of Am. shad passed	24	132	108	0	54	37	26	41	89	84
Percent of Total Passage	19.0%	17.0%	5%	0.0%	22.8%	5.9%	12.0%	2.0%	9.0%	45%
River flow >60,000 cfs										
Number of days	8	2	0	15	4	0	15	0	0	14
Percent of season	16%	5%	0%	88%	6.7%	0.0%	34.9%	0.0%	0.0%	32%
No. of Am. shad passed	20	111	0	21	11	0	27	0	0	223
Daily ave. of Am. shad passed	2	55	0	2	3	0	2	0	0	16
Percent of total passage	0.7%	1.0%	0%	100%	0.3%	0.0%	1.0%	0.0%	0.0%	7.0%

* Denotes seasons of high river flow or frequent spillage.

Table 6**Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2017.**

	Conowingo East	Holtwood		Safe Harbor		York Haven	
		Number	% of C.E.L.	Number	% of Holt.	Number	% of S.H.
1997	90,971	28,063	30.8%	20,828	74.2%	-	-
1998	39,904	8,235	20.6%	6,054	73.5%	-	-
1999	69,712	34,702	49.8%	34,150	98.4%	-	-
2000	153,546	29,421	19.2%	21,079	71.6%	4,687	22.2%
2001	193,574	109,976	56.8%	89,816	81.7%	16,200	18.0%
2002	108,001	17,522	16.2%	11,705	66.8%	1,555	13.3%
2003	125,135	25,254	20.2%	16,646	65.9%	2,536	15.2%
2004	109,360	3,428	3.1%	2,109	61.5%	219	10.4%
2005	68,926	34,189	49.6%	25,425	74.4%	1,772	7.0%
2006	56,899	35,968	63.2%	24,929	69.3%	1,913	7.7%
2007	25,464	10,338	40.6%	7,215	69.8%	192	2.7%
2008	19,914	2,795	14.0%	1,252	44.8%	21	1.7%
2009	29,272	10,896	37.2%	7,994	73.4%	402	5.0%
2010	37,757	16,472	43.6%	12,706	77.1%	907	7.1%
2011	20,571	21	0.1%	8	38.1%	0	0.0%
2012	22,143	4,238	19.1%	3,089	72.9%	224	7.3%
2013	12,733	2,503	19.7%	1,927	77.0%	202	10.5%
2014	10,425	2,589	24.8%	1,336	51.6%	8	0.6%
2015	8,341	5,286	63.3%	3,896	73.7%	43	1.1%
2016	14,276	6,718	47.0%	4,242	63.1%	178	4.2%
2017*	16,265	3,169	19.5%	2,007	63.3%	62	3.1%

*Am. Shad passed at Holtwood from 18-April to 7-June.

Table 7

Daily summary of Holtwood resident fish passage prior to, during, and after the American shad passage season (13 April to 9 June) in spring, 2017.

DATE	4/13	4/14	4/15	4/16	4/17	4/18	4/19	4/20	4/21	4/22	4/23	4/24	4/25	4/26	4/27	4/28	4/29	Totals (13-29 Apr)
Hours of Operation - Tailrace	5.7	5.7	5.7	5.7	5.7	7.8	9.8	9.8	9.8	9.7	7.7		9.6	9.7	9.7	9.6	9.6	131.3
Number of Lifts - Tailrace	7	6	8	8	7	12	11	14	13	14	8		10	11	9	12	12	162
Hours of Operation - Spillway	5.6	5.6	5.6	5.5	5.7	7.8	9.6	9.7	9.7	9.6	3.1		5.3	9.6	9.6	9.5	9.7	121.2
Number of Lifts - Spillway	4	6	7	7	7	13	16	14	13	15	4		5	14	11	13	12	161
Water Temperature (°F)	53.3	55.1	56.3	58.1	59.9	61.0	62.1	62.9	63.3	63.9	61.8	61.3	58.8	58.3	58.5	60.5	62.4	
AMERICAN SHAD	0	0	0	0	1	80	121	255	114	97	16		2	3	6	4	82	781
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0	2	0	0	0		0	0	0	0	0	2
GIZZARD SHAD	465	211	300	611	1,106	5,690	4,742	5,655	4,377	2,564	2,239		4,252	1,782	2,810	3,151	6,309	46,264
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	1
BROWN TROUT	0	0	0	1	0	0	0	0	0	0	0		0	0	0	0	1	2
RAINBOW TROUT	0	0	0	0	2	0	0	2	0	0	0		0	0	0	0	0	4
MUSKELLUNGE	0	0	0	0	0	0	0	0	1	0	0		0	1	0	0	0	2
CARP	0	0	0	0	0	0	22	3	51	1	2		1	9	1	34	120	244
QUILLBACK	0	0	0	0	0	1	0	0	0	0	0		0	0	0	1	0	2
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	10	10
SHORTHEAD REDHORSE	0	0	2	23	27	146	62	26	10	14	62		2	21	18	99	114	626
CHANNEL CATFISH	3	0	0	0	1	3	2	10	5	4	11		1	7	0	3	4	54
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0		1	1	0	0	0	2
WHITE PERCH	0	0	0	0	0	0	0	1	0	1	0		0	0	0	1	0	3
STRIPED BASS	0	0	0	1	1	0	0	0	0	0	0		0	0	0	0	0	2
ROCK BASS	0	0	0	0	0	2	0	1	0	0	1		0	0	0	0	1	5
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
BLUEGILL	0	0	0	0	0	0	1	0	0	0	0		0	0	0	1	0	2
SMALLMOUTH BASS	0	1	2	55	43	368	97	57	40	106	32		9	4	9	172	373	1,368
LARGEMOUTH BASS	0	0	0	3	0	4	1	0	0	0	0		0	0	0	1	10	19
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	1	1	1	0		0	0	0	0	0	3
WALLEYE	7	14	5	15	13	44	36	26	13	17	30		7	9	5	33	40	314
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	1
Totals	475	226	309	709	1,194	6,338	5,084	6,039	4,612	2,807	2,393	0	4,275	1,837	2,849	3,500	7,064	49,711

Table 7 (Continued)

DATE	4/30	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14	5/15	5/16	Totals (30 Apr- 16 May)
Hours of Operation - Tailrace	9.6	9.5	9.6	9.6	9.7	9.6							9.7	9.7	9.7	9.6	9.6	105.9
Number of Lifts - Tailrace	15	15	11	11	12	11							10	10	11	11	11	128
Hours of Operation - Spillway	9.7	9.5	9.6	9.7	9.5	7.0							9.6	9.6	9.6	9.7	9.7	103.2
Number of Lifts - Spillway	11	15	11	15	7	5							10	8	12	11	11	116
Water Temperature (°F)	64.0	66.6	68.1	68.1	66.5	64.4	62.2	59.8	56.9	55.3	56.0	56.3	56.9	56.3	57.0	57.7	60.2	
AMERICAN SHAD	65	76	52	127	23	3							0	3	5	5	41	400
HICKORY SHAD	0	0	0	0	0	0							0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0							0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0							0	0	0	0	0	0
GIZZARD SHAD	9,126	11,136	5,151	4,805	5,767	1,505							643	389	345	915	1,448	41,230
AMERICAN EEL	0	0	0	0	0	0							0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0							0	0	0	0	0	0
BROWN TROUT	0	0	0	0	0	3							0	0	0	1	0	4
RAINBOW TROUT	1	0	0	0	0	0							0	0	0	0	1	2
MUSKELLUNGE	0	0	0	0	1	0							0	0	0	0	0	1
CARP	42	23	43	9	15	2							0	0	0	0	0	134
QUILLBACK	16	2	1	0	3	2							0	0	1	0	0	25
WHITE SUCKER	0	0	0	0	0	0							0	0	0	0	0	0
SHORTHEAD REDHORSE	360	374	49	47	58	4							1	3	25	20	18	959
CHANNEL CATFISH	8	29	11	15	39	41							8	1	3	1	1	157
FLATHEAD CATFISH	2	0	0	0	1	5							0	0	0	1	0	9
WHITE PERCH	0	1	0	0	2	0							0	0	0	0	0	3
STRIPED BASS	0	0	0	0	0	0							0	0	0	0	0	0
ROCK BASS	0	1	1	0	1	0							0	0	0	0	0	3
PUMPKINSEED	0	0	0	0	0	0							0	0	0	0	0	0
BLUEGILL	2	2	1	0	0	0							0	0	0	0	0	5
SMALLMOUTH BASS	210	279	42	21	17	4							7	18	8	14	39	659
LARGEMOUTH BASS	0	1	0	0	0	0							0	0	0	0	0	1
WHITE CRAPPIE	0	0	2	0	0	0							0	0	0	0	0	2
BLACK CRAPPIE	0	0	0	0	0	0							0	0	0	0	0	0
WALLEYE	54	110	6	18	53	1							1	4	11	3	25	286
TIGER MUSKIE	0	0	0	0	0	0							0	0	0	0	0	0
Totals	9,886	12,034	5,359	5,042	5,980	1,570	0	0	0	0	0	0	660	418	398	960	1,573	43,880

Table 7 (Continued)

DATE	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30	5/31	6/1	6/2	6/3	Totals (17 May- 3 June)
<i>Hours of Operation - Tailrace</i>	9.6	9.6	9.5	9.6	9.9	3.8	8.5	9.6	9.7	4.2	10.1	9.6	9.6	9.7	9.6	9.6	9.6	9.7	161.5
<i>Number of Lifts - Tailrace</i>	12	14	13	16	14	6	10	14	13	6	16	17	16	16	15	14	14	14	240
<i>Hours of Operation - Spillway</i>	9.7	9.8	9.7	9.5	9.9	9.7	9.6	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.4
<i>Number of Lifts - Spillway</i>	17	14	8	14	14	15	13	7	0	0	0	0	0	0	0	0	0	0	102
<i>Water Temperature (°F)</i>	61.5	65.7	68.3	68.0	68.8	69.1	69.9	70.3	69.2	69.5	68.2	69.1	69.0	68.4	68.4	70.9	70.2	70.7	
AMERICAN SHAD	152	246	119	240	377	69	32	249	37	86	111	142	36	20	33	18	5	7	1,979
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	2,788	6,037	6,249	5,584	4,149	2,547	2,594	6,173	1,438	809	1,809	4,571	1,715	652	1,695	3,113	2,505	6,259	60,687
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	3
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	4
MUSKELLUNGE	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CARP	0	5	1	5	11	1	0	3	0	0	0	3	0	0	1	5	8	8	51
QUILLBACK	0	0	2	7	2	0	1	0	0	0	0	0	0	0	1	1	0	8	22
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE	50	72	41	16	25	4	3	5	0	1	3	2	2	8	6	1	6	6	245
CHANNEL CATFISH	4	2	12	40	16	1	12	32	5	0	17	6	5	14	25	36	233	76	536
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WHITE PERCH	0	0	0	0	0	0	0	6	4	0	0	3	0	0	3	0	0	16	16
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	2
ROCK BASS	0	1	0	5	0	0	0	0	0	0	0	0	1	1	1	0	1	10	10
PUMPKINSEED	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
BLUEGILL	0	2	6	8	6	0	0	4	3	0	1	2	2	1	2	2	0	1	40
SMALLMOUTH BASS	93	150	152	245	155	15	4	20	3	0	19	21	10	8	8	7	10	31	951
LARGEMOUTH BASS	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6
WHITE CRAPPIE	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2	2
BLACK CRAPPIE	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
WALLEYE	105	73	110	205	150	24	17	37	30	9	26	17	39	58	24	21	26	14	985
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Totals</i>	3,194	6,589	6,696	6,357	4,894	2,661	2,663	6,530	1,520	904	1,984	4,768	1,810	756	1,800	3,214	2,789	6,413	65,542

Table 7 (Continued)

DATE	6/4	6/5	6/6	6/7	6/8	6/9	Total (4-9 June)	Res. Fish Passage Total (13-17 Apr+8-9 June)	Res. Fish during Am. Shad Season (18 Apr- 7 June)	Season Total (13-Apr- 9 June)
<i>Hours of Operation - Tailrace</i>	9.6	9.8	9.6	9.7	5.7	5.8	50.2	40	408.9	448.9
<i>Number of Lifts - Tailrace</i>	13	13	16	11	7	8	68	51	547	598
<i>Hours of Operation - Spillway</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28	268.8	296.8
<i>Number of Lifts - Spillway</i>	0	0	0	0	0	0	0	31	348	379
<i>Water Temperature (°F)</i>	71.4	71.5	70.2	70.0	70.2	70.5				
AMERICAN SHAD	2	2	3	3	1	0	11	2	3,169	3,171
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0	0	2	2
GIZZARD SHAD	2,830	1,779	1,186	619	186	194	6794	3,073	151,902	154,975
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0	0	0	4	4
BROWN TROUT	0	0	0	0	0	0	0	1	5	6
RAINBOW TROUT	0	0	0	0	0	0	0	2	8	10
MUSKELLUNGE	0	0	0	0	0	0	0	0	4	4
CARP	10	1	2	0	0	0	13	0	442	442
QUILLBACK	0	2	0	0	0	0	2	0	51	51
WHITE SUCKER	0	0	0	0	0	0	0	0	10	10
SHORTHEAD REDHORSE	0	1	7	0	0	0	8	52	1,786	1,838
CHANNEL CATFISH	44	18	50	12	2	6	132	12	867	879
FLATHEAD CATFISH	1	0	0	0	0	0	1	0	12	12
WHITE PERCH	0	0	0	0	0	0	0	0	22	22
STRIPED BASS	0	0	0	0	0	0	0	2	2	4
ROCK BASS	0	0	0	0	1	0	1	1	18	19
PUMPKINSEED	0	0	0	0	0	0	0	0	1	1
BLUEGILL	1	2	1	2	0	0	6	0	53	53
SMALLMOUTH BASS	3	1	3	4	0	4	15	105	2,888	2,993
LARGEMOUTH BASS	0	0	1	0	0	0	1	3	24	27
WHITE CRAPPIE	0	0	0	0	0	0	0	0	4	4
BLACK CRAPPIE	0	0	0	0	0	0	0	0	4	4
WALLEYE	14	11	3	5	3	5	41	62	1,564	1,626
TIGER MUSKIE	0	0	0	0	0	0	0	0	1	1
<i>Totals</i>	2,905	1,817	1,256	645	193	209	7,025	3,315	162,843	166,158

Table 8

Comparison of resident fish passage prior to, during, and after American shad passage operations at Holtwood Dam, spring 2017

Total Resident Fish Passed (April 13- June 9)		Res. Fish passed in Am. Shad Season (April 18-June 7)		Total Resident Passage Season (April 13-17: June 8-9)		Resident Passage (April 13-17)		Resident Passage (June 8-9)	
Species	Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed
Smallmouth Bass	2,993	2,888	96.5%	105	3.5%	101	3.4%	4	0.1%
Walleye	1,626	1,564	96.2%	62	3.8%	54	3.3%	8	0.5%
Channel Catfish	879	867	98.6%	12	1.4%	4	0.5%	8	0.9%
Shorthead Redhorse	1,838	1,786	97.2%	52	2.8%	52	2.8%	0	0.0%
Quillback	51	51	100.0%	0	0.0%	0	0.0%	0	0.0%
Carp	442	442	100.0%	0	0.0%	0	0.0%	0	0.0%
Gizzard shad	154,975	151,902	98.0%	3,073	2.0%	2,693	1.7%	380	0.2%

Table 9

Summary of daily average river flow, water temperature, unit operation, fishway weir gate operation, and project water elevations during operation of the Holtwood fish passage facility in Fall, 2017 (Sept. 1 - Oct.15).

Date	River Flow	Ave. Water	Secchi	Number	Weir Gate Operation			Elevation (ft)		
	(cfs)	Temp. (°F)	(in)	of Units	A	B	C*	Forebay	Tailrace	Spillway
1-Sep	9,930	76.0	18	2	X	X		169	109	118
2-Sep	9,480	74.8	18	3	X	X		168	108	118
3-Sep	9,750	73.8								
4-Sep	9,690	72.5								
5-Sep	9,660	72.3	18	3	X	X		168.5	109	119
6-Sep	12,600	72.0	18	2	X	X		169	108.5	118
7-Sep	15,100	71.5	18	3	X	X		169	110.5	118
8-Sep	13,500	70.3	18	3	X	X		169	109	118
9-Sep	12,200	69.9								
10-Sep	11,700	69.8								
11-Sep	10,700	69.8								
12-Sep	10,300	69.5	18	2	X	X		168	108	118
13-Sep	10,000	69.0	18	2	X	X		169	109	118
14-Sep	9,790	70.2	18	2	X	X		168.5	108.5	118
15-Sep	9,130	71.9	18	2	X	X		169	109	118
16-Sep	8,820	72.5	18	2	X	X		169	108	118
17-Sep	8,500	73.1								
18-Sep	8,410	72.5	18	2	X	X		169	109	118
19-Sep	8,350	71.6	18	2	X	X		169	108	118
20-Sep	8,430	72.9	18	2	X	X		169	108	118
21-Sep	8,710	74.2								
22-Sep	8,340	74.9	18	2	X	X		169	108	117
23-Sep	7,650	75.4	18	2	X	X		168.5	107	117
24-Sep	7,340	76.2	18	5	X	X		168.5	109	117
25-Sep	6,940	78.0	18	2	X	X		169	108	117
26-Sep	6,670	77.6	18	2	X	X		169	109	117
27-Sep	6,370	78.1	18	2	X	X		169	108	117
28-Sep	6,110	77.0								
29-Sep	5,870	75.6	18	2	X	X		169	107	117
30-Sep	5,640	74.8								
1-Oct	5,410	73.9	18	1	X	X		168	106	118
2-Oct	5,300	73.8	18	2	X	X		168.5	106	119
3-Oct	5,170	72.6	18	2	X	X		168	107	118
4-Oct	5,170	71.8	18	1	X	X		169	107	118
5-Oct	5,130	71.2	18	2	X	X		168	107	118
6-Oct	5,200	72.1								
7-Oct	5,290	71.1								
8-Oct	5,340	70.8	18	2	X	X		168	108	118
9-Oct	6,240	71.0	18	3	X	X		169	108.5	118
10-Oct	9,010	72.0	18	2	X	X		169	108	118
11-Oct	8,920	71.8	18	2	X	X		169	108	118
12-Oct	9,470	70.8	18	3	X	X		169	107	118
13-Oct	12,100	70.8								
14-Oct	12,000	70.7								
15-Oct	12,100	70.3	18	2	X	X		169	108	118

C*: No operation in Fall 2017 due to repair of spillway hopper hoist and guide beams

Table 10

Daily summary of resident fish passage at the Holtwood Fish Passage Facility in Fall, 2017 (Sept. 1 - October 15).

<i>Date:</i>	<i>1 Sep</i>	<i>2 Sep</i>	<i>3 Sep</i>	<i>4 Sep</i>	<i>5 Sep</i>	<i>6 Sep</i>	<i>7 Sep</i>	<i>8 Sep</i>	<i>9 Sep</i>	<i>10 Sep</i>	<i>11 Sep</i>	<i>12 Sep</i>
Hours of Operation - Tailrace:	6.0	6.0			6.0	6.0	6.0	6.0				4.7
Number of Lifts - Tailrace:	7	7			6	6	7	7				6
Hours of Operation - Spillway:	0.0	0.0			0.0	0.0	0.0	0.0				0.0
Number of Lifts - Spillway:	0	0			0	0	0	0				0
Water Temperature (*F):	76	74.8	73.8	72.5	72.3	72	71.5	70.3	69.9	69.8	69.8	69.5
Gizzard shad	709	114			132	17	384	290				6
Quillback												
Carp												
Minnnows (Notropis sp.)(est.)												
Shorthead Redhorse												
Channel Catfish	7	3			4	4	5	3				2
Flathead Catfish												
Striped Bass												
Bluegill					1							
Smallmouth Bass	4	6			5	2	7	3				3
Largemouth bass												2
Walleye								1				
Daily Total	720	123	0	0	142	23	396	297	0	0	0	13

<i>Date:</i>	<i>13 Sep</i>	<i>14 Sep</i>	<i>15 Sep</i>	<i>16 Sep</i>	<i>17 Sep</i>	<i>18 Sep</i>	<i>19 Sep</i>	<i>20 Sep</i>	<i>21 Sep</i>	<i>22 Sep</i>	<i>23 Sep</i>	<i>24 Sep</i>
Hours of Operation - Tailrace:	5.8	5.7	5.8	5.7		5.7	5.8	5.7		5.6	5.7	5.7
Number of Lifts - Tailrace:	6	7	7	7		6	6	6		6	6	6
Hours of Operation - Spillway:	0.0	0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0
Number of Lifts - Spillway:	0	0	0	0		0	0	0		0	0	0
Water Temperature (*F):	69	70.2	71.9	72.5	73.1	72.5	71.6	72.9	74.2	74.9	75.4	76.2
Gizzard shad	10	10	1	3		203	3	3		156	302	360
Quillback												
Carp						1		1				1
Minnnows (Notropis sp.)(est.)			400	200		100	100	300		1,000	500	
Shorthead Redhorse										1		
Channel Catfish	1		1							7	1	13
Flathead Catfish												
Striped Bass												
Bluegill				2			1					
Smallmouth Bass	3	2	3	1		1	4	3		4	2	2
Largemouth bass						1		1				
Walleye	1		1									
Daily Total	15	12	406	206	0	306	108	308	0	1,168	805	376

Table 10 (Continued)

<i>Date:</i>	25 Sep	26 Sep	27 Sep	28 Sep	29 Sep	30 Sep	1 Oct	2 Oct	3 Oct	4 Oct	5 Oct	6 Oct
<i>Hours of Operation - Tailrace:</i>	5.7	5.8	5.8		5.7		5.7	5.7	5.8	5.7	5.7	
<i>Number of Lifts - Tailrace:</i>	6	6	7		6		6	6	6	6	6	
<i>Hours of Operation - Spillway:</i>	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0	
<i>Number of Lifts - Spillway:</i>	0	0	0		0		0	0	0	0	0	
<i>Water Temperature (*F):</i>	78	77.6	78.1	77	75.6	74.8	73.9	73.8	72.6	71.8	71.2	72.1
Gizzard shad	752	51	3		2		263	182	67	239	104	
Quillback			1									
Carp		3					1					
Minnnows (Notropis sp.)(est.)		2,000	1,200		550		500	500			600	
Shorthead Redhorse												
Channel Catfish	2	10	9		2			4	2	3	1	
Flathead Catfish								1				
Striped Bass		1										
Bluegill								2				
Smallmouth Bass	4	5	3		1			2			1	
Largemouth bass												
Walleye							1					
Daily Total	758	2,070	1,216	0	555	0	765	691	69	242	706	0

<i>Date:</i>	7 Oct	8 Oct	9 Oct	10 Oct	11 Oct	12 Oct	13 Oct	14 Oct	15 Oct	TOTAL
<i>Hours of Operation - Tailrace:</i>		5.7	5.8	5.7	5.8	5.7			5.8	184.0
<i>Number of Lifts - Tailrace:</i>		6	6	6	6	6			6	200
<i>Hours of Operation - Spillway:</i>		0.0	0.0	0.0	0.0	0.0			0.0	0.0
<i>Number of Lifts - Spillway:</i>		0	0	0	0	0			0	0
<i>Water Temperature (*F):</i>	71.1	70.8	71	72	71.8	70.8	70.8	70.7	70.3	
Gizzard shad		245	19	107	17	5			27	4,786
Quillback										1
Carp										7
Minnnows (Notropis sp.)(est.)			500	1,500	2,000	100			10	12,060
Shorthead Redhorse										1
Channel Catfish				3				1		88
Flathead Catfish										1
Striped Bass										1
Bluegill										6
Smallmouth Bass		2		2	1	1			2	79
Largemouth bass										4
Walleye										4
Daily Total	0	247	519	1,612	2,018	106	0	0	40	17,038

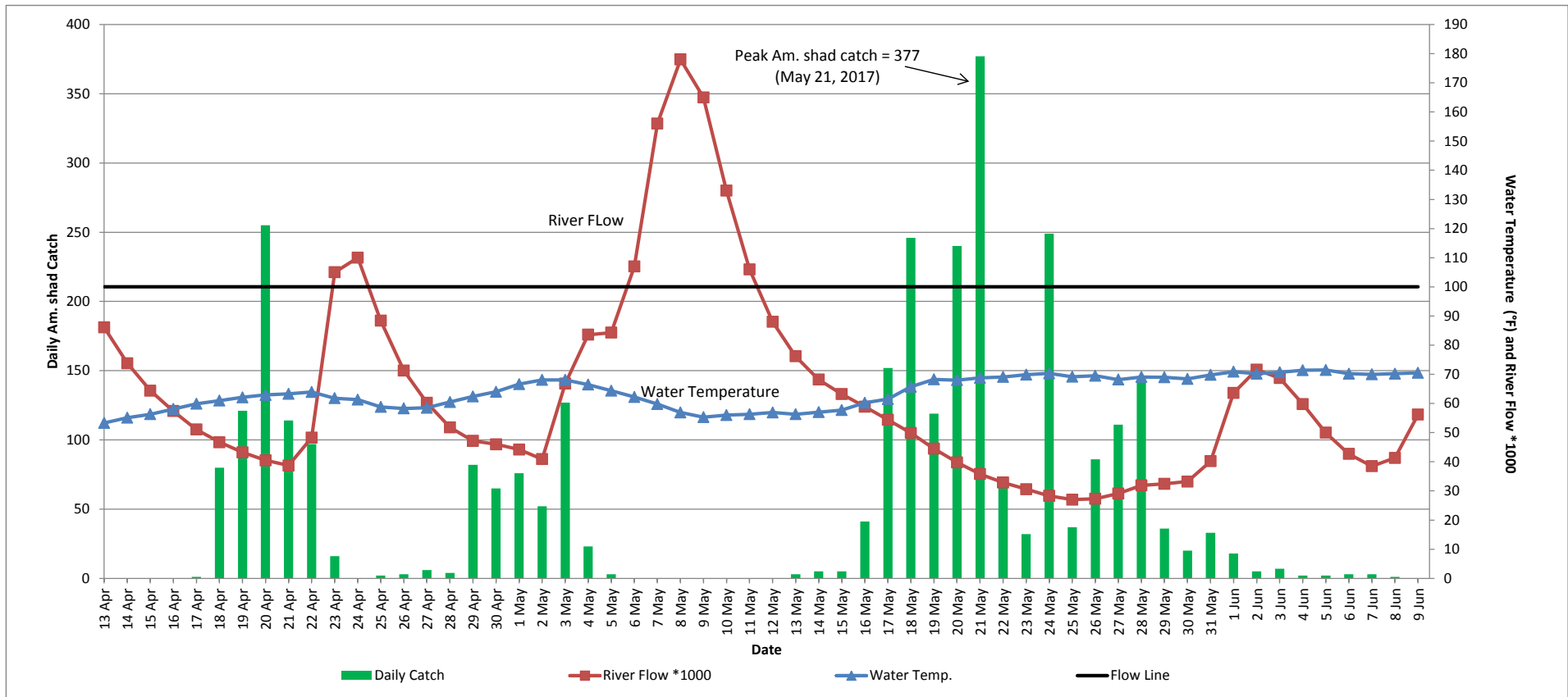


Figure 1

A plot of river flow (USGS Marietta Gauge) and water temperature (°F) in relation to the daily American shad catch at the Holtwood Fish Passage Facility, spring 2017.

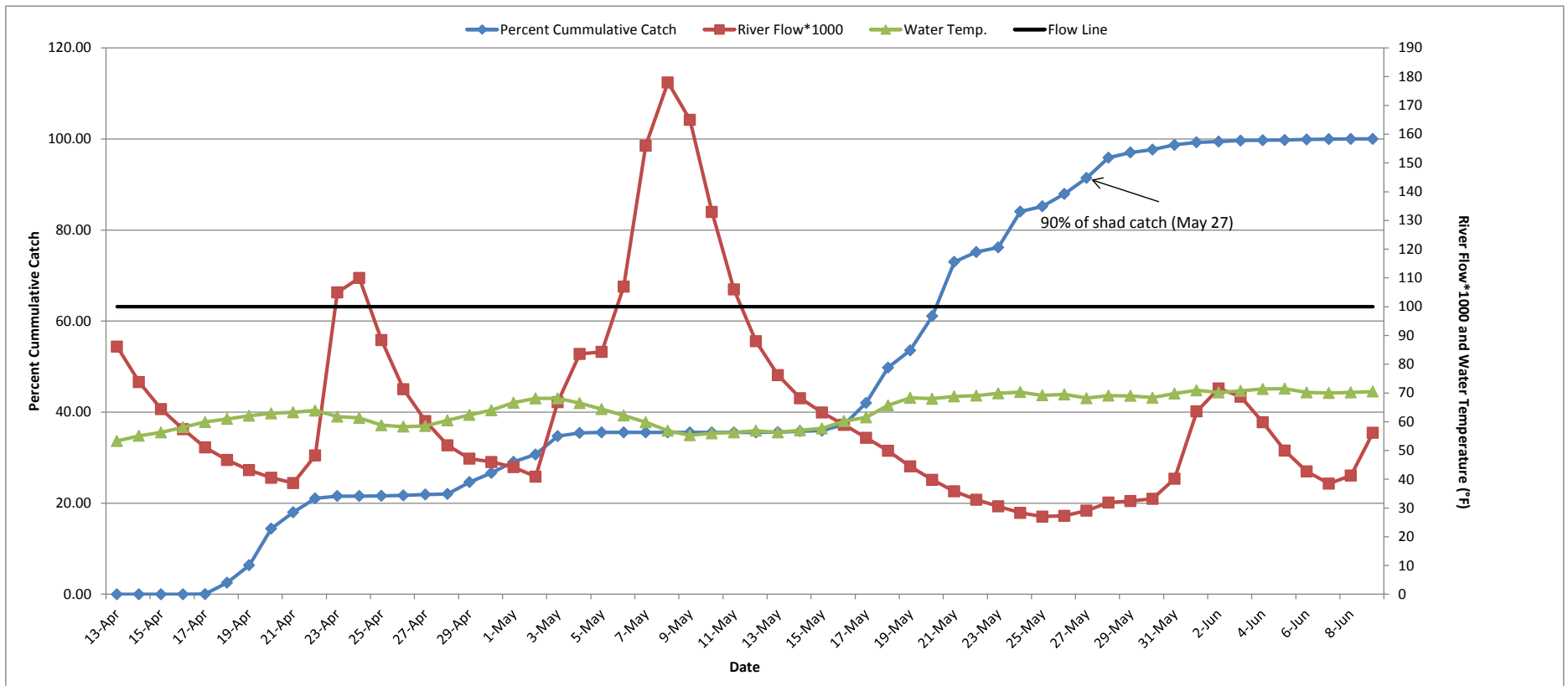


Figure 2

A plot of river flow (x 1000 cfs) and water temperature (°F) in relation to the percent cumulative American shad catch at the Holtwood Fish Passage Facility, spring 2017.

23-May	32	30,600	30.6	69.9	2,416	76.19	100
24-May	249	28,300	28.3	70.3	2,665	84.04	100
25-May	37	27,000	27.0	69.2	2,702	85.21	100
26-May	86	27,300	27.3	69.5	2,788	87.92	100
27-May	111	29,100	29.1	68.2	2,899	91.42	100
28-May	142	31,900	31.9	69.1	3,041	95.90	100
29-May	36	32,400	32.4	69.0	3,077	97.04	100
30-May	20	33,200	33.2	68.4	3,097	97.67	100
31-May	33	40,200	40.2	69.8	3,130	98.71	100
1-Jun	18	63,600	63.6	70.9	3,148	99.27	100
2-Jun	5	71,600	71.6	70.2	3,153	99.43	100
3-Jun	7	68,700	68.7	70.7	3,160	99.65	100
4-Jun	2	59,900	59.8	71.4	3,162	99.72	100
5-Jun	2	50,000	50.0	71.5	3,164	99.78	100
6-Jun	3	42,700	42.7	70.2	3,167	99.87	100
7-Jun	3	38,500	38.5	70.0	3,170	99.97	100
8-Jun	1	41,300	41.3	70.2	3,171	100.00	100
9-Jun	0	56,200	56.2	70.5	3,171	100.00	100

