

**SUMMARY OF OPERATIONS AT THE
HOLTWOOD FISH PASSAGE FACILITY
SPRING, 2016**

November 2016

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Prepared for

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EXECUTIVE SUMMARY

Per the settlement agreement for the Holtwood Redevelopment Project, 2016 marks the second year of fish passage operations for both resident and migratory fish species. The Holtwood fish passage facility commenced resident fish passage operations on April 1, 2016 for six hours per day (river flow permitting), switching to ten hour days of operation when a sufficient number of American shad were 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 not conducted in 2016 due to extensive repairs to the facility from equipment malfunctions that occurred during the June portion of resident fish passage operation. 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 able to start spring fish passage operations on April 1. We operated in resident fish passage mode from April 1 to 20, switching to migratory fish passage mode on April 21 due to the increased passage of American shad at Conowingo (54 and 457 American shad on April 19 and 20, respectively). Migratory fish passage operations continued without interruption through June 8. Migratory fish passage operations ended on June 8, with agency concurrence, due to sustained high water temperatures and low numbers of shad in the daily passage counts. Resident fish passage operations resumed on June 9 but were suspended on June 20, (10 days before scheduled end date of June 30), because of equipment failures at both lifts. Spillway lift operations were suspended on June 16 following the discovery of broken wire strands on the west-side hopper hoist cable and tailrace lift operations ended on June 20 stemming from a malfunction of the crowder which caused extensive damage to the crowder assembly. The facility operated a total of 81 days between April 1 and June 20, 2016, (Tailrace = 81 days; Spillway = 77 days). Fall fish passage operation did not occur in 2016 due to extensive repairs resulting from the malfunctions listed previously. This fish passage season marks the twentieth year of operation at Holtwood.

During the American shad passage season (49 days of operation from April 21 to June 8), the lifts passed 240,420 fish of 29 taxa and 1 hybrid. Gizzard shad, comely shiner, American shad, shorthead redhorse, and walleye dominated the catch, and comprised nearly 96% of the total fish collected and passed. American shad represented the sole *Alosa* species collected and passed at Holtwood in 2016. A total of 6,747 American shad were passed by the Holtwood fishway in 2016 (6,696 during the "official" shad passage season, with 22 and 29 American shad passed during resident fish passage operations in April and June, respectively).

The 2016 American shad passage rate at Holtwood (47% of American shad passing Conowingo passed Holtwood) was the sixth highest rate observed since operations commenced in 1997. This year also marks the longest period of daily operation without interruption from high river flow or equipment malfunction in Holtwood operating history (77 days).

During spring, 2016, resident fish passage operations were conducted on 20 days in April and 12 days in June. The facility operated 6 hours per day from 0900 to 1500 hrs per the settlement agreement. A total of 32,518 fish of 21 taxa plus one hybrid 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. Except for smallmouth bass and shorthead redhorse, 90% or more of the total resident fish observed this spring were passed during the migratory fish passage season. The majority of the smallmouth bass and shorthead redhorse not passed during migratory fish passage operations were passed in the April portion of resident fish passage operations.

Fall resident fish passage operations did not occur in 2016 due to the equipment failures described previously. It is anticipated that all repairs to the facility will be completed before commencement of fish passage operations on April 1, 2017.

This year was the twentieth 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 twentieth operational season.

Objectives of 2016 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 2016, all Obermeyer gates were operable; the installation of Obermeyer gate sections 2 and 3 was completed in December, 2015. Operations began at the Holtwood Fish Lift facility on April 1, 2016 to initiate passage of resident fish species prior to passage of American shad at Conowingo Dam. American shad passage operations at Holtwood (10-hr days) were initiated on April 21, one day after the Conowingo East fish lift passed 457 American shad. River flows greater than 100,000 cfs did not occur during fish passage operations in 2016, resulting in continuous operation from April 1 through June 20, 2016. Spill at the project did not occur except for a 2-hour period (1600 hrs to 1800 hrs) on May 5, (Table 1). In 2016, passage operations for migratory fish (American shad, etc.) ended on June 8, with agency concurrence, due to high water temperatures and low American shad passage. Spring passage operations for resident fish species ended on June 20, due to a major mechanical malfunction of the tailrace crowder system and operations for fall resident fish passage were suspended due to the extensive repairs required to fix the damaged fish lift equipment.

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 2016, 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 for most of the fish passage season. Obermeyer gate sections 2 and 3 were lowered for approximately 2 hours late in the afternoon on May 5 due to a sudden increase in generation from the Safe Harbor hydro facility.

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 new matrix continues. The following gate combinations were utilized in spring, 2016: Entrances A, B, and C (72 days); Entrances A and C (5 days); and Entrances A and B (4 days). All three entrance gates operating in unison was used most often in 2016 since the additional attraction water supply pipe provides a sufficient volume of water for all three entrance gates regardless of the Forebay water level.

2.2.2 Fishway Operation

Daily operation of the Holtwood fishway was based on the American shad catch, and managed to maximize that catch. Constant oversight by Holtwood station personnel and Normandeau staff ensured that maintenance activities and mechanical or electrical problems were dealt with immediately to minimize fish lift operational interruptions. Pre-season equipment preparations began in March, and were completed before season start-up. As in 2015, Gate C was adjusted manually with chain falls due to continued problems with the power screw drive mechanism.

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, 2016 commenced on April 1 and ended on June 20 (total days of operation = 81). The migratory fish passage season (based on presence of American shad in the catch) ran from April 21 to June 8 (49 days of operation). Spillway and tailrace lift operations ended on June 16 and 20, respectively due to two serious mechanical issues; discovery of broken wire strands on the Spillway's west-side hopper hoist cable and a mechanical failure to the tailrace crowder system resulting in extensive damage to the crowder assembly.

For the entire spring fish passage season, the tailrace lift operated on 81 days of the scheduled 91 day season while the spillway lift operated on 77 days. Resident fish passage operational hours were 0900 to 1500 hrs in spring, 2016, and we operated from 0800 to 1800 hrs during the migratory fish passage season per the redevelopment settlement agreement. Fall resident fish passage operations did not occur in 2016 due to extensive repairs required to ensure availability of the fish passage facility in spring, 2017.

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 rates are 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 insure 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 2016 migratory fish passage period (April 21 to June 8) is presented in Table 2. A total of 240,420 fish of 29 taxa plus one hybrid passed upstream into Lake Aldred. Gizzard shad (200,130), comely shiner (15,700), American shad (6,696), shorthead redhorse (4,548), and walleye (3,477),

comprised nearly 96% of all fishes passed. Other abundant fishes passed included spotfin shiner (3,300), spottail shiner (3,000) and smallmouth bass (1,599). The peak one-day passage of all species occurred on May 28, when 14,788 fish were passed, comprised mostly of gizzard shad (14,284), walleye (202), and carp (87).

3.2 American Shad Passage

A total of 6,696 American shad were passed in 49 days at Holtwood during the 2016 official migratory fish passage season (April 21 to June 8); 3,526 American shad passed in the tailrace lift while the spillway lift accounted for 3,170 American shad (Table 3). An additional 22 American shad were passed prior to the start of the migratory fish passage season along with 29 shad passed after the migratory season for an overall total of 6,747 American shad. Collection and passage of shad varied daily with 90% of the overall total shad (6,131) passed by May 26 (Figures 1 and 2). The highest daily American shad catch occurred on April 23 when 387 shad moved upstream during 9.8 hours of operation. On a daily basis, overall shad passage was consistent through the fishway between 0900 hrs and 1759 hrs, with the highest hour of shad passage occurring from 1300 to 1359 hrs (Table 4). Migratory fish passage operations were conducted at average water temperatures ranging from 57.0°F to 80.5°F and river flows between 17,800 and 55,800 cfs. Except for approximately two hours late in the afternoon on May 5, spillage did not occur during the spring migratory or resident fish passage operations in 2016. River water temperatures did not reach 70°F until May 27 and river flows were relatively low and stable during the entire fish passage season (April through June).

The capture of American shad at the fishway in 2016 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 108 ft. to 116.5 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 169 ft (Table 1). A forebay elevation of 168 to 168.5 ft. was observed during migratory fish passage operations for 71% of the season (35 of 49 days). Spillage did not occur at Holtwood during the 2016 migratory fish passage season except for approximately two hours late in the afternoon on May 5.

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 1200 hrs to 1359 hrs. The highest number of American shad passed in one hour (101) occurred from 1300 to 1359 hrs on April 22.

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, 3,552 and 3,195 shad were captured in the tailrace and spillway lifts over the total operating period in spring, 2016, 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 spring, 2016, no additional Alosids (alewife, blueback herring, or hickory shad) were 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 ranging from 18 to 24 inches. The viewing technicians identified 11 American shad with attached Maryland DNR floy tags in 2016. Ten of the 11 floy tags were orange, from this year's tagging efforts downstream of Conowingo Dam, with 1 blue tag observed from tagging efforts in 2015. All floy tags were observed between April 29 and May 30.

3.5 American Shad Passage Evaluation

In spring 2016, 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. The spillway and tailrace lifts operated daily without interruption for 77 days (April 1 through June 16) and 81 days (April 1 to June 20), respectively. Spillway lift operation was suspended after operations ended on June 16 due to the discovery of broken wire strands on the west-side hopper hoist cable. The tailrace lift was unexpectedly shutdown on June 20 due to a malfunction of the crowder that caused serious damage to the entire crowder assembly. Due to the extent of the damage, repairs could not be completed in time to conduct fall resident fish passage operations in 2016. At this time, repairs are ongoing with the expectation that the fish passage facility will be available for the 2017 resident fish passage season starting April 1.

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 86% of American shad passed at river flows less than 40,000 cfs, with 14% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. During migratory fish passage operations in 2016, river flows ranged from 17,800 cfs to 55,800 cfs.

The 2016 American shad passage rate at Holtwood (47% of American shad passed at Conowingo were passed by Holtwood), was the sixth highest passage efficiency rate observed since Holtwood fish passage operations commenced in 1997 and well above the historical average of 31.2% observed at Holtwood from 1997 to 2015 (Table 6).

We seek to optimize future migratory fish passage operations by utilizing knowledge gained through these twenty 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, 2016, resident fish passage operations occurred from April 1 to 20, and June 9 to 20 (32 days). The facility was not operated to the end of June due to the mechanical problems mentioned previously. The facility operated 6 hours per day from 0900 to 1500 hrs per the settlement agreement. A total of 32,518 fish of 21 taxa plus one hybrid was collected and passed during resident fish passage operations this spring (Table 7). Resident fish passage in April accounted for 17,719 fish of 15 species and 1 hybrid while resident fish passage in June accounted for 14,799 fish of 16 taxa.

Gizzard shad comprised 85% of the catch in April with gizzard shad, comely shiner, and spotfin shiner comprising nearly 99% of the catch in June. The majority (98%) of smallmouth bass passed during resident fish passage operations occurred from April 1 to 20, 2016. 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, (Tables 7,8). Except for smallmouth bass and shorthead redhorse, 90% or more of the total resident fish observed this spring were passed during the migratory fish passage season.

4.2 Fall

Due to the extensive repairs required to fix the Holtwood fish passage facility, Fall resident fish passage operations were not conducted in 2016. We anticipate the repairs to be completed prior to the start of resident fish passage operation scheduled for April 1, 2017.

5.0 RECOMMENDATIONS

- 1) Continue 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

Table 1

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, 2016.

Date	River Flow		Secchi (in)	Total Units L/K	Weir Gate Operation				Elevation (ft)		
	Ave. Water Temp. (°F)	(cfs)			A	B	C*	Forebay	Tailrace	Spillway	
1 Apr	53.2	25,900	20	1/2	X	X	X	165.5	110	118	
2 Apr	54.1	25,700	26	6/2	X	X	X	168.5	109.5	118	
3 Apr	54.0	25,000	20	4/2	X	X	X	169	108.5	118	
4 Apr	54.0	24,600	18	10/2	X	X	X	168.5	116	119	
5 Apr	52.9	25,300	18	6/2	X	X	X	169	112	118	
6 Apr	51.6	25,500	20	6/2	X	X	X	167	112.5	118	
7 Apr	49.7	27,000	24	6/2	X	X	X	167	114	118	
8 Apr	48.8	30,400	24	4/2	X	X	X	166	113	118	
9 Apr	48.3	32,400	26	6/2	X	X	X	168	113	118	
10 Apr	47.7	37,900	26	5/2	X	X	X	167	109	118	
11 Apr	47.2	52,400	26	10/2	X	X	X	168	116	119	
12 Apr	47.0	52,400	26	10/2	X	X	X	167	117	118	
13 Apr	47.7	45,900	26	6/2	X	X	X	167	114	118	
14 Apr	48.9	44,200	26	8/2	X	X	X	169	116	118	
15 Apr	51.2	54,700	26	9/2	X	X	X	167.5	117	119	
16 Apr	53.1	54,200	26	10/2	X	X	X	168.5	116.5	119.5	
17 Apr	54.5	47,000	26	10/2	X	X	X	168	115	119	
18 Apr	56.4	41,400	26	4/2	X	X	X	166	110	118	
19 Apr	57.8	37,100	26	8/2	X	X	X	166	115.5	118	
20 Apr	59.5	33,800	26	2/2	X	X	X	168	111	118	
21 Apr	60.7	31,100	24	8/2	X	X	X	168	111	118	
22 Apr	61.5	29,000	22	6/2	X	X	X	168	111.5	118	
23 Apr	62.2	27,700	24	4/2	X	X	X	168	110.5	118	
24 Apr	62.5	26,500	24	6/2	X	X	X	169	113	118	
25 Apr	63.0	25,300	20	5/2	X	X	X	168	112	118.5	
26 Apr	63.6	24,000	20	3/2	X	X	X	168.5	111	118.3	
27 Apr	64.0	23,000	20	4/2	X	X	X	168.5	111	119.7	
28 Apr	63.6	22,400	20	8/2	X	X	X	168.6	110	118.2	
29 Apr	63.4	22,600	20	7/2	X	X	X	168.7	115	118	
30 Apr	62.6	22,000	18	4/2	X	X	X	169	110	118	
1 May	60.6	22,100	18	4/2	X	X	X	168.5	111	118	
2 May	57.8	23,400	18	4/2	X	X	X	168	110	118	
3 May	57.4	29,400	24	6/2	X	X	X	164	112	118	
4 May	57.5	36,000	24	5/2	X	X	X	164	112	118	

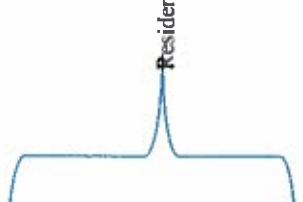
Table 1

Continued.

Date	River Flow (cfs)	Water Temp. (°F)	Secchi (in)	Total Units L/K	Weir Gate Operation			Elevation (ft)		
					A	B	C*	Forebay	Tailrace	Spillway
5 May	49,600	58.1	16-18	9/2	X	X	X	168.5**	115	120
6 May	53,100	58.2	16-18	8/2	X	X	X	168.5	117	120
7 May	55,800	57.0	18	9/2	X		X	167.5	116.5	119.5
8 May	53,300	57.0	18	9/2	X		X	168	116	119
9 May	50,700	58.0	18	8/2	X	X	X	168.5	117	120
10 May	47,500	59.0	18	9/2	X	X	X	168	114	119
11 May	42,600	58.9	18	7/2	X	X	X	168	113	118
12 May	38,200	58.8	18	5/2	X	X	X	168.5	114	118
13 May	35,000	59.5	18	4/2	X	X	X	168.7	113.7	119.5
14 May	33,000	60.4	20	4/2	X	X	X	168.5	112.5	119.5
15 May	31,900	61.3	20	6/2	X	X	X	168	112	119
16 May	31,600	61.7	18	4/2	X	X	X	168	113.5	119
17 May	31,500	61.0	16-18	10/1	X	X	X	169	114	120
18 May	31,000	60.0	16-18	10/1	X	X	X	169	114	120
19 May	29,600	60.6	18-20	10/1	X	X	X	168.5	114	119
20 May	27,400	62.5	18-20	6/1	X	X	X	168	111	118
21 May	25,800	62.5	20-22	5/1	X	X	X	168	110	118.5
22 May	25,600	62.6	22	6/1	X	X	X	168.5	110	119
23 May	25,600	64.2	24	6/1	X	X	X	168.5	111.7	118.5
24 May	30,100	65.4	24	10/1	X	X	X	168.5	112	119
25 May	33,500	66.4	24	6/2	X	X	X	168.5	111	118
26 May	32,500	67.5	24	7/2	X	X	X	168	110	118
27 May	29,600	70.1	24	4/2	X	X	X	168.5	111	118.5
28 May	27,100	72.3	24	4/1	X	X	X	168	109	118.6
29 May	25,000	74.2	26	4/2	X	X	X	168.5	110	118.5
30 May	23,700	76.3	26-28	4/2	X	X	X	168	109	118
31 May	23,000	78.9	26	10/1	X	X	X	169	111	119
1 Jun	20,800	80.0	24	7/2	X	X	X	168	109.5	119
2 Jun	19,000	80.5	24	4/2	X	X	X	168.5	111	119.5
3 Jun	17,900	79.9	18	4/2	X	X	X	169	108	118.5
4 Jun	18,000	79.5	18	6/2	X	X	X	169	109	118
5 Jun	17,800	79.5	18	4/2	X	X	X	168.5	111.5	118
6 Jun	21,400	79.2	18	6/2	X	X	X	168	108.5	118
7 Jun	22,000	78.8	20	4/2	X	X	X	169	112	119
8 Jun	24,500	77.2	18	7/2	X	X	X	168.5	113	118.2
9 Jun	23,800	75.0	18	1/2	X	X	X	168.5	111	118
10 Jun	23,100	73.7	18	1/2	X	X	X	168	111	119
11 Jun	23,500	72.8	18	7/2	X	X	X	168	112	118.5

Table 1

Continued.

Date	River Flow (cfs)	Water Temp. (°F)	Secchi (in)	Total # of Units	Weir Gate Operation				Elevation (ft)		
					A	B	C*	Forebay	Tailrace	Spillway	
12 Jun	21,000	72.5	18	4/2	X	X	X	168	111.5	118.5	
13 Jun	18,400	72.4	20	1/2	X	X	X	168.8	109	119	
14 Jun	16,100	73.3	20	1/1	X	X	X	168	108	118	
15 Jun	14,300	73.7	20	1/1	X	X	X	168	109	118	
16 Jun	13,500	74.0	20-22	1/1	X	X	X	168.5	108.5	118	
17 Jun	13,300	74.6	22	1/1	X	X	X	169	109	119	
18 Jun	12,900	74.8	24	1/2	X	X	X	168.4	108	118.2	
19 Jun	12,600	77.5	24	1/1	X	X	X	168	108.5	118	
20 Jun	12,800	77.9	24	1/1	X	X	X	168.7	107	118.8	
21 Jun	11,600										
22 Jun	10,800										
23 Jun	10,100										
24 Jun	11,300										
25 Jun	10,700										
26 Jun	9,460										
27 Jun	8,660										
28 Jun	9,090										
29 Jun	11,200										
30 Jun	9,540										

Denotes the American shad passage season (fish lift operated 10 hours/day).

Tailrace crowder malfunction

*C Gate set at Elevation 115' for entire season

** denotes Spill

Summary of daily fish passage at Holtwood during the American shad passage season (April 21 - June 8) in spring, 2016.

	Date	4/21	4/22	4/23	4/24	4/25	4/26	4/27	4/28	4/29	4/30
<i>Hours of Operation - Tailrace:</i>		9.8	9.8	9.8	9.8	9.7	9.5	9.7	9.6	9.6	9.7
<i>Number of Lifts - Tailrace</i>		15	18	18	15	17	15	15	16	13	18
<i>Hours of Operation - Spillway:</i>		9.8	9.8	9.7	9.7	9.7	9.5	9.6	9.5	9.7	9.5
<i>Number of Lifts - Spillway:</i>		15	18	17	14	18	13	13	15	13	16
<i>Water Temperature (F)</i>		60.7	61.5	62.2	62.5	63	63.6	64	63.6	63.4	62.6
AMERICAN SHAD		126	346	387	376	242	136	96	377	129	295
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	0	0
GIZZARD SHAD		11,728	6,641	6,199	4,690	3,736	4,409	1,440	6,770	3,118	12,999
AMERICAN EEL		0	0	0	0	0	0	0	0	0	0
SEA LAMPREY		0	0	0	0	0	0	1	0	1	0
BROWN TROUT		0	0	0	0	2	0	2	0	0	0
RAINBOW TROUT		1	0	3	3	1	0	0	0	0	0
MUSKELLUNGE		0	0	1	0	0	2	0	0	0	0
CARP		51	5	0	1	11	5	62	3	3	13
COMELY SHINER		0	0	0	0	0	0	0	0	0	0
SPOTTAIL SHINER		0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER		0	0	0	0	0	0	0	0	0	0
QUILLBACK		1	0	0	1	0	0	29	20	42	9
WHITE SUCKER		0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE		386	274	310	329	294	162	332	182	153	147
CHANNEL CATFISH		1	0	1	1	0	0	6	0	4	5
FLATHEAD CATFISH		0	0	0	0	0	0	0	0	0	0
WHITE PERCH		0	0	0	0	0	0	0	0	0	0
STRIPED BASS		0	0	0	0	0	0	0	0	0	0
ROCK BASS		3	0	0	1	0	0	1	0	2	0
REDBREAST SUNFISH		0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH		0	0	0	0	0	0	0	0	0	0
PUMPKINSEED		0	0	0	0	0	0	0	0	0	0
BLUEGILL		0	2	0	0	1	0	0	0	0	0
SMALLMOUTH BASS		326	221	160	149	99	43	39	34	35	29
LARGEMOUTH BASS		0	0	0	0	1	0	0	0	0	0
WHITE CRAPPIE		0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE		0	0	0	0	0	0	0	0	0	0
YELLOW PERCH		0	1	0	0	0	0	0	0	0	0
WALLEYE		65	55	65	58	35	36	62	69	43	31
TESSELLATED DARTER		0	0	1	0	0	0	0	0	1	0
TIGER MUSKIE		0	0	0	1	0	0	0	0	0	0
STRIPED BASS (HYBRID)		0	0	0	0	0	0	0	0	0	0
BROOK TROUT		0	0	0	1	0	0	0	0	0	0
ATLANTIC NEEDLEFISH		0	0	0	0	0	0	0	0	0	0
<i>Daily Totals</i>		12,688	7,545	7,127	5,611	4,422	4,793	2,070	7,455	3,531	13,528

Table 2 (Continued)

Date	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10
Hours of Operation- Tailrace:	9.6	9.9	9.7	9.6	9.6	9.6	9.6	9.6	9.7	9.6
Number of Lifts - Tailrace	15	16	14	16	17	13	14	16	14	14
Hours of Operation - Spillway:	9.6	10.6	9.5	9.6	9.7	9.6	9.6	9.6	9.6	9.6
Number of Lifts -Spillway:	14	17	15	15	16	13	14	16	17	14
Water Temperature (F)	60.6	57.8	57.4	57.5	58.1	58.2	57	57	58	59
AMERICAN SHAD	28	108	141	179	99	25	52	258	127	30
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	0	0
GIZZARD SHAD	1,658	737	1,017	2,026	2,716	4,367	5,509	4,857	2,900	5,105
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0	0	1	0	0
BROWN TROUT	0	0	0	0	0	0	6	0	0	0
RAINBOW TROUT	0	0	0	0	0	0	0	1	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	2	0	0	1	2	9	0	1	189	2
COMELY SHINER	0	0	0	0	0	0	0	0	0	0
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0
QUILLBACK	0	0	0	0	2	17	6	1	8	2
WHITE SUCKER	0	0	0	0	0	0	1	0	0	0
SHORHEAD REDHORSE	40	0	1	10	85	60	57	54	127	234
CHANNEL CATFISH	0	0	0	0	0	9	0	3	0	0
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0
WHITE PERCH	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	0	0	0	0	0	0	1	0
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	1
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	0	0	0	0	0	0	0	0
SMALLMOUTH BASS	1	0	0	3	5	10	13	10	9	20
LARGEMOUTH BASS	0	0	1	0	0	1	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0
WALLEYE	33	1	5	13	53	17	18	33	31	78
TESSELLATED DARTER	0	0	0	0	0	0	1	0	0	0
TIGER MUSKIE	0	0	0	0	0	0	0	1	0	0
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0
Daily Totals	1,762	846	1,165	2,232	2,962	4,515	5,663	5,220	3,392	5,472

Table 2 (Continued)

	Date	5/11	5/12	5/13	5/14	5/15	5/16	5/17	5/18	5/19	5/20
<i>Hours of Operation - Tailrace:</i>		9.6	9.7	9.6	9.6	9.6	9.7	9.7	9.6	9.6	9.7
<i>Number of Lifts - Tailrace</i>		16	13	14	13	18	16	16	15	13	17
<i>Hours of Operation - Spillway:</i>		9.5	9.6	9.6	9.5	9.7	9.7	9.6	9.7	9.6	9.7
<i>Number of Lifts - Spillway:</i>		13	18	13	13	16	17	16	14	14	17
<i>Water Temperature (F)</i>		58.9	58.8	59.5	60.4	61.3	61.7	61	60	60.6	62.5
AMERICAN SHAD	34	138	45	204	262	260	48	26	343	282	
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	2,171	5,510	1,341	2,809	1,640	2,665	940	518	3,078	1,410	
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	1	0	0	0	0	0	0	0	1	0	0
BROWN TROUT	0	0	0	4	0	0	0	2	0	0	0
RAINBOW TROUT	0	0	0	1	0	0	0	3	0	0	0
MUSKELLUNGE	0	0	0	0	0	1	0	0	0	0	0
CARP	1	0	0	0	0	2	0	1	0	0	6
COMELY SHINER	0	0	0	0	0	0	0	0	0	0	0
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	9	0	0	1	0	0	0	9	2	0	11
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE	196	78	57	109	83	18	38	30	33	84	
CHANNEL CATFISH	6	0	0	0	8	2	0	10	0	0	0
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0
WHITE PERCH	1	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	0	0	1	1	0	1	0	1	0
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	4	0	0	0	1	0	0	0	0	0	0
SMALLMOUTH BASS	28	5	3	48	25	6	10	18	10	15	0
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0	0
WALLEYE	62	54	54	102	110	76	62	32	37	67	
TESSELLATED DARTER	0	0	0	0	0	0	0	0	0	0	0
TIGER MUSKIE	0	0	0	0	1	0	0	0	0	0	0
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0	0
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0
<i>Daily Totals</i>		2,513	5,785	1,500	3,278	2,131	3,031	1,098	650	3,504	1,876

Table 2 (Continued)

Date	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30
Hours of Operation - Tailrace:	9.6	9.7	9.7	9.7	9.7	9.7	9.6	9.6	9.7	9.6
Number of Lifts - Tailrace	13	16	15	18	18	16	16	22	18	20
Hours of Operation - Spillway:	9.6	9.6	9.7	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Number of Lifts - Spillway:	13	16	15	15	17	18	17	21	16	19
Water Temperature (F)	62.5	62.6	64.2	65.4	66.4	67.5	70.1	72.3	74.2	76.3
AMERICAN SHAD	100	120	345	122	154	69	81	61	75	75
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	0	0
GIZZARD SHAD	1,167	1,270	5,201	4,927	4,687	3,386	11,513	14,284	9,870	9,420
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	2	0	1	0	0
BROWN TROUT	0	0	0	0	1	0	0	2	0	0
RAINBOW TROUT	0	0	0	0	2	0	0	7	0	2
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	8	7	0	25	37	7	7	87	16	119
COMELY SHINER	0	0	0	0	0	0	0	0	1,500	0
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0
QUILLBACK	26	17	32	80	80	45	45	44	18	18
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE	57	39	56	45	41	42	86	50	25	17
CHANNEL CATFISH	0	6	0	2	7	2	1	18	23	39
FLATHEAD CATFISH	0	0	0	0	0	0	1	0	0	0
WHITE PERCH	0	0	0	0	0	0	0	1	0	1
STRIPED BASS	0	0	0	0	0	0	0	0	0	1
ROCK BASS	0	0	0	0	4	0	2	1	0	0
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	1	1	0	3	0	3	23	0	0
SMALLMOUTH BASS	34	36	30	23	9	41	7	7	3	0
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0
WALLEYE	67	145	136	168	132	165	229	202	173	124
TESSELATED DARTER	0	1	0	0	0	0	0	0	0	0
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0
Daily Totals	1,459	1,642	5,801	5,392	5,157	3,759	11,975	14,788	11,703	9,816

Table 2 (Continued)

	Date	5/31	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8	Totals
<i>Hours of Operation - Tailrace:</i>		9.6	9.6	9.5	9.6	9.5	9.6	9.6	9.7	9.6	472.8
<i>Number of Lifts - Tailrace</i>		17	18	16	15	16	16	16	13	15	774
<i>Hours of Operation - Spillway:</i>		9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.7	9.6	472.3
<i>Number of Lifts - Spillway:</i>		17	18	16	15	16	16	16	13	15	763
<i>Water Temperature (F)</i>		78.9	80	80.5	79.9	79.5	79.5	79.2	78.8	77.2	
AMERICAN SHAD		44	63	57	16	34	51	18	8	4	6,696
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	0	0
GIZZARD SHAD		5,668	4,282	1,986	1,581	1,819	1,980	895	971	519	200,130
AMERICAN EEL		0	0	0	0	0	0	0	2	0	2
SEA LAMPREY		0	0	0	0	0	0	0	0	0	8
BROWN TROUT		0	0	0	0	0	0	0	0	0	19
RAINBOW TROUT		0	1	0	0	0	0	0	0	0	25
MUSKELLUNGE		0	0	0	0	0	0	0	0	0	4
CARP		27	12	15	14	43	40	0	1	0	835
COMELY SHINER		0	2,500	1,400	2,900	500	2,200	1,200	500	3,000	15,700
SPOTTAIL SHINER		0	0	0	0	0	0	0	0	3,000	3,000
SPOTFIN SHINER		0	600	0	400	500	0	1,800	0	0	3,300
QUILLBACK		14	11	7	3	2	3	0	0	0	615
WHITE SUCKER		0	0	0	0	0	0	0	0	0	1
SHORTHEAD REDHORSE		31	41	20	6	13	14	0	1	1	4,548
CHANNEL CATFISH		15	52	16	77	12	9	3	3	10	351
FLATHEAD CATFISH		0	0	0	0	0	0	0	0	0	1
WHITE PERCH		0	0	0	0	0	0	0	0	0	3
STRIPED BASS		0	0	0	0	1	0	1	0	0	4
ROCK BASS		0	3	0	1	0	0	0	0	0	23
REDBREAST SUNFISH		1	0	0	0	0	0	0	0	1	2
GREEN SUNFISH		0	0	0	1	0	0	0	0	1	2
PUMPKINSEED		0	0	0	0	0	0	0	0	0	0
BLUEGILL		0	8	0	0	0	2	1	2	3	55
SMALLMOUTH BASS		23	0	10	0	0	1	1	0	0	1,599
LARGEMOUTH BASS		0	0	0	0	0	0	0	0	0	3
WHITE CRAPPIE		0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE		0	0	0	0	0	0	0	0	0	0
YELLOW PERCH		0	0	2	0	0	0	0	0	0	3
WALLEYE		156	140	59	37	33	20	13	13	8	3,477
TESSELLATED DARTER		0	0	0	0	0	0	0	0	0	4
TIGER MUSKIE		0	0	0	0	0	0	0	0	0	3
STRIPED BASS (HYBRID)		0	0	0	0	0	0	0	0	0	0
BROOK TROUT		0	0	0	0	0	0	0	0	0	1
ATLANTIC NEEDLEFISH		5	1	0	0	0	0	0	0	0	6
<i>Daily Totals</i>		5,984	7,714	3,572	5,036	2,957	4,320	3,932	1,501	6,547	240,420

Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2016.

Date	Shad Catch	Number Collected		Percent Collected	
		Tailrace	Spillway	Tailrace	Spillway
1-Apr	0	0	0	0%	0%
2-Apr	1	0	1	0%	100%
3-Apr	1	0	1	0%	100%
4-Apr	1	0	1	0%	100%
5-Apr	0	0	0	0%	0%
6-Apr	3	0	3	0%	100%
7-Apr	0	0	0	0%	0%
8-Apr	0	0	0	0%	0%
9-Apr	0	0	0	0%	0%
10-Apr	0	0	0	0%	0%
11-Apr	0	0	0	0%	0%
12-Apr	0	0	0	0%	0%
13-Apr	0	0	0	0%	0%
14-Apr	0	0	0	0%	0%
15-Apr	0	0	0	0%	0%
16-Apr	0	0	0	0%	0%
17-Apr	3	0	3	0%	100%
18-Apr	5	0	5	0%	100%
19-Apr	1	0	1	0%	100%
20-Apr	7	4	3	57%	43%
21-Apr	126	82	44	65%	35%
22-Apr	346	242	104	70%	30%
23-Apr	387	232	155	60%	40%
24-Apr	376	226	150	60%	40%
25-Apr	242	194	48	80%	20%
26-Apr	136	102	34	75%	25%
27-Apr	96	86	10	90%	10%
28-Apr	377	302	75	80%	20%
29-Apr	129	77	52	60%	40%
30-Apr	295	192	103	65%	35%
1-May	28	22	6	79%	21%
2-May	108	0	108	0%	100%
3-May	141	92	49	65%	35%
4-May	179	107	72	60%	40%
5-May	99	50	49	51%	49%
6-May	25	25	0	100%	0%
7-May	52	16	36	31%	69%
8-May	258	3	255	1%	99%
9-May	127	6	121	5%	95%
10-May	30	15	15	50%	50%
11-May	34	26	8	76%	24%
12-May	138	14	124	10%	90%
13-May	45	22	23	49%	51%
14-May	204	61	143	30%	70%
15-May	262	131	131	50%	50%
16-May	260	52	208	20%	80%
17-May	48	29	19	60%	40%
18-May	26	26	0	100%	0%

Table 3
(Continued)

Date	Shad Catch	Number Collected		Percent Collected	
		Tailrace	Spillway	Tailrace	Spillway
19-May	343	69	274	20%	80%
20-May	282	183	99	65%	35%
21-May	100	40	60	40%	60%
22-May	120	66	54	55%	45%
23-May	345	138	207	40%	60%
24-May	122	61	61	50%	50%
25-May	154	92	62	60%	40%
26-May	69	7	62	10%	90%
27-May	81	40	41	49%	51%
28-May	61	24	37	39%	61%
29-May	75	45	30	60%	40%
30-May	75	60	15	80%	20%
31-May	44	40	4	91%	9%
1-Jun	63	63	0	100%	0%
2-Jun	57	51	6	89%	11%
3-Jun	16	12	4	75%	25%
4-Jun	34	32	2	94%	6%
5-Jun	51	51	0	100%	0%
6-Jun	18	13	5	72%	28%
7-Jun	8	6	2	75%	25%
8-Jun	4	1	3	25%	75%
9-Jun	2	2	0	100%	0%
10-Jun	3	2	1	67%	33%
11-Jun	4	3	1	75%	25%
12-Jun	2	1	1	50%	50%
13-Jun	3	3	0	100%	0%
14-Jun	8	4	4	50%	50%
15-Jun	1	1	0	100%	0%
16-Jun	1	1	0	100%	0%
17-Jun	1	1	0	100%	0%
18-Jun	4	4	0	100%	0%
19-Jun	0	0	0	0%	0%
20-Jun	0	0	0	0%	0%
21-Jun	0	0	0	0%	0%
22-Jun	0	0	0	0%	0%
23-Jun	0	0	0	0%	0%
24-Jun	0	0	0	0%	0%
25-Jun	0	0	0	0%	0%
26-Jun	0	0	0	0%	0%
27-Jun	0	0	0	0%	0%
28-Jun	0	0	0	0%	0%
29-Jun	0	0	0	0%	0%
30-Jun	0	0	0	0%	0%
Am. Shad Season	6,696	3,526	3,170	53%	47%
Overall Total	6,747	3,552	3,195	53%	47%

Denotes Beginning and End of American Shad Migration Season
 Mechanical malfunction of tailrace crowder resulting in termination of resident fish passage operations.

Table 4
Hourly summary of American shad passage at the Holtwood fish passage facility in spring, 2016.

DATE	4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8	4/9	4/10	4/11	4/12	4/13	4/14
Viewing Time (Start)	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00
Viewing Time (End)	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00
Viewing Time (hrs)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Water Temp. (°F)	53.2	54.1	54.0	54.0	52.9	51.6	49.7	48.8	48.3	47.7	47.2	47.0	47.7	48.9
Military Time (hrs)														
0600 to 0659														
0700 to 0759														
0800 to 0859														
0900 to 0959	0	0	1	0	0	1	0	0	0	0	0	0	0	0
1000 to 1059	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1100 to 1159	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1200 to 1259	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1300 to 1359	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1400 to 1459	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1500 to 1559	0	1	0	0	0	1	0	0	0	0	0	0	0	0
1600 to 1659														
1700 to 1759														
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	0	1	1	1	0	3	0	0	0	0	0	0	0	0

DATE	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
Viewing Time (Start)	9:00	9:00	9:00	9:00	9:00	9:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00
Viewing Time (End)	15:00	15:00	15:00	15:00	15:00	15:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00
Viewing Time (hrs)	6.0	6.0	6.0	6.0	6.0	6.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Water Temp. (°F)	51.2	53.1	54.5	56.4	57.8	59.5	60.7	61.5	62.2	62.5	63.0	63.6	64.0	63.6
Military Time (hrs)														
0600 to 0659														
0700 to 0759														
0800 to 0859														
0900 to 0959	0	0	1	2	1	1	2	2	31	28	34	10	2	43
1000 to 1059	0	0	0	2	0	1	7	44	40	38	21	29	2	82
1100 to 1159	0	0	0	0	0	0	9	35	32	16	17	11	2	18
1200 to 1259	0	0	1	0	0	0	38	52	30	26	21	8	2	21
1300 to 1359	0	0	0	0	0	1	18	48	44	33	24	11	9	33
1400 to 1459	0	0	0	0	0	0	14	101	47	32	31	16	15	59
1500 to 1559	0	0	1	1	0	4	3	30	56	55	30	17	20	42
1600 to 1659							8	9	49	18	25	5	21	40
1700 to 1759							20	20	29	75	22	3	8	15
1800 to 1859							7	5	29	55	17	26	15	24
1900 to 1959														
2000 to 2059														
Total	0	0	3	5	1	7	126	346	387	376	242	136	96	377

Table 4 (Continued)

DATE	4/29	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
<i>Viewing Time (Start)</i>	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00
<i>Viewing Time (End)</i>	18:00	18:00	18:00	19:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00
<i>Viewing Time (hrs)</i>	10.0	10.0	10.0	11.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
<i>Water Temp. (°F)</i>	63.4	62.6	60.6	57.8	57.4	57.5	58.1	58.2	57.0	57.0	58.0	59.0	58.9	58.8
Military Time (hrs)														
0600 to 0659														
0700 to 0759														
0800 to 0859	12	1	12	0	0	2	10	1	1	0	8	1	1	2
0900 to 0959	9	17	2	0	3	39	12	7	2	19	19	7	4	22
1000 to 1059	8	11	2	0	15	24	12	1	0	15	43	7	3	15
1100 to 1159	6	27	2	0	4	18	19	3	8	31	34	1	4	28
1200 to 1259	16	51	4	0	15	23	9	3	1	31	6	1	2	28
1300 to 1359	10	35	0	1	20	22	6	2	2	76	8	2	5	7
1400 to 1459	14	48	2	0	11	21	7	1	4	28	2	3	3	2
1500 to 1559	21	52	4	0	12	17	15	4	5	43	5	3	7	18
1600 to 1659	16	27	0	0	31	7	7	2	9	14	2	3	4	9
1700 to 1759	17	26	0	76	30	6	2	1	20	1	0	2	1	7
1800 to 1859				31										
1900 to 1959														
2000 to 2059														
Total	129	295	28	108	141	179	99	25	52	258	127	30	34	138

DATE	5/13	5/14	5/15	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26
<i>Viewing Time (Start)</i>	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00
<i>Viewing Time (End)</i>	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
<i>Viewing Time (hrs)</i>	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
<i>Water Temp. (°F)</i>	59.5	60.4	61.3	61.7	61.0	60.0	60.6	62.5	62.5	62.6	64.2	65.4	66.4	67.5
Military Time (hrs)														
0600 to 0659														
0700 to 0759														
0800 to 0859	0	0	0	11	12	0	3	15	10	4	1	18	12	2
0900 to 0959	5	34	5	46	3	2	21	12	4	8	61	36	21	13
1000 to 1059	5	28	11	13	4	0	29	32	3	19	48	3	29	13
1100 to 1159	4	13	21	11	2	1	39	23	7	10	18	12	17	8
1200 to 1259	2	15	85	25	1	7	24	40	12	23	38	4	32	3
1300 to 1359	4	41	52	29	4	3	49	34	28	31	44	21	22	9
1400 to 1459	6	30	30	53	1	7	46	23	12	13	39	16	11	8
1500 to 1559	2	19	20	14	6	2	27	40	6	3	45	8	3	7
1600 to 1659	1	13	27	28	14	3	72	37	10	5	26	3	5	5
1700 to 1759	16	11	11	30	1	1	33	26	8	4	25	1	2	1
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	45	204	262	260	48	26	343	282	100	120	345	122	154	69

Table 4 (Continued)

DATE	5/27	5/28	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8	6/9
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	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	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	10.0	10.0	10.0	6.0
Water Temp. (°F)	70.1	72.3	74.2	76.3	78.9	80.0	80.5	79.9	79.5	79.5	79.2	78.8	77.2	75.0
Military Time (hrs)														
0600 to 0659														
0700 to 0759														
0800 to 0859	4	7	3	14	3	5	1	0	11	8	2	0	0	0
0900 to 0959	4	10	4	12	1	4	14	3	6	13	2	2	3	0
1000 to 1059	4	5	13	12	2	10	20	4	4	6	0	0	0	0
1100 to 1159	5	8	7	11	4	9	9	5	3	7	1	2	0	1
1200 to 1259	15	5	11	3	5	18	3	2	3	8	8	2	1	1
1300 to 1359	25	3	16	8	7	16	5	1	1	4	2	1	0	0
1400 to 1459	13	4	9	0	9	1	1	0	1	3	2	0	0	0
1500 to 1559	5	6	5	2	7	0	3	0	4	0	1	0	0	0
1600 to 1659	3	9	5	6	6	0	0	1	1	0	0	0	0	0
1700 to 1759	3	4	2	7	0	0	1	0	0	2	0	1	0	0
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	81	61	75	75	44	63	57	15	34	51	18	8	4	2

DATE	6/10	6/11	6/12	6/13	6/14	6/15	6/16	6/17	6/18	6/19	6/20	Season Totals
Viewing Time (Start)	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	
Viewing Time (End)	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	11:00	
Viewing Time (hrs)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	2.0	679
Water Temp. (°F)	73.7	72.8	72.5	72.4	73.3	73.7	74.0	74.6	74.8	77.5	77.9	
Military Time (hrs)												
0600 to 0659												0
0700 to 0759												0
0800 to 0859												349
0900 to 0959	0	0	0	0	1	0	0	1	0	0	0	783
1000 to 1059	2	2	0	0	0	0	1	0	0	0	0	621
1100 to 1159	1	0	0	0	2	0	0	0	1	0	0	646
1200 to 1259	0	0	0	0	0	1	0	0	3	0	0	812
1300 to 1359	0	1	2	2	2	0	0	0	0	0	0	979
1400 to 1459	0	1	0	1	3	0	0	0	0	0	0	750
1500 to 1559												616
1600 to 1659												603
1700 to 1759												557
1800 to 1859												31
1900 to 1959												0
2000 to 2059												0
Total	3	4	2	3	8	1	1	1	4	0	0	6,747

Table 5

Holtwood fishway summary table evaluating American shad passage at three river flow ranges (1997-2016).

	1997	1998*	1999	2000*	2001	2002*	2003*	2004*	2005	2006
Migration season start date	18 Apr	27 Apr	25 Apr	06 May	27 Apr	15 Apr	28 Apr	26 Apr	27 Apr	11 Apr
Migration season end date	14 Jun	12 Jun	03 Jun	14 Jun	08 Jun	07 Jun	02 Jun	03 Jun	10 Jun	06 Jun
Season duration (days)	58	47	40	40	43	55	36	39	45	57
Number of days of operation	55	41	40	36	42	35	34	39	36	57
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
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
River flow ≤40,000 cfs										
Number of days	48	22	34	19	40	19	15	2	33	48
Percent of season	87%	54%	85%	53%	95%	54%	44%	5%	92%	84%
No. of Am. shad passed	26,201	7,512	34,069	19,712	109,342	10,322	20,229	2	34,060	35,302
Daily ave. of Am. shad passed	546	341	1,002	1,037	2,733	543	1,348	1	1,032	735
Percent of total passage	93%	91%	98%	67%	99%	59%	80%	0%	99.6%	98.1%
River flow 40,001 to 60,000 cfs										
Number of days	7	2	6	12	2	14	18	20	3	5
Percent of season	13%	5%	15%	33%	5%	40%	53%	51.3%	8%	9%
No. of Am. shad passed	1,862	230	633	9,536	634	7,029	5,019	1,943	129	566
Daily ave. of Am. shad passed	266	115	106	795	317	502	279	97	43	113
Percent of Total Passage	7%	3%	2%	32%	1%	40%	19.8%	56.7%	0.4%	1.6%
River flow >60,000 cfs										
Number of days	0	17	0	5	0	2	1	17	0	4
Percent of season	0%	41%	0%	14%	0%	6%	3%	43.6%	0%	7%
No. of Am. shad passed	0	493	0	173	0	171	6	1,483	0	100
Daily ave. of Am. shad passed	0	29	0	35	0	86	6	87	0	25
Percent of total passage	0%	6%	0%	1%	0%	1%	0.02%	43.3%	0.0%	0.3%

* Denotes seasons of high river flow or frequent spillage.

Holtwood fishway summary table evaluating American shad passage at three river flow ranges (1997-2016).

	2007	2008*	2009*	2010	2011*	2012	2013	2014*	2015	2016
Migration season start date	01 May	21 Apr	03 May	21 Apr	20 May	07 Apr	29-Apr	27-Apr	1-May	21-Apr
Migration season end date	04 Jun	09 Jun	07 Jun	09 Jun	05 Jun	05 Jun	5-Jun	8-Jun	2-Jun	8-Jun
Season duration (days)	35	50	36	50	17	60	38	43	33	49
Number of days of operation	35	49	36	48	10	58	38	37	33	49
Am. shad season total (Conowingo)	25,464	19,914	29,272	37,757	20,571	22,143	12,733	10,425	8,341	14,276
Am. shad season total (Holtwood)**	10,338	2,795	10,896	16,472	21	4,238	2,503	2,589	5,286	6,696
River flow ≤40,000 cfs										
Number of days	27	20	20	40	0	31	34	16	31	42
Percent of season	77%	40%	56%	83%	0%	53%	89%	37%	94%	86%
No. of Am. shad passed	9,549	2,242	8,939	15,606	0	3260	2,355	2248	5203	6,071
Daily ave. of Am. shad passed	354	112	447	372	0	105	70	141	168	144
Percent of total passage	92.3%	80.2%	82%	95%	0%	77%	94%	87%	98%	91%
River flow 40,001 to 60,000 cfs										
Number of days	8	22	14	8	2	18	4	12	2	7
Percent of season	23%	44%	39%	17%	12%	30.0%	11%	28%	6%	14%
No. of Am. shad passed	789	533	1,846	866	0	967	148	314	83	625
Daily ave. of Am. shad passed	99	24	132	108	0	54	37	26	41	89
Percent of Total Passage	7.6%	19.0%	17.0%	5%	0.0%	22.8%	5.9%	12.0%	2.0%	9.0%
River flow >60,000 cfs										
Number of days	0	8	2	0	15	4	0	15	0	0
Percent of season	0%	16%	5%	0%	88%	6.7%	0.0%	34.9%	0.0%	0.0%
No. of Am. shad passed	0	20	111	0	21	11	0	27	0	0
Daily ave. of Am. shad passed	0	2	55	0	2	3	0	2	0	0
Percent of total passage	0.0%	0.7%	1.0%	0%	100%	0.3%	0.0%	1.0%	0.0%	0.0%

* Denotes seasons of high river flow or frequent spillage.

**Official 2016 American shad passage season (21-Apr to 8-Jun).

Table 6**Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2016.**

Year	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%

*Am. Shad passed at Holtwood from 2-April to 8-June, 2016.

Table 7
Daily summary of Holtwood resident fish passage prior to, during, and after the American shad passage season (1 April to 20 June) in spring, 2016.

DATE	4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8	4/9	4/10	4/11	4/12	4/13	4/14	4/15	4/16	4/17	Totals (1-17 Apr)
Hours of Operation - Tailrace	6.0	5.7	5.7	5.7	5.8	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.6	5.8	97.5
Number of Lifts - Tailrace	8	9	6	7	7	6	6	8	6	7	8	8	6	7	6	8	7	120
Hours of Operation - Spillway	6.0	5.7	5.8	5.7	5.8	5.7	5.7	5.6	5.8	5.8	5.7	5.8	5.8	5.8	5.8	5.6	5.8	97.9
Number of Lifts - Spillway	8	9	7	7	9	6	6	8	6	8	7	8	6	8	6	7	7	123
Water Temperature (°F)	53.2	54.1	54.0	54.0	52.9	51.6	49.7	48.8	48.3	47.7	47.2	47.0	47.7	48.9	51.2	53.1	54.5	
AMERICAN SHAD	0	1	1	1	0	3	0	0	0	0	0	0	0	0	0	0	3	9
HICKORY SHAD	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
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	1,264	1,960	202	504	402	332	657	73	7	51	465	504	53	125	354	997	1,368	9,318
AMERICAN EEL	0	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	0	0	0	0	0	0	0	0	0
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	1	0	4	0	0	0	0	0	0	0	0	0	1	1	0	2	2	11
MUSKELLUNGE	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2
CARP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMELY SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE	0	12	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHANNEL CATFISH	2	1	0	1	0	0	0	0	0	0	1	0	1	2	21	265	243	548
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
WHITE PERCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	3
SMALLMOUTH BASS	32	110	10	14	2	2	1	1	0	0	0	0	0	3	55	144	208	582
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	7
WHITE CRAPPIE	0	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	0	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	1	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
WALLEYE	2	22	11	19	7	1	0	0	0	1	16	20	3	0	8	17	8	135
TESSELATED DARTER	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	4
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	1,303	2,106	230	543	412	338	658	74	11	52	482	524	58	132	440	1,435	1,833	10,631

Table 7 (Continued)

DATE	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	5/1	5/2	5/3	5/4	Totals (18 Apr-4 May)
Hours of Operation - Tailrace	5.7	5.8	5.7	9.8	9.8	9.8	9.8	9.7	9.5	9.7	9.6	9.6	9.7	9.6	9.9	9.7	9.6	153.0
Number of Lifts - Tailrace	8	9	8	15	18	18	15	17	15	15	16	13	18	15	16	14	16	246
Hours of Operation - Spillway	5.8	5.8	5.8	9.8	9.7	9.7	9.7	9.7	9.5	9.6	9.5	9.7	9.5	9.6	10.6	9.5	9.6	153.2
Number of Lifts - Spillway	8	9	8	15	18	17	14	18	13	13	15	13	16	14	17	15	15	238
Water Temperature (°F)	56.4	57.8	59.5	60.7	61.5	62.2	62.5	63.0	63.6	64.0	63.6	63.4	62.6	60.6	57.8	57.4	57.5	
AMERICAN SHAD	5	1	7	126	346	387	376	242	136	96	377	129	295	28	108	141	179	2,979
HICKORY SHAD	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
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	1,758	2,633	1,409	11,728	6,641	6,199	4,690	3,736	4,409	1,440	6,770	3,118	12,999	1,658	737	1,017	2,026	72,968
AMERICAN EEL	0	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	0	0	1	0	0	0	0	0	2
BROWN TROUT	0	1	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	5
RAINBOW TROUT	1	0	4	1	0	3	3	1	0	0	0	0	0	0	0	0	0	13
MUSKELLUNGE	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	3
CARP	0	0	0	51	5	0	1	11	5	62	3	3	13	2	0	0	1	157
COMELY SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	0	0	0	1	0	0	1	0	0	29	20	42	9	0	0	0	0	102
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE	110	147	121	386	274	310	329	294	162	332	182	153	147	40	0	1	10	2,998
CHANNEL CATFISH	1	0	0	1	0	1	1	0	0	6	0	4	5	0	0	0	0	19
FLATHEAD CATFISH	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	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	1	0	3	0	0	1	0	0	1	0	2	0	0	0	0	0	8
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	3
SMALLMOUTH BASS	259	325	248	326	221	160	149	99	43	39	34	35	29	1	0	0	3	1,971
LARGEMOUTH BASS	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	4
WHITE CRAPPIE	0	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	0	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
WALLEYE	16	20	18	65	55	65	58	35	36	62	69	43	31	33	1	5	13	625
TESSELLATED DARTER	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
TIGER MUSKIE	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	2,152	3,128	1,808	12,688	7,545	7,127	5,611	4,422	4,793	2,070	7,455	3,531	13,528	1,762	846	1,165	2,232	81,863

Table 7 (Continued)

DATE	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14	5/15	5/16	5/17	5/18	5/19	5/20	5/21	Totals (5-21 May)
<i>Hours of Operation - Tailrace</i>	9.6	9.6	9.6	9.6	9.7	9.6	9.6	9.7	9.6	9.6	9.6	9.7	9.7	9.6	9.6	9.7	9.6	163.7
<i>Number of Lifts - Tailrace</i>	17	13	14	16	14	14	16	13	14	13	18	16	16	15	13	17	13	252
<i>Hours of Operation - Spillway</i>	9.7	9.6	9.6	9.6	9.6	9.6	9.5	9.6	9.6	9.5	9.7	9.7	9.6	9.7	9.6	9.7	9.6	163.5
<i>Number of Lifts - Spillway</i>	16	13	14	16	17	14	13	18	13	13	16	17	16	14	14	17	13	254
<i>Water Temperature (°F)</i>	58.1	58.2	57.0	57.0	58.0	59.0	58.9	58.8	59.5	60.4	61.3	61.7	61.0	60.0	60.6	62.5	62.5	
AMERICAN SHAD	99	25	52	258	127	30	34	138	45	204	262	260	48	26	343	282	100	2,333
HICKORY SHAD	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
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	2,716	4,367	5,509	4,857	2,900	5,105	2,171	5,510	1,341	2,809	1,640	2,665	940	518	3,078	1,410	1,167	48,703
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	3
BROWN TROUT	0	0	6	0	0	0	0	0	0	4	0	0	0	2	0	0	0	12
RAINBOW TROUT	0	0	0	1	0	0	0	0	0	1	0	0	0	3	0	0	0	5
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
CARP	2	9	0	1	189	2	1	0	0	0	0	2	0	1	0	6	8	221
COMELY SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	2	17	6	1	8	2	9	0	0	1	0	0	0	0	2	11	26	94
WHITE SUCKER	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SHORTHEAD REDHORSE	85	60	57	54	127	234	196	78	57	109	83	18	38	30	33	84	57	1,400
CHANNEL CATFISH	0	9	0	3	0	0	6	0	0	0	8	2	0	10	0	0	0	38
FLATHEAD CATFISH	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	1	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
ROCK BASS	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	5
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	5
SMALLMOUTH BASS	5	10	13	10	9	20	28	5	3	48	25	6	10	18	10	15	34	269
LARGEMOUTH BASS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
WHITE CRAPPIE	0	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	0	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WALLEYE	53	17	18	33	31	78	62	54	54	102	110	76	62	32	37	67	67	953
TESSELATED DARTER	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TIGER MUSKIE	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	2,962	4,515	5,663	5,220	3,392	5,472	2,513	5,785	1,500	3,278	2,131	3,031	1,098	650	3,504	1,876	1,459	54,049

Table 7 (Continued)

DATE	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	6/4	6/5	6/6	6/7	Totals (22 May -7 Jun)
Hours of Operation - Tailrace	9.7	9.7	9.7	9.7	9.7	9.6	9.6	9.7	9.6	9.6	9.6	9.5	9.6	9.5	9.6	9.6	9.7	163.7
Number of Lifts - Tailrace	16	15	18	18	16	16	22	18	20	17	18	16	15	16	16	16	13	286
Hours of Operation - Spillway	9.6	9.7	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.7	163.4
Number of Lifts - Spillway	16	15	15	17	18	17	21	16	19	17	18	16	15	16	16	16	13	281
Water Temperature (°F)	62.6	64.2	65.4	66.4	67.5	70.1	72.3	74.2	76.3	78.9	80.0	80.5	79.9	79.5	79.5	79.2	78.8	
AMERICAN SHAD	120	345	122	154	69	81	61	75	75	44	63	57	16	34	51	18	8	1,393
HICKORY SHAD	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
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	1,270	5,201	4,927	4,687	3,386	11,513	14,784	9,870	9,420	5,668	4,282	1,986	1,581	1,819	1,980	895	971	83,740
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	3
BROWN TROUT	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	3
RAINBOW TROUT	0	0	0	2	0	0	7	0	2	0	1	0	0	0	0	0	0	12
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMELY SHINER	7	0	25	37	7	7	87	16	119	27	12	15	14	43	40	0	1	457
SPOTTAIL SHINER	0	0	0	0	0	0	0	1,500	0	0	2,500	1,400	2,900	500	2,200	1,200	500	12,700
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	17	32	80	80	45	45	44	18	18	14	11	7	3	2	3	0	0	3,300
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	600	0	400	500	0	1,800	0	419
SHORTHEAD REDHORSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHANNEL CATFISH	39	56	45	41	42	86	50	25	17	31	41	20	6	13	14	0	1	527
FLATHEAD CATFISH	6	0	2	7	2	1	18	23	39	15	52	16	77	12	9	3	3	285
WHITE PERCH	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
STRIPED BASS	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2
ROCK BASS	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	3
REDBREAST SUNFISH	0	0	0	0	0	2	1	0	0	0	3	0	1	0	0	0	0	11
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
BLUEGILL	1	1	0	3	0	3	23	0	0	0	8	0	0	0	2	1	2	44
SMALLMOUTH BASS	36	30	23	9	41	7	7	3	0	23	0	10	0	0	1	1	0	191
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WHITE CRAPPIE	0	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	0	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
WALLEYE	145	136	168	132	165	229	202	173	124	156	140	59	37	33	20	13	13	1,945
TESSELATED DARTER	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	1,642	5,801	5,392	5,157	3,759	11,975	14,788	11,703	9,816	5,984	7,714	3,572	5,036	2,957	4,320	3,932	1,501	105,049

Table 7 (Continued)

DATE	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/16	6/17	6/18	6/19	6/20	Total (8-20 Jun)	Res. Fish Passage Total (1- 20 Apr + 9-20 June)	Res. Fish during Am. Shad Season (21 Apr - 8 June)	Season Total (1 Apr-20 June)
Hours of Operation - Tailrace	9.6	5.6	5.7	5.6	5.7	5.6	5.6	5.7	5.7	5.7	5.7	5.5	2	73.7	178.8	472.8	651.6
Number of Lifts - Tailrace	15	8	6	8	7	8	9	9	8	8	8	8	0	102	232	774	1,006
Hours of Operation - Spillway	9.6	5.7	5.7	5.6	5.7	5.6	5.7	5.5	5.3	0	0	0	0	54.4	160.1	472.3	632.4
Number of Lifts - Spillway	15	8	6	8	7	8	7	6	6	0	0	0	0	71	204	763	967
Water Temperature (°F)	77.2	75.0	73.7	72.8	72.5	72.4	73.3	73.7	74.0	74.6	74.8	77.5	77.9				
AMERICAN SHAD	4	2	3	4	2	3	8	1	1	1	4	0	0	33	51	6,696	6,747
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	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	519	177	185	937	507	119	545	587	341	665	648	411	12	5,653	20,252	200,130	220,382
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
SEA LAMPREY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	19	22
RAINBOW TROUT	0	0	1	0	0	0	0	0	0	0	0	0	0	1	17	25	42
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	6
CARP	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	835	836
COMELY SHINER	3,000	1,000	500	700	200	0	1,500	0	0	400	0	0	0	7,300	4,300	15,700	20,000
SPOTTAIL SHINER	3,000	0	0	0	0	0	0	0	0	0	0	0	0	3,000	0	3,000	3,000
SPOTFIN SHINER	0	2,000	500	600	200	1,000	0	500	0	400	0	0	0	5,200	5,200	3,300	8,500
QUILLBACK	0	0	0	1	0	0	0	0	2	0	0	0	0	3	3	615	618
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
SHORTHEAD REDHORSE	1	1	1	0	0	0	0	0	0	0	3	0	0	6	931	4,548	5,479
CHANNEL CATFISH	10	0	1	0	3	0	0	2	0	9	1	0	1	27	22	351	373
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
WHITE PERCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0	1	0	1	4	4	5
ROCK BASS	0	0	0	0	0	0	0	1	0	0	1	0	0	2	4	23	27
REDBREAST SUNFISH	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	2
GREEN SUNFISH	1	0	1	0	0	0	0	0	0	0	0	0	0	2	1	2	3
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	3	0	1	0	0	0	0	1	1	5	1	1	0	13	13	55	68
SMALLMOUTH BASS	0	1	2	2	4	2	1	6	2	7	0	1	0	28	1,442	1,599	3,041
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	12
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	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	1	0	0	0	0	0	0	0	0	5	5	3	8
WALLEYE	8	2	3	5	2	3	7	19	22	0	2	1	0	74	255	3,477	3,732
TESSELATED DARTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	8
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
BROOK TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Totals	6,547	3,183	1,198	2,249	919	1,127	2,061	1,117	369	1,487	661	415	13	21,346	37,518	240,420	272,938

Table 8
Comparison of resident fish passage prior to, during, and after American shad passage operations at Holtwood Dam, spring 2016.

Species	Total Resident Fish Passed (April 1-June 20)		Res. Fish passed in Am. Shad Season (Apr 21-Jun 8)		Total Resident Passage Season (April 1-20 + June 9-20)		Resident Passage (April 1-20)		Resident Passage (June 9-20)		
	Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed
Smallmouth Bass	3,041	1,599	52.6%	1,442	47.4%	1,414	46.5%	28	0.9%		
Walleye	3,732	3,477	93.2%	255	6.8%	189	5.1%	66	1.8%		
Channel Catfish	373	351	94.1%	22	5.9%	5	1.3%	17	4.6%		
Shorthead Redhorse	5,479	4,548	83.0%	931	17.0%	926	16.9%	5	0.1%		
Quillback	618	615	99.5%	3	0.5%	0	0.0%	3	0.5%		
Carp	836	835	99.9%	1	0.1%	0	0.0%	1	0.1%		
Gizzard shad	220,382	200,130	90.8%	20,252	9.2%	15,118	6.9%	5,134	2.3%		

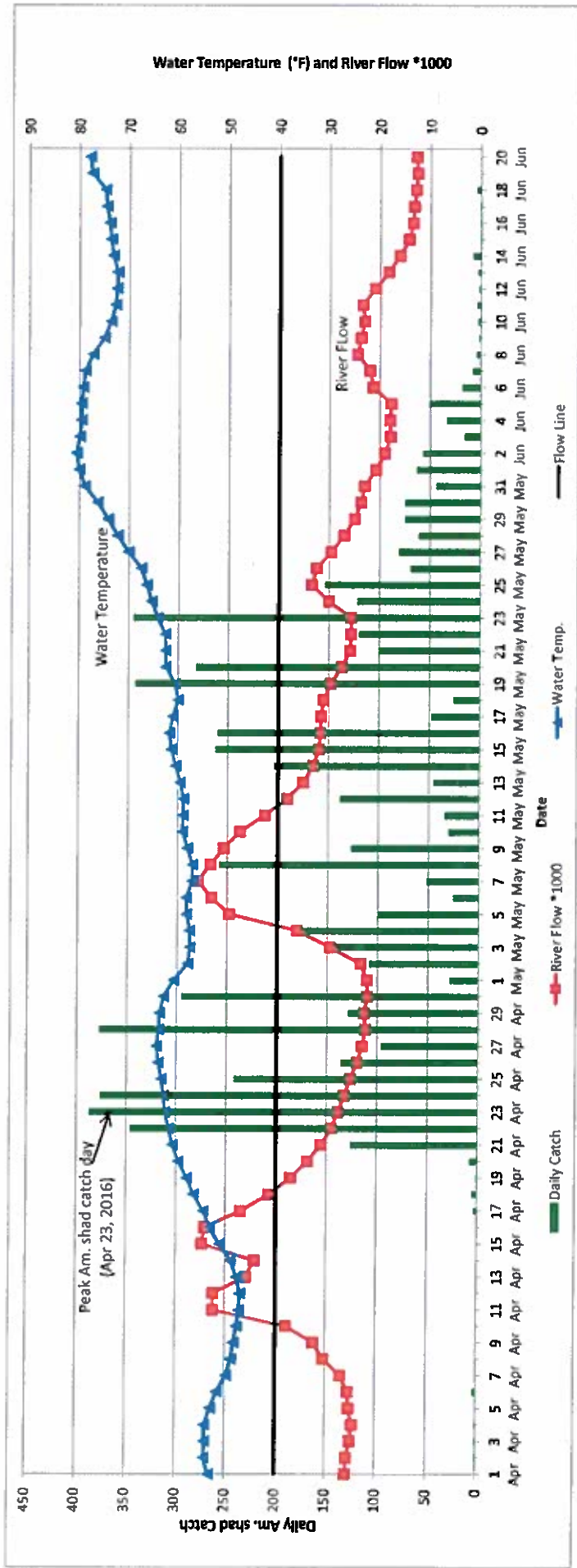


Figure 1

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 2016.

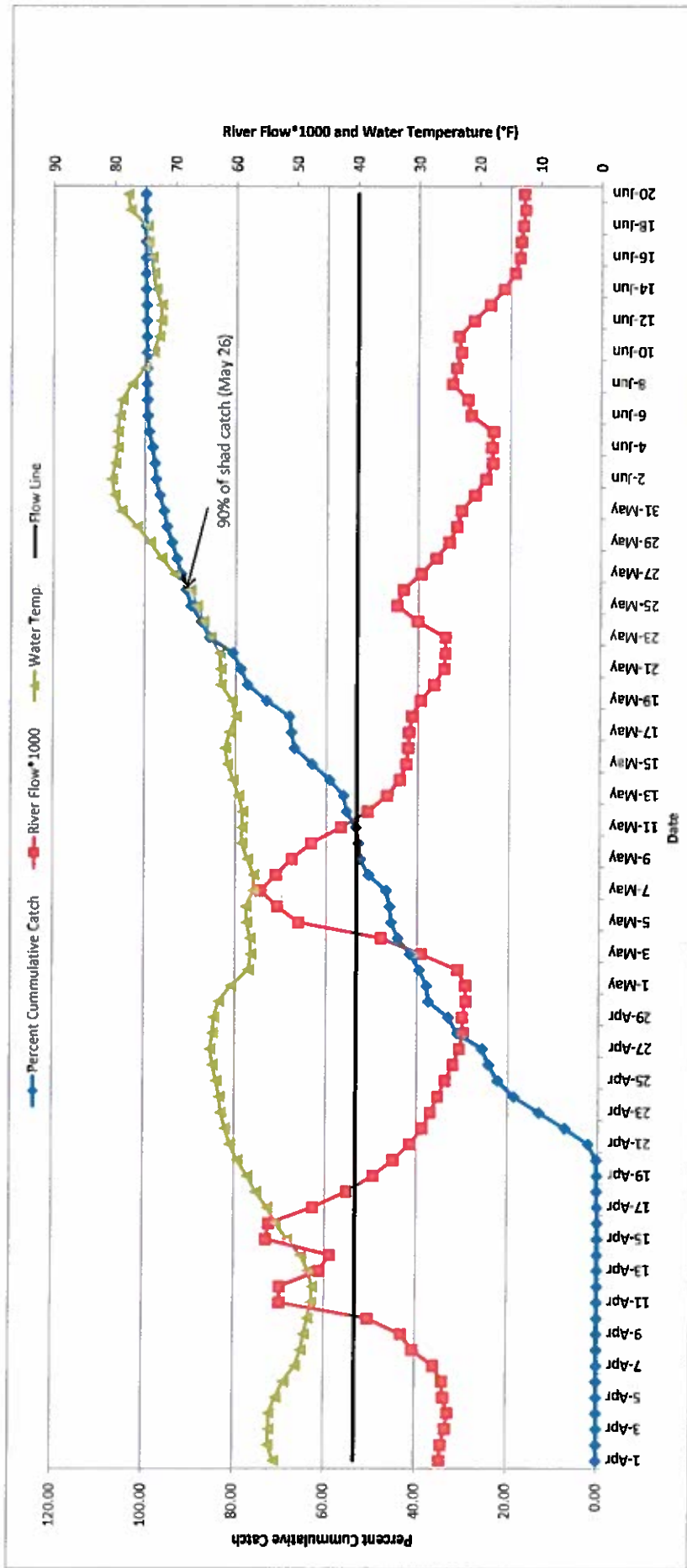


Figure 2

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 2016.