

**SUMMARY OF OPERATIONS AT THE
HOLTWOOD FISH PASSAGE FACILITY
SPRING AND FALL, 2015**

December 2015

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Prepared for

TALen HOLTWOOD HYDRO ELECTRIC STATION, L.L.C.

482 Old Holtwood Road
Holtwood, Pennsylvania 17532

Prepared by

NORMANDEAU ASSOCIATES, INC.

1921 River Road
Drumore, Pennsylvania 17518

Normandeau Associates' Project Number 23240.002

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EXECUTIVE SUMMARY

Per the settlement agreement for the Holtwood Redevelopment Project, 2015 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 for six hours per day (river flow permitting), switching to ten hour days of operation when 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 occurred from September 1 through October 15 (5 days per week when river flow allows). 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. However, operations were suspended from April 6 through April 15 and again from April 22 through April 24 due to river flows at or above 100,000 cfs. The facility operated a total of 78 days between April 1 and June 30, 2015, (Tailrace = 78 days; Spillway = 71 days). The American shad passage season began on May 1 when the first seven shad were passed, and ended, with agency concurrence, on June 2, 2015. The fish lift facility continued to operate in resident fish passage mode until June 30, 2015. Fall fish passage operation occurred from September 1 through October 15 without interruption due to high river flow. This fish passage season marks the nineteenth year of operation at Holtwood.

During the American shad passage season (33 days of operation from May 1 to June 2), the lifts passed 340,268 fish of 30 taxa and 2 hybrids. Gizzard shad, comely shiner, American shad, shorthead redhorse, and walleye dominated the catch, and comprised nearly 99% of the total fish collected and passed. American shad and alewife (residualized) represented the two *Alosa* species collected and passed at Holtwood in 2015. A total of 5,299 American shad were passed by the Holtwood fishway in 2015 (5,286 during the “official” shad passage season and 13 during resident fish passage operations in June).

The 2015 American shad passage rate at Holtwood (63.3% of American shad passing Conowingo passed Holtwood) was the highest rate observed since operations commenced in 1997 and only the second time in Holtwood’s operating history that a shad passage rate greater than 60% was achieved (63.2% in 2006).

During spring, 2015, resident fish passage operations were conducted on 17 days in April and 28 days in June. The facility operated 6 hours per day from 0900 to 1500 hrs per the settlement agreement. A total of 37,405 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 channel catfish, 90% or more of the total resident fish observed this spring were passed during the migratory fish passage season.

Fall resident fish passage operations occurred on 35 days from September 1 through October 15. A total of 603,821 fish of 11 taxa were estimated as passing through the facility with the estimated numbers of juvenile gizzard shad comprising 99.9% of the catch.

This year was the nineteenth 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 (currently Talen Holtwood Hydro Electric Station LLC) 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 nineteenth operational season.

Objectives of 2015 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, installation and integrity of the flash boards along with two Obermeyer gates, and operation of the Safe Harbor Hydroelectric Project.

In 2015, all rubber dams were inoperable (not inflated) due to irreparable damage that occurred in previous years prior to current redevelopment activities. Two Obermeyer gates have been installed; one closest to the fishway exit, with the other adjacent to the west shoreline to provide water to the recreational kayaking facility. Wooden flashboards have been installed in place of the old rubber dam sections. Operations began at the Holtwood Fish Lift facility on April 1, to initiate passage of resident fish species prior to passage of American shad at Conowingo Dam. River flows greater than 100,000 cfs occurred on thirteen days in April, limiting facility operations to seventeen days for the month. Spill at the project did not occur at all in May and not until the last two days of June 2015, which was long after passage of the last American shad on June 6, (Table 1). In 2015, passage operations for migratory fish (American shad, etc.) ended on June 2, with agency concurrence, due to high water temperatures and low American shad passage. Spring passage operations for resident fish species continued through June 30, and operations for fall resident fish passage occurred from September 1 through October 15, 2015.

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. 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.

Four inflatable rubber dams, operated from the hydro control room, had been an integral component of effective spillway lift operation. Prior to fish lift operations in 2013, the rubber dam closest to the fishway exit was replaced with an Obermeyer gate, with flashboards installed upstream of the other three damaged rubber dams to maintain forebay water levels. Additional Obermeyer gates are currently being installed as part of the overall Redevelopment project.

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 an additional attraction water supply pipe and valve (MOV 8), a new operating matrix was developed, but testing and fine-tuning of the new matrix is ongoing. The following gate combinations were utilized in spring, 2015: Entrances A, B, and C (32 days); Entrances A and C (39 days); Entrances A and B (4 days); and Entrance A only (3 days). The combination of Entrance gates A and C were used most often in spring, 2015 due to a malfunction of the gate A split nuts, discovered on May 17. The split nuts were replaced after operations ended on June 30, and all entrance gates were operational during the fall resident passage season. The spillway lift, (Entrance gate C), is used less frequently when spillage occurs or flashboard sections are damaged/missing because spillage may mask or interfere with the attraction flow from spillway entrance gate C.

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 Talen 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. In 2015, Gate C was operated manually with chain falls due to continued problems with the power screw drive mechanism. Extensive efforts were made to repair Gate C, including equipment vendor participation and an independent engineering review by HDR that concluded that dewatering of the Gate C entrance will be necessary to complete the repair.

Per the Holtwood redevelopment settlement agreement, the fish passage facility was operated 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 suspended when river flows exceeded 100,000 cfs and resumed when flows fell below 100,000 cfs.

Holtwood fish passage operations in spring, 2015 commenced on April 1 and ended on June 30 (total days of operation = 78). The migratory fish passage season (based on presence of American shad in the catch) ran from May 1 to June 2 (33 days of operation). For the entire spring fish passage season, the tailrace lift operated on all 78 days while the spillway lift operated on 71 days. Resident fish passage operational hours were 0900 to 1500 hrs in spring and fall, and we operated from 0800 to 1800 hrs during the migratory fish passage season per the redevelopment settlement agreement.

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 2015 migratory fish passage period is presented in Table 2. A total of 340,268 fish of 30 taxa plus two hybrids passed upstream into Lake Aldred. Gizzard shad (319,766), comely shiner (8,370), American shad (5,286), shorthead redhorse (1,681), and walleye (1,565), comprised nearly 99% of all fishes passed. Other abundant fishes passed included carp (1,305), smallmouth bass (918),

quillback (874), and channel catfish (334). The peak one-day passage of all species occurred on May 15, when 35,428 fish were passed, comprised mostly of gizzard shad (34,783), American shad (257), and carp (225).

3.2 American Shad Passage

A total of 5,286 American shad were passed at Holtwood during the 2015 official migratory fish passage season (May 1 to June 2); 4,034 American shad passed in the tailrace lift while the spillway lift accounted for 1,252 American shad (Table 3). An additional 13 American shad were passed after the official end of the migratory fish passage season. Collection and passage of shad varied daily with 90% of total shad (4,784) passed by May 21 (Figures 1 and 2). The highest daily American shad catch occurred on May 7 when 593 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 1459 hrs, (Table 4). Migratory fish passage operations were conducted at average water temperatures ranging from 57.2°F to 78.4°F and river flows between 13,200 and 43,900 cfs. Spillage did not occur during the migratory fish passage season in 2015. River water temperatures reached 70°F on May 10 and river flows were relatively low and stable during the entire month of May and most of June.

The capture of American shad at the fishway in 2015 occurred over a somewhat narrower range of station operation and discharge conditions due to the lower river flows experienced this spring (Table 1). Shad were attracted to the tailrace lift at tailrace water elevations ranging from 108 ft to 115 ft. Tailrace elevations correspond to unit operation, which varied from 5 to 12 units. During spring 2015, tailrace fishway operation generally coincided with 6 to 9 turbines operating. 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 should 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 ft was observed during migratory fish passage for approximately 55% of the 2015 season. Spillage did not occur at Holtwood during the 2015 migratory fish passage season.

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 1359 hrs. The two highest hours of shad passage occurred from 0900 to 1059 hrs (same as observed in 2014).

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, 4,046 and 1,253 shad were captured in the tailrace and spillway lifts over the total operating period in 2015, respectively (Table 3). The percentage of American shad passed by the spillway lift in 2012, 2013, 2014 and 2015 is higher than previous years dating back to 2003, possibly due to the modifications made to the Piney Channel during redevelopment activities.

3.3 Other Alosids

A small number of residualized alewife (2) was passed at Holtwood this season. No other herring or hickory shad were observed.

3.4 Maryland DNR tag-recapture

For most of the spring migratory fish passage season, water clarity was excellent, with visibility at the viewing window ranging from 24 to 36 inches. The viewing technicians identified 3 American shad with attached Maryland DNR floy tags in 2015. All 3 floy tags were blue, from this year's tagging efforts downstream of Conowingo Dam, and all were observed between May 10 and May 19.

3.5 American Shad Passage Evaluation

In spring 2015, 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. Due to a malfunction of the Entrance gate A split nuts, discovered on May 17, the combination of Entrance gates A and C was used most often in spring, 2015. It was determined that Gate A was positioned in the full open position, so any use of Gate B would only reduce the velocity of the attraction flow from both entrances. To avoid interruptions to fish passage operations for the remainder of the season, the split nuts were replaced after operations ended on June 30, and all entrance gates were operational during the fall resident passage season.

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 98% of American shad passed at river flows less than 40,000 cfs, with 2% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. During migratory fish passage operations in 2015, river flows ranged from 13,200 cfs to 43,900 cfs.

The 2015 American shad passage rate at Holtwood (63.3% of American shad passed at Conowingo were passed by Holtwood), was the highest passage efficiency rate observed since Holtwood fish passage operations commenced in 1997 and well above the historical average of 29.4% observed at Holtwood from 1997 to 2014 (Table 6).

We seek to optimize future migratory fish passage operations by utilizing knowledge gained through these nineteen 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, 2015, resident fish passage operations occurred from April 1 to 5, April 16 to 21, April 25 to 30, and June 3 to June 30 (45 days). River flows greater than 100,000 cfs limited resident fish passage operation to seventeen days in April. The facility operated 6 hours per day from 0900 to 1500 hrs per the settlement agreement. A total of 37,405 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 7,657 fish of 11 species while resident fish passage in June accounted for 29,748 fish of 18 taxa plus one hybrid. Gizzard shad comprised nearly 98% of the catch in April with gizzard shad and comely shiner comprising 92% of the catch in June. The majority of channel catfish (99%) and walleye (nearly 76%) passed during resident fish passage operations occurred in June. 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 channel catfish, 90% or more of the total resident fish observed this spring were passed during the migratory fish passage season.

4.2 Fall

Fall resident fish passage operations occurred on 35 days from September 1 through October 15, (Tables 9, 10). The facility was operated 5 days per week (including one week-end day) from 0900 hrs to 1500 hrs per the settlement agreement. During fall operations, the river flow was low, and turbine operation was limited. A total of 603,821 fish of 11 taxa were estimated as passing through the facility. Gizzard shad comprised 99.9% of the total fish passed. Please note that the gizzard shad were estimated due to their small size and large quantities that quickly passed by the viewing window. Approximately 99% of the gizzard shad observed were young-of-the-year (YOY) fish and were 2 to 5 inches in length. A total of 301 channel catfish and 87 walleye passed during fall resident fish passage operations.

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, 2015.

Date	River Flow	Ave. Water	Secchi	Total #	Weir Gate Operation			Elevation (ft)		
	(cfs)	Temp. (°F)	(in)	of Units	A	B	C*	Forebay	Tailrace	Spillway**
1 Apr	45,900	43.1	36	6	X	X	X	171	110	122-S
2 Apr	44,800	43.3	36	9	X	X	X	168	116.5	118
3 Apr	44,600	44.6	36	12	X	X	X	169	118	118-S
4 Apr	46,600	46.0	36	12	X	X	X	170	113	121-S
5 Apr	82,500	47.0	36	12	X	X	X	170	118	120-S
6 Apr	140,000									Spill
7 Apr	130,000									Spill
8 Apr	107,000									Spill
9 Apr	100,000									Spill
10 Apr	123,000									Spill
11 Apr	144,000									Spill
12 Apr	177,000									Spill
13 Apr	160,000									Spill
14 Apr	126,000									Spill
15 Apr	103,000									Spill
16 Apr	92,500	50.4	8	12	X	X	X	171	117	126-S
17 Apr	84,100	53.1	10	12	X	X		171	117	127-S
18 Apr	73,200	54.5	18	12	X	X		170	116	124-S
19 Apr	63,900	56.7	20	12	X	X		168	118	121-S
20 Apr	59,800	56.5	18	12	X	X	X	168	117	120-S
21 Apr	75,100	57.6	18	11	X	X	X	171	115	126-S
22 Apr	113,000	57.5								Spill
23 Apr	123,000	55.0								Spill
24 Apr	109,000	51.4								Spill
25 Apr	93,500	50.0	8	12	X	X	X	171	119	125-S
26 Apr	79,300	50.6	14	12	X	X	X	169	119	123-S
27 Apr	68,100	51.6	18	12	X	X	X	169	117	122-S
28 Apr	60,000	52.5	18	12	X	X	X	169.5	117	123-S
29 Apr	53,200	53.5	20	8	X	X	X	170	115	123-S
30 Apr	47,900	55.4	36	9	X	X	X	164	114	118
1 May	43,900	57.2	36	9	X	X	X	164	115	118
2 May	40,200	58.1	36	10	X	X	X	165	115	118
3 May	36,800	59.5	36	12	X		X	165	115	118
4 May	33,700	60.7	36	7	X		X	164	112	118

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
5 May	30,900	63.0	36	9	X	X	X	168	112	118
6 May	28,700	65.2	28	6	X	X	X	167	112	118
7 May	27,400	66.6	32	7	X	X	X	168	112	119
8 May	26,000	68.1	32	12	X		X	165	111	119
9 May	25,100	69.4	32	10	X	X	X	168	110	120
10 May	24,300	70.3	32	7	X	X	x	168	111	119
11 May	22,800	71.8	32	6	X	X	X	166	110	120
12 May	21,000	73.6	36	8	X			164	109	118
13 May	19,500	73.0	36	5	X	X	X	167	108	118
14 May	18,500	72.9	36	6	X	X	X	167.5	109	118
15 May	17,900	72.1	36	7	X	X	X	168	109	118
16 May	18,800	71.7	36	6	X	X	X	168	109	120
17 May	19,600	71.0	32	6	X		X	169	110	120
18 May	19,500	71.7	32	6	X		X	168	110	120
19 May	23,300	73.2	32	7	X		X	168	111	120
20 May	25,700	73.3	32	6	X		X	168	112	119
21 May	23,400	72.9	30	8	X		X	168	111	119
22 May	25,100	72.1	28	7	X		X	168	111	119
23 May	27,000	70.8	18-24	6	X		X	169	111	120.5
24 May	24,200	68.5	18	5	X		X	169	111	120
25 May	21,100	68.5	18	6	X		X	169	110	119
26 May	19,000	69.0	16-18	11	X		X	168	114	120
27 May	17,100	70.6	18-20	9	X		X	168	111	120
28 May	16,700	74.4	24	5	X		X	168	108	120
29 May	15,200	75.6	24	8	X		X	168	108	120
30 May	14,300	77.1	26	6	X		X	168	109	119
31 May	13,200	77.3	22	9	X		X	169	110	120
1 Jun	14,000	78.4	24	5	X		X	168	108	119
2 Jun	19,400	77.8	18-20	6	X		X	168	112	119
3 Jun	21,600	76.7	18	5	X		X	168	110	119
4 Jun	25,700	76.0	18	10	X		X	168	113	118
5 Jun	22,800	73.3	16	3	X		X	168	110	119
6 Jun	20,400	71.1	14	6	X		X	168	110	120
7 Jun	18,000	70.2	14	3	X		X	168	110	118
8 Jun	16,700	69.9	12	3	X			168	110	118
9 Jun	21,600	71.6	18	8	X	X		168	111	118
10 Jun	22,600	73.1	18-20	6	X	X	X	168	112	119
11 Jun	20,100	75.2	20-22	6	X	X	X	168	109	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
12 Jun	20,900	76.4	22	7	X	X	X	168	110	119
13 Jun	28,100	78.0	22	6	X		X	169	112	119.5
14 Jun	28,100	79.8	20	4	X		X	169	113	119
15 Jun	26,900	81.3	20	5	X		X	168	112	120
16 Jun	25,400	82.0	20	5	X		X	168	111.5	119.5
17 Jun	24,800	82.2	20	6	X		X	168	111	120
18 Jun	39,900	81.3	16	12	X		X	168	112	119
19 Jun	43,800	80.5	16	11	X		X	168	117	119
20 Jun	40,000	79.6	18	9	X		X	168	113	119
21 Jun	50,500	79.2	12	12	X		X	168	116	120
22 Jun	53,200	79.4	8	12	X	X	X	168	115	119
23 Jun	50,700	78.6	8	12	X	X	X	168	117	120
24 Jun	48,600	78.6	8	12	X	X	X	168.5	116	120
25 Jun	42,400	78.2	12	12	X		X	168	115	119
26 Jun	37,500	77.5	12	12	X		X	168	116	118
27 Jun	34,400	76.5	12	10	X		X	168	113	120
28 Jun	48,900	74.6	6	12	X		X	169	116	120
29 Jun	74,100	73.0	6	12	X		X	170	119	121-S
30 Jun	89,900	70.8	6	12	X			172	119	123-S

*C Gate set at Elevation 115' for entire season

** "S" denotes Spill

Summary of daily fish passage at Holtwood during the American shad passage season (May 1 to June 2) in spring, 2015.

<i>Date</i>	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10
<i>Hours of Operation - Tailrace:</i>	6.6	6.8	4.0	9.6	9.6	9.8	9.7	8.6	9.7	9.6
<i>Number of Lifts - Tailrace</i>	8	10	7	15	13	18	16	13	19	15
<i>Hours of Operation - Spillway:</i>	6.6	7.3	9.6	7.2	9.7	9.8	9.8	8.5	9.8	9.5
<i>Number of Lifts -Spillway:</i>	10	11	17	11	13	14	16	12	14	22
<i>Water Temperature (F)</i>	57.2	58.1	59.5	60.7	63.0	65.2	66.6	68.1	69.4	70.3
AMERICAN SHAD	7	76	184	262	463	513	593	360	277	229
ALEWIFE (residualized)	0	0	1	0	0	0	0	0	0	0
GIZZARD SHAD	1,829	7,770	8,013	5,164	13,464	21,273	18,980	16,834	13,105	13,647
STRIPED BASS	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	2	0	0	1	0
RAINBOW TROUT	0	1	0	0	0	1	0	1	2	0
BROWN TROUT	0	0	0	0	1	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	2	0	1	0	0	0
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0
CARP	0	0	0	0	5	49	105	14	71	98
QUILLBACK	0	0	4	0	2	14	20	24	274	34
S. REDHORSE	3	23	67	28	72	197	172	127	275	85
CHANNEL CATFISH	0	0	0	0	0	1	1	11	10	6
WHITE PERCH	0	0	0	0	0	0	0	0	0	0
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	0	0	0	2	0	0	4	2
REDBREAST SUNFISH	0	0	0	0	0	0	0	1	0	0
PUMPKINSEED	0	0	0	0	0	0	0	1	0	0
BLUEGILL	0	0	0	0	0	0	3	1	2	1
SMALLMOUTH BASS	38	73	127	56	70	150	93	50	73	35
LARGEMOUTH BASS	1	0	1	0	1	0	0	0	0	1
WHITE CRAPPIE	0	0	0	0	1	0	1	0	0	0
BLACK CRAPPIE	0	0	0	0	0	1	1	0	0	0
BROWN BULLHEAD	0	0	0	0	0	0	0	0	0	0
WALLEYE	5	5	8	3	45	55	44	39	84	92
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
COMELY SHINER	0	0	0	0	0	0	0	0	0	50
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	3	1
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	1	0	0
RAINBOW SMELT	0	0	0	0	0	1	0	0	0	0
<i>Daily Totals</i>	1,883	7,948	8,405	5,513	14,126	22,259	20,014	17,464	14,181	14,281

Table 2 (Continued)

<i>Date</i>	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	9.8	9.6	10.0	9.8	9.6	10.0
<i>Number of Lifts - Tailrace</i>	18	25	17	17	19	18	18	21	19	15
<i>Hours of Operation - Spillway:</i>	9.5	0.0	9.6	9.5	9.8	9.5	9.9	9.1	9.5	10.0
<i>Number of Lifts -Spillway:</i>	18	0	22	21	18	17	13	15	17	14
<i>Water Temperature (F)</i>	71.8	73.6	73.0	72.9	72.1	71.7	71.0	71.7	73.2	73.3
AMERICAN SHAD	188	133	208	204	257	221	355	87	77	43
ALEWIFE (residualized)	0	0	1	0	0	0	0	0	0	0
GIZZARD SHAD	19,091	15,973	18,866	15,257	34,783	16,211	12,266	13,959	10,326	7,515
STRIPED BASS	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	1	0	1	0	0	1	0	0
RAINBOW TROUT	1	0	0	0	0	0	1	0	0	0
BROWN TROUT	0	0	0	0	2	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
TIGER MUSKIE	0	0	0	0	0	1	0	0	0	0
CARP	77	53	258	13	225	39	8	203	26	11
QUILLBACK	194	12	15	5	10	6	0	82	87	0
S. REDHORSE	118	2	5	41	47	90	43	78	50	17
CHANNEL CATFISH	11	0	8	9	14	27	14	8	14	23
WHITE PERCH	0	0	0	0	0	0	0	0	0	0
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0
ROCK BASS	3	0	2	1	5	4	2	1	0	0
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0
PUMPKINSEED	1	0	3	1	0	0	0	0	0	0
BLUEGILL	2	0	3	2	5	3	1	2	0	1
SMALLMOUTH BASS	21	0	10	10	11	15	17	5	8	7
LARGEMOUTH BASS	0	0	0	2	2	0	1	0	0	2
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0
BROWN BULLHEAD	0	0	0	0	0	1	0	0	0	1
WALLEYE	188	4	80	84	64	122	150	65	72	32
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
COMELY SHINER	0	0	170	0	0	0	230	0	0	0
ATLANTIC NEEDLEFISH	0	0	0	0	1	0	0	0	0	0
GREEN SUNFISH	0	0	1	0	1	2	0	0	0	1
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0
RAINBOW SMELT	0	0	0	0	0	0	0	0	0	0
<i>Daily Totals</i>	19,895	16,177	19,631	15,629	35,428	16,742	13,088	14,491	10,660	7,653

Table 2 (Continued)

<i>Date</i>	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30
<i>Hours of Operation- Tailrace:</i>	9.7	10.0	9.8	9.9	9.7	9.5	9.6	9.5	9.6	10.0
<i>Number of Lifts - Tailrace</i>	17	14	16	11	14	14	16	13	14	13
<i>Hours of Operation - Spillway:</i>	9.3	9.9	9.4	10.0	9.5	9.3	9.2	9.6	9.5	9.9
<i>Number of Lifts -Spillway:</i>	13	13	15	11	15	13	15	11	13	12
<i>Water Temperature (F)</i>	72.9	72.1	70.8	68.5	68.5	69	70.6	74.4	75.6	77.1
AMERICAN SHAD	47	71	35	67	66	15	46	74	50	18
ALEWIFE (residualized)	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	4,171	5,972	3,442	1,541	1,622	1,259	891	4,996	2,838	2,885
STRIPED BASS	0	0	0	0	0	0	6	0	3	0
SEA LAMPREY	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	0
BROWN TROUT	0	0	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0
CARP	0	3	5	0	1	1	2	4	11	10
QUILLBACK	0	0	0	0	0	0	0	3	11	25
S. REDHORSE	62	19	10	4	2	0	0	1	9	4
CHANNEL CATFISH	43	16	14	5	1	8	29	4	22	8
WHITE PERCH	0	0	0	0	0	0	0	0	0	0
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	0	0	0	0	0	1	1	0
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	1
PUMPKINSEED	0	0	1	0	0	0	0	0	0	1
BLUEGILL	0	1	0	0	1	1	5	0	3	0
SMALLMOUTH BASS	0	1	2	0	3	2	7	3	9	10
LARGEMOUTH BASS	0	0	0	0	0	0	2	1	2	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
BROWN BULLHEAD	0	0	0	0	0	0	0	0	0	0
WALLEYE	64	22	14	9	9	11	36	15	22	41
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
COMELY SHINER	0	0	0	0	0	0	0	0	0	3,560
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	1	0	0	1	1	0	1	0
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0
RAINBOW SMELT	0	0	0	0	0	0	0	0	0	0
<i>Daily Totals</i>	4,387	6,105	3,524	1,626	1,705	1,298	1,025	5,102	2,982	6,563

Table 2 (Continued)

<i>Date</i>	5/31	6/1	6/2	<i>Season Totals</i>
<i>Hours of Operation - Tailrace:</i>	10.0	9.9	9.5	308.0
<i>Number of Lifts - Tailrace</i>	12	11	14	500
<i>Hours of Operation - Spillway:</i>	9.9	10.0	9.3	299.0
<i>Number of Lifts - Spillway:</i>	11	10	13	460
<i>Water Temperature (F)</i>	77.3	78.4	77.8	
AMERICAN SHAD	37	17	6	5,286
ALEWIFE (residualized)	0	0	0	2
GIZZARD SHAD	2,017	2,252	1,554	319,766
STRIPED BASS	1	1	10	21
SEA LAMPREY	0	0	0	6
RAINBOW TROUT	1	0	0	8
BROWN TROUT	0	0	0	3
MUSKELLUNGE	0	0	0	3
TIGER MUSKIE	0	0	0	1
CARP	6	1	6	1,305
QUILLBACK	23	21	8	874
S. REDHORSE	24	6	0	1,681
CHANNEL CATFISH	2	8	17	334
WHITE PERCH	0	0	0	0
HYBRID STRIPED BASS	0	1	0	1
ROCK BASS	0	0	0	28
REDBREAST SUNFISH	0	0	0	2
PUMPKINSEED	3	0	0	11
BLUEGILL	0	3	0	40
SMALLMOUTH BASS	6	5	1	918
LARGEMOUTH BASS	3	1	0	20
WHITE CRAPPIE	0	0	0	2
BLACK CRAPPIE	0	0	0	2
BROWN BULLHEAD	0	0	0	2
WALLEYE	17	16	48	1,565
AMERICAN EEL	0	0	0	0
COMELY SHINER	970	3,390	0	8,370
ATLANTIC NEEDLEFISH	0	0	0	1
GREEN SUNFISH	0	0	1	14
FLATHEAD CATFISH	0	0	0	0
BROOK TROUT	0	0	0	1
RAINBOW SMELT	0	0	0	1
<i>Daily Totals</i>	3,110	5,722	1,651	340,268

Table 3

Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2015.

Date	Shad Catch	Number Collected		Percent Collected	
		Tailrace	Spillway	Tailrace	Spillway
1-Apr	0	0	0	0%	0%
2-Apr	0	0	0	0%	0%
3-Apr	0	0	0	0%	0%
4-Apr	0	0	0	0%	0%
5-Apr	0	0	0	0%	0%
6-Apr*					
7-Apr*					
8-Apr*					
9-Apr*					
10-Apr*					
11-Apr*					
12-Apr*					
13-Apr*					
14-Apr*					
15-Apr*					
16-Apr	0	0	0	0%	0%
17-Apr	0	0	0	0%	0%
18-Apr	0	0	0	0%	0%
19-Apr	0	0	0	0%	0%
20-Apr	0	0	0	0%	0%
21-Apr	0	0	0	0%	0%
22-Apr*					
23-Apr*					
24-Apr*					
25-Apr	0	0	0	0%	0%
26-Apr	0	0	0	0%	0%
27-Apr	0	0	0	0%	0%
28-Apr	0	0	0	0%	0%
29-Apr	0	0	0	0%	0%
30-Apr	0	0	0	0%	0%
1-May**	7	7	0	100%	0%
2-May	76	15	61	20%	80%
3-May	184	37	147	20%	80%
4-May	262	183	79	70%	30%
5-May	463	324	139	70%	30%
6-May	513	359	154	70%	30%
7-May	593	474	119	80%	20%
8-May	360	216	144	60%	40%
9-May	277	221	56	80%	20%
10-May	229	137	92	60%	40%
11-May	188	169	19	90%	10%
12-May	133	133	0	100%	0%
13-May	208	206	2	99%	1%
14-May	204	202	2	99%	1%
15-May	257	206	51	80%	20%
16-May	221	177	44	80%	20%
17-May	355	335	20	94%	6%
18-May	87	74	13	85%	15%

**Table 3
(Continued)**

Date	Shad Catch	Number Collected		Percent Collected	
		Tailrace	Spillway	Tailrace	Spillway
19-May	77	50	27	65%	35%
20-May	43	36	7	84%	16%
21-May	47	42	5	89%	11%
22-May	71	65	6	92%	8%
23-May	35	25	10	71%	29%
24-May	67	57	10	85%	15%
25-May	66	53	13	80%	20%
26-May	15	8	7	53%	47%
27-May	46	41	5	89%	11%
28-May	74	64	10	86%	14%
29-May	50	48	2	96%	4%
30-May	18	15	3	83%	17%
31-May	37	33	4	89%	11%
1-Jun	17	16	1	94%	6%
2-Jun**	6	6	0	100%	0%
3-Jun	7	7	0	100%	0%
4-Jun	1	0	1	0%	100%
5-Jun	0	0	0	0%	0%
6-Jun	5	5	0	100%	0%
7-Jun	0	0	0	0%	0%
8-Jun	0	0	0	0%	0%
9-Jun	0	0	0	0%	0%
10-Jun	0	0	0	0%	0%
11-Jun	0	0	0	0%	0%
12-Jun	0	0	0	0%	0%
13-Jun	0	0	0	0%	0%
14-Jun	0	0	0	0%	0%
15-Jun	0	0	0	0%	0%
16-Jun	0	0	0	0%	0%
17-Jun	0	0	0	0%	0%
18-Jun	0	0	0	0%	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	5,286	4,034	1,252	76%	24%
Overall Total	5,299	4,046	1,253	76%	24%

* Shut Down due to High Flow Events (> 100,000 cfs)

**Denotes start and end of American shad passage season (5,286 Am. Shad)

Table 4

Hourly summary of American shad passage at the Holtwood fish passage facility in 2015 (May 1 to June 2).

<i>DATE</i>	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
<i>Viewing Time (Start)</i>	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	8:00
<i>Viewing Time (End)</i>	16:00	16:30	18:00	18:00	18:00	18:30	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00
<i>Viewing Time (hrs)</i>	7.0	7.5	10.0	10.0	10.0	10.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
<i>Water Temp. (*F)</i>	57.2	58.1	59.5	60.7	63.0	65.2	66.6	68.1	69.4	70.3	71.8	73.6	73.0	72.9
<i>Military Time (hrs)</i>														
0600 to 0659														
0700 to 0759														
0800 to 0859														
0900 to 0959	0	1	31	0	19	41	49	1	20	11	2	0	12	6
1000 to 1059	0	21	13	32	35	51	88	7	52	43	10	24	64	12
1100 to 1159	0	16	2	26	55	83	53	0	8	16	21	23	27	23
1200 to 1259	0	11	21	35	57	34	51	57	6	28	20	19	8	28
1300 to 1359	4	7	44	21	65	30	53	81	16	33	32	32	3	43
1400 to 1459	0	5	21	30	36	56	67	45	37	10	21	13	9	36
1500 to 1559	3	7	14	24	66	40	55	33	36	10	20	9	2	13
1600 to 1659		8	16	36	59	22	46	46	17	7	29	1	11	4
1700 to 1759			8	30	49	59	49	86	22	9	17	8	8	1
1800 to 1859							26							
1900 to 1959														
2000 to 2059														
<i>Total</i>	7	76	184	262	463	513	593	360	277	229	188	133	208	204

<i>DATE</i>	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
<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>	72.1	71.7	71.0	71.7	73.2	73.3	72.9	72.1	70.8	68.5	68.5	69	70.6	74.4
<i>Military Time (hrs)</i>														
0600 to 0659														
0700 to 0759														
0800 to 0859	12	3	19	4	8	14	4	1	0	1	11	0	2	0
0900 to 0959	24	39	22	9	17	6	0	10	10	6	11	3	7	14
1000 to 1059	7	38	49	1	20	2	2	17	6	13	8	2	2	19
1100 to 1159	16	54	93	12	13	3	11	13	0	8	1	2	8	7
1200 to 1259	29	46	55	29	8	5	5	8	3	3	8	2	10	10
1300 to 1359	26	19	36	8	2	2	9	0	4	7	6	1	10	13
1400 to 1459	34	13	30	5	5	1	5	8	4	10	5	2	3	4
1500 to 1559	33	8	21	5	1	3	7	7	0	2	5	0	4	6
1600 to 1659	50	1	8	2	1	5	3	4	8	12	10	0	0	1
1700 to 1759	26	0	22	12	2	2	1	3	0	5	1	3	0	0
1800 to 1859														
1900 to 1959														
2000 to 2059														
<i>Total</i>	257	221	355	87	77	43	47	71	35	67	66	15	46	74

Table 4 (Continued)

<i>DATE</i>	5/29	5/30	5/31	6/1	6/2	<i>Season Totals</i>
<i>Viewing Time (Start)</i>	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	
<i>Viewing Time (hrs)</i>	10.0	10.0	10.0	10.0	10.0	325.0
<i>Water Temp.(°F)</i>	75.6	77.1	77.3	78.4	77.8	
<i>Military Time (hrs)</i>						
0600 to 0659						0
0700 to 0759						0
0800 to 0859	1	0	9	4	1	269
0900 to 0959	6	11	10	5	3	699
1000 to 1059	7	1	4	2	1	653
1100 to 1159	5	0	2	4	1	606
1200 to 1259	14	1	5	2	0	618
1300 to 1359	9	2	2	0	0	620
1400 to 1459	5	3	2	0	0	525
1500 to 1559	3	0	0	0	0	437
1600 to 1659	0	0	3	0	0	410
1700 to 1759	0	0	0	0	0	423
1800 to 1859						26
1900 to 1959						0
2000 to 2059						0
<i>Total</i>	50	18	37	17	6	5,286

Table 5

Holtwood fishway summary table evaluating American shad passage at three river flow ranges (1997-2015).

	1997	1998*	1999	2000*	2001	2002*	2003*	2004*	2005
Migration season start date	18 Apr	27 Apr	25 Apr	06 May	27 Apr	15 Apr	28 Apr	26 Apr	27 Apr
Migration season end date	14 Jun	12 Jun	03 Jun	14 Jun	08 Jun	07 Jun	02 Jun	03 Jun	10 Jun
Season duration (days)	58	47	40	40	43	55	36	39	45
Number of days of operation	55	41	40	36	42	35	34	39	36
Am. shad season total (Conowingo)	90,971	39,904	69,712	153,546	193,574	108,001	125,135	109,360	68,926
Am. shad season total (Holtwood)	28,063	8,235	34,702	29,421	109,976	17,522	25,254	3,428	34,189
River flow ≤40,000 cfs									
Number of days	48	22	34	19	40	19	15	2	33
Percent of season	87%	54%	85%	53%	95%	54%	44%	5%	92%
No. of Am. shad passed	26,201	7,512	34,069	19,712	109,342	10,322	20,229	2	34,060
Daily ave. of Am. shad passed	546	341	1,002	1,037	2,733	543	1,348	1	1,032
Percent of total passage	93%	91%	98%	67%	99%	59%	80%	0%	99.6%
River flow 40,001 to 60,000 cfs									
Number of days	7	2	6	12	2	14	18	20	3
Percent of season	13%	5%	15%	33%	5%	40%	53%	51.3%	8%
No. of Am. shad passed	1,862	230	633	9,536	634	7,029	5,019	1,943	129
Daily ave. of Am. shad passed	266	115	106	795	317	502	279	97	43
Percent of Total Passage	7%	3%	2%	32%	1%	40%	19.8%	56.7%	0.4%
River flow >60,000 cfs									
Number of days	0	17	0	5	0	2	1	17	0
Percent of season	0%	41%	0%	14%	0%	6%	3%	43.6%	0%
No. of Am. shad passed	0	493	0	173	0	171	6	1,483	0
Daily ave. of Am. shad passed	0	29	0	35	0	86	6	87	0
Percent of total passage	0%	6%	0%	1%	0%	1%	0.02%	43.3%	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 (1997-2015).

	2006	2007	2008*	2009*	2010	2011	2012	2013	2014*	2015
Migration season start date	11 Apr	01 May	21 Apr	03 May	21 Apr	20 May	07 Apr	29-Apr	27-Apr	1-May
Migration season end date	06 Jun	04 Jun	09 Jun	07 Jun	09 Jun	05 Jun	05 Jun	5-Jun	8-Jun	2-Jun
Season duration (days)	57	35	50	36	50	17	60	38	43	33
Number of days of operation	57	35	49	36	48	10	58	38	37	33
Am. shad season total (Conowingo)	56,899	25,464	19,914	29,272	37,757	20,571	22,143	12,733	10,425	8,341
Am. shad season total (Holtwood)	35,968	10,338	2,795	10,896	16,472	21	4,238	2,503	2,589	5,286**
River flow ≤40,000 cfs										
Number of days	48	27	20	20	40	0	31	34	16	31
Percent of season	84%	77%	40%	56%	83%	0%	53%	89%	37%	94%
No. of Am. shad passed	35,302	9,549	2,242	8,939	15,606	0	3260	2,355	2248	5203
Daily ave. of Am. shad passed	735	354	112	447	372	0	105	70	141	168
Percent of total passage	98.1%	92.3%	80.2%	82%	95%	0%	77%	94%	87%	98%
River flow 40,001 to 60,000 cfs										
Number of days	5	8	22	14	8	2	18	4	12	2
Percent of season	9%	23%	44%	39%	17%	12%	30.0%	11%	28%	6%
No. of Am. shad passed	566	789	533	1,846	866	0	967	148	314	83
Daily ave. of Am. shad passed	113	99	24	132	108	0	54	37	26	41
Percent of Total Passage	1.6%	7.6%	19.0%	17.0%	5%	0.0%	22.8%	5.9%	12.0%	2.0%
River flow >60,000 cfs										
Number of days	4	0	8	2	0	15	4	0	15	0
Percent of season	7%	0%	16%	5%	0%	88%	6.7%	0.0%	34.9%	0.0%
No. of Am. shad passed	100	0	20	111	0	21	11	0	27	0
Daily ave. of Am. shad passed	25	0	2	55	0	2	3	0	2	0
Percent of total passage	0.3%	0.0%	0.7%	1.0%	0%	100%	0.3%	0.0%	1.0%	0.0%

* Denotes seasons of high river flow or frequent spillage.

**Official American shad passage season (May 1 -June 2).

Table 6**Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2015.**

	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	5286*	63.3%	3,896	73.7%	43	1.1%

*Am. Shad passed at Holtwood from May 1 to June 2.

Table 7

Daily summary of Holtwood resident fish passage prior to and after the American shad passage season (1 to 30 April; 3 to 30 June) in spring, 2015.

DATE	4/1	4/2	4/3	4/4	4/5	4/16	4/17	4/18	4/19	4/20	4/21	4/25	4/26	4/27	4/28	4/29	4/30	Totals (1-30 Apr)
<i>Hours of Operation - Tailrace</i>	5.8	5.8	5.8	5.9	5.8	5.6	5.9	5.7	5.9	5.8	5.7	5.8	5.6	3.7	5.8	5.8	5.6	96.0
<i>Number of Lifts - Tailrace</i>	6	6	6	7	7	7	7	7	7	7	7	7	6	5	7	8	6	113
<i>Hours of Operation - Spillway</i>	5.8	5.7	5.7	5.9	5.8	3.5	0.0	0.0	0.0	2.5	2.1	3.0	5.7	3.6	5.7	5.7	5.7	66.4
<i>Number of Lifts - Spillway</i>	7	6	6	7	6	4	0	0	0	3	2	3	6	4	6	6	8	74
<i>Water Temperature (°F)</i>	43.1	43.3	44.6	46	47	50.4	53.1	54.5	56.7	56.5	57.6	50	50.6	51.6	52.5	53.5	55.4	
AMERICAN SHAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	2	6	7	20	67	281	586	469	247	388	480	634	437	144	568	311	2,830	7,477
CARP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
BROWN TROUT	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	3
MUSKELLUNGE	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
QUILLBACK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. REDHORSE	0	0	0	0	0	0	0	2	13	46	3	2	0	0	0	3	0	69
CHANNEL CATFISH	0	0	0	0	0	0	0	2	1	1	1	0	2	0	0	0	0	7
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
GREEN SUNFISH	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	0	0	0	0	0	0	0	0	0	0	0	0
SMALLMOUTH BASS	0	0	0	1	0	0	0	1	0	6	1	0	0	0	2	2	37	50
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	4
YELLOW PERCH	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
WALLEYE	1	1	0	0	4	0	3	5	8	6	3	2	6	1	1	2	0	43
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
FLATHEAD CATFISH	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
<i>Totals</i>	4	7	7	21	73	281	590	479	269	447	489	638	445	147	572	319	2,869	7,657

Table 7 (Continued)

<i>DATE</i>	6/3	6/4	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15
<i>Hours of Operation - Tailrace</i>	6.0	5.6	5.6	5.9	5.6	5.9	5.6	5.6	5.5	5.7	5.9	5.5	5.6
<i>Number of Lifts - Tailrace</i>	7	9	7	7	7	7	7	7	8	8	7	8	8
<i>Hours of Operation - Spillway</i>	6.0	5.5	5.5	5.8	1.0	0.0	0.0	2.5	5.6	5.6	5.9	5.6	5.6
<i>Number of Lifts - Spillway</i>	7	7	4	6	1	0	0	5	8	7	6	8	7
<i>Water Temperature (°F)</i>	76.7	76	73.3	71.1	70.2	69.9	71.6	73.1	75.2	76.4	78	79.8	81.3
AMERICAN SHAD	7	1	0	5	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	117	356	221	603	140	92	174	90	343	249	428	273	56
CARP	0	0	0	0	0	1	0	0	0	0	0	1	0
RAINBOW TROUT	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
MUSKELLUNGE	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	1	0
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0	0	1
S. REDHORSE	0	0	0	1	0	0	0	0	1	0	0	0	0
CHANNEL CATFISH	1	9	4	5	3	0	0	6	0	6	34	79	29
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	2	0	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	1	0	0	0	1	0	0	0	0	2	3
SMALLMOUTH BASS	3	2	0	2	0	0	0	0	4	0	3	2	3
LARGEMOUTH BASS	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	1	0
WALLEYE	2	10	1	3	1	0	1	8	10	2	2	9	10
COMELY SHINER	0	0	0	0	800	0	700	0	0	350	110	0	1,000
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	125	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	550	270	0	200
FLATHEAD CATFISH	1	0	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	2	8	1	2	0
<i>Totals</i>	133	378	227	619	944	93	876	104	360	1,290	848	370	1,302

Table 7 (Continued)

DATE	6/16	6/17	6/18	6/19	6/20	6/21	6/22	6/23	6/24	6/25	6/26	6/27	6/28	6/29	6/30	Totals (30 June)	Totals (1-30 Apr; 3-30 June)
Hours of Operation - Tailrace	5.8	5.8	5.7	5.8	5.7	5.5	5.6	5.6	5.5	5.6	5.5	5.6	5.6	5.6	5.5	152.8	243.2
Number of Lifts - Tailrace	6	6	7	6	8	8	8	8	8	8	8	8	8	8	7	201	308
Hours of Operation - Spillway	5.9	5.9	5.8	5.9	5.5	5.6	5.5	5.5	5.6	5.5	3.6	5.6	5.5	5.6	1.5	127.5	188.2
Number of Lifts - Spillway	6	6	6	6	7	8	7	7	8	7	5	7	8	8	0	155	221
Water Temperature (°F)	82	82.2	81.3	80.5	79.6	79.2	79.4	78.6	78.6	78.2	77.5	76.5	74.6	73	70.8		
AMERICAN SHAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	13
GIZZARD SHAD	219	1,150	2,203	495	4,911	207	2,328	119	274	1,346	163	88	242	409	62	17,358	24,835
CARP	1	1	0	2	0	1	1	1	0	0	0	0	0	0	0	9	9
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2
QUILLBACK	1	1	0	1	0	0	0	1	1	2	0	0	0	1	0	9	9
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
S. REDHORSE	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	72
CHANNEL CATFISH	10	32	99	55	56	112	112	70	38	35	6	15	21	6	37	880	887
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2
GREEN SUNFISH	0	0	3	0	0	0	0	2	0	1	0	0	0	0	0	8	8
BLUEGILL	0	1	1	0	2	0	1	0	2	0	1	2	3	0	0	20	20
SMALLMOUTH BASS	1	4	0	1	3	0	2	0	2	0	0	1	1	1	0	35	85
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
WALLEYE	2	5	8	3	7	10	6	1	3	5	1	8	8	6	3	135	178
COMELY SHINER	0	6,100	1,050	0	0	0	0	0	0	0	0	0	0	0	0	10,110	10,110
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	125
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,020	1,020
FLATHEAD CATFISH	0	0	0	0	0	2	1	0	2	0	0	0	0	0	0	6	6
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	13
<i>Totals</i>	234	7,294	3,364	557	4,979	332	2,451	194	322	1,389	171	115	277	423	102	29,748	37,405

Table 8**Comparison of resident fish passage prior to, during, and after American shad passage operations at Holtwood Dam, spring 2015**

Total Resident Fish Passed (April 1-June 30)		Res. Fish passed in Am. Shad Season (May 1-June 2)		Total Resident Passage Season (April 1-30: June 3-30)		Resident Passage (April 1-30*)		Resident Passage (June 3-30)	
Species	Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed
Smallmouth Bass	1,003	918	91.5%	85	8.5%	50	5.0%	35	3.5%
Walleye	1,743	1,565	89.8%	178	10.2%	43	2.5%	135	7.7%
Channel Catfish	1,221	334	27.4%	887	72.6%	7	0.6%	880	72.1%
Shorthead Redhorse	1,753	1,681	95.9%	72	4.1%	69	3.9%	3	0.2%
Quillback	883	874	99.0%	9	1.0%	0	0.0%	9	1.0%
Carp	1,314	1,305	99.3%	9	0.7%	0	0.0%	9	0.7%
Gizzard shad	344,601	319,766	92.8%	24,835	7.2%	7,477	2.2%	17,358	5.0%

* No operation on 13 days in April due to river flows in excess of 100,000 cfs.

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, 2015 (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	Tailrace	Spillway	Forebay
1-Sep	7,810	79.8	36	1	X	X	X	107	118	169
2-Sep	7,400	80.3	36	2	X	X	X	107	118	169
3-Sep	7,320	80.3	36	2	X	X	X	107	119	169
4-Sep	6,820	81.5	36	2	X	X	X	107	120	169
5-Sep	6,500	81.4	36	1	X	X	X	108	118	168
6-Sep	6,530	81.9			X	X	X			
7-Sep	6,340	81.3			X	X	X			
8-Sep	6,260	80.6	36	2	X	X	X	107	118	169
9-Sep	5,960	81.0	30	2	X	X	X	107	120	169
10-Sep	6,630	80.7	36	1	X	X	X	108	119	169
11-Sep	10,400	79.7	32	2	X	X	X	109	120	169
12-Sep	8,450	79.2	22	2	X	X	X	108	120	169
13-Sep	11,400	77.5	20	2	X	X	X	109	120	169
14-Sep	8,580	75.7	12	3	X	X	X	109	119	169
15-Sep	7,620	75.3	18	2	X	X	X	106	119	169
16-Sep	7,320	76.1	18	1	X	X	X	108	120	169
17-Sep	7,010	75.7	18	1	X	X	X	108	118	169
18-Sep	6,640	74.7			X	X	X			
19-Sep	6,420	74.1			X	X	X			
20-Sep	6,050	73.7			X	X	X			
21-Sep	5,700	73.1	20	2	X	X	X	108	118	169
22-Sep	5,630	72.6	24	2	X	X	X	108	118	169
23-Sep	5,480	72.4	28	1	X	X	X	108	120	169
24-Sep	5,400	72.4	28	6	X	X	X	109	120	169
25-Sep	5,310	72.1			X	X	X			
26-Sep	5,190	71.5	26	1	X	X	X	108	119	168
27-Sep	5,020	71.3	26	1	X	X	X	108	118	168
28-Sep	5,170	71.3	26	2	X	X	X	108	120	169
29-Sep	5,070	71.7	18	2	X	X	X	108	120	169
30-Sep	10,000	71.7	18	3	X	X	X	111	118	168
1-Oct	10,400	70.7	15	1	X	X	X	108	118	168
2-Oct	11,000	69.1			X	X	X			
3-Oct	30,300	67.3			X	X	X			
4-Oct	30,300	65.8	15	4	X	X	X	111	119	168
5-Oct	26,100	62.5	15	3	X	X	X	110	118	166
6-Oct	21,300	60.1	18	6	X	X	X	108	118	165
7-Oct	18,600	60.1	20	3	X	X	X	109	118	168
8-Oct	15,700	60.9	20	3	X	X	X	108	119	168
9-Oct	13,900	61.5			X	X	X			
10-Oct	13,200	62.4			X	X	X			
11-Oct	11,700	63.1	20	2	X	X	X	109	118	169
12-Oct	10,900	63.6	22	2	X	X	X	109	120	169
13-Oct	9,940	63.9	22	2	X	X	X	108	118	169
14-Oct	9,820	64.3	22	2	X	X	X	109	119	168
15-Oct	8,910	63.9	22	2	X	X	X	109	120	169

Table 10

Daily summary of resident fish passage at the Holtwood Fish Passage Facility in fall, 2015 (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>8 Sep</i>	<i>9 Sep</i>	<i>10 Sep</i>	<i>11 Sep</i>	<i>12 Sep</i>
Hours of Operation - Tailrace:	5.8	5.8	5.9	6.0	5.9	5.9	5.7	5.9	5.7	5.8
Number of Lifts - Tailrace:	7	7	7	7	7	6	6	6	7	6
Hours of Operation - Spillway:	2.0	5.8	5.8	6.0	5.9	5.9	5.7	6.0	5.7	5.9
Number of Lifts - Spillway:	1	7	7	7	7	5	7	6	7	6
Water Temperature (*F):	79.8	80.3	80.3	81.5	81.4	80.6	81.0	80.7	79.7	79.2
American eel	0	0	0	0	0	0	0	0	0	0
Gizzard shad (est.)	29,200	488	34,050	9,300	52,400	1,100	65,500	77,000	40,000	57,500
Carp	0	0	0	1	0	0	3	0	1	0
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0
Channel Catfish	4	22	11	16	10	1	7	0	47	21
Flathead Catfish	0	0	0	0	0	0	0	0	0	0
Rock bass	0	0	0	0	0	0	0	0	0	0
Bluegill	0	7	5	1	0	0	2	1	4	2
Smallmouth Bass	0	0	0	1	3	0	0	1	0	0
Walleye	0	1	1	2	0	0	1	0	0	1
Atlantic needlefish	0	0	0	0	0	0	0	0	0	0
Daily Total	29,204	518	34,067	9,321	52,413	1,101	65,513	77,002	40,052	57,524

<i>Date:</i>	<i>13 Sep</i>	<i>14 Sep</i>	<i>15 Sep</i>	<i>16 Sep</i>	<i>17 Sep</i>	<i>21 Sep</i>	<i>22 Sep</i>	<i>23 Sep</i>	<i>24 Sep</i>	<i>26 Sep</i>
Hours of Operation - Tailrace:	5.7	5.8	5.8	5.6	5.7	5.6	5.8	5.8	5.6	5.6
Number of Lifts - Tailrace:	6	6	6	6	7	7	6	6	7	7
Hours of Operation - Spillway:	5.7	5.8	5.8	5.7	5.8	5.7	5.8	5.9	5.6	5.6
Number of Lifts - Spillway:	6	6	6	5	7	7	6	6	7	7
Water Temperature (*F):	77.5	75.7	75.3	76.1	75.7	73.1	72.6	72.4	72.4	71.5
American eel	0	0	0	0	0	0	0	0	0	0
Gizzard shad (est.)	19,000	65,000	60,000	33,000	2,200	300	13,400	400	10,000	570
Carp	0	1	1	0	0	0	0	0	0	0
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0
Channel Catfish	6	43	43	13	0	1	0	0	14	0
Flathead Catfish	0	1	2	0	0	0	0	0	0	0
Rock bass	0	0	0	0	0	0	0	0	1	0
Bluegill	0	0	3	0	3	2	0	2	0	0
Smallmouth Bass	0	0	0	0	1	2	0	0	0	0
Walleye	0	0	0	0	3	0	0	0	1	4
Atlantic needlefish	0	0	0	0	0	0	0	0	0	8
Daily Total	19,006	65,045	60,049	33,013	2,207	305	13,400	402	10,016	582

Table 10 (Continued)

<i>Date:</i>	<i>27 Sep</i>	<i>28 Sep</i>	<i>29 Sep</i>	<i>30 Sep</i>	<i>1 Oct</i>	<i>4 Oct</i>	<i>5 Oct</i>	<i>6 Oct</i>	<i>7 Oct</i>	<i>8 Oct</i>
<i>Hours of Operation - Tailrace:</i>	5.8	5.7	5.6	5.8	5.8	5.5	5.8	5.7	5.8	5.8
<i>Number of Lifts - Tailrace:</i>	6	7	7	6	6	7	6	7	6	6
<i>Hours of Operation - Spillway:</i>	5.8	5.7	5.7	5.8	5.8	5.6	5.8	5.8	5.8	5.9
<i>Number of Lifts - Spillway:</i>	6	7	7	6	6	7	6	7	6	6
<i>Water Temperature (*F):</i>	71.3	71.3	71.7	71.7	70.7	65.8	62.5	60.1	60.1	60.9
American eel	0	1	0	0	0	0	0	0	0	0
Gizzard shad (est.)	300	220	600	2,700	10,000	5,200	800	2,100	500	231
Carp	0	0	0	0	0	1	13	7	0	1
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	1
Channel Catfish	7	6	0	2	10	7	0	0	3	0
Flathead Catfish	0	0	0	0	0	0	0	0	0	0
Rock bass	0	0	0	0	0	0	0	0	0	0
Bluegill	0	0	0	1	0	0	0	0	0	0
Smallmouth Bass	2	2	0	0	0	2	0	0	0	0
Walleye	5	5	0	1	0	8	0	3	3	5
Atlantic needlefish	0	0	0	0	0	0	0	0	0	0
Daily Total	314	234	600	2,704	10,010	5,218	813	2,110	506	238

<i>Date:</i>	<i>11 Oct</i>	<i>12 Oct</i>	<i>13 Oct</i>	<i>14 Oct</i>	<i>15 Oct</i>	<i>TOTAL</i>
<i>Hours of Operation - Tailrace:</i>	5.7	5.6	5.6	5.6	6.0	201.2
<i>Number of Lifts - Tailrace:</i>	7	7	7	7	7	229
<i>Hours of Operation - Spillway:</i>	5.8	5.7	5.6	5.7	6.0	198.6
<i>Number of Lifts - Spillway:</i>	7	7	7	7	7	222
<i>Water Temperature (*F):</i>	63.1	63.6	63.9	64.3	63.9	
American eel	0	0	0	0	0	1
Gizzard shad (est.)	9,300	74	750	120	28	603,331
Carp	1	1	0	0	1	32
Shorthead Redhorse	0	0	0	0	0	1
Channel Catfish	0	3	2	0	2	301
Flathead Catfish	0	0	0	0	0	3
Rock bass	0	0	0	0	0	1
Bluegill	0	1	0	0	0	34
Smallmouth Bass	2	1	0	1	1	19
Walleye	7	10	7	11	8	87
Atlantic needlefish	0	0	0	3	0	11
Daily Total	9,310	90	759	135	40	603,821

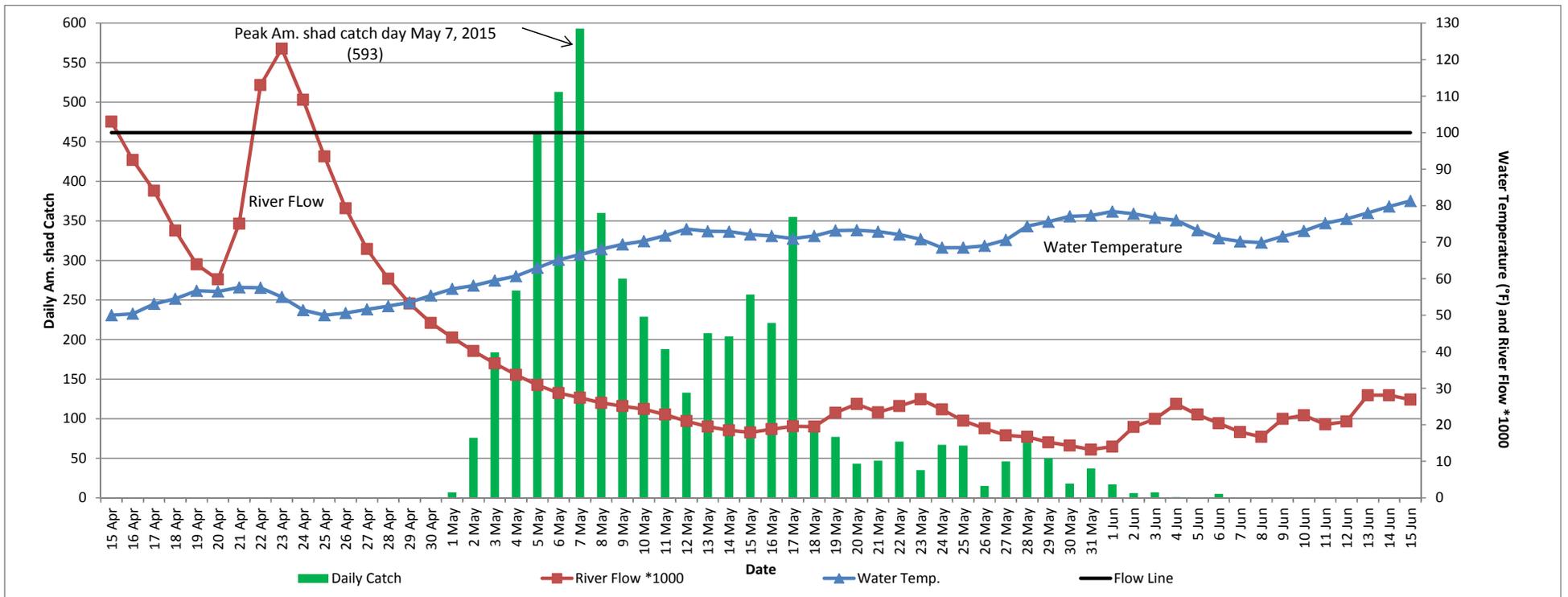


Figure 1

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 2015.

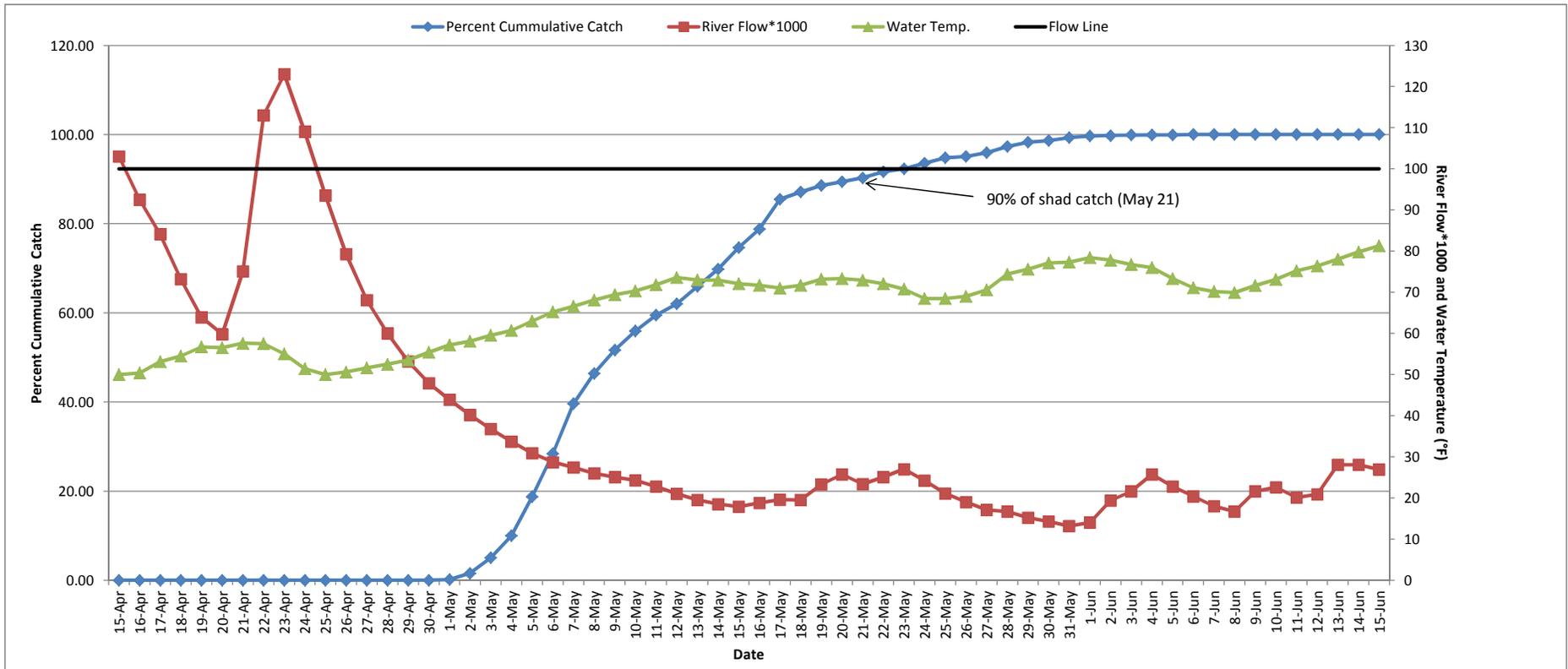


Figure 2

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 2015.