

Summary of Operations at the Holtwood Fish Passage Facility Spring and Fall, 2019

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Executive Summary

Per the settlement agreement for the Holtwood Redevelopment Project, 2019 marks the sixth year of fish passage operations for both resident and migratory fish species. This year also marks the second year that the fish passage facility was operated by local staff (Brookfield employees). The Holtwood fish passage facility commenced resident fish passage operations on April 1, 2019 for six hours per day (river flow permitting), switching to ten hour days of operation on May 3 when a sufficient number of American Shad were passed at Conowingo Dam, and observed in the catch at Holtwood, 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) on June 5. The season was interrupted three separate times due to high river events; April 17 to 24, May 14 to 18, and June 19 to 24. Normal operations continued once river conditions fell below 100,000 cfs.

The spring resident fish passage operations commenced on April 1, switching to migratory fish passage mode on May 3 due to the passage of the first American Shad at Holtwood on May 1. Migratory fish passage operations ended on June 5, with agency concurrence, due to increasing water temperatures and low numbers of shad in the daily passage counts. Resident fish passage operations resumed on June 6 and continued through June 30 per the settlement agreement. The facility operated a total of 72 days between April 1 and June 30, 2019 (Tailrace = 70 days; Spillway = 69 days).

The fall season component of resident fish passage was conducted between September 3 and October 15 on 33 days in 2019 (Tailrace = 15 days; Spillway = 33 days), with the last day of operations on October 15. This component was completed without any interruptions due to high river flow; river flows were below 100,000 cfs during the entire period.

During the American Shad passage season (31 days of operation from May 1 to June 5), the lifts passed 47,517 fish of 21 taxa, and one hybrid. Gizzard Shad dominated the catch, and comprised nearly 93.7% of the total fish collected and passed. American Shad represented the sole *Alosa* species collected and passed at Holtwood in 2019. A total of 571 American Shad were passed by the Holtwood fishway in 2019 (570 American Shad during the migratory fish passage season, with one American Shad passed on June 8 during resident fish passage operations).

The 2019 American Shad passage rate at Holtwood (11.9% of American Shad passing Conowingo passed Holtwood) was the second lowest rate observed since operations commenced in 1997. The American Shad passage season at Holtwood appeared to be hampered by the low numbers passed at Conowingo Dam (4,787), and three separate high river flow events which shut down operations as stated previously.

During spring 2019, resident fish passage operations occurred on 22 days in April, and 19 days in June. The facility operated six hours per day from 0900 to 1500 hours per the settlement agreement. A total of 11,573 fish of 20 taxa and one hybrid, including one American Shad, was collected and passed during resident fish passage operations this spring. The passage of seven resident species (Smallmouth Bass, Walleye, Channel Catfish, Shorthead Redhorse, Quillback, Common Carp, and Gizzard Shad) during resident passage periods was compared to the passage of those same seven species during the migratory passage season. During the spring of 2019, 81.3% of the total resident fish observed were passed during the American Shad migratory fish passage season.

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Fall resident fish passage operations were conducted using both the tailrace and spillway fish lifts. During the 33 days of operation, an estimated total of 212,696 fish comprised of ten species plus shiners (*Notropis* sp.) were passed. *Notropis* sp., (estimated 114,518; combination of Comely, Spotfin, and Spottail Shiners) dominated the total fall catch at 53.8%, with juvenile and some adult Gizzard Shad (97,361) accounting for the second most abundant species at 45.8%. Bluegill (349), Channel Catfish (317) and Smallmouth Bass (113) combined comprised an additional 0.4% of the total catch.

This year was the twenty-third year of fish passage operations at the Holtwood fish passage facility. Future fish passage seasons will continue to build on past years' experience to refine and enhance fish passage operations.

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) 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, 2015, 2017, 2018, and 2019. This year marked the twenty-third operational season.

Objectives of 2019 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 two large Kaplan turbines (100 MW capacity) and a reservoir (Lake Aldred) of 2,400-acre 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 2019, all spillway Obermeyer gates were operable. Operations began at the Holtwood Fish Lift facility on April 1, 2019 to initiate passage of resident fish species prior to passage of American Shad at Conowingo Dam (Table 1). After the passage of the first American Shad on May 1, American Shad passage operations at Holtwood (10-hr days), were initiated on May 3. Holtwood operations were interrupted three separate times when river flows greater than 100,000 cfs occurred; April 17 to 24, May 14 to 18, and June 19 to 24. These high river flow episodes may have impacted American Shad passage this year at Holtwood (Table 1).

In 2019, passage operations for migratory fish (American Shad, etc.) ended on June 5, with agency concurrence, due to increasing water temperatures and low American Shad passage. Spring passage operations for resident fish species resumed on June 6. During this period, technicians observed the last American Shad of the season on June 8. Spring resident fish passage operations concluded on June 30 per the settlement agreement.

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 2019, all four Obermeyer gate sections were available for operation. Generally, the Obermeyer gates are in the closed (up) position during fish passage operations excepting those times when the river flow approaches and exceeds 100,000 cfs.

Design guidelines for fishway operation include seven entrance combinations. These are: (1) entrances A, B, and C; (2) entrances A and B; (3) entrances A and C; (4) entrances B and C; (5) entrance A only; (6) entrance B only; and (7) entrance C only. Completion of the attraction water system after the 1997 season resulted in the drafting of operating protocols and guidelines that are flexible and utilize experience gained during previous years of fish lift operation. In 2014, after installation of the additional attraction water supply pipe and valve (MOV 8), a new operating matrix was developed, but testing and fine-tuning of the matrix continues. The following gate combinations were utilized in spring, 2019: entrances A, B, and C (67 days); entrances A and B (three days); and entrance C only (two days).

2.2.2 Fishway Operation

Daily operation of the Holtwood fishway in 2019 was based on the American Shad catch, and managed to maximize that catch. Pre-season equipment preparations began in March and were completed before season start-up. 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 reached or exceeded 100,000 cfs and resumed when flows fell below 100,000 cfs.

Holtwood fish passage operations in spring 2019 commenced on April 1 and ended on June 30 (total days of operation = 72). The migratory fish passage season (based on presence of American Shad in the catch) ran from May 1 to June 5 (31 days of operation, Table 2). During the spring fish passage season, the tailrace lift operated on 70 days while the spillway lift operated on 69 days. Resident fish passage operational hours were 0900 to 1500 hrs and the operational hours were 0800 to 1800 hrs during the migratory fish passage season, per the redevelopment settlement agreement.

During resident fish passage operations, some interruptions to fishway operation occurred due to mechanical issues. The tailrace crowder program change was preventing the tailrace crowder doors from reaching the proper trap position on April 1. The issue was corrected and the tailrace system was placed back in automatic mode on April 2. Also on April 1, one of the spillway crowder doors would not move from the full open position. Troubleshooting the issue discovered a faulty limit switch that was replaced on April 4, and the spillway lift resumed operation on April 5. During the migratory fish passage season, the Holtwood fishway was not shut down due to mechanical problems. Operations were suspended from May 14 to 18 due to a high river flow event. The spillway crowder limit switch issues occurred again on May 24 causing the crowder to act erratically. The crowder was returned to full service on June 11 upon a second limit switch replacement.

Flashboard repair was conducted on June 19, one day prior to a high flow event, resulting in a one-day shutdown. Damage to the tailrace hopper extension screen limited the number of tailrace lifts to two on June 25, with repairs to fix the hopper extension screen occurring on June 26 and 27. From June 27 through June 30, the spillway crowder began to act abnormally, but was operational enough to finish out the season. During the mid-season maintenance period (July-August), it was found that the spillway crowder festoon cable was water-logged and causing intermittent grounds. This was found to be the root cause of the limit switch failures during the fishing season. The festoon cable was replaced before the start of fall resident fish passage operations and the Crowder worked well the rest of the fishing season.

Fall 2019 resident fish passage operations were conducted on 33 days between September 3 and October 15. The fishway was generally operated five days per week between the hours of 0900 to 1500 hrs. During the fall season, fish lift operators dealt with some mechanical and environmental issues. On September 5, the tailrace crowder motor breaker failed, preventing the use of this crowder through September 6. Crowder repairs were completed on September 6 and the tailrace crowder was back on line on September 7. Also on September 6, low water levels resulted in conditions that made the tailrace inoperable. The spillway hopper was shut down on September 11 to make repairs to the hopper hoist cable. After noticing increased vibration during operation of the tailrace hopper, an inspection on October 1 revealed significant wear to the gears of the tailrace hopper hoist, resulting in termination of the tailrace fish lift for the remainder of the fall season.

The United States Fish and Wildlife Service (USFWS) conducted its seasonal inspection of the fish passage facilities at Holtwood Dam on May 22, 2019. Based on the USFWS review, several issues were observed and mentioned in an inspection report received by Brookfield personnel on October 24, 2019. The USFWS requested a written status report on required repairs for specific items by

December 1, 2019. Brookfield submitted a written status report on November 11, 2019 and is prepared to discuss specific items during the upcoming FPTAC meeting (December 10 and 11, 2019).

Operation of the Holtwood fishway followed methods established during the 1997 and 1998 spring fish migration seasons. Due to pre-season maintenance efforts by the local staff, the fish lift was generally operated in automatic mode by local staff (Brookfield employees). This is the second season this has occurred since the fish lift went into operation. 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 three ft wide, 12 ft long channel on the west side of the trough. The channel is adjacent to a four ft by ten ft window located in the counting room where fish are identified and counted. Passage from the fishway is controlled by one set of gates located just downstream of the viewing window. During the day, fish passage is controlled by the technician who opens/closes the set of gates downstream of the viewing window. At night, fish are denied passage from the fishway by closing these gates. When necessary, flow is maintained through the exit channel to ensure that adequate water quality exists for fish that may be in the trough overnight.

Fish passage data is handled by a single system that records and processes the data. The hourly 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 off-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 2019 migratory fish passage period (May 1 to June 5) is presented in Table 2. A total of 47,517 fish of 21 taxa, and one hybrid passed upstream into Lake Aldred. Gizzard Shad (93.7% or 44,542 of 47,517), Channel Catfish (952), American Shad (570), Quillback (510), and Shorthead Redhorse (503) comprised 99% of the total fish collected and passed. The peak one-day passage of all species occurred on May 26, when 6,226 fish were passed, comprised mostly of Gizzard Shad (6,144) which accounted for nearly 99% of that day's catch.

3.2 American Shad Passage

A total of 570 American Shad were passed in 31 days at Holtwood during the 2019 official migratory fish passage season (May 1 to June 5). One additional American Shad was passed on June 8, after the official migratory season ended, for an overall passage total of 571 American Shad. Collection and passage of American Shad varied daily with 93.1% of the overall total American Shad (531) passed by May 13 (Figures 1 and 2). The highest daily American Shad catch occurred on May 4 when 135 shad moved upstream during ten hours of operation. On a daily basis, overall shad passage was consistent through the fishway between 0900 hrs and 1459 hrs, with the highest hour of American Shad passage (77) during the 1400-1459 hr period, and the lowest hour of American Shad passage (26) occurring from 1700-1759 hrs (Table 3). A total of 361 American Shad (63.3% of total American Shad recorded) passed when river flows were between 40,001 and 60,000 cfs, with the remaining 209 American Shad (36.7%) passed at flows greater than 60,000 cfs. (Table 4). River flows less than 40,000 cfs did not occur during the 2019 migratory fish passage season. The 2019 American Shad passage rate at Holtwood, (11.9% of the 4,787 American Shad that passed Conowingo Dam also passed Holtwood) was the second lowest rate observed since operations commenced in 1997 (Table 5).

Migratory fish passage operations were conducted at average water temperatures ranging from 56.7° to 74.8°F and daily average river flows between 40,700 and 108,000 cfs, (Table 1). Spillage occurred on all but five days during the migratory fish passage season. River water temperatures did not reach 70°F until May 27 while the average river flow during the 31 days of migratory fishway operation was 69,348 cfs.

The capture of American Shad at the fishway in 2019 occurred over a relatively broad range of station operation and discharge conditions this spring (Table 1). American Shad were attracted to the tailrace lift at tailrace water elevations ranging from 110.6 to 118.5 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 167.7 to 172.0 ft (Table 1). Although new flash boards were installed on April 12 and 13, spillage was a common occurrence at Holtwood during the 2019 migratory and resident fish passage seasons, due in part to above average river flows that hindered routine fish passage operations. The entire spring season was interrupted three separate times due to high river flow events; April 17 to 24, May 14 to 18, and June 19 to 24. Fishway operations resumed after river conditions fell below 100,000 cfs.

3.3 Gizzard Shad and Other Alosids

In 2019, a total of 54,798 Gizzard Shad were passed by the Holtwood fish passage facility during the entire spring season (April 1 through June 30). The hourly passage of Gizzard Shad is shown in Table 6. Throughout the season, daily total Gizzard Shad counts ranged from 0 (April 3 and 4) to 6,144 recorded on May 26. During the migratory fish passage season (May 1 to June 5), a total of 44,542 Gizzard Shad were passed, which comprised 93.7% of the total fish passage recorded during the migratory period.

No Hickory Shad or River Herring (Alewife or Blueback Herring) were observed during Holtwood fish passage operations this year.

3.4 Maryland DNR tag-recapture

For most of the spring migratory fish passage season, water clarity was subpar due to above average river flows, with visibility at the viewing window ranging from 6 to 24 inches during the American Shad season. The viewing technicians did not record any Maryland DNR floy tagged American Shad at Holtwood in spring 2019.

4.0 Resident Fish Passage

4.1 Spring

During spring 2019, resident fish passage operations occurred on 22 days in April, and 19 days in June. A compilation of daily fish passage prior to, during, and after the American Shad passage season is provided in Table 7. The facility operated six hours per day from 0900 to 1500 hrs during resident fish passage periods per the settlement agreement. A total of 11,573 fish of 20 taxa and one hybrid, including one American Shad, was collected and passed during resident fish passage operations this spring. The passage of 7 resident species (Smallmouth Bass, Walleye, Channel Catfish, Shorthead Redhorse, Quillback, Common Carp, and Gizzard Shad) passed during resident passage periods was compared to the passage of those same seven species during the migratory passage season (Table 8). During the spring of 2019, 81.3% of the total resident fish observed were passed during the American Shad migratory fish passage season.

4.2 Fall

Fall resident fish passage operations began on September 3, with a river flow of 12,700 cfs, and a water temperature of 78.3°F (Table 9). During the fall resident fish passage season, the tailrace lift was operated on only 15 of the 33 days due to the mechanical issues described previously (Section 2.2.2 Fishway Operation), while the spillway lift operated on every scheduled day. During the 33 days of operation, an estimated total of 212,696 fish comprised of ten species plus shiners (*Notropis* sp.) were passed. *Notropis* sp., (estimated 114,518; combination of Comely, Spotfin, and Spottail Shiners) dominated the total fall catch at 53.8%, with juvenile and some adult gizzard shad (97,361) accounting for the second most abundant species at 45.8%. Bluegill (349), Channel Catfish (317) and Smallmouth Bass (113) combined comprised an additional 0.4% of the total catch (Table 10).

5.0 Maintenance Performed in 2019

Pre-season maintenance included calibration and inspection of the electronic instrumentation and motor operated valves (MOV's). Maintenance and calibration of this equipment allows the lifts to be run in automatic mode except for times when a mechanical failure occurs preventing a piece of equipment from operating automatically. All of the MOV limits were tested and set to the proper locations. All entrance gates were calibrated and the limits were set. A pre-season drawdown was performed to check for debris accumulation and to install some of the antennas associated with the Tier II American Shad radio-telemetry study.

6.0 Recommendations

1. Continue to improve the current maintenance program to identify additional equipment maintenance inspection and testing activities to reduce in-season disruptions to operation. Unusual conditions, (e.g. severe flood events and additional operating requirements) require a more thorough review of the impacts to the equipment.
2. 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.

7.0 Literature Cited

Normandeau Associates, Inc. 1998. Summary of the 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.

Figures

Figure 1. A plot of river flow (USGS Marietta Gauge x 1000 cfs) and water temperature (°F) in relation to the daily American Shad catch at the Holtwood Fish Passage Facility, spring 2019.

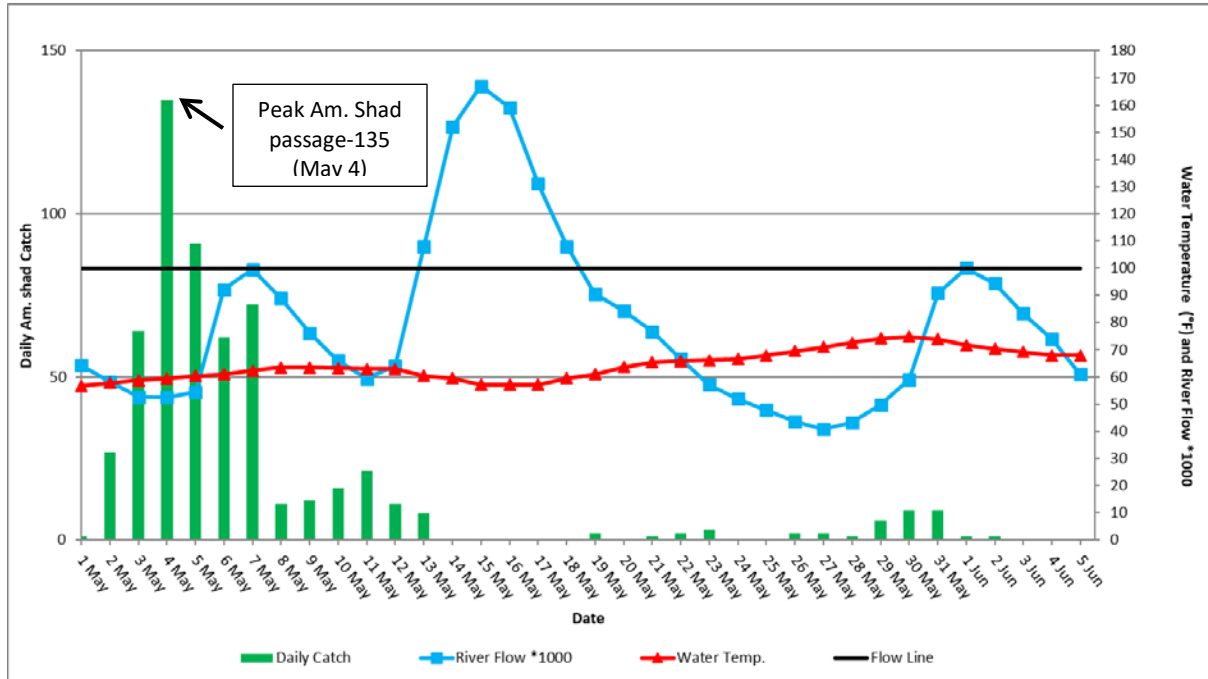
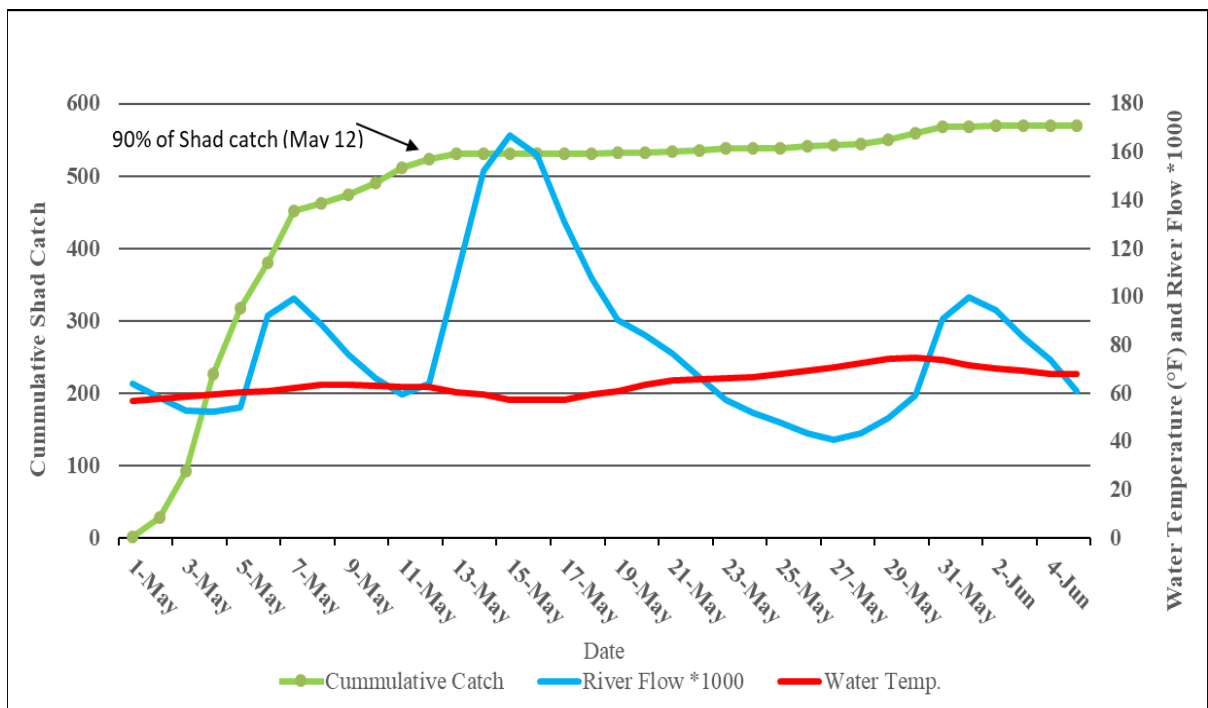


Figure 2. A plot of river flow (x 1000 cfs) and water temperature (°F) in relation to the percent cumulative American Shad catch at the Holtwood Fish Passage Facility, spring 2019.



Tables

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, 2019.

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	52,400	48.5	32	11	X	X	X	164.3	115.5	118
2 Apr	56,300	48.5	34	10	X	X	X	166	116.8	117.5
3 Apr	58,900	48.1	34	11	X	X		166.7	117	118
4 Apr	56,900	48.6	36	11	X	X		165.3	117	117.9
5 Apr	51,300	49.1	36	11	X	X	X	165	116	118
6 Apr	46,600	49.5	36	10	X	X	X	164.6	115.7	117.8
7 Apr	43,800	49.8	34	11	X	X	X	164.5	115.9	118
8 Apr	42,400	51.1	34	11	X	X	X	165.2	113	118
9 Apr	41,300	53.4	30	9	X	X	X	166.8	115	116.5
10 Apr	41,500	55.2	30	10	X	X	X	166.7	114.7	116
11 Apr	42,700	56.6	32	10	X	X	X	166.6	116	116
12 Apr	42,000	56.3	30	7	X	X	X	163.7	112.3	118
13 Apr	50,200	56.6	30	6	X	X	X	164	112.4	118
14 Apr	58,000	57.7	30	11	X	X	X	168	117	118
15 Apr	69,700	58.6	28	11	X	X	X	169.4	116.6	118
16 Apr	96,800	56.7	28	11	X	X	X	172	118	130.7
17 Apr	118,000	57.5								
18 Apr	116,000	56.5								
19 Apr	98,100	55.2								
20 Apr	108,000	56.1								
21 Apr	134,000	58.5								
22 Apr	152,000	60.0								
23 Apr	129,000	60.5								
24 Apr	105,000	60.1								
25 Apr	87,300	58.1	6	11	X	X	X	171.1	118	126
26 Apr	75,100	59.3	18	11	X	X	X	171.8	118	123.8
27 Apr	73,200	58.6	12	11	X	X	X	172	116.4	124
28 Apr	75,000	57.7	18	11	X	X	X	171.9	117.9	123.8
29 Apr	74,000	56.9	18	11	X	X	X	171.3	117.9	122.5
30 Apr	70,800	56.2	18	11	X	X	X	171.1	117.2	122.1
1 May	64,200	56.7	14	11	X	X	X	171	117.5	121.4
2 May	58,200	57.8	22	11	X	X	X	169	117	118
3 May	52,600	58.7	20	11	X	X	X	167.7	115.2	119
4 May	52,500	59.4	20	11	X	X	X	168.3	115.3	119

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

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	54,300	60.3	20	11	X	X	X	168.1	116.8	119
6 May	92,200	61	15	11	X	X	X	171.1	117.8	129.8
7 May	99,500	62.3	8	11	X	X		171.8	118.5	134.2
8 May	88,800	63.5	6	11	X	X	X	171.2	117.9	133.1
9 May	76,000	63.5	10	11	X	X	X	171.2	116.6	130.3
10 May	66,000	63.1	10	11	X	X	X	171	116.4	122.9
11 May	59,300	62.8	18	11	X	X	X	170.4	116.6	120.4
12 May	64,100	62.8	18	11	X	X	X	170.4	117.2	120.1
13 May	108,000	60.4	8-4	8	X	X	X	171.9	117.6	134.3
14 May	152,000	59.5								
15 May	167,000	57.1								
16 May	159,000	57.1								
17 May	131,000	57.1								
18 May	108,000	59.5								
19 May	90,500	61	18	10	X	X	X	172	116.5	126.9
20 May	84,300	63.6	12-18	11	X	X	X	171.9	115.8	128.5
21 May	76,600	65.4	10	11	X	X	X	171	116.5	131
22 May	66,600	65.8	8-10	9	X	X	X	171.1	115.7	125.3
23 May	57,100	66.1	12	11	X	X	X	170	115.8	119.5
24 May	51,800	66.6	12	10	X	X	X	171.6	113.3	123.2
25 May	47,700	67.9	15	5	X	X	X	171.5	112.4	127.8
26 May	43,500	69.4	18	8	X	X	X	171.5	111.5	123.5
27 May	40,700	70.9	24	6	X	X	X	171	110.6	122.4
28 May	43,200	72.5	24	10	X	X	X	169.8	114.8	119.1
29 May	49,600	74.1	20	11	X	X	X	168	116.1	118
30 May	59,100	74.8	18	11	X	X	X	169.2	117	118.1
31 May	90,900	73.8	18	11	X	X	X	171.7	117.2	133
1 Jun	100,000	71.7	8-12	11	X	X	X	172	117	131.4
2 Jun	94,400	70.3	6-8	11	X	X	X	171	116.4	133
3 Jun	83,200	69.2	6-8	11	X	X	X	170.7	116.5	129.5
4 Jun	73,900	67.9	6-8	6	X	X	X	171.3	115	127.8
5 Jun	61,000	67.8	8	5	X	X	X	170.7	115.2	128.8
6 Jun	52,000	68.8	11	9	X	X	X	170.4	115.1	120.8
7 Jun	45,800	70.5	10	8	X	X	X	169	115.6	118
8 Jun	41,200	71.9	8-10	9	X	X	X	169	113.9	118
9 Jun	36,700	72.4	22	11	X	X	X	169	114.4	118
10 Jun	34,100	72	12	10	X	X	X	168.7	113.5	118
11 Jun	32,400	71.6	18	8	X	X	X	170.5	115	120.3

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

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	29,800	71.4	18	9	X	X	X	168.2	113.5	118
13 Jun	29,500	71.2	10	9	X	X	X	168.8	113.7	118.3
14 Jun	29,400	70.8	13	8	X	X	X	168.3	112.7	118
15 Jun	29,300	70.4	18	7	X	X	X	169	113.3	118.3
16 Jun	29,100	70.2	15	6	X	X	X	168.3	112.2	118
17 Jun	27,600	70.7	10	9	X	X	X	168.6	113.1	118
18 Jun	27,000	72.7	12	4	X	X	X	164.1	111.6	118
19 Jun	44,600	72.6								
20 Jun	111,000	74.1								
21 Jun	103,000	71.5								
22 Jun	108,000	69.7								
23 Jun	127,000	69.5								
24 Jun	100,000	69.5								
25 Jun	75,900	70.8	2-4	10	X	X	X	170.9	117.5	130.5
26 Jun	58,700	72	4-6	11			X	170.8	116.4	121.1
27 Jun	48,200	74.1	4-6	9			X	169.8	115	118.1
28 Jun	41,100	76.2	12-18	10	X	X	X	170.2	115	121.9
29 Jun	36,000	78.1	18-20	10	X	X	X	169.7	114.3	118.5
30 Jun	32,700	79.2	18	5	X	X	X	168.7	111.5	118.3

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 2. Summary of daily fish passage at Holtwood during the American Shad passage season in spring 2019 (May 1 - June 5).

<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>	5.9	5.8	9.8	9.7	9.7	9.7	9.5	9.6	9.5	9.4
<i>Number of Lifts - Tailrace</i>	7	7	12	12	12	12	11	12	14	14
<i>Hours of Operation - Spillway:</i>	5.7	5.6	9.7	9.7	9.7	9.7	0.0	9.6	9.5	9.4
<i>Number of Lifts -Spillway:</i>	7	7	12	12	12	12	0	12	14	14
<i>Water Temperature (F)</i>	56.7	57.8	58.7	59.4	60.3	61	62.3	63.5	63.5	63.1
AMERICAN SHAD	1	27	64	135	91	62	72	11	12	16
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	397	1,186	906	2,593	1,953	3,286	1,979	2,361	1,873	3,167
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	2	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	1	0	1	0	1
CARP	1	3	4	1	4	0	2	0	2	2
BROWN BULLHEAD	0	0	0	0	0	1	0	0	0	0
NORTHERN HOGSUCKER	0	0	1	0	0	0	0	0	0	0
QUILLBACK	1	0	1	1	16	7	1	0	0	2
SHORthead REDHORSE	15	24	73	22	49	33	5	0	8	79
CHANNEL CATFISH	4	1	26	16	8	15	9	9	5	6
FLATHEAD CATFISH	0	0	3	0	0	2	0	0	1	5
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	0	0
PUMPKINSEED	0	0	1	0	0	0	0	0	0	0
BLUEGILL	3	1	1	0	0	1	0	0	0	0
SMALLMOUTH BASS	3	3	2	2	7	3	1	1	0	7
LARGEMOUTH BASS	0	1	0	0	0	0	0	0	0	1
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0
WALLEYE	0	2	0	7	13	6	3	0	5	11
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	0	0	0
BROOK TROUT	0	0	1	0	0	0	0	0	0	0
<i>Daily Totals</i>	425	1,250	1,083	2,777	2,141	3,417	2,072	2,383	1,906	3,297

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

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>	9.4	9.4	9.6						9.6	9.7
<i>Number of Lifts - Tailrace</i>	14	14	12						14	14
<i>Hours of Operation - Spillway:</i>	9.4	9.4	9.6	DNO	DNO	DNO	DNO	DNO	9.6	9.7
<i>Number of Lifts -Spillway:</i>	14	14	12						14	14
<i>Water Temperature (F)</i>	62.8	62.8	60.4						61	63.6
AMERICAN SHAD	21	11	8						2	0
HICKORY SHAD	0	0	0						0	0
BLUEBACK HERRING	0	0	0						0	0
ALEWIFE	0	0	0						0	0
GIZZARD SHAD	1,692	1,591	337						315	669
AMERICAN EEL	0	0	0						0	0
RAINBOW TROUT	0	0	0						1	0
MUSKELLUNGE	0	0	0						0	0
CARP	8	3	0						1	20
BROWN BULLHEAD	0	0	0						0	0
NORTHERN HOGSUCKER	0	0	0						0	0
QUILLBACK	30	1	0						0	7
SHORTHEAD REDHORSE	22	10	1						6	22
CHANNEL CATFISH	13	8	8						9	11
FLATHEAD CATFISH	6	5	4						3	3
WHITE PERCH	0	0	0						0	1
STRIPED BASS	0	0	0						0	0
ROCK BASS	0	0	0						0	0
PUMPKINSEED	0	0	0						0	0
BLUEGILL	0	0	0						3	1
SMALLMOUTH BASS	1	0	1						1	2
LARGEMOUTH BASS	1	1	0						1	1
YELLOW PERCH	0	0	0						0	0
WALLEYE	3	4	2						0	3
STRIPED BASS (HYBRID)	0	0	0						0	0
BROOK TROUT	0	0	0						0	0
<i>Daily Totals</i>	1,797	1,634	361	0	0	0	0	0	342	740

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

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>	9.1	9.9	9.9	9.5	9.4	10.0	10.0	9.9	9.9	9.9
<i>Number of Lifts - Tailrace</i>	14	14	14	12	11	14	14	14	15	14
<i>Hours of Operation - Spillway:</i>	9.1	9.9	9.9	9.5	9.4	10.0	10.0	9.9	9.9	9.9
<i>Number of Lifts -Spillway:</i>	14	14	14	12	11	14	14	14	13	14
<i>Water Temperature (F)</i>	65.4	65.8	66.1	66.6	67.9	69.4	70.9	72.5	74.1	74.8
AMERICAN SHAD	1	2	3	0	0	2	2	1	6	9
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	603	475	2,129	724	2,093	6,144	3,397	1,470	402	1,003
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	5	0	0	13	2	12	17	11	10	26
BROWN BULLHEAD	0	0	0	0	0	0	0	0	0	0
NORTHERN HOGSUCKER	0	0	0	0	0	0	0	0	0	0
QUILLBACK	4	0	2	12	0	6	2	115	38	132
SHORthead REDHORSE	5	7	15	13	2	6	9	19	2	20
CHANNEL CATFISH	23	23	20	35	43	40	66	91	149	57
FLATHEAD CATFISH	4	0	2	1	0	2	0	1	0	1
WHITE PERCH	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	0	1
ROCK BASS	1	0	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	1
BLUEGILL	1	0	0	0	0	0	0	0	0	0
SMALLMOUTH BASS	3	2	1	5	3	8	5	4	3	3
LARGEMOUTH BASS	0	0	0	0	2	2	0	0	0	1
YELLOW PERCH	1	0	0	0	0	0	1	0	0	0
WALLEYE	2	1	2	6	4	4	14	9	2	6
STRIPED BASS (HYBRID)	0	0	0	0	0	0	0	1	0	0
BROOK TROUT	0	0	0	0	0	0	0	0	0	0
<i>Daily Totals</i>	653	510	2,174	809	2,149	6,226	3,513	1,722	612	1,260

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 2. (Continued)

<i>Date</i>	5/31	6/1	6/2	6/3	6/4	6/5	<i>Season Totals</i>
<i>Hours of Operation- Tailrace:</i>	10.0	6.8	9.9	9.9	9.7	9.5	289.6
<i>Number of Lifts - Tailrace</i>	14	9	14	13	13	13	393
<i>Hours of Operation - Spillway:</i>	10.0	8.0	9.9	9.9	9.7	9.5	280.8
<i>Number of Lifts -Spillway:</i>	14	11	14	13	13	13	382
<i>Water Temperature (F)</i>	73.8	71.7	70.3	69.2	67.9	67.8	*
AMERICAN SHAD	9	1	1	0	0	0	570
HICKORY SHAD	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0
GIZZARD SHAD	777	179	174	277	118	272	44,542
AMERICAN EEL	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	0	0	0	3
MUSKELLUNGE	0	0	0	0	0	0	3
CARP	4	0	0	1	0	2	154
BROWN BULLHEAD	0	0	0	0	0	0	1
NORTHERN HOGSUCKER	0	0	0	0	0	0	1
QUILLBACK	43	11	23	6	15	34	510
SHORTHEAD REDHORSE	14	1	4	3	4	10	503
CHANNEL CATFISH	211	15	7	6	5	13	952
FLATHEAD CATFISH	0	1	0	1	1	1	47
WHITE PERCH	0	0	0	0	0	0	1
STRIPED BASS	0	0	0	0	0	0	1
ROCK BASS	0	0	0	0	0	0	1
PUMPKINSEED	0	0	0	0	0	0	2
BLUEGILL	0	1	0	0	0	0	12
SMALLMOUTH BASS	0	0	0	1	0	0	72
LARGEMOUTH BASS	0	0	0	0	0	0	11
YELLOW PERCH	0	0	0	0	0	0	2
WALLEYE	10	5	1	0	1	1	127
STRIPED BASS (HYBRID)	0	0	0	0	0	0	1
BROOK TROUT	0	0	0	0	0	0	1
<i>Daily Totals</i>	1,068	214	210	295	144	333	47,517

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 3. Hourly summary of American Shad passage at the Holtwood fish passage facility in spring 2019 (May 1 - June 5).

DATE	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14
<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	
<i>Viewing Time (End)</i>	15:00	15:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	17:00	
<i>Viewing Time (hrs)</i>	6.0	6.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.0	DNO
<i>Water Temp.(°F)</i>	56.7	57.8	58.7	59.4	60.3	61	62.3	63.5	63.5	63.1	62.8	62.8	60.4	
0600 to 0659														
0700 to 0759														
0800 to 0859			9	6	15	9	3	3	1	0	1	1	2	
0900 to 0959	0	5	1	29	5	4	8	1	1	0	6	1	1	
1000 to 1059	1	7	6	12	13	7	17	1	0	1	3	2	0	
1100 to 1159	0	4	6	14	16	2	9	0	0	2	1	3	0	
1200 to 1259	0	3	3	14	10	4	12	0	3	5	2	1	2	
1300 to 1359	0	4	7	12	5	12	13	1	0	1	2	0	0	
1400 to 1459	0	4	13	31	8	10	1	1	2	2	2	2	0	
1500 to 1559			5	8	7	6	5	0	1	3	1	1	3	
1600 to 1659			6	7	5	6	1	1	4	1	3	0	0	
1700 to 1759			8	2	7	2	3	3	0	1	0	0		
1800 to 1859														
1900 to 1959														
2000 to 2059														
<i>Total</i>	1	27	64	135	91	62	72	11	12	16	21	11	8	0

Table 3. (Continued)

DATE	5/15	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28
<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
<i>Viewing Time (End)</i>					18:00	18:00	18:00	17:45	18:00	18:00	18:00	18:00	18:00	18:00
<i>Viewing Time (hrs)</i>	DNO	DNO	DNO	DNO	10.0	10.0	10.0	9.8	10.0	10.0	10.0	10.0	10.0	10.0
<i>Water Temp.(°F)</i>					61	63.6	65.4	65.8	66.1	66.6	67.9	69.4	70.9	72.5
0600 to 0659														
0700 to 0759														
0800 to 0859					0	0	0	2	0	0	0	0	1	0
0900 to 0959					0	0	0	0	2	0	0	0	0	0
1000 to 1059					0	0	0	0	0	0	0	1	0	0
1100 to 1159					0	0	0	0	0	0	0	0	1	0
1200 to 1259					0	0	0	0	1	0	0	0	0	0
1300 to 1359					1	0	0	0	0	0	0	0	0	1
1400 to 1459					0	0	0	0	0	0	0	0	0	0
1500 to 1559					0	0	1	0	0	0	0	1	0	0
1600 to 1659					1	0	0	0	0	0	0	0	0	0
1700 to 1759					0	0	0	0	0	0	0	0	0	0
1800 to 1859														
1900 to 1959														
2000 to 2059														
<i>Total</i>	0	0	0	0	2	0	1	2	3	0	0	2	2	1

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 3. (Continued)

<i>DATE</i>	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5	<i>Season Totals</i>
<i>Viewing Time (Start)</i>	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	
<i>Viewing Time (End)</i>	17:45	18:00	18:00	16:00	18:00	17:30	18:00	18:00	
<i>Viewing Time (hrs)</i>	9.8	10.0	10.0	8.0	10.0	9.5	10.0	10.0	
<i>Water Temp.(°F)</i>	74.1	74.8	73.8	71.7	70.3	69.2	67.9	67.8	
0600 to 0659									
0700 to 0759									
0800 to 0859	1	0	0	1	0	0	0	0	55
0900 to 0959	0	2	6	0	0	0	0	0	72
1000 to 1059	0	1	2	0	0	0	0	0	74
1100 to 1159	1	0	0	0	0	0	0	0	59
1200 to 1259	4	4	1	0	1	0	0	0	70
1300 to 1359	0	0	0	0	0	0	0	0	59
1400 to 1459	0	1	0	0	0	0	0	0	77
1500 to 1559	0	1	0		0	0	0	0	43
1600 to 1659	0	0	0		0	0	0	0	35
1700 to 1759	0	0	0		0	0	0	0	26
1800 to 1859									
1900 to 1959									
2000 to 2059									
Total	6	9	9	1	1	0	0	0	570

Table 4. Holtwood fishway summary table evaluating American Shad passage at three river flow ranges (1997-2019).

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

* Denotes seasons of high river flow or frequent spillage.

Table 4. (Continued)

	2005	2006	2007	2008*	2009*	2010	2011*	2012
Migration season start date	27 Apr	11 Apr	01 May	21 Apr	03 May	21 Apr	20 May	07 Apr
Migration season end date	10 Jun	06 Jun	04 Jun	09 Jun	07 Jun	09 Jun	05 Jun	05 Jun
Season duration (days)	45	57	35	50	36	50	17	60
Number of days of operation	36	57	35	49	36	48	10	58
Am. shad season total (Conowingo)	68,926	56,899	25,464	19,914	29,272	37,757	20,571	22,143
Am. shad season total (Holtwood)	34,189	35,968	10,338	2,795	10,896	16,472	21	4,238
River flow ≤40,000 cfs								
Number of days	33	48	27	20	20	40	0	31
Percent of season	92%	84%	77%	40%	56%	83%	0%	53%
No. of Am. shad passed	34,060	35,302	9,549	2,242	8,939	15,606	0	3260
Daily ave. of Am. shad passed	1,032	735	354	112	447	372	0	105
Percent of total passage	99.6%	98.1%	92.3%	80.2%	82%	95%	0%	77%
River flow 40,001 to 60,000 cfs								
Number of days	3	5	8	22	14	8	2	18
Percent of season	8%	9%	23%	44%	39%	17%	12%	30.0%
No. of Am. shad passed	129	566	789	533	1,846	866	0	967
Daily ave. of Am. shad passed	43	113	99	24	132	108	0	54
Percent of Total Passage	0.4%	1.6%	7.6%	19.0%	17.0%	5%	0.0%	22.8%
River flow >60,000 cfs								
Number of days	0	4	0	8	2	0	15	4
Percent of season	0%	7%	0%	16%	5%	0%	88%	6.7%
No. of Am. shad passed	0	100	0	20	111	0	21	11
Daily ave. of Am. shad passed	0	25	0	2	55	0	2	3
Percent of total passage	0.0%	0.3%	0.0%	0.7%	1.0%	0%	100%	0.3%

* Denotes seasons of high river flow or frequent spillage.

Table 4. (Continued)

	2013	2014*	2015	2016	2017*	2018*	2019*
Migration season start date	29-Apr	27-Apr	1-May	21-Apr	18-Apr	30-Apr	01 May
Migration season end date	5-Jun	8-Jun	2-Jun	8-Jun	7-Jun	6-Jun	5-Jun
Season duration (days)	38	43	33	49	51	38	36
Number of days of operation	38	37	33	49	44	27	31
Am. shad season total (Conowingo)	12,733	10,425	8,341	14,276	16,248	6,992	4,787
Am. shad season total (Holtwood)	2,503	2,589	5,286	6,696	3,169	1,458	570
River flow ≤40,000 cfs							
Number of days	34	16	31	42	13	14	0
Percent of season	89%	37%	94%	86%	29%	52%	0%
No. of Am. shad passed	2,355	2,248	5,203	6,071	1,516	1,368	0
Daily ave. of Am. shad passed	70	141	168	144	117	97	0
Percent of total passage	94%	87%	98%	91%	48%	94%	0
River flow 40,001 to 60,000 cfs							
Number of days	4	12	2	7	17	9	13
Percent of season	11%	28%	6%	14%	39%	33%	41.9%
No. of Am. shad passed	148	314	83	625	1,430	41	361
Daily ave. of Am. shad passed	37	26	41	89	84	4	28
Percent of Total Passage	5.9%	12.0%	2.0%	9.0%	45%	3.00%	63.3%
River flow >60,000 cfs							
Number of days	0	15	0	0	14	4	18
Percent of season	0.0%	34.9%	0.0%	0.0%	32%	15%	58.1%
No. of Am. shad passed	0	27	0	0	223	49	209
Daily ave. of Am. shad passed	0	2	0	0	16	12	11
Percent of total passage	0.0%	1.0%	0.0%	0.0%	7.00%	3.00%	36.7%

* Denotes seasons of high river flow or frequent spillage.

Table 5. Summary of American Shad passage counts and percent passage values at Susquehanna River Dams (1997-2019).

	Conowingo East	Holtwood		Safe Harbor		York Haven	
		Number	% of C.E.L.	Number	% of Holt.	Number	% of S.H.
1997	90,971	28,063	30.8%	20,828	74.2%	-	-
1998	39,904	8,235	20.6%	6,054	73.5%	-	-
1999	69,712	34,702	49.8%	34,150	98.4%	-	-
2000	153,546	29,421	19.2%	21,079	71.6%	4,687	22.2%
2001	193,574	109,976	56.8%	89,816	81.7%	16,200	18.0%
2002	108,001	17,522	16.2%	11,705	66.8%	1,555	13.3%
2003	125,135	25,254	20.2%	16,646	65.9%	2,536	15.2%
2004	109,360	3,428	3.1%	2,109	61.5%	219	10.4%
2005	68,926	34,189	49.6%	25,425	74.4%	1,772	7.0%
2006	56,899	35,968	63.2%	24,929	69.3%	1,913	7.7%
2007	25,464	10,338	40.6%	7,215	69.8%	192	2.7%
2008	19,914	2,795	14.0%	1,252	44.8%	21	1.7%
2009	29,272	10,896	37.2%	7,994	73.4%	402	5.0%
2010	37,757	16,472	43.6%	12,706	77.1%	907	7.1%
2011	20,571	21	0.1%	8	38.1%	0	0.0%
2012	22,143	4,238	19.1%	3,089	72.9%	224	7.3%
2013	12,733	2,503	19.7%	1,927	77.0%	202	10.5%
2014	10,425	2,589	24.8%	1,336	51.6%	8	0.6%
2015	8,341	5,286	63.3%	3,896	73.7%	43	1.1%
2016	14,276	6,718	47.0%	4,242	63.1%	178	4.2%
2017	16,265	3,170	19.5%	2,007	63.3%	62	3.1%
2018	6,992	1,458	20.9%	661	45.3%	NA	NA
2019	4,787	571*	11.9%	316	55.3%	NA	NA

*Am. Shad passed at Holtwood from May 1 through June 8, 2019.

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 6. Hourly summary of Gizzard Shad passage at the Holtwood fish passage facility in 2019 (April 1-June 30).

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)	48.5	48.5	48.1	48.6	49.1	49.5	49.8	51.1	53.4	55.2	56.6	56.3	56.6	57.7
0600 to 0659														
0700 to 0759														
0800 to 0859														
0900 to 0959	0	0	0	0	0	0	0	3	0	2	97	0	0	126
1000 to 1059	1	1	0	0	0	0	0	0	2	12	18	0	6	43
1100 to 1159	0	0	0	0	0	3	3	0	1	10	17	5	0	41
1200 to 1259	0	1	0	0	0	1	9	4	0	26	14	3	3	78
1300 to 1359	0	1	0	0	1	2	0	6	4	28	9	8	12	19
1400 to 1459	0	1	0	0	0	0	0	2	0	8	16	2	103	41
1500 to 1559														
1600 to 1659														
1700 to 1759														
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	1	4	0	0	1	6	12	15	7	86	171	18	124	348

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
Viewing Time (End)	15:00	15:00									15:00	15:00	15:00	15:00
Viewing Time (hrs)	6.0	6.0	DNO	DNO	DNO	DNO	DNO	DNO	DNO	DNO	6.0	6.0	6.0	6.0
Water Temp. (*F)	58.6	56.7									58.1	59.3	58.6	57.7
0600 to 0659														
0700 to 0759														
0800 to 0859														
0900 to 0959	506	222									23	83	284	155
1000 to 1059	187	182									12	74	349	176
1100 to 1159	190	275									18	187	570	63
1200 to 1259	62	283									9	98	488	103
1300 to 1359	105	149									52	148	343	178
1400 to 1459	91	243									36	141	580	161
1500 to 1559														
1600 to 1659														
1700 to 1759														
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	1141	1354	0	0	0	0	0	0	0	0	150	731	2614	836

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 6. (Continued)

<i>DATE</i>	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>	9:00	9:00	9:00	9:00	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>	15:00	15:00	15:00	15:00	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>	6.0	6.0	6.0	6.0	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>	56.9	56.2	56.7	57.8	58.7	59.4	60.3	61	62.3	63.5	63.5	63.1	62.8	62.8
0600 to 0659														
0700 to 0759														
0800 to 0859					89	401	92	236	13	71	51	141	128	31
0900 to 0959	85	159	36	165	153	217	93	281	30	94	81	21	161	54
1000 to 1059	107	174	74	196	68	191	173	159	104	136	204	65	243	101
1100 to 1159	82	259	49	333	81	209	255	204	113	279	211	378	201	120
1200 to 1259	109	284	121	175	52	255	456	334	92	313	312	917	209	352
1300 to 1359	68	155	58	178	56	554	303	1000	543	524	158	311	155	262
1400 to 1459	72	102	59	139	132	291	136	478	464	359	350	668	177	397
1500 to 1559					74	338	202	239	419	258	129	279	220	123
1600 to 1659					59	111	114	194	149	134	328	322	158	73
1700 to 1759					142	26	129	161	52	193	49	65	40	78
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	523	1133	397	1186	906	2593	1953	3286	1979	2361	1873	3167	1692	1591

<i>DATE</i>	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
<i>Viewing Time (End)</i>	17:00						18:00	18:00	18:00	17:45	18:00	18:00	18:00	18:00
<i>Viewing Time (hrs)</i>	9.0	DNO	DNO	DNO	DNO	DNO	10.0	10.0	10.0	9.8	10.0	10.0	10.0	10.0
<i>Water Temp.(°F)</i>	60.4						61	63.6	65.4	65.8	66.1	66.6	67.9	69.4
0600 to 0659														
0700 to 0759														
0800 to 0859	34						13	25	32	14	54	38	342	344
0900 to 0959	21						23	47	59	113	246	126	75	612
1000 to 1059	18						45	103	74	31	137	83	271	1171
1100 to 1159	35						19	95	55	54	193	116	354	972
1200 to 1259	52						67	332	126	62	108	109	283	472
1300 to 1359	34						15	43	68	98	341	56	263	484
1400 to 1459	29						26	12	59	45	572	52	290	113
1500 to 1559	74						46	3	41	22	284	71	162	585
1600 to 1659	40						19	2	60	25	131	49	15	565
1700 to 1759							42	7	29	11	63	24	38	826
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	337	0	0	0	0	0	315	669	603	475	2129	724	2093	6144

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 6. (Continued)

<i>DATE</i>	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
<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	9:00	9:00	9:00	9:00
<i>Viewing Time (End)</i>	18:00	18:00	17:45	18:00	18:00	16:00	18:00	17:30	18:00	18:00	15:00	15:00	15:00	15:00
<i>Viewing Time (hrs)</i>	10.0	10.0	9.8	10.0	10.0	8.0	10.0	9.5	10.0	10.0	6.0	6.0	6.0	6.0
<i>Water Temp.(°F)</i>	70.9	72.5	74.1	74.8	73.8	71.7	70.3	69.2	67.9	67.8	68.8	70.5	71.9	72.4
0600 to 0659														
0700 to 0759														
0800 to 0859	435	16	30	72	251	15	58	70	10	22				
0900 to 0959	491	194	31	31	84	50	65	52	42	47	10	5	22	7
1000 to 1059	234	170	48	151	111	38	0	41	7	26	25	29	3	8
1100 to 1159	214	126	52	82	3	30	47	22	0	61	32	6	26	13
1200 to 1259	574	197	56	65	19	21	0	37	26	19	35	5	43	18
1300 to 1359	371	238	57	172	17	15	2	4	4	30	78	2	10	0
1400 to 1459	531	229	45	114	70	10	0	20	17	42	67	4	15	17
1500 to 1559	232	164	22	92	55		0	10	12	14				
1600 to 1659	226	63	38	138	0		1	6	0	0				
1700 to 1759	89	73	23	86	167		1	15	0	11				
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	3397	1470	402	1003	777	179	174	277	118	272	247	51	119	63

<i>DATE</i>	6/10	6/11	6/12	6/13	6/14	6/15	6/16	6/17	6/18	6/19	6/20	6/21	6/22	6/23
<i>Viewing Time (Start)</i>	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00	9:00					
<i>Viewing Time (End)</i>	15:00	15:00	15:00	15:00	14:45	15:00	14:40	15:00	15:00					
<i>Viewing Time (hrs)</i>	6.0	6.0	6.0	6.0	5.8	6.0	5.7	6.0	6.0	DNO	DNO	DNO	DNO	DNO
<i>Water Temp.(°F)</i>	72	71.6	71.4	71.2	70.8	70.4	70.2	70.7	72.7					
0600 to 0659														
0700 to 0759														
0800 to 0859														
0900 to 0959	6	2	5	4	3	14	2	1	0					
1000 to 1059	0	1	6	1	0	2	0	0	1					
1100 to 1159	6	12	0	0	5	16	3	1	0					
1200 to 1259	3	9	14	3	2	5	5	0	1					
1300 to 1359	5	13	12	10	7	4	0	0	3					
1400 to 1459	1	55	8	3	9	1	2	7	2					
1500 to 1559														
1600 to 1659														
1700 to 1759														
1800 to 1859														
1900 to 1959														
2000 to 2059														
Total	21	92	45	21	26	42	12	9	7	0	0	0	0	0

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 6. (Continued)

<i>DATE</i>	6/24	6/25	6/26	6/27	6/28	6/29	6/30	<i>Season Totals</i>
<i>Viewing Time (Start)</i>		9:00	9:00	9:00	9:00	9:00	9:00	
<i>Viewing Time (End)</i>		15:00	15:00	15:00	15:00	15:00	15:00	
<i>Viewing Time (hrs)</i>	DNO	6.0	6.0	6.0	6.0	6.0	6.0	537
<i>Water Temp. (°F)</i>		70.8	72	74.1	76.2	78.1	79.2	
0600 to 0659								
0700 to 0759								
0800 to 0859								3128
0900 to 0959		2	0	0	3	4	4	5634
1000 to 1059		1	4	7	1	6	4	5916
1100 to 1159		0	3	1	8	8	5	6832
1200 to 1259		0	4	15	16	7	6	7979
1300 to 1359		1	11	10	32	4	0	7903
1400 to 1459		0	3	3	28	12	13	6232
1500 to 1559								3531
1600 to 1659								2313
1700 to 1759								1505
1800 to 1859								
1900 to 1959								
2000 to 2059								
Total	0	4	25	36	88	41	32	54,798

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 7. Daily summary of Holtwood fish passage prior to, during, and after the American Shad passage season in spring 2019 (April 1 – June 30).

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
Hours of Operation - Tailrace	5.9	5.6	5.5	5.7	5.7	5.6	5.7	5.3	5.6	5.5	5.8	5.6	5.1	5.8	6.5	5.8	
Number of Lifts - Tailrace	8	8	7	8	7	7	8	8	7	7	8	8	8	8	9	8	
Hours of Operation - Spillway	5.9	5.6	0.0	0.0	5.6	5.6	5.7	5.3	5.6	5.6	5.8	5.5	5.0	5.8	6.6	4.4	DNO
Number of Lifts - Spillway	8	8	0	0	7	7	8	7	7	7	8	8	8	8	9	6	
Water Temperature (°F)	48.5	48.5	48.1	48.6	49.1	49.5	49.8	51.1	53.4	55.2	56.6	56.3	56.6	57.7	58.6	56.7	
AMERICAN SHAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
HICKORY SHAD	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	
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
GIZZARD SHAD	1	4	0	0	1	6	12	15	7	86	171	18	124	348	1,141	1,354	
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
BROWN BULLHEAD	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	1	0	0	0	3	0	
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	
MUSKELLUNGE	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	3	
CARP	0	0	0	0	0	0	0	0	0	1	0	0	0	6	1	0	
NORTHERN HOGSUCKER	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	1	1	0	0	36	2	0	
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SHORTHEAD REDHORSE	0	0	0	0	0	0	0	1	0	3	29	0	13	32	39	9	
CHANNEL CATFISH	0	1	0	1	0	0	1	0	1	0	6	0	2	15	11	11	
FLATHEAD CATFISH	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	
STRIPED BASS	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	0	0	0	
REDBREAST SUNFISH	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	
BLUEGILL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SMALLMOUTH BASS	0	0	0	0	0	3	7	15	18	39	35	0	14	14	49	14	
LARGEMOUTH BASS	0	2	0	0	0	1	0	0	2	1	1	0	0	0	2	1	
WHITE CRAPPIE	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
YELLOW PERCH	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
WALLEYE	0	0	0	0	0	0	0	0	0	4	6	0	1	6	2	0	
TIGER MUSKIE	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	
STRIPED BASS (HYBRID)	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	
<i>Totals</i>	1	8	0	1	1	10	20	31	30	137	252	25	155	457	1,252	1,392	0

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

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
Hours of Operation - Tailrace								5.6	5.8	5.8	5.7	5.8	5.9	5.9	5.8	9.8	9.7
Number of Lifts - Tailrace								7	8	7	7	7	7	7	7	12	12
Hours of Operation - Spillway	DNO	DNO	DNO	DNO	DNO	DNO	DNO	5.5	5.6	5.8	5.6	5.8	5.8	5.7	5.6	9.7	9.7
Number of Lifts - Spillway								7	8	7	7	7	7	7	7	12	12
Water Temperature (°F)								58.1	59.3	58.6	57.7	56.9	56.2	56.7	57.8	58.7	59.4
AMERICAN SHAD								0	0	0	0	0	0	1	27	64	135
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								150	731	2,614	836	523	1,133	397	1,186	906	2,593
AMERICAN EEL								0	0	0	0	0	0	0	0	0	0
BROWN BULLHEAD								0	0	0	0	0	0	0	0	0	0
BROWN TROUT								0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT								0	0	0	0	0	3	0	2	0	0
MUSKELLUNGE								1	0	0	0	0	0	0	0	0	0
CARP								0	1	0	0	0	0	1	3	4	1
NORTHERN HOGSUCKER								0	0	0	0	0	0	0	0	1	0
QUILLBACK								0	0	2	0	0	1	1	0	1	1
WHITE SUCKER								0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE								2	6	8	2	4	6	15	24	73	22
CHANNEL CATFISH								15	5	5	2	4	6	4	1	26	16
FLATHEAD CATFISH								11	20	1	1	0	0	0	0	3	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	0	0
REDBREAST SUNFISH								0	0	0	0	0	0	0	0	0	0
PUMPKINSEED								0	0	0	0	0	0	0	0	1	0
BLUEGILL								1	0	0	0	0	0	3	1	1	0
SMALLMOUTH BASS								13	3	4	0	1	0	3	3	2	2
LARGEMOUTH BASS								1	0	1	0	0	0	0	1	0	0
WHITE CRAPPIE								0	0	0	0	0	0	0	0	0	0
YELLOW PERCH								0	0	0	0	0	0	0	0	0	0
WALLEYE								1	0	0	2	3	1	0	2	0	7
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	1	0
Totals	0	0	0	0	0	0	0	195	766	2,635	843	535	1,150	425	1,250	1,083	2,777

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

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
Hours of Operation - Tailrace	9.7	9.7	9.5	9.6	9.5	9.4	9.4	9.4	9.6						9.6	9.7	9.1
Number of Lifts - Tailrace	12	12	11	12	14	14	14	14	12						14	14	14
Hours of Operation - Spillway	9.7	9.7	0.0	9.6	9.5	9.4	9.4	9.4	9.6	DNO	DNO	DNO	DNO	DNO	9.6	9.7	9.1
Number of Lifts - Spillway	12	12	0	12	14	14	14	14	12						14	14	14
Water Temperature (°F)	60.3	61	62.3	63.5	63.5	63.1	62.8	62.8	60.4						61	63.6	65.4
AMERICAN SHAD	91	62	72	11	12	16	21	11	8						2	0	1
HICKORY SHAD	0	0	0	0	0	0	0	0	0						0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0						0	0	0
ALEWIFE	0	0	0	0	0	0	0	0	0						0	0	0
GIZZARD SHAD	1,953	3,286	1,979	2,361	1,873	3,167	1,692	1,591	337						315	669	603
AMERICAN EEL	0	0	0	0	0	0	0	0	0						0	0	0
BROWN BULLHEAD	0	1	0	0	0	0	0	0	0						0	0	0
BROWN TROUT	0	0	0	0	0	0	0	0	0						0	0	0
RAINBOW TROUT	0	0	0	0	0	0	0	0	0						1	0	0
MUSKELLUNGE	0	1	0	1	0	1	0	0	0						0	0	0
CARP	4	0	2	0	2	2	8	3	0						1	20	5
NORTHERN HOGSUCKER	0	0	0	0	0	0	0	0	0						0	0	0
QUILLBACK	16	7	1	0	0	2	30	1	0						0	7	4
WHITE SUCKER	0	0	0	0	0	0	0	0	0						0	0	0
SHORthead REDHORSE	49	33	5	0	8	79	22	10	1						6	22	5
CHANNEL CATFISH	8	15	9	9	5	6	13	8	8						9	11	23
FLATHEAD CATFISH	0	2	0	0	1	5	6	5	4						3	3	4
WHITE PERCH	0	0	0	0	0	0	0	0	0						0	1	0
STRIPED BASS	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	1
REDBREAST SUNFISH	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
BLUEGILL	0	1	0	0	0	0	0	0	0						3	1	1
SMALLMOUTH BASS	7	3	1	1	0	7	1	0	1						1	2	3
LARGEMOUTH BASS	0	0	0	0	0	1	1	1	0						1	1	0
WHITE CRAPPIE	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
WALLEYE	13	6	3	0	5	11	3	4	2						0	3	2
TIGER MUSKIE	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
BROOK TROUT	0	0	0	0	0	0	0	0	0						0	0	0
Totals	2,141	3,417	2,072	2,383	1,906	3,297	1,797	1,634	361	0	0	0	0	0	342	740	653

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

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
Hours of Operation - Tailrace	9.9	9.9	9.5	9.4	10	10	9.9	9.9	9.9	10	6.8	9.9	9.9	9.7	9.5	6.8	6.5
Number of Lifts - Tailrace	14	14	12	11	14	14	14	15	14	14	9	14	13	13	13	7	7
Hours of Operation - Spillway	9.9	9.9	9.5	9.4	10	10	9.9	9.9	9.9	10	8	9.9	9.9	9.7	9.5	6.8	6.5
Number of Lifts - Spillway	14	14	12	11	14	14	14	13	14	14	11	14	13	13	13	7	7
Water Temperature (°F)	65.8	66.1	66.6	67.9	69.4	70.9	72.5	74.1	74.8	73.8	71.7	70.3	69.2	67.9	67.8	68.8	70.5
AMERICAN SHAD	2	3	0	0	2	2	1	6	9	9	1	1	0	0	0	0	0
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	475	2129	724	2093	6144	3397	1470	402	1003	777	179	174	277	118	272	247	51
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROWN BULLHEAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
BROWN TROUT	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	0	0	0	0	0	0	0	0	0	0	0
MUSKELUNGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARP	0	0	13	2	12	17	11	10	26	4	0	0	1	0	2	4	0
NORTHERN HOGSUCKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	0	2	12	0	6	2	115	38	132	43	11	23	6	15	34	43	1
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHORthead REDHORSE	7	15	13	2	6	9	19	2	20	14	1	4	3	4	10	12	0
CHANNEL CATFISH	23	20	35	43	40	66	91	149	57	211	15	7	6	5	13	33	40
FLATHEAD CATFISH	0	2	1	0	2	0	1	0	1	0	1	0	1	1	1	1	2
WHITE PERCH	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	1	0	0	0	0	0	0	1	0
ROCK BASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PUMPKINSEED	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
BLUEGILL	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
SMALLMOUTH BASS	2	1	5	3	8	5	4	3	3	0	0	0	1	0	0	3	3
LARGEMOUTH BASS	0	0	0	2	2	0	0	0	1	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
YELLOW PERCH	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
WALLEYE	1	2	6	4	4	14	9	2	6	10	5	1	0	1	1	1	5
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	1	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
Totals	510	2,174	809	2,149	6,226	3,513	1,722	612	1,260	1,068	214	210	295	144	333	346	108

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

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	6/21	6/22	6/23	6/24
Hours of Operation - Tailrace	6.5	6	6.2	5.8	6.6	5.8	6.4	5.7	6.4	6	5.7						
Number of Lifts - Tailrace	8	8	9	8	8	7	7	7	7	7	7						
Hours of Operation - Spillway	6.5	6	6.2	5.8	6.6	5.8	6.4	5.7	6.4	6	5.7	DNO	DNO	DNO	DNO	DNO	DNO
Number of Lifts - Spillway	8	8	9	8	8	7	7	7	7	7	7						
Water Temperature (°F)	71.9	72.4	72	71.6	71.4	71.2	70.8	70.4	70.2	70.7	72.7						
AMERICAN SHAD	1	0	0	0	0	0	0	0	0	0	0						
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	119	63	21	92	45	21	26	42	12	9	7						
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0						
BROWN BULLHEAD	0	0	0	0	0	0	0	0	0	0	0						
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	0						
RAINBOW TROUT	0	0	0	2	0	0	0	0	0	0	0						
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0						
CARP	0	0	0	3	2	0	0	1	0	0	0						
NORTHERN HOGSUCKER	0	0	0	0	0	0	0	0	0	0	0						
QUILLBACK	0	1	0	1	0	0	0	0	0	0	0						
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0						
SHORTHEAD REDHORSE	1	0	0	0	1	0	0	0	0	1	0						
CHANNEL CATFISH	34	61	97	40	27	28	21	14	6	15	4						
FLATHEAD CATFISH	1	0	5	1	1	1	0	0	0	0	0						
WHITE PERCH	0	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	0	0	0	0	0	0	0						
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0	0						
PUMPKINSEED	3	0	2	0	0	1	0	0	0	0	0						
BLUEGILL	0	1	1	0	1	0	1	0	0	1	0						
SMALLMOUTH BASS	9	1	1	1	1	0	0	0	0	0	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						
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0	0						
WALLEYE	9	3	12	1	3	0	0	0	1	0	0						
TIGER MUSKIE	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						
BROOK TROUT	0	0	0	0	0	0	0	0	0	0	0						
Totals	177	130	139	141	81	51	48	57	19	26	11	0	0	0	0	0	0

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 7. (Continued)

DATE	6/25	6/26	6/27	6/28	6/29	6/30	Am. Shad Season May 1 - June 5	Res. Fish Pass. Season Apr. 1- 30; June 6-30	Season Total Apr 1 - June 30
Hours of Operation - Tailrace	2.3	0	0	5.7	6	5.5	289.6	225.2	514.8
Number of Lifts - Tailrace	2	0	0	6	6	6	393	284	677
Hours of Operation - Spillway	5.7	6.3	5.8	5.7	6	5.5	280.8	227.5	508.3
Number of Lifts - Spillway	7	6	6	6	6	6	382	283	665
Water Temperature (°F)	70.8	72	74.1	76.2	78.1	79.2	*	*	*
AMERICAN SHAD	0	0	0	0	0	0	570	1	571
HICKORY SHAD	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	4	25	36	88	41	32	44,542	10,256	54,798
AMERICAN EEL	0	0	0	0	0	0	0	0	0
BROWN BULLHEAD	0	0	0	0	0	0	1	4	5
BROWN TROUT	0	0	0	0	0	0	0	4	4
RAINBOW TROUT	0	0	0	0	0	0	3	7	10
MUSKELLUNGE	0	0	0	0	0	0	3	9	12
CARP	0	0	0	0	0	0	154	19	173
NORTHERN HOGSUCKER	0	0	0	0	0	0	1	0	1
QUILLBACK	0	0	0	2	0	0	510	91	601
WHITE SUCKER	0	0	0	0	0	0	0	0	0
SHORthead REDHORSE	0	0	1	1	0	0	503	171	674
CHANNEL CATFISH	27	9	21	21	10	12	952	606	1558
FLATHEAD CATFISH	2	0	0	0	0	0	47	47	94
WHITE PERCH	0	0	0	0	0	0	1	0	1
STRIPED BASS	0	0	0	0	0	0	1	1	2
ROCK BASS	0	0	0	0	0	0	1	0	1
REDBREAST SUNFISH	0	0	0	0	0	0	0	1	1
PUMPKINSEED	0	0	1	0	0	0	2	8	10
BLUEGILL	0	0	0	0	0	0	12	7	19
SMALLMOUTH BASS	0	0	0	1	2	5	72	256	328
LARGEMOUTH BASS	0	0	0	0	0	0	11	12	23
WHITE CRAPPIE	0	0	0	0	0	0	0	1	1
YELLOW PERCH	0	0	0	0	0	0	2	2	4
WALLEYE	1	0	1	0	0	0	127	63	190
TIGER MUSKIE	0	0	0	0	0	0	0	7	7
STRIPED BASS (HYBRID)	0	0	0	0	0	0	1	0	1
BROOK TROUT	0	0	0	0	0	0	1	0	1
<i>Totals</i>	34	34	60	113	53	49	47,517	11,573	59,090

Table 8. Comparison of resident fish passage prior to, during, and after American Shad passage operations at Holtwood Dam, spring 2019.

Total Resident Fish Passed (April 1- June 30)		Res. Fish passed in Am. Shad Season (May 1-June 5)		Total Resident Passage Season (April 1-April 30: June 6-30)		Resident Passage (April 1-30)		Resident Passage (June 6-30)	
Species	Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed	# Passed	% of Total Passed
Smallmouth Bass	328	72	22.0%	256	78.0%	229	69.8%	27	8.2%
Walleye	190	127	66.8%	63	33.2%	26	13.7%	37	19.5%
Channel Catfish	1,558	952	61.1%	606	38.9%	86	5.5%	520	33.4%
Shorthead Redhorse	674	503	74.6%	171	25.4%	154	22.8%	17	2.5%
Quillback	601	510	84.9%	91	15.1%	43	7.2%	48	8.0%
Carp	173	154	89.0%	19	11.0%	9	5.2%	10	5.8%
Gizzard shad	54,798	44,542	81.3%	10,256	18.7%	9,275	16.9%	981	1.8%

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 2019.

Date	River Flow	Ave. Water	Secchi	Number	Weir Gate Operation			Elevation (ft)		
	(cfs)	Temp. (°F)	(in)	of Units	A	B	C	Tailrace	Spillway	Forebay
3-Sep	12,700	78.3	22	3	X	X	X	109	118	169
4-Sep	11,700	77.4	24	3	X	X	X	109	118	168.6
5-Sep	11,700	77.2	26	6	X	X	X	107.5	118	168
6-Sep	13,100	76.5	25	2			X	107	118	169
7-Sep	14,900	76.1	24	3	X	X	X	107.8	118	169
9-Sep	12,000	76.3	25	2	X	X	X	108	118.2	169
10-Sep	11,500	75.9	20	3	X	X	X	108	118.2	168.4
11-Sep	10,900	76.6	20	1			X	106.7	118.2	168.7
12-Sep	10,300	76.9	20	2			X	107	118	169
13-Sep	9,180	76.3	25	2			X	106	118	169
16-Sep	8,480	76.0	28	2			X	107	118	169
17-Sep	8,880	76.3	28	2			X	108	118	169
18-Sep	9,920	75.9	28	2	X	X	X	108.6	118	169
19-Sep	9,150	75.3	26	2			X	108	118	168
20-Sep	8,330	74.5	21	2	X	X	X	107.6	118	168.3
23-Sep	6,900	74.7	26	2	X	X	X	107.6	118.3	169
24-Sep	6,720	75.0	26	2	X	X	X	107	118.4	168
25-Sep	6,230	74.6	24	3	X	X	X	107	118	169.4
26-Sep	6,320	74.3	26	3	X	X	X	107	118	169.4
27-Sep	6,280	73.6	24	2	X	X	X	107.5	118	169
28-Sep	6,070	73.3	24	2	X	X	X	108	118	168
30-Sep	6,360	73.7	26	2	X	X	X	108.5	118	170
1-Oct	6,150	73.1	26	2			X	108.6	118	169
2-Oct	5,930	73.8	26	2			X	107	118	169
3-Oct	5,900	74.3	26	5			X	107	118	169
4-Oct	5,960	73.2	24	6			X	109.7	118.5	170
7-Oct	7,240	70.6	22	2			X	107	118	169
8-Oct	7,970	69.9	22	2			X	107	118	169.4
9-Oct	8,440	68.8	22	2			X	108	118	169
10-Oct	8,820	68.3	22	2			X	108	118	169
11-Oct	15,800	67.5	22	3			X	108	118	169
14-Oct	13,700	63.6	22	3			X	109	118	169
15-Oct	11,700	63.9	26	3			X	109	118	169

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 10. Daily summary of resident fish passage at the Holtwood Fish Passage Facility in fall 2019.

Date	9/3	9/4	9/5	9/6	9/7	9/8	9/9	9/10	9/11	9/12
<i>Hours of Operation- Tailrace:</i>	5.8	5.6	1.5	0.0	1.6		5.1	5.0	0.0	0.0
<i>Number of Lifts - Tailrace</i>	6	7	1	0	2		2	6	0	0
<i>Hours of Operation - Spillway:</i>	5.8	5.6	5.8	5.7	5.9		1.5	5.7	3.2	5.8
<i>Number of Lifts -Spillway:</i>	7	7	7	7	7		7	7	4	7
<i>Water Temperature (F)</i>	78.3	77.4	77.2	76.5	76.1	76.6	76.3	75.9	76.6	76.9
GIZZARD SHAD	490	557	41	64	4,328		858	933	265	297
CARP	1									
QUILLBACK	1									
SHORTHEAD REDHORSE		1								
CHANNEL CATFISH	38	18	8	12	21		7	5		2
FLATHEAD CATFISH	1	3					1			
BLUEGILL	26	14		5	17			34	2	4
SMALLMOUTH BASS	3		5	2	1		56	1		7
ROCK BASS										
WALLEYE	1									
NOTROPIS sp.	16,075	11,460	5,000	750	12,157		3,450	2,360	500	
<i>Daily Totals</i>	16,636	12,053	5,054	833	16,524		4,372	3,333	767	310

Date	9/13	9/14	9/15	9/16	9/17	9/18	9/19	9/20	9/21	9/22
<i>Hours of Operation- Tailrace:</i>	0.0			0.0	0.0	0.9	0.0	1.7		
<i>Number of Lifts - Tailrace</i>	0			0	0	1	0	3		
<i>Hours of Operation - Spillway:</i>	6.0			5.6	5.8	5.9	5.6	5.6		
<i>Number of Lifts -Spillway:</i>	7			7	7	7	7	7		
<i>Water Temperature (F)</i>	76.3	75.2	75.9	76	76.3	75.9	75.3	74.5	74.6	74.5
GIZZARD SHAD	1,476			10,829	11,100	20,200	5,000	2,825		
CARP										
QUILLBACK										
SHORTHEAD REDHORSE										
CHANNEL CATFISH	15			20	51	3	2	6		
FLATHEAD CATFISH	4			7		1	1			
BLUEGILL	36			1	29	1	1	13		
SMALLMOUTH BASS				13	6		2			
ROCK BASS										
WALLEYE										
NOTROPIS sp.	2,203				9,710	9,300	2,500	1,930		
<i>Daily Totals</i>	3,734			10,870	20,896	29,505	7,506	4,774		

Date	9/23	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2
<i>Hours of Operation- Tailrace:</i>	5.8	0.7	5.9	4.2	5.7	6.0		5.8	0.0	0.0
<i>Number of Lifts - Tailrace</i>	7	1	7	4	6	7		7	0	0
<i>Hours of Operation - Spillway:</i>	5.6	5.9	5.9	5.9	5.7	6.0		5.9	6.0	6.0
<i>Number of Lifts -Spillway:</i>	7	7	7	7	7	7		7	7	7
<i>Water Temperature (F)</i>	78.3	77.4	77.2	76.5	76.1	76.6	76.3	75.9	76.6	76.9
GIZZARD SHAD	6,000	4,225	5,343	5,500	1,753	710		1,250	781	227
CARP	2								2	
QUILLBACK										
SHORTHEAD REDHORSE										
CHANNEL CATFISH	6	17	6	4	14	17		4	10	13
FLATHEAD CATFISH								1		
BLUEGILL		15	11	4	17	12		9	8	17
SMALLMOUTH BASS	7	2	1	3	1	1			1	1
ROCK BASS										
WALLEYE				2					1	
NOTROPIS sp.	6,000	7,770	7,970	4,500	2,183	482		2,340	505	3,290
<i>Daily Totals</i>	12,015	12,029	13,331	10,013	3,968	1,222		3,604	1,308	3,548

SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING AND FALL, 2019

Table 10. (Continued)

<i>Date</i>	10/3	10/4	10/5	10/6	10/7	10/8	10/9	10/10	10/11	10/12
<i>Hours of Operation- Tailrace:</i>	0.0	0.0			0.0	0.0	0.0	0.0	0.0	
<i>Number of Lifts - Tailrace</i>	0	0			0	0	0	0	0	
<i>Hours of Operation - Spillway:</i>	6.0	6.0			6.0	6.0	6.0	6.0	6.1	
<i>Number of Lifts -Spillway:</i>	7	7			7	7	7	7	7	
<i>Water Temperature (F)</i>	78.3	77.4	77.2	76.5	76.1	76.6	76.3	75.9	76.6	76.9
GIZZARD SHAD	4	307			139	3,767	2,250	1,068	2,750	
CARP		2								
QUILLBACK										
SHORTHEAD REDHORSE										
CHANNEL CATFISH	1	8			1	4	1			
FLATHEAD CATFISH						1				
BLUEGILL	4	9			7	33	15	4		
SMALLMOUTH BASS										
ROCK BASS										
WALLEYE							1			
NOTROPIS sp.	32	900			81	842	165	62	1	
<i>Daily Totals</i>	41	1,226			228	4,647	2,432	1,134	2,751	

<i>Date</i>	10/13	10/14	10/15	<i>Season Totals</i>
<i>Hours of Operation- Tailrace:</i>		0.0	0.0	61.3
<i>Number of Lifts - Tailrace</i>		0	0	67
<i>Hours of Operation - Spillway:</i>		6.0	6.0	186.5
<i>Number of Lifts -Spillway:</i>		7	7	228
<i>Water Temperature (F)</i>	78.3	77.4	77.2	*
GIZZARD SHAD		1,542	482	97,361
CARP				7
QUILLBACK				1
SHORTHEAD REDHORSE				1
CHANNEL CATFISH		2	1	317
FLATHEAD CATFISH				20
BLUEGILL			1	349
SMALLMOUTH BASS				113
ROCK BASS			1	1
WALLEYE			3	8
NOTROPIS sp.				114,518
<i>Daily Totals</i>		1,544	488	212,696