

**SUMMARY OF OPERATIONS AT THE
HOLTWOOD DAM FISH PASSAGE FACILITY
SPRING 2010**

October 2010

**SUMMARY OF OPERATIONS AT THE
HOLTWOOD DAM FISH PASSAGE FACILITY
SPRING 2010**

Prepared for

PPL HOLTWOOD, 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 21962

October 2010

EXECUTIVE SUMMARY

Fishway operations at Holtwood Dam began on 21 April, 2010. The tailrace lift was operated for 45 days while the spillway lift operated on 29 days. Lift operations were terminated for the season, with agency concurrence, on 9 June. During the season, (17 May), a serious failure of the tailrace hopper hoist occurred resulting in the loss of approximately 59 hours of fishing time. Prior to and after the tailrace hopper hoist failure, both the tailrace and spillway lifts operated with minimal maintenance issues. The 2010 fish passage season marks the fourteenth year of operation at Holtwood.

The lifts passed 205,937 fish of 21 taxa. Gizzard and American shad, walleye, and shorthead redhorse dominated the catch, and comprised nearly 99% of the total fish collected and passed. American shad represented the sole *Alosa* species collected and passed at Holtwood in 2010.

A total of 15,267 American shad (nearly 93% of total shad catch) were passed in the tailrace lift while the spillway lift accounted for 1,205 American shad (7% of total shad catch). Collection and passage of shad varied daily with 90% of total shad (14,826) passed prior to 29 May. The highest daily shad catch occurred on 23 April when 1,950 shad moved upstream during 10.4 hours of operation. On a daily basis, overall shad passage was strongest through the fishway between 1100 hrs and 1659 hrs.

Fishway operations were conducted at water temperatures ranging from 56.8°F to 80.8°F and river flows between 15,100 and 47,600 cfs. Spillage occurred on 27 of the 48 days of operation, (56% of the season). Four of the days when spillage occurred resulted from the station taking units off line to assist with redevelopment construction activities. River water temperatures fluctuated but river flows were relatively stable throughout the passage season. American shad of advanced or post-spawned condition were observed during fish passage operations from late-May to the end of season.

For most of the season, water clarity was adequate, allowing the viewing technicians to identify American shad with attached Maryland DNR floy tags. The number of floy tags observed at Holtwood in 2010 was 35; 30 pink floy tags from this year's hook and line tagging effort and 5 orange floy tags from 2009.

The 2010 American shad passage rate at Holtwood versus Conowingo (43.6% of fish passing Conowingo passed Holtwood) was above the historical average of 32.4% (1997-2009).

A low, stable, river flow appears to be critical for enhancing American shad passage rates. We documented 95% of American shad passed at river flows less than 40,000 cfs, with 5% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. It should be noted that in 2010, favorable river flows allowed flashboard repairs to be completed prior to the fish passage season, and the boards remained intact through the entire season. This helped maintain forebay water levels and provided an ample volume of water to feed the entire fish lift water supply system and allowed for the simultaneous operation of the tailrace and spillway fish lifts. Future operations of the fishway will build on the past fourteen years of operation experience.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1

2.0 HOLTWOOD OPERATION 1

 2.1 Project Operation 1

 2.2 Fishway Design and Operation 1

 2.2.1 Fishway Design 1

 2.2.2 Fishway Operation 2

 2.3 Fish Counts..... 3

3.0 RESULTS..... 3

 3.1 Relative Abundance 3

 3.2 American Shad Passage..... 3

 3.3 Passage Evaluation 4

4.0 RECOMMENDATIONS 5

5.0 LITERATURE CITED..... 5

TABLES AND FIGURES

LIST OF TABLES AND FIGURES

Table 1 Summary of the daily number of fish passed by the Holtwood Fish Passage Facility in 2010.

Table 2 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 2010.

Table 3 Hourly summary of American shad passage at the Holtwood Fish Passage Facility in 2010.

Table 4 Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2010.

Table 5 Holtwood fishway summary table evaluating American shad passage at three river flow ranges, 1997 to 2010.

Table 6 Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2010.

Figure 1 A plot of river flow and water temperature in relation to the daily American shad catch at the Holtwood Fish Passage Facility, spring 2010.

Figure 2 A plot of river flow and water temperature in relation to the percent cumulative American shad catch at the Holtwood Fish Passage Facility, spring 2010.

1.0 INTRODUCTION

On 1 June 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 (Holtwood) 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, to construct and place a fishway into operation by 1 April 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 successfully operated during spring 1997 through spring 2010. This year marked the fourteenth operational season.

Objectives of 2010 upstream fishway operation were (1) monitor and maximize passage of migratory and resident fishes through the fishway; and (2) minimize interruptions to fish passage operations due to equipment breakdowns or malfunctions.

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 consists of a concrete gravity overflow dam 2,392 ft long by 55 ft high, a powerhouse with ten turbine units having a combined generating capacity of 107 MW, and a reservoir (Lake Aldred) of 2,400 acres surface area. Each unit is capable of passing approximately 3,000 cfs. Spills occur at the project when river flow or project inflow exceeds the station hydraulic capacity of approximately 31,500 cfs.

Hydraulic conditions in the spillway at the project are controlled by numerous factors that change hourly, daily and throughout the fishway operating season. The primary factors are river flows, operation of the power station, installation and integrity of the flash boards along with one remaining rubber dam, and operation of the Safe Harbor Hydroelectric Station.

In spring 2010, rubber dams 2 and 3 were inoperable (not inflated) due to irreparable damage that occurred in March and April of 2007. Rubber dam 4 was also inoperable having been removed from service in November 2008 due to damage similar to the cause of failure of rubber dams 2 and 3. Wooden flashboards have been installed in place of these rubber dam sections. In 2010, flashboard repairs were conducted prior to fish lift start-up operations. The passage of over one-thousand shad at Conowingo Dam on 19 April triggered the start of fish lift operations on 21 April at Holtwood Dam. Due to river flows greater than station capacity, spill occurred during 23 of the 48 days of fish lift operation, (Table 2). Spill occurred during four other days due to activities associated with the redevelopment construction. Passage operations ended on 9 June, with agency concurrence, due to 7 consecutive days of poor American shad passage, (less than 80 shad per day), a lack of pre-spawned shad available for passage and extremely warm water temperatures, (78°F to 80.0°F).

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 the trough through which the fish swim into Lake Aldred. Attraction flows, in, through, and from the lifts, 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 seven 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. During fish lift operations in 2010, only one of the four rubber crest dams was operational and flashboards were installed upstream of the three damaged rubber dams to maintain forebay water levels.

Design guidelines for fishway operation include four entrance combinations. These are: (1) entrance A, B, and C; (2) entrance A and B; (3) entrance A and C; and (4) Entrance C. 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 2010, the following gate combinations were utilized: Entrances A, B, and C (3 days); Entrances A and C (21 days); Entrances A and B (1 day); Entrance A only (23 days); and Entrance C only (6). The spillway lift, (Entrance gate C), is used less frequently when river flows are greater than 40,000 cfs or flashboard sections are damaged/missing or rubber dams are deflated because spillage may mask or interfere with the attraction flow from the spillway entrance gate.

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 PPL 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.

The catch of shad at Conowingo Dam triggered the start of Holtwood operations on 21 April. This year we recorded 48 days of operation. The tailrace lift was operated 45 days during this year's fish passage operation and encountered one major mechanical problem. On 17 May, as the tailrace hopper was being raised, a coupling on the drive shaft connecting the main hoist motor to the hoist gearbox failed. The brakes on the hoist were unable to hold the load and the hopper descended in a near free fall back to the water in the entrance channel. Maintenance personnel from the hoist vendor were called and dispatched to investigate the cause of the failure and make repairs. The main hoist cables were damaged during this incident and had to be replaced. Tailrace fish lift operations resumed on 23 May and continued without mechanical problems to season end. The spillway lift was operated on 29 days this season and encountered only minor mechanical problems which were quickly resolved.

The 2010 American shad passage rate at Holtwood versus Conowingo (43.6% of fish passing Conowingo passed Holtwood) was above the historical average of 32.4% (1997-2009). Although this passage rate is below desired passage values, it is a marked improvement compared to passage in 2008 and 2009. Operational hours varied throughout the season in an attempt to maximize the catch of American shad.

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 lifts 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 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 two different gates. During the day, fish passage rates are controlled by the technician who opens/closes a set of gates downstream of the viewing window. At night fish are denied passage from the fishway by closing this gate. 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 diskette 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 RESULTS

3.1 Relative Abundance

The diversity and abundance of fishes collected and passed in the Holtwood fishway during the spring 2010 operational period is presented in Table 1. A total of 205,937 fish of 21 taxa passed upstream into Lake Aldred. Gizzard shad (182,929), American shad (16,472), walleye (3,189), and shorthead redhorse (1,238) comprised nearly 99% of the fishes passed. The 2010 American shad passage total was the eighth highest observed based on actual numbers of fish, and based on Conowingo results, this was the fifth highest passage percentage rate recorded in the fourteen years of fish lift operations at Holtwood, (Tables 1, 5, and 6). Other abundant fishes passed included channel catfish (736), quillback (522), carp (314), and smallmouth bass (244). The peak one-day passage of all species occurred on 4 May, when 18,995 fish were passed, comprised mostly of gizzard shad (18,385), American shad (396), walleye (98), and shorthead redhorse (97).

For most of the season, water clarity ranged from 20 to 25 inches of visibility, allowing the viewing technicians to identify American shad with attached Maryland DNR floy tags. The number of floy tags observed at Holtwood in 2010 was 35, (30 pink tags), from this season's tagging efforts and 5 orange tags (2009 season). The 30 pink and 5 orange tags accounted for 28% and 55%, respectively, of the 2010 pink and 2009 orange floy tags observed at the Conowingo East Lift viewing room.

3.2 American Shad Passage

A total of 16,472 American shad were passed at Holtwood during 2010; 15,267 American shad passed in the tailrace lift while the spillway lift accounted for 1,205 American shad (Table 4). Collection and passage of shad varied daily with 90% of total shad (14,826) passed prior to 29 May. The highest daily shad catch occurred on 23 April when 1,950 shad moved upstream during 10.4 hours of operation. On a daily basis, overall shad passage was strongest through the fishway between 1100 hrs and 1659 hrs (Table 3). Fishway operations were conducted at water temperatures ranging from 56.8°F to 80.8°F and river flows between 15,100 and 47,600 cfs, (Table 2). Spillage occurred on 27 of the 48 days of operation, (56% of the season). Four of the days when spillage occurred resulted from the station taking units off line to assist with redevelopment construction activities. River water temperatures fluctuated but river flows were relatively stable, (< 40,000 cfs) throughout the passage season. American shad of advanced or post-spawned condition were observed during fish passage operations from late-May to the end of season.

The capture of shad at the fishway occurred over a relatively wide range of station operation and discharge conditions (Table 2). Shad were attracted to the tailrace lift at water elevations ranging from 113 ft. to 119 ft., (a tailrace elevation of 119 ft. occurred on 17 of the 45 days of operation). Tailrace elevations correspond to unit operation, which varies from 0 to 10 units. During spring 2010, tailrace fishway operation generally coincided with a ten turbine operation/generation scenario. Spillway lift operation usually occurs during periods of no or minimal spillage, (spillway water elevation 116 to 119 ft), or when the forebay level is high enough to allow simultaneous operation of both the spillway and tailrace fish lifts, which occurred more often this year because the flashboards were intact during the entire fish passage season.

Passage of shad into Lake Aldred occurred at Holtwood forebay elevations ranging from 167 ft to 172 ft (Table 2). Forebay elevations during passage operations ranged from 168 ft to 169 ft for approximately 50% of the 2010 season.

The hourly passage numbers of American shad at Holtwood are provided in Table 3. Nearly 67% (10,978 American shad) passed through the fishway between 1100hr and 1659hrs. Generally, shad passage was consistent from 0900 hrs to 1759 hrs, then sharply declined until operation was ended each evening.

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. The spillway lift was operated on twenty-nine days in an effort to pass any shad attracted into the spillway area adjacent to the fishlift. 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, 15,267 and 1,205 shad were captured in the tailrace and spillway lifts over the total operating period in 2010, respectively (Table 4).

3.3 Passage Evaluation

In spring 2010, 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.

We present a summary of American shad passage at three river flow ranges in Table 5. As stated in previous reports, low, stable river flows are more conducive to fish passage at Holtwood. In 2010, spill events occurred during 27 of the 48 days of fishway operation. We documented 95% of American shad passed at river flows less than 40,000 cfs, with 5% passing at river flows greater than 40,000 cfs but less than 60,000 cfs, (Table 5 and Figure 2). During fish lift operations in 2010, river

flows ranged from 15,100 cfs to 47,600 cfs. The 2010 American shad passage rate at Holtwood versus Conowingo (43.6% of American shad passed at Conowingo were passed by Holtwood), was above the historical average of 32.4% observed at Holtwood from 1997 to 2009. In 2010, favorable river flows allowed flashboard repairs to be conducted prior to the fish passage season, and the boards remained intact throughout the entire season, which helped maintain forebay water levels that provided an ample volume of water to feed the entire fish lift water supply system and allowed for the simultaneous operation of the tailrace and spillway fish lifts.

We hope to optimize future fishway operations by utilizing knowledge gained through these fourteen 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. Fish survival in the fishways was excellent; we observed 14 shad mortalities, less than 0.01% of total American shad passage.

4.0 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) 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, nightly inspections of picket screens, and daily checks of hopper doors. Routine maintenance activities minimize disruption of fishway operation.
- 4) Implement protocols/guidelines to spill trash through gates 7 and 9. This should be done on an as needed basis prior to or after daily scheduled fishway operations.

5.0 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 the daily number of fish passed by the Holtwood fish passage facility in 2010.**

<i>Date:</i>	<i>21 Apr</i>	<i>22 Apr</i>	<i>23 Apr</i>	<i>24 Apr</i>	<i>25 Apr</i>	<i>26 Apr</i>	<i>27 Apr</i>	<i>28 Apr</i>	<i>29 Apr</i>	<i>30 Apr</i>
<i>Hours of Operation - Tailrace:</i>	5.0	9.6	10.4	10.8	9.6	10.9	9.2	8.9	4.1	6.2
<i>Number of Lifts - Tailrace:</i>	7	18	20	20	18	21	17	14	7	10
<i>Hours of Operation - Spillway:</i>	2.8	1.1	0.0	4.0	4.1	0.0	5.2	2.0	1.9	0.0
<i>Number of Lifts - Spillway:</i>	2	3	0	4	4	0	5	2	4	0
<i>Water Temperature (*F):</i>	58.2	57.6	59.2	60.2	60.8	60.7	60.7	59.1	56.7	56.7
American shad	131	1,570	1,950	1,660	1,028	960	405	68	17	1
Gizzard shad	457	6,599	5,860	5,303	4,691	5,493	5,978	428	333	817
Sea lamprey	0	0	0	1	0	0	0	0	0	0
Rainbow trout	0	0	1	1	0	0	1	1	0	0
Brown trout	0	0	0	0	0	0	0	6	0	0
Muskellunge	0	0	0	1	0	0	0	0	0	0
Carp	1	1	0	0	0	0	0	0	0	0
Quillback	0	1	1	0	3	0	0	0	0	0
Shorthead redhorse	8	16	45	107	63	69	21	49	6	6
Channel catfish	6	0	1	0	2	1	1	0	2	4
Flathead catfish	0	0	0	0	0	0	0	0	0	0
Rock bass	2	0	0	0	0	0	1	0	0	0
Redbreast sunfish	0	0	1	0	0	0	0	0	0	0
Bluegill	0	0	0	1	1	0	0	0	0	0
Smallmouth bass	3	29	12	5	21	4	13	6	2	2
Largemouth bass	0	1	0	9	1	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0	0	0	0
Walleye	67	147	86	96	85	136	39	32	20	14
Striped Bass	0	0	0	0	0	0	0	0	0	0
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0
Total	675	8,364	7,957	7,184	5,895	6,663	6,459	590	380	844

Table 1**Continued.**

<i>Date:</i>	<i>1 May</i>	<i>2 May</i>	<i>3 May</i>	<i>4 May</i>	<i>5 May</i>	<i>6 May</i>	<i>7 May</i>	<i>8 May</i>	<i>9 May</i>	<i>10 May</i>
<i>Hours of Operation - Tailrace:</i>	9.1	8.5	8.5	9.4	9.0	7.2	9.7	10.1	7.4	7.5
<i>Number of Lifts - Tailrace:</i>	14	14	18	19	16	13	17	19	17	14
<i>Hours of Operation - Spillway:</i>	0.0	6.5	2.6	0.0	0.0	0.0	8.4	9.8	1.8	0.0
<i>Number of Lifts - Spillway:</i>	0	7	3	0	0	0	12	10	3	0
<i>Water Temperature (*F):</i>	58.3	62.1	65.1	67.7	68.9	69.6	69.6	69.4	68.1	64.8
American shad	44	105	219	396	145	74	460	636	874	575
Gizzard shad	1,202	7,431	15,372	18,385	12,613	9,004	14,661	10,677	1,815	3,541
Sea lamprey	0	0	0	0	0	0	0	1	0	0
Rainbow trout	0	0	0	0	0	0	0	0	0	0
Brown trout	0	0	0	0	3	0	1	0	0	0
Muskellunge	0	0	0	0	2	0	0	0	0	0
Carp	1	9	4	10	0	2	37	6	0	0
Quillback	0	8	4	1	1	9	141	9	36	1
Shorthead redhorse	85	281	27	97	87	9	65	18	24	1
Channel catfish	32	35	2	0	6	3	7	11	22	0
Flathead catfish	0	0	0	0	0	0	0	0	0	0
Rock bass	0	0	0	0	0	1	1	2	0	0
Redbreast sunfish	0	0	0	0	0	0	0	1	0	0
Bluegill	2	0	0	0	0	0	3	2	0	0
Smallmouth bass	5	31	13	7	7	3	36	5	2	4
Largemouth bass	0	0	0	1	0	0	1	4	0	0
Black crappie	0	0	0	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	1	0	0	0	0
Walleye	36	91	85	98	133	61	478	139	55	26
Striped Bass	0	0	0	0	0	0	0	0	0	0
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0
Total	1,407	7,991	15,726	18,995	12,997	9,167	15,891	11,511	2,828	4,148

Table 1**Continued.**

<i>Date:</i>	<i>11 May</i>	<i>12 May</i>	<i>13 May</i>	<i>14 May</i>	<i>15 May</i>	<i>16 May</i>	<i>17 May</i>	<i>18 May</i>	<i>19 May</i>	<i>20 May</i>
<i>Hours of Operation - Tailrace:</i>	8.2	7.1	8.3	7.9	8.8	8.9	3.2	0.0	0.0	0.0
<i>Number of Lifts - Tailrace:</i>	13	13	12	11	13	13	4	0	0	0
<i>Hours of Operation - Spillway:</i>	0.0	0.0	8.0	6.4	2.2	0.0	8.3	9.7	3.7	0.0
<i>Number of Lifts - Spillway:</i>	0	0	10	6	4	0	8	8	8	0
<i>Water Temperature (*F):</i>	63.7	60.7	58.7	58.1	59.8	63.3	64.6	64.8	63.4	n/a
American shad	90	61	20	3	161	27	13	5	79	--
Gizzard shad	1,219	995	136	52	1,580	2,709	6,161	1,035	2,753	--
Sea lamprey	0	0	0	0	0	0	0	0	0	--
Rainbow trout	0	0	0	0	0	0	0	0	0	--
Brown trout	0	0	0	0	0	0	0	0	0	--
Muskellunge	0	0	0	0	0	0	0	0	0	--
Carp	0	0	0	1	0	3	3	0	0	--
Quillback	0	1	1	0	0	6	57	0	3	--
Shorthead redhorse	8	0	3	2	16	23	53	3	5	--
Channel catfish	0	2	2	0	9	12	1	2	0	--
Flathead catfish	0	0	0	0	0	0	0	0	0	--
Rock bass	0	1	0	0	0	0	0	0	1	--
Redbreast sunfish	0	0	0	0	0	0	0	0	0	--
Bluegill	0	0	0	0	0	0	1	0	1	--
Smallmouth bass	4	2	2	2	3	6	1	2	2	--
Largemouth bass	0	0	0	0	0	0	0	0	0	--
Black crappie	0	0	0	0	0	0	0	0	0	--
Yellow perch	0	0	0	0	0	0	0	0	0	--
Walleye	23	20	15	14	24	49	59	45	37	--
Striped Bass	0	0	0	0	0	0		0	0	--
Spotfin Shiner	0	0	0	0	0	0	0	0	0	--
Total	1,344	1,082	179	74	1,793	2,835	6,349	1,092	2,881	0

Table 1**Continued.**

<i>Date:</i>	<i>21 May</i>	<i>22 May</i>	<i>23 May</i>	<i>24 May</i>	<i>25 May</i>	<i>26 May</i>	<i>27 May</i>	<i>28 May</i>	<i>29 May</i>	<i>30 May</i>
<i>Hours of Operation - Tailrace:</i>	<i>0.0</i>	<i>0.3</i>	<i>10.1</i>	<i>8.4</i>	<i>10.2</i>	<i>9.7</i>	<i>9.8</i>	<i>9.6</i>	<i>10.4</i>	<i>10.0</i>
<i>Number of Lifts - Tailrace:</i>	<i>0</i>	<i>0</i>	<i>16</i>	<i>17</i>	<i>13</i>	<i>13</i>	<i>14</i>	<i>17</i>	<i>17</i>	<i>16</i>
<i>Hours of Operation - Spillway:</i>	<i>0.0</i>	<i>10.0</i>	<i>10.0</i>	<i>0.0</i>	<i>3.6</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>10.1</i>	<i>5.6</i>
<i>Number of Lifts - Spillway:</i>	<i>0</i>	<i>18</i>	<i>10</i>	<i>0</i>	<i>4</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>12</i>	<i>6</i>
<i>Water Temperature (*F):</i>	<i>n/a</i>	<i>64.5</i>	<i>67.4</i>	<i>69.4</i>	<i>70.0</i>	<i>70.5</i>	<i>72.2</i>	<i>73.8</i>	<i>74.0</i>	<i>75.6</i>
American shad	--	349	416	1,349	113	293	112	417	412	255
Gizzard shad	--	808	5,921	4,097	1,957	4,156	1,987	2,330	5,044	1,986
Sea lamprey	--	0	0	0	0	0	0	0	0	0
Rainbow trout	--	1	0	0	0	0	0	0	0	1
Brown trout	--	0	0	0	0	0	0	0	0	0
Muskellunge	--	0	0	0	0	0	0	0	0	0
Carp	--	0	1	0	2	2	1	12	18	19
Quillback	--	5	5	0	14	0	4	53	33	15
Shorthead redhorse	--	0	2	0	11	8	2	3	2	0
Channel catfish	--	7	26	0	80	22	19	43	70	44
Flathead catfish	--	0	0	0	0	0	0	0	0	0
Rock bass	--	0	0	0	0	0	0	1	2	1
Redbreast sunfish	--	0	0	0	1	0	0	0	0	0
Bluegill	--	3	0	0	1	0	0	2	11	1
Smallmouth bass	--	5	1	0	0	0	1	0	1	2
Largemouth bass	--	0	0	0	1	0	0	0	0	0
Black crappie	--	0	0	0	0	0	0	0	0	0
Yellow perch	--	0	0	0	0	0	0	0	0	0
Walleye	--	46	106	33	159	81	73	58	134	65
Striped Bass	--	0	0	0	0	0	1	0	0	0
Spotfin Shiner	--	0	0	0	0	0	0	0	0	200
Total	0	1,224	6,478	5,479	2,339	4,562	2,200	2,919	5,727	2,589

Table 1**Continued.**

<i>Date:</i>	<i>31 May</i>	<i>1 Jun</i>	<i>2 Jun</i>	<i>3 Jun</i>	<i>4 Jun</i>	<i>5 Jun</i>	<i>6 Jun</i>	<i>7 Jun</i>	<i>8 Jun</i>	<i>9 Jun</i>	<i>TOTAL</i>
<i>Hours of Operation - Tailrace:</i>	8.6	8.4	8.6	8.5	7.3	7.6	7.8	7.5	7.1	4.9	276.0
<i>Number of Lifts - Tailrace:</i>	14	14	13	10	11	12	11	10	9	6	445.0
<i>Hours of Operation - Spillway:</i>	8.7	8.5	8.7	0.0	0.0	8.1	7.9	7.1	0.0	0.0	149.2
<i>Number of Lifts - Spillway:</i>	10	9	9	0	0	9	8	7	0	0	174.0
<i>Water Temperature (*F):</i>	76.7	77.2	77.0	78.7	79.5	80.2	80.5	80.8	79.2	78.2	
American shad	113	380	190	74	57	78	25	26	10	26	16,472
Gizzard shad	528	1,366	3,224	445	179	475	659	287	38	142	182,929
Sea lamprey	0	0	0	0	0	0	0	0	0	0	2
Rainbow trout	0	0	1	0	0	0	0	0	0	0	7
Brown trout	0	0	0	0	0	0	0	0	0	0	10
Muskellunge	0	0	0	0	0	0	0	0	0	0	3
Carp	11	42	30	52	7	8	22	2	1	6	314
Quillback	25	11	34	19	0	9	4	3	1	4	522
Shorthead redhorse	0	1	1	0	0	7	0	1	0	3	1,238
Channel catfish	32	36	8	10	1	57	68	8	6	36	736
Flathead catfish	0	0	0	0	0	0	0	0	0	1	1
Rock bass	0	0	0	0	0	0	0	0	0	0	13
Redbreast sunfish	0	0	0	0	0	0	0	0	0	0	3
Bluegill	1	0	1	0	0	0	0	0	0	0	31
Smallmouth bass	0	0	0	0	0	0	0	0	0	0	244
Largemouth bass	0	0	0	0	0	0	0	0	1	0	19
Black crappie	0	0	0	0	1	0	0	0	0	0	1
Yellow perch	0	0	0	0	0	0	0	0	0	0	1
Walleye	63	72	9	6	3	15	21	23	5	7	3,189
Striped Bass	0	0	1	0	0	0	0	0	0	0	2
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0	200
<i>Total</i>	773	1,908	3,499	606	248	649	799	350	62	225	205,937

--Denotes Tailrace Hopper Repairs

Table 2

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 2010.

Date	River Flow (cfs)	Ave. Water Temp. (°F)	Secchi (in)	Number of Units	Weir Gate Operation			Elevation (ft)		
					A	B	C*	Tailrace	Spillway	Forebay
21 Apr	26,100	58.07	20	10	X	X	X	117	116	169
22 Apr	26,100	58.08	20	10	X			116	116	169
23 Apr	23,500	59.73	20	10	X			116	116	168
24 Apr	23,200	60.64	20	10	X		X	116	116	168
25 Apr	21,100	60.95	20	10	X		X	116	116	169
26 Apr	24,400	60.92	20	10	X			117	116	167.7
27 Apr	26,800	60.61	20	10	X		X	116	Spill	170
28 Apr	30,000	58.65	20	10	X		X	115	Spill	170.5
29 Apr	38,900	56.78	20	10			X	115	Spill	171
30 Apr	45,500	57.05	22	10	X			119	Spill	172
1 May	43,400	59.12	24	10	X			119	Spill	171
2 May	37,600	62.53	25	10	X		X	119	Spill	170
3 May	45,700	65.46	24	10	X		X	119	Spill	172
4 May	45,400	68.13	30	10	X			119	Spill	172
5 May	38,500	69.15	24	10	X			119	Spill	171
6 May	33,100	69.46	20	10	X			119	Spill	171
7 May	30,400	69.42	22	10	X		X	119	116	169
8 May	27,200	69.17	20	10	X		X	119	117	168
9 May	27,400	67.18	16	10	X			118	117	167
10 May	25,400	64.49	20	10	X			114	116	168
11 May	26,300	63.15	22	7	X			116	Spill**	171
12 May	28,600	60.19	22	7	X			114	Spill**	171
13 May	30,200	58.76	22	7	X		X	113	Spill**	171
14 May	39,600	58.39	22	7	X	X	X	116	Spill	172
15 May	46,000	60.44	16-6	10	X		X	118	Spill	170
16 May	47,600	63.61	20	10	X			119	Spill	172

Table 2**Continued.**

Date	River Flow (cfs)	Water Temp. (°F)	Secchi (in)	Number of Units	Weir Gate Operation			Elevation (ft)		
					A	B	C	Tailrace	Spillway	Forebay
17 May	43,500	64.66	20	10	X		X	119	Spill	172
18 May	40,200	64.52	25	10			X	119	Spill	170.5
19 May	35,400	63.36	25	10			X	119	Spill	170
20 May	*	--	--	--	--	--	--	--	--	--
21 May	*	--	--	--	--	--	--	--	--	--
22 May	29,900	65.36	25	10			X	119	Spill	170
23 May	28,400	67.89	25	10	X		X	119	117	169.4
24 May	30,300	69.62	25	4-5	X			113.5	Spill***	172
25 May	37,100	70.21	25	10	X		X	119	Spill	171
26 May	31,100	71.02	25	10	X			119	Spill	170
27 May	27,200	73.11	25	10	X			117	Spill	169
28 May	24,500	74.25	24	10	X			116	117	169
29 May	22,500	74.73	24	10	X		X	117	Spill	170
30 May	19,000	76.17	20	10	X		X	118	117	169
31 May	20,200	77.38	20	5-9	X		X	112.5	117	168.6
1 Jun	20000	77.26	22	10	X		X	117	Spill	169
2 Jun	17600	78	16-6	9-10	X		X	115	117	169
3 Jun	16000	79.03	22	9-10	X			116.5	Spill	170
4 Jun	16500	80.16	22	5-10	X			114	117	168
5 Jun	18700	80.67	25	5-10	X		X	116	117	168
6 Jun	19600	80.86	22	4-10	X		X	114	117	168.5
7 Jun	16800	80.31	25	9-10	X		X	115	117	169
8 Jun	15100	79.11	20	10	X			115	117	169
9 Jun	15700	77.48	20	10	X			116	117	168

* No operation due to Tailrace Hopper Hoist Repair

** Spill occurred due to Units 8, 9, 10 off to complete Forebay Cofferdam work

***Spill occurred; 5 or 6 Units offline to assist tailrace dive team work operations

Table 3

Hourly summary of American shad passage at the Holtwood fish passage facility in 2010.

<i>Date:</i>	<i>21 Apr</i>	<i>22 Apr</i>	<i>23 Apr</i>	<i>24 Apr</i>	<i>25 Apr</i>	<i>26 Apr</i>	<i>27 Apr</i>
Observation Time (Start):	15:00	9:25	8:15	8:00	8:30	8:20	8:30
Observation Time (End):	20:00	19:15	19:10	19:10	18:20	19:20	17:45
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	--	10	6	39	54	12	16
0900 to 0959	--	73	71	77	85	177	117
1000 to 1059	--	86	92	115	25	79	38
1100 to 1159	--	70	124	75	58	70	27
1200 to 1259	--	138	196	107	77	76	12
1300 to 1359	--	159	117	126	162	27	27
1400 to 1459	--	109	239	199	122	24	41
1500 to 1559	29	502	462	288	157	114	88
1600 to 1659	23	232	285	202	151	169	18
1700 to 1759	29	140	158	265	108	92	21
1800 to 1859	35	51	175	140	29	96	--
1900 to 1959	15	--	25	27	--	24	--
2000 to 2059	--	--	--	--	--	--	--
Total	131	1,570	1,950	1,660	1,028	960	405

<i>Date:</i>	<i>28 Apr</i>	<i>29 Apr</i>	<i>30 Apr</i>	<i>1 May</i>	<i>2 May</i>	<i>3 May</i>	<i>4 May</i>
Observation Time (Start):	8:20	9:50	10:00	8:25	8:00	8:55	8:05
Observation Time (End):	17:30	16:25	16:20	17:25	16:35	17:35	17:45
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	20	--	--	0	16	4	13
0900 to 0959	8	--	--	0	16	9	47
1000 to 1059	5	3	0	0	5	24	33
1100 to 1159	3	4	0	0	11	21	27
1200 to 1259	0	2	1	2	7	21	39
1300 to 1359	1	3	0	0	16	11	25
1400 to 1459	5	5	0	13	10	33	62
1500 to 1559	5	0	0	14	13	42	78
1600 to 1659	16	0	0	10	11	32	56
1700 to 1759	5	--	--	5	--	22	16
1800 to 1859	--	--	--	--	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	68	17	1	44	105	219	396

Table 3

Continued.

<i>Date:</i>	5 May	6 May	7 May	8 May	9 May	10 May	11 May
<i>Observation Time (Start):</i>	8:20	8:40	8:20	7:55	8:15	9:45	9:00
<i>Observation Time (End):</i>	17:20	16:00	18:15	18:15	17:55	17:30	17:00
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	11	13	0	45	22	--	--
0900 to 0959	42	15	69	61	1	9	6
1000 to 1059	26	11	82	48	22	171	8
1100 to 1159	15	9	64	57	95	184	5
1200 to 1259	5	12	49	45	171	40	5
1300 to 1359	3	3	33	44	200	64	16
1400 to 1459	5	4	59	50	107	51	8
1500 to 1559	21	7	63	96	94	19	29
1600 to 1659	15	--	23	75	92	26	13
1700 to 1759	2	--	13	62	70	11	--
1800 to 1859	--	--	5	53	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	145	74	460	636	874	575	90

<i>Date:</i>	12 May	13 May	14 May	15 May	16 May	17 May	18 May
<i>Observation Time (Start):</i>	8:40	8:05	8:45	8:20	8:00	8:10	8:45
<i>Observation Time (End):</i>	16:10	16:30	16:30	17:15	16:30	16:15	17:30
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	0	0	0	0	6	5	0
0900 to 0959	3	0	0	79	5	4	0
1000 to 1059	11	1	1	35	3	4	0
1100 to 1159	13	0	1	7	3	0	0
1200 to 1259	6	0	1	11	0	0	0
1300 to 1359	12	5	0	9	5	0	0
1400 to 1459	10	3	0	6	1	0	0
1500 to 1559	6	2	0	14	3	0	2
1600 to 1659	0	9	0	0	1	0	2
1700 to 1759	--	--	--	0	--	--	1
1800 to 1859	--	--	--	--	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	61	20	3	161	27	13	5

Table 3

Continued.

<i>Date:</i>	<i>19 May</i>	<i>20 May</i>	<i>21 May</i>	<i>22 May</i>	<i>23 May</i>	<i>24 May</i>	<i>25 May</i>
<i>Observation Time (Start):</i>	8:30	--	--	8:30	8:10	11:00	8:30
<i>Observation Time (End):</i>	13:20	--	--	18:15	18:35	19:20	18:50
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	3	--	--	0	1	--	2
0900 to 0959	18	--	--	27	59	--	19
1000 to 1059	24	--	--	77	47	--	22
1100 to 1159	28	--	--	75	6	281	27
1200 to 1259	6	--	--	65	32	304	19
1300 to 1359	0	--	--	46	36	252	3
1400 to 1459	--	--	--	16	75	256	1
1500 to 1559	--	--	--	19	51	140	2
1600 to 1659	--	--	--	21	34	56	2
1700 to 1759	--	--	--	3	49	13	1
1800 to 1859	--	--	--	0	26	32	15
1900 to 1959	--	--	--	--	--	15	--
2000 to 2059	--	--	--	--	--	--	--
Total	79	0	0	349	416	1,349	113

<i>Date:</i>	<i>26 May</i>	<i>27 May</i>	<i>28 May</i>	<i>29 May</i>	<i>30 May</i>	<i>31-May</i>	<i>1 Jun</i>
<i>Observation Time (Start):</i>	8:30	8:10	8:15	8:00	7:15	7:45	8:15
<i>Observation Time (End):</i>	17:55	17:55	18:00	17:50	17:15	16:25	16:45
Military Time (hrs)							
0700 to 0759	--	--	--	--	30	2	--
0800 to 0859	11	15	47	77	44	15	46
0900 to 0959	46	5	65	84	20	3	92
1000 to 1059	14	5	48	90	12	32	72
1100 to 1159	35	22	49	29	10	25	21
1200 to 1259	24	14	79	26	4	5	37
1300 to 1359	23	7	53	23	49	10	66
1400 to 1459	43	11	7	30	41	13	23
1500 to 1559	58	7	25	31	24	7	9
1600 to 1659	20	15	27	11	16	1	14
1700 to 1759	19	11	17	11	5	--	--
1800 to 1859	--	--	--	--	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	293	112	417	412	255	113	380

<i>Date:</i>	2 Jun	3 Jun	4 Jun	5 Jun	6 Jun	7-Jun	8 Jun
<i>Observation Time (Start):</i>	7:45	8:40	9:20	8:00	7:50	8:15	8:50
<i>Observation Time (End):</i>	16:35	16:55	16:45	16:20	16:00	16:00	16:00
Military Time (hrs)							
0700 to 0759	1	--	--	--	0	--	--
0800 to 0859	43	2	0	1	6	0	0
0900 to 0959	42	5	2	17	5	4	1
1000 to 1059	24	4	17	14	5	4	3
1100 to 1159	33	13	18	24	6	5	2
1200 to 1259	9	21	6	14	0	11	1
1300 to 1359	9	5	9	5	3	0	1
1400 to 1459	10	17	1	2	0	2	1
1500 to 1559	12	2	2	0	0	0	1
1600 to 1659	7	5	2	1	--	--	--
1700 to 1759	--	--	--	--	--	--	--
1800 to 1859	--	--	--	--	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	190	74	57	78	25	26	10

<i>Date:</i>	9 Jun	
<i>Observation Time (Start):</i>	7:50	
<i>Observation Time (End):</i>	12:42	<i>Total</i>
Military Time (hrs)		
0700 to 0759	--	33
0800 to 0859	4	609
0900 to 0959	6	1494
1000 to 1059	4	1,446
1100 to 1159	3	1,655
1200 to 1259	2	1,702
1300 to 1359	7	1,675
1400 to 1459	--	1,715
1500 to 1559	--	2,538
1600 to 1659	--	1,693
1700 to 1759	--	1,149
1800 to 1859	--	657
1900 to 1959	--	106
2000 to 2059	--	0
Total	26	16,472

Table 4

Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2010.

Date	Shad Catch	Number Collected		Percent Collected	
		Tailrace	Spillway	Tailrace	Spillway
21-Apr	131	131	0	100%	0%
22-Apr	1,570	1,570	0	100%	0%
23-Apr	1950	1950	--	100%	--
24-Apr	1,660	1,620	40	98%	2%
25-Apr	1,028	1,028	0	100%	0%
26-Apr	960	960	--	100%	--
27-Apr	405	404	1	100%	0%
28-Apr	68	68	0	100%	0%
29-Apr	17	15	2	88%	12%
30-Apr	1	1	--	100%	--
1-May	44	44	--	100%	--
2-May	105	104	1	99%	1%
3-May	219	218	1	100%	0%
4-May	396	396	--	100%	--
5-May	145	145	--	100%	--
6-May	74	74	--	100%	--
7-May	460	276	184	60%	40%
8-May	636	596	40	94%	6%
9-May	874	874	0	100%	0%
10-May	575	575	--	100%	--
11-May	90	90	--	100%	--
12-May	61	61	--	100%	--
13-May	20	20	0	100%	0%
14-May	3	3	0	100%	0%
15-May	161	47	114	29%	71%
16-May	27	27	--	100%	--
17-May	13	13	0	100%	0%
18-May	5	--	5	--	100%
19-May	79	--	79	--	100%
20-May	* --	--	--	--	--
21-May	* --	--	--	--	--
22-May	349	--	349	--	100%
23-May	416	291	125	70%	30%
24-May	1349	1,349	--	100%	--
25-May	113	113	0	100%	0%
26-May	293	293	--	100%	--
27-May	112	112	--	100%	--
28-May	417	417	--	100%	--
29-May	412	247	165	60%	40%
30-May	255	230	25	90%	10%
31-May	113	91	22	81%	19%
1-Jun	380	342	38	90%	10%
2-Jun	190	188	2	99%	1%
3-Jun	74	74	--	100%	--
4-Jun	57	57	--	100%	--
5-Jun	78	68	10	87%	13%
6-Jun	25	23	2	92%	8%
7-Jun	26	26	0	100%	0%
8-Jun	10	10	--	100%	--
9-Jun	26	26	--	100%	--
Total	16,472	15,267	1,205	93%	7%

* Denotes Tailrace Hopper Repairs

Table 5**Holtwood fishway summary table evaluating American shad passage at three river flow ranges.**

	1997	1998*	1999	2000*	2001	2002*	2003*
Migration season start date	18 Apr	27 Apr	25 Apr	06 May	27 Apr	15 Apr	28 Apr
Migration season end date	14 Jun	12 Jun	03 Jun	14 Jun	08 Jun	07 Jun	02 Jun
Season duration (days)	58	47	40	40	43	55	36
Number of days of operation	55	41	40	36	42	35	34
Am. shad season total (Conowingo)	90,971	39,904	69,712	153,546	193,574	108,001	125,135
Am. shad season total (Holtwood)	28,063	8,235	34,702	29,421	109,976	17,522	25,254
River flow \leq40,000 cfs							
Number of days	48	22	34	19	40	19	15
Percent of season	87%	54%	85%	53%	95%	54%	44%
No. of Am. shad passed	26,201	7,512	34,069	19,712	109,342	10,322	20,229
Daily ave. of Am. shad passed	546	341	1,002	1,037	2,733	543	1,348
Percent of total passage	93%	91%	98%	67%	99%	59%	80%
River flow 40,001 to 60,000 cfs							
Number of days	7	2	6	12	2	14	18
Percent of season	13%	5%	15%	33%	5%	40%	53%
No. of Am. shad passed	1,862	230	633	9,536	634	7,029	5,019
Daily ave. of Am. shad passed	266	115	106	795	317	502	279
Percent of Total Passage	7%	3%	2%	32%	1%	40%	19.8%
River flow >60,000 cfs							
Number of days	0	17	0	5	0	2	1
Percent of season	0%	41%	0%	14%	0%	6%	3%
No. of Am. shad passed	0	493	0	173	0	171	6
Daily ave. of Am. shad passed	0	29	0	35	0	86	6
Percent of total passage	0%	6%	0%	1%	0%	1%	0.02%

* 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.**

	2004*	2005	2006	2007	2008*	2009*	2010
Migration season start date	26 Apr	27 Apr	11 Apr	01 May	21 Apr	03 May	21 Apr
Migration season end date	03 Jun	10 Jun	06 Jun	04 Jun	09 Jun	07 Jun	09 Jun
Season duration (days)	39	45	57	35	50	36	50
Number of days of operation	39	36	57	35	49	36	48
Am. shad season total (Conowingo)	109,360	68,926	56,899	25,464	19,914	29,272	37,757
Am. shad season total (Holtwood)	3,428	34,189	35,968	10,338	2,795	10,896	16,472
River flow \leq40,000 cfs							
Number of days	2	33	48	27	20	20	40
Percent of season	5%	92%	84%	77%	40%	56%	83%
No. of Am. shad passed	2	34,060	35,302	9,549	2,242	8,939	15,606
Daily ave. of Am. shad passed	1	1,032	735	354	112	447	372
Percent of total passage	0%	99.6%	98.1%	92.3%	80.2%	82%	95%
River flow 40,001 to 60,000 cfs							
Number of days	20	3	5	8	22	14	8
Percent of season	51.3%	8%	9%	23%	44%	39%	17%
No. of Am. shad passed	1,943	129	566	789	533	1,846	866
Daily ave. of Am. shad passed	97	43	113	99	24	132	108
Percent of Total Passage	56.7%	0.4%	1.6%	7.6%	19.0%	17.0%	5%
River flow >60,000 cfs							
Number of days	17	0	4	0	8	2	0
Percent of season	43.6%	0%	7%	0%	16%	5%	0%
No. of Am. shad passed	1,483	0	100	0	20	111	0
Daily ave. of Am. shad passed	87	0	25	0	2	55	0
Percent of total passage	43.3%	0.0%	0.3%	0.0%	0.7%	1.0%	0%

* Denotes seasons of high river flow or frequent spillage.

Table 6

Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2010.

	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%

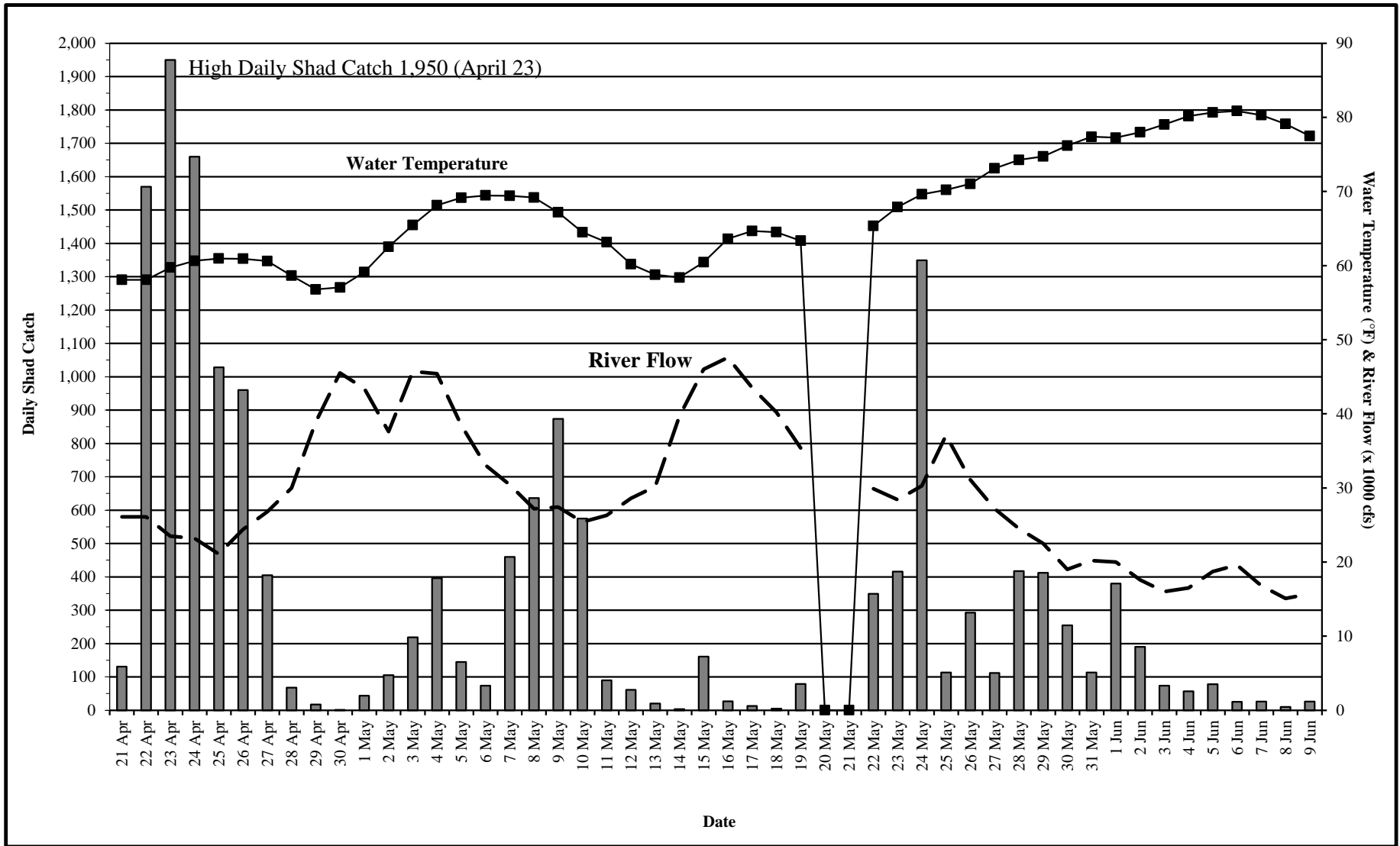


Figure 1

A plot of river flow (x 1000) and water temperature (°F) in relation to the daily American shad catch at the Holtwood Fish Passage Facility, spring 2010. No operation due to hopper hoist repair (May 20-21).

