TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 17
Upstream Passage of Riverine Fish Species Assessment

Final Study Report

In support of Federal Energy Regulatory Commission Relicensing of:

Wilder Hydroelectric Project (FERC Project No. 1892-026)
Bellows Falls Hydroelectric Project (FERC Project No. 1855-045)
Vernon Hydroelectric Project (FERC Project No. 1904-073)

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EXECUTIVE SUMMARY

The goals of this study were to determine the use and temporal distribution of riverine fish passing upstream in the existing Wilder, Bellows Falls, and Vernon fish ladders during the open-water period; and to determine the appropriate operation need and period for these fish ladders to pass riverine and diadromous fish.

This final study report provides clarifications and additional presentation of data in response to stakeholder comments on the initial study report filed May 16, 2016. It also includes results from our review of 2016 Salmonsoft videos recorded by Vermont Fish and Wildlife Department (VFWD) at Vernon with counts of Walleye and White Sucker from April 15 through May 31, 2016. Finally, in response to stakeholder comments the term "net upstream passage" has been changed to "net passage" except where needed for clarity.

The study involved continuous recording of motion-activated video of passage of migratory and resident fish through the fish ladders, as well as quality control video captured once per week per dam. Field work was initiated just after fish ladders opened in early 2015. Video recording extended from April 17, 2015 to January 7, 2016 at the Wilder fish ladder; from April 15, 2015 to January 6, 2016 at the Bellows Falls fish ladder; and from May 5, 2015 to January 6, 2016 at the Vernon fish ladder. Movements of fifteen target species/genera past the viewing areas were tabulated by the direction of movement (upstream or downstream) and net passage counts were calculated (upstream counts – downstream counts) on an hourly basis.

Target categories included four diadromous species and eleven resident species/genera. Species that could not be reliably differentiated from morphometrically similar species were grouped by genera, except that one category, trout, represented three species form three separate genera. Target diadromous species were Atlantic Salmon (*Salmo salar*), American Shad (*Alosa sapidissima*), Sea Lamprey (*Petromyzon marinus*), and American Eel (*Anguilla rostrata*). Target resident species/genera were bass (Smallmouth, *Micropterus dolomieu,* and Largemouth *M. salmoides,* bass), White Sucker (*Catostomus commersonii*), Walleye (*Sander vitreus*), trout (Brook Trout, *Salvelinus fontinalis*; Rainbow Trout, *Oncorhynchus mykiss;* and Brown Trout, *Salmo trutta*), sunfish (*Lepomis spp*., primarily Bluegill, *Lepomis macrochirus*, and Pumpkinseed, *L. gibbosus*), bullhead (Brown, *Ameiurus nebulosus,* and Yellow, A. *natalis*), crappie (Black, *Pomoxis nigromaculatus*, and White, *P. annularis*), Pike/Pickerel (Northern Pike, *Esox Lucius*, and Chain Pickerel, *E. niger*), Yellow Perch (*Perca flavescens*), Common Carp (*Cyprinus carpio*), and 'other'.

In the Wilder fish ladder, three of four target diadromous species (Atlantic Salmon, Sea Lamprey, and American Eel) were observed. Bellows Falls is the historic upstream extent of the range of American Shad so that species was not expected at Wilder. Only one Atlantic Salmon was observed. Five of eleven target resident species/genera (bass, White Sucker, Walleye, trout, and sunfish) were observed in the Wilder fish ladder. Net passage counts were generally low. The species passed in the greatest abundances were trout (net passage = 74), American Eel (N=52), and bass (N=39). Fish passage was observed from May 12, 2015 through shutdown on January 7, 2016. During much of the season, and particularly in the

winter, relatively few counts were made of trout that may have spent extended periods in the ladder. Eighty percent of the seasonal total net passage for all species except American Eel occurred in spring or summer. The American Eel 80% passage point was reached in early fall.

In the Bellows Falls fish ladder, three of four target diadromous species were observed. Based on observation of one Atlantic Salmon passing the Wilder fish ladder, it was assumed that at least one Atlantic Salmon successfully passed Bellows Falls, though its upstream passage was not recorded on video so the date of passage is unknown. Net passage of all diadromous species was generally low: Atlantic Salmon (N=1), American Shad (N=44), Sea lamprey (N=970), and American Eel (N=60). Despite that Bellows Falls is the historic upstream extent of the range of American Shad and the Bellows Falls fish ladder was designed to pass Atlantic Salmon and not American Shad, 44 American Shad were recorded passing. Sea Lamprey passage at Bellows Falls was 40% of that recorded at Vernon. Five of eleven target resident species, the same as observed in the Wilder fish ladder, were observed in the Bellows Falls fish ladder. Net passage counts of resident species were very low.

The species passed in the greatest abundances were trout (net passage = 8), White Sucker (N=7) and sunfish (N=7). Additionally, the net passage count for bass was -47 indicating a net downstream passage. All passage records occurred from May 3, 2015 through November 3, 2015. Anadromous species passed during a relatively short period in late May through early June. Resident species passage reached 80% of the seasonal total during spring (bass, White Sucker) and summer (trout, sunfish). Net passage counts were low for resident species. American Eel passage continued until November 1, but the 80% passage point was reached in mid-September.

All four target diadromous species were observed in the Vernon fish ladder. Net passage of American Shad was a record annual high (N=39,196). The proportional net passage of American Shad at Vernon relative to FirstLight's Turners Falls Gatehouse fish ladder (N=58,079) was 67%. Net passage of Sea Lamprey at the Vernon fish ladder was 2,440 or 29% of Turners Falls passage (N=8,423). Additionally, net passage of six Atlantic Salmon, and 1,545 American Eels were recorded. Ten of the eleven target resident species/genera were observed in the Vernon fish ladder and only Yellow Perch was not recorded. Net passage counts varied, sunfish (N=1,188), bass (N=761), White Sucker (N=322), and Walleye were the most abundant species. All other resident species net counts totaled less than 50. All passage records were encompassed in the period from May 5, 2015 through December 22, though the beginning date may have missed the earliest run of species such as White Sucker and Walleye. The late part of the date range was probably influenced by an unusually warm fall. Anadromous species passed during a relatively short period in late May with 80% passage reached for American Shad and Sea Lamprey on May 30 and May 31, respectively. American Eel passage reached the 80% point on July 21. Resident species passage reached 80% of the seasonal total during spring (White Sucker, Walleye) and summer (bass, sunfish).

Based upon low net passage counts of resident species at the Wilder and Bellows Falls fish ladders, there is little apparent benefit to operating those ladders

specifically for resident species upstream passage beyond the existing anadromous species passage season. Operation of the Vernon fish ladder for anadromous species under the existing ladder operations season also facilitates the upstream passage of resident species and based on the seasonality of passage for most resident species at Vernon, extension of the passage season beyond the existing anadromous species passage window is also not warranted.

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List of Abbreviations

CRASC	Connecticut River Atlantic Salmon Commission
CRWC	Connecticut River Watershed Council
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Power Resources
FWS	U.S. Department of the Interior – Fish and Wildlife Service
NHDES	New Hampshire Department of Environmental Services
NHFGD	New Hampshire Fish and Game Department
RSP	Revised Study Plan
TransCanada	TransCanada Hydro Northeast Inc.
TU	Trout Unlimited
USR	Updated Study Report
VANR	Vermont Agency of Natural Resources
VFWD	Vermont Fish and Wildlife Department
VDEC	Vermont Department of Environmental Conservation

1.0 INTRODUCTION

This final study report presents the findings of the 2015 Upstream Passage of Riverine Fish Species Assessment (Study 17) conducted in support of Federal Energy Regulatory Commission (FERC) relicensing efforts by TransCanada Hydro Northeast Inc. (TransCanada) for the Wilder Hydroelectric Project (FERC Project No. 1892), Bellows Falls Hydroelectric Project (FERC No. 1855) and the Vernon Hydroelectric Project (FERC No. 1904).

In their study requests, US Fish & Wildlife Service (FWS), New Hampshire Department of Environmental Services (NHDES), New Hampshire Fish & Game Department (NHFGD), Vermont Agency of Natural Resources (VANR), and Connecticut River Watershed Council (CRWC) identified issues related to upstream passage of riverine fish species at the Wilder, Bellows Falls, and Vernon projects. Specifically, requesters indicated that no information exists[1] to assess existing year-round fish ladder use by resident fish species or to indicate whether existing upstream passage at the projects is adequate for riverine and diadromous fish species.

Revised Study Plan (RSP) 17, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that project fish ladders would be monitored throughout the open water season (from ice-out until freezing temperatures make it infeasible) to provide baseline data on fish ladder usage.

This final study report provides results from data collected at the project fish ladders during 2015, and reports on observations from other studies including Study 16 – Sea Lamprey Spawning Assessment and Study 21 – American Shad Telemetry Study to the extent that those studies provide supporting information on fish ladder use by those species. This final study report provides clarifications and additional presentation of data in response to stakeholder comments on the initial study report filed May 16, 2016. It also includes results from our review of 2016 Salmonsoft videos recorded by Vermont Fish and Wildlife Department (VFWD) at Vernon with counts of Walleye and White Sucker from April 15 through May 31, 2016. Finally, in response to stakeholder comments the term “net upstream passage” has been changed to “net passage” except where needed for clarity.

2.0 STUDY GOALS AND OBJECTIVES

As stated in the RSP, The goals of this study were to determine the use and temporal distribution of riverine fish passing upstream in the existing Wilder,

[1] In the Pre-Application Documents for the Wilder and Bellows Falls Projects, TransCanada identified resident fish species recorded using the Wilder and Bellows Falls fish ladders and indicated that the data are available from VFWD. TransCanada also noted that VFWD has several years (2007–2012) of seasonal fish passage data not yet analyzed for the May through July period.

Bellows Falls, and Vernon fish ladders during the open-water period, and to determine the appropriate operation period for these fish ladders to pass riverine and diadromous fish.

The objectives of this study were to:

- identify the use and temporal distribution of upstream passage through the Wilder, Bellows Falls, and Vernon fish ladders by riverine and diadromous fish species;
- operate and monitor the fish ladders during the open-water period (ice-out until freezing temperatures make it infeasible) to assess fish ladder use over a longer period than the existing May–July period;
- identify potential appropriate operating windows during the open-water period for the fish ladders for riverine species; and
- identify potential appropriate operating windows during the open-water period for diadromous species, such as American eel and sea lamprey.

3.0 METHODOLOGY

3.1 Equipment and Systems

Digital video fish passage monitoring systems were installed in the counting window of each fish ladder in spring, 2015. Each monitoring system consisted of a closed-circuit video camera, a laptop computer meeting the minimum requirements of the system and running Salmonsoft FishCap/FishRev, Version 2.6.3.0[2], software, an uninterruptable power source (UPS) battery backup, and accessories (Figure 3.1-1, Table 3.1-1). Monitoring system hardware, software, and protocols recommended by VANR, as modified for 2015 studies are included in (Appendix A). Modifications to VANR recommendations included updated video compression software (Xvid MPEG-4 Codec), cameras and digital video converters. Additionally, the use of external illumination was suspended (May 20 at Bellows Falls and Vernon, May 21 at Wilder) because the camera's built-in infrared LED lighting was more effective. Video capture settings are included in Table 3.1-2. TransCanada consulted with VANR to ensure that Salmonsoft equipment was properly installed to account for the effects of both sunlight (i.e., shading) and night time (i.e., directed lights).

TransCanada also coordinated with FWS and the Connecticut River Atlantic Salmon Commission (CRASC) to conduct fish ladder inspections prior to the start of fish ladder operations and video recording to determine the amount of debris accumulation during an operating season. Fish ladders were shut down and pressurized water was used to flush debris down the ladders. Then visual inspections were conducted from overhead rather than from within the ladders due to Occupational Safety and Health Administration's confined space entry requirements. Fish ladders are prepared and opened, operated, and closed in

[2] Licensed to Vermont Agency of Natural Resources

accordance with TransCanada written policies and procedures (Appendix B). Ladders receive thorough cleaning and inspection prior to opening in the spring. During the course of seasonal operations, fish ladders are either automatically operated with daily manual checks (Wilder and Vernon) or by manually adjusting fish ladder flows during the day and set to operate automatically at night (Bellows Falls). In the fall, fish ladders receive thorough cleaning and post-season inspection.

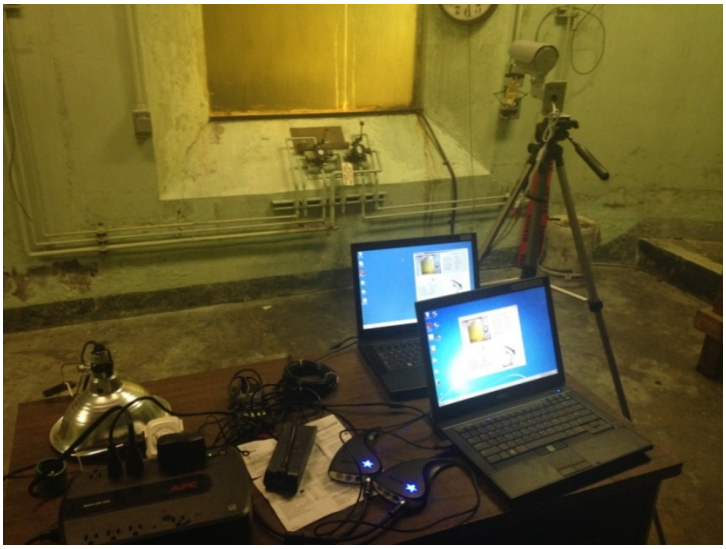

Figure 3.1-1. Salmonsoft FishCap digital video counting system equipment set-up at the Vernon Dam fish ladder with additional laptop for weekly video download and quality control video capture.

Table 3.1-1. Equipment and supplies list for Salmonsoft FishTick/FishRev digital video counting system.

Computer with the following minimum requirements: a Pentium 1.0 GHz processor, a minimum 128 MB of RAM and Windows XP
Tripod for mounting the camera
Camera: Aposonic model A-CDBIV07 2.8-12mm with built in infrared
Dazzle Video Capture USB v1.0 digital video converter
UPS battery backup
External hard drive or USB flash drive 64GB or larger
Extension cords
Power strip
Zip ties
Electrical tape

Table 3.1-2. Capture Settings used for FishCap.

Video Capture Tab	
Capture Driver	Dazzle Video Converter
Capture Resolution	High
Frames Captured Per Second	30
Frames to Capture for Each Recorded Frame	6
Frames Recorded Contain Fish Frames Only	On
Frames Recorded Before Detection Event	5
Frames Recorded After Detection Event	5
Detection Tab	
Detection Algorithm	Motion Trigger
Detection Parameters	
Motion Threshold	5
Automatic Masking	On
Automatic Mask Threshold	2
Automatic Mask Frequency	75
Pixel Threshold	5
Smallest Object	15
LoRes Detection	On
Date/Time Stamp Tab	
Imprint Date/Time Stamp on Video	On
Imprint Conspicuously w/ Black Background	On
Output Tab	
Video Compression	Xvid MPEG-4 Codec
Output Format	
Location Prefix	Dam name
Output Filename	MMM DD HH-Unique
Output Drive/Directory	
Primary	C:\Data
Secondary	
Tertiary	
Minimum Free Space Before Toggling Drives	1000Mb
Start New Output File Every	24 hours
Duplicate Output File to Removable Media	none

3.2 Monitoring

Salmonsoft monitoring systems were installed and recording initiated on April 16, April 15, and May 5 at the Wilder, Bellows Falls, and Vernon fish ladders, respectively. Monitoring systems were checked weekly to ensure proper operation and to download video files for analysis. In the event of a system malfunction, a troubleshooting protocol was executed until the problem was identified and resolved.

The Salmonsoft system was unreliable for monitoring the downstream passage of juvenile American Shad at the Vernon fish ladder. Although some juvenile shad were known to use the Vernon ladder, they appeared as brief flickers or shimmers on the digital video, rather than identifiable fish silhouettes. Even the Salmonsoft motion threshold (30 frames per second) that triggered video capture of those events resulted in near-continuous recording and images that were generally not identifiable – defeating the purpose of the system. Therefore no juvenile shad counts are included in this report.

Quality Control and Maintenance

Salmonsoft is a motion-sensing video capture software, and it has been noted in previous use by VANR and FirstLight that turbidity and bio-fouling of the counting window can limit the effectiveness of the software's ability to detect and record fish movements. As a result, a second camera recording continuous video was used as a backup. These quality control video recordings were used to provide assessment of system accuracy. Quality control video was recorded and checks were done for one randomly selected hour on one randomly selected day each week at each site by splitting the video feed and continuously recording to a separate computer (at 30 frames per second). Passage counts made from the quality control videos were then compared to count results for video captured by Salmonsoft during the same periods.

A protocol for weekly inspections of each fish ladder was implemented to evaluate potential blockages to passage and monitor window fouling. Potential blockages could result from large debris (tree limbs or large branches) caught in the ladder and visible during operation, or small debris (leave, twigs, small branches) blocking orifices at the bottom of a weir and only discernable by the height of the blocked water flowing over the weir. After an inspection of the Wilder ladder with FWS on September 4, 2015, it was shut down briefly for removal of small debris blocking a number of weir orifices and window cleaning on September 23, 2015. The Bellows Falls and Vernon ladders were both shut down for window cleaning on December 8, 2015; debris buildup was minimal and did not warrant removal. Though the counting room windows were scrubbed weekly, biofouling was a constant problem. During window cleaning, TransCanada personnel closed flow gates to dewater the fish ladder and washed counting windows and reflective counting channel backboards with a pressure washer and scrub brushes. While dewatered, a general visual survey of the ladders was also done to identify any debris that may obstruct passage.

Data Collection

Video data were downloaded and replicated at each project weekly, concurrent with quality control checks. Personnel trained in fish identification processed and reviewed video files and compiled fish counts using FishTick, the digitized counting component of the system software. Care was taken to adapt methods previously used at Connecticut River projects to obtain a net count (the sum of upstream and downstream movement records) by target species/genera. Additionally, net passage (upstream movements minus downstream movements) were calculated. Movement and passage counts were tabulated for 15 target species/genera daily and by time of day with project discharge (generation, spill, attraction and fish ladder flows), and water temperature for each fish ladder.

Daily periodicity of movement records were examined by tabulating and plotting the number of upstream and downstream movements and net passage by hour of day for each species observed. Diel phase activity was examined by characterizing each count record by phase: day, night, or crepuscular. Diel phase was determined using twilight and sunrise/sunset tables from U.S. Naval Observatory Data Services (http://aa.usno.navy.mil/data/index.php). Counts recorded from sunrise to sunset were categorized as 'day', from end of civil twilight to sunrise as 'night', and from beginning of civil twilight to sunrise and sunset to end of civil twilight as 'crepuscular'. The proportion of total count records for each species at each site that occurred during the three phases was calculated for comparison.

Target categories included four diadromous species and eleven resident species/genera. Species that could not be reliably differentiated from morphometrically similar species were grouped by genera, except that one category, trout, represented three species form three separate genera. Target diadromous species were Atlantic Salmon (*Salmo salar*), American Shad (*Alosa sapidissima*), Sea Lamprey (*Petromyzon marinus*), and American Eel (*Anguilla rostrata*). Target resident species/genera were bass (Smallmouth, *Micropterus dolomieu*, and Largemouth, *M. salmoides*, bass), White Sucker (*Catostomus commersonii*), Walleye (*Sander vitreus*), trout (Brook Trout, *Salvelinus fontinalis*; Rainbow Trout, *Oncorhynchus mykiss*; and Brown Trout, *Salmo trutta*), sunfish (*Lepomis spp.*, primarily Bluegill, *Lepomis macrochirus*; and Pumpkinseed, *L. gibbosus*), bullhead (Brown, *Ameiurus nebulosus*; and Yellow, *A. natalis*), crappie (Black, *Pomoxis nigromaculatus*; and White, *P. annularis*), Pike/Pickerel (Northern Pike, *Esox Lucius*; and Chain Pickerel, *E. niger*), Yellow Perch *(Perca flavescens*), Common Carp (*Cyprinus carpio*), and 'other'. The 'other' category was largely composed of Channel Catfish (*Ictalurus puntatus*) but also included any unidentified fish. Weekly passage counts of four key species: Atlantic Salmon, American Shad, American Eel and Sea Lamprey, were provided to VANR throughout the study.

In a variance to the RSP, water temperature loggers were not deployed within each fish ladder. Instead, the average of hourly water temperature data logged in the forebay and tailrace of each project (Study 6) were used. A temperature logger was deployed in the Vernon fish ladder by Entergy for other studies, and those data were also incorporated.

Operational variables, including tailrace and headpond elevations, fish ladder and attraction water discharge, project operations discharge, and spill discharge were recorded by TransCanada for the period of operation.

Monitoring Outages

Despite weekly checks on monitoring equipment, some outages occurred during the study which led to episodes of lost or missing data, summarized below.

Wilder:

- Computer (freeze): 9/28, 10/18-10/28. These dates are instances of computer failure that required a simple reboot to get up and running.
- 12/28-12/30 (breaker tripped, UPS drained, lost video of 3 trout swimming back/forth). The power supply at Wilder failed long enough for the UPS to run out of power.

Bellows Falls:

- Camera (documented, lighting): 7/16-7/22. The built-in infrared light started to fail on the camera. Camera was replaced.
- Computer (RCA Y cable->Dazzle converter=no record): 10/18-10/20, 10/24-10/28, 10/31, 11/9-11/10, 11/15-11/19. All of these dates experienced some damaged files because a cable failed. The cable was replaced and the issue was resolved.

Vernon:

- Computer (Freeze): 9/2 (eel 21,-10; other 2, 0). Salmonsoft froze at Vernon on 9/2. The program was restarted and started filming again.

4.0 RESULTS AND DISCUSSION

4.1 Wilder Dam Fish ladder

The Wilder fish ladder was operated from April 17, 2015 at 9:45 through January 7, 2016 at 10:00. Overall, 8 of the 15 target species/genera were observed in 3,775 records. Complete records of fish movement (click history) are included in Appendix C (filed separately in zip/Excel format). Hourly movement and passage counts were tabulated with project discharge (generation, spill, attraction and fish ladder flows), and water temperature for each fish ladder (Appendix D, filed separately in zip/Excel format).

4.1.1 Species Assemblage

Three migratory (diadromous) and five resident target species were recorded at the Wilder fish ladder (Table 4.1-1, Figures 4.1-1 – 4.1-8). Migratory species were recorded with low net passage counts: American Eel (N=52), Sea Lamprey (N=2), and Atlantic Salmon (N=1). The ratio of Wilder counts to Bellows Falls upstream passage counts were: Atlantic Salmon 100%, American Shad 0%, Sea Lamprey 0.2%, and American Eel 87%. Since Bellows Falls is the historic upstream

migratory extent of American Shad and neither the Wilder nor Bellows Falls fish ladders were designed to pass American Shad, no passage was expected at the upstream Wilder fish ladder. Study 16 (Sea Lamprey Spawning Assessment, interim report filed March 1, 2016) tracked one radio-tagged Sea Lamprey as far upstream as the White River, just below the Wilder dam; however, that fish moved into the White River and outside of the project-influenced reach.

Since eels likely represented a diverse age distribution, the passage ratio does not reflect the migratory capacity of a seasonal spawning population. Of the three migratory species recorded, American Eel was the most active with 354 total movements recorded. The high number of both upstream and downstream movements relative to the net passage count suggests milling in the counting window pool that resulted in multiple recordings of the same fish. This is represented in a plot of daily upstream and downstream movements (Figure 4.1-9) which, by the nature of the near mirror image strongly suggests multiple recordings of individuals. That may have resulted from milling or, alternatively, the failure of individuals to ascend the fish ladder (fallback). In either case, however, the number of upstream and downstream movements likely greatly over-estimates the actual number of individuals using the fish ladder. Alternatively, some downstream movements may be the result of different individuals (than those migrating upstream and / or milling) using the ladder for downstream migration, particularly in the fall.

Resident species also had low net passage: trout (N=74), bass (N=39) Walleye (N=21), White Sucker (N=1), and sunfish (N=-5) (Table 4.1-1). As described for American Eel, the high number of upstream and downstream movements of resident species relative to the net passage counts suggests milling of fish in the counting window pool, resulting in multiple recordings of the same fish. That conclusion is supported by anecdotal observations by fisheries technicians of fish resting and/or moving in and out of the field of view. This is best illustrated by the recordings of trout in the fish ladder (Figure 4.1-10). There were 1,114 upstream movements and 1,040 downstream movements recorded, and therefore a net passage count of only 74 fish. The near mirror-image appearance of up / downstream movements on most dates indicates milling that resulted in motion-based video capture of multiple images of the same fish, and indicated a pattern of occupancy rather than passage. Note, however that the calculation of net passage can yield a negative result, as in the case of sunfish, with a net passage count of -5. Appendix D (filed separately in zipfile/Excel format) contains daily summaries of records of upstream and downstream movements with net passage, as well as plots of records of upstream and downstream movements (e.g., Figure 4.1-10) for each target species.

Raw count data (Salmonsoft / Fish Tick click histories) are tabulated in Appendix C. Appendix D includes daily summed upstream and downstream movements, net passage, and cumulative upstream passage tabulated by species, plots of daily net and cumulative passage by species, and plots of daily total upstream and downstream movements by species. Appendix E (filed separately in zip/Excel format) includes hourly discharge (categorized as fish ladder flow, attraction flow, project operations, downstream passage flow, and spill), water temperature, and summed upstream and downstream movements tabulated by species.

Table 4.1-1. Wilder fish ladder counts of upstream (up), downstream (down), total movements recorded and net passage.

Species	Up	Down	Total	Net Passage[a]
Migratory Species				
Atlantic Salmon	1	0	1	1
American Shad	0	0	0	0
Sea Lamprey	4	-2	6	2
American Eel	203	-151	354	52
Resident Species/Genera				
Bass	454	-415	869	39
White Sucker	10	-9	19	1
Walleye	171	-150	321	21
Trout	1114	-1040	2154	74
Sunfish	23	-28	51	-5
Bullhead	0	0	0	0
Crappie	0	0	0	0
Pike/Pickerel	0	0	0	0
Yellow Perch	0	0	0	0
Carp	0	0	0	0
Other	0	0	0	0

a. Negative values indicate total net downstream passage.

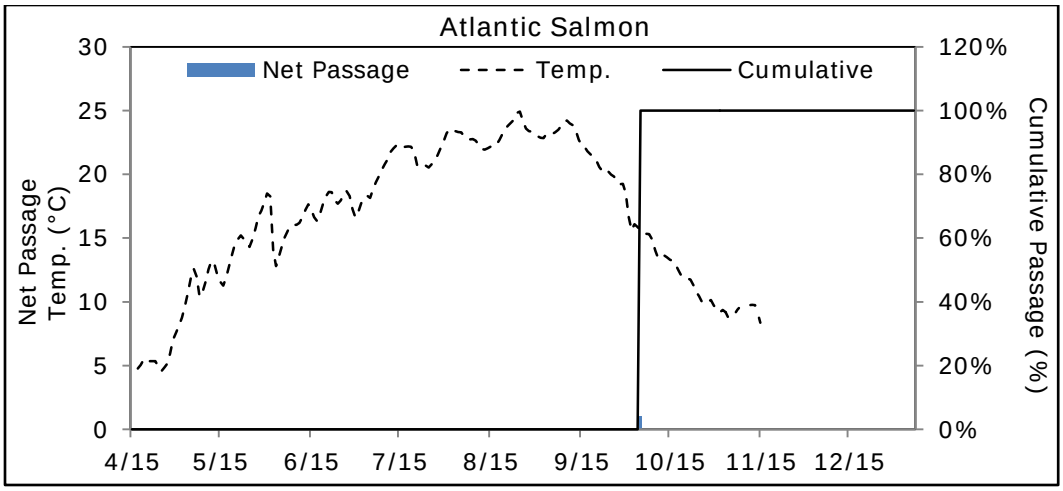

Figure 4.1-1. Wilder fish ladder: Atlantic Salmon daily net passage count and cumulative passage (as % of annual total) with water temperature (°C). One salmon passed on October 5, 2015.

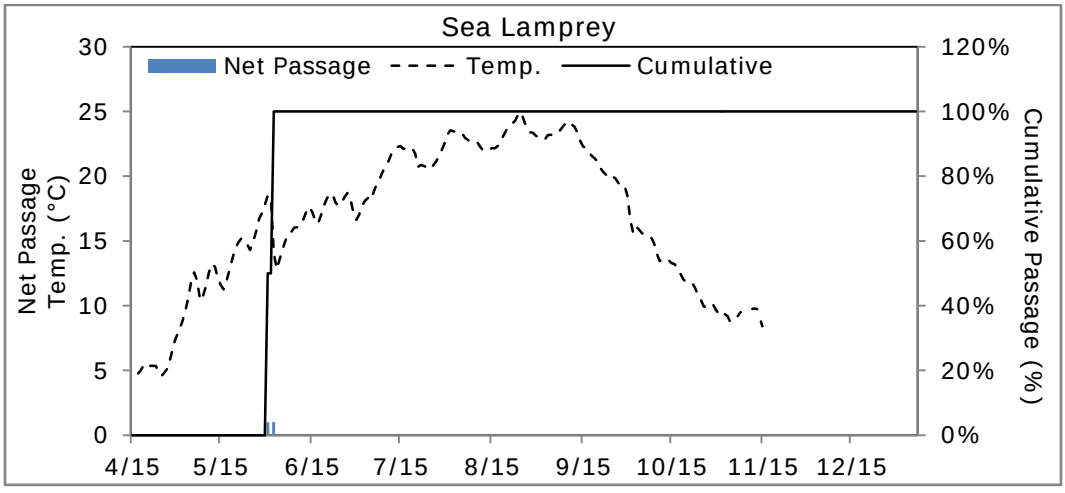

Figure 4.1-2. Wilder fish ladder: Sea Lamprey daily net passage count and cumulative passage (as % of annual total) with water temperature (°C). Two Sea Lamprey passed, one on May 31, 2015 and one on June 2, 2015.

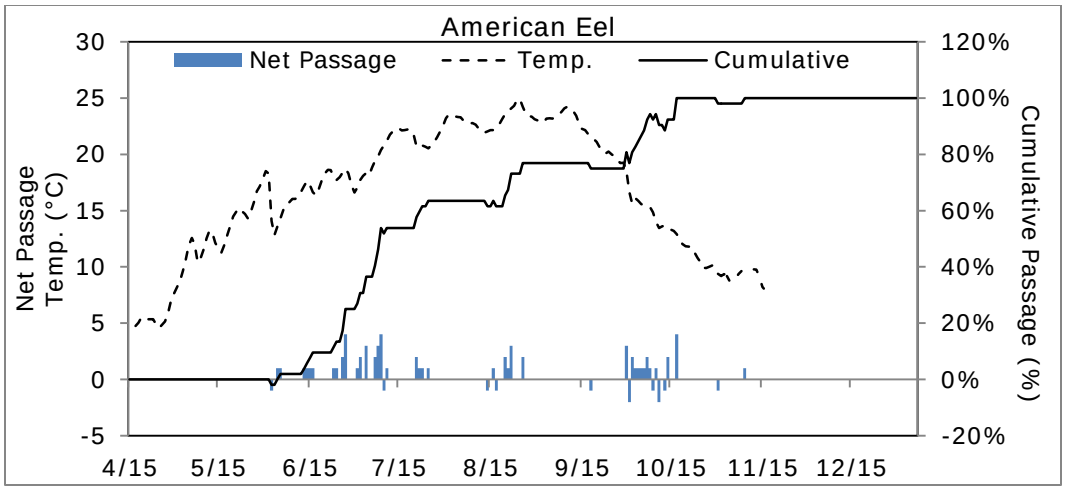

Figure 4.1-3. Wilder fish ladder: American Eel daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

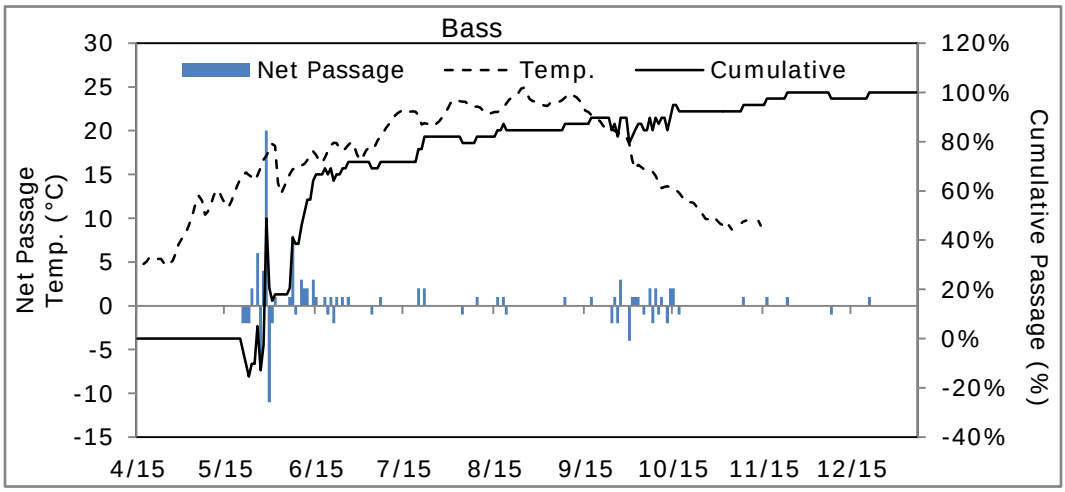

Figure 4.1-4. Wilder fish ladder: Bass daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

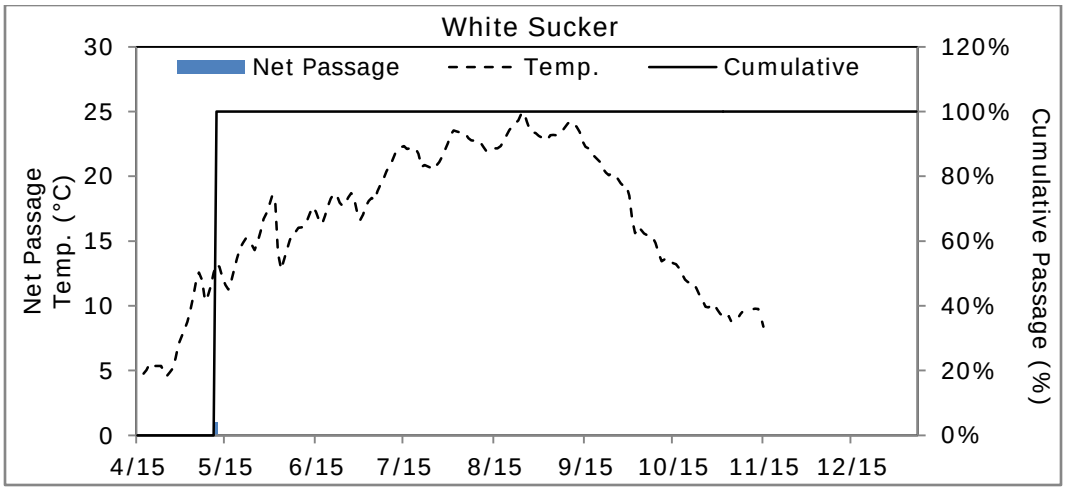

Figure 4.1-5. Wilder fish ladder: White Sucker daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

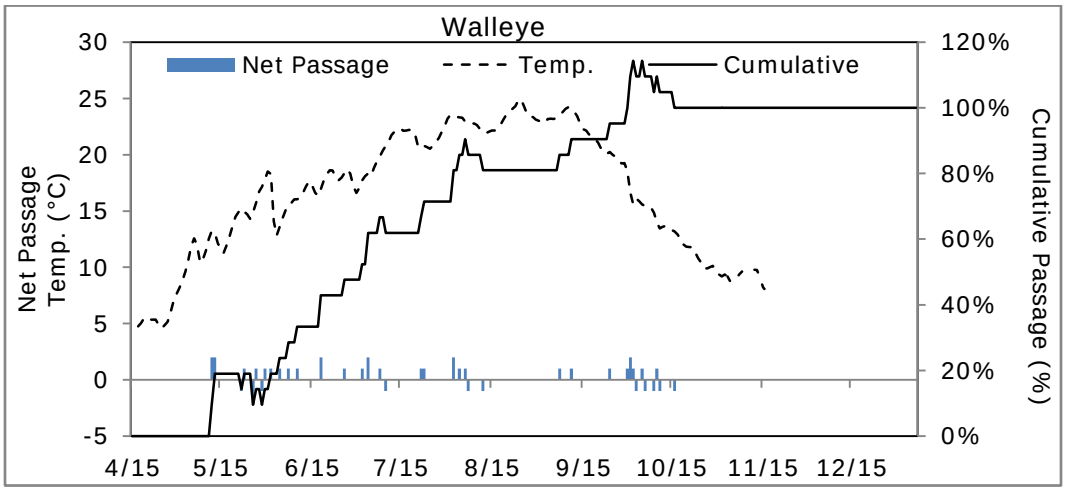

Figure 4.1-6. Wilder fish ladder: Walleye daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

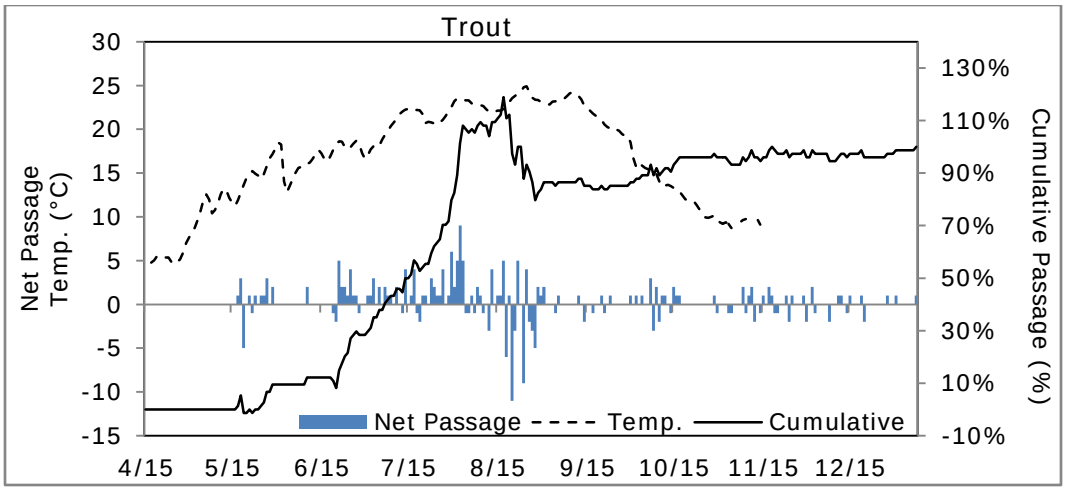

Figure 4.1-7. Wilder fish ladder: trout daily net passage count and cumulative passage (as % of annual total).

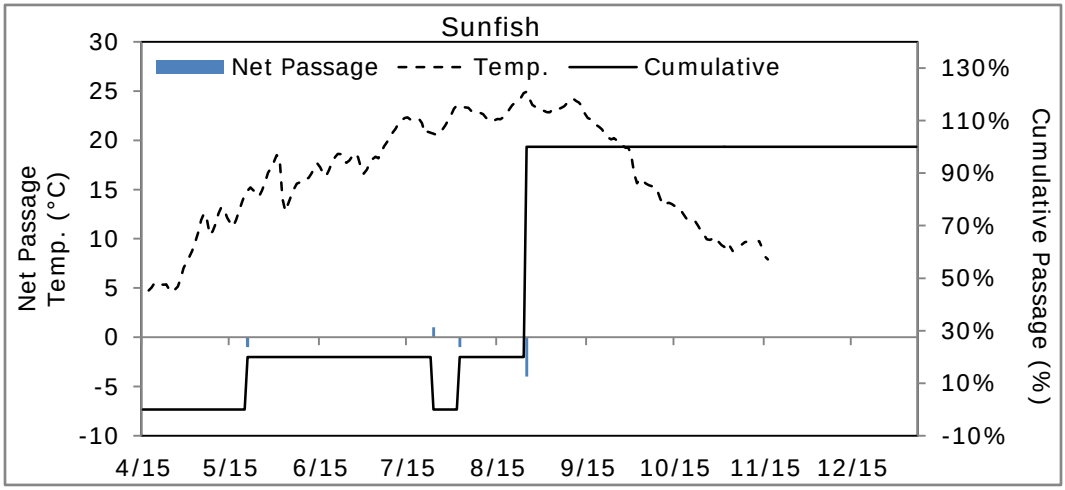

Figure 4.1-8. Wilder fish ladder: sunfish daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

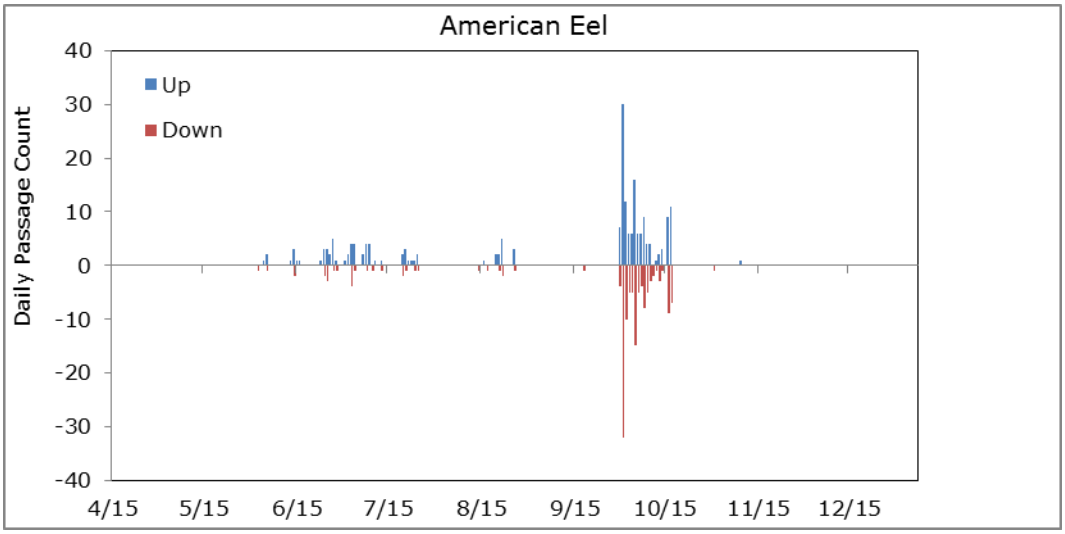

Figure 4.1-9. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for American Eel in the Wilder fish ladder.

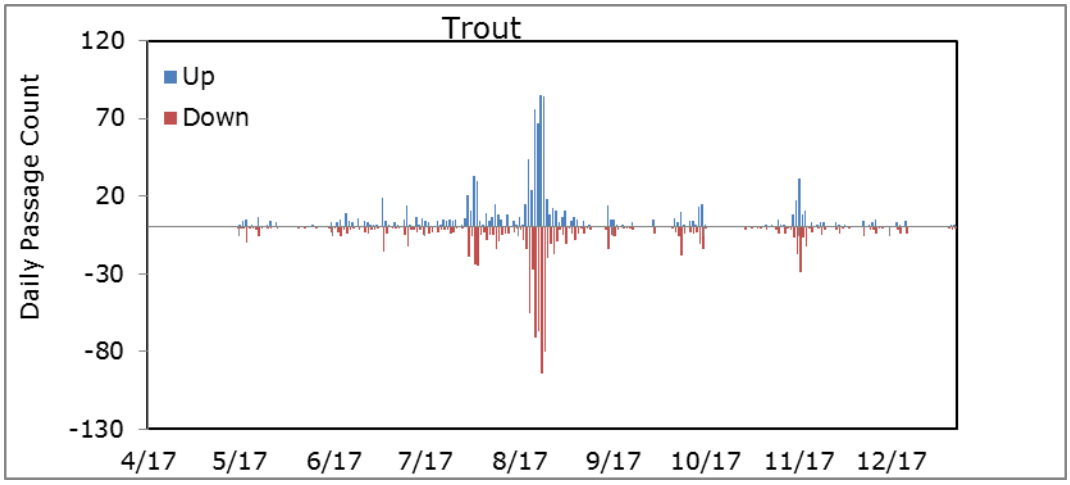

Figure 4.1-10. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for trout in the Wilder fish ladder (see Appendix D for similar plots by species).

4.1.2 Seasonality

The first record of any species in the Wilder fish ladder was May 12 when both Walleye and White Sucker were present, and water temperature averaged 13.2°C. The dates of first and last occurrence, peak passage, and 80% cumulative net passage by species (the date that 80% of the cumulative seasonal total for the species had passed) with corresponding water temperatures are included in Table

4.1-2. Seasonality is presented graphically in Figures 4.1-1 – 4.1-8, and daily records are tabulated in Appendix D.

Peak upstream passage was determined for those species/genera with a total net passage of more than 20, which included American Eel, bass, Walleye, and trout (Table 4.1-2). Only those species are discussed further in this section. Peak upstream passage was defined as those dates when the daily net passage of a species, except for American Eel, was greater than or equal to 10% of its 2015 total net passage. American Eel counts were distributed over the season, and, peak upstream passage was defined as 5% of the total net passage to more closely examine seasonal passage periodicity.

American Eels were recorded in the Wilder fish ladder from June 2 through November 9. The most concentrated activity occurred from early June through mid-July, and late September through mid-October. Peak upstream passage occurred on five days in the summer and one day in the fall with water temperature ranging from 12.9°C (in fall) to 24.4°C. Cumulatively, 80% of the total upstream passage count was recorded on September 30 when water temperature was 18.5°C.

Bass were recorded from May 21 through December 21. The most concentrated period of activity occurred from late May through mid-June. Peak upstream passage occurred on three days in the late spring when water temperature ranged from 14.9° to 17.1°C. Cumulatively, 80% of the total upstream passage count was recorded on July 22 when water temperature was 20.9°C.

Walleye were recorded from May 12 through October 16. There were no distinctly concentrated or defined peak periods of activity. Cumulatively, 80% of the total upstream passage count was recorded on August 2 when water temperature was 23.3°C.

Trout were recorded throughout the season, from May 16, 2015 through January 07, 2016. Peak upstream passage occurred on August 2 when water temperature was 23.2°C, however relatively high downstream passage counts occurred as well (Figure 4.1-7). Cumulatively, 80% of the total upstream passage count occurred on July 30 when water temperature was 22.5°C.

Table 4.1-2. Wilder fish ladder: date (2015) and water temperature of first and last observation, 80% cumulative net passage, and peak passage by species/genera.

Species/Genera	Net Passage	First		Peak[a]		80%		Last	
		Date	Temp. (°C)	Date	Temp. (°C)	Date	Temp. (°C)	Date	Temp. (°C)
Atlantic Salmon	1	10/05	15.6	NA	NA	NA	NA	10/05	15.6
American Shad	0	NA	NA	NA	NA	NA	NA	NA	NA
Sea Lamprey	2	05/30	17.8	NA	NA	06/02	14.1	06/02	14.1
American Eel[b]	52	06/02	14.1	06/27, 07/04, 07/08, 07/09, 08/22, 09/30 10/17	18.7, 18.3, 19.8, 20.4, 24.4, 18.5 12.9	09/30	18.5	11/09	9.7
Bass	49	05/21	14.9	05/26, 05/28 05/29, 06/07	14.9, 16.7, 17.1, 15.6	07/22	20.9	12/21	NA
White Sucker	1	05/12	13.2	NA	NA	NA	NA	06/08	15.7
Walleye	22	05/12	13.2	05/12, 05/13, 06/18, 07/04, 08/02, 10/01	13.2, 13.0, 16.9, 18.3, 23.5, 16.7	08/02	23.5	10/16	13.2
Trout	64	05/16	11.3	08/02	23.5	07/30	22.5	01/07	NA
Sunfish	-5	05/21	14.9	NA	NA	08/25	24.9	09/15	22.3
Bullhead	0	NA	NA	NA	NA	NA	NA	NA	NA
Crappie	0	NA	NA	NA	NA	NA	NA	NA	NA
Pike/Pickerel	0	NA	NA	NA	NA	NA	NA	NA	NA
Yellow Perch	0	NA	NA	NA	NA	NA	NA	NA	NA
Carp	0	NA	NA	NA	NA	NA	NA	NA	NA
Other	0	NA	NA	NA	NA	NA	NA	NA	NA

a. Peak passage (for species where total net passage >20) is defined here as daily net passage ≥10% of species total net passage.

b. For American Eel, the definition of peak passage was >5% of cumulative (not >10% as for other species).

4.1.3 Diel Periodicity

The proportional use of the Wilder fish ladder by diel phase is included in Table 4.1-3. Daily periodicities of use of the Wilder fish ladder were plotted as the number of upstream and downstream movements and net passage by hour of day for each species observed (Figures 4.1-11 – 4.1-18). Considering all species, activity was distributed around-the-clock, but specific activity varied. The one Atlantic Salmon that passed was recorded during daytime. Sea Lamprey records occurred primarily during daytime with some crepuscular records. American Eel activity was around-the-clock, but with a strong preponderance toward nighttime hours. Bass activity was recorded around-the-clock, but with a strong preponderance toward daytime. Walleye activity was recorded around-the-clock with a tendency toward crepuscular movements. White Sucker activity was predominately during daytime. Trout activity was recorded around-the-clock, but predominately during daytime. Sunfish activity was recorded during daytime with some crepuscular records.

Table 4.1-3. Wilder fish ladder percentage of total counts (upstream and downstream combined) by diel phase.

Species	Total Counts	Day	Night	Crepuscular
Migratory Species				
Atlantic Salmon	1	100%	0%	0%
American Shad	0	NA	NA	NA
Sea Lamprey	6	0%	83%	17%
American Eel	354	8%	81%	10%
Resident Species/Genera				
Bass	869	88%	4%	8%
White Sucker	19	95%	5%	0%
Walleye	321	45%	38%	17%
Trout	2154	91%	6%	3%
Sunfish	51	90%	0%	10%
Bullhead	0	NA	NA	NA
Crappie	0	NA	NA	NA
Pike/Pickerel	0	NA	NA	NA
Yellow Perch	0	NA	NA	NA
Carp	0	NA	NA	NA
Other	0	NA	NA	NA

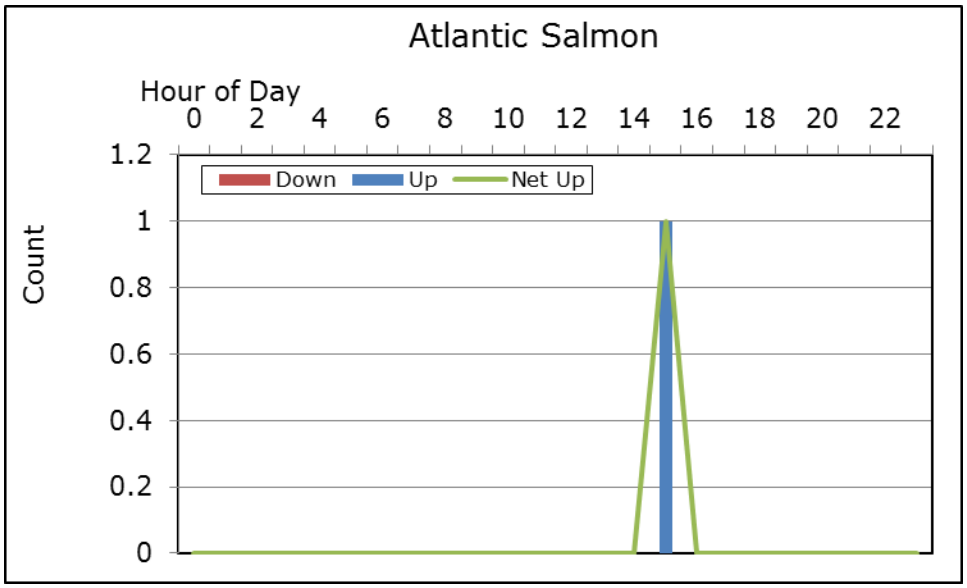

Figure 4.1-11. Wilder fish ladder: recordings of upstream and downstream movements with net passage of Atlantic Salmon.

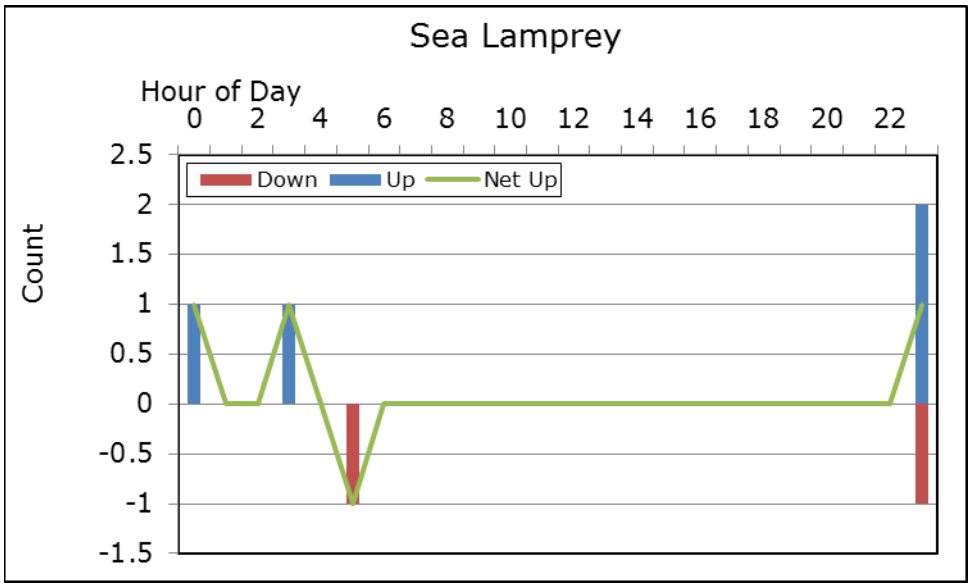

Figure 4.1-12. Wilder fish ladder: recordings of upstream and downstream movements with net passage of Sea Lamprey.

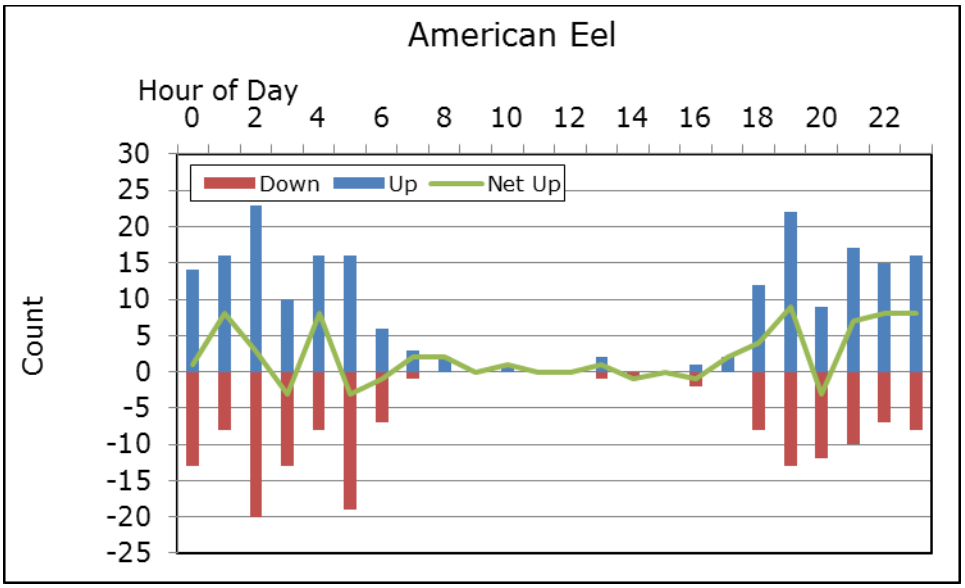

Figure 4.1-13. Wilder fish ladder: recordings of upstream and downstream movements with net passage of American Eel.

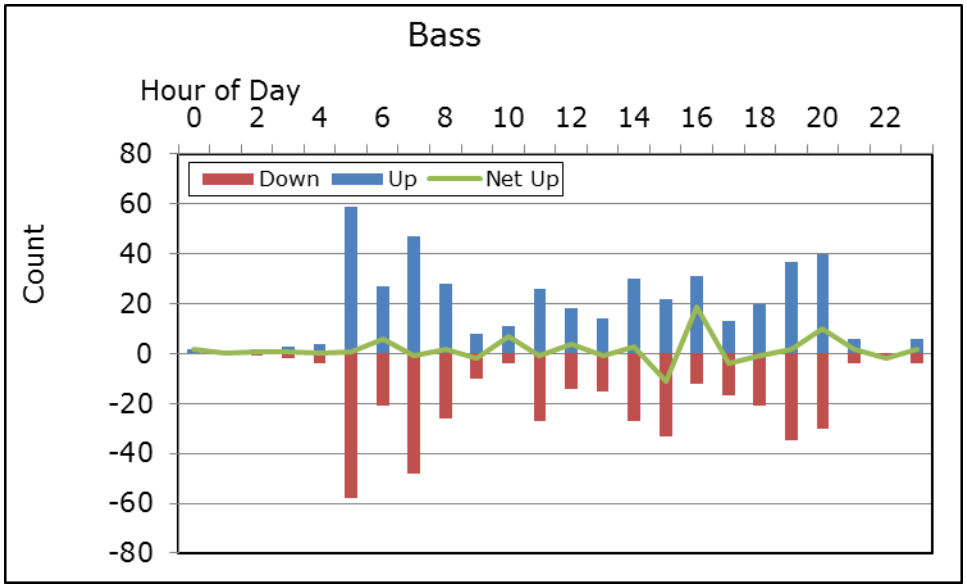

Figure 4.1-14. Wilder fish ladder: recordings of upstream and downstream movements with net passage of bass (*Micropterus spp.*).

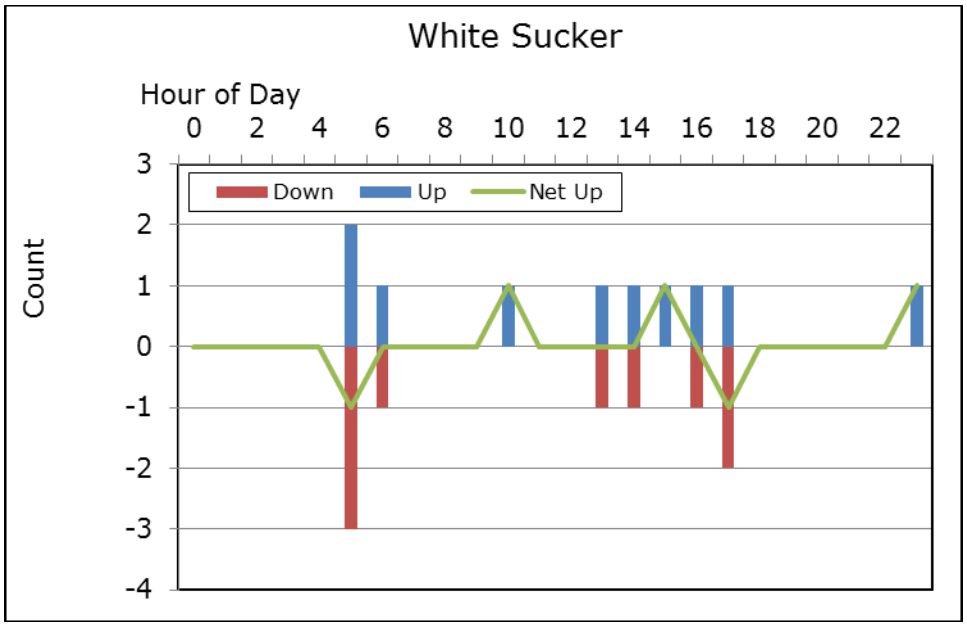

Figure 4.1-15. Wilder fish ladder: recordings of upstream and downstream movements with net passage of White Sucker.

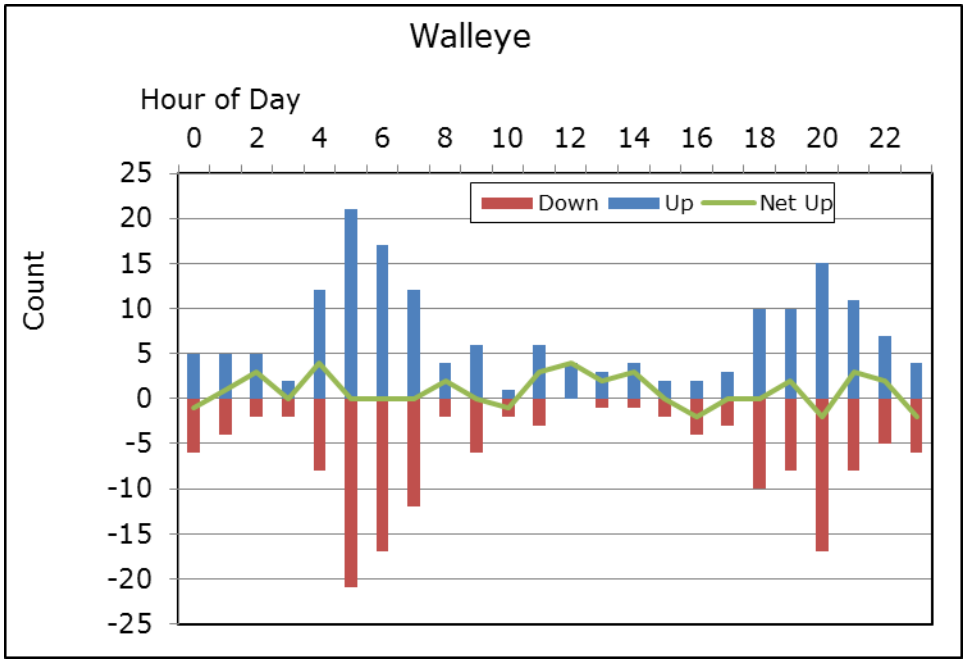

Figure 4.1-16. Wilder fish ladder: recordings of upstream and downstream movements with net passage of Walleye.

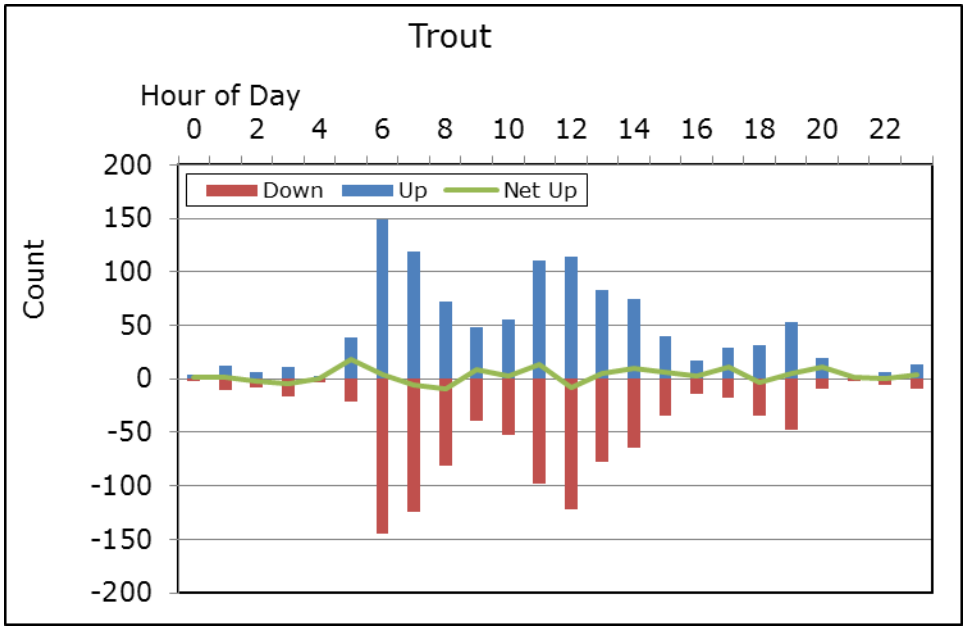

Figure 4.1-17. Wilder fish ladder: recordings of upstream and downstream movements with net passage of trout.

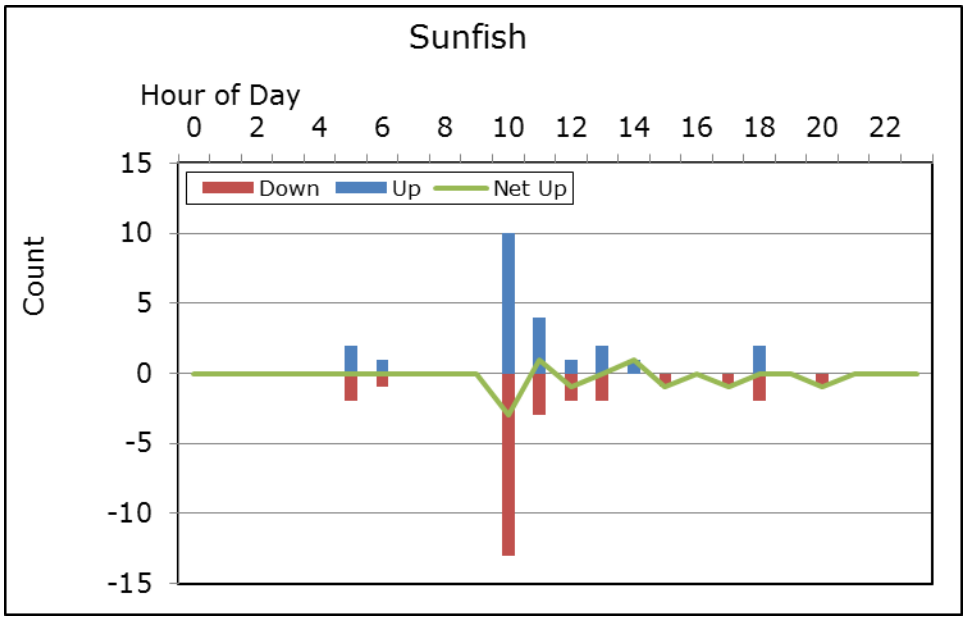

Figure 4.1-18. Wilder fish ladder: recordings of upstream and downstream movements with net passage of sunfish (*Lepomis* spp.).

4.1.4 Fish Passage and River Flows

Hourly river discharge partitioned to fish ladder, attraction water, operational discharge, and spilling flows (cfs) were tabulated with hourly net fish passage in Appendix E. Since, generally, fish passage counts were low, and/or passage was distributed over a range of discharge conditions, it is difficult to draw conclusions regarding the effects of flow. Some points are noteworthy, however. While most species exhibited passage during the spring over a range of river flow conditions, a concentrated period of passage of American Eel, bass, and Walleye occurred in the fall, and appeared to be associated with a brief spike in total river discharge that resulted in spilling conditions.

Throughout the 2015 season, the ratio of passage flow (fish ladder + attraction) to station flow (generation + passage) averaged 45% and ranged from 0.3% to 100%. Note that Wilder generation Unit 3 serves as attraction flow, so its discharge applies to the attraction flow not generation flow in that calculation. The dual role that Wilder Unit 3 plays as both generation and attraction flow is more accurately represented by including it with attraction and passage flows than with other generation flows. The unit operates continually to provide station minimum flow, as well as attraction water during fish ladder operations, with much of that flow going to attraction flow. If Unit 3 is not available (due to temporary unit outage), a Unit 3 bypass supplies the attraction water. The volume of attraction flow cannot be easily parsed out from Unit 3 total flows since it is dependent on head pond and tailrace water elevations and thus varies continually based on the range of generation levels from minimum flow to full generation.

4.2 Bellows Falls Fish ladder

The Bellows Falls Fish ladder was operated from April 15, 2015, with video monitoring beginning at 16:15, through January 6, 2016 at 12:20. Overall, nine of the 15 target species/genera were observed in 6,019 records, 59% more fish observations than were recorded in the Wilder fish ladder (N=3,775). Complete records of fish movement (click history) are included in Appendix C. Hourly movement and passage counts were tabulated with project discharge (generation, spill, attraction and fish ladder flows), and water temperature for each fish ladder (Appendix D).

4.2.1 Species Assemblage

Four migratory (diadromous) and five resident target species were recorded using the Bellows Falls fish ladder (Table 4.2-1, Figures 4.2-1 – 4.2-8[3]). Migratory species net passage counts included American Shad (N=44), Sea Lamprey (N=970), and American Eel (N=60). It was not possible to differentiate juvenile shad. The aspect ratio and distance from target and variable viewing conditions did not permit accurate motion capture or identification of fish so small.

Study 21 (Adult Shad Telemetry Study) tracked radio-tagged adult shad to the Bellows Falls tailrace but it was beyond the scope of that study to determine if any of those fish used the fish ladder and this study could not determine if any passed shad had been radio-tagged as part of Study 21. Similarly, in Study 16 (Sea Lamprey Spawning Assessment) although attempts were made to collect fish for tagging from the Bellows Falls fish ladder, abundances were insufficient to feasibly collect there, so all tagged specimens were collected from the Vernon fish ladder and released in the Bellows Falls impoundment having not used the Bellows Falls fish ladder.

No Atlantic Salmon were recorded moving upstream, however one was recorded moving downstream on June 8, resulting in a net passage count of -1. However, it was assumed that the fish moved upstream prior to that record without being recorded by the Salmonsoft system. Additionally, since one Atlantic Salmon was recorded passing upstream at the Wilder fish ladder on October 5, it is assumed that at least one Atlantic Salmon passed the Bellows Falls ladder successfully (date unknown). Therefore, the net passage for Atlantic Salmon by the Bellows Falls fish ladder is one.

The ratio of Bellows Falls to Vernon upstream passage counts were as follows: Atlantic Salmon 17%, American Shad 0.1%, Sea Lamprey 40%, and American Eel 4%. Since Bellows Falls is the historic upstream migratory extent of American Shad and the Bellows Falls fish ladder was not designed to pass American Shad, this very small proportional shad passage is not surprising. Since eels were likely represented by a diverse age distribution, the passage ratio does not reflect the migratory capacity of a seasonal spawning population.

[3] No plot is presented for Atlantic Salmon because recorded net upstream passage=0.

Sea Lamprey (N=3,712 total movement records) and American Eel (N=430) were the most active migratory species. The high number of both upstream and downstream movements relative to the net passage count suggests milling/resting in the counting window pool that resulted in multiple recordings of the same fish. This is represented in plots of daily upstream and downstream movements (as shown in Figures 4.2-9 and 4.2-10) which, by the nature of the near mirror image strongly suggest multiple recordings of individuals. That may have resulted from milling, or alternatively, the failure of individuals to ascend the fish ladder (fallback). In either case, the number of upstream and downstream movements likely over-estimates the actual number of individuals using the Bellows Falls fish ladder. Alternatively, some downstream movements of American Eel may be the result of different individuals (than those migrating upstream and / or milling) using the ladder for downstream migration, particularly in the fall.

Resident species net passage counts included bass (N=-47), White Sucker (N=7), Walleye (N=2), trout (N=8), and sunfish (N=7). As described for the Wilder fish ladder, resident species had generally high numbers of records of upstream and downstream movements relative to net passage counts. This is best illustrated by the recordings of trout in the fish ladder (Figure 4.2-11). There were 144 upstream movements and 136 downstream movements recorded, and therefore a net passage count of only 8 fish. The near mirror-image appearance of up / downstream movements on most dates indicates milling that resulted in motion-based video capture of multiple images of the same fish, and indicated a pattern of occupancy rather than passage. Note, however that this sum can be negative, as it was for bass, indicating a net downstream passage. Appendix D (filed separately in zipfile/Excel format) contains daily summaries of records of upstream and downstream movements with net passage, as well as plots of records of upstream and downstream movements (e.g. Figure 4.2-11) for each target species.

Raw count data (Salmonsoft / Fish Tick click histories) are tabulated in Appendix C. Appendix D includes daily summed upstream and downstream movements, net passage, and cumulative upstream passage tabulated by species, plots of daily net and cumulative passage by species, and plots of daily total upstream and downstream movements by species. Appendix E includes hourly discharge (categorized as fish ladder flow, attraction flow, project hydroelectric operations, and spill), water temperature, and summed upstream and downstream movements tabulated by species.

Table 4.2-1. Bellows Falls fish ladder counts of upstream (up), downstream (down), total movements recorded and net passage.

Species	Up	Down	Total	Net Passage[a]
Migratory Species				
Atlantic Salmon	1	-1	2	1[b]
American Shad	87	-43	130	44
Sea Lamprey	2341	-1371	3712	970
American Eel	245	-185	430	60
Resident Species/Genera				
Bass	607	-654	1261	-47
White Sucker	49	-42	91	7
Walleye	30	-28	58	2
Trout	144	-136	280	8
Sunfish	30	-23	53	7
Bullhead	0	0	0	0
Crappie	0	0	0	0
Pike/Pickerel	0	0	0	0
Yellow Perch	0	0	0	0
Carp	0	0	0	0
Other	0	0	0	0

a. Negative values indicate total net downstream passage.

b. Recorded net passage of Atlantic Salmon was 0, but because the recorded count for the Wilder fish ladder was 1, it is also assumed to be 1 for the Bellows Falls fish ladder.

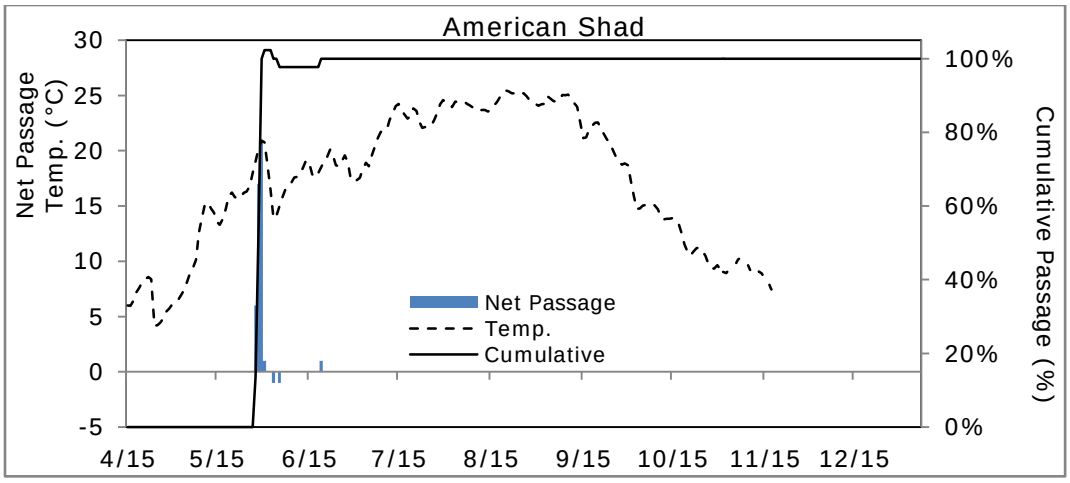

Figure 4.2-1. Bellows Falls fish ladder: American Shad daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

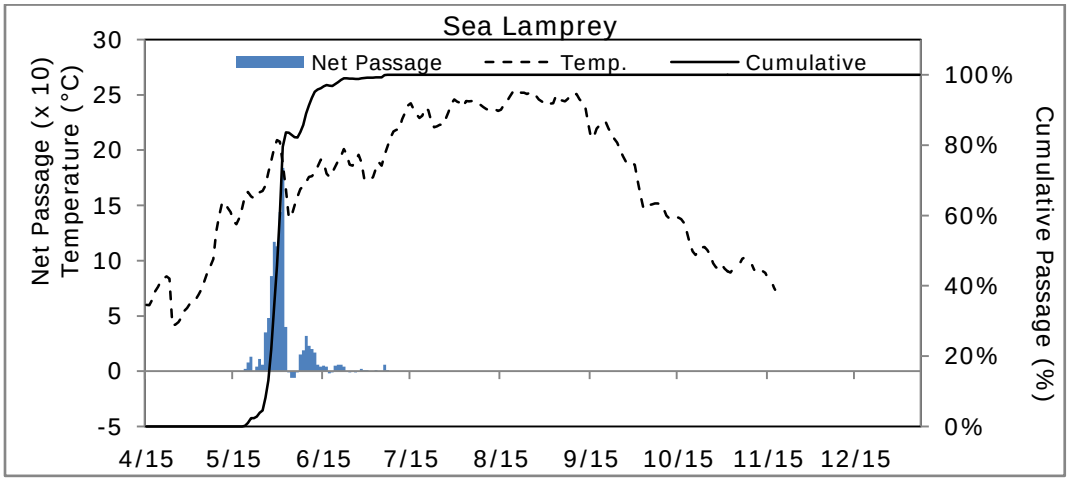

Figure 4.2-2. Bellows Falls fish ladder: Sea Lamprey daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

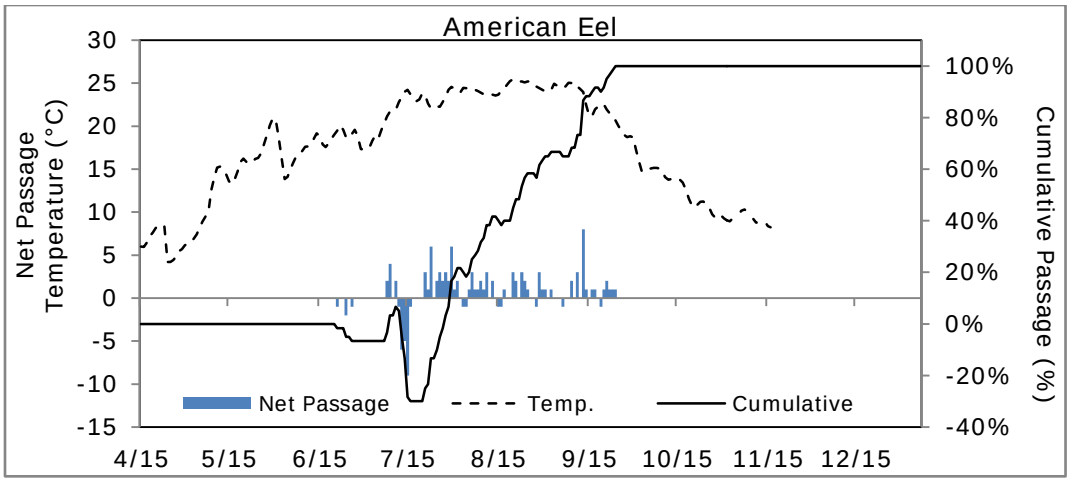

Figure 4.2-3. Bellows Falls fish ladder: American Eel daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

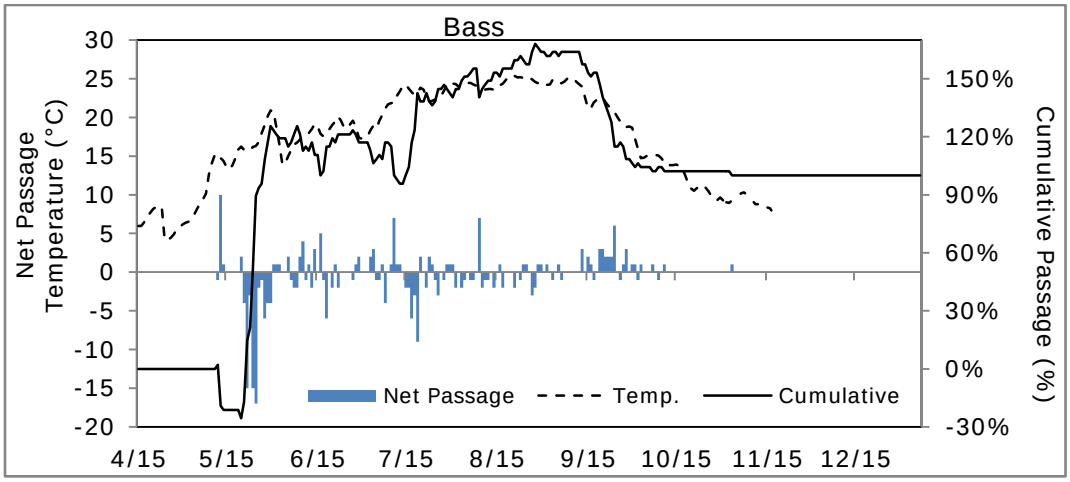

Figure 4.2-4. Bellows Falls fish ladder: Bass (*Micropterus* spp.) daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

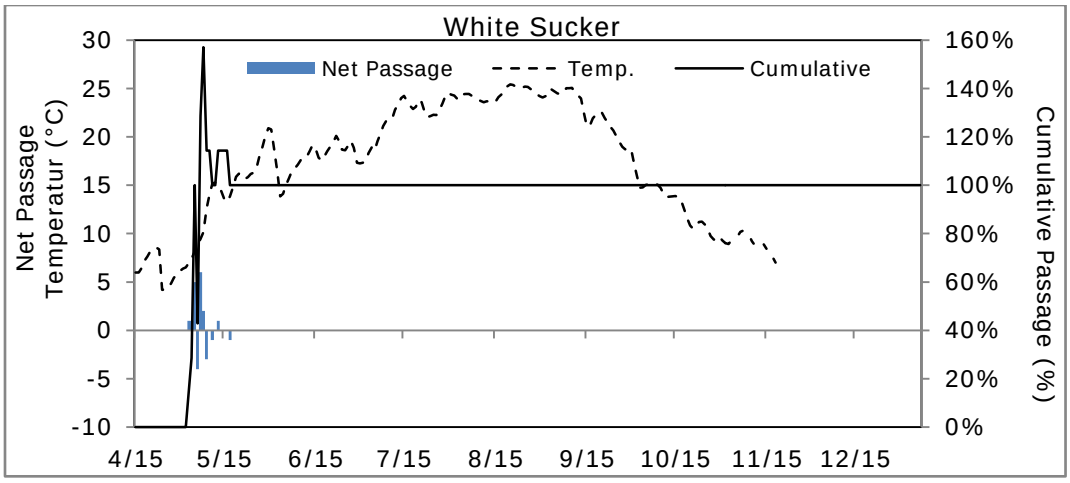

Figure 4.2-5. Bellows Falls fish ladder: White Sucker daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

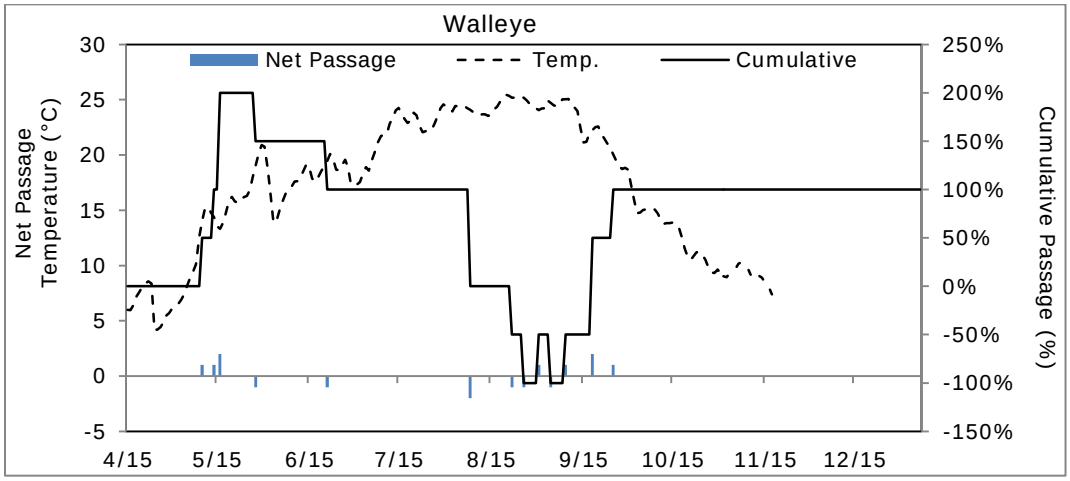

Figure 4.2-6. Bellows Falls fish ladder: Walleye daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

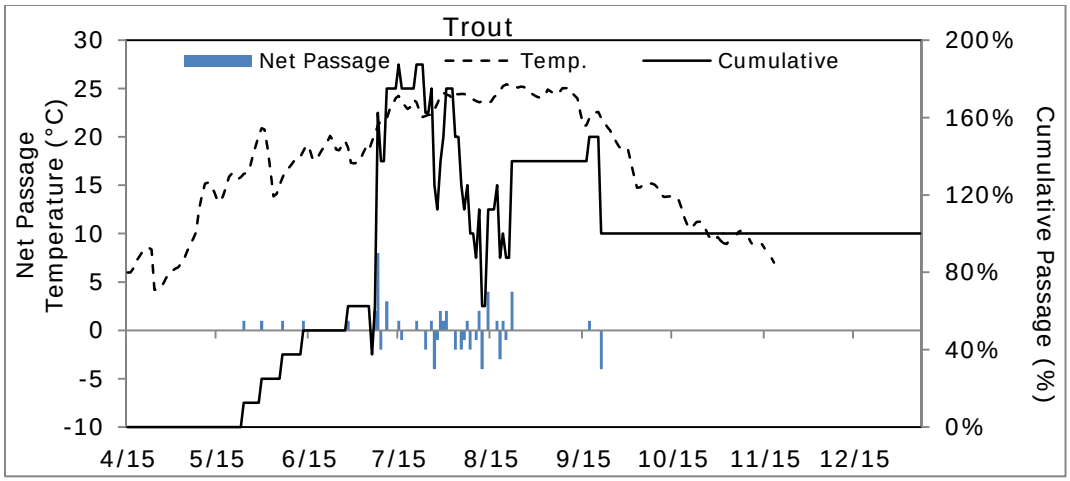

Figure 4.2-7. Bellows Falls fish ladder: Trout daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

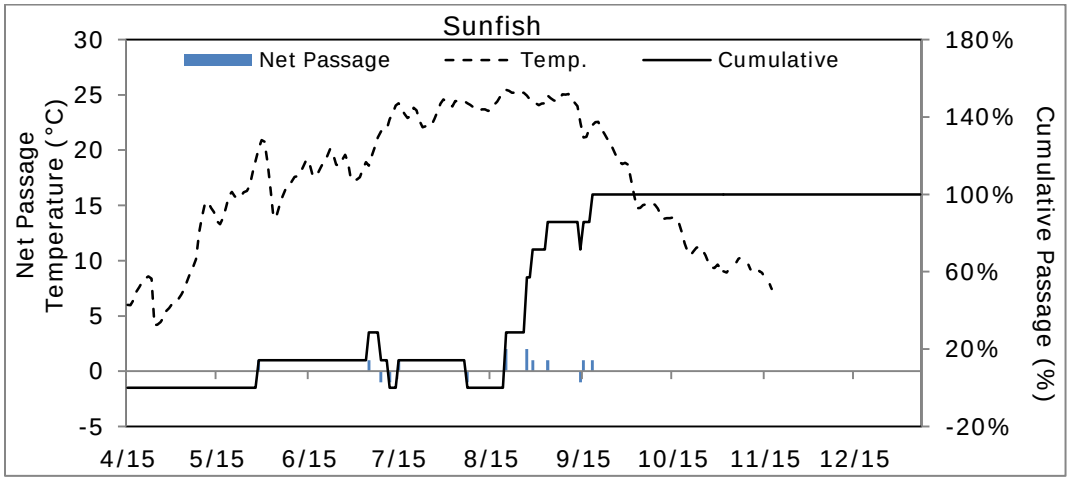

Figure 4.2-8. Bellows Falls fish ladder: Sunfish daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

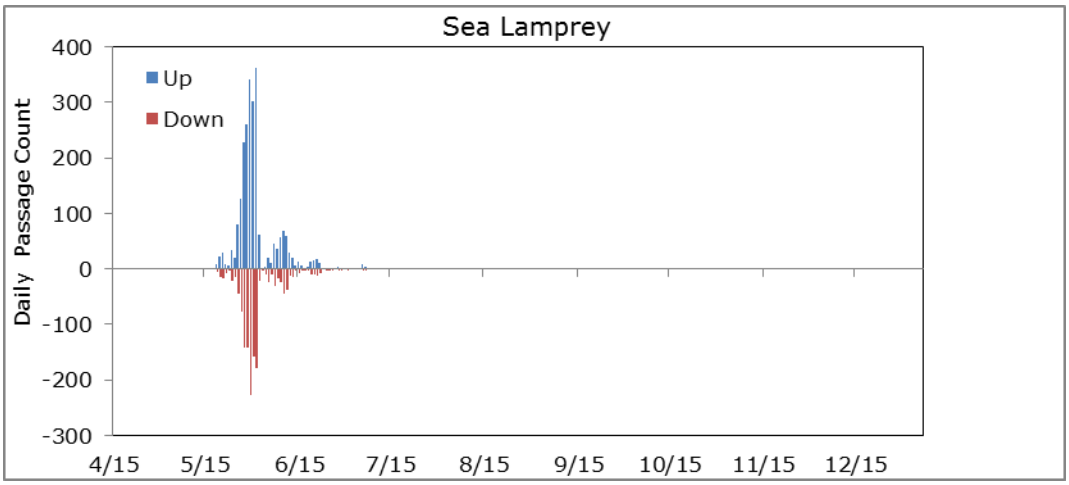

Figure 4.2-9. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for Sea Lamprey in the Bellows Falls fish ladder.

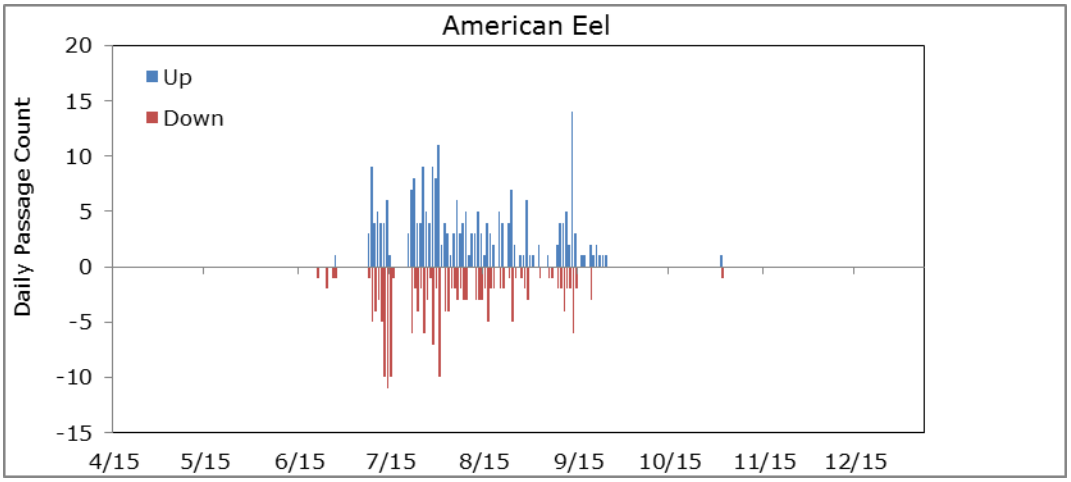

Figure 4.2-10. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for American Eel in the Bellows Falls fish ladder.

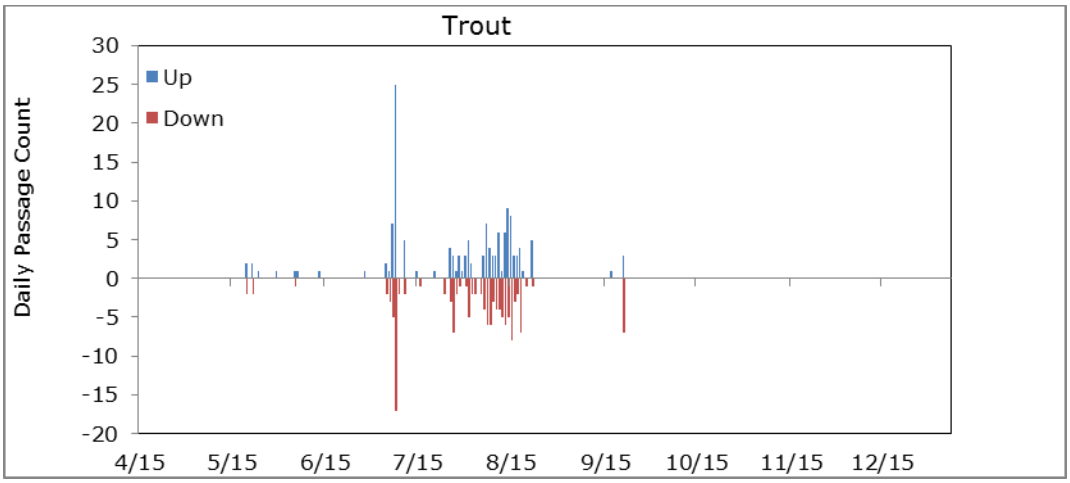

Figure 4.2-11. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for trout in the Bellows Falls fish ladder (see Appendix D for similar plots by species).

4.2.2 Seasonality

The first record of any species in the Bellows Falls fish ladder was May 3 when White Sucker were present and water temperature averaged 6.9°C. The dates of first and last occurrence, peak passage, and 80% cumulative net passage by species (the date that 80% of the cumulative seasonal total for the species had passed) with corresponding water temperatures are included in Table 4.2-2. Seasonality is presented graphically in Figures 4.2-1 – 4.2-8, and daily records are tabulated in Appendix D.

Peak upstream passage was determined for those species/genera with a total net passage of more than 20, which included American Shad, Sea Lamprey, American Eel, and bass (Table 4.2-2). Only those species are discussed further in this section. Peak upstream passage was defined as those dates when the daily net passage of a species, except for American Eel, was greater than or equal to 10% of its 2015 total net passage. American Eel counts were protracted over the season, and, peak upstream passage was defined as 5% of the total net passage to more closely examine seasonal passage periodicity.

American Shad were recorded in the Bellows Falls fish ladder from May 26 through June 20 with water temperature ranging from 14.0 to 21.2°C. Peak passage occurred from May 28 – May 30, and 80% cumulative passage occurred on May 30, when water temperature was 20.9°C.

Sea Lamprey were recorded from May 19 – June 7 with water temperature ranging from 13.6°C to 21.2°C. Peak upstream passage occurred May 29 – June 1 when water temperature ranged from 18.8°C to 20.9°C. Cumulatively, 80% passage occurred on June 1 when water temperature was 18.8°C.

American Eel were recorded from June 21 through November 1. The most concentrated activity occurred from early July through mid-September. Peak

upstream passage occurred on 12 days during summer with water temperatures ranging from 21.7°C – 25.4°C. Cumulatively 80% of the total upstream passage count was recorded on September 13.

Bass were recorded from May 12 through November 3 with water temperatures ranging from 9.3° - 25.6°C. Cumulatively, 80% of the total upstream passage count was recorded on May 25. Overall, bass had net passage count of -47 which suggests a net-downstream migration through the Bellows Falls fish ladder.

Table 4.2-2. Bellows Falls fish ladder: date (2015) and water temperature of first and last observation, 80% cumulative net passage, and peak passage by species/genera.

Species/Genera	Net Passage	First		Peak[a]		80%		Last	
		Date	Temp. (°C)	Date	Temp. (°C)	Date	Temp. (°C)	Date	Temp. (°C)
Atlantic Salmon	1[b]	06/08	16.8	NA	NA	NA	NA	06/08	16.8
American Shad	44	05/26	16.8	05/28-05/30	19.0 - 20.9	5/30	20.9	06/20	19.0
Sea Lamprey	971	05/19	15.9	05/29-06/01	18.8– 20.9	06/01	18.8	07/07	20.3
American Eel[c]	60	06/21	19.5	07/09, 07/21, 07/23, 07/26, 07/28, 07/30, 08/06, 08/11 08/20, 08/23, 08/29, 09/11, 09/13,	21.7, 23.6, 22.1, 22.3, 23.4, 24.6, 24.4, 23.6 25.4, 25.2, 24.4 24.6, 24.0	09/13	24.0	11/01	9.0
Bass	-47	05/12	15.3	NA	NA	05/25	16.3	11/03	9.3
White Sucker	7	05/03	6.9	NA	NA	05/05	8.2	05/26	16.8
Walleye	2	05/10	14.0	NA	NA	05/14	14.4	09/25	20.0
Trout	8	05/20	16.2	NA	NA	07/08	21.1	09/21	21.9
Sunfish	7	05/29	20.1	NA	NA	09/03	24.9	09/18	22.3
Bullhead	0	NA	NA	NA	NA	NA	NA	NA	NA
Crappie	0	NA	NA	NA	NA	NA	NA	NA	NA
Pike/Pickerel	0	NA	NA	NA	NA	NA	NA	NA	NA
Yellow Perch	0	NA	NA	NA	NA	NA	NA	NA	NA
Carp	0	NA	NA	NA	NA	NA	NA	NA	NA
Other	0	NA	NA	NA	NA	NA	NA	NA	NA

a. Peak passage (for species where total net passage>20) is defined here as daily net passage ≥10% of species total net passage.

b. Recorded net passage was 0, but because 1 Atlantic Salmon was recorded at the Wilder fishway, actual net passage is assumed to be 1.

c. Per the definition of peak passage, no dates represented peak for American Eel, though high proportions (>5%) of net passage occurred on the dates listed.

4.2.3 Diel Periodicity

The proportional use of the Bellows Falls fish ladder by diel phase is included in Table 4.2-3. Daily periodicities of use of the Bellows Falls fish ladder were plotted as the number of upstream and downstream movements and net passage by hour of day for each species observed (Figures 4.2-12 – 4.2-20). Considering all species, activity was distributed around-the-clock, but specific activity varied. One Atlantic Salmon was recorded during daytime. American Shad were recorded in each phase, but with a strong preponderance toward daytime. Sea Lamprey were recorded around-the-clock with a preponderance toward daytime. American Eel activity was recorded around-the-clock, but with a strong preponderance toward nighttime. Bass activity was recorded primarily during daytime with minimal nighttime and crepuscular observations. Walleye activity was recorded around-the-clock with a preponderance toward daytime. Both White Sucker and trout activity was recorded predominately during daytime with a negligible number of nighttime and crepuscular period records. Sunfish activity was recorded during daytime with a negligible number of crepuscular period records.

Table 4.2-3. Bellows Falls fish ladder percentage of total counts (upstream and downstream combined) by diel phase.

Species	Total Counts	Day	Night	Crepuscular
Migratory Species				
Atlantic Salmon	2	100%	0%	0%
American Shad	130	74%	11%	15%
Sea Lamprey	3712	66%	31%	3%
American Eel	430	17%	71%	12%
Resident Species/Genera				
Bass	1261	96%	2%	2%
White Sucker	91	93%	2%	4%
Walleye	58	74%	16%	10%
Trout	280	94%	1%	5%
Sunfish	53	98%	0%	2%
Bullhead	0	NA	NA	NA
Crappie	0	NA	NA	NA
Pike/Pickerel	0	NA	NA	NA
Yellow Perch	0	NA	NA	NA
Carp	0	NA	NA	NA
Other	0	NA	NA	NA

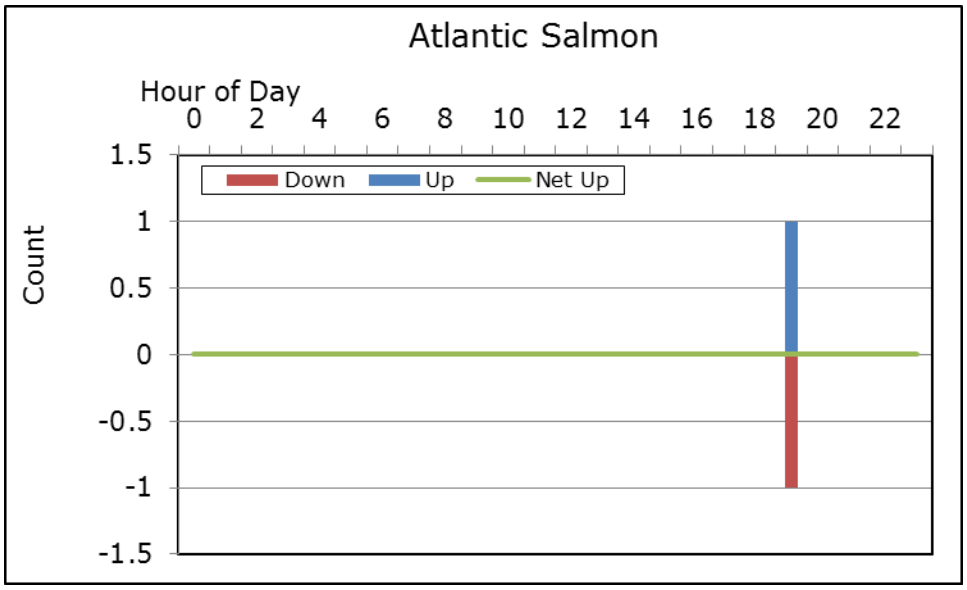

Figure 4.2-12. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of Atlantic Salmon.

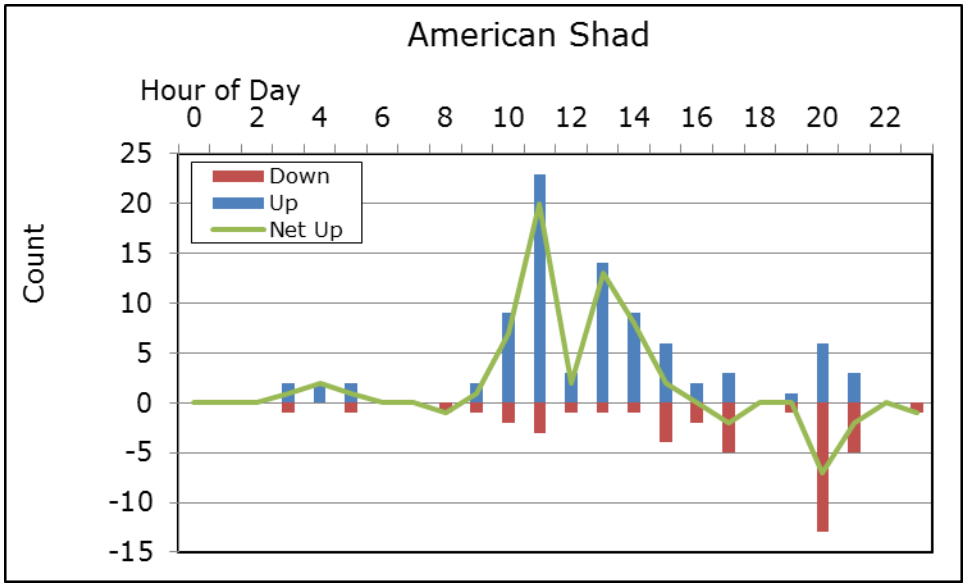

Figure 4.2-13. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of American Shad.

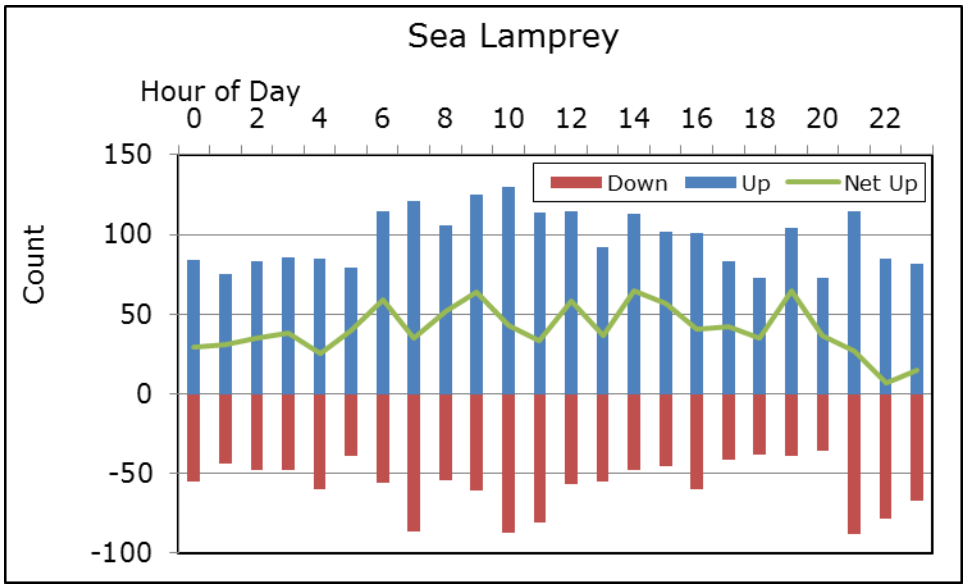

Figure 4.2-14. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of Sea Lamprey.

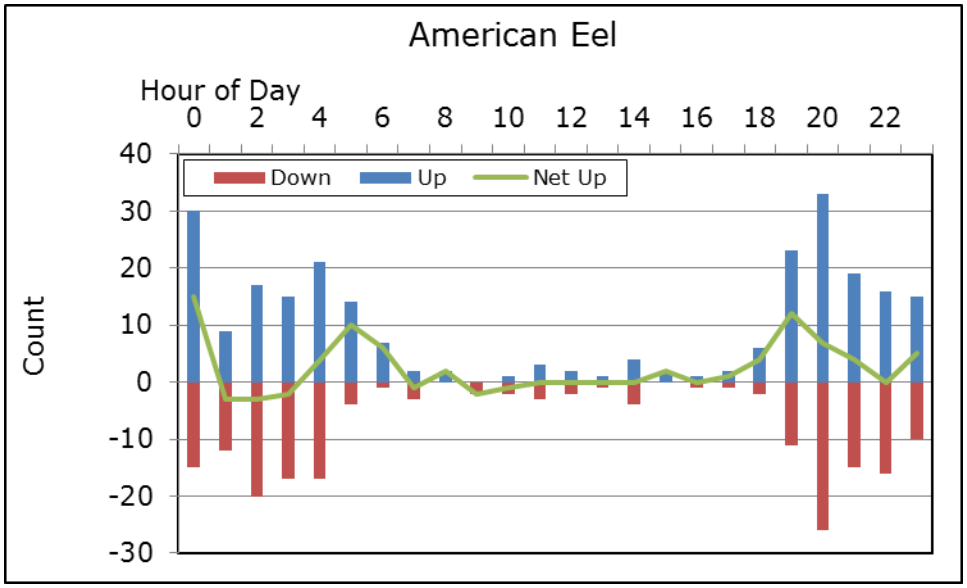

Figure 4.2-15. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of American Eel.

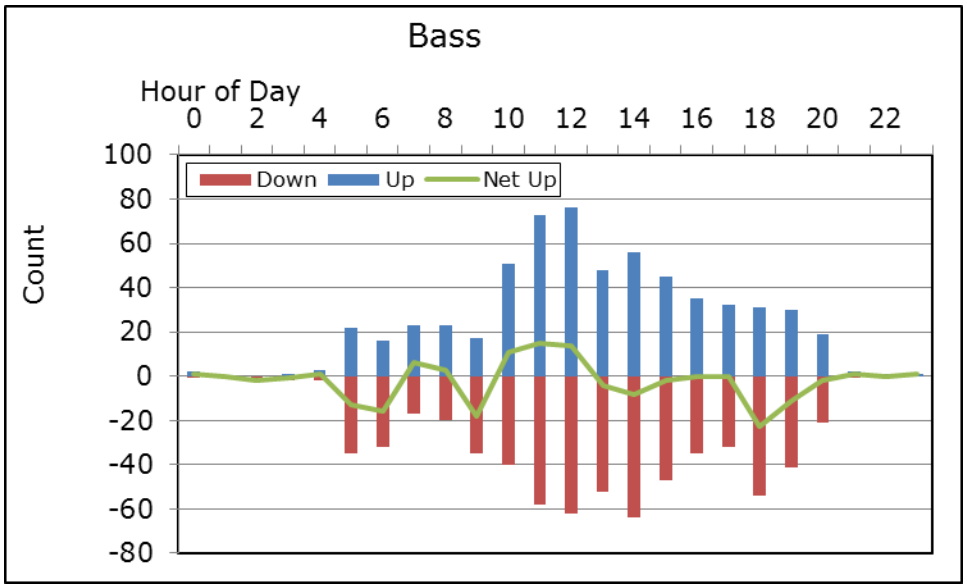

Figure 4.2-16. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of bass (*Micropterus* spp.).

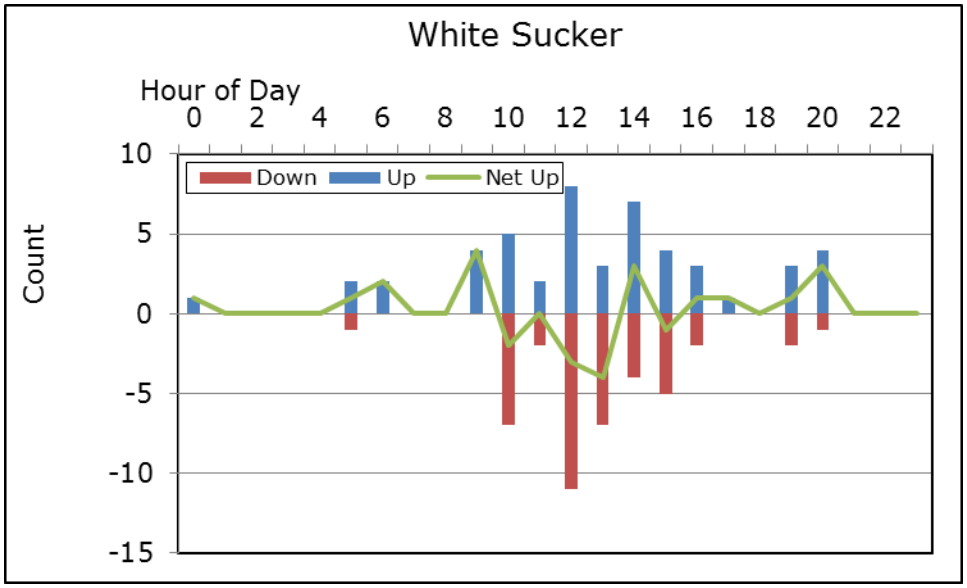

Figure 4.2-17. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of White Sucker.

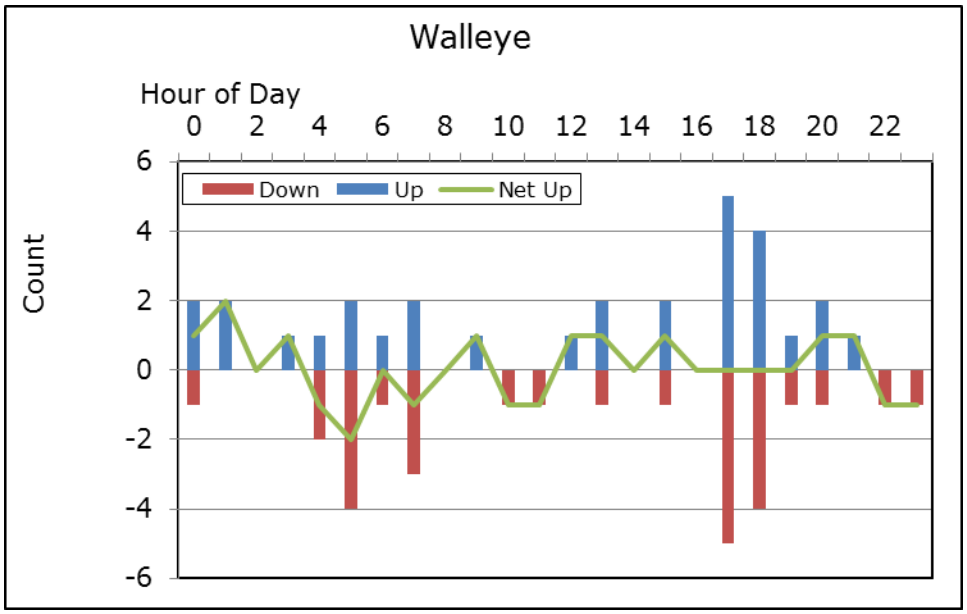

Figure 4.2-18. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of Walleye.

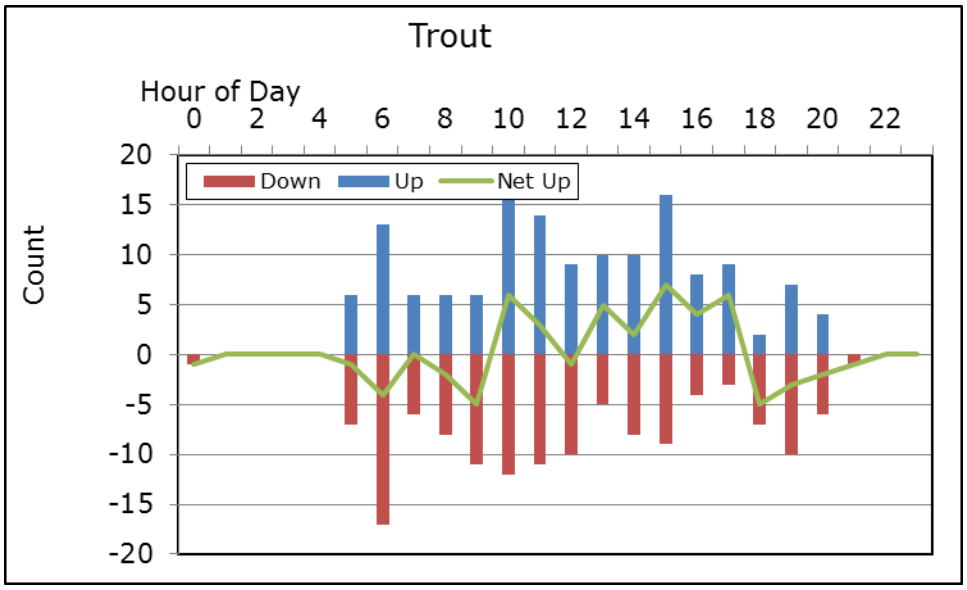

Figure 4.2-19. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of trout.

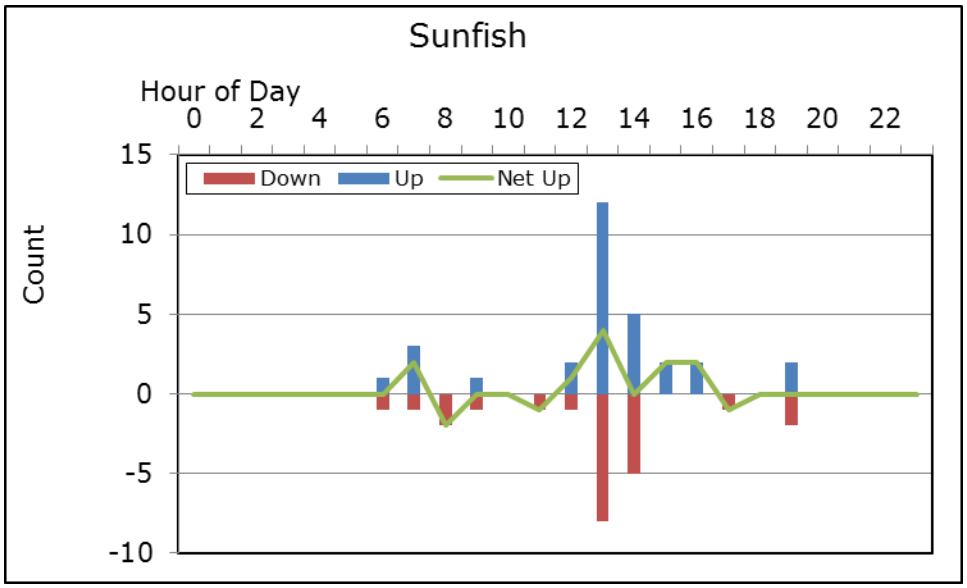

Figure 4.2-20. Bellows Falls fish ladder, recordings of upstream and downstream movements with net passage of sunfish (*Lepomis* spp.).

4.2.4 Fish Passage and River Flows

Hourly river discharge partitioned to fish ladder, hydroelectric operational discharge, and spilling flows (cfs) were tabulated with hourly net fish passage in Appendix E. Although an interactive effect of seasonality (water temperature) and discharge patterns is expected for spring migrants, particularly anadromous species, some patterns are noteworthy. Both American Shad and Sea Lamprey passage activity was most concentrated during a period of relatively low total river discharge following the spring freshet. That may be due to seasonality, however in the case of Sea Lamprey, a reduced rate of passage occurred during a variety of subsequent discharge scenarios including spill. American Eel passage occurred mostly during lower flow scenarios during summer with no evident relationship to peak flow events. Bass passage was distributed over a range of flows including spill during spring and summer. White Sucker passage occurred only during the period in spring when freshet flows were receding. Walleye, trout, and sunfish passage was sporadic and distributed over a variety of flow scenarios from spring till early fall.

Throughout the 2015 season, the ratio of passage flow (fish ladder) to station flow (generation + passage) averaged 0.9% and ranged from 0.2% to 100%. Note that this ratio accounts only for the relatively low fish ladder flow. The entrance to the Bellows Falls fish ladder is sited near the discharge from the trash/ice sluice and its flow serves as supplemental attraction flow within the narrow tailrace canal.

4.3 Vernon Fish ladder

The Vernon fish ladder operated from May 5, 2015 at 08:45 through January 6, 2016 at 14:00. Overall, 14 of the 15 target species/genera were observed in 115,949 records; 18 times more observations than were recorded in the Bellows Falls fish ladder (N=6,019). Of the target species/genera, only Yellow Perch was not recorded. Complete records of fish movement (click history) are included in Appendix C. Hourly movement and passage counts were tabulated with project discharge (generation, spill, attraction and fish ladder flows), and water temperature for each fish ladder (Appendix D).

4.3.1 Species Assemblage

Four migratory (diadromous) and 10 resident target species/genera were recorded using the Vernon fish ladder (Table 4.3-1, Figures 4.3-1 – 4.3-14). Migratory species net passage counts included Atlantic Salmon (N=6), American Shad (N=39,196), Sea Lamprey (N=2,440), and American Eel (N=1,545), presumably including radio and/or PIT-tagged adult shad (from Study 21) that were tracked upstream in the Vernon impoundment. All Sea Lamprey tagged as part of Study 16 were collected in the Vernon fish ladder. These fish were therefore counted in this study as having passed.

The number of diadromous fish passing upstream of FirstLight's Turners Falls Gatehouse fish ladder (source: Connecticut River Coordinators Office, http://www.fws.gov/r5crc/Fish/hist.html) and the ratio of those passing Vernon were as follows: Atlantic Salmon 6, 200%; American Shad 58,079, 67%; Sea Lamprey 8,423, 29%. American Shad, Sea Lamprey, and American Eel were highly active with large numbers of individual (upstream and downstream) movements recorded: American Shad (N= 71,578), Sea Lamprey (N= 12,960), and American Eel (N=8,289).

The high number of both upstream and downstream movements relative to the net passage count suggests milling/resting in the counting window pool that resulted in multiple recordings of the same fish. This is represented in plots of daily upstream and downstream movements (as shown in Figures 4.3-15 - 4.3-17) which, by the nature of the near mirror image strongly suggest multiple recordings of individuals. That may have resulted from milling, or alternatively, the failure of individuals to ascend the fish ladder (fallback). In either case, the number of upstream and downstream movements likely over-estimates the actual number of individuals using the fish ladder. Alternatively, some downstream movements of American Eel may be the result of different individuals (than those migrating upstream and / or milling) using the ladder for downstream migration, particularly in the fall.

Resident species net passage counts included bass (N=761), White Sucker (N=322), Walleye (N=58), trout (N=30), sunfish (N=1,188), bullhead (N=2), crappie (N=14), pike/pickerel (N=-1), Common Carp (N=8), and other, primarily channel catfish (N=12)[4]. As described above resident species had generally high

[4] The other category was primarily composed of Channel Catfish (*Ictalurus punctatus*),

numbers of records of upstream and downstream movements relative to net passage counts. This also suggests milling or resting by some species.

This is illustrated by the recordings of bass in the fish ladder (Figure 4.3-18). There were 5,320 upstream movements and 4,559 downstream movements recorded, and therefore a net passage count of 761fish. The near mirror-image appearance of up / downstream movements on most dates indicates milling that resulted in motion-based video capture of multiple images of the same fish, and indicated a pattern of occupancy rather than passage. Note, however that this sum can be negative, as it was for bass, indicating a net downstream passage. Appendix D (filed separately in zipfile/Excel format) contains daily summaries of records of upstream and downstream movements with net passage, as well as plots of records of upstream and downstream movements (e.g. Figure 4.3-17) for each target species.

Raw count data (Salmonsoft / Fish Tick click histories) are tabulated in Appendix C. Appendix D includes daily summed upstream and downstream movements, net passage, and cumulative upstream passage tabulated by species, plots of daily net and cumulative passage by species, and plots of daily total upstream and downstream movements by species. Appendix E includes hourly discharge (categorized as fish ladder flow, attraction flow, project hydroelectric operations, downstream passage flow, and spill), water temperature, and summed upstream and downstream movements tabulated by species.

Table 4.3-1. Vernon fish ladder counts of upstream (up), downstream (down), total movements recorded and net passage.

Species	Up	Down	Total	Net Passage[a]
Migratory Species				
Atlantic Salmon	6	0	6	6
American Shad	55,387	-16,191	71,578	39,196
Sea Lamprey	7,700	-5,260	12,960	2,440
American Eel	4,197	-3,372	8,289	1,545
Resident Species				
Bass	5,320	-4,559	9,879	761
White Sucker	2,354	-2,032	4,386	322
Walleye	131	-73	204	58
Trout	90	-60	150	30
Sunfish	4,613	-3,425	8,038	1,188
Bullhead	8	-6	14	2
Crappie	14	0	14	14
Pike/Pickerel	1	-2	3	-1
Yellow Perch	0	0	0	0
Carp	88	-80	168	8
Other[b]	136	-124	260	12

a. Negative values indicate total net downstream passage.

b. Primarily Channel Catfish (*Ictalurus punctatus*).

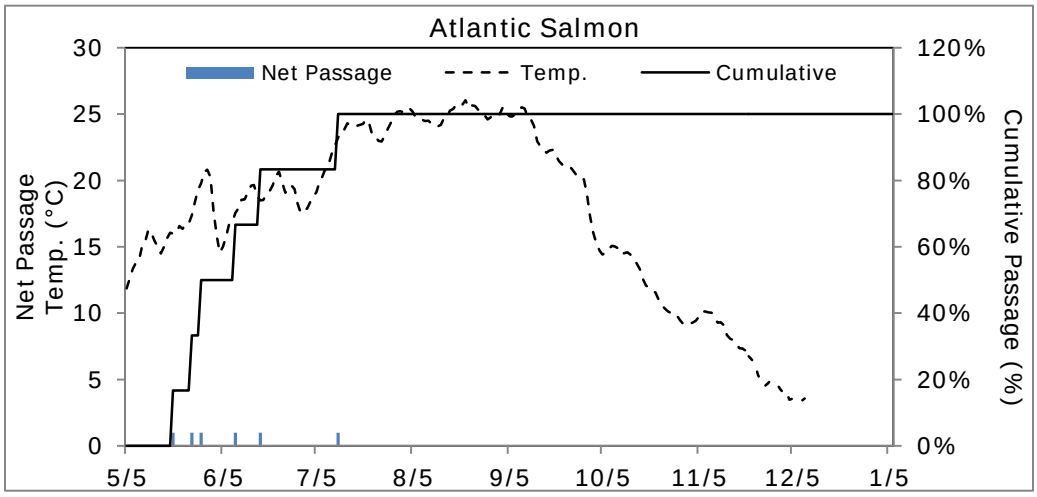

Figure 4.3-1. Vernon fish ladder: Atlantic Salmon daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

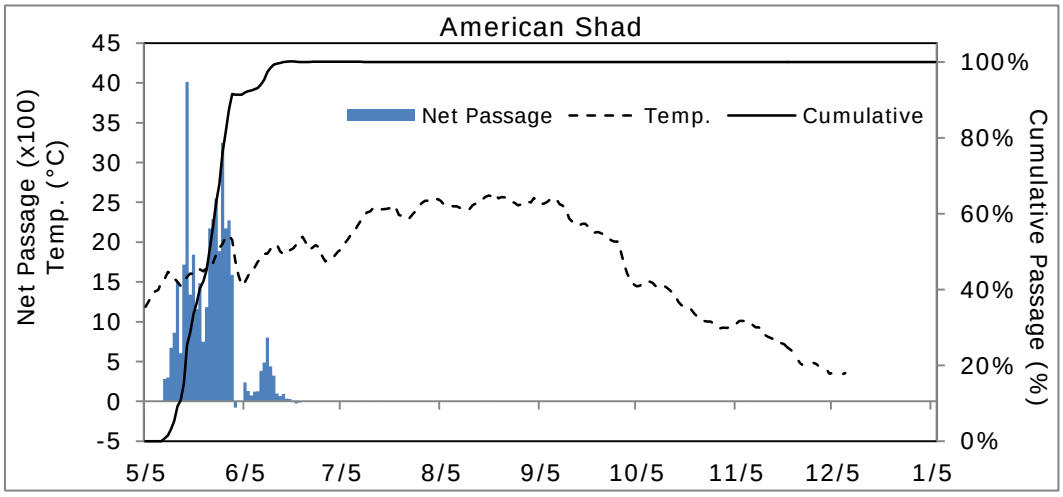

Figure 4.3-2. Vernon fish ladder: American Shad daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

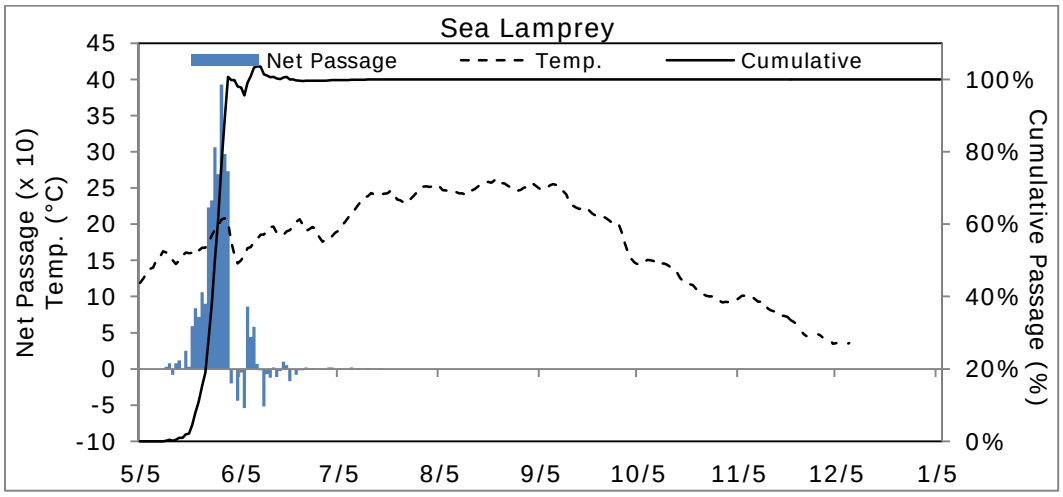

Figure 4.3-3. Vernon fish ladder: Sea Lamprey daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

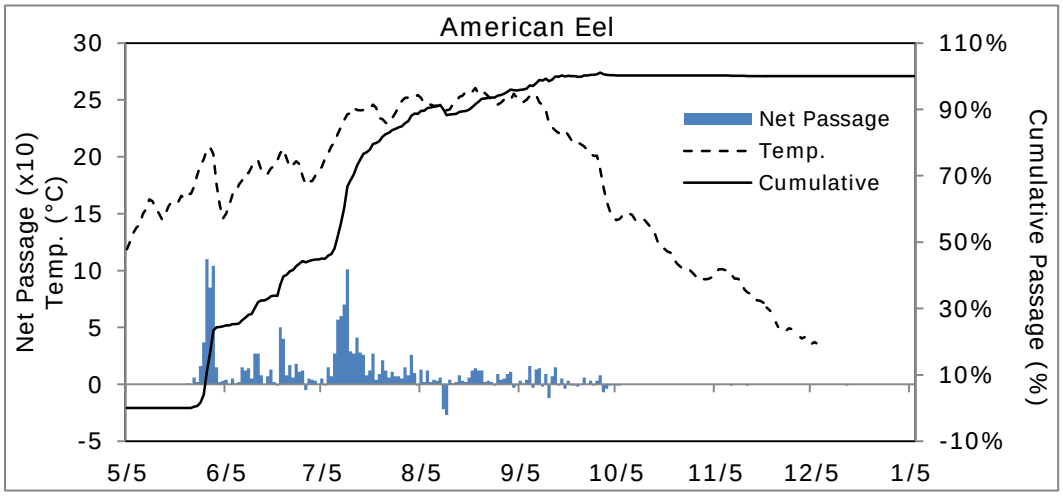

Figure 4.3-4. Vernon fish ladder: American Eel daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

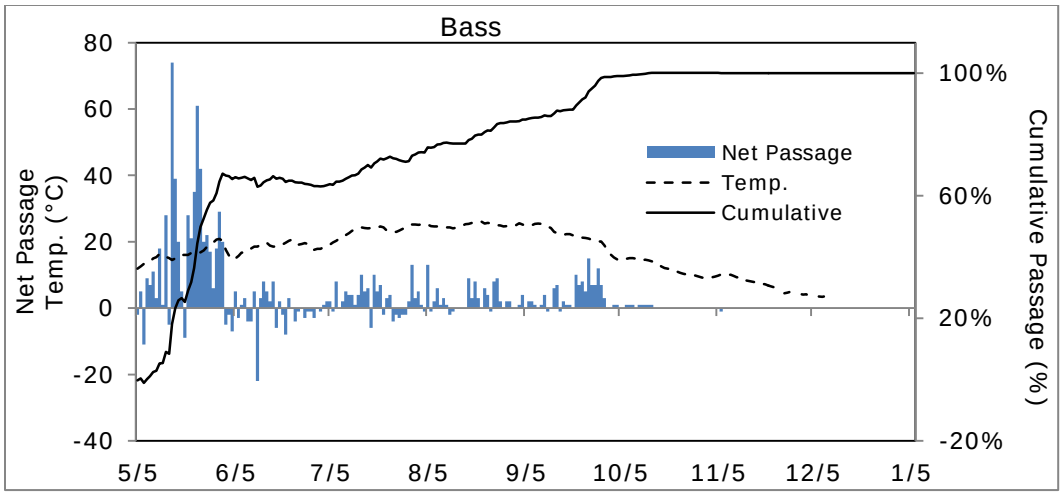

Figure 4.3-5. Vernon fish ladder: Bass (*Micropterus* spp.) daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

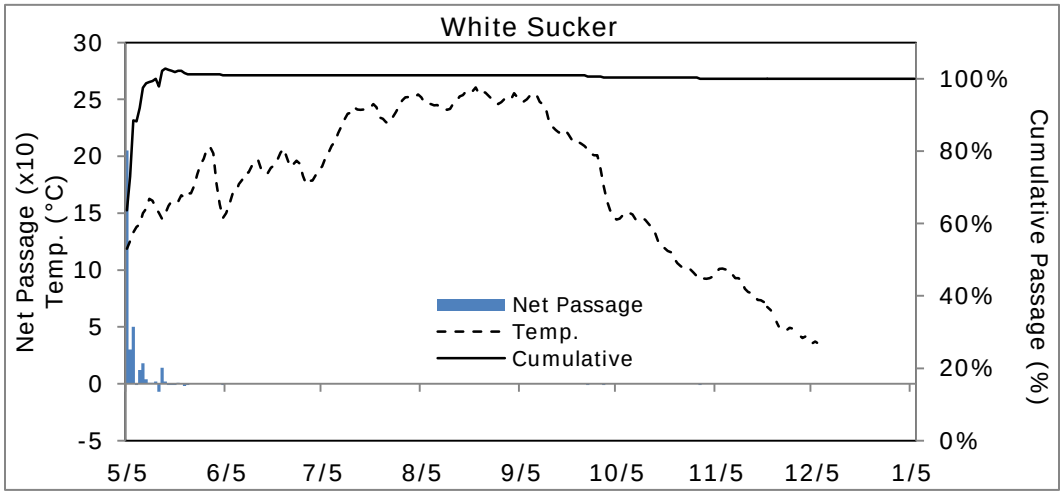

Figure 4.3-6. Vernon fish ladder: White Sucker daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

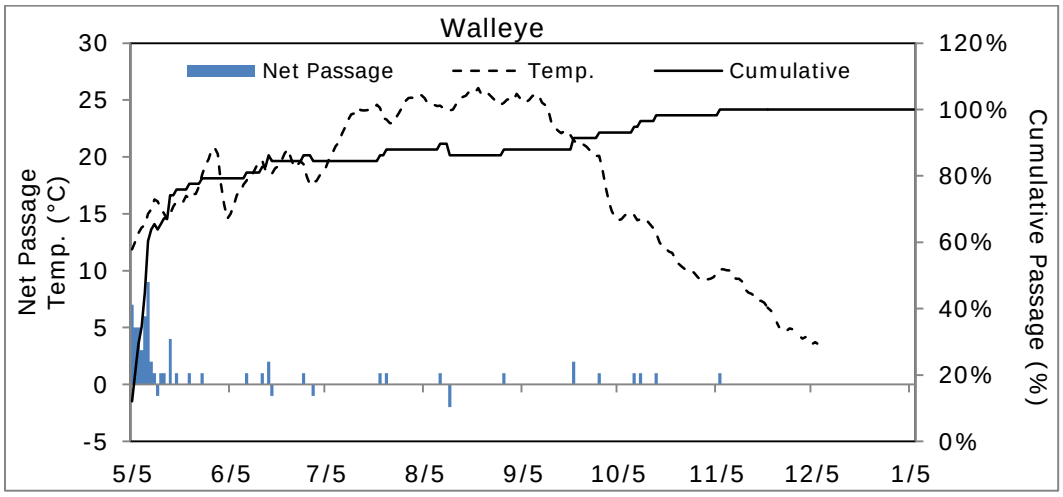

Figure 4.3-7. Vernon fish ladder: Walleye daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

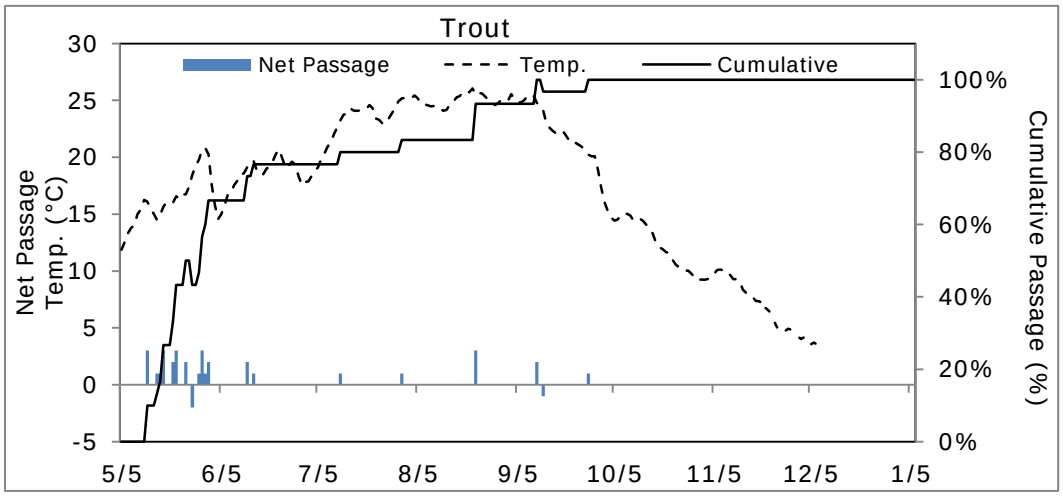

Figure 4.3-8. Vernon fish ladder: trout daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

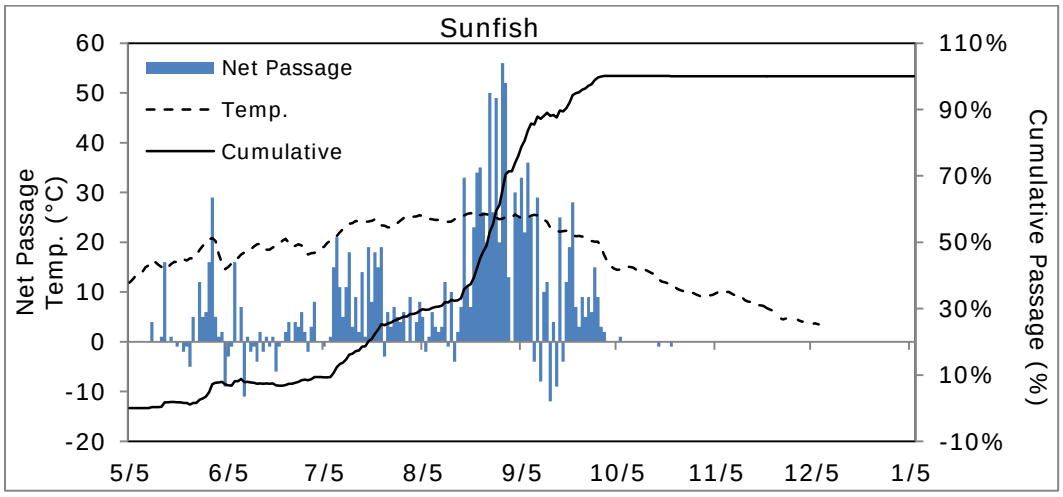

Figure 4.3-9. Vernon fish ladder: sunfish (*Lepomis* spp.) daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

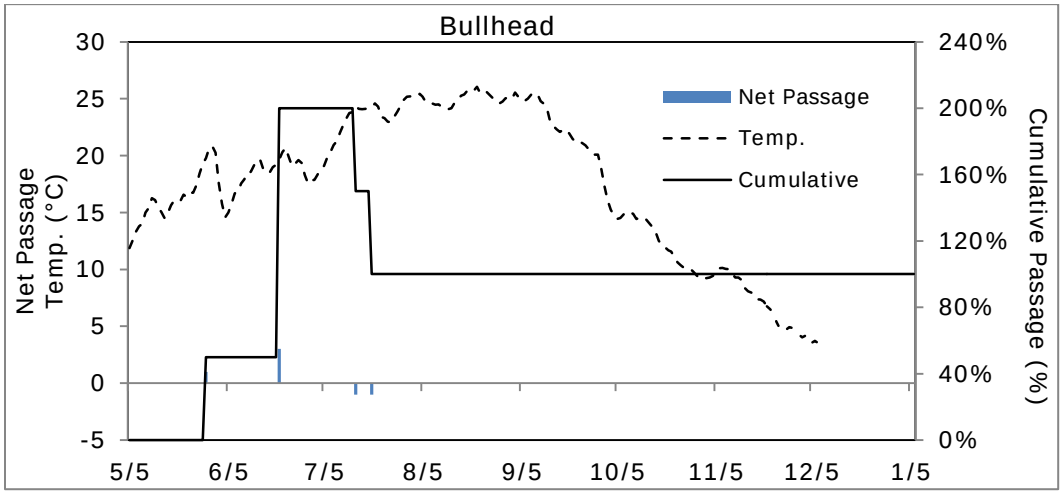

Figure 4.3-10. Vernon fish ladder: Bullhead (*Ameiurus* spp.) daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

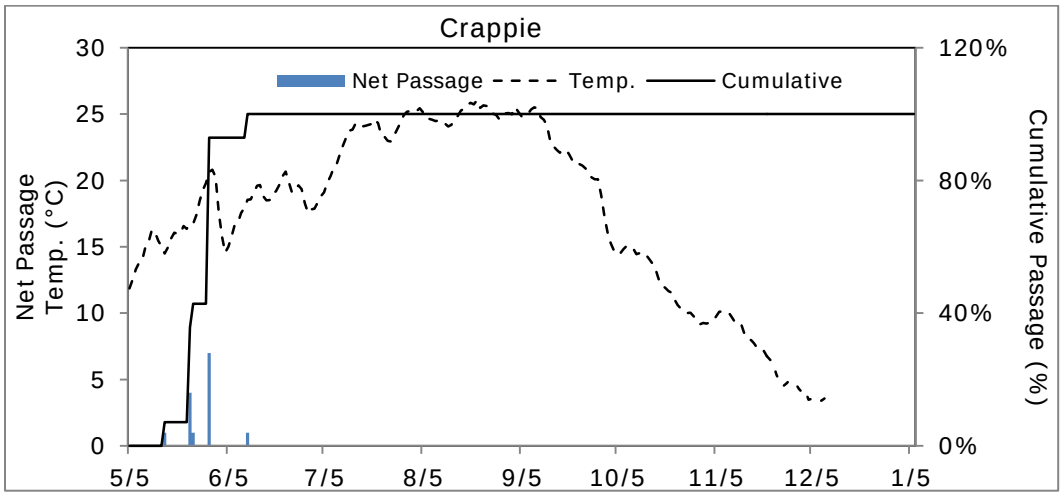

Figure 4.3-11. Vernon fish ladder: crappie (*Pomoxis* spp.) daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

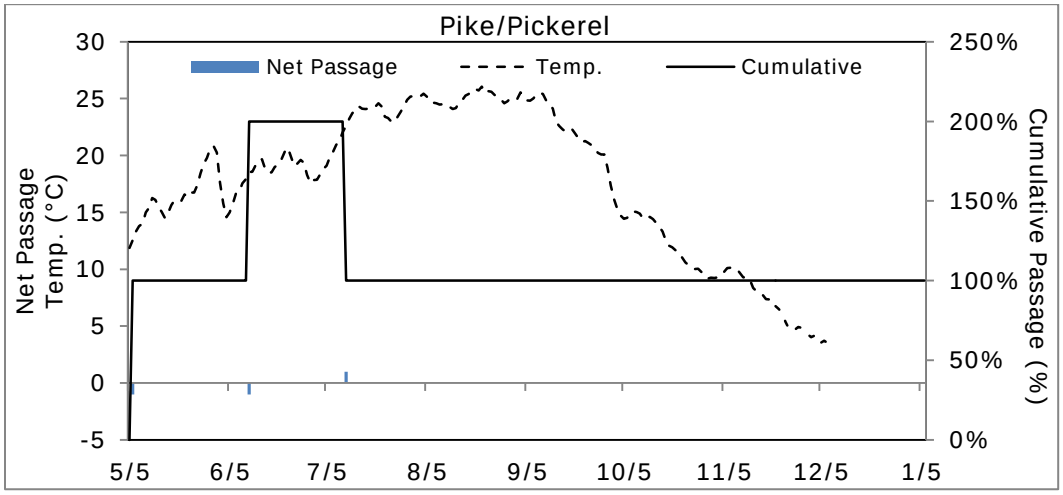

Figure 4.3-12. Vernon fish ladder: pike/pickerel (*Esox* spp.) daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

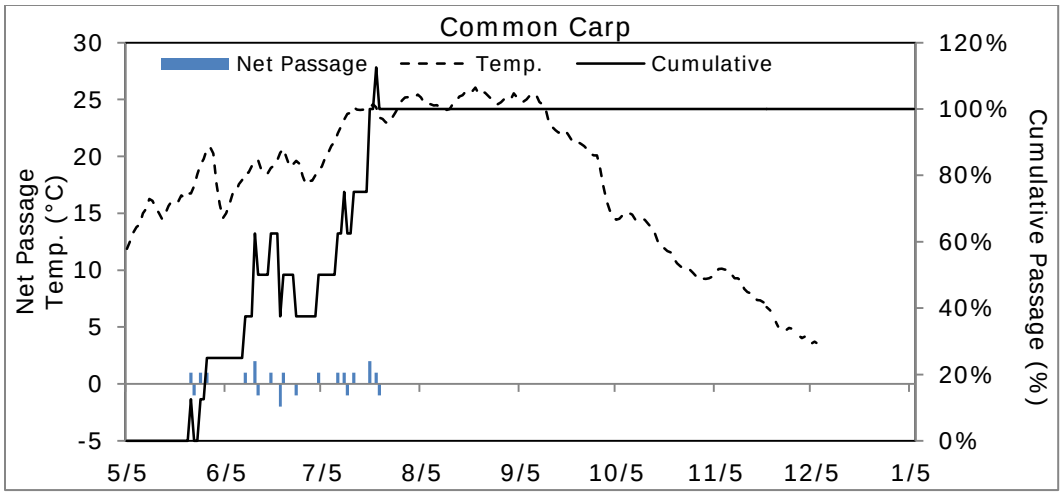

Figure 4.3-13. Vernon fish ladder: Common Carp daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

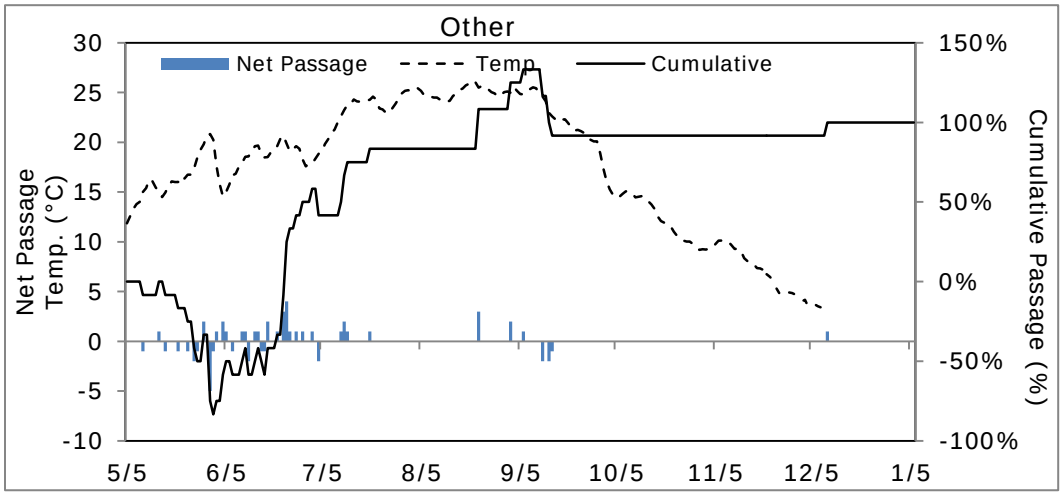

Figure 4.3-14. Vernon fish ladder: 'other' species daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

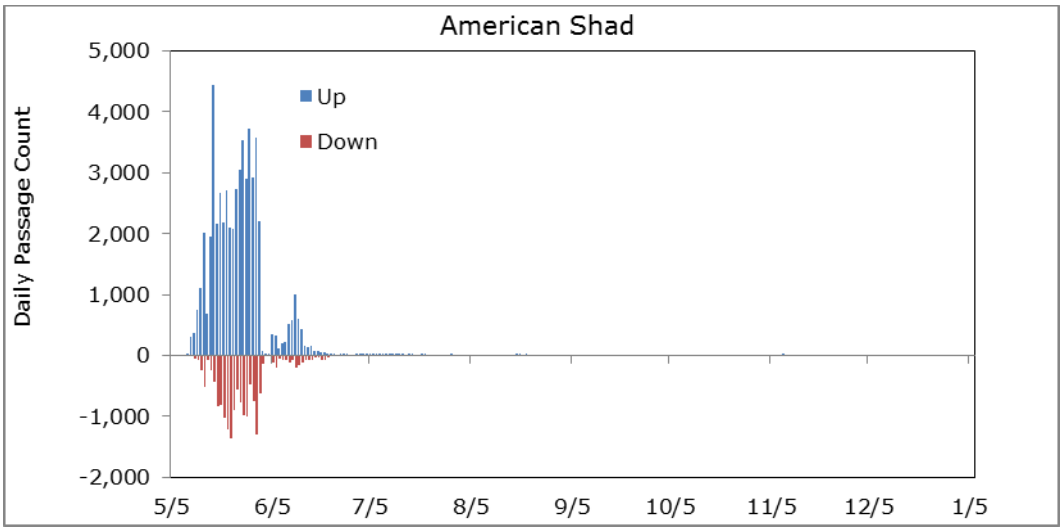

Figure 4.3-15. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for American Shad in the Vernon fish ladder.

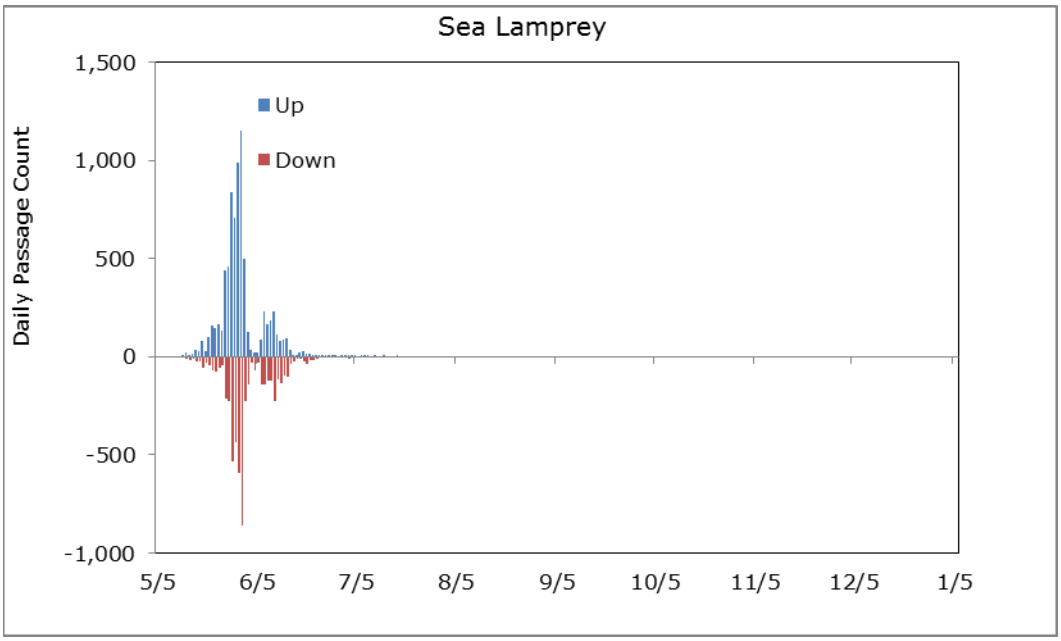

Figure 4.3-16. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for Sea Lamprey in the Vernon fish ladder.

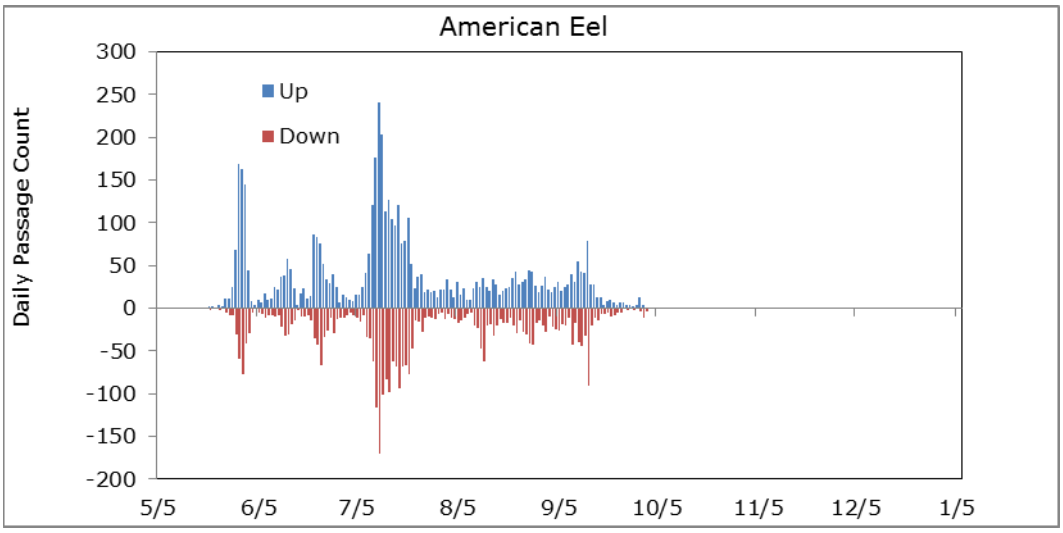

Figure 4.3-17. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for American Eel in the Vernon fish ladder.

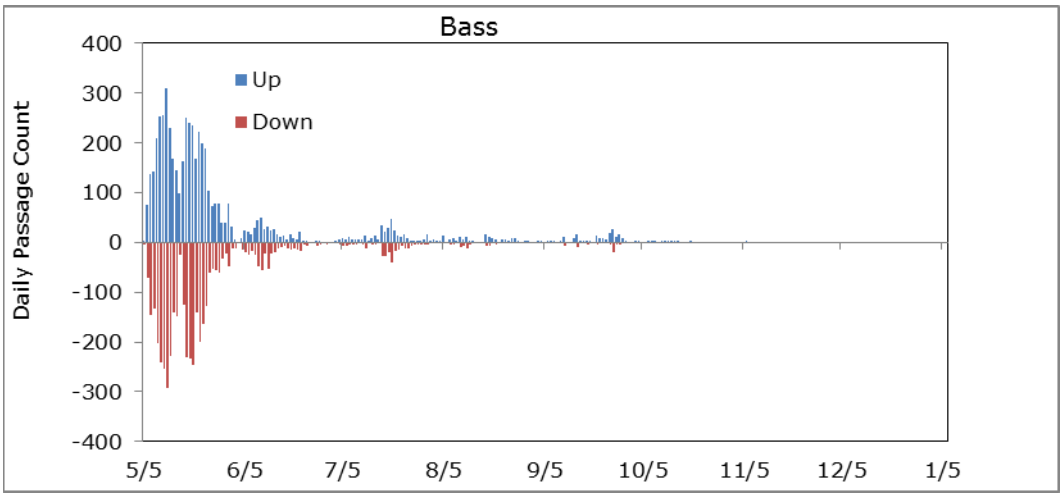

Figure 4.3-18. Daily total upstream (positive bars) and downstream (negative bars) movements recorded for bass in the Vernon fish ladder (see Appendix D for similar plots by species).

4.3.2 Seasonality

The first record of any species in the Vernon fish ladder was May 5, the first day of fish ladder operation, when bass, White Sucker, and Walleye were present and water temperature averaged 11.9°C. The dates of first and last occurrence, peak passage, and 80% cumulative net passage by species (the date that 80% of the cumulative seasonal total for the species had passed) with corresponding water temperatures are included in Table 4.3-2. Seasonality is presented graphically in Figures 4.3-1 – 4.3-13, and daily records are tabulated in Appendix D.

Peak upstream passage was determined for those species/genera with a total net passage of more than 20, which included American Shad, Sea Lamprey, American Eel, bass, White Sucker, Walleye, trout, and sunfish (Table 4.3-2). Only those species are discussed further in this section. Peak upstream passage was defined as those dates when the daily net passage of a species, except for American Eel, was greater than or equal to 10% of its 2015 total net passage. American Eel counts were distributed over the season, and, peak upstream passage was defined as 5% of the total net passage to more closely examine seasonal passage periodicity.

American Shad were recorded in the Vernon fish ladder from May 10 through August 22 with water temperature ranging from 15.0 to 26.0°C. After June 20 net passage counts indicated mostly downstream movements. Peak passage occurred on May 18 when water temperature was 15.6°C. On that date 10 percent of the total net shad passage occurred. The 80% cumulative passage occurred on May 30, when water temperature was 20.7°C.

Sea Lamprey were recorded from May 13 – July 18 with water temperature ranging from 16.1°C to 24.1°C. Peak upstream passage occurred on five consecutive days, May 28 – June 1 when water temperature ranged from 19.3°C to 20.8°C. Cumulatively, 80% passage occurred on May 31 when water temperature was 20.8°C.

American Eel were recorded from May 21 through December 16. The most concentrated activity occurred from late May through July. Peak upstream passage occurred on three days in spring and one day in summer, with water temperatures ranging from 23.0°C – 23.7°C. Cumulatively, 80% of the total upstream passage count was recorded on July 21 when water temperature was 24.6°C.

Bass were recorded from May 5 through November 6 with water temperatures ranging from 10.1°C - 25.9°C. Cumulatively, 80% of the total upstream passage count was recorded on August 20 when water temperature was 25.9°C. Bass were active in the fish ladder throughout the spring through early fall, but the most concentrated upstream passage occurred in the spring.

White Suckers were recorded from May 5 through October 31 with water temperatures ranging from 11.9°C to 13.3°C. Virtually all sucker activity was recorded in the spring, with peak passage on May 5 and May 7, and the 80% cumulative passage count recorded on May 7.

Walleye were recorded from May 5 through November 6, with most activity recorded in the early spring, and periodic occurrences through the rest of the

season. Peak passage occurred on May 5, May 9, and May 10 with water temperatures ranging from 11.9°C to 15.0°C. The 80% cumulative passage count was reached on June 10 when water temperature was 17.9°C.

Trout were recorded from May 12 through November 6, with most activity recorded in the early spring, and periodic occurrences through the rest of the season. Peak passage occurred on four days in spring, May 13, May 18, May 22, and May 30 with water temperatures ranging from 16.1°C to 20.7°C. The 80% cumulative passage count was reached on July 12 when water temperature was 23.2°C.

Sunfish were recorded from May 7 through October 22. Their movements were distributed throughout that period, and there were no specific peak passage days, as defined herein. The 80% cumulative passage count was reached on September 6 when water temperature was 24.8°C.

Table 4.3-2. Vernon fish ladder: date (2015) and water temperature of first and last observation, 80% cumulative net passage, and peak passage by species.

Species/Genera	Net Passage	First		Peak[a]		80%		Last	
		Date	Temp. (°C)	Date	Temp. (°C)	Date	Temp. (°C)	Date	Temp. (°C)
Atlantic Salmon	7	05/20	16.0	NA	NA	06/17	18.5	07/12	23.2
American Shad	39,196	05/10	15.0	05/18	15.6	05/30	20.7	08/22	26.0
Sea Lamprey	2,440	05/13	16.1	05/28 – 06/1	19.3 – 20.8	05/31	20.8	07/18	24.1
American Eel[b]	1,545	05/21	16.0	05/30-06/01, 07/13	20.3 – 20.8, 23.7	07/21	24.6	12/16	no data
Bass	761	05/05	11.9	05/16	14.5	08/20	25.9	11/06	10.1
White Sucker	322	05/05	11.9	05/05, 05/07	11.9, 13.3	05/07	13.3	10/31	9.2
Walleye	58	05/05	11.9	05/05, 05/09, 05/10	11.9, 14.0, 15.0	06/10	17.9	11/6	10.1
Trout	30	05/12	16.3	5/13, 5/18, 5/22, 5/30	16.1, 15.6, 16.6, 20.7	07/12	23.2	12/22	no data
Sunfish	1,188	05/07	13.3	none	NA	09/06	24.8	10/22	11.6
Bullhead	2	05/10	15.0	NA	NA	06/21	19.7	08/13	24.1
Crappie	14	05/16	14.5	NA	NA	05/30	20.7	06/11	18.5
Pike/Pickerel	-1	05/06	12.6	NA	NA	NA	NA	07/11	22.6
Yellow Perch	0	NA	NA	NA	NA	NA	NA	NA	NA
Carp	8	05/25	16.7	NA	NA	07/20	24.3	07/23	23.4
Other	13	05/10	15.0	NA	NA	07/20	23.3	12/10	no data

a. Peak passage (for species where total net passage>20) is defined here as daily net passage ≥10% of species total net passage.

b. Per the definition of peak passage, no dates represented peak for American Eel, though high proportions (>5%) of net passage occurred on the dates listed.

4.3.3 Diel Periodicity

The proportional use of the Vernon fish ladder by diel phase is included in Table 4.3-3. Daily periodicities of use of the Vernon fish ladder were plotted as the number of upstream and downstream movements and net passage by hour of day for each species observed (Figures 4.3-19 – 4.2-32). Long-standing operating procedures dictate that attraction flow (i.e., the volume supplied via the attraction water pumps of 200 cfs) is shut down overnight and operates generally from 7:00 a.m. to 7:00 p.m. during the normal anadromous passage season, although other supplemental flows (e.g., flow in the fish ladder itself, downstream fishway flows) operate at night. Therefore, diel periodicity of fish activity is likely affected by both species behavior and fishway operations. Considering all species, activity was distributed around-the-clock, but specific activity varied. Atlantic Salmon were recorded during daytime. American Shad were recorded primarily during daytime with minimal nighttime and crepuscular records. American Shad net passage occurred generally from 08:00 – 19:00 with the majority from 09:00-18:00. Sea Lamprey were recorded around-the-clock with a preponderance toward daytime. American Eel were recorded around-the-clock with a strong preponderance during nighttime hours. Bass were recorded around-the-clock with a strong preponderance during daytime and negligible nighttime and crepuscular observations. Walleye were recorded around-the-clock with a preponderance toward daytime. White Sucker were recorded primarily during daytime with few nighttime and negligible crepuscular observations. Trout were recorded primarily during daytime with few nighttime observations. Bullhead were recorded around-the-clock. Pike/pickerel were recorded during daytime. Sunfish were recorded primarily during daytime with afternoon peaks, and negligible nighttime and crepuscular observations. Common Carp were recorded during daytime, with minimal nighttime observations. Fish categorized as 'other' were recorded around-the-clock.

Table 4.3-3. Vernon fish ladder fish ladder percentage of total counts (upstream and downstream combined) by diel phase.

Species	Total Counts	Day	Night	Crepuscular
Atlantic Salmon	6	100%	0%	0%
American Shad	71,578	94%	2%	4%
Sea Lamprey	12,960	60%	35%	4%
American Eel	8,289	15%	80%	5%
Bass	9,879	98%	1%	1%
White Sucker	4,386	94%	4%	1%
Walleye	204	82%	15%	3%
Trout	150	97%	3%	0%
Sunfish	8,038	98%	1%	1%
Bullhead	14	43%	36%	21%
Crappie	14	100%	0%	0%
Pike/Pickerel	3	100%	0%	0%
Yellow Perch	0	NA	NA	NA
Carp	168	98%	2%	0%
Other	260	40%	49%	11%

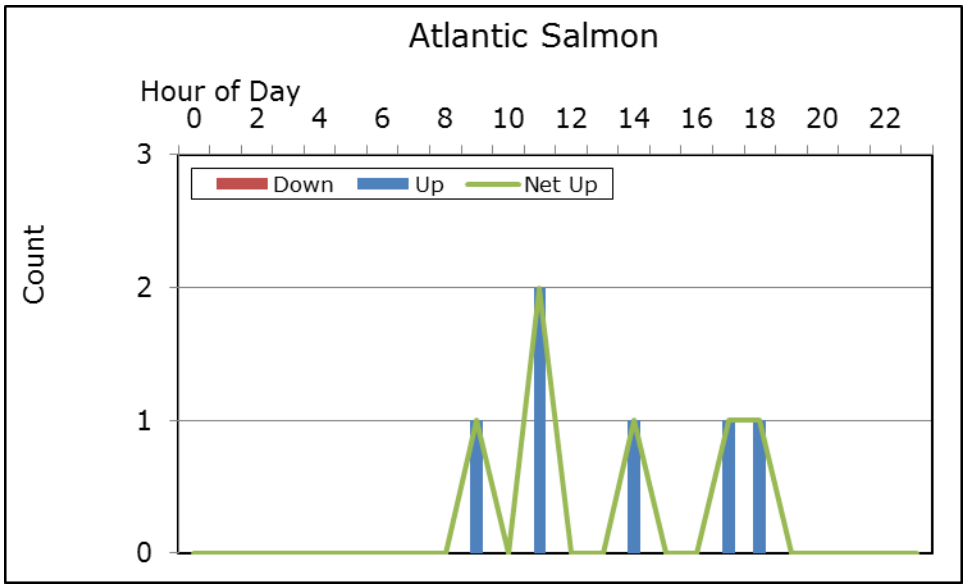

Figure 4.3-19. Vernon fish ladder, recordings of upstream and downstream movements with net passage of Atlantic Salmon.

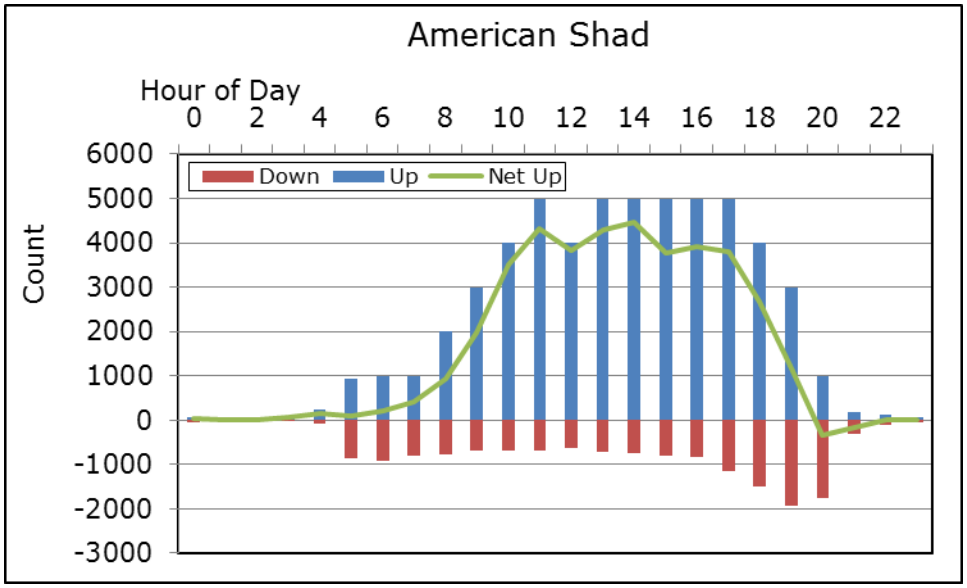

Figure 4.3-20. Vernon fish ladder, recordings of upstream and downstream movements with net passage of American Shad.

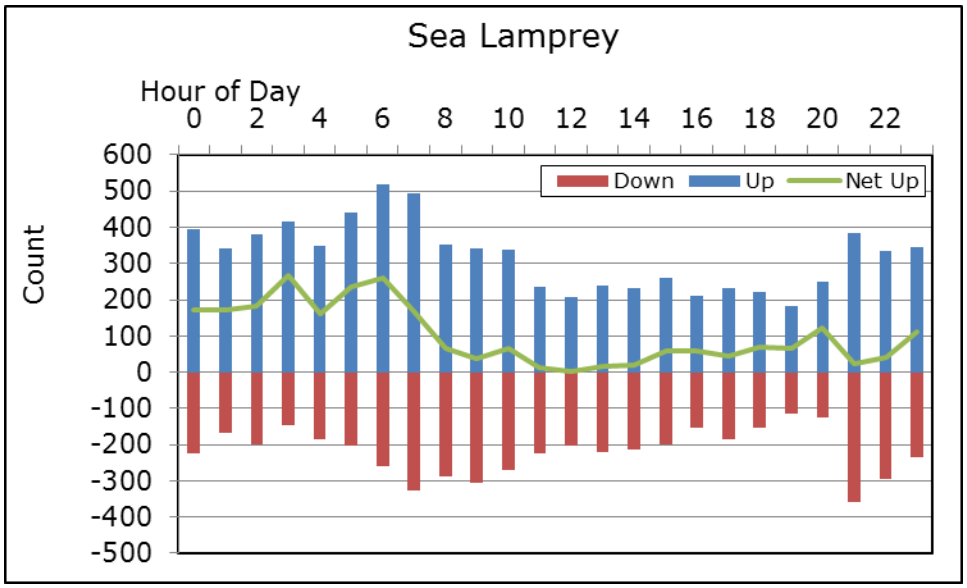

Figure 4.3-21. Vernon fish ladder, recordings of upstream and downstream movements with net passage of Sea Lamprey.

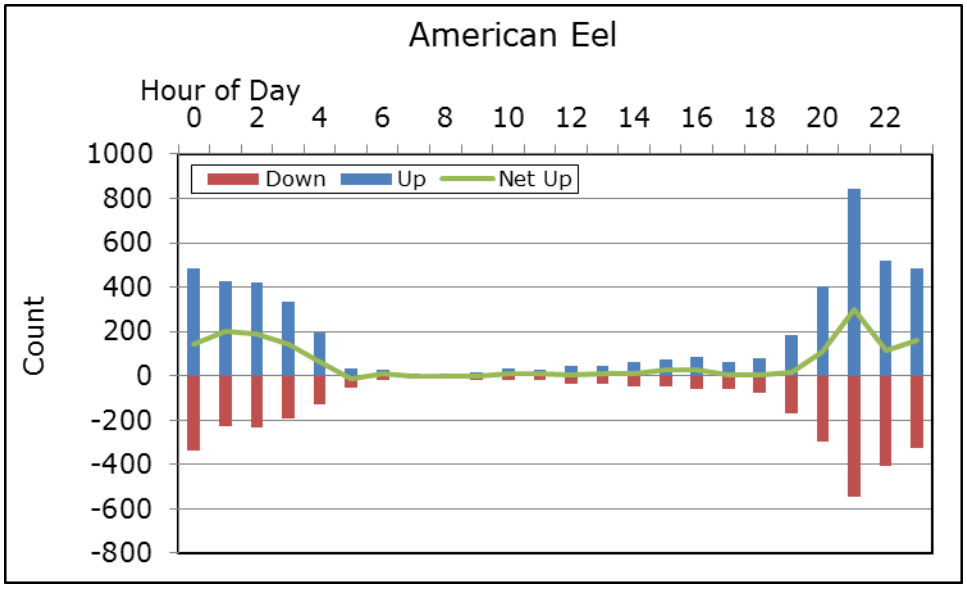

Figure 4.3-22. Vernon fish ladder, recordings of upstream and downstream movements with net passage of American Eel.

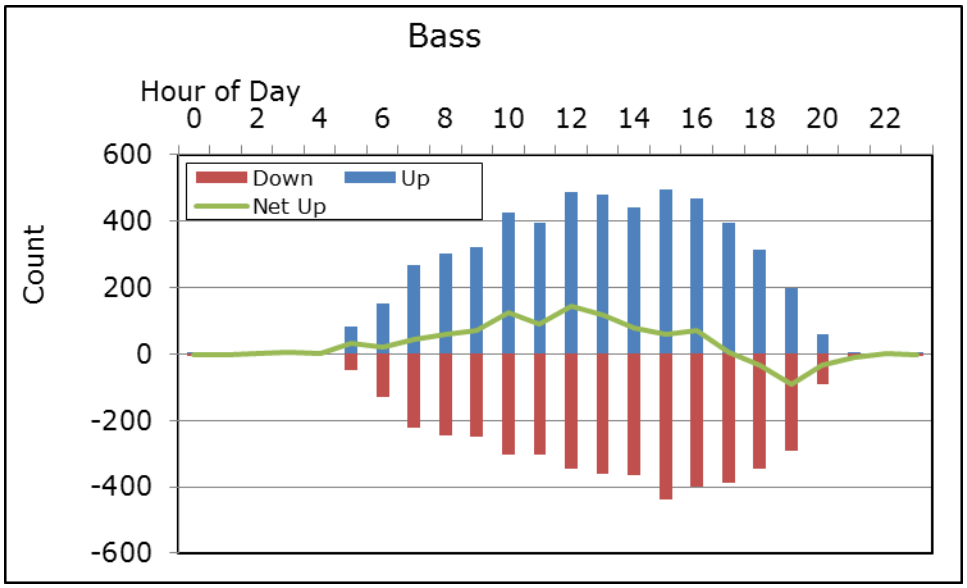

Figure 4.3-23. Vernon fish ladder, recordings of upstream and downstream movements with net passage of bass (*Micropterus* spp.)

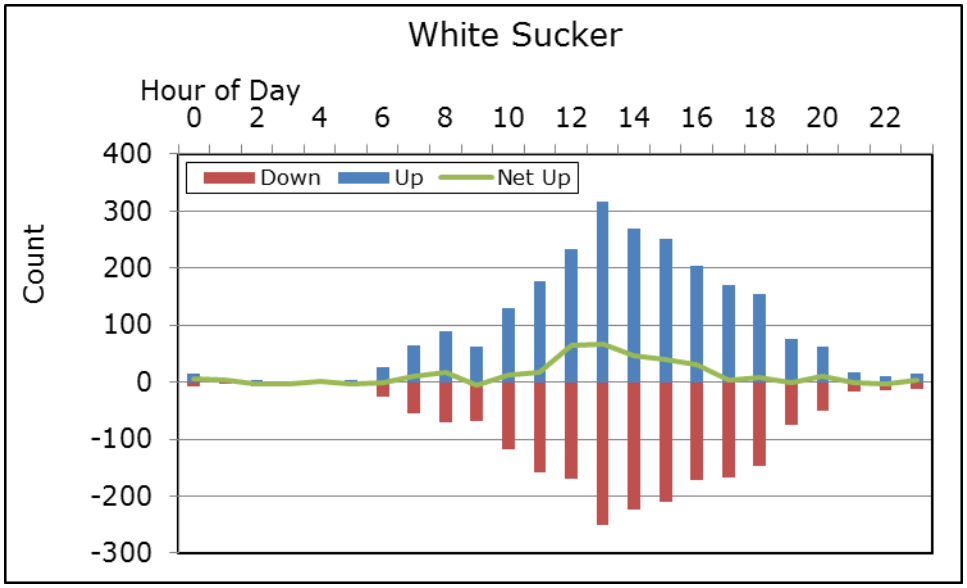

Figure 4.3-24. Vernon fish ladder, recordings of upstream and downstream movements with net passage of White Sucker.

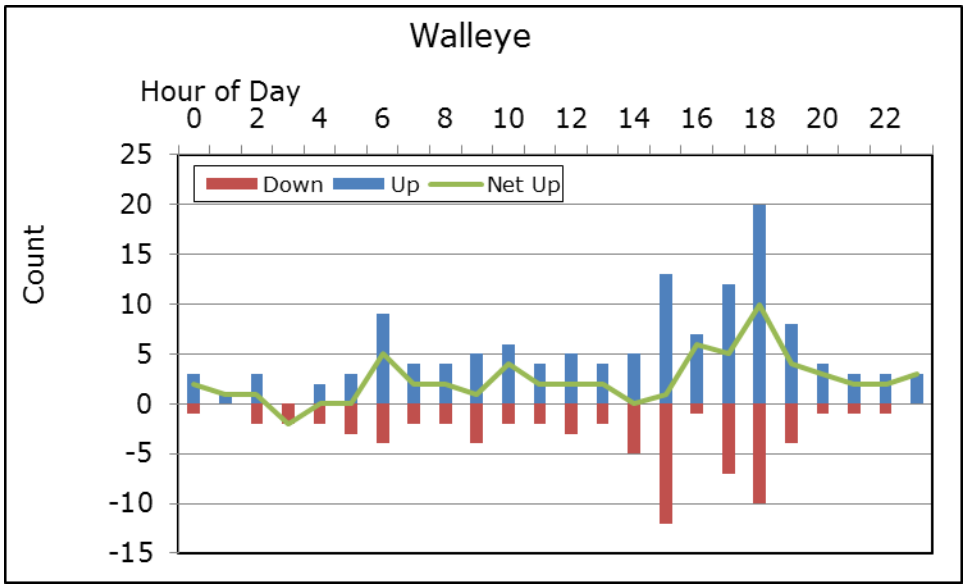

Figure 4.3-25. Vernon fish ladder, recordings of upstream and downstream movements with net passage of Walleye.

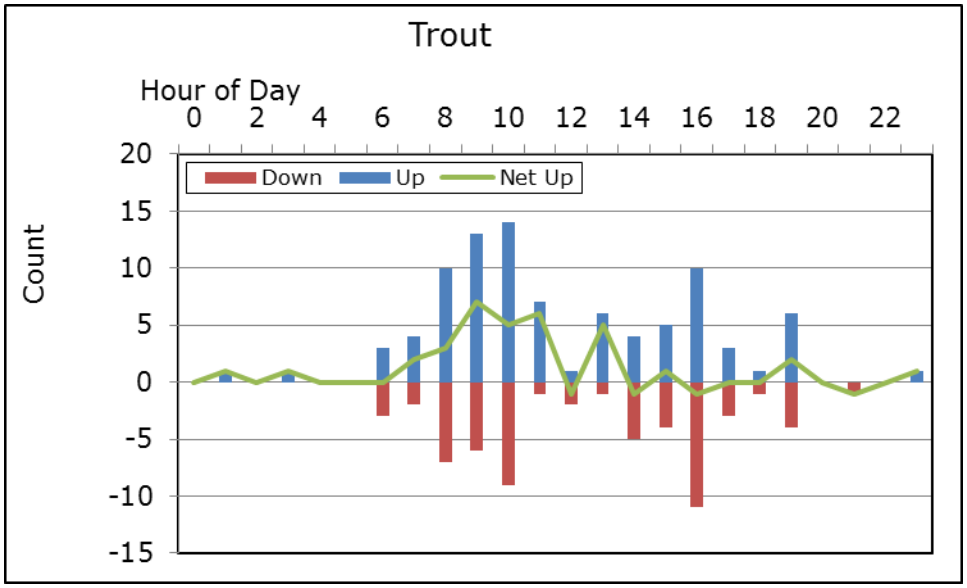

Figure 4.3-26. Vernon fish ladder, recordings of upstream and downstream movements with net passage of trout.

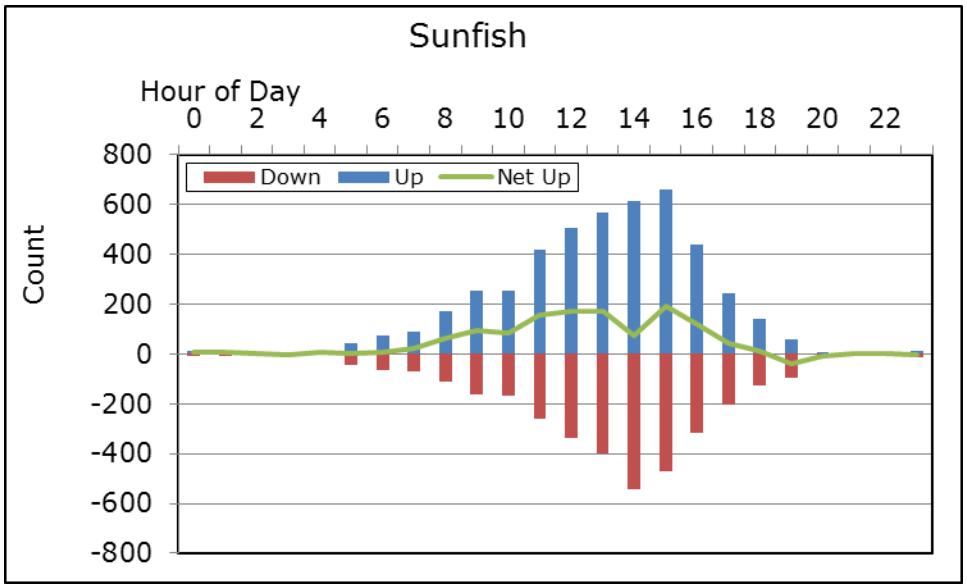

Figure 4.3-27. Vernon fish ladder, recordings of upstream and downstream movements with net passage of sunfish (*Lepomis* spp.)

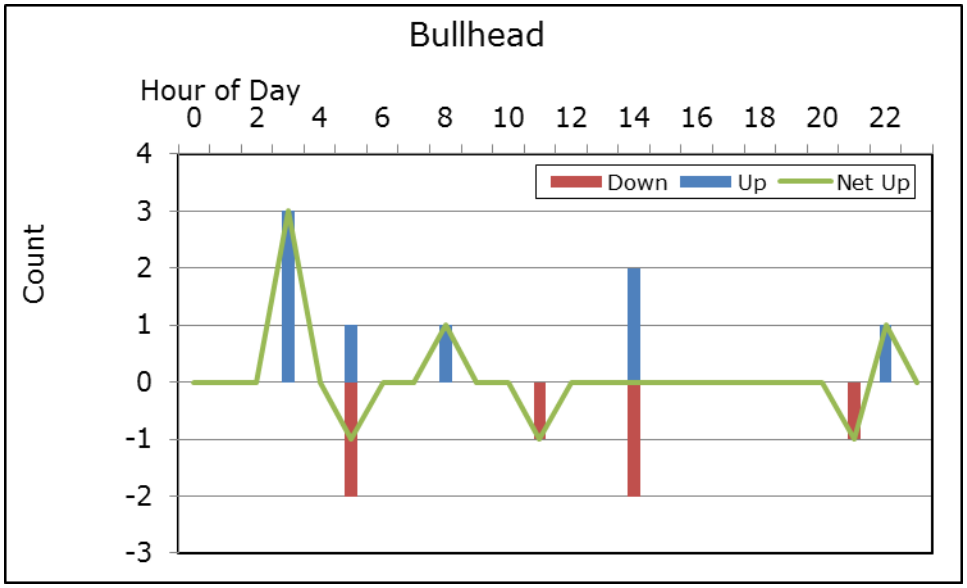

Figure 4.3-28. Vernon fish ladder, recordings of upstream and downstream movements with net passage of bullhead (*Ameiurus* spp.).

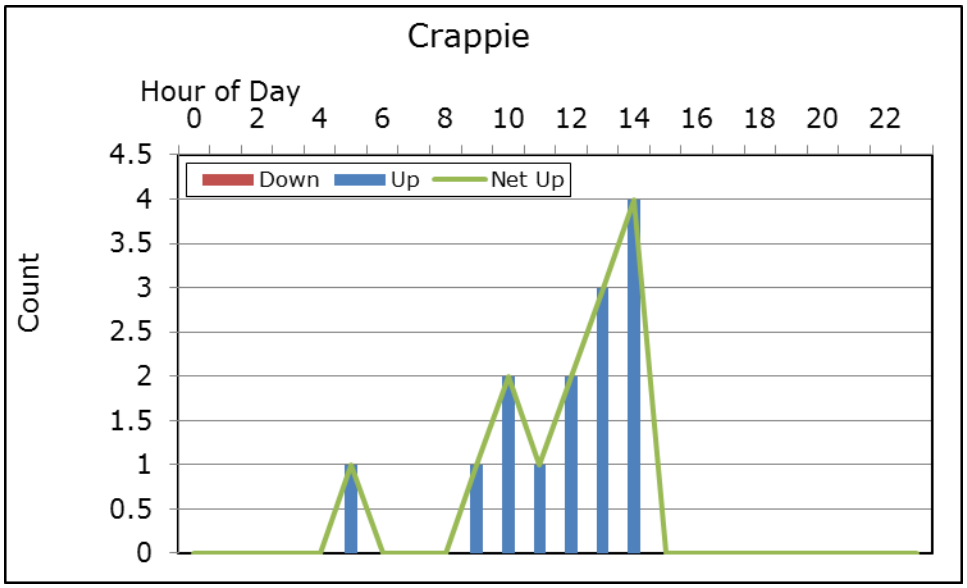

Figure 4.3-29. Vernon fish ladder, recordings of upstream and downstream movements with net passage of crappie (*Pomoxis* spp.).

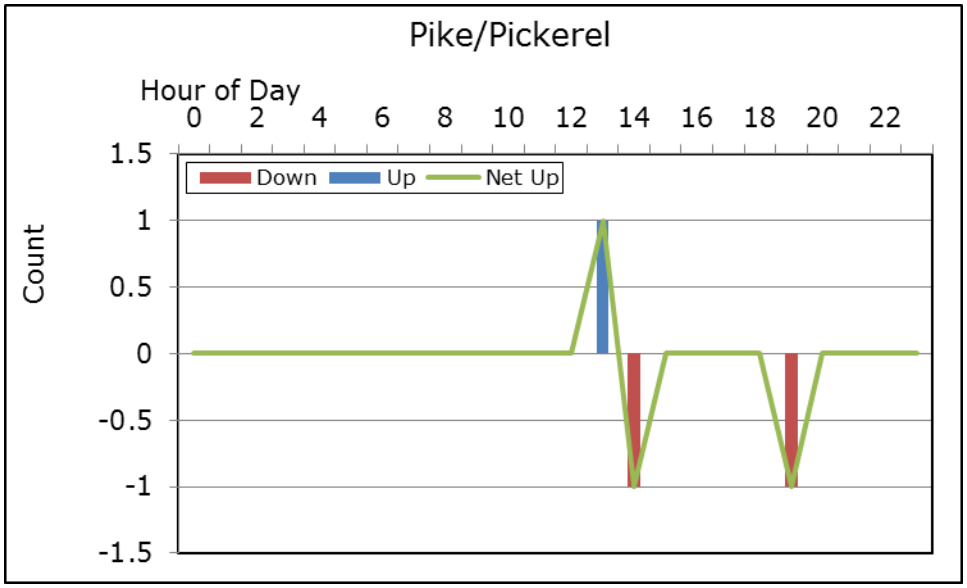

Figure 4.3-30. Vernon fish ladder, recordings of upstream and downstream movements with net passage of pike/pickerel (*Esox* spp.).

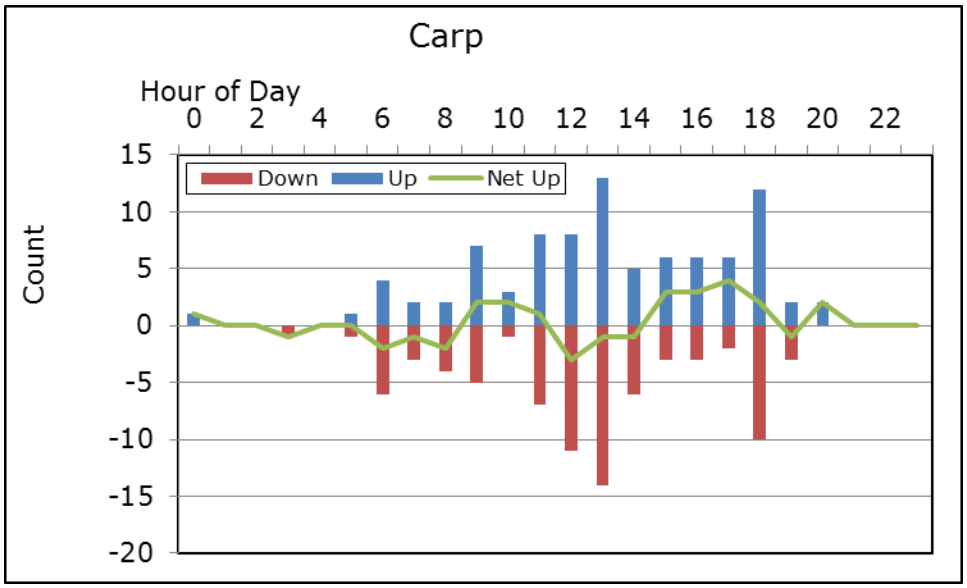

Figure 4.3-31. Vernon fish ladder, recordings of upstream and downstream movements with net passage of Common Carp.

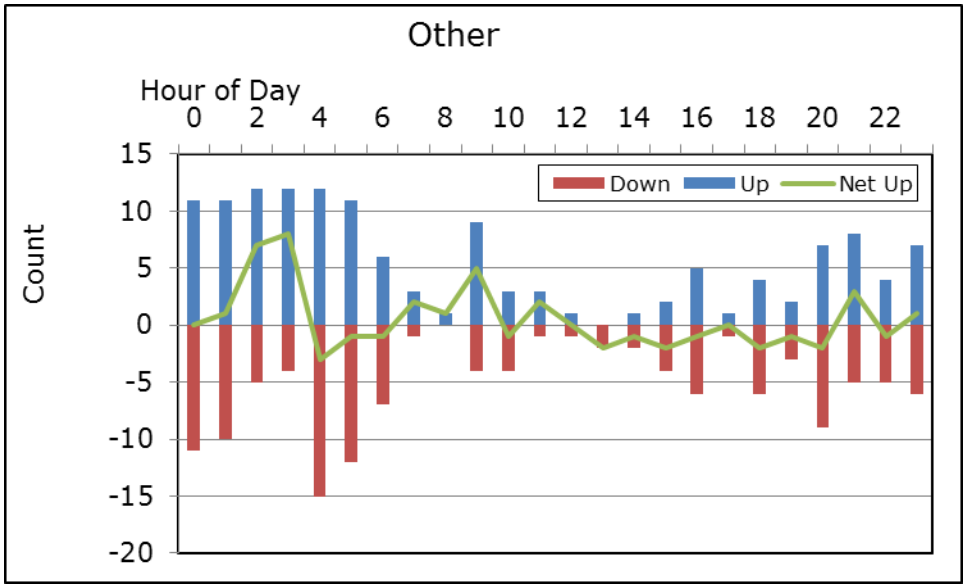

Figure 4.3-32. Vernon fish ladder, recordings of upstream and downstream movements with net passage of unidentified species.

4.3.4 Fish Passage and River Flows

Hourly river discharge partitioned to fish ladder, attraction water, hydroelectric operational discharge, downstream passage, and spilling flows (cfs) were tabulated with hourly net fish passage in Appendix E. Although an interactive effect of seasonality (water temperature) and discharge patterns is expected for spring migrants, particularly anadromous species, some patterns are noteworthy. Both American Shad and Sea Lamprey passage activity was most concentrated during a period of relatively low total river discharge following the end of the spring freshet. That may be due to seasonality, however in the case of Sea Lamprey, a reduced rate of passage occurred during a variety of subsequent discharge scenarios including spill. American Eel passage occurred mostly during low flow scenarios during summer with no evident relationship to peak flow events. Bass passage was distributed over a range of flow scenarios during spring and summer. White Sucker passage occurred only during the period in spring when freshet flows were receding. Walleye, trout, and sunfish passage was sporadic and distributed over a variety of flow scenarios from spring till early fall.

Throughout the 2015 season, the ratio of passage flow (fish ladder + attraction) to station flow (generation + downstream passage) averaged 5.9% and ranged from 0.4% to 100%. During normal seasonal fishway operations (April 15 – July 15), unit operating preference is generally given first to Unit 10 also located nearest to the fish ladder. In 2015, since the fish ladder operated throughout the open water season, Unit 10 operated nearly continuously.

4.4 Discussion

4.4.1 2015 Extended Season

Table 4.5-1 summarizes the findings of this study regarding observation of seasonality and daily periodicity of target species/genera passed upstream through the Wilder, Bellows Falls, and Vernon fish ladders during the 2015 season, which extended from spring 2015 into early January 2016. The unexpected extension of the season resulted from an uncharacteristically warm fall and early winter. Although water temperatures cooled seasonally, the potential for ice formation was exceptionally late. Although some of the summarized information is limited because too few fish passed to fully characterize temporal distribution, overall, target species use of the facilities encompassed wide ranges of seasonal and daily use.

Wilder

Upstream passage of all observed target species occurred in the period from May 12, 2015 through the shut-down date, January 7, 2016. During the winter period, only small numbers of trout were observed, whereas 80% of the seasonal total net passage of trout occurred in July. Bass were also observed through the end of fall (December 21), but similar to trout, 80% upstream passage had occurred in summer (June 26). Both trout and bass were noted to exhibit behavior that suggested extended periods spent in the ladder resulting in multiple records of the same fish moving in both directions. It is possible that many of the observations of those species reflected occupancy of fish ladder. Of all observed target species/genera except for American Eel, the 80% passage point was reached in spring or summer. The 80% passage point for American Eel occurred on September 30.

The results of an early September 2015 inspection of the Wilder fish ladder by FWS hydraulic engineer, Brett Towler, and a subsequent inspection by TransCanada indicated that debris had clogged some submerged orifices and subsequently altered water surface elevations in some ladder pools. This appears to have occurred during the period from August 25, 2016 when sluicing of a heavy debris load likely resulted in debris entrainment in the fish ladder, through September 23, 2016 when the ladder was dewatered for inspection and debris removal. This may have led to potential under- utilization of the ladder during that period. Appendix D documented passage at Wilder for eel, bass, walleye, trout, and sunfish during that period indicating that passage was not entirely restricted during that period.

Figure 4.4-1 includes the daily net passage count and daily cumulative passage (% of total) for all species combined. Cumulative net passage reached 80% for combined species by August 1. Since diadromous fish counts were relatively low at Wilder (N=55), the combined species count was primarily controlled by resident species. Figure 4.4-2 includes daily net and cumulative passage for diadromous species (Atlantic Salmon, Sea Lamprey, and American Eel). Cumulative net passage reached 80% on October 2, but because the passage counts for Atlantic Salmon (N=1) and Sea Lamprey (N=2) were very low, this was controlled by American Eel (N=52).

Figure 4.4-3 includes daily net and cumulative passage for resident species. Cumulative net passage reached 80% by July 30. This was controlled by majority species, primarily bass, walleye and trout. Note that the magnitude of daily net passage counts was generally low (i.e., <10). Also, note that interpretation of combined species plots for other than overall seasonality of passage activity should be done with caution. Specific migratory seasonality, periodicity, behavior, and relative abundance affect daily net passage counts and therefore the cumulative percent of total.

Diel periodicity of upstream passage observed at the Wilder fish ladder varied. Atlantic Salmon (1 observation) passed during daytime, Sea Lamprey were active at night, and American Eels were active around-the-clock, but with a majority of activity at night. Bass, White Sucker, trout, and sunfish were active during the day, while Walleye were active around-the-clock, but with crepuscular passage patterns.

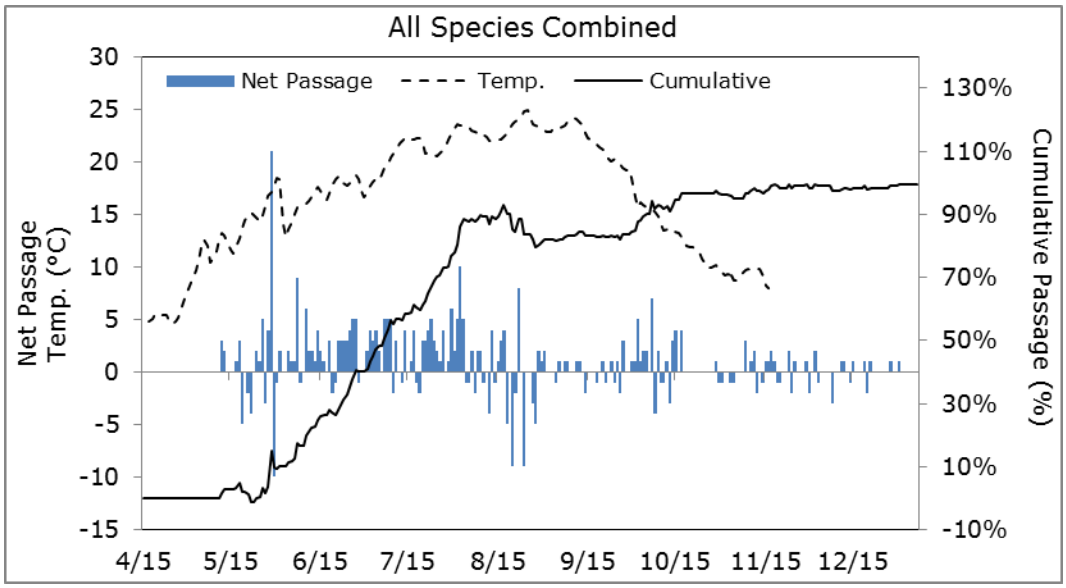

Figure 4.4-1. Wilder fish ladder, all species combined: net passage count and cumulative passage (as % of total) with water temperature (°C).

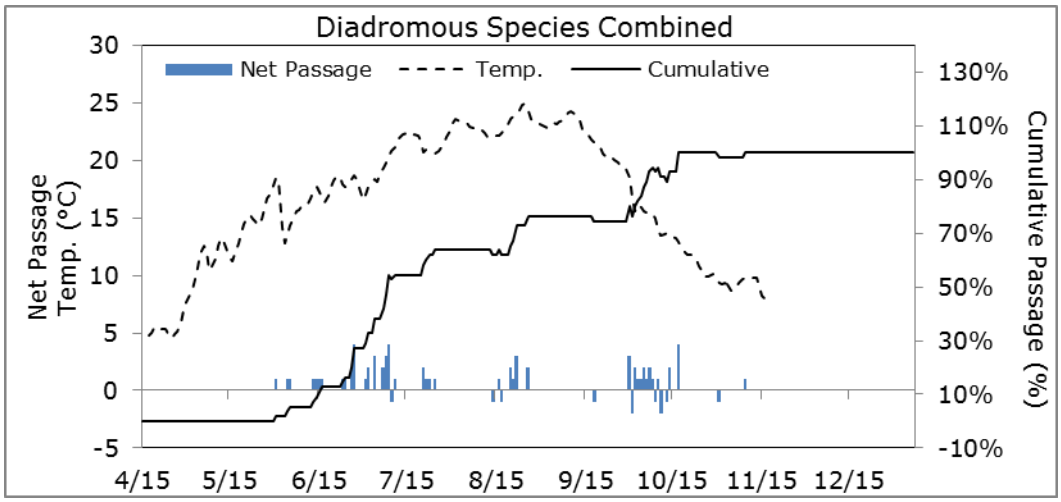

Figure 4.4-2. Wilder fish ladder, diadromous species combined: daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

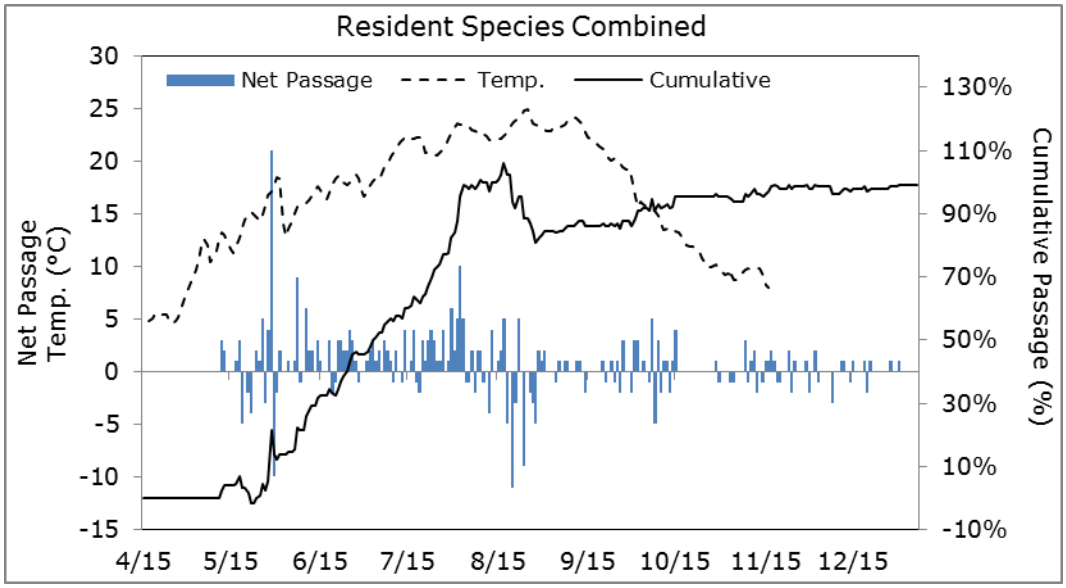

Figure 4.4-3. Wilder fish ladder, resident species combined: daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

Bellows Falls

Upstream passage of all observed target species occurred in the period from May 3 through November 3, 2015. Anadromous species were mostly passed in a brief period during the spring. While Sea Lamprey observations extended until early July, 80% of the seasonal total net passage had occurred by June 1. The last observation of American Eel occurred on November 1 however 80% passage had occurred on September 13. Resident species were temporally more protracted with 80% passage occurring in spring for bass and White Sucker, and in summer for trout and sunfish.

Bass, White Sucker, and trout exhibited behavior that suggested extended periods spent in the ladder resulting in multiple records of the same fish moving in both directions. It is possible that many of the observations of those species reflected occupancy of fish ladder.

Figure 4.4-4 includes the daily net passage count and daily cumulative passage (% of total) for all species combined. Cumulative net passage reached 80% for combined species by June 9. Figure 4.4-5 includes daily net and cumulative passage for diadromous species (Atlantic Salmon, American Shad, Sea Lamprey, and American Eel). Cumulative net passage reached 80% on June 2. Both the combined species and diadromous species counts were controlled by the dominant species, Sea Lamprey.

Figure 4.4-6 includes daily net and cumulative passage for resident species. Cumulative upstream passage reached 80% by May 25. This was controlled by majority species, primarily bass, which had a negative net passage count, indicating downstream migration. Note that the magnitude of daily net passage counts was generally low (i.e., <10). Also, note that interpretation of combined species plots for other than overall seasonality of passage activity should be done with caution. Specific migratory seasonality, periodicity, behavior, and relative abundance affect daily net passage counts and therefore cumulative percent of total.

Diel periodicity of upstream passage observed at the Bellows Falls fish ladder suggested mostly daytime activity of American Shad. American Eel and Sea Lamprey were observed around-the-clock. Sea Lamprey observations were distributed throughout the day, while the majority of American Eel observations occurred during nighttime hours. Resident species were mostly active during the day, except for Walleye which were active around-the-clock with a tendency toward crepuscular activity.

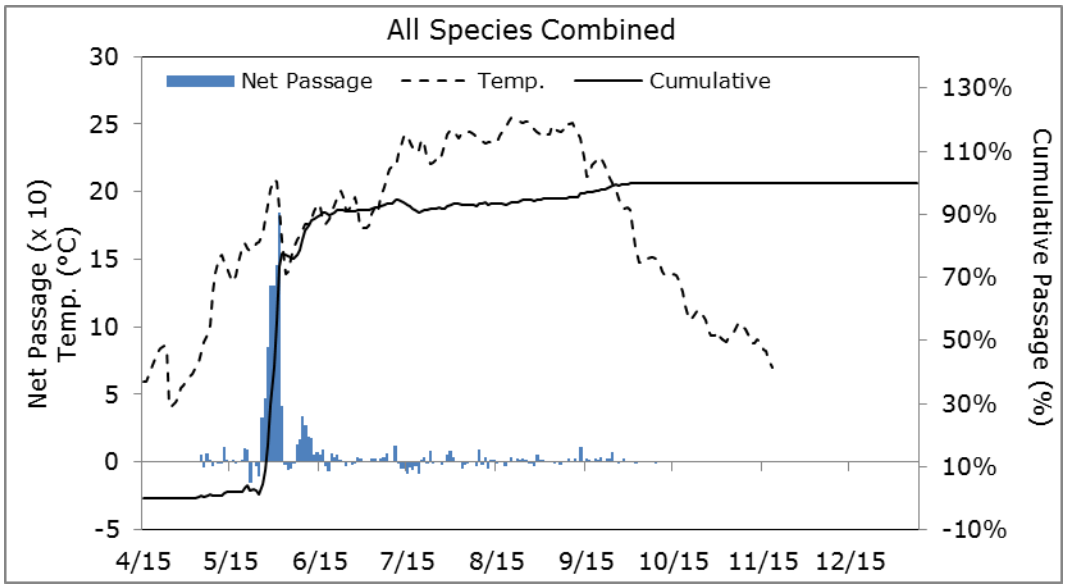

Figure 4.4-4. Bellows Falls fish ladder, all species combined: daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

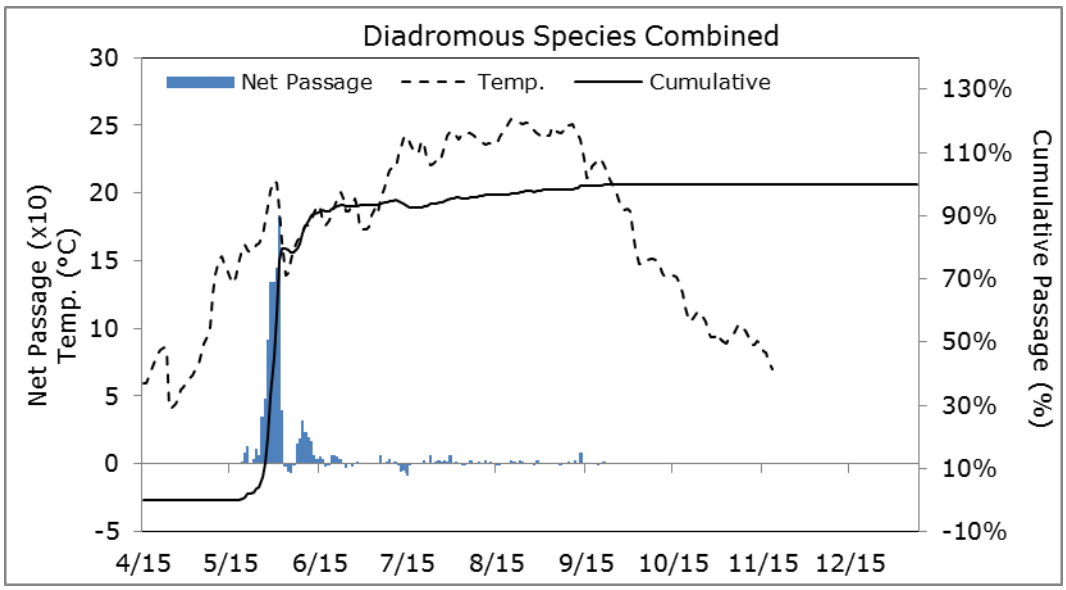

Figure 4.4-5. Bellows Falls fish ladder, diadromous species combined: daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

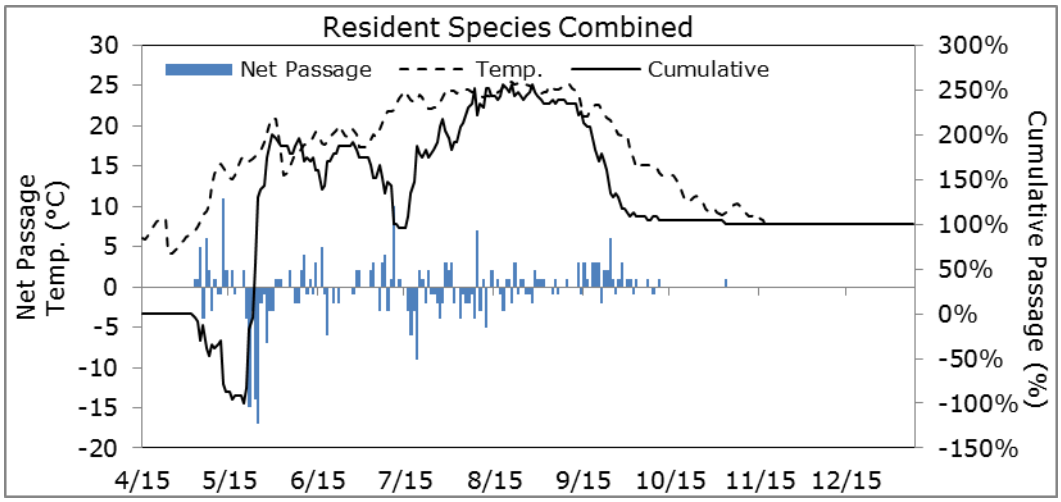

Figure 4.4-6. Bellows Falls fish ladder, resident species combined: daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

Vernon

Upstream passage of all observed target species occurred from the spring through fall period from May 5 through December 21, 2015. Since the Vernon fish ladder was opened on May 5 and three species, bass, Walleye, and White Sucker, were observed on that day, it is apparent that the beginning of the run was missed in monitoring. Water temperature at that time had warmed rapidly to a daily average of 11.9°C. Based on observations of first occurrence of those species in the Bellows Falls and Wilder fish ladders, first occurrence of White Sucker and Walleye may be expected when water temperatures reach approximately 7° and 13°C, respectively.

Anadromous species were mostly passed during spring with 80% passage of both American Shad and Sea Lamprey occurring by the end of May. Atlantic Salmon, however, were observed in the summer with the last occurrence on August 20, and 80% passage, albeit of a very small population, on July 12. American Eel were observed from mid-May through mid-December, but 80% passage occurred on July 21.

Upstream passage of resident species was, overall, temporally protracted with occurrence from May 5 through December 22. However, 80% passage points were reached in spring and early to mid-summer.

Figure 4.4-7 includes the daily net passage count and daily cumulative passage (% of total) for all species combined. Cumulative net passage reached 80% for combined species by May 31. Figure 4.4-8 includes daily net and cumulative passage for diadromous species (Atlantic Salmon, American Shad, Sea Lamprey, and American Eel). Cumulative upstream passage reached 80% on May 31. Both the combined species and diadromous species counts were controlled by the dominant species, American Shad.

Figure 4.4-9 includes daily net and cumulative passage for resident species. Cumulative net passage reached 80% by August 31. This was controlled by majority species, primarily sunfish and bass, which exhibited relatively protracted seasons. Also, note that interpretation of combined species plots for other than overall seasonality of passage activity should be done with caution. Specific migratory seasonality, periodicity, behavior, and relative abundance affect daily net passage counts and therefore cumulative percent of total.

Diel periodicity of upstream passage observed at the Vernon fish ladder suggested daytime activity for Atlantic Salmon and American Shad. As was noted for Bellows Falls and Wilder, American Eel and Sea Lamprey were observed around-the-clock. Sea Lamprey observations were distributed throughout the day, while the majority of American Eel observations occurred during nighttime hours. Radio telemetry assessment of Sea Lamprey (in Study 16) migrating through the Vernon fish ladder supported this conclusion. There, time of passage was distributed throughout the day.

Most resident species were active during the day (bass, White Sucker, trout, sunfish, crappie, pike/pickerel, and carp) while Walleye, bullhead, and ‘other’ were active around-the-clock. As observed for both Wilder and Bellows Falls, Walleye observations occurred around-the-clock. Bullhead observations were limited, but

occurred at varying hours of the day. Likewise, observations in the category 'other' (predominantly Channel Catfish) occurred around-the-clock.

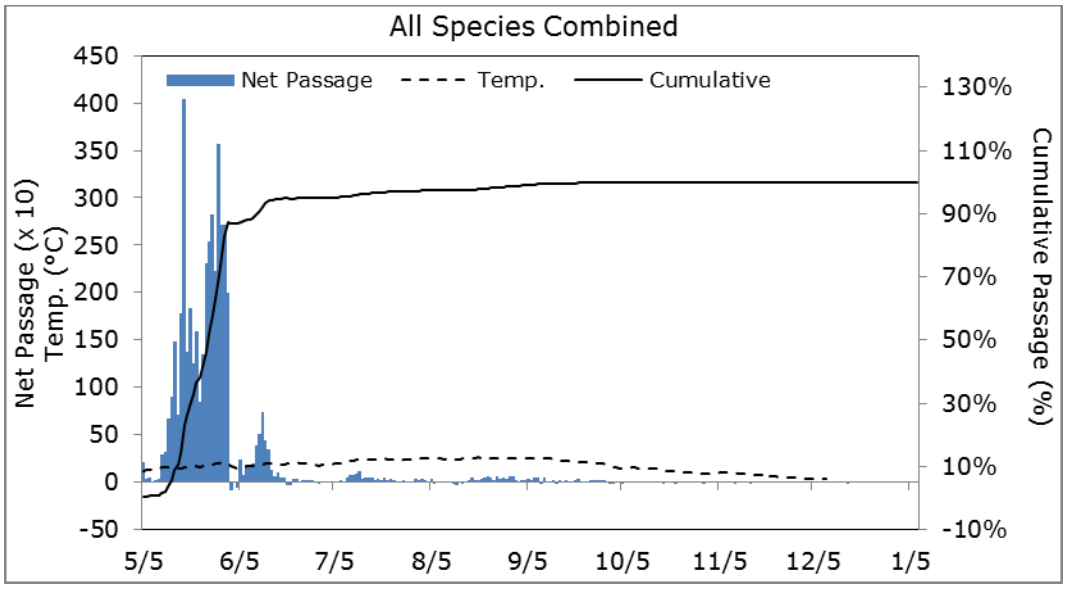

Figure 4.4-7. Vernon fish ladder, all species combined: daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

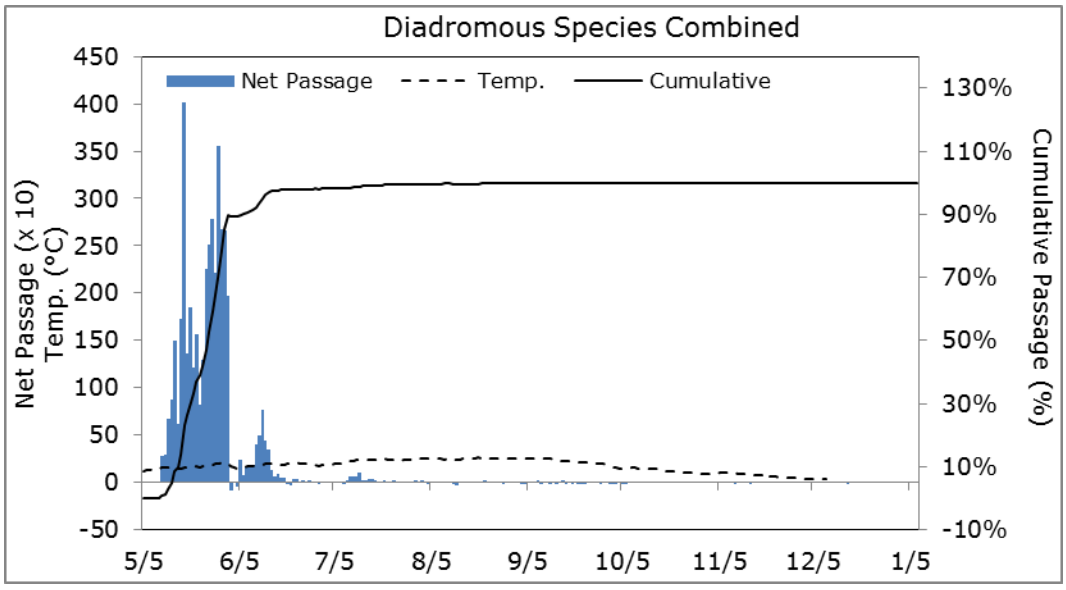

Figure 4.4-8. Vernon fish ladder, diadromous species combined: daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

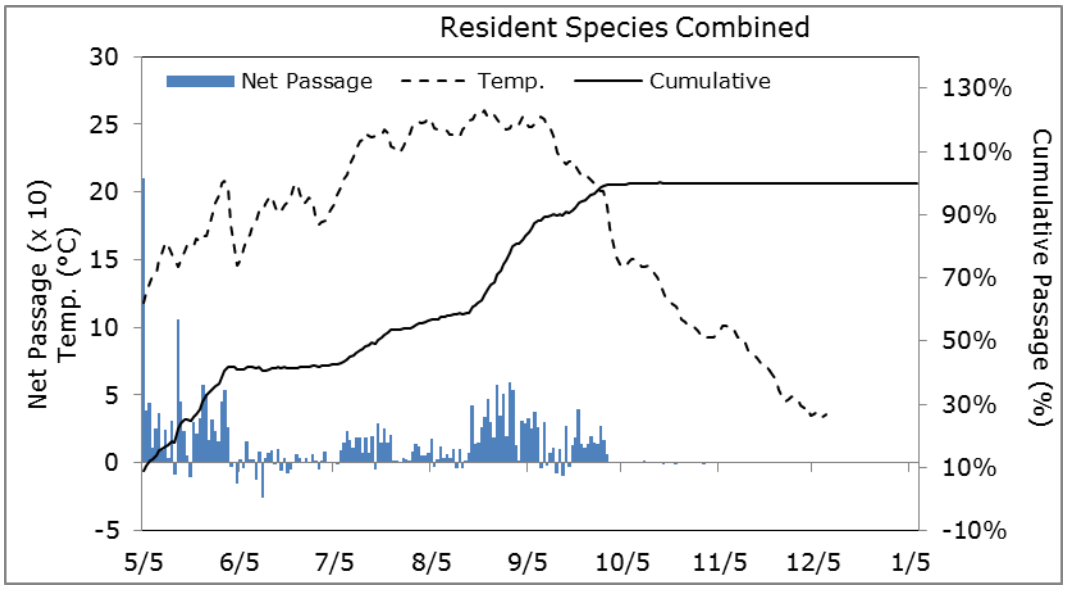

Figure 4.4-9. Vernon fish ladder, resident species combined: daily net passage count and cumulative passage (as % of annual total) with water temperature (°C).

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Table 4.5-1. Summary of seasonality and daily periodicity of upstream passage of fifteen target species/genera by the Wilder, Bellows Falls, and Vernon fish ladders, 2015.

	First Occurrence	Last occurrence	80% Passage	Seasonal Priority	Water Temperature, all observations (°C)			Diel Priority	Net Passage
					Low	High	Mean		
Wilder: Period of Operation: 04/17/15 – 01/07/2016; Maintenance Outage: 08/23/15									
Migratory Species									
Atlantic Salmon	10/05	10/05	NA	fall (1 observation)	15.6	15.6	15.6	day	1
American Shad	NA	NA	NA	NA	NA	NA	NA	NA	0
Sea Lamprey	05/30	06/02	06/02	spring	16.7	18.8	17.7	night, crepuscular	2
American Eel	06/02	11/09	09/30	spring through fall	9.2	24.7	16.9	24hr- (most active night)	52
Resident Species/Genera									
Bass	05/21	12/21	7/22	spring through fall	9.7	23.7	17.0	day	39
White Sucker	05/12	06/08	NA	spring	13.0	15.8	15.0	day	1
Walleye	05/12	10/16	08/02	spring-summer /early fall	12.9	24.2	17.3	24hr – crepuscular	21
Trout	05/16	01/07	07/30	spring – fall	8.1	25.1	20.2	day	74
Sunfish	05/21	09/15	08/25	spring-summer	15.3	25.0	22.7	day	-5
Bullhead	NA	NA	NA	NA	NA	NA	NA	NA	0
Crappie	NA	NA	NA	NA	NA	NA	NA	NA	0
Pike/Pickerel	NA	NA	NA	NA	NA	NA	NA	NA	0
Yellow Perch	NA	NA	NA	NA	NA	NA	NA	NA	0
Carp	NA	NA	NA	NA	NA	NA	NA	NA	0
Other	NA	NA	NA	NA	NA	NA	NA	NA	0
Bellows Falls: Period of Operation: 04/15/15 - 01/06/2016; Maintenance Outage: 12/08/15									
Migratory Species									
Atlantic Salmon	06/08	06/08	NA	spring	16.7	16.7	16.7	day	1[a]
American Shad	05/26	06/20	05/30	spring	14.0	21.2	19.6	day, crepuscular (limited night)	44
Sea Lamprey	05/19	07/07	06/01	spring-(limited in early summer)	13.6	21.2	17.8	24hr	970
American Eel	06/21	11/01	09/13	summer-fall	8.8	25.6	23.5	24hr (most active night)	60
Resident Species/Genera									
Bass	05/12	11/03	05/25	spring-fall	9.3	25.6	20.6	day	-47
White Sucker	05/03	05/26	05/05	spring	6.6	17.1	10.6	day	7
Walleye	05/10	09/18	NA	spring-fall (limited in summer)	12.9	25.5	19.4	24hr – crepuscular	2
Trout	05/20	09/21	07/08	spring-summer	15.0	25.5	22.8	day	8
Sunfish	05/29	09/18	08/29	spring-summer	18.3	25.4	23.2	day	7
Bullhead	NA	NA	NA	NA	NA	NA	NA	NA	0
Crappie	NA	NA	NA	NA	NA	NA	NA	NA	0
Pike/Pickerel	NA	NA	NA	NA	NA	NA	NA	NA	0
Yellow Perch	NA	NA	NA	NA	NA	NA	NA	NA	0
Carp	NA	NA	NA	NA	NA	NA	NA	NA	0
Other	NA	NA	NA	NA	NA	NA	NA	NA	0

	First Occurrence	Last occurrence	80% Passage	Seasonal Priority	Water Temperature, all observations (°C)			Diel Priority	Net Passage
					Low	High	Mean		
Vernon: Period of Operation: 05/05/15 - 01/06/2016; Maintenance Outage: 12/08/15									
Migratory Species									
Atlantic Salmon	05/20	08/20	07/12	spring-summer	16.5	26.0	19.6	day	6
American Shad	05/10	08/22	05/30	spring – (to early summer)	10.1	26.1	18.1	day	39,196
Sea Lamprey	05/13	07/18	05/31	spring-(to early summer)	14.2	24.0	17.8	24hr	2,440
American Eel	05/21	12/16	07/21	spring – summer (to early fall)	8.0	26.4	22.6	24hr (most active night)	1,545
Resident Species/Genera									
Bass	05/05	11/06	08/20	spring-summer	10.1	26.1	19.4	day	761
White Sucker	05/05	10/31	05/07	spring	9.3	23.6	14.7	day	322
Walleye	05/05	11/06	06/10	spring-early fall	10.1	24.8	15.8	24hr	58
Trout	05/12	12/22	07/12	spring-early fall	14.2	25.7	17.9	day	30
Sunfish	05/07	10/06	09/06	spring-summer	11.6	26.4	21.8	day	1,188
Bullhead	05/10	07/15	06/21	summer	15.4	24.3	20.6	24hr	2
Crappie	05/16	05/30	06/11	spring	14.5	20.7	17.4	day	14
Pike/Pickerel	05/06	07/11	NA	spring-early summer	13.0	23.2	18.3	day	-1
Yellow Perch	NA	NA	NA	NA	NA	NA	NA	NA	0
Carp	05/25	07/23	07/20	spring-summer	16.8	24.7	20.7	day	8
Other	05/10	12/10	05/31	spring-summer	14.5	25.5	19.1	24hr	12

a Recorded net passage of Atlantic Salmon was 0, but because the recorded count for the Wilder fish ladder was 1, it was also assumed to be 1 for the Bellows Falls fish ladder.

4.4.2 Comparison of Normal Operating Season to Extended Season

The study goals and objectives were to determine the use and temporal distribution of riverine fish passing upstream in the existing Wilder, Bellows Falls, and Vernon fish ladders during the open-water period, and to determine the appropriate operation period for these fish ladders to pass riverine and diadromous fish.

Wilder

The majority of net passage for all resident species, except trout, and for all resident species combined occurred during the fish ladder's normal operating season (from opening in spring through July 15). While most species exhibited passage during the spring over a range of river flow conditions, a concentrated period of passage of bass and Walleye occurred in the fall and appeared to be associated with a brief spike in total river discharge that resulted in spilling conditions. During much of the 2015 extended operating season, and particularly in the winter, relatively few counts were made of trout that may have spent extended periods in the ladder.

Table 4.5-2 summarizes total recorded movements and percent of resident net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. For the four resident species with net upstream passage, the percentage of net passage to total movements ranged from 5.1 to 13.9% during the normal operating season. For the three species with net upstream passage after July 15, net passage ranged from 2.0 to 3.8% of total movements. For the entire 2015 study season, net upstream passage ranged from 3.4 to 6.5% of total movements. For all resident species combined, the total net passage was 8.25 until July 15, 2.1% after that date, and 3.8% overall. While more total movements were recorded after July 15, the total net passage (n = 52) was low during that period and low overall (n = 130).

Table 4.5-3 summarizes total recorded movements and percent of diadromous net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. The most concentrated activity for American Eel (53.8% of total net passage) occurred from early June through July 15, the end of the normal fish ladder operating season. Peak net passage occurred on June 27 and July 9 with net passage of four eels on each occasion. A second period of concentrated activity occurred from late September through mid-October that resulted in 23 percent of the total net passage for the year. A one-day peak occurred on October 17 with net passage of four eels. More total movements were recorded after July 15 than before that date, but net passage during this period was 46.2% of total net passage for the year.

Table 4.5-2. Wilder fish ladder resident net passage by operating period, 2015.

Species / Genera	Ladder Opening–July 15			July 16–Ladder Closing			Total 2015 Study Period		
	Obser-vations	Net No. Passed[a]	% Net Passage	Obser-vations	Net No. Passed[a]	% Net Passage	Obser-vations	Net No. Passed[a]	% Net Passage
Bass	548	28	5.1	321	11	3.4	869	39	4.5
White Sucker	19	1	5.3	0	0	n/a	19	1	5.3
Walleye	111	13	11.7	210	8	3.8	321	21	6.5
Trout	267	37	13.9	1,887	37	2.0	2,154	74	3.4
Sunfish	3	-1	-33.3	48	-4	-8.3	51	-5	-9.8
Bullhead	No observations								
Crappie	No observations								
Pike/Pickerel	No observations								
Yellow Perch	No observations								
Carp	No observations								
Other	No observations								
Total	948	78	8.2	2,466	52	2.1	3,414	130	3.8

a. Negative values indicate net downstream passage.

Table 4.5-3. Wilder fish ladder percent of migratory net passage by operating period, 2015.

Species	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed
	First	Last	Obser-vations	Net No. Passed	First	Last	Obser-vations	Net No. Passed		
American Eel	June 2	July 13	66	28	July 20	Nov 9	288	24	Sep 30	52
Sea Lamprey	May 30	June 2	6	2	n/a	n/a	0	0	June 2	2
Atlantic Salmon	n/a	n/a	0	0	Oct 5	Oct 5	1	1	n/a	1
American Shad	No observations									
Total			72	30			289	25		55

Bellows Falls

There was very low fish ladder usage overall, and net passage for all resident species combined was negative (i.e., net downstream). The majority of net passage for all resident species, except sunfish, and for all resident species combined occurred during the fish ladder's normal operating season (from opening in spring through July 15). Bass passage was distributed over a range of flows including spill during spring and summer. White Sucker passage occurred only during the period in spring when freshet flows were receding. Walleye, trout, and sunfish passage was sporadic and distributed over a variety of flow scenarios from spring until early fall.

Table 4.5-4 summarizes total recorded movements and percent of resident net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. For the four resident species with net upstream passage, the percentage of net passage to total movements ranged from 5.6 to 17.2% during the normal operating season. For sunfish, which was the only species with net upstream passage after July 15, net passage was 15.8% of total movements. For the entire 2015 study season, net upstream passage ranged from 2.9 to 13.2%. For all resident species combined, total net passage was -2.2% up to July 15, -0.1% after that date, and -1.38 % overall (i.e., net overall downstream movement, influenced primarily by the greater proportion of bass movements).

Table 4.5-5 summarizes total recorded movements and percent of diadromous species net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. American Eels were recorded from June 21 through November 1, with a total net passage of 60. The most concentrated activity occurred from early July through mid-September. All passage was net downstream from the opening of the fish ladder through July 15 (n = -17). Peak upstream passage occurred on 12 days during the summer, and cumulatively, 80% of total net passage occurred by September 13. More total movements were recorded after July 15 than before that date and all net upstream passage occurred after July 15.

Sea Lamprey were recorded from May 19 through July 7 with a total net passage of 970, all during the normal fish ladder operating season. Peak upstream passage occurred from May 29 through June 1, and cumulatively, 80% of net passage occurred by June 1. American Shad were recorded with a net passage of 44 from May 26 through June 20; peak passage occurred from May 28 through May 30, and 80% cumulative passage occurred on May 30.

Table 4.5-3. Bellows Falls fish ladder resident net passage by operating period, 2015.

Species / Genera	Ladder Opening–July 15			July 16–Ladder Closing			Total 2015 Study Period		
	Obser-vations	Net No. Passed[a]	% Net Passage	Obser-vations	Net No. Passed[a]	% Net Passage	Obser-vations	Net No. Passed[a]	% Net Passage
Bass	787	-47	-6.0	474	0	0.0	1,261	-47	-3.7
White Sucker	91	7	7.7	0	0	n/a	91	7	7.7
Walleye	36	2	5.6	22	0	0.0	58	2	3.4
Trout	87	15	17.2	193	-7	-3.6	280	8	2.9
Sunfish	15	1	6.7	38	6	15.8	53	7	13.2%
Bullhead	No observations								
Crappie	No observations								
Pike/Pickerel	No observations								
Yellow Perch	No observations								
Carp	No observations								
Other	No observations								
Total	1,016	-22	-2.2	727	-1	-0.1	1,743	-23	-1.3

a. Negative values indicate net downstream passage.

Table 4.5-4. Bellows Falls fish ladder diadromous net passage by operating period, 2015.

Species	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed
	First	Last	Obser-vations	Net No. Passed[a]	First	Last	Obser-vations	Net No. Passed[a]		
American Eel	June 21	July 15	91	-17	July 16	Nov 1	339	77	Sep 13	60
Sea Lamprey	May 19	July 7	3,712	970	n/a	n/a	0	0	June 1	970
American Shad	May 26	June 20	130	44	n/a	n/a	0	0	May 30	44
Atlantic Salmon	June 8	June 8	2	1[b]	n/a	n/a	0	0	n/a	1[b]
Total			3,935	998			339	77		1,075

a. Negative values indicate net downstream passage.

Vernon

The majority of net passage for all resident species, except sunfish, and for all resident species combined occurred during the fish ladder's normal operating season (from opening in spring through July 15). Bass passage was distributed over a range of flows including spill during spring and summer. White Sucker passage occurred only during the period in spring when freshet flows were receding. Walleye, trout, and sunfish passage was sporadic and distributed over a variety of flow scenarios from spring until early fall.

Table 4.5-5 summarizes total recorded movements and percent of resident net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. For the nine resident species with net upstream passage, the percentage of net passage to total movements ranged from 3.86 to 27.3% (and 100% for crappie) during the normal operating season. For the six resident species with net upstream passage after July 15, the percentage of net passage to total movements ranged from 11.1 to 52.9%.

For the entire 2015 study season and the nine species with net upstream passage, the percent of net passage ranged from 4.69 to 28.4% (100% for crappie) of total movements. For all resident species combined, total net passage was 7.1% through July 15, 18.2% after that date, and 10.4% overall. The Vernon fish ladder usage had more resident species and substantially more total movements and net upstream passage than did the Wilder and Bellows Falls fish ladders. However, net upstream passage for resident species was negative, zero, or less than 10 individuals after July 15 for all species, except bass and sunfish. Sunfish had higher net passage after July 15 (n = 984) than earlier in the season (n = 204). Cumulative net passage for sunfish reached only 17 percent by July 15, but had reached 50% by August 26, and 80% by September 6. Approximately 31 percent of all bass recorded in 2015 (239 of 761) had net passage after July 15, but cumulative passage on that date was 69%, and had reached 80% by August 20.

White Sucker and Walleye were present upon opening of the Vernon fish ladder on May 5, 2015 and according to FWS in their study comments, White Sucker and Walleye runs may have been missed due to the late opening. In 2015, both species were recorded with net upstream passage upon fish ladder opening on May 5, 2015. By May 31, 2015, cumulative net passage was 79 percent for Walleye and 100 percent for White Sucker (100% cumulative passage had occurred on May 14).

TransCanada reviewed Salmonsoft recordings made by VANR from April 15 through May 31, 2016 to determine the level of ladder usage by White Sucker and Walleye. Note that conditions (e.g., flows, temperature) and the number of fish observed in fish ladders will vary from year to year, making comparisons between the numbers of fish observed during specific time frames in different years problematic. However, results of the 2016 evaluation show net upstream passage through May 31 of 7 Walleye and 148 White Sucker, compared to 2015 results through May 31 of 46 Walleye and 326 White Sucker with the later fish ladder opening that year. The first net passage in 2016 occurred on April 17 for Walleye and on April 16 for White Sucker, and 100% net passage occurred on May 17 and May 23, respectively. Overall, more net passage was recorded for both species during the shorter 2015 period from May 5 through May 31, 2016 than during the longer

period from April 15 through May 31, 2016 which suggests that earlier fish ladder opening for these species in spring is not warranted.

We note that Salmonsoft click history for the 2016 evaluation is not included in this revised study report. With the version of Salmonsoft used, an error can occur in the timing system that produces a timestamp for each detection. In the settings within the video capture side of the software, the user chooses how Salmonsoft will record the video. The setting from which the timing problem arises is the "frames captured per second". Regardless of what the user places in this field, the software will film at 30 frames per second. VANR protocol suggests setting the frames captured per second to 15, and another setting called "frames to capture for each recorded frame" set to 3. This ratio will give the user an ending output of video that is 5 frames per second. Unfortunately, because there is a software malfunction associated with these settings, if a value other than 30 is selected for the "frames captured per second" setting, the software will be unable to provide accurate timestamps for each detection. The clock which dictates these values will accelerate throughout the day because it is attempting to count time based on 30 frames per second. If the user wishes to have an output of 5 frames per second, and have correct timestamps in the "click history" files, then 30 must be selected for the "frames captured per second", and 6 must be selected for "frames to capture for each recorded frame". Unfortunately because the problem occurs in a completely erratic manner due to the randomness of the fish detections, a correction factor is not an option to salvage time stamps that have already been collected under the wrong settings. However, because the count files are separated by file name, the total counts are unaffected. The software successfully starts a new file right at midnight even when this problem is happening. For the 2015 study, Salmonsoft settings were such that this error did not occur.

Table 4.5-6 summarizes total recorded movements and percent of diadromous species net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. American Eels were recorded from May 21 through December 16. Net passage was 1,545 with about 70% of cumulative net passage occurring during the normal fish ladder operating season through July 15, and 80% cumulative net passage by July 21. The most concentrated activity occurred from late May through July. Peak upstream passage occurred on three days in spring and one day in summer. Sea Lamprey were recorded from May 13 through July 18 with a total net passage of 2,440, which peaked on May 28 and June 1. Cumulatively, 80% of the total net passage count was recorded on May 31. American Shad were the dominant migratory species counted in the Vernon fish ladder with an historical record of net passage (n = 39,196) from May 10 through August 22. After June 20, net passage counts indicated mostly downstream movements and after July 15, all net passage was downstream. Peak upstream passage occurred on May 18 when 10% of the total net passage occurred. The 80% cumulative passage occurred on May 30.

Table 4.5-5. Vernon fish ladder resident net passage by operating period, 2015.

Species / Genera	Ladder Opening-July 15			July 16-Ladder Closing			Total 2015 Study Period		
	Obser-vations	Net No. Passed[a]	% Net Passage	Obser-vations	Net No. Passed[a]	% Net Passage	Obser-vations	Net No. Passed[a]	% Net Passage
Bass	8,954	522	5.8	925	239	25.8	9,879	761	7.7
White Sucker	4,381	325	7.4	5	-3	-60.0	4,386	322	7.3
Walleye	187	49	26.2	17	9	52.9	204	58	28.4
Trout	138	24	17.4	12	6	50.0	150	30	20.0
Sunfish	2,244	204	9.1	5,794	984	17.0	8,038	1,188	14.8
Bullhead	11	3	27.3	3	-1	-33.3	14	2	14.3
Crappie	14	14	100.0	0	0	n/a	14	14	100.0
Pike/Pickerel	3	-1	-33.3	0	0	n/a	3	-1	-33.3
Yellow Perch	No observations								
Carp	160	6	3.8	8	2	25.0	168	8	4.8
Other	233	9	3.9	27	3	11.1	260	12	4.6
Total	16,325	1,155	7.1	6,791	1,239	18.2	23,116	2,394	10.4

a. Negative values indicate net downstream passage.

Table 4.5-6. Vernon fish ladder percent of migratory net passage by operating period, 2015.

Species	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed
	First	Last	Obser-vations	Net No. Passed	First	Last	Obser-vations	Net No. Passed[a]		
American Eel	May 21	July 15	4,180	1,088	July 16	Dec 16	4,109	457	July 21	1,545
Sea Lamprey	May 13	July 14	12,959	2,439	July 18	July 18	1	1	May 31	2,440
American Shad	May 10	July15	71,541	39,203	July 17	Nov 9	37	-7	May 30	39,196
Atlantic Salmon	May 20	July 12	6	6	n/a	n/a	0	0	June 17	6
Total			88,686	42,736			4,147	451		43,184

a. Negative values indicate net downstream passage

4.5 Post-Season Fish Ladder Inspection Results

Post operation fish ladder inspections were conducted at each project after fish ladder closure in January 2016, and a mid-year inspection was conducted at the Wilder project on September 23, 2015. Inspections consisted of walking the length of the ladder in the dry, and documenting: 1) structural damage such as worn wood plates in the Vernon fish ladder pool and weir section, and 2) recording the presence or absence of debris, type of debris (e.g., large tree branch or limb, leaves, twigs, or man-made debris such as buckets), and the potential for observed debris to block an orifice, weir gate, or otherwise alter normal operation.

The mid-year assessment of the Wilder fish ladder was conducted after a site visit by FWS hydraulic engineer Brett Towler on September 4, 2015. An observed inconsistency in water height over a number of weirs suggested some weir orifices might be blocked, causing water to pool higher than designed. The fish ladder was subsequently shut down, an inspection conducted, debris removed (maintenance personnel enter the fish ladder to remove debris), and the fish ladder put back into operation. The inspection found three areas where debris load likely altered normal operation. These were the same suspect areas identified during the FWS site visit. These problem areas were not identified during the previous week's routine inspection. Discussion with the working foreman revealed that a heavy debris load in the forebay was passed through the trash/ice sluice (next to the fish ladder exit) just a few days before the FWS site visit. Is very probable some of the sluiced debris entered the fish ladder and caused the problems identified. The Wilder fish ladder operated normally outside of this time frame (September 4 – 23).

Post operation inspections of the three ladders were conducted on February 4, 2016 (Wilder), January 27, 2016 (Bellows Falls) and February 1, 2016 (Vernon). Some debris was found in each of the ladders but not enough in any one area of a ladder to cause problems. No weir orifices were blocked, and no structural damage was observed.

5.0 STUDY CONCLUSIONS

This study documented low fish ladder usage and low net passage in 2015 by resident species at Wilder and Bellows Falls. Based on current operational protocols, there is little compelling evidence to suggest that fish ladder operations for upstream passage of resident species, outside of the existing diadromous species passage season is necessary for the Bellows Falls and Wilder fish ladders.

Similarly for diadromous species, total net passage at Wilder was negligible. American Eel did pass in small numbers after July 15 but as indicated in this study and in Study 18, there is no compelling reason to extend the fish ladder operating season for this species. At Bellows Falls, net passage was negligible for Atlantic Salmon and American Shad with higher numbers for Sea Lamprey. All three species used the fish ladder exclusively during the normal operating season. American Eel only had net upstream passage after the normal operating season but numbers were low overall and given the very small number of eels observed in Study 18, there is no compelling reason to extend the operating season for this species.

The Vernon fish ladder passed higher numbers of three resident species primarily during the spring and early summer period although for some species passage continued in small numbers through the fall. Nonetheless, the seasonality of passage for most resident species at Vernon suggests that extension of the passage season beyond the existing anadromous species passage window is not warranted. The 2016 supplemental data for Walleye and White Sucker also support this conclusion.

For diadromous species at Vernon after July 15, American Shad had only net downstream passage and a single Sea Lamprey passed. No Atlantic Salmon passed after that date.

The American Eel passage window is somewhat of an exception to this, as eel passage was distributed over the spring and summer of 2015; however, 80% cumulative passage occurred by July 21. Results from Study 18 in 2015 and 2016 showed few observations of eels attempting upstream passage at Vernon (80 and 70, respectively). Study 18 concluded that that the Vernon fish ladder provided the primary attraction point for eels at Vernon in 2015, and it is likely that fish ladder flows were much higher than required for eel passage, as evidenced by the majority of eel passage occurrence during nighttime when attraction pump water was not provided. On September 23, 2016, after the normal fish ladder operation season, a single eel used the temporary eel trap pass specially designed for eels.

As part of its relicensing studies, FirstLight[5] implemented a study of upstream passage of American Eels at the Turners Falls Project in 2014 in which nearly 6,000 juvenile eels were collected and subsequently released upstream of Turners Falls dam. Although it is unknown how many eels pass the Turners Falls Project undetected, the low abundance observed at Vernon suggests that incidental passage is not substantial. Therefore, the influence that the experimental passage of eels in 2014 (without subsequent experimental passage in 2015 and 2016) may have had on observations of eels at Vernon in 2015 and 2016 is also unknown.

[5] Kleinschmidt and Gomez and Sullivan. 2016. Relicensing Study 3.3.4, Evaluate Upstream Passage of American Eel at the Turners Falls Project. Prepared for FirstLight GDF Suez. February 2016.

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APPENDIX A

VANR Fish Ladder Protocol (as revised for 2015 studies)

Appendix A: VANR Fishway Protocol (as revised for 2015 studies)

Salmonsoft Installation:

Follow on-screen instructions and reference the user manual. An access code will need to be entered in order to fully operate Salmonsoft.

Equipment List:

- A computer with the following minimum requirements: a Pentium 1.0 GHz processor, a minimum 128 MB of RAM and Windows XP
    - Xvid MPEG-4 Codec video compression software
- A tripod for mounting the camera
- Aposonic A-CDBIV07 2.8~12mm CCTV Weather-Proof WDR Camera with built in infrared LED illumination
- Dazzle Video Capture USB v1.0 Video Converter
- APC UPS battery backup
- External hard drive 64GB or larger.
- 1 USB Flash Drive for each Fishway
- Extension cords
- Power strip
- Zip ties
- Electrical tape

Equipment Setup:

The computer should be the first item set up since everything relies on it. Plug in all power cables, keyboard and mouse cables. The power cable to the computer should be plugged into the UPS battery backup. Make sure the UPS battery is connected. This consists of removing the front panel and checking that the two grey connectors are connected. They should be unplugged when stored for a period of time.

Next, attach the video camera to the tripod. The tripod should be set up at a distance away from the window as to where the camera can capture the entire window. It takes some adjusting to get the camera into focus.

The video cable should be connected to the video camera and then connected to the Dazzle video converter. The Dazzle video converter should then be connected to the computer.

A folder should be created on the computer's hard drive with the year and name of the ladder where it is located. This folder will be used to save the video files as they are recorded.

Salmonsoft FishCap Settings:

After FishCap is opened up on the computer, the settings should be adjusted accordingly by clicking on the "Change Parameters" link on the right. The settings should be as follows:

Video Capture Tab

Capture Driver	Dazzle Video Capture USB Video Device
Capture Resolution	High
Frames Captured Per Second	30

Detection Tab

Detection Algorithm	Motion Trigger
Detection Parameters	
Motion Threshold	5
Automatic Masking	On
Automatic Mask Threshold	2
Automatic Mask Frequency	75
Pixel Threshold	5
Smallest Object	30
LoRes Detection	On

Date/Time Stamp Tab

Imprint Date/Time Stamp on Video	On
Imprint Conspicuously w/ Black Background	On

TempTrax Tab NOT USED

Detection Filters Tab

Frames to Capture for Each Recorded Frame	3
Frames Recorded Contain Fish Frames Only	On
Frames Recorded Before Detection Event	5
Frames Recorded After Detection Event	5

Output Tab

Video Compression	Xvid MPEG-4 Codec
Output Format	
Location	
Output Filename	MMM DD HH-Unique
Output Drive/Directory	
Primary	C:\Data
Secondary	
Tertiary	
Minimum Free Space Before Toggling Drives	1000Mb
Start New Output File Every	24 hours
Duplicate Output File to Removable Media	K:\

Once the parameters have been correctly changed, Salmonsoft is ready to start recording. At the main interface below the video screen, click on the red circle to start recording.

Downloading Videos

The setup should be checked once per week per dam to download video and ensure that there are no issues with the software or the equipment. For redundancy, a flash drive dedicated to each ladder and an external hard drive should be used to download the video files from the computer's hard drive in order to review the files back at the office.

Plug the ladder's dedicated flash drive into one of the open usb ports. The computer should recognize the device. Open up "My Computer," local disk C:\, and navigate to the location on the computer where the videos are saved. Copy and paste the pertinent video files from the computer to the flash drive. Once the files have been transferred over, the flash drive can safely be removed by clicking on the usb icon in the bottom right. Make sure to eject the correct drive. Repeat using the external hard drive, making sure to paste the video files into a folder that corresponds to the appropriate ladder.

Reviewing video files

Video files should be reviewed as soon as possible to be able to have the most up-to-date count estimates. Before reviewing the first video, FishRev will need to be set up. Along the bottom of the interface, there will be a horizontal line with a number of different species. These will need to be changed to correspond with the species found in the Connecticut River. This is done by clicking the "Change Parameters" tab on the right. This will open a new window where the species can be selected. Next, make sure the "Use Excel to tally species" box is checked as well as "Autosave worksheet." The template file should be "none." The day should start at "0" and it should be a 24 hour segment.

On the right side, there are five different tabs. The AVI Controls allows the user to change which keys control the video play. These can be set up for user preference. The next tab is IMPORTANT. Make sure the "Record user clicks" box is check. It should be saved under the C:\ drive. A folder will need to be created under the C:\ drive for it to save there. Name the folder "Data" or "Salmon Clicks." Click history records the exact date and time a fish is tallied swimming up or down. The bottom tab does not need to be changed.

After the parameters have properly been changed, videos can start to be reviewed. On the first time reviewing video for each dam, a new workbook or Excel spreadsheet will need to be opened. Click on "Workbook" and then "New." Next, open up the first video file by clicking on the "AVI" tab and navigating to the correct video file. After the first video is reviewed, save the workbook and open up a new AVI file to continue reviewing footage. The same excel file can be used throughout the season for the same ladder. Each ladder will have its own excel file. However, if more than one computer is used to review video files, FishRev needs to be set up EXACTLY the same or it will not save to the same Excel spreadsheet. If video recording carries over into a new calendar year, Salmonsoft cannot save the counts and click histories in the previous years' workbook. A new workbook must be created to properly review those videos.


Panasonic
Panasonic

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APPENDIX B

TransCanada Fish Ladder Operating and Inspection Procedures

TOP Contact: Joseph Avery

1.0 PURPOSE

The purpose of this Task Package is to describe the preparation of fishways in the spring and securing the fishways after the seasonal operation in complete in the fall.

2.0 SCOPE

This Task Package applies to all U.S. NE Hydro power assets which are wholly owned and operated by TransCanada where TransCanada has operational control with fishways and their associated equipment, including but not limited to visitor and viewing centres, attraction equipment, sluiceways, fish elevators, counting houses, fish pipes and ladders.

3.0 FREQUENCY(S)

The Standard Frequencies for performing the inspections included in this Task Package are defined within the Instrument Air Integrity Plan.

- Spring Inspection: M12
- Fall Maintenance: M12

Note: Intervals may be adjusted based on nonstandard local requirements by following the PM Task Change and Maintenance Suspension Procedure and upon receiving proper approval.

Note: Fishway operational dates are determined by the individual Facilities' FERC licenses. The applicable State Agency where the FERC license was granted has the authority to work with the Facilities Operations Personnel to adjust the opening and closing dates based on fish migration patterns and sampling.

4.0 WORK INSTRUCTION

Notes:

1. Each Activity should be performed after reviewing the appropriate CS&E TOPs (Procedures).

Qualification Requirement(s): Appropriate skills and experience are essential to performing this task correctly.

References:

- OEM Maintenance Service Manual(s)
- CS&E and all other TOP documents can be accessed from the TOPs database using this link TOPs.
  Note: TOP documents referenced in this document will have their titles underlined and can be opened up by using the hyperlink below or going to the TOPs database using the above TOPs link.
- PM Task Change and Maintenance Suspension Procedure (EDMS No. 004122195)
- Instrument Air Integrity Plan (EDMS No. 003765861)

4.1 Spring Maintenance (Opening of Fishways)

1. Clear all debris from ladder.
2. Check for possible silt build up at the discharge of ladder.
3. Check all stairs walkways and railing for possible damage during spring freshet
4. Check all wooden weirs for integrity.
5. Clean visitors centre, counting house, and washrooms.
6. Turn on potable water and check for leaks.
7. Turn on air systems as applicable and check for leaks.
8. Operate counting house gates.
9. Operate fish lift.
10. Install signage in the Visitors Centre.
11. Water up the ladder and check viewing windows for leaks.
12. Check intake racks for integrity and clean as necessary.
13. Operate attraction water and main gates to ensure proper operation within the expected range of operation.
14. Blow debris out of the attraction water racks and main gate seals.
15. Begin fish ladder at the request of Vermont Fish and Game.
16. Shut down ladder at the request of Vermont Fish and Game.

4.2 Fall Maintenance (Closing of Fishways)

1. Drain water and ensure no fish are trapped in dry fishway.
2. Secure Potable water and drain all potable water lines.
3. As required add antifreeze to water lines that cannot be adequately drained.
4. Secure air supplies and depressurize air systems.
5. Remove signage from Visitor's centre.

5.0 DOCUMENTATION/REPORTING REQUIREMENTS

1. Record relevant observations, deficiencies, anomalies, and repairs in the closing comments of the Computerized Maintenance management System (CMMS) (e.g. Avantis) work order. Schedule any additional maintenance to be completed in a timely manner.

6.0 LATEST REVISION

Description:	Revision 02 Section 4.1 added points 2 and 3. Periodic review done for document with the following: 1. New document contact assigned by from NE Hydro department. 2. No IITs etc. exist with respect to this document. 3. Applied Lines of Business are correct. 4. Reviewed requirements for licenses, external or internal permits or certificates etc. required for this document. 5. Impact Assessment Form in TOPs database completed for this document revision. 6. Minor formatting updates changes. 7. Feedbacks have been taken in to consideration.
Rationale Statement:	Maintain document at the pre-determined level of correctness so it is current with respect to the subject matter contained with in the document.
Impact Assessment Summary:	Only minor issues found with the document while performing the periodic review and contact update so minimum impact.

7.0 APPROVAL

	Name -Position-Department	**Signature-Date**
TOP Document Contact	Joseph Avery Manager U.S. EO Hydro and Kibby Renewables	joseph A avery joseph A avery (Sep 25, 2012)
Management Approver	Jawad Masud Director U.S. Energy Operations Power	Wayne S Gelinas Wayne S Gelinas (Sep 27, 2012)

SSI CONTACT: AREA SUPERVISOR

1.0 PURPOSE

This process will cover how to inspect, maintain, and operate the fish ladder and fish diversion system.

2.0 SCOPE

To safely inspect, maintain and operate the fish ladder, a reinforced concrete structure designed to provide safe passage for upstream migrating salmon and shad, and fish diversion system, at Bellows Falls Station hydro facility.

Responsibility: Maintenance Technicians.

Department: Bellows Falls Station – NE Hydro.

Schedule:

1. As needed, or as directed by supervisor.
2. This fishway is opened and closed by request of the Vermont Fish and Wildlife Department. The season usually runs from mid-May to the first of July.

3.0 REQUIRED KNOWLEDGE

Certificates & Work Tickets: Must be trained in local operations.

TOPS: None.

Safety Documents: None.

Resources & Equipment:

1. All proper PPE must be worn when performing this task, including Life Vests (PFD).
2. Equipment: Personal Hand Tools; Ladder.
3. Materials: DNO Tags, if working in sluice.

Warnings & Precautions:

1. Strictly follow all guidelines. Performing this task improperly could result in personal injury; slip, trip and fall hazards.
2. Carefully inspect all equipment.
3. Make sure proper tags and locks are in place when performing maintenance in the pools.

4.0 PROCEDURE

4.1 Setup

1. The Bellows Falls fishway is a reinforced concrete structure designed to provide passage past the Bellows Falls Station for upstream migrating salmon and shad. Upstream migrating fish enter the tailrace area, where they are attracted to the fishway entrance by the use of sluiceway diffuser systems.

   From the entrance, the fish are attracted to the vertical slot weir section, where they climb the fishway through a series of pools. Each succeeding pool is one foot higher than the last.

   After climbing the first 44 pools, the fish enter the counting/trapping area. At this point, the migrating fish can be counted, trapped, and removed from the ladder, or released to continue on their upstream journey.

   From the counting/trapping area, the fish continue to climb through an additional 22 pools to the visitor's center viewing area. After passing the last three flow control weir gates, the migrating fish are at the forebay elevation. From there, the fish continue upstream through the intake slide area and up the entrance channel to exit north of the fish ladder diversion boom and into the canal.

2. Make sure proper tags and locks are in place when performing maintenance in the pools.

4.2 Process

To Perform Season Opening of Fishway:

1. Perform inspection of fishway.

a. At the intake slide, located near the visitor's center, place the key switch to local. DNO tag the switch for the person inspecting the fishway.

b. At the control panel for the fishway, located in the control room, place the auto/stop/manual switch to manual. DNO tag for the person inspecting the fishway.

c. Open breaker No.4 (intake slide) in the 480 volt cabinet, located in the rag room in the basement. DNO tag breaker.

d. Place a ladder into the fishway at a point of easy access at the visitor's center.

e. With one person walking along the walkway, another person will walk from the top of the fishway to the bottom of the fishway. This person will ensure that all weir slots and drain holes are clear of debris.

f. Clear entrance to fishway of debris.

g. The person in the fishway can exit at the bottom. A ladder may be necessary to exit fish ladder.

h. Remove the ladder from the fishway at the visitor's center.

i. Close breaker No.4 in 480 volt cabinet.

2. Clean viewing backdrops and clean viewing windows.

3. Receive authorization to open fishway for season.

    a. The Vermont Fish and Wildlife Department will notify the maintenance supervisor when to open the Bellows Falls fishway.

4. Close or check closed weir gates.

    a. If weir gate is open:

        i. At control panel, place auto/stop/manual control switch to manual and close the weir gate.

        ii. At the weir gate, place key switch to local and press closed button. Place key switch back to remote.

5. Open intake slide.

    a. If intake slide is closed:

        i. At control panel, place auto/stop/manual control switch to manual and open the intake slide.

ii. At the intake slide, place key switch to local and press the open button. Place key switch back to remote.

6. Open headgate (located at northwest end of diversion boom).

   a. Remove stop logs from upstream side of headgate if they are still in place.

   b. The headgate can only be opened from the remote location.

   c. Push the open button to open the headgate.

   d. Push the stop button when headgate is clear of the water.

To Perform Daily Operations of Fishway:

1. Perform daily opening.

Note:

This step is normally done at 6 a.m. every day.

   a. On the control panel, place auto/stop/manual switch to stop.

   b. Place sluice gate at desired elevation.

      i. At the sluice gate, unlock cover and with the key switch on local, places the sluice gate at the desired elevation (approximately 1 1/2-feet below the water surface).

      ii. Push stop button.

      iii. Place the key switch to the remote position, close and lock cover.

   c. On the control panel, place auto/stop/manual switch to manual.

   d. Adjust weir gates, if needed.

      i. If Forebay elevation is 288.6-feet to 288.9-feet, all three weir gates must be opened to maintain proper water flow to the fishway.

      ii. If forebay elevation is 289.0-feet to 289.7-feet, No.1 and No.2 weir gates must be opened to maintain proper water flow to the fishway.

      iii. If forebay elevation is 289.8-feet to 290.6-feet, No.1 weir gates must be opened to maintain proper water flow to the fishway.

iv. If forebay elevation is 290.7-feet to 291.6-feet, no weir gates are to be opened. If all weir gates are opened at full pond, the fishway walls could overflow.

e. On control panel, place auto/stop/manual switch to auto. (this Function not currently available)

i. This will sound a low chimney alarm.

ii. The fishway is now automatic.

f. Push the alarm reset switch, which will disable the audible alarm; the light will still blink. When all requirements are met, the alarm will clear itself, and the light will stop blinking.

2. Perform normal operation of upstream migration, including downstream migration.

a. The minimum 255 CFS includes the 55 CFS that goes into the “sidewall diffuser” for attraction water. The “sidewall diffuser” should be run at approximately 58% gate. This will allow the 55 CFS for attraction water. The “floor diffuser” is normally closed.

b. The total fishway CFS is added to the station generation CFS for total station discharge.

3. Perform daily closing.

Note:

This step is normally done at 4 p.m. every day.

a. On control panel, place auto/stop/manual switch to manual.

b. Close sluice gate.

c. Close “sidewall diffuser” and place open/stop/closed switch to stop.

d. On control panel, place auto/stop/manual switch to stop.

e. Place sluice gate on local control. At the sluice gate, the governor attendant unlocks the cover and places the key switch on local control.

f. On control panel, place auto/stop/manual switch to auto.

g. Reset low chimney alarm button. The low chimney light will remain lit.

h. The fishway is now in the auto mode, but only the weir gates are operational to maintain the 25 CFS.

To Perform Season Closing of Fishway:

Note:

A representative of the Vermont Fish and Wildlife Department is normally present during this task.

Note:

Rubber boots and gloves should be worn in the fishway.

1. Receive authorization to close fishway.
    a. The Vermont Fish and Wildlife Department will notify the maintenance supervisor when it is okay to shutdown the fishway for the season.
2. Close or check closed weir gates.
    a. If weir gate is open:
        i. At control panel, place auto/stop/manual control switch to manual and close the weir gate.
        ii. At the weir gate, place key switch to local and press closed button. Place key switch back to remote.
3. Close headgate.
    a. The headgate can only be closed from the remote location.
    b. Push the closed button to close the headgate. Watch the bottom of the headgate to be sure no debris is beneath the headgate.
    c. Push the stop button when the headgate is completely closed.
4. Close intake slide, if needed.
    a. At control panel, place auto/stop/manual control switch to manual and close the intake slide.

b. At the intake slide, place key switch to local and press the closed button. Place key switch back to remote.

5. Inspect fishway.

    a. At the intake slide, place the key switch to local, and DNO tag the switch for the person inspecting the fishway.

    b. At the control panel for the fishway, place the auto/stop/manual switch to manual. DNO tag for the person inspecting the fishway.

    c. Open breaker No.4 (intake slide) in the 480 volt cabinet, located in the rag room in the basement. DNO tag breaker.

    d. Place a ladder into the fishway at a point of easy access at the visitor's center.

    e. With one person walking along the walkways, another person will walk from the top of the fishway to the bottom of the fishway. This person will ensure that any fish trapped in the fishway will be moved safely to the tailrace.

    f. The person in the fishway can exit at the bottom. A ladder may be necessary to exit fish ladder.

    g. Remove the ladder from the fishway at the visitor's center.

    h. Close breaker No.4 in 480 volt cabinet.

6. Set up fish viewing area for summer months.

    a. To water up the viewing area for the visitor's center.

    b. Place a sheet of plywood against the upstream side of the western most weir slot.

    c. Slowly open the intake slide.

    d. This can be removed when the visitor's center closes for the season.

To Perform Winterization of Fishway, Sluiceway, and Diversion Boom:

1. Winterize sluiceway.

    a. To winterize sluiceway:

        i. Place custom-made tarps at both ends of the sluiceway (these are to hold the heat in). The sluiceway shall be DNO tagged for this procedure.

ii. Install custom door to sluiceway from trench in headworks. The trench water control shall be DNO tagged while installation is taking place and while blower is in operation.

iii. Connect heat tube to door in trench.

iv. Attach other end of heat tube to the blower in the headworks.

v. Turn power on to blower

vi. At the sluice gate, place heaters in the sluice gate screw shafts.

b. To open sluiceway after winter:

i. Turn power off to blower.

ii. Remove heat tube from blower and sluiceway door.

iii. Remove sluiceway door.

iv. Remove DNO tag from trench water control.

v. Winterizing equipment is stored at the east end of the headworks.

vi. At the sluice gate, disconnect power supply and remove heaters from sluice gate screw shafts.

2. Winterize fishway.

a. To winterize fishway:

i. Close headgate.

ii. Place stop logs in holder upstream of headgate.

iii. Place ice-away between headgate and stop logs.

b. To open fishway after winter:

i. Remove ice-away.

ii. Remove stop logs.

iii. Open headgate when needed for fishway.

3. Winterize diversion boom.

a. Turn on west bubbler system, located in house next to visitor's center.

b. Turn on east bubbler system. Two units are located inside of carpenter shop on west wall.

c. All three units are checked daily.

4. Winterize counting house.

    a. To winterize counting house:

        i. Close air lines to counting house.

        ii. Close water lines to counting house.

        iii. DNO tag air and water lines to counting house.

        iv. Drain the air and water out of the lines at the counting house.

        v. Drain all traps in the counting house.

        vi. Add anti-freeze to all traps.

        vii. Wash both sides of viewing window.

    b. To open counting house after winter:

        i. Remove DNO tags from air and water lines.

        ii. Open air line to counting house.

        iii. Open water line to counting house.

        iv. Wash both sides of viewing window.

        v. Inspect night gate operation, and repair, if necessary.

5. Winterize visitor's center.

    a. Place wooden snow door at west entrance. This prevents snow from filling the stairway.

    b. Place anti-freeze in floor drains.

    c. Shut off water to sill cock.

To Perform Maintenance on Fishway Equipment:

1. Perform inspection and maintenance of the sluice gate.

a. Perform annual mechanical inspections.

b. Grease gearing monthly.

2. Perform inspection and maintenance on the control panel.

a. Change light bulbs, as needed.

b. Reprogram the computer as needed, following manual.

Note:

Manual is located in the bottom of the control cabinet.

3. Perform annual small motor inspections.

Note:

See appendix A: Small Motors Inspection Form.

a. Inspect No.1, No.2 and No.3 Limitorque weir gate motors.

b. Headgate Limitorque motor.

c. Intake slide Limitorque motor.

d. West fishpipe Limitorque motor.

e. East fishpipe Limitorque motor.

f. Sidewall diffuser Limitorque motor.

g. Floor diffuser Limitorque motor.

h. Sluice gate Limitorque motor.

i. Sluice hoist Limitorque motor.

j. Fishpipe hoist Limitorque motor.

4. Perform inspection of elevation gauges.

Note:

Check to see that wheels move freely and gauges are accurate.

a. Forebay gauge.

b. Tailrace gauge.

c. Chimney gauge.

5. Clean viewing windows, as needed.

Note:

Two people are required to perform this task. One person will perform the task, and the other is there for safety.

a. Put on personal floatation device.

b. Tie off, following company guidelines.

c. Use extension handle to clean windows.

d. Clean as needed.

e. Equipment is located in basement of visitor's center.

4.3 Checklist

N/A

5.0 DOCUMENTATION & REPORTING REQUIREMENTS

- Attach completed SSI to work order in SAP/Work Manager
- For non-work order related SSIs, file completed SSI in EDMS/FileNet

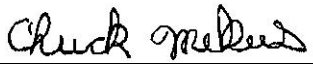
6.0 DEFINITIONS

N/A

7.0 DOCUMENT REVISION

No.	Description	Revised by	Date (mm/dd/yy)
00	Initial Version	Earl Brissette	12/06/12

8.0 APPROVAL

	Name (Print)	**Signature**	**Date** (mm/dd/yy)
Area Supervisor	Chuck Mekus		10/01/13

Does this SSI Require Engineering Review? ☐ Yes ■ No

9.0 ROLES AND RESPONSIBILITIES

Field Technician / Plant Personnel	• Read and Understand SSI • Use SSI • Report any issues with the SSI to Supervisor/Manager • Complete SSI • Attach completed SSI in SAP for work orders or file in EDMS completed folder for non-work orders.
Area Supervisor/Manager	• Ensure SSIs are used • Ensure SSIs are updated per change request process • Ensures Field Employee Completes SSI • Make sure completed SSIs are filed properly

SSI CONTACT: VERNON STATION SUPERVISOR

1.0 PURPOSE

This process will cover the safe and proper way to inspect, maintain and operate the Fish Ladder at Vernon station.

2.0 SCOPE

To safely inspect, maintain and operate the Fish Ladder, which provides a means for migrating fish to travel around the dam, at Vernon station hydro facility.

Responsibility: Maintenance Technicians.

Department: Vernon Station – NE Hydro.

Schedule:

- As needed.
- The fishway is opened and closed at the request of the Vermont Fish and Wildlife Department. The season usually runs from the middle of May to the early part of July. Passage of fish at turner falls determines when the fishway is opened.

3.0 REQUIRED KNOWLEDGE

Certificates & Work Tickets:

- Current mandatory environmental and safety training.
- Must be trained in local operations.

TOPS:

- N/A

Safety Documents:

- N/A

Resources & Equipment:

- All proper PPE must be worn when performing this task, including Personal Floatation Device (PFD).
- Equipment: Personal Hand Tools; Window Washing Equipment; Ladders; Waterproof Window Sealant.
- Materials: Paper Products; Brochures; Signs.

Warnings & Precautions:

- Strictly follow all safety guidelines. Personal injury; or slip, trip and fall hazards possible.
- Carefully inspect all equipment.
- The fishladder is classified as a confine space.

4.0 PROCEDURE

4.1 Setup

Before Inspecting, Maintaining or Operating Fish Ladder:

1. The fish ladder provides a means for migrating fish to travel around the Vernon Dam. The viewing window allows the public to view the fish traveling the ladder. The counting house provides a way for the Vermont Fish and Wildlife Department to monitor fish activity in the river and to capture any desired fish.

4.2 Process

To Perform Season Opening of the Fishway:

1. Prepare visitor's viewing area.
    a. Remove the plywood from the viewing windows.
    b. Wash the ladder side of the windows, inspect the caulking around the windows, and re-seal if necessary.
    c. This is a double pane window. Inside the viewing area, remove the inner glass. A pad should be used to rest the glass on the floor to prevent the glass from resting on the concrete.

d. Wash the inside of the outer glass, inspect the caulking, and re-seal where necessary.

e. Clean the inner pane of glass and replace it.

f. Perform a thorough cleanup of the area.

g. Ensure that lighting is in proper working order.

h. Sweep the parking lot.

2. Prepare counting house area.

a. Remove plywood panels from the viewing window and replace where necessary.

b. Inspect caulking around the window and replace where necessary.

c. Install drain plugs in all water and air lines.

d. Install the sump pump in the floor sump.

e. Operate and inspect the pneumatic gates for the fish trap.

f. Inspect heater, exhaust fan, and the electrical system, and ensure they are working properly (lights, outlets, etc.).

g. Perform proper cleanup of area.

3. Prepare fish ladder.

a. Remove all debris and mud.

b. Wash back drop wall in front of counting house window. Paint if necessary.

c. Visually inspect all wooden baffles.

4. Activate fish ladder.

Note:

The Vermont Fish and Wildlife Department will notify the maintenance supervisor when to open the fishway.

a. Open intake gates.

i. Insert key and turn selector to local.

ii. Push the open button.

iii. When gates are open, turn selector to remote and remove the key. The key is stored in the key cabinet in the main office.

b. Blow out the REW gate to prevent a buildup of silt at the base.

i. Turn on the large air compressor in the station.

ii. At the REW gate, open the air valves.

iii. When finished, shut off air valves and shutdown air compressor.

c. Adjust the REW gate in the tailrace so that the elevation of the water in the fishway is higher than the tailrace elevation. This difference should be enough so that the discharge will attract the fish (approximately 1-foot to 1 1/2-feet).

d. Ensure the pneumatic gates are operable and in the open position. These are operated by the person working in the counting house.

To Perform Operation of the Fishway:

1. Operating requirements.

Note:

The Vernon fish ladder is fully automated.

a. CFS flow through the ladder.

i. When the ladder is in full operation the total flow is 245 CFS.

ii. When the attraction water is off the total flow is 65 CFS (at night).

b. The REW gate between the ladder and the tailrace must be set so that the differential between the fishway elevation and the tailrace elevation is approximately 1-foot to 1 1/2-feet, the fishway elevation being the higher one.

c. The attraction water should be opened (approximately 7 a.m.). This is done by opening the REW SL1 or REW SL2 gate (48-inch pipe) to 65%.

d. The regulating pool elevation must be maintained at an elevation of 208.6. This is controlled by the makeup water valve on the 30-inch pipe.

e. When the run is over for the day, the REW SL1 or REW SL2 gate is closed.

2. Inspections – daily checks.

a. Ensure that the fishway is performing properly.

b. Ensure the fishway/tailrace differential is correct. If it is not, make the proper adjustment with the REW gate. Report problem with fishladder controls to the maintenance supervisor.

c. Ensure the regulating pool is at 208.6 elevation.

To Perform Season Closing of the Fishway:

Note:

The Vermont Fish and Wildlife Department will notify the maintenance supervisor when to close the fish ladder.

1. De-activate the fish ladder.

    a. Close the intake gates.

        i. Insert key and turn selector to local.

        ii. Push the close button.

        iii. When gates are closed, turn selector to remote and remove the key. The key is stored in the key cabinet in the main office.

        iv. REW gate should be left open.

        v. When the water has drained from the ladder, personnel must walk down the ladder floor to remove all fish that are trapped in the ladder. **Caution : This is classified as a confine space.**

2. Close the counting house area.

    a. Remove sump pump from floor sump, clean and store away properly.

    b. Shut off air and water supply to area. Shutoffs are located in the maintenance shop.

        i. Turn off the power supply.

    a. Remove all drain plugs from air and water lines.

    b. Blow out all air and water lines.

    c. Install plywood panels of viewing window.

3. Close the visitor's viewing area.

Note:

Work is to be performed at the maintenance supervisor's discretion.

a. Install plywood panels over viewing window.

4.3 Checklist

N/A

5.0 DOCUMENTATION & REPORTING REQUIREMENTS

N/A

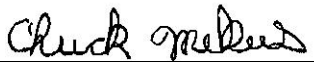
6.0 DEFINITIONS

N/A

7.0 DOCUMENT REVISION

No.	Description	Revised by	Date (mm/dd/yy)
00	Document created	Earl Brissette	12/07/2012
00	Updated to new template	Eric Pero	10/17/2014

8.0 APPROVAL

Title	Name (Print)	Signature	Date (mm/dd/yy)
Area Supervisor	Chuck Mekus		04/25/2013

Does this SSI Require Engineering Review? ☐ Yes ☒ No

9.0 ROLES AND RESPONSIBILITIES

Field Technician / Plant Personnel	• Read and Understand SSI • Use SSI • Report any issues with the SSI to Supervisor/Manager • Complete SSI • Attach completed SSI in SAP for work orders or file in EDMS completed folder for non-work orders.
Area Supervisor/Manager	• Ensure SSIs are used • Ensure SSIs are updated per change request process • Ensures Field Employee Completes SSI • Make sure completed SSIs are filed properly

10.0 APPENDIX

NEW ENGLAND POWER COMPANY

WILDER FISHWAY

GENERAL OPERATION PROCEDURE

3 June 1983

Revised: 6 February 1985, 28 March 1986, & 15 June 1987

WILDER FISHWAY

GENERAL OPERATION PROCEDURE

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WILDER FISHWAY

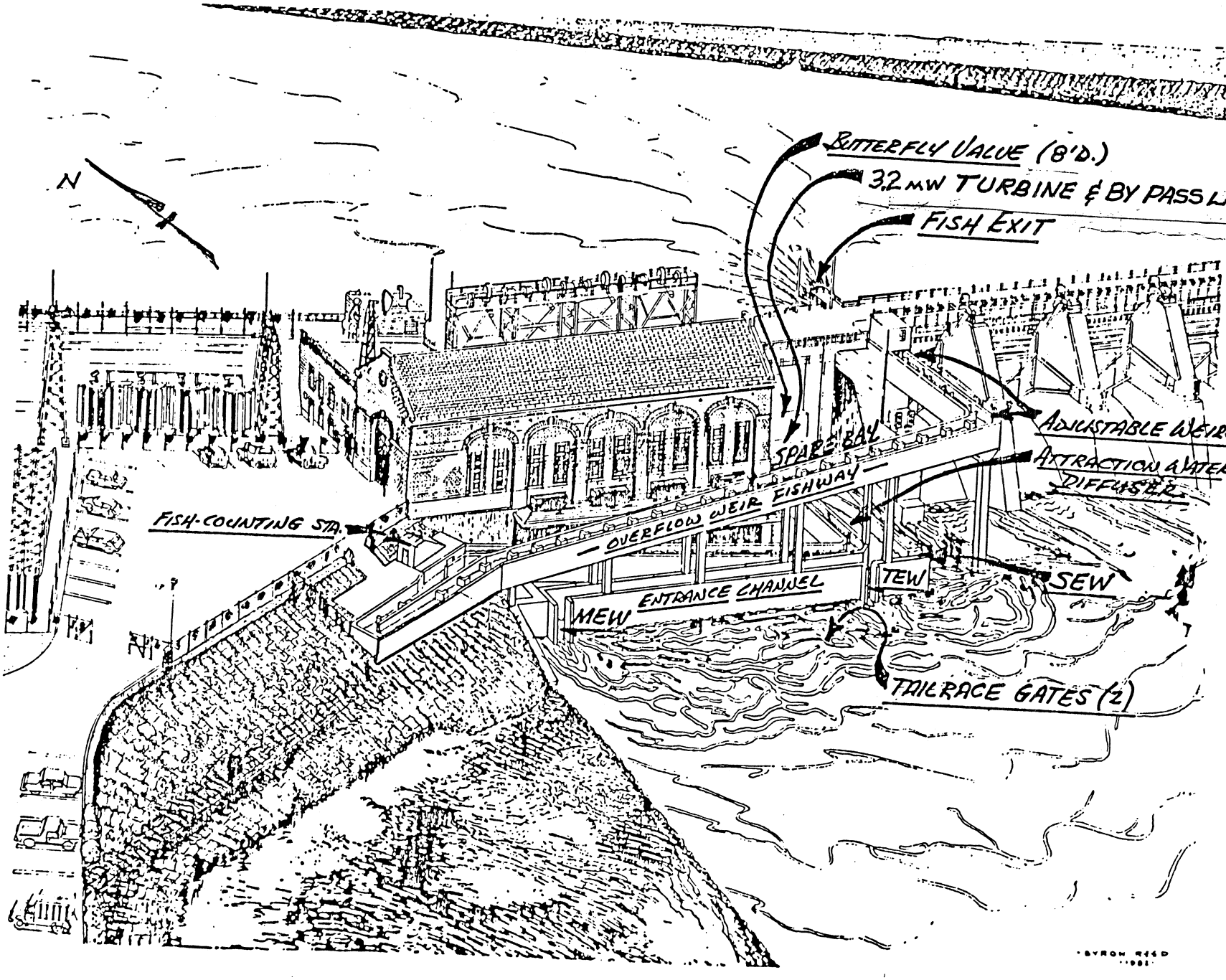
GENERAL OPERATION PROCEDURE

The Wilder Fishway is a reinforced concrete structure with accessory electrical, mechanical, and pneumatic equipment designed to provide passage for migrating Atlantic salmon and American shad past the Wilder Dam. Upstream migrating fish enter the Wilder Hydroelectric Station's tailrace area where, under normal operating conditions (either or both of the main units and Unit 3 are operating), fish are attracted to the main entrance weir (MEW) at the northwest end of the powerhouse. From this point, fish travel through the six-foot wide entrance channel along the powerhouse to the attraction water floor diffuser in the southeast half of a spare turbine bay between the powerhouse and the dam (see Figure 1).

A spillway entrance weir (SEW) and a turbine entrance weir (TEW) are incorporated in the southeast and southwest walls of the attraction water channel for use under varying tailwater conditions. The "SEW" is a gated entrance slot used for fish attraction from the spillway area where fish may congregate during high-water "spill" conditions. The "TEW" is a gated entrance slot which will be used for fish attraction during minimum flow operation of the "continuous-flow" turbine. The attraction water weirs, when used, open fully and are not modulated.

From the attraction water diffuser, the fish enter a six-foot wide fishway entrance channel and "climb" to the forebay by swimming through a series of 58 pools created by a sequence of overflow weirs with each succeeding weir spaced ten feet apart and 12" higher than the last.

After negotiating 28 pools, the fish enter the counting/trapping area, guided by flow and crowder screens, travel through a three foot wide flume, and past an underwater viewing window, where they may be observed and counted. At this location they may be trapped and diverted to a holding pool by means of manually activated pneumatic trapping gates. The fish trap's movable floor is lifted (to allow for netting of fish) by a motor driven cable hoist. Netted fish are placed in a hopper to convey them to a tank truck loading area via a traveling hoist on a monorail.



Wilder Station

FIGURE 1. WILDER FISHWAY ARTIST'S REWERING

The monorail and hoist are also used during maintenance operations to lift the fish trap screens for cleaning.

From the counting/trapping area, fish continue to climb through an additional 30 overflow weirs and pools to the five-foot wide fishway exit channel in the spillway adjacent to the powerhouse. The exit channel (the last pool) includes a motor driven headgate, trash racks with 12" spacing, and slots for wooden stop logs. The headgate is either open or closed.

The last five weirs in the vertical slot section contain adjustable weir gates which can be lowered (opened) to provide a nearly constant 20 CFS fishway flow when the forebay elevation drops through its five-foot operating range. As the pond elevation rises and falls, these five gates are programmed to maintain a nearly constant water level of 12" over the first fixed weir downstream of the five adjustable weirs by means of a water level monitor and control system. The adjustable weir gates are three position gates, operating at full-up, mid-point, or down. With head pond at Elevation 385, all five gates are full-up. For each discrete 1/2 foot change in head pond, gate position follows a pre-set schedule. The schedule is provided on Drawing H-37574. Due to occasional pond level oscillations during plant shutdowns or wave action, gate time delays prevent operation for 2.5 minutes after each gate adjustment. Some surging and ebbing of fishway flow occurs during such pond level oscillation.

Downstream migrating fish are attracted to the existing log sluiceway located between the spare bay and spillway. Future operating experience may require an electrical or mechanical guidance system to this sluiceway. The existing sluice gate is motorized and operated locally as needed.

An outdoor public viewing area with an observation deck and underwater window is located at the fishway's northwest end on the Vermont shore and adjacent to the powerhouse parking lot.

ATTRACTION WATER SYSTEM

The entrance weir's attraction water flows are dependent upon the tailwater elevation. Attraction water flow ranges proportionally from 60 CFS at low tailwater (Station "minimum flow" 700 CFS - Elevation 326' MSL); to 200 CFS at normal tailwater (full-load generation 10,300 CFS - Elevation 332' MSL); to 320 CFS at "Design High Tailwater" (combined generation and spill 15,000 CFS - Elevation 334' MSL).

Attraction water to the entrance weirs consists of 20 CFS from fishway flow with the balance introduced through a floor diffuser just upstream of the entrance channel. The attraction water flow is supplied in varying quantities proportional from Elevations 326' to 332' (No-Spill) and 332' to 334' (Spill) as shown in the following tabulations:

TABLE OF FLOWS

Pond Elevation (Ft. MSL)	Tailrace Elevation (Ft. MSL)	Fishway Flow (CFS)	Attraction Water Flow (CFS)	MEW Outflow (CFS)	SEW Outflow (CFS)	Total Flow (CFS)
Varies	326'(A)	20	40	60*	0	60
From	329'(A)	20	100	120	0	120
380.0'	332'(A)	20	180	200	0	200
to	332'(B)	20	240	200	60	260
385.0'	334'(B)	20	300	240	80	320
MSL	334'+	Fishway	Shutdown			0

*could be discharged through either MEW or TEW
(A)No Spill
(B)Spill

Attraction water supplied to the floor diffuser is conveyed from the forebay through the Unit 3. The Unit #3 turbine will pass 700 CFS. The attraction water system is designed to **utilize** the energy available in the head pond supply source by passing the flow through a 3.2 mW hydraulic turbine and generating unit. During fishway operation the water level in the intermediate tailrace is regulated by twin tailrace

gates, modulated to restrict discharge of the intermediate tailrace and maintain an elevation approximately 1-1/2 feet above the tailrace. This head differential in the intermediate tailrace forces attraction water through a tunnel under the wall bisecting the spare bay, through stilling and turning vanes, where it flows up and through the fishway's floor diffuser.

The attraction water control system is programmed to modulate the tailrace gates to maintain the entrance channel water level 1/2 foot above the tailrace level. Also included are tailrace and diffuser water level monitors and a 2.5 minute time delay to prevent reactivation of tailrace gate operation. A high water alarm sends a visible and audible signal to the station operator, if the fishway-tailrace differential exceeds two feet.

Civil Engineering Department/S. C. Doret
3 June 1983
Revised: 6 February 1985, 28 March 1986, & 15 June 1987

WILDER FISHWAY

ELECTRICAL & MECHANICAL REQUIREMENTS

GATES & MOTORS		SIZE	OPERATION*
FISHWAY			
1. Fishway Intake/Exit Gate (377'-386' MSL)		3'-6"Wx9"H	L-R
2. Adjustable Weir Gates (5) downward opening, 3 position, single leaf slide gates	#1	5'Wx6'-8"H	L-R-A
	#	5'Wx6'-2"H	L-R-A
	#	5'Wx5'-8"H	L-R-A
	#	5'Wx5'-2"H	L-R-A
	#	5'Wx4'-8"H	L-R-A
3. Main Entrance Slide Gate, two position, (MEW)		4'Wx12'H	L-R
4. Spillway Entrance Weir Gate, two position, (SEW)		4'Wx 8'H	L-R
5. Turbine Entrance Overflow Weir Gate, two position, (TEW), (Downward Opening)**		4'Wx12'H	L-R-A
6. Headwater Level Sensor (Exist) and Control System for Adjustable Weirs			
ATTRACTION WATER SYSTEM			
7. Attraction Water Intake Butterfly Valve		8'	L-R-A
8. Turbine		3.2 mW	L-R-A
9. Tailrace Roller Gates (2) modulating		42"Ø	L
10a Bypass Butterfly Guard Valve			
10b Bypass Roto-Valve		36"Ø	L
11. Tailwater and Diffuser Level Monitors and Control System for Attraction Water			

*L - Local
R - Remote
A - Automatic

**TEW gate may require future modulation capability

Civil Engineering Department/S. C. Doret
3 June 1983
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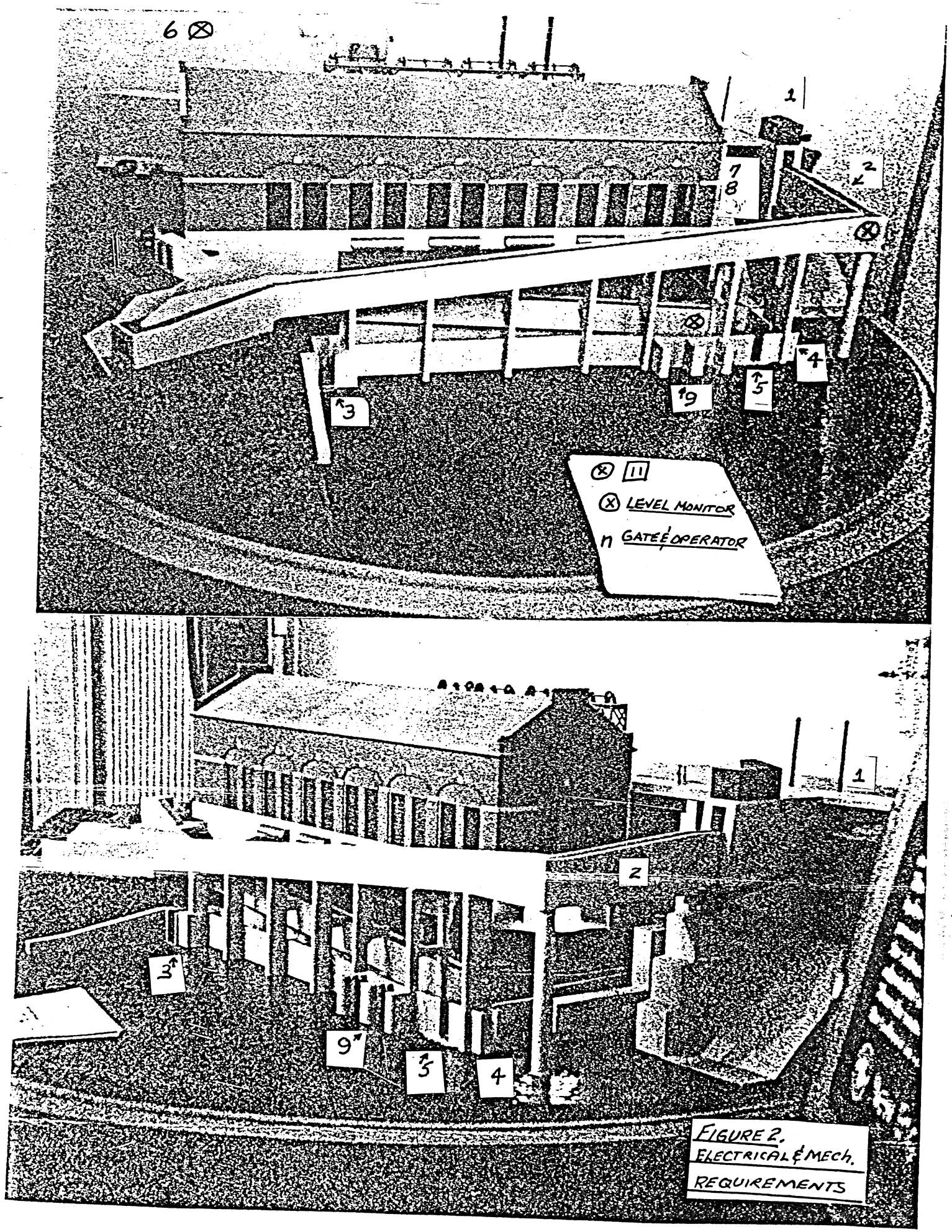
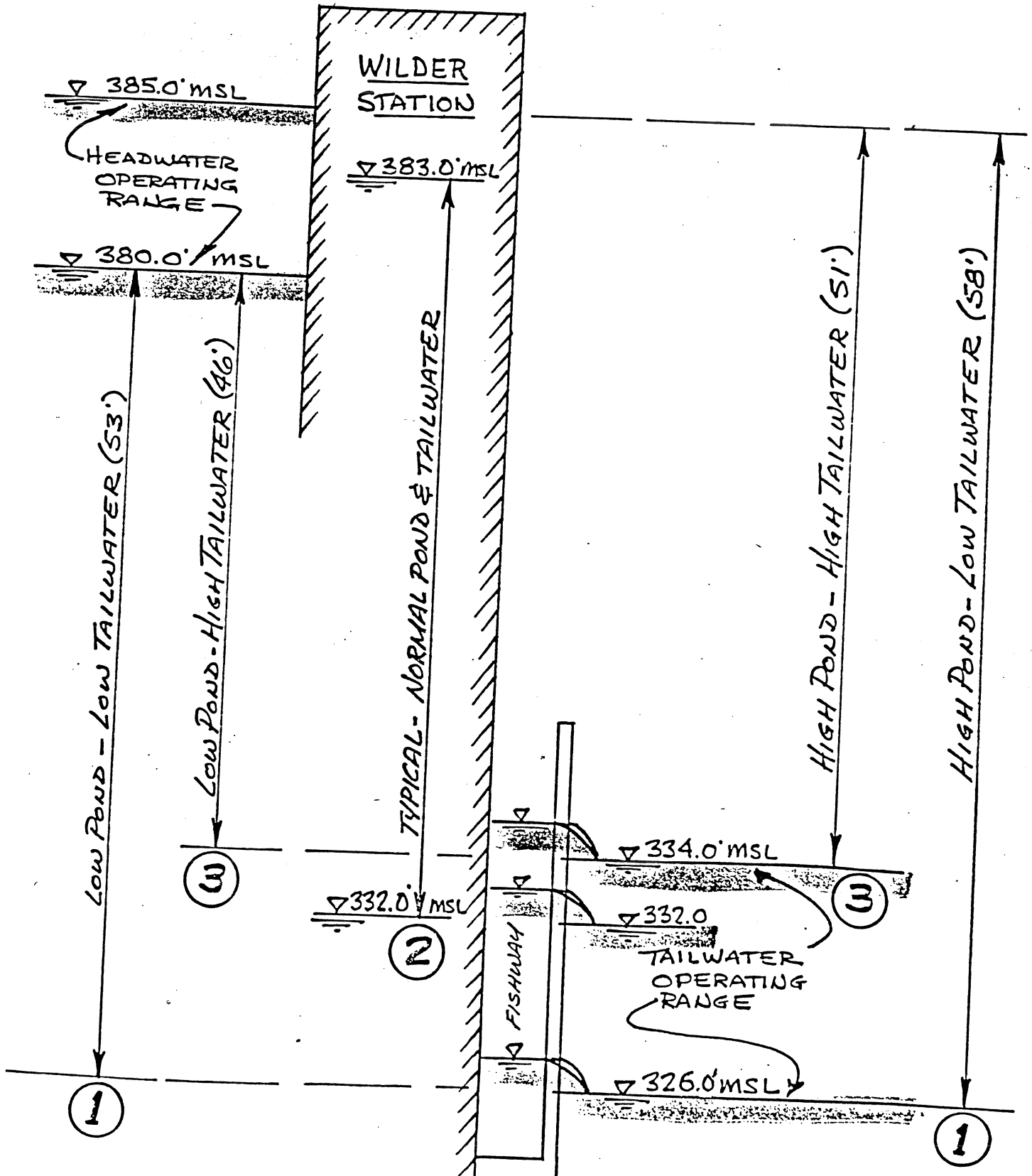


FIGURE 2.
ELECTRICAL & MECH.
REQUIREMENTS

— WILDER FISHWAY —
— HEADWATER-TAILWATER OPERATING RANGE —



AJM

FIGURE 3. WILDER FISHWAY HEADWATER-TAILWATER OPERATING RANGE

HEADWATER-TAILWATER RANGE (SEE FIGURE 3) (1)

LOW TAILWATER W/ MEW

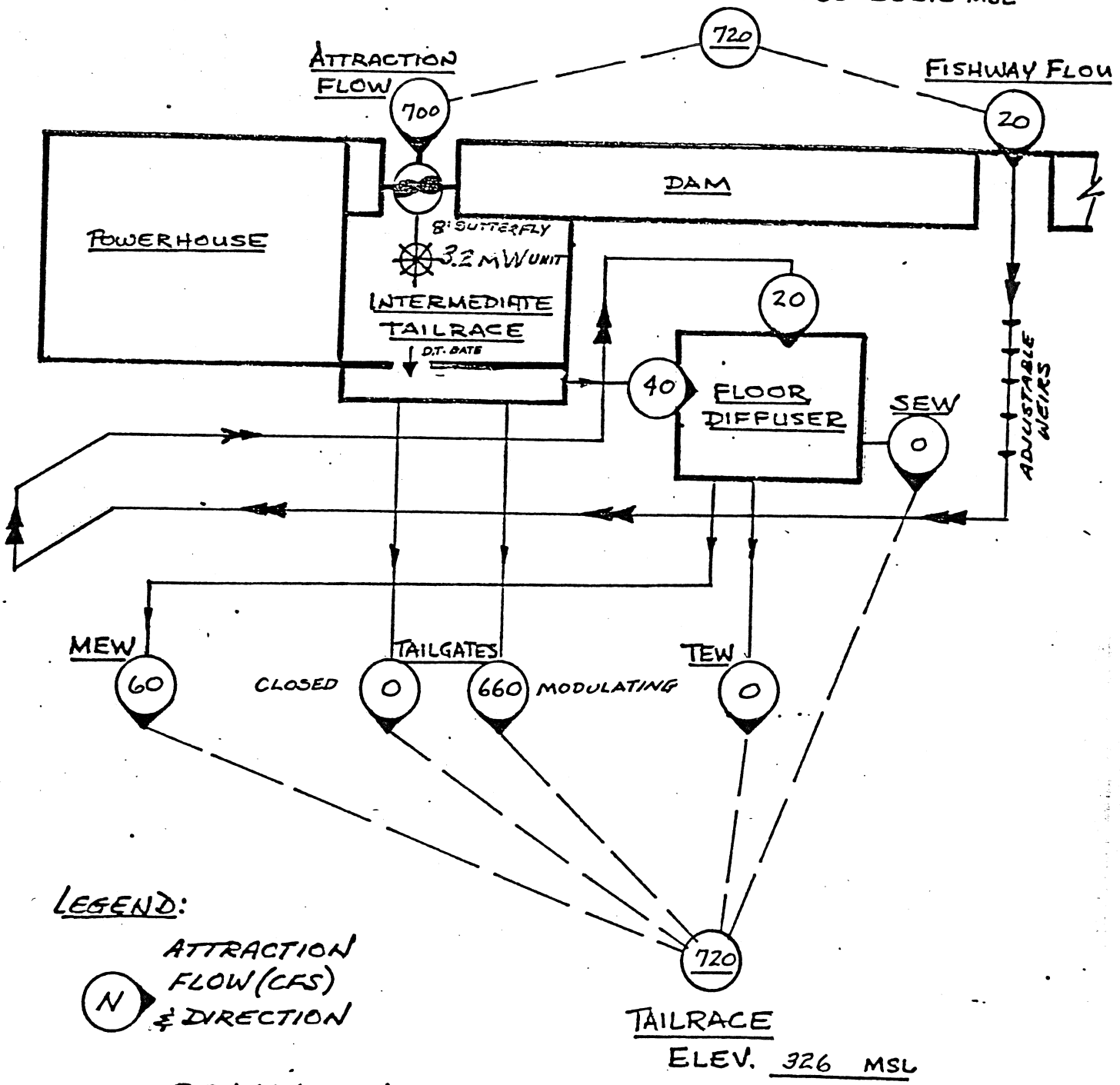


FIGURE . WILDER FISHWAY FLOW DIAGRAM

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4-7-86

HEADWATER-TAILWATER RANGE (SEE FIGURE 3) (1A)

LOW TAILWATER

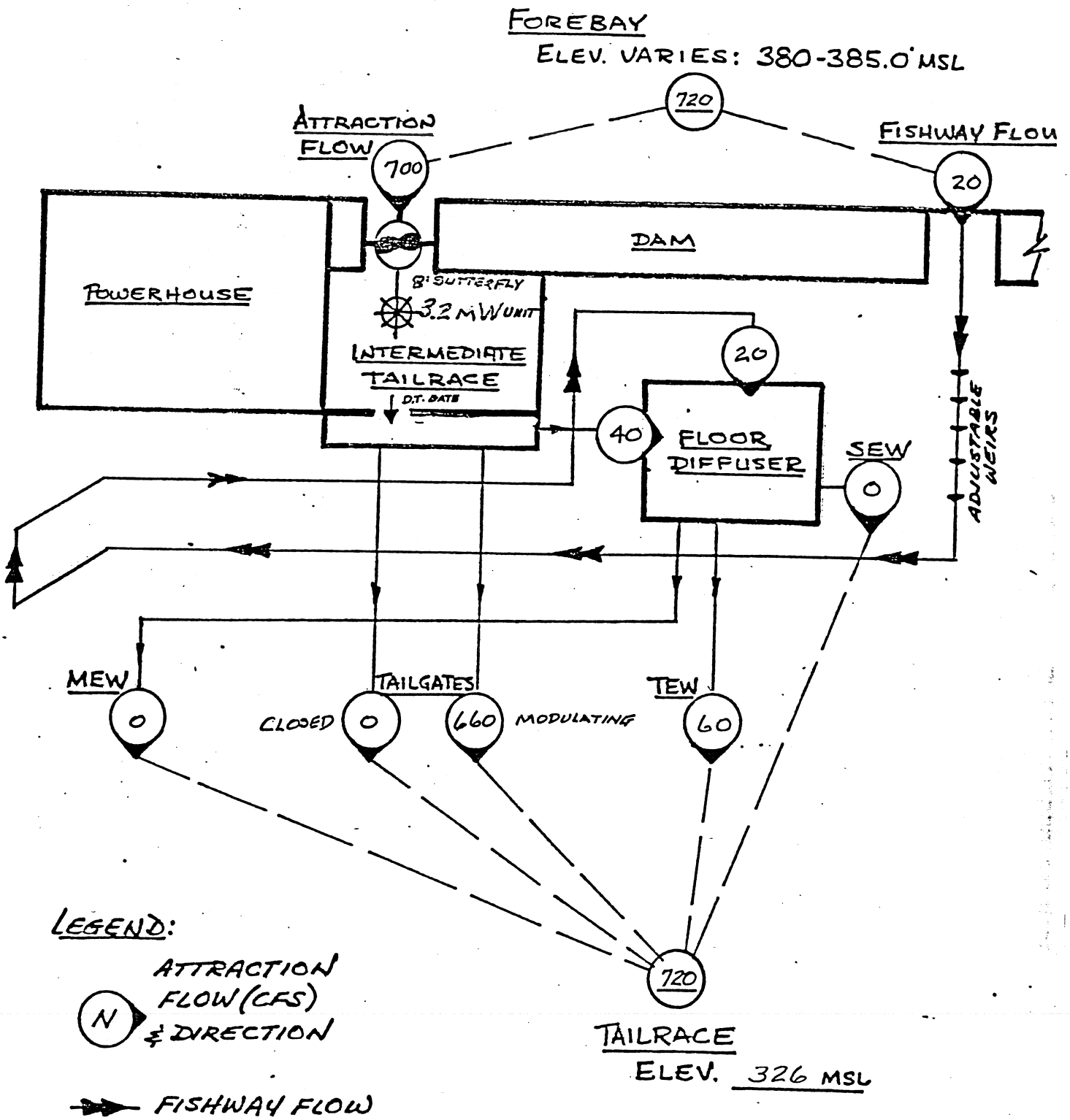


FIGURE 5. WILDER FISHWAY FLOW DIAGRAM

SCD
4-7-94

HEADWATER-TAILWATER RANGE (SEE FIGURE 3) (2)

NORMAL TAILWATER
FULL LOAD - NO SPILL
W/MEW

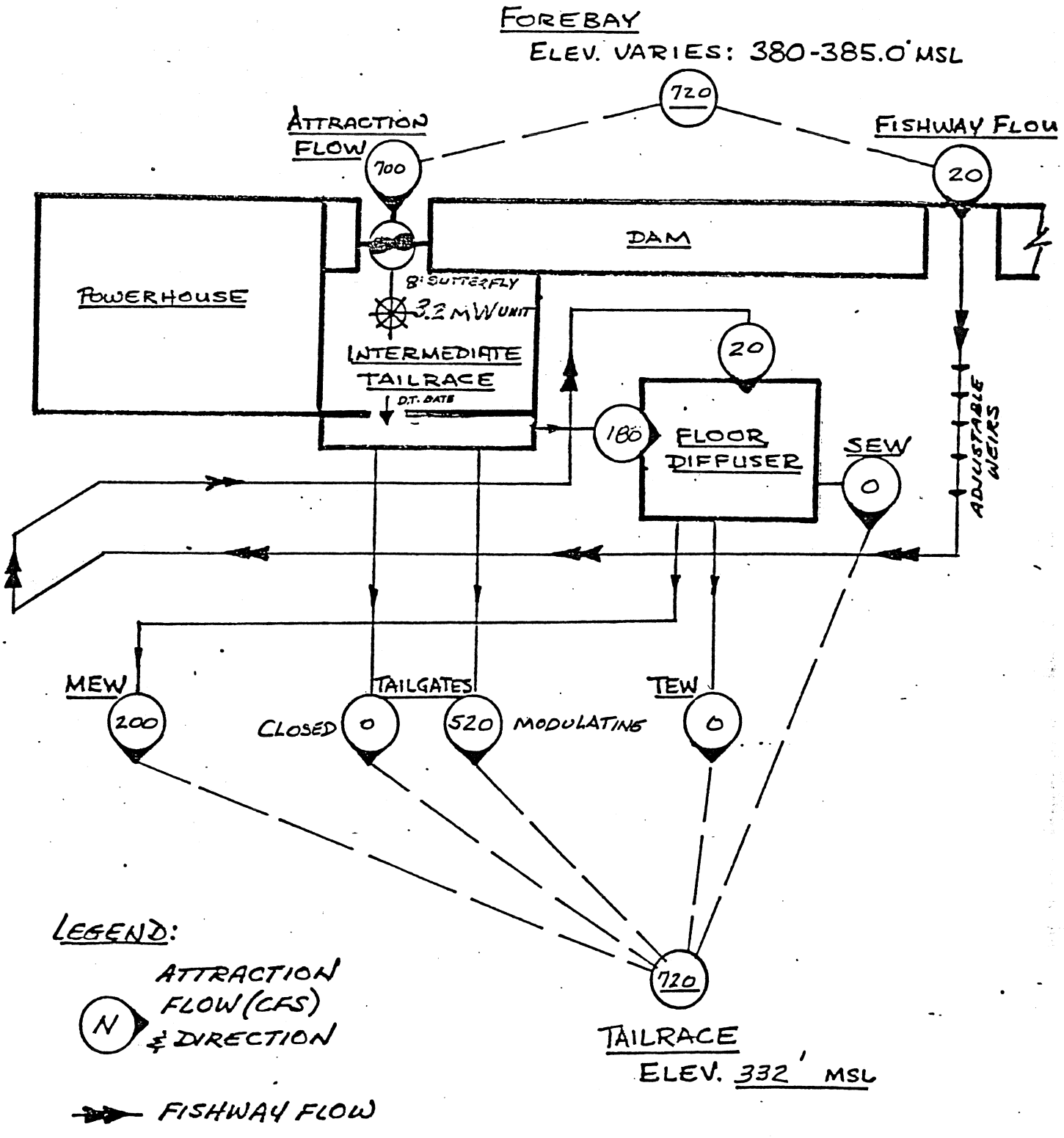


FIGURE 6. WILDER FISHWAY FLOW DIAGRAM

SCD
4-7-8

HEADWATER-TAILWATER RANGE (SEE FIGURE 3) 2A

NORMAL TAILWATER
FULL LOAD - SPILL
W/ MEW & SEW

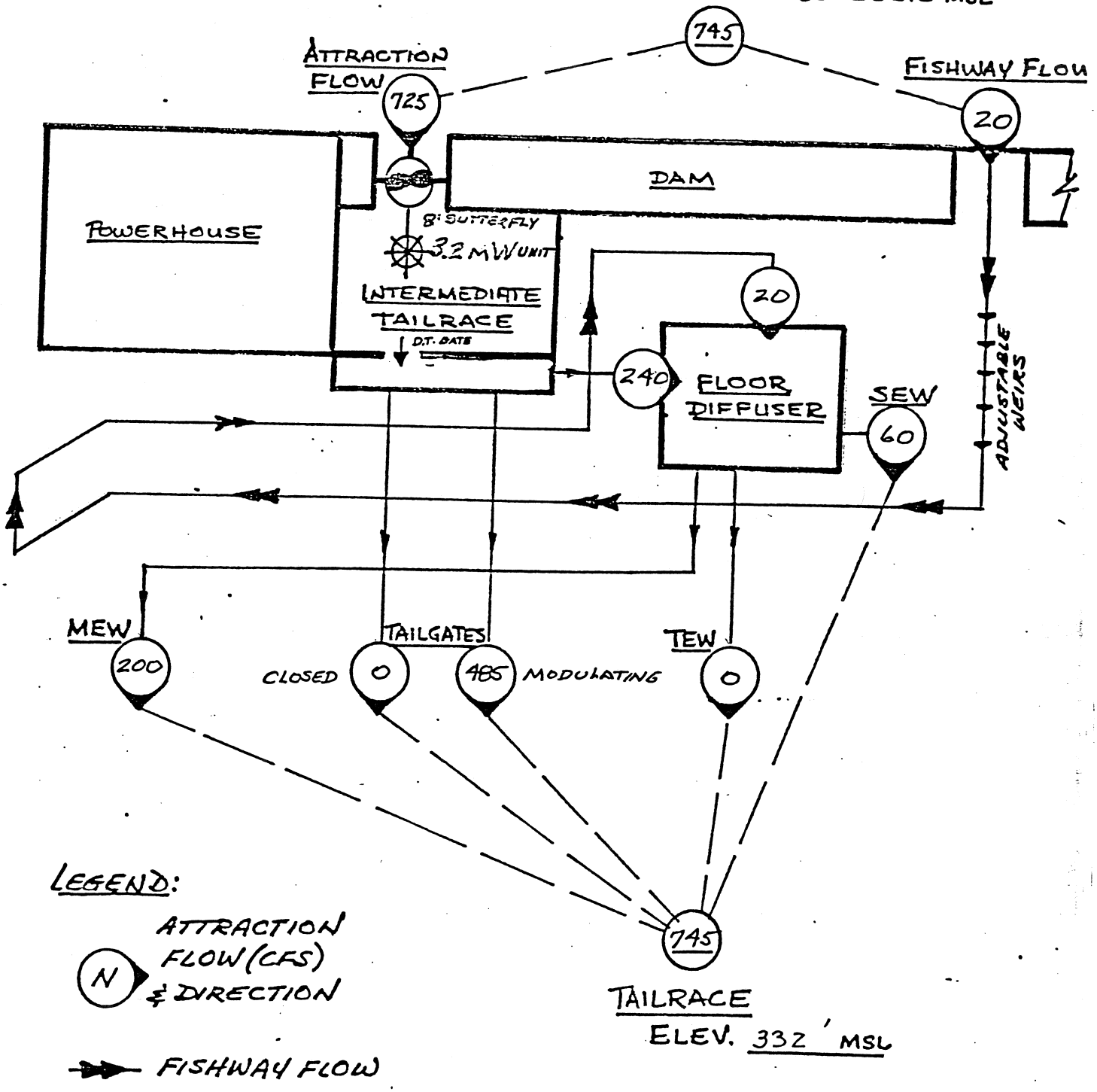


FIGURE 7. WILDER FISHWAY FLOW DIAGRAM

SCD
4-7-86

HEADWATER-TAILWATER RANGE (SEE FIGURE 3) (3)

HIGH TAILWATER W/MEW & SEW

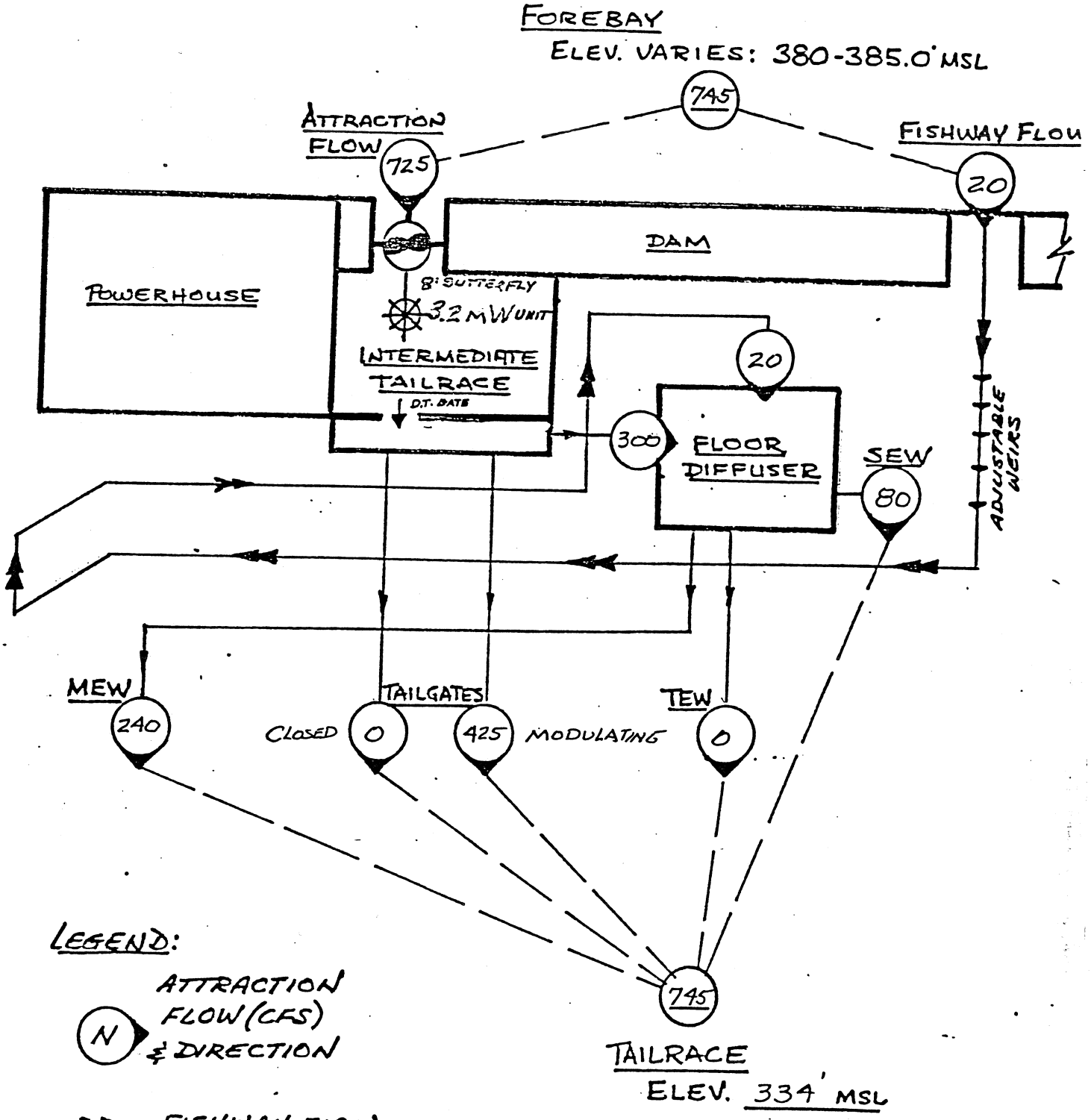


FIGURE 8. WILDER FISHWAY FLOW DIAGRAM

SCD
4-7-81

HEADWATER-TAILWATER RANGE (SEE FIGURE 3) (4)

3.2 MW - INOPERABLE

BY PASS LINE OPEN

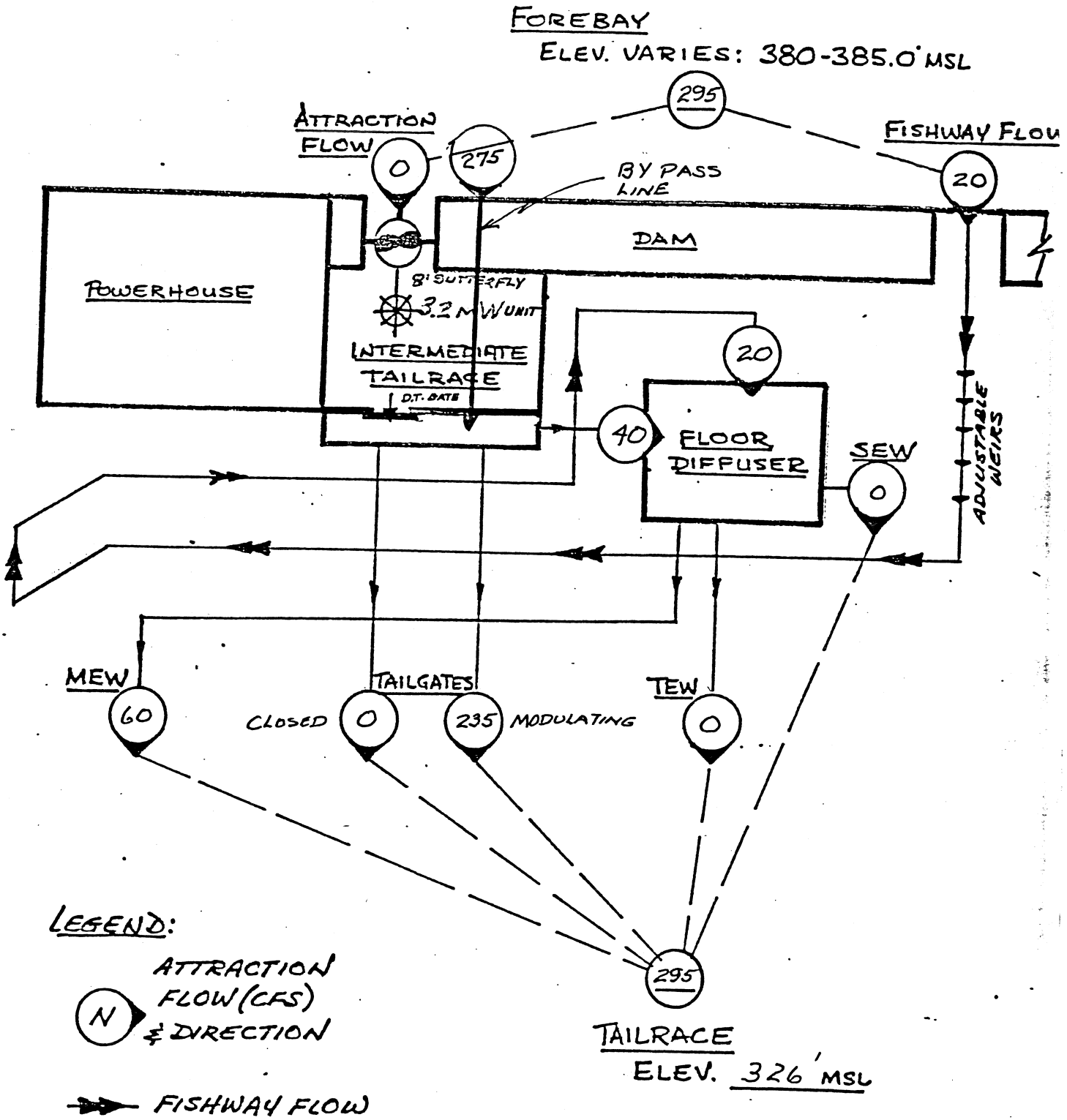


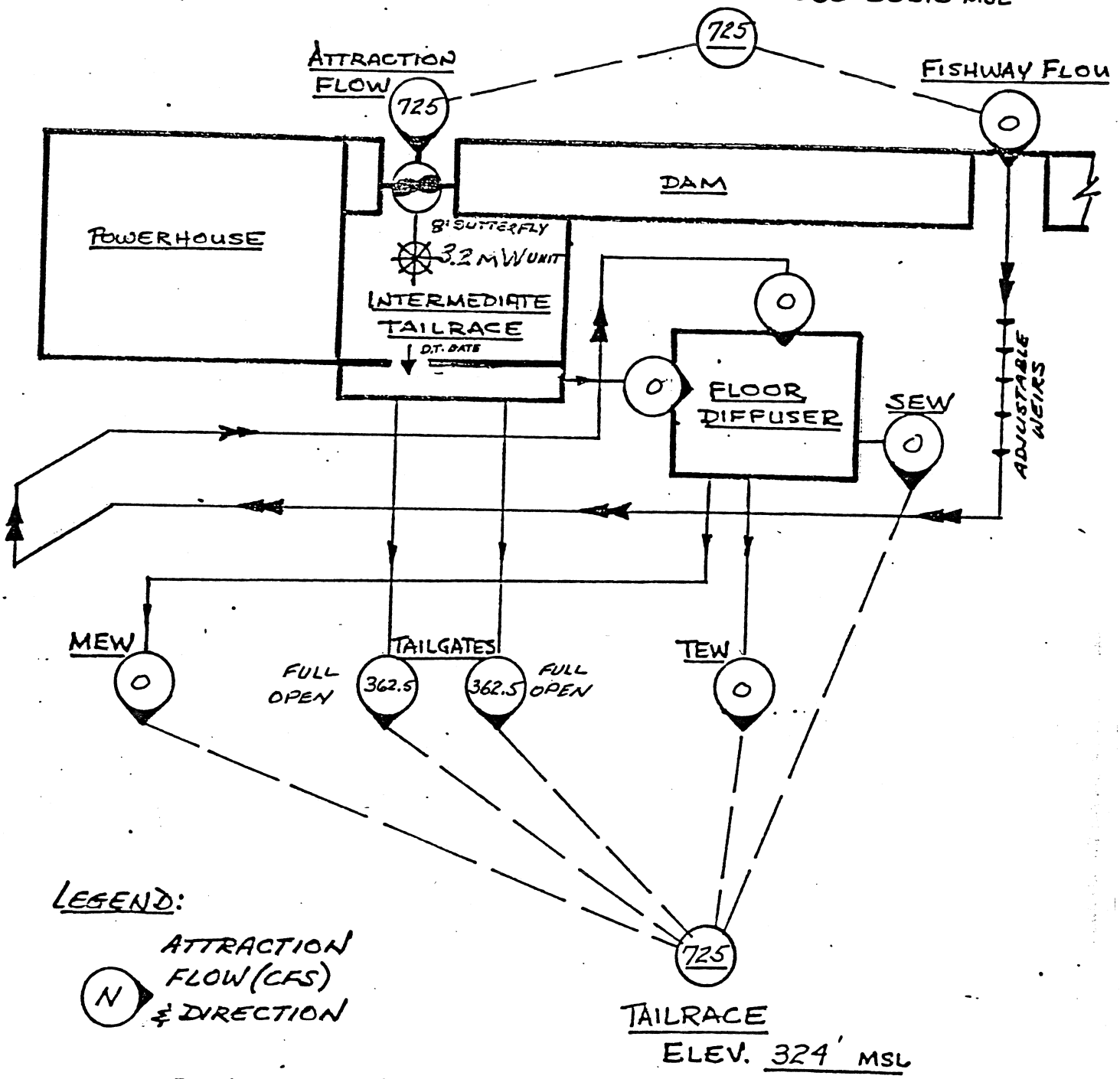
FIGURE 9. WILDER FISHWAY FLOW DIAGRAM

SCD
4-7-81

HEADWATER-TAILWATER RANGE (SEE FIGURE 3) (5)

3.2 MW UNIT - NO FISHWAY

MINIMUM FLOW



LEGEND:

N — ATTRACTION FLOW (CFS) & DIRECTION

→ FISHWAY FLOW

FIGURE 10. WILDER FISHWAY FLOW DIAGRAM

SCD
4-7-86

WILDER FISHWAY

FISHWAY START-UP PROCEDURE

Preliminary Work

Unit #3 must be scheduled off-line for a period of time approaching twelve hours in order to pump down the intermediate tailrace box. This pump down is necessary to inspect the diffuser box, turning vanes, and stilling vanes for damage and debris. All damage should be corrected and debris should be removed at this time.

Pump down is accomplished by cracking the Unit #3 draft tube gate when all entrance weir gates are closed. The Unit #3 draft tube drain valve is opened. The Unit #3 sump pumps will automatically pump down the entire lower fishway area. The lower fishway volume at El. 330 tailwater level is approximately 42,400 CF . Unit #3 sump is equipped with two - 300 gpm (at rated head) pumps.

Inspection/Testing

All gates, gate guides, stems, and operators should be inspected for damage, debris, or any signs of damage caused by the pass period of inoperation.

The **adjustable** weir gates should be run manually through their entire range and checked for smooth operation.

Watering Up

When the above procedures have been completed, the unit #3 draft tube drain valve should be closed, draft tube gate closed, and the main entrance weir opened. This procedure will water up the intermediate tailrace. All attraction water gates should be run through the operating range and checked for smooth operation.

The tailrace roller gates should be positioned full open and Unit #3 placed back into operation.

The fish control system should now be energized and all gate functions placed in automatic operation. The fishway intake exit gate can now be opened to maximum and fishway flow is now established. Utilizing the table of operational ranges supplied as Appendix A to this document, level indication readings appearing on the control console should be checked against the original test data obtained at initial system start-up. Console readings should fall within the ranges shown in Appendix A. If any data is outside the range shown in Appendix A, an adjustable weir gate may not be functioning correctly and should be checked. If no functional problems can be found and levels still fall outside the operation ranges indicated in Appendix A, Westborough Engineering should be consulted.

Design operational ranges of the system are as follows:

1) Levels indicated on the Fishway Water Level read-out should be Elevation 380.0± 0.25.

2) Attraction Water Level elevation should be within the program range of 0.5± 0.05 higher than tailwater. (This parameter may be changed from time to time by the Fisheries' representative.)

3) Tailrace roller gate position is variable depending on whether attraction water is supplied by the Unit #3 turbine or by the bypass water system. Tailrace roller gate percent open readings greater than 5% are acceptable.

4) Entrance weir gates should be positioned as follows:*

   (a) Unit #1 operating - MEW full open.
   (b) Unit #1 and #3 operating - MEW and TEW full open.
   (c) Unit #2 and #3 operating - TEW full open - MEW closed.
   (d) Unit #1, #2, and #3 operating - MEW and TEW full open.
   (e) Spill conditions - MEW, TEW, and SEW full open.
   (f) Tailwater levels above Elevation 334 - fishway shut down.

   ***If bypass flow is utilized for attraction water, only the MEW and 50% of the TEW can be utilized.**

Normal Operation

During normal operation the fishway will operate in the automatic mode and will not require any more than cursory supervision. Fish are attracted to the fishway only during daylight hours. Therefore, attraction water need not be supplied during non-daylight hours. When Unit #3 is operating,

attraction wwater is supplied continuously by design. However, during non-daylight hours, the tailrace roller gates should be brought to full open and the entrance weir gates brought to full open. To maintain the tailrace roller gates in this position, the tailrace roller gates must be placed in **"open"** position on the control panel. The night gate at the counting house should be closed and remain closed until attraction water flows are re-established (when tailrace roller gates are in automatic). During daylight hours, the night gate remains open.

The fishway should be checked for floating debris three times during the normal work day. Debris should be removed as soon as possible.

The check should encompass removal of debris at the intake/exit gate screen, inspection of the adjustable weir gate for trapped debris adjacent to or trapped behind the gates, and any debris in the fish trap area. Upstream forebay river debris should be sluiced every morning in order not to create future problems in the fishway.

Alarms

Two alarm conditions are programmed into the control system. One alarm deals with **"control loop 1"**, the five adjustable weir gates. The loop 1 alarm is based on high water levels in the upper fishway. The alarm takes its logic from the fishway water level sensor located in pool #53 just downstream of #5 adjustable weir gate. This alarm is created when water levels in the upper fishway exceed 18" over the last fixed weir. This alarm can be expected when Unit 1 and/or 2 is shut down. Shutdown of the units creates a surge in head pond raising the head pond over that which was previously experienced when units were operating. This condition is short lived and will clear itself when pond oscilation dies out. When the operator clears the audible alarm, the control panel lights continue to flash until water levels settle down or the adjustable weir gates adjust to the changed head pond water level. Should the lights continue to flash beyond 10 minutes, an inspection of the upper fishway should be made.

The second alarm is also a high water alarm and deals with the differential between the attraction water channel and tailwater. The logic for this alarm is taken from the lower fish ladder sensor located in

the vicinity of the tailrace roller gates. High water alarm in the lower fishway area loop 2 is created when the attraction water level is more than 2 feet higher than the tailrace. This condition can occur when either or both of the units are shut down and tailrace elevation decreases rapidly. After this alarm is acknowledged by operator the control panel lights will continue to flash until the tailrace roller gates adjust to the changed tailrace condition. If this condition exists for longer than 10 minutes, a visual inspection of the lower fishway should be conducted to determine if the roller gates have failed to function automatically.

Shutdown

Fishway shutdown is relatively simple in that the intake/exit gate is closed, all entrance weir gates and the tailrace roller gates are brought to full open and the control panel can be de-energized.

The fishway should be inspected at this time noting any damage or problems and corrective measures scheduled. The intake/exit gate is designed to close **leak** tight. Should the intake/exit gate not close tight, ice build-up over the winter could severely damage the fishway. Drop hoses should be placed upstream of the intake/exit gate in order to prevent ice damage upstream of this gate.

APPENDIX A

FISHWAY OPERATING DATA

(Taken on 3 & 4 June 1987)

This operating data represents initial start-up data readings taken from the control panel read-out in the station control room. Data taken represents the fishway in the automatic mode with the station dispatched between 32 and 34 megawatts of output. The headpond elevation of 385 was created by special request to REMVEC. The intent of the test was to draw headpond from 385 to 381 during the normal working hours over two days. Attraction water was supplied by the bypass system since Unit #3 was not completed at this time. The bypass roto-valve was full open but only three intake stop logs were removed since they were replaced during final Unit #3 start-up testing.

Sensor time delays were set at 5 minutes and all adjustable weir gate limits were set to those given on H-37574. The attraction water to tailwater differential was set at 1.0'±.

The following data was recorded and minor modifications discussed below were made thereafter.

Time	Headwater Elevation	Fishway Pool #53 Elevation	Attraction Water Elevation	Tailwater Elevation	Roller Gate %	3 June 1987 Units #1 & #2 Efficiency 34 Megawatts
7:00 AM	85.01	79.78	29.15	28.17	38%	All Gates Up
8:00 AM	85.03	79.83	29.30	28.31	36%	All Gates Up
8:30 AM						#1 Mid-Point
9:00 AM	84.58	80.04	31.80	30.91	21%	#1 Mid-Point
10:00 AM	84.45	79.95	32.09	31.20	18%	#1 Mid-Point
11:00 AM	84.26	79.80	32.25	31.22	18%	#1 Mid-Point
12:01 PM	84.10	79.91	32.20	31.25	18%	#1 Mid-Point
12:03 PM	84.09	79.91	32.20	31.21	18%	#1 Went Full Open
1:19 PM	83.87	79.80	32.21	31.24	18%	#1 Full Open
1:30 PM	83.84	79.75	32.20	31.24	18%	#1 Full Open
2:00 PM	83.75	79.70	32.25	31.25	18%	#1 Full Open
2:23 PM	83.69	80.08	32.31	31.31	18%	#1 Full Open, #2 Mid-Point
3:30 PM	83.49	79.84	32.37	31.32	19%	#1 Full Open, #2 Mid-Point
3:47 PM	83.42	79.79	32.31	31.32	19%	#1 Full Open, #2 Mid-Point
4:05 PM	83.37	79.78	32.30	31.39	19%	#1 Full Open, #2 Mid-Point
4:11 PM	83.34	79.75	32.36	31.45	17%	#1 Full Open, #2 Mid-Point
4:38 PM	83.24	79.72	32.41	31.48	16%	#1 Full Open, #2 Mid-Point, 9" on Fixed Weir
4:58 PM	83.20	79.68	32.45	31.47	16%	
5:03 PM	83.19	79.69	32.36	31.45	16%	
5:04 PM	83.19	79.68	32.36	31.41	16%	
5:11 PM	83.18	79.79	32.45	31.38	16%	
5:13 PM	83.17	79.81	32.35	31.35	16%	Shifted Between Readings 1 & 2 Full Open
5:42 PM	83.09	80.06	32.40	31.42	17%	All Angles Removed From Adjustable Weir Gates
6:01 PM	83.01	80.00	32.47	31.48	17%	
6:21 PM	82.96	80.00	32.42	31.47	17%	
6:32 PM	82.92	80.01	32.47	31.48	17%	
7:00 PM	82.84	79.88	32.39	31.47	17%	
7:30 PM	82.76	79.77	32.37	31.36	17%	
7:58 PM	82.70	79.68	32.39	31.32	17%	
8:31 PM	82.59	80.24	32.33	31.35	21%	1 & 2 Full Open, #3 Mid-Point
8:53 PM	82.53	80.14	32.32	31.34	21%	9:00 PM Shut Down #1 Unit 17.0 Generator

Time	Headwater Elevation	Fishway Pool #53 Elevation	Attraction Water Elevation	Tailwater Elevation	Roller Gate %	4 June 1987 Units #1 & #2 Efficiency 34 Megawatts
8:09 AM	83.15	79.74	30.83	29.96	35%	Gate Change # 1 & 2, Full Open
8:15 AM	83.11	80.16	31.28	30.24	30%	
8:30 AM	83.00	80.07	31.55	30.66	26%	
8:45 AM	82.91	80.05	31.86	30.89	24%	
9:00 AM	82.89	79.92	32.02	31.02	22%	
9:15 AM	82.82	79.88	32.01	31.10	21%	#1 & #2 Full Open
9:30 AM	82.77	79.79	32.09	31.17	20%	
9:34 AM	82.76	79.78	32.15	31.19	20%	
9:39 AM	82.74	79.77	32.09	31.20	20%	
9:44 AM	82.71	79.75	32.07	31.23	20%	
9:45 AM	82.70	79.74	32.13	31.24	20%	
9:47 AM	82.69	79.72	32.13	31.24	20%	
9:49 AM	82.68	79.71	32.17	31.24	19%	
9:54 AM	82.67	80.25	32.30	31.24	18%	
10:00 AM	82.64	80.22	32.29	31.26	18%	
10:15 AM	82.55	80.13	32.29	31.35	18%	
10:30 AM	82.50	80.18	32.31	31.37	18%	
10:45 AM	82.43	80.07	32.35	31.40	18%	
11:00 AM	82.38	80.03	32.38	31.38	18%	
11:15 AM	82.31	80.00	32.28	31.39	18%	Measured 12" Actual On Fixed Weir
11:29 AM	82.24	79.94	32.33	31.41	18%	#3 Mid-Point Weir Setting Low By A Tenth Foot
11:34 AM	82.21	79.92	32.35	31.41	18%	
11:38 AM	82.20	79.86	32.33	31.42	18%	
11:41 AM	82.19	79.86	32.30	31.42	18%	
11.44 AM	82.17	80.11	32.36	31.41	18%	Gate Change No Indication
11:49 AM	82.16	80.11	32.37	31.40	18%	#1, 2, 3 Full Open; Gate Change Light Change
12:00 PM	82.12	80.07	32.36	31.39	18%	
12:15 PM	82.04	80.04	32.32	31.40	18%	
12:30 PM	81.98	79.95	32.40	32.38	18%	
12.45 PM	81.91	79.88	32.37	31.40	18%	
1:00 PM	81.81	79.78	32.45	31.38	18%	
1:11 PM	81.75	79.70	32.44	31.48	18%	Lower #4 Top Limit By 0.1 Computer Registered 381.7
1:15 PM	81.72	79.70	32.50	31.54	18%	
1:23 PM	81.69	79.68	32.58	31.57	18%	
1:26 PM	81.67	80.20	32.50	31.57	18%	Gate Change @ 2 Min. After
1:30 PM	81.65	80.18	32.53	31.57	18%	Measured Weir @ 15" (#53)
1:49 PM	81.58	80.14	32.53	31.57	18%	
2:00 PM	81.55	80.09	32.49	31.54	18%	
2:54 PM	81.33	79.91	32.24	31.49	03%	
3.14 PM	81.25	79.80	32.41	31.52	03%	Operate Both TEW & MEW
3:30 PM	81.18	79.89	32.49	31.56	03%	
3:45 PM	81.10	79.82	32.60	31.64	02%	Maximum 79.92 - Gate Change Start Light MEW Open, TEW 51.5%
4:00 PM	81.03	79.76	32.57	31.67	02%	Reset TEW To 50%, MEW Open
4:15 PM	80.95	79.74	32.76	31.67	02%	
4:25 PM	80.90	80.15	32.64	31.69	02%	
4:30 PM	80.87	80.11	32.71	31.70	02%	#5 Shift To Mid-Point No Time Delay
4:45 PM	80.81	80.07	32.69	31.71	02%	
5:00 PM	80.78	80.07	32.40	31.50	0%	Shut Down #1 Unit Roller Gate Went Closed
5:07 PM	81.04	79.85	32.00	31.00	3%	Gate Switched, #5 Now Moved To Closed

The computer time delay begins to time when the set point reading is achieved by 0.01 feet. It appeared from the data that the gate time delay was too long on a constant pond draw down causing the fishway flow to decrease below the lower overflow limit. A program change from a 5 minute time delay to a 2-1/2 minute time delay should solve this problem. The Valve Company will make this change.

In addition to the data, Mr. Ben Rizzo of US Fish & Wildlife Service inspected the site from 3:00 PM to 4:00 PM on 4 June 1987. Mr. Rizzo requested:

1. Attraction water may be discontinued from dusk to dawn. Fishway Pool water must be continued throughout the fish run.

2. Weir overflow down the fish ladder was extreme in his opinion and should be reduced. Weir overflow will be adjusted by removing sufficient pieces of the orifice opening filler pieces to decrease the weir overflow. It is believed that removal of just the top and bottom filler pieces will achieve the required results. No adjustments to the pre-programed adjustable weir gates will be attempted.

3. Attraction water channel flow separation occurs at the MEW corner. Mr. Rizzo requested that the tailwater differential presently set at 1.0+ feet be re-programed to 0.5 feet. Re-programing the differential will be accomplished by TVC.

4. Mr. Rizzo required that the turbine entrance weir in conjunction with the MEW be operated when two unit discharges are present. The TEW was opened to 50% while the attraction water is supplied from the bypass system. The TEW will be opened full when Unit #3 is on line.

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Report appendices C – E are being filed simultaneously in a zipfile of Excel workbooks:

Appendix C: 2015 Compiled Salmonsoft click histories for Wilder, Bellows Falls, and Vernon fish ladders

Appendix D: 2015 Daily passage counts with graphic presentation for Wilder, Bellows Falls, and Vernon fish ladders

Appendix E: 2015 Hourly passage counts for Wilder, Bellows Falls, and Vernon fish ladders