Pejepscot Dam Impoundment & Tailrace- 2018 DO & Temp Profiles & Benthic Invertebrate Summary.

Source Topsham Hydro Partners Pejepscot Project Water Quality Study Report April 2020. FERC Project 4784. Comparable to FOMB FPU (upstream) & FPD (downstream) sites.

Figure 5.4-2: Dissolved Oxygen Profiles at the Project Impoundment, 2018

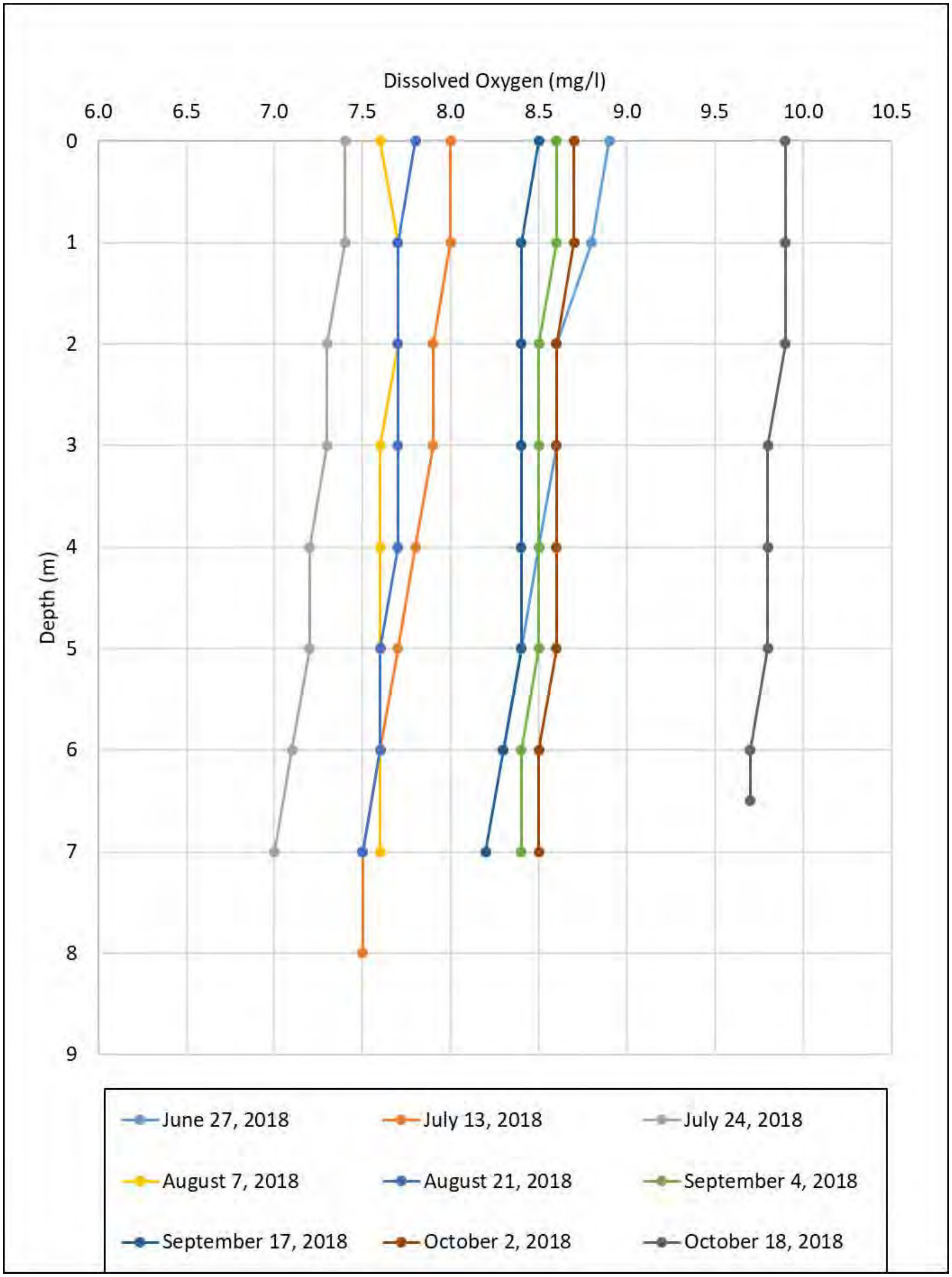


Figure 5.4-3: Dissolved Oxygen Percent Saturation Profiles at the Project Impoundment, 2018

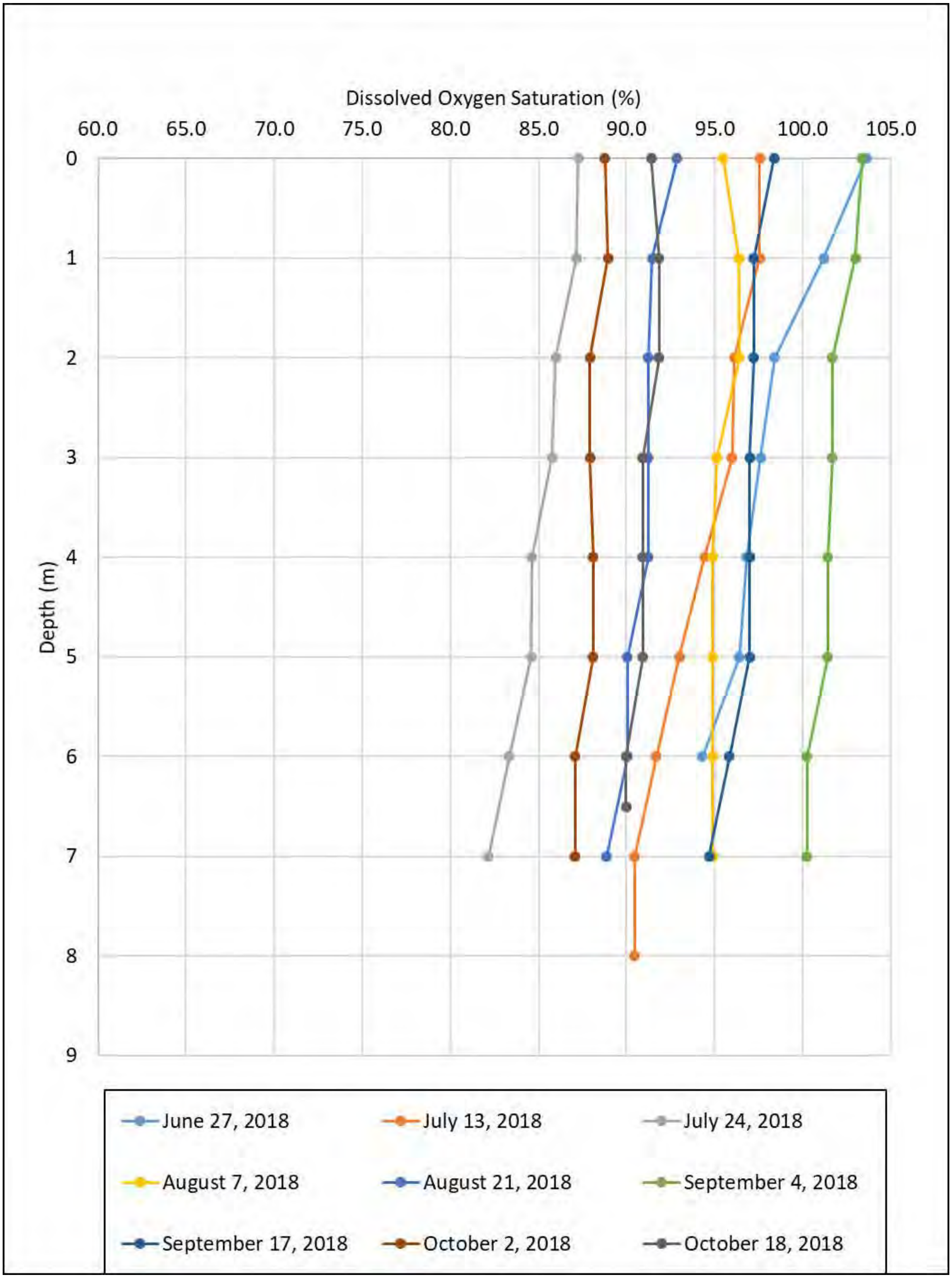
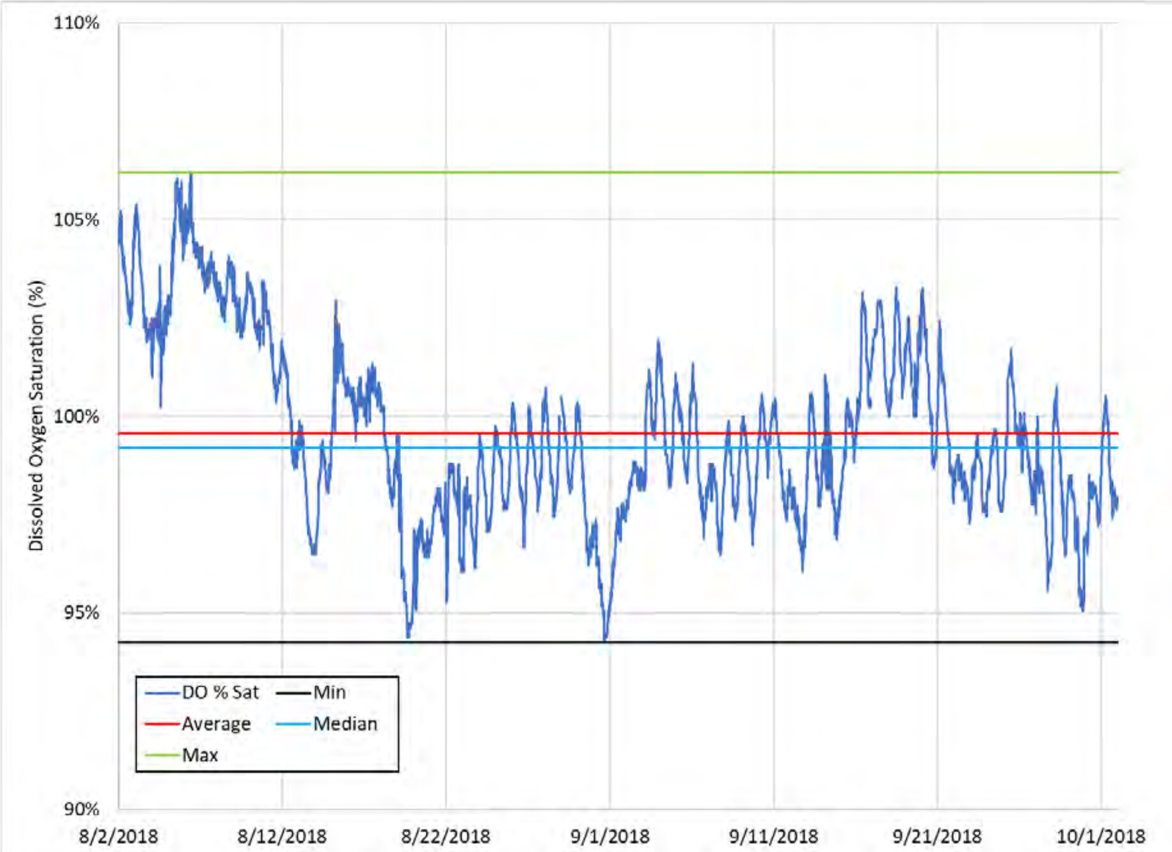


Figure 5.5.1-1: Continuous Water Temperature in the Project Tailwater, August 2 – October 2, 2018

Figure 5.5.2-1: Continuous Dissolved Oxygen in the Project Tailwater, August 2 – October 2, 2018

Figure 5.5.2-2: Continuous Dissolved Oxygen Percent Saturation in the Project Tailwater, August 2 – October 2, 2018



6.0 SUMMARY

The study results indicate that water quality at the Project was within the MDEP's state water quality standards. Water temperatures and dissolved oxygen were relatively uniform throughout the water column within the Project impoundment, which resulted in no summer stratification. Over the study period, water temperature within the Project impoundment ranged from 12.0 ºC (October) to 26.9 ºC (August).

Dissolved oxygen concentrations ranged from 7.0 mg/l (July) to 9.9 mg/l (October) and were above the minimum state standard for Class C waters (5.0 mg/l). The dissolved oxygen percent saturation in the Project impoundment ranged from 82.2 percent (July) to 103.6 (September) percent throughout the monitoring period. The dissolved oxygen percent saturation in the Project impoundment exceeded the established state standard of 60 percent saturation for Class C waters.

The water temperature in the Project tailwater ranged from 16.8 ℃ (October) to 27.3 ℃ (August) with an average of 23.5 ℃.

Dissolved oxygen concentrations in the Project tailwater ranged from 7.8 (August) to 9.7 mg/l (October) with an average of 8.5 mg/l. Observed concentrations were above the minimum state standard for Class C waters (5.0 mg/l). Dissolved oxygen percent saturation ranged from 94.3 to 106.2 percent with an average of 99.6 percent. These values were above the minimum state standard of 60 percent saturation for Class C waters.

The Project impoundment has relatively low levels of nutrients and does not support high densities of algal populations. Sampling data suggest that the Project impoundment is mesotrophic.

Impoundment & tailrace waters meet or exceed Class B DO standards. (FOMB comment).

Benthic Invertebrate Summary. Report Section Begins: Page 31

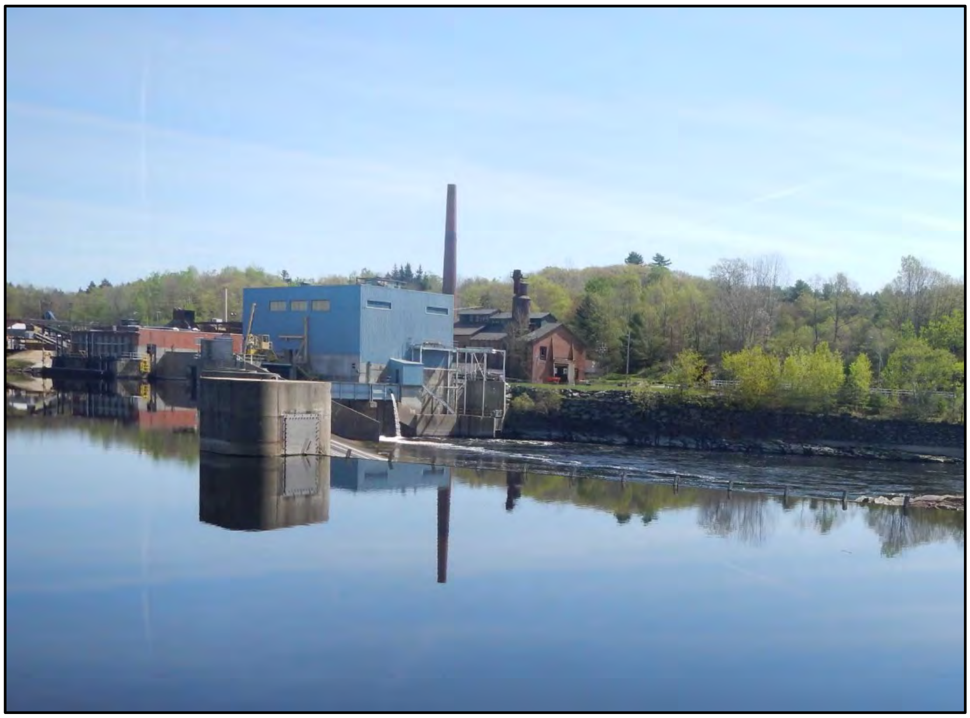
The estimate for the Pejepscot macroinvertebrate community is supportive of a water quality rating of "very good" (Hilsenhoff 1987)…. Normandeau provided taxonomic and habitat information to the MDEP on November 28, 2018 and MDEP returned a Classification Attainment Report on November 30, 2018 (see full report in Appendix B). **The final determination indicated that the macroinvertebrate community sampled downstream of Pejepscot during August 2018 met Class A standards.**

TOPSHAM HYDRO PARTNERS LIMITED PARTNERSHIP

UPDATED DRAFT STUDY REPORTS

PEJEPSCOT HYDROELECTRIC PROJECT

(FERC No. 4784)



Submitted by:

Brookfield Renewable
Topsham Hydro Partners Limited Partnership
150 Main Street
Lewiston, ME 04240

Prepared by:

Gomez and Sullivan Engineers

April 2020

Brookfield

TABLE OF CONTENTS

DRAFT UPDATED STUDY REPORT

WATER QUALITY STUDY

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)

Submitted by:

Brookfield Renewable
Topsham Hydro Partners Limited Partnership
150 Main Street
Lewiston, ME 04240

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Brookfield

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND DEFINITIONS

℃	Degrees Celsius
cfs	cubic feet per second
DO	Dissolved Oxygen
FERC	Federal Energy Regulatory Commission
HETL	Maine Health and Environmental Testing Laboratory
ILP	Integrated Licensing Process
m	meter
MDEP	Maine Department of Environmental Protection
ME	Maine
mg/L	Milligrams per liter
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
PAD	Pre-Application Document
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
PCU	Platinum Cobalt Units
RSP	Revised Study Plan
SD1	Scoping Document 1
SPD	Study Plan Determination
Topsham Hydro	Topsham Hydro Limited Partnership, L.P.
TSI	Trophic State Index
µS/cm	microSiemens/centimeter
ug/l	Micrograms per liter
USGS	United States Geological Survey

1.0 INTRODUCTION

Topsham Hydro Partners Limited Partnership (L.P.) (Topsham Hydro), an indirect member of Brookfield Renewable, is in the process of relicensing the 13.88-megawatt Pejepscot Hydroelectric Project (Project) (FERC No. 4784) with the Federal Energy Regulatory Commission (FERC or Commission). The Project is located on the Androscoggin River in the village of Pejepscot and the Town of Topsham, Maine (ME) to the east, the Town of Lisbon to the north, and the Town of Durham and the Town of Brunswick, ME to the west. The Project straddles the border between Cumberland and Sagadahoc counties and extends into Androscoggin County. The original license was issued on September 16, 1982 and expires on August 31, 2022.

Topsham Hydro is using FERC's Integrated Licensing Process (ILP) as established in regulations issued by FERC July 23, 2003 (Final Rule, Order No. 2002) and found at Title 18 Code of Federal Regulations, Part 5. Topsham Hydro filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to seek a new license for the Project on August 31, 2017.

Topsham Hydro distributed the PAD and NOI simultaneously to Federal and state resource agencies, local governments, Native American tribes, members of the public, and others thought to be interested in the relicensing proceeding. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on October 30, 2017. FERC also held agency and public scoping meetings on November 28, 2017 and a site visit on November 29, 2017. The FERC Process Plan and Schedule provided agencies and interested parties an opportunity to file comments on the PAD and SD1 and request studies by December 29, 2017. FERC subsequently issued Scoping Document 2 on February 5, 2018. Topsham Hydro filed a Proposed Study Plan on February 12, 2018 and held a Study Plan Meeting on March 22, 2018. The Revised Study Plan (RSP) was filed in accordance with the ILP schedule on June 12, 2018. FERC issued a Study Plan Determination (SPD) on July 3, 2018.

In the RSP, Topsham Hydro proposed to conduct the following water quality assessments: 1) trophic state study of the Project impoundment, and 2) riverine water quality sampling of the Project tailwater.

2.0 GOALS AND OBJECTIVES

The goal of the water quality assessment is to update baseline information and document water quality conditions upstream and downstream of the Project dam. The study objectives are to: 1) collect periodic water quality data in the Project impoundment, and 2) collect continuous water temperature and dissolved oxygen data in the Androscoggin River downstream of the Project dam during low flow, warm water temperature conditions.

3.0 STATE WATER QUALITY STANDARDS

The Androscoggin River is classified by MDEP as Class C from its confluence with the Atlantic Ocean at Merrymeeting Bay, upstream, through Project waters, until its confluence with the Ellis River at Rumford Point in Maine about 75 miles upstream of the Project. Class C waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment, fishing, agriculture, recreation in and on the water, industrial process and cooling water supply, hydroelectric power generation (except as prohibited under Title 12, section 403), navigation, and as a habitat for fish and other aquatic life.

The dissolved oxygen content of Class C water may be no less than 5 mg/l or 60% of saturation, whichever is higher, except in identified salmonid spawning areas where water quality is sufficient to ensure spawning, egg incubation, and survival of early life stages. Water quality in these areas must be sufficient for these purposes to be maintained.

Per the state standards, discharges to Class C waters may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.

4.0 METHODS

4.1 Impoundment Trophic Sampling

Trophic sampling was conducted in accordance with the Lake Trophic State Sampling Protocol for Hydropower Studies (MDEP, 2017), and was consistent with Maine Department of Environmental Protection (MDEP) protocols. Sampling personnel received MDEP certification to collect water quality data prior to performing the sampling activities.

4.1.1 Vertical Profiles

Vertical profiles were collected twice per month from June[1] through October 2018 at the deepest location of the impoundment (see AR-01[2], Figure 4.1-1). Topsham Hydro installed a temporary buoy to mark the sampling station for the open water sampling season.

Water temperature and dissolved oxygen profile data were collected at 1-meter intervals from the water surface to the bottom using a YSI ProDSS Multiparameter Water Quality Meter. The instrument was checked prior to each use and calibrated according to manufacturer specifications. One replicate profile measurement was made for every profile collected. Replicates were obtained outside of the metalimnion (if applicable) to avoid remeasuring parameters when they are in a transitional state. A profile was remeasured if replicate values were not within 0.3 mg/l and 0.3 °C, as stated in the Volunteer Lake Monitoring Program instructions or within water quality meter instrumentation error value.

4.1.2 Water Clarity

Water clarity was measured at the impoundment sampling location during each field visit using a Secchi disk and Aquascope. The depth at which the Secchi disk was no longer visible through

[1] The study was not initiated until late June, therefore; Topsham Hydro was only able to conduct one trophic sampling event during the month of June, rather than two.

[2] The buoy was initially installed on June 27, 2018; however, before the July 13, 2018 sampling event the location of the buoy was moved slightly south to an area of slightly deeper water (~1 meter).

the Aquascope was recorded. At least two Secchi disk measurements were made during each field visit and the results were averaged.

4.1.3 Water Quality Sample Parameters

The water quality profile data and Secchi disk readings were used to determine the depth of the epilimnion and the associated core sampling depth. Water samples were collected each visit from the epilimnion using an integrated core sampler at a depth between the surface and two times the Secchi disk depth, or within 1 meter of the bottom, whichever was less, if the impoundment was unstratified.

Per MDEP protocols, all water samples were stored on ice and delivered within 24 hours to the state of Maine's Health and Environmental Testing Laboratory (HETL) in Augusta, ME for analysis of total alkalinity, color, pH, chlorophyll-a, and total phosphorus.

On August 23, 2018, Topsham Hydro collected and submitted additional water samples to HETL for analysis of nitrate and dissolved organic carbon. In addition, samples for chloride, sulfate, specific conductance, total calcium, total iron, total magnesium, total potassium, total silica[3], total sodium, and total dissolved aluminum were submitted to Eastern Analytical, Inc. in Concord, New Hampshire for analysis. The water column was not stratified during the August 23 sampling; thus, per MDEP protocols, an integrated epilimnetic core sample was collected at a depth between the surface and two times the Secchi disk depth, or within 1 meter of the bottom, whichever was less. The MDEP detection limits for all analytes are shown in Table 4.1-1.

4.2 Downstream Water Temperature and Dissolved Oxygen Monitoring

Topsham Hydro monitored water temperature and dissolved oxygen downstream of the Project dam in accordance with the MDEP Sampling Protocol for Hydropower Studies (MDEP, 2017). A location within the Project tailwater (see AR-02 in Figure 4.1-1) was monitored continuously from August 2 to October 2, 2018.

During deployment, dissolved oxygen measurements, using a YSI Handheld Optical Dissolved Oxygen Meter were initially made at AR-02 along a transect across the stream, at the first, second and third quarter points, to determine if there were significant differences (defined by MDEP as ±0.2 mg/l) in dissolved oxygen concentration (Table 4.2-1). There were no violations of dissolved oxygen criteria and no significant differences in concentrations among the quarter points, therefore, the water quality meter was deployed in the location of the main river flow, per MDEP protocols.

The water quality meter (HOBO U26 with temperature and optical dissolved oxygen sensor) was set to record temperature and dissolved oxygen in 15-minute increments continuously throughout the study period. The meter was deployed at approximately mid-depth within the water column.

[3] In an email received on June 30th, 2018, MDEP informed Topsham Hydro that it was making an adjustment to the MDEP Sampling Protocol for Hydropower Studies. Specifically, MDEP was no longer requiring a late summer sample for silica; as this parameter was being removed from the protocol. Since this particular study was already initiated, Topsham Hydro completed the sampling and testing of the silica parameter anyway.

The meter was cleaned, maintained, and offloaded per manufacturer recommendations regularly throughout the study period.

The dissolved oxygen percent saturation was calculated from measured dissolved oxygen concentration, barometric pressure, and measured water temperature using the U.S. Geological Survey (USGS) DOTABLES program. Barometric pressure was obtained from the Portland Jetport, ME National Oceanic and Atmospheric Administration (NOAA) climate station (NOAA, 2018).

4.3 Equipment Specifications

Vertical profile measurements, periodic spot checks, and discrete measurements were collected with a portable hand held multiparameter meter. The meter used for this study for dissolved oxygen and temperature was the YSI ProDSS multiparameter meter. The equipment performance specifications are shown in Table 4.3-1.

Continuous water temperature and dissolved oxygen measurements were collected with Onset HOBO Dissolved Oxygen Loggers (Model U26-001). The equipment performance specifications are shown in Table 4.3-2.

Table 4.1-1: Water Quality Parameter Detection Limits

Parameter	Detection Limit
Field Parameters	
Secchi disk transparency	0.1 m
Temperature	0.1℃
Dissolved Oxygen	0.1 mg/l
Twice Monthly Lab Analytes	
Total phosphorus	0.001 mg/l
Chlorophyll a	0.001 mg/l
Color	1.0 SPU
pH	0.1 SU
Total alkalinity	1.0 mg/l
One-Time Late Summer Sample Analytes	
Total phosphorus	0.001 mg/l
Chlorophyll a (uncorrected*)	0.002 mg/l
Color	1.0 SPU
pH	0.1 SU
Total alkalinity	1.0 mg/l
Nitrate	0.01 mg/l
Dissolved Organic Carbon	0.25 mg/l
Total iron	0.005 mg/l
Total and dissolved aluminum	0.010 mg/l
Total calcium	1.0 mg/l
Total magnesium	0.1 mg/l
Total sodium	0.05 mg/l
Total potassium	0.05 mg/l
Total silica	0.05 mg/l
Specific conductance	1 µS/cm
Chloride	1.0 mg/l
Sulfate	0.5 mg/l

* Chlorophyll a is not needed in stratification samples below the epilimnion. Uncorrected chlorophyll a will be tested via trichromatic determination

Source: MDEP, 2017

Table 4.2-1: Initial Water Temperature and Dissolved Oxygen Measurements made at Deployment, August 2, 2018, Downstream of Pejepscot Dam.

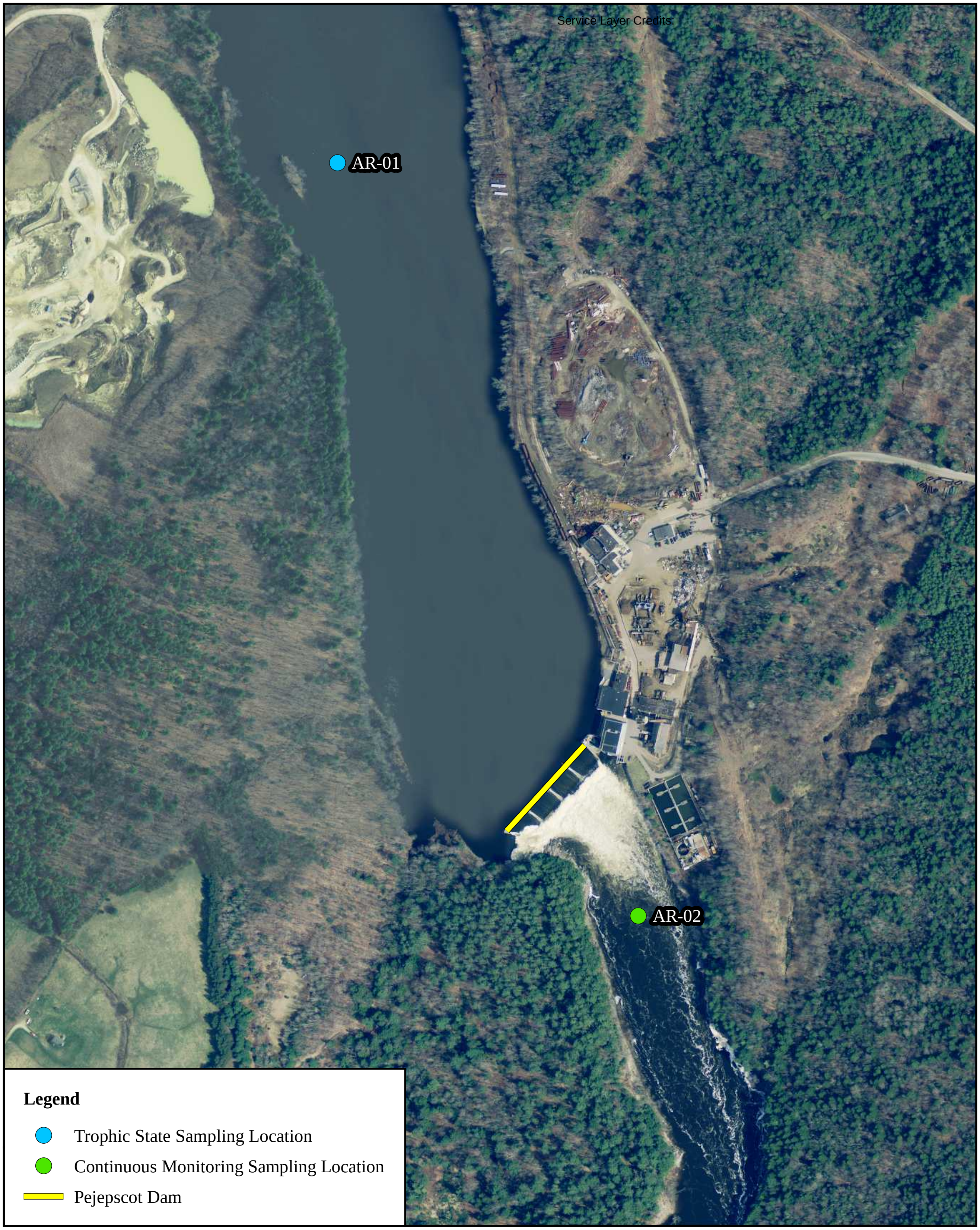
Point	Water Temperature (°C)	Dissolved Oxygen (mg/l)	Dissolved Oxygen Percent Saturation
River Right (25%)	26.1	8.23	101.6
Center (50%)	26.0	8.37	103.2
River Left (75%)	25.9	8.23	101.3

Table 4.3-1: YSI Hand Held Meter Specifications

Parameter	Range	Accuracy	Resolution
Dissolved Oxygen (YSI)	0 to 50 mg/l	0-20 mg/l: ± 0.1 mg/L 20-50 mg/l: ± 8% of the reading	0.01 mg/l
Temperature (YSI)	-5 to +70°C	±0.2°C	0.1°C

Table 4.3-2: HOBO U26-001 Dissolved Oxygen Logger Specifications

Parameter	Range	Accuracy	Resolution
Dissolved Oxygen	0 to 30 mg/l	0.2 mg/l up to 8 mg/l; 0.5 mg/l from 8 to 20 mg/l	0.02 mg/l
Temperature	-5 to +40°C	±0.2°C	0.02°C



Brookfield

N

0 125 250 500 Feet

Pejepscot Hydroelectric Project
(FERC No. 4784)
Water Quality Study

Figure 4.1-1:
Water Quality Sampling Locations

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5.0 RESULTS

5.1 Environmental Conditions

River flow ranged from a low of 1,876 cubic feet per second (cfs) on June 23, 2018 to a high of 6,718 cfs on August 6, 2018 during the study period (Figure 5.1-1). Throughout the majority of the study period, river flow was below the long-term median daily value (Figure 5.1-1).

Monthly air temperatures for the 2018 study period as recorded at the Durham, ME monitoring station are presented in Table 5.1-1 (NOAA, 2018). Monthly mean air temperatures during the study period were warmer than the historic period of 1994 to 2018 for the months of July, August, and September, whereas air temperatures in the months of June and October were cooler. Based on these circumstances, sampling conditions were suitable for monitoring in accordance with MDEP protocols (e.g., low flow, high temperature conditions).

5.2 Impoundment Sampling

5.2.1 Total Phosphorus

Phosphorus is one of the major nutrients needed for plant growth. Since it's natural occurrence in lakes is very low, phosphorus limits the growth of algae in lake ecosystems. Small increases in phosphorus in lake water can cause substantial increases in algal growth (MDEP, 2014). In the Project impoundment, total phosphorus ranged from 13 to 23 ug/l with an average 19 ug/l (Table 5.2-1). Total phosphorus levels were below the proposed state standard upper limit of 33 ug/l for Class C waters (MDEP, 2012).

5.2.2 Color

The amount of color in a lake refers to the concentration of natural dissolved organic acids such as tannins and lignins, which give the water a tea color. Water with a color value greater than 25 platinum cobalt units (PCU) is considered to be colored and may have a reduced Secchi disk transparency (MDEP, 2014). In the Project impoundment, color ranged from 28 to 46 PCU with an average of 35 PCU (Table 5.2-1) suggesting that the impoundment was slightly colored.

5.2.3 Chlorophyll-a

Chlorophyll-a is a measurement of the green pigment found in all plants including microscopic plants such as algae. It is used as an estimate of algal biomass, the higher the Chlorophyll-a number the higher the amount of algae in the lake. Large concentrations of chlorophyll-a can be an indication of eutrophication that can adversely affect lacustrine or riverine processes or dissolved oxygen concentrations (MDEP, 2014). Throughout the 2018 sampling, chlorophyll-a ranged from 0.001 mg/l to 0.004 mg/l with an average of 0.003 mg/l (Table 5.2-1). Chlorophyll-a was below the proposed state standard upper limit of 0.008 mg/l (MDEP, 2012).

5.2.4 Alkalinity

Alkalinity is a measure of the capacity of water to neutralize acids and is also known as the buffering capacity. It is due primarily to the presence of naturally available bicarbonate, carbonate, and hydroxide ions, with bicarbonate being the major form. Water bodies with alkalinity values less than 10 mg/l are considered poorly buffered (MDEP, 2014). Total alkalinity in the Project impoundment ranged from 14 mg/l to 22 mg/l with an average of 18 mg/l (Table 5.2-1).

5.2.5 pH

pH is a measure of the acidity of water and regulates the biological processes that may occur in a water body. pH ranged from 6.9 to 7.2 with an average of 7.1 (Table 5.2-1). All pH values were within the recommended range of 6.0 to 8.5 for Class C waters.

5.2.6 Secchi Disk

Secchi disk transparency is a measure of the water clarity, or transparency, of a waterbody. Factors which reduce clarity are algae, zooplankton, water color and silt. Since algae are generally the most abundant, measuring transparency indirectly measures the algal productivity (MDEP, 2014). In the Project impoundment, the Secchi disk transparency ranged from 2.42 to 4.66 meters with an average of 3.98 meters (Table 5.2-1). The Secchi disk transparency was above the proposed standard of 2.0 m throughout the sampling period (MDEP, 2012).

5.2.7 Trophic State

Total phosphorus, chlorophyll-a, and Secchi disk transparency are often used as indicators of trophic state, or the biological productivity in a water body, particularly a lake (MDEP, 2014). An oligotrophic lake is characterized as having low productivity, a mesotrophic lake has medium productivity, and a eutrophic lake is highly productive. Table 5.2-2 lists the criteria used to classify the trophic state of lakes in Maine (MDEP, 2014).

The Maine Trophic State Index (TSI) for lakes can be calculated as (MDEP, 1996):

$$TSI = 70*\log(\text{mean chlorophyll-a} + 0.7)$$

Using the average chlorophyll-a concentration for the entire sampling period (0.003 mg/l) (Table 5.2-1), the TSI for the Project impoundment is 36, which is categorized as mesotrophic. In addition, the range of chlorophyll-a and total phosphorus values measured in the Project impoundment are within the ranges for mesotrophic waters (Table 5.2-2).

5.3 Late Summer Sampling

5.3.1 Specific Conductance

Specific conductance is a measure of the ability of water to carry an electrical current and is directly related to the dissolved ions (charged particles) present in water. Specific conductance will increase if there is an increase of pollutants entering the lake or pond (MDEP, 2014). Specific conductance was measured for the August 21, 2018 lake trophic core sample. The value was 83 µS/cm.

5.3.2 Dissolved Metals and Nutrients

Table 5.3.2-1 lists the concentrations of metals and nutrients from the August 21, 2018 sampling event within the Project impoundment. Iron (0.27 mg/l) and chloride (9.1 mg/l) concentrations were below the established state standards, which are 1 mg/l and 230 mg/l, respectively. Aluminum (0.050 mg/l) was below the standard of 0.087 mg/l. All other parameters do not have an established standard.

5.4 Impoundment Water Temperature and Dissolved Oxygen Profiles

The water temperature at the lake trophic sample site ranged from 21.6ºC to 23.1ºC during the first profile (June 27) and then increased steadily until August 7, when the highest water temperatures occurred (26.6ºC to 26.9ºC) (Figure 5.4-1). The maximum water temperature during the study (26.9ºC) was measured on August 7 just below the surface; the next highest temperature (25.9ºC) was measured on July 13 just below the surface (Figure 5.4-1). The water temperature steadily decreased throughout late August, September, and October and ranged from 12.0 ºC to 12.2ºC during the last profile (collected on October 18) (Figure 5.4-1). The average water temperature throughout the water column at the lake trophic station ranged from 12.2 ºC on October 18th to 26.7 ºC on August 7.

Throughout the monitoring period, the dissolved oxygen concentration at the lake trophic station ranged from 7.0 mg/l to 9.9 mg/l (Figure 5.4-2). The minimum dissolved oxygen concentration was 7.0 mg/l at a depth of 7 meters on July 24 (Figure 5.4-2). The highest dissolved oxygen concentrations at the lake trophic station ranged from 9.7 mg/l to 9.9 mg/l on October 18. The average dissolved oxygen concentration throughout the water column ranged from 7.2 mg/l on July 24 to 9.8 mg/l on October 18. The dissolved oxygen concentration exceeded the established state standard of 5 mg/l for Class C waters.

The dissolved oxygen percent saturation ranged from 82.2 percent to 103.6 percent throughout the monitoring period (Figure 5.4-3). The highest dissolved oxygen percent saturation value was measured on June 27 (103.6 percent) at the surface (Figure 5.4-3). The average dissolved oxygen percent saturation throughout the water column ranged from 85.1 percent on July 27 to 101.6 percent on September 4. The dissolved oxygen percent saturation exceeded the established state standard of 60 percent saturation for Class C waters.

5.5 Riverine Sampling

5.5.1 Water Temperature

The water temperature in the Project tailwater ranged from 16.8ºC to 27.3ºC with an average of 23.5ºC throughout the sampling period (August 2 – October 2) (Figure 5.5.1-1). The minimum temperature in the Project tailwater was recorded on October 2 at 2:15 pm, and the highest temperature was observed on August 7 at 5:00pm.

5.5.2 Dissolved Oxygen

Hourly dissolved oxygen concentrations in the Project tailwater ranged from 7.8 to 9.7 mg/l with an average of 8.5 mg/l over the monitoring period (Figure 5.5.2-1). Dissolved oxygen percent saturation ranged from 94.3 to 106.2 percent with an average of 99.6 percent (Figure 5.5.2-2).

Table 5.1-1: 2018 and Historic Mean Monthly Air Temperature Recorded at the Durham, ME Monitoring Station

Temperature (°C)	June	July	August	September	October
2018	15.9	20.7	21.1	16.2	7.4
Mean (1994-2018)	17.0	20.1	19.3	15.2	8.7
Difference	-1.1	0.6	1.8	1.0	-1.3

Table 5.2-1: Epilimnetic Core Sample Results

Sample Date	Sample Time	Total Phosphorus (ug/l)	Chlorophyll-a (mg/l)	Total Alkalinity (mg/l)	Color (PCU)	pH	Secchi Disk (meters)
6/27/2018	11:50	19	0.004	18	28	7.1	3.91
7/13/2018	12:07	23	0.003	22	32	7.1	3.89
7/24/2018	13:55	19	0.003	20	32	7.0	4.11
8/7/2018	10:04	19	0.002	14	42	6.9	3.55
8/21/2018	10:27	20	0.002	14	46	6.9	4.30
9/4/2018	11:05	19	0.002	17	30	7.2	4.63
9/17/2018	11:11	13	0.001	18	29	7.2	4.66
10/2/2018	13:25	20	0.002	22	34	7.0	4.34
10/18/2018	12:25	21	0.004	17	40	7.1	2.42
Average		**19**	**0.003**	**18**	**35**	**7.1**	**3.98**
Median		**19**	**0.002**	**18**	**32**	**7.1**	**4.11**
Minimum		**13**	**0.001**	**14**	**28**	**6.9**	**2.42**
Maximum		**23**	**0.004**	**22**	**46**	**7.2**	**4.66**

Table 5.2-2: Criteria for Classifying the Trophic State of Lakes in Maine

Trophic State	Chlorophyll-a (mg/l)	Total Phosphorus (mg\l)	Secchi disk (m)
Oligotrophic	<0.0015	<0.0045	>8
Mesotrophic	0.0015-0.007	0.0045-0.02	4-8
Eutrophic	>0.007	>0.02	<4

Table 5.3.2-1: Late Summer Sampling Parameter Concentrations in the Project Impoundment, August 21, 2018.

Parameter	Units	Value
Nitrate	mg/l	0.14
Dissolved Organic Carbon	mg/l	7.1
Specific conductance	µS/cm	83
Chloride	mg/l	9.1
Sulfate	mg/l	7.6
Total dissolved aluminum	mg/l	0.05
Total Calcium	mg/l	4.6
Total Iron	mg/l	0.27
Total Magnesium	mg/l	0.87
Total Potassium	mg/l	1.0
Total Silica (calculated)	mg/l	4.8
Total Sodium	mg/l	9.8

Table 5.4.1: Temperature and Dissolved Oxygen Profiles at Project Impoundment - Results

Depth (m)	6/27/2018		7/13/2018[4]		7/24/2018		8/7/2018		8/21/2018	
	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)
0	23.1	8.9	25.9	8.0	24.2	7.4	26.9	7.6	24.4	7.8
1	22.3	8.8	25.9	8.0	24.1	7.4	26.7	7.7	24.3	7.7
2	22.0	8.6	25.8	7.9	24.1	7.3	26.7	7.7	24.2	7.7
3	21.8	8.6	25.7	7.9	24.0	7.3	26.7	7.6	24.2	7.7
4	21.7	8.5	25.5	7.8	24.0	7.2	26.6	7.6	24.2	7.7
5	21.7	8.4	25.4	7.7	24.0	7.2	26.6	7.6	24.2	7.6
6	21.6	8.3	25.3	7.6	23.9	7.1	26.6	7.6	24.2	7.6
7			25.3	7.5	23.9	7.0	26.6	7.6	24.2	7.5
8			25.3	7.5						

Depth (m)	9/4/2018		9/17/2018		10/2/2018		10/18/2018	
	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)
0	25.1	8.6	22.8	8.5	16.7	8.7	12.0	9.9
1	24.9	8.6	22.8	8.4	16.8	8.7	12.2	9.9
2	24.8	8.5	22.8	8.4	16.8	8.6	12.2	9.9
3	24.8	8.5	22.7	8.4	16.8	8.6	12.2	9.8
4	24.7	8.5	22.7	8.4	16.9	8.6	12.2	9.8
5	24.7	8.5	22.7	8.4	16.9	8.6	12.2	9.8
6	24.7	8.4	22.7	8.3	16.9	8.5	12.2	9.7
7	24.7	8.4	22.7	8.2	16.9	8.5	12.2	9.7

[4] The buoy was initially installed on June 27, 2018; however, before the July 13, 2018 sampling event the location of the buoy was moved slightly south to an area of slightly deeper water (~1 meter).

Figure 5.1-1: River Flow at USGS Gage No. 1059000 Androscoggin River near Auburn, ME prorated to the Project

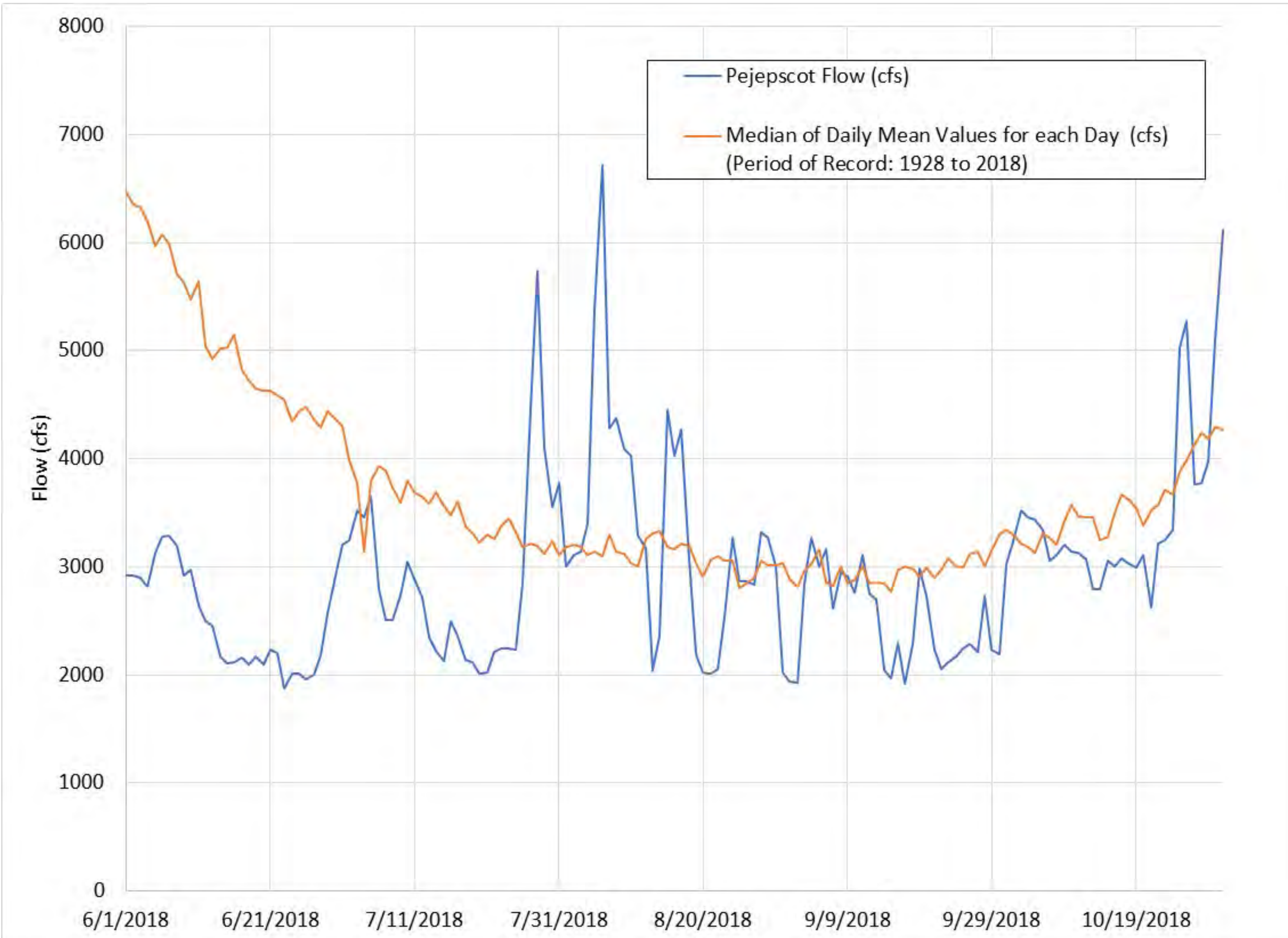


Figure 5.4-1: Water Temperature Profiles at the Project Impoundment, 2018

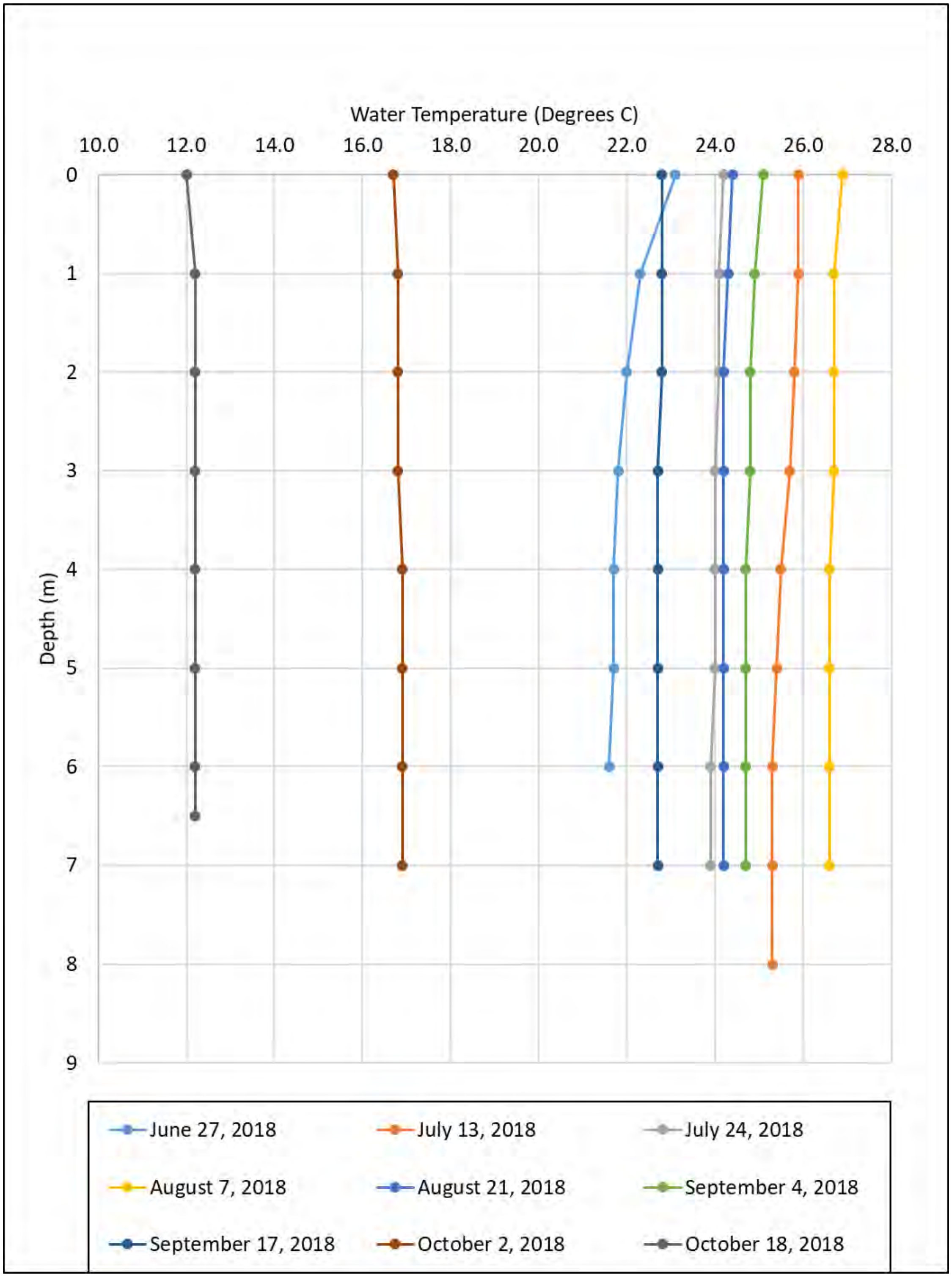


Figure 5.4-2: Dissolved Oxygen Profiles at the Project Impoundment, 2018

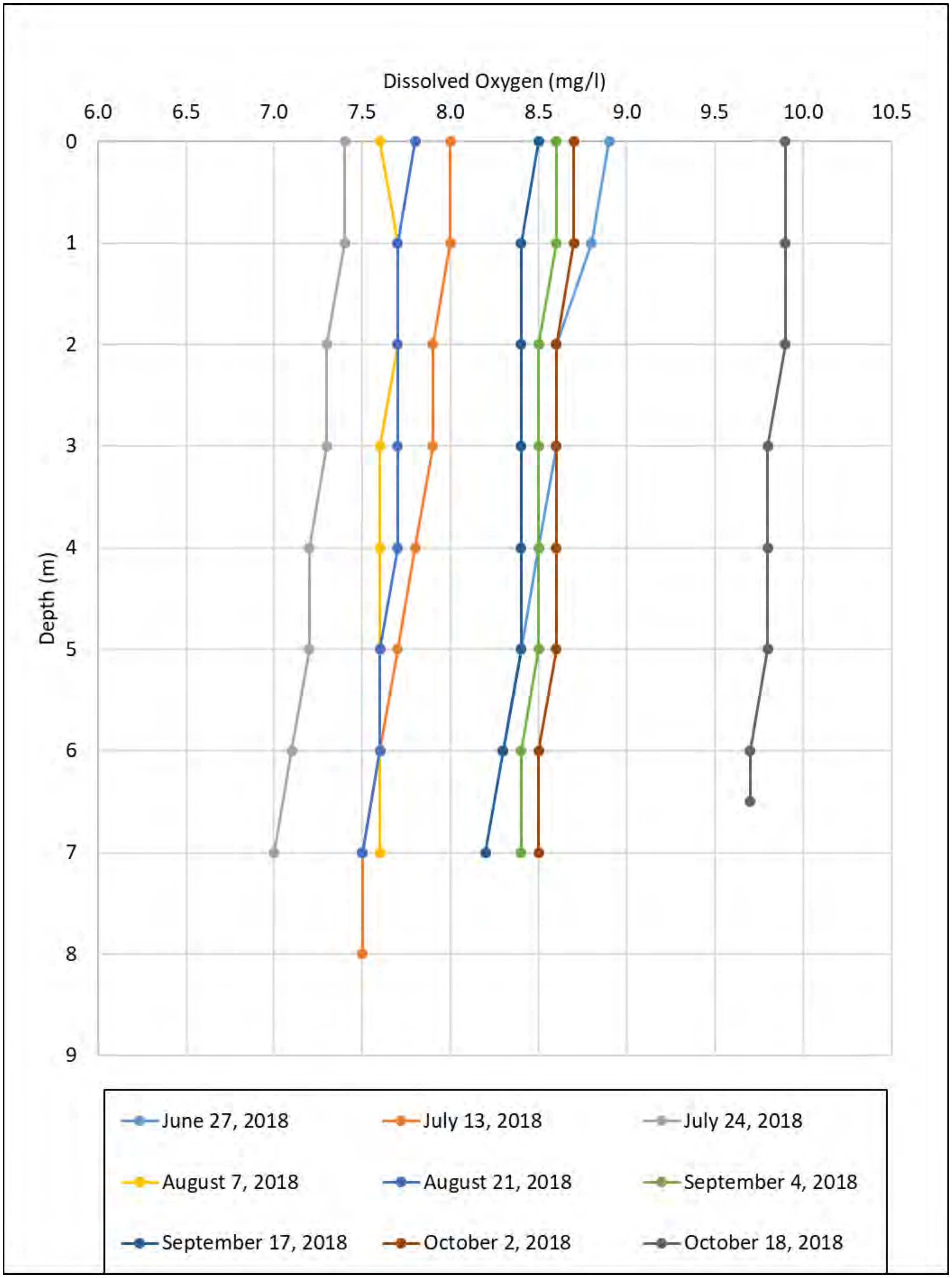


Figure 5.4-3: Dissolved Oxygen Percent Saturation Profiles at the Project Impoundment, 2018

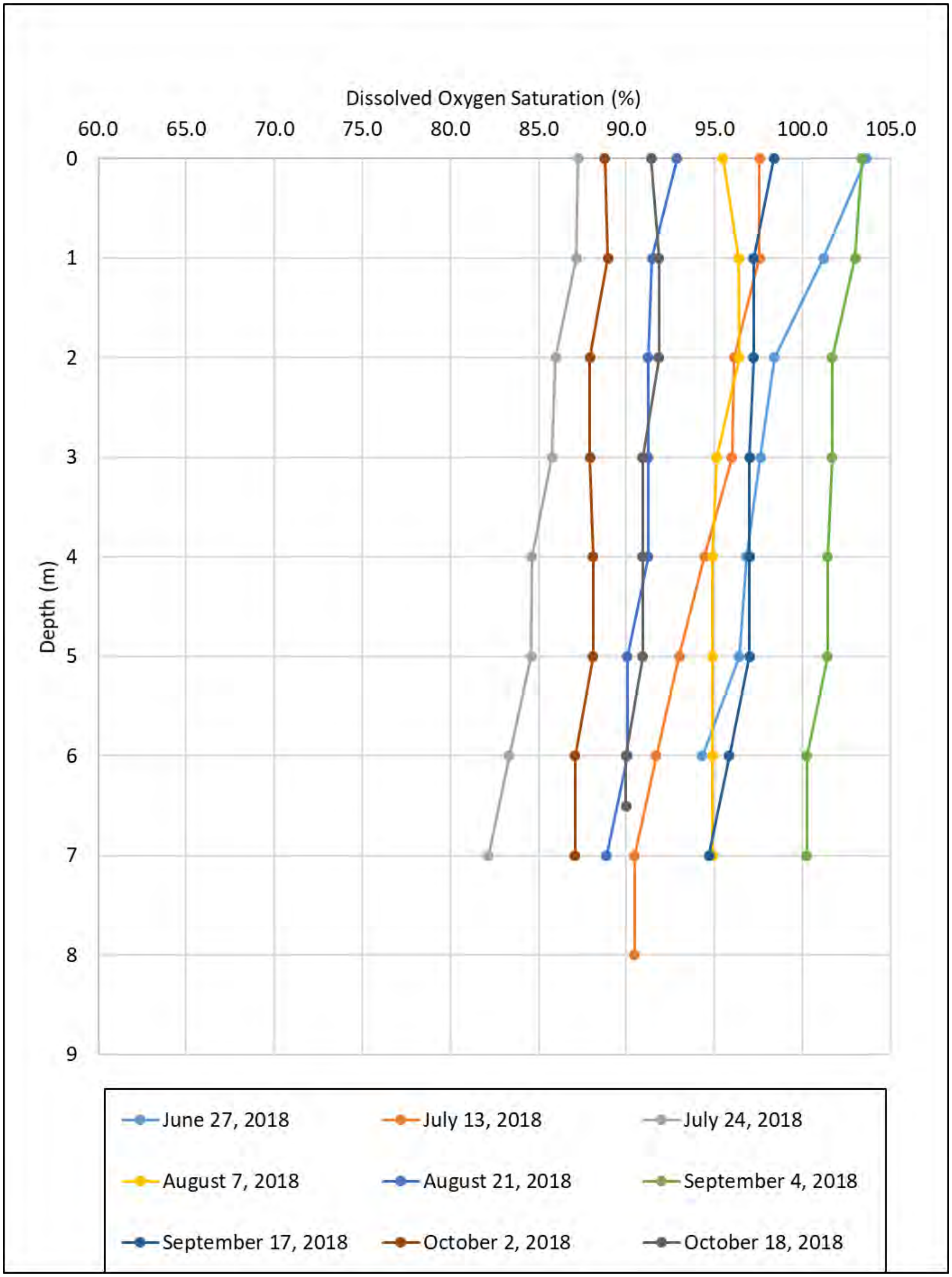
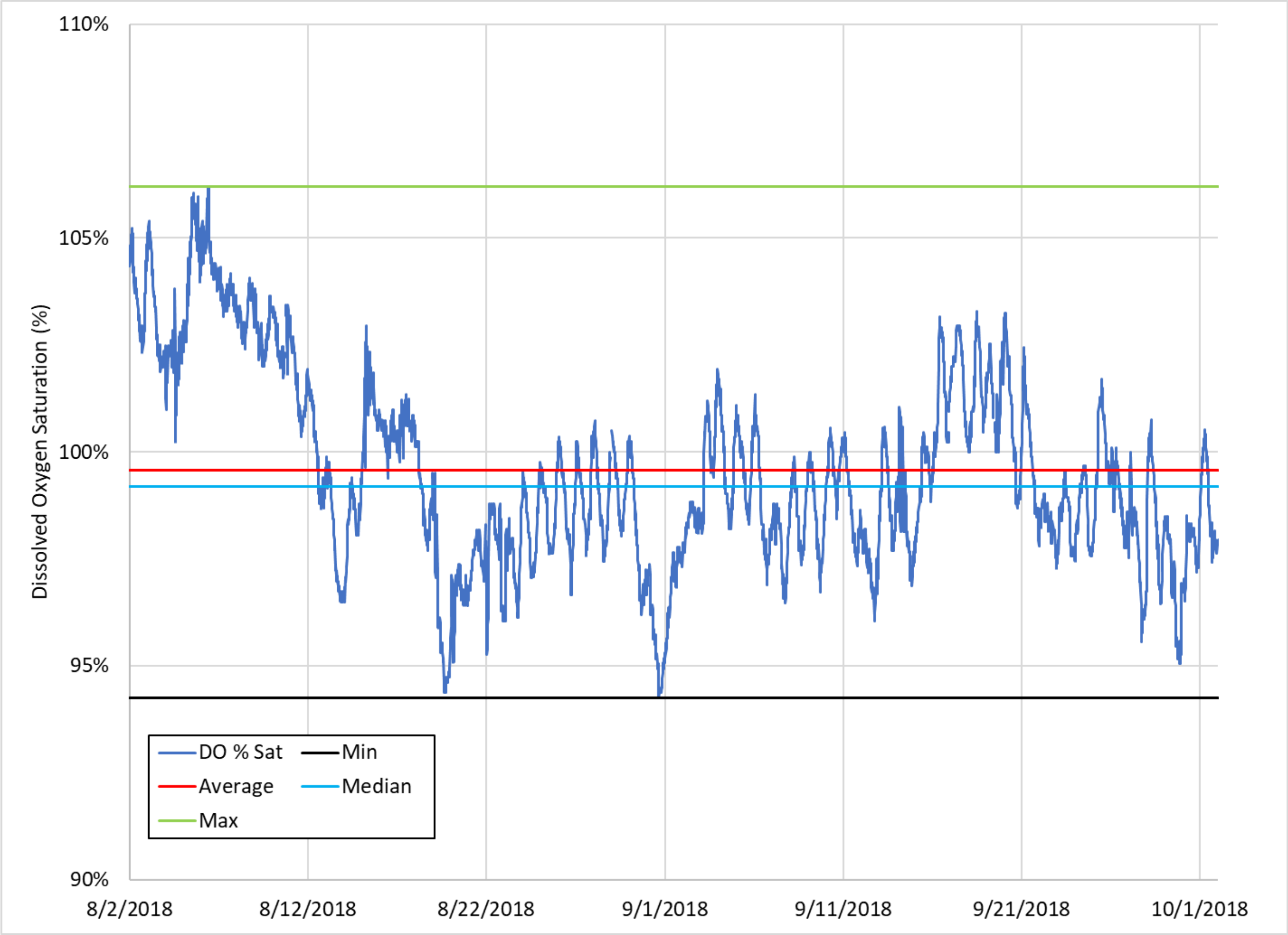


Figure 5.5.1-1: Continuous Water Temperature in the Project Tailwater, August 2 – October 2, 2018

Figure 5.5.2-1: Continuous Dissolved Oxygen in the Project Tailwater, August 2 – October 2, 2018

Figure 5.5.2-2: Continuous Dissolved Oxygen Percent Saturation in the Project Tailwater, August 2 – October 2, 2018



6.0 SUMMARY

The study results indicate that water quality at the Project was within the MDEP's state water quality standards. Water temperatures and dissolved oxygen were relatively uniform throughout the water column within the Project impoundment, which resulted in no summer stratification. Over the study period, water temperature within the Project impoundment ranged from 12.0 ºC (October) to 26.9 ºC (August). Dissolved oxygen concentrations ranged from 7.0 mg/l (July) to 9.9 mg/l (October) and were above the minimum state standard for Class C waters (5.0 mg/l). The dissolved oxygen percent saturation in the Project impoundment ranged from 82.2 percent (July) to 103.6 (September) percent throughout the monitoring period. The dissolved oxygen percent saturation in the Project impoundment exceeded the established state standard of 60 percent saturation for Class C waters.

The water temperature in the Project tailwater ranged from 16.8 ºC (October) to 27.3 ºC (August) with an average of 23.5 ºC. Dissolved oxygen concentrations in the Project tailwater ranged from 7.8 (August) to 9.7 mg/l (October) with an average of 8.5 mg/l. Observed concentrations were above the minimum state standard for Class C waters (5.0 mg/l). Dissolved oxygen percent saturation ranged from 94.3 to 106.2 percent with an average of 99.6 percent. These values were above the minimum state standard of 60 percent saturation for Class C waters.

The Project impoundment has relatively low levels of nutrients and does not support high densities of algal populations. Sampling data suggest that the Project impoundment is mesotrophic.

7.0 VARIANCES FROM THE FERC APPROVED STUDY PLAN

The study was not initiated until late June. Therefore, Topsham Hydro was only able to conduct one trophic sampling event during the month of June, rather than two. In addition, Unit 1 was offline for the duration of the study while undergoing maintenance. Inflow was passed over the spillway during this time.

8.0 REFERENCES

Maine Department of Environmental Protection (MDEP). 1996. 06-096 Chapter 581 Regulations Relating to Water Quality Evaluations. May 4, 1996 http://www.maine.gov/dep/water/wd/general.html.

Maine Department of Environmental Protection (MDEP). 2012. Draft Chapter 583 Nutrient Criteria for Surface Waters. June 12, 2012. https://www.maine.gov/dep/water/nutrient-criteria/chapter583-6-12-2012.pdf

Maine Department of Environmental Protection (MDEP). 2014. Maine Volunteer Lake Monitoring Program Maine Lakes Report 2013. http://www.mainevlmp.org/maine-lake-report/

Maine Department of Environmental Protection (MDEP). 2017. DEP Sampling Protocol for Hydropower Studies. December 2017.

National Oceanic and Atmospheric Administration (NOAA) 2018. [Online] URL: (https://w2.weather.gov/climate/xmacis.php?wfo=gyx). Accessed November 2018.

DRAFT UPDATED STUDY REPORT

TAILWATER BENTHIC MACROINVERTEBRATE SURVEY

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)

Submitted by:

Brookfield Renewable
Topsham Hydro Partners Limited Partnership
150 Main Street
Lewiston, ME 04240

Prepared by:

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

April 2020

Brookfield

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND DEFINITIONS

EPT	Ephemeroptera, Plecoptera, and Trichoptera
FERC	Federal Energy Regulatory Commission
HBI	Hilsenhoff Biotic Index
MDEP	Maine Department of Environmental Protection
ME	Maine
mg/L	Milligrams per liter
Normandeau	Normandeau Associates, Inc.
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
RSP	Revised Study Plan

1.0 INTRODUCTION

A survey of benthic macroinvertebrates was conducted in support of the relicensing of the Pejepscot Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 4784, as identified in the Revised Study Plan (RSP) submitted by Topsham Hydro Partners Limited Partnership (Topsham) on June 12, 2018 and approved by the FERC in its Study Plan Determination letter dated July 3, 2018. This is a report for the 2018 study efforts of the Tailwater Benthic Macroinvertebrate Survey. The majority of work for this study was conducted by Normandeau Associates, Inc. (Normandeau). The Maine Department of Environmental Protection (MDEP) was provided with a listing of observed taxonomic classifications and abundance (data listing provided in Appendix A) in order to aid them in their determination of water classification standards for the Project tailrace.

2.0 OBJECTIVES

The goal of this study was to determine if the attainment of Class C habitat and aquatic life criteria is being met in the river reach below the Project dam. The study objective was to determine the composition of the benthic macroinvertebrate community within the tailrace reach of the dam in accordance with the most recent MDEP protocol for macroinvertebrate sampling.

3.0 STUDY AREA

The study area included the section of the Androscoggin River located approximately 600-700 feet downstream of the Project. As specified in the RSP, a single sampling station was established within representative habitat downstream of the Project facilities (Figure 3-1).

Brookfield

Pejepscot Hydroelectric Project
(FERC No. 4784)
Tailwater Benthic Macroinvertebrate Survey

0 100 200 400
Feet

N

Figure 3-1:
Location of Benthic
Macroinvertebrate
Sampling Station
Downstream of Pejepscot Dam
August, 2018

Path: P:\1925\maps\Study Plans\Macroinvertebrates_Study\Figure_3-1.mxd

4.0 METHODS

Benthic macroinvertebrate community sampling downstream of the Project was conducted following the MDEP's Methods for Biological Sampling and Analysis of Maine's Rivers and Streams (Davies and Tsomides 2014) which presents the standard practices and procedures that have been adopted by MDEP to acquire benthic macroinvertebrate data for purposes of aquatic life classification attainment evaluation. As described in the RSP, a set of three rock baskets were deployed at a sampling location downstream of the power station and within representative benthic macroinvertebrate habitat. Samplers were filled with 7.25 ± 0.5 kg of clean, washed cobble graded to a uniform diameter range of 3.8-7.6 cm. Pejepscot samplers were deployed during the late summer low-flow period from July 1 to September 30 specified in the MDEP protocol and remained in the river for the required 28 days (± 4 days). At the time of deployment, baskets were oriented parallel to stream flow and were placed at locations where there was a high degree of certainty that they would remain watered for the duration of the study period and were outside of any potential bank effects.

At the completion of the exposure period, samplers were approached from the downstream side and collected by carefully lifting them into an aquatic sampling net. Following collection, samplers were washed through a 600 micron sieve bucket. Each rock was visually inspected, and the surface was rinsed through the bucket. Contents of the sieve bucket were placed in double-labeled jars and preserved with a 70% solution of ethyl alcohol. Habitat and water quality measurements were collected at the time of deployment and retrieval at both sampling locations. Habitat parameters evaluated were those shown on the physical habitat data sheet included in the MDEP protocol. These included substrate composition, canopy coverage, land use, and terrain characteristics. Water quality measurements included velocity, temperature, specific conductance, dissolved oxygen, pH, and total dissolved solids. Also noted were the dates of exposure.

The benthos samples were sent to Normandeau's benthic taxonomy laboratory located in Stowe, Pennsylvania. Taxonomists there sorted, identified and enumerated the full contents of the three rock basket samplers. Samples were analyzed using stereo-zoom and compound microscopes. Organisms were identified and enumerated to the lowest practical taxon, generally genus and species, dependent on their age and condition using published taxonomic keys. Chironomidae (midges) larvae were slide mounted after being prepared in a clearing solution and identified using a compound microscope. Worms were also slide mounted and identified using a compound microscope.

The following metrics were evaluated for the macroinvertebrate samples collected downstream of Pejepscot:

- **Total Number of Taxa**: The number of genera identified.

- **Number of EPT Taxa**: Number of genera in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), collectively referred to as the "EPT" taxa. These three groups of benthic insects are considered particularly sensitive to pollution.

- **Number of Ephemeroptera Taxa**: The number genera classified as mayflies.
- **Number of Plecoptera Taxa**: The number genera classified as stoneflies.
- **Number of Trichoptera Taxa**: The number genera classified as caddisflies.
- **Percent EPT**: The percentage of the total number of specimens in a sample representing individuals classified as mayflies, stoneflies or caddisflies.
- **Percent Ephemeroptera**: The percentage of the total number of specimens that are mayfly nymphs.
- **Number of Intolerant Taxa**: The number of genera considered to be sensitive to environmental perturbation (tolerance values = 0 – 3).
- **Percent Tolerant Organisms**: The percent of macroinvertebrate specimens considered tolerant to environmental perturbations (tolerance values = 7 – 10).
- **Percent Dominant Taxon**: The percent abundance of the single most abundant taxon.
- **Hilsenhoff Biotic Index (HBI)**: A weighted average of the tolerance values of all taxa present. Organisms are assigned a tolerance value from 0 to 10 indicating their sensitivity to organic pollutants (0 being most sensitive, 10 being most tolerant). HBI is calculated as:
  - HBI= (Σn_i x a_i)/N
    - Where:
      - n = number of specimens in taxa i
      - a = tolerance value of taxa i
      - N = total number of specimens in sample
- **Shannon Diversity Index (base e)**: This metric compares the distribution of individuals among all taxa present in a sample. Shannon Diversity (H') is calculated as H' = Σ pi ln pi, where pi is the proportion of the total number of individuals occurring in taxon i. Maximum diversity is obtained when the numbers of individuals are equally distributed among taxa. A value near zero indicates community dominance by a small number of taxa. Higher values indicate that the numbers of individuals are evenly distributed.

5.0 RESULTS

5.1 Habitat and Macroinvertebrate Collections

Macroinvertebrate samplers were installed at the sampling location downstream of Pejepscot on August 2, 2018 and were retrieved 27 days later on August 29, 2018. Recorded physical habitat parameters at the time of deployment and retrieval are summarized in Table 5-1. In general, aquatic habitat in the area approximately 660 feet downstream of the Project was primarily a mix of boulder (<10 inch) and rubble (3-10 inch) substrates. Areas of filamentous algae were present on the substrate at the sampling location during both deployment and retrieval of the samplers.

A total of 1,707 individuals representing 43 taxonomic classifications were collected from the three samplers deployed downstream of Pejepscot (Table 5-2). Caddisfly species (genus *Hydropsyche*) and the black fly (genus *Simulium*) were the two most dominant members of the benthic macroinvertebrate community and combined to make up approximately 50% of the total number of specimens.

Metrics evaluating community tolerance/intolerance revealed that sensitive genera comprised a measurable proportion of the macroinvertebrate community downstream of Pejepscot. Members of the orders Ephemeroptera, Plecoptera, and Trichoptera are considered particularly sensitive to pollution and can provide information important to the condition of the benthic macroinvertebrate community. Individuals from the EPT assemblage were present at the downstream sampling location, comprising 66.3% of the total number of specimens collected.

In addition to evaluation of the EPT contribution to the community, each taxonomic group was assigned a value of tolerance using classifications provided by MDEP. Tolerance values (range = 0-10) were further classified as Intolerant (i.e., sensitive to water quality; values = 0-3), Semi-tolerant (i.e., intermediate in their tolerance to water quality; values = 4-6) or Tolerant (i.e., low sensitivity to water quality; values 7-10). Genera classified as Intolerant to poor water quality comprised 27% of the total number of genera observed at the downstream sampling location (replicates 1-3, combined). Individuals belonging to taxonomic groups considered to be tolerant of low water quality represented only 2.6% of all specimens enumerated at from the samplers located downstream of Pejepscot.

The Hilsenhoff Biotic Index rating provides an estimate of the overall tolerance of the community in the sample area. For the sampling location downstream of Pejepscot this value were estimated at 4.19. Values for the HBI index range from 0 to 10 with lower values reflecting a higher abundance of sensitive groups. The estimate for the Pejepscot macroinvertebrate community is supportive of a water quality rating of "very good" (Hilsenhoff 1987).

5.2 Water Quality Classification Standards

A full listing of taxonomic classifications and abundance values for each of the three replicates from the downstream sampling location as well as all the physical data collected during deployment and retrieval of the samplers were provided to MDEP for their determination as to whether or not the macroinvertebrate community sampled downstream of Pejepscot meets the aquatic life criteria for that section of the Androscoggin River. The statutory class of the Androscoggin River downstream of Pejepscot is Class C. MDEP characterizes Class C waters as being of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; navigation; and as habitat for fish and other aquatic life. The dissolved oxygen content of Class C water may be not less than 5 parts per million or 60% of saturation, whichever is higher.

Normandeau provided taxonomic and habitat information to the MDEP on November 28, 2018 and MDEP returned a Classification Attainment Report on November 30, 2018 (see full report in Appendix B). The final determination indicated that the macroinvertebrate community sampled downstream of Pejepscot during August 2018 met Class A standards.

Table 5-1: Summary of Macroinvertebrate Sampling Location Habitat and Conditions Downstream of Pejepscot Dam, August 2018

Parameter	Sample Location	
	Deployment	Retrieval
Date-Time	8/2/18-13:10	8/29/18-10:56
No. Samplers	3	3
Coordinates	N43.95536 W70.02387	
Land Use (500 m radius US)	upland conifer, upland hardwood	
Terrain (500 m radius US)	Flat, rolling	
Canopy Cover (upstream view)	Open (0-25% shaded)	
Physical Bottom Characteristics	Boulders (<10") - 50% Rubble (3"-10") - 40% Sand (<1/8") - 10%	
Channel Width (m)	~80 m	
Site Depth (cm)	97	97
Flow (cm/s)	37.9	45.4
Dissolved O_2 (mg/L)	8.21	7.97
Temperature (°C)	25.9	25.2
pH	7.09	6.95
SPC (µS/cm)	106	93
Observations		
Fish	juvenile YOY smallmouth bass observed	
Algae/Macrophytes	Present in mats on bottom substrate	
Habitat Quality	Good in appearance	
Dams/Impoundments	Pejepscot - US ~660 ft	
Discharges	Powerhouse	
Nonpoint stressors	None observed	

Table 5–2: Summary of Macroinvertebrate Metrics for Replicates Collected Downstream of Pejepscot, August 2018

Metric	Sample Location 1			
	Rep. 1	Rep. 2	Rep. 3	All
Total Number of Individuals	576	191	940	**1,707**
Total Number of Taxa	29	29	35	**43**
Number of EPT Taxa	16	20	20	**22**
Number of Ephemeroptera Taxa	5	7	8	**9**
Number of Plecoptera Taxa	1	2	2	**2**
Number of Trichoptera Taxa	10	11	10	**11**
Percent EPT	73.4%	85.3%	58.1%	**66.3%**
Percent Ephemeroptera	24.0%	30.9%	10.5%	**17.3%**
Number of Intolerant Taxa	7	10	10	**12**
Percent Tolerant Organisms	3.7%	3.1%	1.9%	**2.6%**
Percent Dominant Taxon	30.9%	23.6%	31.8%	**30.6%**
Hilsefhoff Biotic Index (HBI)	4.24	4.25	4.14	**4.19**
HBI Water Quality Rating	Very Good	Very Good	Very Good	**Very Good**
Shannon Diversity (base e)	2.58	2.71	2.29	**2.55**

6.0 SUMMARY

The macroinvertebrate community was sampled approximately 660 feet downstream of Pejepscot following approved MDEP field and laboratory methods during August 2018. Macroinvertebrate samples collected at the downstream location yielded adequate numbers of sensitive taxa indicating that under the current operational regime there are no detrimental impacts to the macroinvertebrate community.

7.0 VARIANCES FROM FERC-APPROVED STUDY PLAN

There was no variance from the methodologies and schedule as described in the FERC-approved study plan.

8.0 REFERENCES

Davies, S.P., and L. Tsomides. 2014. Methods for Biological Sampling and Analysis of Maine's Rivers and Streams. DEP LW0387-C2014.

Hilsenhoff, W.L. 1987. An improved biotic index of stream pollution. The Great Lakes Entomologist 20: 31-36.

APPENDIX A. TAXONOMIC LISTING FOR MACROINVERTEBRATE SAMPLES COLLECTED DOWNSTREAM OF PEJEPSCOT DAM DURING AUGUST 2018

MDEP Taxonomic Code	Taxon Name	No. Identified		
		Rep 1	Rep 2	Rep 3
09020401008	*Acentrella*		1	1
09020401007011	*Acerpenna pygmaea*	44	17	11
09020209042	*Acroneuria*	4	3	1
10010104013	*Amnicola*	5	3	8
09020309048	*Argia*			1
09020401001	*Baetis*	31	11	31
09020301004012	*Boyeria vinosa*		2	
09020618072	*Ceraclea*	8	7	2
09020604015	*Cheumatopsyche*	36	15	21
09020601003	*Chimarra*	16	7	49
09021011037	*Cricotopus*	16	3	15
09021011024	*Diamesa*	1		
09021011085	*Dicrotendipes*			1
03010102	*Dugesiidae*	11	1	13
09020401005	*Heterocloeon*	9	3	3
09010203006011	*Hyalella azteca*	1		
09030101	*Hydrachnidia*			1
09020604016030	*Hydropsyche morosa*	6		9
09020604016047	*Hydropsyche phalerata*	172	45	290
09020604016	*Hydropsyche*	5	3	5
09020607026	*Hydroptila*	9	1	3
09020404018	*Isonychia*	16	1	18
09020402011	*Leucrocuta*			1
09020402015046	*Maccaffertium exiguum*	4		1
09020402015	*Maccaffertium*	34	25	32
09020604018	*Macrostemum*	17	4	49
09020618074	*Nectopsyche*	1	1	
05	*Nematoda*	1		
09021011012	*Nilotanypus*			5
09020603009	*Nyctiophylax*		1	1
09020618078	*Oecetis*	3	3	1
09020209049151	*Paragnetina media*		1	8
09020401012	*Plauditus*			1
09020603010	*Polycentropus*	8	13	8
09021011102182	*Polypedilum flavum*	1	1	8
09021011102185	*Polypedilum illinoense group*	2	3	
09021011026045	*Potthastia gaedii*			2
09021011072127	*Rheotanytarsus exiguus group*	4	2	3

MDEP Taxonomic Code	Taxon Name	No. Identified		
		Rep 1	Rep 2	Rep 3
09021011072128	*Rheotanytarsus pellucidus*	5		3
09021012047	*Simulium*	89	11	241
09021113070055	*Stenelmis crenata*	1		
08020202014001	*Stylaria fossularis*	1		
09021011076	*Tanytarsus*			1
09021011062	*Thienemanniella*	10	1	82
09021011020041	*Thienemannimyia group*			1
09020411038	*Tricorythodes*		1	
09021011065113	*Tvetenia vitracies*	5	1	9

APPENDIX B. MDEP CLASSIFICATION ATTAINMENT REPORT FOR SAMPLE LOCATION DOWNSTREAM OF PEJEPSCOT DAM DURING AUGUST 2016

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: S-954
Waterbody: Androscoggin River - Station 954
Town: Brunswick
Directions: BELOW PEJEPSCOT DAM; UP RIVER RD FROM BRUNSWICK TO PUBLIC FISHING PARK ACCESS AND CANOE PORTAGE

River Basin: Androscoggin
HUC8 Name: Lower Androscoggin
Latitude: 43 57 19.82 N
Longitude: 70 1 26.95 W
Stream Order: 5

Sample Information

Log Number: 2716
Subsample Factor: X1
Type of Sample: ROCK BASKET
Replicates: 3
Date Deployed: 8/2/2018
Date Retrieved: 8/29/2018

Classification Attainment

Statutory Class: C
Model Result with P≥0.6: A
Date Last Calculated: 11/29/2018
Final Determination: A
Reason for Determination: Model
Comments:
Date: 11/30/2018

Model Probabilities

First Stage Model

Class A	0.49	Class C	0.02
Class B	0.48	NA	0.00

C or Better Model

Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model

Class A or B	1.00
Class C or Non-Attainment	0.00

A Model

Class A	0.75
Class B or C or Non-Attainment	0.25

Model Variables

01 Total Mean Abundance	569.00
02 Generic Richness	42.00
03 Plecoptera Mean Abundance	5.67
04 Ephemeroptera Mean Abundance	98.67
05 Shannon-Wiener Generic Diversity	3.53
06 Hilsenhoff Biotic Index	4.15
07 Relative Abundance - Chironomidae	0.11
08 Relative Generic Richness Diptera	0.29
09 *Hydropsyche* Abundance	178.33
11 *Cheumatopsyche* Abundance	24.00
12 EPT Generic Richness/ Diptera Generic Richness	1.75
13 Relative Abundance - Oligochaeta	0.00
15 Perlidae Mean Abundance (Family Functional Group)	5.67
16 Tanypodinae Mean Abundance (Family Functional Group)	2.00
17 Chironomini Abundance (Family Functional Group)	5.33
18 Relative Abundance Ephemeroptera	0.17
19 EPT Generic Richness	21.00
21 Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	0.33
23 Relative Generic Richness- Plecoptera	0.05
25 Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	35.67
26 Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	34.67
28 EP Generic Richness/14	0.79
30 Presence of Class A Indicator Taxa/7	0.29

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Hydropsyche*	31.34
2	*Simulium*	19.98
3	*Maccaffertium*	5.62
4	*Thienemanniella*	5.45
5	*Baetis*	4.28

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: S-954	Town: Brunswick		Date Deployed: 8/2/2018
Log Number: 2716	Waterbody: Androscoggin River - Station 954		Date Retrieved: 8/29/2018

Sample Collection and Processing Information

Sampling Organization: NORMANDEAU ASSOCIATES   Taxonomist: NORMANDEAU ASSOCIATES

Waterbody Information - Deployment		Waterbody Information - Retrieval	
Temperature:	25.9 deg C	Temperature:	25.2 deg C
Dissolved Oxygen:	8.21 mg/l	Dissolved Oxygen:	7.97 mg/l
Dissolved Oxygen Saturation:	101.3 %	Dissolved Oxygen Saturation:	96.9 %
Specific Conductance:	106 uS/cm	Specific Conductance:	93 uS/cm
Velocity:	37.9 cm/s	Velocity:	45.4 cm/s
pH:	7.09	pH:	6.95
Wetted Width:	81.1 m	Wetted Width:	80.8 m
Bankfull Width:	90.5 m	Bankfull Width:	88.4 m
Depth:	97 cm	Depth:	97 cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain	
Upland Conifer	Open	Flat	
Upland Hardwood			

Potential Stressor	Location	Substrate	
Regulated Flows	Below Dam	Boulder	50 %
	Main Stem	Rubble/Cobble	40 %
		Sand	10 %

Landcover Summary - 2004 Data

Sample Comments

Aquatic Life Taxonomic Inventory Report

Station Number: S-954 Waterbody: Androscoggin River - Station 954 Town: Brunswick

Log Number: 2716 Subsample Factor: X1 Replicates: 3 Calculated: 11/29/2018

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Dugesiidae	03010102	8.33	8.33		--	1.5	1.5
Nematoda	05	0.33	0.33		--	0.1	0.1
Stylaria	08020202014		0.33		CG		0.1
Stylaria fossularis	08020202014001	0.33			--	0.1	
Hyalella	09010203006		0.33	8	CG		0.1
Hyalella azteca	09010203006011	0.33			--	0.1	
Acroneuria	09020209042	2.67	2.67	0	PR	0.5	0.5
Paragnetina	09020209049		3.00	1	PR		0.5
Paragnetina media	09020209049151	3.00			--	0.5	
Boyeria	09020301004		0.67	2	PR		0.1
Boyeria vinosa	09020301004012	0.67			--	0.1	
Argia	09020309048	0.33	0.33	7	PR	0.1	0.1
Baetis	09020401001	24.33	24.33	4	CG	4.3	4.3
Heterocloeon	09020401005	5.00	5.00	2	SC	0.9	0.9
Acerpenna	09020401007		24.00	5	CG		4.2
Acerpenna pygmaea	09020401007011	24.00			--	4.2	
Acentrella	09020401008	0.67	0.67	3	CG	0.1	0.1
Plauditus	09020401012	0.33	0.33		CG	0.1	0.1
Leucrocuta	09020402011	0.33	0.33	1	SC	0.1	0.1
Maccaffertium	09020402015	30.33	32.00	4	SC	5.3	5.6
Maccaffertium exiguum	09020402015046	1.67			--	0.3	
Isonychia	09020404018	11.67	11.67	2	CF	2.1	2.1
Tricorythodes	09020411038	0.33	0.33	4	CG	0.1	0.1
Chimarra	09020601003	24.00	24.00	2	CF	4.2	4.2
Nyctiophylax	09020603009	0.67	0.67	5	PR	0.1	0.1
Polycentropus	09020603010	9.67	9.67	6	PR	1.7	1.7
Cheumatopsyche	09020604015	24.00	24.00	5	CF	4.2	4.2
Hydropsyche	09020604016	4.33	178.33	4	CF	0.8	31.3
Hydropsyche morosa	09020604016030	5.00			--	0.9	
Hydropsyche phalerata	09020604016047	169.00			--	29.7	
Macrostemum	09020604018	23.33	23.33	3	CF	4.1	4.1
Hydroptila	09020607026	4.33	4.33	6	P	0.8	0.8
Ceraclea	09020618072	5.67	5.67	3	CG	1.0	1.0
Nectopsyche	09020618074	0.67	0.67	3	SH	0.1	0.1
Oecetis	09020618078	2.33	2.33	8	PR	0.4	0.4
Nilotanypus	09021011012	1.67	1.67	6	PR	0.3	0.3
Thienemannimyia	09021011020		0.33	3	PR		0.1

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-954 Waterbody: Androscoggin River - Station 954 Town: Brunswick

Log Number: 2716 Subsample Factor: X1 Replicates: 3 Calculated: 11/29/2018

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Thienemannimyia group	09021011020041	0.33			--	0.1	
Diamesa	09021011024	0.33	0.33	5	CG	0.1	0.1
Potthastia	09021011026		0.67	2	CG		0.1
Potthastia gaedii	09021011026045	0.67			--	0.1	
Cricotopus	09021011037	11.33	11.33	7	SH	2.0	2.0
Thienemanniella	09021011062	31.00	31.00	6	CG	5.4	5.4
Tvetenia	09021011065		5.00	5	CG		0.9
Tvetenia vitracies	09021011065113	5.00			--	0.9	
Rheotanytarsus	09021011072		5.67	6	CF		1.0
Rheotanytarsus exiguus group	09021011072127	3.00			CF	0.5	
Rheotanytarsus pellucidus	09021011072128	2.67			CF	0.5	
Tanytarsus	09021011076	0.33	0.33	6	CF	0.1	0.1
Dicrotendipes	09021011085	0.33	0.33	8	CG	0.1	0.1
Polypedilum	09021011102		5.00	6	SH		0.9
Polypedilum flavum	09021011102182	3.33			--	0.6	
Polypedilum illinoense group	09021011102185	1.67			--	0.3	
Simulium	09021012047	113.67	113.67	4	CF	20.0	20.0
Stenelmis	09021113070		0.33	5	SC		0.1
Stenelmis crenata	09021113070055	0.33			--	0.1	
Hydrachnidia	09030101	0.33	0.33		--	0.1	0.1
Amnicola	10010104013	5.33	5.33		SC	0.9	0.9

DRAFT UPDATED STUDY REPORT

EEL MONITORING SURVEYS

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)

Submitted by:

Brookfield Renewable
Topsham Hydro Partners Limited Partnership
150 Main Street
Lewiston, ME 04240

Prepared by:

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

April 2020

Brookfield

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND DEFINITIONS

cfs	cubic feet per second
FERC	Federal Energy Regulatory Commission
gpm	gallons per minute
in	inch
Normandeau	Normandeau Associates, Inc.
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
RSP	Revised Study Plan
SPD	Study Plan Determination
Topsham	Topsham Hydro Partners Limited Partnership

1.0 INTRODUCTION

Topsham Hydro Partners Limited Partnership (L.P.) (Topsham Hydro or Licensee), an indirect member of Brookfield Renewable (Brookfield), is in the process of relicensing the 13.88-megawatt (MW) Pejepscot Hydroelectric Project (Project) (FERC No. 4784) with the Federal Energy Regulatory Commission (FERC or Commission). The Project is located on the Androscoggin River in the village of Pejepscot and the Town of Topsham, Maine (ME) to the east, the Town of Lisbon to the north, and the Towns of Durham and Brunswick, ME to the west. The Project straddles the border between Cumberland and Sagadahoc counties and extends into Androscoggin County. The original license was issued on September 16, 1982 and expires on August 31, 2022.

The Licensee is using FERC's Integrated Licensing Process (ILP) as established in regulations issued by FERC July 23, 2003 (Final Rule, Order No. 2002) and found at Title 18 Code of Federal Regulations (CFR), Part 5. The Licensee filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to seek a new license for the Project on August 31, 2017.

The Licensee distributed the PAD and NOI simultaneously to Federal and state resource agencies, local governments, Native American tribes, members of the public, and others thought to be interested in the relicensing proceeding. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on October 30, 2017. FERC also held agency and public scoping meetings on November 28, 2017 and a site visit on November 29, 2017. The FERC Process Plan and Schedule provided agencies and interested parties an opportunity to file comments on the PAD and SD1 and request studies by December 29, 2017. FERC subsequently issued Scoping Document 2 (SD2) on February 5, 2018. The Licensee filed a Proposed Study Plan (PSP) on February 12, 2018 and held a Study Plan Meeting on March 22, 2018. The Revised Study Plan (RSP) was filed in accordance with the ILP schedule on June 12, 2018. FERC issued a Study Plan Determination (SPD) on July 3, 2018.

In the RSP, Topsham Hydro proposed to conduct nighttime visual monitoring surveys to investigate upstream migrating American eel movements at the Project.

2.0 OBJECTIVES

The goal of this study was to evaluate the need and potential location for an upstream eel passage facility at the Project. The specific objectives for this study included:

- systematic surveys of eel presence/abundance at the Project to identify where eels concentrate when staging in pools or attempting to ascend wetted structures; and
- identification of potential locations that may be viable sites for a permanent eel trap/pass structure.

3.0 STUDY AREA

The study area was restricted to the portion of the Androscoggin River immediately downstream of the Project powerhouse and dam (Figure 3-1). Areas of specific focus included (1) the spillway as viewed from the east side of the river, (2) the spillway as viewed from the west side of the river, (3) the area near the entrance to the upstream fish lift, (4) the wetted area adjacent to the spillway as viewed from the entrance to the counting room, (5) the portion of the upper exit flume associated with the upstream fish lift as viewed from the counting room, and (6) the western shoreline accessed via the Pejepscot Fishing Park canoe portage trail.

Brookfield

N

0 37.5 75 150
Feet

Pejepscot Hydroelectric Project
(FERC No. 4784)
Eel Monitoring Surveys

Figure 3-1:
2019 Locations of Areas Surveyed
During American Eel Monitoring
Surveys at the Pejepscot Project

Path: P:\1925\maps\Study Plans\American_Eel\Figure_3-1.mxd

4.0 METHODS

As described in the RSP, nighttime visual monitoring surveys were conducted during the expected period of upstream juvenile eel migration for the Androscoggin River (i.e., June 15 - August 31). Surveys were conducted twice weekly for the period from June 15 to July 15, once weekly from July 15 to August 15 and one final survey during the last two weeks of August.

Each visual survey was conducted immediately following sunset. In an effort to limit personnel moving around in the reach downstream of the Project spillway during the night hours, eel surveys were conducted from safely accessible locations. A pair of field personnel were equipped with spotlights and binoculars during each survey event. The extent of the area available for visual survey was driven by operations at the Project at the time of visitation. High flows and the presence of spill limited or prevented effective visual searching of some or all areas downstream of the Project.

On each survey date, the duration and timing of searches at each location was recorded. All observations of eels (i.e., presence/absence, abundance, and distribution among pre-defined size classes) was recorded for each survey point and weather and lunar cycle were recorded for each survey. Representative water quality data (i.e., temperature, dissolved oxygen) was collected. Temperature and dissolved oxygen measurements were taken in the headpond from the east side of the river using a handheld YSI meter. The water quality meter was calibrated immediately before each sample was taken. The field crew conducting the surveys also maintained notes related to observations on Project operations (i.e., generation and spill).

5.0 RESULTS

A total of 14 surveys were conducted over the period from June 17 to August 26, 2019. Table 5-1 provides a summary of the timing, environmental conditions, operational conditions, water quality and eel counts for the full set of survey dates. A full listing of the reported operational conditions for each survey period is provided in Appendix A. Over the course of the survey period, visual searches were initiated between the hours of 2000 – 2120. Most survey events were completed within 1-2 hours. Weather conditions were clear for half of the survey events (7 of 14) and cloudy or rainy conditions were present for the remainder. Average daily total river flow ranged between 7,058 cfs and 2,281 cfs during the fourteen survey dates (Figure 5-1). Average daily spill conditions greater than 450 cfs were present for two of the survey events (June, 24 and August 26). Field crews noted leakage conditions on the spillway during 12 of the 14 survey dates. The single Kaplan turbine (i.e., Unit 1) was online during all but one of the survey events (No unit generation during 8/26/19 survey). The three Project Francis units (i.e., Units 21, 22, and 23) were offline during all 14 survey events.

There were no juvenile eels observed during the visual searches conducted at the Project on any of the survey dates between June 17 and August 26.

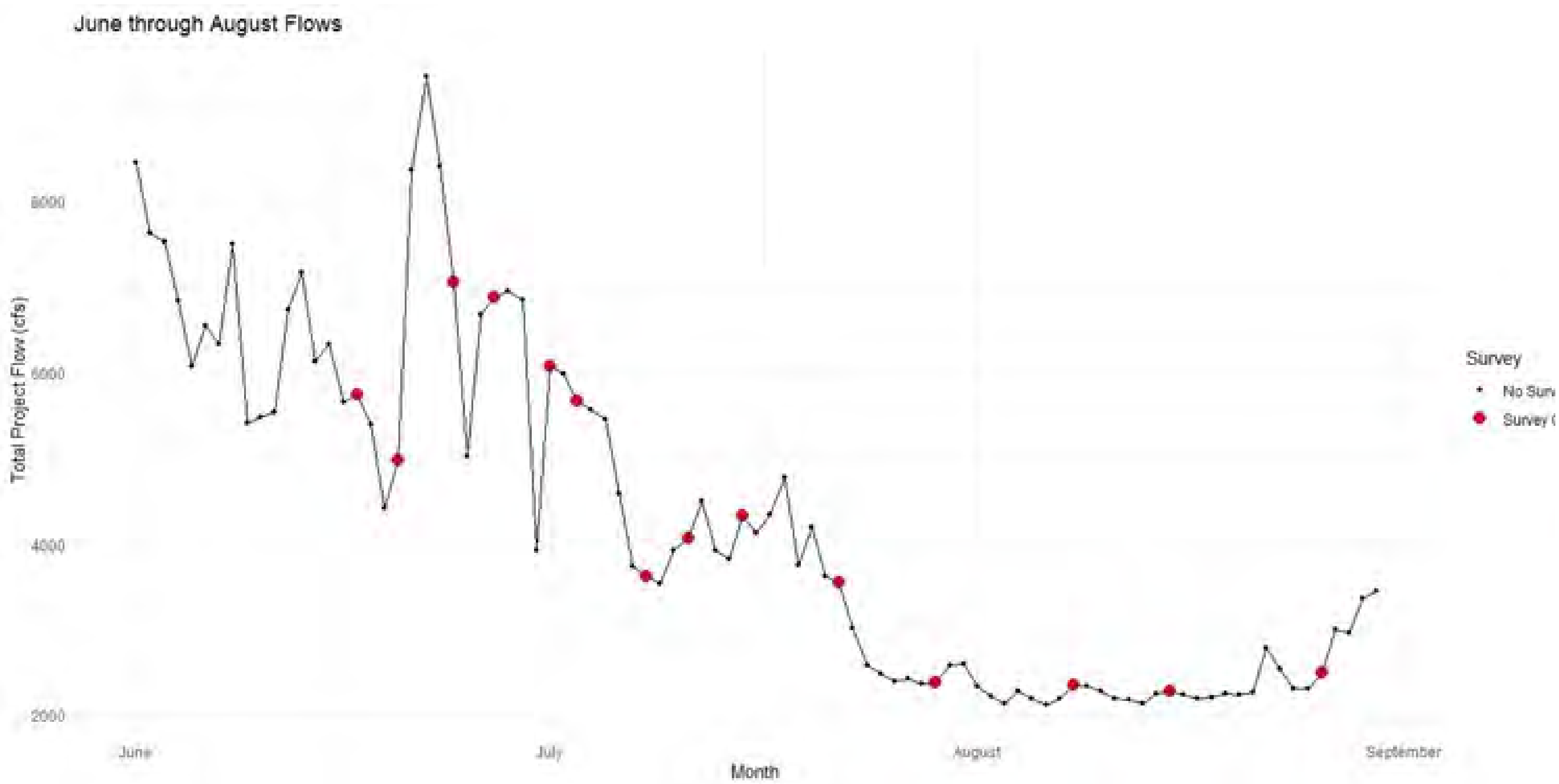


Figure 5-1: Total Androscoggin River flow as reported at Pejepscot for the months of June-August, 2019

Juvenile eel survey dates indicated with red markers.

Table 5–1: Summary of Survey Information and Site Conditions During Juvenile American Eel Searches at Pejepscot During June-August, 2019

Date	Start Time	Weather	Lunar Cycle	Spill? Observed	Gate 1 open?	Gate 2 open?	Gate 3 open?	Unit Generation?	Water Temp (oC)	Dissolved Oxygen (mg/L)	No. Eels Seen
6/17/2019	21:07	Clear, 63 ºF	Full 100% Illumination	No	No	No	No	Yes	17.8	n/a	0
6/20/2019	21:10	Rain, 57 ºF	Waning, 90% Illumination	No	No	No	No	Yes	19.7	10.2	0
6/24/2019	21:04	Clear, 63 ºF	Waning, 59% Illumination	No	No	No	No	Yes	20.7	10.2	0
6/27/2019	21:08	Full Cloud cover + Fog, 61 ºF	Waning, 30% Illumination	Yes	Closed, but some leakage	No	Closed, but some spill	Yes	20.9	9.21	0
7/1/2019	21:15	Mostly Cloudy, 72 ºF	Waning, 2% Illumination	No	No	No	No	Yes	22.2	8.56	0
7/3/2019	21:20	Clear, 70 ºF	Waxing, 1% Illumination	No	No	No	No	Yes	23.6	8.49	0
7/8/2019	21:15	Clear, 68 ºF	Waxing, 39% Illumination	No	No	No	No	Yes	24.8	9.18	0
7/11/2019	21:16	Rain, 65 ºF	Waxing, 72% Illumination	No	No	No	No	Yes	n/a	n/a	0
7/15/2019	21:15	Clear, 70 ºF	Waxing, 98% Illumination	No	No	No	No	Yes	25.1	7.1	0
7/22/2019	21:04	Light rain, 64 ºF	Waning, 74% Illumination	No	No	No	No	Yes	26.7	6.5	0
7/29/2019	21:07	Clear, 72 ºF	Waning, 10% Illumination	No	No	No	No	Yes	27.2	6.6	0
8/8/2019	21:12	Partly Cloudy, 68 oF	Waxing , 58% Illumination	No	No	No	No	Yes	26	6	0
8/15/2019	20:51	Partly Cloudy, 75 oF	Full, 100% Illumination	No	No	No	No	Yes	25.1	8	0
8/26/2019	20:05	Clear, 58 oF	Waning , 21% Illumination	Yes	Yes	Yes	No	No	23.2	7.2	0

n/a = calibration issue or meter unavailable

6.0 SUMMARY

A total of 14 nighttime visual surveys targeting juvenile American eels downstream of the Project were conducted between mid-June and late-August. Survey events were limited to observations of search areas made at distance from several shoreline locations. It is likely that the lack of access within the areas immediately downstream of the Project dam by boat or foot limited the ability to visually detect juvenile eels.

Although the series of surveys conducted downstream of the Project during this study did not yield any observations of juvenile eels, the physical conditions which promote congregations of migrating juvenile eels have been described at numerous other hydroelectric projects. Juvenile eels in the genus Anguilla tend to orient close to a riverbank when migrating upstream, depending on size and life stage (Piper and Kemp 2012; Watz et al. 2019). Due to this behavior, it is generally recommended that upstream eel passage structure entrances be placed on one or both banks of the river to produce the highest passage numbers of juvenile eels. The bank habitat is thought to provide areas with reduced velocities (relative to the main river flow) and diverse substrate in which migrating eels can take shelter between upstream movements (Barbin and Krueger 1994). Some larger yellow phase eels have been observed to have the highest efficiency with a passage structure entrance positioned in the center of the channel (Piper and Kemp 2012). This is likely due to increasing swim capabilities as the juvenile eels increase in size. Facilities can maximize the efficiency of their planned permanent eel passage structures by placing several temporary eel ladders in a variety of locations likely to produce congregations, and then decide which location(s) produced the highest passage counts (USFWS 2019).

Juvenile eels tend to prefer the edges of plunging flow for attempting upstream passage (Piper and Kemp 2012). Providing a small amount of plunging flow to attract eels to the entrance of passage structures is known to aid in passage efficiency (Piper and Kemp 2012). However, upstream migrating eels tend to prefer lower velocities on the actual passage structure once they have found the entrance and oriented themselves to pass (Watz et al. 2019). Although eels need flow in order to be attracted to passage structures, their more limited swimming capacity does not require attraction velocities as high as other diadromous species such as Atlantic salmon or American shad (USFWS 2019). Recommended attraction flow is 50 gallons per minute (gpm) plus an additional gpm for every inch of ramp width beyond 8 in. (USFWS 2019). The depth of water needed on a passage structure varies based on ramp width, flow, slope, and climbing substrate, but as a general rule 1/16th in. to 1/8th in. is recommended across a flat ramp (USFWS 2019).

As juvenile eels have been documented passing upstream at the Worumbo Project, juvenile eels are present downstream of the Pejepscot Project and some degree of upstream passage at the Project is occurring. When the upstream passage preferences for juvenile eels as well as the physical characteristics of the area immediately downstream of Pejepscot are considered, congregation locations for juvenile eels may be occurring:

- At the vicinity of the downstream bypass outflows where plunging flow conditions are present;

- Along the banks, especially near the attraction flow of the existing fishway, due to the availability of the bankside substrate that can be used for resting areas during periods of upstream movement; and
- Any locations along the spillway which may receive regular amounts of leakage resulting in a consistently wetted surface. Due to the presence of the inflatable dam sections at Pejepscot, regular leakage and resulting wetted surfaces along the spillway are not anticipated.

7.0 VARIANCES FROM FERC-APPROVED STUDY PLAN

There were no variances from the methodologies and schedule as described in the FERC-approved study plan. The full set of nighttime surveys were conducted as described in the RSP.

8.0 REFERENCES

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Yoder, C.O., B.H. Kulik, J.M. Audet, and J.D. Bagley. 2006. The Spatial and Relative Abundance Characteristics of the Fish Assemblages in Three Maine Rivers. Technical Report MBI/12-05-1. September 1, 2006.

APPENDIX A. PROJECT OPERATIONS DATA DURING JUVENILE AMERICAN EEL SURVEYS AT PEJEPSCOT CONDUCTED JUNE-AUGUST, 2019

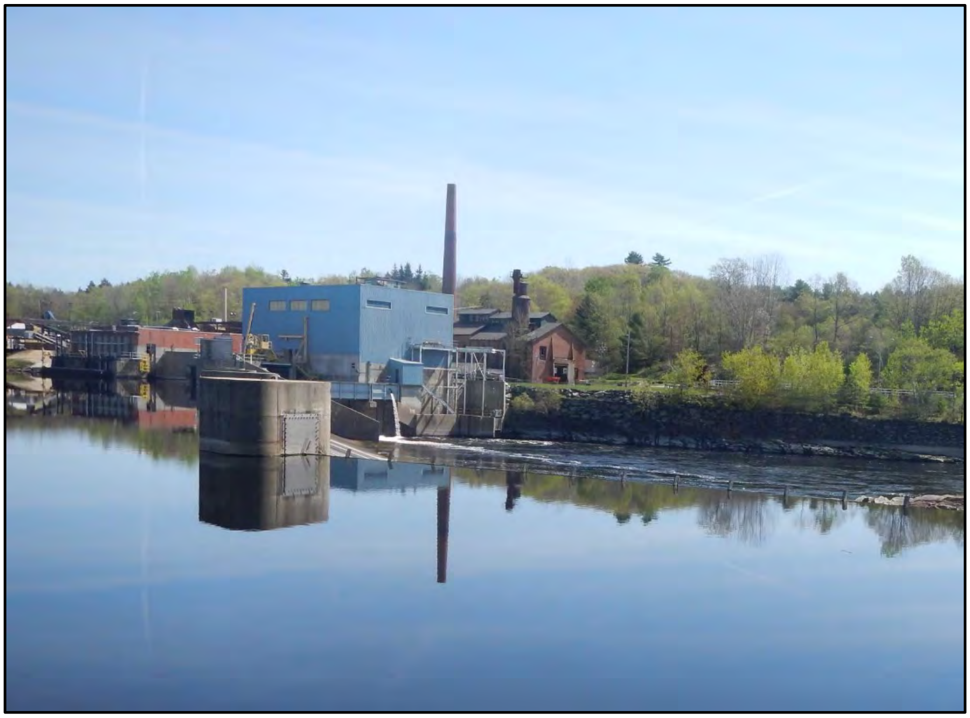
Date	Time	Discharge (cfs)			Elevation (ft)	
		Project	Spillway	Unit 1	Headpond	Tailrace
6/17/2019	19:00	4,436	352	3,541	67.4	41.5
	20:00	5,249	389	5,232	67.4	42.1
	21:00	6,379	186	6,298	67.1	42.6
	22:00	4,672	202	4,678	67.2	42.2
6/20/2019	19:00	6,396	197	6,509	67.2	42.8
	20:00	5,989	210	6,042	67.2	42.7
	21:00	7,185	201	6,968	67.2	43.1
	22:00	7,051	205	7,011	67.2	43.1
6/24/2019	19:00	6,153	205	6,183	67.2	42.7
	20:00	5,918	221	5,936	67.2	42.7
	21:00	6,053	200	5,995	67.2	42.6
	22:00	6,165	205	6,098	67.2	42.7
6/27/2019	19:00	7,081	204	7,067	67.2	43.1
	20:00	7,195	233	7,025	67.3	43.1
	21:00	7,124	281	7,098	67.3	43.1
	22:00	7,207	332	7,198	67.4	43.1
7/1/2019	19:00	6,542	211	6,503	67.2	42.8
	20:00	6,520	212	6,586	67.2	42.9
	21:00	6,066	212	6,092	67.2	42.7
	22:00	6,111	207	6,207	67.2	42.8
7/3/2019	19:00	5,732	214	5,732	67.2	42.6
	20:00	6,115	194	6,219	67.2	42.7
	21:00	6,276	206	6,211	67.2	42.7
	22:00	6,327	211	6,408	67.2	42.8
7/8/2019	19:00	3,760	202	3,761	67.2	41.5
	20:00	2,947	228	2,936	67.2	41.2
	21:00	3,883	206	3,884	67.2	41.6
	22:00	3,032	210	3,067	67.2	41.4
7/11/2019	19:00	4,105	217	4,192	67.2	41.7
	20:00	3,922	214	3,938	67.2	41.7
	21:00	3,688	206	3,716	67.2	41.8
	22:00	4,567	207	4,580	67.2	41.9
7/15/2019	19:00	4,047	230	4,056	67.2	41.8
	20:00	4,088	213	4,125	67.2	41.9
	21:00	4,299	218	4,361	67.2	42.1
	22:00	4,439	217	4,456	67.2	41.9
7/22/2019	19:00	3,259	199	3,247	67.2	41.6
	20:00	3,370	228	3,367	67.2	41.4

Date	Time	Discharge (cfs)			Elevation (ft)	
		Project	Spillway	Unit 1	Headpond	Tailrace
	21:00	3,154	214	3,168	67.2	41.5
	22:00	3,279	223	3,275	67.2	41.4
7/29/2019	19:00	2,048	235	2,027	67.2	40.7
	20:00	2,221	206	2,225	67.2	40.8
	21:00	2,211	242	2,206	67.2	40.7
	22:00	2,014	207	2,023	67.2	40.8
8/8/2019	19:00	2,051	203	2,044	67.2	40.7
	20:00	2,181	244	2,195	67.2	40.6
	21:00	2,472	213	2,452	67.2	40.9
	22:00	1,929	243	1,929	67.2	40.6
8/15/2019	19:00	2,275	199	2,282	67.2	40.8
	20:00	1,802	230	1,808	67.2	40.4
	21:00	1,924	199	1,930	67.2	40.6
	22:00	2,184	225	2,176	67.2	40.5
8/26/2019	19:00	0	2,596	0	67.2	40.4
	20:00	0	2,617	0	67.2	40.5
	21:00	0	2,731	0	67.3	40.5
	22:00	0	2,750	0	67.2	40.5

DRAFT UPDATED STUDY REPORT

SPRING ANADROMOUS FISH PASSAGE EFFECTIVENESS

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC NO. 4784)



Submitted by:

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April 2020

Brookfield

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND DEFINITIONS

°C	degrees Celsius
cfs	cubic feet per second
FERC	Federal Energy Regulatory Commission
ft	feet
m	meter
mm	millimeters
ME	Maine
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
PCU	Platinum Cobalt Units
RM	river mile
RSP	Revised Study Plan
SPD	Study Plan Determination
Topsham Hydro	Topsham Hydro Limited Partnership, L.P.

1.0 INTRODUCTION

An evaluation of the upstream and downstream passage effectiveness for adult river herring and American Shad was conducted in support of the relicensing of the Pejepscot Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 4784, as identified in the Revised Study Plan (RSP) submitted by Topsham Hydro Partners Limited Partnership (Topsham Hydro) on June 12, 2018. FERC approved with modification the spring migration passage study in its Study Plan Determination (SPD) letter dated July 3, 2018. Within the SPD, FERC requested that Topsham Hydro conduct a desktop assessment of the potential effectiveness of the existing upstream fish lift at the Project to pass adult Atlantic Salmon. This is a report for the 2019 field study to evaluate the existing Project passage structures for the upstream and downstream movement of adult alosines. The additional information requested by FERC in the SPD will be provided as a separate stand-alone document (*Pejepscot Project Atlantic Salmon Upstream Fish Life Evaluation*).

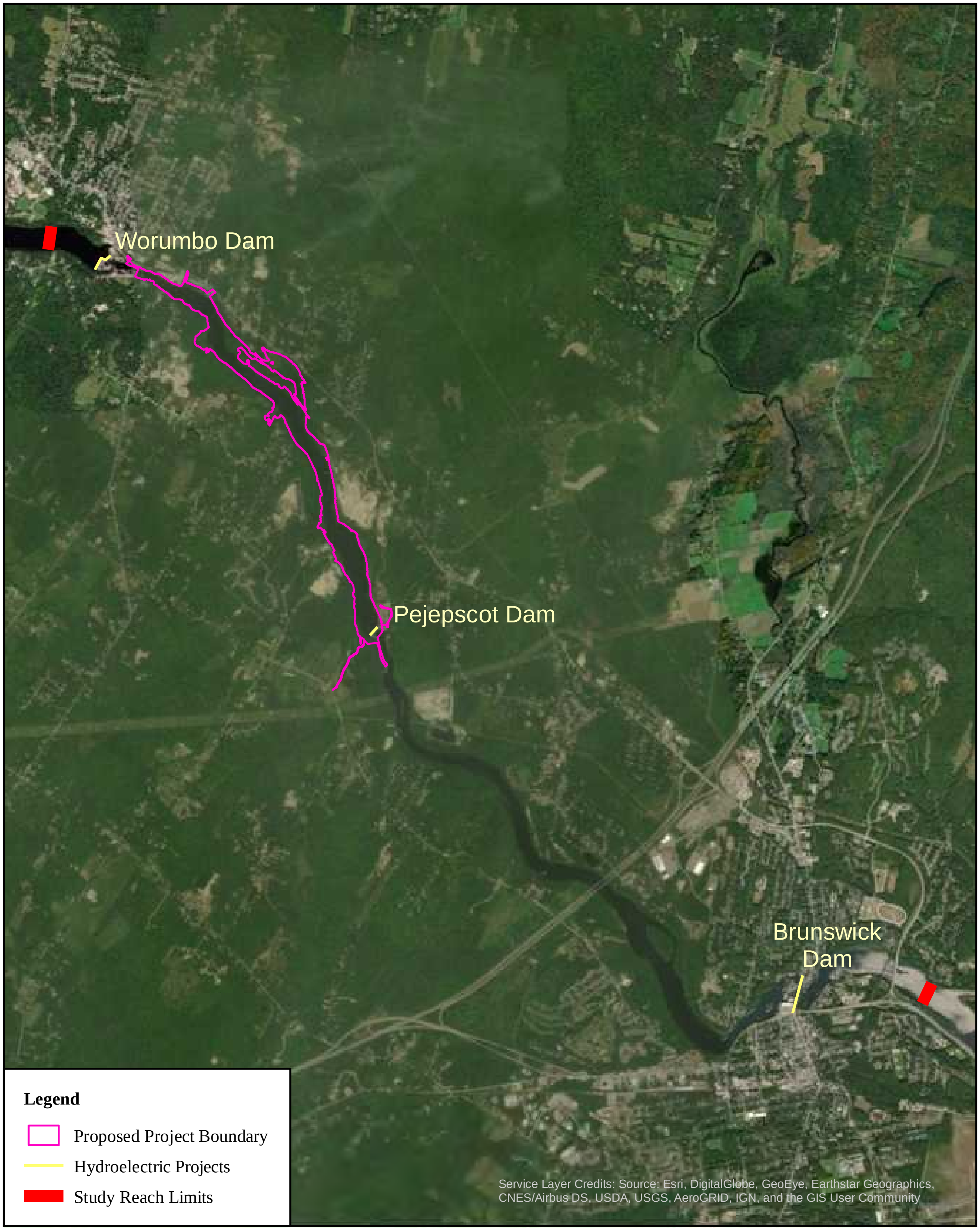
2.0 STUDY GOAL AND OBJECTIVES

The goal of this study was an evaluation of the effectiveness of the existing upstream and downstream fish passage facilities at the Project for adult river herring (i.e., Alewife and Blueback Herring) and American Shad during the spring migration period of May 1 – July 31. Specifically, this study sought to:

- Estimate the proportion of adult river herring and American Shad that approach and successfully pass upstream via the existing Project fish lift.
- Estimate the residence time for adult river herring and American Shad in the area immediately downstream of the Project, prior to successful passage in the upstream fish lift or downstream departure from the study area.
- Estimate the survival or passage success for adult river herring and American Shad passing upstream through defined river reaches as they approach the Project.
- Describe the spatial and temporal distribution of adult river herring and American Shad presence within the tailwater downstream of the Project during the period of residence time prior to successful passage in the upstream fish lift or downstream departure from the study area.
- Describe the extent of mortality that occurs to adult river herring and American Shad during upstream passage.
- Estimate downstream passage survival for outmigrating adult river herring and American Shad at the Project.
- Evaluate the use of available downstream passage routes by outmigrating adult river herring and American Shad at the Project.
- Estimate the residence time for outmigrating adult river herring and American Shad in the area immediately upstream of the Project, prior to downstream passage.
- Examine the temporal distribution of arrival times for outmigrating adult river herring and American Shad to the Project area upstream of the dam.
- Estimate transit times for outmigrating adult river herring and American Shad through defined reaches upstream and downstream of the Project.

3.0 STUDY AREA

The study area included the section of the Androscoggin River from river mile (RM) 4.8 located 1.2 miles downstream of the Brunswick Hydroelectric Project (FERC No. 2284) to RM 14.4 located 0.4 miles upstream of the Worumbo Hydroelectric Project (FERC No. 3248) (Figure 3-1). As specified in the RSP, remote radio-telemetry monitoring stations were established at specified locations throughout the overall study area.



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(FERC No. 4784)
Spring Anadromous Fish Passage
Effectiveness Study

Figure 3-1:
Study Reach of the Androscoggin River Considered during the Spring Anadromous Fish Passage Effectiveness Evaluation

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4.0 METHODS

Effectiveness of the existing upstream and downstream passage facilities for spring migrants at the Project were evaluated via radio-telemetry. As described in the RSP, this study focused on the upstream and downstream passage of radio-tagged adult American Shad and river herring at the Project. Following the release of radio-tagged individuals into the Androscoggin River, their movements were monitored using a series of stationary radio-telemetry receivers in place at the Project as well as at several additional stationary monitoring stations installed at bank-side locations upstream and downstream of the Project to inform on general movements and Project passage success.

4.1. Radio Telemetry Equipment

Movements of radio-tagged adult alosines were recorded via a series of stationary radio-telemetry receivers. Radio-telemetry equipment used during the 2019 evaluation of upstream and downstream passage at Pejepscot included Orion receivers, manufactured by Sigma Eight, as well as SRX receivers manufactured by Lotek Wireless. Each receiver was paired with either an aerial or underwater antenna (dropper antenna). Aerial antennas (four or six element Yagi) were utilized to detect radio-tagged fish within the larger, more open sections of river, such as within the tailrace or at locations downriver of Pejepscot. Dropper antennas were fixed at locations within the lift structure (entrance, behind hopper, and upper exit flume) to determine fish lift effectiveness and at downstream passage locations (e.g., downstream bypasses, Francis units). Dropper antennas were custom built by stripping the shielded ends of RG58 coaxial cables.

Adult alosines tagged during this study were fitted with Pisces radio transmitters (model TX-PSC-I-80-D (river herring) or TX-PSC-I-80 (shad)) manufactured by Sigma-Eight. The TX-PSC-I-80-D transmitter measures approximately 22 x 10 x 10 mm, weighs 3.3 g, and has an estimated battery life of 64 days when set at a 2.0 second burst rate. The TX-PSC-I-80 is slightly more robust measuring 27 x 10 x 10 mm, weighing 4.2 g, and having an estimated battery life of 64 days when set at a 2.0 second burst rate. Given the high likelihood of multiple transmitters in the same location during this study, more than one frequency and burst rate were used in an effort to minimize signal collisions. Transmitters for this study operated on one of three distinct frequencies (149.360, 149.400, or 149.440 MHz). Burst rates for the set of transmitters within any one frequency were varied among settings of 2.0, 2.5, and 3.0 seconds to provide greater separation of signals.

4.2. Monitoring Stations

The RSP identified a total of fifteen monitoring stations to be set up at or upstream/downstream of Pejepscot for the spring passage effectiveness evaluation. All fifteen monitoring locations identified in the RSP were installed as described and each location consisted of a data-logging receiver, antenna, power source, and were configured to receive transmitter signals from a designated area continuously throughout the study period. During installation of each station, range testing was conducted to configure the antennas and receivers in a manner that maximized detection efficiencies at each location. The operation of the radio telemetry receivers was initially established during installation, then confirmed throughout the study period by using beacon tags. A number of beacon tags were stationed at strategic locations within the detection range of either multiple or single antennas, and they emitted signals at programmed time intervals. These signals were detected and logged by the receivers and used to record the functionality of the system throughout the study period.

The locations of monitoring stations installed for the spring passage effectiveness evaluation are outlined here and presented in Figure 4-1.

Monitoring Station S1: This station was installed at a location 1.2 miles downstream of Brunswick and was used to inform on the departure of radio-tagged adult alosines from the lower Pejepscot Project study area (i.e., the 4.5-mile reach between the Pejepscot and Brunswick Dams). This station consisted of a single receiver coupled to an aerial antenna oriented perpendicular to the river channel.

Monitoring Station S2: This station detected radio-tagged adult alosines approaching the Brunswick Project from upriver. Station S2 consisted of a pair of receivers, each coupled to an aerial antenna oriented in an upstream direction. Antennas were installed at a location adjacent to the powerhouse along the western bank and at a location adjacent to the tainter gates along the eastern bank. Detection information from this location was utilized for evaluation of downstream passage success at the Pejepscot Project.

Monitoring Station S3: This station consisted of a single receiver coupled to an aerial antenna and was located bankside at a point approximately 0.5 miles upstream of Station S2 and approximately 2.25 miles downstream of Station S4. Detection information from this location was used for evaluation of downstream passage success at the Pejepscot Project and also informed on upstream passage success for radio-tagged alosines through the reach between Pejepscot and Brunswick Dams.

Monitoring Station S4: Station S4 detected radio-tagged adult alosines passing a point approximately 1.8 miles downstream of the Pejepscot Project. This monitoring station consisted of a receiver coupled to an aerial antenna and was located on the Brunswick & Topsham Water District property along the eastern bank of the river. Detection information from this location was used for evaluation of downstream passage success at the Pejepscot Project and also informed on upstream passage success for radio-tagged alosines through the reach between Pejepscot and Brunswick Dams.

Monitoring Station S5: This station detected radio-tagged adult alosines approaching the area immediately downstream of the Pejepscot Project and consisted of a single receiver and aerial antenna providing coverage at a point approximately 500 feet downstream of the powerhouse. Tag detections from this location were used to establish the initiation of residence times for radio-tagged adult alosines approaching the Project from points downstream.

Monitoring Station S6: This station detected radio-tagged adult alosines as they (1) approached the area of powerhouse discharge and the nearfield area adjacent to the fish lift entry and (2) passed downstream of the Project via Unit 1[1]. This station consisted of a single receiver and aerial antenna.

Monitoring Station S7: This station detected radio-tagged adult alosines that (1) utilized the area below the spillway during their period of residence downstream of the Project prior and to upstream passage and (2) passed downstream of the Project via the spillway.

Monitoring Station S8: Station S8 consisted of a single receiver and an underwater drop antenna. It was positioned inside of the entrance to the fish lift and was used to provide detection information for individuals which entered into the lower entrance flume.

Monitoring Station S9: Station S9 consisted of a single receiver and an underwater drop antenna. It was positioned in the vicinity of the counting window and detected radio-tagged alosines which exited the lift hopper. Detection information from this location was also used to identify downstream passage of radio-tagged adult alosines exiting via this route.

Monitoring Station S10: Station S10 consisted of a single receiver and an underwater drop antenna. It was positioned at the end of the exit flume prior to entry into the headpond. This receiver provide detection information for individuals which exited the upstream end of the fish lift.

Monitoring Station S11: This station was installed at a location approximately 650 feet upstream of the dam and provided (1) arrival timing information on radio-tagged adult alosines as they entered the Project area prior to downstream passage and (2) headpond departure timing for radio-tagged adult alosines having recently passed upstream via the fish lift. Station S11 consisted of a single receiver and aerial antenna oriented perpendicular to the river channel.

Monitoring Station S12: This station monitored downstream passage through the three horizontal Francis units in the northern powerhouse. It consisted of a single receiver and a number of custom-made underwater drops. The dropper antennas were positioned at equally spaced intervals across the width of Units 21, 22, and 23 (Francis units) and combined to create a single large underwater antenna for full coverage of the units. Detections of a transmitter passing through Units 21, 22 or 23 (Francis units) were collected as a single data set and not identified to a particular turbine.

Monitoring Station S13: This station monitored downstream passage of radio-tagged adult alosines through the left side weir (i.e., downstream bypass). It consisted of a single receiver connected to a pair of staggered, custom built drop antennas. The drop antennas were installed through the weir entrance and into the outlet pipe to ensure that detections were of fish committed to the route.

[1] With regards to determination of downstream passage via Unit 1 (Kaplan unit), gate well slots for that turbine are not accessible for the insertion of underwater drop antennas. As a result, it was necessary to use process of elimination to distinguish radio-tagged alosines passing via Unit 1 (Kaplan unit) from other passage routes. This approach was also utilized during the most recent Atlantic salmon smolt passage evaluation at the Project conducted during spring 2018.

Monitoring Station S14: This station monitored downstream passage of radio-tagged adult alosines through the right side weir (i.e., downstream bypass). It consisted of a single receiver connected to a pair of staggered, custom built drop antennas. The drop antennas were installed through the weir entrance and into the outlet pipe to ensure that detections were of fish committed to the route.

Monitoring Station S15: This station was installed at a location approximately 0.4 miles upstream of Worumbo and was used to inform on the movement of radio-tagged adult alosines upstream and out of the Pejepscot impoundment. This station consisted of a single receiver coupled to an aerial antenna oriented perpendicular to the river channel.

4.3. Tagging and Release Procedures

4.3.1. River Herring

Adult river herring tagged as a part of this evaluation were obtained from the Brunswick fishway. Following capture at Brunswick, river herring were visually assessed to ascertain their suitability for tagging. Any individuals exhibiting excessive scale loss or other signs of significant stress were deemed unfit for tagging and released. Individuals deemed acceptable were measured (total length, nearest mm), and sex was determined (when possible) by gently expressing eggs or milt from running-ripe fish. Radio transmitters were inserted gastrically. To facilitate gastric implantation, transmitters were affixed to a flexible tube with their trailing antenna running through the hollow center. The transmitter and leading edge of the flexible tube were pushed into the mouth and down to the stomach. Once in place, the tube was removed leaving the transmitter antenna trailing from the mouth. Following tagging, fish were immediately transferred to a stocking vehicle filled with aerated Androscoggin River water. Salt was added to the transport tank in an effort to reduce stress of tagged fish.

A total of four releases of river herring intended to assess upstream passage effectiveness were conducted to ensure that the arrival of radio-tagged fish at the Pejepscot tailrace did not occur all at once, potentially causing issues with receiver detection efficiency. Each group of radio-tagged river herring released downstream of Pejepscot was accompanied by an additional number of untagged adult river herring (to replicate natural schooling behavior). All releases of river herring associated with the upstream passage evaluation took place at the Mill Street hand-carry boat launch approximately 0.6 miles upstream from Brunswick. Upon arrival at the stocking location, test fish were netted from the transport tank, released into the river, and the date and time of release was recorded.

A total of four release events of radio-tagged river herring intended to assess downstream passage effectiveness at Pejepscot were conducted. Those individuals were transported via stocking truck from the Brunswick upstream fishway to the Pejepscot public boat launch located 2.6 miles upstream of the Project. Following arrival of the stocking truck at the release location, the tank contents were sluiced directly into the river to avoid any further netting or handling. The date and time of each release was recorded.

4.3.2. American Shad

The RSP identified the Brunswick fishway as a source of adult American Shad for the spring passage effectiveness study at Pejepscot. During consultation with the resource agencies during the study plan development process it was agreed upon that additional collection methodologies or adult shad sources may be required to obtain an adequate number of test fish for passage effectiveness evaluation.

Adult shad for evaluation of upstream passage effectiveness at Pejepscot were all collected via hook and line from the Androscoggin River immediately downstream of Brunswick. Project personnel fished by boat just downstream of the Frank J. Wood Bridge. Upon being hooked, shad were quickly landed on the boat then immediately transferred to an onboard holding tank filled with lightly salted, recirculating Androscoggin River water. Fish were then transported downstream to the Brunswick public boat launch where they were transported by net to the tagging station located off to the side of the parking area. Tagging methodologies followed those described above for river herring. Following tagging, fish were immediately transferred to a stocking vehicle filled with aerated Androscoggin River water. Salt was added to the transport tank in an effort to reduce stress of tagged fish. Individual loads of radio-tagged shad were maintained in the stocking truck for no more than two hours prior to being driven upstream to the release site. This resulted in a total of 13 release groups over a five day period of shad sampling. All releases of radio-tagged adult American Shad associated with the upstream passage evaluation occurred at the Mill Street hand-carry boat launch approximately 0.6 miles upstream from Brunswick. Upon arrival at the stocking location, test fish were netted from the transport tank, released into the river, and the date and time of release was recorded.

Adult shad for the downstream passage effectiveness were collected from the fish lift at the Cataract Hydroelectric Project (FERC No. 2528) on the Saco River. Per guidance from the MDMR, adult shad from the Cataract lift could be made available for evaluating downstream passage at Pejepscot once a total of 1,000 adult shad had been trucked from Cataract to stocking points within the Saco River watershed. Following capture at the east channel lift, adult shad were dip-netted from the sorting tank and visually assessed to ascertain their suitability for tagging. Tagging methodologies for these fish were consistent with those described above. Once tagged, adult shad were placed in a stocking truck loaded with recirculating, salted, and oxygenated Saco River water and driven to the release site. A single release of radio-tagged adult American Shad associated with the downstream passage evaluation occurred at the Pejepscot public boat launch located 2.6 miles upstream of the Project. Upon arrival at the stocking location, test fish were netted from the transport tank, released into the river, and the date and time of release was recorded.

4.4. Data Collection

4.4.1. Stationary Telemetry Data

Receiver downloads occurred a minimum of once weekly during the period from the initial tag and release event until mid-August, 2019. Backup copies of all telemetry data were made prior to receiver initialization. Field tests at the time of download to ensure data integrity and receiver performance included confirmation of file integrity, confirmation that the last record was consistent with the downloaded data (beacon tags were critical to this step), and lastly, confirmation that the receiver was operational upon restart and actively collecting data post download. Within a data file, transmitter detections were stored as a single event (i.e., single data line). Each event included the date and time of detection, frequency, ID code, and signal strength.

4.4.2. Manual Telemetry Data

To provide supplemental detection information to the stationary receiver data set, manual tracking was conducted on several occasions from the time of initial release through mid-August, 2019. Tracking efforts were conducted once every two weeks and attempted to cover the section of the mainstem Androscoggin River from Worumbo downstream to Brunswick. Manual tracking conducted during the 2019 spring telemetry evaluation was a combination of boat and shore-based (i.e., truck, foot) effort.

4.4.3. Operational and Environmental Data

Androscoggin River water temperature was recorded via a continuously operating logger installed in the vicinity of the exit flume at to the Project fishway. Hourly records for operations data were provided by Brookfield for the 2019 evaluation period and included spill discharge (cubic feet per second (cfs)), gate settings for inflatable sections 1 through 5, unit discharge for Units 1, 21, 22, and 23 (cfs), head pond elevation (ft), and tailwater elevation (ft).

4.4.4. Downstream Drift Assessment

A set of freshly dead adult alosines were radio-tagged and released downstream of the Pejepscot Project during the release period to simulate “movements” of adult alosines killed during downstream passage. The downstream progression of these known mortalities were recorded via both the stationary receivers as well as during manual tracking events and helped inform on the probability that downstream receivers might record false positive detections associated with dead study fish drifting passed the receiver (this would result in biased estimates of downstream passage survival).

4.5. Analytical Methodology

4.5.1. Data Processing

Tag detections in each downloaded stationary telemetry data file were validated through a series of site-specific and logical criteria, which included:

1. Signal strength threshold level of the detection,
2. Frequency of the radio tag signals per unit of time, and
3. Spatial and temporal characteristics of each individual detection with respect to the full series of detections at monitoring stations within the entire detection array.

To determine the signal strength threshold for a valid tag signal, power levels associated with background noise were recorded at each monitoring station prior to the release of radio-tagged fish. These “false” signals are typically received at relatively low power levels, and they were removed from the analysis using a series of data filters. The frequency of the signal detections for an individual radio tag was examined at each monitoring station, such that over a set period of time, there were an adequate number of detections to rule out an isolated false detection (e.g. at least 3 detections within 1 minute). Finally, the spatial and temporal distributions of detections across multiple monitoring stations were examined to verify that the pattern of detections was not occurring in a manner that was unreasonable (i.e., time for a fish to have relocated within the time between the detections).

4.5.2. Evaluation of Upstream Fish Passage Effectiveness

4.5.2.1. Fish Movement and Project Area Usage

The stationary telemetry data set collected as part of this effort was examined and used to evaluate a number of metrics related to upstream movement and usage of the project area. These metrics included:

Approach Duration: This value was calculated as the duration of time from release into the Androscoggin River at the Mill Street boat launch until initial detection at Monitoring Station S5, approximately 500 feet downstream of the dam. The duration and rates of upstream ascent for tagged adult alosines from the release location to the dam were further broken down to the discrete sections as bounded by Monitoring Stations S3 to S4 and S4 to S5.

Time at Large: This value was calculated as the duration of time from the initial detection at Monitoring Station S5 until (1) upstream passage at the Pejepscot fish lift, or (2) movement downstream and permanently away from the project area. Final departure times were determined by the first detection at Monitoring Stations S10 and S11 for fish passing upstream or the last detection at Monitoring Station S5 for fish departing downstream.

Cumulative Project Residence Duration: Nearly all radio-tagged adult alosines determined to have approached within 500 feet of Pejepscot did not remain there for the duration of their calculated time at large, but rather made a series of movements in and out of the monitored portions of river downstream of the powerhouse and spillway. As a result, the period of actual residence in the vicinity of the Pejepscot tailrace (and associated proximity to the fishway entrance) was the sum of several shorter durations which represent all or a percentage of the calculated time at large. To examine this, a “cumulative project residence duration” was determined for each individual fish. This process relied on the ability to identify the breaks in the detection time series for a particular individual to indicate when that fish was or was not present in the detection field of one or more receivers. Since signal transmissions during a period of residence within the detection zone of a receiver can go unrecorded for a variety of reasons (e.g., receiver scan time, signal collision, background interference, etc.), it was not appropriate to set a threshold interval between detections equal to the transmission rate of the tags (Castro-Santos and Perry 2012). To determine the appropriate threshold interval for coverage of the two reaches of interest (i.e., the powerhouse tailrace and the spillway bypass reach), the intervals between all successive detections for each individual at those two locations were calculated. Monitoring Station S7 was used to inform on presence within the spillway bypass reach, and Monitoring Stations S6 and S8 were used to determine presence within the powerhouse tailrace area.

For both the spillway bypass reach and the powerhouse tailrace reach, a threshold interval for determining continued presence was identified as the 95th percentile of the observed set of interval durations (Figure 4-2). This value was calculated at 153 seconds for the spillway bypass reach and 141 seconds for the powerhouse tailrace reach. These two threshold values were used to delineate when each period of residence was started and completed for a tagged individual. The departure of a radio-tagged alosine from one of the two detection zones was determined when the time interval between successive detections exceeded the specific threshold interval for that zone.

Fish Lift Entrance Events: A proportion of the radio-tagged adult alosines which were determined to have approached with 500 feet of Pejepscot were eventually detected within the entrance flume to the upstream fish lift. Following the technique described above for determination of cumulative residence duration in the regions downstream of the powerhouse and spillway, the cumulative duration of time spent within the detection zone of the underwater drop antenna within the fish lift entrance flume (i.e. Monitoring Station S8) was determined. A threshold interval for determining continued presence was identified as the 97th percentile of the observed set of interval durations and was set at 197 seconds (Figure 4-3). Applying this technique allowed for estimation of the number and duration of occurrences where an individual alosine was within the Station S8 detection field (determined by field testing to extend from several feet inside the fish lift entrance to a point just shy of where the lower flume turns to approach the hopper). As a result, the number of "events" calculated for an individual does not necessarily represent the number of individual entries into the lower flume nor does the duration represent the full amount of time spent in the lower flume (only that within range of Station S8).

The stationary telemetry data set was also examined to provide insight into the seasonal and diel pattern of successful upstream passage events for radio-tagged individuals.

4.5.3. Parameter Estimates for Evaluation of Upstream Passage

Upstream passage success at the Project was estimated using a standard Cormack-Jolly-Seber (CJS) model run for the set of individual encounter histories (i.e., the series of detection/no detection through the linear sequence of receivers from downstream to upstream) for each species evaluated. This approach provided a series of reach-specific "survival" or passage success estimates for:

- Monitoring station S3 to Monitoring station S4;
- Monitoring station S4 to Monitoring station S5 (i.e., lower tailrace);
- Monitoring station S5 (i.e., lower tailrace) to Monitoring station S6 (i.e., nearfield);
- Monitoring station S6 (i.e., nearfield) to Monitoring station S8 (i.e., lift entrance);
- Monitoring station S8 (i.e., lift entrance) to Monitoring station S9 (i.e., upper exit flume);
- Monitoring station S9 (i.e., upper exit flume) to Monitoring station S10 (i.e., flume exit);

Standard error and confidence bounds for each estimate were generated. The product of adjacent reach-specific estimates were used to evaluate passage success. Nearfield effectiveness was estimated as the probability of a fish detected at Station S6 (nearfield area) to move to Station S8 (lift entrance). Internal effectiveness was estimated as the joint probability of a fish detected at the lift entrance to move to the window and for a fish detected at the window to move to the lift entrance (i.e., (StnS8 to StnS9)*(StnS9 to StnS10)). Total effectiveness was estimated as the joint probability to move from the nearfield area to the lift exit (i.e., (StnS6 to StnS8)*(StnS8 to StnS9)*(StnS9 to StnS10)).

To evaluate passage success using the CJS models, a suite of candidate models were developed in Program MARK (White and Burnham 1999) based on whether survival (i.e., passage success), recapture (i.e., detection), or both vary or are constant among stations. Models developed during this study included:

- *Phi(t)p(t)*: survival and recapture may vary between receiver stations;
- *Phi(t)p(.)*: survival may vary between stations; recapture is constant between stations;
- *Phi(.)p(t)*: survival is constant between stations; recapture may vary between stations;
- *Phi(.)p(.)*: survival and recapture are constant between stations;

Where;

- *Phi* = probability of survival
- *p* = probability of detection
- *(t)* = parameter varies
- *(.)* = parameter is constant

To evaluate the fit of the CJS model, goodness of fit testing was conducted for the “starting model” (i.e., the fully parameterized model) using the function RELEASE within Program MARK. Akaike’s Information Criterion (AIC) was used to rank the models as to how well they fit the observed mark-recapture data. Lower AIC values denote a more explanatory yet parsimonious fit than higher AIC values. Assuming the assumptions of the model with the lowest AIC value were reasonable with regards to this study, that model was selected for the purposes of generating passage effectiveness estimates.

4.5.4. Evaluation of Downstream Fish Passage Effectiveness

4.5.5. Fish Movement and Passage Route Selection

Following the completion of data file processing, a complete record of all valid stationary receiver detections for each radio-tagged adult alosine was generated. The pattern and timing of detections in these individual records were reviewed, and a route of passage as well as project arrival and passage times were assigned to each radio-tagged individual. In the instance that a downstream route could not be clearly determined from the collected data, the passage event for that particular fish was classified as ‘unknown’.

Where data were available, upstream residence and project residence times were calculated. Values for the upstream residence for adult alosines were calculated as the duration of time from release at the Pejepscot boat launch until arrival at the Project as defined by detection at Station S11. Upstream project duration was defined as the duration of time from the initial detection at Station S11 until the determined time of downstream passage.

4.5.6. Parameter Estimates for Evaluation of Downstream Passage

Similar to upstream passage success, downstream passage survival for adult alosines at the Project was evaluated using a CJS model. Candidate models, goodness of fit testing and model ranking for the downstream CJS model were the same as those described above for the upstream CJS model. Downstream parameter estimates for *Phi* and *p* were obtained using the encounter histories constructed for each radio-tagged fish indicating their presence or absence at detection locations from the approach receiver (i.e., Monitoring Station 11) through the second receiver located downstream of the Project (i.e., Monitoring Station 3). The downstream CJS model generated reach-specific survival estimates for radio-tagged adult American Shad and river herring from:

- Release location to Monitoring station S11 (i.e., upstream approach);
- Monitoring station S11 (i.e., upstream approach) to downstream passage;
- Downstream passage to Monitoring station S4;
- Monitoring station S4 to Monitoring station S3.

The joint probability of the two Project reach survival estimates (i.e., (Station S11 to Passage)*(Passage to Station S4)) was taken as the estimate of total passage survival for the Project. This approach resulted in mortality estimates that include both background mortality (i.e., natural mortality such as predation) and mortality due to Project effects for radio-tagged adult alosines in the 650-foot section upstream of the Project dam as well as in the reach downstream of the Project dam extending to the first downstream receiver. Thus, the results reflect a minimum estimate of survival attributable to Project effects for adult river herring and American shad.

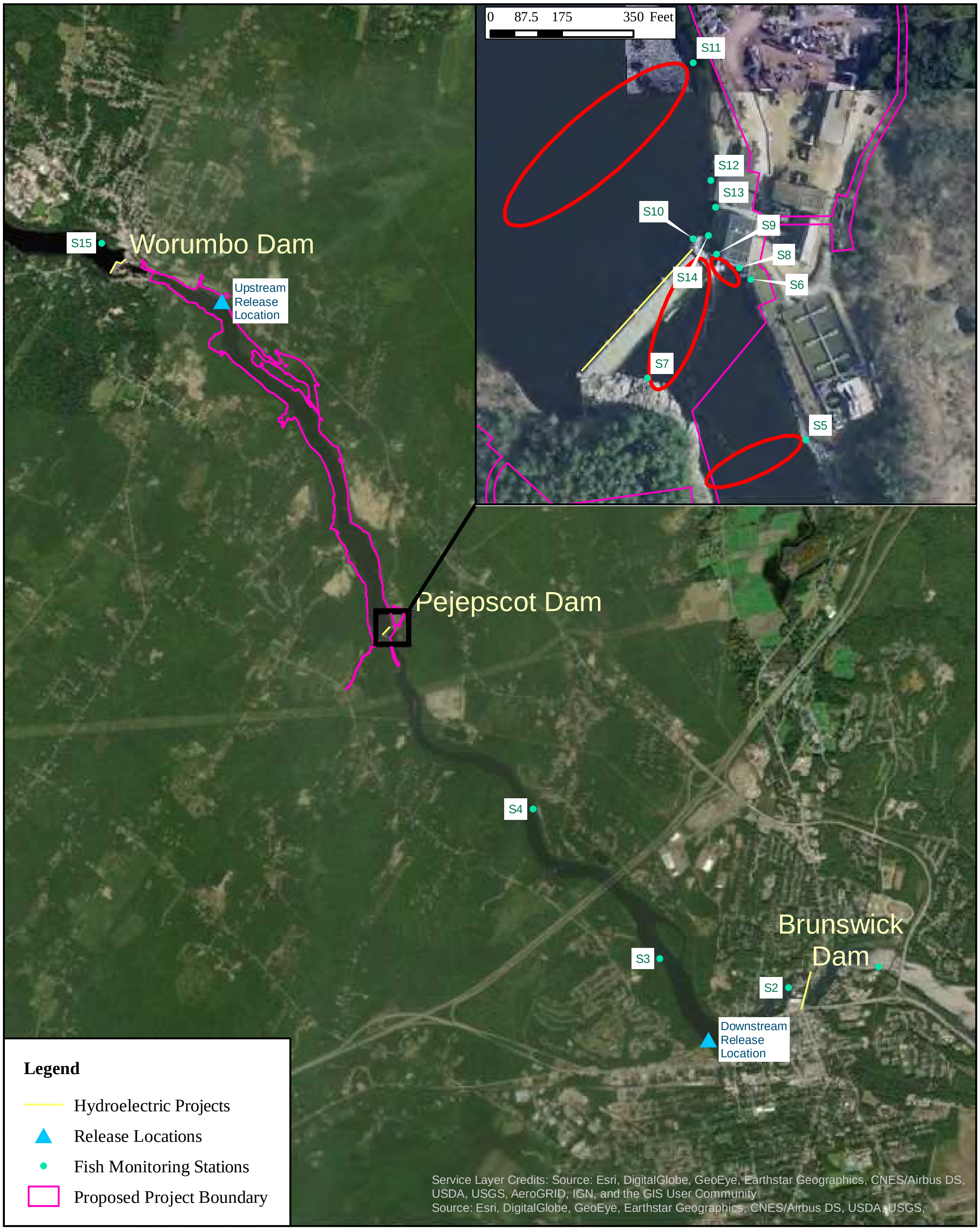

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Figure 4-1:
Locations and Approximate Detection Areas for Monitoring Stations S1-S15 during the 2019 Adult Alosine Upstream and Downstream Passage Effectiveness Evaluation

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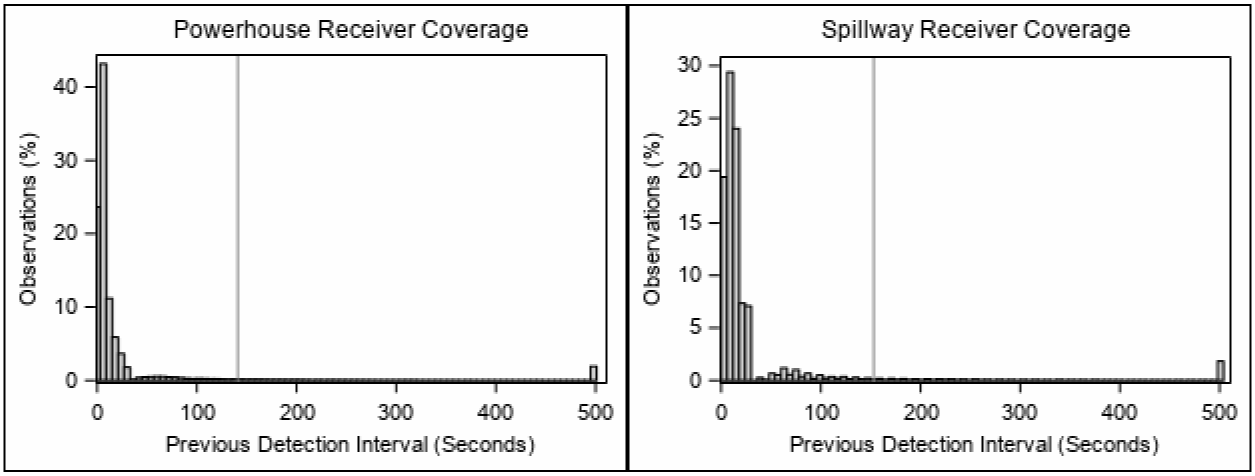


Figure 4-2: Frequency Distribution (%) of Intervals Since Last Detection of Radio-tagged Adult Alosines Transmitting from the Pejepscot Spillway Bypass Reach (Right Panel) and Pejepscot Powerhouse Tailrace Reach (Left Panel). Vertical Line Indicates the Unique Threshold Interval Used to Delineate a New Period of Residence

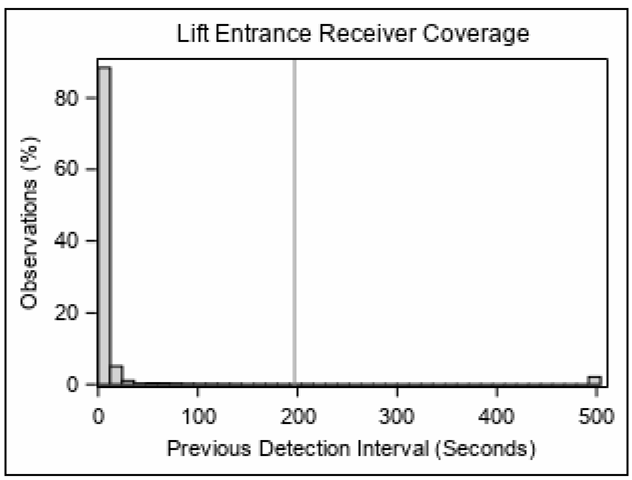


Figure 4-3: Frequency Distribution (%) of Intervals Since Last Detection of Radio-tagged Adult Alosines Transmitting from the Pejepscot Fish Lift Entrance. Vertical Line Indicates the Unique Threshold Interval Used To Delineate a New Period of Residence

5.0 RESULTS

5.1. Androscoggin River Conditions and Pejepscot Project Operations

Figure 5-1 presents the total river flow and water temperature for the Androscoggin River for the period May 20 to August 12, 2019. Total river flow values are the sum of the reported unit discharge and spill values as reported for Pejepscot and Androscoggin River temperature readings were recorded hourly in the Project headpond. The mean total Androscoggin River flows ranged between 11,832 and 16,666 cfs for dates where radio-tagged river herring were released into the system. The mean total Androscoggin River flows ranged between 4,408 and

7,695 cfs for dates where radio-tagged adult shad were released downstream of Pejepscot and was 4,072 cfs on the single date where they were released upstream of Pejepscot. Water temperature ranged between 10.3 and 29.3 °C from the time of first release until the end of monitoring period. Mean daily Androscoggin River temperatures were less than or equal to 14 °C on release dates for radio-tagged herring and 20 °C on release dates for radio-tagged shad released downstream of Pejepscot. The single release of radio-tagged shad upstream of Pejepscot took place in early July when river temperature was 24°C.

Pejepscot operational flows are presented in Figure 5-2. Androscoggin River flows at Pejepscot exceeded the station capacity of 8,550 cfs during May. Spill was present for the duration of May. With the exception of a few relatively short duration high flow events, Androscoggin River flows were below station capacity for the study months of June, July and August.

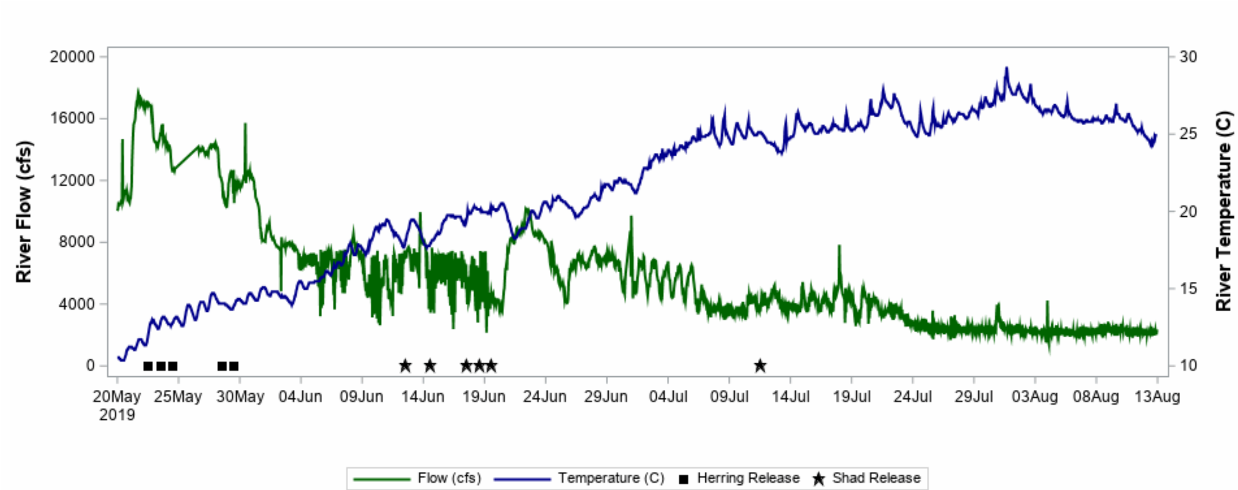


Figure 5-1: Androscoggin River Discharge and Temperature for the Period May 20 to August 12, 2019

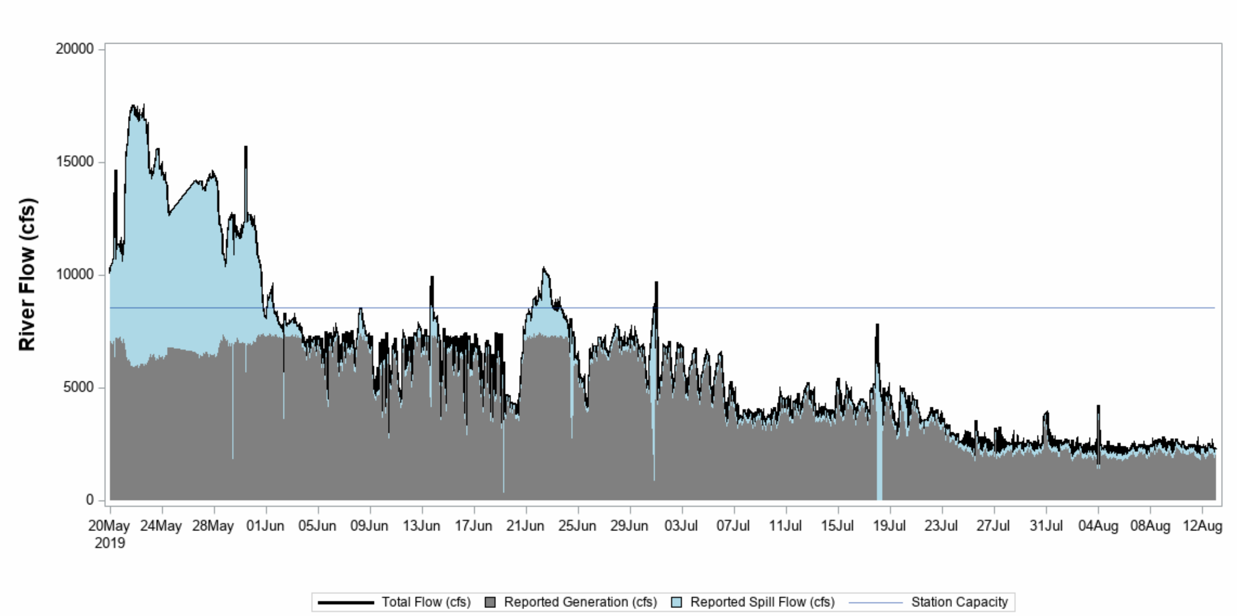


Figure 5-2: Total, Powerhouse, and Spill Flow (Cfs) Relative to Station Capacity at Pejepscot for the Period May 20 to August 12, 2019

5.2. Monitoring Station Functionality

Radio-tagged adult river herring and American Shad were released into the Androscoggin River beginning in the latter part of May, 2019. The RSP called for continuous monitoring at each stationary receiver location through the end of July. Monitoring was extended by two weeks due to the late procurement of adult American Shad for the downstream passage evaluation and to make sure adequate time was allowed to document any downstream movement from that release group. Normandeau conducted weekly checks and downloads at all stationary receivers during that period. Station coverage was determined by a combination of beacon transmitter detections and observations reported by field personnel conducting the receiver checks and data downloads.

The majority of the radio-telemetry monitoring stations installed to evaluate adult alosines at Pejepscot operated without issue for the full study period (Figure 5-3). Interruptions in continuous coverage were noted at three stations. A number of relatively short outages (i.e., 5 hours to 1.3 days) were reported at Station S1, located downstream of Brunswick, during the latter part of July and early August. These periods were attributed to full data banks on the scanning receiver due to one or more stationary transmitters in the field of detection. These outages did not have any impact on evaluation of upstream or downstream passage effectiveness at Pejepscot. A similar outage occurred at Station S2 (Brunswick) for a 7 hour period on July 3. This outage impacted only the receiver located on the powerhouse side of the river at Brunswick. The spill side receiver operated throughout the spring monitoring period. Lastly, coverage was interrupted due to a corrupted receiver memory card at Station S10 (fish lift exit) for a seven day period starting on July 22. This outage period did not have an impact on evaluation of either upstream or downstream passage effectiveness at the Project as evidenced by the lack of detections at the fish lift count window for fish passing either upstream or downstream during the impacted period.

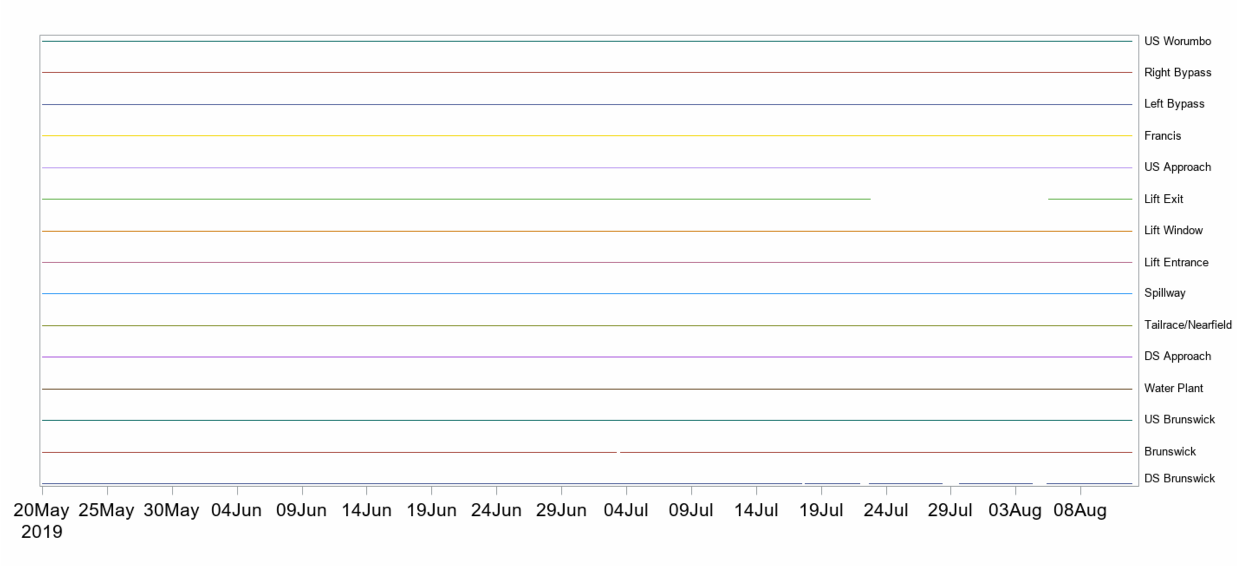


Figure 5-3: Monitoring Station Operational Coverage for Telemetry Receivers at Pejepscot during the Spring Adult Alosine Evaluation Period, May 20 to August 12, 2019

5.3. Downstream Drift Assessment

A total of five freshly dead adult American Shad were radio-tagged and released directly into the tailrace at Pejepscot on July 11, 2019. Of the five dead shad released into the tailrace, two were detected at Monitoring Stations S4, S3, and S2 (located 1.8, 4.1, and 4.5 miles downstream of the dam, respectively). The two dead individuals required a mean duration of 1 day, 14 hours and 20 minutes to cover the 4.5 mile reach (a rate of 0.1 mph). Individual drift durations for the two shad were 39.7 hours and 36.7 hours to drift from Pejepscot to Brunswick. When the total drift time from Pejepscot to Brunswick was examined among the three monitored reaches downstream of Pejepscot, the majority of the "travel" time for the two dead shad which reached Brunswick was spent in the reach between the Pejepscot tailrace and first downstream receiver. Transit through the lower two monitored reaches was relatively quick by comparison (0.05 mph for the upper most reach versus 0.6 and 0.9 mph for the lower two reaches). It is likely this was a function of the time for a dead fish to decay to the point where the carcass becomes more buoyant. The remaining three shad were not detected at any of the three downstream monitoring locations.

The duration and rate of drift for these dead individuals was considered during evaluation of project survival for adult river herring and shad passing downstream of Pejepscot during 2019 (Sections 5.6.4 and 5.7.4).

5.4. Adult River Herring Upstream Passage Evaluation

A total of 102 adult river herring were radio-tagged following collection at the Brunswick upstream fishway during May 2019 and were released into the Androscoggin River for the purposes of evaluating upstream passage at Pejepscot (Table 5-1). Four groups of radio-tagged adult herring were released downstream of Pejepscot at the Mill Street boat launch over an eight day period from May 22 to May 29. All releases were conducted between 1100 and 1500. The tagging and release of radio-tagged adult herring downstream of Pejepscot encompassed the range of dates representing the peak of herring returns counted at Brunswick for the 2019 passage season (Figure 5-4). Adult river herring radio-tagged and released downstream of Pejepscot ranged in total length from 273-320 mm. Each release group of radio-tagged individuals was accompanied by approximately 200 untagged adult herring. A full listing of river herring tagged as part of this assessment is provided in Appendix A.

5.4.1. Post-release Movements and Project Area Usage

5.4.1.1. Post-release Movements

Adult river herring released downstream of Pejepscot were free to (1) move upstream and enter into the monitored section of the Androscoggin River immediately downstream of the Project, (2) utilize the section of the Androscoggin River between Pejepscot and Brunswick, or (3) move downstream and depart the study reach via passage at Brunswick. Each radio-tagged individual was classified into a unique post-release movement category based on their pattern of detections among the various monitoring stations. Individuals which were determined to have moved upstream within 500 feet of the project (based on detection at Monitoring Station S5) were classified as “Approached”. Individuals which were limited to detections at the first monitoring station downstream of the Pejepscot tailrace (Station S4) were classified as “Downstream”. Individuals which moved downstream immediately following release (as indicated by detections at Station S3, Brunswick (Station S2) and Station S1 were classified as “Fallback”. A single radio-tagged herring went undetected following its release into the Androscoggin River.

As presented in Table 5-2, the majority of radio-tagged adult herring were determined to have successfully moved upstream and into the reach immediately downstream of the Pejepscot Project following their release. Of the 102 radio-tagged herring released, 79% (81 of the 102) were determined to have approached Pejepscot Dam. A total of 17 radio-tagged adult herring (17% of all tagged individuals) partially ascended the reach between Pejepscot and the release site but failed to approach the Project. All seventeen of these individuals were determined to have eventually descended downstream to Brunswick and 12 of the 17 were subsequently detected at Station S1, 1.2 miles downstream of Brunswick Dam. The total time at large for this group of fish from release until their initial detection at Brunswick Dam ranged from 13.5 hours to 11.4 days (median = 5.4 days). Only three radio-tagged adult herring were limited to detections only at Brunswick Dam following their release at the Mill Street boat launch.

5.4.1.2. Return Duration and Time at Large

The median approach duration for radio-tagged adult river herring (i.e., the duration of time from release until initial detection at the point approximately 500 feet downstream of Pejepscot Dam) was 10.0 hours (range = 3.0 hours to 10.1 days; Table 5-3). When examined by release date, the median approach duration to Pejepscot was quickest for adult herring released as part of the first group on May 22, 2019 (Figure 5-5). The range of approach durations for radio-tagged herring to arrive at Pejepscot following release widened over the course of the full set of releases.

The duration of time at large following the initial detection at the point 500 feet downstream of Pejepscot determined for each radio-tagged individual ranged from 0.1 hours to 17.1 days (median = 2.7 days; Table 5-4). For an individual herring, the calculated value for time at large represented time from initial detection until either (1) upstream passage out of the study area at the Pejepscot fish lift, or (2) the final movement downstream and away from the project area.

When examined by behavioral type, the median duration of time at large for adult herring successfully passing upstream at the Pejepscot fish lift was 1.6 days, whereas it was 2.9 days for adult herring which did not pass upstream of Pejepscot. Figure 5-6 presents the distribution of time at large durations observed for radio-tagged adult herring which either failed to pass or successfully passed upstream at the Pejepscot lift during spring 2019.

5.4.1.3. Cumulative Project Residence and Zone Usage

The values for the overall time at large for each individual radio-tagged herring presented above (Table 5-4; Figure 5-6) represent the duration of time from their initial detection in the area immediately downstream of Pejepscot until the final detection in the area downstream of the Project (as determined by upstream passage at the lift or their final outmigration downstream and away from the Project). During that time at large, radio-tagged adult herring were free to move in and out of the detection fields for stationary receivers covering (1) the tailrace and fish lift area immediately below the Pejepscot powerhouse, or (2) the reach located downstream of the spillway. In addition, tagged adult herring were free to move into areas downstream of Pejepscot and away from the receiver detection zones. The sum of time spent within range of stationary receivers covering the reach 500 feet downstream of the powerhouse and spillway (i.e., the cumulative project residence duration) represented between <1% and 99% of the overall time at large when all radio-tagged river herring are considered (Table 5-5). When examined by release group, the median percentage of time at large spent within the range of detection for stationary receivers was fairly consistent, ranging between 12% and 27%.

Of principal interest to the overall study objective of evaluating the effectiveness of the Pejepscot fish lift is the distribution of the cumulative project residence time for radio-tagged adult herring between the powerhouse tailrace and downstream of the spillway section. When the full set of radio-tagged adult herring determined to have approached Pejepscot are considered, an average of 36% of the cumulative residence duration was spent within the tailrace area immediately downstream of the powerhouse and in proximity to the fish lift. Conversely, an average of 64% of the cumulative residence time was spent within the region downstream of the dam spillway. The average percentage of time spent in the detection zones for the tailrace and bypass reach varied when the eventual fate of individual adult herring is considered (i.e., successful or unsuccessful upstream passage at the Pejepscot fish lift). Radio-tagged adult herring successfully passing upstream at Pejepscot were detected in range of the powerhouse tailrace receiver for an average of 62% of their cumulative residence time and in range of the spillway receiver for an average of 38% of the time. Radio-tagged adult herring failing to successfully pass upstream at Pejepscot were detected in range of the powerhouse tailrace receiver for an average of 30% of their cumulative residence time and in range of the spillway receiver for an average of 70% of the time.

5.4.2. Upstream Passage Effectiveness

5.4.2.1. Entrance Events

The full time series of recorded detections for each radio-tagged adult river herring was reviewed and interactions with the Pejepscot fish lift entrance were quantified based on the analytical approach described in Section 4.5.2.1. Of the 81 radio-tagged adult river herring which were determined to have approached within 500 feet of the downstream side of the Pejepscot Dam, 75 (93%) were detected on at least one occasion at the fish lift entrance. The cumulative sum of time spent (i.e., the cumulative lift entrance duration) and number of unique occurrence events in the detection zone of Monitoring Station S8 is presented by release group in Table 5-6. When all radio-tagged herring which entered the lift are considered, the median number of occurrence events in the fish lift entrance detection field was eight with a median cumulative lift entrance duration of 0.3 hours (range = <0.1 to 9.1 hours). There did not appear to be any difference in the number of entrance events or cumulative duration of time spent in the Station S8 detection zone for adult herring which successfully passed (median number of entrance events = 8; median cumulative lift entrance duration = 0.3 hours [range = <0.1 – 2.8 hours]) or did not pass (median number of entrance events = 9; median cumulative lift entrance duration = 0.3 hours [range = <0.1 – 9.1 hours]). As noted earlier, the number of entrance events calculated for an individual does not necessarily represent the number of individual entries into the lower flume nor does the duration represent the full amount of time spent in the lower flume (only that within range of Station S8).

Figure 5-7 presents the distribution of fish lift entrance detections as recorded by hour during the 2019 passage season. Although detections in the vicinity of the lift entrance occurred during all hours, the frequency of detection at the Pejepscot lift entrance showed a bimodal distribution with peaks during the hours of 1000 and 1600. The current operational window from 0800 to 1800 encompassed 85% of all detections of radio-tagged river herring at the lift entrance.

5.4.2.2. Passage Events

Of the 81 radio-tagged adult river herring which were determined to have approached within 500 feet of the downstream side of the Pejepscot Dam, 16 individuals were determined to have successfully located and used the existing fish lift for upstream passage. Figure 5-8 presents the range of upstream passage dates for those individuals. Radio-tagged herring were noted passing upstream of Pejepscot over a range of dates from May 25 through June 10. The majority of those passage events took place between May 25 and May 30. Spill conditions were present at the Project for the duration of that time period Upstream passage events for tagged adult river herring at Pejepscot were recorded within the range of normal lift operational hours at the Project (0800-1800; Figure 5-9). Upstream passage events for radio-tagged individuals were more frequent during the early morning hours.

As described above in Section 5.4.1 (Return Duration and Time at Large), the calculated values of time at large for radio-tagged adult herring which were successful in passing upstream via the Pejepscot fish lift represent the duration of time from their initial detection at the 500 foot mark until their initial detection at the upstream exit of the exit flume. Figure 5-6 presents the distribution of those calculated durations prior to passage for each of the 16 radio-tagged herring which successfully passed upstream. The median time to pass was 1.6 days. Approximately 44% of tagged adult herring passed upstream via the lift within 24 hours of arriving at the 200 m mark downstream, and approximately 57% did so within 48 hours.

5.4.2.3. Passage Effectiveness

The CJS model *Phi(t)p(t)* provided the best fit for the observed mark-recapture data associated with upstream movements of radio-tagged adult river herring approaching Pejepscot (Table 5-7). Specific passage success estimates at Pejepscot ranged between 0.213-1.0 among discretely monitored river sections from Monitoring Station S3 up to the exit at the upstream end of the fish lift exit flume (Table 5-8). The detection efficiency for telemetry receivers recording passage of adult river herring at monitoring stations at and downstream of Pejepscot ranged from 1.000 to 0.975 (Table 5-9).

As defined in Section 4.5.3, the specific passage success estimates obtained from the CJS model for radio-tagged adult herring approaching Pejepscot were used to estimate (1) near field attraction, (2) fish lift internal efficiency, and (3) overall fish lift effectiveness. As stated earlier the nearfield attraction rate is the probability of an adult river herring to move from the nearfield/tailrace region into the downstream entrance of the lift, the internal efficiency is the probability of an adult herring to move from the lift entrance to the lift exit and the overall efficiency is the probability of an adult herring to move from the tailrace/nearfield region to the upstream exit from the fish lift. Upstream passage effectiveness estimates for adult river herring at Pejepscot during 2019 are as follows:

- Nearfield attraction effectiveness:
    - 92.6% (75% CI = 88.5-95.3%)
- Fish lift internal efficiency:
    - 21.3% (75% CI = 16.0-26.9%)
- Overall fish lift effectiveness:
    - 19.8% (75% CI = 14.8-24.9%)

Table 5-1: Summary Of Release and Biological Information (Total Length and Sex) for Adult River Herring Radio-tagged and Released into the Androscoggin River at the Mill Street Boat Launch during May, 2019

Adult River Herring	Upstream Effectiveness Release Group			
	#1	#2	#3	#4
Release Location	Mill Street boat launch			
Release Date	May 22	May 23	May 28	May 29
Release Time	11: 40	14: 24	12: 19	12: 00
No. Tagged Released	25	25	25	27
No. Untagged Released	200	211	250	207
% Male	20%	60%	20%	63%
% Female	0%	20%	76%	33%
% Undetermined	80%	20%	4%	4%
Min. Total Length (mm)	279	273	285	274
Max Total Length (mm)	306	314	320	310
Mean Total Length (mm)	292	294	301	290

Table 5-2: Summary of Post-Release Movement for Adult River Herring Radio-tagged and Released Downstream of Pejepscot during Spring 2019

Post-release Movement	Release Group				
	May 22	May 23	May 28	May 29	All
Approach	25	25	16	15	81
Downstream	-	-	6	11	17
Fallback	-	-	2	1	3
Unknown	-	-	1	-	1
Total	25	25	25	27	102

Table 5-3: Minimum, Maximum, Mean and Median Approach Duration (Hours) for Adult River Herring Radio-tagged and Released Downstream of Pejepscot by Release Group, Spring 2019

Release Group	Approach Duration (hours)			
	Min	Max	Median	Mean
May 22	5.3	21.8	8.1	9.9
May 23	4.1	113.9	18.0	18.9
May 28	3.6	198.9	23.9	35.6
May 29	3.0	243.5	10.5	44.2
All	3.0	243.5	9.5	24.1

Table 5-4: Minimum, Maximum, Mean and Median Time at Large (Hours) for Adult River Herring Radio-tagged and Released Downstream of Pejepscot by Release Group and Passage Success, Spring 2019

	Time at Large (hours)			
Release Group	Min	Max	Median	Mean
May 22	1.4	335.0	70.3	91.8
May 23	1.2	409.7	46.3	90.6
May 28	1.0	273.9	111.8	121.4
May 29	0.1	251.8	31.8	65.3
All	0.1	409.7	64.7	92.4
Pejepscot Passage	**Time at Large (hours)**			
	Min	**Max**	**Median**	**Mean**
Non-pass	0.1	335.0	70.3	93.3
Passed	0.5	409.7	37.6	88.8

Table 5-5: Minimum, Maximum, Mean and Median Values for the Percentage of Time at Large Represented by the Calculated Cumulative Residence Duration for Adult River Herring Radio-tagged and Released Downstream of Pejepscot by Release Group, Spring 2019

Release Group	Cumulative Residence Duration			
	Min	Max	Median	Mean
May 22	1.1%	98.9%	15.0%	19.9%
May 23	0.2%	46.0%	15.5%	19.1%
May 28	1.0%	38.3%	12.0%	13.6%
May 29	1.5%	92.3%	26.9%	27.2%
All	0.2%	98.9%	15.3%	19.8%

Table 5-6: Minimum, Maximum, Mean and Median Values for the Cumulative Lift Entrance Duration and Number of Lift Entrance Events for Adult River Herring Radio-tagged and Released Downstream of Pejepscot by Release Group, Spring 2019

Release Group	Cumulative Lift Entrance Duration (hours)				Lift Entrance Events (No.)			
	Min	Max	Median	Mean	Min	Max	Median	Mean
May 22	<0.1	9.1	0.2	0.8	1	78	6	11
May 23	<0.1	2.7	0.4	0.8	1	62	9	15
May 28	<0.1	4.8	0.3	0.8	1	36	9	12
May 29	0.1	2.9	0.6	0.8	1	35	14	15
All	<0.1	9.1	0.3	0.8	1	78	8	13
Pejepscot Passage	**Cumulative Lift Entrance Duration (hours)**				**Lift Entrance Events (No.)**			
	Min	**Max**	**Median**	**Mean**	**Min**	**Max**	**Median**	**Mean**
Non-pass	<0.1	9.1	0.3	0.8	1	78	9	13
Passed	<0.1	2.9	0.3	0.6	1	35	8	13

Table 5-7: CJS Model Selection Criteria for Upstream Passage Effectiveness of Adult River Herring at Pejepscot during 2019

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
Phi(t) p(t)	336.10	0.00	0.90	1.00	9	5.43
Phi(t) p(.)	340.52	4.41	0.10	0.11	8	11.91
Phi(.) p(t)	536.78	200.68	0.00	0.00	5	214.32
Phi(.) p(.)	560.72	224.62	0.00	0.00	2	244.34

Table 5-8: Passage Success Probability Estimates (*Phi*), Standard Errors and Likelihood 75 and 95% Confidence Intervals for Radio-tagged Adult River Herring Approaching the Pejepscot Fish Lift during 2019

River Section	*Phi*	SE	95% CI		75% CI	
S3 to S4	0.970	0.017	0.910	0.990	0.942	0.984
S4 to Approach	0.827	0.038	0.739	0.889	0.778	0.866
Approach to Nearfield	1.000	0.000	-	-	-	-
Nearfield to Entrance	0.926	0.029	0.845	0.966	0.885	0.953
Entrance to Window	0.213	0.047	0.135	0.320	0.164	0.273
Window to Exit	1.000	0.000	-	-	-	-

Table 5-9: Detection Efficiency Estimates (*p*) for Monitoring Locations Installed to Detect Radio-tagged Adult River Herring at Pejepscot for Evaluation of Upstream Passage Effectiveness during 2019

Location	*p*	SE	95% CI	
Station S3	0.980	0.014	0.922	0.995
Station S4	1.000	0.000	-	-
Station S5 (approach)	0.975	0.017	0.907	0.994
Station S6 (nearfield)	1.000	0.000	-	-
Station S8 (entrance)	1.000	0.000	-	-
Station S9 (window)	1.000	0.000	-	-
Station S10 (exit)	1.000	0.000	-	-

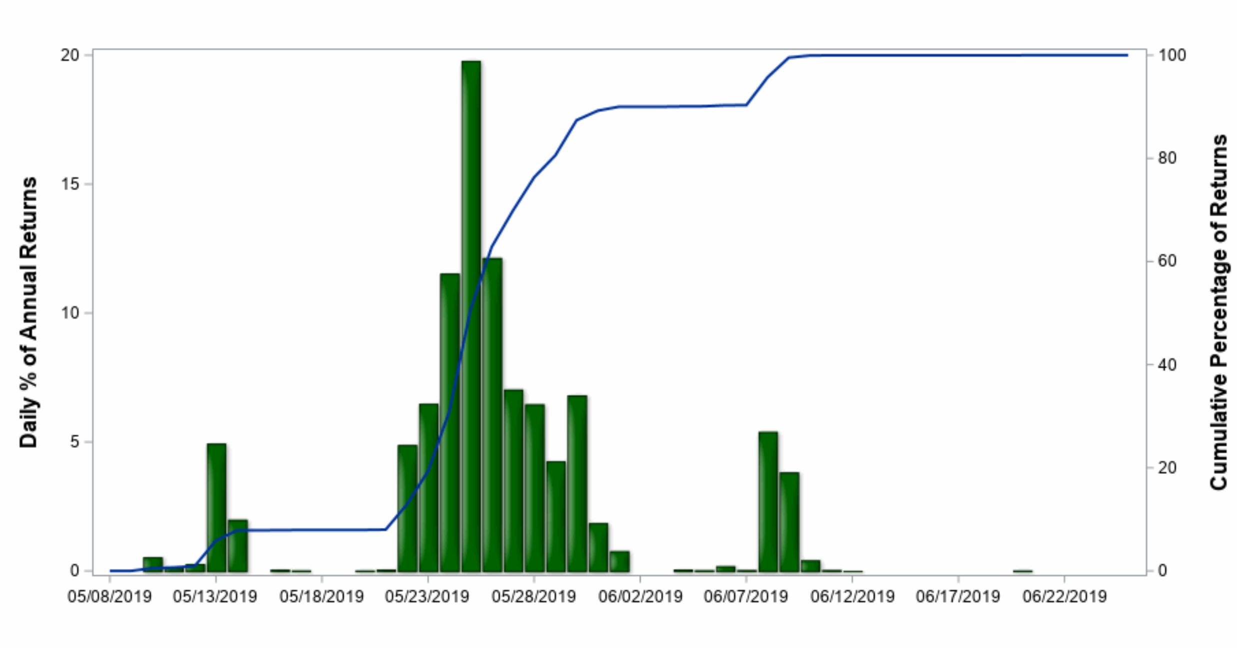


Figure 5-4: Daily Percentage (Green Bars) and Cumulative Percentage (Blue Line) of Adult River Herring Returns at the Brunswick Fishway for the 2019 Passage Season

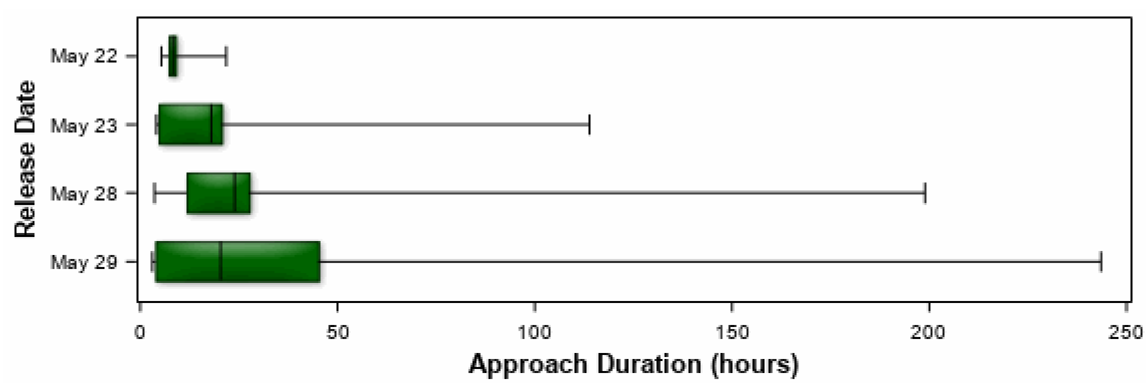


Figure 5-5: Duration of Time from Release until Approach at Pejepscot For Radio-tagged Adult Herring by Release Group during Spring 2019.

Left And Right Edges Of Box Represent First And Third Quartiles, Middle Line Represents Median, And Whiskers Represent Width Of All Outliers

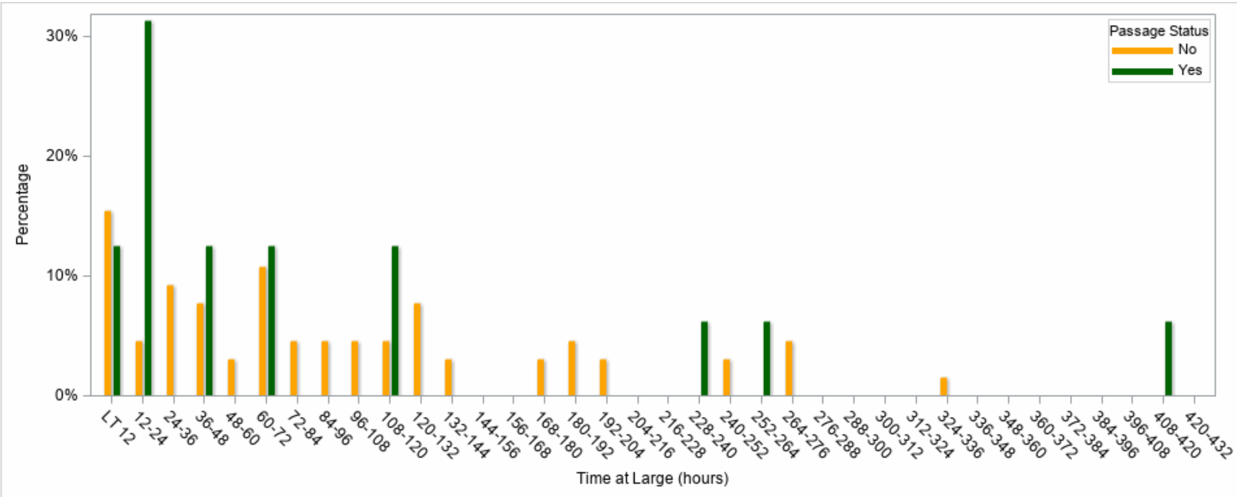


Figure 5-6: Duration of Time at Large from Arrival at Pejepscot until Successful Upstream Passage (green bars) or Departure from Study Area (orange bars) for Radio-tagged Adult River Herring at Pejepscot, Spring 2019

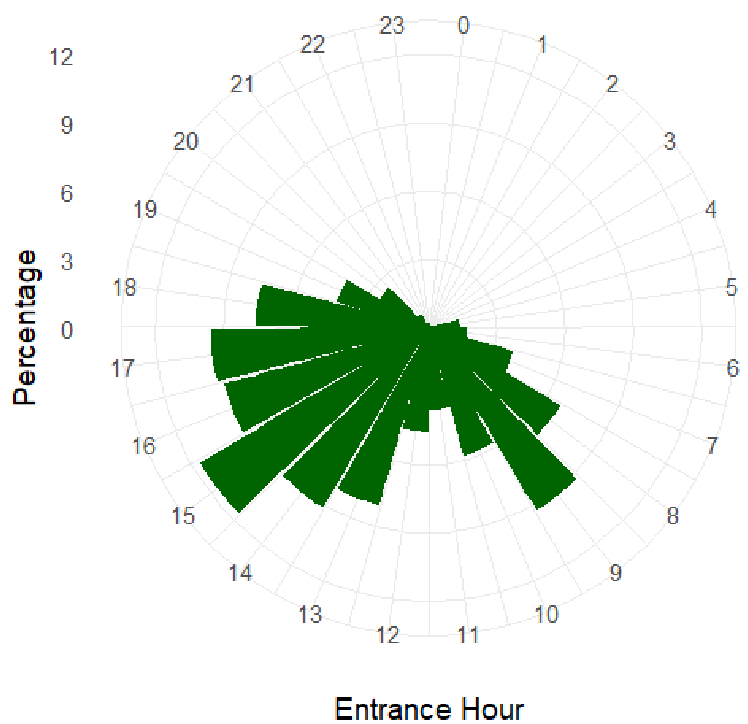


Figure 5-7: Frequency of Detection For Radio-tagged Adult River Herring At The Entrance To The Pejepscot Fish Lift, Spring 2019

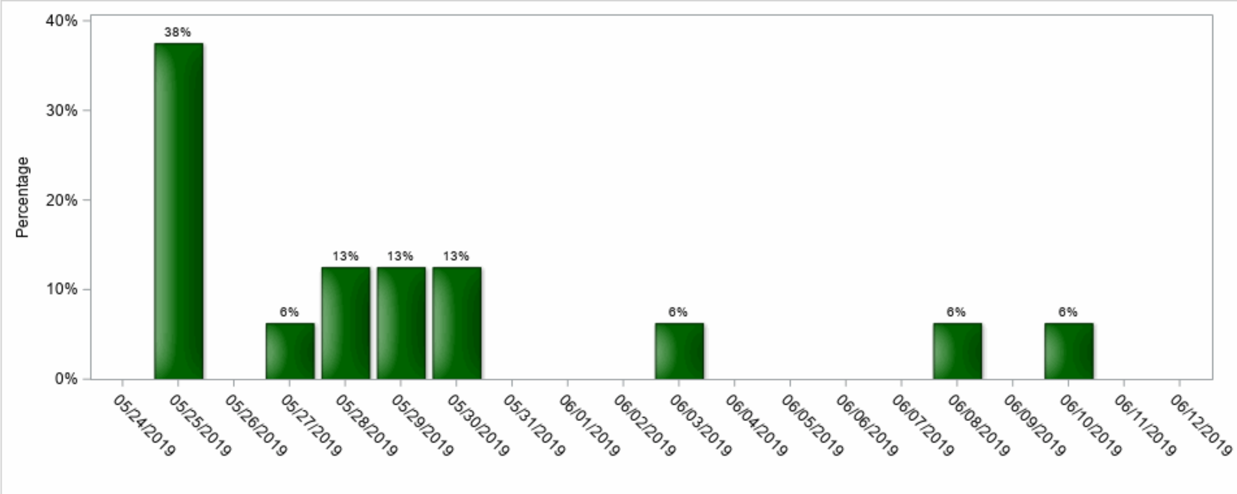


Figure 5-8: Distribution for the Date of Upstream Passage Observed for Radio0tagged Adult River Herring at Pejepscot, Spring 2019

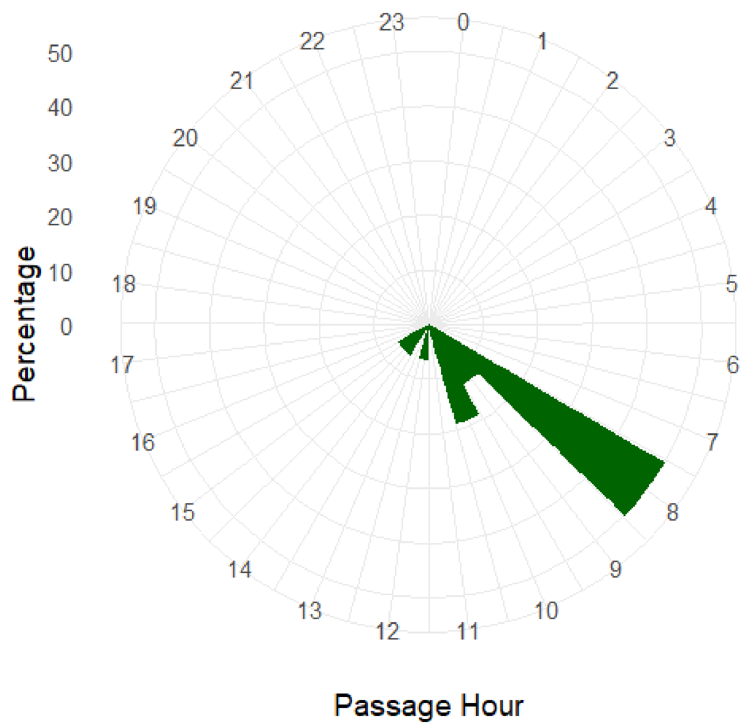


Figure 5-9: Distribution for the Time of Upstream Passage Observed for Radio-tagged Adult River Herring at Pejepscot

5.5. Adult American Shad Upstream Passage Evaluation

A total of 129 adult American Shad were radio-tagged following rod and reel collection downstream of Brunswick during June 2019 (Figure 5-10). Tagged shad were trucked and released into the Androscoggin River for the purposes of evaluating upstream passage at Pejepscot. Five groups of radio-tagged adult shad were released downstream of Pejepscot at the Mill Street boat launch over a seven day period from June 12 to June 19 (Table 5-10). The dates of collection of adult shad for radio-tagging coincided with period of returns at the Brunswick fishway for the 2019 season (Figure 5-11). Adult shad radio-tagged and released downstream of Pejepscot ranged in total length from 358-570 mm. A full listing of American Shad tagged as part of this assessment is provided in Appendix A.

5.5.1. Post-release Movements and Project Area Usage

5.5.1.1. Post-release Movements

Adult American Shad released downstream of Pejepscot were free to (1) move upstream and enter into the monitored section of the Androscoggin River immediately downstream of the Project, (2) utilize the section of the Androscoggin River between Pejepscot and Brunswick, or (3) move downstream and depart the study reach via passage at Brunswick. Each radio-tagged individual was classified into one of the unique post-release movement categories described for river herring in Section 5.4.1 (“Approached”, “Downstream”, and “Fallback”).

As presented in Table 5-11, 28% of radio-tagged adult shad (36 of the 129 individuals) released at the Mill Street boat launch were determined to have successfully moved upstream and into the reach immediately downstream of the Pejepscot Project following their release. A total of 29 radio-tagged adult shad (22% of all tagged individuals) partially ascended the reach between Pejepscot and the release site but failed to approach the Project. Of those 29 individuals, 26 were determined to have eventually descended downstream to Brunswick and 18 of the 26 were subsequently detected at Station S1, 1.2 miles downstream of Brunswick Dam. The total time at large for this group of fish from release until their initial detection at Brunswick Dam was 30.7 hours to 28.3 days (median = 5.8 days). A total of 58 radio-tagged adult shad (45% of those released) were classified as fallback and were limited to the Androscoggin River downstream of Monitoring Station S4. Of that group, 53 of the 58 approached Brunswick and of those, 31 were detected at Station S1, 1.2 miles downstream of Brunswick Dam. The median time at large for radio-tagged adult shad classified as fallback from their release until their initial detection at Brunswick Dam was 12 hours (range = 1.1 hours to 51.8 days).

5.5.1.2. Return Duration and Time at Large

The median approach duration for radio-tagged adult shad (i.e., the duration of time from release until initial detection at the point approximately 500 feet downstream of Pejepscot Dam) was 3.3 days (range = 15.4 hours to 17.2 days; Table 5–12). When examined by release date, the median approach duration to Pejepscot was shortest for adult shad released as part of the first group on June 12, 2019 (Figure 5-12).

For an individual shad, a value of time at large was calculated to represent the duration of time from initial detection at the downstream “approach” receiver (Station S5) until the final movement downstream and away from the project area. The duration of time at large for radio-tagged adult shad ranged from <0.1 hours to 42.5 days (median = 9.1 hours; Table 5-13).

5.5.1.3. Cumulative Project Residence and Zone Usage

The values for the overall time at large for each individual radio-tagged adult shad presented above (Table 5-13) represent the duration of time from their initial until final detection in the area downstream of the Project (as determined by their first and last detection at Monitoring Station S5). During that time at large, radio-tagged adult shad were free to move in and out of the detection fields for stationary receivers covering (1) the tailrace and fish lift area immediately below the Pejepscot powerhouse, or (2) the reach located downstream of the spillway. In addition, tagged adult shad were free to move into areas downstream of Pejepscot and away from the receiver detection zones. The sum of time spent within range of stationary receivers covering the reach 500 feet downstream of the powerhouse and spillway (i.e., the cumulative project residence duration) represented between <1% and 100% of the overall time at large when all radio-tagged American Shad are considered (Table 5-14). When examined by release date, the median percentage of time at large spent within the range of detection for stationary receivers was fairly consistent, ranging between 1% and 19%.

Of principal interest to the overall study objective of evaluating the effectiveness of the Pejepscot fish lift is the distribution of the cumulative project residence time for radio-tagged adult shad between the powerhouse tailrace and downstream of the spillway section. When the full set of radio-tagged adult shad determined to have approached Pejepscot are considered, an average of 1% (range = 0 – 5%) of the cumulative residence duration was spent within the tailrace area immediately downstream of the powerhouse and in proximity to the fish lift. Conversely, an average of 99% (range = 95-100%) of the cumulative residence time was spent within the region downstream of the dam spillway.

5.5.2. Upstream Passage Effectiveness

5.5.2.1. Entrance Events

Of the 36 radio-tagged adult American Shad which were determined to have approached within 500 feet of the downstream side of the Pejepscot Dam, only seven were detected on at least one occasion at the fish lift entrance. Entrance occurrences for six of the seven shad were limited to five or fewer detections comprising a single entrance event. One radio-tagged adult shad was present in the detection zone of Monitoring Station S8 on two separate occasions. The combined cumulative lift entrance duration for that individual was less than 0.1 hours.

Figure 5-13 presents the distribution of fish lift entrance detections for radio-tagged adult shad as recorded by hour during the 2019 passage season. Detections in the vicinity of the lift entrance were limited with a peak in occurrence during the late afternoon hours (1500-1600). The distribution observed in Figure 5-13 was largely driven by a single radio-tagged individual which was present in the lift entrance for a period of time during the 1500 hour on July 13, 2019. The current operational window from 0800 to 1800 encompassed 90% of all detections of radio-tagged adult shad at the lift entrance.

5.5.2.2. Passage Effectiveness

Of the 129 adult American Shad radio-tagged and released downstream of the Project, 36 were determined to have approached within 500 feet of the downstream side of the Pejepscot Dam. The CJS model *Phi(t)p(t)* provided the best fit for the observed mark-recapture data associated with upstream movements of radio-tagged adult shad approaching Pejepscot (Table 5-15). However, due to the limited number or lack of detections for tagged shad at the receiver locations associated with the fish lift structure, reach-specific probabilities and associated confidence intervals for upstream passage success of adult American Shad by the CJS model were limited to the lower-river reaches presented in Table 5-16. The detection efficiency rates for telemetry receivers recording passage of adult American Shad at monitoring stations downstream of Pejepscot were similar to those presented for river herring in Table 5-9.

Lacking adequate detection data to inform the CJS model, an estimate of the nearfield attraction of the existing Pejepscot lift for radio-tagged adult shad was generated as the percentage of individuals detected in the nearfield/tailrace region to be subsequently detected at the fish lift entrance (32%). Estimates of internal (i.e., the probability of an adult shad to move from the lift entrance to the lift exit) and overall (i.e., the probability of an adult shad to move from the tailrace/nearfield region to the upstream exit from the fish lift) fish lift effectiveness are 0% due to the lack of observed upstream passage for radio-tagged individuals of that species.

Table 5-10: Summary of Release and Biological Information (Total Length and Sex) for Adult American Shad Radio-tagged and Released into the Androscoggin River at the Mill Street Boat Launch during June, 2019

Adult American Shad	Upstream Effectiveness Release Group				
	#1	#2	#3	#4	#5
Release Location	Mill Street boat launch				
Release Date	June 12	June14	June 17	June 18	June 19
Release Time	13:30-16:25	13:30-15:45	12:30-18:00	10:35-18:30	10:20-16:00
No. Tagged Released	20	16	25	29	39
% Male	20%	44%	40%	48%	23%
% Female	70%	56%	56%	52%	74%
% Undetermined	10%	0%	4%	0%	3%
Min. Total Length (mm)	417	358	384	390	380
Max Total Length (mm)	570	512	555	528	540
Mean Total Length (mm)	500	467	474	473	485

Table 5-11: Summary of Post-Release Movement for Adult American Shad Radio-tagged and Released Downstream of Pejepscot during Spring 2019

Post-release Movement	Release Group					
	June 12	June14	June 17	June 18	June 19	All
Approach	10	5	8	5	8	36
Downstream	3	1	8	7	10	29
Fallback	7	10	9	15	17	58
Unknown	-	-	-	2	4	6
Total	20	16	25	29	39	129

Table 5–12: Minimum, Maximum, Mean and Median Approach Duration (Hours) for Adult American Shad Radio-tagged and Released Downstream of Pejepscot by Release Group, Spring 2019

Release Group	Approach Duration (hours)			
	Min	Max	Median	Mean
June 12	15.4	211.2	41.5	58.6
June 14	20.0	243.5	110.4	126.5
June 17	16.6	167.3	93.3	87.9
June 18	37.8	159.1	83.1	84.9
June 19	58.0	414.0	96.8	141.6
All	15.4	414.0	78.3	96.6

Table 5-13: Minimum, Maximum, Mean and Median Time at Large (Hours) for Adult American Shad Radio-tagged and Released Downstream of Pejepscot by Release Group and Passage Success, Spring 2019

Release Group	Time at Large (hours)			
	Min	Max	Median	Mean
June 12	0.1	229.2	11.0	77.7
June 14	0.5	317.5	3.8	76.7
June 17	0.0	115.9	5.8	18.2
June 18	0.5	140.4	46.3	50.3
June 19	<0.1	1021.3	304.5	351.0
All	<0.1	1021.3	9.1	121.3
Pejepscot Passage	**Time at Large (hours)**			
	Min	**Max**	**Median**	**Mean**
Non-pass	<0.1	1021.3	9.1	121.3
Passed	-	-	-	-

Table 5-14: Minimum, Maximum, Mean and Median Values for the Percentage of Time at Large Represented by the Calculated Cumulative Residence Duration for Adult American Shad Radio-tagged and Released Downstream of Pejepscot by Release Group, Spring 2019

Release Group	Cumulative Residence Duration			
	Min	Max	Median	Mean
June 12	0.0%	63.7%	7.0%	16.3%
June 14	2.3%	19.5%	4.0%	9.2%
June 17	2.4%	100.0%	19.0%	29.0%
June 18	0.2%	18.5%	3.1%	6.7%
June 19	<0.1%	6.1%	0.6%	1.8%
All	<0.1%	100.0%	6.1%	14.3%

Table 5-15: CJS Model Selection Criteria for Upstream Passage Effectiveness of Adult American Shad at Pejepscot during 2019

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
Phi(t) p(t)	484.60	0.00	0.98	1.00	7	17.57
Phi(t) p(.)	492.86	8.26	0.02	0.02	5	29.98
Phi(.) p(t)	568.41	83.81	0.00	0.00	5	105.53
Phi(.) p(.)	600.37	115.77	0.00	0.00	2	143.62

Table 5-16: Passage Success Probability Estimates (*Phi*), Standard Errors and Likelihood 75 and 95% Confidence Intervals for Radio-tagged Adult American Shad Approaching the Pejepscot Fish Lift during 2019

River Section	*Phi*	SE	95% CI		75% CI	
S3 to S4	0.504	0.044	0.418	0.589	0.453	0.554
S4 to Approach	0.579	0.063	0.453	0.696	0.505	0.650
Approach to Nearfield	0.682	0.119	0.422	0.863	0.533	0.801

Figure 5-10: Rod and Reel Collection of Adult American Shad from the Androscoggin River Downstream of Brunswick, June 2019

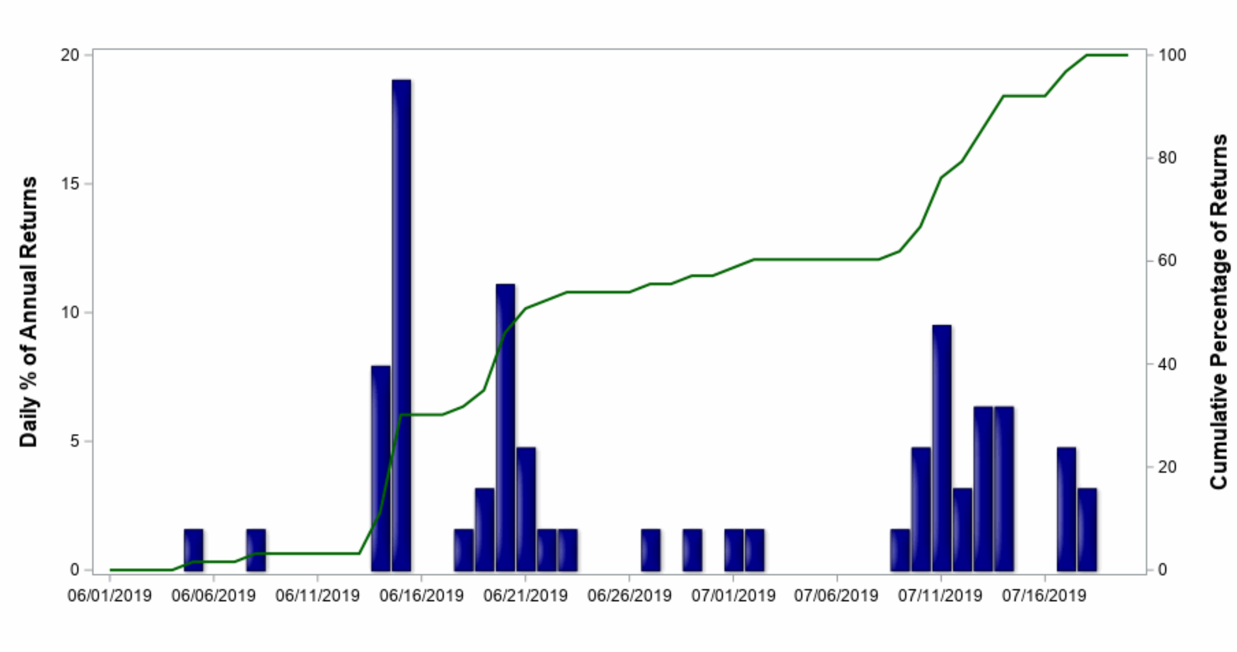


Figure 5-11: Daily Percentage (Blue Bars) and Cumulative Percentage (Green Line) of Adult American Shad Returns at the Brunswick Fishway for the 2019 Passage Season

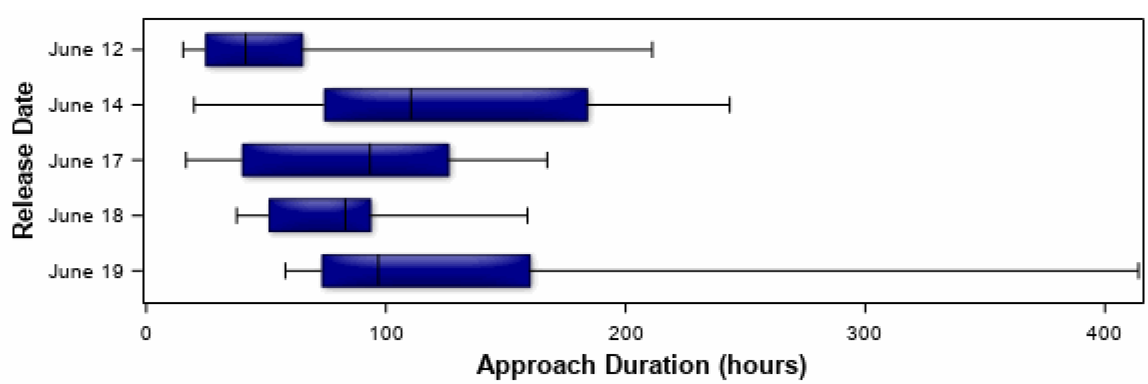


Figure 5-12: Duration of Time from Release until Approach at Pejepscot for Radio-tagged Adult Shad By Release Group during Spring 2019

Left and right edges of box represent first and third quartiles, middle line represents median, and whiskers represent width of all outliers.

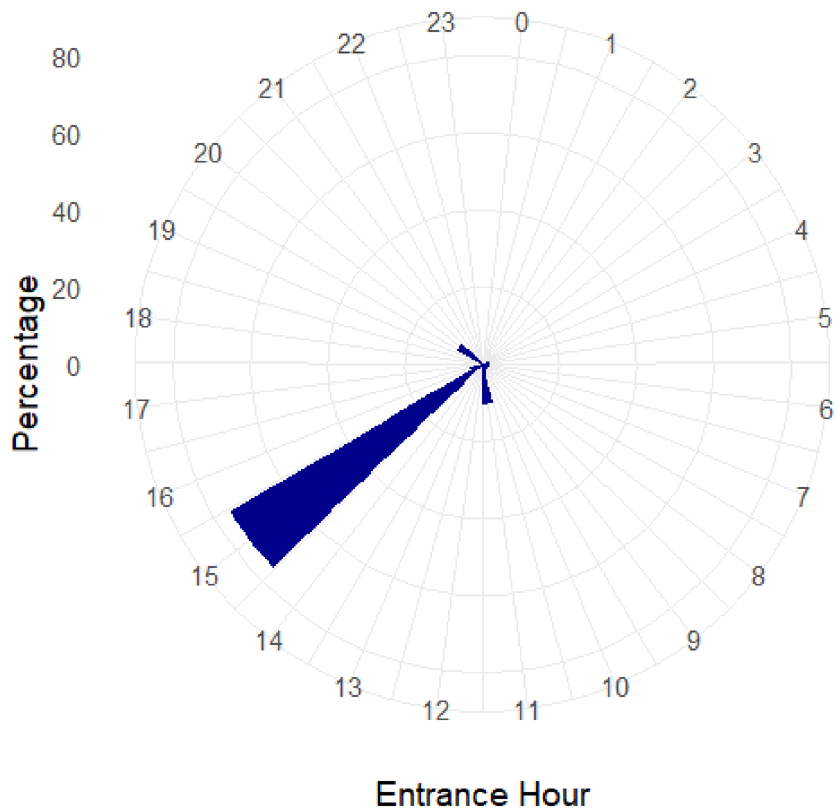


Figure 5-13: Frequency of Detection for Radio-tagged Adult American Shad at the Entrance to the Pejepscot Fish Lift, Spring 2019

5.6. Adult River Herring Downstream Passage Evaluation

A total of 99 adult river herring were radio-tagged following collection at the Brunswick upstream fishway during May 2019 and were released into the Androscoggin River for the purposes of evaluating downstream passage at Pejepscot (Table 5-17). Four groups of radio-tagged adult herring were released upstream of the Project at the Pejepscot boat launch over an eight day period from May 22 to May 29. All releases were conducted around mid-day. Adult river herring tagged and released upstream of the Project ranged in total length from 270-321 mm.

In addition to the 99 radio-tagged adult river herring released upstream of the Project, another 16 tagged adult herring released downstream of Pejepscot at the Mill Street boat launch successfully ascended the fish lift and were included in the downstream analysis. When the full time series of detections for all 115 fish was reviewed, a total of 95 radio-tagged adult river herring were determined to have approached the Pejepscot Dam and had an opportunity to pass downstream. Estimates for the upstream residence time, upstream project duration, downstream passage route selection, downstream transit duration, and passage survival of adult river herring at Pejepscot were based on those 95 individuals and are presented in Sections 5.6.1 to 5.6.4. A full listing of adult river herring radio-tagged as part of this assessment is provided in Appendix A.

5.6.1. Project Returns and Upstream Residence Duration

Following their release at the upper end of the Pejepscot impoundment or upstream passage at the Pejepscot lift, radio-tagged river herring were free to (1) ascend further upstream via passage at the Worumbo Project or (2) approach and interact with the Pejepscot Project for the purposes of outmigration. A total of 24 of the 99 individuals released at the Pejepscot boat ramp and 9 of the 16 individuals originally released downstream of Pejepscot were determined to have ascended upstream of Worumbo based on detection at Monitoring Station S15. Of those 33 individuals, five were not detected at Pejepscot following that time spent upstream.

Figure 5-14 presents the distribution of arrival dates for outmigrating adult river herring at the project as determined by detection at Monitoring Station S11. Initial detections of radio-tagged adult herring at Pejepscot were recorded over the range of dates from May 25 to June 15 with a peak number of events occurring on May 30. Table 5-18 provides a summary of the duration of time spent at large (i.e., the upstream residence duration) in the Androscoggin River upstream of Pejepscot from their time of release until arrival at Pejepscot for attempted downstream passage. The median duration of time for adult herring to approach Pejepscot following release into the Project impoundment was 6.4 days (range = 3.5 hours to 21.2 days).

The duration of time radio-tagged individuals were present immediately upstream of Pejepscot (i.e., the project duration) was determined for all individuals which approached and eventually passed downstream of the dam. The project duration was calculated as the duration of time from initial detection at Station S11 until confirmed downstream passage via one of the available routes. Information was available to calculate this duration for 84 of the 85 adult river herring which were determined to have arrived and passed downstream at Pejepscot Dam. When those individuals are considered, project residence time prior to downstream passage ranged between 0.1 hours and 8.9 days (median = 0.9 hours; Figure 5-19). Of the radio-tagged adult herring which approached Pejepscot Dam, 80% passed in fewer than 24 hours after initial detection and 86% in fewer than 2 days after initial detection (Figure 5-15).

5.6.2. Downstream Passage

Passage routes for the 95 adult river herring detected immediately upstream of Pejepscot Dam are presented in Table 5-20. The majority of individuals passed downstream of the dam via Unit 1 (51%) or during periods of spill flow at the bascule gates (27%). Usage of the downstream bypass system was observed for 10 individuals and all entries into that system were identified to the left gate (looking downstream). A total of eight radio-tagged herring approached the dam but did not pass. Radio-tagged adult herring were observed passing downstream of Pejepscot Dam between the dates of May 25 and June 17 (Figure 5-16). The majority of downstream passage events (i.e., 80% of all events) occurred on or before June 4, 2019. Figure 5-17 presents the temporal distribution of downstream passage events for radio-tagged adult herring at Pejepscot. The majority of individuals passed downstream during the afternoon and early-night hours (1300-0000).

5.6.3. Downstream Transit Durations

Table 5-21 provides a summary of the minimum, maximum, median and mean transit durations for radio-tagged adult herring following downstream passage at Pejepscot until detection at Brunswick, 4.5 miles downstream. The median duration of time was relatively short for adult herring moving from (1) the Pejepscot tailrace to Station 4 (2.2 hours), (2) Station 4 to Station 3 (1.3 hours), Station 3 to Brunswick (0.4 hours), and (4) the Pejepscot tailrace to Brunswick Dam (4.8 hours). When the downstream transit durations for all radio-tagged river herring which passed Pejepscot and reached Brunswick Dam are considered, 94% transited the 4.5 mile reach in less than 36 hours (Figure 5-18).

A review of the reach-specific rates for the radio-tagged herring which transited the 4.5 mile stretch downstream of the Project in 36 or more hours indicated a pattern comparable to that observed for the dead drift alosines (see Section 5.3) with an extended amount of time spent in the reach immediately downstream of the dam followed by relatively quick “passage” through the lower two reaches. A single radio-tagged herring with a downstream transit time in excess of 36 hours was likely active in the tailrace following downstream passage as evidenced by multiple detections at Monitoring Stations S6 (tailrace), S7 (downstream of spillway) and S8 (lift entrance) over a 4.5 day period. Following its eventual departure from the Pejepscot tailrace this individual was detected at Brunswick approximately 12 hours later. The set of individuals with downstream transit times in excess of 36 hours and a comparable detection pattern among the downstream receivers were treated as passage mortalities in the evaluation of passage survival (Section 5.6.4).

5.6.4. Passage Survival

The CJS model *Phi(t)p(t)* provided the best fit for the observed mark-recapture data associated with downstream movements of radio-tagged adult river herring approaching Pejepscot Dam (Table 5-22). The reach-specific survival estimates ranged between 1.0-0.882 among river reaches from the dam approach to passage, passage to the first downstream receiver, from the first to the second downstream receiver, and from the second downstream receiver to Brunswick (Table 5-23). The detection efficiency for telemetry receivers recording passage of adult river herring at monitoring stations at Pejepscot, Brunswick and the remote riverside locations ranged from 1.000 to 0.974 (Table 5–24).

The CJS-derived survival estimates for the two Pejepscot project reaches (i.e., dam approach (Station S11) to passage; passage to first downstream receiver (Station S4)) were 0.918 and 0.882 (Table 5-23), which resulted in an estimate of survival for the entire project reach (~650 feet upstream of the dam to the first downstream receiver) of 80.9% (75% CI = 76.3-85.7%). This estimate of downstream passage survival for adult herring at Pejepscot includes background mortality (i.e., natural mortality) for the species in the reach from the approach receiver to the first downstream receiver, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult river herring at Pejepscot.

When specific passage routes for adult river herring at Pejepscot are considered, 100% (10 of 10), 85% (22 of 26), and 88% (42 of 48) of individuals respectively passing the dam via the downstream bypass, spill, and Unit 1 were determined to have reached the first receiver below the project. Radio-tagged adult herring which approached Pejepscot but failed to pass downstream (n = 8) represented nearly half of the individual herring lost during the study within the Project reach from the point 650 feet upstream of the dam to the first downstream receiver.

Table 5-17: Summary of Release and Biological Information (Total Length and Sex) for Adult River Herring Radio-tagged and Released into the Androscoggin River at the Pejepscot Boat Launch during May, 2019.

Adult River Herring	Downstream Passage Release Group			
	#1	#2	#3	#4
Release Location	Pejepscot Boat Launch			
Release Date	May 22	May 23	May 24	May 29
Release Time	13: 50	12: 23	11: 59	12: 53
No. Tagged Released	25	25	25	24
No. Untagged Released	210	135	203	204
% Male	68%	80%	64%	33%
% Female	32%	12%	8%	67%
% Undetermined	0%	8%	28%	0%
Min. Total Length (mm)	278	270	275	275
Max Total Length (mm)	321	307	315	304
Mean Total Length (mm)	293	293	290	288

Table 5-18: Minimum, Maximum, Median and Mean Upstream Residence Times for Radio-tagged Adult River Herring between Release and Arrival at Pejepscot, Spring 2019

Date	Location	Upstream Residence (hours)			
		Min	Max	Median	Mean
23-May	Pejepscot ramp	80.6	492.8	197.4	215.8
24-May	Pejepscot ramp	65.9	509.7	160.3	189.7
28-May	Pejepscot ramp	33.5	338.2	136.9	155.6
29-May	Pejepscot ramp	3.5	414.3	141.1	161.5
All	Pejepscot ramp	3.5	509.7	154.4	182.5
various	Mill Street ramp	0.1	426.4	156.9	161.3

Table 5-19: Minimum, Maximum, Median and Mean Project Residence Times for Radio-tagged Adult River Herring Following Arrival at Pejepscot, Spring 2019

Release Date		Project Residence (hours)			
Date	Location	Min	Max	Median	Mean
22-May	Pejepscot ramp	0.1	78.4	2.9	16.7
23-May	Pejepscot ramp	0.1	214.4	0.7	21.8
24-May	Pejepscot ramp	0.1	50.7	2.2	7.1
29-May	Pejepscot ramp	0.1	67.9	0.8	13.6
various	Mill Street ramp	0.1	105.3	0.4	13.8
All	***-***	***0.1***	***214.4***	***0.9***	***14.9***

Table 5-20: Downstream Passage Route Selection For Radio-tagged Adult River Herring At Pejepscot, Spring 2019.

Release Date		Downstream Route				
Date	**Location**	**No Pass**	**Spill**	**DS Bypass**	**Unit 1**	**Unknown**
23-May	Pejepscot ramp	3	6	2	11	1
24-May	Pejepscot ramp	2	8	2	12	.
28-May	Pejepscot ramp	.	9	1	9	.
29-May	Pejepscot ramp	3	2	4	10	1
various	Mill Street ramp	.	1	1	6	1
All	***sum***	***8***	***26***	***10***	***48***	***3***
	pct	***8%***	***27%***	***11%***	***51%***	***3%***

Table 5-21: Minimum, Maximum, Median and Mean Downstream Transit Durations for Radio-tagged Adult River Herring within Defined River Sections Downstream of Pejepscot, Spring 2019

Reach	Release Date		Downstream Transit (hours)			
	Date	**Location**	**Min**	**Max**	**Median**	**Mean**
Pejepscot to Station S4 (1.8 miles)	23-May	Pejepscot ramp	0.7	45.8	1.8	8.5
	24-May	Pejepscot ramp	0.9	35.7	2.9	8.8
	28-May	Pejepscot ramp	0.7	124.2	6.1	16.6
	29-May	Pejepscot ramp	0.8	22.5	2.1	6.1
	various	Mill Street ramp	0.7	11.7	1.5	3.1
	All	-	***0.7***	***124.2***	***2.2***	***9.4***
Station S4 to Station S3 (2.2 miles)	23-May	Pejepscot ramp	0.6	15.6	1.3	2.7
	24-May	Pejepscot ramp	1.1	13.7	1.3	2.3
	28-May	Pejepscot ramp	1.1	9.4	1.4	2.4
	29-May	Pejepscot ramp	1.0	15.2	1.4	3.2
	various	Mill Street ramp	1.2	3.2	1.6	1.8
	All	-	***0.6***	***15.6***	***1.3***	***2.6***
Station S3 to Brunswick (0.5 miles)	23-May	Pejepscot ramp	0.0	2.2	0.5	0.6
	24-May	Pejepscot ramp	0.2	2.4	0.4	0.7
	28-May	Pejepscot ramp	0.2	23.4	0.4	1.9
	29-May	Pejepscot ramp	0.2	2.1	0.4	0.6
	various	Mill Street ramp	0.3	8.6	0.8	2.3
	All	-	***0.0***	***23.4***	***0.4***	***1.1***
Pejepscot to Brunswick (4.5 miles)	23-May	Pejepscot ramp	2.1	48.0	3.9	11.8
	24-May	Pejepscot ramp	2.7	39.4	5.2	11.9
	28-May	Pejepscot ramp	2.2	125.9	9.1	20.9
	29-May	Pejepscot ramp	2.5	28.0	5.1	10.0
	various	Mill Street ramp	2.8	23.2	4.0	7.6
	All	-	***2.1***	***125.9***	***4.8***	***13.1***

Table 5-22: CJS Model Selection Criteria for Downstream Passage of Adult River Herring at Pejepscot during Spring 2019

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
Phi(t)p(t)	360.42	0.00	0.87	1.00	6	1.35
Phi(t)p(.)	364.16	3.74	0.13	0.15	5	7.14
Phi(.)p(t)	393.70	33.29	0.00	0.00	4	38.72
Phi(.)p(.)	418.72	58.30	0.00	0.00	2	67.79

Table 5-23: Reach-specific Survival Probability Estimates (Phi), Standard Errors and Likelihood 75 and 95% Confidence Intervals for Radio-tagged Adult River Herring Approaching and Passing Pejepscot Dam during Spring 2019

Reach	Reach Length (mile)	*Phi*	SE	95% CI		75% CI	
Station S11 - Pass	0.2	0.918	0.029	0.840	0.959	0.878	0.945
Pass - Station S4	1.8	0.882	0.035	0.795	0.936	0.836	0.917
Station S4 - Station S3	2.2	1.000	0.000	-	-	-	-
Station S3 - Brunswick	0.5	1.000	0.000	-	-	-	-

Table 5–24: Detection efficiency estimates (*p*) for Monitoring Locations Installed to Detect Radio-tagged Adult River Herring at Pejepscot for Evaluation of Downstream Passage during Spring 2019

Location	*p*	SE	95% CI	
Station S11	0.989	0.011	0.923	0.998
Pejepscot	0.974	0.018	0.902	0.993
Station S4	1.000	0.000	1.000	1.000
Station S3	1.000	0.000	1.000	1.000
Brunswick	1.000	0.000	1.000	1.000

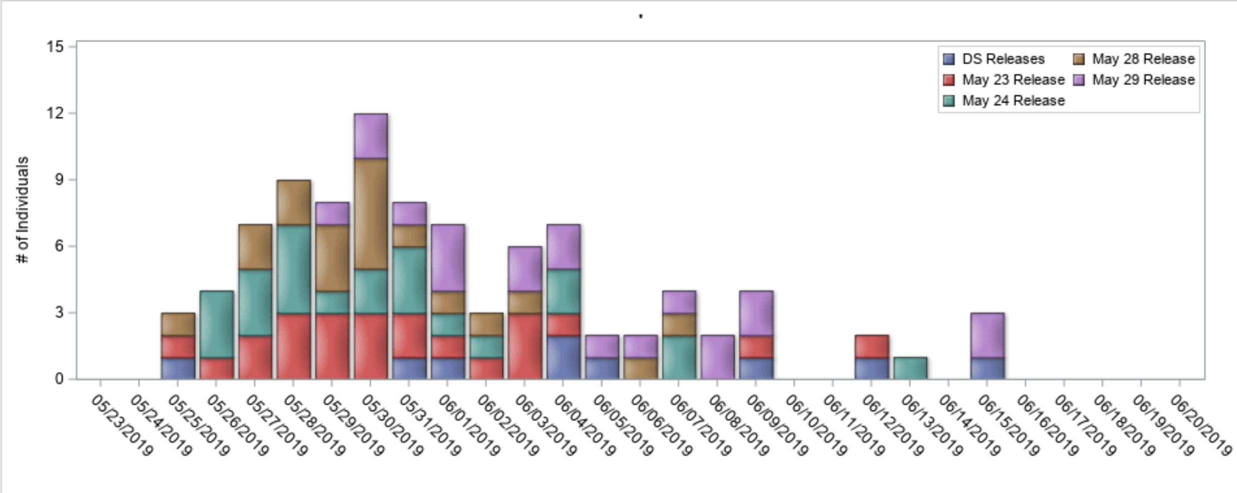


Figure 5-14: Distribution of Arrival Dates for Each Release Group of Radio-tagged Adult River Herring at Pejepscot Prior to Attempted Downstream Passage

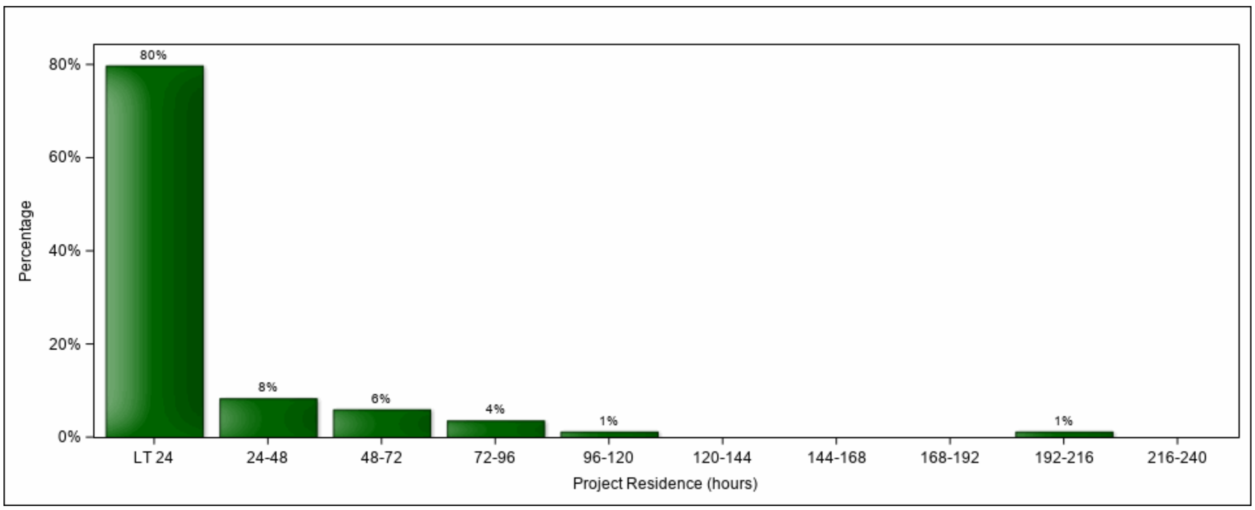


Figure 5-15: Distribution of Project Residence Duration in 24-hour Increments Observed for Radio-tagged Adult River Herring at Pejepscot prior to Attempted Downstream Passage

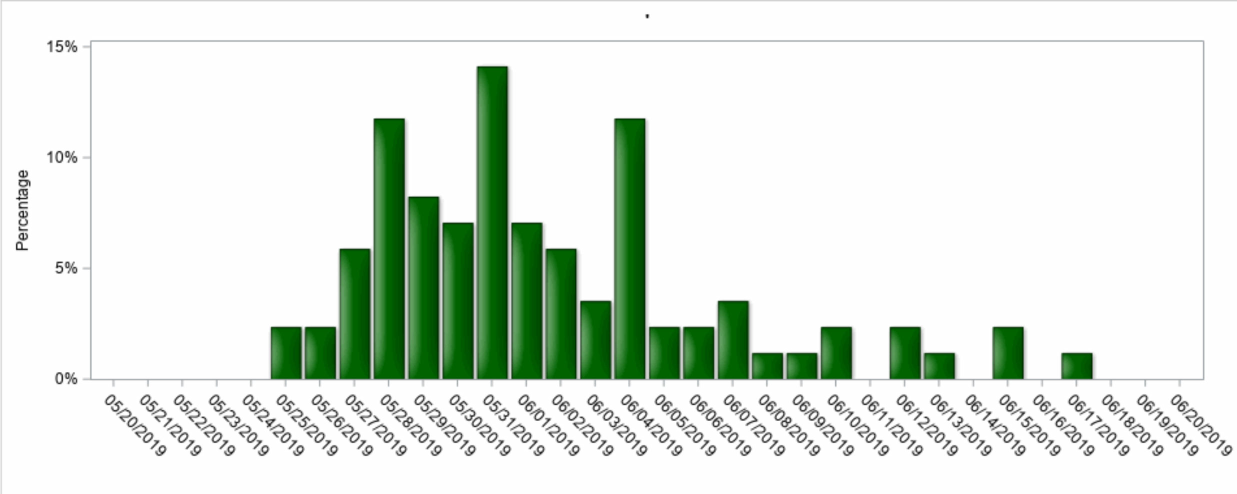


Figure 5-16: Distribution for the Date of Downstream Passage Observed for Radio-tagged Adult River Herring at Pejepscot.

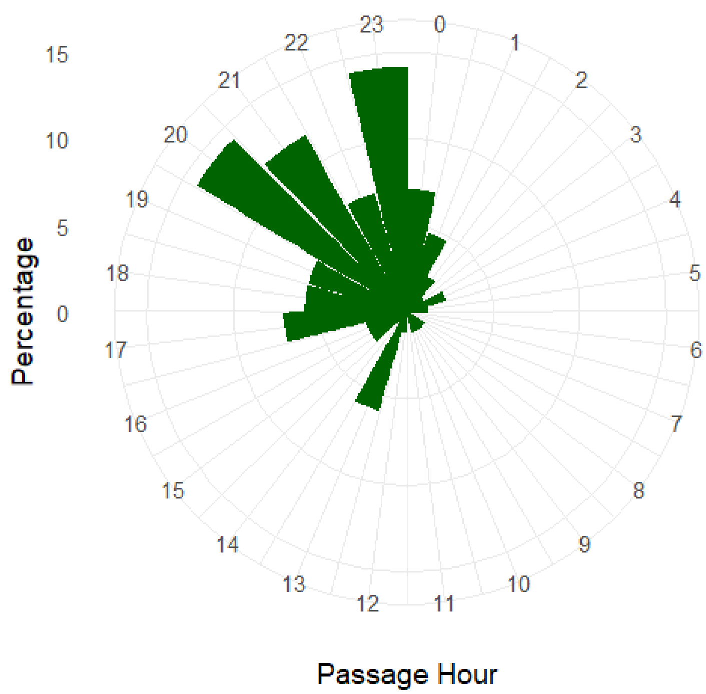


Figure 5-17: Distribution for the Time of Downstream Passage Observed for Radio-tagged Adult River Herring at Pejepscot.

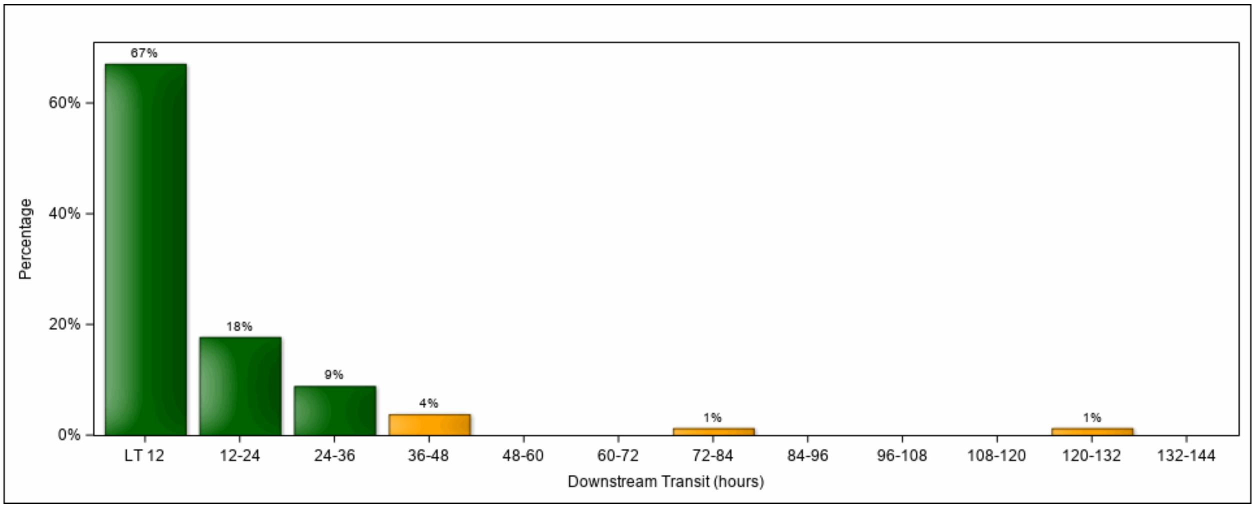


Figure 5-18: Distribution of Downstream Transit Duration in 12-hour increments Observed for Radio-tagged Adult River Herring at Pejepscot following Downstream Passage

Green shading indicates durations less than that observed for "dead" alosines. Orange shading indicates durations greater than that observed for "dead" alosines.

5.7. Adult American Shad Downstream Passage Evaluation

A total of 42 adult American Shad were collected at the Cataract fish lift, radio-tagged, transported by truck and released into the Androscoggin River for the purposes of evaluating downstream passage at Pejepscot (Table 5-25). Releases of radio-tagged shad upstream of Pejepscot was limited to a single event (July 11, 2019) due to the availability and overall condition of adult shad at the Cataract lift at that point in the passage season. Adult American Shad tagged and released upstream of Pejepscot ranged in total length from 411-572 mm.

None of the 129 radio-tagged adult shad released downstream of Pejepscot (see Section 5.6) passed upstream of the Project and were subsequently available to contribute to the downstream passage assessment. As a result, on the 35 of the 42 adult shad released at the Pejepscot boat ramp approached the Project dam and had an opportunity to pass downstream. Estimates for the upstream residence time, upstream project duration, downstream passage route selection, downstream transit duration, and passage survival of adult shad at Pejepscot was based on those 35 individuals and is presented in Sections 5.7.1 to 5.7.4. A full listing of adult shad radio-tagged as part of this assessment is provided in Appendix A.

5.7.1. Project Returns and Upstream Residence Duration

Figure 5-19 presents the distribution of arrival dates for outmigrating adult shad at Pejepscot as determined by detection at Monitoring Station S11. Although initial detections of radio-tagged adult shad were recorded over a range of dates from July 11 to July 20, the majority of individuals arrived at the Project within one or two days of release into the upper end of the impoundment. The median duration of time for adult shad to approach Pejepscot following release into the Project impoundment was 18.3 hours (range = 4.2-211.0 hours; mean = 29.0 hours). The duration of time radio-tagged shad were present immediately upstream of Pejepscot (i.e., the project duration) was determined for all individuals which approached and eventually passed downstream of the dam. The project duration was calculated as the duration of time from initial detection at Station S11 until confirmed downstream passage via one of the available routes. Information was available to calculate this duration for each of the 23 adult shad which were determined to have arrived and passed downstream at Pejepscot Dam. When those individuals are considered, project residence time prior to downstream passage ranged between 2.7 hours and 10.4 days (median = 127.9 hours; mean = 107.9 hours). Of the radio-tagged adult shad which approached Pejepscot Dam, only 9% passed in fewer than 24 hours after initial detection and 26% in fewer than 2 days after initial detection (Figure 5-20). The majority of radio-tagged adult shad were resident upstream of Pejepscot for greater than 96 hours following their initial detection.

5.7.2. Downstream Passage

Passage routes for the 35 adult shad detected immediately upstream of Pejepscot Dam are presented in Figure 5-21. The majority of adult shad (34%) failed to pass downstream of the Project following their initial detection at the dam. Radio-tagged adult shad which did pass downstream did so using the downstream bypass, spill and Unit 1 turbine. Approximately 9% of outmigrating shad used the downstream bypass. Similar to observations for radio-tagged adult herring, recorded instances of usage of the downstream bypass system were identified to the left gate (looking downstream). All instances of downstream passage by adult shad on spill (26% of all passage events) occurred during a narrow window from approximately 2300 on July 17 to 1000 on July 18 when Unit 1 went offline and spill flows were present at the bascule gates (Figure 5-2). Nearly a third of radio-tagged adult shad passing downstream at Pejepscot did so via Unit 1.

Radio-tagged adult shad were observed passing downstream of Pejepscot Dam from the initial date of release (July 11) until July 22 (Figure 5-22). The peak daily occurrence of downstream passage events (i.e., 52% of all events) occurred over the two day period of July 17 and 18 and was likely a function of the spill conditions triggered by a brief outage at Unit 1. Figure 5-23 presents the temporal distribution of downstream passage events for radio-tagged adult shad. The majority of individuals passed downstream during the overnight and early-morning hours (2000-0700).

5.7.3. Downstream Transit Durations

Table 5-26 provides a summary of the minimum, maximum, median and mean transit durations for radio-tagged adult herring following downstream passage at Pejepscot until detection at Brunswick, 4.5 miles downstream. The median duration of time was relatively short for adult shad moving from (1) the Pejepscot tailrace to Station 4 (1.8 hours), (2) Station 4 to Station 3 (1.6 hours), Station 3 to Brunswick (0.6 hours), and (4) the Pejepscot tailrace to Brunswick Dam (4.2 hours). When the downstream transit durations for all radio-tagged adult shad which passed Pejepscot and reached Brunswick Dam are considered, 94% transited the 4.5 mile reach in less than 36 hours (Figure 5-24).

A review of the downstream transit rates for the radio-tagged shad within the 4.5 mile stretch downstream of the Project revealed a single individual with a transit time from Pejepscot to Brunswick near to the minimum calculated drift time of 36 hours observed in the dead drift alosine test (see Section 5.3). The detection pattern for this individual was similar to that observed for the dead drift alosines with an extended amount of time spent in the reach immediately downstream of the dam followed by relatively quick “passage” through the lower two reaches. For the purposes of this study, this single adult shad was treated as a passage mortality in the evaluation of passage survival (Section 5.7.4).

5.7.4. Passage Survival

The CJS model *Phi(t)p(t)* provided the best fit for the observed mark-recapture data associated with downstream movements of radio-tagged adult shad approaching Pejepscot Dam (Table 5-27). The reach-specific survival estimates at Pejepscot ranged between 1.0-0.657 among river reaches from the dam approach to passage, passage to the first downstream receiver, from the first to the second downstream receiver, and from the second downstream receiver to Brunswick (Table 5-28). The detection efficiency for telemetry receivers recording passage of adult shad at monitoring stations at Pejepscot, Brunswick and the remote riverside locations ranged from 1.000 to 0.941 (Table 5-29).

The CJS-derived survival estimates for the two Pejepscot project reaches (i.e., dam approach (Station S11) to passage; passage to first downstream receiver (Station S4)) were 0.657 and 0.783 (Table 5-28), which resulted in an estimate of survival for the entire project reach (~650 feet upstream of the dam to the first downstream receiver) of 51.4% (75% CI = 41.6-61.1%). This estimate of downstream passage survival for adult shad at Pejepscot includes background mortality (i.e., natural mortality) for the species in the reach from the approach receiver to the first downstream receiver, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult shad at Pejepscot.

When specific passage routes for adult shad at Pejepscot are considered, 33% (1 of 3), 89% (8 of 9), and 82% (9 of 11) of individuals respectively passing the dam via the downstream bypass, spill, and Unit 1 were determined to have reached the first receiver below the project. Radio-tagged adult shad which approached Pejepscot but failed to pass downstream (n = 12) accounted for more losses within the Project reach than did mortality during dam passage.

Table 5-25: Summary of Release and Biological Information (Total Length and Sex) for Adult American Shad Radio-tagged and Released into the Androscoggin River at the Pejepscot Boat Launch during July, 2019

Adult American Shad	Downstream Passage Release Group
Release Location	Pejepscot Boat Launch
Release Date	July 11
Release Time	12: 55
No. Tagged Released	42
% Male	21%
% Female	76%
% Undetermined	2%
Min. Total Length (mm)	411
Max Total Length (mm)	572
Mean Total Length (mm)	499

Table 5-26: Minimum, Maximum, Median and Mean Downstream Transit Durations for Radio-tagged Adult American Shad within Defined River Sections Downstream of Pejepscot, Spring 2019

Reach	Downstream Transit (hours)			
	Min	Max	Median	Mean
Pejepscot to Station S4 (1.8 miles)	0.6	31.5	1.8	4.4
Station S4 to Station S3 (2.2 miles)	0.8	24.4	1.6	3.1
Station S3 to Brunswick (0.5 miles)	0.3	8.6	0.6	1.2
Pejepscot to Brunswick (4.5 miles)	1.8	35.6	4.2	8.8

Table 5-27. CJS Model Selection Criteria for Downstream Passage of Adult American Shad at Pejepscot during Spring 2019

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
Phi(t)p(t)	157.88	0.00	0.83	1.00	6	1.10
Phi(t)p(.)	161.31	3.42	0.15	0.18	6	4.53
Phi(.)p(t)	166.08	8.20	0.01	0.02	3	15.72
Phi(.)p(.)	171.15	13.26	0.00	0.00	2	22.87

Table 5-28: Reach-specific Survival Probability Estimates (Phi), Standard Errors and Likelihood 75 and 95% Confidence Intervals for Radio-tagged Adult American Shad Approaching and Passing Pejepscot Dam during Spring 2019

Reach	Reach Length (mile)	S	SE	95% CI		75% CI	
Station S11 - Pass	0.2	0.657	0.080	0.488	0.794	0.560	0.743
Pass - Station S4	1.8	0.783	0.086	0.572	0.907	0.668	0.866
Station S4 - Station S3	2.2	0.944	0.054	0.693	0.992	0.839	0.982
Station S3 - Brunswick	0.5	1.000	0.000	-	-	-	-

Table 5-29: Detection Efficiency Estimates (p) for Monitoring Locations Installed to Detect Radio-tagged Adult American Shad at Pejepscot for Evaluation of Downstream Passage during Spring 2019

Location	S	SE	95% CI	
Station S11	1.000	0.000	-	-
Pejepscot	1.000	0.000	-	-
Station S4	1.000	0.000	-	-
Station S3	0.941	0.057	0.680	0.992
Brunswick	1.000	0.000	-	-

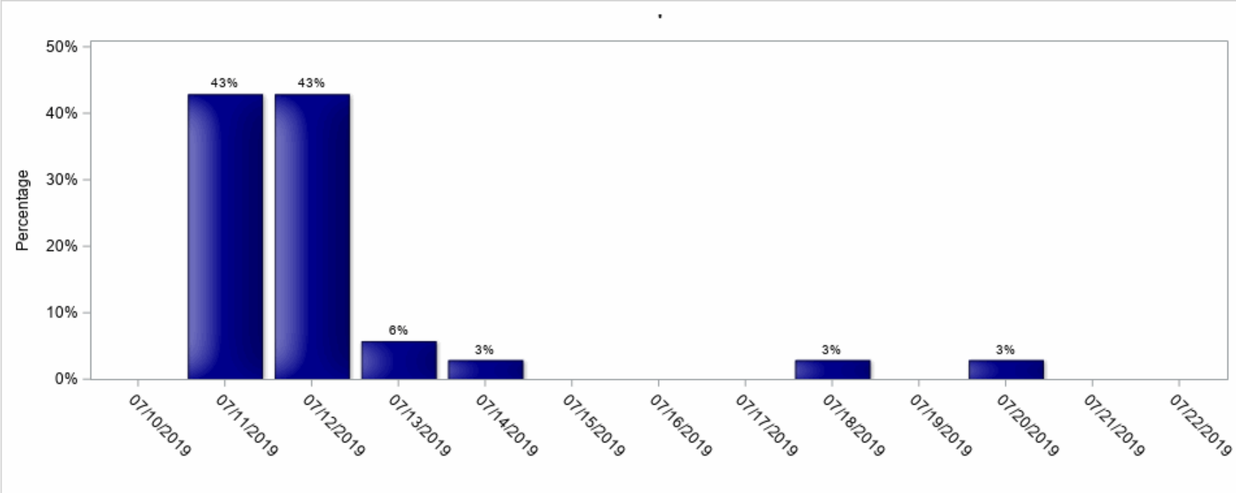


Figure 5-19: Distribution of Arrival Dates for Radio-tagged Adult American Shad at Pejepscot Prior to Attempted Downstream Passage, Spring 2019

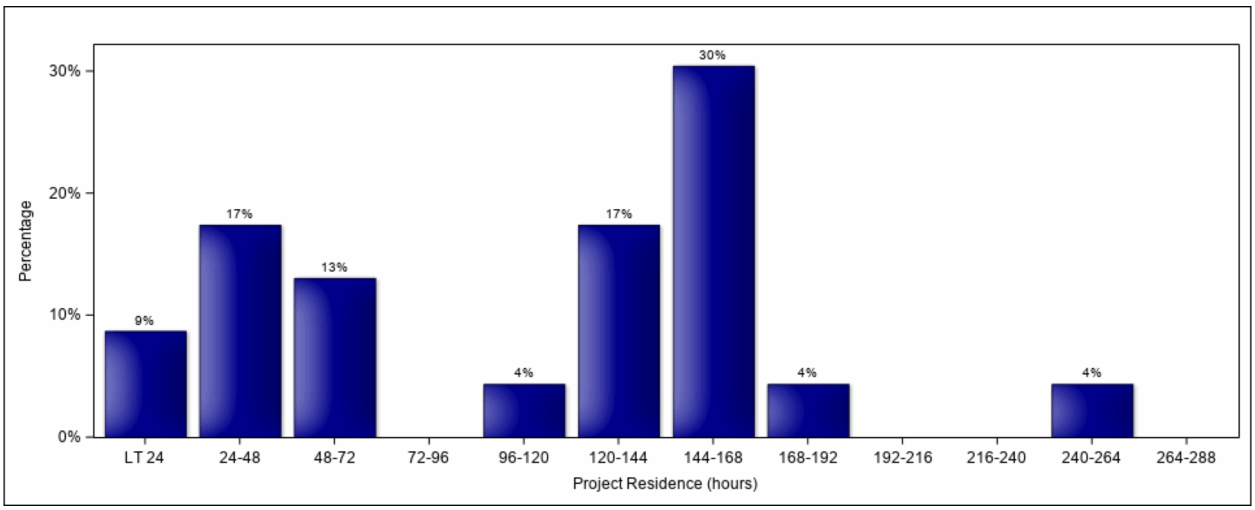


Figure 5-20: Distribution of Project Residence Duration in 24-hour Increments Observed for Radio-tagged Adult American Shad at Pejepscot Prior to Attempted Downstream Passage, Spring 2019

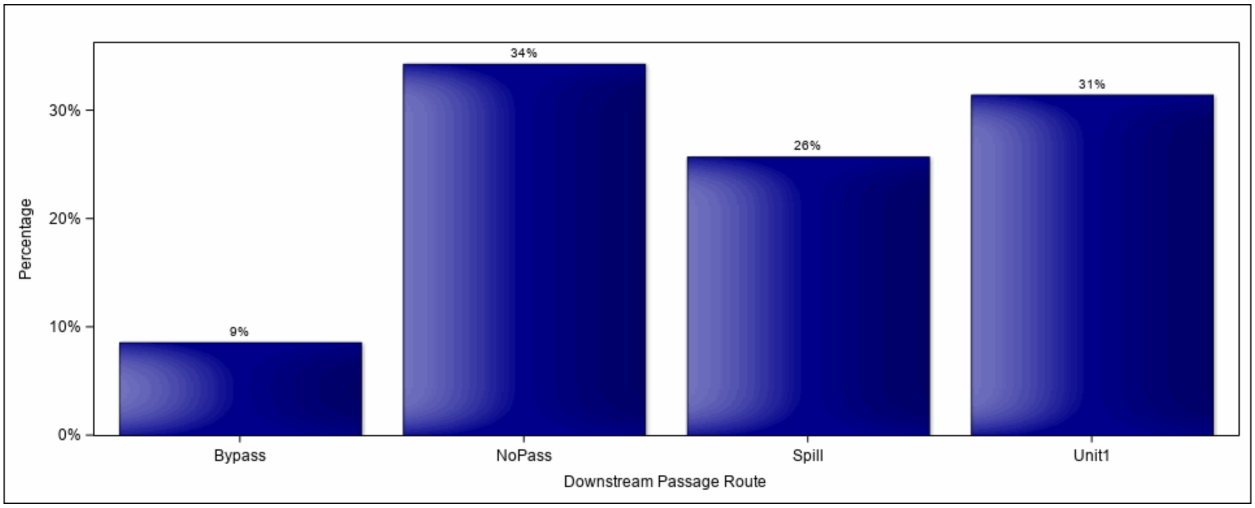


Figure 5-21: Distribution of Downstream Passage Route Selection for Radio-tagged Adult American Shad at Pejepscot, Spring 2019

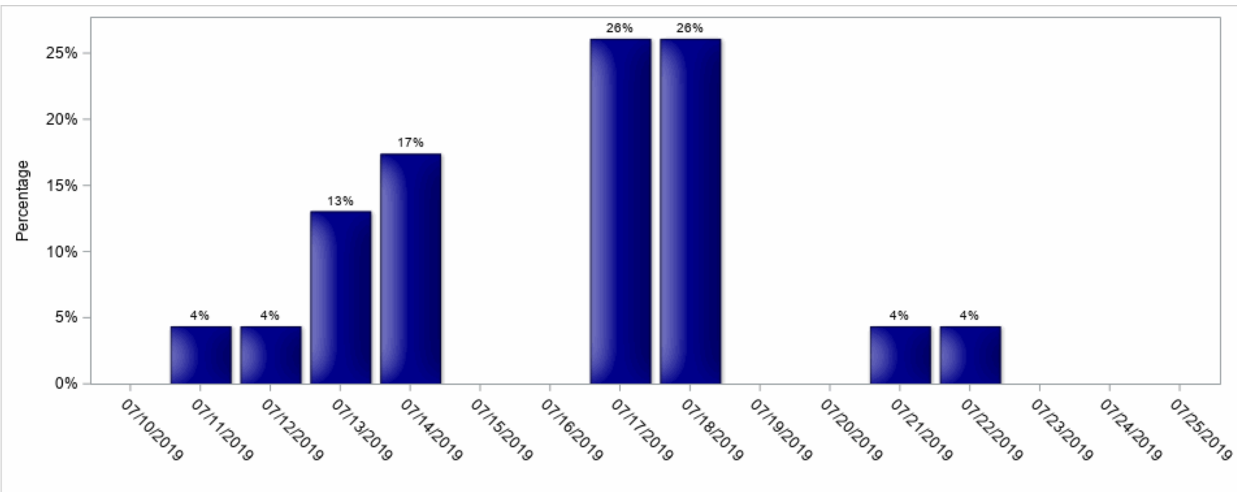


Figure 5-22: Distribution for the Date of Downstream Passage Observed for Radio-tagged Adult American Shad at Pejepscot, Spring 2019

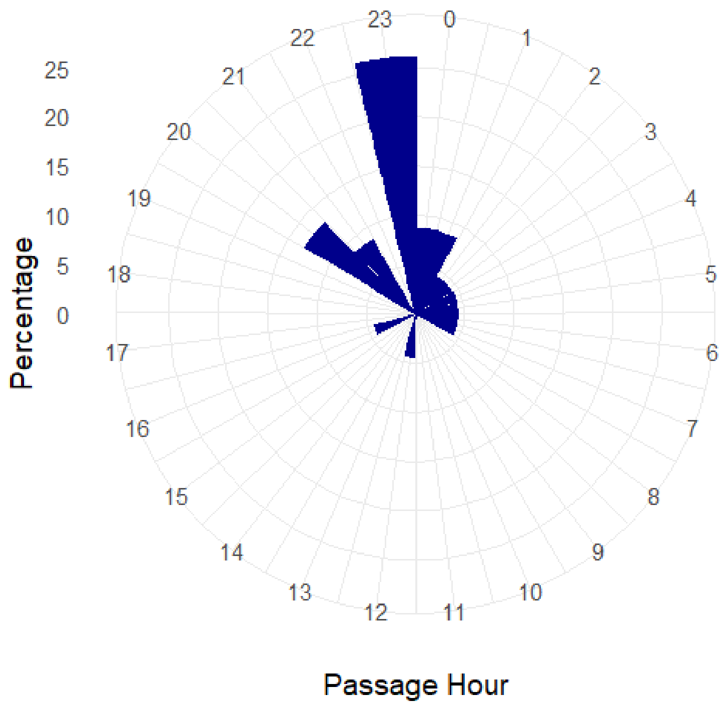


Figure 5-23: Distribution for the Time of Downstream Passage Observed for Radio-tagged Adult American Shad at Pejepscot, Spring 2019

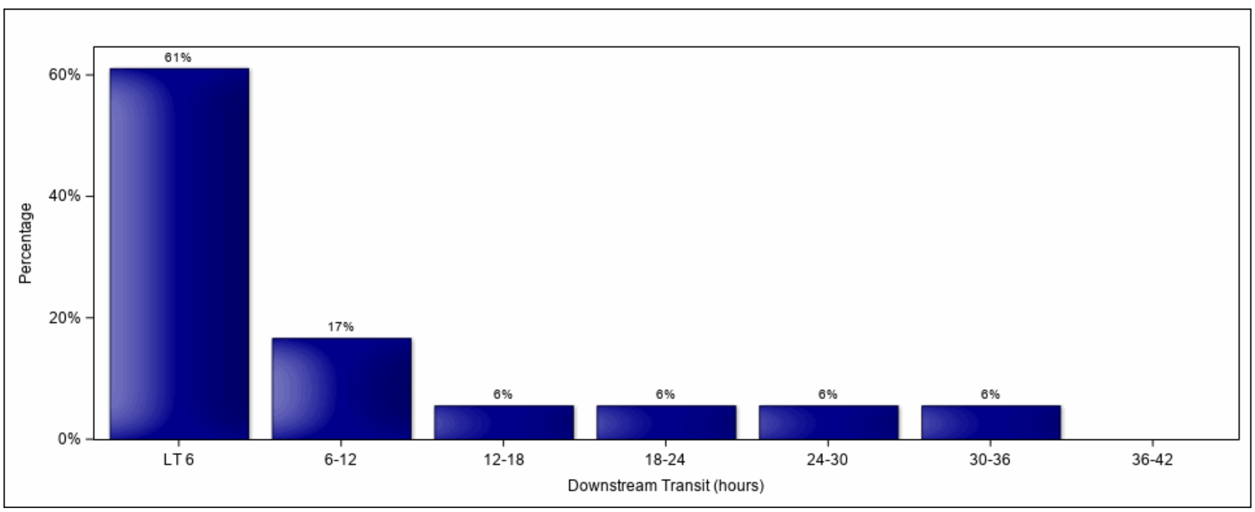


Figure 5-24: Distribution of Downstream Transit Duration in 6-hour Increments Observed for Radio-tagged Adult American Shad at Pejepscot following Downstream Passage, Spring 2019.

6.0 SUMMARY

An evaluation of the upstream and downstream passage effectiveness for adult river herring and American Shad was conducted in support of the FERC relicensing of the Pejepscot Project. Fish passage effectiveness was evaluated using radio-telemetry during the 2019 spring migration season (May 20 – August 12, 2019).

6.1. Adult River Herring

A total of 201 adult river herring were collected at the Brunswick fishway and radio-tagged over an eight day period during late-May, 2019. Of that total, 102 were released downstream of Pejepscot at the Mill Street boat launch and were monitored for evaluation of upstream passage at the Project. The remaining 99 radio-tagged adult herring were released upstream of the Project at the Pejepscot boat ramp and were monitored for evaluation of downstream passage. Of the radio-tagged adult river herring released downstream of the Project, 79% were determined to have approached Pejepscot Dam and were available to assess passage effectiveness of the fish lift. When radio-tagged herring from the original upstream release group (i.e., those at the Pejepscot boat ramp) and radio-tagged individuals which were originally released downstream but successfully ascended the Pejepscot fish lift are considered, a total number of 95 radio-tagged adult river herring were available to evaluated downstream passage at the Project.

River herring releases downstream of the Project occurred over four dates between May 22 and May 29, 2019. Ascent from the release location upstream to the Project occurred quickly for most tagged herring (median duration = 10 hours). Spill conditions were present at Pejepscot throughout the tagging and release period with river flows not coming under operational control until early June (June 2, 2019). Tailwater elevation downstream of Pejepscot during that spill period ranged from 43.2-46.4 feet (median = 45.3 feet). Due to the high tailwater elevations, the upstream fish lift was operated manually as conditions permitted. Regardless of tailrace conditions, 93% of radio-tagged adult herring which were determined to have approached the Project were detected on at least one occasion within the entrance to the fish lift. Detections at the Pejepscot lift entrance showed a bimodal distribution with peaks during the hours of 1000 and 1600. The current operational window from 0800 to 1800 encompassed 85% of all detections of radio-tagged river herring at the lift entrance during the 2019 evaluation.

Radio-tagged herring passed upstream of Pejepscot over a range of dates from May 25 through June 10 with the majority of those passage events between May 25 and May 30. As a result, spill was present for the duration of the “time at large” for the majority of the herring which successfully passed upstream. When the cumulative residence duration of tagged herring downstream of Pejepscot is examined, the competing spill flow attracted most individuals away from the fish lift side for some proportion of time. Radio-tagged adult herring successfully passing upstream at Pejepscot were detected in the tailrace area immediately downstream of the powerhouse and in proximity to the fish lift for an average of 62% of their cumulative residence time, and within the region downstream of the dam spillway for an average of 38% of the time. Radio-tagged adult herring failing to successfully pass upstream at Pejepscot were detected in the tailrace area for an average of 30% of their cumulative residence time, and downstream of the spillway for an average of 70% of the time. The overall effectiveness of the Pejepscot fish lift for adult river herring passage during 2019 was estimated at 19.8% (75% CI = 14.8-24.9%). Despite spill conditions during the period of arrival for most radio-tagged river herring at the Project, location and entry into the lower flume of the existing fishway was good (93%). It is suspected that due to the relative infrequency of lift opportunities, radio-tagged herring moved around the region immediately downstream of the dam with a disproportionate amount of time spent in areas of false attraction from spill observed for herring which ultimately did not pass the project.

Outmigration of radio-tagged adult river herring was observed over a range of dates from May 25 to June 15 with a peak number of events occurring on May 30. The median project residence time prior to downstream passage was 0.9 hours. Of the radio-tagged adult herring which approached Pejepscot Dam, 80% passed in fewer than 24 hours after initial detection and 86% in fewer than 2 days after initial detection. The majority of individuals passed downstream of the dam via Unit 1 (51%) or during periods of spill flow at the bascule gates (27%). Use of the downstream bypass system was observed for 11% of radio-tagged adult river herring. Downstream passage survival for the entire project reach (~650 feet upstream of the dam to the first downstream receiver) was estimated at 80.9% (75% CI = 76.3-85.7%). This estimate of downstream passage survival for adult herring at Pejepscot includes background mortality (i.e., natural mortality) for the species in the project reach, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult river herring at Pejepscot.

6.2. Adult American Shad

A total of 171 adult American Shad were radio-tagged during this study. Of that total, 129 were collected via rod and reel from the Androscoggin River downstream of Brunswick and were released below Pejepscot at the Mill Street boat launch. Those individuals were monitored for evaluation of upstream passage at the Project. The remaining 42 radio-tagged adult shad were obtained from the Saco River (Cataract fish lift) and released upstream of the Project at the Pejepscot boat ramp to evaluate downstream passage. Of the radio-tagged adult shad released downstream of the Project, 28% were determined to have approached Pejepscot Dam and were available to assess passage effectiveness of the fish lift. The majority of radio-tagged shad released downstream of Pejepscot either partially ascended the approximately four mile reach between release and the Project (22%) or dropped downstream to Brunswick (45%). It is suspected that the extensive handling and transport associated with the use of adult shad from the Androscoggin River downstream of Brunswick negatively affected upstream motivation of test fish during this evaluation. When radio-tagged shad from the upstream release group were considered, a total number of 35 radio-tagged individuals were available to evaluate downstream passage at the Project.

Releases of radio-tagged American Shad downstream of the Project occurred between June 12 and June 19, 2010. Ascent from the release location upstream to the Project was slower for shad than was observed for river herring (median duration = 3.3 days). With the exception of a few relatively short duration spill events, Androscoggin River flows were mostly under control during the tagging and release period for shad downstream of Pejepscot. Spill conditions were present at Pejepscot over an approximately four day period immediately following the last release group of adult shad downstream of the Project (June 21-24). During the spring monitoring period, only seven radio-tagged adult shad were determined to have approached the Project and be detected on at least one occasion within the entrance to the fish lift. The current operational window from 0800 to 1800 encompassed 90% of all detections of radio-tagged adult shad at the lift entrance.

There were no recorded upstream passage events for radio-tagged shad during the study period. When the cumulative residence duration of tagged shad downstream of Pejepscot is examined, radio-tagged adult shad were detected in the tailrace area for an average of 1% (range = 0 – 5%) of their cumulative residence time, and downstream of the spillway for an average of 99% (range = 95-100%) of the time. Location and entry into the lower flume of the existing fishway was low for radio-tagged adult shad during this study with only 32% of the individuals detected in the nearfield/tailrace region being subsequently detected at the fish lift entrance.

Outmigration of radio-tagged adult shad was observed over a range of dates from July 11 to July 22 with a peak number of events occurring on July 17/18. Downstream passage events for radio-tagged shad during those two dates were a function of spill conditions triggered by a brief outage at Unit 1. The median project residence time prior to downstream passage was 5.3 days. Of the radio-tagged adult shad which approached Pejepscot Dam, 9% passed in fewer than 24 hours after initial detection and 26% in fewer than 2 days after initial detection. The majority of adult shad (34%) failed to pass downstream of the Project following their initial detection at the dam. Downstream passage of radio-tagged adult shad which did pass downstream occurred via Unit 1 (31%), spill (26%) and the downstream bypass (9%). Downstream passage survival for the entire project reach (~650 feet upstream of the dam to the first downstream receiver) was estimated at 51.4% (75% CI = 41.6-61.1%). This estimate of downstream passage survival for adult shad at Pejepscot includes background mortality (i.e., natural mortality) for the species in the project reach, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult shad at Pejepscot.

As evidenced by the extended project residence time prior to downstream passage and the proportion of radio-tagged adult shad which approached Pejepscot but failed to pass, shad passage under the non-spill conditions observed during the 2019 study was poor. Individuals were present in the upstream project area for extended periods of time (most greater than 96 hours) prior to either passing downstream via Unit 1 or the bypass system. Nearly one third of all observed downstream passage events occurred during a narrow window from approximately 2300 on July 17 to 1000 on July 18 when Unit 1 went offline and spill flows were present at the bascule gates.

7.0 VARIANCES FROM FERC-APPROVED STUDY PLAN

The FERC approved RSP specified that “Pending availability, a total of 200 radio-tagged adult alewives and 250 radio-tagged adult shad will be transported by truck to one of two release locations”. Efforts during the 2019 spring telemetry assessment resulted in the collection, tagging and release of 201 adult river herring and 171 adult American shad. As was discussed during study plan development, adult shad were not readily available to collect for tagging from the Brunswick fishway. In lieu of fishway collections, Topsham Hydro targeted manual collections of adult shad for tagging from the lower Androscoggin River. The results of the significant rod and reel effort was the collection of 129 of the targeted 150 adult shad for upstream passage evaluation. As was discussed during study plan development, the adult shad for evaluating downstream passage at Pejepscot were collected and transported to the Project from the Cataract fish lift on the Saco River. Due to an extended shutdown period of the east channel lift at Cataract followed by prioritization of in-basin stocking of adult shad in the Saco River watershed, a limited number of fish were available at the end of the passage season for radio-tagging and release at Pejepscot.

The RSP called for the tagging and release of five “freshly dead” adult river herring and five “freshly dead” adult American Shad during the 2019 study period to inform on rates and magnitude of downstream drift following mortality at the Project. The release of dead river herring was overlooked during the May 22-May 29 window of time when releases of live river herring were being conducted. Although that oversight was noticed during mid-June, Topsham Hydro was unable to obtain fresh herring to meet that study component. However, a total of five freshly dead American Shad were radio-tagged and successfully monitored for “passage” through the study reach. Information from those individuals was used to help inform estimates of downstream passage survival for both species.

8.0 REFERENCES

Castro-Santos, T., and R. Perry. 2012. Time to event analysis as a framework for quantifying fish passage performance. Pages 427-452 *in* N.S. Adams, J.W. Beeman, and J.H. Eiler, editors. Telemetry Techniques: A Users Guide for Fisheries Research. American Fisheries Society, Bethesda, Maryland.

APPENDIX A. RELEASE INFORMATION FOR ADULT ALOSINES RADIO-TAGGED AS PART OF THE PEJEPSCOT UPSTREAM AND DOWNSTREAM ASSESSMENT OF PASSAGE EFFECTIVENESS

River Herring – Release Groups Downstream of Pejepscot Project

Species	Frequency (149.xxx)	ID	Total Length (mm)	Sex	Release Date	Release Time	Release Group	Reached Project	Passed Upstream
Herring	360	70	285	U	5/22/2019	11: 40: 00	US1	1	0
Herring	360	71	297	U	5/22/2019	11: 40: 00	US1	1	0
Herring	360	72	290	U	5/22/2019	11: 40: 00	US1	1	0
Herring	360	73	279	U	5/22/2019	11: 40: 00	US1	1	0
Herring	360	80	298	U	5/22/2019	11: 40: 00	US1	1	0
Herring	360	81	281	M	5/22/2019	11: 40: 00	US1	1	0
Herring	360	82	288	M	5/22/2019	11: 40: 00	US1	1	0
Herring	360	83	285	M	5/22/2019	11: 40: 00	US1	1	0
Herring	400	86	299	U	5/22/2019	11: 40: 00	US1	1	0
Herring	400	87	283	U	5/22/2019	11: 40: 00	US1	1	1
Herring	400	88	300	U	5/22/2019	11: 40: 00	US1	1	0
Herring	400	95	289	U	5/22/2019	11: 40: 00	US1	1	0
Herring	400	96	282	U	5/22/2019	11: 40: 00	US1	1	1
Herring	400	97	291	U	5/22/2019	11: 40: 00	US1	1	0
Herring	400	98	292	U	5/22/2019	11: 40: 00	US1	1	0
Herring	400	99	280	U	5/22/2019	11: 40: 00	US1	1	0
Herring	400	100	290	U	5/22/2019	11: 40: 00	US1	1	0
Herring	440	103	300	U	5/22/2019	11: 40: 00	US1	1	1
Herring	440	104	284	U	5/22/2019	11: 40: 00	US1	1	0
Herring	440	105	302	U	5/22/2019	11: 40: 00	US1	1	0
Herring	440	109	305	U	5/22/2019	11: 40: 00	US1	1	0
Herring	440	110	302	U	5/22/2019	11: 40: 00	US1	1	0
Herring	440	111	306	M	5/22/2019	11: 40: 00	US1	1	0
Herring	440	115	297	M	5/22/2019	11: 40: 00	US1	1	0
Herring	440	116	288	U	5/22/2019	11: 40: 00	US1	1	0
Herring	360	74	310	F	5/23/2019	14: 24: 00	US2	1	0
Herring	360	75	295	M	5/23/2019	14: 24: 00	US2	1	0
Herring	360	76	306	U	5/23/2019	14: 24: 00	US2	1	0
Herring	360	77	309	M	5/23/2019	14: 24: 00	US2	1	1
Herring	360	78	300	F	5/23/2019	14: 24: 00	US2	1	0
Herring	360	79	289	M	5/23/2019	14: 24: 00	US2	1	1
Herring	360	84	282	U	5/23/2019	14: 24: 00	US2	1	0
Herring	360	85	288	M	5/23/2019	14: 24: 00	US2	1	0
Herring	400	89	296	U	5/23/2019	14: 24: 00	US2	1	0
Herring	400	90	314	M	5/23/2019	14: 24: 00	US2	1	1
Herring	400	91	284	M	5/23/2019	14: 24: 00	US2	1	0
Herring	400	92	285	M	5/23/2019	14: 24: 00	US2	1	0
Herring	400	93	274	M	5/23/2019	14: 24: 00	US2	1	0
Herring	400	94	302	F	5/23/2019	14: 24: 00	US2	1	0
Herring	400	101	298	U	5/23/2019	14: 24: 00	US2	1	0
Herring	400	102	281	M	5/23/2019	14: 24: 00	US2	1	1
Herring	440	106	308	F	5/23/2019	14: 24: 00	US2	1	1
Herring	440	107	295	U	5/23/2019	14: 24: 00	US2	1	0

River Herring – Release Groups Downstream of Pejepscot Project

Species	Frequency (149.xxx)	ID	Total Length (mm)	Sex	Release Date	Release Time	Release Group	Reached Project	Passed Upstream
Herring	440	108	273	M	5/23/2019	14: 24: 00	US2	1	1
Herring	440	112	296	M	5/23/2019	14: 24: 00	US2	1	0
Herring	440	113	303	M	5/23/2019	14: 24: 00	US2	1	1
Herring	440	114	274	M	5/23/2019	14: 24: 00	US2	1	0
Herring	440	117	309	F	5/23/2019	14: 24: 00	US2	1	0
Herring	440	118	280	M	5/23/2019	14: 24: 00	US2	1	1
Herring	440	119	295	M	5/23/2019	14: 24: 00	US2	1	0
Herring	360	120	286	U	5/28/2019	12: 19: 00	US3	1	0
Herring	360	121	304	F	5/28/2019	12: 19: 00	US3	1	0
Herring	360	122	290	F	5/28/2019	12: 19: 00	US3	1	0
Herring	360	123	304	M	5/28/2019	12: 19: 00	US3	1	0
Herring	360	124	290	M	5/28/2019	12: 19: 00	US3	1	0
Herring	360	125	290	M	5/28/2019	12: 19: 00	US3	1	0
Herring	360	126	303	F	5/28/2019	12: 19: 00	US3	1	0
Herring	360	127	313	F	5/28/2019	12: 19: 00	US3	1	0
Herring	360	128	316	F	5/28/2019	12: 19: 00	US3	0	0
Herring	400	129	290	F	5/28/2019	12: 19: 00	US3	0	0
Herring	400	130	285	F	5/28/2019	12: 19: 00	US3	1	0
Herring	400	131	320	F	5/28/2019	12: 19: 00	US3	1	0
Herring	400	132	297	F	5/28/2019	12: 19: 00	US3	1	1
Herring	400	133	301	F	5/28/2019	12: 19: 00	US3	0	0
Herring	400	134	303	F	5/28/2019	12: 19: 00	US3	0	0
Herring	400	135	300	F	5/28/2019	12: 19: 00	US3	1	0
Herring	440	136	309	F	5/28/2019	12: 19: 00	US3	0	0
Herring	440	137	303	F	5/28/2019	12: 19: 00	US3	1	0
Herring	440	138	307	F	5/28/2019	12: 19: 00	US3	0	0
Herring	440	139	298	M	5/28/2019	12: 19: 00	US3	1	1
Herring	440	140	306	F	5/28/2019	12: 19: 00	US3	1	0
Herring	440	141	311	F	5/28/2019	12: 19: 00	US3	0	0
Herring	440	142	296	F	5/28/2019	12: 19: 00	US3	1	0
Herring	440	143	308	F	5/28/2019	12: 19: 00	US3	0	0
Herring	440	144	303	M	5/28/2019	12: 19: 00	US3	0	0
Herring	360	170	282	M	5/29/2019	12: 00: 00	US4	0	0
Herring	360	171	295	M	5/29/2019	12: 00: 00	US4	1	0
Herring	360	172	286	U	5/29/2019	12: 00: 00	US4	0	0
Herring	360	173	279	M	5/29/2019	12: 00: 00	US4	1	0
Herring	360	174	285	M	5/29/2019	12: 00: 00	US4	0	0
Herring	360	175	287	F	5/29/2019	12: 00: 00	US4	1	0
Herring	360	176	284	M	5/29/2019	12: 00: 00	US4	1	1
Herring	360	177	300	F	5/29/2019	12: 00: 00	US4	1	0
Herring	360	178	299	F	5/29/2019	12: 00: 00	US4	0	0
Herring	400	179	290	F	5/29/2019	12: 00: 00	US4	1	0
Herring	400	180	288	M	5/29/2019	12: 00: 00	US4	1	0

River Herring – Release Groups Downstream of Pejepscot Project

Species	Frequency (149.xxx)	ID	Total Length (mm)	Sex	Release Date	Release Time	Release Group	Reached Project	Passed Upstream
Herring	400	181	310	F	5/29/2019	12: 00: 00	US4	0	0
Herring	400	182	294	M	5/29/2019	12: 00: 00	US4	0	0
Herring	400	183	287	M	5/29/2019	12: 00: 00	US4	1	0
Herring	400	184	293	F	5/29/2019	12: 00: 00	US4	1	0
Herring	400	185	300	M	5/29/2019	12: 00: 00	US4	0	0
Herring	400	186	274	M	5/29/2019	12: 00: 00	US4	0	0
Herring	440	187	286	M	5/29/2019	12: 00: 00	US4	1	0
Herring	440	188	283	M	5/29/2019	12: 00: 00	US4	1	1
Herring	440	189	286	M	5/29/2019	12: 00: 00	US4	0	0
Herring	440	190	294	F	5/29/2019	12: 00: 00	US4	0	0
Herring	440	191	281	M	5/29/2019	12: 00: 00	US4	0	0
Herring	440	192	280	M	5/29/2019	12: 00: 00	US4	1	0
Herring	440	193	291	M	5/29/2019	12: 00: 00	US4	0	0
Herring	440	194	289	M	5/29/2019	12: 00: 00	US4	1	1
Herring	440	195	285	F	5/29/2019	12: 00: 00	US4	1	0
Herring	440	196	309	F	5/29/2019	12: 00: 00	US4	1	0

American Shad – Release Groups Downstream of Pejepscot Project:

Species	Frequency (149.xxx)	ID	Total Length (mm)	Gender	Release Date	Release Time	Reached Project	Passed Upstream
Shad	360	45	490	U	6/12/2019	13: 30: 00	0	0
Shad	360	46	470	M	6/12/2019	13: 30: 00	1	0
Shad	360	47	521	U	6/12/2019	13: 30: 00	1	0
Shad	360	48	570	F	6/12/2019	13: 30: 00	1	0
Shad	360	49	495	F	6/12/2019	13: 30: 00	1	0
Shad	360	50	545	F	6/12/2019	13: 30: 00	0	0
Shad	360	51	475	M	6/12/2019	13: 30: 00	1	0
Shad	360	52	523	F	6/12/2019	13: 30: 00	1	0
Shad	360	53	485	F	6/12/2019	16: 20: 00	0	0
Shad	360	54	520	F	6/12/2019	16: 20: 00	0	0
Shad	360	55	417	M	6/12/2019	16: 20: 00	0	0
Shad	400	56	506	F	6/12/2019	16: 20: 00	0	0
Shad	400	57	462	F	6/12/2019	16: 20: 00	0	0
Shad	400	58	525	F	6/12/2019	16: 20: 00	0	0
Shad	400	59	451	M	6/12/2019	16: 20: 00	1	0
Shad	400	60	540	F	6/12/2019	16: 20: 00	1	0
Shad	400	61	480	F	6/12/2019	16: 20: 00	1	0
Shad	400	62	505	F	6/12/2019	16: 20: 00	1	0
Shad	400	63	475	F	6/12/2019	16: 20: 00	0	0
Shad	400	64	535	F	6/12/2019	16: 20: 00	0	0
Shad	360	57	480	F	6/14/2019	13: 26: 00	1	0
Shad	360	58	505	F	6/14/2019	13: 26: 00	1	0
Shad	360	59	500	F	6/14/2019	13: 26: 00	0	0
Shad	360	60	512	F	6/14/2019	13: 26: 00	0	0
Shad	400	27	358	M	6/14/2019	13: 26: 00	0	0
Shad	400	28	374	M	6/14/2019	13: 26: 00	0	0
Shad	400	29	467	F	6/14/2019	13: 26: 00	0	0
Shad	400	30	415	M	6/14/2019	13: 26: 00	0	0
Shad	400	31	475	M	6/14/2019	13: 26: 00	1	0
Shad	360	56	484	F	6/14/2019	15: 40: 00	0	0
Shad	400	32	508	F	6/14/2019	15: 40: 00	1	0
Shad	400	33	496	M	6/14/2019	15: 40: 00	0	0
Shad	400	34	494	F	6/14/2019	15: 40: 00	1	0
Shad	400	35	456	M	6/14/2019	15: 40: 00	0	0
Shad	400	36	471	F	6/14/2019	15: 40: 00	0	0
Shad	440	70	484	M	6/14/2019	15: 40: 00	0	0
Shad	440	71	484	F	6/17/2019	12: 42: 00	0	0
Shad	440	72	415	M	6/17/2019	12: 42: 00	0	0
Shad	440	73	468	M	6/17/2019	12: 42: 00	1	0
Shad	440	74	521	U	6/17/2019	12: 42: 00	0	0
Shad	440	75	555	F	6/17/2019	12: 42: 00	0	0
Shad	440	76	433	M	6/17/2019	12: 42: 00	0	0
Shad	440	77	449	F	6/17/2019	12: 42: 00	0	0
Shad	440	78	438	M	6/17/2019	12: 42: 00	1	0
Shad	440	79	498	M	6/17/2019	12: 42: 00	0	0
Shad	440	80	496	F	6/17/2019	12: 42: 00	0	0
Shad	440	81	487	F	6/17/2019	12: 42: 00	0	0
Shad	440	82	463	M	6/17/2019	12: 42: 00	0	0
Shad	440	83	495	F	6/17/2019	12: 42: 00	1	0

American Shad – Release Groups Downstream of Pejepscot Project:

Species	Frequency (149.xxx)	ID	Total Length (mm)	Gender	Release Date	Release Time	Reached Project	Passed Upstream
Shad	360	129	494	F	6/17/2019	16: 00: 00	1	0
Shad	360	130	418	M	6/17/2019	16: 00: 00	0	0
Shad	360	131	410	M	6/17/2019	16: 00: 00	0	0
Shad	360	136	479	F	6/17/2019	16: 00: 00	0	0
Shad	400	137	514	F	6/17/2019	16: 00: 00	0	0
Shad	440	84	435	M	6/17/2019	16: 00: 00	1	0
Shad	400	138	525	F	6/17/2019	18: 05: 00	1	0
Shad	400	139	498	F	6/17/2019	18: 05: 00	0	0
Shad	400	140	515	F	6/17/2019	18: 05: 00	0	0
Shad	400	141	384	M	6/17/2019	18: 05: 00	0	0
Shad	440	152	490	F	6/17/2019	18: 05: 00	1	0
Shad	440	153	485	F	6/17/2019	18: 05: 00	1	0
Shad	360	132	484	F	6/18/2019	10: 35: 00	0	0
Shad	360	133	478	M	6/18/2019	10: 35: 00	0	0
Shad	360	139	495	F	6/18/2019	10: 35: 00	0	0
Shad	360	140	517	M	6/18/2019	10: 35: 00	0	0
Shad	400	142	487	F	6/18/2019	10: 35: 00	0	0
Shad	400	145	434	M	6/18/2019	10: 35: 00	0	0
Shad	400	147	493	F	6/18/2019	10: 35: 00	0	0
Shad	440	145	390	M	6/18/2019	10: 35: 00	1	0
Shad	440	146	528	F	6/18/2019	10: 35: 00	1	0
Shad	440	150	441	F	6/18/2019	10: 35: 00	0	0
Shad	440	151	409	M	6/18/2019	10: 35: 00	0	0
Shad	440	154	494	F	6/18/2019	10: 35: 00	0	0
Shad	440	156	418	M	6/18/2019	10: 35: 00	0	0
Shad	360	134	481	F	6/18/2019	14: 05: 00	0	0
Shad	360	135	527	F	6/18/2019	14: 05: 00	1	0
Shad	360	144	441	M	6/18/2019	14: 05: 00	0	0
Shad	360	153	445	M	6/18/2019	14: 05: 00	0	0
Shad	400	122	442	M	6/18/2019	14: 05: 00	1	0
Shad	400	123	420	M	6/18/2019	14: 05: 00	0	0
Shad	400	146	501	F	6/18/2019	14: 05: 00	0	0
Shad	440	147	502	F	6/18/2019	14: 05: 00	0	0
Shad	440	148	499	F	6/18/2019	14: 05: 00	0	0
Shad	360	137	476	M	6/18/2019	18: 30: 00	0	0
Shad	360	138	496	M	6/18/2019	18: 30: 00	1	0
Shad	400	143	485	F	6/18/2019	18: 30: 00	0	0
Shad	400	148	522	F	6/18/2019	18: 30: 00	0	0
Shad	440	149	494	F	6/18/2019	18: 30: 00	0	0
Shad	440	170	445	M	6/18/2019	18: 30: 00	0	0
Shad	440	171	468	M	6/18/2019	18: 30: 00	0	0
Shad	360	141	415	M	6/19/2019	10: 18: 00	0	0
Shad	360	142	520	F	6/19/2019	10: 18: 00	0	0
Shad	360	143	495	F	6/19/2019	10: 18: 00	1	0
Shad	400	120	498	F	6/19/2019	10: 18: 00	0	0
Shad	400	121	440	M	6/19/2019	10: 18: 00	0	0
Shad	400	128	512	F	6/19/2019	10: 18: 00	0	0
Shad	400	144	517	F	6/19/2019	10: 18: 00	1	0
Shad	440	155	472	F	6/19/2019	10: 18: 00	0	0

American Shad – Release Groups Downstream of Pejepscot Project:

Species	Frequency (149.xxx)	ID	Total Length (mm)	Gender	Release Date	Release Time	Reached Project	Passed Upstream
Shad	440	172	500	F	6/19/2019	10: 18: 00	0	0
Shad	440	176	514	F	6/19/2019	10: 18: 00	0	0
Shad	440	178	455	M	6/19/2019	10: 18: 00	1	0
Shad	360	153	490	F	6/19/2019	12: 56: 00	0	0
Shad	360	154	513	F	6/19/2019	12: 56: 00	0	0
Shad	360	155	398	M	6/19/2019	12: 56: 00	0	0
Shad	360	179	530	F	6/19/2019	12: 56: 00	0	0
Shad	360	180	484	F	6/19/2019	12: 56: 00	0	0
Shad	400	124	485	F	6/19/2019	12: 56: 00	0	0
Shad	400	125	410	M	6/19/2019	12: 56: 00	0	0
Shad	440	173	500	F	6/19/2019	12: 56: 00	0	0
Shad	440	174	458	F	6/19/2019	12: 56: 00	1	0
Shad	440	175	520	F	6/19/2019	12: 56: 00	0	0
Shad	440	177	465	F	6/19/2019	12: 56: 00	0	0
Shad	360	181	533	F	6/19/2019	16: 04: 00	0	0
Shad	360	190	500	U	6/19/2019	16: 04: 00	0	0
Shad	360	191	500	F	6/19/2019	16: 04: 00	0	0
Shad	360	192	540	F	6/19/2019	16: 04: 00	0	0
Shad	400	126	535	F	6/19/2019	16: 04: 00	0	0
Shad	400	127	425	M	6/19/2019	16: 04: 00	0	0
Shad	400	187	526	F	6/19/2019	16: 04: 00	0	0
Shad	400	188	495	F	6/19/2019	16: 04: 00	1	0
Shad	400	189	530	F	6/19/2019	16: 04: 00	0	0
Shad	400	193	506	F	6/19/2019	16: 04: 00	0	0
Shad	400	194	465	M	6/19/2019	16: 04: 00	1	0
Shad	400	195	465	F	6/19/2019	16: 04: 00	0	0
Shad	440	86	505	F	6/19/2019	16: 04: 00	0	0
Shad	440	87	438	M	6/19/2019	16: 04: 00	1	0
Shad	440	182	495	F	6/19/2019	16: 04: 00	0	0
Shad	440	183	380	M	6/19/2019	16: 04: 00	0	0
Shad	440	184	495	F	6/19/2019	16: 04: 00	1	0

River Herring – Release Groups Upstream of Project:

Species	Frequency (149.xxx)	ID	Total Length (mm)	Gender	Release Date	Release Time	Release Group	Passage Route
Herring	360	20	293	F	5/22/2019	13: 50: 00	DS1	Unit1
Herring	360	21	283	M	5/22/2019	13: 50: 00	DS1	Unit1
Herring	360	22	284	M	5/22/2019	13: 50: 00	DS1	Spill
Herring	360	23	292	M	5/22/2019	13: 50: 00	DS1	Unit1
Herring	360	24	290	M	5/22/2019	13: 50: 00	DS1	No Pass
Herring	360	25	300	M	5/22/2019	13: 50: 00	DS1	No Detect
Herring	360	26	293	M	5/22/2019	13: 50: 00	DS1	No Detect
Herring	360	27	294	M	5/22/2019	13: 50: 00	DS1	Unit1
Herring	400	37	286	M	5/22/2019	13: 50: 00	DS1	Unit1
Herring	400	38	283	M	5/22/2019	13: 50: 00	DS1	Unit1
Herring	400	39	281	M	5/22/2019	13: 50: 00	DS1	Spill
Herring	400	40	286	M	5/22/2019	13: 50: 00	DS1	Unit1
Herring	400	41	290	M	5/22/2019	13: 50: 00	DS1	No Pass
Herring	400	42	314	F	5/22/2019	13: 50: 00	DS1	Spill
Herring	400	43	297	F	5/22/2019	13: 50: 00	DS1	Spill
Herring	400	44	291	M	5/22/2019	13: 50: 00	DS1	Unit1
Herring	400	45	321	F	5/22/2019	13: 50: 00	DS1	Bypass
Herring	440	54	293	F	5/22/2019	13: 50: 00	DS1	Spill
Herring	440	55	298	F	5/22/2019	13: 50: 00	DS1	Unit1
Herring	440	56	294	M	5/22/2019	13: 50: 00	DS1	Unknown
Herring	440	57	310	F	5/22/2019	13: 50: 00	DS1	Unit1
Herring	440	58	297	F	5/22/2019	13: 50: 00	DS1	Bypass
Herring	440	59	278	M	5/22/2019	13: 50: 00	DS1	Spill
Herring	440	60	301	M	5/22/2019	13: 50: 00	DS1	Unit1
Herring	440	61	288	M	5/22/2019	13: 50: 00	DS1	No Pass
Herring	360	28	305	F	5/23/2019	12: 23: 00	DS2	Spill
Herring	360	29	295	M	5/23/2019	12: 23: 00	DS2	Spill
Herring	360	30	270	M	5/23/2019	12: 23: 00	DS2	Unit1
Herring	360	31	305	M	5/23/2019	12: 23: 00	DS2	Spill
Herring	360	32	288	M	5/23/2019	12: 23: 00	DS2	No Detect
Herring	360	33	280	M	5/23/2019	12: 23: 00	DS2	Spill
Herring	360	34	301	M	5/23/2019	12: 23: 00	DS2	Unit1
Herring	360	35	280	M	5/23/2019	12: 23: 00	DS2	Unit1
Herring	360	36	290	M	5/23/2019	12: 23: 00	DS2	No Pass
Herring	400	46	300	U	5/23/2019	12: 23: 00	DS2	Unit1
Herring	400	47	280	M	5/23/2019	12: 23: 00	DS2	Bypass
Herring	400	48	295	M	5/23/2019	12: 23: 00	DS2	Spill
Herring	400	49	286	M	5/23/2019	12: 23: 00	DS2	Spill
Herring	400	50	290	M	5/23/2019	12: 23: 00	DS2	Unit1
Herring	400	51	280	U	5/23/2019	12: 23: 00	DS2	Unit1
Herring	400	52	294	M	5/23/2019	12: 23: 00	DS2	Unit1
Herring	400	53	307	M	5/23/2019	12: 23: 00	DS2	Bypass
Herring	440	62	295	F	5/23/2019	12: 23: 00	DS2	Unit1

River Herring – Release Groups Upstream of Project:

Species	Frequency (149.xxx)	ID	Total Length (mm)	Gender	Release Date	Release Time	Release Group	Passage Route
Herring	440	63	292	M	5/23/2019	12: 23: 00	DS2	Unit1
Herring	440	64	296	M	5/23/2019	12: 23: 00	DS2	Spill
Herring	440	65	305	M	5/23/2019	12: 23: 00	DS2	Unit1
Herring	440	66	280	M	5/23/2019	12: 23: 00	DS2	Unit1
Herring	440	67	300	M	5/23/2019	12: 23: 00	DS2	No Pass
Herring	440	68	296	M	5/23/2019	12: 23: 00	DS2	Spill
Herring	440	69	303	F	5/23/2019	12: 23: 00	DS2	Unit1
Herring	360	145	275	M	5/24/2019	11: 59: 00	DS3	Unit1
Herring	360	146	286	M	5/24/2019	11: 59: 00	DS3	Spill
Herring	360	147	310	F	5/24/2019	11: 59: 00	DS3	Spill
Herring	360	148	287	M	5/24/2019	11: 59: 00	DS3	No Detect
Herring	360	149	295	M	5/24/2019	11: 59: 00	DS3	No Detect
Herring	360	150	294	M	5/24/2019	11: 59: 00	DS3	Spill
Herring	360	151	296	M	5/24/2019	11: 59: 00	DS3	Spill
Herring	360	152	290	U	5/24/2019	11: 59: 00	DS3	Unit1
Herring	400	153	296	M	5/24/2019	11: 59: 00	DS3	Unit1
Herring	400	154	295	M	5/24/2019	11: 59: 00	DS3	Unit1
Herring	400	155	291	M	5/24/2019	11: 59: 00	DS3	No Detect
Herring	400	156	315	M	5/24/2019	11: 59: 00	DS3	Bypass
Herring	400	157	284	M	5/24/2019	11: 59: 00	DS3	No Detect
Herring	400	158	299	M	5/24/2019	11: 59: 00	DS3	Unit1
Herring	400	159	275	U	5/24/2019	11: 59: 00	DS3	No Detect
Herring	400	160	298	U	5/24/2019	11: 59: 00	DS3	Spill
Herring	400	161	275	M	5/24/2019	11: 59: 00	DS3	Unit1
Herring	440	162	285	F	5/24/2019	11: 59: 00	DS3	Spill
Herring	440	163	289	M	5/24/2019	11: 59: 00	DS3	Unit1
Herring	440	164	279	M	5/24/2019	11: 59: 00	DS3	Unit1
Herring	440	165	290	U	5/24/2019	11: 59: 00	DS3	Spill
Herring	440	166	280	U	5/24/2019	11: 59: 00	DS3	Unit1
Herring	440	167	284	U	5/24/2019	11: 59: 00	DS3	Spill
Herring	440	168	292	U	5/24/2019	11: 59: 00	DS3	Spill
Herring	440	169	294	M	5/24/2019	11: 59: 00	DS3	No Detect
Herring	360	37	287	F	5/29/2019	12: 53: 00	DS4	Bypass
Herring	360	38	277	M	5/29/2019	12: 53: 00	DS4	No Pass
Herring	360	39	297	F	5/29/2019	12: 53: 00	DS4	Unit1
Herring	360	40	291	F	5/29/2019	12: 53: 00	DS4	Spill
Herring	360	41	275	M	5/29/2019	12: 53: 00	DS4	Bypass
Herring	360	42	300	F	5/29/2019	12: 53: 00	DS4	No Detect
Herring	360	43	284	F	5/29/2019	12: 53: 00	DS4	Unit1
Herring	360	44	276	F	5/29/2019	12: 53: 00	DS4	Unit1
Herring	400	20	285	M	5/29/2019	12: 53: 00	DS4	No Pass
Herring	400	21	276	M	5/29/2019	12: 53: 00	DS4	Unit1
Herring	400	22	297	F	5/29/2019	12: 53: 00	DS4	No Detect

River Herring – Release Groups Upstream of Project:

Species	Frequency (149.xxx)	ID	Total Length (mm)	Gender	Release Date	Release Time	Release Group	Passage Route
Herring	400	23	302	F	5/29/2019	12: 53: 00	DS4	Spill
Herring	400	24	285	F	5/29/2019	12: 53: 00	DS4	Unit1
Herring	400	25	289	M	5/29/2019	12: 53: 00	DS4	Unit1
Herring	400	26	290	F	5/29/2019	12: 53: 00	DS4	No Detect
Herring	440	27	301	F	5/29/2019	12: 53: 00	DS4	Unit1
Herring	440	28	304	F	5/29/2019	12: 53: 00	DS4	No Detect
Herring	440	29	280	M	5/29/2019	12: 53: 00	DS4	Unit1
Herring	440	30	282	M	5/29/2019	12: 53: 00	DS4	Bypass
Herring	440	31	276	F	5/29/2019	12: 53: 00	DS4	Unknown
Herring	440	32	293	F	5/29/2019	12: 53: 00	DS4	Unit1
Herring	440	33	285	F	5/29/2019	12: 53: 00	DS4	Unit1
Herring	440	34	292	M	5/29/2019	12: 53: 00	DS4	No Pass
Herring	440	35	291	F	5/29/2019	12: 53: 00	DS4	Bypass

American Shad – Release Group Upstream of Project

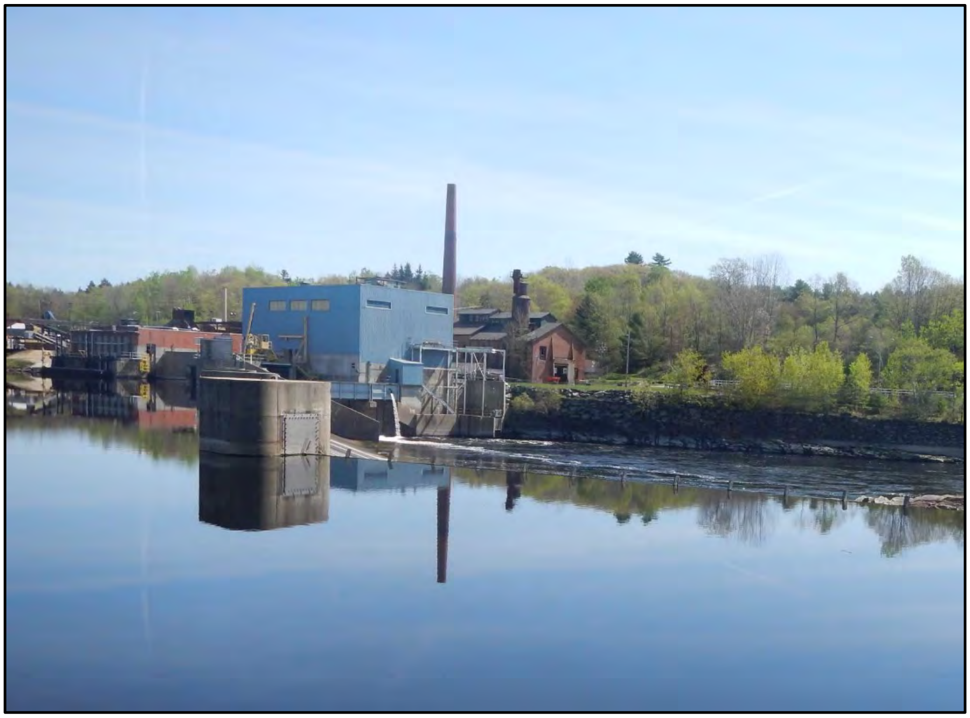
Species	Frequency (149.xxx)	ID	Total Length (mm)	Sex	Release Date	Release Time	Passage Route
Shad	360	10	430	M	7/11/2019	12: 55: 00	Spill
Shad	360	11	489	F	7/11/2019	12: 55: 00	No Detect
Shad	360	12	474	F	7/11/2019	12: 55: 00	No Pass
Shad	360	13	466	M	7/11/2019	12: 55: 00	No Pass
Shad	360	14	515	F	7/11/2019	12: 55: 00	Bypass
Shad	360	15	572	F	7/11/2019	12: 55: 00	No Detect
Shad	360	16	519	F	7/11/2019	12: 55: 00	Unit1
Shad	360	17	520	F	7/11/2019	12: 55: 00	Spill
Shad	360	18	543	F	7/11/2019	12: 55: 00	No Detect
Shad	360	19	519	F	7/11/2019	12: 55: 00	Spill
Shad	360	157	523	F	7/11/2019	12: 55: 00	No Pass
Shad	360	158	504	F	7/11/2019	12: 55: 00	Bypass
Shad	360	159	558	F	7/11/2019	12: 55: 00	Spill
Shad	360	160	483	F	7/11/2019	12: 55: 00	Unit1
Shad	400	103	436	F	7/11/2019	12: 55: 00	Unit1
Shad	400	104	492	F	7/11/2019	12: 55: 00	Unit1
Shad	400	105	527	F	7/11/2019	12: 55: 00	No Detect
Shad	400	106	497	F	7/11/2019	12: 55: 00	No Pass
Shad	400	107	459	F	7/11/2019	12: 55: 00	No Pass
Shad	400	108	500	F	7/11/2019	12: 55: 00	No Pass
Shad	400	109	450	M	7/11/2019	12: 55: 00	Spill
Shad	400	110	536	F	7/11/2019	12: 55: 00	Bypass
Shad	400	111	566	F	7/11/2019	12: 55: 00	Unit1
Shad	400	112	529	F	7/11/2019	12: 55: 00	Unit1
Shad	400	113	435	M	7/11/2019	12: 55: 00	No Pass
Shad	440	36	440	M	7/11/2019	12: 55: 00	No Pass
Shad	440	37	503	M	7/11/2019	12: 55: 00	No Pass
Shad	440	38	524	U	7/11/2019	12: 55: 00	Unit1
Shad	440	39	495	F	7/11/2019	12: 55: 00	No Detect
Shad	440	40	497	F	7/11/2019	12: 55: 00	Spill
Shad	440	41	484	F	7/11/2019	12: 55: 00	No Detect
Shad	440	42	541	F	7/11/2019	12: 55: 00	No Pass
Shad	440	43	455	M	7/11/2019	12: 55: 00	Unit1
Shad	440	44	536	F	7/11/2019	12: 55: 00	Spill
Shad	440	45	560	F	7/11/2019	12: 55: 00	No Pass
Shad	440	46	489	F	7/11/2019	12: 55: 00	Spill
Shad	440	47	472	M	7/11/2019	12: 55: 00	Unit1
Shad	440	48	490	F	7/11/2019	12: 55: 00	Unit1
Shad	440	49	509	F	7/11/2019	12: 55: 00	Spill
Shad	440	50	502	F	7/11/2019	12: 55: 00	No Detect
Shad	440	51	491	F	7/11/2019	12: 55: 00	Unit1

American Shad – Release Group Upstream of Project

Species	Frequency (149.xxx)	ID	Total Length (mm)	Sex	Release Date	Release Time	Passage Route
Shad	440	52	411	M	7/11/2019	12: 55: 00	No Pass

DRAFT UPDATED STUDY REPORT
FALL DIADROMOUS FISH PASSAGE EFFECTIVENESS

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC NO. 4784)



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Brookfield

Table of Contents

List of Appendices

List of Tables

List of Figures

List of Abbreviations and Definitions

°C	degrees Celsius
cfs	cubic feet per second
CJS	Cormack-Jolly-Seber
FERC	Federal Energy Regulatory Commission
ft	feet
m	meter
mm	millimeters
ME	Maine
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
PCU	Platinum Cobalt Units
RM	river mile
RSP	Revised Study Plan
SPD	Study Plan Determination

1 INTRODUCTION

An evaluation of the downstream passage of adult American Eels and juvenile alosines (i.e., shad and herrings) was conducted in support of the relicensing of the Pejepscot Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 4784, as identified in the Revised Study Plan (RSP) submitted by Topsham Hydro Partners Limited Partnership on June 12, 2018 and approved by FERC in its Study Plan Determination (SPD) letter dated July 3, 2018. This is a report for the 2019 field study which evaluated the existing downstream passage structures at the Project for the downstream movement of adult eels and juvenile alosines.

2 STUDY GOAL AND OBJECTIVES

The goal of this study was an evaluation of the effectiveness of the existing downstream fish passage facilities at the Project for juvenile alosines and adult (silver-phase) American Eels during the fall migration period of August 1 – November 30. Specifically, this study sought to:

- Estimate the residence time for outmigrating juvenile alosines and adult American Eels in the area immediately upstream of the Project prior to downstream passage.
- Evaluate the use of available downstream passage routes by outmigrating juvenile alosines and adult American Eels at the Project.
- Examine the distribution for the hour of arrival at the Project for outmigrating juvenile alosines and adult American Eels to the Project area upstream of the dam.
- Estimate transit times for outmigrating juvenile alosines and adult American Eels through defined reaches immediately upstream and downstream of the Project.
- Estimate downstream project passage survival for outmigrating adult American Eels at the Project.

3 STUDY AREA

The study area included the section of the Androscoggin River from river mile (RM) 6.0 (i.e., the Brunswick Hydroelectric Project (FERC No. 2284) to the upper end of the Pejepscot impoundment located approximately 3.5 miles upstream of the dam. As specified in the RSP, remote monitoring stations were established at specified locations within the overall study reach (Figure 3-1).

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Pejepscot Hydroelectric Project
(FERC No. 4784)
Fall Diadromous Fish Passage
Effectiveness Study

Figure 3-1.
Study Reach of the Androscoggin River considered during the Fall Anadromous Fish Passage Effectiveness Evaluation for the Pejepscot Relicensing

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4 METHODS

Effectiveness of the existing downstream passage facilities for fall migrants at the Project were evaluated via radio-telemetry. As described in the RSP, this study focused on the downstream passage of radio-tagged juvenile alosines and adult American Eels at the Project. Following the release of radio-tagged individuals into the Androscoggin River, their movements were monitored using a series of stationary radio-telemetry receivers in place at the Project as well as at several additional stationary monitoring stations installed at bank-side locations upstream and downstream of the Project to inform on general movements, distribution among available passage routes and Project passage success.

4.1 Radio Telemetry Equipment

Movements of radio-tagged individuals during the fall season were recorded via a series of stationary radio-telemetry receivers. Radio-telemetry equipment used during this evaluation of downstream passage at Pejepscot included Orion receivers, manufactured by Sigma Eight, as well as SRX receivers manufactured by Lotek Wireless. Each receiver was paired with either an aerial or underwater antenna (dropper antenna). Aerial antennas (four or six element Yagi) were utilized to detect radio-tagged fish within the larger, more open sections of river, such as within the tailrace or at locations downriver of Pejepscot. Dropper antennas were fixed at downstream passage locations (e.g., downstream bypasses, Francis units). Dropper antennas were custom built by stripping the shielded ends of RG58 coaxial cables.

Juvenile alosines were tagged using individually coded Lotek NTQ-1 transmitters. The NTQ-1 transmitters measured approximately 5 x 3 x 10 mm, weighed 0.25 g, and had an estimated battery life of 10 days when set at a 2.0 second burst rate. Transmitters for this study operated on one of two distinct frequencies (149.340 or 149.420 MHz). Burst rates for the full set of transmitters were programmed at a setting of 2.0 seconds.

All eels radio-tagged during 2019 were equipped with a Sigma Eight TX-PSC-I-450 radio transmitter (150.600 or 150.680 MHz, pulse rate = 2.0 seconds). The TX-PSC-I-450 transmitters measured approximately 12 x 12 x 46 mm, weighed 8.5 g and had an estimated battery life of 357 days when set at a 2.0 second burst rate. Each transmitter was coded to emit a unique identifying signal so that individual eels could be identified by a receiver.

4.2 Monitoring Stations

The RSP identified a total of ten monitoring stations to be set up at Pejepscot for the fall passage effectiveness evaluation. Each of the ten monitoring locations identified in the RSP were installed as described and each location consisted of a data-logging receiver, antenna, power source, and were configured to receive transmitter signals from a designated area continuously throughout the study period. During installation of each station, range testing was conducted to configure the antennas and receivers in a manner which maximized detection efficiencies at each location. The operation of the radio telemetry receivers was initially established during installation, then confirmed throughout the study period by using beacon tags. A number of beacon tags were stationed at strategic locations within the detection range of either multiple or single antennas, and they emitted signals at programmed time intervals. These signals were detected and logged by the receivers and used to record the functionality of the system throughout the study period.

The locations of monitoring stations installed for the fall passage effectiveness evaluation are outlined here and presented in Figure 4-1.

Monitoring Station F1: This station was installed at a location approximately 650 feet upstream of the dam and provided arrival timing information on radio-tagged juvenile alosines and adult American Eels as they entered the Project area prior to downstream passage. Station F1 consisted of a single receiver and aerial antenna oriented perpendicular to the river channel.

Monitoring Station F2: Station F2 consisted of a single receiver and an underwater drop antenna. It was positioned in the vicinity of the counting window and was used to identify downstream passage of radio-tagged juvenile alosines and adult American Eels exiting via this route.

Monitoring Station F3: This station monitored downstream passage through the three horizontal Francis units in the northern powerhouse. It consisted of a single receiver and a number of custom-made underwater drops. The dropper antennas were positioned at equally spaced intervals across the width of Units 21, 22, and 23 (Francis units) and combined to create a single large underwater antenna for full coverage of the units. Detections of a transmitter passing through Units 21, 22 or 23 (Francis units) were collected as a single data set and not identified to a particular turbine.

Monitoring Station F4: Station F4 monitored downstream passage of radio-tagged juvenile alosines and adult American Eels through the left side weir (i.e., downstream bypass). It consisted of a single receiver connected to a pair of staggered, custom built drop antennas. The drop antennas were installed through the weir entrance and into the outlet pipe to ensure that detections were of fish committed to the route.

Monitoring Station F5: This station monitored downstream passage of radio-tagged juvenile alosines and adult American Eels through the right side weir (i.e., downstream bypass). It consisted of a single receiver connected to a pair of staggered, custom built drop antennas. The drop antennas were installed through the weir entrance and into the outlet pipe to ensure that detections were of fish committed to the route.

Monitoring Station F6: Station F6 was used to determine fish passage through Unit No. 1 (Kaplan unit). Gate well slots at Unit 1 are not accessible for the insertion of underwater drop antennas. As a result, a single aerial antenna was installed to monitor the outflow area from Unit 1. Due to the lack of access, it was necessary to use process of elimination to distinguish radio-tagged juvenile alosines and adult American Eels passing via Unit 1 from other passage routes.

Monitoring Station F7: This station detected radio-tagged juvenile alosines and adult American Eels passing the Project via spill over the dam crest and consisted of a single receiver and an aerial antenna mounted overlooking the downstream side of the dam.

Monitoring Station F8: Station F8 detected radio-tagged juvenile alosines and adult American Eels passing a point approximately 1.8 miles downstream of the Pejepscot Project. This monitoring station consisted of a receiver coupled to an aerial antenna and was located on the Brunswick & Topsham Water District property along the eastern bank of the river. Detection information from this location was used for evaluation of downstream passage success at the Pejepscot Project for adult eels and also informed on rates of movement following passage for both species between the Pejepscot and Brunswick Dams.

Monitoring Station F9: This station consisted of a single receiver coupled to an aerial antenna and was located bankside at a point approximately 0.5 miles upstream of Station F10 and approximately 2.25 miles downstream of Station F8. Detection information from this location was used for evaluation of downstream passage success at the Pejepscot Project for adult eels and also informed on rates of movement following passage for both species between the Pejepscot and Brunswick Dams.

Monitoring Station F10: This station detected radio-tagged juvenile alosines and adult American Eels approaching the Brunswick Project from upriver. Station F10 consisted of a pair of receivers, each coupled to an aerial antenna oriented in an upstream direction. Antennas were installed at a location adjacent to the powerhouse along the western bank and at a location adjacent to the tainter gates along the eastern bank. Detection information from this location was used for evaluation of downstream passage success at the Pejepscot Project for adult eels and also informed on rates of movement following passage for both species between the Pejepscot and Brunswick Dams.

4.3 Tagging and Release Procedures

4.3.1 Juvenile Alosines

Juvenile alosines were collected via beach seine at the outlet of Sabattus Pond, Maine. Following capture, juvenile alosines were transported by truck to a temporary tank facility established at the Brunswick Project. Prior to tagging, fish were lightly anesthetized using diluted soda water (10:1 river water: soda water ratio), and each individual was quickly measured to ensure a total length of at least 100 mm. Lotek NTQ-1 transmitters were attached to a dry fly hook using bonding cement and were spray-painted black to reduce visibility once attached to fish. The hook was inserted posterior to the dorsal fin with the majority of the tag and antenna trailing behind the insertion point (Figure 4–2). After tagging, fish were held in 32-gallon holding cans and maintained in ambient Androscoggin River water until they were transported to the release site.

For testing, four groups of juvenile alosines were externally radio-tagged, transported by boat, and released approximately 0.5 miles upstream of the Pejepscot boat barrier. Each release group was split into half, with one set of tagged juvenile alosines released in the eastern third of the river and the other half released in the western third of the river. A number of untagged juvenile alosines were released in conjunction with tagged fish during each release event to provide a "schooling" feel for the tagged fish. All releases were conducted during the evening hours. The date and time of each release was recorded.

4.3.2 Adult Silver Eels

A total of 50 silver-phase American Eels were purchased from a commercial eel trapper operating on the St. Croix River in Maine. Eels were transported by truck from the St. Croix area to holding tanks at Brunswick on October 2, 2019. All eels were held for a minimum of 24 hours prior to tagging. Individuals were visually examined and if they appeared healthy were anesthetized in a clove oil and ethanol solution (Figure 4-3). Eels were held and visually monitored in the anesthesia bath for approximately 10–15 min prior to tagging. Once sedated, eels were removed from the bath and placed on a clean, wet towel. The total length (TL) and eye diameter (horizontal and vertical; nearest 0.1 mm) were measured. Although the capture method virtually guarantees sample specimens are migratory, a previously described correlation between eye size, body length and gonad development was used to confirm whether individuals were mature and likely to be active outmigrants (Pankhurst 1982). This eye index relationship (I) was described using the formula:

$$I = [(A+B/4)^2\pi/L]*100$$

where A = horizontal eye diameter, B = vertical eye diameter, and L = total body length. Silver-phase American Eels typically have an eye index between 6.0 and 13.5, with a bronze coloration along the lateral line that separates the dark, silver back from the white belly. Eels meeting these characteristics were selected for surgical tagging. In short, an incision was made off center on the ventral surface of the individual and of an adequate length to insert the transmitter into the body cavity. A hollow needle was inserted into the incision and was pushed through the body wall just off of the ventral mid-line and at a point posterior to the incision. The antenna was fed through the needle and gently pulled so that the transmitter entered the body cavity. The needle was then fully pulled through the body wall and removed from the antenna. The transmitter was positioned by pulling the antenna so that it lay directly under the incision. The incision was closed with two or three interrupted sutures (chromic gut with a 4-0 cutting needle) evenly spaced across the incision. A small amount of an antibacterial ointment was applied to the incision site to prevent infection.

Following tagging, each individual was transferred to an acclimation tank supplied with ambient river water for an additional 24-h observation period to allow eels to recover from surgery. Following the recovery period, eels were assessed for normal behavior prior to release and were then trucked to the Pejepscot boat launch at the upstream end of the Project impoundment and were released from the shoreline. Two separate release groups, each comprising 25 radio-tagged eels were released during the 2019 study. The date and time of each release was recorded.

4.4 Data Collection

4.4.1 Stationary Telemetry Data

Receiver downloads occurred a minimum of once weekly during the period from the initial tag and release event until the end of November, 2019. Backup copies of all telemetry data were made prior to receiver initialization. Field tests at the time of download to ensure data integrity and receiver performance included confirmation of file integrity, confirmation that the last record was consistent with the downloaded data (beacon tags were critical to this step), and lastly, confirmation that the receiver was operational upon restart and actively collecting data post download. Within a data file, transmitter detections were stored as a single event (i.e., single data line). Each event included the date and time of detection, frequency, ID code, and signal strength.

4.4.2 Manual Telemetry Data

To provide supplemental detection information to the stationary receiver data set, manual tracking was conducted on several occasions from the time of initial release through November, 2019. Tracking efforts attempted to cover the section of the mainstem Androscoggin River from the Pejepscot headpond area downstream to Brunswick. Manual tracking conducted during the 2019 fall telemetry evaluation was a combination of boat and shore-based (i.e., truck, foot) effort.

4.4.3 Operational and Environmental Data

Androscoggin River water temperature was recorded via a continuously operating logger installed in the vicinity of the exit flume at to the Project fishway. Hourly records for operations data were provided by Brookfield for the 2019 evaluation period and included spill discharge (cfs), gate settings for inflatable sections 1 through 5, unit discharge for Units 1, 21, 22, and 23 (cfs), head pond elevation (ft), and tailwater elevation (ft).

4.5 Analytical Methodology

4.5.1 Data Processing

Tag detections in each downloaded stationary telemetry data file were validated through a series of site-specific and logical criteria, which included:

1. Signal strength threshold level of the detection,
2. Frequency of the radio tag signals per unit of time, and
3. Spatial and temporal characteristics of each individual detection with respect to the full series of detections at monitoring stations within the entire detection array.

To determine the signal strength threshold for a valid tag signal, power levels associated with background noise were recorded at each monitoring station prior to the release of radio-tagged fish. These “false” signals are typically received at relatively low power levels, and they were removed from the analysis using a series of data filters. The frequency of the signal detections for an individual radio tag was examined at each monitoring station, such that over a set period of time, there were an adequate number of detections to rule out an isolated false detection (e.g. at least 3 detections within 1 minute). Finally, the spatial and temporal distributions of detections across multiple monitoring stations were examined to verify that the pattern of detections was not occurring in a manner that was unreasonable (i.e., time for a fish to have relocated within the time between the detections).

4.5.2 Data Analysis

The stationary telemetry data set collected as part of this effort was examined and used to evaluate a number of metrics related to downstream movement and usage of the project area.

4.5.3 Downstream Movement and Passage Route Selection

Following the completion of data file processing, a complete record of all valid stationary receiver detections for each radio-tagged juvenile alosine and adult American Eel was generated. The pattern and timing of detections in these individual records were reviewed, and a route of passage as well as project arrival and passage times were assigned to each radio-tagged individual. In the instance that a downstream route could not be clearly determined from the collected data, the passage event for that particular fish was classified as ‘unknown’. Downstream passage route determinations were made for both juvenile alosines and adult silver eels.

Where data were available, approach duration and project residence times were calculated. Values for approach duration were calculated as the duration of time from release until arrival at the Project as defined by detection at Station F1. Upstream project residence time was defined as the duration of time from the initial detection at Station F1 until the determined time of downstream passage. Approach and project residence durations were calculated for both juvenile alosines and adult silver eels.

4.5.4 Parameter Estimates for Evaluation of Downstream Passage

Downstream passage success at the Project was estimated for adult American Eels using a standard Cormack-Jolly-Seber (CJS) model run for the set of individual encounter histories (i.e., the series of detection/no detection through the linear sequence of receivers from upstream to downstream). This approach provided a series of reach-specific “survival” or passage success estimates for:

- Release location to Monitoring Station F1 (i.e., upstream approach);
- Monitoring Station F1 (i.e., upstream approach) to downstream passage;
- Downstream passage to Monitoring Station F8 (i.e., first downstream receiver); and
- Monitoring Station F8 (i.e., first downstream receiver) to Monitoring Station F9 (i.e., second downstream receiver)

Standard error and confidence bounds for each estimate were generated. The joint probability of the two Project reach survival estimates (i.e., (StnF1 to Passage)*(Passage to StnF8)) was used as the estimate of total passage survival for the Project. This approach resulted in a mortality estimate that included both background mortality (i.e., natural mortality such as predation) and mortality due to Project effects in the reach extending from 650 feet upstream of the dam to the first downstream receiver. Thus, the results presented in this report reflect a minimum estimate of survival attributable to Project effects for adult silver eels.

To evaluate passage success using the CJS models, a suite of candidate models were developed in Program MARK (White and Burnham 1999) based on whether survival (i.e., passage success), recapture (i.e., detection), or both vary or are constant among stations. Models developed during this study included:

- *Phi(t)p(t)*: survival and recapture may vary between receiver stations;
- *Phi(t)p(.)*: survival may vary between stations; recapture is constant between stations;
- *Phi(.)p(t)*: survival is constant between stations; recapture may vary between stations;
- *Phi(.)p(.)*: survival and recapture are constant between stations;

Where;

- *Phi* = probability of survival
- *p* = probability of detection
- *(t)* = parameter varies
- *(.)* = parameter is constant

To evaluate the fit of the CJS model, goodness of fit testing will be conducted for the “starting model” (i.e., the fully parameterized model) using the function RELEASE within Program MARK. Akaike’s Information Criterion (AIC) was used to rank the models as to how well they fit the observed mark-recapture data. Lower AIC values denote a more explanatory yet parsimonious fit than higher AIC values. Assuming the assumptions of the model with the lowest AIC value were reasonable with regards to this study, that model was selected for the purposes of generating passage effectiveness estimates.

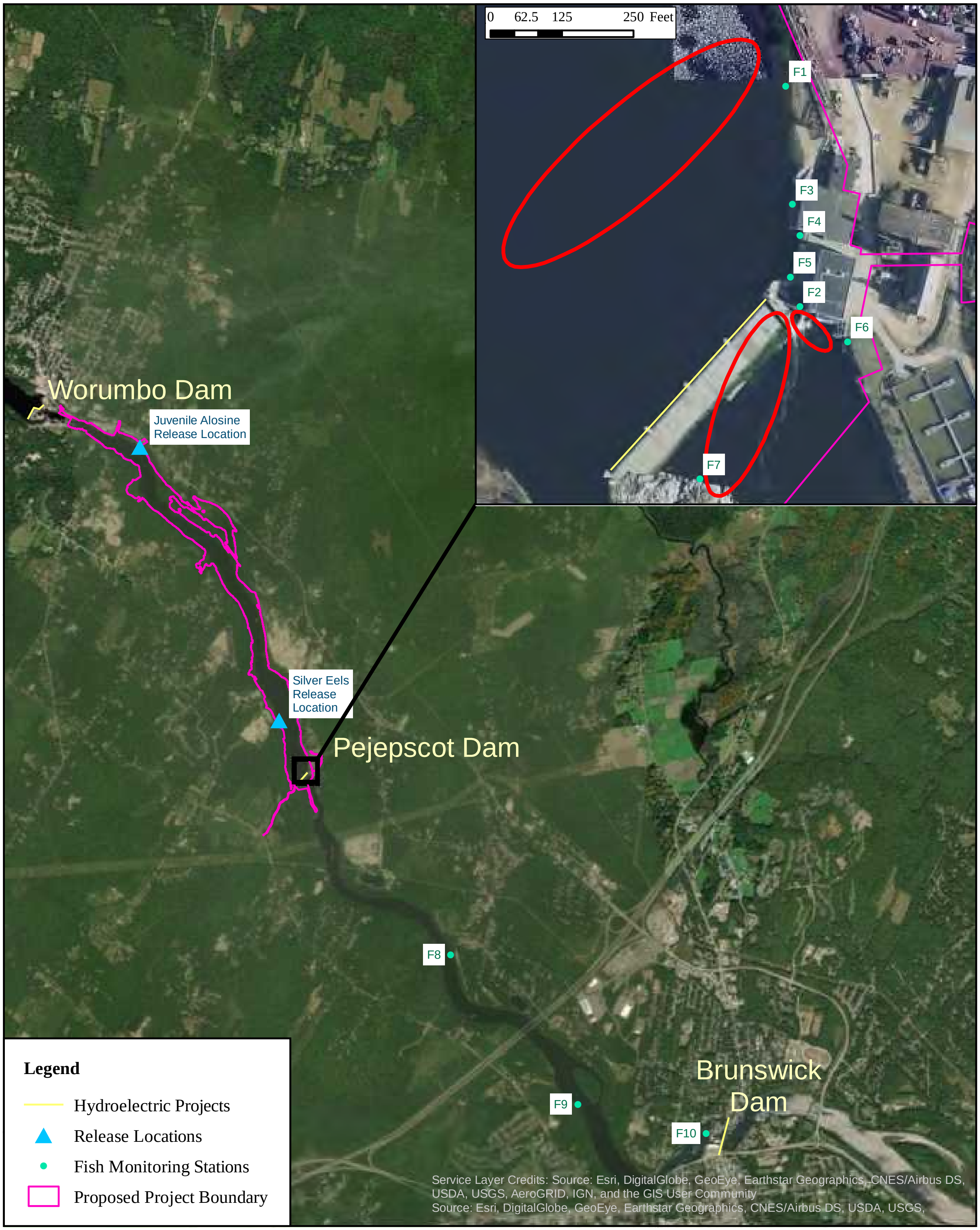

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Figure 4-1:
Locations and Approximate Detection Areas for Monitoring Stations during the 2019 Juvenile Alosine and Adult American Eel Downstream Passage Evaluation

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Figure 4-2: Externally Radio-tagged Juvenile Alosine Showing Relative Position of Transmitter Attachment

Figure 4-3: Tagging Process for Silver-phase American Eels

5 RESULTS

5.1 Androscoggin River Conditions and Pejepscot Project Operations

Figure 5-1 presents the total river flow and water temperature for the Androscoggin River for the period October 1 to November 31, 2019. Total river flow values are the sum of the reported unit discharge and spill values as reported for Pejepscot and Androscoggin River temperature readings were recorded hourly in the Project headpond. Androscoggin River flow ranged between 1,582 and 15,782 cfs during the two month fall study period. Mean daily river flow was 2,945 and 4,857 on the two dates of release for radio-tagged silver eels (October 3 and October 8) and ranged between 2,479 and 4,828 over the four dates of release for radio-tagged juvenile alosines. Flows were below station capacity at the Pejepscot Project on all six release dates during the 2019 evaluation. Water temperature ranged between 17 and less than 1 ^{o}C from the time of first release until the end of monitoring period. Mean daily Androscoggin River temperatures were 16-17 ^{o}C on release dates for radio-tagged adult eels and 12-14 ^{o}C on release dates for radio-tagged juvenile alosines.

Pejepscot operational flows for the period October 1 to November 30, 2019 are presented in Figure 5-1. Spill conditions during the two-month period were limited to a brief period during early October (and prior to any releases of tagged fish) and a longer duration event from October 23 to November 5. The three Francis units (U21, U22, and U23) operated only during the periods of spill flow. The downstream bypasses were operated normally.

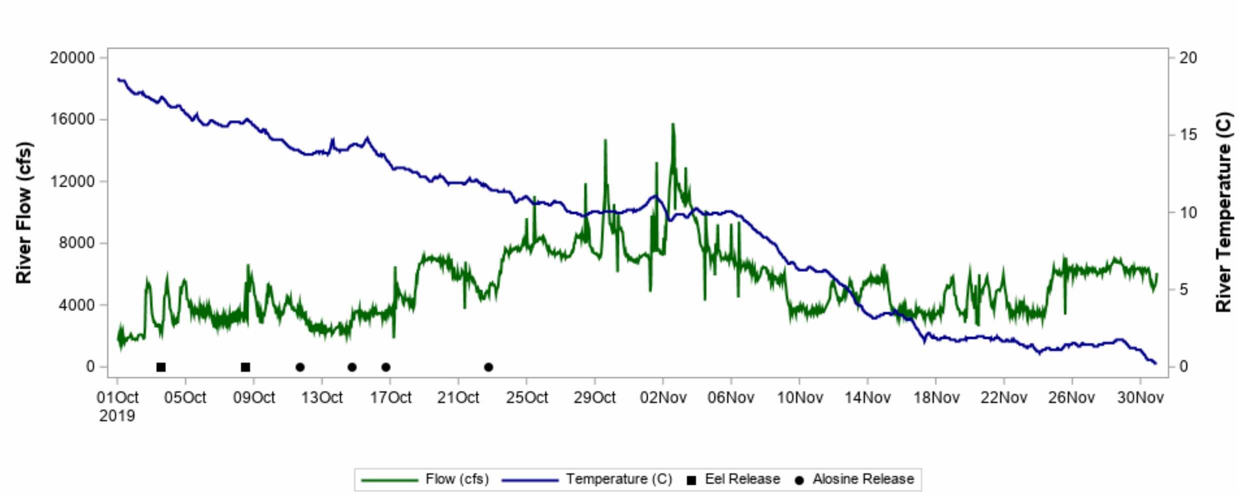


Figure 5-1: Androscoggin River Discharge and Temperature for the Period October 1 to November 30, 2019

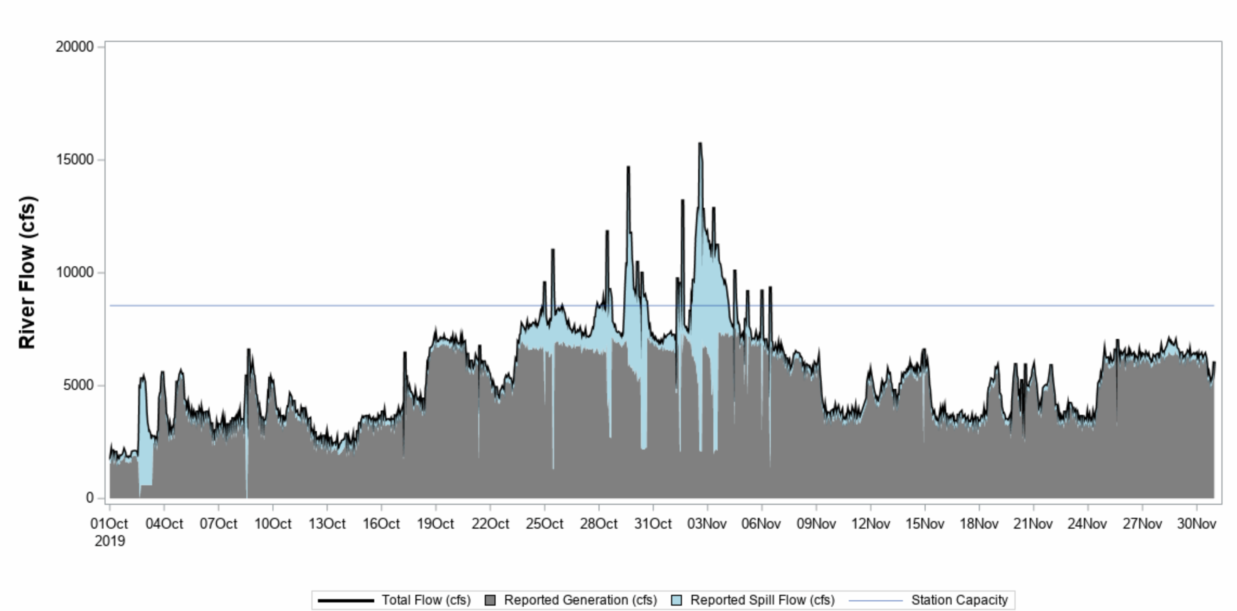


Figure 5–2: Total, Powerhouse, and Spill Flow (cfs) Relative to Station Capacity at Pejepscot for the Period October 1 to November 30, 2019.

5.2 Monitoring Station Functionality

Radio-tagged juvenile alosines and adult American Eels were released into the Androscoggin River beginning in early October, 2019. The RSP called for continuous monitoring at each stationary receiver location through the end of November. Figure 5-3 and Figure 5-4 provide an overview of the continuity of monitoring at each of the ten stationary receiver locations during the fall period. Due to differences in frequencies and transmitter sizes, passage of eels and juvenile alosines were recorded on their own receiver at each monitoring station location. The majority of the radio-telemetry monitoring stations installed to evaluate passage at Pejepscot during the fall study operated without issue for the full period. Operation of the upstream fishway was terminated during early November and telemetry coverage of that route was subsequently ended on November 7 for receivers monitoring both species.

An interruption in coverage occurred for eels and alosines at the upstream approach receiver from 1400 on October 30 until 1500 on October 31 due to a battery failure. However, as there were no downstream passage events for either species after October 23, this outage period had no effect on evaluation of downstream passage at the Project.

An error in the frequency table of the juvenile alosine receiver installed at Station F9 located 0.5 miles upstream of Brunswick impacted juvenile alosines carrying transmitters operating on 149.340 MHz during the period from the first release on October 11 until prior to the second release on October 14. As a result passage times for those individuals from the first release group were missed. However, all radio-tagged juvenile alosines detected upstream of Station F9 at Station F8 were also detected downstream at Station F10 (Brunswick). The absence of data for these fish at the downstream location (Station F9) had no impact on the primary study objective of downstream passage route selection at the Project.

A coaxial cable associated with the eel receiver at Station F9 was damaged and impacted coverage during the period from 1400 on October 9 to 1400 on October 11. As a result, the downstream passage times for two radio-tagged eels at Station F9 were missed. However, those passage times for both individuals were recorded at Stations F8 and F10. The loss of passage data at F9 for those two individuals had no impact on the overall estimation of downstream passage success for silver eels at the Project.

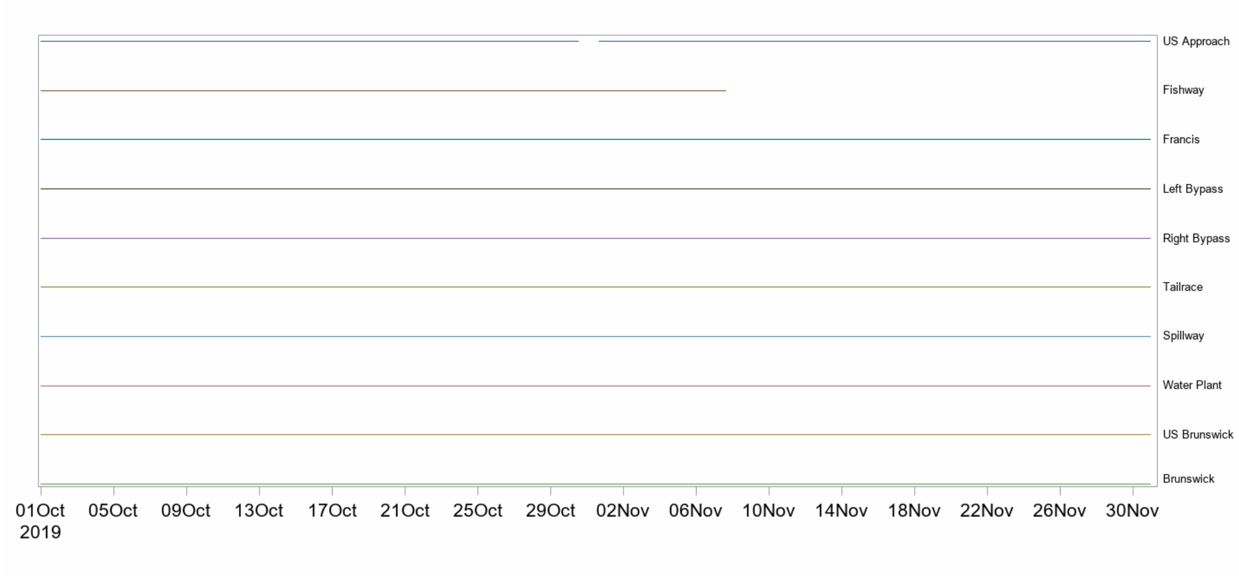


Figure 5-3. Monitoring Station Operational Coverage for Telemetry Receivers at Pejepscot during the Fall Juvenile Alosine Evaluation Period, October 1 to November 30, 2019

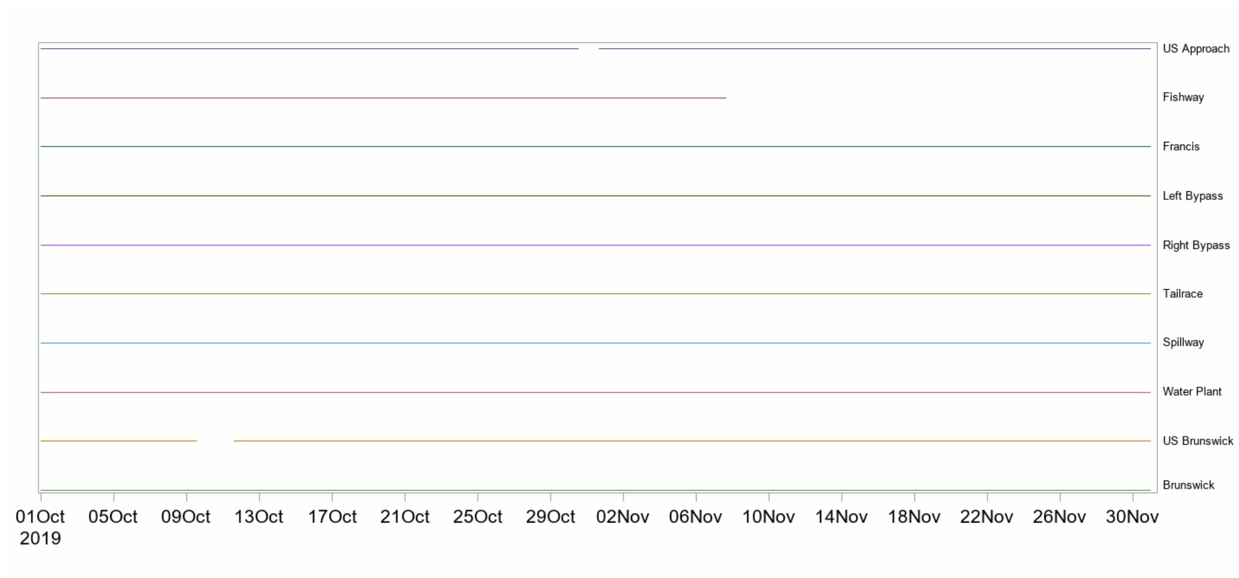


Figure 5-4: Monitoring Station Operational Coverage for Telemetry Receivers at Pejepscot during the Fall Adult American Eel Evaluation Period, October 1 to November 30, 2019

5.3 Juvenile Alosine Downstream Passage Evaluation

A total of 98 radio-tagged juvenile alosines were released approximately 0.5 mi upstream of the Pejepscot Dam during October 2019. Two of the original 100 transmitters failed to activate during tagging and were not available for releases. Juvenile alosines tagged and released upstream of the Project ranged in total length from 102-132 mm (Table 5-1; median = 125 mm). Of the total released, 97% (95 out of 98) were determined to have approached Pejepscot Dam and had an opportunity to pass downstream. The upstream residence times, downstream passage routes, and downstream transit durations for juvenile alosines at Pejepscot are presented in Sections 5.3.1 – 5.3.3. A full listing of the juvenile alosines radio-tagged as part of this assessment is provided in Appendix A.

5.3.1 Project Returns and Upstream Residence Duration

Radio-tagged juvenile alosines were released upstream of Pejepscot on four dates during October, 2019 (October 11, 14, 16, and 22). Figure 5-5 presents the distribution of arrival dates at the Project as indicated by detection at Monitoring Station F1. Initial detections of radio-tagged juvenile alosines at Pejepscot were recorded over the range of dates from October 11 to October 23. In all instances, radio-tagged juvenile alosines arrived at Pejepscot within two days of release. A summary of the approach durations (i.e., the duration of time from release into the river until arrival at the Project as determined by detection at Station F1) is provided in Table 5-2. When juvenile alosines from all releases are considered, the median approach duration was 2.1 hours (range = 0.7-23.1 hours).

The duration of time radio-tagged individuals were present upstream of Pejepscot (i.e., the “upstream residence duration”) was determined for all individuals which approached and eventually passed downstream of the Pejepscot Dam, and was calculated as the duration of time from initial detection at Station F1 until confirmed downstream passage via one of the available routes. When those individuals are considered, upstream residence time prior to downstream passage ranged between 0.1 and 18.2 hours (median = 0.5 hours; Table 5-3). When examined by release group, median values for residence duration upstream of Pejepscot ranged from 0.2 to 1.6 hours (Figure 5-6; Table 5-3). The median residence duration was longer for individuals released in the eastern third of the river (powerhouse side; 0.7 hours) versus those released in the western third of the river (spillway side; 0.4 hours). Of the radio-tagged alosines which approached Pejepscot Dam, 100% passed in fewer than 24 hours after initial detection (Figure 5-6).

5.3.2 Downstream Passage

Passage routes for the 95 radio-tagged juvenile alosines released upstream of Pejepscot Dam and determined to have approached the Project are presented in tabular format in Table 5-4 and graphically in Figure 5-6. The majority of radio-tagged juvenile alosines passed downstream of the dam via Unit 1 (68%). An additional 31% passed downstream via the downstream bypass system. When examined by entrance, 55% of radio-tagged juvenile alosines using the downstream bypass system were determined to have used the left gate (as determined looking downstream). The remaining 45% of individuals did so via the right entrance. A single radio-tagged juvenile alosine approached Pejepscot but failed to successfully pass downstream.

Radio-tagged juvenile alosines were observed passing downstream of Pejepscot Dam between the dates of October 11 and October 23 (Figure 5-8). The majority of individuals passed downstream at dusk (hours 1900 – 2200) with the greatest peak in the number of downstream passage events occurring during the 2000 hour (24.5%; Figure 5-9). This was likely a function of the timing of upstream release groups above the Project coupled with the relatively quick Project return and upstream residence durations observed for most tagged juvenile alosines.

5.3.3 Downstream Transit Durations

Three monitoring stations were installed downstream of the Project for the purpose of detecting radio-tagged juvenile alosines following passage at Pejepscot Dam. Those receivers were located approximately 1.8 (Monitoring Station F8) and 4.0 (Monitoring Station F9) miles downstream of the dam. In addition, Monitoring Station F10 (located at Brunswick Dam) recorded arrival times for radio-tagged juvenile alosines at the downstream end of the study reach. The range of downstream transit times through these three reaches are presented in Table 5-5 and median values for radio-tagged juvenile alosines downstream of Pejepscot were 3.1, 0.9, and 0.6 hours, respectively. Of the 94 radio-tagged juvenile alosines which passed downstream at Pejepscot, 80 were determined to have reached Brunswick Dam. Downstream transit times for those individuals ranged between 2.8 to 72.4 hours (median = 6.0 hours).

Table 5-1: Summary of Tagging and Release Information for Juvenile Alosines Radio-tagged and Released into the Androscoggin River upstream of Pejepscot during Fall 2019

Juvenile Alosines	Release Group			
	#1	#2	#3	#4
Release Location	0.5 mi Upstream of Project			
Release Date	11-Oct-19	14-Oct-19	16-Oct-19	22-Oct-19
Release Time	18:21	17:42	17:44	17:45
River Temperature (°C)	14.0	14.1	13.7	11.8
Station Discharge (cfs)	3,713	2,479	2,988	4,828
Spill Flow (cfs)	0	0	0	0
No. Tagged Released	25	25	25	23
No. Untagged Released	20	20	20	28
Min. Total Length (mm)	123	115	102	119
Max Total Length (mm)	132	132	131	130
Mean Total Length (mm)	127	124	122	125

Table 5-2: Minimum, Maximum, Mean, and Quarterly Percentiles (P 25, P 50 (Median), and P 75) of the Observed Duration of Time for Radio-tagged Juvenile Alosines to Approach Pejepscot Following Release

Release Group	Approach Duration (hrs)					
	Min	Max	Mean	P 25	Median	P 75
October 11	1.4	23.1	5.2	2.4	3.4	6.9
October 14	0.7	9.5	2.4	0.8	1.7	3.4
October 16	0.9	6.2	2.5	1.0	1.8	3.1
October 19	1.1	8.8	2.4	1.4	1.8	2.5
All	0.7	23.1	3.1	1.4	2.1	3.7

Table 5-3: Minimum, Maximum, Mean, and Quarterly Percentiles (P 25, P 50 (Median), and P 75) for Radio-tagged Juvenile Alosine Upstream Residence Duration Prior to Downstream Passage at Pejepscot

Release Group	Upstream Residence Duration (hrs)					
	Min	Max	Mean	P 25	Median	P 75
October 11	0.2	8.8	1.5	0.3	0.5	1.5
October 14	0.8	7.1	1.0	0.2	0.4	1.2
October 16	0.1	6.0	2.0	0.7	1.6	2.9
October 19	0.1	18.2	1.2	0.2	0.2	0.5
All	0.1	18.2	1.4	0.2	0.5	1.7

Table 5-4: Summary of Downstream Passage Route Distribution for Radio-tagged Juvenile Alosines at Pejepscot during Fall 2019

Passage Route	No. of Individuals	Percentage
Did not approach	3	-
Did not pass	1	1.1%
Right Bypass	13	13.7%
Left Bypass	16	16.8%
Fishway	0	0.0%
Francis Units	0	0.0%
Unit 1	65	68.4%
Spillway	0	0.0%

Table 5-5: Minimum, Maximum, Mean, and Quarterly Percentiles (P 25, P 50 (Median), And P 75) for Radio-tagged Juvenile Alosine Downstream Transit Duration following Downstream Passage at Pejepscot

River Reach	Downstream Transit (hrs)			
	Min	Max	Median	Mean
Pejepscot to Station F8	0.8	69.8	3.1	7.8
Station F8 to F9	1.5	12.2	1.9	2.7
Station F9 to F10 (Brunswick)	0.2	5.0	0.6	0.8

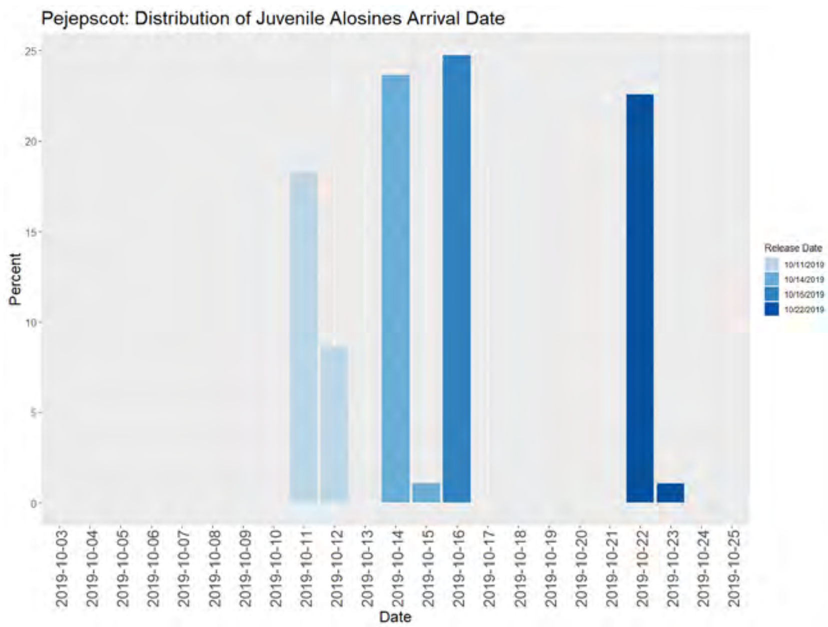


Figure 5-5: Distribution of Arrival Dates for each Release Group of Radio-tagged Juvenile Alosines at Pejepscot prior to Attempted Downstream Passage, Fall 2019

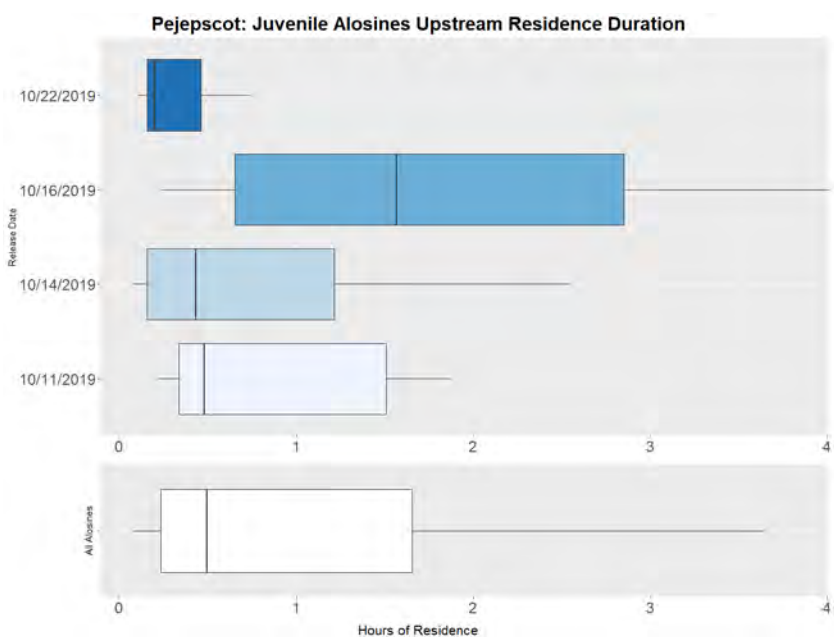


Figure 5-6: Boxplot Showing Upstream Residence Duration for Radio-tagged Juvenile Alosines at Pejepscot prior to Downstream Passage, Fall 2019[1]

[1] The solid line represents the median while left and right portions of the box represent the first and third quartiles, respectively. Whiskers extend to the range of the data within the interquartile range (quartile*1.05) such that outliers outside of this range are not displayed.

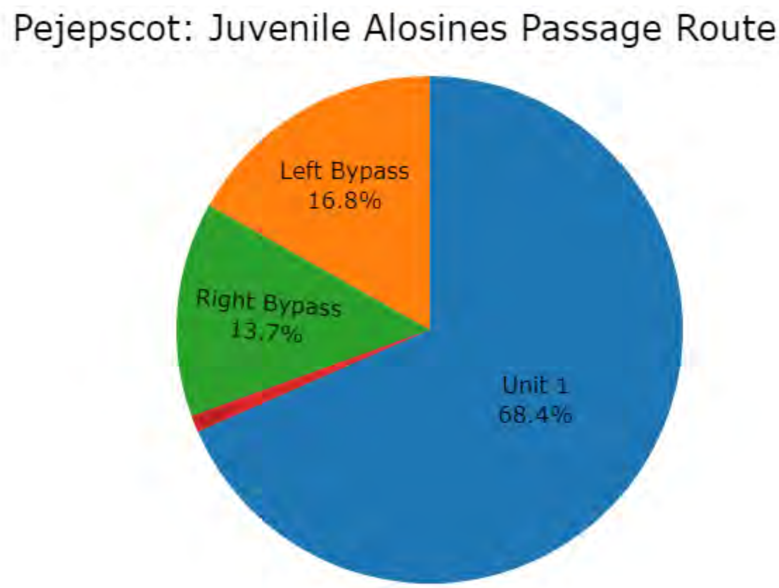


Figure 5-7: Distribution of Downstream Passage Route Usage for Radio-tagged Juvenile Alosines at Pejepscot during Fall 2019

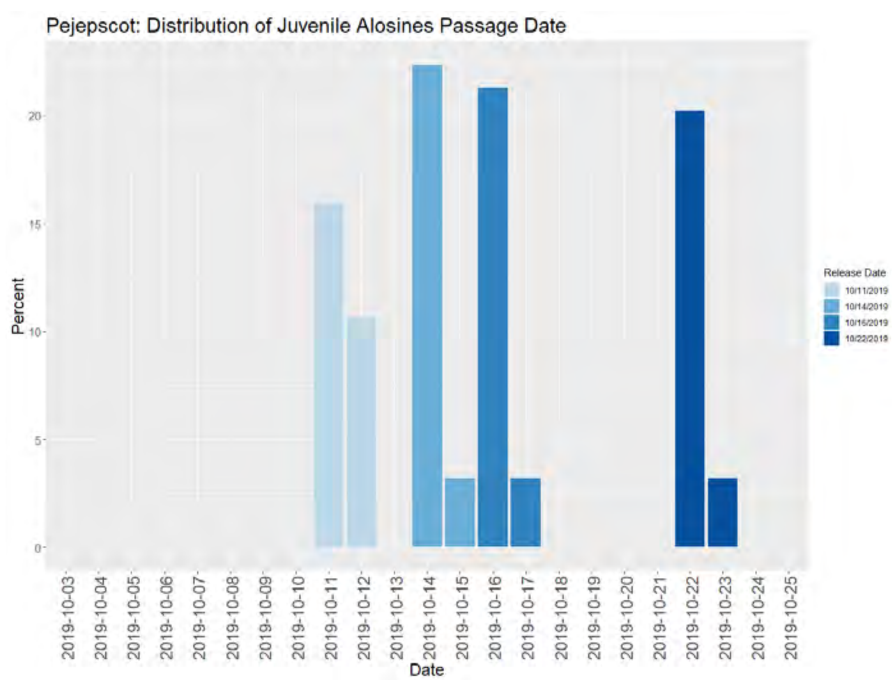


Figure 5-8: Distribution of Downstream Passage Dates for Radio-tagged Juvenile Alosines at Pejepscot during Fall 2019

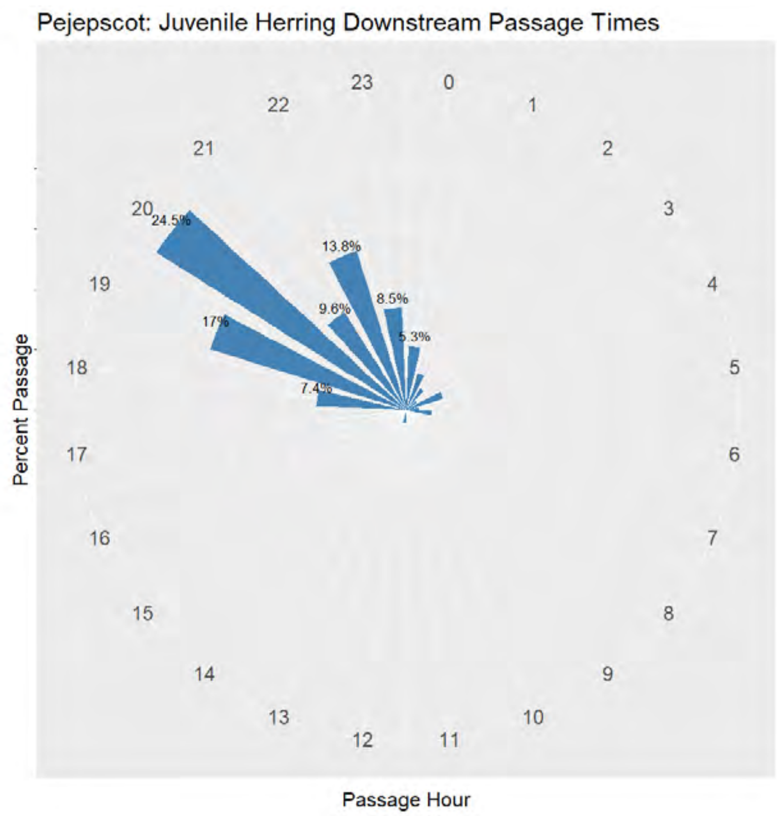


Figure 5-9: Distribution of Downstream Passage Times for Radio-tagged Juvenile Alosines at Pejepscot during Fall 2019

5.4 Adult American Eel Downstream Passage Evaluation

A total of 50 silver-phase American Eels were delivered to holding tanks at Brunswick on October 2, 2019 (Table 5-6). Eels were held overnight and visually evaluated the following day to ensure they were active in the tank following transport. Eels were tagged and released in two groups of 25 individuals each. Releases upstream of Pejepscot occurred on October 3 and 8. Eels obtained and tagged as part of the 2019 passage evaluation ranged in length from 658 to 998 mm with the majority of individuals between 800-849 mm (Figure 5-10). Eye index values recorded as part of this study (6.8-13.1) were all within the reported range (6.0-13.5) for outmigrating eels. A listing of tagging and biocharacteristics information for eels released during 2019 is provided in Appendix A.

5.4.1 Project Returns and Upstream Residence Duration

Radio-tagged silver eels were released upstream of Pejepscot on October 3 and October 8, 2019. Figure 5-11 presents the distribution of arrival dates at the project as indicated by detection at Monitoring Station F1. Initial detections of radio-tagged eels at Pejepscot were recorded over the range of dates from October 3 to October 17, with the majority occurring within two or three days following release. A summary of the approach durations (i.e., the duration of time from release into the river until arrival at the Project as determined by detection at Station F1) is provided in Table 5-1. When adult eels from both releases are considered, the median approach duration was 24.7 hours (range = 1.7 hours to 13.5 days).

The duration of time radio-tagged individuals were present upstream of Pejepscot was determined for all individuals which approached and eventually passed downstream of the Pejepscot Dam. This ‘upstream residence duration’ was calculated as the duration of time from initial detection at Station F1 until confirmed downstream passage via one of the available routes. When all individuals are considered, upstream residence time prior to downstream passage ranged between 0.1 hours to 19.4 days (median = 2.1 hours; Table 5-8; Figure 5-12). Of the radio-tagged eels which approached Pejepscot Dam, 65% passed in fewer than 24 hours after initial detection. A total of 22% of outmigrating American Eels took greater than five days (120 hours) to pass downstream of Pejepscot following their initial detection at the Project.

5.4.2 Downstream Passage

A summary of the passage routes for the 50 radio-tagged silver eels released upstream of Pejepscot Dam is presented in Table 5-9. The majority of individuals passed downstream of the dam via unit 1 (96%). In addition, one individual passed via spill and one individual passed through the fishway. No radio-tagged eels were detected using the left or right bypasses or the Francis units. Radio-tagged silver eels were observed passing downstream of Pejepscot Dam between the dates of October 3 and October 23 (Figure 5-13). The majority of individuals passed downstream at dusk (hours 1800 – 2200) with a peak in the number of downstream passage events during the hour of 2000 (20%; Figure 5-14).

5.4.3 Downstream Transit Durations

Three monitoring stations were installed downstream of the Project for the purpose of detecting radio-tagged adult eels following passage at Pejepscot Dam. Those receivers were located approximately 1.8 (Monitoring Station F8) and 4.0 (Monitoring Station F9) miles downstream of the dam. In addition, Monitoring Station F10 (located at Brunswick Dam) recorded arrival times for radio-tagged adult eels at the downstream end of the study reach. The range of downstream transit times through these three reaches are presented in Table 5-10 and median values for radio-tagged eels downstream of Pejepscot were 4.9, 1.7, and 0.7 hours, respectively. Of the 50 radio-tagged adult silver eels which passed downstream at Pejepscot, 43 were determined to have reached Brunswick Dam. Downstream transit times for those individuals ranged between 2.5 hours to 19.6 days (median = 4.0 days).

5.4.4 Passage Survival

The CJS model *Phi(t)p(t)* provided the best fit for the observed mark-recapture data associated with downstream movements of radio-tagged adult American Eels approaching Pejepscot Dam (Table 5-11). The reach-specific survival estimates at Pejepscot ranged between 1.0-0.90 among river reaches from the dam approach to passage, passage to the first downstream receiver, and from the first to the second downstream receiver (Table 5-12). The detection efficiency for telemetry receivers recording passage of adult eels at monitoring stations at Pejepscot and the remote riverside locations ranged from 1.000 to 0.740 (Table 5-13). The relatively poor detection efficiency rate (0.740) was estimated for the approach receiver (Station F1). It is suspected that radio-tagged eel behaviors to follow the bottom contours as they moved downstream towards the

Project may have led to lower than desired detection rates at the approach receiver. However, detection was 100% for eels at Pejepscot as well as the first downstream receiver.

The CJS-derived survival estimates for the two Pejepscot project reaches (i.e., dam approach (Station F1) to passage; passage to first downstream receiver (Station F8)) were 1.0 and 0.90 (Table 5-12), which resulted in an estimate of survival for the entire project reach (~650 feet upstream of the dam to the first downstream receiver) of 90.0% (75% CI =86.0-94.0%). This estimate of downstream passage survival for adult eels at Pejepscot includes any background (i.e., natural) or tagging-related mortality for the species in the reach from the approach receiver to the first downstream receiver. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult eels at Pejepscot.

Five of the 50 radio-tagged eels which passed downstream at Pejepscot failed to reach the first downstream monitoring station (Station F8). Of the silver eels failing to reach the downstream station, four of the five passed the Project via Unit 1 and the fifth was detected using the upstream fishway. The route-specific estimate of passage survival for silver eels via Unit 1 is 91.7% (75% CI = 87.5-95.8%).

Table 5–6: Summary of tagging and release information for adult American Eels radio-tagged and released into the Androscoggin River upstream of Pejepscot during fall 2019.

Silver Eels	Release Group	
	#1	#2
Release Location	0.5 mi Upstream of Project	
Release Date	03-Oct-19	08-Oct-19
Release Time	16:45	18:50
River Temperature (ºC)	17.2	15.8
Station Discharge (cfs)	2945	4857
Spill Flow (cfs)	0	0
No. Tagged Released	25	25
Min. Total Length (mm)	740	658
Max Total Length (mm)	981	998
Mean Total Length (mm)	848	816

Table 5–7: Minimum, Maximum, Mean, and Quarterly Percentiles (P 25, P 50 (median), and P 75) of the Observed Duration of Time for Radio-tagged Adult American Eels to Approach Pejepscot following Release

Release Group	Approach Duration (hrs)					
	Min	Max	Mean	P 25	Median	P 75
October 3	1.8	323.5	33.3	3.8	8.1	26.3
October 8	2.0	195.6	46.1	8.3	59.7	50.1
All	1.7	323.5	39.2	4.8	24.7	33.5

Table 5–8: Minimum, Maximum, Mean, and Quarterly Percentiles (P 25, P 50 (Median), and P 75) for Radio-tagged Adult American Eel upstream residence duration prior to Downstream Passage at Pejepscot

Release Group	Upstream Residence Duration (hrs)					
	Min	Max	Mean	P 25	Median	P 75
October 3	0.1	465.8	67.5	0.2	0.7	55.1
October 8	0.1	189.5	60.5	0.2	5.1	142.7
All	0.1	465.8	64.3	0.2	2.1	86.6

Table 5-9: Summary of Downstream Passage Route Distribution for Radio-tagged Adult American Eels at Pejepscot during Fall 2019

Passage Route	No. of Individuals	Percentage
Fishway	1	2.0
Unit 1	48	96.0
Spillway	1	2.0

Table 5-10: Minimum, Maximum, Mean, and Quarterly Percentiles (P 25, P 50 (Median), and P 75) for Radio-tagged Adult American Eel Downstream Transit Duration Following Downstream Passage at Pejepscot

River Reach	Downstream Transit (hrs)			
	Min	Max	Median	Mean
Pejepscot to Station F8	0.8	461.0	4.9	81.2
Station F8 to F9	1.13	139.3	1.7	19.1
Station F9 to F10 (Brunswick)	0.2	311.5	0.7	40.5

Table 5-11: CJS Model Selection Criteria for Downstream Passage of Adult American Eels at Pejepscot during Fall 2019

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
Phi(t)p(t)	157.44	0.00	0.98	1.00	5	3.44
Phi(.)p(t)	164.91	7.47	0.02	0.02	3	15.08
Phi(t)p(.)	188.39	30.96	0.00	0.00	3	38.56
Phi(.)p(.)	198.85	41.41	0.00	0.00	2	51.08

Table 5-12: Reach-specific Survival Probability Estimates (*Phi*), Standard Errors and Likelihood 75 and 95% Confidence Intervals for Radio-tagged Adult American Eels Approaching and Passing Pejepscot Dam during fall 2019

Reach	Reach Length (mile)	*Phi*	SE	95% CI		75% CI	
Station F1 - Pass	0.2	1.000	0.000	-	-	-	-
Pass - Station F8	1.8	0.900	0.042	0.781	0.958	0.840	0.939
Station F8 - Station F9	2.2	0.982	0.023	0.816	0.999	0.926	0.996

Table 5-13: Detection Efficiency Estimates (*p*) for Monitoring Locations Installed to Detect Radio-tagged Adult American Eels at Pejepscot for Evaluation of Downstream Passage during Fall 2019

Location	*p*	SE	95% CI	
Station F1	0.740	0.062	0.602	0.843
Pejepscot	1.000	0.000	-	-
Station F8	1.000	0.000	-	-
Station F9	0.837	0.056	0.696	0.920

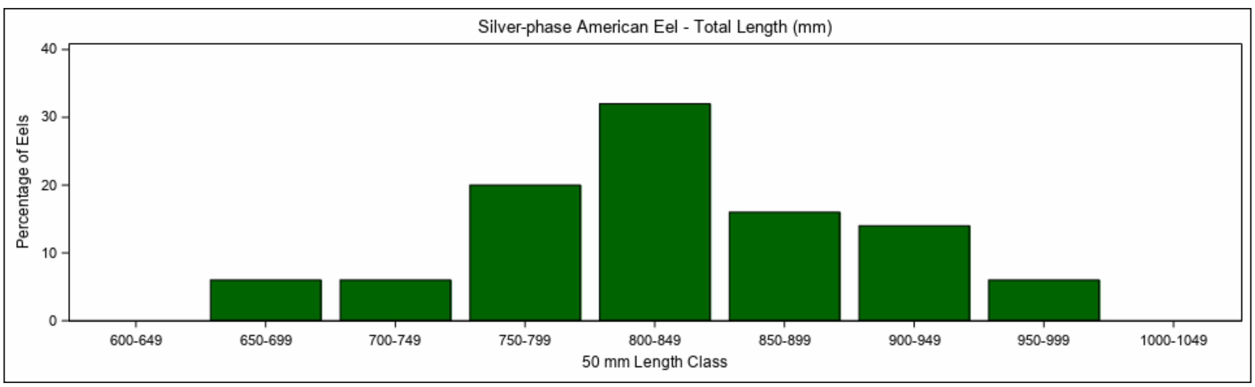


Figure 5-10: Frequency Distribution of Total Length (50 mm length classes) for Radio-tagged Adult American Eels Released Upstream of Pejepscot

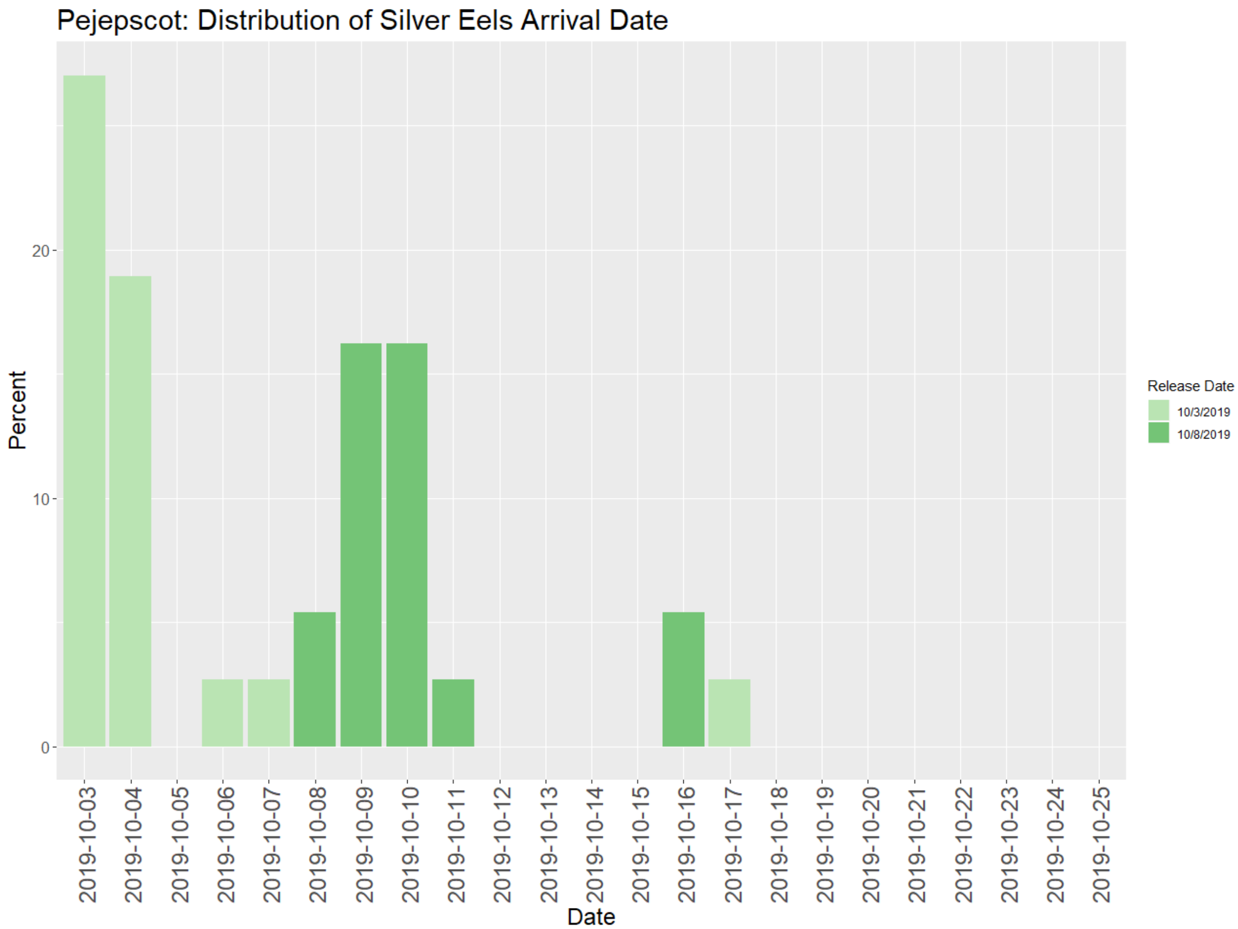


Figure 5-11: Distribution of Arrival Dates for each Release Group of Radio-tagged Adult American Eels at Pejepscot prior to Attempted Downstream Passage, Fall 2019

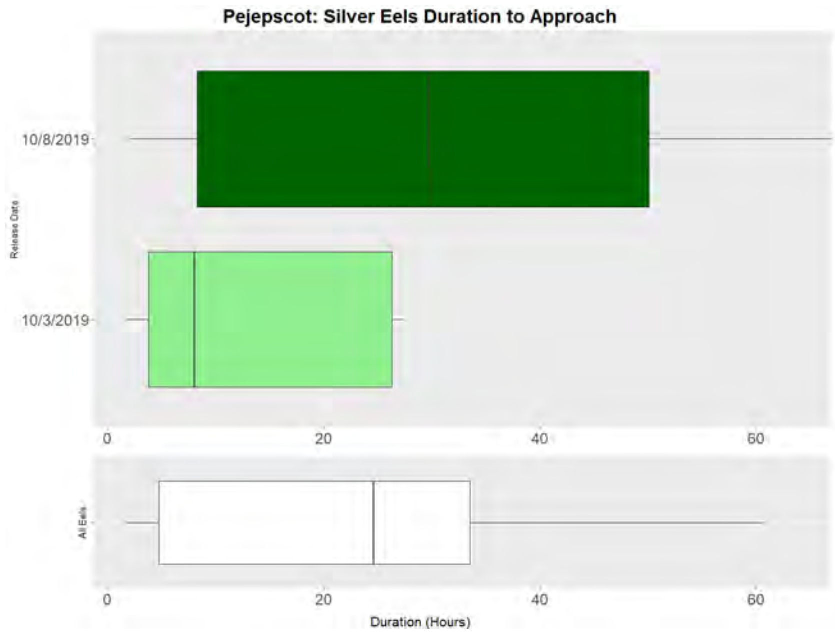


Figure 5-12: Boxplot showing Upstream Residence Duration for Radio-tagged Adult American Eels at Pejepscot prior to Downstream Passage, Fall 2019. [2]

[2] The solid line represents the median while left and right portions of the box represent the first and third quartiles, respectively. Whiskers extend to the range of the data within the interquartile range (quartile*1.05) such that outliers outside of this range are not displayed.

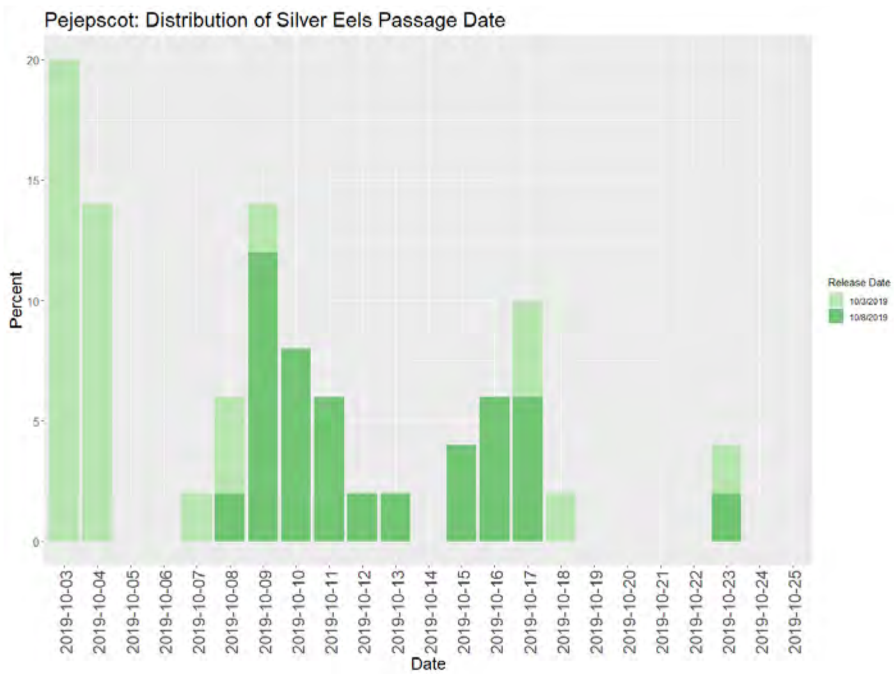


Figure 5-13: Distribution of Downstream Passage Dates for Radio-tagged Adult American Eels at Pejepscot during Fall 2019

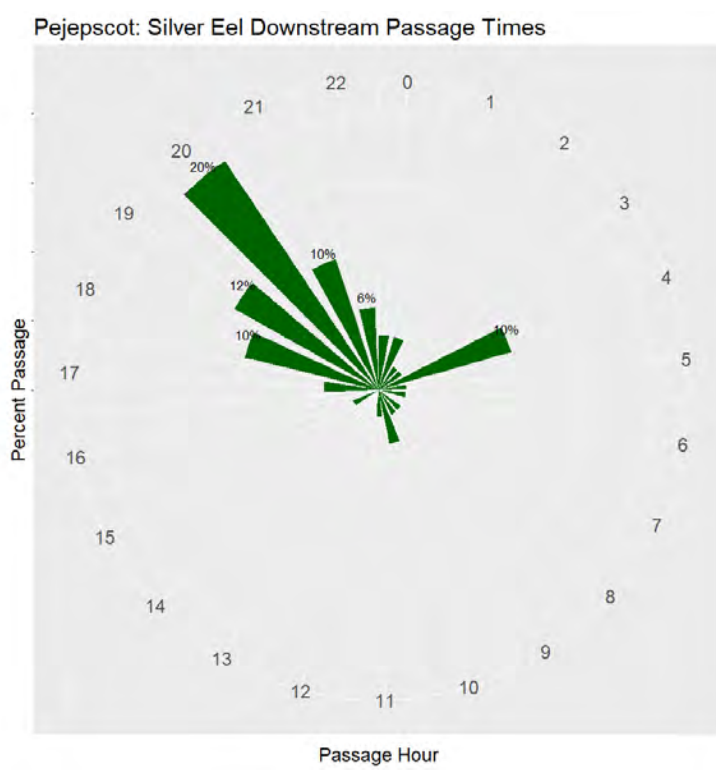


Figure 5-14: Distribution of Downstream Passage Times for Radio-tagged Adult American Eels at Pejepscot during Fall 2019

6 SUMMARY

An evaluation of the downstream passage for juvenile alosines and adult American Eels was conducted in support of the FERC relicensing of the Pejepscot Project. Fish passage effectiveness was evaluated using radio-telemetry during the 2019 fall migration season (October 1 to November 31, 2019). Monitoring of juvenile alosines focused on evaluation of residence time upstream of the project prior to passage and determination of the proportional distribution of use among available passage routes. Adult eel monitoring focused on residence time prior to passage, passage route selection and estimation of downstream passage survival at the Project.

6.1 Juvenile Alosines

Of the 98 radio-tagged individuals, 97% continued downstream following handling and tagging and were determined to have approached the Pejepscot Dam. Of those individuals, only one did not pass downstream, resulting in a total of 94 individuals with which to estimate the proportional use of downstream passage routes at the Project. Based on Androscoggin River flows and operational conditions at the station, radio-tagged juvenile alosines approaching Pejepscot during this study were limited to passage via the downstream bypass system, upstream fishway or the operating turbine unit (Unit 1). Although there was spill present during a portion of the overall monitoring period (October 23 to November 5), the onset of that period of spill did not overlap with the presence of any tagged juvenile alosines in the upstream Project area. Under the operational conditions at the Project at the time of arrival for radio-tagged juvenile alosines, the majority passed downstream via the turbine. Downstream bypass effectiveness was estimated at 31% with a nearly even split in entry locations (i.e., entrances adjacent to the Unit 1 intake area to the left or right). Downstream movement for juvenile alosines tagged as part of this study was relatively quick. When the full duration of time from release until arrival at Brunswick (~4.7 miles) is considered, tagged juvenile alosines did so in a median time of 32.4 hours (25^{th} percentile = 21.5 hours; 75^{th} percentile = 50.3 hours).

6.2 Adult American Eels

A total of 50 adult silver eels were obtained from a commercial vendor operating on the St. Croix River, Maine and were transported for evaluation of downstream passage at Pejepscot. All 50 individuals were surgically radio-tagged and were released upstream of the Project on one of two release dates in early October to assess downstream passage. Downstream passage was observed for each of the radio-tagged eels and occurred over a range of dates from October 3 to October 23. The median period of residence for radio-tagged eels upstream of the dam was 2.1 hours with 65% passing downstream within the first 24 hours of their initial detection. Based on Androscoggin River flows and operational conditions at the station, passage route opportunities for radio-tagged adult eels tagged during this study were limited to the downstream bypass system, spillway, upstream fishway or the operating turbine unit (Unit 1). Although there was spill present during a portion of the overall monitoring period (October 23 to November 5), the onset of that period of spill overlapped with the presence of only a single tagged eel in the upstream Project area. That individual passed downstream via the spillway shortly after spill flow became available. During the non-spill conditions which characterized the majority of the eel passage period, most radio-tagged eels passed downstream via Unit 1. There were no observations of adult eels passing downstream via the bypass system. Downstream passage survival for the entire project reach (~650 feet upstream of the dam to the first downstream receiver) was estimated at 90.0% (75% CI =86.0-94.0%). This estimate of downstream passage survival for adult eels at Pejepscot includes any background (i.e., natural) or tagging-related mortality for the species in the reach from the approach receiver to the first downstream receiver. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult eels at the Project.

7 VARIANCES FROM FERC-APPROVED STUDY PLAN

There were no variances from the FERC-approved study plan for this evaluation.

APPENDIX A. TAGGING AND RELEASE INFORMATION FOR JUVENILE ALOSINES AND ADULT EELS.

Juvenile Alosines:

Species	Frequency (149.xxx MHz)	ID	Total Length (mm)	Release Bank	Release Date	Release Time
alosine	340	163	126	west	10/11/2019	18:23:00
alosine	340	164	125	east	10/11/2019	18:21:00
alosine	340	167	127	west	10/11/2019	18:23:00
alosine	340	172	129	east	10/11/2019	18:21:00
alosine	340	184	128	west	10/11/2019	18:23:00
alosine	340	189	125	west	10/11/2019	18:23:00
alosine	340	197	126	east	10/11/2019	18:21:00
alosine	340	198	129	east	10/11/2019	18:21:00
alosine	340	200	128	west	10/11/2019	18:23:00
alosine	340	201	132	east	10/11/2019	18:21:00
alosine	340	203	125	east	10/11/2019	18:21:00
alosine	340	204	128	west	10/11/2019	18:23:00
alosine	420	156	123	east	10/11/2019	18:21:00
alosine	420	157	129	east	10/11/2019	18:21:00
alosine	420	159	123	west	10/11/2019	18:23:00
alosine	420	180	126	west	10/11/2019	18:23:00
alosine	420	182	127	east	10/11/2019	18:21:00
alosine	420	183	128	west	10/11/2019	18:23:00
alosine	420	184	125	east	10/11/2019	18:21:00
alosine	420	185	127	east	10/11/2019	18:21:00
alosine	420	187	125	west	10/11/2019	18:23:00
alosine	420	189	127	east	10/11/2019	18:21:00
alosine	420	196	125	west	10/11/2019	18:23:00
alosine	420	200	128	west	10/11/2019	18:23:00
alosine	420	203	127	west	10/11/2019	18:23:00
alosine	340	160	118	east	10/14/2019	17:42:00
alosine	340	162	127	west	10/14/2019	17:44:00
alosine	340	165	125	east	10/14/2019	17:42:00
alosine	340	168	131	west	10/14/2019	17:44:00
alosine	340	174	124	east	10/14/2019	17:42:00
alosine	340	176	124	east	10/14/2019	17:42:00
alosine	340	187	122	east	10/14/2019	17:42:00
alosine	340	188	130	east	10/14/2019	17:42:00
alosine	340	193	115	west	10/14/2019	17:44:00

Species	Frequency (149.xxx MHz)	ID	Total Length (mm)	Release Bank	Release Date	Release Time
alosine	340	194	126	west	10/14/2019	17:44:00
alosine	340	195	125	east	10/14/2019	17:42:00
alosine	340	196	126	west	10/14/2019	17:44:00
alosine	340	199	121	west	10/14/2019	17:44:00
alosine	420	170	122	west	10/14/2019	17:44:00
alosine	420	171	123	west	10/14/2019	17:44:00
alosine	420	172	132	west	10/14/2019	17:44:00
alosine	420	174	127	east	10/14/2019	17:42:00
alosine	420	177	121	east	10/14/2019	17:42:00
alosine	420	181	132	west	10/14/2019	17:44:00
alosine	420	186	120	east	10/14/2019	17:42:00
alosine	420	188	116	west	10/14/2019	17:44:00
alosine	420	190	122	east	10/14/2019	17:42:00
alosine	420	191	119	east	10/14/2019	17:42:00
alosine	420	195	126	east	10/14/2019	17:42:00
alosine	420	205	117	west	10/14/2019	17:44:00
alosine	340	158	123	east	10/16/2019	17:44:00
alosine	340	161	124	east	10/16/2019	17:44:00
alosine	340	166	126	east	10/16/2019	17:44:00
alosine	340	171	119	west	10/16/2019	17:46:00
alosine	340	173	118	west	10/16/2019	17:46:00
alosine	340	175	124	east	10/16/2019	17:44:00
alosine	340	178	126	east	10/16/2019	17:44:00
alosine	340	185	129	west	10/16/2019	17:46:00
alosine	340	186	120	west	10/16/2019	17:46:00
alosine	340	190	128	east	10/16/2019	17:44:00
alosine	340	191	102	west	10/16/2019	17:46:00
alosine	340	192	126	west	10/16/2019	17:46:00
alosine	420	160	120	east	10/16/2019	17:44:00
alosine	420	161	129	east	10/16/2019	17:44:00
alosine	420	164	112	west	10/16/2019	17:46:00
alosine	420	167	125	west	10/16/2019	17:46:00
alosine	420	168	116	west	10/16/2019	17:46:00
alosine	420	175	119	east	10/16/2019	17:44:00
alosine	420	176	124	east	10/16/2019	17:44:00
alosine	420	178	129	west	10/16/2019	17:46:00
alosine	420	179	123	west	10/16/2019	17:46:00

Species	Frequency (149.xxx MHz)	ID	Total Length (mm)	Release Bank	Release Date	Release Time
alosine	420	192	131	west	10/16/2019	17:46:00
alosine	420	197	122	east	10/16/2019	17:44:00
alosine	420	198	123	west	10/16/2019	17:46:00
alosine	420	202	123	east	10/16/2019	17:44:00
alosine	340	157	119	east	10/22/2019	17:45:00
alosine	340	169	123	east	10/22/2019	17:45:00
alosine	340	170	123	east	10/22/2019	17:45:00
alosine	340	177	125	west	10/22/2019	17:46:00
alosine	340	179	120	west	10/22/2019	17:46:00
alosine	340	180	128	west	10/22/2019	17:46:00
alosine	340	181	125	east	10/22/2019	17:45:00
alosine	340	182	127	east	10/22/2019	17:45:00
alosine	340	183	123	west	10/22/2019	17:46:00
alosine	340	202	119	east	10/22/2019	17:45:00
alosine	340	205	129	west	10/22/2019	17:46:00
alosine	420	158	127	west	10/22/2019	17:46:00
alosine	420	162	127	east	10/22/2019	17:45:00
alosine	420	163	128	east	10/22/2019	17:45:00
alosine	420	165	125	east	10/22/2019	17:45:00
alosine	420	166	130	west	10/22/2019	17:46:00
alosine	420	169	122	west	10/22/2019	17:46:00
alosine	420	173	126	east	10/22/2019	17:45:00
alosine	420	193	124	west	10/22/2019	17:46:00
alosine	420	194	127	east	10/22/2019	17:45:00
alosine	420	199	122	west	10/22/2019	17:46:00
alosine	420	201	126	west	10/22/2019	17:46:00
alosine	420	204	126	east	10/22/2019	17:45:00

Adult American Eels:

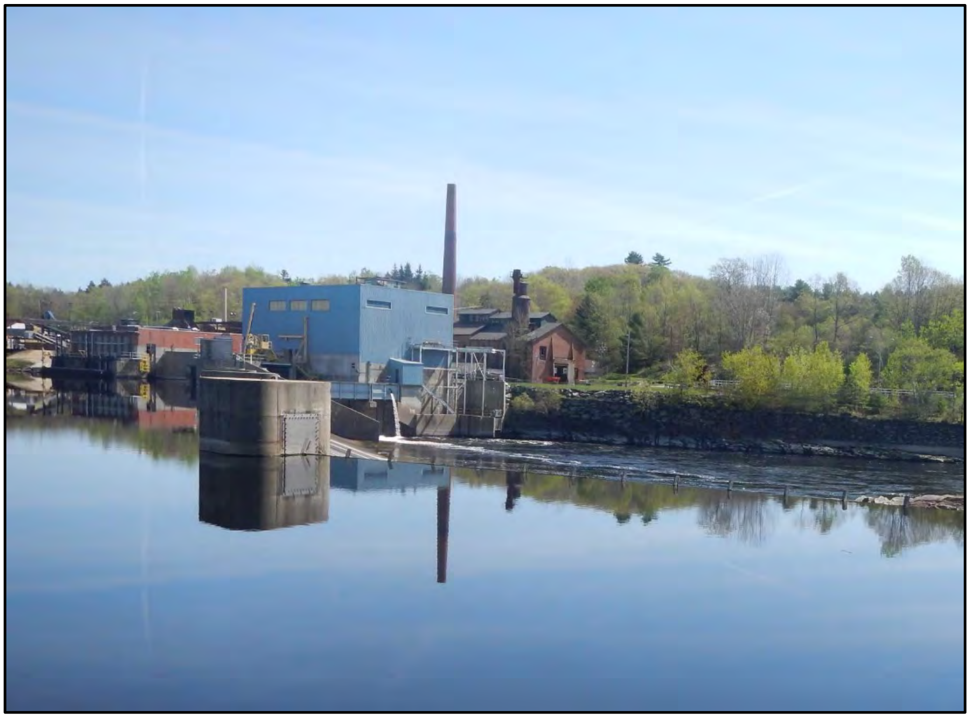
Species	Frequency	ID	Total Length (mm)	Eye Measurements			Release Date	Release Time
				Horizontal	Vertical	Index		
Eel	150.600	62	922	10.2	11.4	9.9	10/3/2019	16:45:00
Eel	150.600	63	838	10.2	10.6	10.1	10/3/2019	16:45:00
Eel	150.600	64	820	10.9	11.1	11.6	10/3/2019	16:45:00
Eel	150.600	65	924	9.9	11.0	9.3	10/3/2019	16:45:00
Eel	150.600	66	938	11.8	12.6	12.4	10/3/2019	16:45:00
Eel	150.600	67	839	10.2	10.5	10.0	10/3/2019	16:45:00
Eel	150.600	68	886	10.1	10.5	9.4	10/3/2019	16:45:00
Eel	150.600	69	847	7.7	9.6	6.9	10/3/2019	16:45:00
Eel	150.600	70	930	10.9	10.7	9.8	10/3/2019	16:45:00
Eel	150.600	71	826	9.3	9.3	8.3	10/3/2019	16:45:00
Eel	150.600	72	805	10.1	9.8	9.6	10/3/2019	16:45:00
Eel	150.600	73	780	9.8	11.2	11.2	10/3/2019	16:45:00
Eel	150.600	74	848	8.7	9.4	7.6	10/3/2019	16:45:00
Eel	150.680	50	744	7.6	8.8	7.1	10/3/2019	16:45:00
Eel	150.680	51	783	9.9	10.2	10.1	10/3/2019	16:45:00
Eel	150.680	52	822	9.6	9.2	8.5	10/3/2019	16:45:00
Eel	150.680	53	740	9.0	9.5	9.1	10/3/2019	16:45:00
Eel	150.680	54	815	9.3	9.7	8.6	10/3/2019	16:45:00
Eel	150.680	55	885	10.9	11.4	10.9	10/3/2019	16:45:00
Eel	150.680	56	981	11.8	13.0	12.3	10/3/2019	16:45:00
Eel	150.680	57	755	8.9	9.3	8.6	10/3/2019	16:45:00
Eel	150.680	58	901	10.2	11.5	10.3	10/3/2019	16:45:00
Eel	150.680	59	849	9.2	10.5	8.9	10/3/2019	16:45:00
Eel	150.680	60	802	9.8	10.1	9.6	10/3/2019	16:45:00
Eel	150.680	61	926	11.1	11.5	10.8	10/3/2019	16:45:00
Eel	150.600	88	890	10.7	10.9	10.3	10/8/2019	18:50:00
Eel	150.600	89	682	9.8	10.8	12.2	10/8/2019	18:50:00
Eel	150.600	91	842	10.7	11.0	11.0	10/8/2019	18:50:00
Eel	150.600	92	793	9.7	10.5	10.1	10/8/2019	18:50:00
Eel	150.600	93	950	12.2	13.0	13.1	10/8/2019	18:50:00
Eel	150.600	94	776	9.4	9.7	9.2	10/8/2019	18:50:00
Eel	150.600	95	831	10.5	10.7	10.7	10/8/2019	18:50:00
Eel	150.600	96	998	10.5	11.4	9.4	10/8/2019	18:50:00
Eel	150.600	97	731	9.3	9.5	9.5	10/8/2019	18:50:00
Eel	150.600	98	658	8.6	8.6	8.8	10/8/2019	18:50:00
Eel	150.600	99	821	9.2	9.1	8.1	10/8/2019	18:50:00
Eel	150.600	100	687	9.2	9.6	10.0	10/8/2019	18:50:00
Eel	150.680	75	854	8.6	8.6	6.8	10/8/2019	18:50:00

Species	Frequency	ID	Total Length (mm)	Eye Measurements			Release Date	Release Time
				Horizontal	Vertical	Index		
Eel	150.680	76	845	10.0	10.3	9.6	10/8/2019	18:50:00
Eel	150.680	77	768	8.2	9.0	7.5	10/8/2019	18:50:00
Eel	150.680	78	874	9.9	11.0	9.7	10/8/2019	18:50:00
Eel	150.680	79	764	8.4	9.5	8.2	10/8/2019	18:50:00
Eel	150.680	80	851	9.0	9.6	8.0	10/8/2019	18:50:00
Eel	150.680	81	890	9.2	10.1	8.2	10/8/2019	18:50:00
Eel	150.680	82	772	8.8	8.8	7.9	10/8/2019	18:50:00
Eel	150.680	83	875	9.5	10.1	8.6	10/8/2019	18:50:00
Eel	150.680	84	750	8.9	9.4	8.7	10/8/2019	18:50:00
Eel	150.680	85	802	9.5	10.0	9.3	10/8/2019	18:50:00
Eel	150.680	86	786	9.0	8.9	8.0	10/8/2019	18:50:00
Eel	150.680	87	917	9.9	10.2	8.7	10/8/2019	18:50:00

DRAFT UPDATED STUDY REPORT

FISH ENTRAINMENT AND TURBINE SURVIVAL ASSESSMENT

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC NO. 4784)



Submitted by:

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April 2020

Brookfield

Table of Contents

List of Tables

List of Figures

List of Abbreviations and Definitions

bs	blade spacing in meters
°C	degrees Celsius
cfs	cubic feet per second
EPRI	Electric Power Research Institute
FERC	Federal Energy Regulatory Commission
fps	feet per second
ft	feet
ILP	Integrated Licensing Process
in	inch or inches
m	meter
mm	millimeters
MW	megawatt
PAD	Pre-Application Document
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
NOI	Notice of Intent
ROR	run of river
rpm	revolutions per minute
RSP	Revised Study Plan
SD1	Scoping Document 1
TBSA	Turbine Blade Strike Analysis
Topsham Hydro	Topsham Hydro Limited Partnership, L.P.

1 INTRODUCTION

Topsham Hydro Partners Limited Partnership (Topsham Hydro or Licensee), an indirect member of Brookfield Renewable (Brookfield), is in the process of relicensing the 13.88-megawatt (MW) Pejepscot Hydroelectric Project (Project) (FERC No. 4784) with the Federal Energy Regulatory Commission (FERC or Commission). The Project is located on the Androscoggin River in the village of Pejepscot and the Town of Topsham, Maine to the east, the Town of Lisbon to the north, and the Towns of Durham and Brunswick, Maine to the west. The Project straddles the border between Cumberland and Sagadahoc counties and extends into Androscoggin County. The original license was issued on September 16, 1982 and expires on August 31, 2022.

The Licensee is using FERC's Integrated Licensing Process (ILP) as established in regulations issued by FERC July 23, 2003 (Final Rule, Order No. 2002) and found at Title 18 Code of Federal Regulations, Part 5. The Licensee filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to seek a new license for the Project on August 31, 2017.

The Licensee distributed the PAD and NOI simultaneously to Federal and state resource agencies, local governments, Native American tribes, members of the public, and others thought to be interested in the relicensing proceeding. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on October 30, 2017. FERC also held agency and public scoping meetings on November 28, 2017 and a site visit on November 29, 2017. The FERC Process Plan and Schedule provided agencies and interested parties an opportunity to file comments on the PAD and SD1 and request studies by December 29, 2017. FERC subsequently issued Scoping Document 2 on February 5, 2018. The Licensee filed a Proposed Study Plan on February 12, 2018 and held a Study Plan Meeting on March 22, 2018. The Revised Study Plan (RSP) was filed in accordance with the ILP schedule on June 12, 2018. FERC issued a Study Plan Determination on July 3, 2018. Within the RSP, FERC approved with no modification the desktop impingement and entrainment study proposed by the Licensee.

2 STUDY GOAL AND OBJECTIVES

The goal of this study was to conduct a qualitative desktop analysis to assess the impingement and entrainment potential and turbine survival of diadromous fish at the Project. Specifically this study sought to:

- Provide a description of the physical characteristics of the Project (including forebay characteristics, intake location and dimensions, calculated approach velocities, and rack spacing);
- Analyze target species for factors that may influence vulnerability to entrainment and mortality;
- Assess the potential for the impingement or entrainment of target species; and
- Evaluate turbine entrainment passage survival using available site-specific estimates, comparable project estimates and calculated values.

3 METHODS

This study addresses the qualitative classification of impingement, entrainment, and the probability of turbine passage survival at the Project using a review of relevant biological criteria and physical Project characteristics for five diadromous fish species of interest. Factors that can influence the potential for impingement or entrainment at a hydropower project include structural characteristics such as the size and depth of the intake structure, the velocity of water as it enters the intake structure, the location of the intake structure relative to fish habitat, and the biological and behavioral characteristics (e.g., size, movement or migration patterns, and habitat preferences) of the specific life stages of fish species of interest. The likelihood of impingement is also highly dependent on the physical features and water velocities found at or near the trash racks along with species-specific physiological capabilities (i.e., swim speed). Turbine survival rates are primarily affected by engineering factors such as the amount of head differential of a turbine, its number of blades, rotational speed, hydraulic capacity, and the length of an entrained fish.

3.1 Project Impoundment, Intake and Turbine Description

The first step in the evaluation of the potential for fish impingement and entrainment was to describe the physical features of the impoundment, intake structure, and turbine units that will affect entrainment, impingement and turbine passage survival. Where possible, Project features and dimensions were obtained from engineering drawings and historical descriptions the Project.

3.2 Life History and Habitat Requirements of Target Fish Species

A description of the life history, habitat requirements, and behavior of fish species was compiled to determine the likelihood of presence near the Project intakes and to evaluate entrainment potential. The "Traits Based Assessment" of Čada and Schweizer (2012) was used to qualitatively assess the potential entrainment risk for fish species, which considers each species' primary location within the Project, preferred habitat, local movements and reproductive strategy. Species-specific behavioral requirements determine if and when a given life stage interacts with intake operation. The potential for each species to be susceptible to entrainment can be determined based on their life history characteristics in relation to the location of the Project's intake structures.

Categories of entrainment potential based on the likelihood that a fish species/life stage will be located near the intake structures are described as:

- None - species/life stage (e.g., adult, spawning, or juvenile) are not known to prefer the habitat near the intake structures
- Minimal - species may only occasionally be found occupying the habitat near the intake structures
- Moderate - species routinely or seasonally found occupying the habitat near the intake structures
- High - species likely to be found occupying the habitat near the intake structures

3.3 Entrainment Potential of Target Fish Species

The distance between bars on a trash rack, i.e., clear spacing, can affect the likelihood of an individual fish being excluded from moving through the trash rack and entering the turbine intakes. Fish species and life stages with a body width greater than the clear spacing are physically excluded from passing through a trash rack and becoming entrained. Proportional estimates of body width to total length (scaling factor) were compiled by Smith (1985) for the identified target species. This scaling factor was then used to determine the minimum length of each species excluded from the intake by the trash racks at each of the Project intakes (Table 3-1). The clear spacing values were divided by the scaling factors to calculate the minimum length for each target species that would be excluded at the Project.

3.4 Electric Power Research Institute Entrainment Database Review

The Electric Power Research Institute (EPRI) (1997) entrainment database provides results from entrainment field studies conducted at 43 hydroelectric facilities east of the Mississippi River using full-flow tailrace netting. The database contains site characteristics of each of these facilities, as well as the total number of individuals of each species collected at each of the sites. The species counts are separated into variable size classes ranging from 2 to 30 inches.

A comparison of the EPRI entrainment database was made to provide a literature based assessment to compare with potential entrainment at the Project. To do so, the EPRI database was filtered for characteristics that match or are similar to those found at the Project which included the following:

1. Trash rack clear spacing between 1.5 and 2.5 inches;
2. Total powerhouse hydraulic capacities between 1,710 and 8,600 cfs;
3. Plant operated in run-of-river mode; and
4. Target or surrogate fish species.

First, the collection totals were summarized by the size classes provided in the database for the target species (or a closely related surrogate). Second, the smaller size classes (less than 2 inches, 2 to 4 inches, 4 to 6 inches, and 6 to 8 inches) were combined into two size classes (less than 4 inches and 4 to 8 inches). Finally, the size class composition of the total number collected was summarized for each target species.

3.5 Impingement Potential of Target Fish Species

The ability for an individual fish to avoid being impinged or entrained at a powerhouse intake often depends on its swimming performance (Castro-Santos and Haro 2005). The swimming performance is directly related to the size of an individual fish; however, the swimming capability also varies among species based on morphological differences. Although there is no standard method that defines how swimming performance is measured, three commonly used definitions or types of swim speed are described in the scientific body of literature for fish (Katopodis and Gervais 2016). The three swim speed types, cruising, prolonged, and burst, are described as the following:

- Cruising or sustained swim speeds can be maintained indefinitely (Bain and Stevenson 1999).
- Prolonged swim speeds can be maintained between 5 and 8 minutes (Bain and Stevenson 1999).
- Burst (also called startle, darting or sprint) swim speeds can be maintained for less than 20 seconds (Beamish 1978).

Burst swim speeds are used to assess if a fish can adequately escape involuntary impingement or entrainment. If a fish has a greater burst swim speed than the turbine intake approach velocity, it is capable of moving away from the intake flow field to avoid interaction. To assess swimming capabilities of the five species of interest, burst swim speeds were compiled from the available scientific literature.

To ascertain whether or not a certain size fish of a particular species is likely to be impinged or entrained, the burst swim speeds were compared to the calculated approach velocity of the intake trash racks at the maximum hydraulic capacity of the Project. The approach velocity at the Project intakes was calculated using the velocity equation Q = V*A where Q = flow rate (cfs), V = velocity (fps) and A = area (square feet); Q is the hydraulic capacity of the Project and A is the surface area of the trash racks. The species and sizes whose burst swim speeds are less than the approach velocity at the Project intake are likely to be impinged at the trash racks if their body widths are greater than the trash rack spacing. If the body width of a fish is less than the trash rack spacing and its burst swim speed is less than the approach velocity, it is likely to be entrained.

3.6 Turbine Survival Evaluation

To estimate survival of fish that entrain and pass through turbines at the Project, theoretical predictions were used to estimate a survival rate using a blade-strike model developed by the Department of Energy (Franke *et al.* 1997) that uses various turbine, fish and operations characteristics of a hydroelectric project to calculate a turbine blade strike and survival probability. This model was further modified by the United States Fish and Wildlife Service which produced the Turbine Blade Strike Analysis (TBSA) model that determines the fraction of a population of fish that are killed by blade strike passing through a hydroelectric project (Towler and Pica 2018). TBSA creates a normally distributed population of fish described by its number, mean length, and standard deviation of length that are routed through hazards at a hydroelectric project, e. g., a turbine. Monte Carlo simulations are performed to determine the percentage of individuals subjected to turbine blade strike. The blade strike probabilities are based on the Project turbine specifications and calculated using methods outlined in Franke *et al.* (1997). The probability of blade strike in the model is based on several factors, including the number of runner blades, fish length, runner blade speed, turbine type, runner diameter, turbine efficiency, and total discharge. These factors are inputs into the model which predicts survival for a fish of any species at a designated length. Table 3-2 lists the turbine specifications used as input into the TBSA model which was used to predict turbine passage survival estimates for the maximum lengths (rounded to whole inch) of each target fish species that could entrain through the different trash rack spacing dimensions utilized at the Project. Lastly, the TBSA model simulations were run using a correlation factor of 0.2 which is the recommended conservative value (Towler and Pica 2018).

Previously conducted evaluations of turbine passage survival of American and European eels have demonstrated that they have higher survival rates than are typically estimated using the standard blade strike theoretical models. As a result, available multiple regression survival models were used to predict turbine passage survival for American eels rather than the TBSA model used for other teleost fishes. The multiple regression equations developed by Alden (2017) were developed from an analysis of turbine survival estimates generated by field studies.

The regression equation for propeller-type turbines was developed based on results from 59 separate field evaluations of eel passage survival and can be expressed as:

$$S = 100.222+(4.221*bs)+(-.0157*rpm)+(-43.364*l)+(0.059*g)$$

Where:

S = predicted eel survival
bs = blade spacing in meters (where blade spacing = (runner diameter*π)/no. blades)
rpm = rotational speed
l = eel body length (in meters)
g = gate opening (0-100)

Field evaluation data for passage of eels through Francis turbines is more limited and as a result the available regression equation incorporates data from five eel passage studies. In their report, Alden notes that the Francis unit regression was conducted with limited data and should not be considered a robust analysis with respect to typical statistical standards. However, it does provide a means to estimate survival of silver eels passing through the Francis units at the Project. The regression equation for el passage survival through Francis units can be expressed as:

$$S = 100.007+(0.737*bs)+(-.055*rpm)$$

Where:

S = predicted eel survival
bs = blade spacing in meters (where blade spacing = (runner diameter*π)/no. blades)

3.7 Electric Power Research Institute (EPRI) Turbine Survival Database Review

Similar to the comparison of the EPRI entrainment database review, the EPRI 1997 turbine survival database was reviewed to provide an equitable literature-based comparison of the turbine survival estimates calculated for the Project. To do so, the EPRI database was filtered for characteristics that match or are similar to those found at Pejepscot. The following are the characteristics selected from the database for comparison to the Project:

- Vertical Kaplan turbines;
- Horizontal Francis turbines;
- Head rating less than 24 feet;
- Hydraulic capacity rating equal to or less than 8,600 cfs; and
- Target or surrogate fish species.

The immediate, 24-hour, and 48-hour, and control survival estimates were selected, if available, as they provided the greatest range of time difference post-turbine passage for each species.

3.8 Qualitative Assessment of Entrainment and Turbine Survival Potential

Data collected during the literature review and site-specific evaluation process (i.e., habitat and life history, swim speeds, and turbine survival model estimates) were used to compile a qualitative assessment of the potential entrainment of target fishes. The qualitative assessment used a multi-step rank of:

- High (H)
- Moderate (M)
- Low (L)

Desktop impingement and entrainment assessments will assign an overall entrainment potential to each member of the suite of target species and life stages considered based on consideration of habitat and life history, swim speed relative to intake velocity, and minimum exclusion lengths relative to trash rack spacing. In general, fish with life history attributes that include obligatory downstream migration are given a rating of ‘High’, while those with juvenile life history stages placing them in the vicinity of the intakes or as adults with swim speeds not necessarily greater than the approach velocity are labeled as ‘Moderate’ risk. Species with life history attributes that generally keep them away from the intakes or fish that had a burst swim speed greater than the intake velocity are listed as a ‘Low’ risk for entrainment. In relation to swim speed, regardless of life stage, fish are considered ‘High’ risk if the maximum burst speed does not exceed the intake velocity, ‘Moderate’ risk if the intake velocity falls within the range of burst swim speed, and ‘Low’ risk if the burst swim speed completely exceeded the intake velocity.

The entrainment potential classification for each trash rack spacing depended on the minimum body length exclusion results. If the minimum exclusion length for each trash rack spacing was longer than the standard length for a juvenile or adult (i.e., many individuals of that species and life stage are likely to be shorter than the minimum exclusion length) it received a “High” entrainment risk potential. A “Moderate” entrainment risk potential was applied when the minimum exclusion length overlapped with a portion of the individuals that would be expected to achieve that length by the life stage indicated. A “Low” entrainment risk potential was applied when the minimum exclusion length of a trash rack was less than the standard length of the life stage being considered. For example, the adult category for Atlantic salmon received a “Low” risk for 1.5 inch trash rack spacing because its minimum exclusion length was shorter than standard lengths for that life stage.

The risk categories for the turbine survival potential were based on the TBSA model estimates. TBSA results were converted to a qualitative ranking system similar to Winchell *et al.* (2000) for standard lengths of the juvenile and adult life stages. “High” survival potential was applied to estimates greater than 85%, “Moderate” for estimates between 70-85%, and “Low” for estimates less than 70%.

Table 3-1: Pejepscot Project Impoundment and Intake Characteristics

Site Characteristic	Pejepscot Project				
Normal Full Pond Elevation (ft)	67.5				
Operating Mode	Run-of-River				
Surface Area at Normal Full Pond (acres)	225				
Total Storage Volume (acre-feet)	3,278				
Impoundment Length (miles)	~ 3				
Total Hydraulic Capacity (cfs)	8,600				
	Unit 1		**Unit 21**	**Unit 22**	**Unit 23**
Top Rack Elevation (ft)	61.35		69.7		
Bottom Rack Elevation (ft)	36		43.3		
Trash Rack Spacing (in)	El. 61.35-55.1 section	1.5	1.5		
	El. 55.1-36.0 section	2.5			
Trash Rack Length (ft)	25.35		26.4	26.4	26.4
Trash Rack Width (ft)	91.6		23.8	23.8	23.8
Trash Rack Surface Area (sq. ft)	1.5-inch section	572.5	576	576	576
	2.5-inch section	1,750			
Maximum Turbine Discharge (cfs)	7,550		350	350	350
Intake velocity (fps)	3.25		0.6	0.6	0.6

Table 3-2: Pejepscot Project Turbine Characteristics

Characteristic	Pejepscot Project			
	Units 1	**Unit 21**	**Unit 22**	**Unit 23**
Turbine Type	Vertical Kaplan	Horizontal Francis		
Number blades	4	--	14	14
Max turbine discharge (cfs)	7,550	350	350	350
Turbine efficiency [1]	0.9	0.85	0.85	0.85
Min turbine discharge (cfs)	1,170	350	350	350
Efficiency at peak discharge [1]	90.0%	90.0%	90.0%	90.0%
Runner diameter (ft)	18	--	3.45	3.45
RPM	81.8	180	180	180
Design head (ft)	24	13.5	13.5	13.5

1 = assumed estimates based on default values in TBSA model for Kaplan/Francis unit.

Blank cell indicates information not available.

4 RESULTS

4.1 Description of Project's Fish Protection Features

4.1.1 Project Reservoir and Features

The Pejepscot Project is located on the Androscoggin River in the town of Topsham, Maine draining 3,420 square miles with an annual average inflow of approximately 7,000 cfs. The project is located approximately 14 miles upstream from the confluence of the Androscoggin and Kennebec Rivers at Merrymeeting Bay and is 4 miles upstream of the first barrier on the river in Brunswick, Maine. The impoundment stretches approximately 3 miles upstream and at a normal pool elevation (El. 67.5) has a surface area of 225 acres, a gross storage capacity of 3,278 acre-ft, and approximately 6.6 miles of shoreline. Available storage is minimal as the Project is operated as a run-of-river facility.

4.1.2 Powerhouse, Intake Structure, and Trash racks

Pejepscot contains two powerhouses including the original powerhouse completed in 1898 and the new powerhouse completed in 1987. The Project has two separate intake structures, the old powerhouse intake and the new powerhouse intake, both of which are integral with the powerhouses.

The original powerhouse is located along the eastern shoreline and contains three horizontal Francis turbines (Units 21, 22, 23) screened by an intake rack spanning a distance of 71.4 ft. and a depth of 26.4 ft. The upper portion of the rack extends 2.2 feet above the normal pond elevation and extends to a depth of 24.2 ft. below normal pond elevation. Overlaying the intake is a continuous trash rack with 1.5 inch clear spacing covering a total area of 1,728 square feet (576 square feet per unit).

The new powerhouse contains a single vertical Kaplan turbine generator unit (Unit 1) and is located immediately downstream of the old powerhouse along the eastern shoreline. The intake for Unit 1 is 91.6 ft. wide and spans a depth of 25.35 ft. The top of the intake is approximately 6 ft below normal pond elevation and extends to a depth of 31.35 ft. below normal pond elevation. The upper portion of the intake extending vertically 6.25 ft. includes a trash rack with 1.5 inch clear spacing and encompasses an area of 572.4 square feet. Below that, the trash rack increases to 2.5 inch clear spacing (encompassing 1,749.6 square feet).

4.1.3 Downstream Bypass Structure

The downstream fish passage facilities consist of two entry weirs, one on either side of the Unit 1 turbine intake. From each weir, an outlet pipe transports the fish in water down to the tailwater. The weir gates are four feet wide and are part of an inlet box with the outlet pipe located on the side opposite the weir. The right-side weir has a 30-inch diameter transport pipe and the left-side weir has a 24-inch diameter transport pipe. Both pipes have a free discharge to the water below the dam. To ensure downstream passage safety for Atlantic salmon smolts and post-spawned adults (i.e., kelts) migrating in the Androscoggin River system, the downstream fishway is currently operated from April 1 to December 31, as river conditions allow.

4.1.4 Turbines

Pejepscot contains four generating units including three horizontal Francis units, with a combined generating capacity of approximately 1.6 MW, and a vertical Kaplan unit with a generating capacity of 12.3 MW. The combined FERC authorized capacity of the four generating units is 13.9 MW.

The original (northerly) powerhouse contains three rehabilitated horizontal Francis units (identified as Nos. 21, 22, and 23) with a combined output capacity of about 1.6 MW. Each of the units has an intake gate for dewatering, which is operated with a rack-and-pinion gear-type hoist. These units rotate at 180 revolutions per minute (rpm) and have a maximum flow through each unit of approximately 350 cfs. The tailrace water passage for the three units can be isolated from the downstream tailwater by means of a bulkhead-type gate, which is operated from the new powerhouse intake deck using a mobile crane.

The newer powerhouse contains a vertical-shaft, low speed, adjustable-blade, propeller type (Kaplan) turbine-generator unit (identified as Unit No. 1) rated at 12.3 MW, with four blades and 18 feet in diameter; it rotates at 82 rpm. The maximum flow through the turbine is 7,550 cfs. The Project discharges into a short tailrace that meets the Androscoggin River approximately 25 feet downstream of the powerhouse.

4.1.5 Project Operations

The Project is operated as a run-of-river facility with the main turbine generator unit (Unit 1) operated on pond level control. Unit 1 controls the turbine wicket gates to maintain a preset pond level at El. 67.2 or approximately 0.3 feet below the top of the spill gates. The three vertical Francis units located in the old powerhouse are primarily used when Unit 1 reaches its maximum capacity of 7,550 cfs which is typically only reached during large storm events and the period encompassing spring runoff. The Francis units are started manually and set to operate at peak efficiency. Tables 4-1 and 4-2 provide a summary of the percentage of time by month that the Francis (Units 21, 22, 23) and Kaplan Unit 1 historically operated during the years 2015-2019.

A minimum flow of 1,710 cfs, or inflow if that is less, is required at Pejepscot Project. The minimum flow is conveyed to the Project tailrace as flow through the powerhouse, as spill over the dam, or as a combination. Under normal operations, Unit 1 is operated up to it capacity of 7,550 cfs after which one or more of the vertical Francis units are manually started with increasing inflow up to the station capacity of 8,600 cfs. When inflow exceeds station capacity, additional water is spilled over the dam until pond levels reach El. 69.0 (approximately 1.5 feet above spill gates) at which point the bascule gates are lowered starting with those located nearest to the powerhouse. The Project has a spillway discharge capacity of 95,000 cfs. Overtopping of the dam does not occur until the headwater reaches El. 81, at which point the spillway discharge is approximately 110,000 cfs.

4.2 Life History and Habitat Requirements of Target Fish Species

Five diadromous fish species were considered during this analysis, (1) American eel, American shad, Atlantic salmon, alewife, and blueback herring. A brief description of the life history characteristics for each target fish species is provided below. A summary of habitat preferences and behaviors that influence the likelihood of entrainment is provided in Table 4-3.

4.2.1 American Eel

The American eel, *Anguilla rostrata*, is a catadromous species common in rivers, streams, lakes, tidal marshes and estuaries throughout the Northern Atlantic. It is native to Atlantic coastal waters from Newfoundland to South America. Males typically reach sizes up to 24 inches (61 cm) in length, while females reach larger sizes of 30 to 40 inches (76 to 102 cm). They are a long lived species and can reach up to 30 years of age. Spending the majority of its life in fresh water, but upon reaching maturity, eels descend to the Atlantic Ocean in the fall. They migrate to the Sargasso Sea and spawn in February to April, dying shortly after. Females are prolific egg producers, with one female producing up to 20 million eggs. After spawning, leptocephalus larvae drift at sea for up to a year, and are gradually transported north by the Gulf Stream. As they approach the North American coast, the larvae metamorphose into unpigmented juveniles known as glass eels. During this metamorphosis, the body becomes cylindrical, the jaw and head are altered and the digestive tract becomes functional (Collette and Klein-MacPhee 2002). Glass eels appear in southern New England in March at 2 to 4 inches in length. They migrate upstream at night into freshwater where they feed, and become pigmented; this is known as the “elver” life stage. They grow slowly until they sexually mature, which can take up to 20 years. However, eels are known to reach maturity as small as 11 inches (28 cm) for males and 18 inches (46 cm) for females. Once sexual maturity occurs in late summer to early fall, the eel begins moving downstream, the eyes and pectoral fins enlarge, and feeding stops (Collette and Klein-MacPhee 2002). Specific spawning migration routes and egg life history information are unknown.

American eels are most abundant in the tidal river portion of the Androscoggin River, downstream of Brunswick dam (Yoder *et al.* 2006). Despite the fact that eels have been captured in the fishway at Brunswick Dam, no eel specific passage facilities exist there, and the current fishway is likely not successful in capturing large numbers of juvenile eels due to their small size. However, eels have been observed passing the Brunswick dam by climbing over the spillway. Eels that have been captured further upstream were found to be relatively larger (Yoder *et al.* 2006). After upstream eel passage measures were installed at Worumbo Fishway in 2012, 17 and 131 eels were captured in 2012 and 2013, respectively, according to annual fish passage reports filed with FERC (Miller Hydro 2013; Miller Hydro 2014).

Period of greatest likelihood to exposure to intakes at Pejepscot:

- September-November: Adult “silver” eels migrate downstream to begin spawning migration to the Sargasso Sea.

4.2.2 American Shad

American shad, *Alosa sapidissima*, are an anadromous, highly migratory, coastal pelagic, schooling species that ranges from northern Labrador to Florida. They are the largest member of the herring family (Clupeidae), and females are larger than males at all ages. Mature male shad range from 12 to 17.5 inches (30.5 - 44.7 cm) and mature females range from 15 to 19 inches (38.3 - 48.5 cm) (Stier and Crance 1985). Males mature at age 4, while females mature at ages 5-7. The maximum age is 11 years. Spending the majority of their life in the sea, mature adults migrate upriver to natal rivers to spawn from May to July. Although shad spawn in freshwater, there is no apparent required distance upstream of brackish water (Stier and Crance 1985). American shad return downstream to marine waters soon after spawning. American shad are known to be prolific spawners, with females producing up to 600,000 eggs. After broadcast-spawning, fertilized eggs sink to the bottom, where they become lodged in rubble and water-harden. Hatching typically occurs after 1-2 weeks, dependent on water temperature. Larvae may remain in freshwater, or drift into brackish water and grow rapidly, transforming into juveniles approximately 4 to 5 weeks after hatching (Stier and Crance 1985). During the first fall of their life, juvenile shad leave fresh water and migrate in schools downstream to the sea. Upon reaching the ocean, they become long-range coastal migrants. While at sea, American shad form large schools and migrate vertically to feed on zooplankton.

Numbers of American shad passed at the Brunswick fishway have ranged from zero to 1,123 fish from 2000 to 2016. The falls at Brunswick are regarded as an impassible barrier for American shad, and the Androscoggin River may not historically be considered a shad river (Taylor 1951).

Period of greatest likelihood to exposure to intakes at Pejepscot:

- June-July: Following spawning at upstream locations, adult American shad migrate downstream to return to marine habitat
- September-October: Following time spent in upstream rearing habitat, juveniles migrate downstream to enter marine habitat.

4.2.3 Atlantic Salmon

The Atlantic salmon, *Salmo salar*, is an anadromous species native to the Gulf of Maine ranging from the Housatonic River to Northern Labrador. The Gulf of Maine Distinct Population Segment was first listed as Endangered in December of 2000, and subsequently re-affirmed as endangered in 2009. The Gulf of Maine, and more specifically the Penobscot River, provides habitat to one of the only remaining viable runs of wild Atlantic salmon. Despite massive management efforts, stocks have continued to decline since the species was federally listed. Atlantic salmon have a relatively complex life history, going through numerous phases identified by physiological and behavioral changes. Adult Atlantic salmon typically return to their natal river starting in April and continuing into October, resulting in both spring and fall runs. Feeding typically ceases during these upriver migrations, and their colors darken. Each spawning run typically includes a number of different age groups to promote genetic exchange between generations. Spawning begins by female Atlantic salmon creating gravel depressions, known as redds, to deposit eggs. Males fertilize the eggs as they are deposited. Upon fertilization, the females will dig further upstream of the redd to bury the eggs. Post-spawn adult salmon (kelts) will return to marine waters during the fall/early winter after spawning or, more typically, over-winter in the river and return during spring (Fay *et al.* 2006) Over winter, the eggs develop into very small salmon known as alevin. In the spring, the alevin swim out of the redd and become fry. Fry grow into parr, which are typically 2 inches (5 cm) long and camouflaged to protect them from predators. For to 2-3 years, the parr grow in freshwater to become smolts in the early spring. Their internal physiology adjusts to allow them to swim to the ocean where they spend 1 to 2 years maturing into adults. Most smolts in Gulf of Maine rivers enter the sea during May and June to begin their feeding migration (Collette and Klein-MacPhee 2002). The adult salmon, or kelts, return to their natal river to spawn. Females returning to spawn after two winters lay an average of 7,500 eggs, of which 15-35% will survive to the fry stage. Those that return to freshwater after only one year at sea are known as "grilse" and are considered 1-sea-winter fish. The average size is about 22 inches (56 cm) for individuals that have spent 1 year at sea, 30 inches (76 cm) for those 2 years at sea, and 35 inches (89 cm) for those 3 years at sea (Baum 1997).

In recent years, there has been a very low number of Atlantic salmon returning to the Androscoggin River; Atlantic salmon are considered extirpated in waters to the south of the Androscoggin River watershed (NMFS 2012). Given the extremely low return rate, coupled with the prevalence of hatchery origin fish, wild populations of Atlantic salmon in the Androscoggin River are no longer present. Stocking of Atlantic salmon in the Androscoggin River has been limited compared to other large river systems in the Gulf of Maine, with approximately 18,000 fry stocked since 2001 (USASAC 2015).

Period of greatest likelihood to exposure to intakes at Pejepscot:

- Late-April - early-June: juvenile smolt stage outmigrates from upstream rearing habitat to marine environment
- Late-October - December; April-May: post-spawn adult kelt lifestage outmigrates past project to marine environment.

4.2.4 River Herring (Alewife and Blueback Herring)

Blueback herring, *Alosa aestivalis*, and alewife, *Alosa pseudoharengus*, are clupeid species very similar in appearance and behavior. Since it is difficult to distinguish between the two species, they are frequently considered together under the collective term "river herring". They are anadromous, euryhaline, coastal, and pelagic fish (Bigelow and Schroeder 1953, Cooper 1961, Collette and Klein-MacPhee 2002). Alewife range from the St. Lawrence River, Canada to North Carolina (Neves 1981), and mature between ages 3-6, and are typically 10 to 11 inches (250-280 cm) in length (Bigelow and Schroeder 1953). They form large schools during their spring spawning migrations from the ocean to coastal rivers. Spawning migrations occur in a south-to-north progression as water temperatures warm in the spring, typically taking place in late April to mid-May in Maine (Bigelow and Schroeder 1953). Blueback herring have a greater geographical range than alewife, ranging from Cape Breton, Nova Scotia to Florida. They also spawn in early June in Maine, roughly four weeks later in the season than alewife. Similar to alewife, blueback herring mature between the ages of 3-6 years. Adults require little or no current for spawning, utilizing ponds, lakes, or slow-flowing riverine areas at water temperatures of 13° to 20°C (55° to 68° F) (Otto *et al.* 1976, Wyllie *et al.* 1976, Kellogg 1982). There appears to be little preference for sediment type as spawning has been observed over hard sand, gravel, stone, detritus-covered bottoms and among sticks and vegetation (O'Dell 1934, Havey 1961). Eggs are about 1 mm in diameter, adhesive, and require 3 to 6 days to hatch over a temperature range of 16° to 22° C (61 to 72 °F). Larvae hatch at 0.1 to 0.2 inches (3 to 5 mm) in total length and become juveniles at approximately 0.8 inches (20 mm; Cianci 1969, Jones *et al.* 1978).

River herring have declined in recent years. The Atlantic States Marine Fisheries Commission reports that river herring stocks are depleted to near historic lows along the Atlantic coast

(ASMFC 2012). Despite this, river herring are the most abundant anadromous fish captured at the Brunswick fishway. Following collection at that facility, they are transported to locations within the Androscoggin River watershed. In recent years, the number captured at Brunswick has exceeded the MDMR stocking rate targets of 27,358 river herring into 4,562 acres of habitat.

Period of greatest likelihood to exposure to intakes at Pejepscot:

- May-June: Following spawning at upstream locations, adult river herring migrate downstream to return to marine habitat
- September-October: Following time spent in upstream rearing habitat, juveniles migrate downstream to enter marine habitat.

4.3 Entrainment Potential of Target Fish Species

Minimum exclusion lengths for juvenile and adult migrant life stages for both trash rack sizes at Pejepscot are presented in (Table 4-4). Proportional estimates of body width to total length (scaling factor) were used to determine the minimum length of each target species that would be excluded from entraining through the two sizes of trash rack present at Pejepscot (minimum exclusion size = rack clear spacing/scaling ratio). Some of the calculated estimates yielded lengths for a species that are unlikely to be present in the Project (i.e., a length outside of the range expected for the species in the Androscoggin River). For example, the minimum size of blueback herring predicted to be excluded from a 2.5 inch trash rack is 29 inches, a length not attained by this species. In cases where the maximum size of the species did not exceed the minimum exclusion size, a designation of 'none' was applied.

At Pejepscot, all lengths attributed to migrant juvenile life stages were susceptible to entrainment based on the current trash rack clear spacing of 1.5 and 2.5 inches. Adult out-migrant life stage susceptibility varied by species and clear spacing. When evaluating the trash rack sections with 1.5 inch spacing, all but the largest river herring and American eel are susceptible to entrainment while only the smaller sized American shad and no adult Atlantic salmon are likely to be entrained. When considering the 2.5 inch clear spacing racks, all sizes of American eel and river herring are likely to be entrained. Only the larger sized American shad and Atlantic salmon (> 19 and 24 inches respectively) would be excluded.

4.4 Electric Power Research Institute (EPRI) Entrainment Database Review

Seven hydroelectric projects in the EPRI 1997 database met the selection criteria for similarity to the Pejepscot Project (Table 4-5). Of the target species considered in the desktop assessment at Pejepscot, only one (American eel) was collected at any of the seven comparable hydroelectric facilities in the EPRI data set. Four target species: alewife, American shad, Atlantic salmon, blueback herring were not identified in entrainment collections from any of the comparable sites within the EPRI database. In lieu of the target diadromous species, brown trout (*Salmo trutta*) and gizzard shad (*Dorosoma cepedianum*) were examined as surrogates for Atlantic salmon and the diadromous alosines.

The results of entrainment potential for the available target and surrogate species from the EPRI dataset are presented in Figure 4-1. Approximately 50% of brown trout entrained were less than eight inches. EPRI data for American eel and gizzard shad indicates that only larger fish (greater than 10 inches) are entrained. These results are biased due to a limited sample size (both in the number of comparable Projects and the limited number of target/surrogate species available from them) and are not likely reflect the actual length composition exposed to entrainment that could be expected at Pejepscot.

In an attempt to compensate for the lack of representative species length classes, the data from these seven representative facilities was compiled for all entrained species based on length class to gain a better perspective on how size classes would be represented in entrainment. The results are presented in Figure 4-2. Based on this analysis, the majority of entrained fish ranged from 6-20 inches with smaller percentages represented by the smallest size classes (2.1-4.0 inches) and larger fish (20.1-30 inches). Winchell *et al.* (2000) indicated that the majority of fish entrained at the 43 EPRI sites considered were less than 4 inches in length (71.3%) although the trash rack spacing did not appear to impact the size distribution of fish entrained.

4.5 Impingement Potential of Target Fish Species

A literature review of burst swimming speeds available for the target species selected are presented in Table 4-6. Burst swim speeds vary greatly among species and between sizes of the same species. Among the adult target species considered during this analysis, adult American shad have the highest reported burst swim speeds followed by the other adult members of the Clupeidae family. The lowest adult swim speeds were observed for American eel and Atlantic salmon. Juvenile Atlantic salmon smolts have the highest reported burst speed among juvenile fish considered in this analysis while the lowest were distributed among the clupeids species. Generally, larger individuals of the same species have greater burst swim speeds. The exception for this is the lower recorded burst speed for out-migrating Atlantic salmon kelts which is likely due to the depleted energy reserves resulting from a prolonged spawning run (Booth *et al.* 1996).

Figure 4-3 provides a visual representation of the reported burst speeds for the target species and life stages relative to the calculated intake velocities at the Project turbine units. The species and sizes of target fish likely to become impinged are those whose burst swim speeds are less than the approach velocity at the Project intake. The calculated intake velocity for the horizontal Francis units (21, 22, and 23) is 0.6 fps. At this velocity, the minimum burst speeds presented in Table 4-6 indicate that all of the target species and life stages would be capable of avoiding impingement at the trash racks. Unit 1 has a calculated intake velocity of 3.25 fps at the trash racks. Although the burst speed for juveniles of the three alosine species are less than the Unit 1 intake velocity, the potential for impingement of those life stages is low due to the rack spacing at the Project. Juvenile alosines exposed to the approach velocities at Unit 1 are more likely to be entrained than impinged as they will fit through the existing rack spacing at the Project. Salmon smolts and the adult life stage for all species examined have minimum burst swim speeds that exceed 3.25 fps, indicating the ability to avoid impingement at the Unit 1 intake.

4.6 Turbine Survival Evaluation

4.6.1 Kaplan Unit (Unit 1)

Table 4-7 provides a summary of the TBSA turbine survival estimates for fish entrained at Unit 1. The values in Table 4-7 are estimates for the salmonid and alosine target species. American eel estimates were evaluated separately. For the two trash rack spacing values (1.5 and 2.5 inch), survival values were estimated for the range of body lengths anticipated to be prone to entrainment based upon the minimum exclusion sizes presented in Table 4-4. As would be expected, estimates of turbine passage were inversely related to body length with highest survival estimated for fish at 2 inches of length (99.3%) and the lowest for fish at 24 inches of length (91.3%). As described in Table 4-4, there was no minimum exclusion sizes for the juvenile life stage of all target species (i.e., they are all small enough to fit through existing rack spacing). Survival estimates in Table 4-7 for fish between two and eight inches (96.8-99.3%) are presumed to provide an adequate representation of passage of juvenile target species through Pejepscot Unit 1.

Survival estimates generated using the Alden multiple regression equations for American Eel within the size ranges assumed representative for the Project area (Table 4-4) and representative of the range of test eels released at Pejepscot during fall 2019[1] are presented in Table 4-8. Estimates of survival ranged from 91.6% to 65.2% depending on body length. Similar to the blade strike analysis for other target species, survival decreased with increasing fish size. Based on the calculated minimum exclusion lengths, the largest fish from Table 4-4 (i.e., greater than 40.5 inches [1,029 mm]) should be excluded from entrainment at the 1.5 inch clear space trash racks). Despite this, the benthic nature of eels and the 2.5 inch clear space racks nearer to the bottom increases the likelihood of entrainment. All of the out-of-basin test eels obtained for the fall 2019 telemetry evaluation were of a body length that is susceptible to entrainment at either of the Pejepscot trash rack sizes (based on the minimum calculated exclusion lengths in Table 4-4).

4.6.2 Francis Units (Unit 21, 22, and 23)

Table 4-9 provides a summary of the TBSA turbine survival estimates for fish entrained at the Francis Units. Physical unit parameters for Units 22 and 23 were the same and for this analysis have been assumed to be representative of Unit 21 (Table 3-2). Similar to the analysis for Kaplan Unit 1, the values in Table 4-9 are estimates for the salmonid and alosine target species. American eel estimates were evaluated separately.

Trash rack spacing at Francis Units 21-23 is 1.5 inches and as a result is capable of entraining target fish species up to 14 inches in length. Similar to the trend observed for Kaplan Unit 1, estimates of Francis turbine passage were inversely related to body length with highest survival estimated for fish at 2 inches of length (81.8%) and the lowest for fish at 14 inches of length (0.4%). As described in Table 4-4, there was no minimum exclusion sizes for the juvenile life stage of all target species (i.e., they are all small enough to fit through existing rack spacing). Survival estimates in Table 4-9 for fish between two and eight inches (81.8-36.6%) are presumed to provide an adequate representation of passage of juvenile target species through Pejepscot Francis Units.

As noted in Section 3.6, the multiple regression equation developed by Alden for Francis units is based on limited field evaluation and is not to be considered a robust analysis of passage survival

[1] Initial Study Report for Fall Diadromous Fish Passage Effectiveness

of the species. Regardless, the Francis multiple regression model was fitted with parameter estimates specific to Pejepscot resulting in an estimated rate of turbine passage survival of 90.2%.

4.7 Electric Power Research Institute (EPRI) Turbine Survival Database Review

Upon initial review of the EPRI survival database, only a single hydroelectric facility (Craggy Dam, NC) had comparable characteristics for a direct comparison with Pejepscot as originally outlined in Section 3.7. As a result, the selection criteria for head rating was increased from 24 ft to 55 ft. When that was done, a total of five hydroelectric facilities were found that met the criteria (Table 4-7). However, none of the target species selected for this evaluation were identified in survival tests summarized by EPRI for the sites with comparable physical features and operating conditions as found at Pejepscot.

In general, survival through turbines is typically related to fish size with smaller the fish entrained typically having higher survival rates than larger fish. Winchell *et al.* (2000) provides a review of the EPRI (1997) database and a generalized summary of survival based on turbine characteristics and fish size (Table 4-11). Winchell *et al.* (2000) reports highest survival for small fish with decreasing rates with progressively larger sizes. Despite maximum survival rates of 100% for all fish sizes, the mean survival rates were consistently higher for the low speed axial flow units when compared with the radial flow units.

4.8 Qualitative Assessment of Entrainment and Turbine Survival Potential

Evaluating entrainment potential of the five target diadromous fish species at the Project requires combining and synthesizing the species-specific behavioral traits, life stages, and swimming capabilities and comparing them to the Project’s unique intake, water conveyance and infrastructure characteristics. The blending of these factors yields a qualitative assessment of whether or not an individual of the target fish species will potentially entrain through the Project’s intakes or not. If a fish becomes entrained, a secondary evaluation of the potential of that individual surviving passage through the Project’s turbines depends primarily on its length and the physical dimensions and operating conditions of the turbines at the time of passage. A final qualitative assessment of the potential for surviving downstream passage at the Project takes into consideration and summarizes all of the factors that influence entrainment and turbine passage. The results of this qualitative assessment are presented in Table 4-12.

As shown in Table 4-12, all species and life stages considered in this analysis receive a qualitative rating of “high” when only their life history strategies are considered due to their obligatory downstream passage needs to access the marine environment. All juveniles have the potential to become entrained through the 1.5 inch spaced racks because their body dimensions allow them to fit through these openings. In addition to juveniles, adult river herring and American eel are of a minimum body width incapable of avoiding entrainment through the 1.5 inch spaced trash racks. However, adults of that size for both species are in possession of burst speeds in excess of the calculated intake velocities at the Project. Conversely, the minimum exclusion size for adult American shad and Atlantic salmon indicates that the adult life stage would not be entrained in the 1.5 inch racks due to both a physical inability to fit through the rack spacing and burst speeds in excess of intake velocities. Nearly all life stages for target species would be susceptible to entrainment at the section of 2.5 inch trash racks shielding the lower portion of the Unit 1 intake. The exception to that includes larger adult American shad (>19 inches) and Atlantic salmon (>24 inches). In general, outmigrating salmon and alosines are generally surface oriented as evidenced by their affinity for passing downstream of hydroelectric projects via overflow spillways or bypasses. That behavior may help to reduce the overall entrainment through the 2.5 inch rack section at Pejepscot. Adult American eels are bottom oriented. Based on their behavior during outmigration and their ability to fit through the existing rack spacing, it is likely that a high proportion of outmigrating eels at the Project will pass through the wider rack spacing covering the bottom portion of the Unit 1 intake.

If the event that an individual is entrained and passes downstream of the Project through Kaplan Unit 1, it has a high probability of survival. Although survival probabilities are higher for smaller sized individuals, estimates of survival for larger sized adult fish (as estimated using the TBSA) were rated as “high” for adult herring and “moderate” for adult shad and salmon. Results from the multiple regression analysis provided survival estimates classified over a range from “low” to “high”. Estimates of survival for eels near or greater than 1,000 mm (~39.5 inches) scored as low for passage at Pejepscot Unit 1. The Project prioritizes the operation of Unit 1 over the smaller, older Francis Units. Units 21, 22 and 23 are primarily used when Unit 1 reaches its maximum capacity of 7,550 cfs which is typically only reached during large storm events and the period encompassing spring runoff. Operation of the Francis Units has averaged 36%, 21%, 43%, and 44% during the peak outmigration months of May, June, September, and October for the period 2015-2019 (Table 4-1). In the event a target species was to be entrained at the Francis Units (i.e., did not move self from intake flow, fit through rack spacing, and unit was operating), survival probabilities were rated as “moderate to low” for juveniles and “low” for adults.

Table 4-1: Monthly Percentage of Time Pejepscot Francis Units 21, 22, or 23 Operated for Years 2015-2019

Month	Operation Year				
	2015	2016	2017	2018	2019
January	49%	21%	0%	35%	98%
February	0%	39%	10%	0%	100%
March	0%	85%	7%	30%	100%
April	66%	72%	51%	87%	76%
May	27%	10%	100%	43%	0%
June	52%	6%	14%	35%	0%
July	14%	0%	0%	100%	0%
August	0%	7%	0%	100%	0%
September	40%	39%	19%	99%	19%
October	15%	40%	52%	99%	14%
November	18%	0%	49%	99%	18%
December	30%	11%	0%	98%	0%

Table 4-2: Monthly Percentage of Time Pejepscot Kaplan Unit 1 Operated for Years 2015-2019

Month	Operation Year				
	2015	2016	2017	2018	2019
January	59%	99%	100%	100%	0%
February	100%	100%	100%	96%	0%
March	100%	99%	93%	100%	0%
April	99%	100%	99%	100%	0%
May	94%	100%	100%	100%	66%
June	100%	94%	100%	64%	98%
July	100%	100%	100%	0%	99%
August	100%	93%	100%	0%	87%
September	62%	61%	81%	0%	79%
October	100%	60%	58%	0%	97%
November	100%	100%	92%	0%	100%
December	100%	99%	100%	0%	100%

Table 4-3: General Habitat Use and Behavior of Target Fish Species

Common Name	Life Stage	Freshwater Habitat Requirement	Behavioral Movements	Likelihood of Proximity To Intakes
American Eel	Adult Spawning (Silver)	Spawning occurs in marine environment	Migrate from freshwater to saltwater. Spawn in Sargasso Sea during fall/winter	High
	Immature (Yellow)	Deep, slow-moving water with vegetation/structure and soft, silty sediments or at bottom of water column in deep, open water	Continued upstream movement and residency in freshwater until maturity	Minimal
	Immature (Elver)	Slow-moving water with vegetation/structure and soft, silty sediments	Catadromous: migrate upriver from estuary in spring/summer	Minimal
American Shad	Adult Spawning	Broad flats with relatively shallow water and moderate current	Anadromous; migrate from saltwater to freshwater in spring to spawn, returning to saltwater after spawning	High
	Adult	Remain in shallow, coastal waters	Anadromous; remain in saltwater when not migrating to spawn	None
	Juvenile	Strongly influenced by temperature- between 10-31°C	Anadromous; migrate downstream to saltwater during fall	High
Atlantic Salmon	Adult Spawning	Riverine reaches between spawning grounds and ocean; soft or hard sediments with structural cover, spawn in tributaries; cold, shallow water with riffles over gravel or cobble substrates	Anadromous: to freshwater in spring/some return to saltwater	High
			Post-spawn	
	Adult	Marine residency	Within marine environment	None
	Juvenile	Riverine stretches between spawning grounds and ocean	Anadromous: downstream migration of smolts to the ocean	High
River Herring (Alewife)	Adult Spawning	Quiet waters in coves, sluggish stretches of streams above head of the tide; when further migration is barred by dams, they spawn in shore-bank eddies or deep pools	Anadromous; movements occur in daylight with high water flow and higher temperatures. Migrate downstream to ocean after spawning.	High
	Adult	Remain in coastal waters	Anadromous; remain in saltwater when not migrating to spawn	None

Common Name	Life Stage	Freshwater Habitat Requirement	Behavioral Movements	Likelihood of Proximity To Intakes
	Juvenile	Slow moving riverine stretches	Migrate to downstream to ocean first fall of their life	High
River Herring (Blueback Herring)	Adult Spawning	Firm substrate with swift flow	Anadromous; return to freshwater to spawn in late spring	High
	Adult	Remain in coastal waters	Remain in saltwater when not migrating to spawn; vertical migrators at sea	None
	Juvenile	Slow moving riverine stretches	Anadromous; return to saltwater in first fall of their life	High

Table 4-4: Minimum Length for Target Fish to be excluded from Entrainment Based on Existing Trash Rack Spacing at Project

Common Name	Scaling Factor for Body Width	Typical Length (inches) for diadromous juvenile and adults likely encountered at Pejepscot		Minimum Length Excluded (inches)	
				1.5 in Rack Space	2.5 in Rack Space
American Eel	0.037	Adult	18-42[1]	40.5	none
American Shad	0.134	Juvenile	2-6	none	
		Adult	20-24[2]	11	19
Atlantic Salmon	0.104	Juvenile	5-7 [3]	none	
		Adult	25-30[3]	14	24
River Herring (Alewife)	0.105	Juvenile	2-6 [4]	none	
		Adult	11-12 [4]	14	none
River Herring (Blueback Herring)	0.087	Juvenile	2-6 [4]	none	
		Adult	11-12 [4]	none	none

1 Maine Department of Inland Fisheries and Wildlife. (2020). Species Information: American Eel. Site accessed 2/12/20. https://www.maine.gov/ifw/fish-wildlife/fisheries/species-information/american-eel.html

2 United States Fish and Wildlife Service (2020) Freshwater Fish of America: American Shad. Site accessed 2/12/20. https://www.fws.gov/fisheries/freshwater-fish-of-america/american_shad.html

3 Fay, C., M. Bartron, S. Craig, A. Hecht, J. Pruden, R. Saunders, T. Sheehan, and J. Trial. 2006. Status Review for Anadromous Atlantic Salmon (*Salmo salar*) in the United States. Report to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. 294 pages.1 Maine Department of Marine Resources (2020). Maine River Herring Fact Sheet. Site accessed 2/7/20. https://www.maine.gov/dmr/science-research/searun/alewife.html

Table 4-5: Hydroelectric Facility Characteristics from the EPRI Entrainment Database Comparable to Pejepscot

Facility Name	Total Capacity (cfs)	Operating Mode[1]	Trash Rack Clear Spacing (in)
Crowley	2400	ROR	2.375
Four Mile Dam	1500	ROR	2.00
Grand Rapids	3870	ROR	1.75
Norway Point Dam	1775	ROR	1.69
Potato Rapids	1380	ROR	1.75
Schaghticoke	1640	ROR	2.125
Wisconsin River Division	5150	ROR	2.19
Pejepscot	8550	ROR	1.5-2.5

1 ROR = run-of-river

Table 4-6: Burst Swim Speed Information Compiled from Scientific Literature for Target Fish Species

Common Name	Life Stage	Typical size likely encountered in Maine (in)	Study Test Size Range and Burst Speeds				Citation
			Minimum Size (in)	Minimum Burst Swim Speed (fps)	Maximum Size (in)	Maximum Burst Speed	
Alewife	Juvenile	2-6 [3]	2.5	3	3	3	Bell 1991
	Adult	11-12 [3]	6	7	11	11.5	Bell 1991, Haro *et al.* 2004[1]
American Shad	Juvenile	2-6 [3]	1	2.5	3	2.5	Bell 1991
	Adult	20-24 [4]	12	14	14	14	Bell 1991, Weaver 1965 (in Beamish 1978)
Blueback Herring	Juvenile	2-6 [3]	3.3	1.2	3.5	2.6	Terpin *et al.* 1997 in Dixon 2000
	Adult	11-12 [3]	8	11.5	10	11.5	Haro *et al.* 2004[1]
American Eel	Adult	18-42 [7]	12.5	4.3	27.6	4.4	Solomon and Beech (2004), Quintella *et al.* (2010)[2]
Atlantic Salmon	Juvenile	5-7 [5]	6	5.6	10	5.6	Booth *et al.* (1996)
	Adult	25-30 [5]	19	4.6	24	4.6	Booth *et al.* (1996)

1 Tests in Haro *et al.* (2004) included fish ascending a known distance against water velocity after optionally entering study. Not a true 'burst speed' but is an indication of ability to escape velocity in front of intakes.

2 Based on Ucrit or sustained swim speed measurement, converted to burst speed by using formula in Bell (1991): VS (sustained swimming velocity)=0.5 VM (maximum swimming velocity).

3 Maine Department of Marine Resources (2020). Maine River Herring Fact Sheet. Site accessed 2/7/20. https://www.maine.gov/dmr/science-research/searun/alewife.html

4 United States Fish and Wildlife Service (2020). Freshwater Fish of America: American Shad. Site accessed 2/12/20. https://www.fws.gov/fisheries/freshwater-fish-of-america/american_shad.html

5 Fay *et al.* (2006)

6 United States Fish and Wildlife Service (2020). American eel (Anguilla rostrata). Site accessed 2/12/20. https://www.fws.gov/northeast/americaneel/pdf/American_Eel_factsheet_2015.pdf

7 Maine Department of Inland Fisheries and Wildlife. (2020). Species Information: American Eel. Site accessed 2/12/20. https://www.maine.gov/ifw/fish-wildlife/fisheries/species-information/american-eel.html

Table 4-7: TBSA Predicted Survival Estimates for Passage through Pejepscot Unit 1 for Body Lengths with a Probability of Entrainment Based on Rack Spacing and Minimum Exclusion Length

Values calculated for Unit 1 at maximum capacity (7,550 cfs), 90% efficiency, and a correlation factor = 0.2

Project Rack Spacing/Body Length/Predicted Survival							
1.5 inch							
2.5 inch							
2 in	4 in	6 in	8 in	12 in	14 in	19 in	24 in
99.3	98.5	97.6	96.8	95.6	95.5	92.9	91.3

Table 4-8: Alden Multiple Regression Predicted Survival Estimates for Passage through Pejepscot Unit 1 for American Eel

Eel length range from Table 4-4 (mm)			Eel lengths from 2019 telemetry project (mm)			
Minimum	Median	Maximum	Minimum	Maximum	Median	Mean
457	762	1,067	658	998	835	832
Survival Estimates (Percent)						
91.6	78.4	65.2	82.9	68.2	75.2	75.4

Table 4-9: TBSA Predicted Survival Estimates for Passage through Pejepscot Unit 21-23 for Body Lengths with a Probability of Entrainment Based on Rack Spacing and Minimum Exclusion Length

Values calculated for Units 21-23 at maximum capacity (350 cfs), 90% efficiency, and a correlation factor = 0.2

Project Rack Spacing/Body Length/Predicted Survival					
1.5 inch					
2 in	4 in	6 in	8 in	12 in	14 in
81.8	65.8	47.3	36.6	2.2	0.4

Table 4-10: Hydroelectric Facility Characteristics from the EPRI Turbine Survival Database Comparable to Pejepscot

Facility Name	Turbine Type	Rated Head (ft)	Rated Flow (cfs)	Speed (rpm)	Diameter Runner (ft)	Runner Blades
Buzzards Roost	Kaplan (vertical)	55	1,310	240	-	-
Chalk Hill	Kaplan (vertical)	28	1,331	150	8.5	-
Craggy Dam	Bulb (s-type)	19.7	636	229	15	4
Grand Rapids	Francis (horizontal)	28	645	-	-	-
Grand Rapids	Francis (horizontal)	28	926	-	-	-
Higley	Francis (horizontal)	45	695	257	4	13

Table 4-11: Fish Survival Rates for Generating Units Comparable to Project based on EPRI (1997) Database and Summarized by Winchell (2000)

Turbine Type	Runner Speed (rpm)	Hydraulic Capacity	Fish Size (mm)	Average immediate survival (all species combined)		
				Minimum	Maximum	Mean
Pejepscot Unit 1 (Vertical Kaplan)	81.2	7,550	-	-	-	-
Axial-Flow (includes Kaplan units)	<300	636-1,203	<100	94%	98%	95%
		636-21,000	100-199	90%	98%	95%
		636-2,200	200-299	77%	97%	87%
		1,203-2,200	300+	87%	100%	93%
Pejepscot Units 21,22,23 (Horizontal Francis)	180	216	-	-	-	-
Radial-Flow (Francis)	<250	440-1,600	<100	86%	100%	94%
		370-1,600	100-199	75%	100%	92%
		370-2,450	200-299	59%	100%	87%
		440-1,600	300+	36%	100%	73%

Table 4-12: Qualitative Project Passage Survival Potential for Target Fish Species Relative to Factors Influencing Entrainment and Turbine Survival at the Project

Species and Life Stage	Entrainment Potential					Survival	
	Behavior, Habitat and Life History	Trash rack Clear Spacing		Swim Speed compared to Unit 21,22,23 Approach Velocity	Swim Speed compared to Unit 1 Approach Velocity		
		1.5 inch	2.5 inch	(0.6 fps)	(3.25 fps)	Francis	Kaplan
American Eel							
Adult (silver)	H	H	H	L	L	H	L
American Shad							
Juvenile	H	H	H	L	H	M-L	H
Adult	H	L	M	L	L	L	M
Atlantic Salmon							
Juvenile	H	H	H	L	L	M-L	H
Adult	H	L	M	L	L	L	M
River Herring							
Juvenile	H	H	H	L	H	M-L	H
Adult	H	H	H	L	L	L	H

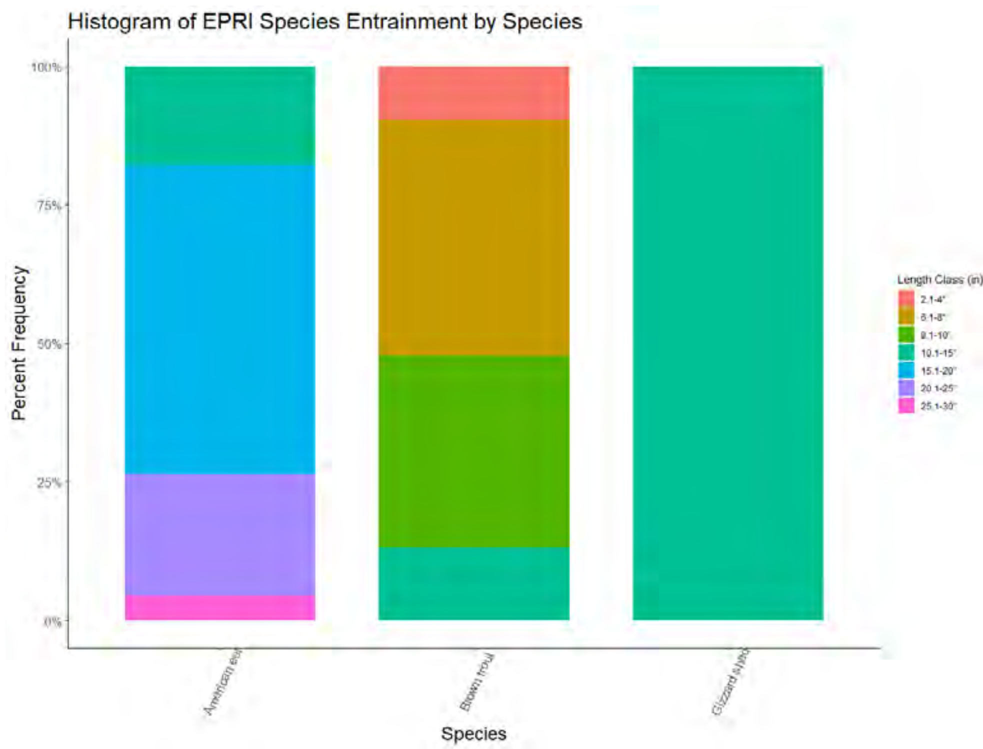

Figure 4-1: Length Class Composition of Target Fish Species from the Subset of Comparable Hydroelectric Projects within the EPRI Entrainment Database

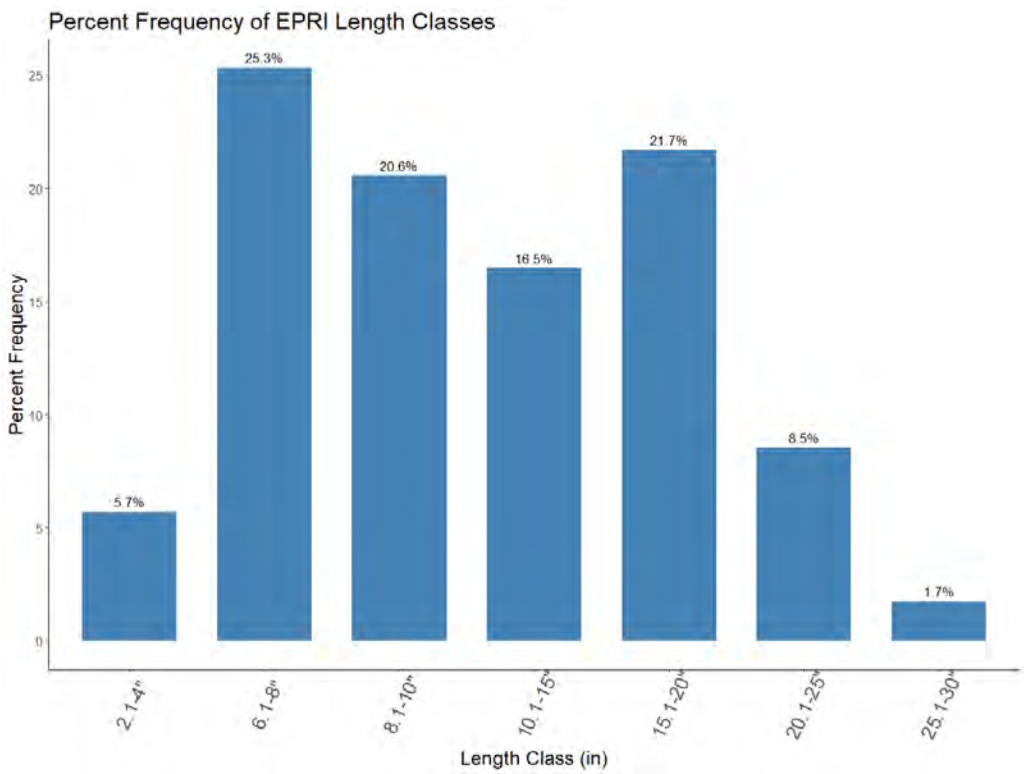

Figure 4-2: Length Class Composition of all Fish Species from the Subset of Comparable Hydroelectric Projects within the EPRI Entrainment Database

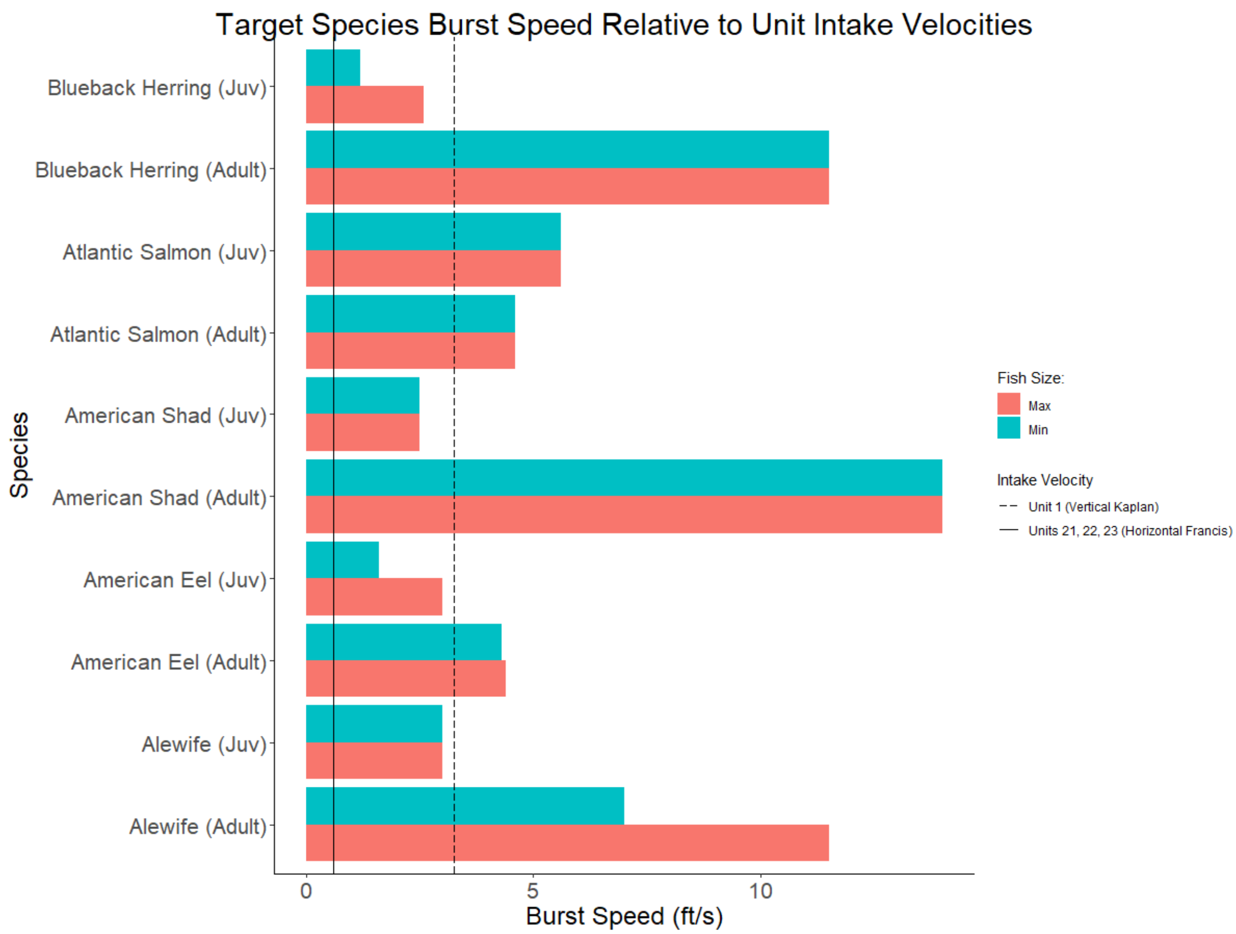

Figure 4-3: Burst Swim Speed of Target Fish Species Compared to Approach Velocities Calculated for Project Intakes

5 SUMMARY

Interactions with Pejepscot for each of the target species and life stages considered during this assessment are unavoidable based on their obligatory seasonal movements. For each of the target species (excluding American Eel) both the adults and juvenile life stages are required to pass downstream of the Project. For this assessment, American Eel was only considered as an entrainment/impingement risk during the adult life stage when they are actively out-migrating. Project interactions for alosines and Atlantic salmon occur most frequently during the spring/early summer and fall/early winter when following upstream movement to freshwater spawning areas adults return to the marine environment post-spawn and juveniles are migrating to marine waters.

When the calculated minimum exclusion lengths for target species are considered, all but individuals towards the upper end of the size range for adult Atlantic salmon, American eel, and American shad are susceptible to entrainment based on their ability to fit through rack spacing. Intake velocities, a factor impacting involuntary entrainment and impingement, vary depending on the specific unit. The horizontal Francis units have an intake velocity of 0.6 fps. At this velocity all target species, regardless of life stage are capable of avoiding involuntary entrainment or impingement. The vertical Kaplan (Unit 1) has an intake velocity of 3.25 fps. Juvenile alosines, unable to produce burst swimming speeds greater than this velocity, are vulnerable to entrainment while all other target species/ life stages are strong enough swimmers to avoid entrainment or impingement. A review of the EPRI (1997) database resulted in seven hydroelectric projects with similar characteristics to Pejepscot at which entrainment studies were conducted. While only a few of the target species (or surrogate species selected for this exercise) were identified, a general review of all species based on length collected at these projects identified the majority of fish entrained ranging from 6 to 20 inches. These results differ from the finding of Winchell *et al.* (2000) who found the majority of fish entrained at the 43 study sites used in the EPRI 1997 database to be less than 4 inches.

Survival of entrained fish primarily depends on the size of the individual. A TBSA assessment was run for fish lengths representative of (1) the size range of target species likely to be present at Pejepscot, and (2) body lengths less than the minimum exclusion length which would be subject to entrainment. The TBSA analysis produced a range of survival estimates for turbine survival through Kaplan Unit 1 and Francis Units 21, 22, and 23. Within that range of estimates, survival increased with decreasing body size, a trend also identified in a review of the 1997 EPRI database by Winchell *et al.* (2000). TBSA estimates were considered as representative for alosines and Atlantic salmon but not for American Eel. Desktop estimates of eel passage survival through Pejepscot Unit 1 were performed using a multiple regression equation developed by Alden Labs. Similar to the TBSA, the eel regression analysis also identified a pattern of higher survival with decreasing body size. An estimate of eel passage survival through Units 21, 22 and 23 was also generated using a multiple regression approach. However, that estimate should be viewed with caution as to date a limited number of empirical studies evaluating eel passage survival through Francis type turbines have been conducted and are available to inform that model.

A number of radio telemetry studies conducted at Pejepscot have evaluated survival through Unit 1[2]. These studies have included Atlantic salmon smolts, adult American shad, adult river herring and adult American eels. Survival estimates from those studies are presented in Table 5-1. Passage survival at Pejepscot Unit 1 was higher for eels observed during the 2019 field telemetry evaluation than estimates calculated for similar sized eels using the multiple regression analysis. Adult American shad and river herring survival rates for Pejepscot Unit 1 estimated during the 2019 spring telemetry study were lower than those calculated during the desktop TBSA assessment. It should be noted that the sample size of adult shad passing downstream via Unit 1 was limited to 11 individuals. The range of estimates for Atlantic salmon smolt passage downstream through Pejepscot Unit 1 was comparable between the TBSA assessment and previously conducted radio-telemetry evaluations.

A qualitative assessment of entrainment potential and turbine survival was performed for each target species. In general, susceptibility to entrainment is high based on the migratory life histories for each of the target species. However, juvenile alosines were the only species/life stage potentially incapable of avoiding entrainment at the Unit 1 intake due to their relatively limited swim speeds and size relative to the existing trash rack spacing. Although the majority of the target species possess the ability to avoid impingement or entrainment based on burst swim speed estimates, the obligatory migratory requirements for these species may result in voluntary entrainment, particularly during periods of limited to no spill.

Table 5-1: Survival (%) of Target Species from Radio Telemetry Studies at Pejepscot and from TBSA and Multiple Regression Analysis from Desktop Study

Species	Life Stage	From Pejepscot Telemetry studies (2015 - 2019)			Based on TBSA or multiple regression	
		# of fish	Size range (in)	Survival (%)	Size Range (in)	Survival (%)
American Eel	Adult (silver)	48	26 to 391	91.7% (75% CI = 87.5-95.8%)	26 to 39	68.2% to 82.9%
American Shad	Adult	11	14 to 232	82%	14 to 233	91.3% to 95.6%
Atlantic Salmon	Juvenile	55/604	6 to 9	92.7% to 100%	6 to 95	96.8% to 97.6%
River Herring	Adult	48	11 to 132	88%	11 to 136	95.5% to 95.6%

1 From 2019 American Eel fall telemetry study at Pejepscot Project - length range includes all radio tagged fish, not specific to those using U1 for downstream passage.

2 From 2019 adult American Shad and river herring spring telemetry study at Pejepscot Project - length range includes all radio tagged fish, not specific to those using U1 for downstream passage.

3 Used TBSA range calculated for 12 and 24 inch fish

4 Two studies provided survival estimates (2015/2018). The 2015 study estimate used a paired release model while the 2018 study used a CJS model.

2 Initial Study Reports for Spring Anadromous Fish Passage Effectiveness and Fall Diadromous Fish Passage Effectiveness, Normandeau 2016; Normandeau 2019

5 Used TBSA range calculated for 6 and 8 inch fish
6 Used TBSA range calculated for 12 and 14 inch fish.

6 VARIANCES FROM FERC-APPROVED STUDY PLAN

There were no variances from the FERC-approved study plan for evaluation.

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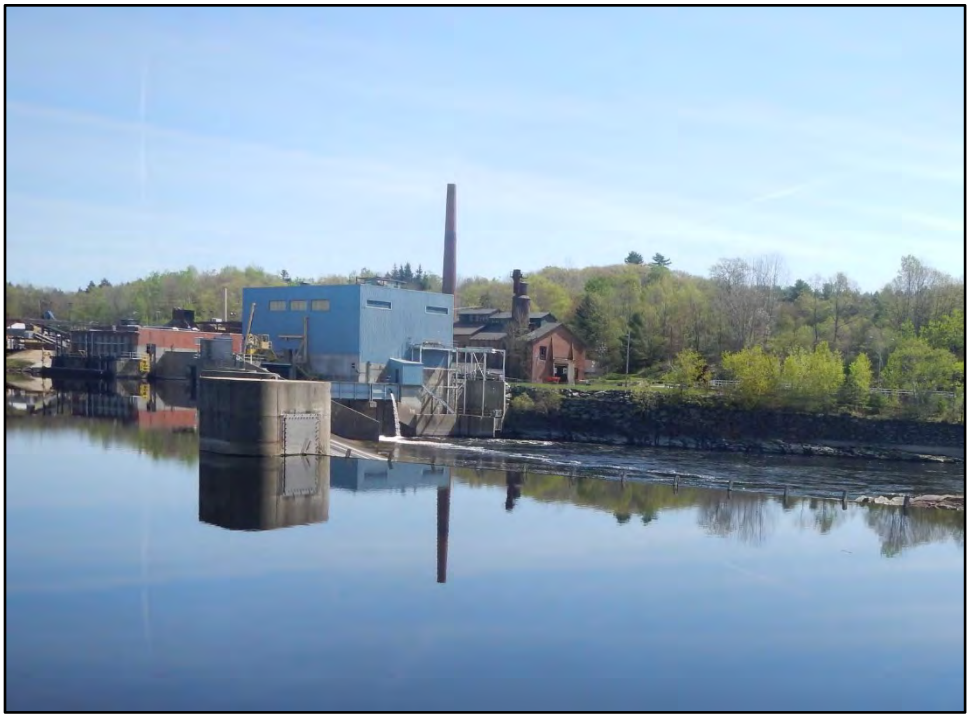
DRAFT UPDATED STUDY REPORT

ATLANTIC SALMON UPSTREAM FISH LIFT EVALUATION

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC NO. 4784)



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Brookfield

Table of Contents

List of Tables

List of Figures

List of Abbreviations and Definitions

cfs	cubic feet per second
GOM DPS	Gulf of Maine Distinct Population Segment
FERC	Federal Energy Regulatory Commission
ft	feet
ILP	Integrated Licensing Process
m	meter
mm	millimeters
ME	Maine
megawatt	MW
MDMR	Maine Department of Marine Resources
NMFS	National Marine Fisheries Service
PAD	Pre-application Document
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
PCU	Platinum Cobalt Units
RM	river mile
RSP	Revised Study Plan
SHRU	Salmon Habitat Recovery Unit
SPD	Study Plan Determination
Topsham Hydro	Topsham Hydro Limited Partnership, L.P.
USFWS	United State Fish and Wildlife Service

1 INTRODUCTION

Topsham Hydro Partners Limited Partnership (Topsham Hydro or Licensee), an indirect member of Brookfield Renewable (Brookfield), is in the process of relicensing the 13.88-megawatt (MW) Pejepscot Hydroelectric Project (Project) (FERC No. 4784) with the Federal Energy Regulatory Commission (FERC or Commission). The Project is located on the Androscoggin River in the village of Pejepscot and the Town of Topsham, Maine to the east, the Town of Lisbon to the north, and the Towns of Durham and Brunswick, Maine to the west. The Project straddles the border between Cumberland and Sagadahoc counties and extends into Androscoggin County. The original license was issued on September 16, 1982 and expires on August 31, 2022.

The Licensee is using FERC's Integrated Licensing Process (ILP) as established in regulations issued by FERC July 23, 2003 (Final Rule, Order No. 2002) and found at Title 18 Code of Federal Regulations, Part 5. The Licensee filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to seek a new license for the Project on August 31, 2017.

The Licensee distributed the PAD and NOI simultaneously to Federal and state resource agencies, local governments, Native American tribes, members of the public, and others thought to be interested in the relicensing proceeding. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on October 30, 2017. FERC also held agency and public scoping meetings on November 28, 2017 and a site visit on November 29, 2017. The FERC Process Plan and Schedule provided agencies and interested parties an opportunity to file comments on the PAD and SD1 and request studies by December 29, 2017. FERC subsequently issued Scoping Document 2 on February 5, 2018. The Licensee filed a Proposed Study Plan (PSP) on February 12, 2018 and held a Study Plan Meeting on March 22, 2018. The Revised Study Plan (RSP) was filed in accordance with the ILP schedule on June 12, 2018. FERC issued a Study Plan Determination (SPD) on July 3, 2018.

Within the RSP, Topsham Hydro proposed to use radio-telemetry to evaluate the upstream passage effectiveness of migrating adult river herring and American shad at the project fish lift. Due to limited numbers of sea run returns in the Androscoggin a comparable evaluation for adult Atlantic Salmon was not proposed. Rather, Topsham Hydro indicated in the RSP that passage efficiencies for Atlantic Salmon at Pejepscot would continue to be assessed following criteria described in the Interim Species Protection Plan at the Project. These evaluations include (1) video camera monitoring of the number of Atlantic Salmon using the fish lift from 2017 through 2022; and (2) conducting an adult upstream passage effectiveness study (using radio tagging and tracking methodology) in consultation with the fisheries agencies when at least 40 adult Atlantic Salmon of Androscoggin River origin are counted at the Brunswick fish trap for two consecutive years.

The FERC SPD recommended that Topsham Hydro conduct a desktop analysis of the potential effectiveness of the fish lift for passing adult Atlantic Salmon. The analysis should consider variables such as the size of the hopper, the timing of operation both seasonally and daily, attraction flows, orientation of the hopper entrance, and the possible sources of injury to fish who have entered the hopper.

2 GOALS AND OBJECTIVES

The goal of this study was to conduct a desktop-based analysis to evaluate the potential upstream passage effectiveness of the existing fish lift at Pejepscot for the passage of adult Atlantic Salmon. The specific objectives of this analysis were to:

- Describe the configuration and operation of the existing upstream fish lift facility at the Project;
- Review and summarize findings from adult Atlantic Salmon fish lift effectiveness studies conducted at other locations within the State of Maine (including a summary of the lift configuration and operations schedules at those locations); and
- Draw inferences from regional adult Atlantic Salmon evaluations related to the timeliness and effectiveness of upstream passage to gain a perspective on the potential performance of the existing Pejepscot fish lift.

3 ATLANTIC SALMON

3.1 ESA Listing of Atlantic Salmon

The Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic Salmon was first listed as endangered by the United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) on November 17, 2000 (USFWS and NMFS 2000). The November 2000 final rule listing the GOM DPS did not include fish that inhabit the mainstem and tributaries of the Androscoggin River (USFWS and NMFS 2000).

The 2006 Status Review for anadromous Atlantic Salmon in the U.S. (Fay *et al.* 2006) assessed genetic and life history information and concluded that the GOM DPS, as defined in 2000, should be redefined to encompass the Androscoggin River. On June 19, 2009, the USFWS and NMFS published a final rule determining that naturally spawned and conservation hatchery populations of anadromous Atlantic Salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, including those that were already listed in November 2000, constitute a DPS and hence a "species" for listing as endangered under the ESA (USFWS and NMFS 2009). This range includes the Androscoggin River.

The GOM DPS of Atlantic Salmon is divided into three salmon habitat recovery units (SHRUs) within the range of the GOM DPS and includes the following: the Downeast Coastal SHRU, the Penobscot Bay SHRU, and the Merrymeeting Bay SHRU. The three SHRUs were created to ensure that Atlantic Salmon were widely distributed across the DPS such that recovery of the GOM DPS of Atlantic Salmon is not limited to one river or one geographic location, because widely distributed species are less likely to become threatened or endangered by limited genetic variability and tend to be more stable over space and time (USFWS and NMFS 2009).

The Merrymeeting Bay SHRU contains historically accessible spawning and rearing habitat for Atlantic Salmon. The Merrymeeting Bay SHRU incorporates two large basins: the Androscoggin and Kennebec. A variety of issues and conditions, including dams, affect Atlantic Salmon recovery in the Androscoggin River, including also agriculture, forestry, industry, changing land use, hatcheries and stocking, roads and road crossings, mining, dredging, aquaculture, and introductions of non-native species such as smallmouth bass (NMFS 2009a).

3.2 Status of Atlantic Salmon in the Project Area

Historically, Atlantic Salmon were reportedly abundant in the Androscoggin River, but runs of the species as well as other anadromous fish on the lower Androscoggin River have declined since the late 1700s and early 1800s with the industrialization of the river and the construction of dams throughout the river basin, which prevents full access of migratory fish to historical habitat (NMFS 2013).

Within the Androscoggin watershed, Rumford Falls was the historic upper extent of Atlantic Salmon migration. The Little Androscoggin River is the largest major subbasin of the Androscoggin with historically important salmon habitat that was accessible as far up as Snow's Falls located 3.2 kilometers outside of West Paris (Foster and Atkins 1867). Prior to its damming, the Androscoggin River provided access to a large amount of diverse aquatic habitat for numbers of diadromous and resident fish species (Foster and Atkins 1867).

The first dam was constructed on the mainstem at Lewiston Falls shortly after 1770, and records indicate a similar dam was built on the Little Androscoggin River in 1797. Great Falls, located at the head-of-tide in Brunswick, was occupied by a series of dams. In 1807, one of the dams caused alewife and American shad runs to decline sharply, but it did not prevent the passage of Atlantic Salmon that were able to leap over the dam. However, subsequent dams were higher and insurmountable. As a result, Atlantic Salmon were no longer caught at Lewiston after 1815 and were extirpated above tidewater in 1844 (MDMR 2017).

Since the 1970s, state and federal fishery agencies have undertaken efforts to restore anadromous fish stocks to the lower Androscoggin River. Some of the initiatives undertaken by the state and federal fishery agencies, along with hydroelectric project and dam owners include:

- Maine Department of Marine Resources (MDMR) initiated an anadromous fish restoration program in the Androscoggin River in 1983 when upstream and downstream fish passage was installed at the Brunswick Project Dam and was anticipated at the next two upstream hydroelectric projects. Passage was constructed at the Pejepscot Project dam in 1987 and at the Worumbo Project dam in 1988. Passage at all three projects resulted from recommendations made by state and federal resource agencies during the federal relicensing process.
- MDMR biologists operate the trapping facility that is located at the upstream end of the Brunswick Project fishway. When fish reach the top of the fishway, fixed grating guides them past a viewing window and into a 500-gallon capacity fish hoist (trap). The hoist raises fish to overhead tanks where staff sort fish and either load them into stocking trucks, sluice them upstream into the headpond, collect biological samples, or return exotic species, such as carp or white catfish, to the river below the dam.
- MDMR uses passive methods of Atlantic Salmon fish restoration in the Androscoggin River; restoration is accomplished by allowing returning fish to pass upstream and spawn naturally (MDMR 2017).

In recent years, returns of adult Atlantic Salmon to the Androscoggin River have been low, and mostly comprised of stray, hatchery origin fish from active restoration programs on other rivers (Letter from MDMR to FERC dated March 25, 2010). Since the mid-1990s, returns of adult Atlantic Salmon to the Androscoggin River have been estimated based on the number of fish captured in the Brunswick fishway and have ranged from a high of 44 in 2011 to single digit totals annually since 2012 (including 1 during the most recent 2019 passage season).

Adult Atlantic Salmon that ascend the Brunswick fishway are released above the Brunswick Dam to continue upstream migration after biological data (e.g., length) are collected. The mean fork length of returning adults was 603 mm in 2008 and 735 in 2009 (MDMR 2010). Several adult salmon have been captured at the Brunswick fishway with fin-clips or tags, indicating that these fish are strays or stocked salmon from other rivers (MDMR 2010). Documented annual runs of returning adult salmon consisted primarily (98%) of fish originating as hatchery smolts released into Maine rivers. In 2007 and 2008 several returning adults captured at the Brunswick fishway were determined to be fry-stocked or naturally reared fish. As stocking efforts in other DPS rivers increase so does the amount of strays captured at the Brunswick Dam.

With passage at the first three dams on the river (i.e., Brunswick, Pejepscot, and Worumbo), Atlantic Salmon have access up to Lewiston Falls (Fay *et al*. 2006; MDMR 2010). This available habitat represents approximately 27 miles of accessible water in the lower Androscoggin River from the Brunswick Project to Lewiston Falls. Atlantic Salmon habitat is quantified in the GOM DPS by mapping Hydrologic Unit Codes 10 scale (HUC10) to define suitable Atlantic Salmon habitat units (NMFS 2009a). Each habitat unit equals 100 square meters. The Androscoggin River consists of 97,598 historic HUC10 habitat units. An estimated 17% (16,978 units) of these historic habitat units within the Androscoggin River system are considered to be occupied and occur in the lower Androscoggin River drainage (NMFS 2009a). Atlantic Salmon habitat quality is measured in HUC10s based on the suitability of several parameters using a scale from zero to three, which include temperature, biological communities, water quality, and substrate and cover. Low quality habitat scores have been assigned to the lower Androscoggin River, while high scores were determined in the upper inaccessible reaches of the river (NMFS 2009a).

In 2011, HDR evaluated the spawning habitat in the Little River, 800 meters downriver of the Worumbo Project, and found numerous barriers and poor substrates. However, MDMR indicates that there is a significant amount of habitat in the Little River and that it could hold “tens of thousands of eggs” (MDMR 2012b). During the 2011 telemetry study, MDMR documented a radio tagged female Atlantic Salmon moving throughout the Little River, and it is thought that it may have spawned in Gillespie Brook, one of its tributaries (MDMR 2012b). The mainstem Androscoggin River is expected to provide minimal spawning habitat due to the existing impoundments and/or unsuitable substrates. However, MDMR identified the Pejepscot (in the mainstem) and Lower Barker (in the Little Androscoggin) bypass reaches as containing suitable spawning habitat (MDMR 2012b). In addition, tributaries in the central reaches of the Androscoggin River contain abundant (-40,000 units) suitable Atlantic Salmon spawning and rearing habitat that is presently inaccessible due to dams (NMFS 2009b). Above Worumbo Dam the only sizeable tributary other than the Little Androscoggin that might provide suitable spawning and rearing habitat would be the Sabattus River; however, Lower Dam (a.k.a. Farwell Mill Dam), which is located about three kilometers upstream in the mouth of the Sabattus River, blocks access to the majority of the habitat.

The amount of natural reproduction occurring in the Androscoggin watershed is not known (MDMR 2017). Atlantic Salmon stocking practices are common in the region for the GOM DPS stock enhancement program, although the Androscoggin River has been stocked with fewer fish than any other river with a stocking program for anadromous Atlantic Salmon. A total of 13,000 fry have been stocked in the Androscoggin River since stocking commenced in 2001 (USASAC 2012). Most recently, the total number of juvenile salmon stocked in the Androscoggin River (fry only) was 2,000 individuals in 2009 and 1,000 in 2010 and 1,000 in 2011 (USASAC 2010, 2011, 2012).

There have been few studies of Atlantic Salmon in the Androscoggin River. In 2011, MDMR radio tagged 21 adult salmon (12 wild and 9 hatchery raised) when they were trapped at the Brunswick dam (MDMR 2012b). Twenty-nine percent (29%) (6 out of 21) of these fish dropped out of the Androscoggin soon after they were released, and at least four of these continued their migration in the Kennebec River. 43% (9 out of 21) of the tagged fish successfully migrated past the Pejepscot Project, whereas fewer than 10% (2 out of 21) successfully passed all three dams in the lower Androscoggin (MDMR 2012b). The remaining 29% (6 out of 21) passed the Brunswick Project but did not migrate any further up the river. The study showed minimal use of tributaries in the system, although many fish were detected in the mainstem, holding in the vicinity of cool water tributaries during the summer months (Little River and Meadow Brook downstream of the Worumbo project; Gerrish Brook upstream of the Worumbo Project; and Simpson Brook downstream of the Pejepscot Project). One female Atlantic Salmon was detected several times in the Little River, and may have spawned with an untagged male in one of its tributaries. Similarly, one tagged male was detected in the bypass reach of Lower Barker Dam and may have spawned with an untagged female (MDMR 2012b).

MDMR concluded that the fact that only 10% (2 out of 21) of the tagged adult Atlantic Salmon successfully migrated past all three of the lower dams in 2011 may indicate poor passage efficiencies at the Pejepscot and Worumbo Projects or that the salmon are poorly motivated to seek out upstream habitat. According to MDMR, this conclusion is further supported by the fact that nearly one third of the salmon dropped out of the river soon after release in the Brunswick headpond and did not return. Overall, this study appears to support the conclusion that the majority of Atlantic Salmon that enter the Androscoggin are strays that were stocked in other GOM DPS rivers (MDMR 2012b).

4 PEJEPSCOT PROJECT

Pejepscot is the second dam on the Androscoggin River located at approximately river mile (RM) 14. The Project dam is approximately 4 miles upstream of the Brunswick Hydroelectric Project and 3.25 miles downstream of the Worumbo Hydroelectric Project. The Pejepscot Dam is a 560 foot-long, 47.5 foot-high structure equipped with five 96-foot long by 3-foot high hydraulically operated bascule gates that can be operated manually or automatically (Figure 4-1). The two powerhouses at the Project contain a total of four generating units that discharge into the tailrace.

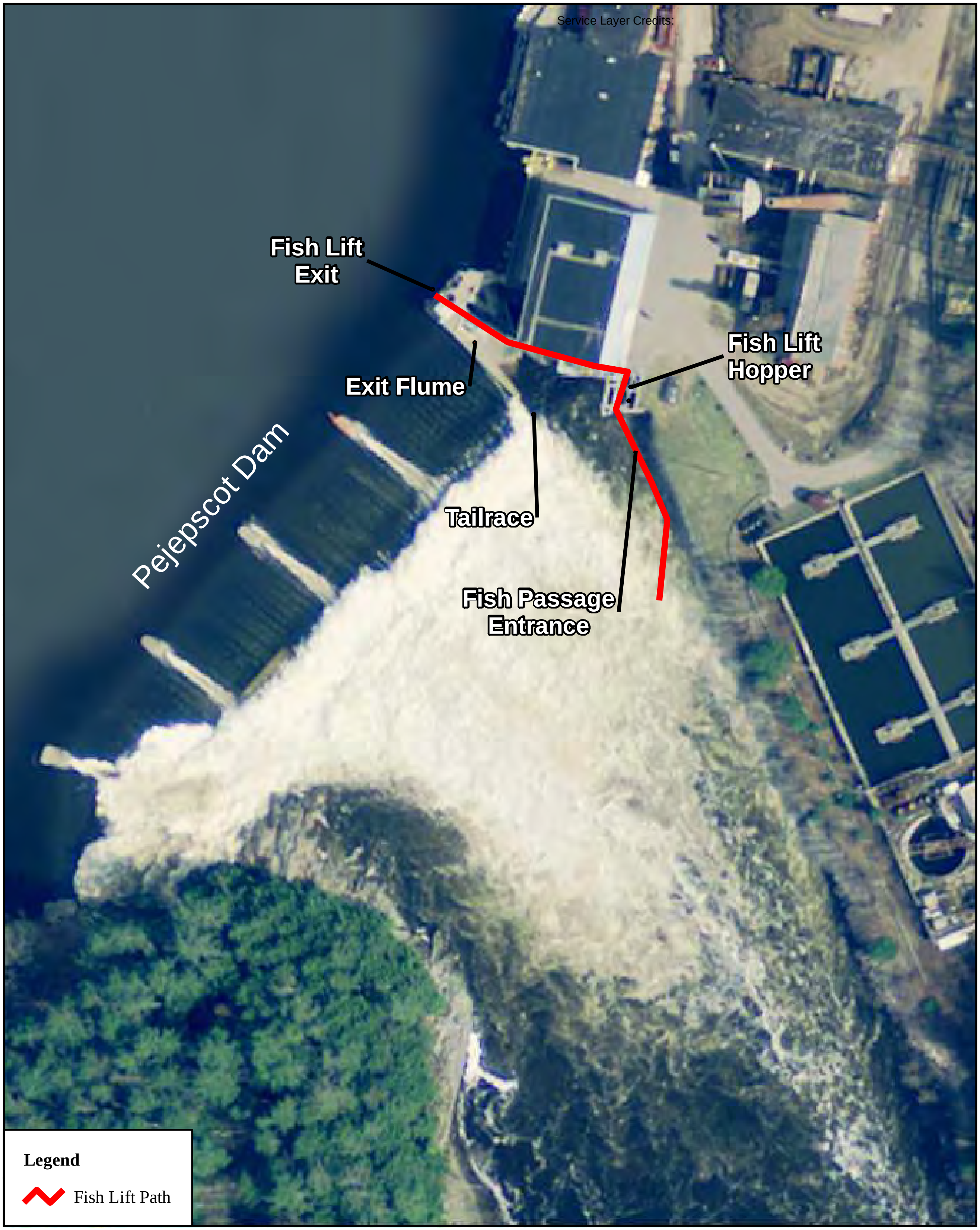
4.1 Upstream Fish Passage Facility

The upstream fish passage facility (fish lift) is a vertical lift elevator that lifts migratory fish in a hopper about 30 feet vertically from near the powerhouse tailrace to the impoundment level behind the dam (Figure 4-2). The lift hopper is about 20 feet long and 7 feet wide with a sloping bottom that assists in removal of the fish from the hopper. The inlet to the hopper is a V-trap about 8 inches wide by 8 feet high opening. In front of the entry gate there are four attraction pumps under a grating that create an additional flow up to 160 cfs through the entry channel to attract the fish to the lift. These pumps can be sequenced to change the volume of water passing through the entry channel, depending on the flow out of the powerhouse tailrace. The lift basket discharges the fish into a metal channel about six feet wide and eight feet high. The channel is approximately 110 feet long from the lift hopper to the gate at the dam. There is a continuous flow of about 30 cfs from the impoundment to the lift basket to attract the fish to the impoundment.

The upstream fish passage is operated annually from April 15 to November 15. The lift is operated automatically to lift the fish hopper every two hours beginning at 8 a.m. for a total of five lifts per day. The four attraction pumps are operated by station technicians; the number of pumps operating is determined based on the flow coming through the turbine and out the tailrace. When river flows are less than 1,700 cfs, one pump is operated (total attraction flow 30 cfs). When river flows are between 1,700 and 3,500 cfs, two pumps are operated (total attraction flow 110 cfs). When river flows are between 3,500 and 5,200 cfs, three pumps are operated (total attraction flow 150 cfs). Finally, when river flows are greater than 5,200 cfs, four pumps are operated (total attraction flow 190 cfs). The total of 190 cfs (attraction flow from four pumps (160 cfs) plus an additional 30 cfs provided from the impoundment via the exit trough) represents approximately 2.2% of the Project maximum turbine discharge capacity (8,550 cfs).

A preset weir in the channel provides an attraction flow through the channel and hopper. The channel from the hopper to the impoundment is opened when the seasonal operation is started for passage of anadromous fish. The gates in the channel that allow fish to be counted through the observation window are left open unless they are being used for counting. Fish at the plant are not actively counted and, historically, the counting facilities have only been used for efficiency tests.

Figure 4-1: Pejepscot Hydroelectric Project, Androscoggin River, Maine



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Pejepscot Hydroelectric Project
(FERC No. 4784)
Atlantic Salmon Upstream Fish Evaluation

Figure 4-2:
Overview of the Pejepscot Project and Fish Lift Structure

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5 PREVIOUS PROJECT EVALUATIONS

This section provides a summary of upstream passage effectiveness studies conducted for adult Atlantic Salmon at hydroelectric projects within New England. Two facilities, the Milford Hydroelectric Project on the Penobscot River and Lockwood Hydroelectric Project on the Kennebec River, have recently evaluated upstream passage for Atlantic Salmon at fish lift facilities at those locations. Descriptions of those lift facilities as well as a summary of key findings related to salmon passage are provided here.

5.1 Milford Hydroelectric Project (FERC No. 2534)

5.1.1 Milford Project Description

The Milford Dam is the first barrier on the mainstem of the Penobscot River (RM 38.5) and includes a 1,159 foot long, 20 foot high concrete gravity dam set with 4.5 foot high steel-hinge flashboards on the western spillway and 4 foot high Obermeyer inflatable flashboards on the eastern spillway (Kleinschmidt 2016; Figure 5-1). The Project operates in run-of-river mode and is equipped with a powerhouse abutting the eastern shoreline that includes a total of six turbine units with a total installed capacity of 7.9 MW. In addition to the existing fish lift located on the eastern side of the tailrace, a Denil fishway, constructed in 1967, is maintained for emergency use in the event fish lift operations are curtailed during the fish passage season.

5.1.2 Milford Upstream Fish Passage Facility

A single entrance fish lift is located on the east shore immediately downstream from the Milford powerhouse and includes an upper flume that exits to the head pond as well as a fish trapping, sorting, and trucking facility. Construction of the existing lift at Milford was completed in 2014 as part of Penobscot River Restoration Plan to increase access for diadromous species to upstream habitat. The operational schedule begins nominally on April 15 and runs through November 15 with automated lifts occurring every half hour between 0400 and 2200 hours. Following its initial opening, the Milford upstream fishway was modified to reduce air that was entrained in the attraction water, which caused bubbles that interfered with American shad passage, and possibly the passage of other species. Operational modifications were attempted without success and a wooden baffle was subsequently added to the attraction water supply in August 2016, which improved the hydraulics such that the attraction water could be provided at a rate close to the design capacity without significant amounts of entrained air. Attraction and passage into the primary hopper now appears to function as intended, although the attraction flow is typically set lower than the full design specification.

The entrance is 10-feet-wide with a 180 degree turn leading to the lifting hopper. The facility is capable of passing up to 300 cfs of attraction flow through a combination of conveyance flow from the upper flume and an auxiliary water supply system. The lower flume consists of an electrically operated gate for dewatering the entrance channel and hopper pit, a manually adjusted “overshot” attraction flow gate, an adjustable V-gate, and a blocking/diffusion screen. The fish lift hopper, which can be operated manually or automatically using a programmable logic controller, rises by mechanical hoist about 20 feet and discharges into a 10-foot-wide by 300 foot long upper flume that passes through the east end of the powerhouse to the headpond upstream of the intake trashracks.

Fish can pass upstream through the upper flume, past a counting window, and directly to the headpond, or are trapped and lifted via a second hopper to the sorting facility which is operated by MDMR. Once sorted, fish are released into the headpond or transported for hatchery and stocking programs. The fish lift facility is designed to pass 12,500 Atlantic Salmon, 633,000 American shad and 3,800,000 river herring annually. MDMR operates the sorting facility on a daily basis and releases or transports fish collected at Milford based on current management objectives.

5.1.3 Milford Upstream Adult Salmon Passage Assessments

Assessments of the Milford fish lift to evaluate the upstream passage effectiveness for adult Atlantic Salmon were conducted by the Licensee during the 2014 and 2015 passage seasons (HDR 2015; Kleinschmidt 2016). Concurrent with those evaluations, researchers from the University of Maine also evaluated upstream passage of adult salmon at Milford during those two passage years (Izzo *et al.* 2016).

The primary objective of the 2014 and 2015 studies conducted by the Licensee was to evaluate compliance with the upstream performance standard described in the 2012 Biological Opinion and species protection plan (SPP) for the Milford Project. The 2012 SPP defined a passage standard requiring 95% of adults entering the Milford tailrace (defined as 200 meters downstream of the lowermost turbine discharge structure) locate and pass the fish lift within 48 hours. The upstream performance standard is only applied to periods when the ambient water temperature conditions are below 23^{o}C.

Adult salmon radio tagged by the Licensee demonstrated high rates of return following release downstream as well as upstream passage following arrival at Milford. Return and passage rates observed during the Licensee studies were: 2014 – 38 of 40 returned to Milford and 33 of 38 recaptured in upper flume of the fish lift; 2015 – 48 of 49 returned to Milford and 47 of 48 recaptured in upper flume of the fish lift. The median passage times observed for radio tagged adult salmon at Milford was 1.1 days (range 0.1 to 16.1 days) during the 2014 and 7.8 days (range 0.1 to 35.1 days) during the 2015 studies conducted by the Licensee (HDR 2015; Kleinschmidt 2016). During Licensee evaluations the majority of individuals did not achieve upstream passage within the 48 hour period following their initial detection in the project tailrace (52% achieved ≤48 hours during 2014; 17% achieved ≤48 hours during 2015).

Izzo *et al.* (2016) evaluated the upstream passage of adult Atlantic Salmon on the Penobscot River during 2014 and 2015 with the objective of assessing potential delays at the dam remnant locations for Great Works and Veazie, the Stillwater confluence and Orono Dam tailwater, and the Milford fish lift. In both years, upstream passage speeds through the dam remnant locations for Great Works and Veazie as well as the Stillwater confluence were comparable to speeds through unobstructed reaches of river. Izzo *et al.* (2016) reported movement rates through the Milford Dam reach slower than that observed in both unobstructed river reaches as well as at the historic Veazie and Great Works locations. Median upstream speeds at Milford were reported as 0.006 km/hr in 2014 and 0.005 km/hr in 2015. The majority of radio tagged adult salmon tagged by the University of Maine and known to have approached Milford successfully ascended the fish lift (95.5% during 2014 and 100.0% during 2015). Individual tagged salmon made between 1 and 47 visits (median = 11) to the Milford fish lift entrance prior to passage with the majority of visits lasting less than 90 minutes. Passage times following arrival at Milford for adult salmon tagged by the University of Maine ranged from 0.03 to 78.4 days (median 3.0 days) during 2014 and 0.4 to 26.9 days (median 4.3 days) during 2015. When considered relative to the passage standard at Milford, 55% passed within the 48 hour window during 2014 and 34.7% did so during 2015.

Figure 5-1: Milford Hydroelectric Project, Penobscot River, Maine.

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Pejepscot Hydroelectric Project
(FERC No. 4784)
Atlantic Salmon Upstream Fish Evaluation

Figure 5-2:
Overview of the Milford Project and Fish Lift Structure

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5.2 Lockwood Hydroelectric Project (FERC No. 2574)

5.2.1 Lockwood Project Description

Lockwood Dam is the first barrier on the mainstem Kennebec River at RM 63 and consists of an 875 foot long, 17 foot high dam with two spillway sections, a 160 foot long forebay headworks section, a 450 foot long power canal, and two powerhouses (Figure 5-3). The two spillway sections are equipped with 15 inch high flashboards. The older powerhouse contains a total of six vertical Francis units (U1-U6) while the newer powerhouse contains a single horizontal Kaplan unit (U7). The total installed capacity for the Project is 6.8 MW at a combined flow of approximately 5,600 cfs. The Project tailrace returns water to the Kennebec River approximately 1,300 feet downstream of the eastern spillway section.

The Project has a 1,300 foot long bypassed reach lying parallel to the power canal. Flow through that reach is currently limited to leakage around and through the flashboards, including through three (three feet long by eight inches high) engineered orifices cut into the flash boards (estimated at a total of 50 cfs), or as spill over the flashboards when river flow exceeds about 5,600 cfs.

5.2.2 Lockwood Upstream Fish Passage Facility

The Lockwood fish lift is positioned on the western side of the river with the entrance channel located adjacent to the Unit 7 discharge. The operational schedule begins nominally on May 1 and runs through October 31. During this period, operations occur 7 days a week during the peak migration period for river herring, shad, and salmon (May through mid-July). After mid-July, the lift operations are a function of migratory fish presence, river flow and water temperature. Lift operations are initiated based on direct camera viewing at hopper and v-gate. Operations are suspended when water temperatures achieve 24.5^{o}C or higher to prevent unintended injury or mortality to Atlantic Salmon.

The lift operates with an attraction flow of 170 cubic feet per second. Fish lift entrance water velocities are 4 to 6 feet per second (fps). The lift has an approximate 10 minute cycle time and is operated as follows. An attraction flow (170 cfs) draws fish through the fish lift entrance gate into the lower flume. The fish then swim through a crowder gate and remain in the lower flume of the lift. During the cycling process, the crowder closes to hold the fish in the hopper area.

The 1,800 gallon water-filled hopper lifts the fish to the holding tank elevation and the fish are sluiced into the 2,500 gallon round discharge tank. Liquid oxygen is introduced into all tanks via carbon micro porous stones to reduce stress and mortality. Auxiliary water pumps provide a constant flow of ambient river water to all the tanks. These pumps also provide ambient river water to the stocking trucks. The fish lift operates to accommodate all target species and attraction flows are passed continuously during lift operation.

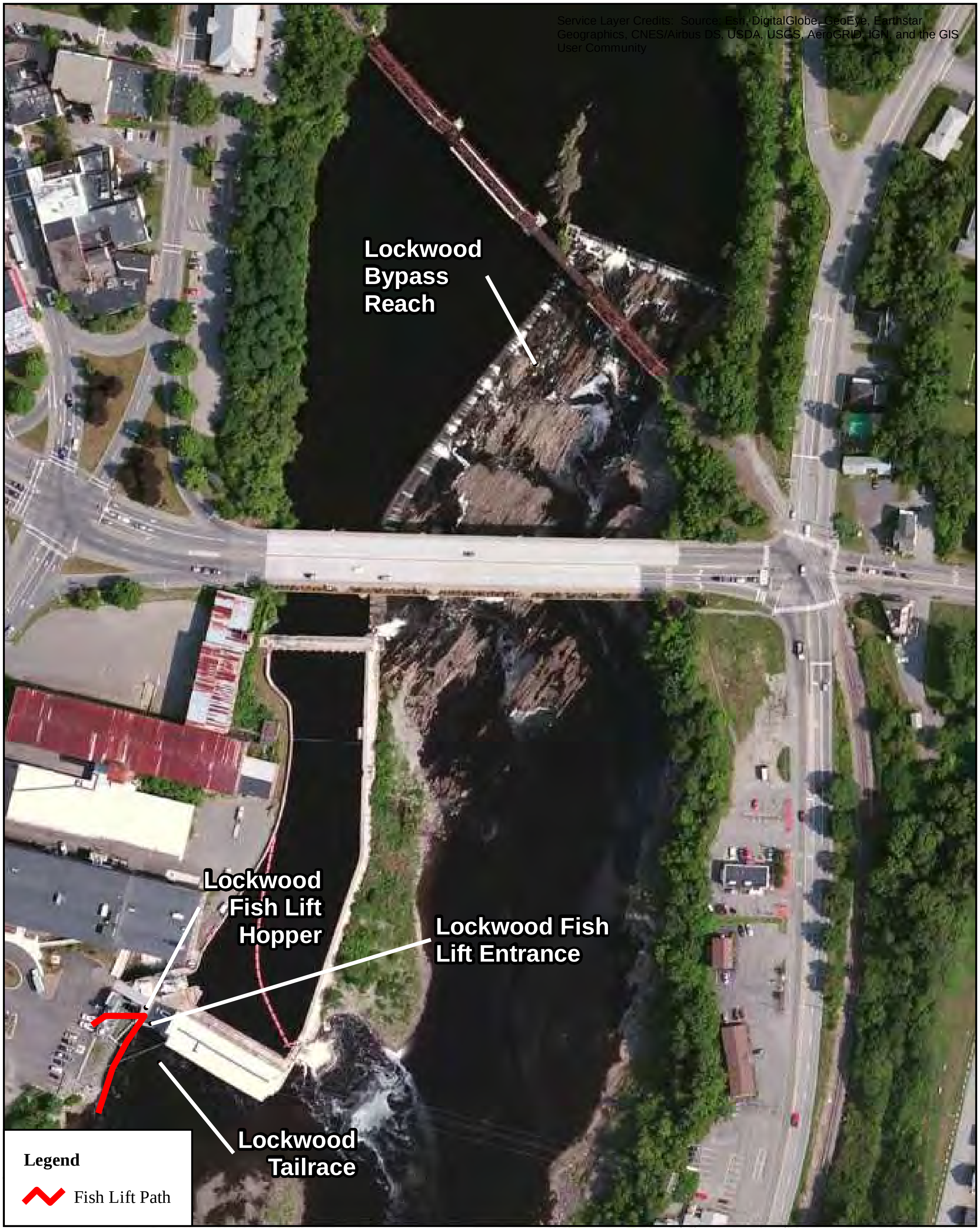
The Lockwood fish lift was constructed in 2006 with the designed capacity to pass 164,640 alewife and blueback herring (collectively referred to as river herring), 228,470 American shad, and 4,750 Atlantic Salmon.

5.2.3 Fish Lift Assessment

The Licensee conducted two years of evaluation of upstream passage effectiveness for adult Atlantic Salmon at the Lockwood fish lift during 2016 and 2017 (Normandeau 2017; Normandeau 2018). During those two study years, adult salmon were collected at the Lockwood fish lift, tagged, and released downstream of the Project. During the 2016 study year, the fish lift was operated based on the use of underwater cameras to initiate a lift sequence. During the 2017, the lift was initially operated on a 'semi-automatic' 15 minute lift cycle. Each lift was manually initiated by lift personnel. That operational scheme was terminated in mid-June and the standard use of the underwater camera system to initiated lift sequences was implemented.

Returns of radio-tagged salmon to the Project were high during both study years (18 of 20 during 2016 and 20 of 20 during 2017) and the mean duration of time from release until detection downstream of Lockwood was similar between the two study years (5.9 vs 6.7 days). When the 2016 and 2017 study years are considered, a total of 30 of 38 (79%) of tagged adult salmon which returned to the project area were recaptured at the fish lift. Radio-tagged salmon during both study years were regularly detected in the upper section of the Lockwood bypassed reach (83% of individuals during 2016 and 100% of individuals during 2017). Time spent in the upper portion of the bypassed reach represented an average of 22% and 31% of the total cumulative residence time for adult salmon downstream of Lockwood during 2016 and 2017, respectively. All individuals present in the Lockwood study area during 2016 and 2017 made at least one approach event resulting in detection at the fish lift entrance. Time at large for tagged adult salmon from initial detection downstream of Lockwood until recapture at the fish lift ranged from 0.7 to 111.2 days (median = 9.8 days) during the 2016 study and from 3.3-123.0 days (median = 16.0 days) during the 2017 study.

Figure 5-3: Lockwood Hydroelectric Project, Kennebec River, Maine



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0 50 100 200 Feet

Pejepscot Hydroelectric Project
(FERC No. 4784)
Atlantic Salmon Upstream Fish Evaluation

Figure 5-4:
Overview of the Lockwood Project and Fish Lift Structure

Path: P:\Modeling\Projects\01925\maps\Study Plans\Atlantic_Salmon\Figure_5-4.mxd

6 PROJECT COMPARISON

Table 6-1 provides a brief summary of the three hydroelectric projects considered as part of this desktop assessment. All three project location lie on major rivers within listed Critical Habitat for Atlantic Salmon within the State of Maine (Androscoggin, Kennebec and Penobscot Rivers). Adult Atlantic Salmon approaching Pejepscot have already contended with upstream passage at Brunswick whereas fish approaching Lockwood and Milford had an unimpeded approach upstream to that point. All three projects are operated as run-of-river and total station capacities at each are comparable and in the range of 8.5 to 5.8 kcfs. Although the dam at Milford is twice the width of that at Pejepscot, the downstream faces of the dam and powerhouse at both of those locations sit in line with one another. The configuration of Lockwood differs from that at Milford and Pejepscot due to the presence of a 1,300 foot long bypassed reach, the entrance of which sits in line with the powerhouse discharge.

Fish passage engineering design criteria (USFWS 2019) provides guidelines for fish lifts to ensure that they meet the standards necessary to provide optimal fish passage past hydroelectric plants. Per that reference, the entrance placement should be immediately downstream of the most upstream point of the project or immediately downstream of the dominant attraction flow. The orientation of the entrance should be parallel to the adjacent competing flow and minimize any impact on the attraction jet from the lift attraction water. Internally, the hopper should be free of sharp corners and have gaps no greater than 1 inch between the hopper and pit side walls. Attraction water (i.e., the sum discharge from the auxiliary water source as well as through lift flow combined) at hydroelectric plants should consist of a minimum of 5% of the station capacity. Internally, there should be a velocity of 1.0-1.5 cfs from the flume exit and over the hopper, 1.5-4.0 ft in the entrance channel, and an entrance jet velocity of 4-6 ft/s. The entrance of the lift should be a minimum of 4-ft wide and have an adjustable gate/weir that always maintains a minimum depth over the top of 2 ft.

Table 6-2 provides a summary of parameters related to the entrance, hopper, and exit flumes at the three Projects considered in this report. Note that Lockwood operates as a trap and truck facility only and as a result does not have an associated exit flume. All three lift entrances sit adjacent to the project powerhouse discharge and are oriented such that the entrance is facing downriver and parallel to the adjacent competing flow. Entrances to the lower flume at Milford and Pejepscot are both 10 feet whereas the Lockwood lift is somewhat narrower—the entrance gate is approximately 6 feet wide, and the hopper is approximately 8 feet wide. After passing over the entrance weir, fish at Milford must navigate an 180^{o} turn prior to approaching the v-gate lift hopper. Fish at both Pejepscot and Lockwood are faced with a 90^{o} turn after passage over the entrance weir and prior to approach at the v-gate.

The Milford fish lift is operated with target values of 190-210 cfs entrance flow (i.e., 3.0%-3.1% of station capacity), an entrance velocity of 4-6 ft/s, a depth over the entrance attraction water gate of greater than 3.0 ft, and a velocity through the hopper of 1.0-1.5 ft/s. The fish lift at Lockwood operates with an attraction flow of 170 cfs (2.9% of station capacity), an entrance velocity of 4-6 ft/s, a depth over the entrance attraction water gate of>3.0 ft, and a velocity through the hopper of 1.0-1.5 ft/s. The fish lift at Pejepscot operates with an attraction flow of up to 190 cfs (2.2% of station capacity (Table 6-2). As per the USFWS criteria, the fish lifts at the Milford and Lockwood Projects meet the guidance for depth at the entrance weir, as well as entrance and through-hopper velocities. Entrance weir depth and through velocities at Pejepscot need to be verified relative to current USFWS operating criteria. When compared with USFWS criteria the overall attraction flow is shy of the recommended 5% of total station capacity at each of the three Projects. It should be noted that variations in the total river flow, headpond level, and tailwater elevation will all influence lift conditions at the three project locations.

The period of operations and frequency of lifts for each Project is presented in Table 6–3. The lift seasons are relatively similar among the three locations. Pejepscot and Milford operate for a period running from April 15 through November 15 whereas Lockwood operates from May 1 through October 31 (start updates being subjected to river flow conditions at all locations). The Milford fish operates for a larger proportion of the day with lift events initiating at 0400 and running until 2200 hours. Lifts at Milford generally occur two times per hour during the passage season (more frequently during periods of high fish passage). In comparison, the Lockwood and Pejepscot lifts operations begin later (0700 or 0800) and terminate earlier (1900 or 1800). In general, 5-8 manually triggered fish lift events occur daily at Lockwood although that number can increase considerably during peak periods of upstream fish passage. A total of five lifts occur daily at Pejepscot, one lift every two hours. Although both Pejepscot and Milford are primarily allowed to operate in an automated mode, both locations can be operated manually. As a trapping only facility, Lockwood fish lift ceases operations when water temperatures exceed 24.5^{o}C.

Table 6-1: General Project Characteristics for Pejepscot, Lockwood and Milford

Project	River	Relative Position on River	River Mile	Project Operations	Watershed Size (mi^2)	Station Capacity (cfs)	Dam Size (linear ft)	Project Configuration
Pejepscot	Androscoggin	2nd	14	Run-of-river	3,450	8,550	560	Dam and tailrace inline
Lockwood	Kennebec	1st	63	Run-of-river	5,870	7,922	875	Dam offset from tailrace with 1,300 ft bypassed reach
Milford	Penobscot	1st	38.5	Run-of-river	8,570	6,730	1,159	Dam and tailrace inline

*Milford does have a Denil fishway for use in event of mid-season shut down at lift

Table 6-2: Entrance, Hopper, and Exit Flume Characteristics for the Pejepscot, Lockwood, and Milford Fish Lifts

	Entrance								Hopper Size/Capacity				Exit Flume		
Project	**Location**	**Bank**	**Orientation**	**Width (ft)**	**Depth over Entrance Weir**	**Attraction Flow Capacity**	**Entrance Velocity**	**V-Trap Setting**	**Width**	**Length**	**Volume**	**Hopper Velocity**	**Width**	**Length**	**Attraction Flow**
Pejepscot	Adjacent to powerhouse (shore side)	east	In line with discharge flow	10	TBD	Up to 109 (2.2%)	TBD	8	7	20	1,000	TBD	6	110	30
Milford	Adjacent to powerhouse (shore side)	east	In line with discharge flow	10	>3.0	Up to 300 (4.5%)	4-6	14	8.9	17.5	4,600	1.0-1.5	10	300	20-40
Lockwood	Adjacent to powerhouse (shore side)	west	In line with discharge flow	6	>3.0	170 (2.9%)	4-6	6-18	8	TBD	1,800	1.0-1.5	n/a	n/a	n/a

Table 6–3: Daily and Seasonal Operations Summary for the Pejepscot, Lockwood, and Milford Project Fish Lifts.

Project	Lift Start Date	Lift End Date	Lift Start Time	Lift End Time	Lift Schedule	Automated	Operation Schedule if not Automated	Notes
Pejepscot	15-Apr	15-Nov	0800	1800	5 lifts per day	Y	Can be operated manually	
Milford	15-Apr	15-Nov	0400	2200	2 lifts per hour	Y	Can be operated manually	
Lockwood	1-May	31-Oct	0700	1900	5-8 per day in consult with MDMR	N	Based on visual assessment from underwater camera	operations are suspended when water temperature reach 24.5ºC

7 SUMMARY OF PASSAGE POTENTIAL

In their SPD, FERC requested Topsham Hydro conduct a desktop analysis to assess the potential effectiveness of the existing Pejepscot fish lift for the upstream passage of adult Atlantic Salmon. In an effort to accommodate this request, studies detailing the timeliness and effectiveness of fish lifts in operation elsewhere in Atlantic Salmon critical habitat in Maine were reviewed. Projects considered included Milford, the first mainstem hydroelectric on the Penobscot River, and Lockwood, the first mainstem hydroelectric on the Kennebec River. In general, the operation and configuration of the existing Pejepscot fish lift is most similar to the fish lift in operation at Milford. Both structures have 10 foot wide entrances which are located on the shoreline side of the powerhouse and are oriented parallel to the adjacent competing flow. The dam and powerhouse structure at Milford and Pejepscot are positioned linearly with one another. In addition, both structures operate following criteria presented in the most recent USFWS guidelines with regards depth over the entrance weir and entrance/hopper velocities. The lift and project layout at Lockwood differs somewhat from the other two project locations in that the entrance width is slightly narrower. However, the largest difference separating Lockwood from Milford and Pejepscot is the presence of the 1,300 foot long bypassed reach. As result the dam and powerhouse structure do not sit linearly across the river but are offset allowing for approaching fish to move past the lift entrance and move upstream into the bypassed reach.

In general, the fish lift assessments conducted to date for adult Atlantic Salmon demonstrate a high overall passage rate coupled with relatively long duration of time from arrival at the Project until recapture. When all adults released at Milford during 2014 and 2015 are considered, 96% of the radio-tagged adults were successfully recaptured at the fish lift. However, values for the median period of residence downstream of the dam following return to the Project area ranged from 1.1 days to 7.8 days depending on the year and investigator (i.e., licensee vs University of Maine). Recapture rates were somewhat lower (79%) and the median period of residence prior to recapture was longer (9.8-16 days) for adult salmon approaching Lockwood. Based on observations of radio-tagged adult salmon movements within the downstream project area at Lockwood, those rates are very likely a function of false attraction to competing flows present in the extended bypassed reach at that location. At the present time, the Licensee for Lockwood is assessing options for an additional fish passage structure at the upstream end of the bypassed reach to improve the timeliness of passage.

Based on consideration of adult salmon passage study results from elsewhere in Maine as well as the review of the physical and operational designs for those fish lifts relative to the structure at Pejepscot, it is most likely that the Pejepscot lift will have a rate of effectiveness for passing adult salmon between that estimated at Milford and Lockwood. Due to the lack of an extended downstream bypass reach it is likely that salmon approaching Pejepscot will pass at a higher rate and in less time than was observed over the two study years at Lockwood. Similarities in entrance width, operating flows, and the spatial layout of the entrance, powerhouse discharge and downstream face of the dam suggest the overall ability of adult salmon to pass at Pejepscot could be similar to the rate observed at Milford. However, it is likely that the time from initial arrival downstream of the Project until recapture in the fish lift at Pejepscot could be longer than durations observed at Milford due to the relative infrequency with which the fish lift is run. The Milford lift runs in an automated mode from 0400 to 2200 with a minimum of two lift events per hour (approximately 36 lift cycles per day). As presently programmed the lift at Pejepscot runs a total of five lift cycles per day between the hours of 0800 and 1800.

As described in the *Evaluation of Spring Migration Season Fish Passage Effectivenes*s study report, the effectiveness of the Pejepscot fish lift was evaluated for adult river herring and American shad during the 2019 upstream passage season. A total of 93% of the radio-tagged adult herring determined to have approached Pejepscot were detected on at least one occasion within the entrance to the fish lift. Nearfield attraction for adult American shad was lower than that observed for river herring with only 19% of radio-tagged individuals determined to have approached Pejepscot detected within the entrance to the fish lift. The overall effectiveness of the Pejepscot fish lift for adult river herring passage during 2019 was estimated at 20%. Observations from the 2019 river herring observation suggested that due to the relative infrequency of lift opportunities, radio-tagged herring moved around the region immediately downstream of the dam. Radio-tagged adult river herring which failed to ultimate pass upstream of the project were noted to spend a disproportionate amount of time spent in areas of false attraction from spill. There were no recorded upstream passage events for radio-tagged shad during the 2019 Pejepscot study period.

Similar evaluations of upstream passage effectiveness for adult alosines have previously been conducted for the Milford and Lockwood fish lifts. Effectiveness of the Milford fish lift was evaluated for adult river herring during 2019 (Normandeau 2020). Similar to Pejepscot, the nearfield attraction rate was high for radio-tagged adult herring at Milford with 95% of individuals detected on at least one occasion within the entrance to the fish lift. In contrast, the overall effectiveness of the Milford fish lift for adult river herring passage during 2019 was estimated at 65%. Differences in the efficiency rate for river herring at the Pejepscot and Milford fish lifts may be related to a number of factors including differences in attraction flow and frequency of fish lifts occurrences. The effectiveness of the Lockwood fish lift for attracting and passing adult American shad was evaluated during 2009 and 2015 (ASA 2010; Normandeau 2016). There were no observations of radio-tagged adult shad entering the Lockwood fish lift during either evaluation. A proportion of individuals during both study years were observed to move in and out of the bypassed reach and hold at locations in the Kennebec River downstream of the Project. Similarly, radio-tagged adult shad at Pejepscot were detected downstream of the spillway section and in the reach below the dam and downstream to Brunswick.

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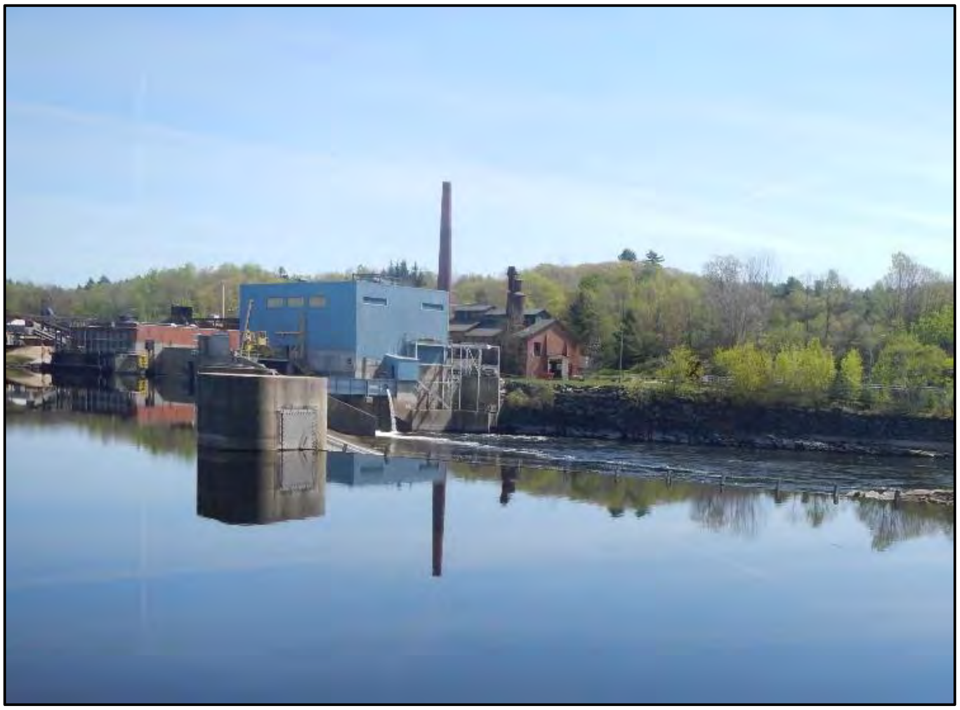
DRAFT UPDATED STUDY REPORT

LARGEMOUTH AND SMALLMOUTH BASS SPAWNING HABITAT SURVEY

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)



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April 2020

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND DEFINITIONS

FERC	Federal Energy Regulatory Commission
ILP	Integrated Licensing Process
Licensee	Topsham Hydro Partners Limited Partnership
MDIFW	Maine Department of Inland Fisheries and Wildlife
ME	Maine
NOI	Notice of Intent
PAD	Pre-Application Document
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
RSP	Revised Study Plan
Topsham Hydro	Topsham Hydro Partners Limited Partnership
SD1	Scoping Document 1
SPD	Study Plan Determination

1.0 INTRODUCTION

Topsham Hydro Partners Limited Partnership (L.P.) (Topsham Hydro or Licensee), an indirect member of Brookfield Renewable, is in the process of relicensing the 13.88-megawatt Pejepscot Hydroelectric Project (Project) (FERC No. 4784) with the Federal Energy Regulatory Commission (FERC). The Project is located on the Androscoggin River in the village of Pejepscot and the Town of Topsham, Maine (ME) to the east, the Town of Lisbon to the north, and the Towns of Durham and Brunswick, ME to the west. The Project straddles the border between Cumberland and Sagadahoc counties and extends into Androscoggin County. The original license was issued on September 16, 1982 and expires on August 31, 2022.

The Licensee is using FERC's Integrated Licensing Process (ILP) as established in regulations issued by FERC July 23, 2003 (Final Rule, Order No. 2002) and found at Title 18 Code of Federal Regulations, Part 5. The Licensee filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to seek a new license for the Project on August 31, 2017.

The Licensee distributed the PAD and NOI simultaneously to Federal and state resource agencies, local governments, Native American tribes, members of the public, and others thought to be interested in the relicensing proceeding. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on October 30, 2017. FERC also held agency and public scoping meetings on November 28, 2017 and a site visit on November 29, 2017. The FERC Process Plan and Schedule provided agencies and interested parties an opportunity to file comments on the PAD and SD1 and request studies by December 29, 2017. FERC subsequently issued Scoping Document 2 on February 5, 2018. The Licensee filed a Proposed Study Plan on February 12, 2018 and held a Study Plan Meeting on March 22, 2018. The Revised Study Plan (RSP) was filed in accordance with the ILP schedule on June 12, 2018. FERC issued a Study Plan Determination (SPD) on July 3, 2018.

In the RSP, the Licensee proposed to conduct a Largemouth and Smallmouth Bass Spawning Habitat Survey to provide information regarding bass spawning habitat within the Project impoundment in lieu of the Maine Department of Inland Fisheries and Wildlife (MDIFW) requested Bass Population Study.

2.0 GOALS AND OBJECTIVES

The goal of the evaluation was to provide information regarding the spawning activities of Largemouth and Smallmouth Bass in the Project impoundment. The study objective was to document bass spawning habitat, and nesting areas with differentiation by species within the Project impoundment.

3.0 BACKGROUND AND EXISTING INFORMATION

MDIFW indicated that bass species are one of the most sought sport fish species by ME recreational anglers. Existing data indicate that Smallmouth Bass are one of the most abundant resident sport fish located in the Project area, and likely provide the predominant recreational fishery resource.

Electrofishing surveys were performed along 0.6 miles of shoreline at each of three sites in the vicinity of the Project by Yoder *et al*., (2006) in late July 2003. Because of the seasonal timing of the surveys, data were primarily representative of the resident fish assemblage. Overall, 16 species were captured from the areas downstream of Worumbo Dam to the areas downstream of Pejepscot Dam, and relative abundance varied between the sites sampled. Overall, the catch was dominated by cyprinids and/or centrarchids. The highest abundance was observed in the Project impoundment, primarily due to large numbers of spottail shiner captured there. Because many individuals collected during the surveys were small or juvenile fish, biomass by species shows a different pattern, with Smallmouth Bass and White Sucker dominating the overall fish biomass in the riverine areas upstream of the Project impoundment and below the Project dam. Smallmouth Bass and Yellow Perch followed by Redbreast Sunfish dominated the fish biomass in the Project impoundment.

In the SPD, FERC indicated that the existing data was sufficient to provide information on the fish assemblage and did not require the Largemouth and Smallmouth Bass Spawning Habitat Survey. However, the Licensee elected to conduct this reconnaissance level survey of bass spawning habitat activity to supplement the existing data.

4.0 METHODS

4.1 Literature Review

Prior to conducting the field investigation, a desktop literature review was performed to determine when Largemouth and Smallmouth Bass in the Project area typically spawn. In addition to the timing of spawning, identification of typical habitat types used by Largemouth and Smallmouth Bass for spawning, as well as spawning behavior and habits were reviewed to aid in the subsequent field survey.

4.2 Field Survey

The study area for the field survey was the Project impoundment from the Pejepscot dam boat barrier upstream to the Route 125 Bridge (approximately 600 ft downstream of the Worumbo dam). The field survey took place on June 18, 2019. Visual observations were made by systematically traversing the littoral zone via boat and wading to identify any Largemouth and Smallmouth Bass nests, egg masses/deposits, and spawning habitat. Underwater view tubes were used to identify spawning nests/habitats where they could not be easily identified from the surface. Water quality parameters were collected at various times during the survey. Where possible, water velocity data was collected at nests, nest characteristics and water depths were collected, and water clarity was estimated.

5.0 RESULTS

5.1.1 Literature Review

Table 5.1.1-1 provides information on various aspects of Largemouth and Smallmouth Bass spawning habitat requirements.

The habitat suitability index model for Largemouth Bass (Stuber and Maughan, 1982) indicates that optimal riverine habitat includes large slow-moving rivers or pools of streams with soft bottoms, aquatic vegetation and relatively clear water with a low gradient. Optimal lacustrine habitat includes large shallow areas to support submergent vegetation and deeper areas for overwintering. In the case of both environments, cover should be 40 to 60% of the pool or littoral area with low current velocity. Largemouth Bass spawning typically begins when water temperatures reach 12.0-15.5°C and most of spawning takes place when water temperatures are between 16-22°C. The preferred substrate for Largemouth Bass spawning is gravel, however, they will nest on a wide range of other substrates including cobble, sand, mud, roots, and vegetation. Nests are typically built in one to three feet of water but have been documented in areas between 0.5 to 24 feet of water.

The habitat suitability index model for Smallmouth Bass (Edwards and Maughan, 1983) indicates that optimal riverine habitat includes cool, clear waters with abundant cover or shade, deep pools, moderate current, and substrates of rubble or gravel. Optimal lacustrine habitat includes large, clear lakes and reservoirs with rocky shoals or areas of broken rock and boulder substrate. Smallmouth Bass are very cover oriented and utilize deep, dark quiet waters and submerged covers like crevices, rocks, boulders, trees, roots, and stumps. Smallmouth Bass spawning takes place from mid-April to July when water temperatures reach 12.8-21.0°C. Spawning typically occurs in river shallows or backwater areas with stone, rock, or gravel substrates. They will build nests over bedrock, rootlets in silt or sand if the preferred gravel substrate is unavailable.

5.1.2 Field Survey Results

The field survey took place on June 18, 2019 when appropriate visual conditions in the littoral zone were present, and the Project impoundment was at the normal pool elevation of 67.2 feet, mean sea level. At the start of the field survey (11:15 am), weather conditions were overcast with calm winds and flat water leading to good visual conditions with slightly dark water. The average daily river flow was 2,000 cubic feet per second as measured at the Auburn, ME United States Geological Survey gage. At the start of the survey, water temperature at the surface was 19.6°C, dissolved oxygen was 8.68 mg/L, dissolved oxygen saturation was 94.7%, and the secchi disk reading was 8.3 feet deep. During the survey, water temperature was also taken at identified nest locations (Table 5.1.2-5). The average water temperature over the entire survey period was 21.4°C.

A total of 19 individual areas were identified in the Project impoundment as potential bass spawning habitat locations; six of these spawning habitat locations contained nest sites within them. Areas with potential spawning habitat were identified based on habitat suitability criteria such as cover and substrate. Figure 5.1.2-1 displays the map of recorded nest and potential spawning habitat locations identified during the survey. Thirteen potential spawning habitat locations were located on the left bank[1] of the Project impoundment and six potential spawning habitat locations were located on the right bank. Table 5.1.2-1 and 5.1.2-2 summarize the field observations for each spawning habitat location identified.

[1] Assumes looking downstream

Most spawning habitat locations were characterized by multiple substrates. Of the areas where substrate was identified and recorded, twelve locations contained sand substrates, fourteen locations contained mud substrates, seven locations contained a mixture of vegetation, woody debris, or other detritus, one location contained gravel, and one location contained bedrock. Additional habitat criteria such as cover was also considered when delineating potential habitat areas.

A total of six spawning habitat locations contained depressions where nest information was collected (Table 5.1.2-3 and 5.1.2-4). Data were collected for ten individual nests. Table 5.1.2-5 summarizes the nest information that was collected. Of these ten nests, five had fines/sand substrates, two had mud substrates, one had sand/detritus, one had a mixtures of gravel/fines/sand substrate and one had mud/sand/detritus substrate. No egg deposits were found in any of the nests and no bass were present in the nests. Six nests had sparse vegetation, one nest had abundant vegetation, and three nests had no vegetation. Of the observed nests, only one was determined to be a Smallmouth Bass nest based on size and substrates present. However, no Largemouth or Smallmouth Bass were present on nests at the time of the survey to allow for complete identification. The majority of nests contained characteristics consistent with Largemouth Bass habitat requirements. At NLB 2, the four depressions were determined to be from the previous year based on accumulated detritus in the nests. Nest areas are swept or cleaned out during nest building. Approximate diameters of the nests ranged from eight inches to thirty-six inches. Figure 5.1.2-2 to 5.1.2-7 provide representative photographs of the six nest locations were data were collected.

Table 5.1.1-1: Literature Review Summary

Species	Spawning Period	Spawning Water Temperatures	Preferred Spawning Substrate	Additional Substrates	Preferred Water Depths	Optimal Riverine Habitat	Cover Requirements
Largemouth Bass	Late Spring to mid-Summer (peak early to mid-June)	16-22°C	Gravel	Vegetation, roots, sand, mud, cobble	1-3 feet (Nest building is documented as ranging from 0.5 ft to 24 ft)	Large, slow moving rivers or pools, soft bottoms, aquatic vegetation, and relatively clear water	Vegetation (40-60% of littoral area)
Smallmouth Bass	Mid-April-July	12.8-21.0°C	Clean stone, rock, or gravel	Bedrock, rootlets in silt or sand.	1-3 feet (Nest building is documented up to 23 feet)	Cool, clear rivers, with abundant shade/cover, deep pools, moderate current, gravel or rubble substrate	Strong cover seeking behavior. Deep dark quiet water, boulders, rocks, stumps, root masses trees, and crevices

Table 5.1.2-1: Spawning Habitat Locations-Left Bank

Location Number	Location Description	Substrate Description	Nest Observed	Nest Size	Bass Observed	Comments
LB 1	Protected shallow area, crib, concrete structures	None recorded	No	NA	No	Some suitable area + substrate
LB 2	Small protected area next to large pipe	Suitable substrate present (not described)	No	NA	No	
LB 3	Mouth of Little River	None recorded	No	NA	2 SMB (9-11”) caught while blind casting	Water too turbid and covered in foam to see
LB 4	Strip of sand and mud	Sand, mud,	No	NA	No	Small areas of suitable substrate along shore
LB 5	Back cove area	Mud/Sand, woody debris	No	NA	1 SMB (10”) caught on rocks outside of cove	No bass nests observed. Sunfish nest building observed.
LB 6	2 areas on shallow rocks and bedrock cleared	bedrock	No bass nests observed.	Not Recorded	No	1 nest guarded by Redbreast sunfish
LB 7	Backwater area	Mud flat with weeds	No	NA	1 (SMB 11”) in backwater	Good visibility
LB 8	Back Basin	Mud, detritus, sparse vegetation	Yes (not counted)	NA	No	Old depressions found in mud onshore (south

Location Number	Location Description	Substrate Description	Nest Observed	Nest Size	Bass Observed	Comments
						portion)
LB 9	Back Cove with tributary Mouth	Mud, sand, thick weed flat	No	NA	No	Spawning sunfish observed. Sunfish nests present.
LB 10	Shallow, narrow flat	None recorded	Yes (n=5) old depressions with detritus	1 foot across. 0.15 ft nest depth	No	Water depth 0.9 ft
LB 11	Point bar downstream end of island	Sand	No	NA	No	Sunfish observed
LB 12	Long narrow shoreline weed flat	Mud/Sand	No	NA	No	
LB 13	Tiny tributary mouth with small flat	Mud/Sand	Yes (n=1)	NA	No	Depressions with detritus and sunfish observed

Table 5.1.2-2: Spawning Habitat Locations-Right Bank

Location Number	Location Description	Substrate Description	Nest Observed	Nest Size	Bass Observed	Comments
RB 1	Furthest downstream island tip. Shallow point bar	Not recorded	No	NA	No	
RB 2	Flat upstream of island along RB	Mud bottom, vegetation and woody debris	No	NA	No	
RB 3	Small sand flat	sand	No	NA	No	
RB 4	Big shallow area	Mud	Yes (n=6+ depressions)	Not recorded	No	
RB 5	Small tributary back cove	Sand/Mud	Yes (n=5 depressions)	NA	No	
RB 6	Shallow weedy sand flat	Sand/vegetation	Yes (n=5 depressions)	Not recorded	No	

Table 5.1.2-3: Spawning Nests-Left Bank

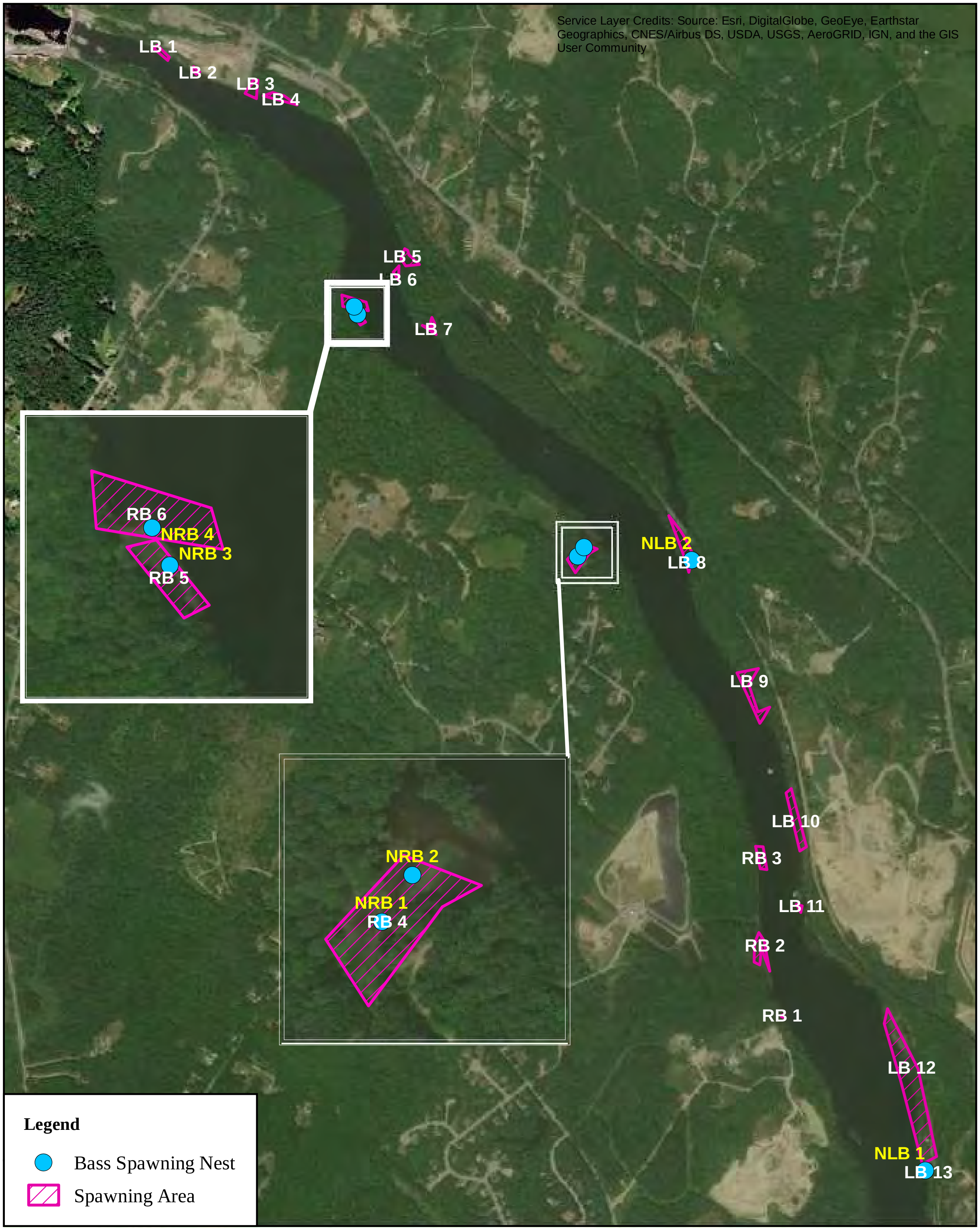
Nest Location Number	Spawning Habitat Location	Location Description	Substrate Description	Nest Observed	Nest Size	Bass Observed	Comments
NLB 1	LB 13	Protected shallow area, crib, concrete structures	Gravel, muddy clay	Yes	15”	No	
NLB 2	LB 8	Small protected area next to large pipe	Sand, mud, detritus	Yes	24”	No	Last year’s nest. Nest were out of water at 14:15 in afternoon. Revisited at 17:35

Table 5.1.2-4: Spawning Nests-Right Bank

Nest Location Number	Spawning Habitat Location	Location Description	Substrate Description	Nest Observed	Nest Size	Bass Observed	Comments
NRB 1	RB 4	Cove	Mud	Yes (n=6)	8-21”	No	Appears water level has dropped due to sedimentation on bank
NRB 2	RB 4	Downstream of NRB 1 on opposite side of backwater channel	Mud	Yes (n=2)	20”	No	
NRB 3	RB 5	Small sand flat	Fine/Sand	Yes (n=5+)	18-36”	No	No bass fry. Multiple depressions connected
NRB 4	RB 6	Big shallow area	Sand/ detritus	Yes (n=5)	12-18”	No	

Table 5.1.2-5: Spawning Nest Data Summary

Nest Location Number	Time	Water Temperature	Water Depth (ft)	Nest Depth (ft)	Velocity (ft/sec)	Substrate	Outer Diameter (inches)	Fish Present	Vegetation	Comment
NLB 1	15:15	20.8	1.1	0.2	-0.24	Gravel, fines+sand	24	No	Sparse	
NLB 2	17:35	20.5	0.5	0.3	0	Mud, sand, detritus	24	No	Yes	
NRB 1	16:25	21.5	0-0.25	0.33-0.5	0	Mud	21	No	Sparse	
NRB 2	16:32	21.5	0.16	0.5	0	Mud	20	No	Sparse	
NRB 3	16:50	21.9	0	0.5	0	Fines+sand	24	No	Sparse	
NRB 3	16:50	21.9	0	0.5	0	Fines+sand	30	No	Sparse	
NRB 3	16:50	21.9	0.1	0.3	0	Fines+sand	36	No	No	
NRB 3	16:50	21.9	0.1	0.4	0	Fines+sand	18	No	No	
NRB 3	16:50	21.9	0.1	0.3	0	Fines+sand	24	No	No	
NRB 4	17:05	21.5	0.3	0.4	0	Sand/detritus	18	No	Sparse	Last year's nests



Brookfield

N

0 500 1,000 2,000 Feet

Pejepscot Hydroelectric Project
(FERC No. 4784)
Bass Spawning Survey

Figure 5.1.2-1:
Observed Potential
Spawning Habitat Areas

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Figure 5.1.2-2: Nests found at Spawning Habitat Location LB 13 (Nest Site-NLB 1)

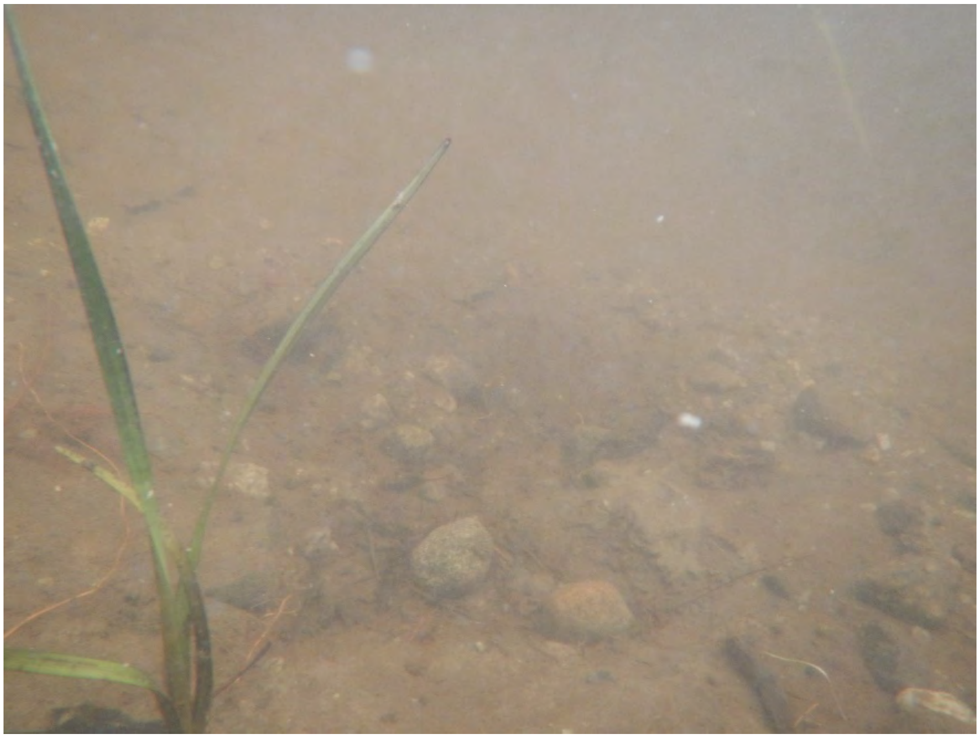


Figure 5.1.2-3: Nests found at Spawning Habitat Location LB 8 (Nest Site-NLB 2)

Figure 5.1.2-4: Nests found at Spawning Habitat Location RB 4 (Nest Site-NRB 1)

Figure 5.1.2-5: Nests found at Spawning Habitat Location RB 4 (Nest Site-NRB 2)

Figure 5.1.2-6: Nests found at Spawning Habitat Location RB 5 (Nest Site-NRB 3)

Figure 5.1.2-7: Nests found at Spawning Habitat Location RB 6 (Nest Site-NRB 4)

6.0 SUMMARY

There are several suitable spawning habitats in the Project impoundment for bass species, some of which appear to be actively used for spawning. The majority of nest and habitat identified during the survey are presumed to be for Largemouth Bass based on habitat preference. The placement of nests in soft bottom substrate areas (mud, sand, vegetation) are indicators of Largemouth Bass habitat. Only one nest was identified as a possible Smallmouth Bass nest due to the presence of gravel and its location along the impoundment shoreline (as opposed to backwater areas). No bass were observed on the nests, making full identification difficult. Angling during the survey resulted in the catch and release of Smallmouth Bass at two locations (LB 3 and LB 5) and one observed bass at LB 7.

7.0 VARIANCES FROM THE FERC APPROVED STUDY PLAN

The study plan originally anticipated two individual surveying events. The available window for the survey occurred in June when water temperatures were at the high end of the spawning temperature spectrum for both bass species. It was determined that both species would have spawned by the time of the survey, therefore only one survey was needed.

8.0 REFERENCES

Edwards, E.A., G. Gebhart, and O.E. Maughan. 1983. Habitat suitability information: Smallmouth bass. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.36.

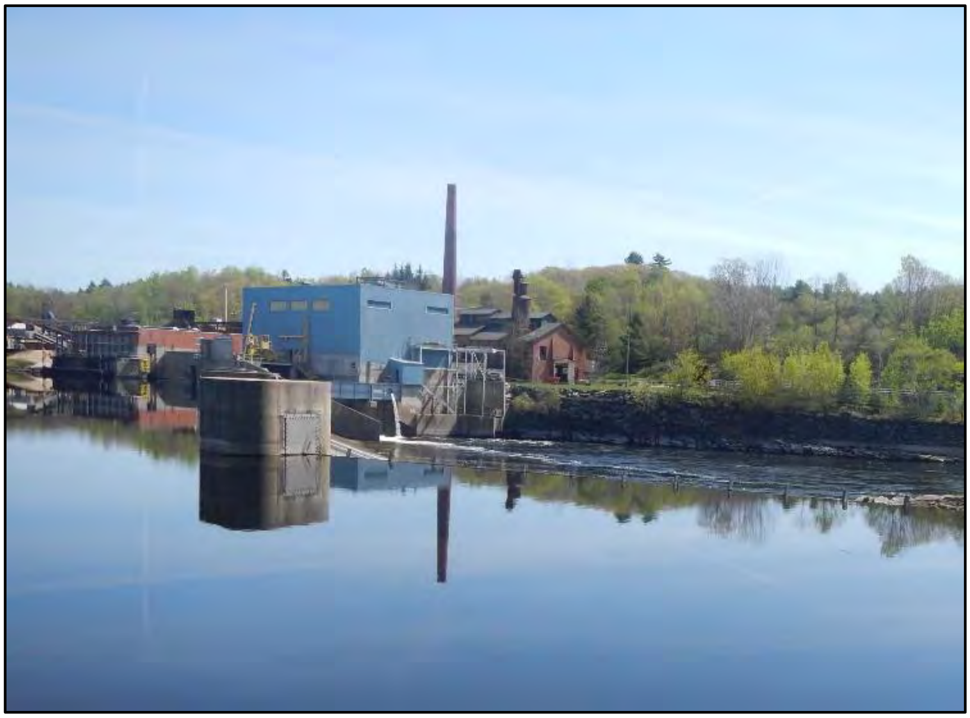
Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: Largemouth bass. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.16.

Yoder, C.O., B.H. Kulik, J.M. Audet, and J.D. Bagley. 2006. The Spatial and Relative Abundance Characteristics of the Fish Assemblages in Three Maine Rivers. Technical Report MBI/12-05-1. September 1, 2006.

DRAFT UPDATED STUDY REPORT

STRANDING EVALUATION

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)



Submitted by:

Brookfield Renewable
Topsham Hydro Partners Limited Partnership
150 Main Street
Lewiston, ME 04240

Prepared by:

GOMEZ AND SULLIVAN ENGINEERS

April 2020

Brookfield

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS AND DEFINITIONS

FERC	Federal Energy Regulatory Commission
ILP	Integrated Licensing Process
ME	Maine
MW	Megawatt
NOI	Notice of Intent
PAD	Pre-Application Document
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
RSP	Revised Study Plan
Topsham Hydro	Topsham Hydro Partners Limited Partnership
SD1	Scoping Document 1
SPD	Study Plan Determination

1.0 INTRODUCTION

Topsham Hydro Partners Limited Partnership (L.P.) (Topsham Hydro), an indirect member of Brookfield Renewable, is in the process of relicensing the 13.88-megawatt (MW) Pejepscot Hydroelectric Project (Project) (FERC No. 4784) with the Federal Energy Regulatory Commission (FERC). The Project is located on the Androscoggin River in the village of Pejepscot and the Town of Topsham, Maine (ME) to the east, the Town of Lisbon to the north, and the Town of Durham and the Town of Brunswick, ME to the west. The Project straddles the border between Cumberland and Sagadahoc counties and extends into Androscoggin County. The original license was issued on September 16, 1982 and expires on August 31, 2022.

Topsham Hydro is using FERC's Integrated Licensing Process (ILP) as established in regulations issued by FERC July 23, 2003 (Final Rule, Order No. 2002) and found at Title 18 Code of Federal Regulations, Part 5. Topsham Hydro filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to seek a new license for the Project on August 31, 2017.

Topsham Hydro distributed the PAD and NOI simultaneously to Federal and state resource agencies, local governments, Native American tribes, members of the public, and others thought to be interested in the relicensing proceeding. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on October 30, 2017. FERC also held agency and public scoping meetings on November 28, 2017 and a site visit on November 29, 2017. The FERC Process Plan and Schedule provided agencies and interested parties an opportunity to file comments on the PAD and SD1 and request studies by December 29, 2017. FERC subsequently issued Scoping Document 2 on February 5, 2018. Topsham Hydro filed a Proposed Study Plan on February 12, 2018 and held a Study Plan Meeting on March 22, 2018. The Revised Study Plan (RSP) was filed in accordance with the ILP schedule on June 12, 2018. FERC issued a Study Plan Determination (SPD) on July 3, 2018.

In the RSP, Topsham Hydro proposed to conduct a stranding evaluation to provide information regarding the potential for fish stranding below the Project spillway.

2.0 GOALS AND OBJECTIVES

The goal of the evaluation was to provide information regarding the potential for fish stranding below the Project spillway. The study objective was to determine if potential stranding pools are present in the ledges immediately below the western end of the Project spillway, after spill operations cease.

3.0 BACKGROUND AND EXISTING INFORMATION

As noted in the RSP, prior to conducting this evaluation there was no existing information regarding stranding-prone areas or operational scenarios for the Project. This study was needed to quantify Project effects on a potential source of fish mortality and injury.

On September 12, 2018, the reconnaissance-level field survey portion of the study was conducted jointly with representatives from Topsham Hydro, Gomez and Sullivan Engineers, D.P.C., Normandeau Associates, Inc., the National Marine Fisheries Service, the United States

Fish and Wildlife Service, and the Maine Department of Marine Resources participating. Streamflow, as recorded at the Androscoggin River at Auburn, ME United States Geological Survey gage, was approximately 2,230 cubic feet per second. Before the survey began, all streamflow at the Project was passed through bascule gate No. 1, as the Project turbines were out-of-service (Figure 3.0-1).

Figure 3.0-1: Flow Conditions before Stranding Evaluation Survey

4.0 METHODS

4.1 Operational Data Review

Prior to conducting the field investigation, a desktop literature review was performed to gather information on the typical sequencing of bascule gate operations, as well as the frequency of annual spill operations at the Project. This information was used to determine the inflow and operational conditions under which the ledges might experience variable flows.

4.2 Field Survey

The study area for the field survey was focused upon the exposed bedrock area on the right side (looking downstream) of the Project dam, below bascule gate No. 5. The field survey consisted of lowering bascule gate No. 5, and simultaneously raising bascule gate No. 1. The objective of this operation was to convey all streamflow through bascule gate No. 5, onto the exposed bedrock area. After completion of this operation and bascule gate No. 5 was fully lowered and bascule gate No. 1 was fully raised, the operation would be reversed. Once the reverse operation was complete, and all streamflow was again passed through bascule gate No. 1, the exposed bedrock area on river right would be investigated for the occurrence of potential stranding pools. The field survey was photo-documented and videotaped.

5.0 RESULTS

The survey participants convened on river left, near the Project powerhouse, to view the bascule gate operations. Lowering of bascule gate No. 5 and the raising of bascule gate No. 1 began at 9:19 am (Figure 5.0-1)[1]. The total elapsed time to complete this operation was approximately 18 minutes (Figure 5.0-2). The operation of the gates was then reversed, and bascule gate No. 5 was returned to the fully raised position and bascule gate No. 1 was returned to its previously lowered position (total elapsed time approximately 16 minutes). Figure 5.0-3 shows a view from river left of the exposed bedrock area shortly after bascule gate No. 5 was fully raised.

The survey participants then traveled to river right to more closely view the exposed bedrock area. Due to safety precautions, the exposed bedrock area was not traversed. However, the survey participants did view the study area from the streambank top, where a several potential stranding pools were noted in the bedrock outcrop (Figure 5.0-4).

The survey participants discussed potential mitigation options to alleviate the stranding potential of the pools within the bedrock area. Options discussed included the following:

1. After a typical lowering and raising operation of bascule gate No. 5, Project operations staff could survey the pools in the bedrock area for any stranded fish, and steps could be taken to return fish to the river, if necessary;

[1] Videotape documentation of the bascule gate operations was collected, and is available using the following links:
Crest Gate Lowering =>https://www.youtube.com/watch?v=UM0Sy04KUgk&t=21s
Crest Gate Raising=>https://www.youtube.com/watch?v=-2JvSlDQC20&t=13s

2. The potential stranding pools could be filled with concrete/grout to prevent their occurrence, and remove the fish stranding hazard; and

3. Excavation of channels in the bedrock could be performed to allow for draining of the pools and egress of any fish within the pools.

Figure 5.0-1: Initiation of Bascule Gate Operation (9:19 am)

Figure 5.0-2: Bascule Gate No. 5 in Fully Lowered Position (9:37 am)

Figure 5.0-3: Exposed Bedrock Area Below Bascule Gate No. 5 (9:54 am)

** As viewed from river left shortly after Bascule Gate No. 5 was returned to the fully raised position*

Figure 5.0-4: Exposed Bedrock Area Below Bascule Gate No. 5 (10:31 am)

** As viewed from river right shortly after Bascule Gate No. 5 was returned to the fully raised position*

6.0 SUMMARY

Several potential stranding pools were noted in the bedrock outcrop on the right side of the Project dam, below bascule gate No. 5. The survey participants discussed several potential mitigation options to alleviate the stranding potential in this area, including: 1) conducting surveys of the pools following spill operations to locate any stranded fish and return them to the river, if necessary; 2) filling the potential stranding pools with concrete/grout to prevent future fish stranding; or 3) excavation of channels in the bedrock to allow for draining of the pools and egress of any fish with the pools.

7.0 VARIANCES FROM THE FERC APPROVED STUDY PLAN

The methodology proposed in the RSP called for on-ground surveys to traverse any pools, visually document fish present, and look for fish trapped under rocks. Due to safety concerns, field crews were not permitted to traverse the pools where potential stranding could occur. Instead, field crews observed the potential stranding areas from an elevated position along the adjacent bank.

DRAFT UPDATED STUDY REPORT

TAILRACE AQUATIC HABITAT STUDY

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)

Submitted by:

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Topsham Hydro Partners Limited Partnership
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April 2020

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND DEFINITIONS

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GPS	Global Positioning System
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ME	Maine
NOI	Notice of Intent
PAD	Pre-Application Document
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
PSP	Proposed Study Plan
RSP	Revised Study Plan
SD1	Scoping Document 1
SPD	Study Plan Determination
Topsham Hydro	Topsham Hydro Partners, L.P.

1.0 INTRODUCTION

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In the RSP, Topsham Hydro did not adopt the agency requested Sediment Storage and Mobility Study. However, the SPD issued by FERC required that the Licensee conduct an aquatic habitat inventory to characterize aquatic habitat and substrate in the un-impounded stream reach below the Project.

2.0 GOALS AND OBJECTIVES

The goal of the survey is to gather information on the quality of habitat in the un-impounded river section downstream of the Project dam.

The objective includes characterizing the aquatic habitat and substrate in the un-impounded downstream reach

3.0 METHODS

3.1 <u>Field Data Collection</u>

3.1.1 Mesohabitat Mapping

The aquatic habitat in the un-impounded reach downstream of the Project dam (Figure 3.1.1-1) was characterized by mesohabitat type (i.e., riffle, run, pool, etc.). Data were collected using a field computer equipped with Global Positioning System (GPS) and ArcGIS. Mesohabitat polygons were delineated in the field based on visual assessment. The survey was conducted on August 13, 2019 at a river flow of approximately 1,990 cfs, as measured at the Androscoggin River near Auburn, ME USGS streamflow gage (No. 01059000).

3.1.2 Substrate Data Collection

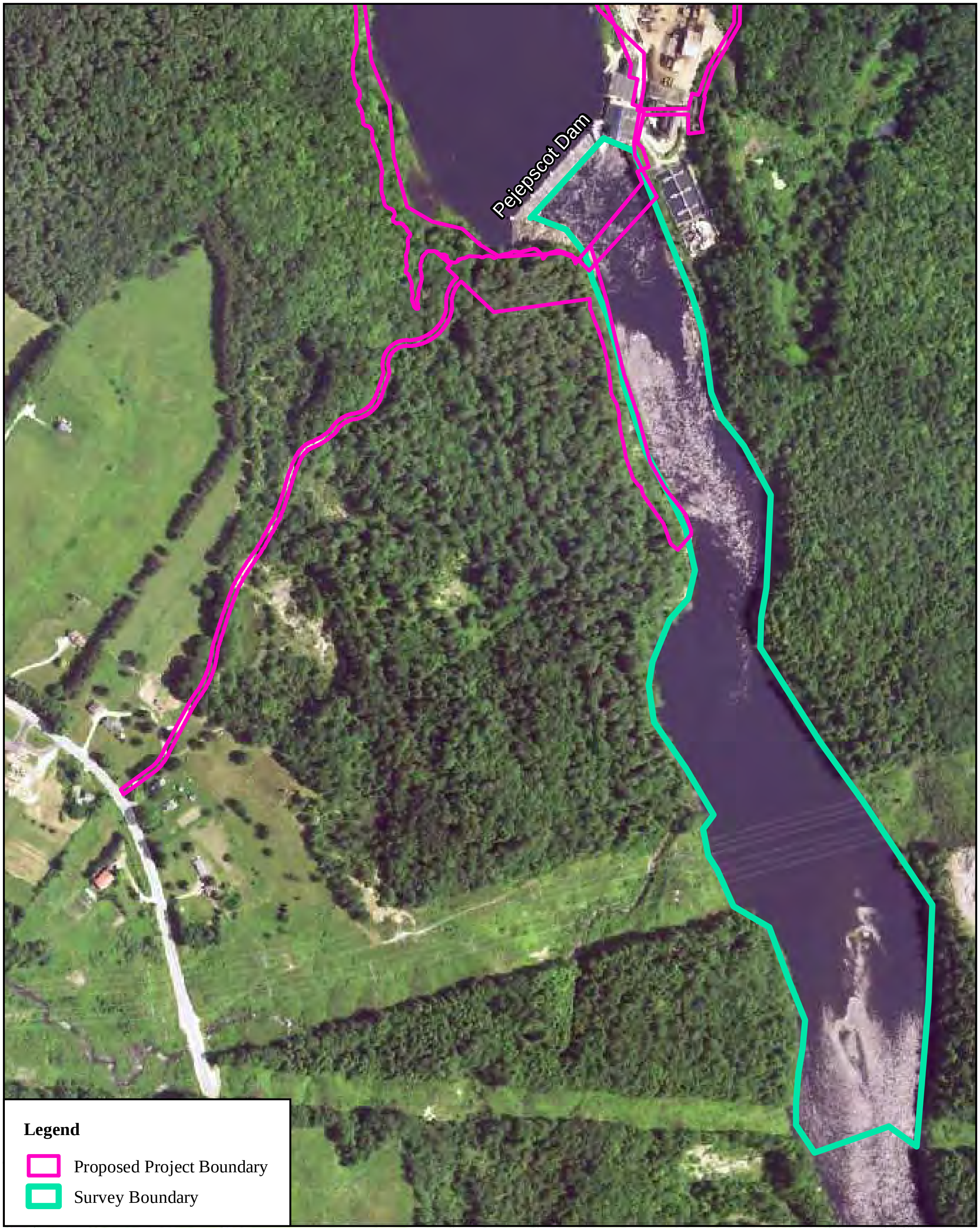
Substrate data (i.e., primary, secondary, and tertiary component types) within the study area were collected based on visual assessment, and delineated using a field computer equipped with GPS and ArcGIS. Areas too deep to evaluate visually, either while wading or using an AquaScope from a boat, were surveyed with probing rods that allowed for substrate identification by feel. Table 3.1.2-1 displays the coding system used to characterize the substrate types encountered during the field survey.

3.1.3 Data Processing and GIS Mapping

Data collected on the GPS equipped field computers was imported into an ArcGIS database for further analysis and quality assurance. Maps for habitat and substrate were developed.

Table 3.1.2-1: Field Survey Substrate Codes

Substrate	Code	Grain Size (in)
Detritus/Organic	DO	--
Mud	MD	--
Silt	ST	--
Sand	SD	--
Gravel (fine)	GRf	0.15-0.6
Gravel (small)	GRs	0.6-1.25
Gravel (large)	GRl	1.25-2.5
Cobble	CO	2.5-5
Rubble	RB	5-10
Boulder (small)	BLs	10-24
Boulder (large)	BLl	24+
Smooth Bedrock	BRs	--
Complex Bedrock	BRc	--



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Pejepscot Hydroelectric Project
(FERC No. 4784)
Tailrace Aquatic Habitat Study

Figure 3.1.1-1:
Tailrace Aquatic Habitat Survey Location

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4.0 RESULTS

4.1 Mesohabitat Results

Six major mesohabitat categories were identified during the field survey, including backwater, glide, pool, riffle, run, and other. Other was used to denote habitats that were out of the water at the time of the survey. A total of thirty-five individual mesohabitat units were delineated during the field survey. Figure 4.1-1 is a map displaying the location of mesohabitats identified during the field survey. Table 4.1-1 provides information on the percentage breakdown of each mesohabitat type.

Backwater habitats are defined as water backed up in its course as compared with its normal or natural condition of flow (Langbein and Iseri, 1972). Eighteen backwater habitats were identified during the survey (28.6% of total study area).

Pool habitats are defined as a deep reach of stream or reach of stream between two riffles (Langbein and Iseri, 1972). Four pool habitats were identified during the survey (38.1% of total study area).

Riffle habitats are defined as a rapid in a stream (Langbein and Iseri, 1972). Three riffle habitats were identified during the survey (6.1% of total study area).

Run habitats are defined as deep with fast water and little or no turbulence (Cave, 1998). Six run habitats were identified during the survey (20.1% of total study area).

Glide habitats are defined as wide areas with even flow, low to moderate velocities, and little to no surface turbulence. They often form a transition from a pool to the upper portion of a riffle (Lobb and Femmer, 2017). One glide habitat was identified during the survey (1.0% of total study area).

Finally, three areas that were out of water at the time of the survey were defined as other (6.1% of total study area).

4.2 Substrate

Primary, secondary, and tertiary substrates for each mesohabitat unit were identified (Table 4.2-1). Of the thirty-five total mesohabitat units, five were unable to have substrate identified (14.3%) due to depth of the mesohabitat unit not allowing for visual observation or probing. Of the remaining thirty mesohabitat units, primary substrates (Figure 4.2-1) were identified: eight were gravel medium (22.9%), seven were cobble (20.0%), six were sand (17.1%), three were complex bedrock (8.6%), three were boulder small (8.6%), two were rubble (5.7%), and one was boulder large (2.9%). Figure 4.2-2 displays a map of the survey area based on the secondary substrate information. Figure 4.2-3 displays a map of the survey area based on the tertiary substrate information.

4.2.1 Fine Substrates

Of the thirty-five mesohabitat units, eight had a percentage of fine substrates recorded. Fine substrates were considered to be sand or substrates smaller than sand (i.e., silt, mud, etc.). Of the eight mesohabitat units with fine substrates, seven were classified as backwater or pool, and one was classified as run (Table 4.2.1-1).

4.2.2 Potential Spawning Areas

Evidence of potential sea lamprey spawning activity was recorded at three locations during the study. All three locations were listed as other, due to being out of water during the summer low-flow period when the survey was conducted (mesohabitat units IDs: 4, 6, and 21). Depressions and mounds of mixed substrates typically cobble, large gravel, small gravel and fine gravel were observed (Figure 4.2.2-1 and Figure 4.2.2-2).

4.3 Depth

When possible, maximum and mean depths of each mesohabitat unit were recorded. For maximum depths, four mesohabitat units did not have a maximum depth recorded. Maximum depths ranged from less than one foot to fifty feet. (Table 4.2-1)

Table 4.1-1: Distribution of Mesohabitats Types in the Study Area

Mesohabitat Type	Percentage of Total Habitat Area	Total Area (sq. ft.)
Backwater	28.6	390,312
Pool	38.1	520,073
Glide	1.0	14,180
Riffle	6.1	83,136
Run	20.1	274,363
Other	6.1	83,817

Table 4.2-1: Primary, Secondary, Tertiary Substrate by Mesohabitat Unit

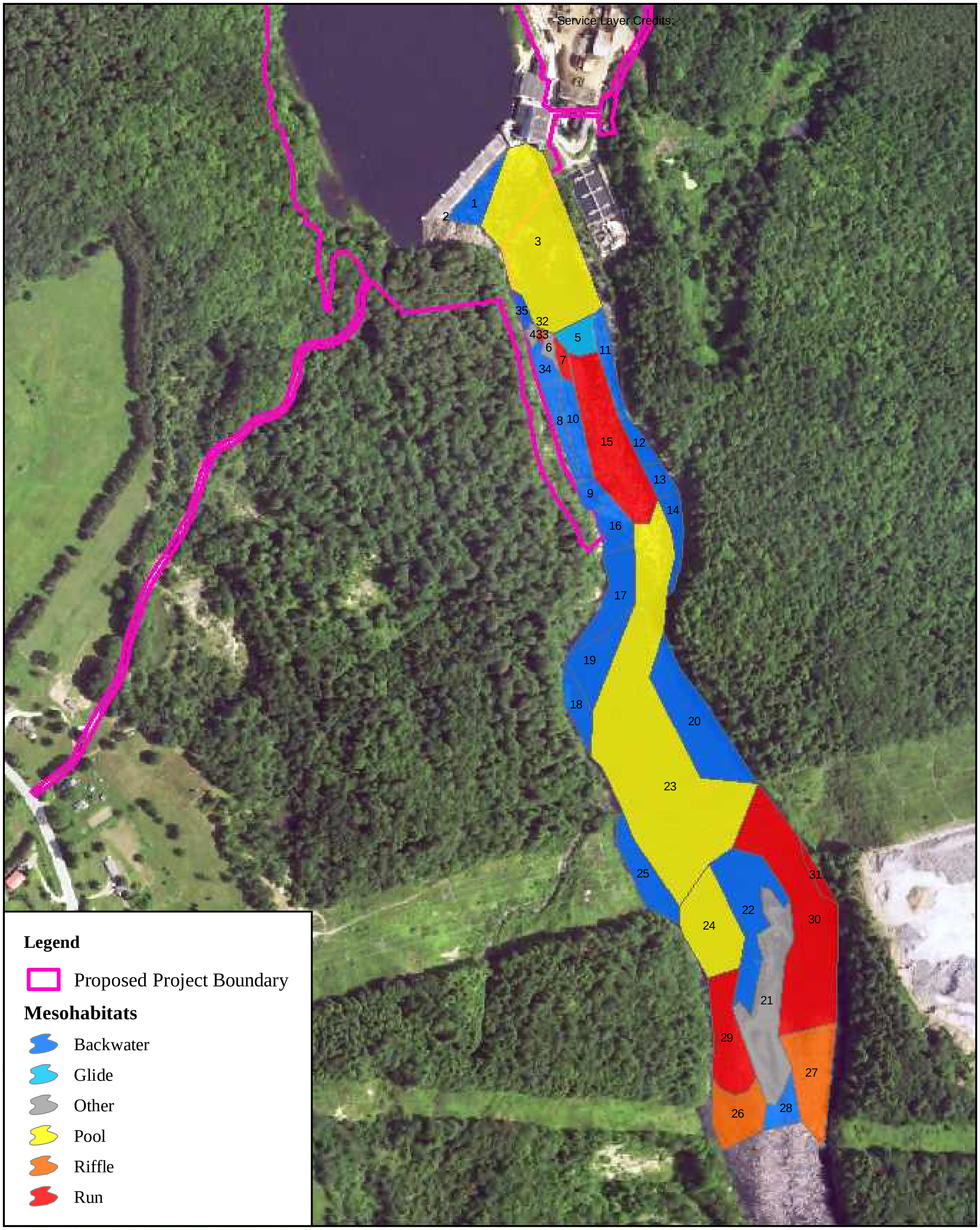
Mesohabitat Unit ID	Mesohabitat Type	Primary Substrate	Secondary Substrate	Tertiary Substrate	Total Area (sq. ft.)	Max Depth (ft)	Mean Depth (ft)
1	Backwater	Sand	Complex Bedrock	Boulder large	18,147	--	12
2	Pool	Complex Bedrock	Boulder large	Sand	153	8	5
3	Pool	--	--	--	157,312	27	15
4	Other	Cobble	Gravel medium	Rubble	2,628	0	0
5	Glide	Cobble	Sand	Boulder small	14,180	8	6
6	Other	Boulder small	Rubble	Boulder large	4,234	--	--
7	Run	Boulder small	Sand	Boulder large	5,226	4	2
8	Backwater	Rubble	Cobble	Boulder small	14,049	5	3
9	Backwater	Complex Bedrock	--	--	8,725	7	3
10	Backwater	Sand	Boulder large	Rubble	18,393	8	6
11	Backwater	Complex Bedrock	Rubble	--	15,979	5	1
12	Backwater	Gravel medium	Cobble	Rubble	9,280	10	6
13	Backwater	Sand	Silt	Cobble	9,211	10	6
14	Backwater	Boulder large	Complex Bedrock	Gravel small	13,661	11	8
15	Run	Boulder small	Sand	--	82,596	16	10
16	Backwater	Rubble	Gravel small	Boulder small	17,924	12	10
17	Backwater	Sand	Silt		33,933	--	10
18	Backwater	Cobble	Gravel small	Sand	16,282	6	3
19	Backwater	--	--	--	27,910	26	15
20	Backwater	--	--	--	68,909	30	15
21	Other	Cobble	Gravel medium	Gravel small	76,956	0	0
22	Backwater	Gravel medium	Cobble	Gravel small	61,292	2	1
23	Pool	--	--	--	306,713	50	35

Mesohabitat Unit ID	Mesohabitat Type	Primary Substrate	Secondary Substrate	Tertiary Substrate	Total Area (sq. ft.)	Max Depth (ft)	Mean Depth (ft)
24	Pool	Cobble	Sand	Gravel medium	55,896	8	6
25	Backwater	Sand	Gravel medium	Cobble	29,239	8	3
26	Riffle	--	--	--	32,814	2	0.5
27	Riffle	Cobble	Gravel medium	Gravel small	49,864	4	1
28	Backwater	Gravel medium	Cobble	Gravel small	13,557	2	0.5
29	Run	Gravel medium	Cobble	Gravel small	44,711	5	3
30	Run	Cobble	Sand	Gravel medium	135,107	8	4
31	Run	Sand	Gravel medium	--	6,095	--	--
32	Riffle	Gravel medium	Cobble	Gravel small	457	1.5	1
33	Run	Gravel medium	Cobble	Gravel small	627	2	1
34	Backwater	Gravel medium	Cobble	Gravel small	9,195	2	1
35	Backwater	Gravel medium	Gravel small	Cobble	4,618	1	0.5

Blanks: Not recorded

Table 4.2.1-1: Mesohabitat Units with Fine Substrates Recorded

Mesohabitat Unit ID	Mesohabitat Type	Percentage of Fines	Total Area (sq. ft.)
2	Pool	10	153
8	Backwater	1	14,049
12	Backwater	5	9,280
13	Backwater	10	9,211
17	Backwater	100	33,933
18	Backwater	5	16,282
25	Backwater	50	29,239
31	Run	50	6,095



Brookfield

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Pejepscot Hydroelectric Project
(FERC No. 4784)
Tailrace Aquatic Habitat Study

Figure: 4.1-1:
Delineated Mesohabitats

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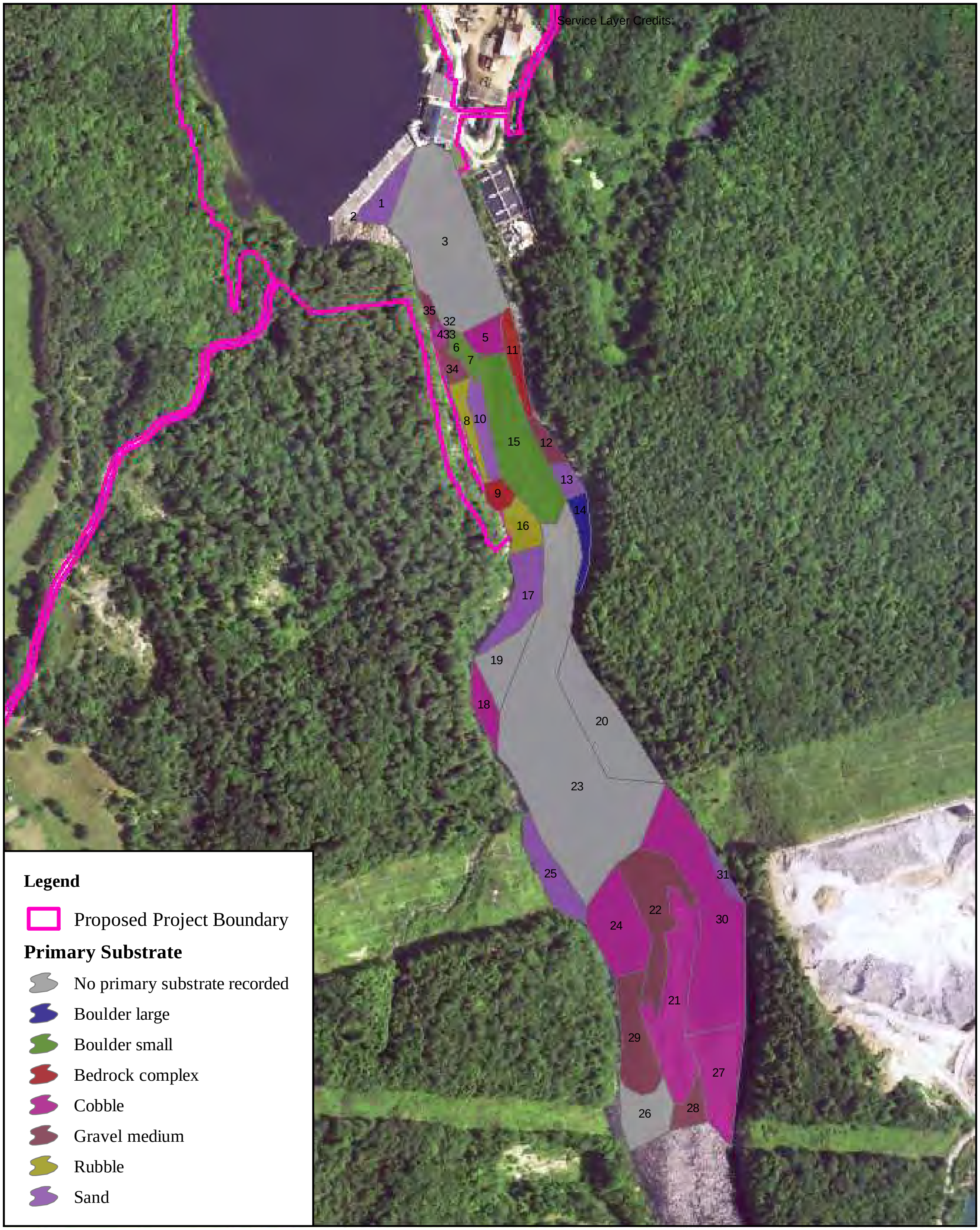

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Pejepscot Hydroelectric Project
(FERC No. 4784)
Tailrace Aquatic Habitat Study

Figure 4.2-1:
Mesohabitat Primary Substrates

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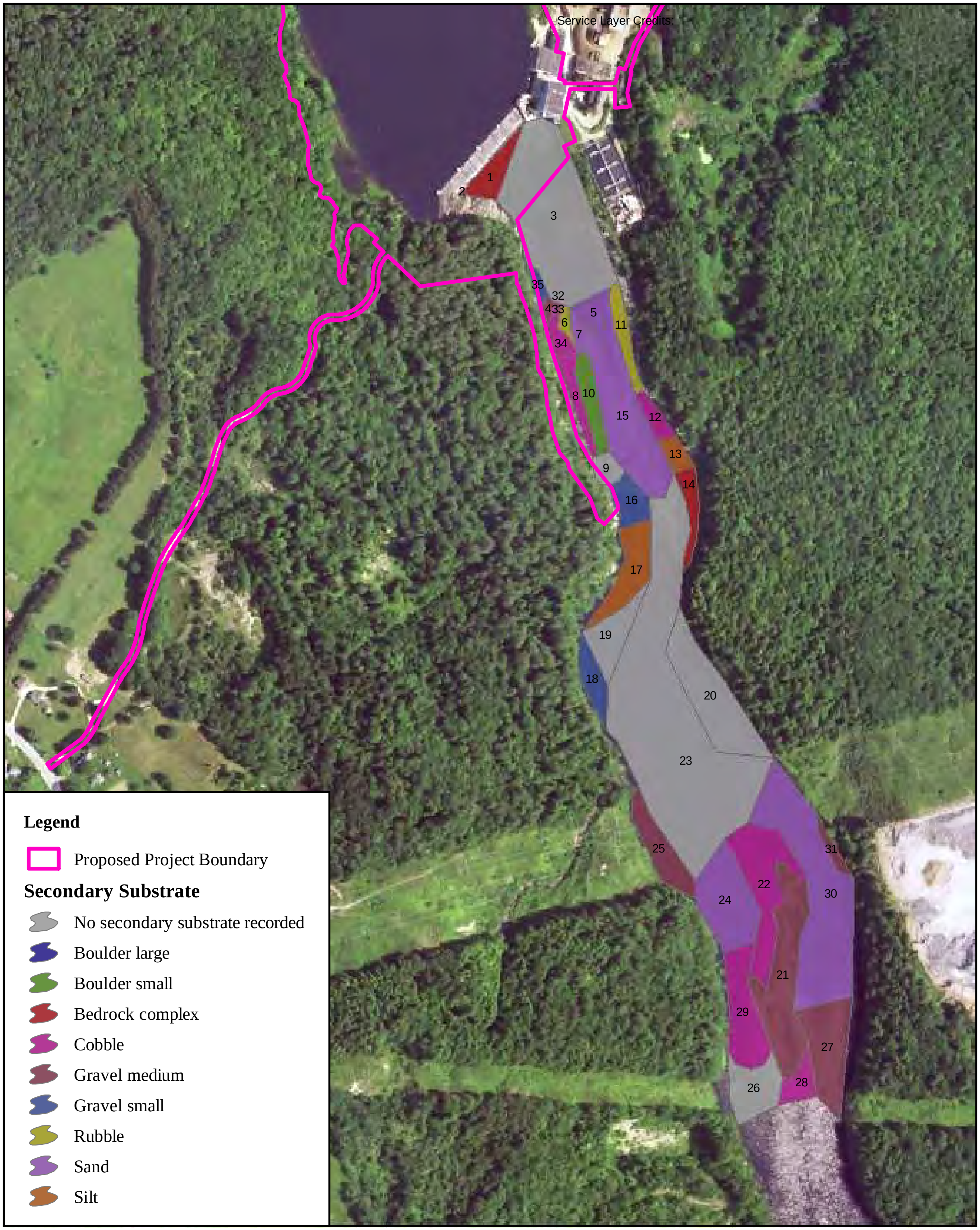

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Pejepscot Hydroelectric Project
(FERC No. 4784)
Tailrace Aquatic Habitat Study

Figure 4.2-2:
Mesohabitat Secondary Substrates

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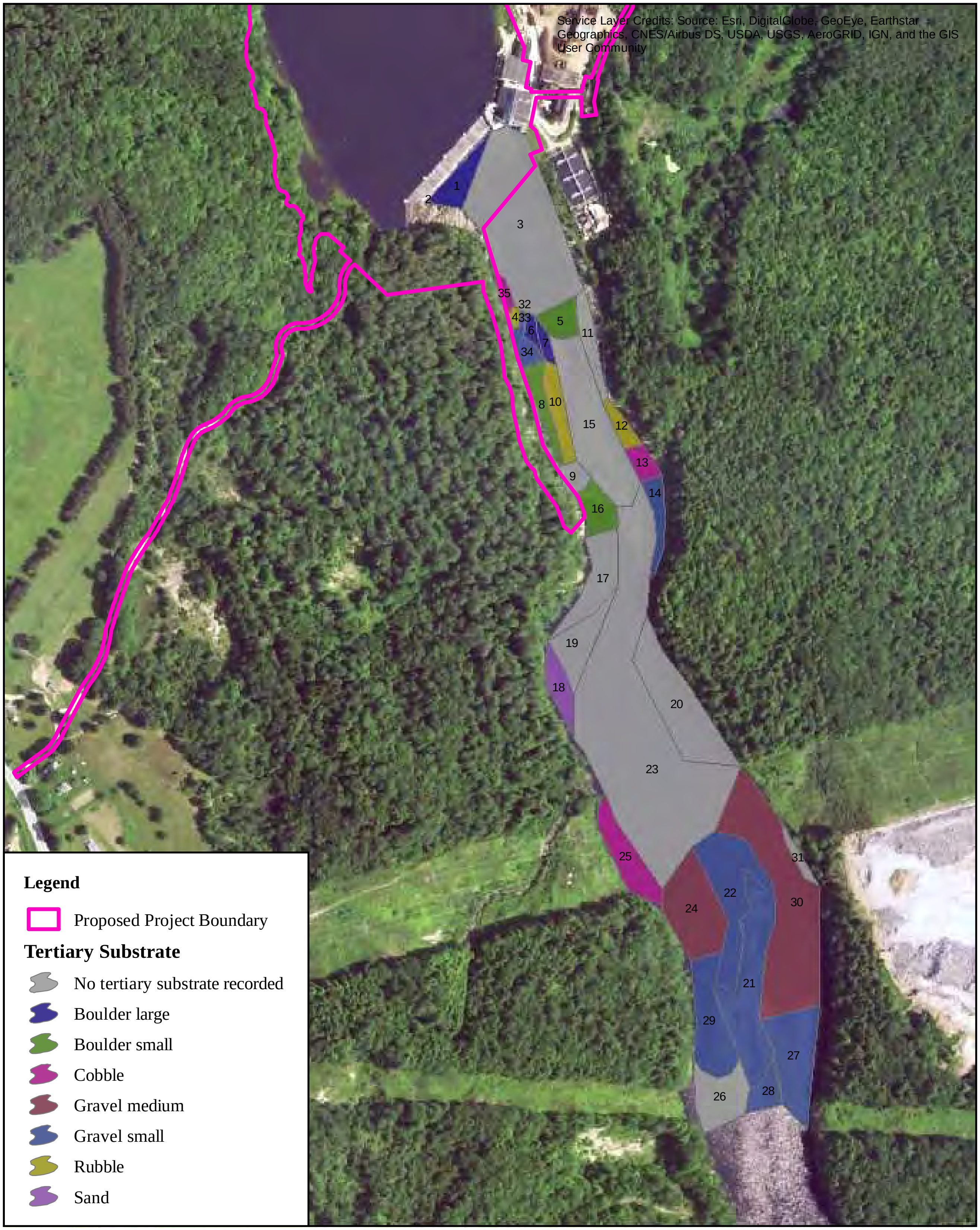

Brookfield

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Pejepscot Hydroelectric Project
(FERC No. 4784)
Tailrace Aquatic Habitat Study

Figure 4.2-3:
Mesohabitat Tertiary Substrates

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Figure 4.2.2-1: Example of Mounds and Depressions found at Downstream End of Survey Area (Mesohabitat Unit 21)

Figure 4.2.2-2: Additional Mounds and Depressions (Mesohabitat Unit 6)

5.0 SUMMARY

Backwaters, pools, and runs made up the majority of mesohabitats identified in the tailrace aquatic habitat survey area. The top three primary substrates identified in the survey area were gravel medium, cobble, and sand. Some areas of fine sediments were identified as were areas of mounds and depressions that may represent potential spawning areas.

6.0 VARIANCES FROM THE FERC APPROVED STUDY PLAN

There was no variance from the methodologies and schedule as described in the FERC-approved study plan.

7.0 REFERENCES

Brookfield Renewable. (2017). Pre-Application Document. Prepared by Topsham Hydro Partners Limited Partnership. Lewiston, ME: Author. Filed with FERC August 31, 2017.

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Langbein W.B. and Iseri, K.T. 1972. General Introduction and Hydrologic Definitions. Manual of Hydrology: Part 1: General Surface-Water Techniques. USGS: US Department of the Interior. United States Government Printing Office. Washington DC. https://pubs.usgs.gov/wsp/1541a/report.pdf#page=8

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LARGE WOODY DEBRIS

{This study report will be filed with the Final License Application}

DRAFT UPDATED STUDY REPORT

BOTANICAL AND WILDLIFE RESOURCES SURVEYS

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)

Submitted by:

Brookfield Renewable
Topsham Hydro Partners Limited Partnership
150 Main Street
Lewiston, ME 04240

Prepared by:

GOMEZ AND SULLIVAN ENGINEERS

April 2020

Brookfield

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND DEFINITIONS

Brookfield	Brookfield Renewable
FERC	Federal Energy Regulatory Commission
GPS	Global Positioning System
ILP	Integrated Licensing Process
ME	Maine
MDIFW	Maine Department of Inland Fisheries and Wildlife
NOI	Notice of Intent
PAD	Pre-Application Document
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
RSP	Revised Study Plan
SD1	Scoping Document 1
TE	Threatened and Endangered
Topsham Hydro	Topsham Hydro Partners, L.P.

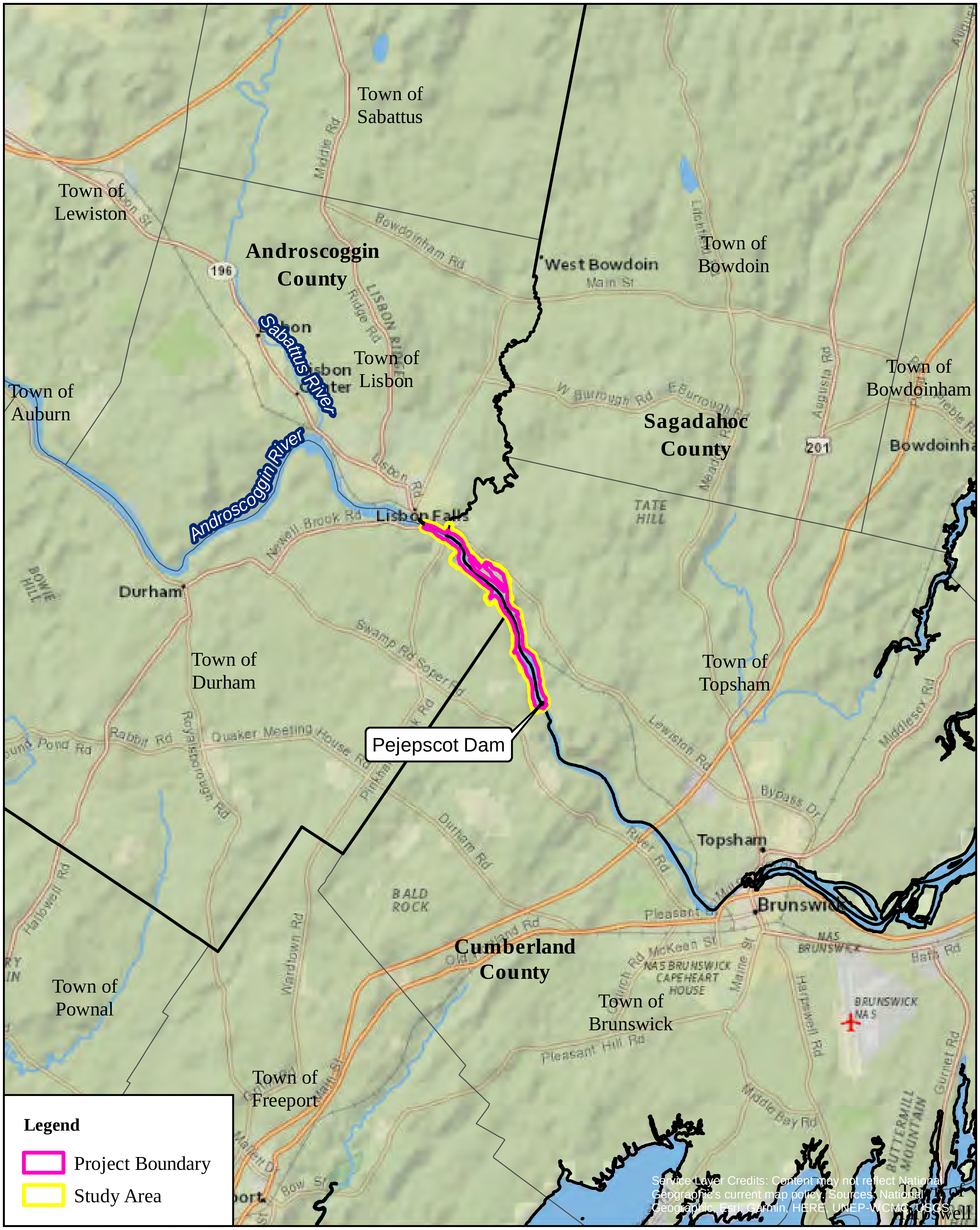
1.0 INTRODUCTION

Topsham Hydro Partners Limited Partnership (L.P.) (Topsham Hydro), an indirect member of Brookfield Renewable (Brookfield), is in the process of relicensing the 13.88-megawatt Pejepscot Hydroelectric Project (Project) (FERC No. 4784) with the Federal Energy Regulatory Commission (FERC). The Project is located on the Androscoggin River in the village of Pejepscot and the Town of Topsham, Maine (ME) to the east, the Town of Lisbon to the north, and the Town of Durham and the Town of Brunswick to the west. The Project straddles the border between Cumberland and Sagadahoc Counties and extends into Androscoggin County (Figure 1.0-1). The original license was issued on September 16, 1982 and expires on August 31, 2022.

Topsham Hydro is using FERC’s Integrated Licensing Process (ILP) as established in regulations issued by FERC July 23, 2003 (Final Rule, Order No. 2002) and found at Title 18 Code of Federal Regulations, Part 5. Topsham Hydro filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to seek a new license for the Project on August 31, 2017.

Topsham Hydro distributed the PAD and NOI simultaneously to federal and state resource agencies, local governments, Native American tribes, members of the public, and others thought to be interested in the relicensing proceeding. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on October 30, 2017. FERC also held agency and public scoping meetings on November 28, 2017 and a site visit on November 29, 2017. The FERC Process Plan and Schedule provided agencies and interested parties an opportunity to file comments on the PAD and SD1 and request studies by December 29, 2017. FERC subsequently issued Scoping Document 2 on February 5, 2018. Topsham Hydro filed a Proposed Study Plan on February 12, 2018 and held a Study Plan Meeting on March 22, 2018. The Revised Study Plan (RSP) was filed in accordance with the ILP schedule on June 12, 2018. FERC issued a Study Plan Determination on July 3, 2018.

In the RSP, Topsham Hydro proposed to conduct reconnaissance level habitat surveys to document the wildlife and botanical resources in the Project Area, to document any threatened and endangered (TE) species, and to provide information pertinent to potential Project effects on wildlife and botanical resources. This report summarizes the findings of both habitat surveys, which were conducted in August 2018.



PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)
BOTANICAL AND WILDLIFE
RESOURCES SURVEYS

Brookfield

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Figure 1.0-1:
Pejepscot Hydroelectric Project General Location

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2.0 GOALS AND OBJECTIVES

2.1 Botanical Resources

The reconnaissance level survey is designed to provide information pertinent to:

- the nature and extent of riparian and wetland botanical resources; and
- the presence or absence of TE plant species or associated habitats within the Project area.

2.2 Wildlife Resources

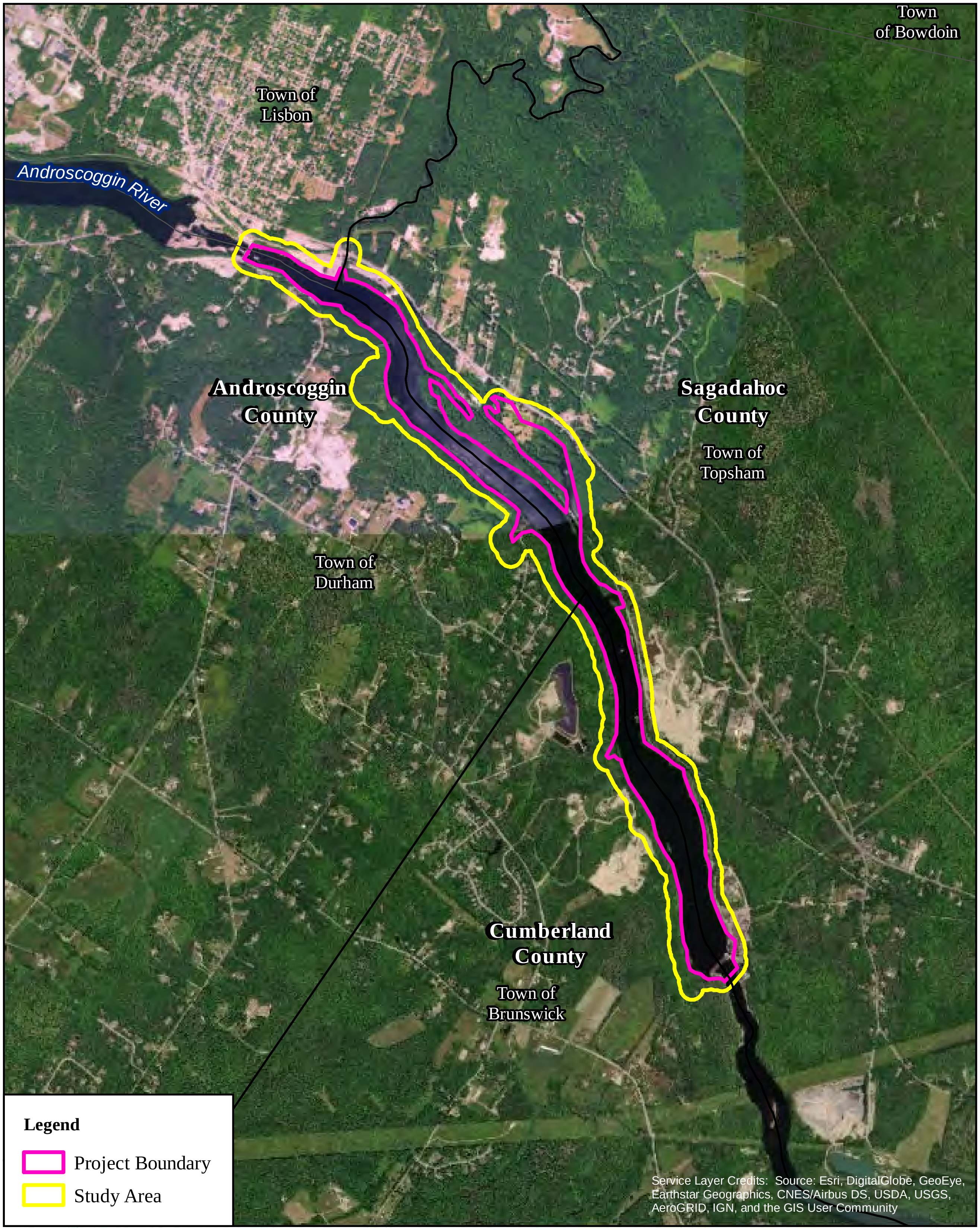
The reconnaissance level survey is designed to provide information pertinent to:

- existing wildlife (bird and mammal) habitats in riparian, wetland, and upland areas of the Project impoundment and tailwater shoreline;
- the presence of wildlife species at the Project; and
- the presence of TE species or associated habitats.

3.0 STUDY AREA DESCRIPTION

The Project is in the Laurentian Mixed Forest Province and, more specifically, the Central Maine Coastal and Interior Section. The Laurentian Mixed Forest Province lies between the boreal forest and broadleaf deciduous forest zones and, as such, is considered transitional (Bailey, 1995). The Central Maine Coastal and Interior Section is also described as a transitional zone. From west to east, the forest transitions from mixed hardwoods typical of the southern New England coastal plain to northern coastal spruce-fir and spruce-fir northern hardwood communities. From south to north, coastal communities typically transition to northern hardwood communities (Bailey, 1995).

The Project boundary approximately follows the contour level of 75 feet above mean sea level, except in the vicinity of the dam and powerhouse and at the upstream limit of the reservoir. The Project boundary extends approximately 3 miles upstream from the Pejepscot Dam to approximately 200 feet downstream of the existing Route 125 bridge, which is located approximately 0.25 miles downstream of the Worumbo Dam and 0.3 miles upstream of the confluence of the Androscoggin and Little Rivers. The Project boundary terminates approximately 260 feet downstream of the Pejepscot Dam. The Project boundary encompasses a total of approximately 229 acres. The study area included areas enclosed in the Project boundary as well as adjacent areas within 200 feet of the 75-foot contour level, approximately 514 acres. Figure 3.1-1 depicts the Project boundary and study area.



Brookfield

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)
BOTANICAL AND WILDLIFE
RESOURCES SURVEYS

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0 0.25 0.5 1 Miles

**Figure 3.1-1:
Pejepscot Hydroelectric
Project Boundary and Study Area**

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4.0 METHODS

4.1 Botanical Resource Survey Methods

4.1.1 Study Design

The reconnaissance level survey was designed to provide information pertinent to the nature and extent of riparian and wetland botanical resources, and the presence or absence of TE botanical species or associated habitats within the study area. The vegetation survey involved three phases of work: desktop analysis, field verification, and the production of a cover type map. The field data collection was performed according to the RSP (Brookfield, 2018) and was conducted in conjunction with the Wildlife Resources Survey (Section 5.0).

4.1.2 Field Data Collection

Prior to fieldwork, background data were gathered, including digital imagery, ecological information about Androscoggin River shoreline communities as well as historical information about land use at the Project site. The general vegetation cover types were identified through photo interpretation and referencing the National Land Cover Database (USGS, 2011). A base map was developed showing draft depictions of plant communities. The base map was refined using data gathered during the field survey.

Biologists surveyed plant communities and botanical resources from August 21, 2018 through August 23, 2018. The study area was systematically traversed on foot or by small motorboat. Field mapping was electronically recorded on a Global Positioning System (GPS) equipped field computer running ArcGIS software. The wireless field computer was loaded with the land cover data from the desktop analysis. Field biologists updated the polygon boundaries, delineated new features as needed, and assigned attributes to all unique land cover types found during the surveys. Polygons were drawn to delimit the boundaries of each distinct cover category area and the boundaries of each plant community. Each polygon was given a unique number for identification and the following data were collected:

- plant species composition, including the dominant and more prominent associated species in each vegetation layer (tree, shrub and herbaceous layers);
- predominant land use(s) associated with each cover type;
- rare, unique, and particularly high-quality habitat;
- occurrence of any TE plant species; and
- occurrence of exotic invasive plant species

The natural plant communities were defined using Maine's Natural Heritage Classification Keys (MDACF, 2018b) and descriptions were recorded for the disturbed or developed areas.

Newcomb's Wildflower Guide (1977) and Gleason and Cronquist's Flora of Eastern North America and Adjacent Canada (1991) were the primary sources for plant species identification.

4.1.3 Data Processing and GIS Mapping

Data collected on the GPS equipped field computers was imported into an ArcGIS database for further analysis and quality assurance. Land features that were not mapped in the field, such as roads and railroads, were digitized as a desktop exercise. The data were then checked for spatial inaccuracies such as gaps in coverage or overlaps between different land cover types using ArcGIS topology tools. ArcGIS topology tools are a collection of rules that allow geodatabases to more accurately model data. After the topology checks were performed, analysts performed statistical analysis on the seamless data.

4.2 Wildlife Resources Survey Methods

4.2.1 Study Design

The reconnaissance level survey was designed to provide information on the type and quantity of habitat and wildlife resources that have become established under existing Project operation as well as the presence of TE species or associated habitats. The observation survey was performed according to the RSP (Brookfield, 2018) and was conducted in conjunction with the Botanical Resources Survey (Section 4.1).

4.2.2 Field Data Collection

Records from the Maine Natural Areas Program, Maine Department of Inland Fisheries and Wildlife (MDIFW), and United States Fish and Wildlife Service were reviewed prior to the survey to gather a list of potential state or federal TE wildlife species. Biologists accessed the study area on foot, by car, or in a small motorboat. The survey was conducted from August 21, 2018 through August 23, 2018 using binoculars and/or a spotting scope to minimize disturbance to wildlife. Observations made by the biologists were documented on the field datasheets. The Sibley's Guide to Birds (2003) was the primary source for species identification and nomenclature. The identification of the non-bird species was confirmed using the MDIFW website (MDIFW, 2018a).

5.0 RESULTS

5.1 Botanical Resources

The study area encompasses approximately 514 acres. Within this area, twenty different cover types were mapped (Figure 5.1-1). Table 5.1-1 summarizes acreages of each cover type as well as percentages of the total 514-acre study area. Plant species identified during the study are listed in Table 5.1-2 and are discussed further below. Field photos taken during the survey are shown in Appendix A.

Cover Type

In the study area, the dominant cover types were open water (219.7 acres, 43%), mixed forest (129.4 acres, 25%), and deciduous forest (65.8 acres, 13%). The plant communities were identified using Maine's Natural Heritage Plant Community Classification Index (MDACF, 2018b). The major plant communities found in the mixed forest cover type were hemlock forest (55.8 acres) and oak-pine woodland (47.7 acres) vegetation. The deciduous forest cover type was mostly comprised of oak-pine woodland (26.5 acres) and birch-oak talus woodland (16.5 acres). Common species observed in these forest areas included red maple (*Acer rubrum*), red oak, (*Quercus rubra*), white ash (*Fraxinus americana*), paper birch (*Betula papyrifera*), red pine (*Pinus resinosa*), and eastern hemlock (*Tsuga canadensis*).

Emergent wetland plant communities occupied 25.6 acres (5%) and were primarily pickerelweed macrophyte aquatic beds (MDACF, 2018b). The most abundant species in these communities were pickerelweed *(Pontederia cordata*), American bur-reed (*Sparganium americanum)*, and broadleaf arrowhead *(Sagittaria latifolia)*. Forested wetland accounted for 5.3 acres (<1%) of the study area. Other vegetated areas covered 13.8 acres (3%) of the study area.

The remaining area was comprised of non-vegetated or developed cover types covering 54.4 acres (11%) of the study area.

Upland Vegetation

The upland vegetation found throughout the study area was dense. Within upland cover types, areal vegetation cover was approximately 80%. The herbaceous plant community found in the more open areas was growing vigorously and included several species of native and naturalized wildflowers such as Joe-pye weed (*Eutrochium purpureum*), common bone-set (*Eupatorium perfoliatum*), and grasses (*Poa* sp.) as well as small populations of reed canary grass (*Phalaris arundinacea*), which is sometimes considered non-native. Most mature forested areas had well-developed understories with intact shrub and herbaceous layers.

Invasive Species

Invasive species noted within the study area included: flowering rush (*Butomus umbellatus*) purple loosestrife (*Lythrum salicaria)*, Morrow's and/or Tatarian honeysuckle (*Lonicera morrowii*, *L. tatarica*), Japanese knotweed (*Reynoutria japonica*), common buckthorn (*Rhamnus cathartica*), and glossy buckthorn (*Frangula alnus*). Each of these species is listed as currently or probably invasive in Maine by the Maine Natural Areas Program (MDACF, 2018a).

Threatened and Endangered Species

Several state-listed plant species were identified in the PAD as potentially occurring in or near the Project area (Table 5.1-3); however, no TE species were observed during the botanical surveys. Aquatic species listed in the PAD included comb-leaved mermaid-weed (*Proserpinaca pectinata,* Endangered) and spotted pondweed (*Potamogeton pulcher,* Threatened). Comb-leaved mermaid-weed is an aquatic perennial, with highly dissected leaves and axial flowers with four separate carpels. It flowers and fruits from July through September and may be found in ponds, lakes, and impoundments. No individuals of the species were found, but habitat for the plant does exist within the wetlands that lie along impoundment. Spotted pondweed is an aquatic perennial with narrow, lance-shaped submerged leaves, oval floating leaves and black spotted stems. It is found in peaty, tannic waters, and flowers from June to September. No individuals of this species were observed, and the waters within the study area do not occur over peaty substrates nor are they particularly tannic. Habitat for this species does not exist within the study area.

Two listed species normally found in bogs and fens that were listed in the PAD include showy lady's slipper (*Cypripedium reginae,* Special Concern) and white adder's mouth (*Malaxis monophyllos,* Endangered). Showy lady's slipper is an orchid found in more neutral bogs, edges of mossy forests and open wetlands. The species flowers from June through July. White adder's mouth is a small orchid found in wet gravel deposits, calcareous bogs and fens. The plant has a single leaf from which comes a flower stalk with a raceme of greenish-white flowers, which generally appear in July. Neither of these orchids were noted during the field survey, and there are no bogs, fens or wet gravel deposits within the study area.

Several state-listed species that occur in wetlands or moist woods were listed in the PAD. These included hollow Joe-pye weed (*Eutrochium fistulosum,* Special Concern), smooth winterberry holly (*Ilex laevigata,* Special Concern), spicebush (*Lindera benzoin,* Special Concern), and sweet pepper-bush (*Clethra alnifolia,* Special Concern). Hollow Joe-pye weed is a tall member of the *Asteraceae* found in wet areas. The plant has a hollow, purplish stem with a whitish bloom, and flowers from July through September. A con-generic species, sweet Joe-pye weed (*Eutrochium purpureum*), was found in the study area. Sweet Joe-pye weed tends to occur on drier sites than hollow Joe-pye weed and has a solid stem with no whitish bloom. No individuals of hollow Joe-pye weed were found, but habitat for the species does exist within the study area in the open wetlands.

Smooth winterberry is a deciduous holly shrub with shiny leaves. It is found in swamps and dense thickets. Flowers appear from May to June, with berries appearing on female plants in late June. No members of the genus *Ilex* were found, but habitat for the species does exist within the forested and marsh and shrub wetlands of the study area. Sweet pepper-bush grows as a small tree or shrub. The plant has alternate, ovate, toothed leaves on short pedicels. Terminal racemes of white flowers with protruding stamens appear in July through August. No individuals were found, but habitat for sweet pepper-bush does exist within the forested and marsh and shrub wetlands in the study area.

Finally, three species found in moist or mesic woods were listed in the PAD. These were spicebush (*Lindera benzoin,* Special Concern), mountain-laurel (*Kalmia latifolia,* Special Concern) and broad beech fern (*Phegopteris hexagonoptera,* Special Concern). Spicebush is an understory tree or shrub found along brooks, in swamps and in the understories of moist forests. Its leaves are ovoid with entire margins. The tree flowers from late April to May but is easily identifiable by the lemony-spicy scent given off from bruised leaves and twigs. Mountain laurel is an evergreen flowering shrub found in rocky or gravelly woods and clearings, clearings in or edges of mesic woods and occasionally swamps. The pink and white flowers have five petals fused into a disc or saucer shape and appear from May through July. Broad beech fern is a large fern with a triangular leaf arrangement, hairy stems, yellowish scales, winged axis and lobed sub leaflets. The fern occurs in sunny openings in moist woods. No individuals of these three species were found in the study area, but habitat for each of them does exist within the mesic woods mapped.

Table 5.1-1: Summary of Cover Type Polygons Mapped During Botanical Resources Survey

Cover Type	Total Acres	Percent of Study Area	Associated Land Uses[1]	Habitat Type
Open Water	219.7	42.8%	Open Water	Water
Mixed Forest	129.4	25.2%	Deciduous Forest and Mixed Forest	Upland
Deciduous Forest	65.8	12.8%	Deciduous Forest, Mixed Forest, and Shrub/Scrub	Upland
Wetland	25.6	5.0%	Emergent Herbaceous Wetland	Wetland
Railroad	14.6	2.8%	Railroad	Other
Dam and Related Facilities	11.4	2.2%	Developed, High and Low Density	Other
Sand	10.5	2.0%	Barren Land (Rock/Sand/Clay)	Other
Parking	7.2	1.4%	Barren Land (Rock/Sand/Clay) and Developed, Low Intensity	Other
Shrub	6.7	1.3%	Deciduous Forest and Shrub/Scrub	Other
Forested Wetland	5.3	1.0%	Woody Wetland	Upland
Young woods	4.5	0.9%	Deciduous Forest and Mixed Forest	Wetland
Paved/road	3.6	0.7%	Developed, Low Intensity	Other
Rock	2.3	0.4%	Barren Land (Rock/Sand/Clay)	Upland
Residential	2.2	0.4%	Developed, Low Intensity	Other
Quarry	1.7	0.3%	Barren Land (Rock/Sand/Clay)	Other
Old field	1.2	0.2%	Barren Land (Rock/Sand/Clay) and Shrub/Scrub	Upland
Agriculture	0.9	0.2%	Cultivated Crops	Upland
Water structure	0.7	0.1%	Developed, Medium Intensity	Other

[1] USGS, 2014

Cover Type	Total Acres	Percent of Study Area	Associated Land Uses[1]	Habitat Type
Conifer Plantation	0.6	0.1%	Evergreen Forest	Upland
Boat launch	0.2	<0.1%	Developed, Open Space	Other
TOTAL	**513.9**	**100%**		

Table 5.1-2: Plant Species Observed in Pejepscot Study Area

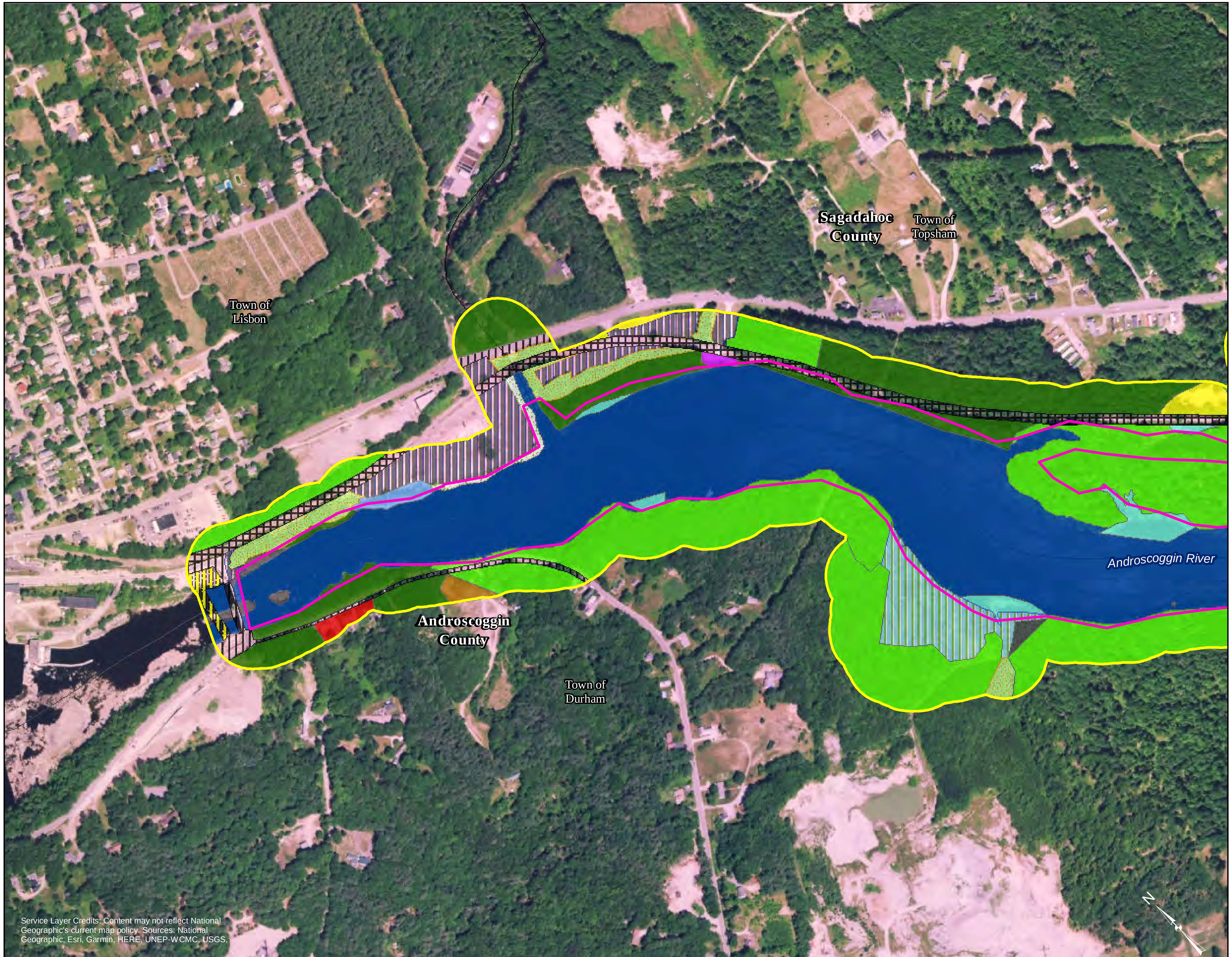
Common Name	Scientific Name	Status[2]
Red maple	*Acer rubrum*	Native
Silver maple	*Acer saccharinum*	Native
Sugar maple	*Acer saccharin*	Native
Mountain maple	*Acer spicatum*	Native
Alder	*Alnus sp.*	Native
Sweet birch	*Betula lenta*	Native
Paper birch	*Betula papyrifera*	Native
Flowering rush	*Butomus umbellatus*	Invasive
Longhair sedge	*Carex comosa*	Native
Hop sedge	*Carex lupulina*	Native
American hornbeam	*Carpinus caroliniana*	Native
Buttonbush	*Cephalanthus occidentalis*	Native
Sweetfern	*Comptonia peregrina*	Native
Silky dogwood	*Cornus amomum*	Native
Red osier dogwood	*Cornus sericea*	Native
Yellow nutsedge	*Cyperus esculentus*	Native and Introduced
Wild carrot	*Daucus carota*	Introduced
Cockspur grass	*Echinocloa crus-galli*	Native and Introduced
Common boneset	*Eupatorium perfoliatum*	Native
Joe-Pye-weed	*Eutrochium purpureum*	Native
Japanese knotweed	*Reynoutria japonica*	Invasive
Glossy buckthorn	*Frangula alnus*	Invasive
White ash	*Fraxinus americana*	Native
Honey locust	*Gleditsia triacanthos*	Native
American witch-hazel	*Hamamelis virginiana*	Native
Woodland sunflower	*Helianthus divaricatus*	Native
Soft rush	*Juncus effusus*	Native
Rice cutgrass	*Leersia oryzoides*	Native
Cardinal flower	*Lobelia cardinalis*	Native
Morrow's honeysuckle	*Lonicera morrowii*	Invasive
Tatarian honeysuckle	*Lonicera tatarica*	Invasive
Purple loosestrife	*Lythrum salicaria*	Invasive
Sweet clover	*Melilotus officinalis*	Introduced
Fragrant water-lily	*Nymphaea odorata*	Native
Sensitive fern	*Onoclea sensibilis*	Native
Deer-Tongue Grass	*Panicum clandestinum*	Native
Reed canary grass	*Phalaris arundinacea*	Invasive
Norway spruce	*Picea abies*	Introduced
White spruce	*Picea alba*	Native

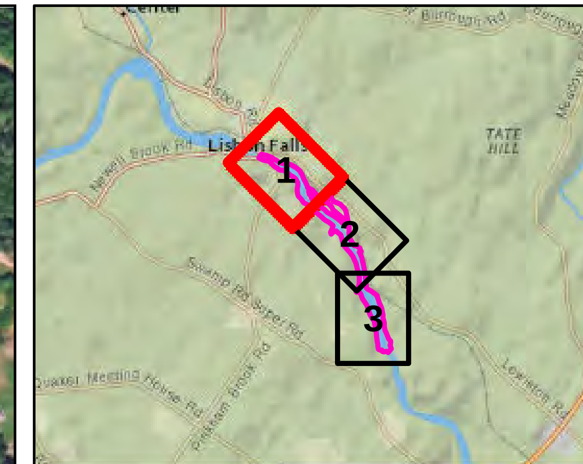
[2] Source: (MDACF, 2018a)

Common Name	Scientific Name	Status[2]
Blue spruce	*Picea pungens*	Introduced
Red pine	*Pinus resinosa*	Native
Pitch pine	*Pinus rigida*	Native
White pine	*Pinus strobus*	Native
Meadow-grass, bluegrass, tussock, and speargrass	*Poa* spp.	Native and Introduced
Pickerelweed	*Pontederia cordata*	Native
Quaking aspen	*Populus tremuloides*	Native
Broad-leaved pondweed	*Potamogeton natans*	Native
Black cherry	*Prunus serotina*	Native
Red oak	*Quercus rubra*	Native
White oak	*Quercus alba*	Native
Common buckthorn	*Rhamnus cathartica*	Invasive
Staghorn sumac	*Rhus typhina*	Native
Broadleaf arrowhead	*Sagittaria latifolia*	Native
Black willow	*Salix nigra*	Native
Willow	*Salix* spp.	Native and Introduced
Woolgrass	*Scirpus cyperinus*	Native
Late goldenrod	*Solidago altissima*	Native
Goldenrod	*Solidago* spp.	Native
American bur-reed	*Sparganium americanum*	Native
Prairie cordgrass	*Spartina pectinata*	Native
White meadowsweet	*Spirea alba*	Native
Basswood	*Tilia americana*	Native
Eastern hemlock	*Tsuga canadensis*	Native
Broadleaf cattail	*Typha latifolia*	Native
American elm	*Ulmus americana*	Native
Common nettle	*Urtica dioica*	Native and Introduced
Blueberry	*Vaccinium* spp.	Native
Blue vervain	*Verbena hastata*	Native
Arrowwood viburnum	*Viburnum dentatum*	Native
Downy arrowwood	*Viburnum rafinesquianum*	Native
Unidentified grass	not available	not available

Table 5.1-3: State-listed Plants Listed in the PAD

Common Name	Species Name	Status	Found in Study Area?	Habitat in Study Area?
Sweet pepperbush	*Clethra alnifolia*	Special Concern	No	Yes, in forested and marsh and shrub wetlands
Showy lady's slipper	*Cypripedium reginea*	Special Concern	No	No
Hollow Joe-pye weed	*Eutrotrichium fistulosum*	Special Concern	No	Yes, in open (non-wooded) wetlands
Smooth winterberry holly	*Ilex laevigatum*	Special Concern	No	Yes, in forested and marsh and shrub wetlands
Mountain laurel	*Kalmia latifolia*	Special Concern	No	Yes, in mesic woods
Spicebush	*Lindera benzoin*	Special Concern	No	Yes, in mesic woods
White adder's mouth	*Malaxis monophyllus*	Endangered	No	No
Broad beech fern	*Phegopteris hexagonoptera*	Special Concern	No	Yes, in mesic woods
Spotted pond weed	*Potamogeton pulcher*	Threatened	No	No
Comb-leaved mermaid weed	*Prosperinaca pectinata*	Endangered	No	Yes, in wetlands along the impoundment





PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)
BOTANICAL AND WILDLIFE RESOURCES SURVEYS

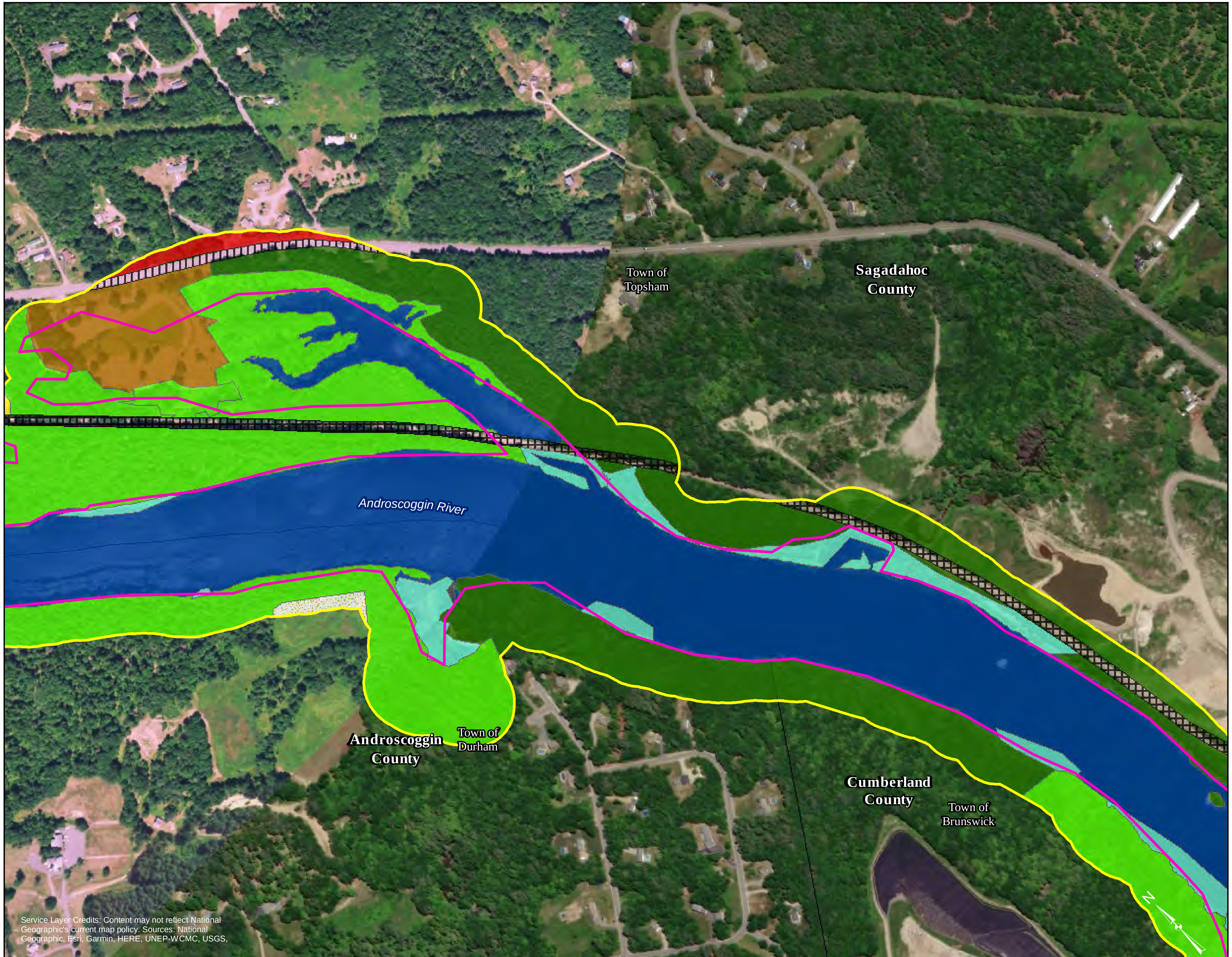
Figure 4.2-1: Botanical Cover Types
Page 1 of 3

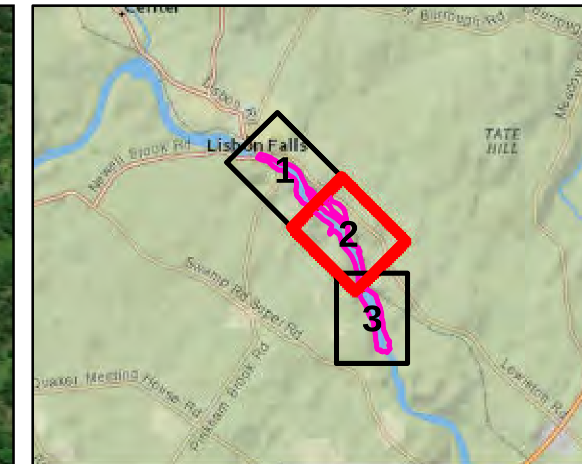
Legend

- Project Boundary
- Study Area
- Old field
- Shrub
- Deciduous forest
- Mixed forest
- Sand
- Residential
- Boat launch
- Rock
- Parking
- Paved/road
- Railroad
- Dam and related facilities
- Young woods
- Wetland
- Forested wetland
- Water structure
- Open water

0 250 500 1,000 Feet

Brookfield





PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)
BOTANICAL AND WILDLIFE
RESOURCES SURVEYS

Figure 4.2-1: Botanical Cover Types
Page 2 of 3

Legend

- Project Boundary
- Study Area
- Agriculture
- Old field
- Deciduous forest
- Mixed forest
- Sand
- Residential
- Rock
- Paved/road
- Railroad
- Wetland
- Open water

0 250 500 1,000 Feet

Brookfield

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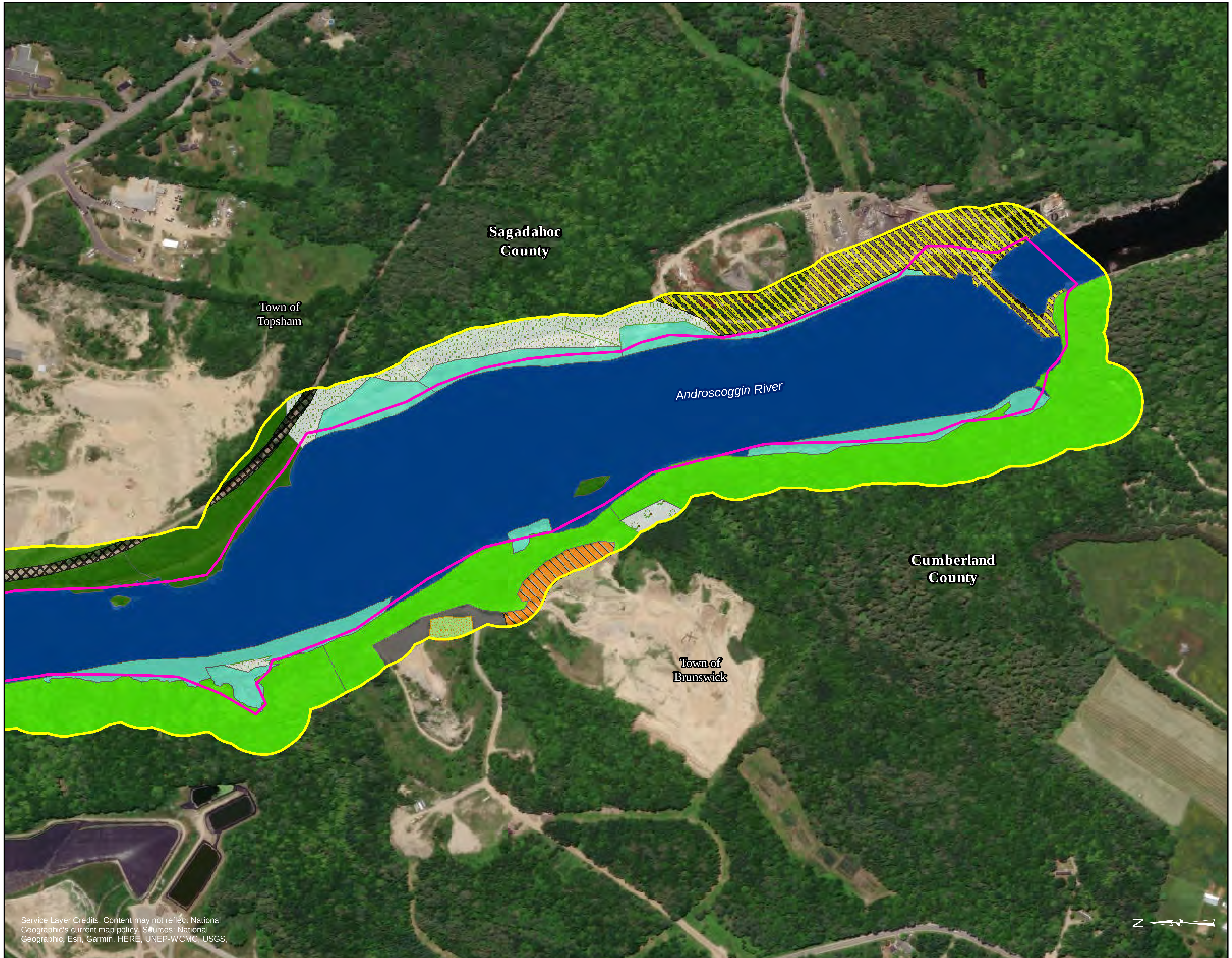

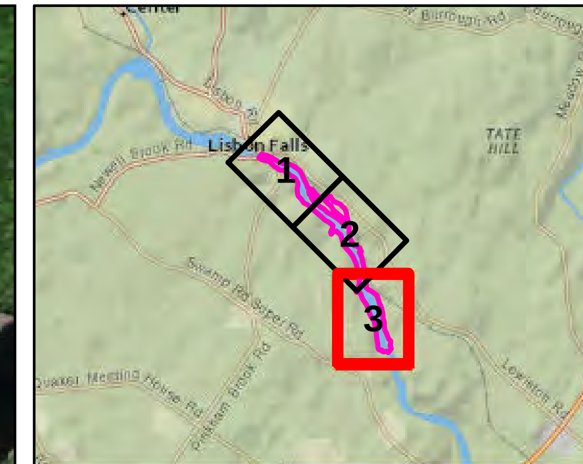

PEJEPSCOT HYDROELECTRIC PROJECT
(FERC No. 4784)
BOTANICAL AND WILDLIFE
RESOURCES SURVEYS

Figure 4.2-1: Botanical Cover Types
Page 3 of 3

Legend

- Project Boundary
- Study Area
- Conifer plantation
- Shrub
- Deciduous forest
- Mixed forest
- Rock
- Quarry
- Railroad
- Dam and related facilities
- Young woods
- Wetland
- Open water

0 250 500 1,000
Feet

Brookfield

Path: P:\1925\maps\Study Plans\botanical_resources_study\figure_5_1-1_cover_type.mxd

5.2 Wildlife Resources

The study area provides habitat for numerous species of song birds, wading birds, gulls and waterfowl. A total of 26 bird species were observed during the field survey, including three species of Special Concern[3] (Table 5.2-1). The Special Concern species observed included Great Blue Heron (*Ardea herodias*), Eastern Towhee (*Pipilo erythrophthalmus*), and Tree Swallow (*Tachycineta bicolor*). Bald Eagles were also observed, which are protected by the federal Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d). No TE bird species were observed during survey.

Eastern gray and red squirrels (*Sciurus carolinensis* and *S. vulgaris*) and an eastern milk snake (*Lampropeltis triangulum triangulum*) were also observed during the survey. Insects that were seen included monarch butterflies (*Danaus plexippus*), bumble bees (*Bombus* sp.), and yellow jackets (*Vespinae* sp.). Biologists were unable to determine if any of the observed bumble bees were on the TE or Special Concern list from MDIFW (MDIFW, 2015). Small fish, two turtles, and tadpoles were also observed in or near the Androscoggin River waters during the field survey. These were spotted as glimpses and could not be identified. The only reptile to be identified was an eastern milk snake (*Lampropeltis triangulum triangulum*), which was observed on the railroad tracks along the eastern shoreline. This species currently has no state status. All the non-bird species identified during the survey are listed in Table 5.2-2.

Several bat species are listed in the PAD (Brookfield, 2017) as having the potential to occur in the Project area. These species include the state endangered and federally threatened northern long-eared myotis (*Myotis septentrionalis*), the state endangered little brown bat (*Myotis lucifugus*), the state threatened eastern small-footed myotis (*Myotis leibii*), as well as five species of special concern: (big brown bat (*Eptesicus fuscus*), silver haired bat (*Lasionycteris noctivagans)*, eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), and the tri-colored bat (*Perimyotis subflavus*). The northern long-eared, little brown, silver haired, hoary and tri-colored bats all utilize a diversity of forest habitats for roosting, foraging and raising young. The habitats for several bat species do exist in the study area. The New England cottontail is also known to exist near the Project area. New England cottontail habitat includes dense stands of deciduous trees, which are present in the Project area. No TE mammal species were observed in the Project area during the field survey, nor were any non-native animal species.

[3] A species of special concern is any species of fish or wildlife that does not meet the criteria of an endangered or threatened species but is particularly vulnerable, and could easily become, an endangered, threatened, or extirpated species due to restricted distribution, low or declining numbers, specialized habitat needs or limits, or other factors. Special concern species are established by policy, not by regulation, and are used for planning and informational purposes; they do not have the legal weight of endangered and threatened species (MDIFW, 2015).

Table 5.2-1: Bird Species Observed in the Pejepscot Project Area

Common Name	Scientific Name	Observation Type		Maine Status[4]
		Seen	Heard	
Wood Duck	*Aix sponsa*	X		No status
Mallard	*Anas platyrhynchos*	X		No status
American Black Duck	*Anas rubripes*	X		No Status
Common Egret	*Ardea alba*	X		No Status[5]
Great Blue Heron	*Ardea herodias*	X		Special Concern
Red-tailed Hawk	*Buteo jamaicensis*	X	X	No status
Turkey Vulture	*Cathartes aura*	X		No status
American Crow	*Corvus brachyrhynchos*	X	X	No status
Common Raven	*Corvus corax*	X	X	No status
Blue Jay	*Cyanocitta cristata*	X		No status
Gray Catbird	*Dumetella carolinensis*	X	X	No status
Bald Eagle	*Haliaeetus leucocephalus*	X		Delisted 2009, protected by the federal Bald and Golden Eagle Protection Act
Pileated Woodpecker	*Hylatomus pileatus*	excavation	X	No status
Ring-billed Gull	*Larus delawarensis*	X		No status
Song Sparrow	*Melospiza melodia*		X	No status
Osprey	*Pandion haliaetus*	X		No status
Double-crested Cormorant	*Phalacrocorax auritas*	X		No status
Eastern Towhee	*Pipilo erythrophthalmus*		X	Special Concern
Prothonotary Warbler	*Protonotaria citrea*	X		No status
Common Grackle	*Quiscalus quiscula*	X		No status
Eastern Phoebe	*Sayornis phoebe*		X	No status
White-breasted Nuthatch	*Sitta carolinensis*	X		No status
Common Eider	*Somateria mollissima*	X		No status
Tree Swallow	*Tachycineta bicolor*	X		Special Concern
American Robin	*Turdus migratorius*		X	No status
Mourning Dove	*Zenaida macroura*	X		No status

[4] Source: MDIFW, 2015
[5] Removed from MDIFW, 2015

Table 5.2-2: Non-bird Animal Species Observed in the Pejepscot Project Area

Common Name	Scientific Name	Observation Type		Status[6]
		Seen	Heard	
Bumble Bee	*Bombus* sp.	X		TE and SC
Monarch Butterfly	*Danaus plexippus*	X		Under review
White-tailed Deer (tracks)	*Odocoileus virginianus*	X		No status
Eastern Milk Snake	*Lampropeltis triangulum triangulum*	X		No status
Eastern Gray Squirrel	*Sciurus carolinensis*	X		No status
Red Squirrel	*Sciurus vulgaris*	X		No status
Yellow Jacket	*Vespinae* sp.	X		No status

[6] Source: MDIFW, 2015

6.0 SUMMARY

A total of 20 cover types were mapped within the study area. The dominant cover type was open water (43%). The dominant vegetated cover types included mixed forest (25%) and deciduous forest (13%). Non-vegetated/developed cover types encompassed (11%) of study area. The least dominant cover types were wetlands (5%) followed by other vegetated areas (3%) and forested wetlands (<1%). The forested and wetland cover types represent native plant communities in Maine. Natural forested communities included hemlock forest, oak-pine woodland and birch-oak talus woodlands. The most common natural wetland community was the pickerelweed-macrophyte aquatic bed.

The natural plant communities appeared to be healthy and vigorous. Forested areas had intact canopy, shrub and herbaceous layers, were generally mature and showed a mix of tree ages. Most wetlands were a mix of open water and vegetated areas and appeared to be stable. Shrub-dominated areas were mostly successional stands.

Invasive species were present but not overly abundant. No state or federally listed TE plant species were observed in the study area during the field survey, though there is potential habitat for several of the listed species shown in the PAD.

The plant communities in the study area provide habitat for a variety of wildlife species. Wading birds and ducks were observed on and around the impoundment. Mammals that are commonly found in woodlands, wetlands and urban areas were noted during the study. No observations of mammalian predators (coyotes, foxes, etc.) were noted, but these are often elusive and may be present in the area. Several bat species were listed in the PAD as being potentially present in the study area. No bats were observed during the field studies, which occurred during daylight hours. The species listed in the PAD are often found in forested areas, particularly those near a water source over which insects may be abundant. Forested habitats surround large portions of the impoundment, therefore appropriate roosting and foraging habitat for these bat species does exist in the study area. Reptiles and amphibians were observed, but the only herptile identified was the eastern milk snake. Most of the wildlife observed were birds. Biologists saw 26 different bird species, including three species of Special Concern. No TE wildlife species were observed in the study area.

7.0 VARIANCES FROM THE FERC APPROVED STUDY PLAN

There were no variances from the methodologies and schedule as described in the FERC-approved study plan.

8.0 REFERENCES

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APPENDIX A: PHOTOGRAPHS FROM BOTANICAL AND WILDLIFE RESOURCES SURVEYS

Wetland on western shoreline of the impoundment

Mixed forest on western shoreline of the impoundment

Mixed forest on western shoreline of the impoundment

Wetland and mixed forest on western shoreline of the impoundment

Wetland and mixed forest on western shoreline of the impoundment

Wetland cover on western shoreline of the impoundment

Wetland cover on western shoreline of the impoundment

Ecosystems gradient (wetland, brush cover and deciduous forest) on eastern shoreline of the impoundment

Deciduous forest on eastern shoreline of the impoundment

Ecosystems gradient (wetland, brush cover and mixed forest) on eastern shoreline of the impoundment

Eastern shoreline of the impoundment

Wetland on eastern shoreline of the impoundment

Dam related facilities southern end of Pejepscot Project, looking downstream

Wetland on western shoreline of the impoundment

Wetland along western shoreline of the impoundment

Wetland along western shoreline of the impoundment

Wetland along western shoreline of the impoundment

Wetland along eastern shoreline of the impoundment

Wetland along eastern shoreline of the impoundment

Wetland on western shoreline of the impoundment

Wetland on western shoreline of the impoundment

Railroad adjacent to eastern shoreline of the impoundment

Boat launch at the impoundment

Canal St bridge at northern end of the impoundment

Hardened shoreline/developed areas on north-eastern end of the impoundment

Wetland cove area along eastern shoreline of the impoundment

Wetland cove area along eastern shoreline of the impoundment

Wetland cove area along eastern shoreline of the impoundment

Bald Eagles (*Haliaeetus leucocephalus*) seen at the impoundment area

Common Egret (*Ardea alba*) at the impoundment area

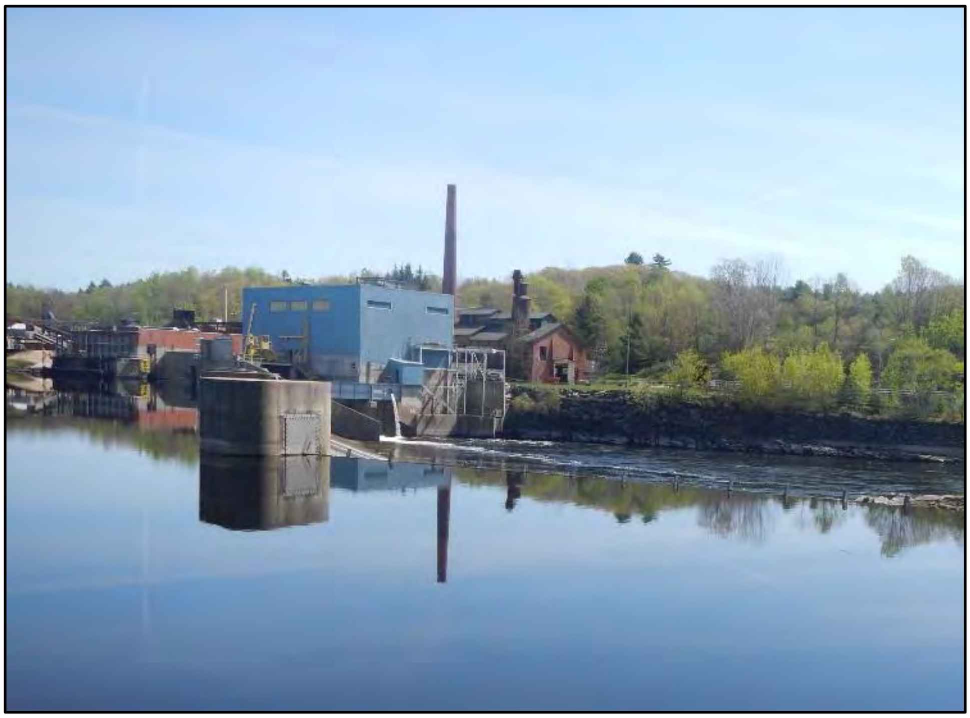
Great Blue Heron (*Ardea herodias*) at the impoundment area

DRAFT UPDATED STUDY REPORT

RECREATION FACILITIES INVENTORY AND PUBLIC RECREATION USE ASSESSMENT

PEJEPSCOT HYDROELECTRIC PROJECT

(FERC No. 4784)



Submitted by:

Brookfield Renewable
Topsham Hydro Partners Limited Partnership
150 Main Street
Lewiston, ME 04240

Prepared by:

GOMEZ AND SULLIVAN ENGINEERS

April 2020

Brookfield

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND DEFINITIONS

CFR	Code of Federal Regulations
FERC	Federal Energy Regulatory Commission
ILP	Integrated Licensing Process
Licensee	Topsham Hydro Partners Limited Partnership
ME	Maine
NOI	Notice of Intent
PAD	Pre-Application Document
Project	Pejepscot Hydroelectric Project (FERC No. 4784)
PSP	Proposed Study Plan
Topsham Hydro	Topsham Hydro Partners Limited Partnership
SD1	Scoping Document 1

1.0 INTRODUCTION

Topsham Hydro Partners Limited Partnership (L.P.) (Topsham Hydro or Licensee), an indirect member of Brookfield Renewable, is in the process of relicensing the 13.88-megawatt Pejepscot Hydroelectric Project (Project) (FERC No. 4784) with the Federal Energy Regulatory Commission (FERC). The Project is located on the Androscoggin River in the village of Pejepscot and the Town of Topsham, Maine (ME) to the east, the Town of Lisbon, ME to the north, and the Towns of Durham and Brunswick, ME to the west. The Project straddles the border between Cumberland and Sagadahoc counties and extends into Androscoggin County. The original license was issued on September 16, 1982 and expires on August 31, 2022.

The Licensee is using FERC's Integrated Licensing Process (ILP) as established in regulations issued by FERC July 23, 2003 (Final Rule, Order No. 2002) and found at Title 18 Code of Federal Regulations (CFR), Part 5. The Licensee filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to seek a new license for the Project on August 31, 2017.

The Licensee distributed the PAD and NOI simultaneously to Federal and state resource agencies, local governments, Native American tribes, members of the public, and others thought to be interested in the relicensing proceeding. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on October 30, 2017. FERC also held agency and public scoping meetings on November 28, 2017 and a site visit on November 29, 2017. The FERC Process Plan and Schedule provided agencies and interested parties an opportunity to file comments on the PAD and SD1 and request studies by December 29, 2017. FERC subsequently issued Scoping Document 2 on February 5, 2018. The Licensee filed a Proposed Study Plan (PSP) on February 12, 2018 and held a Study Plan Meeting on March 22, 2018. In the PSP, the Licensee proposed to conduct a recreation facilities inventory and public recreation use assessment to provide information regarding recreational use and opportunities in the Project vicinity. The Revised Study Plan containing the same proposed recreation assessment was filed in accordance with the ILP schedule on June 12, 2018. FERC issued a Study Plan Determination on July 3, 2018 approving the Recreation Facilities Inventory and Public Recreation Use Assessment (Recreation Study) without modification.

2.0 GOALS AND OBJECTIVES

The goal of the Recreation Study was to conduct a recreation facilities inventory and condition assessment and to estimate existing recreational use and activity at the Project. Study objectives were as follows:

- Inventory and map existing public recreation sites and access areas within the immediate Project vicinity, including site locations, facilities/amenities, general conditions, ownership, and management responsibility; and

- Assess recreational use of existing Project recreation facilities, including the extent of use and the types of activities participated in at each site.

3.0 PROJECT DESCRIPTION AND STUDY AREA

3.1 Existing Recreation Sites

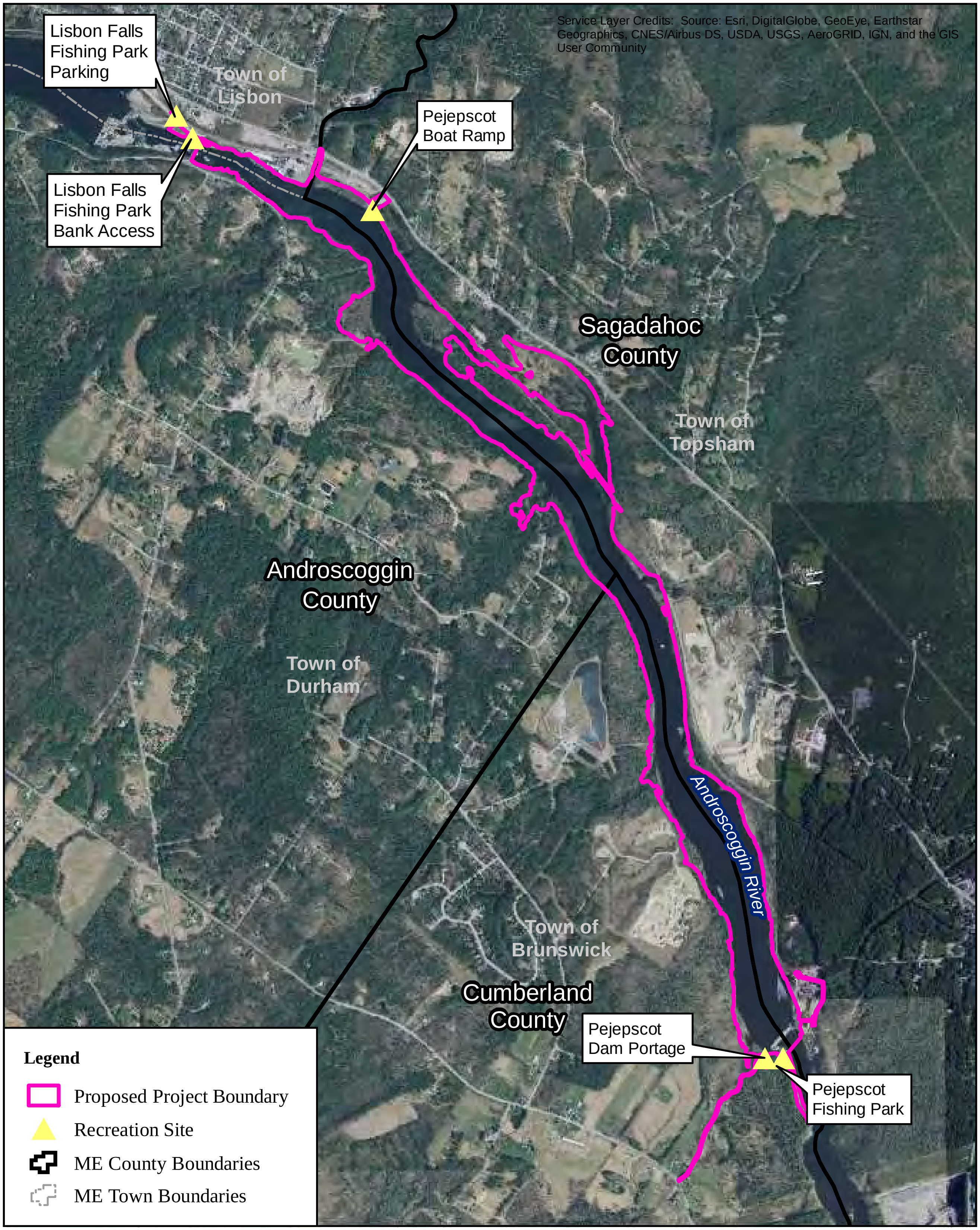
The Licensee operates the following three FERC-approved Project recreation facilities:

- Pejepscot Boat Ramp: located in Topsham off Route 196 on the eastern shore of the Androscoggin River just downstream from Lisbon Falls. The site provides Project impoundment access for trailered and hand-carry boats via a concrete ramp with an asphalt approach.
- Pejepscot Fishing Park: located off River Road in Brunswick, on the western shore of the Androscoggin River. The site provides access to the river above and below the dam, as well as a boat landing, trail, and metal staircase for portaging around the dam.
- Lisbon Falls Fishing Park: located adjacent to the Route 125 Bridge approximately 600 feet downstream of Worumbo Dam. The Fishing Park includes a parking area on the north side of Route 125 as well as a footpath and a staircase leading to the Androscoggin River.

Figure 3.1-1 depicts existing Project recreation facilities.

3.2 Study Area

The study area included recreation facilities within or abutting the Project boundary. Figure 3.1-1 depicts the Project boundary as well as the recreation sites included in the study area.



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N

0 0.1 0.2 0.4 Miles

Pejepscot Hydroelectric Project
(FERC No. 4784)
Recreation Facilities Inventory and
Public Recreation Use Assessment

Figure 3.1-1.
Recreation Sites
in the Vicinity of the
Pejepscot Project

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4.0 METHODOLOGY

The following sections discuss the methodology for the data gathering and analysis performed for this study. Study results are discussed in Section 5.0. Note that calculations for this report were performed prior to rounding; therefore, statistics may not reflect the precise sum or product of the given input data.

4.1 Field Inventory and Condition Assessment

The Licensee conducted a field inventory and site condition assessment at Project recreation facilities on October 15 and 16, 2019. For each Project recreation site, the following information was recorded:

- A physical description of the recreational feature, including parking availability and any associated amenities;
- The type of recreation opportunity provided (boating access, angler access, etc.);
- The type of access (boat, vehicle, walk-in) and parking capacity (if applicable);
- Photographic documentation of the location and amenities;
- The condition of the facility and any amenities; and
- Primary activities supported by or undertaken at the site.

The parking lot capacity of each recreation facility was estimated based on the following parking stall dimensions: for vehicles without trailers, nine (9) feet wide by 18 feet long; for vehicles with trailers, nine (9) feet wide by 40 feet long.

4.2 Field Study of Existing Use

The Licensee conducted a field study at Project recreation sites during the open water recreation season (Memorial Day weekend through Columbus Day weekend) to estimate recreation use by activity type. Monitoring equipment was placed at each Project recreation facility for the duration of the study period as follows:

- Pejepscot Boat Ramp: A TRAFx Infrared Trail Counter was installed at the facility entrance and configured to count vehicles entering and exiting the park. Figure 4.2-1 depicts the location of the monitoring equipment at this facility.

- Pejepscot Fishing Park: A TRAFx Vehicle Counter was installed along the access road just above the parking area to count vehicles entering and exiting the park. A Bushnell Trophy Cam HD Aggressor trail camera was installed along the portage trail to record boaters using the portage facility. Figure 4.2-2 depicts the location of counter and trail camera equipment at this facility.

- Lisbon Falls Fishing Park: A TRAFx Infrared Trail Counter was installed at the north end of the footpath and configured to count pedestrians entering and exiting the park. Figure 4.2-3 depicts the location of the monitoring equipment at this facility.

Monitoring equipment for each site recorded a continuous tally over the study period each time the equipment was triggered. Field technicians downloaded data from the monitoring equipment two times per month.

To supplement and calibrate data obtained from monitoring equipment, field technicians conducted calibration counts at each Project recreation facility on a total of 14 days throughout the study period. Sample days were stratified by weekdays, weekend days, and peak use days, including holidays and holiday weekends, with the majority of the surveys conducted during the peak recreation season (Memorial Day through Labor Day). Sample days were randomly selected and distributed throughout the study period as follows: at least one weekday and one weekend day or peak use day per month, plus two additional weekdays during the peak recreation season. During each calibration count, a field technician visited each site for three hours and recorded data on a standard observation form, presented in Appendix A, including number of people using the facilities for recreation, the primary activities engaged in, number of vehicles entering and exiting the site, peak utilization of the parking area, and duration of visit[1]. Each Project recreation site was visited once per sample day. Routes between sites remained the same each day; however, the starting location changed each sample day to cover each site at different times of day throughout the study. Table 4.2-1 provides sample day dates and times for calibration counts at Project facilities.

During calibration counts, field technicians recorded all use of a site, including obvious non-recreational use such as maintenance vehicles or vehicles simply using a site to turn around. Comparing total use at each site to the counts as recorded by the sites' monitoring equipment allowed for an assessment of the equipment's accuracy. This information was closely monitored throughout the study period to determine whether equipment was functioning properly, or whether field settings or conditions needed adjustments to ensure accuracy. To account for sites that are regularly accessed for non-recreational purposes (e.g., the Pejepscot Boat Ramp site is often used as a turnaround or a brief rest stop off Route 196), technicians noted for each observation whether the purpose of the visit was recreational or non-recreational. For each recreation site, a calibration factor then was calculated by dividing total recreational use observed during each calibration count by total overall use as recorded by monitoring equipment during those same timeframes. Each site's calibration factor thus accounts for equipment accuracy as well as the proportion of site visits that were recreational (as opposed to non-recreational) in purpose.

Recreation use estimates for Project facilities are presented in terms of the total number of recreation days spent from Memorial Day weekend through Columbus Day weekend. Consistent with FERC's definition, a recreation day is defined as each visit by a person to the study area for recreational purposes during any portion of a 24-hour period. Use of the portage facility was determined by viewing portage camera images over the entire study period. Use of the Pejepscot Boat Ramp, Pejepscot Fishing Park, and Lisbon Falls Fishing Park was calculated using DataNet, TRAFx's online data management program. As monitoring equipment at each site was located such that it would record users or vehicles both entering and exiting the recreation facility, DataNet was set to divide all counts by two to avoid double counting. For each site, an

[1] Where users were already at the recreation site prior to the beginning of the calibration count and/or were still present at the site at the end of the count, duration of visit was assumed to be four hours.

adjustment factor was also applied. For the Lisbon Falls Fishing Park, which was monitored by equipment that directly counted recreationists, the adjustment factor was the calibration factor, discussed above. The adjustment factor for the Pejepscot Boat Ramp and Pejepscot Fishing Park, which were monitored by equipment that counts vehicles, was calculated by multiplying the calibration factor by the average number of people per vehicle as calculated from data obtained during calibration counts.

Recreation site capacity and percent utilization were estimated for each recreation facility based on parking area utilization during average non-peak weekends during the study period. Point-in-time tallies of vehicles taken at the beginning of each calibration count conducted on non-peak weekends were averaged to produce an average level of use at the site’s parking area. This average parking area use was compared to the maximum vehicle capacity of the parking area to determine an average percent utilization. Peak observed utilization was also calculated based on the ratio of the highest level of use observed during the study period to the capacity of the parking area.

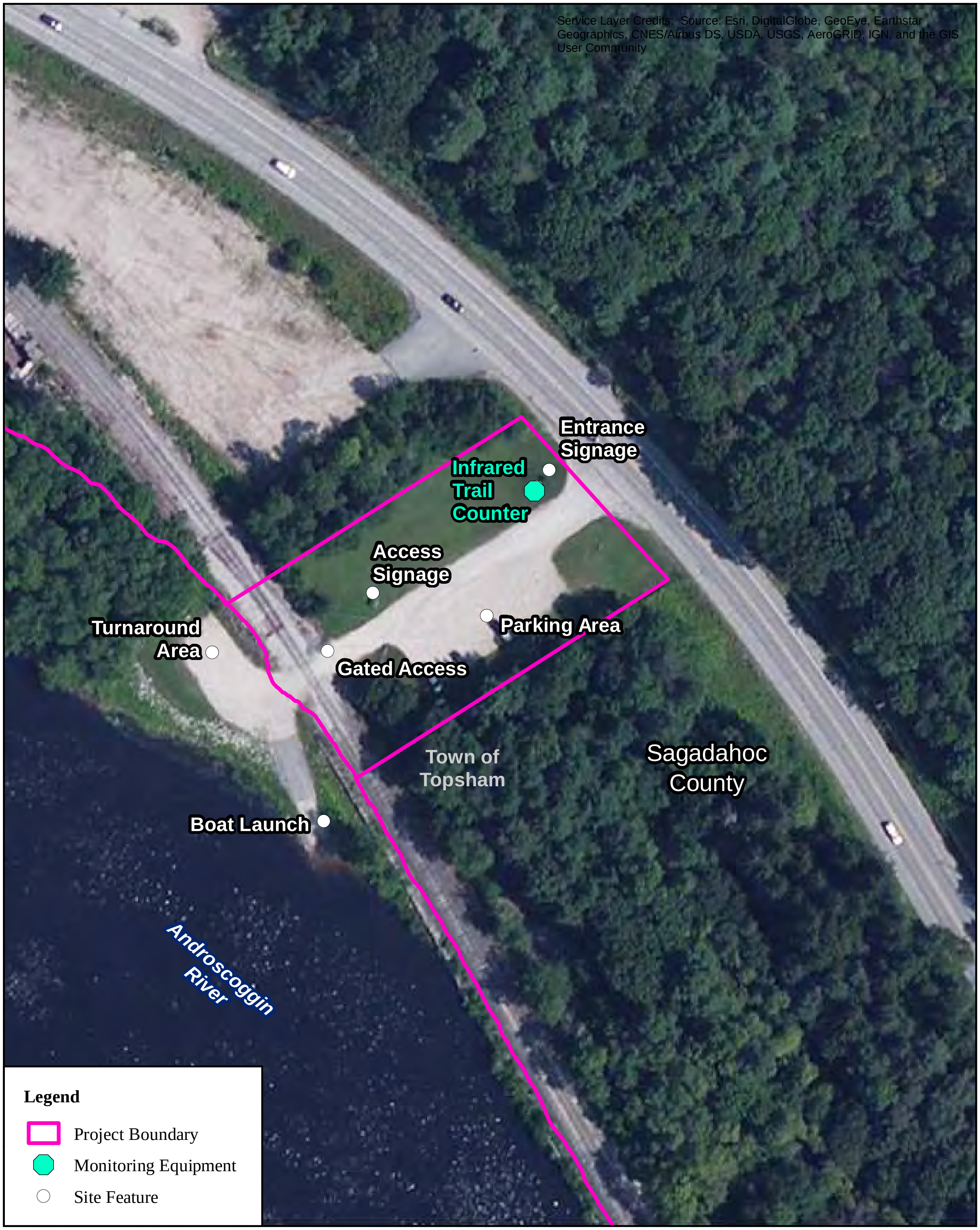
4.3 Variances from the FERC Approved Study Plan

The trail camera set to monitor the Pejepscot Fishing Park portage trail did not capture any images from noon on October 1st to just before noon on October 10th due to equipment malfunction. Use of this facility is discussed in Section 5.2.2. Considering the low usage of this facility throughout the remainder of the study period, this data gap did not significantly affect the results of the study.

Table 4.2-1: Calibration Count Sample Dates and Times

Sample #	Start Date (2019)[1]	Day Type	Day 1		Day 2
			11:00 PM - 2:00 PM	3:00 PM - 6:00 PM	8:00 AM - 11:00 AM
1	Saturday, May 25	Peak Use	Site 1[2]	Site 2[3]	Site 3[4]
2	Thursday, May 30	Weekday	Site 2	Site 3	Site 1
3	Tuesday, June 4	Weekday	Site 3	Site 1	Site 2
4	Saturday, June 22	Weekend	Site 1	Site 2	Site 3
5	Monday, July 1	Weekday	Site 2	Site 3	Site 1
6	Saturday, July 13	Weekend	Site 3	Site 1	Site 2
7	Thursday, July 25	Weekday	Site 1	Site 2	Site 3
8	Wednesday, August 7	Weekday	Site 2	Site 3	Site 1
9	Saturday, August 17	Weekend	Site 3	Site 1	Site 2
10	Wednesday, August 28	Weekday	Site 1	Site 2	Site 3
11	Sunday, September 1	Peak Use	Site 2	Site 3	Site 1
12	Monday, September 16	Weekday	Site 3	Site 1	Site 2
13	Wednesday, October 9	Weekday	Site 1	Site 2	Site 3
14	Saturday, October 5	Weekend	Site 2	Site 3	Site 1

[1]Calibration counts were conducted over two days. Two sites were visited on Day 1, and one site was visited the morning of Day 2.
[2]Site 1 denotes the Pejepscot Boat Ramp.
[3]Site 2 denotes the Lisbon Falls Fishing Park.
[4]Site 3 denotes the Pejepscot Fishing Park, including the portage facility.



Brookfield

N

0 25 50 100 Feet

Pejepscot Hydroelectric Project
(FERC No. 4784)
Recreation Facilities Inventory and
Public Recreation Use Assessment

Figure 4.2-1:
Pejepscot Boat Ramp
Facility Overview

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Brookfield

N

Pejepscot Hydroelectric Project
(FERC No. 4784)
Recreation Facilities Inventory and
Public Recreation Use Assessment

0 87.5 175 350 Feet

Figure 4.2-2:
Pejepscot Fishing Park
Facility Overview

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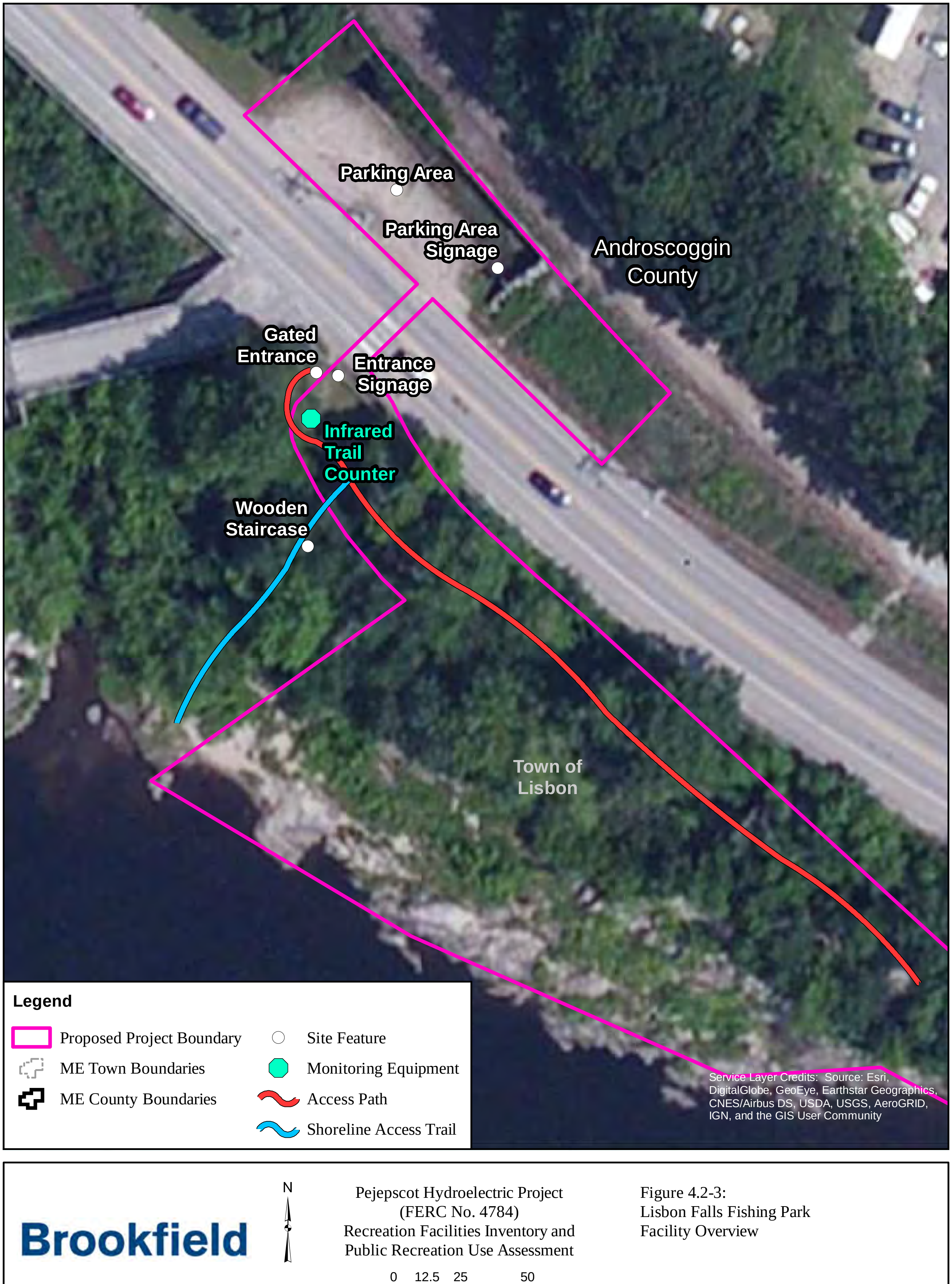

Brookfield

Pejepscot Hydroelectric Project
(FERC No. 4784)
Recreation Facilities Inventory and
Public Recreation Use Assessment

Figure 4.2-3:
Lisbon Falls Fishing Park
Facility Overview

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5.0 RESULTS

5.1 Existing Recreation Facilities

Results of the recreation field inventory conducted on October 15 and 16, 2019 are presented by site below. Photographic documentation of each site and associated amenities is included as Appendix B.

Pejepscot Boat Ramp

Description

The Pejepscot Boat Ramp is operated by the Licensee and is located approximately 2.5 miles upstream of the dam directly off Lisbon Street/Route 196 in the Town of Topsham. The facility consists of a large gravel parking area, a gated gravel access lane that crosses a railroad track, a gravel turnaround area, and a boat ramp providing access to the Project impoundment. Figure 4.2-1 presents an overview of the facility. The site is comprised of two parcels divided by the railroad right of way: one parcel holds the parking area and the other holds the boat ramp and gravel turnaround area. The Licensee holds easements on the parking and boat ramp parcels and a private railroad crossing permit to connect them.

A large sign near the site entrance, visible from traffic passing in both directions on Lisbon Street/Route 196, identifies the site as the Pejepscot Boat Ramp. A smaller attached sign indicates that the park is open for public use from one hour before sunrise to one hour after sunset. A large sign between the parking area and the gated access lane identifies the Licensee as the site owner, provides a map of recreation sites in the Pejepscot Recreation Area, provides contact information and the FERC project number, includes hours of operations, and prohibits overnight camping. Nearby signage contains safe boating guidelines and a Maine Department of Inland Fisheries and Wildlife informational sign.

The access road leading from the parking area to the turnaround area and boat launch is gated; the gate is closed during high flow conditions or as needed for safety considerations based on the discretion of Project operating and safety staff. The access road leads to a gravel turnaround area, large enough to allow for vehicles with trailers to pivot in order to back down the boat ramp. The approach to the boat ramp is a nearly 15 foot wide asphalt road. The ramp itself is composed of two sets of concrete planks each 7.5 feet wide. The total ramp length, including the asphalt approach, is approximately 45 feet.

Opportunities Provided

The site provides boat launching opportunities for trailered and cartop boats and angler access to the Project impoundment.

Vehicular Access and Parking

Access to the site consists of an approximately 25 foot wide gravel driveway off Lisbon Street/Route 196. The gravel parking area is approximately 115 feet long and 40 feet wide, with space for approximately 12 vehicles with trailers.

Site Condition

The site was in overall fair condition at the time the inventory was conducted. The parking and turnaround areas were in serviceable condition, but erosion ruts and loose surface material were noted in both areas. At the driveway entrance there was a significant rut approximately two to three inches deep at the edge of the pavement. This rut, along with the loose surface material, likely makes it difficult to pull out of the site onto Lisbon Street/Route 196, especially with a trailer.

The boat ramp was of constant grade, and no cracking or significant wear was noted on either the concrete planks or the asphalt. However, the 15 foot width of the ramp had been reduced by encroaching sediment, which was stabilized in place with grass. The effective width at the bottom of the ramp was 11 feet. There were two sets of 7.5-foot planks, which at full width would allow a boat to be parked at the toe of the ramp while another was being launched. The sediment covering the ramp likely doesn't prevent launching or use of the ramp; however, it would likely hinder use by two boats simultaneously. Signage at the site was in good condition, aside from the entrance signage identifying the park, which is cracked and peeling.

Pejepscot Fishing Park

Description

The Pejepscot Fishing Park, also known as the Pejepscot Dam Recreation Area, is located off River Road in the Towns of Topsham and Brunswick. The site is accessed via a long gravel access road and consists of a small parking area, angler access above and below the dam, and a portage facility. Figure 4.2-2 presents an overview of the facility. The site is situated on three parcels; the Licensee owns one of the parcels and holds easements on the remaining two.

A large wooden sign at the top of the access road off River Road identifies the site as the Pejepscot Fishing Park. Attached signage indicates that the park is open for public use from one hour before sunrise to one hour after sunset and that the use of tobacco is prohibited on the property. The access road leads to a small gravel parking area; vehicular access beyond the parking area is blocked by a cable strung between two posts. A trash receptacle is provided near the parking area.

Beyond the parking area and adjacent to the portage trail is a flat, open area overlooking the Project dam. Access to and views of the Project are restricted by fencing. A large sign posted on the fencing identifies the Licensee as the site owner, provides a map of recreation sites in the Pejepscot Recreation Area, provides contact information and the FERC project number, includes hours of operations, and prohibits overnight camping.

The portage facility consists of an unimproved boat landing area above the dam, a 600-foot-long trail leading around the dam, and a put-in below the dam. The take-out landing is located just above the dam along a steep boulder wall. An informal footpath was observed leading roughly 100 feet upstream to an area with a shallower grade; it was assumed that this area is informally used as a take-out landing.

To access the take-out, boaters pass around the western edge of the upstream boat barrier (installed from May 15 through October 15) and follow the inner canoe barrier along the shore. From the take-out, boaters follow the edge of the fence along an unimproved dirt path indicated by a canoe portage sign. The trail continues up the hill to the dam overlook area and continues along the edge of the fence downhill to a set of steel stairs descending a steep exposed ledge face. Along the stairs is a ramp upon which canoes and kayaks can be slid down. At the bottom of the stairs is a flat rock landing with handrails guiding users down a steep section of ledge to a lower shelf. The lower shelf runs for approximately 55 feet to an area where the slope to water's edge is more gradual. The put-in is located in a gentle backwater with a gradual rocky slope into the water.

Anglers access the shoreline above and below the dam using the portage trail. In addition, there is an informal footpath leading from the parking area to the shoreline approximately 1,300 feet downstream from the dam.

Opportunities Provided

The site provides recreational access to the river above and below Pejepscot Dam, views of the dam and appurtenant facilities, boat take-out and put-in opportunities above and below the dam, and a trail for portaging around the dam.

Vehicular Access and Parking

Access to the site is provided by an approximately 2,000 foot long gravel access road. The road is generally wide enough for single lane travel. The gravel parking area provides three parking spaces separated by trees.

Site Condition

With the exception of the steel portage staircase, this site is generally maintained in primitive condition. At the time the inventory was conducted, the access road was in serviceable condition. The parking area showed signs of rutting but was generally in fair condition. The unimproved portage trail was flat and of constant grade, although in places roots and boulders projected up from the path and in others loose gravel was noted on the path's surface.

The boat slide adjacent to the steel stairs is constructed of wood and appeared to have originally been topped with a carpet material, which has since worn away. The stairs appeared stable and sturdy; however, at the top right (looking downslope) a support was missing. The bottom of the steps was anchored by rocks placed to provide flat footing, and the railing around this platform had several loose nuts. The transition from the bottom of the stairs to the ledge did not provide stable footing. Downed trees were found across both informal footpaths at the site. Existing signage at the site was in good condition; however, there does not appear to be signage upstream of the portage take-out identifying the facility.

Lisbon Falls Fishing Park

Description

The Lisbon Falls Fishing Park, operated by the Licensee, is located in the Town of Lisbon off Canal Street/Route 125. The Licensee holds easements on the parcels comprising the site; these easements terminate at the end of the current FERC license. The site consists of a parking area, a gravel access path leading to the shoreline, and informal access along the shoreline. Canal Street/Route 125 separates the parking area from the recreation area, which is fenced and gated. Figure 4.2-3 presents an overview of the facility.

The gravel parking area measures approximately 95 by 23 feet and is bordered by a large boulder wall approximately 20 feet high. A large sign at the east end of the parking area identifies the site as the Lisbon Falls Fishing Park. A smaller attached sign indicates that the park is open for public use from one hour before sunrise to one hour after sunset.

A crosswalk leads from the parking area to the gated path entrance. The site is also accessible by pedestrians using the sidewalk on the south side of Canal Street/Route 125. A large sign affixed to the fencing identifies the Licensee as the site owner, provides a map of recreation sites in the Pejepscot Recreation Area, provides contact information and the FERC project number, includes hours of operations, and prohibits overnight camping. The approximately 10 foot wide access path runs on top of the bank along the shoreline downstream to the Route 125 bridge. The access path ends near the upstream bridge abutment, but informal footpaths continue to the top of the rocks downstream from the bridge.

Approximately 70 feet along the access path from the gated entrance, a set of wooden stairs leads down to a narrower trail extending to the shoreline. Several informal footpaths lead along the river to provide angler access to approximately 300 feet of shoreline.

Opportunities Provided

The site provides angler access to the Androscoggin River approximately 3.2 miles upstream of the Project and immediately downstream from the Worumbo Project (FERC No. 3428).

Vehicular Access and Parking

Vehicular access to the site is directly off Canal Street/Route 125. The gravel parking area measures approximately 95 by 23 feet, providing space for 10 vehicles without trailers.

Site Condition

The site was in overall fair condition at the time the inventory was conducted. The gravel parking lot was generally flat and appeared to drain toward the roadway. A few recent gravel fill deposits were observed as well as minor depressions. The gravel path was of firm and constant grade. Generally, vegetation had started to encroach on all gravel surfaces. The wooden stairs were in serviceable condition, although minor graffiti and settlement or warping of the landing platform was observed. The trail below the stairs was in primitive condition, as were the informal footpaths along the shoreline. Signage at the site was in good condition, aside from the entrance signage identifying the park, which has minor graffiti.

5.2 Existing Recreation Use

Overall use of Project recreation facilities during the study period was estimated at 5,890 recreation days. Table 5.2-1 presents recreation use over the study period by site and month, along with estimated average daily use for each site. Figure 5.2-1 depicts monthly use, with use in May and October extrapolated based on average daily use for those months. As shown, use for all facilities increased as summer progressed, peaked in July, and decreased through October. The Pejepscot Boat Ramp saw the highest use of the three facilities, with an average daily use of 23.1 recreation days. Lisbon Falls Fishing Park and Pejepscot Fishing Park had similar use over the study period, with average daily uses of 10.0 and 8.1 recreation days, respectively. Figure 5.2-2 depicts use by primary activity at each Project recreation facility, shown as the percentage of total Project recreation use. As shown, fishing was the most popular activity at the Project, accounting for approximately 40 percent of combined use. Hiking was the next most popular activity, accounting for roughly 32 percent of use. Sightseeing and motorized boating are significantly less popular, at 11 and nine percent, respectively. Picnicking, non-motorized boating, and other uses combined comprise less than 10 percent of use at the Project. The following sections discuss use by site, including the primary activities participated in at each facility.

Pejepscot Boat Ramp

Use at the Pejepscot Boat Ramp over the study period was estimated at 3,299 recreation days. Although on average 35.0 vehicles accessed the site per day, only around 45 percent of these accessed the site for recreational purposes. The remaining 55 percent used the parking area as a turnaround area or for a brief rest stop. On average, 15.9 vehicles accessed the site per day for recreational purposes, with an average of 1.5 people per vehicle. The average duration for recreational visits was 1.8 hours. Table 5.2.1-1 depicts the percentage of users observed engaged in each activity over the study period. As shown, fishing was the most popular activity at the site, accounting for 30 percent of site use. Anglers were observed fishing along the shoreline at the site as well as walking along the railroad track to offsite locations. Hiking, generally along the railroad track, was the next most popular activity at 25 percent. Boating accounted for 20 percent of overall site use (16 percent of use was attributed to motorized boating and four percent to non-motorized boating).

Based on parking area utilization, the site was used at approximately 25 percent capacity on average non-peak weekends over the study period. Peak use observed was on the Monday of Labor Day weekend, when six vehicles were observed in the lot at one time, for a peak utilization of 50 percent of parking capacity. Table 5.2.1-2 presents parking area capacity utilization over the study period.

Pejepscot Fishing Park

Use at the Pejepscot Fishing Park over the study period was estimated at 1,164 recreation days. On average, 4.7 vehicles accessed the site per day for recreational purposes, with an average of 1.7 people per vehicle. The average duration for recreational visits was 2.1 hours. Table 5.2.2-1 depicts the percentage of users observed engaged in each activity over the study period. As shown, fishing was the most popular activity at the site, accounting for 49 percent of use. The majority of anglers were observed using the portage trail to access the shoreline. A small percentage of anglers were observed using the informal footpath near the parking area for shoreline access. The next most popular activity at the site was hiking, accounting for 36 percent of use. Sightseeing accounted for the remaining 15 percent of use.

Based on parking area utilization, the site was used at approximately 33 percent capacity on average non-peak weekends over the study period. Peak use observed was two vehicles in the lot at one time, for a peak utilization of 67 percent of parking capacity; this occurred during five of the 14 calibration counts. Table 5.2.2-2 presents parking area capacity utilization over the study period.

Although the portage trail was observed to be used for non-boating activities throughout the study period, only four instances of use for portaging boats around the dam were captured by the trail camera. Three of these occurred in June and one in August. A total of 7 people were observed portaging; three were kayaking and four were canoeing.

Lisbon Falls Fishing Park

Use at the Lisbon Falls Fishing Park over the study period was estimated at 1,427 recreation days. On average, 4.2 vehicles accessed the site per day for recreational purposes, with an average of 2.4 people per vehicle. The average duration for recreational visits was 1.4 hours. Table 5.2.3-1 depicts the percentage of users observed engaged in each activity over the study period. As shown, fishing was the most popular activity at the site, accounting for 55 percent of use. The remaining 45 percent of users were hiking.

Based on parking area utilization, the site was used at approximately 10 percent capacity on average non-peak weekends over the study period. Peak use observed was on the Saturday of Memorial Day weekend, when three vehicles were observed in the lot at one time, for a peak utilization of 30 percent of parking capacity. Table 5.2.3-2 presents parking area capacity utilization over the study period.

Table 5.2-1: Estimated Use, Project Recreation Facilities, May 25 to October 14, 2019

Site	May*	June	July	Aug.	Sept.	Oct.*	Average Daily Use	Total
Pejepscot Boat Ramp	142	741	832	803	566	215	23.1	3,299
Pejepscot Fishing Park	58	270	321	284	167	64	8.1	1,164
Lisbon Falls Fishing Park	82	358	400	334	211	42	10.0	1,427
							Total	**5,890**

*Months with partial data.

Table 5.2.1-1: Use by Activity, Pejepscot Boat Ramp, May 25 to October 14, 2019

Activity	Percent of Total Use	Estimated Recreation Days
Fishing	30%	994
Hiking	25%	835
Boating (motorized)	16%	517
Sightseeing	14%	477
Other Use[1]	6%	199
Picnicking	5%	159
Boating (non-motorized)	4%	119
	Total	**3,299**

[1]"Other" use includes use that was not identified; this may include both recreational and non-recreational use

Table 5.2.1-2: Parking Area Capacity Utilization, Pejepscot Boat Ramp, May 25 to October 14, 2019

Available Spaces	Average Non-Peak Weekend		Peak Use Observed	
	Spaces in Use[1]	Percent Capacity	Spaces in Use	Percent Capacity
12	3	25%	6	50%

[1]Rounded up to nearest whole number.

Table 5.2.2-1: Use by Activity, Pejepscot Fishing Park, May 25 to October 14, 2019

Activity	Percent of Total Use	Estimated Recreation Days
Fishing	49%	567
Hiking	36%	418
Sightseeing	15%	179
	Total	**1,164**

Table 5.2.2-2: Parking Area Capacity Utilization, Pejepscot Fishing Park, May 25 to October 14, 2019

Available Spaces	Average Non-Peak Weekend		Peak Use Observed	
	Spaces in Use[1]	Percent Capacity	Spaces in Use	Percent Capacity
3	1	33%	2	67%

[1]Rounded up to nearest whole number.

Table 5.2.3-1: Use by Activity, Lisbon Falls Fishing Park, May 25 to October 14, 2019

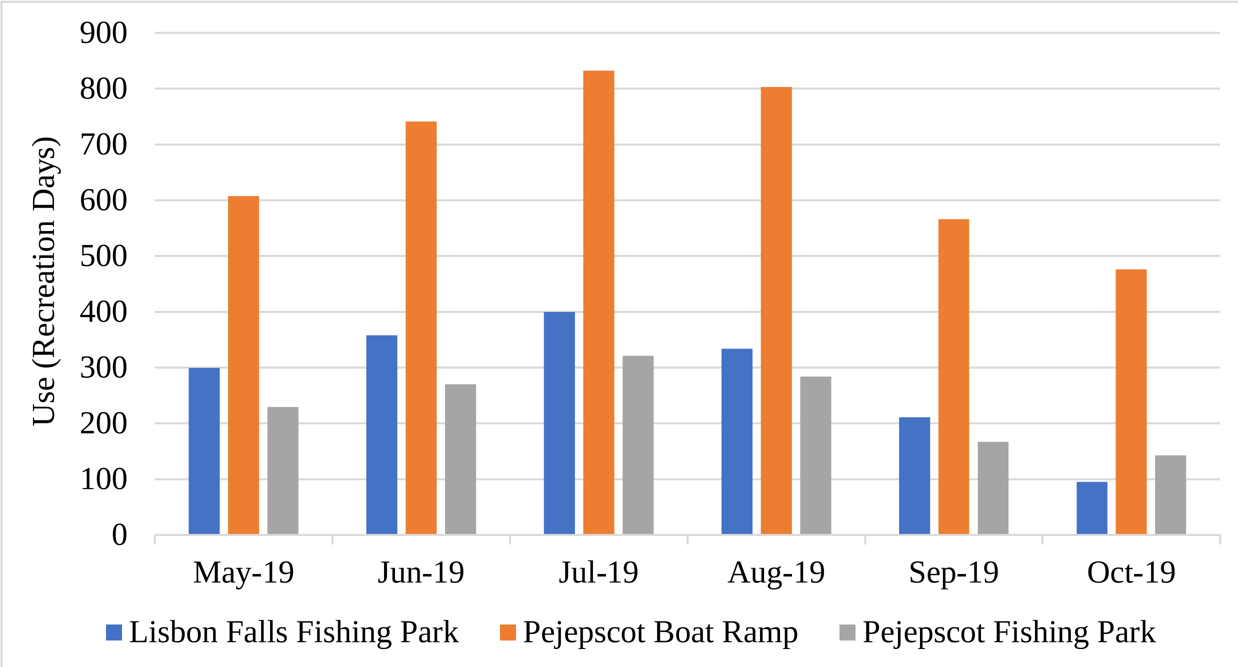
Activity	Percent of Total Use	Estimated Recreation Days
Fishing	55%	786
Hiking	45%	641
	Total	**1,427**

Table 5.2.3-2: Parking Area Capacity Utilization, Lisbon Falls Fishing Park, May 25 to October 14, 2019

Available Spaces	Average Non-Peak Weekend		Peak Use Observed	
	Spaces in Use[1]	Percent Capacity	Spaces in Use	Percent Capacity
10	1	10%	3	30%

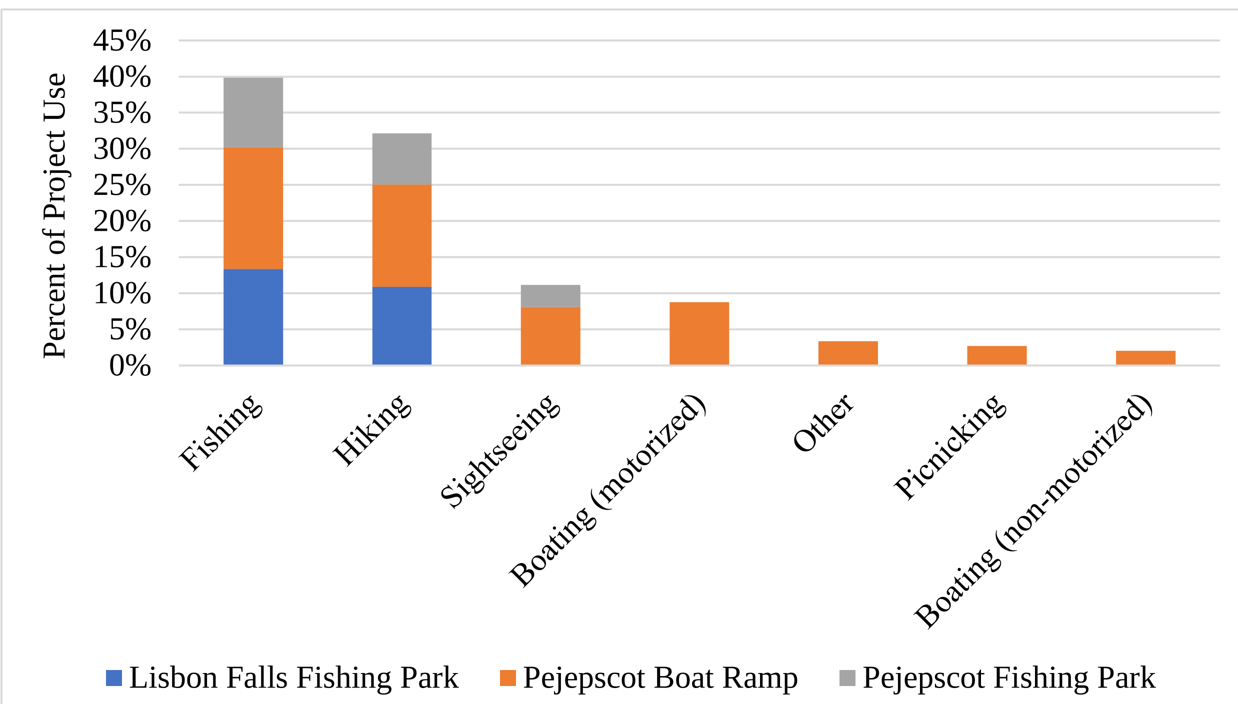
[1]Rounded up to nearest whole number.

Figure 5.2-1: Estimated Monthly Use* at Project Recreation Facilities, May through October, 2019



*Estimated use for May and October based on average daily use.

Figure 5.2-2: Use by Facility and Activity, May 25 to October 14, 2019



6.0 DISCUSSION

The results of the Recreation Study provide a comprehensive picture of recreational use and opportunities at the Project. Data collection efforts spanned 143 days over three seasons and included 14 onsite calibration counts and a field assessment of recreation facilities. These efforts included continuous monitoring during daylight hours and thus provided complete representation of weekdays, weekend days, and holidays. The results provide information on the recreational opportunities available within the study area, the level of usage at each recreation site, the types of activities engaged in, the condition of the facilities, and the facilities' ability to meet the recreational demand.

The three FERC-approved recreation facilities in the study area provide an array of recreational opportunities, including access to the Androscoggin River both above and below the dam. Fishing was the most popular primary activity observed at the Project during the study period, comprising 40 percent of overall use. Hiking was the second most popular activity at 32 percent of overall use. Sightseeing and boating (motorized and non-motorized) each accounted for just 11 percent of overall use at the Project.

Total recreational use of Project recreation facilities was estimated to be 5,890 recreation days over the study period. The Pejepscot Boat Ramp saw the highest use of the three facilities, with nearly 3,300 recreation days. Use at the Pejepscot Fishing Park was estimated at roughly 1,400 recreation days and use at Lisbon Falls Fishing Park was estimated at nearly 1,200. At the Pejepscot Boat Ramp, fishing was the most popular activity, followed by hiking. Motorized boating accounted for 16 percent of use and sightseeing accounted for roughly 15 percent. At the Lisbon Falls Fishing Park, fishing made up 55 percent of all use, and hiking accounted for the remaining 45 percent. At the Pejepscot Fishing Park, fishing accounted for nearly half of all use. Hiking comprised 36 percent and sightseeing comprised 15 percent. Only seven boaters were recorded using the portage facility during the study period.

The results of the study demonstrate that there is ample access and capacity for recreational demand in the study area. The Pejepscot Boat Ramp was used at approximately 25 percent capacity on average non-peak weekends over the study period. The Pejepscot Fishing Park was used at approximately 33 percent capacity, and the Lisbon Falls Fishing Park was used at approximately 10 percent.

Existing recreation sites were found to be in fair condition, although maintenance issues were identified at each site. The Pejepscot Boat Ramp driveway has some rutting, most notably at the facility entrance. The Pejepscot Fishing Park access road is in serviceable condition, and the steel staircase on the portage trail requires maintenance. The Lisbon Falls Fishing Park needs minor vegetation maintenance. Aside from maintenance considerations, the facilities appear to serve the recreational demand in the Project vicinity.

APPENDIX A. CALIBRATION COUNT DATA SHEETS

Pejepscot Public Recreation Use Assessment – Standard Calibration Form

Site	Observer	Date	Day type (circle one)	Start time		End time		Weather (circle one)	Air temp.
Fishing Park		__/__/2019	Weekday / Weekend / Holiday	__:__	a.m. p.m.	__:__	a.m. p.m.	Sunny / Partly Cloudy / Cloudy Overcast / Rainy	__°F
Number of vehicles in lot on arrival:									
Maximum number of vehicles observed in lot during count:									
Fishing park gate open or closed?									

General info								Number of people participating in activity during visit					
Group description	Total # of vehicles	Total # of trailers	Total # of Non-recreational vehicles	Time in	Time out	Total # of recreationists	# times counter tripped	Fish	Hike/Run/Walk	Picnic	Sightsee/view wildlife/Photography	OTHER (specify activity)	Notes

Notes:

1. Count all vehicles, people and their activities (if possible) upon arrival. Note “upon arrival” under “Time in” column.
2. Count vehicles that pull in to parking area for non-recreational purposes, but note it in “Group description” column, put # vehicles under Non-recreational vehicles, and note time in and time out. No need to note number of people if they are not recreating, unless they trip the counter.
3. If non-recreationists trip the counter, note them in the “# times counter tripped” column, but do not include them in “Total # of recreationists” column.
4. For “# times counter tripped” column, estimate number of trips based on number of times person walked past counter within 1.5 second delay window

Data Collection Continued:

General info								Number of people participating in activity during visit					
Group description	Total # of vehicles	Total # of trailers	Total # of Non-recreational vehicles	Time in	Time out	Total # of recreationists	# times counter tripped	Fish	Hike/Run/Walk	Picnic	Sightsee/view wildlife/Photography	OTHER (specify activity)	Notes

Observer's notes:

Pejepscot Public Recreation Use Assessment – Standard Calibration Form

Site	Observer	Date	Day type (circle one)	Start time		End time		Weather (circle one)	Air temp.
Recreation Area		__/__/2019	Weekday / Weekend / Holiday	__:__	a.m. p.m.	__:__	a.m. p.m.	Sunny / Partly Cloudy / Cloudy Overcast / Rainy	__°F
Number of vehicles in lot on arrival:									
Maximum number of vehicles observed in lot during count:									

General info							Number of people participating in activity during visit										
Group description	Total # of vehicles	Total # of trailers	Total # of Non-recreational vehicles	Time in	Time out	Total # of recreationists	Bicycle	Fish	Hike/Run/Walk	Motor boat	Non-motor boat	Picnic	Sightsee/view wildlife/Photography	Swim	OTHER (specify activity)	Notes

Notes:

1. Count all vehicles, people and their activities (if possible) upon arrival. Note "upon arrival" under "Time in" column.
2. Count vehicles that pull in to turn around if they trip the counter; put "turnaround" in "Group description" column, put # vehicles under Non-recreational vehicles, and note time in and time out. No need to note number of people if they are not recreating.

Data Collection Continued:

General info							Number of people participating in activity during visit									
Group description	Total # of vehicles	Total # of trailers	Total # of Non-recreational vehicles	Time in	Time out	Total # of recreationists	Bicycle	Fish	Hike/Run/Walk	Motor boat	Non-motor boat	Picnic	Sightsee/view wildlife/Photography	Swim	OTHER (specify activity)	Notes

Notes/Observations:

Pejepscot Public Recreation Use Assessment – Standard Calibration Form

Site	Observer	Date	Day type (circle one)	Start time		End time		Weather (circle one)	Air temp.
Boat Launch		__/__/2019	Weekday / Weekend / Holiday	__:__	a.m. p.m.	__:__	a.m. p.m.	Sunny / Partly Cloudy / Cloudy Overcast / Rainy	__°F
Number of vehicles in lot on arrival:									
Maximum number of vehicles observed in lot during count:									
Boat launch gate open or closed?									

General info							Number of people participating in activity during visit										
Group description	Total # of vehicles	Total # of trailers	Total # of non-recreational vehicles	Time in	Time out	Total # of recreationists	Bicycle	Fish	Hike/Run/Walk	Motor boat	Non-motor boat	Picnic	Sightsee/view wildlife/Photography	Swim	OTHER (specify activity)	Notes	

Notes:

1. Count all vehicles, people and their activities (if possible) upon arrival. Note "upon arrival" under "Time in" column.
2. Do not count vehicles/bicyclists/people that pull into entryway to turn around but do not trip counter.
3. Count vehicles that pull in to turn around if they trip the counter; put "turnaround" in "Group description" column, put # vehicles under Non-recreational vehicles, and note time in and time out. No need to note number of people if they are not recreating.
4. Count each time a vehicle enters site/trips counter, even if they visited the site previously during the same calibration period. If a visit does not appear to be for recreational purposes, indicate that in the notes and in the "Total # of non-recreational vehicles" column. Note repeat visit in "Group description" column.

Data Collection Continued:

General info							Number of people participating in activity during visit									
Group description	Total # of vehicles	Total # of trailers	Total # of non-recreational vehicles	Time in	Time out	Total # of recreationists	Bicycle	Fish	Hike/Run/Walk	Motor boat	Non-motor boat	Picnic	Sightsee/view wildlife/Photography	Swim	OTHER (specify activity)	Notes

Observer's notes:

Pejepscot Public Recreation Use Assessment – Standard Calibration Form

Site	Observer	Date	Day type (circle one)	Start time		End time		Weather (circle one)	Air temp.
Portage		__/__/2019	Weekday / Weekend / Holiday	__:__	a.m. p.m.	__:__	a.m. p.m.	Sunny / Partly Cloudy / Cloudy Overcast / Rainy	__°F

General info					Number of people participating in activity during visit			
Group description	Time in	Time out	Total # of boats	Total # of recreationists	Canoe	Kayak	OTHER (specify activity)	Notes

Notes:

1. Note use of portage as a take-out or put-in for boats on Rec Area form, as it will affect vehicle counter calibration. This form should only reflect portaging of boats around dam.

Data Collection Continued:

General info					Number of people participating in activity during visit			
Group description	Time in	Time out	Total # of boats	Total # of recreationists	Canoe	Kayak	OTHER (specify activity)	Notes

Observer's notes:

APPENDIX B. SITE PHOTOGRAPHS

LIST OF PHOTOS

Pejepscot Boat Ramp

Photo 1: Pejepscot Boat Ramp, Entrance Signage

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/15/2019)

Photo 2: Pejepscot Boat Ramp, Parking Area

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/15/2019)

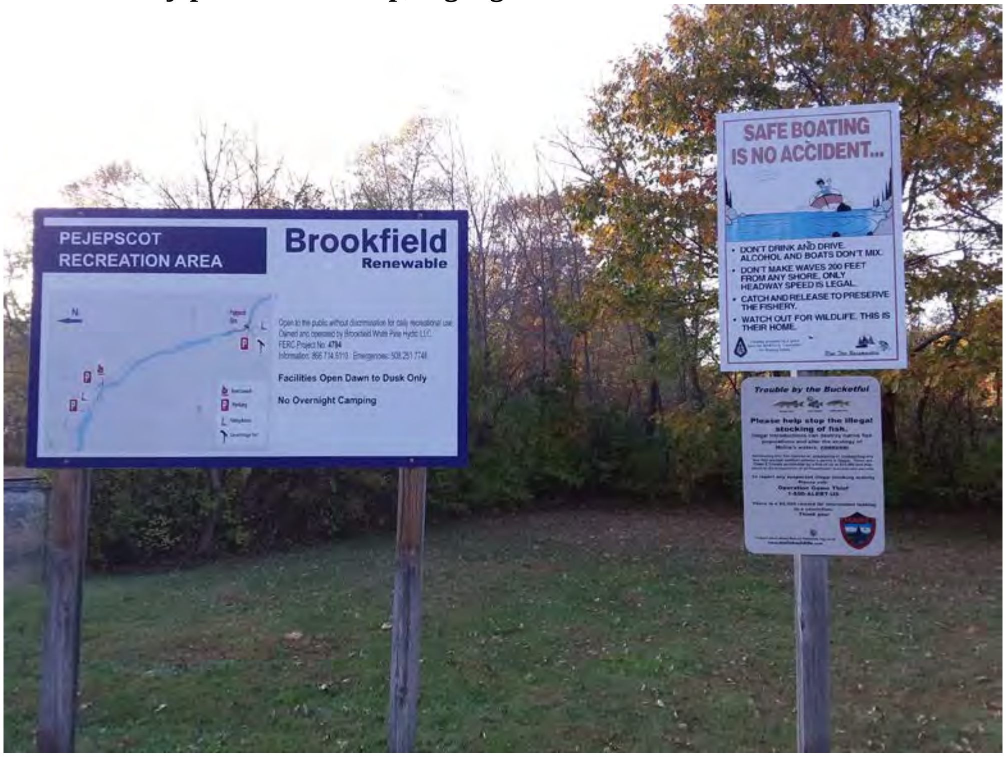
Photo 3: Pejepscot Boat Ramp, Infrared Counter

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/15/2019)

Photo 4: Pejepscot Boat Ramp, Gated Access Road, Signage

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/15/2019)

Photo 5: Pejepscot Boat Ramp, Signage



(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/15/2019)

Photo 6: Pejepscot Boat Ramp, Turnaround Area

(Photo taken by J. Commerford, Gomez and Sullivan Engineers, 10/16/2019)

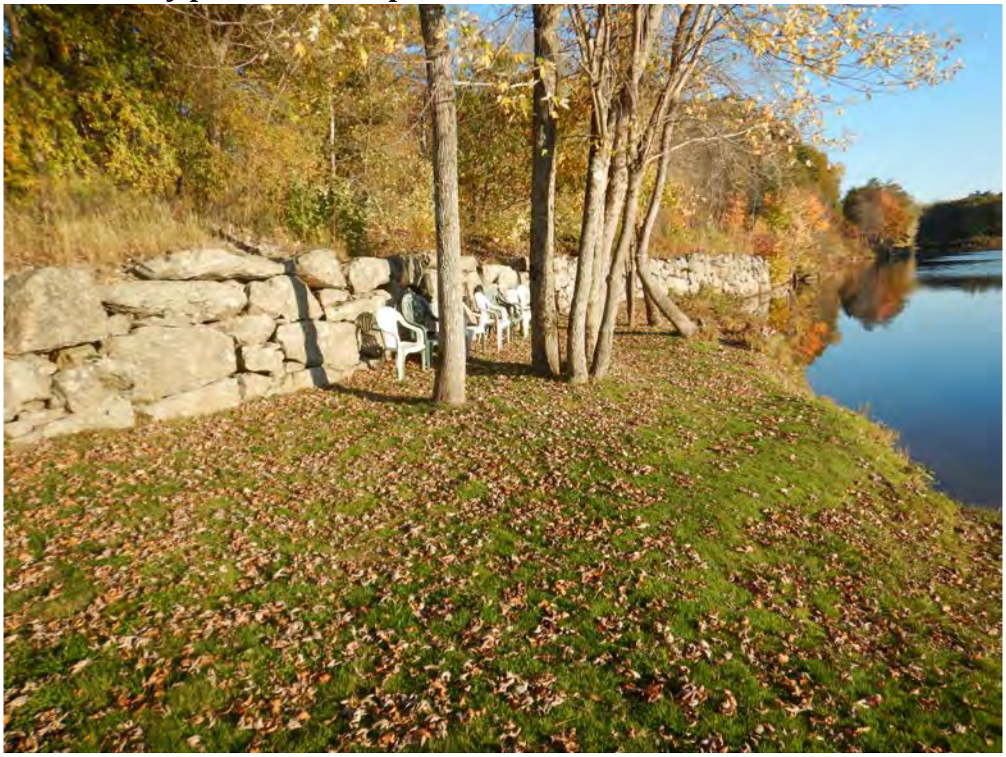
Photo 7: Pejepscot Boat Ramp, Launch Approach

(Photo taken by J. Commerford, Gomez and Sullivan Engineers, 10/16/2019)

Photo 8: Pejepscot Boat Ramp, Launch

(Photo taken by J. Commerford, Gomez and Sullivan Engineers, 10/16/2019)

Photo 9: Pejepscot Boat Ramp, Bank Downstream from Launch



(Photo taken by J. Commerford, Gomez and Sullivan Engineers, 10/16/2019)

Pejepscot Fishing Park

Photo 10: Pejepscot Fishing Park, Entrance Signage

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 11: Pejepscot Fishing Park, Access Road, Vehicle Counter

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 12: Pejepscot Fishing Park, Vehicle Counter

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 13: Pejepscot Fishing Park, Parking Area

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 14: Pejepscot Fishing Park, Cabled Entrance to Recreation Area

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

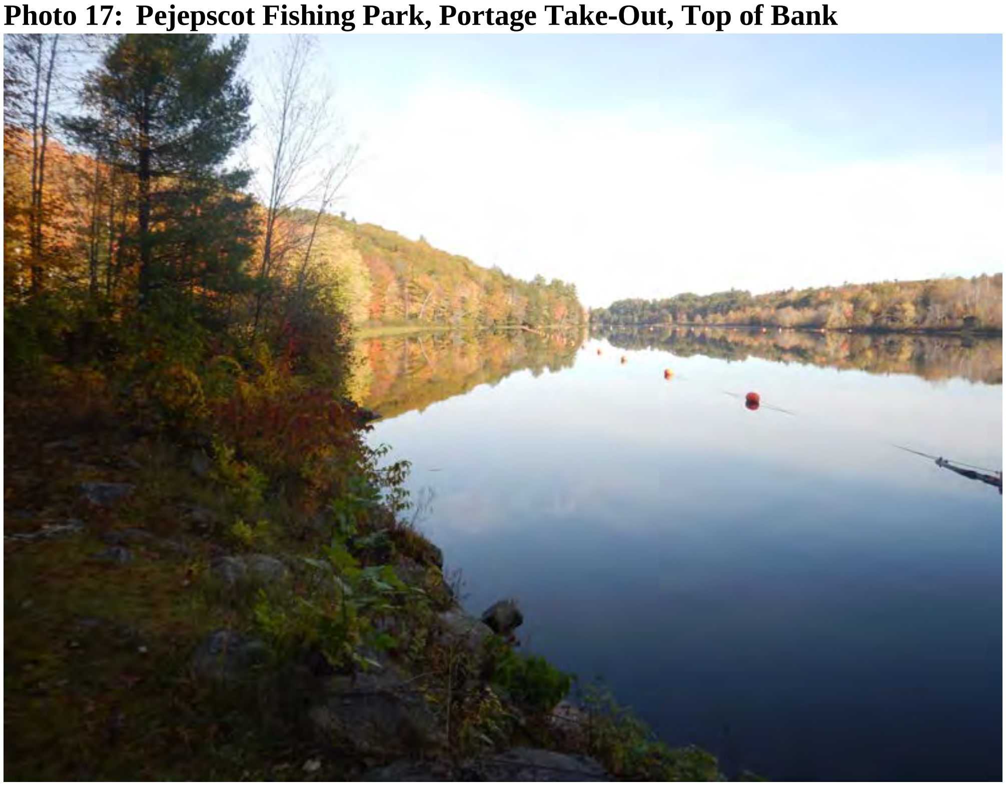
Photo 15: Pejepscot Fishing Park, Dam Overlook Area

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 16: Pejepscot Fishing Park, Dam Overlook Area Signage

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 17: Pejepscot Fishing Park, Portage Take-Out, Top of Bank



(Photo taken by J. Commerford, Gomez and Sullivan Engineers, 10/16/2019)

Photo 18: Pejepscot Fishing Park, Portage Take-Out, Bottom of Bank

(Photo taken by J. Commerford, Gomez and Sullivan Engineers, 10/16/2019)

Photo 19: Pejepscot Fishing Park, Canoe Portage Directional Sign

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 20: Pejepscot Fishing Park, Alternate Portage Take-Out

(Photo taken by J. Commerford, Gomez and Sullivan Engineers, 10/16/2019)

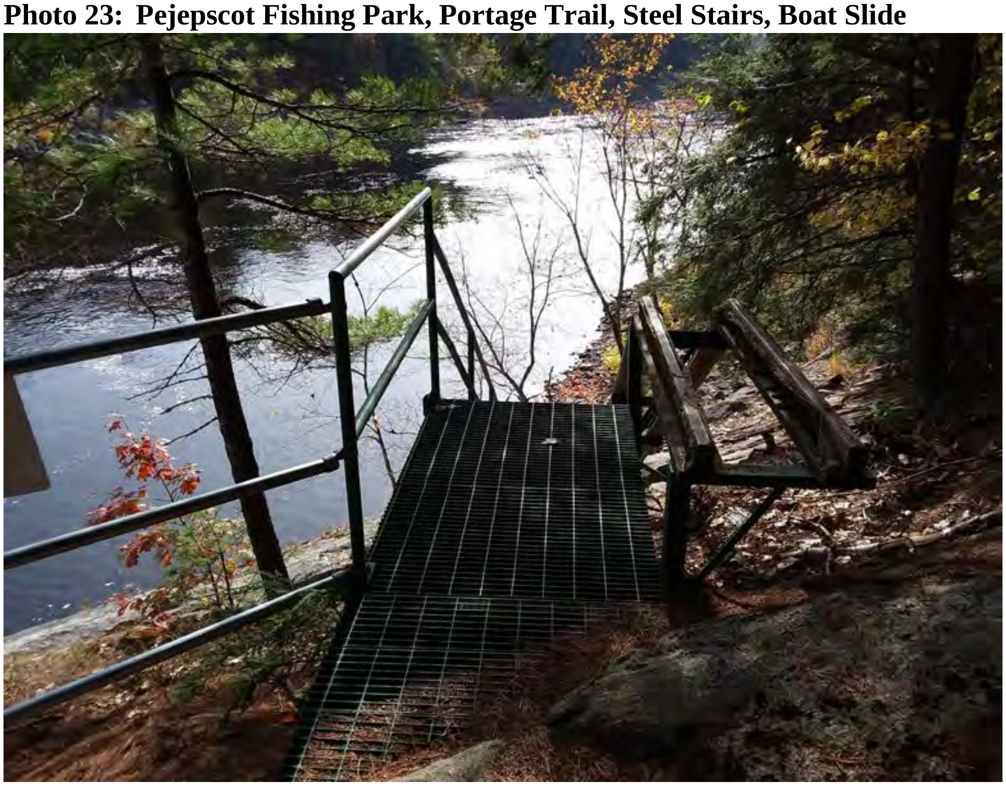
Photo 21: Pejepscot Fishing Park, Alternate Portage Take-Out, Informal Footpath

(Photo taken by J. Commerford, Gomez and Sullivan Engineers, 10/16/2019)

Photo 22: Pejepscot Fishing Park, Portage Trail

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 23: Pejepscot Fishing Park, Portage Trail, Steel Stairs, Boat Slide



(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 24: Pejepscot Fishing Park, Portage Trail, Steel Stairs, Rock Ledge

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 25: Pejepscot Fishing Park, Portage Put-In

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 26: Pejepscot Fishing Park, Informal Angler Access Footpath

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Lisbon Falls Fishing Park

Photo 27: Lisbon Falls Fishing Park, Parking Area Signage

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 28: Lisbon Falls Fishing Park, Parking Area

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 29: Lisbon Falls Fishing Park, Crosswalk to Gated Entrance

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 30: Lisbon Falls Fishing Park, Entrance Signage

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 31: Lisbon Falls Fishing Park, Access Path, Infrared Counter

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 32: Lisbon Falls Fishing Park, Infrared Counter

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 33: Lisbon Falls Fishing Park, Wooden Staircase

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 34: Lisbon Falls Fishing Park, Wooden Staircase, Shoreline Access Trail

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 35: Lisbon Falls Fishing Park, Shoreline Access, Looking Downstream

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 36: Lisbon Falls Fishing Park, Shoreline Access, Looking Upstream

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 37: Lisbon Falls Fishing Park, Access Path, Bridge Abutment

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)

Photo 38: Lisbon Falls Fishing Park, Access Path, Informal Footpaths at End

(Photo taken by M. Rheaume, Gomez and Sullivan Engineers, 10/16/2019)