Turbine Survival Study Technical Report

Stevens Creek Hydroelectric Project

FERC No. 2535

Prepared for:
Dominion Energy South Carolina, Inc.

Prepared by:
Kleinschmidt Associates

Kleinschmidt

March 2023

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

Dominion Energy South Carolina, Inc. (DESC; Licensee) is the Licensee of the Stevens Creek Hydroelectric Project (FERC No. 2535; Project). The Project has an installed capacity of 17.28 megawatts (MW) and is located in Edgefield and McCormick counties, South Carolina and Columbia County, Georgia, at the confluence of Stevens Creek and the Savannah River. The project's dam is located approximately one mile upstream of the Augusta Diversion Dam, and approximately 13 miles downstream of the U.S. Army Corps of Engineers (USACE) J. Storm Thurmond Dam (JST Dam). The Stevens Creek reservoir is approximately 25 miles long, extending upstream to the JST Dam and 12 miles up Stevens Creek. The surface area of the reservoir at normal full pond level (elevation of 187.5 feet) is 2,400 acres. The project drainage area is approximately 7,173 square miles.

DESC operates the Project to generate clean, renewable energy and re-regulate highly variable river flows discharged by the USACE from the JST Dam. The Stevens Creek Project is operated in accordance with an Operating Plan on file with the Federal Energy Regulatory Commission (FERC; Order issued June 22, 2018). The plan was developed in consultation with the USACE, U.S. Fish and Wildlife (USFWS), Georgia Department of Natural Resources (GDNR), South Carolina Department of Natural Resources (SCDNR), and the City of Augusta. The normal operating target range for the Stevens Creek Project is to provide an hourly discharge of ±15 percent of the scheduled daily average discharge from the JST Dam, if the actual discharge from the JST Dam is within 500 cubic feet per second (cfs) of the scheduled discharge.

On November 22, 1995, FERC issued a 30-year license for the Project which is scheduled to expire on October 31, 2025. DESC intends to file an application for a new license with FERC on or before October 31, 2023. DESC is currently conducting the relicensing process for the Project which involves cooperation and collaboration between DESC, as Licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. DESC established a Water Quality, Fish and Wildlife Resource Conservation Group (RCG) with interested stakeholders to address potential project resource issues related to aquatic and terrestrial resources. In its comments on the Preliminary Application Document, the National Marine Fisheries Service (NMFS) requested that DESC perform a desktop turbine survival study on adult Blueback Herring and American Eel. Kleinschmidt Associates (Kleinschmidt) presented preliminary results of blade strike model simulations at a

Resource Conservation Group (RCG) Meeting on February 25, 2021. Based on resource agency comments at that meeting, additional simulations were performed and are summarized in this report.

1.1 Goals and Objectives

The objective of this study was to assess the turbine survival of adult Blueback Herring and American Eel at the Project.

1.2 Background Information

During the previous relicensing of the Project, DESC studied entrainment of fishes through the turbines. The study results provided the following:

- Some reservoir fish approaching the Stevens Creek Dam are entrained at the powerhouse intakes and become subject to mortality risks associated with turbine passage;
- Trash racks on the intake structures, consisting of vertical bars with 3-inch to 3.5-inch spacing, generally exclude larger game fish from passing through the turbines;
- American Eel captured during the entrainment study ranged in size from 187 to 609 mm total length;
- Blueback Herring captured during the entrainment study ranged in size from 94 to 153 mm total length;
- Over 90 percent of fish entrained at the Project survived passage;
- Multi-seasonal fish entrainment surveys and intensive entrainment mortality studies conducted at the Project indicate that turbine- induced mortality results in the annual loss of approximately 15,000 fish representing 17 species under normal operating conditions (FERC 1995);
- Species with the highest losses to turbine mortality were Threadfin Shad, Bluegill, Yellow Perch, American Eel, and Blueback Herring (FERC 1995);
- Turbine-related mortality rates documented in the study (i.e., four to six percent) represent only a small proportion of the high natural mortality that occurs among small fish;

.

2.0 METHODS AND ANALYSIS

2.1 Blueback Herring

The software program Stryke (Nebiolo 2022) was used to simulate the results of passing adult Blueback Herring through the Project turbines. Stryke utilizes the Franke et al. (1997) equations to calculate the probability that a fish will be struck by a turbine blade. Parameter values that were used in the simulation are listed in Table 2.1. For adult Blueback Herring simulations, a total length of 10 inches with a standard deviation of 2 was used.

Table 2.1 Parameter Values Used in the Turbine Blade Strike Analysis

Parameter	Value
Turbine Type	Francis
Runner Diameter (D)	9.7 ft
Number of Blades (N)	16
Runner Height (β)	3.05
Turbine Discharge (Q)	1,000 cfs
Discharge at Optimal Efficiency (Q_{opt}/Q)	0.956
Net Head (H)	27 ft
Speed (ω)	75 rpm
Swirl Coefficient (ξ)	1.1
Correlation Coefficient (λ)	0.20
Runner Diameter at Inlet (D1)	7.0 ft
Runner Diameter at Outlet (D2)	8.3 ft
Turbine Efficiency (η)	0.95

2.2 American Eel

A literature search was conducted to identify sources of data for turbine passage survival of yellow/silver phase American Eel. A total of 11 studies were identified at hydropower sites with Francis turbines that included, at a minimum, the mean total length (TL) of eels that were tested and 48-hour survival data. Turbine survival data from the 11 studies were fit to a beta distribution using R (version 4.1.3, 2022) and the fitdistrplus package (Delignette-Muller and Dutang 2015) to produce a median turbine survival estimate with upper and lower credible intervals (CI).

3.0 RESULTS

3.1 Blueback Herring

The Stryke model simulation was run using a population of 1000 individual fish and 100 iterations. The simulations yielded a median survival rate of 95.2 percent, with lower CI of 93.8 percent and an upper CI of 96.4 percent.

3.2 American Eel

Studies identified in the literature search included results for eels that ranged in mean TL from 553 mm to 900 mm (Table 3.1). Most of these studies were conducted at sites with turbine characteristics that were very similar to the Stevens Creek Project. Survival rates from these studies ranged from 75.7 percent to 98 percent. Analysis of these data by beta distribution fitting yielded a median survival rate of 92.7 percent, with upper and lower CIs of 98.5 percent and 80.3 percent, respectively.

Table 3.1 American Eel Survival Studies at Sites with Francis Turbines

Project	No. of Blades	Runner Diameter (ft)	Head (ft)	Discharge (cfs)	Runner Speed (rpm)	Eel Mean TL (mm)	48-hr Survival %
Stevens Creek	**16**	**9.7**	**27**	**1,000**	**75**		
Bellows Falls[1]	15	14.8	57.4	3,214	85.7	846	98
Cabot Station Unit 2[1]	15	9.8	57.4	2,295	97.3	683	96
Station1, Unit 1[1]	13	4.6	44.0	650	200	636	90
Vernon (Unit 4)[1]	13	9.2	44.3	1,307	75	818	93.5
Vernon (Unit 9)[1]	12	9.2	34.4	992	62.5	796	97.9
Minetto[2]	16	11.6	17.3	1,500	72	553	93.6
Beauharnois[3]	-	17.8	78.0	7,200	75	900	84.2
Luray, Unit 2[3]	12	5.2	18.0	256	164	870	91.1
Newport[4]	-	-	-	-	-	854	75.7
Warren[4]	-	-	-	-	-	854	95.2
Millville[4]	-	-	-	-	-	854	91.4

[1]Heisey et al. 2019; [2]Niagra Mohawk Power Corporation 1995; [3]EPRI 2001; [4]Eyler et al. 2016

4.0 REFERENCES

Delignette-Muller, M. L. and C. Dutang. 2015. fitdistrplus: An R Package for Fitting Distributions. Journal of Statistical Software, 64(4), 1–34.

Electric Power Research Institute (EPRI). 2001. Review and Documentation of Research and Technologies on Passage and Protection of Downstream Migrating Catadromous Eels at Hydroelectric Facilities. EPRI, Palo Alto, California.

Eyler, Sheila M., S.A. Welsh, D.R. Smith, and M.M. Rockey. 2016. Downstream Passage and Impact of Turbine Shutdowns on Survival of Silver American Eels at Five Hydroelectric Dams on the Shenandoah River. Transactions of the American Fisheries Society, 145:5, 964-976.

Franke, G., D. Webb, R. Fisher, Jr., D. Mathur, P. Hopping, P. March, M. Headrick, I. Laczo, Y. Ventikos, and F. Sotiropoulos. 1997. Development of Environmentally Advanced Hydropower Turbine System Design Concepts. Voith Hydro. Inc., Report. No.2677-0141 to U.S. Department of Energy, Idaho Falls, Idaho. 456 pp.

Heisey, Paul G., D. Mathur, J.L. Phipps, J.C. Avalos, C.E. Hoffman, S.W. Adams, and E. De-Oliveira. 2019. Passage Survival of European and American eels at Francis and propeller turbines. Journal of Fish Biology 95:1172-1183. The Fisheries Society of the British Isles.

Nebiolo, Kevin P. 2022. Stryke Model. Available: https://github.com/knebiolo/stryke.

Niagara Mohawk Power Corporation. 1995. Fish Entrainment and Mortality Study, Final Report, Oswego River Project, FERC No. 2474. Prepared by Kleinschmidt Associates.

R Core Team. 2022. R: a language and environment for statistical computing. R Foundation of Statistical Computing, Vienna, Austria. URL https://www.R-project.org/