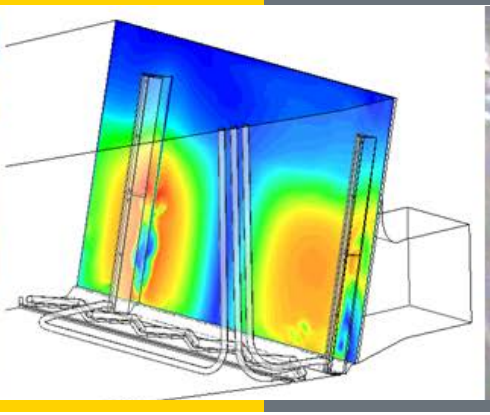


Modular and Scalable Downstream Passage Systems for Silver American Eel

DE-EE0008340

Hydropower Program

Wednesday, October 9

Steve Amaral

Alden Research Laboratory, Inc.

Project Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Summary

The goal of our project is to address the need for biologically and cost effective downstream passage for silver American Eel at hydropower dams. To achieve this goal, we are evaluating and optimizing the design and operation of two new bypass systems developed specifically for silver eels. Our study includes lab, field, and hydraulic modeling evaluations to determine biological performance. A desktop assessment of potential application at U.S. hydropower projects is also being conducted. The combination of evaluation methods will produce a robust set of biological and operational performance data to guide future applications of each technology.

Project Objective & Impact

The primary project objectives are (1) determine biological performance of both bypass systems; (2) develop design and operation recommendations based on lab and field test results; (3) provide biological and operational performance information for installation of full-scale systems; and (4) complete a cost and total project survival analysis of the two systems compared to the existing standards. The expected outcomes of the project include: (1) a set of biological and operational performance data for the two bypass designs; (2) recommended design and operational specifications and guidelines for each design; and (3) information describing the potential for application of each technology at US hydropower projects.

Project Information

Project Principal Investigator(s)

Steve Amaral, Alden Research Laboratory

WPTO Lead

Corey Vezina

Project Partners/Subs

Lakeside Engineering, Inc.
Blue Leaf Environmental, Inc.
City of Nashua, NH

Project Duration

- August 1, 2018
- December 31, 2019

Alignment with the Program

Hydropower Program Strategic Priorities

Environmental R&D and Hydrologic Systems Science

Big-Data Access and Analysis

- Technology R&D for Low-Impact Hydropower Growth
- R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet
- Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration

Alignment with the Hydro Program

Environmental R&D and Hydrologic Systems Science

- Develop better monitoring technologies to evaluate environmental impacts
- **Develop technologies and strategies that avoid, minimize, or mitigate ecological impacts**
- Support development of metrics for better evaluating environmental sustainability for new hydropower developments
- Assess potential impacts of long-term hydrologic variations to hydropower generation and flexibility
- Improve abilities to assess potential methane emissions from reservoirs
- Better identify opportunities and weigh potential trade-offs across multiple objectives at basin-scales

Our study is designed to determine the biological performance and potential application of two new downstream eel bypass designs.

If effective, these technologies will prevent or minimize mortality of silver eels passing downstream at hydropower projects during their annual spawning migration to the Atlantic Ocean.

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$799,999	$219,200	$1,019,199

FY17	FY18	FY19 (Q1 & Q2 Only)	Total Actual Costs FY19 Q1 & Q2 (October – March 2019)
Costed	Costed	Costed	Total
N/A	$25,000	$385,000	$284,391

- The laboratory evaluation was completed at a lower cost than budgeted. Alden and sub-recipients expended less labor to complete this phase of the study than initially anticipated.
- A portion of the unused funds was reallocated for CFD modeling of the test flume and field site and to purchase or lease additional equipment for monitoring eel behavior during field testing (e.g., additional DIDSON camera, conventional video cameras, and 3D acoustic telemetry tags).

Management and Technical Approach

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Modular and Scalable Downstream Passage Systems for Silver American Eel

Prime Recipient: Alden Research Laboratory, Inc.

Lead Investigator: Steve Amaral, Principal Fisheries Biologist

Laboratory Evaluation

Alden
- Biological Testing
- Test Facility D&C
- Data Processing & Analysis
- Reporting

Lakeside Engineering
Bypass System Design, Fabrication, & Installation

Blue Leaf Environmental
- DIDSON Acoustic Camera
- Data Processing

Field Evaluation

Alden
- Biological Testing
- Test Equipment Installation
- Data Processing & Analysis
- Reporting

Lakeside Engineering
Bypass System Design, Fabrication, & Installation

Blue Leaf Environmental
- 3D Acoustic Telemetry
- DIDSON Acoustic Camera
- Data Processing & Analysis

City Of Nashua/Essex Hydro
- Study Site
- Bypass Installation Support

Application Assessment

Alden
- Info Search & Review
- Case Study Evaluation
- Reporting

CFD Hydraulic Modeling

Alden
- Laboratory Flume Modeling
- Field Study Site Modeling

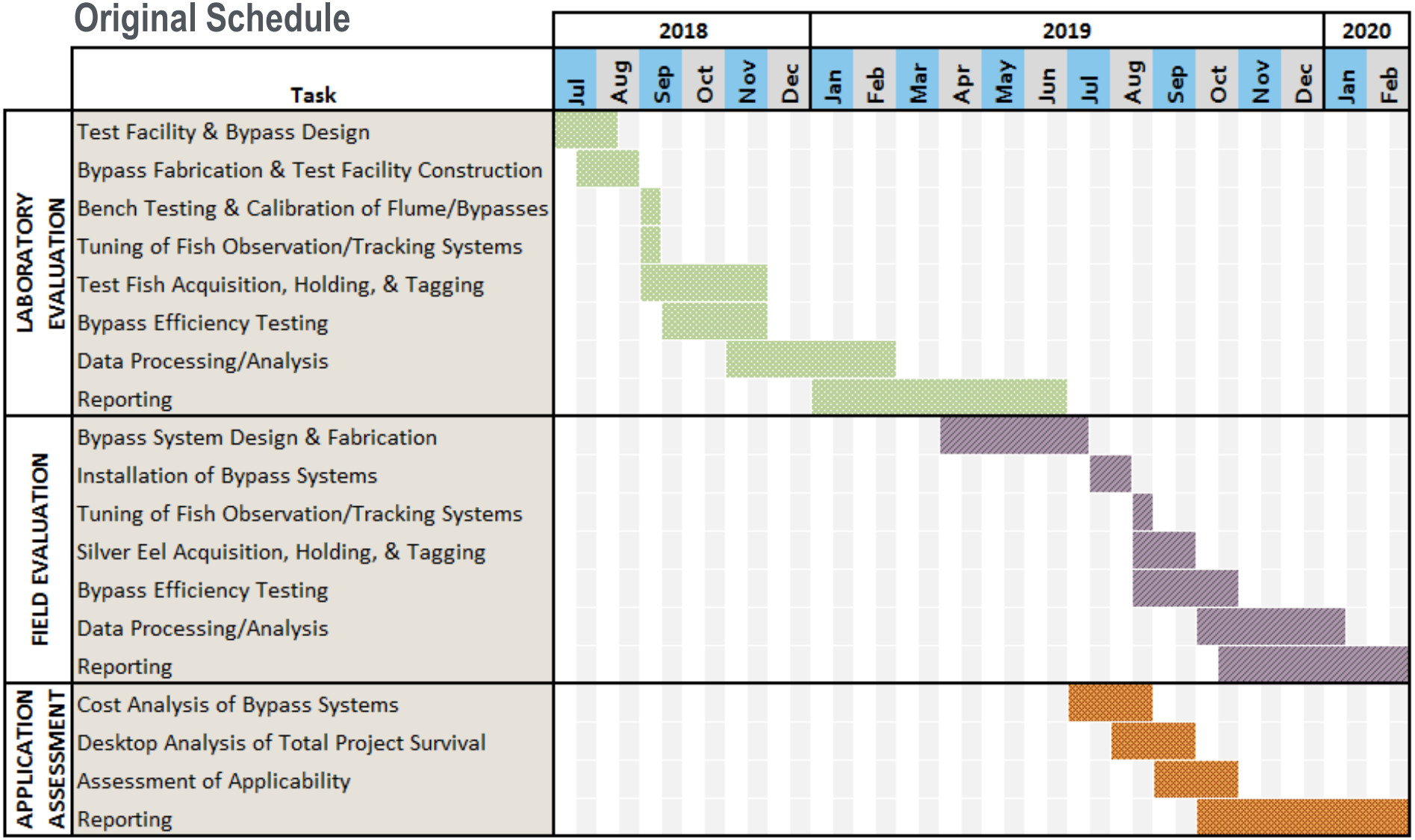
Management and Technical Approach

Management Approach

- Alden is responsible for project management, schedule, and all deliverables.
- Alden staff are the biological and engineering technical leads and are supported by sub-recipient scientists and engineers for specific tasks and study components.
- Alden's lead investigator is the primary contact for WPTO staff and is responsible for submitting all deliverables (e.g., study reports, quarterly progress reports, budget documents).
- Project team meetings are held as needed to facilitate the planning and completion of each study component. These have included conference calls, in-person meetings, and lab and field study site visits.
- Deviations in study tasks, test facility design, and experimental design have been decided through team discussions (either with whole team or the most relevant partners depending on the issue).

Management and Technical Approach

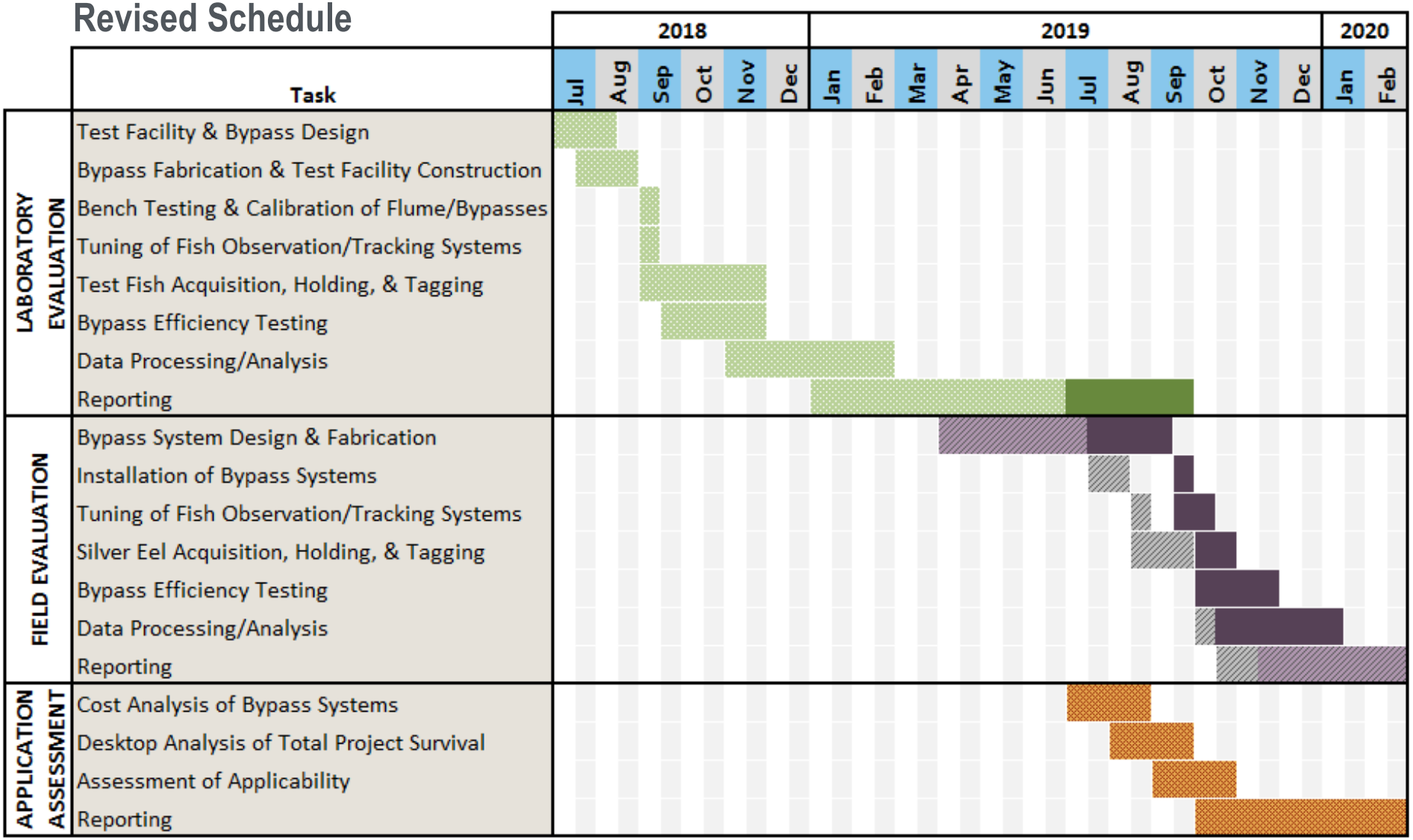
Original Schedule



Management and Technical Approach

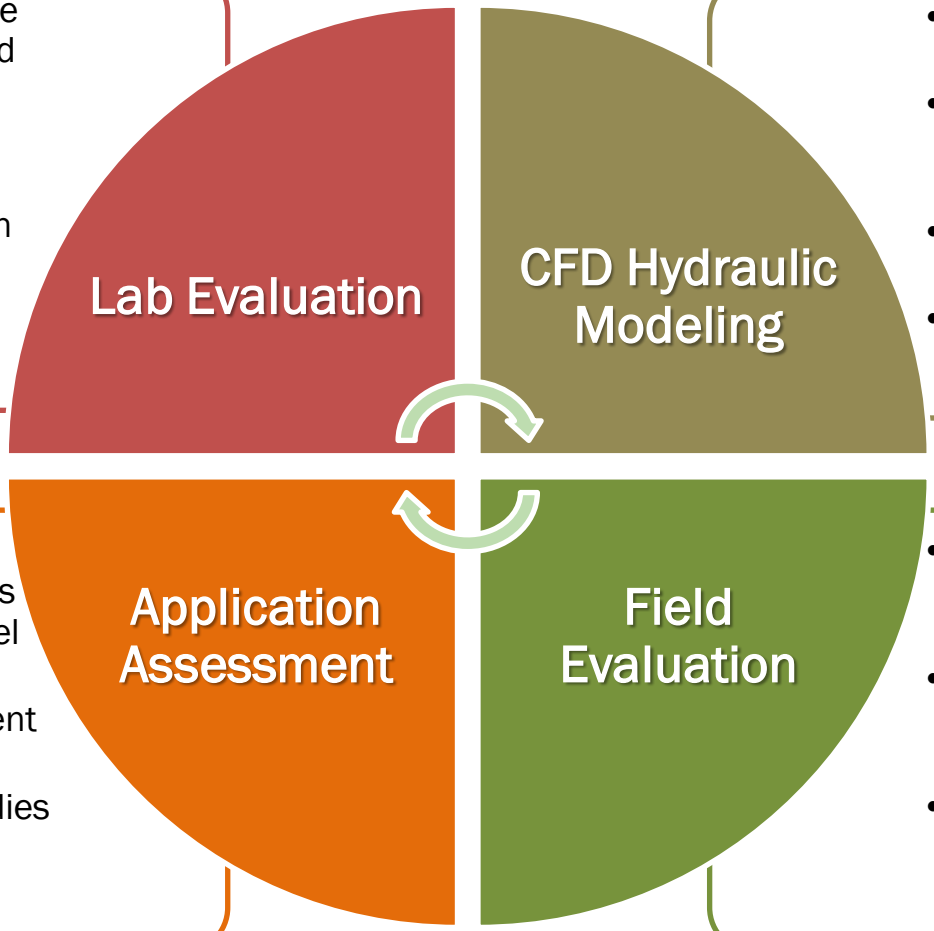
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Revised Schedule



Management and Technical Approach

Technical Approach



- Evaluate bypass performance with silver eels in a controlled laboratory setting
- Determine bypass efficiency and behavioral responses
- Identify design and operation modifications to improve performance

- Perform hydraulic modeling of lab and field conditions
- Assess hydraulics with respect to eel behavior and bypass performance
- Optimize design and operation of field systems
- Compare lab and field hydraulic conditions

- Assess potential for application at hydro projects within range of American eel
- Compare costs and generation impacts to current passage standards
- Complete several case studies to provide examples of potential biological and economic benefits

- Evaluate bypass performance with silver eels at a small hydro project
- Determine bypass efficiency and behavioral responses
- Make recommendations for optimizing design and operation

Technical Approach: LAB EVALUATION

- Bypass performance was evaluated with silver American Eels using full-scale systems of each bypass design and a simulated turbine intake (i.e., standard bar rack positioned across the full depth and width of the flume perpendicular to approach flow).
- Test conditions included trials with each bypass system operating alone and together, 1 and 2-inch clear bar spacing on trash rack, and use of a perforated-plate overlay over the lower 16-inches of the bar rack to reduce entrainment of eels located near the bottom of the flume.
- Bypass efficiencies were estimated for each set of test conditions; underwater video was used to analyze eel interactions with the bypass openings on each system.
- The lab study was successfully completed and provided reliable data and information on the biological performance of the two bypass systems.

Technical Approach: LAB EVALUATION

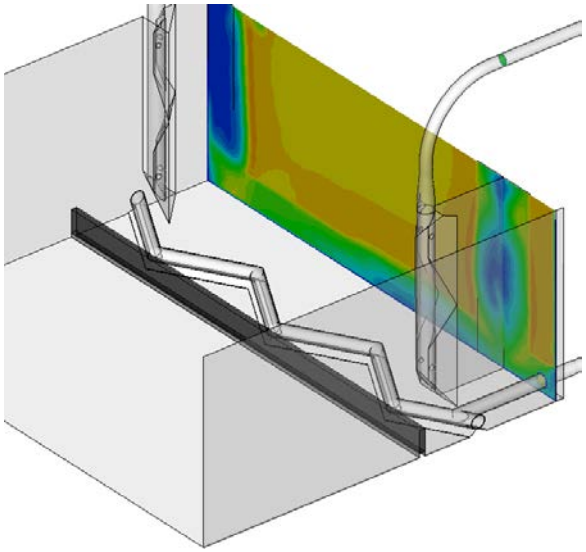
Critical Success Factors:

- Ability to determine bypass use and entrainment (i.e., effectively determine eel location at end of each trial);
- Ability to effectively observe eel behavior and quantify spatial and temporal aspects of bypass discovery and passage;
- Ability to acquire migrating silver eels in the numbers required for lab and field testing; and
- Ability to identify important operation and design parameters that contribute to optimization of each bypass design with respect to bypass discovery and efficiency.

Technical Approach: LAB EVALUATION

Technical Approach: CFD HYDRAULIC MODELING

- Conduct computational fluid dynamics (CFD) modeling of laboratory test flume and field study site.
- Analyze hydraulic conditions with respect to bypass performance, eel behavior, and potential impacts to generation at the field site.
- Provide recommendations for bypass design at the field site.
- Compare hydraulic conditions between the lab and the field to address any differences in bypass performance and/or observed eel behaviors.

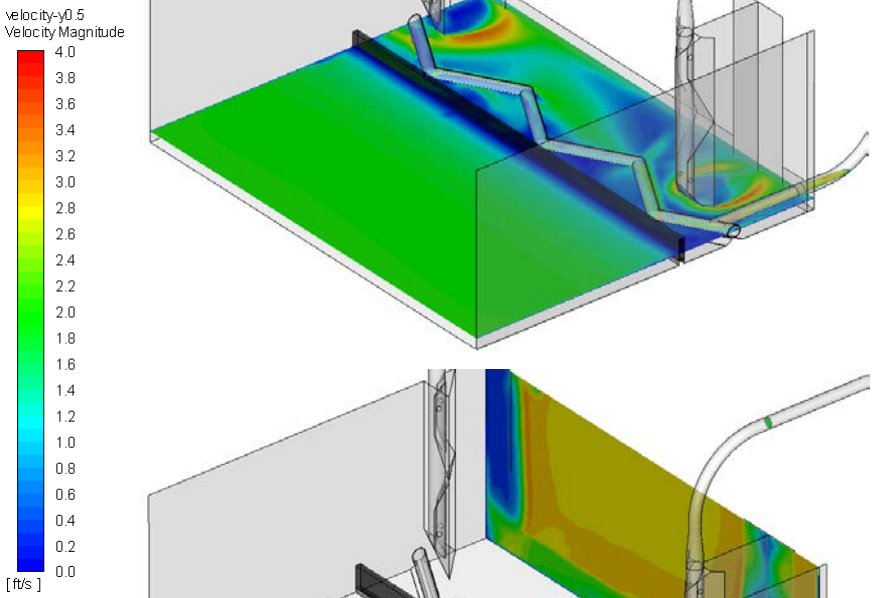


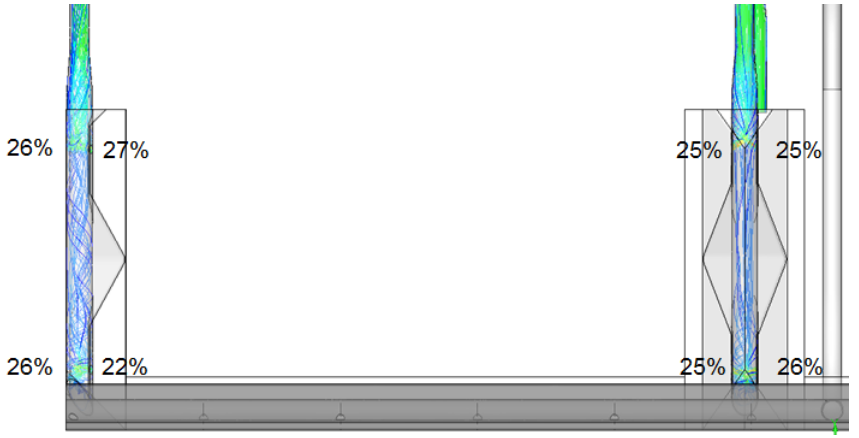
Critical Success Factor:

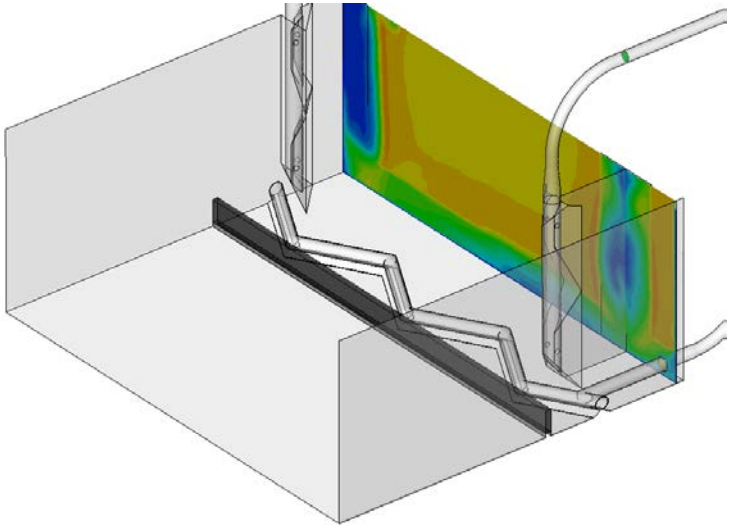
- Model inputs accurately represent lab and field conditions.

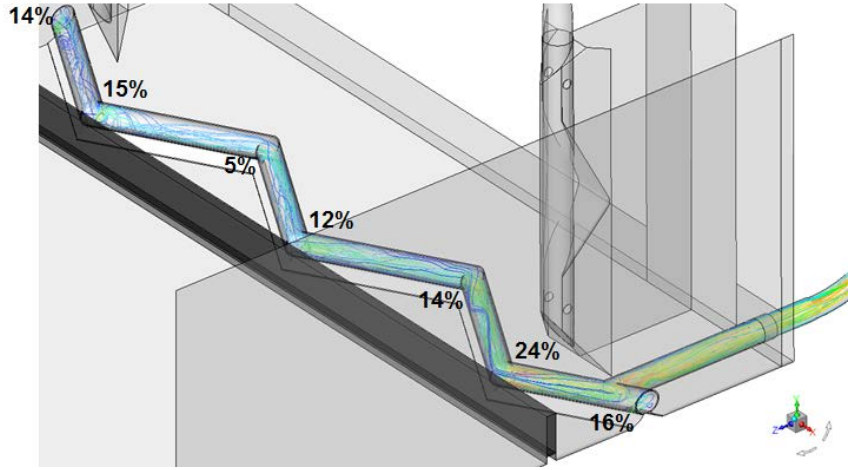
Management and Technical Approach

Technical Approach: CFD HYDRAULIC MODELING – LAB

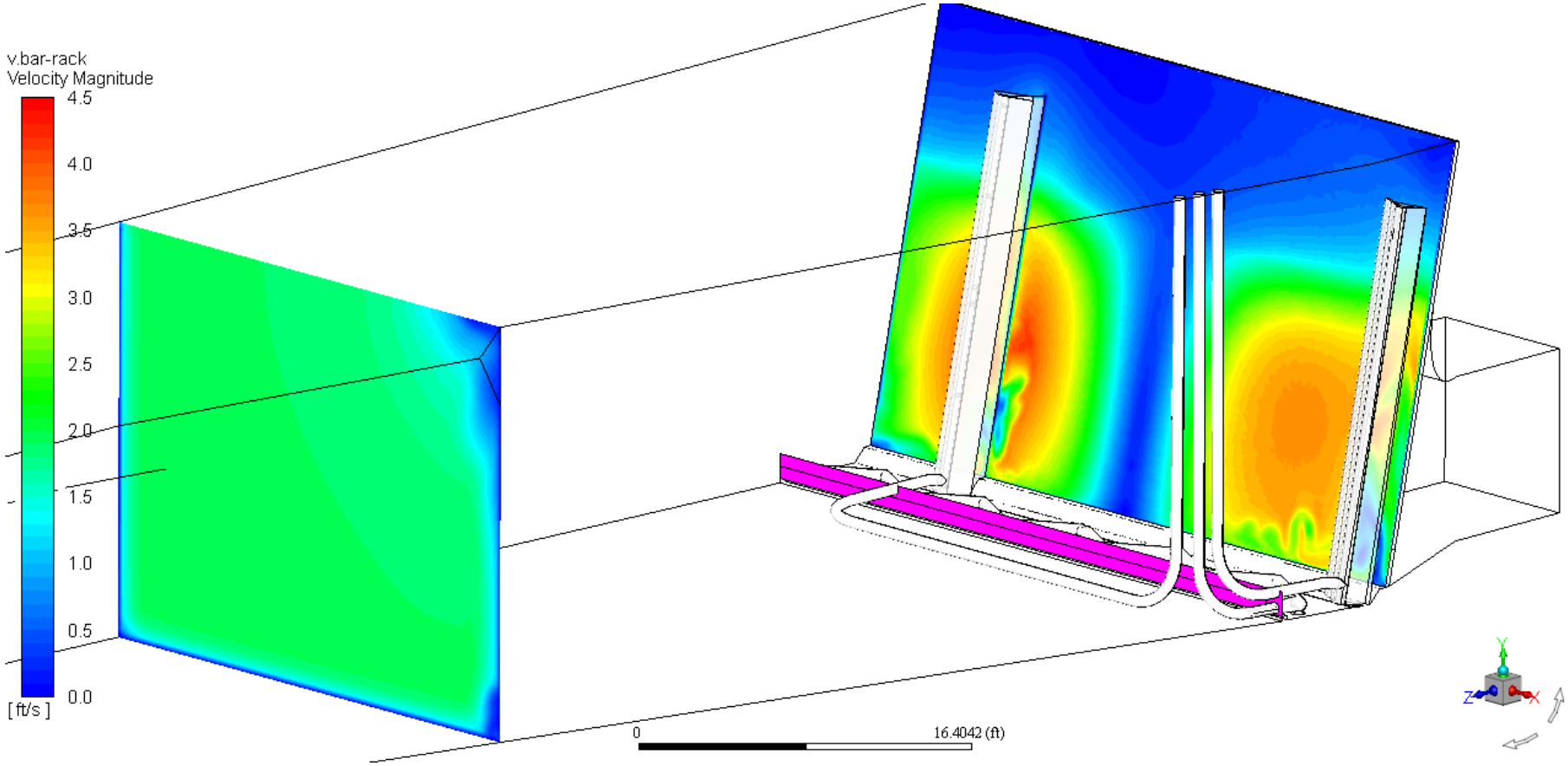








Technical Approach: CFD HYDRAULIC MODELING – Field



Technical Approach: FIELD EVALUATION

- Evaluate biological and operation performance of both bypass systems at the Mine Falls Hydro Project on the Nashua River in Nashua, NH.
- Release groups of silver eels tagged with 3D acoustic telemetry transponders and PIT tags at upstream end of power canal. Use conventional and DIDSON acoustic cameras for visual assessments of eel behavior.
- Evaluate two clear bar spacings (1 and 3 inches) and two generation levels (50 and 100%).
- Primary challenges include weather and project operation impacts on ability to achieve test conditions targeted for evaluation.

Technical Approach: FIELD EVALUATION

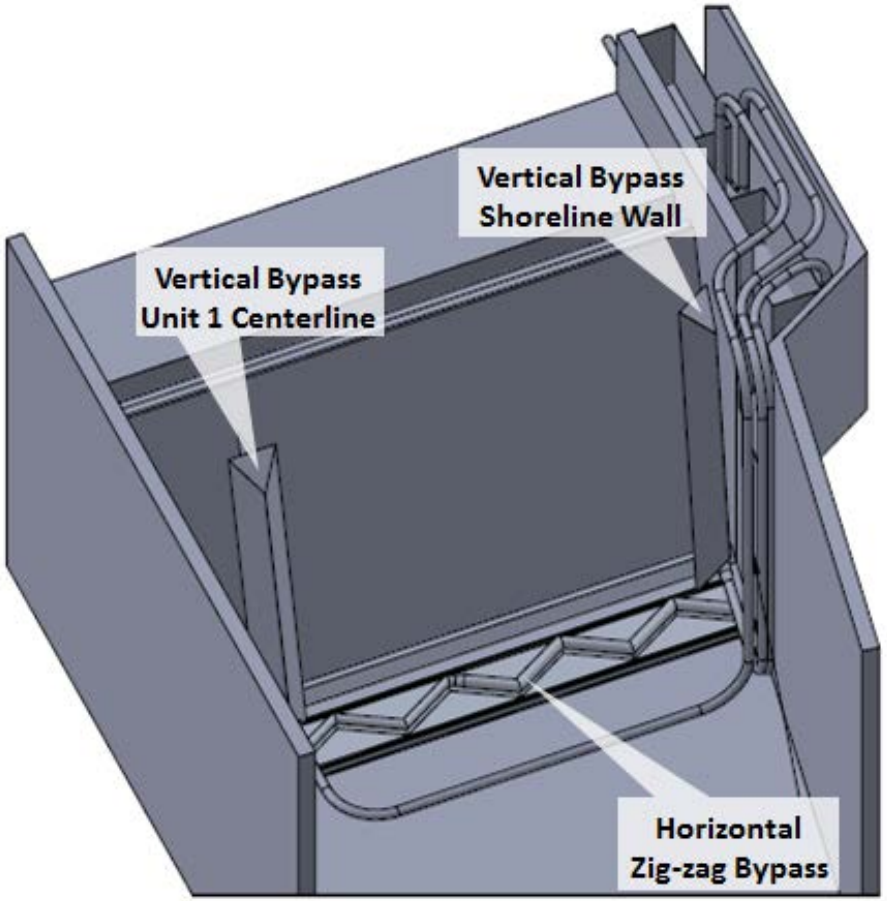
Critical Success Factors:

- Ability to determine bypass use and entrainment;
- Ability to effectively observe eel behavior and quantify spatial and temporal aspects of bypass discovery and passage (i.e., timely and high percentage passage through a bypass system);
- Ability to acquire migrating silver eels in the numbers required for lab and field testing; and
- Ability to identify important operation and design parameters that contribute to optimization of each bypass design with respect to bypass discovery and efficiency.

Challenges:

- Unit 1 is out of commission and will not return to operation until at least November 11.

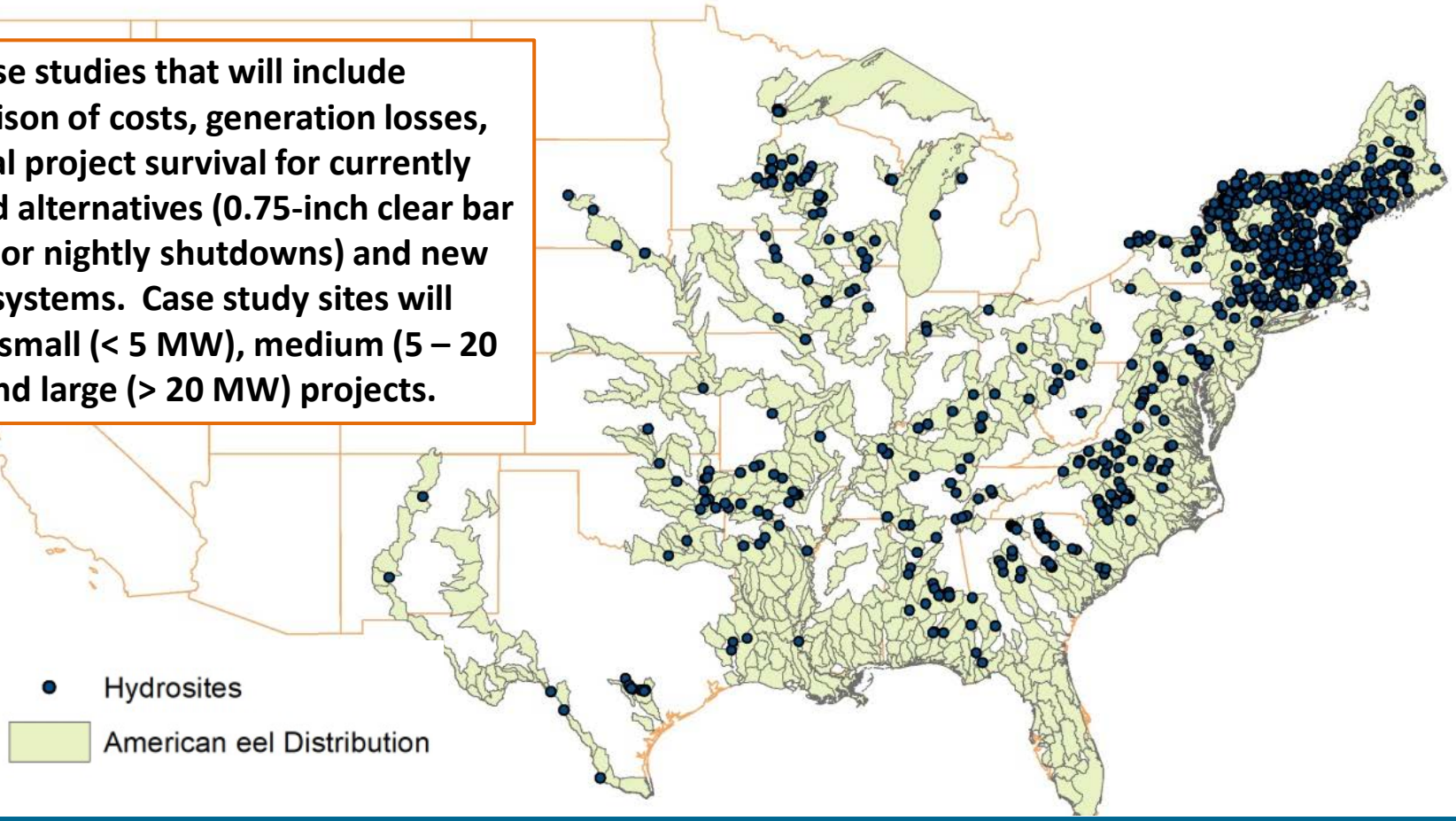
Technical Approach: FIELD EVALUATION



Technical Approach: APPLICATION ASSESSMENT

873 (39%) of 2,247 non-federal hydropower projects are within the native range of American Eel
65% are small hydro projects (< 5 MW) and 263 are being relicensed before 2035

3 – 5 case studies that will include comparison of costs, generation losses, and total project survival for currently required alternatives (0.75-inch clear bar spacing or nightly shutdowns) and new bypass systems. Case study sites will include small (< 5 MW), medium (5 – 20 MW), and large (> 20 MW) projects.



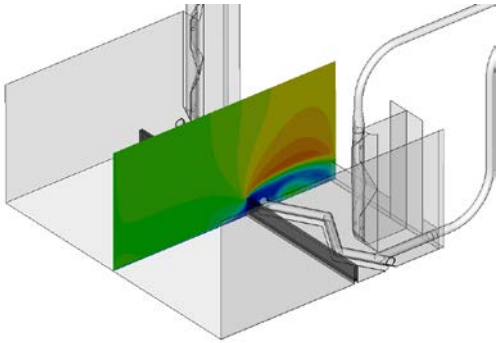
End-User Engagement and Dissemination Strategy

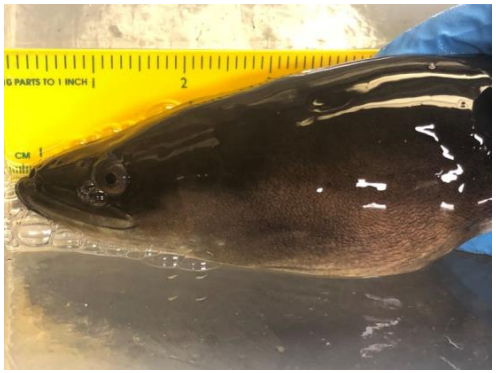
- The primary end-users for the two eel downstream bypass systems are hydropower dam owners and developers who need to provide safe and efficient downstream eel passage while minimizing impacts to power generation and project economics.
- If shown to be effective, state and federal resource agencies will also be able to consider these technologies as acceptable alternatives for reducing turbine entrainment of silver eels.
- The primary strategy for end-user engagement and dissemination involves giving presentations at relevant workshops and conferences and publishing manuscripts in peer-reviewed journals.
- Laboratory study results were presented during a webinar for EPRI's Eel Interest Group and at the National Hydropower's Northeast Regional Meeting in 2019 and will be presented at the 2019 AFS Annual Meeting, the Fish Passage 2020 Conference, and HydroVision 2020.

Technical Accomplishments

Study Accomplishments

- ***Completion of laboratory study***: Provided estimates of bypass efficiency for each system and recommendations for design and operational modifications to be considered for field study application.
- ***Completion of CFD modeling***: Hydraulic models of laboratory test flume and field study site provided insights on bypass performance and eel behavior and provided information on hydraulic conditions to guide the design and operation of the bypass systems installed for the field evaluation.
- ***Final Design and fabrication of field bypass systems***: The design and fabrication of the fish bypass systems to be evaluated at Mine Falls has been completed and installation will occur the between September 23 and October 4.
- ***Initial assessment of technology application***: An initial assessment of the number of projects that could benefit from the new eel bypass systems has been completed and the case study evaluations are ongoing.





Summary of Laboratory Study Results

Entrainment and Bypass Efficiency

Bar Rack Spacing (in)	Test Condition	16-inch Perf-Plate Overlay on Lower Rack	Number Released	Number Recovered at by Location					Percentage Entrained[1]	Bypass Efficiency[2] (%)
				Entrained	Horizontal Bypass	Vertical Bypass	Upstream	Unknown		
2	Both bypass systems	No	90	34	19	4	30	2	39.1	40.4
	Horizontal zig-zag bypass only	Yes	90	16	48	--	26	0	17.8	75.0
	Vertical bypasses only	Yes	89	54	--	9	26	0	60.7	14.3
	No bypass system (baseline)	No	89	52	--	--	36	1	59.1	--
1	Both bypass systems	Yes	90	7	60	11	12	0	7.8	91.0
	Vertical bypasses only	Yes	90	21	--	44	25	0	23.3	67.7

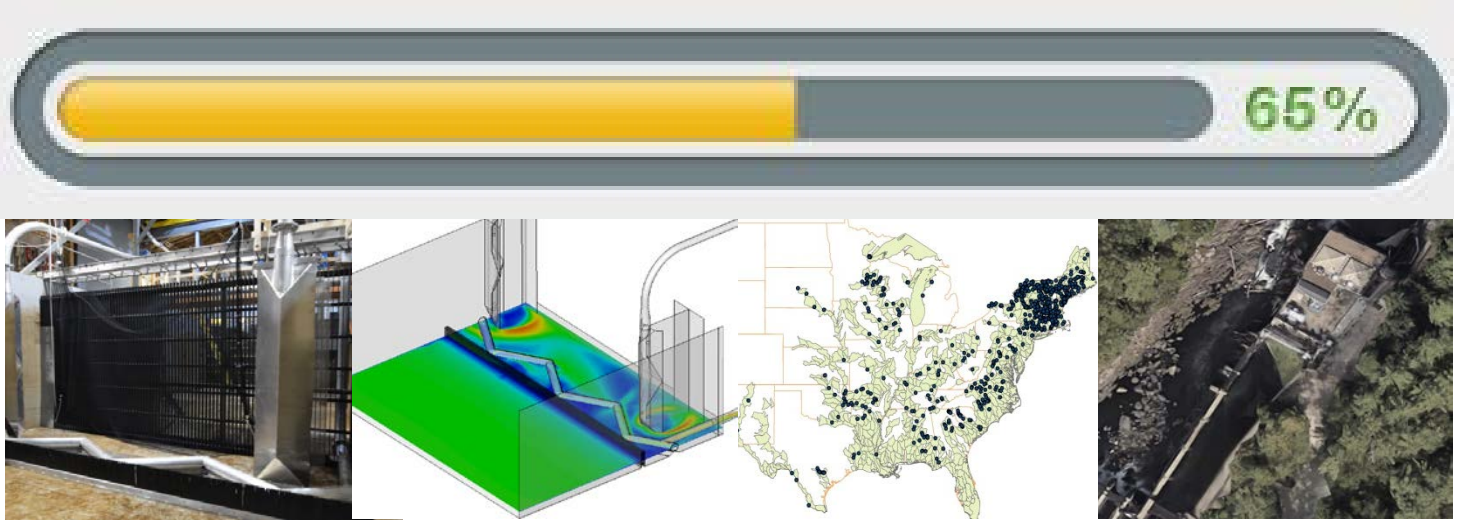
[1] Percentage entrained is the number of eels entrained divided by the total recovered from all locations combined (bypassed, entrained, and upstream).

[2] Bypass efficiency is the number of eels bypassed divided by the total recovered from downstream locations (bypassed + entrained).

Progress Since Project Summary Submittal

Study Progress

- Planning and preparation was completed for the field installation of the two bypass systems and eel monitoring equipment (acoustic telemetry and PIT tag systems, DIDSON/ARIS acoustic cameras, video cameras).
- Field installation will be completed between September 23 and October 4.



Future Work

- Field evaluation of bypass performance (mid-October to mid-November, 2019).
- Completion of application assessment.
- Final study report preparation.
- Workshop/conference presentations; peer-reviewed publications.