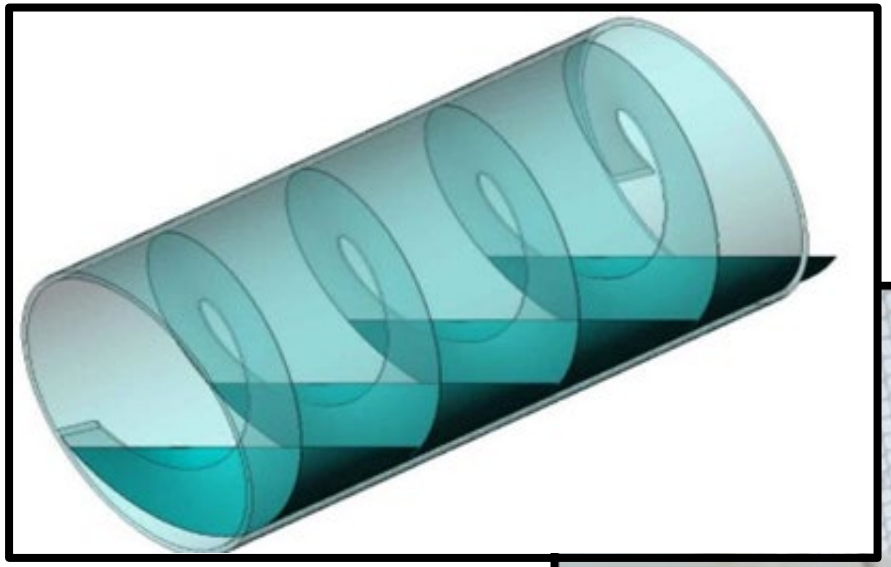
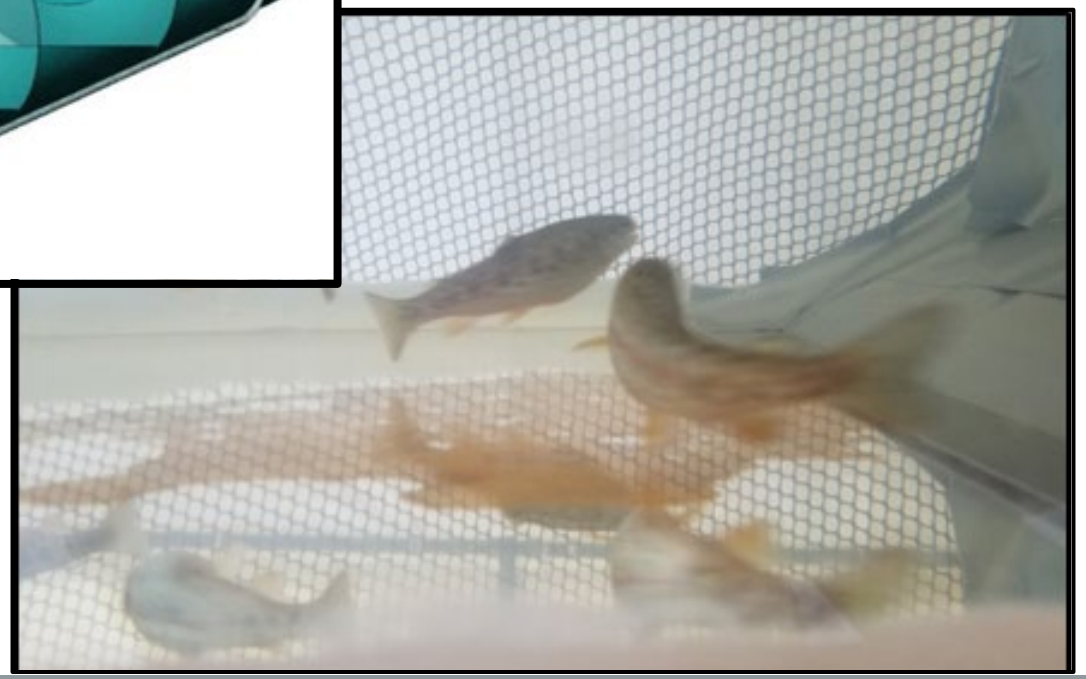
EE0008945 – Development of a Modular Helical Fish Passage for Low Head Applications





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Project Overview

The Critical Driver for the Innovation:

The high cost and complexity of conventional fish passages absolutely requires new cost-effective modular fish passage technologies be developed for future small hydro-plants

- **Current Fish Passage Costs projected to exceed the cost of the Small Hydropower plant-works**

Intended Outcomes

The project goal is to dramatically lower the cost of fish passage solutions and to manufacture the components in the U.S.

Key Benefits and Impact:

- Safer and quicker volitional passage for fish
- Order of magnitude improvement in cost over conventional fish passes
- Brings U.S. supplier/expertise into world market for new advances in fish passage

Project Summary

This Project will Develop a Helical Fish Passage Module that operates as a rotating weir to connect upstream and downstream habitats and fish species

Technical Approach:

- Leverage recent patented work of Percheron Power on the Composite Archimedes Hydrodynamic Turbine
- Perform computational analysis and laboratory testing of scale models prior to full-sized prototype testing
- Utilize advanced manufacturing methods to produce modular, easily-assembled components of inexpensive composite materials
- Perform live fish testing of full-size prototype at the Aquatics Research Lab of PNNL to validate

Project Information

Principal Investigator(s)

Percheron Power, LLC (Lead)

Project Partners/Subs

- Pacific Northwest National Laboratory
- Oak Ridge National Laboratory
- Utah Water Research Laboratory/USU
- Plastic Injection Molding, Inc.
- Biomark, Inc.

Project Status

Ongoing

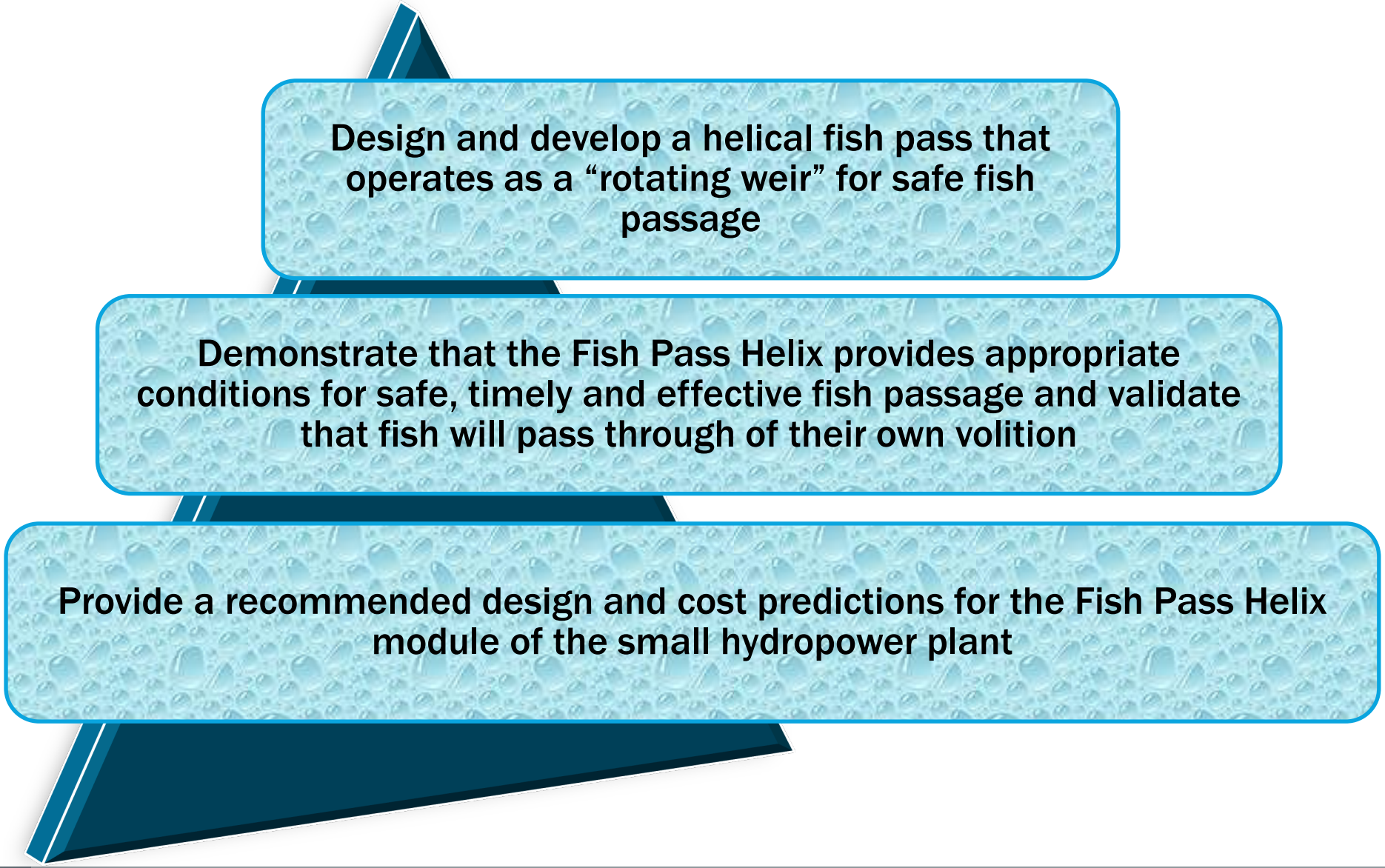
Project Duration

- Start: Feb 1 2021
- End: May 31 2023

Total Costed (FY19-21)

$710 K ($ 549 K Federal; $161 K Match)

Percheron Power's Key Project Objectives

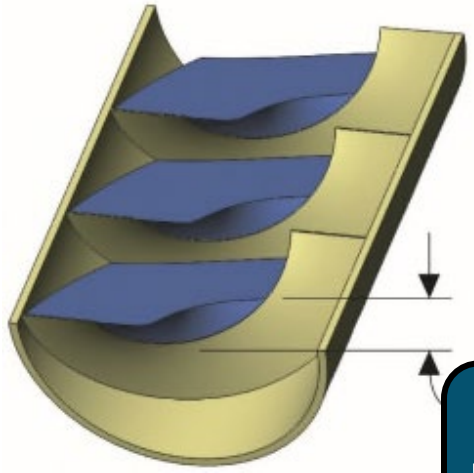


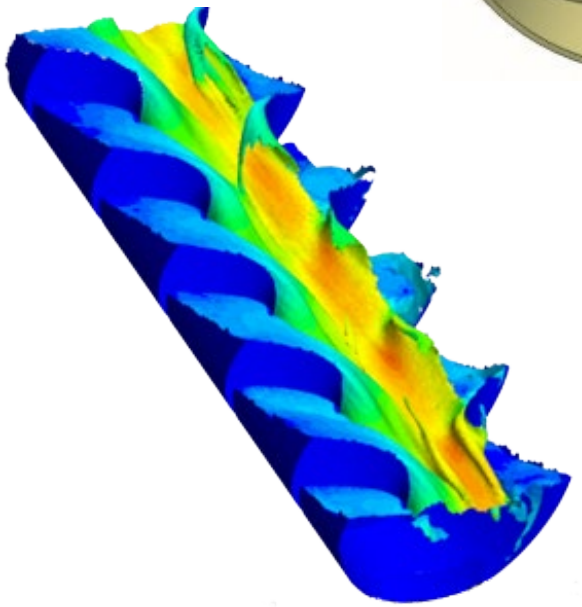
Project Objectives: Relevance

This project is WPTO mission centric: it involves research, development, testing and commercialization of an innovative new fish passage device which:

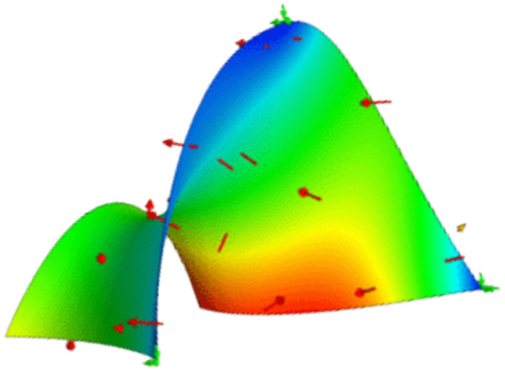
- Leverages new manufacturing methods/materials to dramatically lower costs of components and systems
- Enables new or existing small hydropower plants to incorporate ecological and social objectives, including providing, improving, connecting (or re-connecting) aquatic/riverine habitats, and
- Employs new technology to advance and lower the costs of next-generation hydropower thereby driving innovation to support hydropower growth
- Provides a critical modular solution for the WPTO *Standard Modular Hydropower* (SMH) vision that standardization, modularity, and preservation of stream functionality must become essential and fully realized features of next-generation hydropower technologies and project designs

Design and Development of Helix Component





Utilize an interactive phased approach, including:



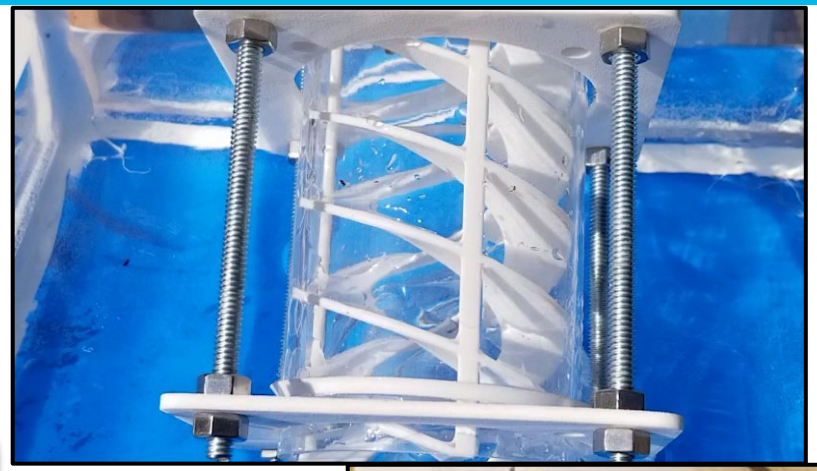
- Mathematical analyses/modeling of the water “slugs” in the helix for different designs
- Development and Bench Testing of Laboratory-scale Models
- CFD modeling regarding turbulence, etc. for various designs/conditions
- FEA analyses for structural design
- Fabrication and Testing of Full-scale prototype at PNNL Aquatics Research Lab (BP2)

Validation and Risk Reduction Approach: 3 Stages of Testing

Mini Laboratory Scale Tests – Complete

3-inch diameter X 8.5-inch long helices

- Test and Compare various designs
- Select optimum designs for CFD and Bench Tests



Bench Testing of Laboratory Scale Models – Complete

10-inch diameter X 6-ft long helix

- Select 2 helix designs and Perform Computational Fluid Dynamics prior to testing
- Physically test models and compare to CFD results

Full-sized Prototype Testing – Upcoming - Ongoing

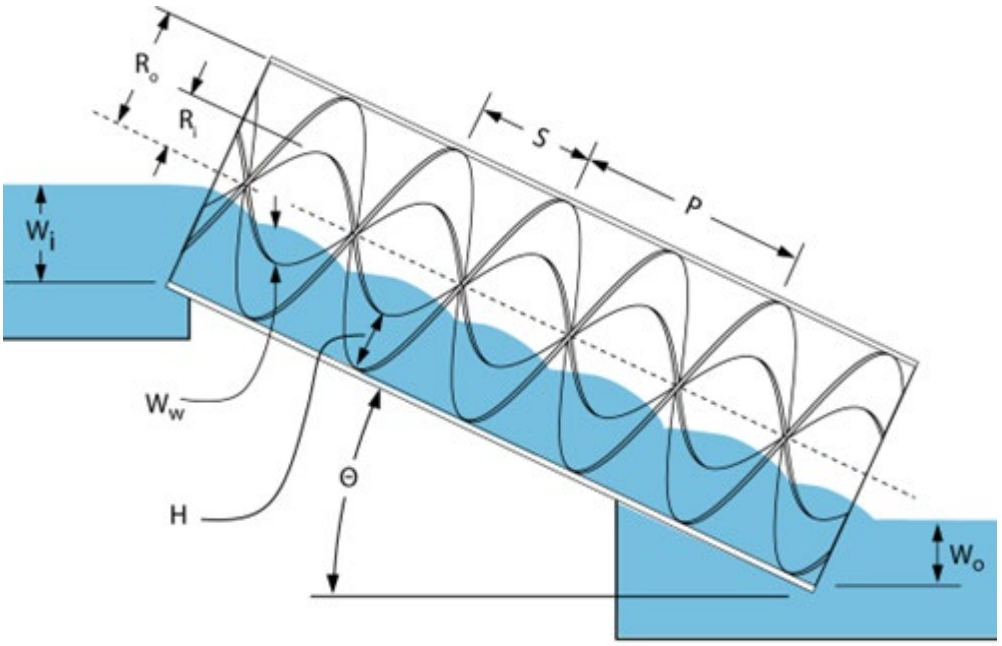
36-inch diameter X 15-ft long helix

- Select, Design and Fabricate up to 2 Prototypes
- Fish Testing with several species at PNNL ARL

Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

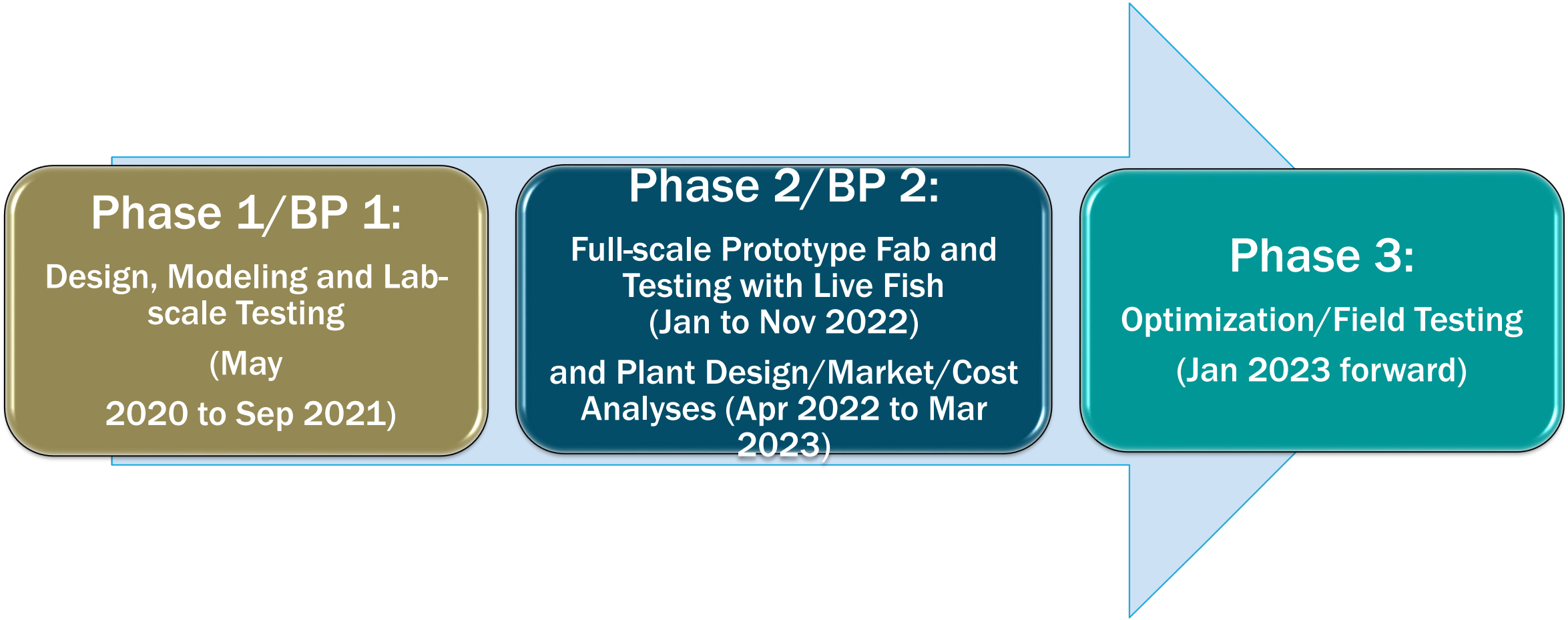
- A totally new bi-directional fish passage device — which has been performance-validated through hydraulic and physical modeling as well as full-scale laboratory testing
- 3 sizes, or scales of the device are developed and tested
  - Cumulative knowledge rapidly pushes the design/validation process forward
  - Wildlife agencies/regulators involved throughout - in setting and validating desired passage parameters (market-driven)



Outcomes:

- Following required field testing, the Bi-directional Fish Pass Helix is accepted by wildlife agencies/regulators as equivalent or best available technology for fish passage of multiple species
- Site owners, hydropower developers and other entities adopt new technology in U.S. and worldwide, and at dramatically lower cost than conventional passages
- Multiple market applications for the Fish Pass Helix, at hatcheries, diversions, and other aquatic barriers not associated with hydropower, as well as hydropower plant applications –- will further expand the market potential and acceptance of the modular device while decreasing its unit costs

Fish Passage Project Phases and Schedule



Phases 1 and 2 are Budget Periods 1 and 2 funded by DOE under this Award

Project Timeline – By Fiscal Year

FY 2019

July 7, 2019 - Proposal Submitted

FY 2020

Oct 31, 2019 – Selection Notification received

May 27, 2020 - Contract Executed with DOE

Aug 31, 2020 – Established Fish Pass Advisory Group

Sep 14, 2020 – Defined Target Design Parameters to DOE

FY 2021

Nov 25, 2020 – Provided Report/Photos of Mini Helix Scale Models

Nov 2020 to Aug 2021 Fabricated and Tested 10 different Helix Designs

Sep 14, 2021 – Helix Design Selected and Documented

Sep 14, 2021 - Go No/Go Report Submitted to DOE

FY 2022:

Nov 2, 2021 – Go No/Go Review completed

Dec 10, 2021 – Provisional "Go" received

April 4, 2022 – Contract Executed with DOE for BP 2

Upcoming in FY 2023:

- Oct 2022: Prototype Helix Fully Assembled
- Nov 2022: Live Fish Test Plan Completed and all Permits/Approvals Received
- Feb 2023: Summary Report and Cost Predictions Provided to DOE

- **All Milestones and Tasks Successfully Completed for Budget Period 1**
- **Go/No-Go Documentation submitted in September 2021**
- **Budget Period 2 contract provided by WPTO/executed April 2022 – all Tasks moving forward as planned**

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$1,000 K	$250K	$1,250 K

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$0 K	$255 K	$455 K	$710 K

- Materials and fabrication costs have increased significantly since 2019 proposal and 2021 Go/No-Go Update
- Project timeline has expanded ~ 1 year due to DOE contract process with increased labor costs
  - Available fixed funding under this contract results in one prototype being fabricated/tested instead of two and increased cost share from Percheron
  - Additional funds being sought to expand live fish testing at PNNL Aquatics Research Lab

End-User Engagement and Dissemination

During the pre-proposal stage, Percheron identified wildlife agency/regulator involvement as being critical to adoption of any new fish passage device

- per NOAA/NMFS, innovative/experimental fish passages must provide equivalent or better passage to conventional approaches:

  "There is potential for future development of new passage devices that may safely pass fish at a rate comparable with conventional technology. These new concepts are considered "experimental" until they have been through the process described herein and have been proven in a prototype evaluation validated by NMFS." and *"results of both laboratory tests and field prototype evaluations must **demonstrate a level of performance equal to or exceeding that of conventional fish passage devices before NMFS may support permanent installations".***

- Formed and Fish Pass Helix Advisory Group as one of first tasks

- **Engaging with other Stakeholders (Biologists/Hatcheries/Equipment Manufacturers/Tribes, etc.)**
- **ORNL providing support in Market Analyses to determine key species/regions to assist in helix sizing and market commercialization strategy**
- **Expect multiple other non-powered sites to be interested in the Fish Pass Helix (existing diversions/dams and other aquatic barriers)**
- **Identifying key sites for next steps/field testing of the device, which have wildlife agency support**

Role of Fish Pass Advisory Group

Percheron and PNNL established a Fish Pass Advisory Group at project outset to guide development and testing of the device

(inc. NOAA, USGS, USFWS, WA DFW, PNNL)

The Group's desired key contributions to the project

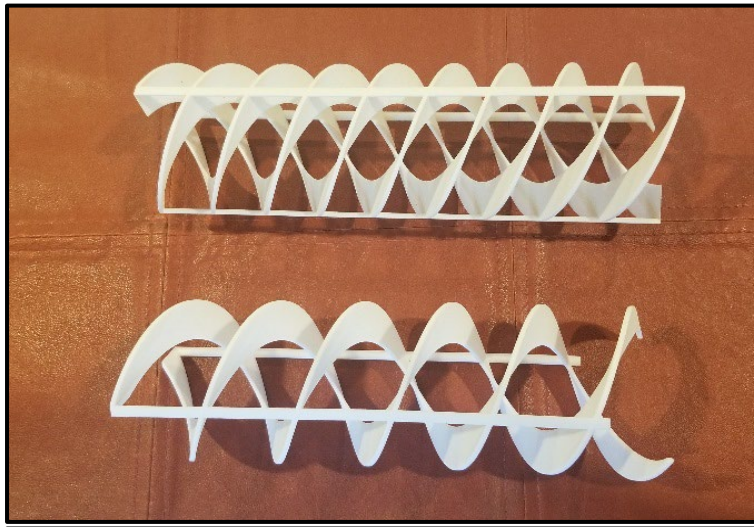
- Refining and providing Percheron with functional and performance requirements (constraints) or targets for the fish pass
- Reviewing the planned testing program for the fish pass, and overseeing and evaluating the results
- Helping formulate future study plan for field testing expected to be required by wildlife agencies prior to commercial adoption

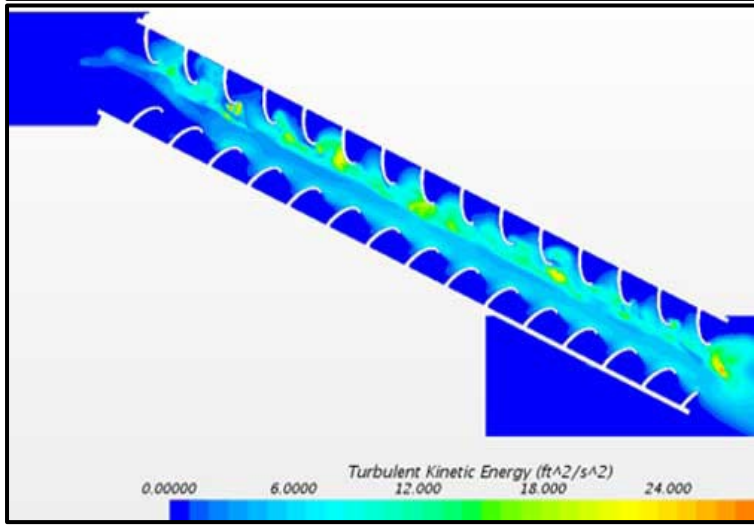
Performance: Accomplishments and Progress

All Milestones and Deliverables for BP 1 achieved, received positive Go/No-Go decision, and BP 2 underway and on target

Key Accomplishments

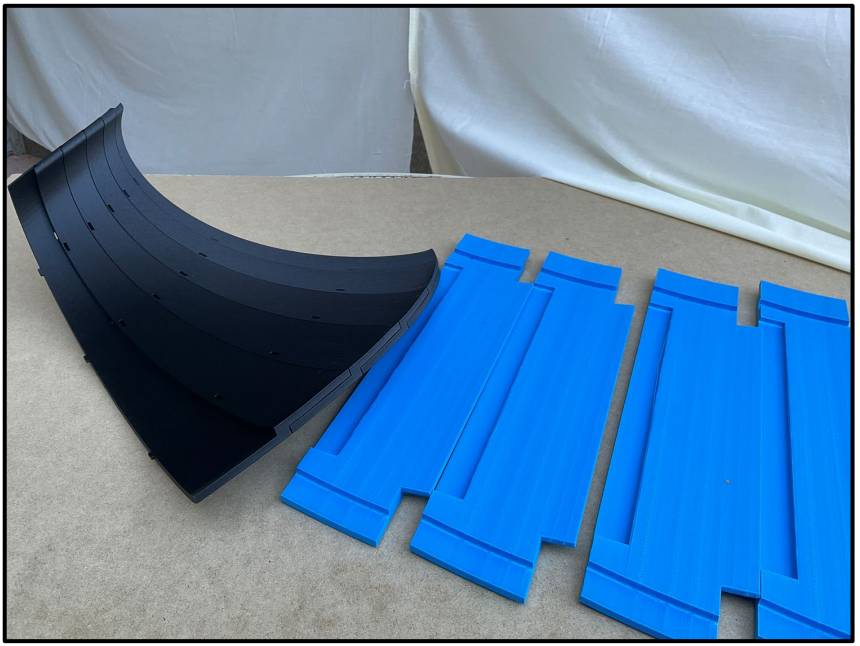
- Developed a proprietary/patent pending design for a Bi-Directional Fish Pass Helix
  - Used rapid prototyping/3-D printing to quickly and efficiently test/evolve 10 different helix designs and select best design for full-sized prototype
- Demonstrated that the new Fish Pass Helix should enable fish to volitionally pass in both directions
  - Hydraulic modeling shows low and very acceptable turbulent kinetic energies and velocities throughout the device





Performance: Accomplishments and Progress (cont.)

- Biological Performance Models (BioPA) of PNNL predict negligible probability of impact to fish
- Live fish testing at bench scale (10-in dia) showed successful passage of juvenile trout in both directions



- Evaluated multiple advanced fabrication methods
  - Developed an innovative design and process for fabrication of the helix with an integral outer cylinder
    - Utilize Plastic Injection Molding of multiple small radial and axial sections which are designed to interlock for assembly
  - Validated the concept by 3D-printing and assembling some full-sized prototype segments

- **Filed Provisional Patent Application for Bi-Directional Fish Pass Helix on 10/6/20**

Key Results and Benefits Expected

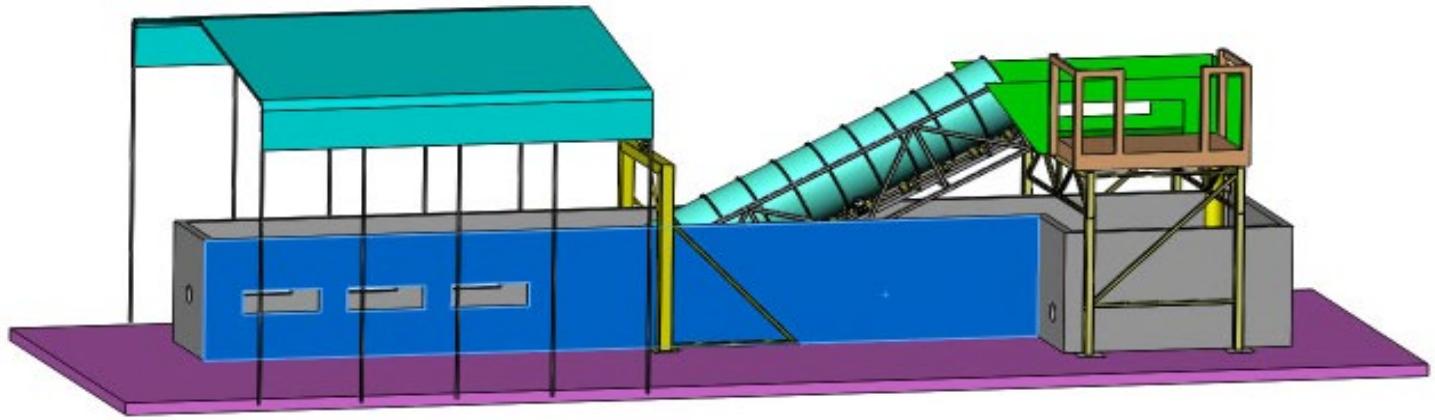
- Utilized ORNL, PNNL Support and Literature to scope current fish passage costs and performance issues at low head hydropower projects
  - Mandatory Fish passage costs averaged $1 -3 M per site with a range to $12 M
  - Expect the new Fish Pass Helix cost to be an order of magnitude less (~$250K)

- **The Fish Pass Helix also may provide multiple improvements over conventional volitional fish passes (the baseline technologies)**
  - Decreased Fish Passage Time
  - Decreased Fish Stress/Injury/Mortality Rates
  - Decreased Water needed for Fish Passage
  - Decreased Maintenance and Operations
  - Decreased Footprint at installation Site
  - Decreased Construction Time
  - No Sediment/Trash Buildup

Future Work

- Full-sized Prototype Fish Pass Helix in final design for fabrication
  - 3 ft Diameter X 15 ft long with water tanks above and below
  - Test with various fish species at PNNL Aquatics Research Laboratory this Fall
  - Seeking additional funding for expanded testing and future field sites

- Market Analyses and Cost Predictions/Comparison work with ORNL support continues
  - Teamwork to Develop "Commercialization Roadmap" and Strategy for Fish Pass Helix



Q&A