# 2023 Hydropower Environmental and Industry R&D Summit Review

## Summary of Findings – Key Takeaways and Actions

Dana McCoskey, Environmental Technologies Manager,

U.S. Department of Energy, Water Power Technologies Office | May 9, 2023

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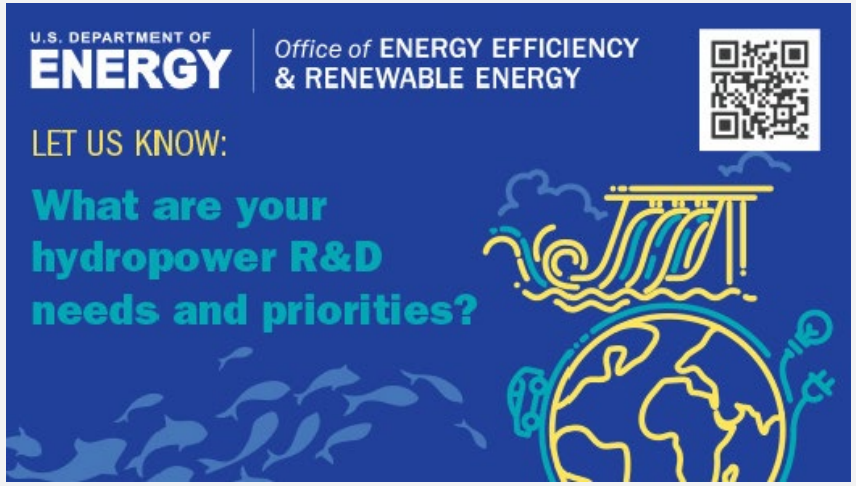
# Agenda

- WPTO Hydropower Program Portfolio Overview
- Past Summits Overview
- Overview of the April 25, 2023 Industry and Environmental R&D Summit:
  - Summary of R&D Needs and Priorities of Participants
  - **Interactive Session**
  - Summary of Breakout Session Topics and real-time audience input
- Next Steps
- Q&A



# Water Power Technologies Office (WPTO) Overview

WPTO enables research, development, and testing of emerging technologies to advance **marine energy** and next-generation **hydropower** and **pumped storage** systems for a flexible, reliable grid

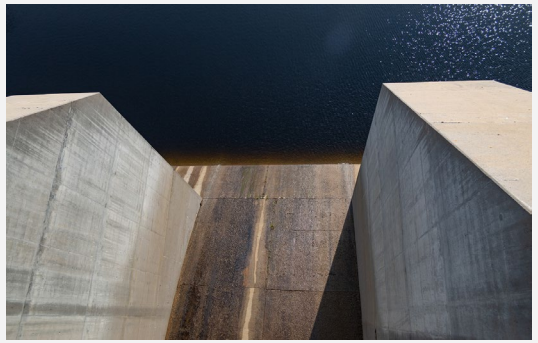
**Hydropower Program**

**Marine Energy Program**

# WPTO Budget

*Note: This graph shows annual appropriations and enacted funding only. This graph does not reflect the nearly $1B of BIL funding for hydropower and marine energy.*

# Hydropower Program Overview



Upgrades for Existing Hydropower

Non-Powered Dams and Conduits

New Low-Impact Projects

Pumped Storage Hydropower

# Hydropower Program Overview – Activity Area Breakdown

| INNOVATIONS FOR LOW-IMPACT HYDROPOWER GROWTH | GRID RELIABILITY, RESILIENCE, AND INTEGRATION (HYDROWIRES) | FLEET MODERNIZATION, MAINTENANCE, AND CYBERSECURITY |
|---|---|---|
| Develop, test, and validate cost-effective, sustainable technologies for non-conventional hydropower applications in new-stream reaches, NPDs, and conduits. | Understand, enable, and improve hydropower and PSH's contributions to reliability, resilience, and integration in a rapidly evolving electricity system. | Develop digitalization, maintenance, and cybersecurity tools and capabilities to enable data-driven decision making, improve system reliability and reduce costs; and enhance infrastructure security. |
| ENVIRONMENTAL AND HYDROLOGIC SYSTEMS SCIENCE | | |
| Research and develop new technologies to better characterize river systems and evaluate potential impacts; avoid, minimize, or mitigate environmental impacts; and improve understanding of various hydrologic risks and uncertainty. | | |
| DATA ACCESS, ANALYTICS, AND WORKFORCE DEVELOPMENT | | |
| Improve access to relevant hydropower, river, and water information—including hydropower educational and training materials—and develop analytical tools to explore opportunities and weigh potential trade-offs across multiple objectives at basin-scales. | | |

# WPTO's 5-year Plan for R&D - *through FY25*

## Water Power Technologies Office Releases First Multi-Year Program Plan

MARCH 9, 2022

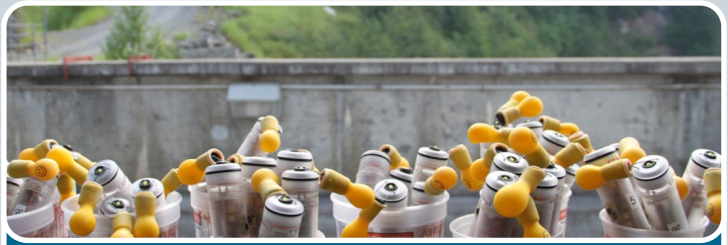
Water Power Technologies Office » Water Power Technologies Office Releases First Multi-Year Program Plan

The U.S. Department of Energy's Water Power Technologies Office (WPTO) has released its first **Multi-Year Program Plan** (MYPP), which outlines the Office's research priorities and plans through 2025.

The MYPP serves as both a strategic vision and an operational guide to help WPTO manage and coordinate its activities, as well as a vehicle to communicate WPTO's mission, goals, and plans to water power stakeholders and the public. It details WPTO's research, development, demonstration, and commercial activities across both hydropower and marine energy for the coming years and outlines how these efforts can help meet the nation's energy and sustainability goals.

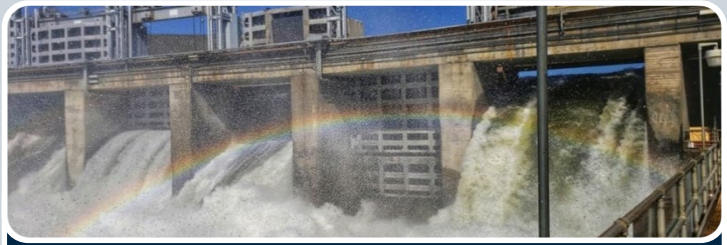
The MYPP features key performance goals for 2025, as well as additional objectives running through 2030. All outlined goals contribute to the overarching mission of WPTO to enable research, development, and testing of new technologies to advance marine energy and hydropower systems for a flexible, reliable grid.

# Environmental R&D and Hydrologic Systems Science Portfolios



**R&D to Improve Environmental Performance**

*Improving understanding of fish movement, habitat use, and survival through the development of advanced monitoring technologies, relevant metrics, and other impact assessment tools.*



**Hydrologic Systems Science**

*Addressing fundamental questions of hydrologic variation, impacts on ecosystems, and risks for operations and engineering of hydropower systems.*

# Research Area Themes

## Environmental R&D

- Monitoring Technologies
- Avoid, Minimize, Mitigate Environmental Impacts
- Environmental Metrics

## Hydrologic Systems Science

- Climate Change and Hydrologic Science
- Methane Emissions from Reservoirs

# Environmental R&D – Monitoring Technologies

**Fish Tracking Capabilities:**

- Juvenile Eel/Lamprey Tag (PNNL)
- Shad Tag (PNNL)
- Lab-on-a Fish (PNNL)
- Self-powered Tag (PNNL)

**Data Collection/Processing:**

- Machine learning with sonar to detect/ classify fish FOA (EPRI/PNNL)
- Sensor Fish Mini (PNNL)

**Water Quality:**

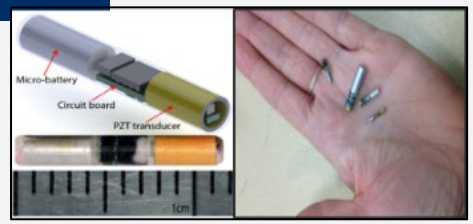
- WQ Sensors ROV with real-time data (PNNL)

**Innovative Monitoring**

- eDNA (ORNL)
- Otolith microchemistry (PNNL)

**WPTO Monitoring Goals FY21-FY25**

- **Develop fish tracking capabilities**: Provide more accurate and greater data for sensitive species over greater spatial and temporal scales
- **Long-term field tests of advanced fish tracking capabilities:** Conduct field tests to demonstrate advances in fish tracking capabilities
- **Identify methods to modernize data collection, processing, and analysis:** Identify and develop tools for data automation and investigate methods to apply artificial intelligence and machine learning for processing and analysis for rapid and real-time environmental assessments.
- **Deploy artificial intelligence and machine learning enhanced technologies:** Demonstrate tools that utilize artificial intelligence and machine learning for environmental monitoring and quantify improvements in the data pipeline and cost reductions.
- **Develop advanced water quality monitoring capabilities**: Research and prototype tools and technologies for more accurate and representative water quality measurements.
- **Utilize capabilities to enhance model performance:** Develop more robust models and methods to inform real-time operations for improved water quality.



# Environmental R&D – Avoid, Minimize, & Mitigate Impacts

**Multi-species Fish Passage:**

- Entrance Palisade FOA (U Mass Amherst/ Conte Lab)
- Eel Bi-pass FOA (Alden Research Laboratory)
- HydroPASSAGE (PNNL & ORNL):
  - HBET & BioPA Tool
  - 99 Dose-response relationships
- Fish Protection Prize:
  - Alden Research Lab – Deal w/ the Devil Fish Screen
  - Prometheus LLC – innovative Materials
  - Natel Energy – Center Sender Fish Guidance
- Absolute Injury Blade Strike, Sensor Fish (PNNL)
- Turbine Entrainment and Survival Risk (PNNL)
- Tech Support to Tribes:
  - Juvenile Lamprey Collector Prototype PNW (PNNL)
  - Connectivity Planning Eastern Band Cheroke Reservation (ORNL)
  - Fish Restoration Planning Shasta McCloud (PNNL)

**Water Quality**

- Environmentally Acceptable Lubricants (SBIR)

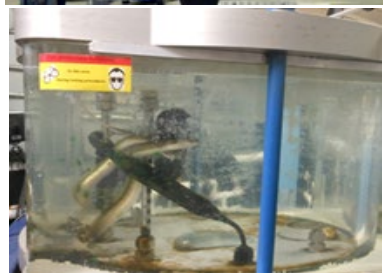
## WPTO Mitigation Goals FY21-FY25

- **Develop multi-species fish passage**: Design and test innovative up- and down-stream fish passage technologies to support fish communities and prevent invasive species movements and investigate methods for relating technology choices to fish restoration goals.
- **Field tests of multi-species fish passage technologies**: Quantify performance of innovative technologies and applied modeling capabilities to assess population-level impacts and restoration goals.

## R&D for Low Impact Growth: *Cross-cutting Hydropower R&D*

**Standard Modular Hydropower (FOA)**

- Natel Energy - **Restoration Hydro Turbine**
- Percheron Power – **Two-way fish migration technology**
- Littoral Power Systems – **Zero Ascend Omnispecies Modular Fish Passage**

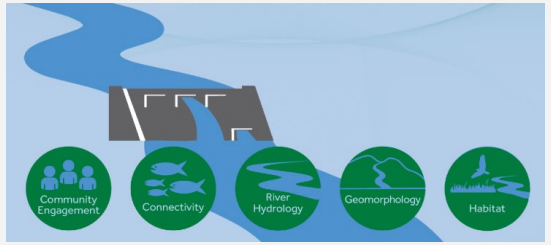


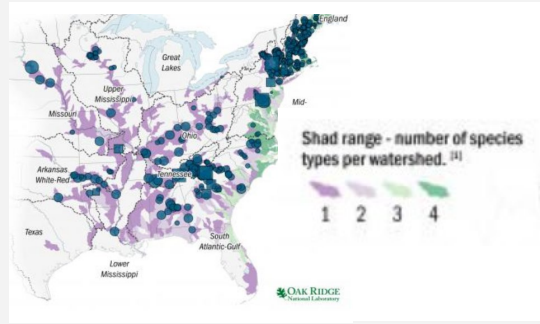
- **HydroWIRES: *Cross-cutting Hydropower R&D***
  - Environmental Impacts of Closed- and Open-Loop Pumped Storage Hydro Report

# Environmental R&D – Environmental Metrics

**Decision Support Tools (ORNL):**

- Catalogue of **Environmental Metrics for Hydropower:**
  - Biota and Biodiversity
  - Water Quality
  - Geomorphology
  - Connectivity and Fragmentation
  - Water Quantity
  - Landscape and Land Cover
- **River Function Indicator Questionnaire Tool**
- Relating Impacts to Mitigation (ORNL/NREL)
- National Fish Passage Dataset and Cost Analysis (ORNL)
- Social Science Applications (PNNL)




**WPTO Metrics Goals FY21-FY25**

- Develop decision support tools and resources: Provide information and science-based tools that utilize established environmental metrics indicators.
- Access utility of tools in hydropower environmental assessments: Demonstrate toolkits with hydropower stakeholders and assess capabilities to identify key environmental impacts and relevant mitigation methods.

**HydroWIRES: *Cross-cutting Hydropower R&D***

**Instream Flows and Hydropeaking**

- Power System and Environmental Flow Tradeoffs

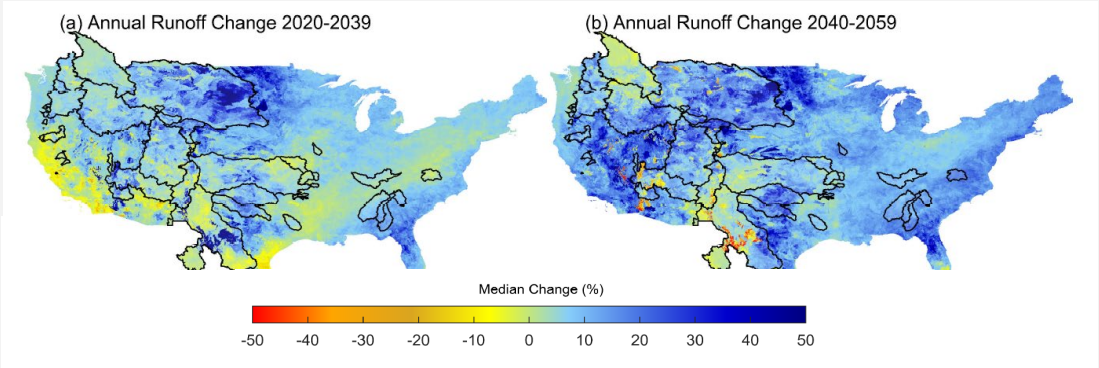
# Climate Change and Hydrologic Science

**PROJECTS**

- Third Secure Water Act Section 9505 Assessment on **Climate Risks to Hydropower** (ORNL/PNNL)
- Large ensemble of **long-term hydroclimate projections** (ORNL/PNNL)
- **Drought impacts analysis** on hydropower in the Western US (PNNL)
- Water risk analysis of **grid assets and operations and interactive platform tool** (NREL)
- Improving large-scale **hydrologic and hydrodynamic modeling** (PNNL)

**WPTO Climate Change and Hydrologic Science Goals FY21-FY25**

- **Determine needs for additional modeling assessments:** Assess the need to conduct additional modeling assessments or develop models with new capabilities.
- **Provide relevant data and tools for the entire hydropower fleet**: Utilize modeling capabilities to clarify potential risks and uncertainties to better understand climate change and hydrologic variations.
- **Develop numeric models, computing, and artificial intelligence capabilities**: Identify and apply advanced methods to increase understanding of basic hydrologic systems science and potential applications.
- **Quantify risks at plant and basin-scales**: Develop tools for different user groups to investigate risks of climate change and evolving hydrology at different spatial scales.



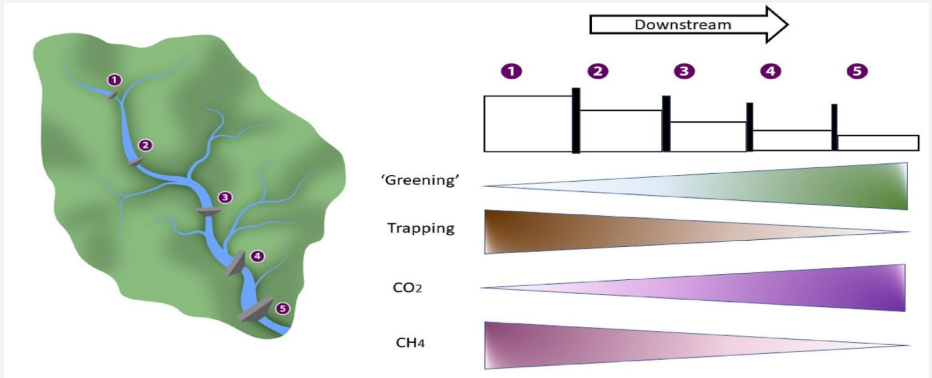
# Hydrologic Systems Science – Methane Emissions

**PROJECTS**

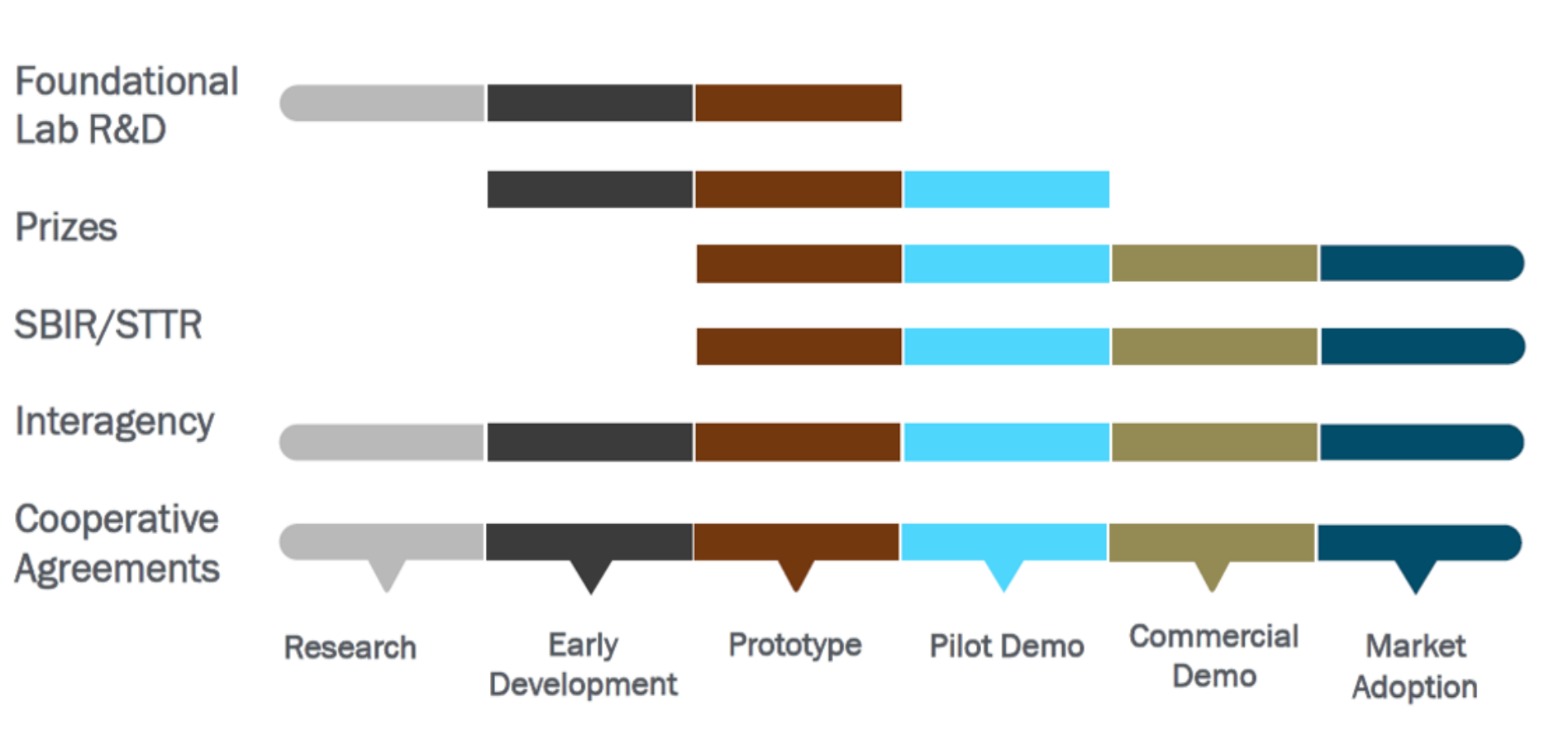
- Methane Emissions (ORNL)
  - Synthesize the **state of the science** of GHG emissions from reservoirs
  - **Data collection and analysis** in coordination with EPA
  - Evaluate and improve International Hydropower Association's **G-res Tool**
  - **Improve spatial and temporal** understanding of emissions from reservoirs

**WPTO Methane Emissions Goals FY21-FY25**

- **Develop capabilities to understand methane emissions from reservoirs:** Characterize the state of the science on methane emissions from reservoirs and other water bodies.
- **Address core scientific questions about methane emissions from reservoirs**: Conduct Foundational science on carbon transport and methane formation.
- **Develop remote sensing capabilities to measure methane emissions from reservoirs**: Advance current and novel technologies to test and validate methane measurement capabilities for different types of reservoirs and water bodies.
- **Classify reservoirs and quantify measurements**: Develop and utilize a reservoir classification scheme to assess risk and uncertainties of methane emissions.



# Using all WPTO's Funding Mechanisms to Address Environmental Needs through Innovation, Research and Development



# Previous Summits

# Hydropower Executive R&D Summit Summary

## Washington D.C. May 4th, 2017

- **Top environmental R&D needs presented by the hydropower industry:**
  - Fish Passage
  - Water Quality/ Dissolved Oxygen
  - Water/ Habitat Quality
  - Licensing/ Relicensing Guidance
  - Decommissioning Guidance
  - Management
  - Invasive Species
  - Information Sharing and Coordination

# Hydropower Environmental R&D Workshop Summary

## Washington D.C. April 25th, 2018

- **Research Agencies and National Laboratories Shared Ongoing and Recent R&D**

- **Summary of community needs presented by federal resource agencies and NGO hydropower stakeholders:**

- **The need for accessible, rigorous data**
  - Environmental information
  - New and advanced technologies
  - Mitigation measures
  - Adaptive management
  - Regional or basin-scale data

**Specific research needs for:**

- Fish passage and behavior
- Environmental flows
- Adaptive management and mitigation

- **Standardization of study methodologies**
- **The need for accessible, interoperable models**
  - Open source and easy to use
  - Stream channel and riparian habitat models
  - Reservoir operations and mass balance models
  - Flow-habitat and flow-ecology models
  - Predictive models that support long-term planning

# Hydropower Environmental R&D Workshop Summary

## Washington D.C. September 17-18, 2019

- **Two-day meeting where participants had the opportunity to:**
  - build upon findings from past Summits to further the conversation around hydropower R&D needs;
  - identify more details within the previously identified R&D needs and topics;
  - begin to discuss the prioritization of the needs and to discuss how the R&D needs could be met

- **Focused on identifying opportunities for federal agencies and environmental entities to work together to address the R&D needs:**
  - Break out discussion on fish passage
  - Confirmed the next Summit would include participants/attendees from both industry and environmental entities to discuss crosscutting issues identified during the previous Summits

# Industry and Environmental R&D Summit

Washington DC and virtual April 25, 2023

- WPTO Hydropower Program Overview
- Industry, Agency, and NGO Roundtable on Current R&D priorities/needs
- Interactive Session on Attendee R&D priorities/needs
- Breakout Groups on Current R&D Topics

MAVEL · Natel Energy · Southern Company · U.S. Department of the Interior · ALDEN a verdantas company · GE · NOAA Fisheries · Hydropower Foundation · PG&E

U.S. Fish & Wildlife Service · American Rivers · santec · USGS science for a changing world · ACORE American Council on Renewable Energy · Low Impact Hydropower Institute · NHA National Hydropower Association · US Army Corps of Engineers

Hydropower Reform Coalition · Advanced Hydro Solutions · Bonneville Power Administration · National Park Service · EPRI Electric Power Research Institute · U.S. Department of the Interior Bureau of Indian Affairs · Pacific Northwest Center of Excellence for Clean Energy · TVA

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# Interactive Session

Audience Perspectives on R&D Priorities and Needs

# WPW Audience Perspectives on R&D Needs and Priorities

- **Goal:** Gather and exchange information, not to establish Department of Energy policy or to reach a consensus
- **Activity** (see handout)
  1. Read through summary list of priorities and needs from past summits
  2. Identify top 3 priority areas that are important to you and/or your work
  3. Identify top 3 needs within those areas
  4. Identify new priorities/needs not included on this list

# Top Priorities from Past R&D Summits, 2017-2019

*2023 Summit attendees identified top needs from a list of 50+*

| 2023 Summit's Top Priorities / R&D Needs | Area |
|---|---|
| Predictive models that support long-term planning | Data Management & Models |
| Data on climate change impacts on watershed hydrology and operations | Water Management |
| Data from field testing and monitoring | Fish Passage & Aquatic Ecology |
| Data from state, regional, watershed, and basin scales | Data Management & Models |
| Framework for monitoring and sharing research and data | Best Practices & Coordination |
| Engineering designs that account for hydrologic uncertainty and change | Adaptive Mgmt & Mitigation |
| Models and tools to forecast future fleet and role of hydropower | Data Management & Models |
| Information and data on water quality, quantity, biota, and nutrients | Water Management |
| Tools to identify and quantify operational impacts from environmental constraints | Adaptive Mgmt & Mitigation |
| Information and data on new and advanced technologies | Data Management & Models |
| Advanced designs and evaluation of fish passage and screening | Fish Passage & Aquatic Ecology |
| Information and data on GHG emissions from water storage reservoirs | Water Management |

# New Priorities from 2023 R&D Summit

*2023 Summit attendees identified 90+ new priorities and needs*

- Data guidelines/consistency and validation measures
- Best practices for incorporating DEI and TEK into project planning and education
- Guidance for considering climate change in operations and relicensing
- Information and data on extreme event and climate change impacts
- Integration of machine learning and AI for environmental monitoring and multispecies/selective fish passage
- Assessment and valuation of grid services
- GHG assessments under different operational and water quality scenarios
- Improved coordination between license surrender, decommissioning, and dam removal
- Longitudinal and lateral connectivity considerations

# Breakout Session

- Testing Needs and Centers
- Fish Passage
- Water Availability and Quality
- New Approaches to Environmental Data

# Testing Centers & Needs

## R&D Priorities

- Full scale testbed to understand performance and use for model validation
- Tools to identify and characterize flow channel to powerhouse to assess and minimize coffer dam design to decrease costs
- Improve and standardize site assessment techniques to assess number of potential sites
- Standardized design to be tested for multiple sites
- Demonstration for acceptability for equipment and whole systems pertaining to different interests

## Collaboration Opportunities

- Workshops – Industry, Labs, Owner/operators
- Industry collaboration with research centers/ labs, that are already aligned/possess expertise for doing work
- Developer and industry communication/ collaboration for technology and knowledge sharing/ transfer

## Near-Term Actions

- Acceptable methods of implementation without physical models
- Minimization of cost and time

# Fish Passage: Information Needs & Technologies

## R&D Priorities

- Data/model access and consolidation (e.g., post-passage study data, life cycle costs)
- Validation pathways from models to field testing
- Data linking fish behavior and flow/quality; attribution of hydro impacts; facility passage and fish lifecycle
- Multispecies/selective fish passage and monitoring across watershed
- Specifications for technology development and support tools for technology selection
- Clarify passage responsibilities/actions for dam owner vs. external partnerships (e.g., off site actions)
- Case studies on what does/not work
- Best practices and data on incorporating cultural knowledge and resources

## Collaboration Opportunities

- Developing standard methods for data collection/analysis (e.g., AFS guidance) and limited-release data sharing (e.g., NHA Op-Ex safety data, USGS)
- Expanding use of DOE-developed tools and technologies (e.g., ORNL fish passage database, PNNL fish barotrauma testing lab)
- Expanding community and indigenous engagement

# Water Availability & Quality: Past, Present, & Future

**R&D Priorities**

- Basin-scale planning and coordination – across spatial and temporal scales and stakeholders
- Consistent data from a diverse set of stakeholders needed to inform basin level decisions
- Climate change impacts to facilities

**Collaboration Opportunities**

- American Water Resources Association is doing Integrated Water Management Plans
- Water resource agencies and hydropower operators
- Develop an interagency task group that includes representatives from state to local communities.

**Near-Term Actions**

- Application of AI to data collection and access
- Dialogue around all water users to address issues around competing demands and needs
- Inventory of aquatic barriers beyond those in the National Inventory of Dams, for better planning

# New Approaches to Enviro Data: Sensors, AI, & Monitoring

## R&D Priorities

- Data access and consolidation
- Improve hydrodynamic modeling using high performance computing tools
- Improve prioritization of dam safety efforts through risk-informed assessment
- Standardize the measurement and quantification of methane emissions from reservoirs
- Integrate water datasets for monitoring and decision-making

## Collaboration Opportunities

- NOAA National Water Model and Water quality
- USGS, water data in general
- EPA methane emissions
- MethaneSAT

## Near-Term Actions

- Novel Sensors
- Collaboration with NOAA and USGS
- Modernization of legacy computer software

# Next Steps

## Analysis of Inputs from Summit and Water Power Week

- R&D needs/ priorities exercise input
- Breakout session input (e.g., testing centers, fish passage, water availability/ quality, sensors)
- Identify recurring themes and topics that require further discussion
- Map R&D needs to WPTO Portfolios to identify gaps

## Continue conversations with the hydropower community on specific topics

- WPTO Deep Dive Webinars on top areas of interest and/or findings
- Workshops to bring in additional expertise on specific topics
- Improve communications on projects and products (including existing datasets) of interest

## Inform WPTO

- Assess WPTO resources and funding structures to address R&D needs and gaps
- Identify specific approaches and activities to address challenges
- Identify and develop partnerships
- Make recommendations for the next WPTO Program Plan

# Contact Information

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