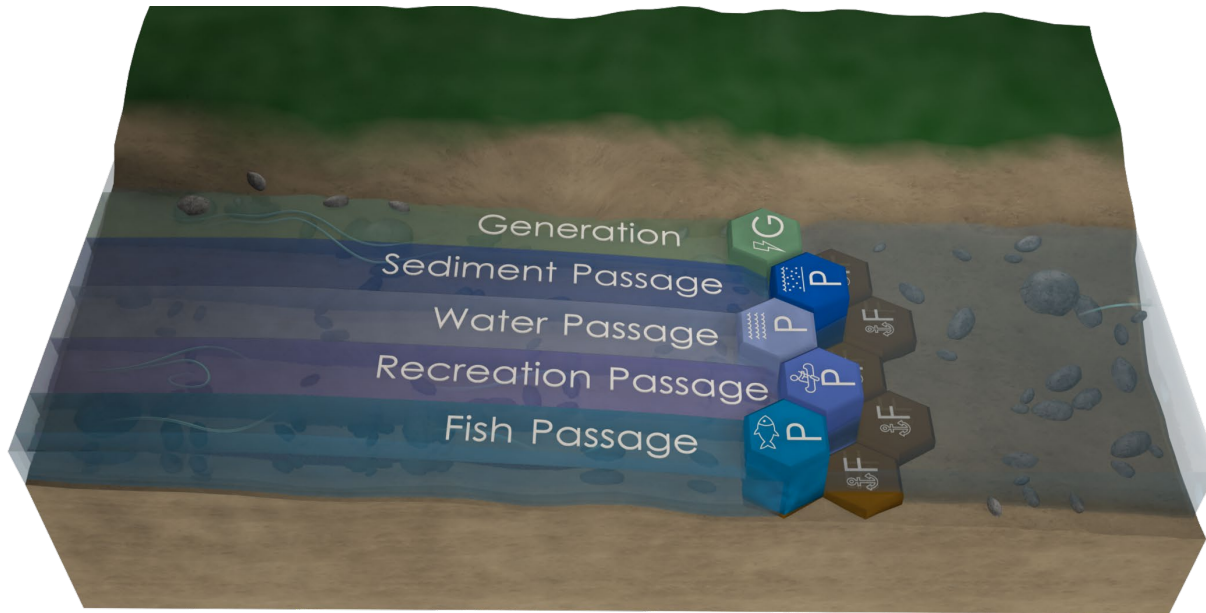


1.1.1.501 – Standard Modular Hydropower Technology Acceleration



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July 26, 2022



Project Overview

Project Summary

- To address challenges facing small hydropower development, the Standard Modular Hydropower (SMH) Technology Acceleration project defines **standardization, modularity, and environmental compatibility** as three enabling principles of a **low-cost, environmentally sustainable** hydropower growth strategy. The project takes multiple research approaches for promoting SMH technology acceleration. Together, the associated research activities aim to **enable the design and development of new SMH technologies** for both existing water infrastructure and new stream-reach development.

Intended Outcomes

- Significant U.S. **deployment of new, small, low-impact hydropower projects** that integrate multiple social, ecosystem, and energy needs and realize value and revenue from a variety of sources.
- New business growth** for companies developing new, low-impact hydropower technologies and/or projects.
- Increased resiliency of river ecosystems** from improved science regarding environmental impacts of hydropower .
- Improved decision-making processes and basin-wide management** of river resources for multiple objectives, including energy, **enabled by improved data and analytical tools.**

Project Information

Principal Investigator(s)

- Scott DeNeale, *Oak Ridge National Lab*

Project Partners/Subcontractors

Partners: (1) Littoral Power Systems;
 (2) Natel Energy; (3) Percheron Power;
 (4) University of Minnesota
Subcontractors: (1) Kearns & West;
 (2) Knight Piésold Consulting; (3) Saffron Systems;
 (4) Small Hydro Consulting;
 (5) University of Tennessee

Project Status

Ongoing

Project Duration

- Project Start Date: October 1, 2015
- Project End Date: September 30, 2023

Total Costed (FY19–FY21)

\$3,900,000

Project Objectives: Relevance to Program Goals



Challenge: *“limited opportunities for new, affordable hydropower growth.”*



Mission: enable *“Innovations for Low-Impact Hydropower Growth”*

Programmatic Activities:

- *“Innovate new technologies for both existing water infrastructure and new stream-reach applications that incorporate ecological and social objectives.”*
- *“Leverage new manufacturing and materials to dramatically lower costs of components and systems.”*



Intermediate Outcome: achieve *“Cost reductions and commercialization of standard modular hydropower technologies for existing water infrastructure and new stream-reach development.”*



Long-Term Outcome: achieve *“Deployment of new, small, low-impact hydropower projects in the U.S. that integrate multiple social, ecosystem, and energy needs.”*

Project Objectives: Approach

Approach:

- **SMH research goal:** stimulate innovative designs that incorporate **standardization, modularity, and environmental compatibility** as enabling design principles of small, low-head hydropower facilities
- **Three core research tasks:** (1) Module Research & Development, (2) SMH Facility Research & Development, and (3) SMH for Non-Powered Dam (NPD) Development



Standardization:

Standard siting methods, designs & technologies, manufacturing, project review, regulatory pathways, construction sequencing, etc. *to reduce site specificity and project costs.*



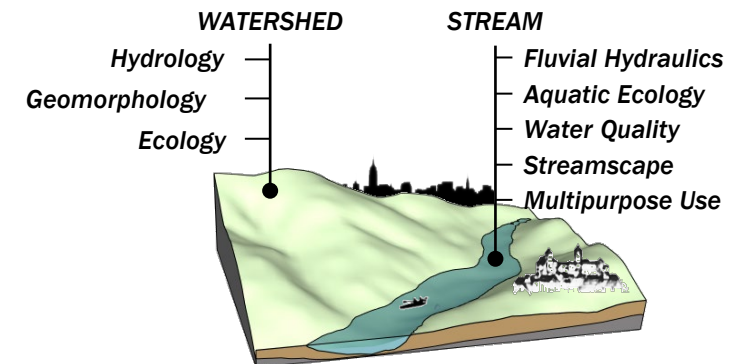
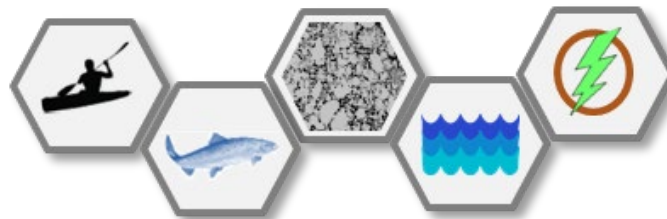
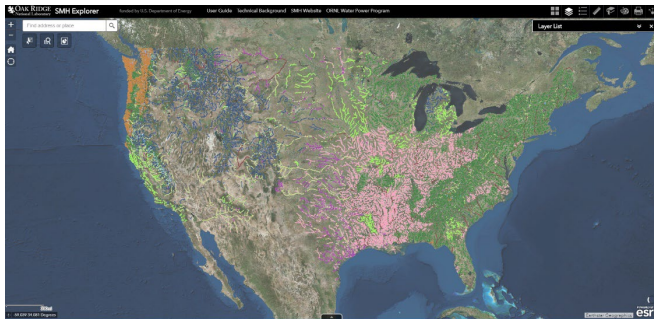
Modularity:

The physical organization of a hydropower facility into discrete functional units, allowing scalability *to deliver energy and environmental benefits at many different sites.*



Environmental Compatibility:

Facilities sited and operated as coupled human-natural systems to minimize disturbances *to maintain stream functionality and ecosystem health.*



Project Objectives: Research Tasks

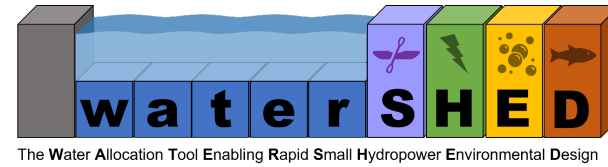
Approach:

- Three core research tasks:
 1. **Module Research & Development**
 - a. Funding Opportunity Announcement DE-FOA-0002080
 2. **SMH Facility Research & Development**
 - a. Funding Opportunity Announcement DE-FOA-0001836
 - b. Water Allocation Tool Enabling Rapid Small Hydropower Environmental Design (waterSHED)
 - c. Hydropower Co-Development Research
 3. **SMH for Non-Powered Dam (NPD) Development**
 - a. NPD Classification Research & Data Access Improvement
 - b. Web Tools: NPD Explorer and NPD Custom Analysis and Taxonomy App
 - c. NPD Retrofit Exemplary Design Specification Development

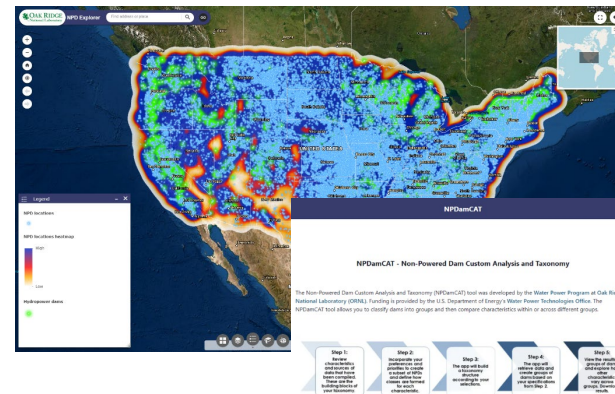
Technical Support to FOA Awardees



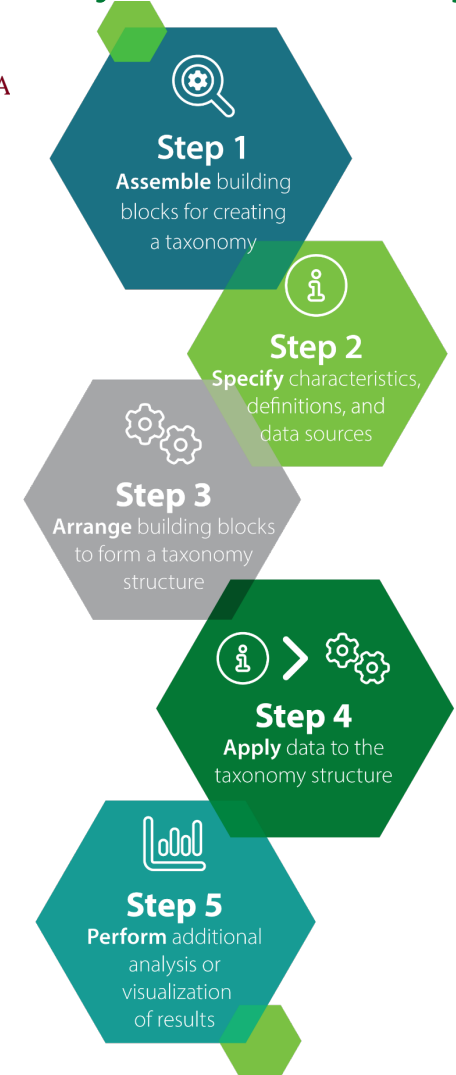
waterSHED Tool Development



NPD Classification, Tool, and Design Specification Development



Non-Powered Dam Custom Analysis and Taxonomy



Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- **Technical support:** to Funding Opportunity Announcement (FOA) awardees.
- **Data:** NPD Characteristics Inventory
- **Tools:** (1) NPD Explorer, (2) NPDamCAT App, (3) waterSHED Tool/Code
- **Publications:** (1) SMH Design Case Study, (2) Journal on NPD Data Needs and Research Gaps, (3) NPD Taxonomy Framework Report, (4) NPD Tools User Guide, (5) NPD Retrofit Exemplary Design Report, (6) waterSHED User Guide

Outcomes:

- **Attract** stakeholders using webpage and outreach materials.
- **Create** data and tools to support SMH and NPD development.
- **Accelerate** SMH technology development, demonstration, and deployment.
- **Advance** industry partner technology readiness.
- **Stimulate** low-impact, hydropower growth for existing water infrastructure and new stream-reach development.

Project Timeline

FY2019

FY2020

FY2021

development.

Project Budget

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
\$1,301K	\$1,539K	\$1,060K	\$3,900K

- Includes approximately \$590K in direct technical support to FOA awardees.

End-User Engagement and Dissemination

Engagement Activities conducted during FY2019-FY2021 include:

1. Direct **technical support** to FOA awardees.
2. SMH Innovation Advisory Group to provide stakeholder vetting for FOA-1836.
3. December 2020 **virtual workshop** on “Challenges and Opportunities for Non-Powered Dams: Improving Classification and Data Access.”
4. July 22, 2021 **virtual workshop** on “NPD Explorer and NPDamCAT: web tools for supporting analysis of non-powered dams.”
5. **Two additional virtual workshops conducted in late 2021.*

Dissemination of research products via OSTI.GOV and SMH website (<https://smh.ornl.gov/>).

- (as of May 31, 2022): 2 Journals, 9 Reports, 3 Tools, 3 Datasets, 4 Other Products

NPD Workshop Stakeholder Representation



Innovation Advisory Group Representation

- Aquatic biology and ecology
- Fish passage design
- Grid and interconnection
- Licensing and environmental protection
- Low impact development



Performance: Accomplishments and Progress (since FY2018)

Module R&D

Technical Support to 4 FOA Awardees



Percheron Power UNIVERSITY OF MINNESOTA

ORNL Technical Support Scope

- **Littoral:** computational fluid dynamics modeling, advanced manufacturing (AM) consulting.
- **Natel:** AM consulting.
- **Percheron:** target market analysis, AM consulting, cost analysis.
- **University of Minnesota:** AM consulting, AM prototype fabrication, sediment guide vane research and design, cost analysis.

SMH Facility R&D

Technical Support to 2 FOA Awardees to Advance SMH Facility Design Concepts



Publication of waterSHED Tool



5/22

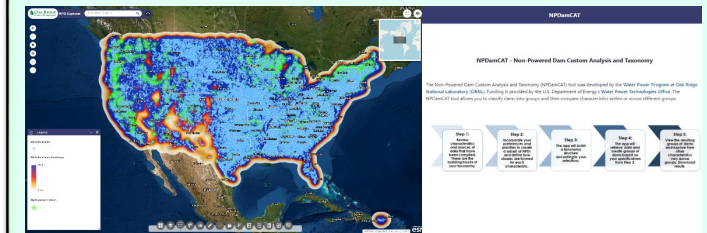
The Water Allocation Tool Enabling Rapid Small Hydropower Environmental Design

Co-Development Research

- **2019 White Paper:** internal deliverable to DOE, defining *co-development* for incorporating hydrologic, water quality, and recreation enhancement for new hydropower development.
- **2019 Low-Flow Co-Development Research:** completed a preliminary national assessment for powering low flow across US hydropower fleet. Conducted implementation study with Tennessee Valley Authority (TVA) to assess opportunities for adding low flow units to TVA facilities.

SMH for NPDs

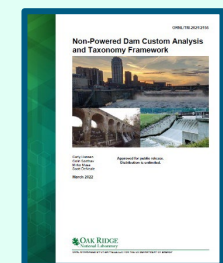
Development of NPD Classification Tools and NPD Dataset



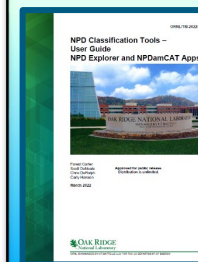
Publications (2 Journals, 3 Reports)



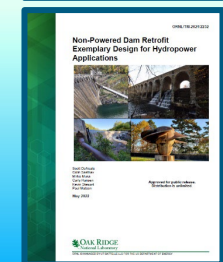
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Performance: Accomplishments and Progress (*Publications*)

Year	Citation
2022	Hansen, C., Sasthav, C., Musa, M., DeNeale, S. (2022) Non-Powered Dam Custom Analysis and Taxonomy (NPDamCAT) Framework, ORNL Technical Report ORNL/TM-2021/2155, https://doi.org/10.2172/1855679
2022	Carter, F., DeNeale, S., DeRolph, C., Hansen, C. (2022) NPD Classification Tools – User Guide NPD Explorer and NPDamCAT Apps, ORNL Technical Report ORNL/TM-2022/2389, https://doi.org/10.2172/1855640
2022	DeNeale, S. (2022) Fact Sheet for Standard Modular Hydropower Technology Acceleration
2022	Sasthav, C., Oladosu, G. (2022) Environmental design of low-head run-of-river hydropower in the United States: A review of facility design models, Renewable and Sustainable Energy Reviews 160, https://doi.org/10.1016/j.rser.2022.112312
2022	DeNeale, S., Sasthav, C., Musa, M., Hansen, C., Stewart, K., Matson, P., (2022) Non-Powered Dam Retrofit Exemplary Design for Hydropower Applications, ORNL Technical Report ORNL/TM-2021/2232, https://doi.org/10.2172/1869108
2021	Hansen, C., Musa, M., Sasthav, C., DeNeale, S. (2021) Hydropower development potential at non-powered dams: Data needs and research gaps, Renewable and Sustainable Energy Reviews 145, https://doi.org/10.1016/j.rser.2021.111058
2018	Witt, A., DeNeale, S., Papanicolaou, T., Abban, B., Bishop, N. (2018) Standard Modular Hydropower: Case Study on Modular Facility Design ORNL Technical Report ORNL/TM-2018/915 https://doi.org/10.2172/1484123
2018	Bevelhimer, M., DeRolph, D., Witt, A. (2018) Site Classification for Standard Modular Hydropower Development: Characterizing Stream Reaches by Module Need. ORNL Technical Report ORNL/TM-2018/898 https://doi.org/10.2172/1463991
2018	Stewart, K.M., Smith, B.T., Witt, A., DeNeale, S., Bevelhimer, M., Pries, J.L., et al (2017) Simulation and Modeling Capability for Standard Modular Hydropower Technology. ORNL Technical Report ORNL/TM-2017/175 https://doi.org/10.2172/1394299
2017	Smith, B.T., Witt, A., Stewart, K.M., Lee, K., DeNeale, S., Bevelhimer, M., et al (2017) A Multi-Year Plan for Research, Development, and Prototype Testing of Standard Modular Hydropower Technology ORNL Technical Report ORNL/TM-2016/102 https://doi.org/10.2172/1343501
2017	Witt, A., Fernandez-McKeown, A., Mobley, M., DeNeale, S., Bevelhimer, M., Smith, B. (2017) How Standard Modular Hydropower Can Enhance the Environmental, Economic, and Social Benefits of New Small Hydropower HydroVision International
2017	Witt, A., Smith, B., Bevelhimer, M., Fernandez, A., Bishop Jr., N. (2017) Making Small Hydro Development Affordable and Acceptable Hydro Review 36, 7
2017	Fernandez, A., Bishop, N., Bevelhimer, M.S., Smith, B.T., Witt, A.M. (2017) Standard Modular Hydropower Technology Acceleration Workshop: Summary Report ORNL Technical Report ORNL/TM-2017/328 https://doi.org/10.2172/1394271
2017	Witt, A. (2017) Summary Handout of Standard Modular Hydropower Innovator Engagement
2017	Witt, A., Smith, B.T., Tsakiris, A., Papanicolaou, T., Lee, K., Stewart, K.M., et al. (2017) Exemplary Design Envelope Specification for Standard Modular Hydropower Technology ORNL Technical Report ORNL/TM-2016/298 https://doi.org/10.2172/1343525

Performance: Accomplishments and Progress (*Other Output*)

Video

- [SMH Overview Animation Video](#)

Tools

- [Non-Powered Dam Explorer](#)
- [Non-Powered Dam Custom Analysis and Taxonomy App](#)
- [Standard Modular Hydropower Explorer](#)

Data

- [NPD Characteristics Inventory](#)
- [Stream Network Attributes for SMH Explorer](#)
- [Stream Network Clustering Attributes for SMH Explorer](#)

Workshop Series on Non-Powered Dams (December 2020 to December 2021)

- [December 6, 2021: NPD Explorer Tool Beta Review](#)
- [November 15, 2021: NPD Explorer Beta Demo](#)
- [July 22, 2021: NPD Explorer and NPDamCAT: web tools supporting analysis of non-powered dams](#)
- [December 10, 2020: Challenges and Opportunities for Non-Powered Dams: Improving Classification and Data Access](#)

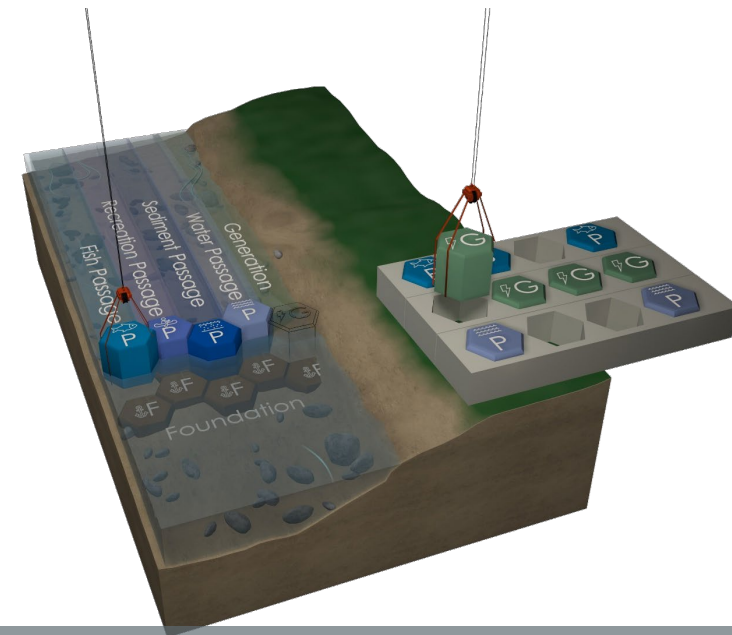
Standard Modular Hydropower (SMH) Resources Webinar (September 6, 2018)

- [Webinar Slides](#)
- [Webinar Video](#)

Future Work

Project planned to extend to FY2022-FY2023

- Complete technical support to FOA-1836 and FOA-2080 awardees.
- Publish waterSHED Tool and User Guide (*completed 5/2022*).
- Conduct two, FY2022 virtual workshops.
- Publish reports on:
 - NPD Custom Analysis and Taxonomy Framework (*completed 3/2022*)
 - NPD Tool User Guide (*completed 3/2022*)
 - NPD Retrofit Exemplary Design (*completed 5/2022*)
 - White Paper on Alluvial Pockets for Restoration Hydro
- Publish peer-reviewed journal articles:
 - Hydro Review Article on NPD Research Products
 - Hydropower Co-Development
 - Fish Exclusion Review and Cost Analysis



Q&A

