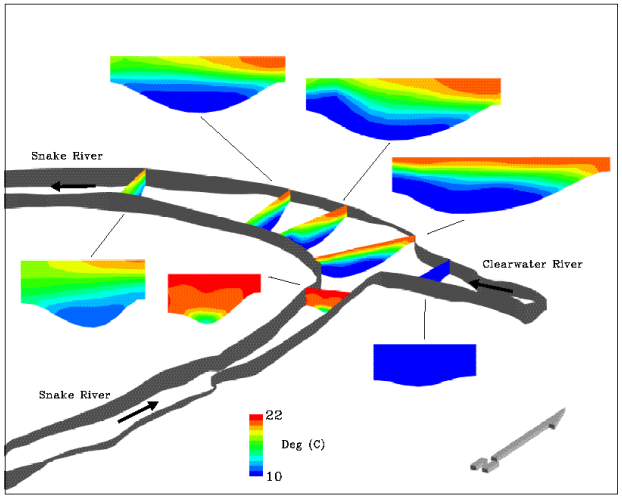

Informing Hydropower Investment and Operational Decisions under Changing Hydrologic Conditions

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Project Overview

Informing Hydropower Investment and Operational Decisions in the Face of a Changing Climate intends to provide a scalable, physics-based modeling framework to better understand and evaluate hydropower investments and operational decisions in the face of changing climate, ultimately:

- Quantifying risk, at the plant and system levels
- Identifying impacts of altered climate on hydropower and thermoelectric production; water temperature; and ecosystem resources.

Challenge: **Of specific interest is the relationship between: changing water temperature regimes in rivers; electric power generation from hydropower, thermoelectric plant cooling and discharge; and water-quality and habitat needs for sensitive species** (2014 DOE The Water-Energy Nexus: Challenges and Opportunities).

Who Benefits: Provide decision makers with the ability to predict the probable location, timing, duration, and severity of water-temperature events and explore alternative operations and infrastructure investments to mitigate the frequency and duration of such events.

Partners: Kearns and West , National Renewable Energy Laboratory (NREL), Portland State University, Industrial Stakeholders, Action Agencies (e.g. Bonneville Power Administration [BPA], U.S. Army Corps of Engineers (USACE), U.S. Bureau of Reclamation [USBR])

Next Generation Hydropower (HydroNEXT)

Optimization

- Optimize technical, environmental, and water-use efficiency of existing fleet
- **Collect and disseminate data on new and existing assets**
- Facilitate interagency collaboration to increase regulatory process efficiency
- Identify revenue streams for ancillary services

Growth

- Lower costs of hydropower components and civil works
- Increase power train efficiency for low-head, variable flow applications
- Facilitate mechanisms for testing and advancing new hydropower systems and components
- Reduce costs and deployment timelines of new PSH plants
- Prepare the incoming hydropower workforce

Sustainability

- Design new hydropower systems that minimize or avoid environmental impacts
- Support development of new fish passage technologies and approaches
- **Develop technologies, tools, and strategies to evaluate and address environmental impacts**
- **Increase resilience to climate change**

Program Strategic Priorities

Sustainability

- Develop technologies, tools, and strategies to evaluate and address environmental impacts
- Increase resilience to climate change

The project aims to provide decision makers with the capability to model the likelihood, location, and severity of water-temperature events under both current conditions and a range of future climate scenarios to evaluate alternative operations and infrastructure investments to mitigate such events.

- Plant and system level risk
- Hydropower and thermoelectric production
- Ecosystem resources.

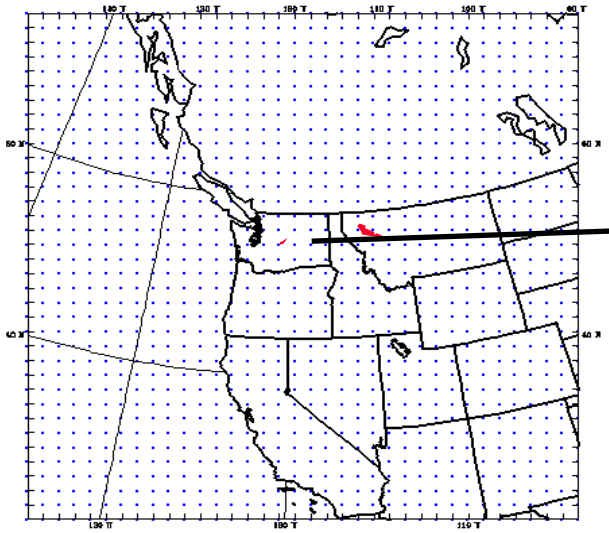
Technical Approach

- Stakeholder Engagement through an initial User Needs Assessment to scope and focus our modeling framework
  - National Steering Committee (NSC) and Basin Stakeholder Groups to serve as guides throughout the project.

- Initial development and demonstration of the system will be done in a portion of the greater Columbia River Basin
  - 40% of the nation's hydropower generated in the Pacific Northwest
  - Snow dominated basin
  - Already facing climate-related issues - summer of 2015, water temperatures in many locations throughout the mainstem and major tributaries were physiologically unsustainable for salmon, resulting in the death of a quarter-million sockeye
  - A recent Federal Court ruling found the current/proposed salmon protection plan fails to adequately consider climate change and address the federal hydropower dams' effect on fish.*
  - Federal agencies were given two years to write a new Biological Opinion and initiate a National Environmental Policy Act (NEPA) process that considers alternatives, including dam removal.*

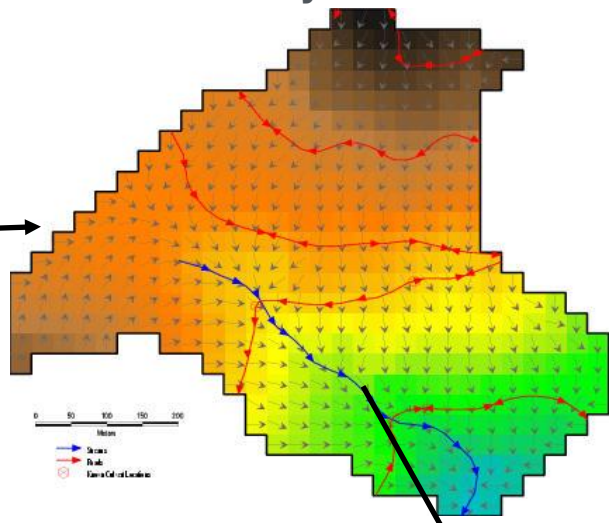
* Note: this research project is not directly related to nor will provide results used for the court proceedings or NEPA process.

Technical Approach

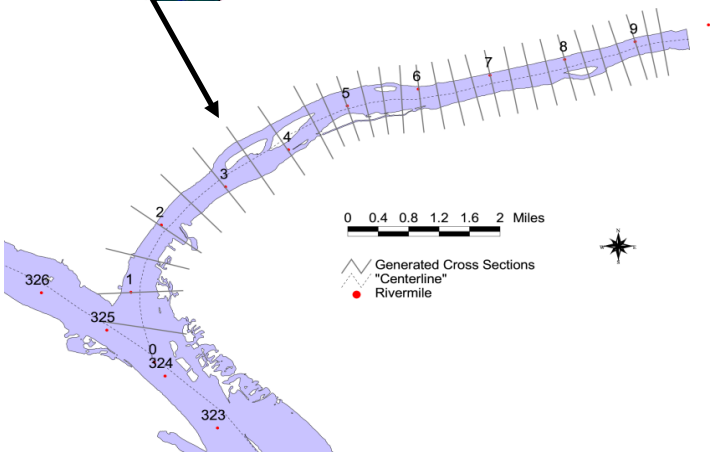


Regional Climate Model
WRF 6-km ensembles

DHSVM Distributed Watershed Model
90-m tributary streamflow & Temperature



MASS1 and MASS2 River Models (also interface with USACE reservoir operations models)



Accomplishments and Progress

This project only just started at the end of FY16 so progress is limited

- Coordination kick-off meeting with major Federal Columbia River Basin stakeholders BPA, USACE, and USBR in Portland, OR
- Participated in Columbia River Management Joint Operating Committee (RMJOC-II) workshop for long term planning
- Coordination with University of Washington task for RMJOC
- Entered into contracts with partners 1) Kearns & West, and 2) Portland State University
- Begun stakeholder outreach to establish NSC and Columbia Basin Stakeholder Groups (BSG).

Project Plan & Schedule

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

Milestone/Deliverable (selected)	FY2016				FY2017				FY2018				FY2019			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Stakeholder Engagement																
Ensemble Climate Modeling																
Watershed Hydrologic Modeling																
River and Reservoir Water Quality Modeling																
Environmental Impacts Assessment																
Future Hydropower Impact Assessment																

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
				$625K*	

* Received December 2016

Research Integration & Collaboration

Partners, Subcontractors, and Collaborators:

- Kearns & West: Facilitate the national and regional user needs assessments, report on those activities, and assist with project outreach efforts
- Portland State University: Evaluate the Columbia River Basin estuarine environment to provide a system-level look at the integrated impacts of climate change on the basin
- NREL: Application of the Regional Energy Deployment System (ReEDS) model and use that model to translate *Hydropower Vision* ReEDS scenario results into new deployments.
- The framework will be structured to accommodate other models provided they are technically acceptable and open source.
- The modeling framework will be compatible with PRIMA, DOE Office of Science's IAM/IAV model set housed at PNNL's Joint Global Change Research Institute.
- Other partners, subcontractors and collaborators TBD.

Technology Transfer, Next Steps and Future Research

Communications and Technology Transfer

- Stakeholder interaction with NSC and BSG (Columbia River and TBD second basin)
- Participation in national and local conferences, workshops, and meetings to listen and report out
- Publication of peer-reviewed documents

FY17/Current research:

- Conduct national User Needs Assessment to understand how hydropower investment and operational decisions are made to inform model framework construction
- Establish NSC and Columbia BSG
- Engage the scientific community (e.g., university researchers, technical staff at the BPA, USACE, BOR) for feedback on the proposed modeling methodology
- Based on stakeholder input, begin setup of watershed-river-reservoir models in the Snake River subbasin.

Next Steps and Future Research

Proposed future research:

- Columbia Basin
  - Complete climate simulations
  - Complete watershed, river, reservoir model runs
  - Complete environmental assessment
  - Evaluate alternative hydrosystem operations.

- Second demonstration basin
  - Select basin, establish BSG, and complete needs assessment
  - Begin climate simulations
  - Complete model setup and calibration
  - Complete environmental model runs
  - Evaluate alternative hydrosystem operations .

- Complete ReEDS-NHAAP analysis of future hydropower development

- Document modeling framework and make available to users.