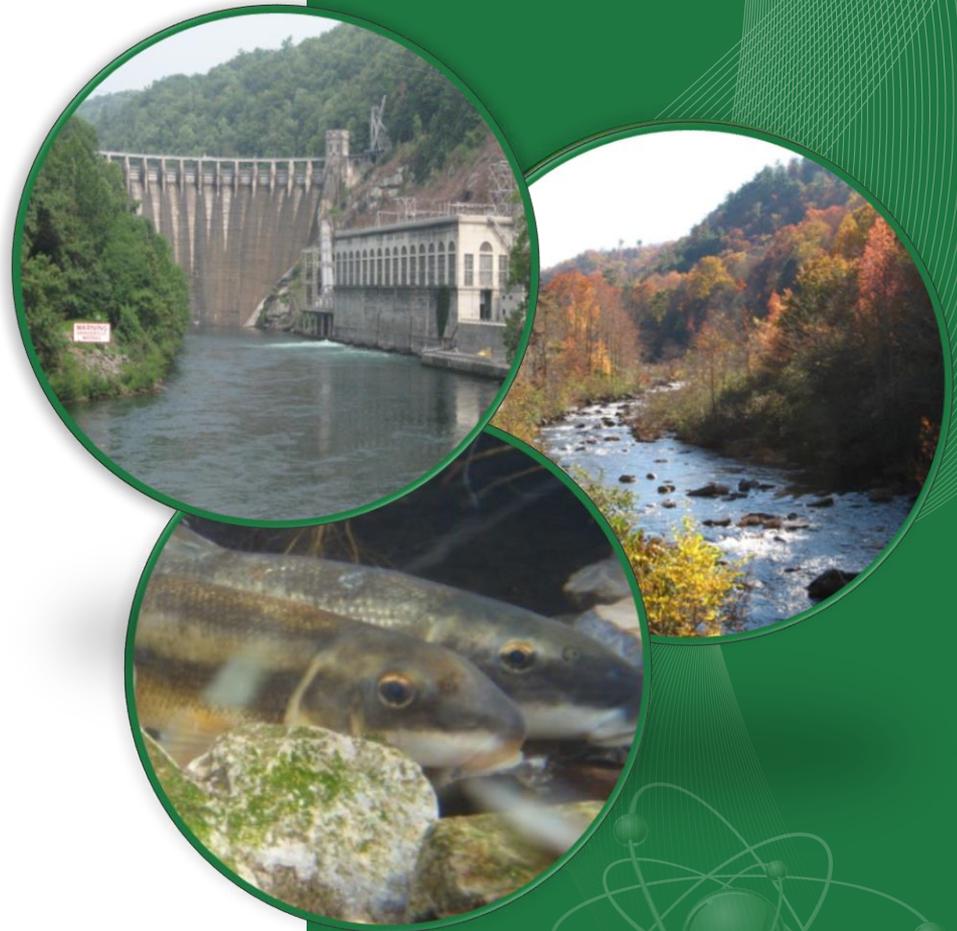


# Data, Tools, and Products to assist in hydropower mitigation

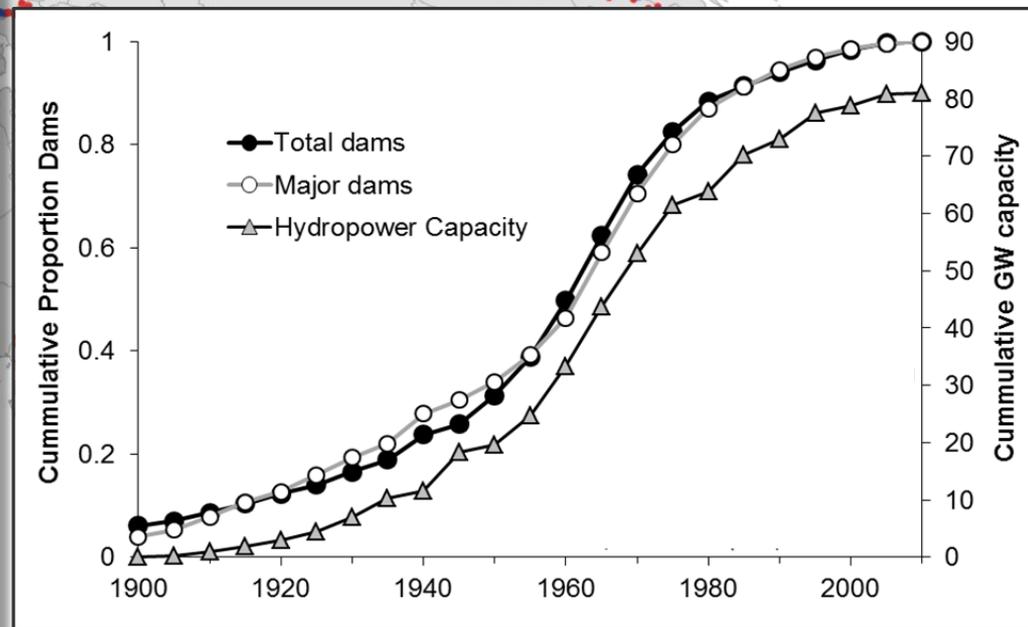
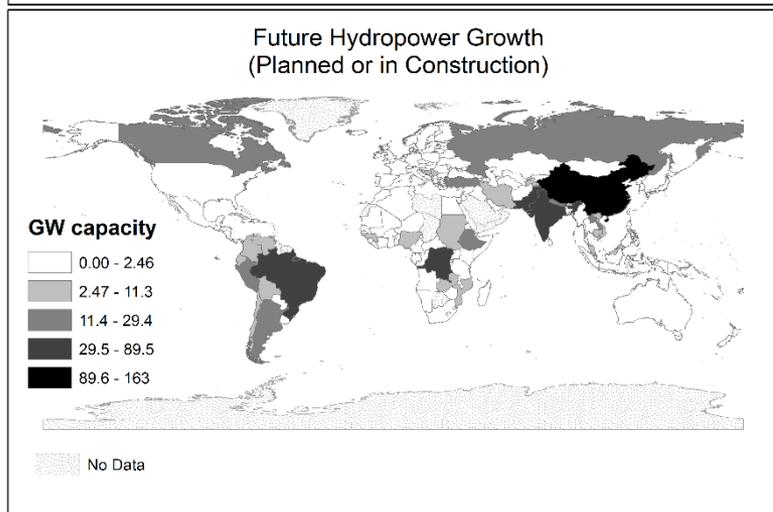
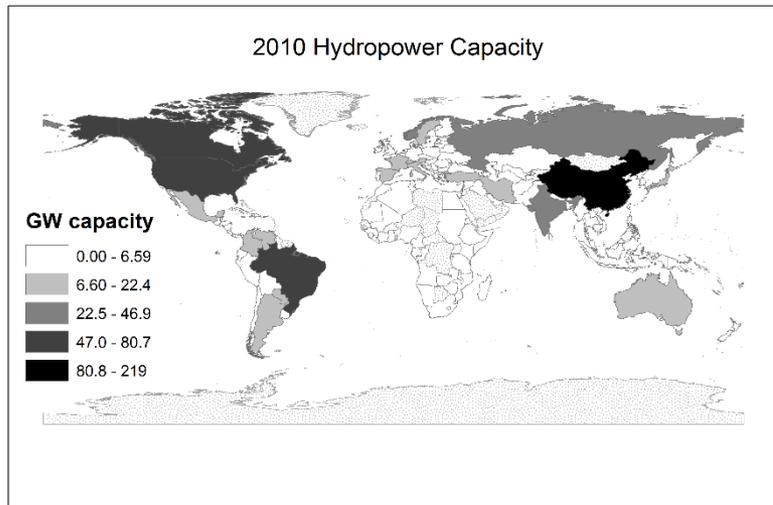
**Ryan McManamay**

USFS Instream Flow  
Training

January 10, 2018



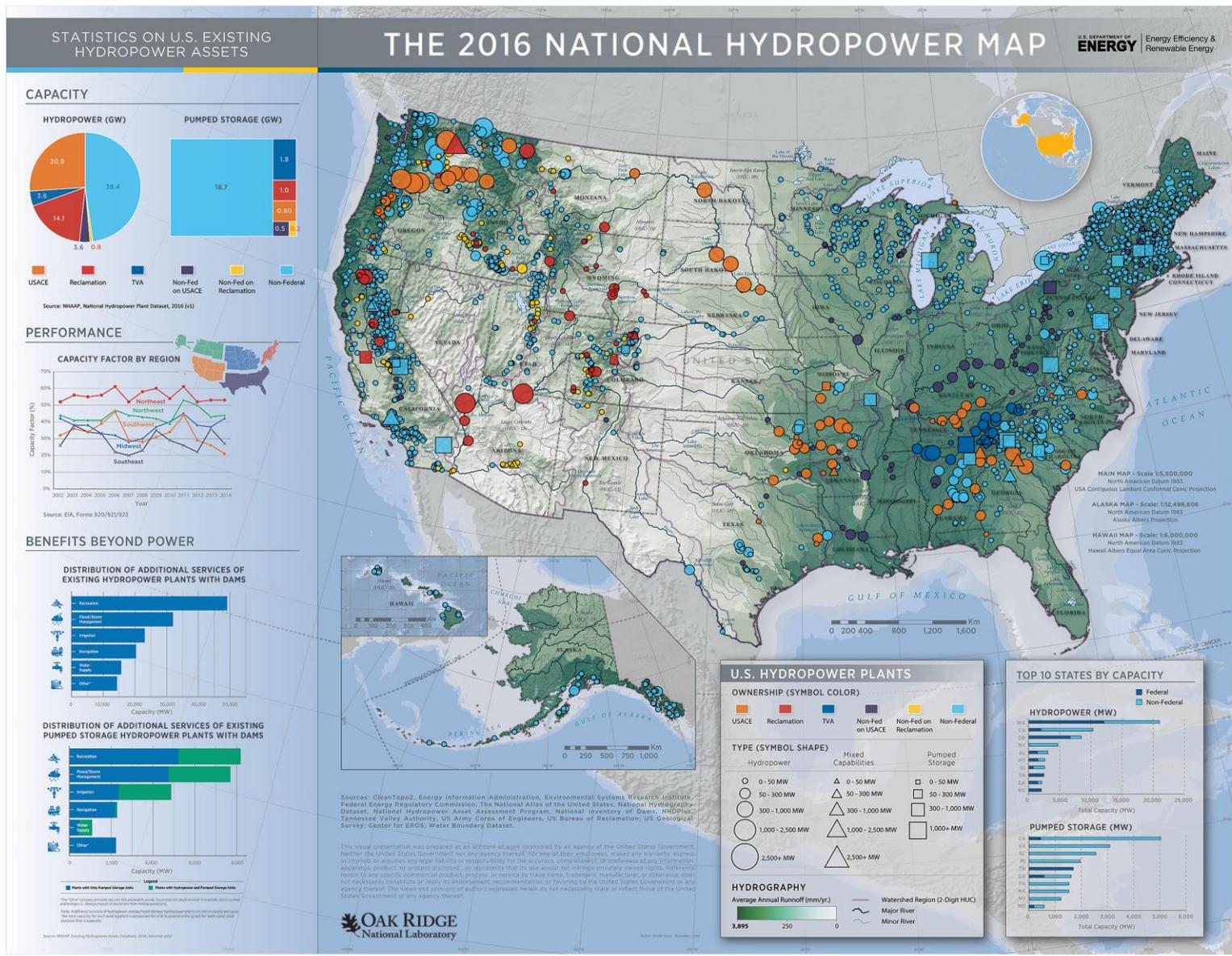
# Global Hydropower Expansion



Dams under construction  
Dams planned

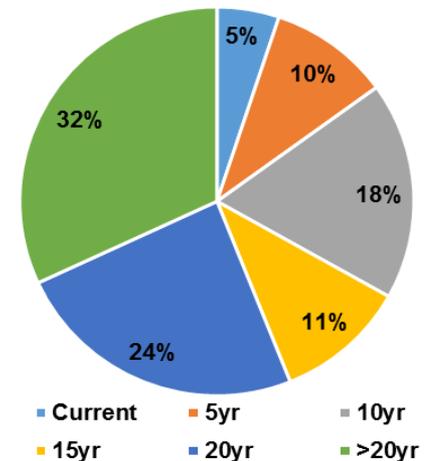
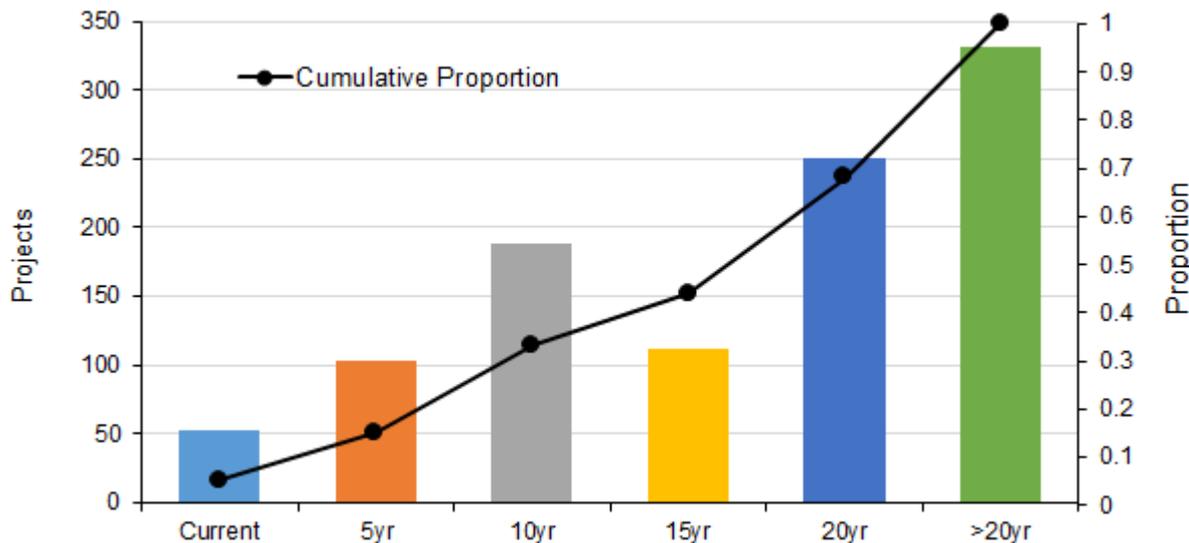
Zarr et al. 2015 – Aquatic Sciences

# US Hydropower Assets



# Near Future of Federal Energy Regulatory Commission (FERC) licensing

- 50% of the FERC hydropower projects will undergo relicensing in the next 15 years
- 70% of the projects will undergo relicensing in the next 20 years
- Doesn't include new licenses



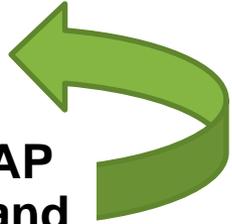
# With the looming relicensing storm...

- Need for data, tools, and frameworks to pre-inform stakeholders prior to engagement in FERC licensing process
- Need for early indicators of mitigation needs

# Outline

- Steps of FERC licensing
- Present a framework to organize the application of data and tools associated with licensing
- Examples of data, tools and their application
- Brier tour of National Hydropower Asset Assessment Program
- Stream Classification Web Application

NHAAP  
Data and  
Tools



*McManamay et al. 2016. Env  
Management*

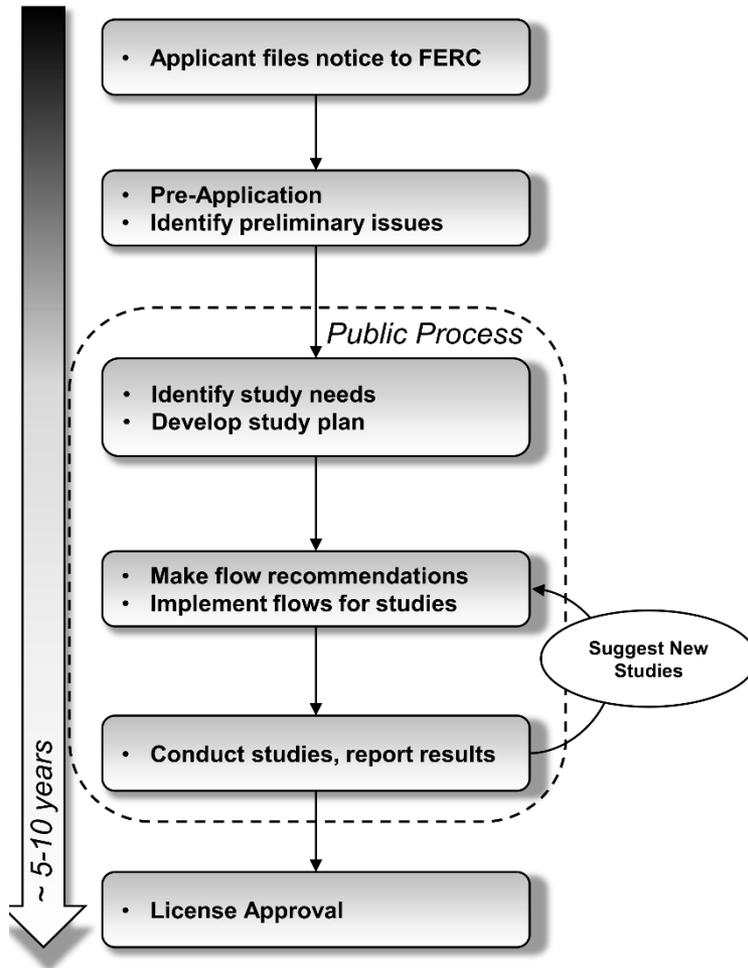
# FERC Licensing Procedure Types

Licensing Process	Description
Traditional Licensing Process (TLP)	Historically, it was the predominant procedure. 3-stage consultation process. Stage 1: NOI, PAD, joint meeting, comments, study proposal disputes. Stage 2: Conduct studies, draft application, stakeholders provide comments/disagreements/resolution. Stage 3: Final application files
Integrated Licensing Process (ILP)	Default procedure. Implemented in 2003 to create efficiency in process. Same as TLP except: <ul style="list-style-type: none"><li>• Early issue identification and resolution of studies (fill info gaps), avoiding studies post-filing;</li><li>• Integration of other stakeholder permitting needs;</li><li>• Established time frames to complete process steps for all stakeholders, including the Commission.</li></ul>
Alternative Licensing Process (ALP)	Designed to improve communication and flexibility. <ul style="list-style-type: none"><li>• Tailor the pre-filing consultation process to each case;</li><li>• Combine into a single process the pre-filing consultation process and EIS</li><li>• Allow for prep of draft EIS by an applicant or contractor</li></ul>

# Major Steps in FERC Licensing Process

## FERC Licensing Process

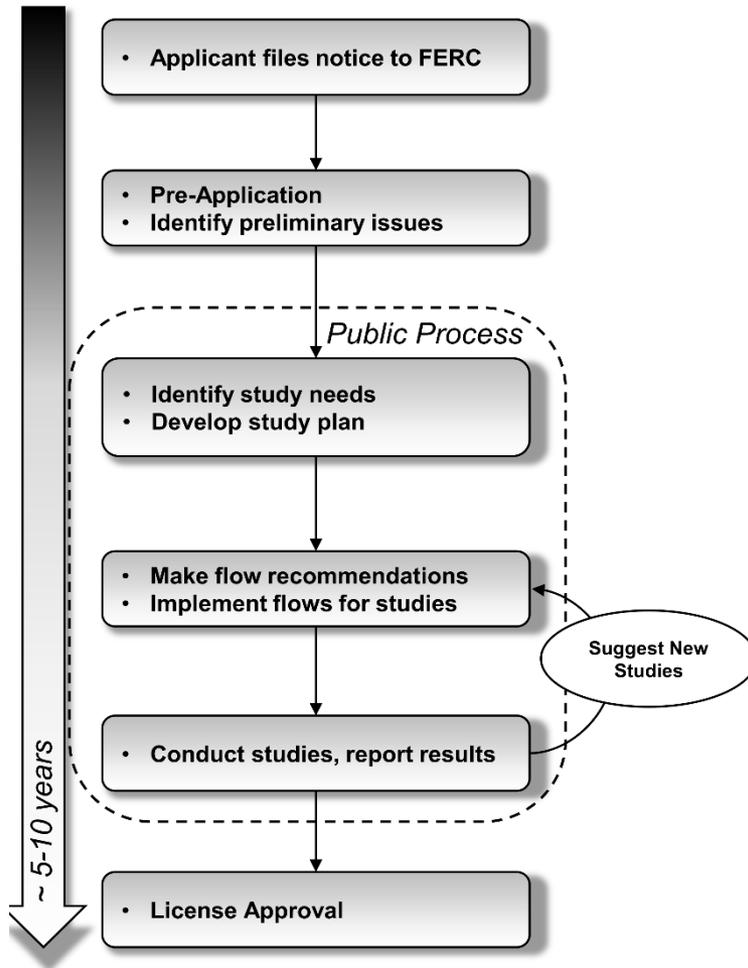
*Integrated Licensing Process*



# Major Steps in FERC Licensing Process

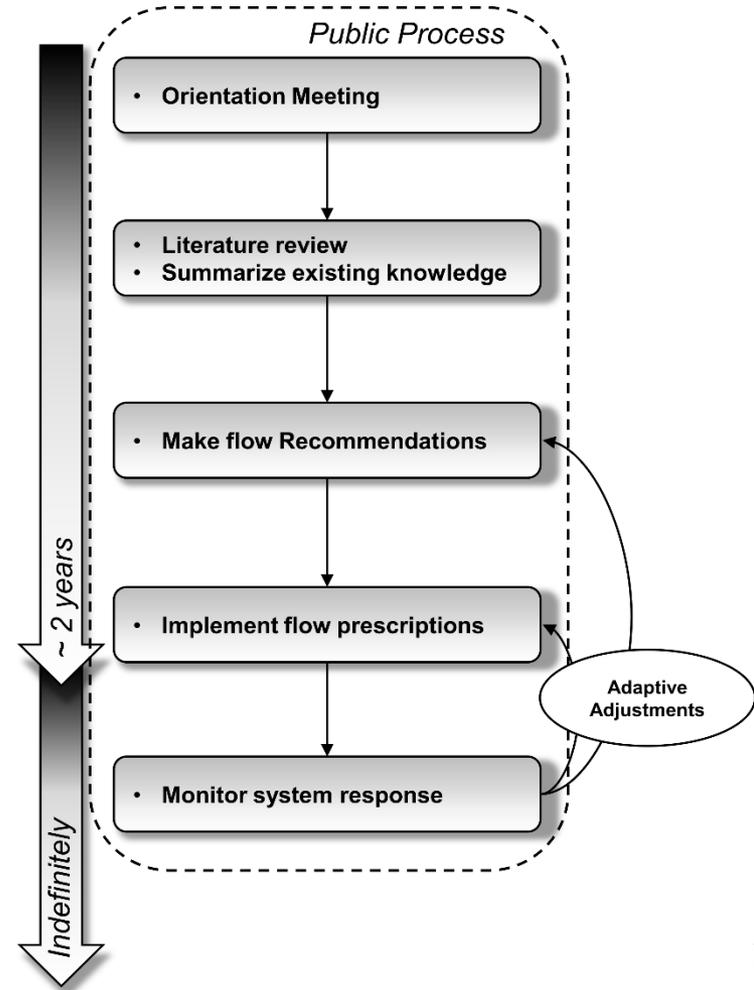
## FERC Licensing Process

*Integrated Licensing Process*



## Science-Based Process

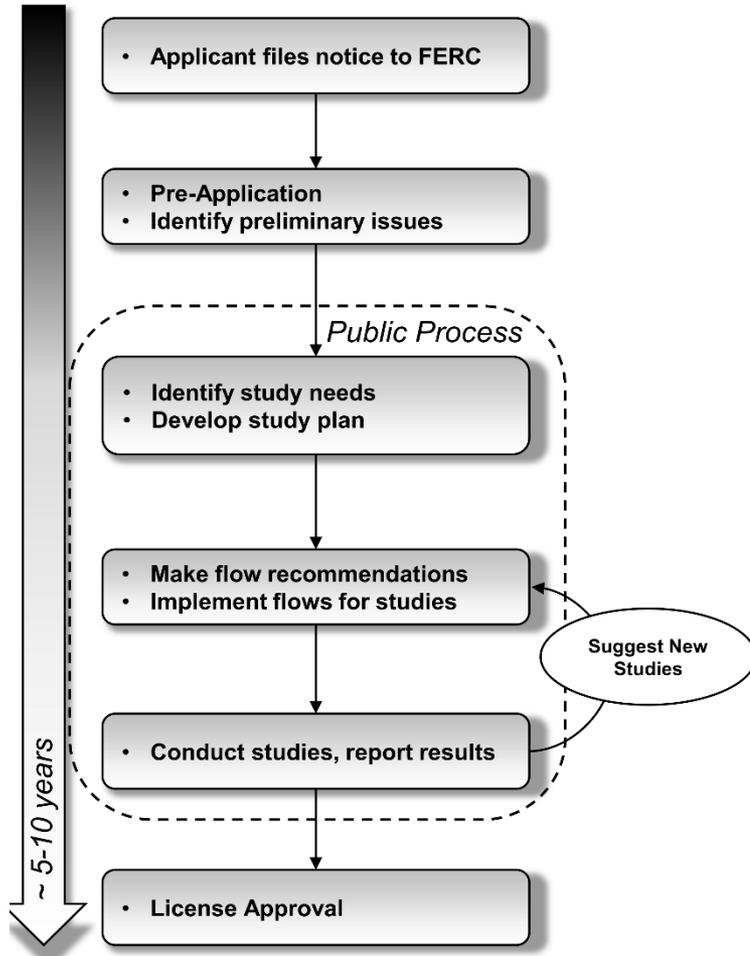
*from Richter et al. 2006*



# Placing Regulations Into a Meaningful Framework

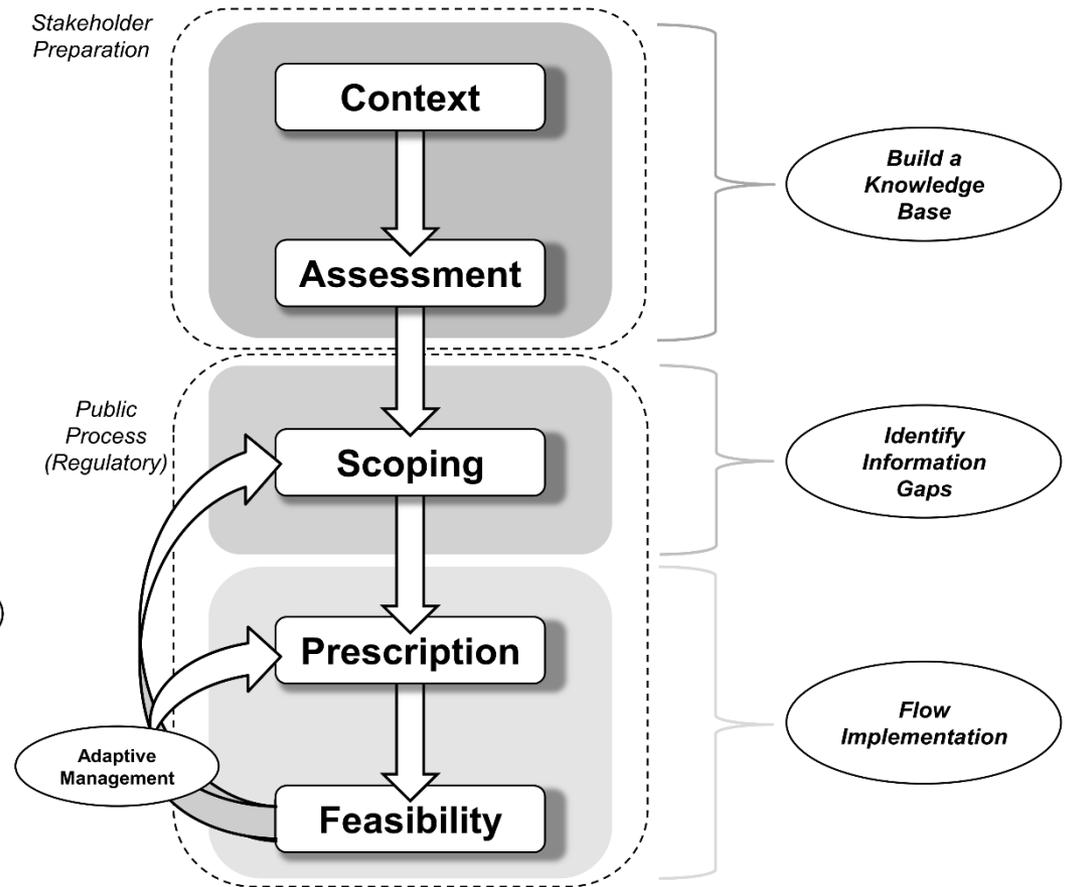
## FERC Licensing Process

*Integrated Licensing Process*



## Organizational Framework

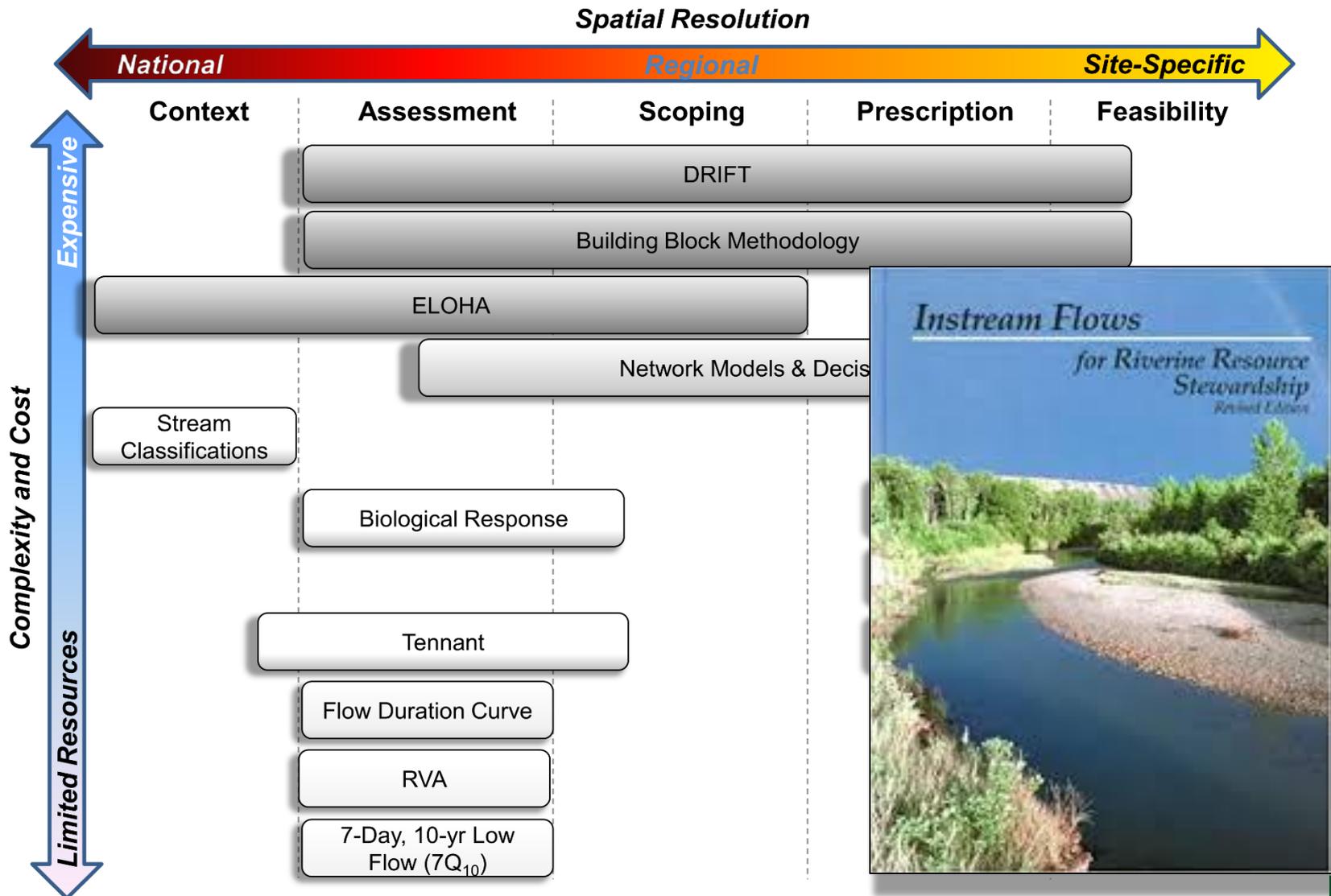
*McManamay et al. 2016. Env Manag*



# Terminology

- **Context:** provided at basin or regional scales to characterize the biophysical and operational settings around each hydropower project and provides a point of reference to other regulated rivers and reference streams.
- **Assessment:** conducted at national or regional scales and includes fully describing the current hydrologic and ecologic conditions relative to stakeholder determined ecological and hydrologic objectives.
- **Scoping:** used to identify key hydrologic and ecological targets, isolate information gaps, and develop flow-ecology relationships to predict the ecological outcomes of alternative flows.
- **Prescription:** Based upon best available knowledge, prescription presents a series of alternative flow scenarios based on objectives and the knowledge gained within the assessment and scoping stages.
- **Feasibility:** analyses that determine the ecological versus economic impacts of alternative flows at the site-specific scale.

# Organizing when and where tools are applicable



# Context

- Provided at basin or regional scales to characterize the biophysical and operational settings around each hydropower project and provides a point of reference to other regulated rivers and reference streams
- This helps to understand the environmental and political setting, as well as the potential opportunities and constraints to environmental mitigation

- Relevant Data

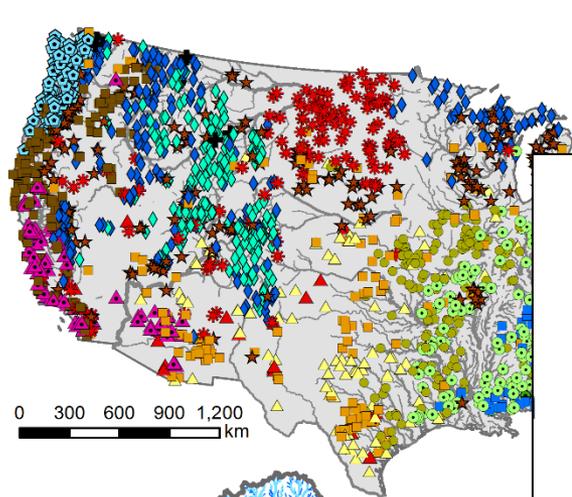
- Project Infrastructure, Reservoirs, Attributes
- Land Ownership
- Project Economics (Generation)
- Mode of operation
- Species occurrences
- Hydrologic gauges, water temperature stations
- Stream typologies
- Environmental mitigation requirements

- Supported in NHAAP
- Partially supported in NHAAP
- In planning
- Not supported

- Relevant Tools

- Stream Classification Web Application
- Hydropower Project and Water Resource Mapper
- Historical Generation
- River Function Framework

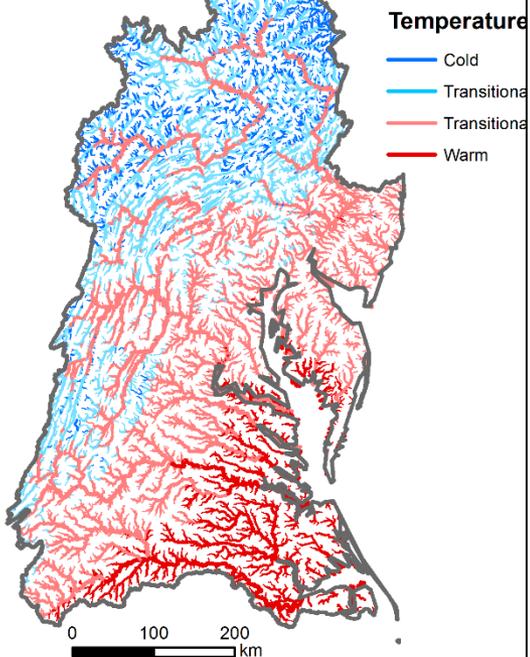
# Context



Hydrologic Classes



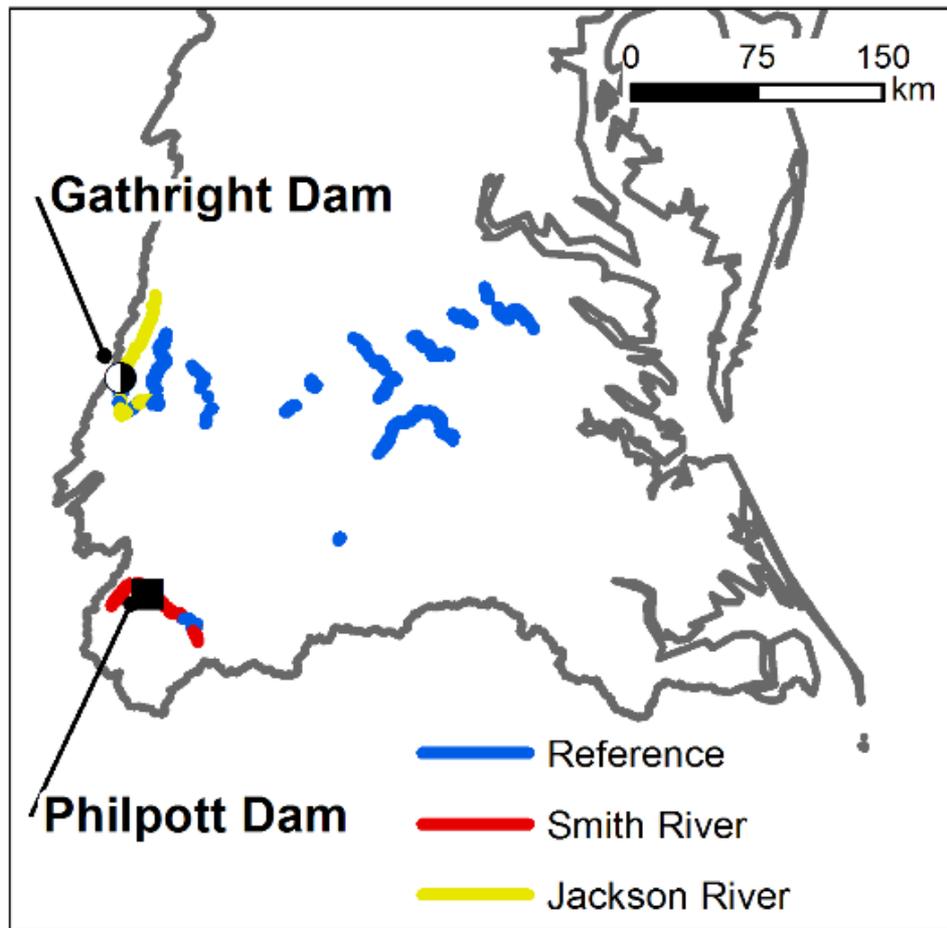
- \* Intermittent Flashy 1
- Unpredictable Perennial
- Perennial Baseflow 1



Temperature

- Cold
- Transitional
- Transitional
- Warm

## Case Studies



Gathright Dam

Philpott Dam

- Reference
- Smith River
- Jackson River

# Assessment

- National or regional scales and includes fully describing the current hydrologic and ecologic conditions relative to stakeholder objectives.

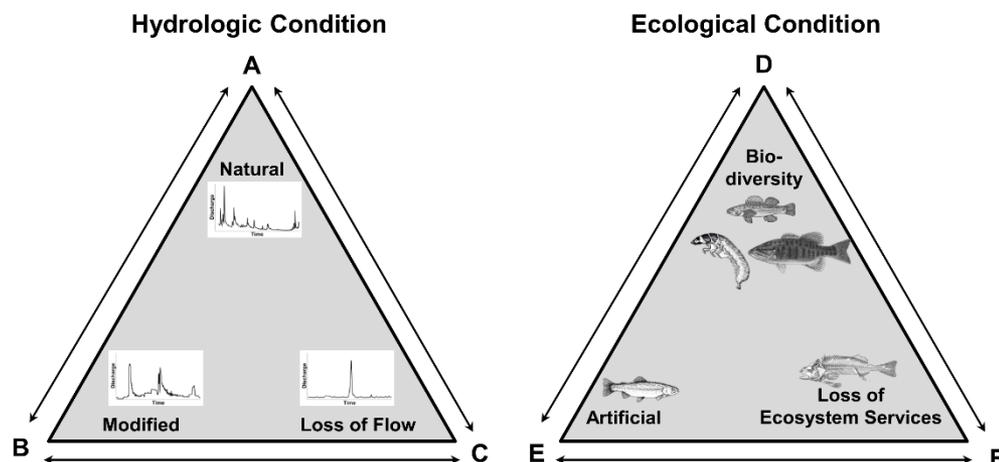
- What is the limiting factor(s) in this system?

- Relevant Data

- Hydrologic Gauges
- Water Temperature Monitoring
- Substrate monitoring
- Hydrologic Alteration Assessment
- Species Occurrences
- Observations and Pictures

- Relevant Tools

- Flow-ecology relationships
- Stream Classification Web Application
- Tennant Method
- IHA and RVA
- 7Q10



 Supported in NHAAP

 Partially supported in NHAAP

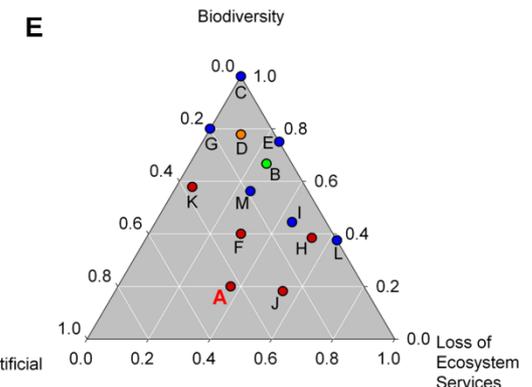
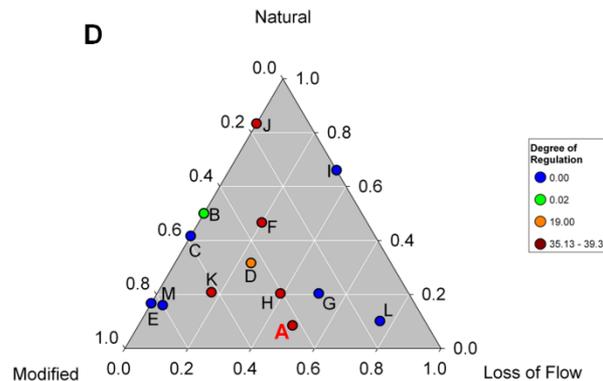
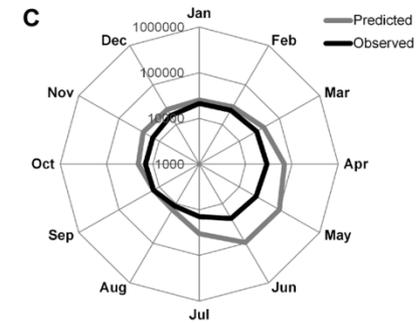
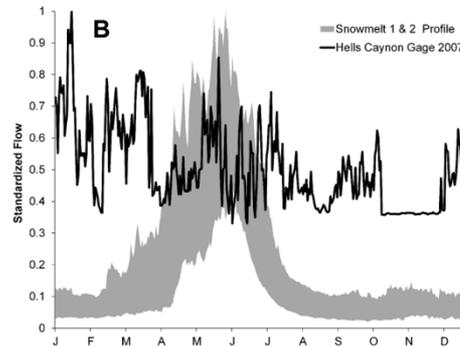
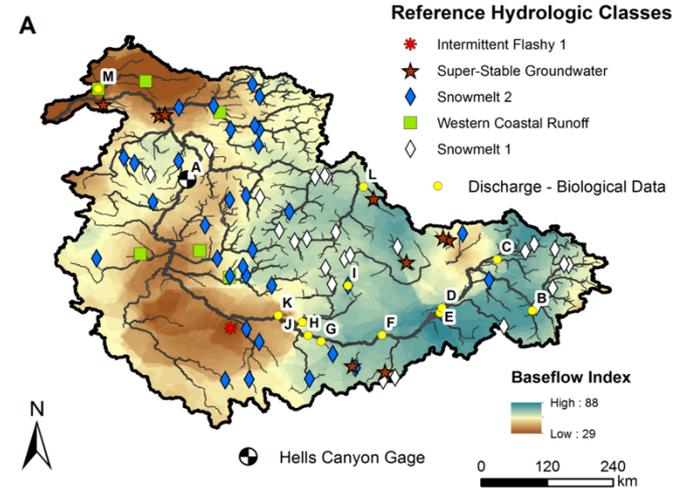
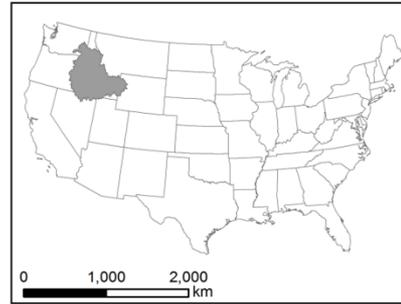
 In planning

 Not supported

# Assessment

General findings from the 30,000' view:

- Complete loss of seasonal profile
- Loss of major timing of peak flows
- Overall loss of flow magnitude, extremely apparent in spring/early summer
- Hells Canyon displays a loss of flow volume and highly modified flow regime and loss of biodiversity and ecosystem services
- Comparison to other sites reveals missing ecologically-relevant flow components



# Scoping

- used to identify key hydrologic and ecological targets, isolate information gaps, and develop flow-ecology relationships to predict the ecological outcomes of alternative flows
- What are the knowledge gaps? What studies are needed to fill those gaps?
- Need hard evidence and supporting data
- Relevant Synthesized Data
  - Hydrologic Gauges
  - Water Temperature Monitoring
  - Substrate monitoring
  - Hydrologic Alteration Model
  - Species Occurrences
  - Observations and Pictures
- Relevant Tools
  - Flow-ecology relationships
  - Stream Classification Web Application
  - River Function Framework Checklist



-  Supported in NHAAP
-  Partially supported in NHAAP
-  In planning
-  Not supported

# Prescription

- Based upon best available knowledge, prescription presents a series of alternative flow scenarios based on objectives and the knowledge gained within the assessment and scoping stages

- Relevant Field Data

- Field observations
- Cross-sectional profiles
- Biological surveys
- Stage/height information
- Bedload
- Substrate assessment

- Relevant Tools

- IFIM (e.g., PHABSIM)
- Reservoir Operation
- Floodplain Inundation
- HECRAS
- Flushing Flows
- Flow-ecology relationships

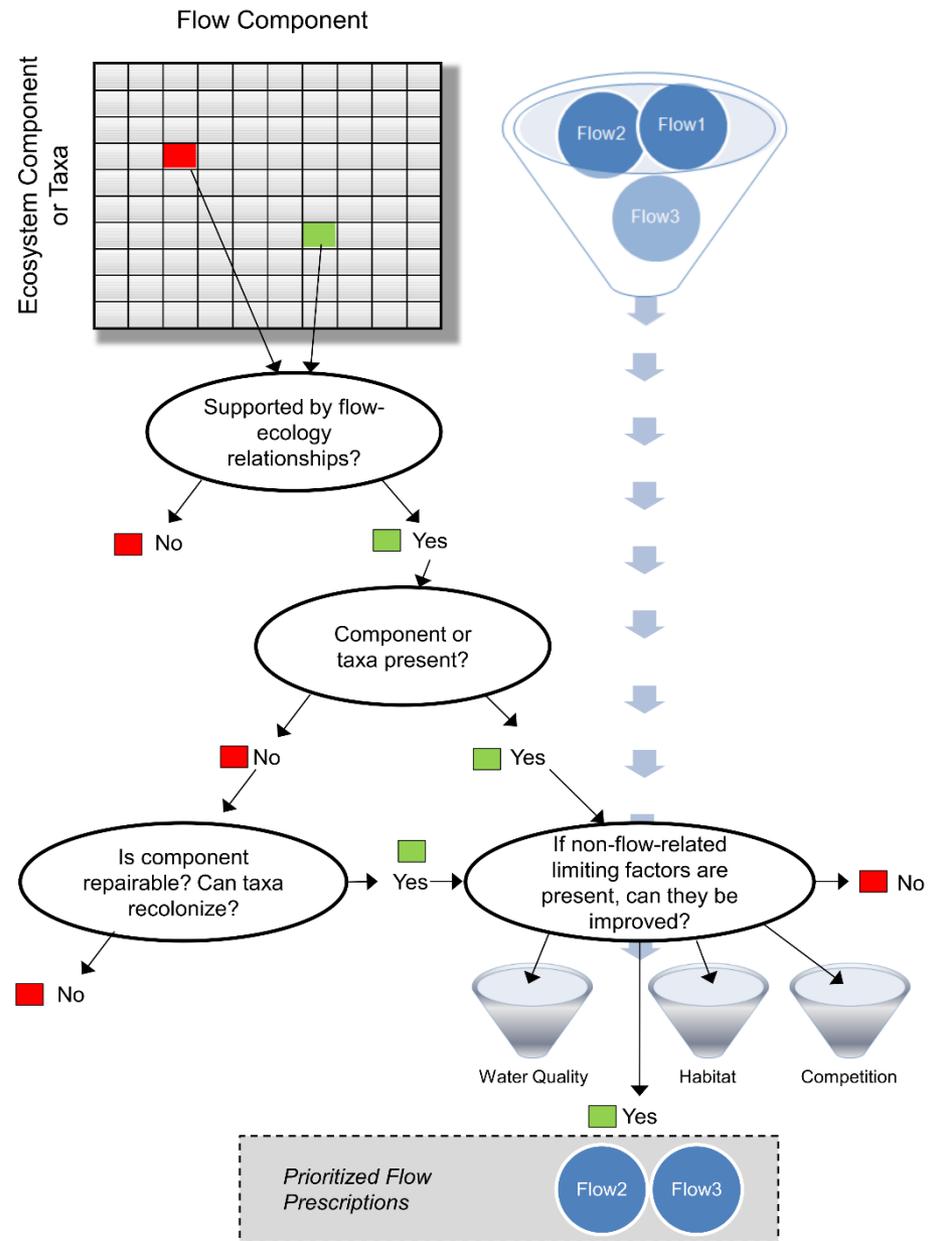
**Table 1** Examples of alternative flow scenario components to be tested during feasibility studies for stream reaches below hydropower facilities. Alternative scenarios can represent one to many different

flows within each component and/or one to many different combinations of components

Flow scenario component	Description	Potential ecological/societal benefit
<b>Baseflow</b>		
Minimum flow	Constant baseflow supplied year-round between generation	Entire channel perimeter remains inundated and reduces fish stranding following generation. Creates more stable environment
Seasonally variable baseflow	Baseflow magnitude varies according to season	Seasonally fluctuating flow provides enhanced flows during different spawning times for fish and habitat refugia to support varying life stages of macroinvertebrates and riparian vegetation
<b>Flood pulses</b>		
Frequent small flood (rafting release)	Scheduled releases of small flood events periodically during year (5–10 times) during appropriate seasons	Provides channel maintenance such as scouring or flushing sediment, inundating roots, removing encroaching vegetation, and redistributing spawning substrates. Also could provide recreational boating opportunities
Annual large flood (floodplain pulse)	Scheduled large flood event (per 1.5 years)	Creates new habitats by shifting large amounts of substrates, provides organic matter inputs from floodplain, inundates backwater habitats, and provides nursery habitats for fish
<b>Special-events</b>		
Attractant flow	Pulsed flows attract upstream migrating fish to ladders	Enhances fish passage, reproduction, and population viability
Passage flow	Pulsed flows to enhance/protect outmigration	Enhances fish survival, recruitment, and population viability
<b>Subdaily</b>		
Ramping restriction	Restrictions in the rate of change of the rising limb of generation pulse	Creates less disturbance by reducing square-shaped hydrograph. Allows time for behavioral responses to initiation of peak generation
Down-ramping restriction	Restrictions in the rate of change of the falling limb of generation pulse	Prevents fish stranding by providing time for behavioral responses to flow recession
Daily range restriction	Restrictions in range of min/max flows during day	Reduces disturbance and creates more stable environment to enhance feeding and spawning habitats
Diurnal variation in generation	Shifting the timing of generation within a day	Generating during different times of the day may provide more temporal overlap of hydrologic stability and peak feeding times

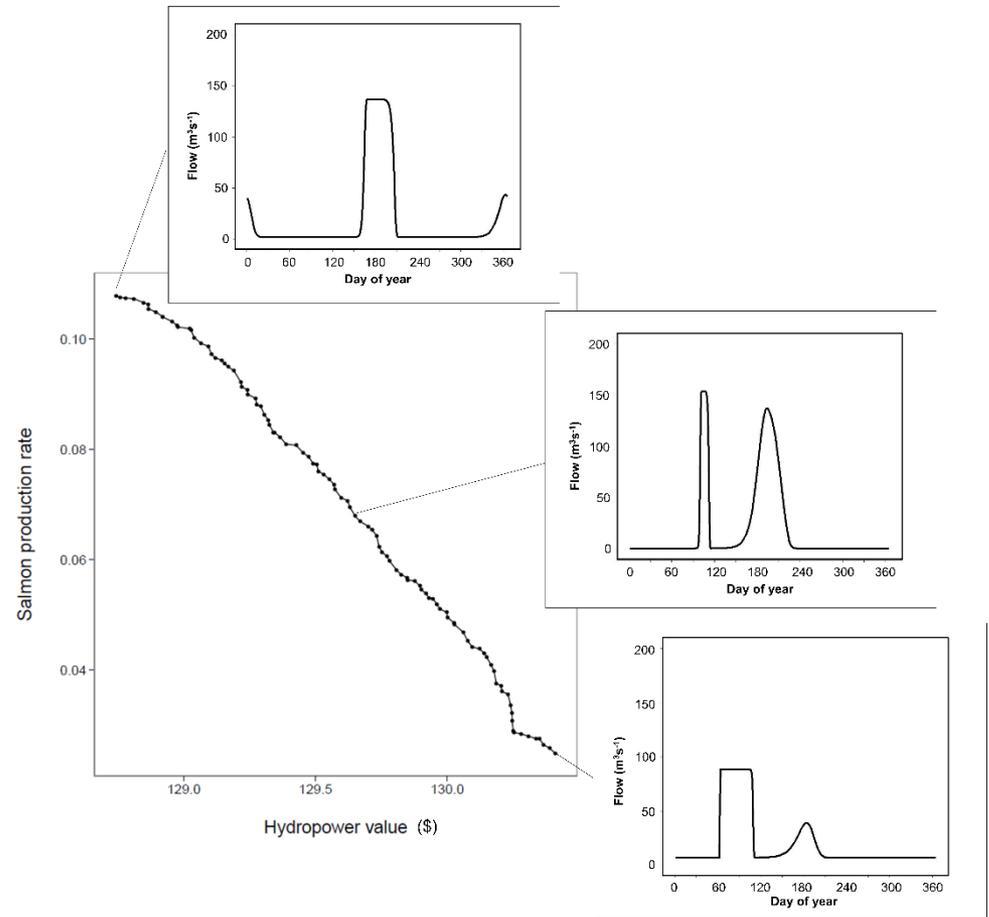
# Prescription

- Currently, there is 600 different hydrologic statistics that can be calculated (USGS)
- Need to prioritize components of the flow regime to focus mitigation efforts
- Use a decision-tree approach



# Feasibility

- analyses that determine the ecological versus economic impacts of alternative flows at the site-specific scale
- Relevant Data
  - Project Generation
  - Project infrastructure
  - Synthesized Field Data
  - Observations and Pictures
- Relevant Tools
  - IFIM (e.g., PHABSIM)
  - Reservoir Operation
  - Floodplain Inundation
  - HECRAS
  - Flushing Flows
  - Optimization
  - Flow-ecology relationships



# Tour of NHAAP Resources



## National Hydropower Asset Assessment Program

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The Oak Ridge National Laboratory's (ORNL) National Hydropower Asset Assessment Program (NHAAP) is an integrated energy, water, and ecosystem research and geospatial data integration effort for efficient, sustainable, and environmentally friendly hydroelectricity generation and water management. The NHAAP is sponsored by the US Department of Energy Office of Energy Efficiency and Renewable Energy's (EERE) [Water Power Program](#) and our partners include state and federal agencies, non-governmental organizations, technology and resource developers, utilities, and researchers.

### Project Overview



The overarching goal of the NHAAP effort is to provide the Federal database standard for existing and potential hydropower resource evaluation in the US. By offering the most comprehensive geospatial coverage and unmatched accuracy currently available, the NHAAP effort aims to deliver consistent and reliable information that is critical for stimulating US hydropower market acceleration, deployment, technology-to-market activities, and environmental impact reduction. Through ongoing development efforts, we aim to increase the quality, functionality, and depth of detail of the NHAAP database and build on our analysis capabilities to enable more effective and efficient support for activities of the US DOE's [Water Power Program](#).

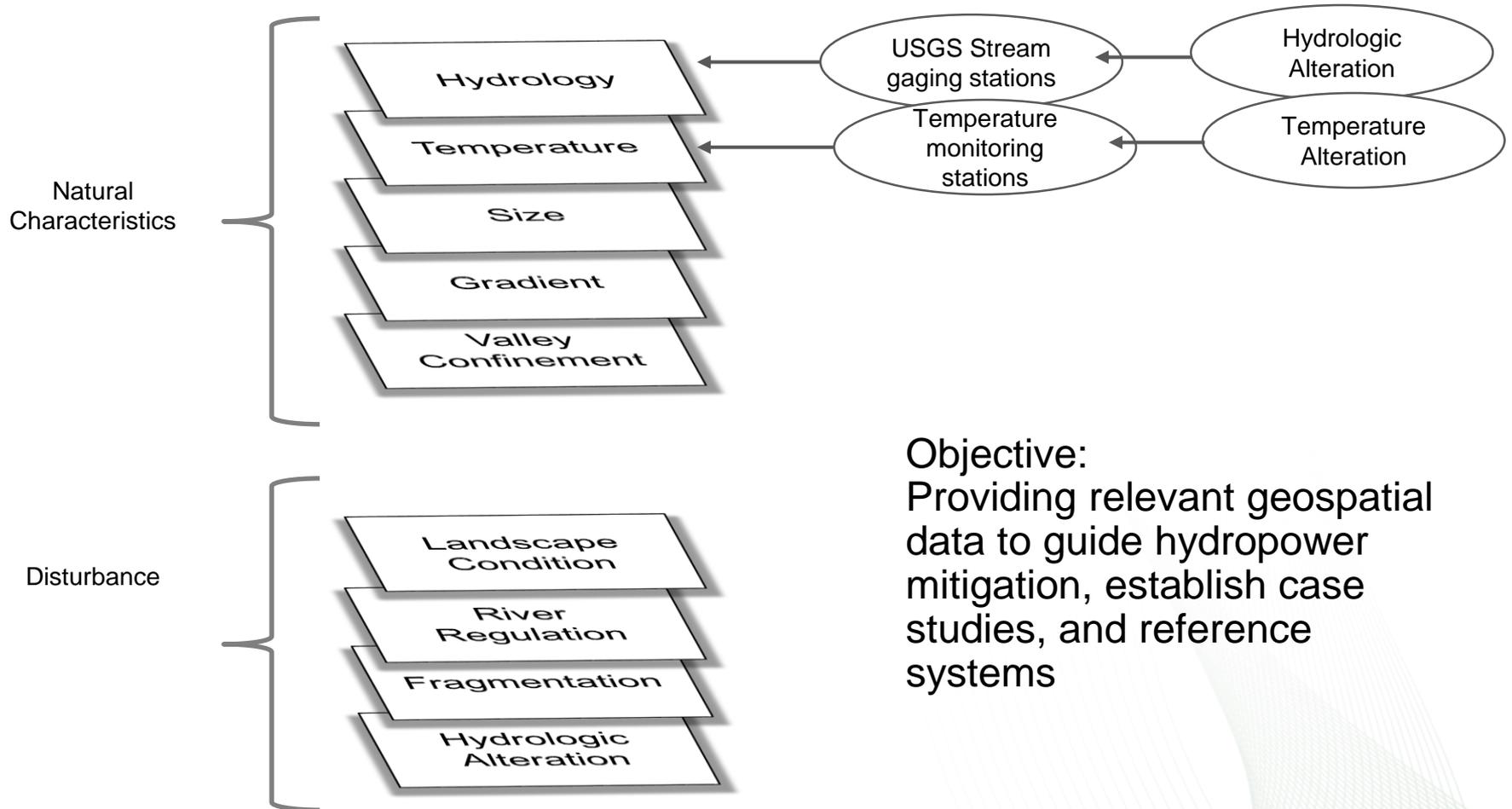
**U.S. DEPARTMENT OF ENERGY** | Energy Efficiency & Renewable Energy

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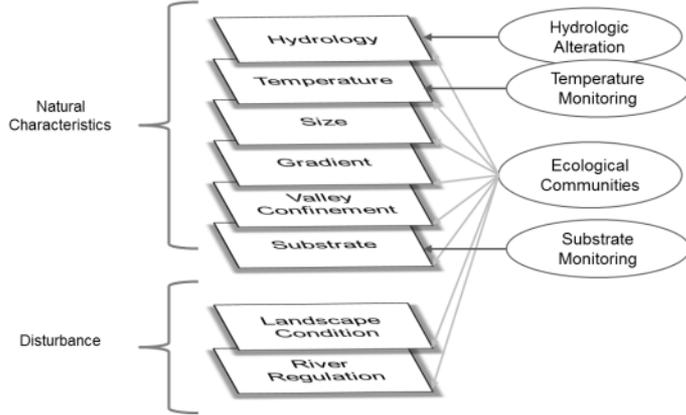
# US Stream Classification System

## Stream Classification System



# Eastern Stream Classification

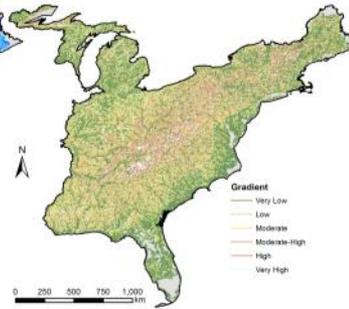
## Stream Classification System



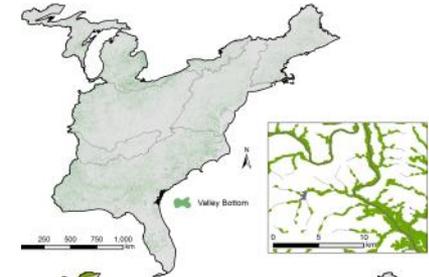
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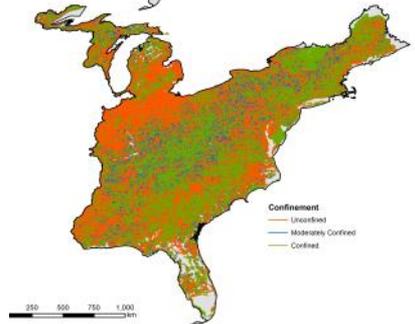
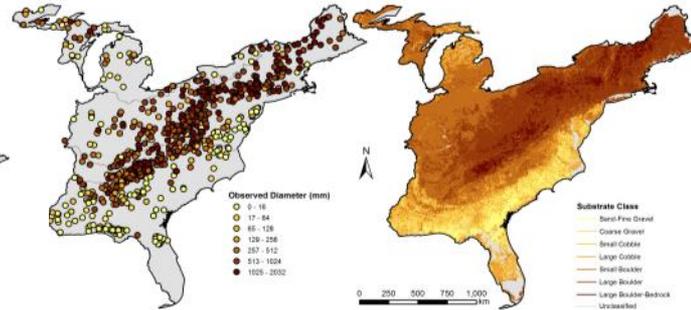
## Gradient



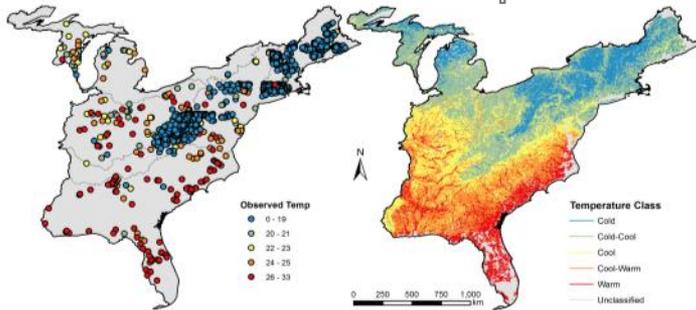
## Confinement



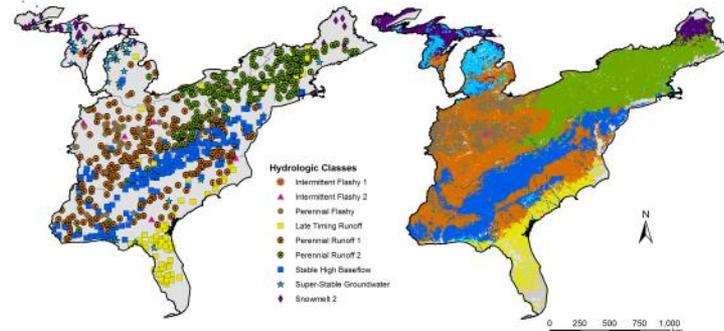
## Substrate



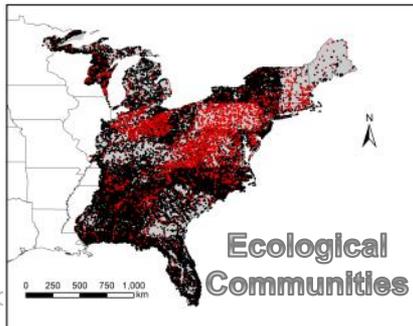
## Temperature



## Hydrology

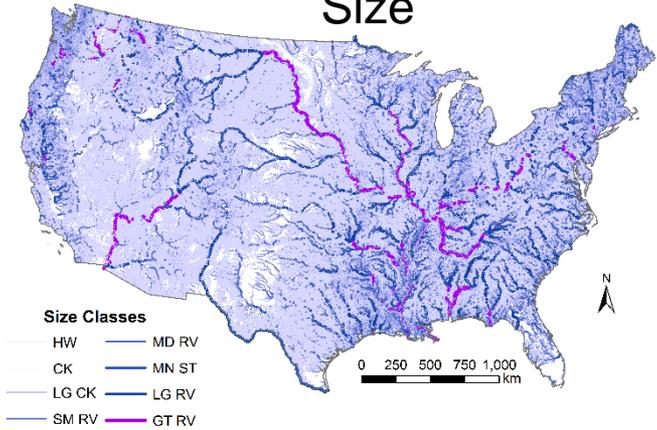


## Ecological Communities

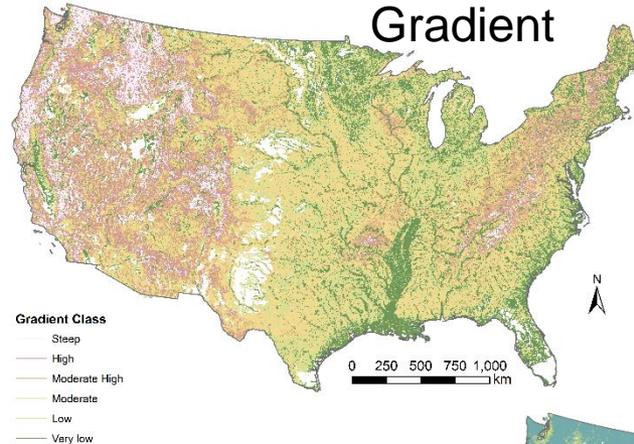


# US Stream Classification System

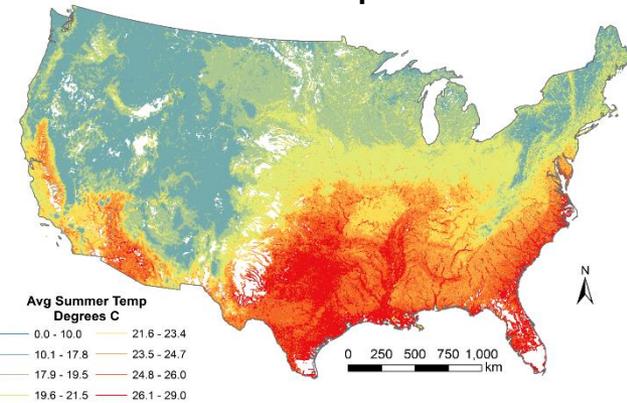
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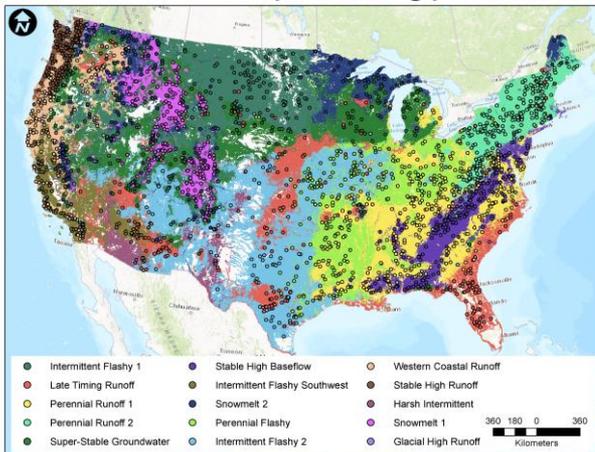
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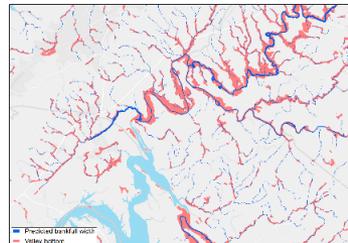
## Temperature



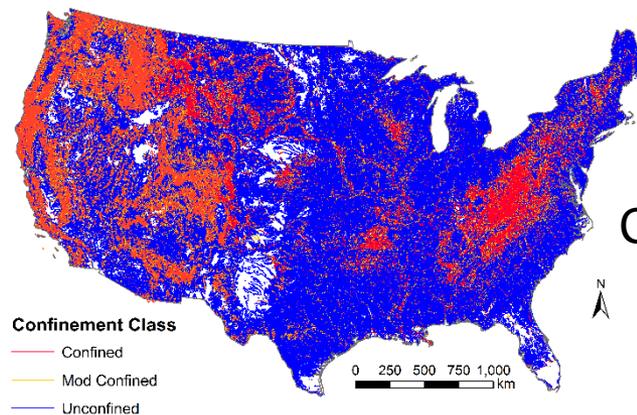
## Hydrology



## Valley Confinement Closeup



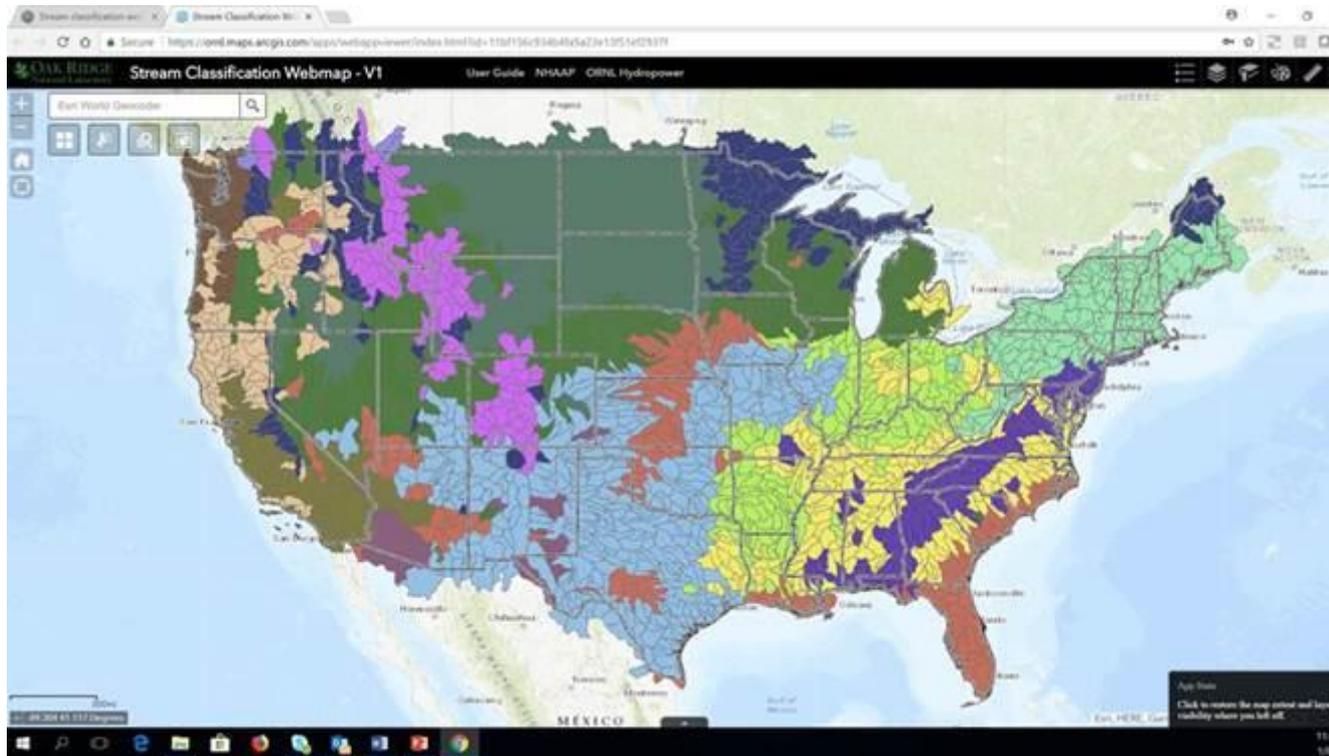
## Valley Confinement



# Stream Classification

- Identify stream type for hydropower projects, restoration projects, etc
- Identify case studies or reference streams
- Find powerplants or gages on similar stream types
- Assess hydrologic and temperature alteration
- Delineate watersheds

# Stream Classification Web Application



# Additional Support Slides

# Tour of NHAAP Research



## National Hydropower Asset Assessment Program

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**NHAAP Public Portal**  
<http://nhaap.ornl.gov/>



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# NHAAP Research & Data

## National Hydropower Asset Assessment Program

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### RESEARCH & DATA

The National Hydropower Asset Assessment (NHAAP) was initiated in FY2010, starting with gathering, organizing, and analyzing the network, facility configuration, historic generation, and capacity of the nation's hydropower production and capacity of the National Hydropower Program. Given the NHAAP has been continuously updated, recent research efforts such as **Non-Powered Dam Environmental Analysis**. By analyzing the data from various angles, the goal is to provide a comprehensive view of hydropower in the most efficient manner.

- Environmental Mitigation
- 2014 Hydropower Market Report
- New Stream-reach Development Resource Assessment
- Non-powered Dam Resource Assessment
- Climate Change Impact Assessment
- Environmental Attribution
- Existing Hydropower Assets



### Environmental Mitigation

#### ENVIRONMENTAL MITIGATION

In consideration of goals to accelerate the development and deployment of sustainable hydropower technologies, the Environmental Mitigation effort addresses the uncertainties of environmental requirements included as license conditions by FERC. The goal of the Environmental Mitigation task, as part of the larger NHAAP effort to provide hydropower development analysis tools, is to (1) develop a database of mitigation included in the FERC licenses of non-federal hydropower facilities, and (2) develop predictive models that can be used to anticipate mitigation scenarios based on project location and design characteristics.



#### Mitigation Database

Mitigation requirements were compiled from FERC hydropower licenses issued from 1998 through 2013. Each mitigation record is associated with a unique plant identifier, state, hydrologic unit code, and a mitigation classification. Database development methodology and mitigation assessment reports are forthcoming. Summarized mitigation data at the 2-digit hydrologic unit code (HUC-02) level are available on NHAAP's HydroGIS. Mitigation data are available as a Microsoft Access database and in Excel format below (note that critical infrastructure information such as location coordinates have been removed from publicly accessible data).

### Site Map - Research & Data

- [Hydropower Market Report](#)

### Existing Assets

#### EXISTING HYDROPOWER ASSETS

As part of the NHAAP database effort, ORNL integrates data from multiple data sources and provides the most current, detailed, and spatially comprehensive information for analyzing and visualizing existing US hydropower assets. Existing Hydropower Asset data are housed within the comprehensive NHAAP geographic information system (GIS) at ORNL and used to support various research initiatives for the US Department of Energy (DOE) Water Power Program. Existing Hydropower Asset data allow the nation to monitor its largest source of renewable electricity. Integrate it with other resource assessments, and perform a wide variety of analyses that inform management decisions and policy.

NOTE: NHAAP provides publicly available geographic data on a provisional basis from various resource assessments, environmental mitigation research, and data integration efforts. Select information from NHAAP Existing Hydropower Assets data are summarized and may be viewed in HydroGIS Viewer. Geospatial Existing Hydropower Asset data are not currently available for public download through HydroGIS Viewer due to existing privacy agreements with our collaborators and data source providers. Please refer to the [GIS Data & Maps](#) web page to find downloadable geospatial data, maps, tools, and related information from NHAAP.

#### The National Hydropower Map

The National Hydropower Map was first created in 2013 to display the distribution and characteristics of the existing US hydropower fleet. NHAAP Existing Hydropower Assets data were used to produce the original map. The 2014 version is now available and includes the most recent hydropower plant information from NHAAP Existing Hydropower Assets geospatial data layers and updated map elements.

#### The 2014 National Hydropower Map

Map Title	The 2014 National Hydropower Map
Primary Data Source	NHAAP-Existing Hydropower Assets
Description	Spatial distribution of US hydropower plants by installed capacity, facility type, and ownership type; spatial distribution of runoff by 8-digit hydrologic unit code; spatial accounting units; major US river systems.
Cartographer	Nicole Samu



### Non-Powered Dams

#### NON-POWERED DAM RESOURCE ASSESSMENT

The US Department of Energy (DOE) Water Power Program has assessed the National Inventory of Dams (NID) to evaluate the potential of additional hydropower from non-powered dams (NPDs) that could contribute to the amount of renewable energy available across the nation. Oak Ridge National Laboratory (ORNL), with input from the Idaho National Laboratory (INL), executed a technical analysis and identified 54,000 NPDs in this hydropower resource assessment effort. The main purpose was to estimate the maximum generation potentials of all NPDs in a nationally consistent manner (Figure 1). This information is available to developers for use in focusing the attention on selected regions for more detailed site identification and analysis. This resource assessment is not intended to provide economic feasibility of the 54,000 potential sites.

U.S. Non-powered Dams with Potential Capacity Greater than One Megawatt



### New Stream-Reach Assessment

#### NEW ENGLAND REGION 1

#### Summary of NSD Findings - Region 1 New England

Total Potential in Undeveloped Stream reaches	Potential Capacity (MW)	Potential Annual Generation (PMA)	Capacity Factor
Larger Stream-reaches (>1000 per reach)	1,093	4,343,200	67%
Smaller Stream-reaches (<1000 per reach)	1,093	6,272,000	66%

#### Reports:

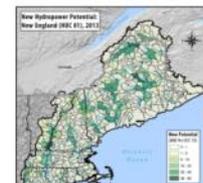
- Final Report on Findings (Karr et al., 2014)

#### Data:

- NSD Hydro Power Potential (Metadata: NSD\_Hydro) [Data Excel | Shapefile]
- NSD Environmental Attributes (Metadata: NSD\_Env) [Data Excel | Shapefile]

#### Maps:

- NSD Hydro Power Potential (NSD\_Hydro\_2013\_1\_4\_10)
- Existing Hydropower Assets (NSD\_Env\_2013\_1\_28\_10)



#### Maps within Various Environmental Categories

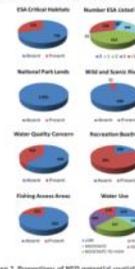


Figure 2. Potential of NSD potential capacity

# NHAAP Geospatial Tools



## National Hydropower Asset Assessment Program

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### GEOSPATIAL TOOLS

ORNL has created the following tools for users to use for purposes such as:

- Locating and exploring existing hydropower plants, dams, generators, and associated project information
- Viewing hydrologic and environmental characteristics in relation to existing and potential hydropower
- Exploring hydropower generation trends;
- Identifying and exploring potential for new hydropower development;
- Identifying and removing potential environmental barriers to hydropower development.

- Stream Classification Tool
- Historical Generation
- HydroGIS Viewer

### Stream Classification Tool

**STREAM CLASSIFICATION TOOL**

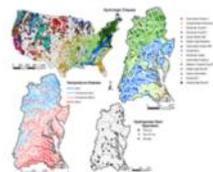
*A classification system to characterize and generalize the biophysical settings of stream environments including hydrologic, thermal, geomorphological, and ecological dynamics.*

**Objectives:**

Biophysical settings determine the extent and nature of hydropower development and operations, constraints to development and operations, and associated mitigation requirements. The Stream Classification Tool (SCT) is useful for:

- Improving the efficiency of Environmental Impact Assessment (EIA) and scoping for licensing/relicensing.
- Providing high resolution datasets to foster future water power research.
- Prioritizing conservation measures for different stream types or prioritizing areas for future development.
- Providing a generalized framework to understand the extent and nature of hydropower and associated mitigation measures.

To date this project has classified almost 1 million stream reaches of the Eastern US into groups of similar hydrology, temperature, and morphological types as well as assessing hydrologic alteration and temperature alteration. These datasets provide a tool that can be used to assess mitigation needs at finer resolutions, prioritize mitigation actions, identify case studies or reference streams for comparison, and fill information gaps. The datasets are available to [download by subbasin](#).



**Explore Map Layers**

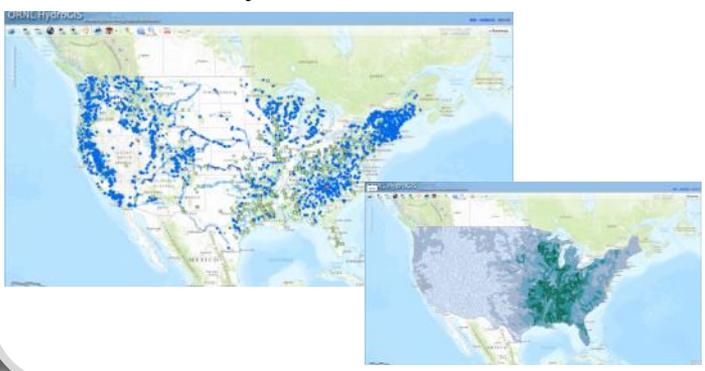
Stream Classification Tool

HydroGIS Viewer

**Visualize Generation Trends**

Historical Generation Charts

### HydroGIS Viewer



### Historic Generation

**US HYDROPOWER GENERATION OVER TIME**

ORNL developed interactive charts of annual and monthly plant-level hydropower generation over time using historical data from the Energy Information Administration (EIA). Select a state from the drop-down menu or map to drill down to plant-level summaries. Please note: EIA data used for calculating historical trends includes records of hydropower and pumped storage generation and excludes any plants not currently online. Charts were excluded for power plants lacking sufficient historical data for calculating statistics (CA, containing more than 50% of EIA records between 2002 - 2013).

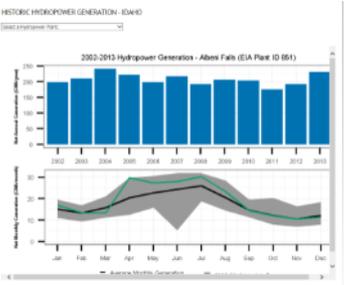
SELECT A STATE:



**HISTORIC HYDROPOWER GENERATION - IDAHO**

SELECT A POWER PLANT:

**2002-2013 Hydropower Generation - Albert Falls (EIA Plant ID 861)**



# Example: Public Access via HydroGIS

HydroGIS

National Hydropower Asset Assessment Program

OAK RIDGE National Laboratory

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## HYDROGIS VIEWER

### Introduction

The HydroGIS Viewer is a geographic information system that allows registered users to view select key information from the NHAAP. Geospatial information that can be visualized through HydroGIS Viewer include:

- Geospatial distribution
- Environmental mitigation
- Geospatially summarized Assessment;
- Geospatial distribution
- Streamflow and climate
- Geographic reference

The intended use of HydroGIS is for assessing potential or feasibility for NHAAP. Please note that HydroGIS is provisional and may change.

Please read and agree to the following terms and conditions:

### Additional Resources:

- [Getting Started with HydroGIS](#)
- [HydroGIS Viewer - Data](#)

[Login to HydroGIS](#)

Stream Classification Tool

Historical Generation

HydroGIS Viewer

Public Sources

ORNL HydroGIS

Presenting Hydro Energy Related Information

Sign in

Please sign in to access the item on <https://hydro.ornl.gov> (NHAAP/HydroGIS\_Public)

User Name:

Password:

OK Cancel

# Example: Finding Context for an Existing

ORNL HydroGIS Presenting Hydro Energy Related Information

Layers

- Existing Hydropower Assets
  - Dam
  - Plant
  - Generator
- New Hydropower Potential
- Environmental Mitigation
- Environmental Attribution
- Hydrology

FERC/EIA	Franklin (NC)
FERC/EIA	Tennessee Creek
TVA	Hiwassee Dam

ORNL HydroGIS eLibrary - Docket Sheet

https://hydro.ornl.gov/cgi-bin/ferc/docket.php?id=P-2698

FERC Online eLibrary (formerly FERRIS)

<http://www.ferc.gov>

Search AdvSearch New Dockets Docket Search Daily Search

Print Version

## Federal Energy Regulatory Commission

### Docket Sheet

#### Docket P-2698 (ALL Subdockets)

**This is a very large query. The download will take longer than the usual time.**

Applicant(s)/Docket: Nantahala Power & Light Company

Sub Docket: 000

**Docket Description:** There is a problem with archive data and system. Contact Administrator.

**Issued By:** ATLANTA REGIONAL OFFICE

**Filed Date:** 2/25/1982

**Accession No.:** 19820309-0005

**Description:** Advises that emergency action plans are incomplete. Lists needed additions re Nantahala Power & Light Co.

**Information:** [FILE LIST](#) [DOC INFO](#)

**Source:** eLibrary

**Issued By:** ATLANTA REGIONAL OFFICE

**Filed Date:** 3/2/1982

**Accession No.:** 19820316-0329

GIS

Basemap

esri

# Example: Linking water information to hydropower facilities

HydroGIS

The image displays the ORNL HydroGIS web interface, which is designed for presenting hydro-energy related information. The main interface includes a map of the Nantahala Mountains region in Georgia, with various layers such as Existing Hydropower Assets, Dam, Plant, Generator, New Hydropower Potential, Environmental Mitigation, Environmental Attribution, Hydrology, USGS Gauge Station, NHDPlus Flowline, and Watershed Boundary Dataset. A 'Select Features' panel is visible, showing 'Target Layer: Dam' and 'By Feature' options. An inset window shows the USGS National Water Information System (NWIS) web interface for station 03508000, titled 'TUCKASEGEE RIVER AT TUCKASEGEE, NC'. This interface provides 'PROVISIONAL DATA SUBJECT TO REVISION' and includes a table of available parameters and their periods of record.

Available Parameters	Period of Record
<input type="checkbox"/> All 1 Available Parameters for this site	
<input checked="" type="checkbox"/> 00060 Discharge(Mean)	1934-07-01 1976-10-04

Below the table, there is a link for 'Summary of all available data for this site' and 'Instantaneous-data availability statement'. A line graph titled 'Discharge, cubic feet per second' shows the daily discharge for the Tuckasegee River at Tuckasegee, NC, from January 1951 to November 1951. The y-axis represents 'DAILY Discharge, cubic feet per second' on a logarithmic scale from 50 to 2000. The x-axis shows months from Jan 1951 to Nov 1951. The graph shows significant seasonal fluctuations in discharge, with peaks in the spring and winter months and lower flows in the summer.

# Example: Finding Historical Generation for an Existing Hydropower Facility

Historic Generation

OAK RIDGE  
National Laboratory

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### GEOSPATIAL TOOLS

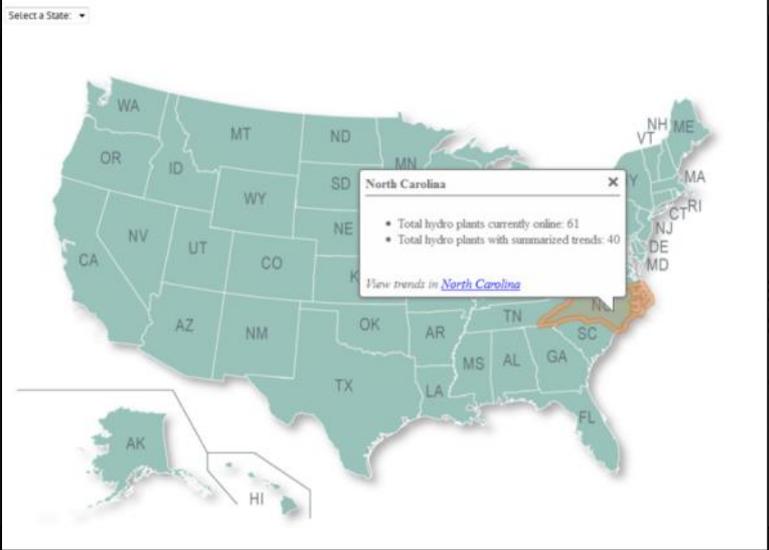
ORNL has created the following tools for users to use that are useful for purposes such as:

- Stream Classification Tool
- Historical Generation**
- HydroGIS Viewer

- Locating and exploring existing hydropower plants, dams, generators, and associated infrastructure
- Viewing hydrologic and environmental characteristics in relation to existing and proposed facilities
- Exploring hydropower generation trends

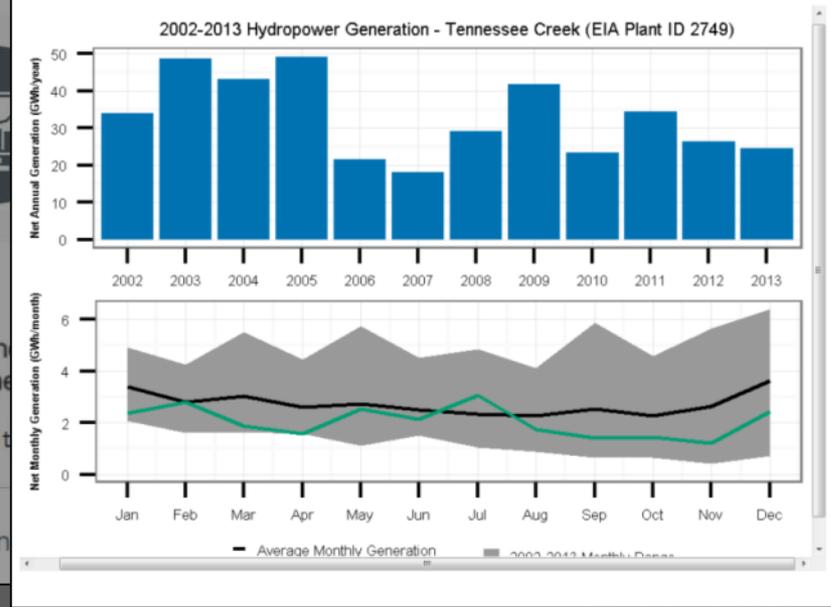
**U.S. HYDROPOWER GENERATION OVER TIME**

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### HISTORIC HYDROPOWER GENERATION - NORTH CAROLINA

Tennessee Creek (EIA Plant ID 2749)



# Example: Finding Characteristics of New Stream-reach Development Potential

HydroGIS

ORNL HydroGIS Presenting Hydro Energy Related Information

Layers

- Existing Hydropower Assets
  - Dam
  - Plant
  - Generator
- New Hydropower Potential
- Non-Powered Dams >1MW
- New Stream-Reach Development Potential

Select Features

Target Layer: New Stream-Reach Development Potential

By Feature Within an Area

Find Features Inside Buffer 0.000 Miles

New Stream-Reach Development Potential: Upper Tuckasegee River

Watershed Name	Upper Tuckasegee River
10-Digit Hydrologic Unit Code	0601020301
Number of >1MW NSD Reaches	1

New Reach Potential

ORNL HydroGIS Presenting Hydro Energy Related Information

Layers

- Dam
- Plant
- Generator
- New Hydropower Potential
- Non-Powered Dams
- New Stream-Reach Development Potential
- Environmental
  - Fish Traits
  - Hydrologic
  - Federally Listed Fish Species
- Water Use
- Hydrology

Select Features

Target Layer: Federally Listed Fish Species [By Total Listed Fish Species]

By Feature

Find Features

Federally Listed Fish Species [By Total Listed Fish Species]: Tennessee Region

Subbasin Name	Tuckasegee
10-Digit Hydrologic Unit Code	06010203
Area (ac)	469644
Area (sq mi)	734
No. of Fish Species under IUCN ranking	0
No. of Fish Species Falling under ESA designation	1
No. of Candidate Fish Species under ESA	1
No. of Endangered Fish Species under ESA	0

Federally listed fish species

## Other layers (eg.)

- Protected Lands
- Critical Habitats
- Salmonid distributions

# Example: Data-Driven Analysis of Environmental Mitigation Requirements

National Hydropower Asset Assessment Program

**Environmental Mitigation Tool**

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All Access Objects

Search...

**Tables**

- lookup\_FISH\_SOC
- lookup\_MITIGATION
- lookup\_T1
- lookup\_T2

Non-Federal Hydropower Mitigation Database v1

Record_ID	Mitigation	PlantID	T2_Category	T1_Category	State	County	HUC08	HUC02	Water	FcIssue	FC_Dock	MitigationID	T2ID
3261	Surface Collector	pn62	Downstream Fish Passage	Fish Passage	WA	Mason	17110017	17	North Fork Sko	7/30/1998	P-460	0101001	0101
3262	Surface Collector	pn145	Downstream Fish Passage	Fish Passage	OR	Jefferson	17070306	17	Deschutes River	6/21/2005	P-2030	0101001	0101
3263	Surface Collector	pn160	Downstream Fish Passage	Fish Passage	WA	Clark	17080002	17	Lewis River	6/26/2008	P-2071	0101001	0101

Search:

Arch: RC

Provals

ed

All Access Objects

Search...

**Tables**

- lookup\_FISH\_SOC
- lookup\_MITIGATION
- lookup\_T1
- lookup\_T2
- lookup\_TES
- lookup\_TES\_Group
- lookup\_WQLoc
- lookup\_WQParams
- records\_Bypass\_Locations
- records\_Fish\_SOC
- records\_Licenses
- records\_Required\_Mitigation
- records\_TES
- records\_WQMon
- tbl\_Plant\_Attributes

**Queries**

- Pres\_Abs\_AllMitigation
- Pres\_Abs\_TISummaries

Non-Federal Hydropower Mitigation Database v1

Record_ID	Mitigation	PlantID	T2_Category	T1_Category	State	County	HUC08	HUC02	Water	FcIssue	FC_Dock	MitigationID	T2ID
3261	Surface Collector	pn62	Downstream Fish Passage	Fish Passage	WA	Mason	17110017	17	North Fork Sko	7/30/1998	P-460	0101001	0101
3262	Surface Collector	pn145	Downstream Fish Passage	Fish Passage	OR	Jefferson	17070306	17	Deschutes River	6/21/2005	P-2030	0101001	0101
3263	Surface Collector	pn160	Downstream Fish Passage	Fish Passage	WA	Clark	17080002	17	Lewis River	6/26/2008	P-2071	0101001	0101
3264	Surface Collector	pn173	Downstream Fish Passage	Fish Passage	WA	Skamania	17080002	17	Lewis River	6/26/2008	P-2111	0101001	0101
3265	Surface Collector	pn188	Downstream Fish Passage	Fish Passage	WA	Whatcom	17110005	17	Baker River	10/17/2008	P-2150	0101003	0101
3266	Surface Collector	pn189	Downstream Fish Passage	Fish Passage	WA	Skagit	17110005	17	Baker River	10/17/2008	P-2150	0101003	0101
3267	Surface Collector	pn214	Downstream Fish Passage	Fish Passage	OR	Clackamas	17090011	17	Clackamas River	12/21/2010	P-2195	0101003	0101
3268	Surface Collector	pn216	Downstream Fish Passage	Fish Passage	OR	Clackamas	17090011	17	Clackamas River	12/21/2010	P-2195	0101003	0101
5048	Trap and Transport	pn76	Downstream Fish Passage	Fish Passage	WA	Clark	17080002	17	Lewis River	6/26/2008	P-935	0101003	0101
5049	Trap and Transport	pn99	Downstream Fish Passage	Fish Passage	OR	Douglas	17100301	17	North Umpqua	11/18/2003	P-1927	0101003	0101
5050	Trap and Transport	pn144	Downstream Fish Passage	Fish Passage	OR	Jefferson	17070306	17	Deschutes River	6/21/2005	P-2030	0101003	0101
5051	Trap and Transport	pn160	Downstream Fish Passage	Fish Passage	WA	Clark	17080002	17	Lewis River	6/26/2008	P-2071	0101003	0101
5052	Trap and Transport	pn173	Downstream Fish Passage	Fish Passage	WA	Skamania	17080002	17	Lewis River	6/26/2008	P-2111	0101003	0101
5053	Trap and Transport	pn188	Downstream Fish Passage	Fish Passage	WA	Whatcom	17110005	17	Baker River	10/17/2008	P-2150	0101003	0101
5054	Trap and Transport	pn189	Downstream Fish Passage	Fish Passage	WA	Skagit	17110005	17	Baker River	10/17/2008	P-2150	0101003	0101
1721	Modification of Spill or Gate Operation	pn175	Downstream Fish Passage	Fish Passage	WA	Grant	17020010	17	Columbia River	4/17/2008	P-2114	0101003	0101
1722	Modification of Spill or Gate Operation	pn354	Downstream Fish Passage	Fish Passage	NY	St. Lawrence	04150302	04	Oswegatchie R	1/6/2012	P-2850	0101003	0101
1723	Modification of Spill or Gate Operation	pn129	Downstream Fish Passage	Fish Passage	MA	Hampden	01080201	01	Connecticut Ri	8/20/1999	P-2004	0101003	0101
1724	Modification of Spill or Gate Operation	pn158	Downstream Fish Passage	Fish Passage	WI	Sawyer	07050001	07	East Fork Chipp	8/12/2005	P-2064	0101003	0101
1725	Modification of Spill or Gate Operation	pn160	Downstream Fish Passage	Fish Passage	WA	Clark	17080002	17	Lewis River	6/26/2008	P-2071	0101003	0101
1726	Modification of Spill or Gate Operation	pn174	Downstream Fish Passage	Fish Passage	WA	Grant	17020016	17	Columbia River	4/17/2008	P-2114	0101003	0101
1727	Modification of Spill or Gate Operation	pn214	Downstream Fish Passage	Fish Passage	OR	Clackamas	17090011	17	Clackamas River	12/21/2010	P-2195	0101003	0101
1728	Modification of Spill or Gate Operation	pn221	Downstream Fish Passage	Fish Passage	OR	Clackamas	17090002	17	Clackamas River	12/21/2010	P-2195	0101003	0101
4460	Conduit	pn218	Downstream Fish Passage	Fish Passage	VT	Chittenden	02010005	02	Lamoille River	6/20/2005	P-2205	0101006	0101
4461	Conduit	pn219	Downstream Fish Passage	Fish Passage	VT	Chittenden	02010005	02	Lamoille River	6/20/2005	P-2205	0101006	0101
4462	Conduit	pn220	Downstream Fish Passage	Fish Passage	VT	Chittenden	02010005	02	Lamoille River	6/20/2005	P-2205	0101006	0101
4463	Conduit	pn221	Downstream Fish Passage	Fish Passage	VT	Franklin	02010005	02	Lamoille River	6/20/2005	P-2205	0101006	0101

**Data:** Primary Key

- Mitigation Database [Data: Access, Excel] [Metadata: Excel] [Classification Structure: PDF] [Citation] Bevelhimer, M.S., M.P. Schramm, C.R. DeRolph (2015), Non-Federal Hydropower Mitigation Database, Oak Ridge National Laboratory, available at: <http://nhaap.ornl.gov/environmental-mitigation>, accessed online: [Month, date, year.]

# New Science – Data-Based Stream Classification for Improved Environmental Assessment

OAK RIDGE National Laboratory

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Stream Classification Tool

**Stream Classification Tool**

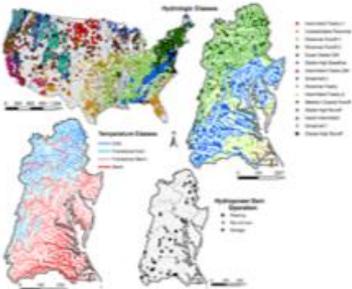
Historical Generation  
HydroGIS Viewer  
Public Sources

*A classification system to characterize and assess the biophysical settings of stream environments including hydrologic, thermal, geomorphological, and...*

**Objectives:**

Biophysical settings determine the extent and nature of hydropower development and operations, constraints to development and operations, and associated mitigation requirements. The Stream Classification Tool (SCT) is useful for:

- Improving the efficiency of Environmental Impact Assessment (EIA) and scoping for licensing/relicensing,
- Providing high resolution datasets to foster future water power research,
- Prioritizing conservation measures for different stream types or prioritizing areas for future development,
- Providing a generalized framework to understand the extent and nature of hydropower and associated mitigation measures.



To date this project has classified almost 1 million stream reaches of the Eastern US into groups of similar hydrology, temperature, and morphological types as well as assessing hydrologic alteration and temperature alteration. These datasets provide a tool that can be used to assess mitigation needs at finer resolutions, prioritize mitigation actions, identify case studies or reference streams for comparison, and fill information gaps. The datasets are available to [download by subbasin \(4-digit HUC\)](#) and view within Google Earth to provide a user-friendly, open-access platform for stakeholder, regulator, and industry use.

**What is a Stream Classification?**

At a basic level, stream classifications are an inventory of different types of streams. Classifications help us explore similarities and differences among different types of streams, make inferences regarding stream ecosystem behavior, and communicate the complexities of ecosystem. While classifications aid in understanding fundamental differences among streams, they also have many applied outcomes, such as grouping sites with similar character, stratifying analyses for monitoring and/or experimentation, prioritizing mitigation or aquatic conservation, and generalizing ecological responses to disturbances.

**How is it useful to Hydropower?**

The SCT is useful to environmental mitigation for hydropower dams in multiple ways. The purpose of the SCT is to create efficiency in the regulatory process by creating an objective and data-rich means to address meaningful mitigation actions. First, the SCT addresses



# New Science – Data-Based Stream Classification for Improved Environmental Assessment



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**Stream  
Classification  
Tool**

**STREAM CLASSIFICATION TOOL USER  
MANUAL: FOR USE IN APPLICATIONS  
IN HYDROPOWER-RELATED  
ENVIRONMENTAL MITIGATION**



Ryan A. McManamay  
 Matthew J. Troia  
 Christopher R. DeRolph  
 Nicole M. Samu

January 2016

*Note: For best results, please view and download data using Google Chrome or Internet Explorer web browsers. Potential errors may occur with Firefox.*

Subregion	HUC	Data   Metadata
<a href="#">+ Upper Tennessee</a>	0601	Updated - 10/21/2015
Sites Temperature	0601	<a href="#">KMZ 2.2 KB</a>
Sites Substrate	0601	<a href="#">KMZ 8.4 KB</a>
Sites Hydrology	0601	<a href="#">KMZ 17.6 KB</a>
Sites Fish	0601	<a href="#">KMZ 8.3 MB</a>
Disturbance	0601	<a href="#">KMZ 8.3 MB</a>
Class Temperature	0601	<a href="#">KMZ 8.3 MB</a>
Class Substrate	0601	<a href="#">KMZ 8.3 MB</a>
Class Size	0601	<a href="#">KMZ 8.3 MB</a>
Class Hydrology	0601	<a href="#">KMZ 8.3 MB</a>
Class Gradient	0601	<a href="#">KMZ 8.3 MB</a>
Class Confinement	0601	<a href="#">KMZ 8.3 MB</a>
<a href="#">+ Middle Tennessee-Hiwassee</a>	0602	Updated - 10/21/2015
<a href="#">+ Middle Tennessee-Elk</a>	0603	Updated - 10/21/2015



# New Science – Data-Based Stream Classification for Improved Environmental Assessment

## Stream Classification Tool

Google Earth

File Edit View Tools Add Help

Search

Wolf Creek Lake, NC

Search

ex: 37 25' 19.1"N, 122 05' 06"W

Get Directions History

Wolf Creek Lake

Wolf Creek

Wolf Creek

Places

- My Places
  - Sightseeing Tour
- Temporary Places
  - Subregion0601\_SitesHydrology
  - Subregion0601\_ClassHydrology
  - Subregion0601\_ClassHydrology

Layers

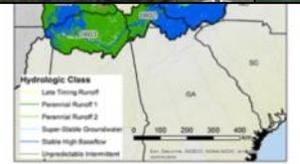
Primary Database

- Youtagat
- Borders and Labels
- Places
- Photos
- Roads
- 3D Buildings
- Ocean
- Weather
- Gallery
- Global Awareness
- More

**Stream Classification Tool**

To use the data, you must first have Google Earth or Google Earth Pro installed on your computer (Click here for installation options). Choose a sub-region from the table below and then click to launch any KMZ layers of your choice in Google Earth. For full instructions and detailed information, please refer to the resources listed above.

*Note: For best results, please view and download data using Google Chrome or Internet Explorer web browsers. Potential errors may occur with Firefox.*



Subregion	HUC	Data   Metadata
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Class Size	0601	KMZ 8.3 MB
Class Hydrology	0601	KMZ 8.3 MB
Class Gradient	0601	KMZ 8.3 MB
Class Confinement	0601	KMZ 8.3 MB
<a href="#">+ Middle Tennessee-Hiwassee</a>	0602	Updated - 10/21/2015
<a href="#">+ Middle Tennessee-Elk</a>	0603	Updated - 10/21/2015
<a href="#">+ Lower Tennessee</a>	0604	Updated - 10/21/2015

**Robinson Creek**

Robinson Creek

FID 8388

COMBID 19730388

QHS\_NAME Robinson Creek

FTYPE StreamRiver

CUMDRAINAG 17.1963

Size Creek

Gradient High

Confinemen Confined

Substrate Large Boulder-Bedrock

Hydrology Stable High Baseflow

Temperatur Cold-Cool

Shape\_Leng 0.02579

# New Science – Data-Based Stream Classification for Improved Environmental Assessment

Stream Classification Tool

## Stream Classification Tool

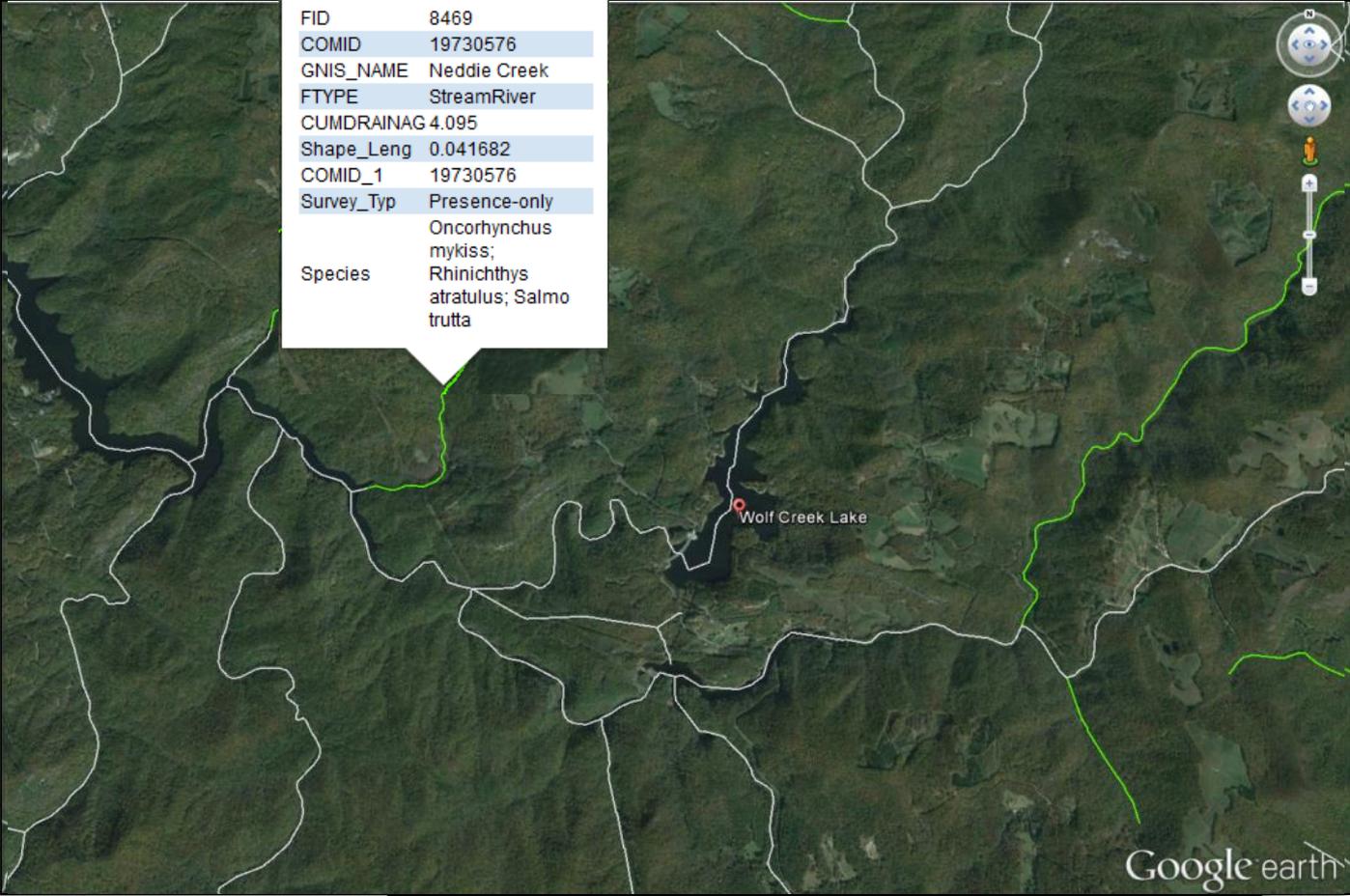
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Sites Substrate	0601	KMZ 8.4 KB
Sites Hydrology	0601	KMZ 17.6 KB
Sites Fish	0601	KMZ 8.3 MB
Disturbance	0601	KMZ 8.3 MB
Class Temperature	0601	KMZ 8.3 MB
Class Substrate	0601	KMZ 8.3 MB
Class Size	0601	KMZ 8.3 MB
Class Hydrology	0601	KMZ 8.3 MB
Class Gradient	0601	KMZ 8.3 MB
Class Confinement	0601	KMZ 8.3 MB
+ Middle Tennessee-Hiwassee	0602	Updated - 10/10/10
+ Middle Tennessee-Elk	0603	Updated - 10/10/10
+ Lower Tennessee	0604	Updated - 10/10/10

**Neddie Creek** [X]

Neddie Creek	
FID	8469
COMID	19730576
GNIS_NAME	Neddie Creek
FTYPE	StreamRiver
CUMDRAINAG	4.095
Shape_Leng	0.041682
COMID_1	19730576
Survey_Typ	Presence-only
Species	Oncorhynchus mykiss; Rhinichthys atratulus; Salmo trutta



Google earth