IDAHO POWER®

Your local energy company since 1916

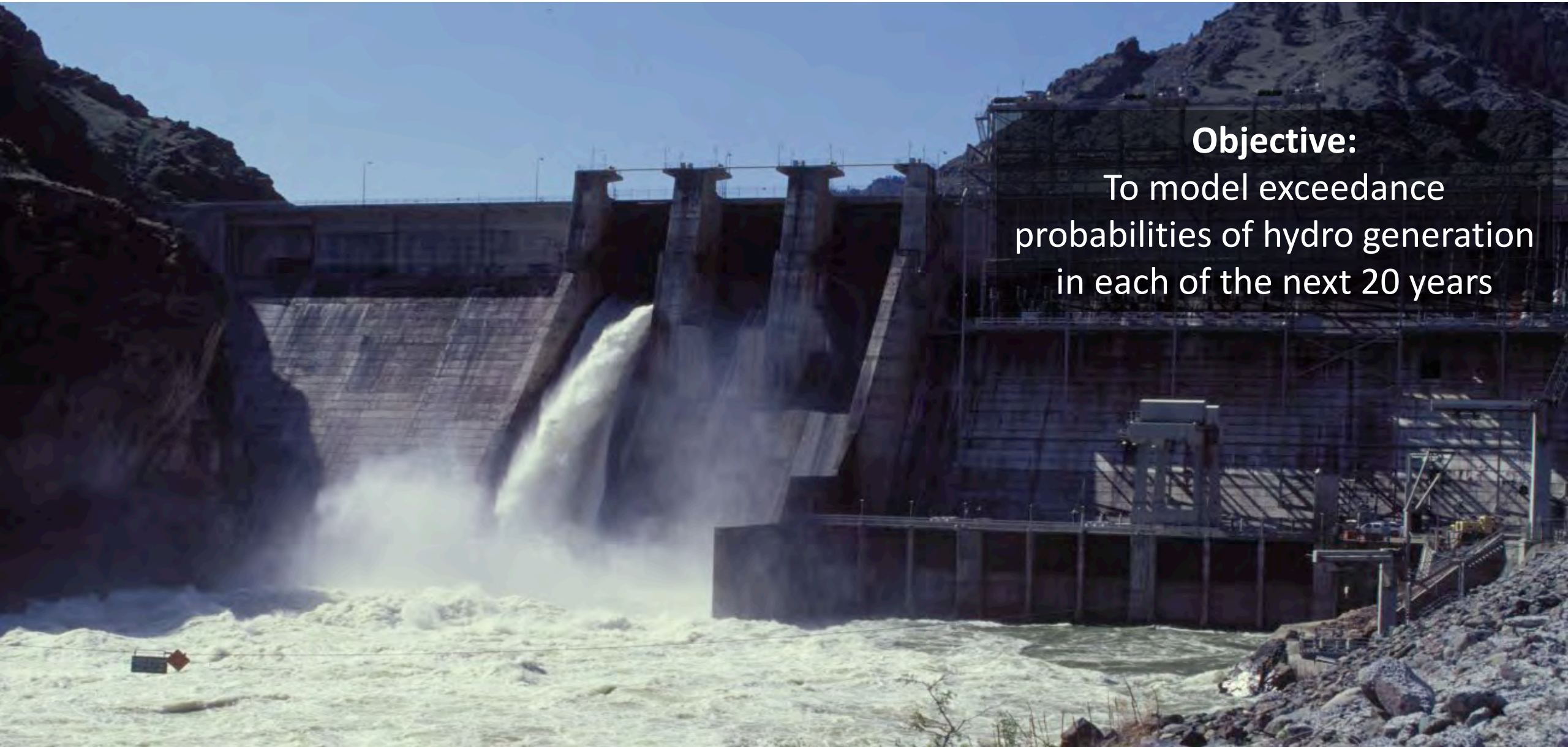
Hydro Resource Modeling

Integrated Resource Plan

John Hildreth

Principal Engineer

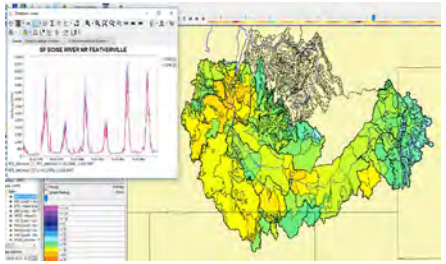
IRP Hydro Generation Planning



Objective:
To model exceedance probabilities of hydro generation in each of the next 20 years

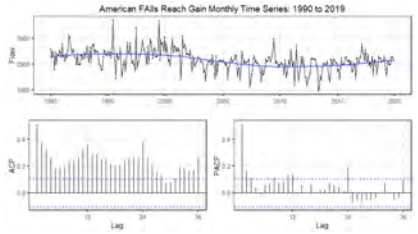
Modeling Process

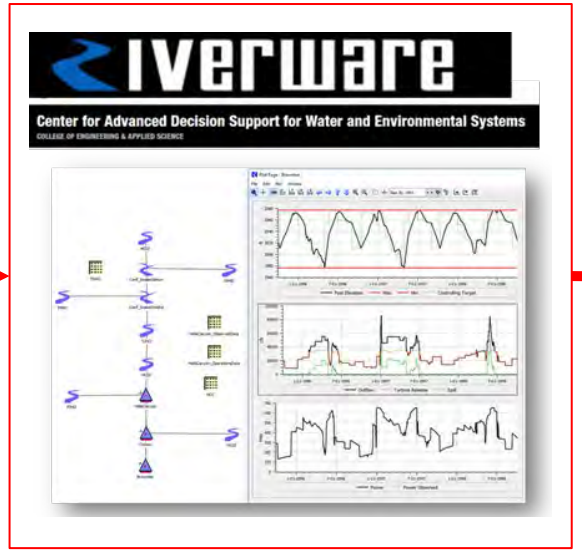
EFS Cloud Seeding SA



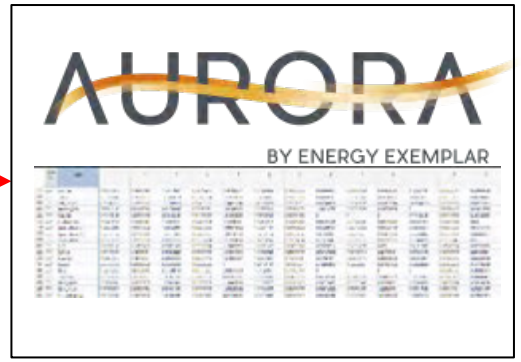
ESPAM 2.2

Statistical Trend Modeling





Monthly Exceedance Plant Hydro Generation (aMW)



CADSWES RiverWare

- Software from the University of Colorado Boulder, Center for Advanced Decision Support for Water and Environmental Systems
- What is it?
  - Object-oriented, multi-objective river and reservoir modeling decision support system
  - Widely used, well-funded, and actively developed software
  - Large collection of support tools
  - Allows for automation
  - Allows for adaptive water management modeling and implementation of water policy

RiverWare Users and Benefits

Bureau of Reclamation: 27 offices

Tennessee Valley Authority

U.S. Army Corps of Engineers: 13 offices

10 Federal agencies, Tribes and research labs

31 state, city and district water agencies

8 electric utilities in the U.S. and Canada

23 consulting companies and NGOs

12 universities and research groups

19 foreign entities

Baseline RiverWare Models

- Three different models used to represent different sections of river
  - Malad River Basin
  - Snake River above Brownlee
  - Hells Canyon Complex
- All models use a baseline recent historical hydrology
  - Building block for the future ensemble distribution
- Models are “present conditioned”
  - Water management is updated to reflect current operating logic
  - Irrigation demands patterned to reflect recent years
  - Irrigation return fractions updated to current estimates
  - Spring discharge represent current

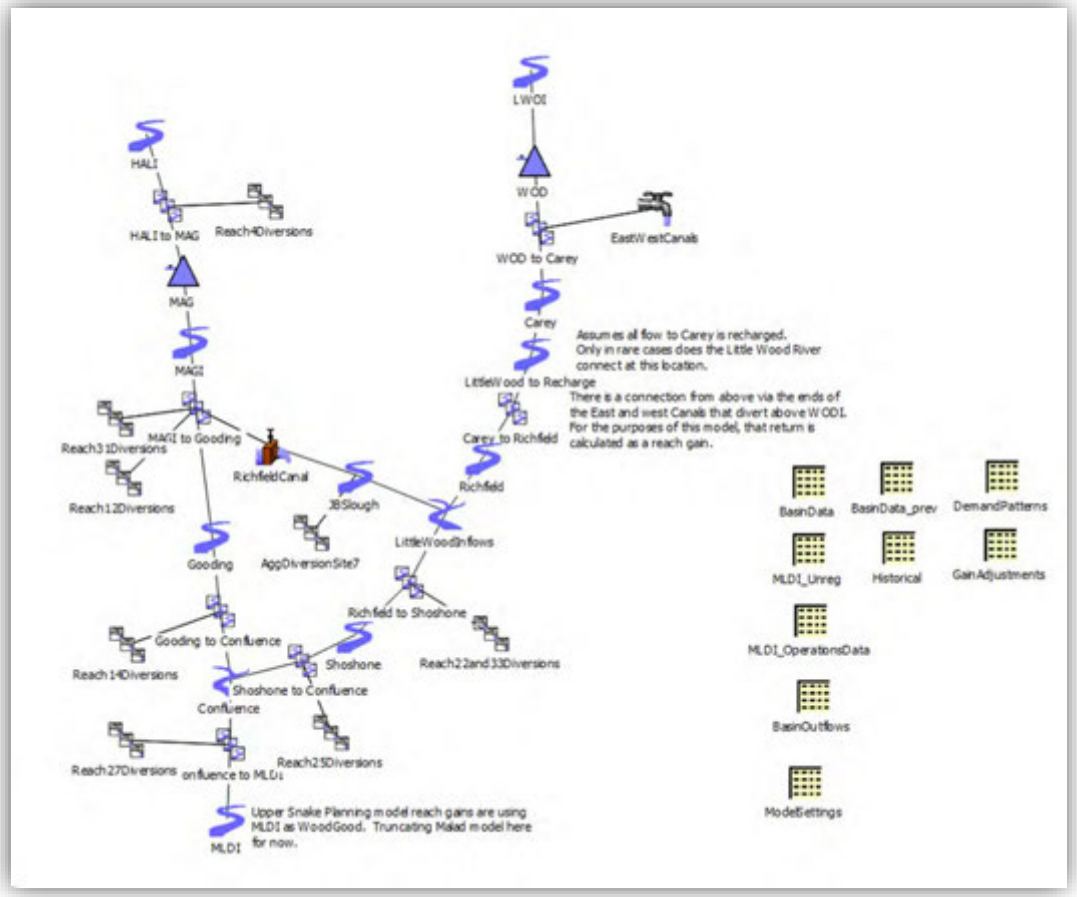
Malad RiverWare Planning Model

Purpose: Simulate change in reach losses (recharge) and basin outflow in response to cloud seeding

- Baseline reach gains from Malad unregulated model
- Reservoir operations simulated in rule logic
  - Flood releases
  - Irrigation releases
- Diversions simulated with demand patterns

Scenarios:

- Baseline (no reach gain adjustment)
- Current cloud seeding
- Full build-out cloud seeding



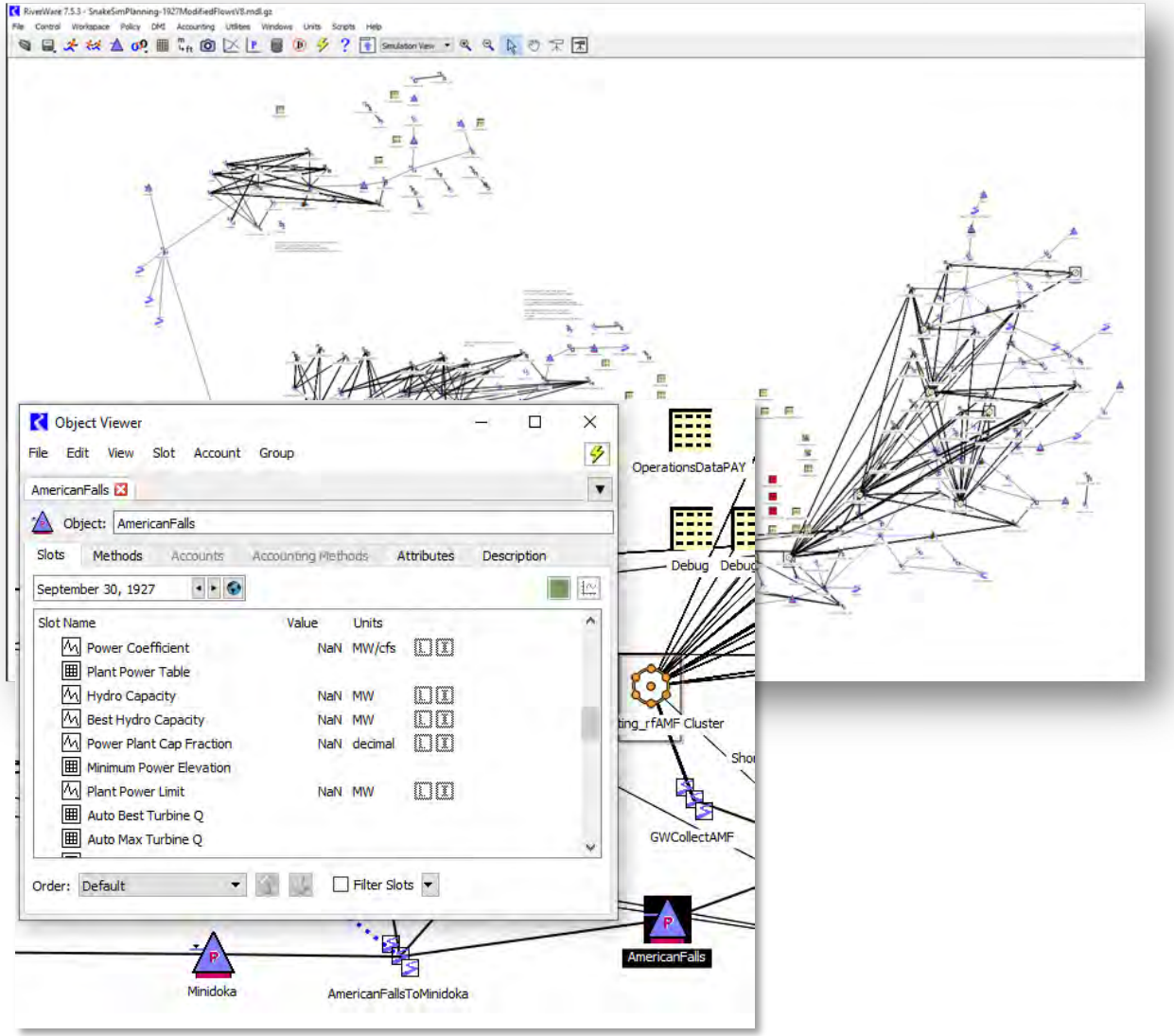
Snake RiverWare Planning Model

Acquired model from U.S. Bureau of Reclamation (USBR) in early 2020

- Same model used by USBR for the BPA 2020 Modified flows study

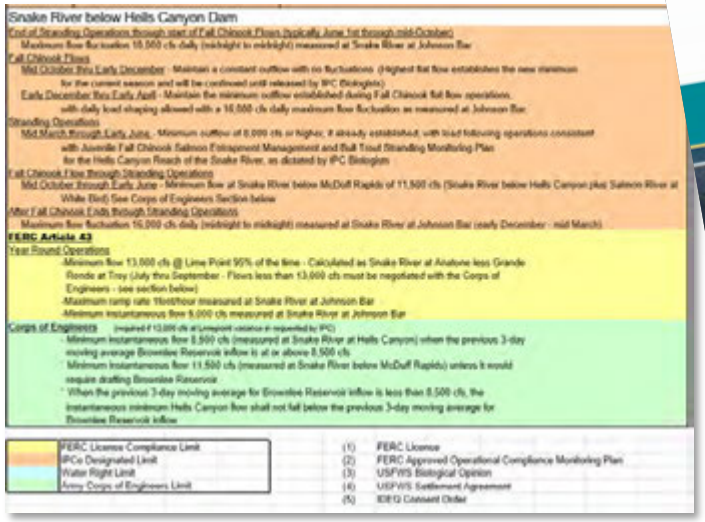
Model was created to answer USBR-specific questions

- Model has undergone major changes from the original USBR model
- Enhancements added to be used for Idaho Power modeling
  - Inclusion of managed recharge
  - Update to reflect current reservoir operations
  - Inclusion of cloud seeding and other management practices affecting reach gains
  - Inclusion of Idaho Power primary American Falls storage
  - Allow 0 cfs at Milner
  - Inclusion of missing Idaho Power hydro projects
  - Update of plant capacities at all Idaho Power projects
  - Inclusion of hydrogeneration at all Idaho Power projects

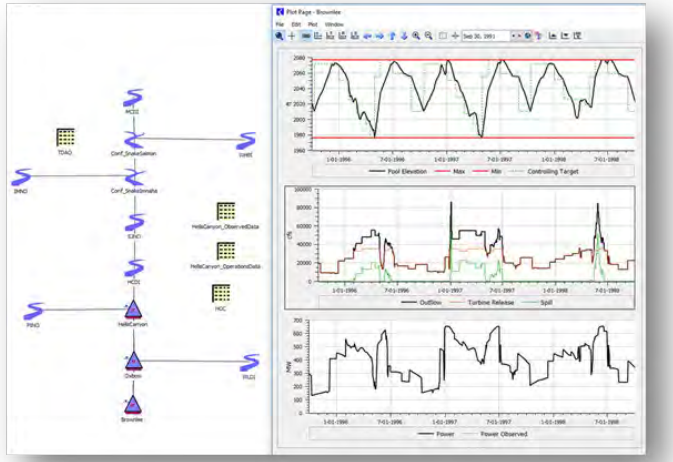


Hells Canyon Complex Planning model

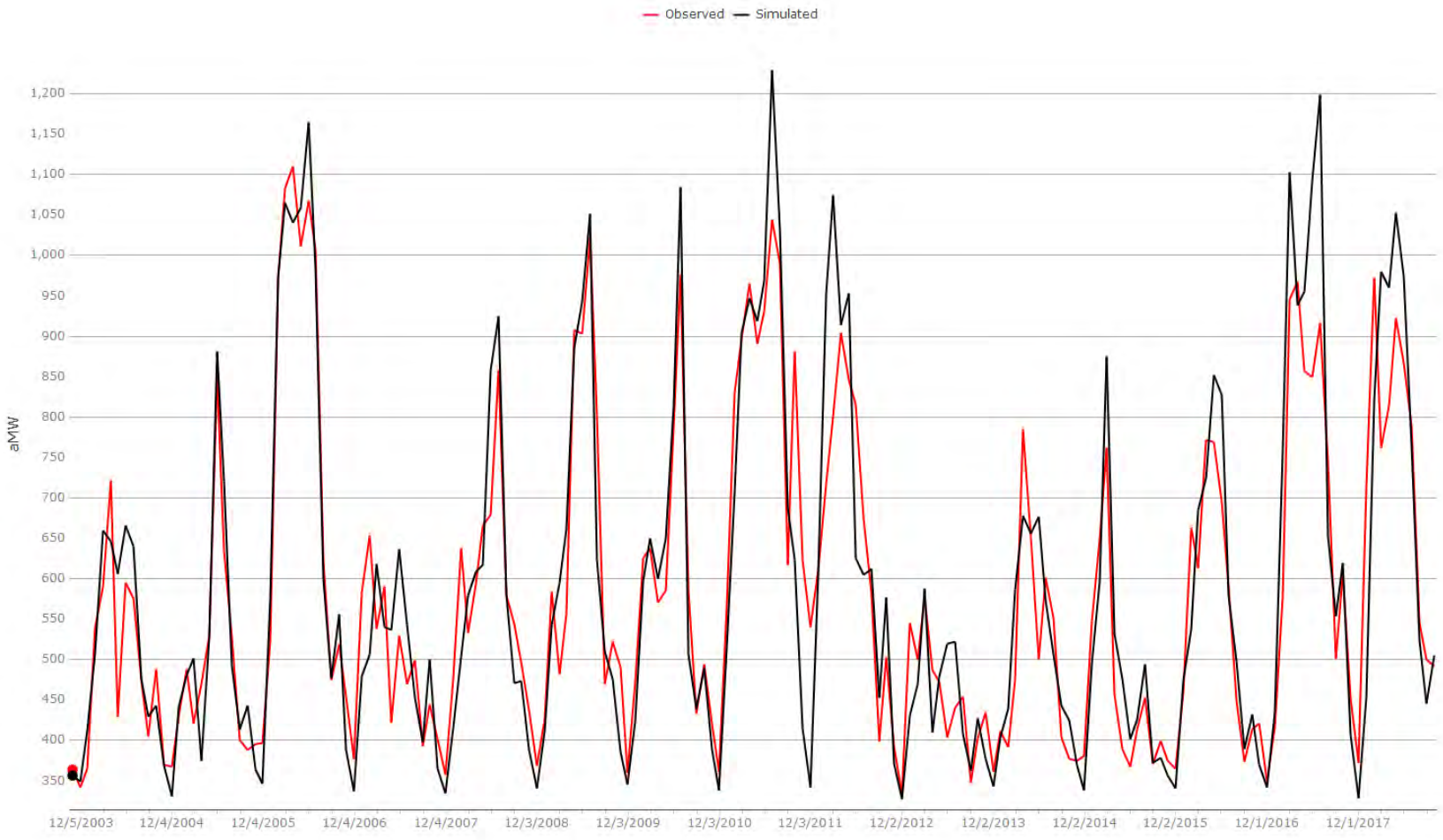
- CADSWES built HCC planning model in RiverWare for Idaho Power
- Reflects current level reservoir management practices
  - License requirements
  - Recreational
  - Environmental
  - Flood control
- Dynamic operations based on inflow and year
- Plant-based hydro generation modeling



RiverWare
Center for Advanced Decision Support for Water and Environmental Systems
COLLEGE OF ENGINEERING & APPLIED SCIENCE



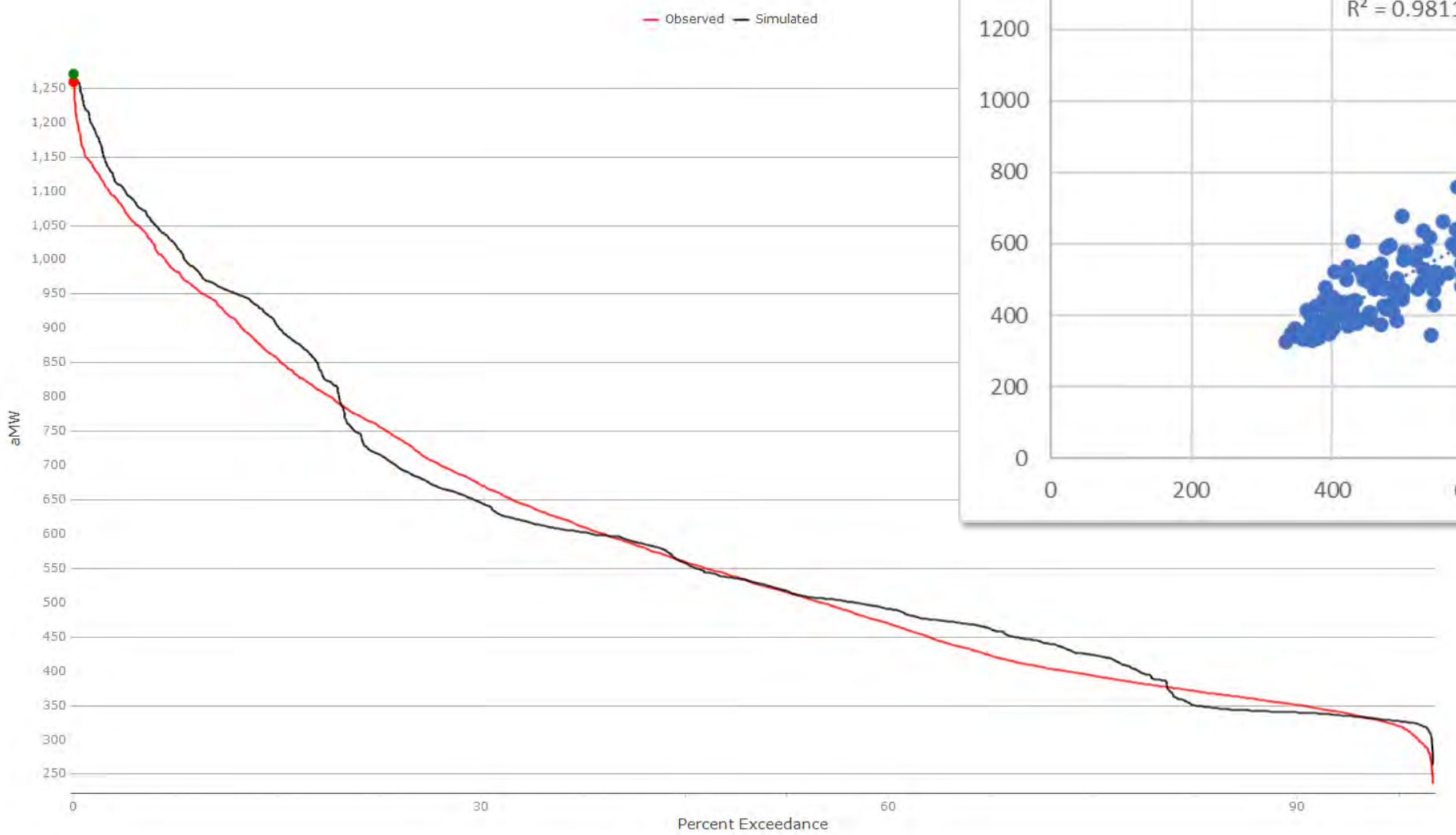
Hells Canyon Complex Generation

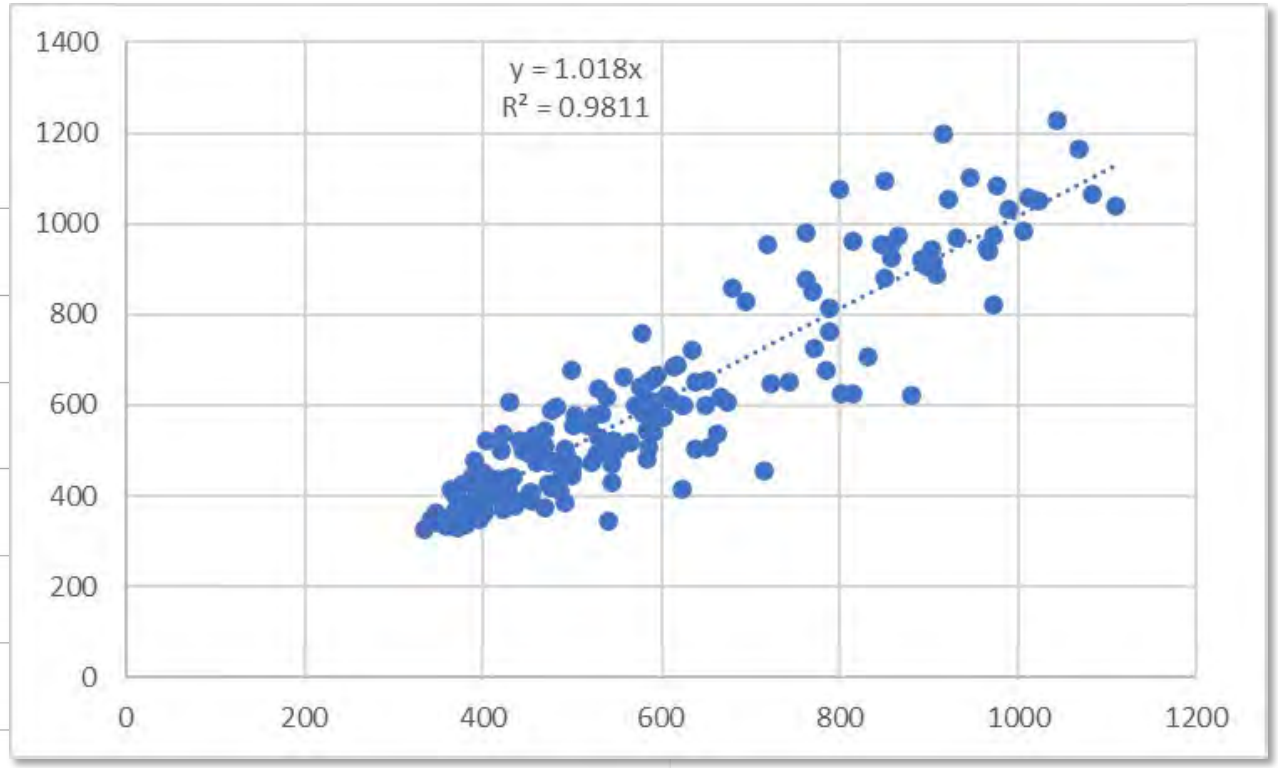


- Observed maintenance and operating reserves are not simulated in RiverWare. This is accounted for in Aurora.
- Modeling purpose is to produce total available aMW with the given water conditions.

Hells Canyon Monthly Exceedance

Probability: water years 2004–2018



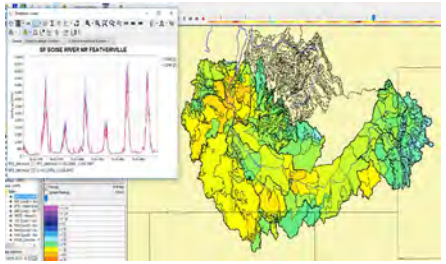


Future Assumptions Influencing Water Supply

- Weather modification
- Reach declines
  - Based on trend analysis
- Expected water management activities
  - Managed Recharge
    - Idaho Water Resource Board
    - Private
  - Groundwater pumping reductions
  - System conversions (groundwater supply converted to surface water supply)

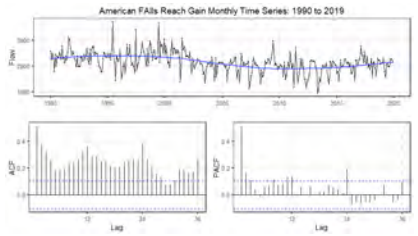
Modeling Process

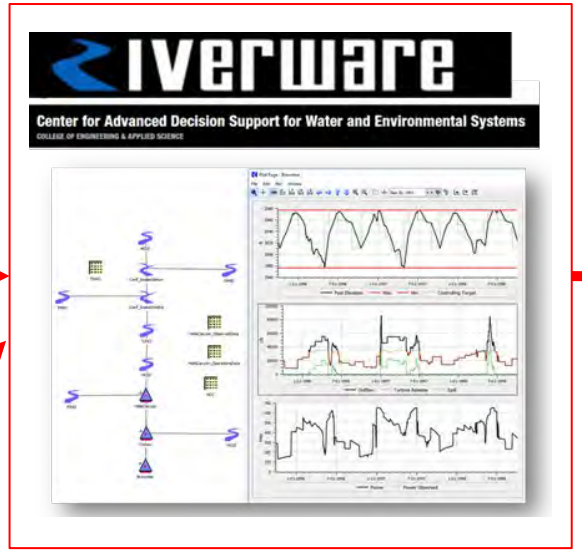
EFS Cloud Seeding SA



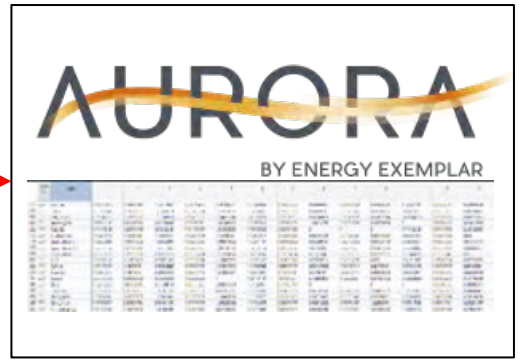
ESPAM 2.2

Statistical Trend Modeling

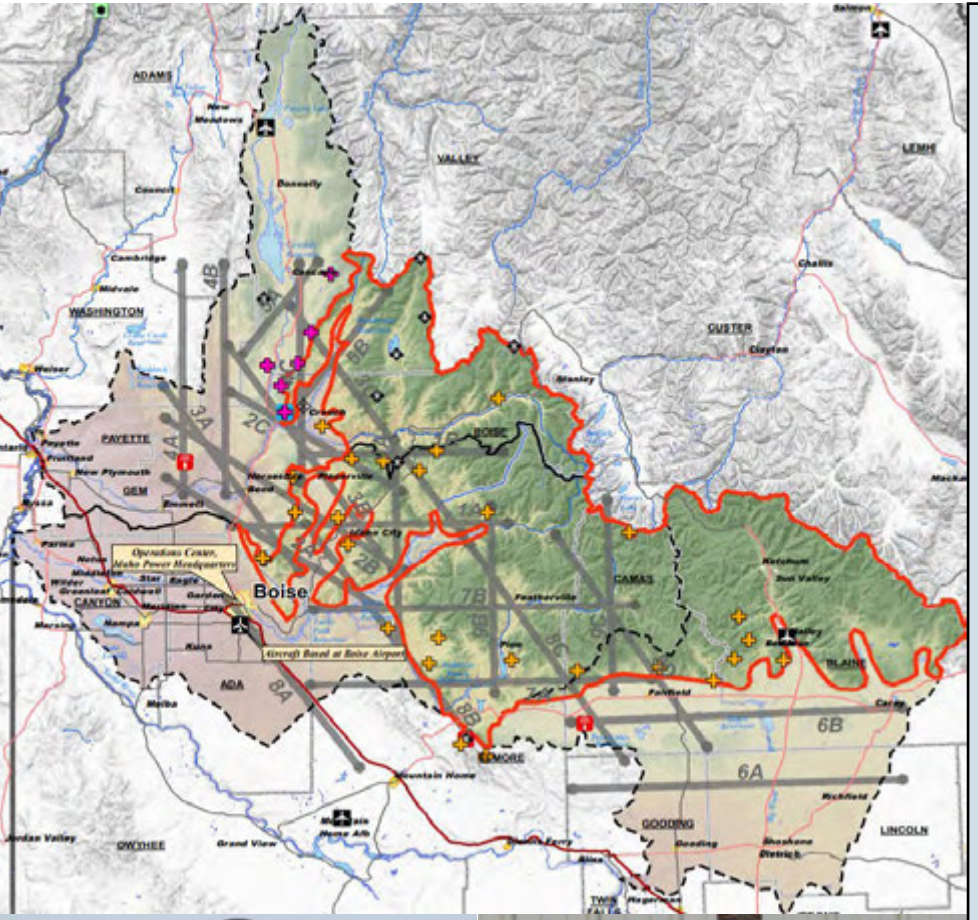




Monthly Exceedance Plant Hydro Generation (aMW)



Idaho Collaborative Cloud Seeding Program



Central Mountains

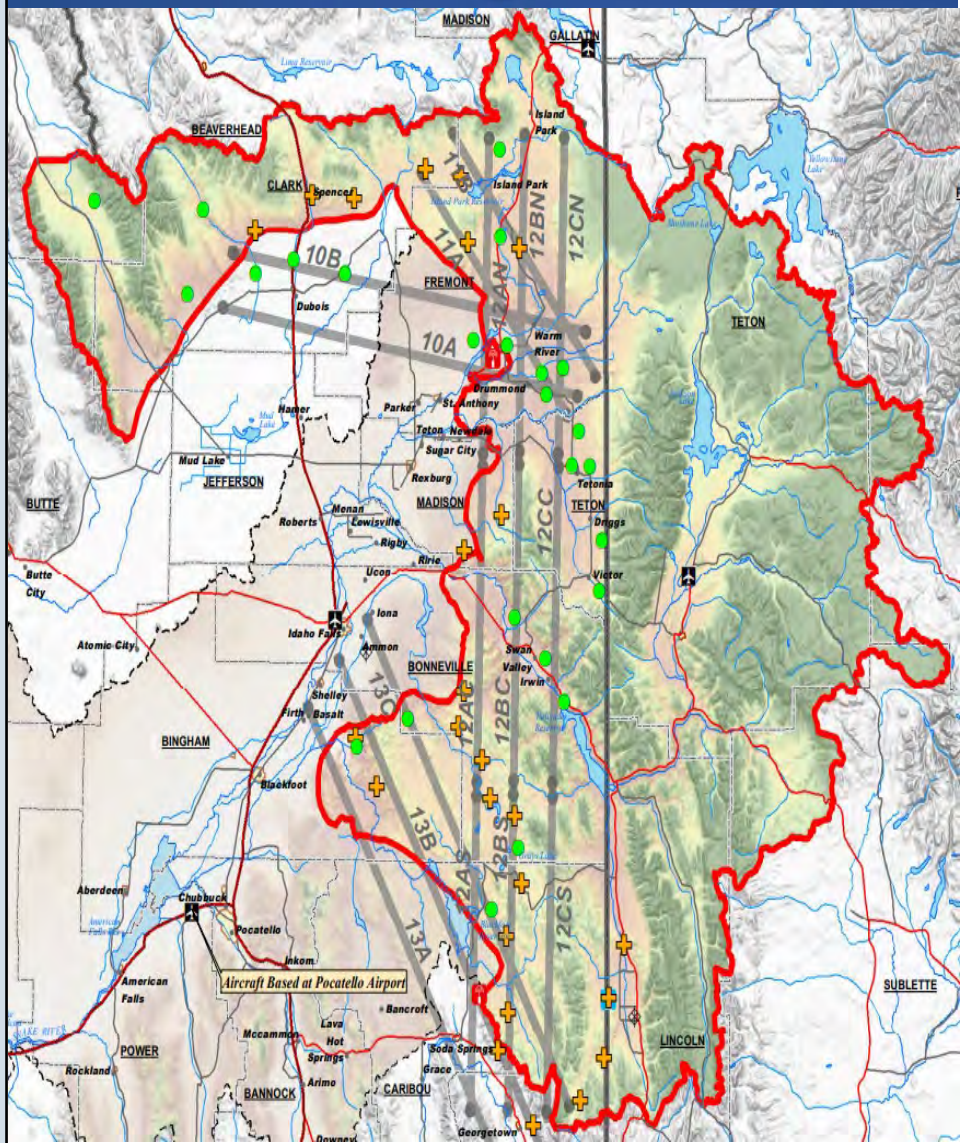
- 32 Idaho Power Remote Ground AgI Generators
  - 17 Payette
  - 15 Boise/Wood
- 2 Aircraft

Upper Snake

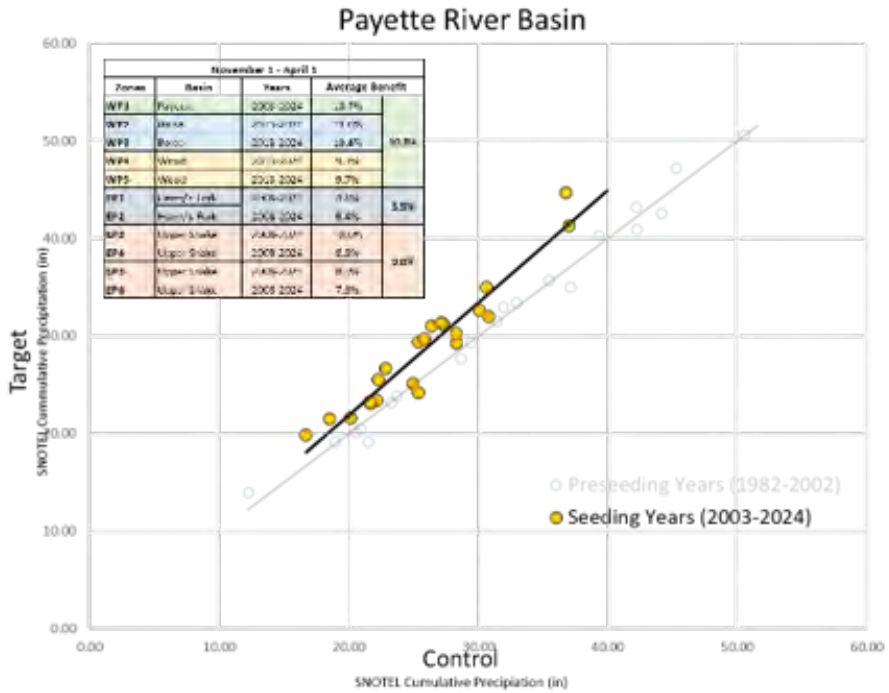
- 25 Idaho Power Remote Ground AgI Generators
- 1 Aircraft
- 25 Let It Snow Manual Ground AgI Generators

Across the Program

- High Performance Computing System
- High Resolution WRF Weather Model
- WRF-WxMod Module
- High Resolution weather instrumentation

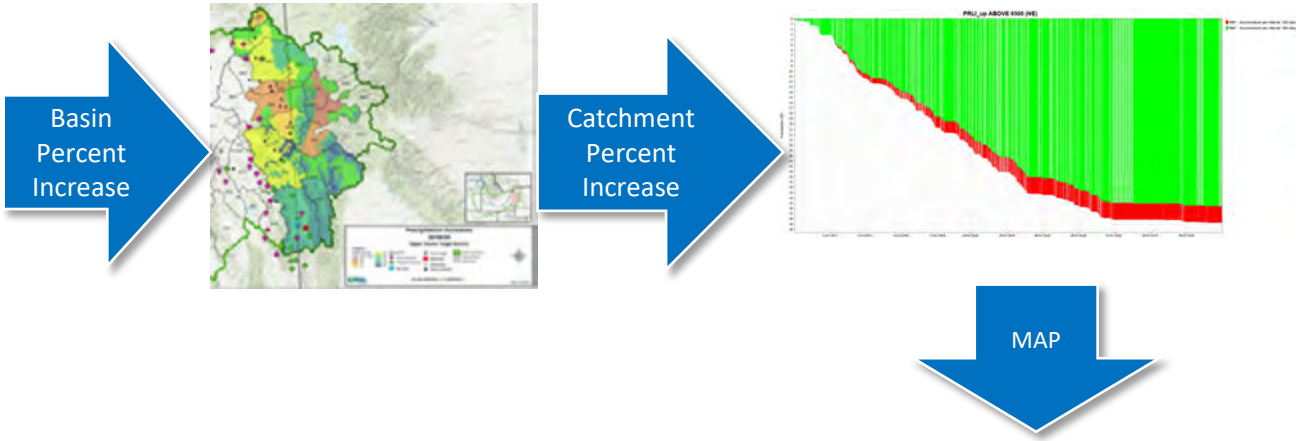


Cloud Seeding Benefit Modeling



Spatial distribution of percent increase to catchment

Mean Areal Precipitation development



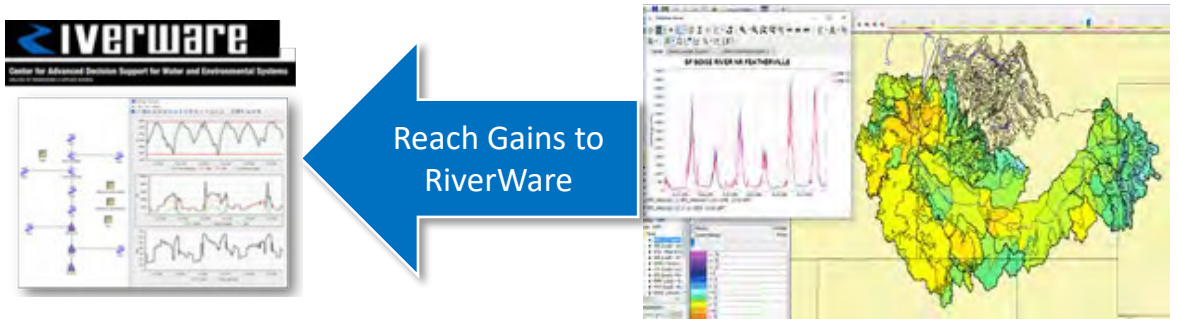
EFS is our internal stream-flow forecasting system

- Calibrated lumped parameter hydrologic model of the Snake Basin
- Inputs include Mean Areal Precipitation and Mean Areal Temperature

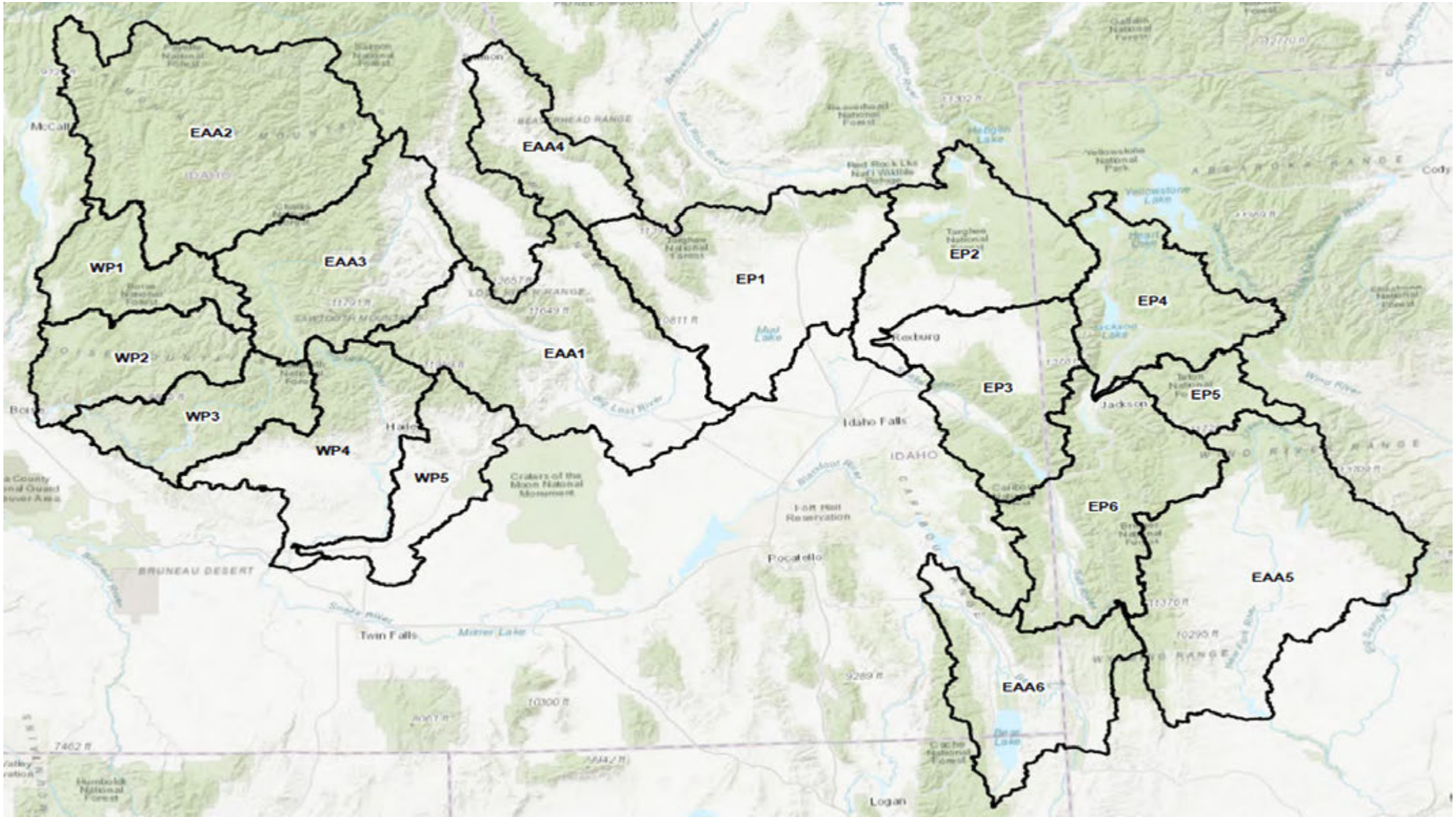
2 Scenarios Developed

- Current cloud seeding program
- Future cloud seeding build-out

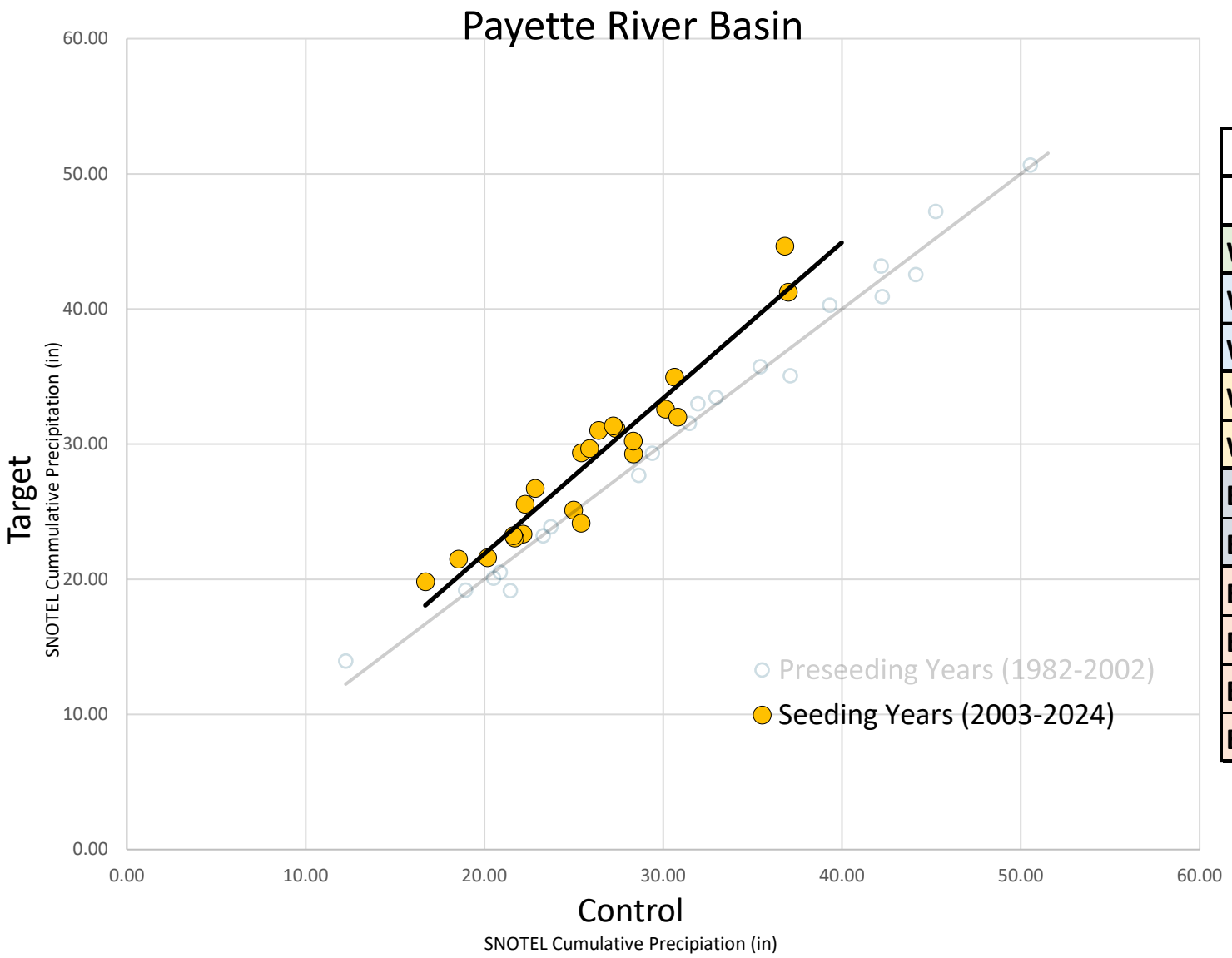
EFS Cloud Seeding SA



Target Control Areas



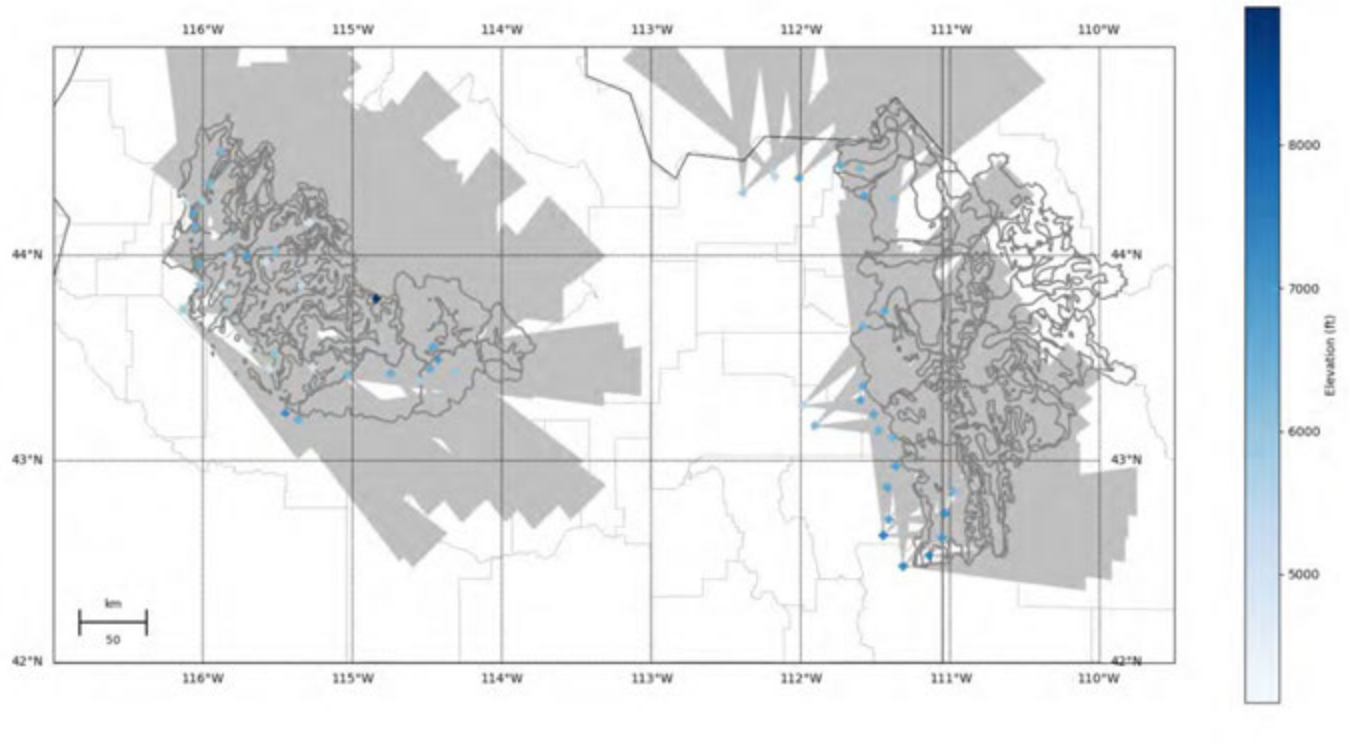
Target-Control Analysis



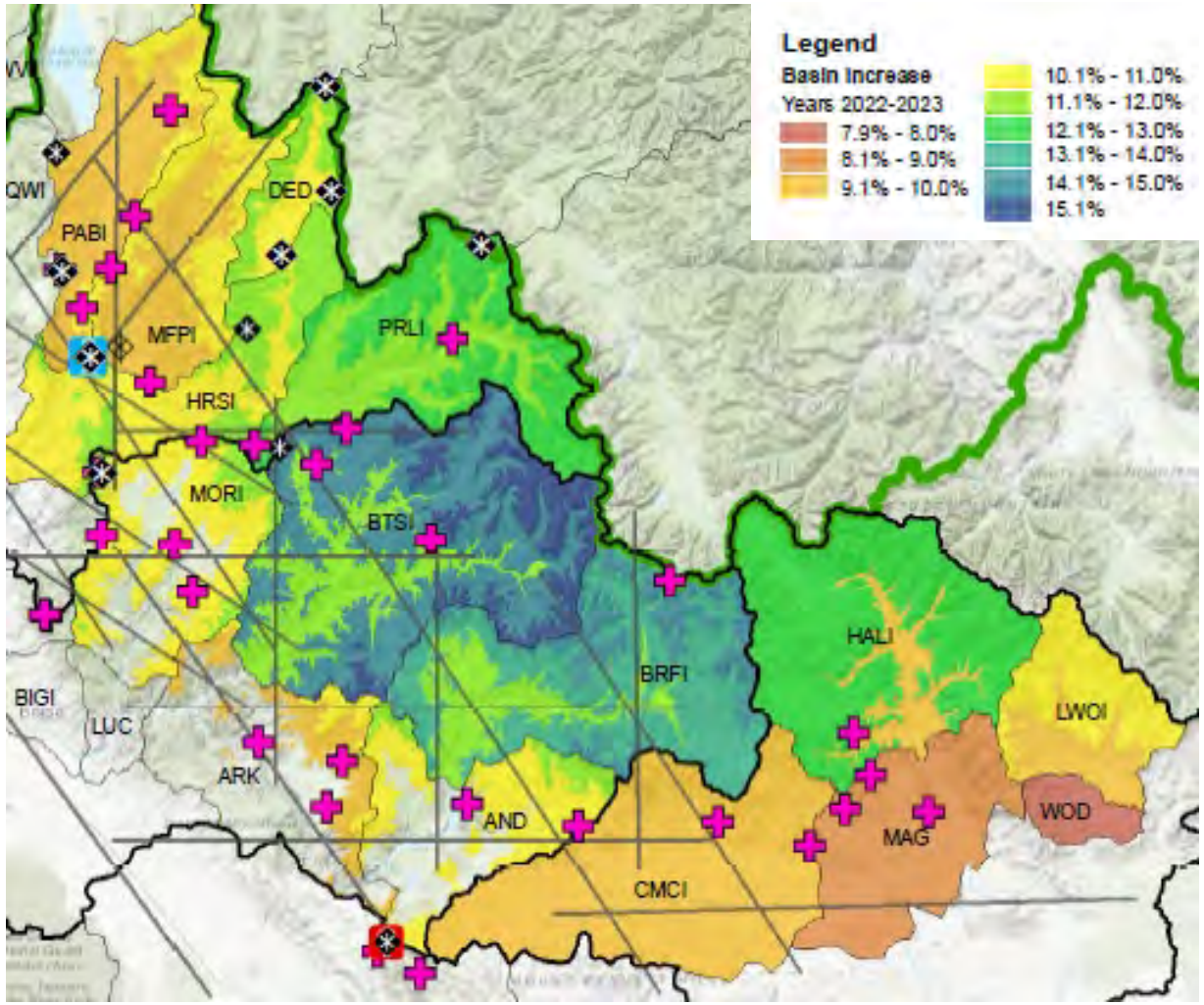
November 1 - April 1				
Zones	**Basin**	**Years**	**Average Benefit**	
WP1	Payette	2003-2024	10.7%	**10.0%**
WP2	Boise	2013-2024	11.0%	
WP3	Boise	2013-2024	10.4%	
WP4	Wood	2013-2024	9.3%	
WP5	Wood	2013-2024	9.7%	
EP1	Henry's Fork	2008-2024	4.8%	**5.5%**
EP2	Henry's Fork	2008-2024	6.4%	
EP3	Upper Snake	2008-2024	10.0%	**9.0%**
EP4	Upper Snake	2008-2024	8.8%	
EP5	Upper Snake	2008-2024	8.9%	
EP6	Upper Snake	2008-2024	7.8%	

Spatial Downscaling

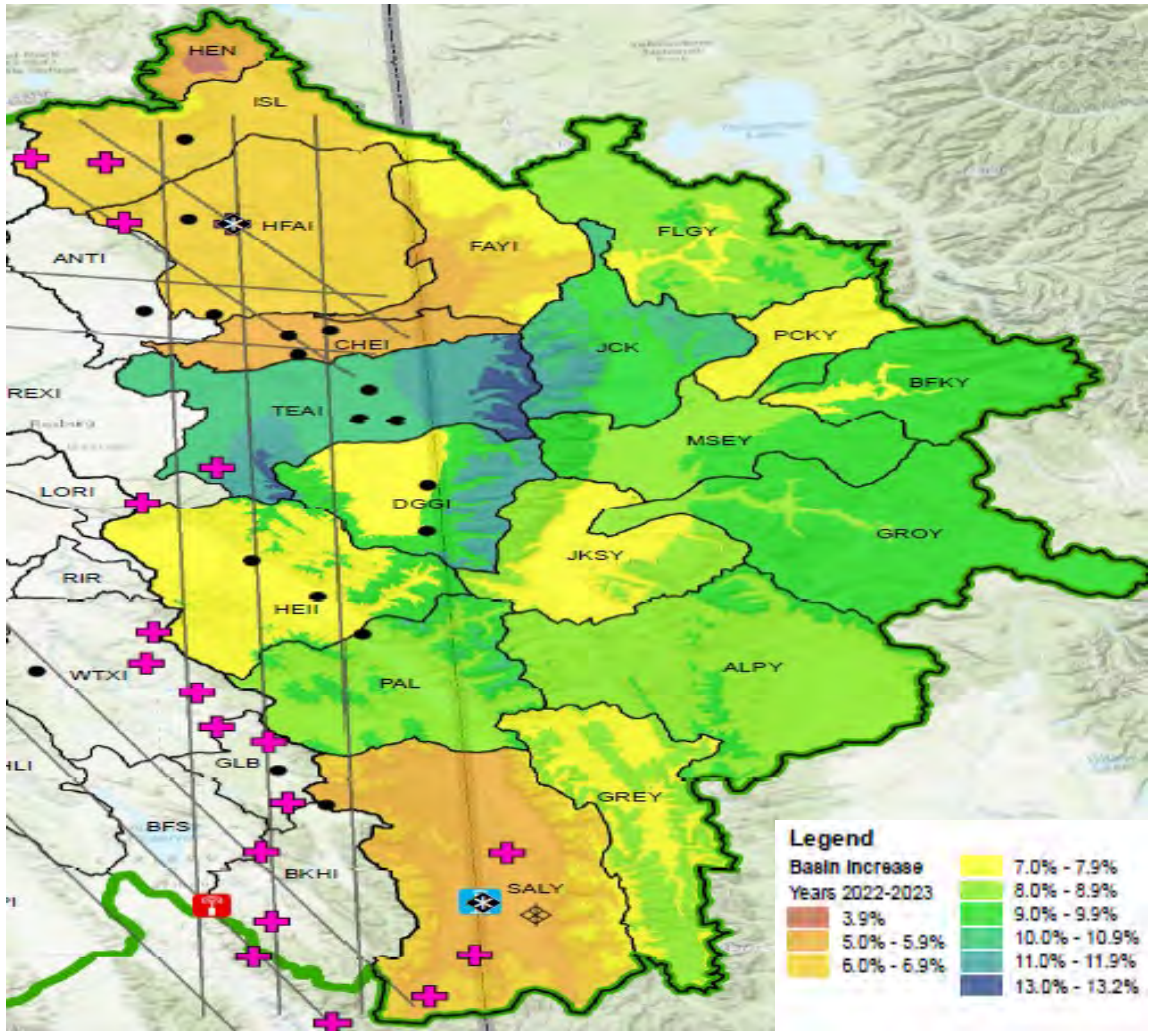
- Uses the Target Control operational units
- Disaggregates basin-wide results to spatial resolution that is used in hydrologic model
- Applies factors to the elevation bands within these units
  - Operational Usages
    - Historical operational hours
  - Wind Weight
    - Wind direction ratio
  - Elevation Weight
    - PRISM climate normal
    - Ratio of elevation band precipitation to entire basin precipitation



Average Precipitation Benefit Estimate



Central Mountain Target Basins

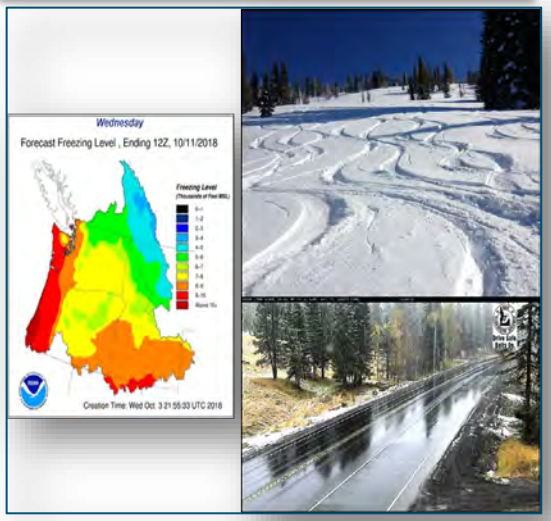


Upper Snake Target Basins

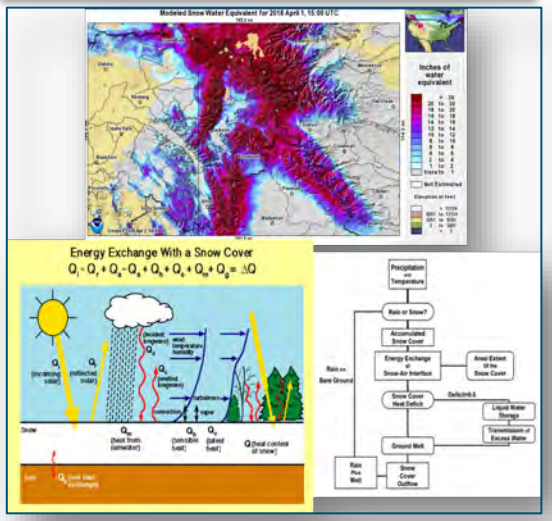
Enhanced Forecast System

Mean Areal Precipitation

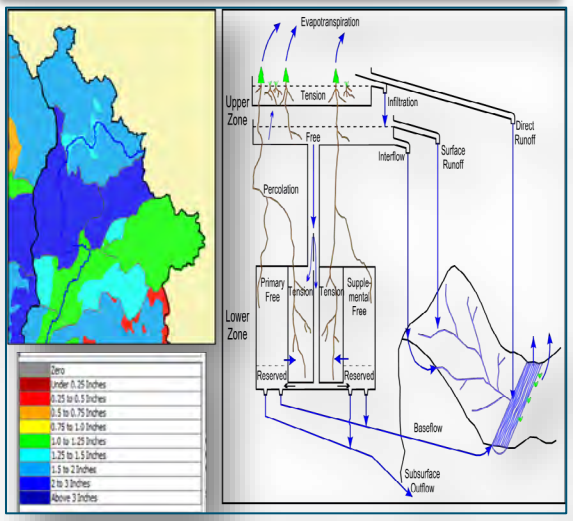
Precipitation Typing (RSNWELEV)



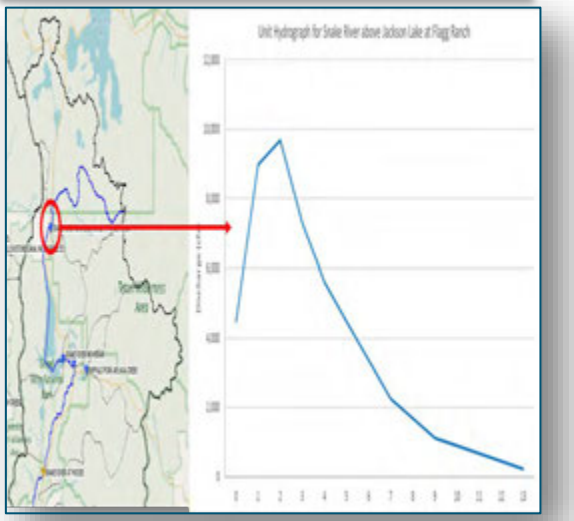
Snow Accumulation and Melt (SNOW17)



Runoff, Infiltration, Percolation, Baseflow (SACSMA)



Runoff Hydrograph (UNITHG)

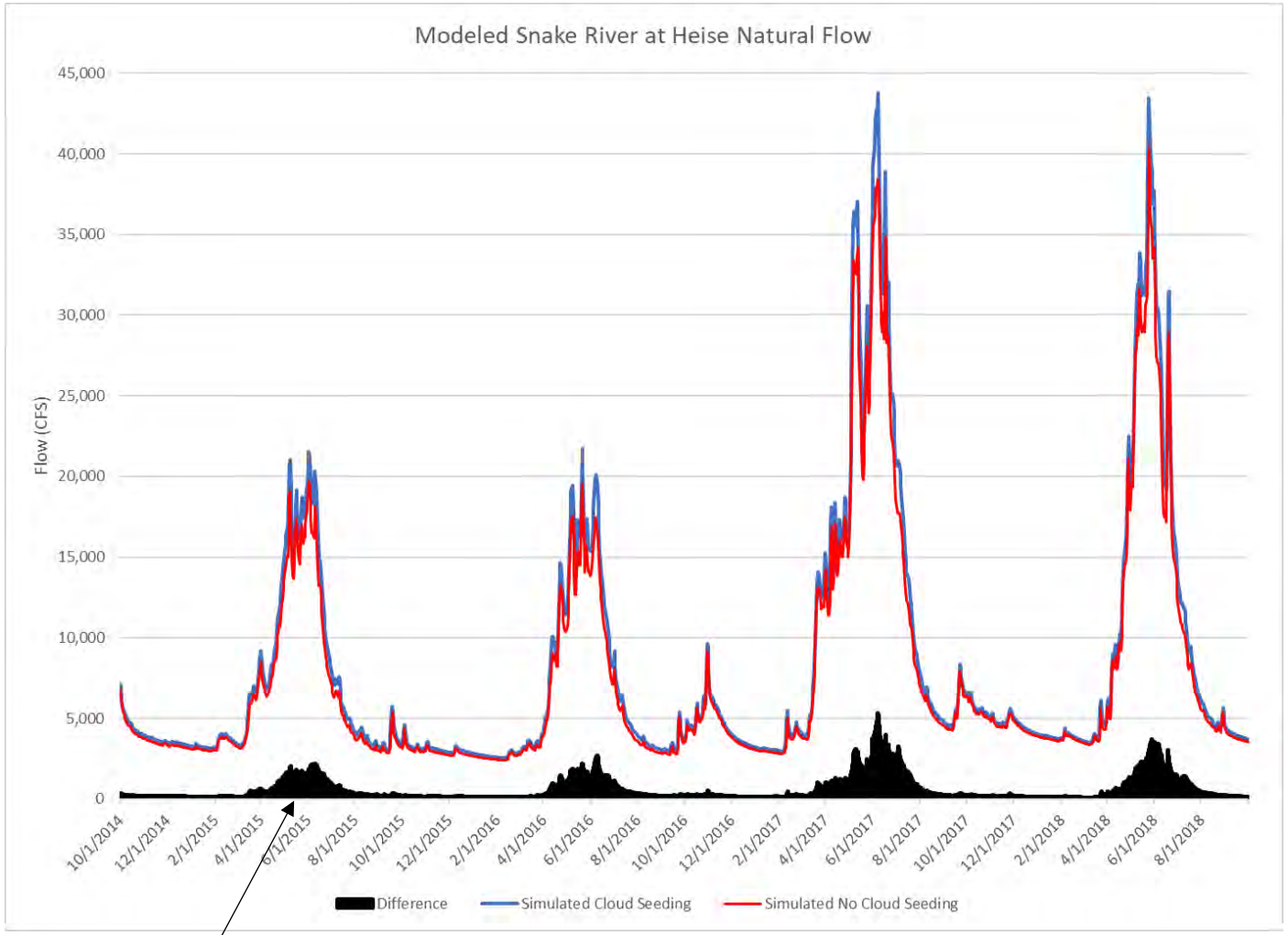


Mean Areal Temperature

Natural Flow

Hydrologic Modeling

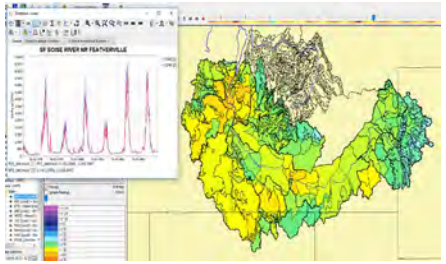
- Run scenarios through hydrologic model
  - Baseline
  - With cloud seeding
  - Without cloud seeding
- Scenarios adjusted for when cloud seeding was and was not occurring
- Runoff benefit = (seeding) – (no seeding)



Estimated Daily Runoff Benefit

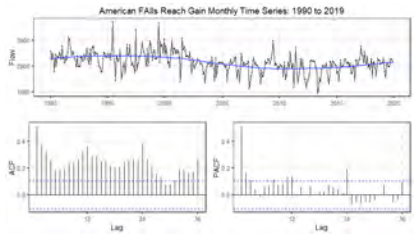
Modeling Process

EFS Cloud Seeding SA



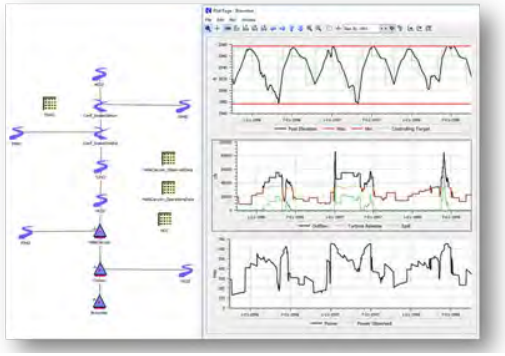
ESPAM 2.2

Statistical Trend Modeling



RiverWare

Center for Advanced Decision Support for Water and Environmental Systems



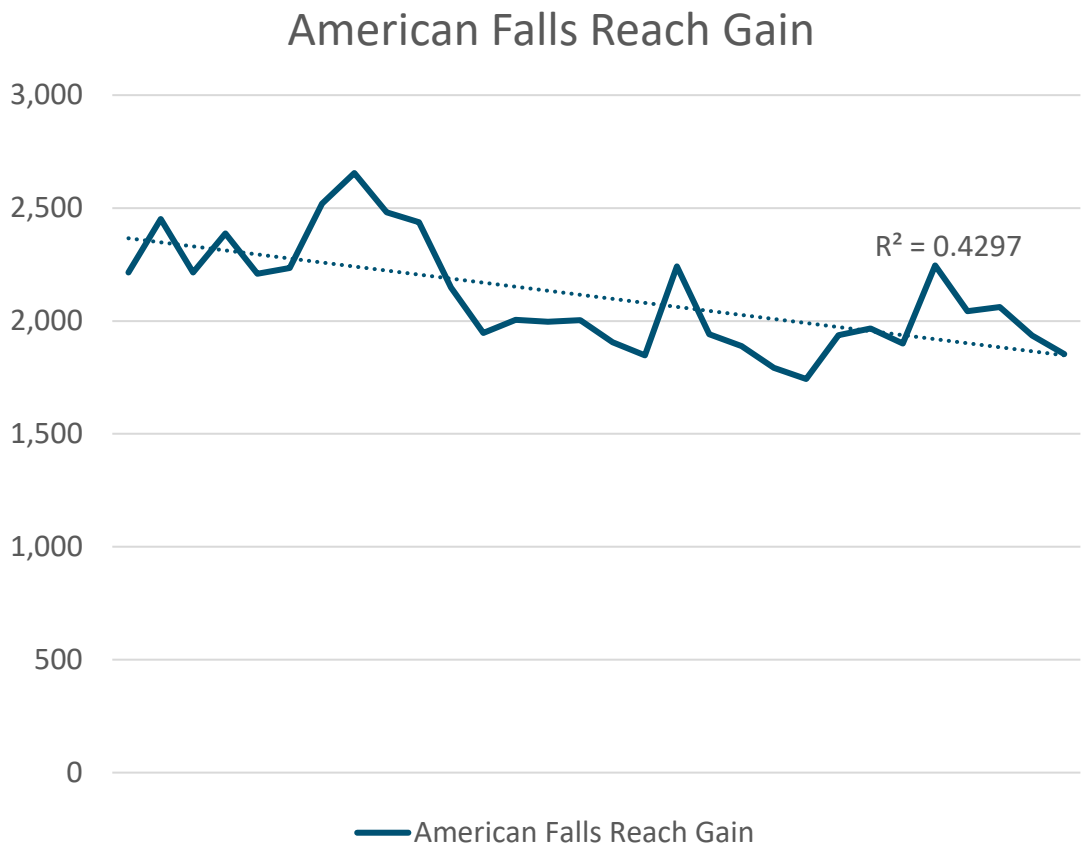
Monthly Exceedance Plant Hydro Generation (aMW)

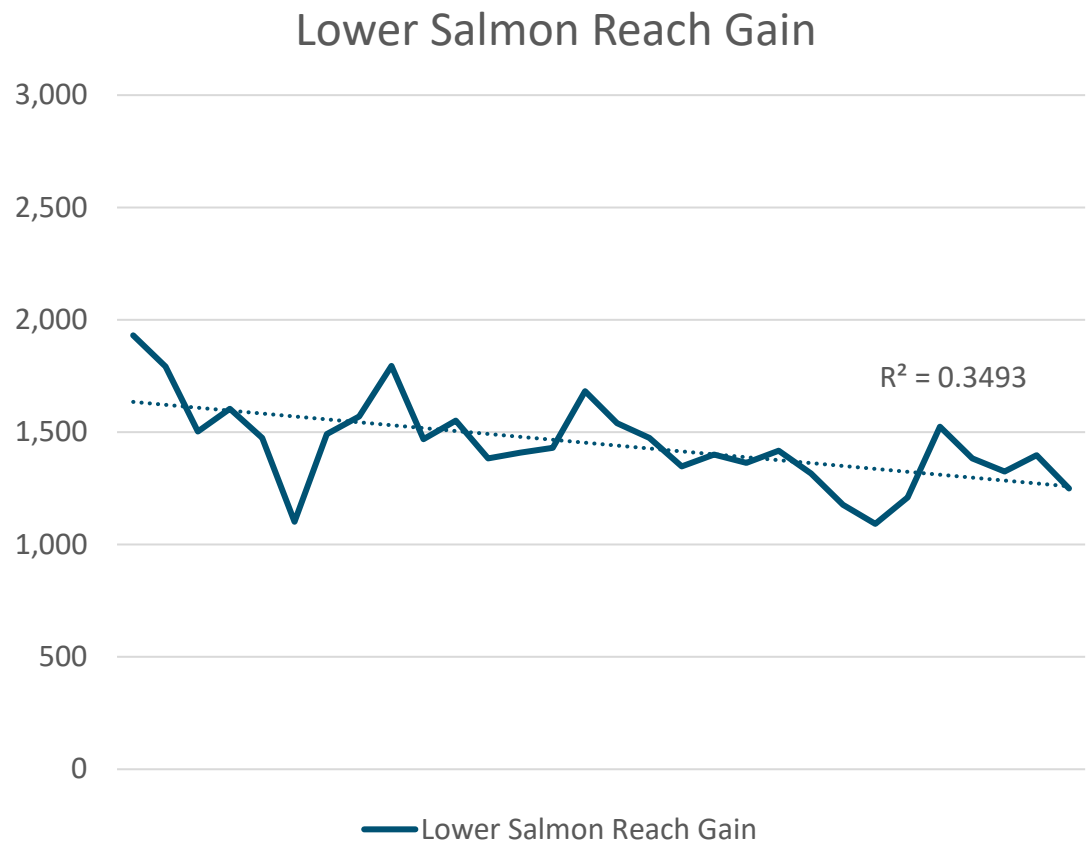
AURORA

BY ENERGY EXEMPLAR

Trend Analysis

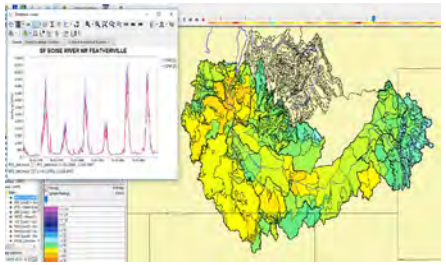
Reach Gain Location	Trend (cfs/month)	P-Value Less than 0.01	TFPW RESULTS
American Falls	-1.31	TRUE	(-) TREND
Lower Salmon Falls	-1.25	TRUE	(-) TREND





Modeling Process

EFS Cloud Seeding SA



ESPAM 2.2

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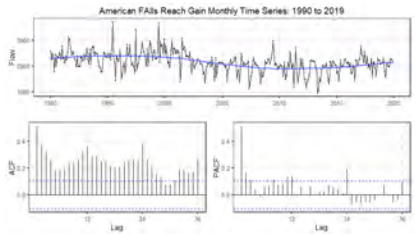
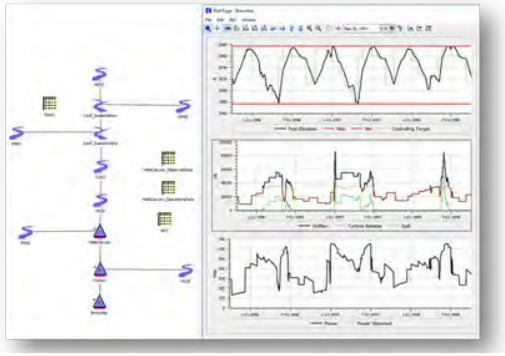


RIverware

Center for Advanced Decision Support for Water and Environmental Systems

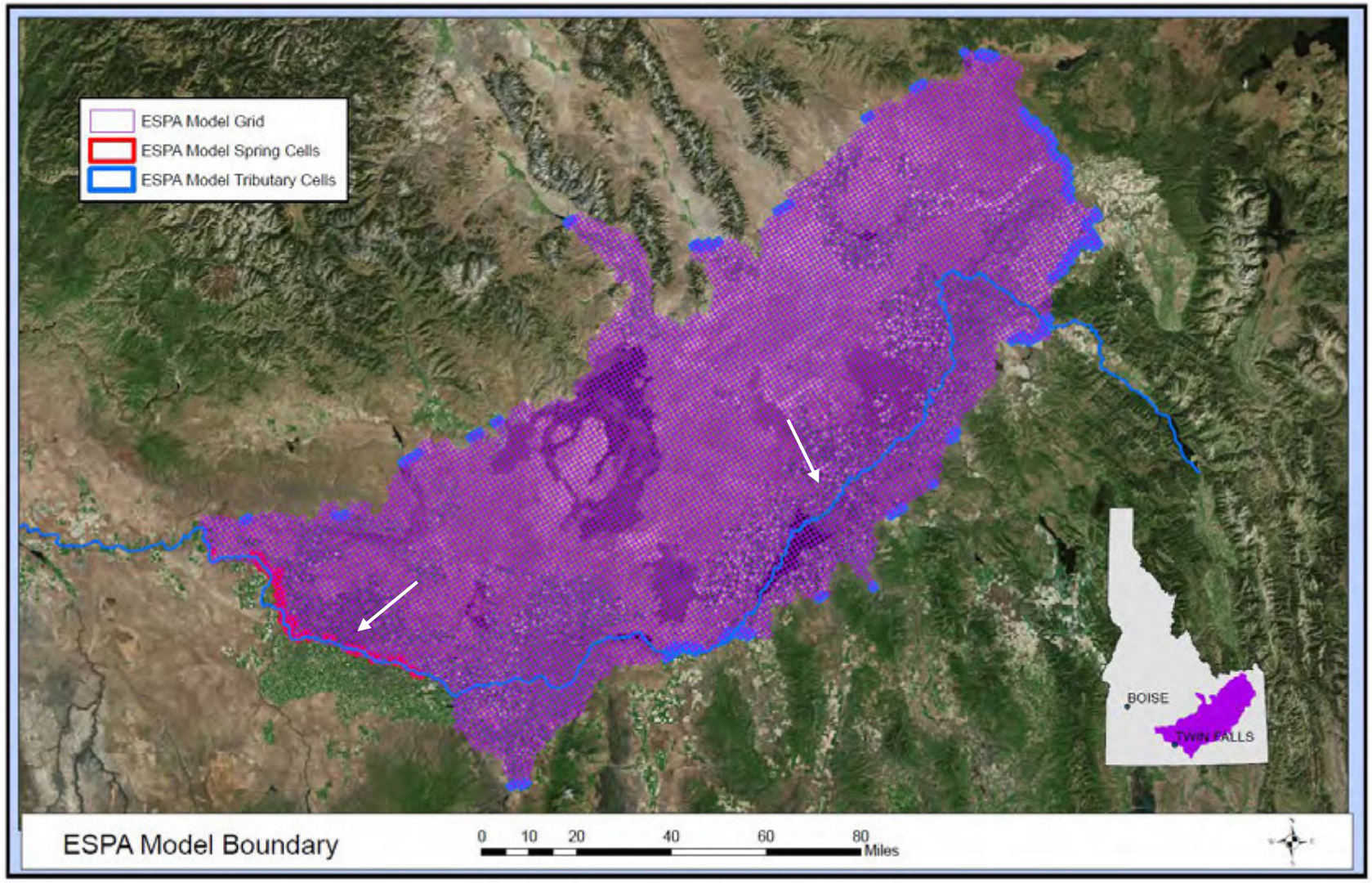


Monthly Exceedance Plant Hydro Generation (aMW)

AURORA

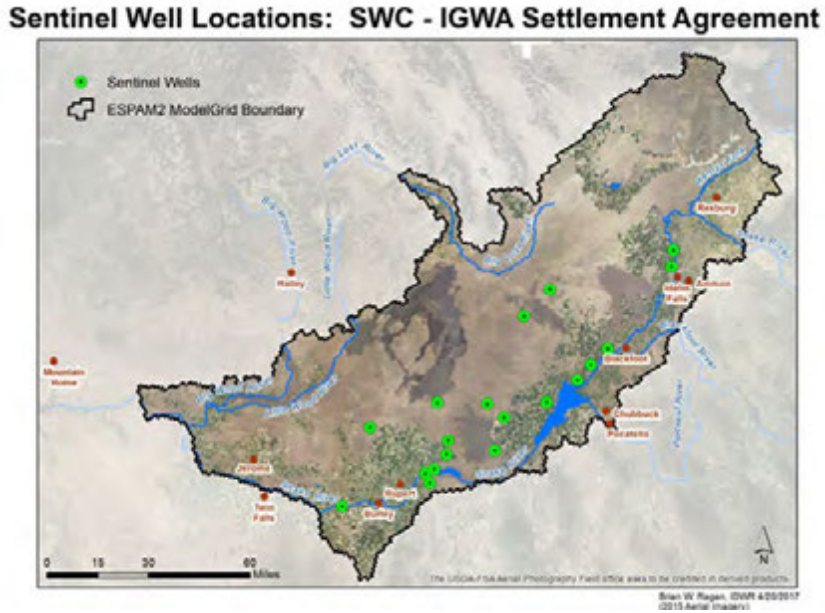
BY ENERGY EXEMPLAR

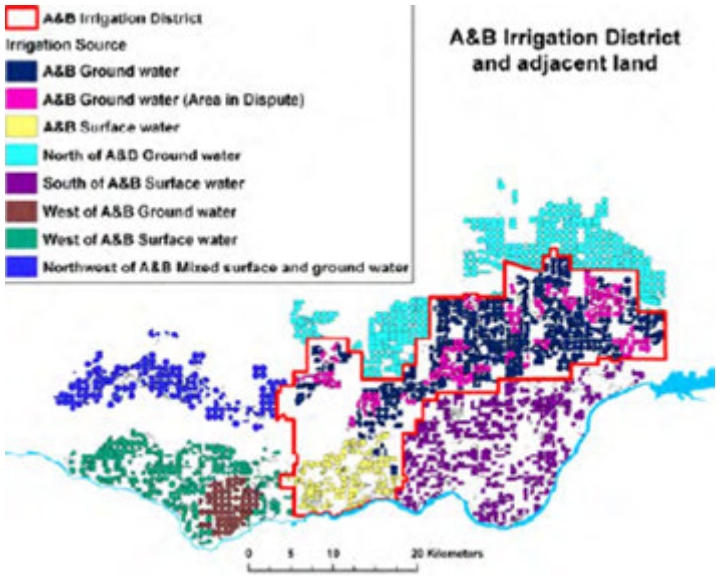
Enhanced Snake Plain Aquifer Model (ESPAM)



Conjunctive Management

- SWC-IGWA* Settlement Agreement
  - Reduced groundwater pumping
  - Support IWRB* managed recharge program
  - Storage water delivery to SWC
- SWID-SWC* Agreement
  - Conversion of groundwater to surface water irrigation
  - Delivery of storage water to cover conversions
- Managed Recharge
  - IWRB Natural and Storage
  - Private





***SWC**=Surface Water Coalition, **IGWA**=Idaho Ground Water Appropriators,*
***SWID**=Southwest Irrigation District, **IWRB**=Idaho Water Resource Board*

Modeling Sequence

- Preliminary RiverWare run with expected reach gain changes
  - Cloud seeding
  - Trend declines
  - ESPAM simulated reach gains from observed water management practices
    - SWC agreement implementation
    - System conversions
    - Recharge
      - Idaho Water Resource Board
      - Private
- Use preliminary run determine the average monthly recharge volumes by upper valley and lower valley canals
- Rerun ESPAM with new recharge assumptions for the 20 years of the IRP

Additional Resources

- idwr.idaho.gov/legal-actions/settlements/SWC-IGWA/
- idwr.idaho.gov/water-data/projects/espam/
- iwrbrecharge-idwr.hub.arcgis.com/
- www.riverware.org/