UMassAmherst

Lessons learned: Four years of actively using RFC ESP to inform reservoir management

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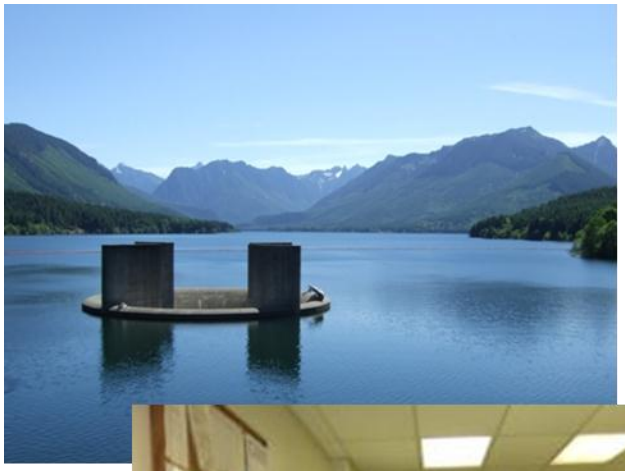
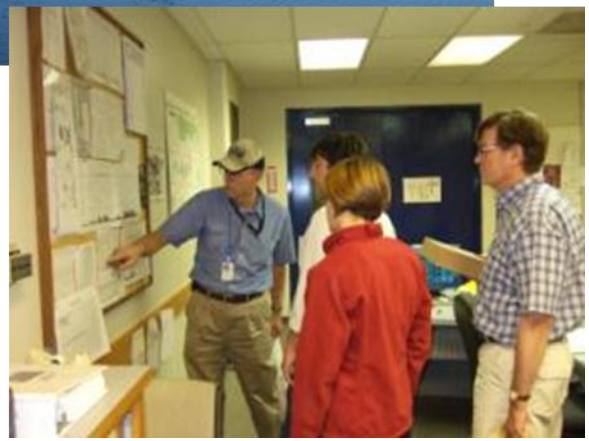
AGU Fall Meeting

Department of Civil and Environmental Engineering

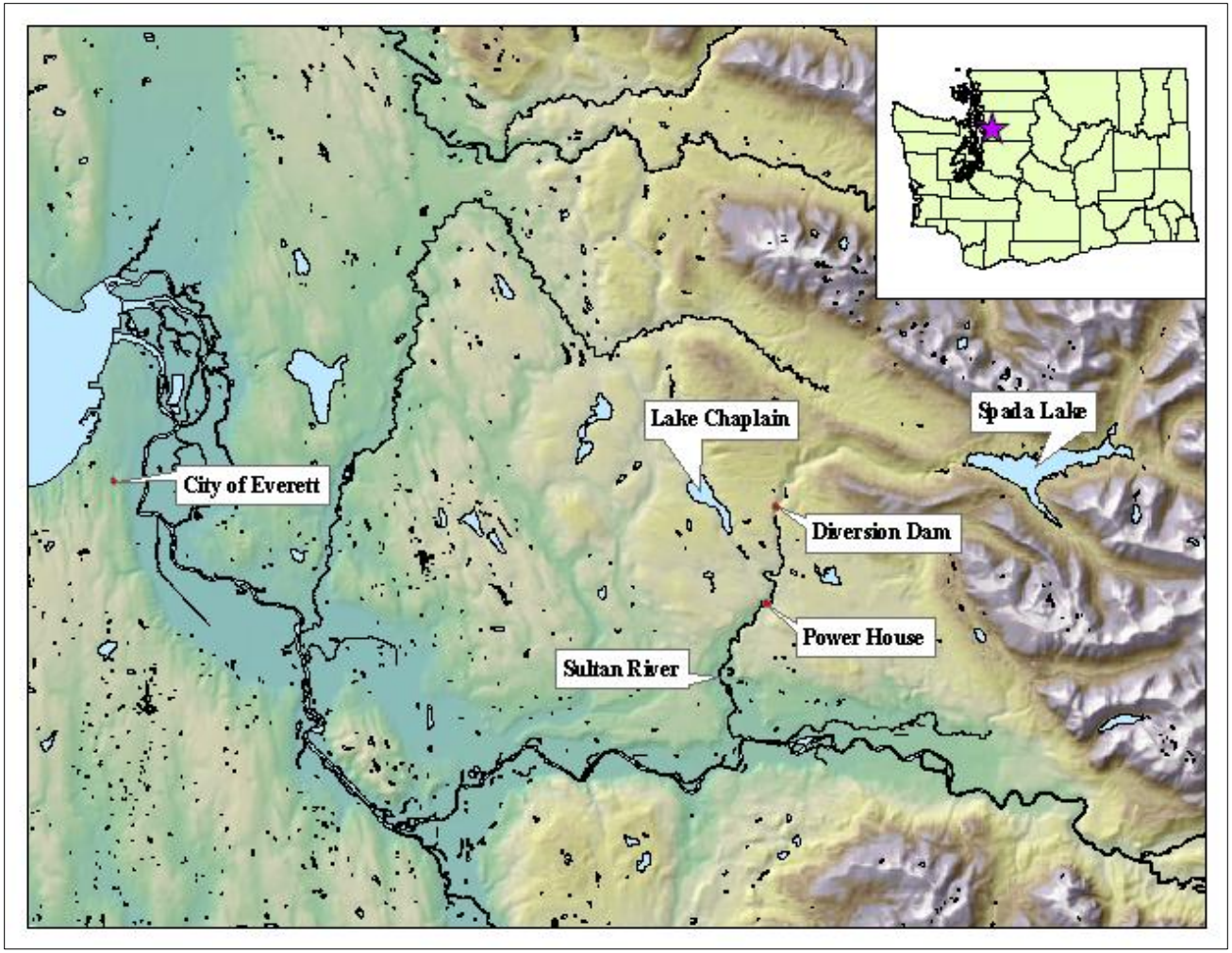
Outline

- Foundational Work
  - Alemu et al 2010
- Current Forecasting Scheme
  - Tuesday Morning Quarterback Club
  - Weekly operational forecasts
- Lessons Learned & A Look Ahead
  - NOAA SARP Project





Overview – Jackson Hydropower System



The Need For Forecasts

- Meet operational constraints while maintaining hydropower production
  - Water Supply, Environmental Concerns, Flood Management, Recreational Objectives
- Highly productive watershed
  - Water Year July to June
  - Average precipitation of 163 inches
- Short and long lead forecasts provide opportunity for adaptive management
  - Drawdown planning must be done over days to weeks
  - Advance planning can avoid spill or take advantage of energy prices

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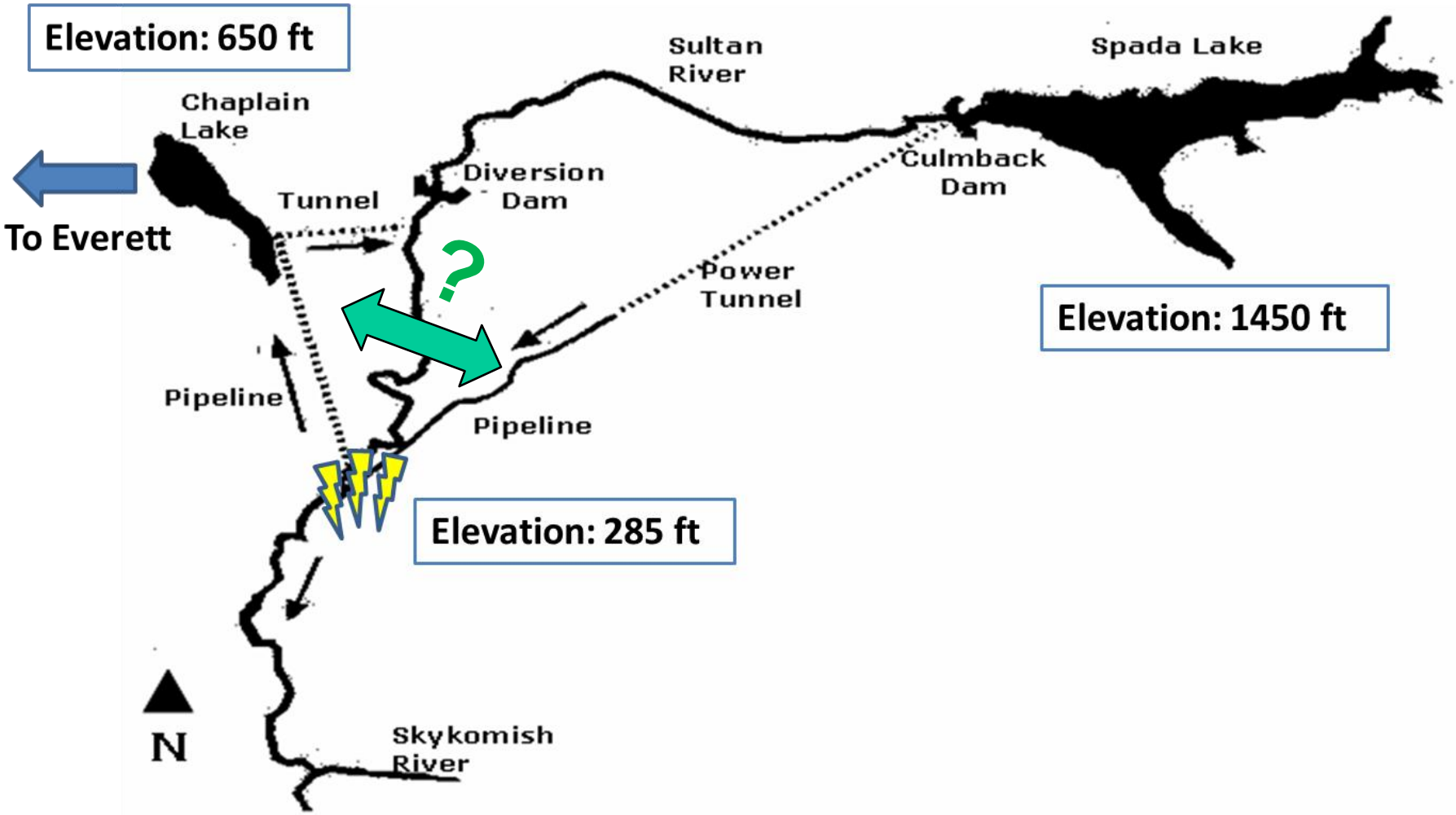
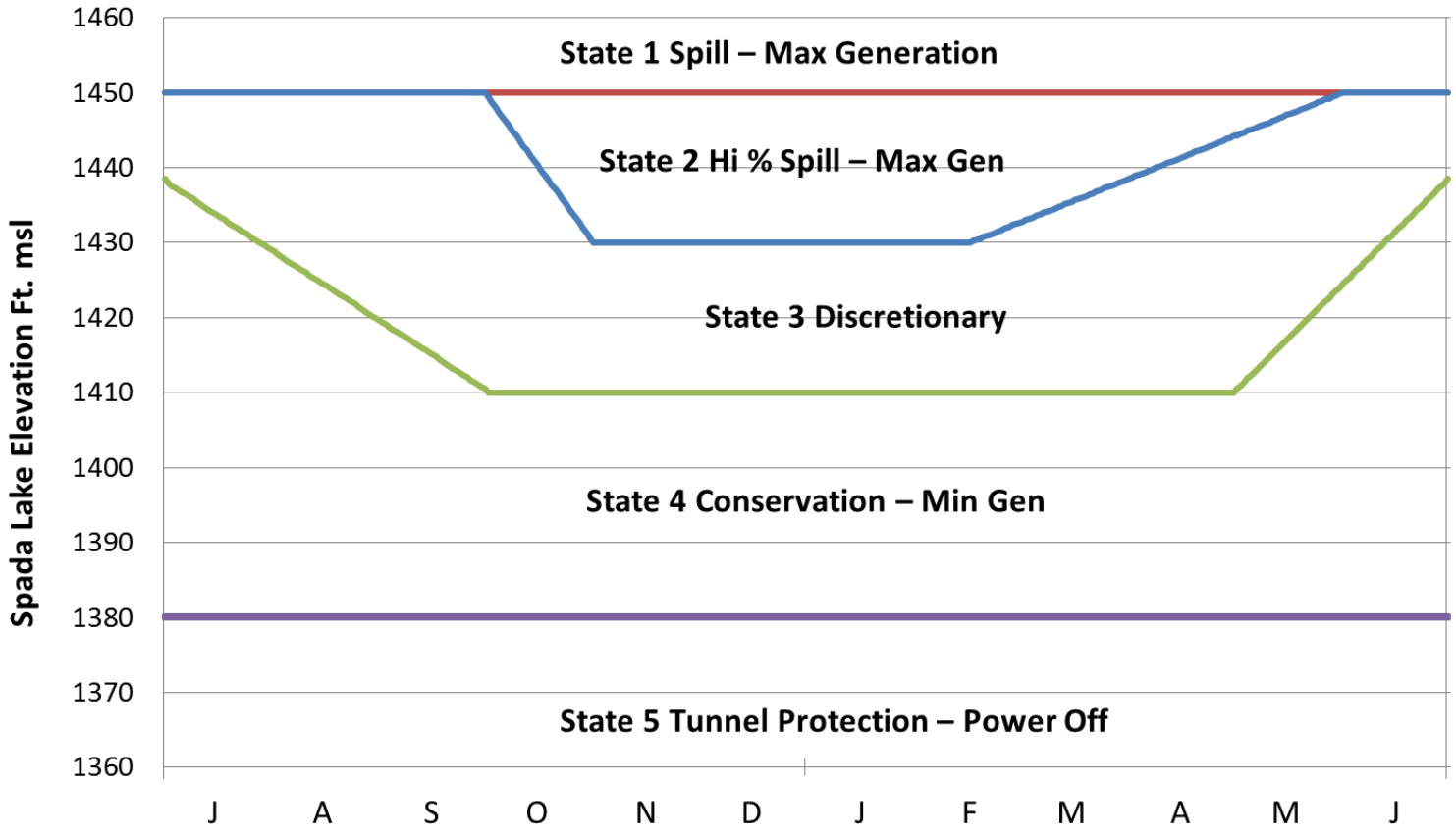
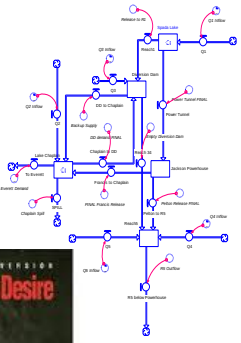


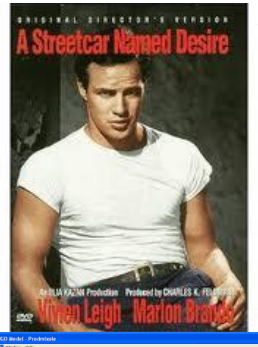
Operational Rule Structure

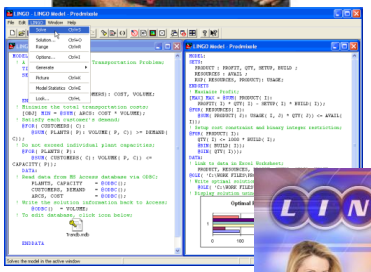


Foundational Work – Alemu et al. 2010

- Use retrospective hydrologic and energy price forecasts to drive the Decision Support System
  - *Retrospective Streamflow* - forecasts were created using a hydrology model (DHSVM) and past meteorological records to create an Ensemble Streamflow Prediction (ESP).
  - *Retrospective energy price* - forecasts were created by using current measured forecast error applied to previous spot energy prices
- Combined modeling approach – linked simulation and optimization framework





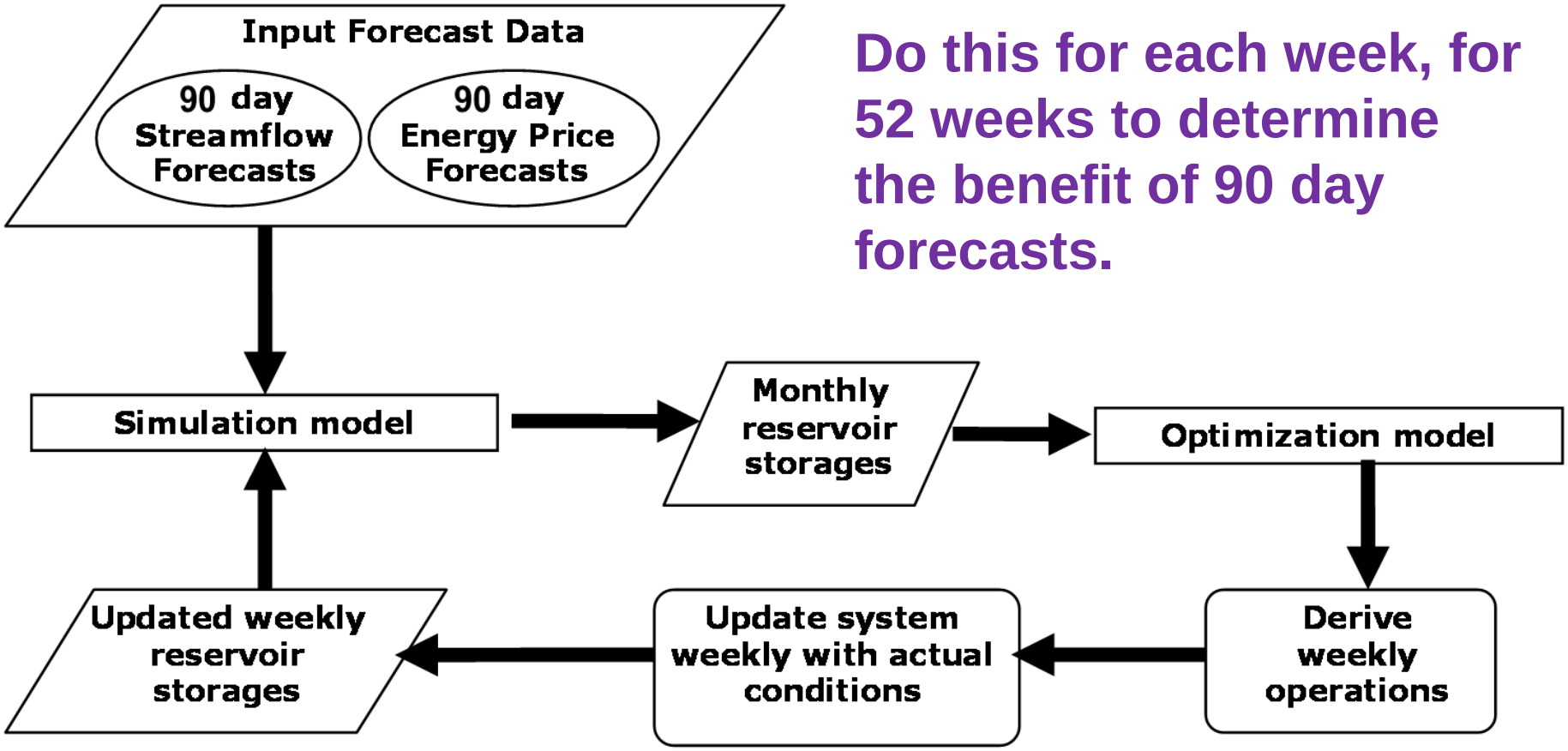


Proof of Concept - Method

- Use DSS to evaluate revenue gains in three hydrologically different years
- Compare the use of forecast information against 'perfect knowledge'

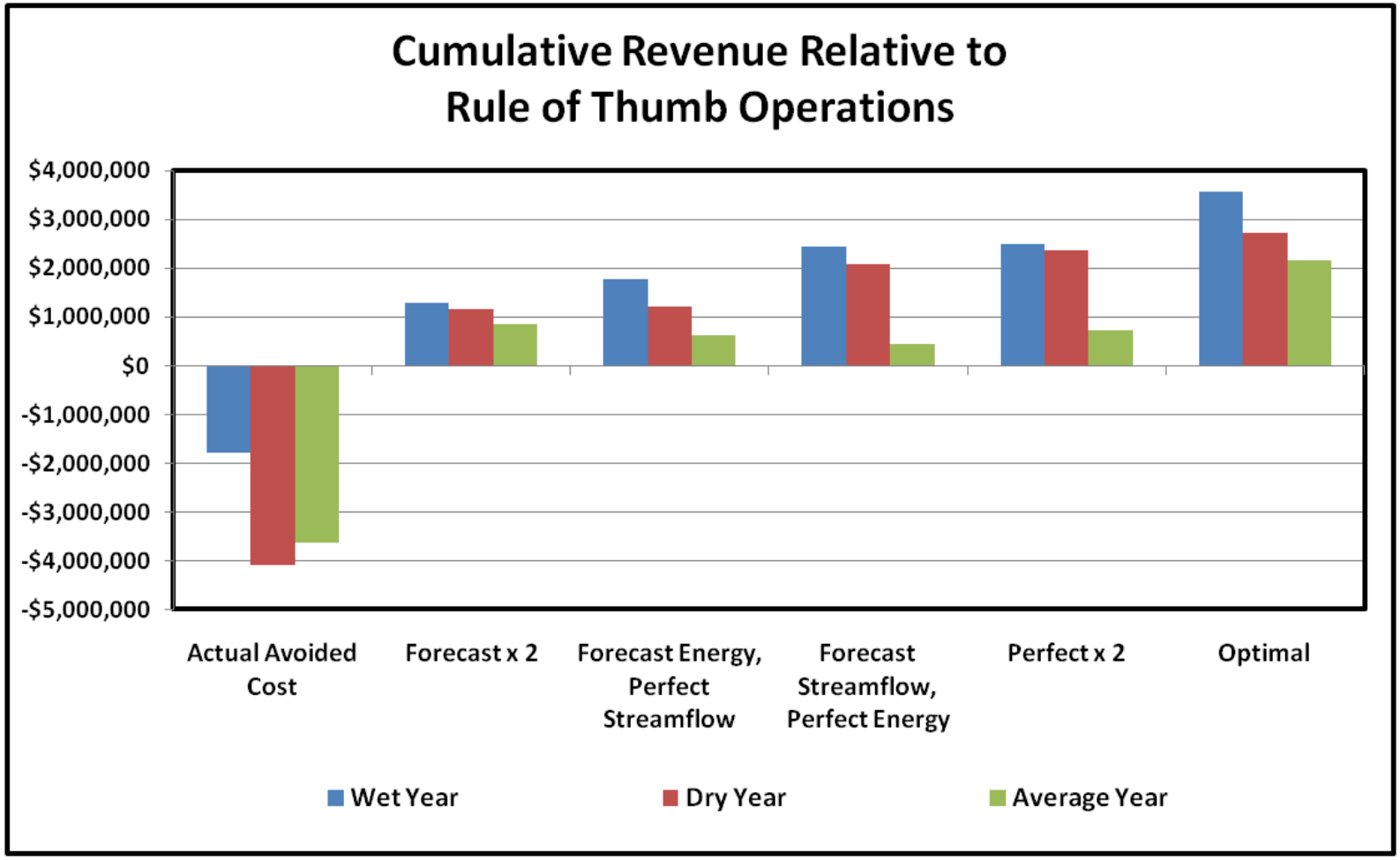
	Annual Inflow (AF)	Average Energy Price	Standard Deviation In Energy Prices
2001-2002	697,800	$25.93	$13.44
2002-2003	522,489	$31.07	$13.29
2003-2004	554,374	$39.49	$6.70

Proof of Concept - Method



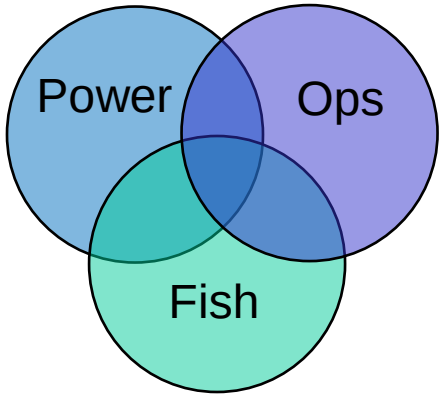
Do this for each week, for 52 weeks to determine the benefit of 90 day forecasts.

Proof of Concept - Results

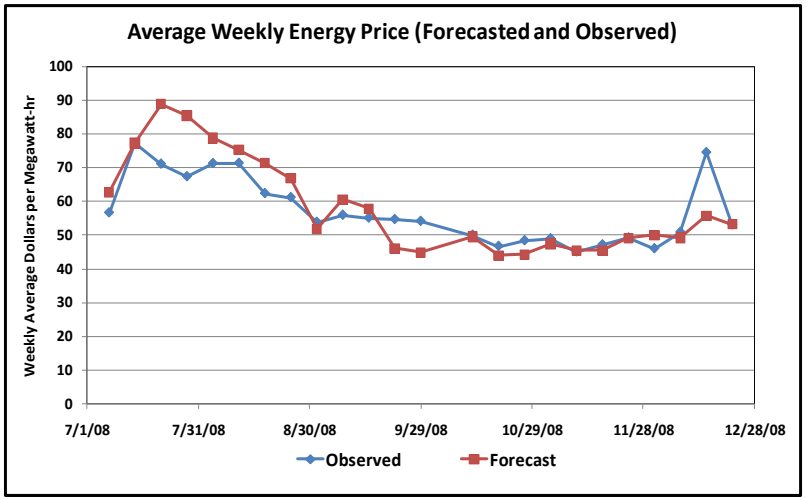


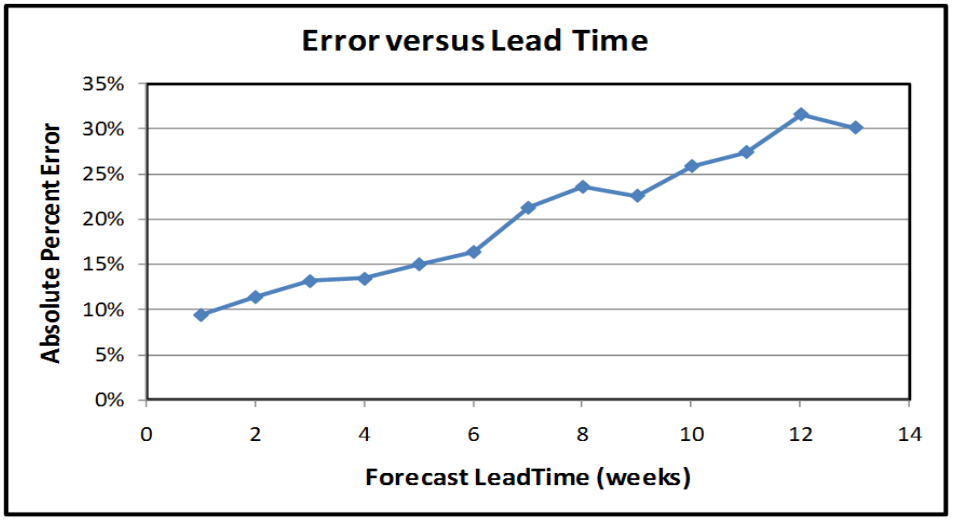
Current Forecasting Framework - TMQC

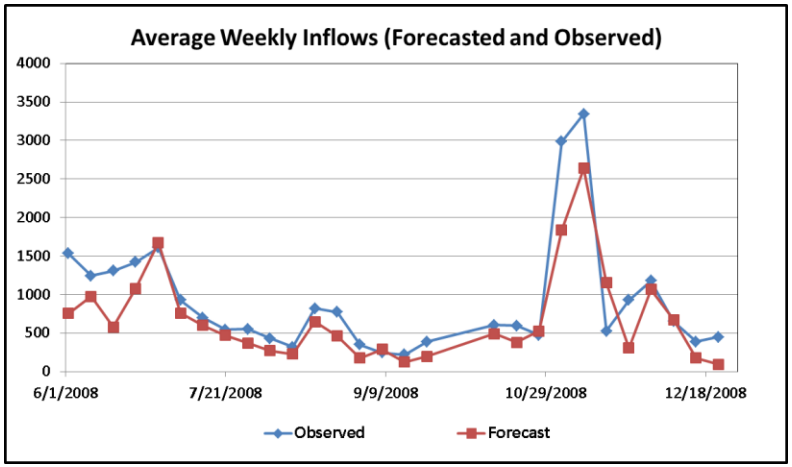
- Tuesday Morning Quarterback Club
  - Stemmed from work of Alemu et al. 2010
  - Weekly meeting between decision makers
  - Examine forecast for the week and make collective decision
  - Over 4 years of collaborative, informed decision making
- Organization has taken over responsibilities of incorporating ESP forecasts and modeling efforts into planning

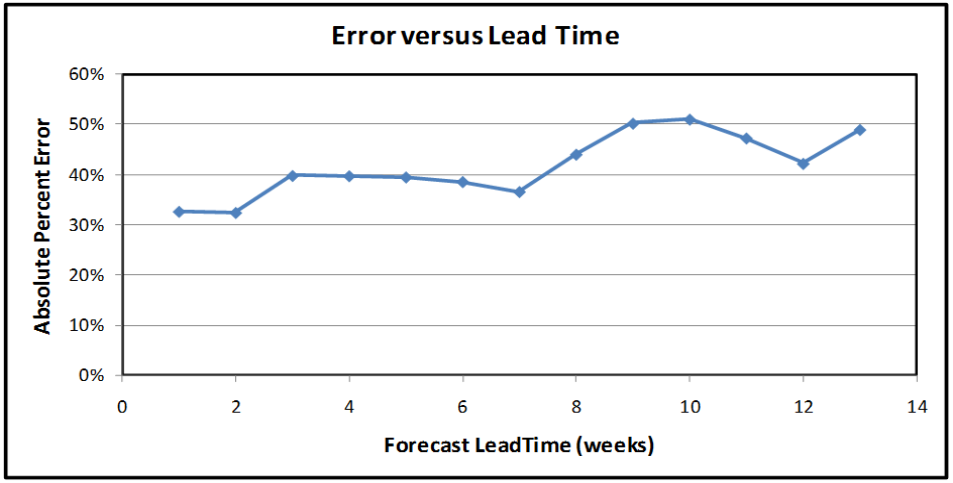


Slide About Quality of Forecasts









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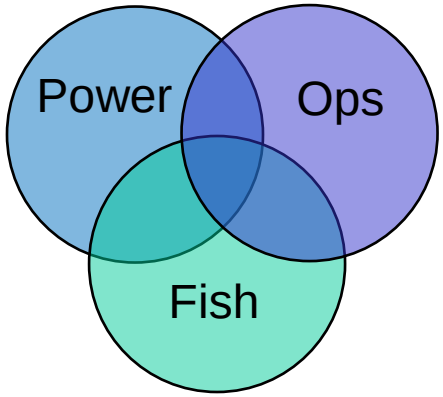
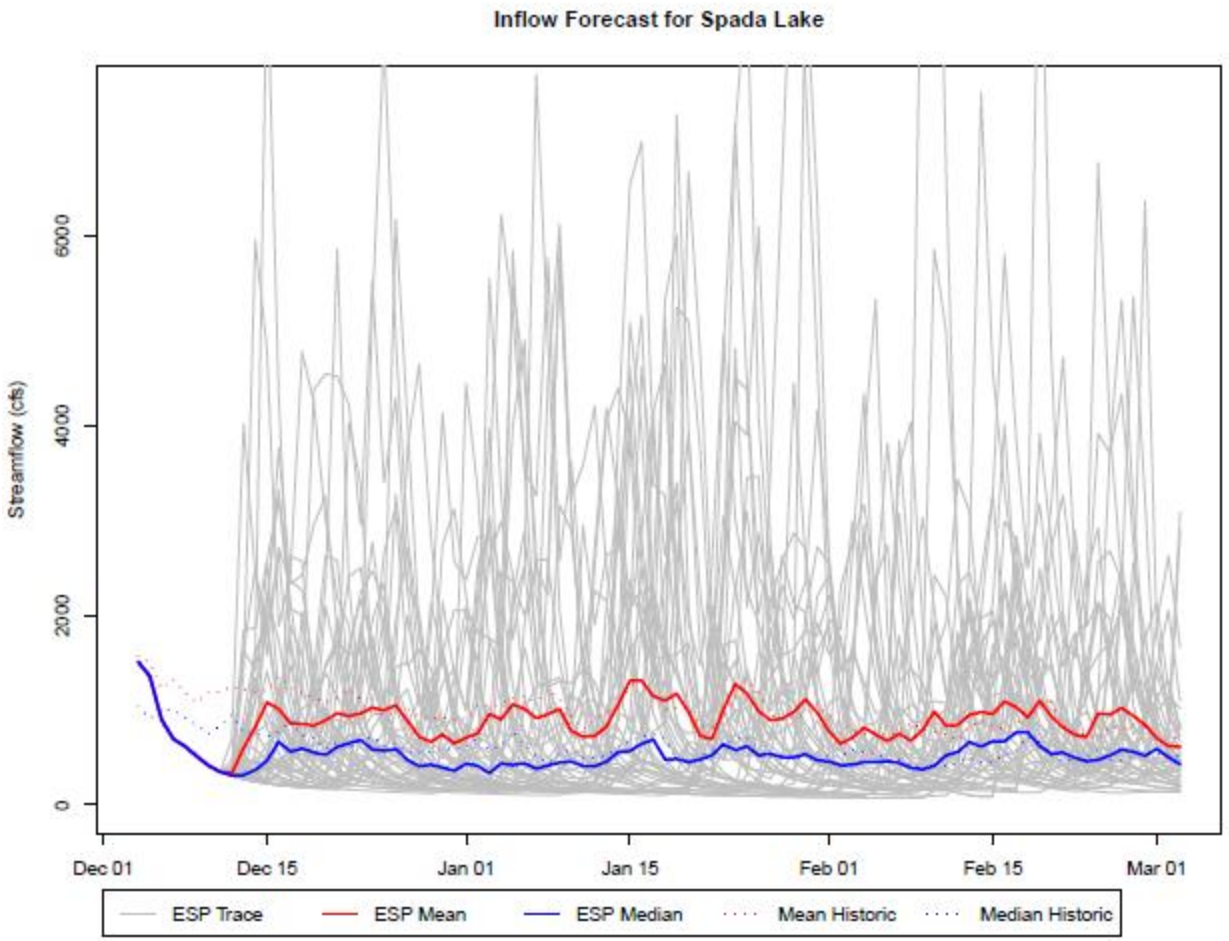


Examples of Weekly Forecast Information



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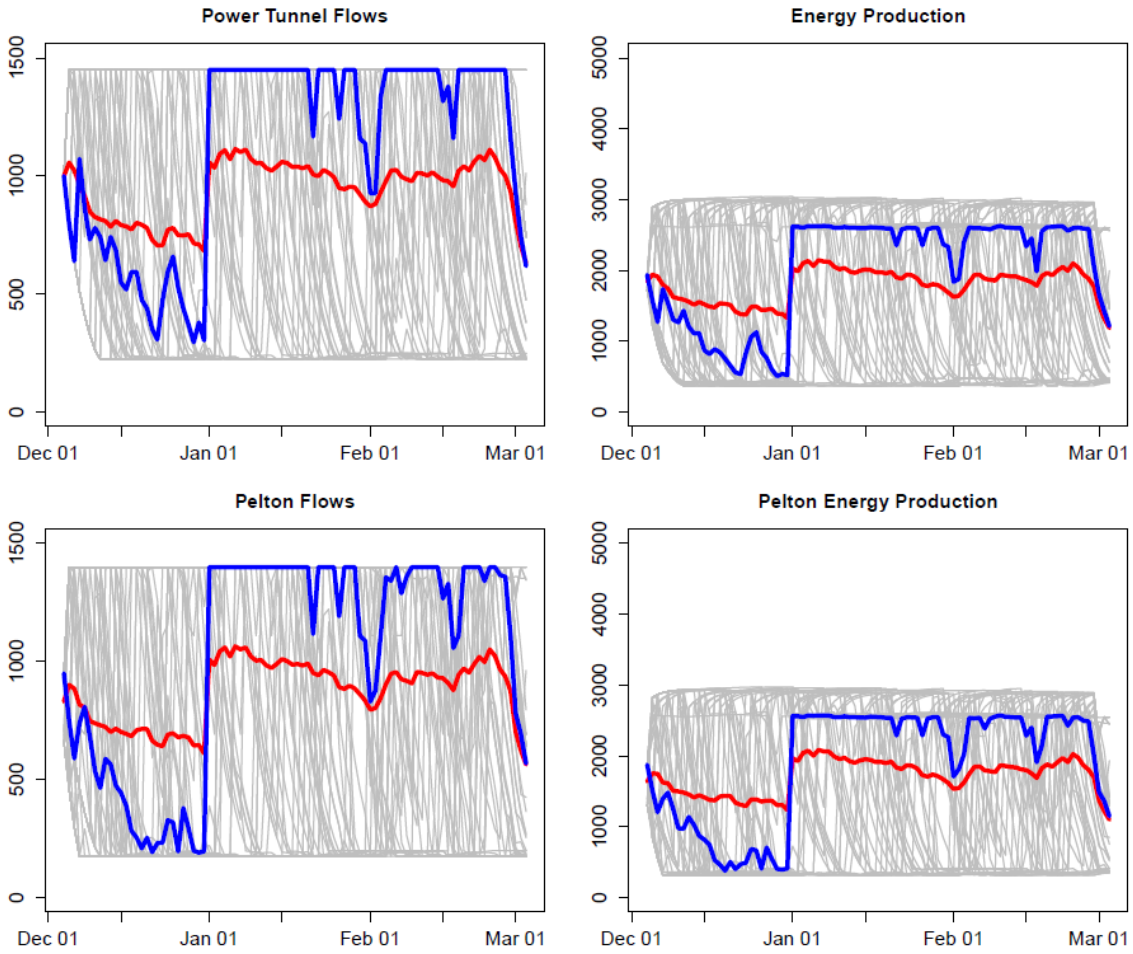

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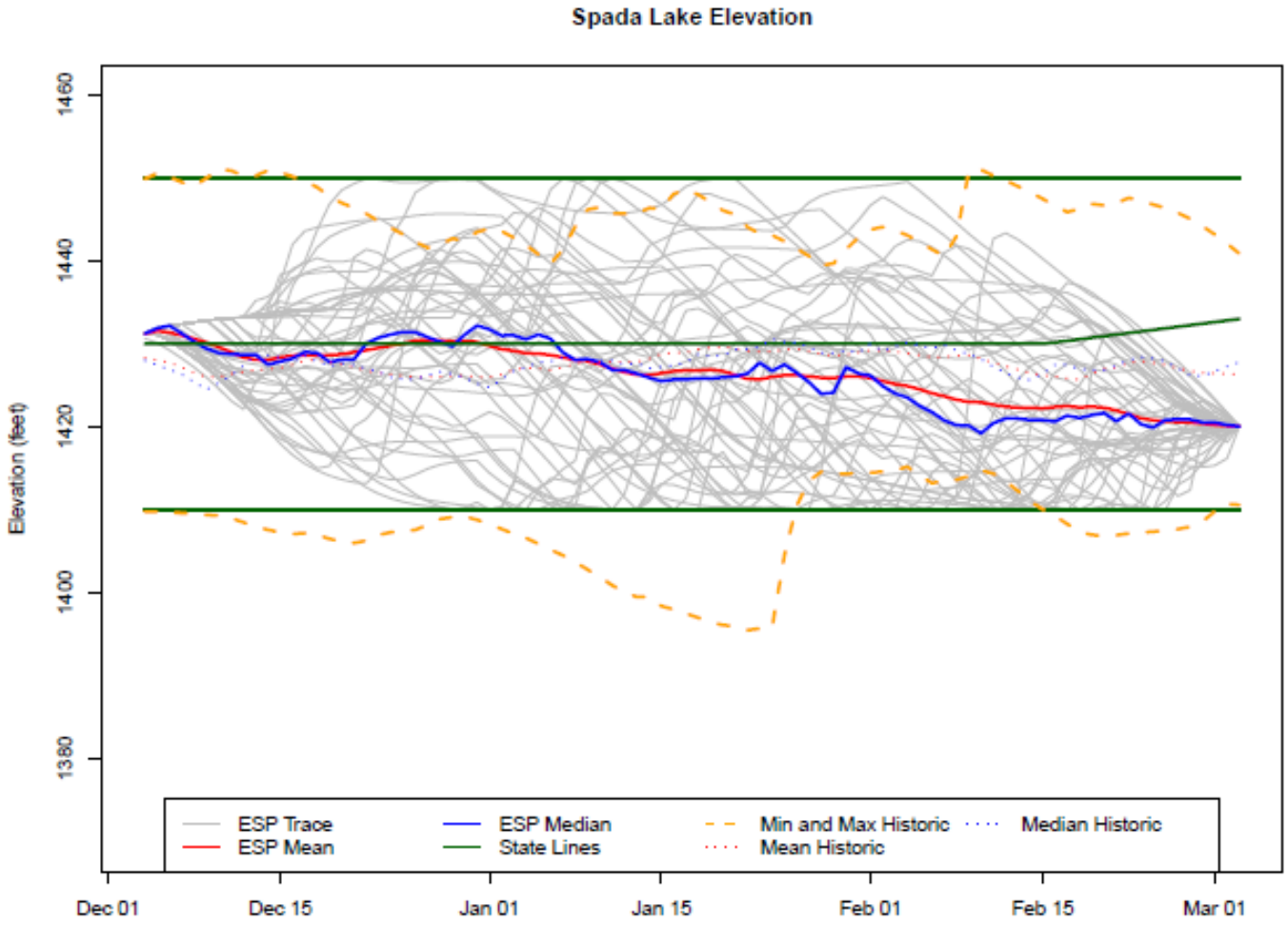


Lessons Learned

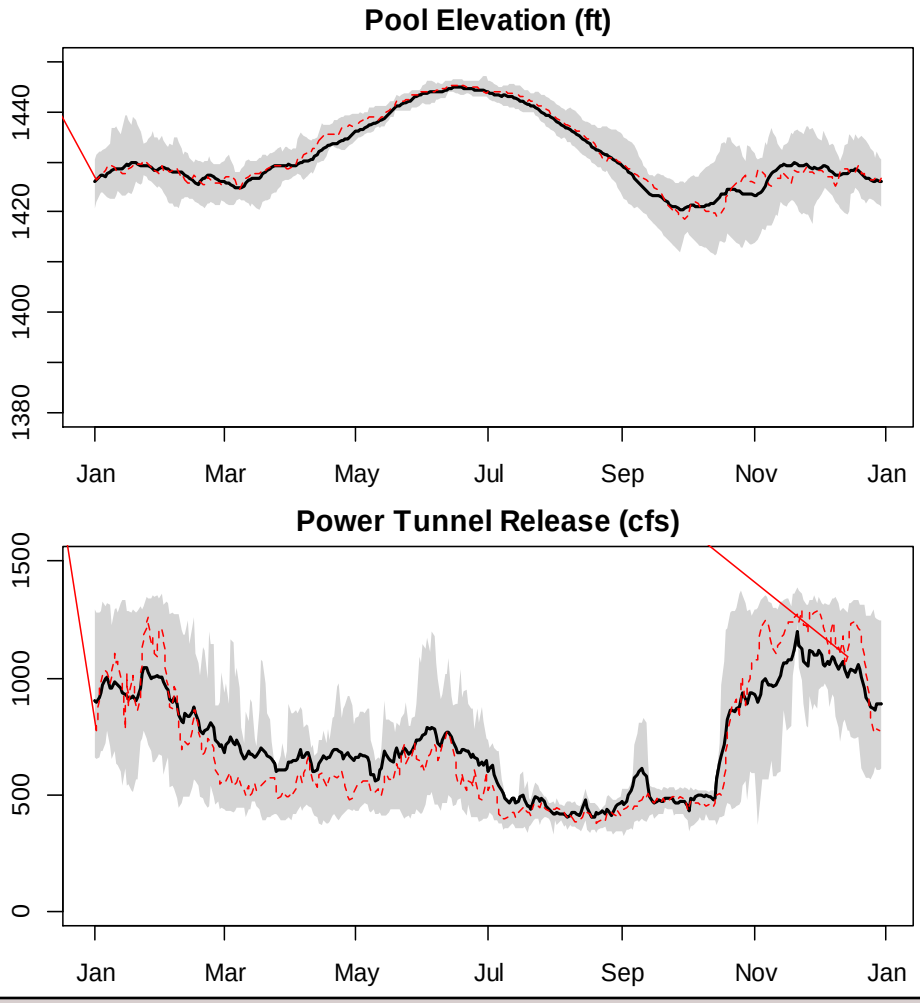
- When is a forecast useful?
  - Always!
    -
  - Especially useful in 'critical' decision periods and for ancillary operations
    - Maintenance scheduling, maintaining/planning fish flows, recreational releases, etc
    - State 3 is decision making location – forecast can take on more weight in decision making process

Lessons Learned

- When is a forecast useful?
  - Always…**just kidding**
    - Many times forecasts were unnecessary and SOP/stay the course implemented
  - Especially useful in 'critical' decision periods and for ancillary operations
    - Maintenance scheduling, maintaining/planning fish flows, recreational releases, etc
    - State 3 is decision making location – forecast can take on more weight in decision making process

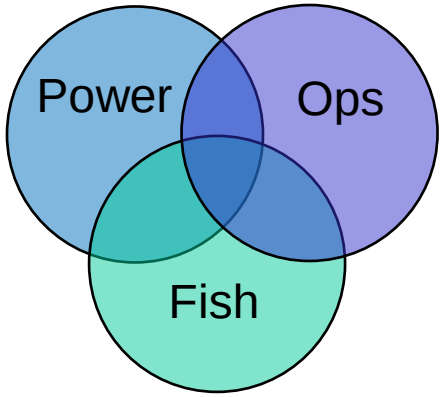
Critical Operating Periods

- When are Ensembles useful in decision making?
  - Drawdown and refill periods
    - How much latitude is there for hydropower
  - Critical periods tend to take a probabilistic lens
    - High or low in reservoir (Spill or power-off)
- Non-critical periods - tend to focus on the mean of ESP forecast



Lessons Learned

- Working with RFCs critical
  - Opportunity to strengthen bond between utilities and RFCs
  - More ESP members = conditioning (maybe better skill?)
- Forecast skill can be improved
  - Decent skill is critical for use in management!
- Large potential for including climate forecasts
- Potentially large role in flexible/dynamic FERC licenses
- Transfer of knowledge (retaining institutional knowledge)
  - Probabilistic thinking
  - Use of models and forecasting
  - Decisions made collaboratively

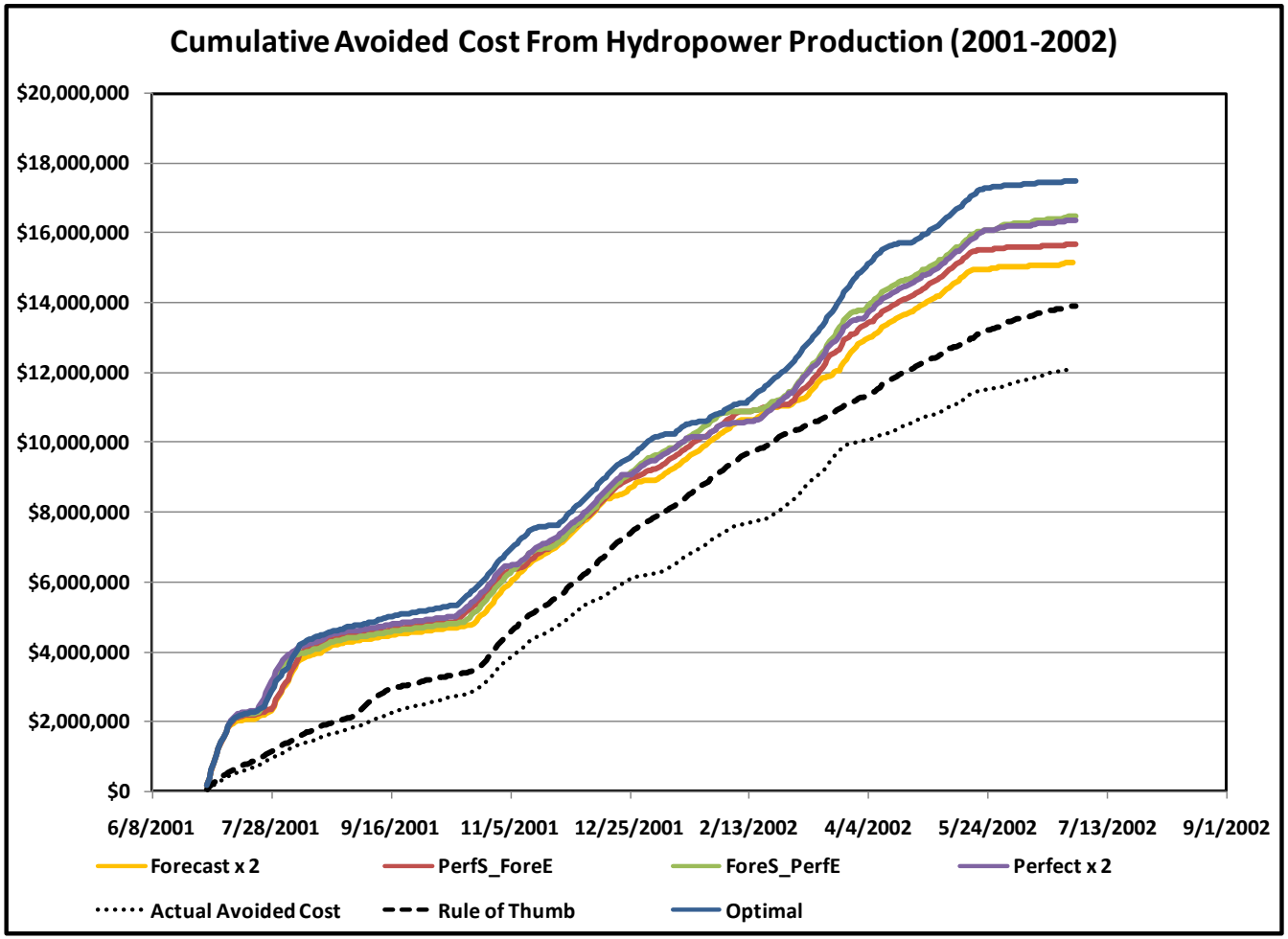


SARP – Integrating Climate Forecasts and Reforecasts into Decision Making

- NOAA SARP project
  - Working with RFCs to evaluate ensemble forecasts in context of water management
  - Compare climatology, GFS, and CFSv2
  - Evaluate critical periods
- Partnering with Dallas, SLC, SnoPUD and Pacificorp
- blogs.umass.edu/sarp

Thank You!

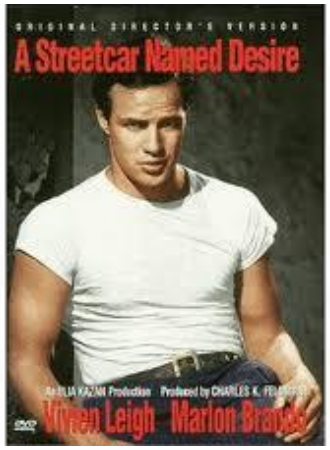
Proof of Concept - Results

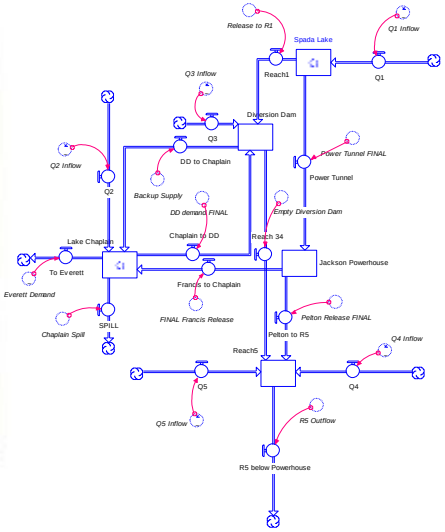


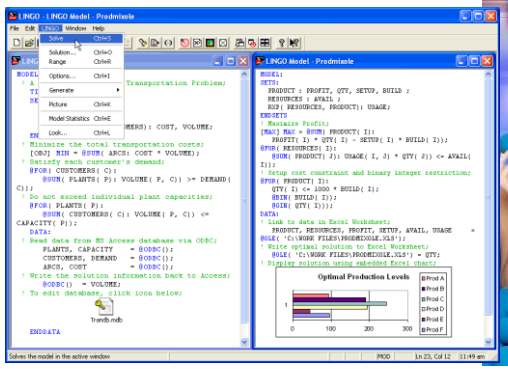
Models Used – Stella and LINGO

Simulation Model

- Simulates system operations at the Jackson Hydropower Plant
- Shows how water is routed through the system
- Incorporates variation in streamflow and environmental flow requirements
- Used to develop targets that constrain Linear Program







Models Used - Stella and LINGO

Linear Optimization Model

- Represents the hydrologic and hydraulic elements of the system in a linear mathematical framework
- Optimizes system operations using forecasts of streamflows and predicted energy prices
- Calculates the quantity and timing of reservoir releases that maximize energy production
- Uses environmental flows, target storages, and hydraulic capabilities as constraints