



# RiverWare and the Water-Energy Nexus

---

**Tim Magee**

Understanding the Water-Energy Nexus: Integrated Water and Power System Modelling  
September 28, 2016




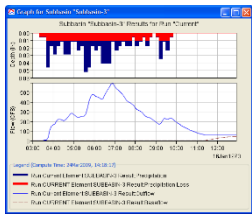


US Army Corps  
of Engineers



Center for Advanced Decision Support  
for Water and Environmental Systems  
UNIVERSITY OF COLORADO **BOULDER**

# RiverWare's Inputs and Outputs

 Hydrology  
 Forecast  
 OR  
 Historic Record  
 OR  
 Stochastic Ensemble  
 OR  
 Rainfall – Runoff Model



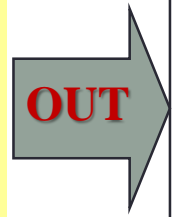
**Models interaction of**  
**Hydrologic response of**  
**River /Reservoir system**  
**(includes Hydropower)**



With



**Multi-objective**  
**operating policies**

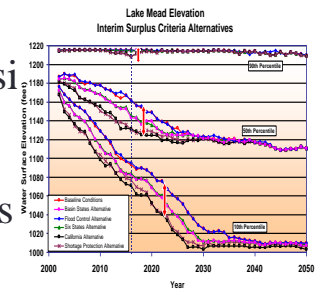


Values of Decision Variables,  
 Performance Indicators  
 Schedule for Operations  
 Water accounting data  
 Statistics  
 Reports



## Post-Processing

Export data to DSS, HDB, any DB  
 Export directly to Excel, Tableau,  
 netCDF, GPAT  
 Statistical Analysis  
 Policy Analysis  
 Tradeoff Analysis



# RiverWare Overview


- **Uses:** river system and reservoir operations and planning, hydropower scheduling, policy evaluation and negotiation, water rights accounting, climate change studies
- **Solvers:** Simulation, Rules, and Optimization
- **Accurate and flexible modeling:**
  - Physical process alternatives
  - Multiple objective modeling including hydropower
  - Basin specific prioritized policy
  - Customizable inputs and outputs
- **Analysis:** Solution path information, diagnostics and debugging tools, many output options

# RiverWare is Designed for Model Coupling, enabling Power System Analysis

- Automated data interfaces to databases, files, and spreadsheets
- Execute in batch mode via scripting
- Expanding integration with other tools
  - Deltares FEWS (with and without RiverWare GUI)
  - Corps Water Management System (CWMS)
  - Planned: National Weather Service Community Hydrologic Prediction Systems (CHPS)

# Water – Energy Nexus: Deployed Applications for Operations

## • Tennessee Valley Authority

- Hydrothermal Constraints, esp. Nuclear
  - Separate models 
  - Minimum flows, steady flows, flow ramping constraints
  - Issues usually in August when cold water has been used
- Value of hydropower with depth – “Block Costs”
  - Low priority
  - Reflects thermal generation and market alternatives
    - Pseudo joint optimization of hydro, thermal, and market resources

## • Bonneville Power Administration

- Reserve capacity modeling (partially because of wind)
- Spill priorities due to negative electricity prices

# Water – Energy Nexus: Research with DOE

- Oak Ridge Collaboration: [Integrated Hydropower and Wind Generation analysis on the Columbia Basin](#)  
developed framework for analysis -- (Magee et al., Final Report to ORNL, 2011)
- NREL collaboration: [Plexos and RiverWare](#) (Ibanez et al., 2014, Energy)
  - Plexos sends Block Costs to RiverWare
  - RiverWare sends hydropower to Plexos
- NREL collaboration (current project): [Modeling electric sector dynamics considering water quality](#): add REPRA and GateCycle
  - Model curtailment from hydrothermal issues
  - New “Power Plant” object in RiverWare
- Proposed Future:
  - [Co-optimize hydropower and other power at a grid level](#) while including the hydrothermal effects
  - Ancillary services
  - Multiple time scale planning