Application of RiverWare for Hydropower Optimization of the TVA Reservoir System

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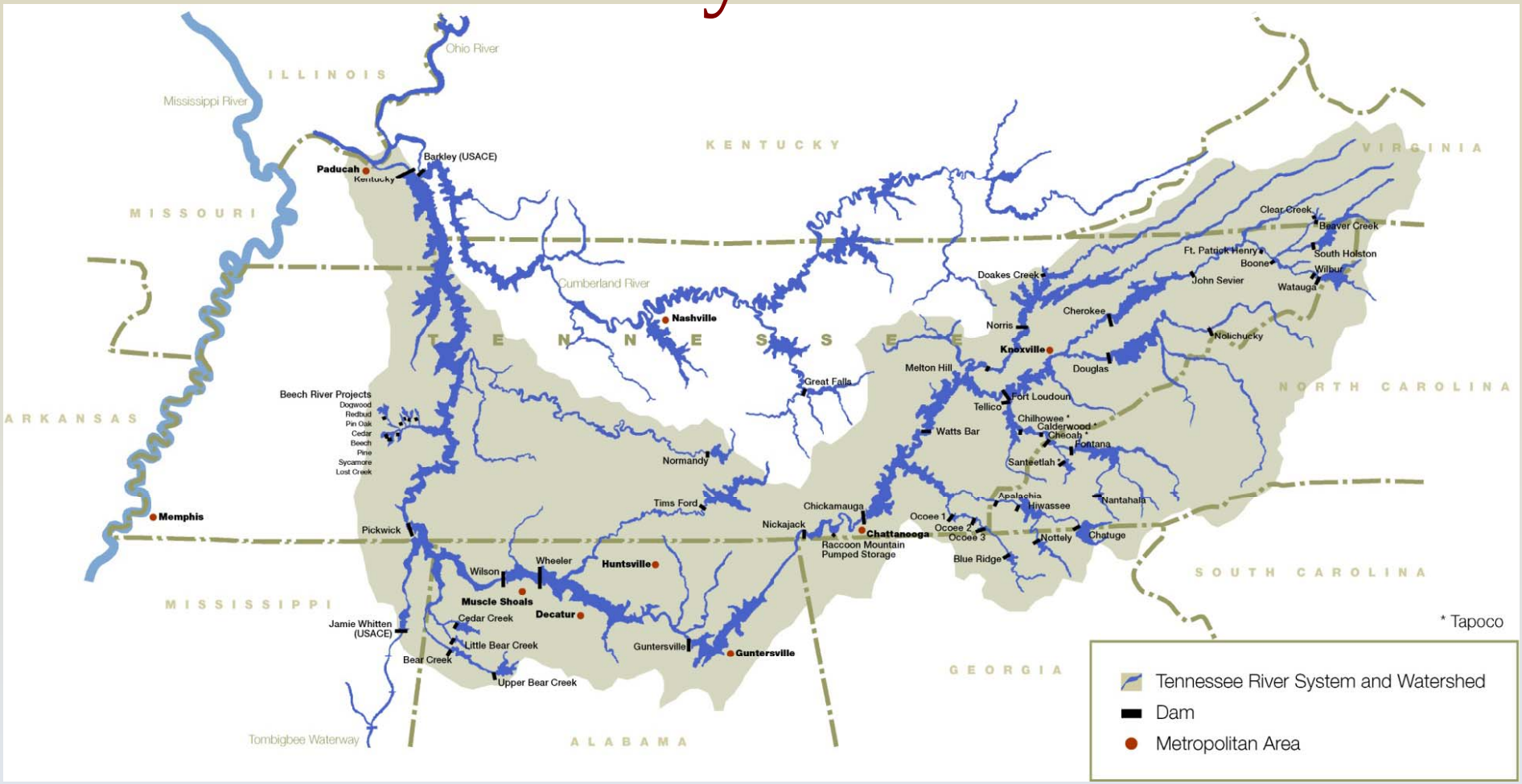
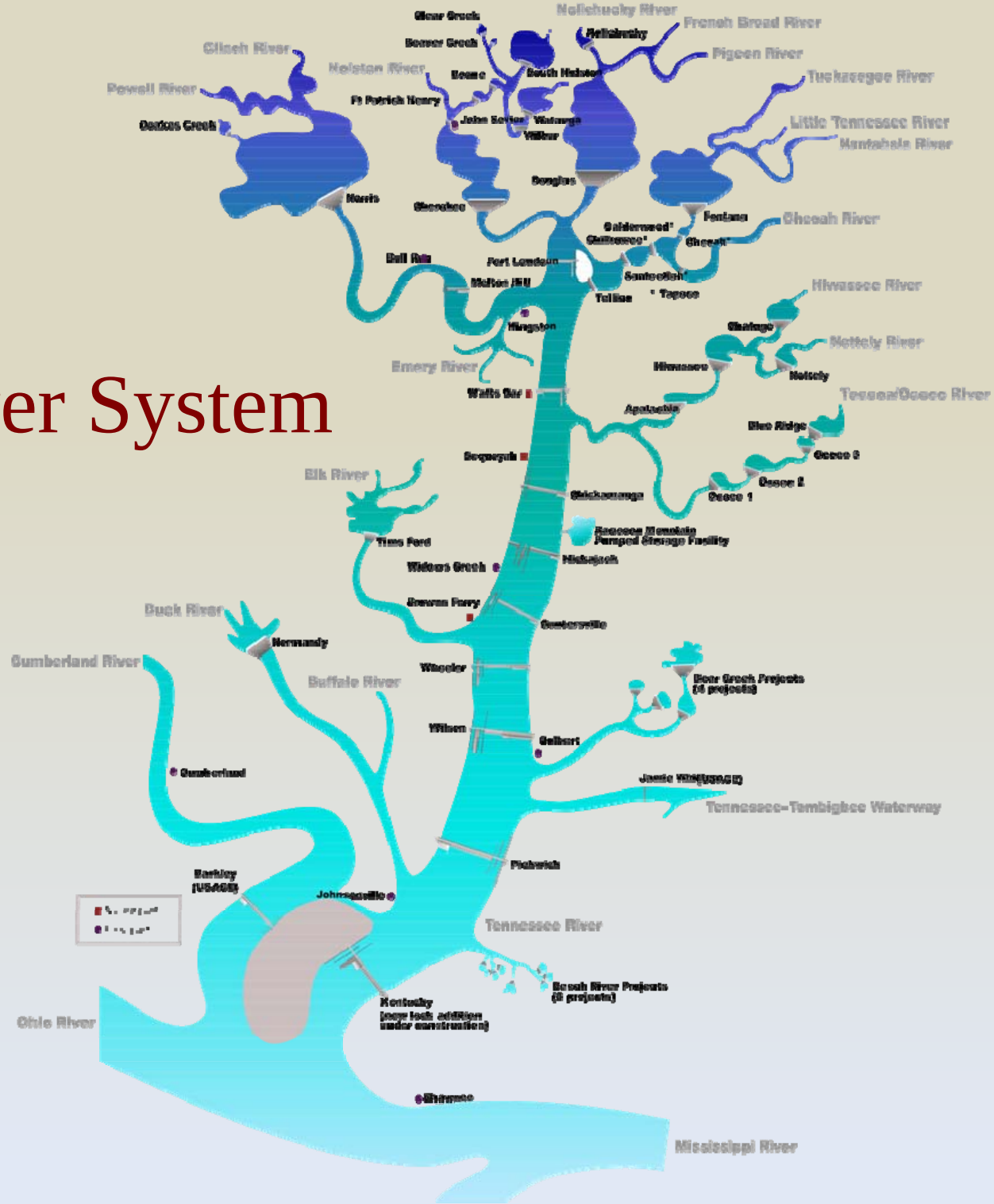
Tennessee River System

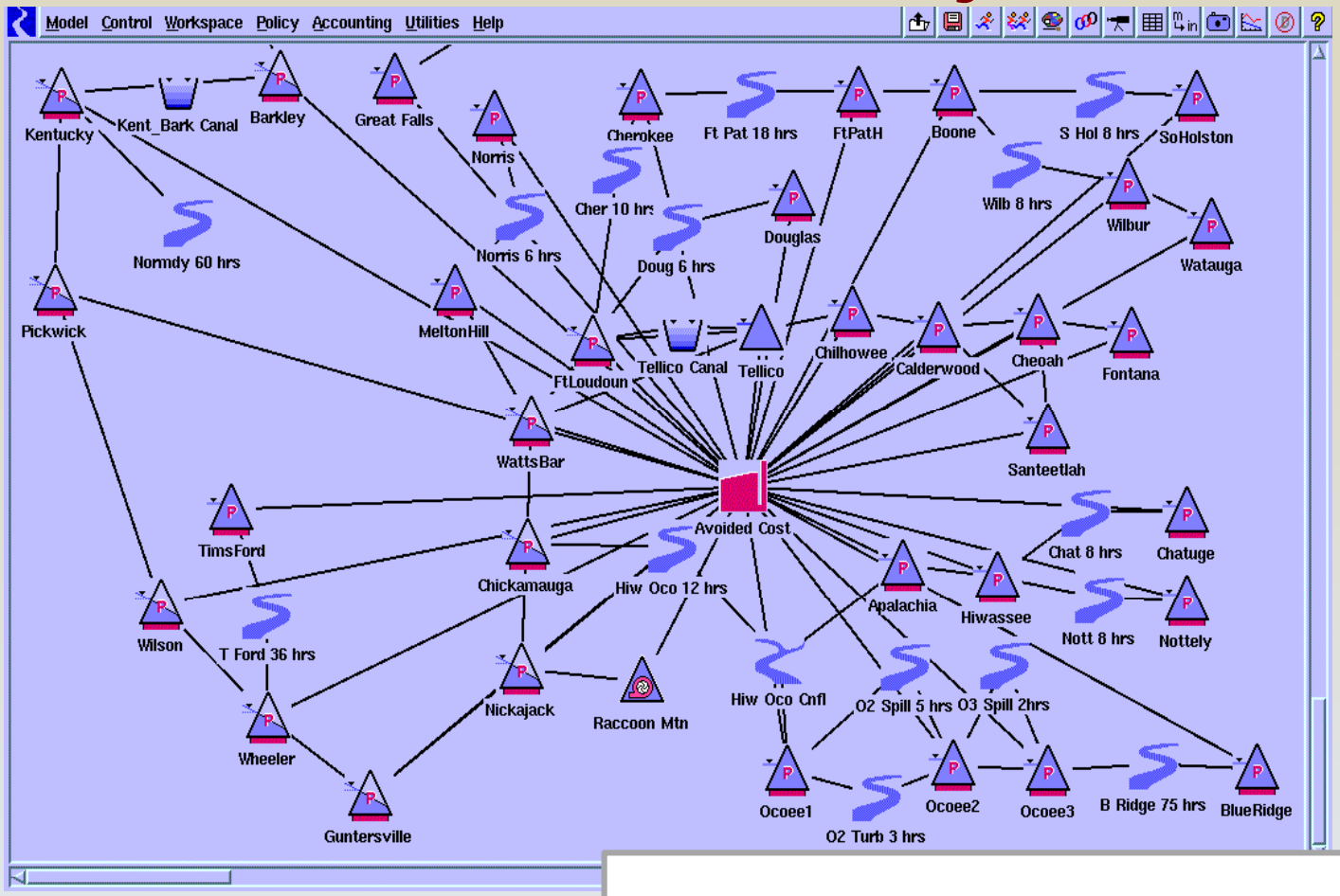


Conceptualized Version

Tennessee River System



Modeled Reservoir System



The reservoir system is modeled as a whole for hydropower optimization.

Optimization considers power economics plus other demand on the reservoir system

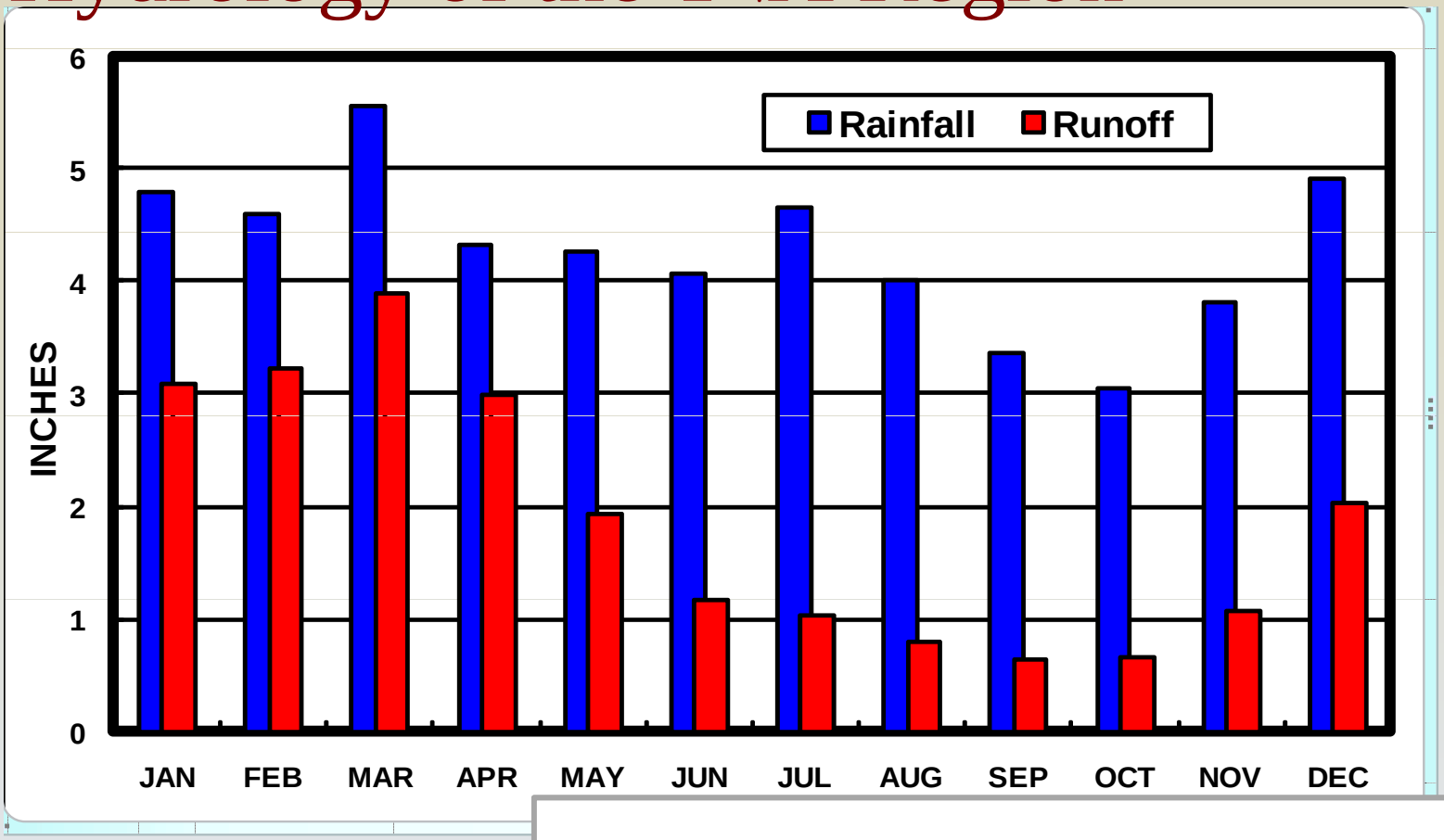
- Flood control
- Navigation
- Recreation
- Water quality
- Water supply
- Special operations





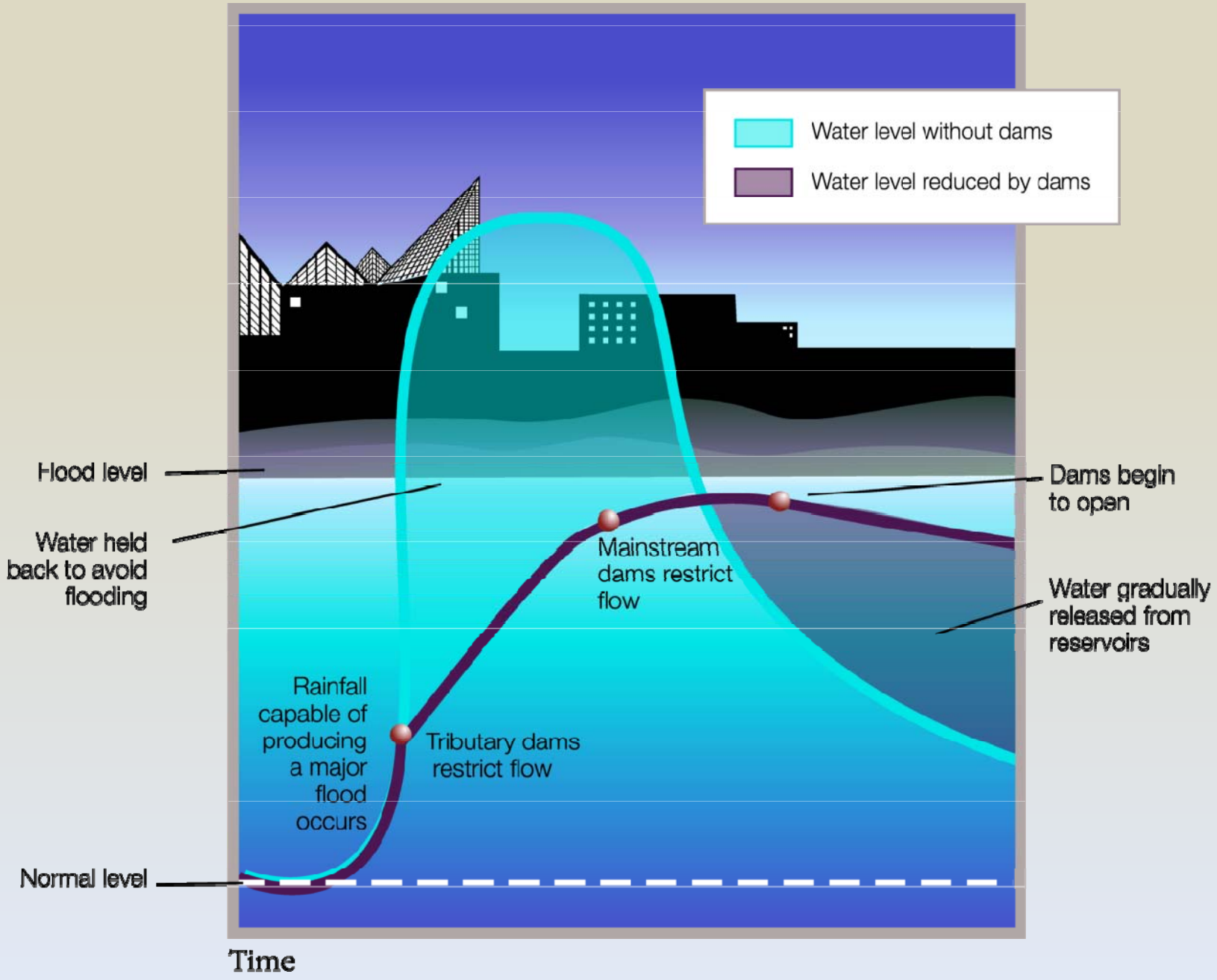


Hydrology of the TVA Region

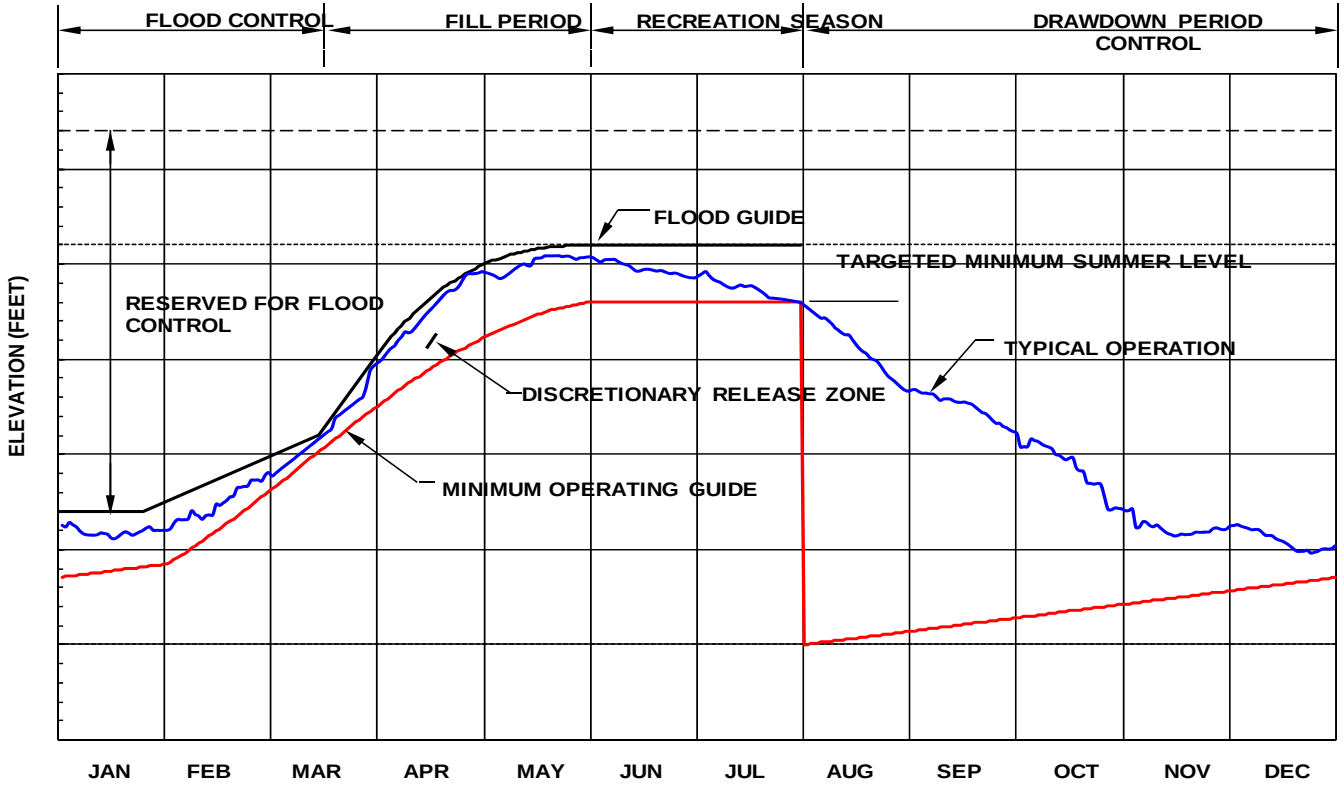


Average annual rainfall above Chattanooga is about 51 inches and runoff is about 22 inches.

How a Flood is Flattened

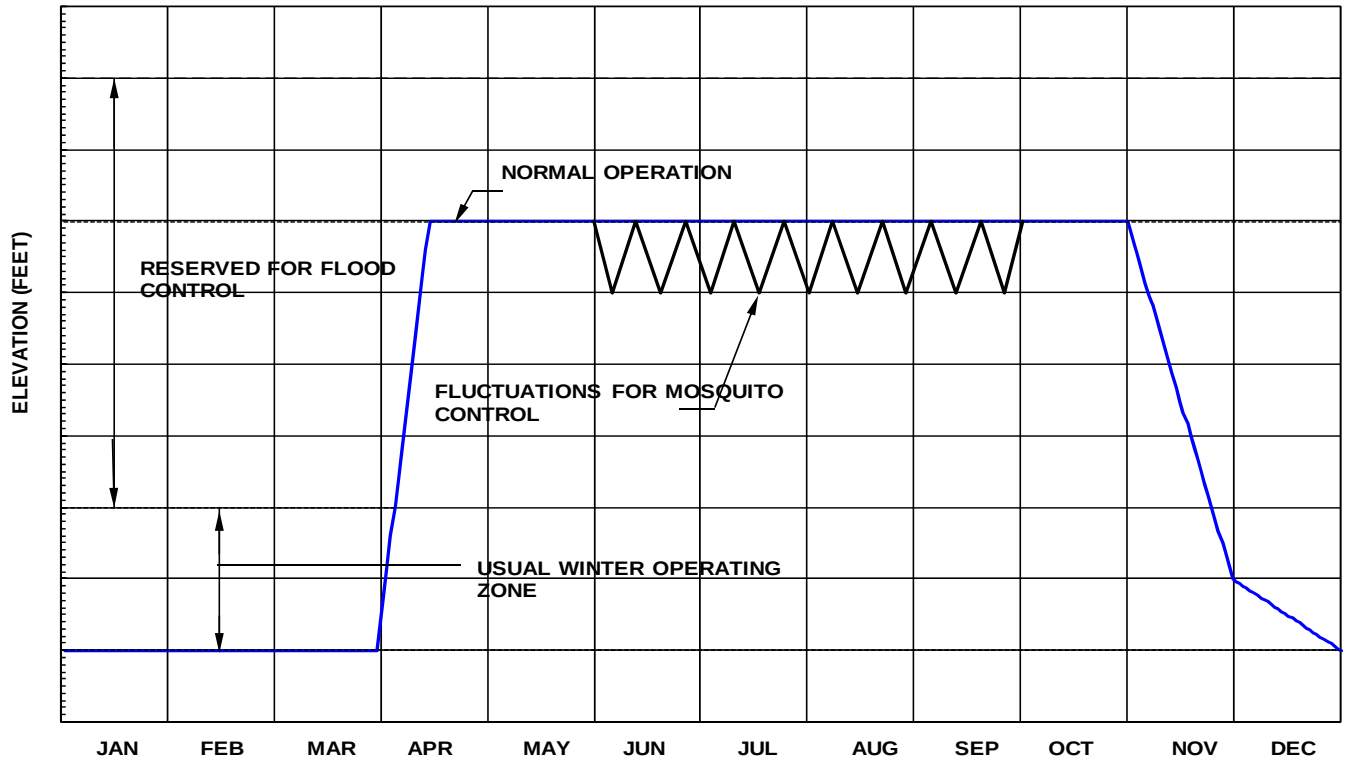


Tributary Storage Reservoir Guide Curves



Guide curves are part of the constraint set.

Main River Reservoir Guide Curves



Guide curves are part of the constraint set.

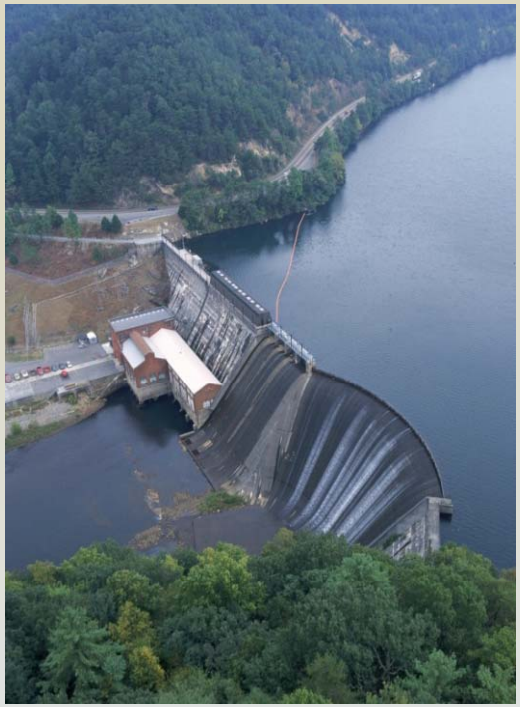
River Scheduling Staff Responsibilities

- Forecasting unregulated inflows to the TVA system.
- Determining the amount of water stored and released at each hydro plant over the next 10–12 days.
- Interfacing with the public on real-time operations and operating policies.
- Monitoring the system.

River Scheduling Teams

- Forecast Center is staffed 24 hours per day, 7 days a week.
- There are forecasting “teams” which work 12-hour shifts.

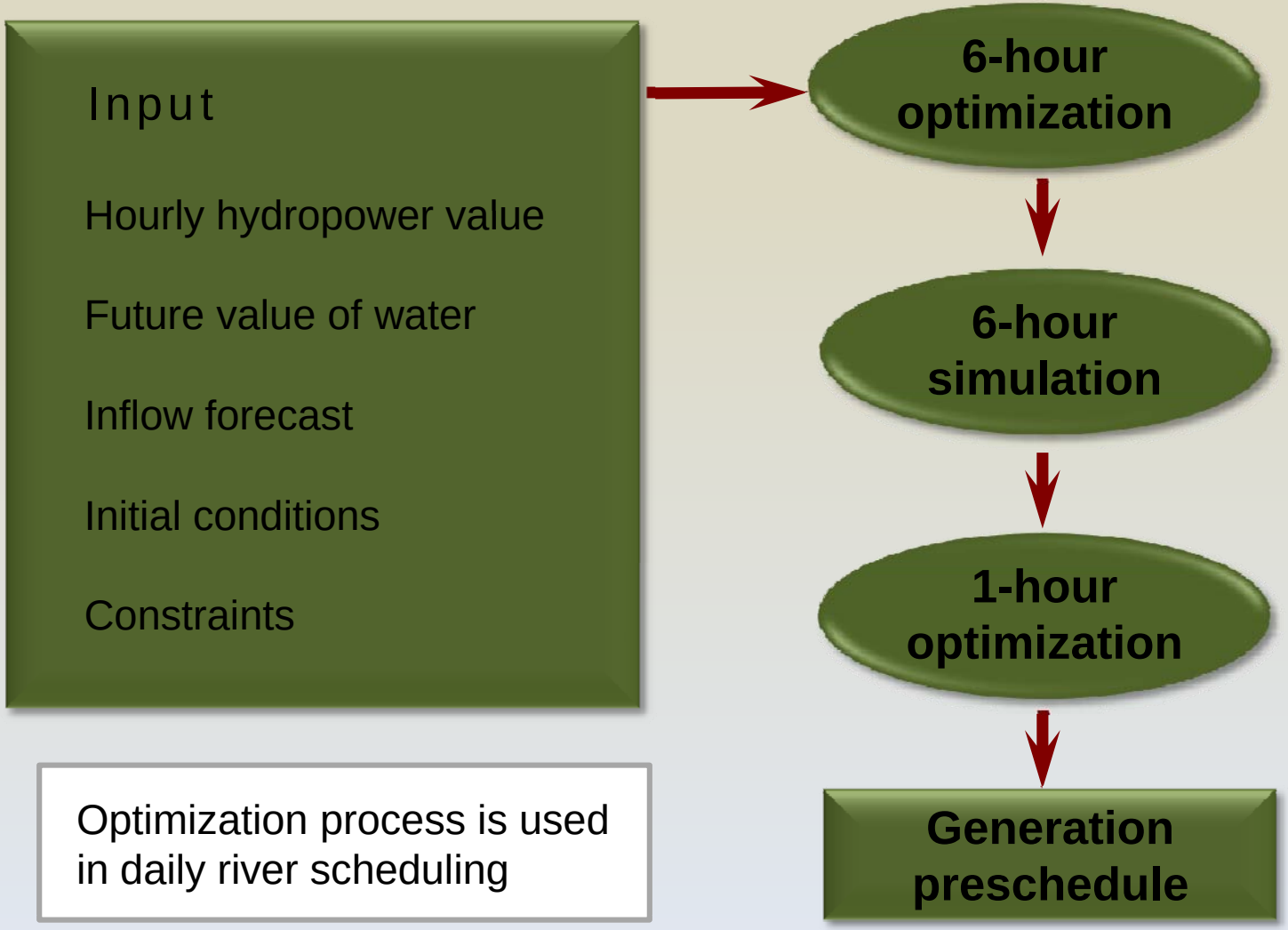
- Teams are comprised of 2–3 engineers and 1 technician.
- Computer specialists are on call 24 hours per day.



Using RiverWare

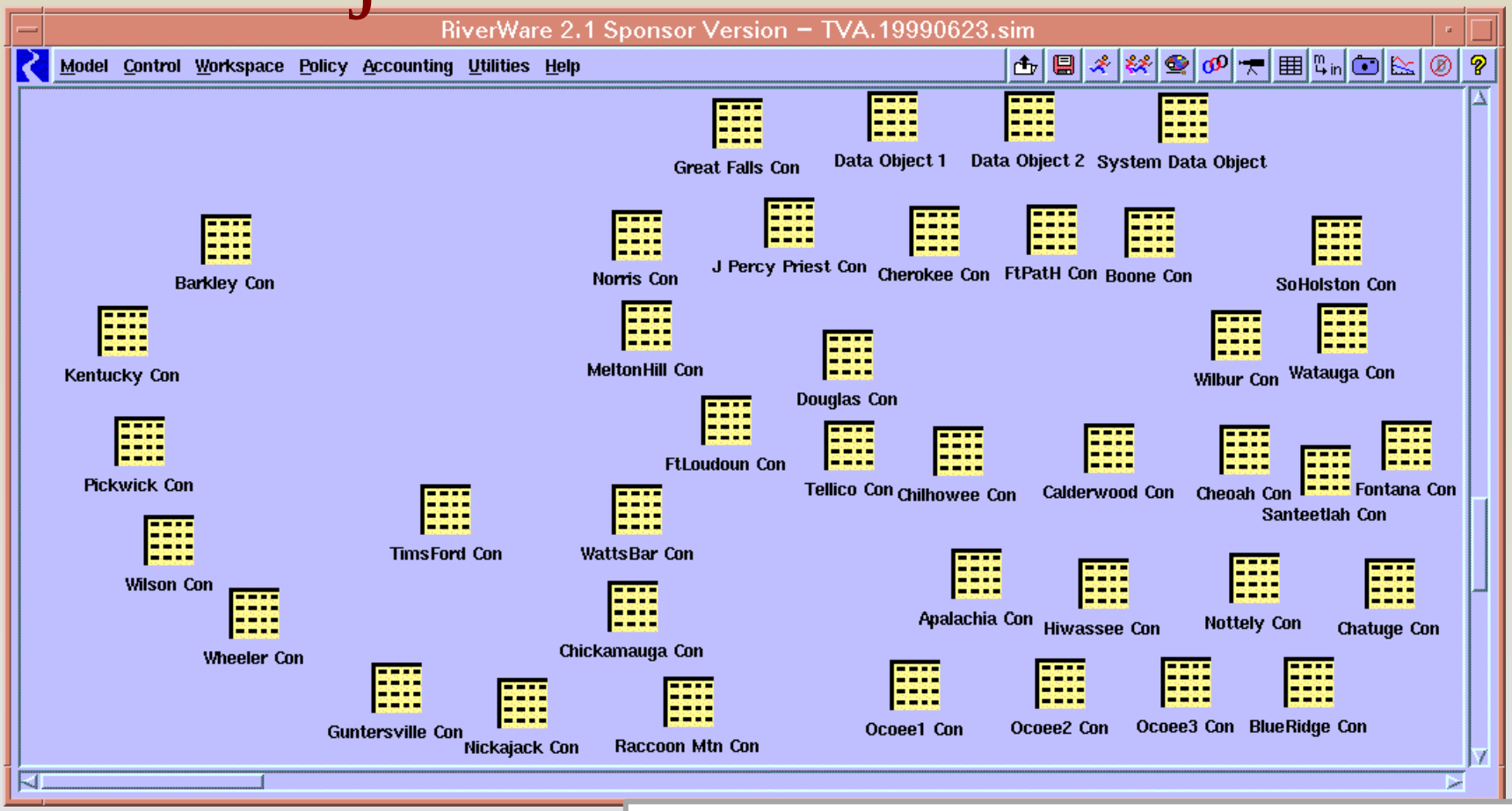
- Teams issue 2–4 river forecasts per day.
- RiverWare simulation has been used for producing final schedules since 1996.
- Optimization has been used as guidance for final scheduled since 1998.

Optimization Process



Optimization process is used in daily river scheduling

Data Objectives



Data objectives are used to specify variables used in constraints.

Modeling Constraints

- Current day operating scheduling (all reservoirs).
- Forecast period operating schedule for Kentucky and Barkley Reservoirs.
- Target elevations for nonstorage reservoir (tributaries and main river).
- Canal slope on Kentucky-Barkley Canal.

Constraints are Used in Modeling the River System

- Top and bottom of daily operating zone on nonstorage reservoirs (tributaries and main river).
- Minimum flow requirements.
- Minimum operating guides (tributary storage reservoirs).
- No spill.

Many Constraints are Used in Modeling the River System

- Allowable pool fluctuations
- Ramp rates
- Flood guides
- Special operations
- Balancing constraints for storage reservoirs
- Objective functions

Special Operations

Over 200 special operations are completed each year.

- Whitewater recreation
- River cleanups
- Mosquito fluctuations
- Dam safety inspections and maintenance
- Unit maintenance
- Special releases for thermal compliance

Data requirements in addition to those used for simulation modeling

- Forecasts of hourly hydropower values for optimization period.
- Expected future hydropower value of stored energy (beyond end of optimization period).
- Constraints

Objective functions are used for hydropower optimization

- Maximum sum of hydro project net avoided costs.
  - Net avoided cost = maximum avoided operating cost + cumulative value of storage.

Optimization Produces

- A hydropower generation schedule that utilizes the flexibility of the reservoir system.
- A schedule that is for 7 days in 6-hour timesteps.
- A 1-day hourly timestep optimization model.