Water Resources Modeling Simulation Modeling

Dr. Samuel Sandoval Solis
Professor and Specialist in Water Resources Management
UC Davis – UC Agriculture and Natural Resources

UC DAVIS WATER MANAGEMENT LAB

University of California Agriculture and Natural Resources

UC DAVIS UNIVERSITY OF CALIFORNIA

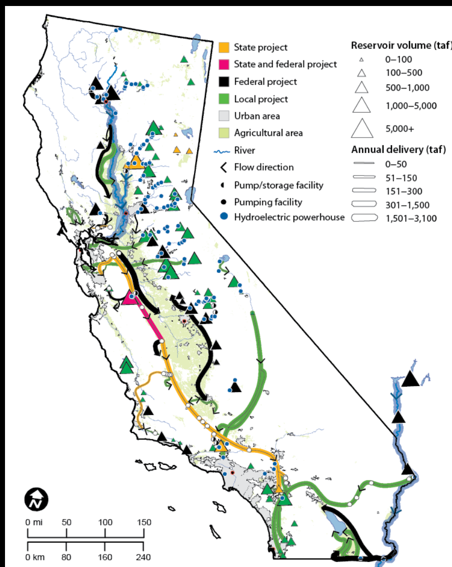
Outline

- Water Resources Modeling
- Simulation Modeling

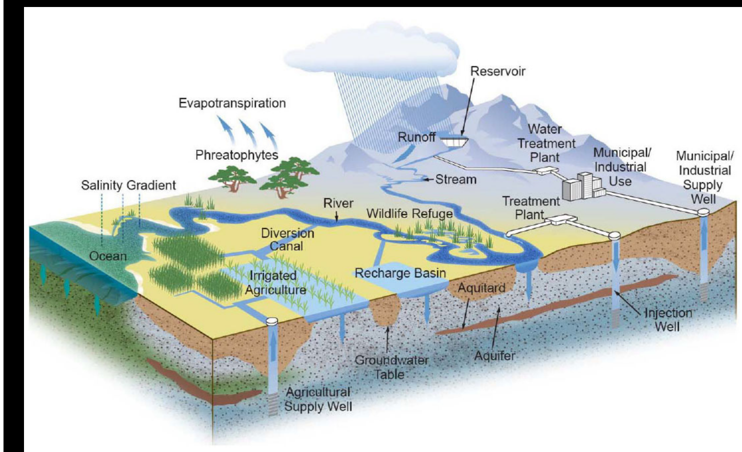
UC DAVIS WATER MANAGEMENT LAB

Water Resources Systems

UCDAVIS WATER MANAGEMENT LAB

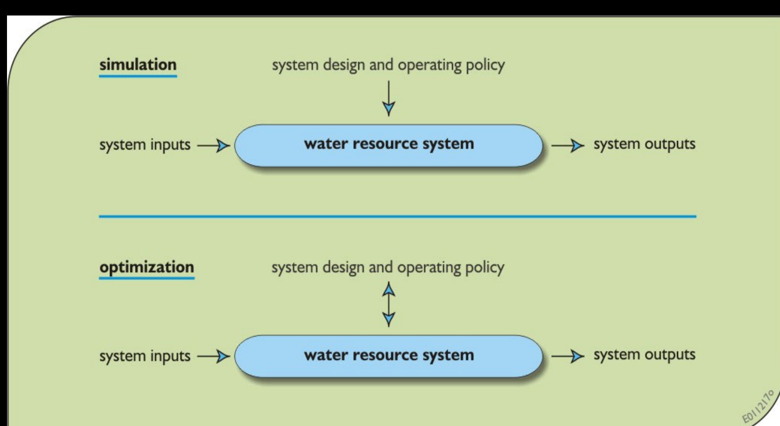


There is a need for tools



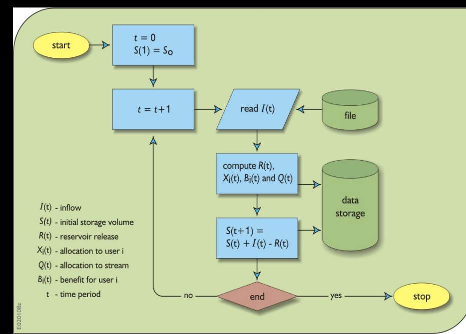
Simulation and Optimization

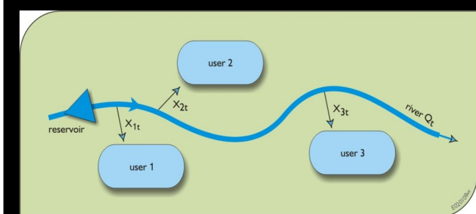
- Simulation models: Predict response to **given design**
- Optimization models: Identify **optimal design** or operation

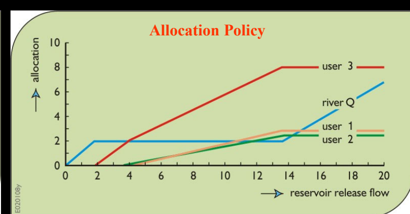


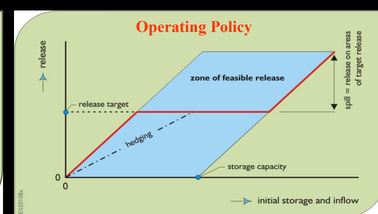
Simulation

- Address "**What if …**" questions
- What will likely happen
- Include larger hyd, econ, and env. data
- i.e. "evaluate change <u>given a design or policy</u>"



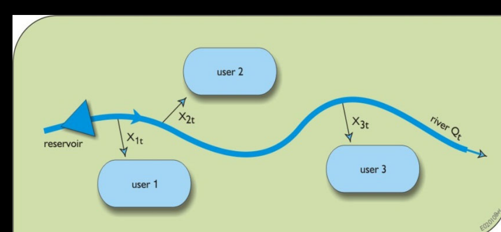






Optimization

- Used for design:
  - "Maximize the Net Benefits …" or
  - "Minimize the shortages"
- Look for the best (ideal) operation
- Perfect foresight



Optimization model

Benefits: $B_i(x_{it})$

Decision Variables: x_{it}

Objective: $Maximize \sum_{t=1}^{T} \sum_{i=1}^{3} B_i(x_{it})$

Constraints:

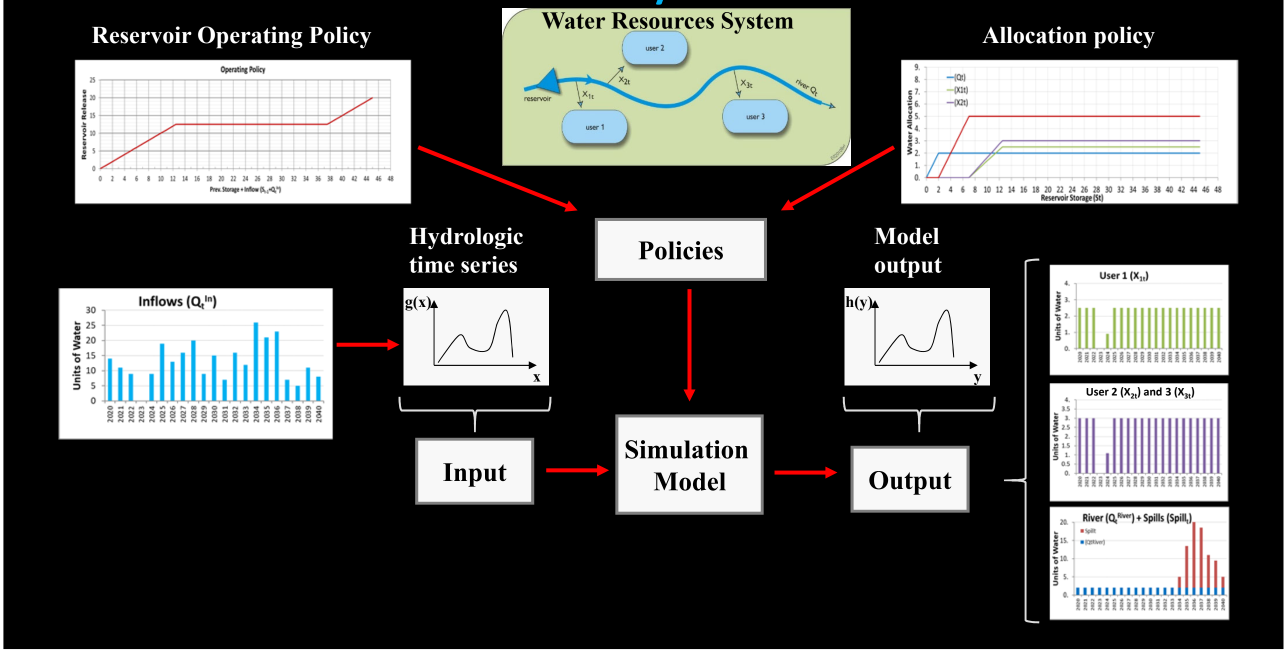
$x_{1t} + x_{2t} + x_{3t} \le R_t \quad t = 1,2,\cdots$

$S_{t+1} = S_t + I_t - R_t \quad t = 1,2,\cdots$

$S_t \le K \quad t = 1,2,\cdots$

Optimization model

Water Resources Systems Simulation



Uncertainty

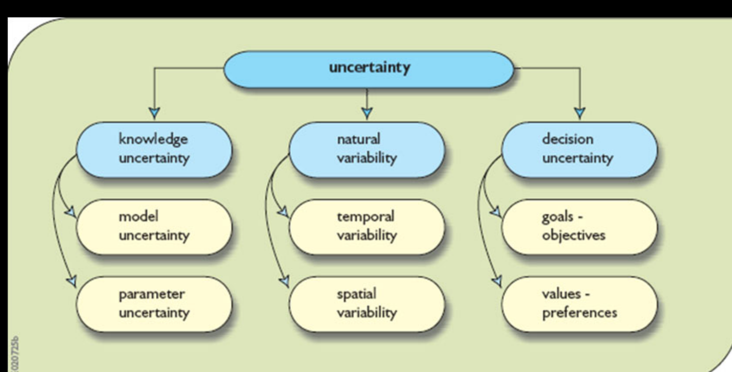
UCDAVIS WATER MANAGEMENT LAB

Deterministic process

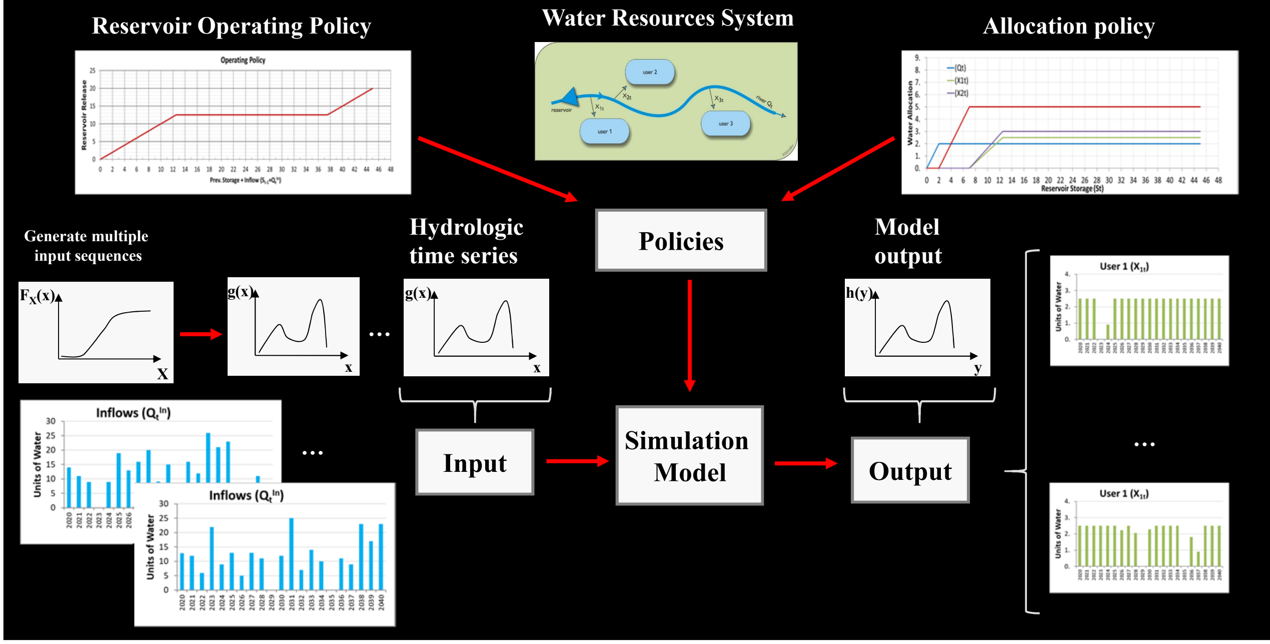
- Inputs assumed known.
- Ignore variability
- Assume inputs are well represented by average values.
- Over estimates benefits and underestimates losses

Stochastic process

- Explicitly account for variability and uncertainty
- Inputs are stochastic processes
- Historic record is one realization of process.



Water Resources Systems Simulation

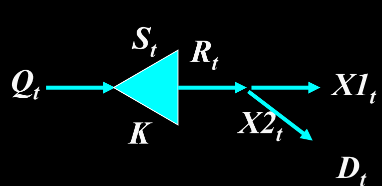


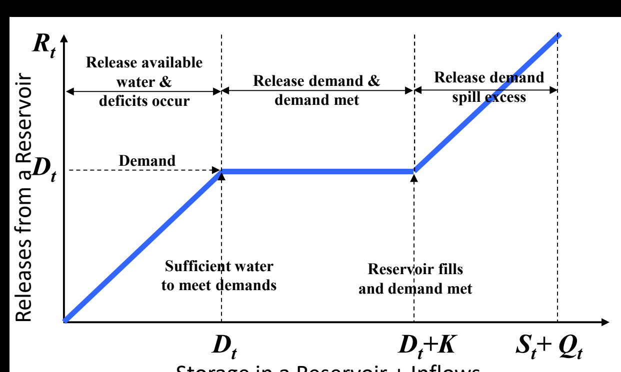
Standard Operating Policy

Reservoir operating policy - release as function of storage volume and inflow

$R_t = R_t(S_t, Q_t)$

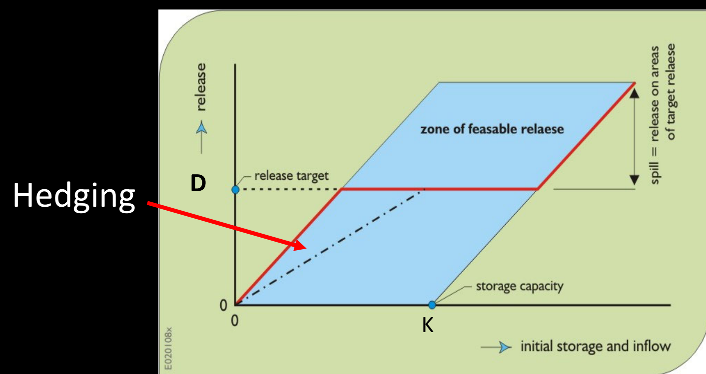
$$R_t = \begin{cases} S_t + Q_t & \text{if } S_t + Q_t < D_t \\ D_t & \text{if } D_t < S_t + Q_t < D_t + K \\ S_t + Q_t - K & \text{if } S_t + Q_t > D_t + K \end{cases}$$





Hedging Rule

Reduce releases in times of drought (hedging) to save water for future releases in case of an extended period of low inflows.

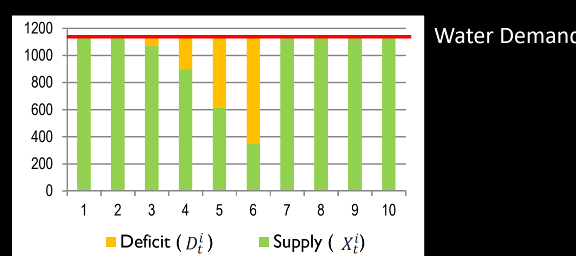


Performance Evaluation

- Reliability (Time & Volume)

$$Reliability(time)^i = \frac{\#\ of\ times\ Deficit_t^i = 0}{n}$$

$$Reliability(volume)^i = \frac{\sum X^i_{Supplied,t}}{\sum X^i_{Demand,t}}$$



- Vulnerability (Severity of the Deficits)

$$Vulnerability^i = \frac{\left(\frac{\sum Deficit_t^i}{\#\ of\ times\ Deficit_t^i > 0\ occured}\right)}{Water\ Demand^i}$$

- Resilience (How fast the system recovers)

$$Resilience^i = \frac{\#\ of\ times\ Deficit_t^i = 0\ follows\ Deficit_t^i > 0}{\#\ of\ times\ Deficit_t^i > 0\ ocurred}$$

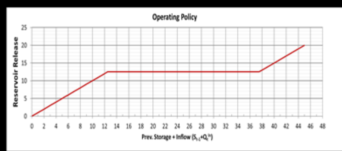
- WR Sustainability Index

$$SI^i = \left[\prod_{m=1}^{M} \text{Performance Criteria}_m^i\right]^{1/M}$$

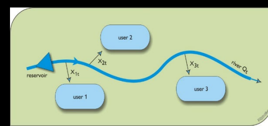
$$SI^i = \left[Rel(time)^i * Rel(Volume)^i * Res^i * (1 - Vuln^i)\right]^{1/4}$$

Water Resources Systems Simulation

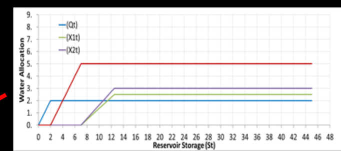
Reservoir Operating Policy



Water Resources System



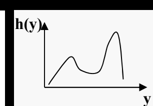
Allocation policy



Hydrologic time series

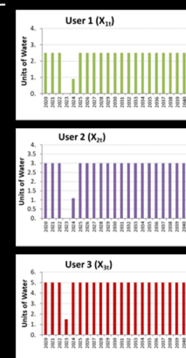
Policies

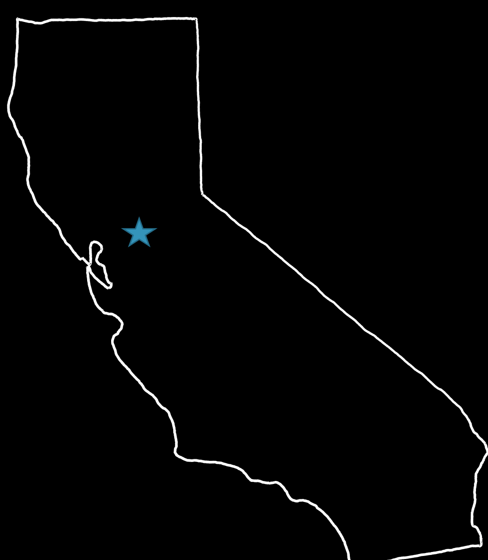
Model output



	(Q_t^{River})	(X_{1t})	(X_{2t})	(X_{3t})
Reliability (time) =	100%	90%	90%	95%
Reliability (volume) =	100%	92%	92%	97%
Vulnerability =	0%	82%	82%	70%
Resilience =	100%	50%	50%	100%
Sustainability Index =	**100%**	**52%**	**52%**	**72%**

Output





Thank you

samsandoval@ucdavis.edu

watermanagement.ucdavis.edu

eflows.ucdavis.edu

University *of* California
Agriculture and Natural Resources

UC DAVIS WATER MANAGEMENT LAB

Needs for tools

Allocate reservoir release R_t to 3 users and provide instream flow Q_t