Incorporating Uncertainty into Integrated Regional Water Resources Planning

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Planning under Uncertainty

- Planning *with* certainty is a rare luxury
- Planning under uncertainty is the norm

Outline

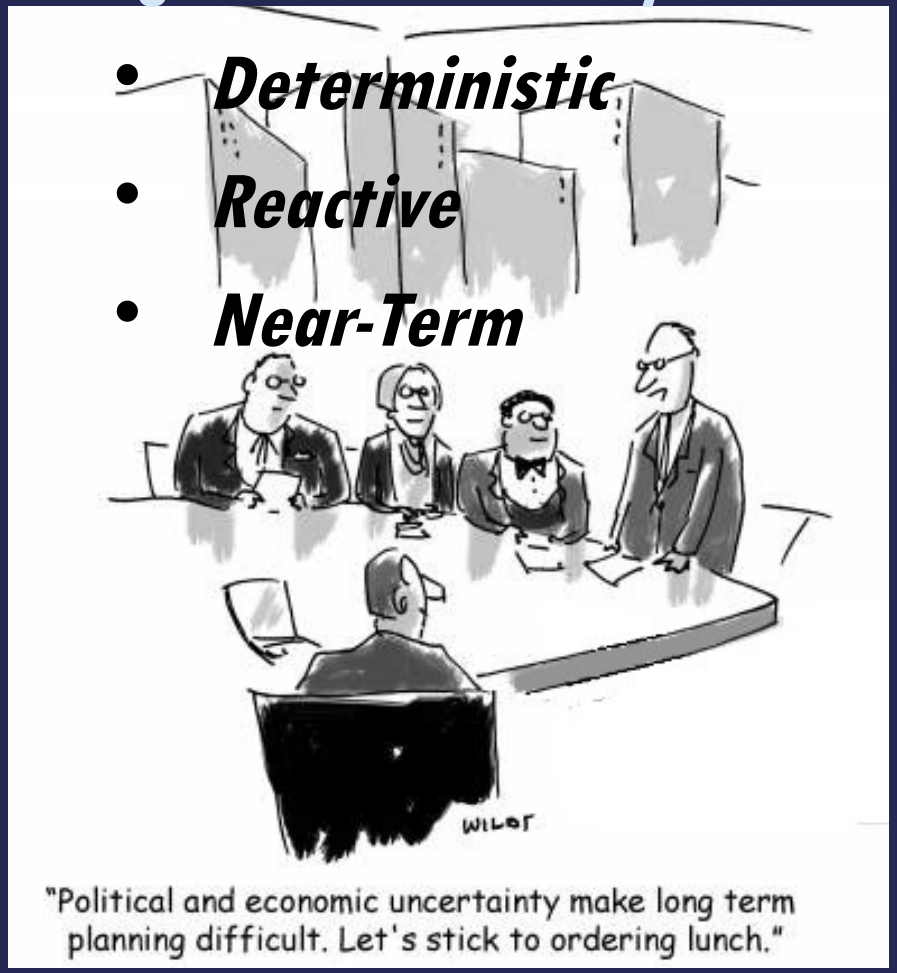
- Planning under uncertainty
- 5-steps for uncertainty assessment
- Case-Study – Texas water planning
- Lessons learned

The Planning Process

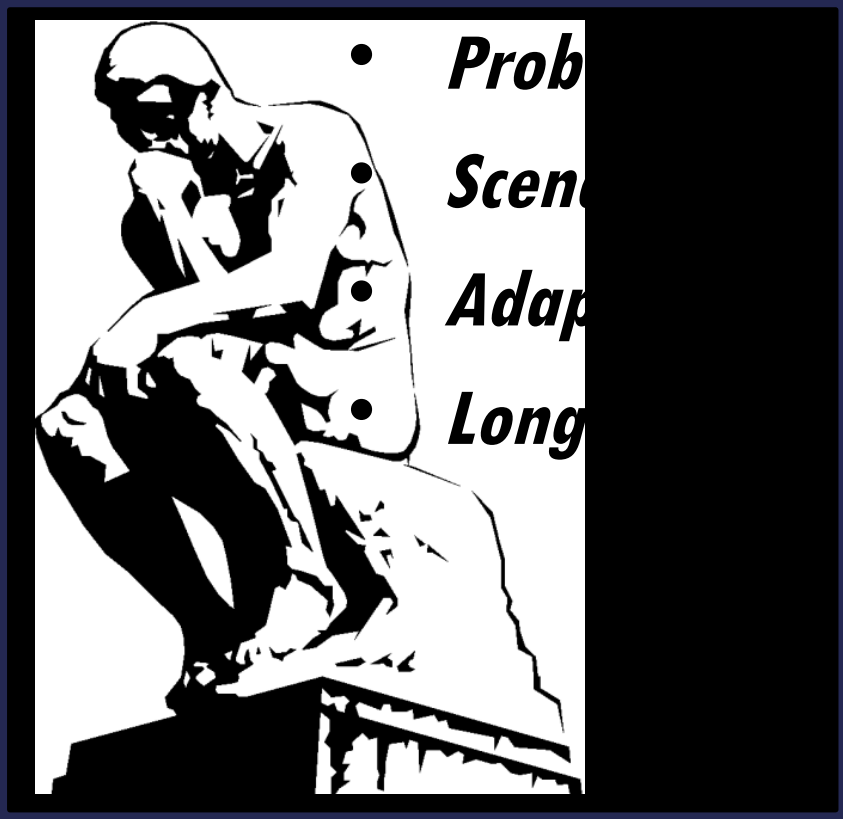
Planning under Uncertainty

Alternatives?

- Ignore uncertainty
  - *Deterministic*
  - *Reactive*
  - *Near-Term*



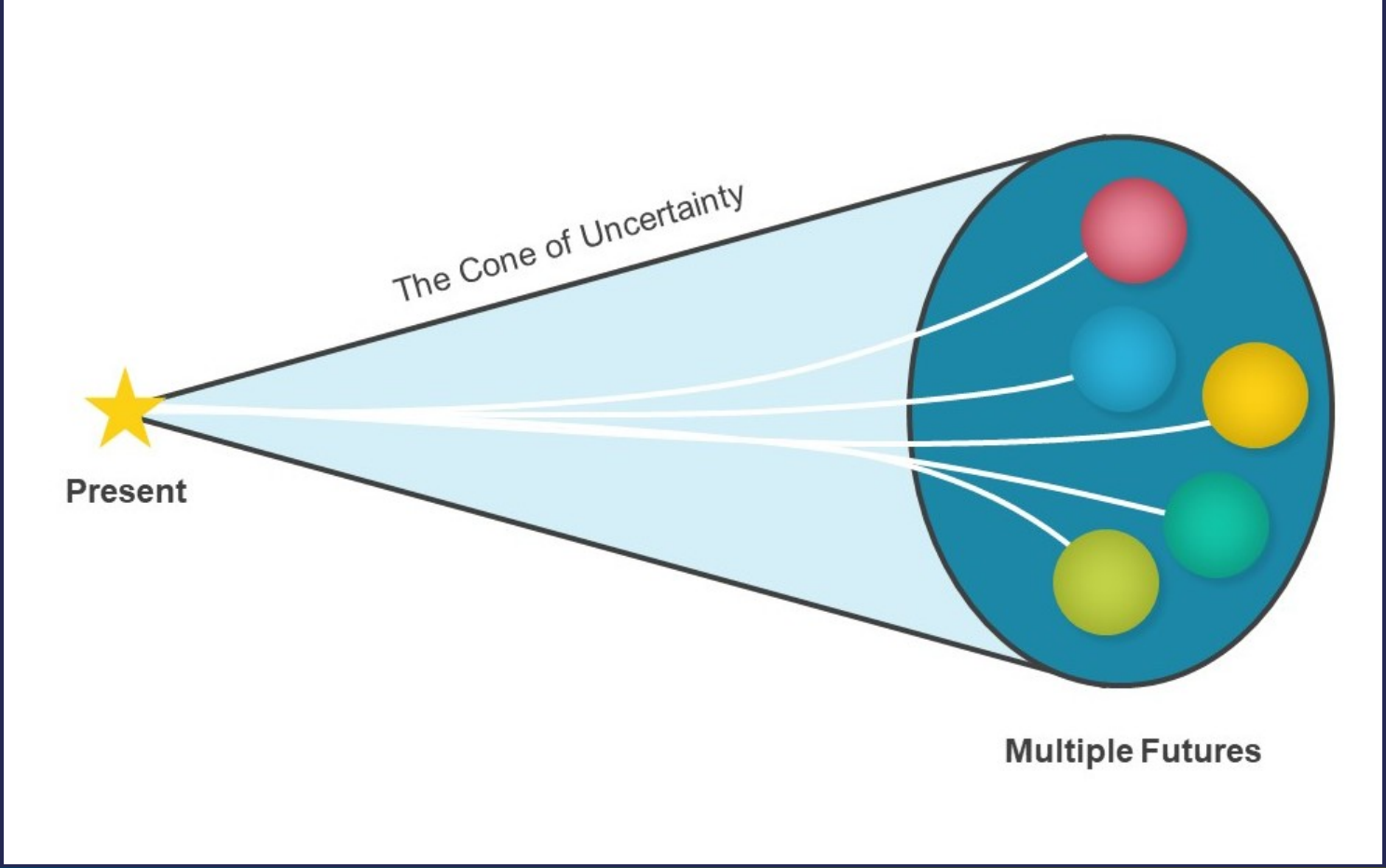
"Political and economic uncertainty make long term planning difficult. Let's stick to ordering lunch."



- Account for uncertainty

Planning under Uncertainty

- How do we maximize our chance of success given everything we do not know?



5-step Program

1. Identify Uncertainties
   - Known Unknowns/Unknown Unknowns
2. Characterize Uncertainties
3. Relate Uncertainty to Key Decisions
4. Assess Sensitivity to/Importance of Uncertainties
5. Manage Uncertainty
   - Reduce Uncertainty
   - Increase Reliability/Reduce Risk
   - Increase Resilience
   - Monitor, Measure, and Adapt

Case Study

Analyzing Uncertainty and Risk in the Management of Water Resources for the State of Texas

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Texas Water Development Board

Texas Water Planning Framework

- Regional water planning process for resilient water supply
  - Drought of record
  - Deterministic
- Stake-holder driven process
  - Regional water planning groups
- 50-year planning horizon
  - Updated every 5 years
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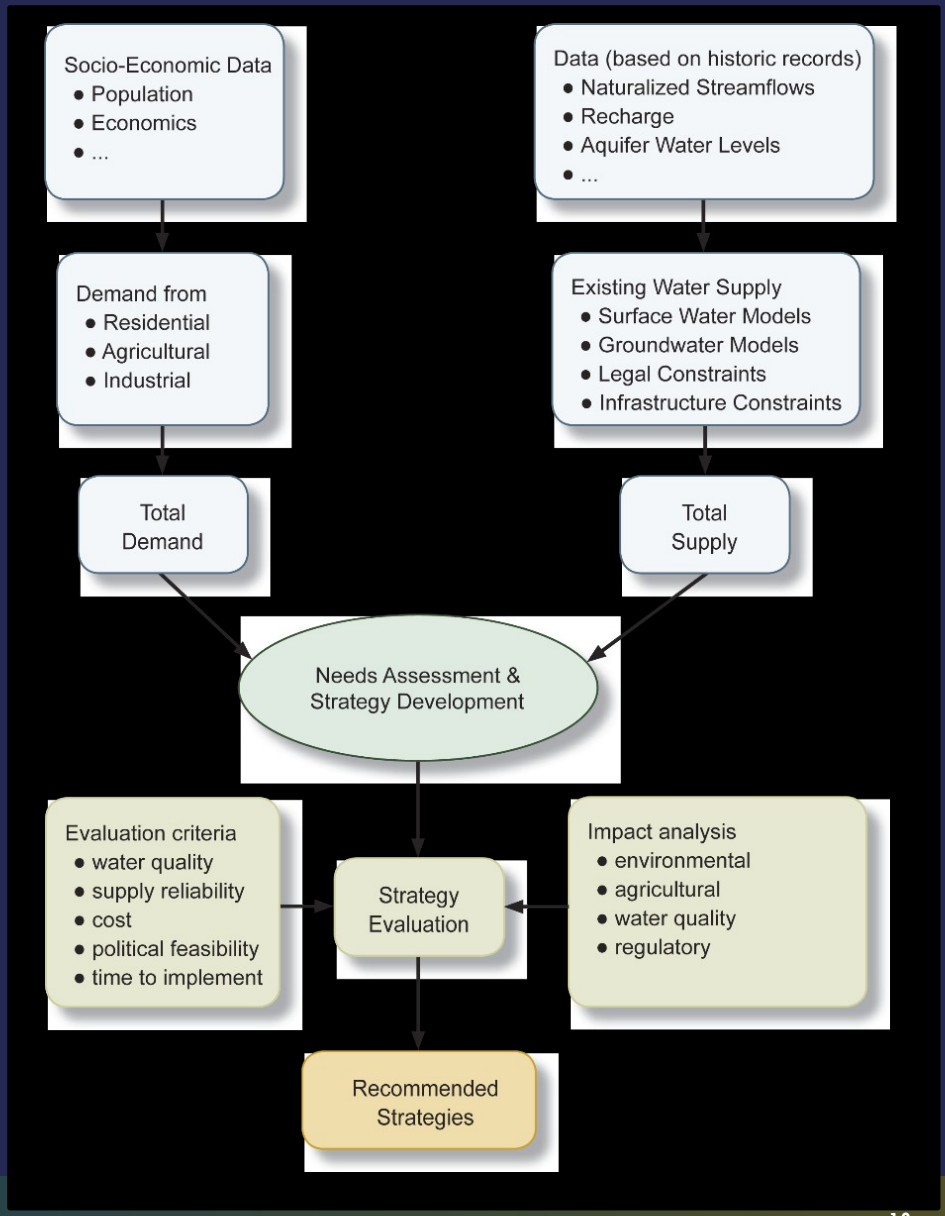
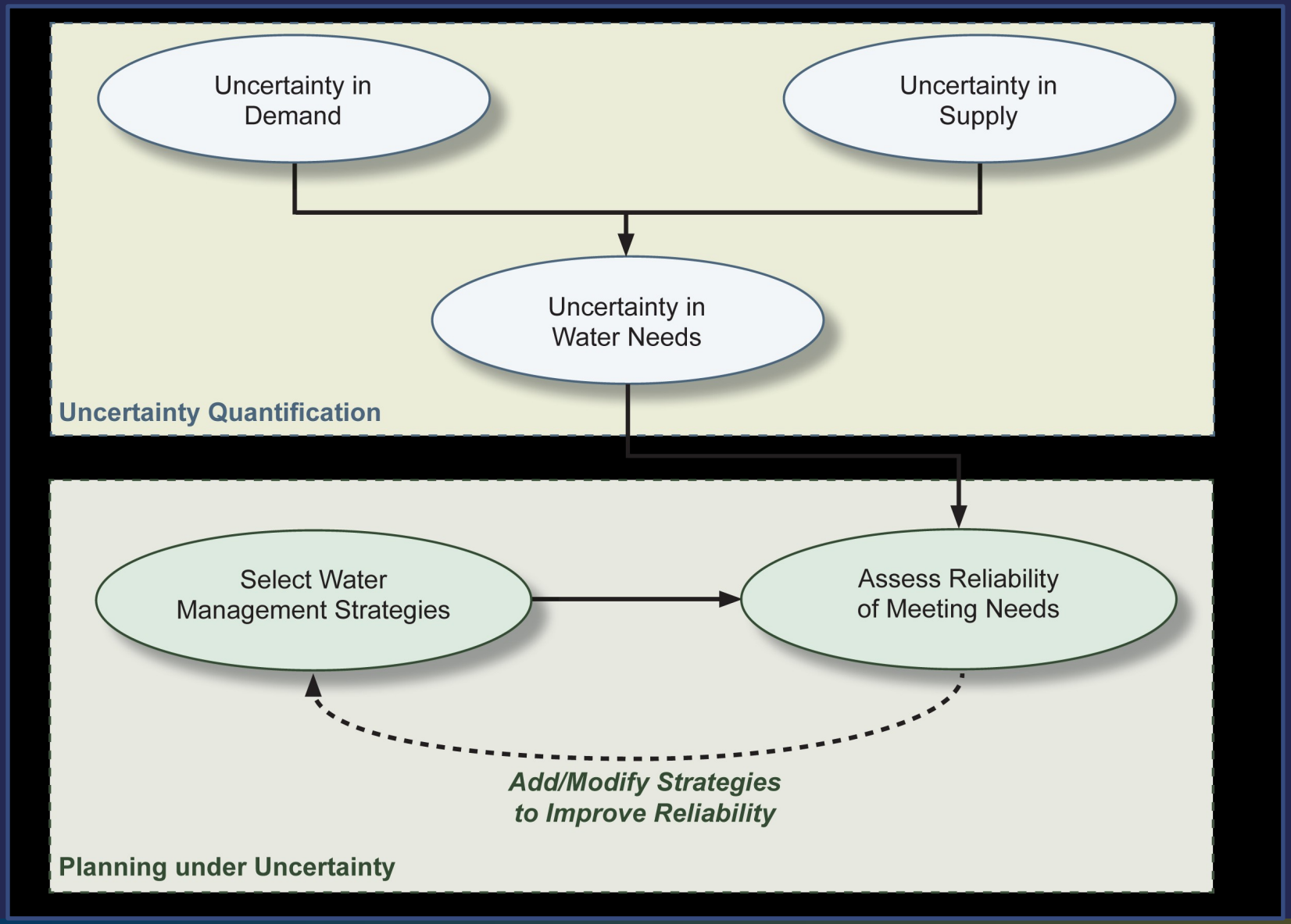


Objective

- **Methodology** to inform decision-makers how to **characterize and account for uncertainty** in regional water resources planning
  - Build on the current (deterministic) water planning framework

Methodology

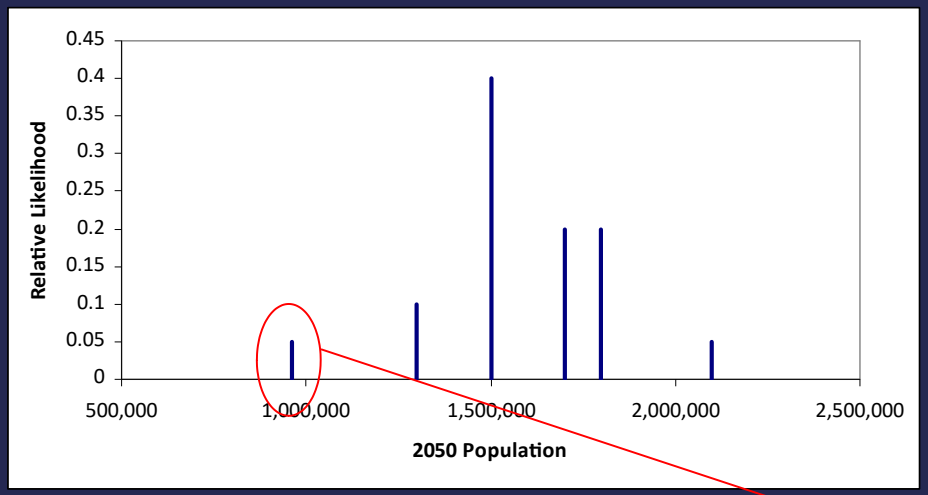


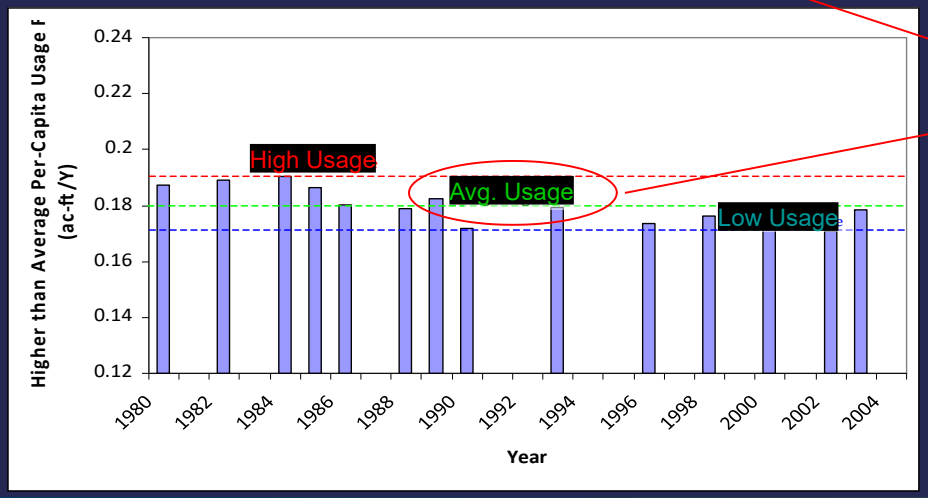
Uncertainty Characterization

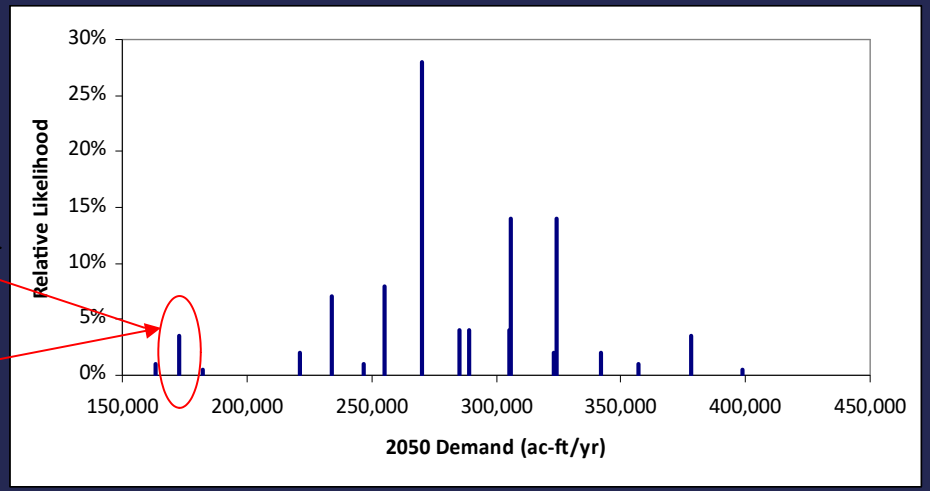
- Uncertainty in demand
  - Population projections
  - Water usage rates
- Uncertainty in supplies
  - Water supplies in future droughts
  - Climate-change impacts
- Create multiple demand and supply scenarios

Demand Scenarios

- 6 Pop. Proj. x 3 usage rate = 18 demand scenarios

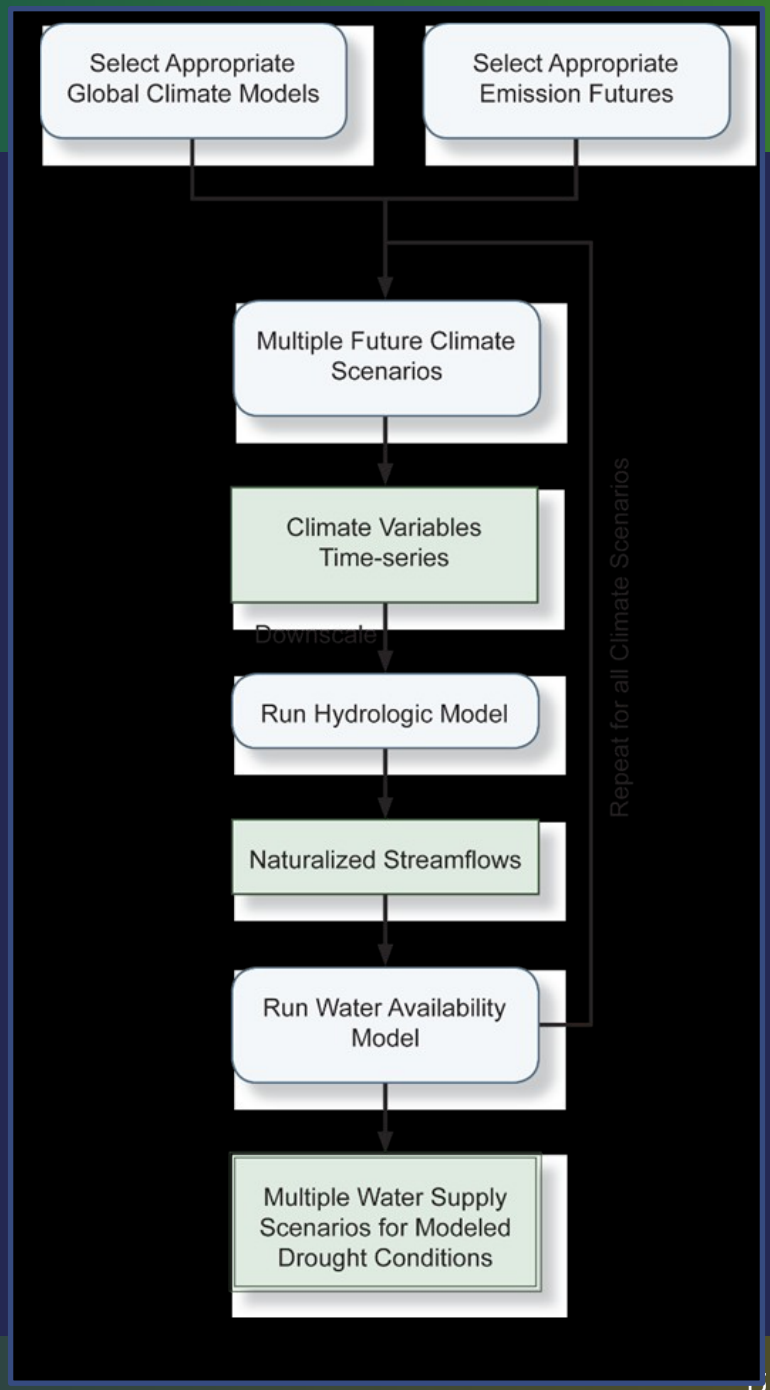






Supply Scenarios

- LCRA/SAWS Climate Change Study used as basis for modeling uncertainty in climate
- 2 GCMs x 2 Future Emission Scenarios + 1 Baseline = 5 Supply Scenarios

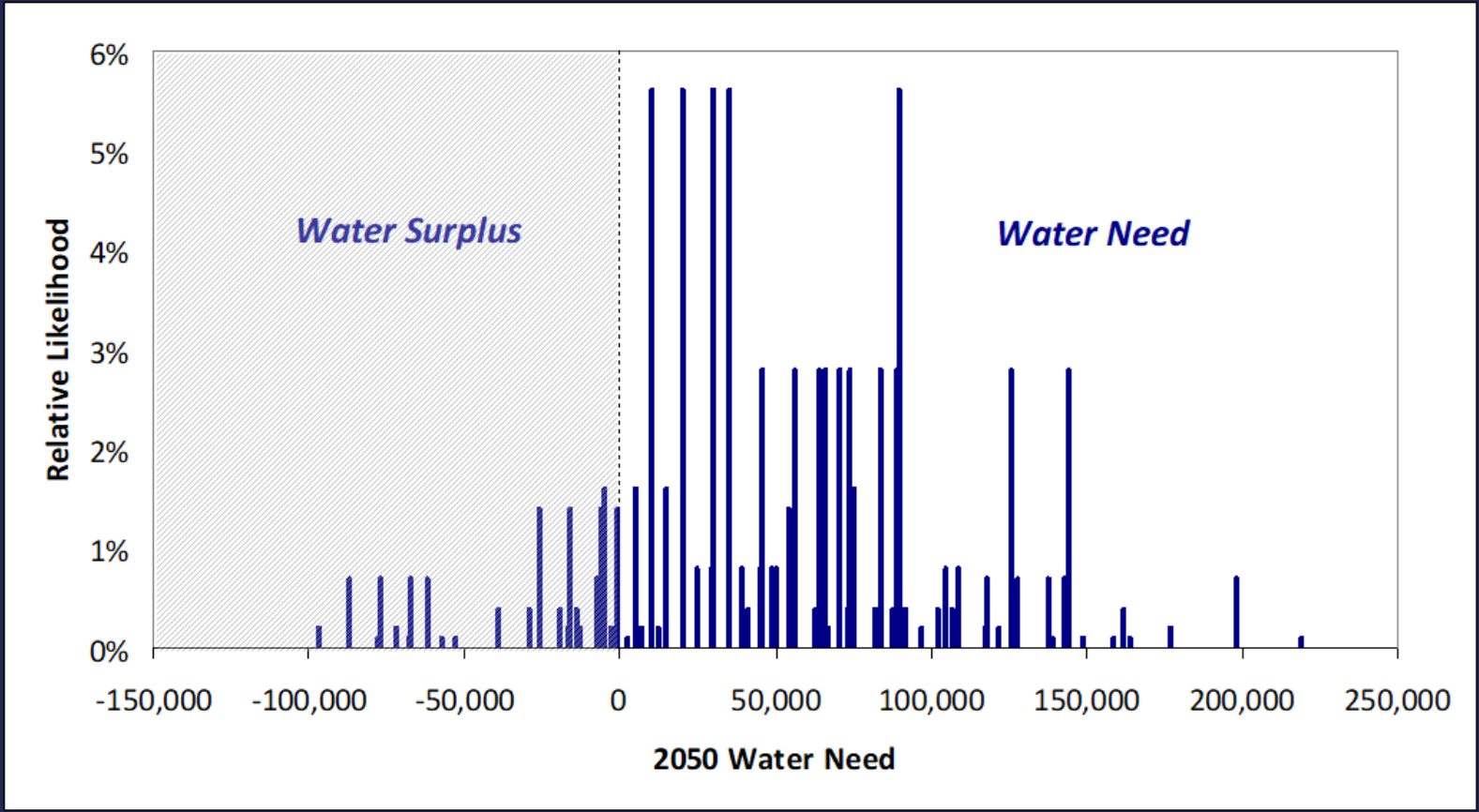


Supply Scenarios

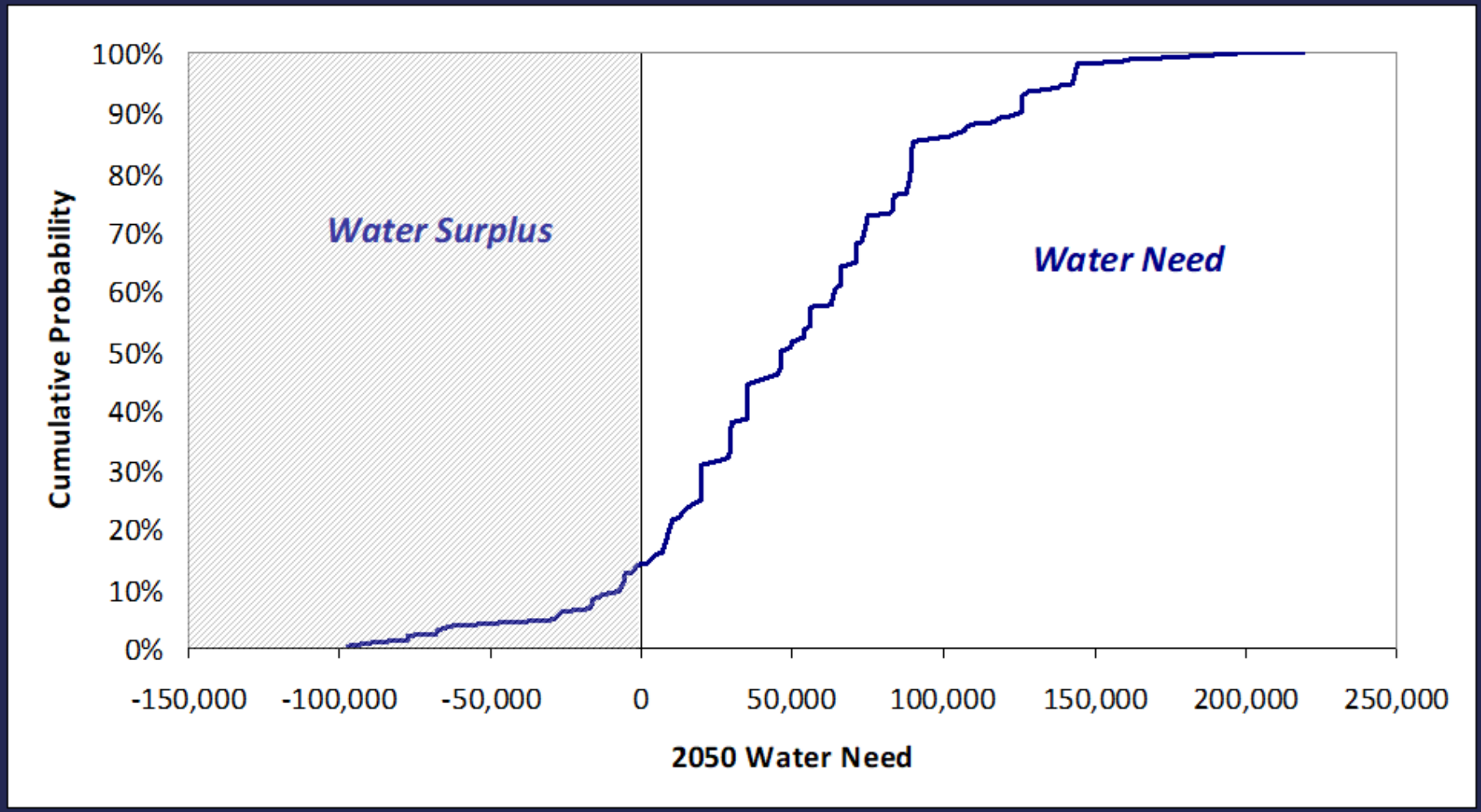
Climate scenario	No Climate-Change	CCSM-A2	CCSM-B1	GFDL-A2	GFDL-B1

Water Needs Scenarios

- Water Need = Water Demand – Water Supply

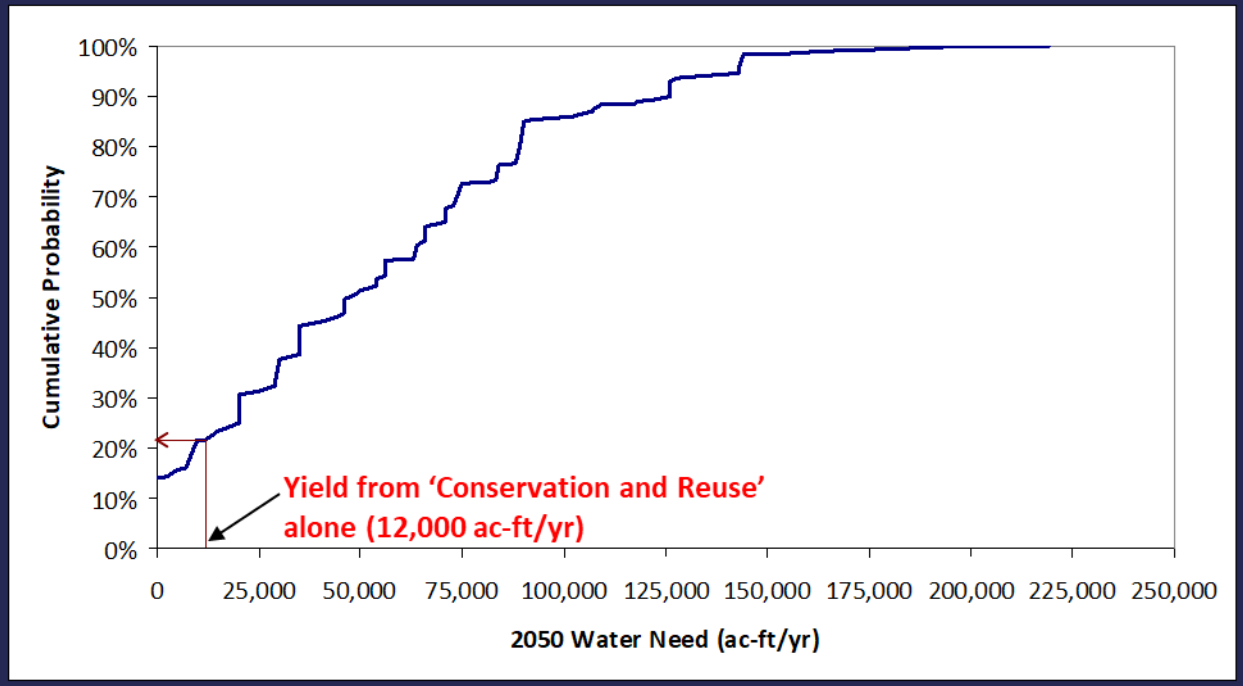


Water Needs Scenarios



Evaluating Projects

- Baseline strategy = Conservation and Reuse (C&R)
  - Meets (deterministic) projected water needs (10,000 AFY)
  - Only 22% reliable



Evaluating Projects

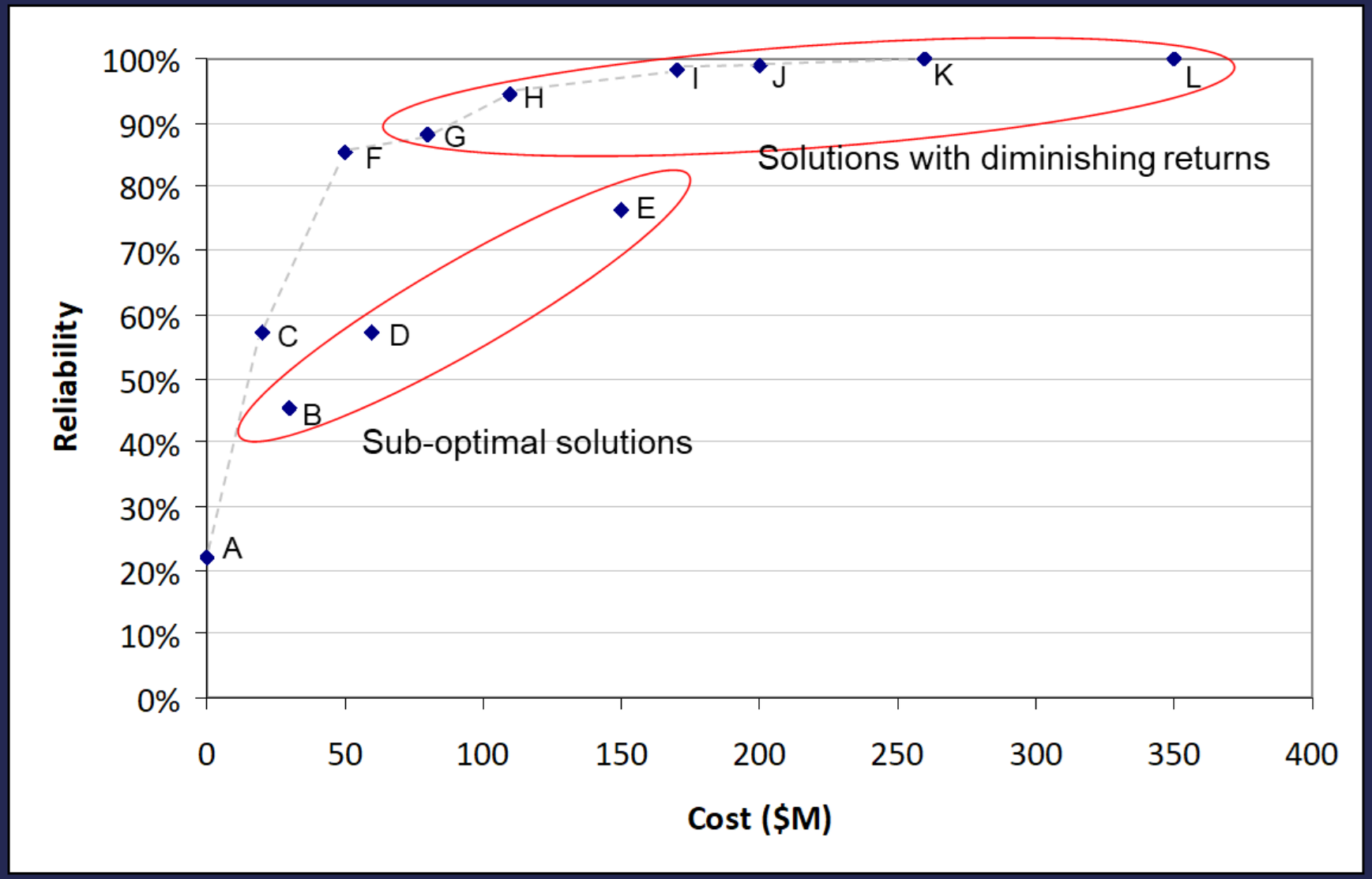
- 6 potential strategies to meet the deficit

Strategy ID	Strategy	Capital cost ($ million)	Expected yield[1] (ac-ft/yr)

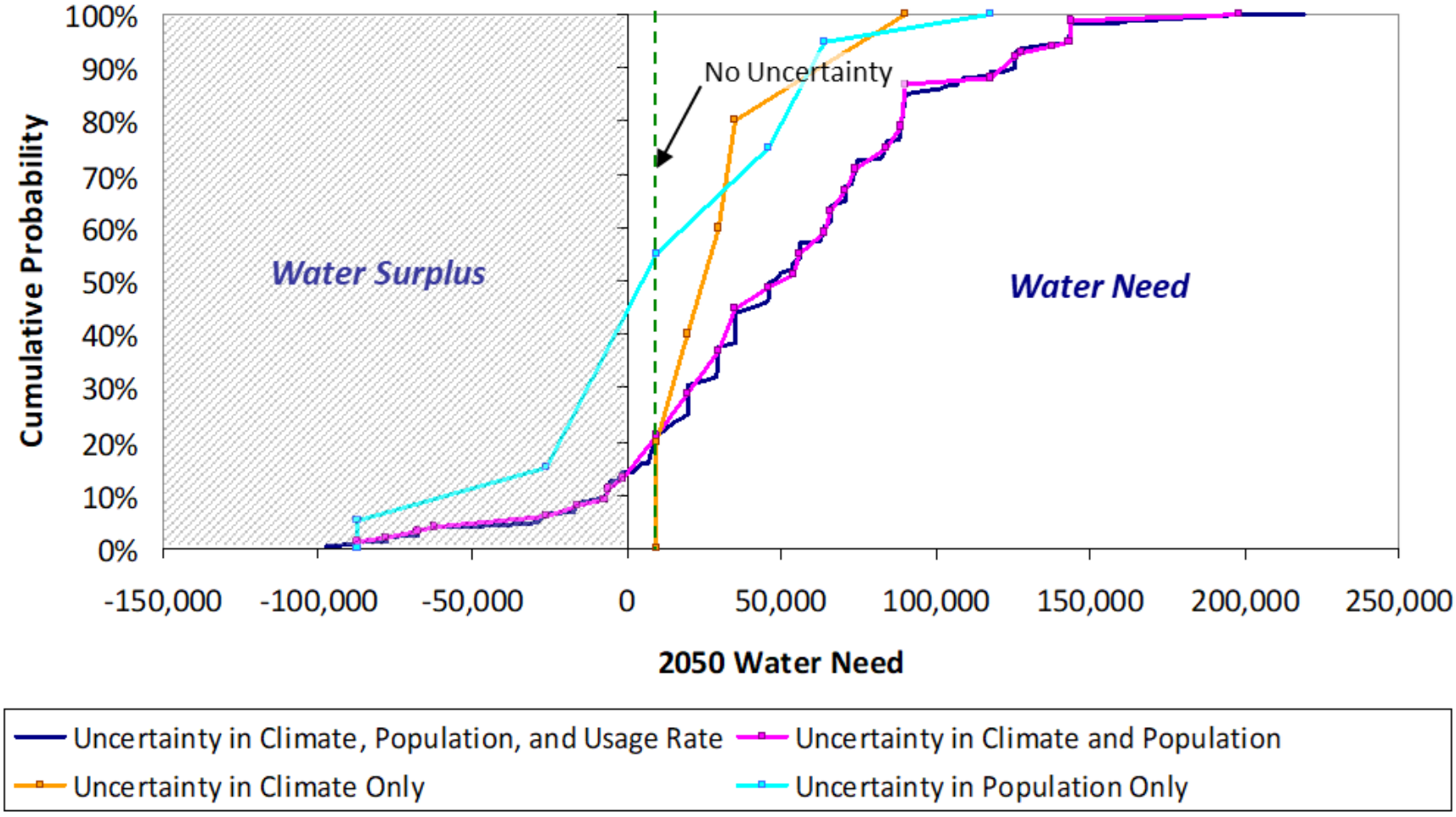
Project Portfolios

Strategy Sets	Strategies considered	Capital cost ($M)	Expected total yield (ac-ft/yr)	Reliability
A	Conservation and reuse	1	12,000	22%
B	Conservation and reuse GW development	31	42,000	45%
C	Conservation and reuse Wastewater reuse	21	62,000	57%
D	Conservation and reuse Pipeline	61	62,000	57%
E	Conservation and reuse Reservoir	151	87,000	76%
F	Conservation and reuse Wastewater reuse GW development	51	92,000	85%
G	Conservation and reuse Wastewater reuse Pipeline	81	112,000	88%
H	Conservation and reuse Wastewater reuse GW development Pipeline	111	142,000	94%
I	Conservation and reuse Wastewater reuse Desalination Pipeline	171	152,000	98%
J	Conservation and reuse Wastewater reuse GW development Reservoir	201	167,000	99%
K	Conservation and reuse Wastewater reuse GW development Pipeline Reservoir	261	217,000	100%
L	(ALL) Conservation and reuse Wastewater reuse GW development Desalination Pipeline Reservoir	351	257,000	100%

Cost-Reliability Trade-Off



Sensitivity to Uncertainty



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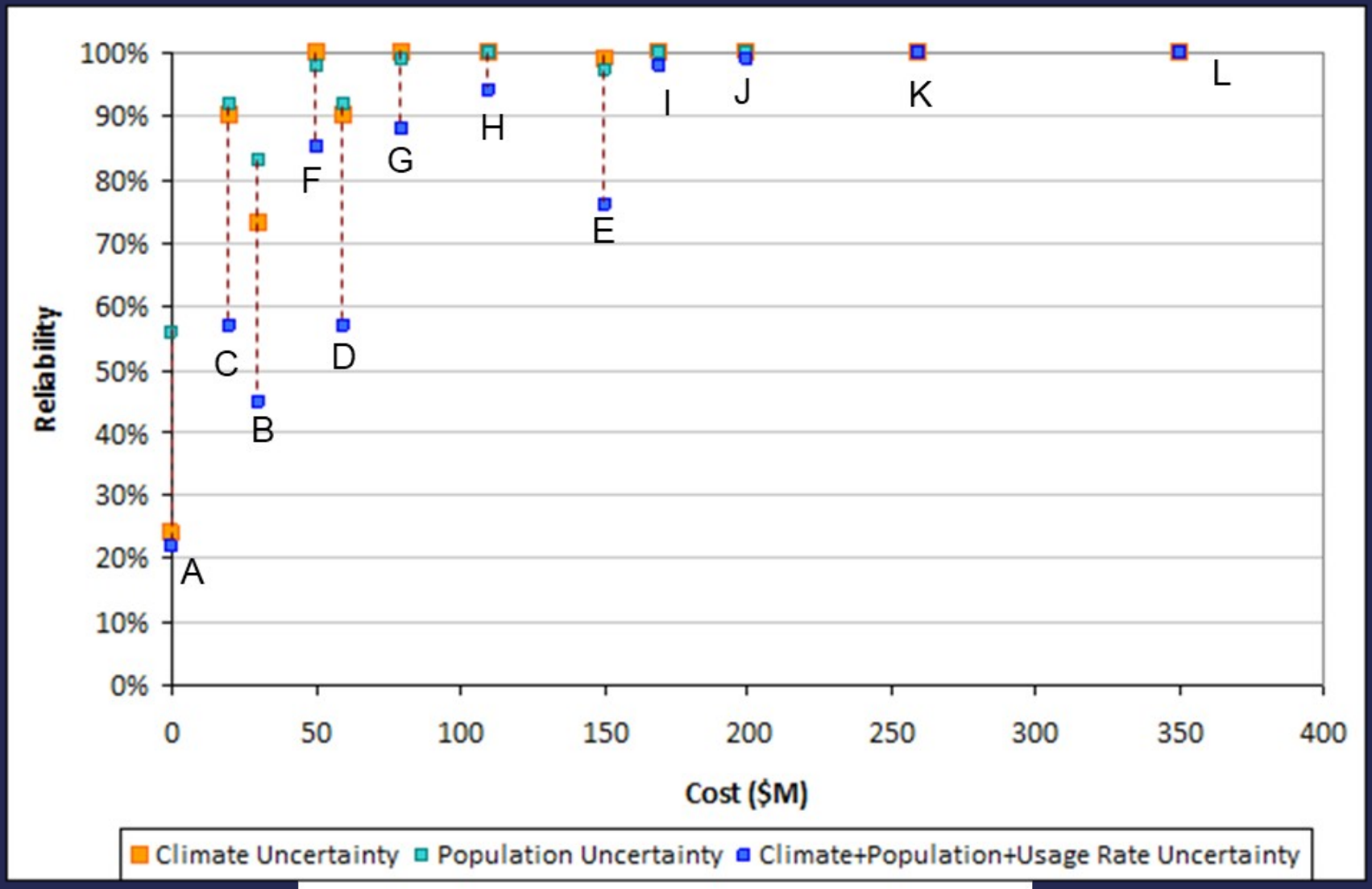

Summary

- Framework to plan under uncertainty based on existing planning framework
- Identified and characterized key uncertainties in demands and supplies
- Developed project portfolios to improve reliability of water plan
- Evaluated trade-offs in cost and reliability to rank and select project portfolios
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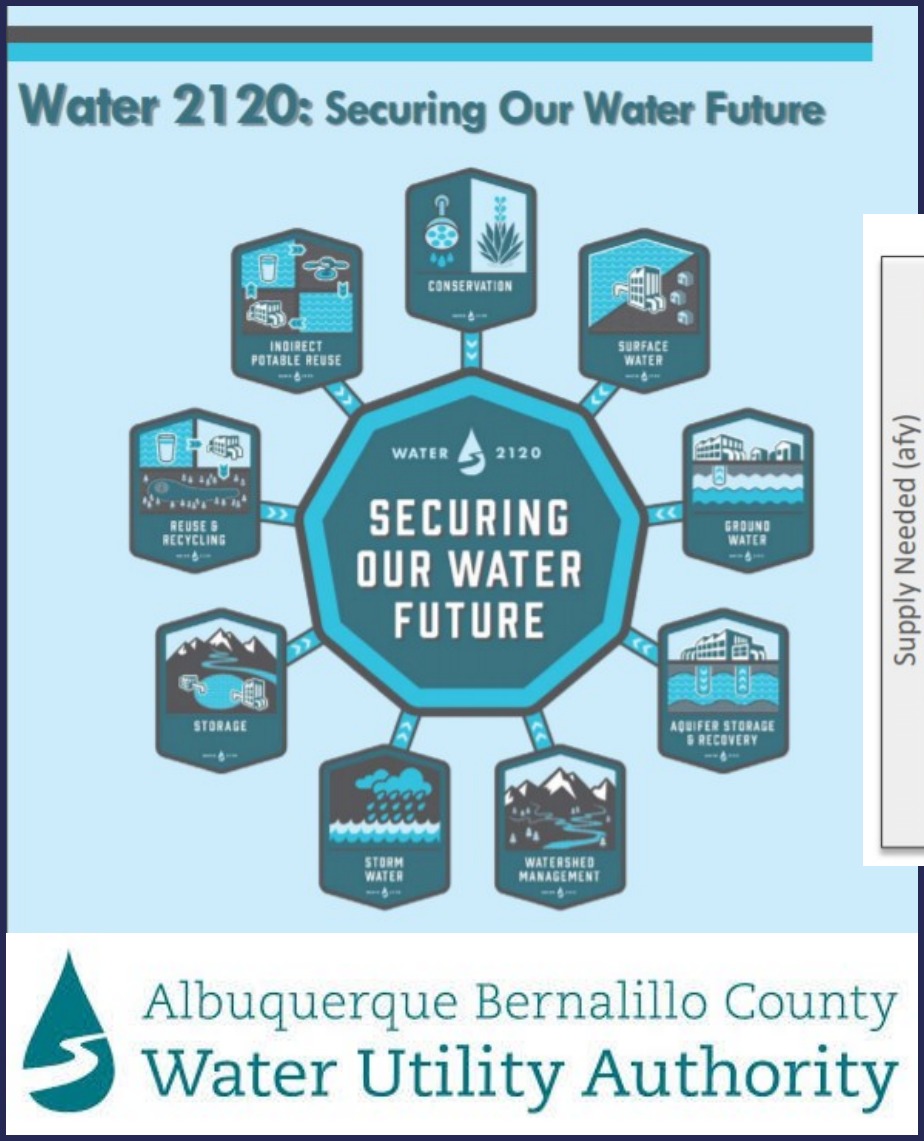
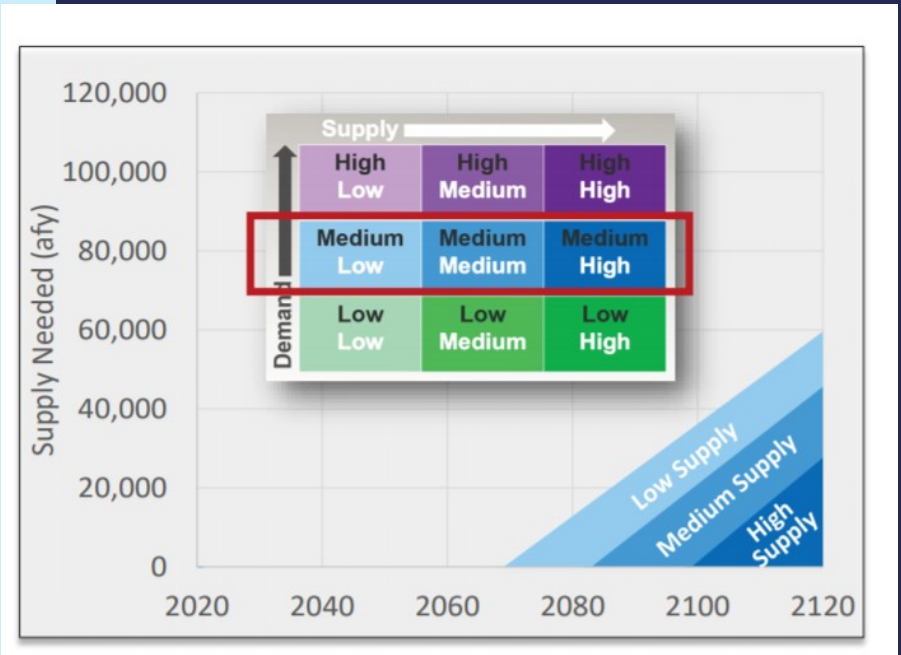
Other Planning Studies…





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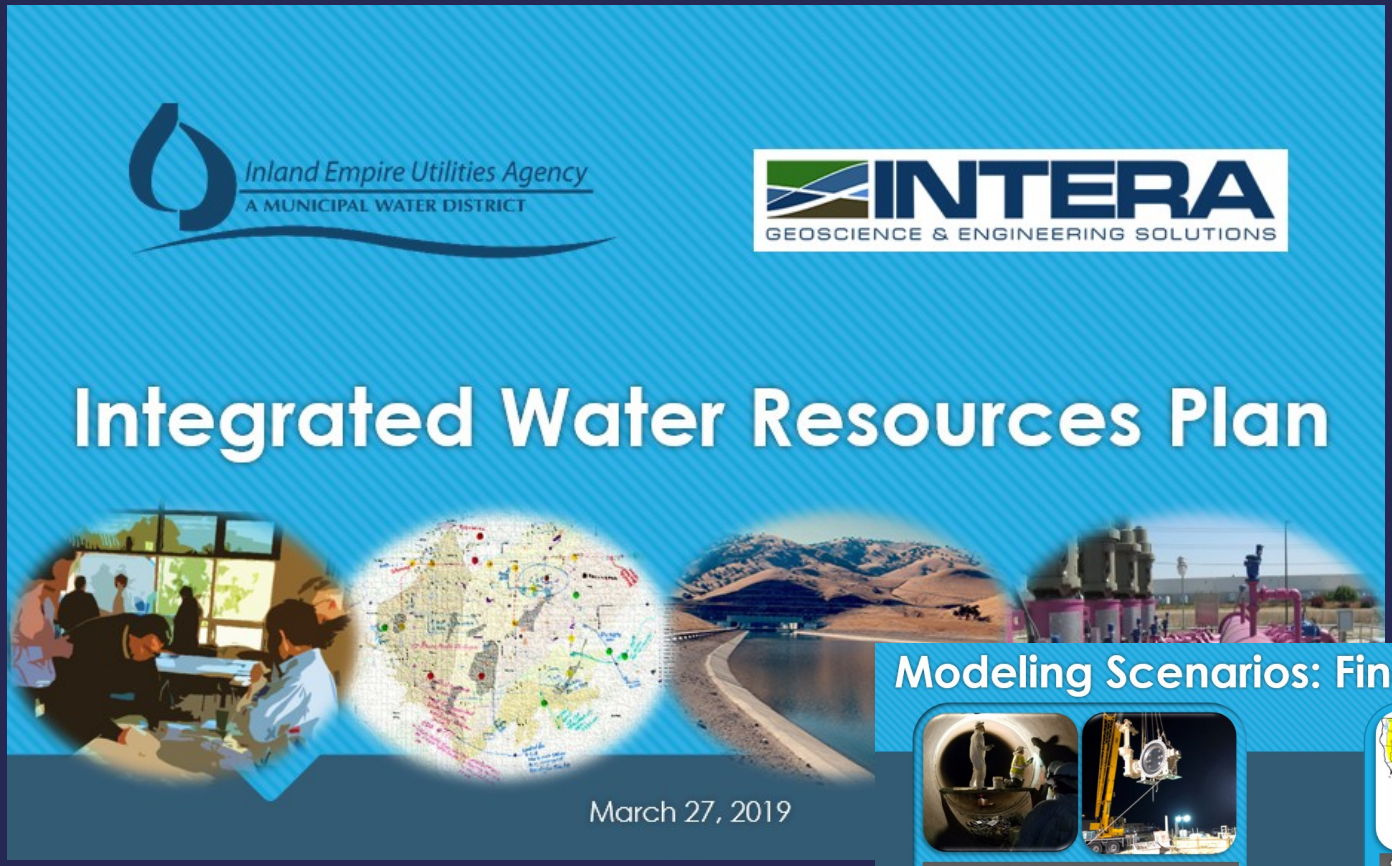

Lessons Learned

- Demonstrate importance of considering uncertainty
  - 'Baseline' solution not reliable
- Having a well-defined deterministic planning framework is key
- Start simple – easier to communicate ideas to stakeholders
  - Sequentially add 'layers' of uncertainty
  - Scenarios keep things 'real'
  - Sensitivity analysis shows importance of different uncertainties
- Enables more robust decision making
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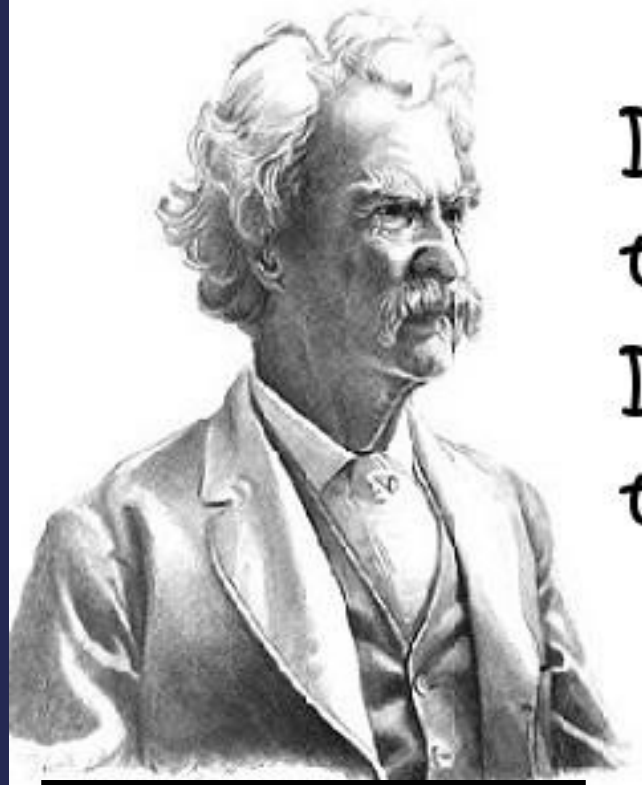

It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.

Mark Twain ?