

A Decision Framework for the California Water Plan 2013 Update

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SWAN – February 2013

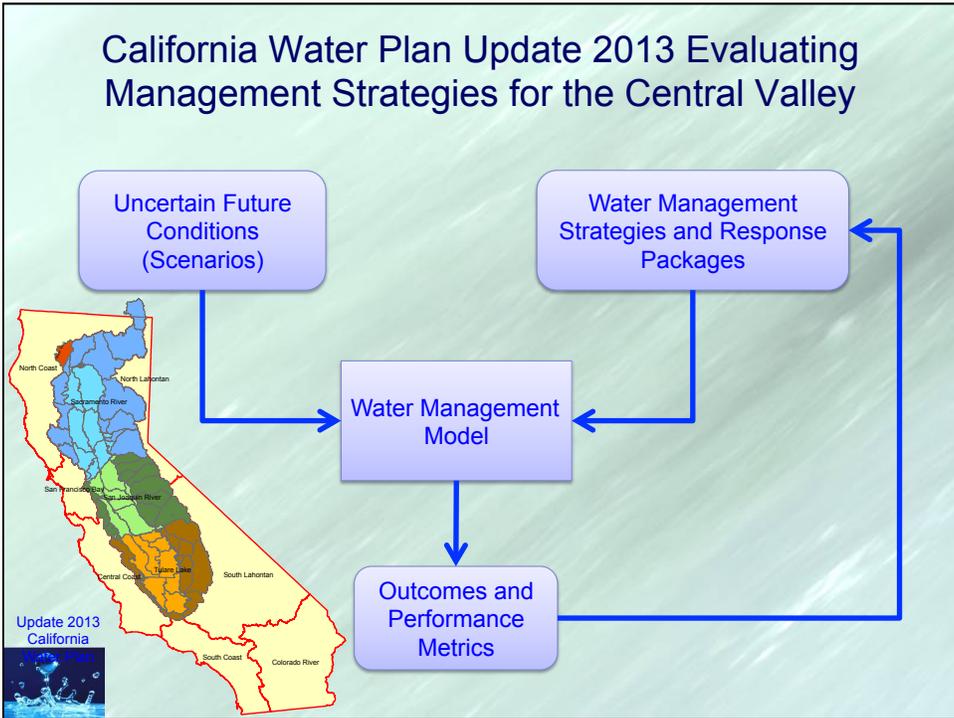
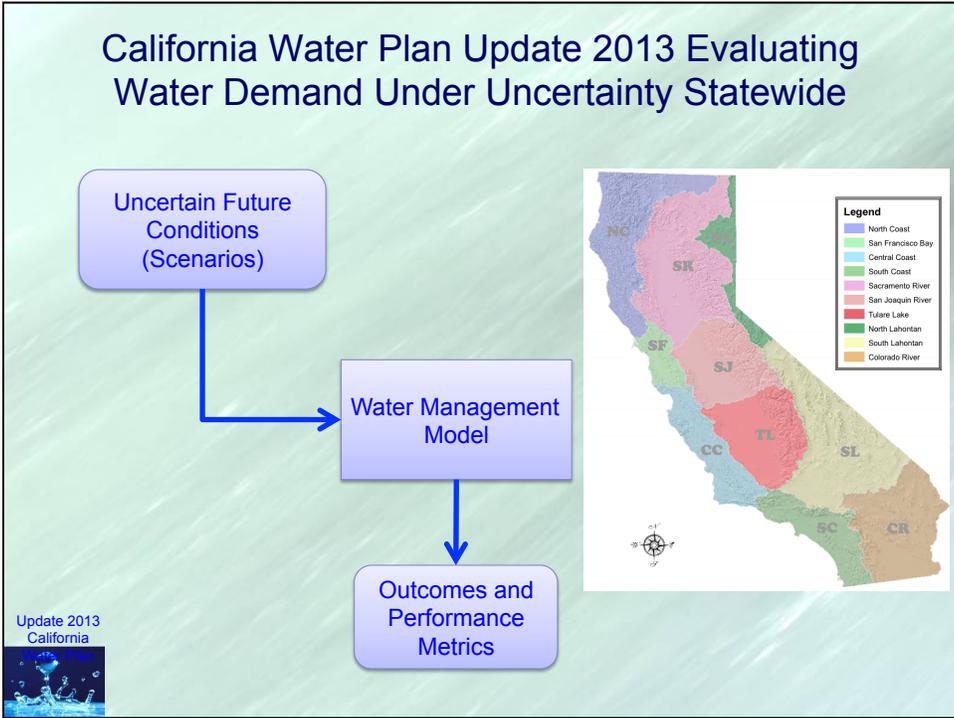
1

California Water Plan to Evaluate Uncertain Future Water Management Challenges and Solutions

- ◆ How might demand, supply, and other water management conditions change between now and 2050?
- ◆ Which uncertain drivers are the most important?
- ◆ How can different water management strategies and response packages improve outcomes?
- ◆ What are the key tradeoffs among different strategies?

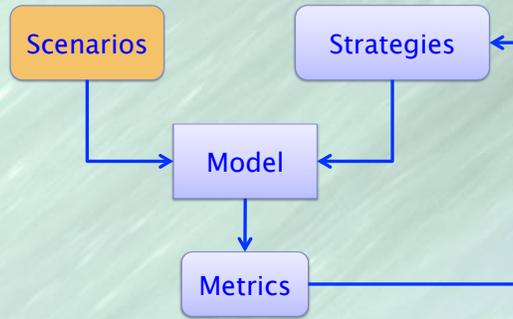


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Scenarios Reflect Changes in... *How Many People Live in California*

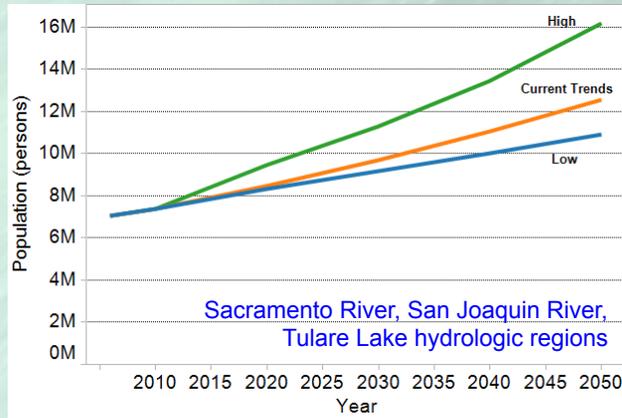
- Three population projections by hydrologic region



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Scenarios Reflect Changes in... *How Many People Live in California*

- Three population projections by hydrologic region

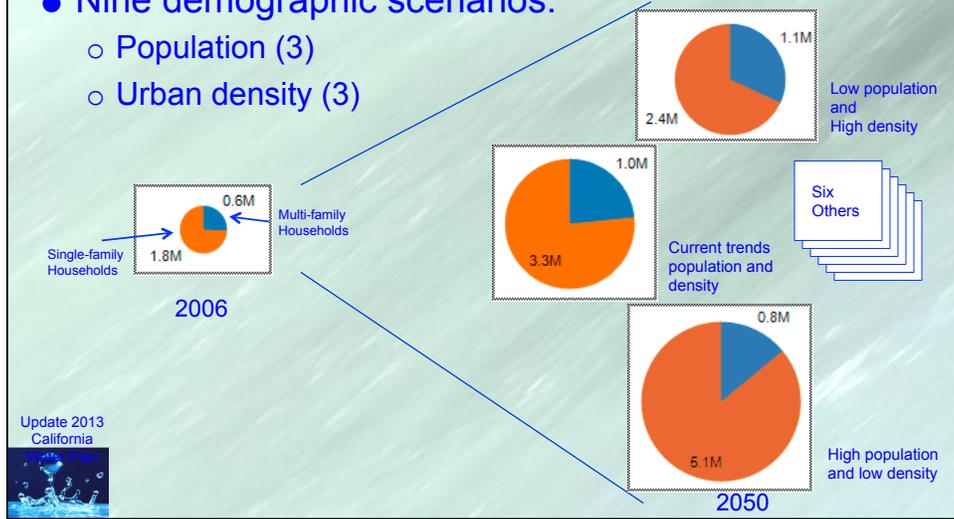


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Scenarios Reflect Changes in... *Where and How People Live*

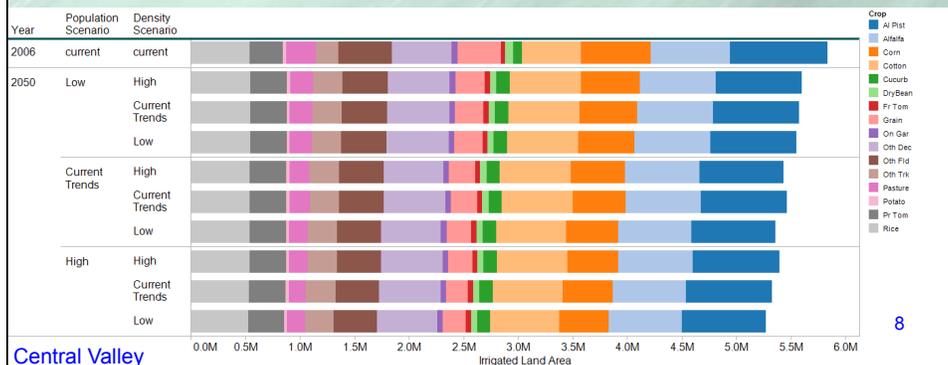
◆ Nine demographic scenarios:

- Population (3)
- Urban density (3)



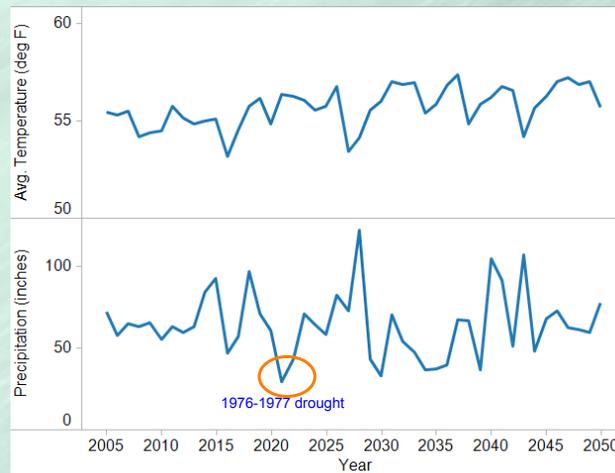
Scenarios Reflect Changes in... *How Much Agricultural Land is Irrigated*

- ◆ Nine scenarios of irrigated agricultural land
- Conversion from agriculture to urban development
 - Shift towards more high value crops



Scenarios Also Reflect Uncertainty about Future Climate

Repeat of historical climate patterns



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Scenarios Also Reflect Uncertainty about Future Climate

Repeat of historical climate patterns



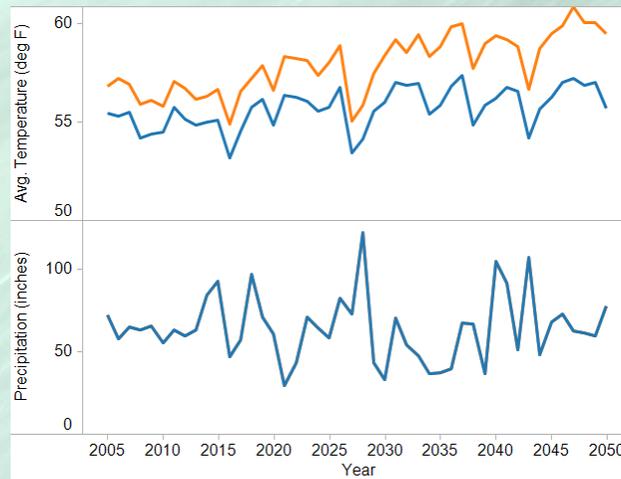
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5 offsets
evaluated

10

Scenarios Also Reflect Uncertainty about Future Climate

- Repeat of historical climate patterns with climate warming

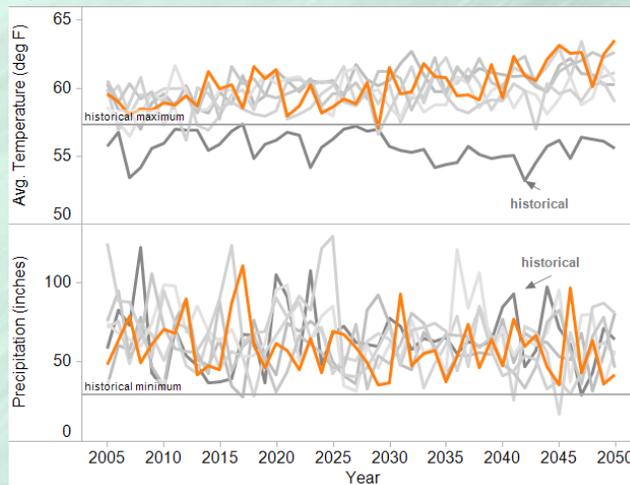


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Scenarios Also Reflect Uncertainty about Future Climate

- Global climate model scenarios of temperature and precipitation

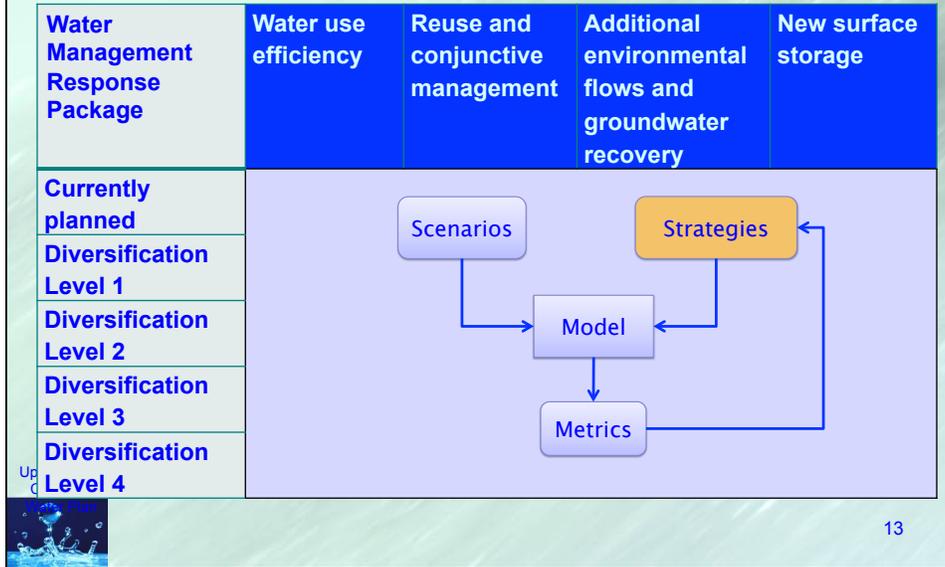


Showing projections from 6 of 12 climate simulations

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Response Packages Define Combinations of Management Strategies



Response Packages Define Combinations of Management Strategies

Water Management Response Package	Water use efficiency	Reuse and conjunctive management	Additional environmental flows and groundwater recovery	New surface storage
Currently planned	currently planned	current	current	none
Diversification Level 1	moderate	moderate	currently planned	none
Diversification Level 2	aggressive	moderate	moderate	none
Diversification Level 3	aggressive	aggressive	moderate	one facility
Diversification Level 4	aggressive	aggressive	aggressive	two facilities

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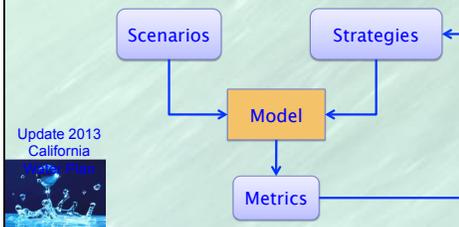
Water Management Models Evaluate System Across Many Scenarios

Statewide Model

- ◆ Statewide
- ◆ Evaluation of monthly water demands by hydrologic region
- ◆ Reflect demographic and climate uncertainty

Central Valley Model

- ◆ Sacramento, San Joaquin, and Tulare Lake hydrologic regions
- ◆ Simulation of monthly demand, supplies, and management under uncertainty
- ◆ Evaluation of water management strategies



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Both models built in user-friendly modeling environment to support collaboration



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Statewide Model Estimates Future System Performance



💧 Urban demand



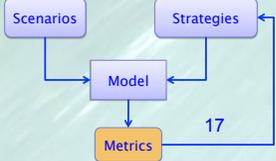
💧 Agricultural demand



💧 Additional environmental demands

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graph TD
    S[Scenarios] --> M[Model]
    St[Strategies] --> M
    M --> Me[Metrics]
    Me -- 17 --> St
            
```

Central Valley Model Estimates Future System Performance



💧 Urban unmet demand

- Reliability
- Magnitudes of shortages



💧 Agricultural unmet demand

- Reliability
- Magnitudes of shortages



💧 Environmental performance

- Reliability of meeting In-stream Flow Requirements

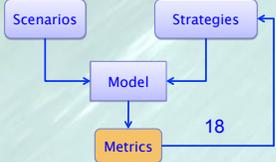


💧 Groundwater storage

- Change over time

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graph TD
    S[Scenarios] --> M[Model]
    St[Strategies] --> M
    M --> Me[Metrics]
    Me -- 18 --> St
            
```

Summary of Analysis

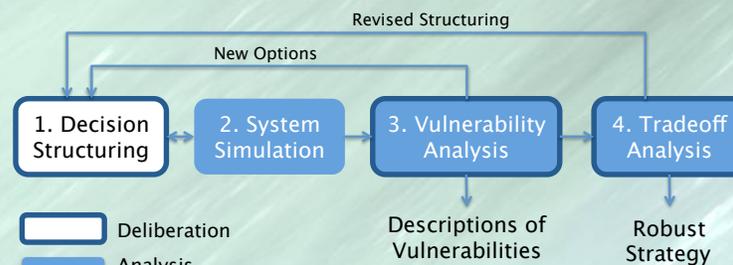
Uncertain Factors (X) and Scenarios	Management Strategies (L) and Response Packages
<ul style="list-style-type: none"> Population Housing density Climate 	<p>Current Management</p> <p>Additional strategies</p> <ul style="list-style-type: none"> Agricultural water use efficiency Urban water use efficiency New surface storage Conjunctive management & groundwater storage Recycled municipal water Meeting additional flow targets and groundwater recovery goals
Models (R)	Performance Metrics (M)
<ul style="list-style-type: none"> UPLAN SWAP Statewide Model Central Valley Model 	<ul style="list-style-type: none"> Urban unmet demand Agricultural unmet demand Unmet instream flow requirements and targets Groundwater levels



Key:
Statewide and Central Valley
Central Valley only

Robust Decision Making (RDM) Provides Structure for Identifying Robust Water Management Strategies

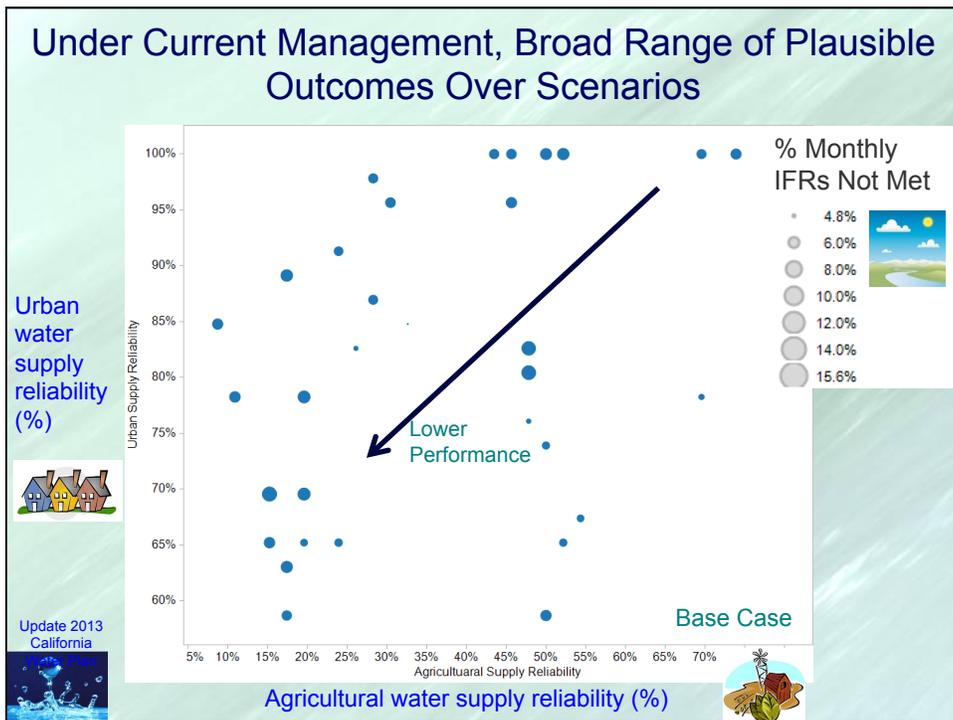
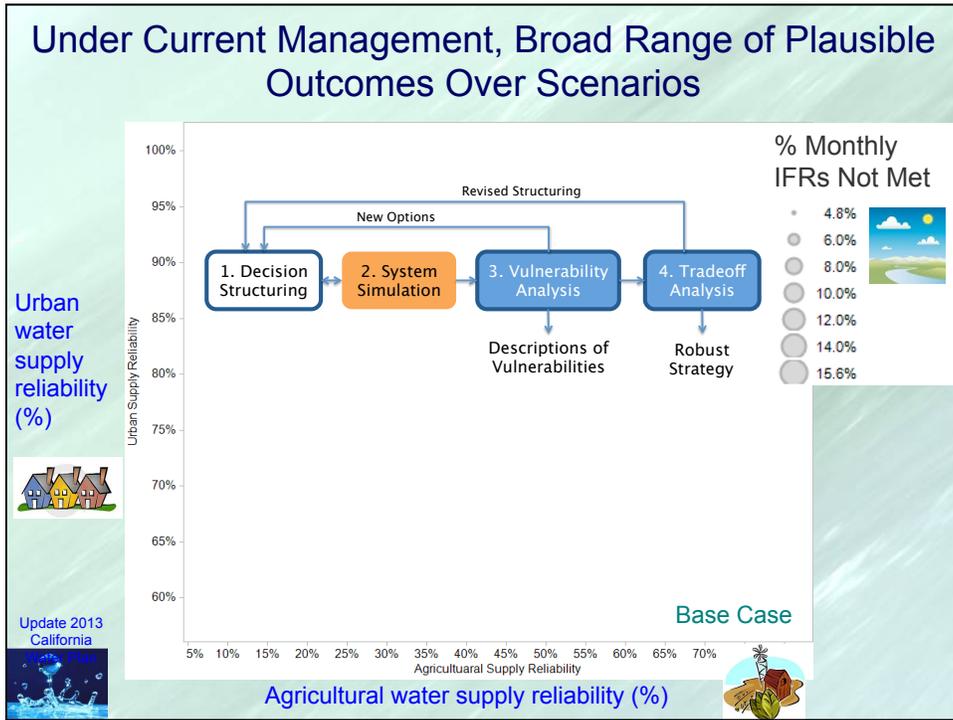
- Evaluates water system across numerous scenarios
- Identifies key vulnerabilities
- Defines tradeoffs among different decisions

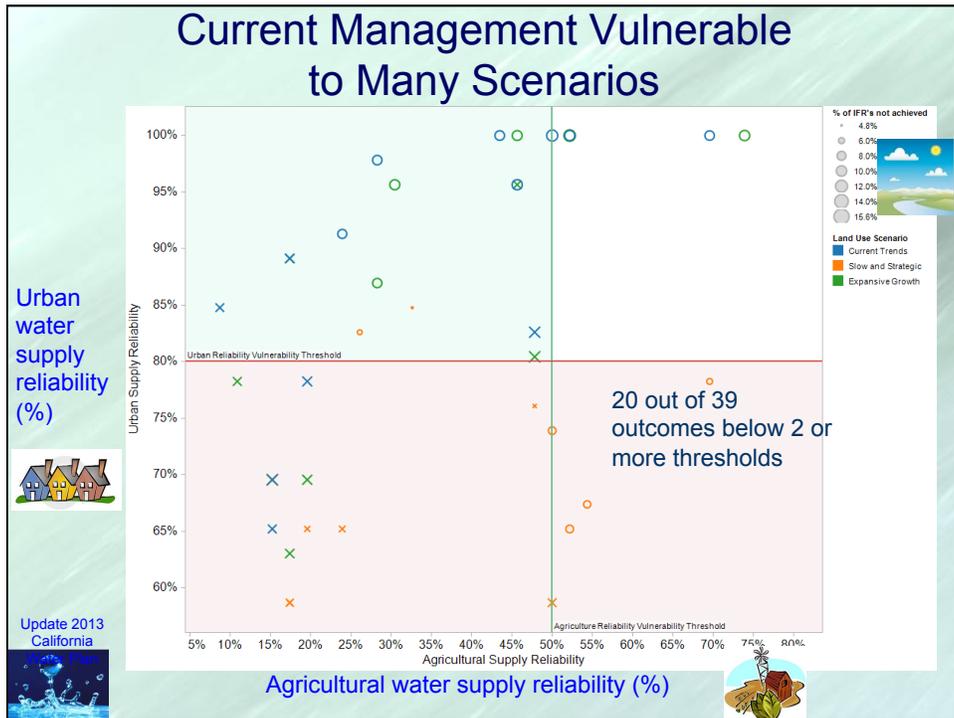
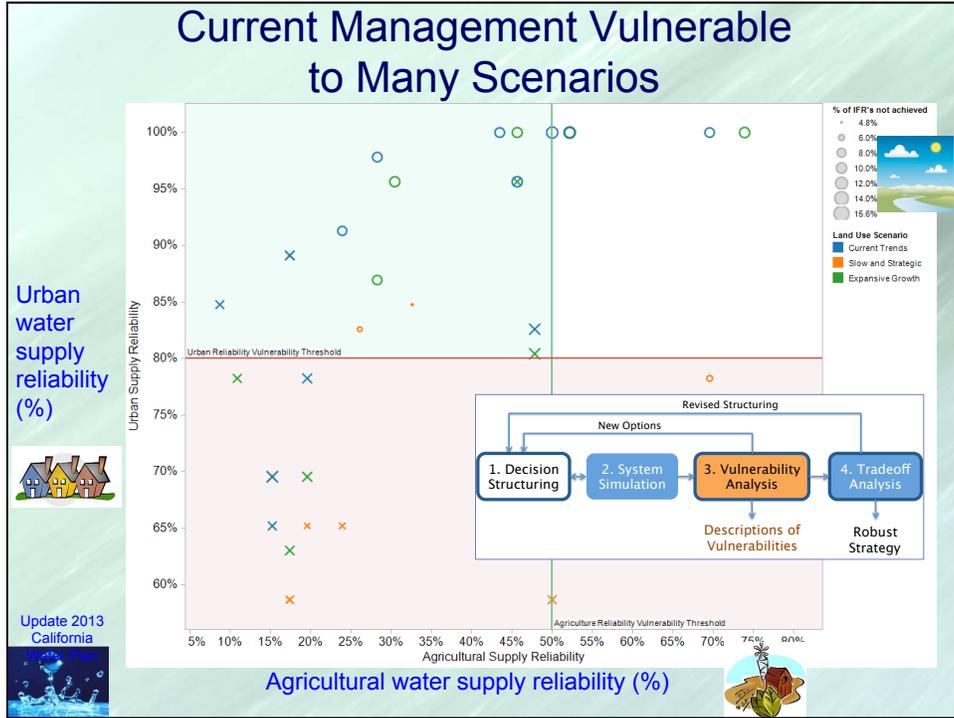


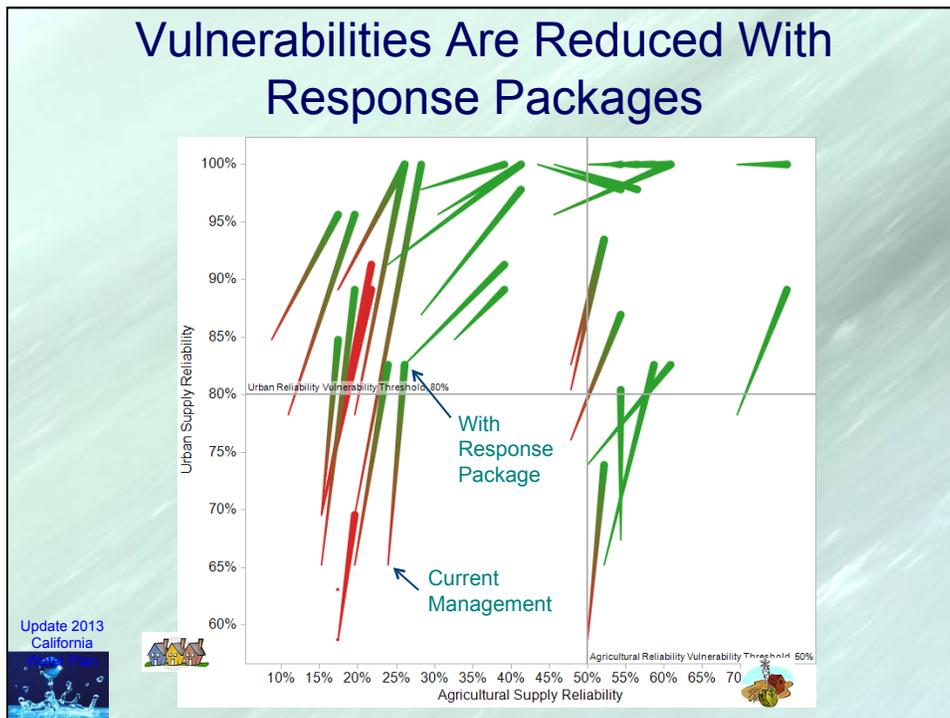
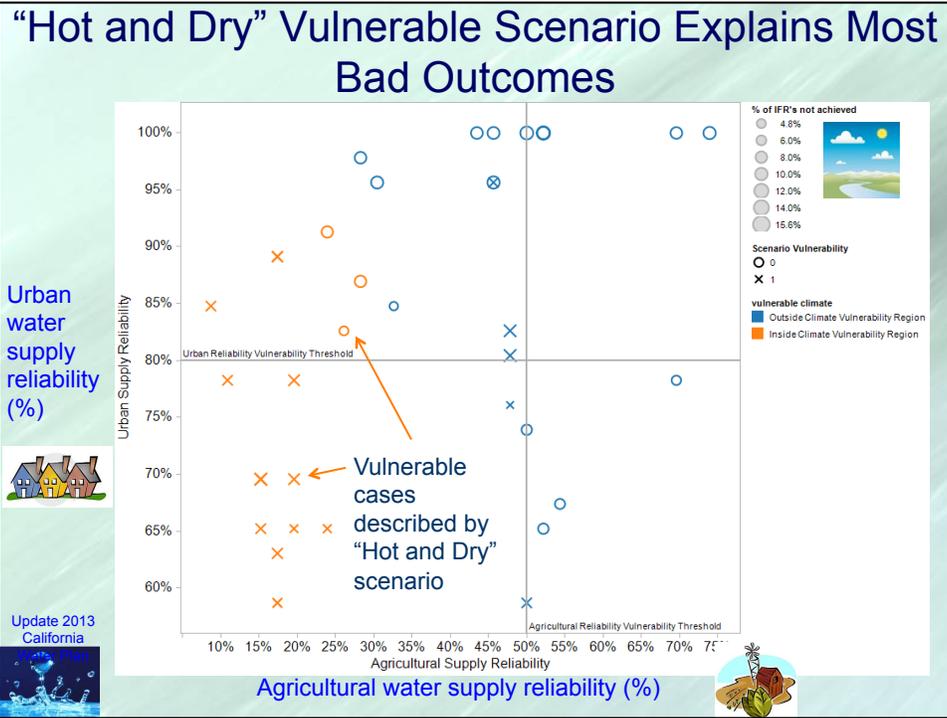
Deliberation
 Analysis
 Deliberation with Analysis

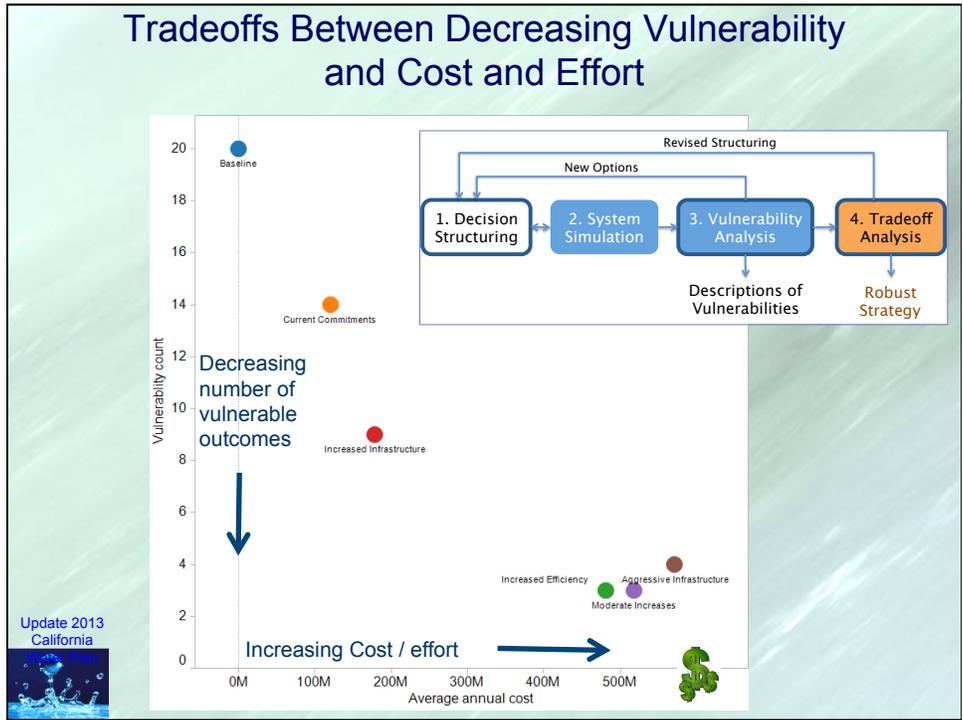
Following results from Proof-of-Concept analysis











Initial Vulnerability Results for the Central Valley

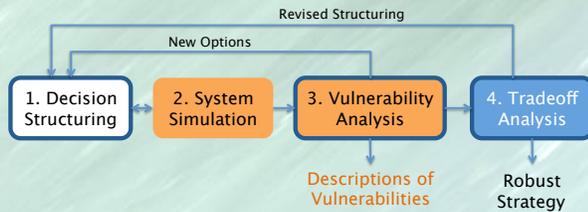
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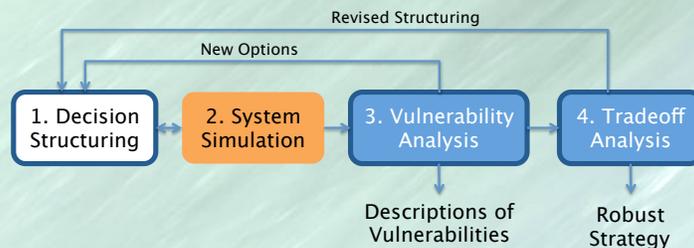
Presentation Goals

- ◆ Illustrate preliminary vulnerability analysis results for Central Valley
- ◆ Interactively explore:
 - Additional results
 - Effects of analytic choices on results



Current Management System Evaluated Under Many Plausible Futures

Growth Scenarios		Climate Scenarios		Total Futures
3 population	X	5 Historical ISM	X	243
		5 Historical Drought		
5 Historical Drought + Steady Warming				
12 Downscaled Climate Model				
3 urban densities				



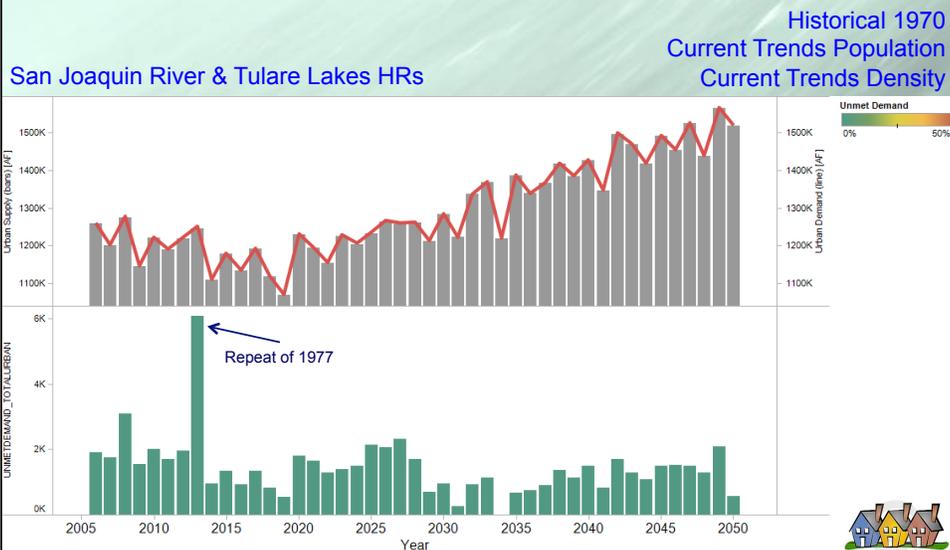
WEAP Model Simulates Many Aspects of System Over Time

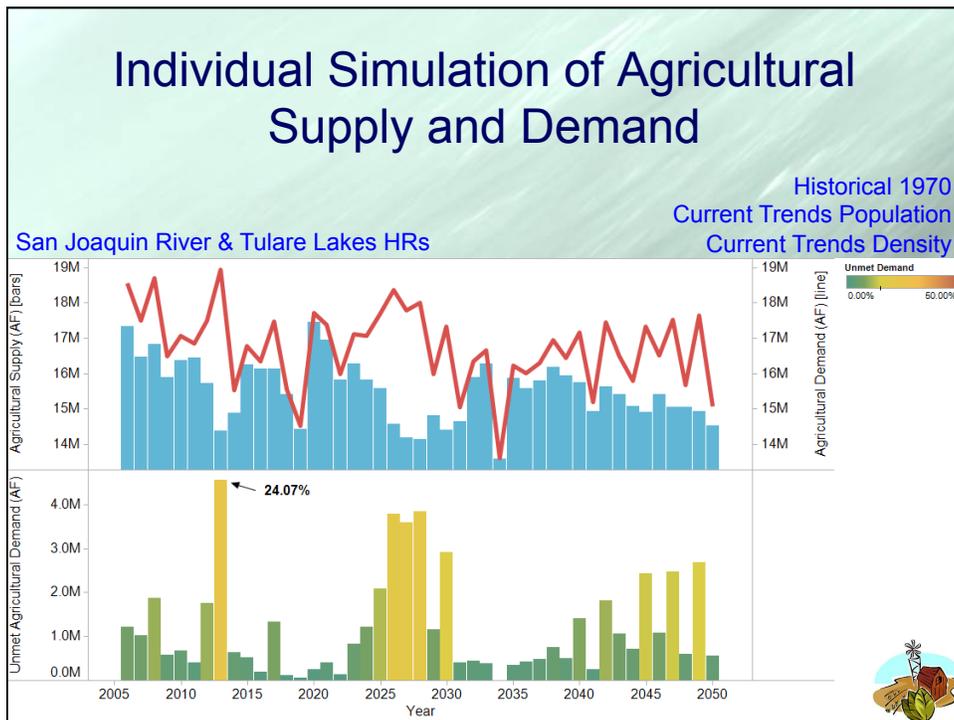
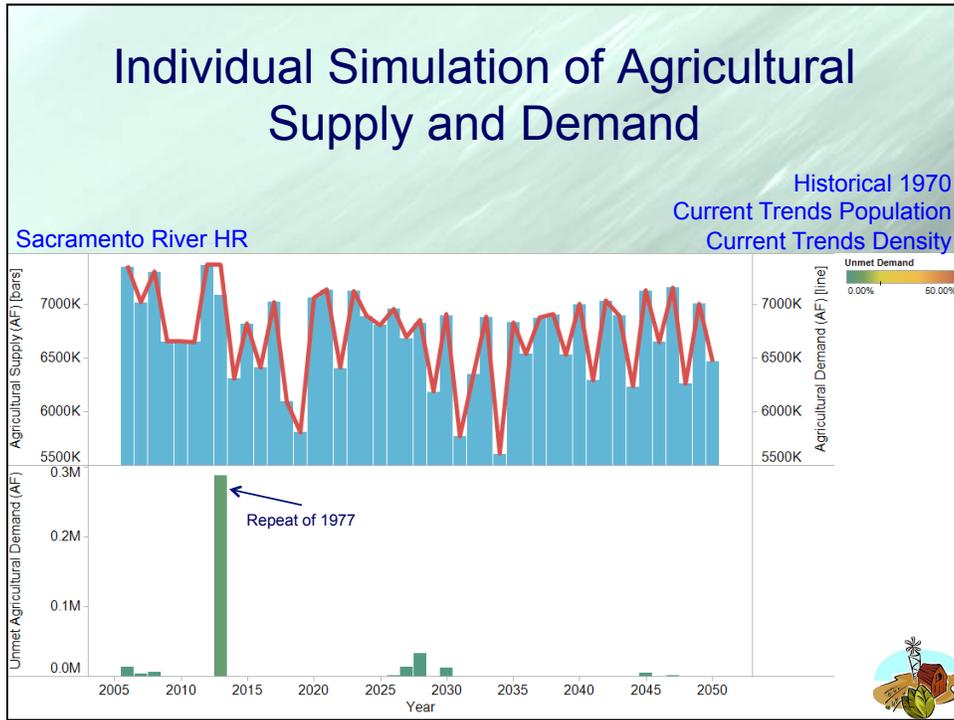
- ◆ Demand (urban and agricultural)
- ◆ Supply (urban and agricultural)
- ◆ Instream flows
- ◆ Unmet demand
- ◆ Groundwater and surface water storage
- ◆ Many others...

Different Futures Lead to Different Results

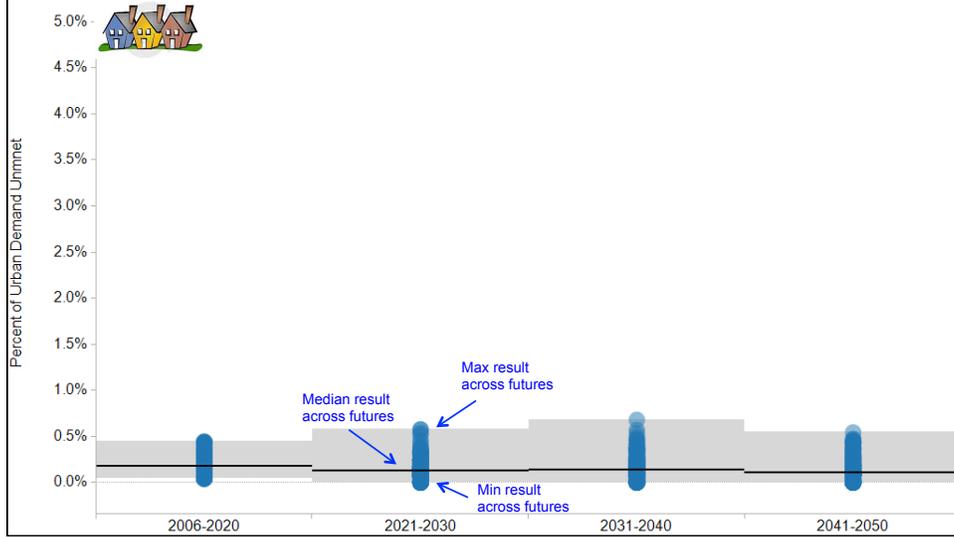


Individual Simulation of Urban Supply and Demand

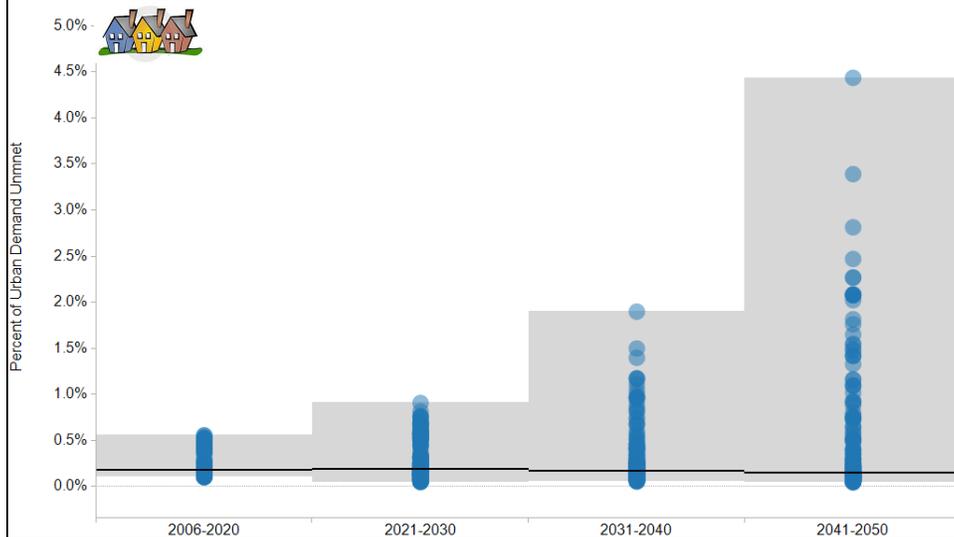




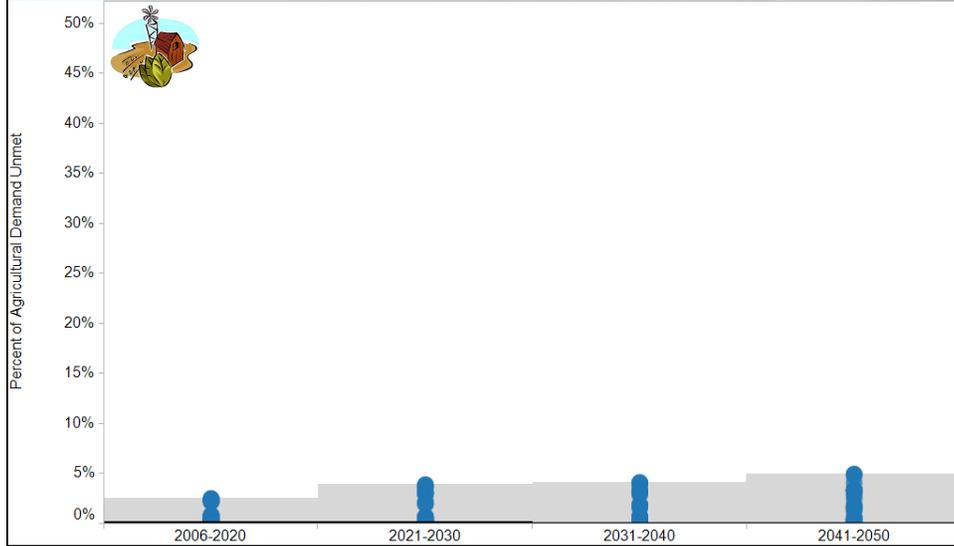
Low Urban Unmet Demand Across Scenarios in Sacramento River Region



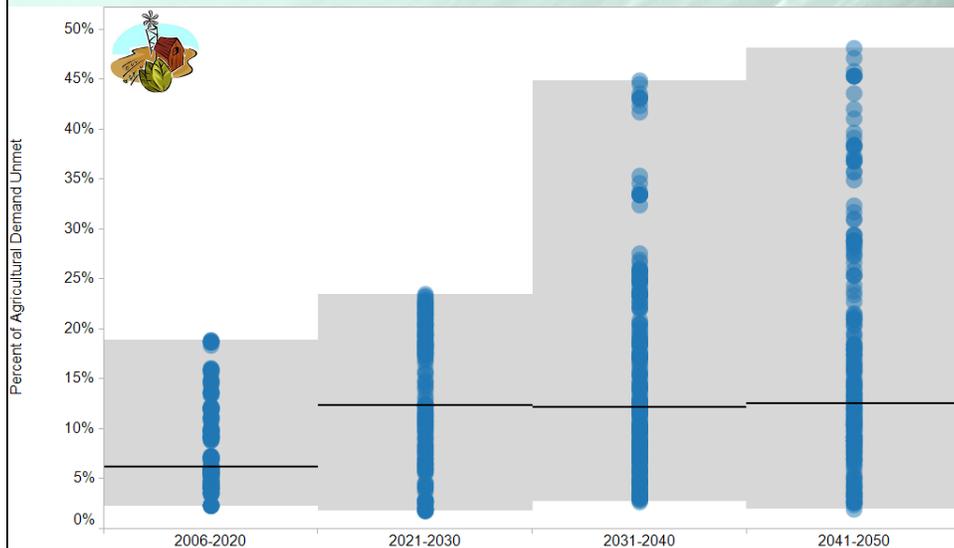
Increasing Urban Demand in San Joaquin River and Tulare Lake Region



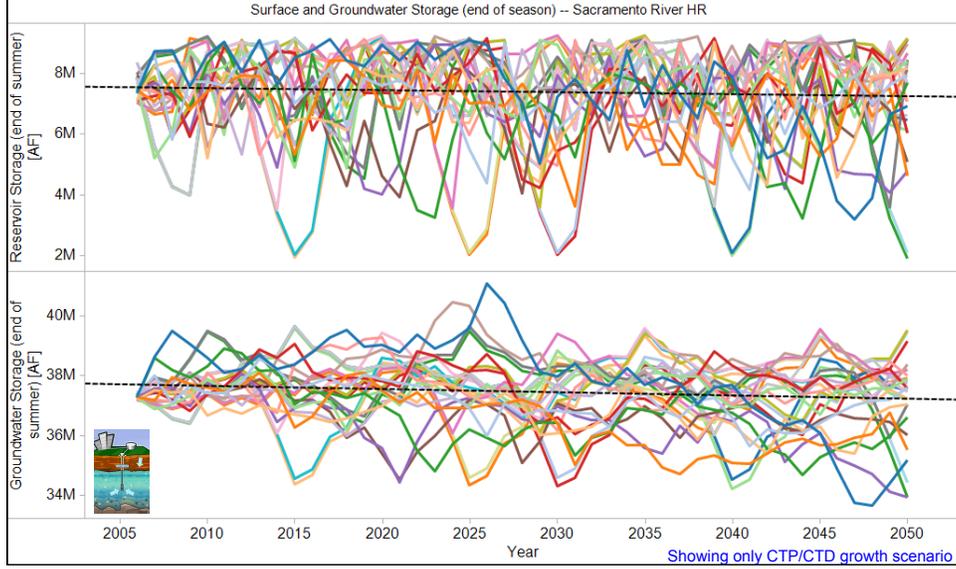
Low Agricultural Unmet Demand Across Scenarios in Sacramento River Region



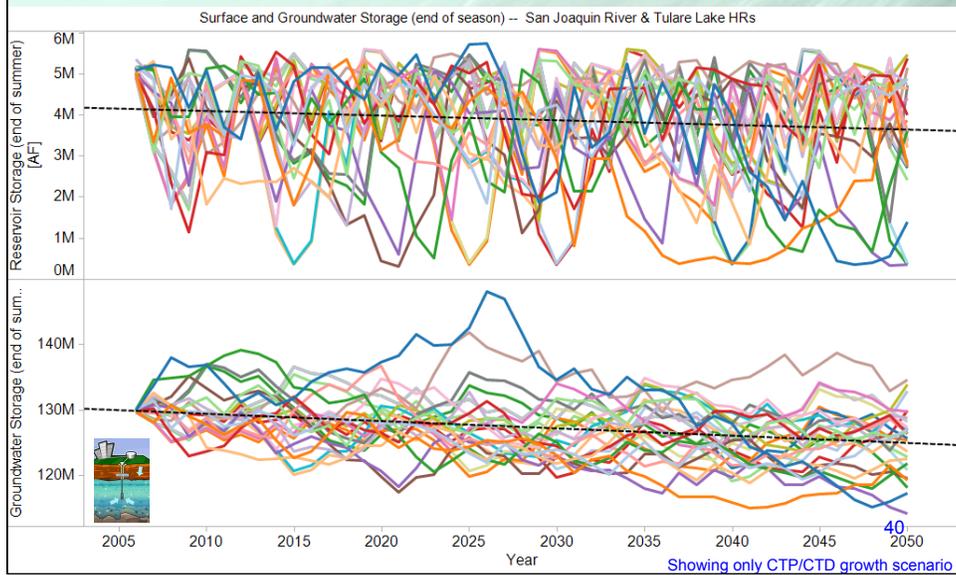
Significant and Increasing Unmet Agricultural Demand in San Joaquin River and Tulare Lake Regions



Stable but Variable Surface and Groundwater in Sacramento River Region



Declining and Highly Variable Surface and Groundwater in San Joaquin River and Tulare Lake Regions

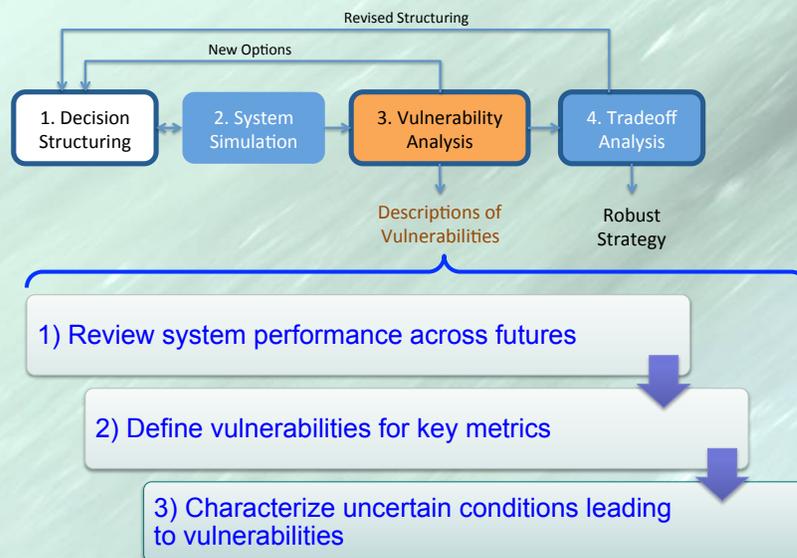


Key Observations of System Performance

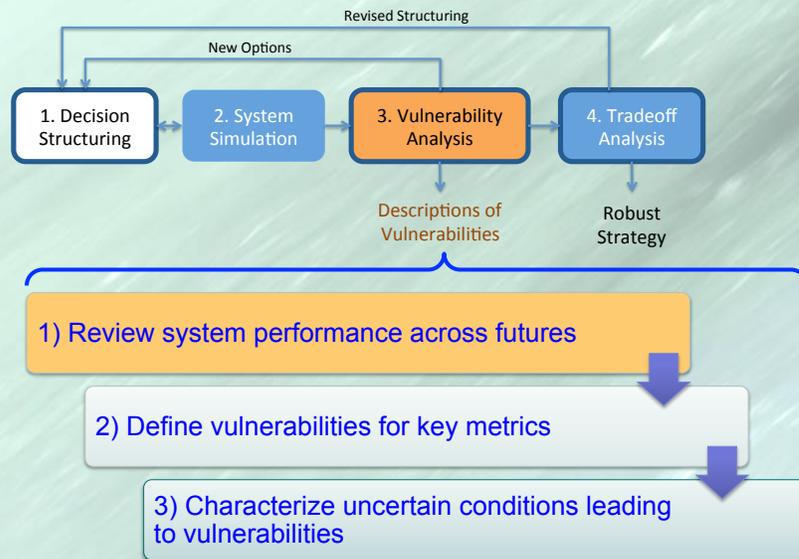
- ◆ High urban and agricultural reliability in the Sacramento River region across futures
 - Stable groundwater and surface water for most futures
- ◆ Modest declines in urban reliability in San Joaquin River and Tulare Lakes regions for some futures
 - Up to 5% shortages in 2040 in some futures
- ◆ Degrading agricultural reliability in San Joaquin River and Tulare Lakes regions for most futures
 - Up to 50% shortage by 2040 in some futures
 - Declining groundwater storage amounts



Key Steps to Vulnerability Analysis



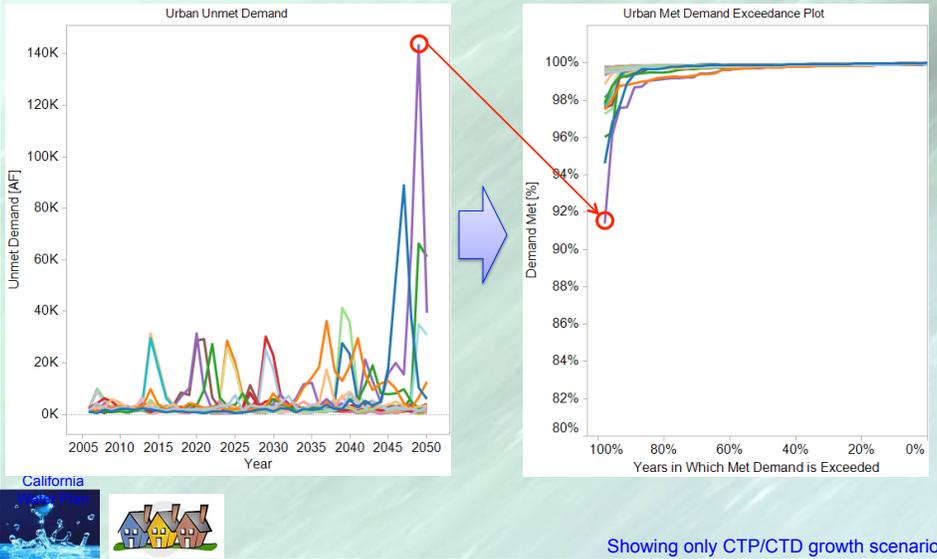
Key Steps to Vulnerability Analysis



Vulnerability Analysis Focuses on Key Performance Metrics

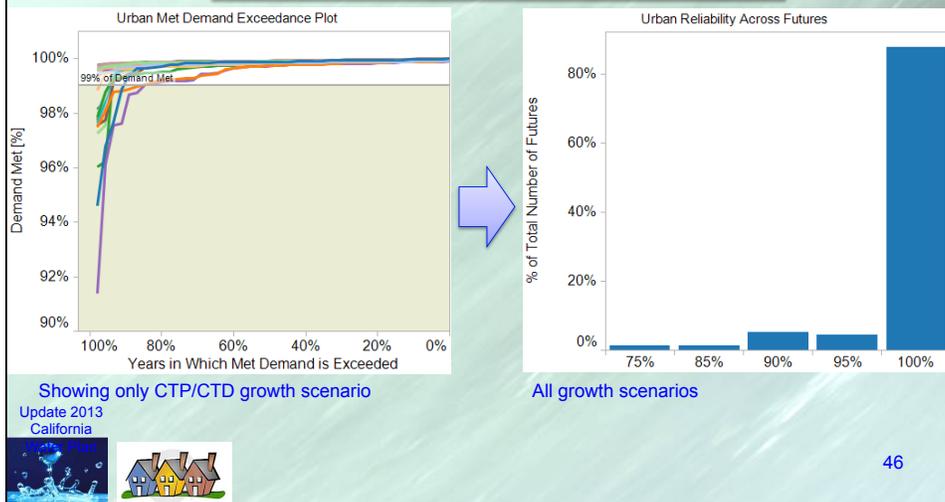
- ◆ Urban unmet demand
 }
Reliability and maximum shortages
 - ◆ Agricultural unmet demand
 }
Reliability and maximum shortages
 - ◆ Unmet instream flow requirements
 }
Frequency of unmet requirements
 - ◆ Groundwater storage
 }
Trends over time
- 44
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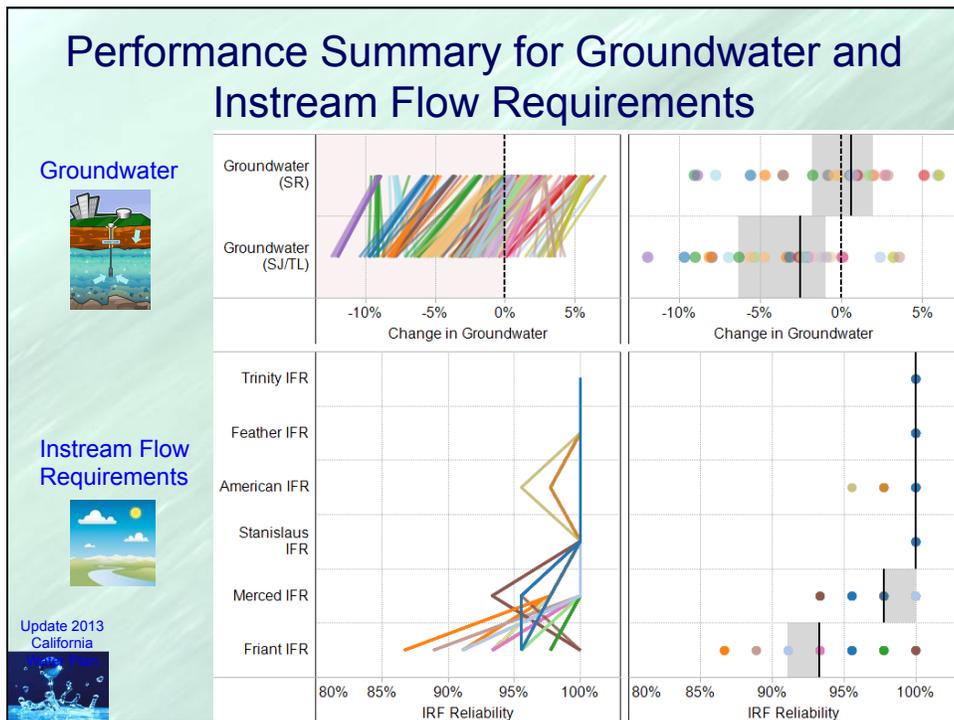
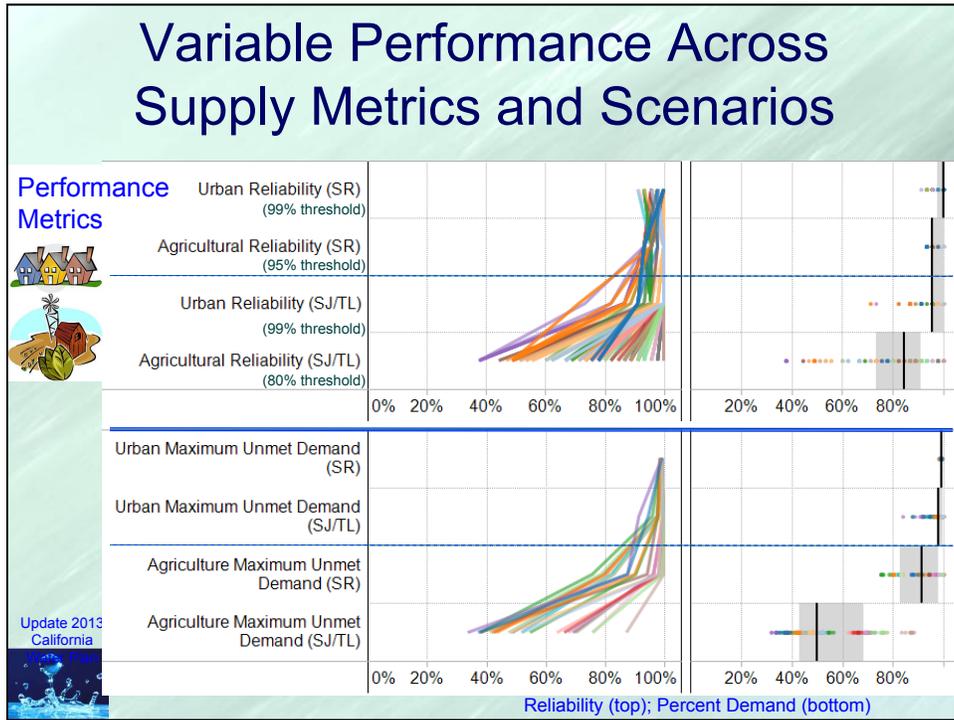
Exceedance Plots Summarize Simulations of Unmet Demand Over Time



Urban Reliability Derived from Exceedance Results

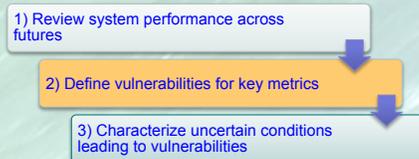
Reliability based on a 99% met demand threshold





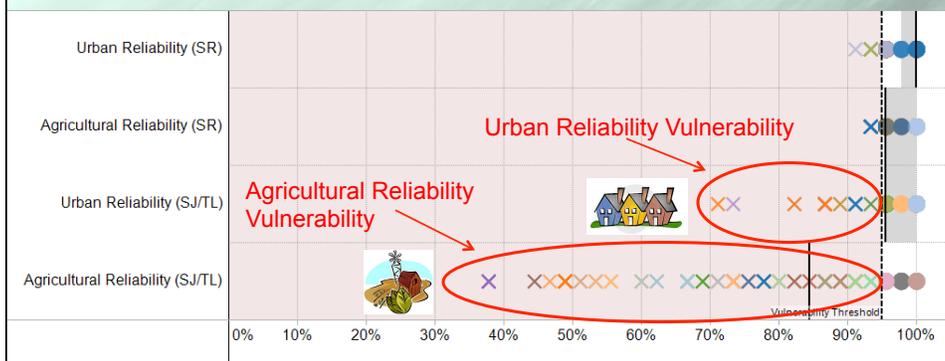
Vulnerabilities Focus Uncertainty Analysis on What Matters to Management Decisions

- ◆ Vulnerabilities are futures in which objectives are not met
 - Defined via thresholds, e.g., Reliability < 95%
- ◆ Subsequent steps:
 - define external conditions that lead to vulnerabilities
 - compare how different response packages reduce vulnerable conditions



What Future Conditions Drive Poor Performance?

Urban and Agricultural Reliability



Analyzed Different Characterizations of Scenarios to Understand What Affects Reliability

- ◆ Climate Conditions
 - Average temperature (2006-2050, 2030-2050)
 - Average precipitation (2006-2050, 2030-2050)
 - Average precipitation in driest 2 year period
 - Average precipitation in driest 5 year period
 - Year of driest 2 year period
 - Year of driest 5 year period
- ◆ Demographic Conditions
 - Trends in housing
 - Trends in total irrigated crop area



Two Key Conditions Best Explain Urban and Agricultural Vulnerabilities

(1) Average Temperature (2030-2050)



(2) Average Precipitation (2030-2050)

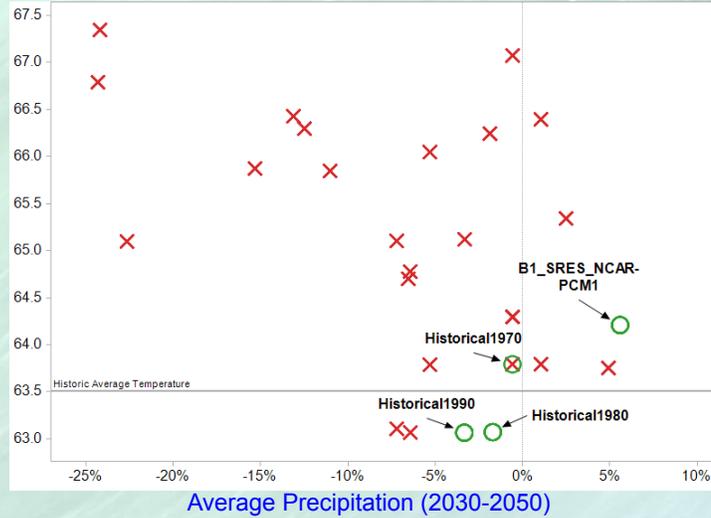


Agricultural Reliability Vulnerable to All But Coolest Historical and Wettest Climate Scenario



Average Temperature °F (2030-2050)

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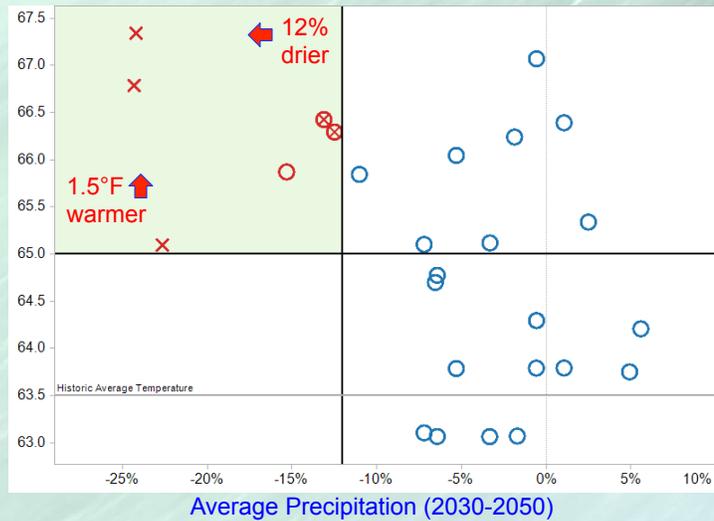
Urban Reliability Is Vulnerable to Futures 12% Drier and 1.5°F Warmer

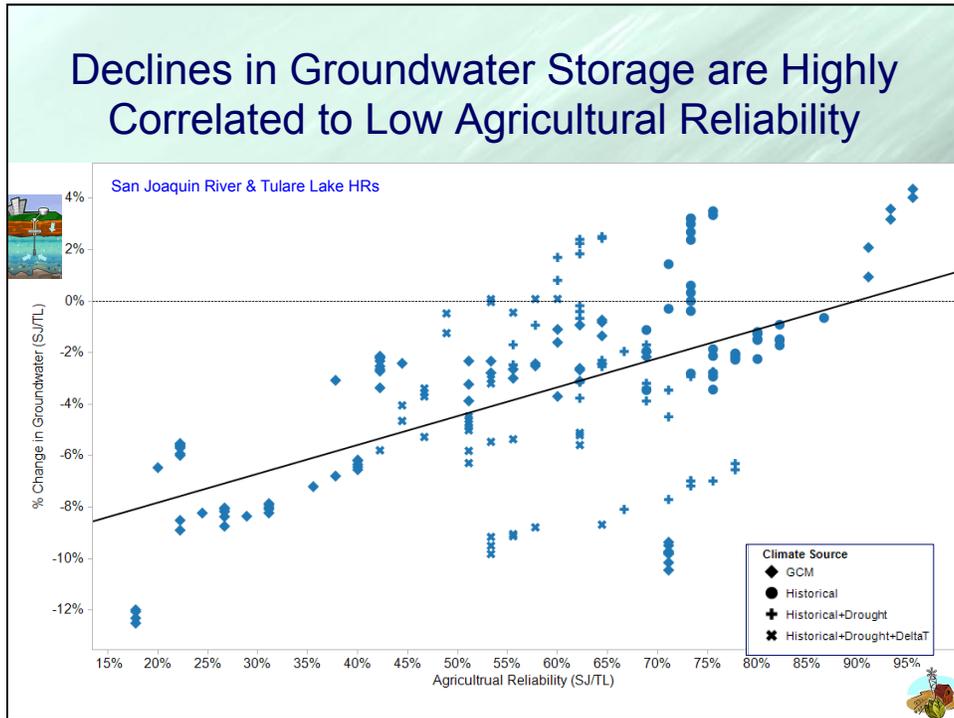


Average Temperature °F (2030-2050)

Density = 56% Coverage = 100%

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Key Results from Vulnerability Analysis

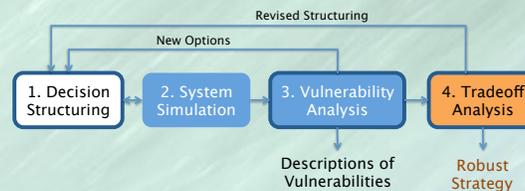
- ◆ The San Joaquin River and Tulare Lake hydrologic regions vulnerable to some plausible future conditions
 - Urban reliability:
 - Driest and warmest of climate model projections
 - Agricultural reliability:
 - All but the wettest and coolest of historical and climate projections
 - Groundwater conditions vulnerable to similar conditions

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Next Steps for Analysis

- ◆ Expand vulnerability analysis to additional metrics
- ◆ Simulate system with response packages
- ◆ Calculate reductions in vulnerability with response packages
- ◆ Compare tradeoffs among response packages



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Interactive Visualization Software Allows for Exploration of Data and Results

- ◆ Interactive visualization software supports data exploration and “what-if” analyses:
 - Explore simulation results
 - Change reliability thresholds
 - Change vulnerability thresholds
 - Change definitions of vulnerable conditions
- ◆ Version for stakeholder use to be made available soon

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