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AND ENVIRONMENT**

# ***Incorporating Climate Change into California Water Management***

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**CCAP Urban Leaders Adaptation Initiative  
May 21, 2008**

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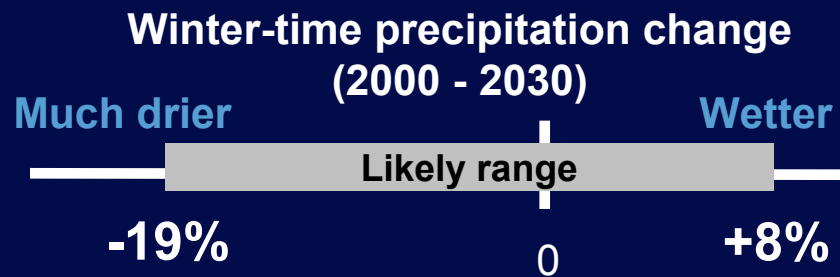
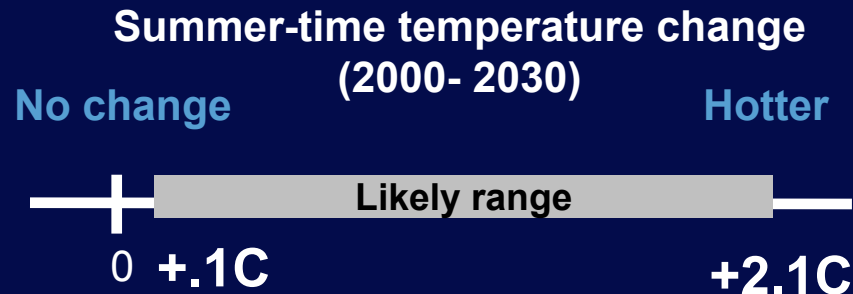
# ***Climate Change Poses Significant Challenge for Local Governments' Planning***

- **Climate change presents a novel and serious challenge for many communities**
  - But most already include climate (often implicitly) in many decisions
- **“Stationarity is dead”**
  - Amidst all the uncertainty one thing we do know for sure -- tomorrow's climate will not be like the past's
- **Relaxing this assumption poses key challenges**
  - How do you plan under (deep, long-term) uncertainty?
  - How do you communicate these plans, especially when uncertain long-term benefits require near-term costs?
  - Which actions should you take now and which actions later?
  - How do you respond to potentially consequential but presumably low probability events?

## ***For Water Managers, Costs of Adaptation Could Be High If Not Properly Anticipated and Planned***

- **Changes in West are likely to include:**
  - Increased temperatures
  - Changes in precipitation patterns
  - More intense storms
  - Declining snow pack and summertime river flows
- **Without proper planning:**
  - Supply expectations may not be met
  - Demand may grow faster than can be accommodated
  - Infrastructure may fail
- **But current planning methods often prove inadequate**
  - Precise climate impacts remain deeply uncertain
  - Limited data are available for reliable probability estimates

# Planners in S. California, for Instance, Face a Range of Possible Future Climate Conditions



Results based on statistical summary of 21 of the world's best  
Global Climate Models

**Water managers also face many similarly, if not more, disruptive uncertainties**

# ***RAND Has Pioneered a New Approach to Climate Vulnerability and Response Option Analysis***

- **Robust decision making is a new approach to supporting decisions under “deep” uncertainty**
  - Focus of NSF-funded activity on climate decision making
  - Successful in a wide range of public and private sector applications
- **Key ideas**
  - Treat uncertainty with a wide range of plausible futures
  - Identify robust, rather than optimal actions
  - Explicitly consider plans that evolve over time
  - Combine participant engagement of traditional scenario planning with rigor of formal decision analysis

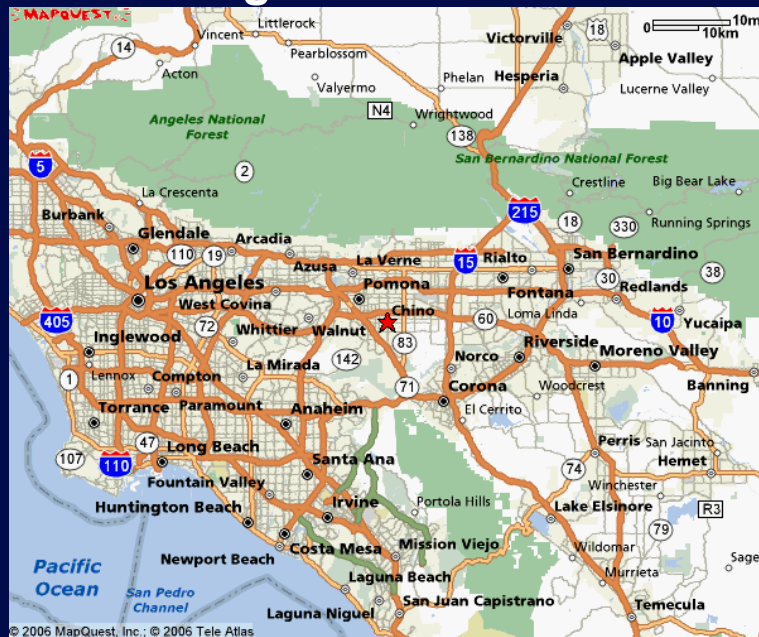


# *Outline*

- **Example climate vulnerability and options analysis**
- **Evaluating impacts of analysis**
- **Broader Implications**

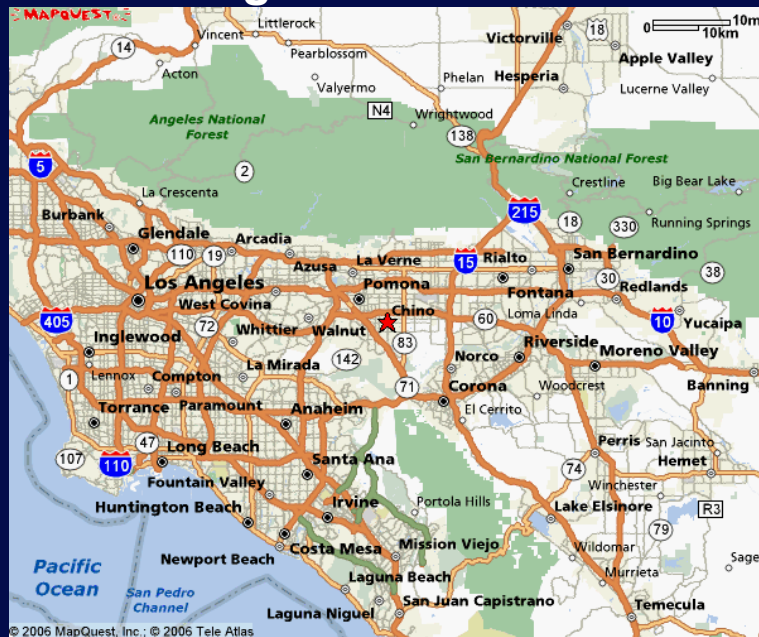
# Conducted Vulnerability and Options Analysis for Inland Empire Utilities Agency (IEUA)

- IEUA currently serves 800,000 people
  - May add 300,000 by 2025
- Water presents a significant challenge



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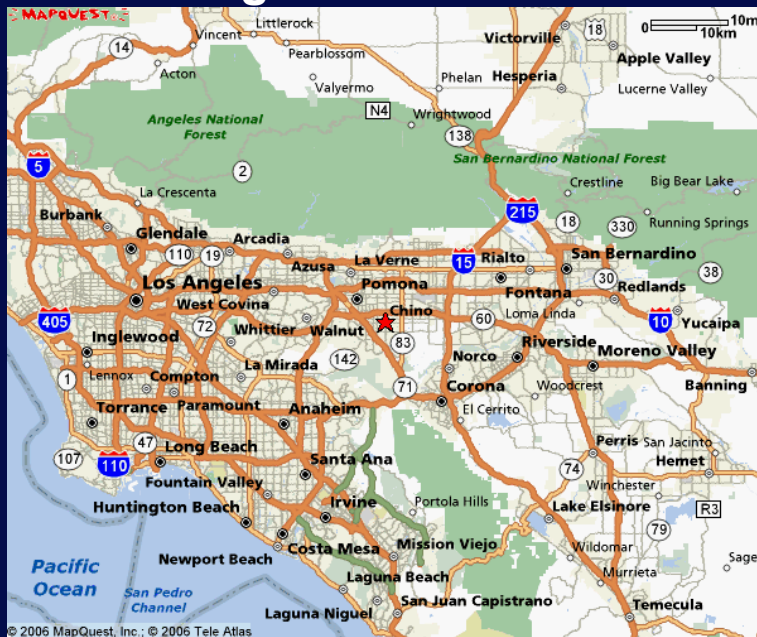


## – Current water sources include:

- Groundwater 56%
- Imports 32%
- Recycled 1%
- Surface 8%
- Desalter 2%

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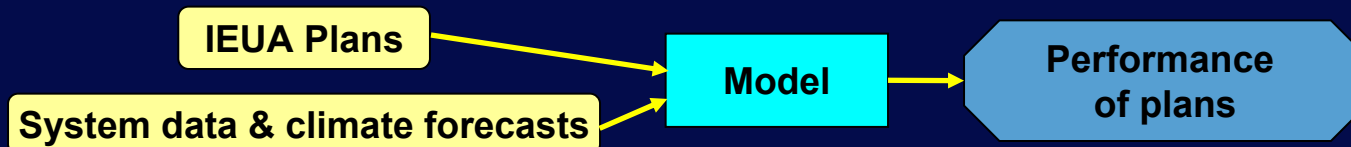


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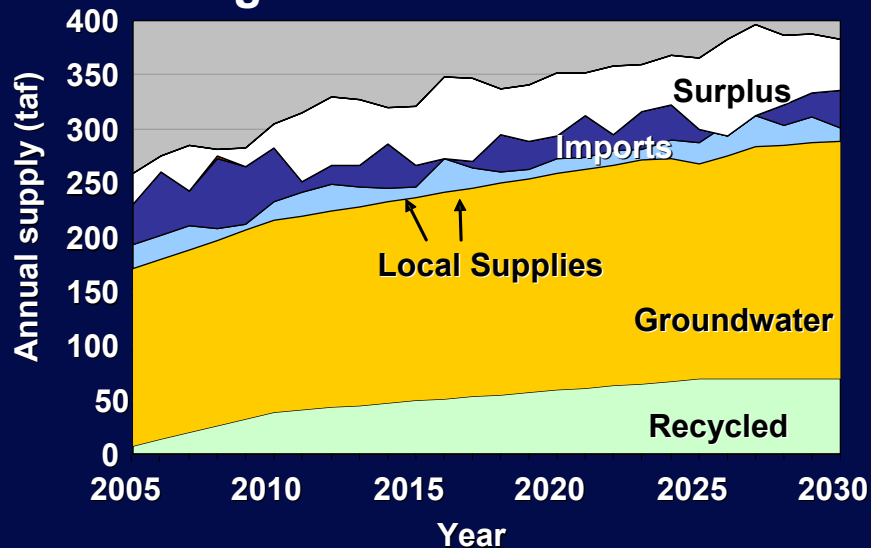
**Focus of IEUA's 20 year plan**

# Built Model to Assess Performance of IEUA Plans in Different Future States of World



## Scenario A

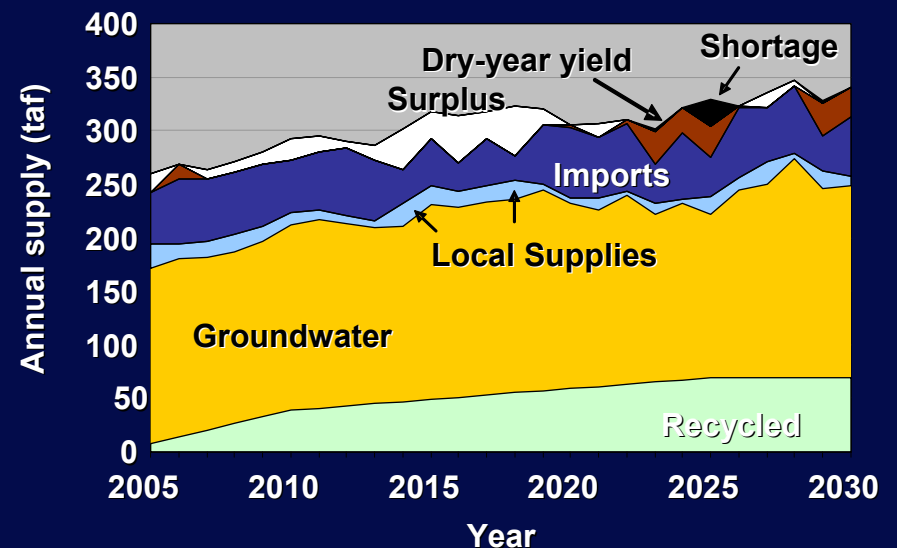
Plan generates surpluses in benign future climate



Temp: +0.7°C Precip: +3%

## Scenario B

Plan suffers shortages in adverse future climate



Temp: +1.6°C Precip: -10%

# ***Many Uncertain Factors Could Impact the Performance of Current IEUA Plan***

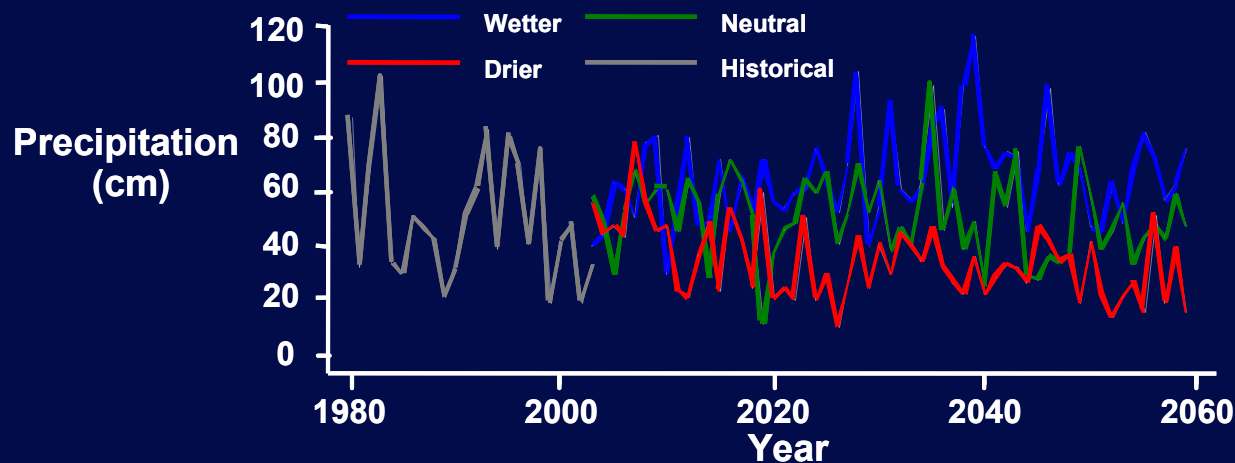
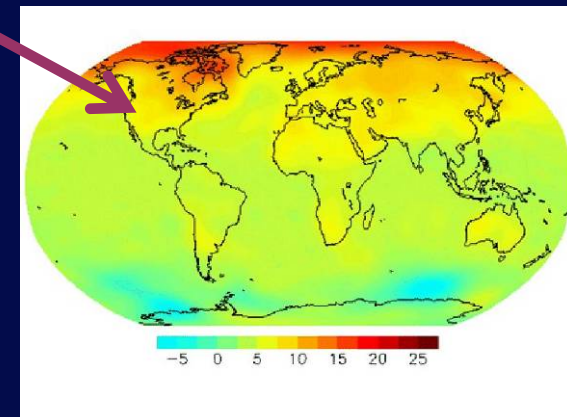
<b>Natural Processes</b>	<ul style="list-style-type: none"><li>• Future temperatures</li><li>• Future precipitation</li><li>• Changes in groundwater processes</li></ul>
<b>Performance of Management Strategies</b>	<ul style="list-style-type: none"><li>• Development of aggressive waste-water recycling program</li><li>• Implementation of groundwater replenishment</li></ul>
<b>Costs of Future Supplies and Management Activities</b>	<ul style="list-style-type: none"><li>• Imported supplies</li><li>• Water use efficiency</li></ul>

# Downscaled, Probabilistic Climate Projections Used to Create Hundreds of Local Weather Sequences

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How do these general trends affect IEUA?

21 global climate models



Hundreds of sequences of local weather

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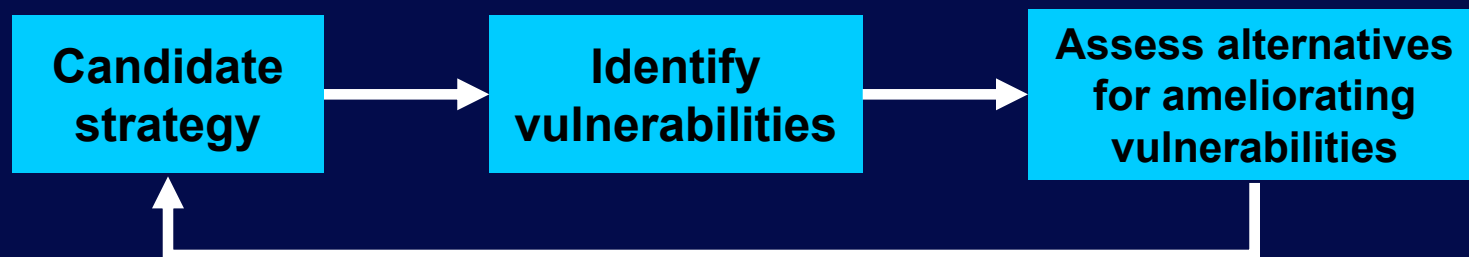
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# ***Robust Decision Making (RDM) Enables Good Decisions Under Deep Uncertainty***

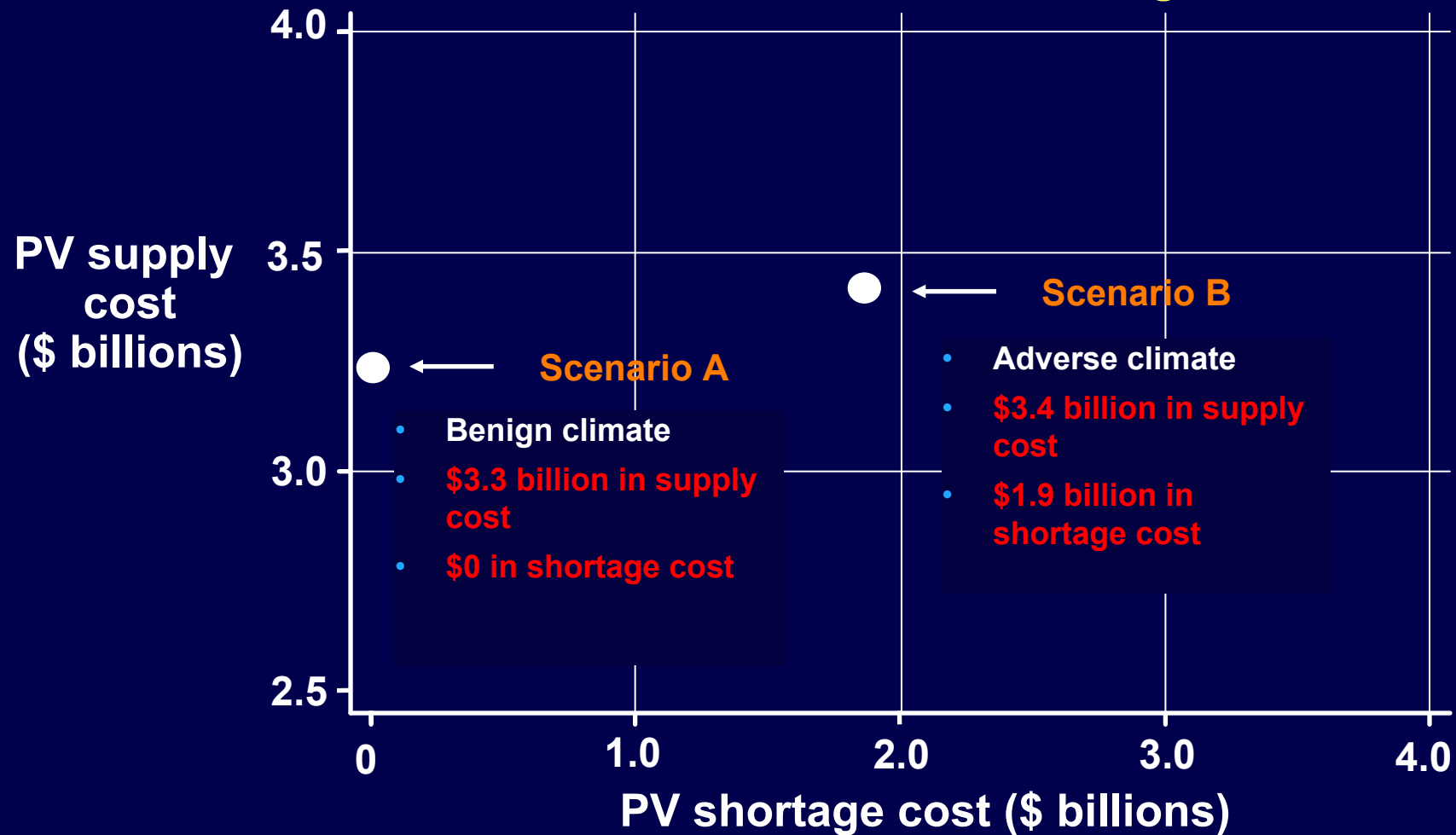
- **Deep uncertainty obtains when**
  - Decision makers don't know or agree on the system model or the probability distributions for the inputs to the model
- **RDM is a quantitative decision analytic approach that**
  - Identifies robust strategies, ones that work reasonably well compared to the alternatives across a wide range of plausible scenarios



- **RDM combines key advantages of scenario planning and quantitative decision analysis in ways that**
  - Decision makers find credible
  - Contribute usefully to contentious debates

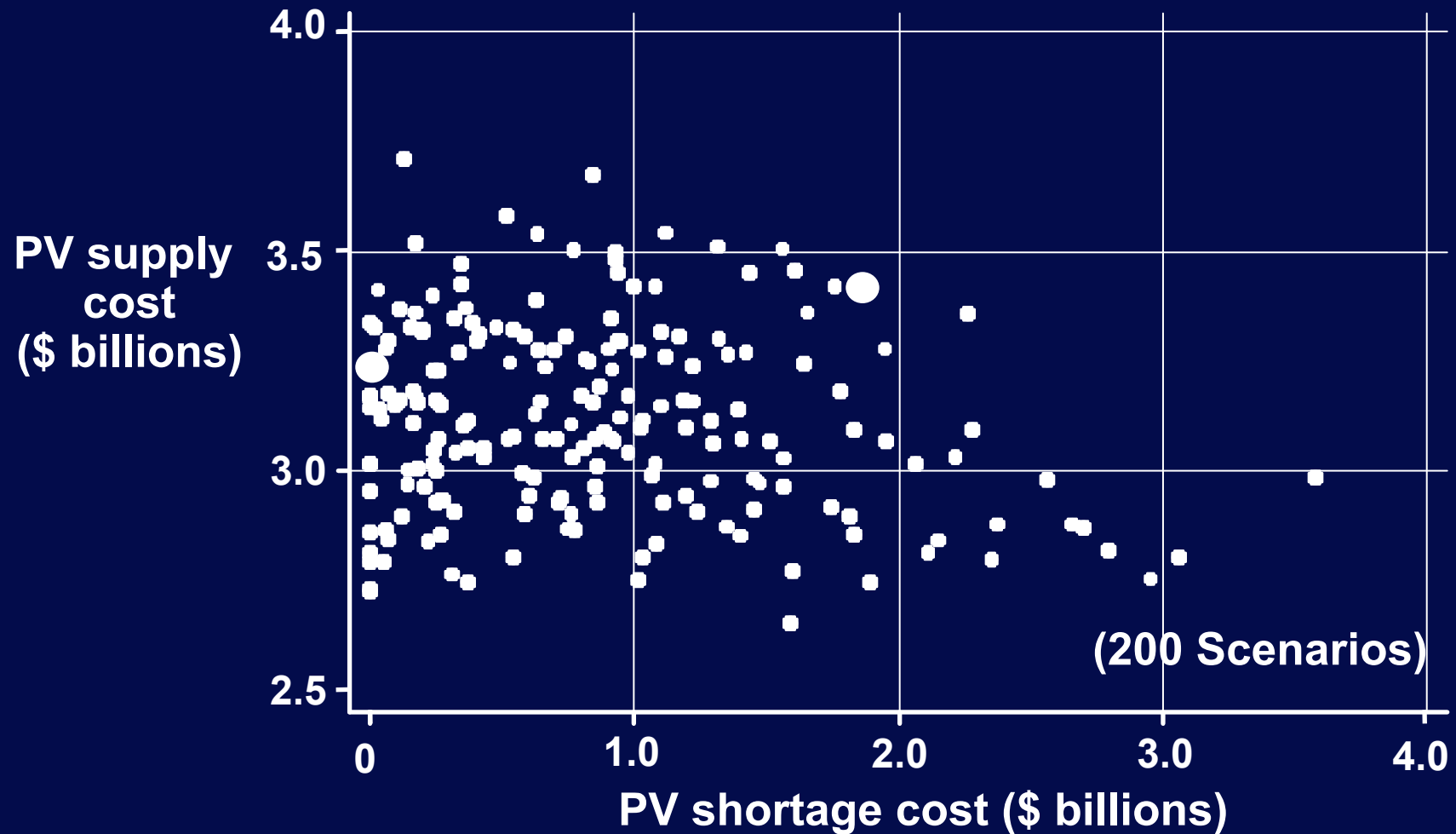
# *“Scenario Maps” Help Decision Makers Visualize How Plans Evolve Over Many Futures*

## Current IEUA 2005 Urban Water Management Plan



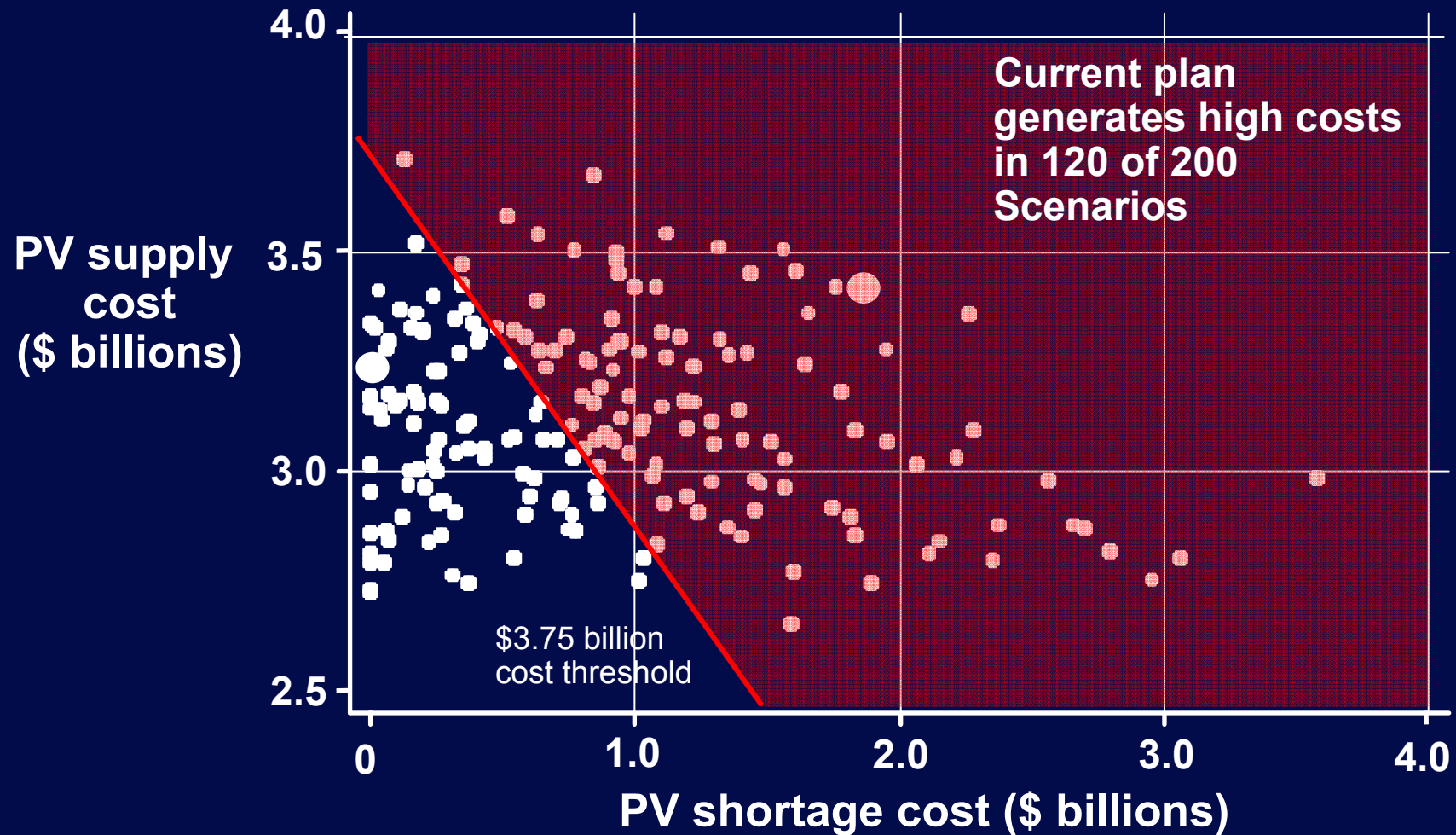
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**Current IEUA Plan**

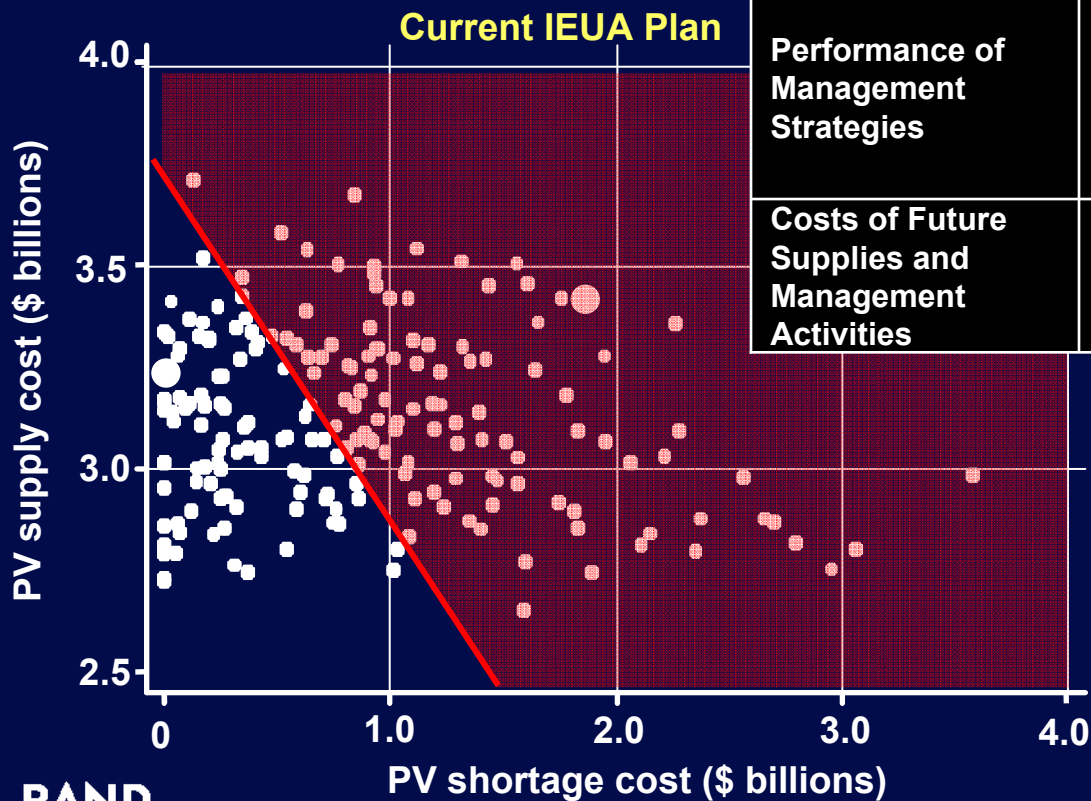


# *“Scenario Maps” Help Decision Makers Visualize How Plans Evolve Over Many Futures*

## Current IEUA Plan



# Analysis Suggests The Key Factors That Create Vulnerabilities for Existing Plan



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These three factors explain 70% of vulnerabilities of IEUA's current plans

# Response Options May Help IEUA Address These Vulnerabilities

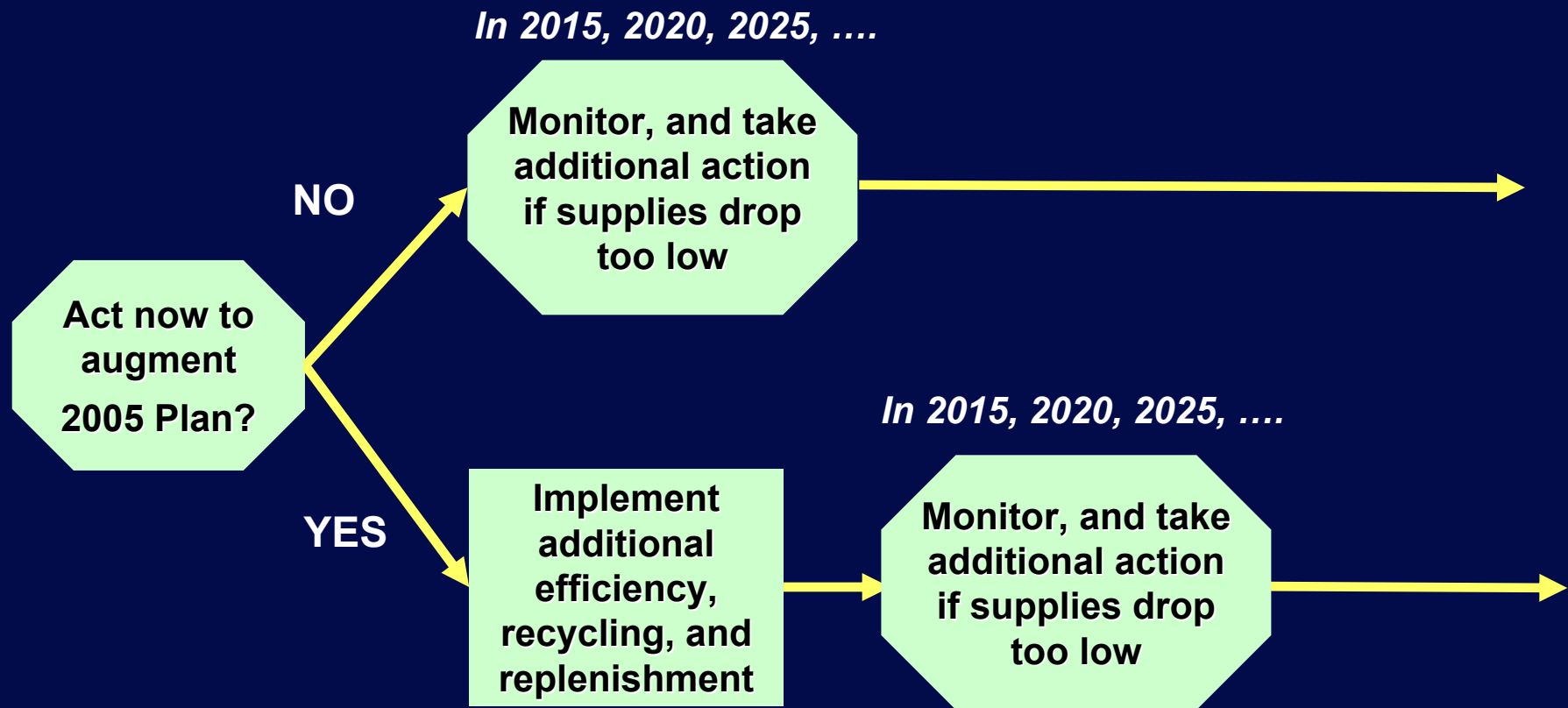
## Each Option Has Benefits and Costs

Improve Water Use Efficiency	<ul style="list-style-type: none"><li>• Strengthen landscape ordinances for new construction</li><li>• Retrofit indoor devices</li><li>• Retrofit outdoor landscapes</li></ul>
Expand Recycled Water Use System	<ul style="list-style-type: none"><li>• Speed up system expansion</li></ul>
Improve Groundwater Management	<ul style="list-style-type: none"><li>• Increase size of Metropolitan Dry Year Yield (DYY) program</li><li>• Increase allowable fraction of recycled water for replenishment</li><li>• Increase capture of storm-water for replenishment</li></ul>

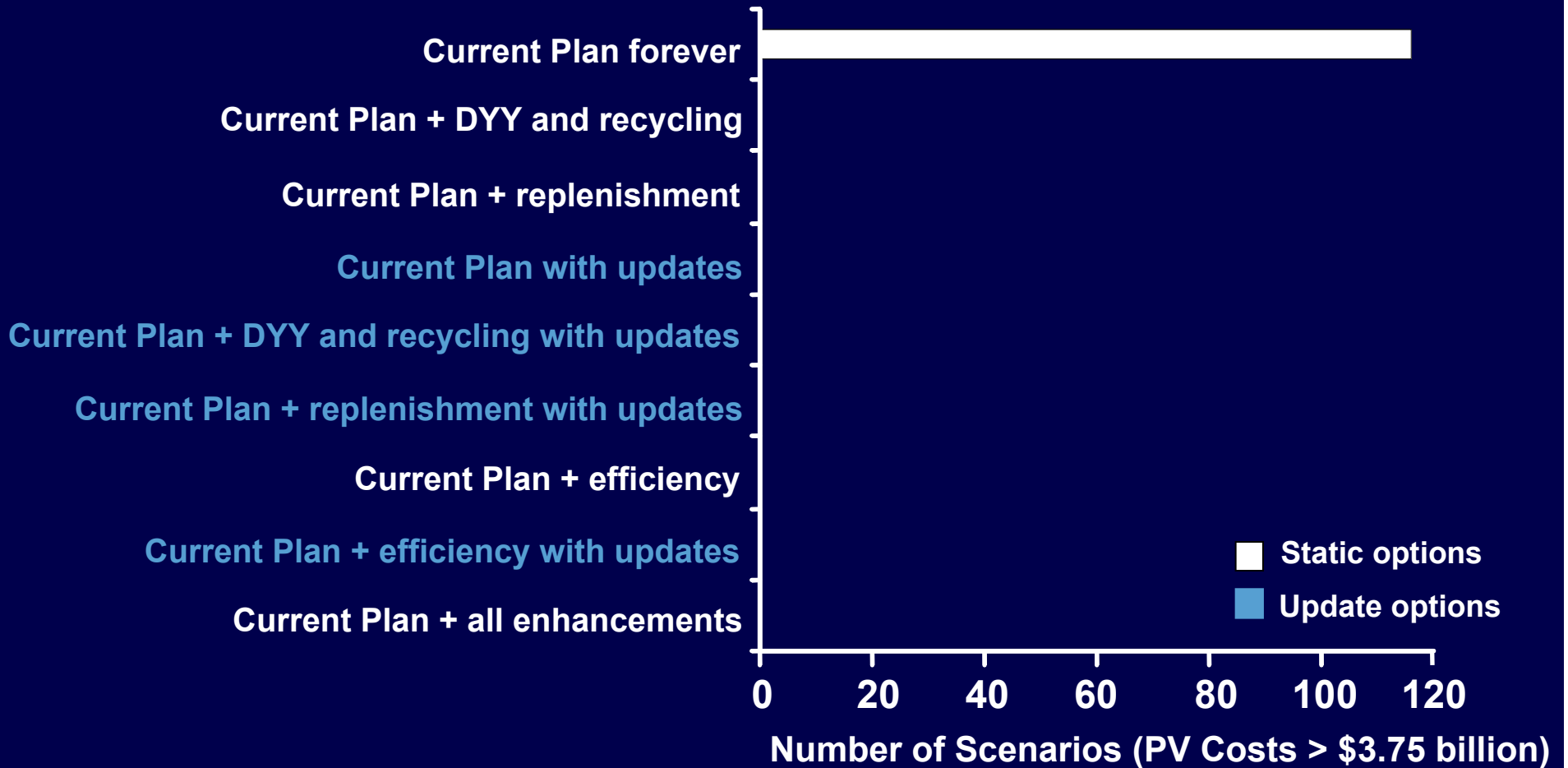
- Efficiency reduces demand but imposes costs on customers and requires customer participation
- Recycled water use is a drought-proof supply but requires significant public support

- Improved groundwater management increases resilience to shortages but requires significant cooperation and faces unknown costs

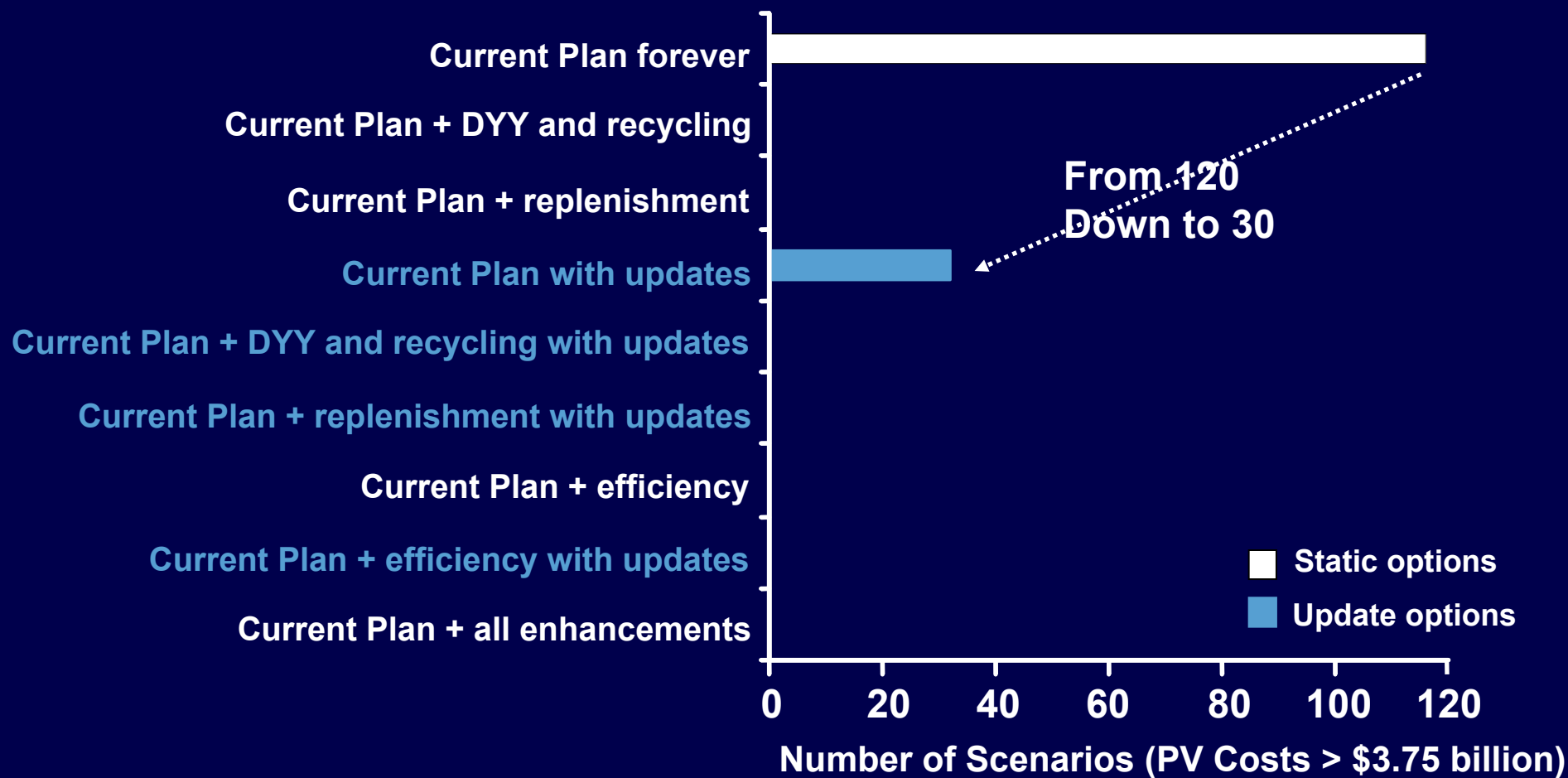
# Should IEUA Act Now or Later to Reduce Potential Climate Vulnerabilities?



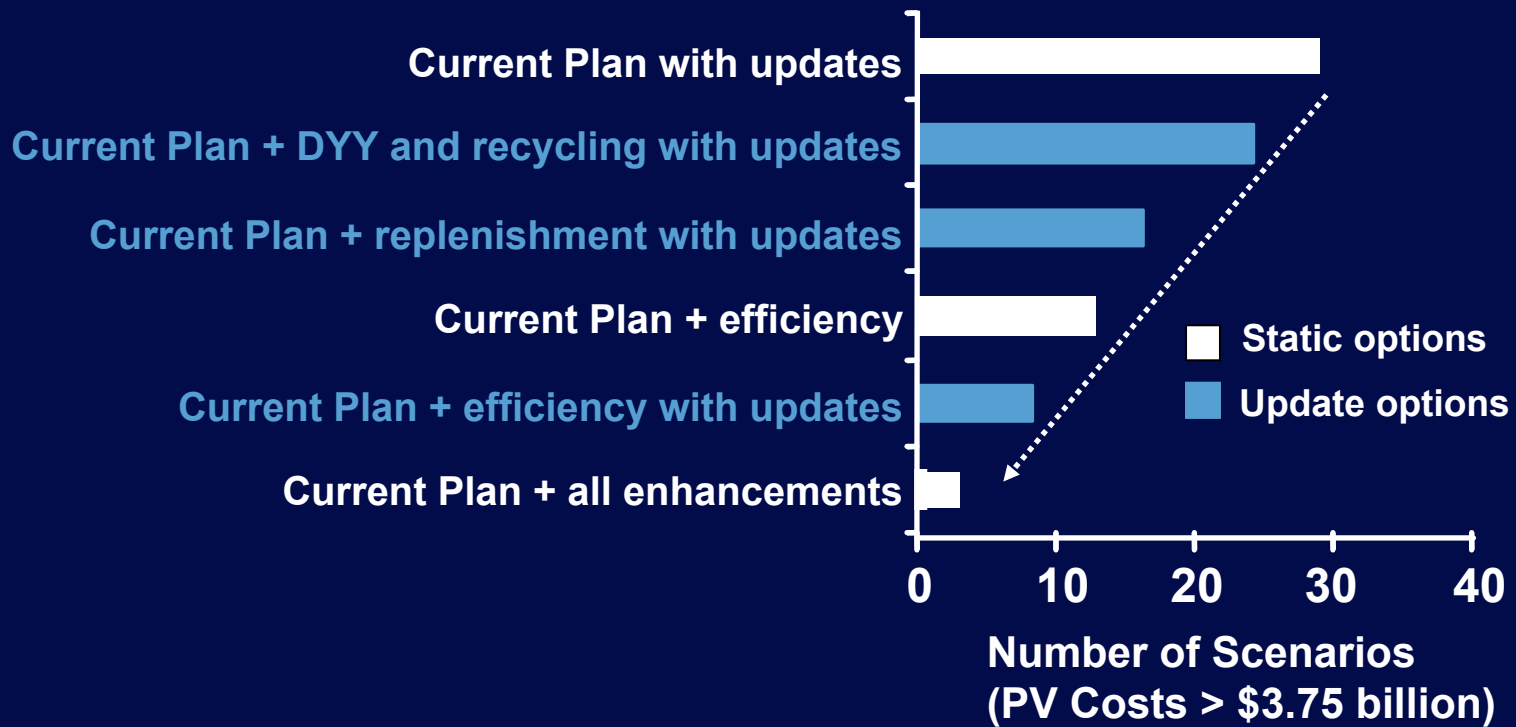
# Compare Nine Strategies Over 200 Scenarios Reflecting Key Uncertainties



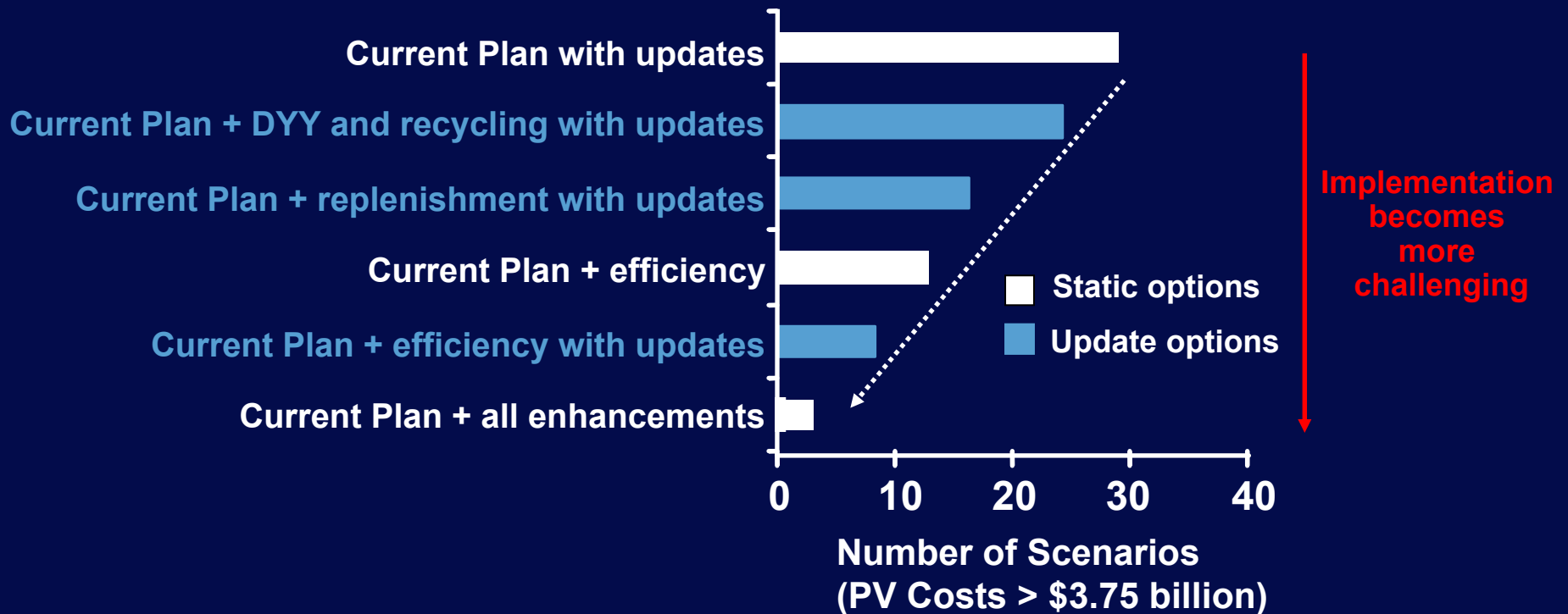
# Just Allowing IEUA's Current Plan to Update Reduces Vulnerability Substantially



# Acting Now Reduces Future Vulnerabilities Even More



# Acting Now Reduces Future Vulnerabilities Even More



*This analysis helped IEUA decide to make more near-term efficiency investments, and to monitor performance and adapt as needed down the road*

# ***Key Component of Work Evaluated How These Tools Affect Policy-Makers' Views***

- **Four IEUA workshops presented modeling results to participants including:**
  - **Agency professional managers and technical staff**
  - **Local elected officials**
  - **Community stakeholders**
  
- **“Real-time” surveys measured participants’**
  - **Understanding of concepts**
  - **Willingness to adjust policy choices based on information presented**
  - **Views on RDM**

# ***Surveys Suggest Workshop Changed Views***

## **Participants reported:**

- RDM helped support comparison of climate-related risks and choice among plans
- Preference for scatter plot over histogram scenario displays

## **After the workshop:**

- 35% said consequences of bad climate change now appeared “more serious” than before
- 40% thought the likelihood of of bad climate change outcomes for the IEUA was “greater” than before
- 75% though the ability of IEUA planner to plan for and manage effects was “greater” than before

## **Overall, analysis increased:**

- Perceived likelihood of serious climate impacts
- Confidence that IEUA could take effective actions to reduce its vulnerability to climate change
- Support for near-term efficiency enhancements to current IEUA plan

# ***New Methods May Be Broadly Useful for Planning Adaptation to Climate Change***

- **Replace stationary climate assumption with deeply uncertain forecasts by**
  - Considering many plausible futures
  - Identifying robust policies
  - Considering plans that evolve over time
- **Many agencies considering adopting new approach**
  - DWR, MWD, CEC, and others
  - Scenario-based analytics link well to participatory processes
- **May provide means to address high consequence, unknown probability events**
  - For instance, large sea level rise

## ***Some Summary Observations***

- **Used properly, current climate information is sufficient to inform robust adaptation plans**
- **Decision makers may**
  - **More readily engage with the full range of potential climate impacts**
  - **If they have confidence they can respond to them**
- **Community planners confront many deep uncertainties in addition to climate change**
  - **Addressing climate may provide an opportunity to improve overall planning**

## ***More Information***

David G. Groves, Robert J. Lempert, Debra Knopman, Sandra H. Berry: Preparing for an Uncertain Climate Future: Identifying Robust Water Management Strategies, RAND DB-550-NSF, 2008.

David G. Groves, Debra Knopman, Robert J. Lempert, Sandra H. Berry, and Lynne Wainfan, Presenting Uncertainty About Climate Change to Water Resource Managers, RAND TR-505-NSF, 2007.

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Steven W. Popper, Robert J. Lempert, and Steven C. Bankes: "Shaping the Future," Scientific American, vol 292, no. 4 pp. 66-71, April 2005

Robert J. Lempert, Steven W. Popper, Steven C. Bankes: Shaping the Next One Hundred Years: New Methods for Quantitative, Long-Term Policy Analysis, RAND MR-1626-RPC, Aug 2003

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