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Managing Water in the West

An Approach to Scenario Planning in the Colorado River Basin – The Colorado River Basin Study

RNRF – Congress on Sustaining Western Water
Washington, DC
December 1-2, 2015

U.S. Department of the Interior
Bureau of Reclamation

Overview of the Colorado River System

- 16.5 million acre-feet (maf) allocated annually
  - 7.5 maf each to Upper and Lower Basins
  - 1.5 maf to Mexico
- ~ 16 maf average annual “natural flow” (from historical record)
  - 14.8 maf in the Upper Basin and 1.3 maf in the Lower Basin
- Inflows are highly variable year to year
- 60 maf of storage (~ 4X the annual inflow)
- Operations and water deliveries governed by the “Law of the River”

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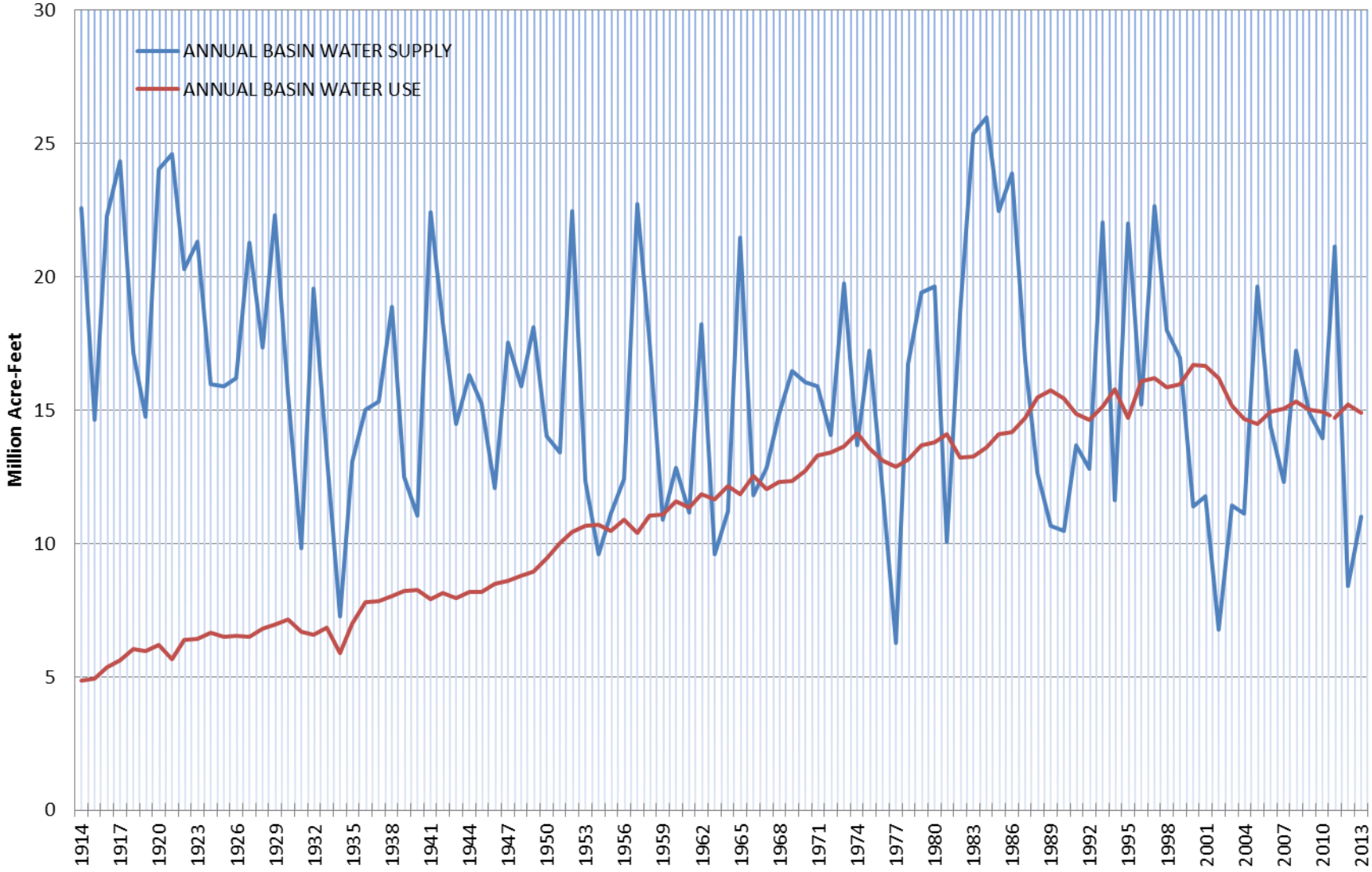
Historical Annual Colorado River Basin Supply & Use



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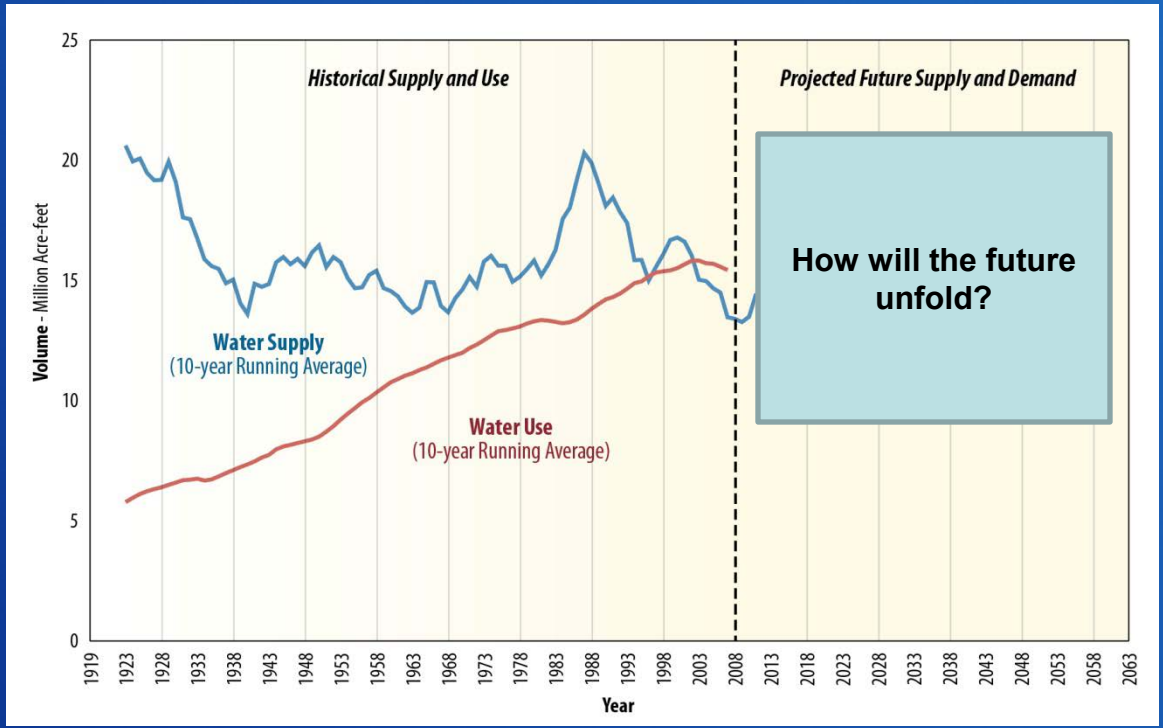
Colorado River Basin Water Supply and Demand Study

- Study Objective
  - Assess future water supply and demand imbalances over the next 50 years
  - Develop and evaluate opportunities for resolving imbalances
- Conducted through the WaterSMART Basin Study Program, completed in 2012
- Conducted by Reclamation and the Basin States, in collaboration with stakeholders throughout the Basin



- A planning study – did *not* result in any decisions, but provides the technical foundation for future activities

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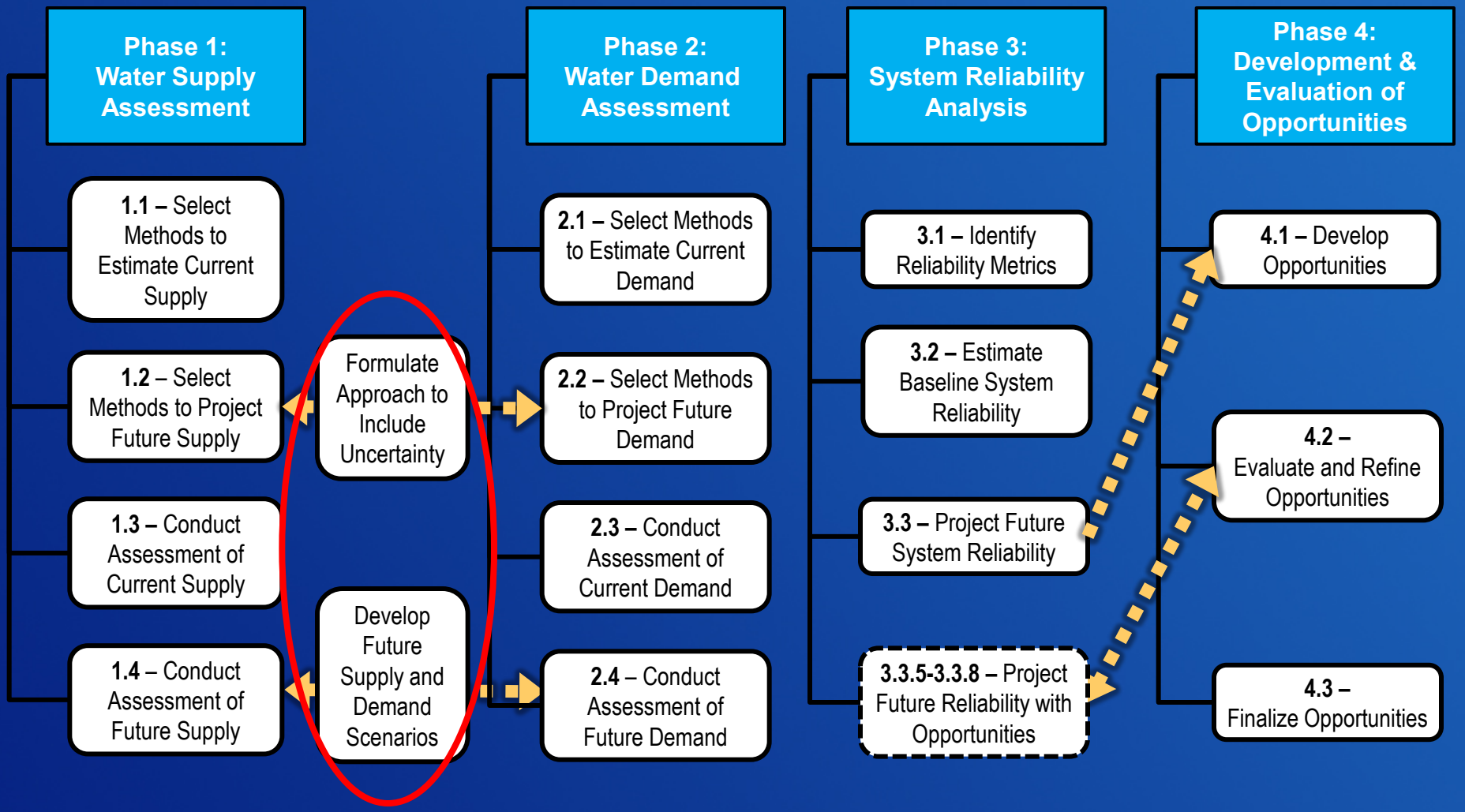
Study Phases and Tasks



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50 Years of Colorado River Changes

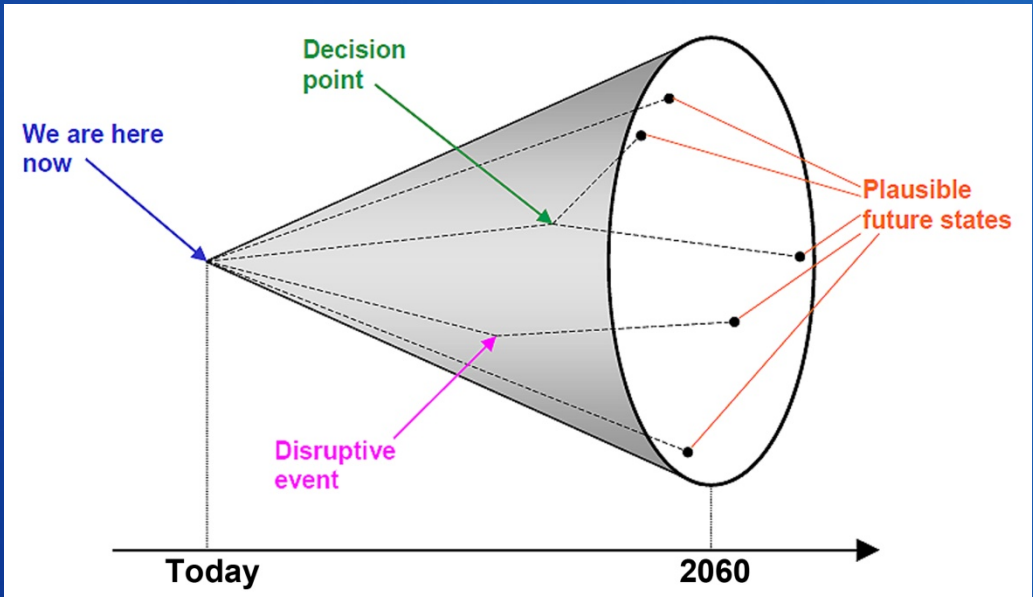
	1960	2010
Demographics / Land Use • Population served • Acres irrigated	12 million < 3 million	30 million 3 million
Physical System • Storage capacity • Hydropower generation capacity	30 maf 6,700 GW	67 maf 12,400 GW
Natural System • Annual mean natural flow at L.F. • Lowest 10-yr average flow at L.F.	15.1 maf 12.5 maf (1931-1940)	15.0 maf 12.0 maf (2001-2010)
Institutions, Governance • Legislation, Policies, Agreements	• Colorado River Compact • Boulder Canyon Project Act • US-Mexico Water Treaty • UC River Basin Compact • CR Storage Project Act	• Decree in *AZ v. CA* • NEPA • ESA • QSA • 2007 Interim Guidelines

Scenario Planning: Addressing an Uncertain Future

- The path of major influences on the Colorado River system is uncertain and can not be represented by a single view

- An infinite number of plausible futures exist

- A manageable and informative number of scenarios are being developed to explore the broad range of futures



(adapted from Timpe and Scheepers, 2003)

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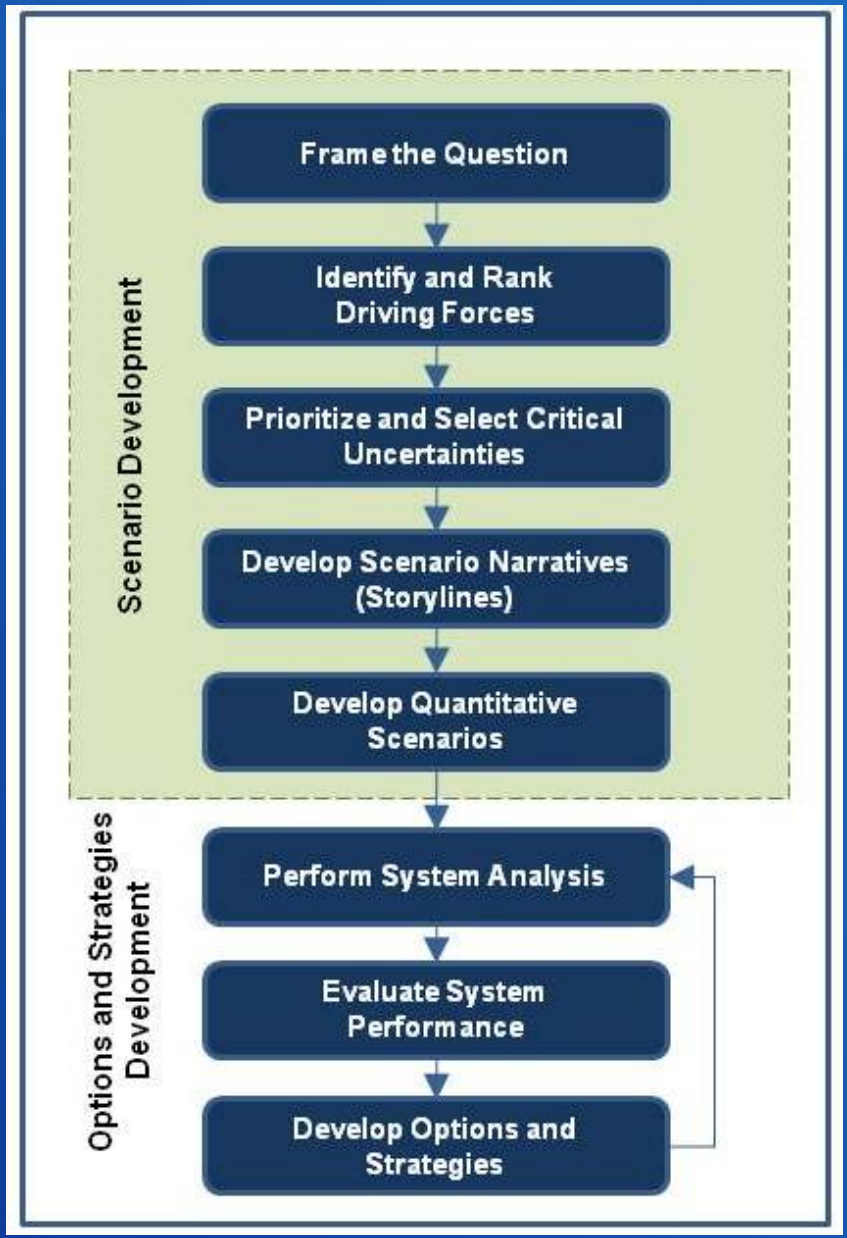
Key Elements of Scenario Approach

- Frame the Question
  - Main question or focal issue to be addressed in study
- Identify and rank driving forces
  - Major forces influencing outcome of focal issue
- Prioritize and select critical uncertainties
  - Key driving forces that are highly important and highly uncertain
- Develop scenario narratives
  - Narrative descriptions that weave the critical uncertainties into plausible future trajectories
- Develop scenarios
  - Specific, quantitative outcomes of the storylines



Colorado River Basin Study - Technical Report A: Figure A-2

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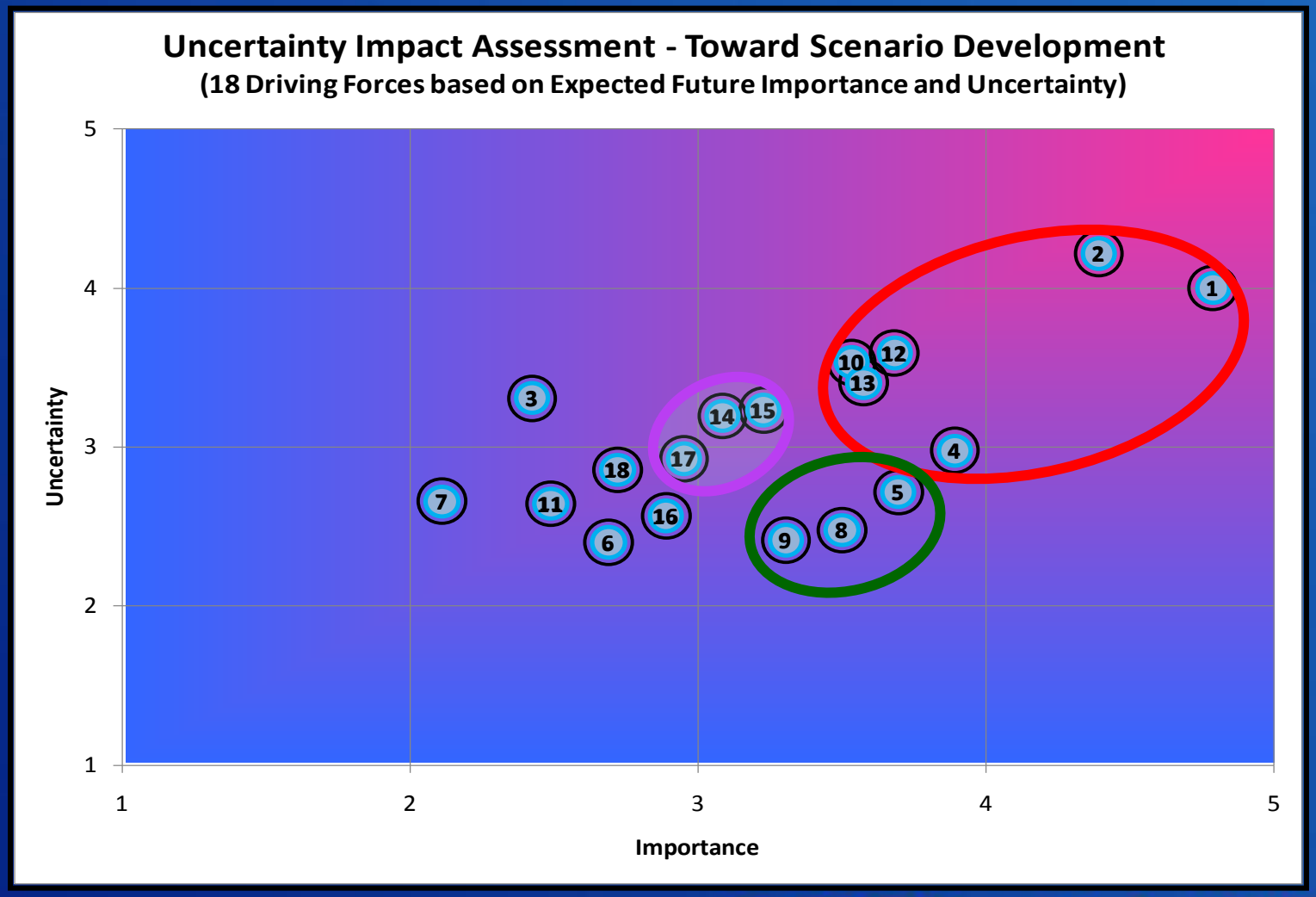
Key Driving Forces Impacting Future Reliability

No.	Driving Forces
1	Changes in streamflow variability and trends
2	Changes in climate variability and trends (e.g. temperature, precipitation, etc.)
3	Changes in watershed conditions (e.g. diseases, species transitions, etc.)
4	Changes in population and distribution
5	Changes in agricultural land use (e.g. irrigated agricultural areas, crop mixes, etc.)
6	Changes in urban land use (e.g. conversion, density, urbanization, etc.)
7	Changes in public land use (e.g. forest practices, grazing, wilderness areas, etc.)
8	Changes in agricultural water use efficiency
9	Changes in municipal and industrial water use efficiency
10	Changes in institutional and regulatory conditions (e.g. laws, regulations, etc.)
11	Changes to organization or management structures (e.g. state, federal, bi-national institutions)
12	Changes in water needs for energy generation (e.g. solar, oil shale, thermal, nuclear, etc.)
13	Changes in flow-dependent ecosystem needs for ESA-listed species
14	Changes in other flow-dependent ecosystem needs
15	Changes in social values affecting water use
16	Changes in cost of energy affecting water availability and use
17	Changes in water availability due to tribal water use and settlement of tribal water rights claims
18	Changes in water quality including physical, biological, and chemical processes

Driving Forces Survey & Groupings



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Water Supply Scenario Narratives

Observed Resampled:

- future hydrologic trends and variability will be similar to the past 100 years

Paleo Resampled:

- future hydrologic trends and variability are represented by the distant past (approximately 1250 years)

Paleo Conditioned:

- future hydrologic trends and variability are represented by a blend of the wet dry states of the paleo-climate record but magnitudes are more similar to the observed period

Downscaled GCM Projected:

- future climate will continue to warm with regional precipitation trends represented through an ensemble of future GCM projections

Water Demand Scenario Narratives

Current Projected (A):

- growth, development patterns, and institutions continue along recent trends

Slow Growth (B):

- low growth with emphasis on economic efficiency

Rapid Growth (C1 and C2):

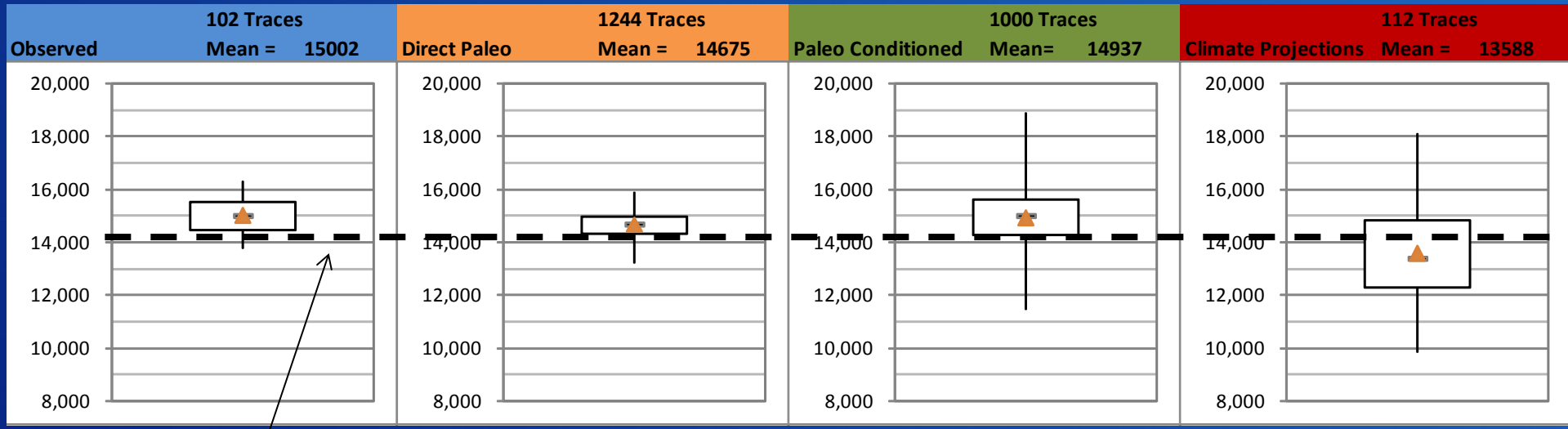
- economic resurgence (population and energy) and current preferences toward human and environmental values
  - C1 – slower technology adoption
  - C2 – rapid technology adoption

Enhanced Environment (D1 and D2):

- expanded environmental awareness and stewardship with growing economy
  - D1 – with moderate population growth
  - D2 – with rapid population growth

Quantification of Water Supply Scenarios

Projections of 2011-2060 Average Natural Flow at Lees Ferry



Past 50-year average (1966 – 2015)

Box represents 25th – 75th percentile, whiskers represent min and max, and triangle represents mean of all traces

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Approach to Quantifying Demand Scenarios

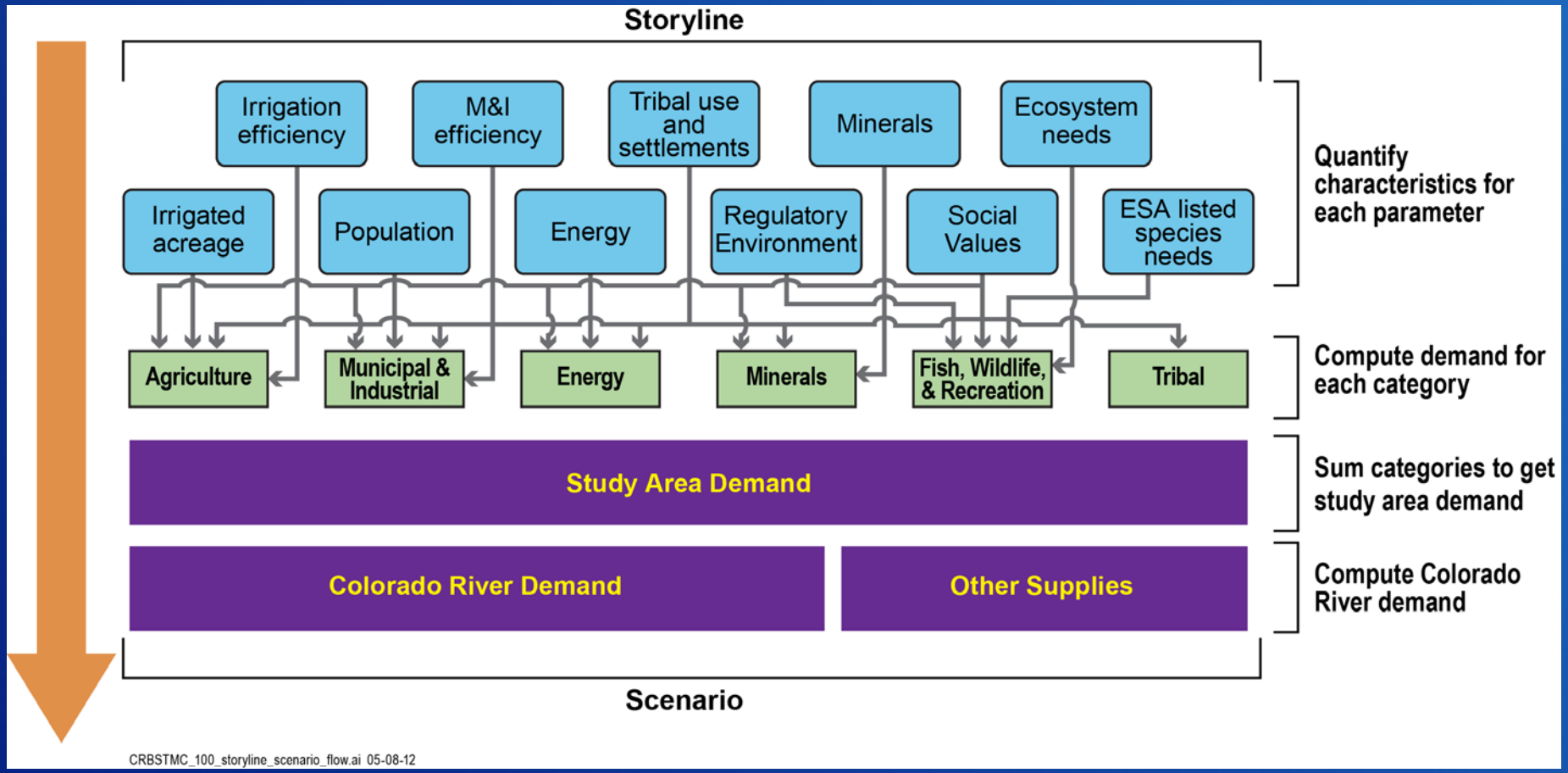

Figure C-2 Approach to Quantifying Demand Scenarios

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Changes in Parameters by Scenario

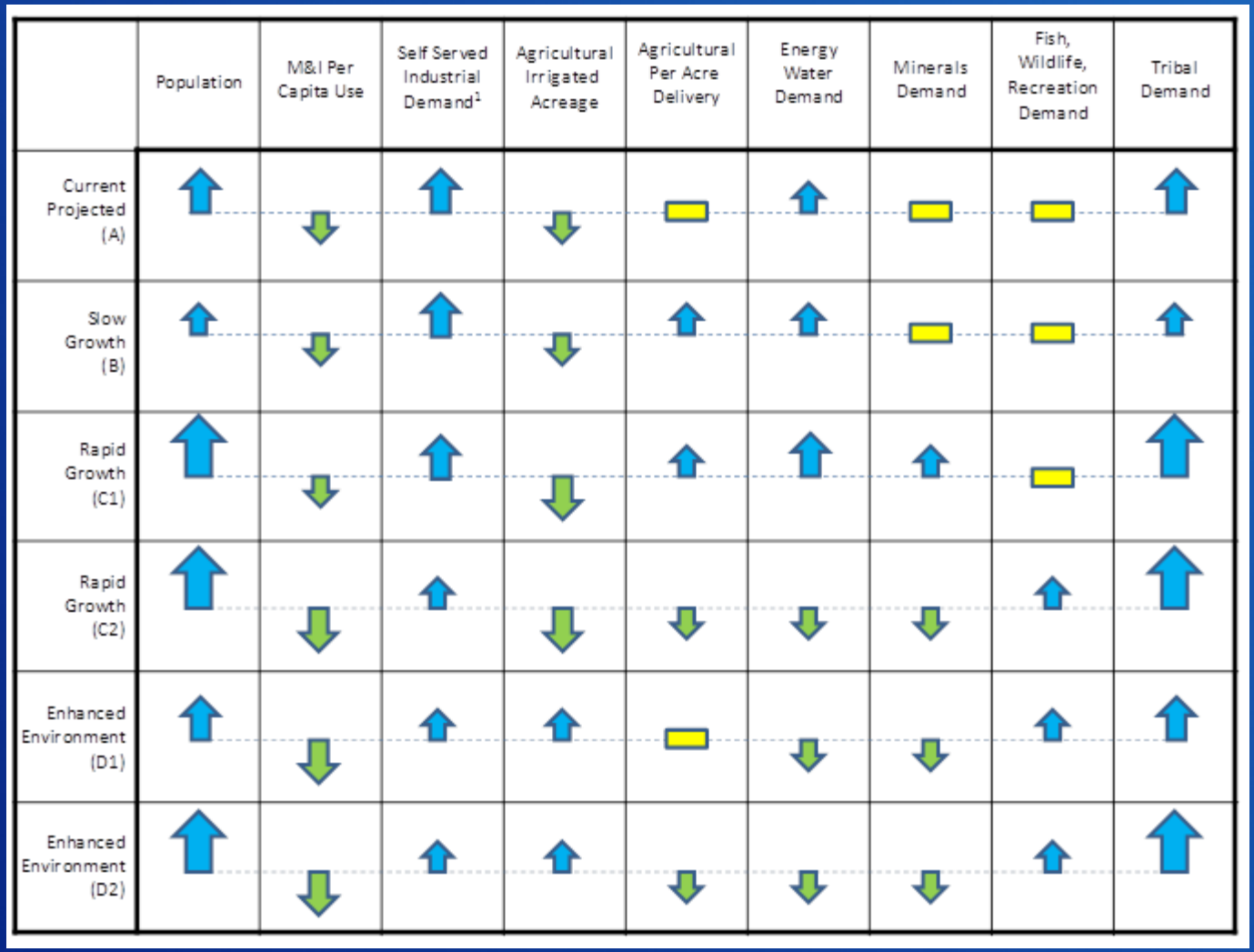

Table C-2 Scenario Matrix of Changes in Parameters

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Water Demand Quantification Results

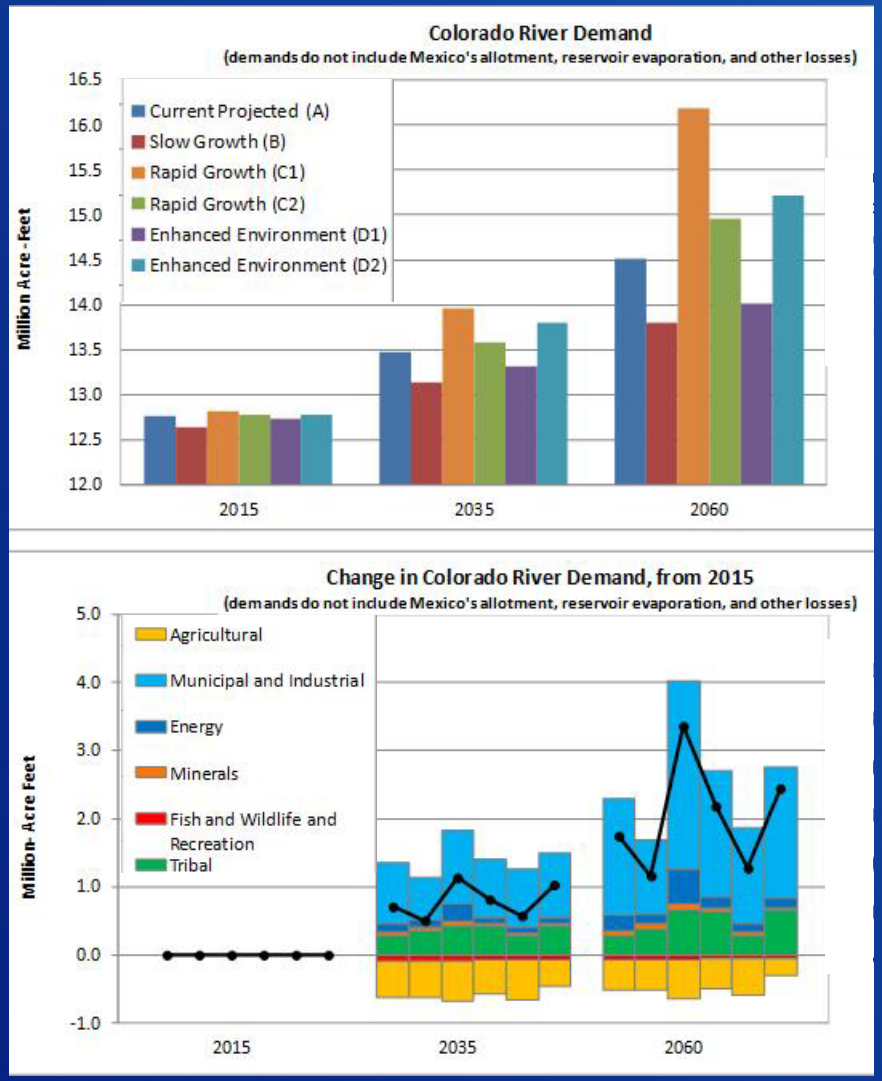

Figure C-7 Study Area, Colorado River, and Change in Colorado River Demand

- Parameters driving demands include population, per capita water use, and irrigated acreage and are projected to change from 2015 to 2060:
  - Population increase from about 40 million people by 23% (49 million) to 91% (77 million)
  - Per capita water use decrease by 7% to 19%
  - Irrigated acreage decrease from about 5.5 million acres by 6% (5.2 million) to 15% (4.6 million)

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Water Demand Quantification Results

- Demand for consumptive uses ranges between 13.8 and 16.2 maf by 2060 (including Mexico and losses 18.1 and 20.4 maf by 2060)
- Approximately a 20% spread between the lowest (Slow Growth) and highest (Rapid Growth – C1) demand scenarios

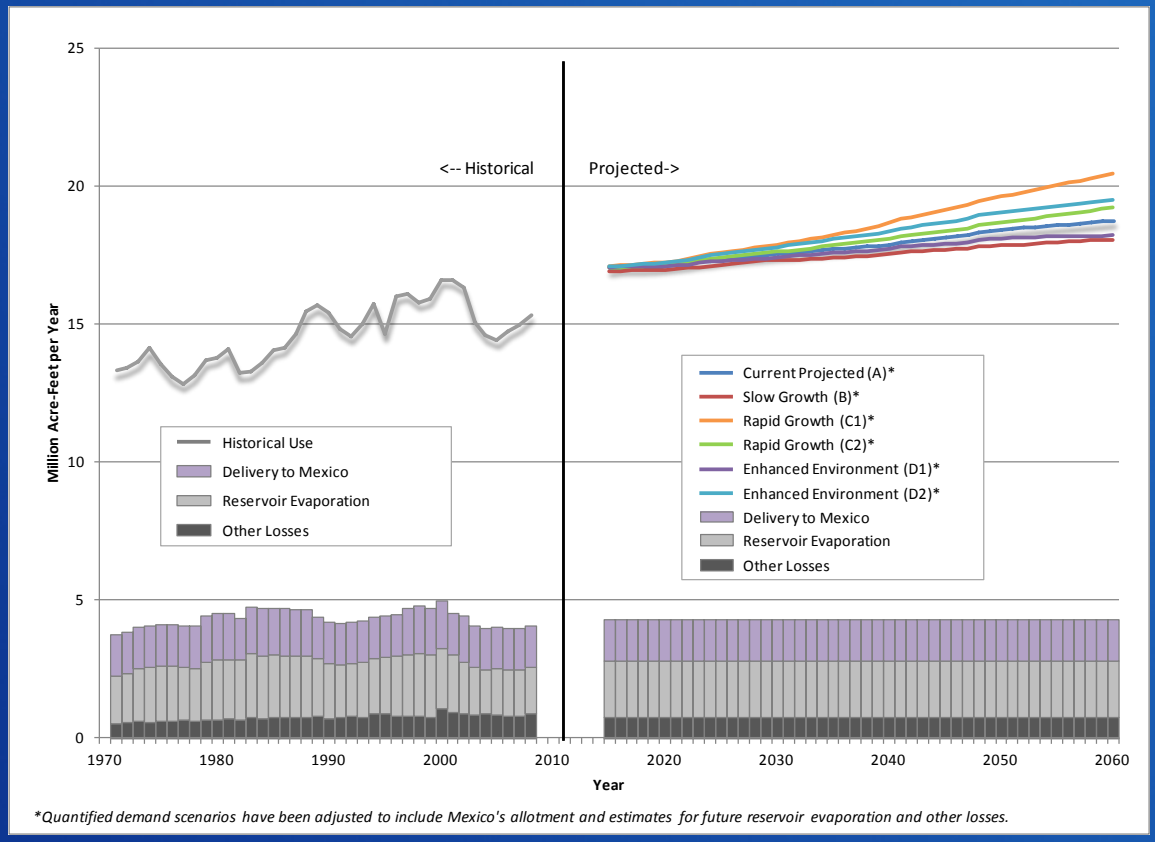

Figure C-4 Colorado River Basin Historical Use and Projected Demand

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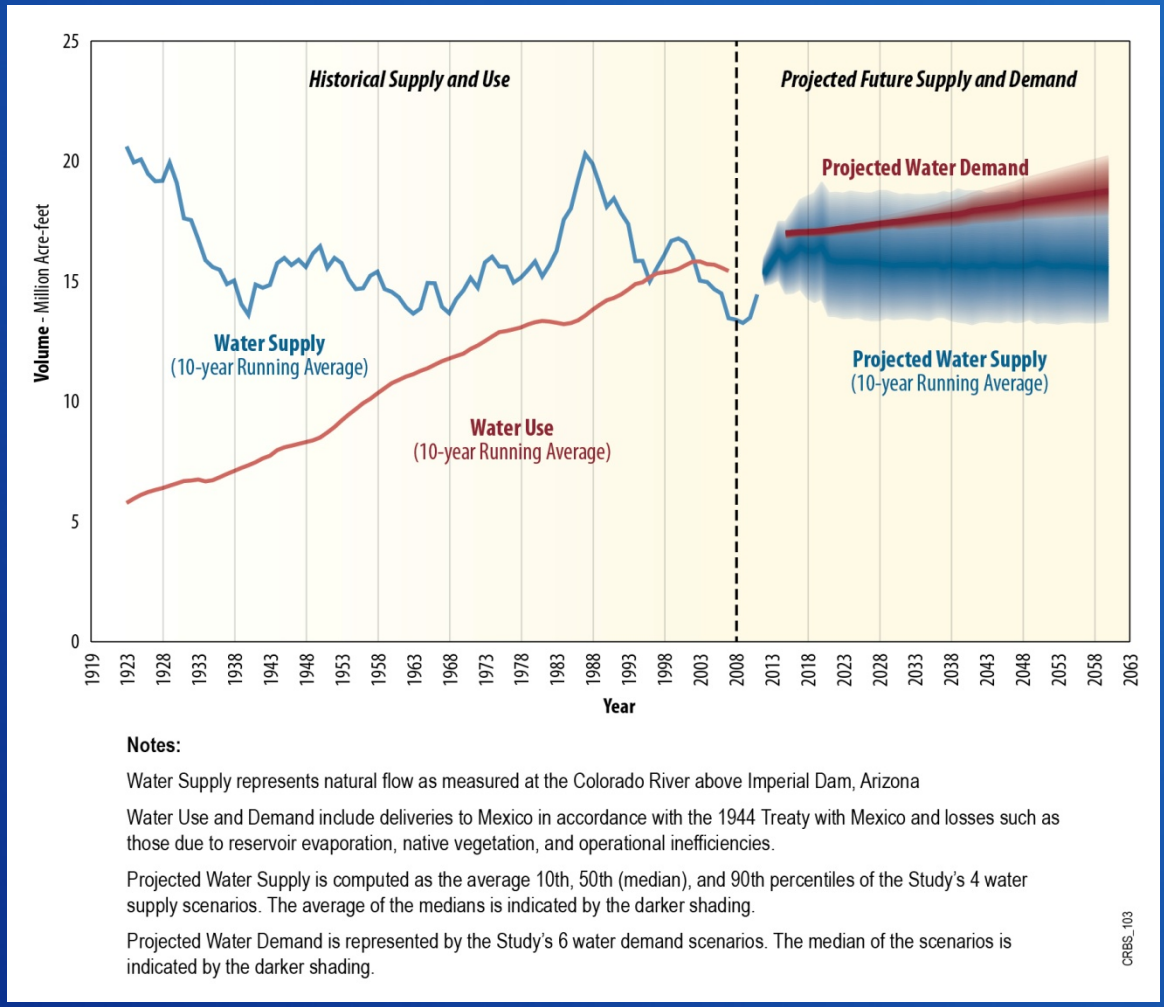
Projected Future Colorado River Basin Water Supply and Demand

- Median supply-demand imbalances by 2060 are approximately 3.2 million acre-feet
- This imbalance may be more or less depending on the nature of the particular supply and demand scenario
- Imbalances have occurred in the past and deliveries have been met due to reservoir storage



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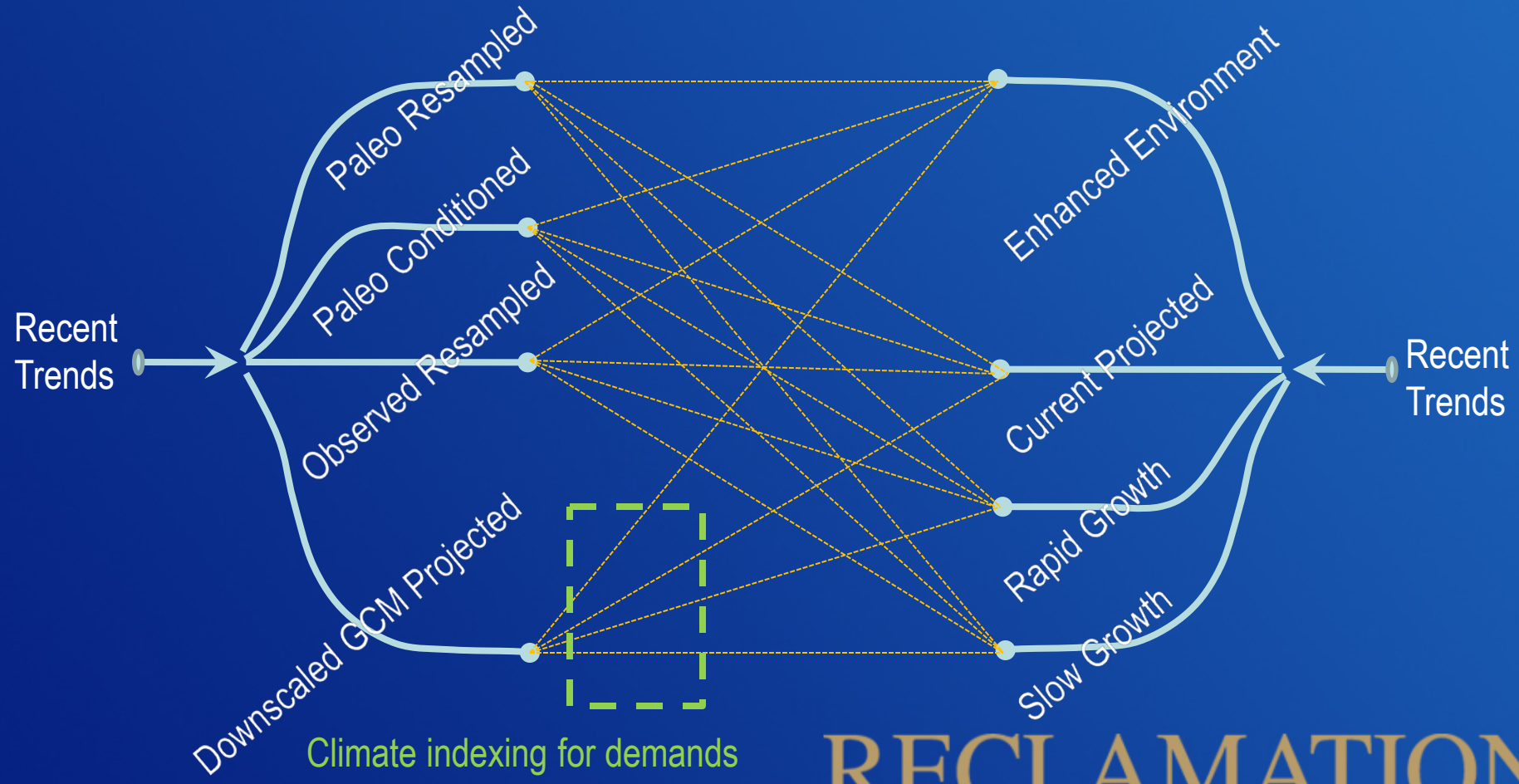
Integration of Supply and Demand Scenarios

Water Supply Scenarios
(100+ realizations for each scenario)

Water Demand Scenarios



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Summary

- Scenario planning provided a venue for broad thinking about the way the future would unfold
  - Enabled the quantification of a wide range of future risks to Basin resources
  - Also enabled to development of robust portfolios of options and strategies to mitigate and adapt to those risks
- Provided a mechanism for incorporating differing stakeholder views and values
- Led to a transparent process regarding the quantification of future demands
- The Basin Study was an initial step- the process is evolving and results are being updated

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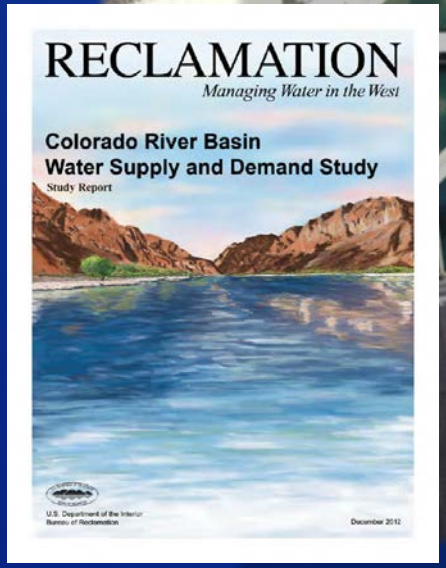

Study & *Moving Forward* Contact Information

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