

RECLAMATION

Managing Water in the West

Colorado River Basin Study: Moving Forward with Climate Science

Co-Producing Actionable Science for Water Utilities
Boulder, CO
May 2, 2016



U.S. Department of the Interior
Bureau of Reclamation

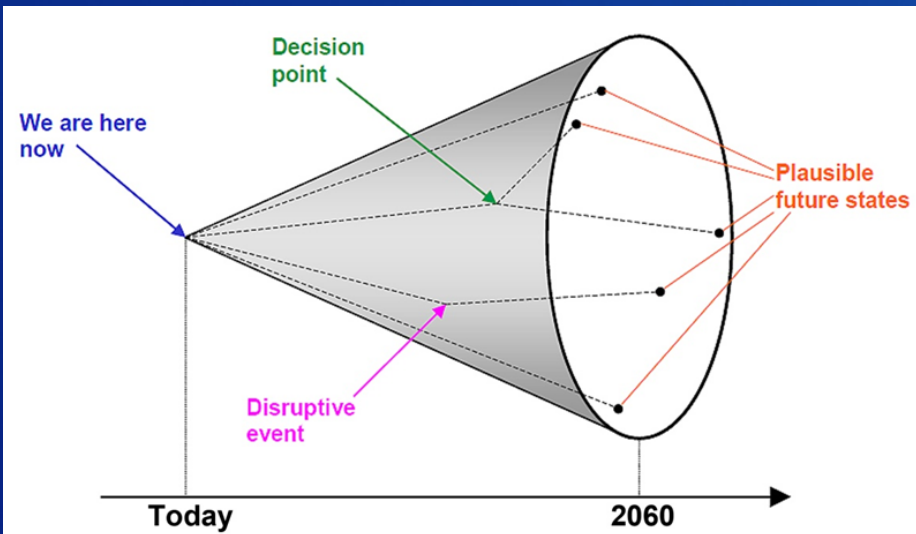
Colorado River Basin Water Supply and Demand Study

- 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
- Conducted by Reclamation and the Basin States, in collaboration with stakeholders throughout the Basin
- Began in January 2010 and completed in December 2012
- A planning study – did *not* result in any decisions, but provided the technical foundation for future activities



Scenario Planning

- An infinite number of plausible futures exist and the path
- A manageable and informative number of scenarios were developed to explore the broad range of futures



Water Supply Scenario

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:

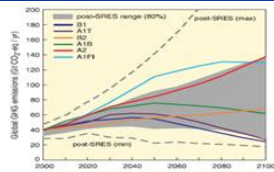
- future climate will continue to warm with regional precipitation trends represented through an ensemble of future GCM projections

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Water Supply Scenarios

Downscaled Global Climate Model (GCM) Projected

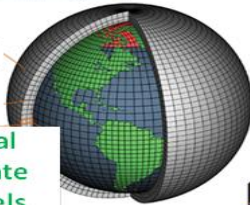
- future climate will continue to warm with regional precipitation trends represented through an ensemble of future GCM projections
- 112 sequences of future streamflow



Emission Scenarios

(3 scenarios: A2, A1b, B1)

Global Climate Models
16 GCMs



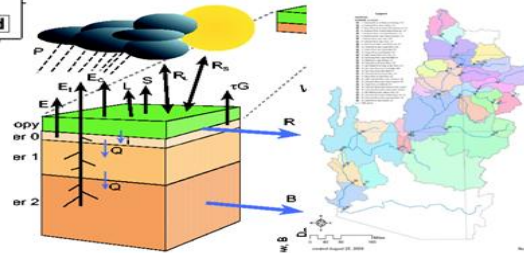
Bias Correction & Spatial Downscaling

(112 downscaled projections)



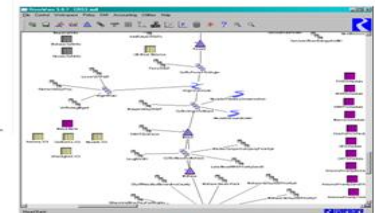
Hydrologic Modeling

(112 downscaled projections)



Systems Modeling

(112 sequences)



Bias Correction & Spatial Downscaling



- Released 2007
- 112 projections of Precip and Temp

Hydrology Modeling

Reclamation's Colorado River Hydrology Workgroup

AMEC Consultants (2010)

Reclamation's Research and Development Program (2011)

WWA CIRES & NOAA ESRL (2011)

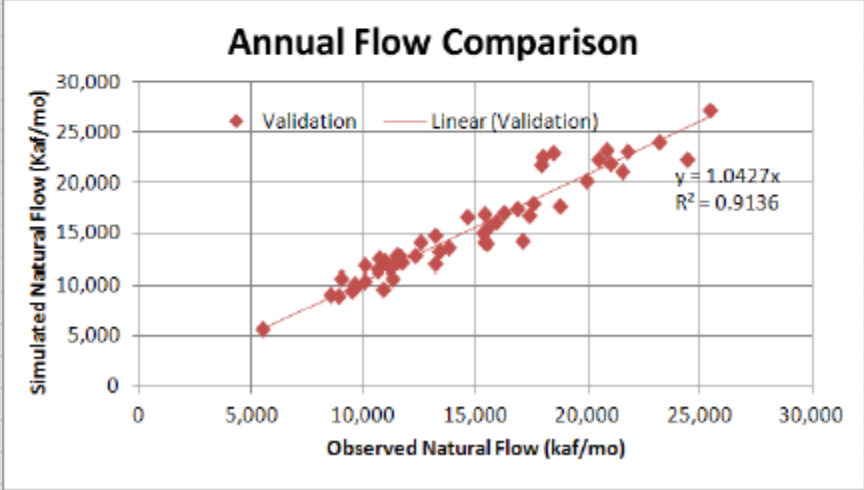
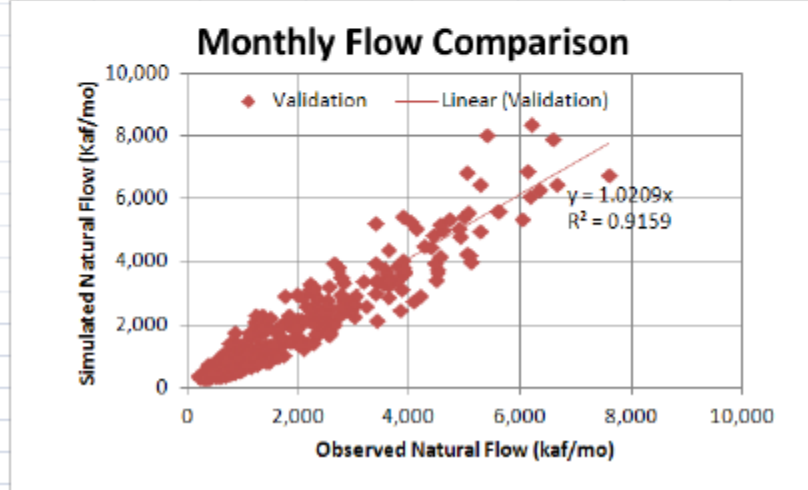
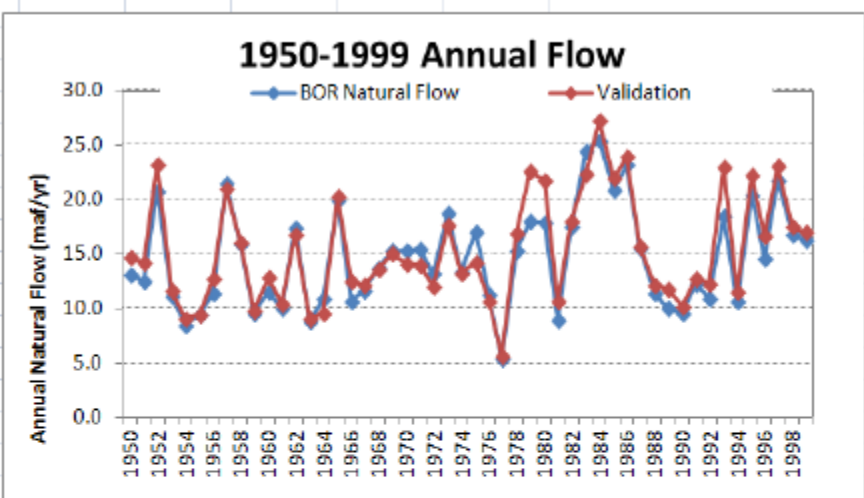
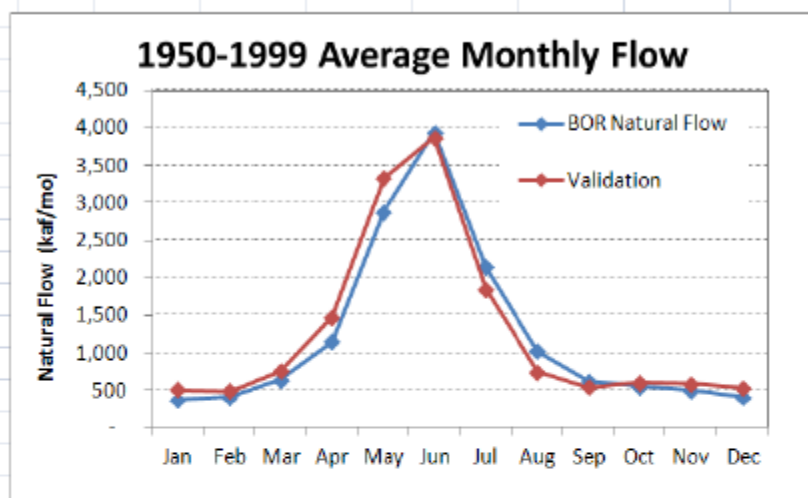
Systems Modeling

Reclamation's Colorado Basin Study Study Team

CH2M (2011-12)

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FIGURE B4-2
VIC Validation Summary for Colorado River at Lees Ferry, Arizona



Bias Correction & Spatial Downscaling



- Released 2007
- 112 projections of Precip and Temp

Hydrology Modeling

Reclamation's Colorado River Hydrology Workgroup

AMEC Consultants (2010)

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Systems Modeling

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CH2M (2011-12)

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Secondary Bias Correction

performed by CH2M during Basin Study

FIGURE B4-7

Comparisons of the January Cumulative Distribution Function (CDF) (left) and Mean Monthly (right) Streamflow Developed from VIC-simulated Streamflow, VIC Monthly Bias-Corrected, and Natural Streamflow Colorado River at Parker Dam, Arizona location. Simulated streamflow from VIC simulation as driven by downscaled climate model forcings from Trace 44.

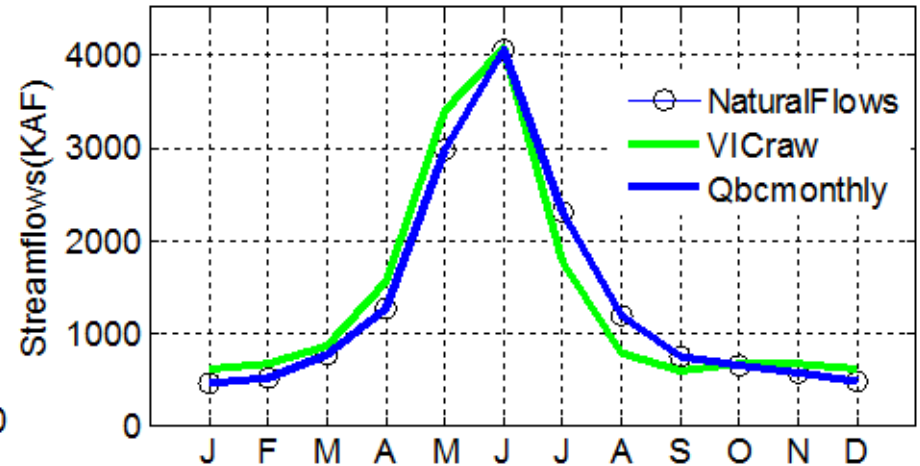
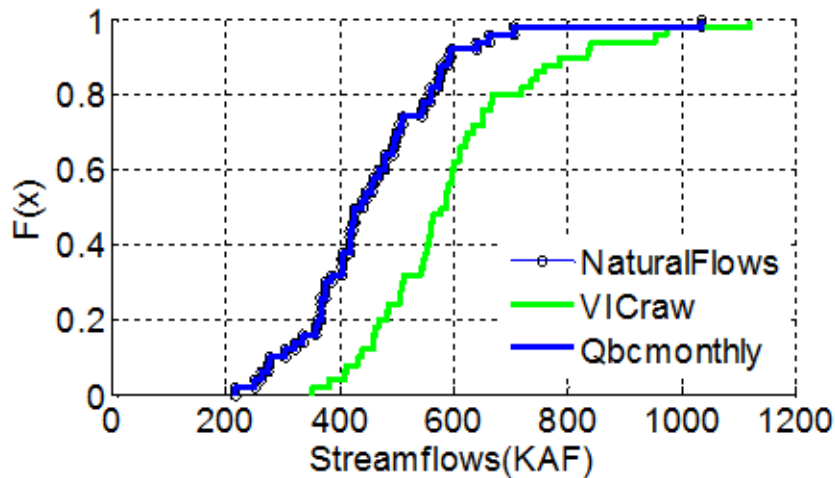
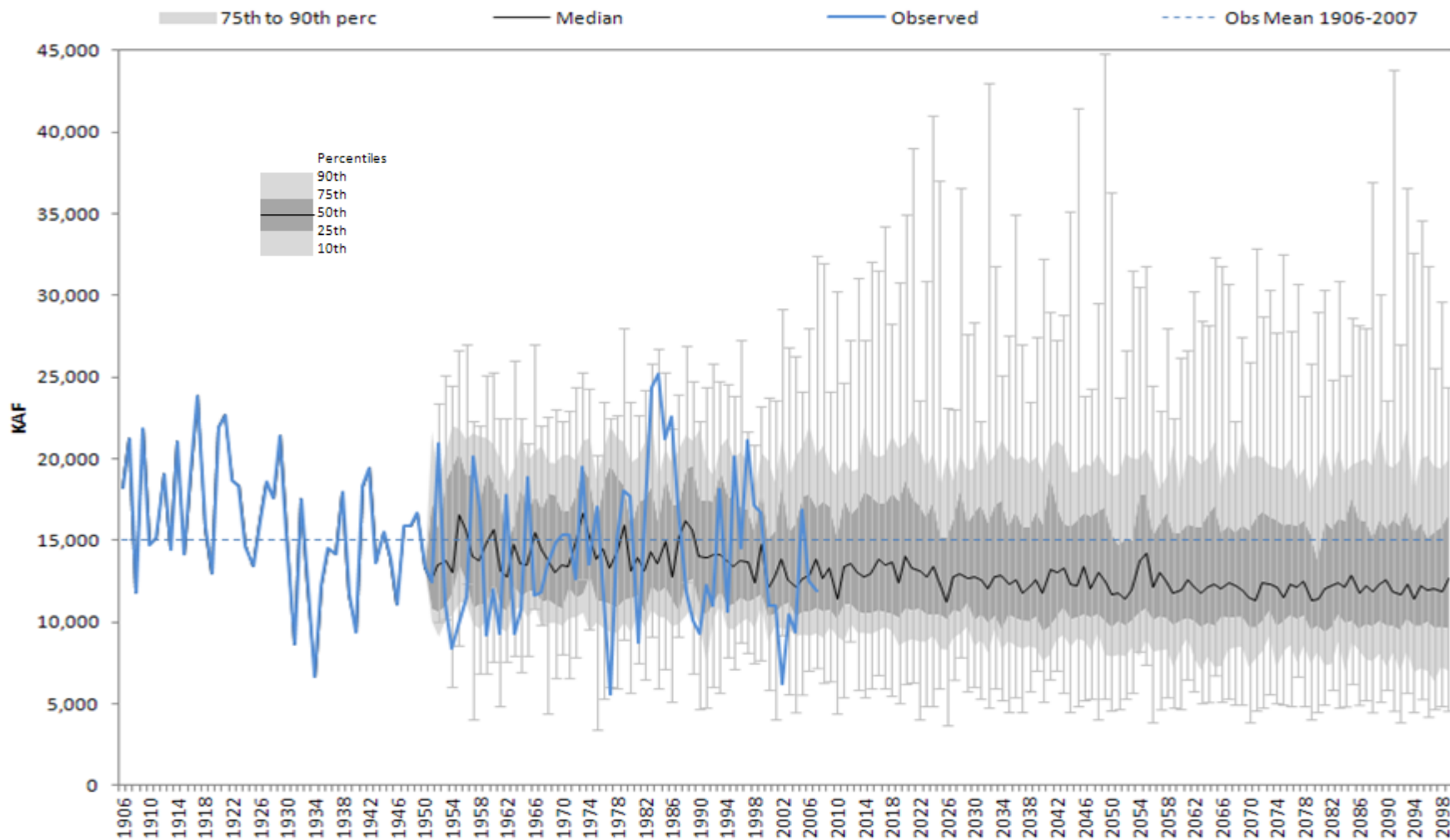


FIGURE B-46

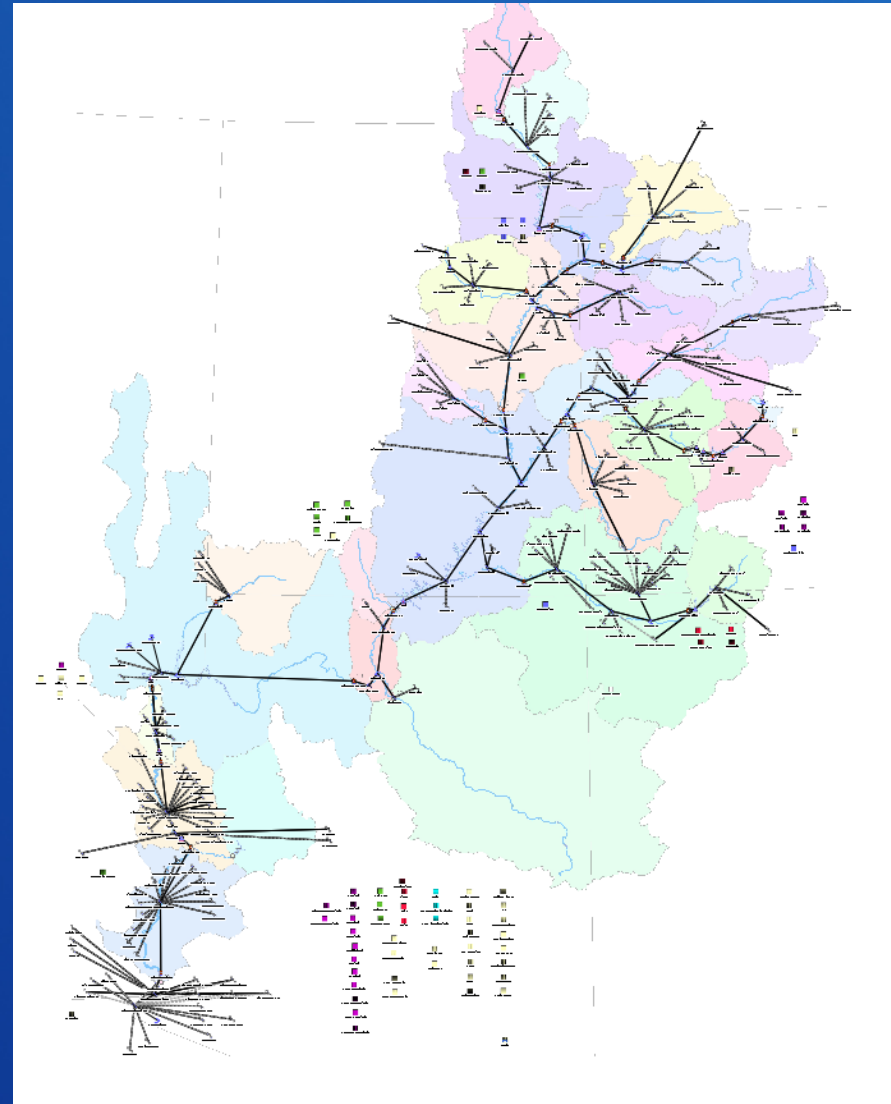
Colorado River at Lees Ferry, Arizona Natural Flow Statistics for the Downscaled GCM Projected Scenario as Compared to Observed Flow

Median (line), 25th–75th percentile band (dark shading), 10th–90th percentile band (light shading), max/min (whiskers), and 1906–2007 observed (blue line).

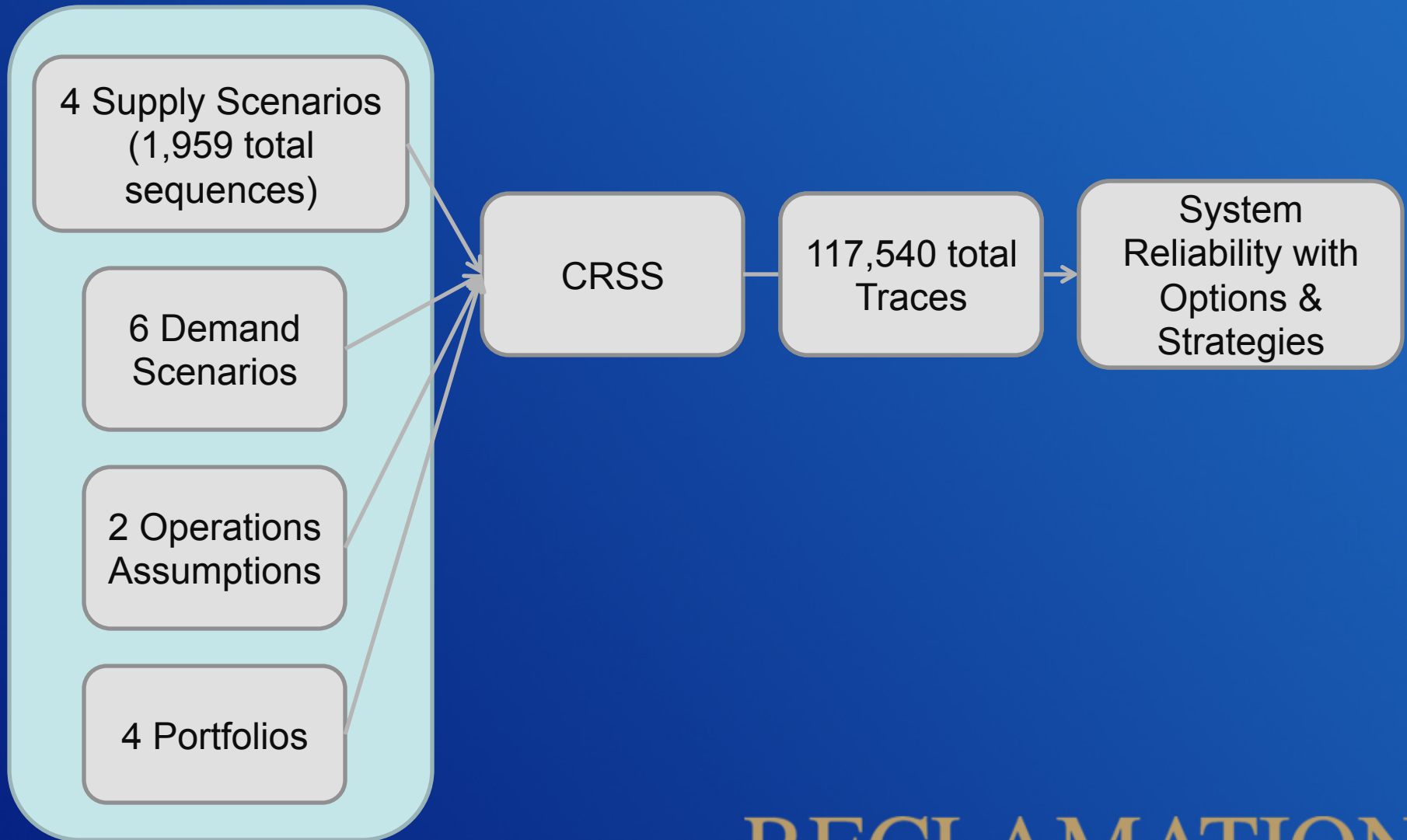


Colorado River Simulation System (CRSS)

- UC/LC Region's official Basin-wide long-term planning model
- Implemented in RiverWare™
- Simulates operations at 12 reservoirs and deliveries to over 500 individual 'water users' at a monthly time-step
- Model logic reflects reservoir operations
- Gives a range of potential future system conditions



System Reliability Analysis Approach



Water Deliveries

Percent of All Plausible Futures that Result in Vulnerability

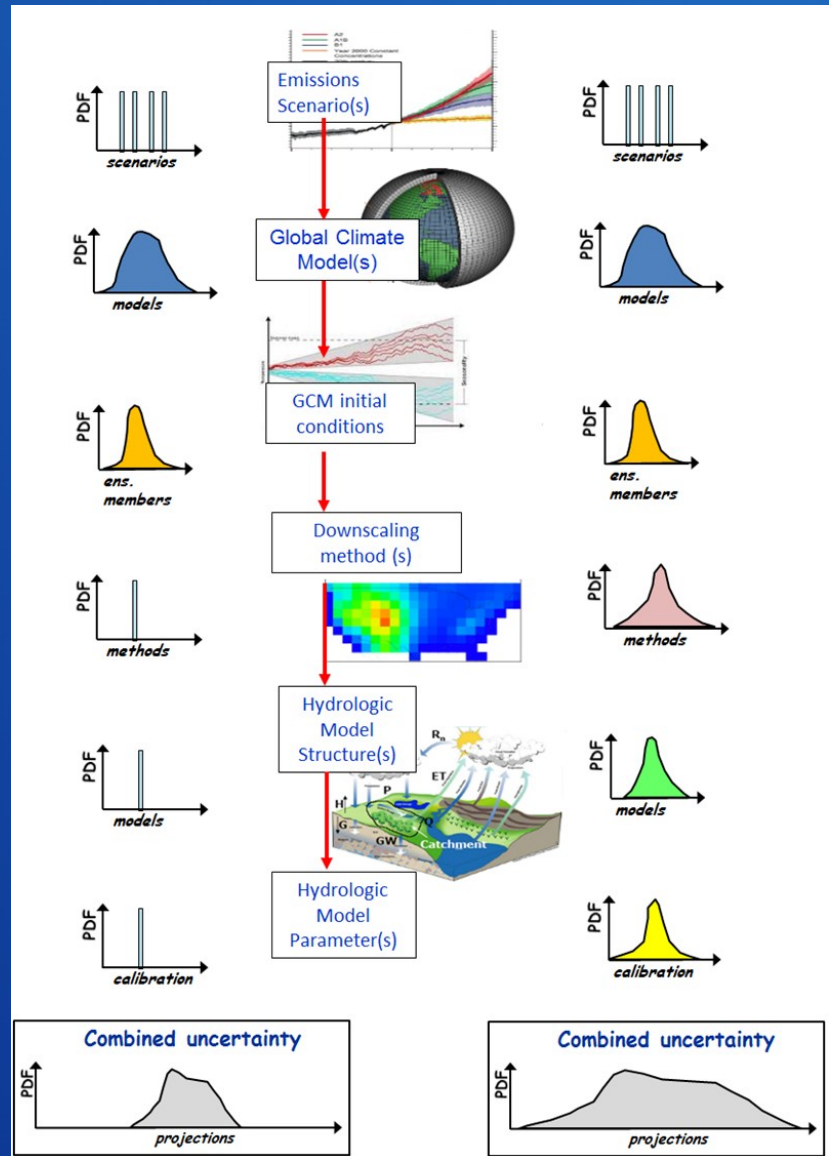
	Time Period	Baseline	Portfolio A	Portfolio B	Portfolio C	Portfolio D
Upper Basin Shortage (exceeds 25% of requested depletion in any one year)	2012-2026	38%	36%	36%	36%	37%
	2027-2040	45%	36%	31%	36%	33%
	2041-2060	59%	26%	27%	31%	35%
Lee Ferry Deficit (exceeds zero in any one year)	2012-2026	2%	2%	2%	2%	2%
	2027-2040	9%	3%	5%	3%	6%
	2041-2060	16%	4%	9%	5%	11%
Lake Mead Pool Elevation < 1000 feet (below 1000 feet in any one month)	2012-2026	13%	12%	11%	12%	12%
	2027-2040	25%	17%	15%	18%	18%
	2041-2060	40%	10%	10%	14%	15%
Lower Basin Shortage (exceeds 1 maf over any two year window)	2012-2026	22%	16%	15%	16%	16%
	2027-2040	59%	48%	43%	48%	49%
	2041-2060	80%	35%	34%	38%	40%

Summary

- Scenario planning provided a venue for broad thinking about the way the future would unfold
 - Provided stakeholders with setting to be more comfortable with alternative water supply futures
 - Enabled the quantification of a wide range of future risks to Basin resources
- Benefitted and learned from multiple entities engaged in processing and understanding climate change information
- Choices about how to incorporate climate information influenced by abilities of systems model (i.e. was not a limited factor)
- Challenge to present “multi-dimensional” results in a succinct way. Used several different approaches that best conveyed results

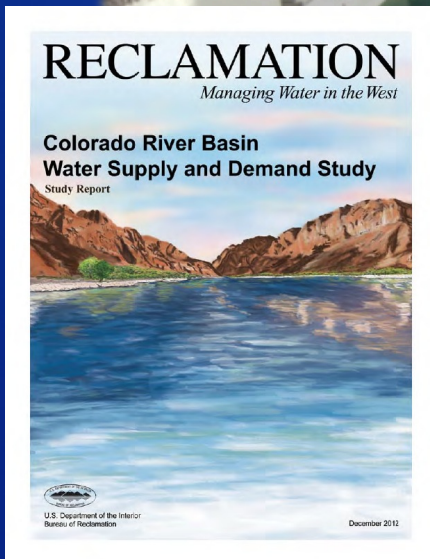
Present Efforts

- Analysis CMIP 5
- Explore more downscaling approaches
 - CH2M & Scripps
- Watch the continued work of NCAR-RAL
- Continue of to advance our Decision Making Framework



Reclamation (2016) West-Wide Climate Risk Assessments: Hydroclimate Projections
Technical Memorandum No. 86-68210-2016-01

Colorado River Basin Study: Moving Forward with Climate Science



Study & Moving Forward Contact Information

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