Modeling and Analysis Work Group #7

ARIZONA RECONSULTATION COMMITTEE

Meeting Logistics Summary

- Roll Call
  - Members will unmute and acknowledge their attendance when their name is called.
- Modeling and Analysis Workgroup Members
  - Use the WebEx “raise hand” feature to request to speak or ask questions.
  - Wait to be recognized before speaking to ensure clear communication and remain muted when not speaking.
- Livestream Attendees
  - Electronic public comment forms are available at cap-az.com/ARC for anyone wishing to submit a comment or question during the meeting.
  - All submissions will be addressed during the Call to the Public at the end of the meeting, unless relevant to a specific topic in the presentation.
- Modeling and Analysis Workgroup and ARC Information
  - Meeting materials have been posted on the ADWR and CAP ARC pages: cap-az.com/ARC or new.azwater.gov/ARC.

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MAWG #7 - Meeting Agenda

- Welcome and Introductions
- Recap of MAWG Activities
- Sensitivity Analysis
- Discussion of Hydrologies & Methods
- Next Steps
- Call to the Public

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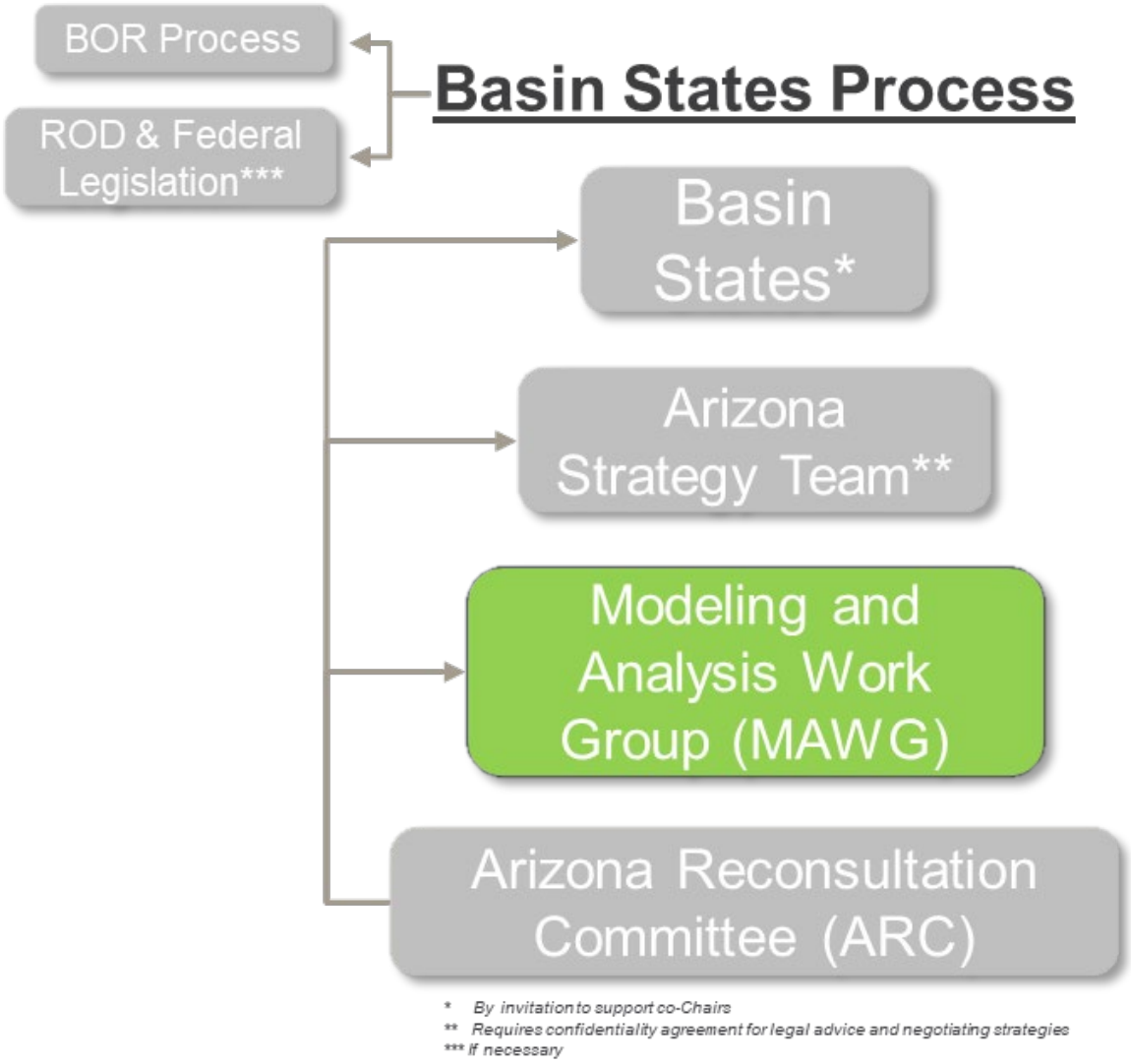
MAWG Overview

Modeling and Analysis Workgroup established by the Arizona Reconsultation Committee (ARC)

Co-chaired by ADWR and CAWCD Colorado River Program Managers

Purpose:

Support ARC decision-making by providing fact-based analysis of risks, vulnerabilities, and impact to Arizona's overall Colorado River supply including On-River and CAP users.



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MAWG Initial Conditions Scenarios Summary

Scenario	Hydrology	Upper Basin Demand	Arizona On-River Demand	CAP Utilization
IC #1	Stress Test	Guidelines Period UB Use Extended	0.1% Growth	Medium
IC #2	Paleo-Conditioned	2016 UCRC Upper Basin Growth	0.2% Growth	Medium
IC #3	Pluvial-Removed	Guidelines Period UB Use Extended	0.1% Growth	Medium
IC #4	Downscaled GCM	2016 UCRC Upper Basin Growth	0.2% Growth	Fast
IC #5	Pluvial-Removed	Upper Basin Guidelines Period Average	On-River Guideline Average	Medium
IC #6	Stress Test	2012 Basin Study Current Trends Growth	0.2% Growth	Fast

**All scenarios assume Lake Powell equalization line is capped at 3,652 ft starting in 2027*

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MAWG Initial Conditions Scenarios Summary

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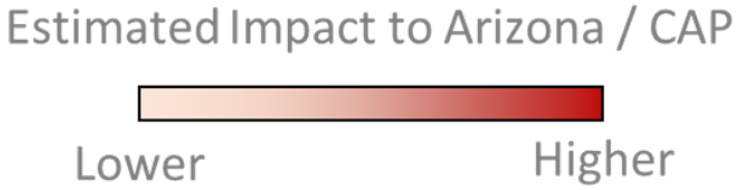

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Sensitivity Analysis

Response to request from MAWG members to pare down the initial scenarios

- More manageable set of runs
- Pairwise comparison to isolate the impact of specific assumptions

Hydrology

- CMIP3
- Pluvial-removed

Upper Basin Demand

- 2016 UCRC
- Capped at 2008 – 2018 average

On-River Growth

- None (i.e., capped at current average)
- 0.1% per year
- 0.2% per year

CAP Utilization

- Medium
- Fast

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MAWG Selected Hydrology

Hydrology		Observed	Pluvial Removed	Stress Test	Paleo Resample	CMIP3	Paleo Conditioned Natural Flow
Time Period or Type		1906 to 2019	1931 to 2019	1988 to 2019	726 to 2005	Projected: 2023 to 2060	Projected: 2023 to 2072
# of Traces/Records		114	89	32	1,244	112	500
Annual Flow at Powell (MAF)	10%	9.50	8.91	9.35	10.10	9.12	9.55
	Median	14.51	13.65	12.72	14.83	12.73	14.58
	Mean	14.76	13.95	13.14	14.65	13.91	14.79
	90%	21.01	20.02	18.92	18.97	20.34	21.76
Use		'Official' Model	Sensitivity analysis with Mexico	DCP and 5-year table	Sensitivity Analysis '07 Guidelines	2012 Basin Study	Sensitivity Analysis '07 Guidelines

CMIP3: Incorporates future climate projections (variability)
Pluvial-Removed (1931-2019): Preserves historical record

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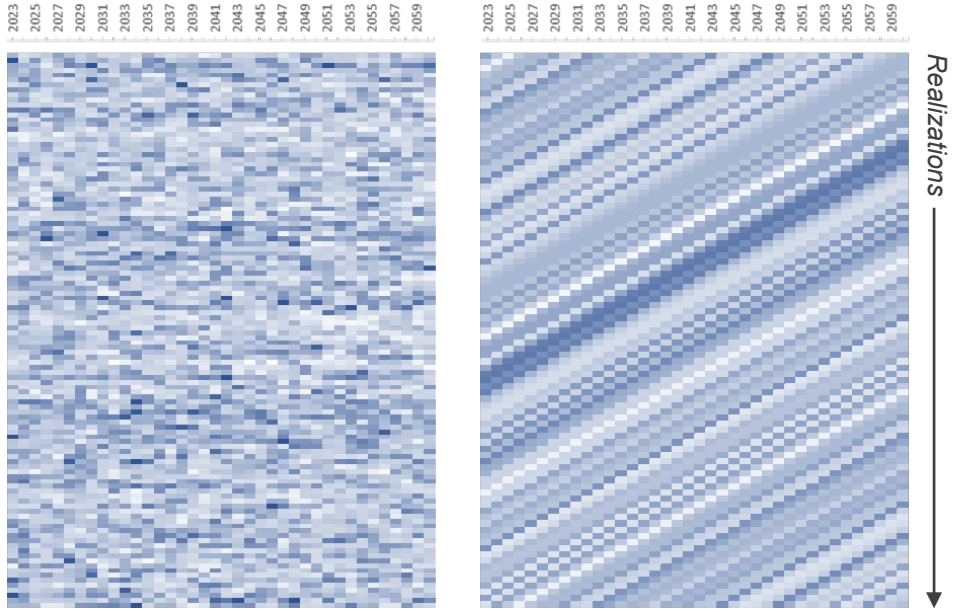
Sensitivity Analysis

CRSS Inputs [Basin Scale]

Hydrology

CMIP3 = 112 Traces
Average = 13.5 MAF
Median = 12.3 MAF

Pluvial Removed = 89 Traces
Average = 14.0 MAF
Median = 13.7 MAF



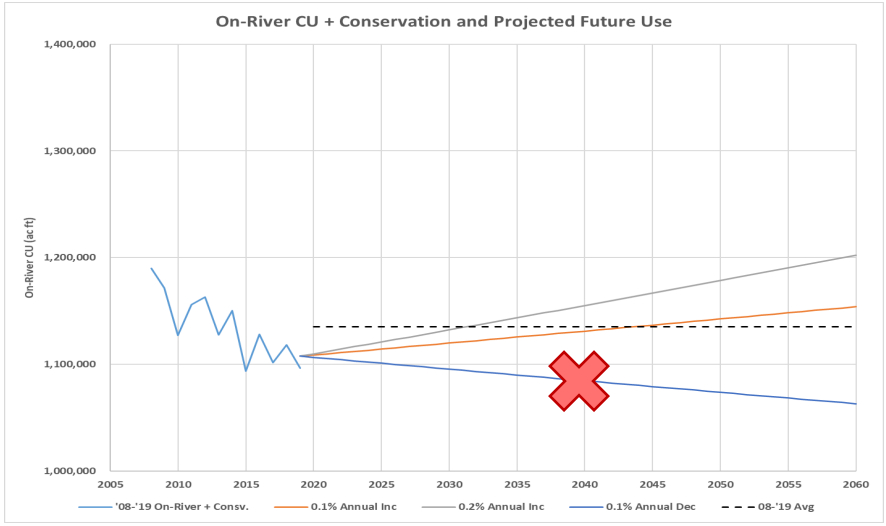
UB Demand

Scenario	2025	2030	2040	2050	2060
2016 UCRC	4.86	4.97	5.16	5.36	5.42
Capped*	3.91	3.91	3.91	3.91	3.91

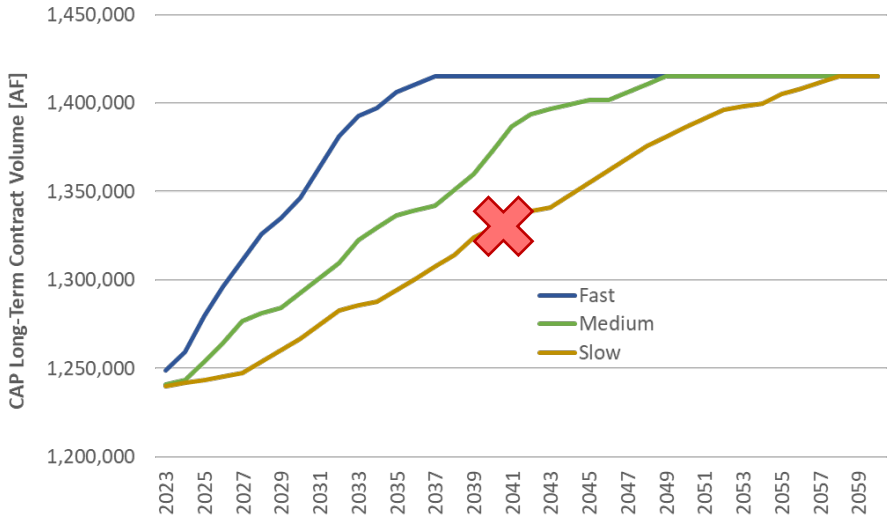
** Guideline Period (2008 – 2018) Average*

JSAM Inputs [Service Area Scale]

On-River Use

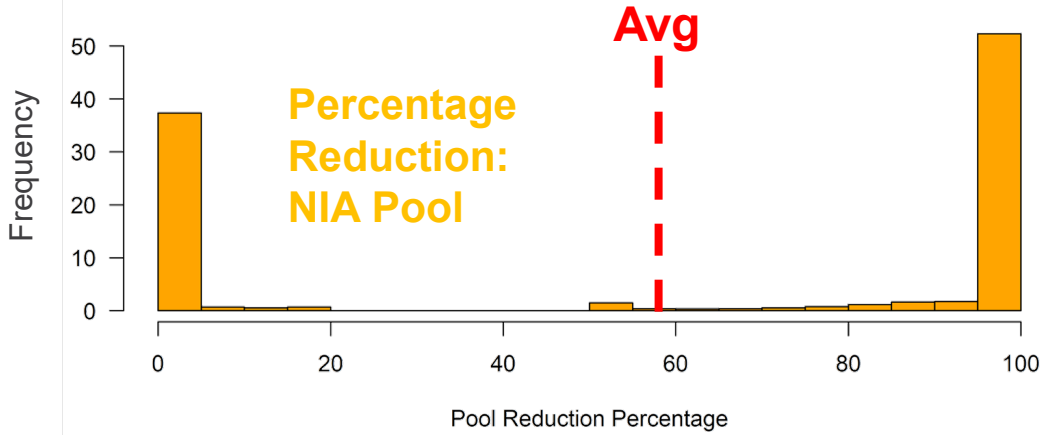


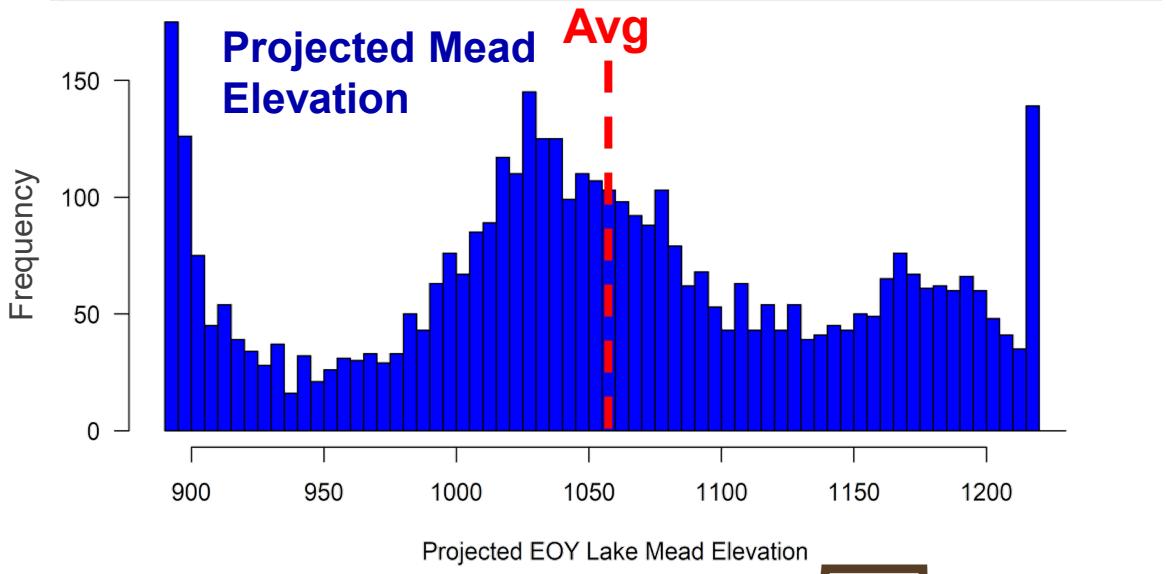
CAP Utilization



Sensitivity Analysis - Terciles

- Many of our modeling results are not normally distributed
  - Bimodal – e.g., NIA Availability
  - Multimodal – e.g., Mead Elevations
- Central tendency metrics can mask phenomenon
- Analyzing results by groupings can be useful





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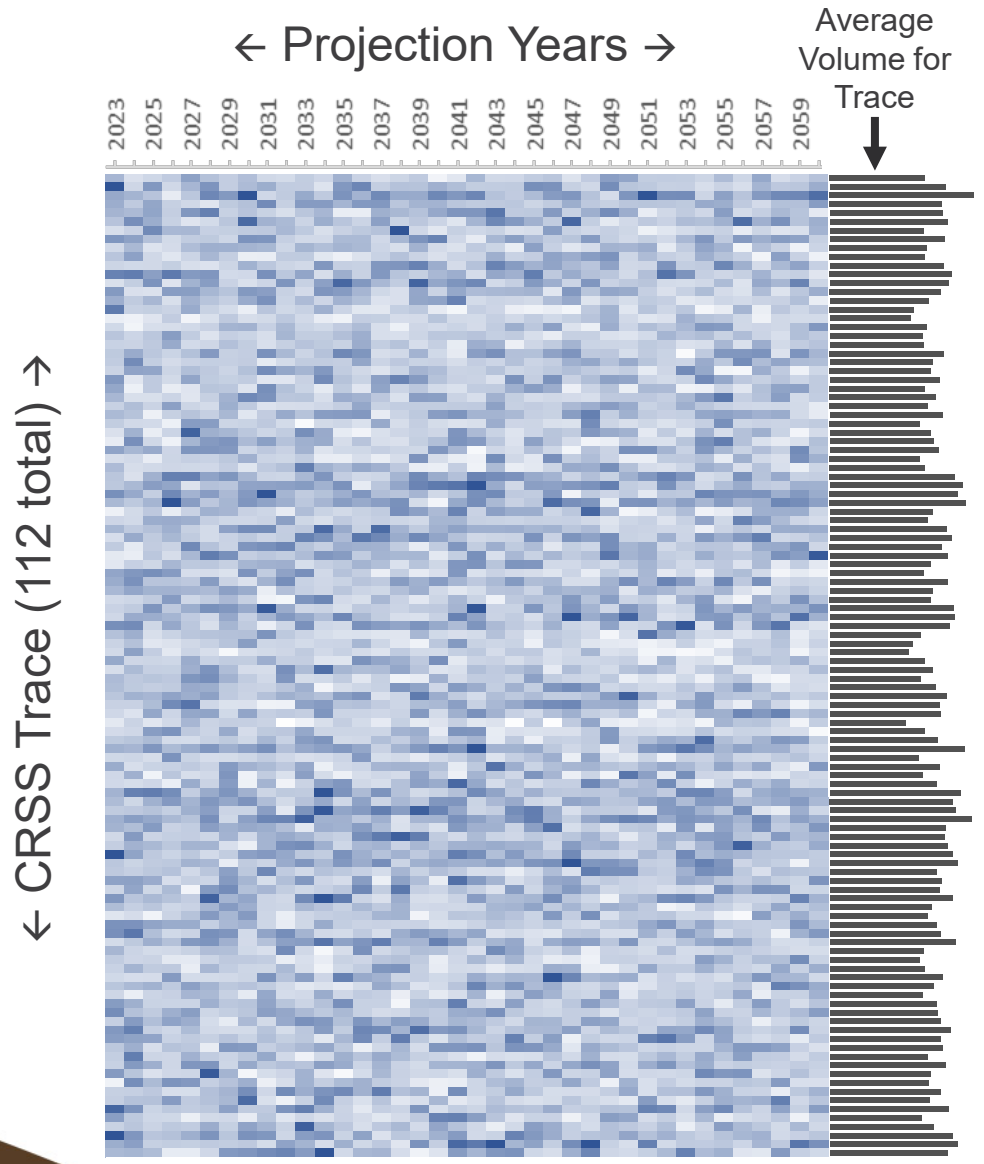
Sensitivity Analysis - Terciles

Example: CMIP3 Input Hydrology

Cell = Total Annual Natural Flow at Lees Ferry for Given CRSS Trace and Projection Year

Drier | Natural Flow Volume | Wetter



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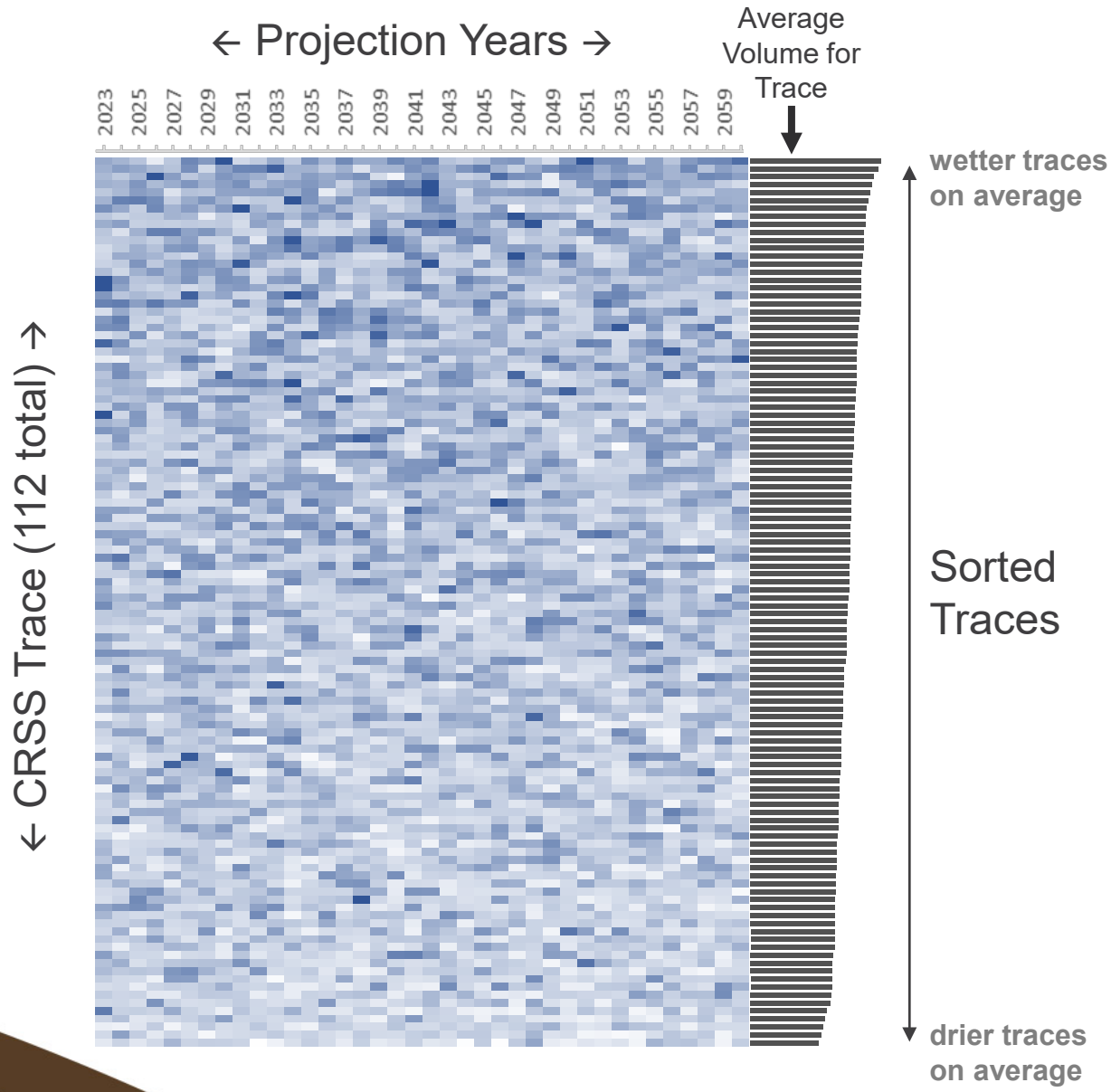

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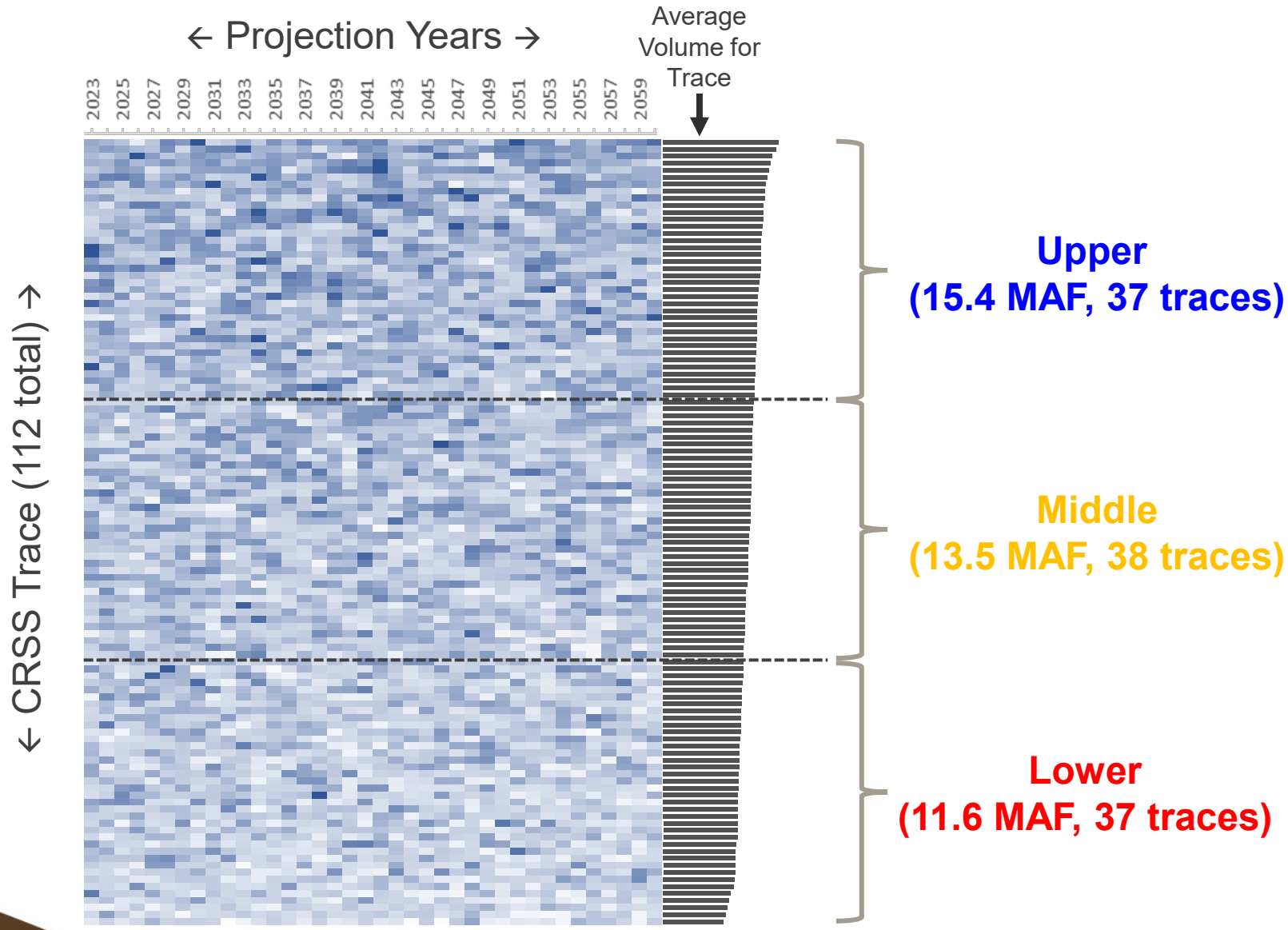
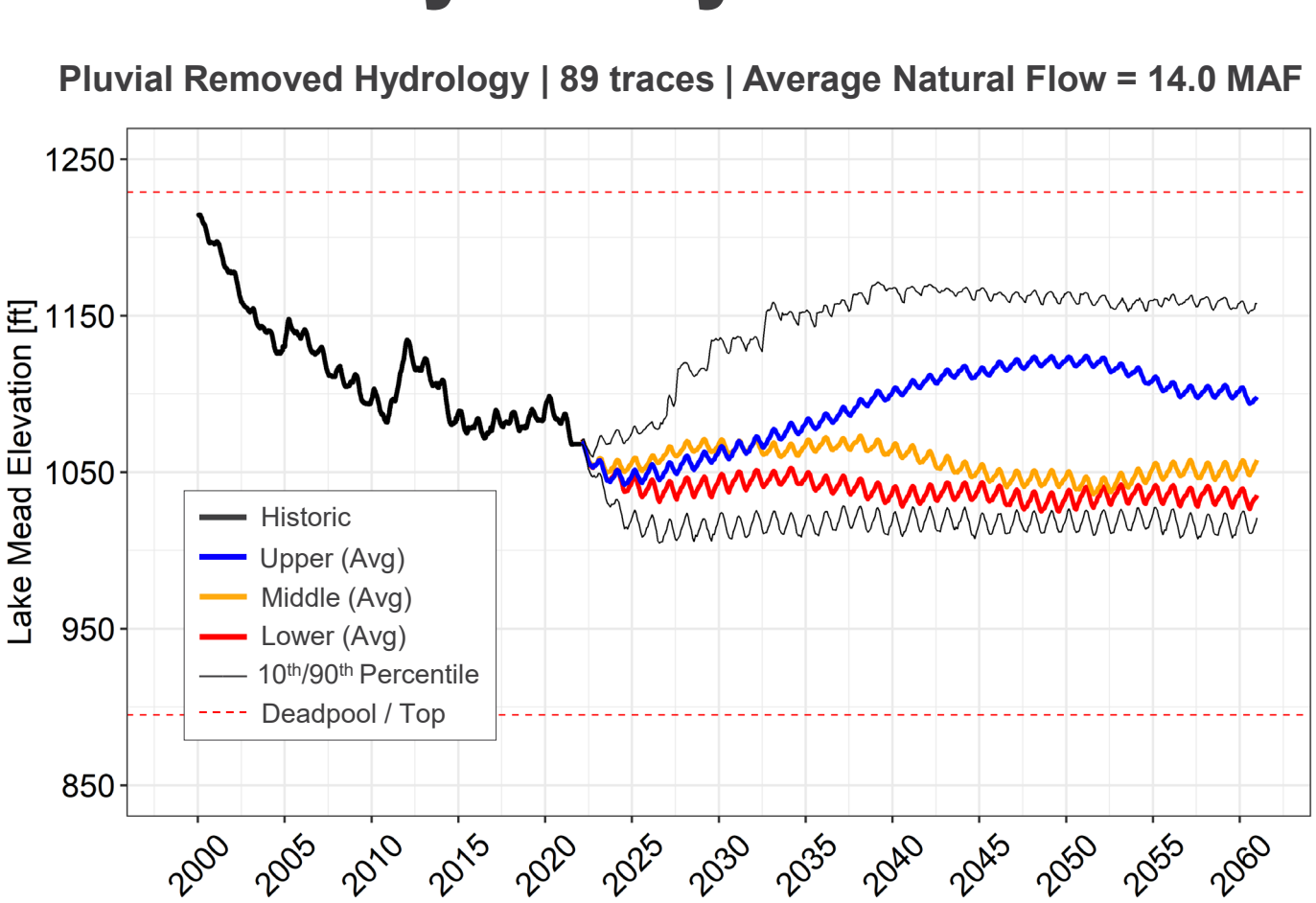
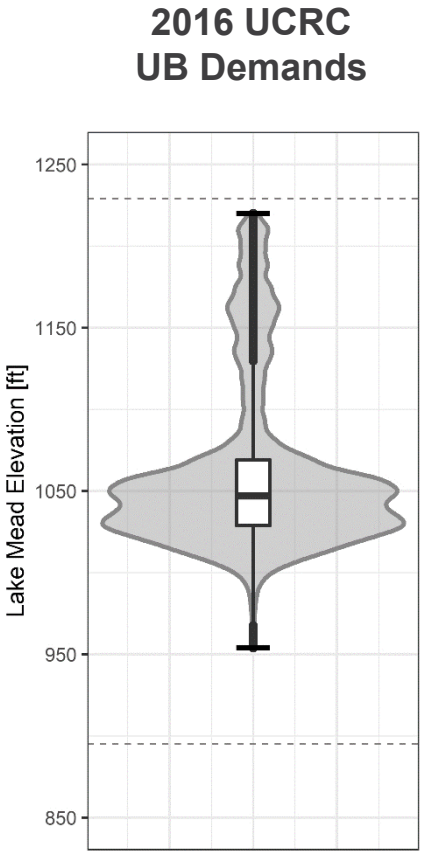


Sensitivity Analysis – UB Demands

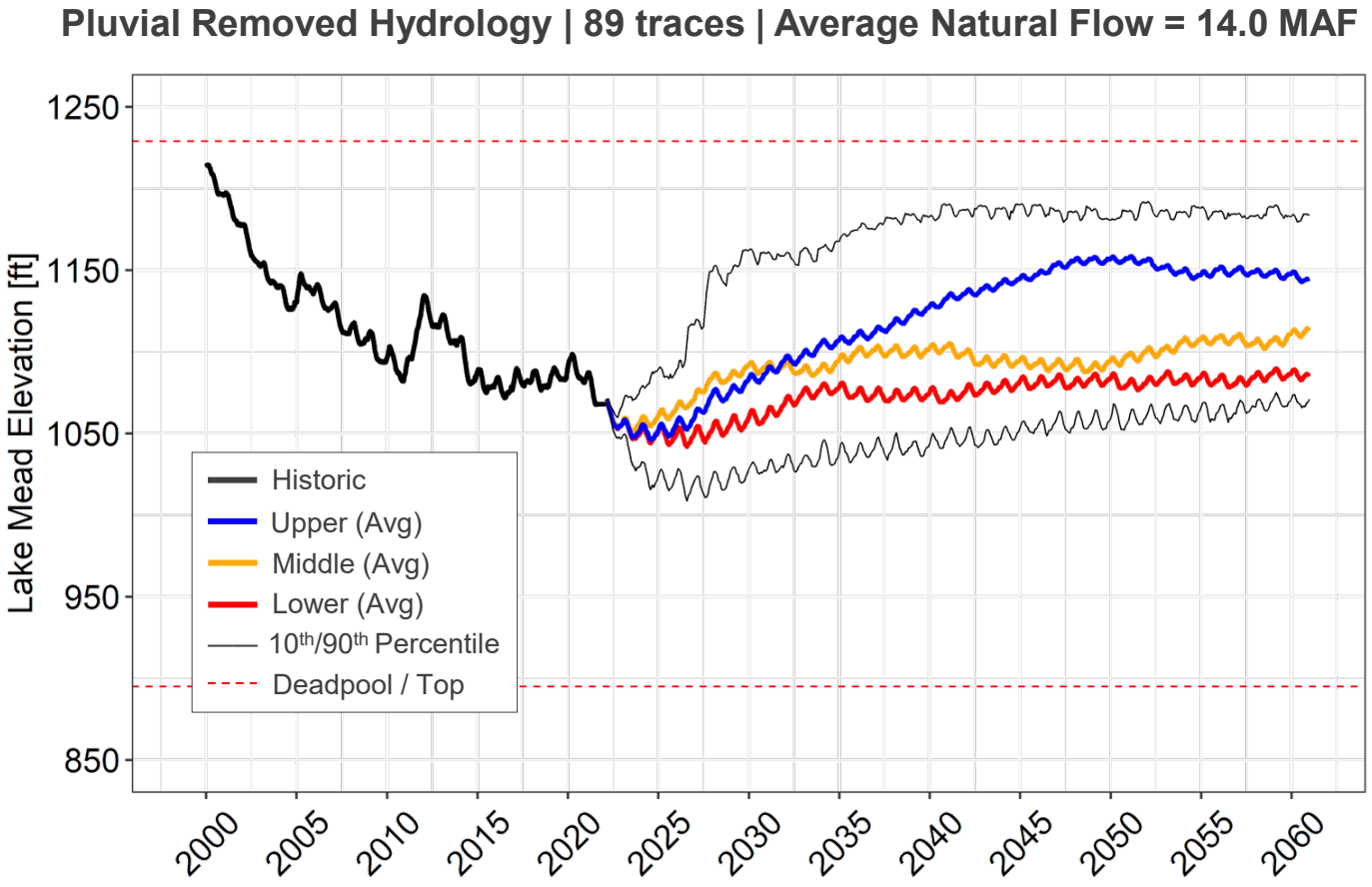


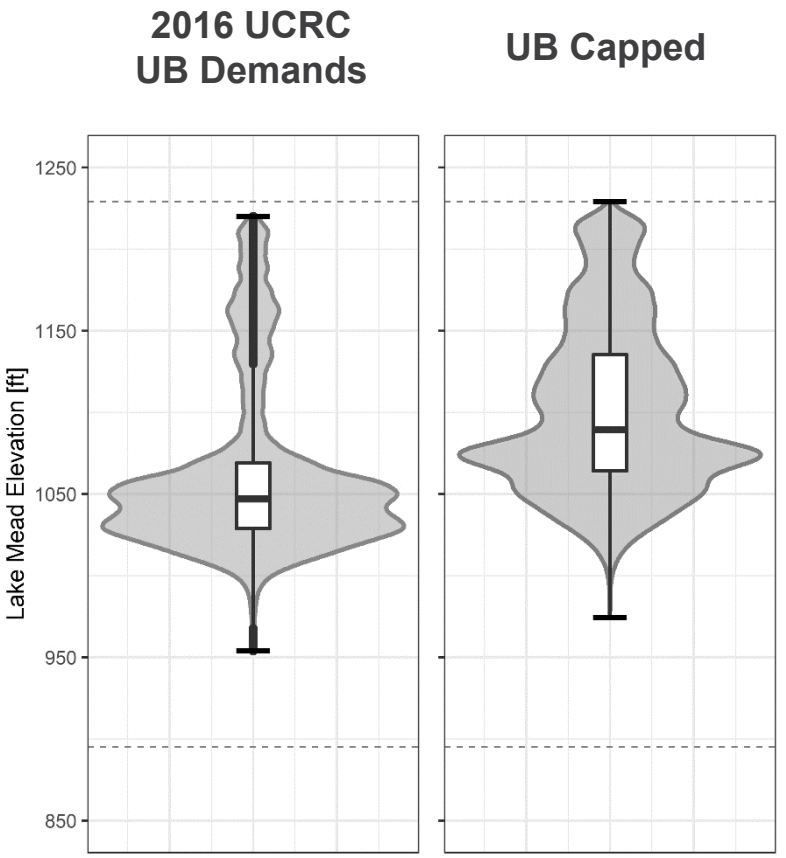


Mead Elevation [ft]

Scenario	Q1	Median	Average	Q3
2016 UCRC	1,029	1,047	1,062	1,069

Sensitivity Analysis – UB Demands

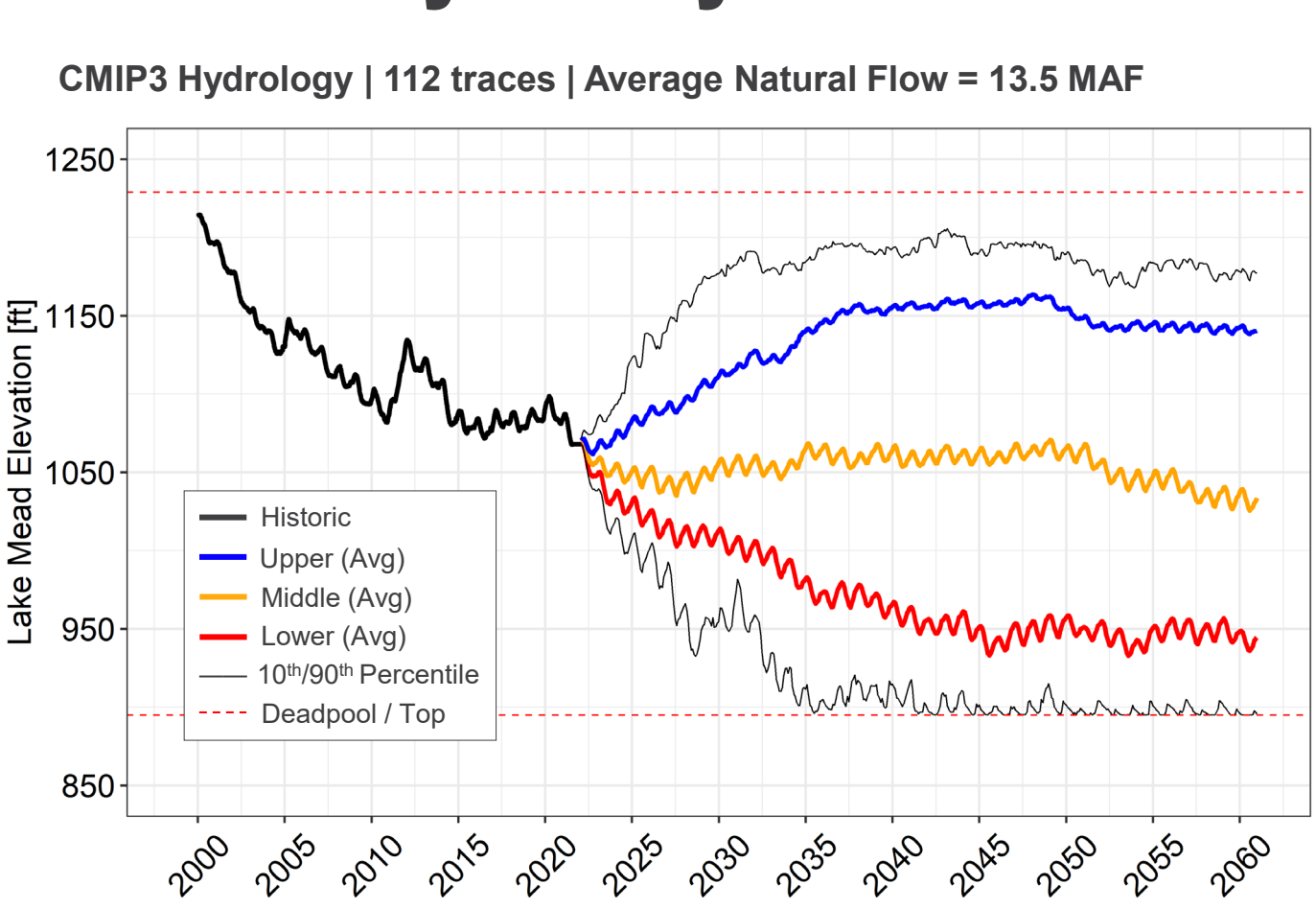


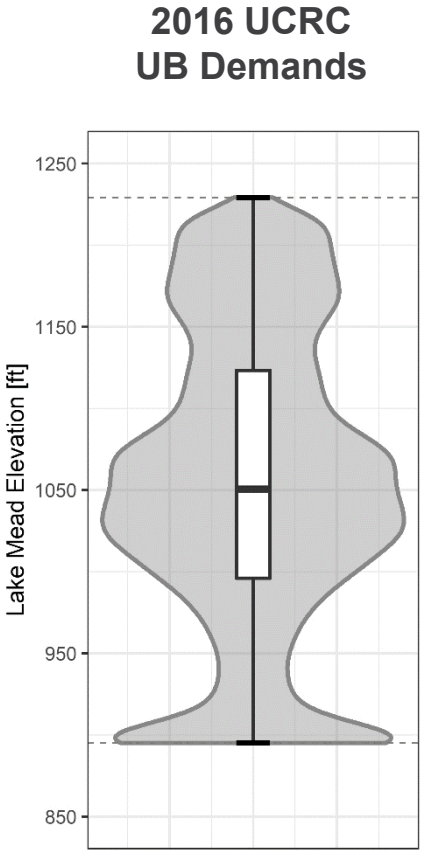


Mead Elevation [ft]

Scenario	Q1	Median	Average	Q3
2016 UCRC	1,029	1,047	1,062	1,069
Capped	1,064	1,089	1,102	1,135
Difference	35	42	40	66

Sensitivity Analysis – UB Demands

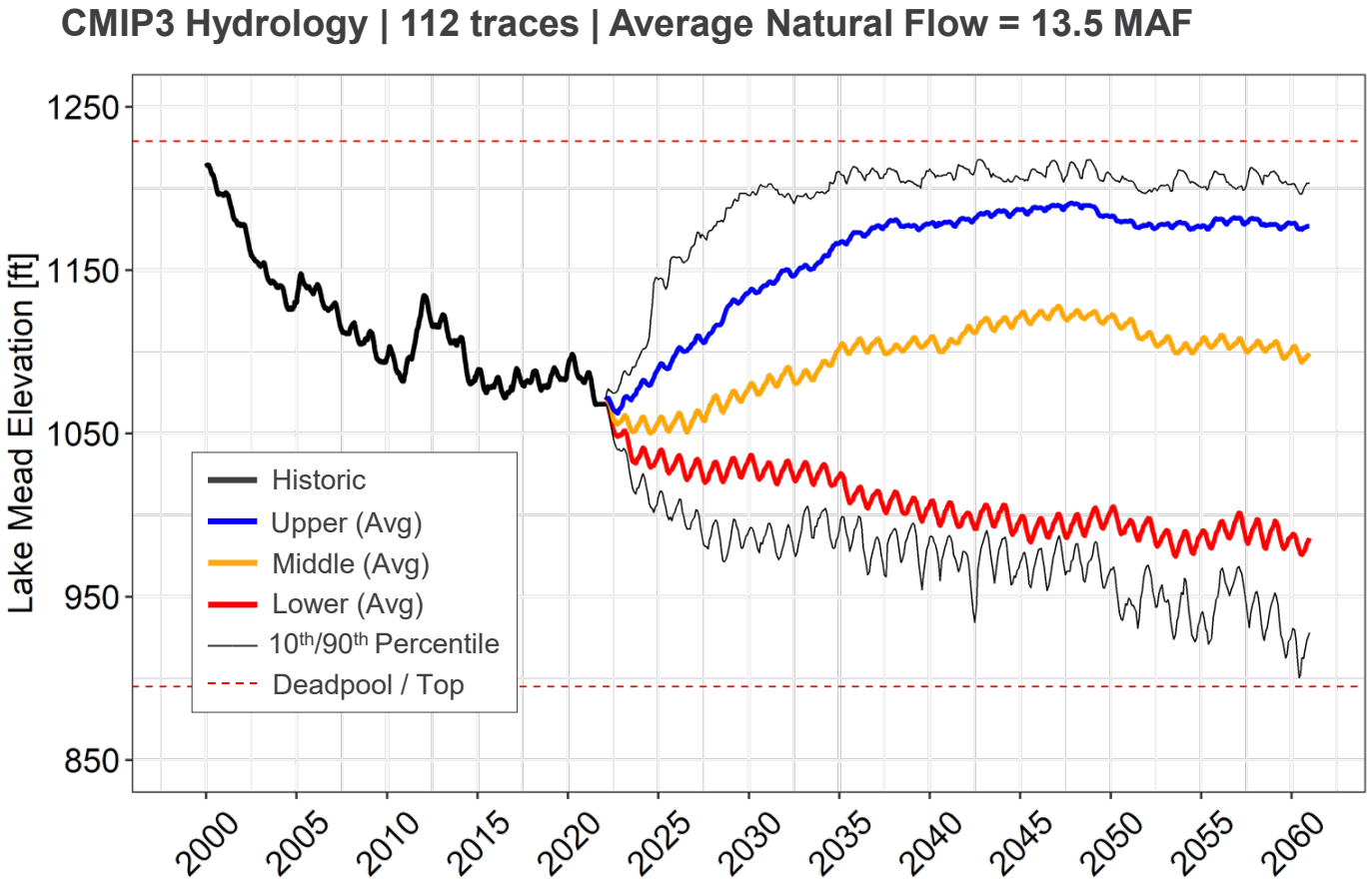


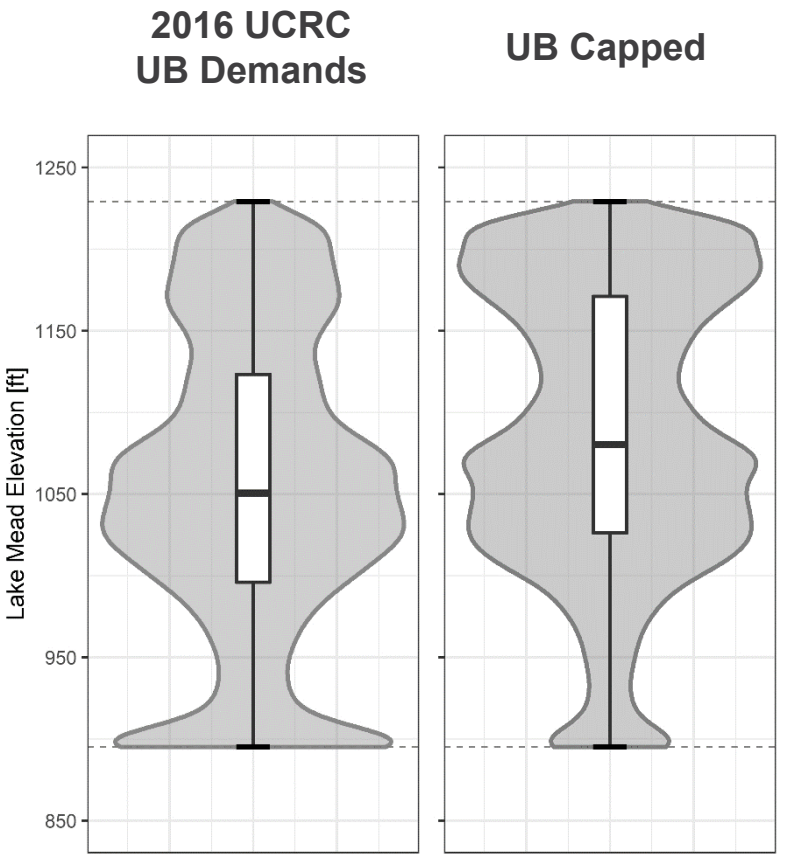


Mead Elevation [ft]

Scenario	Q1	Median	Average	Q3
2016 UCRC	996	1,051	1,053	1,123

Sensitivity Analysis – UB Demands





Mead Elevation [ft]

Scenario	Q1	Median	Average	Q3
2016 UCRC	996	1,051	1,053	1,123
Capped	1,026	1,080	1,088	1,171
Difference	30	29	35	48

Critical Mead Elevations – 1,025 ft

Percentage of EOY Projected Mead Elevations <= 1,025

Input Hydrology	UB Demand Assumption: 2016 UCRC	UB Demand Assumption: UB Capped
Pluvial Removed	15%	2%
CMIP3	36%	24%

Percentage of Realizations with at Least One 5-Year Period Where EOY Mead Elevation <=1,025

Input Hydrology	UB Demand Assumption: 2016 UCRC	UB Demand Assumption: UB Capped
Pluvial Removed	9%	0%
CMIP3	54%	40%

* Total EOY Projections = No. of Realizations *x* No. of Projection Years

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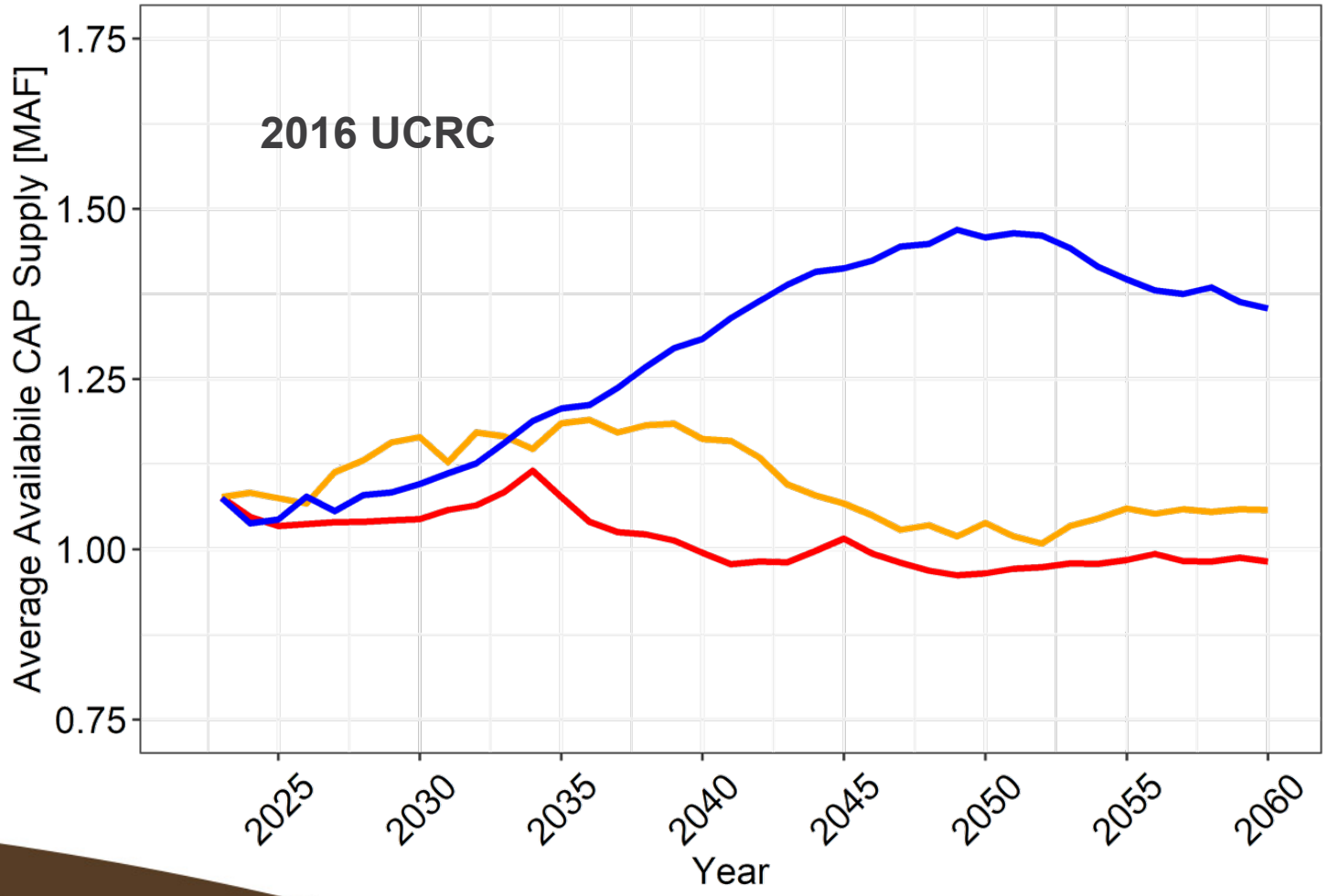
Sensitivity Analysis – Impact of UB Demand



- UB demand assumption has a large impact on the supply available to CAP

Tercile
- Lower
- Middle
- Upper

38 Year Average [MAF]

Scenario	Lower	Middle	Upper
2016 UCRC	1.01	1.10	1.29
Capped*	1.30	1.41	1.49

** 2008 – 2018 Average*

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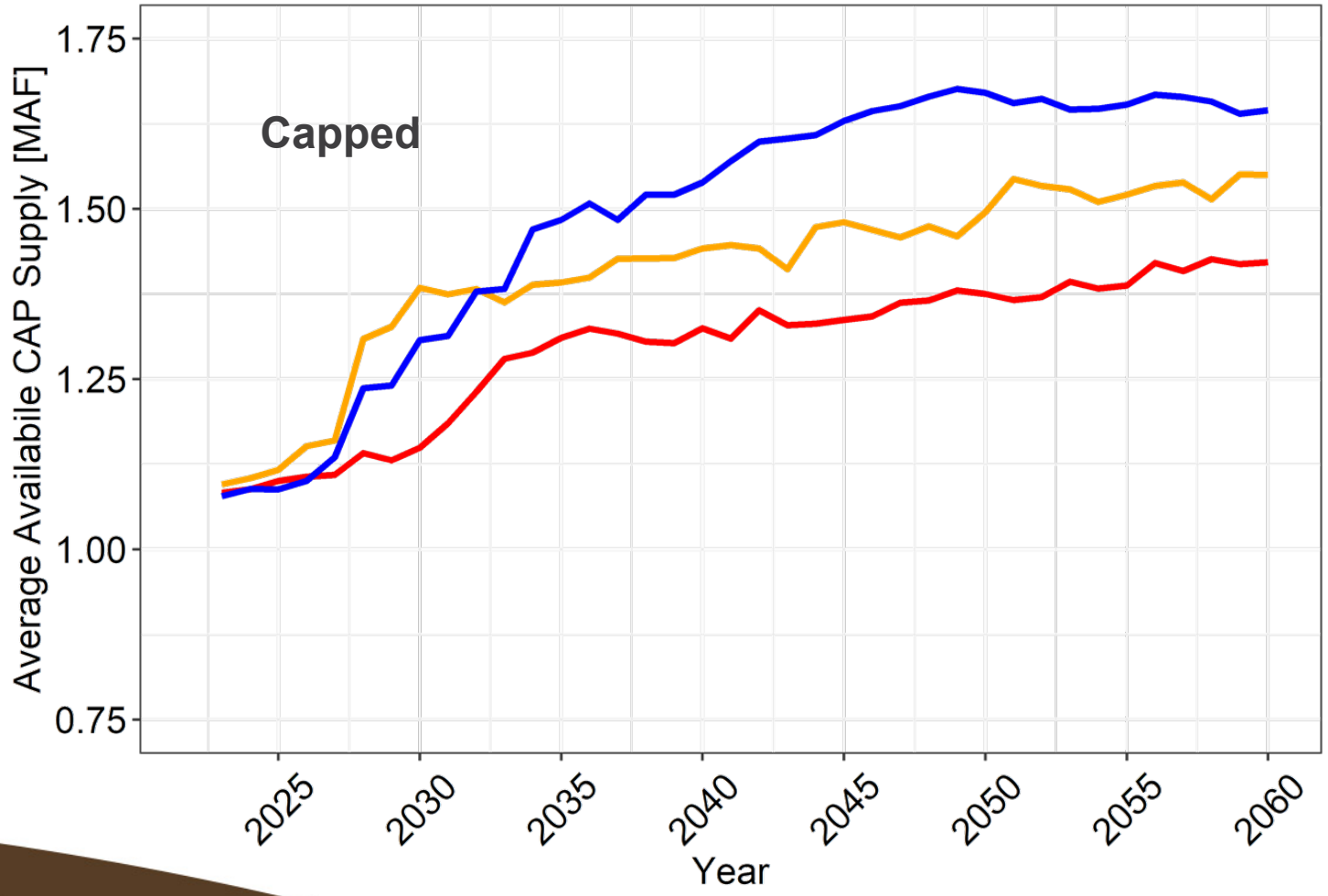
Sensitivity Analysis – Impact of UB Demand



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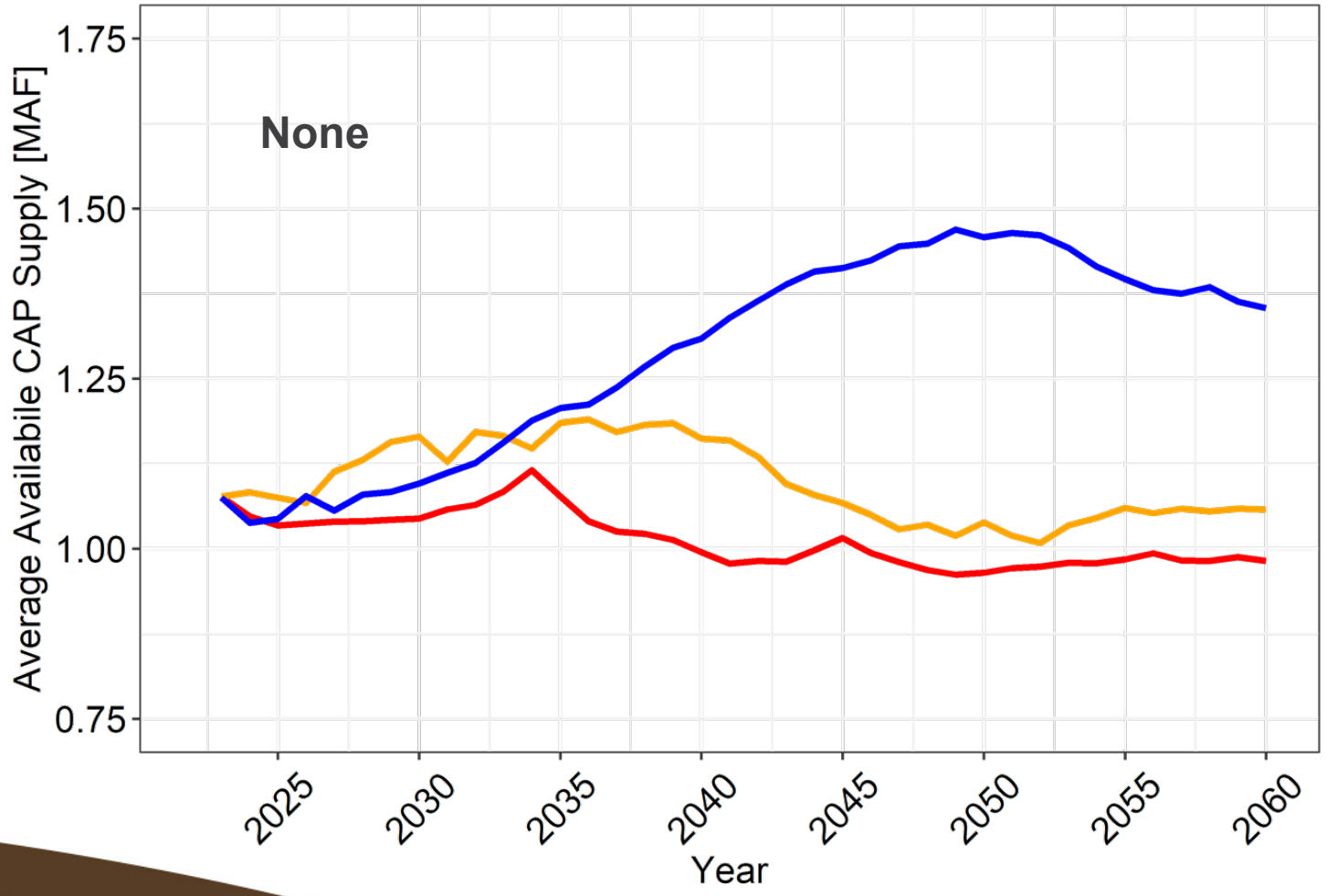
Sensitivity Analysis – Impact of On-River Growth



- Changes in On-River Demand have a modest impact on the supply available to CAP

Tercile
- Lower
- Middle
- Upper

38 Year Average [MAF]

Scenario	Lower	Middle	Upper
None*	1.01	1.10	1.29
0.10% Growth	0.99	1.08	1.26
0.20% Growth	0.97	1.05	1.24

** 2008 – 2018 Average*

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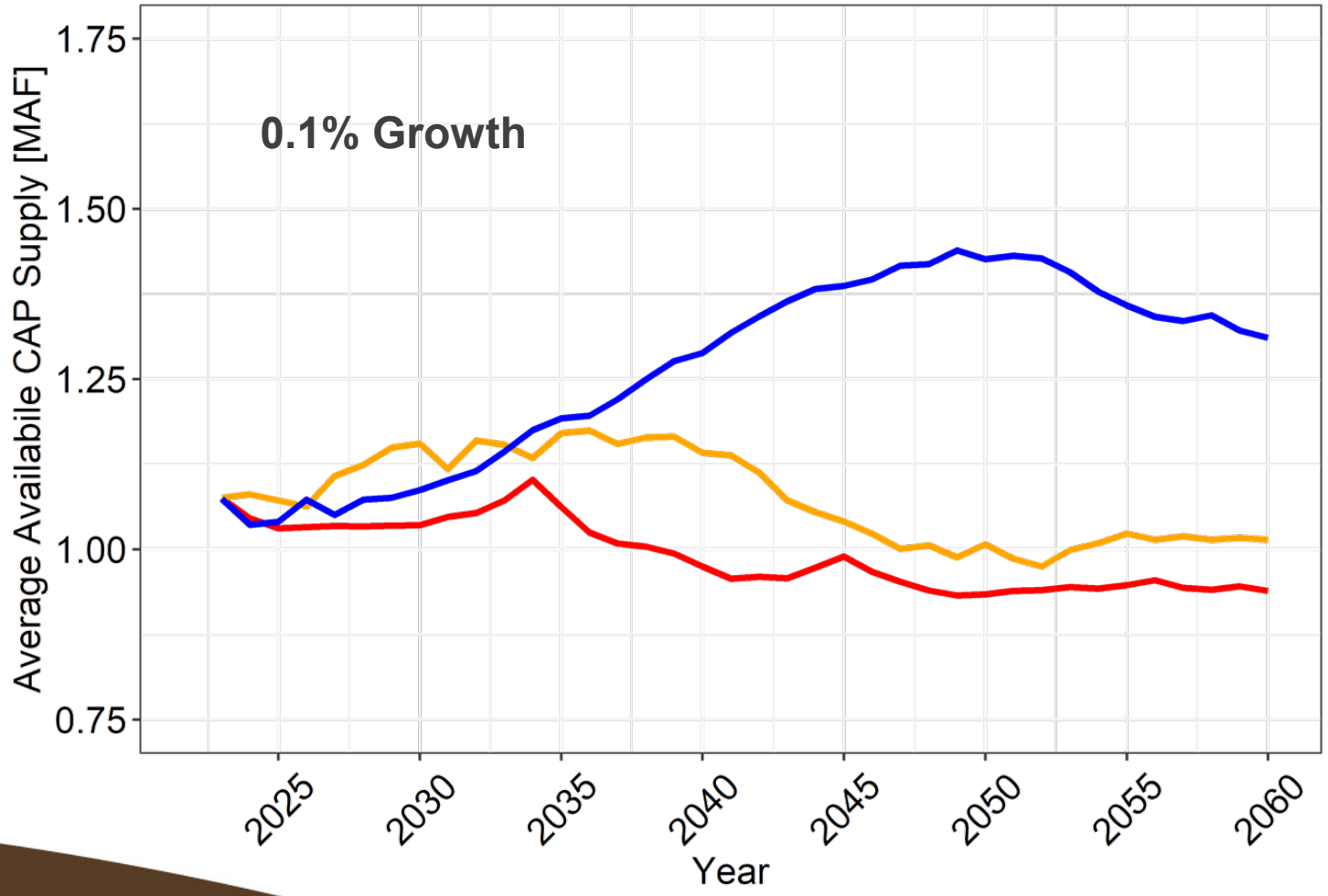
Sensitivity Analysis – Impact of On-River Growth



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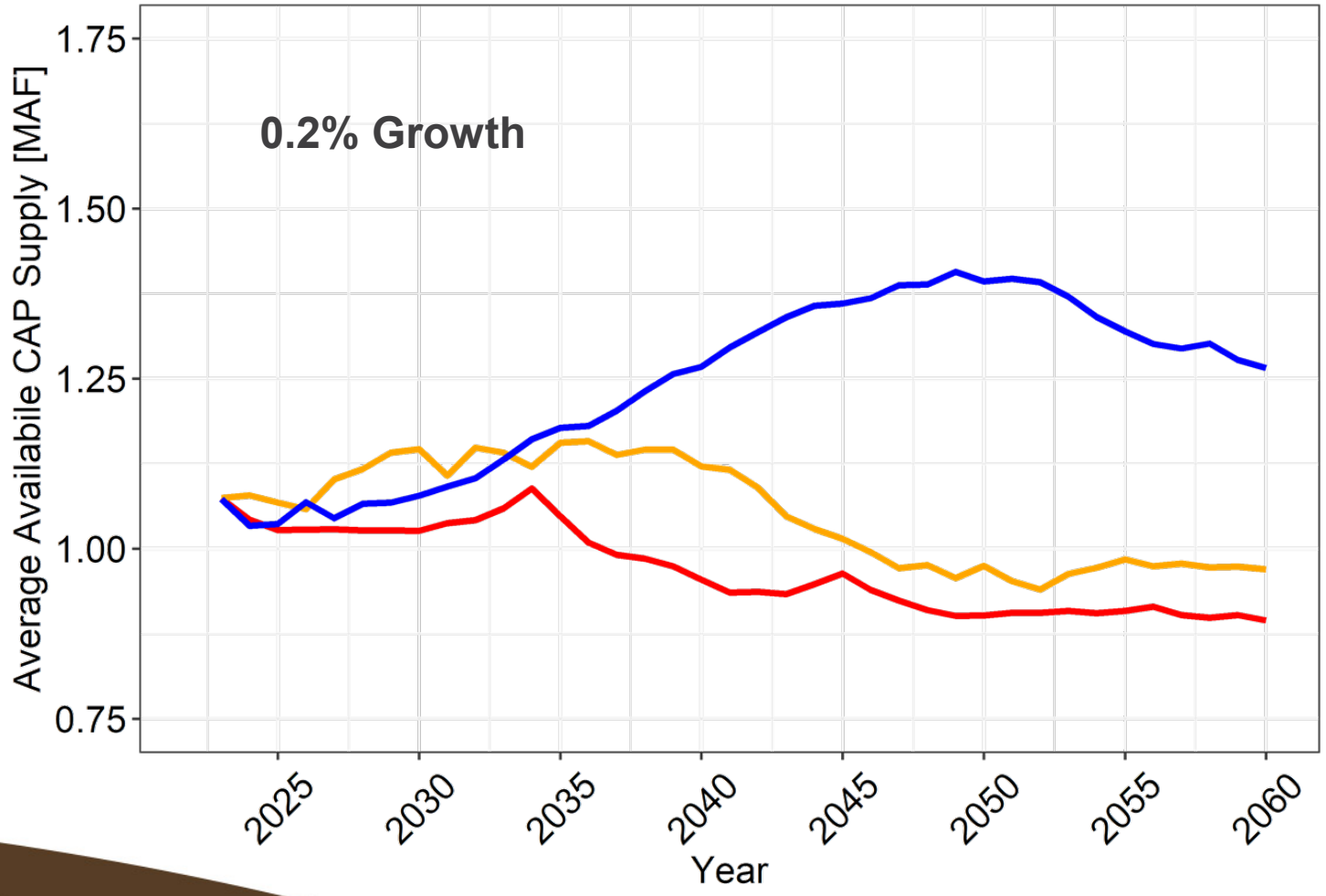

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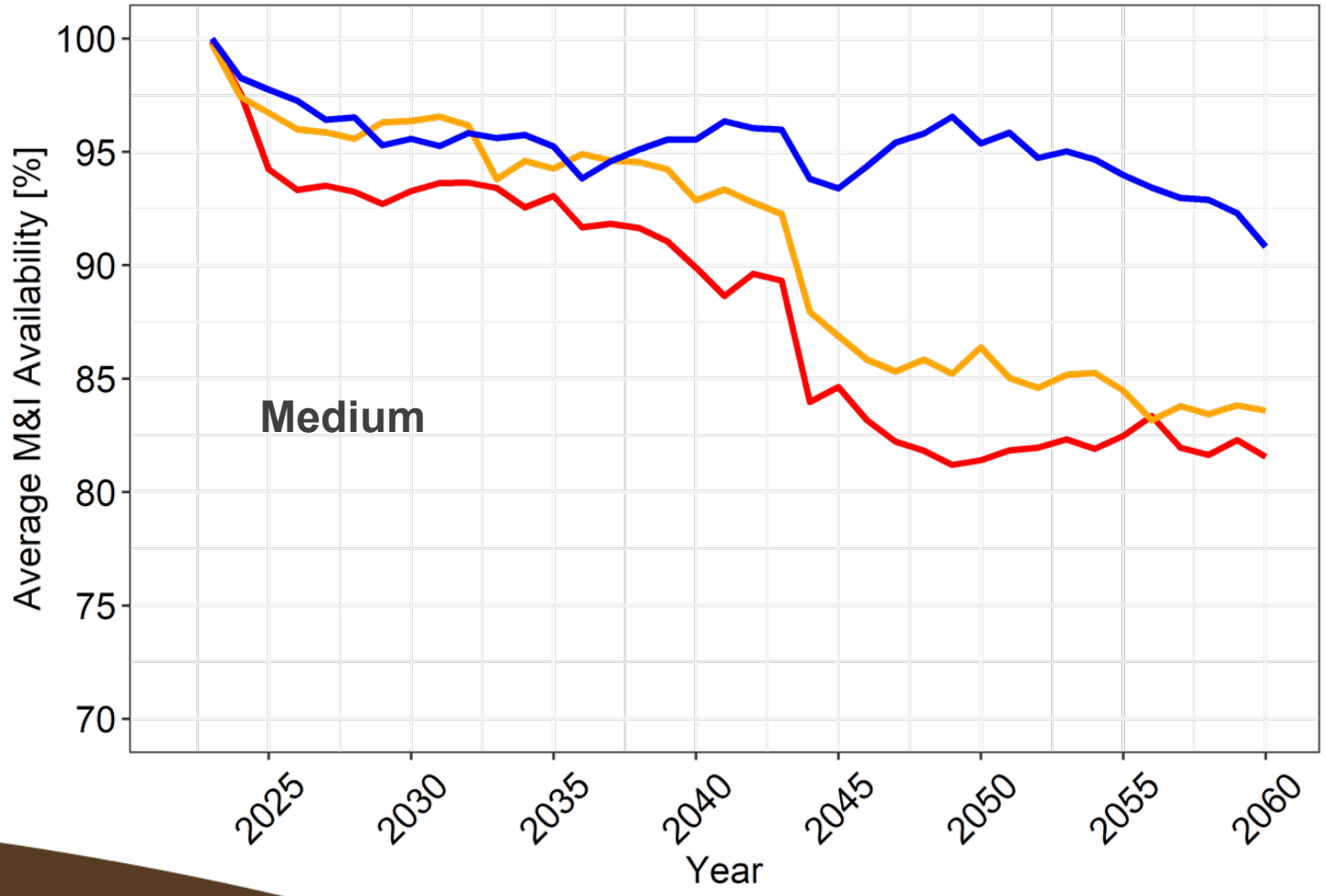
Sensitivity Analysis – Impact of CAP Utilization



- CAP utilization rates affect supply availability during the first half of the projection period

Tercile
- Lower
- Middle
- Upper

38 Year Average [%]

Scenario	Lower	Middle	Upper
Medium*	88	91	95
Fast**	88	90	95

** Full CAP Long-Term Contract Use by 2045*
*** Full CAP Long-Term Contract Use by 2035*

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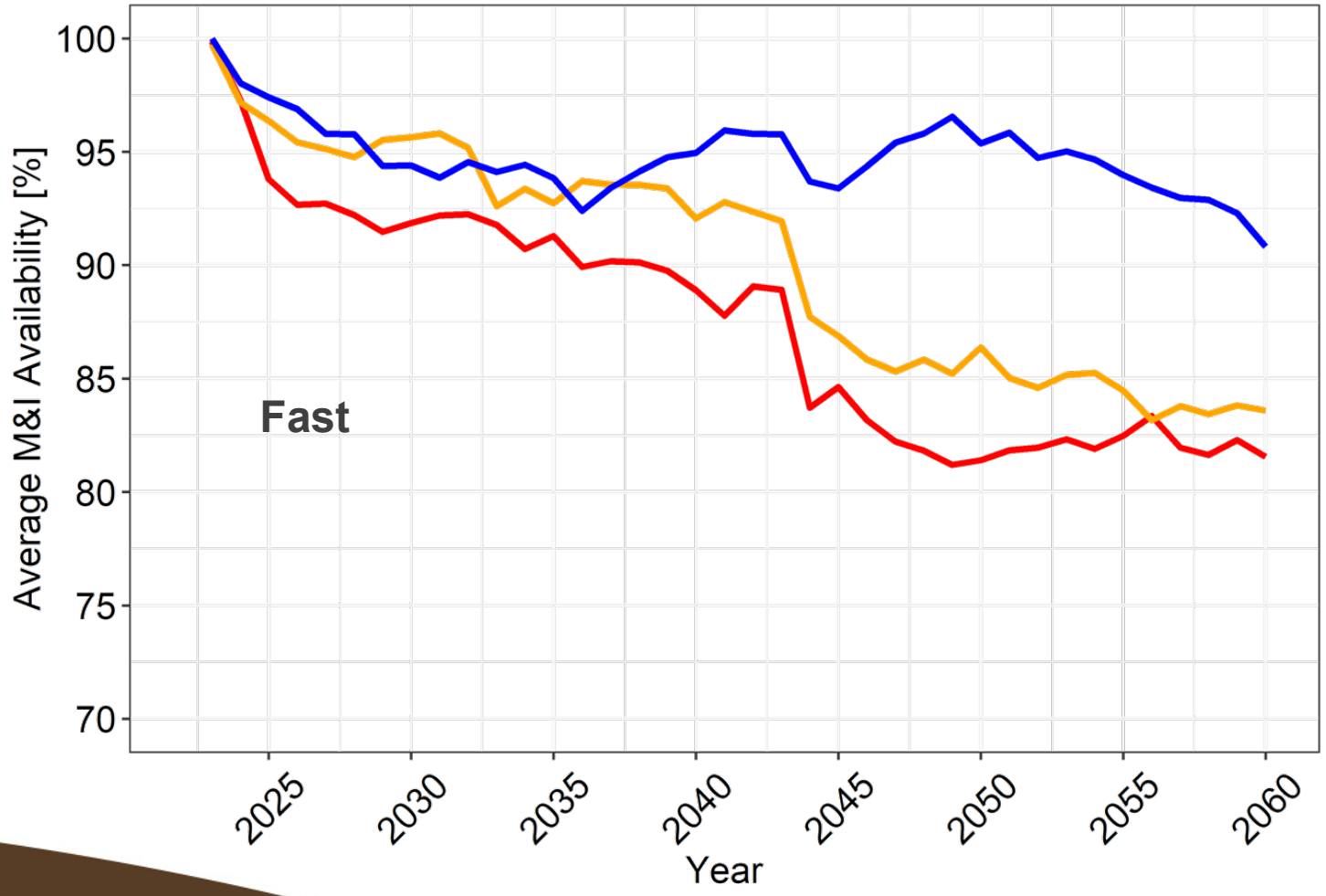
Sensitivity Analysis – Impact of CAP Utilization



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** Full CAP Long-Term Contract Use by 2045*
*** Full CAP Long-Term Contract Use by 2035*

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Sensitivity Analysis – Main Takeaways

- We have refined our set of initial scenarios
  - There is sufficient variability in the subset of scenarios to move forward and evaluate a range of future operating scenarios
- Impacts to Arizona are largely influenced by Upper Basin demand
  - Magnitude
  - Frequency/Duration
- Sensitivity to On-River growth and CAP utilization rates is less pronounced but does have implications for the service area and the timing of reductions

Break

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Discussion of Hydrologies & alternate methods

- **Response to request from MAWG members to evaluate more ‘worse case’ scenarios**

- **Selected Reclamation Hydrologies:**
  - Pluvial-removed (Index Sequential Method)
  - CMIP3 (Climate change)

- **Further Exploration:**
  - Pluvial-removed
    - Adjusted pluvial-removed hydrology (1931 to 2019) to an average of 11 MAF/year
    - Adjusted pluvial-removed hydrology (1931 to 2019) to an average of 10 MAF/year
  - Climate Change
    - CMIP3 subset
    - CMIP5 subset

Terminology

GCM: General Circulation Model (climate model)

BCSD: Bias Correction and Spatial Disaggregation (downscaling method for climate models)

CMIP3: Coupled Model Intercomparison Project phase 3 (released with Intergovernmental Panel on Climate Change Fourth Assessment Report in 2007)

CMIP5: Coupled Model Intercomparison Project phase 5 (released with Intergovernmental Panel on Climate Change Fifth Assessment Report in 2014)

LOCA: Localized Constructed Analogs (downscaling method for climate models)

VIC: Variable Infiltration Capacity (hydrologic model)

Hydrologies & alternate methods

Hydrology		Pluvial Removed	CMIP3	Pluvial Removed Adjusted to 11 MAF	Pluvial Removed Adjusted to 10 MAF	CMIP5 (Selected Ensemble)
Time Period or Type		1931 to 2019	Projected: 2023 to 2060	1931 to 2019	1931 to 2019	Projected: 2023 to 2060
# of Traces/Records		89	112	89	89	16
Natural Flow at Lees Ferry (MAF)	**10%**	8.91	9.12	7.02	6.38	7.40
	Median	13.65	12.73	10.76	9.78	12.18
	Mean	13.95	13.91	11.00	10.00	12.41
	90%	20.02	20.34	15.78	14.35	17.96

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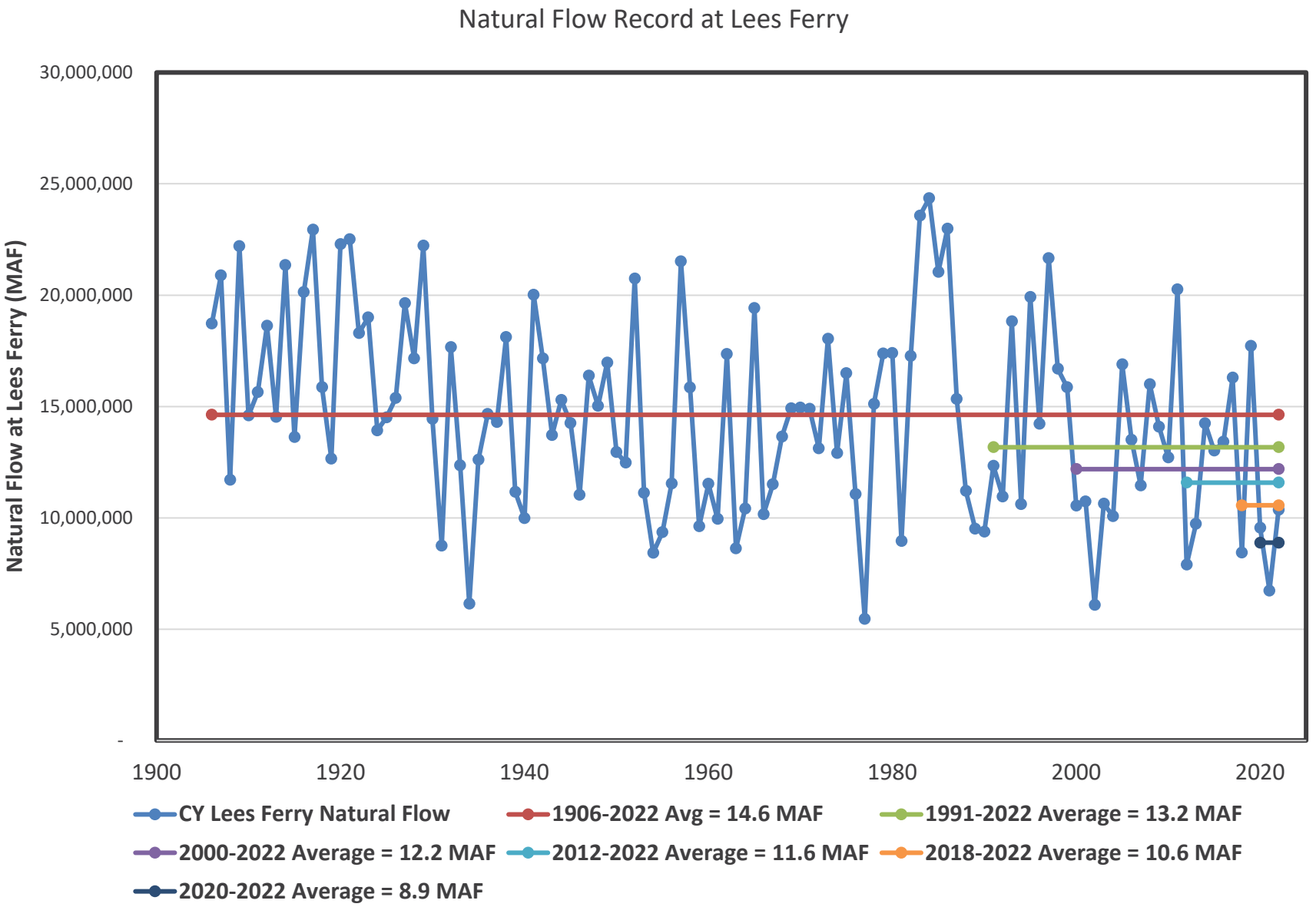
Hydrology Model Assumptions

- CRSS Run Duration = 2023 to 2060
- Policy
  - Interim Guidelines and Lower Basin Drought Contingency Plan are assumed to extend through 2060
- Water Demands
  - Upper Basin capped at 2008 – 2018 average (3.9 MAF/year)
  - Lower Basin demands are according to the schedules provided for the 2007 FEIS with updates to Nevada's demands in May 2019

Natural Flow Record at Lees Ferry



Time Period	Average (MAF)
1906-2020 average	14,734,969
1931-2019 average*	**13,955,812**
1991-2022 average	13,171,669
2000 to 2022 average	12,191,268
2012 to 2022 average	11,582,628
2018 to 2022 average	10,561,951
2020 to 2022 average	8,882,482

*Pluvial Removed time period

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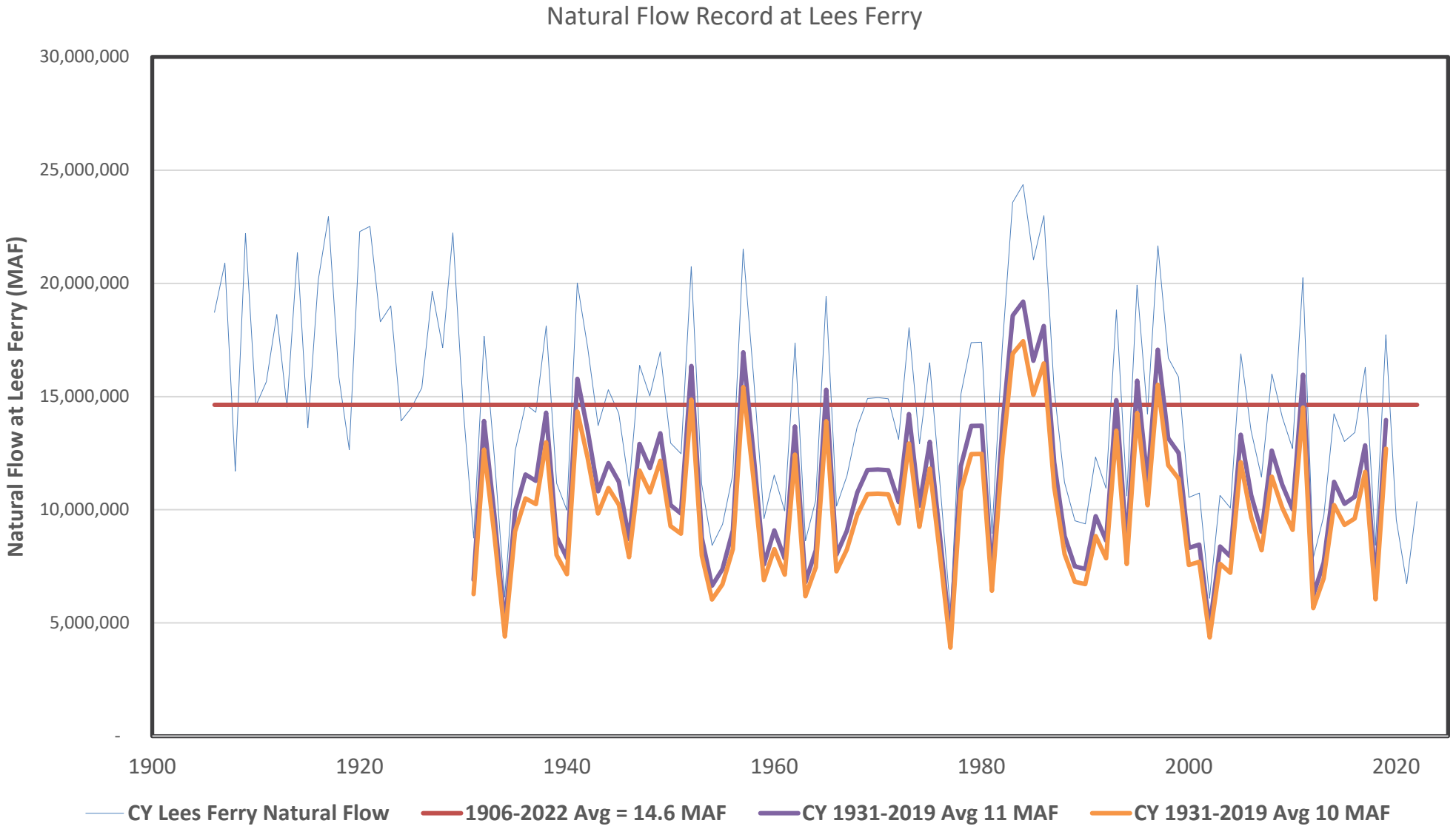
Adjusted Pluvial Removed (1931 to 2019) to 10, 11 MAF/year



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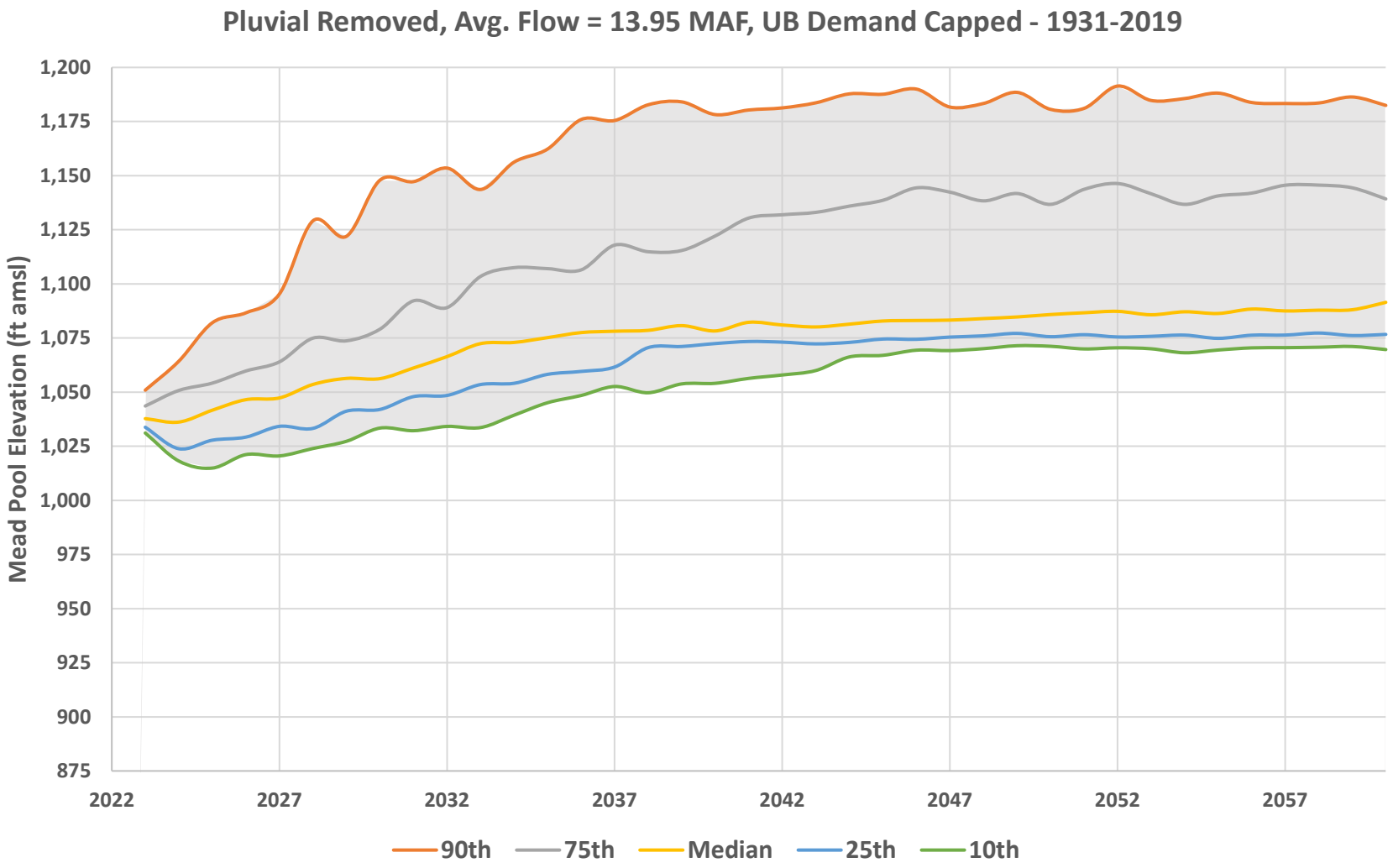
Pluvial Removed (1931 to 2019), UB Demand Capped, Avg. Flow = 13.95 MAF



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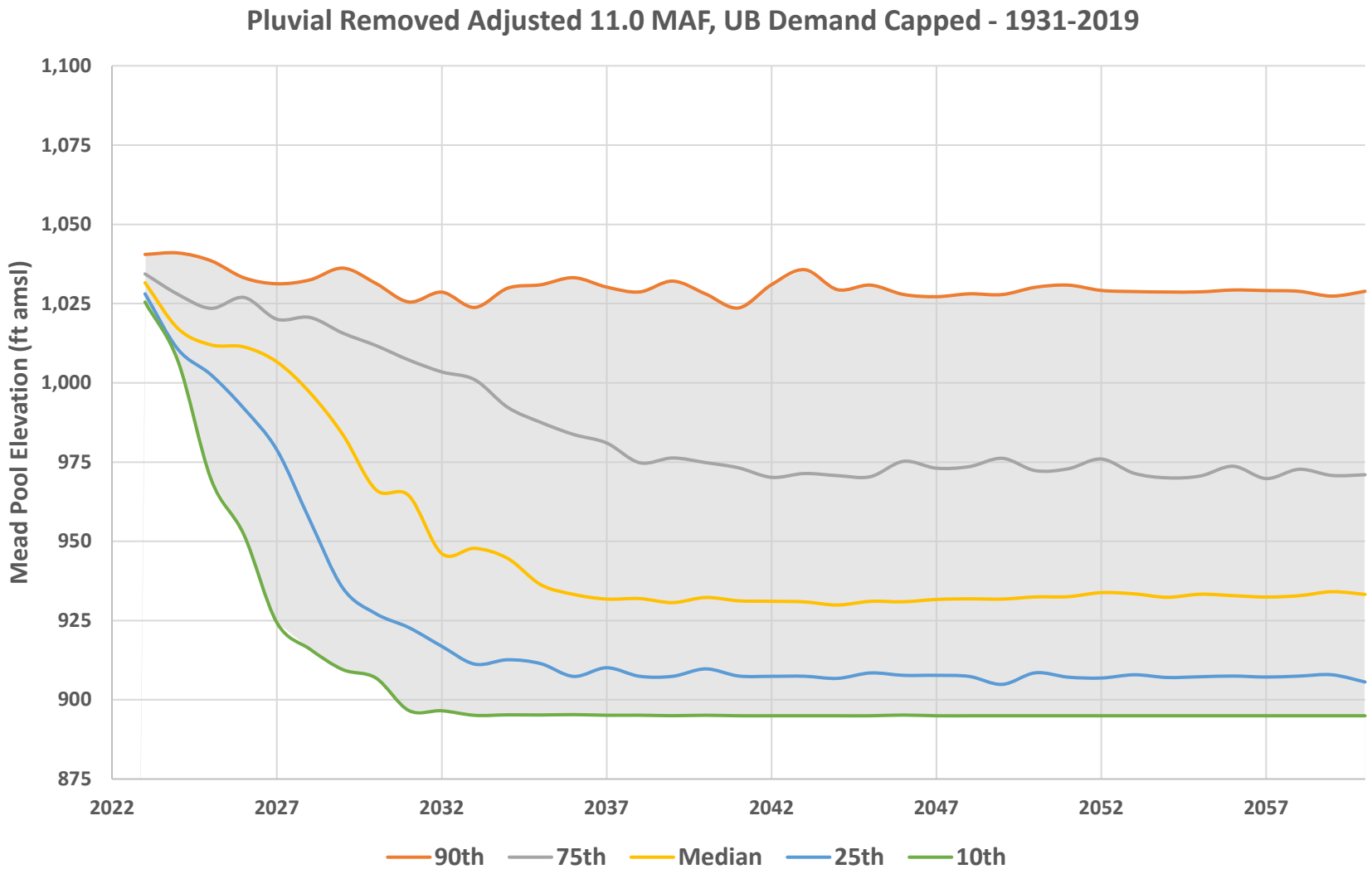
Adjusted Pluvial Removed (1931 to 2019) to 11 MAF/year, UB Demand Capped



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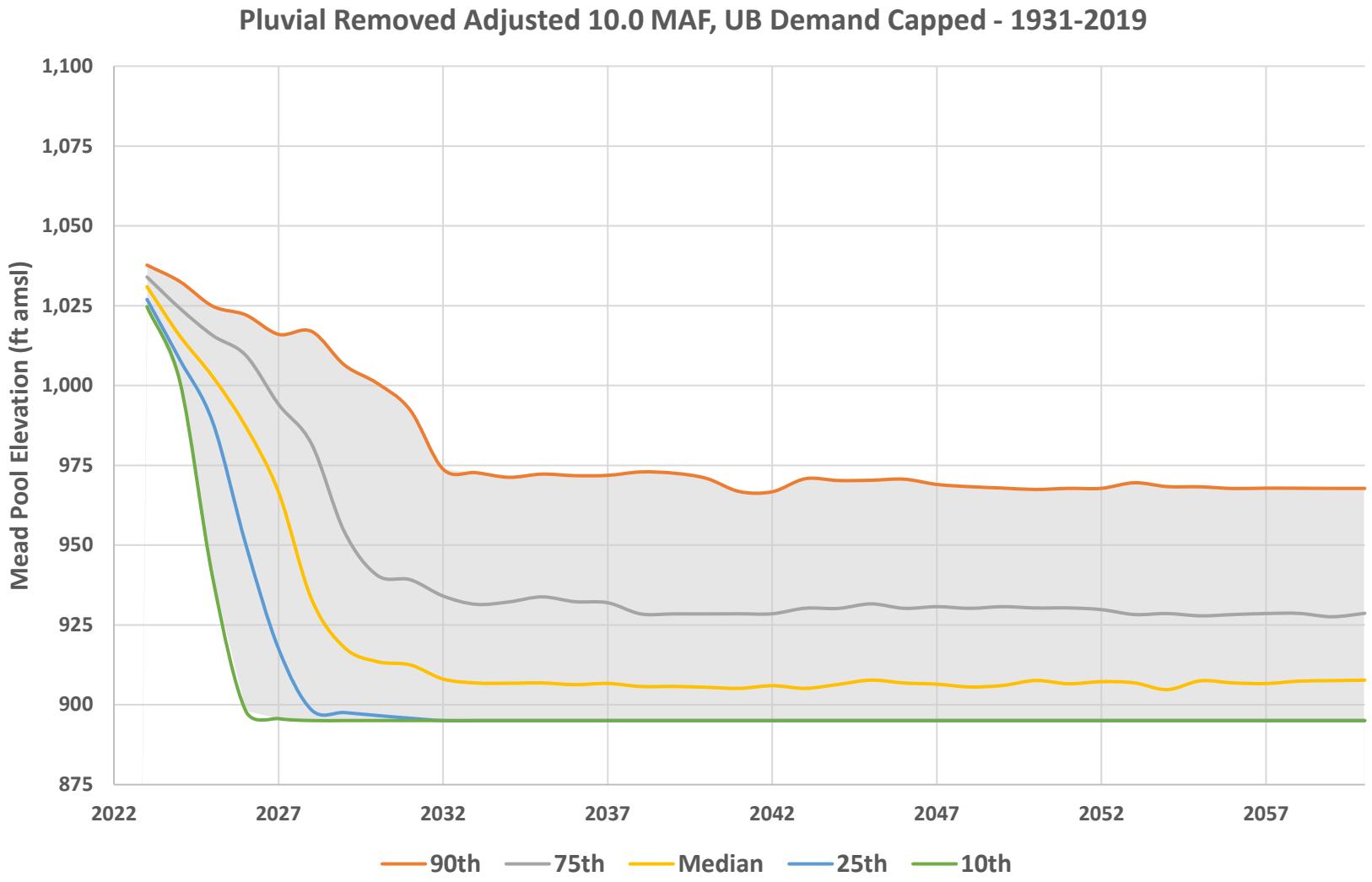
Adjusted Pluvial Removed (1931 to 2019) to 10 MAF/year, UB Demand Capped



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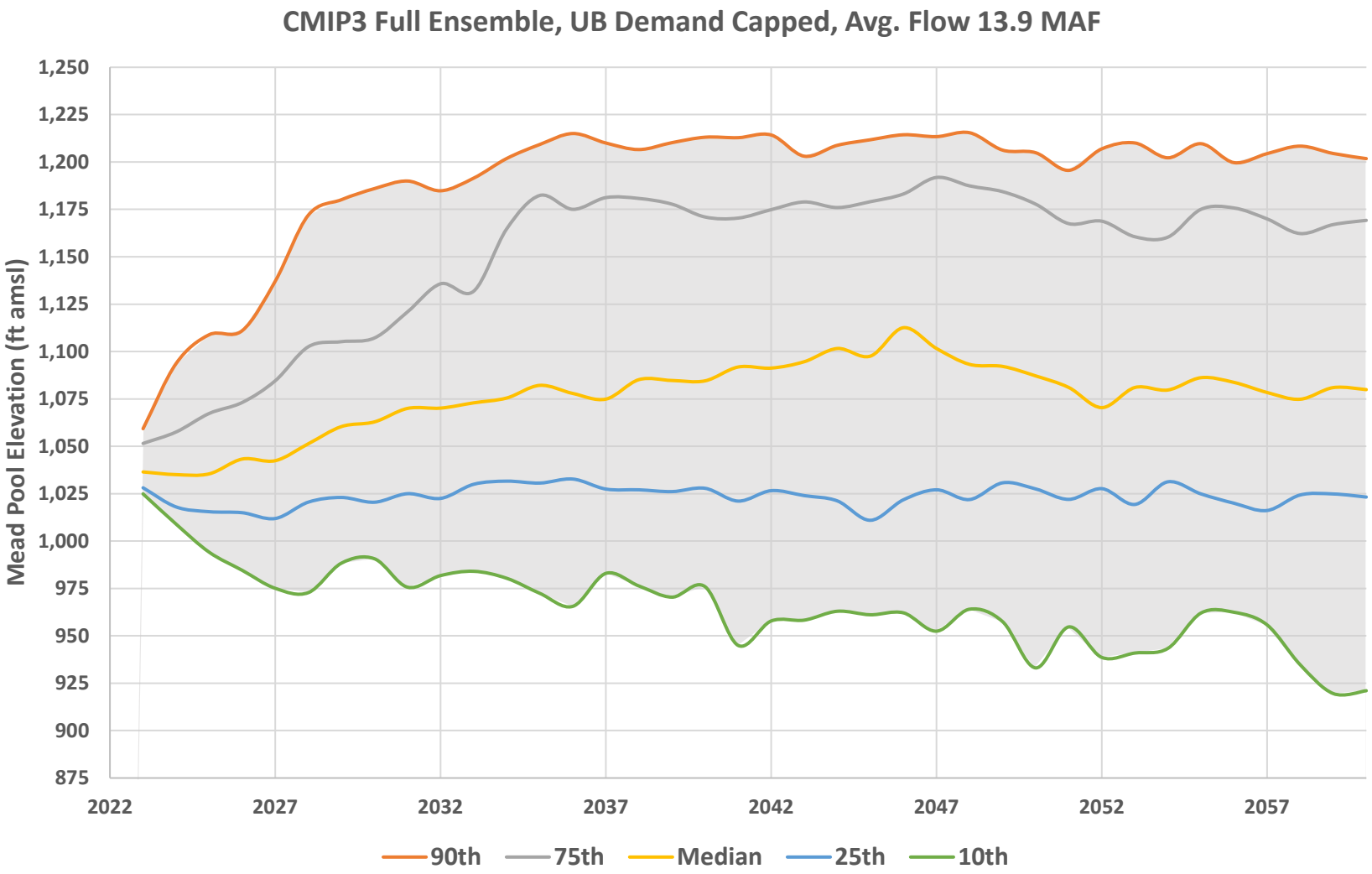
CMIP3 Ensemble of 112 GCMs – UB Demands Capped



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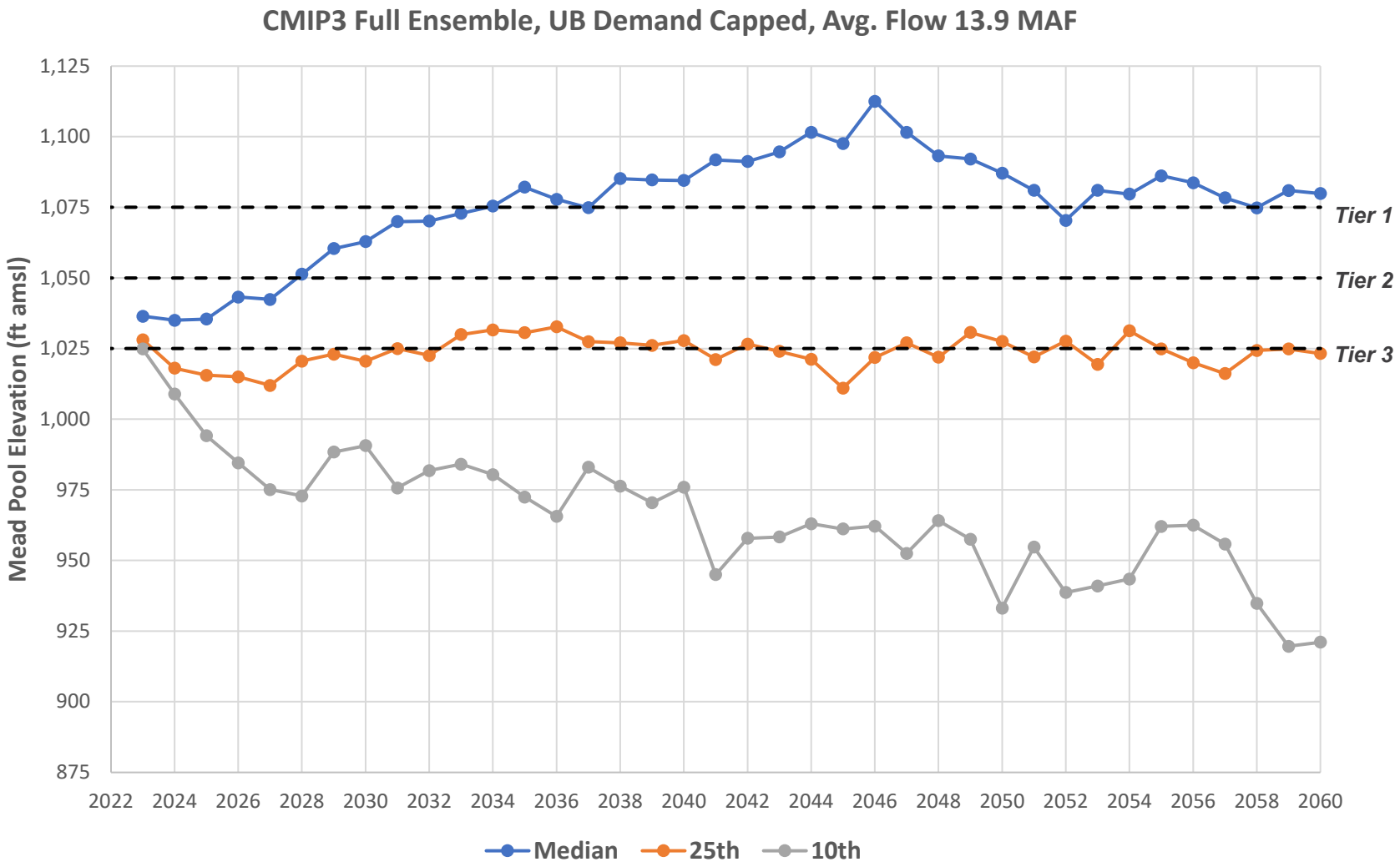

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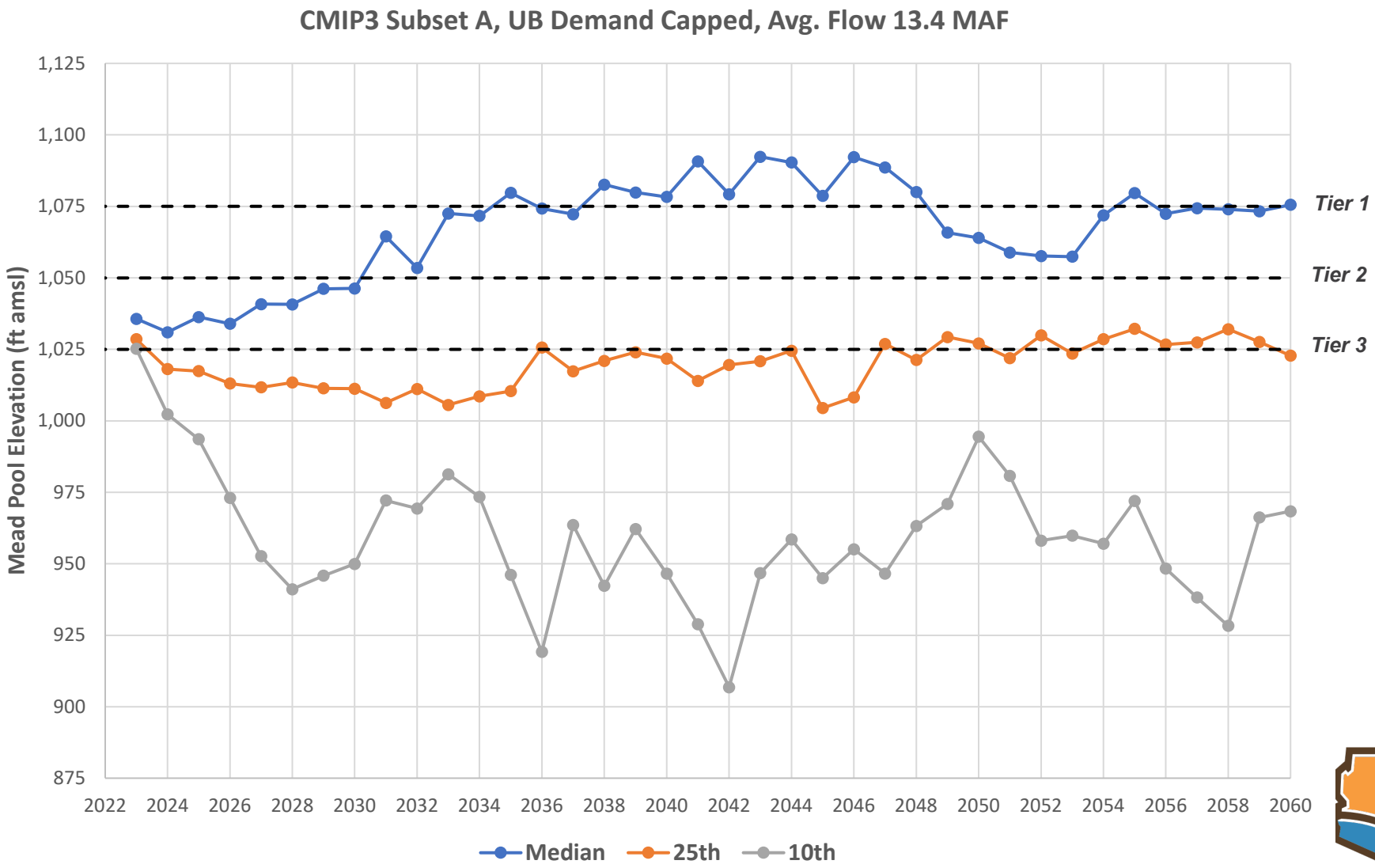
CMIP3 Subsets



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CMIP5 Subset

- ASU-NASA-CAP collaborative project from 2019 to 2022
- CMIP5 models were ranked in reproducing observed seasonal precipitation and temperature in Colorado River Basin subbasins
- Final output is 16 GCM projections from CMIP5, downscaled using the LOCA technique, utilizing VIC version 5.0 hydrology model → CRSS inputs.

CMIP5 *= Coupled Model Intercomparison Project phase 5 (released with Intergovernmental Panel on Climate Change Fifth Assessment Report in 2014)*

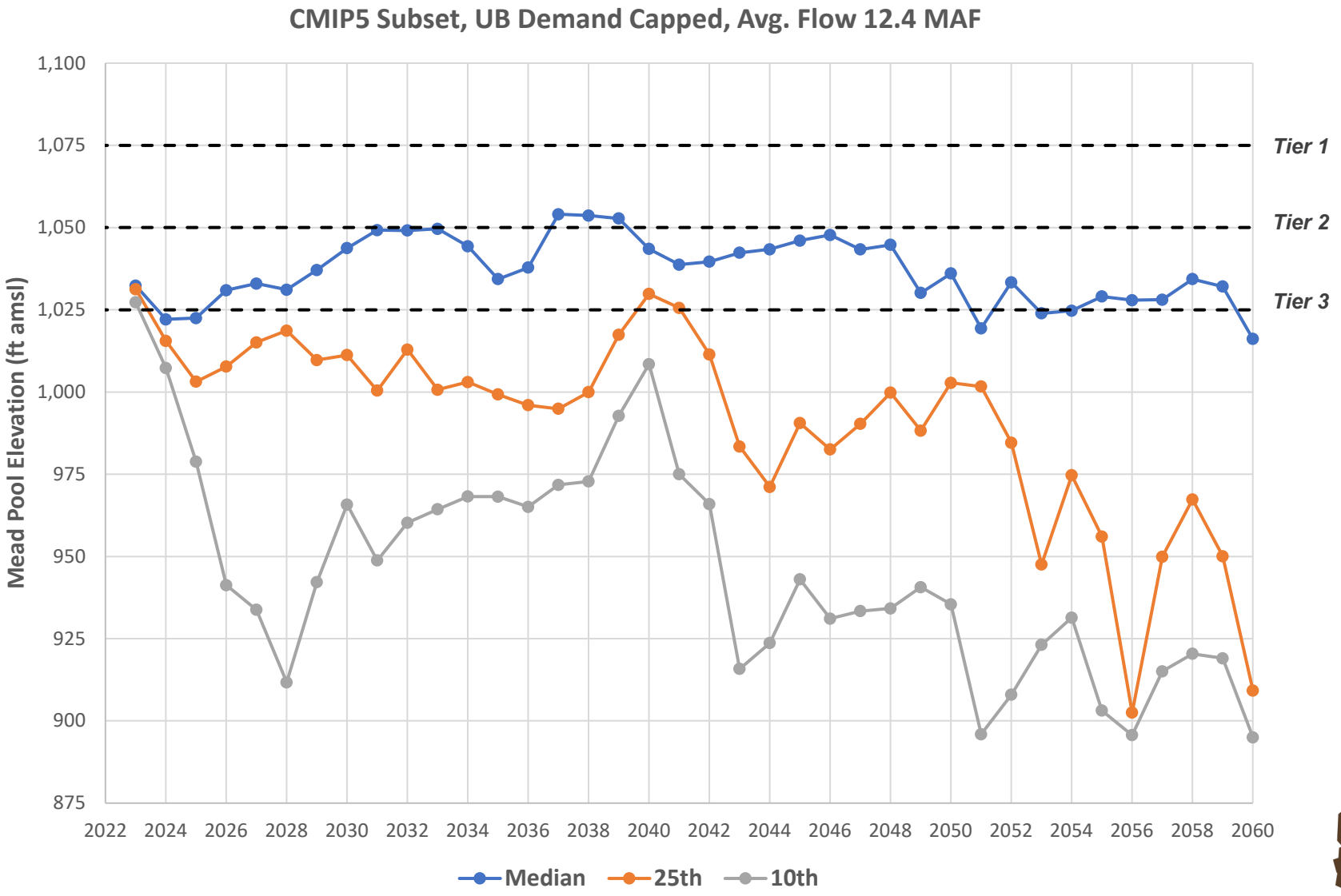
CRSS *= Colorado River Simulation System*

GCM *= general circulation model (climate model)*

LOCA *= Localized constructed analogs (downscaling method for climate models)*

VIC *= variable infiltration capacity hydrologic model*

CMIP5 Subset



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MAWG Next Steps

- Engage in the course of the NEPA process
- MAWG update to ARC at its next meeting
- Reclamation to release CRSS version 6.0 Fall 2022, intends to use for post 2026 analysis going forward

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Call to the Public

- Submit questions or comments using the electronic public comment form at cap-az.com/ARC

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