

# Modeling Risk in the Colorado River Basin

Upper Colorado River Basin Water Forum  
November 8, 2018

# Topics

- Background & Modeling Approach
- **Sensitivity of Risk to Different Hydrologic Assumptions**
- 2012 Colorado River Basin Water Supply and Demand Study



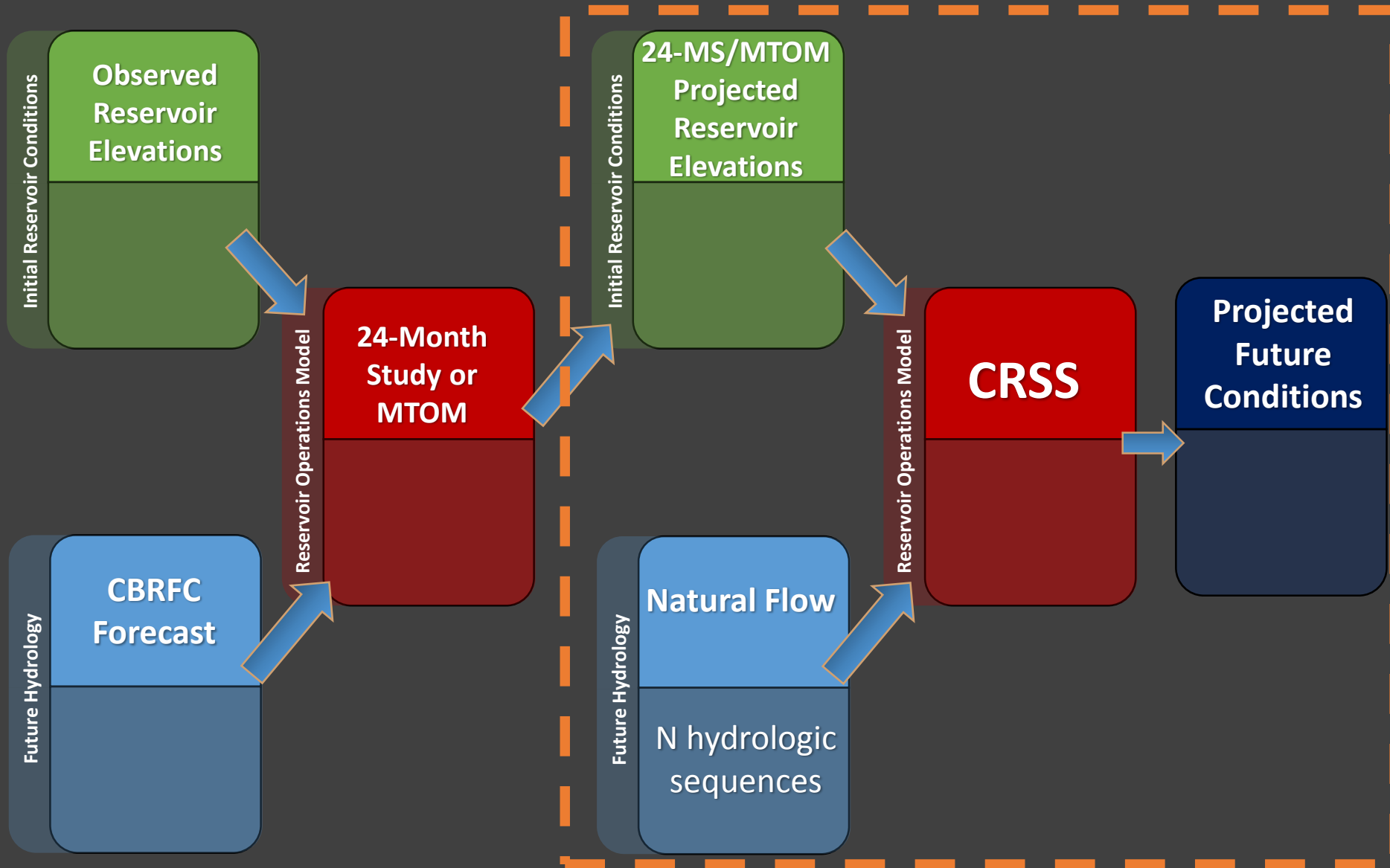
# How do we model risk?

## Using CRSS: A Basin-Wide, Long-Term Planning and Policy Model

- Comprehensive model of the Colorado River Basin
- Developed in RiverWare™
- Probabilistic – gives range of outcomes
- Monthly timestep over decades
- Operating policy is represented by “rules” that drive the simulation and mimic how the system operates
- 12 reservoirs, 500+ “water users”



# Modeling Approach



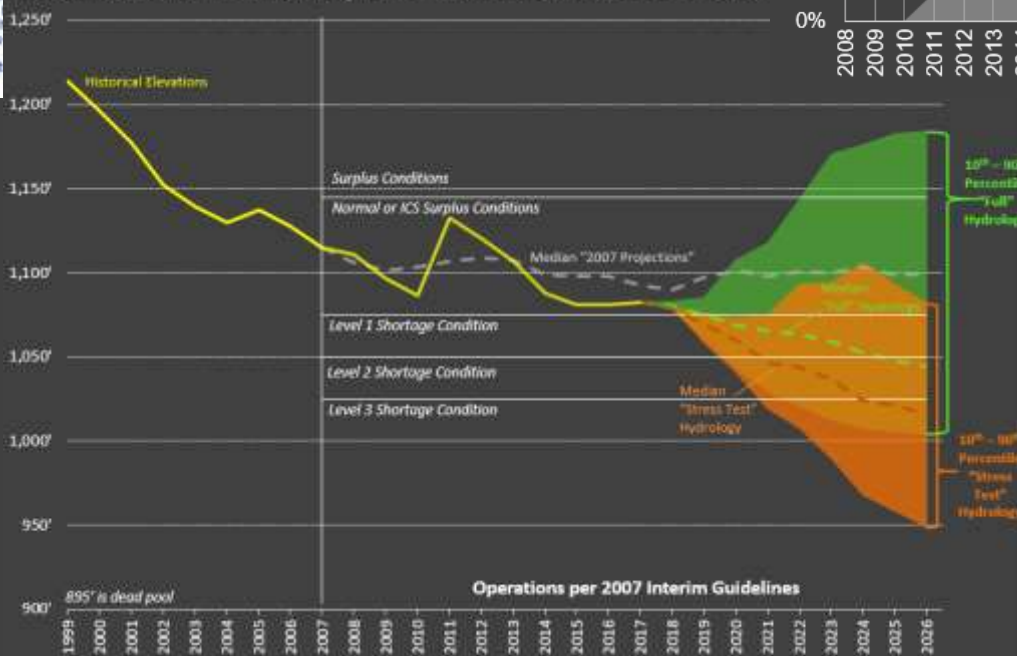
# Example Analyses

Percent of Traces with Event or System Condition  
Results from August 2018 CRSS<sup>1,2,3,4,5</sup> (values in percent)

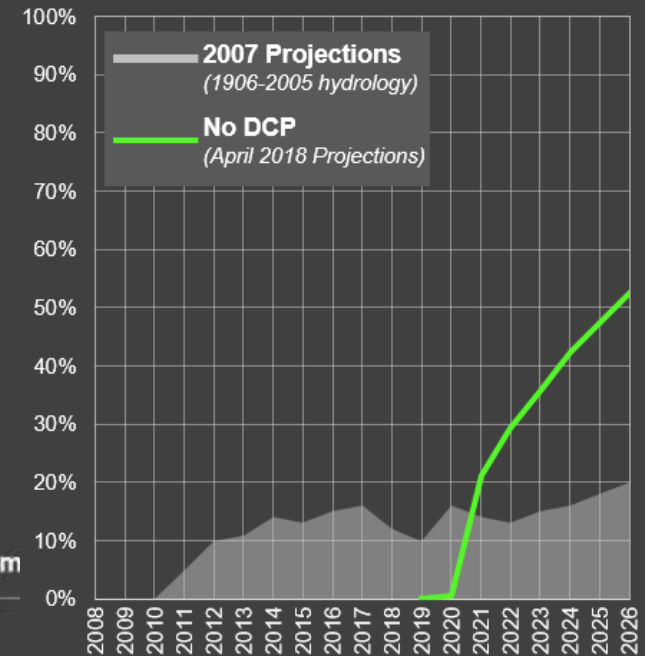
Event or System Condition		2019	2020	2021	2022	2023
Upper Basin - Lake Powell	Equalization Tier	N	11	16	19	23
	Equalization – annual release > 8.23 maf	0	11	16	19	21
	Equalization – annual release = 8.23 maf	0	0	0	0	2
	Upper Elevation Balancing Tier	100	49	52	51	44
	Upper Elevation Balancing – annual release > 8.23 maf	75	43	43	43	33
	Upper Elevation Balancing – annual release = 8.23 maf	25	5	9	8	10
	Upper Elevation Balancing – annual release < 8.23 maf	0	1	0	0	1
	Mid-Elevation Release Tier	0	40	22	16	19
	Mid-Elevation Release – annual release = 8.23 maf	0	0	0	1	3
Mid-Elevation Release – annual release = 7.48 maf	0	40	22	15	16	
Lower Elevation Balancing Tier	0	0	10	14	15	
Lower Basin - Lake Mead	Shortage Condition – any amount (Mead ≤ 1,075 ft)	0	57	68	70	65
	Shortage – 1 <sup>st</sup> level (Mead ≤ 1,075 and ≥ 1,050)	0	57	42	40	28
	Shortage – 2 <sup>nd</sup> level (Mead < 1,050 and ≥ 1,025)	0	0	26	23	24
	Shortage – 3 <sup>rd</sup> level (Mead < 1,025)	0	0	0	7	14
	Surplus Condition – any amount (Mead ≥ 1,145 ft)	0	0	3	5	7
	Surplus – Flood Control	0	0	0	1	2
Normal or ICS Surplus Condition	100	43	29	25	27	

<sup>1</sup> Reservoir initial conditions based on December 31, 2018 conditions  
<sup>2</sup> Percentages computed from 110 hydrologic inflow sequences  
<sup>3</sup> Percentages shown may not sum to 100% due to rounding to 1%  
<sup>4</sup> Percentages shown may not be representative of the full range that could occur with different modeling assumptions  
<sup>5</sup> The chance of a mid-year adjustment to equalization is negligible

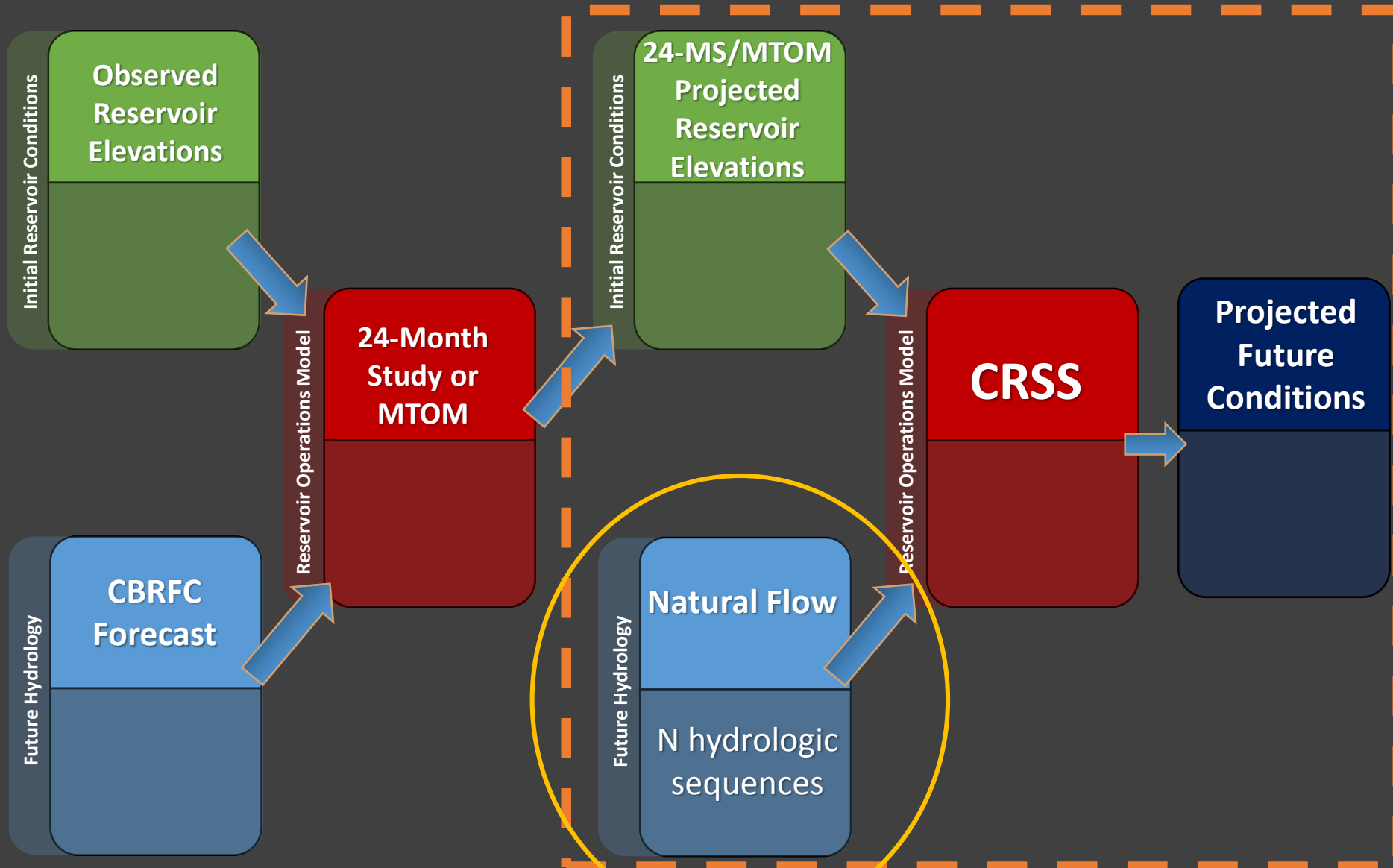
Historical and Future Projected Lake Mead End-of-Decem



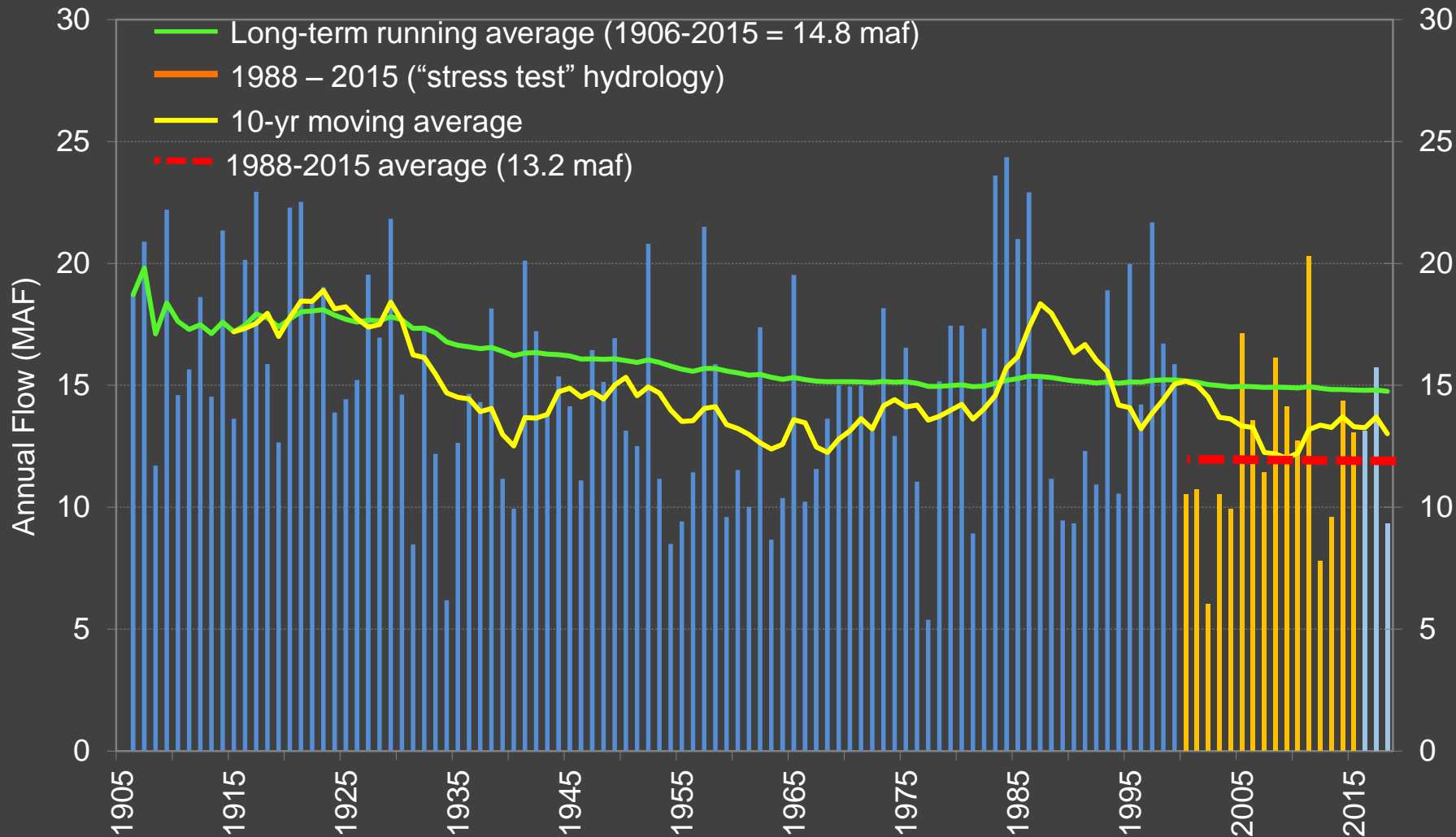
Risk of Lake Mead < 1,050'  
Full Hydrology (1906-2015)



# Modeling Approach



# Lees Ferry Natural Flow Water Year 1906 to 2018

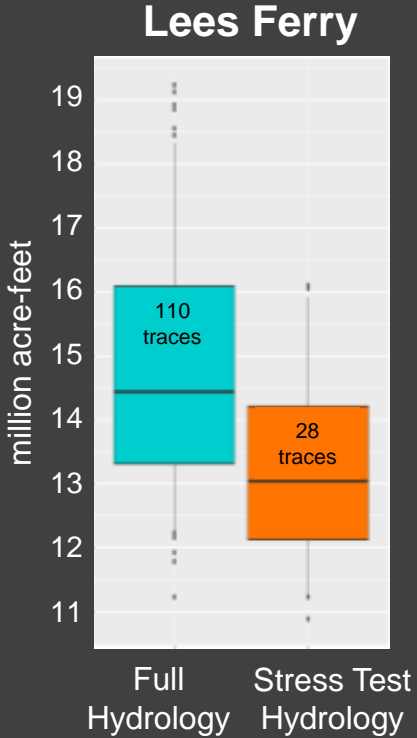


Provisional data, subject to change

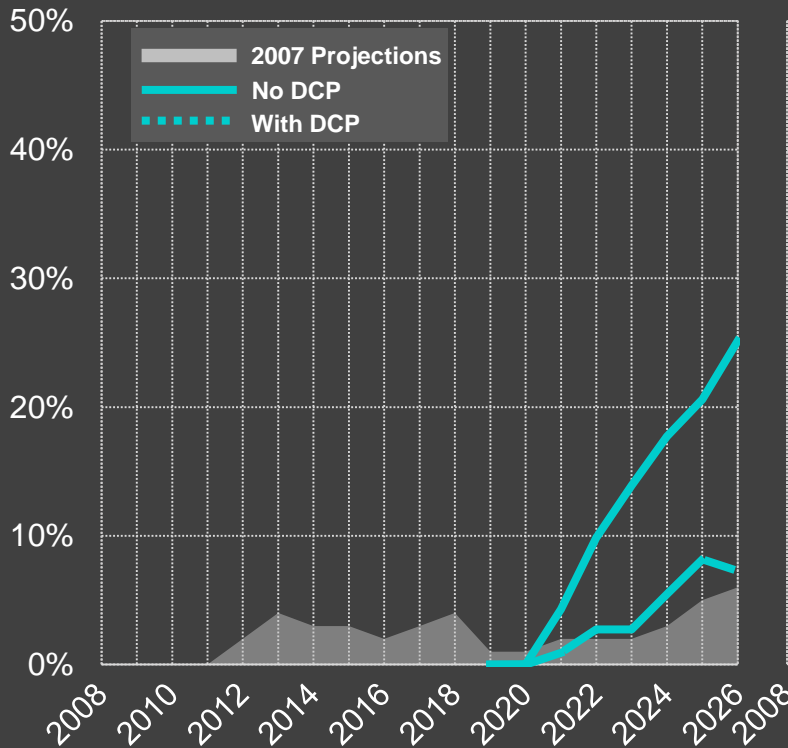
Estimated values for 2016-2018

# Risk of Lake Mead < 1,020'

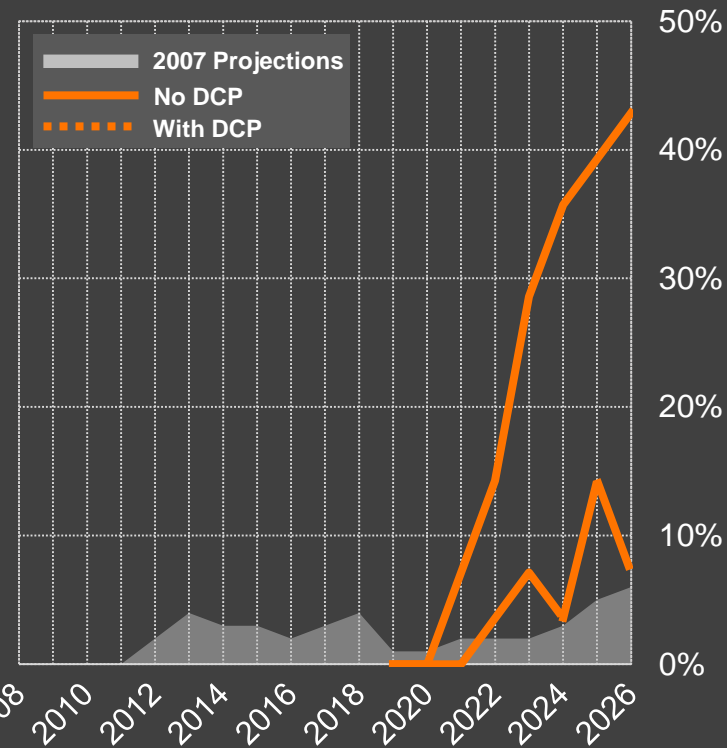
## 8-year (2019-2026) Average Flow at Lees Ferry



## Full Hydrology (1906-2015)



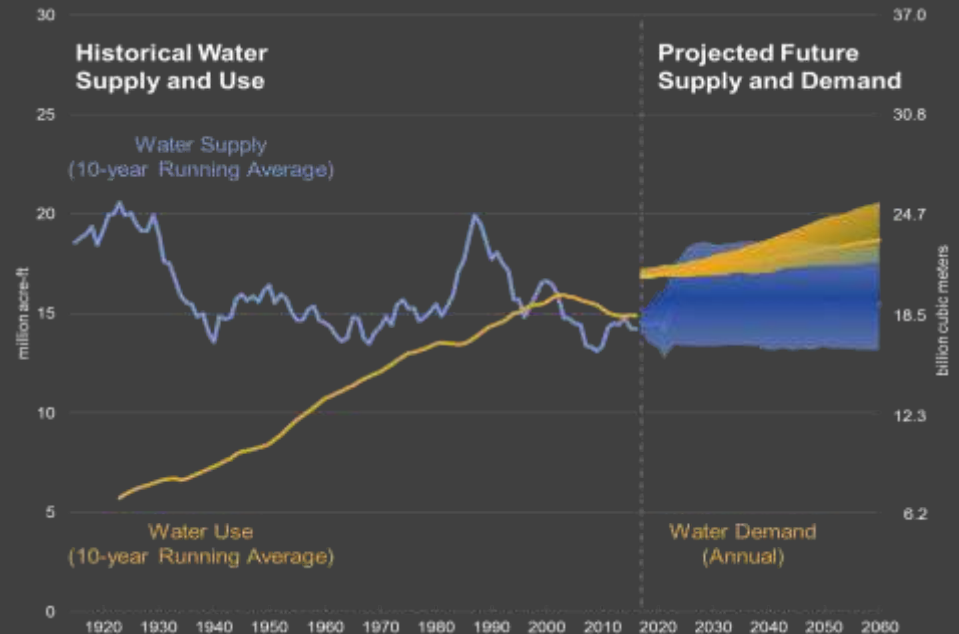
## Stress Test Hydrology (1988-2015)





# Colorado River Basin Water Supply and Demand Study

- Study Objectives
  - Assess future water supply and demand imbalances over the next 50 years
  - Develop and evaluate opportunities for resolving imbalances
- Conducted by Reclamation and the 7 Colorado River Basin States, in collaboration with stakeholders throughout the Basin
- A planning study – did not result in any decisions but provides technical foundations for future activities



# Water Supply and Demand Assessment

## Water Supply Scenarios

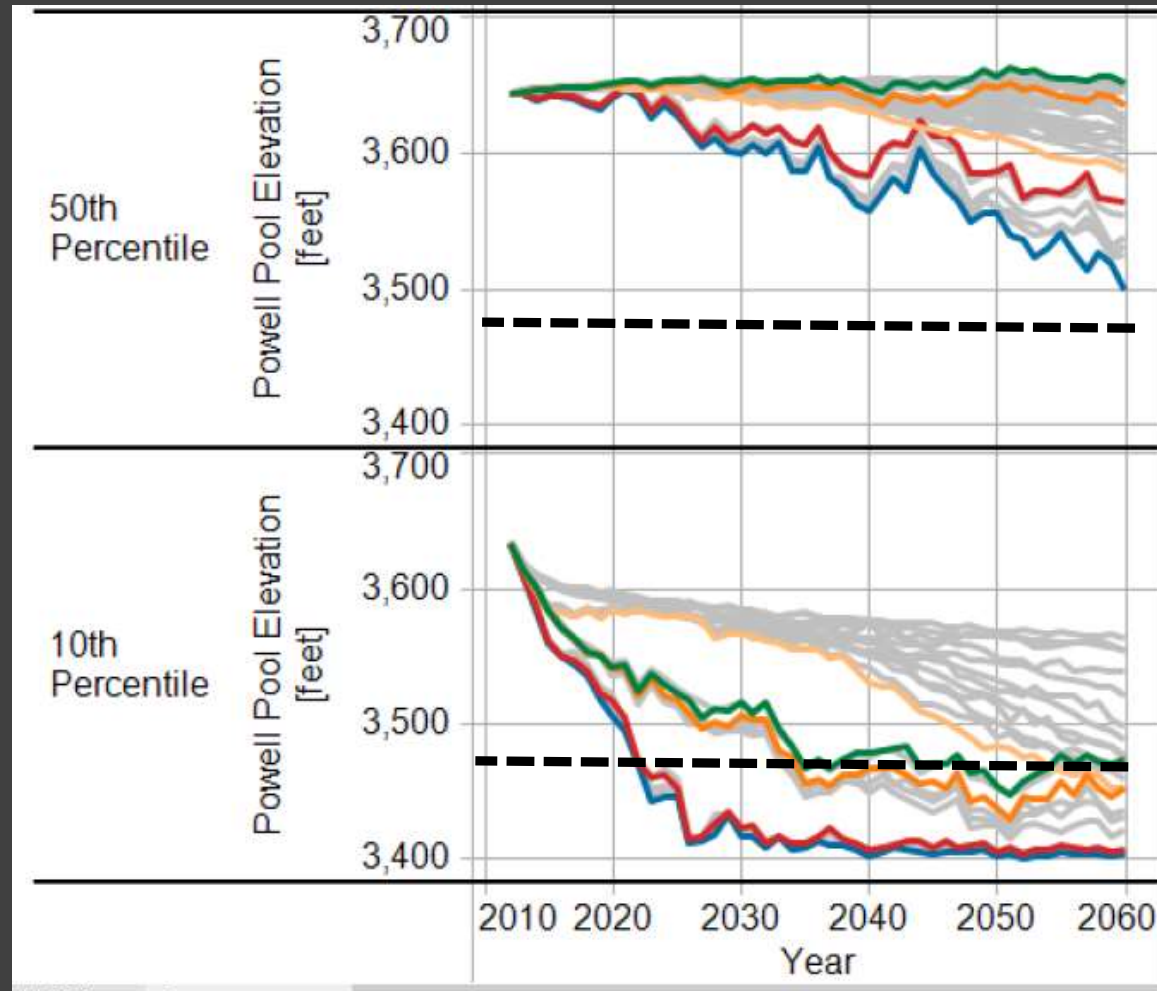
- Observed Resampled
  - Future will be similar to past 100 years
- Paleo Resampled
  - Future represented by distant past (1,250 years)
- Paleo Conditioned
  - Blend paleo and observed records for view of future
- Downscaled GCM Projected
  - Future represented by ensemble of GCM projections

## Water Demand Scenarios

- Current Trends
  - Future continues along recent trends
- Slow Growth
  - Low growth with emphasis on economic efficiency
- Rapid Growth (*2 branches*)
  - Economic resurgence with varying technology adoption rates
- Enhanced Environment (*2 branches*)
  - Expanded environmental awareness with varying population growth

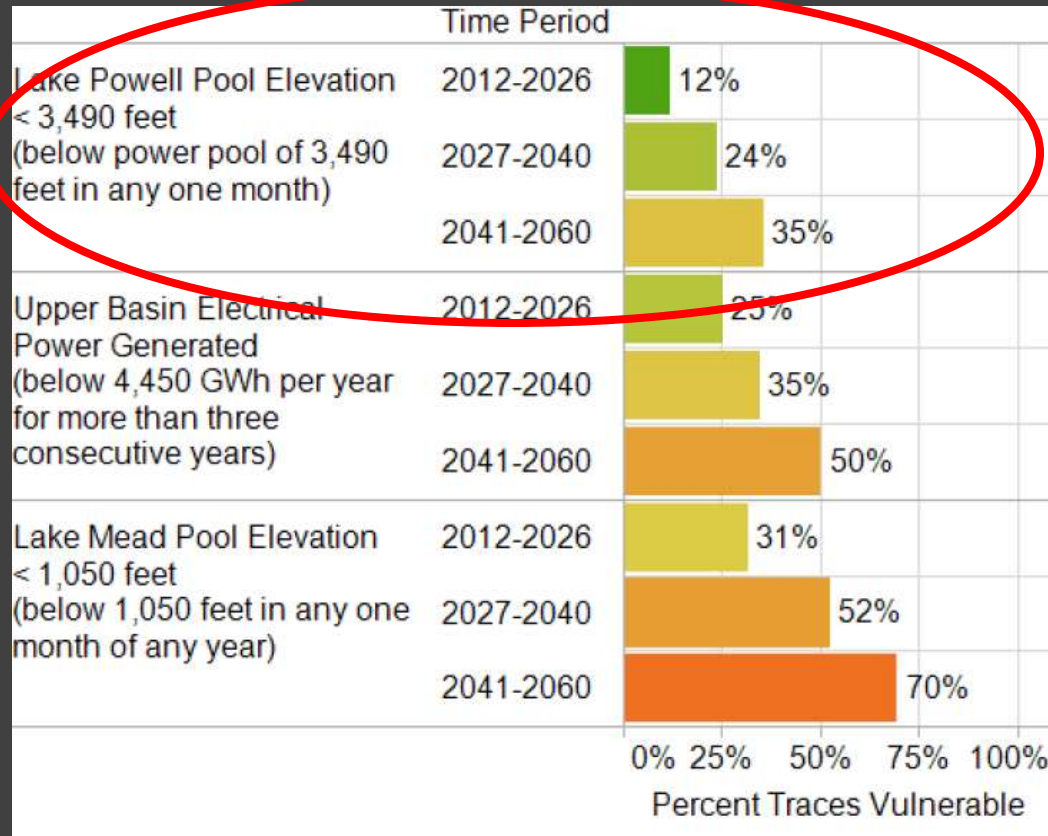
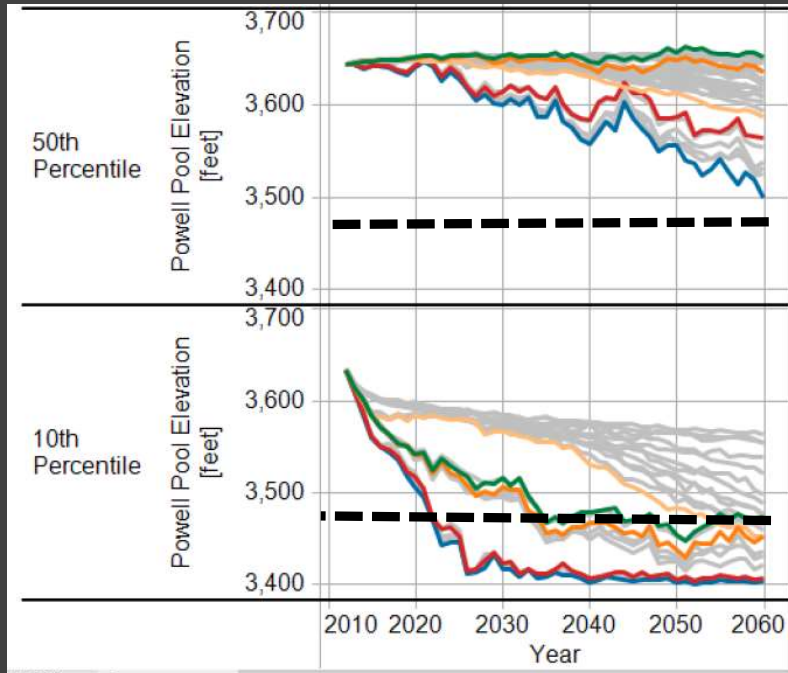
# Basin Study – Analyzing Results

## Lake Powell pool elevation



# Basin Study – Analyzing Results

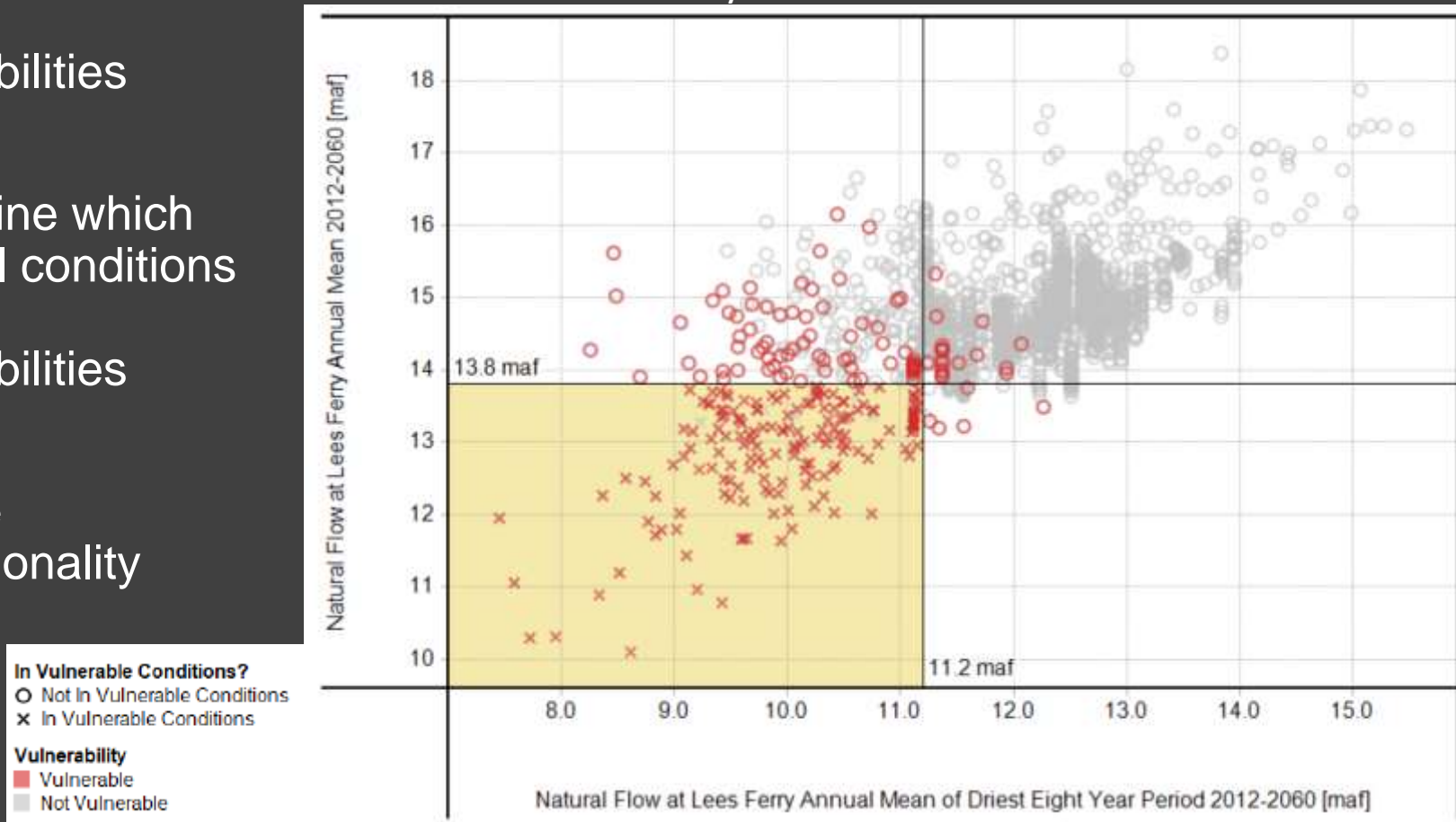
## Lake Powell pool elevation



# Basin Study – Defining Vulnerable Conditions

- Define vulnerabilities
- Determine which external conditions lead to vulnerabilities
- Reduce dimensionality

Vulnerable Conditions for  
Lee Ferry 10-Year Volume < 75 maf





**What's next?  
+  
Questions**

**Additional Information:**

<https://www.usbr.gov/lc/>

<https://www.usbr.gov/lc/region/g4000/riverops/crss-5year-projections.html>

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