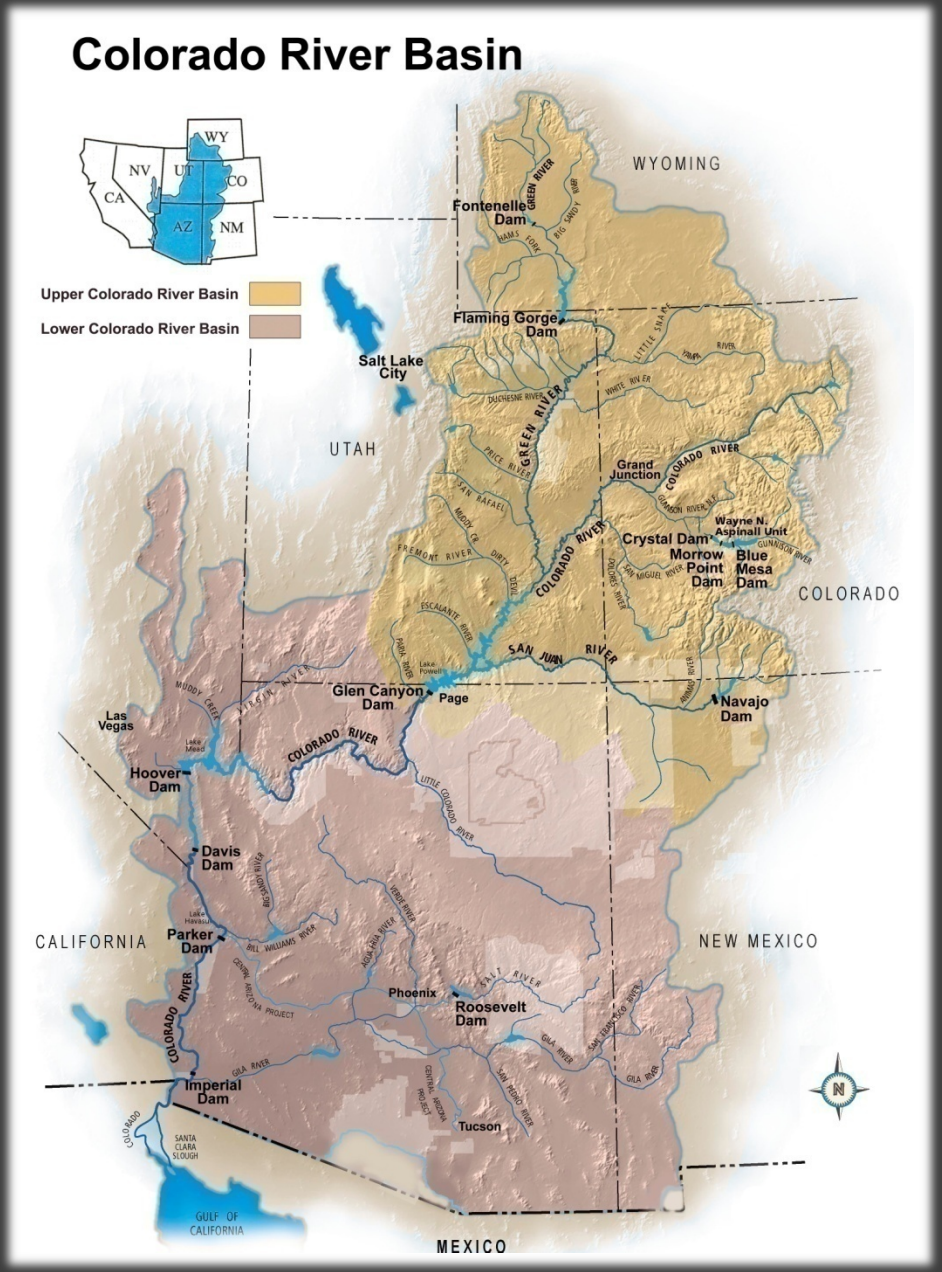
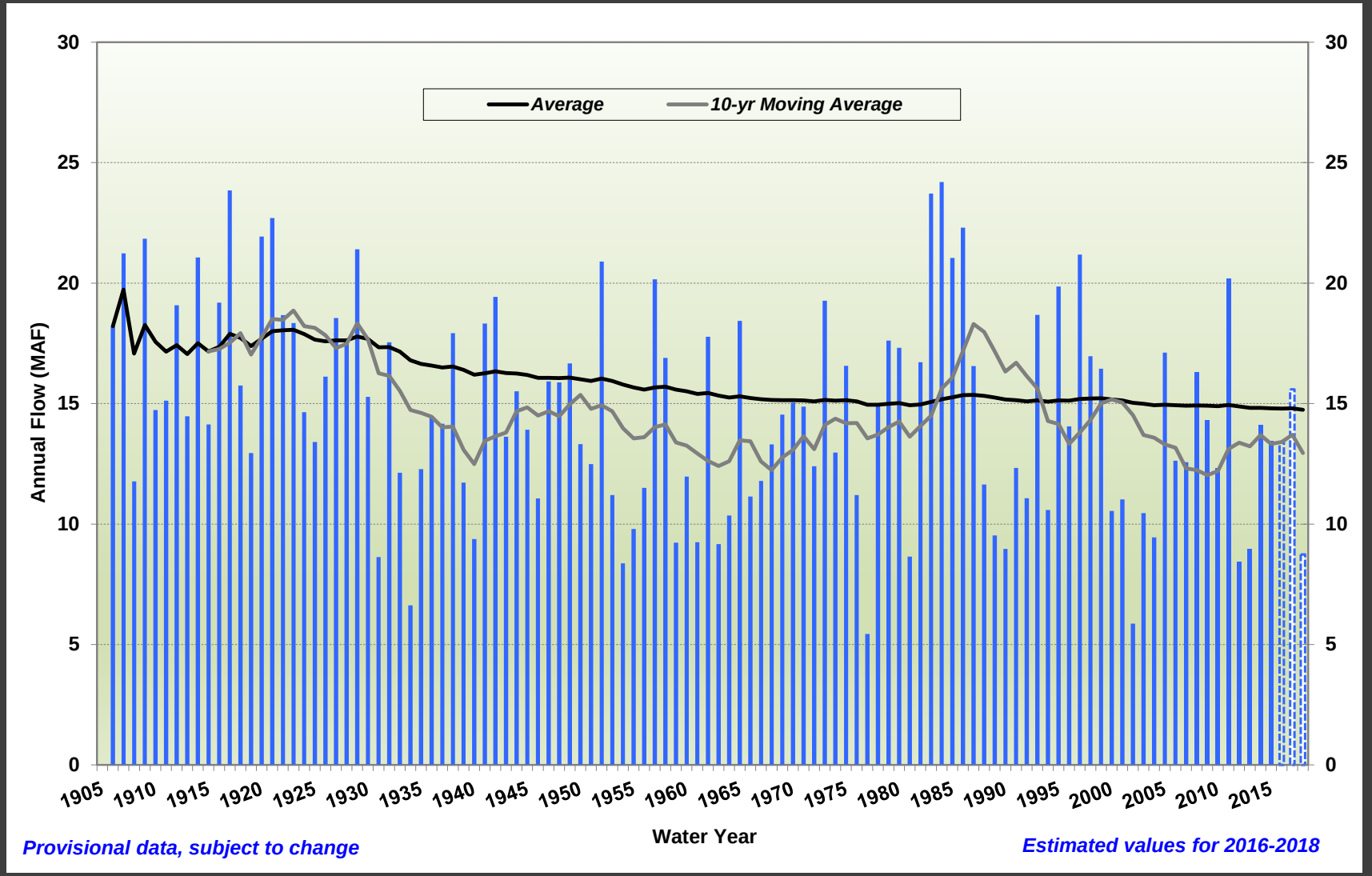
Colorado River Basin

- 16.5 million acre-feet (maf) allocated annually
- 13 to 14.5 maf of consumptive use annually
- 60 maf of storage
- 14.8 maf average annual “natural” inflow into Lake Powell over past 110 years
- Inflows are highly variable year-to-year



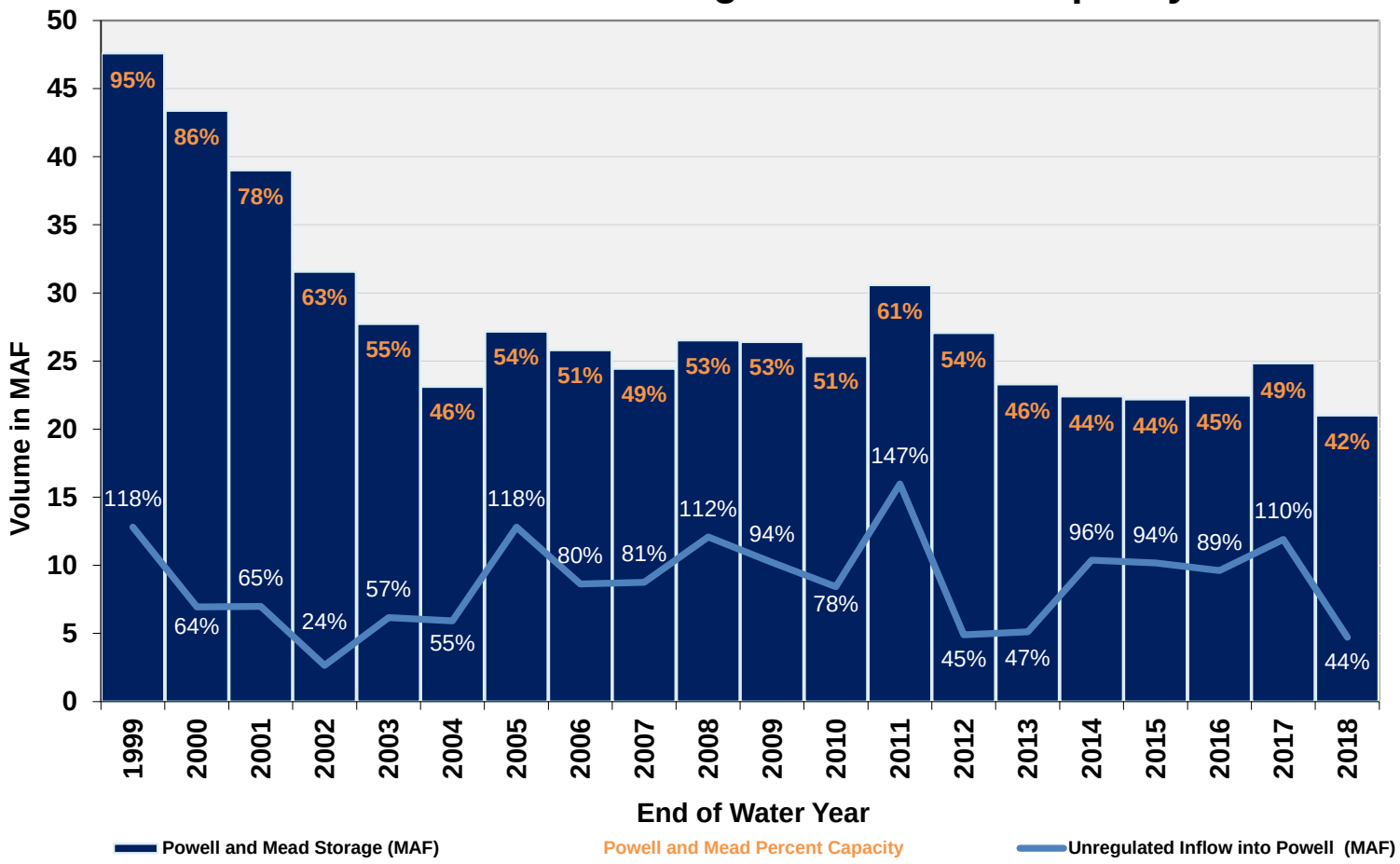
RECLAMATION
Managing Water in the West

Natural Flow
Colorado River at Lees Ferry Gaging Station, Arizona
Water Year 1906 to 2018



RECLAMATION
Managing Water in the West

State of the System (Water Years 1999-2018)[1,2]

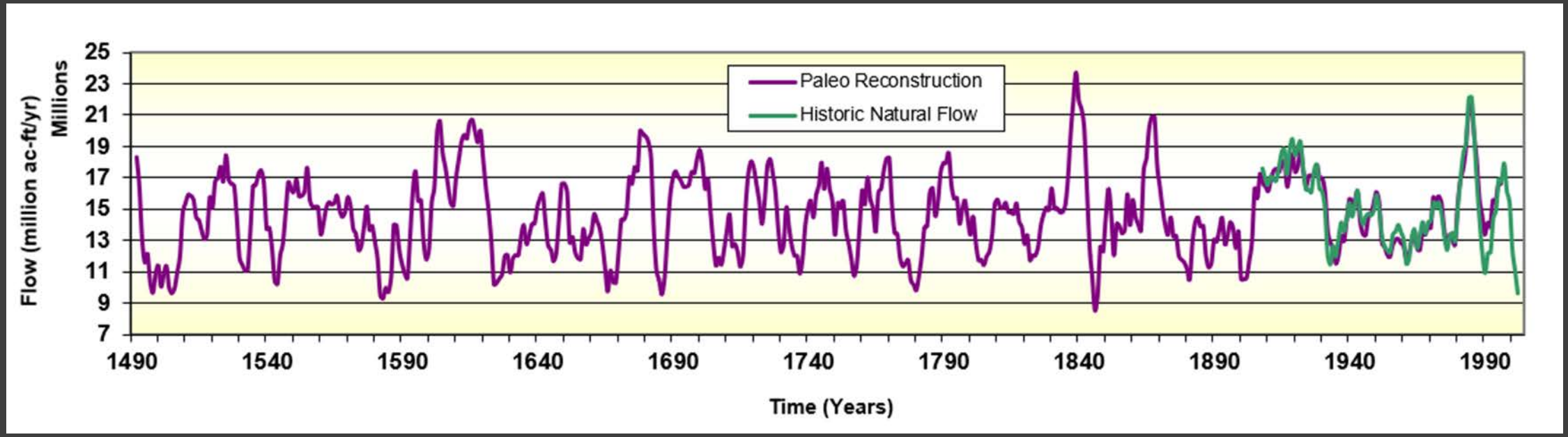


[1]Values for Water Year 2018 are projected. Unregulated inflow is based on the latest CBRFC forecast dated September 17, 2018. Storage and percent capacity are based on the September 2018 24-Month Study.

[2]Percentages on the light blue line represent percent of average unregulated inflow into Lake Powell for a given water year. The percent of average is based on the period of record from 1981-2010.

Colorado River Drought

- 2000-2018 is the driest 19-year period in over 100 years of historical records (2016-2018 are estimated)
- Tree-ring reconstructions show more severe droughts have occurred over the past 1200 years (e.g., drought in the mid 1100s)



[1] Percent of average is based on the period of record from 1981-2010.

2007 Interim Guidelines[1] - A Robust Solution

- Operations specified through the full range of operation for Lake Powell and Lake Mead
- Encourage efficient and flexible use and management of Colorado River water through the ICS mechanism
- Strategy for shortages in the Lower Basin, including a provision for additional shortages if warranted[2]
- In place for an interim period (through 2026) to gain valuable operational experience
- Basin States agree to consult before resorting to litigation

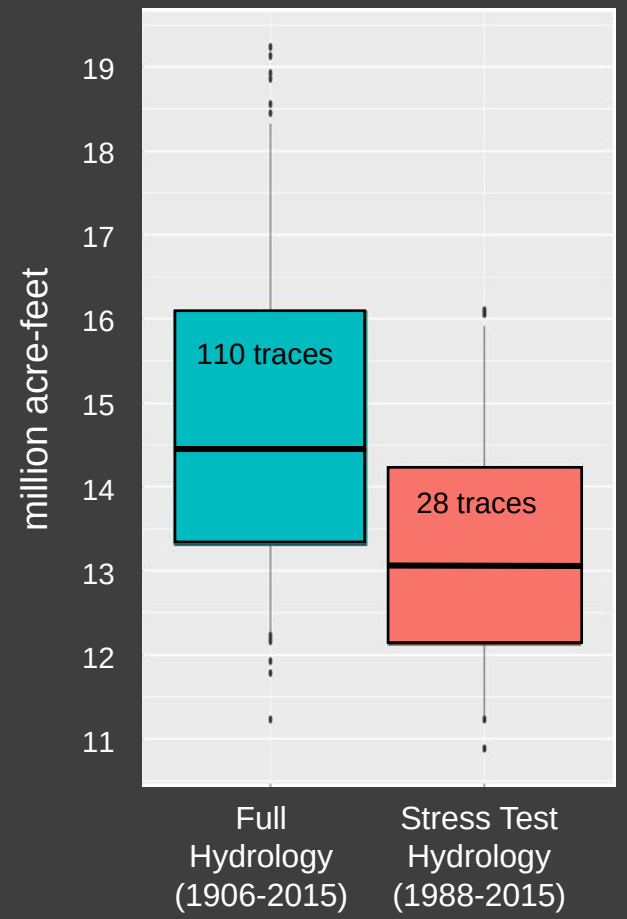
1. Issued in Record of Decision, dated December 13, 2007; available at http://www.usbr.gov/lc/region/programs/strategies.html
2. Mexico water deliveries are not directly affected by these guidelines

Management and research activities since implementing the 2007 Interim Guidelines

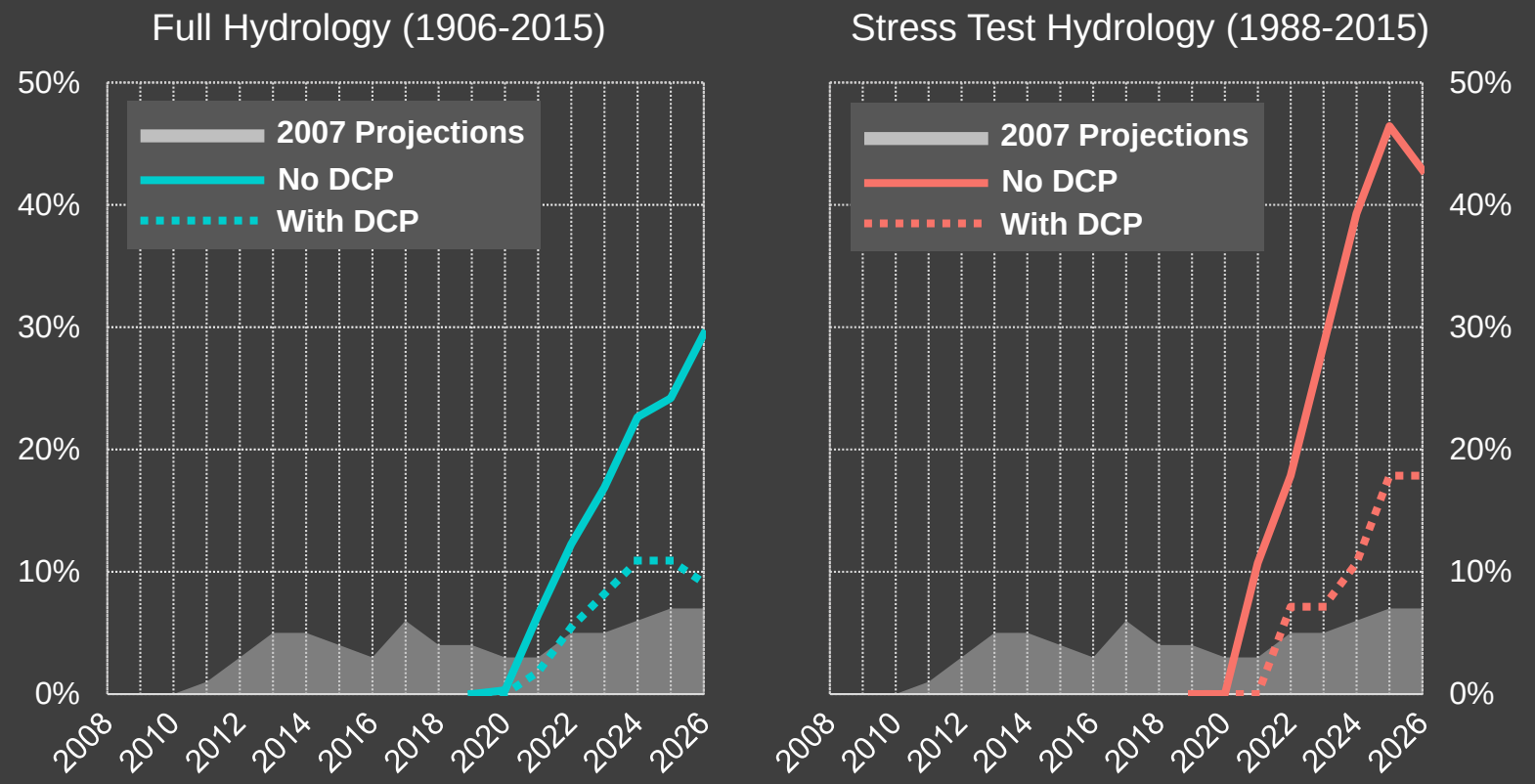
- Drought Contingency Planning process leading to an expanded view of risk and new communication approaches
- Increased urgency in research
  - Recent observed record
    - is this climate change and if so, when did it start?
  - Seeking to connect drought, climate change, and climate projections
- Stakeholders coordinating research agendas

Offering an alternate view of the future during Drought Contingency Plan negotiations

Annual Lees Ferry Flow



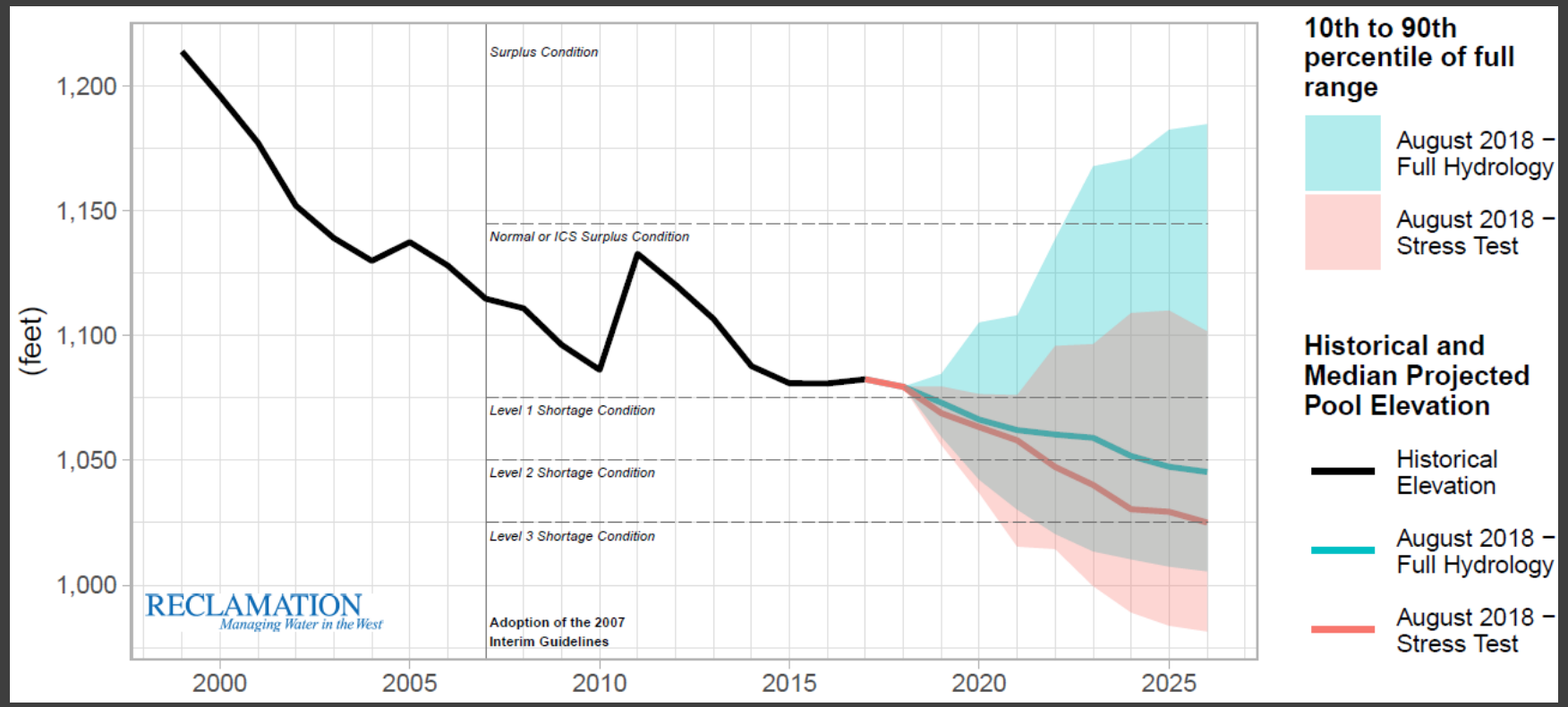
Risk of Lake Mead < 1,025'



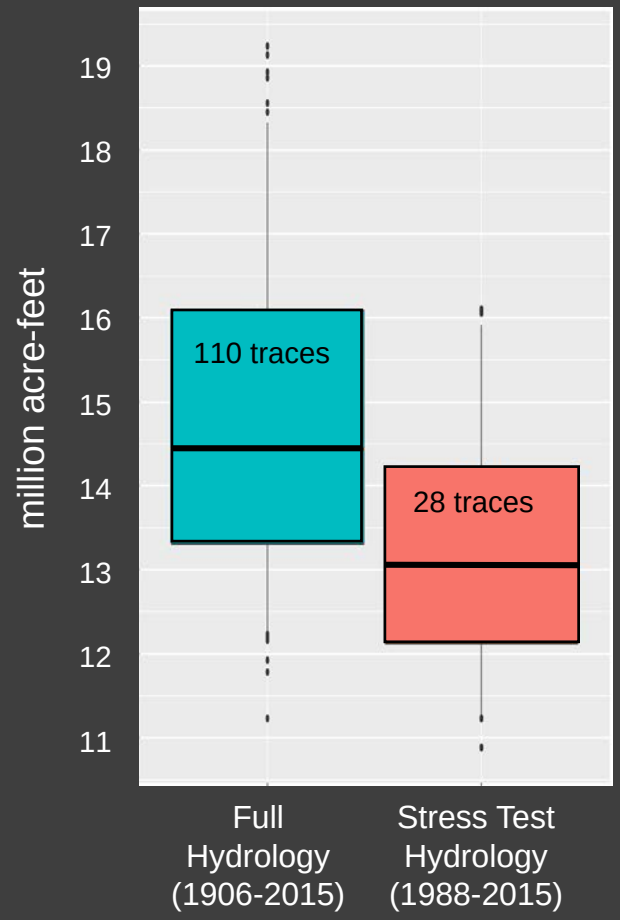
RECLAMATION
Managing Water in the West

Communicating uncertainty to stakeholders

Lake Mead End-of-December Elevation



Annual Lees Ferry Flow



RECLAMATION
Managing Water in the West

Is this climate change? Mining the historical record

- Woodhouse et al (2016): “recent droughts have been amplified by warmer temperatures that exacerbate the effects of relatively modest precipitation deficits”
- McCabe et al (2017): “reductions in flow because of increasing temperatures are the largest documented temperature-related reductions since record keeping began”
- Xiao et al (2018): “pervasive warming has reduced snowpacks and enhanced ET over the last 100 years; over half of the long-term decreasing runoff trend is associated with the general warming. Negative winter precipitation trends have occurred in the handful of highly productive subbasins that account for over half of the streamflow at Lees Ferry”

It’s warm and getting warmer, so climate projections are getting *something* right, but…

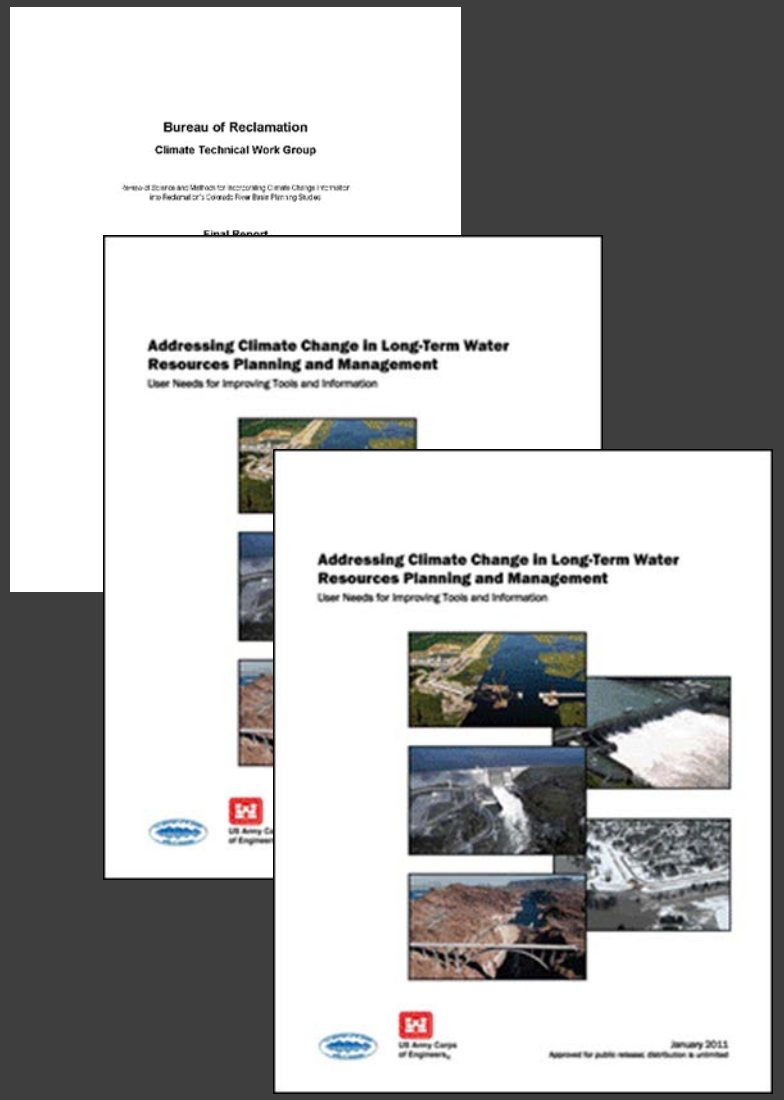
- Udall & Overpeck (2017): “approximately half of the CMIP5 models and one-quarter of the CMIP3 models cannot simulate the 2000–2014 drought at any point in the twenty-first century”
- Some, but not all, CMIP5 models performed better than the CMIP3 models in comparison to regional temperature, precipitation, and atmospheric circulation metrics and after a simple bias correction was applied [forthcoming Reclamation CMIP5 report in collaboration with Scripps Institute and Jacobs]

Coming together on a Colorado River research agenda

- Stakeholder and researcher workshops for Kathy Jacobs' NSF project
- NOAA led workshop on understanding the causes of the historical changes in flow of the Colorado River
- Colorado River Basin Climate and Hydrology Workgroup
  - Basin States, Utilities partnered with Reclamation and CBRFC
  - Proposing a range of short, mid, and long term research projects
  - Funding the Colorado River Basin Climate and Hydrology State of the Science Report

State of the Science Report

- Working with WWA and CLIMAS
- Building on past reports
  - Review of Science and Methods for Incorporating Climate Change Information into Reclamation's Colorado River Basin Planning Studies (2007)
  - Addressing Climate Change in Long-Term Water Resources Planning and Management: User Needs for Improving Tools and Information (2011)
  - Short-Term Water Management Decisions: User Needs for Improved Climate, Weather, and Hydrologic Information (2013)



RECLAMATION
Managing Water in the West

State of the Science Report objectives

- Consolidate recent findings and methods related to climate and hydrology
- Provide a scientific foundation on which to enter the renegotiation of the Interim Guidelines
- Prompt research ideas and inform priorities
- Inform the scientific community about our models, their applications, and our research needs

Reclamation's climate, hydrology, and decision making research

- Ongoing
  - S2S Watershed-scale Climate Forecast Products for Water Management (Baker and Wood)
  - Decision Making under Deep Uncertainty (DMDU) methods for development of reservoir operational policies in the Colorado River Basin (Alexander and Kasprzyk)
  - Colorado River Basin CMIP5 Climate Change Assessment (CH2M, Pierce, Cayan, and Goodrich)
  - Colorado River State of Climate and Hydrologic Science Report (WWA and CLIMAS)
- Proposed
  - Generating and evaluating temperature-perturbed Colorado River Basin streamflows (Towler and Balaji)
  - Using ICAR and En-GARD to develop Colorado River Basin climate change projections (Gutmann)