Modeling and Analysis Work Group Kickoff

July 30, 2020

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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Meeting Agenda

- Welcome and Introductions
- Modeling and Analysis Workgroup Overview
- Colorado River System – Modeling Background
- Arizona and CAP Colorado River Perspectives
- Modeling Tools Used in Analyses – Overall Colorado River, Arizona, and CAP Tools
- Modeling Framework and Proposal for Initial Scenarios
- Next Steps
- Call to the Public

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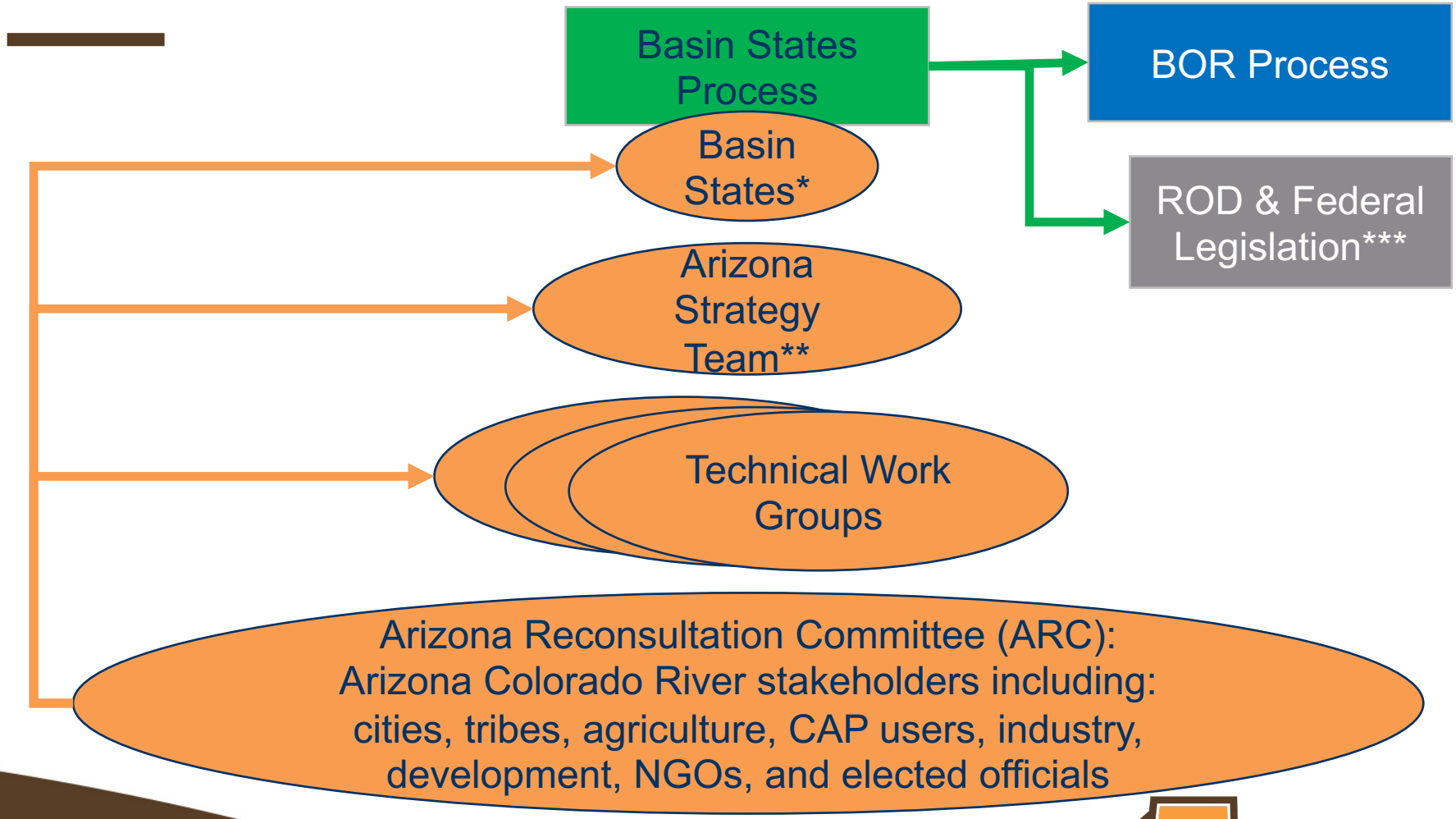
Arizona Reconsultation Process



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*By invitation to support the co-Chairs
**Requires confidentiality agreement for legal advice and negotiating strategies
***Federal legislation if necessary

Modeling and Analysis Workgroup

- Modeling analysis will be necessary to evaluate the long-term risks and vulnerabilities to Arizona's Colorado River supply
- Need to consider multiple scenarios and explore different proposals for new operations from ***Arizona's perspective***
- ARC established the Modeling and Analysis Work Group (MAWG) – co-chaired by ADWR and CAWCD technical staff

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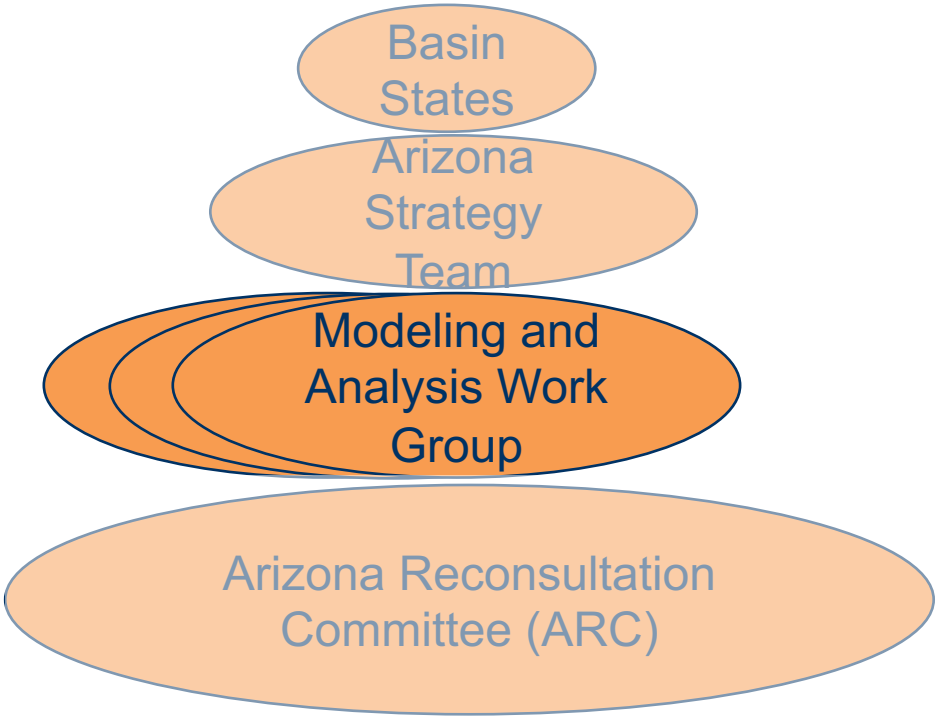
ARC MAWG Overview



- Addresses questions and examinations from the ARC groups
- Provide a fact-basis to inform ARC discussions
- Examine risks, vulnerabilities and impacts to:
  - Arizona's overall Colorado River supply
  - On-River priorities and users
  - CAP priorities and users
- Consider a broad range of future conditions
- All ARC members and alternates are invited to attend and participate (not recorded) – non-delegates may observe and provide input

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MAWG Purpose and Goals

- Purpose

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

- Goals
  - Analyze issues and answer technical questions posed by the ARC
  - Consider a range of future hydrologic conditions
  - Analysis of different operating scenarios including those provided by Reclamation
  - Consider a range of future demand conditions including analysis of different growth scenarios
  - Evaluate and validate technical enhancements to AZ specific modeling tools

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MAWG Membership and Public Process

- ARC Delegate may designate a technical representative to the MAWG
- Co-chairs: Vineetha Kartha (ADWR) and Chuck Cullom (CAWCD)
- Meetings will be open to the public including in our virtual meeting format
- Meetings will not be recorded
- Meeting notices will be posted on the ADWR and CAWCD ARC pages: cap-az.com/ARC or new.azwater.gov/ARC.

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MAWG Responsibilities

- Provide an open and transparent forum for ARC technical representatives to analyze and discuss future operating scenarios and demand conditions plus implications to Arizona water users
- Collaborate across any other ARC workgroups to ensure all expertise is available to support the process
- The MAWG will report to ARC regularly on its activities and results
- ADWR and CAWCD will provide modeling, technical and logistical support to the group

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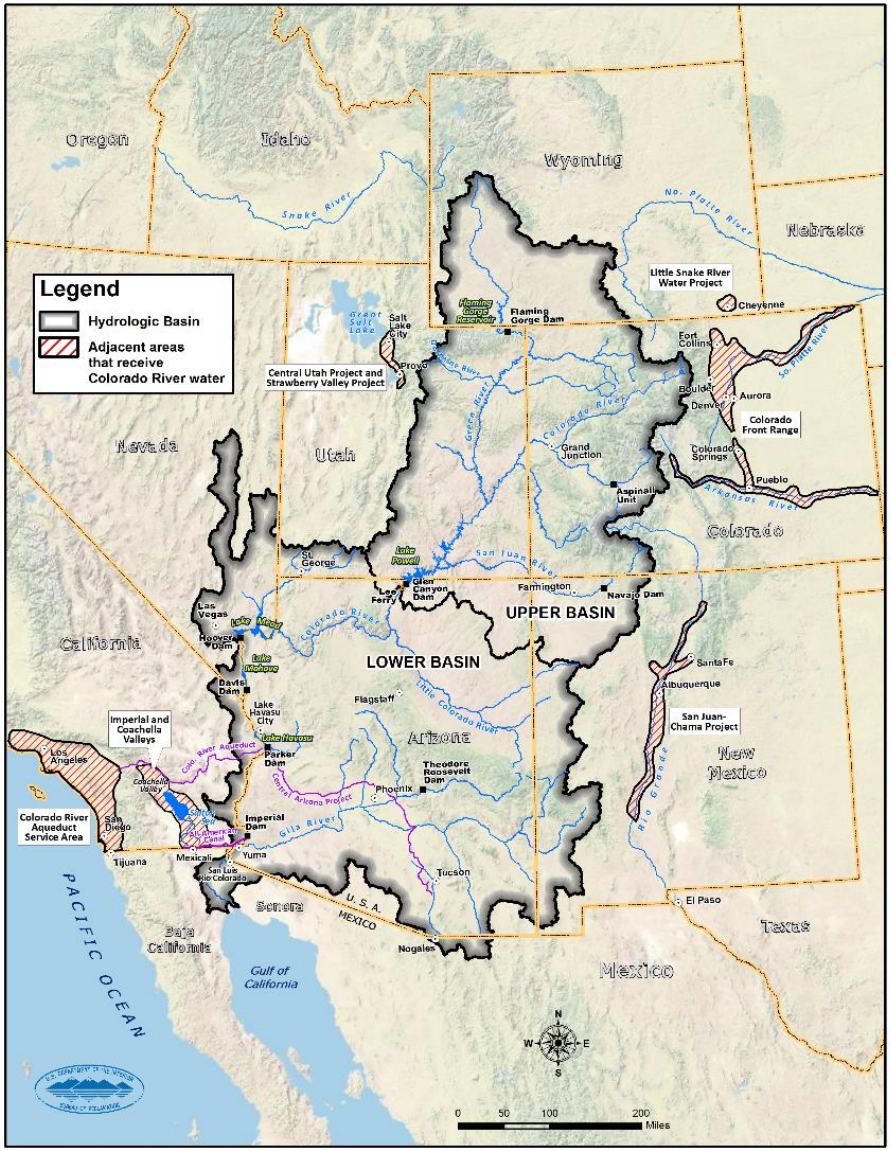
Colorado River System Overview

- Serving US and Mexico
- ~40 Million people
- ~5 M acres of irrigation
- Significant hydropower
- Environmental resources
- Storage 4x Avg flow



Colorado River Flows – 2 Types

Natural Flows (Q_N, 1906-2018)

$$Q_N = \text{Flows}_{\text{observed}} + \text{Depletions} + \text{Exports} - \text{Imports} + (\text{Depletions}_{\text{unmeasured}} - \text{Returns}_{\text{unmeasured}}) \pm \Delta_{\text{storage}}$$

Unregulated Inflows to Lake Powell (Q_U, 1963-Present)

$$Q_U = \text{Flows}_{\text{observed}} + \text{Depletions} + \text{Exports} - \text{Imports} \pm \Delta_{\text{storage}}$$

Note: unmeasured depletions/returns are a modeled component unique to the calculation of Natural Flows

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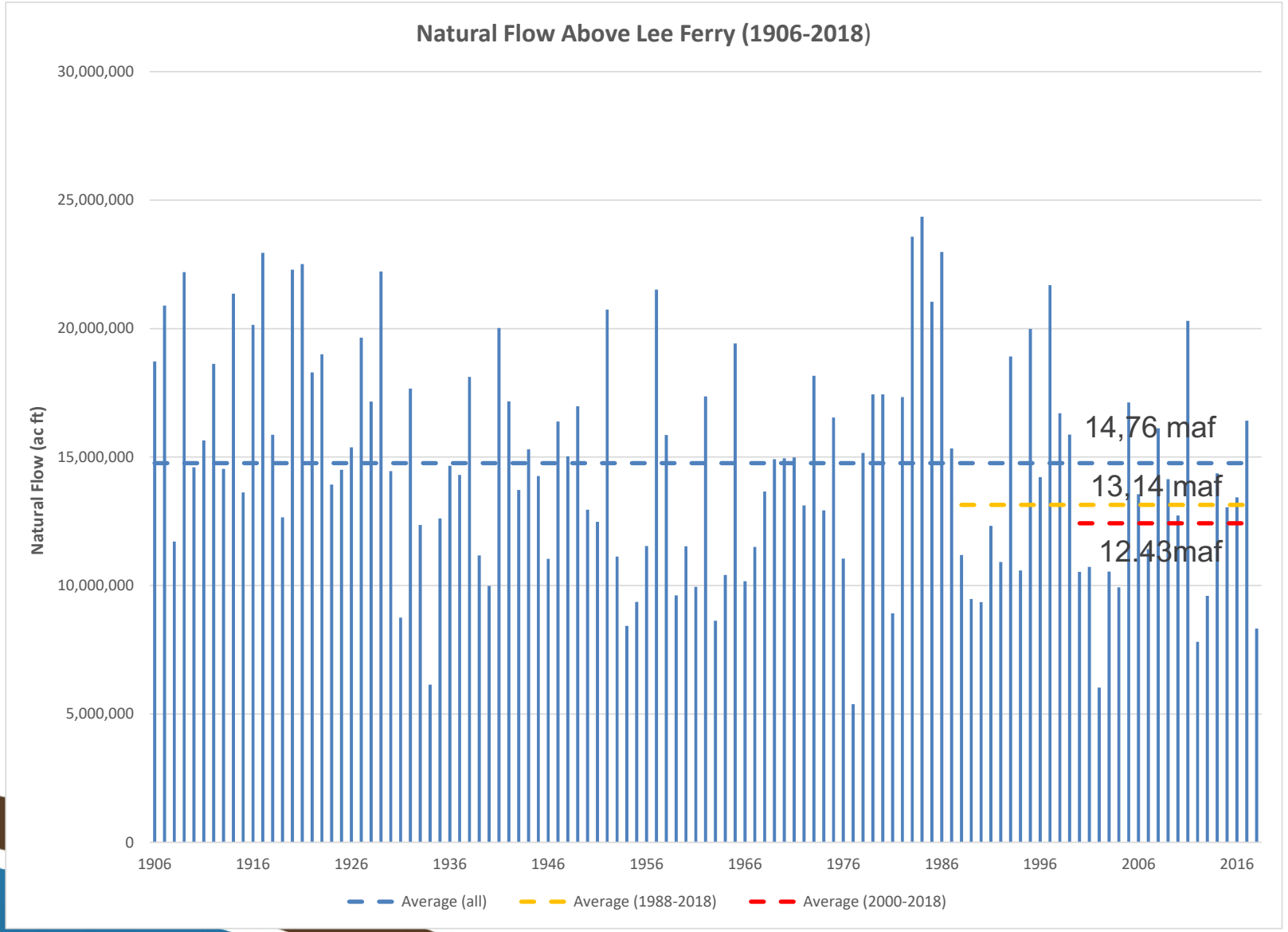
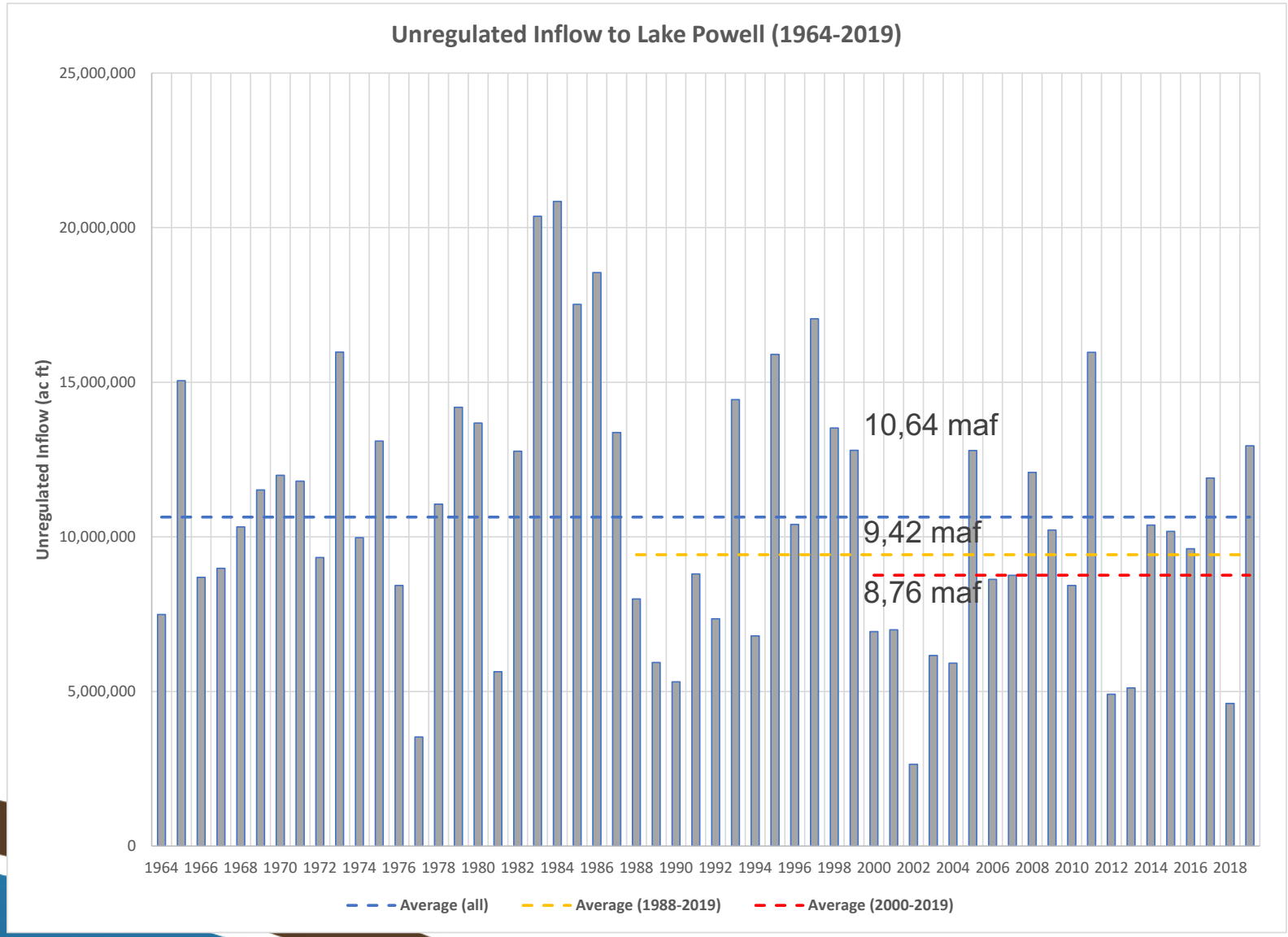
Colorado River Flow: Natural Flow



Colorado River Flow: Unregulated



Colorado River System Uses

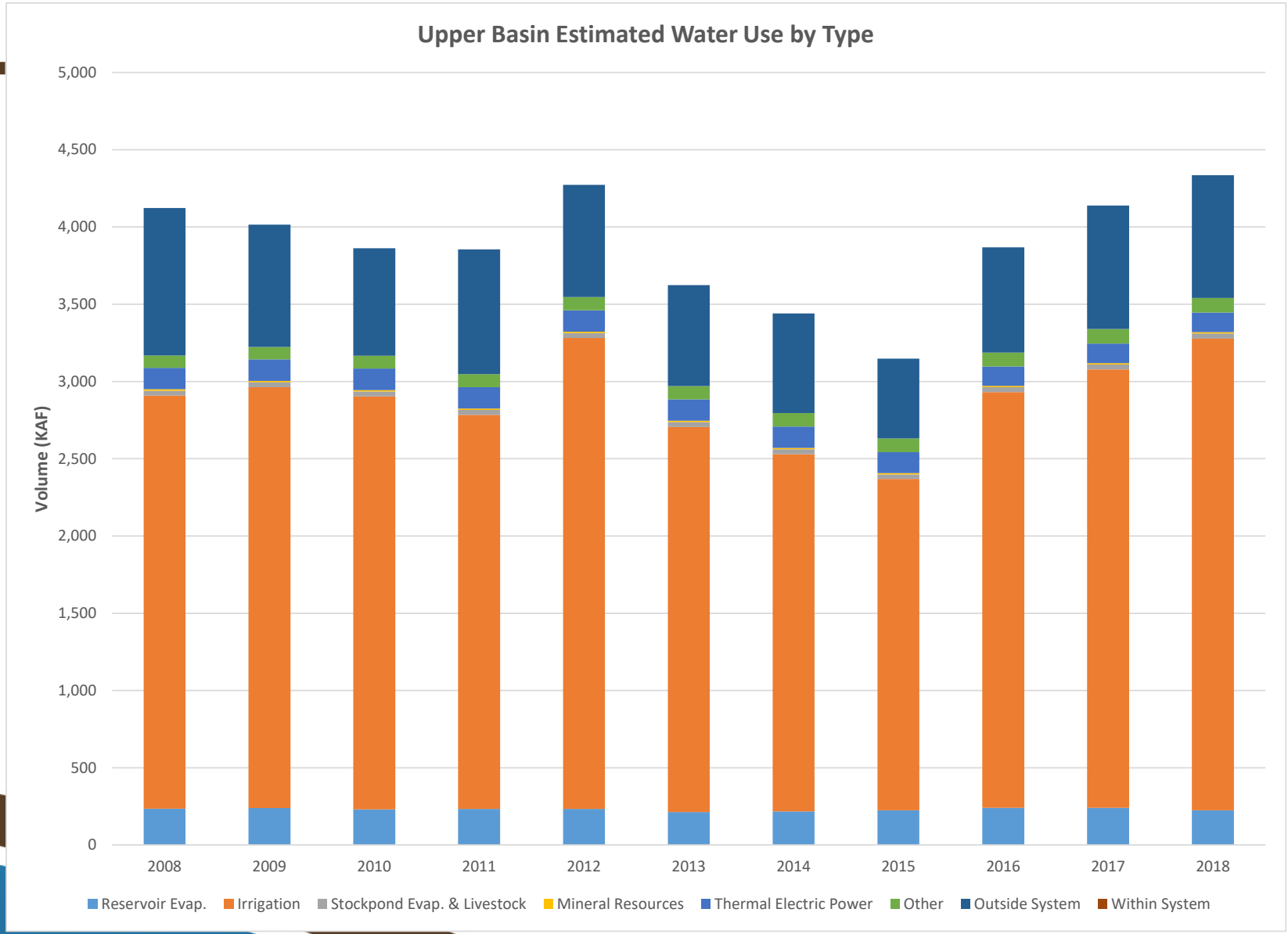
Upper Basin Depletions:

- Upper Basin depletions include tributary uses and reservoir evaporation losses

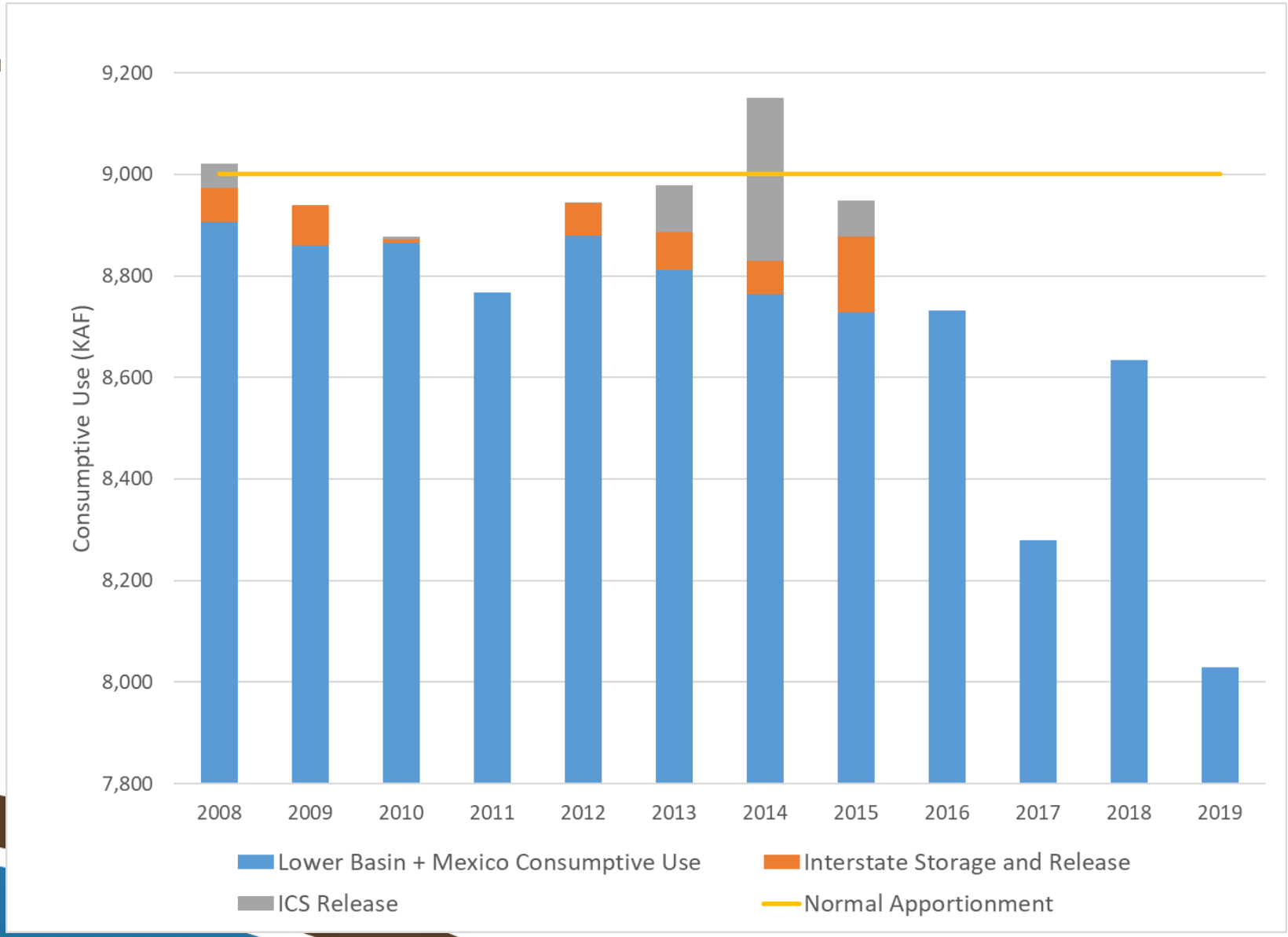
Lower Basin Consumptive Use:

- Lower Basin consumptive uses, confirmed by AZ v. CA, consider mainstem diversions less return flows

Colorado River UB Depletions



LB + Mexico Consumptive Uses



Colorado River System Storage

Three operational considerations

1) Lake Mead + Lake Powell (~50 MAF)
   - Conjunctively managed between Upper and Lower Basin

2) Upper Basin Storage + Lake Mead (~57 MAF)
   - Upper Basin Reservoirs + Mead, consistent with CRBPA

3) System Storage incl. LB Reservoirs (~60 MAF)
   - All major reservoirs: CRSP, Mead, Mohave + Havasu

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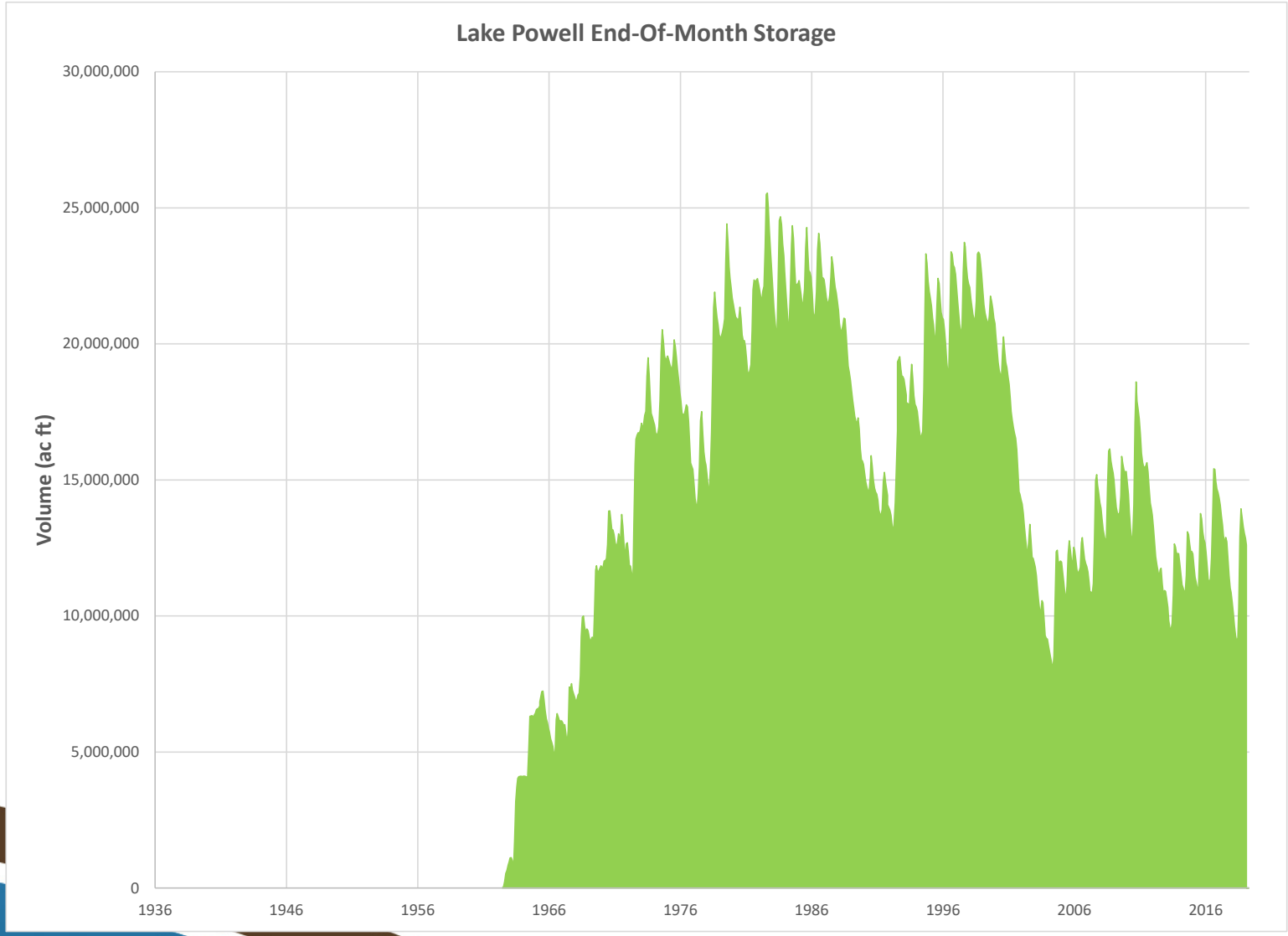
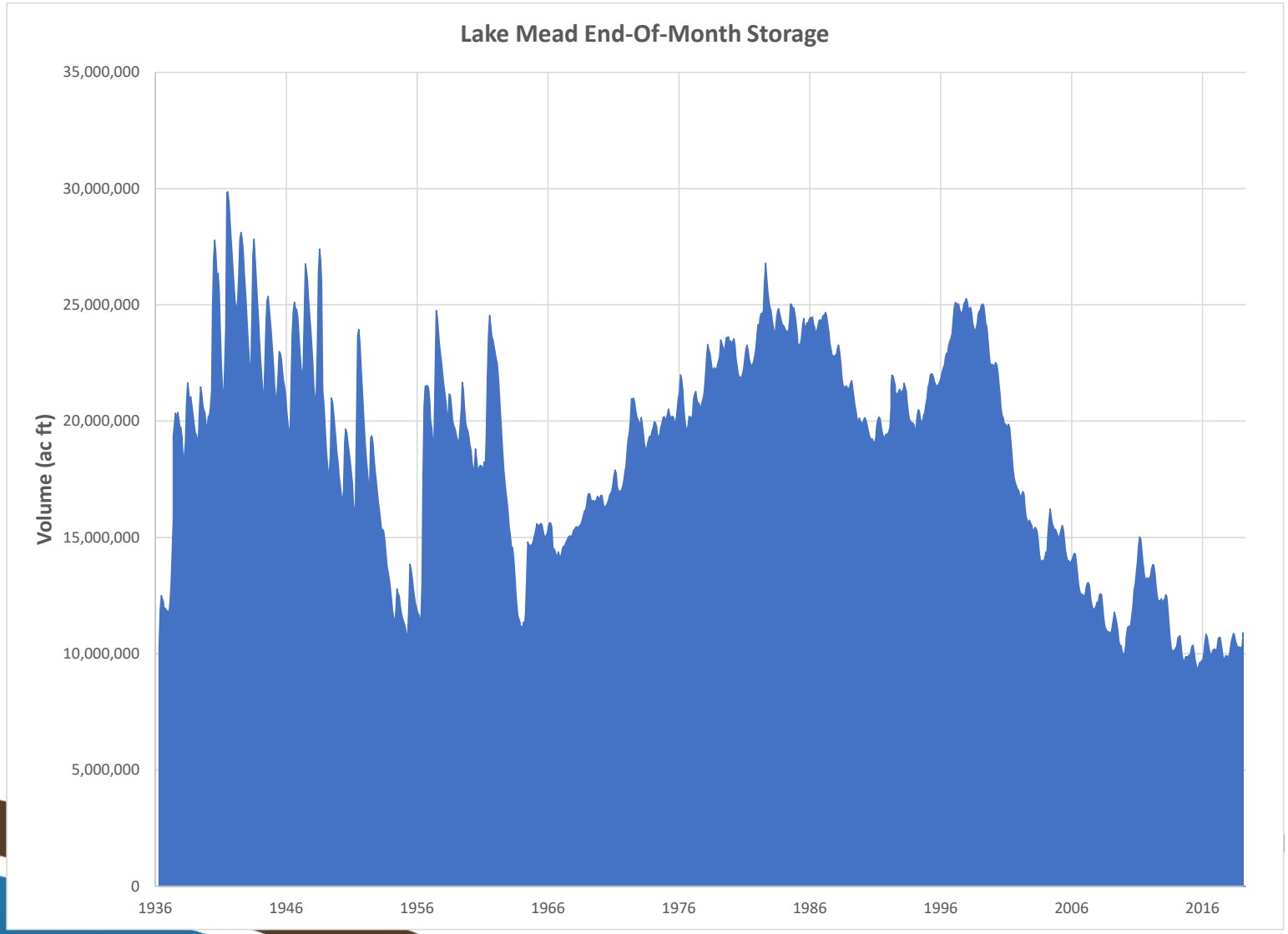
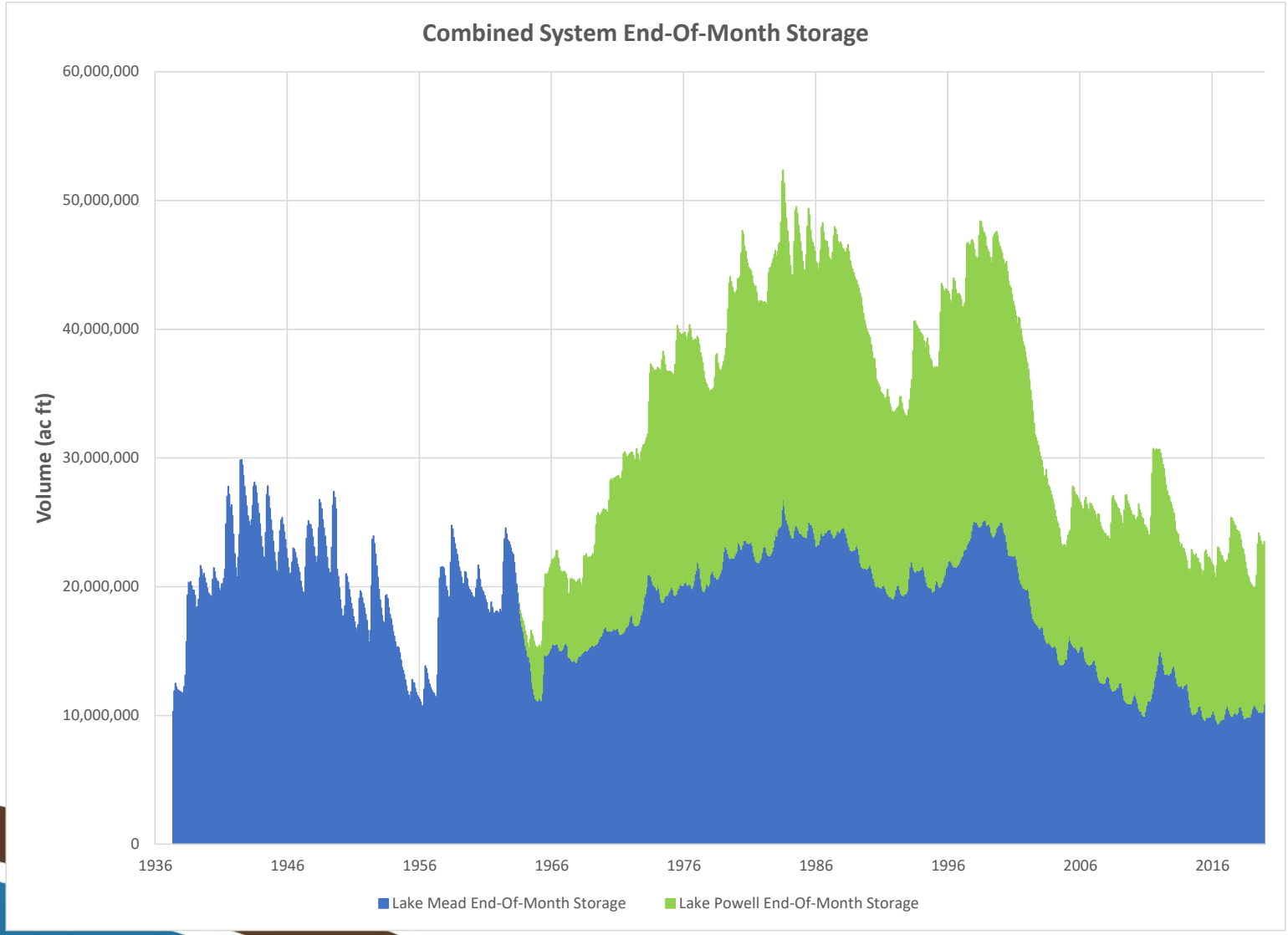
Colorado River System Storage



Colorado River System Storage

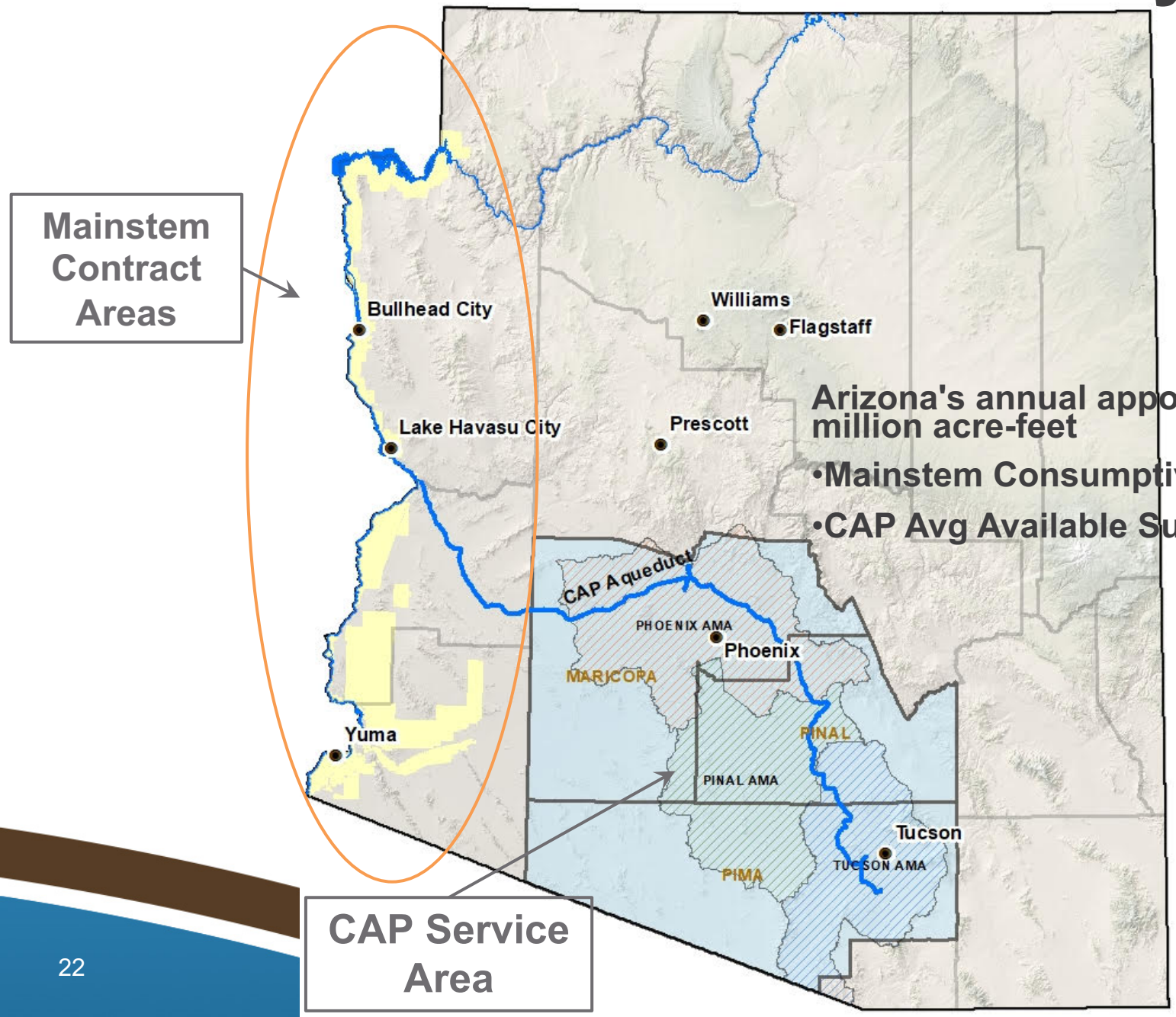


Colorado River System Storage

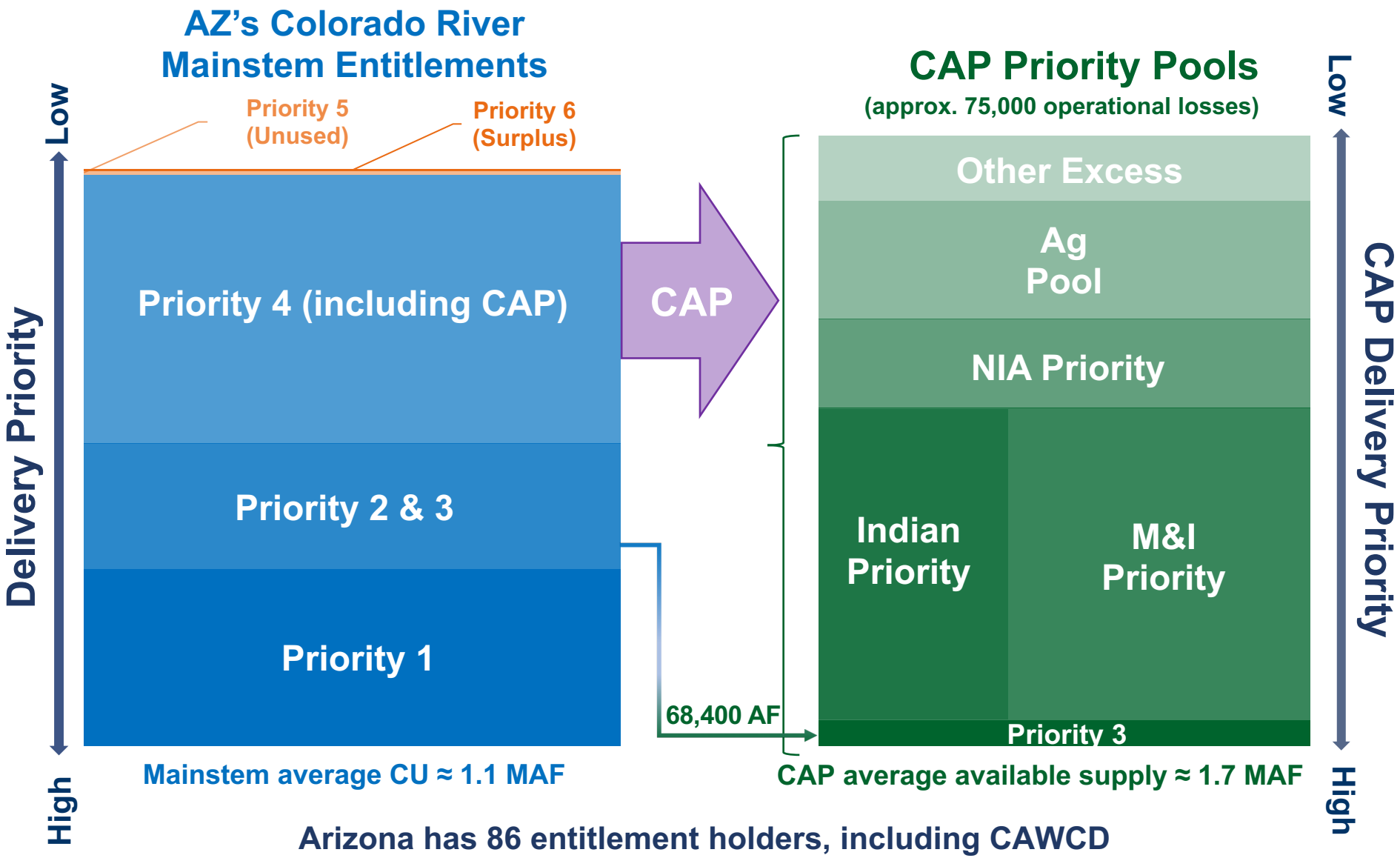


BREAK

Arizona – Colorado River System

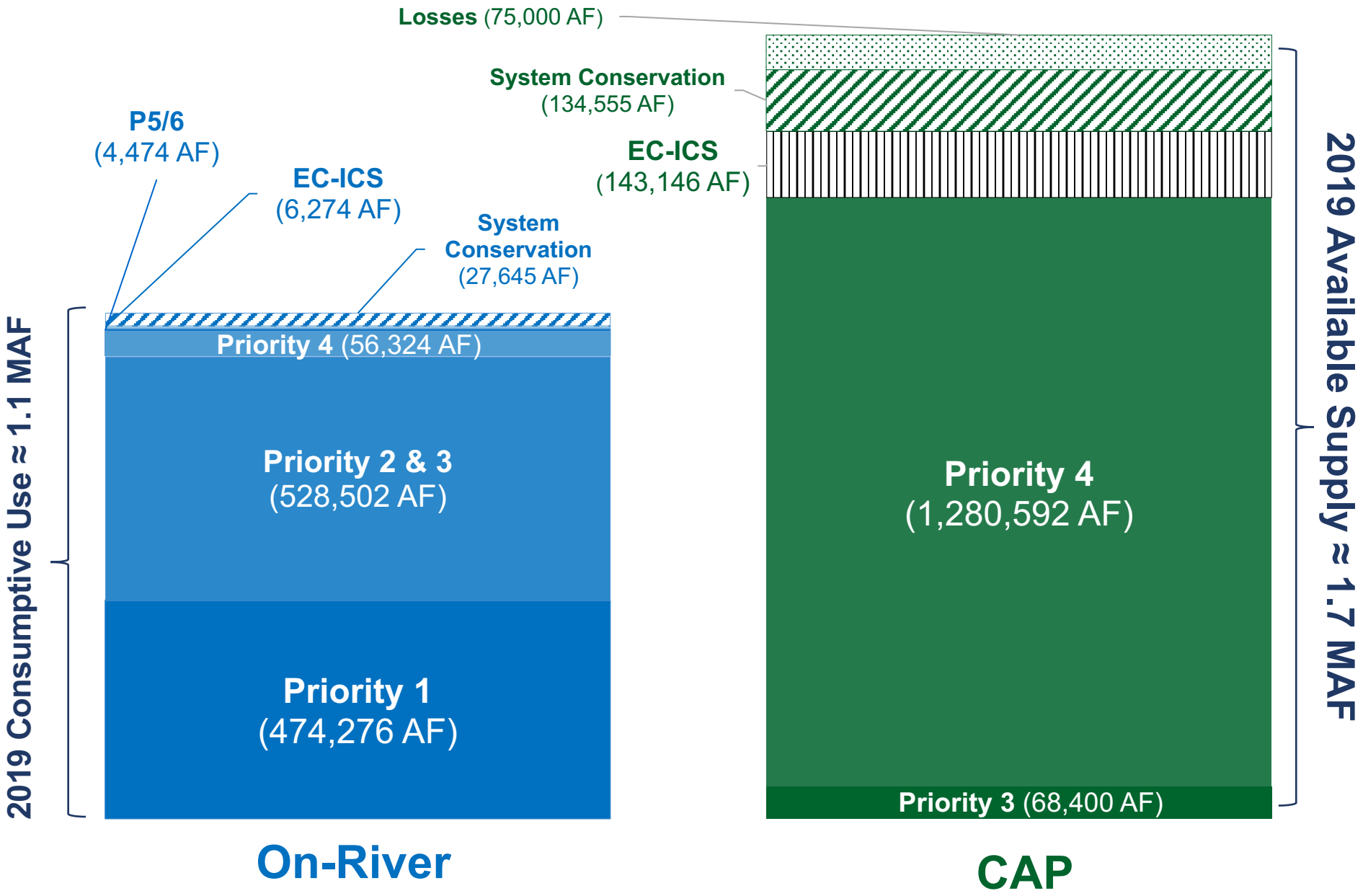


Arizona's Colorado River Priority System

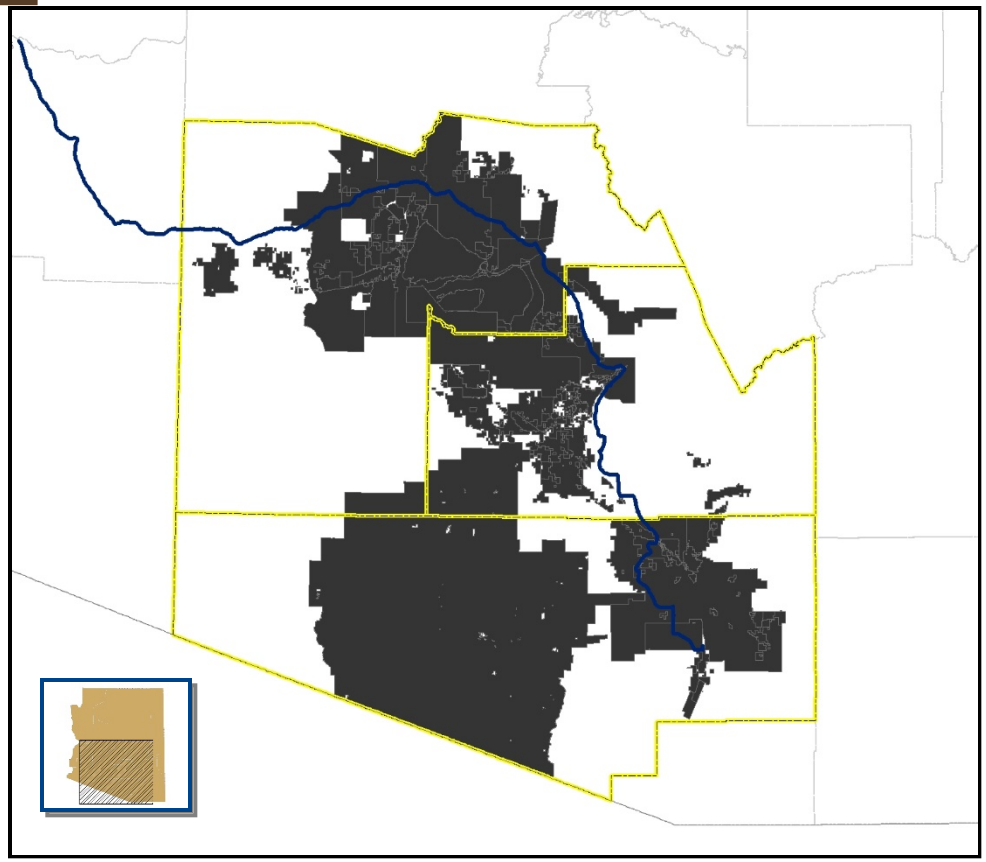


Arizona has 86 entitlement holders, including CAWCD
Approximately 20 contractors have entitlements greater than 10,000 AF

Arizona's 2019 Uses



CAP Service Area



CAP's Service Area and Water Users*

- 3-County Service Area
- Indian Contractors
- M&I Subcontractors
- Irrigation Districts
- Non-subcontractors w/CAGRD relationship

* Based on Jurisdictional Boundary or Planning Area

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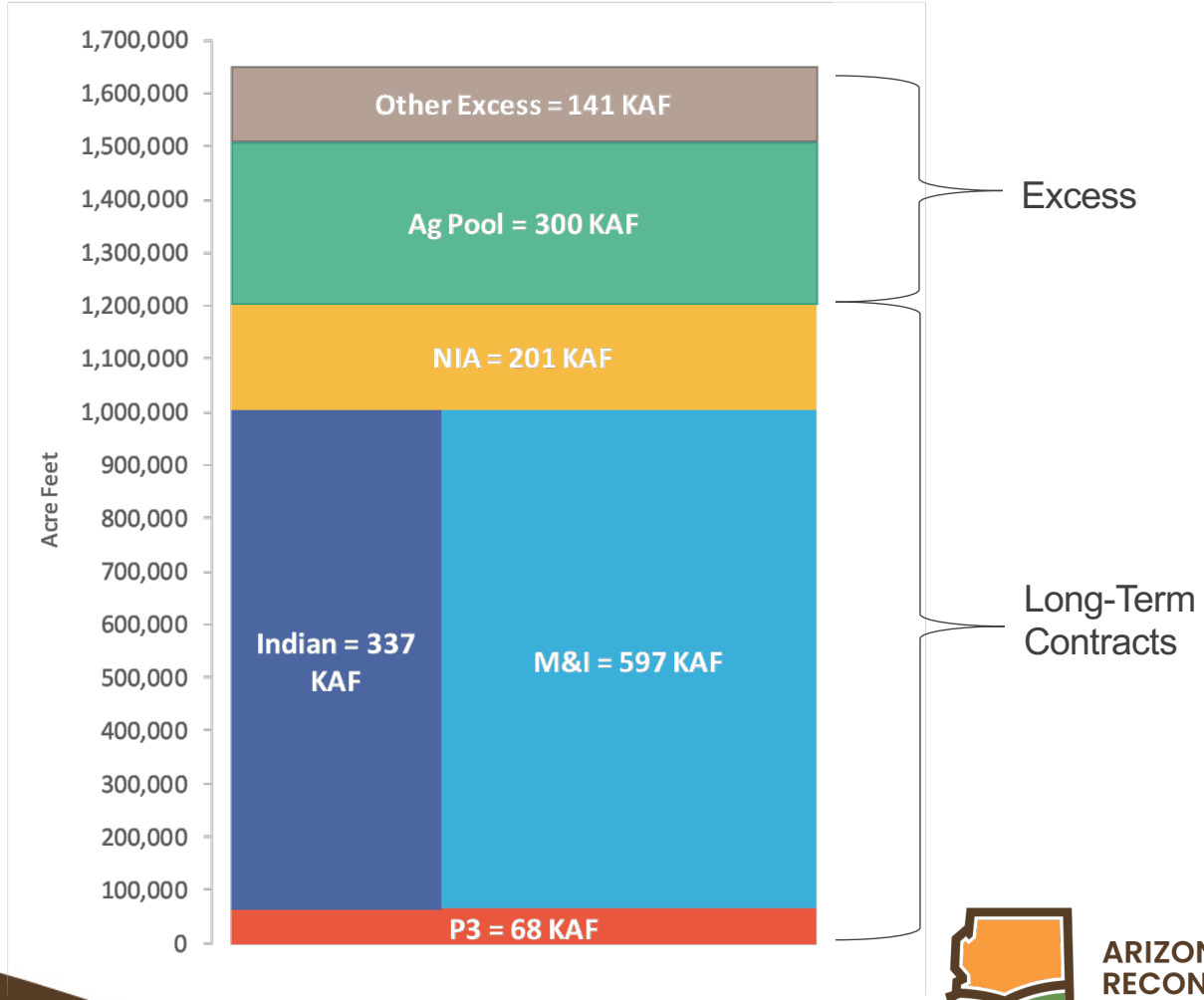
CAP Priorities

Volumes based on 2020 orders, prior to Tier 0 DCP contributions, System Conservation and ICS creation



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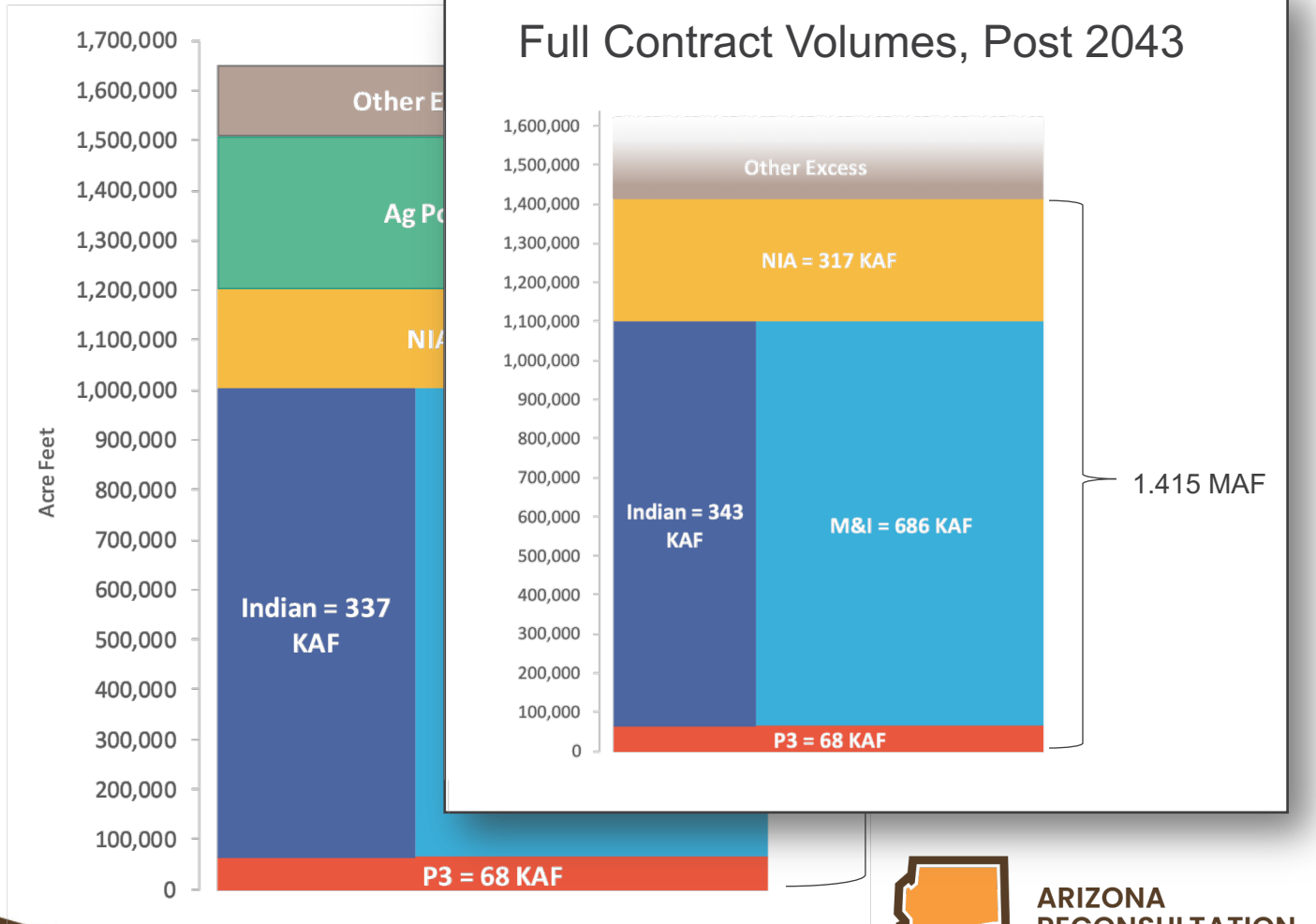

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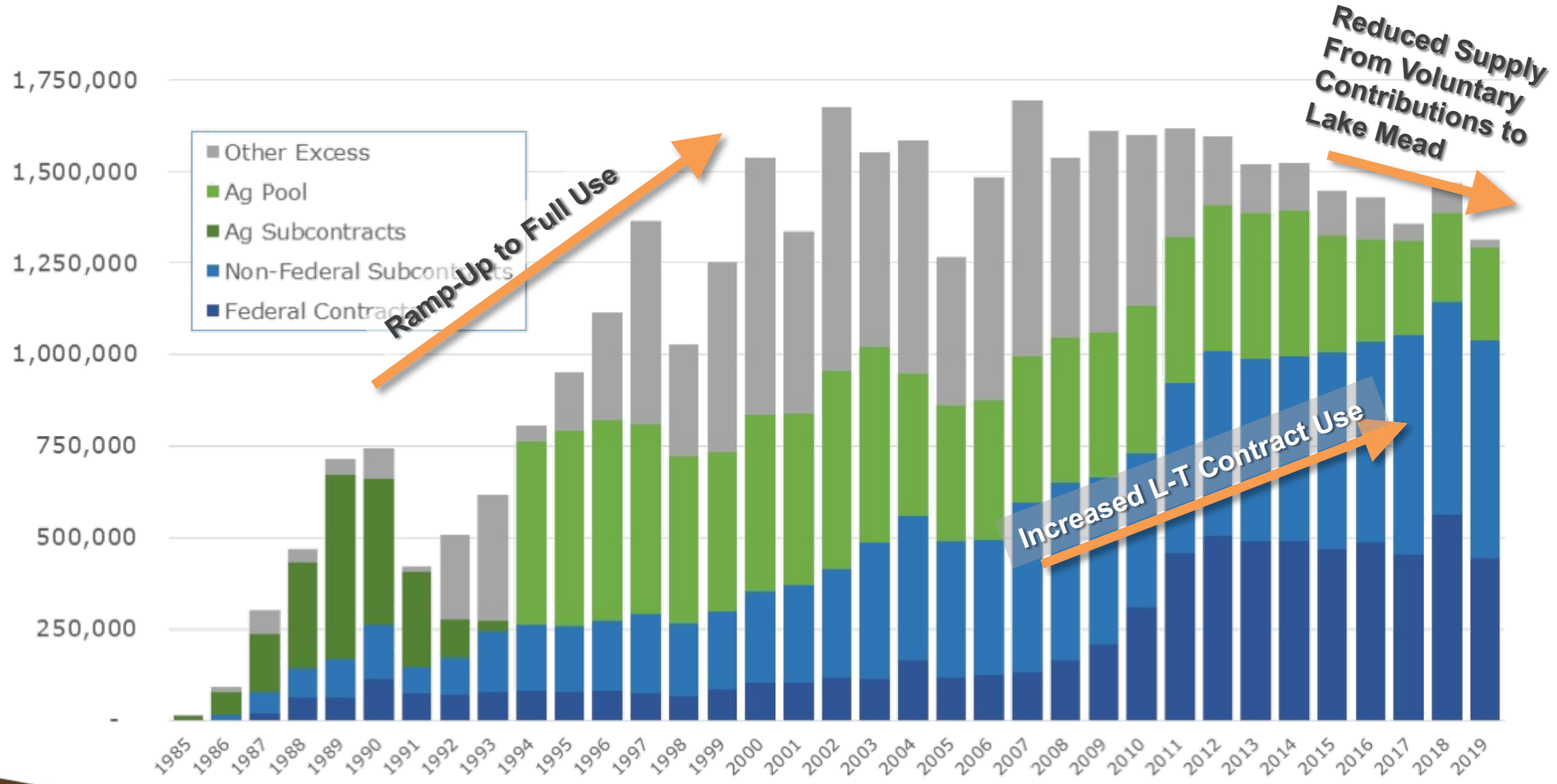
CAP Contract Utilization

1985 to 2019, by Contract Category



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Summary of key factors influencing available supply and impacts

AZ Colorado River Supply

- Hydrology
- Antecedent Conditions
- Precipitation
- Intervening Flows
- Upper Basin Demands
- System Operations

AZ Demands

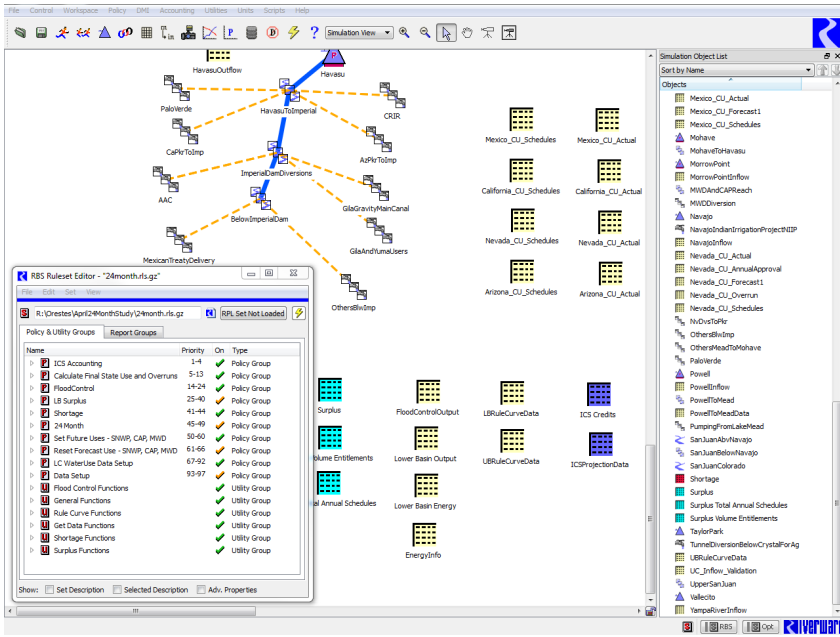
- P1-3 demands
- On-River P4 M&I and Ag demands
- CAP demands

Available Modeling and Analysis Tools

- **Colorado River (interstate tools)**
  - **24-Month Study:** Lower Basin shortages and the Coordinated Operations of Lake Powell and Lake Mead
  - **MTOM:** Risk-based operational planning and analysis
  - **CRSS:** Long-term planning studies, operational criteria development and risk analysis
- **Arizona (intrastate tools)**
  - **On-River Models:** Estimates demands and available supplies to Arizona On-River Colorado River users and salinity
  - **CAP Joint Shortage Analysis Model:** Model to evaluate the impact of variations in CAP supply to CAP users

CR Modeling Tools:

24-Month Model



- Deterministic (forecast)
- Decision framework model
- Rule-based
  - 2007 Interim Guidelines + DCP
- ≤2 yr operations
- Hydrology Inputs
  - Colorado Basin River Forecast Center
  - "min-", "max-", and "most probable"
- Run parameters
  - Duration = 24 mo.
  - Monthly initial conditions
  - Monthly time-step
- Outputs of interest
  - EOM Dec. Lake Mead pool elev.
    - Aug 24MS
  - EOM Sept. & Dec. Lake Powell pool elev.
    - Apr & Aug 24MS

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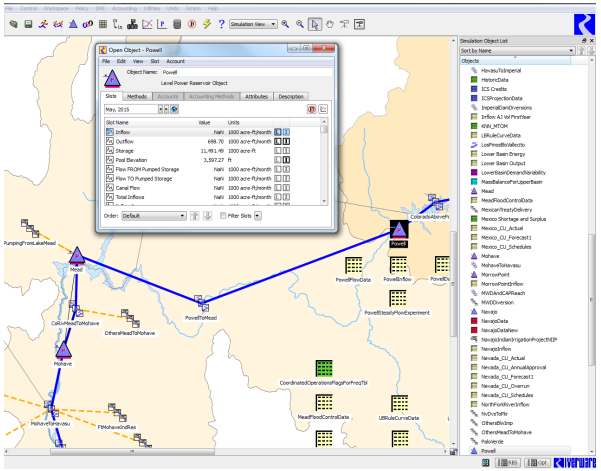
CR Modeling Tools:

Mid-term Probabilistic Operations Model (MTOM)



- Probabilistic
- Planning tool
- Rule-based
  - 2007 Interim Guidelines + DCP
- 1-5 yr planning
- Hydrology input
  - UB: Unregulated flows as modeled by Colorado Basin River Forecast Ctr. “Calibration Period (1981-2010)” precip. & temp.
  - LB: observed side inflows 1981-2010
- Run parameters
  - Duration = 5 years
  - Initial conditions: current 24MS results
  - Monthly time-step
- Outputs of interest
  - Lake Mead pool elevation
  - Lake Powell pool elevation
  - Releases
  - Shortages

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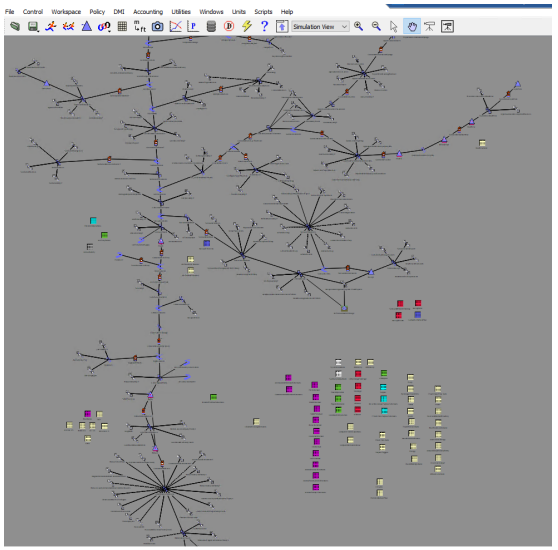
CR Modeling Tools:

Colorado River Simulation System (CRSS)



- Probabilistic
- Rule-based
  - 2007 Interim Guidelines + DCP
- ≥ 10 yr planning
- Hydrology inputs
  - Observed (113 yr record - 1906-2018)
  - “Stress Test” (1988-2017 extremely dry period
  - Variable Infiltration Capacity (VIC [climate change scenarios])
  - “Other”
- Run parameters
  - Duration ≤ 40 years
  - Initial conditions: Actual or predicted Jan.
  - Monthly time-step
- Outputs of interest
  - Lake Mead pool elevation
  - Lake Powell pool elevation
  - Conservation volumes
    - State
    - USBR
    - Users

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Arizona On-River Tools

- Simple excel model and a GoldSIM model
- Accounts for all Arizona On-River entitlement holders for Colorado River water
- Accounts for the type of use under each priority (Priorities 1-4)
- Input into the model is available Colorado River supply to AZ based on CRSS runs
- Model determines available P4 supply after water is allocated to P 1-3 users
- Also determines available CAP supply and On-River P4 supply
- Includes model of salinity management impacts to Arizona Colorado River supplies

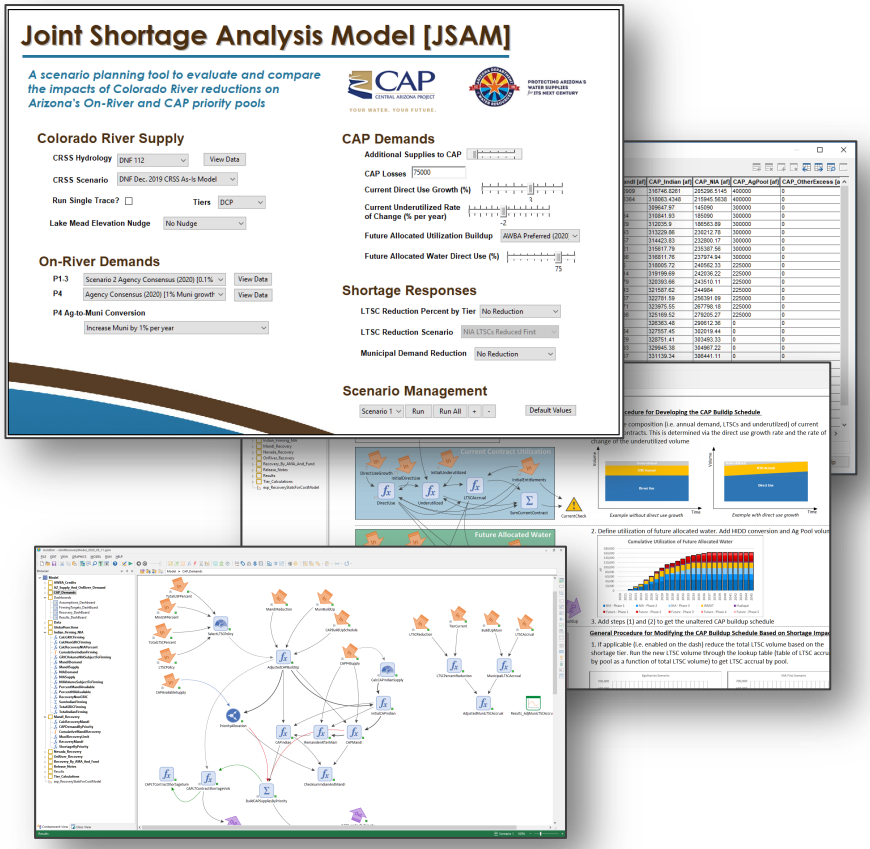
CAP Modeling Tools:
Joint Shortage Analysis Model (JSAM)

A joint ADWR/CAP model adapted from the tool used for AWBA recovery planning

Designed for scenario planning, with the ability to simulate a wide range of future conditions

Will be used to evaluate and compare impacts of shortages on CAP priority pools

- Takes Lake Mead elevation output directly from CRSS and retains trace-level detail
- Can simulate demand responses by shortage tier
- Can evaluate alternate shortage tiers



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CAP Modeling Tools:
CAP Shortage Visualization and Analysis

A set of visualization and analysis tools originally developed to support the Arizona DCP process

Tools are being updated and refined

Emphasis is on ways to characterize and summarize differential impacts by CAP priority pool

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Initial Modeling and Analyses Framework - Concept

- Work Group to develop multiple modeling scenarios
- Consider a range of future hydrologic conditions:
  - Potential consideration of observed conditions, climate change projected conditions, surrogate records (“tree ring” data), and statistical methods
- Consider a range of future Colorado River uses and depletions, including Upper Basin, Lower Basin, Arizona On-River and CAP uses for impact analysis
- Consider a range of future Colorado River system operating conditions

Initial Modeling Proposal

- ADWR-CAWCD staff to prepare initial modeling scenarios
- At November WG Meeting, ADWR-CAWCD will present initial modeling scenarios for the Work Group to review and discuss, including ranges for key factors
- The Work Group will propose the initial modeling scenarios to the ARC as the basis for preliminary comparisons of key factors, risks, vulnerabilities and impacts
- ADWR-CAWCD will conduct model runs, and review results with WG, then report results to ARC

MAWG Next Steps

- Report to ARC on Work Group meeting and next steps
- Proposed Agenda for November MAWG meeting
  - Summary of recent Colorado River Trends
  - Outline initial modeling scenarios for consideration
  - Examples of modeling results for discussion and review

Call to the Public

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

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