



**ARIZONA
RECONSULTATION
COMMITTEE**

Modeling and Analysis Work Group #4

March 11, 2021

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

- Review of Colorado River Conditions
- Review of MAWG #3
- Arizona Priority System
- Arizona On-River Uses
- Yuma Area Operations
- Salinity Management Impacts to Arizona
- Multi-Species Conservation Program (MSCP) Constraints
- CAP System and Model Overview
- Preview of MAWG #5
- Call to the Public

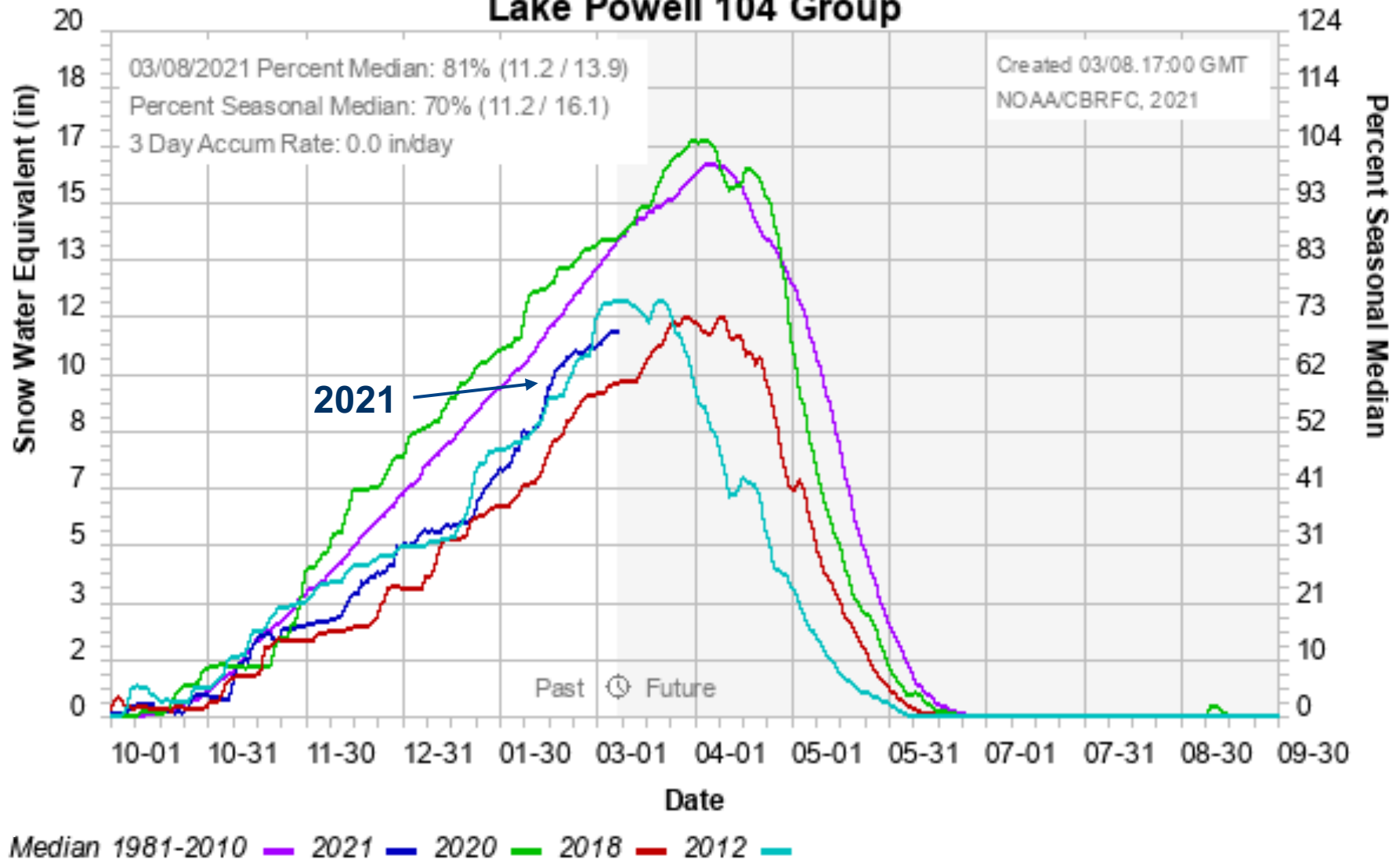


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Colorado River System Update

Colorado Basin River Forecast Center

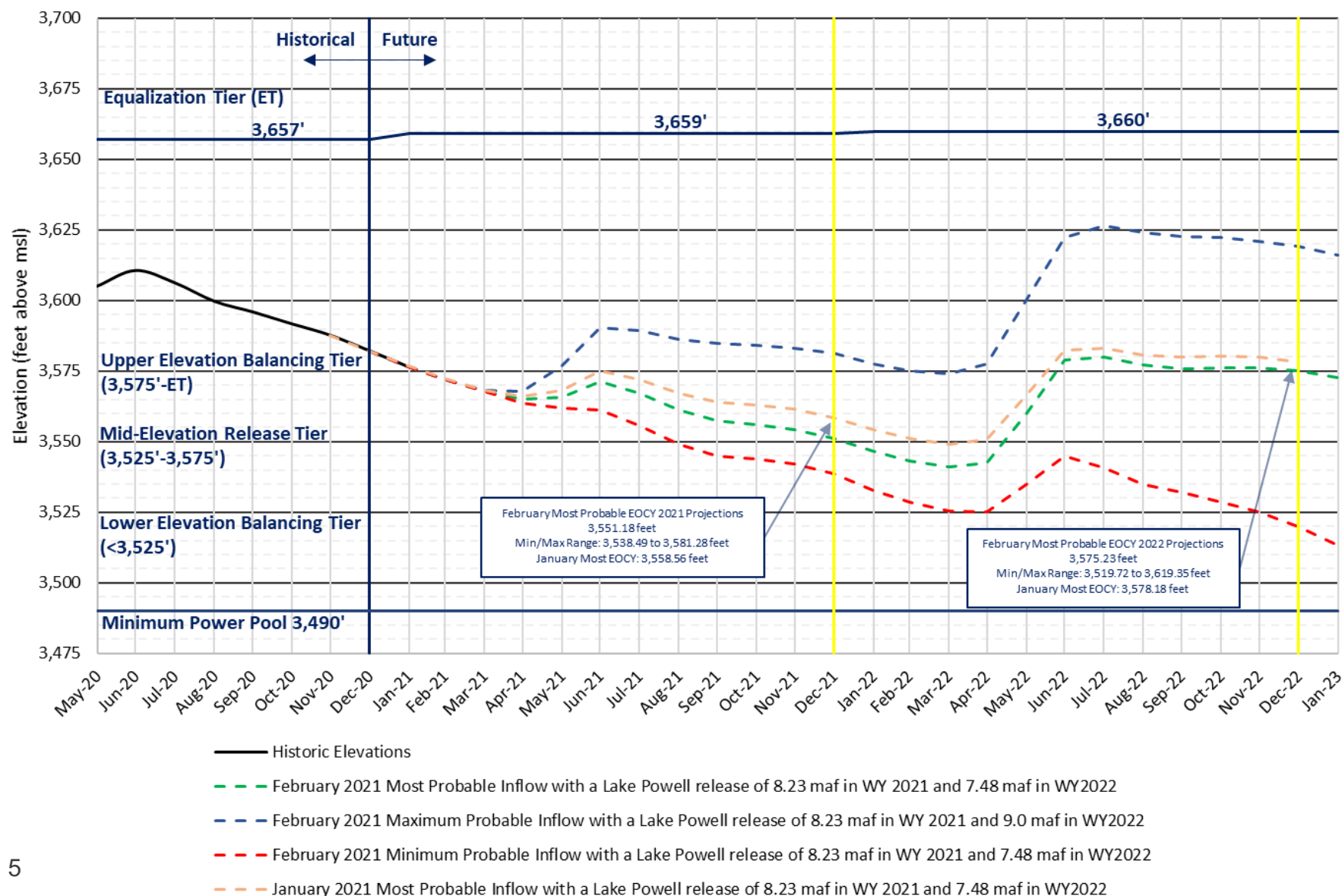
Lake Powell 104 Group



Colorado River System

Lake Powell End of Month Elevations

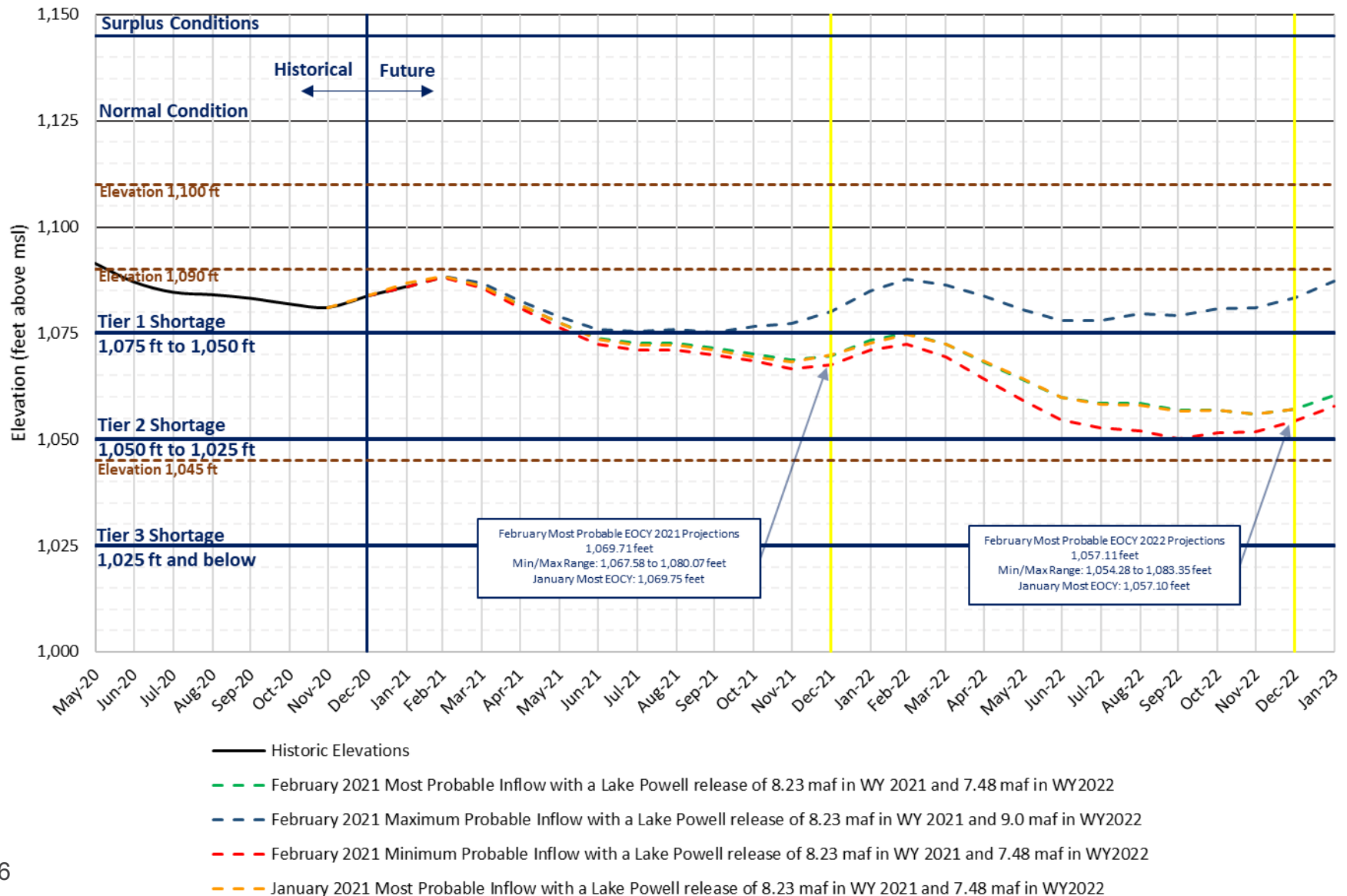
Historic and Projected based on February and January 2021 24-Month Study Inflow Scenarios



Colorado River System

Lake Mead End of Month Elevations

Historic and Projected based on February and January 2021 24-Month Study Inflow Scenarios



Colorado River System Update

Lower Basin – Lake Mead

Percent of Traces with Event or System Condition

Results from January 2021 MTOM/CRSS using the **Full Hydrology** and **Stress Test Hydrology** (values in percent)

Event or System Condition	2021	2022	2023	2024	2025	2021	2022	2023	2024	2025
Surplus Condition – any amount (Mead \geq 1,145 ft)	0	0	0	2	5	0	0	0	0	<1
Surplus – Flood Control	0	0	0	0	<1	0	0	0	0	0
Normal or ICS Surplus Condition (Mead < 1,145 and > 1,075 ft)	100	40	18	23	22	100	40	18	14	12
Recovery of DCP ICS / Mexico's Water Savings (Mead \geq 1,110 ft)	0	0	<1	6	10	0	0	0	<1	1
DCP Contribution / Mexico's Water Savings (Mead \leq 1,090 and > 1,075 ft)	100	34	16	16	12	100	34	16	13	6
Shortage Condition – any amount (Mead \leq 1,075 ft)	0	60	82	75	73	0	60	82	86	88
<i>Shortage / Reduction – 1st level (Mead \leq 1,075 and \geq 1,050)</i>	0	60	75	41	36	0	60	70	36	33
DCP Contribution / Mexico's Water Savings (Mead \leq 1,075 and > 1,050 ft)	0	60	75	41	36	0	60	70	36	33
<i>Shortage / Reduction – 2nd level (Mead < 1,050 and \geq 1,025)</i>	0	0	7	34	29	0	0	12	50	35
DCP Contribution / Mexico's Water Savings (Mead \leq 1,050 and > 1,045 ft)	0	0	5	8	5	0	0	9	7	6
DCP Contribution / Mexico's Water Savings (Mead \leq 1,045 and > 1,040 ft)	0	0	1	8	6	0	0	3	10	4
DCP Contribution / Mexico's Water Savings (Mead \leq 1,040 and > 1,035 ft)	0	0	<1	8	7	0	0	<1	16	7
DCP Contribution / Mexico's Water Savings (Mead \leq 1,035 and > 1,030 ft)	0	0	0	6	6	0	0	0	12	9
DCP Contribution / Mexico's Water Savings (Mead \leq 1,030 and \geq 1,025 ft)	0	0	0	3	5	0	0	0	5	10
<i>Shortage / Reduction – 3rd level (Mead < 1,025)</i>	0	0	0	<1	8	0	0	0	<1	20
DCP Contribution / Mexico's Water Savings (Mead \leq 1,025 ft)	0	0	0	<1	8	0	0	0	<1	20

Notes:

¹ Modeled operations include the 2007 Interim Guidelines, Upper Basin Drought Response Operations, Lower Basin Drought Contingency Plan, and Minute 323, including the Binational Water Scarcity Contingency Plan.

² Reservoir initial conditions on December 31, 2020 were simulated using the January 2021 MTOM based on the CRRFC unregulated inflow forecast ensemble dated January 6, 2021.

³ Each of the 35 initial conditions from MTOM were coupled with 113 hydrologic inflow sequences from the Full Hydrology that resamples the observed natural flow record from 1906-2018 for a total of 3955 traces analyzed and with 31 hydrologic inflow sequences from the Stress Test Hydrology that resamples the observed natural flow record from 1988-2018 for a total of 1,085 traces analyzed.

⁴ Percentages shown in this table may not be representative of the full range of future possibilities that could occur with different modeling assumptions.

⁵ Percentages shown may not sum to 100% due to rounding to the nearest percent.



Summary of MAWG #3

- Reservoir Operations (specifically coordinated operations of Lakes Powell and Mead) are a key driver of Lake Mead elevations.
- Average Upper Basin use over the last ten years (2008-2018) are around 3.9 maf (excluding CRSP evap)
- Multiple UB Use scenarios have been developed: 2016 UCRC schedule reaches 5.48 maf in 2060 (excluding CRSP evap)
- CRSS Projections of Lake Mead elevations are sensitive to the UB demand schedules and Lower Basin uses
- Lower Division States are at full apportionment. ICS and System conservation use behaviors impact Lake Mead elevation

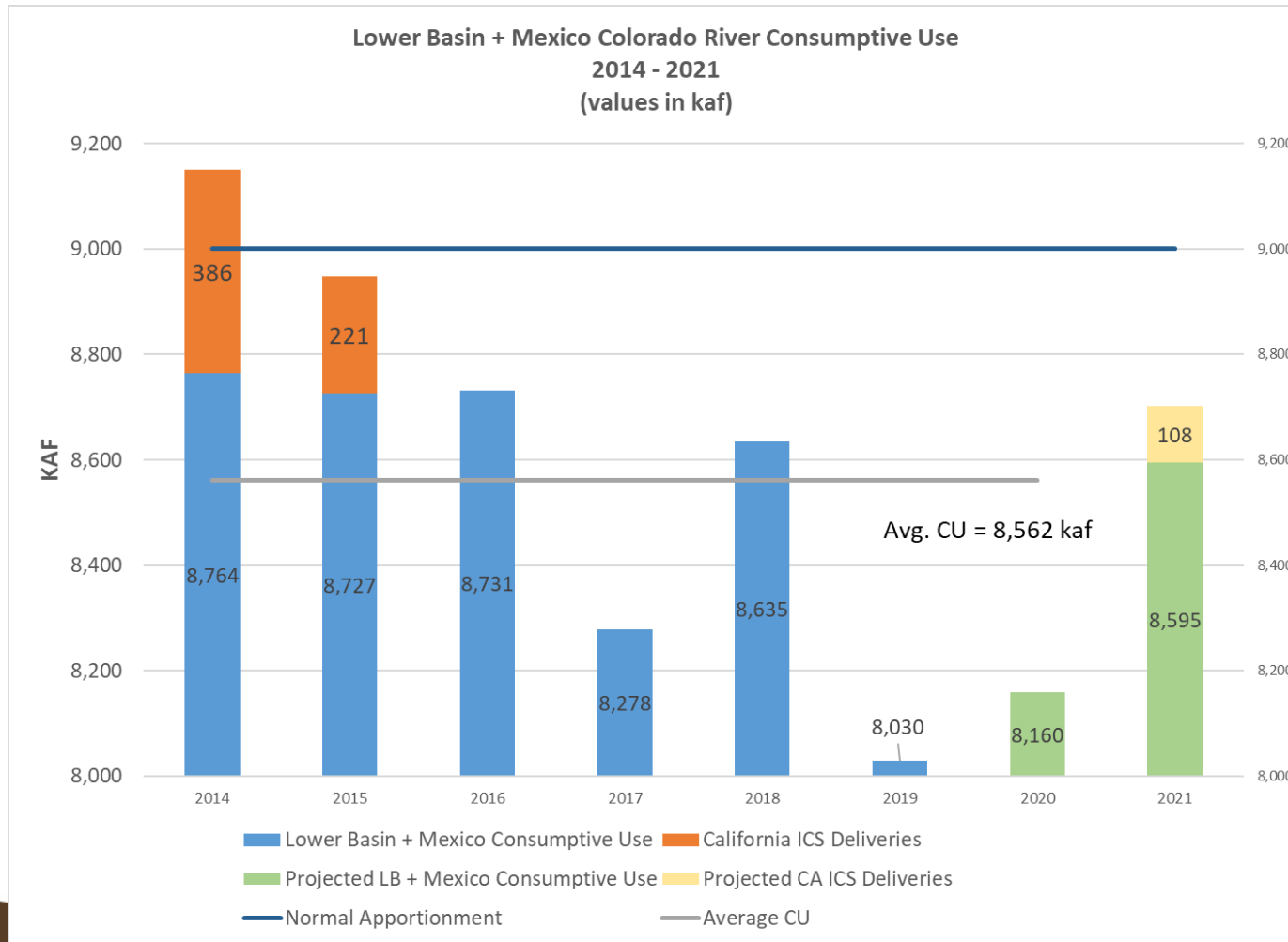


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Comparison of UB Demand Schedules (excludes CRSP evaporation)

Name	2020 (MAF)	2030 (MAF)	2040 (MAF)	2050 (MAF)	2060 (MAF)
1999	4.85	5.03	5.15	5.32	5.43
2007 UCRC	5.08	5.33	5.46	5.56	5.57
Basin Study (Current Projected)	4.87	5.11	5.30	5.45	5.55
2016 UCRC	4.80	5.01	5.22	5.42	5.48
Guideline Period Trend Extended	4.25	4.46	4.67	4.88	5.09
Average 2008 - 2018	3.92	NA	NA	NA	NA

Lower Basin Water Use

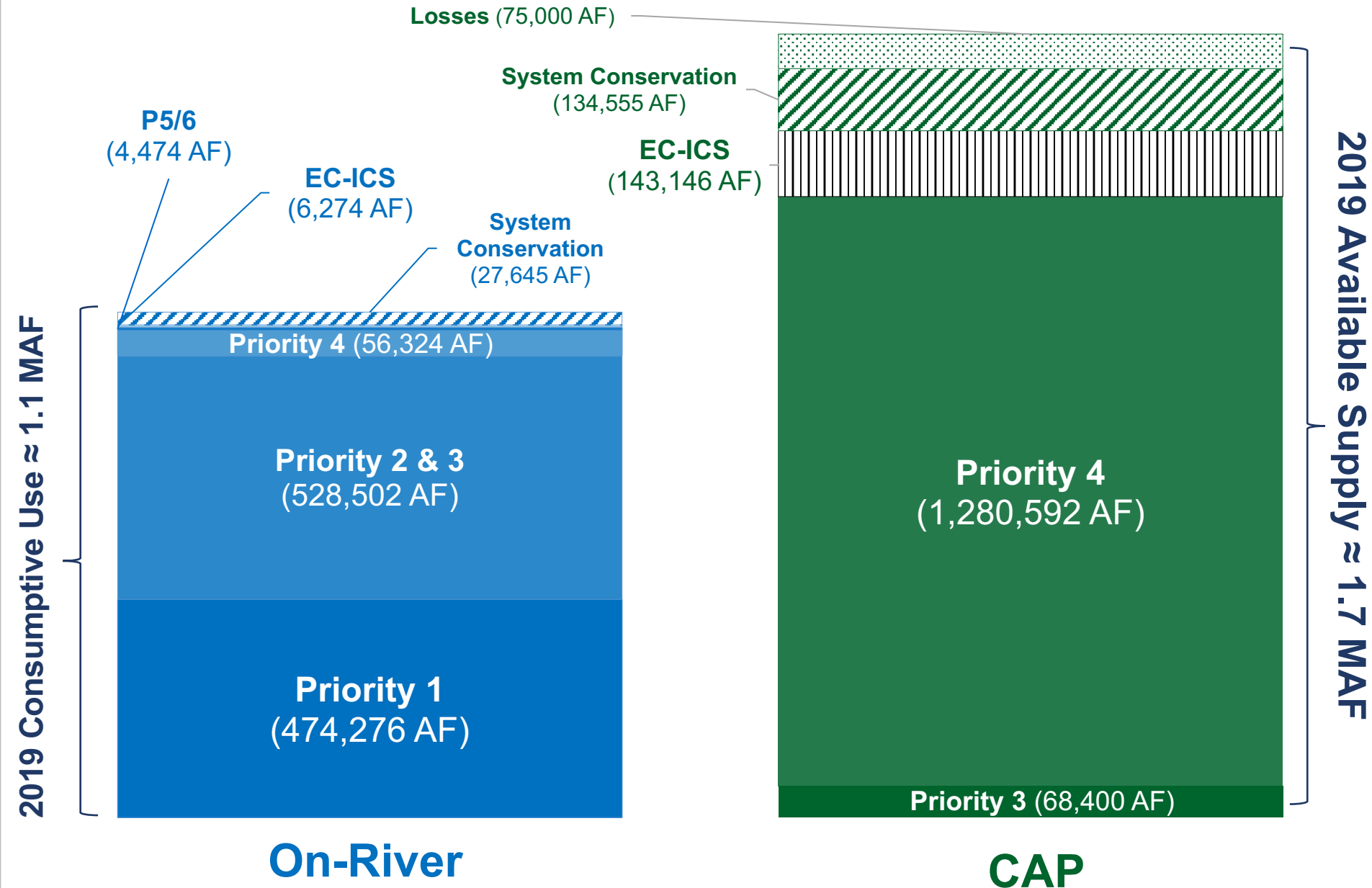


- Since 2014, average CU in LB has been about 400 kaf lower than apportionment
- System conservation
- Intentionally Created Surplus (ICS)
- Prior to this time period, CU was about 300 kaf higher



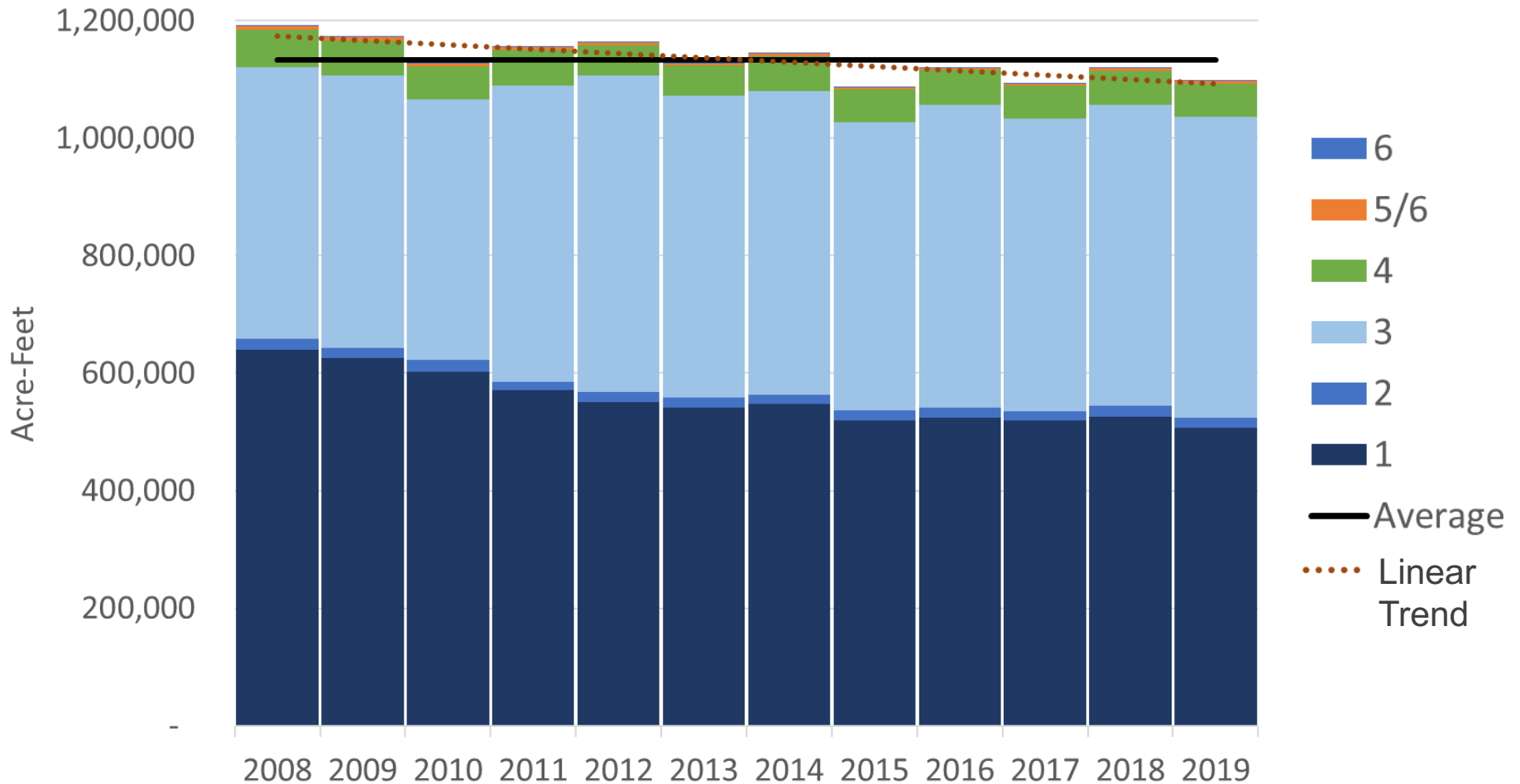
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Arizona's 2019 Uses



Mainstem Water Use, by Priority

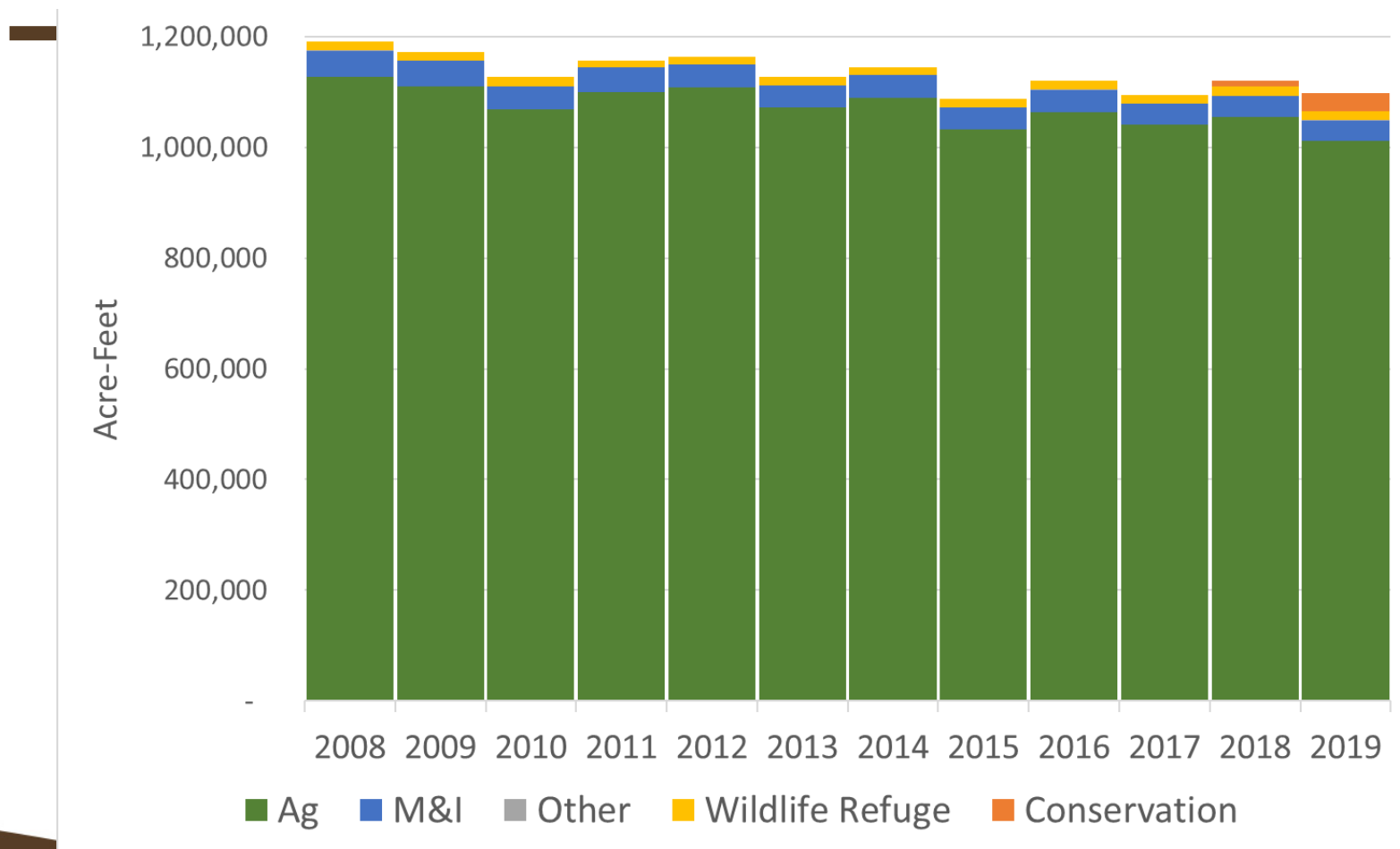
(Total Consumptive Use, plus System Conservation and ICS Creation)



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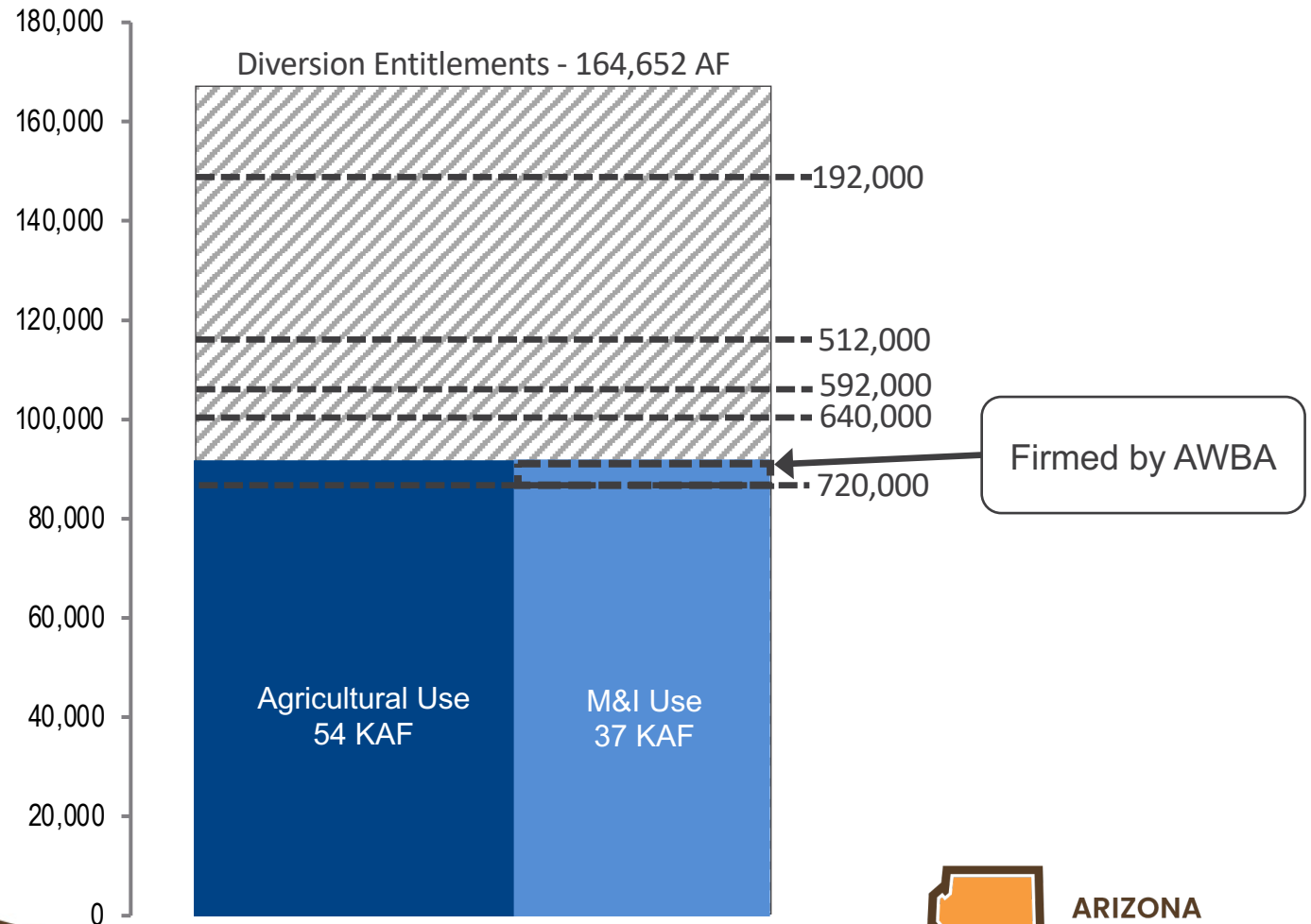
Mainstem Water Use, by Type

(Total Consumptive Use, plus System Conservation and ICS creation)



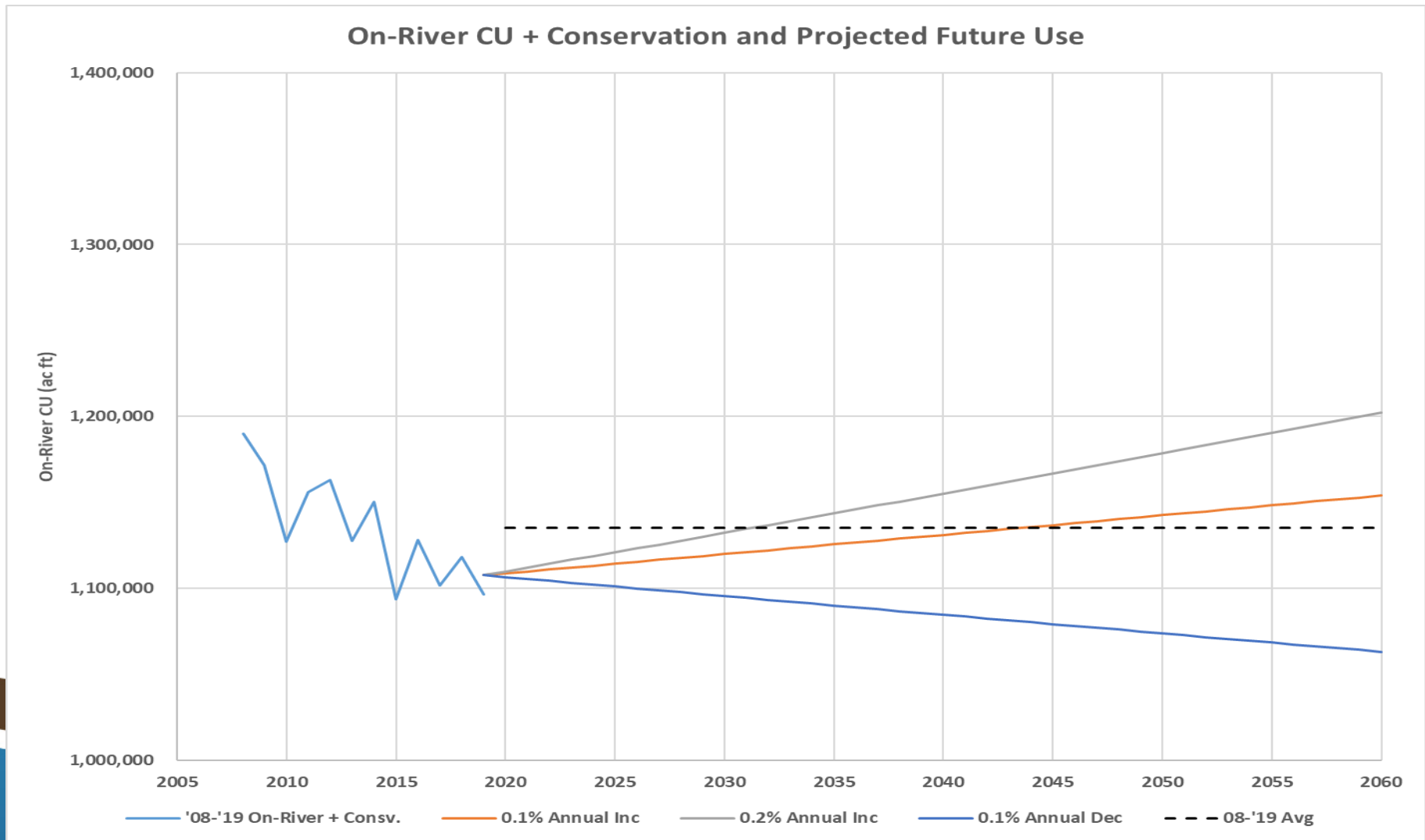
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P4 On-River Reductions Consistent with Arizona Shortage Sharing Recommendation (Current P4 On-River Use)



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Arizona On-River Uses Scenarios

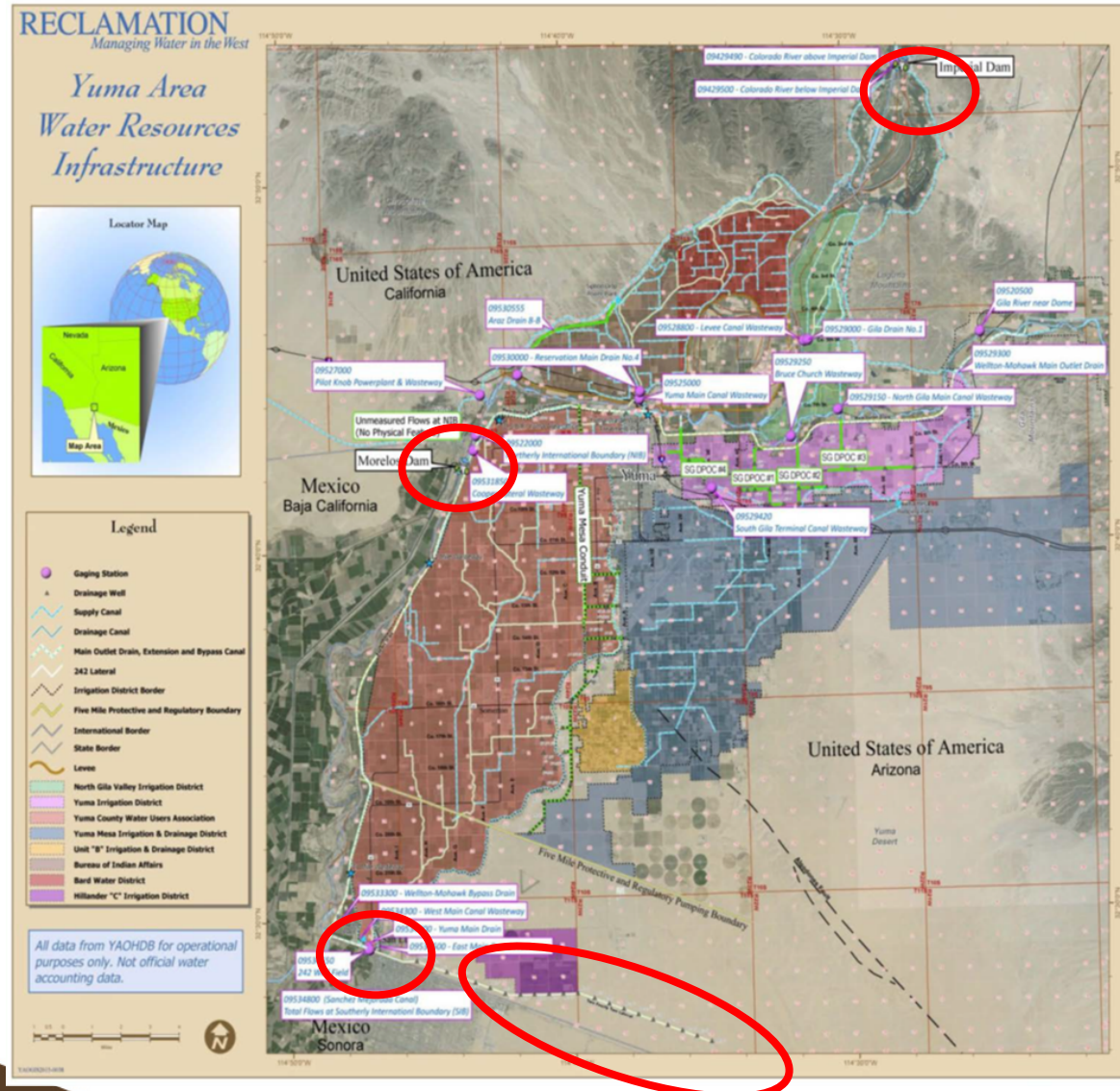


Arizona On-River Uses Scenarios

Name	2020 (MAF)	2030 (MAF)	2040 (MAF)	2050 (MAF)	2060 (MAF)
0.1% Growth Trend*	1.109	1.120	1.131	1.143	1.154
Available to CAP	1.691	1.680	1.669	1.657	1.646
0.2% Growth Trend*	1.110	1.132	1.155	1.178	1.202
Available to CAP	1.690	1.668	1.645	1.622	1.598
0.1% Declining Trend*	1.107	1.096	1.085	1.074	1.063
Available to CAP	1.693	1.704	1.715	1.726	1.737
Average 2008 – 2019	1.135	1.135	1.135	1.135	1.135
Available to CAP	1.665	1.665	1.665	1.665	1.665
* Trend begins at 2015-2019 average. Potential refinement for different use sectors and priorities					

Yuma Area Salinity Management

- Minute 242 defines water quality requirements for US deliveries to Mexico
- Minute 242 requirement WQ at Morelos Dam = 115 +/- 30ppm at Imperial Dam
- NIB = 1.360 MAF/yr
- SIB = 0.140 MAF/yr



Yuma Area Operations: 2019

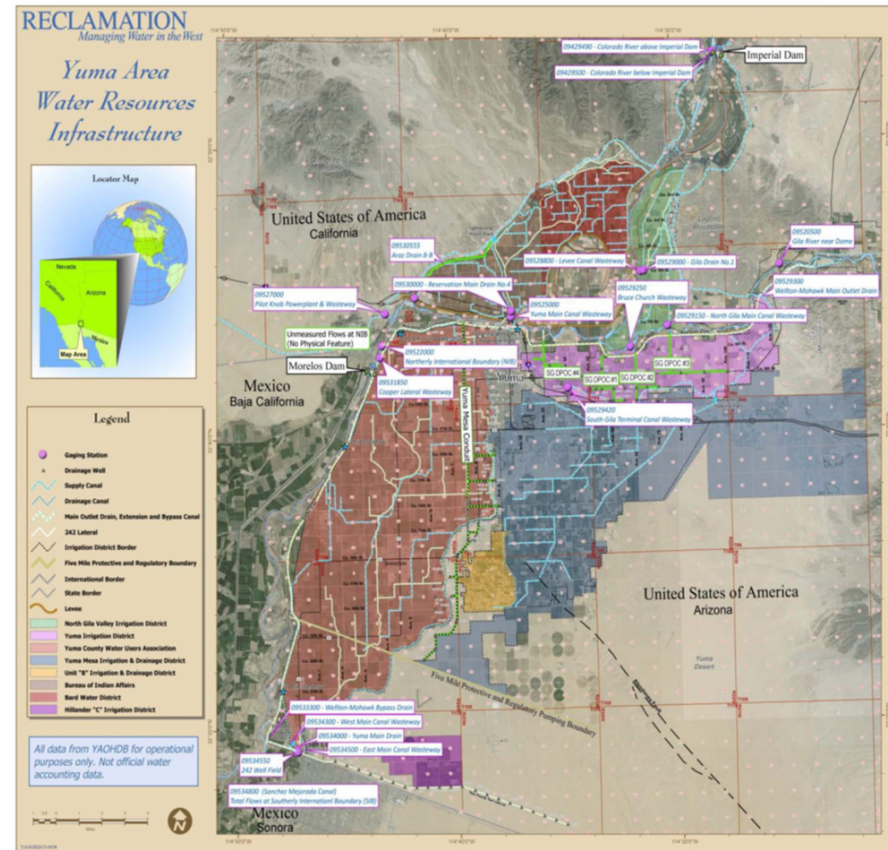
2019 Bypass + Excess*

- Bypass 143 kaf (5 yr avg = 139 kaf/yr)
- Excess 39 kaf (5 yr avg = 18 kaf/yr)
- 2019 = 182 kaf (5 yr avg = 157 kaf/yr)

2019 Impacts

- Decrease in Return Flows (incr. in CU)
- Decrease availability to CAP
- Loss to Lake Mead

*Source = BOR CR Water Accounting Reports



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Yuma Area Modeling Tools

- Reclamation operates a Yuma area drainage and salinity model in RiverWare
 - Guides real-time and near-term operations and management
- Some aspects of Yuma area operation included in CRSS
- CAP has developed a Yuma Area salinity analysis model in GoldSim
 - Monthly time step
 - Calibrated from 2003-2019



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MSCP Overview

- **Purpose:** Provide Endangered Species Act (ESA) coverage for ongoing and future operations and maintenance activities on the Lower Colorado River (LCR) through 2055.
 - Planning area: Lake Mead full pool to the Southerly International Border (SIB) with Mexico.
 - Balances Lower Colorado River water use and the conservation of native species and their habitats.
 - Reclamation is the Program's implementing agency, with input and oversight from the Program Steering Committee.
- **27 Federal or State listed, candidate, and sensitive species and their associated habitat**
 - Program creates at least 8,132 acres of habitat;
 - Provides 660k subadult razorback suckers and 620k bonytail to augment existing LCR populations.
 - Program costs shared among Federal and non-Federal partners:
 - BOR: 50%, CA: 25%, AZ: 12.5%, NV: 12.5%
 - FY '21 ~\$30.3M



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MSCP Constraints

- Integrates Section 7 and Section 10 responsibilities under the ESA
- Program considerations related to AZ Reconsultation:
 - Flow-related covered activities include power production, changes to points of diversion and reduction in water releases from Hoover, Davis and Parker Dams. Covered reductions in flow:
 - 845 kaf below Hoover Dam (Reach 2)
 - 860 kaf below Davis Dam (Reach 3)
 - 1.574 maf below Parker Dam to Imperial Dam (Reaches 4 & 5)

Evaluation of future flow within MSCP will be necessary as part of the Guidelines Reconsultation Process.



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MSCP Key Reaches

- 845 kaf below Hoover Dam (Reach 2)
- 860 kaf below Davis Dam (Reach 3)
- 1.574 maf below Parker Dam to Imperial Dam (Reaches 4 & 5)

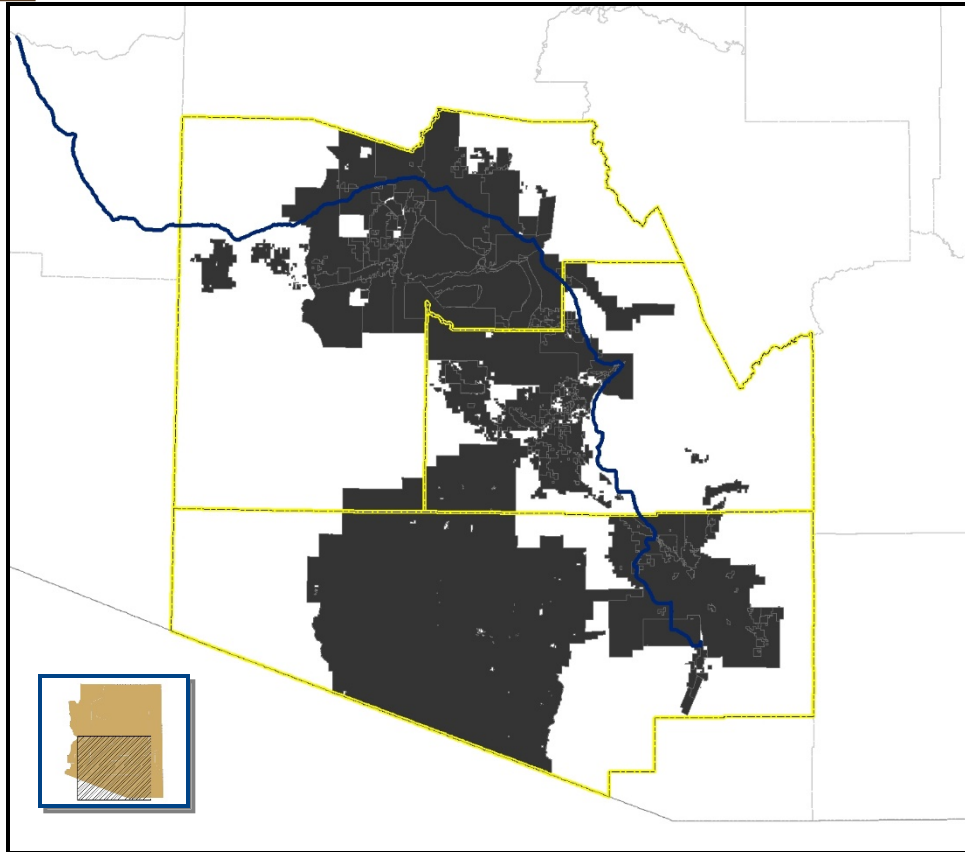


BREAK



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CAP Service Area



* Based on Jurisdictional Boundary or Planning Area

CAP's Service Area and Water Users*

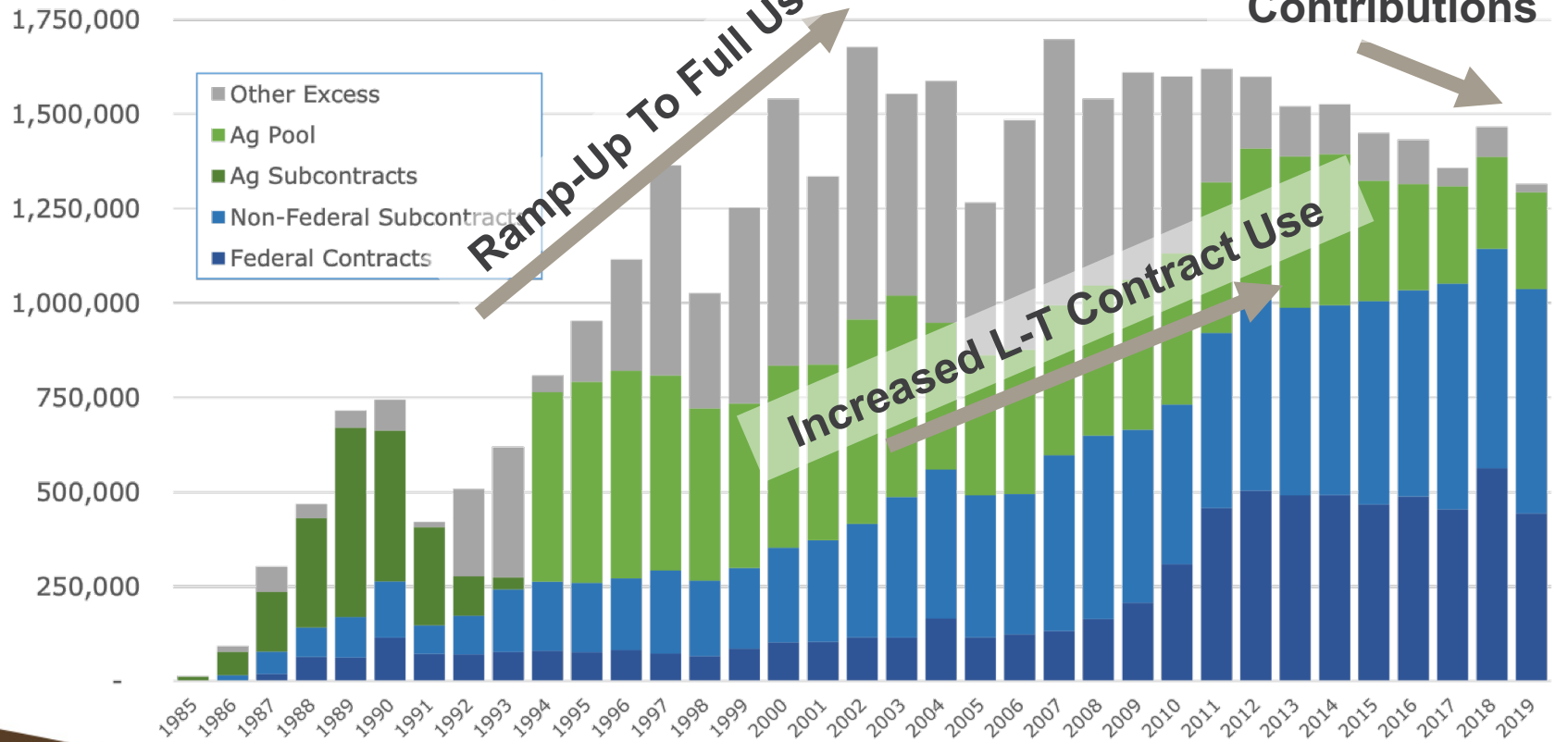
- 3-County Service Area
- Indian Contractors
- M&I Subcontractors
- Irrigation Districts
- Non-subcontractors w/CAGRDR relationship



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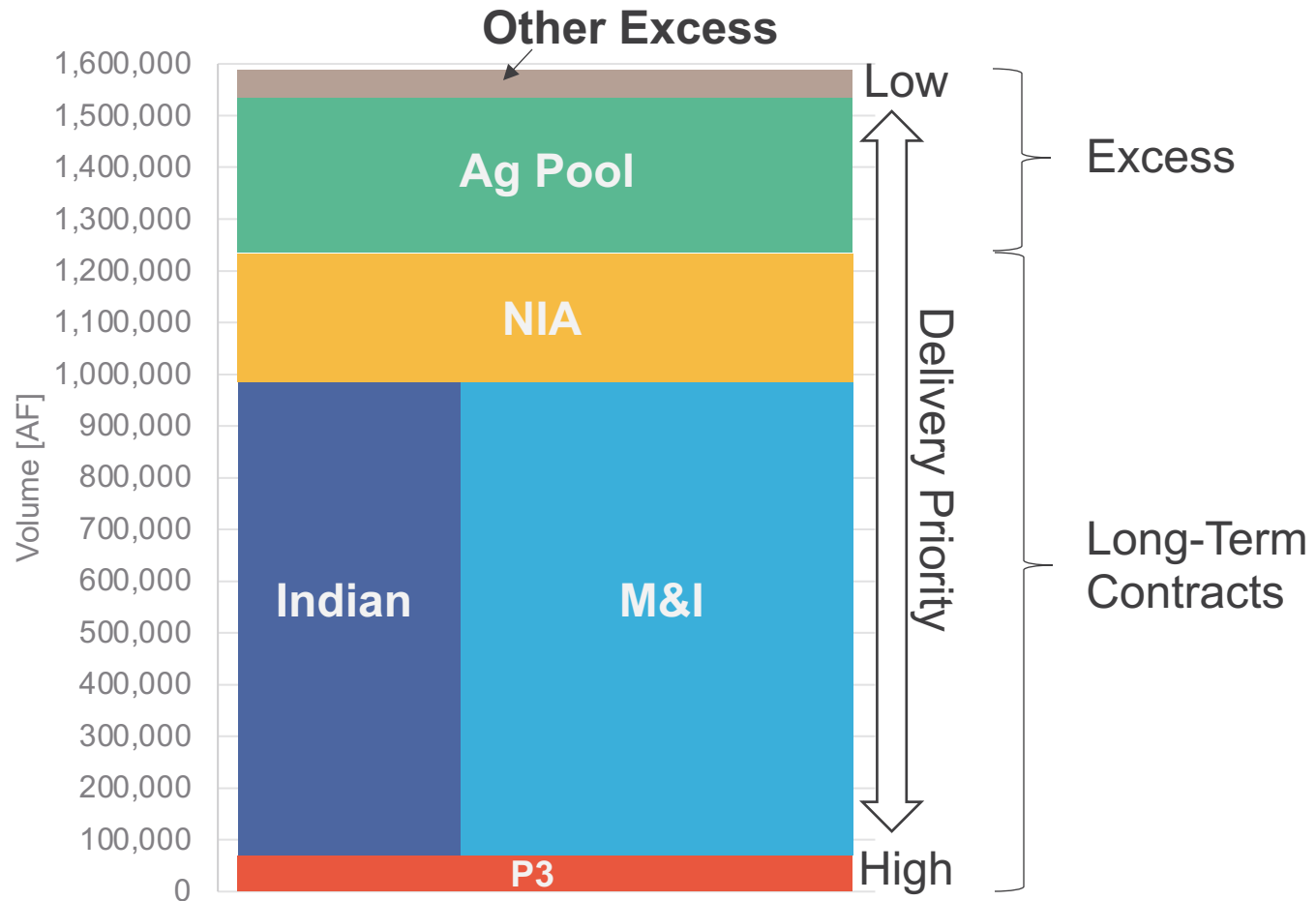
CAP Contract Utilization

1985 – 2019 (by Contract Category)



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CAP Priority System



**Based on 2021 Orders Prior to DCP contribution, System Conservation and ICS Creation (includes NIA reallocation water)*

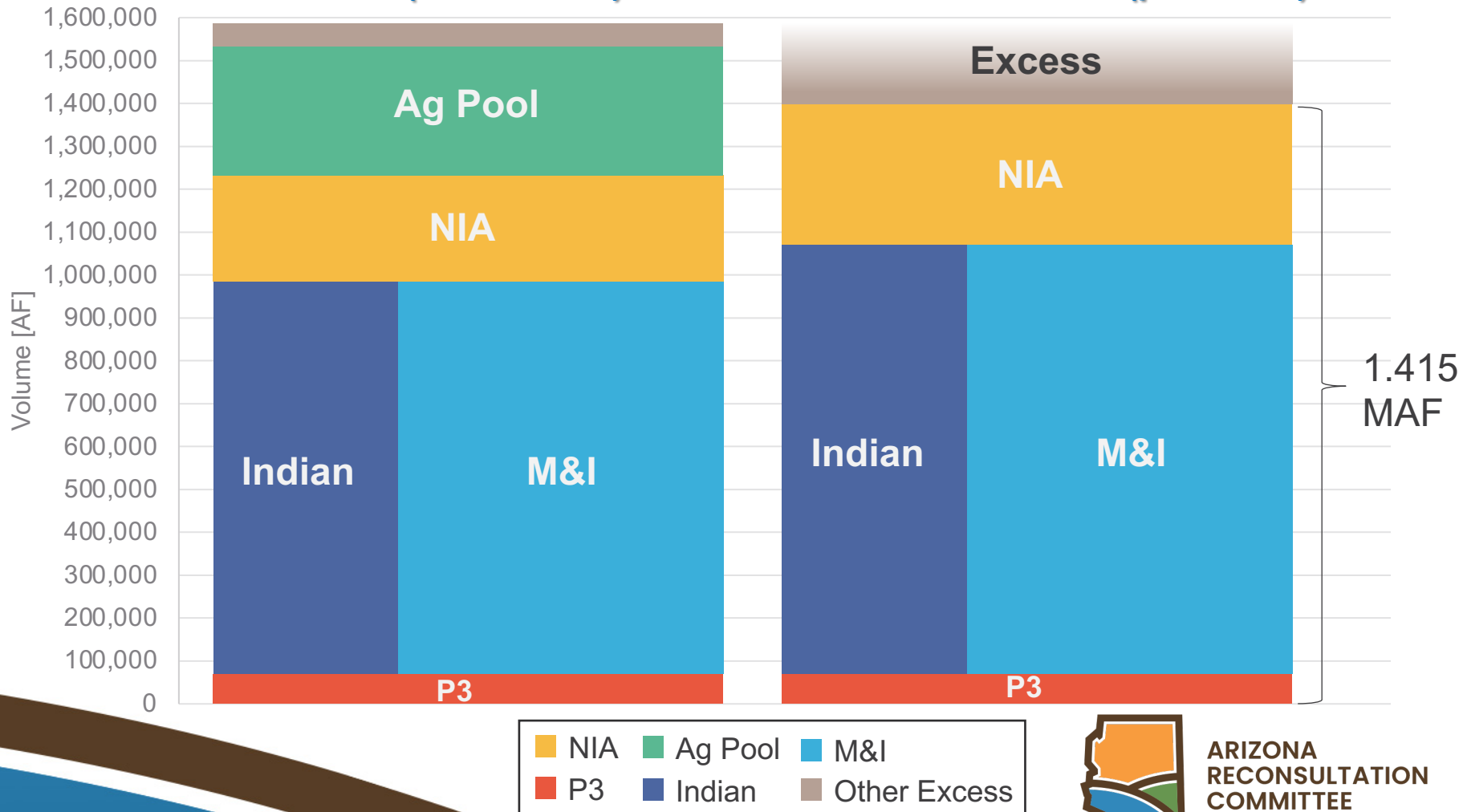


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CAP Priority System (Full Supply)

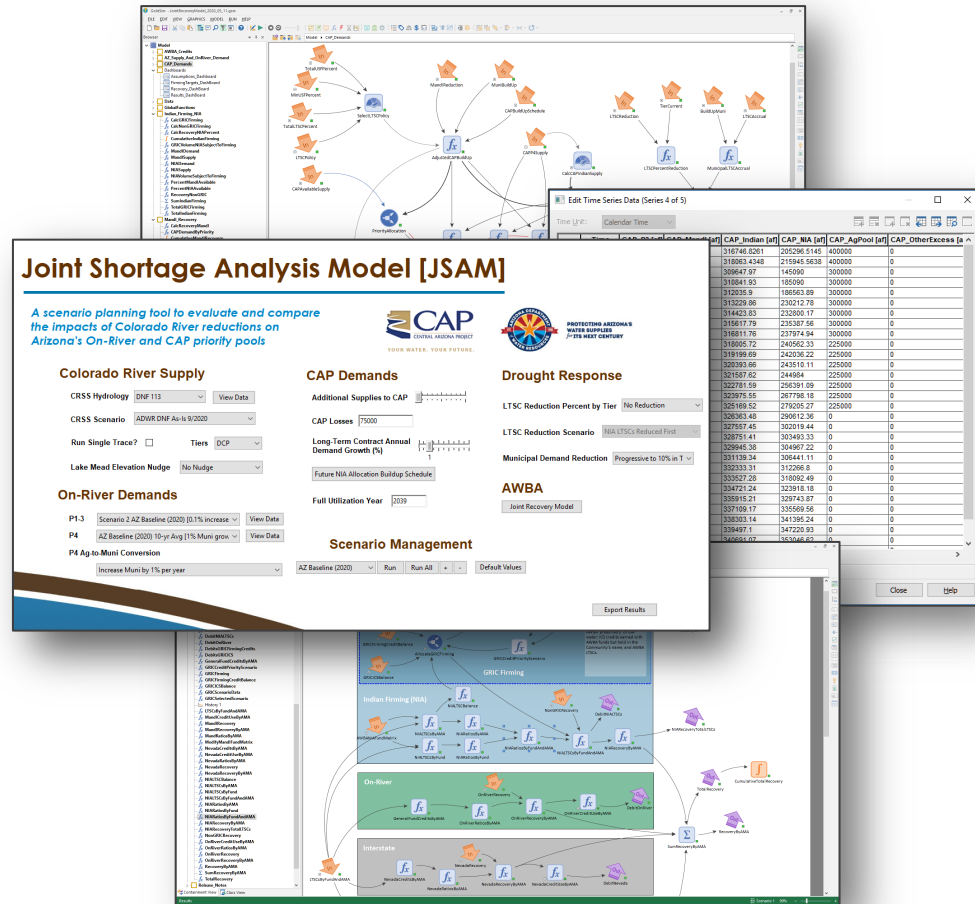
2022 (Current Use)

Full Buildout (post-2043)



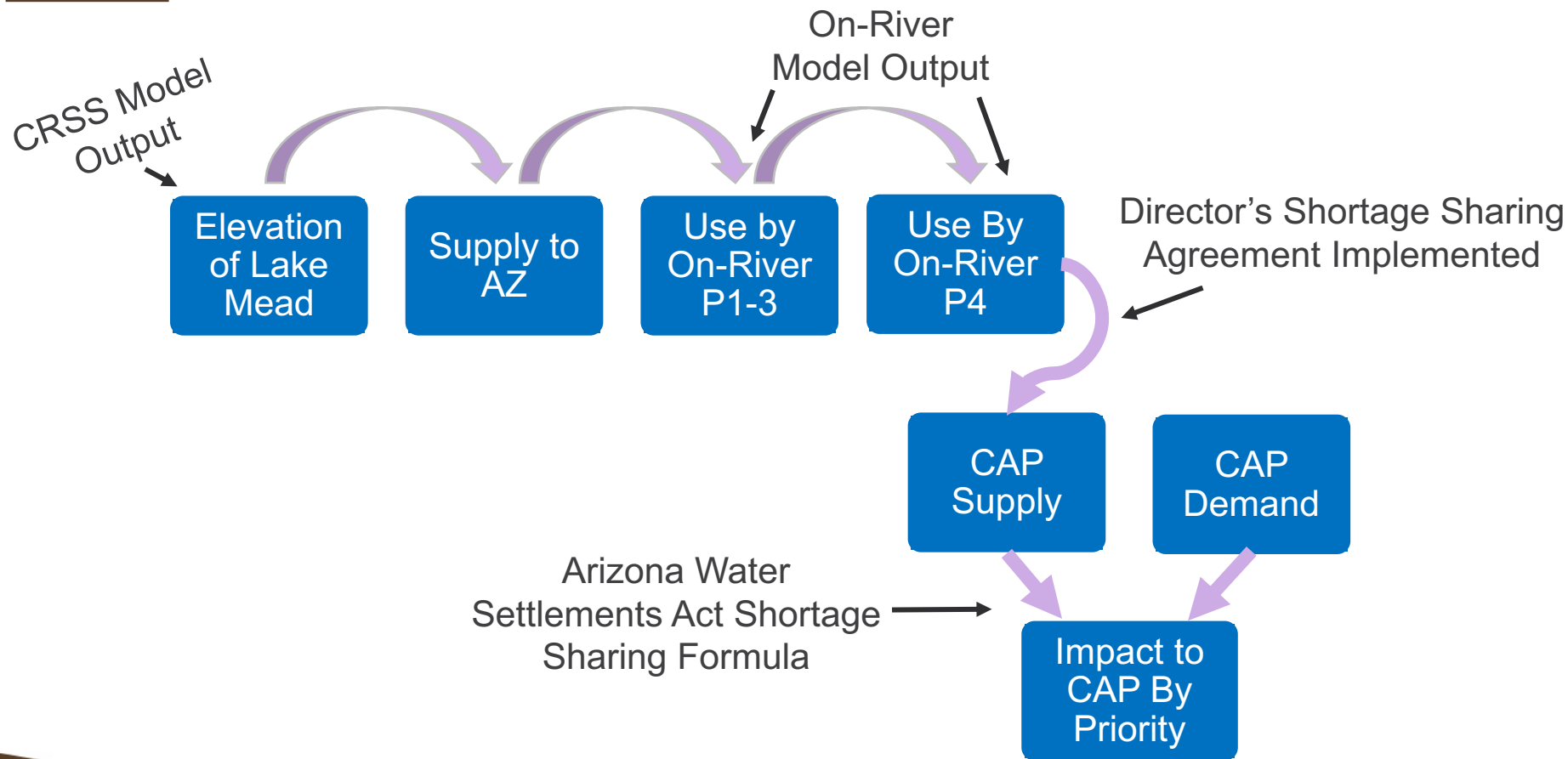
Joint Shortage Analysis Model (JSAM)

- Joint effort to develop shared analytical tools (ADWR, CAP & AWBA)
- Suitable for CAP shortage analysis at a pool level
- Designed for scenario planning
- Takes Lake Mead elevation output directly from CRSS and retains trace-level data



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JSAM Modeling Steps (Generalized)



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Key Factors Influencing Available CAP Supply and Impacts

- AZ Colorado River Supply
 - Function of Upper Basin Demand, System Operations, Hydrology, etc.
- On-River Demands
 - P1-3
 - P4 M&I and Ag
- CAP Demands
 - Utilization of existing Long-Term Contracts
 - Timing and magnitude of future allocation of NIA supplies
- Drought Response
 - Rate of LTSC accrual
 - Changes in annual direct demands

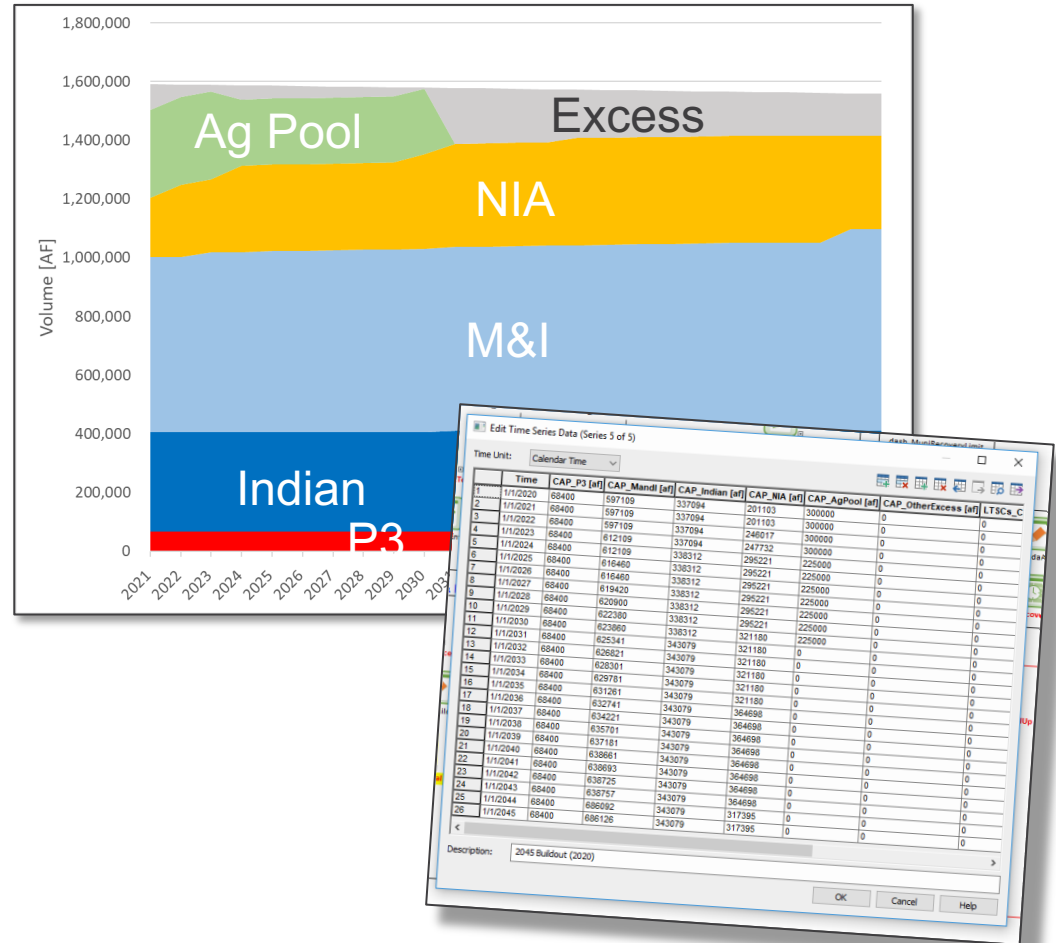
**CAP Driving
Forces in
JSAM**



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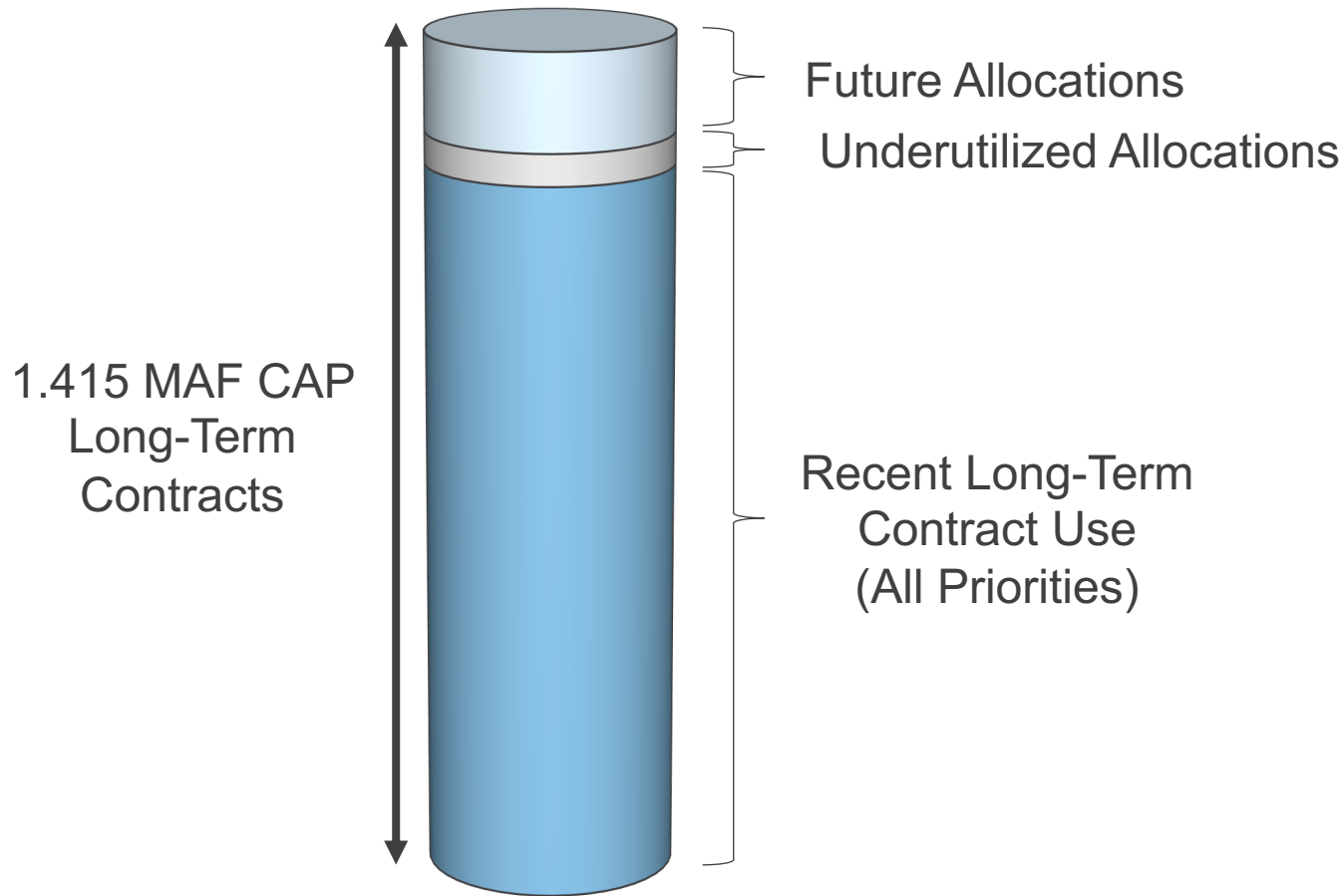
CAP Buildup Schedule

- Defines supply utilization through time at the pool level
- Includes both current and future uses
- Expressed as a time-series in JSAM



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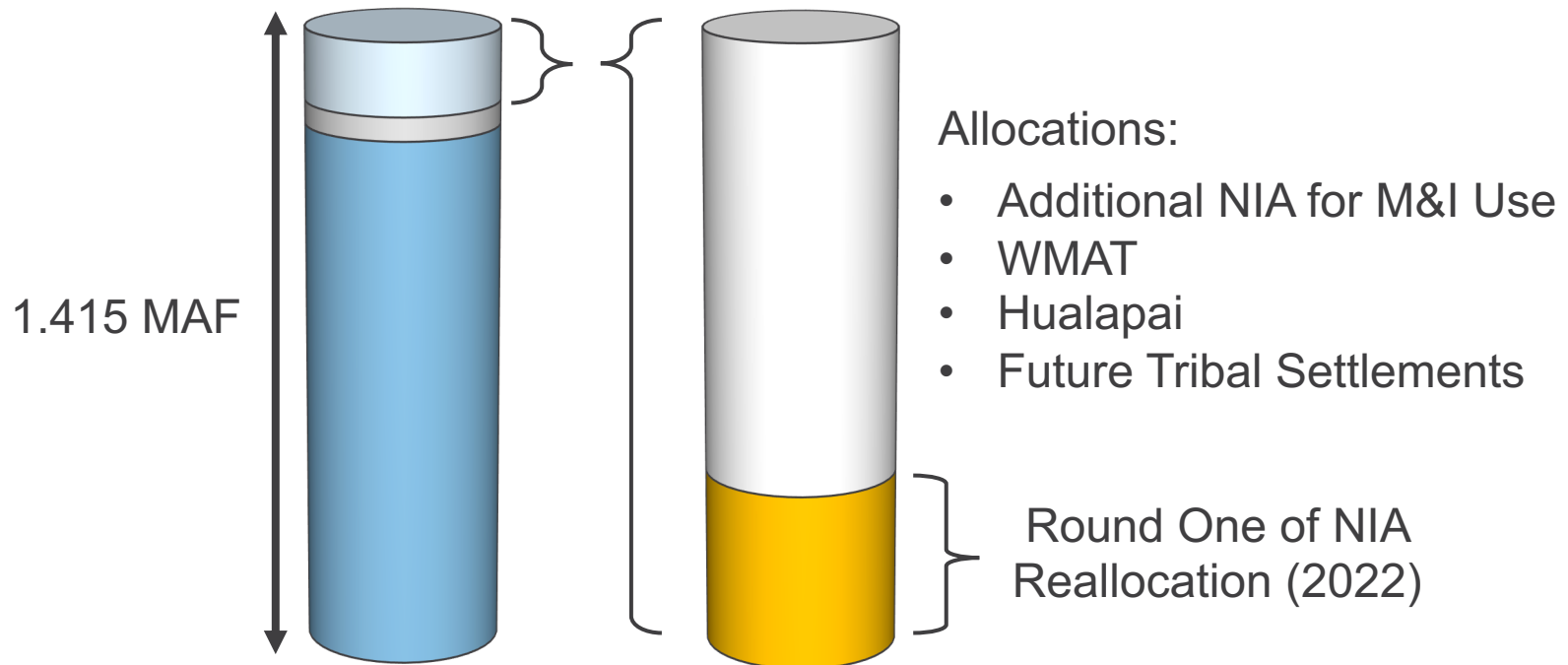
CAP Buildup Schedule



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CAP Buildup Schedule

Pending and Future Allocations (164,813 af)



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CAP Buildup Schedule

- Allocation of future supplies is uncertain
- JSAM allows for evaluation of different timing and magnitude
- The settings ultimately affect the point when all long-term contracts are allocated and used
 - e.g., 2040, 2050, or 2060

Joint Shortage Analysis Model [JSAM]

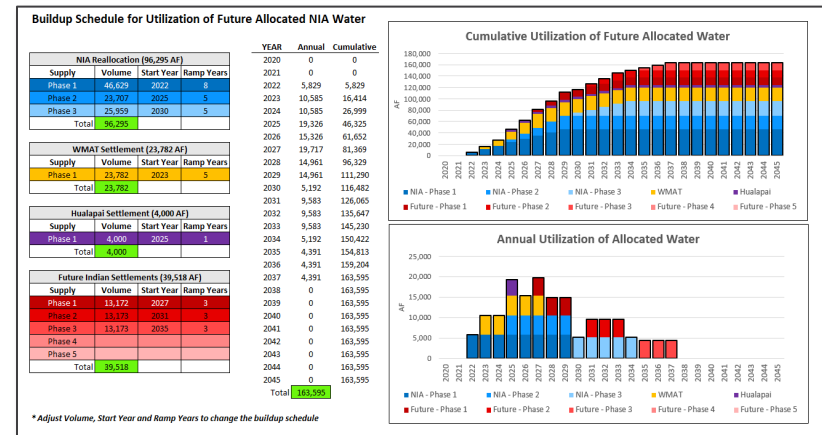
A scenario planning tool to evaluate and compare the impacts of Colorado River reductions on Arizona's On-River and CAP priority pools

A tool to define the utilization schedule for future NIA priority supplies

Supply Type Compute Buildup or Enter Manually? Start Year Full Utilization Year Full Utilization Volume

NIA Reallocation - Phase 1	Calculate	2021	2025	46629 AF	Buildup
NIA Reallocation - Phase 2	Calculate	2025	2029	23707 AF	Buildup
NIA Reallocation - Phase 3	Calculate	2030	2034	25959 AF	Buildup
Hualapai Settlement	Calculate	2025	2026	4000 AF	Buildup
WMAT Settlement	Calculate	2023	2027	23782 AF	Buildup
Future Indian Settlements - Phase 1	Calculate	2027	2029	13172 AF	Buildup
Future Indian Settlements - Phase 2	Calculate	2031	2033	13172 AF	Buildup
Future Indian Settlements - Phase 3	Calculate	2035	2038	13173 AF	Buildup

Main Dash



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Demand Response to Shortages

- JSAM can simulate reduced demands during shortage conditions
 - Cost
 - Drought response
 - Demand management
- Reduction in demand by pool is tied to shortage tiers

Joint Shortage Analysis Model [JSAM]

A scenario planning tool to evaluate and compare the impacts of Colorado River reductions on Arizona's On-River and CAP priority pools

Colorado River Supply

CRSS Hydrology: DNF 113 [View Data]

CRSS Scenario: ADVIR DNF As-Is 9/2020 [View Data]

Run Single Trace? ☐ Tiers: DCP

Lake Mead Elevation Nudge: No Nudge

On-River Demands

P1-3: Scenario 2 AZ Baseline (2020) [0.1% increase] [View Data]

P4: AZ Baseline (2020) 10-yr Avg [1% Muni grow] [View Data]

P4 Ag-to-Muni Conversion: Increase Muni by 1% per year

Drought Response

LTSC Reduction Percent by Tier: 25% Reduction

LTSC Reduction Scenario: NIA LTSCs Reduced First

Municipal Demand Reduction: Progressive to 10% in T

Export Results

Municipal Demand Reduction

Scenario	Tier 1	Tier 2a	Tier 2b	Tier 3
No Reduction	0%	0%	0%	0%
Progressive to 10%	0%	5%	7%	10%
Progressive to 20%	0%	10%	14%	20%



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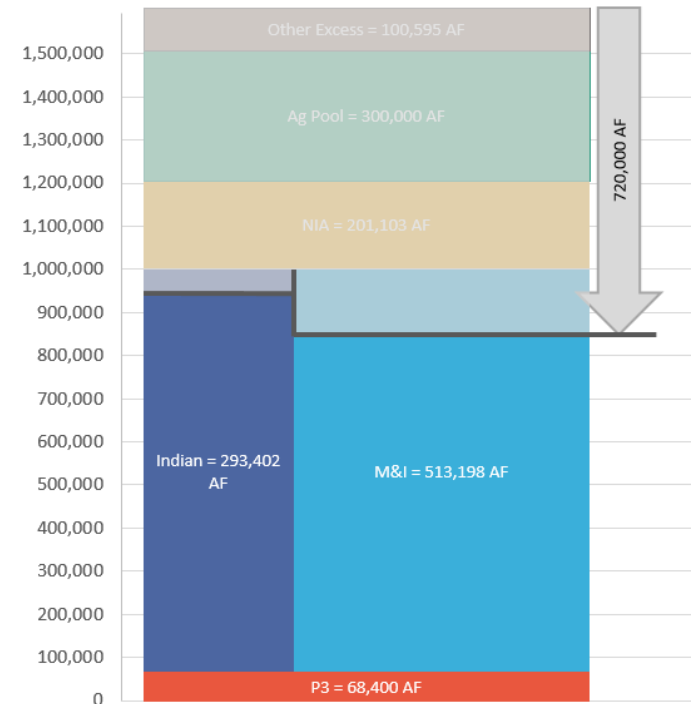
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Supply Availability by Priority



CAP Supply - *Test Case

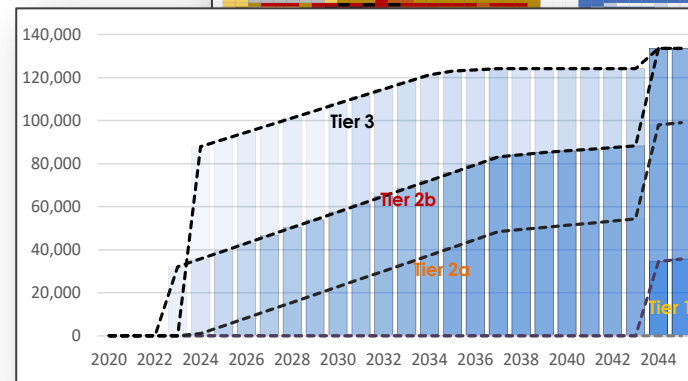
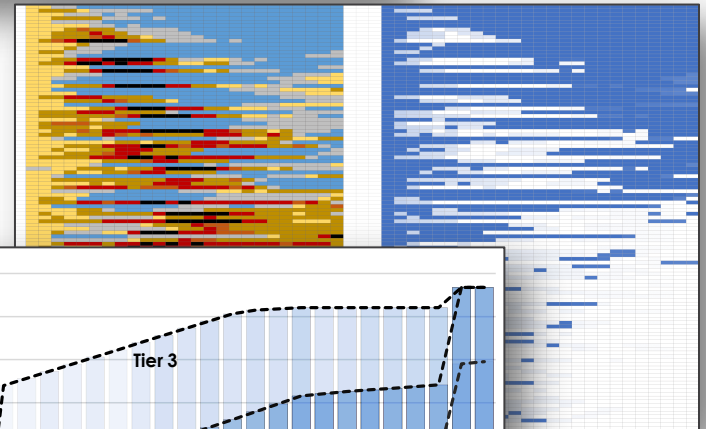
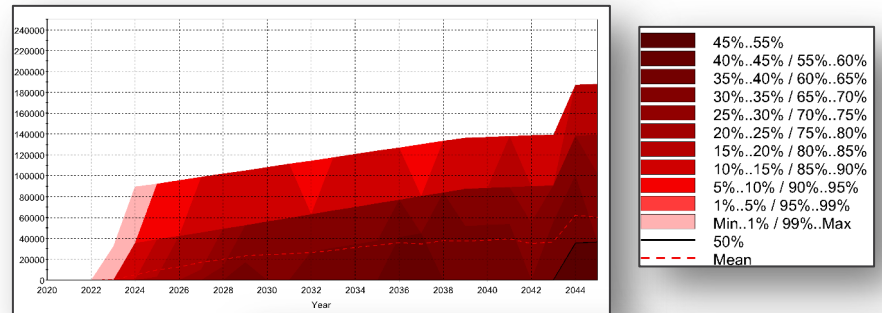
Total = 1,595,000 AF



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JSAM Visualizations

- JSAM generates a variety of outputs from each set of inputs from CRSS
 - Evaluated within the model or post-processed in Excel or R
- Recent examples include
 - Heatmaps
 - Histograms
 - Volume/Probability Charts



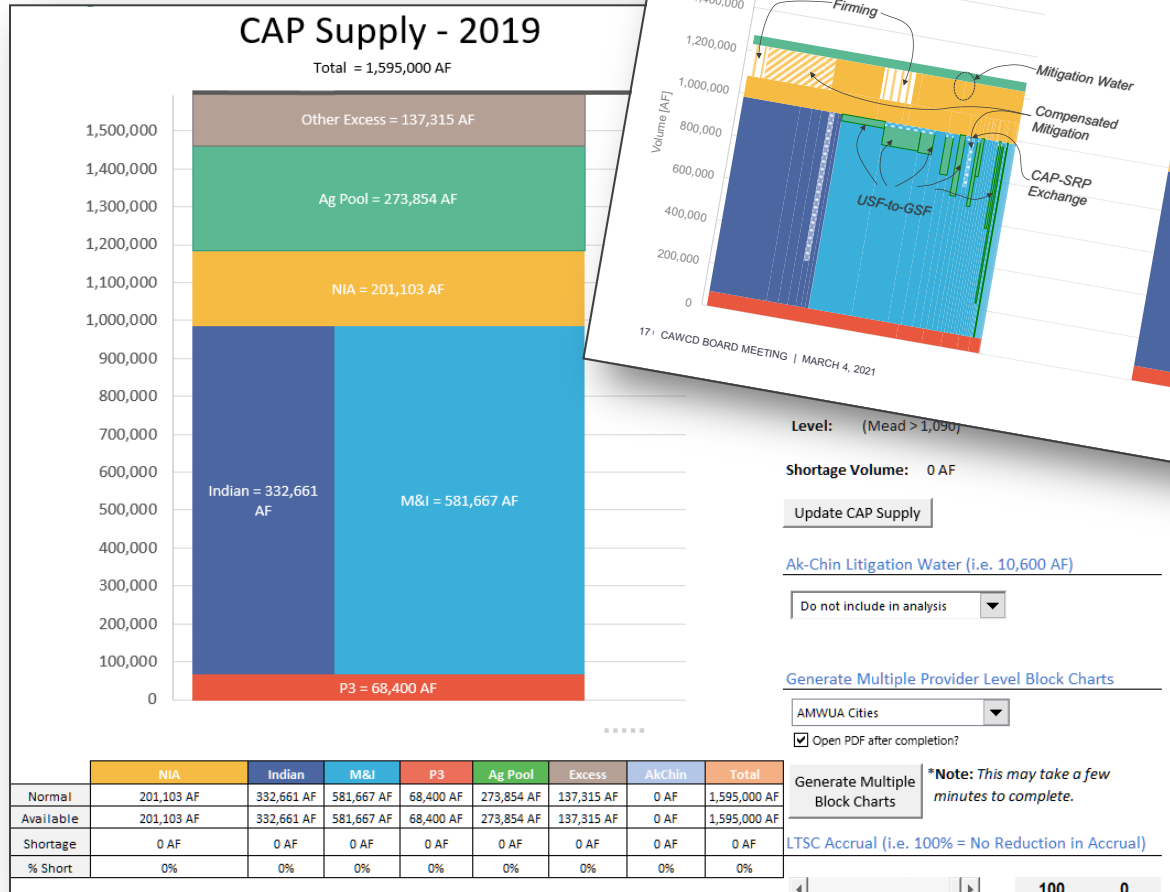
Additional Evaluation Tools

- During the AZDCP discussions a set of stand-alone interactive tools for visualizing and comparing scenarios was developed
 - Single-Year Tool
 - Single-Trace Tool
 - Multiple-Trace Tool
- Versions of these are being updated and refined to support MAWG and other efforts



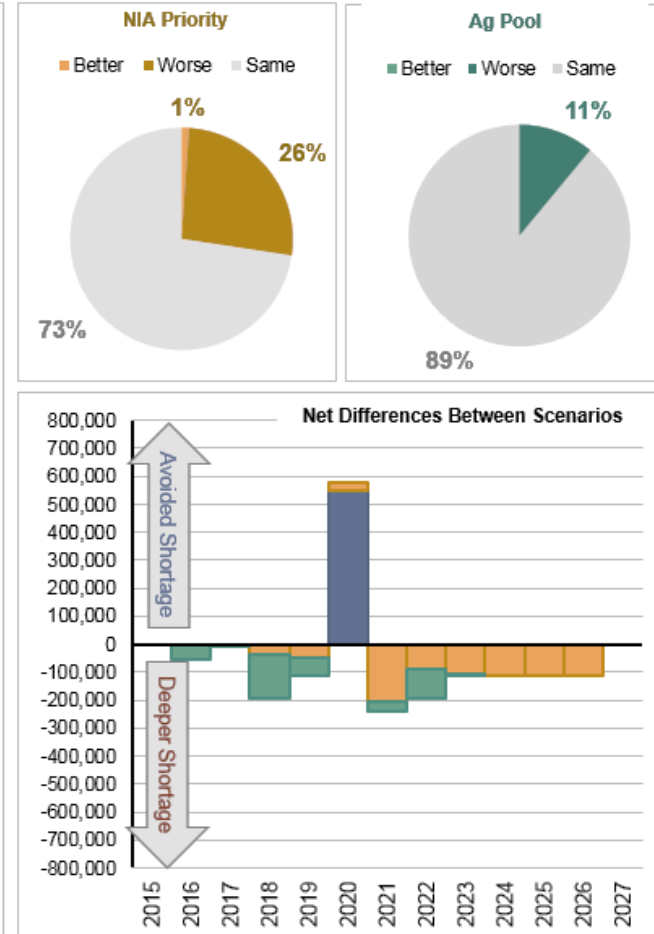
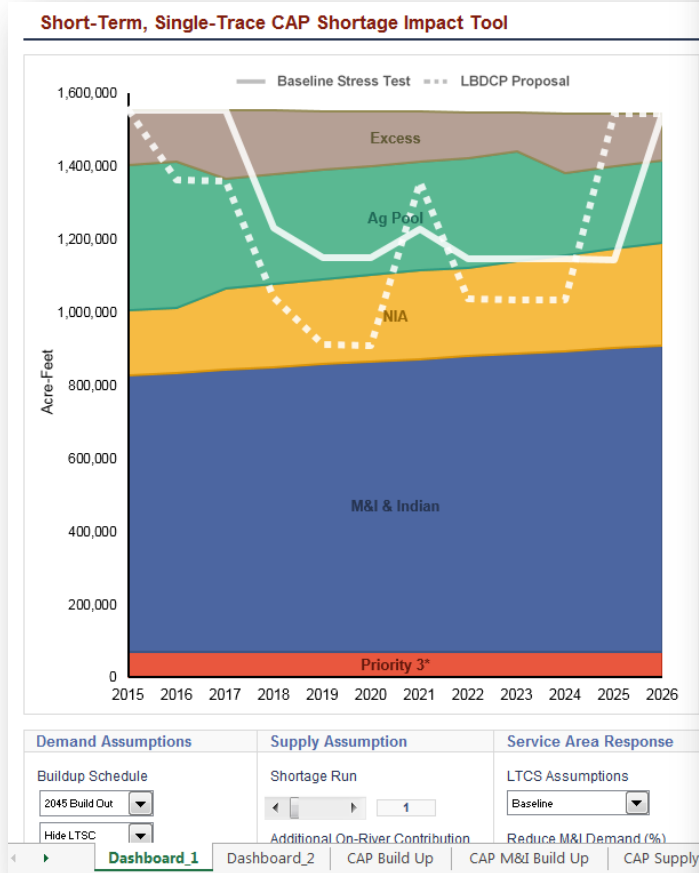
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Single-Year Tool



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Single-Trace Tool



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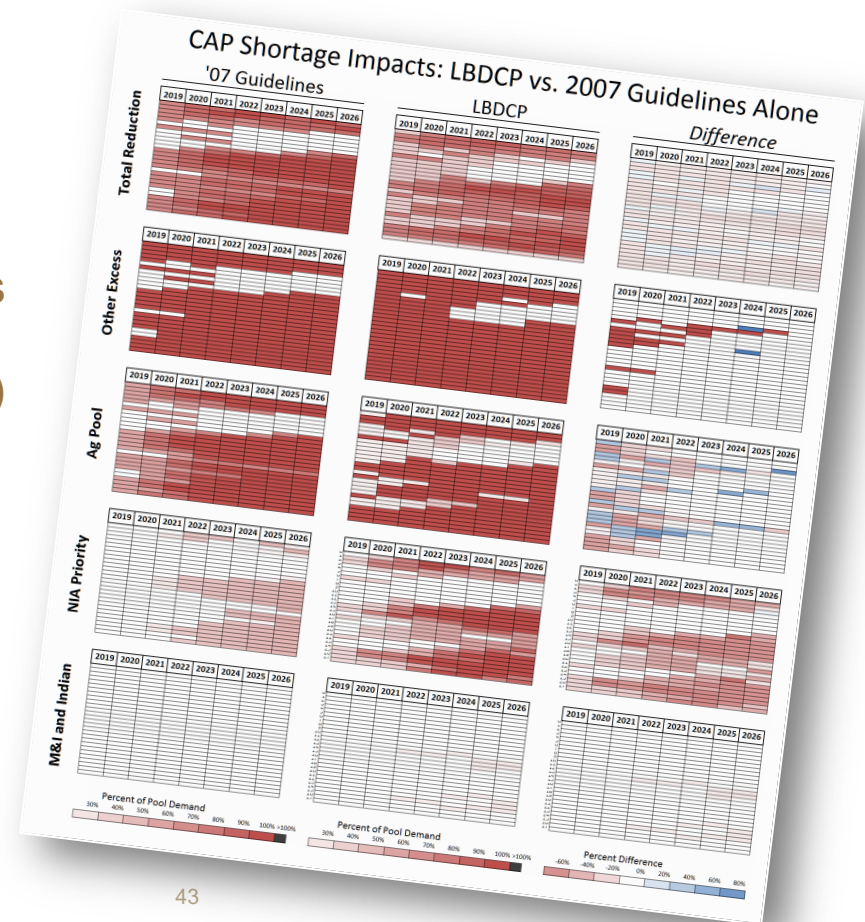
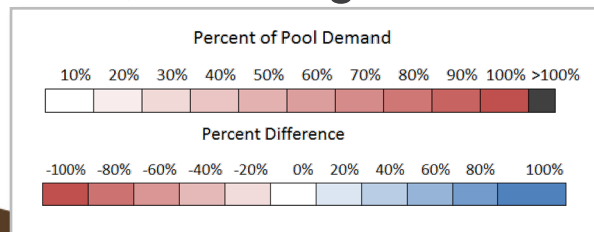
Multi-Trace Tool

Displays and manipulates all of the data points

- DCP analysis example: 28 Runs X 10 Years X ((4 Pools + 1 Total) X (2 Scenarios + 1 Comparison)) = **4,200** data points

Use of color coding allows both detailed and high-level information to be conveyed

- “Red is bad; Blue is good”

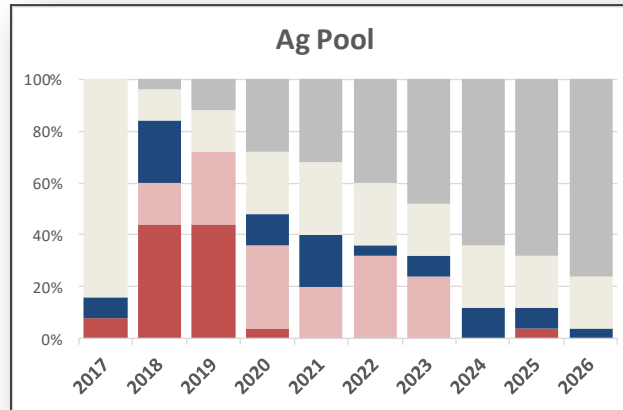
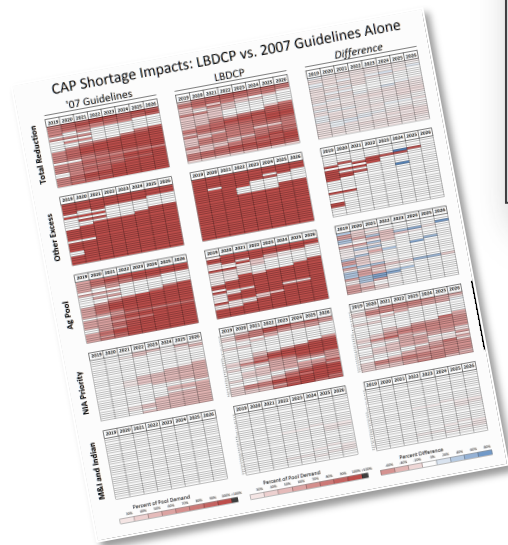


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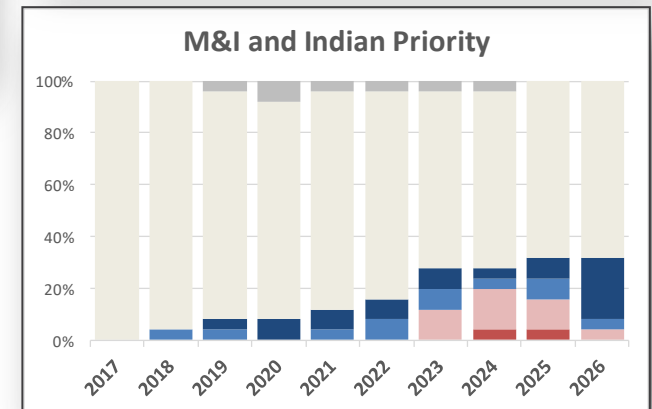
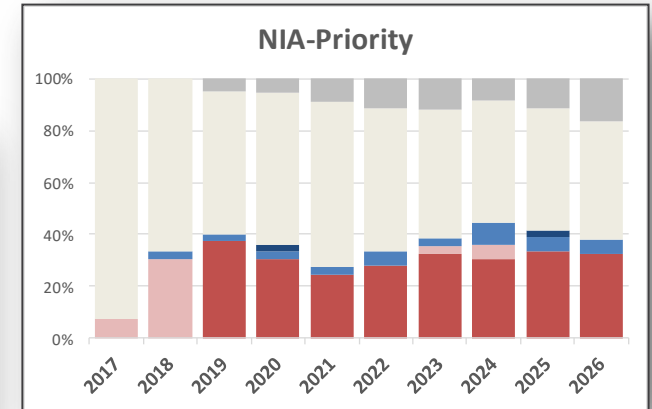
Multi-Trace Tool



Count by
Year

Legend

- No Change, No Supply
- No Change, Full Supply
- A Lot Better
- A Little Better
- A Little Worse
- A Lot Worse

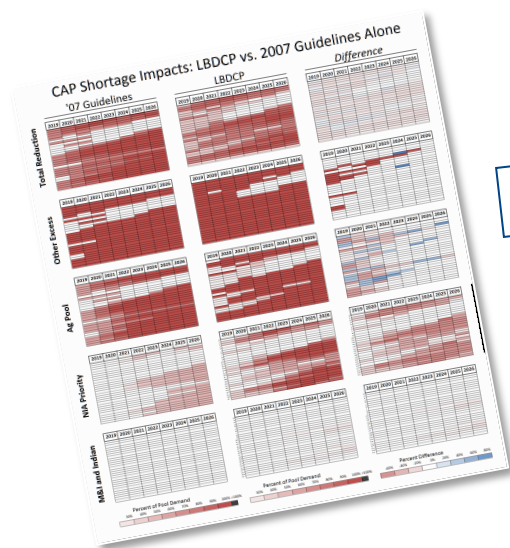


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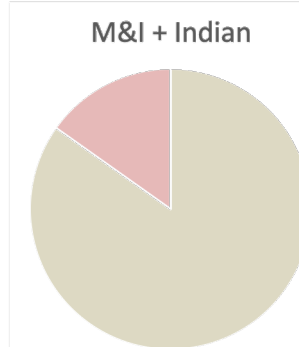
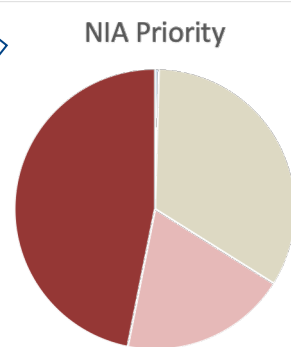
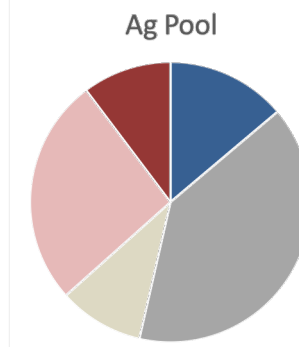
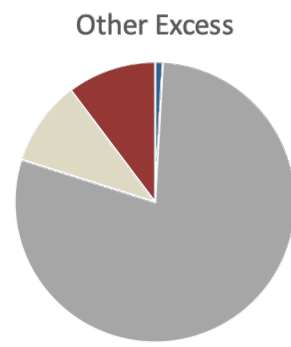


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Multi-Trace Tool



Count All Years



Legend

Available Supply

- A Lot More
- A Little More
- No Change, No Supply
- No Change, Full Supply
- A Little Less
- A Lot Less

Assumptions

- Stress Test Hydrology (1988-2015)
- USBR's April 2018 DCP CRSS Model
- 2019 through 2026
- Slice Size = # of occurrences
- "A Little" < 30%
- "A Lot" >= 30%



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CAP Shortage Impact Analysis

- The primary modeling tools and visualizations are available to simulate and analyze a wide range of plausible futures at the CAP priority pool level
- Additional refinements are expected based on feedback from the MAWG and ARC members, and the evolving needs of the Reconsultation process
 - The ability to evaluate differences in alternatives will become increasingly important



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Preview of MAWG #5 Scenario Development

- Review of modeling scenario components
 - Colorado River Basin
 - Arizona On-River
 - CAP
- Initial Conditions Scenario Development Exercise
- Recommendation(s) to ARC
- Modeling and analysis of results in follow up meetings
 - Post-confirmation by ARC



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Selection of Initial Scenario Components

Colorado River Basin

- Hydrology:
 - Observed
 - Pluvial Removed
 - Stress Test
 - Paleo Resampled
 - Paleo Conditioned
 - Downscaled GCM
- Upper Basin Demand:
 - 1999 Schedule
 - 2007 UCRC
 - USBR Basin Study (Current Projected)
 - 2016 UCRC
 - Guidelines Period Trend Extended
 - Average 2008-2018
- Operations:
 - DCP Extended



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Selection of Initial Scenario Components

Arizona On-River

- Uses:
 - Average 2008-2019
 - 0.1% Growth Trend
 - 0.2% Growth Trend
 - 0.1% Declining Trend
- Conservation/Salinity Management:
 - Current conservation and salinity management conditions



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Selection of Initial Scenario Components

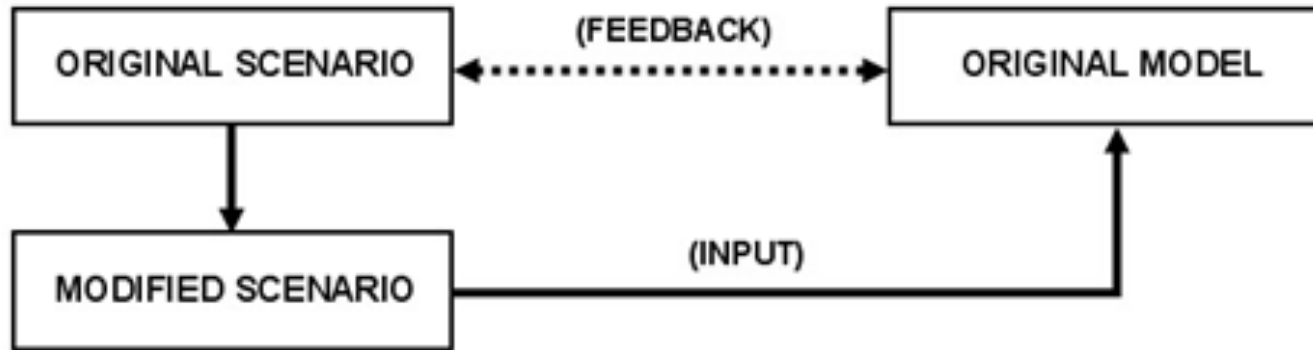
CAP

- Uses/Supply:
 - Trends in Long-term Contract Use
 - Low Growth
 - Medium Growth
 - High Growth
 - Timing and Magnitude of Future NIA Supply
 - Rapid
 - Slow
 - Drought Response Demand Management
 - No Demand Management
 - Moderate Management
 - Aggressive Management



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Scenario Development



Guidance on selection of scenario components:

- Each combination of scenario components represents a scenario
- Each scenario should target a particular theme, exploration, or goal
- The combination of scenario components for each scenario should be logical, plausible, and consistent
- Each scenario should be unique by selecting different combinations of scenario components for each scenario



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Summary

- On-River Uses average 1.135 MAF/yr, including conservation (2008 – 2019)
- 4 On-River Use Scenarios identified: Average Extended, 0.1 % Growth Trend, 0.2 % Growth Trend, 0.1% Declining Trend
- Yuma area drainage and salinity management impact consumptive use in AZ, influencing the supply available to CAP
- MSCP flow constraints will be evaluated as part of Reconsultation process
- CAP system modeling and analysis tools are available to evaluate impacts to CAP priority pools
- MAWG #5 – MAWG will develop Initial Conditions Scenarios



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MAWG #5 Initial Scenario Development Draft Agenda

- May 13, 2021 tentative date
- Colorado River Update
- Review of Key components
 - Basin Scale
 - On-River Scale
 - CAP Scale
- Initial Conditions Scenario Development Exercise
- Recommendation(s) to ARC
- Next Steps for MAWG



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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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