Water & Sustainability in the Southwest US

Jim Holway, Ph.D.
Board Member, Central Arizona Project

NSF - WET Center

Semi-Annual Meeting
December 8, 2016

SUSTAINABILITY

$$S = f(P * R * L * T * G + A)$$

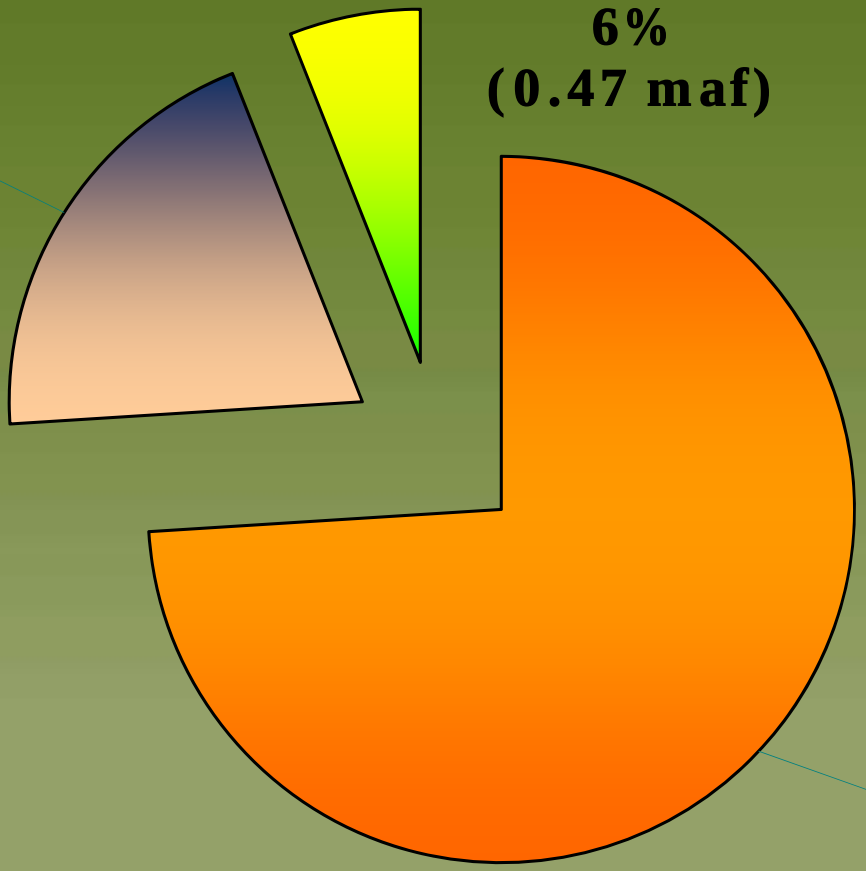
(state variables & change trajectories)

- **P: Population**
- **R: Resource Base (including Climate)**
- **L: Lifestyle (Consumption Patterns)**
- **T: Technology for Managing Resources**
- **G: Governance**
- **A: Adaptation (Resilience)**

Arizona Water Supply
Annual Water Budget

Water Source	Million Acre-Feet (maf)	% of Total
SURFACE WATER		
Colorado River	2.8	37.8 %
CAP	*1.6*	*22%*
On-River	*1.2*	*16%*
In-State Rivers	1.4	18.9%
Salt-Verde	*1.0*	*14%*
Gila & others	*0.4*	*5%*
GROUNDWATER	2.9	39.2%
RECLAIMED WATER	0.3	4.1%
Total	7.4 maf	

Arizona Consumption



Sources: ADWR, UofA, USGS

Colorado River Compact Allocations

Upper Basin (7.5 MAF)

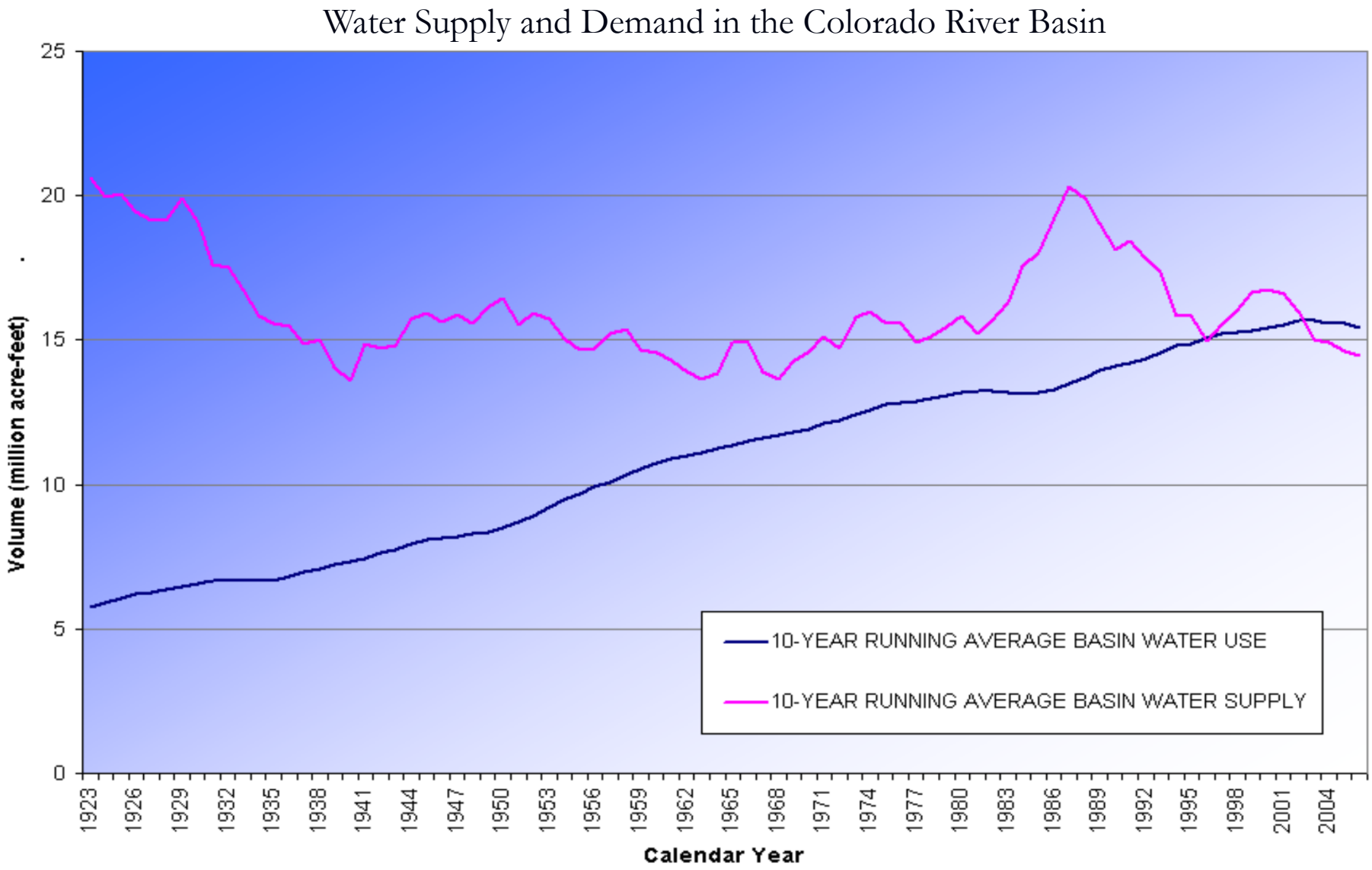
- **CO - 51.75%**
- **WY - 14%**
- **UT - 23%**
- **NM - 11.25%**
- **AZ - 50,000 af**

Lower Basin (7.5 MAF)

- **CA – 4.4 MAF**
- **AZ – 2.8 MAF**
- **NV – 0.3 MAF**

Mexico 1.5 MAF

Growing Competition…



Water and …..

DRIVING FORCES

- Growth
- Energy
- Climate

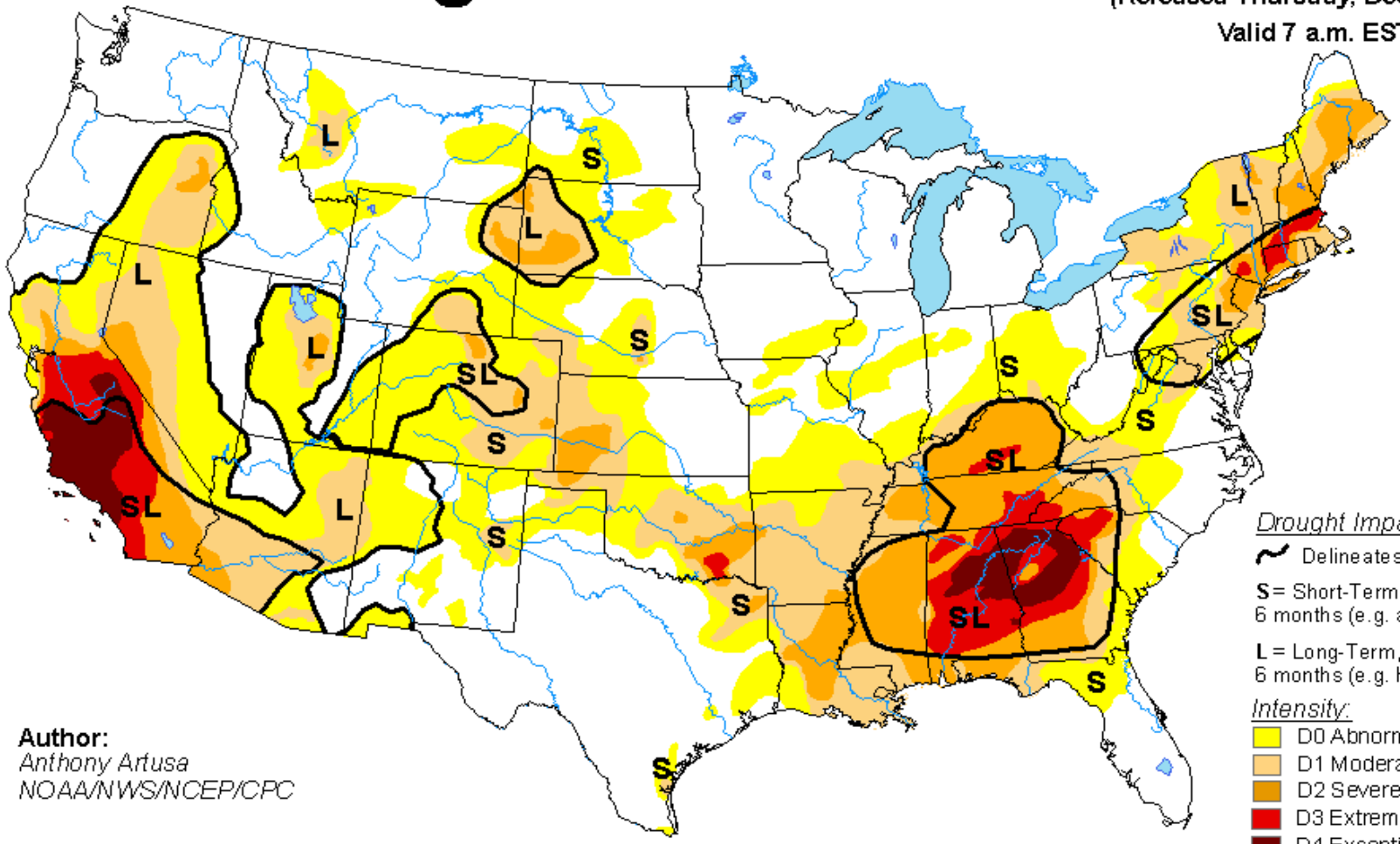
- Agriculture…. Is this the source ?
- Environment ….. Is anything left ?

U.S. Drought Monitor

December 6, 2016

(Released Thursday, Dec. 8, 2016)

Valid 7 a.m. EST



Author:
Anthony Artusa
NOAA/NWS/NCEP/CPC

Drought Impact Types:

Delineates dominant impacts

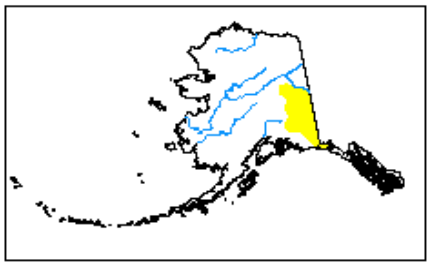
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

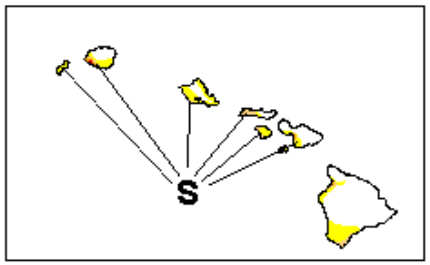
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

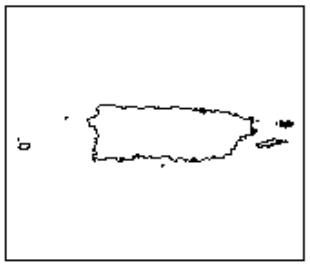
Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.







USDA

National Drought Mitigation Center

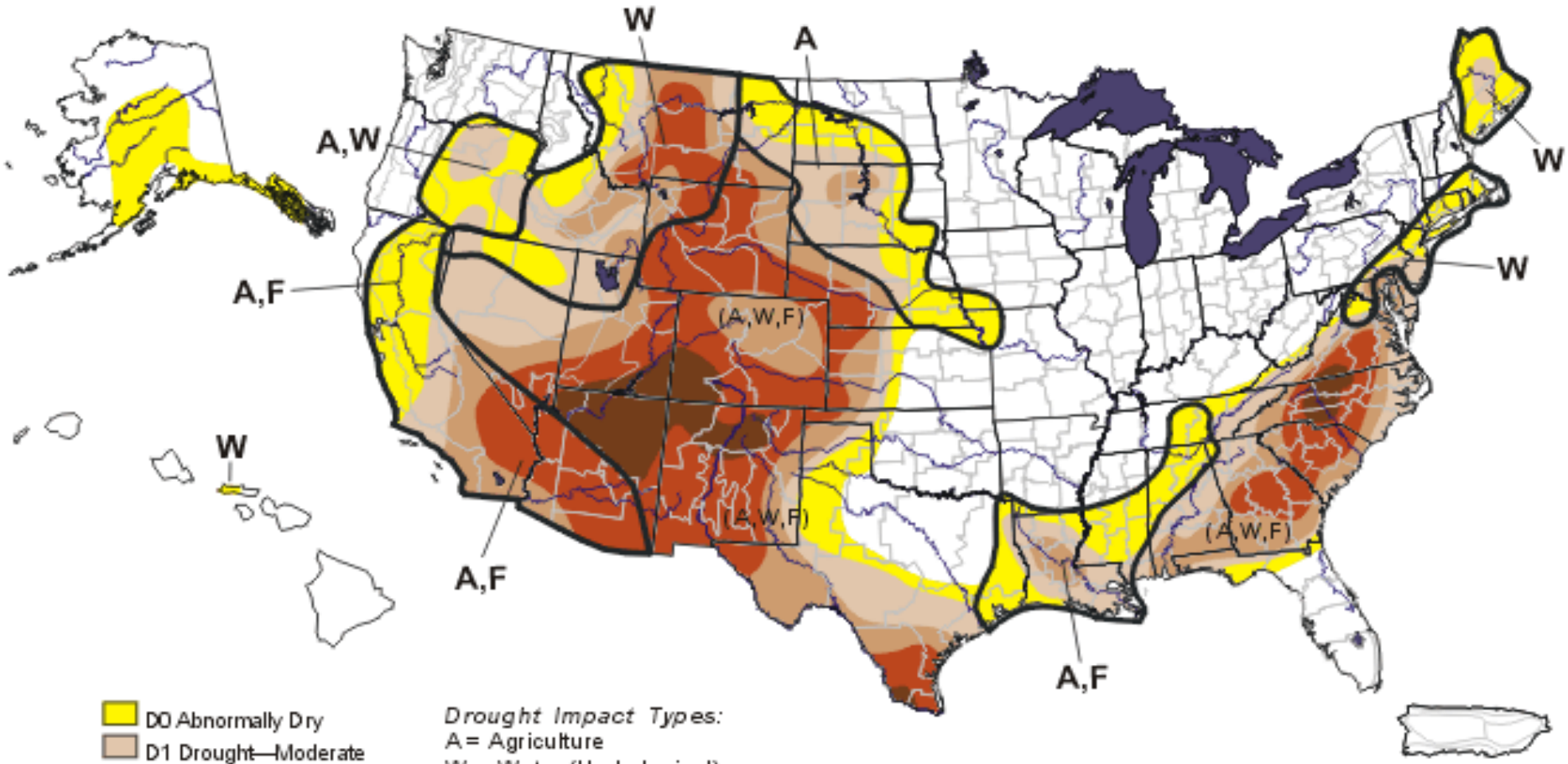
NOAA

http://droughtmonitor.unl.edu/

U.S. Drought Monitor

June 25, 2002

Valid 8 a.m. EDT



D0 Abnormally Dry
D1 Drought—Moderate
D2 Drought—Severe
D3 Drought—Extreme
D4 Drought—Exceptional

Drought Impact Types:
A = Agriculture
W = Water (Hydrological)
F = Fire danger (Wildfires)
Delineates dominant impacts
(No type = All 3 impacts)

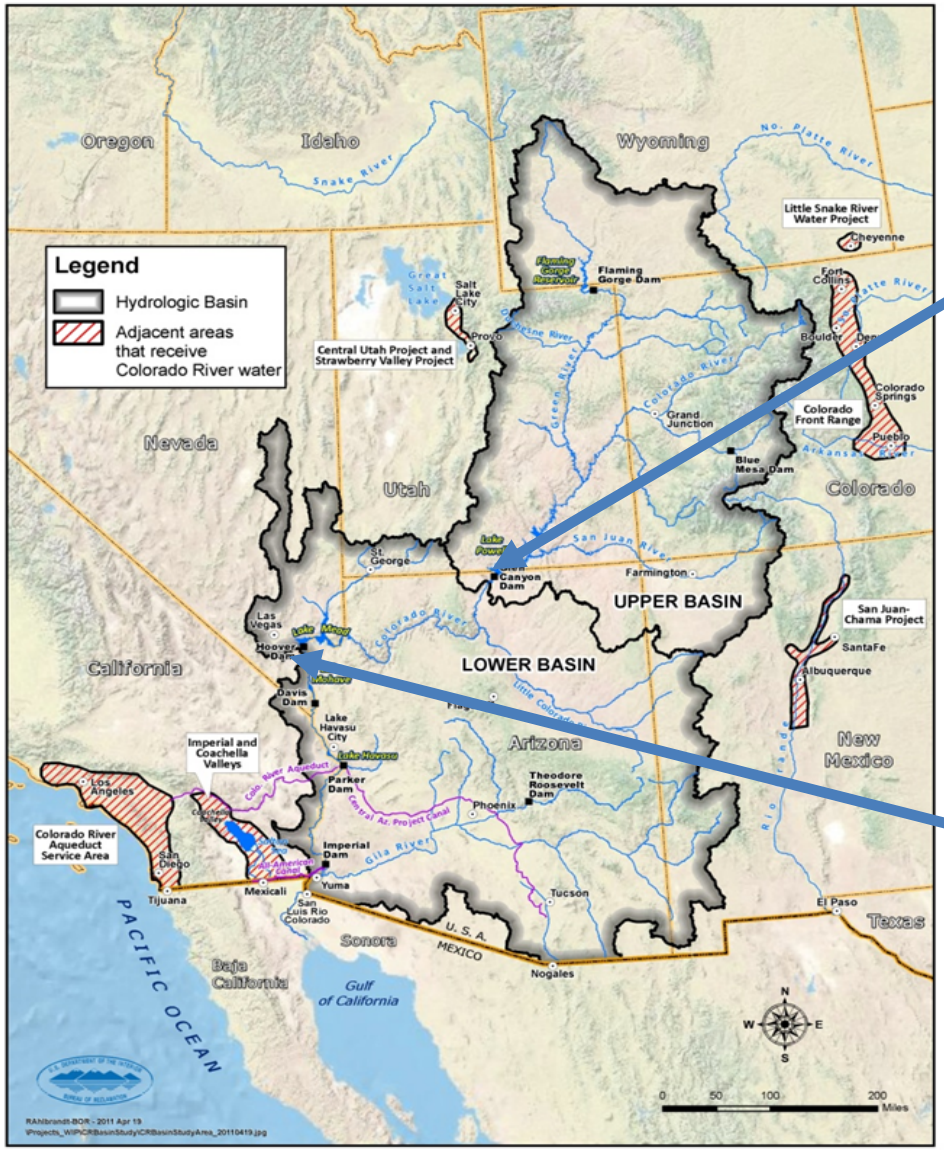
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

Released Thursday, June 27, 2002

Author: *David Miskus, JAWF/CPC/NOAA*

Lake Mead and Lake Powell: Backbone of the Colorado River



1/1/2000 87% Full
(21.3 MAF)

9/05/2016
54% Full
(13.0 MAF)

Lake Powell

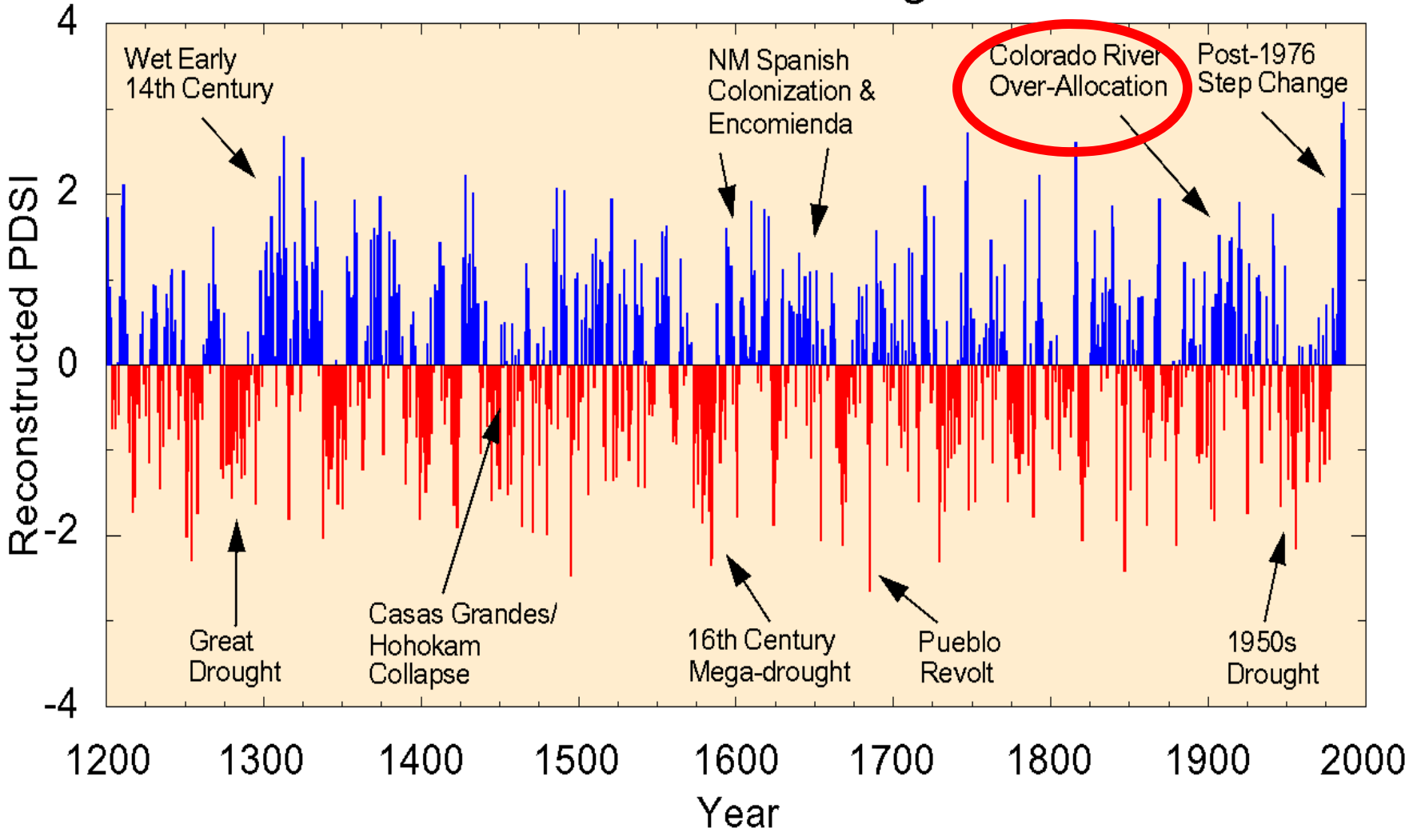
1/1/2000 91% Full
(25 MAF)

9/05/2016
37% Full
(9.6 MAF)

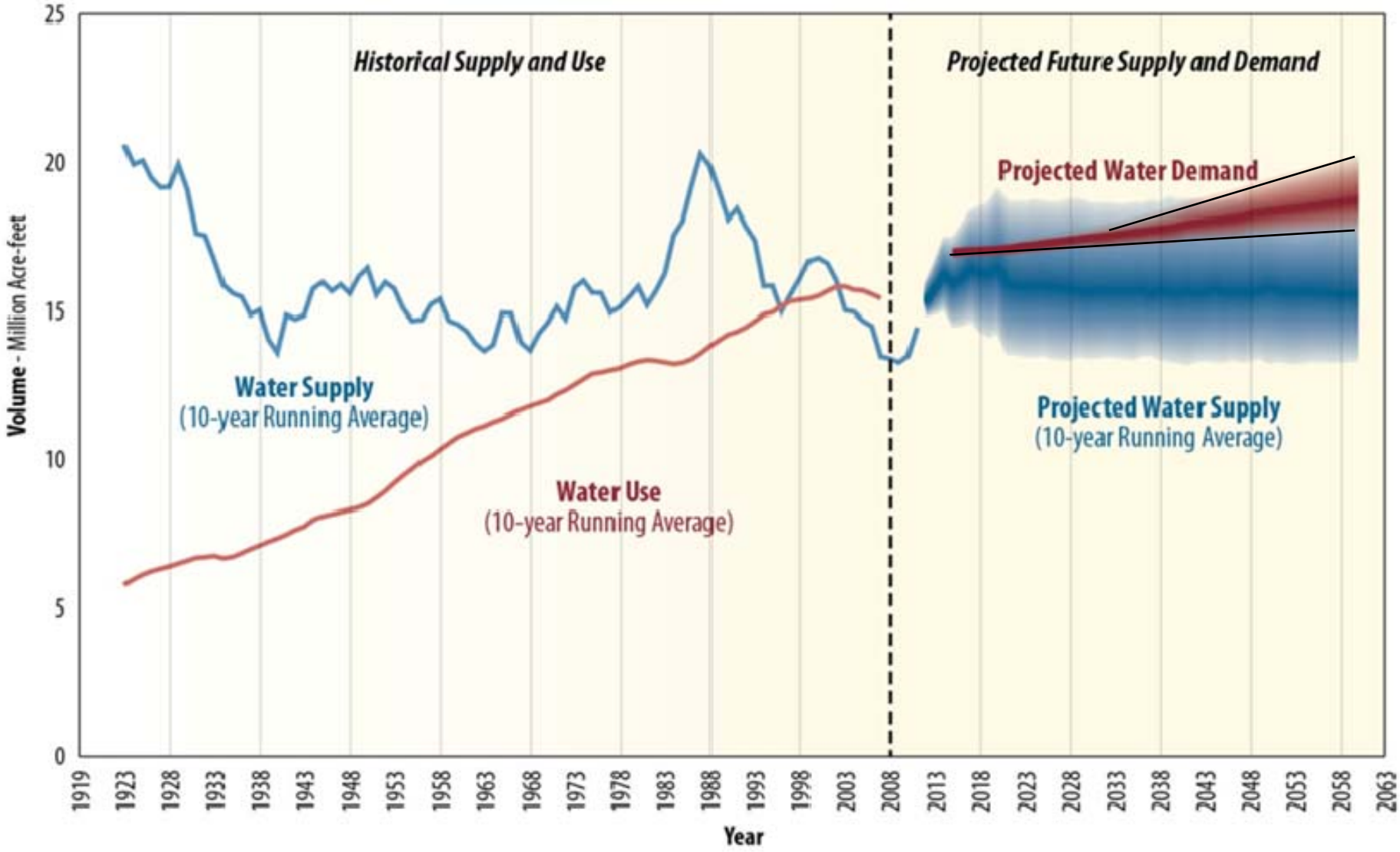
Lake Mead

CAP
CENTRAL ARIZONA PROJECT

Cook's Southwest Drought Index

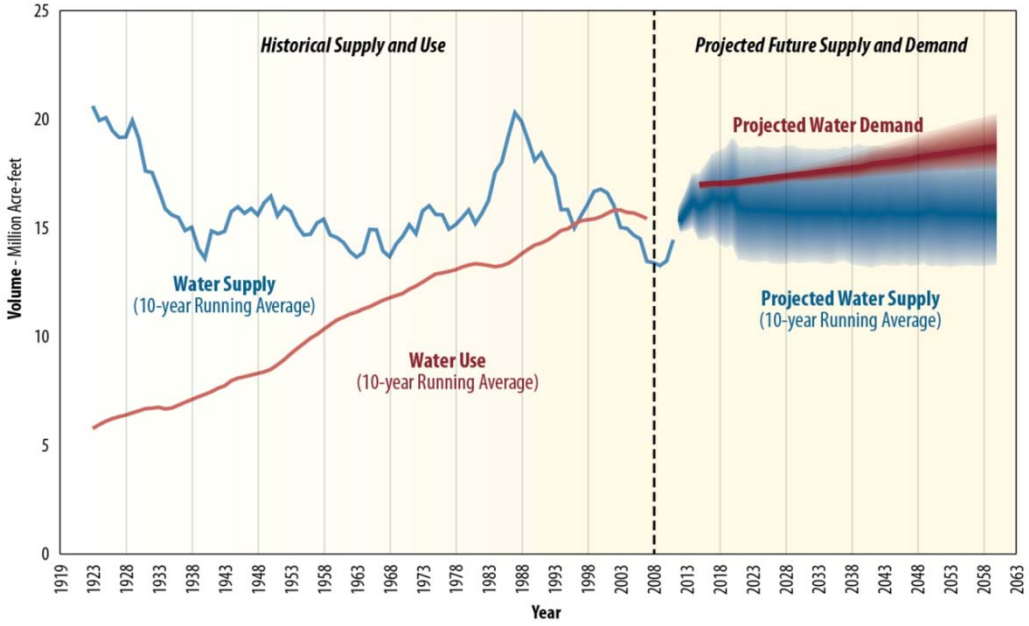


Significant Cultural Events


Historical Supply and Use
Projected Future Supply and Demand
Projected Water Demand
Water Supply
(10-year Running Average)
Water Use
(10-year Running Average)
Projected Water Supply
(10-year Running Average)
Volume - Million Acre-feet
Year
0
5
10
15
20
25
1919
1923
1928
1933
1938
1943
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023
2028
2033
2038
2043
2048
2053
2058
2063

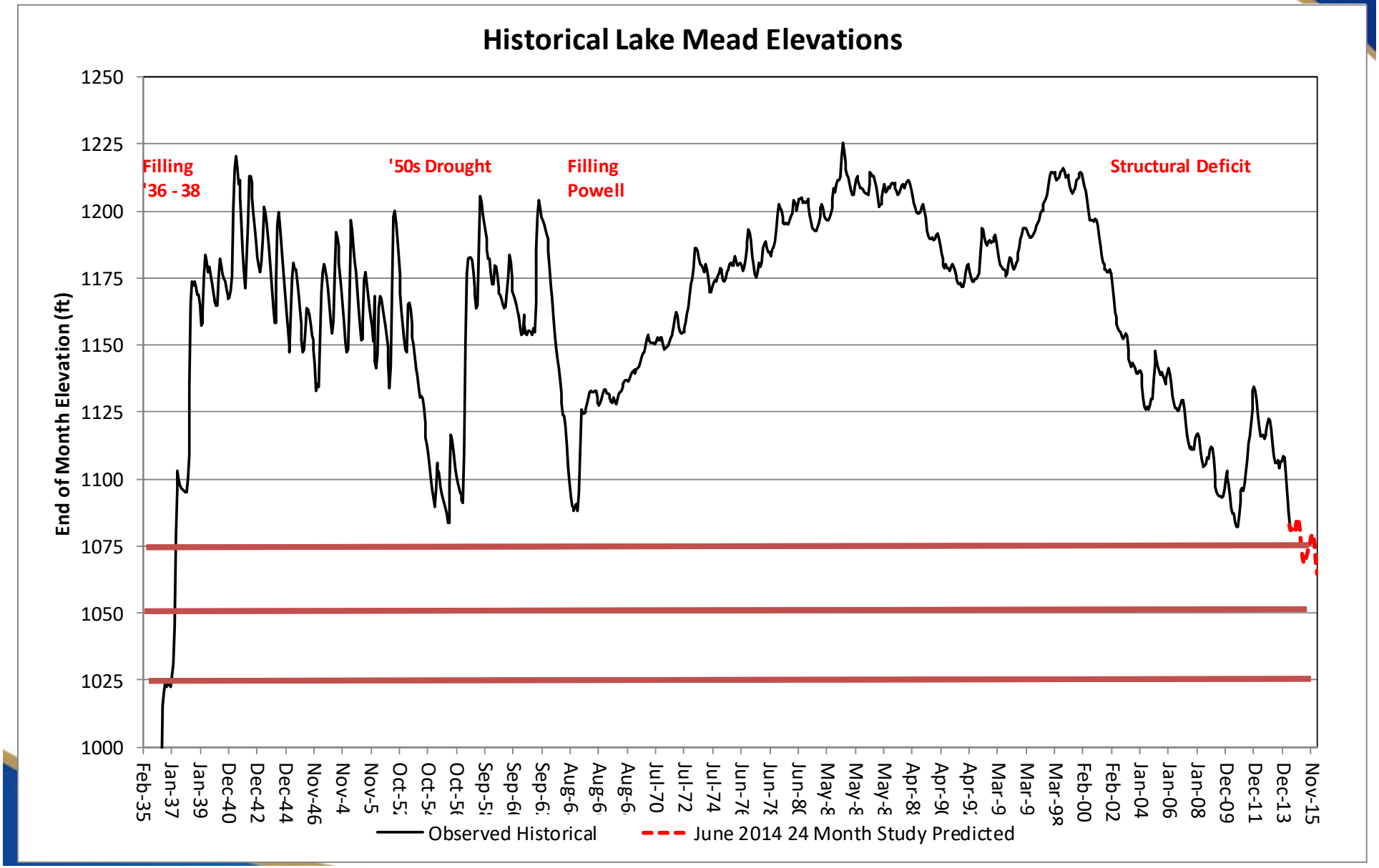
Colorado River Basin Supply and Demand Study

- Study was first of its kind to incorporate GCM downscaled projection in quantifying future water supply for Colorado River
- Modeling impact of climate change on water supply through downscaled GCM projected scenario results in decrease of 9% in mean streamflow in basin by 2060
- Basin study determined median imbalance in supply and demand of 3.2 MAF, under GCM projected water supply scenario this imbalance is approximately 5 MAF



CAP
CENTRAL ARIZONA PROJECT

Lake Mead Historical Operating Range & Shortage Tiers



The Problem

- The Colorado River system is in a fragile state due to years of drought compounded by the “structural deficit”
- Storage in Lake Mead is in critical decline
- There is uncertainty about what actions the Secretary may take to protect storage if Lake Mead goes below 1025’
- CAP’s bears the brunt of impacts due to our junior priority

CAP
CENTRAL ARIZONA PROJECT

Water Budget at Lake Mead

- Inflow = 9.0 maf
  (release from Powell + side inflows)
- Outflow = - 9.6 maf
  (AZ, CA, NV, and Mexico delivery
  + downstream regulation and gains/losses)
- Mead evaporation losses = - 0.6 maf
- Balance = - 1.2 maf

Given basic apportionments in the Lower Basin, the allotment to Mexico, and an 8.23 maf release from Lake Powell, Lake Mead storage declines about 12 feet each year

RECLAMATION

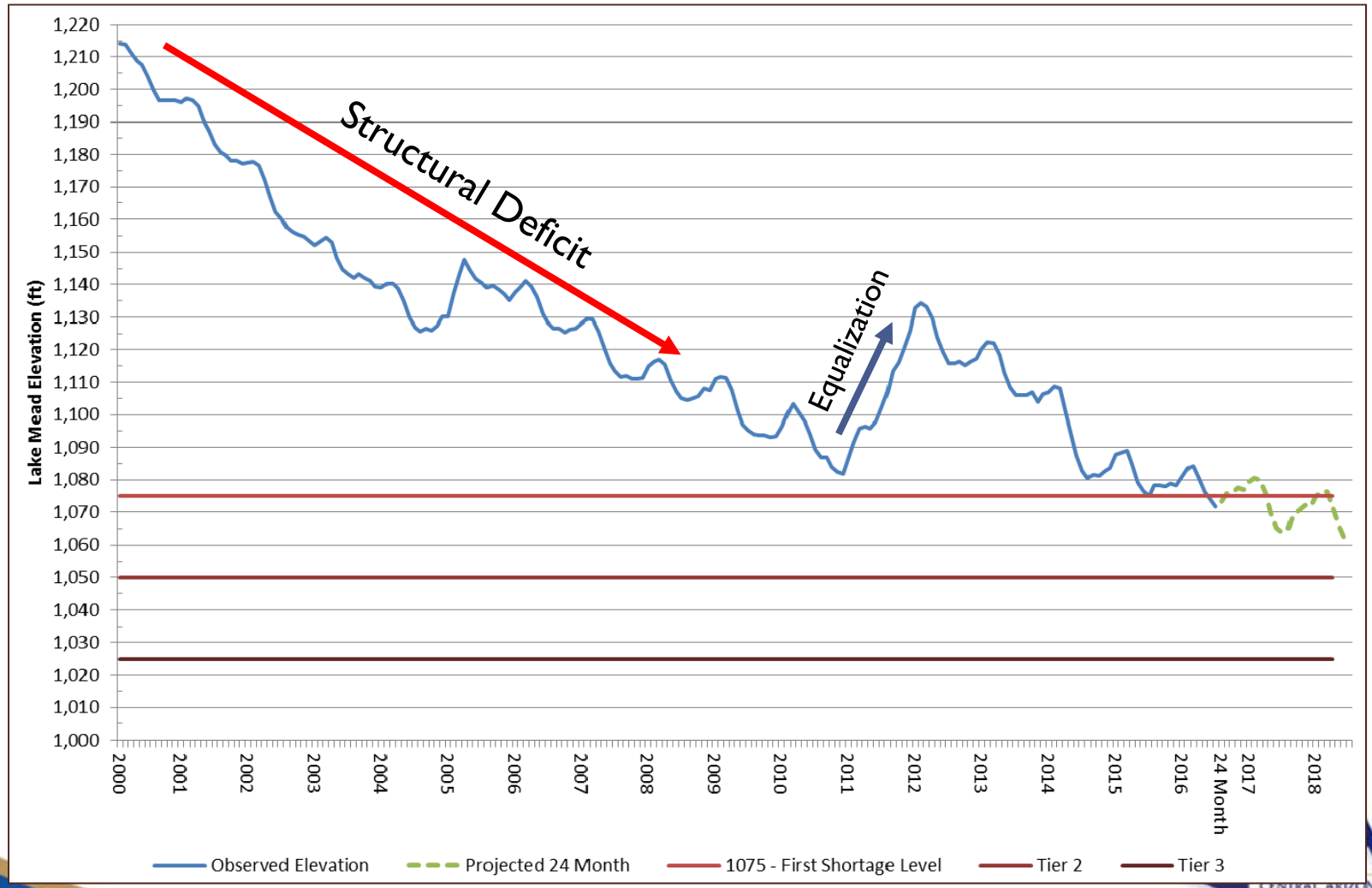
Impacts of the Structural Deficit

- Results in a decline of 12+ feet in Lake Mead every year when releases from Powell are “normal” (8.23 MAF)
- Results in a decline of 4 feet in Lake Mead every year when releases from Powell are “balancing” (9.0 MAF)
- Drives Lower Basin to shortage
- CAP forced to bear obligations of others
  - Evaporation and other system losses
  - Lower Basin’s half of Mexican Treaty obligation

CAP
CENTRAL ARIZONA PROJECT

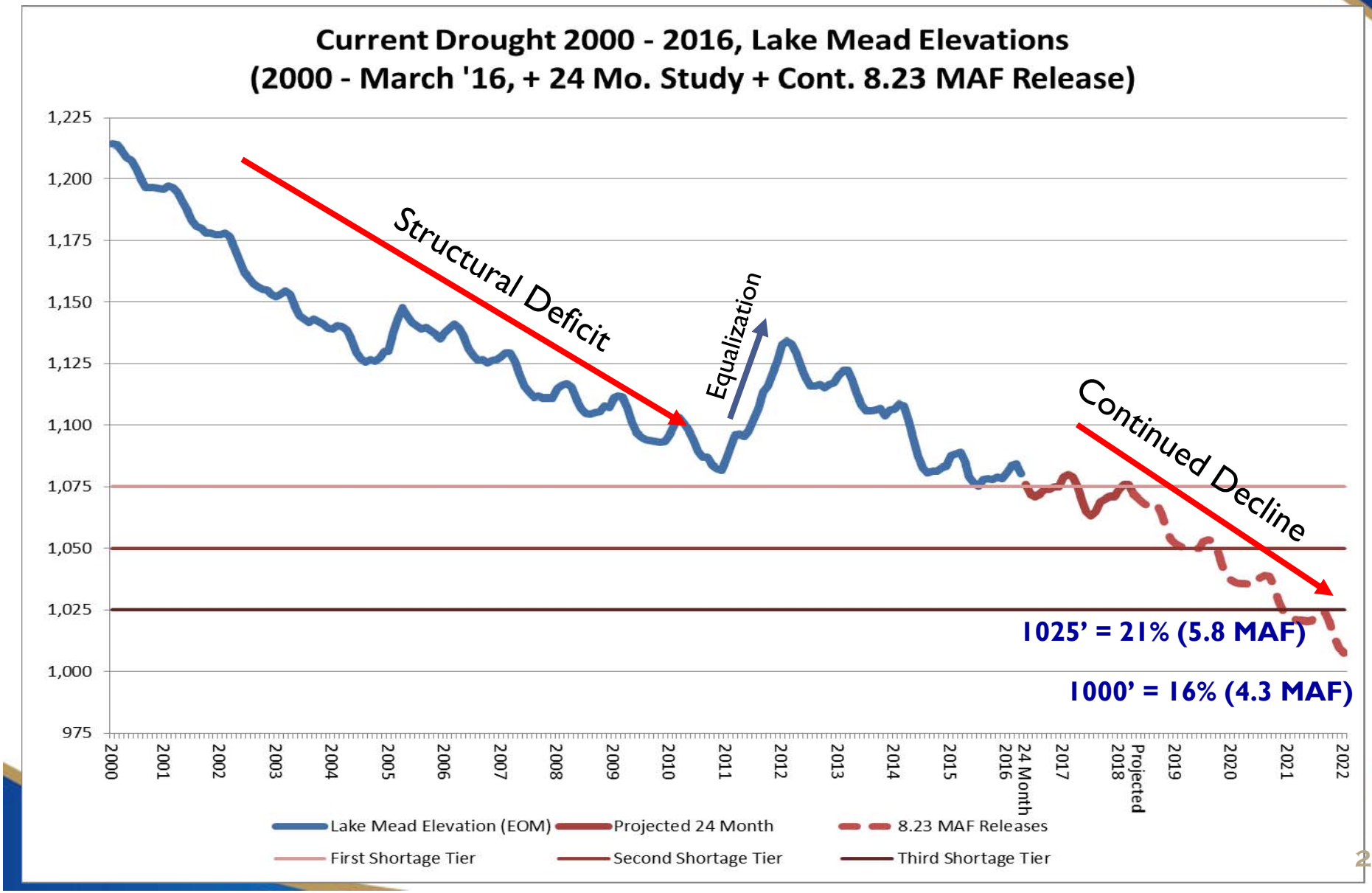
Lake Mead Elevations

Historic Levels, with July 2016 to July 2018 Projection



CENTRAL ARIZONA PROJECT

Continued Lake Mead Declines with Normal Releases



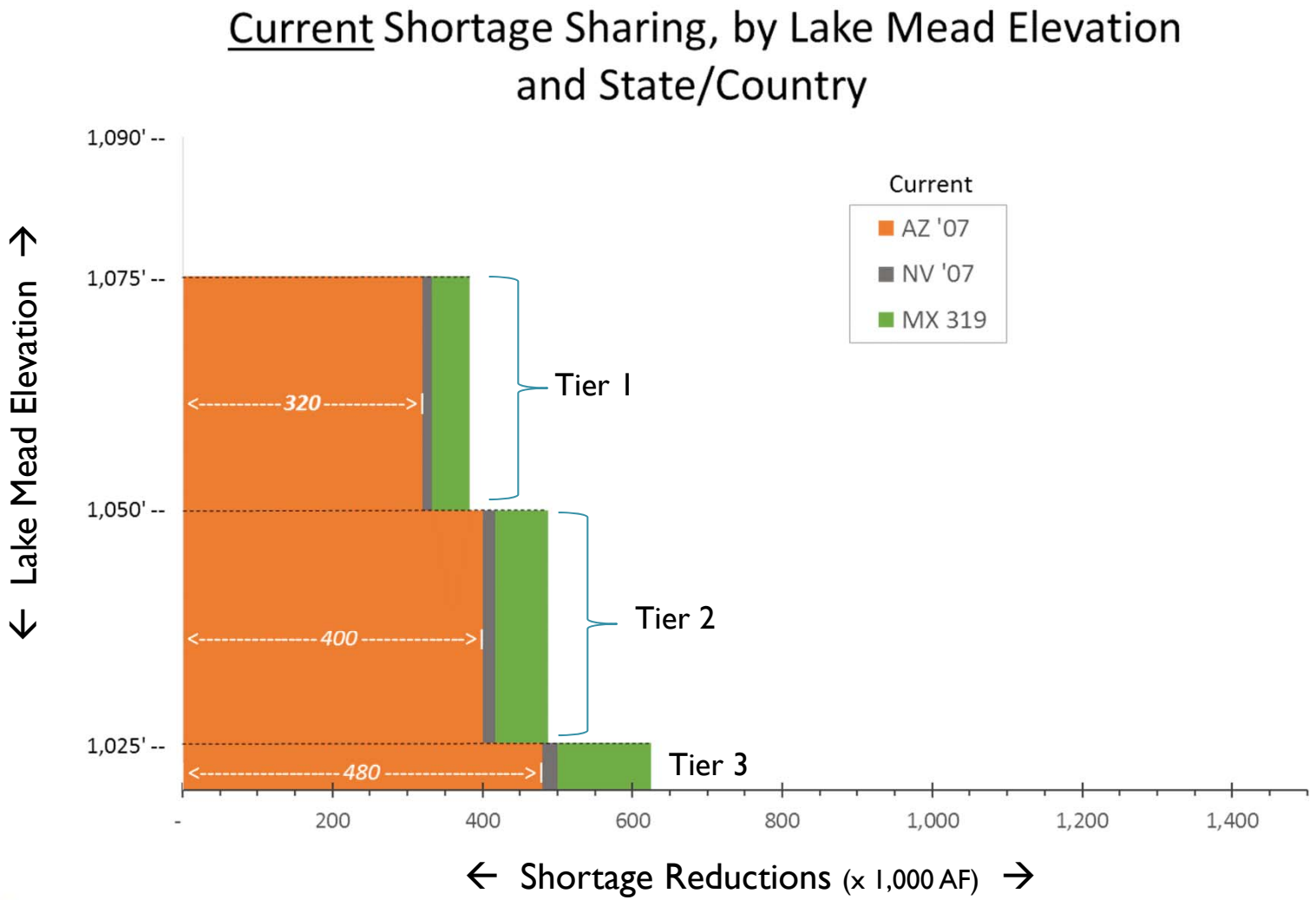
2007 Guidelines Shortage Sharing

- Based on Reclamation's August 24 Month Projection of Jan 1, Lake Mead elevation,
- Arizona and Nevada share Lower Basin shortages under the 2007 Guidelines
- Mexico voluntarily agreed in Minute 319 to accept reductions in its deliveries at the same elevations

Lake Mead Elevation	Arizona Reduction	Nevada Reduction	Mexico Reduction
1075'	320,000 AF	13,000 AF	50,000 AF
1050'	400,000 AF	17,000 AF	70,000 AF
1025'	480,000 AF	20,000 AF	125,000 AF

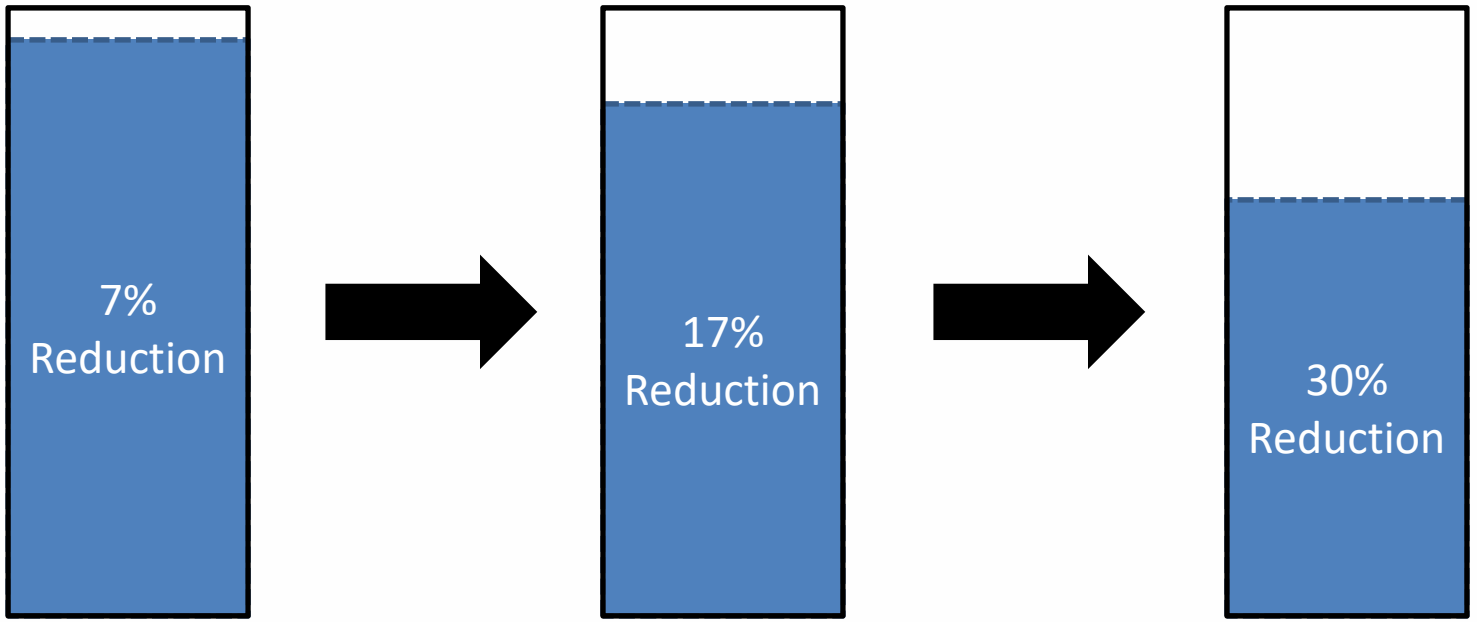
CAP
CENTRAL ARIZONA PROJECT

2007 Guidelines + Minute 319



Impact of Water Shortage due to Climate Change

To put it a Tier 3 shortage in perspective…



Lower Colorado River Basin
(Tier 3 Short: Interim Guidelines)

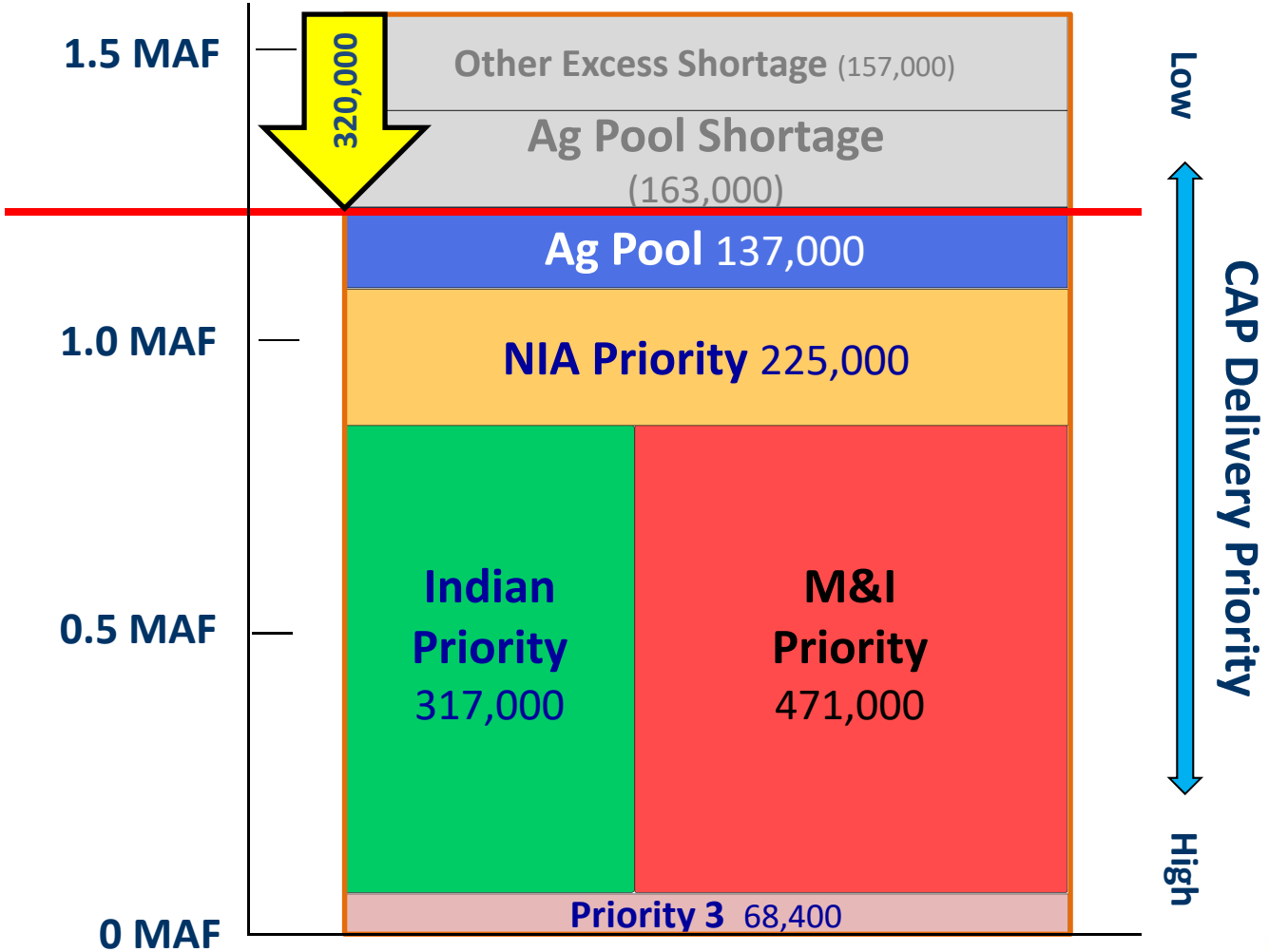
Arizona
(Average 2006-2010 On-River Use)

Central Arizona Project

Under current water use, a reduction of 7% in Colorado River water supply in the Lower Basin results in a reduction of 30% for water available to Central Arizona (CAP)

CAP
CENTRAL ARIZONA PROJECT

2017 Level 1 Shortage



CAP
CENTRAL ARIZONA PROJECT

Consequences of Lake Mead Decline

1075'
- Arizona takes 320 KAF shortage

1050'
- Arizona takes 400 KAF shortage reduction
- Reductions in hydropower generation

1025'
- Arizona takes 480 KAF shortage reduction
- Uncertainty about what actions Secretary will take to protect Lake Mead
- Potential loss of hydropower generation and instability in the electrical grid

1000'
- Active storage in Lake Mead is less than CA's allocation (~4.3 MAF)
- "Run of River" operations – insufficient storage to meet deliveries to AZ, CA, NV and MX

895'
- Dead pool; only 2 MAF in storage

CAP
CENTRAL ARIZONA PROJECT

The Risk

There is a risk that Arizona, and CAP in particular, will be required to take catastrophically deep reductions, with associated adverse impacts on the society, environment and economy of Arizona.

CAP
CENTRAL ARIZONA PROJECT

Programs to Address Risks

Storage and Recovery

- 3.4 MAF of underground storage in partnership with AWBA

Augmentation

- Weather modification projects in the Upper Basin
- Local and binational desalination

Lower Basin Pilot Drought Response Actions MOU

- Interstate plan to leave 740 KAF in Lake Mead by end of 2017
- CAP's share is 345 KAF – will be accomplished by end of 2016

Innovative Conservation ("Pilot System Conservation")

- Interstate funding to conserve >75 KAF in the Colorado River
- Conservation research grant program

Lower Basin Drought Contingency Plan ("DCP") Pending

CAP
CENTRAL ARIZONA PROJECT

Lower Basin Drought Contingency Plan - Background

- LBDCP is an “insurance policy” to provide more certainty and greater protection of Colorado River supplies
- LBDCP process led by BOR and LB States built on the initial progress in the pilot projects
- LBDCP process has identified key concepts outlining additional proposed reductions to “bend the curve” in the decline of Lake Mead

CAP
CENTRAL ARIZONA PROJECT

Lower Basin Drought Contingency Plan

- New proposed reductions (in addition to the ‘07 guidelines) by each Lower Basin State, and conservation commitment by USBR
- Earlier and larger reductions by Arizona and Nevada
- Conservation by USBR
- Reductions by California at lower Lake Mead elevations
- Mexico to be asked to participate via Minute 32x
- Overlay on the ‘07 Guidelines

CAP
CENTRAL ARIZONA PROJECT

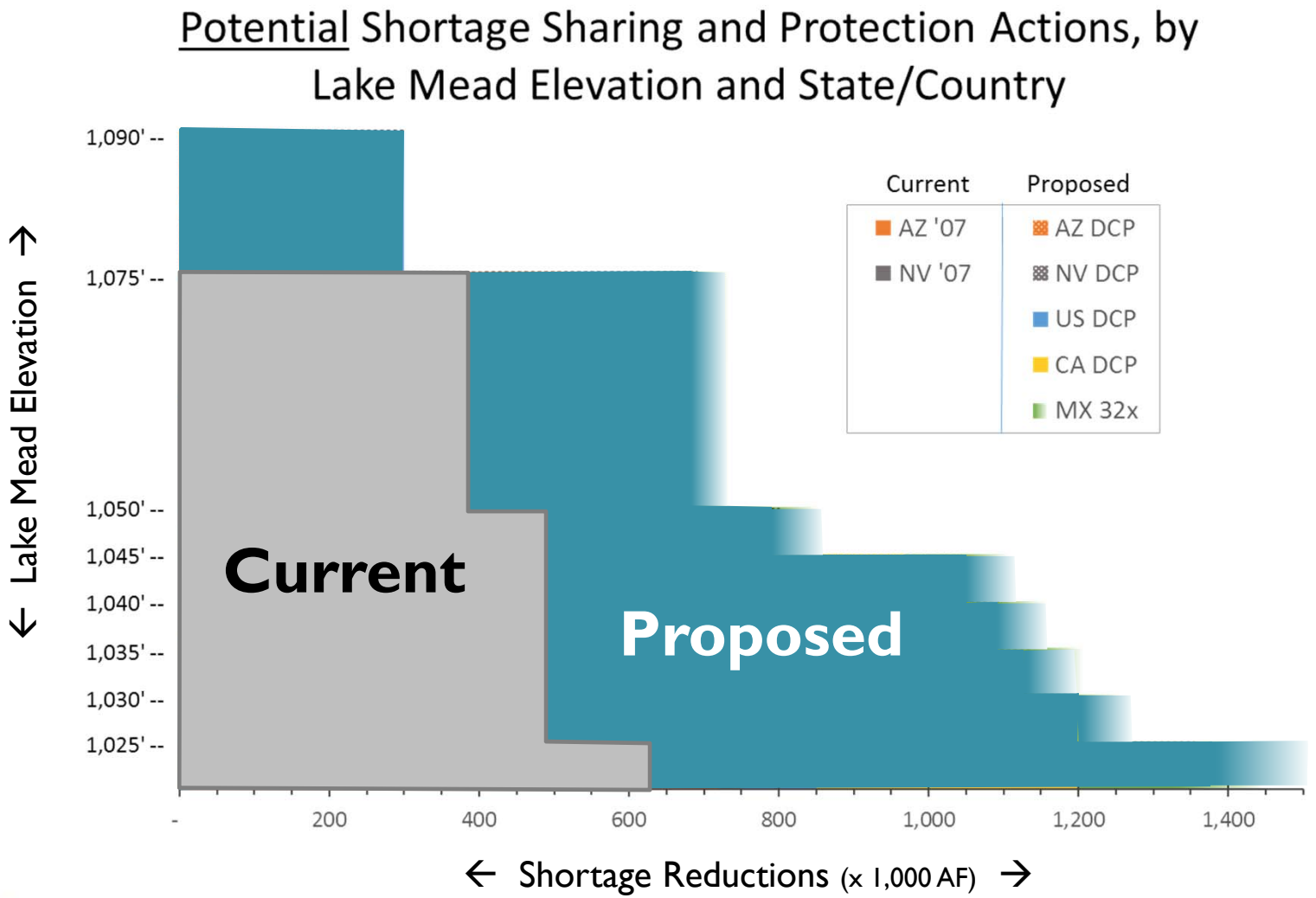
LBDCP Reductions Summary

Lake Mead Elevation	AZ Total	NV Total	CA Total	USBR	Mexico Minute 319*	Total
1,090-1,075	192,000	8,000	0	100,000	0	300,000
1,075-1,050	512,000	21,000	0	100,000	50,000	683,000
1,050-1,045	592,000	25,000	0	100,000	70,000	787,000
1,045-1,040	640,000	27,000	200,000	100,000	70,000	1,037,000
1,040-1,035	640,000	27,000	250,000	100,000	70,000	1,087,000
1,035-1,030	640,000	27,000	300,000	100,000	70,000	1,137,000
1,030-1,025	640,000	27,000	350,000	100,000	70,000	1,187,000
<1,025	720,000	30,000	350,000	100,000	125,000	1,325,000

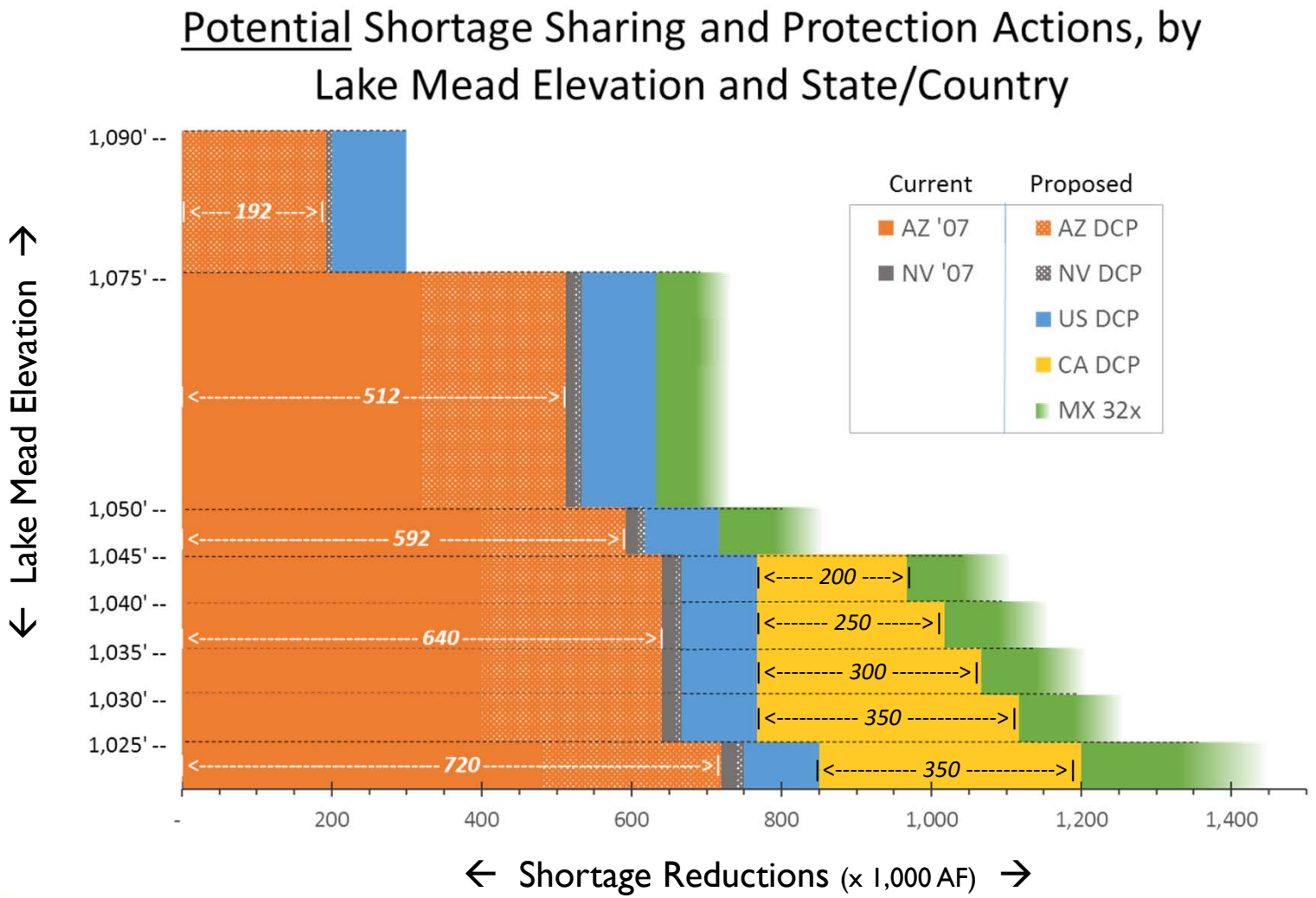
*Minute 319 reductions extend through 2017. Assume reductions continue in Minute 32X.

CAP
CENTRAL ARIZONA PROJECT

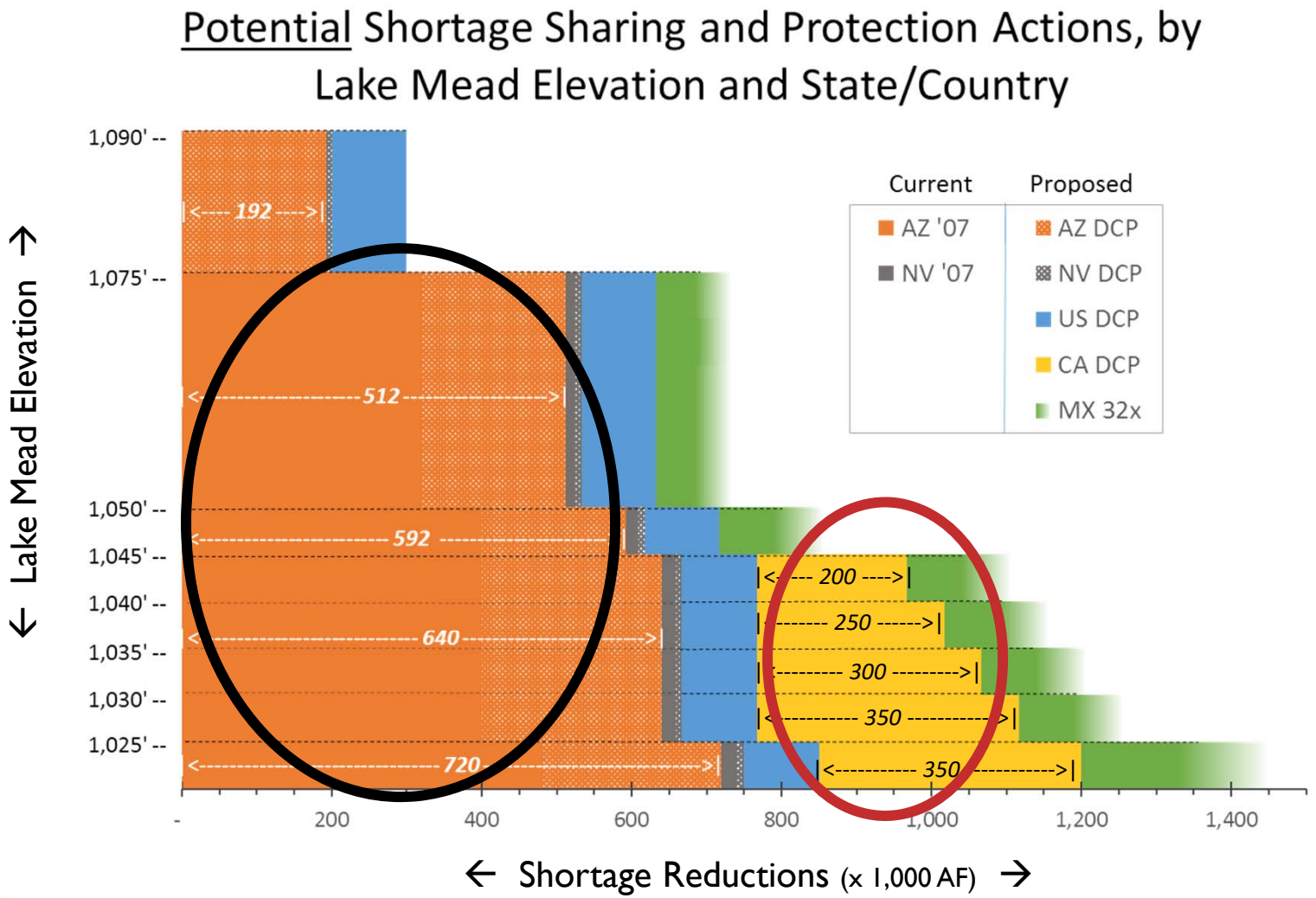
Drought Contingency Proposal



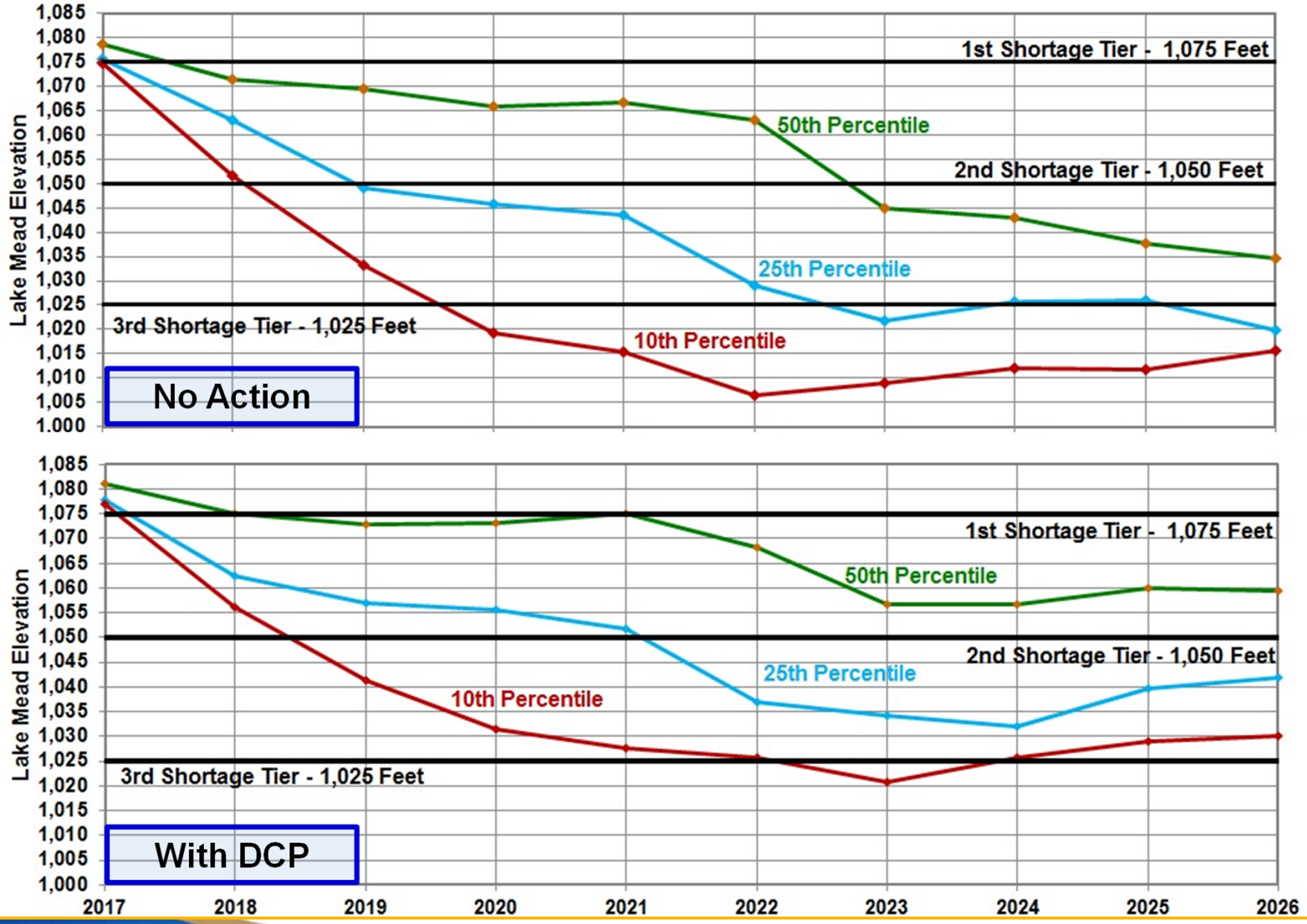
‘07 Guidelines + LBDCP Reductions + Minute 32x



‘07 Guidelines + LBDCP Reductions + Minute 32x



Lake Mead – Selected Percentile Elevations
Stress Test Hydrology – "No Action" and With DCP



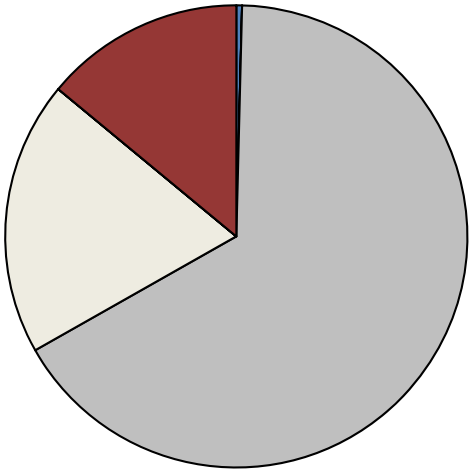
Summary

- Lake Mead is declining due to drought and imbalances between supplies and demands
- Current projections show the '07 Guidelines may not be sufficient to address the declines
- CAP, with partners, have invested in Lake Mead protection efforts, and Basin-wide conservation, resulting in avoiding shortages in 2016 and in 2017. The efforts are similar to the first level of DCP reductions
- More actions are needed to address the continuing risks of Lake Mead falling below critical reservoir elevations
- The LBDCP aims to address a large portion of the current risks in the system

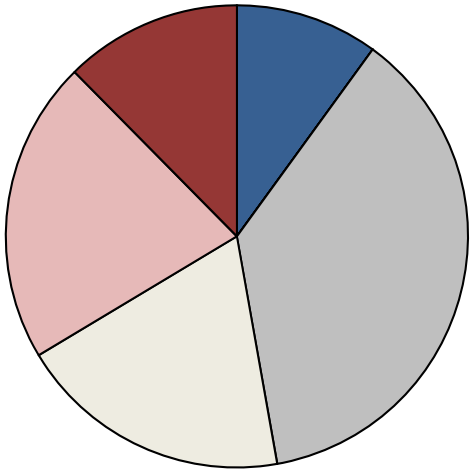
CAP
CENTRAL ARIZONA PROJECT

LBDCP vs. Base Case

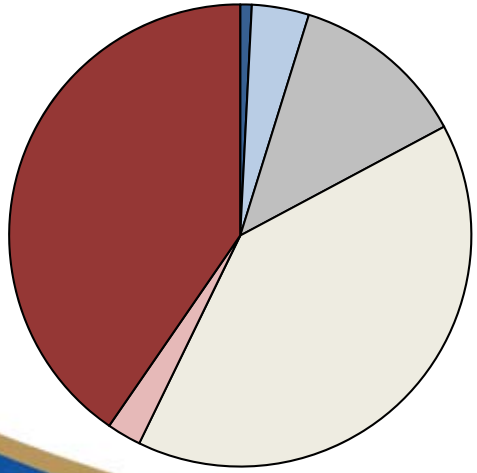
Other Excess



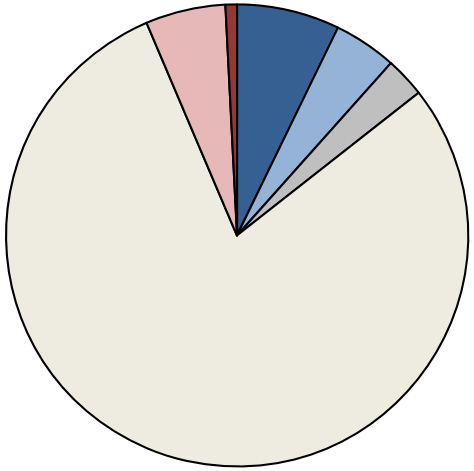
Ag Pool



NIA Priority



M&I + Indian

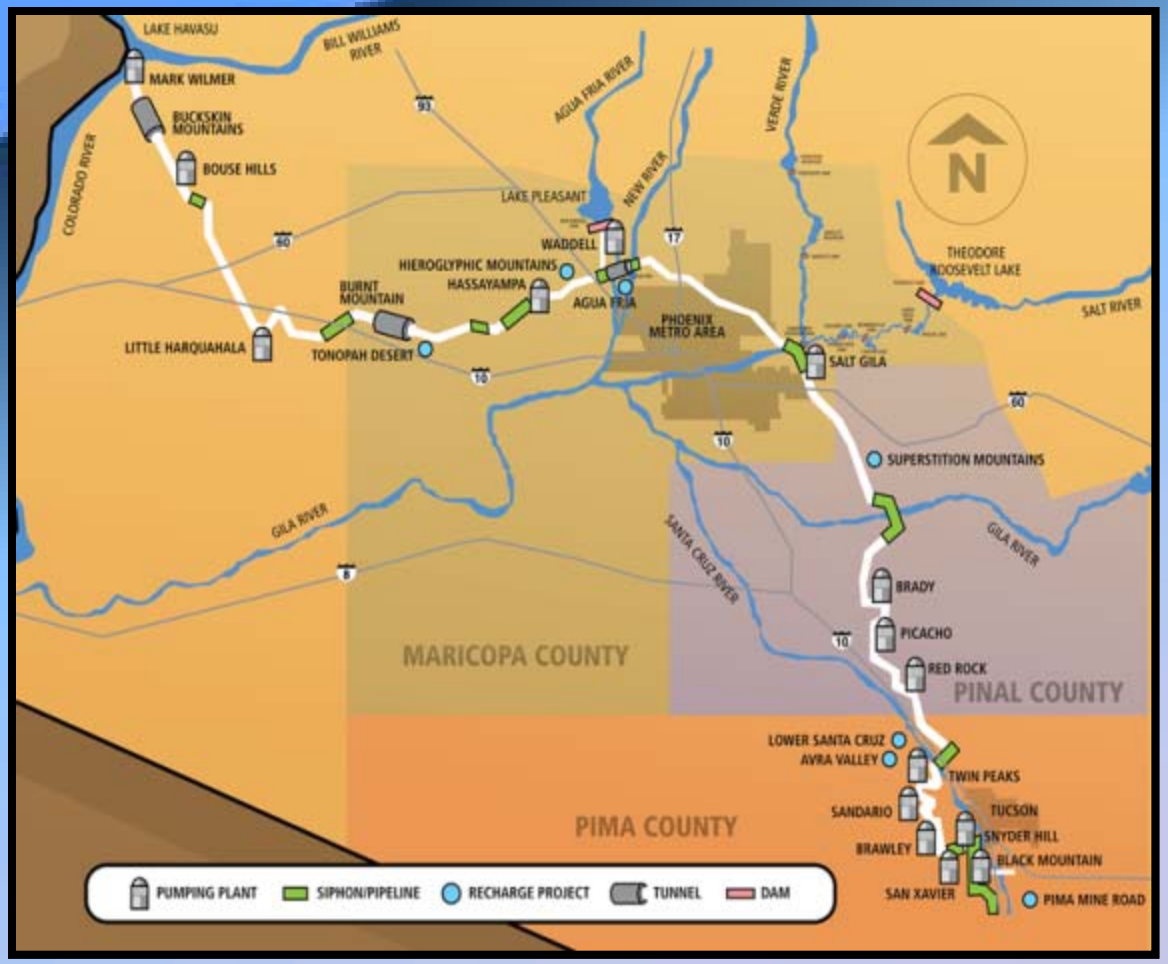


Legend

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

CAP
CENTRAL ARIZONA PROJECT

A Word About Central Arizona Project



336-mile aqueduct stretches from Lake Havasu to Tucson

14 pumping plants lift water nearly 3000 feet

8 siphons, 3 tunnels

Lake Pleasant/New Waddell Dam

Delivers 1.6 million acre-feet of Colorado River water annually

Navajo Generating Station provides power

CAP Recharge Facilities

Tonopah Desert	150k
Hieroglyphic	35k
Agua Fria	100k
Superstition Mountains	56.5k
Lower Santa Cruz	50k
Pima Mine Road	30k

Replenishment through direct recharge or groundwater savings projects

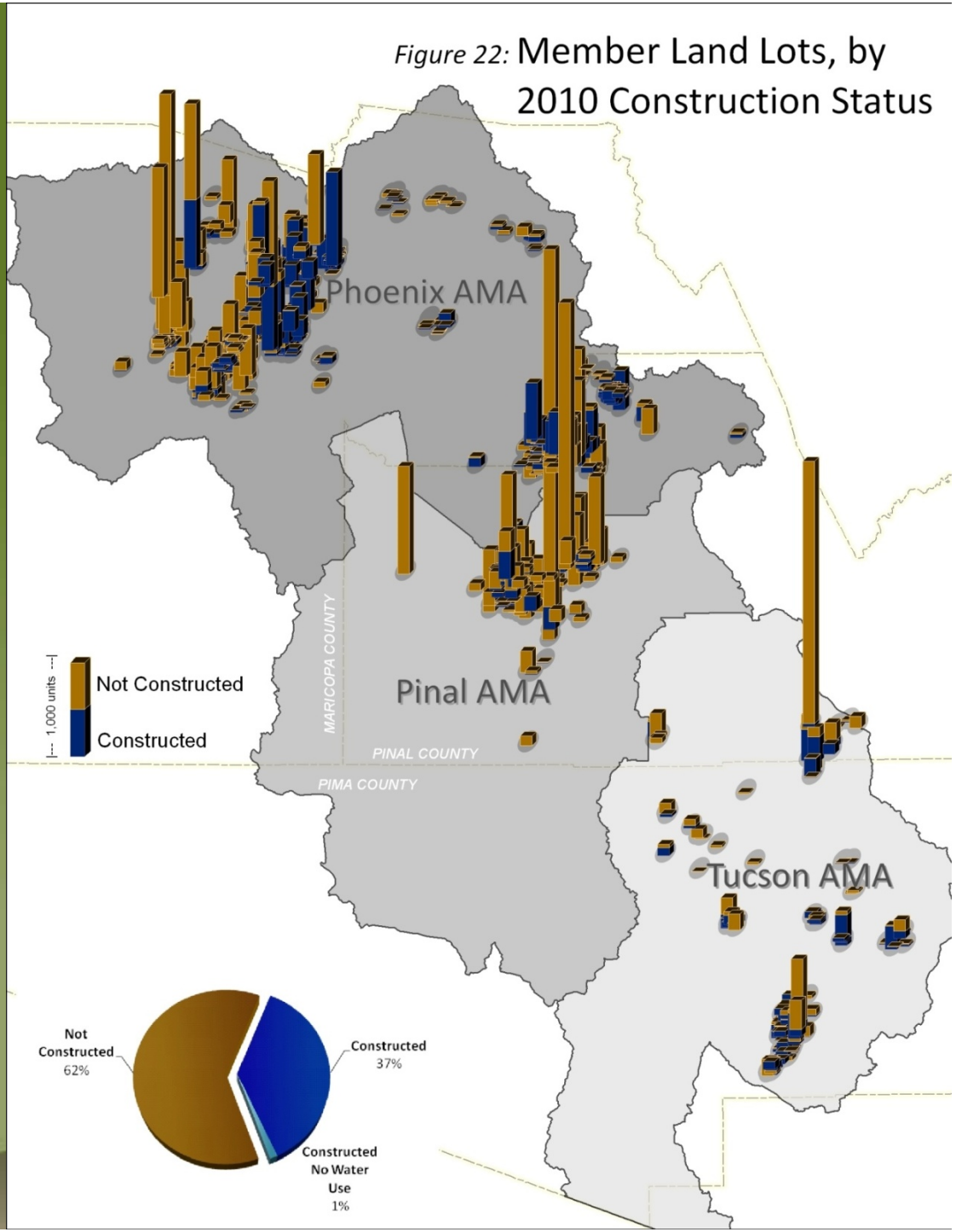
CAP
CENTRAL ARIZONA PROJECT

A Question of Power

95% of the energy used by CAP is produced at the Navajo Generating Station near Page, AZ

CAP, through the Bureau of Reclamation, has access to nearly 25% of the power produced at NGS

Central Arizona Groundwater Replenishment District (CAGRD)



A Global Responsibility:
If we can't work it out here who can?

"We assume a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development — economic development, social development and environmental protection — at local, regional, and global levels."

Johannesburg Declaration
on Sustainable Development