



Using RiverWare to Support the Ongoing Bi-National Discussions for Management of the Colorado River



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Purpose of Discussions

- Joint Cooperative Measures for Colorado River Management
- Mutual Benefits for United States and Mexico



Background

- 1944 Treaty
 - Allotment of Water to Mexico
- Minute 317 – June 2010
 - Conceptual Framework for U.S. – Mexico Discussions on Colorado River Cooperative Actions
- Minute 318 – December 2010
 - Adjustment of Delivery Schedules for Water Allotted to Mexico as a matter of international comity as a Result of Infrastructure Damage...



Background

- 2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lakes Powell and Mead
 - Proactive System Management
 - Reductions of Water Allocation for Lower Basin States
 - “Shortage” Volumes Based on Lake Mead Elevations
 - Only Pertains to United States



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Hydrology Sub-Workgroup

- United States and Mexico Participants
- Explore Alternatives
 - Mexico Shortage Triggers
 - Mexico Surplus Triggers



Alternative Trigger Mechanisms

1. Reservoir Storage Triggers
2. Climate-Based Triggers
3. Combination Storage/Climate Triggers
4. Unique Index Value
 - Colorado River Index (CRI)

Key Assumptions

- 1906-2008 Historical Hydrology
- Fixed Surplus and Shortage Values
- 2012-2026 Time Horizon



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APPROACH

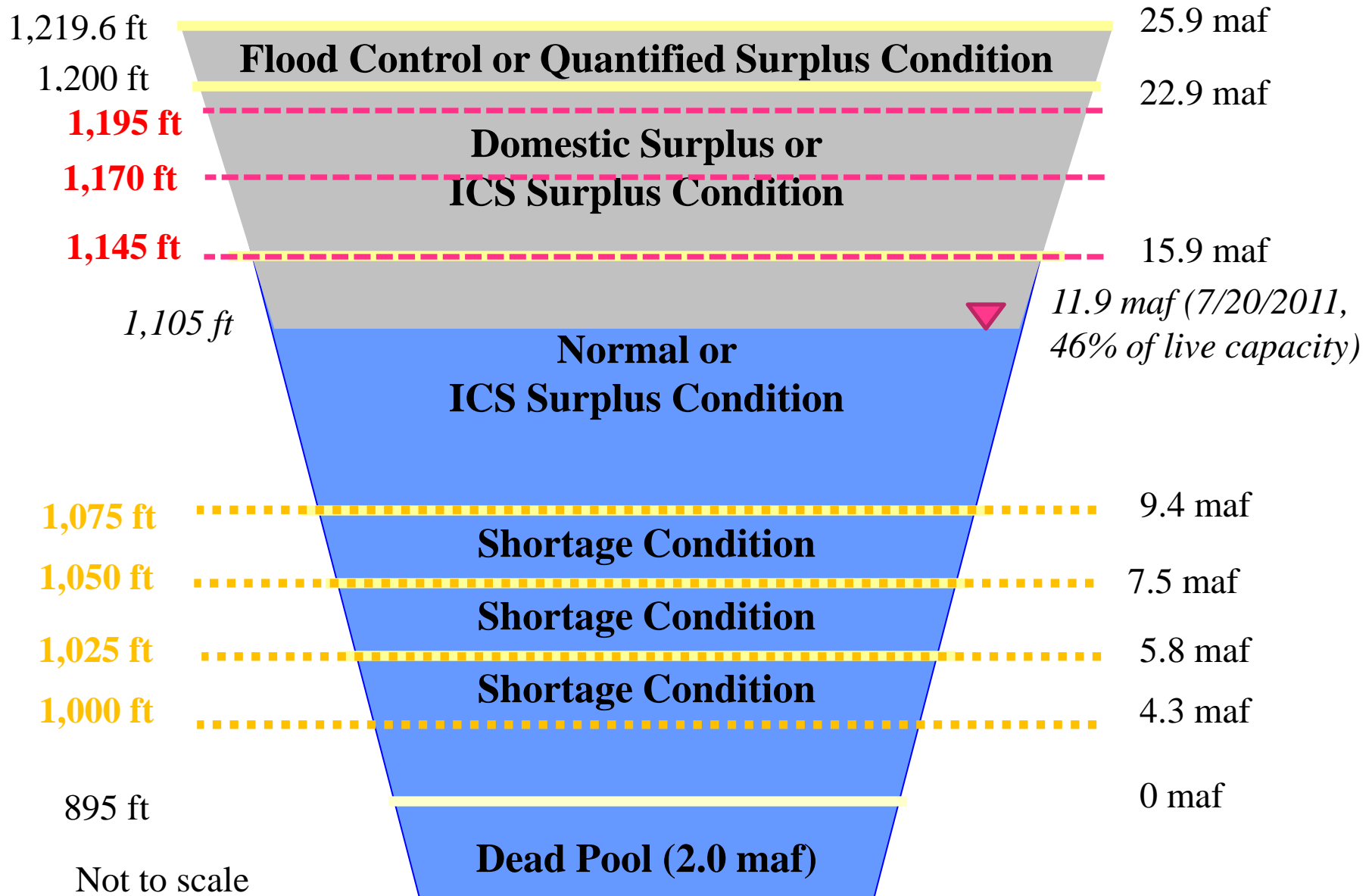
- Colorado River Simulation System (CRSS)
- Multiple Runs using Index Sequential Method
- Rule-Based Policy Modifications
 - Reductions of Mexico Demands During Shortage
 - Increases of Mexico Demands During Surplus
- Data Objects
 - Control Panel
 - Internal RiverWare Analyses
- External GPAT Analysis

A map of Mexico is shown with a blue water ripple effect centered over the country. The ripple starts as a small drop and expands into concentric circles. State names are visible on the map: CALIFORNIA, ARIZONA, NEW MEXICO, BAJA CALIFORNIA, GUAHUA, COAHUILA, TEXAS, NUEVO LEON, and TAMAULIPAS. A scale bar at the bottom left shows distances in kilometers (0, 50, 100, 150, 200) and miles (0, 100, 200).

Scenarios Studied

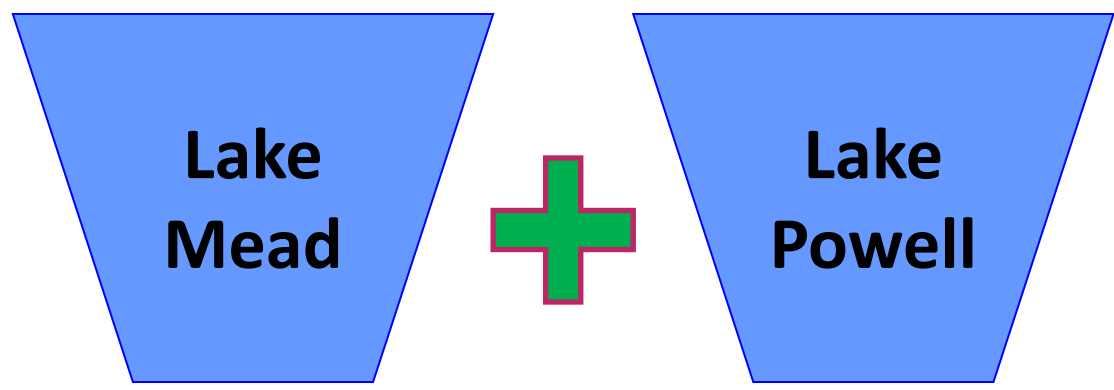
- 100+ Exploratory Scenario Runs
- 38 Unique Scenarios Reported
 - 18 Storage Triggered Scenario
 - 5 Climate Triggered Scenarios
 - 10 Storage/Climate Combination Triggered Scenarios
 - 5 Index Triggered Scenarios

12 Lake Mead Trigger Scenarios



6 Combined Storage Trigger Scenarios

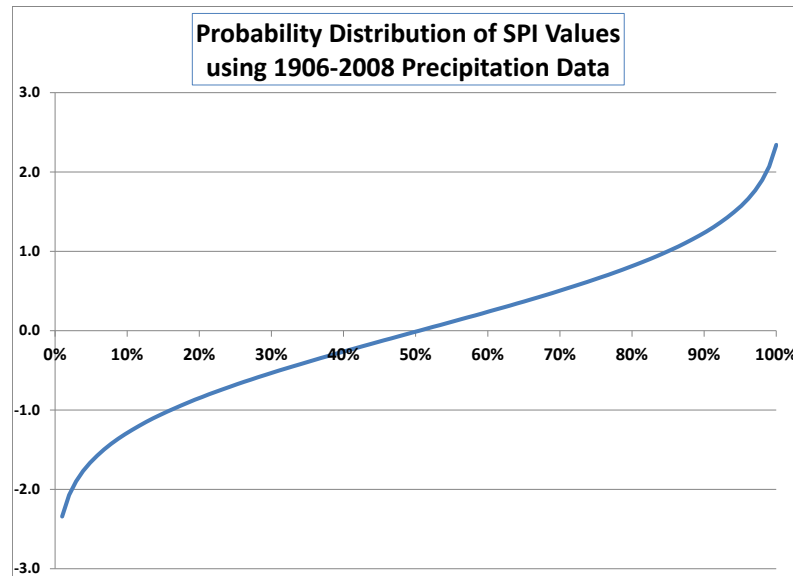
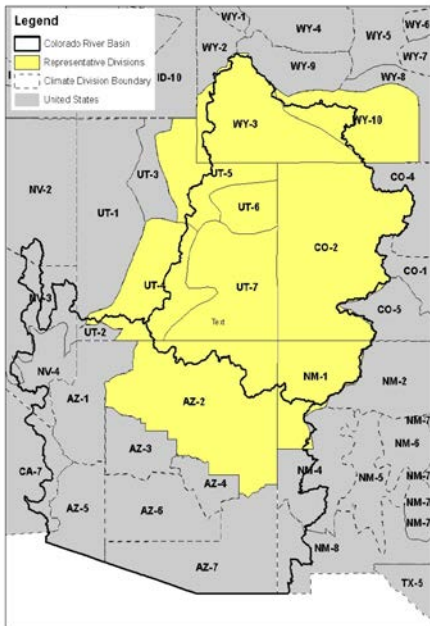
1,219 ft



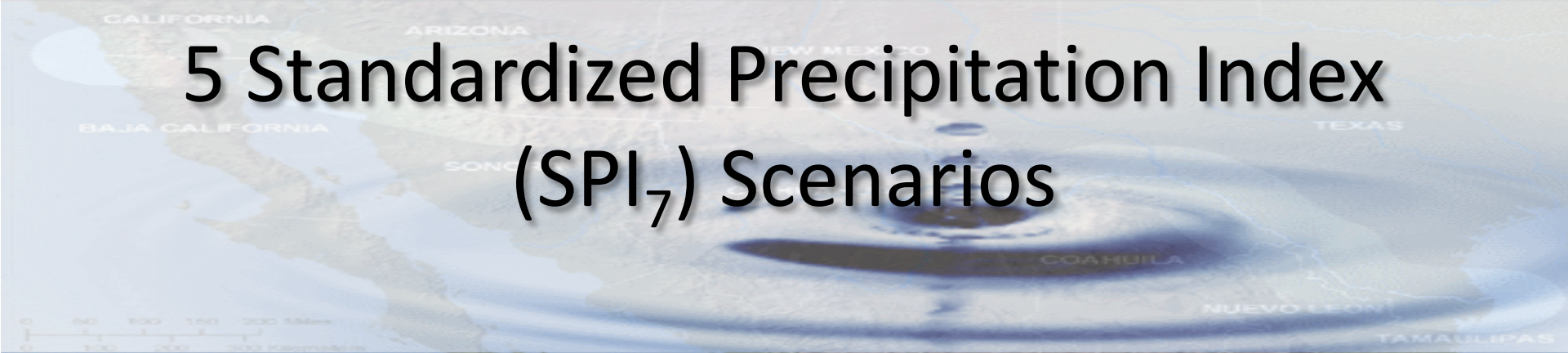
Shortage Threshold	Surplus Threshold
< 10%	> 90%
< 20%	> 80%
< 30%	> 70%
< 40%	> 60%
< 50%	> 50%
< 43%	> 64.5%

Climate Indicator Trigger

- Standardized Precipitation Index (SPI)
 - Fits a Precipitation Data to a Gamma Distribution
 - 7-Year SPI₇ Best Correlated with Reservoir Elevations



<i>SPI Values</i>	<i>Category</i>
≥ 2.00	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to -1.49	Moderately dry
-1.50 to -1.99	Severely dry
≤ -2.00	Extremely dry



5 Standardized Precipitation Index (SPI₇) Scenarios

Shortage Threshold	Surplus Threshold
< 0	> 0
< -0.5	> -0.5
< -1.0	> -1.0
< -1.5	> -1.5
< -2.0	> -2.0

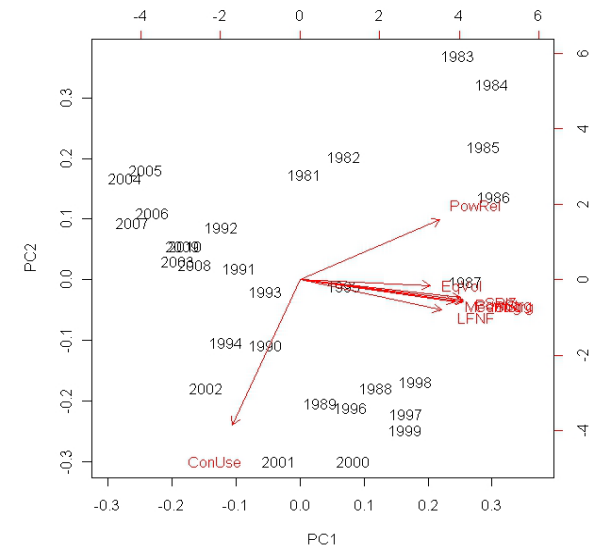
SPI Values	Category
≥ 2.00	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to -1.49	Moderately dry
-1.50 to -1.99	Severely dry
≤ -2.00	Extremely dry

10 Combination Storage AND/OR Precipitation Scenarios

Condition	Threshold
Surplus	$SPI_7 > 0$ AND Mead $> 1145'$
Shortage	$SPI_7 < 0$ AND Mead $< 1075'$
Surplus	$SPI_7 > +0.5$ AND Mead $> 1145'$
Shortage	$SPI_7 < -0.5$ AND Mead $< 1075'$
Surplus	$SPI_7 > +1.0$ AND Mead $> 1145'$
Shortage	$SPI_7 < -1.0$ AND Mead $< 1075'$
Surplus	$SPI_7 > +1.5$ AND Mead $> 1145'$
Shortage	$SPI_7 < -1.5$ AND Mead $< 1075'$
Surplus	$SPI_7 > +2.0$ AND Mead $> 1145'$
Shortage	$SPI_7 < -2.0$ AND Mead $< 1075'$
Surplus	$SPI_7 > 0.0$ OR Combined $> 70\%$
Shortage	$SPI_7 < 0.0$ OR Combined $< 30\%$
Surplus	$SPI_7 > +0.5$ OR Combined $> 70\%$
Shortage	$SPI_7 < -0.5$ OR Combined $< 30\%$
Surplus	$SPI_7 > +1.0$ OR Combined $> 70\%$
Shortage	$SPI_7 < -1.0$ OR Combined $< 30\%$
Surplus	$SPI_7 > +1.5$ OR Combined $> 70\%$
Shortage	$SPI_7 < -1.5$ OR Combined $< 30\%$
Surplus	$SPI_7 > +2.0$ OR Combined $> 70\%$
Shortage	$SPI_7 < -2.0$ OR Combined $< 30\%$

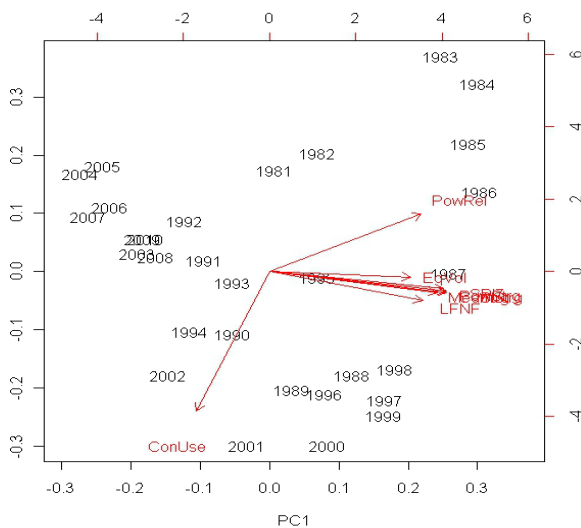
Colorado River Index

- Developed through a Principal Component Analysis of:
 - SPI_7
 - Lake Powell Storage
 - Lake Mead Storage
 - Combined Lake Powell and Lake Mead Storage
 - Lake Powell Water Year Release
 - Equalization Release from Lake Powell
 - Natural Flow at Lee's Ferry Gaging Site
 - Basin-wide Consumptive Use



5 Colorado River Index Scenarios

	SPI	PowellStor	MeadStor	ComStor	LFNatFlow	PowellRel	Equalization	ConUse
SPI	1.00	0.85	0.71	0.80	0.89	0.71	0.64	-0.26
PowellStor	0.85	1.00	0.88	0.97	0.68	0.62	0.65	-0.29
MeadStor	0.71	0.88	1.00	0.97	0.66	0.57	0.55	-0.28
ComStor	0.80	0.97	0.97	1.00	0.69	0.61	0.62	-0.30
LFNatFlow	0.89	0.68	0.66	0.69	1.00	0.58	0.44	-0.19
PowellRel	0.71	0.62	0.57	0.61	0.58	1.00	0.75	-0.50
Equalization	0.64	0.65	0.55	0.62	0.44	0.75	1.00	-0.13
ConUse	-0.26	-0.29	-0.28	-0.30	-0.19	-0.50	-0.13	1.00



$$\begin{aligned}
 CRI = & (0.48) * A \\
 & + (0.43) * B \\
 & + (0.48) * C \\
 & + (0.47) * D \\
 & + (-0.36) * E
 \end{aligned}$$

$$A = \frac{SPI_7 - 0.15}{0.46}$$

$$B = \frac{CS \text{ in MAF} - 37.38 \text{ MAF}}{8.59 \text{ MAF}}$$

$$C = \frac{LF \text{ in MAF} - 14.85 \text{ MAF}}{2.70 \text{ MAF}}$$

$$D = \frac{PR \text{ in MAF} - 10.49 \text{ MAF}}{2.22 \text{ MAF}}$$

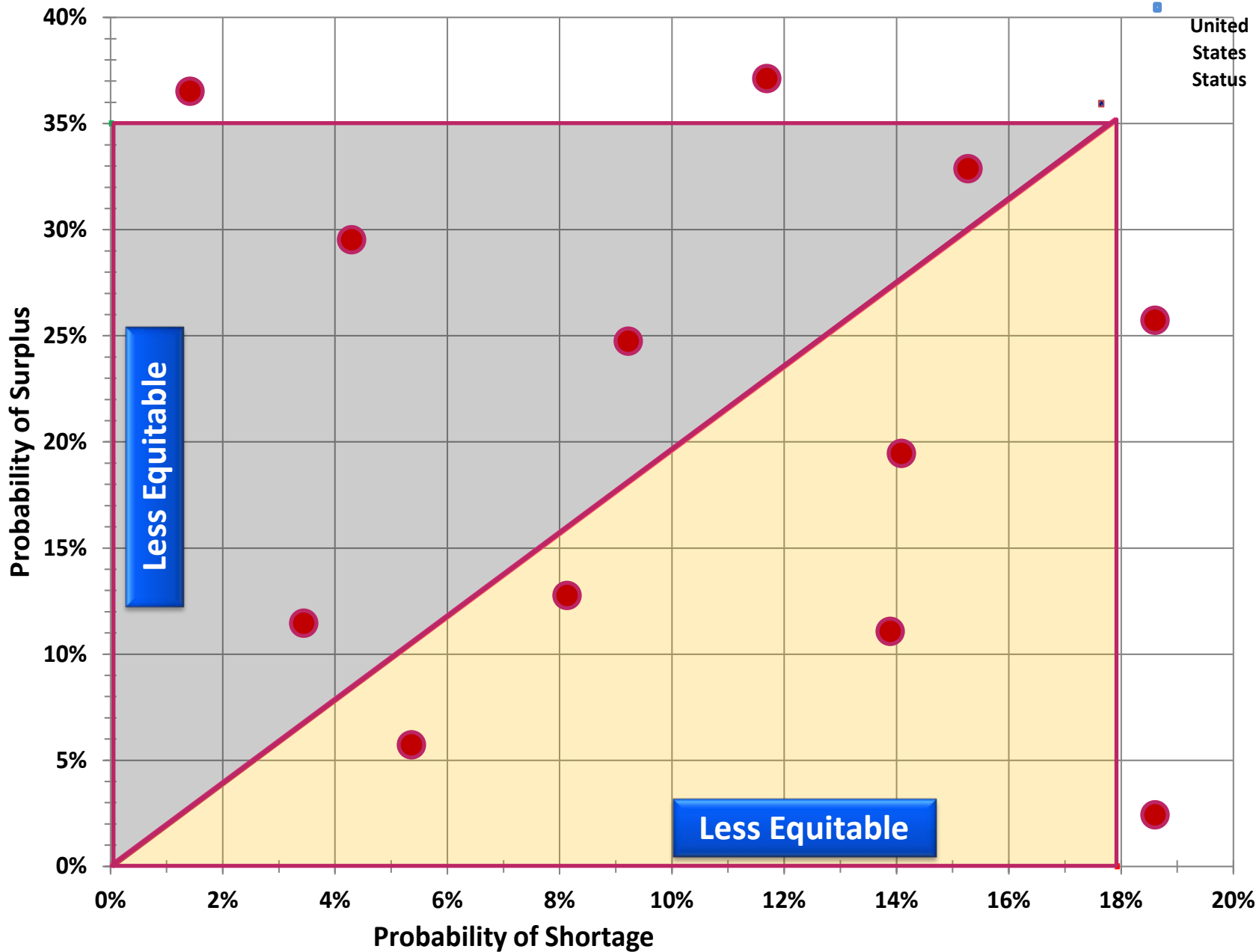
$$E = \frac{CU \text{ in MAF} - 12.34 \text{ MAF}}{1.01 \text{ MAF}}$$

Evaluation of Scenarios

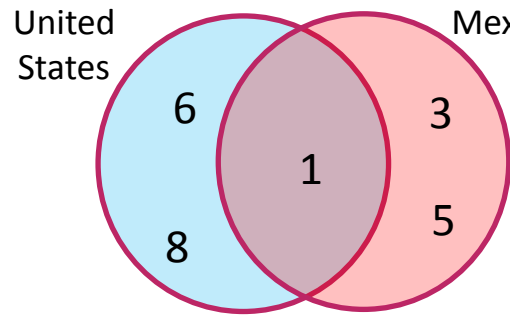
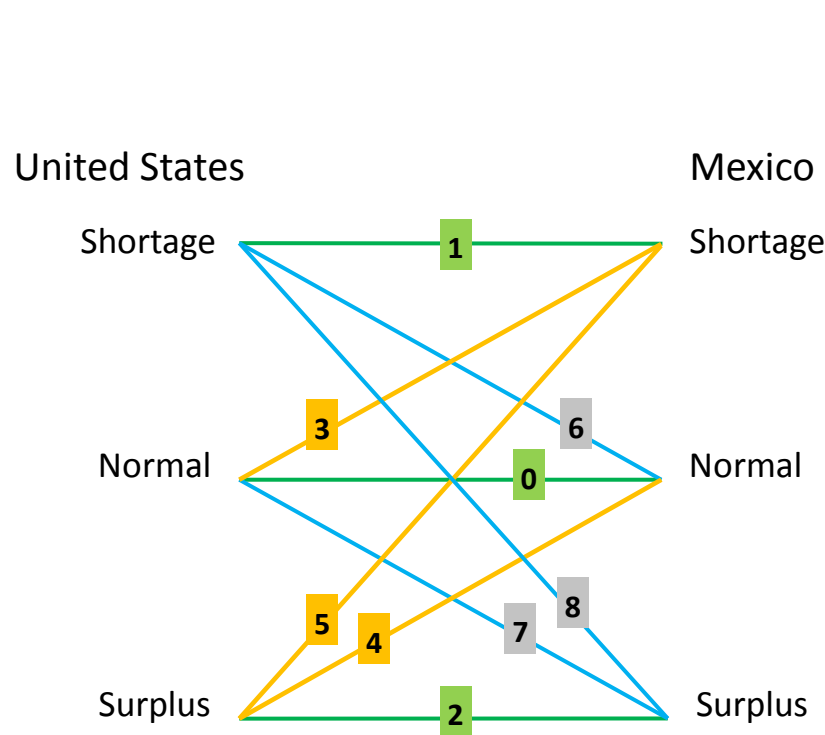
- Determine Probability of Shortages and Surplus to Mexico for 2012-2026
- Compare with Projections for the United States
- Determine Frequency of Alignment of Shortage and Surplus Conditions



Probability of Surplus vs. Probability of Shortage 2012-2026

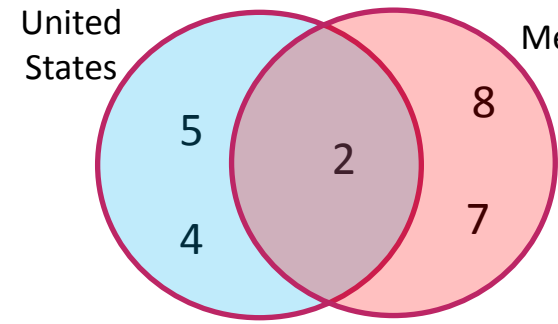


Probability of Alignment or Shortage or Surplus



$$\text{Shortage Alignment} = \frac{\text{Both Countries in Shortage}}{\text{Either Country in Shortage}}$$

$$= \frac{1}{\Sigma\{1,6,8,3,5\}}$$

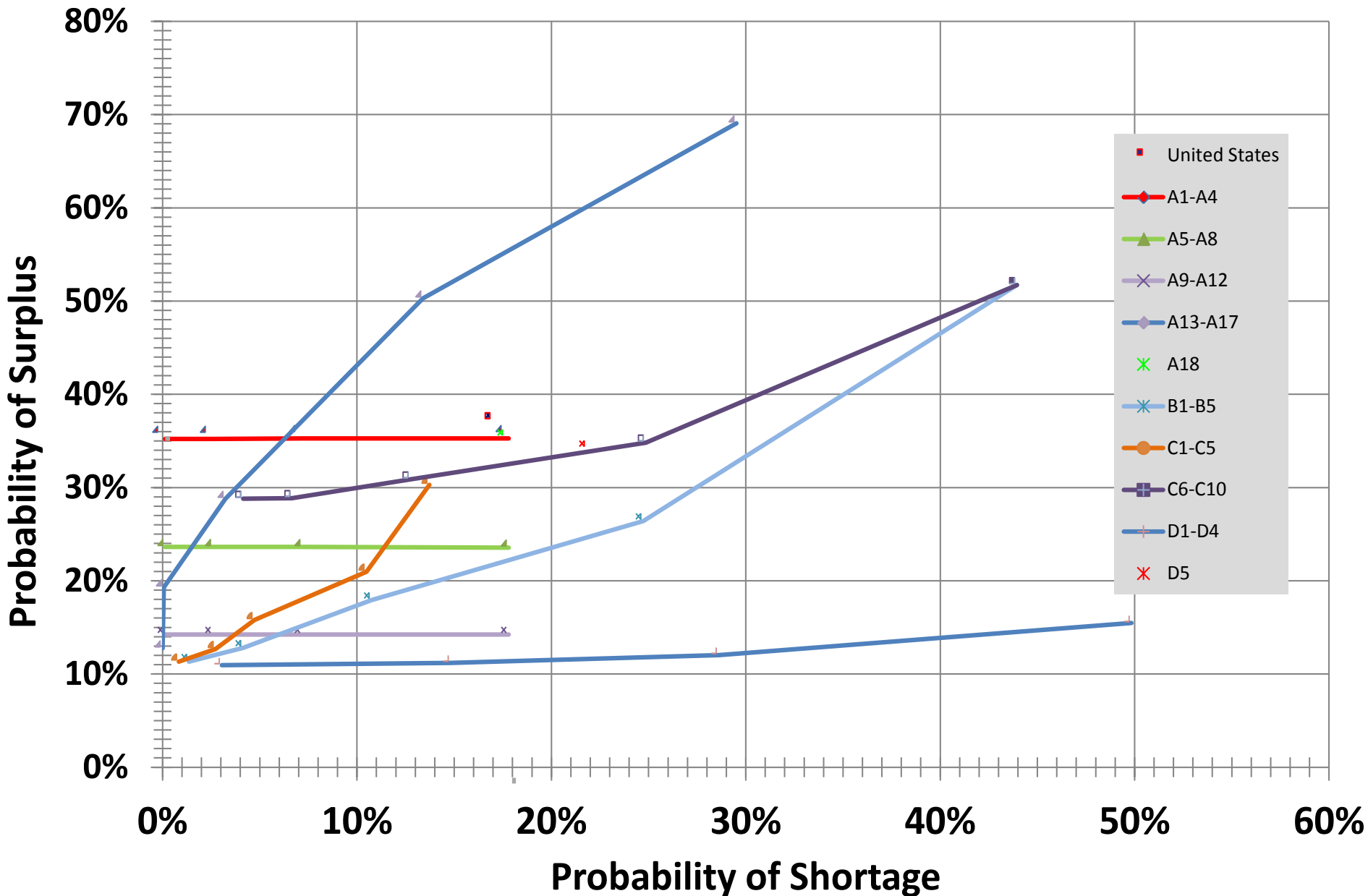


$$\text{Surplus Alignment} = \frac{\text{Both Countries in Surplus}}{\text{Either Country in Surplus}}$$

$$= \frac{2}{\Sigma\{2,4,5,7,8\}}$$

Probability of Surplus vs. Probability of Shortage

2012-2026



- ✓ Primary Task of the Hydrology Workgroup is Completed
- ✓ Decision Makers Have a Full Suite of Options
- ✓ Stay Tuned for the Results...

Questions?



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