The Colorado River Water Shortage: Agricultural Implications

Yuma Fresh Vegetable Association

12 May 2022

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Environmental Science Department

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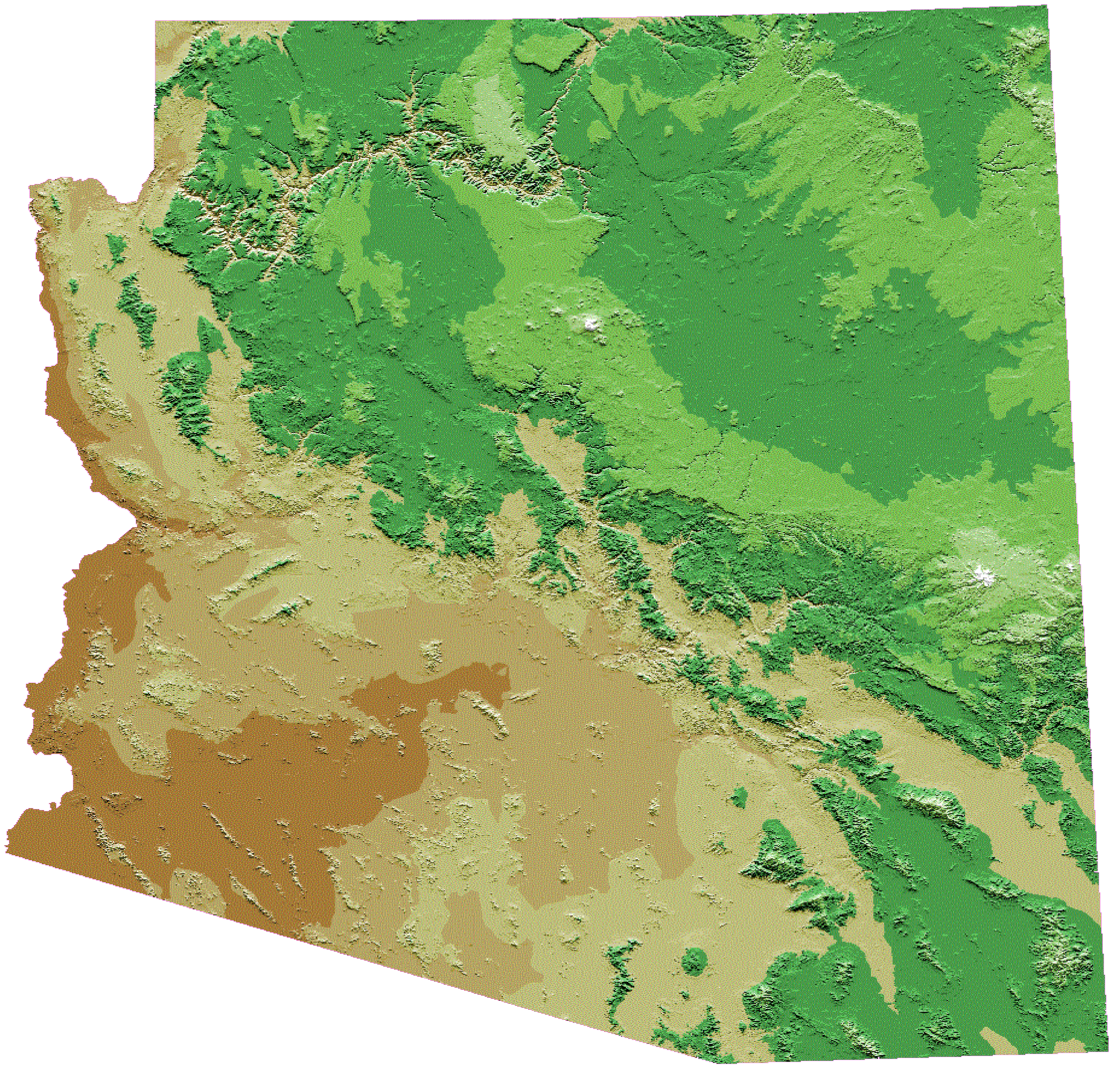
The Great State of Arizona

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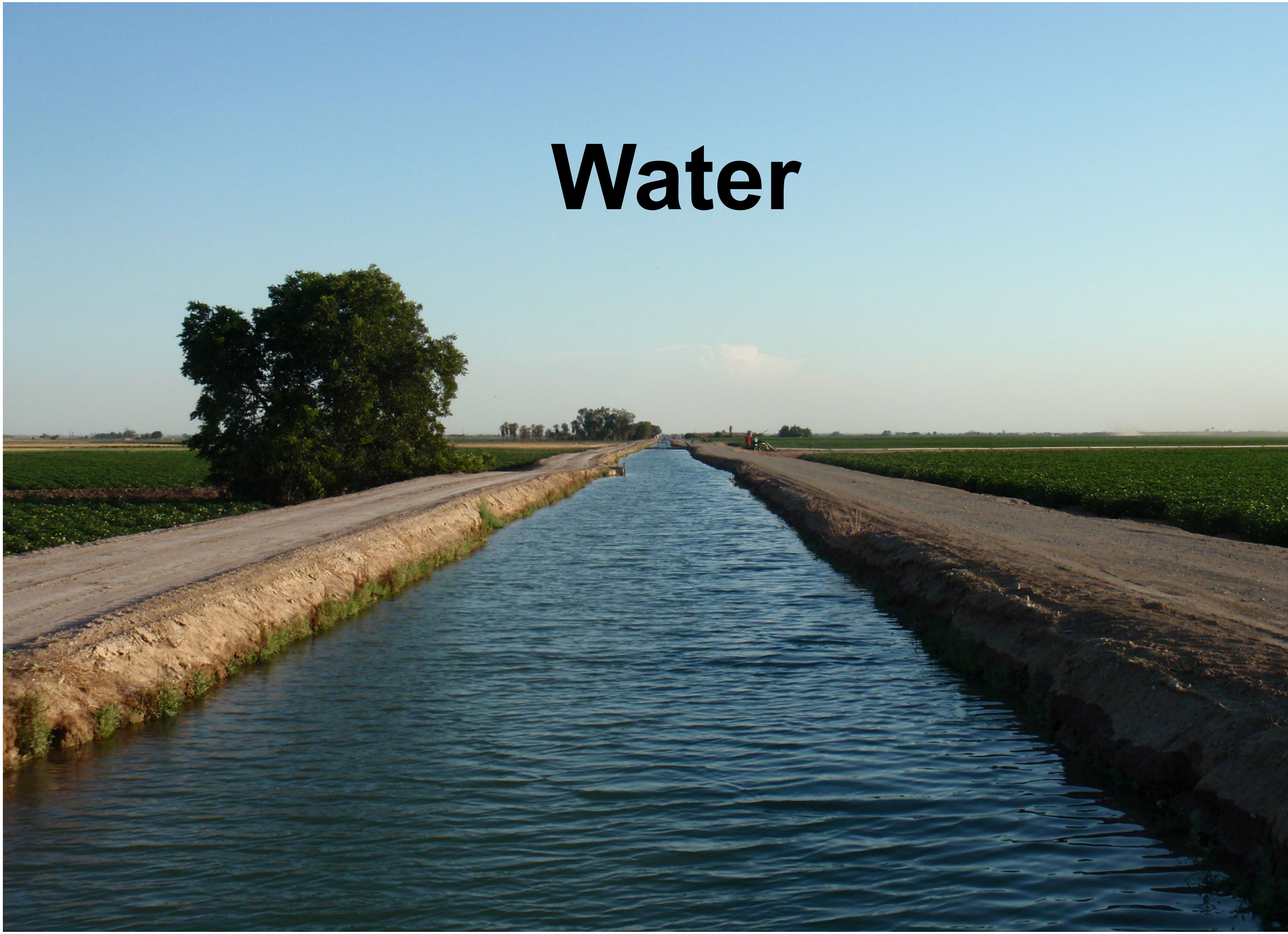
Water

Limiting Factors in Desert Agriculture

1. **Water**
2. Bio-available Nitrogen
3. Plant Genetics

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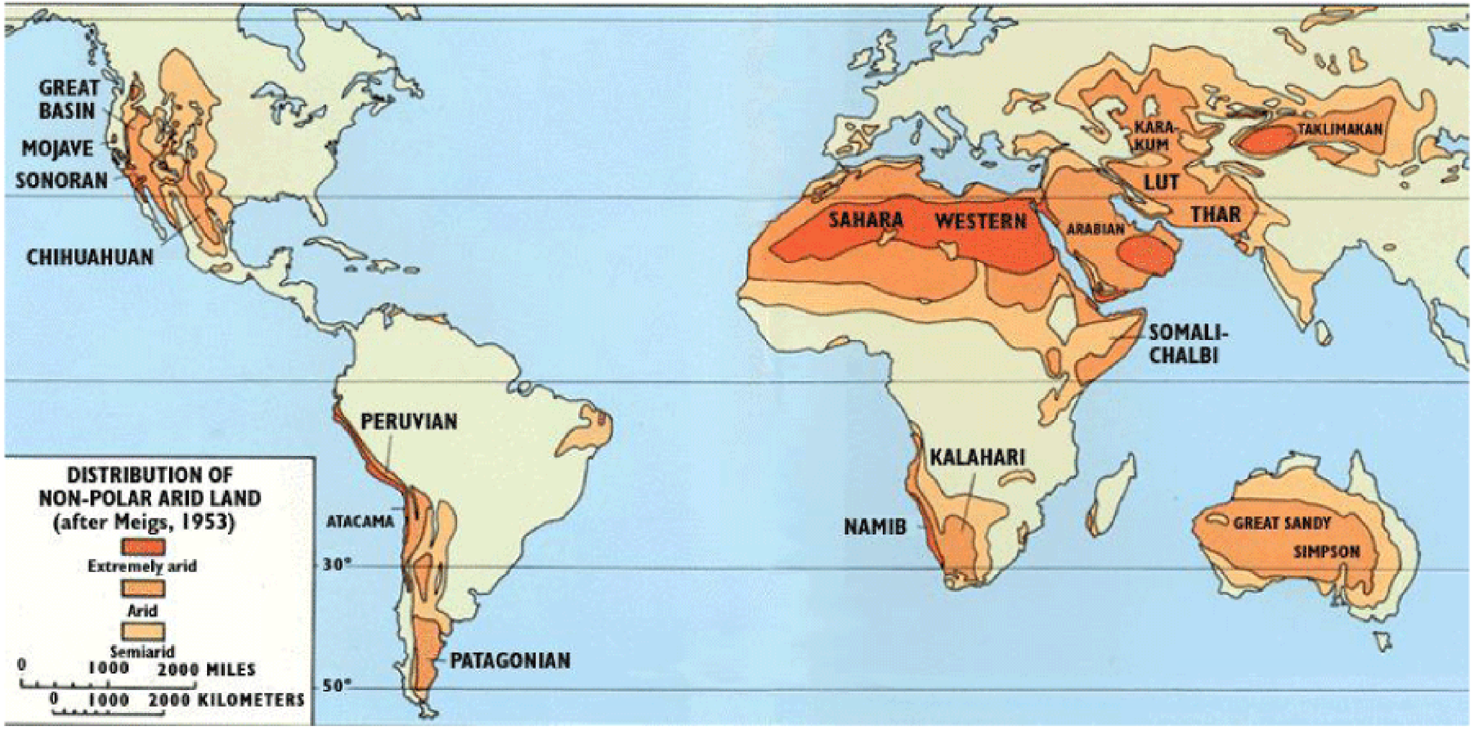
Global Freshwater Use

70% - Agriculture

Primarily in arid & semi-arid regions



Arid/Semi-Arid Regions

~ 40% of total crop production

~ 60-65% of grain production

~ 40-45% of global population

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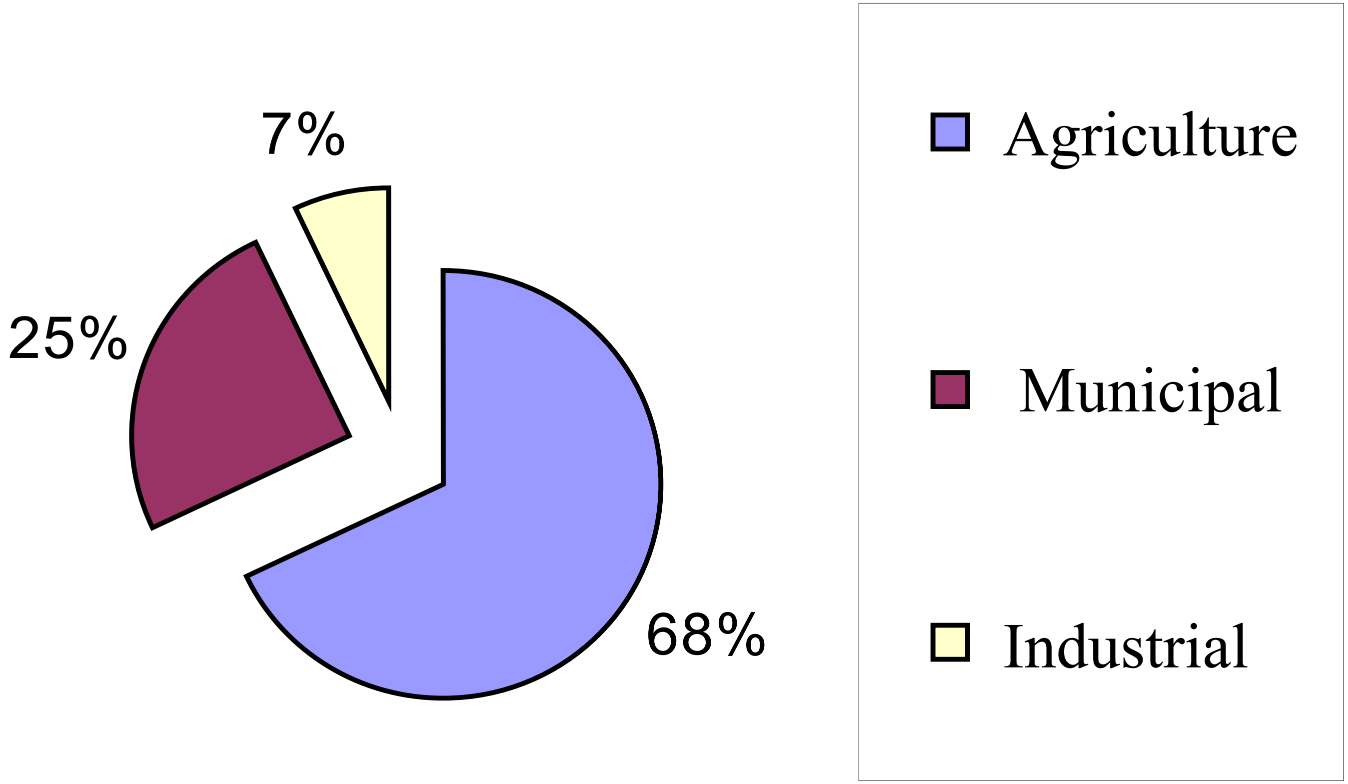
Distribution of Arizona Water



Arizona Agriculture - Water

- Arizona Ag utilizes ~ 70% of freshwater, $23.3B value (AZ GDP of $334.03B)
  - ~ 7% of AZ GDP
  - ~ 70% of Arizona is *diverted* to agriculture

- Arizona animal and crop production industries
  - Food and fiber products for Arizona, nation, and world.

Critics of Arizona Agriculture

"Despite the storied history and outsize impact of agriculture, this industry must be scrutinized. Currently, the Arizona GDP is about $300 billion and agriculture contributes less than 1% to that figure. Agriculture employs about 1% of Arizona workers while consuming 36% of our land and about 80% of our water. The thirsty and water intensive land uses that may have helped our state grow and flourish historically are now out of step with our disappearing water resources brought by drought, overuse, and climate change." Person, Ariz. Capital Times, 10/8/21

Note: $23B/$300B ~ 7.66%

Watersheds of the U.S.

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Colorado River Watershed

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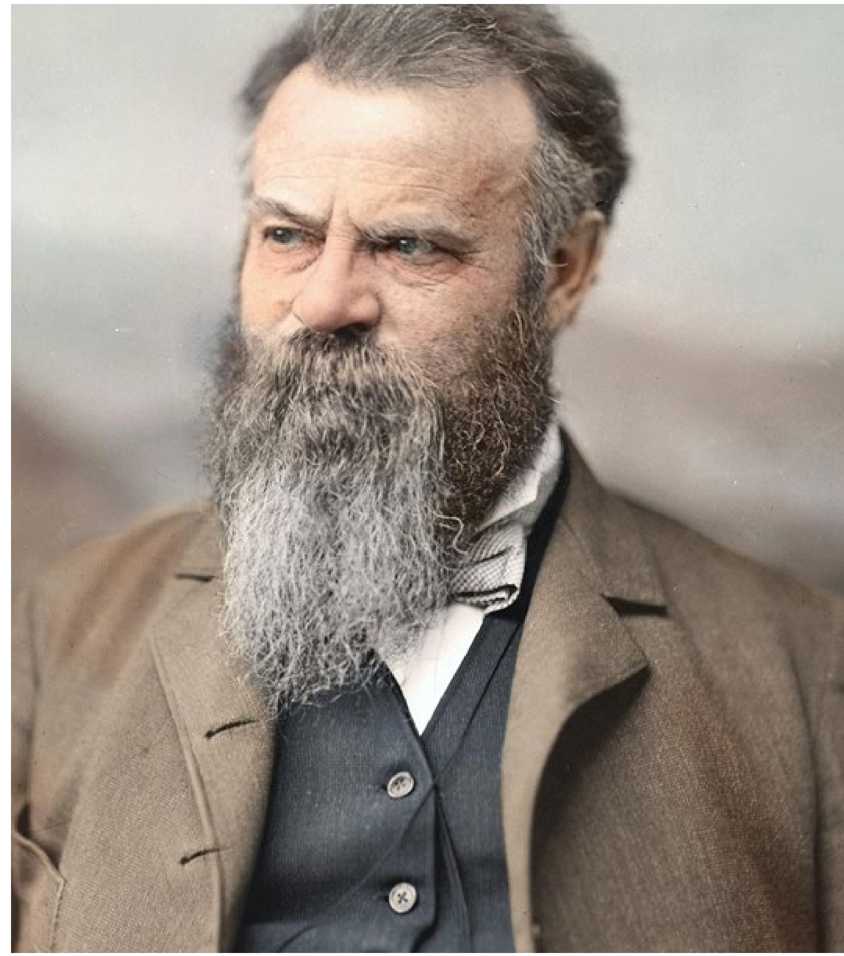
Colorado River Watershed

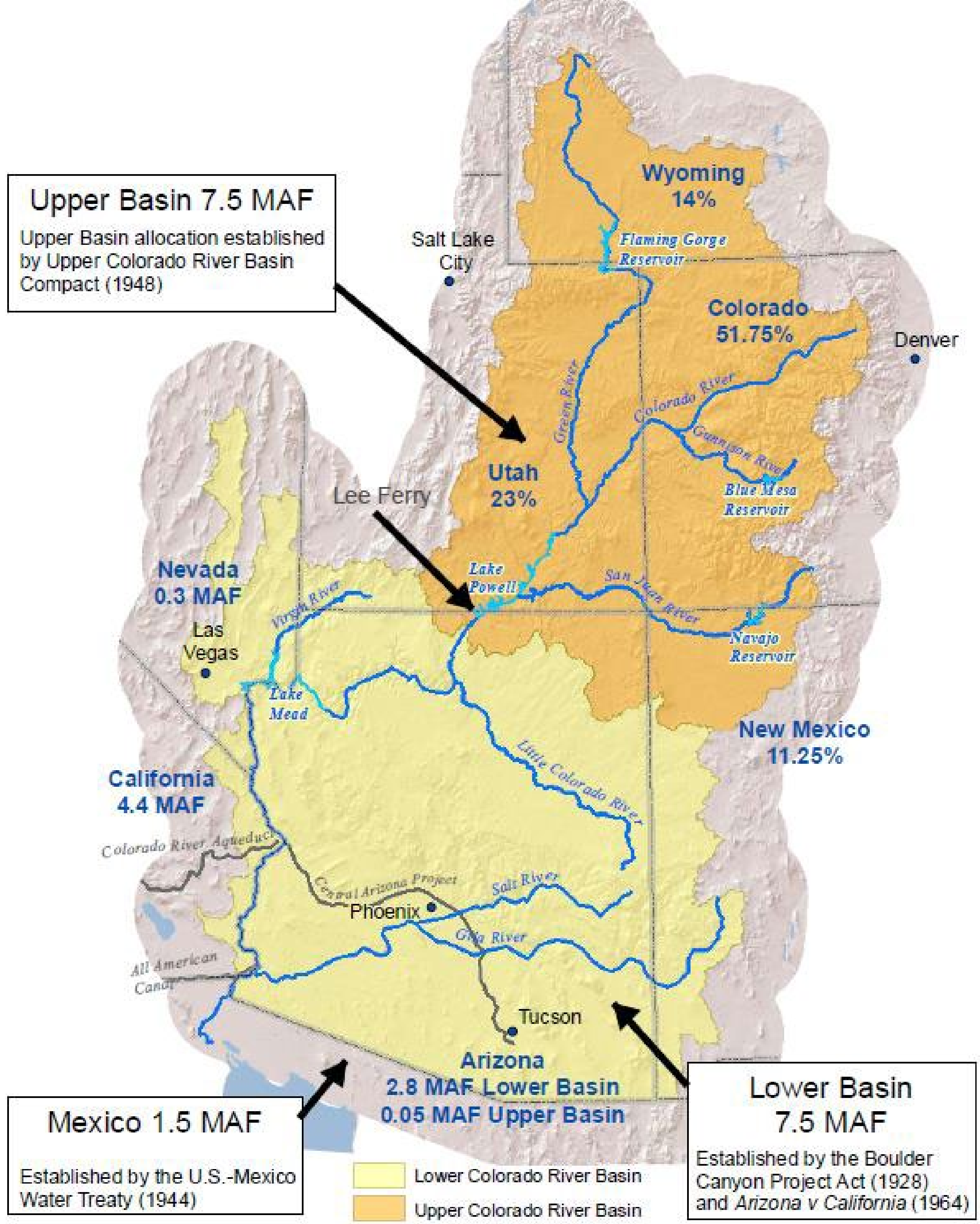
- 1,450 mile river channel
- 244,000 sq. mile drainage
- greatest elevation drop in North America
- budgeted volume = 15 million acre-ft/year
  - Columbia River: 192 million acre-ft/year
  - Mississippi River: 400 million acre-ft/year
- covers portions of 7 states and 2 nations
- 40M people
- 5.5M acres of farmland

John Wesley Powell

“All the great values of this territory have ultimately to be measured to you in acre feet”.

John Wesley Powell, Montana Constitutional Convention, 1889.



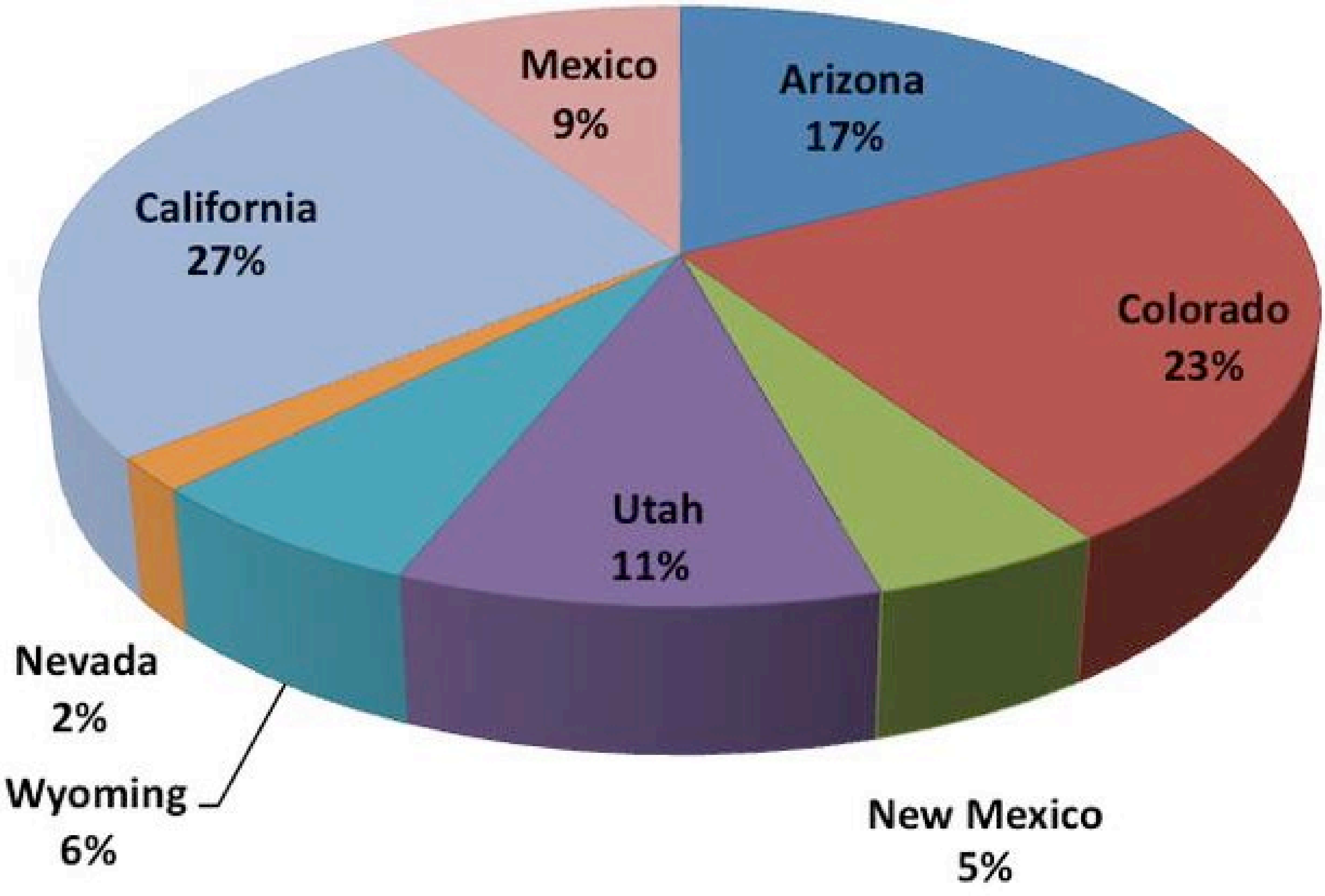

Upper Basin 7.5 MAF
Upper Basin allocation established by Upper Colorado River Basin Compact (1948)
Wyoming
14%
Flaming Gorge Reservoir
Salt Lake City
Colorado
51.75%
Denver
Green River
Colorado River
Gunnison River
Blue Mesa Reservoir
Utah
23%
Lee Ferry
Lake Powell
San Juan River
Navajo Reservoir
Nevada
0.3 MAF
Virgin River
Las Vegas
Lake Mead
New Mexico
11.25%
Little Colorado River
California
4.4 MAF
Colorado River Aqueduct
Central Arizona Project
Salt River
Phoenix
Gila River
All American Canal
Tucson
Arizona
2.8 MAF Lower Basin
0.05 MAF Upper Basin
Mexico 1.5 MAF
Established by the U.S.-Mexico Water Treaty (1944)
Lower Colorado River Basin
Upper Colorado River Basin
Lower Basin
7.5 MAF
Established by the Boulder Canyon Project Act (1928) and Arizona v California (1964)

Colorado River Use/Allocation (Totals)

State	Allocation	Use*	Difference
		Million acre-feet	
Wyoming	0.840	0.498	+0.342
Colorado	3.105	2.359	+0.746
New Mexico	0.675	0.548	+0.127
Utah	1.380	0.997	+0.383
Nevada	0.300	0.177	+0.123
Arizona	2.840	2.294	+0.546
California	4.403	5.271	-0.868
(Mexico)	1.500	1.542	-0.042
Totals	**15.043**	**13.686**	

*Annual flow has averaged 14 million acre-feet since 1930. Evaporation losses (reservoirs) approximately 2 million acre-feet/year.

Colorado River Apportionment



Colorado River

- Average flow between 2000 and 2018
  - ~ 12.4MAF

    16 % lower than the 1906-2017 average of 14.8MAF/year

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Rio Colorado – Sonora/Baja California/Arizona

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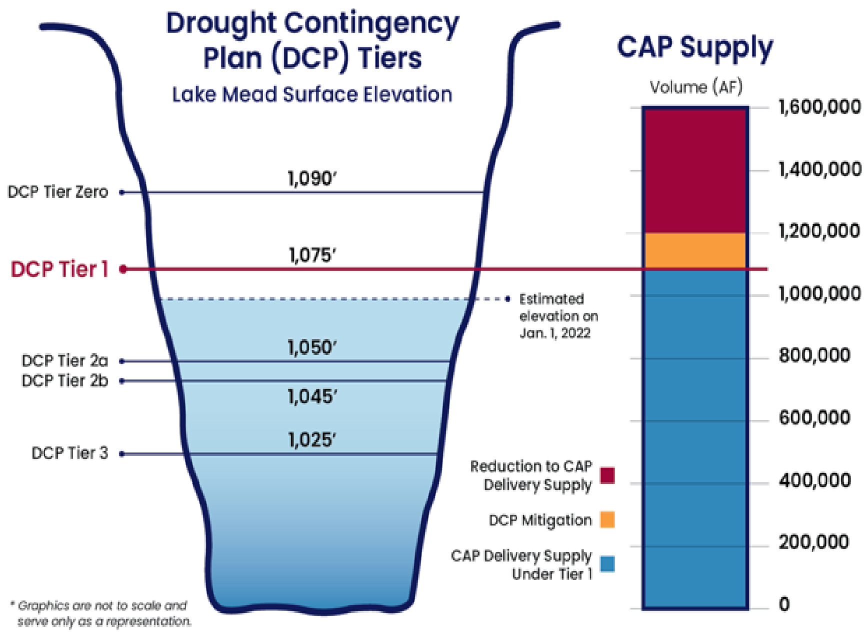
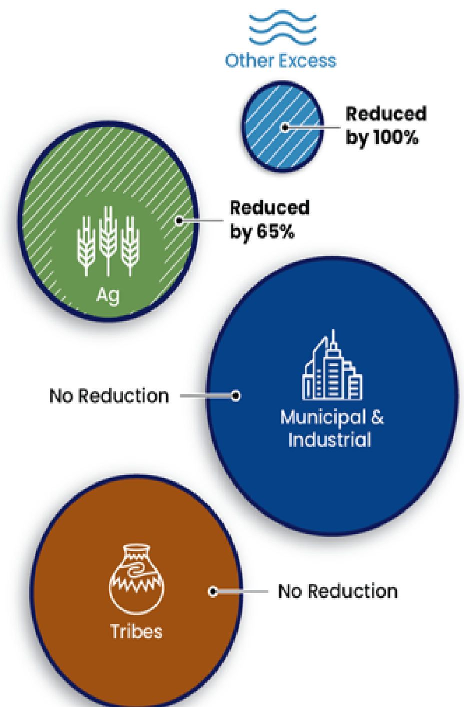
2022 – Tier 1 Shortage

CAP Reductions



To learn more, please visit: www.cap-az.com/colorado-river-shortage

2022 Reduction to CAP Users After DCP Mitigation



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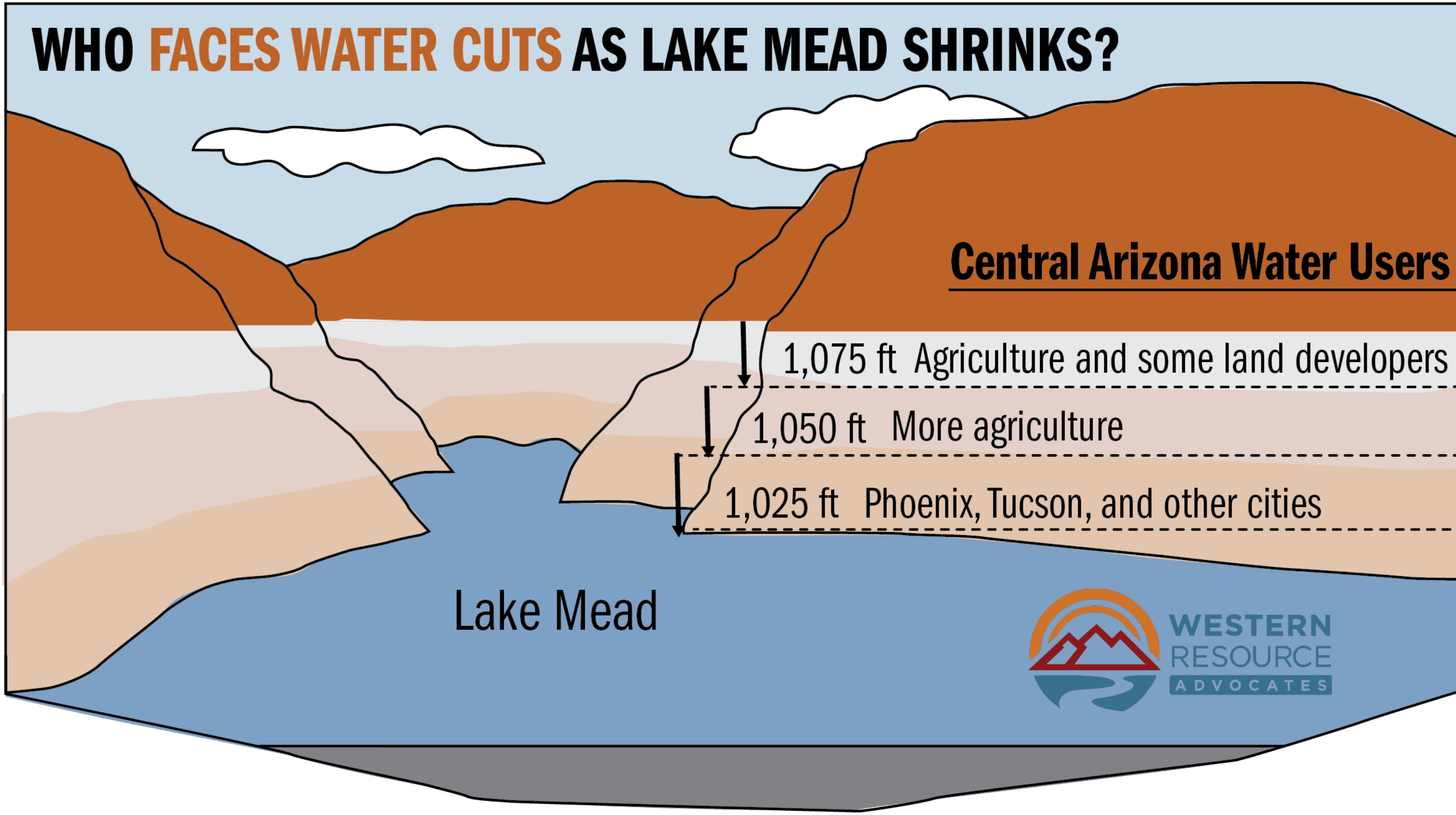
DCP Tier Reductions

Lake Level (fas)	Tier Level	Reduction	Total Reduction
1,075	1	512 K AF	512 K AF
1,050	2a	80 K AF	592 K AF
1,045	2b	48 K AF	640 K AF
1,025	3	480 K AF	1.2 M AF

DCP = Drought Contingency Plan
fas = feet above sea level on Lake Mead
KAF = thousand acre-feet
MAF = million acre-feet

90% probability Tier 2a 2022 (July)
25% probability Tier 3 2023



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Doctrine of Prior Appropriations

First person to take water from a source for beneficial use, has the right to continue to use that quantity of water for that purpose

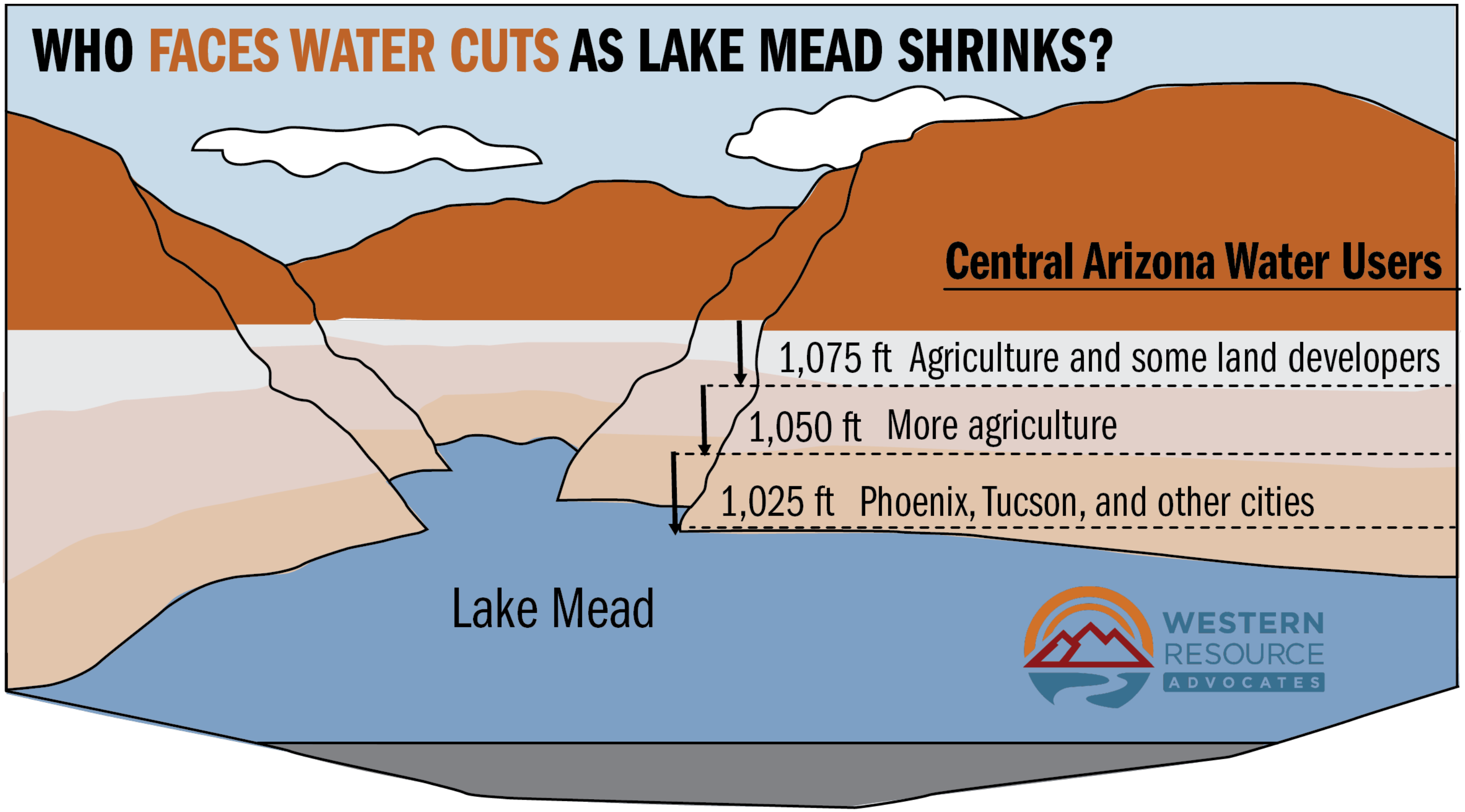
Remaining water may be used by others, so long as their use does not impinge on the rights of previous users

Doctrine was developed in the Western United States, and differs from riparian water rights, which are applied in the rest of the U.S.

Four essential elements consist of: intent, diversion, beneficial use, and priority

The Yuma Project – Laguna Dam

- Passage of the **Reclamation Act of 1902**
- **10 May 1904 - The Yuma Project** was authorized
  - one of the earliest irrigation projects for the new Reclamation Service.
  - Construction of Laguna Dam began in July 1905 and was completed in **March 1909**.



Prior Appropriation: First in time, first in right….

In times of shortage, burden is NOT shared equally.

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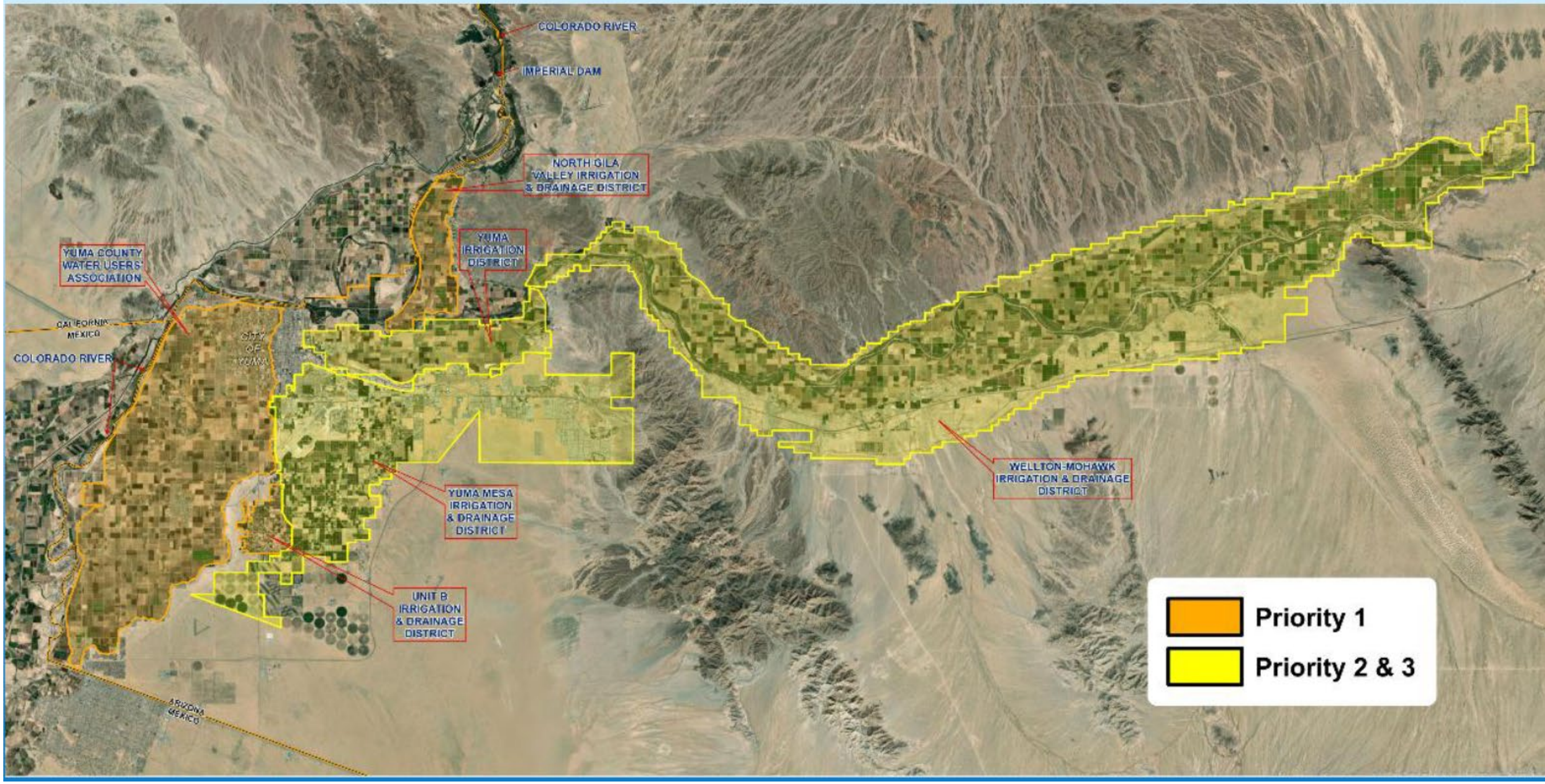
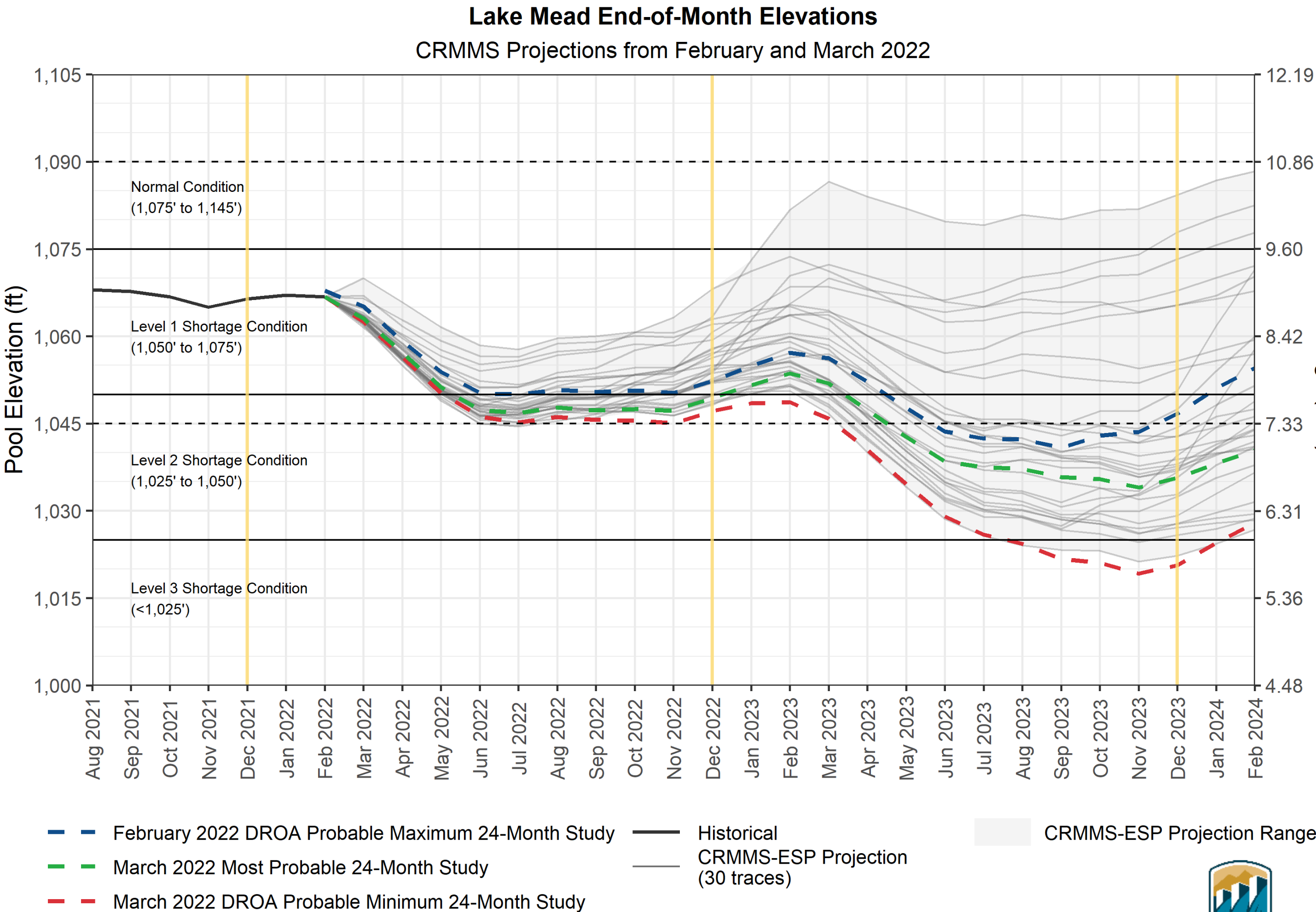

COLORADO RIVER
IMPERIAL DAM
NORTH GILA VALLEY IRRIGATION & DRAINAGE DISTRICT
YUMA IRRIGATION DISTRICT
YUMA COUNTY WATER USERS' ASSOCIATION
CALIFORNIA
MEXICO
COLORADO RIVER
CITY OF YUMA
YUMA MESA IRRIGATION & DRAINAGE DISTRICT
UNIT B IRRIGATION & DRAINAGE DISTRICT
WELLTON-MOHAWK IRRIGATION & DRAINAGE DISTRICT
ARIZONA
MEXICO
Priority 1
Priority 2 & 3



End of CY 2022 Projections

Most Probable:
1,049.37 feet (29% full)

Probable Min:
1,047.10 feet

End of CY 2023 Projections

Most Probable:
1,035.63 feet (26% full)

Probable Min:
1,020.63 feet

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Lake Mead

End of CY 2022 Projections:

Most Probable: 1,049.37 feet (29% full)

→ Tier 2a

Probable Min: 1,047.10 feet

Lake Mead

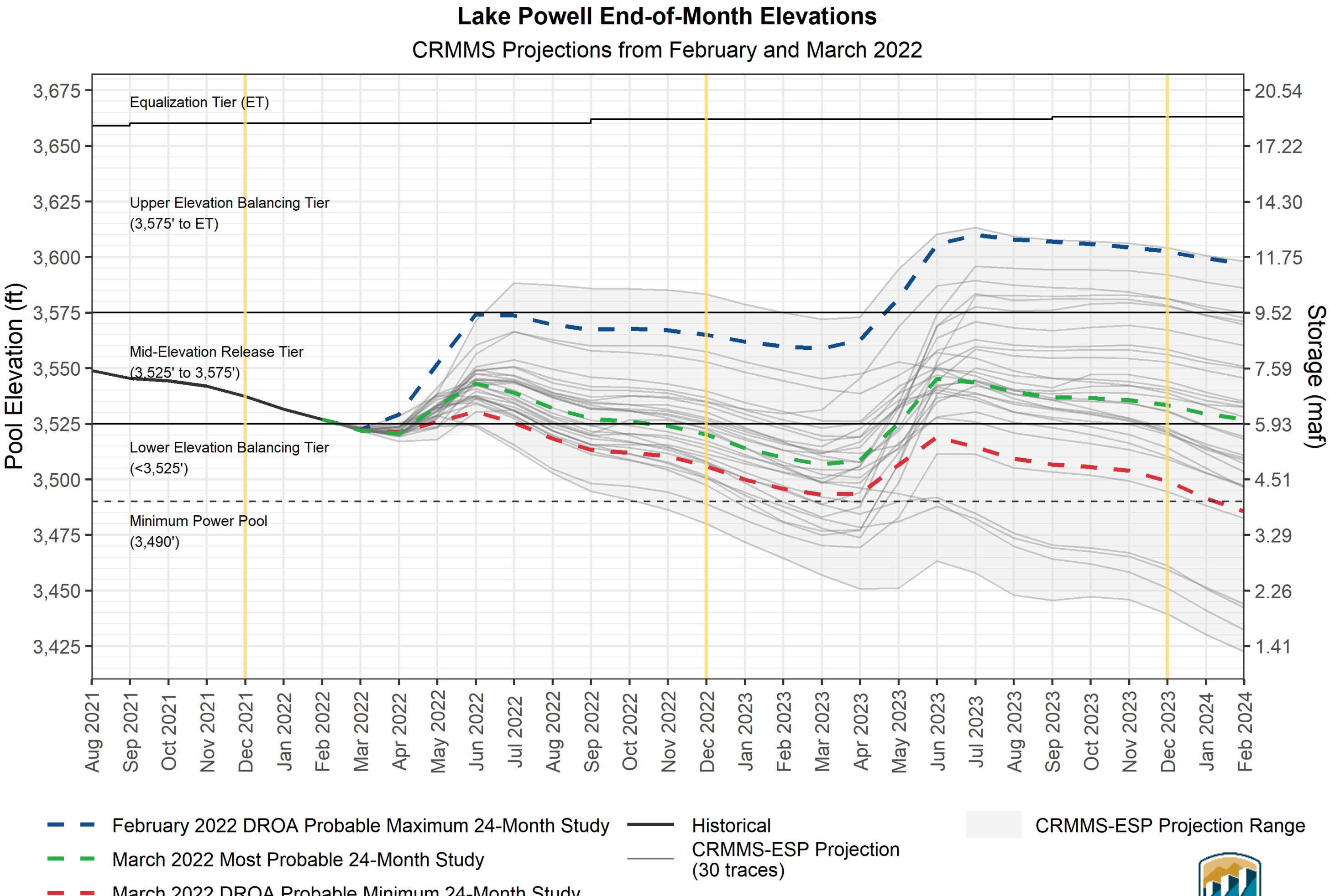
End of CY 2023 Projections:

Most Probable: 1,035.63 feet (26% full)

→ Tier 2b

Probable Min: 1,020.63 feet

→ Tier 3



End of CY 2022 Projections
Most Probable: 3,520.08 feet (23% full)
Probable Min: 3,505.84 feet

End of CY 2023 Projections
Most Probable: 3,533.37 feet (27% full)
Probable Min: 3,499.31 feet

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Lake Powell – End of CY2022

Most Probable: 3,520.08 ft. (23% full)

Probable Min: 3,505.84 ft.

If the lake falls to 3,490 ft., there would not be enough water to operate the generators in Glen Canyon Dam

- provides power to Wyoming, Utah, Colorado, New Mexico, Arizona, Nevada, and Nebraska.

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BoR Lake Powell – 21 April 2022

- Proposed to reduce the risk of damage to the hydropower turbines at Lake Powell:
  - **7.48 MAF** to **7MAF** reduction in flow to Lake Mead in fiscal 2022.
  - Also serves to protect water deliveries to Page and the Navajo Nation.

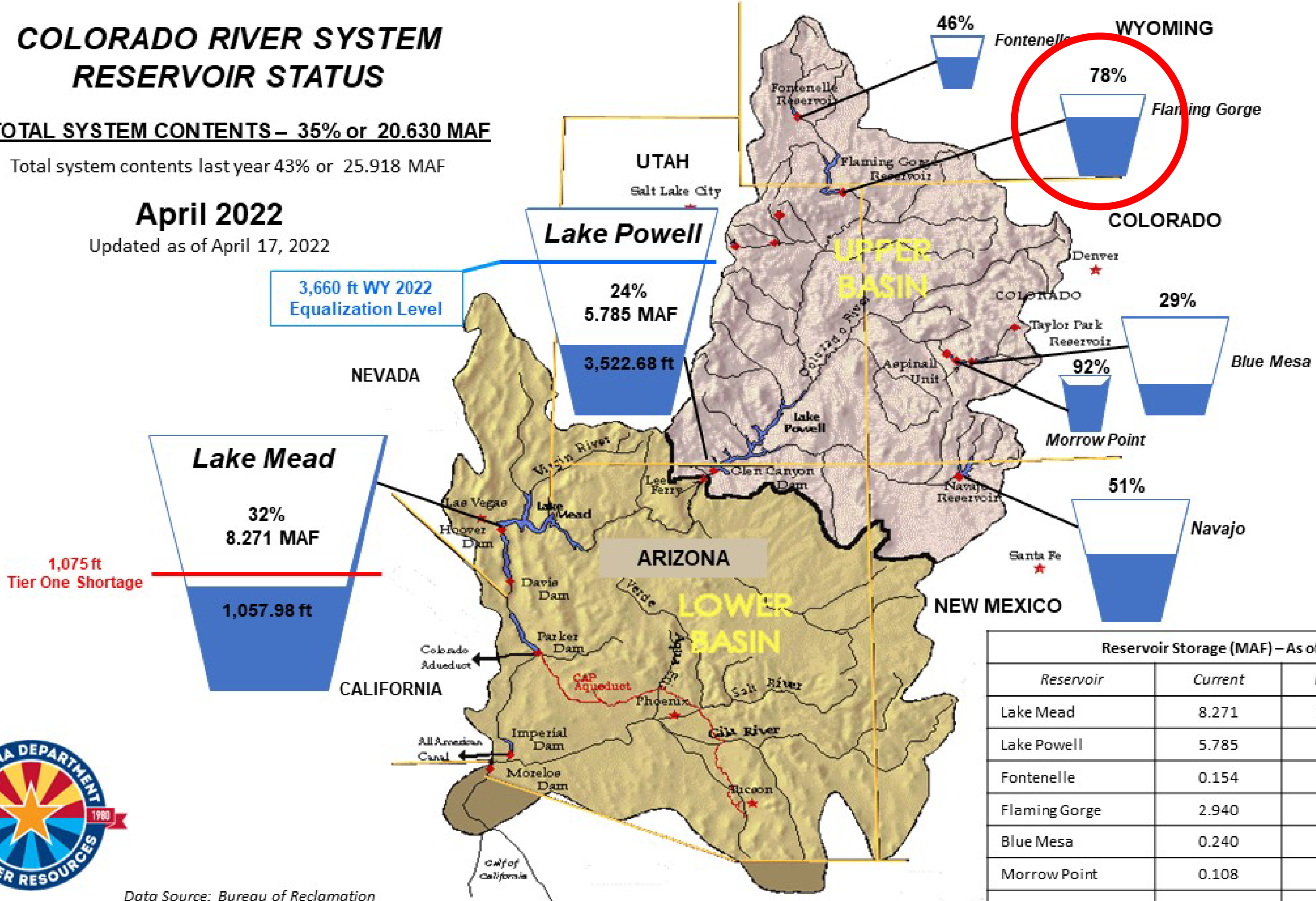
COLORADO RIVER SYSTEM RESERVOIR STATUS

TOTAL SYSTEM CONTENTS – 35% or 20.630 MAF

Total system contents last year 43% or 25.918 MAF

April 2022

Updated as of April 17, 2022



Reservoir Storage (MAF) – As of April 17, 2022			
Reservoir	*Current*	*Last Year*	*Maximum*
Lake Mead	8.271	10.184	26.120
Lake Powell	5.785	8.655	24.322
Fontenelle	0.154	0.126	0.334
Flaming Gorge	2.940	3.180	3.749
Blue Mesa	0.240	0.390	0.830
Morrow Point	0.108	0.102	0.117
Navajo	0.870	1.050	1.696

ARIZONA DEPARTMENT of WATER RESOURCES EST. 1980

Data Source: Bureau of Reclamation

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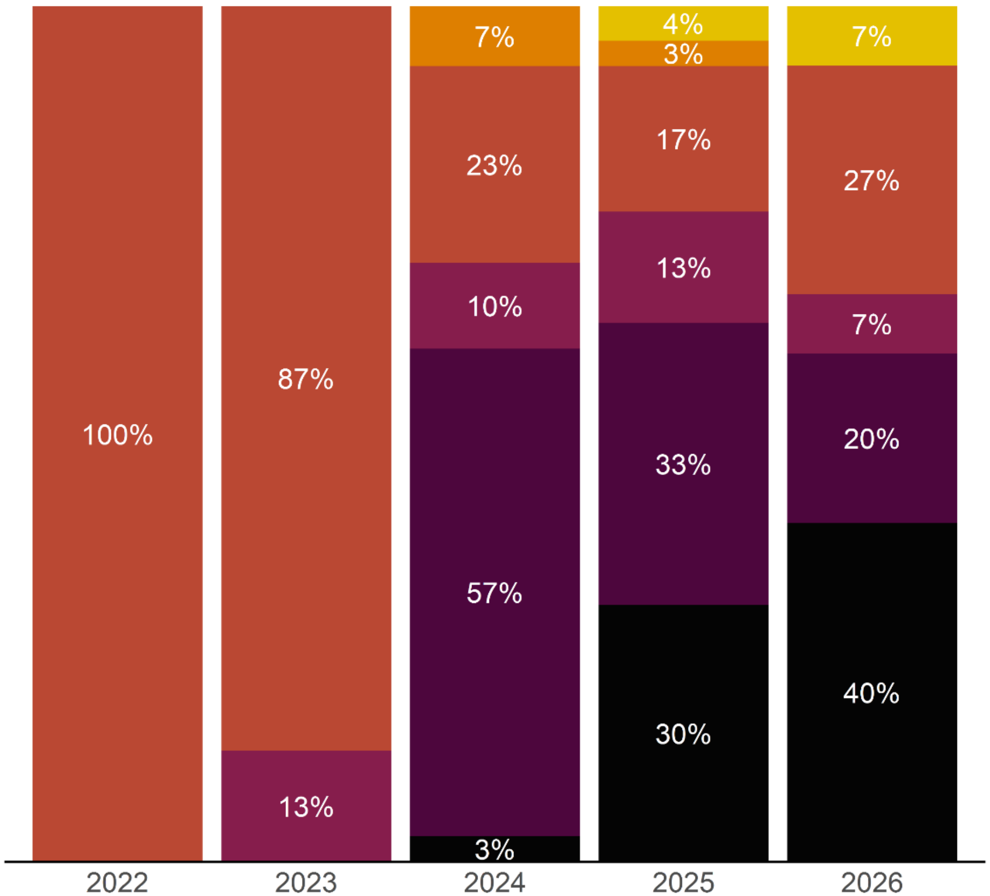
BoR Lake Powell – 3 May 2022

- **500KAF** of water will come from Flaming Gorge Reservoir, located approximately 455 river miles upstream of Lake Powell.

- **480KAF** will be left in Lake Powell by **reducing Glen Canyon Dam's annual release volume from 7.48MAF to 7.0MAF**, as outlined in the 2007 Interim Guidelines that control operations of Glen Canyon Dam and Hoover Dam.

Percent of Traces with Event or System Condition - Lake Mead

February 2022 CRMMS-ESP Projections



Data Source: Bureau of Reclamation

Operating Condition	Pool Elevation	AZ Reduction & Contribution
Surplus	≥ 1,145'	0 KAF
Normal	> 1,090' and < 1,145'	0 KAF
Tier 0	> 1,075' and ≤ 1,090'	192 KAF
Tier 1	≥ 1,050' and ≤ 1,075'	512 KAF
Tier 2a	> 1,045' and < 1,050'	592 KAF
Tier 2b	≥ 1,025' and ≤ 1,045'	640 KAF
Tier 3	< 1,025'	720 KAF

Water & Arizona Agriculture

Good Stewards of Arizona Land & Water Resources

Irrigated Systems

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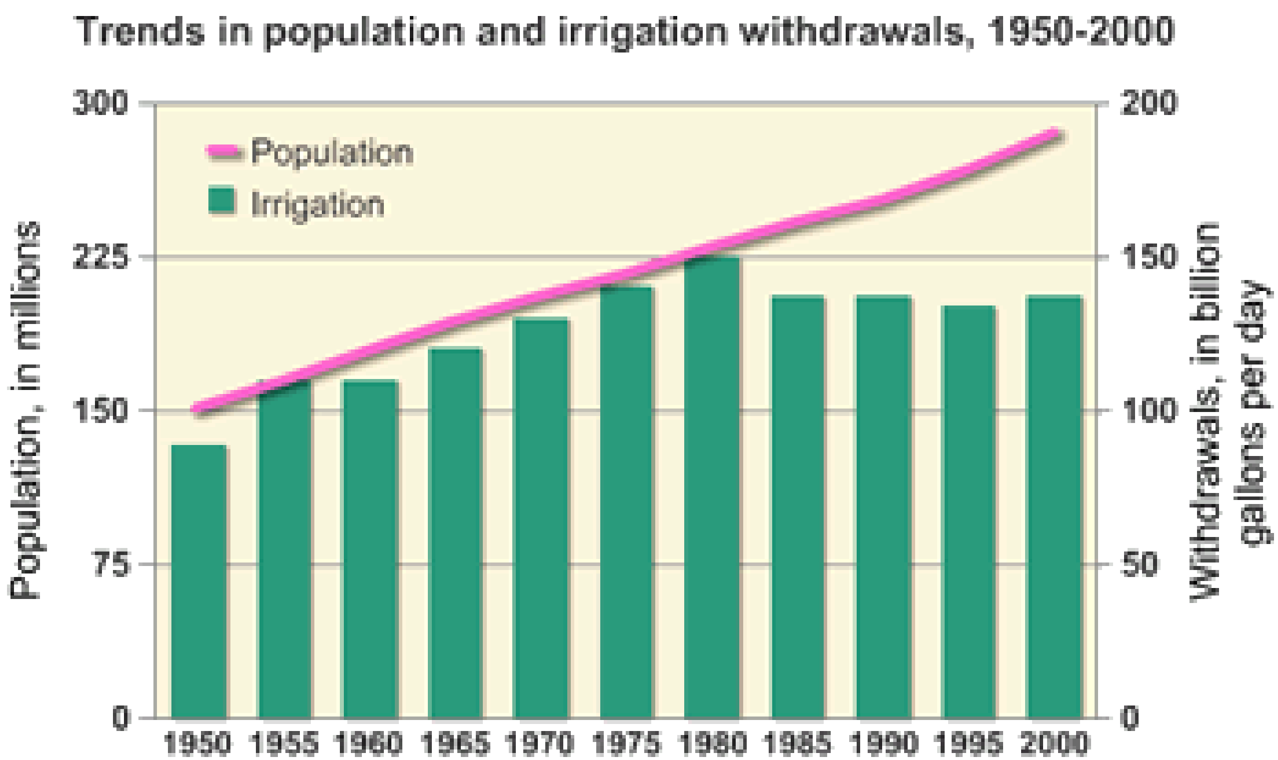
Decades of Improvements

- Yields and efficiencies of production have increased.
  - Higher yields
    - Highest yields and quality of crops in the world.
  - Less land utilized
  - Less irrigation water utilized per acre
  - Less crop inputs, e.g. pesticides & fertilizers
  - Increased diversification of crops and cropping systems.
    - Including extensive seed production

Ag Water Use – U.S. 1950-2000



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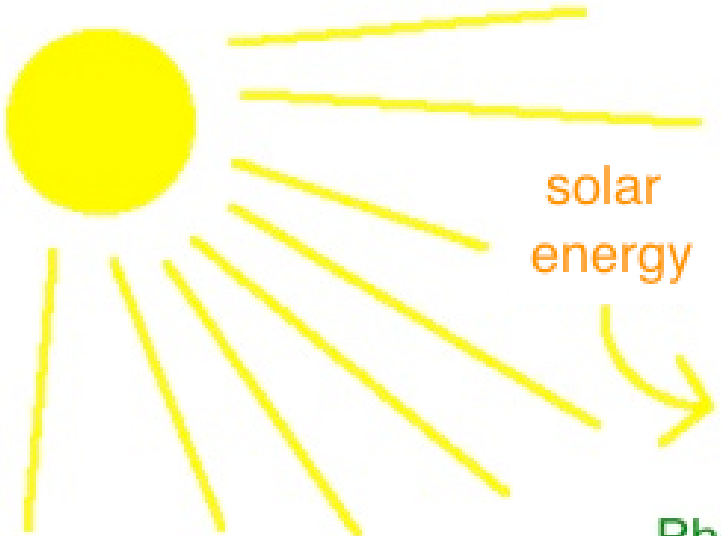
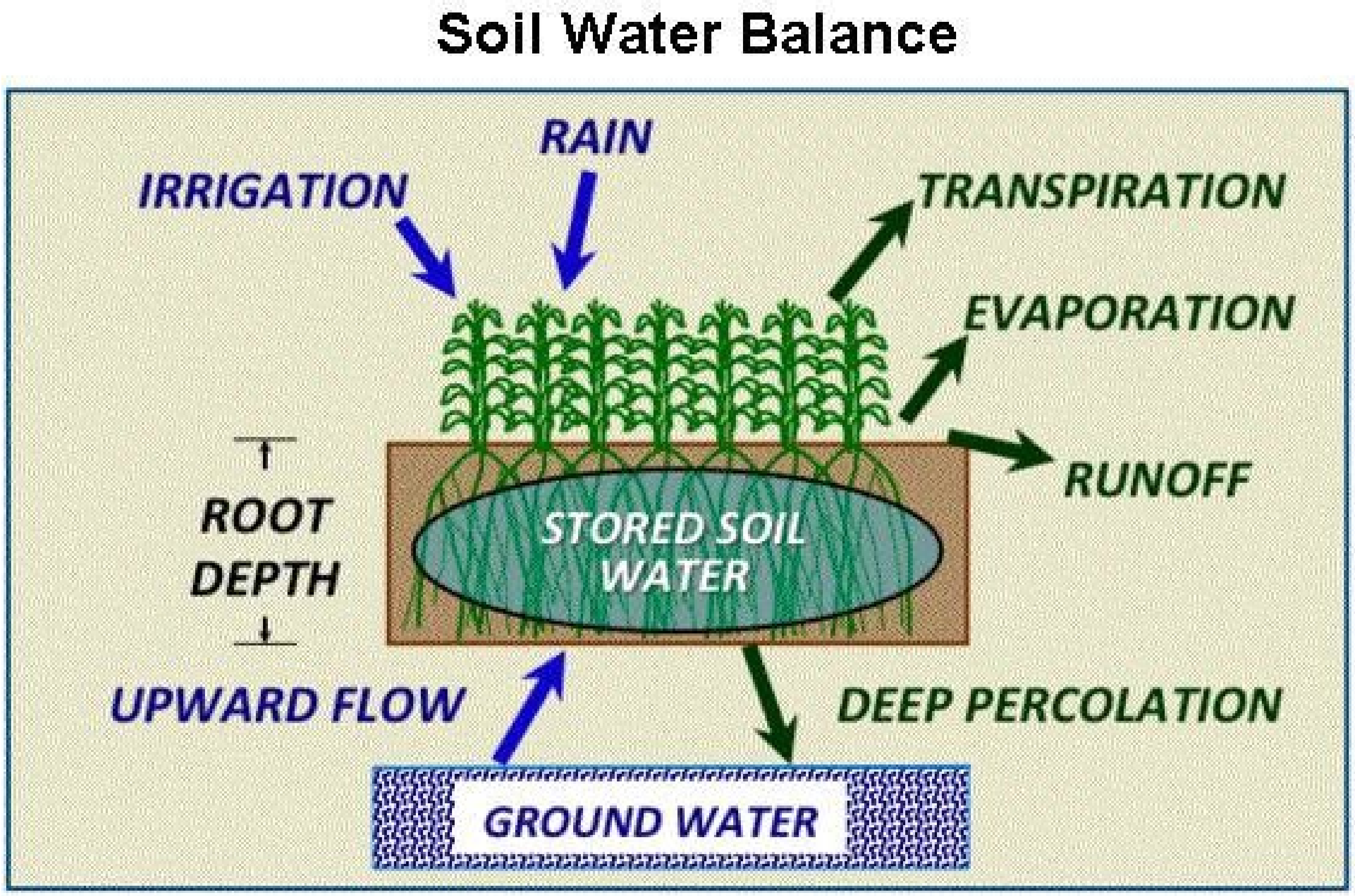


Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow{\text{Photosynthesis}} C_6H_{12}O_6 + 6O_2$$

carbon dioxide	water	glucose	oxygen

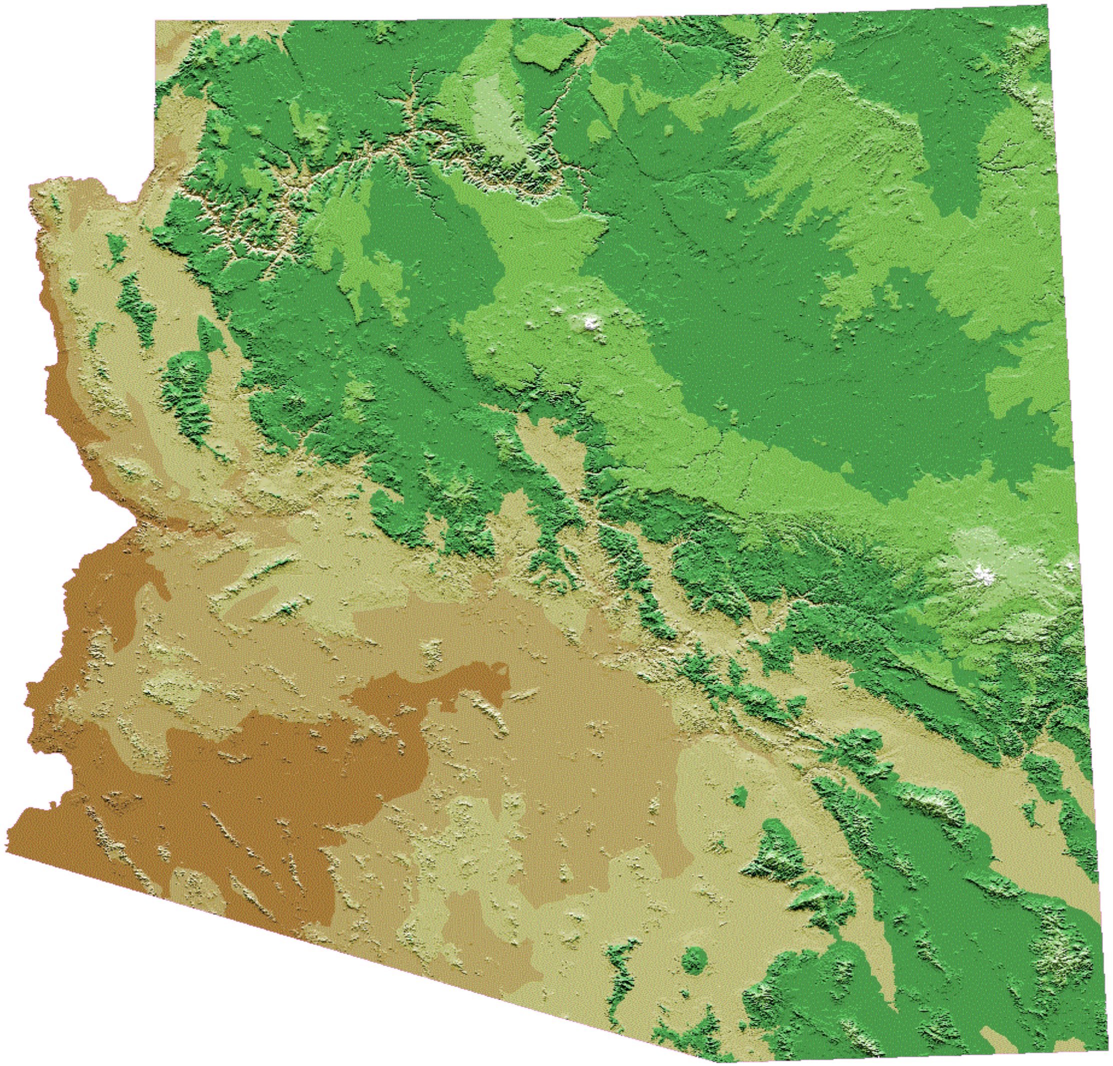
Soil Water Balance



Efficiency Objectives

- Agronomic
  - Inputs and crop response
- Economic
  - Cost of production and net returns on the crop
- Environmental
  - Short-term impacts
  - Long-term impacts

Agriculture and The Great State of Arizona



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Irrigation Systems in Arizona

- Efficiency: ~ 50 – 100%

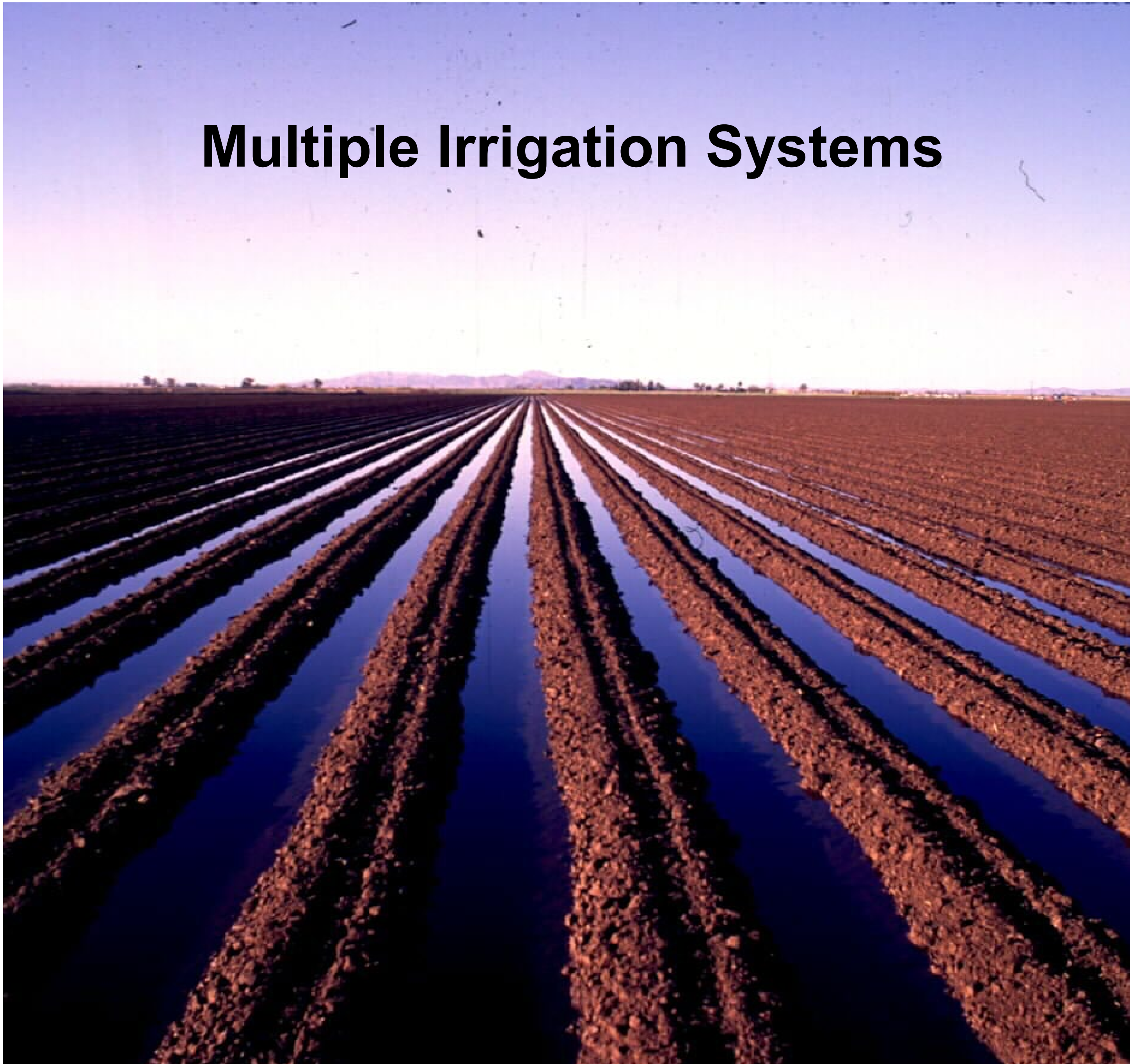
  Depends on the system design and management

  – Inefficient irrigation systems tend to have long runs, low flow turnouts, and a high degree of slope

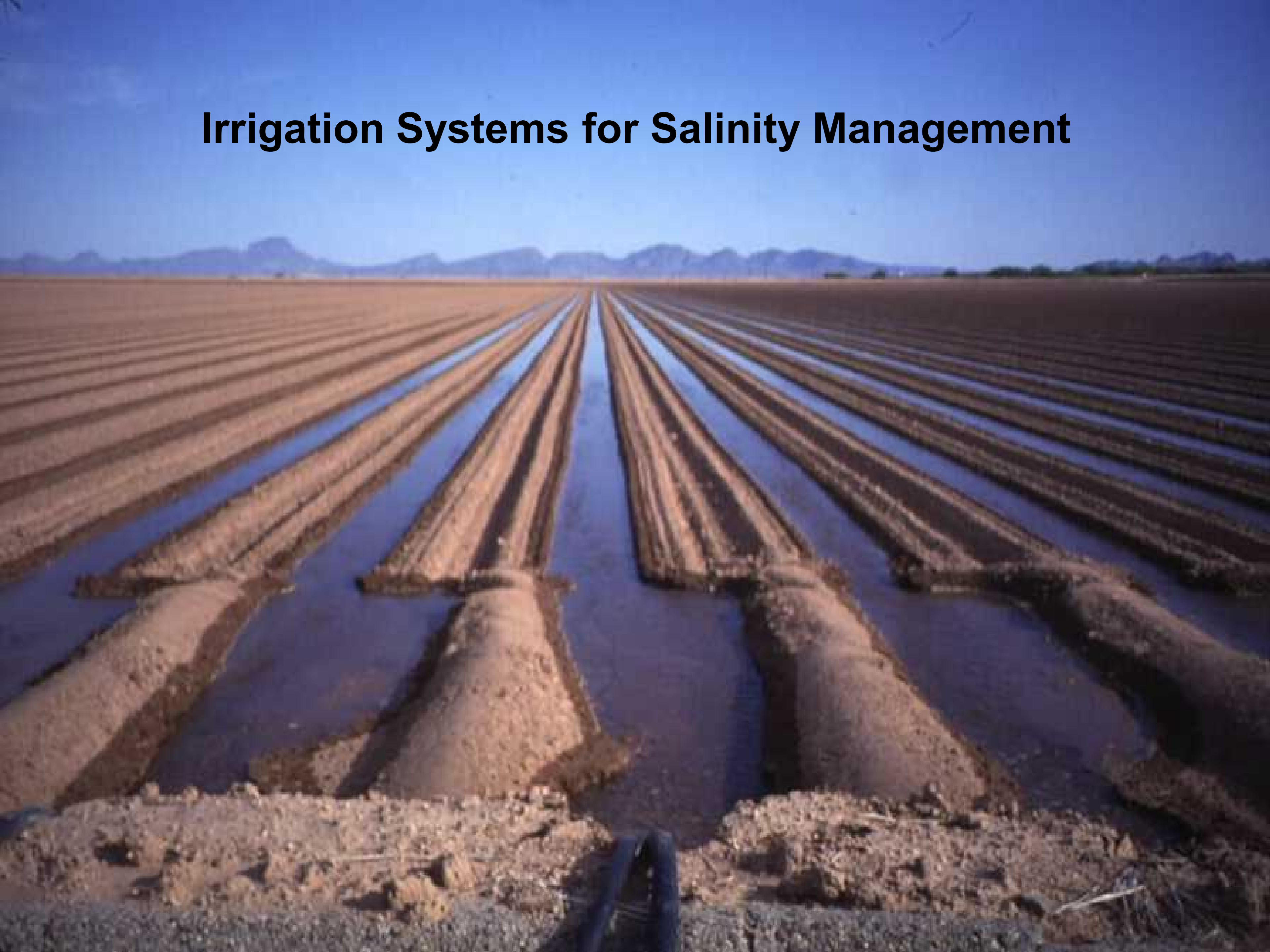
  – Fields that are level, with high flow turnouts, or drip systems tend to be most efficient

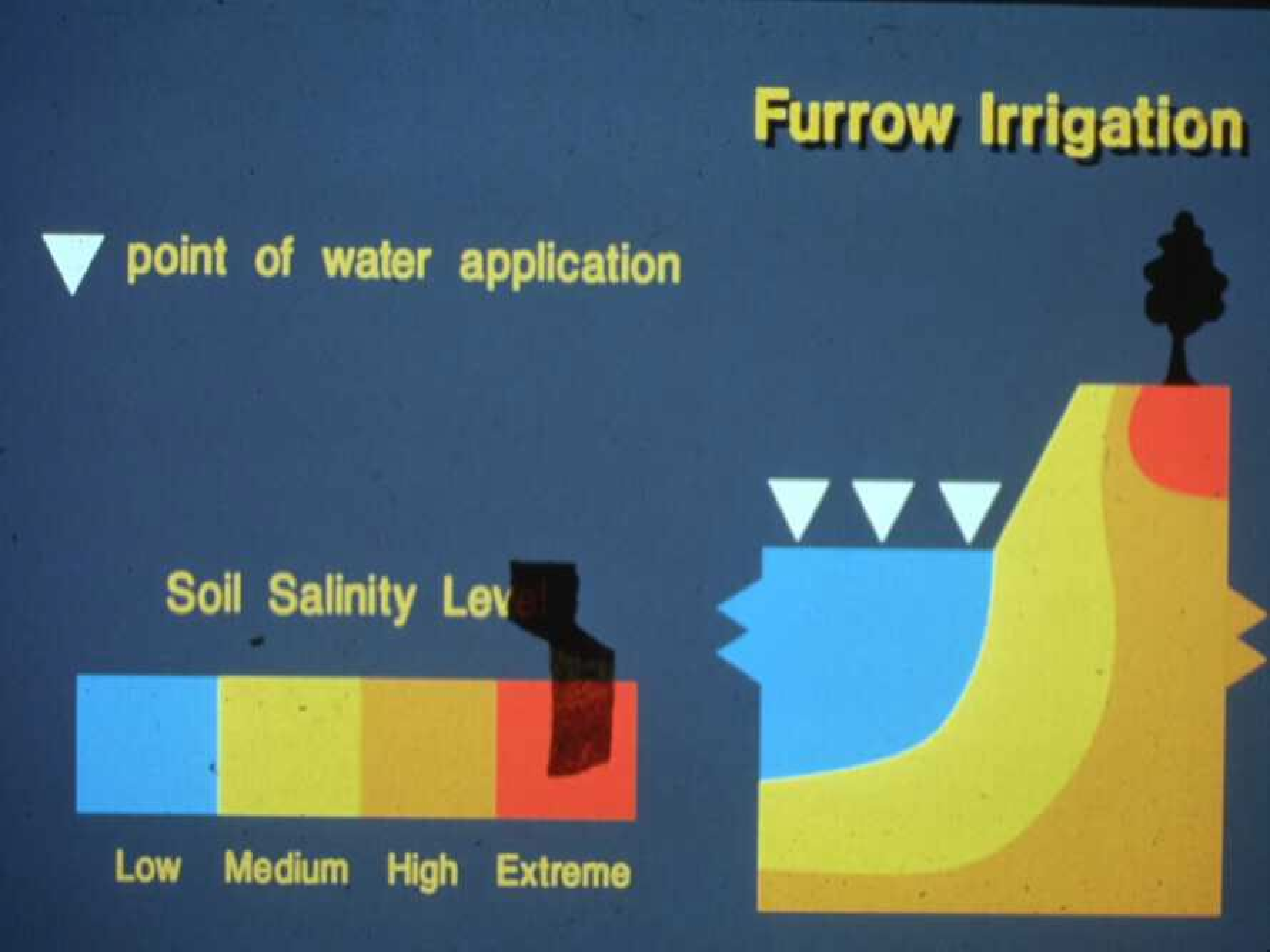
    - High efficiency is possible with sprinklers but not a certainty

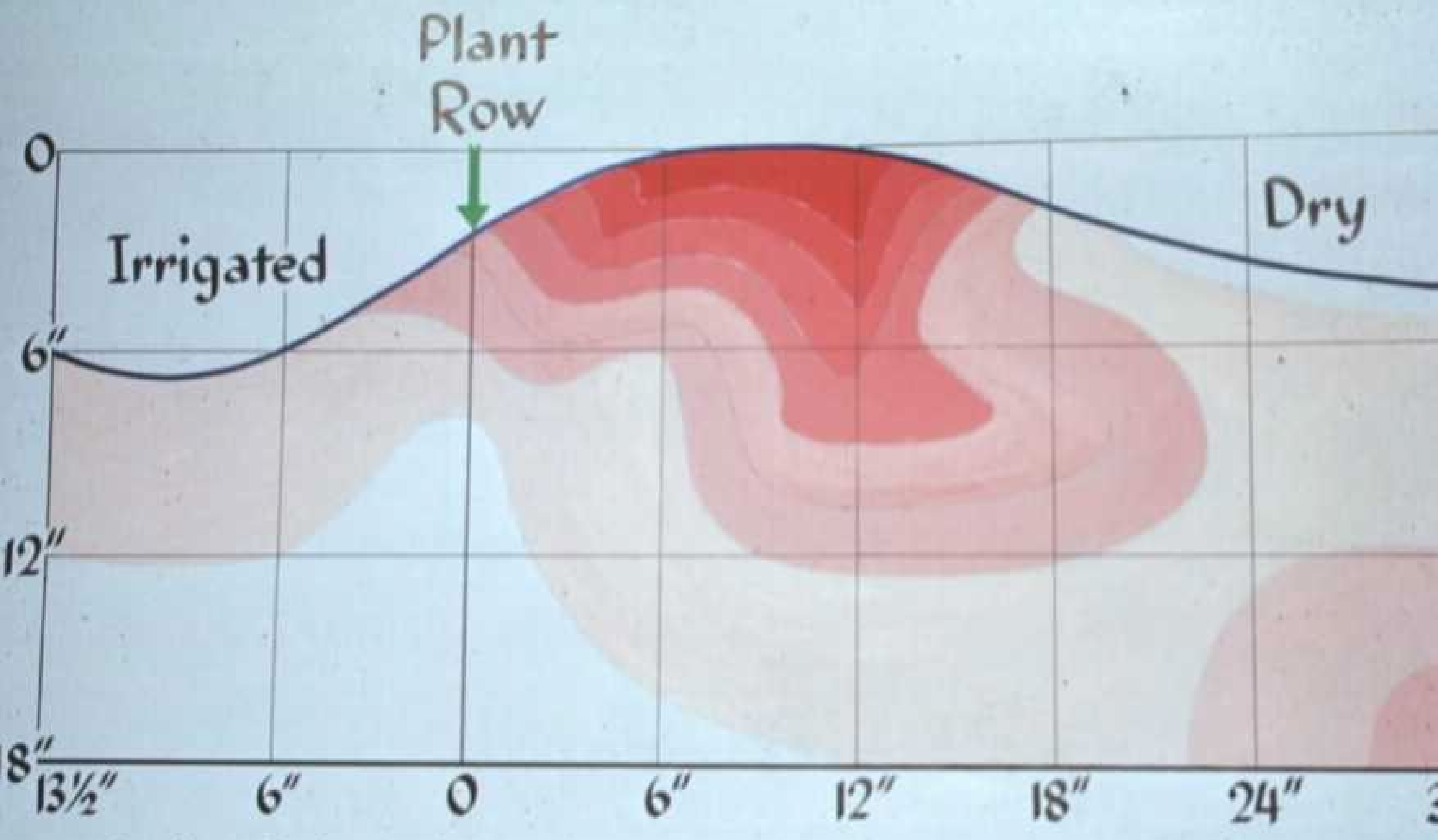
Multiple Irrigation Systems



Irrigation Systems for Salinity Management




Furrow Irrigation
point of water application
Soil Salinity Level
Low
Medium
High
Extreme



Salt Distribution in Bed Profile

VARIABLE ROW SPACING

Irrigation Water Management

- Irrigator's Equation: **Q x t = d x A**

  Q = the flow rate, in cubic feet per second (cfs);

  t = the set time or total time of irrigation (hours);

  d = the depth of water applied (inches)
  A = the area irrigated (acres).

Irrigation Water Management

- Irrigator's Equation: **Q x t = d x A**

Solving for irrigation set time (t):

$$t = d \times A / Q$$

Soil Texture & Water Holding Capacity

Textural class	*Water holding capacity, inches/foot of soil*
Coarse sand	0.25 - 0.75
Fine sand	0.75 - 1.00
Loamy sand	1.10 - 1.20
Sandy loam	1.25 - 1.40
Fine sandy loam	1.50 - 2.00
Silt loam	2.00 - 2.50
Silty clay loam	1.80 - 2.00
Silty clay	1.50- 1.70
Clay	1.20 - 1.50


IRC LLC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Crop Water Demand & Management

- **Crop Consumptive Use (CU)**
  - **ET (evapotranspiration)**
    - **Evaporation (soil) + Transpiration (crop)**
    - **Describes the demand for irrigation – how much to apply.**

- Leaching requirement
  - Need to provide adequate soil leaching (salinity managment)
  - Irrigated crop production systems
  - Arid and semi-arid regions

Irrigation Water Management

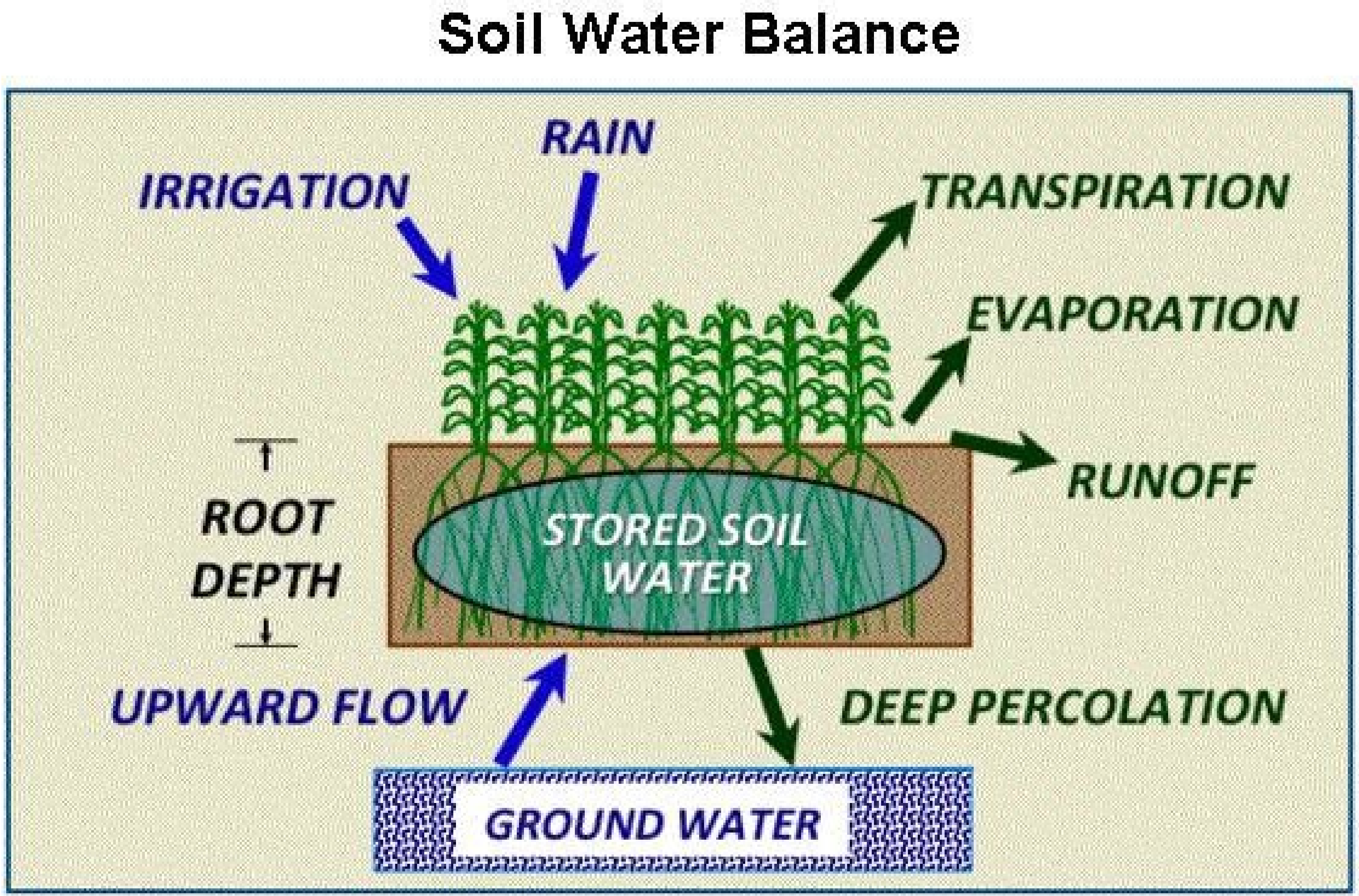
- Irrigator's Equation: **Q x t = d x A**

Solving for irrigation set time (t):

$$t = d \times A / Q$$


Irrigation Management

Soil Water Balance



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  - **Arid and semi-arid regions**

Salinity – Desert Agriculture

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Salinity
A Desert Agriculture Challenge

"Successful irrigation schemes in arid regions carry seeds of their own demise" (Gardner, 1985)

Example: ppm X 2.7 = lbs./AF-water

700 ppm X 2.7 = 1,890 lbs. salt/AF

X 5 AF-water = 9,450 lbs. salt/acre

(4.7 T salt/acre)

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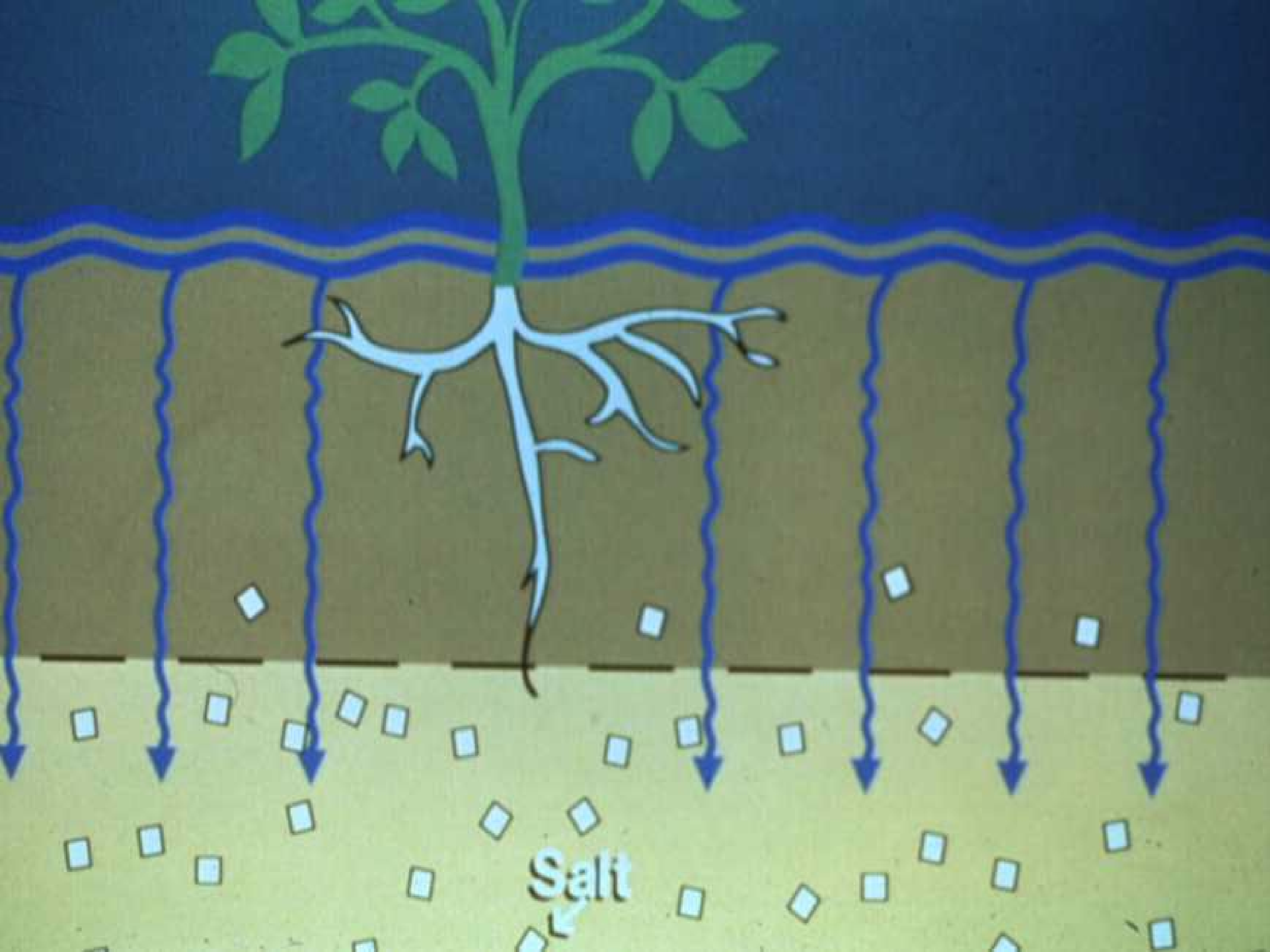
Salt

Leaching Requirement Calculation (LR)

- electrical conductivity (EC)
  - EC for the water (EC_w)
  - Critical plant salinity tolerance (EC_e)
  - Development of salinity equilibrium

$$LR = \frac{EC_w}{5(EC_e) - EC_w}$$

Salinity/Leaching Management

- Monitor water quality for salinity/sodicity
- Monitor soil salinity/sodicity
- Monitor crop response patterns
- Crop rotations
  - Variations in root system development
  - Irrigation management
    - Furrow, basin flood, sprinklers, etc.

Crop Production = Art + Science

Manage irrigation systems for efficiency & sustainability

Colorado River Watershed

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Sustainable Systems for the Next Generations

Water is Life

Photo Credit: Jon Dinsmore

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You can't always get what you want
But if you try sometimes, well, you just might find
You get what you need

M. Jagger

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