Natural Delta Outflow Water Balance

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What do we mean by “natural” conditions?

- Land use and hydrology radically modified since mid-18th century
- Major rivers could not carry normal winter runoff and spring snowmelt
- Natural “level of development”, i.e. natural landscape + contemporary climate

Water Balance Model

Long-Term Average Annual Natural Delta Outflow
Water Years 1922-2009

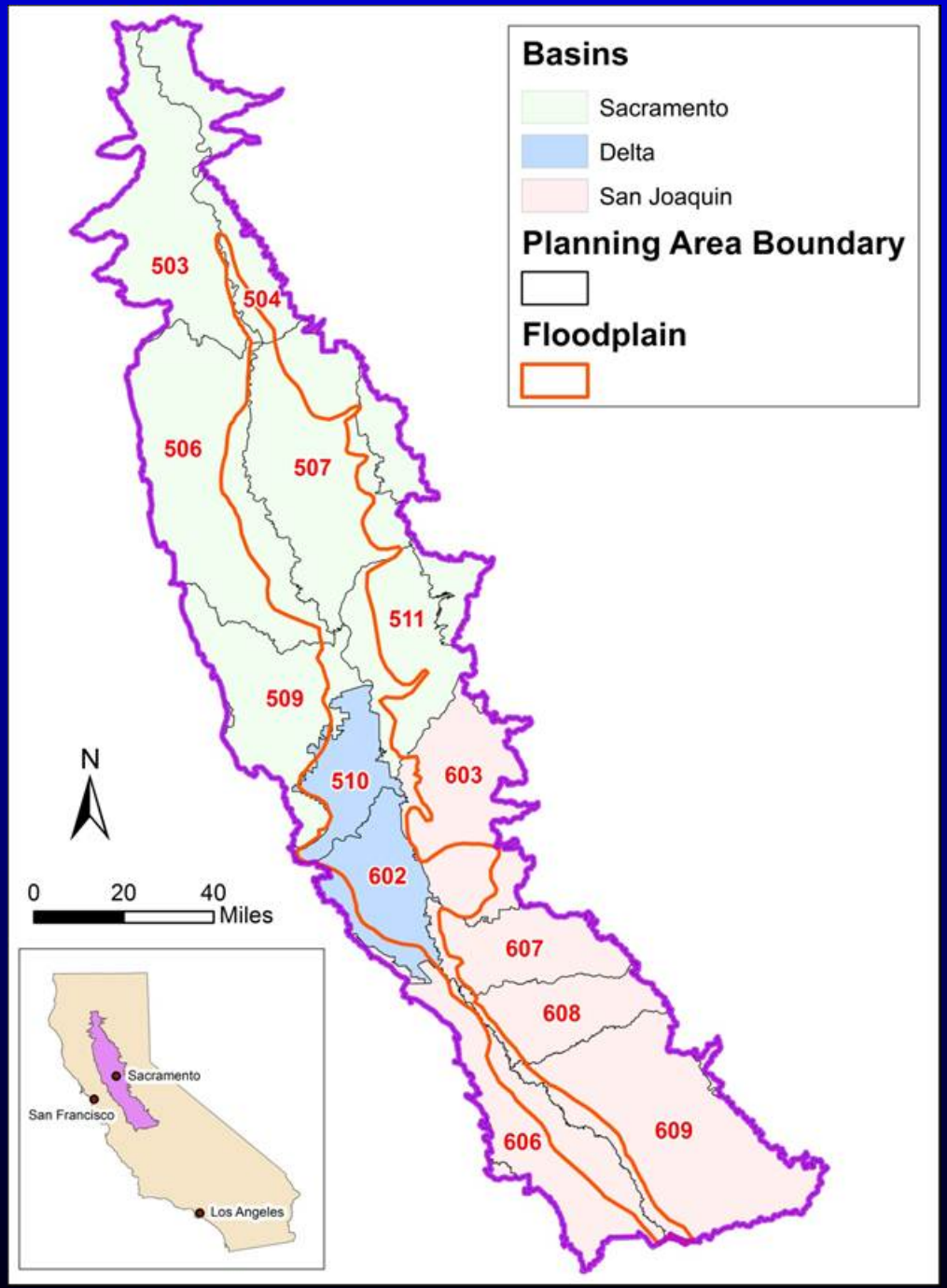
Delta Outflow = Water Supply – Water Use

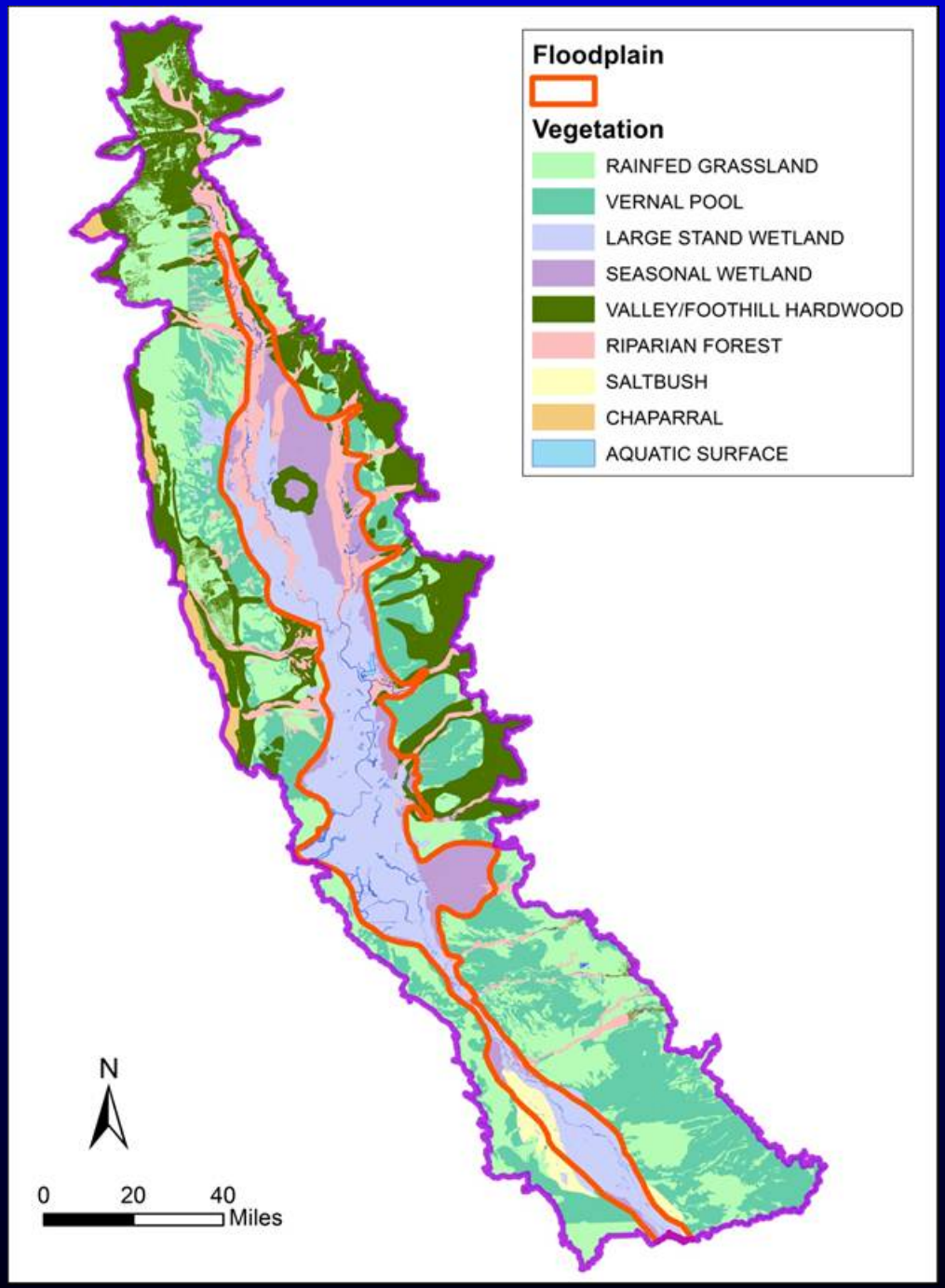
where:

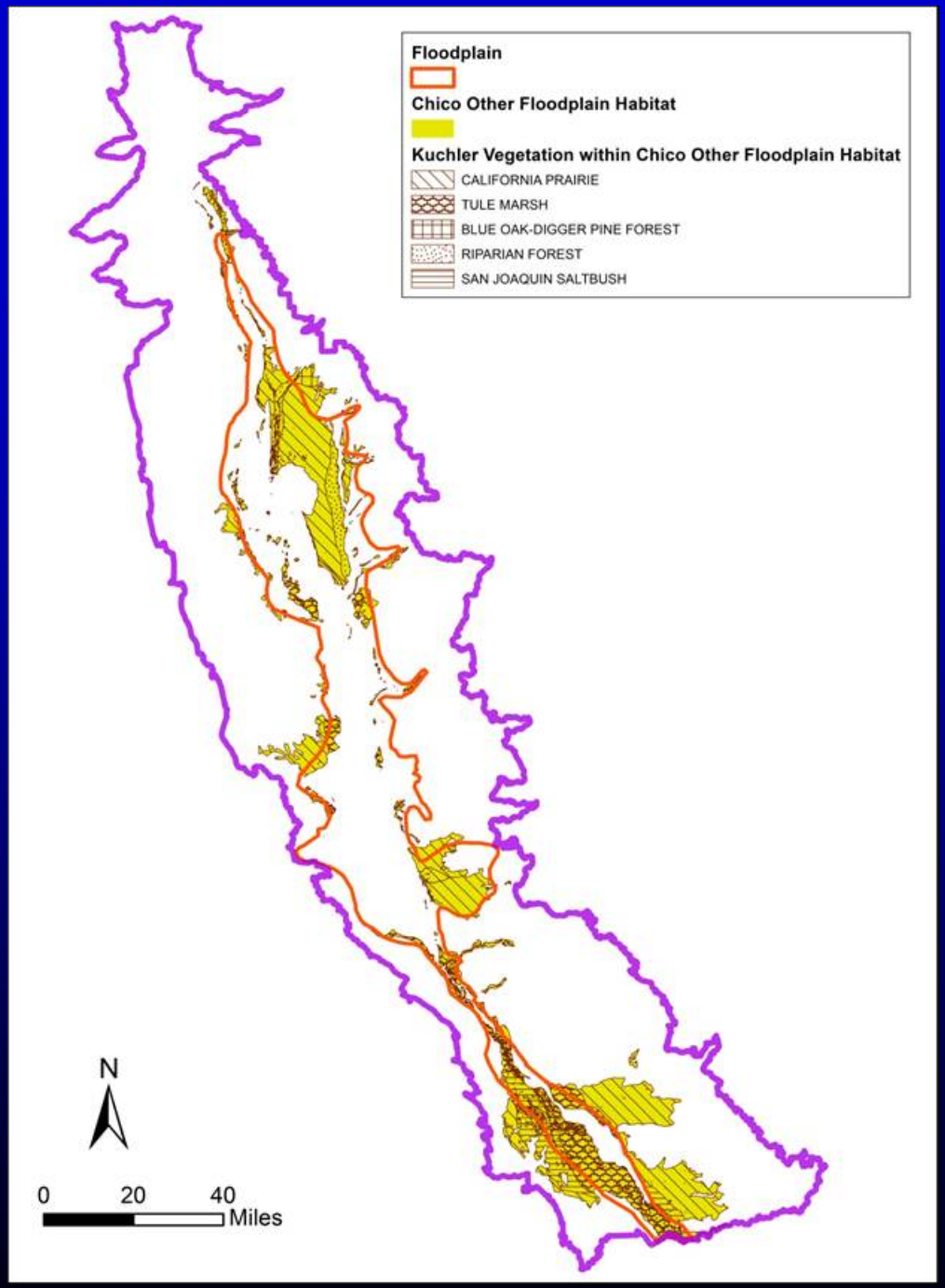
Water Supply = Rim Inflows + Valley Floor Precipitation

Water Use = $\sum \sum (ET_v * A_v)$

summed over all vegetation classes
summed over all planning areas

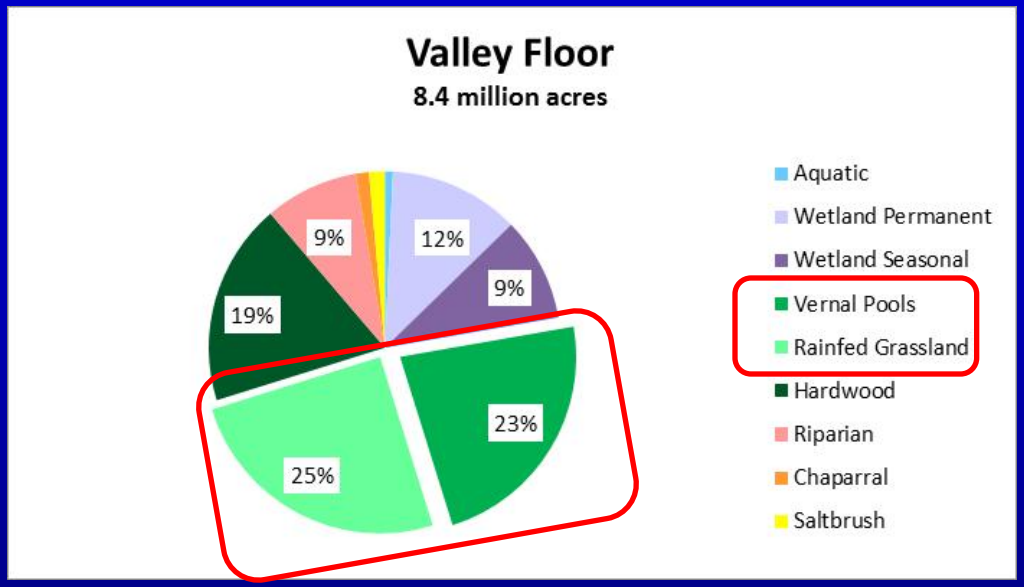

Basins
Sacramento
Delta
San Joaquin
Planning Area Boundary
Floodplain
503
504
506
507
511
509
510
603
602
607
608
606
609
N
0
20
40
Miles
Sacramento
San Francisco
Los Angeles

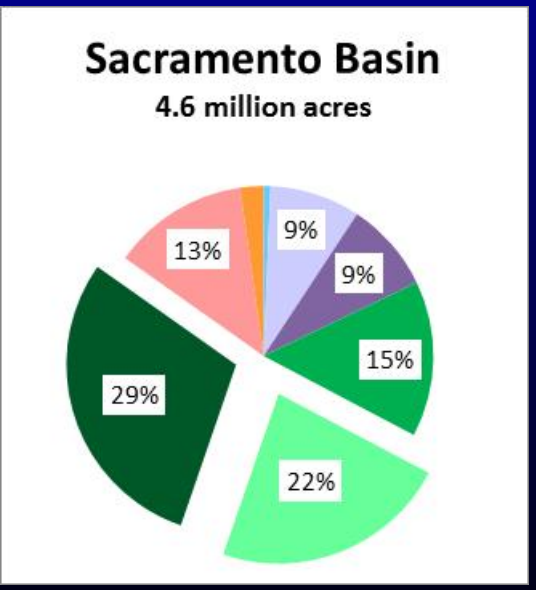

Floodplain
Vegetation
RAINFED GRASSLAND
VERNAL POOL
LARGE STAND WETLAND
SEASONAL WETLAND
VALLEY/FOOTHILL HARDWOOD
RIPARIAN FOREST
SALTBUSH
CHAPARRAL
AQUATIC SURFACE
N
0
20
40
Miles

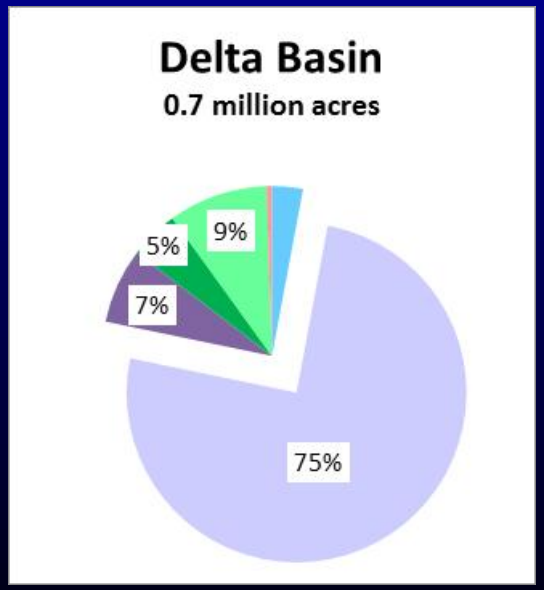

Floodplain
Chico Other Floodplain Habitat
Kuchler Vegetation within Chico Other Floodplain Habitat
CALIFORNIA PRAIRIE
TULE MARSH
BLUE OAK-DIGGER PINE FOREST
RIPARIAN FOREST
SAN JOAQUIN SALTBUSH
N
0
20
40
Miles

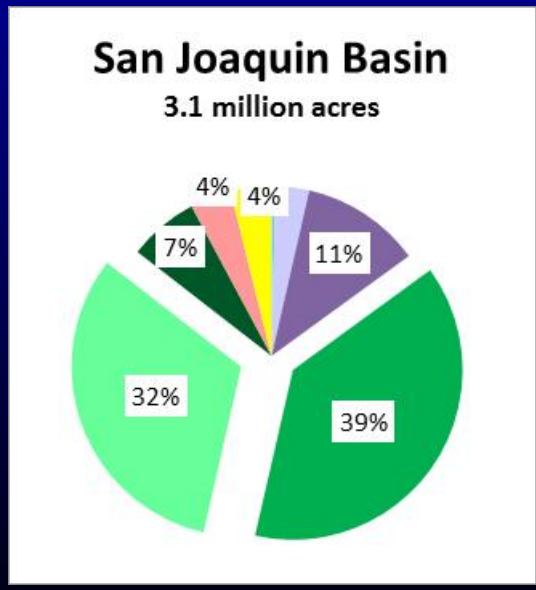
Natural Vegetation Distribution

Scenario 1: Grasslands as a Static Mix of Rainfed & Vernal Pools









Evapotranspiration Rates (ET_v)

88-Year Average (feet per year)

		Grasslands (48%)			Wetlands (21%)		Forest (28%)			Other (3%)		
Basin	**Planning Area**	Rainfed	Perennial	Vernal Pools	Permanent	Seasonal	Foothill Hardwood	Valley Oak Savanna	Riparian	Saltbush	Chaparral	Aquatic Surface
Sacramento	**503**	1.3	4.3	2.5	4.6	4.2	1.5	2.2	4.4	2.0	1.0	4.2
	504	1.1	4.2	2.4	4.6	4.2	1.3	2.1	4.3	2.0	0.9	4.1
	506	1.1	4.4	2.6	4.8	4.4	1.3	2.2	4.5	2.0	0.8	4.3
	507	1.2	4.6	2.6	4.9	4.5	1.4	2.3	4.7	2.1	0.9	4.5
	509	1.1	4.5	2.6	4.8	4.4	1.3	2.2	4.6	2.1	0.8	4.3
Delta	**510**	1.0	4.5	2.6	4.9	4.4	1.3	2.2	4.6	2.1	0.8	4.4
	602	0.9	4.0	2.3	4.3	3.9	1.1	1.9	4.1	1.8	0.6	3.9
San Joaquin	**511**	1.1	4.7	2.7	5.1	4.6	1.4	2.4	4.8	2.2	0.9	4.6
	601	0.9	3.7	2.2	4.0	3.7	1.1	1.8	3.8	1.7	0.6	3.6
	603	1.1	4.7	2.7	5.1	4.6	1.4	2.3	4.8	2.2	0.8	4.6
	606	0.8	4.4	2.6	4.8	4.4	1.0	2.0	4.6	2.1	0.6	4.3
	607	1.0	4.6	2.7	5.0	4.5	1.2	2.2	4.7	2.1	0.7	4.5
	608	0.9	4.7	2.8	5.1	4.7	1.2	2.3	4.9	2.2	0.7	4.6
	609	1.0	5.0	2.9	5.4	4.9	1.2	2.3	5.1	2.3	0.7	4.9
Range		**0.9-1.2**	**3.7-5.0**	**2.2-2.9**	**4.0-5.4**	**3.7-4.9**	**1.0-1.5**	**1.8-2.4**	**3.8-5.1**	**1.7-2.3**	**0.6-1.0**	**3.6-4.9**

#	Scenario Category	Deviation from Scenario 1
2	Constant Area Grassland Scenarios	Grassland vegetation assumed as “Vernal Pools”
3		Grassland vegetation assumed as mix of “Vernal Pools” and “Perennial”
4		Grassland vegetation assumed as mix of “Vernal Pools” and “Perennial” in Sacramento & Delta Basins & assumed as “Rainfed” in San Joaquin Basin
5	Variable Area Grassland Scenarios	Grassland vegetation (except “Vernal Pools”) assumed as mix of “Perennial” and “Rainfed” that varies annually with Valley Floor natural inflow
6		Grassland vegetation assumed as mix of “Perennial” and “Rainfed” that varies annually with Valley Floor natural inflow
7	Other Scenarios	Hardwood vegetation assumed as “Valley Oak Savanna”
8		Same as Scenario 5 except “Seasonal Wetlands” assumed as “Rainfed Grasslands” in San Joaquin Basin floodplain

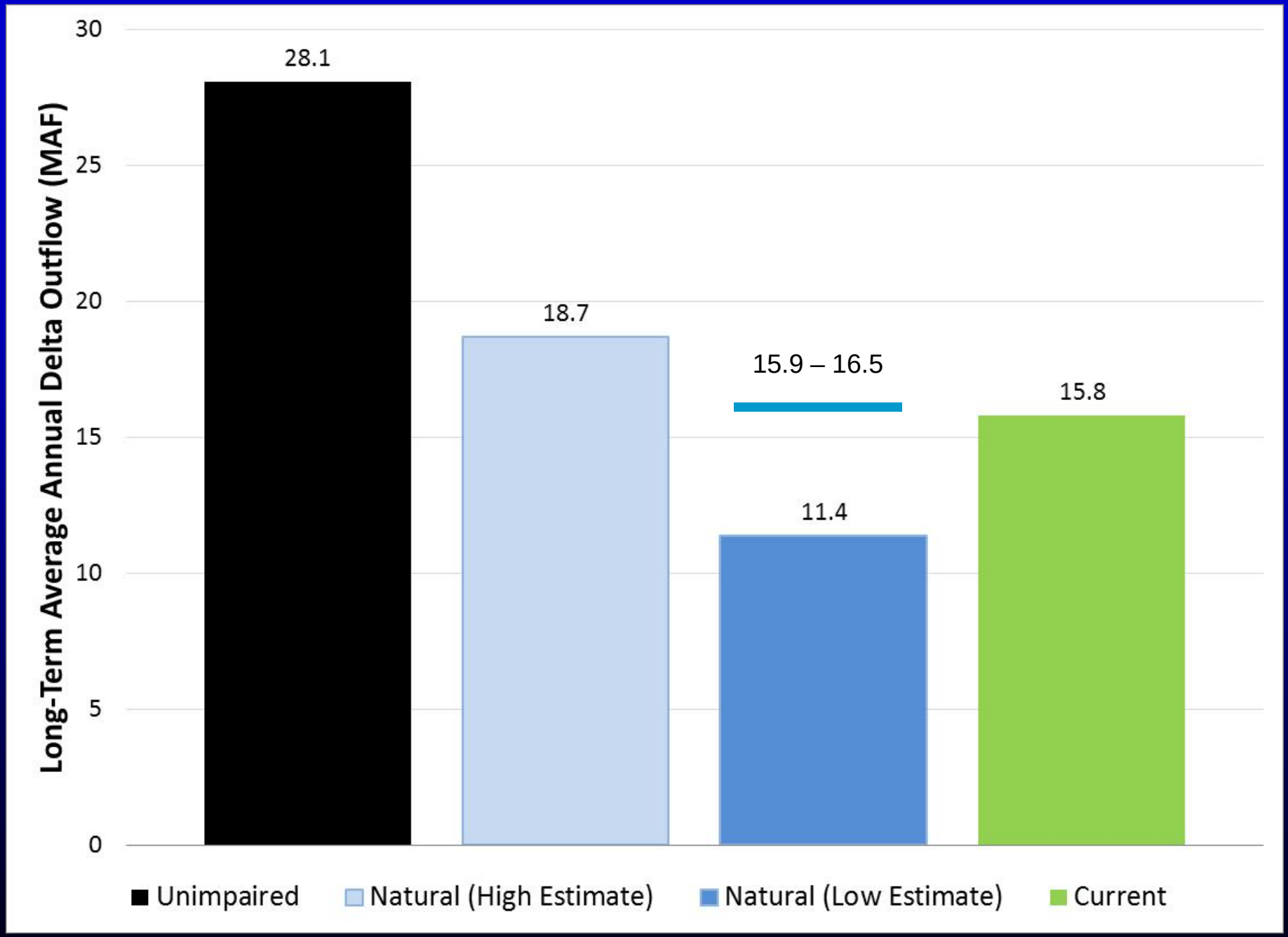
Natural Water Balance

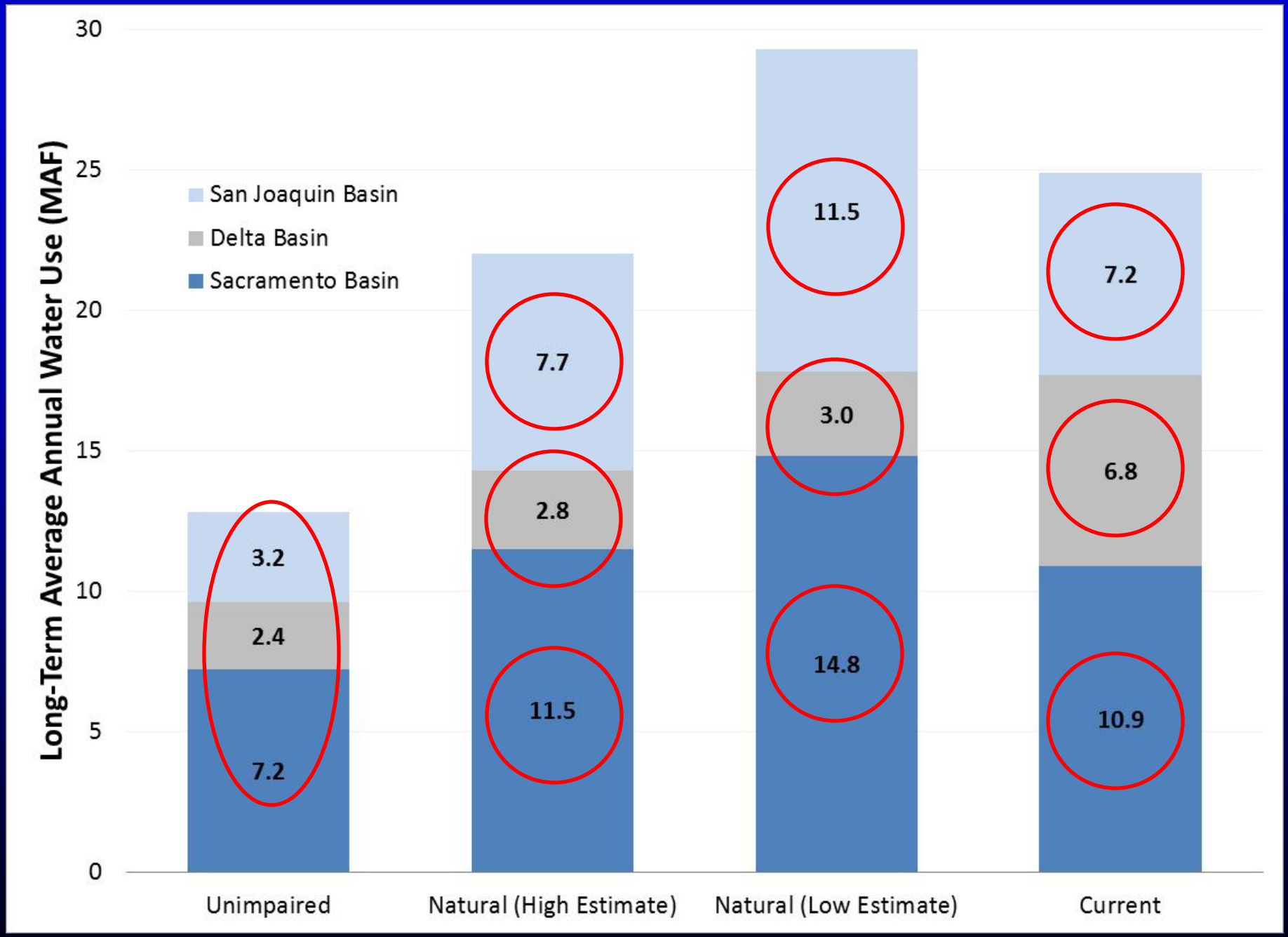
Water Years 1922-2009

MAF per year

Water Supply	
Rim Inflow	**27.7**
Precipitation	**12.9**
Total	**40.6**

Water Use	#1	#2	#3	#4	#5	#6	#7	#8
Sacramento Basin	11.5	12.9	14.8	14.8	12.7	12.6	12.6	14.8
Delta Basin	2.8	2.9	3.0	3.0	2.8	2.8	2.8	3.0
San Joaquin Basin	7.7	9.5	11.5	5.4	9.1	8.6	7.9	4.1
Total	21.9	25.2	29.2	23.2	24.7	24.1	23.2	21.9
Delta Outflow	**18.7**	**15.4**	**11.4**	**17.4**	**15.9**	**16.5**	**17.4**	**18.7**


Long-Term Average Annual Delta Outflow (MAF)
30
25
20
15
10
5
0
28.1
18.7
15.9 – 16.5
11.4
15.8
Unimpaired
Natural (High Estimate)
Natural (Low Estimate)
Current


Long-Term Average Annual Water Use (MAF)
30
25
20
15
10
5
0
San Joaquin Basin
Delta Basin
Sacramento Basin
3.2
2.4
7.2
7.7
2.8
11.5
11.5
3.0
14.8
7.2
6.8
10.9
Unimpaired
Natural (High Estimate)
Natural (Low Estimate)
Current

Conclusions

- Long-term average annual Delta outflow is approximately 16 MAF under natural conditions, roughly the same as current outflow.
- Unimpaired outflow calculations should not be used to represent natural conditions, as they do not account for the natural landscape and vegetation water use.
- Natural grassland composition poses the most significant area of uncertainty and is thought to be strongly influenced by groundwater conditions and flood frequency and duration.

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