CALIFORNIA DEPARTMENT OF WATER RESOURCES

Merced Watershed Study

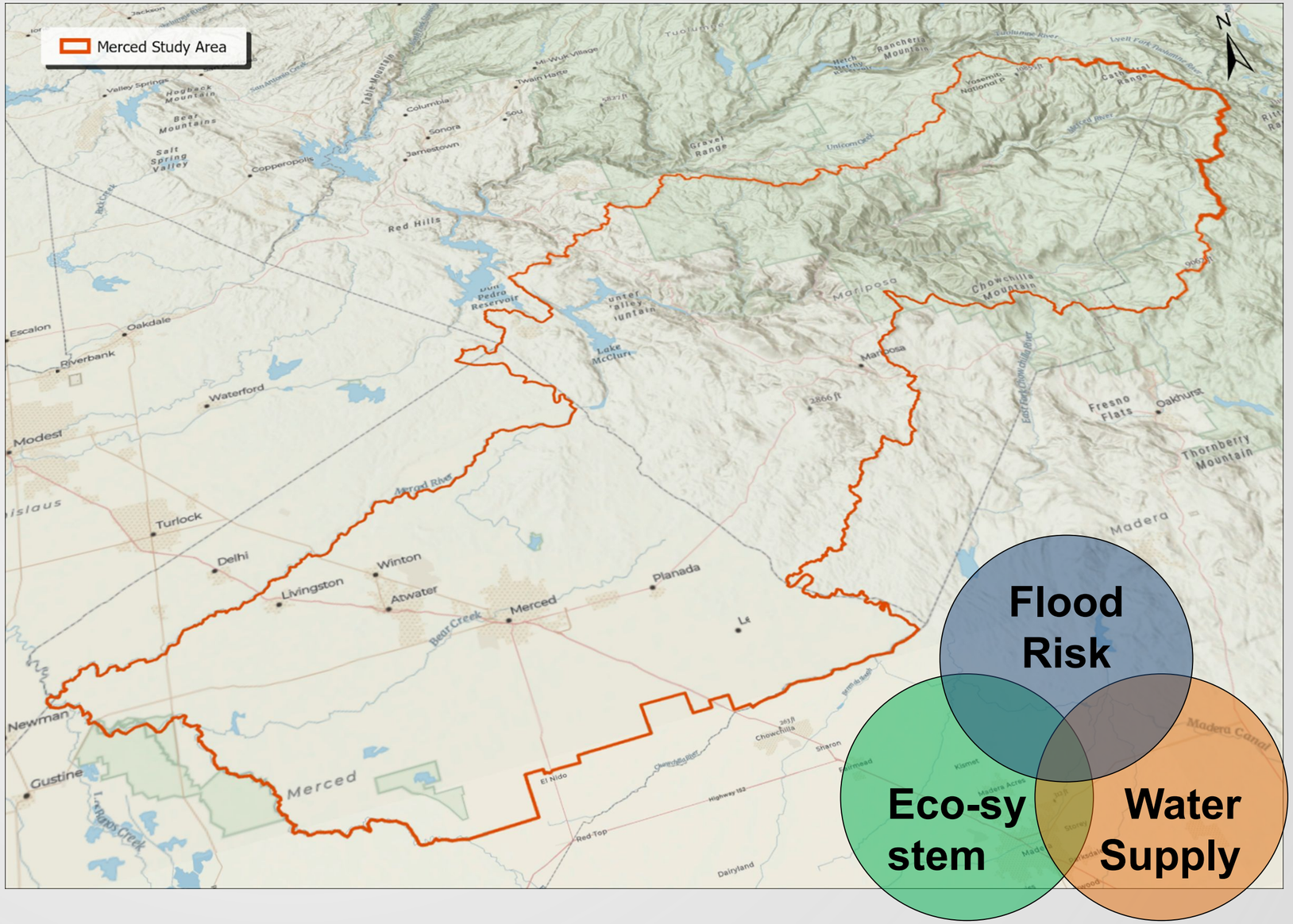
Integrated Watershed | Climate Vulnerability | Flood-MAR | FIRO-MAR

August 4th, 2022

David Arrate

Study Purpose & Goals

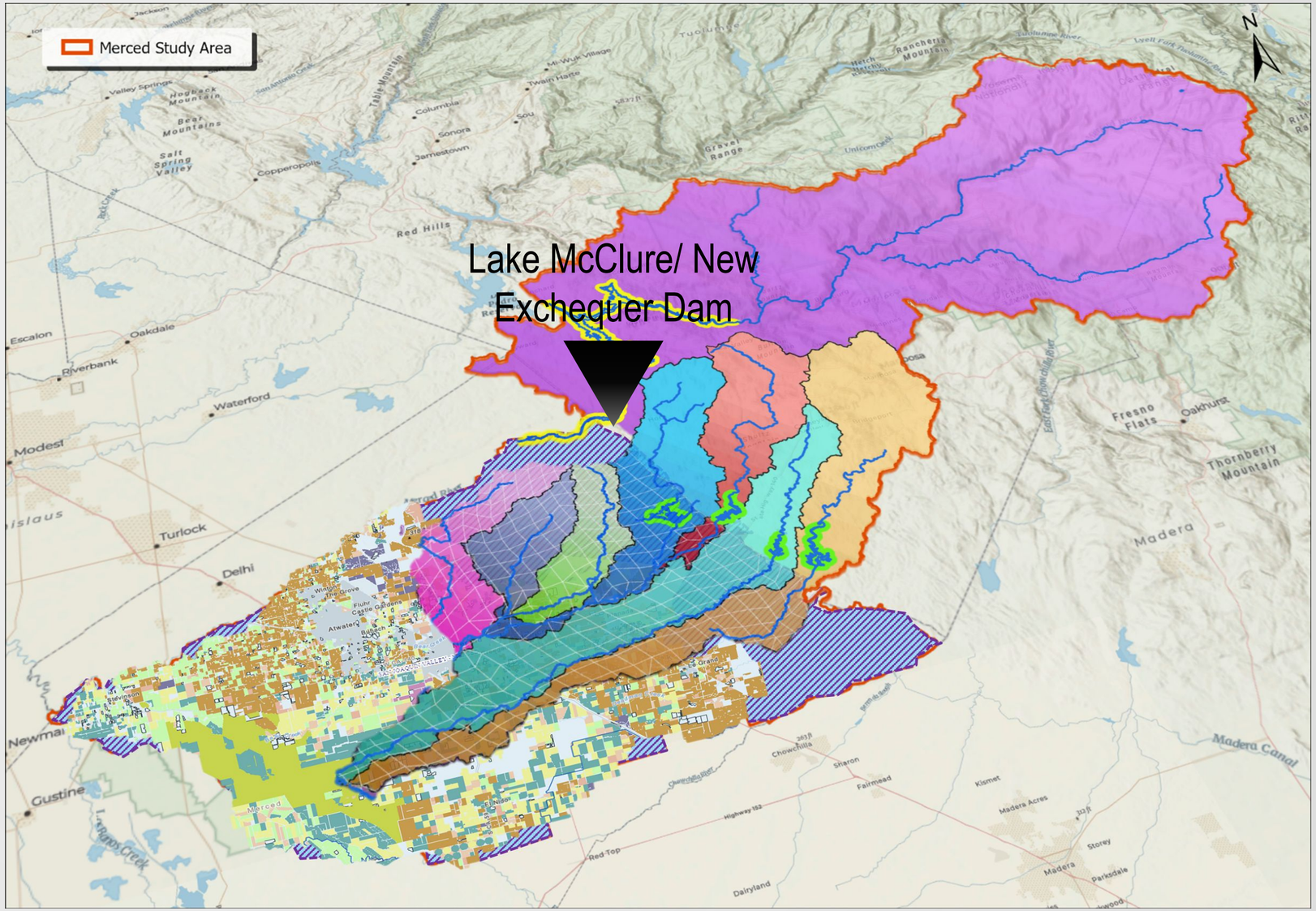
- Proof of concept study
- Integrated Watershed Modeling
- Assess vulnerability and adaptation
- Evaluate multi-sector effects
- Template for future studies and projects



CALIFORNIA DEPARTMENT OF WATER RESOURCES

Background

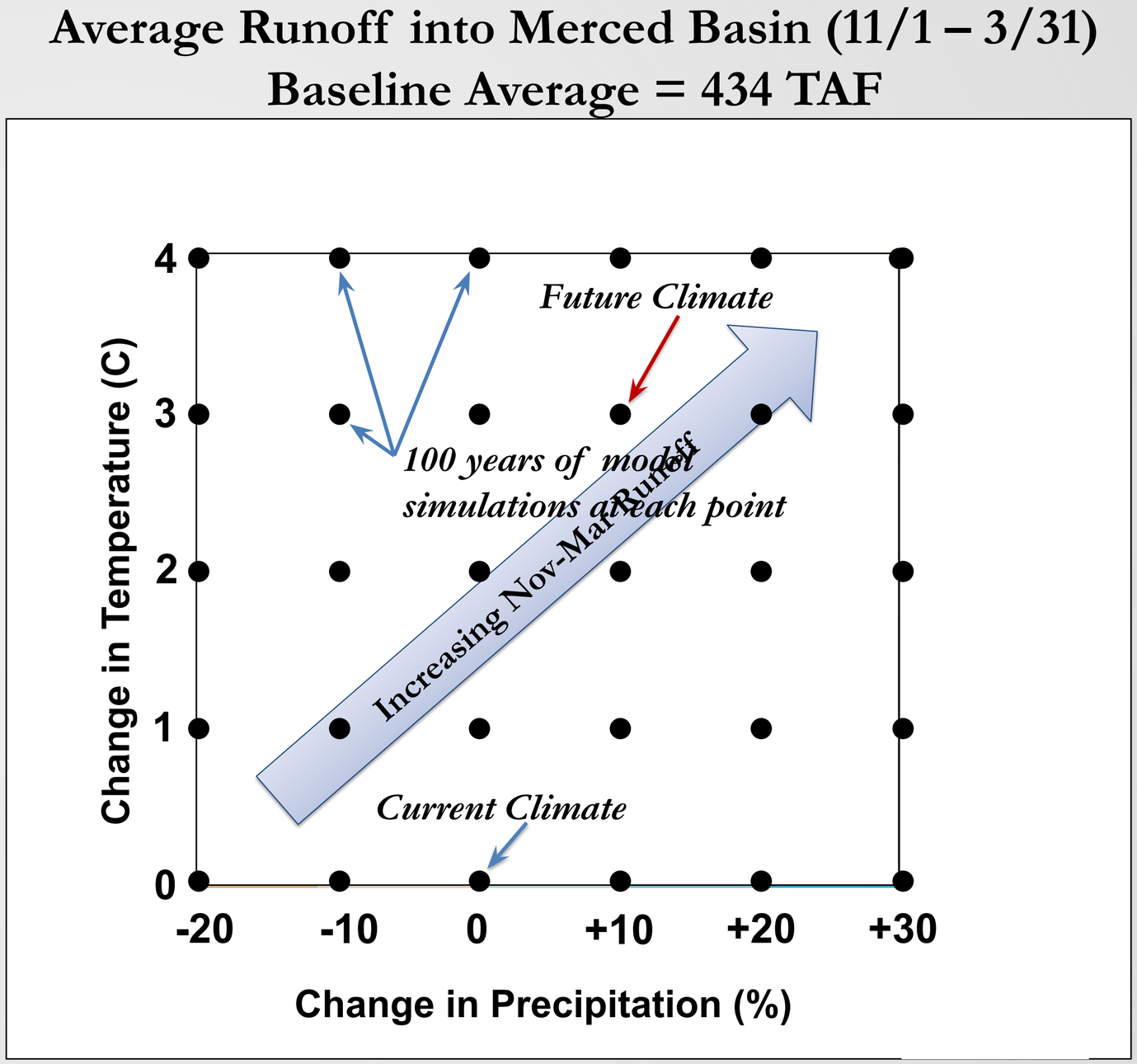
- Merced watershed
- One major reservoir
- 862 miles of conveyance
  - Main Canal
  - Northside Canal
- 132,000 acres of agricultural land
  - Merced Subbasin
  - Turlock Subbasin



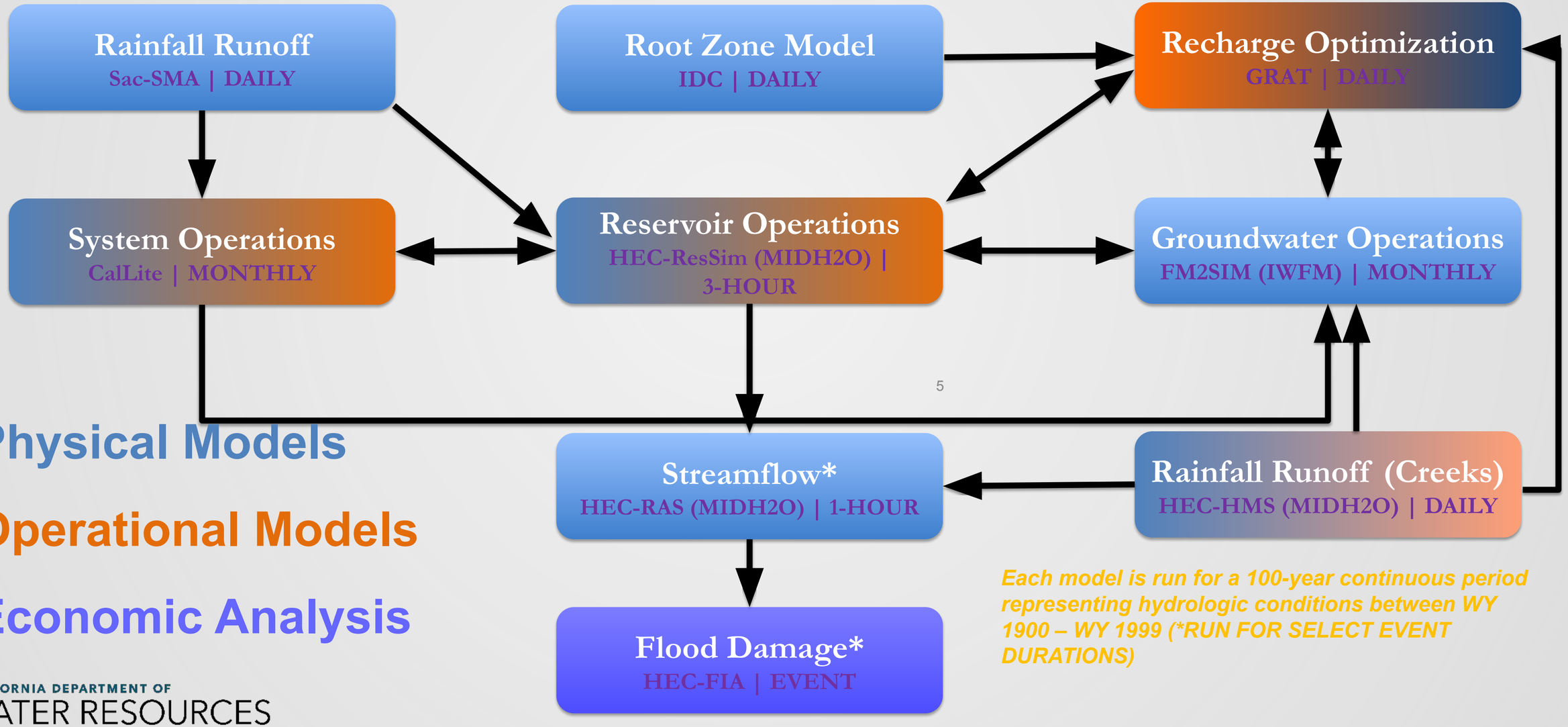
CALIFORNIA DEPARTMENT OF WATER RESOURCES

Climate Change

- Decision scaling approach
- 100 years of simulated hydrology
  - 1900 to 1999
- 30 climate scenarios
  - 0° to 4° Celsius increase in temperature
  - -20% to +30% change in precipitation



Model Integration Flowchart



Physical Models

Operational Models

Economic Analysis

*Each model is run for a 100-year continuous period representing hydrologic conditions between WY 1900 – WY 1999 (*RUN FOR SELECT EVENT DURATIONS)*

CALIFORNIA DEPARTMENT OF WATER RESOURCES

Modeling Beyond Study Area

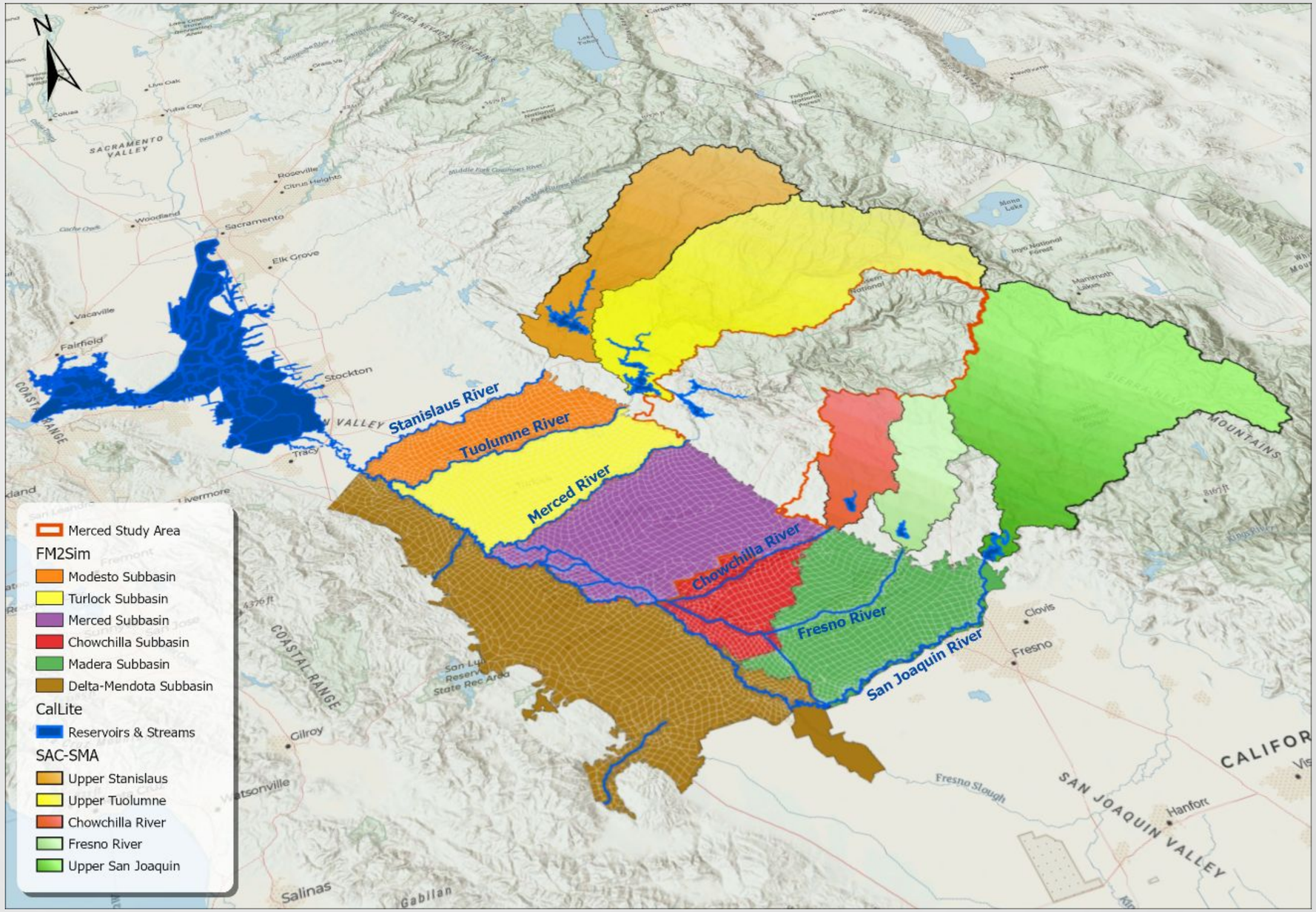
Rainfall Runoff
Sac-SMA

↓

System Operations
CalLite

↓

Groundwater Operations
FM2SIM



CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Watershed Scale Modeling

Rainfall Runoff
Sac-SMA

↓

Reservoir Operations
HEC-ResSim (MIDH2O)

↓

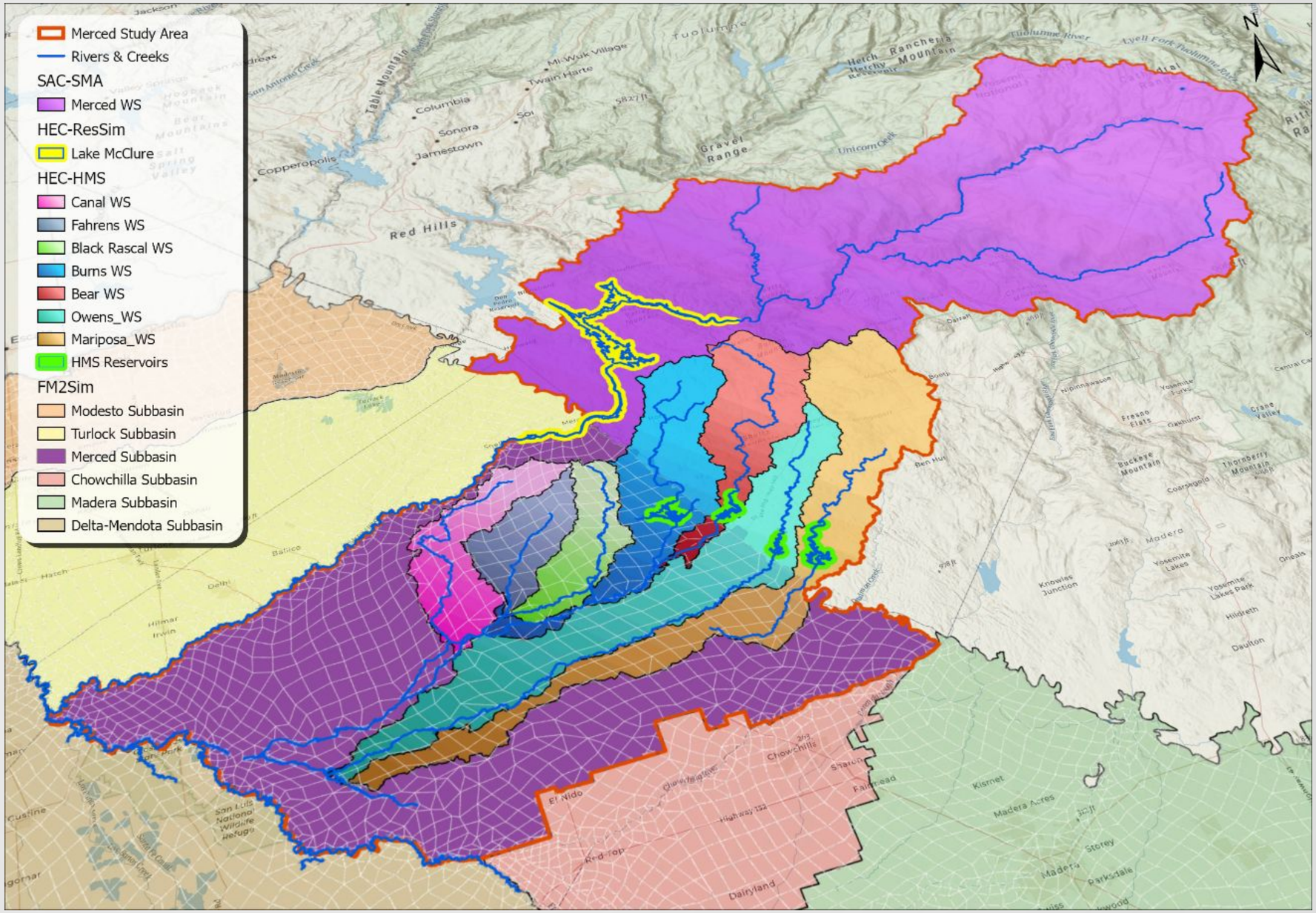
Rainfall Runoff (Creeks)
HEC-HMS (MIDH2O)

↓

Recharge Optimization
GRAT

↓

Groundwater Operations
FM2SIM



WATER RESOURCES

Watershed Scale Modeling

Potential Recharge Sites

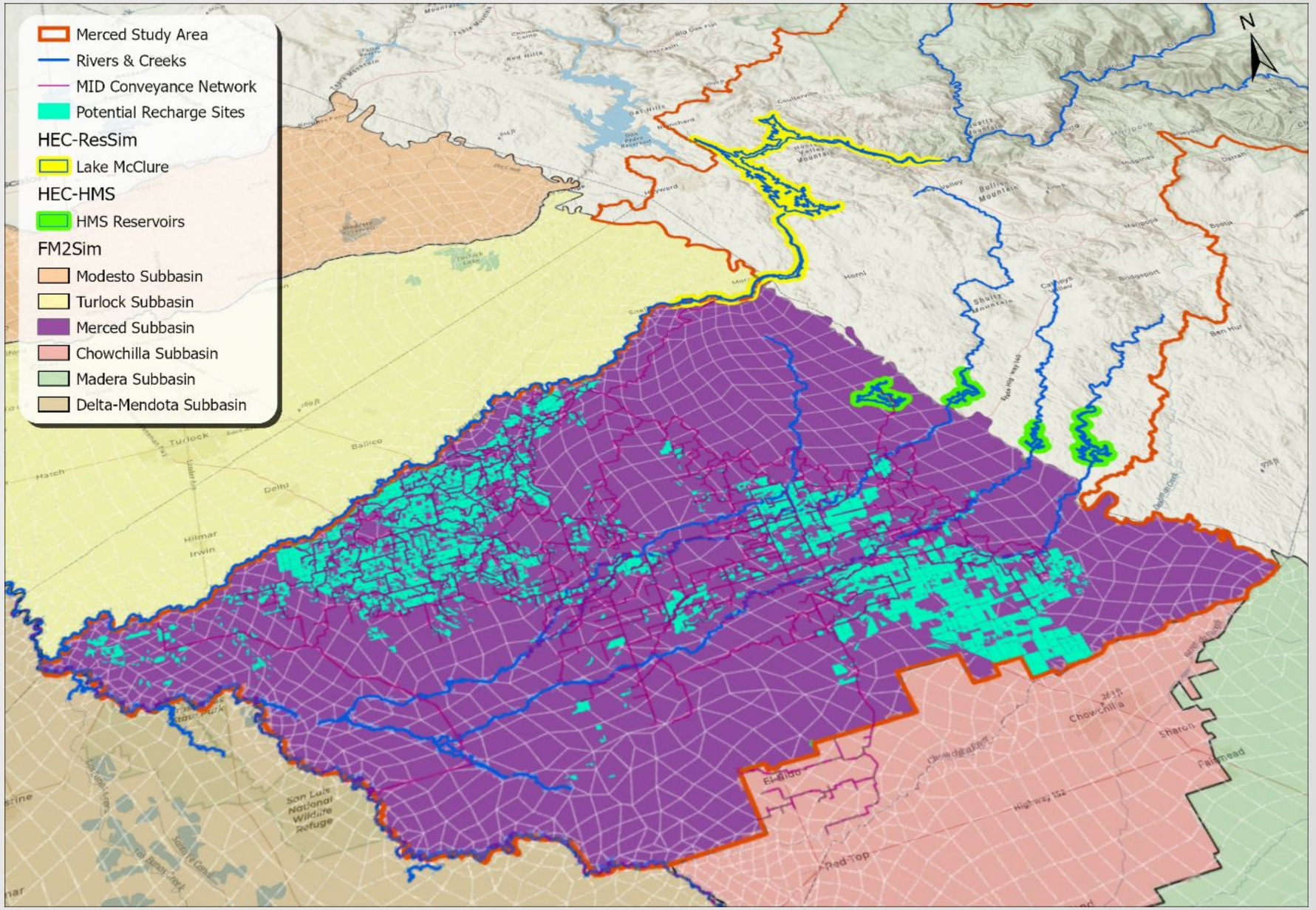
Flood-MAR WAFR
ResSim & HMS

↓

Recharge Optimization
GRAT

↓

Groundwater Operations
FM2SIM



CALIFORNIA DEPARTMENT OF
WATER RESOURCES

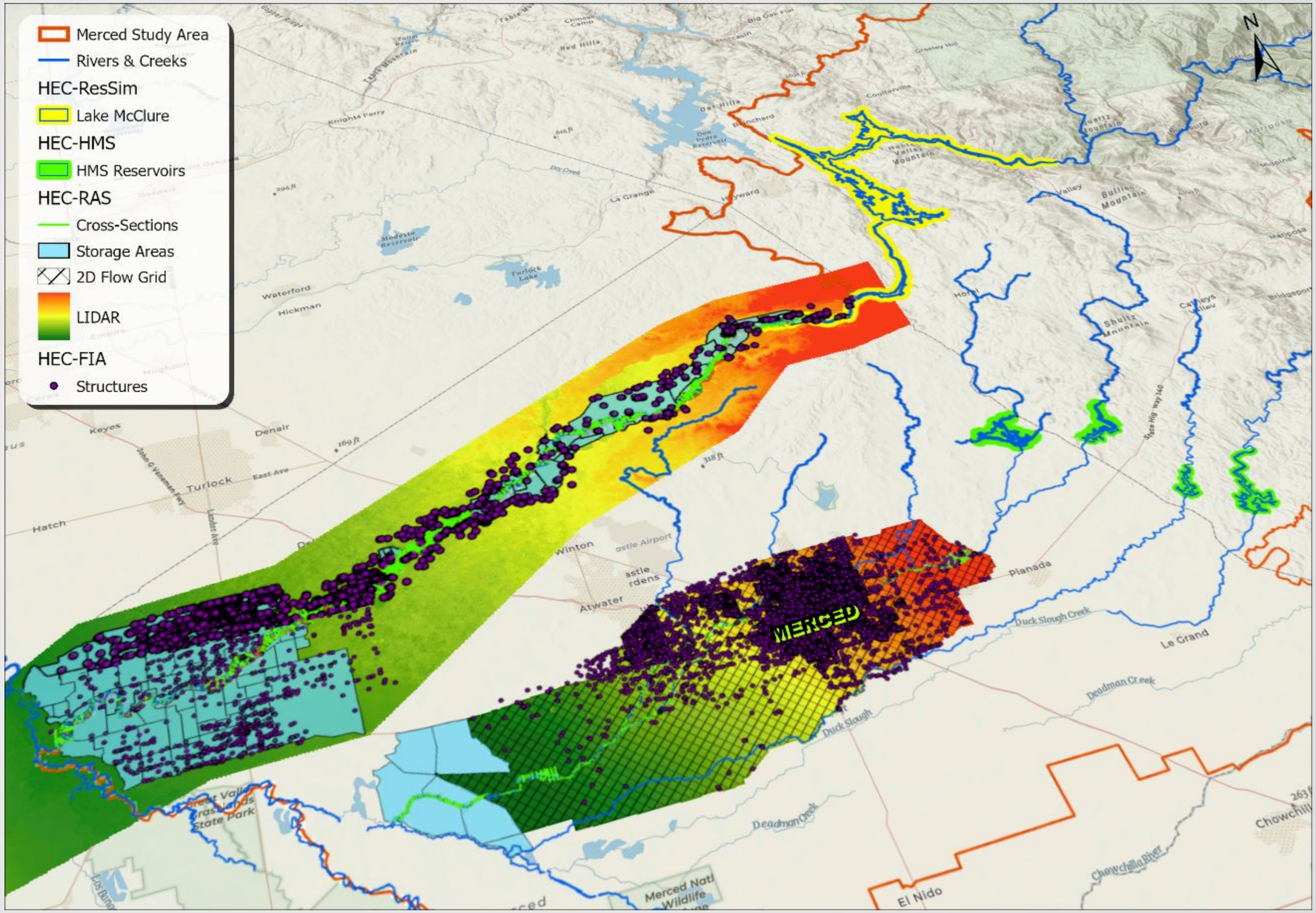
Watershed Scale Modeling

Reservoir Operations
HEC-ResSim (MIDH2O)

Rainfall Runoff (Creeks)
HEC-HMS (MIDH2O)

Streamflow
HEC-RAS (MIDH2O)

Flood Damage
HEC-FIA



CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Climate Vulnerability – Select Results

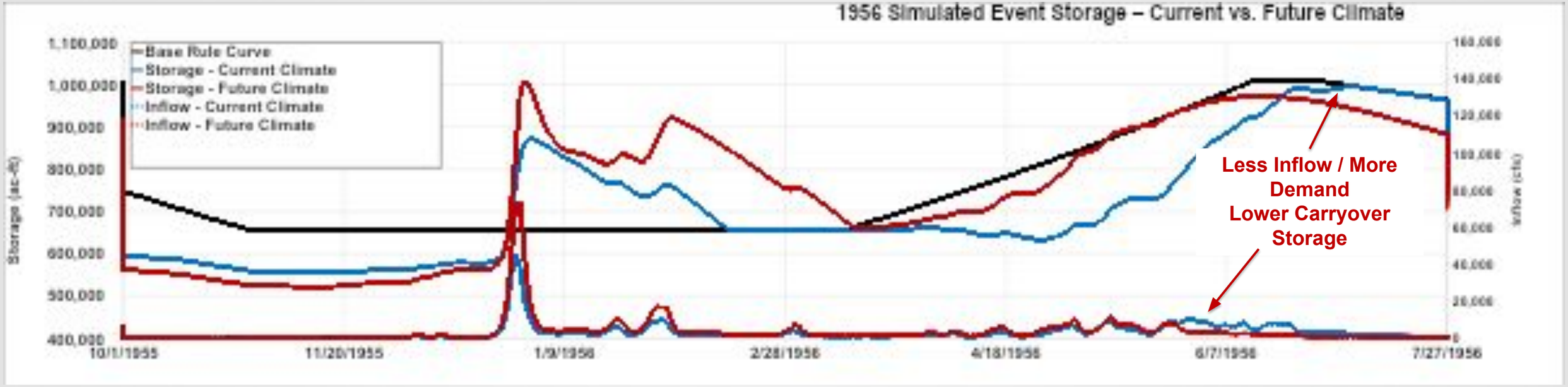
Performance Indicator: **Decline** | No significant change | **Improvement**

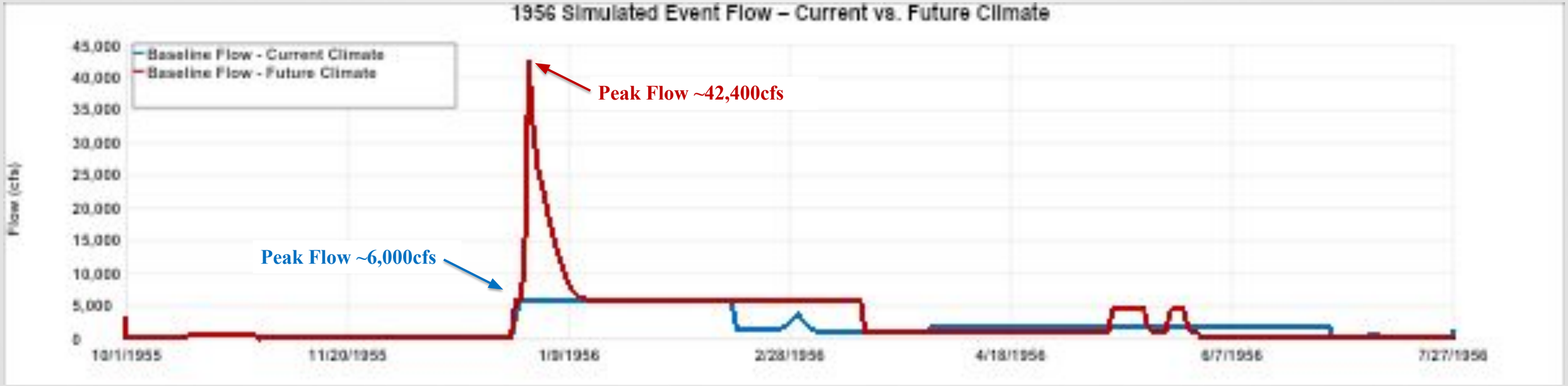
Preliminary Results – Subject to Change

					VULNERABILITY		
					CURRENT	DT3DP1.1	Difference
					BASELINE		
Watershed Conditions	Upper Watershed Runoff	Oct – Sep	*TAF/ year*		1,123	1,277	+154
		Nov – Mar	*TAF/ season*		434	688	+254
		Apr – Oct	*TAF/ season*		689	589	-100
	Applied Demand	Agricultural Demand (Oct – Sep)	*TAF/ year*		800	854	+54
Flood Risk	Merced River Flood Conditions	Maximum simulated flow	*cfs*		6,000	42,400	+36,400
		# Years with flows > 7300 cfs	*Years*		0	9	+9
		# Days with flows > 7300 cfs	*Days*		0	112	+112
Water Supply/ Surface Water (SW)	Lake McClure Storage	End of October Storage	*Avg. TAF*		518	474	-44
		# Years allocation ≤ 80%	*Years*		7	7	0
	SW Deliveries	Oct – Sep	*TAF/ year*		355	372	+17
Water Supply/ Groundwater (GW)	GW Pumping	Oct – Sep	*TAF/ year*		466	499	+33
	Δ GW Storage	Change in basinwide GW storage	*TAF/ year*		-50	-60	+10

CLIMATE VULNERABILITY (1956 EVENT)

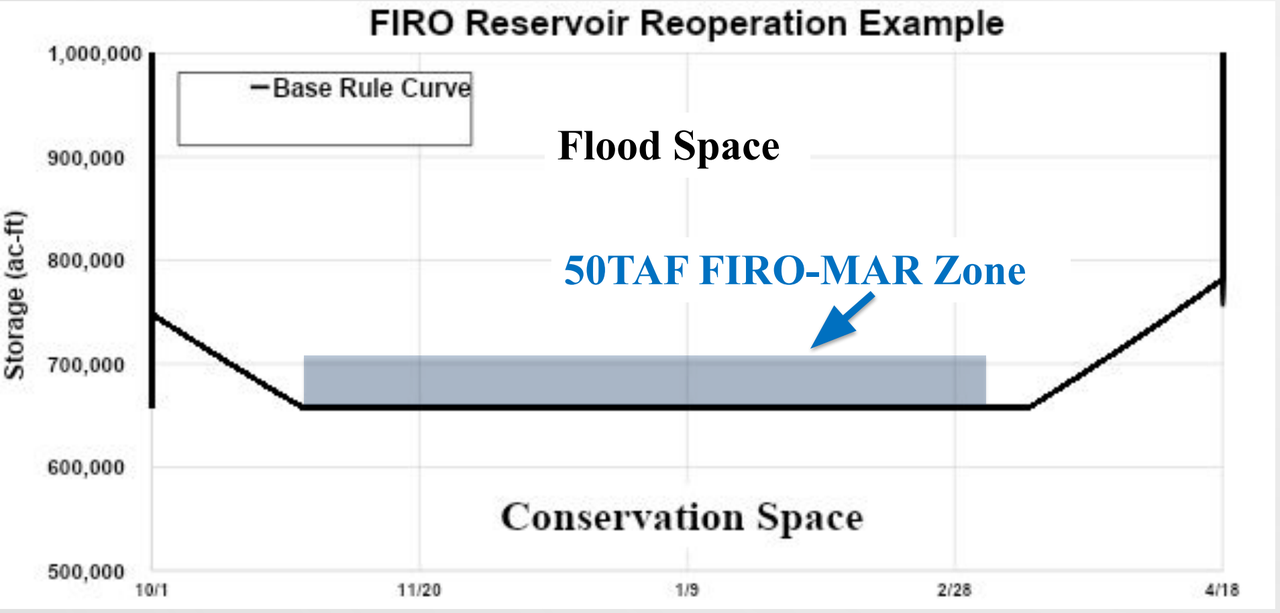
Preliminary Results – Subject to Change

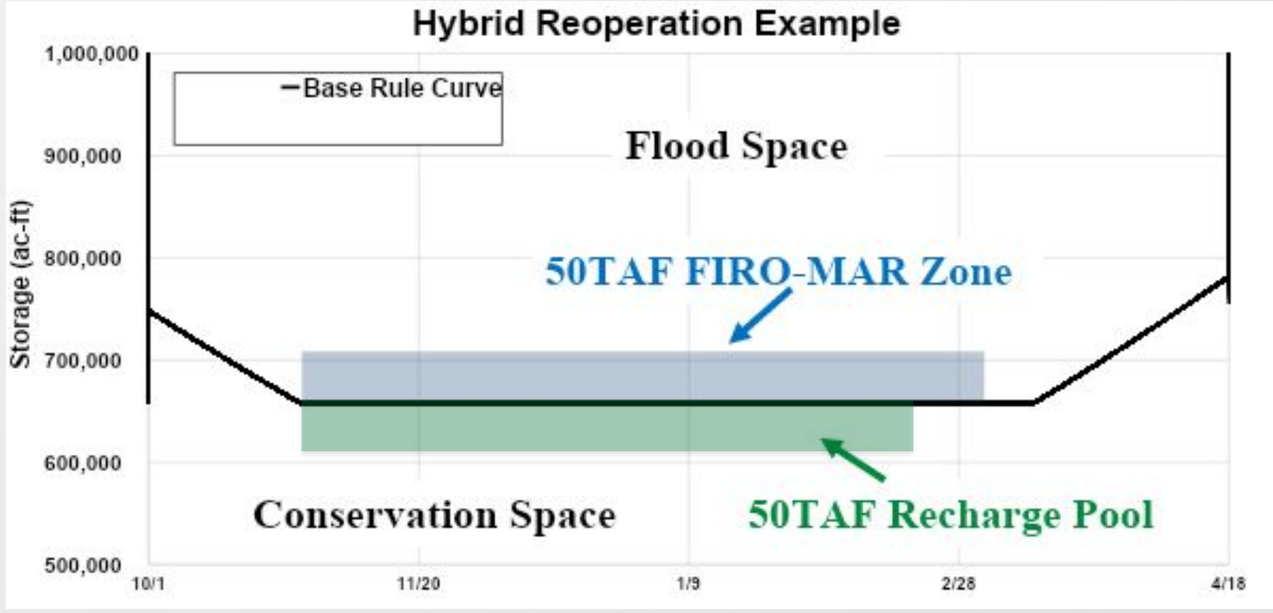




Flood-MAR Implementation Scenarios

	Recharge using Excess Flows			Recharge + Reservoir Reop			**Recharge + Reservoir Reop +** Infrastructure Improvements		
	Canal Only	**Canal + On-Farm**	**Maximum Canal + On Farm**	**FIRO**	**FIRO/ Recharge Pool**	**Recharge Pool**	**FIRO**	**FIRO/ Recharge Pool**	**Recharge Pool**
Management Emphasis				Ecosystem	DAC's Subsidence	Recharge Retention	Ecosystem	DAC's Subsidence	Recharge Retention
Current Climate		✔							
Future Climate		✔					✔	✔	



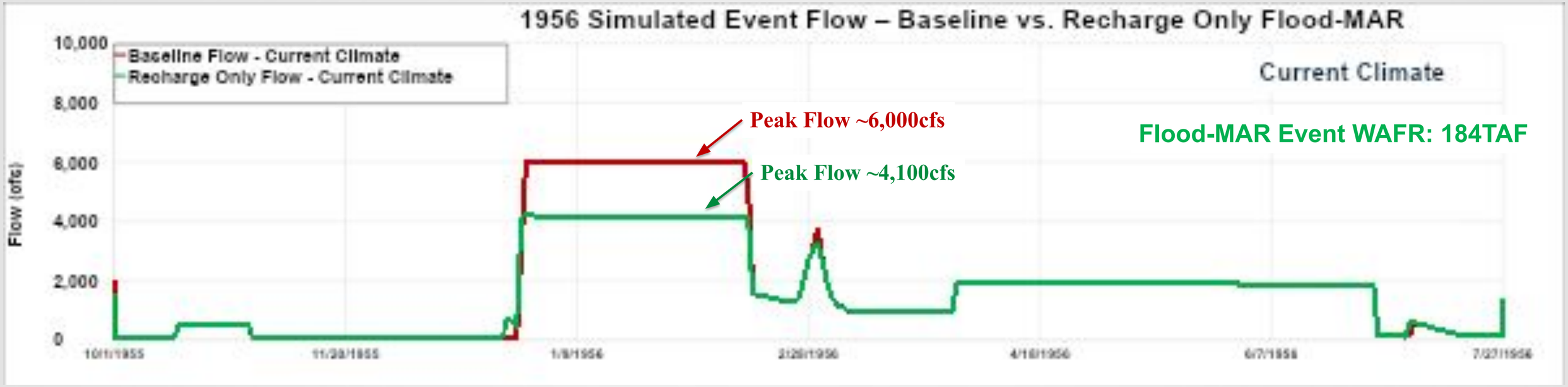


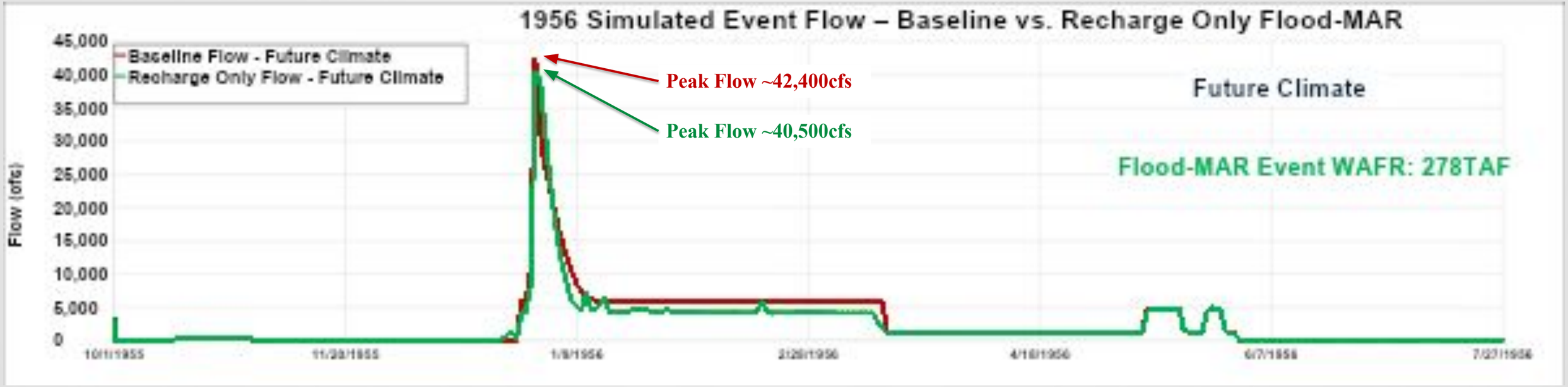
Recharge using High Flows

- During flood management season
  - November 1 through March 31
- Excess flows threshold
  - 90th percentile monthly flow
  - Delta Excess Conditions
- Restricted by conveyance capacity
- Canal and on-farm recharge

RECHARGE USING HIGH FLOWS

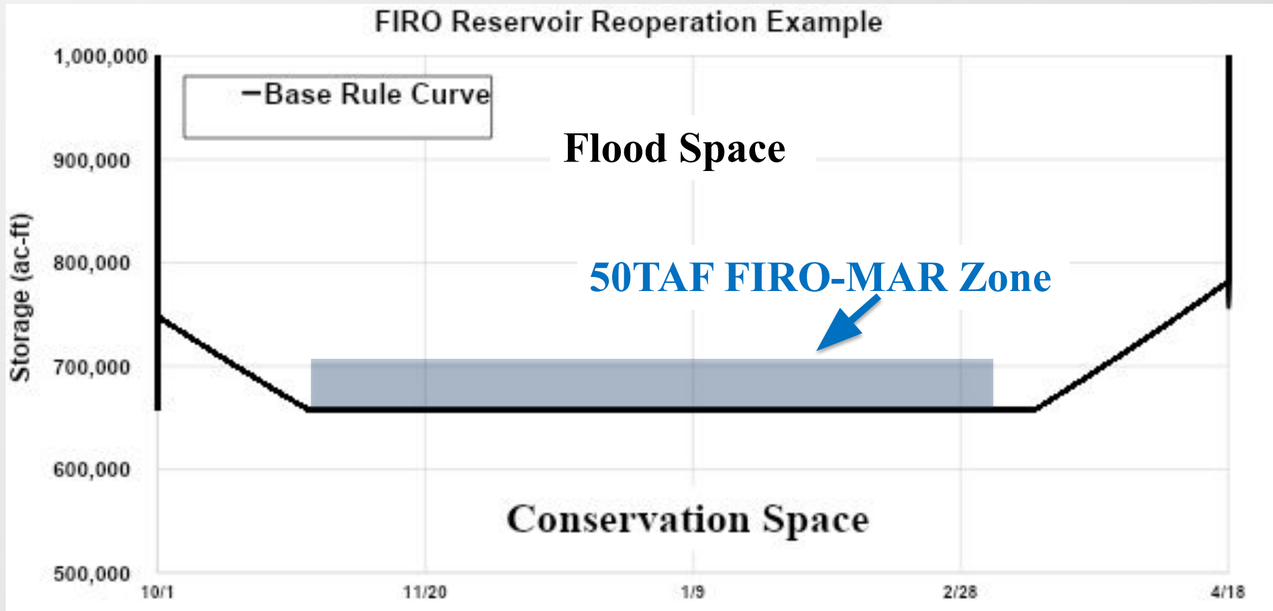
Preliminary Results – Subject to Change





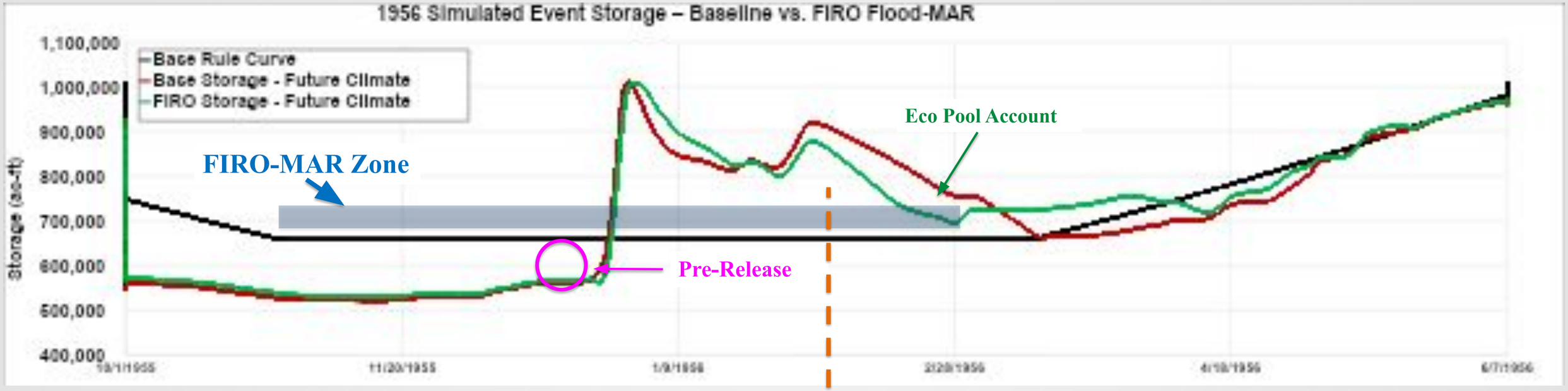
Reservoir Reoperation – L3 FIRO-MAR

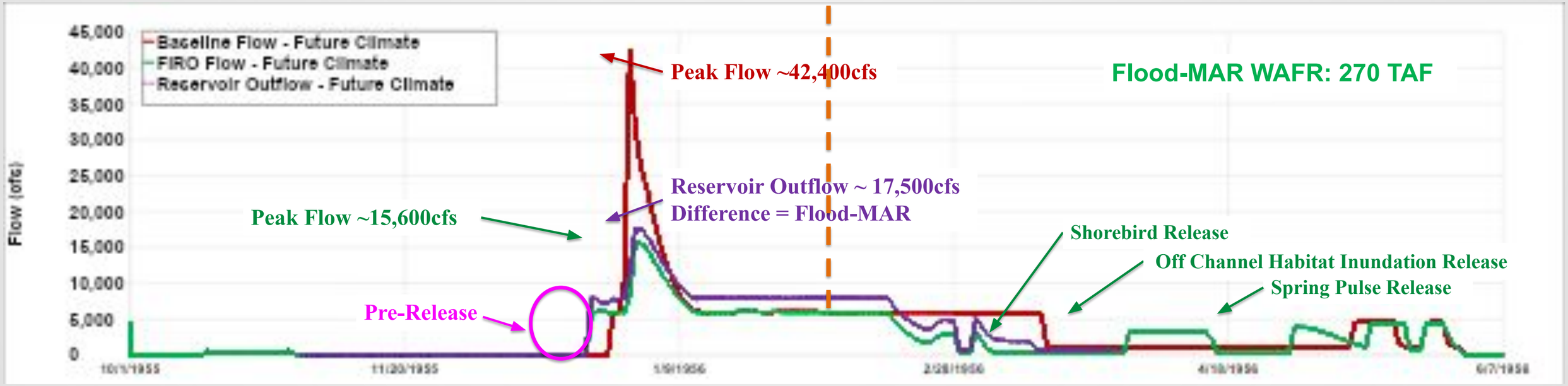
- Increases flood release capacity (6,000 +1,900cfs)
- FIRO Operations (5-day forecast period)
- Pre-release ahead of large forecasted inflows
- 50 TAF FIRO-MAR Zone
- Increased minimum flow release
- Eco Pool Operations
  - ✔ Eco Pool Account (reshaping flood control and snowmelt releases)
  - ✔ Shorebird release
  - ✔ Off channel habitat inundation release
  - ✔ Spring pulse release



L3 FIRO-MAR – FUTURE CLIMATE (1956 EVENT)

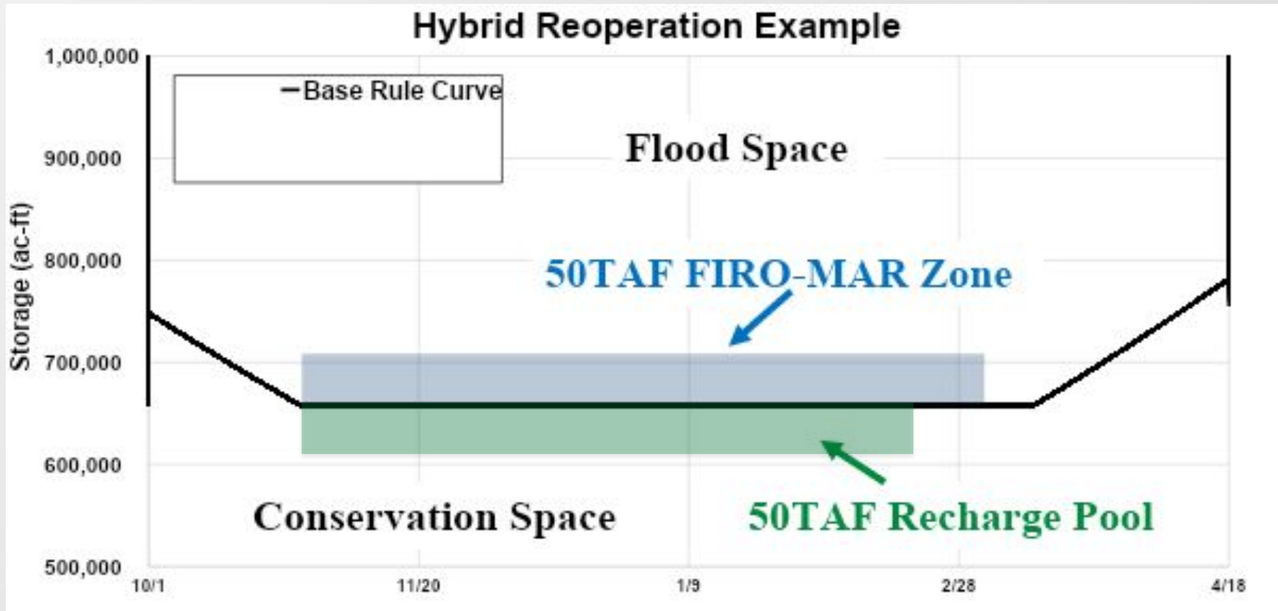
Preliminary Results – Subject to Change





FIRO/Recharge Pool Reoperation – L3 Hybrid-MAR

- FIRO-MAR Operations
- Increases flood release capacity (6,000 +1,900cfs)
- Draws storage down to 50TAF below TOC
- Tracks the cumulative storage deficit created by Recharge Pool releases
- The deficit is refilled when:
  - Delta is in excess conditions
  - Reservoir would've spilled during baseline operations



Flood-MAR Adaptation Potential – Select Results

Performance Indicator: **Decline** | No significant change | **Improvement**

Preliminary Results – Subject to Change

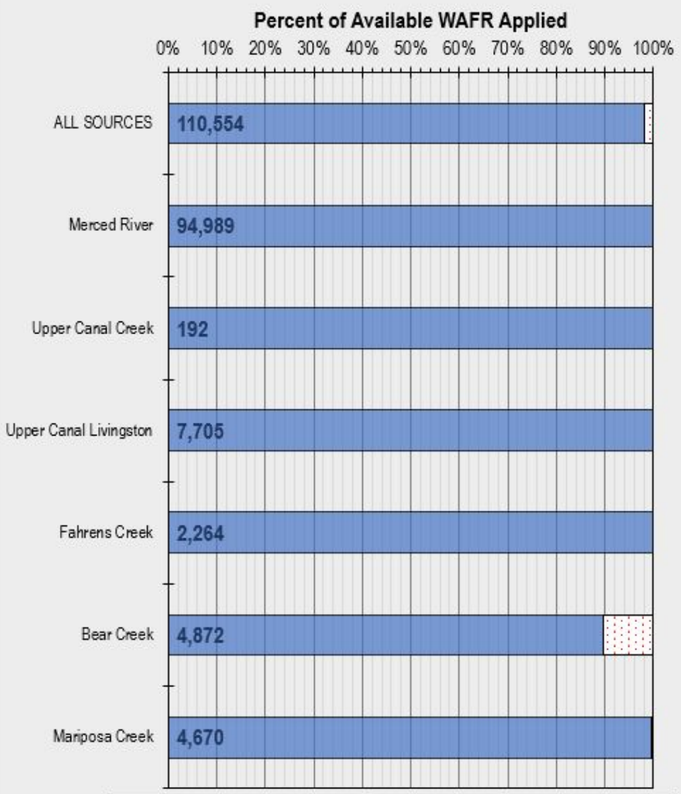
Performance evaluated with respect to Baseline Current Conditions | *Performance evaluated with respect to Baseline DT3DP1.1 Scenario*

					VULNERABILITY		ADAPTATION PERFORMANCE	
				CURRENT	DT3DP1.1	DT3DP1.1		
				BASELINE		High Flow	FIRO-MAR	Hybrid-MAR
Flood Risk	Merced River Flood Conditions	Maximum simulated flow	*cfs*	6,004	**42,412**	**40,552**	**15,600**	**13,850**
		# Years with flows > 7300 cfs	*Years*	0	**9**	9	**1**	**3**
		# Days with flows > 7300 cfs	*Days*	0	**112**	**82**	**10**	**23**
Water Supply/ Surface Water (SW)	Lake McClureStorage	End of October Storage	*Avg. TAF*	518	**474**	474	472	**454**
		# Years allocation ≤ 80%	*Years*	7	7	7	**8**	**8**
	SW Deliveries	Mar – Oct	*TAF/ year*	355	**372**	372	369	367
Water Supply/ Groundwater (GW)	GW Pumping	Oct – Sep	*TAF/ year*	466	**499**	499	501	504
	Δ GW Storage	Change in basinwide GW storage	*TAF/ year*	-50	**-60**	**-51**	**-32**	**-21**
Flood-MAR	Merced River WAFR	Avg. annual physically available Water Available For Recharge	*TAF/ year*	n/a	n/a	**70**	**95**	**124**

Metrics Development

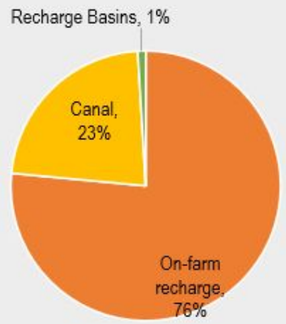
Long-term average across the entire 100-year simulation period.

Applied WAFR by Supply Source (Acre-Feet per Year)

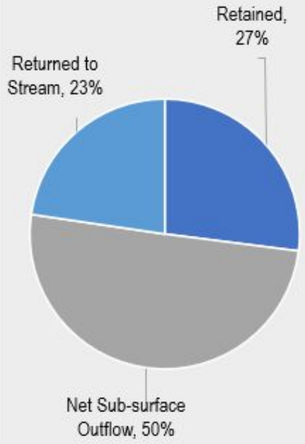


	Mariposa Creek	Bear Creek	Fahrens Creek	Upper Canal Livingston	Upper Canal Creek	Merced River	ALL SOURCES
Applied	4,670	4,872	2,264	7,705	192	94,989	110,554
Unused	14	554	0	0	0	0	2,098
Available	4,684	5,425	2,264	7,705	192	94,989	119,021

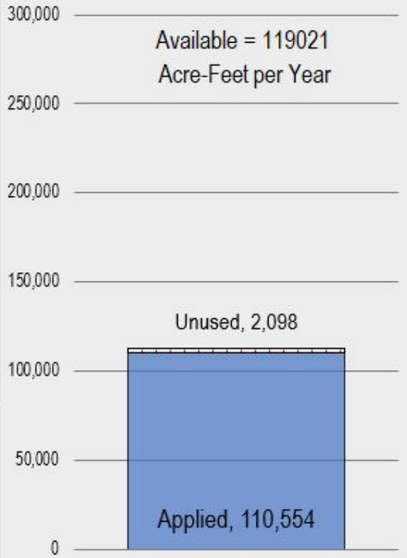
Applied WAFR by Recharge Source



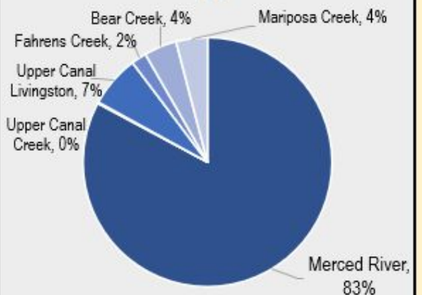
Fate of Recharged Water



Water Available For Recharge (WAFR)

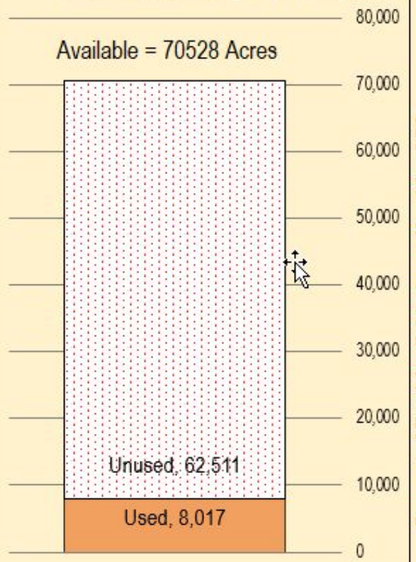


Source of Applied WAFR

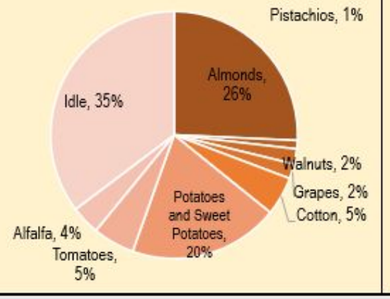


Long-term average reported only for Water Years with on-farm recharge operations.

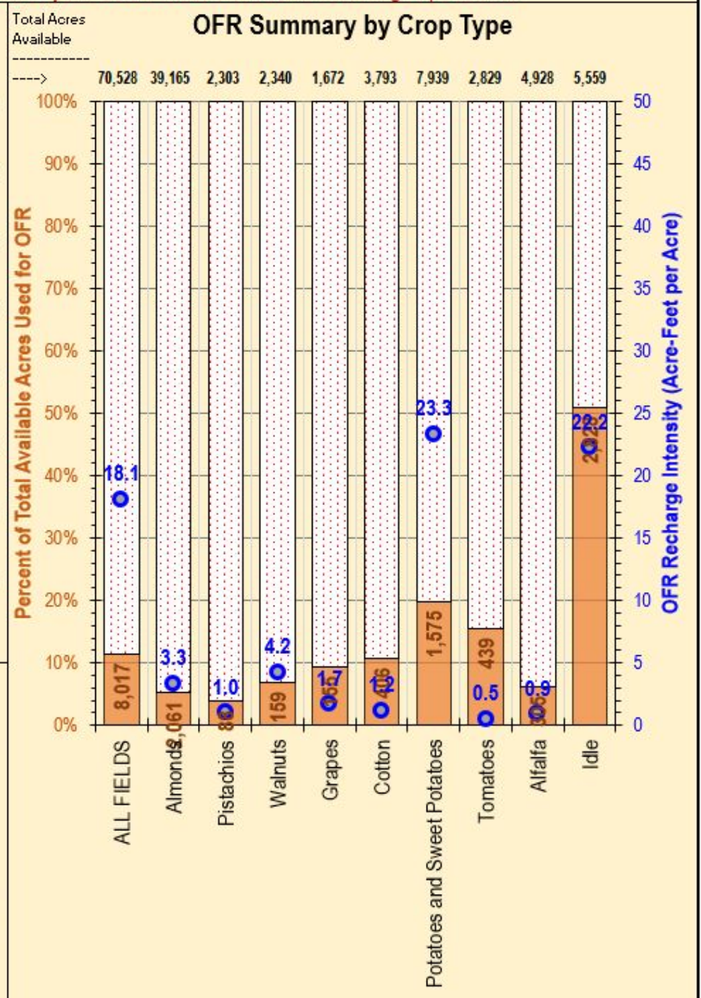
Fields used for On-Farm Recharge (OFR)



Crop Types for OFR



OFR Summary by Crop Type



CALIFORNIA DEPARTMENT OF WATER RESOURCES

Flood-MAR Watershed Studies

- Updates to FIRO-MAR scenarios
- Weather Generator
- Probabilistic forecast of inflow vs. perfect foresight
- FIRO forecast window (5 to 15-day)
- FIRO zone determination
- Eco Releases as result of FIRO operations, and determination of Eco-Pool account

DAVID.ARRATE@WATER.CA.GOV

DEPARTMENT OF WATER RESOURCES • STATE OF CALIFORNIA •

ESA

MBK ENGINEERS

Sustainable Conservation

Woodard & Curran

theEARTH GENOME
REVEALING THE POSSIBLE

MID MERCED IRRIGATION DISTRICT
WATER & POWER