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State Water Resources Control Board
Cal/EPA Headquarters
1001 "I" Street, 24th Floor
Sacramento, CA 95814



Submitted via email to commentletters@waterboards.ca.gov

RE: Comments on San Joaquin River Flows and Southern Delta Water Quality SED

Dear Members of the Board,

Please accept the attached report / synthesis of recent scientific research on Climate Change in the San Joaquin River Basin from California Water Resources. The report cites evidence from recent climate change modelling and the historical record which indicate that precipitation and runoff patterns in the basin may have begun to shift to a more arid state. In particular, dry periods in the San Joaquin River basin have been significantly drier in the past few decades, and there has been a corresponding increase in critically dry years.

Given these trends, we believe that the proposal in the San Joaquin plan to respond to climate change in the San Joaquin River basin through adaptive management is wholly inadequate to protect beneficial uses in the basin, and in the Sacramento-San Joaquin Delta. Year round , minimum flow standards, such as those recommended by the Bay Institute, must be set. In addition, we strongly support the conclusions of the US Fish and Wildlife Service that the adaptive management framework is insufficient. Clear, numeric targets for fish populations and smolt survival must be set.

Given the drying trends in the San Joaquin River basin, it is likely that cropping patterns, particularly the production of forage crops for the dairy industry, will need to shift, and water-saving irrigation technologies will need to be more widely adopted. The Board does not do

water diverters any favors by allowing them to delay such adaptations until there is a major crisis.

Pro-active regulatory policies allow both farmers and lawmakers to anticipate shifts in basin water supply. Funding can then be provided for adaptation. The same policies also allow the fish and wildlife agencies to anticipate environmental needs, and develop proactive responses which minimize impacts of climate change on the aquatic environment and aquatic species.

Sincerely,

Deirdre Des Jardins

California Water Research

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Climate Change in the San Joaquin River Basin

The precipitation patterns in the 2012-2013 water year are similar to drying patterns that have been predicted by climate change modelling. California saw a very wet November and December, followed by an extremely dry January to March.

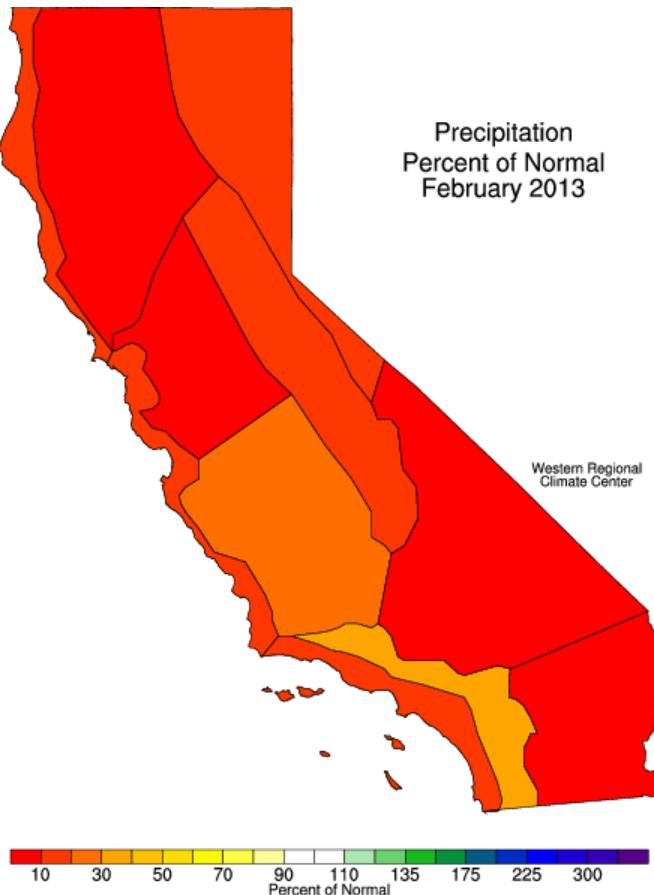


Figure 1 February 2013 statewide precipitation.

Source: Western Regional Climate Center

The snowpack in the Northern Sierras is 53% of average, 56% in the Central Sierras, and 40% of average in the Southern Sierras.¹

The Central and Southern Sierras and inland Southern California are on the Western edge of the Southwest climate region, that has experienced a significant drying trend in the past decade. In “Model

¹ California Data Exchange Center, California Snow Water Content, March 29, 2013, Percent of April 1 Average. Available at http://cdec.water.ca.gov/cgi-progs/products/PLOT_SWC.pdf. Accessed on March 30, 2013. Incorporated by reference.

Projections of an imminent shift in Climate in the Southwest," Richard Seager et. al. described the climate changes that could be occurring:

The six severe, multiyear, droughts that have struck western North America in the instrumental record have all been attributed, using climate models, to variations of sea surface temperatures (SSTs) in the tropics, particularly persistent La Niña-like SSTs in the tropical Pacific Ocean (15–19). The future climate of intensified aridity in the Southwest is caused by different processes since the models vary in their tropical SST response to anthropogenic forcing. Instead it is caused by rising humidity that causes increased moisture divergence and changes in atmospheric circulation cells that include a poleward expansion of the subtropical dry zones. The drying of subtropical land areas that, according to the models is imminent or already underway, is unlike any climate state we have seen in the instrumental record. It is also distinct from the multidecadal megadroughts that afflicted the American Southwest during Medieval times (20–22) which have also been attributed to changes in tropical SSTs (18, 23). The most severe future droughts will still occur during persistent La Niña events but they will be worse than any since the Medieval period because the La Niña conditions will be perturbing a base state that is drier than any experienced recently (25).²

To get a deeper understanding of the kinds of changes that could be occurring, we refer to the very detailed modeling of potential changes in runoff in the Central Valley by R.T. Hanson et. al. under the US Geological Survey. The study was done in collaboration with Daniel Cayan, who oversaw the modeling for the California Climate Adaptation Strategy.³ The group chose a medium-high greenhouse gas emissions scenario (A2), using the Global Fluid Dynamics Lab model. Like most of the global climate models under higher GHG scenarios, the model predicts intermittent droughts in the near term, followed by more severe and persistent droughts towards the end of the century.

Below is a graph of predicted river flows in the Central Valley. The USGS study model projects an 18% reduction in Tuolumne River flows from 2020-2030 and 2040-2050, and a 41% reduction by 2080-2090. Smaller reductions are predicted for the Sacramento River.

² Seager et. al., Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America, Science 25 May 2007: Vol. 316 no. 5828 pp. 1181-1184 April 5, 2007. Available at <http://www.sciencemag.org/content/316/5828/1181.full>. Incorporated by reference.

³ R.T. Hanson et. al., "A method for physically based model analysis of conjunctive use in response to potential climate changes," Feb 4, 2012. Available at http://ca.water.usgs.gov/projects/cvhm/Hanson_et.al_2012_WRR.pdf. Incorporated by reference.

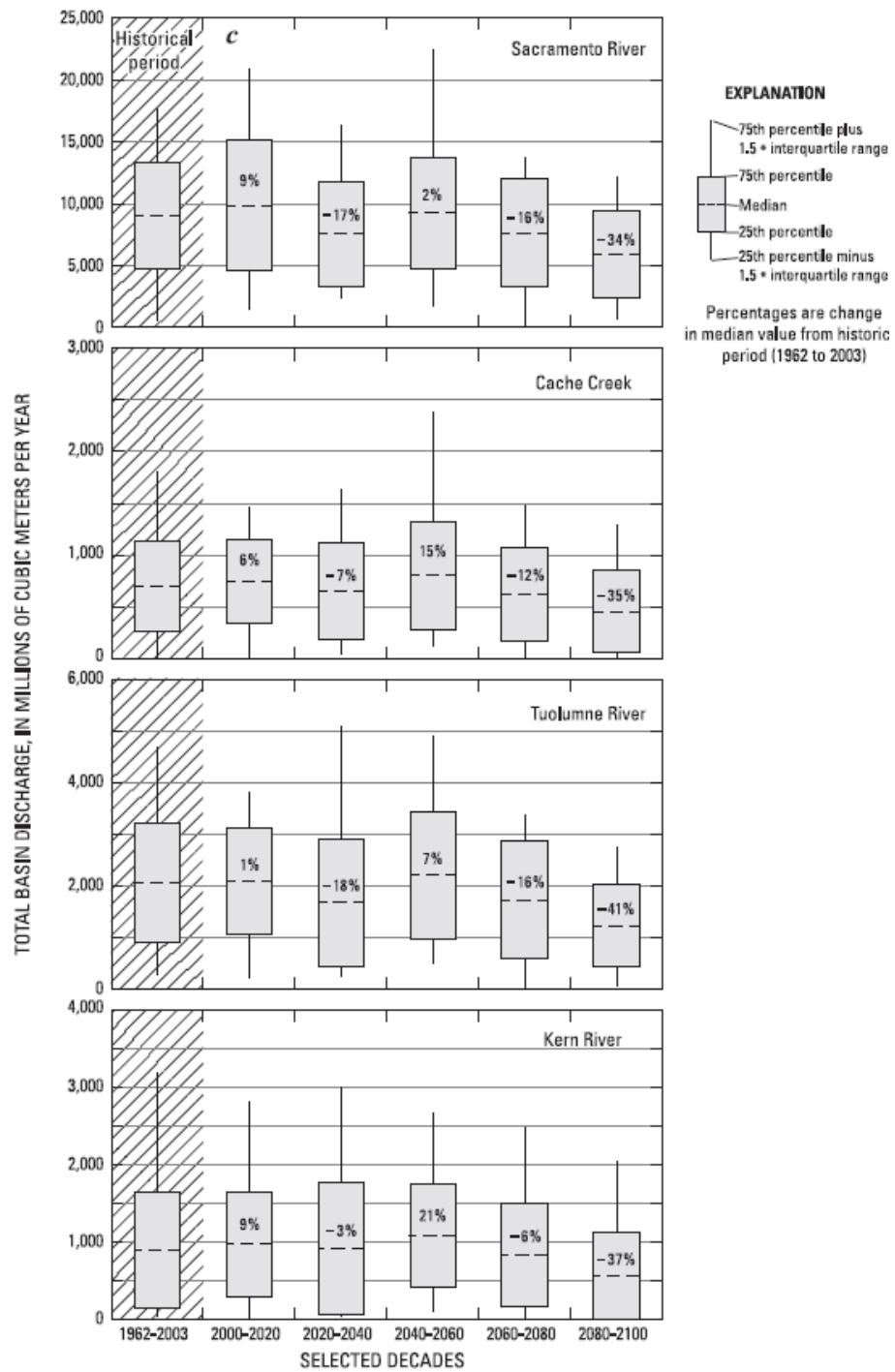


Figure 3. (continued)

The basin maps on the next page show details of the projected reduction in river inflows. The different basins are color-coded, based on flow. The model projects a large reduction in flow in all basins by the end of the century.

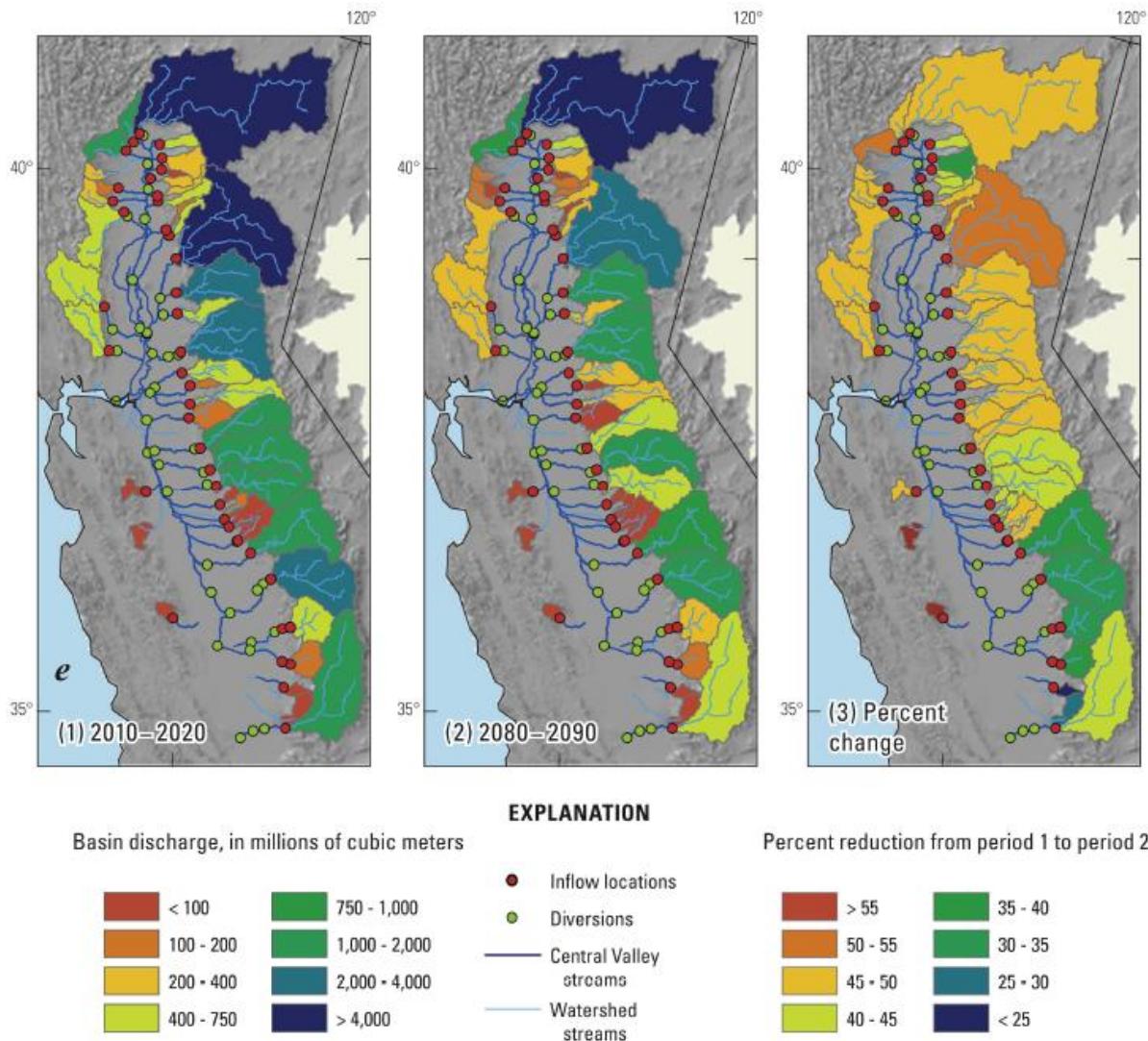
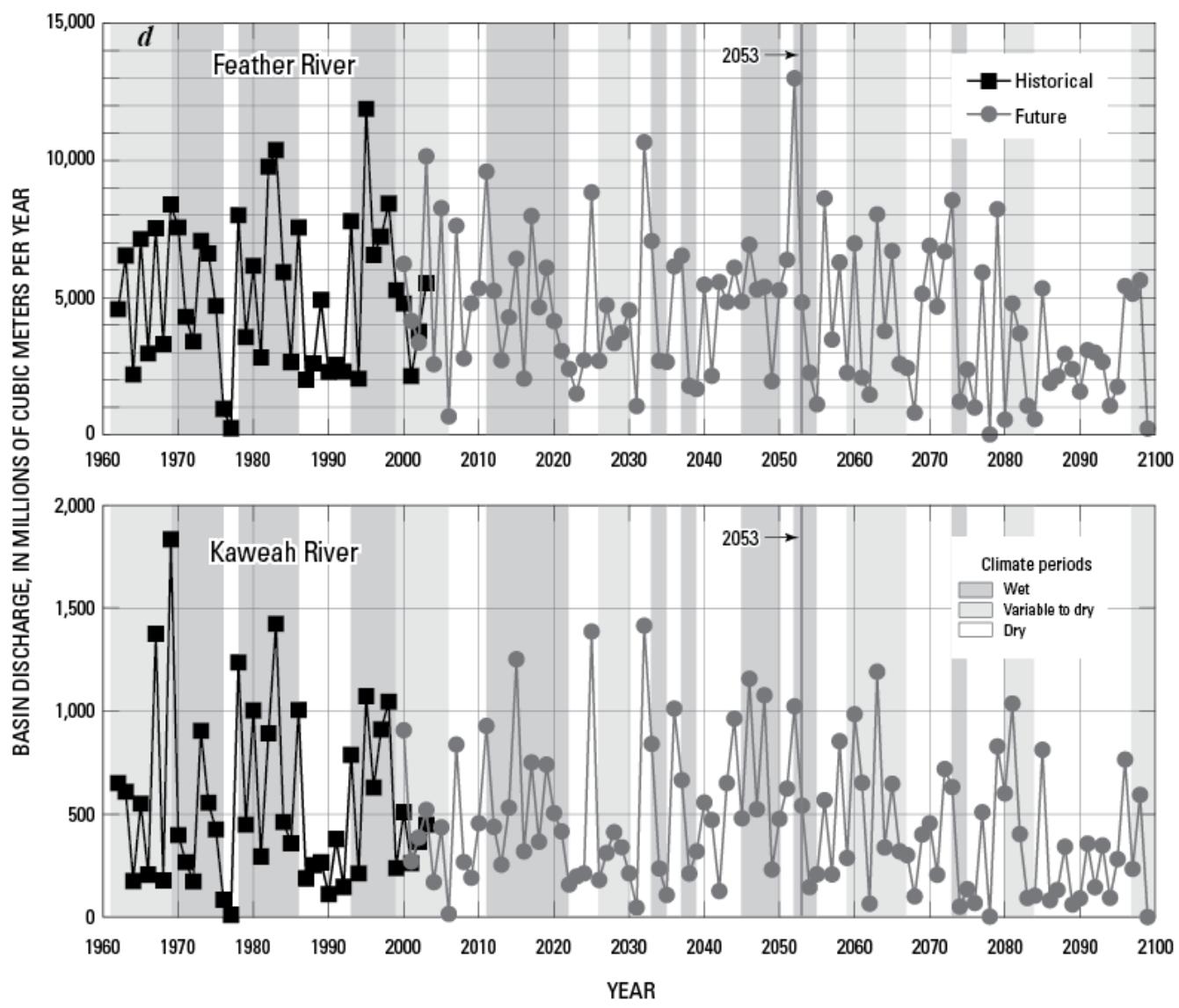


Figure 3. (continued)

The graph below shows how the reductions in streamflow are projected to happen – by increasing frequency of dry and critically dry periods.



Source: Hanson et. al. 2012

Another study by Sarah Null and Josh Viers at UC Davis showed how the frequency of dry and critically dry years could increase in the Central Valley. The study used the six global climate models from the second California Climate Assessment, and made projections under the A2 (medium-high) and B1 (low) greenhouse gas emissions scenarios that were used in that assessment. The study also used the same

Variable Infiltration Capacity model that DWR uses for downscaling, with Bias-Corrected Spatial Disaggregation.⁴

The results of the models under the A2 and B1 scenarios show a marked shift in climate in the Central Valley. Most of the models show major increases in dry and critically dry years, and decreases in wet and below-normal years. The histograms on the next page shows the projected changes in the frequency of water year types for the Sacramento Valley Index.

All of the models show a significant increase in dry and critically dry years by the latter half of the century, with a corresponding decrease in wet and above normal years. Most of the models also show an increase in dry and critically dry years in the first half.

The table below shows water year types, averaged over all six GCM models, for the two scenarios.

Table 6. Percentage of Years in Each Water Type by Modeled Time Period and Emissions Scenario
(italicized values are percent change from historical period)

		SVI					
		1951-2000 (%)		2001-2050 (%)		2051-2099 (%)	
		A2	B1	A2	B1	A2	B1
Critical		8.7	8.3	11.3 (2.7)	6.7 (-1.7)	18.4 (9.7)	14.0 (5.6)
Dry		7.7	10.0	12.0 (4.3)	15.7 (5.7)	19.4 (11.7)	20.1 (10.1)
Below Normal		23.3	21.3	23.3 (0.0)	17.3 (-4.0)	18.7 (-4.6)	19.4 (-1.9)
Above Normal		21.0	22.7	16.7 (-4.3)	20.7 (-2.0)	12.9 (-8.1)	18.4 (-4.3)
Wet		39.3	37.7	36.7 (-2.7)	39.7 (2.0)	30.6 (-8.7)	28.2 (-9.4)
		SJI					
		1951-2000 (%)		2001-2050 (%)		2051-2099 (%)	
		A2	B1	A2	B1	A2	B1
Critical		26.0	26.0	41.3 (15.3)	35.3 (9.3)	60.9 (34.9)	54.1 (28.1)
Dry		13.0	12.3	11.0 (-2.0)	12.7 (0.3)	8.2 (-4.8)	11.9 (-0.4)
Below Normal		19.3	19.7	15.7 (-3.7)	14.0 (-5.7)	10.5 (-8.8)	10.9 (-8.8)
Above Normal		13.7	13.3	9.3 (-4.3)	12.0 (-1.3)	8.5 (-5.2)	10.9 (-2.5)
Wet		28.0	28.7	22.7 (-5.3)	26.0 (-2.7)	11.9 (-16.1)	12.2 (-16.4)

Null and Viers state:

For the SJI, considerably more years fall into the critical category with fewer years in all other year types, particularly toward the end of this century (Figure 7). Results indicate a 28 to 35 percent increase in critical water years by the last half of this century, with the larger changes under A2 assumptions.

⁴ Null, S. E., and J. H. Viers (Center for Watershed Sciences, University of California, Davis). 2012. Water and Energy Sector Vulnerability to Climate Warming in the Sierra Nevada: Water Year Classification in Non-Stationary Climates. California Energy Commission. Publication number: CEC-500-2012-015. Available at <http://www.energy.ca.gov/2012publications/CEC-500-2012-015/CEC-500-2012-015.pdf>. Incorporated by reference.

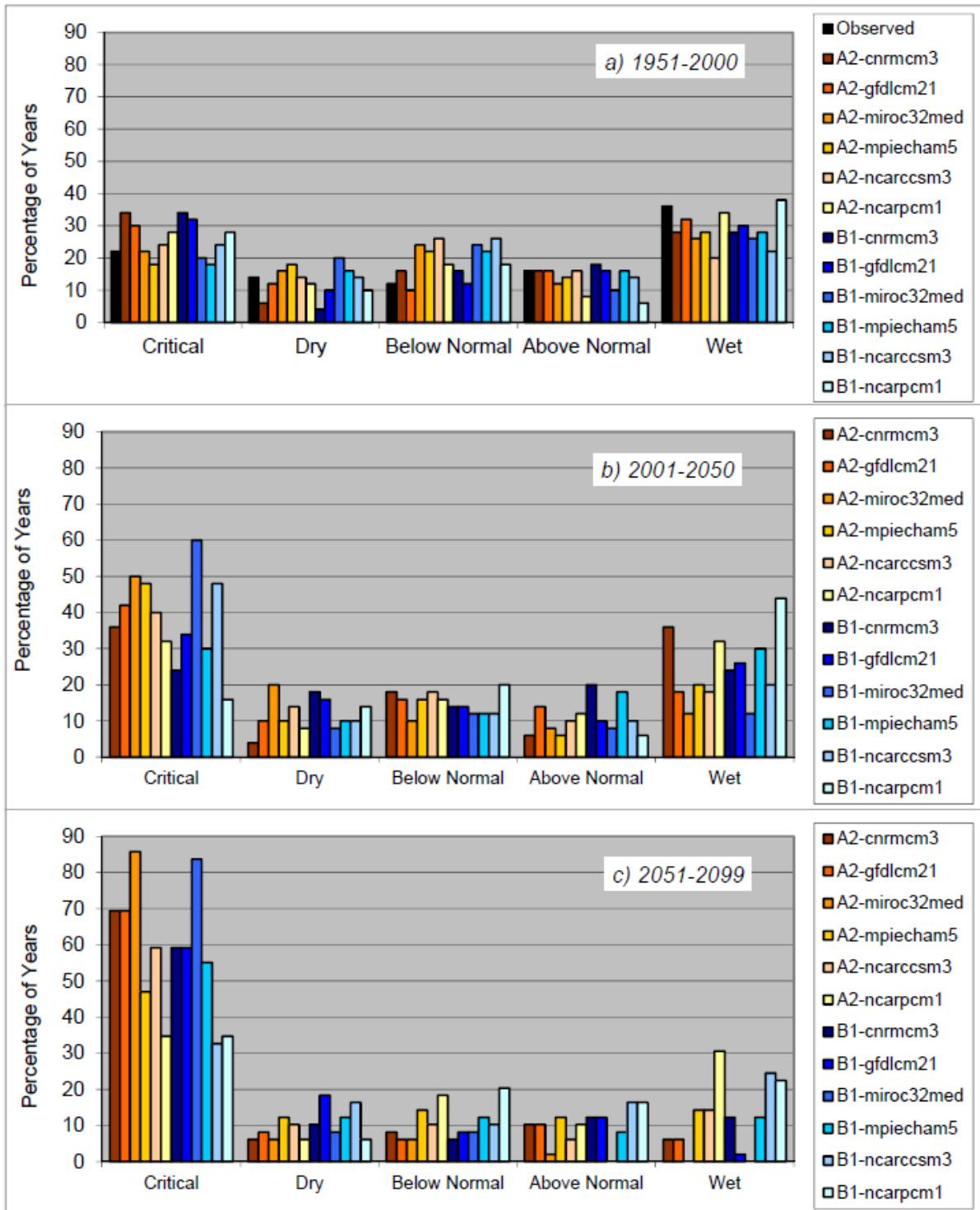
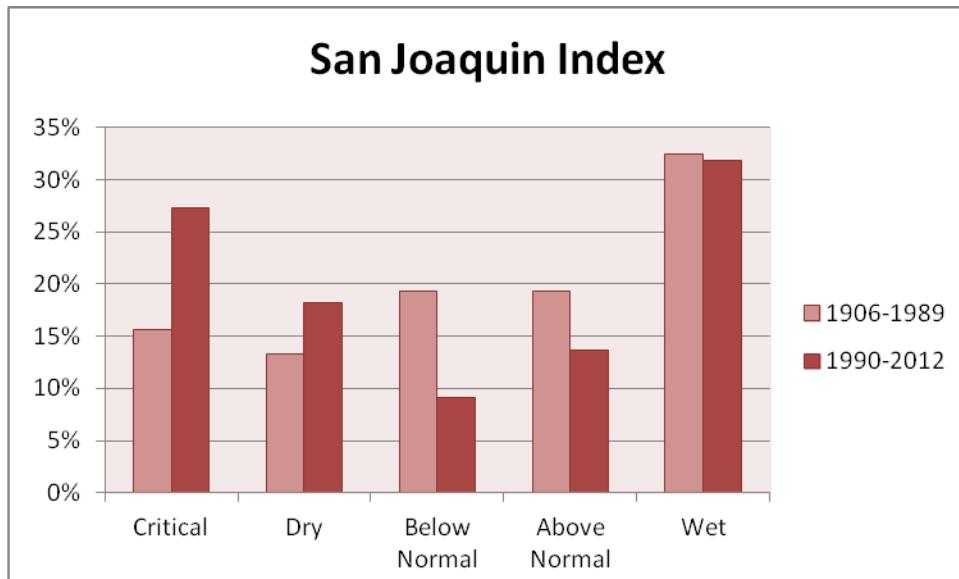


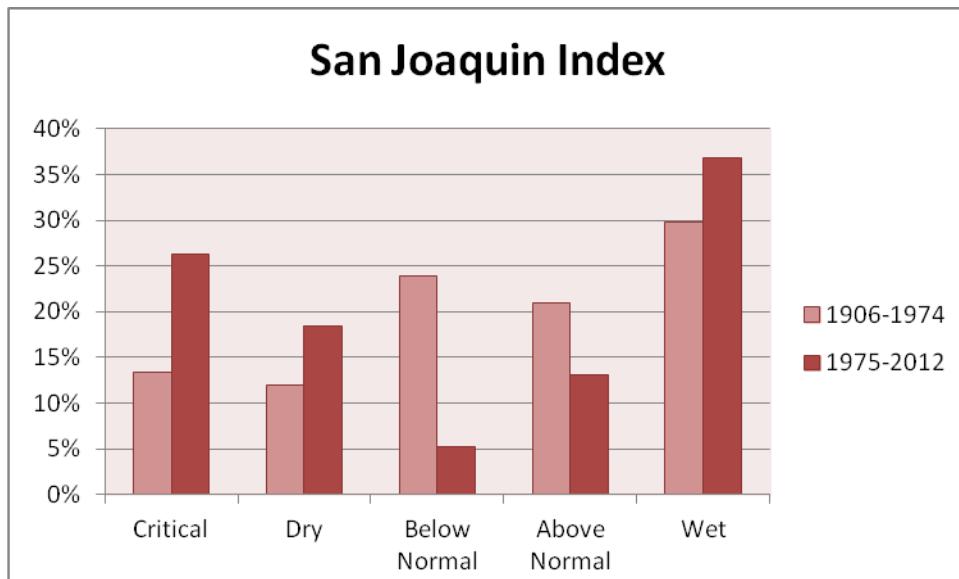
Figure 7. SJI Relative Frequency Histograms for (a) 1951-2000, (b) 2001-2050, and (c) 2051-2099

The modeling by Null and Viers predicts shifts to increasing frequency of dry and critically dry years in the current period. The historical record does appear to show a marked shift in the frequency of dry and critically dry years in the San Joaquin Valley in recent decades.

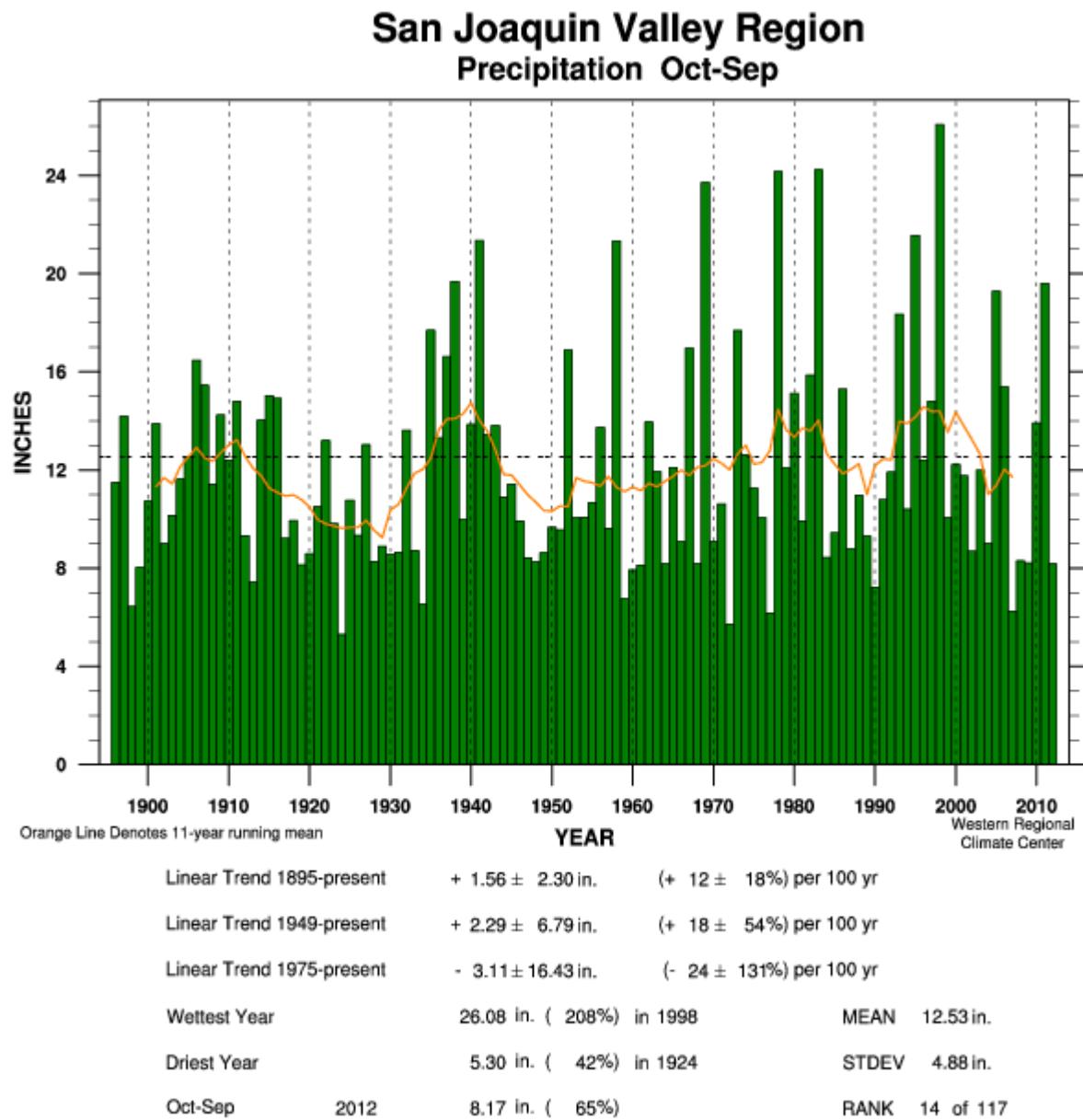
The graphs below show are from DWR's estimates of unimpaired flows that determine the San Joaquin River Index. The distributions of dry and critically dry years show a significant drying trend between the series for 1906-1989, and for 1990-2012



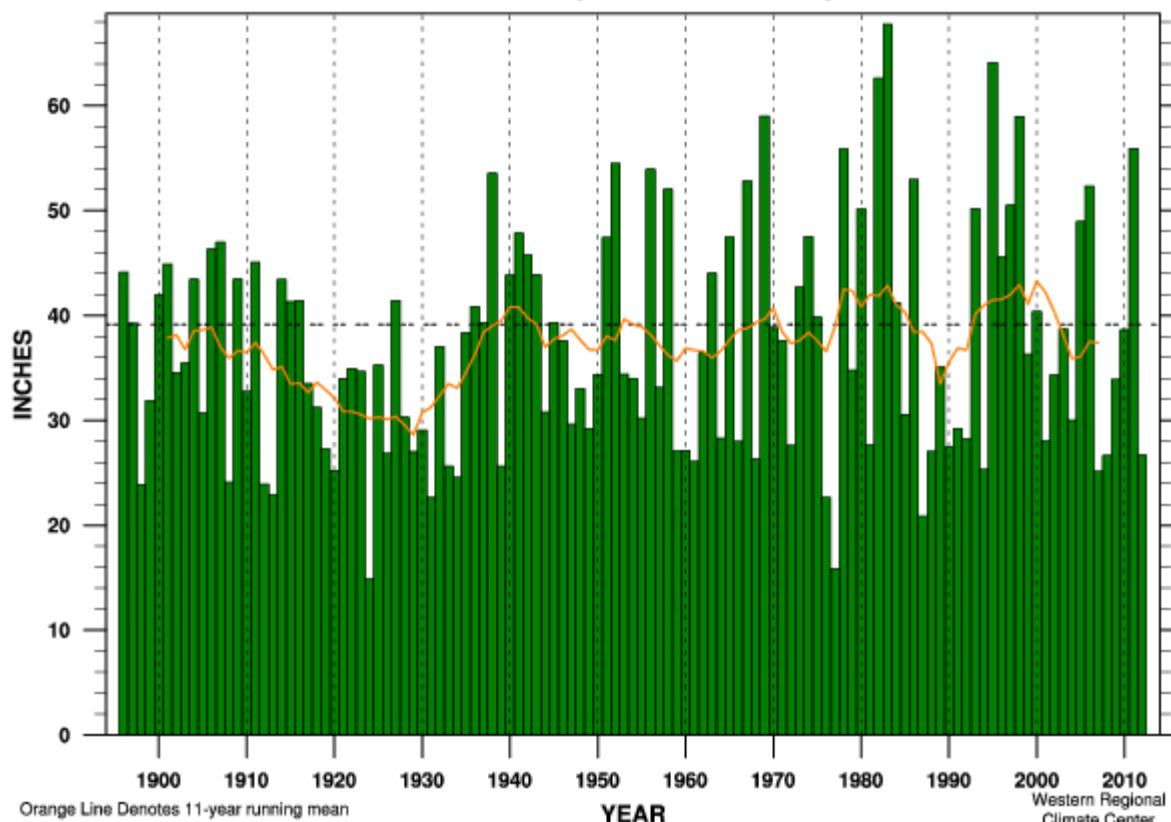
The graph below shows the same comparison, but for 1906-1974, and 1975-2012.



Precipitation records in San Joaquin Valley & Sierra Regions also show decreases since 1975. The graphs below are from the Western Regional Climate Data Center.



Sierra Region Precipitation Oct-Sep



Linear Trend 1895-present	$+ 4.60 \pm 5.79$ in.	(+ 11 ± 14%) per 100 yr
Linear Trend 1949-present	$+ 0.12 \pm 17.11$ in.	(+ 0 ± 43%) per 100 yr
Linear Trend 1975-present	$- 0.97 \pm 43.11$ in.	(- 2 ± 110%) per 100 yr
Wettest Year	67.79 in. (- 173%) in 1983	MEAN 39.15 in.
Driest Year	14.89 in. (- 38%) in 1924	STDEV 12.33 in.
Oct-Sep	2012 26.67 in. (- 68%)	RANK 19 of 117

Killam and Bui also found similar shifts when analyzing long time series of precipitation data for stations in California.⁵

These shifts are also consistent with the projections of the ensemble of 112 climate model / GHG scenario combinations, used by the U.S. Bureau of Reclamation in the Westwide Climate Risk Assessment.⁶ The

⁵ Temperature and precipitation trends in California: Global warming and Pacific Ocean influences. Steve LaDochy, Pedro Ramirez, Dan Killam, Ann Bui, William Patzert and Josh Willis. AMS Climate extended abstract. Available at [https://ams.confex.com/ams/91Annual/webprogram/Manuscript/Paper177504/AMS%20climate%20Extended%20abstract-pedro\(2\).pdf](https://ams.confex.com/ams/91Annual/webprogram/Manuscript/Paper177504/AMS%20climate%20Extended%20abstract-pedro(2).pdf). Incorporated by Reference.

ensemble includes a large number of lower GHG emissions scenarios, and so may underestimate the drying trend.

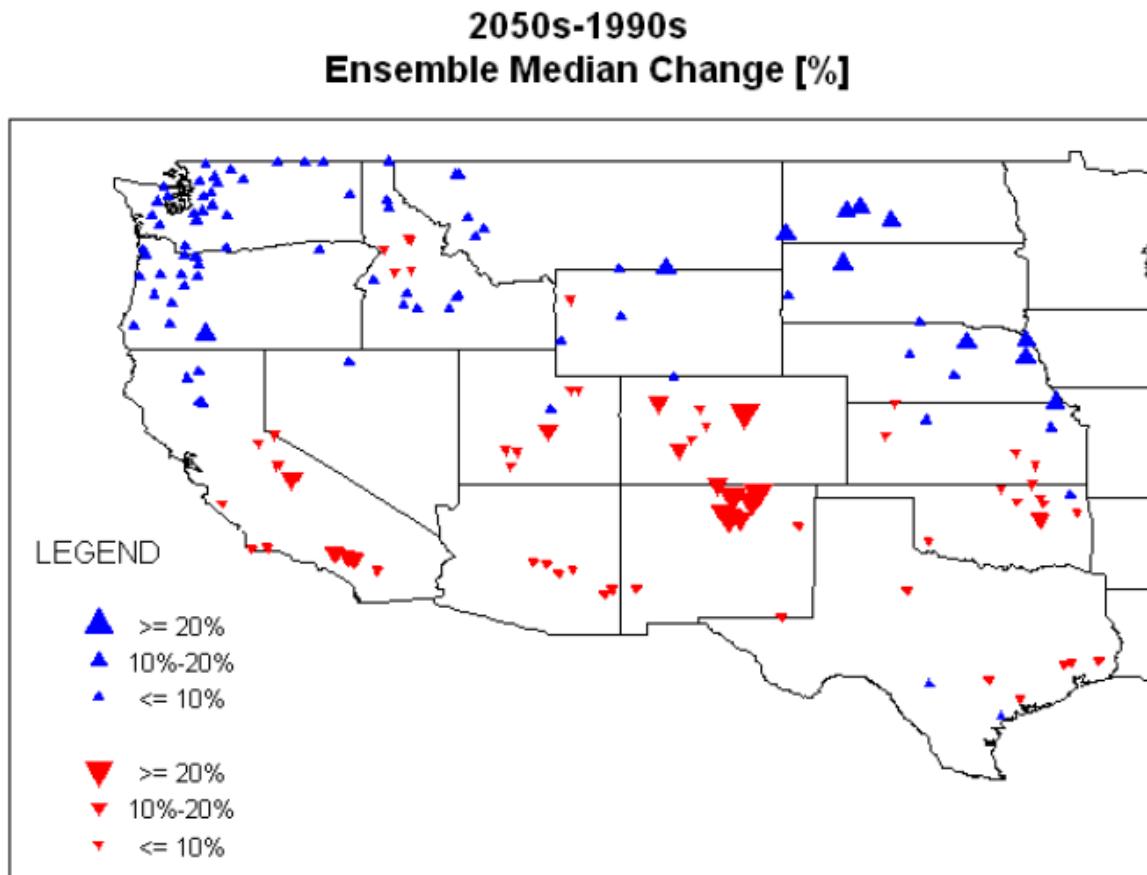


Figure 2 Median projected changes in annual precipitation from ensemble of 112 GCM / scenario combinations, mid-century Source: U.S. Bureau of Reclamation, Westwide Climate Risk Assessment, 2011

⁶ West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections, U.S. Department of the Interior Bureau of Reclamation Technical Memorandum No. 86-68210-2011-01, March 2011. Available at <http://www.usbr.gov/WaterSMART/docs/west-wide-climate-risk-assessments.pdf>. Incorporated by reference.