

California's Water Supply Forecasting

DWR & Water Education Foundation:
Challenges for Water Operations

April 26, 2016

Fresno State University



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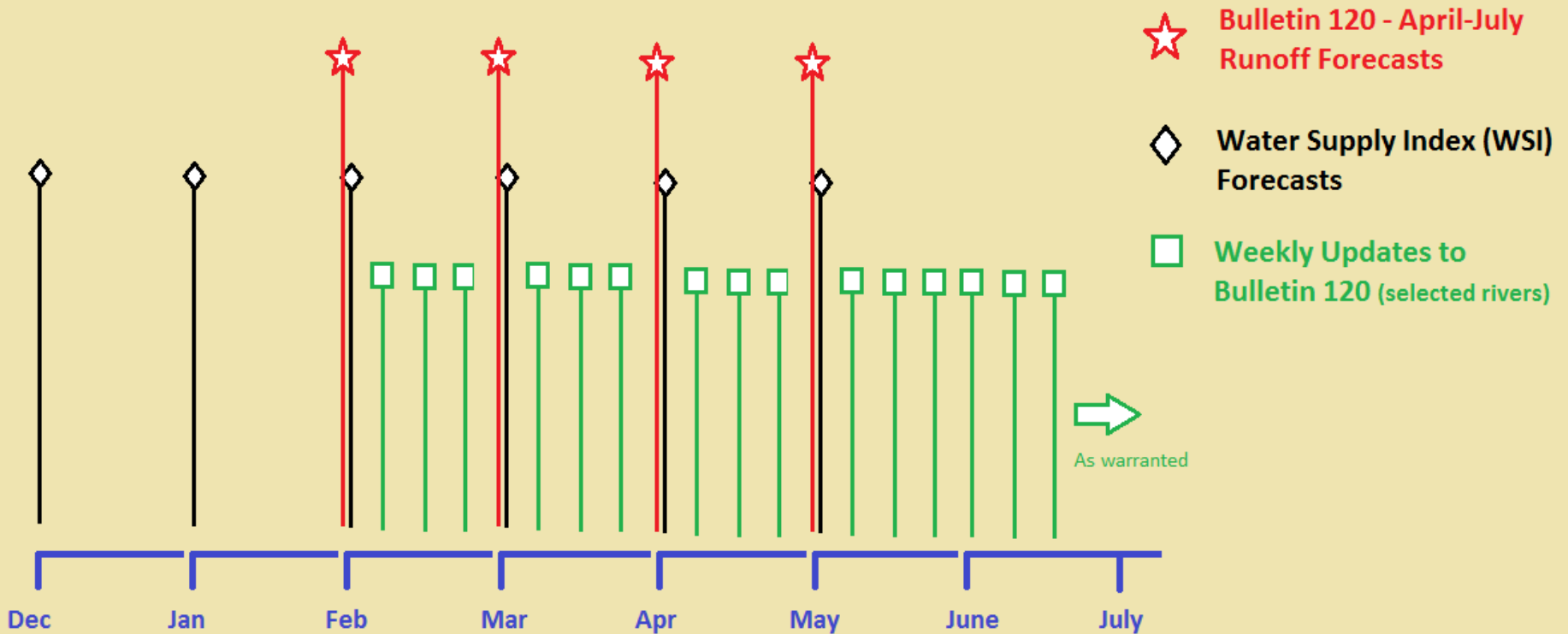
California Department of Water Resources



Background on Water Supply Forecasting Products

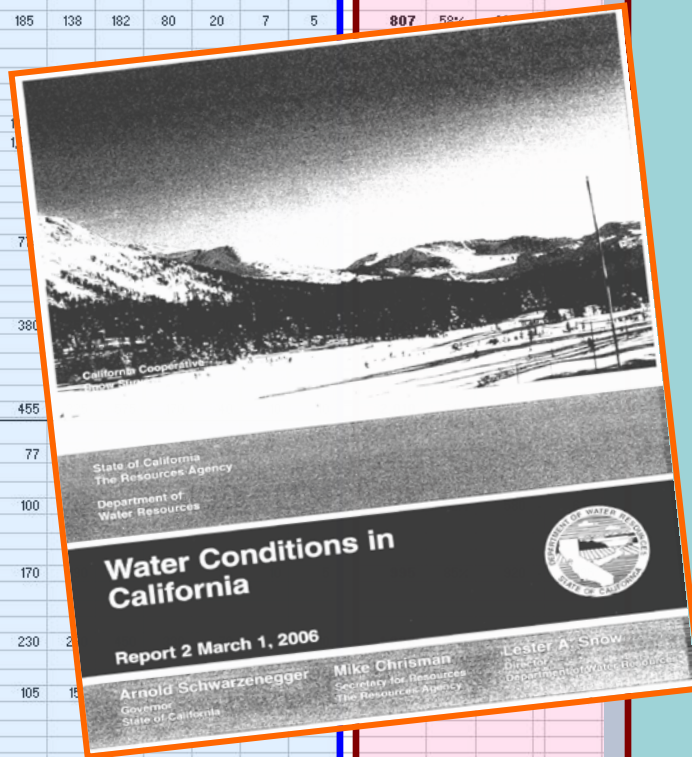
Bulletin 120 and Water Year Forecast Schedules

Annual Water Supply Forecast Schedule



Bulletin 120: Seasonal Runoff Forecasts

HYDROLOGIC REGION and Watershed	Unimpaired Runoff in 1000 Acre-Feet (1)						Unimpaired Runoff in 1000 Acre-Feet (1)												FORECAST			
	HISTORICAL			FORECAST			HISTORICAL			DISTRIBUTION									FORECAST			
	50 Yr Avg (2)	Max of Record	Min of Record	Apr-Jul Forecasts	Pot of Avg	80% Probability Range (1)	50 Yr Avg (2)	Max of Record	Min of Record	Oct Thru Jan*	Feb *	Mar *	Apr *	May	Jun	Jul	Aug	Sep	Water Year Forecasts	Pot of Avg	80% Probability Range (1)	
North Coast																						
Trinity River at Lewiston Lake (10)	654	1,593	8	420	64%	360 - 580	1,398	2,990	200	113	77	185	138	182	80	20	7	5	807	58%		
SACRAMENTO RIVER																						
Upper Sacramento River																						
Sacramento River at Delta above Shasta Lake	298	711	3	280	94%		887	1,965	165													
McCloud River above Shasta Lake	392	850	18	360	92%		1,217	2,353	55													
Pit River near Montgomery Creek + Squaw Creek	1,066	2,098	48	840	79%		3,159	5,150	1,488													
Total Inflow to Shasta Lake	1,819	3,525	72	1,600	88%	1,450 - 1,940	6,107	10,796	2,473	915	665											
Sacramento River above Bend Bridge, near Red Bluff	2,494	5,075	94	2,150	86%	1,890 - 2,600	8,907	17,180	3,294	1,215	1,035	1										
Feather River																						
Feather River at Lake Almanor near Prattville (3)	333	675	12	260	78%		780	1,269	366													
North Fork at Pulga (3)	1,028	2,416	24	770	75%		2,417	4,400	666													
Middle Fork near Clio (4)	86	518	60	70%			219	637	24													
South Fork at Ponderosa Dam (3)	110	267	1	75	68%		291	562	32													
Feather River at Oroville	1,782	4,676	39	1,380	77%	1,150 - 1,720	4,620	9,492	994	475	475	7										
Yuba River																						
North Yuba below Goodyears Bar	279	647	5	240	86%		564	1,056	102													
Inflow to Jackson Mlws and Bowman Reservoirs (3)	112	236	2	95	85%		181	292	30													
South Yuba at Langs Crossing (3)	233	481	5	190	82%		379	565	98													
Yuba River near Smartsville plus Deer Creek	1,006	2,424	20	880	88%	760 - 1,010	2,373	4,926	363	205	230	380										
American River																						
North Fork at North Fork Dam (3)	282	716	4	210	80%		616	1,234	66													
Middle Fork near Auburn (3)	522	1,406	10	460	88%		1,070	2,575	144													
Silver Creek Below Camino Diversion Dam (3)	173	386	3	150	87%		318	705	53													
American River below Folsom Lake	1,240	3,074	22	1,110	90%	970 - 1,270	2,719	6,382	343	185	240	455										
SAN JOAQUIN RIVER																						
Cosumnes River at Michigan Bar	126	363		100	79%	75 - 135	390	1,253	20	18	34	77										
Mokelumne River																						
North Fork near West Point (5)	437	829	10	380	87%		626	1,009	19													
Total Inflow to Pardee Reservoir	461	1,065	10	430	93%	400 - 480	755	1,800	123	45	40	100										
Stanislaus River																						
Middle Fork below Beardsley Dam (3)	334	702	6	300	90%		471	929	88													
North Fork Inflow to McKays Point Dam (3)	224	503	3	200	89%																	
Stanislaus River below Goodwin Reservoir (7)	702	1,710	11	640	91%	570 - 720	1,171	2,952	155	95	75	170										
Tuolumne River																						
Cherry Creek & Eleanor Creek near Hetch Hetchy	315	727	9	290	92%		461	1,147	12													
Tuolumne River near Hetch Hetchy	604	1,392	15	560	93%		770	1,661	258													
Tuolumne River below La Grange Reservoir (A)	1,220	2,682	30	1,110	91%	1,030 - 1,260	1,951	4,631	38	200	115	230	2									
Merced River																						
Merced River at Pohono Bridge	372	888	8	320	86%		461	1,020	92													
Merced River below Merced Falls (9)	632	1,587	12	540	85%	490 - 630	1,007	2,787	150	85	60	105	15									
San Joaquin River																						
San Joaquin River at Mammoth Pool (7)	1,026	2,279	23	820	80%		1,337	2,964	308													
Big Creek below Huntington Lake (8)	91	264	4	70	77%		112	298	14													
South Fork near Florence Lake (7)	201	511	5	170	85%		248	653	7													
San Joaquin River inflow to Millerton Lake	1,254	3,355	26	970	77%	850 - 1,100	1,836	4,642	362	155	80	140	230	380	270	90	25	15	1,395	75%	1,250 - 1,520	
TULARE LAKE																						
Kings River																						
North Fork Kings River near Cliff Camp (3)	239	565	5	180	75%		284	607	58													
Kings River below Pine Flat Reservoir	1,224	3,113	27	940	77%	850 - 1,040	1,721	4,287	388	130	65	110	215	360	275	90	30	10	1,285	75%	1,190 - 1,400	
Kaweah River below Terminus Reservoir	286	814	6	200	70%	170 - 250	454	1,402	94	39	23	33	54	85	48	12	4	2	300	66%	260 - 360	
Tule River below Lake Success	64	259	3	31	49%	25 - 48	148	615	16	10	9	11	11	14	5	1	0	0	61	41%	50 - 80	
Kern River																						
Kern River near Kernville	384	1,203	8	240	63%		558	1,577	163													
Kern River inflow to Lake Isabella	461	1,657	8	270	59%	230 - 330	730	2,318	175	70	25	40	65	95	80	30	15	10	430	59%	380 - 500	



April-July Forecast and % of Average

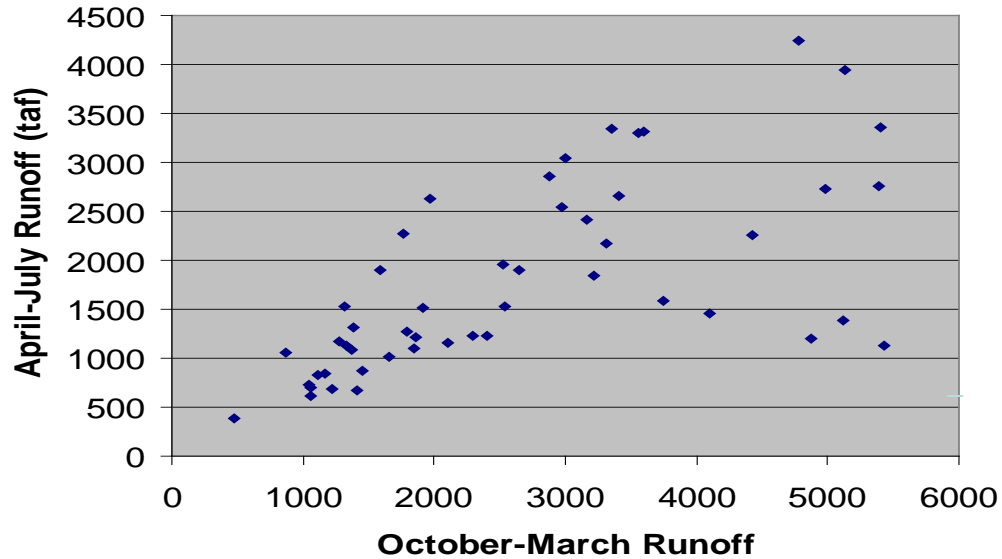
April-July Forecast 80% Prob. Range

Water Year F'Cast Distribution

Water Year Forecast and % of Avg.

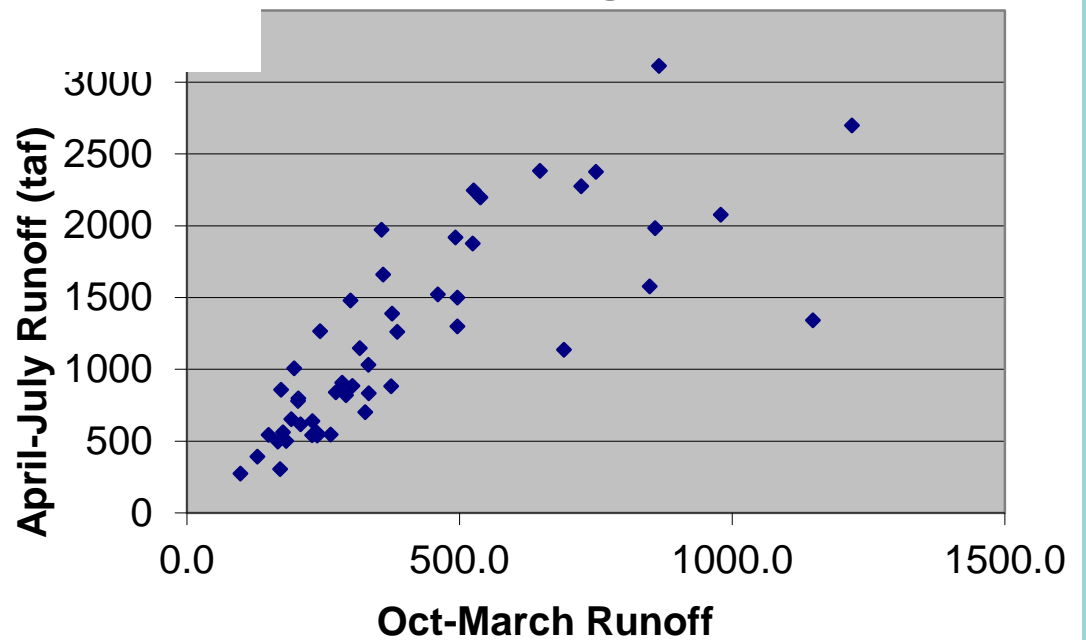
Water Year F'Cast 80% Prob. Range

Feather River



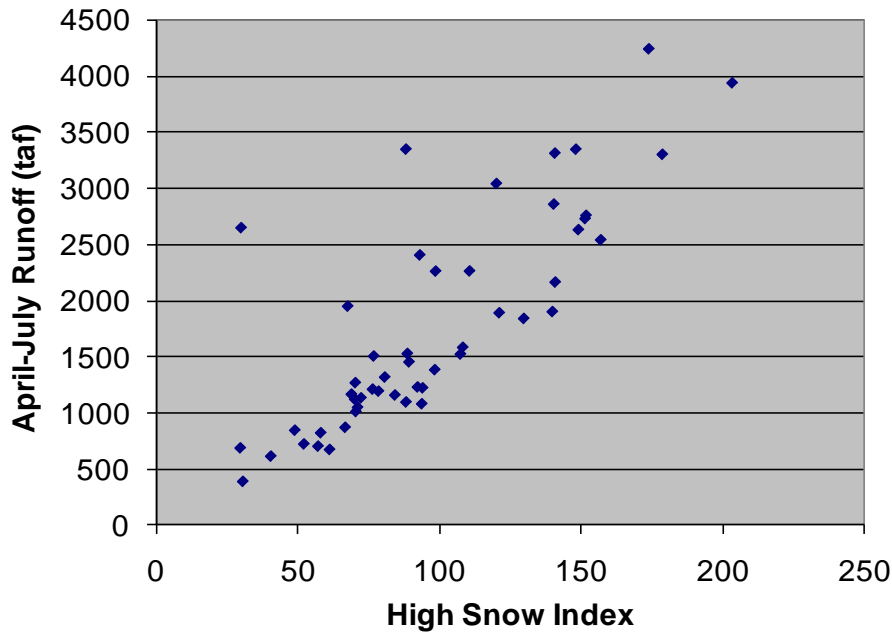
**How Well Does Fall /
Winter Unimpaired
Runoff
Predict of AJ Volumes?**

Kings River

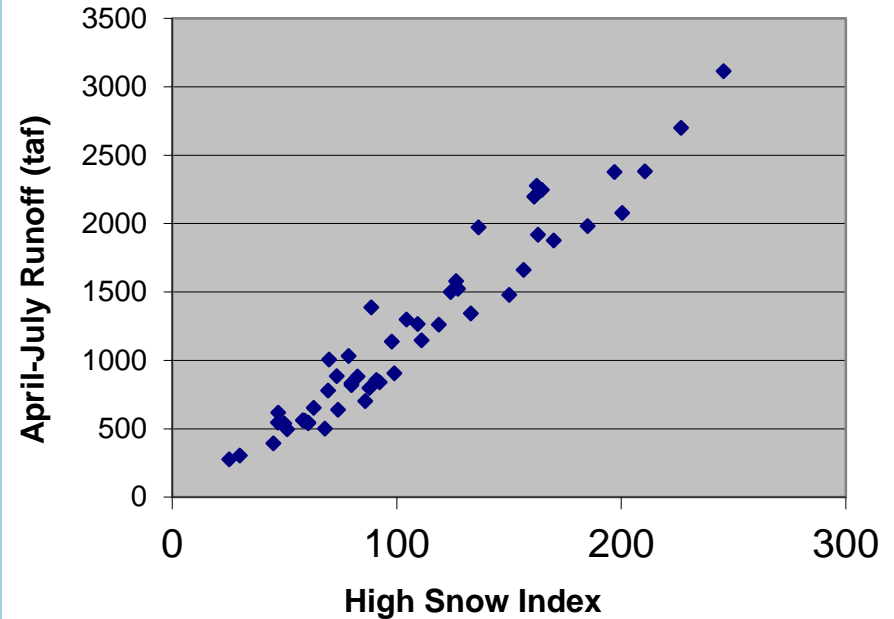


Correlation of AJ Runoff to High Elevation Snow Index

Feather River



Kings River



“Non Snow Driven” Basin (Feather)

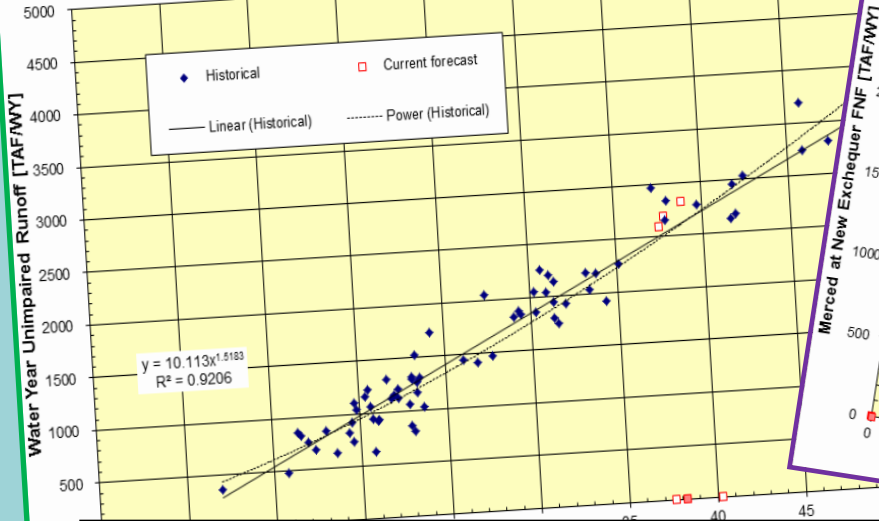
vs.

“Snow Driven” Basin (Kings)

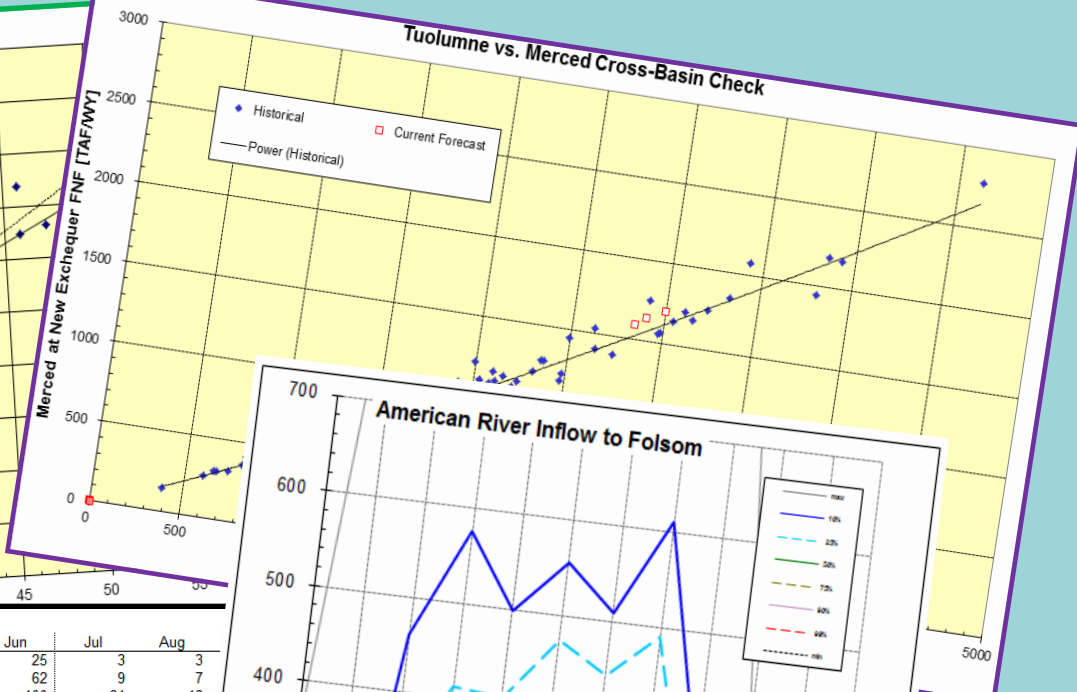
We analyze similar patterns and correlations for precipitation data

Graphical Analyses = Reality Check

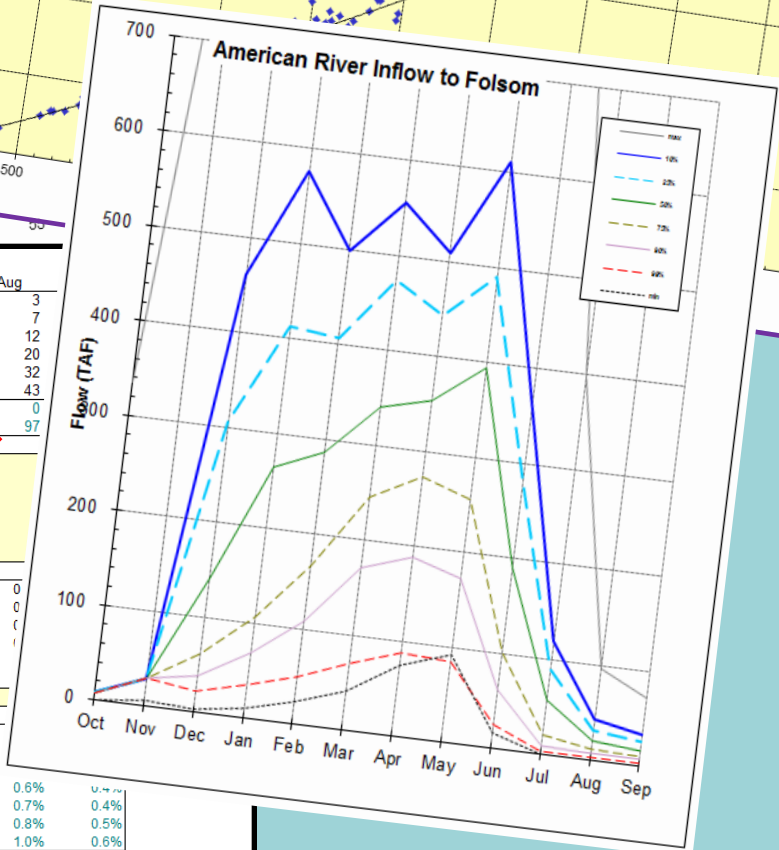
San Joaquin River at Millerton



Tuolumne vs. Merced Cross-Basin Check



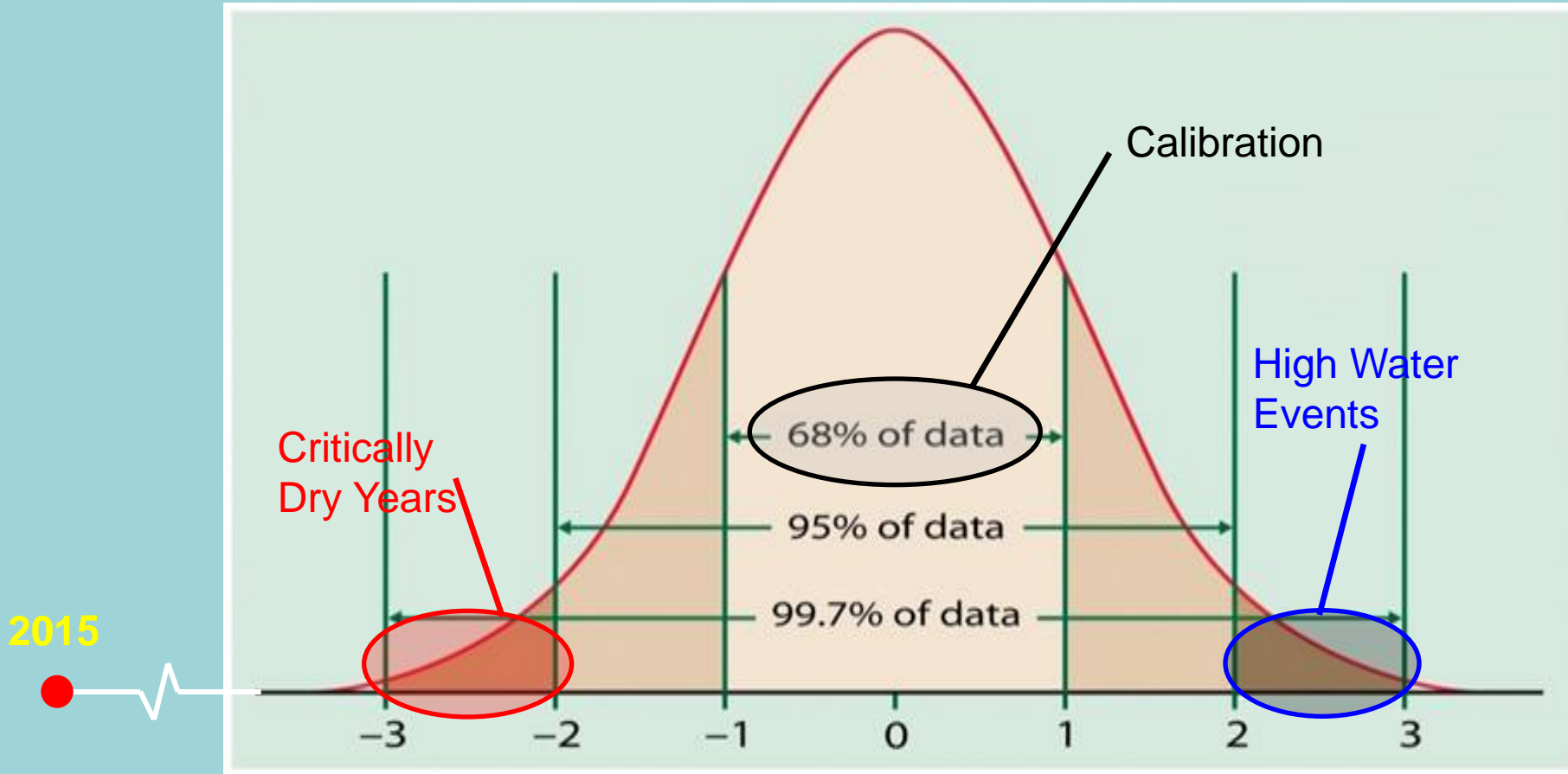
American River Inflow to Folsom



American River Unimpaired Inflow to Folsom [taf]											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
99%	8	29	22	35	49	70	87	85	25	3	3
90%	8	29	38	69	108	171	189	173	62	9	7
75%	8	29	62	107	166	246	273	256	100	21	12
50%	8	29	140	264	287	340	353	395	191	57	20
25%	8	29	305	413	407	474	443	490	283	90	32
10%	8	29	461	577	500	555	510	611	364	119	43
min	0	6	3	11	24	42	75	92	17	0	0
max	335	985	1509	1988	1866	1525	1130	1136			97
Actual or Estimated (leave blank to use hist. distribution, enter, or link to observed or B120)											
99%	8	29				70		85			
90%	8	29									
75%	8	29									
50%	8	29				340					
25%	8	29						490			
10%	8	29									
Scaled percent of water year runoff for projected wy total flow											
99%	3.7%	4.1%	5.1%	8.3%	11.7%	18.8%	20.7%	19.1%	5.9%	0.8%	0
90%	2.8%	4.0%	4.3%	7.8%	12.1%	19.2%	21.1%	19.3%	6.9%	1.0%	0
75%	1.9%	3.7%	4.6%	8.0%	12.5%	18.5%	20.6%	19.3%	7.5%	1.6%	0
50%	1.7%	3.8%	6.4%	12.0%	13.0%	16.1%	16.0%	17.9%	8.7%	2.8%	0
25%	1.5%	4.0%	9.6%	13.0%	12.8%	14.9%	13.9%	16.8%	8.9%	2.8%	0
10%	1.3%	4.3%	11.5%	14.4%	12.5%	13.9%	12.7%	15.3%	9.1%	3.0%	0
scale	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Historical percent of water year runoff for given wy total flow (from QmonDist4.xls)											
0	4.1%	3.7%	5.9%	8.7%	11.2%	18.3%	21.2%	20.1%	5.5%	0.4%	
800	2.6%	3.7%	3.9%	7.6%	11.9%	19.1%	22.1%	20.4%	7.2%	0.7%	
1200	1.5%	3.4%	4.2%	7.3%	12.2%	18.6%	22.1%	20.5%	7.9%	1.3%	
2000	1.3%	3.5%	5.7%	11.7%	12.9%	16.1%	17.2%	19.2%	9.1%	2.4%	0.6%
3300	1.0%	3.8%	10.4%	13.1%	12.5%	14.4%	14.1%	17.6%	9.4%	2.7%	0.7%
4500	0.8%	4.3%	12.4%	15.7%	12.0%	13.0%	13.1%	14.8%	9.7%	2.9%	0.8%
5500	0.7%	4.0%	11.8%	16.5%	11.0%	12.6%	12.7%	14.5%	10.4%	4.1%	1.0%
av mo%	1.0%	3.1%	6.4%	10.7%	12.2%	15.2%	17.1%	19.2%	10.9%	2.9%	0.7%



Using Averages to Predict Extremes



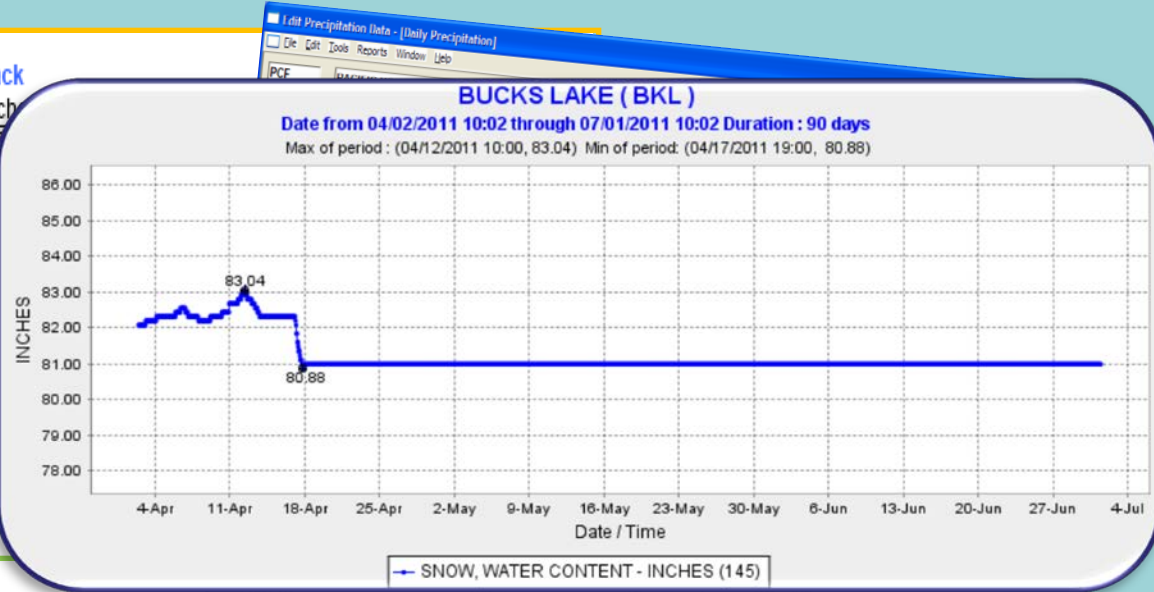
- Based on...historical measurements
- Errors are part of the process / define confidence levels

When Data Goes bad...

Feather River inflow to Lake Oroville

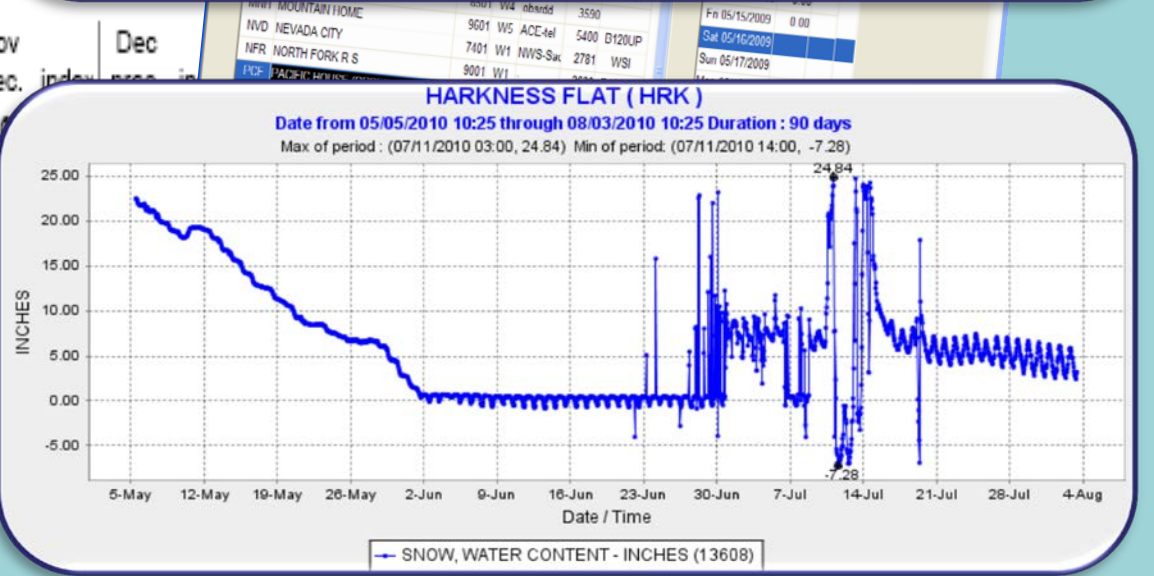
High Snowpack

#	ID	Name	Basin Dir	Elev	4/1avg	Pr.st	Ratio	Sch
361	KTL	Kettle Rock	Feath ↕	7300'	23.0	7	7	7
48	MDY	Mount Dyer	Feath ↑	7100'	25.5	6	1.0	
359	GRZ	Grizzly	Feath ↕	6900'	30.3	7	1.1	
279	ERB	Eureka Bowl	Feath ↓	6800'	44.3	8	2.6	
280	RWL	Rowland Creek	Feath →	6700'	17.8	7	7	1
360	MHG	Mount Hough	Feath ↕	6700'	29.5	7	1.1	1
75	CHU	Church Meadows	Feath ↓	6700'	32.1	8	1.9	1
74	YBP	Yuba Pass	Yuba ↘	6700'	30.9	8	9	
45	SVR	Silver Lake Meado	Susan ↖	6450'	29.6	5	9	
53	3LK	Three Lakes	Feath ←	6250'	39.9	7	1.5	
54	MLF	Mill Creek Flat	Feath ←	5900'	39.2	7	1.5	
49	LTT	Letterbox	Feath ←	5600'	49.9	7	1.9	
Basin average:				6590'	32.7			



Feather River inflow to Lake Oroville

ID	Name	Dir	Elev [ft]	Oct-Mar avg	Oct prec.	Nov index	Nov prec.	Dec index
(8)	Scaling factor:				0.5		0.5	
SRR	Sierraville RS	↘	4975'	16.90	.88	2.8	3	
MNR	Mineral	↖	4875'	33.90	4.31	6.4	6	
PRT	Portola	→	4850'	13.30	.58	2.2	2	
CNY	Canyon Dam	↖	4560'	25.60	2.00	3.9	8	
BCR	Brush Creek RS	↙	3560'	47.00	4.25	4.5	6	
QNC	Quincy RS	↕	3410'	26.70	2.28	4.3	6	
CBO	Caribou PH	↕	2990'	27.50	1.95	3.5	4	
BUP	Bucks Creek PH	←	1760'	45.40	4.34	4.8	6	
Basin average:				3870'	29.54	2.57	4.0	



When Landscapes Change...



When Climate Changes...

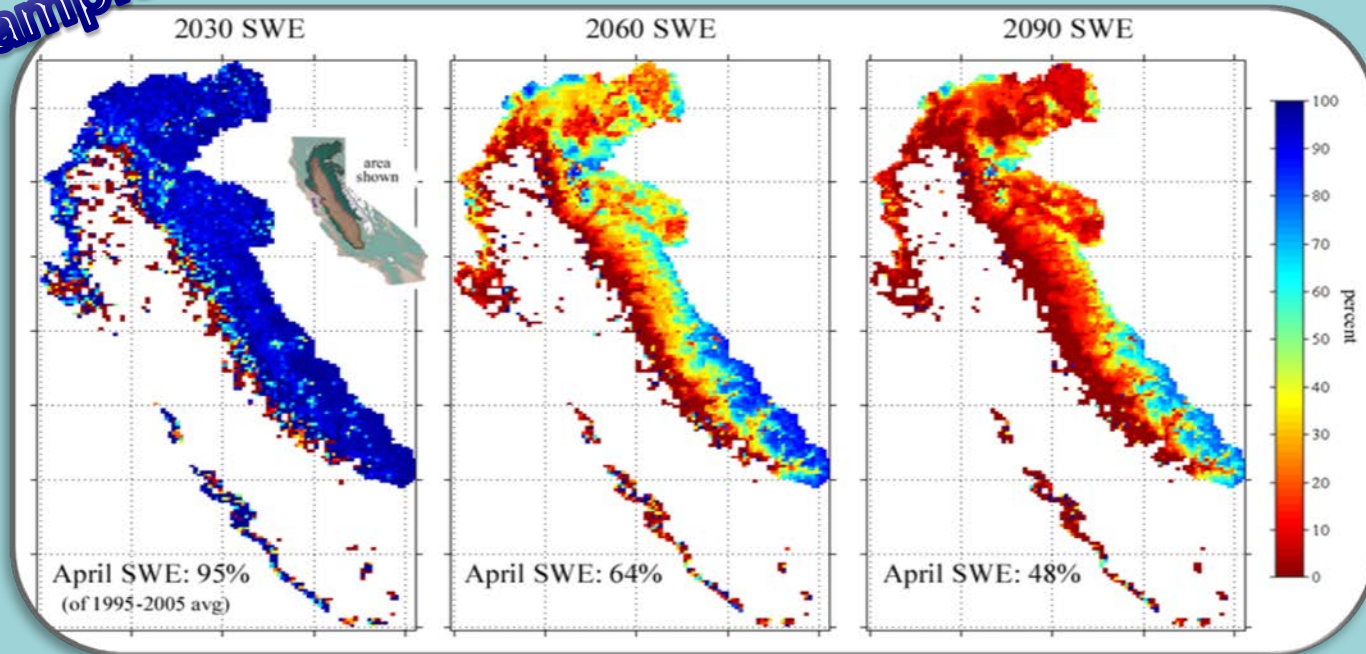
“The Only Constant In Life Is Change”

-Heraclitus, c 535 BC

Warning! Climate Change Slide!

Example:

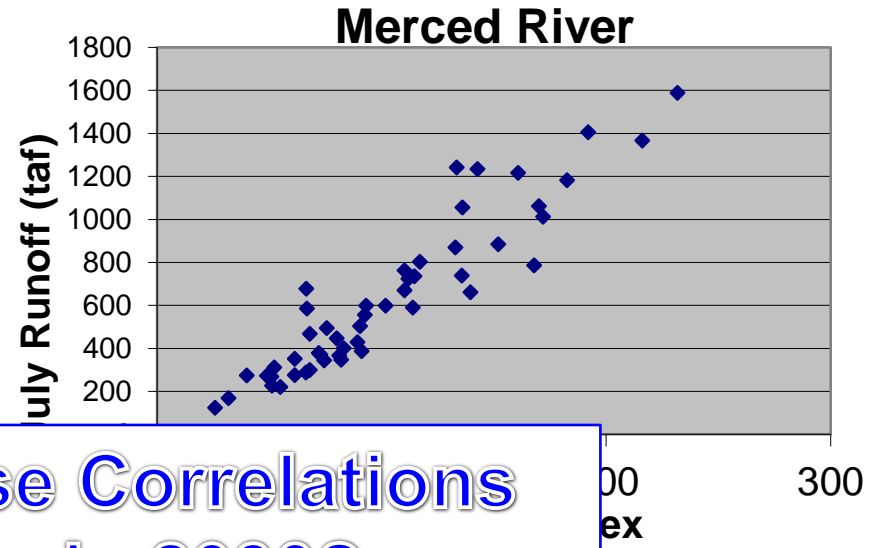
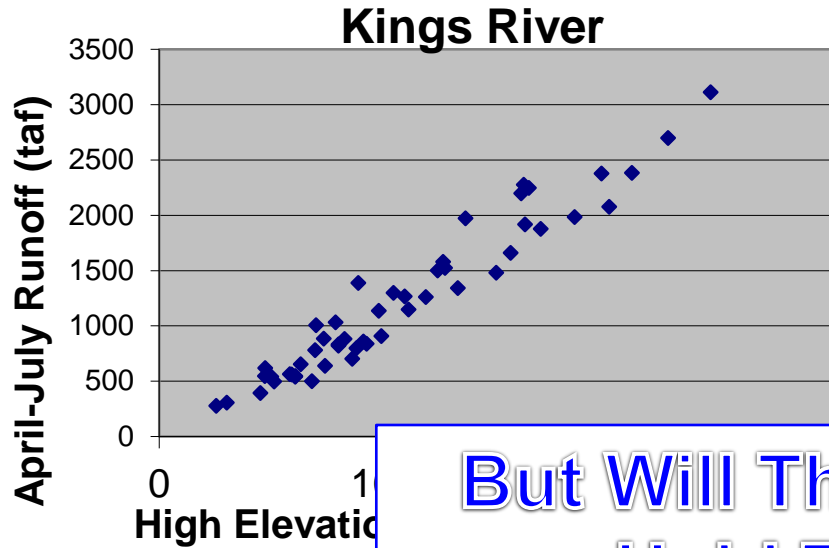
Springtime SWE Under Projected Temperature Increases



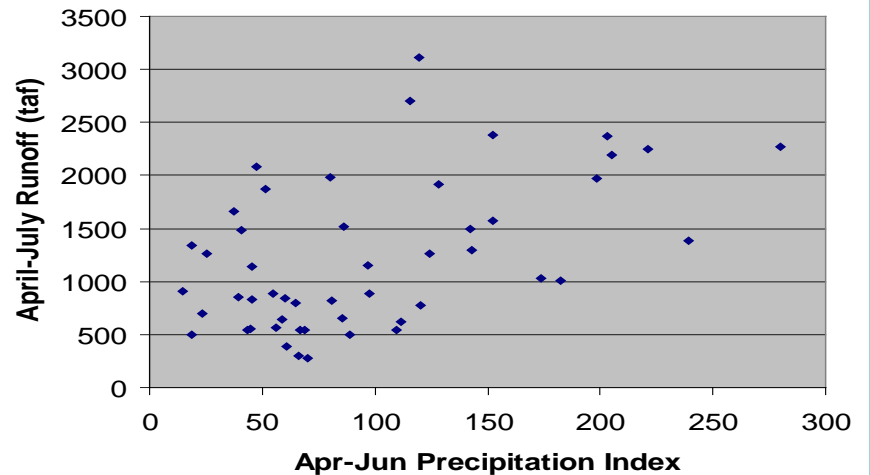
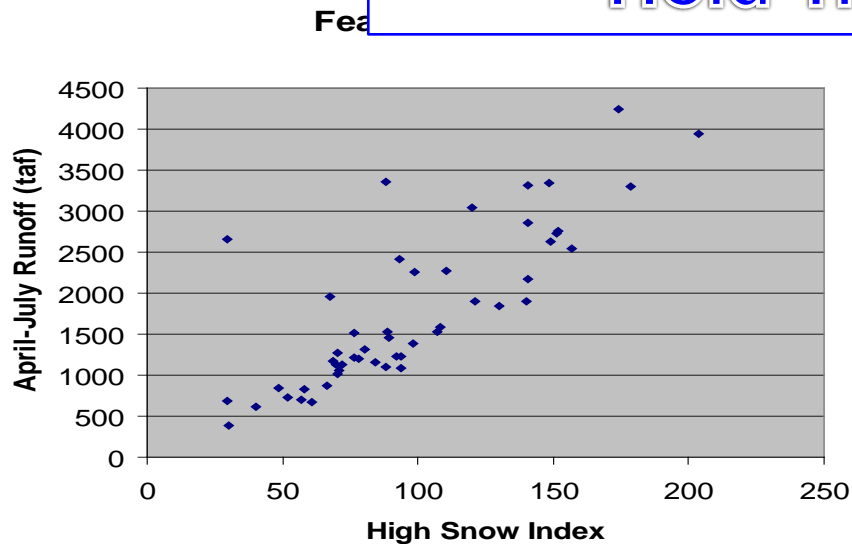
Source: Knowles and Cayan, 2002

Notes: Projected temperature increases: 0.6C (2020-2039), 1.6C ((2050-2069), and 2.1C (2080-2099), expressed as a percentage of average present conditions

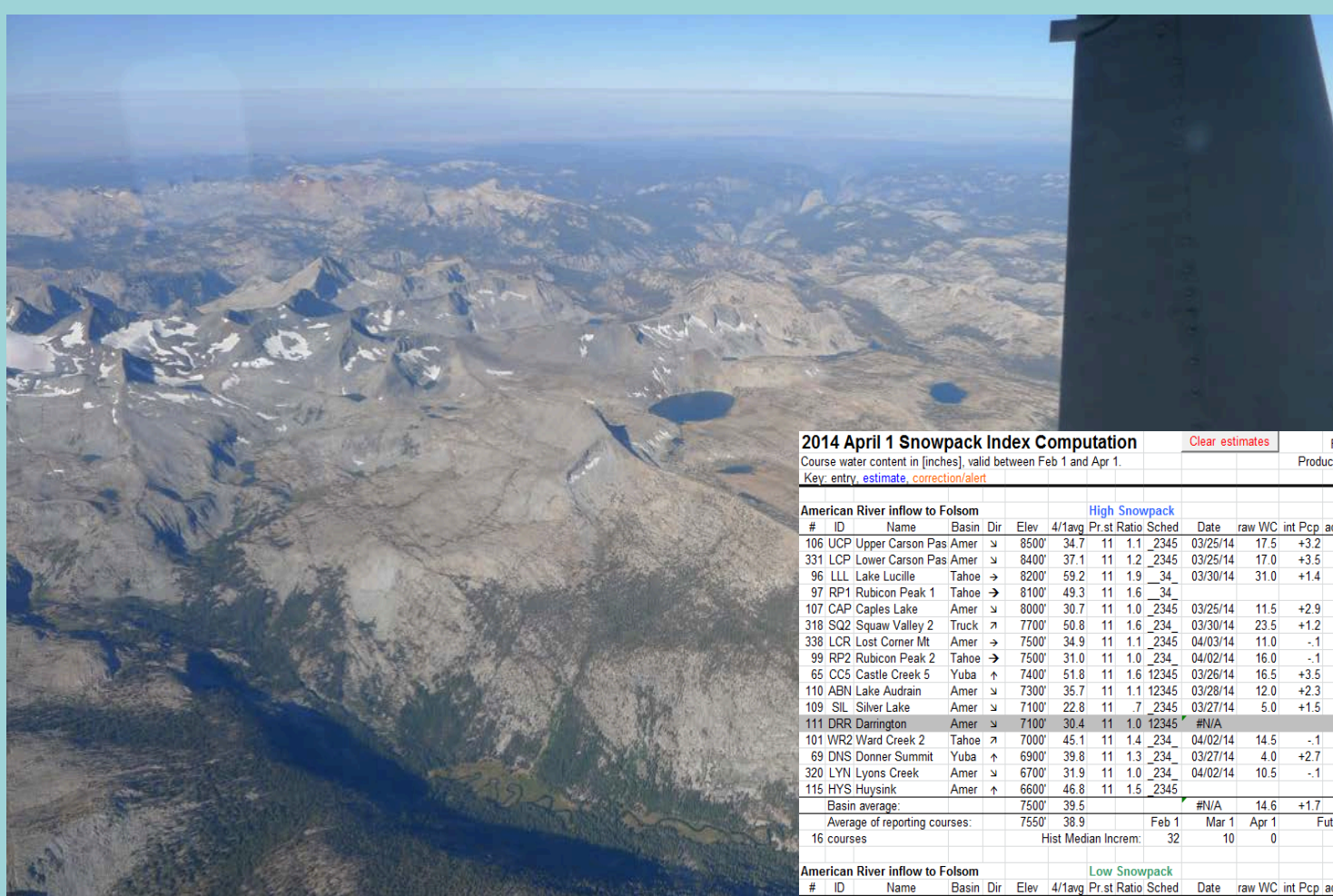
We Are Only As Good as Our Data



But Will These Correlations Hold True in 2030?



Modernizing Forecasting



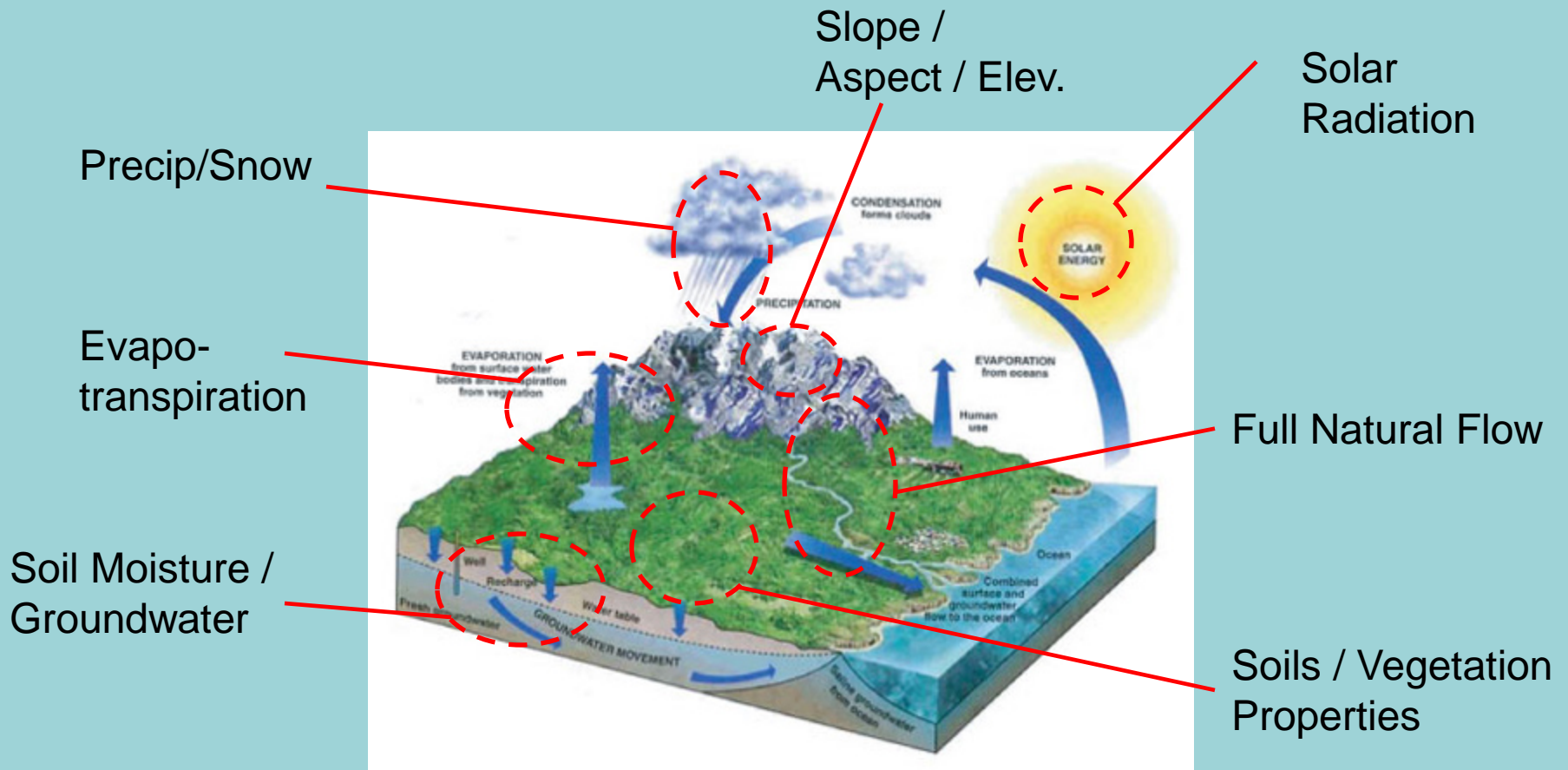
2014 April 1 Snowpack Index Computation															Clear estimates		Forecast Date: 4/1/14		4/1 date for increment lookup				
Course water content in [inches], valid between Feb 1 and Apr 1.																	Production Run Date: 4/1/14		4 month				
Key: entry, estimate, correction/alert																			OK for dates >Apr 1				
American River inflow to Folsom															High Snowpack								
#	ID	Name	Basin	Dir	Elev	4/1avg	Pr.st	Ratio	Sched	Date	raw WC	int Pcp	adj WC	% avg	est %	adj %	rec'd?	altern.	note	Lat	Yr.Est		
106	UCP	Upper Carson Pas	Amer	↘	8500'	34.7	11	1.1	2345	03/25/14	17.5	+3.2	20.7	60		60	ok			38.70	1930		
331	LCP	Lower Carson Pas	Amer	↘	8400'	37.1	11	1.2	2345	03/25/14	17.0	+3.5	20.5	55		55	ok	Blue Lks c/s		38.69	1951		
96	LLL	Lake Lucille	Tahoe	→	8200'	59.2	11	1.9	34	03/30/14	31.0	+1.4	32.4	55		55	ok	Echo Pk s		38.86	1913		
97	RP1	Rubicon Peak 1	Tahoe	→	8100'	49.3	11	1.6	34								miss			38.99	1910		
107	CAP	Caples Lake	Amer	↘	8000'	30.7	11	1.0	2345	03/25/14	11.5	+2.9	14.4	47		47	ok	s		38.71	1951		
318	SQ2	Squaw Valley 2	Truck	↗	7700'	50.8	11	1.6	234	03/30/14	23.5	+1.2	24.7	49		49	ok	SQV s		39.19	1954		
338	LCR	Lost Corner Mt	Amer	→	7500'	34.9	11	1.1	2345	04/03/14	11.0	-1	10.9	31		31	ok			39.02	1959		
99	RP2	Rubicon Peak 2	Tahoe	→	7500'	31.0	11	1.0	234	04/02/14	16.0	-1	16.0	51		51	ok	s		39.00	1912		
65	CC5	Castle Creek 5	Yuba	↑	7400'	51.8	11	1.6	12345	03/26/14	16.5	+3.5	20.0	39		39	ok	-		39.35	1946		
110	ABN	Lake Audrain	Amer	↘	7300'	35.7	11	1.1	12345	03/28/14	12.0	+2.3	14.3	40		40	ok	Echo Sum c		38.82	1941		
109	SIL	Silver Lake	Amer	↘	7100'	22.8	11	.7	2345	03/27/14	5.0	+1.5	6.5	28		28	ok	s		38.68	1930		
111	DRR	Darrington	Amer	↘	7100'	30.4	11	1.0	12345	#N/A							miss			38.83	1941		
101	WR2	Ward Creek 2	Tahoe	↗	7000'	45.1	11	1.4	234	04/02/14	14.5	-1	14.4	32		32	ok	Ward Cr 3 s		39.14	1913		
69	DNS	Donner Summit	Yuba	↑	6900'	39.8	11	1.3	234	03/27/14	4.0	+2.7	6.7	17		17	ok	Snow Lab s		39.31	1910		
320	LYN	Lyons Creek	Amer	↘	6700'	31.9	11	1.0	234	04/02/14	10.5	-1	10.5	33		33	ok			38.81	1937		
115	HYS	Huysink	Amer	↑	6600'	46.8	11	1.5	2345						12	12	miss	s		39.28	1937		
Basin average:					7500'	39.5				#N/A	14.6	+1.7	16.3	41.3	39.2	39.2					38.96		
Average of reporting courses:					7550'	38.9			Feb 1	Mar 1	Apr 1				Future Increment:	0.0						38.94	
16 courses															Apr 1 Index:	39.2						39.00	
Hist Median Increment:									32		10		0										
American River inflow to Folsom															Low Snowpack								
#	ID	Name	Basin	Dir	Elev	4/1avg	Pr.st	Ratio	Sched	Date	raw WC	int Pcp	adj WC	% avg	est %	adj %	rec'd?	altern.	note	Lat	Yr.Est		
365	APH	Alpha	Amer	↘	7600'	35.4	11	1.1	12345	04/02/14	13.5	-1	13.4	38		38	ok	s	too high	38.81	1965		
316	WRG	Wrights Lake	Amer	↘	6900'	32.4	11	1.0	2345	03/31/14	11.5	0	11.5	35		35	ok			38.85	1956		
113	PHL	Phillips	Amer	↘	6800'	28.8	11	.9	234	04/01/14	8.0	-0	8.0	28		28	ok			38.82	1941		
289	TMF	Tamarack Flat	Amer	↘	6550'	28.7	11	1.1	234	04/01/14	14.5	-1	14.4	50		50	ok			38.81	1939		
114	WBM	Wabena Meadows	Amer	↑	6300'	42.3	11	1.3	234	03/28/14	6.5	+2.7	9.2	22		22	ok			39.23	1937		
120	ONN	Onion Creek	Amer	↑	6100'	22.2	11	.7	2345	03/26/14	1.0	+1.5	2.5	11		11	ok			39.28	1937		
80	CCO	Cisco	Yuba	↑	5900'	26.3	11	.8	234	03/27/14	1.5	+1.7	3.2	12		12	ok			39.30	1918		
123	SVX	Sixmile Valley	Amer	↖	5750'	23.5	11	.7		#N/A							-	Cisco c		39.32	1930		
122	TBC	Talbot Camp	Amer	↑	5750'	20.7	11	.6	234	03/28/14	1.5	+1.3	2.8	13		13	ok			39.19	1940		
124	STW	Strawberry	abandi	↘	5700'	8.4	11	.3		#N/A							-	TMF		38.79	1942		
322	RBV	Robbs Valley	Amer	↔	5600'	21.3	11	1.5	2345	03/31/14	3.0	0	3.0	14		14	ok	Robbs Sad s		38.92	1932		
128	CPF	Carpenter Flat	Amer	↖	5300'	18.0	11	.6		#N/A							-	Blue Can s		39.30	1946		
85	SPD	Lake Spaulding	Yuba	↖	5200'	24.4	11	.8	234	03/27/14	1.5	+1.7	3.2	13		13	ok	Blue Can s		39.32	1927		
Basin average:					6110'	25.6				#N/A	6.3	+9	7.1	23.7	23.7	23.7					39.07		
Average of reporting courses:					6270'	28.3			Feb 1	Mar 1	Apr 1				Future Increment:	0.0						39.05	
13-1 courses															Apr 1 Index:	23.7						39.00	
Hist Median Increment:									17		-3		0										

What a Watershed looks like:
Lyell Fork of the Tuolumne River

Watersheds from
An equation's point of view

Feed Me!

“Healthy” Models Need Many Sources of Many Types of Good-Quality, Long-Term Data



Conceptualized Physical Hydrology Model

Consider a 5% Error When...

Wet Year

- 5% Error on the A-J Inflow To Friant Dam in WY2011 was 112,153 AF (above and beyond our typical 5-10% error) or about 21% of Millerton's capacity.
- 5% Error on the A-J Inflow to Folsom Lake during WY2006 was 131,119 AF or about 13% of Folsom's capacity

Dry Year

- 5% Error on the May 2012 A-J Inflow Forecast (175,000 AF) to Terminus Lake on the Kaweah is equal to 8,750 AF. An over-forecast means the A-J would have been less than 172,000 AF which is a Normal/Dry year trigger on the Kaweah River.

The Snapshot

- Current forecasting and data network is the backbone of our “early warning system” for Flood ER as well as responding to droughts
- Climate Change may limit regression correlations in the future leading to an increase in forecast error
- Advanced modeling capabilities have big appetites for data
- Limited access to Wilderness is a threat to remote data collection

Measuring Snow Into the Future!!



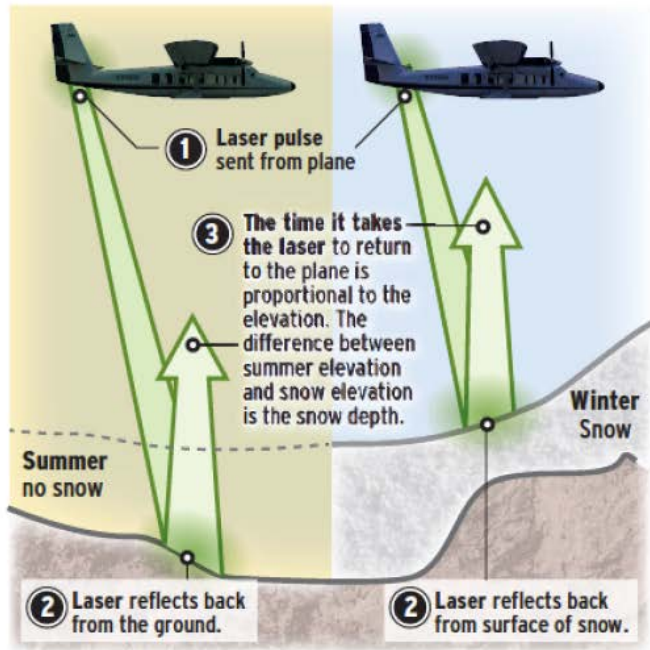
Airborne Snow Observatory

Imaging snow water equivalent and predicting runoff for
water management

Principal Investigator: Thomas H. Painter, JPL/Caltech
Bruce J. McGurk, McGurk Hydrologic, and Frank Gehrke, CA DWR

How much snow?

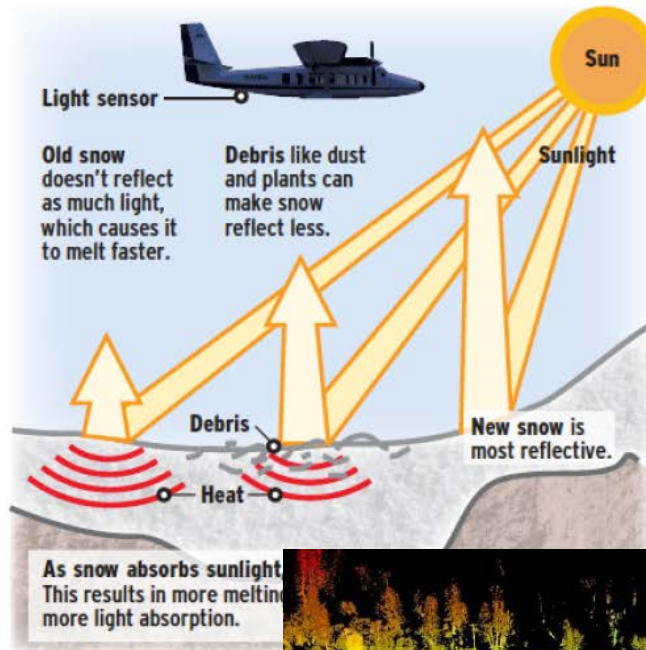
Using laser radar, known as Lidar, researchers measure the depth of snowpack in California.



Sources: Thomas Painter, Frank Gehrke, Optech Inc.

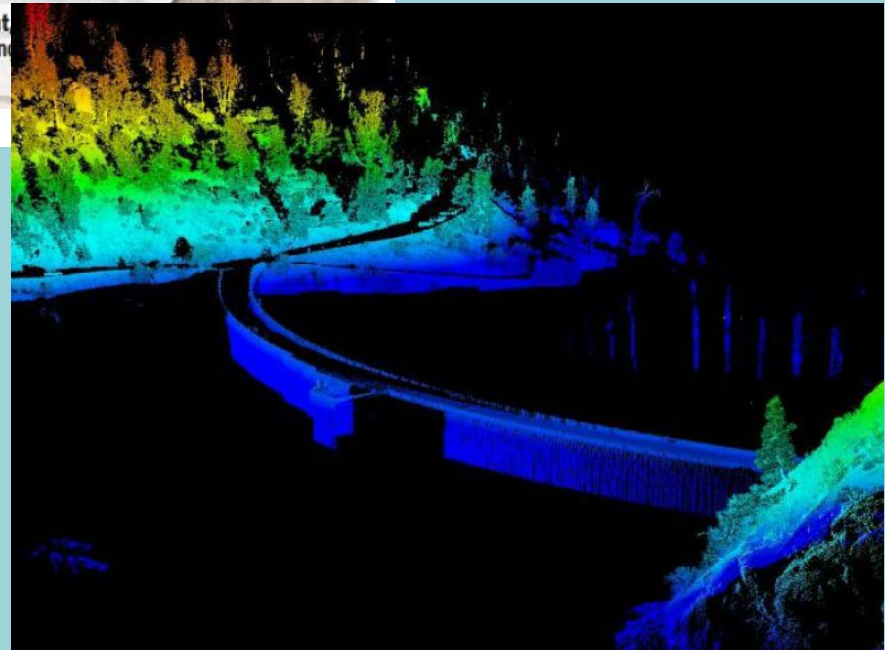
How will it melt?

With an advanced light sensor, scientists measure snow's reflectivity – an indicator of how it will melt.

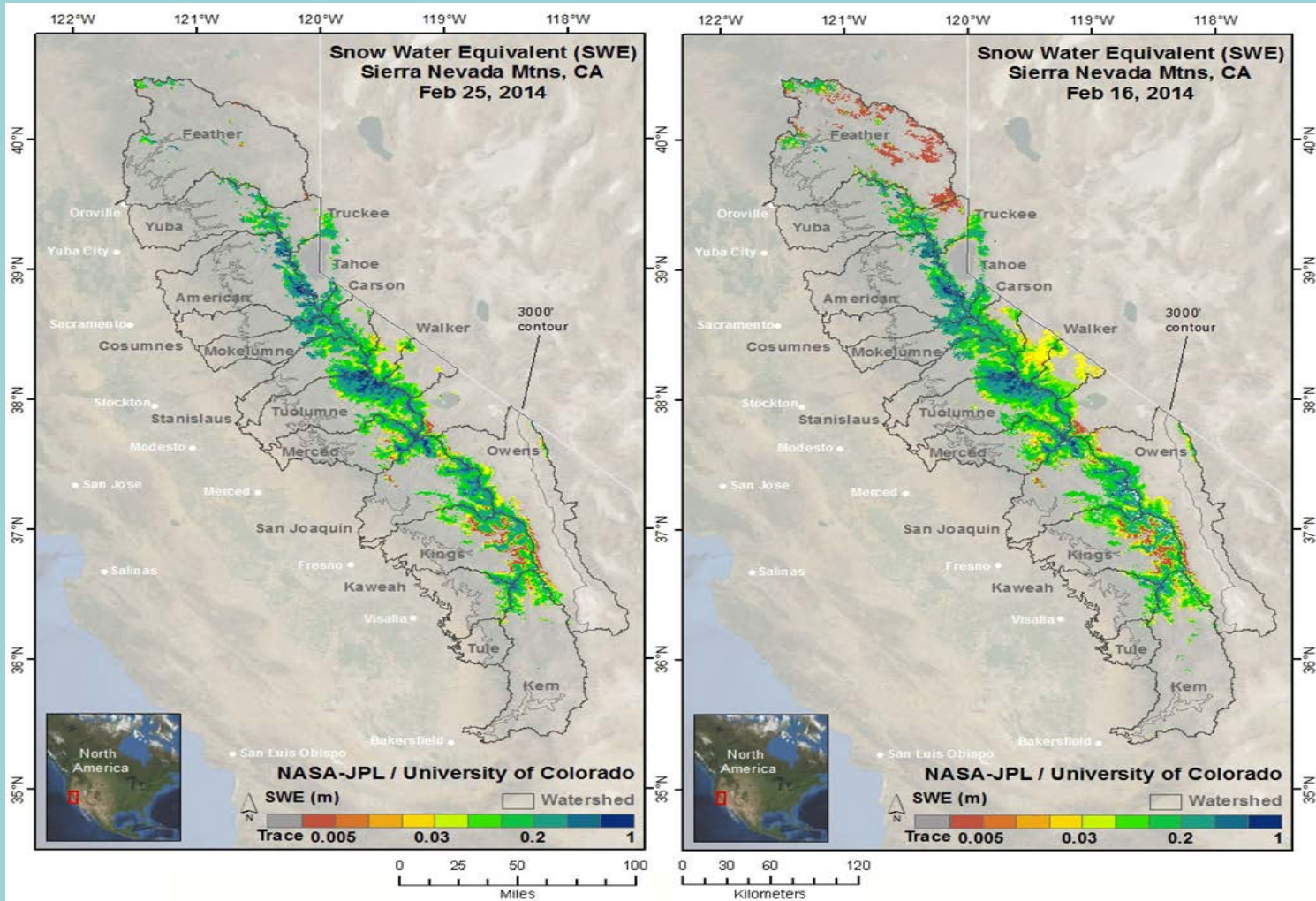
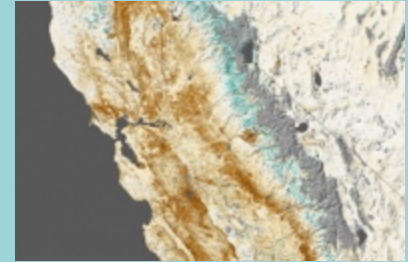


Using Airplane Based LiDAR

Hetch Hetchy Reservoir

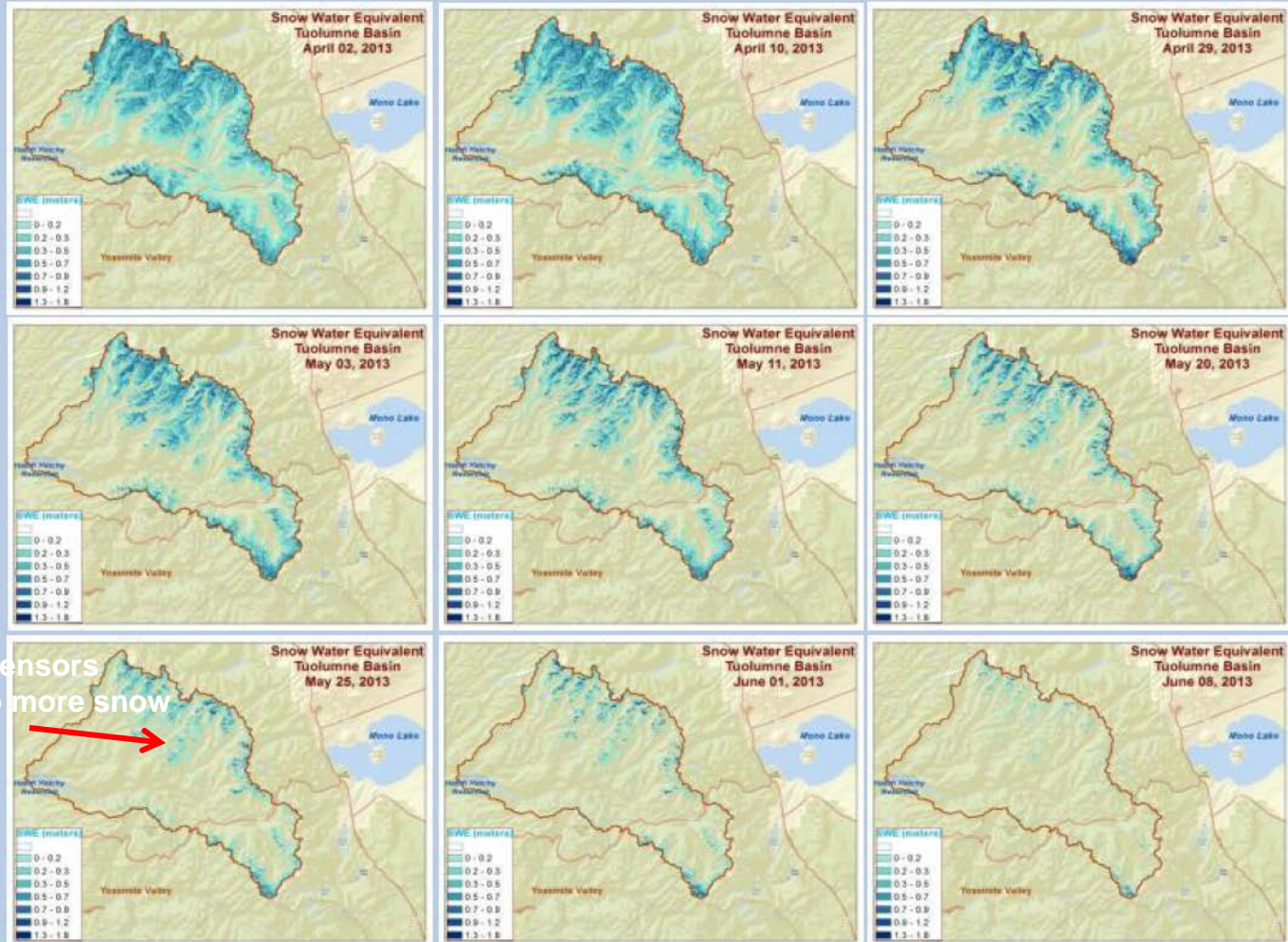


And Satellites!



Measuring Snow Into the Future!!

ASO time series of snow water equivalent Tuolumne Basin 2013



When snow sensors
suggested no more snow



Water Supply Forecast Review

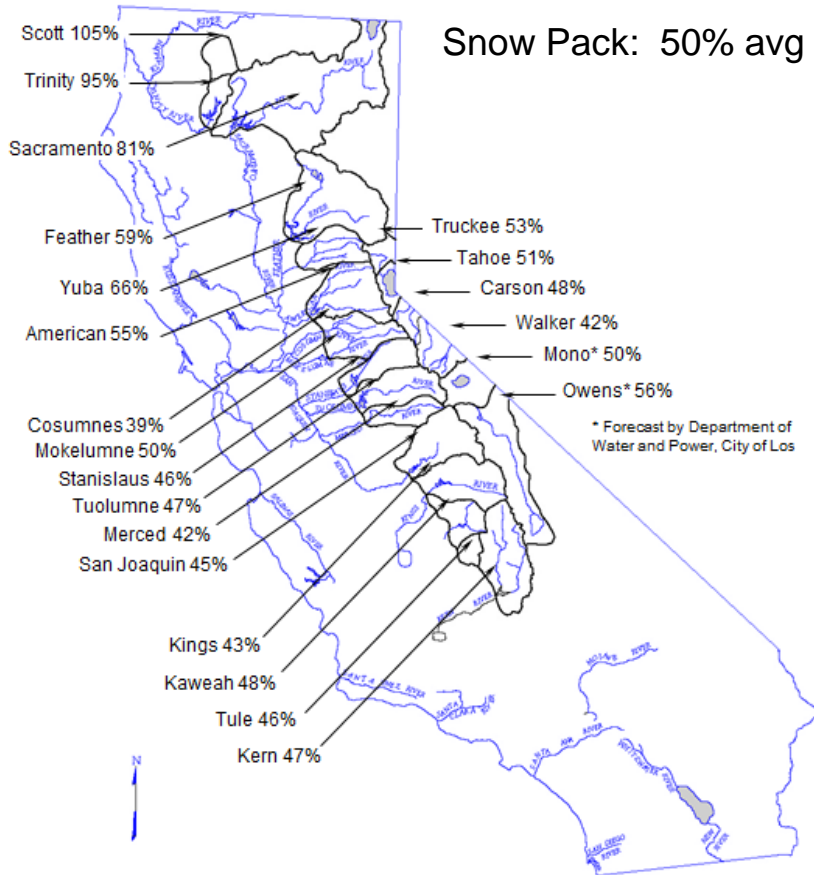
April and May Bulletin 120 Forecasts

2012 and 2013

Department of Water Resources
 California Cooperative Snow Surveys
 Forecast of April through July Unimpaired Runoff
 in percent of historical average
 as of April 1, 2012

Statewide Precip: 70% avg

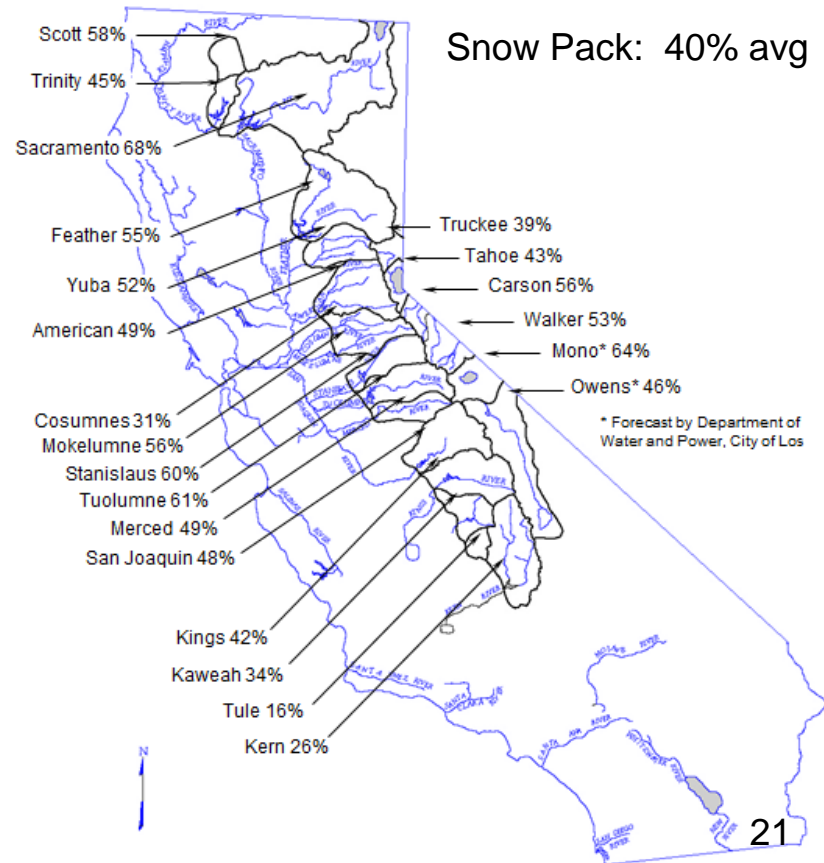
Snow Pack: 50% avg



Department of Water Resources
 California Cooperative Snow Surveys
 Forecast of April through July Unimpaired Runoff
 in percent of historical average
 as of April 1, 2013

Statewide Precip: 75% avg

Snow Pack: 40% avg

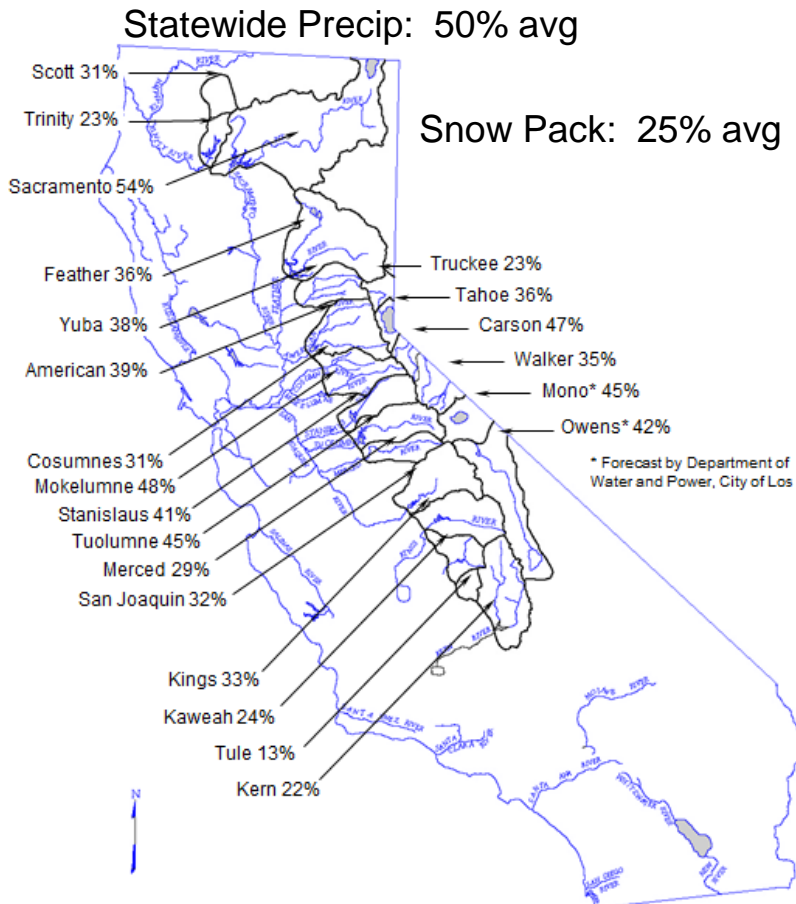


Water Supply Forecast Review

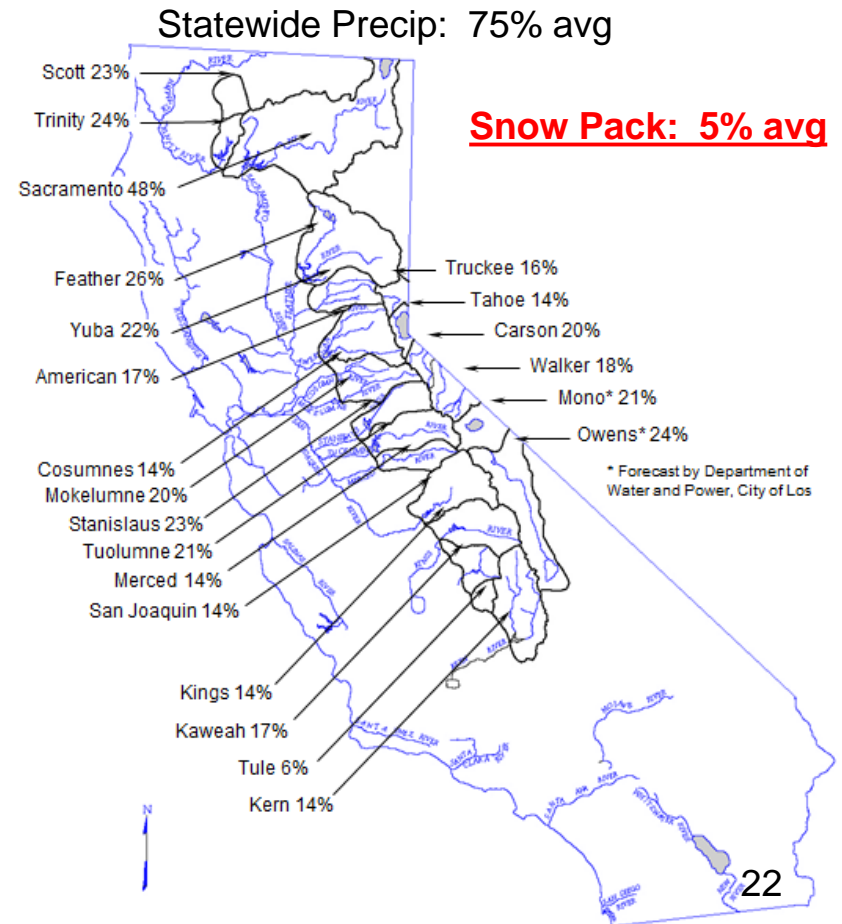
April and May Bulletin 120 Forecasts

2014 and 2015

Department of Water Resources
California Cooperative Snow Surveys
Forecast of April through July Unimpaired Runoff
in percent of historical average
as of April 1, 2014



Department of Water Resources
California Cooperative Snow Surveys
Forecast of April through July Unimpaired Runoff
in percent of historical average
as of April 1, 2015



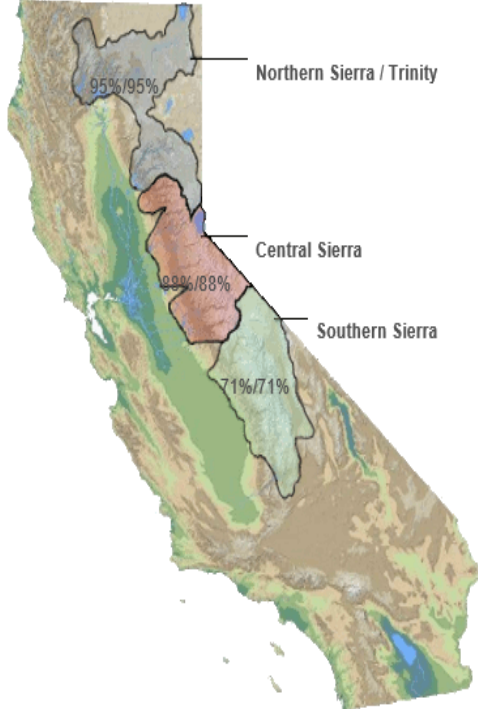
April 1, 2016 Hydrologic Conditions

Snow Water Equivalents (inches)

Provided by the California Cooperative Snow Surveys

Data For: 01-Apr-2016

% Apr 1 Avg. / % Normal for this Date



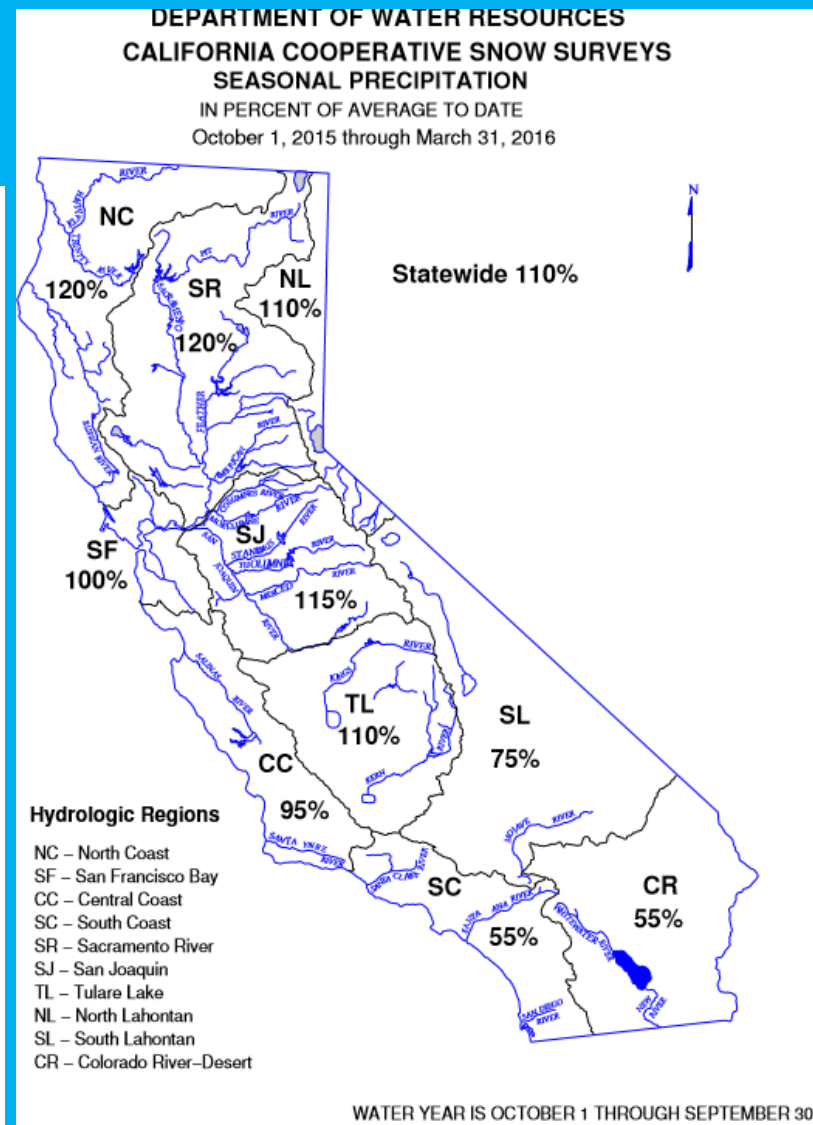
Change Date:

NORTH	
Data For: 01-Apr-2016	
Number of Stations Reporting	28
Average snow water equivalent	27.4"
Percent of April 1 Average	95%
Percent of normal for this date	95%

CENTRAL	
Data For: 01-Apr-2016	
Number of Stations Reporting	39
Average snow water equivalent	25.1"
Percent of April 1 Average	88%
Percent of normal for this date	88%

SOUTH	
Data For: 01-Apr-2016	
Number of Stations Reporting	28
Average snow water equivalent	19.1"
Percent of April 1 Average	71%
Percent of normal for this date	71%

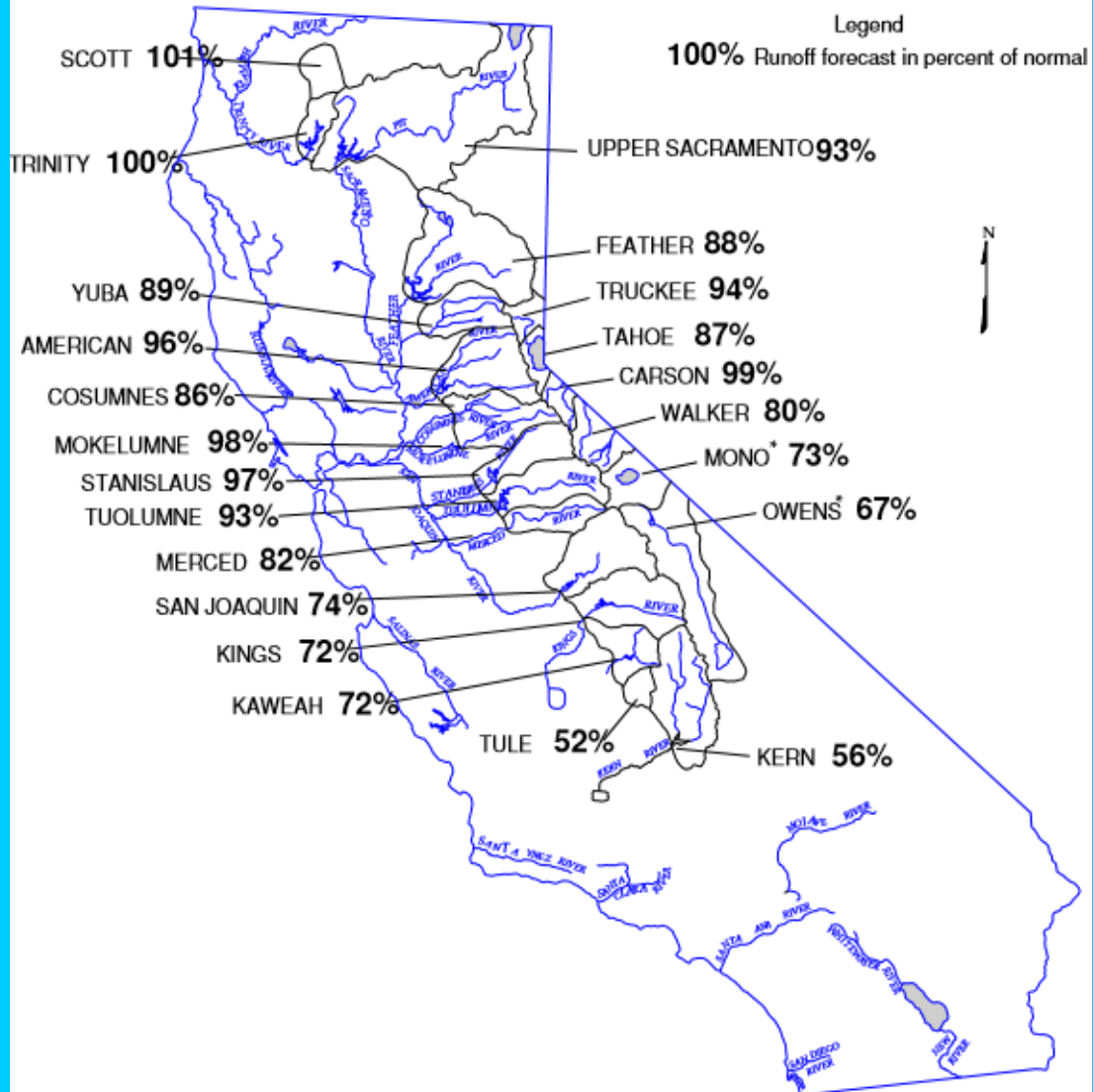
STATEWIDE SUMMARY	
Data For: 01-Apr-2016	
Number of Stations Reporting	95
Average snow water equivalent	24.0"
Percent of April 1 Average	85%
Percent of normal for this date	85%



DEPARTMENT OF WATER RESOURCES
 CALIFORNIA COOPERATIVE SNOW SURVEYS
 FORECAST OF APRIL – JULY
 UNIMPAIRED SNOWMELT RUNOFF

April 1, 2016

April 1, 2016
 Bulletin 120
 Forecast



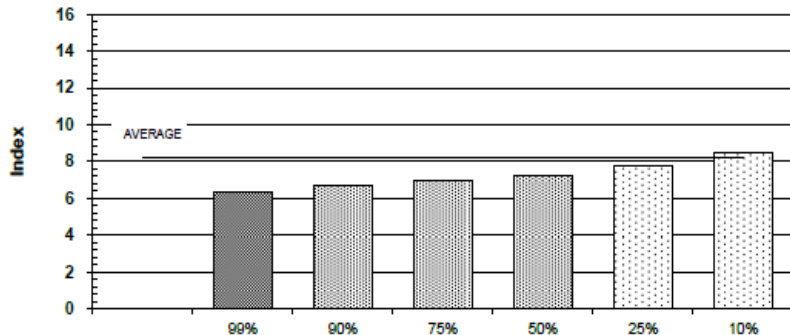
* FORECAST BY DEPARTMENT OF WATER AND POWER, CITY OF LOS ANGELES

April 1, 2016 Water Supply Index Forecasts

Department of Water Resources

California Cooperative Snow Surveys

SACRAMENTO VALLEY WATER YEAR TYPE INDEX (40-30-30) 2016 Water Year Forecast as of April 1, 2016



Date of Forecast	99%	90%	75%	50%	25%	10%
December 1, 2015	2.4	3.3	4.0	5.3	6.8	8.5
January 1, 2016	3.4	4.1	4.8	5.8	7.2	8.6
February 1, 2016	4.5	5.1	5.8	6.5	8.0	9.5
March 1, 2016	4.5	5.0	5.6	6.4	7.2	8.4
April 1, 2016	6.4	6.7	7.0	7.3	7.8	8.5

Water Year Index based on flow in million acre feet

$$\text{Index} = 0.4 * \text{Current Apr-Jul Runoff}^{(1)} + 0.3 * \text{Current Oct-Mar Runoff}^{(1)} + 0.3 * \text{Previous Year's Index}^{(2)}$$

Notes:

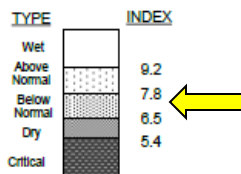
- (1) Runoff is the sum of unimpaired flow in million acre-feet at:
 Sacramento River above Bend Bridge
 Feather River at Oroville (aka inflow to Lake Oroville)
 Yuba River near Smartville
 American River below Folsom Lake

- (2) Maximum 10.0 for previous year index term

Previous Water Year Indices:

2015 =	4.0	48% of avg.
1977 (Min) =	3.1	38% of avg.
1983 (Max) =	15.3	186% of avg.
1981-2010 average =	8.2	

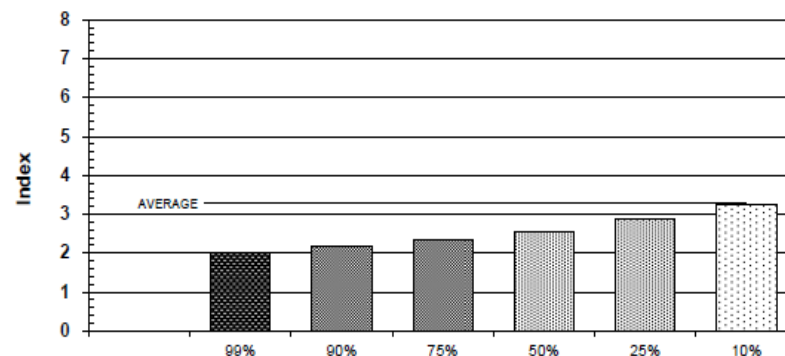
Year Classification



Department of Water Resources

California Cooperative Snow Surveys

SAN JOAQUIN VALLEY WATER YEAR TYPE INDEX (60-20-20) 2016 Water Year Forecast as of April 1, 2016



Date of Forecast	99%	90%	75%	50%	25%	10%
December 1, 2015	0.6	1.1	1.5	2.2	3.0	4.0
January 1, 2016	1.0	1.4	1.9	2.4	3.1	3.9
February 1, 2016	1.7	2.0	2.4	2.8	3.7	4.5
March 1, 2016	1.6	1.9	2.1	2.4	2.9	3.6
April 1, 2016	2.0	2.2	2.4	2.5	2.9	3.3

Water Year Index based on flow in million acre feet

$$\text{Index} = 0.6 * \text{Current Apr-Jul Runoff}^{(1)} + 0.2 * \text{Current Oct-Mar Runoff}^{(1)} + 0.2 * \text{Previous Year's Index}^{(2)}$$

Notes:

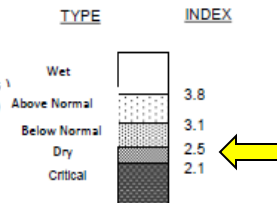
- (1) Runoff is the sum of unimpaired flow in million acre-feet at:
 Stanislaus River below Goodwin Reservoir (aka inflow to New Melones Res)
 Tuolumne River below La Grange (aka inflow to New Don Pedro Reservoir)
 Merced River below Merced Falls (aka inflow to Lake McClure)
 San Joaquin River inflow to Millerton Lake

- (2) Maximum 4.5 for previous year index term

Previous Water Year Indices:

2015 =	0.8	25% of avg.
2015 (Min) =	0.8	25% of avg.
1983 (Max) =	7.2	219% of avg.
1981-2010 average =	3.3	

Year Classification



Questions?

