



Great Flood of 1862

A Modern Perspective

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Intro

Greatest flood ever recorded in the West “extending from the Canadian to the Mexican borders”. It happened here.

1862 flood/rain account –

From the Sacramento Union, December 10, 1861.

“Another calamity has overtaken our City--a destructive flood--it came with the rapidity of a hurricane--in a few hours the whole City was under water--the damage has been great--thousands are houseless while hundreds are in second stories in this City of 15,000 inhabitants--many houses, two story high were swept and dashed to fragments on their way to Sutterville--at 10:00 o'clock, the water had receded two inches.”

“Unfortunately, no record has ever been kept of the rainfall in this region; in some parts it must have been enormous, probably more than 200 inches perpendicular for the entire wet season of six months.” -Thomas Rowlandson, Meteorology of the United States and Territories of the Pacific

Then Thomas Speaking of a larger storm previous to 1862 said the following - “marks exist on trees, growing in the San Joaquin Valley, showing that a former flood had been fully six feet higher.” He was told by Indians that it had occurred 40 years previous to 1862.

Interesting accounts prove to us the size of the event but also show that these records need to be taken with a grain of salt. Good reliable records are hard to come by and good methods are just as hard. These accounts when coupled with sound reasoning and judgment represent what could actually happen in the future.

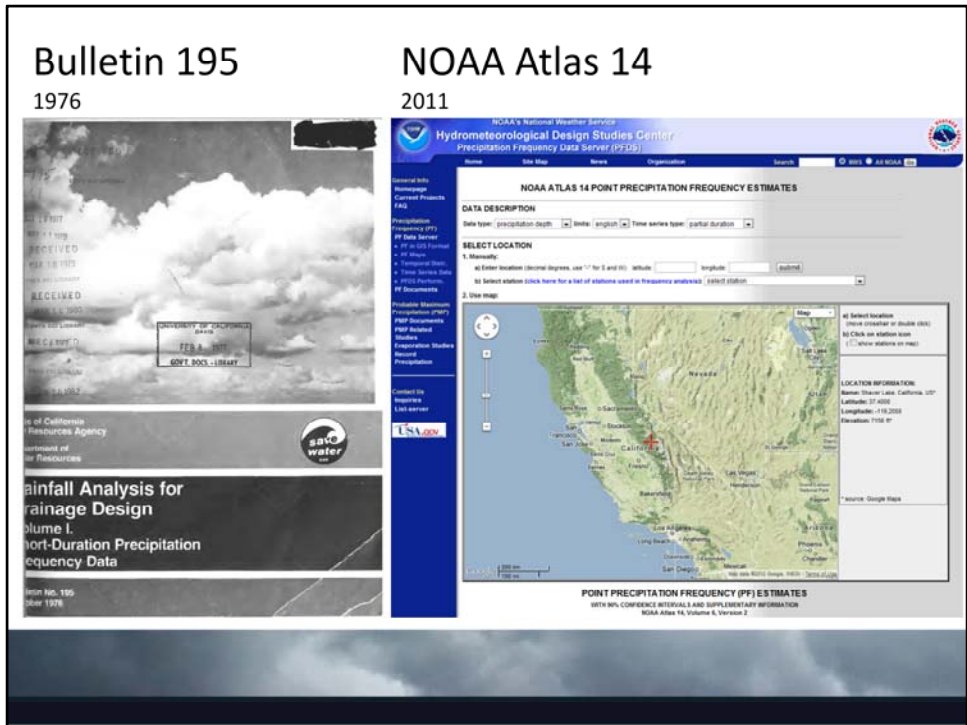
Battling
the
Inland
Sea



Modern Perspective

- 1862 Precipitation
 - Bulletin 195 and NOAA Atlas 14
- 1862 Flows Compared
 - 1955
 - 1964
 - 1986
 - 1997

These objective are mainly for my own reference. But may serve as a nice template.



Short background on bulletin 195 and Noaa 14

-Last update for bulletin 195 was in 1976. Contains data from as early as the 1930's for California only

- 1. Collected rain data from Counties, Cities, Agencies, Utility Districts, Universities and more
- 2. based on Pearsons Type III distribution for durations of 5 Min to 30 Days and Weibull distribution for 60 day durations.
- 3. Max frequency is 10,000 Year and PMP

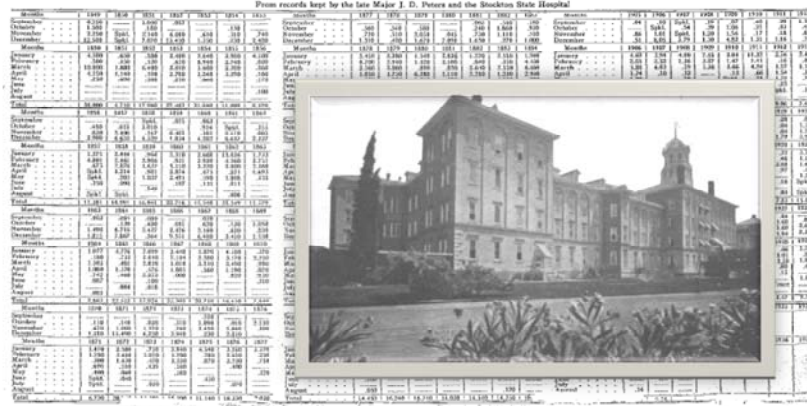
-NOAA 14 was released for final publication in April 2011 and,where available, contained data through May 2010

- 1. Max Frequency is 1,000 yr and PMP
- 2. regional frequency analysis approach based on L-moment statistics calculated from annual maximum series (L moments used to summarize shape of distribution)
- 3. NWS stations but also used federal state, county resources and private resources.

Many big storms occurred during the 30 years between release dates of the two documents which gives them both different perspectives. The early 1900's were relatively dry where as the last 20 years have been wet.

Precipitation Records

RAINFALL IN STOCKTON SINCE 1849



Stockton State Hospital – ca. 1910

Precip data collection history

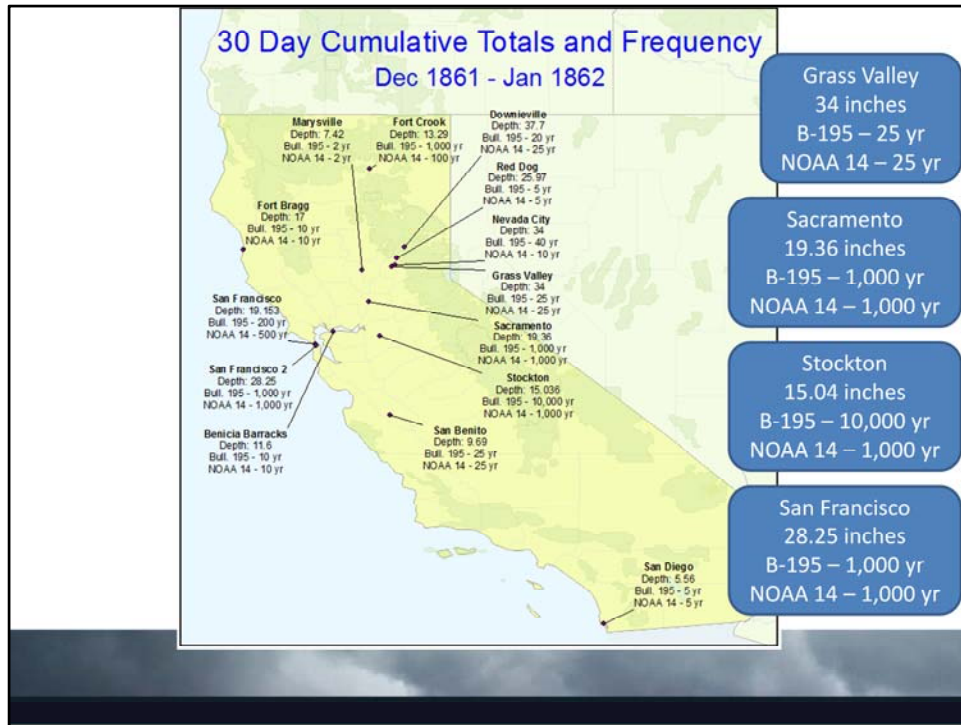
San Francisco Rainfall data is taken from U.S. National Archives, Climatological Records of the Weather Bureau 1819-1892

Stockton – Late Major J.D. Peters and the Stockton State Hospital

Nevada City data were adjusted using ratios of 16 day totals

Downieville data was found from the Oregonian Newspaper (Jan 16th, 1862)

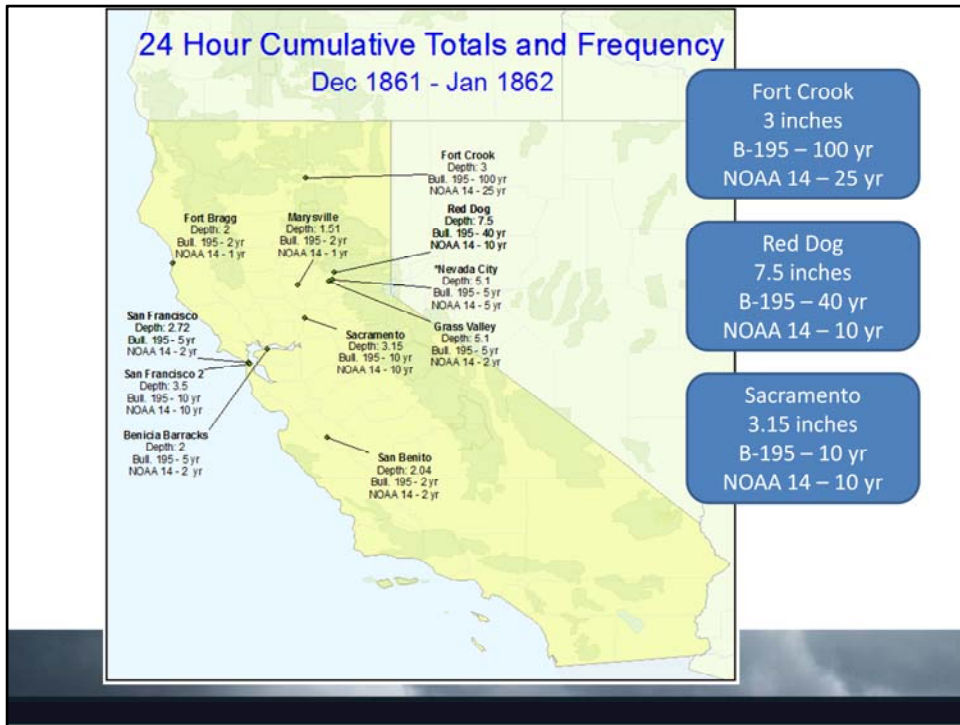
Other data was taken from CDEC



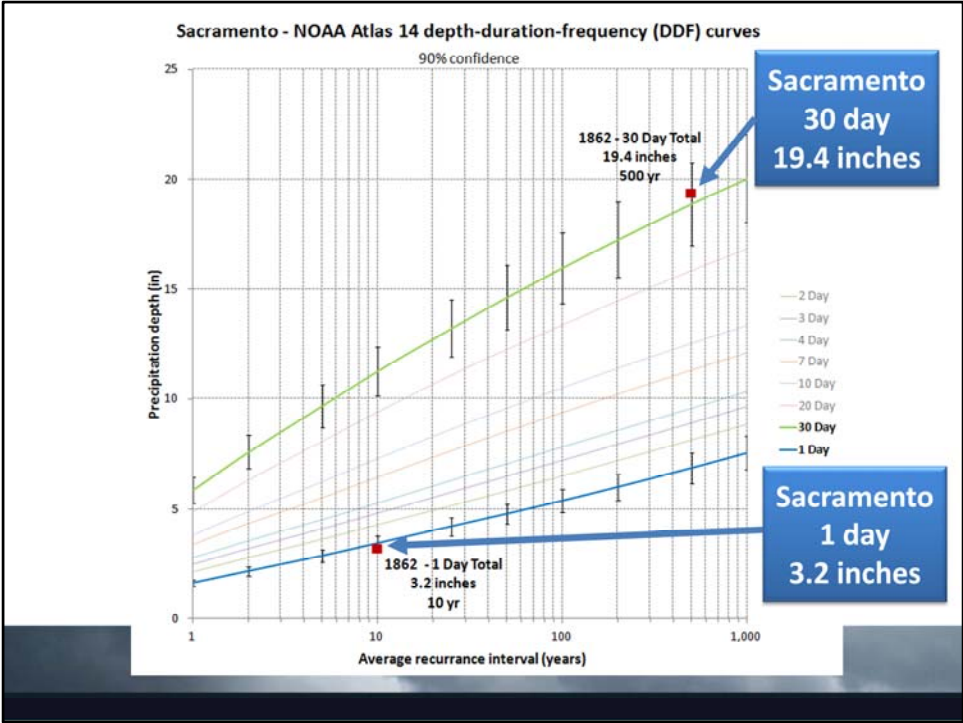
Rain –

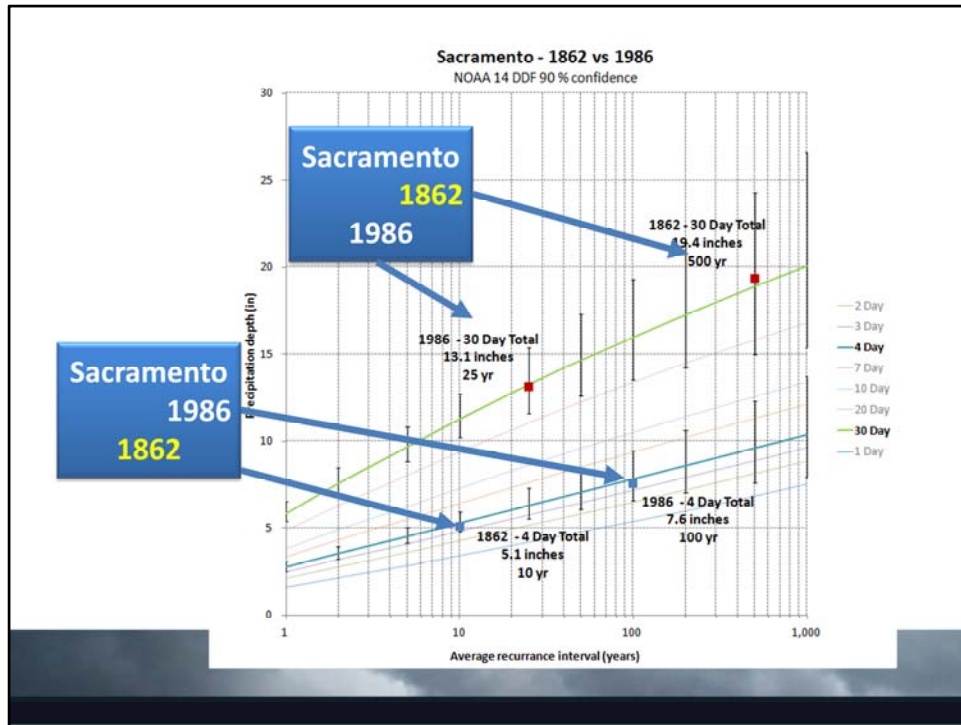
"The rainy season commenced on the 8th of November, and for four weeks, with scarcely any intermission, the rain continued to fall very gently in San Francisco, but in heavy showers in the interior." Lansing Wells, Edward (1947). "Notes on the Winter of 1861–2 in the Pacific Northwest". Northwest Science 21: 76–83.

Map of 1862 records throughout California 1 day and 30 day totals



I can make more of these pretty easily if needed.





Return period analysis

-Comparing return significant return periods and comparable later storms

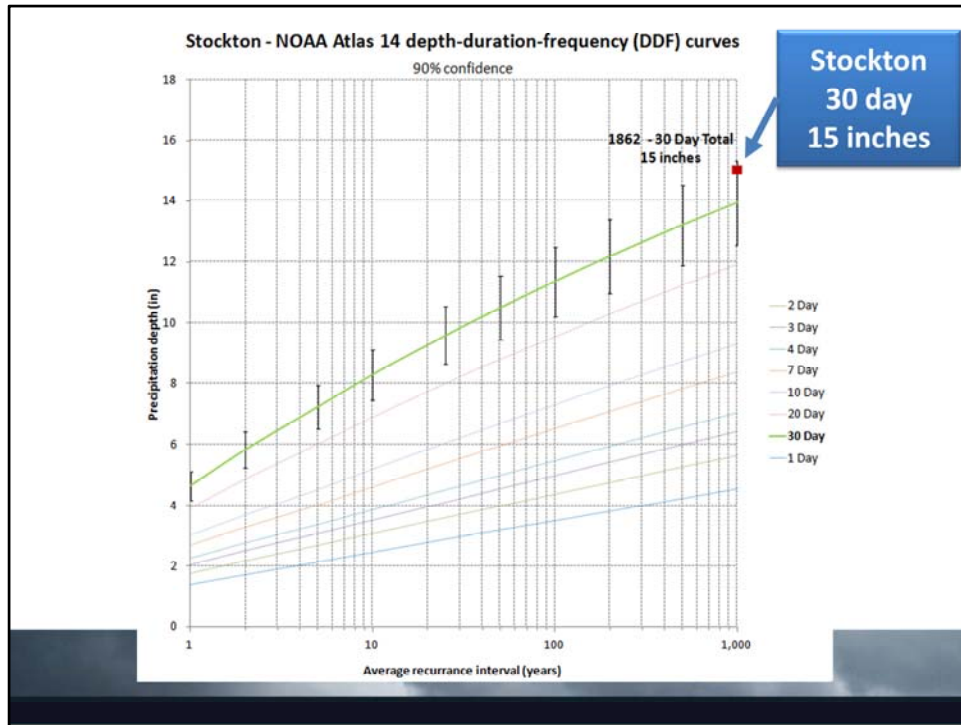
1. Compare Sacramento 1862 with 1986 storm.

1. What made 1862 so destructive was that it lasted so long. Sacramento was flooded 3 times in two months.
2. You can see 5-10 yr return periods for up to 10 day cumulative totals but the 30 day was 1000 yr return period
3. Compare to 1986 next slide. 2-10 day totals are substantial but 30 day is low

2. Compare Sonora bulletin 195 and NOAA 14 1862 to modern floods (10,000 yr compared to 2-5 yr storms)

Accounts of Sierra cities told of gale force hurricanes and ravines 70 ft tall full of rushing water.

3. Other interesting records are Stockton, San Francisco², Fort Crook (10 day),

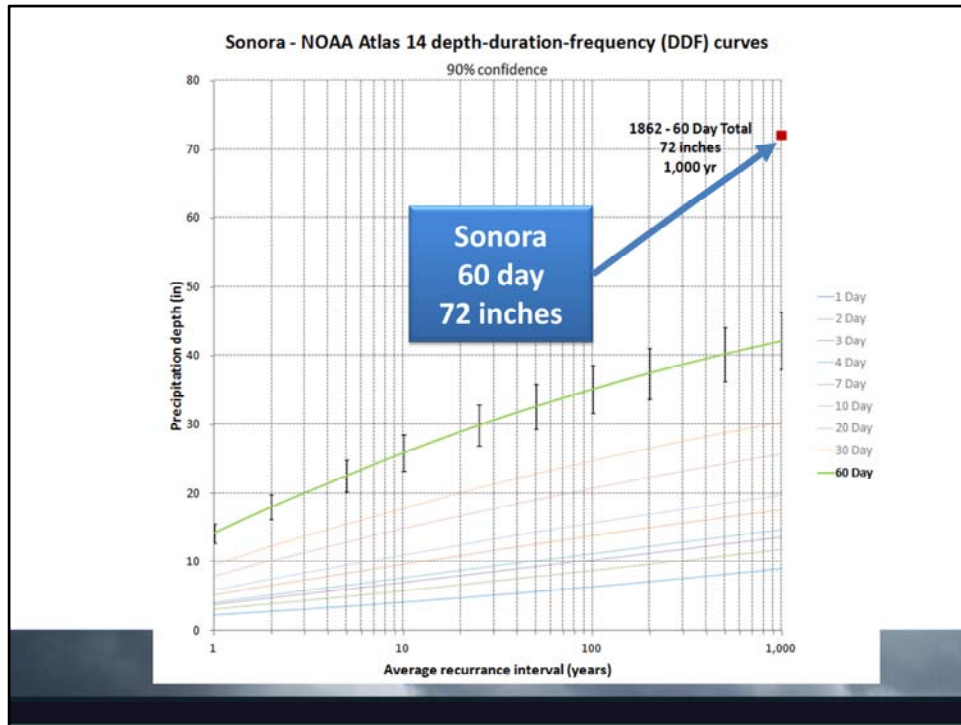


There were descriptions of hard relentless rain in Marysville but the data only shows a 2 year return period at best.

-There also may have been some missing data from the beginning and end of January.

-While the rest of the state gets constant rain throughout January, Marysville has holes

-No data for December. The data shown is only for January

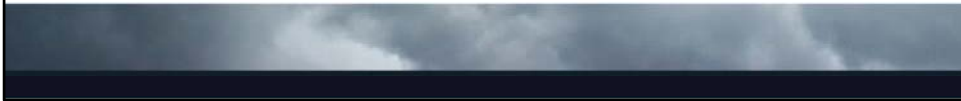


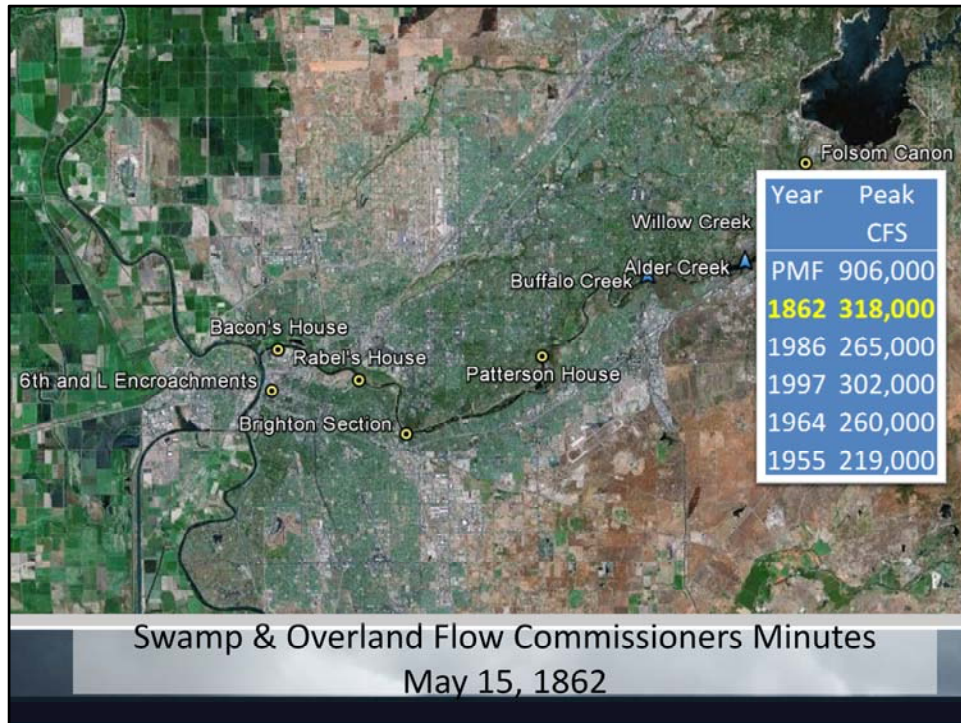
Wow.

The largest rainfall since 1862 was in 1890
 33.94 inches in 60 days (50 yr, 50 yr)
 60 day total was the only available record.

Historic Floods

- 1862 Discharge in Lower American River
 - Swampland Minutes
 - Compare unregulated flows
 - Compare to similar drainage basins





Peak Flows –

"We slept until about 4 o'clock in the morning, when Uncle Joe called out, " What is wanted?" Jerry replied, "The bridge is gone—not a stick left, and, the water will soon be up to the house." - Carr, John (1891). ["Pioneer days in California"](#). Times publishing company. pp. 291–295, 397

Historical sites of Interest from Swamp minutes detailing flood of Jan 9-10, 1862:

*Folsom Cañon – Estimated 509,000 cfs @ 46fps

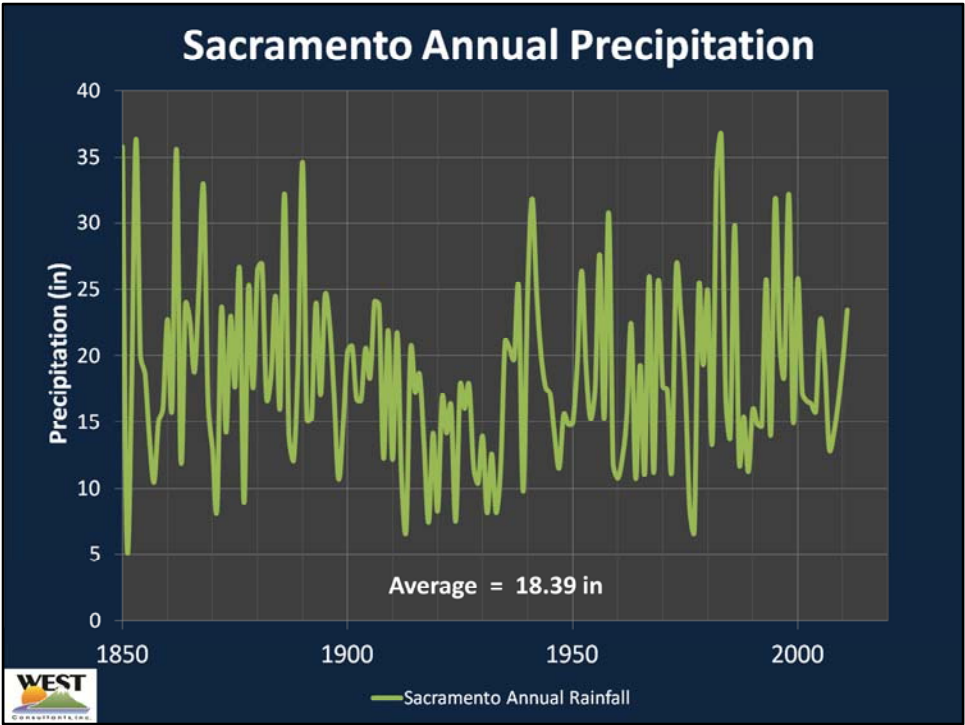
*Patterson' House – flow contained in channel until this point, incapable of conveying it spilled into overbanks

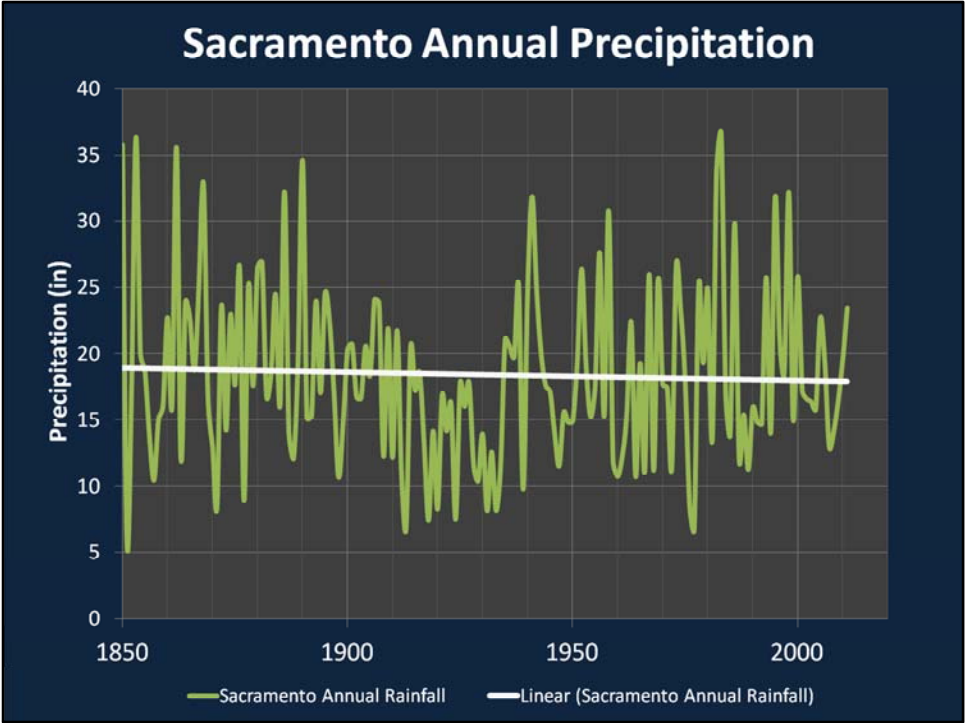
*Brighton Section – discharge estimated (including overbanks): 321,900 cfs at 10fps

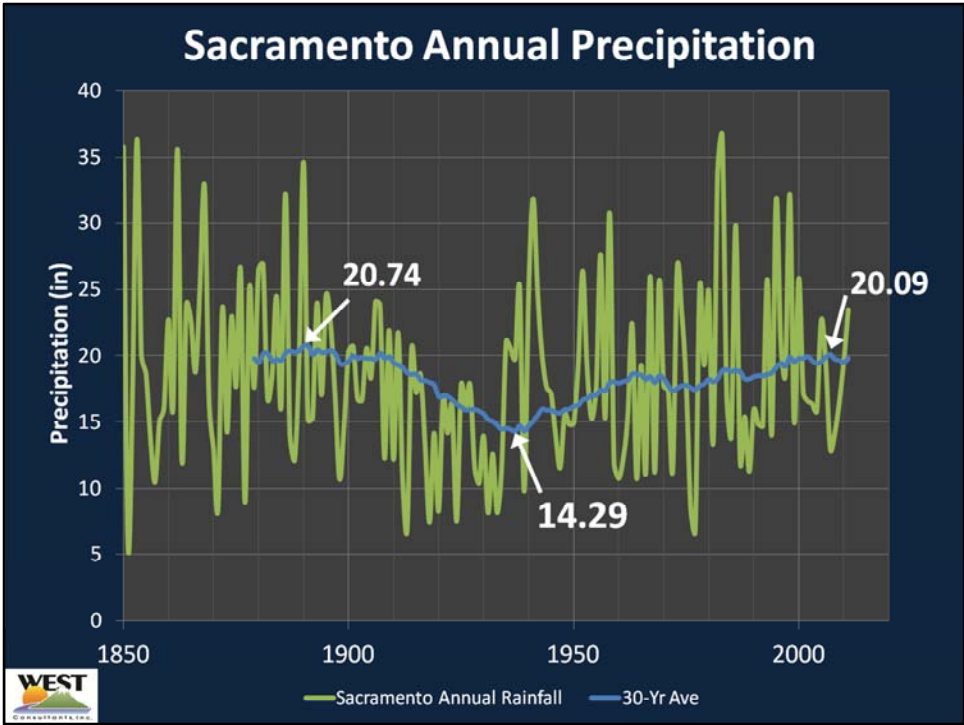
*Rabels' House (or Rabels'Tannery) – Main levee breach formed crevisse. 46,000 cfs into Sacramento

*Bacons House – levee break

*also of interest are the additional flows at Buffalo creek, willow creek and Alder Creek which were believed to have contributed up to an additional half of the flow at Folsom on top of the Flow at folsom.







Conclusions

- 1862 Precipitation
 - Relentless
 - Some extreme 30-60 day totals
- Recent Discharges ~1862
- Climate change
 - (That's what climates do!)

“I learned that there was a tradition existing among the Indians, that during one year not a drop of rain fell in central California, whilst the converse of this is also reported, namely that heavier rains and floods than have been witnessed during 1861-62, have been known. The truth of the latter is greatly corroborated by the fact, that marks exist on trees, growing in the San Joaquin Valley, showing that a former flood had been fully six feet higher.”

-Notabilia of the floods of 1861-62, written by Thomas Rowlandson



Fort Crook

Fort Crook	24HR	2day	3day	4day	10day	30day
1862	3	3.35	4.05	4.5	6.32	13.29
1955	1.7	2.38	2.38	2.61	4.74	5.09
1964	1.75	2.64	2.95	3.17	3.75	6.25
1986	2.6	3.28	4.03	4.47	7.43	10.43
B 195						
1862	100yr	20yr	10-20yr	10yr	25yr	1000 yr
1955	2 yr	5 yr	2 yr	2 yr	5 yr	2 yr
1964	2 yr	5 yr	5 yr	5 yr	2 yr	5 yr
1986	10 yr	10 yr	10 yr	10 yr	50 yr	100 yr
NOAA 14						
1862	25 yr	10 yr	25yr	25yr	25yr	100 yr
1955	2 yr	5 yr	2 yr	2 yr	5 yr	2 yr
1964	2 yr	5 yr	5 yr	5 yr	2 yr	2 yr
1986	10 yr	10 yr	10 yr	10 yr	50 yr	25 yr

Shows the same trend as Sacramento – 10 day totals for the 1986 storm were larger. Data was lacking for 3 and 4 day cumulatives. A few daily records indicated totals for the previous 3 or 4 days ,not daily.
Large difference in B195 and NOAA14.

Sierra Nevadas Region

Downieville	30day	Nevada City	24HR	2day	3day	4day	30day
1862	37.70	1862	5.10	9.43	12.20	12.33	34.00
1955	17.74	1955	3.09	3.51	4.33	4.38	13.76
1964	15.58	1964	2.99	4.46	5.95	7.42	12.47
1986	35.73	1986	7.49	14.44	17.95	20.63	35.47
1997	44.84	1997	7.75	11.62	15.15	18.19	44.62
B 195		B 195					
1862	20yr	1862	5 yr	10 yr	20 yr	10 yr	40 yr
1955		1955	1 yr	1 yr	1 yr	1 yr	1 yr
1964		1964	1 yr	1 yr	1 yr	1 yr	1 yr
1986	20 yr	1986	40 yr	200 yr	200 yr	200 yr	40 yr
1997	100 yr	1997	40 yr	40 yr	50 yr	100 yr	200 yr
NOAA 14		NOAA 14					
1862	10-25yr	1862	5 yr	10 yr	10 yr	5 yr	10 yr
1955	1 yr	1955	1 yr	1 yr	1 yr	1 yr	1 yr
1964		1964	1 yr	2 yr	1 yr	1 yr	1 yr
1986	10 yr	1986	25 yr	100 yr	100 yr	100 yr	25 yr
1997	50 yr	1997	25 yr	25 yr	50 yr	50 yr	100 yr

Downieville and Nevada City are the closest data points to American River basin. Since the flow in the American River originated in the Sierras, one would think that the rain in the sierras have been substantial. That's not the case. So why havent we seen similar flows in recent times in the American River? Or Have we?

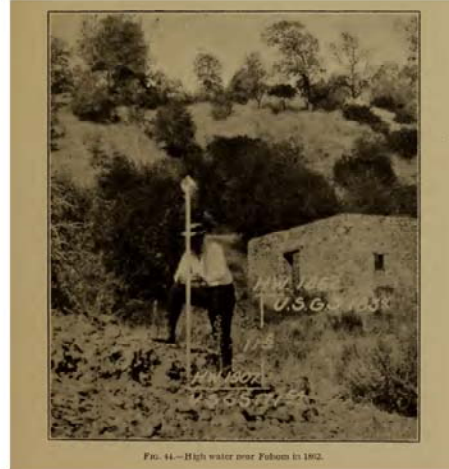
Sierra Nevadas Cont...

Grass Valley	24HR	2day	3day	4day	10day	30day
1862	5.10	9.43	12.20	12.33	21.07	34.00
1955	3	3.42	3.67	5.46	8.54	12.67
1964	4.33	5.55	6.66	8.06	9.97	12.24
1986	6.77	12.27	15.13	16.96	22.47	28.07
1997	6.31	9.94	12.06	14.73	20.13	37.41
B 195						
1862	5 yr	10 yr	10 yr	10 yr	20 yr	25 yr
1955	2 yr	-	-	-	-	-
1964	2 yr	2 yr	2 yr	2 yr	-	-
1986	10 yr	40 yr	40 yr	50 yr	25 yr	10 yr
1997	10 yr	10 yr	10 yr	20 yr	20 yr	50 yr
NOAA 14						
1862	2 yr	10 yr	10 yr	5 yr	25 yr	25 yr
1955	1 yr	1 yr	-	1 yr	1 yr	-
1964	2 yr	1 yr	1 yr	2 yr	1 yr	-
1986	5 yr	25 yr	25 yr	25 yr	25 yr	10 yr
1997	5 yr	5 yr	10 yr	10 yr	10 yr	50 yr

Not the biggest storms in the sierras according to data.

Old Records, Modern Methods

- Manning's Equation
 - Channel
 - Roughness
- Other Methods



Old Records, Modern methods

Back calculated n using provided sectional area and slope. The minutes detailed fall and length for the top of flood wave at the different observation points. The sectional area was approximated using a trapezoidal channel for calculating hydraulic radius. Back calculated $n = 0.024$. This seems very low for a flood and knowing the terrain. Based on current conditions and photo of a high water mark in Folsom (above picture is taken from *The Rivers and Floods of the Sacramento and San Joaquin Watersheds* – Weather Bureau, 1913), n is approximately 0.05 using Chows table of values. Hard to estimate a value to represent terrain 150 years ago. Adjusted Q is approximately 250,000 cfs using the new Mannings roughness coefficient.

Based on the history of hydraulics, Chezy and Ganggillet-Kutter equations were around at the time even though the Chezy equation really wasn't published until the late 1800's. Some other form of hydraulic flow may have been used but it was not discussed in the notes.

Additional analysis was performed using Chezy and Ganggillet-Kutter and resulted in similar flows to the Mannings method.

A similar analysis was performed at the Brighton section. This time a much higher n value was used due to the amount of overbank flow.

Back calculated $n = 0.06$, $v = 10$ fps and $Q = 321,000$ with over 180,000 cfs left unaccounted for from Folsom plus the amount that was not measured from Alder, Buffalo, and Willow Creeks.

Estimated $n = 0.08 - 0.1$ yields a velocity of 4 - 5 fps and a total discharge of 190,000 to 250,000 cfs

Old Records, Modern Methods

- Results
 - Folsom: ~250,000 cfs
 - $n = 0.02$ to 0.05
 - Brighton: ~200,00 cfs
 - $n = 0.06$ to $0.08-0.1$

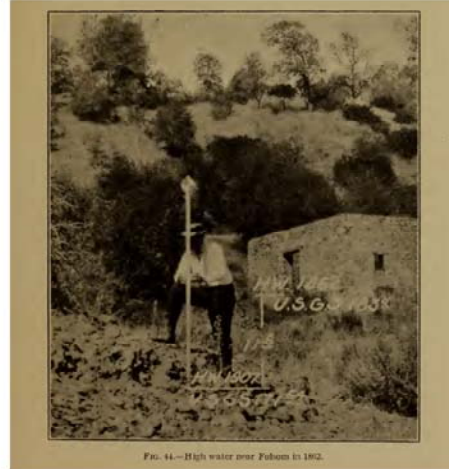


FIG. 44.—High water near Folsom in 1862.

Old Records, Modern methods

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American River at Fair Oaks
PMF and Maximum Unregulated Historic Rain Floods

Ordered by Maximum 3-day Flow

Water Year	Date of Peak	Peak cfs	1-day cfs	3-day cfs
PMF	Dec-Jan	906,000	698,000	472,000
1862	9-Jan	300,000 est.	208,000 est.	180,000est
1986	9-Jan	265,000	160,000	166,000
1997 ¹	2-Feb	302,000 ²	252,500 ¹	165,000
1997 ³	2-Feb	300,000 ²	248,900 ³	164,200 ³
1965	23-Dec	260,000	183,200	140,300
1956	23-Dec	219,000	189,100	127,400

Notes:

¹ Derived from USGS Water-Data Report published in 1998.

² COE peak estimate for the 1997 flood.

³ Data provided by DWR's CDEC database used in the latest COE frequency analysis and results from 2001 Folsom PMF Report.

The Corps of Engineers have kept records of the unregulated flow in the American River below Folsom Lake since 1905. These flows are kept in the Water Control Manual for the Sacramento River Basin (We have a pdf copy of this). The discharge is estimated after the completion of the dam in 1955. Previously to 1955 the peak flow occurred in 1951, 180,000 cfs. After 1955 the peak flow was estimated to be 302,000 cfs. However the data from 1862 has been re evaluated and included on the USGS website – 318,000 cfs.

Robert F. Collins presented his research on creating theoretical floods from historic floods with the Sacramento District, U.S. Army Corps of Engineers.

Unregulated historic Flows along the American River at Fair Oaks. This was presented by
1862 flow has been revised to be 318,000 cfs. Currently trying to find the source.

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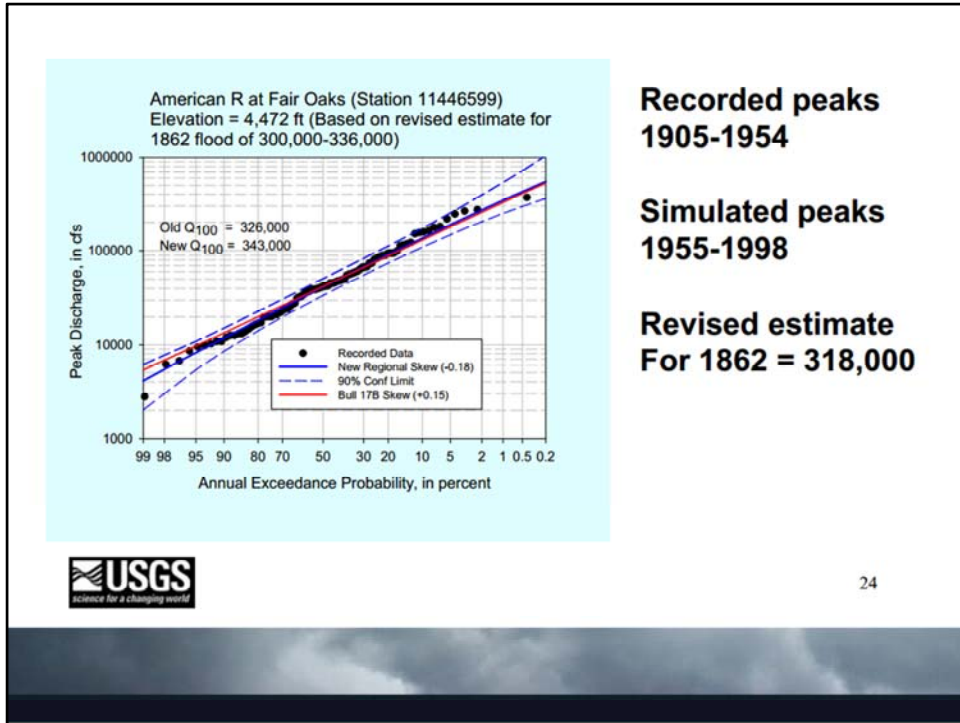
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Parrett presented findings for the new release of a USGS report called *Regional Skew for California, and Flood Frequency for Selected Sites in the Sacramento-San Joaquin River Basin, Based on Data through Water Year 2006*. He presented these findings in the 2011 CEP symposium.

Parrett's Exceedance probability of American River at Fair Oaks Station includes peak flow from 1862

Exceedance = 0.4-0.5% or 200-250 yr return

Im not sure what we should share here yet. There are a lot of interesting things to explain

Location	Year	Drainage Area (sq mi)	Qp (cfs)	Qp/DA (cfs/sq mi)
Original Folsom Cañon	1862	1861	501294	269
Adjusted Folsom Cañon 1	1862	1861	240187	129
Adjusted Folsom Cañon 2	1862	1861	208000	112
Coastal Region				
Eel River At Fort Seward, CA	1965	2107	561000	266
Northern Region				
Trinity River at Burnt Ranch, Ca	1956	1439	172000	120
Sierras				
American River Fair Oaks	1862	1888	318000	168
American River Fair Oaks	1997	1888	309000	164
Stanislaus River Knights Ferry	1862	980	100000	102
Yuba River at Smartsville, CA	1928	1200	120000	100
NF Feather River at NR Rich Bar	1997	1025	88800	87
Tolumne River La Grange	1862	1532	130000	85
Feather River	1955	1341	104000	78
Kings River at Trimmer, Ca	1956	1342	85200	63
Feather River Oroville	1904	3624	230000	63
Sacramento River Hamilton City	1940	10833	350000	32

Drainage Basin Comparison

Eel River had comparable rainfall during th 1965 event and produced similar flows as originally estimated at Folsom.

If you compare to more similar watersheds with snow pack or in the Sierra region, the discharges are not as high for their peak flows. But they are more comparable to the adjusted flows at Folsom.