

Dr. Snell's Precipitation Measurements of December 1861-January 1862 Are Valid!

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BIOGRAPHICAL SKETCH

1. Born in Deweyville, Utah May 6, 1923
2. Graduate from Bear River High School in Garland, Utah in 1941
3. Married Margaret Worlton of Lehi, Utah June 10, 1947
4. Four Children (Claudia, Martin, Elizabeth and Arthur), 17 Grandchildren and 4 Great Grandchildren. We have 9 grandsons that are Eagle Scouts.
5. WWII: Bomber Pilot and combat crew training--flew both B-17s & B-29s
6. B.S. Degree "Aeronautics"---St. Louis University
7. M.S. Degree "Meteorology"---MIT
8. Chief Meteorologist (1966-68)---Pacific Gas & Electric Co. (San Francisco) and with PG&E Meteorology Dept. from 1958-1968.
9. Associate Professor (1971-74)---California State University (Sonoma)
10. T.V. Meteorologist---KPIX Ch.#5 (San Francisco), KTVL Ch.#10 & KOBI Ch.#5 in Medford, Oregon
11. President (or Chairman) Northern Calif. Chapter of the American Meteorological Society, 1967-68
12. Founded Jet Stream Weather in 1979 (supplied weather forecasts to a network of radio stations in Oregon, Northern Calif. & Wyoming)
13. Continued with a 7:15 AM Weathercast on KDOV-FM radio in Medford, Oregon through mid-April 2009.
14. Received the Oregon Broadcasters "Broadcast Heritage Award" for Contributions to Oregon's broadcast industry—1999
15. Spring of 1971 - KPIX (SFO)'s Evening News, Sports and Weather was the highest rated newscast of all the major T.V. markets in the U.S. *Yours truly was the first professional on-air meteorologist in San Francisco.*

ABSTRACT

Validation of Dr. Snell's rainfall measurements changes the way we look at flood history on the American River watershed. It indicates that the amount of precipitation which fell on the American River watershed in January 1862 has been significantly under estimated---by as much as 20%. A repeat of the December 1861-January 1862 Flood Series would challenge the now approved levee modifications designed to protect Sacramento and would exceed any other flood which has been experienced on the American River since 1861-62.

DR. SNELL'S PRECIPITATION MEASUREMENTS OF DECEMBER 1861–JANUARY 1862 FLOODS ARE VALID!

Introduction:

Thank you Gary for the opportunity to participate in the 2010 California Extreme Precipitation Symposium. I began researching historical floods in California in the early 1960s. In other words, long before my hair turned gray and a bald spot began to appear on the crown of my head.

Since the time is short, I'm going to present my conclusions first. What was the weather like in the lower Sacramento Valley during the early part of January 1862? The valley was already filled with water from a major flood in early December which was followed by a moderate sized flood over the Christmas holidays. On the 3rd and 4th of January it was cold enough to freeze ice in Antioch. In Nevada City and Napa, ice froze one half inch thick.

On the 5th and 6th of January heavy snow fell at low elevations with up to 15 inches being reported in the Grass Valley-Nevada City area. By late on the 8th of January a heavy, warm storm had moved in and it was raining all the way up to the summit. This event produced a super-flood, 30-40% greater than the major flood of December 1964. The peak flow during this flood (on the American River at Folsom) occurred on January 10, 1862. Only 12 days later (on January 22, 1862) there was a repeat performance that once again produced flows of super-flood proportions—30-40% greater than the major flood of December 1964.

Transition: Did the snow and frozen ground have any effect on the runoff?

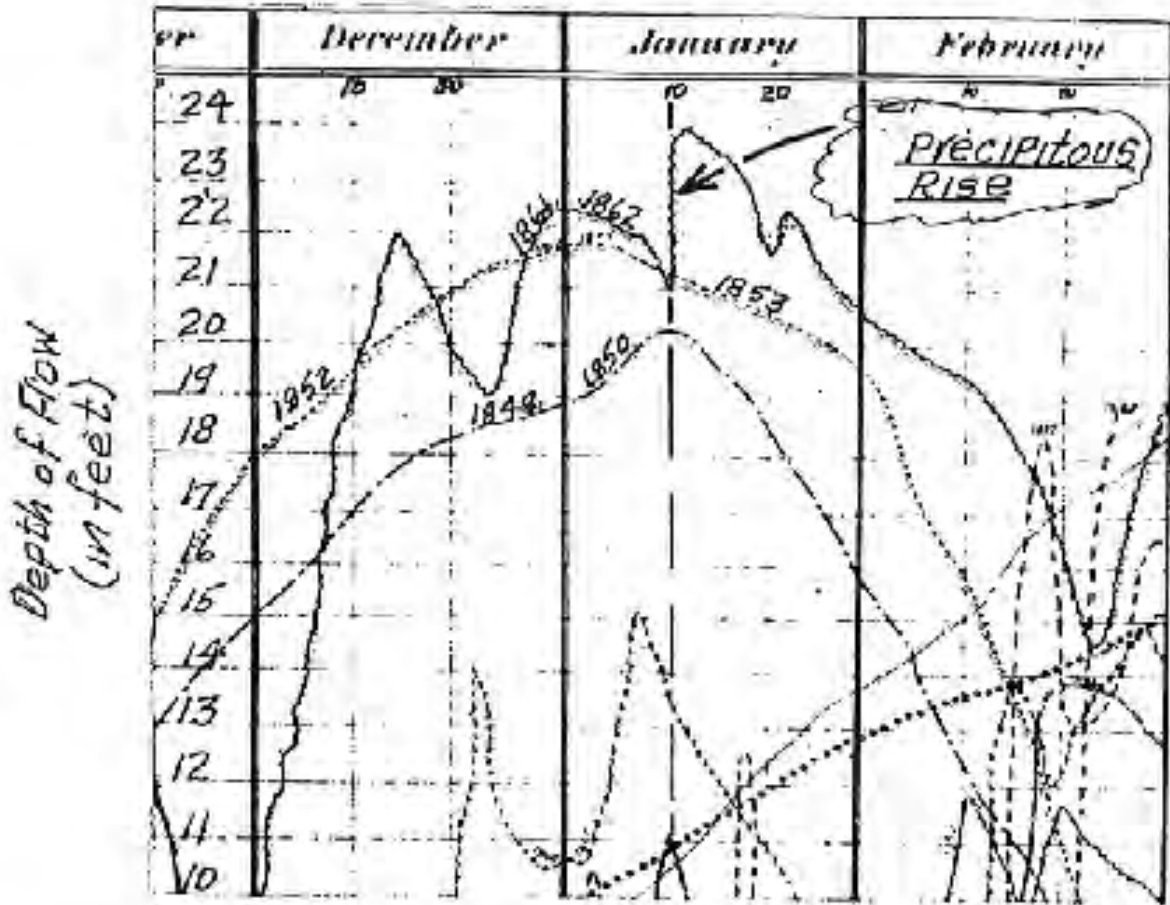
Logan's Hydrograph:

Notice the sharp rise in Logan's Hydrograph on January 10, 1862. Either the mechanism on the hydrograph stopped turning or there was frozen ground underneath the snow pack. It turned out to be frozen ground caused by a cold wave very similar to the one that hit Northern and Central California 100 years later, in January 1962.

The heavy snow at low elevations on top of frozen ground prior to the heavy warm rains caused us to wonder if earlier estimates of peak flow during the 1862 floods were too low. So we decided to make an estimate for the January 10, 1862 peak flow on the American River at Folsom. We turned a copy of our work over to Joe Countryman. Joe was kind, he let us down easy. He said, "Estimating peak flows is a pastime of hydrologists." Joe's gentle nudge, along with a footnote on page 13 of the 1999 National Research

DIAGRAM-B

* CHART of THE OSCILLATIONS of THE SACRAMENTO RIVER
 (@ Sacramento) - 1849 through 1862



* A Segment from the *Chart of the Oscillations of the Sacramento River* by THOMAS M. LOGAN, M.D.

Council's report: *Improving AMERICAN RIVER FLOOD FREQUENCY Analyses*, started us off in a new direction. The footnote stated: "Daily rather than instantaneous flows are critical to flood management decisions on the American River because of the significant volume of upstream storage." At this point we changed our focus from estimating peak flows to estimating volumes.

Transition: In the process, we decided to take another look at Dr. Snell's often disputed precipitation measurements made in Sonora during the 1861–1862 season.

Dr. Snell's RAINFALL MEASUREMENTS:

From the beginning of the wet season (on or about November 11, 1861 until January 14, 1862) 72 inches of rain fell in Sonora. Then, ten days later (from January 14th until the 23rd) he recorded another 30 inches—raising the seasonal total to a whopping 102 inches. We say "whopping" because Sonora's normal annual rainfall is approximately 32 inches.

Exhibit A:

Compares ten consecutive days of rainfall at Grass Valley and Sonora for seven major floods of the 20th Century on the American River watershed. In all cases the 10 day total for Grass Valley exceeded the 10 day total for Sonora by a substantial margin. However, the same rainfall comparison for the 10 day period from January 14, 1862 through January 23, 1862 was reversed—30 inches in Sonora compared with a little more than 18 inches in Grass Valley.

Transition: There appears to be ample proof that the storm track had expanded and shifted toward the south. Peak flow information from up and down the state supports this conclusion.

Peak Flow Information—January 22, 1862 Flood

Santa Ana River: An all time record peak flow—**317,000 cfs**—over three times larger than the devastating flood of 1938.

American River at Sacramento: The largest peak flow in Sacramento occurred on January 10, 1862 and was only 15 inches above the peak flow on January 22, 1862. *The location of this flow comparison is believed to be at 7th and P Streets.*

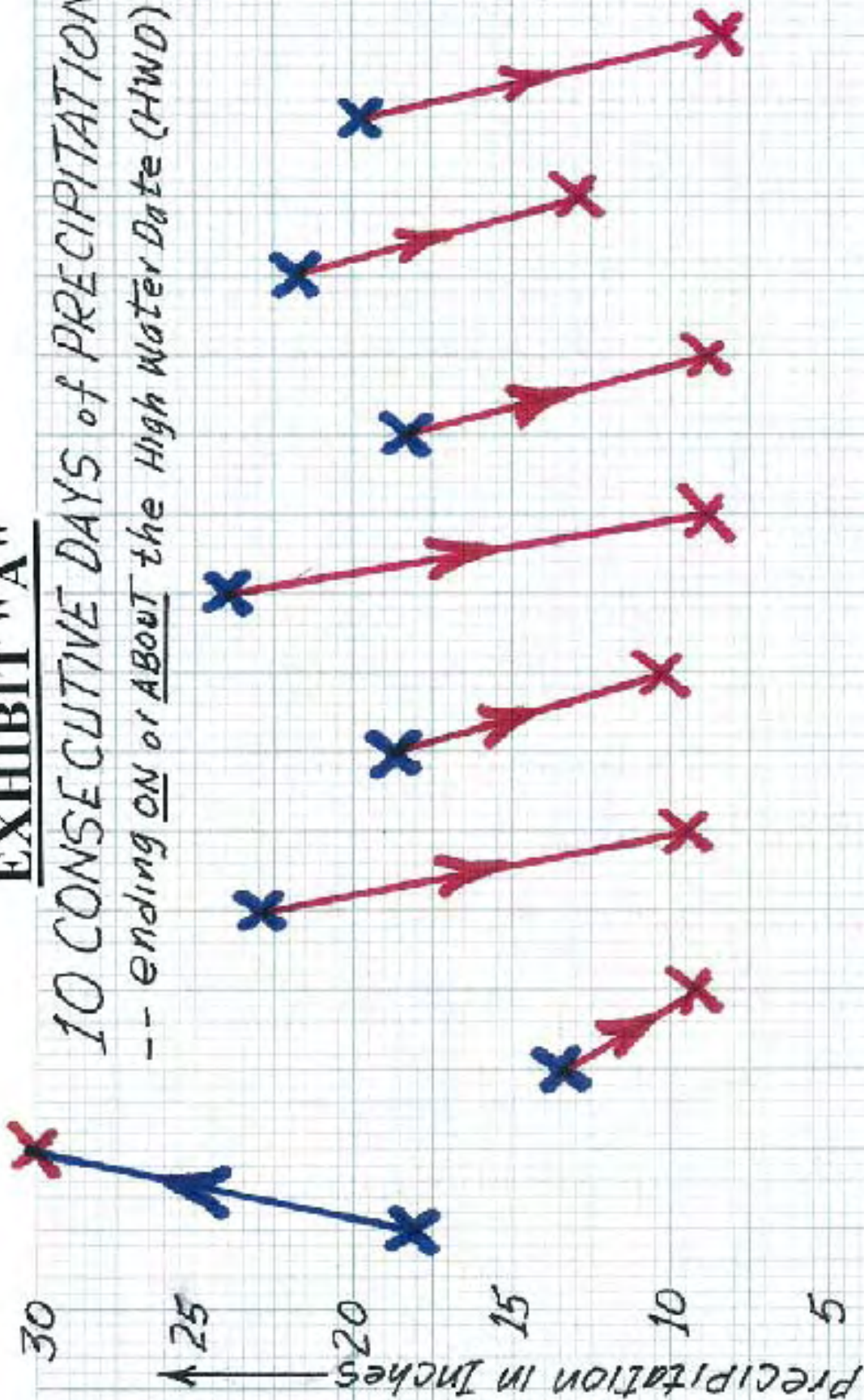
Middle Fork of Feather River at Nelson's Point: On January 22, 1862, the peak flow at Nelson's Point was 26 feet above the low water mark, only two feet shy of the record-breaking stage of 28 feet set 12 days earlier on January 10th. *Nelson's Point is located approximately ten miles south of Quincy.*

Sacramento River at Red Bluff: One foot higher than previous 1861–62 flood peaks.

EXHIBIT "A"

10 CONSECUTIVE DAYS of PRECIPITATION

-- ending ON or ABOUT the High Water Date (HWD)



G.V. SO. G.V. SO. G.V. SO. G.V. SO. G.V. SO. G.V. SO. G.V. SO. G.V. SO.

1862 1907 1909 1950 1955 1964 1986 1997

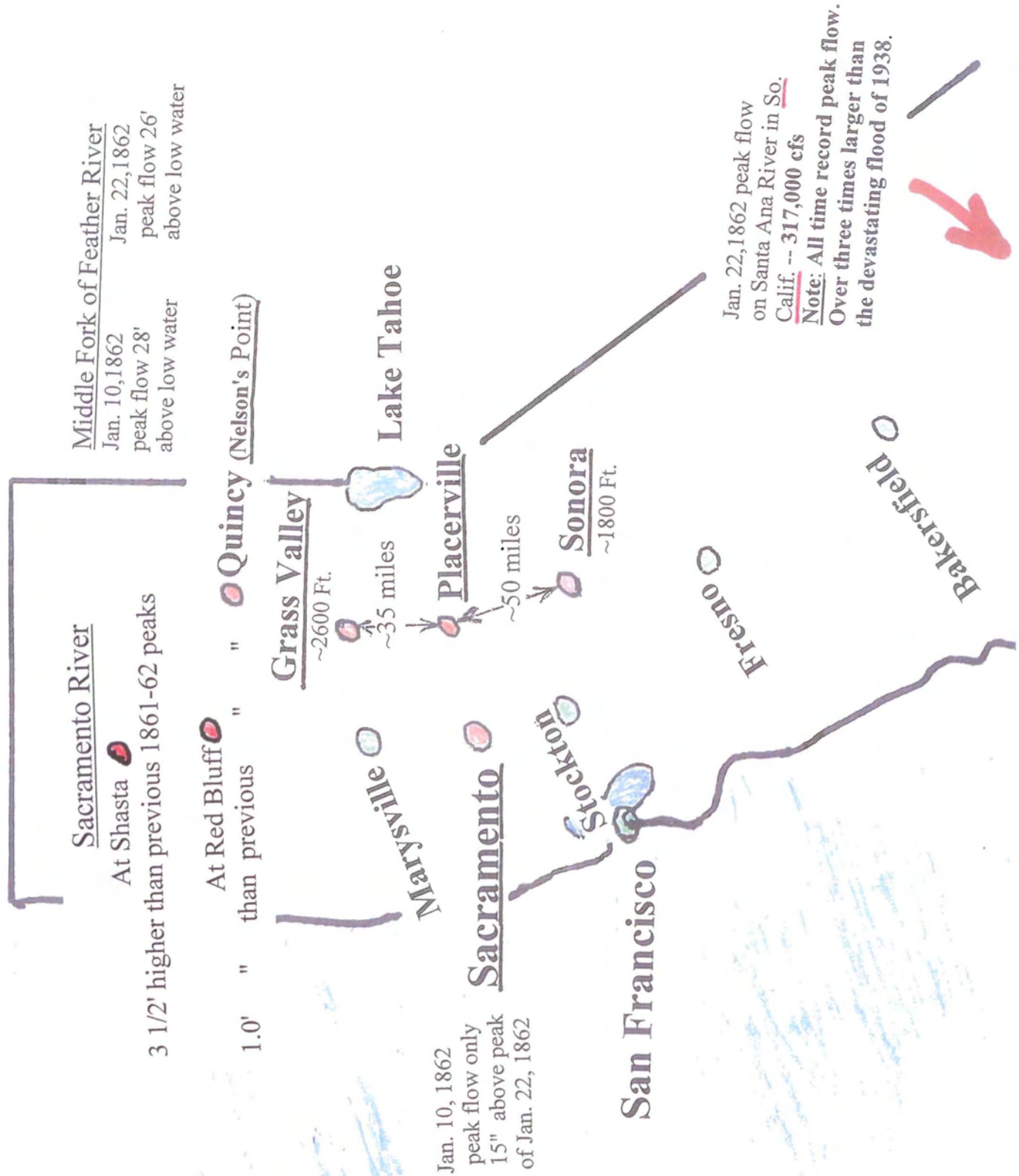
G.V. - Grass Valley

MAJOR FLOODS

SO. - SONORA

PEAK FLOW INFORMATION

--Jan. 22, 1862 Flood



Sacramento River at Shasta: Three and a half feet higher than previous 1861–1862 flood peaks.

Comment: On or about January 22, 1862, either record flooding or near record flooding occurred from Southern California to the Oregon border.

Perez Snell, M.D.:

Snell, Tuolumne County's pioneer scientist, was the founder and leading spirit of the Snell Historical and Scientific Society of Sonora. Intensely interested in all fields of research, Snell maintained the county's first rainfall record and collected a large variety of fossils and artifacts exhumed by the early miners of Tuolumne County. Dr. Snell was born in Vermont in 1783, moved to Louisiana (fought in the war of 1812) and ended up in Sonora in the mid-1850s. He died in Sonora on December 18, 1869 at the age of 87. (Source: *Tuolumne County Historical Society*)

Transition: **What are the implications of accepting Dr. Snell's rainfall measurements? In our opinion, it is a game changer. It changes the way we look at flood history on the American River watershed.**

Example No. 1:

Let us briefly review the February 23, 1999 DWR report that analyzes the January 1862 precipitation and runoff on the American River watershed. In the process of calculating the average daily flow for the three heaviest consecutive days, the DWR assumed an average depth of water on the watershed of 50 inches for January. Using the Snell rainfall measurements as a guide, we believe the average depth of water on the American River watershed in January 1862 was closer to 55–60 inches over a period of only 20–21 days. The DWR average three day calculations for a 50 inch water depth on the watershed was 200,000 cfs. It is obvious calculations using a 55–60 inch water depth across the watershed would produce an average daily flow for the three day period significantly greater than 200,000 cfs.

Example No. 2, Exhibit B:

We have been toying with what appears to be a useable correlation between 10 day Sonora precipitation totals and the average daily runoff for a 30 day period during the annual Maximum Rain flood on the American River at Fair Oaks. Our preliminary results indicate that the average daily flow for a 30 day period during the December 1861–January 1862 flood series was approximately **50,000 cfs.**

Perez Snell, M.D.
**Tuolumne County's
Pioneer Scientist**



COURTESY OF DONALD L. WELCHERSON

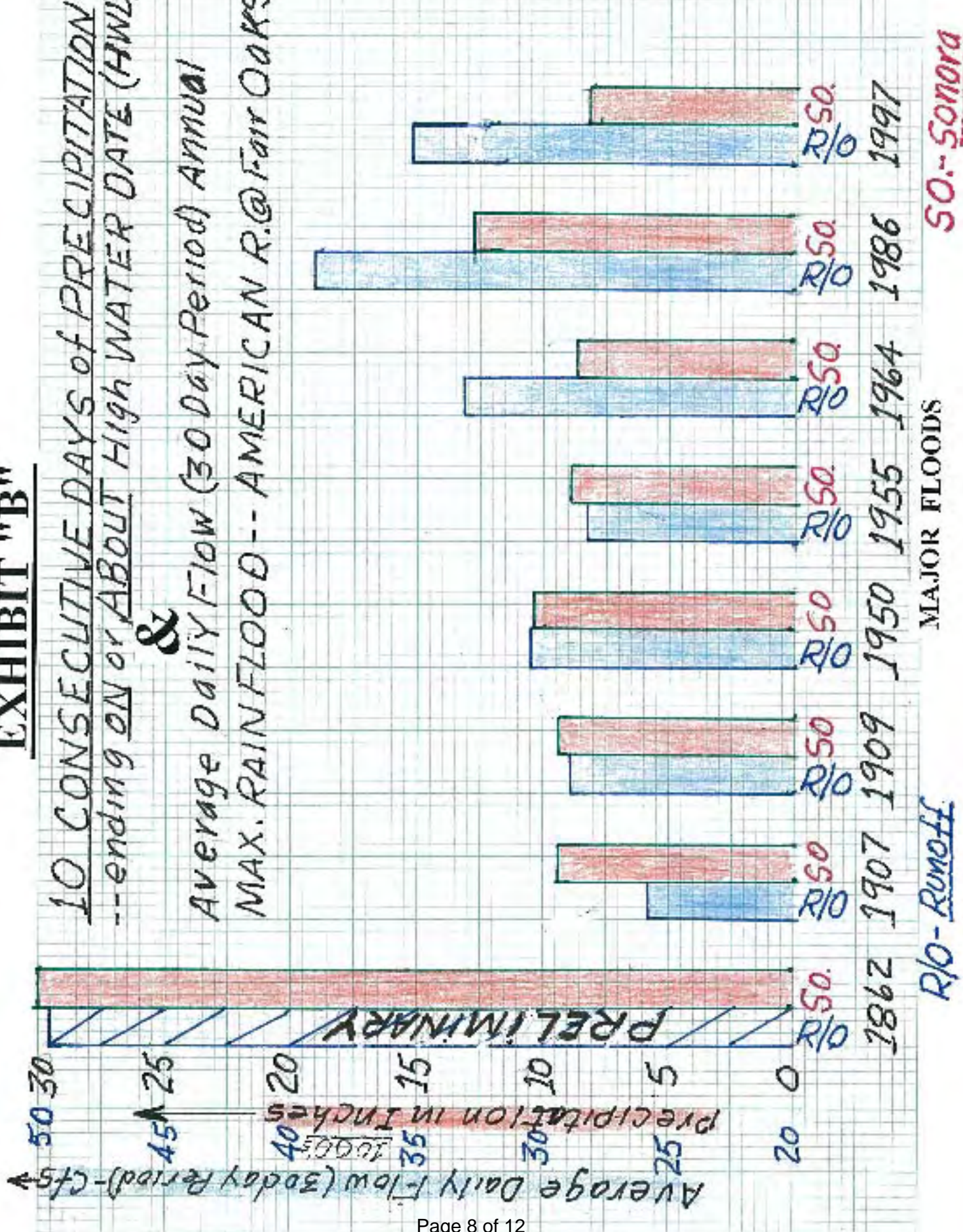
Perez Snell, M.D., Tuolumne County's pioneer scientist, and founder and leading spirit of the Snell Historical and Scientific Society of Sonora. Intensely interested in all fields of research, Snell maintained the county's first rainfall records and collected a large variety of fossils and artifacts exhumed by the early miners of Tuolumne County.

Snell came to California from Louisiana. A man with an established reputation as a geologist, his opinion was eagerly sought by local mining men and his advice on their mining ventures valued.



EXHIBIT "B"

10 CONSECUTIVE DAYS OF PRECIPITATION
 --ending ON or ABOUT HIGH WATER DATE (HWD)
 &
 Average Daily Flow (30 Day Period) Annual
 MAX. RAIN FLOOD -- AMERICAN R. @ Fair Oaks



SO. - Sonora

MAJOR FLOODS

R/O - Runoff

A. Preliminary Estimate:

The method used to arrive at a preliminary estimate of **50,000 cfs** for the daily average flow during the heaviest 30 day period in the December 1861–January 1862 flood series:

Precipitation stations used to estimate average 10 day totals on the American River Watershed:	Dec. 1964 (inches)	Feb. 1986 (inches)	Jan. 1997 (inches)	Elev. (Feet)
Lake Spaulding*	32.78	35.84	32.11	5156
Iowa Hill**	20.57	19.78	21.58	2930
Forest Hill**	19.95	25.74	21.17	3200
Georgetown R.S.**	20.95	25.10	23.08	3001
Placerville	10.72	15.05	12.20	1890

*For the sake of consistency, Lake Spaulding data were substituted for Blue Canyon because the National Climatic Data Center in Asheville, North Carolina did not have Blue Canyon data for the January 1997 flood.

**For the calculations, these three precipitation stations' totals were averaged.

B. Calculations:

1. 30 day flow comparisons on the American River at Folsom:

Dec. 1964:	Jan. 1862 (estimate):
32.78 inches	30.00 inches (Snell's 10 day 1862 Sonora total)
20.49 inches (3 station average)	<u>-21.33 inches</u> (1964 average)
<u>10.72 inches</u>	8.67 inches/21.33=
63.99 inches/3=21.33 average	.406 X 33,106 cfs=13,441 cfs
	<u>+ 33,106 cfs</u>
	46,547 cfs

Summary: Average daily flow for 30 days at Folsom (Fair Oaks)

Dec. 1964: 33,106 cfs (USACE)

Jan. 1862: 46,547 cfs (estimate)

2. 30 day flow comparisons on the American River at Folsom (Fair Oaks)
(Feb. 1986 and Jan. 1862 estimate)

Summary: Using the same procedure outlined in section 1 above, the results are as follows:

Feb. 1986: 39,100 cfs (USACE)
Jan. 1862: 47,272 cfs (estimate)

3. 30 day flow comparisons on the American River at Folsom (Fair Oaks)
(Jan. 1997 and Jan. 1862 estimate)

Summary: Using the same procedure outlined in section 1 above, the results are as follows:

Jan. 1997: 35,299 cfs (USACE)
Jan. 1862: 47,971 cfs (estimate)

Final Summary: An average of the three January 1862 30-day flow estimates, listed above, equals **47,263 cfs**. Following the same procedure, if we increase the Snell measurement by 2.0 inches, the average daily runoff during a 30-day period on the American River at Folsom, would increase approximately 7%—up to **50,415 cfs**. **Considering the increase in orographic lift as air moves north from Sonora, the assumption of 32 inches of precipitation in 10 days on the American River watershed appears to be on track.**

C. Statement:

The flood of January 2–11, 1862 was also a super-flood. *Our line of reasoning is based upon the following information:*

1. Dr. Snell's 1861–62 Sonora Precipitation Measurements
 - a. From the beginning of the season on or about Nov. 11, 1861 until Jan. 14, 1862 72 inches of precipitation fell in Sonora.
 - b. An additional 30 inches fell from Jan. 14–Jan. 23, 1862.
2. Grass Valley Precipitation Amounts (1861-62)
 - a. Total for the months of Nov. And Dec.= 41.70 inches
 - b. *Downieville (same general area)= 41.49 inches*
 - c. Grass Valley: Jan. 2-11 = 14.49 inches
 - d. Grass Valley: Jan. 14-23 = 18.13 inches
3. General Discussion
 - a. During all of the major floods of the 20th century, the 10 day precipitation totals at Grass Valley were significantly larger than the

similar 10 day totals for Sonora.

b. Therefore, we conclude that the seasonal precipitation total for Grass Valley through mid December 1861 was larger than for Sonora.

This conclusion is based upon the following newspaper reports:

1) Nevada Democrat (December 14, 1861): The Cosumnes, Mokelomne and Calaveras rivers were very high but not overflowing.*

2) Nevada Democrat (December 21, 1861): All the extraordinary floods appear to have been in the streams north of the Mokelomne*

c. However, as the Christmas holidays approached, the jet stream (storm track) began to shift southward, as evidenced by a report of rain starting to fall in the Los Angeles basin on Christmas Day. This report also stated that a “nice pleasant rain” continued on through the holiday season. It then rained continuously for 15 days and nights. This was followed by a downpour for 24 hours, or longer. *Source: “The Great California Flood of 1862”, page 7, authors “The Taylor Brothers”.*

*These articles were both referring to the first major flood of the 1861–62 series, the one that occurred in early December 1861.

The statement underlined above indicates that the intensity of the rain increased in the Los Angeles basin on or about January 2, 1862. It is also our opinion that the seasonal rainfall totals for Grass Valley and Sonora were about equal at this point— approximately 42 inches. If you add 30 inches, the total comes to 72 inches*, which is equal to the seasonal total that Dr. Snell reported for Sonora up to January 14, 1862.

In summary: we propose that approximately 30 inches of rain fell in Sonora during the 10 day period from Jan. 2, 1862–Jan. 11, 1862, matching the Jan. 14, 1862–Jan. 23, 1862 total.

*During this same time period (Nov. 11, 1861–Jan. 14, 1862) 56.19 inches of precipitation fell in Grass Valley.

Conclusions:

1. In January 1862, there were two super-floods on the American River watershed. The peak flows produced by these floods at Folsom, were only 12 days apart—one on January 10th followed by another on January 22nd.

2. We estimate that the magnitude of each flood was 30 to 40% greater than the major flood of December 1964.
3. Dr. Snell was an honorable, civic minded man—definitely qualified to make accurate rainfall measurements.

Closing Comments:

1. However, we believe the actual average daily flow was larger during the latter of the two super-floods. This is because the base flow at the beginning of the second super-flood was larger than the base flow at the start of the first episode approximately 10 days earlier. This base flow was likely large enough to push the average daily flow, for a 30-day period in January 1862, above our preliminary estimate of approximately 50,000 cfs. At this point we will “bow out”. People with more expertise need to take over.
2. Claude and I are both ex-Californians and have fond memories of the Golden State. We are willing to share our findings and thoughts with anyone interested in digging deeper into California’s flood history, especially the series of major floods that occurred during December 1861 and January 1862.

Leon Hunsaker, MS (MIT)
with
Claude Curran, Ph.D. (U of Oklahoma)
June 23, 2010