Parrett, 2009
U.S. Geological Survey internal document
Recommended revised estimate of Jan. 1862 peak discharge on
American River at Fair Oaks gage (USGS 11446500)

This internal USGS document recommended the USGS provide "our best estimate of the 1862 flood peak at Fair Oaks (gage) in the USGS Peak Flow File." The thinking behind the recommendation is explained. An email from Parrett in 2016 with additional explanation is also included as the first two pages of the PDF.

2009	Parrett Charles (Chuck) Parrett, Hydrologist, U.S. Geological Survey, California Water Science Center, Sacramento, CA Internal USGS document recommending that USGS provide "our best estimate of the 1862 flood peak at Fair Oaks (gage) in the USGS Peak Flow File." (Dec. 31, 2009) Source: Christine O'Neil, Hydrologic Technician, U.S. Geological Survey, California Water Science Center, Sacramento, CA

Research by Gary Estes
California Extreme Precipitation Symposium (CEPSYM)
Feb. 2017

Subject: Re: Looking for documents on peak discharge in American River in Jan. 1862
From: "O'Neil, Christine" <csoneil@usgs.gov>
Date: 9/1/2016 1:38 PM
To: <gary@cepsym.org>
CC: Christine O'Neil <csoneil@usgs.gov>

Good afternoon,

Attached is Chuck's documentation that he mentioned in email.

Thanks,
Chris

Chris O'Neil
Hydrologic Technician
USGS California Water Science Center

916-278-3164
fax 916-278-3190

On Wed, Aug 31, 2016 at 2:38 PM, charles parrett <chuckparrett@yahoo.com> wrote:

Hi Gary,

Yes, retirement is nice, but I do miss working on flood hydrology. As to the USGS estimate of the 1862 flood, I had access to an old unpublished USGS paper that showed a partial rating curve for the old stone stable site near Folsom. As I recall, it showed peak flood elevations for the 1862, 1907, and a couple more early day floods on the American River. Discharges were available for the 1907 and the other early floods, but not for the 1862 flood. A rating curve shows flood elevations plotted against flood discharge, and at USGS gage locations typically there are many plotted points through which a smooth log-log curve can be drawn. For a flood whose peak elevation exceeds any other point on the rating curve (like the 1862 flood at the stone stable site) the plotted curve can usually be extended on a straight-line basis to provide an estimate of the discharge corresponding to the known flood elevation.

At this old site near Folsom, there were only a few measured elevations with known discharges, so I am calling it only a partial rating curve. I fit a straight line through the logs of the elevations and discharges and used that a basis for the estimated discharge for 1862. The documentation for my analysis is probably skimpy, I am afraid, but I recall that I left that information with Chris O'Neil at the Sacramento Water Science Center office. Chris was in charge of placing flood information into the USGS Peak Flow file, which is where you obtained the information about the estimated 1862 peak discharge and how it was estimated from the rating curve extension. Chris's phone number and email (I'm not sure whether she has retired yet or not) are 916-278-3164 and csoneil@usgs.gov. I am sending Chris a copy of this email to give her a heads-up about the info you are seeking. Good luck!

Chuck

From: Gary Estes <gary@cepsym.org>
To: Chuck Parrett <chuckparrett@yahoo.com>
Sent: Tuesday, August 30, 2016 12:48 PM
Subject: Looking for documents on peak discharge in American River in Jan. 1862

Chuck,

Hope this finds you enjoying retirement. I am working on collecting historic documents used to estimate the peak discharge on American River in Jan. 1862. I remember you worked at USGS on estimating the 1862 peak discharge from historic documents.

Can you help me locate the document identified on the USGS website as follows: "discharge, 318,000 ft^3/s, estimated, from rating curve extended above 163,000 $ft^3/$"s?

Where would I look for the "rating curve" at USGS?

I found at the National Archives in San Bruno a cross-section of the American River in the "Folsom canyon" beside the Folsom State Prison located at the Stockton and Coover stone stable foundation (unfortunately no longer there due to Folsom Dam construction). The cross-section shows the high water elevations for the 1862 and 1907 floods at the stone stable and "USGS datum" is noted on the drawing.

The document also had are two pictures of the high water marks from 1862 and 1907 flood events at the Stockton and Coover stone stable foundation. The pictures show high water elevations for 1862 and 1907 floods based on USGS elevation.

Also there is a picture looking from the stable foundation across the American River "showing the character of river bed."

This has been an interesting journey so far and more to discover.

Thank you for any help you can provide.

Gary

Gary Estes
Coordinator
California Extreme Precipitation Symposium (CEPSYM)
Ph. 530-889-9025

Attachments:

11446500 (1).pdf	213 KB
11446500 (2).pdf	503 KB

11446500

On December 14, 1951 Howard Matthai of the USGS wrote a 3-page summary of work documenting a revision of the 1928 peak discharge for the American River at Fair Oaks (attached). Matthai used data from several published reports to develop an 8-point rating curve for a site near Folsom termed the Stone Stable site. According to Matthai, this site is stable and can be reliably used to estimate discharge for the downstream Fair Oaks site for large floods. At the end of his summary on page 3, Matthai states that a logarithmic extension of the rating he drew for the Stone Stable site results in an estimated peak discharge for the 1862 peak (gage height at Stone Stable = 183.0 ft) of 340,000 cfs.

Although the original rating developed by Matthai is not available, I reconstructed a curve based on the data Matthai showed on page 2 of his summary report.
I subtracted 104.3 ft from each gage height listed for the Stone Stable site. This was done to simply reduce the gage heights to reasonable values that would be indicative of a positive, but not unreasonably large PZF. Although Matthai stated that his rating was based on 8 points, the data on page 2 show 9 values of discharge and gage height. I presumed that he did not use one of the two discharge values of 136,000 cfs shown on page 2. The gage heights for the two discharges differed by 0.3 ft, and I retained only the lower gage height for this discharge.

For my reconstructed rating curve, the lowest discharge in 1942 clearly did not fit well with the remaining 8 points. I thus drew another curve without the 1942 peak and used both curves to calculate a plausible range for the 1862 peak discharge. Based on the two curves, I conclude that the 1862 peak was between 289,000 and 318,000 cfs. The best fit to the highest recorded peaks of

In their 1999 report titled Improving American River Flood Frequency Analyses, the National Research Council used an 1862 flood peak of 265,000 cfs obtained from the following reference:

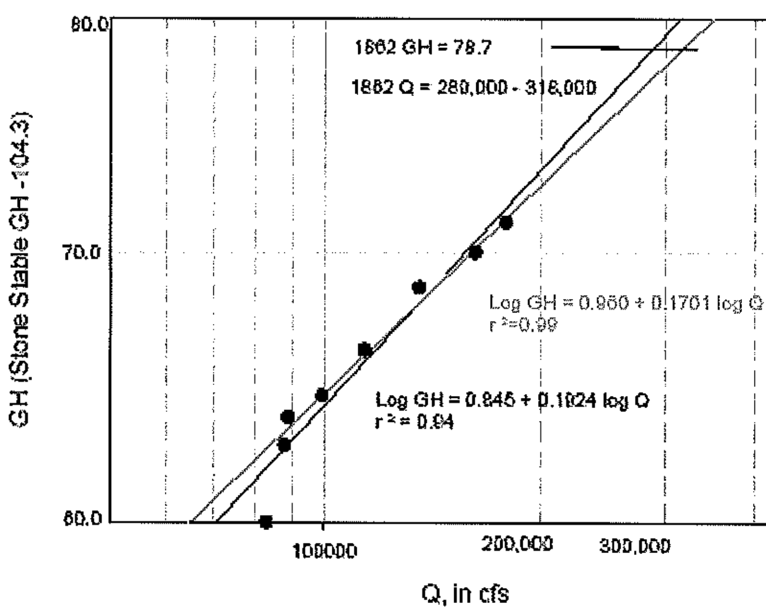
Bossen, L.E., Discharge rating curves of the American River at Fair Oaks and at Folsom, August 1941 and February 1943.

I have not read the Bossen report, but most of the flood stage data used by Matthai is footnoted as being from "Corps of Engineers report compiled in 1941, amended in 1943, 1951". I believe the Corps report is the Bossen report.

Given that floods and flood frequency is a major concern on the American River, I recommend that the USGS provide as much information on flood magnitude as we can by providing our best estimate of the 1862 flood peak at Fair Oaks in the USGS Peak Flow File. I further recommend that we use the higher peak from my reconstructed curves (318,000 cfs) as our best value for this discharge and that it be coded as an estimate.

Charles Parrett
12/31/2009

American River at Fair Oaks (11446500)
Estimated 1862 Peak based on Rating
Curve Analysis by H. Matthai (12-14-1951)



Revision of Peak Discharge

of

American River at Fair Oaks, Calif., Mar. 25, 1928

Abstract

In 1928 the U. S. G. S. published a peak discharge for March 25, 1928, of 182,000 cfs. based on a discharge measurement of 181,000 cfs. made by timing drift in a reach near the gage. In 1938 this figure was revised to 140,000 cfs. on the basis of the 1937 high-water studies and when the 1928 float measurement was discarded after consultation with the engineer of the Division of Water Resources, State of California, who made it.

In connection with the Corps of Engineers studies for Folsom Dam operation, it is to the best interest of all parties concerned to again revise the 1928 peak discharge on the basis of data subsequent to 1937 and especially the 1950 high-water studies. The revised figure is 163,000 cfs.

Ratings

The high-water rating for the Fair Oaks gage is unstable; however, it is the opinion of many engineers who have studied flood flows on the American River that the high-water rating at the Stockton and Coover Stone Stable just upstream from Folsom is permanent. Inflow between these two points is negligible during major flood peaks.

Crest stages at the Stone Stable have been observed since 1862 as listed below.

Date	U. S. G. S. Elev.	Discharge at Fair Oaks
1862, Jan. 10	183.0 a,b/	
1907, Mar. 19	171.5 b/	~~110,000~~ (140,000)
	171.8 a/	
1925, Feb. 6	168.8 a/	99,500
1928, Mar. 25	174.3 c/	
	174.5 d/	
	175.0 a/	
1937, Dec. 11	170.5 e/	114,000
	171.1 a/	
1940, Feb. 28	167.0 a/	58,100
1940, Mar. 30	168.0 a/	89,200
1942, Jan. 27 ?	164.3 a/	85,200
1943, Jan. 21	172.9 a/	136,000
1950, Nov. 19	174.3 a/	163,000
1950, Nov. 21	175.5 f/	180,000
	175.8 a/	
1950, Dec. 4	173.2 a/	136,000

a/ A Corps of Engineers report compiled in 1941, amended 1943, 1951.

b/ 1912 report of A. Given and C. E. Grunsky on "Flood Discharge of American River."

c/ A. M. Barton, Report of December 1929 to Trustees, American River Flood Control District.

d/ "Flood Discharge of American River, Mar. 25, 1928" by A. M. Wells (in files of State Division of Water Resources).

e/ Joseph W. Cross, Sacramento, California.

f/ Observation by F. A. Johnson and Harlowe Stafford, U. S. G. S., Sacramento, California, on 2-28-51.

A rating (see attached curves) for the Stone Stable was constructed using the elevations as listed above and the peak discharges at Fair Oaks. This method should give reliable results as major crests on the American River last about one hour, and the time interval from Folsom to Fair Oaks is about one hour.

All peak discharges except those for 1928, Feb. 1940, and Jan. 1942 plot very well on this rating. The 1907 peak was plotted as 119,000 cfs. as originally published.

Conclusions

Using this rating based on eight points, the 1928 peak discharge for Fair Oaks becomes 163,000 cfs. which should be much more reliable than either 140,000 or 182,000 cfs.

As the stage at the Stone Stable was 3.0 feet lower in 1907 than it was in 1928, the reference "flood of Mar. 19, 1907, reached a stage of 31.4 feet, present datum (discharge probably about same as that of Mar. 25, 1928)" should be deleted from the extremes paragraph.

An extension of the Stone Stable rating by logarithmic plotting to the stage of the 1862 flood gives a peak discharge for that flood of about 340,000 cfs.

Howard F. Matthai
12-14-51

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agricultural practices (Anderson and Moratto, 1996). In the late 1950s, after more than a half century of active fire suppression, greater emphasis was placed on prescribed burning to reduce the buildup of fuelwood and hence decrease the potential of catastrophic fires (Weise and Martin, 1995). It is not known whether the hydrologic effects of prescribed burns are the same as those of wildfires.

Levees were built in the Sacramento area to aid in draining wetlands for agriculture and for protection from floods on the American and Sacramento Rivers. As noted in Chapter 1, the first levees were built following the flood of 1850. These levees failed in the 1852 flood, and were subsequently rebuilt to higher levels (Woodward and Smith, 1977). Following the disastrous flooding in 1861-1862, substantial efforts were directed towards major levee projects. Unfortunately, as a result of aggradation from mining sediments, the height of flood waters for a given discharge progressively increased. This led to levee failures during moderate floods, requiring additional levee improvements.

Most rivers in the Sierra Nevada have surface water impoundments for multi-use purposes to help support the rapid population growth in California, particularly after World War II. These impoundments can dramatically affect streamflows, reducing flood flows and increasing low flows. As a result of the substantial impact of impoundments on flood flows it is necessary to correct measured streamflows to establish unregulated conditions, as discussed previously in this chapter.

What are the implications of these various human activities with respect to the use of historical and paleoflood data for flood frequency estimation on the American River? The most obvious implication is that the enormous amount of mining sediment in the American River during the latter part of the 19th century makes it very difficult to accurately estimate historical flood discharges during that period, precisely the period when historical information is available. There is also the possibility that the net effect of human activity has been to increase the flood response of the American River. With the available information it is not possible to quantify this potential effect.

Historical Data

Reliable observations of historical floods on the American River began in 1848 with the discovery of gold at Sutter's Mill. Major floods damaged Sacramento in 1850, 1862, 1867, 1881, 1891, and 1907 (the systematic flood record begins in 1905). Of these, the flood of 1862 clearly had the largest peak discharge, although the maximum stage of the 1867 flood on the lower American River may have been higher as a result of channel aggradation (McGlashan and Briggs, 1939).

The winter of 1861-1862 was extremely wet with few interruptions of the heavy rains from early November 1861 to mid-January 1862. The culminating event was a warm storm in January that had a three-day precipitation of 12.2 inches at Nevada City, the only station in the upper American River basin having records (Weaver, 1962). This was exceeded at this site by only the February 1986 storm (15 inches) and the January 1997 storm (12.7 inches). Flooding was extreme on all rivers

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from the Klamath south to San Diego (Hoyt and Langbein, 1955; McGlashan and Briggs, 1939). Lynch (1931) concluded that the flood of 1862 was probably the largest in California since the settlement of the Spanish missions in 1769; he had little information for northern California. McGlashan and Briggs (1939) indicated that the floods of 1861-1862 appear to have been the largest in California since at least the early 19th century. The flood is described as covering the entire Sacramento valley with a vast inland sea (Guinn, 1907) except Marysville Buttes (Ellis, 1939). According to Engstrom (1996) the inland sea or lake ranged from 250 to 300 miles long and from 20 to 60 miles wide. Sacramento was submerged and almost ruined by the floods (Guinn, 1907). Bossen (1941) estimated the peak flow on the American River at Fair Oaks to be 265,000 cfs.

The utility of the historical record from about 1848 to 1907 (and perhaps even part of the early systematic gaged record) is questionable because of unknown cumulative effects of land-use changes associated with gold mining. The largest peak flood (1862) in the systematic and historic period occurred during the period of maximum watershed disturbance. Limited precipitation data in Sacramento and Nevada City available during the winter of 1861-1862 suggests that the rainfall and snowmelt contributing to the peak discharge was comparable to the record storms in 1986 and 1997. The estimated peak flood discharge in 1862 was only slightly larger than the floods in 1986 and 1997, suggesting that even with the extensive basin disturbance in the last half of the nineteenth century, basin response may not have been much different from today. One possible explanation is that snowpack covering disturbed surfaces may have masked the potential increase in runoff from mining and vegetation removal. It is also possible that the estimated peak discharge of the 1862 event is low. In any case, it is prudent to cautiously incorporate the historical data in the flood frequency analysis.

Paleoflood Data

As this report was being prepared, the U.S. Bureau of Reclamation (USBR) was concluding a comprehensive paleoflood investigation of the American River and nearby basins. The primary objective of the USBR study was to characterize the probabilities of flood magnitudes greater than those contained in the historical record for use in risk assessment of Folsom Dam. Summarized below are some of the major findings of the paleoflood study provided by Dean Ostenaa (U.S. Bureau of Reclamation, written communication, 1998).

The American River, both upstream and downstream from Folsom Dam, is flanked by a distinct series of stream terraces. These terraces represent abandoned floodplains whose surface morphology and underlying soils accurately record the time since the last major flood. The main objective of the USBR study was to identify and assign ages to terrace surfaces adjacent to the river that serve as limits or paleohydrologic bounds for the stage, and therefore discharge, of past large floods over particular time intervals.

Paleohydrologic records were developed at 12 sites along the American, Consumnes, Mokelumne, and Stanislaus Rivers. Despite the extensive mining activity locally along these rivers, the geologic record of floods remains intact and

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hydraulic conditions are definable in localized reaches conducive to paleoflood reconstructions. Chronology for paleohydrologic bounds was established by 60 radiocarbon ages, 21 archaeological sites, published soil surveys, and 39 soil/stratigraphic sections. Paleohydrologic discharge estimates were established by a variety of hydraulic modeling techniques. For some sites, discharge estimates were obtained by comparison to measured and estimated discharges at nearby gaging stations. For other sites, detailed topographic surveys provided the basis for two-dimensional flow modeling of study reaches up to 12 miles in length. Paleoflood sites were located in bedrock-controlled reaches; channel geometry for the reach near Fair Oaks, which has changed substantially in the 20th century, was reconstructed from topographic surveys made in 1907.

USBR study results indicate that the flood experience in the American River over the last 50 years is not anomalous. Floods of a magnitude similar to the January 1997 flood have occurred during the past few hundred to several thousand years. Geomorphic and stratigraphic evidence also indicates that there have been floods somewhat larger than the January 1997 flood, but there is no evidence of floods with peak discharges substantially larger than that of January 1997. Peak stage indicators consisting of fine-grained flood sediments, which included mining debris, were used to estimate the peak stage of the largest flood, probably the flood of 1862. The estimated stage was slightly higher than the 1997 peak stage. The peak estimated discharge at Fair Oaks was 260,000 cfs, which is close to the estimate of Bossen (1941). Paleoflood data for the lower American River indicate that a peak discharge of about 300,000 cfs to 400,000 cfs has not been exceeded in the past 1,600 to 3,500 years. These results are consistent with paleoflood data at sites upstream of Folsom Dam and at sites on other rivers in the region.

The quality of the USBR data and analysis is excellent. The committee finds no reasons to disagree with the paleoflood information that the USBR has assembled. As discussed previously, the committee has serious doubts about the assumption that flood magnitudes have been completely independent and identically distributed in time during the period represented by the paleoflood information. Although paleoflood chronologies have not been well documented in the Sierra Nevada (the USBR study is the first systematic attempt to document paleofloods in the region), other paleoclimatic studies have indicated systematic variations in climate there that are consistent with regional and global patterns. For example, paleoecological data (Woolfender, 1995) indicate that the Sierras experienced persistent above-average temperatures during the Medieval Warm Period (approximately A.D. 950-1350) and persistent below-average temperatures during the Little Ice Age (about A.D. 13501850). During the latter period, the Sierras experienced multiple advances of alpine glaciers and a decrease in the number of fire events (Birman, 1964; Burke and Birkland, 1983; Curry, 1969; Gillespie, 1982; Scuderi, 1984, 1987; Swetnam, 1993). Given that extreme floods on the American River occur in winter storms that mainly produce rain rather than snow, it is possible that the frequency of extreme floods would have been lower during the Little Ice Age.

The key issue regarding the usefulness of any data on past floods to a particular planning or design problem is the information the data provide on the potential for flooding during the planning horizon. If floods can be assumed to be independent and identically distributed in time, then all past information is equally

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TABLE 2.2 Maximum Peak Discharges on the American River (Unregulated Conditions at Fair Oaks)

Year	Discharge	Source
1862	265,000	Bossen, 1941
1963	240,000	1987 Folsom Control Manual
1964	260,000	1987 Folsom Water Control Manual
1997	295,000[a]	Roos, 1999[a]

[a] Estimated at Folsom Dam. Source: Maury Roos, memorandum to Kenneth Potter dated February 16, 1999.

Probable Maximum Flood

In October 1996, the U.S. Bureau of Reclamation, in consultation with the USACE Sacramento District, used HMR 58 to estimate a mean probable maximum storm amount for the American River basin of 29.62 inches (Pick, 1996; NWS, in press). Using loss rates based on saturated soil for unfrozen ground and snow cover for frozen ground, the USBR calculated one- and three-day probable maximum flood discharges of 575,000 and 401,000 cfs, respectively, for regulated conditions upstream. Due to the combined volume of upstream storage and likely extent of occupied storage at flood time, the equivalent unregulated volumes were expected to exceed regulated values by only a few percentage points. In 1997, following the January 1 flood, USACE Sacramento District re-estimated the probable maximum flood for the basin by applying loss rates equivalent to those observed for this large event (0.7 inches loss of 11.8 inches total) to the probable maximum storm derived in 1996. The resulting three-day runoff was 29.07 inches and the maximum three-day average flow was 485,000 cfs.

PMF estimates for the American River provide some information about the upper tail of the flood distribution. In theory the PMF is the maximum flood that can be expected at a site, the PMF concept is largely empirical, and hence a PMF estimate should be thought of as a very large flood discharge that is highly unlikely to be exceeded. While the committee is unable to specify the distribution of the likely values of the exceedance probability of a PMF for the American River, empirical data suggest that the exceedance probability should probably be smaller than 1×10^{-4} and almost surely smaller than 1×10^{-3}. In the case of the American River, the committee decided to use the two PMF estimates as likely upper bounds on the flood quantile associated with a probability of 1×10^{-3}.

Summary

A variety of data are available for use in flood frequency analysis on the American River. Based on the committee's consideration of these data, it has concluded the following:

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