

U.S. Army Corps of Engineers (USACE)
Sacramento District
American River peak discharge estimates for Jan. 1862 at Fair Oaks gage

This is one of three documents which contain American River peak discharge estimates for January 1862 flood event at the Fair Oaks gage (USGS 11446500). These documents were produced to help size and design Folsom Dam by estimating the largest flood the dam and reservoir would experience.

1941	Bossen Leslie E. Bossen, Assistant Engineer, U.S. Army Corps of Engineers, Sacramento District "THE 1862 FLOOD ON THE AMERICAN RIVER, CALIFORNIA" (Aug. 1941) Source: Ronald Stork, Friends of the River, 1418 20th Street, Suite 100, Sacramento, CA 95811
1941	Bossen Leslie E. Bossen, Assistant Engineer, U.S. Army Corps of Engineers, Sacramento District "DISCHARGE RATING CURVES OF AMERICAN RIVER AT FAIR OAKS AND AT FOLSOM" (Aug. 1941) Source: Ronald Stork, Friends of the River, 1418 20th Street, Suite 100, Sacramento, CA 95811
1943	Bossen Leslie E. Bossen, Assistant Engineer, U.S. Army Corps of Engineers, Sacramento District "THE FLOOD CREST OF JANUARY, 1943 ON THE AMERICAN RIVER" (Feb. 1943) Source: Ronald Stork, Friends of the River, 1418 20th Street, Suite 100, Sacramento, CA 95811

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DISCHARGE RATING CURVES OF AMERICAN
RIVER AT FAIR OAKS AND AT FOLSOM

American River at Fair Oaks, California

1. Location of Gages.

The U. S. Geological Survey maintained a staff gage at the bridge from 1904 to sometime after the 1928 flood. The original datum of this gage has been maintained for the period of U.S.G.S. record but due to an error made while painting post marks on the staff sometime between 1908 and 1928, readings over about 28 feet were in error, a reading of 30.4 indicated a reading of 31.4 gage datum. A short while before the 1928 flood the State Division of Water Resources had installed a water stage recorder on the right bank about 850 feet downstream of the bridge and a stage hydrograph from this recorder is available for that flood. Sometime after the 1928 flood the U. S.G.S. placed a recorder near the bridge and at present a permanent installation is on the right bank about 75 feet upstream of the bridge.

2. Flow Measurements.

The U.S.G.S. has made measurements of discharge at Fair Oaks up to the flow of 60,000 second-feet. Above this stage a few drift velocity determinations of discharge have been made. Among these is the measurement made at the time of the 1928 flood by Mr. M. Blote of the State Division of Water Resources. The state report by Mr. Wells on the 1928 flood on the American River gives the result of this measurement. The value obtained in this method was 184,000 second feet with a ratio of mean velocity to surface velocity of 0.85. Off hand this ratio is very good and apparently the work was carried on very well. A few criticisms of the result of this measurement can be made however. This measurement was made at the bridge timing drift from up to downstream. The cross-section at, and upstream of the bridge is much deeper than at the flow control downstream. This being true the tendency would be for drift surface velocities to increase as the flow progresses through the section restricted by bridge piers and toward the shallower control section. This condition increases the ratio of surface velocity to mean velocity. Doubt can be placed on the value of ratio of mean velocity to surface velocity. Looking at the results in this light, they could will be reduced. Two slope area determinations of the March 1928 flood discharge were made from data obtained 3 days after the peak. For the two cross-sections surveyed at that time a mean value of 190,000 second feet was computed using a value for Kutter's 'n' of 0.035. For flood flow conditions and for a channel as rough as this one and in view of computed coefficients of roughness for similar channels, it is not unreasonable to believe that the value in this case is nearer .045. This value used in computation would give 148,000 second feet for the 1928 flood flow. Taking the peak flow for December 1937 at Fair Oaks dividing by the total of peak flows at the three main tributary stations for the same flood and multiplying by the total tributary flow of 1928 gives a value a little larger than 140,000 second feet for the 1928 Fair Oaks discharge. This latter deviation of course assumes a similar timing of peak flows past the three tributary stations for both 1937 and 1928 floods.

3. Establishment of High Water Rating Curve for Fair Oaks Station.

This discharge rating curve was extended above 75,000 second feet

in 1938 by the U.S.G.S. on basis of recent surface velocity measurements and hydraulic properties of the bridge cross section. This extension gave a value of 140,000 second feet for the flood flow of March 1928 at gage height 31.4. In the Welle's State report on the March 1928 flood on the American River were three cross sections taken by Mr. Blote after the 1928 flood. One of these was taken at the bridge and the two others downstream. Extensions of the Fair Oaks rating curve were made on the basis of hydraulic properties of these three cross sections. The results obtained using first the cross section at the bridge and then using the two downstream of the bridge were identical being 146,000 c.f.s. each case for the March 1928 peak flow.

4. March 1928 flood magnitude.

After considering all evidence available at this time it was concluded that the 1928 flood at Fair Oaks must have been approximately 150,000 c.f.s. at crest of 31.4 on the U.S.G.S. gage.

American River at Folsom, California

1. Location of Gage.

From about 1906 to date the U.S. Weather Bureau has maintained a staff gage at the powerhouse at Folsom. As far as is known the original datum of this gage has been maintained. The State Division of Water Resources has operated during recent years a water stage recorder at this same location. High water marks for the 1907 and 1928 floods the largest of the last 40 years on the American River have been observed at the old powerhouse site and their heights painted in the old turbine well. The March 1928 flood reached 26.8 and the March 1907 flood reached 27.2 powerhouse gage datum.

2. Flow measurements and Establishment of Discharge Rating Curve at U.S.W.B. powerhouse Gage.

As far as is known by the writer there has been no measurement of discharge except for low river stages at Folsom. Therefore, any deviation of a rating curve for this site must be by slope-area determinations or by correlation of flows at this location with those at Fair Oaks, for instance. The former method will fail in accuracy for several reasons, therefore, one must use a correlation with Fair Oaks. From many observed flood crest stages at both Folsom and Fair Oaks a correlation of gage heights has been made by the State and also by the U.S.E.D. Also by routings of a flood of the magnitude of that of 1928 it was estimated that the maximum amount of peak flow reductions which could take place in the reach from Folsom to Fair Oaks is 5,000 c.f.s. Thus if the peak flow was 150,000 c.f.s. at Fair Oaks the peak flow at Folsom could have been no more than 155,000 c.f.s. With this deviation, Fair Oaks discharge curve, a gage correlation curve and a discharge rating curve for Folsom powerhouse location was computed.

3. Gages and Establishment of Rating Curves for Folsom Bridge Site.

Mr. Joseph Gross, Sacramento civil engineer, previous to 1941 placed gage markings in keel upon the south arch abutment of the concrete bridge at Folsom and obtained simultaneous readings of this gage and the Folsom powerhouse gage described in the above paragraph. In April, 1941 like readings were made at a lower stage of flow, readings being referred to temporary gage markings of L. E. Bossen. The datum planes of these

two gages were established and readings of both Gross and Bossen determined a correlation of powerhouse gage to Gross gage readings. Differential levels were established from the U.S.G.S.B.M. at the powerhouse to the bridge and at the same time (1941) the elevations of 1937 and 1928 drift marks and wash lines at and downstream of the bridge were obtained (see U.S.E.D. field book). The observations of 1937 heights were well defined but some time was spent in obtaining unmistakable 1928 drift and wash lines. The elevation of zero on the powerhouse gage was verified at 111.22 and the elevation of zero of Mr. Gross's gage at 114.90 both U.S.G.S. datum. The zero point of temporary markings used by Bossen was approximately 5.5 feet above that of Mr. Gross's gage. Drift marks found at the bridge (1941) establish the 1928 high water crest at 142.2 and the 1937 crest at 138.5 both U.S.G.S. datum. From a photo (Mr. Gross's file) taken March 25, 1928 during the flood at the Folsom bridge and note concerning time photo was taken an approximate crest elevation was determined at both the bridge and the powerhouse. This fairly inaccurate method gave the elevation of crest 1.2 feet lower than drift marks observed by Bossen. From above mentioned data a very good correlation curve of powerhouse versus bridge gage readings was established up to the crest of the 1928 flood. From this and the previously computed powerhouse rating curve a fairly good rating curve for the bridge site was established. As far as known by the writer nothing but low water flow measurements have been made at the bridge.

4. High Water Levels and Discharge Rating Curve for the Channel at the Old Stone Stable, Folsom.

At this site about 4,000 feet upstream of the Folsom Bridge the following data are available: highwater elevations for the flood crests of 1862, 1874, 1907, 1925, 1928, 1937 and 1940 and simultaneous discharges for the floods of 1925, 1928, 1937 and 1940 at the Folsom powerhouse gage. The 1925 and 1928 high water levels at the stable site were established by the State (see the Welles Report on 1928 flood) at 168.8 and 174.5 U.S.G.S. datum respectively. A note on file in the office of Mr. J. Gross states that the elevation of the 1928 flood at the stable was 170.5 U.S.G.S. This is without doubt in error as this is the approximate stage of the 1937 flood. In discharge it was well above the 1937 flood. In April 1941 levels were established for the drift lines of the 1940 and 1937 floods near the stable. Although no clear markings were found any nearer than 80 feet from the stable an extension of hydraulic grade lines establishes the crest of these two floods at the stable at 168.0 for March 1940 and 171.0 for December 1937 both U.S.G.S. datum. At the same time elevations of old wash lines were determined and the 175.0 found at that time checks very closely the 174.5 the State Engineer obtained in 1928 for the March 1928 flood crest. From the relationship of gage heights at the Folsom powerhouse and elevations for same flood crests at the old stone stable a fairly consistent discharge rating curve was established for this site between the range of 60,000 to 160,000 c.f.s.

Establishment of Extreme Discharge Curves for Fair Oaks and Folsom Sites on the American River

1. General.

With the assumed hydraulic principle that discharge for given stages varies according to the formula $Q = C_1 A R^{2/3}$ and that C is a constant variable with stage and amounts to $1.49 S^{1/2}$, Q is discharge in c.f.s, A is area in

square feet and R is hydraulic radius in feet for a given stage, computations for extension of rating curves were made. Cross sections at or near the flow control points for the discharge stations were available. From these hydraulic properties and principles were obtained results enumerated in following paragraphs.

2. Location of Hydraulic Sections.

At Fair Oaks ~~cross~~ sections were available for three locations immediately downstream of the bridge and also for the bridge location. These sections were measured in 1928 after the flood of that year. At Folsom an approximate cross section taken April 1941 was available for the control at powerhouse gage. A cross section surveyed in 1917 at the present Folsom bridge was available. At the control section below the Old Stone Mill above Folsom an approximate ~~cross~~ section was taken in April 1941 and another was surveyed after the 1928 flood at or near same location.

3. Results of Rating Curves Extensions on Bases of foregoing Data.

With the original of this report are included the work sheets and curve results as obtained in this study. The following tabulation shows in column form the salient results obtained.

RESULTS OF 1862 FLOOD DISCHARGE DETERMINATION

Station	Assumed 1928 Flow c.f.s	Hydraulic Sections	1862 Flood Flow c.f.s
Fair Oaks	150,000	at bridge	258,000
	155,000	at bridge	268,000
	150,000	downstream	275,000
	155,000	of bridge	286,000
Folsom**	155,000	at bridge	322,000
Bridge	160,000	at bridge	352,000
Folsom at Old Mill	155,000	at assumed	254,000
	160,000	control	262,000
	155,000	at Mill	265,000
	160,000	at Mill	278,000
	160,000	at Mill	265,000*

* This result is by method of velocity-area curves extension only

** For some unexplained reason results at this location are out of line with those at other locations. On basis of quality of data for this location not much weight was given to these results.

4. Conclusions.

On the basis of and after analysis of the results obtained in this study the following decisions were reached: that the 1862 flood crest flows at Folsom and Fair Oaks must have been about 280,000 and 265,000 c.f.s. respectively, that the 1928 flood crest flows at same stations must have been about 160,000 and 150,000 c.f.s. respectively, that the 1907 flood

crest flows must have been about 145,000 and 140,000 c.f.s and that the 1909
flood crest flows must have been about 135,000 and 130,000 c.f.s.

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