American River flood-control project performance: A quick reference guide

FRIENDS OF THE RIVER

In designing Folsom Dam and other flood control projects, Corps engineers used historic rainfall records, river flows, runoff, land use, and statistical tools available at the time to design a project "[t]o eliminate flood damages along [the] American River."[1] This was to be achieved (initially) by designing the facility to handle the largest historic flood in the watershed (1862), then was upsized to "assure that a higher or 'project design' degree of protection would be provided."[2] This method of project sizing is a predecessor methodology to the later standard-project-flood methodology. The peak inflow into Folsom Dam of this design flood was 340,000 cfs.

Unlike design floods (which are expressed in volumes or peak discharges of the design hydrograph — and only change when topography or the flood-control facilities change), statistical characterizations of the "level of protection" of this and other project design floods vary widely, depending on statistical methodologies and the underlying data set, which evolves with time. This is particularly true for statistical estimates for the probability distribution of hypothetical flood magnitudes — which, after all, have never been experienced.

Statistical analysis to characterize the Folsom's design flood at the time of initial design suggested that the dam and levee system could contain the modeled 1000-year flood.[3] When

---

[1] Master Manual of Reservoir Regulation, Sacramento River Basin, California, Appendix II, Reservoir Regulation for Flood Control, Folsom Dam and Reservoir, American River, California, 1 October 1956, Revised March 1959, U.S. Army Engineer District, Corps of Engineers, Sacramento, CA, Part B, Operational Requirements.

[2] "In the design of Folsom Reservoir, the Corps of Engineers recognized the need to provide protection against a very large winter rain flood. The flood of January 1862 was thought to be the largest experienced flood for which estimates could be made, and those estimates were initially considered by the local Corps of Engineers' staff for the Folsom flood control design operation plan. Objections raised by higher echelons of the Corps of Engineers, based on flood control experience throughout the United States resulted in discarding the estimated 1862 flood hydrograph and preparing a revision of the design flood to assure that a higher or "project design" degree of protection would be provided by the flood control operation under consideration, when allowance for unforseen contingencies was included." Corps of Engineers Comments on Draft of USBR 'Amendment to the Final Environmental Statement and Supplement on Auburn-Folsom South Unit," Dated July 11, 1974, Amendment to the Final Environmental Statement and Supplement on Auburn-Folsom South Unit, American River Division, Central Valley Project-California, Volume 2, Department of the Interior, USBR, p. 248. The reservoir design flood for Folsom Dam was developed from statistically centering the 1937 large regional flood over the American River Basin and computing its outflow—developing a peak inflow of 340,000 cfs at the design hydrograph used at the time. A Preliminary Study of Flood Control Alternatives on the Lower American River. California Department of Water Resources, Central District, September 1982, p. 7.

[3] A Preliminary Study of Flood Control Alternatives on the Lower American River, California Dept. of Water Resources 1982, p.7

Folsom Dam was built, it was expected to provide 250-year protection.[4] But soon after the dam was constructed, a 120-year level of protection was modeled, an annual flooding risk of 0.7%.[5]

Four large storms hit the region during and after the Folsom Dam construction; these four storms in 1955, 1964, 1986 and 1996-97 produced rainfall in excess of any pre-construction storm on record for the region with the exception of the 1862 flood, which predated stream-guage records. In both 1986 and 1997, the volume of flood waters came within 90% of Folsom Dam's original flood operation capacity (or 80% of the capacity with the improved levee and operational changes authorized and largely in place today), and because of operational problems described in a 1995 National Research Council report[6], in 1986 releases were made that produced river flows in Sacramento that exceeded the dam's normal objective design flood outflow — 115,000 cfs (cubic feet per second).

---

[4] ARWI Feasibility Report, Main Report, 1992, p. III-5

[5] After the 1950 and 1955 high water events on the American River, this assessment was changed to 120-year protection , A Preliminary Study of Flood Control Alternatives on the Lower American River, California Dept. of Water Resources 1982, p. 7. This assessment varied. In the 1962 Letter From the Secretary of the Interior Transmitting a Report on the Auburn-Folsom South Unit Proposing Expansion of the Central Valley project in California, Pursuant to Section 9(a) of the Reclamation Act of 1939 (53 Stat. 1187), and Section 2 of the American River Basin Development Act of October 14, 1949 (63 Stat. 852), House Document #305, 87th Congress, 2nd Session, p. 16, the Department estimated the modeled level of protection at that time to be 200 years. (January 18, 1962)

[6] "On February 13 and 14 the California Department of Water Resources (CDWR) began preparations for a full flood fight, given computer projections of a[n] extraordinary storm approaching the state from across the Pacific (CDWR, 1986). The American River flood flows began in earnest on February 15, with inflows rising to over 60,000 cfs early the next day, but Figure 2.1 shows that Folsom operators did not begin to evacuate the flood control storage volume, nor did releases from Folsom match the inflows to the lake. Operators expressed a major concern for the effect of large Folsom releases on recreational facilities in the lower American River floodway; releases were held to 20,000 cfs for 36 hours. This is inconsistent with the 1977 USACE flood control diagram in force at the time; the diagram states that when Folsom storage is in the flood control reservation the water "shall be released as rapidly as possible" subject to ramping limits. Even after increased releases from Folsom began on February 16, and before they reached the 115,000-cfs limit, Folsom releases continued to lag behind inflows into Folsom Lake by 30,000 cfs or more. USACE-prescribed ramping limits of "15,000 cfs during any 2-hour period" do not appear to have limited the rate of increase of Folsom releases during the 1986 flood, nor were physical release rate limits at Folsom Dam a constraint given the initial elevation of the reservoir.

"If the Bureau of Reclamation had been able to more closely match outflow to inflows while inflows were less than 115,000 cfs, then releases into the American River would not have exceeded 115,000 cfs during the 1986 flood using the nominal storage capacity of the reservoir, even without anticipation of the Auburn cofferdam failure. Fortunately, disaster was averted by the use of extra surcharge storage in Folsom and by the ability of the downstream channel and levee system to handle releases of 130,000 cfs." Flood Risk Management and the American River Basin, An Evaluation, NRC Committee on Flood Control Alternatives in the American River Basin, National Academy Press, 1995, box 2.2, pp. 46–47.

The 1986 flood did show a height problem with the Natomas East Main Drainage Canal (NEMDC) levee (as constructed) and its upstream levee collectors system, which failed to extend far enough upstream.[7] It was the latter circumstance that caused localized severe flooding behind the NEMDC levee (Strawberry Manor). These deficiencies were remedied by the SAFCA North Area Project of the early 1990s, which was designed with sufficient freeboard for a 180,000 cfs flow in the American River. The North Area Project Feasibility studies characterize the problem and their solution. The American River project levees all had several to many feet of freeboard (vertical distance from the water surface to the top of the levee) in 1986 and showed no signs of serious stress.[8]

By the time that Auburn dam was being planned in the 1950s and 1960s, the standard of federal flood-control planning for high valued urban property and where significant risks to human life existed was the Standard Project Flood (SPF)[9]:

> "A hypothetical flood representing the most severe combination of meteorological and hydrological conditions that is considered reasonably characteristic of the watershed."

The SPF concept was the foundation of the California Floodplain Management Report planning concept called "the reasonably foreseeable flood."[10]

The multipurpose Auburn dam that was authorized by the Congress in 1965 was designed to control a flood of the SPF magnitude, a storm with an inflow into Folsom Dam of 460,000 cfs[11]

---

[7] For an elegant discussion of design levee height and flow criteria and how they differed from actual operational heights and "safe" flows, see Pages 3-17 to 18 of the Folsom Dam Raise & Auxilliary Spillway Alternative Project Alternative Solutions Study (Pass) II, Final Report, June 2006, ACE, Rec Board, DWR, USBR, SAFCA.

[8] A description of design freeboard of American River levees and the 1986 flows was made published in the January 1995 Proceedings of Phase Two, The Lower American River Task Force. The Proceedings assessed existing levee freeboard conditions at various flows along the American river and concluded the following:

> For a release of 115,000 cfs, the existing minimum is the same for both left and right bank levees (about 6 feet). The 130,000 cfs release condition also has about the same freeboard at the lowest point (interpolated to about 5.5 feet). p. L-2, L-3.

[9] The standard project flood methodology was the subject of a Corps engineering manual: USACE, ER 1105-2-101, 1952 revised 1965. It has been updated subsequently.

[10] Final Recommendations Report, California Floodplain Management Task Force, December 2002, p. 58.

[11] Letter From the Secretary of the Interior Transmitting a Report on the Auburn-Folsom South Unit Proposing Expansion of the Central Valley project in California, Pursuant to Section 9(a) of the Reclamation Act of 1939 (53 Stat. 1187), and Section 2 of the American River Basin Development Act of October 14, 1949 (63 Stat. 852), January 18, 1962, House Document #305, 87th Congress, 2nd Session. pp.

or the largest runoff expected for the watershed.[12] Record peak inflows do not exceed 300,000 cfs.[13] The peak of the design flood hydrograph of the Folsom Dam Joint Federal Project is expected to exceed 470,000 cfs. The peak of the design flood of the Folsom Dam Joint Federal Project is expected to exceed 500,000 cfs when forecast-based-release operational plans are created for the new spillways.

It should also be noted that SAFCA is in the process of doing the finishing touches of the Federal "Common Elements" project designed to ensure that the American River levees can (if required) reliably carry up to 160,000 cfs of sustained operational or emergency releases from Folsom Dam. (This flow is the existing target emergency release for Folsom Dam. The emergency release is a flow designed to fully utilize the downstream levee system while not causing levee breaks. Releases in excess of the emergency release are to be avoided for as long as possible when a reservoir is above its normal maximum pool and experiencing large inflows. This is accomplished by allowing the reservoir to rise higher than would normally be allowed.)

Finally, it is not particularly meaningful or appropriate to characterize the performance of the Folsom Dam Joint Federal Project in terms of level of protection. In addition to being 65% larger than any historic flood, 500,000 cfs exceeds the extrapolated estimates of the 200-year flood. The American River rain flood frequency analysis by the Corps of Engineers prepared with the advice of the National Research Council's Committee on American River Flood Frequencies does not extrapolate the frequency curve beyond 1 in 200.[14]

January 7, 2008 *rev 6/15/2008*

16-18. Subsequent planning resulted in Interior recommending an enlarged dam in a supplemental report in the 88th Congress embodied in House Document #171. Congress subsequently authorized this project (see House Report #295, 89th Congress). Following the recommendations of the two reports Congress authorized the Auburn dam project with 250,000 acre-feet acre feet of storage space seasonally allocated to flood control to control the standard project flood. Auburn Folsom South Unit, American River Division, Central Valley Project, Auburn Dam, Reservoir and Powerplant Folsom South Unit, Environmental Statement, November 13, 1972, pp 2–3 & 6–7.

[12] "It provides additional flood control which will protect the Sacramento metropolitan area against all probable floods." Auburn-Folsom South Unit, American River Divsion, Central Valley Project California, House of Representatives Report 295, 89th Congress 1st Session, May 6, 1965, p. 4.

[13] "Based on descriptions of the 1862 event, the Corps supports the position that the estimated volume of the 1862 event should not be less than that of the 1997 event because the 1862 event resembles both the point precipitation and antecedent conditions which occurred during the 1997 event." U.S.A.C.E. Sacramento District, American River, California Rain Flood Flow Frequency Analysis, Feb. 3, 1998. U.S.A.C.E. Sacramento District, Folsom Dam and Lake, American River, California, Water Control Manual, Appendix VIII to Master Water Control Manual, Sacramento River Basin, California, 1987 p. IV.

[14] U.S.A.C.E. Sacramento District, American River, California, Adopted Rain Flood Flow Frequency Analysis, April 1999, plate 1.