California Water Research

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July 13, 2017 **Via email**

The Honorable John Laird
Natural Resources Agency
Sacramento, CA

Cindy Messer,
Acting Director,
Department of Water Resources
Sacramento, CA

Michael Lauffer,
Acting Executive Director
State Water Resources Control Board
Sacramento, CA

Scott Cantrell, Water Branch Chief
Calif. Department of Fish and Wildlife
Sacramento, CA

Charlton Bonham, Director
Calif. Department of Fish and Wildlife
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Randy Fiorini, Chair
Delta Stewardship Council
Sacramento, CA

Brooke Rachel White
California Water Fix Program Manager
Bureau of Reclamation
Sacramento CA

David Murillo, Regional Director
U.S. Bureau of Reclamation
Sacramento, CA

Cc:

Jay Lund, Chair
Delta Independent Science Board
Sacramento, CA

Via email to:, info@baydeltaconservationplan.com, BDCPComments@icfi.com, bdcp.comments@noaa.gov, calwaterfix@water.ca.gov

Re: Comments on BDCP / WaterFix Final EIR/EIS regarding failure to disclose or analyze reservoir operations criteria

Dear Mr. Laird, Ms. Messer, Mr. Lauffer, Mr. Bonham, Mr. Fiorini, Ms. White, and Mr. Murrillo and responsible DWR, DFW, and USBR officials copied by email:

These comments are submitted on behalf of California Water Research.

As documented in the attached report, there has been a failure to disclose State Water Project and Central Valley Project reservoir carryover storage criteria in the BDCP/WaterFix CEQA/NEPA process, and the rule curves used in project operations appear not to have been disclosed in previous regulatory processes or CEQA/NEPA analyses.

The attached report pieces together from information revealed on cross-examination in the WaterFix hearing to show that the State Water Project, as currently operated, takes significant risks with carryover storage to increase average deliveries, with major impacts to water supply reliability and the ability to meet Bay-Delta Water Quality Control Plan requirements.

The report also documents the failure in the BDCP/WaterFix CEQA/NEPA documents to disclose the rule curves or analyze their impacts, as well as misleading and inaccurate statements about reservoir operations and the dead pool conditions shown in the CALSIM modeling for the WaterFix CEQA/NEPA documents.

Please address these issues in a re-circulated Final EIR/EIS.

Sincerely,

Deirdre Des Jardins
Principal, California Water Research

South Fork of Lake Oroville, California's second largest reservoir, on Sept. 5, 2014

Failure to Disclose Changes in Reservoir Operations Criteria

This report documents that the California Department of Water Resources began considering major changes to the State Water Project reservoir carryover storage criteria in the years after the 1982 legislation to authorize the Peripheral Canal was defeated. The changes appear to have greatly increased risks of draining Oroville reservoir in droughts, and greatly diminished the ability of the State Water Project to meet water quality and ecosystem flow obligations in dry and critically dry years.

As explained in this report, the 1983 California Water Plan documents that changes to carryover storage rules were considered to increase average water deliveries, without building new infrastructure. But the analyses of the new rule curves were made in unpublished documents, and Department of Water Resources appears not to have disclosed the actual rule curves used by the Chief Operators in any subsequent regulatory process or CEQA analysis of the impacts of State Water Project operations.

Even less information is available on Central Valley Project carryover storage rule curves, but the available documentation indicates that the rule curves change annually. This was also not discussed or analyzed in regulatory processes or NEPA analyses of the impacts of Central Valley Project Operations.

The changes in State Water Project (SWP) and Central Valley Project (CVP) reservoir carryover storage rules also appear to be related to the failure by the Department of Water Resources to do an adequate historical validation of the CALSIM II simulation of State Water Project and Central Valley project operations. Validation is a standard of practice in simulation development.[1] Failure to follow this standard of practice was noted in the 2003 Strategic Review of CALSIM II by Close et. al., sponsored by the Bay-Delta Authority, and is discussed later in this report.

Lack of disclosure of changes

Lack of disclosure of the changes in SWP and CVP carryover storage criteria was notable in the 1986 EIR/EIS for the Coordinated Operating Agreement,[2] which stated in part,

> Joint commitment of about 2.3 million acre- feet of water supply for Delta outflow during critical water supply periods to meet Exhibit A standards for protection of the environment. This supply is removed from being a potential export source and will provide a benefit by eliminating the direct entrainment of fish at both the Federal and State Delta export facilities that could occur without a commitment to Exhibit A standards. (p. 10)

The EIR/EIS also stated

> The amount and timing of in-basin use is not known to or controlled by the project operators and cannot be readily measured, but the Delta is downstream from all other in-basin uses, and compliance with the Exhibit A requirements or "standards" for the Delta can be monitored. If the Exhibit A standards are being met, all other in-basin use requirements are being met, because the Delta gets only the water that remains after upstream uses have been satisfied. (p. 8)

This lack of disclosure was also notable in the 2006 plan prepared by the Department of Water Resources to meet Decision 1641 requirements, and submitted to the State Water Resources Control Board as directed by Water Code 138.10:

> (a) On or before January 1, 2006, the director, in collaboration with the Secretary of Interior or his or her designee, shall prepare a plan to meet the existing permit and license conditions for which the department has an obligation, as described in the State Water Resources Control Board Decision No. 1641.

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[1] See, for example, US Department of Defense, Instruction 5000.61 on DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), 2003. Available at http://www.public.navy.mil/cotf/OTD/DoDI_MS_VVA_5000.61.pdf.

[2] U.S. Department of Interior, Bureau of Reclamation, Joint Environmental Impact Statement and Environmental Impact Report : Proposed Agreement Between the United States of America and the Department of Water Resources of the State Of California for Coordinated Operation of the Central Valley Project and the State Water Project, 1986. Available at https://archive.org/details/jointenvironment00sacr.

The 2006 plan, entitled, Description of Department of Water Resources Compliance with State Water Resources Control Board Water Right Decision 1641[3], only discussed past compliance with D 1641 requirements, and did not disclose reservoir operations criteria.

Changes in CVP and SWP reservoir operations criteria and rule curves also appear to not have been adequately disclosed or analyzed for the 2008 Long Term Operations Criteria and Plan Biological Assessment (OCAP BA.) In 2010, the National Research Council Review of Environmental Management in the California Bay-Delta[4] noted that there were significant deviations of the simulated storages and exports from the historical data:

> *It is a standard practice to ensure the appropriate use of models through the processes of calibration and testing (ASTM, 2004; NRC 2008)*. Validation of CalSim-II is described in Appendix U of the OCAP BA (USBR, 2008), which provides a comparison of Study 7.0 (existing condition) with the recent historical data. A review of those results shows that there are significant deviations of the historical data from the simulated storages and exports that may be of the same magnitude as the differences between the scenarios being evaluated. Thus, while the tool itself performs well, some questions remain regarding the gross nature of generalized rules used in CalSim-II to operate CVP and SWP systems, relative to actual variability of dynamic operations (USBR, 2008, pages 9-4). (Chapter 4, Use of Models, p. 11)

The Bay Delta Conservation Plan was started in 2006 to "implement a comprehensive strategy for restoring ecological functions of the Delta and improving water supply reliability in the State of California."[5] Appropriate reservoir carryover storage criteria were necessary to achieve these goals. But the actual reservoir carryover storage criteria were not disclosed or analyzed in the Bay Delta Conservation Plan Second Administrative Draft EIR/EIS, the 2013 Bay Delta Conservation Plan Public Draft EIR/EIS, the 2015 WaterFix Partially Recirculated Draft EIR/ Supplemental Draft EIS, and the 2016 WaterFix Final EIR/EIS.

CALSIM II operations simulation results for the May 2013 Bay Delta Conservation Second Administrative Draft EIR/EIS showed the reservoirs being drawn to dead pool in critically dry years in Late Long Term. Water agencies in the Sacramento Valley had begun raising strong concerns about the forecast dead pool conditions.

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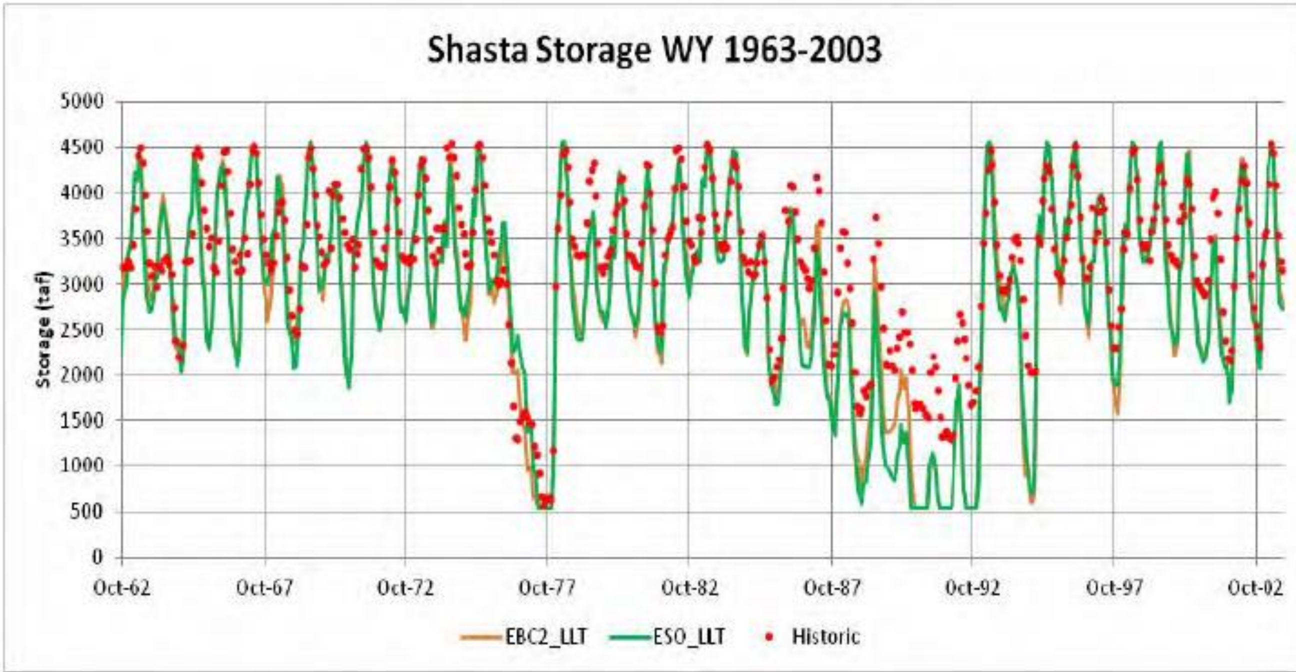
[3] Description of Department of Water Resources Compliance with State Water Resources Control Board Water Right Decision 1641, Response to Senate Bill 1155 Enacting California Water Code Section 138.10. Available at http://baydeltaoffice.water.ca.gov/announcement/D1641_final.pdf. Accessed on June 12, 2017.

[4] National Research Council, Report of the 2010 National Research Council Committee on Sustainable Water and Environmental Management in the California Bay-Delta, entitled, A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endangered Fishes in California's Bay Delta, 2010. Available at http://www.nap.edu/catalog/12881/a-scientific-assessment-of-alternatives-for-reducing-water-management-effects-on-threatened-and-endangered-fishes-in-californias-bay-delta.

[5] Bay Delta Conservation Plan / WaterFix Final EIR/EIS, 2016. Chapter 1, p.1-1. Available at http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Final_EIR-EIS_Chapter_1_-_Introduction.sflb.ashx.



1 Graph of Shasta Storage from Appendix 5A-C of the Second Administrative Draft EIR/EIS

The response was to remove the graphs of sequential annual reservoir operations from the 2013 Public Draft EIR/EIS, and to only include annual exceedance graphs. The Public Draft EIR/EIS also called the CALSIM II operations model results "anomalies." Chapter 5 of the Draft EIR/EIS stated:

> Despite these detailed model inputs and assumptions, the model will still sometimes show in very dry years dead pool conditions that appear to prevent Reclamation and DWR from meeting their contractual obligations to these contractors. <u>Such model results are anomalies</u> that reflect the inability of the model to make real-time policy decisions under extreme circumstances, as the actual (human) operators must do. Thus, any reductions simulated due to reservoir storage conditions being near dead pool for these types of delivery should only be considered an indicator of stressed water supply conditions under that Alternative, and should not necessarily be understood to reflect literally what would occur in the future. In actual future operations, as has always been the case in the past, the project operators would work in real time to satisfy legal and contractual obligations given then current conditions and hydrologic constraints.
> (p. 5-46, underlining added.)

The Draft Bay Delta Conservation Plan EIR/EIS thus failed not only to adequately disclose dead pool conditions in multi-year droughts, but failed to disclose that the dead pool conditions were a consequence of the riskier carryover storage policy, combined with a need for minimum "Health and Safety" pumping by the State Water Project and Central Valley Project in critically dry years.   The language in Chapter 5 of the Draft EIR/EIS continued through the Final EIR/EIS (p.5-47.) Similar language is also in the August 2016 Revised Draft Biological Assessment, which states:

> Under stressed water supply conditions, given the generalized nature of specified operations rules, CalSim II model results should only be considered an indicator of stressed water supply conditions, and should not necessarily be understood to reflect literally what would occur in the future under a given scenario. For example, CalSim II model can result in instances where the required minimum instream flows, or regulatory flow/salinity requirements cannot be achieved, or deliveries to senior water rights holders could be shorted due to extreme water supply conditions in the reservoirs. CalSim II does not currently reflect potential relaxations of standards that the State Water Resources Control Board in coordination with other regulatory agencies might invoke under such dry circumstances. As a result, CalSim II may tend to underestimate reservoir storages and overestimate flows during the most severe droughts. CalSim II also does not account for the compromises and temporary arrangements that are made among stakeholders during such dry circumstances. In reality the operations are managed in close coordination with various regulatory agencies and stakeholders under such extreme circumstances. In actual future operations, the project operators would continue to work in real time to satisfy legal and contractual obligations based on the water supply conditions and other information available at the time. (Appendix 5A, p. 5A-13, underlining added)

As explained in this report, these statements in the WaterFix CEQA/NEPA documents and Biological Assessment are misleading in that they do not clearly indicate that a decision was made by the Department of Water Resources to reduce carryover storage for State Water Project reservoirs in a way which creates stressed water conditions in dry and critically dry years. The impacts of the carryover storage rule curves are thus forseeable consequences of the reservoir operations rules.   The effects of those rules on system reliability are not adequately disclosed or addressed in the WaterFix CEQA/NEPA documents or the WaterFix Biological Assessment.

The effect of changing the reservoir carryover storage criteria was also not analyzed in the WaterFix CEQA/NEPA documents or the WaterFix Biological Assessment, on the basis that the simulation showed the current State Water Project and Central Valley Project reservoir operations continuing into the future.   But as discussed in this report, both the State Water Project and Central Valley Project reservoir carryover targets are regularly changed. Testimony in the WaterFix Hearing revealed that the State Water Project carryover storage rules were changed after experiences in the 2013-2016 drought, and are currently different from the rules in the CALSIM II modeling for the CEQA/NEPA documents.   The Central Valley Project carryover storage rules are reported to change annually.

The following sections discuss these issues in more detail.

Changes to SWP Reservoir Carryover Storage Policies in the 1980s

DWR's 1983 California Water Plan, published as Bulletin 160-83,[6] documents that Oroville reservoir was designed for long-term carryover storage in case of a repeat of the six year drought from 1928-1934. Bulletin 160-83 states:

> A few major reservoirs were developed for long-term carryover storage (water stored for use over several dry years), which means that storage capacity is several times the firm annual yield. Examples of such facilities are Shasta, Oroville, Berryessa, and New Melones. (p. 23)

But DWR proposed to take greater risks with State Water Project carryover storage to increase average deliveries. This was done on the basis that the 1928-1934 drought only had a probability of recurrence of 1 in 200 to 400 years. Not only is this analysis wrong, the risky carryover storage policy appears not to have been changed after the 1987-1992 drought, which happened a few years later.

Bulletin 160-83 states:

> **Supply Dependability and Risk**
>
> The thrust in California water development over the past few decades has been to increase water supplies to match needs, and in many areas, to increase the dependability of supplies. Much attention has been given to this by the SWP and the CVP which were designed to withstand reoccurrence of the 1928-1934 drought. Projects, facilities, and programs of other agencies have similar built-in-risks. <u>But uncertainty regarding the capability of increasing developed supplies over the next several decades may justify and in fact may require taking greater risks in delivering water to customers</u>.
>
> Selection of the 1928-1934 drought to evaluate yield was not based on the relation of drought frequency to cost of facilities. Rather, it was based on the fact that both the CVP and SWP received popular support following the 1928-1934 drought, and Californians wanted the projects to provide essentially a full supply during the entire drought, regardless of its frequency of reoccurrence. Of course, during normal and above-normal years, projects can deliver much more water than is defined as yield under this criterion. Surface water projects of other agencies use different yield-determining dry periods, but the concept is the same. This operational procedure works well where adequate water supplies are already developed to meet existing and future uses. <u>Unfortunately, the State's water uses are outpacing the rate at which increased supplies are being added</u>.

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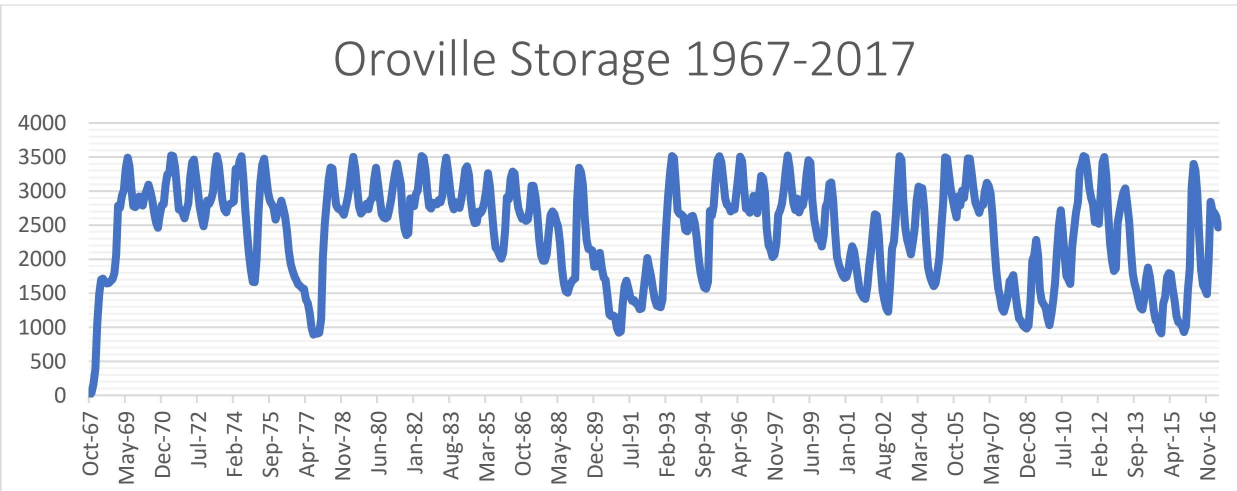
[6] California Department of Water Resources, Bulletin 160-83, The California Water Plan, Projected Use and Available Water Supplies to 2010. Available from DWR's Water Data Library at http://www.water.ca.gov/waterdatalibrary/docs/historic/Bulletins/Bulletin_160/Bulletin_160-83__1983.pdf. Accessed on June 12, 2017.

Some water projects would take greater risks by delivering a higher annual supply, leaving less carryover storage in case of drought. This would allow growing needs to be met in normal years. While the final answer lies in what nature will actually provide, there is a good argument that, in the present era of uncertainty regarding future water development, given the frequency of reoccurrence of droughts, existing facilities may be operating in a more conservative manner than is necessary. The 1928-1934 dry period is estimated to have a reoccurrence of one in 200 to 400 years. However, such dry periods could occur in successive decades. Nevertheless, with such a small frequency probability, it may be that projects should take a greater risk and deliver a higher annual average supply. (p. 255-256, underlining added)

Data from the California Data Exchange Center (CDEC)[7] shows a marked change in minimum storage in Oroville, starting around 1985. The graph below shows monthly storage in Oroville reservoir from October 1967, when the reservoir construction was completed, and May 2017.



Drought Recurrence

The estimate in the 1983 California Water Plan that the 1928-1934 dry period has a recurrence rate of one in 200 to 400 years is not supported by the Sacramento Valley hydrology reconstructed from tree rings by David Meko. The reconstruction was discussed by David Meko et. al. in 2001 article in the Journal of the American Water Resources Association.[8] A

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[7] Monthly storage data for ORO sensor. Available at http://cdec.water.ca.gov/.

[8] Meko, D. M., Therrell, M. D., Baisan, C. H. and Hughes, M. K. (2001), Sacramento River Flow Reconstructed to A.D. 869 from Tree Rings. Journal of the American Water Resources Association, 37: 1029–1039. doi:10.1111/j.1752-1688.2001.tb05530.x. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/PCFFA&IGFR/PCFFA_74_Meko01.pdf. Accessed on June 12, 2017.

table in the article shows that six year droughts of similar severity to the 1928-34 drought occurred in the 1840s and 1780s. (Table 2, p. 7.), giving a frequency of once every 100 years in the past 3 centuries. Six year droughts of lesser severity occur with greater frequency in Meko's tree ring construction. Four years after Bulletin 160-83, the 1987-92 drought began.

Documented changes to the State Water Project Rule Curves

The 1983 California Water Plan, Bulletin 160-83, did not disclose what the actual changes to carryover storage rules. But these changes were disclosed in a 1988 paper in the academic journal Climatic Change by William E. Riebsame, "Adjusting Water Resources Management to Climate Change"[9] Riebsame cited an unpublished 1985 report by DWR, "Evaluation of the State Water Project Rule Curve Procedure," and an unpublished report in 1988, "State Water Project Rule Curve for 1988." The new and old rule curves for total end of year system storage was reproduced by Riebsame on p. 84, and are shown on the following page.

State Water Project Chief Operator John Leahigh testified in the State Water Resources Control Board's WaterFix Change Petition Hearing. The graph was shown to Leahigh on cross-examination in Part 1A of. Leahigh stated in response:

> I wouldn't describe this as any kind of change in operations. The procedures for making delivery determinations have changed many -- many times over the years as far as getting a good balance. (WaterFix Hearing Transcript. August 19, 2016, 22:7-22:20.)[10]

Leahigh also stated,

> There's -- yes, there's always going to be trade-offs with respect to deliveries and average annual deliveries and water supply reliability. Typically, though, we do guard against prolonged period of dry years in our assessment of carryover storages. So that is an aspect that we continue today. (WaterFix Hearing Transcript. August 19, 2016, 24:5-24:11.) [11]

[9] Riebsame, W.E., Adjusting Water Resources Management to Climate Change, Climatic Change (1988) 13: 69-97. doi:10.1007/BF00140162 Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/dd_jardins/DDJ_210.pdf. Accessed on June 12, 2017.

[10] State Water Resources Control Board, California WaterFix Change Petition Hearing Transcript, August 19, 2016. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/docs/transcripts/20160819_transcript.pdf. Accessed on June 16, 2017.

[11] Ibid.

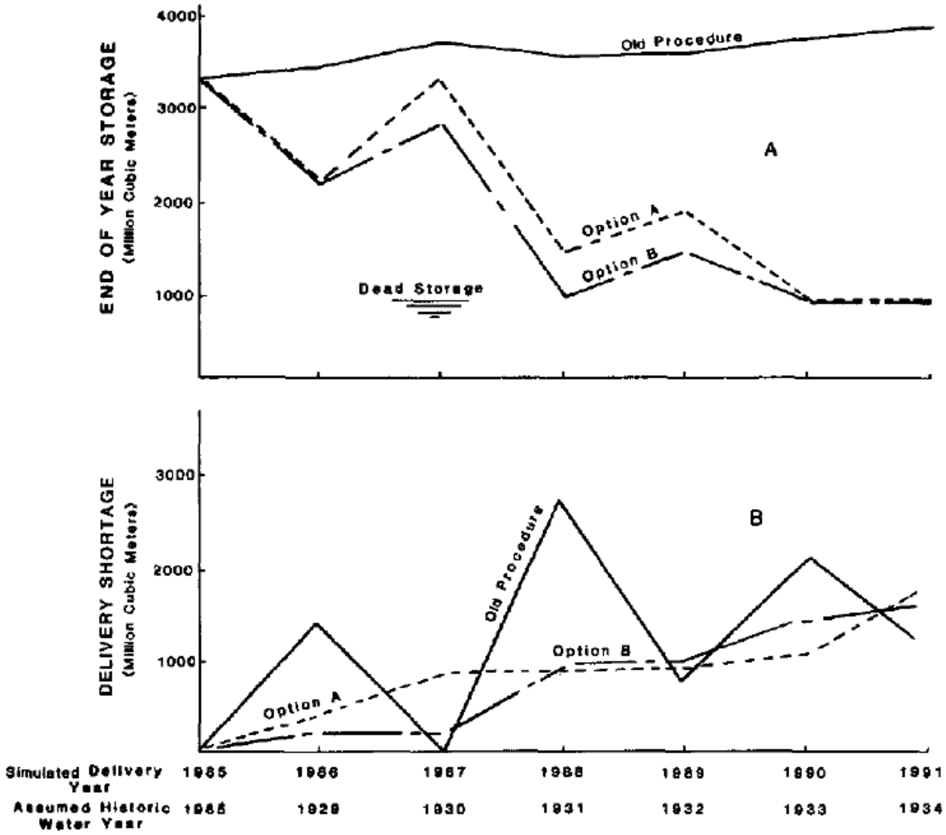


Fig. 5. Simulated SWP operations based on the 1977 rule curve and two alternatives proposed in 1985, for a hypothetical drought beginning with 1985 precipitation and storage conditions, and following the pattern of the 1929–34 design drought: (a) Total project storage at the end of each simulated year; (b) Delivery shortfalls from contract amounts. Source: California Department of Water Resources.

2 DWR's unpublished 1985 rule curve analysis, reproduced in Riebsame, p. 84.

Chris Schutes, analyst for the California Sportfishing Protection Alliance (CSPA) testified in Part 1B of the WaterFix hearing that the State Water Project and Central Valley Project systematically leave insufficient water in storage to meet water quality standards in dry and critically dry years.[12]

> CalSim II modeling in support of the proposed CWF does not clarify baseline reservoir operations, No Action Alternative reservoir operations, or planned reservoir operations under CWF. The reservoir levels simulated in CalSim II model runs in support of CWF

[12] State Water Resources Control Board, California WaterFix Change Petition Hearing, Exhibit CSPA-4, Testimony of Chris Schutes. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/CSPA%20et%20al/cspa_4.pdf. Accessed on June 18, 2017.

are not binding on SWP and CVP operators, and the documentation for the modeling does not describe the actual rules that govern the modeled operations.

[…] There is no basis to assume that additional diversion of unregulated flow using CWF facilities will reduce pressure on SWP and CVP reservoirs. Instead, it is much more reasonable to expect that the availability of greater, more frequent and more efficient export capacity because of CWF will add unregulated exports to existing and in some cases greater levels of export of stored water.

[…] Over the past 15 years, and particularly during the 2012-2015 drought period, operation of SWP and CVP reservoirs already affected legal users of water by limiting water supplies and degrading water quality in the Sacramento – San Joaquin Bay-Delta. (p. 3-4)

Leahigh stated in written rebuttal testimony[13]

> the track record of the Projects for meeting water quality standards has been excellent other than for recent examples… Based on this record, I find the broad assertion by CSPA that the Projects systematically leave insufficient water in storage to meet water quality standards to be without merit. (p. 7:11-16.)

There was no way to examine this assertion, because the Operations and Control Office of the Department of Water Resources did not disclose the actual carryover storage criteria. However, during rebuttal cross-examination by Chris Schutes for the California SportFishing Protection Alliance, John Leahigh testified that the monthly water operations report to the State Water Contractors contained an equation which set Oroville reservoir carryover storage targets (May 9, 2017 transcript, 8:19-9:17.)[14] The Department of Water Resources provided a copy of the February 2012 report for the hearing.[15] The equation, on p. 7, states:

Eq 1 Lake Oroville storage target = 1.000 MAF + "F" x (3.045 MAF - 1.000 MAF) on September 30; where "F" = 1/2 x Possible Table A %.

The equation, which dates to 2005, sets target storage for Lake Oroville for the following End of September (EOS.) The value is 1.000 MAF = F x (Previous EOS – 1.000 MAF.) In the

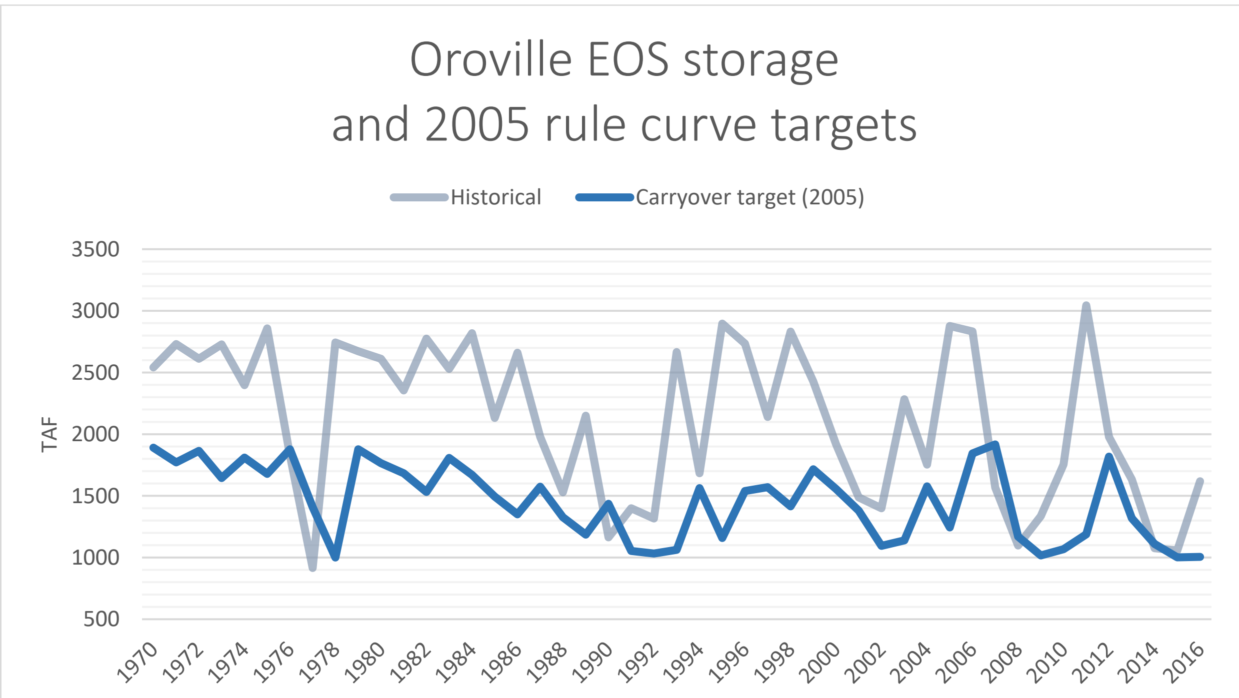
[13] State Water Resources Control Board, California WaterFix Change Petition Hearing, Exhibit DWR-78, Rebuttal Testimony of John Leahigh, Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/petitioners_exhibit/dwr/DWR-78.pdf. Accessed on June 16, 2017.

[14] State Water Resources Control Board, WaterFix Change Petition Hearing Transcript. May 29, 2017. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/docs/transcripts/20170509_transcript.pdf.

[15] Department of Water Resources Exhibit 902, Water Operations Committee Meeting Notes, February 29, 2012. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/petitioners_exhibit/dwr/dwr_902_swp.pdf

equation , the value of 3.045 MAF was the storage at the end of September 2011. Leahigh testified that the formula used the storage from the previous September to set a storage target, multiplied by the forecast Table A allocation. As the forecast Table A allocation increases, the storage target increases, until there was a final storage allocation and final storage target. But the EOS storage target is quite low compared to actual historical EOS storage.

Using historical EOS storage for Oroville reservoir, one can compare the historical EOS storage with the target under the 2005 rule, had this rule been in operation. The graph on the following page shows the historical EOS storage and target EOS storage.[16] End of September storage appears to only recover during wet years when exports are not dependent on reservoir releases.



[16] Table A percent allocations in notices to State Water Project contractors were historically calculated by several different procedures. The calculation uses the announced Table A allocation, and divides by the total State Water Project Contracts in that year to get an allocation percentage. The announced allocation is different from the actual Table A deliveries.

2014 Temporary Urgency Change Petition

The January 2014 Temporary Urgency Change Petition stated that a primary reason for the TUCP was that Oroville carryover storage was very low at 1.2 million acre-feet (MAF):

> Extremely low reservoir storage levels are forecasted for this year in Northern California, in some cases surpassing prior record low levels. At this time, total storage at the SWP's Lake Oroville is roughly 1.2 million acre-feet (MAF), and the total combined storage at the CVP's Shasta and Folsom reservoirs is also very low at about 1.8 MAF. Storage in all three reservoirs is below what they were at this time in 1977 when the state was in a severe drought (see http://cdec.water.ca.gov/cgi-progs/products/rescond.pdf).

The EOS storage in 2013 had been 1.6 million acre-feet, which was too low if there was a dry fall, which happened in 2013. Thus the rule drives carryover storage down sufficiently that Temporary Urgency Change Petitions may be needed.

Environmental groups protested the relaxation of minimum ecosystem flows under Decision 1641 in the 2014 Temporary Urgency Change Petition.[17] California Sportfishing Protection Alliance et. al. commented on the high levels of exports and dramatic reduction in storage in reservoirs north of the Delta in 2012 and 2013.[18]

> Huge carryover storage from the (very) wet water year 2011 allowed the major CVP and SWP (Projects) reservoirs north of Delta to fill in 2012, despite the fact that water year 2012 was a below normal year. Between May 2012 and February 2014, combined storage in Folsom, Shasta and Oroville dropped from 8,941,671 AF to 2,916,297 AF. (CDEC). Total exports for water year 2013 were just over 4,000,000 AF. (Bureau of Reclamation data). The Projects exported almost 1,700,000 AF between June 2013 and September 2013. (Bureau of Reclamation data) The Projects continued to export throughout the fall: though there was almost no precipitation, and had been none since December, 2012. Indeed, some 589 TAF of water was exported from October through December,1 at levels ranging above 10,000 AF per day in November and above 5,000 AF per day through December (CDEC). (p. 1.)

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[17] See, for example, March 2014 comments by Kate Poole fore the Natural Resources Defense Council, Pacific Coast Federation of Fishermen's Associations and the Institute for Fisheries Resources, Golden Gate Salmon Association, Defenders of Wildlife, and The Bay Institute. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/comments/nrdcetal_poole031714.pdf

[18] California Sportfishing Protection Alliance, AquAlliance, and California Water Impact Network. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/comments/cspa_shutes030314.pdf

The table below shows historic Oroville End of September storage and carryover targets with the 2005 rule, computed from the previous year's actual End of September storage.

Storage below 1.6 MAF, which was the storage in September 2013, is highlighted in yellow. Storage values below 1.3 MAF are highlighted in red. It seems likely that all of the red highlighted storages would make it impossible for the projects to meet Decision 1641 Water Quality Control Plan requirements, as could the yellow highlighted storages in dry or critically dry years. This is not conservative operation of Oroville reservoir.

Oroville End of September Storage and computed carryover targets

(Using 2005 rule.)

Yellow – below 1.6 MAF Red – below 1.3 MAF

Date	Year Type	Historical TAF	Carryover target TAF
1970	W	2542	1890
1971	W	2730	1771
1972	BN	2612	1865
1973	AN	2729	1645
1974	W	2397	1810
1975	W	2857	1678
1976	C	1828	1878
1977	C	915	1409
1978	AN	2744	1000
1979	BN	2672	1877
1980	AN	2611	1765
1981	D	2354	1684
1982	W	2775	1531
1983	W	2529	1808
1984	W	2818	1670
1985	D	2132	1494
1986	W	2661	1351
1987	D	1979	1575
1988	C	1529	1327
1989	D	2150	1186
1990	C	1163	1436
1991	C	1399	1053
1992	C	1317	1033
1993	AN	2666	1063

1994	C	1683	1562
1995	W	2897	1158
1996	W	2735	1540
1997	W	2140	1570
1998	W	2831	1416
1999	W	2428	1715
2000	AN	1920	1557
2001	D	1488	1380
2002	D	1400	1094
2003	AN	2284	1139
2004	BN	1753	1578
2005	AN	2877	1245
2006	W	2833	1844
2007	D	1568	1917
2008	C	1097	1170
2009	D	1337	1017
2010	BN	1755	1067
2011	W	3045	1189
2012	BN	1977	1818
2013	D	1633	1318
2014	C	1076	1111
2015	C	1057	1002
2016	BN	1619	1006

Other changes to Oroville carryover storage targets

Leahigh testified that "various forms" of the equation had governed Oroville reservoir carryover storage targets for the past 20 years.

> MR. SHUTES: Very good. Thank you. Where did this equation come from? What – What is the derivation of it?
>
> WITNESS LEAHIGH: So this -- this equation -- this particular one . . . So, we've had various forms of this throughout my tenure with State Water Project operations, so for the last 20 years. We've had essentially something similar to this type of equation as an expression of that policy for at least the last 20 years, since I've been involved in my current role.
>
> (May 9, 2017 transcript, 15:3-14.)

There is documentation that in 2005, the reservoir carryover storage policy was relaxed even further. In 2005, Ryan Wilbur gave a presentation to the California Water and Environmental

Modeling Forum (CWEMF)[19] on a comparative CALSIM II study done on modifying the Oroville carryover targets for the State Water Project Operations and Control Office. The presentation states:

> DWR SWP Operations Control Office Requested analysis of water supply guidelines used to develop SWP allocations (p. 2)

Ryan Wilbur's 2005 CWEMF presentation was shown to John Leahigh on cross-examination on May 11, 2017.[20] Leahigh acknowleged this consultation.

The table in Wilbur's CWEMF presentation showing the pre-2005 Oroville carryover target rule and 2005 carryover target rule is shown below (from p. 7.)

Ex.	Forecasted Hydrology	Oroville Carryover Target Rule	Description
A	Jan-Mar 99% Apr-May 90%	1+0.5*(Sep-1) MAF	WSI-DI
B	Jan 95% Feb-May 99%	1+0.5*(Sep-1) MAF	Pre-2005 Rules
C	Jan-May 90%	1+X*(Sep-1) MAF X=0.5*Allocation%	2005 Rules

The table shows that before 2005, the carryover target was 1 million acre feet + 0.5 * (previous September – 1 million acre feet). This means that the target uses a "floor" of 1 million acre feet, then adds half of the amount of End of September Storage from the previous year, over 1 million acre feet.

The 2005 rule changed to 1 million acre feet +X*(previous September - 1 million acre feet), where X = 0.5*allocation%. (The allocation% is the Table A allocation.) Since Table A allocations are low in dry years, multiplying by the Table A allocation will quickly drive reservoir carryover targets down to 1 million acre feet in multiple dry years. Testimony by Mr. Leahigh stated that the 2005 rule was the rule until recently.

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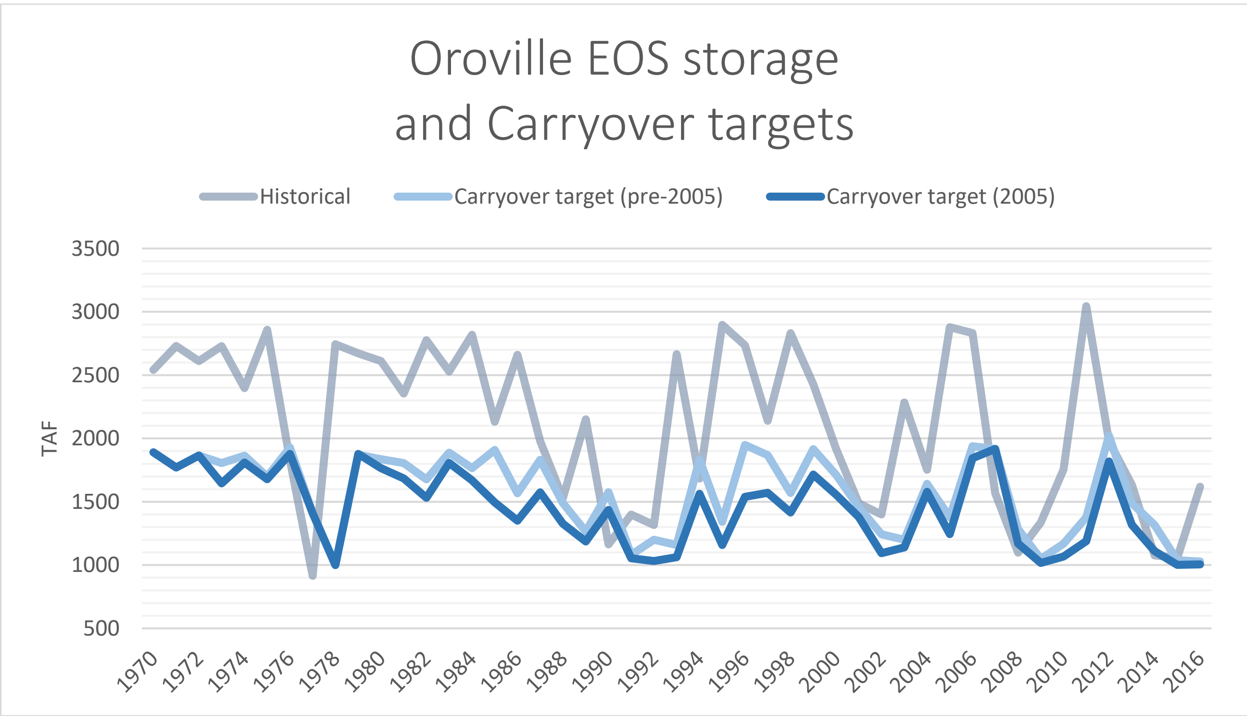
[19] Ryan Wilbur, CalSim-II Allocations Module for State Water Project Simulation, California Water and Environmental Modeling Forum, March 1-3, 2005. Available at http://www.cwemf.org/Asilomar/Wilbur.pdf

[20] State Water Resources Control Board, WaterFix Change Petition Hearing Transcript, May 11, 2017 65:21-23. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/docs/transcripts/20170511_transcript.pdf.

Wilbur's CWEMF presentation states that the reason for the change was that the pre-2005 rule was "too conservative."

> The pre-2005 operating guidelines are very conservative and provides room for improvements in delivery capability with little risk of lower reservoir storages
>
> This analysis provided the basis for the 2005 SWP water supply guidelines update used for determining allocations (p. 11.)

The table below shows historical carryover storage, and carryover targets computed using the pre-2005 and 2005 rules. The reason there was little risk of lower reservoir storages than with the pre-2005 rule, is that the pre-2005 rule already had very low carryover storage targets.



Mr. Leahigh testified that, after the 2013-2016 drought, the"floor" in the Oroville target formula increased to 1.3 million acre feet, which would change the curve to that shown below. This is likely not enough of an increase in carryover storage targets, given that the 2013 End of September carryover storage was about 1.6 million acre-feet.

> **Eq 2 Lake Oroville storage target = 1.300 MAF + "F" x (3.045 MAF - 1.300 MAF) on September 30; where "F" = 1/2 x Possible Table A %.**

Central Valley Project carryover storage targets change annually

The Central Valley Project also apparently does not disclose carryover storage targets, which old reporst show as changingannually. In 2000, as part of a 2000 series of workshops on the Central Valley Project Municipal and Industrial (M&I) contract shortage policy, the M&I contractors asked about the mechanism for determining allocations.[21] The response indicated that the operating criteria are based on the 1992 Central Valley Project Operations Criteria and Plan (CVP-OCAP):

> **What operating criteria should apply during shortages?**
>
> We currently operate under the CVP Operations Criteria and Plan (CVP-OCAP) developed in 1992 as modified by policies and agreements to meet the ever changing environment. The 1992 CVP-OCAP identified the many factors influencing the physical and institutional conditions and decision-making process under which the project operated at that time. Regulatory and legal requirements were explained, alternatives operating models and strategies described, and the Water Year Operations Plan were provided. Elements of the CVP-OCAP have changed since 1992 as a result of regulatory requirements mentioned above, i.e., the Water Quality Plan, the B-2 Accounting, the ESA, etc. (p. 5.)

The1992 CVP-OCAP stated that the actual carryover storage targets change annually as part of the "process of allocating CVP supplies"[22]:

> **Water Supply for the Upcoming Year**
>
> No reliable forecasts exist which are capable of predicting hydrologic conditions for the upcoming water year. Operators must assume that conditions may range from drought to flood. For this reason, reservoir's must be operated with consideration for some degree of protection for future supplies in the event of dry conditions. The volume of water or carryover storage that CVP operators attempt to retain in the reservoirs at the end of September forms the initial basis for the water supply for the upcoming year. During years when water is scarce, the objectives for carryover storage influence the amount of water available to meet water requests. Reclamation does not have a standing policy on carryover storage; rather, it has established annual carryover storage objectives as part of the process of allocating CVP water supplies. Carryover objectives consider existing water demands, forecasted water supply, cold water supplies, power system requirements and other CVP capabilities. Carryover storage objectives also consider the risks of

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[21] U.S. Bureau of Reclamation, Mid-Pacific Region, M&I Shortage Policy - Central Valley Project, Issue #6: Available at https://www.usbr.gov/mp/cvpia/3404c/mi_shortage/docs/workshop_11-21-00/pos6_allocation_process.pdf.

[22] U.S. Bureau of Reclamation, Mid-Pacific Region, 1992 Long Term Central Valley Project Operations Criteria and Plan. Available at https://archive.org/details/longtermcentralv00sacr.

continued droughts and possible impacts beyond the end of the current water year. In carrying out CVP operations, carryover storage is considered flexible. Early in the water year (October- November), a carryover storage objective may be used to help determine CVP capabilities. Once the rainy season is over (in May), objectives for CVP operations are generally fixed and CVP storage may vary as necessary to meet these objectives. Actual carryover storage may be affected by contingencies affecting CVP operations, unforeseen hydrologic events, and variations from forecasted inflows.

The M&I contractors also asked about operation and allocation trigger mechanisms for determining shortages between 75% and 100%. The response indicated that actual carryover targets continued to change annually[23]:

Carryover Storage and Water Allocation

Providing the water needed for contractor's beneficial uses requires a strategy that recognizes two competing requirements: 1) the need to retain sufficient carryover storage to reduce the risks of future shortages and to ensure sufficient temperature control capability; and 2) the need to draw from storage in a given year to provide sufficient water delivery to avert health, safety, economic, and environmental hardship.

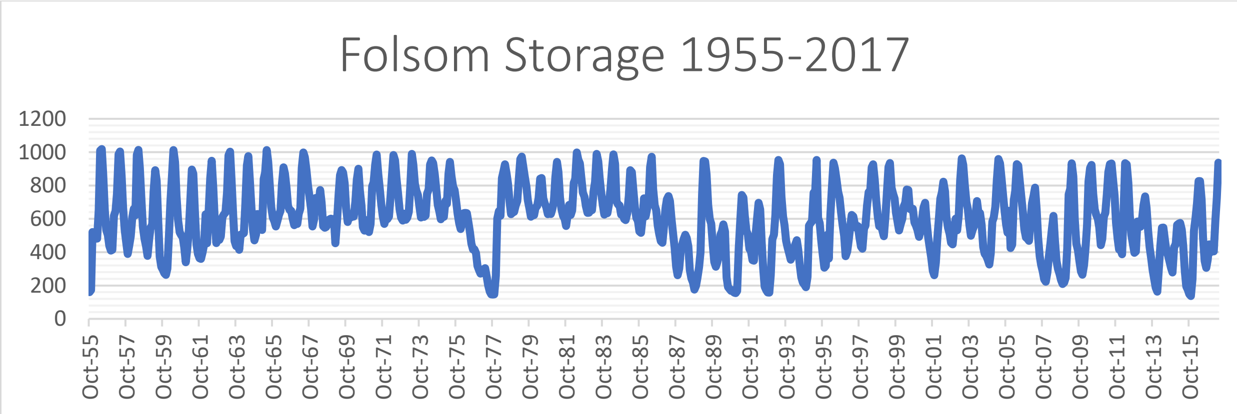
Since the implementation of the NMFS biological opinion in 1993, CVP carryover storage is primarily an outcome of the annual balancing of the requirements to manage storage and releases to provide for upper Sacramento River temperature control, with the use of CVP storage, diversion and conveyance facilities to make water available for other beneficial uses, including instream flows, water quality, water delivery and CVPIA purposes .

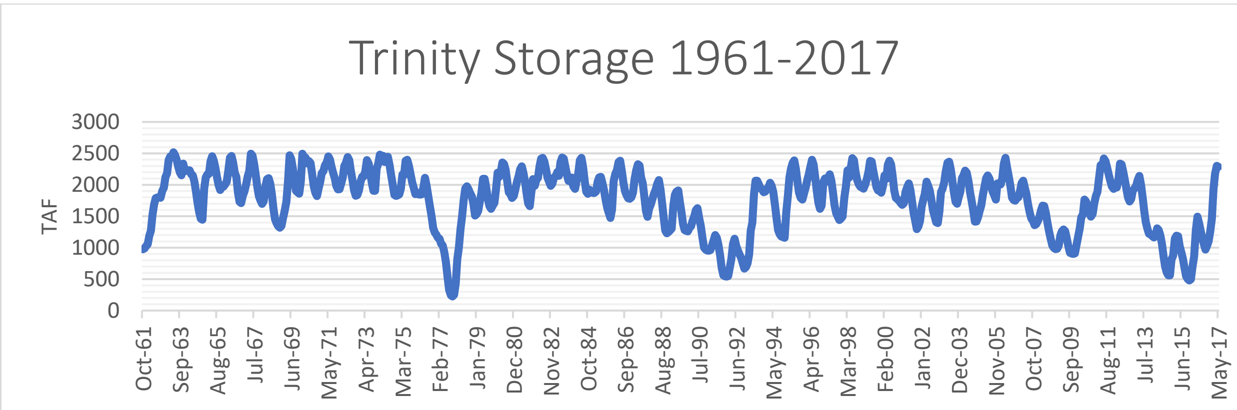
Data from the California Data Exchange Center (CDEC) show a marked change in minimum storage for Folsom reservoir, starting around 1985.[24] CDEC data shows similar but lesser changes in minimum storage for Trinity reservoir.[25]

[23] U.S. Bureau of Reclamation, Mid-Pacific Region, November 21, 2000 M&I Shortage Policy workshop, Issue #5: Forecast Procedures https://www.usbr.gov/mp/cvpia/3404c/mi_shortage/docs/workshop_11-21-00/pos5_forecast_predictions.pdf.

[24] California Data Exchange Center, Monthly storage data for FOL sensor. Available at http://cdec.water.ca.gov/.

[25] California Data Exchange Center, Monthly storage data for CLE sensor. Available at http://cdec.water.ca.gov/.





The 2003 CALSIM II Historic Operations Study

The historic validation of the CALSIM II operations model in 2003 would normally have shown major discrepancies between the modeled carryover storage and the actual carryover storage in pre-1986 years, related to the increased risks taken with carryover storage. However, when the Department of Water Resources and the U.S. Bureau of Reclamation did the 2003 Historic Operations Simulation[26], the demands were set to actual deliveries in years with no restriction, and to the contractors' request in years with restriction, which was significantly less than the full Table A amounts that have been requested since around 2000. (Table 5.) Changing the demands in this way would obfuscate the differences caused by changing carryover storage rules.

[26] California Department of Water Resources, Bay-Delta Office, CalSim II Simulation of Historical SWP-CVP Operations, Technical Memorandum Report, November 2003. Available at http://www.science.calwater.ca.gov/pdf/CalSimII_Simulation.pdf.

The Historic Operations Simulation report was presented for the 2003 review of CALSIM II by Close et. al., organized by the Bay-Delta Authority.[27] The review panel noted:

> Because the SWP south of delta demands were set to historical deliveries in many years, comparison with the historical deliveries in the validation report is of limited validity. (p. 68)

The review panel also noted:

> Most successful applications of optimization that attempt to simulate the behavior of a system have calibrated their objective functions (i.e., set the weights that prioritize flows over time and space) so that the model results correspond to what actually happens or would happen under a particular hydrologic and demand scenario. In these cases the model's decisions correspond to those the operators would make, as often prescribed by rules that have been worked out in a legal/political process. It does not appear that such a calibration of the objective function weights in CALSIM has yet been completed. (p. 4)

The review panel recommended that the validation presented in the Historic Operations Simulation report be re-done. The Department of Water Resources stated in the 2004 response to the review panel[28] that reservoir operations policy could change:

> In discussing the merits of calibration it is important to distinguish between physical parameters that remain essentially constant (e.g. stream-bed conductance), and behavioral parameters that may change and adapt (e.g. reservoir operating policy).
> …
>
> DWR and Reclamation suggest that a more reasonable approach to defining behavioral parameters is through discussions with system operators to define current operational policy or rules. California's water system, especially with regard to the Delta, has undergone many changes in the 1990s (Delta Water Quality Control Plan, CalFed, ESA actions, CVPIA (b)(2), Environmental Water Account) so that calibration to historical practice has limited value. It would appear more reasonable to define operating rules in conversations with operators and subsequently use a recent wet, normal and dry year in a validation exercise. (p. 19, emphasis in original)

However, since 2004, no limited validation exercise has been reported. The failure to validate the CALSIM II modeling of reservoir operations appears to be related to the failure to disclose the changes in reservoir operations criteria.

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[27] Close et. al., "A Strategic Review of CALSIM II and its Use for Water Planning, Management, and Operations in Central California," report of the Strategic Review of CALSIM II, sponsored by the Bay-Delta Authority Science Program, (December 2003.) Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/daviswoodland/daviswoodland_cspa_es9.pdf.

[28] Department of Water Resources and US Bureau of Reclamation, August 2004 response by the to the 2003 Strategic Review, entitled, "PEER REVIEW RESPONSE: A Report by DWR/Reclamation in Reply to the Peer Review of the CalSim-II Model Sponsored by the CALFED Science Program in December 2003," (August 2004) Available at http://baydeltaoffice.water.ca.gov/modeling/hydrology/Peer%20Review%20Response%20(August%202004).pdf.