California WaterFix Hearing
Exhibit No. DOI-43

Introduction

My name is Nancy Parker. I am a water resources engineer with the Bureau of Reclamation's Technical Service Center in Denver, Colorado and my expertise is in river systems modeling and other hydrologic analyses. I have over 20 years of experience modeling the CVP/SWP system and am one of the original developers of CalSim. I work closely with multiple Divisions in Reclamation's Mid Pacific Region, providing modeling analysis to support a range of planning and operations studies. My statement of qualifications has previously been submitted as DOI-35.

My rebuttal testimony for Part 2 of the California WaterFix Change in Point of Diversion Hearings will focus on the following topics:

- Rebuttal to other parties' testimony requesting that the Board adopt NMFS's 2017 Draft Proposed Amendment to the Shasta Reservoir Reasonable and Prudent Alternative (Shasta RPA) from the 2009 Biological Opinion, as a condition on approval of the California WaterFix. This criteria is not feasible, limits CVP operational flexibility, and is not related to the WaterFix petition.
- Rebuttal to claims that the WaterFix causes reductions in Folsom storage conditions. Such claims are misleading and mis-characterize the impacts of the California WaterFix.
- Rebuttal to ARWA's testimony requesting that the Board adopt the Modified American River Flow Management Standard as a condition on approval of the California WaterFix. This criteria limits CVP operational flexibility and is not related to the WaterFix petition.
- Rebuttal to claims of impact of the California WaterFix on Trinity Reservoir conditions and releases. Such claims are unfounded.

To re-iterate consistent petitioner testimony, analysis performed for this hearing demonstrates that the California WaterFix does not adversely affect CVP or SWP storage or contract obligations, and it is my opinion that proposed terms and conditions are not analytically related to the WaterFix permit application. Furthermore, Reclamation operates CVP facilities in a fully integrated manner, and flexibility is key to achieving the multiple purposes of the CVP, including its regulatory obligations. Facility-specific storage criteria severely limits this flexibility, and other parties have not fully, or in some cases at all, analyzed the conditions they propose. My testimony will focus on the re-directed impacts, utter ineffectiveness, infeasibilties, and lack of relationship to the CWF of the criteria being proposed.

Terminology

2006FMS	CalSim study of ARWA baseline American River Flow Management Standard
ModFMS	CalSim study of ARWA proposed Modified American River Flow Management Standard
Q5	CalSim input dataset of inflows and hydrologic conditions affected by Early Long Term (2025-centered) central tendency climate change, along with assumptions of 15 cm Sea Level Rise
Q0	CalSim input dataset of inflows and hydrologic conditions reflecting recorded historical data, along with an assumption of no Sea Level Rise

Rebuttal Addressing Proposals to Adopt NMFS 2017 Draft Proposed Shasta RPA Amendment

NRDC and a few other protestants have suggested that the Board implement criteria specified in the NMFS 2017 Draft Proposed Shasta RPA Amendment (NMFS DPA) as a condition on a permit for the California WaterFix, contending that this is necessary to protect cold water-dependent resources of the Sacramento River. This proposal is not supported by my analysis. Petitioner model results demonstrate that the CWF does not adversely affect North of Delta conditions, including Shasta storage levels or releases. No analysis has been done by protestants to demonstrate how these criteria might affect operations in the Sacramento San Joaquin Bay Delta System. This is irresponsible, given the drastic departure from current regulations that these criteria imply.

I have analyzed the NMFS DPA using both CalSim modeling and a spreadsheet application based on historical data, and Reclamation has presented my analysis in multiple stakeholder meetings. It is my opinion that the NMFS DPA criteria are not supported by Sacramento River hydrology. Reclamation has not agreed with NMFS that the 2009 Biological Opinion RPA for Shasta can or should be revised as set forth in the NMFS DPA through the adaptive management provisions in the BO. The temperature management plan that was submitted in May 2018, and received concurrence from NMFS in the same month, is not consistent with the criteria in the draft proposal. Reclamation is continuing to work with NMFS on appropriate revisions to the RPA through the Reinitiation of Consultation on Long Term Operations process.

Selected NMFS DPA criteria are shown in Table 1. This testimony will address the storage targets for spring fill and end-of-September carryover, as well as spring limits on Keswick release. These criteria are all specified by Sacramento Index water year type.

Operations for Spring Fill Targets

An analysis was done to test the hydrologic viability of producing the conditions called for in the NMFS proposal. This analysis answered the following question: "Assuming that the NMFS end-of-September carryover target is met, what is the capability of meeting the spring fill target in the following water year, assuming only minimum release?"

For example, from a wet year carryover requirement of 3200 TAF, if the following water year is dry, Shasta would need to gain 700 TAF (3900-3200=700), plus any losses due to evaporation and seepage, to fulfill NMFS's spring proposed storage requirement. Similarly, from a dry year carryover requirement of 2200 TAF, if the following year is above normal, a storage gain of 2000 TAF is needed to meet the fill target of 4200 TAF. There are multiple year over year sequences of water year types. Figure 1 shows the results of this analysis using historical hydrology for the period of record 1922-2017. This analysis tested an October 1 – April 30 operation, picking the mid-point in NMFS' spring period (April 1 – May 31) for convenience. For each year, the volume of water calculated as the total October-April inflow minus a constant release of 3250 cfs was compared to the volume of storage gain necessary to meet the NMFS DPA criteria. Note that 3250 cfs is a minimum flow condition for Keswick release based SWRCB Order 90-5 and it is a reasonable minimum value to assume for the purpose of this exercise. The line in Figure 1 is the break-even point, where inflow minus release is sufficient. The plot shows a number of points which are below the threshold line, indicating years when the available water supply is not enough to fill Shasta to the NMFS DPA levels.

This analysis was repeated for multiple climate change scenarios. Every scenario resulted in numerous points below the break-even line – similar to what is shown in Figure 1. Summary information is presented in Table 2 for how many years of which year type showed a shortfall in meeting the fill criteria, including the average amount by which the criteria was missed. In most critical years, even when assuming that previous year September carryover targets are met, the fill targets proposed by NMFS cannot be achieved even with the limited release of 3250 cfs. The same is true in up to 20% of dry years.

Of course, the steady 3250 cfs release in this analysis is a minimal assumption – higher releases are commonly necessary for delta water quality, flood control, and other flow requirements, in addition to water supply. If these higher releases were to be considered, there would be a far greater inability to meet the NMFS DPA fill targets in more years and wetter water year types.

Operations for September Carryover Targets

A similar approach was taken for investigating the September carryover target. Here, we asked "if the peak spring target is met, what is the capability for the September carryover target to be met?" This question was posed to CalSim results from Petitioners' No Action Alternative, which serves as a reasonable, baseline depiction of how Shasta may be managed to address multiple project obligations under a range of hydrology conditions. Table 3 shows a summary of years in which model results meet NMFS' proposed spring fill targets but do not meet their end-of-September carryover targets. The questions are "why not" and "by how much"? The table shows which criteria control Shasta release specifically (WS = Wilkins Slough minimum flow requirement, FC = flood control) or CVP releases generally (Delta criteria for X2, Net Delta Outflow, or Water Quality) in June through September. These results reflect the CVP allocations and senior water right requirements in the No Action Alternative. The 5th column in this table specifies the volume by which the study missed the September carryover target. This is June-September delivery that would have to be foregone to keep water in storage to meet the carryover target – volumes that sometimes represent more than just the allocations to CVP Service contractors and could reduce senior water right holders and/or flows to meet Delta requirements. Summer delivery curtailments would have repercussions across the whole year, considering the broader monthly distribution of annual demands.

It is notable that these years are almost all Wet or Above Normal types, and that releases to meet FWS Biological Opinion Delta outflows for Fall X2 (which top 10,000 cfs) are typically controlling in the month (September) when Shasta falls below the 3200 TAF target. A key message from Table 3 is that 27 of the 39 Wet and Above Normal years could not meet the September criteria without deep cuts to deliveries even in years when Shasta fills. Logically in the wet and above normal year types when the spring fill levels are NOT met, and even more so in drier year types, Shasta would have an even greater challenge in meeting fall carryover requirements. These challenges would likely shift more responsibility for Delta and flow criteria to Trinity and Folsom. These storage targets, even the ones that are physically feasible, would fundamentally strangle the operational flexibility of the CVP to serve all of its multiple purposes.

Comparison of Proposed NMFS Criteria to Historical Operations

Figure 2 shows historical spring peak and End-of-September storage conditions for years 2008-2017, and shows NMFS DPA targets as black horizontal dashes. In these recent years, NMFS DPA criteria would not have been met in dry and critical water year types. Extremely dry years, especially when occurring in sequence, simply did not have the inflows to support the proposed spring fill criteria. Many of the past

10 years have seen severely limited CVP allocations, especially in Dry and Critical years. Under these conditions, Shasta releases have been made under close coordination with FWS, NMFS, DWR, and the SWRCB to primarily support in-stream flows and Delta water quality. The hydrology in these conditions, combined with often-competing regulatory demands, simply does not support meeting the NMFS DPA criteria.

April Flow Criteria

NMFS has proposed water year type based Keswick release thresholds in April and May with the intention of conserving storage for maintaining cold water pool in Shasta. The inherent nature of a storage operation is to conserve spring runoff, and both historical and modeled data demonstrate that the NMFS DPA levels are consistent with Reclamation's efforts to do exactly that. But the April criteria in particular is problematic when viewed in the contexts of both hydrology and operations to meet CVP obligations and system regulatory criteria.

Figure 3 shows average monthly historical releases at Keswick (CDEC) for 1994 -2017. In many cases, the NMFS DPA threshold criteria is met, but there are clearly years when flood control forces higher releases. Other years which exceed the threshold by smaller margins occur in every water year type. To examine the potential reasons for this, I analyzed April results from Petitioners' CWF NAA CalSim study. Table 4 shows a summary of all April Keswick releases. The primary reason for missing the criteria in wetter years is flood control release - occurring in about one third of all wet and above normal water years. NAA model results show releases above proposed NMFS levels in 18 of the 43 drier years, and in most of those instances Shasta is releasing, at least in part, to meet minimum flows at Wilkins Slough, Delta outflow or water quality.

Reclamation generally operates Shasta to minimize releases in April and conserve water in storage where possible. NMFS' April flow criteria is in line with this goal; however the inflexible limitation ignores many of the responsibilities that Reclamation meets with releases from Shasta and limits the flexibility of the CVP to meet its numerous obligations.

Conclusion on NMFS Proposed RPA Amendment

Reclamation understands that NMFS’ intent in proposing storage targets and spring flow thresholds was to produce storage conditions supportive of cold water resources for Sacramento River fish. Extensive analysis has shown that these criteria are infeasible, from both hydrologic (e.g. insufficient natural inflow) and operational (e.g. flood control) bases.

In wetter years, the storage criteria severely reduce the active storage pool available to meet regulatory and delivery responsibilities of the CVP, and promote conditions that increase winter spills. In all year types, end-of-year carryover targets often cannot be met, even with extremely limited CVP allocations, as Shasta resources are needed to meet flow and water quality criteria as well as senior water rights. In the driest years, if the hydrology is insufficient, spring fill targets cannot be met regardless of previous year carryover.

In my opinion, there are no impacts of the California WaterFix on Shasta storage. Adoption by the Board of the NMFS proposed 2017 Draft Shasta RPA amendment as a condition on approval for the WaterFix would be a measure un-connected to the California WaterFix petition, and would be unachievable, ineffective, and unduly restrictive to CVP operations.

Folsom Storage Conditions

I believe that Mr. Ryan Bezerra's (City of Roseville, Sacramento Suburban Water District, San Juan Water District, The City of Folsom, and Yuba County Water Agency) cross examination of Mr. Erik Reyes (DWR) on March 2, 2018 has led to misinformation in the record about the impacts of CWF on Folsom storage conditions. I disagree with the inferences resulting from Mr. Bezerra's questions. The following testimony will discuss that:

- Individual monthly changes in storage at one reservoir are not representative of deliberate CWF effects – petitioner modeling used the same facility operations logic and balancing goals facilities in CWF_H3+ as in NAA.
- Overall CVP NOD storage results should therefore be the focus of WaterFix impacts analysis, rather than isolated reductions in a single facility's storage (Folsom) in the example years introduced by Mr. Bezerra.

Mr. Bezerra asked Mr. Reyes about whether results for Folsom storage in the WaterFix scenario were lower than the storage in the No-Action Alternative, referring to exhibit BKS-257 for examples from 1923-1924, 1932-1933, 1961-1962, 1981-1982, 1994-1995, and 2001-2002. In response to an objection to his line of questioning, Mr. Bezerra stated that "*in a substantial portion of years, Petitioners' own modeling depicts that Folsom Reservoir storage is lower in the With-Action Alternative than the No-Action. They have chosen not to confirm and authenticate these results, but I'd like to read into the record what they are.*" The implication of having Mr. Reyes confirm that specific CWF_H3+ results were lower than NAA results was that the exchange inferred direct WaterFix responsibility for these lower storage conditions. The premise of the question is not correct, and expanding on Mr. Reyes' responses will clarify information in the record. The effect of the proposed project on storage conditions should be determined **not** by comparing individual facility conditions in individual months, but instead by looking at the frequency of storage conditions through the entire period of record on a system-wide basis.

The six examples in BKS-257 each demonstrate a 13-month May-to-May period during which the CWF_H3+ results for Folsom storage are lower than the No Action Alternative for several months. BKS-257 did not present the operational context provided by results for the other CVP storage facilities. The plots in Figure 4, which covers two large-format pages in the Figures and Tables section, show additional storage results alongside reproductions of the plots provided in BKS-257. Explanations for each year are at the right side of the figure, and are further summarized here.

- One example cited is 1932, a critical year in the middle of the dry period of record, and as discussed numerous times in this hearing, CalSim does not have specific logic to address highly stressed water supply conditions. Under clearly limited operational flexibility, one month's change in reservoir release when CVP allocations are zero percent should not be considered as indicative of a specific storage response to the WaterFix.
- In most of the other cases in BKS-257, the lower storage in Folsom is offset by higher storage in Shasta or Trinity or both.
- In 1961 and 1981 when there *is* an overall storage reduction in CWF_H3+ compared to the NAA, it is very small compared to the total storage condition, which is nowhere near perilous.
- In 3 cases, the release from Folsom that creates the storage deficit is due to a model constraint that penalizes the release of water from Shasta at a rate that exceeds power plant capacity, even though it would be logical for the model to release from Shasta because it has relatively more water than Folsom. (This is certainly an area of potential refinement for CalSim.)

In summary, none of the cases raised by Mr. Bezerra indicate meaningful changes in overall storage condition, and none are indicative of a deliberate model action calculated to change Folsom operation due to the WaterFix.

The type of issue raised by Mr. Bezerra – monthly differences in system conditions which are seen by protestants as a direct and negative impact of the WaterFix – have been brought up numerous times throughout this hearing. Fresh context on the CalSim modeling may assist both the Board and other parties with this concept. CVP North of Delta reservoirs obey a myriad of criteria that collectively drive individual releases, including flood control, local flow requirements, and power plant capacity. CalSim uses methodology to set operational levels that help to balance these differently sized facilities while also addressing local and system-wide responsibilities and requirements. None of this logic changed in the CWF_H3+ scenario relative to the NAA.

The logic and input data differences between the CWF_H3+ and NAA models focus on the physical implementation of the California Water Fix (adding the diversion point, NDD and export capacity, bypass criteria, diversion limits) and associated proposed criteria (HORG settings, OMR limits, Delta outflow targets). Petitioners did not change or newly implement any other logic – not for water supply allocation, reservoir balancing, CVP/SWP sharing, or even the split between NDD and through-Delta exports. This approach ensured that model results would focus on the issues important to the petition – i.e. isolating and revealing any WaterFix impact on CVP/SWP obligations – by removing any hint of pre-determined outcomes for other facilities and operations.

Differences between NAA and CWF_H3+ scenario results can be caused not only by the operational flexibility offered by the WaterFix but also by the modified regulatory criteria associated with it. Exports and Delta outflows are lower in some months, higher in others, and the balance is captured in overall, inter-annual storage conditions and project export capability. A change in one reservoir's release in one month can be the ultimate result of a changed operation or condition from months earlier. Reservoir release criteria, storage level definitions, and balancing logic were not adjusted between the NAA and CWF_H3+, and specific monthly increases or decreases in individual reservoir conditions can be the result of a number of other influences on the solution algorithm as the model responds to the ***other*** criteria that ***were*** changed.

This is why, throughout this hearing process, petitioners have consistently explained that

- The effect of the proposed project on storage conditions should be determined **not** by comparing individual facility conditions in individual months, but instead by looking at the frequency of storage conditions through the period of record on a system-wide basis.
- Model results which depict extremely low system-wide storage levels are indicators of stressed conditions and are not to be interpreted as intended operations.

Mr. Bezerra's cross examination of Mr. Reyes on the differences in CVP reservoir storage between the WaterFix and No Action scenarios wrongly implied that Folsom storage reductions were specifically caused by the WaterFix. It is my opinion that overall system storage frequency is the correct way to assess the effects of the WaterFix.

American River Water Agencies Modified Flow Management Standard

Tom Gohring's testimony in ARWA-500 stated that CWF modeling showed Folsom drained to dead pool and that the proposed action would reduce storage in Folsom Reservoir. ARWA has proposed that the Modified Flow Management Standard (ModFMS), as described in ARWA-602, be adopted as a condition on WaterFix permit approval.

I disagree with this proposal for two reasons. First, ARWA modeling and testimony confirm that the ModFMS operation does have re-directed impacts to other CVP storage facilities, particularly Shasta. This type of criteria decreases the operational flexibility that helps Reclamation to meet system-wide regulations and obligations. My analysis will clarify the nature of these re-directed impacts. Second, as discussed in the previous section, the lower storage conditions seen in Folsom Reservoir in CWF_H3+ relative to NAA are not the direct result of specific withdrawals that are exported by the WaterFix. They are an artifact of CalSim modeling that focuses on the system-wide water supply reliability effects of the WaterFix and should not be interpreted as characterizing detailed operational changes to specific facilities. ARWA's association of the proposed Modified American River Flow Management standard with the WaterFix is misplaced. My analysis shows that the ModFMS is irrelevant to the WaterFix and is therefore not a necessary mitigation for the CWF.

To address both of my ARWA rebuttal points, I conducted several sensitivity analyses as variations on ARWA's CalSim models – Part 2 ARWA Exhibits 2006FMS_20171105.zip and ModFMS_20171108.zip. These sensitivity studies will be referenced in the sections which follow, and are listed and described here:

- implementation of the California WaterFix in ARWA's original studies to determine the impact of the CWF on the ModFMS and the impact of ModFMS on the CWF
    - 2006FMS_CWF (Exhibit DOI-43a)
    - ModFMS_CWF (Exhibit DOI-43b)
- substitution of Q5 hydrology inputs and 15 cm Sea Level Rise into the ARWA studies (which use historical Q0 inputs with custom modifications to Folsom inflows and no sea level rise) to determine the influence that varying hydrology has on the ModFMS, and as a bridge to comparison with Petitioners' modeling
    - 2006FMS_Q5 (Exhibit DOI-43c)
    - ModFMS_Q5 (Exhibit DOI-43d)
- implementation of both Q5 hydrology and the California WaterFix in the ARWA studies to determine the combined influence of these inputs for better comparison to Petitioners' modeling
    - 2006FMS_Q5CWF (Exhibit DOI-43e)
    - ModFMS_Q5CWF (Exhibit DOI-43f)

<u>ModFMS Re-directs Impacts to Other CVP Storage Operations</u>

Under cross-examination by SVWU's Kevin O'Brien (20180319_Volume_18 – Part 2 Transcript.pdf pp 178-191), Jeff Weaver acknowledged that impacts of the ModFMS on CVP system operations could be understated by ARWA modeling, and that ARWA modeling does show ModFMS impacts to Shasta storage in some drought conditions. It is important to distinguish the difference between the changes to storage conditions realized in the ARWA studies from those in the CWF studies. Petitioners have explained that CWF effects should be viewed from an overall system perspective due to the fact that

CWF modeling focuses on CWF implications to system-wide storage and delivery conditions, and not on specific facility operations. The ARWA studies, on the other hand, *do* focus on a specific facility operation – changing monthly storage conditions at Folsom was the primary goal of the ModFMS.

Relative to their 2006FMS baseline, ARWA's ModFMS scenario raises end-of-September carryover at Folsom about 40% of the time and raises end-of-December storage about 50% of the time. The largest storage increase in either of these target months is 185 TAF. The increased storage conditions are enabled by retaining water in storage that was released to meet CVP obligations in the baseline, and this necessarily has an impact somewhere else in the system. Relative to the baseline, this water is either not being delivered, or it is being withdrawn from other storage reserves. The sequence of water years 1989-1995 provides the longest and clearest example of effect on storage, shown by the two plots in Figure 5. Figure 5a shows storage at Folsom, Shasta, and Trinity individually, and Figure 5b shows the differences between ARWA's ModFMS and 2006FMS CalSim results for Folsom and combined Shasta and Trinity storage. Both Figure 5a and Figure 5b demonstrate increased Folsom storage and decreases in Shasta and Trinity storage. The changes in Folsom storage closely coincide with equal and opposite changes in combined Shasta and Trinity storage.

Figure 6 shows the full time series of differences through the entire period of record 1922-2003. The drought period of the early 90's detailed in the Figure 5 plots has the largest and most sustained effect, but there are numerous other years with unmistakable re-directed impacts. It is logical that the greatest effects on Folsom come in drier years, and this is precisely when the re-directed impacts are greatest – when Shasta and Trinity are also experiencing lower conditions. I re-ran ARWA's CalSim studies using Q5 hydrology, which is more demanding on storage resources to meet regulatory criteria. Q5 is the input dataset used in Petitioners' modeling, so this exercise provides a bridge to other comparisons as well. The results for this analysis are shown in Figure 7, which should be viewed in concert with Figure 6. The strong mirror image between Folsom differences and Shasta/Trinity differences in Figure 7 indicates that the re-directed impacts of the ModFMS scenario grow stronger with more limiting hydrology, corroborating the indication from the 90's drought in ARWA's studies.

ARWA has depicted their proposal as a "sweet spot" in the relationship between improved Folsom storage conditions and avoiding impacts to Sacramento River fisheries. But the proposal affects Shasta storage the most in drier years, thus undermining its viability for ensuring the very protection it sought.

American River ModFMS is Not Mitigation for the California Water Fix

ARWA has introduced the ModFMS in the WaterFix petition process claiming that it is a means to protect Folsom from being affected by the WaterFix, but they have produced no analysis which demonstrates any such operation. As I have discussed in previous sections of this document, CWF effects on overall North of Delta storage are limited, or generally reflect a small increase, showing that the proposed project can be operated in a manner that does not degrade storage conditions. The WaterFix modeling did not include any specific logic to re-operate Folsom or to derive any targeted benefit from Folsom releases.

ARWA modeling analyzes only the performance of their preferred alternative relative to a baseline. It does not portray the effect of the ModFMS on a system that includes the CWF. A logical analytical process would have been to implement the CWF in their baseline, note any effects, and then add the ModFMS to identify their claim of mitigation. I followed this investigation route by generating new sensitivity modeling studies based on ARWA's CalSim modeling. These studies were listed at the head of this section and have been submitted as exhibits in this hearing (DOI-43 a-f). Tables 5a and 5b show overall summary values for major system results.

I examined the sequence of CalSim studies

1. 2006FMS_20171105 (ARWA's baseline study)
2. 2006FMS_CWF (ARWA's baseline with petitioners' CWF added)
3. ModFMS_CWF (ARWA's ModFMS scenario with petitioners' CWF added).

Figure 8 shows results from these studies as exceedance plots for collective and individual CVP NOD storage. As anticipated, adding the CWF to ARWA's baseline produced changes in storage that were similar to those in petitioners modeling. Folsom storage sees some negative changes, mostly for higher storage levels, Shasta and Trinity both show increases in storage, and total CVP NOD storage shows minor net increases. When the ModFMS is added to this scenario, there are the expected storage increases in Folsom, about half of which, on average (see the yellow-headed section of Table 5b) are offset by storage decreases in Shasta and Trinity.

In my opinion, this sequence of studies does not show the ModFMS mitigating for storage conditions caused by the CWF. It demonstrates a specific operation for Folsom and the American River, to which the model reacts by taking stored water from Shasta and Trinity storage.

A further sensitivity element was added by changing the hydrology in our three-study sequence to use the Q5 hydrology inputs and sea level rise assumptions that are used in petitioners modeling. Figure 9 shows the storage exceedance results from these studies analogous to the plots in Figure 8, and the message is very much the same. When the CWF is implemented in the ARWA baseline, changes are similar to Petitioners' analysis, and when the ModFMS is added, Folsom increases and Shasta and Trinity storage decreases. Referring to the blue-headed section of Table 5b, it is clear that the influence of the ModFMS on Folsom storage is similar in both the Q0 and Q5 study sets, but the re-directed impact of ModFMS to Shasta and Trinity is tripled with Q5 inputs. This analysis reinforces conclusions reached in the previous section about response of the system to the ModFMS scenario under less than ideal conditions.

One more perspective using results from the Q5 sequence may be helpful. Figure 10 is a set of three exceedance plots showing the differences in storage between the three steps of the sequence. The blue lines show increases or decreases in storage resulting from the WaterFix implementation in ARWA's baseline. The orange lines show the incremental changes due to the ModFMS. And the dashed black lines show the cumulative changes due to both the WaterFix and ModFMS. The plot of total CVP NOD storage conveys the message that the overall impact of the combined WaterFix and ModFMS is roughly the same as the impact of just the WaterFix. But the impacts are distributed to higher storage in Folsom and lower storage in Shasta and Trinity. It is understandable that ARWA and other protestants see this as "correcting" the distribution of impacts from the WaterFix studies. But that could have been done by calibrating a few balancing goals or weights in Petitioner's model. Instead, the rigid criteria in the ModFMS limit the ability of the CVP to operate.

<u>Conclusion on ARWA's Proposed Modified FMS</u>

Reclamation understands that ARWA is proposing the Modified Flow Management Standard to improve conditions in Folsom Lake to protect local water supplies and to support American River fisheries. This is a proposal to address the concerns of local water users. The drier years in which Folsom storage conditions would benefit the most from the proposal are the very years when re-directed impacts to Shasta and Trinity storage would be most likely and this could potentially compromise Sacramento River conditions. My analysis also raises concerns that the proposed criteria lacks robust adaptability to near term climate change and sea level rise. ARWA claims the ModFMS will protect Folsom from the WaterFix, but analysis continues to show that no protection is necessary, and that the ModFMS simply reduces CVP operational flexibility by shifting responsibility for meeting Project obligations to other storage reserves in drier years.

Trinity River Conditions

In testimony for Pacific Coast Federation of Fishermen's Associations (PCFFA), Thomas Stokely provided his opinion that analysis performed for the California WaterFix was inadequate for the Trinity River, that the modeling depicted unacceptable storage impacts to Trinity, and called for flow, fill, and carryover storage provisions to be implemented as conditions on any Board approval of the water right change petition. In my opinion, the analysis submitted by Petitioners is indeed appropriate, as it demonstrates no impact of the WaterFix implementation on Trinity River resources.

Figures 13a and 13b compare Trinity storage results for Petitioners' NAA and CWF_H3+ scenarios. The exceedance of CWF_H3+ storage values in Trinity is very close to or even above the NAA results. Figure 13a shows the entire data set, and Figure 13b zooms in on the higher exceedance range of 80% - 100% to highlight the fact that even under drier conditions, Trinity storage with the CWF is typically at or above the NAA status.

Figure 14 shows three additional storage exceedance plots which also demonstrate no impact to Trinity Reservoir from the WaterFix. I calculated the maximum and minimum storage for each operations season in the model results and have plotted these exceedances, along with the exceedance for end-of-September. These plots demonstrate no meaningful reduction to Trinity storage as a result of the WaterFix implementation. The values objected to by Mr. Stokely are above the 95% exceedance value on the end-of-September plot. These specific storage results for the CWF_H3+ scenario are from water years 1931 and 1933. Petitioners continue to point out that specific model decisions made by CalSim under extremely water-short conditions are simply not representative of a proposed Project operation. In order to fully meet all regulatory criteria and senior water rights, CalSim will take storage conditions down to dead pool if necessary. This is what caused the two data points that Mr. Stokely holds out as examples of a WaterFix impact on Trinity, but this is not an appropriate interpretation of Petitioner model results.

Concluding Statement

In my opinion, Petitioners' modeling demonstrates that the WaterFix does not adversely affect CVP and SWP abilities to meet project obligations. The CVP operates its North of Delta facilities in a fully integrated manner, and relies on flexibility to be able to react to specific challenges of this very large system. The hard storage and flow criteria proposed by various protestants would absolutely reduce this flexibility, create re-directed impacts and unintended consequences, and in some cases they are fundamentally infeasible. Moreover, they are fundamentally un-connected to the WaterFix project.

Figures and Tables Referenced in DOI-43

(Presented in the order referenced.)

Table 1 – Criteria for Shasta Storage and Keswick Release from NMFS 2017 Draft Proposed Amendment to the Shasta RPA

	Minimum Storage April 1 - May 31 no less than	End of Sept Storage no less than	April Keswick Release Limit
	(MAF)	(MAF)	(CFS)
Wet	4.2	3.2	8000
Abv Normal	4.2	3.2	6500
Blw Normal	4.2	2.8	6000
Dry	3.9	2.2	6000
Critical	3.5	1.9	4000

Figure 1 – Testing hydrologic feasibility of NMFS spring storage targets

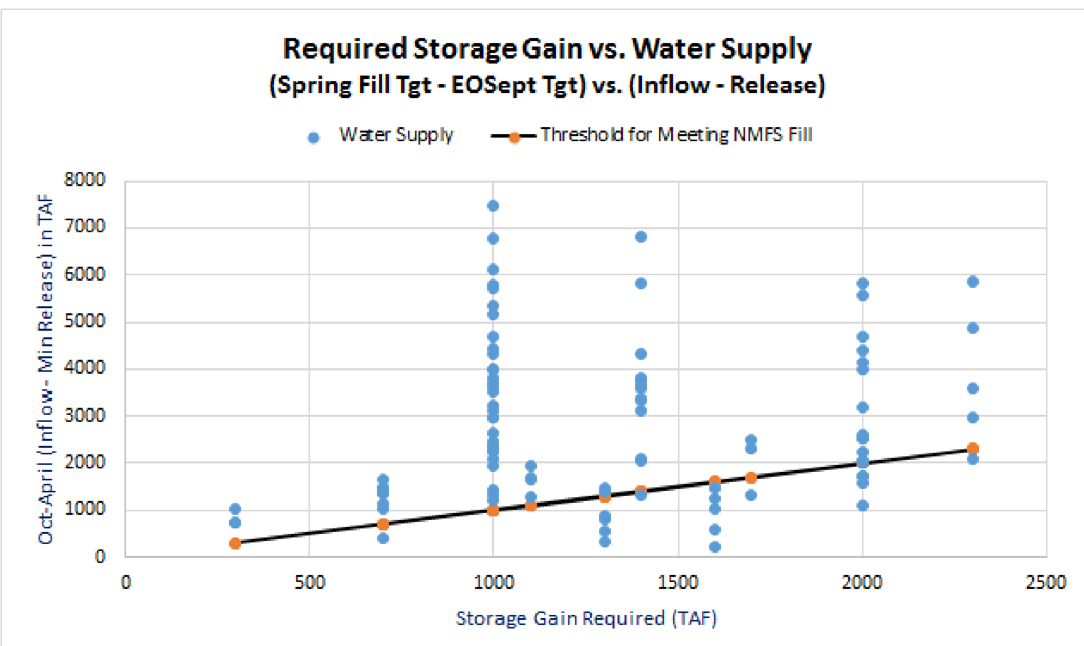


Table 2 – October-April inflow support for spring storage.
The table summarizes years when water supply (inflow – minimum release) is not sufficient to fill Shasta from an end-of-September carryover target to the next year's spring fill target by April 30th. The analysis was repeated for several commonly used inflow (climate) scenarios. Shortfalls are summarized by water year type.

Hydrology Scenario	Year Type	# of Years	# of Years with Fill Shortfall	Average Fill Shortfall (TAF)	% of Years with Fill Shortfall
2020D09E	BlwNor	18	3	-249	17%
	Dry	21	4	-457	19%
	Critical	15	10	-634	67%
2025Q5	Dry	23	5	-321	22%
	Critical	15	11	-677	73%
2060Q5	Dry	24	4	-157	17%
	Critical	16	12	-595	75%
WSIP2030	Dry	19	3	-175	16%
	Critical	15	8	-534	53%
WSIP2070	BlwNor	17	2	-161	12%
	Dry	23	1	-14	4%
	Critical	15	7	-613	47%

Table 3 – All Values in TAF. Summary of years in Petitioners' No Action Alternative which meet NMFS' spring fill targets but do not meet their end-of-September carryover targets. The table shows which criteria are controlling both Shasta release specifically (WS = Wilkins Slough flow req't, FC = flood control), or CVP releases generally (Delta criteria for X2, Net Delta Outflow, or Water Quality).

Year	WY Type	Spring Target	Over Spring Tgt By	Missed Sept Target By	Month Fell Below Sept Target	Controlling factor												
						June				July			August			September		
1922	Wet	4200	352	-438	Sep		WS			NDO	WS		NDO	WS		X2		
1927	AN	4200	352	-339	Aug		WS			NDO		WQ	NDO	WS		X2		
1928	AN	4200	310	-855	Jul	X2		WQ		NDO		WQ	NDO			X2		
1938	Wet	4200	301	-280	Sep		WS			NDO	WS		NDO	WS		X2		
1941	Wet	4200	352	-82	Sep		WS			NDO			NDO	WS		X2		
1942	Wet	4200	352	-170	Sep		WS			NDO	WS		NDO	WS		X2		
1943	Wet	4200	352	-564	Sep	X2	WS			NDO		WQ	NDO			X2		
1946	AN	4200	53	-727	Jul	X2	WS			NDO		WQ	NDO			X2		
1951	AN	4200	177	-585	Aug		WS	WQ		NDO		WQ	NDO			X2		
1953	Wet	4200	352	-163	Sep				FC	NDO			NDO			X2		
1954	AN	4200	346	-251	Sep	X2				NDO		WQ	NDO			X2		
1956	Wet	4200	352	-230	Sep		WS			NDO			NDO			X2		
1957	AN	4200	352	-158	Sep	X2	WS			NDO		WQ	NDO			X2		
1958	Wet	4200	352	-25	Sep				FC	NDO			NDO		FC	X2		
1963	Wet	4200	331	-461	Sep	X2	WS			NDO		WQ	NDO	WS		X2		
1965	Wet	4200	348	-217	Sep	X2	WS			NDO		WQ	NDO	WS		X2		
1966	BN	4200	217	-158	Aug	X2				NDO		WQ	NDO				NDO	
1971	Wet	4200	352	-154	Sep		WS			NDO		WQ	NDO	WS		X2		
1973	AN	4200	232	-348	Aug	X2				NDO		WQ	NDO	WS		X2		
1975	Wet	4200	352	-90	Sep		WS			NDO			NDO	WS		X2		
1978	AN	4200	352	-113	Sep		WS			NDO		WQ	NDO	WS		X2		
1980	AN	4200	45	-155	Aug		WS			NDO	WS		NDO	WS		X2		WS
1984	Wet	4200	275	-498	Sep	X2	WS			NDO		WQ	NDO	WS		X2		
1996	Wet	4200	352	-177	Sep		WS			NDO		WQ	NDO	WS		X2		
1999	Wet	4200	352	-236	Sep	X2	WS			NDO		WQ	NDO	WS		X2		
2000	AN	4200	349	-264	Aug	X2				NDO		WQ	NDO			X2		
2003	AN	4200	352	-213	Sep		WS			NDO		WQ	NDO			X2		

Figure 2 – Historical Shasta Storage and Proposed NMFS criteria under recent operations

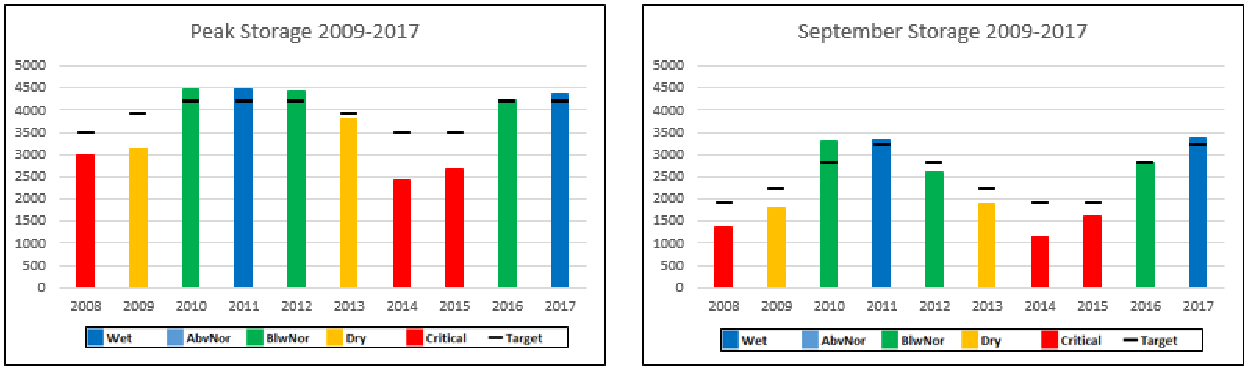


Figure 3 – April Keswick Release – Historical Release, and NMFS Thresholds

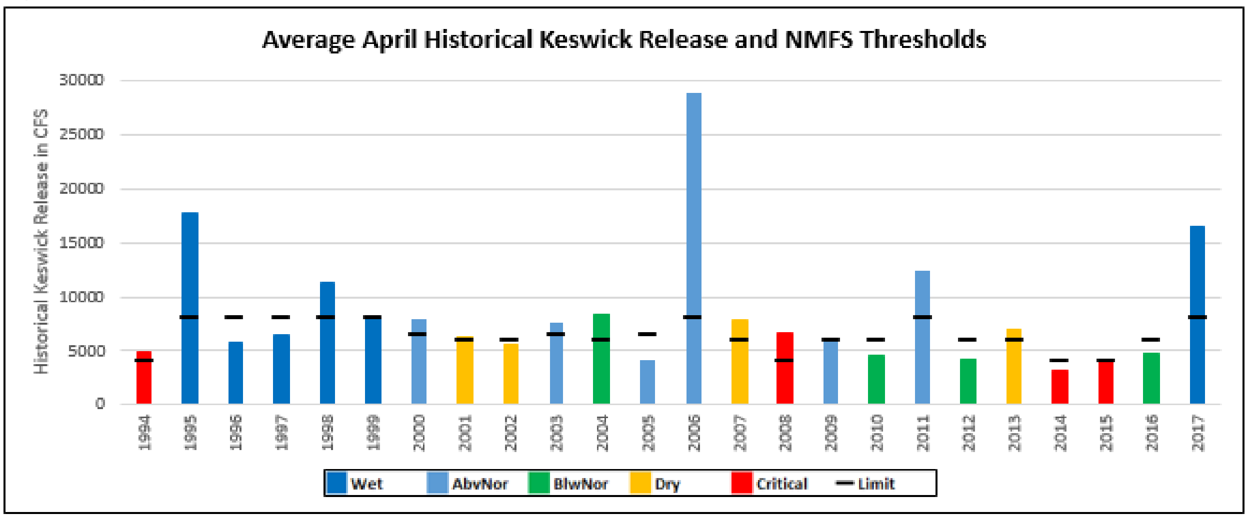
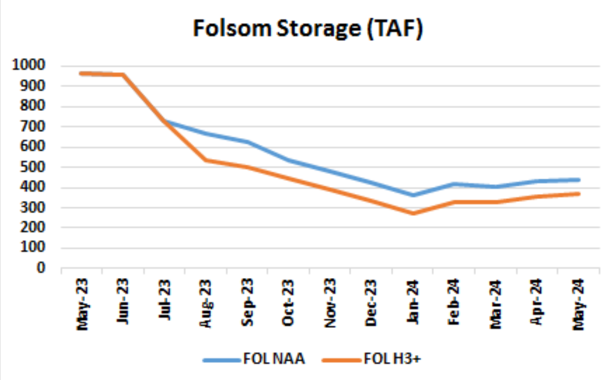
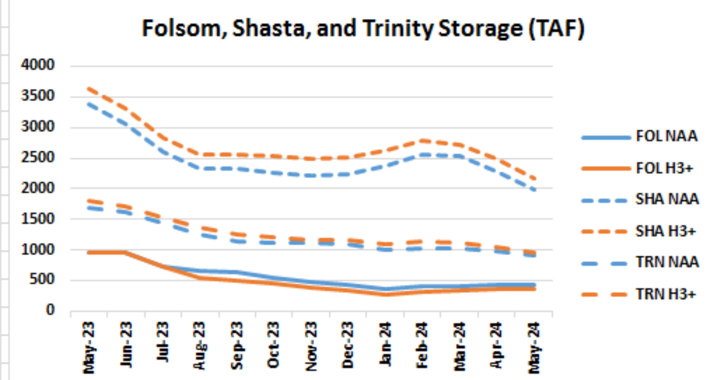


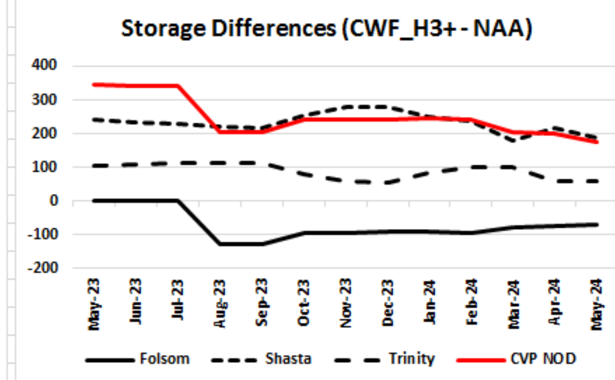
Table 4 – April results for Keswick releases in Petitioners' NAA model which do not meet NMFS DPA flow criteria (flow values in CFS)

	NMFS flow criteria	# Aprils not met	Avg flow when criteria not met	# Releases for Flood Control	# Releases for Delta Outflow
Wet	8000	9	15390	9	
AbvNor	6500	5	8732	3	
BlwNor	6000	5	7129		2
Dry	6000	3	7386		3
Critical	4000	10	6894		6

Figure 4 (part 1) – Individual and Total CVP storage results and (CWF_H3plus - NAA) differences in years presented in BKS-257.

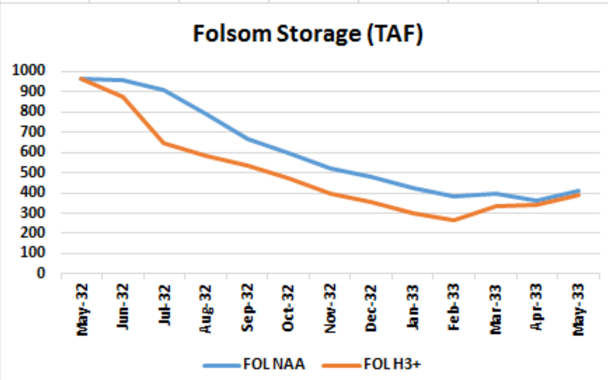


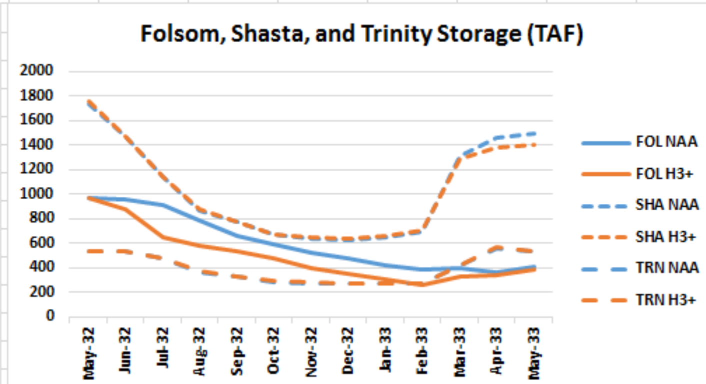


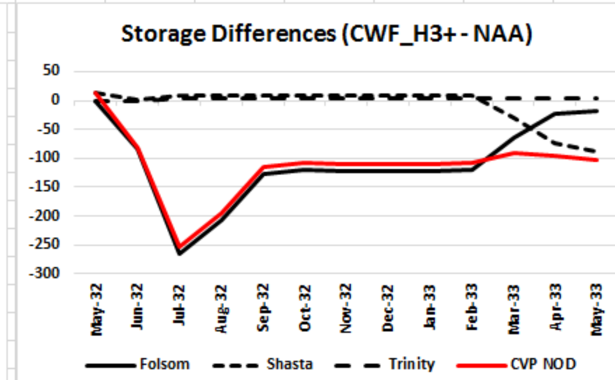


	Folsom	Shasta	Trinity	CVP NOD
05/31/1923	0	240	104	344
06/30/1923	0	235	107	342
07/31/1923	0	228	113	341
08/31/1923	-128	220	112	204
09/30/1923	-127	218	112	203
10/31/1923	-94	255	81	242
11/30/1923	-94	279	57	242
12/31/1923	-91	278	56	243
01/31/1924	-91	252	84	244
02/29/1924	-93	236	99	242
03/31/1924	-76	180	99	203
04/30/1924	-76	217	58	199
05/31/1924	-70	187	57	174

The modified storage condition in Folsom begins in August of 1923, when a release is made to support SOD delivery at a low point in San Luis storage. Throughout the example, total NOD system storage is higher in in the CWF scenario. Conditions in this example are not unreasonable. 1923 is a Below Normal year and CVP Ag allocation is 30%.

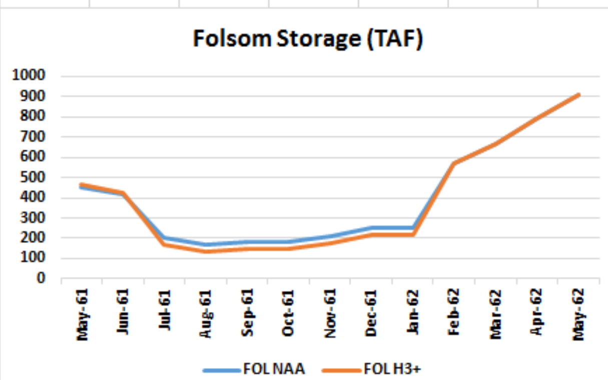


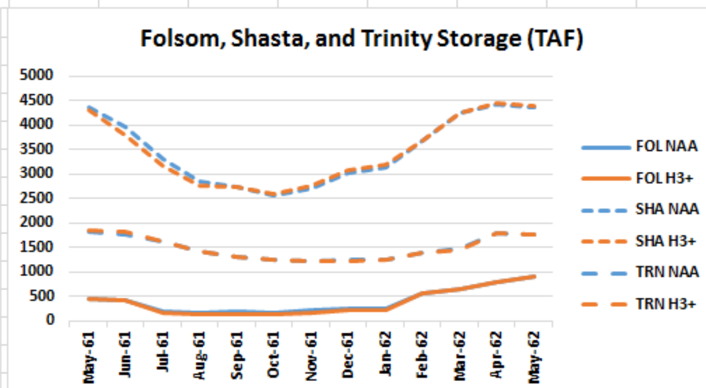


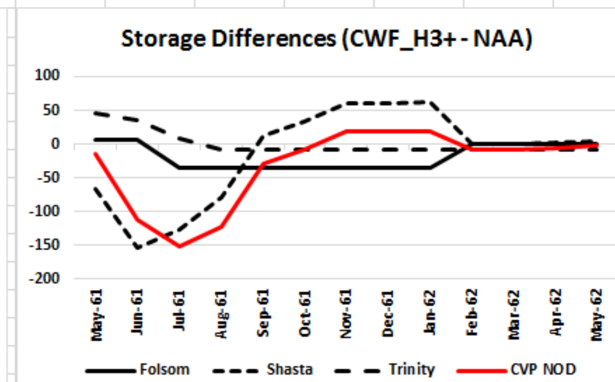


	Folsom	Shasta	Trinity	CVP NOD
05/31/1932	0	14	0	14
06/30/1932	-82	1	0	-82
07/31/1932	-265	8	3	-254
08/31/1932	-207	9	3	-195
09/30/1932	-128	8	3	-116
10/31/1932	-120	8	3	-108
11/30/1932	-122	8	3	-110
12/31/1932	-122	8	3	-110
01/31/1933	-122	8	3	-110
02/28/1933	-119	8	3	-108
03/31/1933	-64	-31	3	-92
04/30/1933	-24	-75	3	-95
05/31/1933	-18	-88	3	-103

1932 is a good example of model results that indicate a CVP/SWP system operating under stressed water supply conditions. This is the middle of the driest 4 years in the period of record. All CVP reservoirs are depleted below realistic levels to meet regulatory criteria and project obligations, and CVP flexibility is limited.



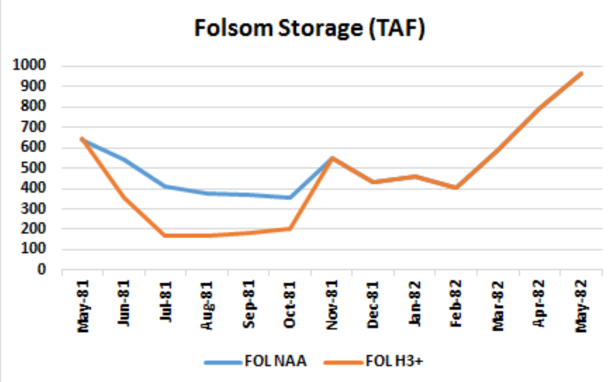


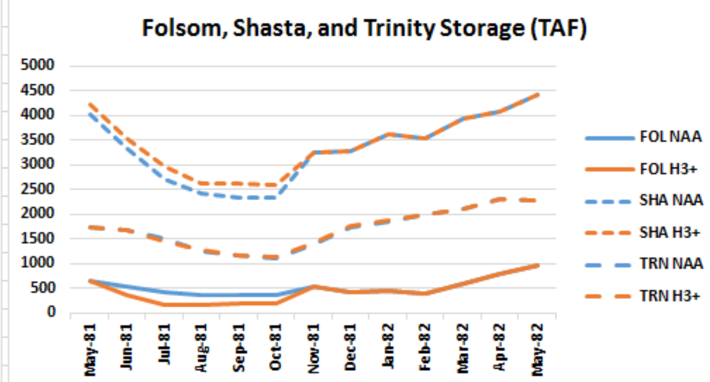


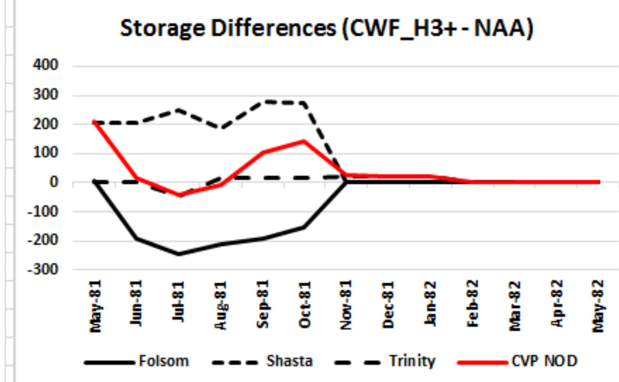
	Folsom	Shasta	Trinity	CVP NOD
05/31/1961	7	-67	45	-14
06/30/1961	5	-154	36	-112
07/31/1961	-35	-126	9	-153
08/31/1961	-35	-79	-8	-122
09/30/1961	-35	13	-8	-30
10/31/1961	-35	34	-8	-8
11/30/1961	-34	61	-8	18
12/31/1961	-34	61	-8	18
01/31/1962	-34	62	-8	19
02/28/1962	0	0	-8	-8
03/31/1962	0	0	-8	-8
04/30/1962	0	1	-8	-7
05/31/1962	1	5	-8	-2

The storage difference is created in July, and CalSim takes the water from Folsom because Shasta release was at max power plant capacity. Folsom condition is low because 1961 is drier in the American than elsewhere in the system. Overall storage differences are very small compared to storage conditions.

Figure 4 (part 2) – Individual and Total CVP storage results and (CWF_H3plus - NAA) differences in years presented in BKS-257.

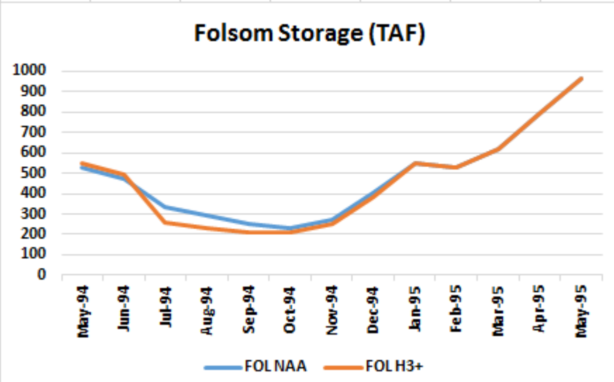


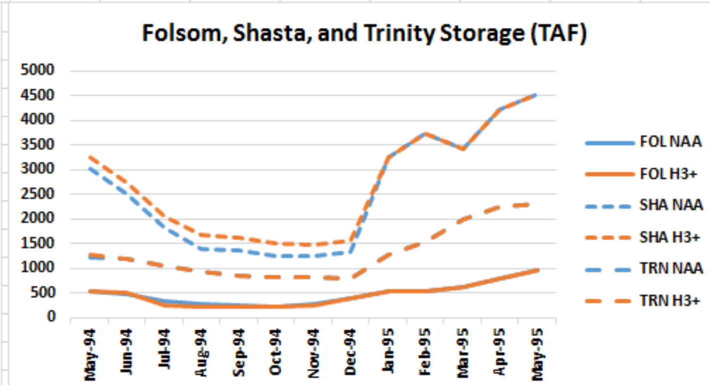


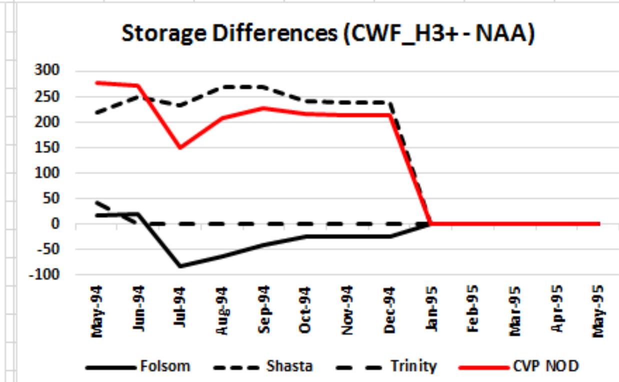


	Folsom	Shasta	Trinity	CVP NOD
05/31/1981	5	205	1	211
06/30/1981	-190	204	1	15
07/31/1981	-245	251	-47	-41
08/31/1981	-212	187	18	-7
09/30/1981	-190	276	18	104
10/31/1981	-153	276	18	141
11/30/1981	0	3	24	27
12/31/1981	0	0	24	24
01/31/1982	0	0	24	24
02/28/1982	0	0	0	0
03/31/1982	0	0	0	0
04/30/1982	0	0	0	0
05/31/1982	0	0	0	0

Similar situation to 1961. Drier conditions at Folsom than at Shasta, but June and July took more release from Folsom because Shasta release was at max power plant capacity. Overall storage differences are mostly positive, and small relative to overall conditions.

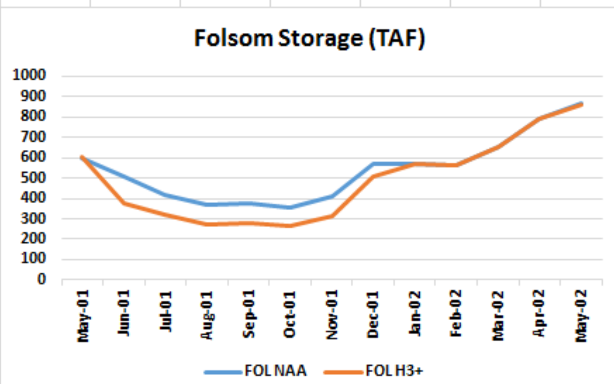


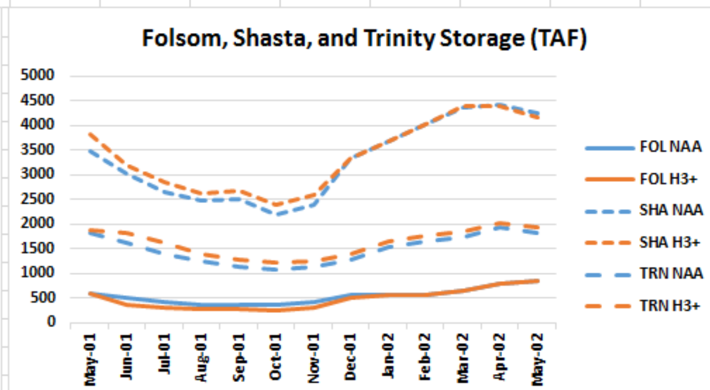


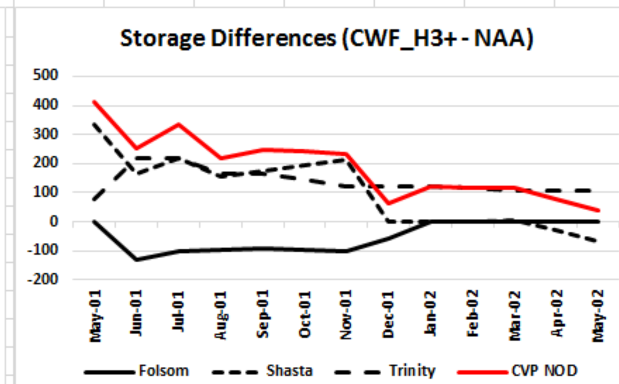


	Folsom	Shasta	Trinity	CVP NOD
05/31/1994	16	219	43	278
06/30/1994	21	250	0	271
07/31/1994	-82	233	0	151
08/31/1994	-62	271	0	209
09/30/1994	-41	270	0	228
10/31/1994	-24	241	0	217
11/30/1994	-24	239	0	215
12/31/1994	-24	239	0	215
01/31/1995	0	0	0	0
02/28/1995	0	0	0	0
03/31/1995	0	0	0	0
04/30/1995	0	0	0	0
05/31/1995	0	0	0	0

Again, Shasta release is at maximum power plant capacity in July of 1994. Shasta storage difference is positive and contributes to higher overall storage relative in the CWF study relative to the NAA.







	Folsom	Shasta	Trinity	CVP NOD
05/31/2001	2	335	77	414
06/30/2001	-129	166	218	255
07/31/2001	-101	220	217	336
08/31/2001	-99	154	165	220
09/30/2001	-94	177	164	247
10/31/2001	-94	192	144	241
11/30/2001	-102	215	120	234
12/31/2001	-59	0	120	61
01/31/2002	0	0	120	120
02/28/2002	0	0	114	114
03/31/2002	0	5	109	114
04/30/2002	0	-30	109	79
05/31/2002	-2	-68	108	39

Although Folsom storage is lower in the CWF study due to a release in June, overall storage is higher than NAA during this entire period.

Figure 5a – CVP Storage results of ARWA CalSim studies for water years 1989-1995. Folsom storage is higher through the entire drought period, while Shasta and Trinity storage experience reductions.

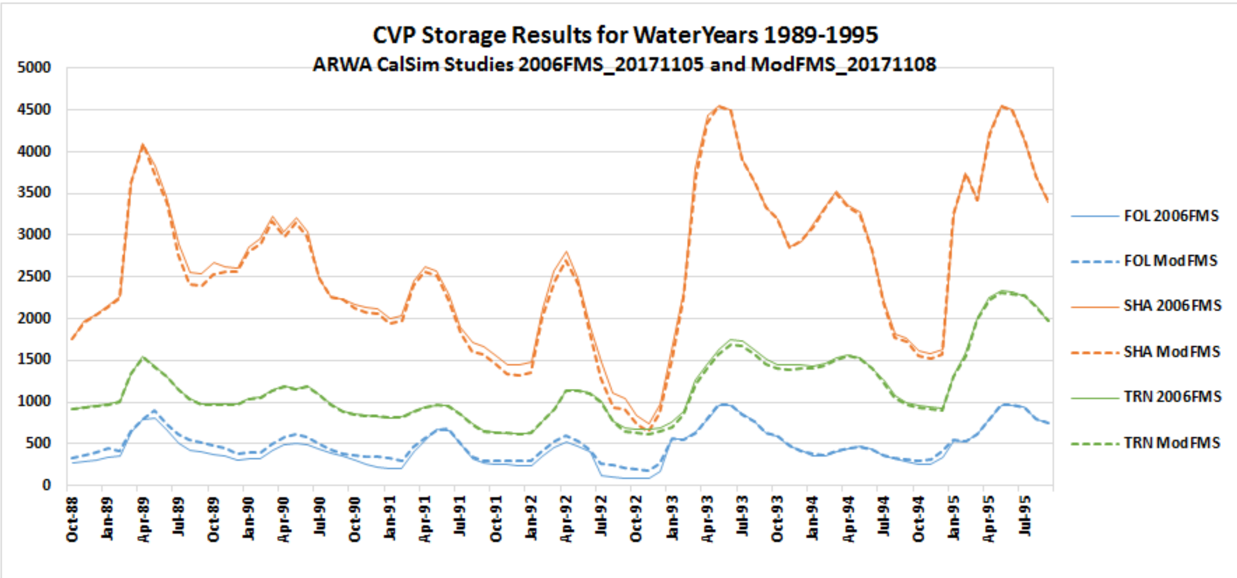


Figure 5b – Storage differences calculated from the data displayed in Figure 7a. The increases in Folsom storage closely coincide with decreases in combined Shasta and Trinity storage.

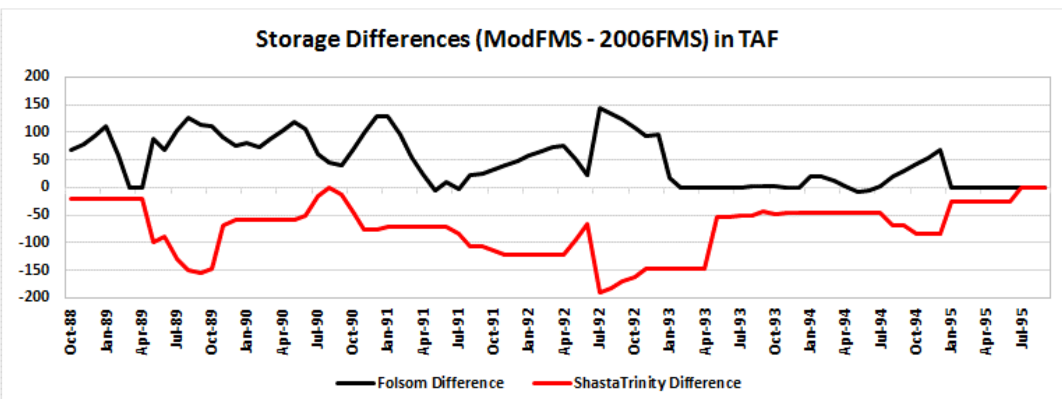


Figure 6 – Full period of record differences between ModFMS and the baseline (ARWA studies)

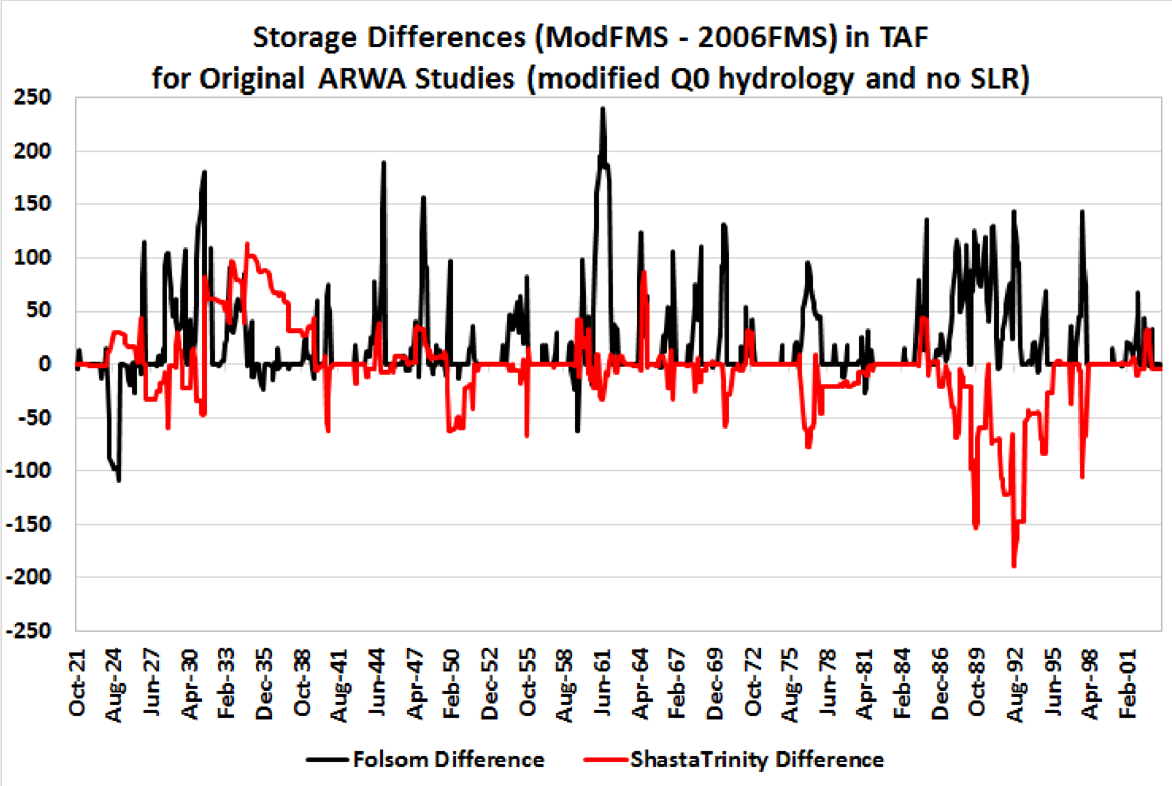


Figure 7 – Impacts of the ModFMS proposal are more equal and opposite if studied using Q5 inputs

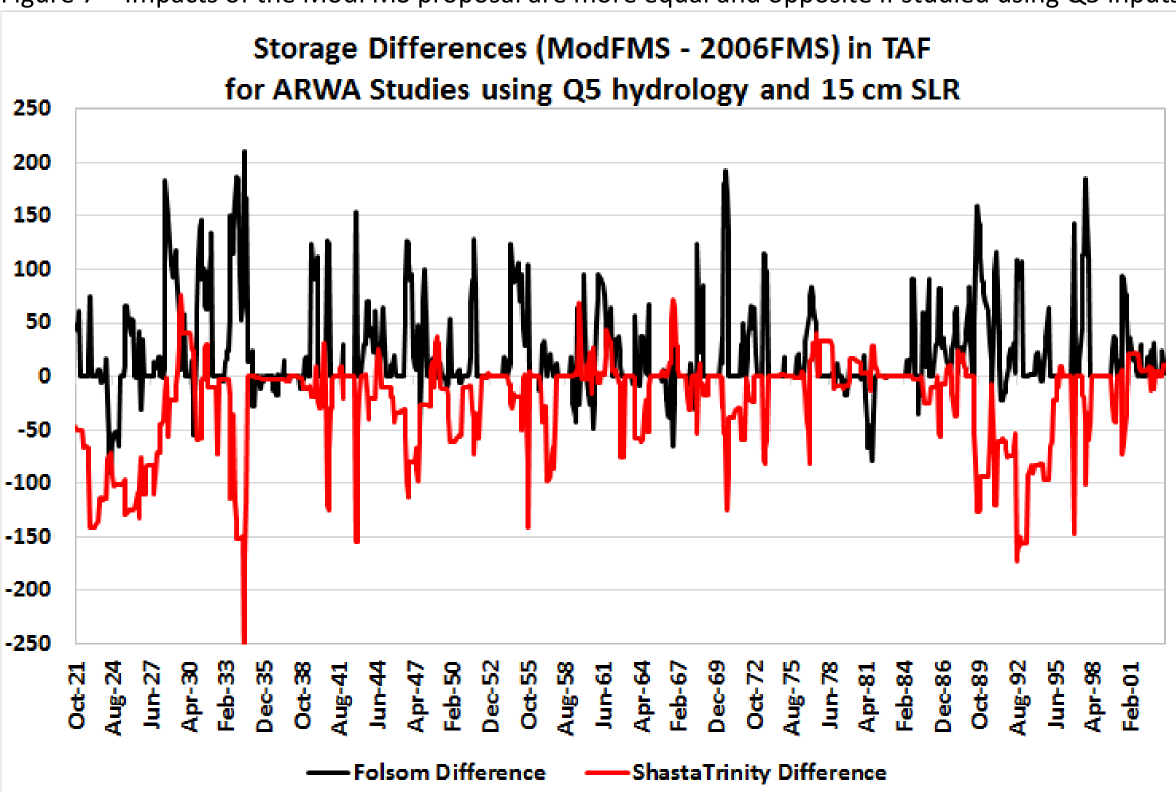


Table 5a – Results for Sensitivity Runs of the ARWA models with California Water Fix and/or Q5 Hydrology. All values are average annual Oct-Sep total flow volumes in TAF or average end-of-September storage in TAF.

	Average Annual Flow Volumes or Average Monthly Storage									
	2006FMS_ ARWA	ModFMS _ARWA	2006FMS _CWF	ModFMS _CWF	2006FMS _Q5	ModFMS _Q5	2006FMS _Q5CWF	ModFMS _Q5CWF	CWF_NAA	CWF_H3plus
	(taf)	(taf)	(taf)	(taf)	(taf)	(taf)	(taf)	(taf)	(taf)	(taf)
Total Delta Outflow	15655	15657	15419	15419	16167	16175	15923	15923	16094	15857
Req'd Delta Outflow	5276	5272	5258	5262	5573	5577	5452	5445	5584	5458
North Delta Diversion	0	0	2641	2640	0	0	2576	2578	0	2532
Shasta	3203	3202	3225	3220	3068	3062	3113	3097	3026	3070
Folsom	566	586	559	580	559	580	552	574	554	549
Trinity	1590	1588	1600	1595	1510	1491	1519	1509	1478	1498
Oroville	2134	2135	2180	2177	2033	2032	2082	2080	2014	2063
CVP San Luis	473	466	506	500	473	472	496	496	456	487
SWP San Luis	502	501	566	566	462	466	533	535	457	523
Nimbus Release	2282	2281	2283	2282	2368	2366	2368	2366	2373	2372
Banks Export	2687	2687	2928	2926	2607	2616	2854	2857	2583	2822
Jones Export	2212	2211	2192	2194	2106	2097	2092	2092	2088	2072
Total Export	4899	4898	5120	5120	4714	4712	4945	4950	4672	4894
CVP NOD Delivery	2335	2336	2333	2334	2296	2292	2293	2291	2317	2317
CVP SOD Delivery	2331	2330	2322	2322	2232	2224	2226	2226	2214	2208
SWP NOD Delivery	1218	1217	1236	1236	1193	1191	1205	1207	1190	1201
SWP SOD Delivery	2493	2492	2588	2589	2436	2442	2536	2538	2419	2514

Table 5b – Differences calculated from values in 4a. All values are average annual Oct-Sep totals in TAF or average monthly storage in TAF.

	ARWA Hydrology w No SLR		Q5 Hydrology w 15 cm SLR		Petitioner
	2006FMS_CWF - 2006FMS	ModFMS_CWF - 2006FMS_CWF	2006FMS_CWF - 2006FMS	ModFMS_CWF - 2006FMS_CWF	CWF_H3+ - NAA
	(taf)	(taf)	(taf)	(taf)	(taf)
Total Delta Outflow	-236	0	-244	0	-237
Req'd Delta Outflow	-18	5	-121	-6	-126
North Delta Diversion	2641	0	2576	3	2532
Shasta	22	-5	45	-16	43
Folsom	-7	21	-6	21	-5
Trinity	9	-4	10	-11	20
Oroville	46	-2	49	-3	49
CVP San Luis	33	-6	24	-1	31
SWP San Luis	64	0	71	2	66
Nimbus Release	1	-1	0	-2	-1
Banks Export	241	-2	247	4	239
Jones Export	-20	2	-15	1	-17
Total Export	221	0	232	4	222
CVP NOD Delivery	-2	1	-3	-2	0
CVP SOD Delivery	-9	1	-6	0	-7
SWP NOD Delivery	18	0	12	1	11
SWP SOD Delivery	96	1	99	2	96

Figure 8 – Historical Hydrology CalSim Study Sequence with WaterFix and ModFMS

This figure shows storage results for a three-study sequence from 2006FMS_20171105 to 2006FMS_CWF to ModFMS_CWF (all studies use ARWA hydrology inputs and 0 cm sea level rise). For context, the storage results for petitioners' modeling is also shown. Storage results for petitioners' modeling is generally lower because it uses input data reflecting Q5 hydrology and 15 cm of sea level rise.

The distribution of total CVP NOD storage changes approximately the same amount due to CWF when viewed from the 2006FMS or CWF_NAA baseline – there is a small overall increase. The ModFMS has no perceptible influence on total storage when it is implemented in addition to the CWF.

Comparing the three CVP storage facilities, the CWF has a similar effect at each facility from both petitioners' NAA baseline and the 2006FMS baseline. The addition of ModFMS increases Folsom storage conditions (as intended). Note that the different scales on each plot make it hard to compare visually, but there are decreases to Shasta and Trinity storage conditions offsetting the Folsom gains due to the ModFMS.

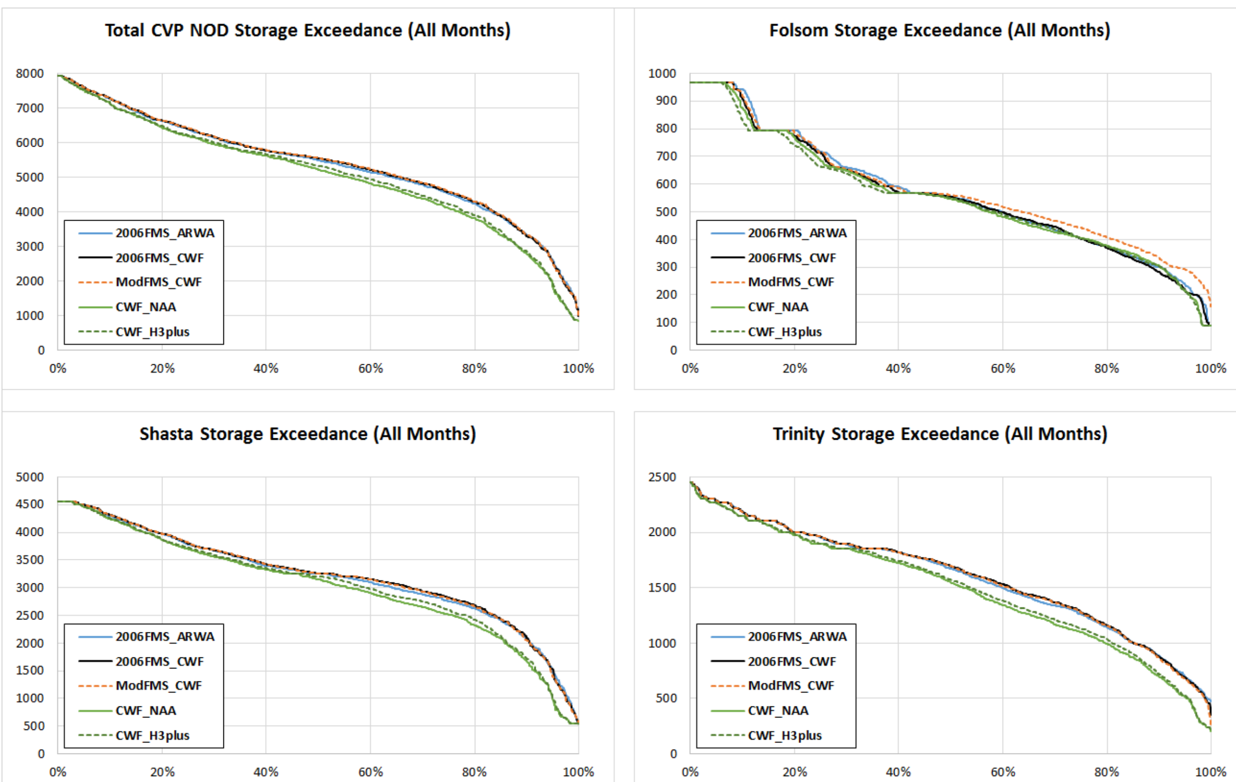


Figure 9 – Q5 Hydrology CalSim Study Sequence with WaterFix and ModFMS

These plots are similar to Figure 10, but with the Petitioner model results removed since they overlay the plotted data for the ARWA studies.

With Q5 hydrology inputs, similar to the results with Q0 inputs, CWF causes changes to storage conditions that are consistent with Petitioner modeling. ModFMS logic layered on the CWF operation increases Folsom storage and shows re-directed impacts to storage conditions in Shasta and Trinity.

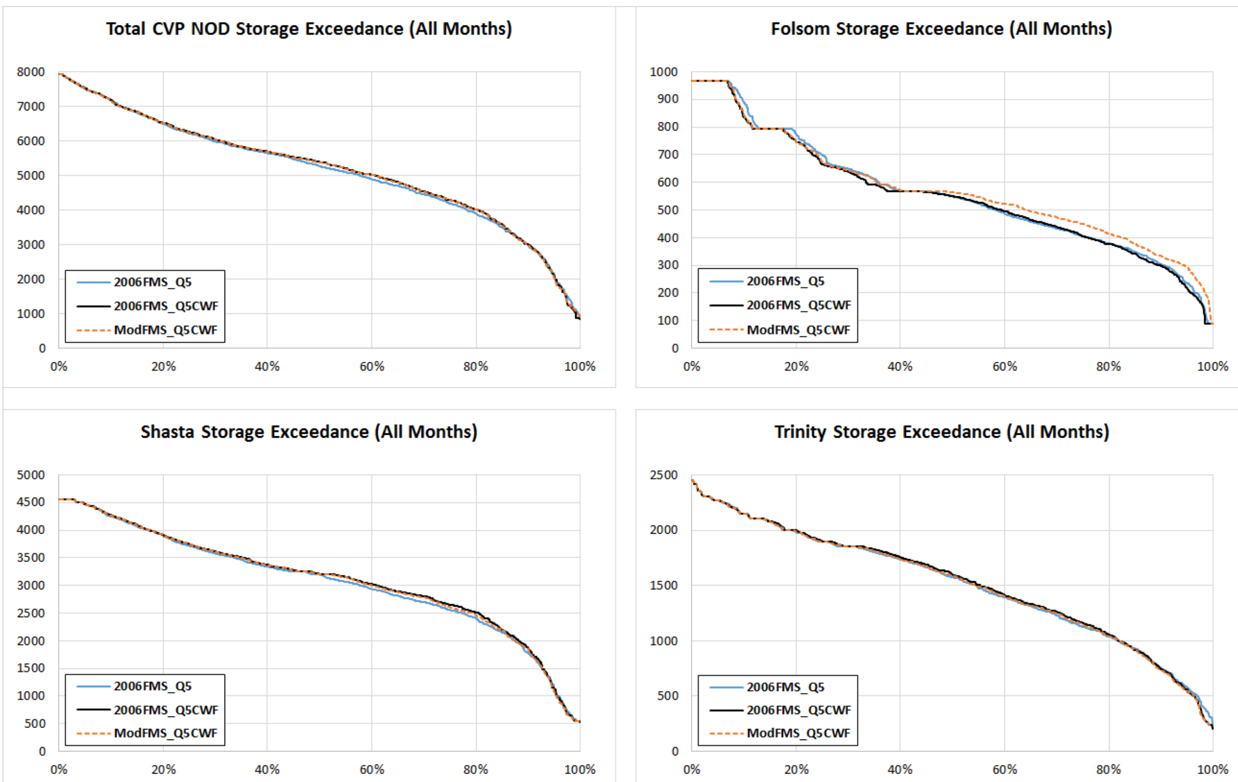
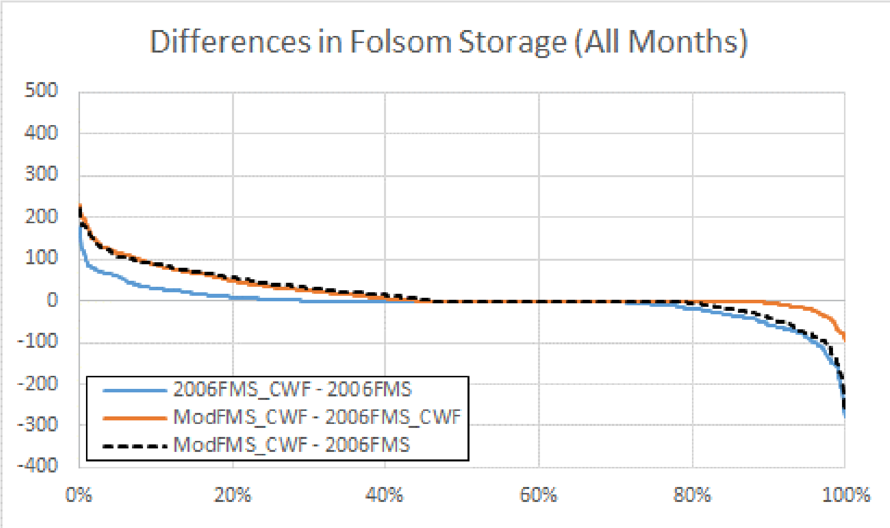
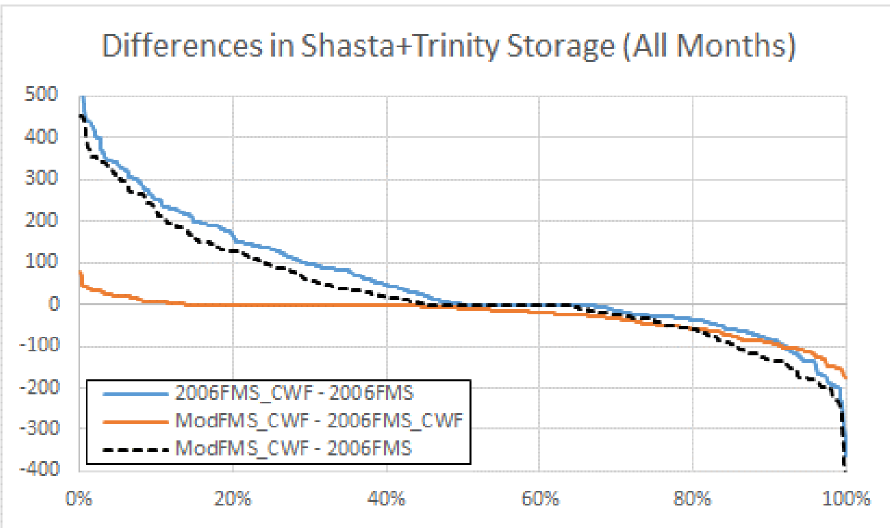


Figure 10 – Storage Differences for the Q5 sequence of WaterFix and ModFMS studies





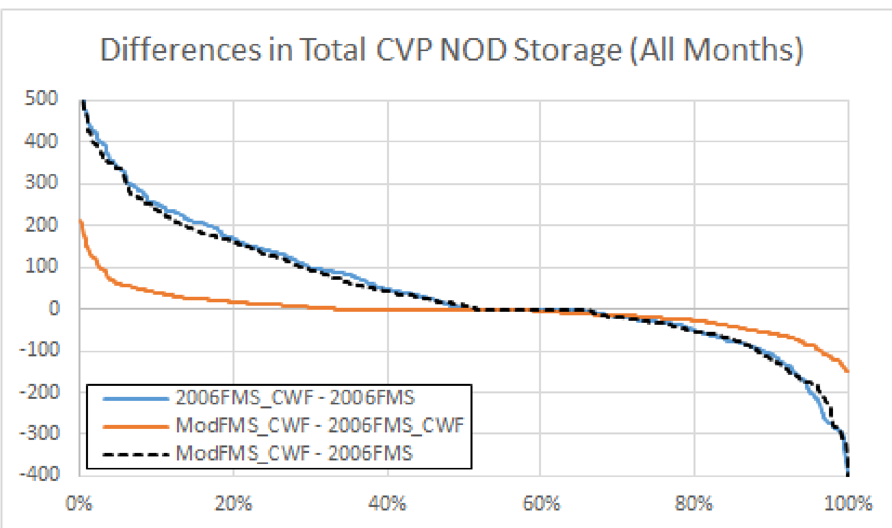


Figure 13a – Trinity storage exceedance for all months shows CWF_H3+ values at or above NAA values

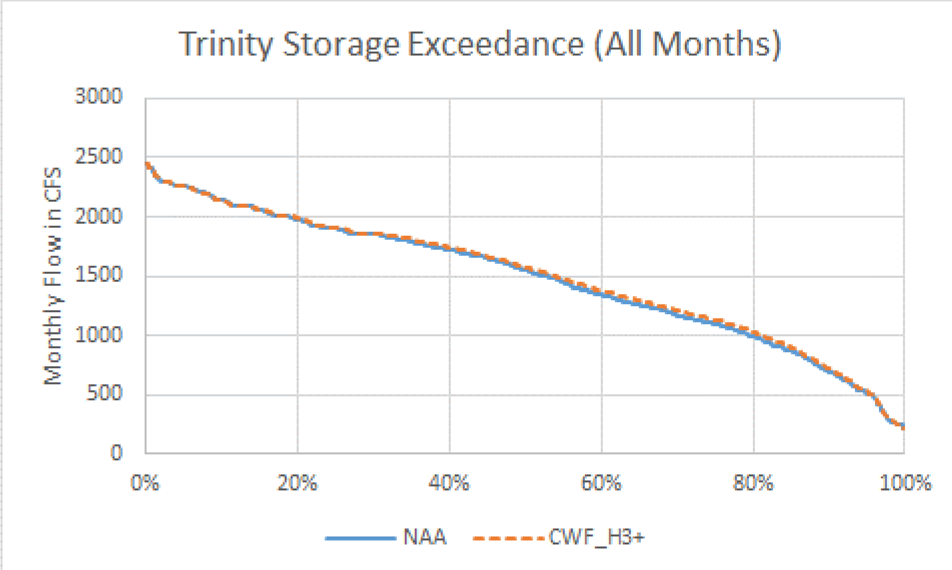


Figure 13b – A zoom in on the highest 20% of the exceedance range shows CWF_H3+ values at or above NAA values

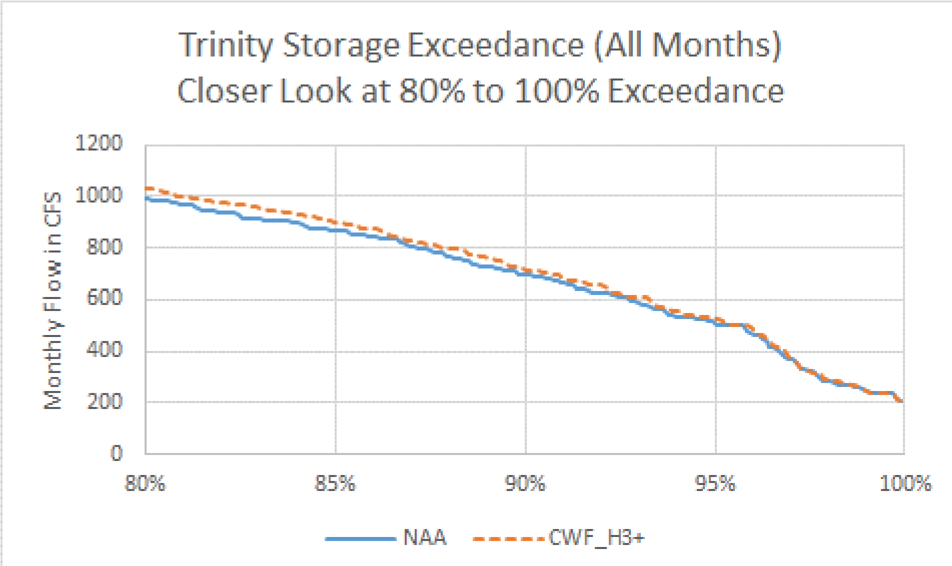


Figure 14 – Maximum annual (Mar-Jun) storage condition, minimum annual (Aug-Dec) storage condition, and end-of-September storage condition exceedances all show CWF_H3+ conditions almost always at or above NAA conditions.

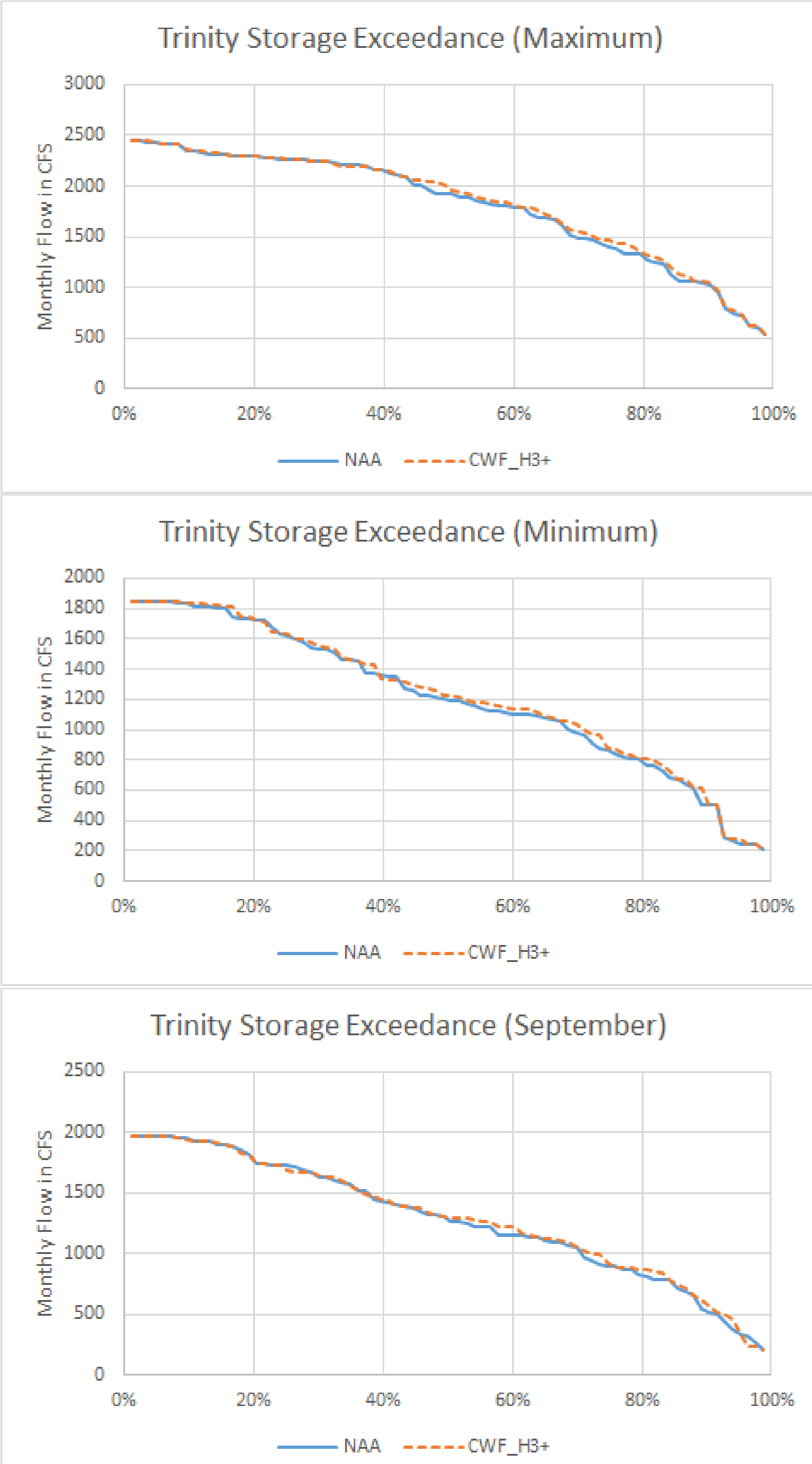


Figure 15 – Trinity River Releases and Exports to the Sacramento River – Flow volumes are mostly higher due to a few additional spills given slightly higher storage conditions. Exports are driven by the balance between Shasta and Trinity storage, and the changes in CVP NOD storage balance seen with CWF_H3+ is the root cause of differences in these exports. No rules were changed between the CWF_H3+ and NAA scenarios for reservoir balancing or for Carr Tunnel targets, so these differences are simply an artifact of a model outcome that was not calibrated to new timing of reservoir balancing relationships. Average annual exports are 525 in the NAA and 518 in the CWF_H3+, a difference of 1% annual volume.