CALIFORNIA WATER FIX

MODELING REVIEW

MBK ENGINEERS

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SVWU-107

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Executive Summary

Proponents of the California Water Fix (CWF) have developed and submitted exhibits and testimony regarding their modeling work to the State Water Resources Control Board for the CWF hearing. We have determined that their modeling does not correctly analyze the potential effects and impacts of the CWF on legal users of water, due to inappropriate assumptions regarding the operations of the Central Valley Project (CVP) and State Water Project (SWP) with the addition of the CWF. We have determined that the modeling results submitted by CWF's proponents cannot be relied on to demonstrate a lack of such impacts, and instead have concluded that the CWF is likely to result in increased risks of adverse impacts to other legal users of water.

We have examined the underlying CalSim II model used for the proponents' CWF exhibits and testimony, have analyzed the proposed operational scenario contained in the January 2016 CWF Draft Biological Assessment (CWF BA), and have concluded that their modeling does not realistically simulate CVP and SWP operations with CWF and that system-wide effects of the CWF therefor are not adequately represented. Because it was not possible to determine how the CWF may affect CVP and SWP operations or legal users of water with the CWF Draft Biological Assessment (BA) modeling, MBK performed independent modeling to assess the potential effects of the CWF. It was necessary for MBK to develop and analyze two separate modeling scenarios because of contradictions that exist between CWF BA modeling assumptions and the project description in the CWF BA.

MBK modeling provides more-realistic evaluations of the potential CWF yield and potential impacts to other legal users of water. Our modeling indicates that the future operation of the CWF could take advantage of releases of upstream storage to increase the overall yield of the CWF. This potential greater use of previously stored water represents a risk to other legal users of water. MBK modeling indicates, due to the CWF, senior water right holders who have settlement contracts with the U.S. Bureau of Reclamation and the California Department of Water Resources could have their supplies reduced in some water-year types, water users with Term 91 in their water right permits or licenses would have their diversions curtailed more frequently, and north of Delta CVP water service contractors would receive reduced allocations.

Key Conclusions Regarding CWF BA Modeling

We evaluated the modeling performed by the California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR or Reclamation) for the January 2016 CWF Draft BA (DWR/USBR BA Model) as representing one possible, and reasonably likely, scenario for the operation of the CVP and the SWP with CWF in place. Based on this review, we have concluded that inappropriate assumptions in the DWR/USBR BA Model result in impractical and unrealistic modeling of CVP and SWP operations. Therefore, the CWF BA Model provides only limited useful information to illustrate the effects of the CWF, and cannot be relied upon to demonstrate lack of impacts to other legal users of water. The primary reason for impractical and unrealistic operations in the DWR/USBR BA Model is that its model parameters are set to limit use of the additional capacity that the CWF's North Delta Diversion (NDD) would make available to the CVP and SWP.

Our primary conclusions regarding the most significant model parameters and resulting effects on modeled CVP/SWP operations are as follows:

1. **DWR/USBR BA Model does not consider the additional capacity that would be made available by the NDD when modeling allocations to South of Delta CVP and SWP contractors.**

Although the NDD would provide increased ability to convey water released from storage in upstream reservoirs to south Delta exports, export estimates used in CalSim II to calculate south-of-Delta (SOD) CVP water service contract allocations and SWP Table A contract allocations in the DWR/USBR BA Alternative 4A are set to those in the DWR/USBR BA NAA. This artificially and unrealistically limits the modeled ability of the CWF to increase CVP and SWP SOD allocations through use of the NDD. The ability to convey water through the Delta has restricted CVP SOD allocations in approximately two out of every three years since the addition of Old and Middle River (OMR) requirements in 2008. Therefore, this model assumption has the potential to significantly affect model results. This assumption tends to artificially and incorrectly keep modeled storage in north-of-Delta (NOD) CVP and SWP reservoirs higher under DWR/USBR BA Alternative 4A as compared to the No Action Alternative.

2. **DWR/USBR BA Model includes artificial limits on the modeled use of Joint Point of Diversion (JPOD).**

DWR/USBR BA Alternative 4A modeling limits JPOD to remaining Banks South Delta Diversion (SDD) permitted capacity (under the permit issued by the U.S. Army Corps of Engineers under Section 10 of the Rivers and Harbors Act), regardless of whether the water is modeled as being conveyed through the SDD or the NDD. This assumption limits the CVP's modeled ability to use JPOD to convey both excess Delta outflow (outflow in excess of existing regulatory requirements) and water stored in upstream CVP reservoirs. This assumption tends to artificially and incorrectly keep modeled storage in NOD CVP reservoirs higher under DWR/USBR BA Alternative 4A as compared to the No Action Alternative.

3. **DWR/USBR BA Model changes NOD/SOD reservoir balancing criteria so that less stored water is modeled as being conveyed from North of Delta (NOD) reservoirs to San Luis Reservoir during summer months.**

CalSim II balances Sacramento Valley CVP and SWP reservoir storage with storage in San Luis Reservoir by setting target storage levels in San Luis Reservoir. These operations criteria, in conjunction with CVP and SWP SOD contract allocations, govern how much stored water is modeled as being released from upstream reservoirs and exported from the Delta. DWR/USBR BA Alternative 4A increased modeled San Luis Reservoir target storage levels in winter and spring months and then decreased modeled target storage levels during summer months. When combined with Parameter 1 above, related to export estimates and SOD contract allocations, the result is a decrease in modeled release and conveyance of previously stored water from NOD CVP and SWP reservoirs. These criteria tend to artificially and incorrectly keep modeled storage in NOD CVP and SWP reservoirs higher under DWR/USBR BA Alternative 4A as compared to the No Action Alternative.

4. **CalSim II does not address effects on many types of water users.**

CalSim II is used for this modeling analysis, and although CalSim II simulates changes in Delta exports, Delta outflows, river flows, and CVP and SWP reservoir storage levels, it does not model any changes in water deliveries to Sacramento River Settlement Contractors, Feather River Settlement Contractors, wildlife refuges, CVP Exchange Contractors or non-Project water right holders. Because all CVP and SWP Settlement Contractor deliveries and all non-Project water user deliveries are "Hard Coded", the model is forced to meet these deliveries unless it runs out of water. For the purpose of CalSim II, it runs out of water when a reservoir reaches dead pool.

Because CalSim II does not reduce water use by non-Project water right holders or reduce deliveries to Settlement Contractors as necessary to comply with regulatory requirements, effects on these water users must be determined by evaluating the model output. Lower storage during spring of dry and critical years would likely result in operational changes to protect cold water in Shasta Reservoir. The lower storage may cause the State Water Resources Control Board, CVP, or SWP to reduce deliveries to the Sacramento and Feather River Settlement contractors to meet regulatory requirements.

5. **DWR/USBR BA Model constrains modeled diversions of excess Delta outflows beyond limits described in the CWF BA.**

The CWF BA includes a description of a spring Delta outflow criteria in Table 3.3-1 (page 3-88) and Table 3.3-2 (page 3-95). The upper limit for the spring Delta outflow criteria is 44,500 cfs. However, the USBR/DWR BA Alternative 4A modeling prevents diversions of Delta excess when Delta outflow exceeds 44,500 cfs. This assumption limits modeled CVP and SWP diversions of Delta excess flows, and underestimates the changes in Delta outflow that actually would occur. Furthermore, limiting the modeled CVP and SWP diversions of excess flow may result in lower modeled allocations to SOD CVP water service contracts and SWP Table A contracts in the DWR/USBR BA Alternative 4A than what may realistically occur. Diversion of excess flows would affect operations in subsequent months and may change project allocations and reservoir carryover storage.

Summary of MBK Modeling of CWF

In addition to the five key conclusions described above, many modeling modifications were made in the MBK modeling to address important aspects of operations that will likely be affected by the CWF. These additional modifications affect many aspects of modeled water operations including reservoir storage, river flows, CVP and SWP contract allocations, and system-wide water supply. MBK modeling was performed by modifying the CalSim II model used for the CWF BA. There are approximately 12 changes made to the USBR/DWR BA NAA to develop the MBK NAA, with an additional 8 changes made to represent the MBK Alternative 4A for analyses of the CWF based on the CWF BA modeling. An additional 6 changes were developed for the MBK Alternative 4A Delta Outflow (DO) to evaluate the CWF as is described in the CWF BA. MBK Alternative 4A DO was developed to address the contradiction that exists between CWF BA modeling assumptions and the project description in the CWF BA. These changes are described in detail in this report in sections 2-A, 2-B, and 3-A. The results of these changes are summarized here.

Key Changes in CVP and SWP Operations

Modifications to both the NAA and Alternative 4A in MBK modeling result in different operational effects of CWF than those shown by the DWR/USBR BA Model. **Table 1** contains a summary of annual average changes in key model results due to the CWF that are based on comparing the results of Alternative 4A to the results of the NAA for both the USBR/DWR and MBK modeling. This table also shows the differences between MBK and USBR/DWR modeling results. One of the key differences in model results is that while total Delta exports increase with CWF by an average of 226 thousand acre-feet (TAF) in the USBR/DWR modeling, this increase more than doubles (491 TAF) in MBK Alternative 4A, and almost triples (661 TAF) in MBK Alternative 4A DO that is based on the project description in the CWF BA. The NDD is modeled to convey about 408 TAF and 596 TAF more per year on average in the MBK modeling than in the USBR/DWR modeling. Both MBK modeling approaches show increased movements of stored water, resulting in lower upstream end-of-September (carryover) storage and increased risks to upstream storage and upstream water users. The combined modeled *reduction* in Shasta, Oroville, and Folsom reservoir carryover storage caused by CWF is 325 TAF (136 + 26 + 163) and 349 TAF in the MBK modeling compared to a modeled *increase* in upstream carryover storage of 103 TAF in the USBR/DWR modeling.

Table 1. Summary of Annual Average Modeling Differences

	USBR/DWR BA	MBK modeling based on BA modeling		MBK modeling based on BA description	
	Alternative 4A minus NAA	Alternative 4A minus NAA	Difference from USBR/DWR	Alternative 4A DO minus NAA	Difference from USBR/DWR
Change in total Delta exports	226	491	*265*	661	*435*
North Delta Diversion	2560	2968	*408*	3156	*596*
Change in South Delta Diversion	-2334	-2477	*-143*	-2495	*-161*
Change in Delta outflow	-241	-464	*-223*	-622	*-381*
Change in Shasta carryover	25	-111	*-136*	-131	*-156*
Change in Folsom carryover	-11	-37	*-26*	-29	*-18*
Change in Oroville carryover	89	-74	*-163*	-86	*-175*
Change in CVP delivery	-11	177	*188*	208	*219*
Change in SWP delivery	216	270	*54*	392	*176*

All Values are in 1,000 acre feet

Term 91

Term 91 is a standard term the State Water Resources Control Board (SWRCB), Division of Water Rights (Division) included for water right permits issued in about 1965 or later. The purpose of Term 91 is to curtail diversions under those water rights when necessary to make the remaining natural flow available to meet water quality requirements, and to protect the use of water released from storage in NOD CVP and SWP reservoirs from diversions by those junior water right holders. For Term 91 curtailments to be invoked, two conditions must exist. First, the Delta must be in balanced conditions, meaning there is enough water (unregulated flow and CVP/SWP storage releases) in the system to meet: a) in-basin uses including Delta water quality and outflow requirements and b) Delta exports. Second, storage withdrawals from CVP and SWP facilities, including Trinity imports, must be greater than total exports; the water derived from these storage withdrawals is referred to as supplemental water.

Term 91 is implemented by the SWRCB on a quasi-real-time basis; that is, the Division knows when balanced conditions exist in the Delta and then monitors storage withdrawals from CVP and SWP facilities (including Trinity imports) on a daily basis to verify that supplemental water exists on a consistent basis (not just a single day). For these reasons, CalSim II is not the best available tool to evaluate Term 91 implementation; however, a review of the results from DWR/USBR BA modeling and MBK Alternative 4A do provide the following conclusions:

- For May, MBK modeling results indicate there will be an increase of approximately 10 percent in the frequency of Term 91 curtailments with the CWF. This increase is logical considering the increased Delta outflow requirement during May associated with the CWF.

- For all other months during April through September, the MBK modeling results indicate a greater frequency of Term 91 curtailments. This increase is logical with the increased Delta outflow with CWF resulting in the Delta being in balanced conditions more often, together with the NDD of the CWF providing greater opportunity for the CVP and SWP to have Delta exports exceed storage withdrawals.

Introduction

The main component of the California Water Fix (CWF) is a proposed diversion on the lower Sacramento River, near Hood, called the North Delta Diversion (NDD). The ability to export water through the NDD, in addition to existing South Delta Diversion (SDD) export facilities, would increase the SWP's and CVP's ability to export water to areas south of the Delta and may result in different system-wide operations, including different operations of north-of-Delta (NOD) reservoirs, and different Delta flow regimes. Modeling is used to assess what changes may occur if the NDD is constructed. Several different modeling efforts have been performed to assess effects due to the NDD, including: the Bay Delta Conservation Plan (BDCP) DEIS/DEIR, draft Biological Assessment under Section 7 of the Endangered Species Act (ESA), California Water Fix RDEIR/FDEIS, and additional modeling recently released by DWR and the Bureau of Reclamation.

This report contains a summary of MBK Engineers' (MBK) findings and opinions on the hydrologic modeling that the U.S. Bureau of Reclamation (Reclamation or USBR) and the California Department of Water Resources (DWR) performed for the CWF draft Biological Assessment (BA) under Section 7 of the ESA. This report also contains an independent modeling assessment of CWF operations using the same project-specific assumptions as the CWF BA, but more appropriate assumptions regarding system-wide water operations.

This report is organized into two overall sections. One describes our review of the DWR/Reclamation modeling for the CWF BA under Section 7 of the ESA, and the other contains results from MBK's independent modeling analysis of the CWF. MBK modeling performed for this effort includes one modeling analysis that assumes additional spring outflow requirements will be satisfied using the methods in DWR/Reclamation modeling and the second assumes spring outflow requirements are based on the description of the proposed action in the CWF BA.

1. Review of DWR/Reclamation Modeling for Biological Assessment

This review focuses on water operations modeling using CalSim II. CalSim II is a computer program jointly developed by DWR and Reclamation. CalSim II presents a comprehensive simulation of State Water Project (SWP) and Central Valley Project (CVP) operations. CalSim II is widely recognized as the most prominent water management model in California, and it is generally accepted as a useful and appropriate tool for assessing the water delivery capability of the SWP and CVP. CalSim II estimates, for various times of the year, how much water will be diverted, how much will serve as instream flows, and how much will remain in reservoirs.

Reclamation and DWR applied CalSim II to analyze how CVP and SWP operations would change as a result of implementation of the CWF. The coding and assumptions included in the CalSim II model drive the results. Data and assumptions, such as the amount of precipitation runoff at a certain measuring station or the demand for water by specific water users, are input into the model. There are both discretionary and nondiscretionary operating criteria used to operate the CVP and the SWP in the CalSim II model. Nondiscretionary operating criteria assumed in CalSim II include regulatory requirements such as State Water Resources Control Board (SWRCB) standards, requirements in Biological Opinions, flood control requirements, and other requirements. Discretionary operational logic coded into CalSim II controls how DWR and Reclamation would operate the

CVP/SWP system under circumstances for which there are no regulatory or otherwise definitive rules, e.g. when to move water from storage in CVP and SWP reservoirs upstream of the Delta to CVP and SWP reservoirs downstream of the Delta. This attempt to simulate the logic sequence and relative weighting CVP and SWP operators use as part of their operations decisions is a critical element of CalSim II, and these discretionary operational criteria significantly influence model results.

The CalSim II model is the foundational model for analysis of the CWF, including effects and impacts analyses. Results from CalSim II are used to examine how water supply and reservoir operations would be modified by the CWF for each project alternative. CalSim II results are also used by subsequent models to determine physical and biological effects including effects on water quality, water levels, water temperature, Delta flows, and fish. Any inappropriate assumptions, errors, or inconsistencies identified in the underlying CalSim II model therefore also will be present in subsequent analyses of environmental effects.

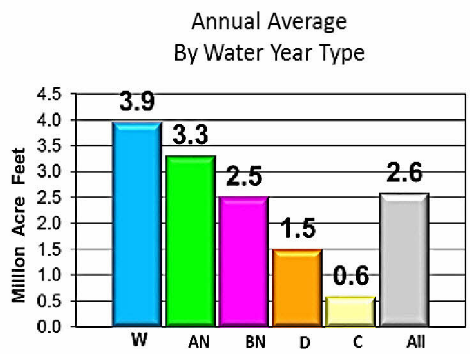
CalSim II is most often used in a mode of comparing two model runs: one that contains a proposed project alternative and one that does not. Differences in certain factors, such as deliveries, river flows, and reservoir storage levels, are analyzed to determine the effects of the project alternatives on system-wide operations. For the purpose of this review, the No Action Alternative and with Project modeling are reviewed, but the main focus is on differences between these modeling scenarios.

A. North Delta Diversion

Modeled use of the North Delta Diversion (NDD) is constrained and influenced by pulse flow criteria, low level pumping criteria, bypass flow criteria, fish screen sweeping velocity criteria, proposed Delta outflow criteria and export limitations, existing and proposed Delta standards, and available water supply. A constraint restricting modeled use of the NDD is that Sacramento River flow below the NDD must be maintained above specified bypass flow requirements and the Sacramento River flow at the NDD must be sufficient to maintain fish screen sweeping velocities.

With constraints applied in modeling performed for the CWF BA (DWR/USBR BA Alternative 4A), results show an average annual NDD of 2.6 Million Acre Feet (MAF). **Figure 1** shows the average annual NDD by water year type, ranging from 3.9 MAF in wet years to 0.6 MAF in critical years. A majority of this diversion would occur in winter and summer months, with lower diversions in April and May.

Figure 2 contains probability of exceedance charts of simulated Sacramento River flows above and below the NDD, diversions at the NDD, and the maximum allowable total diversions. The plots are scaled so that lower flow conditions may be examined in greater detail. The green dashed curve in each figure shows the maximum allowable diversion and the red curve represents diversions at the NDD facility, thus, the red curve must always be on or below the green dashed curve. Differences between the solid blue curve and the dotted blue curve show the differences between Sacramento River flows above and below the NDD. Modeling performed for the BA assumes constrained use of the NDD in April and May based on San Joaquin River flow at Vernalis and existing constraints in the Delta smelt Biological Opinion; therefore, diversions are always less than those allowed by the NDD bypass criteria. Modeling assumes use of the NDD from July through September would have a lower priority than the South Delta Diversion (SDD) until the SDD is at least 3,000 cfs; therefore, the NDD is often less than what is allowed in the bypass criteria.



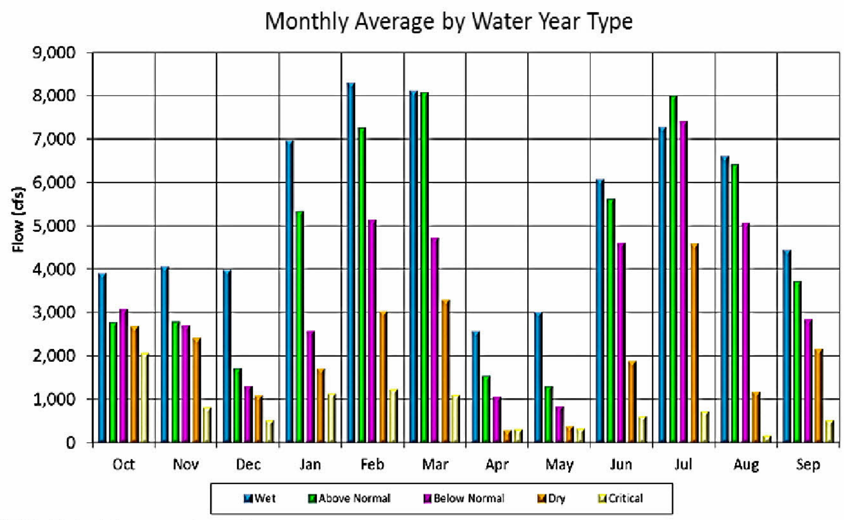


Figure 1. North Delta Diversion – DWR/USBR BA Alternative 4A

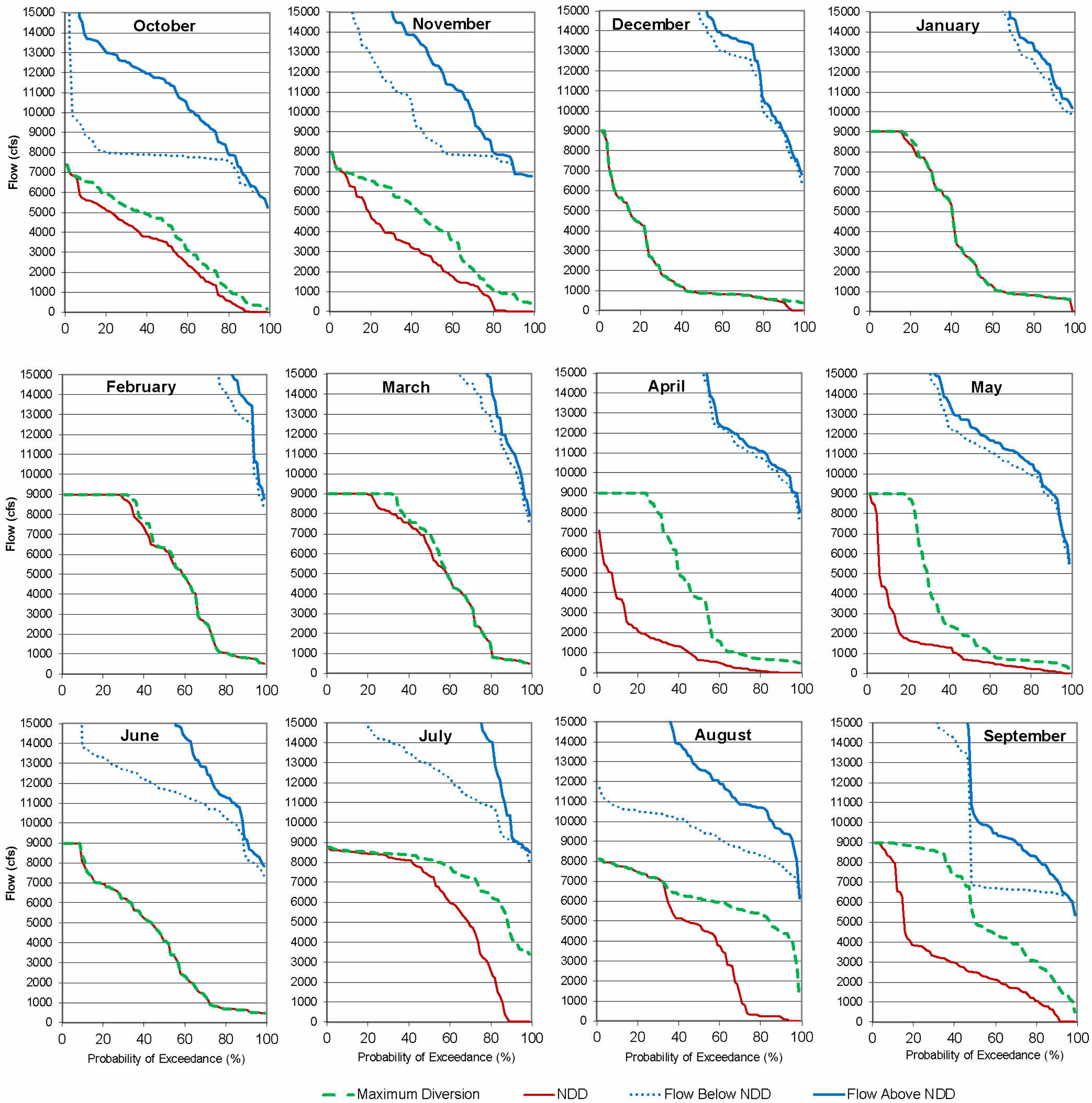


Figure 2. Sacramento River and NDD - DWR/USBR BA Alternative 4A

B. Delta Outflow Requirement

One of the components of the CWF is a spring Delta outflow requirement. The CWF BA's proposed spring Delta outflow criteria is an average March through May Delta outflow requirement expressed in the form of the probability of exceedance curve listed in **Table 2**. According to the CWF BA, the outflow criterion is based on the DWR/USBR BA NAA results. **Figure 3** shows the DWR/USBR BA NAA average March through May Delta outflow probability of exceedance (black dots) and the spring Delta outflow criterion (green circles). The DWR/USBR BA NAA results and the resulting criteria are close to equal in the 30 to 90 percent range of the exceedance curve. The NAA results stray from the criteria at the 10% and 20% exceedance levels where the proposed spring outflow criterion is capped at 44,500 cfs and the NAA results range from 46,660 cfs to 69,772 cfs.

Table 2. Proposed Average March through May Spring Outflow Criteria

Exceedance	Outflow criterion (cfs)
10%	44,500
20%	44,500
30%	35,000
40%	27,900
50%	20,700
60%	16,800
70%	13,500
80%	11,500
90%	9,100

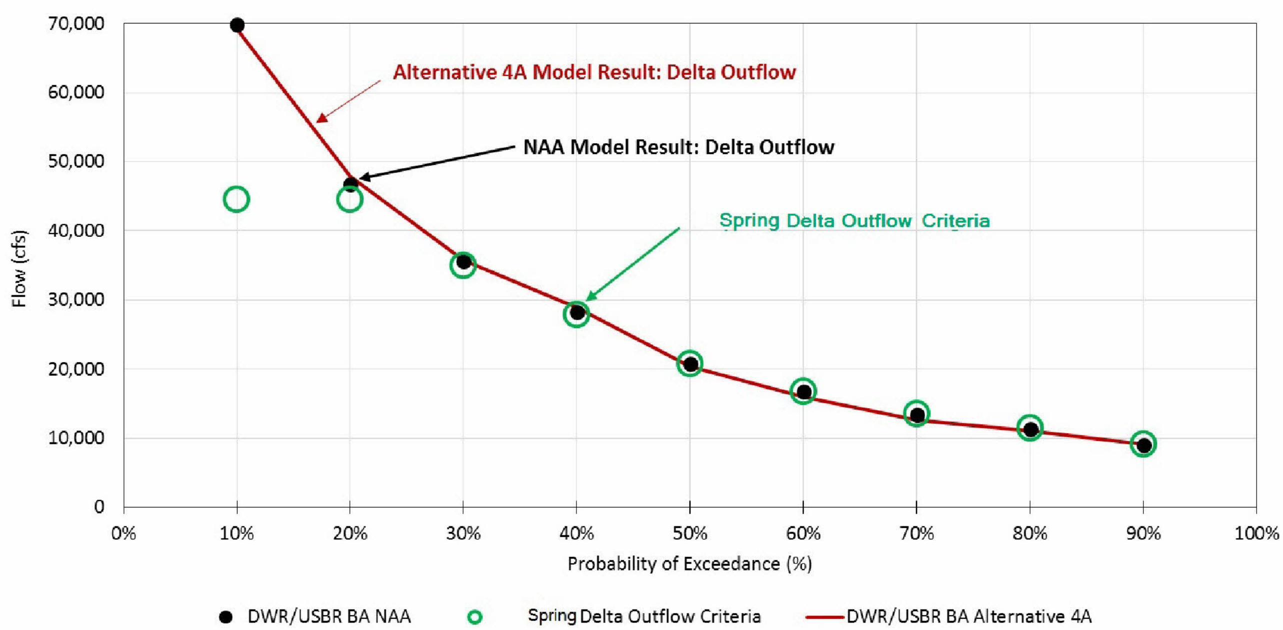


Figure 3. CWF BA Delta Outflow Criteria and Results

In the DWR/USBR BA Alternative 4A modeling there is no direct implementation of the proposed spring Delta outflow criteria. Instead, the model applies the San Joaquin River Inflow to Export Ratio (SJR IE) to total Delta exports, both SDD and NDD, and the spring outflow criterion is incidentally met by constraining Delta exports. The DWR/USBR BA Alternative 4A average March-May Delta outflow probability of exceedance is plotted in **Figure 3**. As shown, the modeled outflow meets the spring Delta outflow target across specified range of exceedances. This occurs even though the model applies the SJR IE only in April and May and not in March. The NDD facility bypass criteria and the proposed additional OMR flow constraints also contribute to meeting the specified flow criteria in DWR/USBR BA Alternative 4A.

While the SJR IE is used to incidentally meet the outflow criteria in DWR/USBR BA Alternative 4A, it is not clear that extending the SJR IE to include NDD diversions actually is part of the proposed action. Table 3.3-1 in the CWF BA suggests that it may be: *"The 2011 NMFS BiOp action IV.2.1 (San Joaquin River i-e ratio) will be used to constrain Apr–May total Delta exports under the PA to meet March–May Delta outflow targets per current operational practices (National Marine Fisheries Service 2009)."*

However, in a paragraph preceding its Table 3.3-1, the CWF BA states that the spring Delta outflow criteria will be met with a combination of purchased water and operations of the SWP and CVP: "*To avoid a reduction in overall abundance for longfin smelt, the PA includes spring outflow criteria, which are intended to be provided by appropriate beneficiaries through the acquisition of water from willing sellers. If sufficient water cannot be acquired for this purpose, the spring outflow criteria will be accomplished through operations of the CVP/SWP to the extent an obligation is imposed on either the SWP or CVP under federal or applicable state law."*

This last quote from the CWF BA implies that DWR and Reclamation will have operational flexibility in meeting the spring Delta outflow criteria, because operations of the CVP/SWP include both reservoir releases and exports. Furthermore, this quote makes it clear that this proposal is for a spring Delta outflow *requirement*, as opposed to an export restriction. Sharing of export restrictions is currently not addressed in the Coordinated Operations Agreement (COA) and it has not been determined how the CVP and SWP would share responsibility for meeting outflows by only reducing exports. Currently, Delta outflow requirements are considered to be an in-basin use under COA, and there is a defined sharing of obligations to satisfy outflow requirements in COA. However, this sharing may be subject to change if new requirements are adopted.

Given the description of the spring Delta outflow criteria in the CWF BA, there are three significant potential problems with DWR/USBR BA model representation:

(1) The CWF BA caps the required average March-May Delta outflow objective at 44,500 cfs. There are years in DWR/USBR BA Alternative 4A where the modeled average Delta outflow is well above 44,500 cfs, which is the maximum required outflow in the criteria. The DWR/USBR BA Alternative 4A continues to regulate total exports with the SJR IE in these years, even though such regulation would not be necessary to meet the required Delta outflows. Diversion of excess flow when Delta outflow exceeds 44,500 cfs in actual operations would result in lower outflows and higher exports than those modeled.
(2) If the intent of the CWF BA is to allow operators flexibility in meeting the spring Delta outflow criteria with either reservoir releases *or* export constraints when purchased water is not available, then the modeled DWR/USBR BA Alternative 4A should reflect that. By only constraining Delta exports, the modeled DWR/USBR BA Alternative 4A impacts to NOD reservoir carryover are likely underestimated for wetter years.

(3) As a required Delta outflow, the spring Delta outflow criteria would be subject to COA accounting as an in-basin use. Constraining exports to satisfy spring Delta outflow criteria is not addressed in COA, therefore sharing responsibility to meet outflow through export constraints also is not address in COA.

C. CVP/SWP Exports

With the modeled addition of the North Delta Diversion, the water exported dramatically shifts from South Delta diversions to North Delta diversions under DWR/USBR Alternative 4A compared to DWR/USBR NAA. **Figure 4** illustrates the changes in modeled South Delta diversions under DWR/USBR BA Alternative 4A compared to the DWR/USBR BA NAA. On average, exports through the South Delta facility are projected to decrease by about 2.3 MAF and the NDD are expected to export about 2.6 MAF, which includes about 2.3 MAF shifted from the South Delta facility plus an additional 226 TAF of increased exports.

Figure 5 contains charts for July, August, and September for DWR/USBR BA Alternative 4A that plot NDD against SDD. Table 3.3-2 on Page 3-96 of the CWF BA specifies operations for Delta water quality and residence time during these three months, diversions from the NDD should not occur until there is a least 3,000 cfs diversion from the SDD. However, as shown in **Figure 5**, there are times when diversions at the NDD are greater than 8000 cfs and SDD diversions are below the prescribed 3,000 cfs threshold indicated by the green curves in the charts. However, this is not expected to alter conclusions reached from CalSim II modeling. Other than this 3,000 cfs rule and the NDD bypass criteria, an operations plan that describes how decisions to allocate diversions by the NDD and the SDD would be made is not available. Therefore, actual operations may differ from what is modeled. Because there are no clear operations criteria, the effects of the proposed project cannot be fully assessed. There are times when combined exports are close to 14,400 cfs during July and August, this is the full capacity of both the Jones and Banks export facilities and is indicated in **Figure 5** with the purple line.

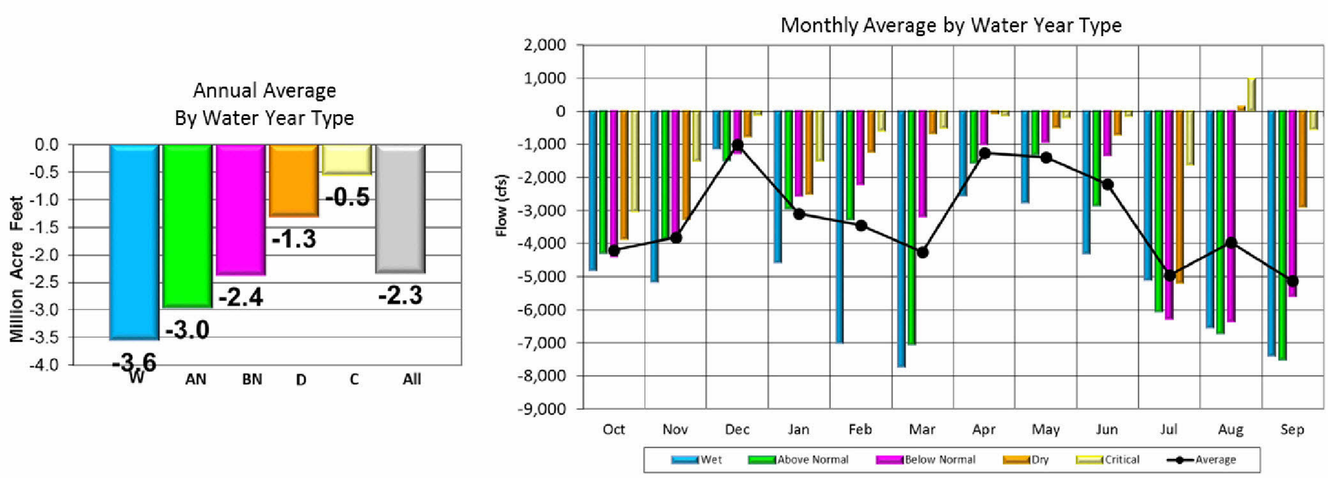


Figure 4. Change in South Delta Diversion – DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

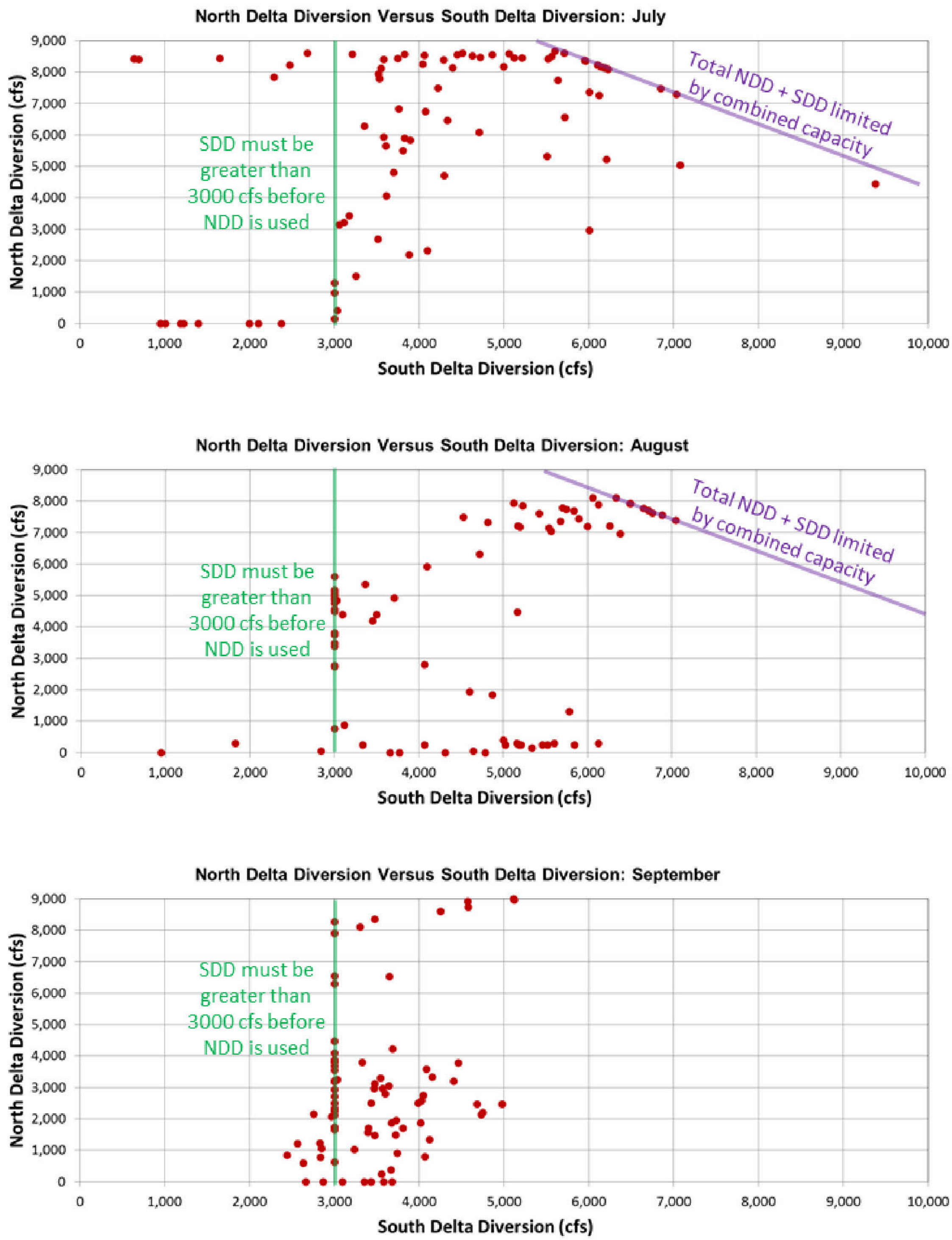


Figure 5. North Delta Diversion versus South Delta Diversion - DWR/USBR BA Alternative 4A

Overall, the DWR/USBR BA Alternative 4A would increase exports compared to exports under the DWR/USBR BA NAA. **Figure 6** shows an average annual increase in total Delta exports of 226 TAF, which range from about 376 TAF in wet years to 13 TAF in critical years. Exports in April and May would change very little, while exports in winter and early summer months would increase. Exports would decrease in the September through November period.

Figure 7 shows changes in Jones exports. Jones exports include combined NDD and SDD. There is an annual average decrease in Jones exports of about 24 TAF, with the largest decreases in wetter years and an increase in dry years. Jones exports tend to increase in June and then decrease from September through November. This change in monthly exports would tend to decrease upstream CVP reservoir storage from June through September.

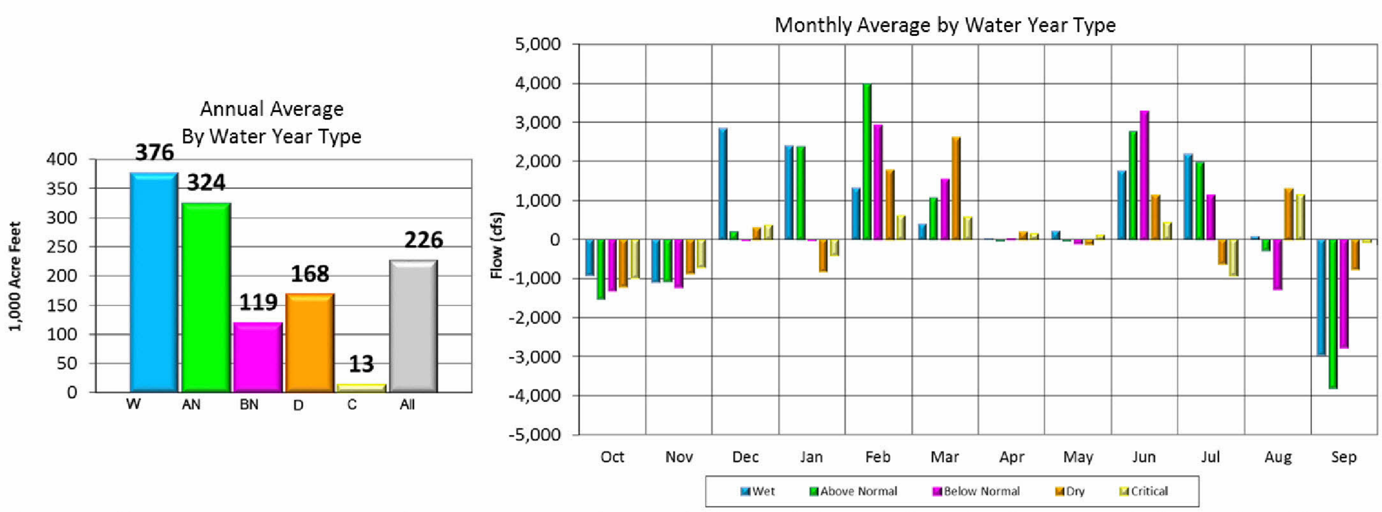


Figure 6. Change in Delta Exports (Jones plus Banks) DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

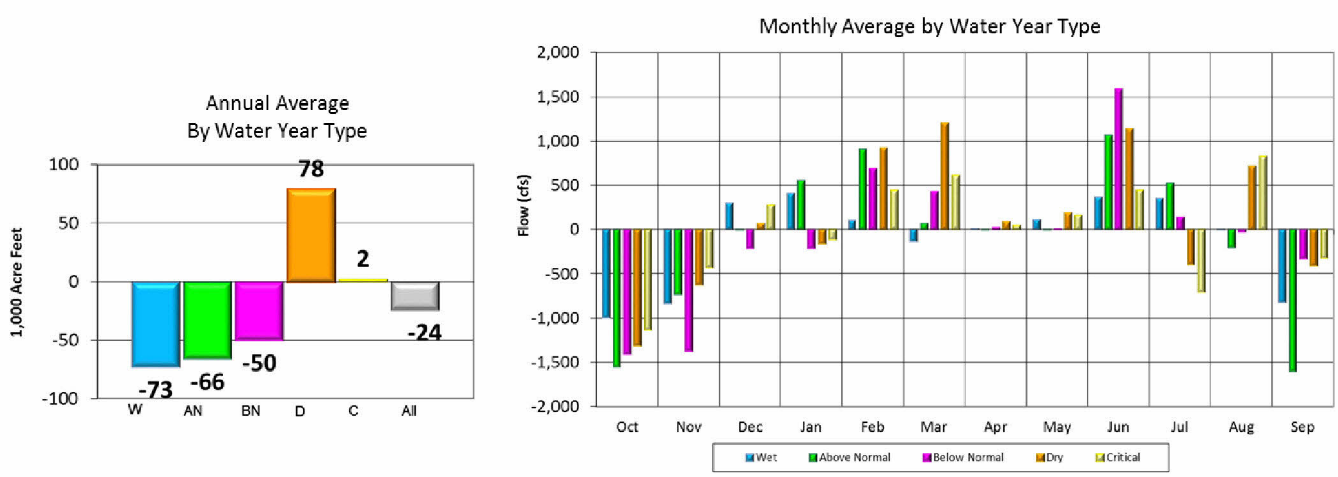


Figure 7. Change in Jones Delta Exports - DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

Figure 8 illustrates a comparison between the DWR/USBR BA Alternative 4A and the DWR/USBR BA NAA Banks exports. Banks exports include combined NDD and SDD. Although combined exports would increase by an annual average of 226 TAF, Banks exports would increase by about 249 TAF. Banks exports would tend to increase during periods of Delta excess. This is why wet year increases in Banks exports (448 TAF) are larger than the increase in drier years (12 TAF).

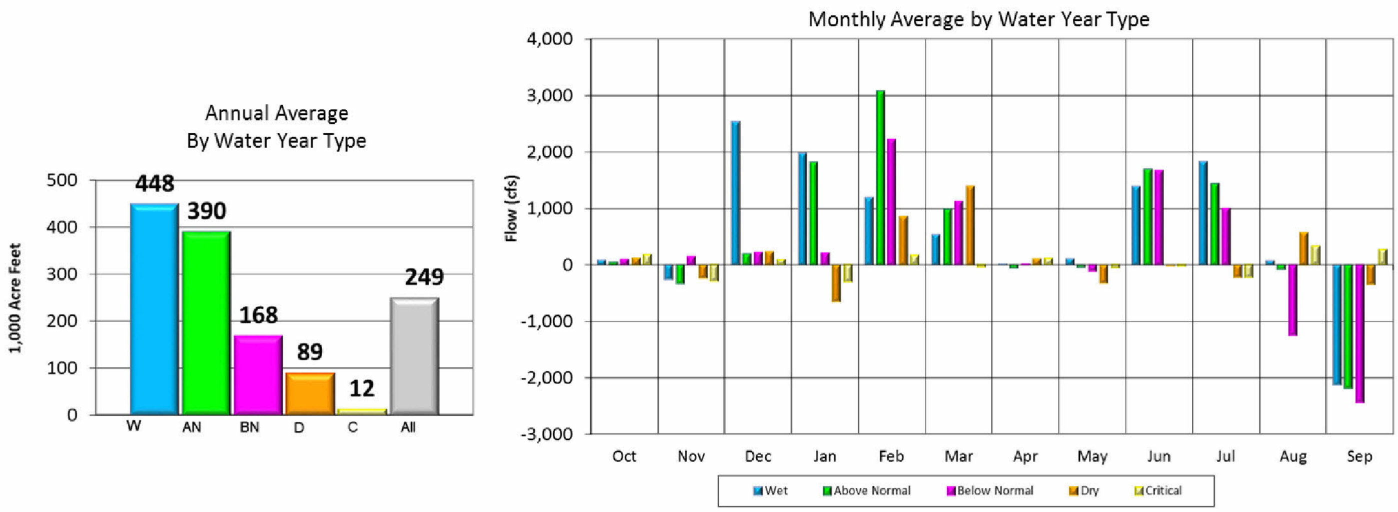


Figure 8. Change in Banks Exports - DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

Figure 9 shows changes in CVP use of SWP pumping capacity at Banks in the DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA. Shared use of export facilities is called Joint Point of Diversion (JPOD).

The addition of the NDD would allow the SWP and CVP to better utilize Banks Pumping Plant's full physical capacity of 10,300 cfs. South Delta exports at Banks are currently limited to Corps of Engineers permitted capacity of 6,680 cfs from March 16 through December 14 and may be authorized to be higher from December 15 through March 15, depending on San Joaquin River flow at Vernalis. With the NDD in place, Banks would be able to use its full physical capacity more often. While this certainly means the SWP would be able to better capture surplus during the winter and convey water released from storage in upstream SWP reservoirs during the summer, it would also increase the CVP's ability to wheel water through Banks under existing Cross Valley Canal and Joint Point of Diversion agreements.

As shown in **Figure 9**, DWR/USBR BA Alternative 4A would increase JPOD wheeling by 15 TAF over the DWR/USBR BA NAA on an annual average basis. It was expected JPOD would be used more frequently to help boost CVP SOD service contractor deliveries. However, DWR/USBR BA Alternative 4A modeling limits JPOD to remaining Banks South Delta Diversion (SDD) permitted capacity (under the permit issued by the Corps under Section 10 of the Rivers and Harbors Act) regardless of whether the water is modeled as being conveyed through the SDD or the NDD. This assumption limits the CVP's ability to use JPOD to convey both Delta excess and water stored in upstream CVP reservoirs. This tends to artificially and incorrectly keep modeled storage in NOD CVP reservoirs higher under DWR/USBR BA Alternative 4A than under the No Action Alternative.

Cross Valley Canal wheeling is affected by both CVP SOD Agricultural service contract allocations (SOD Ag service allocations) and available capacity at Banks. Overall, DWR/USBR BA Alternative 4 would slightly reduce SOD Ag service allocations, but would provide additional capacity when CVC wheeling needs to be conveyed. As shown in **Figure 10**, this would result in a 7 TAF increase in CVC wheeling when compared to the DWR/USBR BA NAA. A more significant change in CVC wheeling is the timing. In the DWR/USBR BA NAA, Banks capacity is often not available until the fall, but in the DWR/USBR BA Alternative 4 capacity often becomes available in July, August and September. This shift in timing is shown by the monthly average bar chart in **Figure 10.**

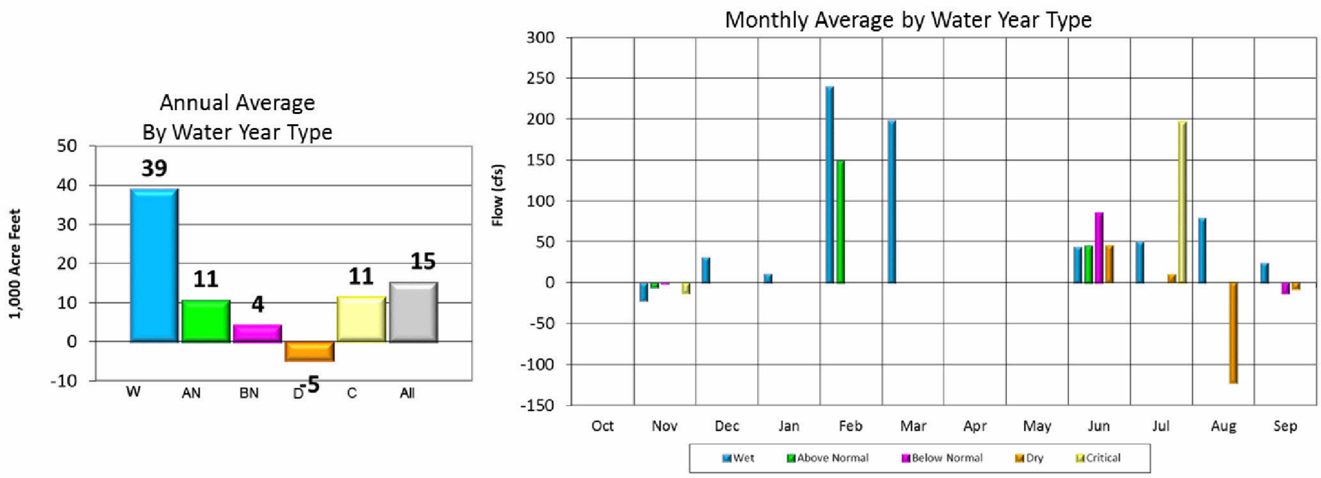


Figure 9. Change in CVP JPOD at Banks DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

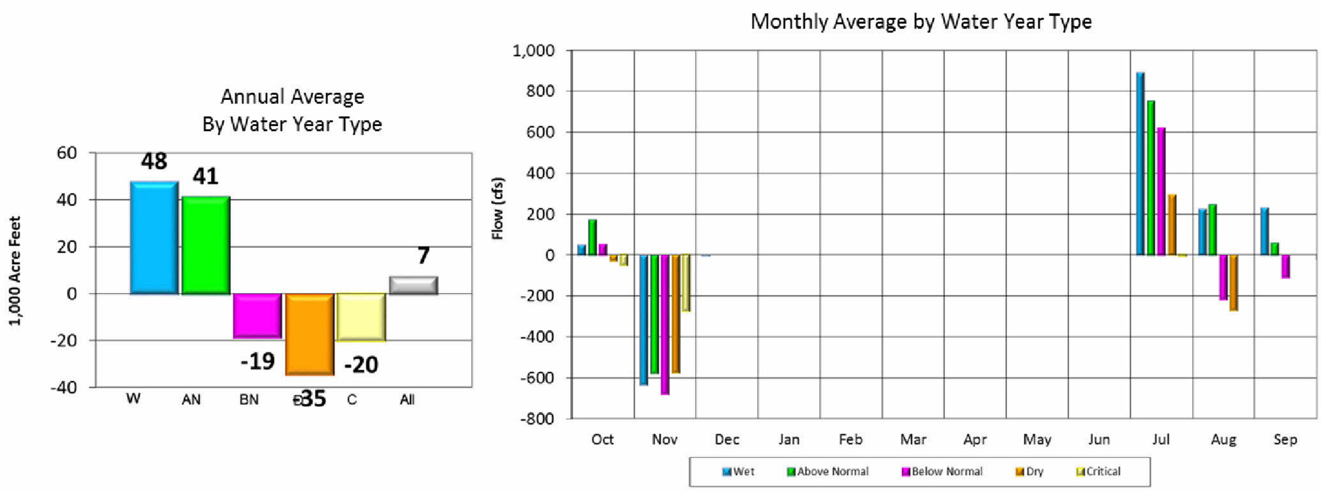


Figure 10. Change in Exports at Banks for CVP Cross Valley Canal DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

D. Delta Outflows

Figure 11 illustrates a comparison of Delta outflows under the DWR/USBR BA Alternative 4A and the DWR/USBR BA NAA. Decreases in Delta outflows would be the result of the CVP and SWP ability to increase Delta exports in DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA. The magnitude of decrease in Delta outflows is very similar to the magnitude of increase in Delta exports. The modeled increase in Delta outflow in October is partially due to additional export restrictions though Old and Middle River flow requirements and increases in Rio Vista required flow. However, the modeled increase in October Delta outflow is also due to an unrealistic modeled operation of the Delta Cross Channel. The additional modeled export restrictions cause the flow standards imposed at Rio Vista to be the controlling point in CVP and SWP operations, even though the water quality standards are all being met and do not require flows above the amount needed to satisfy the Rio Vista standard. Meeting the Rio Vista flow standards without closing the Delta Cross Channel gate would result in releasing more water from upstream reservoirs than would otherwise be necessary. This would occur because a certain amount of the water released to meet the Rio Vista flow standards would flow into the Central Delta through the Delta Cross Channel gate. This water would not make it to Rio Vista and therefore would not be counted towards meeting the Rio Vista flow standards. However, due to the DWR/USBR BA Alternative 4A model's assumed restrictions on exports at this time, this water could not be pumped from the South Delta facilities and thus ends up as "extra" Delta outflow. By closing the Delta Cross Channel gate, the operators actually would assure that all of the water released to meet the Rio Vista flow standards would be counted towards those standards. Assumptions in CWF BA modeling that the Delta Cross Channel gate would not be closed are not reasonable, and do not reflect a sensible operation, and the CVP and SWP operators have demonstrated that they actually would close the gate during these conditions to avoid the unnecessary losses of water supplies (as was done in October and November 2013). The assumption in the USBR/DWR BA NAA and USBR/DWR BA Alternative 4A scenarios that the Delta Cross Channel gate would remain in the open position causes the modeled amount of Delta outflow to be overstated for October.

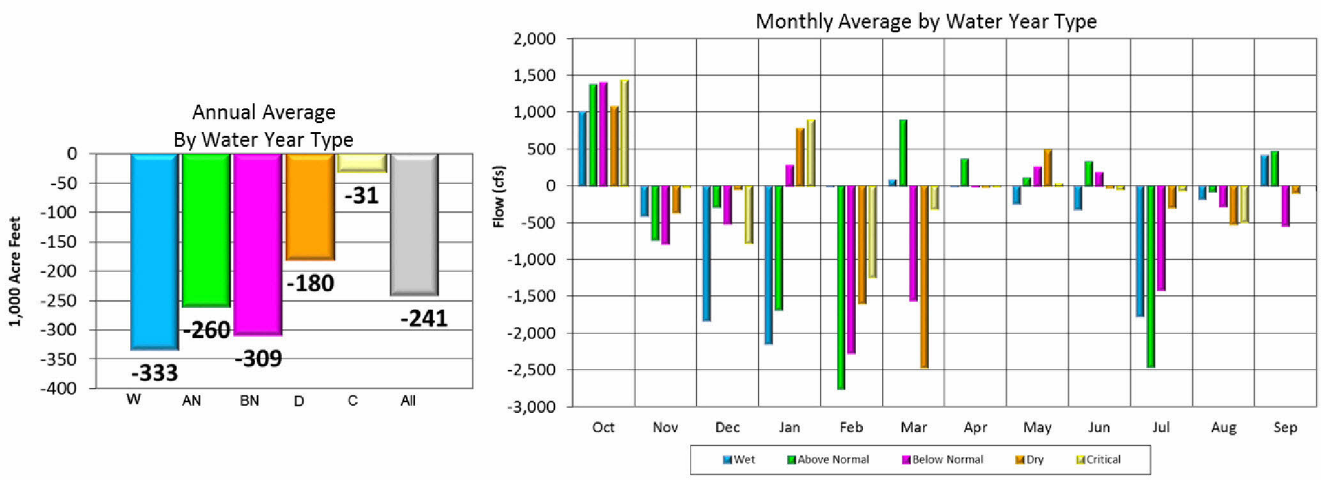


Figure 11. Delta Outflow Change - DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

E. Reservoir Storage and Operations

CVP and SWP reservoir operating criteria in the USBR/DWR BA Alternative 4A scenario differ from those in the USBR/DWR BA NAA scenario. This difference is primarily driven by changes in both CVP and SWP San Luis Reservoir target storage, known as the San Luis Rulecurves. CalSim II balances upstream Sacramento Basin CVP and SWP reservoirs with storage in San Luis Reservoir by setting target storage levels in San Luis Reservoir. CalSim II will model releases of water from upstream reservoirs to meet Rulecurve (target storage levels) in San Luis Reservoir, and the Rulecurve storage will be modeled as being met, as long as there is capacity to convey water and water is available in upstream reservoirs. In USBR/DWR BA Alternative 4A, the CVP San Luis Reservoir target storage in the Rulecurve is set very high for the spring and early summer months, and then is set very low for August and is set to 90 TAF from September through December. **Figure 12** shows the average monthly CVP San Luis Reservoir Rulecurve amounts for the NAA and DWR/USBR Alternative 4A and the differences between these monthly amounts, and **Figure 13** shows these monthly amounts for the SWP San Luis Rulecurve. These changes in CVP San Luis Rulecurve monthly amounts cause modeled storage in upstream reservoirs under the DWR/USBR Alternative 4A to be drawn down from June through August relative to the USBR/DWR BA NAA amounts and then to be recovered by reducing upstream reservoir releases in September. USBR/DWR BA Alternative 4A upstream modeled CVP storage then remains close to the modeled storage for the USBR/DWR BA NAA during fall months. Changes in these operational criteria cause changes in modeled upstream reservoir operations and result in modeled changes to cold water pool management and would affect several resource areas. These changes are shown in **Figure 14**, **Figure 15**, and **Figure 16,** which contain exceedance plots for CVP end-of-September carryover storage and bar charts of average monthly changes in storage by Sacramento Valley Water Year Type for North of Delta CVP reservoirs. Both Shasta and Folsom modeled storage are lower in June and July and then modeled releases are reduced in September due to lower San Luis Rulecurve.

A combination of under-allocation and a May through September reduction in SWP San Luis Rulecurve results in higher modeled Oroville storage in most years under the DWR/USBR BA Alternative 4A in comparison to the DWWR/USBFR NAA scenario. **Figure 17** shows an average increase in modeled Oroville carryover storage of about 90 TAF. This fundamental shift in SWP operations would be an inefficient operation of the SWP and, in particular, would be an inefficient use of the additional export capacity that would be provided by the California Water Fix. For many of the years that modeled Oroville carryover is higher, there was sufficient modeled export capacity to convey the water SOD, which would allow for an increase in modeled SWP Table A allocations, and such increases would likely occur under actual operations.

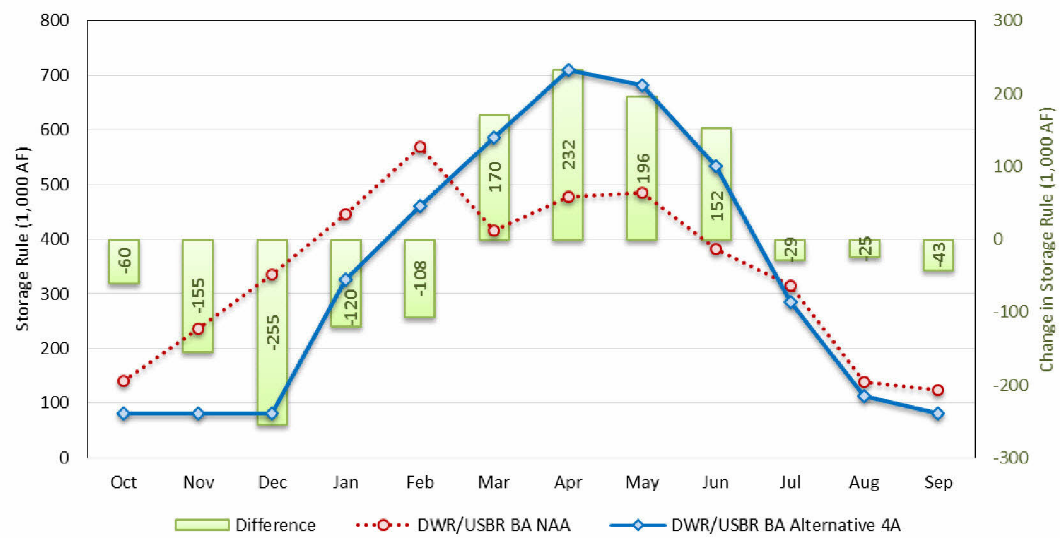


Figure 12. CVP San Luis Reservoir Rulecurve

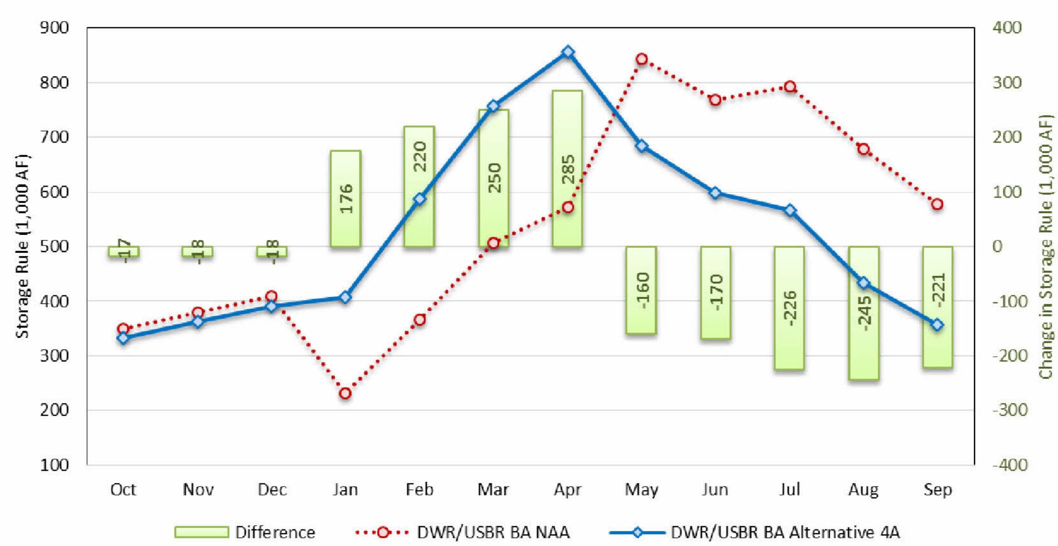


Figure 13. SWP San Luis Reservoir Rulecurve

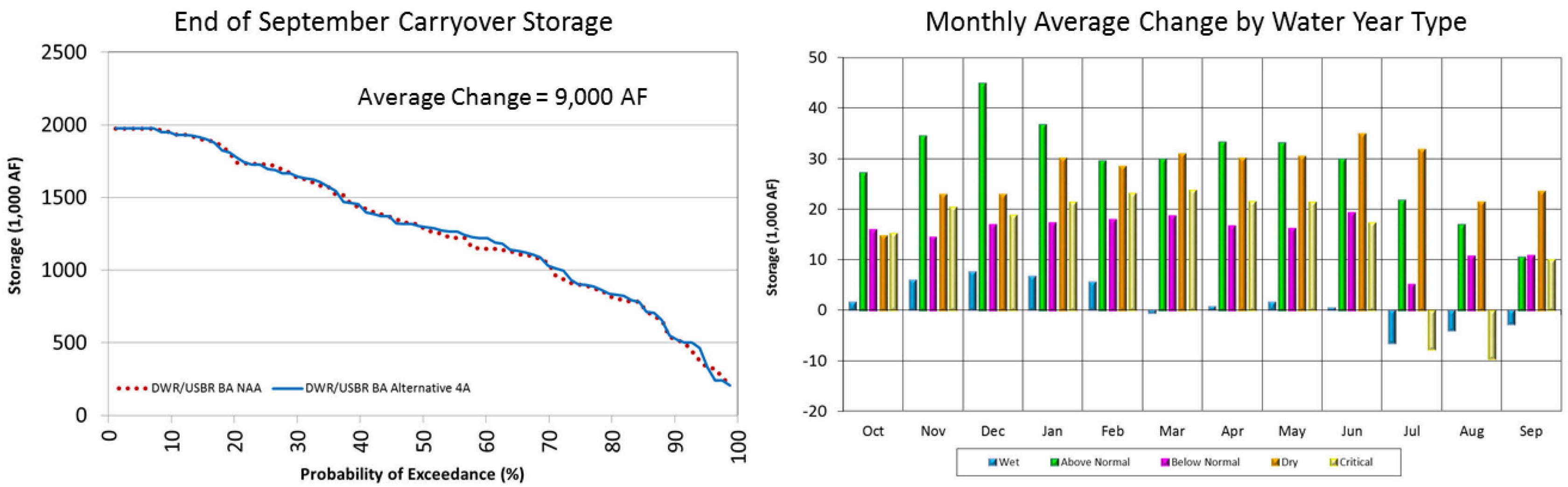


Figure 14. Trinity Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

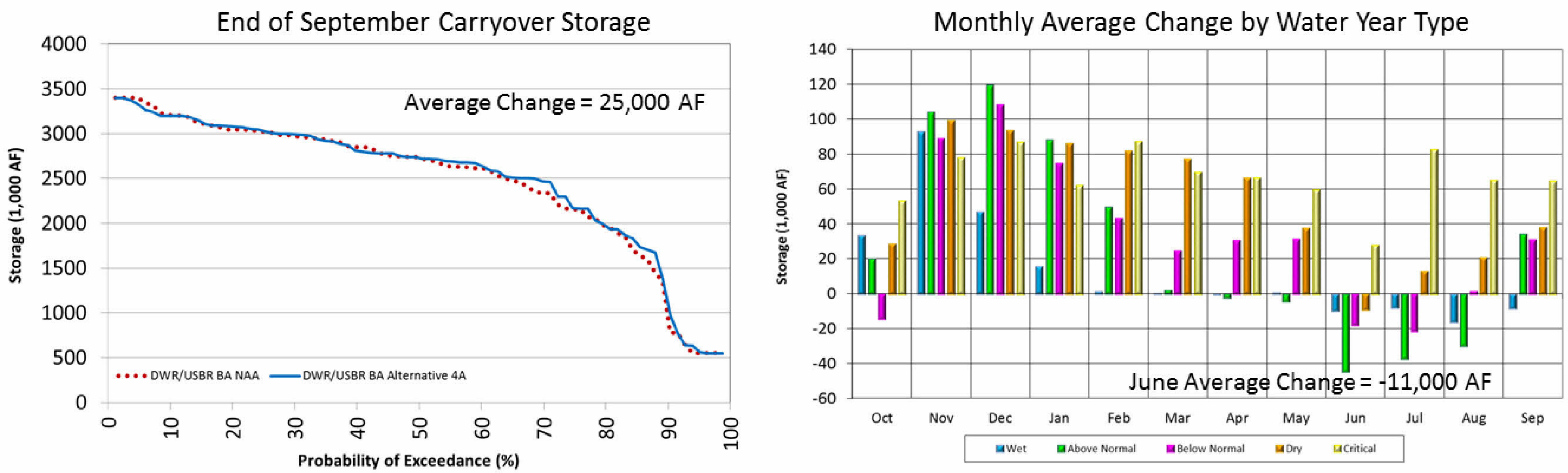


Figure 15. Shasta Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

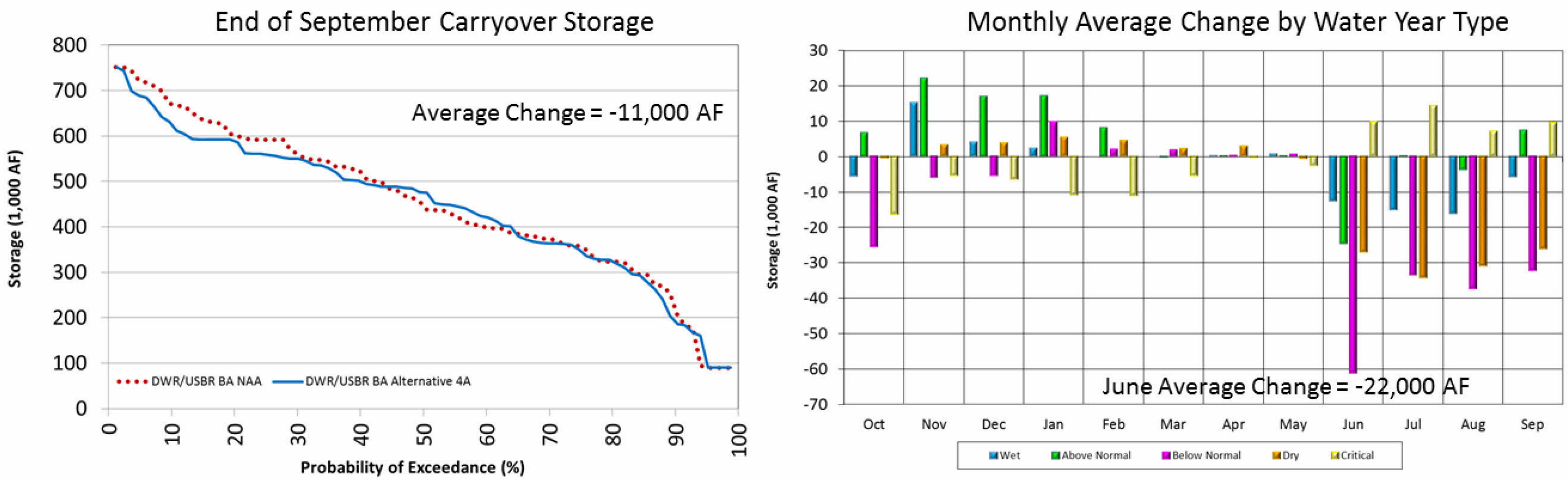


Figure 16. Folsom Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

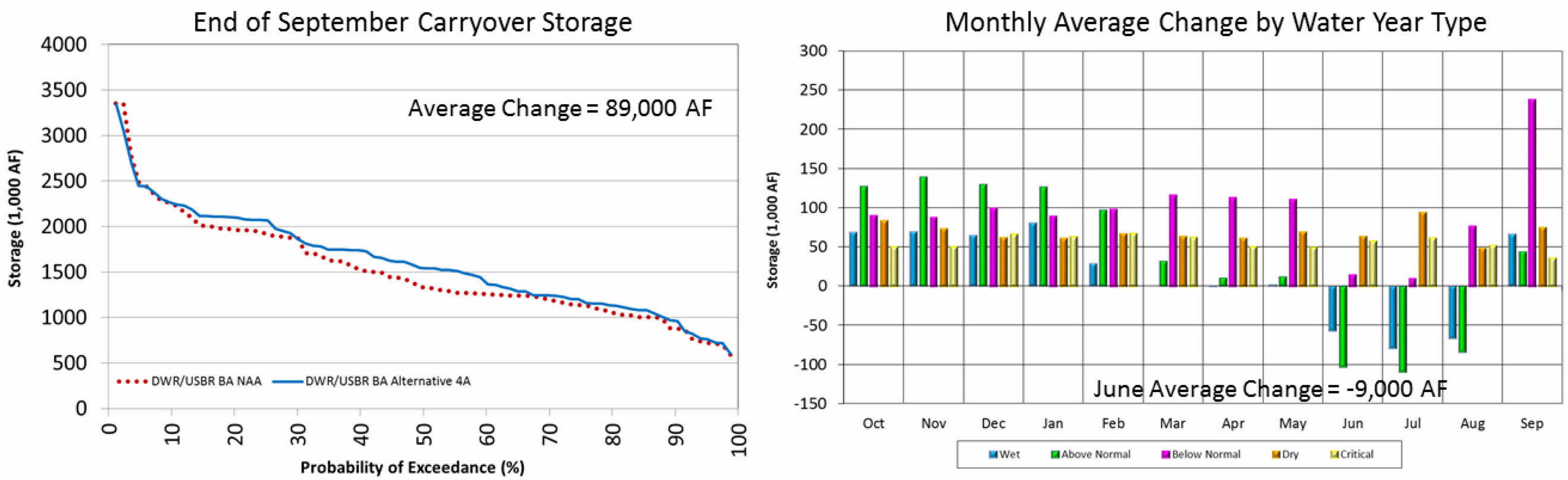


Figure 17. Oroville Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

Figure 18 and **Figure 19** show exceedance probability plots for CVP and SWP San Luis Reservoir annual high and low points for both the DWR/USBR BA Alternative 4A and DWR/USBR BA NAA. The CVP share of San Luis would fill about 10% more often in the DWR/USBR BA Alternative 4A than under the DWR/USBR BA NAA, while the SWP share would fill about 30% more often. The SWP share of San Luis would fill more often than the CVP share because Banks would have greater pumping capacity than Jones and could use increased diversion capacity made available by the NDD to capture Delta surplus.

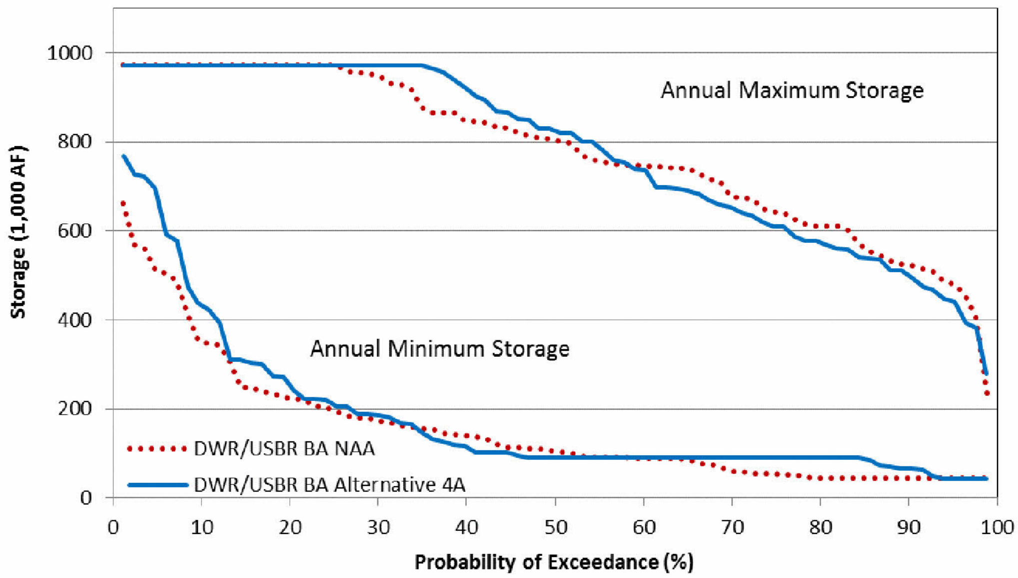


Figure 18. CVP San Luis Reservoir Storage – Annual Maximum and Minimum Storage DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

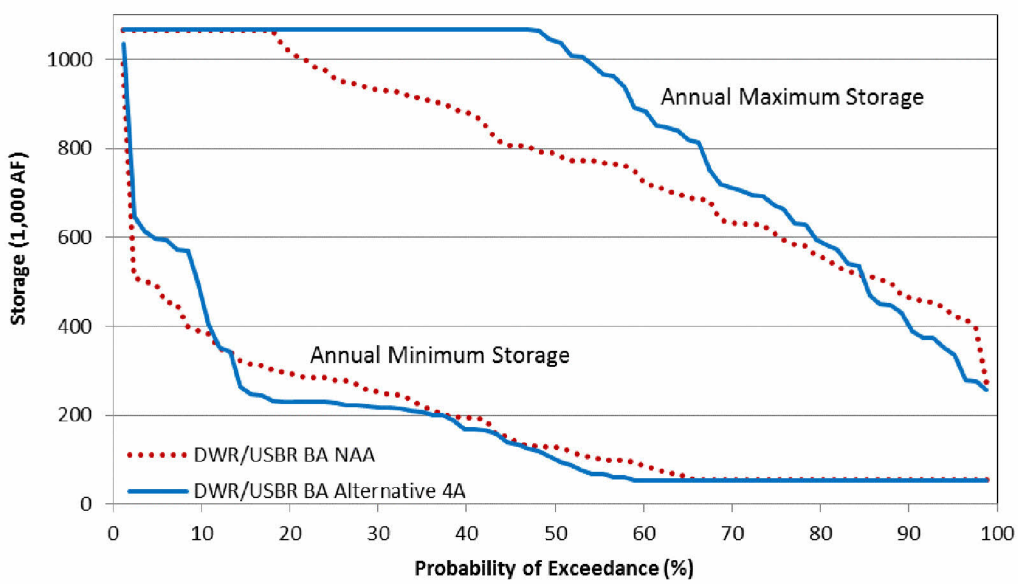


Figure 19. SWP San Luis Reservoir Storage – Annual Maximum and Minimum Storage DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

F. River Flows

Figure 20 shows average monthly changes in modeled American River flows below Nimbus, for DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA scenario. Under the DWR/USBR BA Alternative 4A scenario, modeled American River flow is higher in the month of June, and lower in July and September through November. Higher releases in June would cause the changes in Folsom storage shown in previous figures. Likewise, lower releases in July and September would bring simulated end-of-September storage in Alternative 4A closer to the NAA. Changes in Nimbus release under the DWR/USBR BA Alternative 4A would likely affect cold-water pool management and water temperatures downstream of Folsom Dam. Increased releases in June typically reduce the available cold-water pool, lower reservoir water surface elevations, and may require the shutters at Folsom Dam to be removed earlier. From July through September, temperature management would likely be affected by the combination of a reduced cold-water pool and lower releases from Nimbus, i.e. lesser amounts of warmer water would be released and that water would warm up more quickly as it flowed downstream.

Figure 21 contains probability of exceedance charts of simulated American River flows at H Street for each month, illustrating differences between the DWR/USBR BA Alternative 4A and DWR/USBR BA NAA scenarios. DWR/USBR modeling shows a higher probability of American River flows at H Street being above Hodge Flows[1] in June and a higher probability of flows being below Hodge Flows in July and September through November. When American River flows at H Street are below Hodge Flows, diversion limitations under the City of Sacramento's American River water right permits for the Fairbairn Water Treatment Plant on the American River can force the City of Sacramento to shift a portion of its diversion to its Sacramento River Intake. In the DWR/USBR BA Alternative 4A the City of Sacramento would be able to divert more water from the American River during June and less during July and September through November. Although the DWR/USBR modeling does not include this shift in diversion locations, these changes in American River flows would affect the location of the City of Sacramento's diversion, which could have impacts on the City and the entities to which it delivers water.

Modeled flows in the lower American River at H Street drop below 500 cfs in both the DWR/USBR BA Alternative 4A and DWR/USBR BA NAA scenarios. Such drops would have critical effects on the City of Sacramento, because its ability to divert water from the American River is affected when American River flows at H Street drop below 500 cfs. There are times when modeled American River flows at H Street drop below 500 cfs more often in the DWR/USBR BA Alternative 4A than in the DWR/USBR BA NAA scenario. **Figure 21** shows this occurring about 10% more often in August.

[1] 'Hodge Flows' are levels of lower American River flows that Judge Richard Hodge defined as minimum flows for the East Bay Municipal Utility District to divert water from the river in a 1990 decision. Those flow levels have been incorporated into the City of Sacramento's water-right permits to divert water from the lower American River.

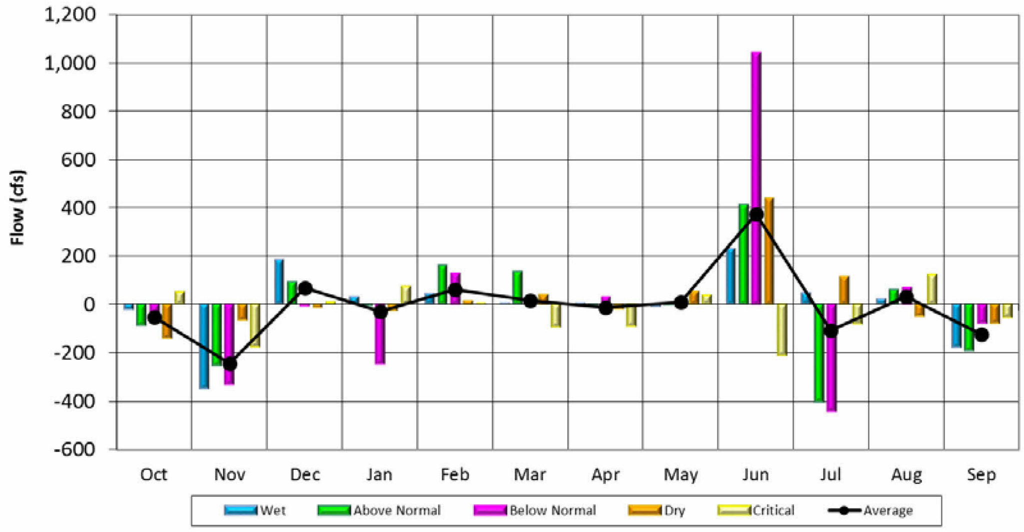


Figure 20. American River below Nimbus – DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

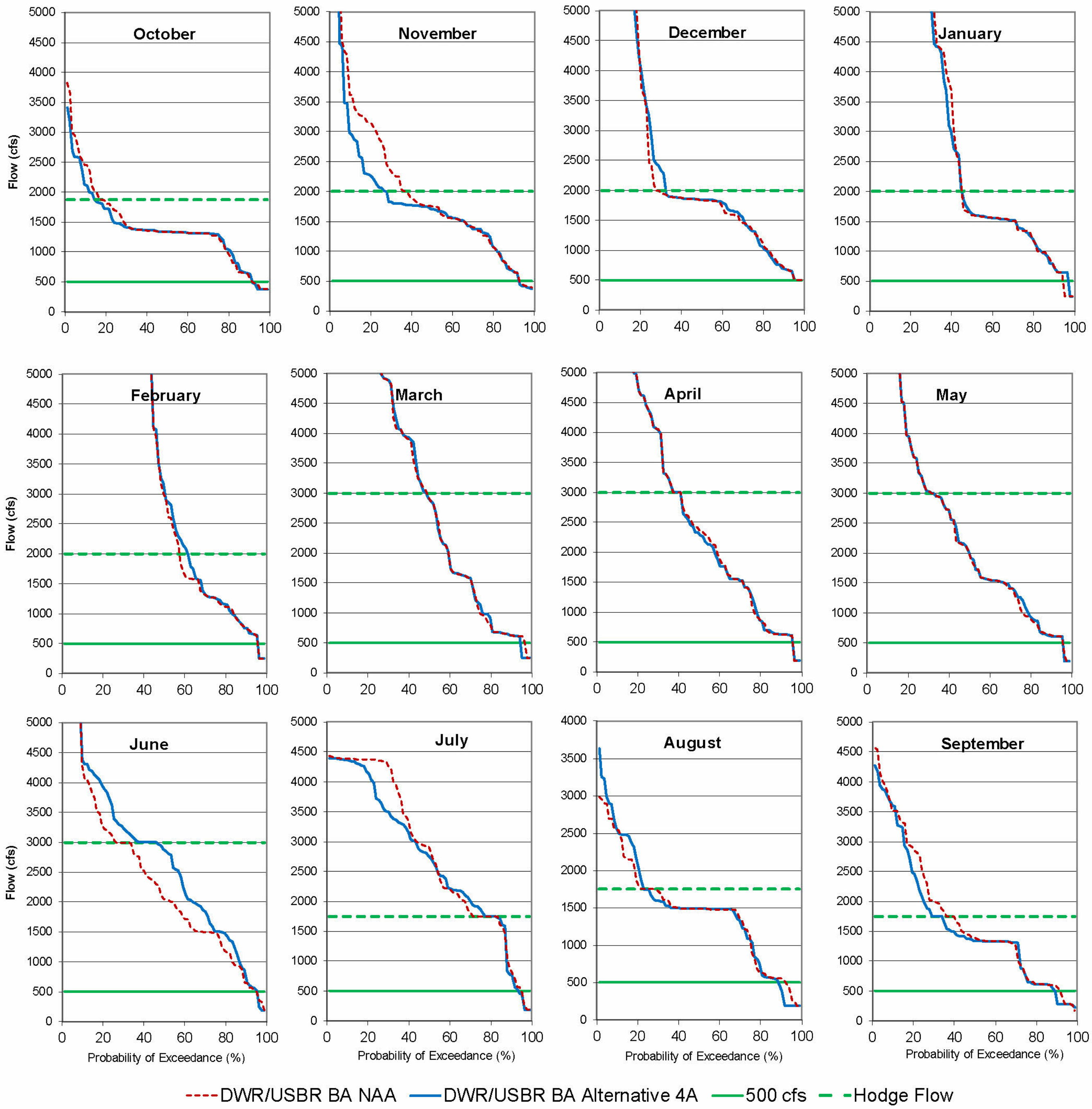


Figure 21. American River at H Street – DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

Figure 22 shows average monthly changes in modeled Keswick releases to the Sacramento River for DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA scenario. Results show that under DWR/USBR BA Alternative 4A average monthly Sacramento River flow would be higher from December through June, and lower from September through November. Higher releases in May and June would cause changes in Shasta storage and water surface elevations. Likewise, lower releases from July of dry and critical years, along with September decreases, bring simulated end-of-September storage in the DWR/USBR BA Alternative 4A closer to those in the DWR/USBR BA NAA scenario. Changes in Keswick releases under the DWR/USBR BA Alternative 4A would likely affect Shasta Reservoir cold-water pool management, especially in dry and critical years.

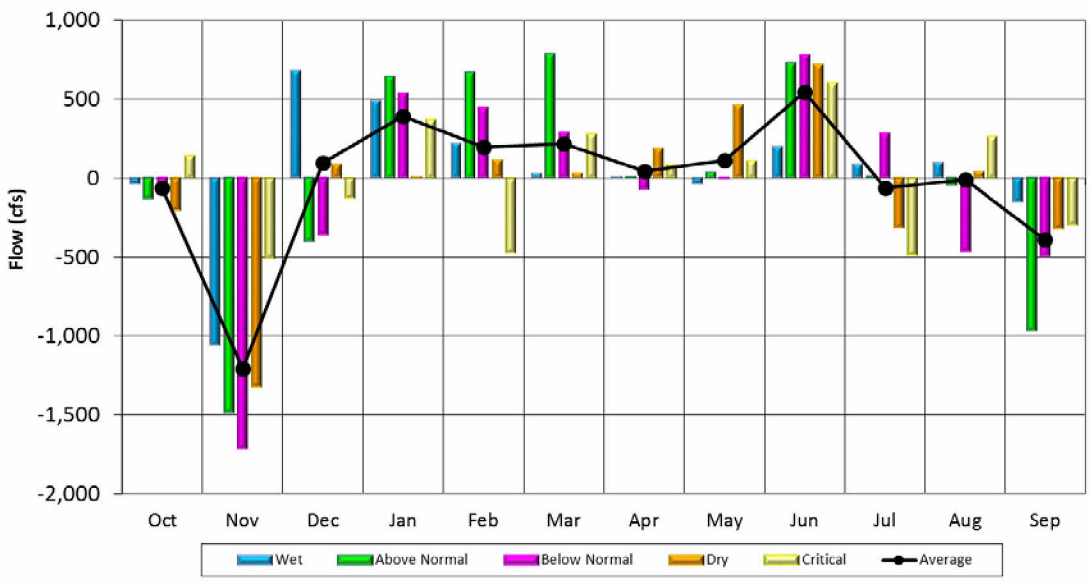


Figure 22. Sacramento River below Keswick – DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

Figure 23 contains probability-of-exceedance charts of simulated Sacramento River flows below Keswick for each month, illustrating differences between the DWR/USBR BA Alternative 4A and DWR/USBR BA NAA. Although the data used to calculate averages contained in **Figure 23** are the same data plotted in **Figure 24**, **Figure 23** shows the frequency of flow changes, which would occur in most years. The black horizontal line in each monthly plot shows the minimal acceptable flow listed the Salmon Biological Opinion below Keswick of 3250 cfs. There are a few times in September, October, and November when Keswick releases would drop below 3250 cfs, and this would occur more frequently in the DWR/USBR BA Alternative 4A than in the DWR/USBR BA NAA scenario.

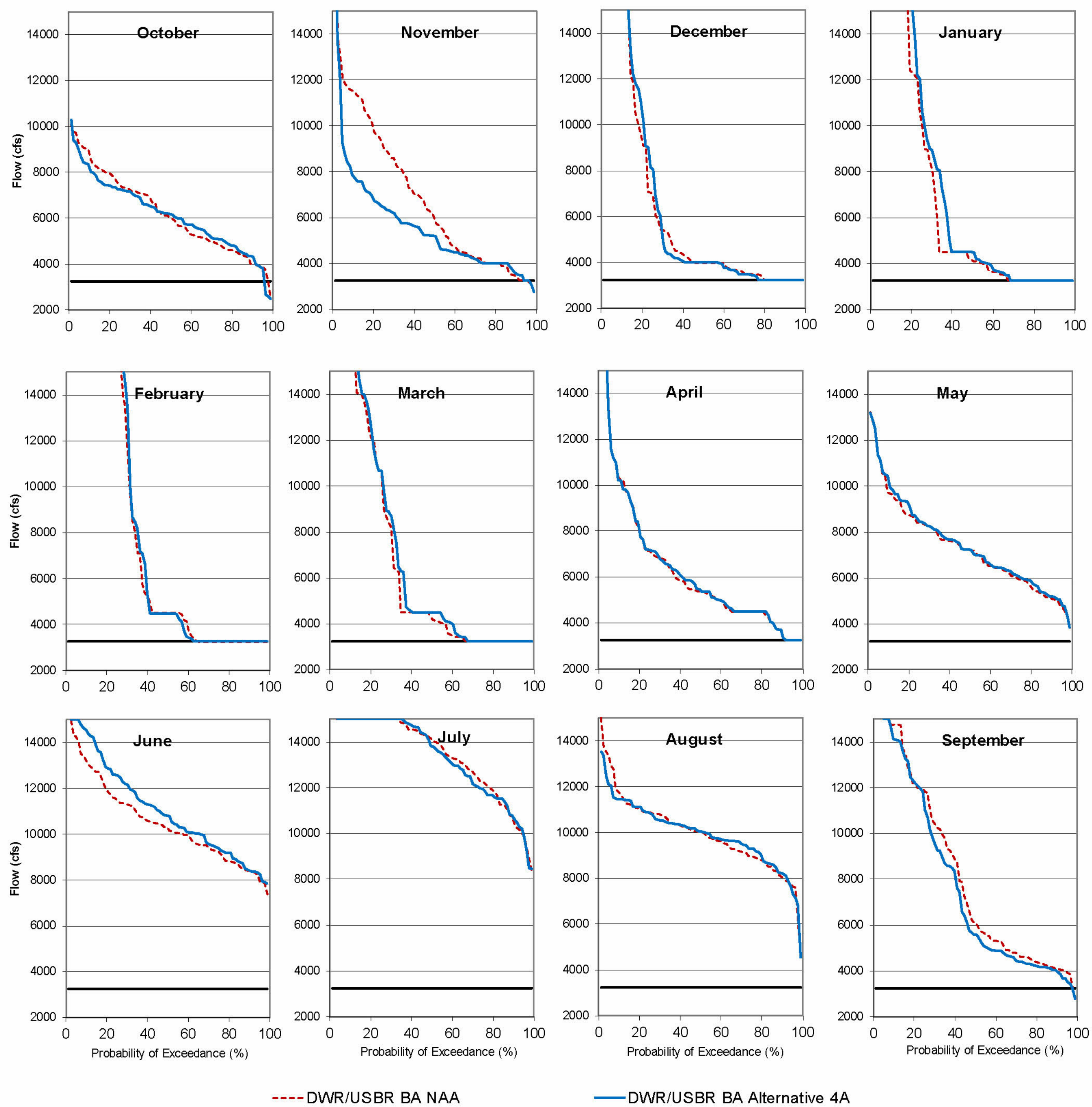


Figure 23. Sacramento River below Keswick – DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

Figure 24 shows average monthly changes in modeled Feather River flows below the return flows from Thermalito for DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA scenario. Results show that under the DWR/USBR BA Alternative 4A scenario average monthly flow in June would be about 900 cfs higher in the DWR/USBR BA Alternative 4A and average monthly flow would be about 1500 cfs less in September. Average monthly Feather River flows would be higher in February and March in wetter years. This is partly due to increases in modeled spills from Oroville due to increases in carryover storage (see **Figure 17**).

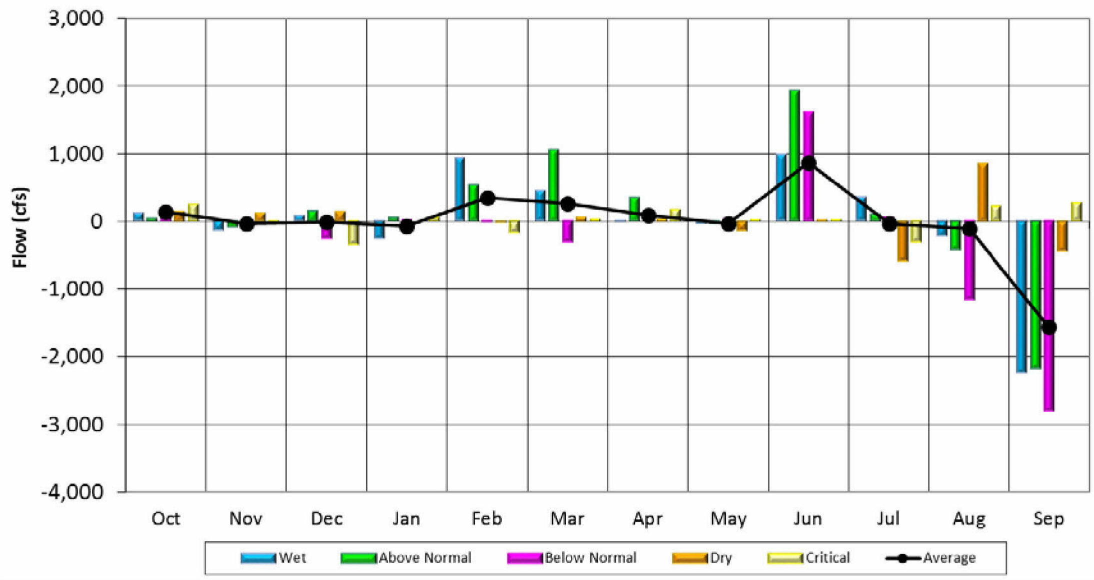


Figure 24. Feather River below Thermalito – DWR/USBR BA Alternative 4A and DWR/USBR BA NAA

i. *CVP Water Supplies*

Average annual changes in water supplies to CVP contractors, based on contractor type and water year type, are shown in **Table 3.** Average annual modeled CVP South of Delta deliveries in the DWR/USBR BA Alternative 4A are about 12 TAF lower than in the DWR/USBR BA NAA scenario, while modeled North of Delta CVP deliveries increase by 1 TAF. CalSim II allocates water to all CVP water service contractors based on system-wide water availability, but may reduce allocations to SOD water service contractors after accounting for available Delta conveyance capacity. Conveyance capacity limited CVP SOD allocations are calculated by summing available storage in CVP San Luis Reservoir and forecasted CVP exports. CVP export forecasts represent the volume of water expected to be exported and available for delivery during the current irrigation season. These forecasts, or estimates, are input to CalSim II. Although the NDD would provide increased ability to convey water from upstream reservoirs in the DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA, export estimates in the DWR/USBR BA Alternative 4A are set equal to those in the DWR/USBR BA NAA scenario. This artificially limits the model's ability to increase CVP SOD allocations and forces the model to limit use of the NDD. **Figure 25** contains an exceedance probability plot of CVP South of Delta Agricultural Service contract allocation for USBR/DWR BA NAA and USBR/DWR BA Alternative 4A. Although there is a slight increase in the number of times with 100% allocation in the USBR/DWR BA Alternative 4A, there are decreases in allocations in the 50% to 20% allocation range.

CalSim II is used for this modeling analysis, and although CalSim II simulates changes in Delta exports, Delta outflows, river flows, and CVP and SWP reservoir storage levels, it does not model any changes in water deliveries to Sacramento River Settlement Contractors, Feather River Settlement Contractors, wildlife refuges, CVP Exchange Contractors or non-Project water right holders. Because all CVP and SWP Settlement Contractor deliveries and all non-Project water user deliveries are "Hard Coded", the model is forced to meet these deliveries unless it runs out of water. For the purpose of CalSim II, it runs out of water when a reservoir reaches dead pool. Because CalSim II is forced to meet demands for San Joaquin River Exchange Contractors and wildlife refuges, they are modeled as receiving full deliveries in the DWR/USBR BA Alternative 4A in accordance with their contract provisions. Modeled deliveries to CVP Sacramento River Settlement Contractors are shown to have an average critical year decrease of 7 TAF. This is due to Shasta hitting dead pool earlier in the year in the DWR/USBR BA Alternative 4A than it does in the DWR/USBR BA NAA. **Figure 26** shows annual CVP Sacramento River Settlement Contractor deliveries for the DWR/USBR BA Alternative 4A and DWR/USBR BA NAA and the differences between the scenarios. There about 4 years when modeled deliveries are lower, with the largest decrease being 45 TAF.

Table 3. CVP Delivery Summary

Average Annual CVP Delivery by Water Year Type - DWR/USBR BA NAA

	North of Delta					South of Delta					North + South
	Ag Service	M&I Service	Settlement	Refuge	Total	Ag Service	M&I Service	Exchange	Refuge	Total	Total
All Years	184	191	1858	83	2315	790	112	852	273	2211	4526
Wet	306	222	1857	88	2473	1357	133	875	281	2830	5303
Abv. Norm	243	199	1716	81	2240	913	111	802	258	2251	4491
Blw. Norm	149	190	1903	89	2330	612	110	875	281	2062	4392
Dry	91	166	1894	86	2237	427	97	864	277	1848	4085
Critical	25	136	1741	55	1957	127	80	741	233	1364	3320

All Values are in 1,000 acre feet *Total North + South includes Cross Valley Canal*

Average Annual Change in CVP Delivery by Water Year Type DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

	North of Delta					South of Delta					North + South
	Ag Service	M&I Service	Settlement	Refuge	**Total**	Ag Service	M&I Service	Exchange	Refuge	**Total**	**Total**
All Years	2	1	-1	0	1	-13	1	0	0	-12	-11
Wet	-2	-1	-1	0	-4	-27	-1	0	0	-28	-31
Abv. Norm	2	4	0	0	5	-10	1	0	0	-9	-4
Blw. Norm	-4	-3	0	0	-8	-40	-1	0	0	-41	-49
Dry	11	3	0	0	14	23	4	0	-1	27	41
Critical	3	1	-7	0	-3	-9	1	0	1	-6	-9

All Values are in 1,000 acre feet

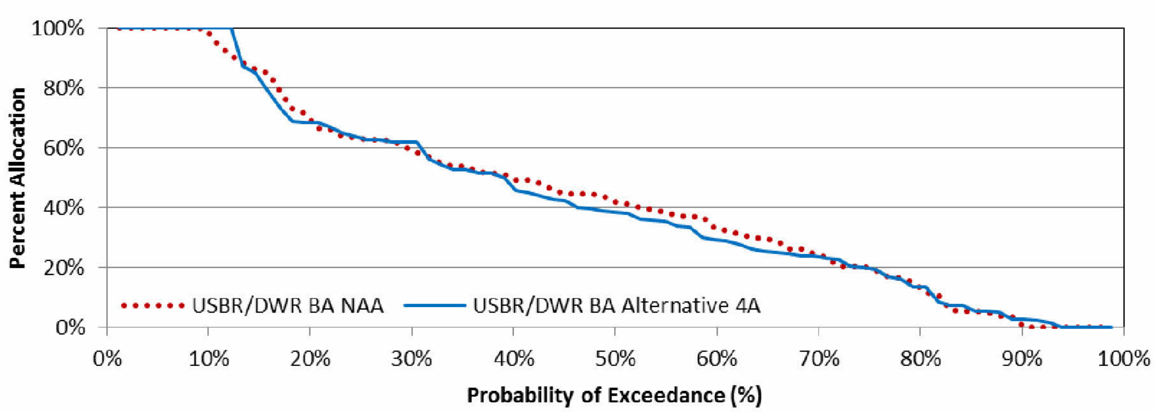


Figure 25. CVP South of Delta Agricultural Service Contract Allocation for USBR/DWR BA NAA and USBR/DWR BA Alternative 4A

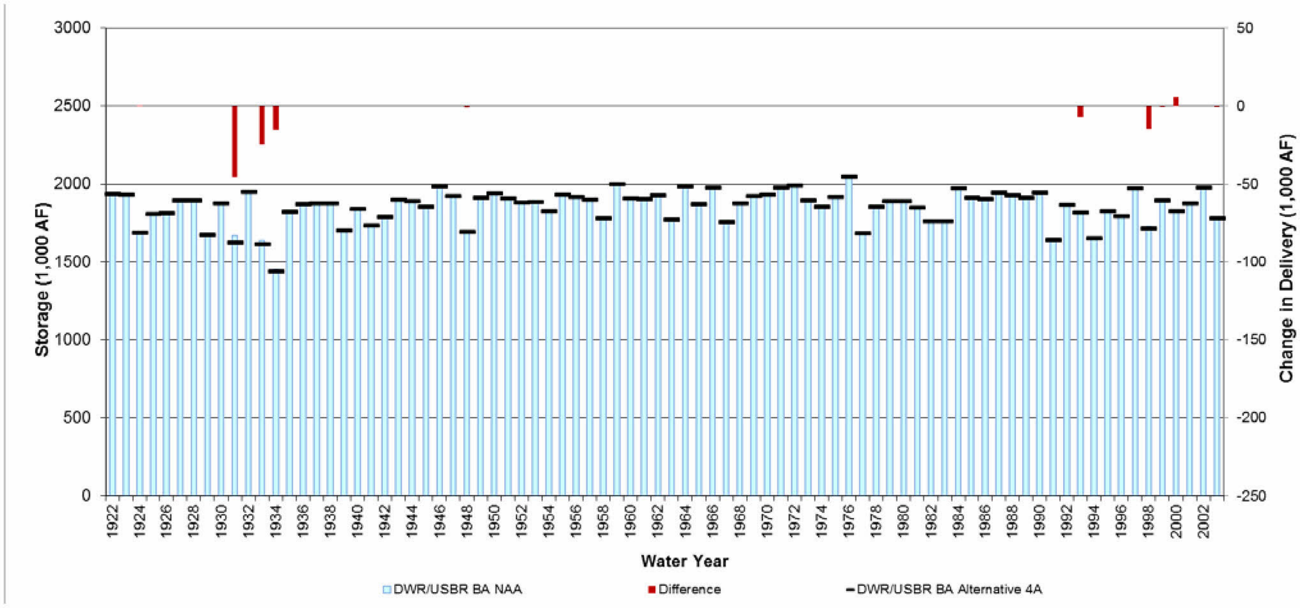


Figure 26. Sacramento River Settlement Contractor Deliveries

ii. *SWP Water Supplies*

Table 4 illustrates the SWP water supply benefits of the DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA. These studies show an increase in average annual modeled SWP SOD deliveries of approximately 216 TAF, but a reduction in critical year deliveries of approximately 59 TAF. Modeled SWP deliveries increase less than increases in modeled Banks exports because a portion of the modeled Banks export increase is due to increases in wheeling for CVP, Cross Valley Canal contractors, and JPOD. **Figure 27** contains an exceedance probability plot of State Water Project Table A Allocations for USBR/DWR BA NAA and USBR/DWR BA Alternative 4A. Modeled allocations are higher for most years, but there are decreases for critical years. As for the Sacramento River Settlement Contractors, CalSim II does not change irrigation season deliveries to the Feather River Service Area Settlement contractors. Therefore these deliveries are same in each alternative.

Table 4. SWP Delivery Summary

Average Annual SWP Delivery by Water Year Type DWR/USBR BA NAA

	Table A	Article 21	Article 56	Total
All Years	2374	60	67	2501
Wet	3214	97	86	3397
Abv. Norm	2648	91	45	2784
Blw. Norm	2539	61	86	2687
Dry	1612	14	60	1686
Critical	1035	13	27	1075

All Values are in 1,000 acre feet

Average Annual Change in SWP Delivery by Water Year Type
DWR/USBR BA Alternative 4A minus DWR/USBR BA NAA

	Table A	Article 21	Article 56	Total
All Years	126	84	6	216
Wet	161	166	17	344
Abv. Norm	102	79	9	190
Blw. Norm	176	66	-3	240
Dry	168	37	-1	204
Critical	-57	-2	0	-59

All Values are in 1,000 acre feet

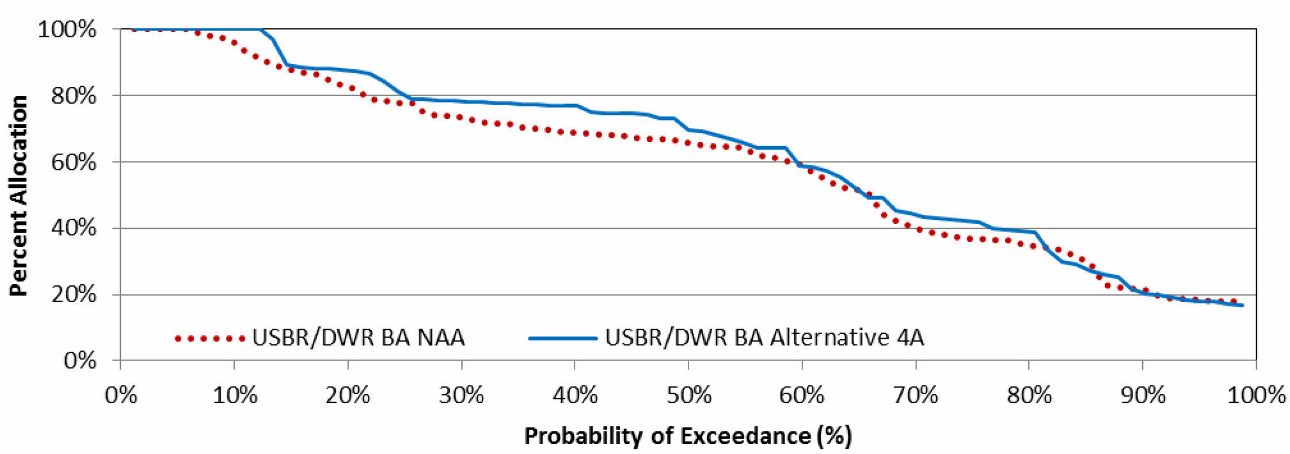


Figure 27.State Water Project Table A Allocation for USBR/DWR BA NAA and USBR/DWR BA Alternative 4A

G. Term 91

Many appropriative water rights in the Sacramento River Basin contain Term 91, and are subject to curtailment of diversions when the State Water Resources Control Board (SWRCB) evaluates hydrologic conditions and CVP and SWP operations and determine that specific criteria are met. Term 91 was originally adopted by the SWRCB on March 25, 1980. Term 91 was revised through Order WR 81-15, adopted by the SWRCB on November 19, 1981. Order WR 81-15 also set forth the method for implementing Term 91. Subsequent Order 84-2 and Decision 1594 upheld the language and methodology contained in Order 81-15 and identified the water rights which were to include Term 91. Generally, Term 91 is included in all appropriative water right permits within the Sacramento River watershed that were issued in 1965 or later. According to Decision 1594, appropriative water rights for diversions of less than 1.0 cfs or less than 100 acre-feet per year are not subject to Term 91.

Changes in CVP and SWP operations with the CWF may alter the frequency that Term 91 curtailments are imposed. CalSim II does not address curtailments of diversions under non-Project water rights or Term 91 curtailments. Therefore we calculated Term 91 curtailment periods using model output from each scenario. **Figure 28** illustrates the difference in the frequency of water right curtailments pursuant to Term 91 under the DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA. The DWR/USBR BA Alternative 4A shows a 15% reduction in frequency that Term 91 may be imposed in October due to increases in Rio Vista flow requirements in conjunction with additional OMR restrictions. Although the DWR/USBR modeling shows that Term 91 may be imposed less often in most months in the DWR/USBR BA Alternative 4A scenario, this results is not reliable because of the incorrect assumptions discussed above that limit the modeled use of stored water for increased Delta exports.

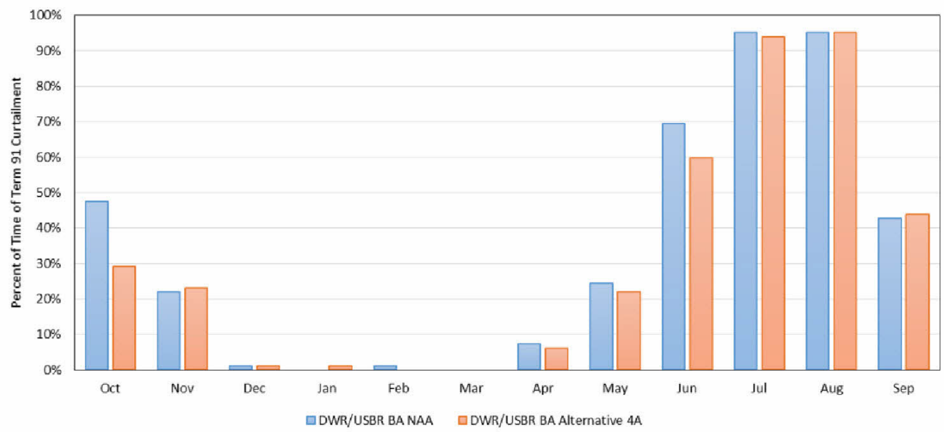


Figure 28. Frequency of Term 91 Curtailments - DWR/USBR BA NAA and DWR/USBR BA Alternative 4A

H. Use of Expanded SOD Export Capacity in the DWR/USBR BA Alternative 4A

The addition of the NDD would create more opportunities for the CVP and SWP to convey water to users in the Delta export service area. Although modeled total exports increase by an annual average of 226 TAF in the DWR/USBR BA Alternative 4A relative to the DWR/USBR BA NAA, there is still significant unused modeled export capacity in Alternative 4A. During winter and spring, DWR/USBR BA Alternative 4A uses the additional export capacity to capture Delta surplus and during these times export capacity is typically fully utilized. However, in summer months during balanced conditions, the DWR/USBR BA Alternative 4A operational logic is configured such that the expanded export capacity would be underutilized when stored water is available in upstream reservoirs for delivery to SOD contractors.

Figure 29 charts the DWR/USBR BA Alternative 4A unused July through September Delta export capacity probability of exceedance by water year type. The average July through September unused capacity over the full 82-year period of simulation is greater than 800 TAF. During the summer, the Delta is mostly in balance and any increase in exports would require additional releases from upstream reservoirs such as Shasta, Folsom, or Oroville. During dry and critical years, when storage is low, additional releases from storage for export would not be a reasonable operation. However, in wet and above normal years (and maybe in some below normal years), when carryover storage is expected to be above what would be needed to satisfy all upstream requirements, it is likely that additional stored water would be released to increase South of Delta water supplies. However, the DWR/USBR BA Alternative 4A modeling does not show such increases.

There are many years in DWR/USBR BA Alternative 4A when modeled upstream end-of-September reservoir carryover is high and flood control spills are likely to occur during the following winter. In years when Shasta and Folsom carryover storage is greater than 3 MAF (2.4 MAF for Shasta and 0.4 MAF for Folsom with a 0.2 MAF buffer) there would be enough water to satisfy upstream environmental criteria and to increase releases for SOD water supplies. **Figure 30** shows the ability to increase SOD CVP water supply. It is estimated as the minimum of Shasta plus Folsom storage over the 3 MAF threshold and available June through September export capacity (export capacity includes Jones pumping plant and JPOD wheeling capacity through Banks pumping plant). In **Figure 30**, each year is labeled with the SOD Ag Service percent allocation. As shown, there are many years with low SOD allocations (significantly less than 100%) and corresponding high upstream storage even though there is ample export capacity. For example, in 1975, there is 500 TAF of additional water in combined Shasta and Folsom storage above the 3 MAF threshold that might have been exported and delivered SOD; at the same time, SOD Ag service contractors were getting a 24% allocation. Under such conditions, it is reasonable to assume that operators would use that available water and conveyance capacity to increase allocations. However, the DWR/USBR BA Alternative 4A does not include such increases.

Figure 31 shows a measure of the ability to increase SOD SWP water supply in DWR/USBR BA Alternative 4A. For the purpose of this illustration, the ability to increase SOD SWP water supply is assumed to be the minimum of Oroville carryover storage above the 1.5 MAF and available June through September export capacity. Although Oroville carryover storage is about 89 TAF higher in DWR/USBR BA Alternative 4A compared to the DWR/USBR BA NAA, there are many times with available export capacity, high storage conditions, and less than full Table A allocations.

It is important to note that the underutilization of available summer export capacity is just a modeling decision. This modeled operation would not be required by any existing regulations or by any proposed actions in the CWF BA. One problem affecting this modeling decision for CVP exports is the model assumption that JPOD wheeling up to Banks pumping plant SDD permitted capacity would not occur, as discussed above. In actual operations, the CVP and SWP operators would likely take this additional available export capacity into account when making their annual allocation decisions. It is our expectation that the CVP and SWP operators would consider this additional conveyance capacity in their allocation decisions if the NDD is built. In DWR/USBR BA Alternative 4A, this added capacity, in particular for JPOD wheeling, was not sufficiently accounted for in CVP and SWP allocations.

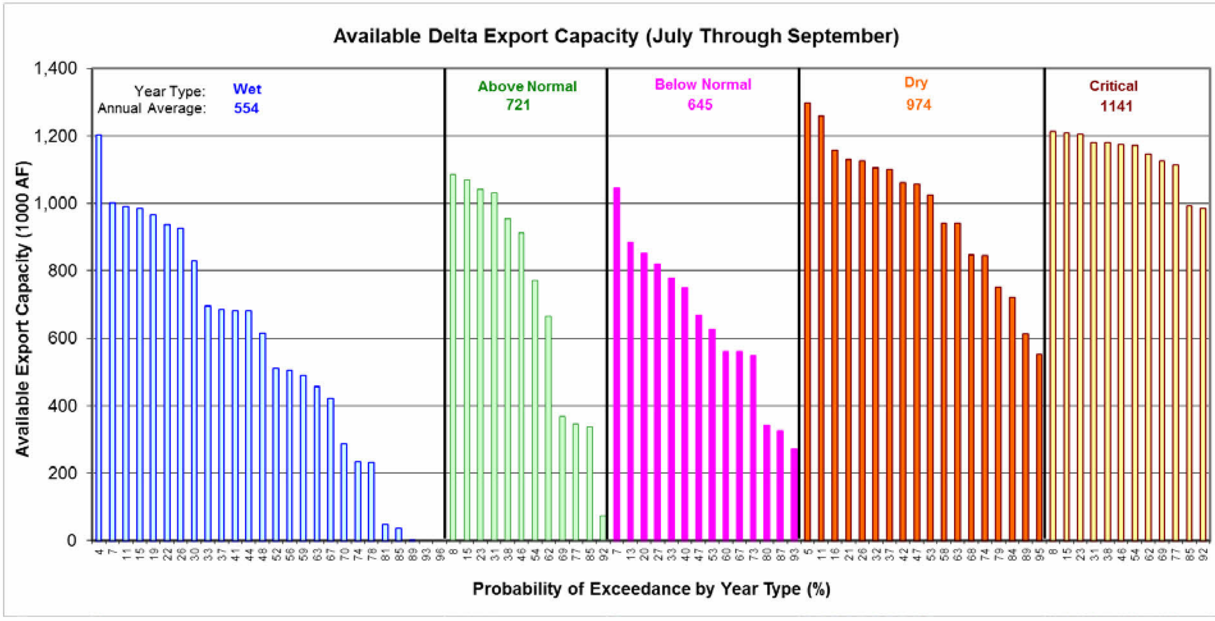


Figure 29. Available Delta Export Capacity (July through September) - DWR/USBR BA Alternative 4A

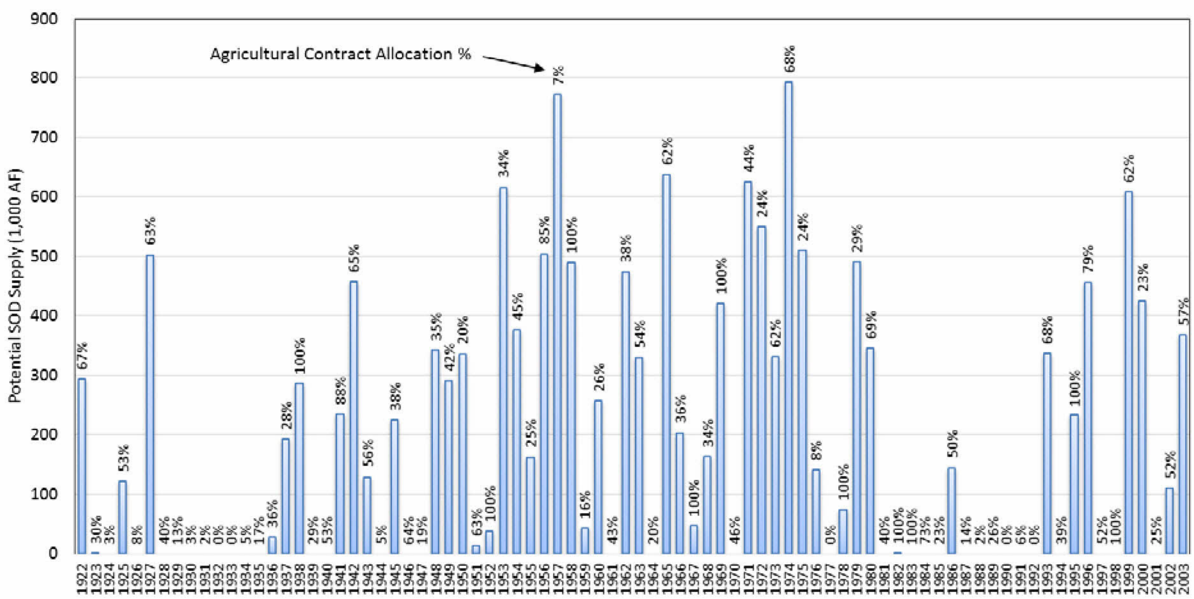


Figure 30. Ability to Increase CVP SOD Water Supply DWR/USBR BA Alternative 4A (minimum of available capacity and available upstream storage)

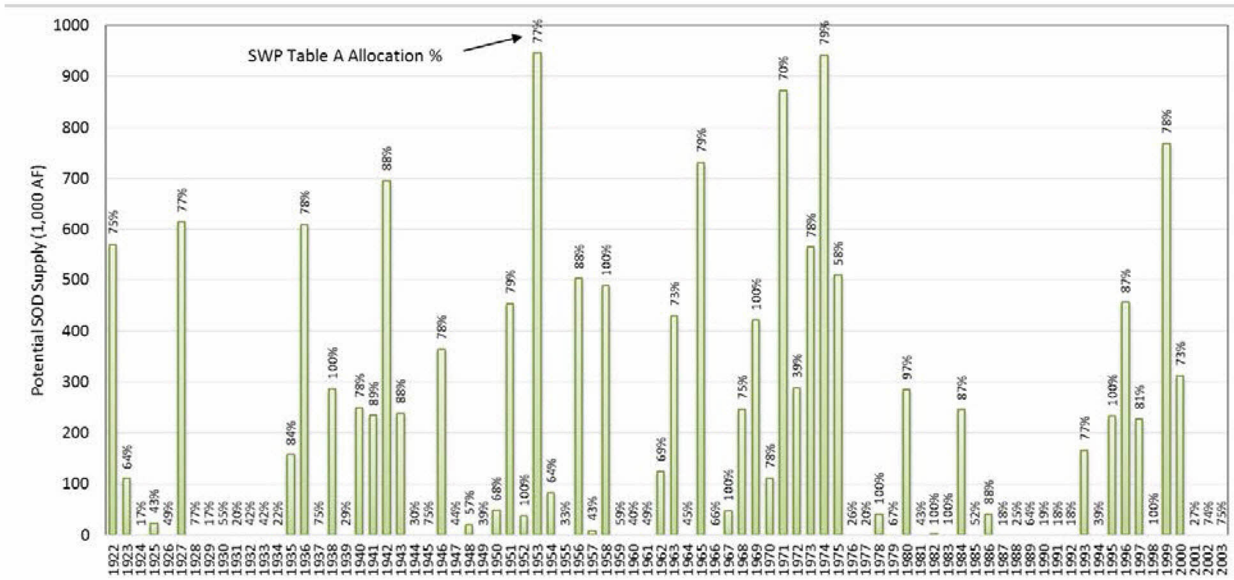


Figure 31. Ability to Increase SWP SOD Water Supply DWR/USBR BA Alternative 4A (minimum of available capacity and available upstream storage)

SVWU-107

2. MBK Analysis Using BA Modeling Assumptions

Because it was not possible to determine how the CWF may affect CVP and SWP operations or legal users of water from the CWF BA modeling, MBK performed additional modeling to assess the potential effects of the CWF. The first phase of MBK modeling effort was development of an updated without-project baseline, which is similar to the No Action Alternative but with more-accurate model assumptions. In this section, changes to the USBR/DWR BA NAA and USBR/DWR BA Alternative 4A models are described and then modeling results are presented. This section describes the MBK modeling assessment of CWF operations that used the same project-specific assumptions as the DWR/USBR modeling for CWF BA.

A. Revisions made to the CalSim II DWR/USBR BA NAA to Formulate the MBK NAA

The following changes were made to the DWR/USBR BA NAA version of CalSim II to develop the MBK NAA:

- Reverted from Early Long Term climate representation to current climate representation
    - Replaced inflow input time series in state variable file
    - Replaced 15 cm sea level rise based Artificial Normal Network (ANN) with 0 cm sea level rise based ANN
    - Replaced lookup tables for various hydrologic indices, unimpaired flow forecasts, the D1641 maximum allowable February export to inflow ratio, and the FWS BO Action 3 temperature trigger dates
- Updated Delta Cross Channel and Georgianna Slough flow equations
- Changed Navigation Control Point (Wilkins Slough) flow requirement logic
- Changed Knight's Landing Ridge Cut gate operation
- Changed Delta salinity standard logic for negative carriage water conditions
- Changed CVP and SWP San Luis Rulecurve logic
- Changed Jones Pumping Plant Health and Safety pumping level
- Implemented Spring Head of Old River Barriers
- Changed CVP and SWP allocation logic
    - Updated Water Supply Index-Delivery Index (WSI-DI)
    - Altered SWP and CVP export estimates for export based allocation logic
    - Added lookup table for user defined NOD and SOD CVP water service contractor allocation

These changes are described in the following paragraphs.

All other facets of the MBK NAA are identical to the DWR/USBR BA NAA.

i. *Climate Change*

In the DWR/USBR BA NAA CalSim II model, Early Long Term climate change was assumed (see draft CWF BA, released January 15, 2016). A combination of reduced reservoir inflows and sea level rise that increases Delta salinity exacerbates water supply shortages in critical drought periods (1929 - 1934, 1976 - 1977, and 1987 - 1992). During these critical drought periods, modeled storage amounts for Shasta, Folsom, and Trinity reservoirs are drawn to dead pools for several months of the DWR/USBR BA NAA. CalSim II is not designed to realistically simulate operations under these extreme circumstances, but these critical drought periods are some of the most important for water supply planning, water rights, and environmental assessments. To correct this problem, the MBK NAA was run with current climate conditions. Under current climate conditions, the existing rules of operation, as developed in current versions of CalSim II, mostly avoid dead pool conditions and, as a result, model results better reflect actual operations.

ii. *Navigation Control Point Flow Requirement*

The Navigation Control Point (NCP), or Sacramento River flow at Wilkins Slough, flow requirement in the DWR/USBR BA NAA varies from 3250 cfs to 5000 cfs, depending on NOD CVP Ag service contract allocations. Lower allocations result in lower required flows and higher allocations result in higher required flows.

In real-time operations, NCP flow requirement schedules are not dependent on Ag service contract allocations, but on storage conditions in Shasta and, more importantly, on the forecasted carryover storage in Shasta. The MBK NAA varies the NCP schedule based on forecasted Shasta carryover storage. The forecast updates at the beginning of each CVP contract year (March 1st). The flow schedule is shown in **Table 5.** The Shasta carryover forecasts are pre-processed using a representative baseline. If a study update significantly changes Shasta carryover, then the forecasts of carryover can be updated for purposes of setting an appropriate NCP flow schedule.

Table 5. NCP Required Flow Schedule Based on Forecasted Lake Shasta Carryover Storage

Forecast Shasta Carryover (TAF)	Sacramento River Navigation Control Point Required Flow Schedule											
	OCT (CFS)	NOV (CFS)	DEC (CFS)	JAN (CFS)	FEB (CFS)	MAR (CFS)	APR (CFS)	MAY (CFS)	JUN (CFS)	JUL (CFS)	AUG (CFS)	SEP (CFS)
> 2400	5000	4000	4000	4000	4000	4000	5000	5000	5000	5000	5000	5000
> 2000	4000	3500	3500	3500	3500	3500	4000	4000	4000	4000	4000	4000
> 1600	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
< 1600	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250

iii. *Knight's Landing Ridge Cut Gate Operation*

Gates to the Knight's Landing Ridge Cut are modeled as being opened to allow excess drainage from the Colusa Drain to pass through when the Sacramento River stage is too high to allow drainage back into the river at Knights Landing. In CalSim II, this stage is assumed to correspond with a Sacramento River flow of 15,000 cfs or greater. In previous versions of CalSim II and in the DWR/USBR BA NAA, there were instances where modeled Shasta Reservoir releases would provide additional water to raise the Sacramento River flow at Wilkins Slough up to 15,000 cfs just so that the gates would be opened, and the additional water then is modeled to flow down the Ridge Cut and to supply a highly weighted diversion. This does not reflect a decision that would be made in real-time operations. For this reason, the model logic was changed to maintain the connection of the gate operation and stage in the Sacramento River, but to disconnect this modeled gate operation from Keswick release decisions.

iv. *Negative Carriage Water Operations Logic*

Delta carriage water is the additional Delta outflow above minimum required Delta outflow (MRDO) necessary to meet D-1641 salinity standards. Carriage water is defined as marginal export costs, or the extra water needed to carry a unit of water across the Delta to the SDD pumping plants while maintaining a constant salinity. Or more practically, when the exports are increased by one unit, the Sacramento flow is increased by one unit plus the amount of carriage water to maintain a constant Delta salinity. When salinity is controlling, an increase in exports requires an increase in releases from upstream reservoirs to the Delta that equals the export increase plus the carriage water amount. In other words, carriage is the water cost of Delta exports when salinity standards are controlling. While higher exports typically result in higher carriage water amounts, there are times of the year when Rock Slough and Emmaton salinity standards can be met with higher exports and negative carriage water amounts. Essentially, when a negative carriage salinity constraint is controlling, a unit increase in Delta exports is supplied partially by a decrease in carriage water (decrease in Delta outflow) and the remainder by an increase in upstream reservoir release. While negative carriage might be counterintuitive, it is an actual phenomenon observed in Delta operations.

Negative carriage water in CalSim II presents problems of prioritization. In CalSim II, Delta outflow above MRDO, whether the outflow is surplus or carriage water, is given a relatively highly negative weight (low priority). The intent is to discourage any modeled Delta outflow in excess of MRDO. So when a negative carriage salinity constraint is controlling operations, CalSim II will model operations to minimize Delta outflow even though it might cause an imbalance between modeled NOD and SOD storage. Modeled Delta outflow is reduced through increased exports, but some water still has to be released from upstream reservoirs to support part of the increased export. If NOD reservoirs are relatively full, this could be a desirable operation, but if NOD reservoirs are low and further exports are not needed to support the current year's allocation, minimizing Delta outflow at the expense of upstream storage is an unwarranted operational decision. During the critical periods, the DWR/USBR BA NAA CalSim II model makes several of these decisions that result in the modeled transfer of NOD storage to San Luis when the water would be better kept NOD.

The implemented negative carriage operation fix in the MBK NAA is to remove the model flexibility to make an unwarranted decision. In CalSim II, SWP and CVP export estimates are made to guide operations when salinity standards are controlling. This is used to ensure that needed exports are made even if positive carriage must be paid. In the MBK NAA, similar export estimates are now used to limit how much carriage can be reduced through increases in exports under a negative carriage constraint. Essentially, under an Emmaton or Rock Slough negative carriage constraint, the carriage is held at the level to support the estimated export – no more and no less. CalSim II does not get an objective function benefit of releasing more water from upstream storage for a fractional reduction in Delta outflow.

v. *CVP and SWP San Luis Rulecurve Logic*

The CVP and SWP San Luis Rulecurves are used in CalSim II to prioritize balance between NOD storage and San Luis storage for the CVP and SWP. These San Luis Rulecurves control upstream releases for export when there is a choice between storing water in upstream reservoirs and releasing water for export and storage in San Luis. Operational constraints such as flood pool, minimum instream flow requirements, export regulations, health and safety pumping requirements, and physical pump capacity override these Rulecurves. When any of these operational constraints control operations, choices for balancing NOD storage are limited.

During the winter, when the Delta is often in excess conditions, additional upstream reservoir releases are not needed and these Rulecurves do not govern upstream reservoir operations. During winter months, upstream reservoir releases are often controlled by flood pool or minimum flow requirements, and exports are controlled by OMR flow requirements or maximum pumping capacity. Because these Rulecurves do not play a significant role in driving winter San Luis operations, there was no need to modify wintertime Rulecurve logic.

Where the Rulecurves do make a difference, or should make a difference, is during balanced conditions in the irrigation season when there are windows of opportunity to coordinate upstream reservoir releases with Delta exports. During the summer, SOD project demand typically exceeds Delta exports. Under these conditions, SOD project demand is met with a combination of Delta exports and San Luis releases, and if the Rulecurves are controlling, they influence the balance between Delta exports and San Luis reservoir releases. If the Rulecurves are set lower, exports decrease and San Luis releases increase. When the Rulecurves are set higher, the opposite occurs; exports increase and San Luis releases decrease. Ideally the combination of San Luis releases and project exports over the irrigation season will be sufficient to satisfy project allocations and San Luis targeted carryover storage, and the Rulecurves should be set to encourage the appropriate balance.

Therefore, formulation of the Rulecurves during the irrigation season should be an export scheduling problem, to be solved by determining how much water to export within a season to achieve delivery and carryover goals, how to distribute these exports from month to month, and where to set SWP and CVP Rulecurves to encourage those Delta exports and the supporting upstream releases. The problem with the current irrigation season Rulecurve formulations in CalSim II is that they do not consider the amount of exports needed over the season. In fact, for both the SWP and CVP, the Rulecurve formulations assume exports of 60 TAF per month whether that is sufficient to meet operational objectives or not. Rulecurve levels are driven by this export assumption.

The implemented fix to the modeled irrigation season Rulecurve formulation is to incorporate export scheduling in the MBK NAA; SWP and CVP formulations vary slightly. With the CVP, exports need to be scheduled to ensure the project can meet peak summer demand and prevent San Luis low point issues through the end of September. The SWP has similar concerns, but must also consider Article 56 carryover into the next calendar year with the added complication of Feather River flow limitations for half of October and all of November that can interfere with the SWP's ability to make Oroville releases for export. So while the CVP's export scheduling formulation extends from May through September, the SWP's export scheduling starts in April and extends through December.

vi. *Jones Pumping Plant Health and Safety Pumping Level*

In CalSim II, it has been assumed that Jones Pumping Plant health and safety pumping levels were equal to having one pump turned on (800 cfs). In years with low upstream storage, it was assumed that pumps could be cycled such that a monthly average pumping rate of 600 cfs could be achieved. The 2012-2015 drought has forced the CVP to cycle pumps to bring daily average pumping rates down to 300 cfs. This set a new threshold for Jones PP H&S levels which was assumed in the MBK NAA. This is an important assumption for balancing NOD storage and San Luis during the critical periods.

vii. *Spring Installation of Head of Old River Barriers*

Because spring Head of Old River Barriers (HORB) is a NMFS requirement, because the FWS recently issued a new Biological Opinion that allows the HORB (either rock or non-physical), and because DWR has found that the rock barrier is more effective at protecting salmon than the non-physical barrier, it is reasonably foreseeable that a physical HORB will be installed and closed in April and May. Therefore, it is appropriate to include this assumption in the NAA. In CalSim II and in future real-time operations, the HORB will impede flow from the San Joaquin River into Old River and will cause OMR requirements to control Delta exports more often in April and May. This reduces exports in some months.

viii. *CVP and SWP Allocation Logic*

An important decision that SWP and CVP operators must make each year is how much water to allocate to their contractors. Considerations include forecasted inflows, in-basin water demands including Delta outflow requirements and salinity standards, instream flow requirements and temperature standards, reservoir storage carryover targets, and Delta export capacity limitations. Operators weigh the hydrologic uncertainty by simulating the system under a range of forecasted conditions (inflows, export restrictions, in-basin uses, etc.) in a trial-and-error process. A reasonable allocation is neither overly aggressive nor overly conservative. An overly aggressive allocation could leave SOD contractors short of the supply they were allocated due to insufficient export capacity, or it could leave NOD reservoirs below desired September carryover targets if expected inflows do not materialize or salinity standards tax supplies more than expected. Conversely, an overly conservative allocation would be a lost opportunity to meet contractors' demands for water. While it is often a difficult balance, it is one that SWP and CVP operators seek to achieve every.

CalSim II allocation logic has had difficulty replicating this balance. This was especially true with the implementation of the Delta smelt and salmon BO's that include OMR flow requirements and the SJR IE. CalSim II combines its WSI-DI based methodology with an export forecast based methodology to formulate allocations. The WSI-DI based allocation assesses aggregate supply (forecasted inflow plus storage), but it does not adequately address limitations of available export capacity necessary to move the NOD supply to SOD contractors. Conversely, the export forecast based allocation is intended to address export capacity limitations, but the export forecasts used in CalSim II are often inaccurate.

For the MBK NAA, the standard CalSim II modeling practice of modifying the SWP and CVP WSI-DI curves to improve allocations was employed. For the export forecast based allocations, a more accurate set of export forecasts was used that recognizes the unique hydrologic circumstances of each year just as operators do in their operations forecasts. These two steps alone were enough to simulate reasonable SWP Table A allocations.

Problems with the CVP allocations could not be resolved with adjustments to CalSim II's WSI-DI curve and the export forecasts alone. This is due to the frequent disconnection of CVP NOD and SOD water service contract allocations. It is CVP policy that NOD and SOD service contractors in the same category (Ag or M&I) will receive equal allocations unless SOD allocations are limited by Delta export capacity. In the MBK NAA, SOD contractor allocations are conveyance limited in 40 years of the 82 year simulation. When conveyance capacity does not limit allocations, NOD and SOD contractors share an aggregate supply. When Delta export capacity does limit SOD allocations, SOD contractors are cut off from some portion of that supply. With the Delta export capacity limitation, SOD contractor allocations are limited by the sum of forecasted exports plus current San Luis storage above targeted carryover. While CalSim II correctly quantifies the SOD allocation, the NOD allocation is based on WSI-DI which divides and aggregate supply (forecasted inflows and Shasta, Folsom, Trinity, and San Luis storage) amongst all the contractors (NOD and SOD). This tends to suppress NOD contractor allocations below what would be reasonable for the resulting Shasta and Folsom carryover. NOD contractor allocations should be limited only by Shasta and Folsom carryover considerations.

There was no easily automated fix for the CVP NOD water service contract allocation issue when SOD allocations were Delta export capacity limited. Therefore, a user defined allocation override logic was used in years the combined WSI-DI and export forecast based logic was not providing a reasonable NOD water service contractor allocations. The logic allows the user to specify a percent allocation for SOD and NOD Ag service contract allocations, M&I service allocations are then set by the CVP water shortage policy. Providing control of both SOD and NOD Ag service allocations allowed the SOD allocation to be truly capacity constrained by pushing it to a limit at which SOD shortages began occurring. Once it was determined that the SOD allocation was capacity constrained, the NOD allocation was set to an appropriate level based on projected Shasta and Folsom carryover. Rules for making NOD CVP allocations in CalSim II are based on recent CVP operations and allocations. **Figure 32** contains the historical relationship between Shasta carryover storage and NOD CVP allocations. **Figure 33** shows resulting Shasta carryover storage and CVP NOD agricultural service contractor allocation from the MBK NAA, **Figure 33** also shows this information for the USBR/DWR BA NAA modeling. Full allocations are made 56% of the time in the MBK NAA, while full allocations occur 22% of the time in the USBR/DWR BA NAA. There are many times in the DWR/USBR BA NAA when NOD allocations are low relative to available upstream water supply. There are also times in the DWR/USBR BA NAA with low Shasta storage and allocations are higher than would likely occur in actual operations.

The difference in NOD CVP Ag service allocations from the DWR/USBR BA NAA is significant. This is primarily because in the BA NAA's, the CVP NOD allocations are too low relative to available NOD water supply. Therefore, changes in CVP upstream storage resulted in little change to NOD allocations. When allocations are established based on available water supply, changes in water supply will affect allocations in a more realistic manner.

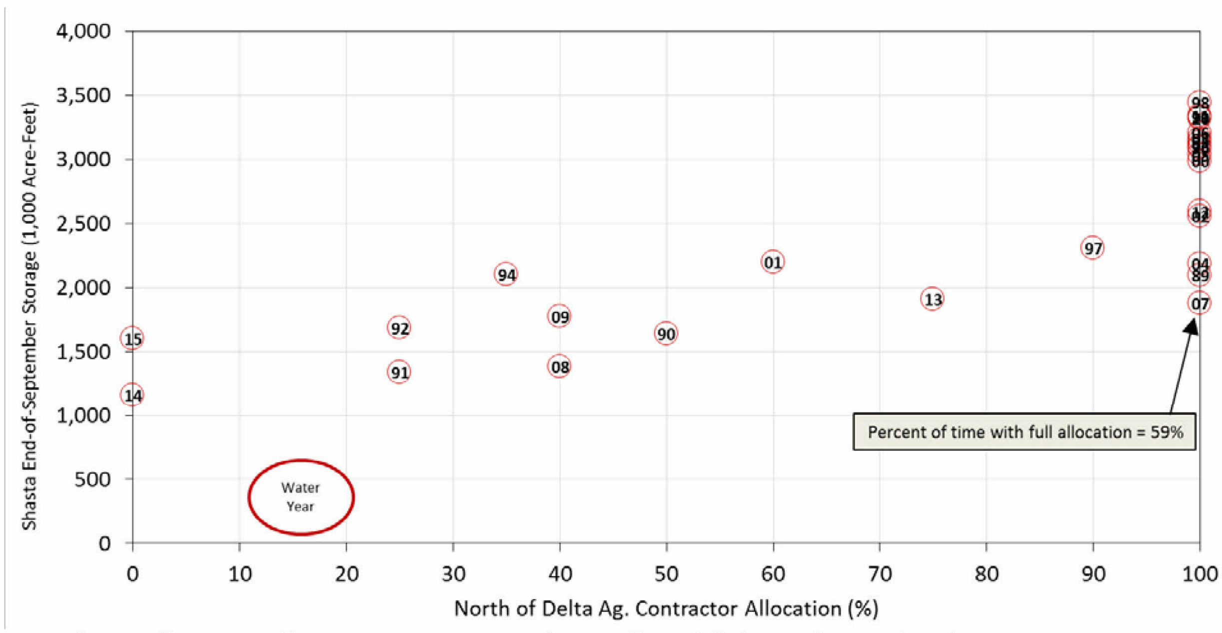


Figure 32. Shasta Carryover Storage versus North of Delta CVP AG Allocation – Historical

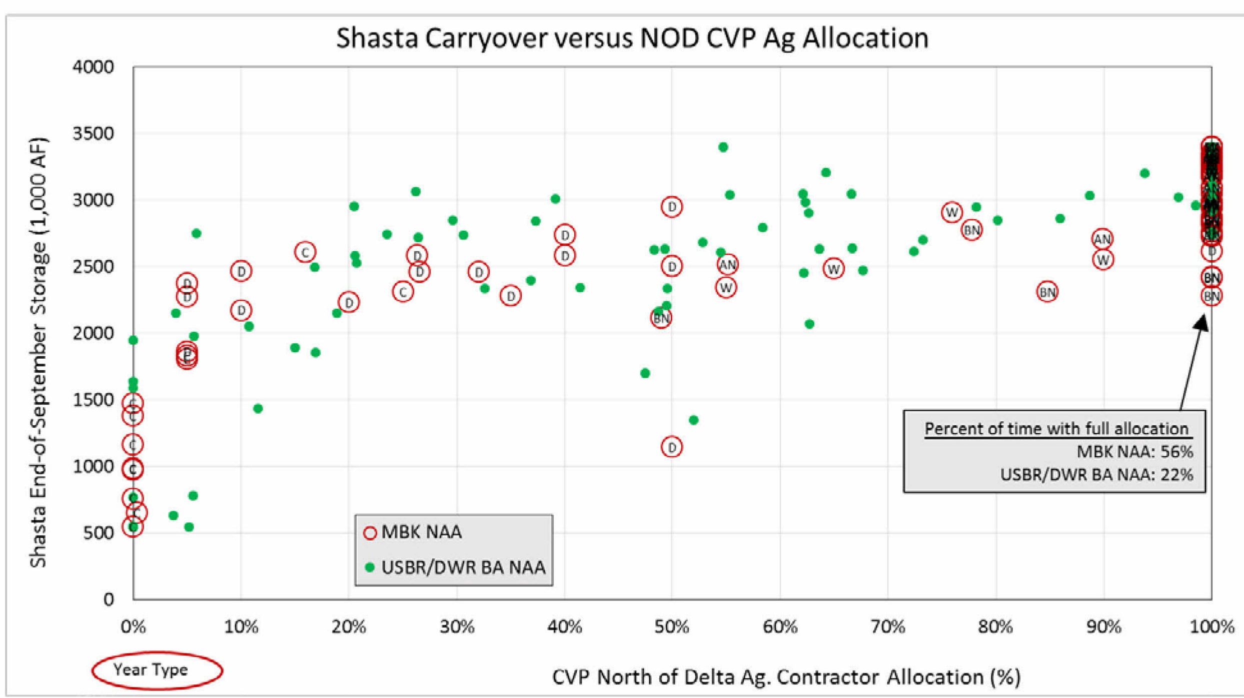


Figure 33. Shasta Carryover Storage versus North of Delta CVP AG Allocation - MBK NAA and USBR/DWR BA NAA

B. Revisions made to the CalSim II DWR/USBR BA Alternative 4A to formulate the MBK Alternative 4A

The following changes made to formulate the MBK NAA were also included in the MBK Alternative 4A and the explanations for these changes that are described above also apply here.

- Reverted from Early Long Term climate representation to current climate representation
    - Replaced inflow input time series in state variable file
    - Replaced 15 cm sea level rise based Artificial Normal Network (ANN) with 0 cm sea level rise based ANN
    - Replaced lookup tables for various hydrologic indices, unimpaired flow forecasts, the D1641 maximum allowable February export to inflow ratio, and the FWS BO Action 3 temperature trigger dates
- Updated Delta Cross Channel and Georgianna Slough flow equations
- Changed Navigation Control Point (Wilkins Slough) flow requirement logic
- Changed Knight's Landing Ridge Cut gate operation
- Changed Delta salinity standard logic for negative carriage water conditions
- Changed CVP and SWP San Luis Rulecurve logic
- Changed Jones Pumping Plant Health and Safety pumping level
- Implemented Spring Head of Old River Barriers
- Changed CVP and SWP allocation logic
    - Updated Water Supply Index-Delivery Index (WSI-DI)
    - Altered SWP and CVP export estimates for export based allocation logic
    - Added lookup table for user defined NOD and SOD CVP water service contractor allocation

The additional edits for the formulation of MBK Alternative 4A are:

- Changed timing and priority of Cross Valley Canal wheeling to allow for more effective use of JPOD
- Changed NDD facility capacity sharing logic for SWP and CVP
- Changed Late-Summer and Fall Storage Balance between San Luis and NOD Reservoirs
- Changed allowance of JPOD wheeling above Banks permitted capacity when NDD exports through Bank allow
- Made adjustments to allocation logic similar to MBK NAA edits but taking into account NDD facility in WSI-DI, export forecasts, and user defined allocations
- Changed NDD facility bypass criteria implementation (the bypass criteria are the same, but the model implementation is different)
- Turned off logic to push storage release for export when carriage is applied to Delta conveyance
- Changed Delta Cross Channel Gate Reoperation in October

i. *Changes in Timing and Priority of Cross Valley Canal Wheeling to Allow for Effective JPOD Wheeling*

The additional Banks PP capacity (above the Corps of Engineers permitted capacity) that could be accessed through the NDD facility would allow for Cross Valley Canal wheeling to occur earlier in the year. Without the NDD facility, CVC wheeling is often delayed until November because Banks PP capacity is fully utilized by the SWP due to the limits on the authorized rates of Banks pumping directly from the south Delta. With the NDD facility, CVC wheeling could commence in July. The additional Banks PP capacity also would open up more opportunity for JPOD wheeling. In fact, if JPOD wheeling capacity could be included in the CVP allocation process as a reliable means to convey CVP stored water, it could be used to boost CVP SOD allocations in years that SOD allocations are export capacity constrained. However, for the connection between available JPOD capacity and allocations to be made, JPOD must be given priority over CVC wheeling when it is needed to support storage levels in San Luis. No such priority was given in the DWR/USBR BA Alternative 4A and CVC wheeling is often frontloaded in July as a result. MBK Alternative 4A CVC wheeling logic alters the CalSim II logic to spread deliveries over the summer months, as opposed to concentrating deliveries in July, and to give priority to JPOD wheeling from July to September when it is needed to maintain CVP San Luis Rulecurve.

ii. *North Delta Diversion Facility Capacity Sharing Logic between SWP and CVP*

The DWR/USBR BA Alternative 4A does not include any NDD capacity sharing logic between the SWP and CVP. The MBK Alternative 4A does include sharing logic. However, this sharing logic does not override COA and it would not affect the total exports of either the CVP or the SWP; it would just recognize when both projects are exporting water and when both NDD and SDD diversions are being taken and try to divide the low salinity NDD water between Tracy and Banks equitably.

iii. *Late-Summer and Fall Storage Balance between San Luis and NOD Reservoirs*

In the DWR/USBR BA NAA and the MBK NAA, the model has a priority to release Shasta and Folsom storage, above the amounts needed to satisfy upstream requirements, to support exports at Jones Pumping Plant to storage in San Luis Reservoir in the late summer and early fall months. The purpose was to get a head start on filling San Luis Reservoir for the coming water year if there is a high likelihood of Shasta or Folsom spilling. This was an assumed CVP/SWP adaptation to the export reductions in the winter and spring months due to the salmon and smelt biological opinions. However, with the NDD facility in MBK Alternative 4A, winter and spring export restrictions would impact CVP exports much less and there is no longer a reason to impose this risk on upstream storage. For this reason, the weights, or prioritizations, of storage in Shasta and Folsom were raised so that excess water would not be modeled as being released specifically to increase CVP San Luis Reservoir storage above the San Luis Rulecurves. This was changed in MBK Alternative 4A, and not in the MBK NAA, to better reflect how the system would operate under these different conditions and to ensure that impacts to Shasta and Folsom were not being overestimated. This is also different from the DWR/USBR BA Alternative 4A.

iv. *Allowance of JPOD Wheeling Above Banks Permitted Capacity When NDD Exports through Banks Allow*

As discussed previously, DWR/USBR BA Alternative 4A did not allow JPOD wheeling when Banks PP was operating above permitted capacity even if the JPOD wheeling was conveyed through the NDD facility. There was no reason given for restricting JPOD wheeling in such a manner, but not applying such a restriction to SWP exports, CVC wheeling, or transfers. Therefore, MBK Alternative 4A removed the permitted capacity constraint from JPOD wheeling when the additional Banks PP capacity was made available through NDD.

v. *Adjustments to Allocation Logic*

Adjustments were made to the CalSim II Water Supply Index – Delivery Index (WSI-DI) to account for the additional control over water supply that the NDD facility provides to the SWP and CVP. Also, the export forecasts used in the export based allocation logic were updated to account for the additional export capacity. These two adjustments were sufficient refinement for SWP Table A allocations. CVP water service contract allocations were further refined with the user defined allocation logic as discussed above for the MBK NAA.

vi. *North Delta Diversion Bypass Criteria*

The daily disaggregation method for implementing NDD bypass criteria was modified to properly fit the bypass criteria implementation within the latest CalSim II operations formulation. Modifications are as follows:

1. No NDD operations occur in cycles 6 through 9 so that Delta operations and constraints can be fully assessed without NDD interference.
2. Cycles 10 and 11 (Daily 1 and Daily 2 respectively) were added to determine NDD operations given various operational constraints including the NDD bypass criteria.
3. From July to October, bypass criteria are based on monthly average operations (no daily disaggregation). Given the controlled reservoir releases at this time and the constant bypass criteria (5,000 cfs from July to September and 7,000 cfs in October), this was determined to be a reasonable assumption. This also simplified coordination of DCC gate operations with NDD in October, which will be discussed later in this report.
4. When warranted by conditions in cycle Daily 1 (cycle 10), the bypass criteria in May and June were allowed to be modeled on a monthly average basis in cycle Daily 2 (cycle 11). This allowed a reduction in the number of cycles necessary to determine the fully allowed NDD under the bypass criteria when the Delta was in balance and additional upstream releases were made to support diversions at the NDD.

vii. *Turn Off Logic to Push Storage Release for Export When Carriage is Applied to Delta Conveyance*

There are situations where exports are necessary to meet allocated contractor deliveries at the same time salinity standards in the Delta require high amounts of carriage water. Without the NDD facility, all exports must pass through the Delta and are subject to that carriage water requirement. CalSim II has logic to ensure that when exports are needed to meet allocated deliveries negative impact that carriage has on the objective function does not outweigh the positive impact of the exports; a CalSim II variable called C400_MIF ensures that the water needed SOD is released from upstream reservoir and exported and the associated carriage is paid. However, with the NDD facility, carriage for through Delta conveyance can be bypassed. Under these conditions, the logic is unnecessary and has the potential to cause an imbalance between NDD and SDD. The DWR/USBR BA Alternative 4A does not remove the C400_MIF logic, but the study nullifies its NDD-SDD balance effects through other means. The MBK Alternative 4A turns the logic off.

viii. *Delta Cross Channel Gate Reoperation in October*

The DWR/USBR BA Alternative 4A results in significantly more October surplus Delta outflow as compared to the DWR/USBR BA NAA. The cause of this Delta surplus at a time when the Delta is frequently in balance is a combination of proposed SDD constraints (OMR flow criteria and no through-Delta exports during the San Joaquin River October pulse period), Rio Vista flow requirements, and DCC gate operations. In DWR/USBR BA NAA and DWR/USBR BA Alternative 4A, it was assumed that the DCC gates would be open for the entire month of October thereby requiring much higher Sacramento River flows at Hood in order to meet the Rio Vista flow requirement than if DCC gates were closed. In contrast, in the MBK Alternative 4A scenario it was assumed DCC gates were closed for a number of days during the month such that the 7,000 cfs NDD bypass criteria would be sufficient to meet the weekly average Rio Vista flow requirements. The intent was to minimize surplus Delta outflow while meeting Delta salinity standards and maintaining enough bypass flow to use the NDD facility for SOD exports. This is an approximation of what would likely occur in real-time operations under similar circumstances, as long as the Delta salinity standards are met, operators have indicated that they would indeed close the DCC in this manner (as was done in October and November 2013). Further gate closures may be possible as salinity standards allow if operators were to decide to preserve upstream storage at the expense of NDD diversions. This type of operation would require additional model refinements.

ix. *Operational Strategy*

The NDD would increase operational flexibility and improve the CVP's and SWP's abilities to convey water from the Sacramento River basin to the export service area. The NDD also would improve the CVP's and SWP's abilities to divert surplus flows, and to convey water released from storage in upstream CVP and SWP reservoirs, made available through transfers or other sources. Upstream reservoirs are intended to capture high inflows and then to release this water to satisfy multiple beneficial uses. The NDD would allow for greater use of water stored in upstream reservoirs. This would increase the operational efficiency of these reservoirs and allows use of the proposed NDD. Therefore, the MBK modeling assumes that if the NDD is constructed, it will be used to convey available supplies in upstream CVP and SWP reservoirs. The basic operational strategy would be, given regulatory constraints, is to divert as much surplus as possible and to operate upstream CVP and SWP reservoirs to convey surplus stored water when possible.

Figure 34 shows the ability to increase SOD CVP water supply from the MBK Alternative 4A scenario. The potential SOD increase is estimated as the minimum of Shasta plus Folsom carryover storage over 3 MAF and available June through September Export capacity. There are several years where combined Shasta and Folsom storage would be greater than 3 MAF and there would be available export capacity. However, most of these occurrences are when water supply allocations already would be at 100%.

Figure 35 shows the ability to increase SOD SWP water supply. It is estimated as the minimum of Oroville carryover storage above the 1.5 MAF threshold and available June through September export capacity. Similar to CVP operations, there are several years when Oroville storage is available with high Table A allocations and there is little need for additional movement of stored water.

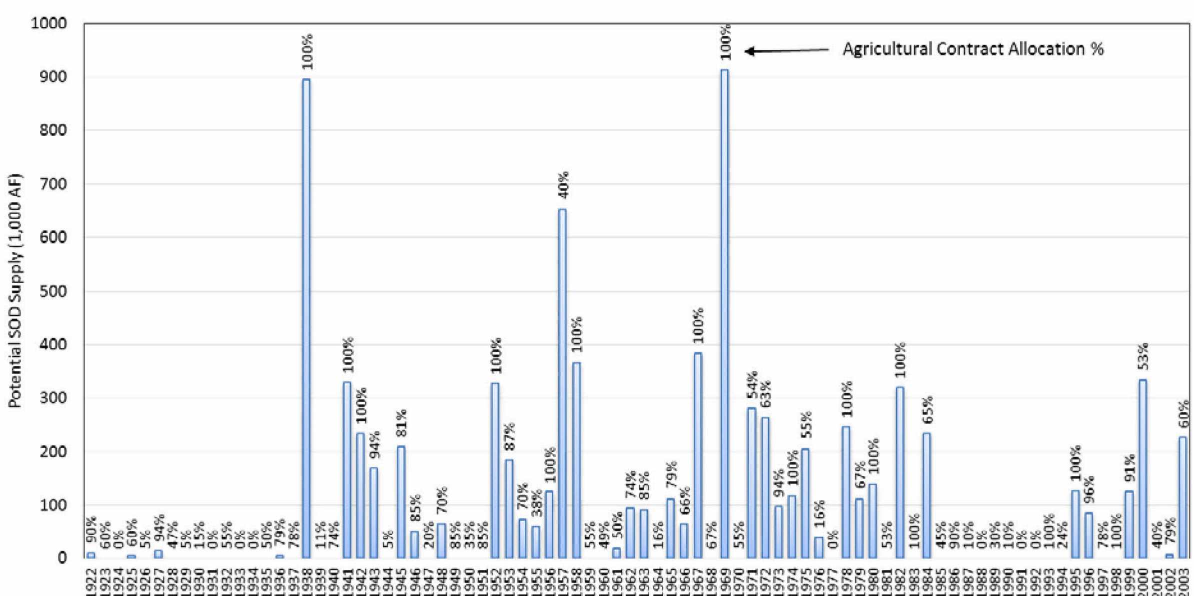


Figure 34. Ability to Increase CVP SOD Water Supply, MBK Alternative 4A (Minimum of Available Capacity and Available Upstream Storage)

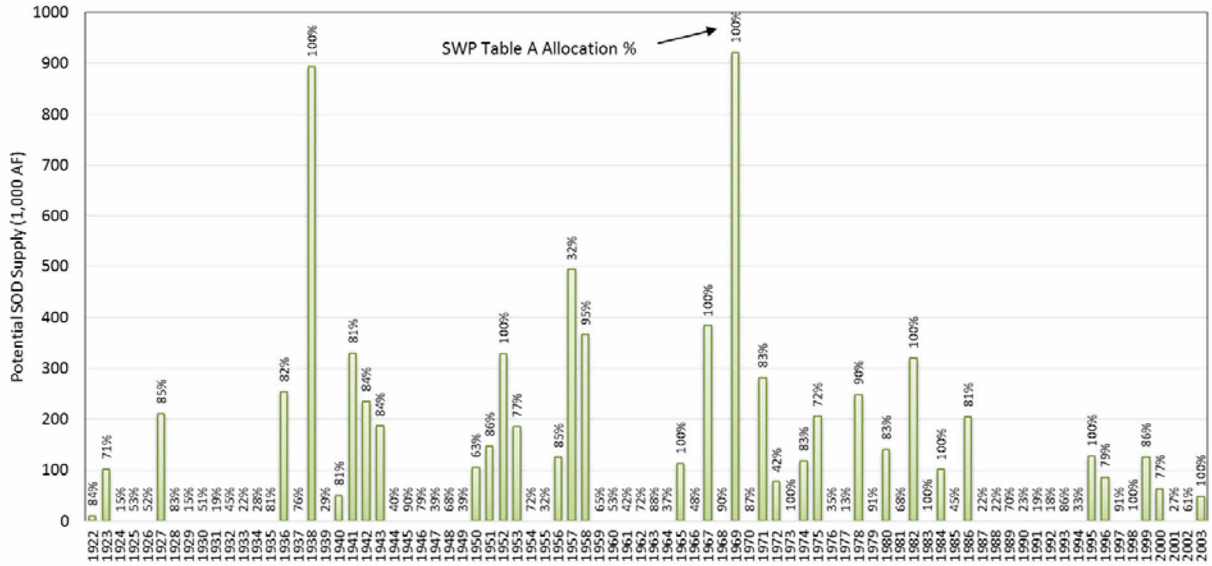


Figure 35. Ability to Increase SWP SOD Water Supply, MBK Alternative 4A (minimum of available capacity and available upstream storage)

C. North Delta Diversion

With the same constraints applied in modeling performed for the CWF BA, the MBK modeling (MBK Alternative 4A) results show an average annual NDD of 3.0 MAF. **Figure 36** shows the average annual diversion ranging from 4.4 MAF in wet years to 0.7 MAF in critical years, a majority of this diversion occurs in winter and summer months with lower use in April and May. Use of the NDD in the MBK modeling is greater during summer months than in the DWR/USBR modeling due to movement of water stored in upstream reservoirs.

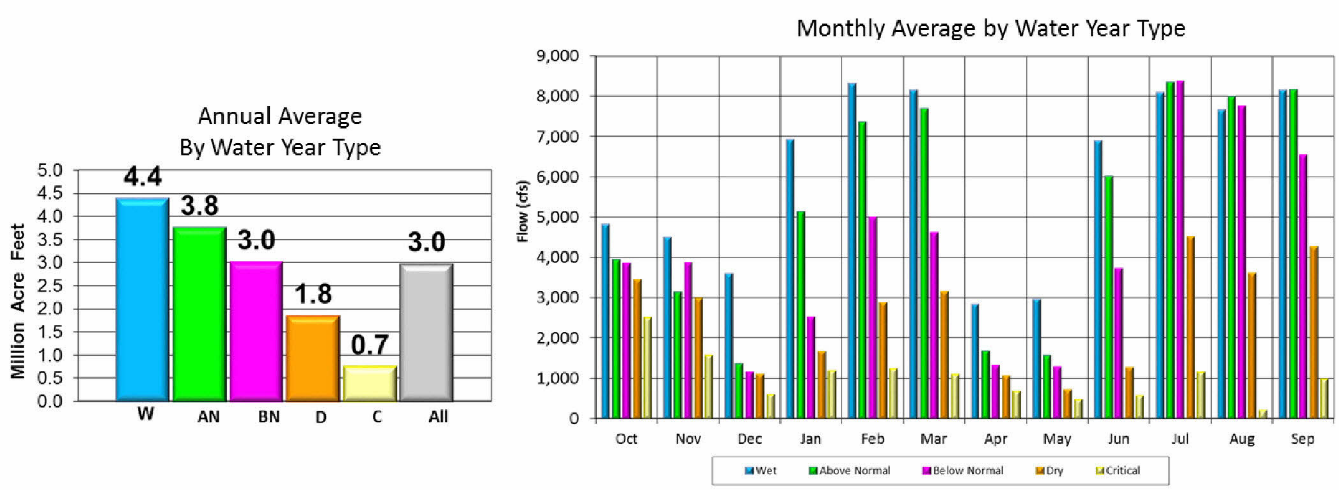


Figure 36. North Delta Diversion - MBK Alternative 4A

Figure 37 contains probability of exceedance charts of simulated Sacramento River flow above and below the NDD, diversion at the NDD, and maximum allowable diversion given the bypass criteria, fish screen sweeping velocity constraints, and capacity of the tunnels. The plots are scaled so that lower flow conditions may be examined in greater detail. The green dashed curves show the maximum diversion and the red curves represent the diversions at the NDD facility. The red curve must be on or below the green dashed curve. The differences between the solid blue curves and the dotted blue curves show the difference between Sacramento River flow above and below the NDD. Modeling performed for the BA constrains use of the NDD in April and May based on San Joaquin River flow at Vernalis and existing constraints in the Delta smelt Biological Opinion. Therefore, diversions are always less than those allowed in the NDD bypass criteria. Use of the NDD from July through September has a lower priority than the South Delta Diversion (SDD) until the SDD is at least 3,000 cfs, therefore the NDD is often less than what is allowed in the bypass criteria.

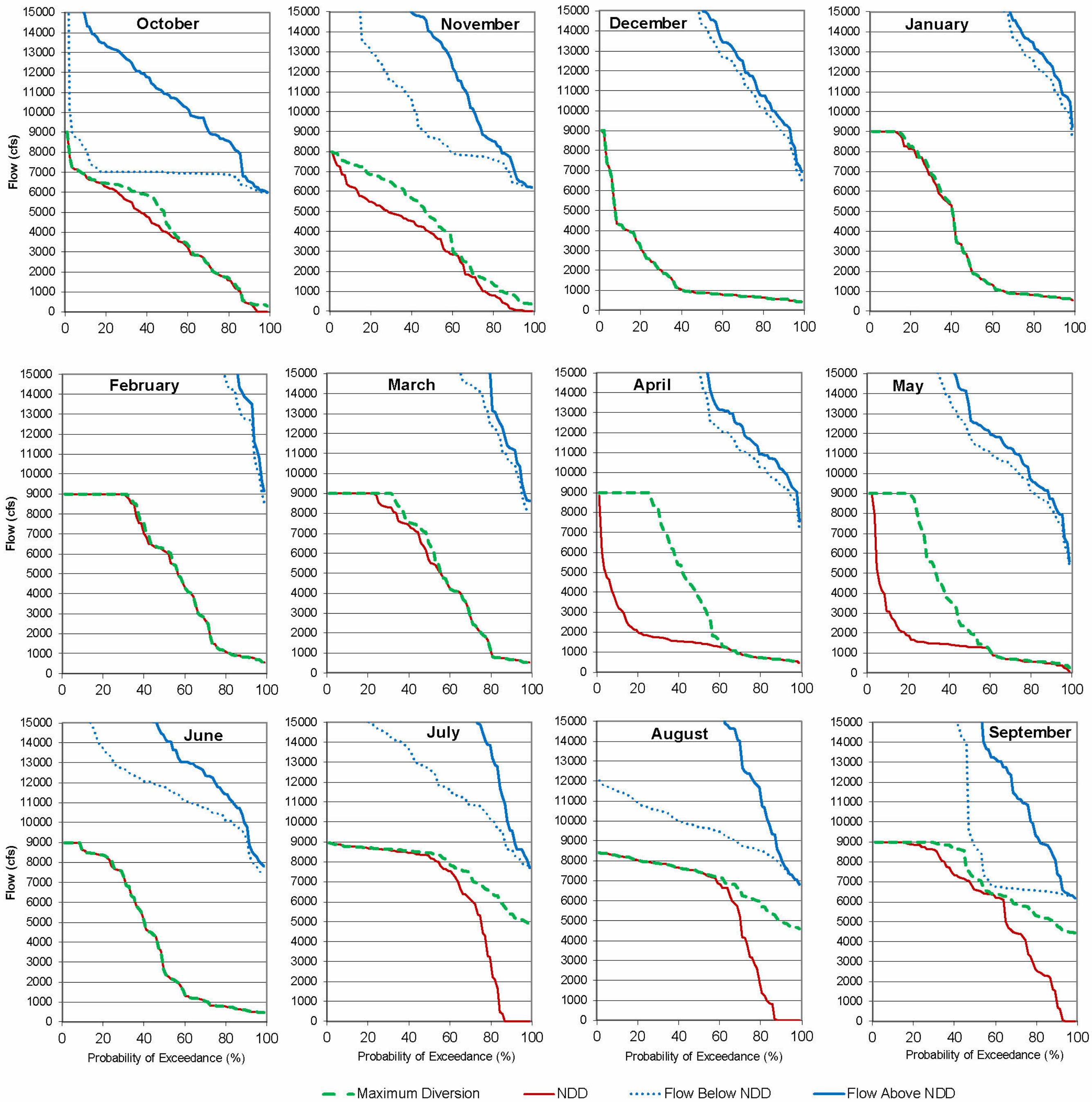


Figure 37. Sacramento River and NDD -MBK Alternative 4A

i. *Spring Delta Outflow Requirement*

The MBK Alternative 4A implemented the spring outflow proposed action listed in **Table 2**. As for the DWR/USBR BA Alternative 4A, the outflow criteria were met incidentally by constraining total exports, both SDD and NDD, to the SJR IE. There was no guarantee that employing the SJR IE would result in meeting the March through May outflow criteria at the specified probability of exceedance. One reason was that the MBK Alternative 4A did not include climate change. This change can alter modeled reservoir releases, which can change modeled Delta outflows, just as reducing modeled Delta exports can change modeled Delta outflows. As discussed above, the outflow criteria were based on the DWR/USBR BA NAA, which included climate change. The other reason the MBK Alternative 4A may not meet the spring outflow criteria is that the MBK Alternative 4A would draw stored water from NOD CVP and SWP reservoirs more aggressively than the MBK NAA (this will be explained later in this document) and, as a result, additional modeled reservoir refills could occur in the March-May period. This could reduce modeled March - May outflows even though total exports in April and May would be limited by SJR IE.

Even with these concerns, the SJR IE constraint on total exports still would maintain spring outflow standard as shown in **Figure 38**. The black dots show the DWR/USBR BA NAA results which were the basis of the proposed outflow criteria. The proposed March-May average outflow criteria is represented by the green circles. The DWR/USBR BA Alternative 4A and MBK Alternative 4A results are the red lines and blue dashed lines respectively. As shown in **Figure 38**, the MBK Alternative 4A would meet the spring Delta outflow criteria just as effectively as the DWR/USBR BA Alternative 4A.

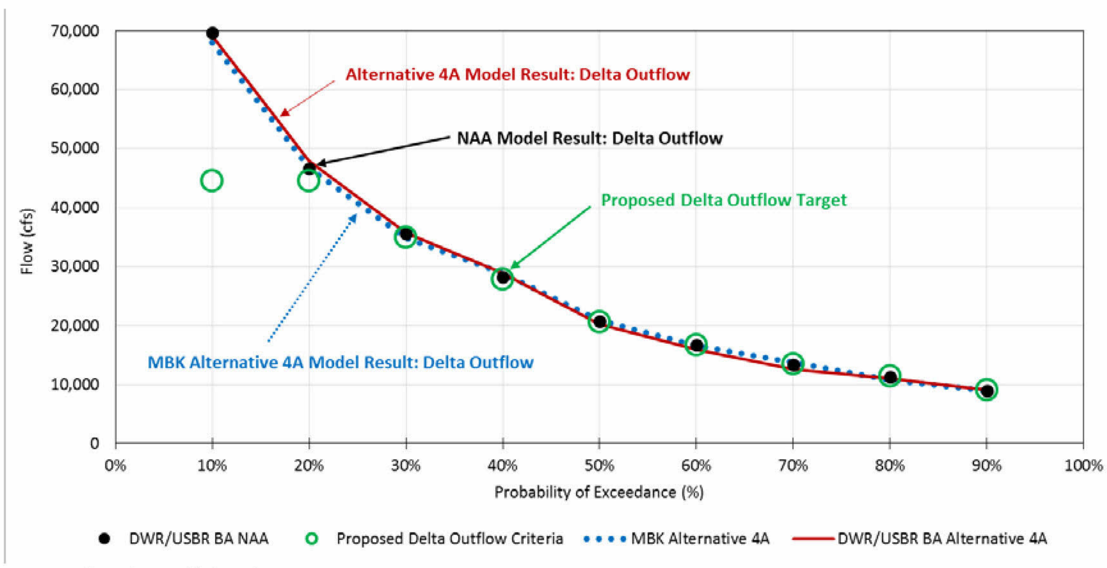


Figure 38. Delta Outflow Criteria and Results

D. CVP/SWP Exports

With the addition of the North Delta Diversion facility, the water exported would shift exports from South Delta diversions to North Delta diversions. **Figure 39** illustrates the change in routing of South of Delta exports under MBK Alternative 4A compared to the MBK NAA. On average, exports through the South Delta facility are projected to decrease by 2.5 MAF and the North Delta diversions are expected to export 3.0 MAF, which includes the 2.5 MAF shifted from the South Delta facility plus an additional 491 TAF of increased exports.

Figure 40 contains charts for July, August, and September for MBK Alternative 4A that plot exports at NDD against exports at SDD. During these three months, diversion from the NDD would not occur until there is a least 3,000 cfs diversion from the SDD, indicated by the green line in the charts. Other than this 3,000 cfs rule and the NDD bypass criteria, an operations plan is not available that describes how decisions will be made whether to use the NDD or SDD for export water. Therefore, actual operations may differ from what is modeled. There are times when combined exports would be close to 14,400 cfs, this is the full capacity of both the Jones and Banks export facilities, and is indicated in **Figure 40** with the purple line. Because there are no clear operations criteria, the effects due to the proposed project cannot be fully assessed.

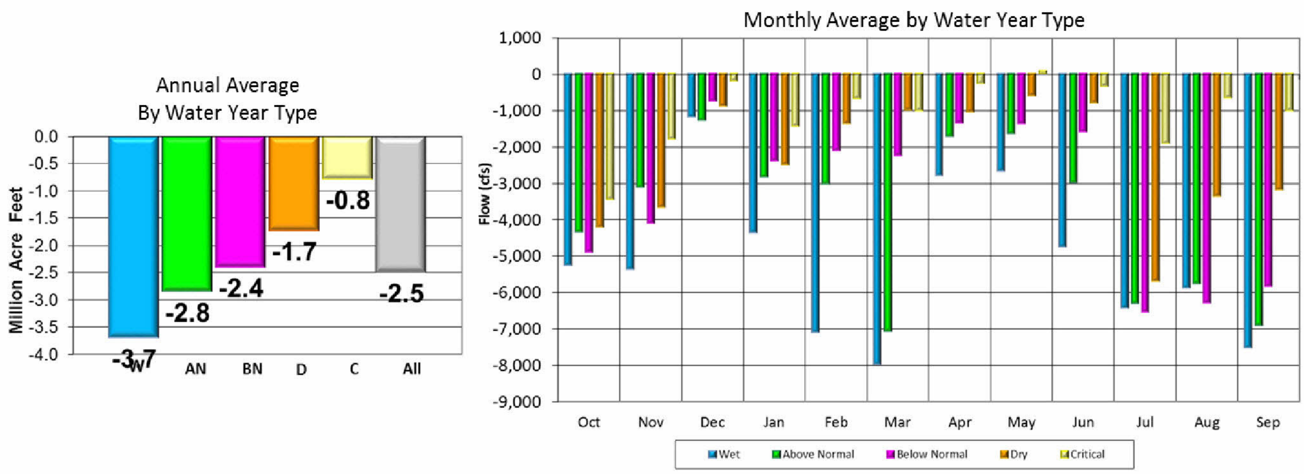


Figure 39. Change in South Delta Diversion – MBK Alternative 4A minus MBK NAA

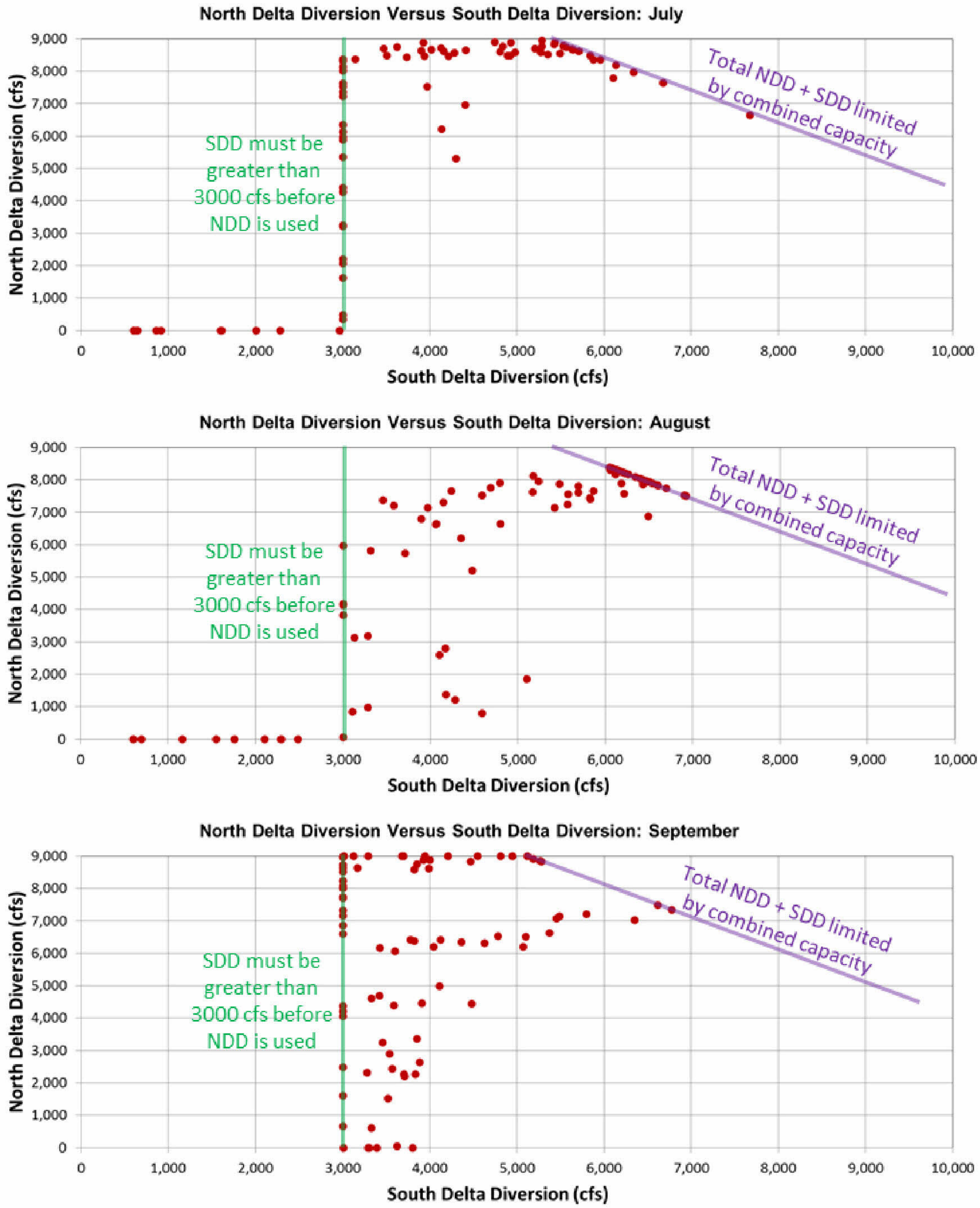


Figure 40. North Delta Diversion versus South Delta Diversion - MBK Alternative 4A

Overall, MBK Alternative 4A would increase exports compared to the MBK NAA. **Figure 41** shows an average annual increase in total Delta exports of 491 TAF, ranging from about 920 TAF in above normal years to -25 TAF in critical years. Exports in April and May would change very little, while exports in winter and early summer months would increase. Exports would decrease in the October through November period.

Figure 42 shows changes in modeled Jones exports. There would be an annual average increase in Jones exports of about 63 TAF with the largest increase in above normal years and a smaller increase in dry years. Jones exports would tend to increase in June, and then decrease starting in October. This change in monthly export would tend to reduce upstream CVP reservoir storage from June through September.

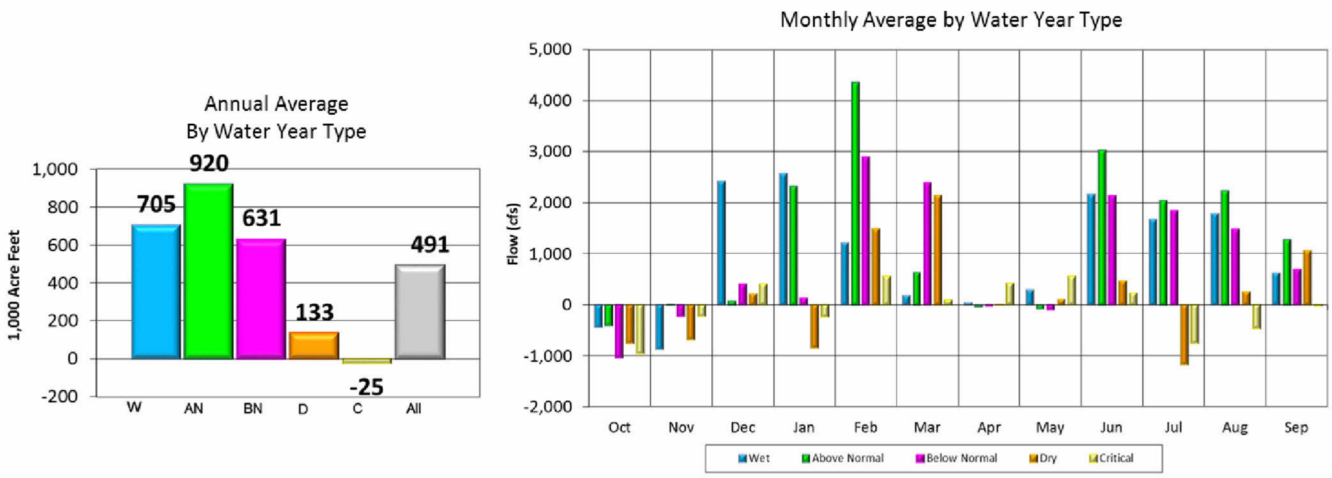


Figure 41. Change in Delta Exports (Jones plus Banks) - MBK Alternative 4A minus MBK NAA

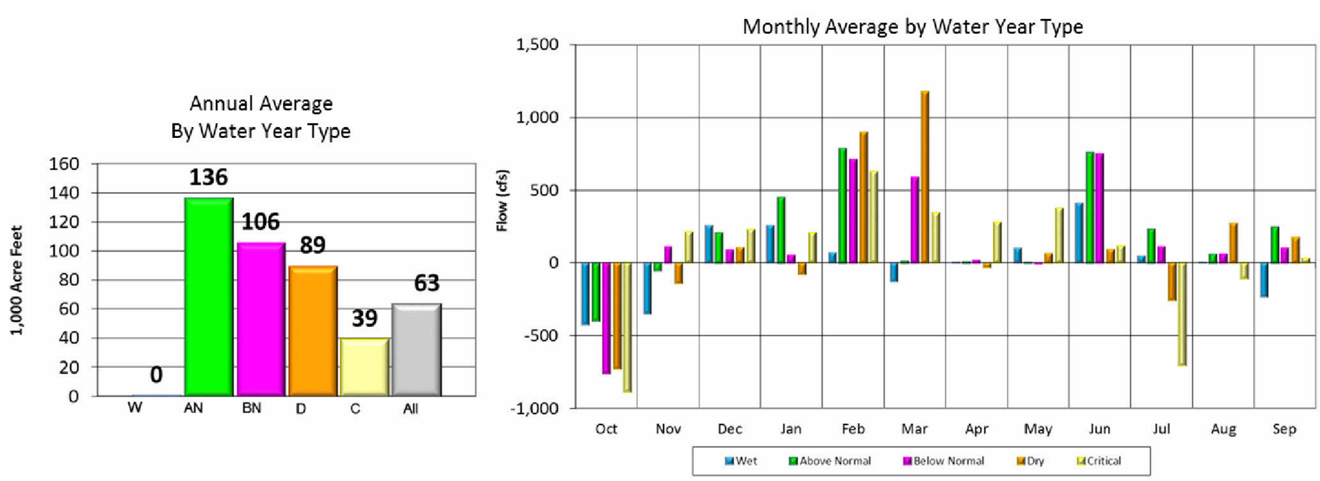


Figure 42. Change in Jones Delta Exports - MBK Alternative 4A minus MBK NAA

Figure 43 illustrates a comparison of Banks export under the MBK Alternative 4A and the MBK NAA for Banks exports. Combined modeled exports increase by an annual average of 491 TAF, and modeled Banks exports increase by about 428 TAF. Banks exports would tend to increase when during periods of Delta surplus. This is why modeled wet year increases in Banks exports are about 700 TAF. Above normal and below normal year increase would be due in part to diversion of surplus flow, but would be augmented by release of water stored in upstream reservoirs. Because the SWP would take advantage of pumping during surplus conditions, there would be a decrease reliance on stored water releases from Oroville to support SWP demands. Total Banks exports would increase more than under the DWR/USBR modeling during summer months due to increase movement of CVP and SWP stored water and JPOD use.

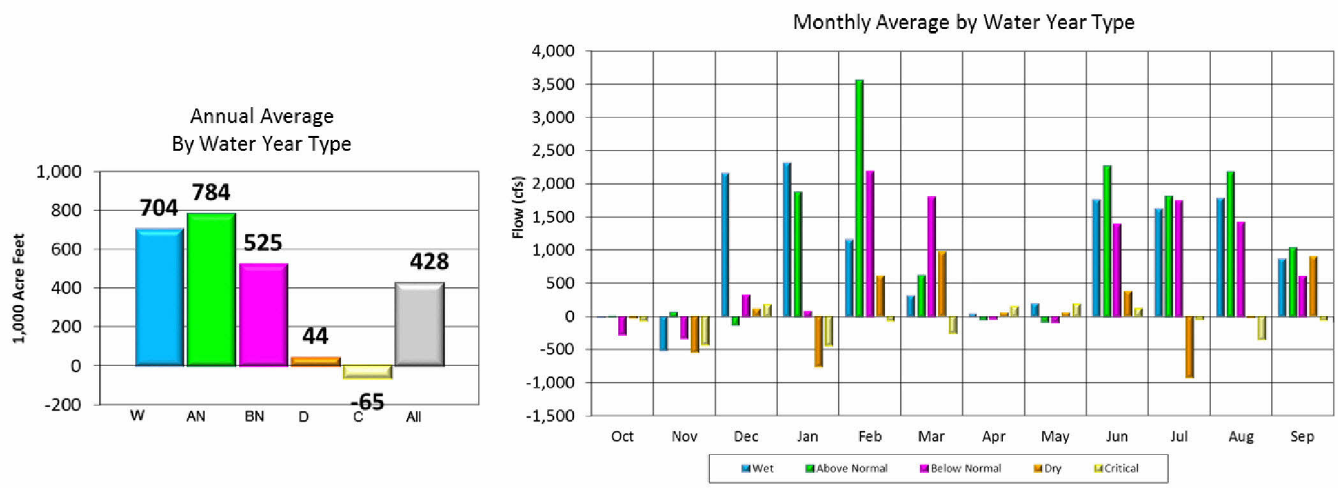


Figure 43. Change in Banks Delta Exports - MBK Alternative 4A minus MBK NAA

In MBK Alternative 4A, JPOD would be used to boost CVP SOD service contractor supply where appropriate. To do this, the constraint that artificially suppresses JPOD in the DWR/USBR BA Alternative 4A (MAXJPOD_CVP in WHEELCAP.WRESL) was modified to allow JPOD use of Banks full physical capacity when conveyed through the NDD facility. Efficient use of JPOD also required its consideration in CVP SOD service allocations. This was done when refining forecasts used in the export forecast based method of CVP allocations, and available JPOD capacity in combination with available upstream storage was considered in the user defined allocations. The San Luis Rulecurve automatically adjusts to allocation and the current storage condition in San Luis and provides the priority for using JPOD when Jones PP is at maximum capacity and Banks PP capacity is available. The change in JPOD between MBK Alternative 4A and MBK NAA, as shown in **Figure 44**, is 128 TAF on an annual average basis. As expected, JPOD would increase significantly in wet years (192 TAF) while there would be almost no change in critical years. Also shown in **Figure 44**, the increase in JPOD would come mostly in the summer months when the CVP would uses the additional export capacity convey stored water to CVP SOD Ag service contractors.

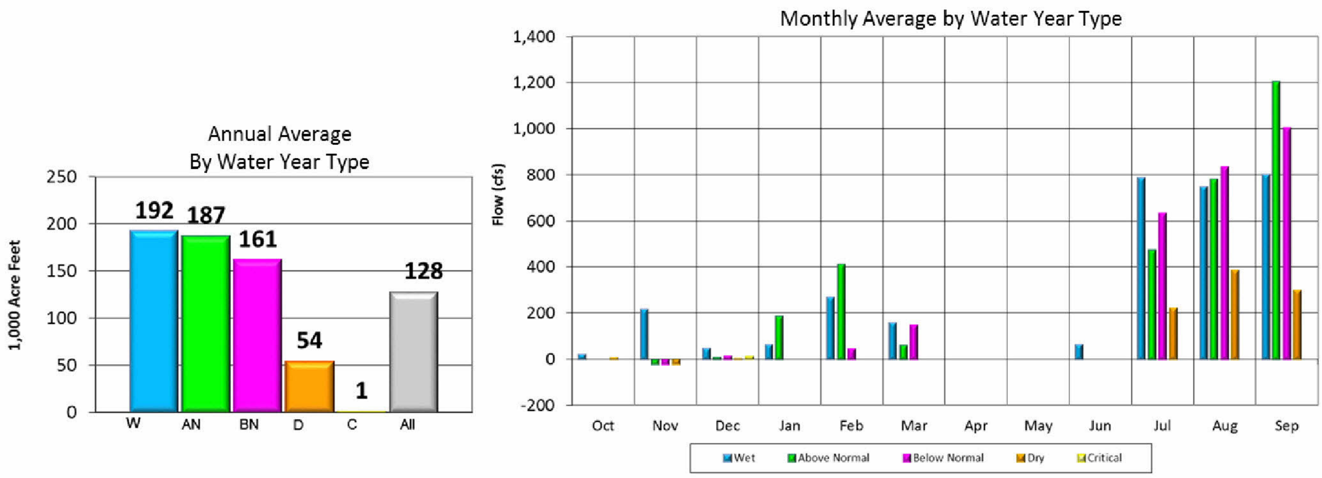


Figure 44. Change in CVP Joint Point of Diversion at Banks - MBK Alternative 4A minus MBK NAA

Like the DWR/USBR BA Alternative 4A, the MBK Alternative 4A has a shift in CVC wheeling from fall to summer when compared to its respective NAA **(Figure 45**). However, the MBK Alternative 4A included logic to spread CVC wheeling over the summer rather than to allow it to be frontloaded in July. The reason for this was to leave sufficient Banks capacity for JPOD to avoid San Luis low point issues.

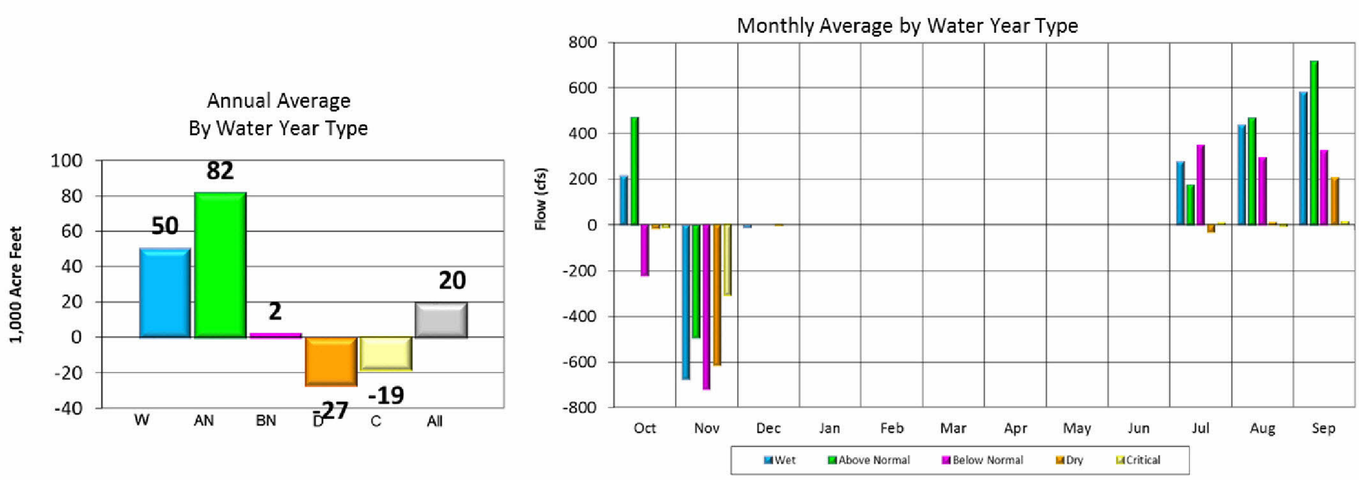


Figure 45. Change in Exports at Banks for CVP Cross Valley Canal - MBK Alternative 4A minus MBK NAA

E. Delta Outflow

Figure 46 illustrates a comparison of Delta outflows between the MBK Alternative 4A and MBK NAA. Decreases in Delta outflow are the result of the CVP and SWP ability to increase Delta exports under MBK Alternative 4A relative to the MBK NAA. Average annual decreases in Delta outflows are about 464 TAF. The magnitude of decrease in outflows is very similar to increases in Delta exports. Although the Delta Cross Channel gate is operated in these modeling scenarios, the apparent increase in Delta outflows in October is partially due the Rio Vista flow requirement and additional export restrictions though Old and Middle River flow requirements.

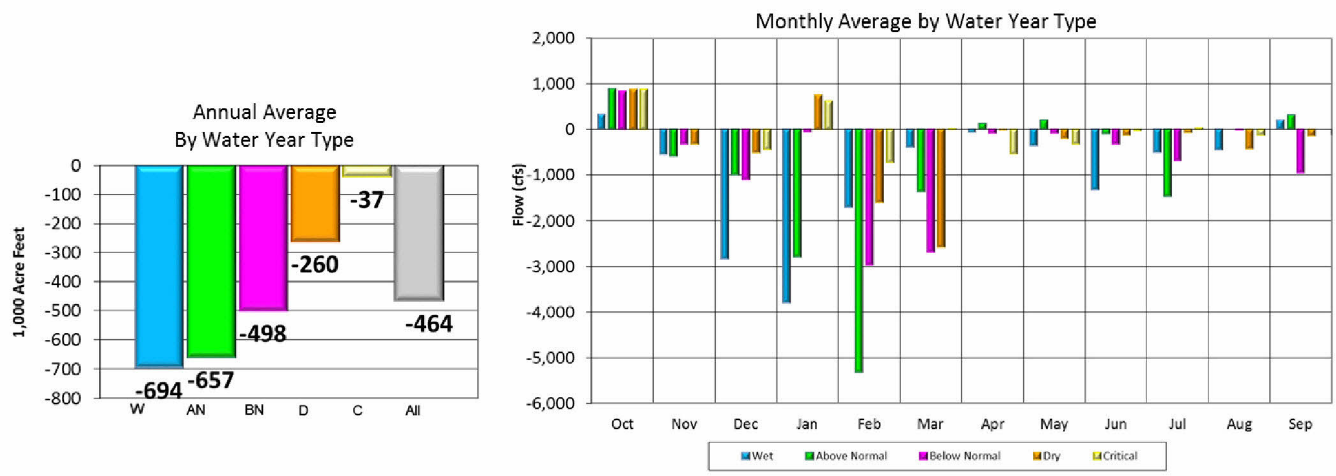


Figure 46. Change in Delta Outflow - MBK Alternative 4A minus MBK NAA

F. Reservoir Storage and Operations

Figure 47, **Figure 48**, **Figure 49**, and **Figure 50** contain exceedance probability charts for CVP and SWP carryover storage and average monthly changes in storage by Sacramento Valley Water Year Type for North of Delta CVP and SWP reservoirs. Carryover storage in all Project reservoirs tends to be lower in the MBK Alternative 4A than in the MBK NAA scenario. This is due to conveyance of available stored water. The conveyance of stored water generally would occur in wetter years when reservoirs would have more than required amounts. Conveyance of stored water would decrease in critical years or when storage levels are projected to fall below acceptable levels.

When reservoir storage would be drawn down in wetter years, there would be an increased risk of reduced supply during drier conditions due to lower carryover. For example, if reservoir carryover storage is predicted to be high in a wetter year and additional water is released so that resulting storage is lower, it may affect the following year if the reservoir does not fill. This happens in dry and critical years that are preceded by wetter years.

Although the operations of CVP and SWP reservoirs are affected by San Luis storage and Rulecurves, this logic in the MBK Alternative 4A and MBK NAA are the same. Variations in San Luis Rulecurves occur based on the integrated operation of the Projects and are tied to water supply allocations. Therefore, the Rulecurves change with addition of the NDD, but these changes are expected and are consistent with actual operations.

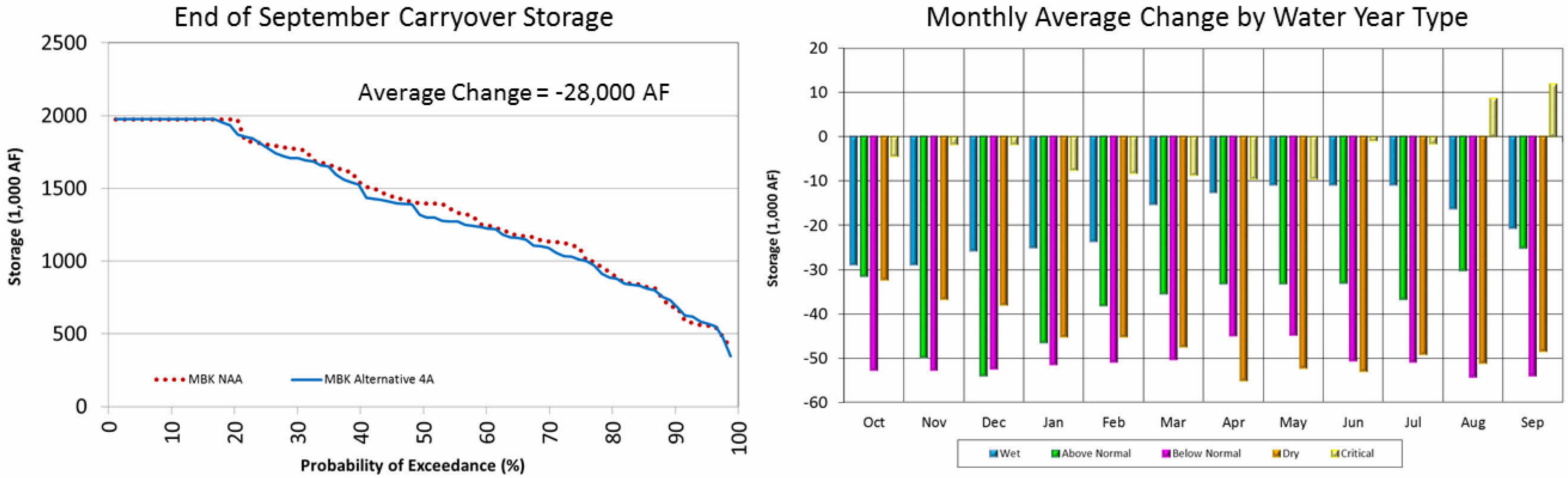


Figure 47. Trinity Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type MBK Alternative 4A and MBK NAA

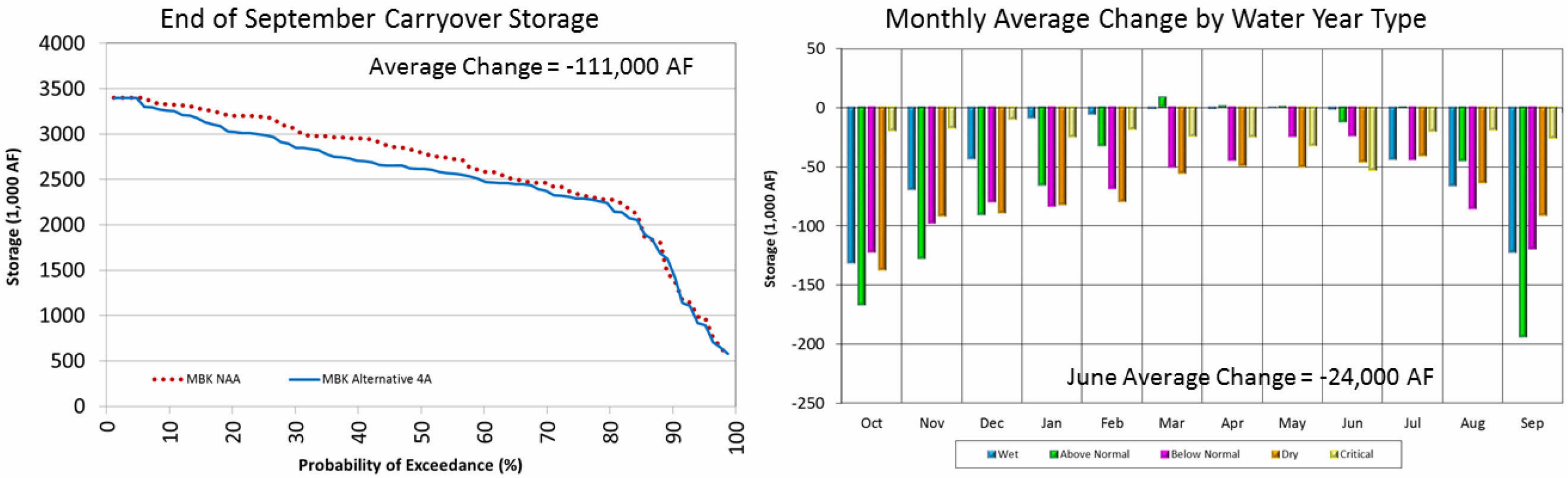


Figure 48. Shasta Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type MBK Alternative 4A and MBK NAA

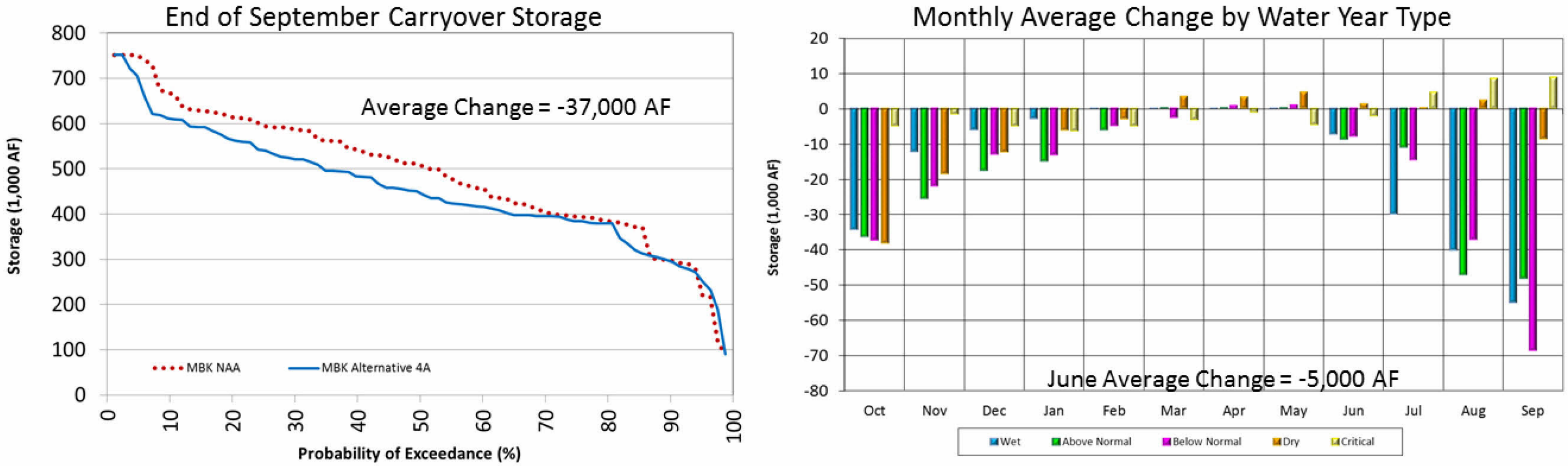


Figure 49. Folsom Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type MBK Alternative 4A and MBK NAA

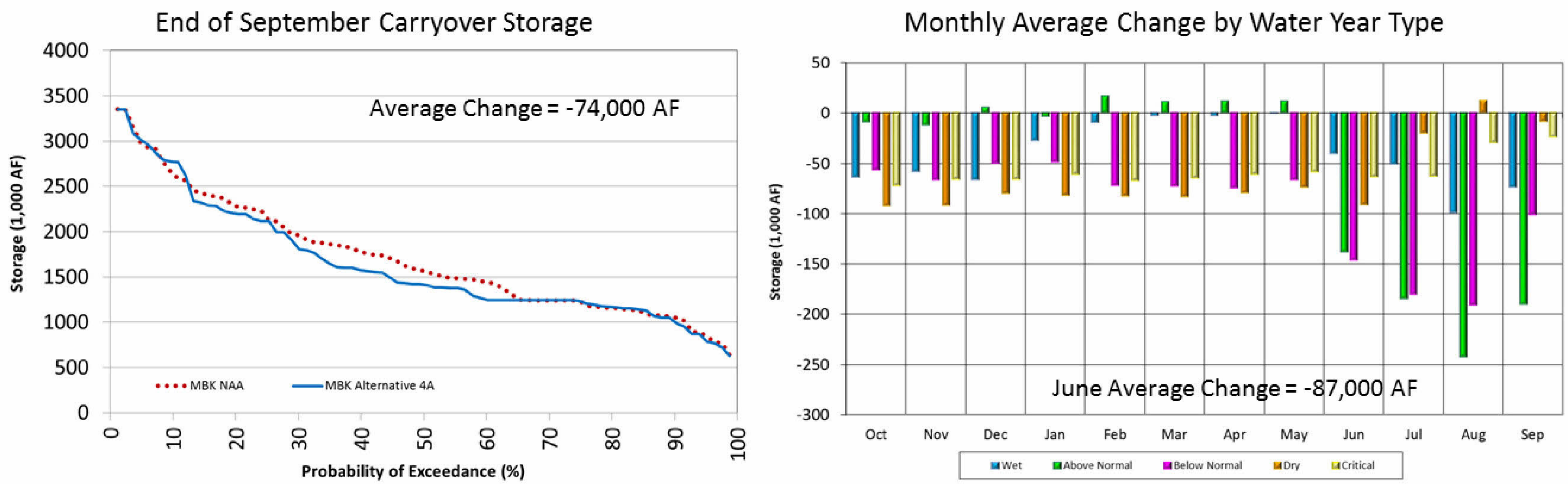


Figure 50. Oroville Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type MBK Alternative 4A and MBK NAA

Figure 51 and **Figure 52** show exceedance probability plots for CVP and SWP San Luis Reservoir annual high and low points for both the MBK Alternative 4A and the MBK NAA. The modeled CVP share of San Luis fills about 10% more often under the MBK Alternative 4A than under the MBK NAA, while the modeled SWP share fills about 30% more often. The SWP share of San Luis would fill more often than the CVP share because Banks has greater pumping capacity than Jones and can use increased diversion capacity made available by the NDD to divert Delta surplus flows.

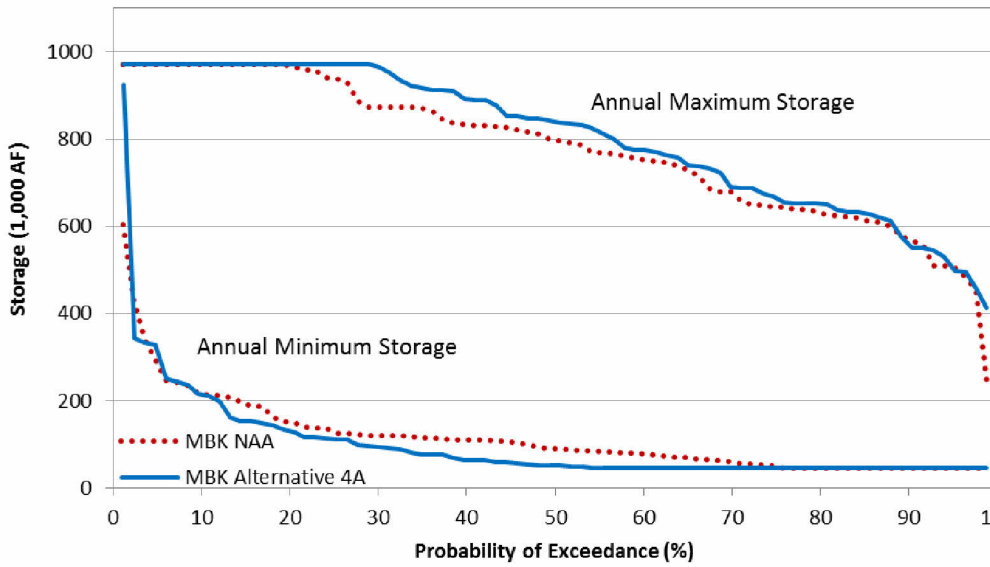


Figure 51. CVP San Luis Reservoir Storage – Annual Maximum and Minimum Storage MBK Alternative 4A and MBK NAA

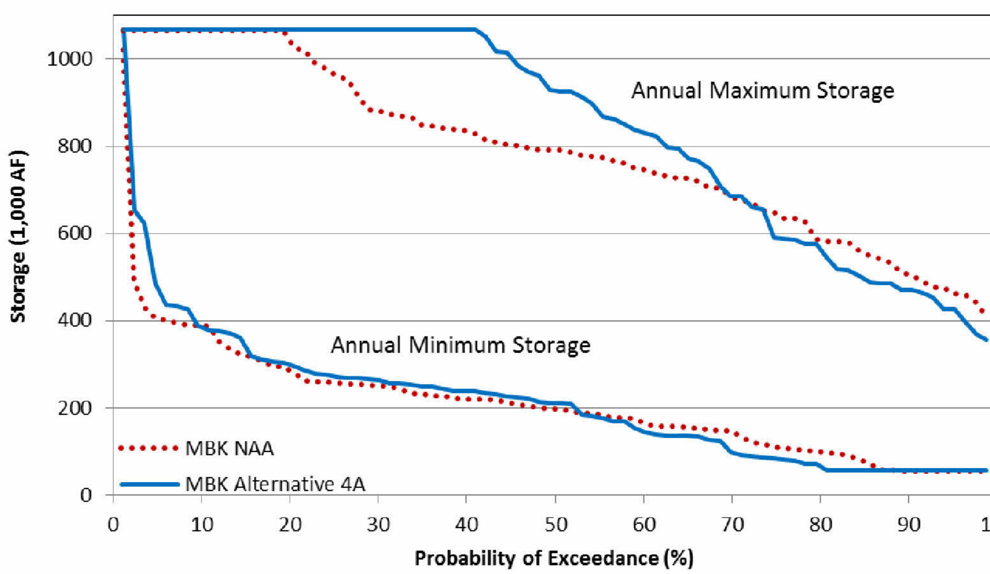


Figure 52. SWP San Luis Reservoir Storage – Annual Maximum and Minimum Storage MBK Alternative 4A and MBK NAA

G. River Flows

Figure 53 show average monthly changes in Folsom releases and flows at Nimbus for MBK Alternative 4A relative to the MBK NAA scenario. Results show that under the MBK Alternative 4A scenario American River flows would be higher in the months of June through September when additional stored water is released to support Delta exports. Flows are lower during October through March as Folsom Reservoir fills during periods of high American River Basin runoff.

Changes in Nimbus releases under the MBK Alternative 4A would likely affect cold-water pool management and water temperatures downstream of Folsom Dam. Increased releases in June through September would reduce cold-water pool amounts, lower reservoir water surface elevations, and require shutters to be removed earlier. From July through September temperature management would be affected by the combination of a reduced cold-water pool and increased releases.

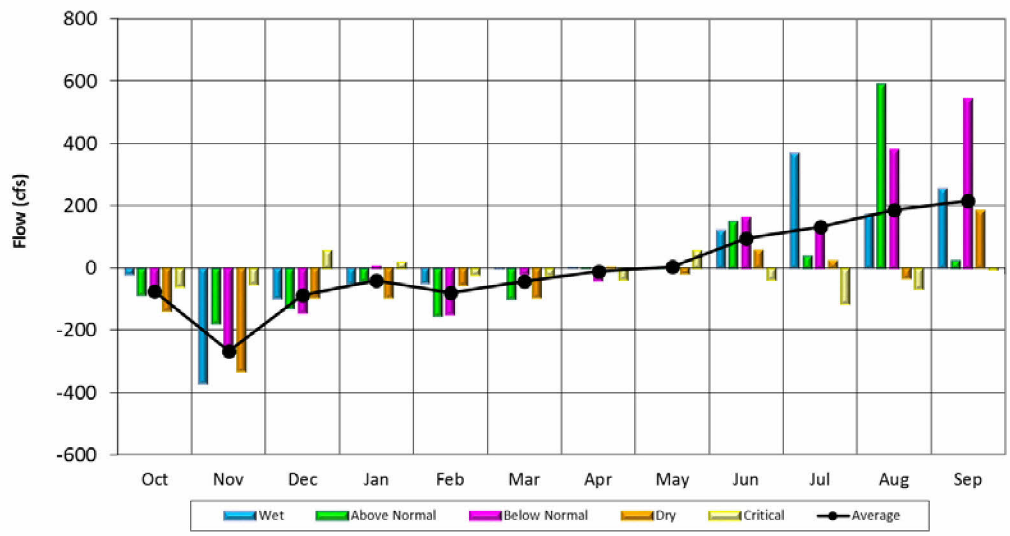


Figure 53. American River below Nimbus – MBK Alternative 4A minus MBK NAA

Figure 54 shows average monthly changes in Sacramento River flows below Keswick for the MBK Alternative 4A relative to the MBK NAA scenario. Results show that under the MBK Alternative 4A scenario Sacramento River flows would be higher in the months of June through October and lower November through March. As for Folsom operations, modeled Keswick releases are increased from June through October to convey stored water to areas south of the Delta and releases are less when Shasta fills during the winter months.

Figure 55 shows average monthly changes in Feather River flow below the return flows from Thermalito for MBK Alternative 4A relative to the MBK NAA scenario. Average monthly Feather River flows would tend to be higher during the first part of the summer and then lower in the latter part of summer.

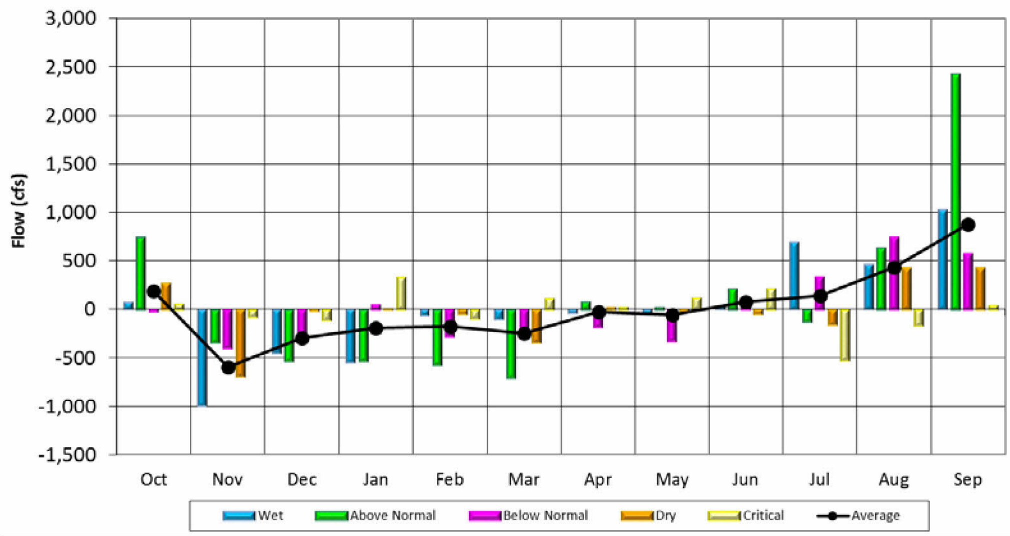


Figure 54. Sacramento River below Keswick – MBK Alternative 4A minus MBK NAA

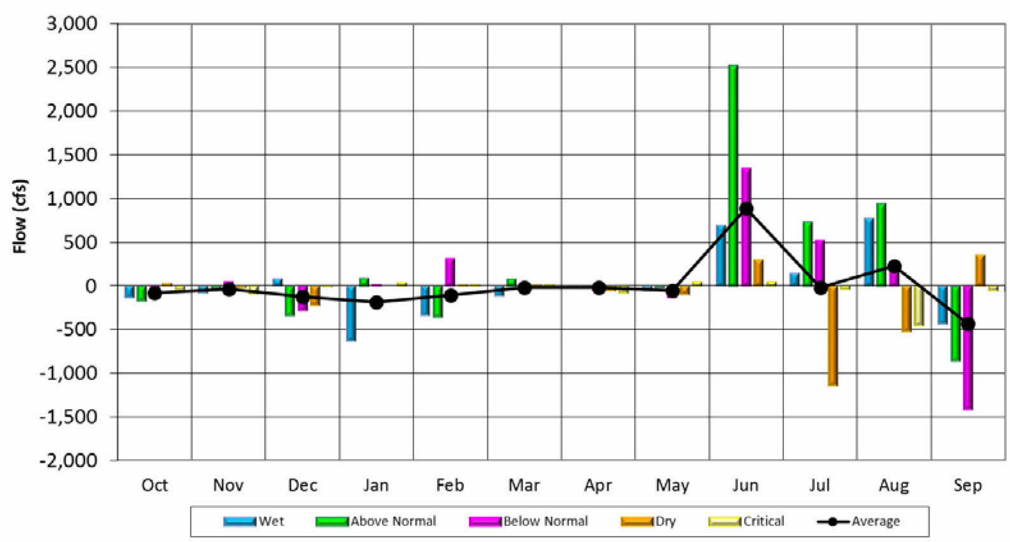


Figure 55. Feather River below Thermalito – MBK Alternative 4A minus MBK NAA

H. CVP Water Supply

Average annual changes in water supply to CVP customers, based on customer type and water year type, are shown in **Table 6**. Average annual CVP South of Delta deliveries in the MBK Alternative 4A would be about 193 TAF higher than the MBK NAA scenario, while North of Delta CVP deliveries would decrease by 16 TAF.

Figure 56 and **Figure 57** contain annual exceedance probability plots for NOD and SOD agricultural service contractor allocations for both the MBK Alternative 4A and MBK NAA scenarios. In the MBK NAA scenario, NOD agricultural contractors would receive full allocations just under 60% of the time while SOD agricultural contractors would receive full allocations just over 10% of the time. There also would be a large difference between NOD and SOD allocations. With increased conveyance capacity, the ability for the CVP to achieve the goal of equal allocations to CVP water service with similar types of contracts would be achieved more often. Therefore, the differences in NOD and SOD allocations would be smaller when the NDD is available and there is a reduction in modeled NOD CVP water service contractor allocations. This reduction in delivery may result in a variety of effects, including reductions in groundwater levels, land use changes, and other changes. **Figure 58** and **Figure 59** contain exceedance probability plots for CVP South and North of Delta Agricultural water contract allocations, CVP SOD allocations increase about 60% of the time and CVP NOD decrease in over 20% of years.

Table 6. CVP Delivery Summary

Average Annual CVP Delivery by Water Year Type - MBK NAA

	North of Delta					South of Delta					North + South
	Ag Service	M&I Service	Settlement	Refuge	Total	Ag Service	M&I Service	Exchange	Refuge	Total	Total
All Years	243	203	1863	83	2392	895	117	852	273	2321	4713
Wet	333	227	1858	88	2506	1421	137	875	281	2898	5404
Abv. Norm	308	209	1716	81	2314	1045	116	802	258	2389	4703
Blw. Norm	332	227	1901	89	2549	900	118	875	281	2358	4906
Dry	139	178	1898	85	2301	527	104	864	277	1955	4256
Critical	15	138	1769	57	1979	79	80	741	234	1318	3297

All Values are in 1,000 acre feet *Total North + South includes Cross Valley Canal*

Difference in Average Annual CVP Delivery by Water Year Type - MBK Alternative 4A minus MBK NAA

	North of Delta					South of Delta					North + South
	Ag Service	M&I Service	Settlement	Refuge	**Total**	Ag Service	M&I Service	Exchange	Refuge	**Total**	**Total**
All Years	-14	-2	0	0	-16	186	7	0	0	193	177
Wet	1	0	0	0	0	212	6	0	0	218	219
Abv. Norm	-13	0	0	0	-14	248	10	0	0	258	244
Blw. Norm	-62	-10	0	0	-72	285	13	0	0	298	226
Dry	-8	-1	0	0	-9	140	5	0	0	145	136
Critical	2	1	0	0	3	5	0	0	-2	4	7

All Values are in 1,000 acre feet

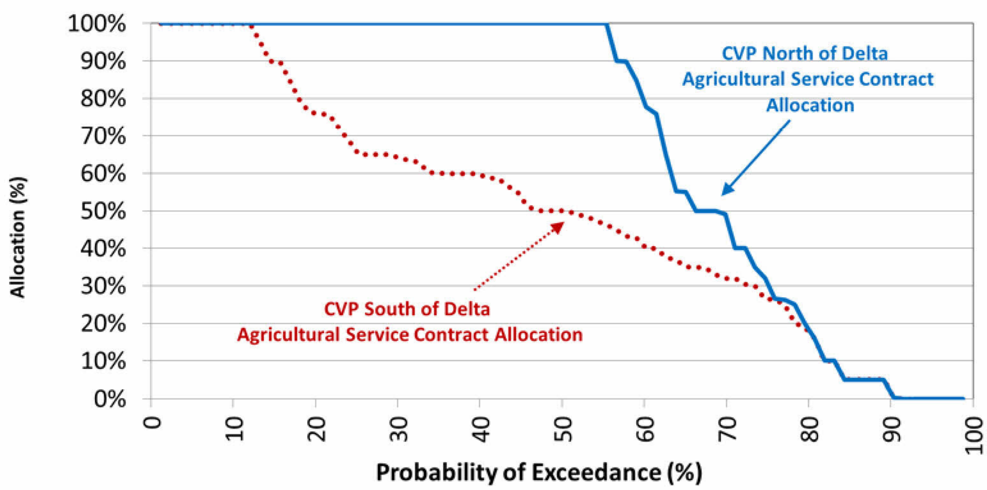


Figure 56. CVP North and South of Delta Agricultural Allocation – MBK NAA

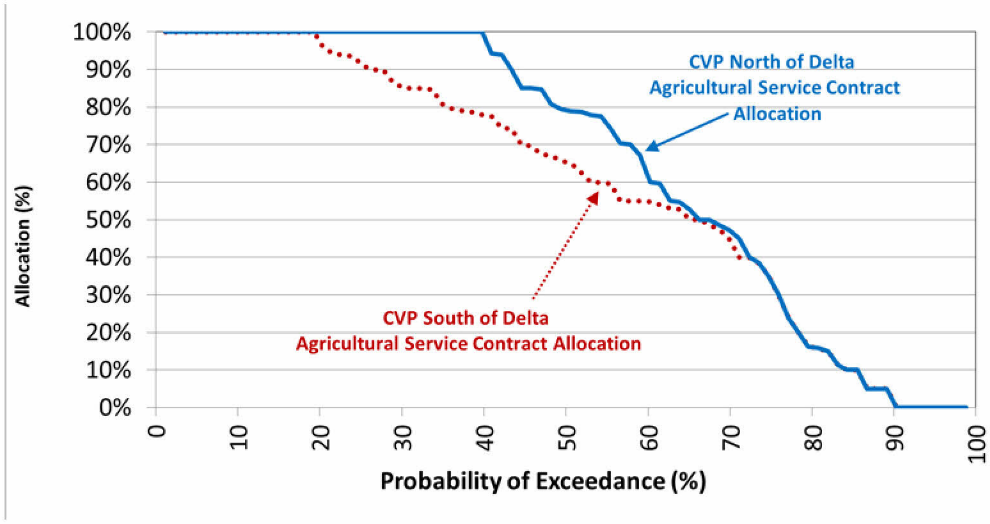


Figure 57. CVP North and South of Delta Agricultural Allocation – MBK Alternative 4A

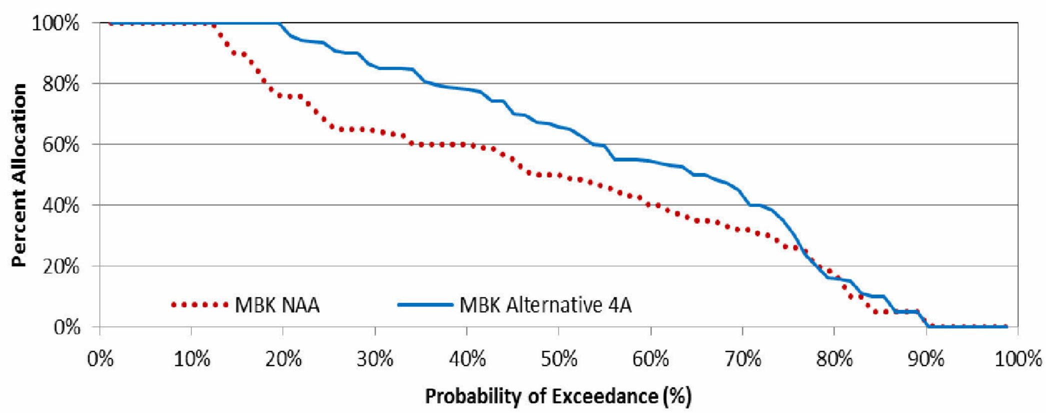


Figure 58. CVP South of Delta Agricultural Allocation – MBK NAA and MBK Alternative 4A

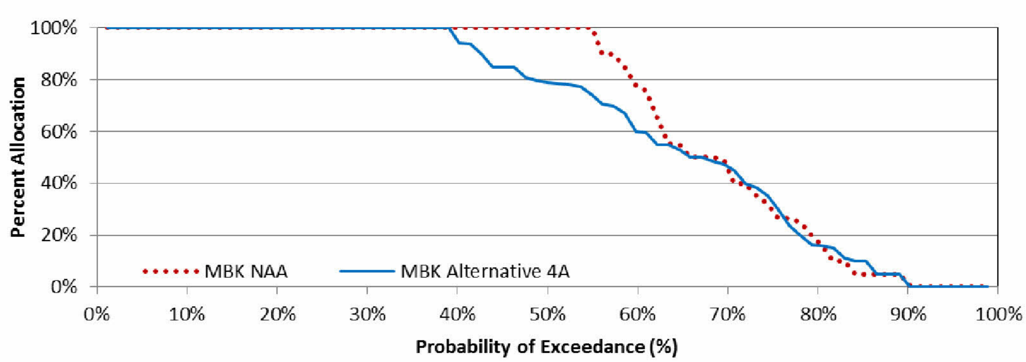


Figure 59. CVP North of Delta Agricultural Allocation – MBK NAA and MBK Alternative 4A

I. SWP Water Supply

Table 7 illustrates SWP water supply the benefits of the MBK Alternative 4A relative to the MBK NAA scenario. These studies show an increase in average annual SWP SOD deliveries of approximately 270 TAF, but a reduction in critical year deliveries of approximately 74 TAF. SWP delivery increases are less than increases in Banks exports because there is increased wheeling for the Cross Valley Canal contractors and JPOD.

Table 7. SWP Delivery Summary

Average Annual SWP Delivery by Water Year Type - MBK NAA

	Table A	Article 21	Article 56	Total
All Years	2414	54	83	2551
Wet	3219	84	108	3411
Abv. Norm	2568	80	56	2704
Blw. Norm	2569	49	98	2716
Dry	1849	21	73	1943
Critical	980	14	47	1041

All Values are in 1,000 acre feet

Difference - MBK Alternative 4A minus MBK NAA

	Table A	Article 21	Article 56	Total
All Years	183	61	27	270
Wet	304	117	25	446
Abv. Norm	295	96	26	417
Blw. Norm	311	24	35	371
Dry	-5	25	37	57
Critical	-78	-2	5	-74

All Values are in 1,000 acre feet

J. Term 91

Changes in CVP and SWP operations with the CWF may alter frequency that Term 91 curtailments are imposed. **Figure 60** illustrates the difference in the frequency of water right curtailments pursuant to Term 91 under the MBK Alternative 4A relative to the MBK NAA scenario. Contrary to the DWR/USBR modeling, the MBK modeling shows that Term 91 may be imposed more often during April through September in the Alternative 4A scenario relative to the NAA scenario. Term 91 is expected to be imposed less often in October. This is a result of increased OMR export restrictions in combination with increased Rio Vista flow requirements.

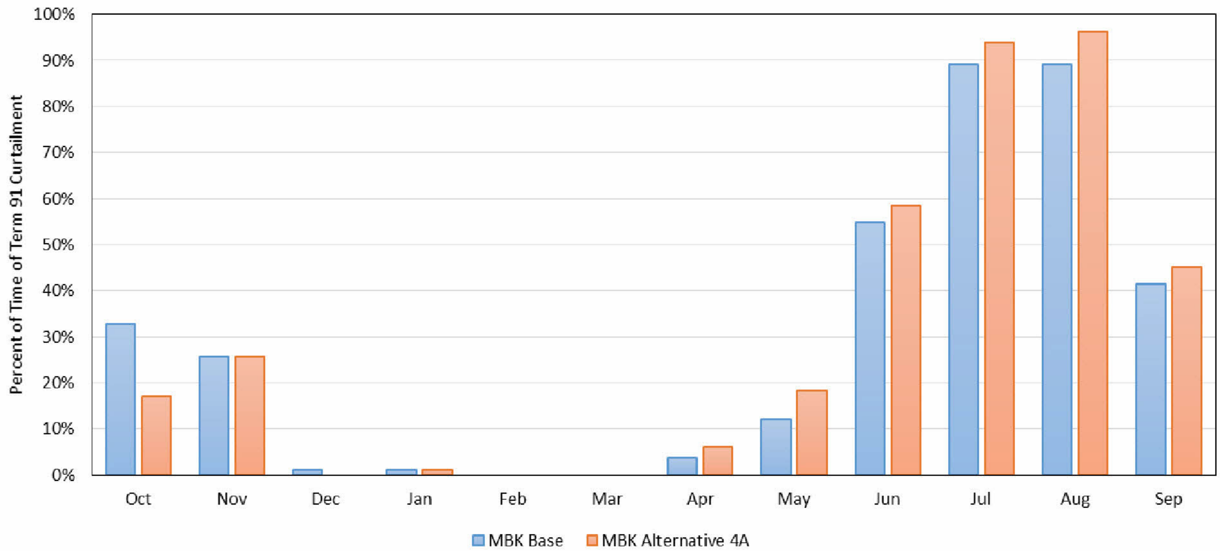


Figure 60. Frequency of Term 91 Curtailments - MBK Alternative 4A and MBK NAA

3. MBK Analysis Using BA Description

As discussed in the review of the DWR/USBR BA Alternative 4A scenario, the spring outflow proposed action was modeled by incidentally using an export constraint: the SJR IE. The following three potential problems with this method are:

(1) The CWF BA caps the required average March-May Delta outflow at 44,500 cfs. There are years in DWR/USBR BA Alternative 4A where the simulated average Delta outflow is well above 44,500 cfs, which is the maximum required outflow in the criteria. However, the DWR/USBR BA Alternative 4A continues to constrain total exports with the SJR IE in these years even though it is not necessary. This artificially reduces the Delta exports in some years.

(2) If the intent of the CWF BA is to allow operators flexibility in meeting the spring outflow criteria with reservoir releases or export constraints when purchased water is not available, then the DWR/USBR BA Alternative 4A should reflect that. By only looking at the export constraint option, DWR/USBR BA Alternative 4A probably underestimates impacts to NOD reservoir carryover in wetter water years.

(3) As a required Delta outflow, the spring outflow criteria should be subject to COA accounting as an in-basin use. In the DWR/USBR BA Alternative 4A, it is not.

To test the significance of these issues, MBK Alternative 4A Delta Outflow (DO) was developed by modifying MBK Alternative 4A. In MBK Alternative 4A DO, the spring outflow criteria was treated as a required Delta outflow. From March - May, Delta outflow must satisfy the D1641 X2 standard, but in April and May, the spring outflow proposed action was also applied. SJR IE was used to estimate the Delta outflow requirement in April and May, but was not applied as an export contraint to meet the Delta outflow requirement. The model was allowed to determine whether the outflow target would be met through reservoir releases or export reductions, but purchase of water was not considered. The required outflow is included in COA accounting as an In-Basin Use, and the required outflow was capped such that the targeted average March-May Delta outflow did not exceed 44,500 cfs, which is the maximum outflow requirement listed in the BA's proposed action.

A. Changes to MBK Alternative 4A to Formulate MBK Alternative 4A DO

Changes to MBK Alternative 4A to formulate MBK Alternative 4A DO include:

- Cycle 6 spring outflow requirement determination
- Set required Delta outflow based Cycle 6 determined target in remaining cycles
- Limit Upstream Release in Support of Spring Delta Outflow
- SWP and CVP Rulecurve
- SWP and CVP Allocation Logic

B. Cycle 6 Spring Outflow Requirement Determination

In current versions of CalSim II, the purpose of Cycle 6 (named PRESETUP) is to determine the full potential of upstream reservoir control. NOD storage, exports, and surplus Delta outflow are prioritized such that upstream reservoirs (Shasta, Folsom, Trinity, and Oroville) will only release water to supply in-basin use including required Delta outflow, instream flow requirements, and export levels up to health and safety requirements. The modeling also assumes that the reservoirs would make flood control releases. Any exports above health and safety requirements in this cycle are incidental and would otherwise be surplus Delta outflows. (In MBK Alternative 4A and MBK Alternative 4A DO, the NDD facility isn't operational until Cycle 10). Under these circumstances, Cycle 6 provides a convenient step in the model to determine the SJR IE based outflow target by constraining total exports (NDD and SDD) by the SJR IE. This is only done in April and May.

C. Set April and May Required Delta Outflow in Remaining Cycles

In Cycles 7 through 12, the required Delta outflow in April and May is set as the minimum of total outflow simulated in Cycle 6 (SJR IE based outflow) or the outflow necessary to meet the March-May average 44,500 cfs upper bound of the spring outflow criteria. The required Delta outflow implemented such that it is accounted for as an in-basin use under COA.

As an example, assume the month is April, average outflow in the month of March was 90,000 cfs, and April Cycle 6 total outflow (SJR IE based outflow) was 30,000 cfs. To determine the April outflow necessary to meet the March-May average of 44,500 cfs, we have to forecast an outflow for May because we don't know what that is yet. We forecast a conservative value of 7,000 cfs in all years for May so that we don't underestimate what is needed in April. The upper bound based outflow target for April is calculated as follows:

April Upper Bound on Required Outflow = 3.*44,500 – 90,000 – 7,000 = 36,500 cfs

The resulting required Delta outflow is the minimum of the SJR IE based outflow (30,000 cfs) or the April upper bound (36,500 cfs); this is equal to 30,000 cfs. MBK Alternative 4A DO allows this to be met through maintaining exports at the SJR IE level or increasing reservoir releases thereby allowing the NDD facility to export above the SJR IE level.

Now we start the month of May knowing that the average outflow in March was 90,000 cfs and the average outflow in April was the required Delta outflow of 30,000 cfs. Furthermore, the May SJR IE based Delta outflow determined in Cycle 6 was 20,000 cfs. The May upper bound based outflow target is calculated follows:

May Upper Bound on Required Outflow = 3.*44,500 – 90,000 – 30,000 = 13,500 cfs

The resulting May required Delta outflow is the minimum of the SJR IE based outflow (20,000 cfs) or the upper bound based required outflow (13,500 cfs); this equals 13,500 cfs. This required Delta outflow will be more than met by the outflow that was already occurring in Cycle 6. As such, when the NDD facility is turned on in Cycle

10, it can divert the 6,500 cfs of surplus (20,000 cfs minus 13,500 cfs) subject to the NDD bypass criteria and fish screen sweeping velocity constraints. And if capacity remains, additional releases can be made from upstream for export SOD.

D. Limit Upstream Release in Support of Spring Delta Outflow

During early attempts to formulate a reasonable MBK Alternative 4A DO operation, it became clear that the decision of whether to release additional water from upstream in April and May when the spring outflow criterion would be controlling needed storage based limitations. For Shasta, storage necessary to keep water levels above the upper gates of the temperature control facility was selected. This was equal to 3.926 MAF. If, in April and May, modeled Shasta storage dropped below this level, then additional CVP releases to meet the spring outflow criteria were not allowed. For the SWP, an Oroville storage threshold of 3.2 MAF was selected. As a result of these model constraints that MBK independently imposed to protect cold water pool in Shasta, this report's discussion of the CWF DO alternative may underestimate possible CWF effects on upstream water users.

E. San Luis Rulecurve Logic

The spring Delta outflow criteria in MBK Alternative 4A DO greatly increases the model sensitivity to the SWP and CVP Rulecurves in April and May. This is because, with the new required outflow, the Delta is frequently in balance in April and May and the model has a choice whether to increase releases from upstream reservoirs to support higher exports or to meet the higher outflow requirement by reducing exports. The Rulecurves are the modeling mechanism for prioritizing that choice. If San Luis storage is below the Rulecurves, the priority is on increasing releases from upstream storage to increase exports and augment San Luis storage. If San Luis storage is above Rulecurves, then the reverse is prioritized and in-basin use including required Delta outflow is met as much as possible through cuts in exports while preserving upstream storage.

In MBK NAA and MBK Alternative 4A, the CVP export schedule based Rulecurve formulation begins in May and extends through September. With the April and May operational flexibility to release for export provided in MBK Alternative 4A DO, the Rulecurve export scheduling logic was expanded to include the month of April. This allowed the model to base its April release for export decisions on need for water to meet SOD allocations during the coming irrigation season.

The April and May SWP Rulecurve formulation in MBK Alternative 4A DO was adjusted to remove consideration of potential excess Oroville storage. When this term was included, it caused the release of too much water from Oroville too early in the season in MBK Alternative 4A DO. This was not an issue in MBK Alternative 4A because total exports were controlled by SJR IE in April and May. With the elimination of the Oroville excess term, the April-May Rulecurve formulation was based solely on the SOD need for water to meet the current year's allocation while maintaining the targeted San Luis carryover. Oroville excess (storage above targeted September carryover) remained a consideration in the SWP Rulecurve formulation from June to September.

F. SWP and CVP Allocation Logic

MBK Alternative 4A DO used the same CVP and SWP WSI-DI curves and allocation export forecasts as MBK Alternative 4A. This ignores the operational flexibility given to the projects to meet the spring outflow criteria. The added operational flexibility provides an export opportunity in April and May that was not allowed in the MBK Alternative 4A. This would be a good reason to adjust the WSI-DI curves and export forecasts if there was no other way to refine allocations to the changed circumstances. For this study, there was another option. As discussed previously, a lookup table for user defined CVP NOD and SOD service contactor allocations was added to the MBK NAA and also used in the MBK Alternative 4A. This was adjusted as necessary in the MBK Alternative 4A DO scenario. A lookup table for user defined SWP Table A allocations was added also to allow for override of the WSI-DI and export forecast based allocation where appropriate.

The refinement procedure started by first running a simulation where CVP and SWP allocations were entirely WSI-DI or export forecast (WDEF) based. Next, SWP allocations were refined using the user defined SWP Table A allocation lookup table by stepping through each year of the initial simulation and making a determination of whether the WDEF based allocation was appropriate. Considerations included SOD shortages, San Luis carryover, Oroville carryover, and available export capacity to convey additional stored water from Oroville to SOD contractors. If it was deemed that the WDEF based allocation was reasonable, it was left intact. If it was determined to be a significant over or under-allocation, then a more reasonable allocation was substituted in its place using the user define lookup table. SWP allocations were refined prior to CVP allocations to ensure the SWP was getting first priority to available Banks capacity; however, effects of SWP water transfers are not considered in this analysis. CVP allocations were then refined in a similar manner by looking at SOD shortages, San Luis carryover, Shasta and Folsom carryover, and available export capacity. JPOD wheeling though Banks pumping plant added significant export capacity for consideration in CVP allocation decisions.

G. MBK Alternative 4A DO Results

i. *Compliance with Spring Delta Outflow Criteria*

As described previously, MBK Alternative 4A DO treats the spring Delta outflow criteria as an actual Delta outflow requirement where there is operational flexibility to meet the criteria through reductions in exports or increases in reservoir releases. This is unlike MBK Alternative 4A and DWR/USBR BA Alternative 4A where the criteria is met using SJR IE as a constraint on total exports. **Figure 61** illustrates compliance with the proposed Delta outflow criteria. Even with the difference in operational implementation, both MBK alternatives reasonably meet the outflow criteria as specified, but MBK Alternative 4A DO reduces average March - May Delta outflows at higher outflow levels compared to MBK Alternative 4A. There are two mechanisms causing this. The first is that MBK Alternative 4 DO recognizes Delta outflow in excess of the maximum required average March-May flow of 44,500 cfs and allows it to be diverted. This explains the difference shown at the 10% and 20% exceedance levels in **Figure 61.** The second mechanism is a reduction of flood control releases in March, April and May. As discussed previously, this could be the result of more effectively delivering stored water in previous years resulting in reservoirs capturing high flows rather than spilling them.

Reductions in spill may also occur if stored water is released for export in March or April to meet outflow and support exports rather than reduce exports. If Shasta fills and spills in May, the resulting spill is smaller since the water was released for export in the previous month. This has the effect of decreasing the targeted outflow in May because the outflow requirement is the outflow that would have occurred if SJR IE was controlling in that given month. We do not look back and make a determination what the flow would have been if we had operated differently in a previous month.

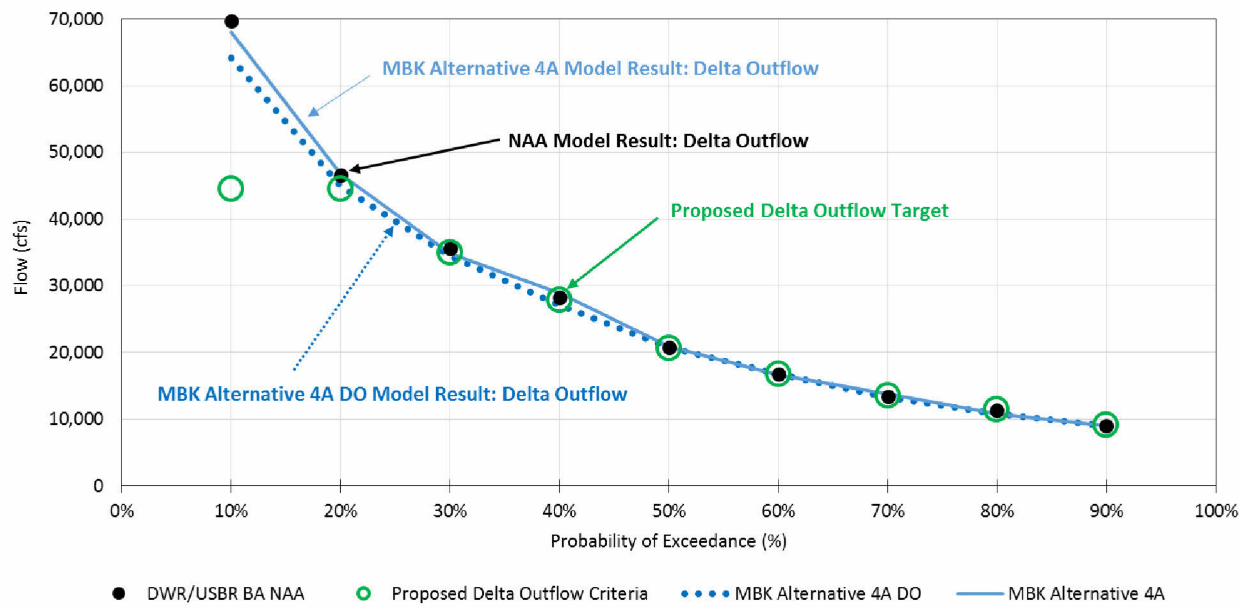


Figure 61. Delta Outflow Criteria and Results

ii. *Change from Surplus to Balanced Conditions in April and May*

By applying the spring Delta outflow criteria as a required Delta outflow, the Delta is frequently in balance in April and May in the MBK Alternative 4A DO simulation. **Figure 62** and **Figure 63** show required and total Delta outflows in the months of April and May respectively. Required Delta outflows are illustrated by the blue bars. Total Delta outflows are represented by the orange bars. In years where an orange bar does not show, total Delta outflow equals required Delta outflow and the Delta is in balance. This is important because COA sharing is enforced when the Delta is in balance. In real-time operations, debts will be accounted for and repayments will occur at a later date. In the MBK Alternative 4A DO simulation, the COA balance in maintained within the given month.

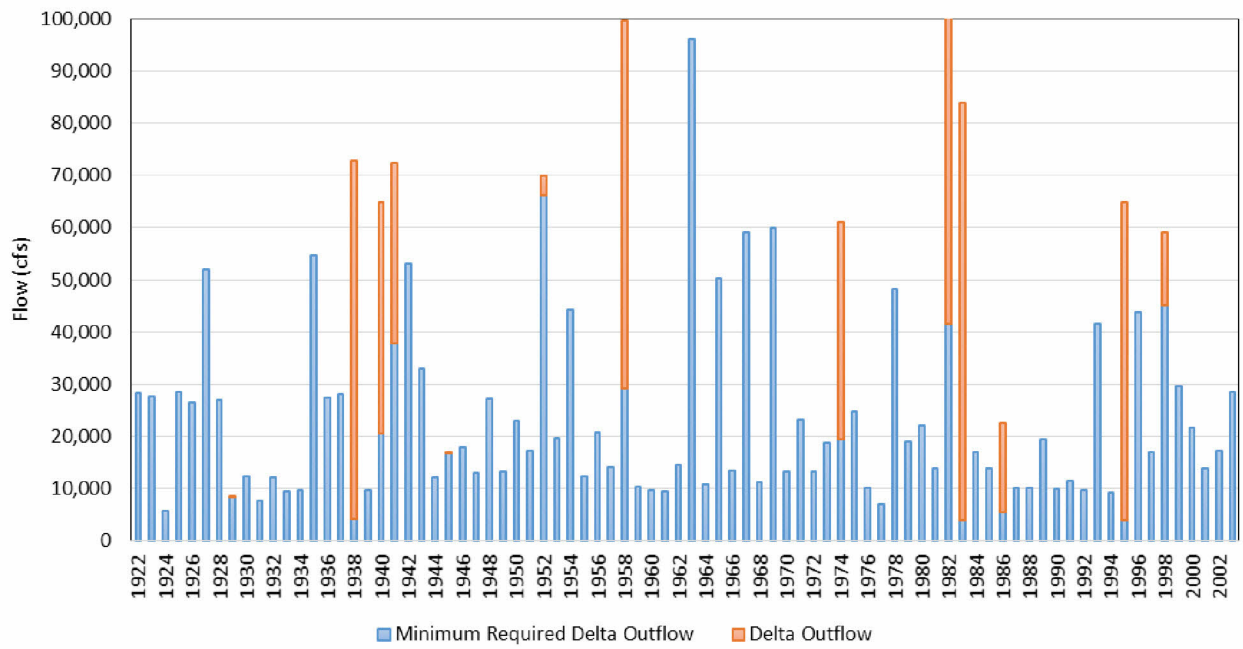


Figure 62. Delta Outflow and Required Delta Outflow for April - MBK Alternative 4A DO

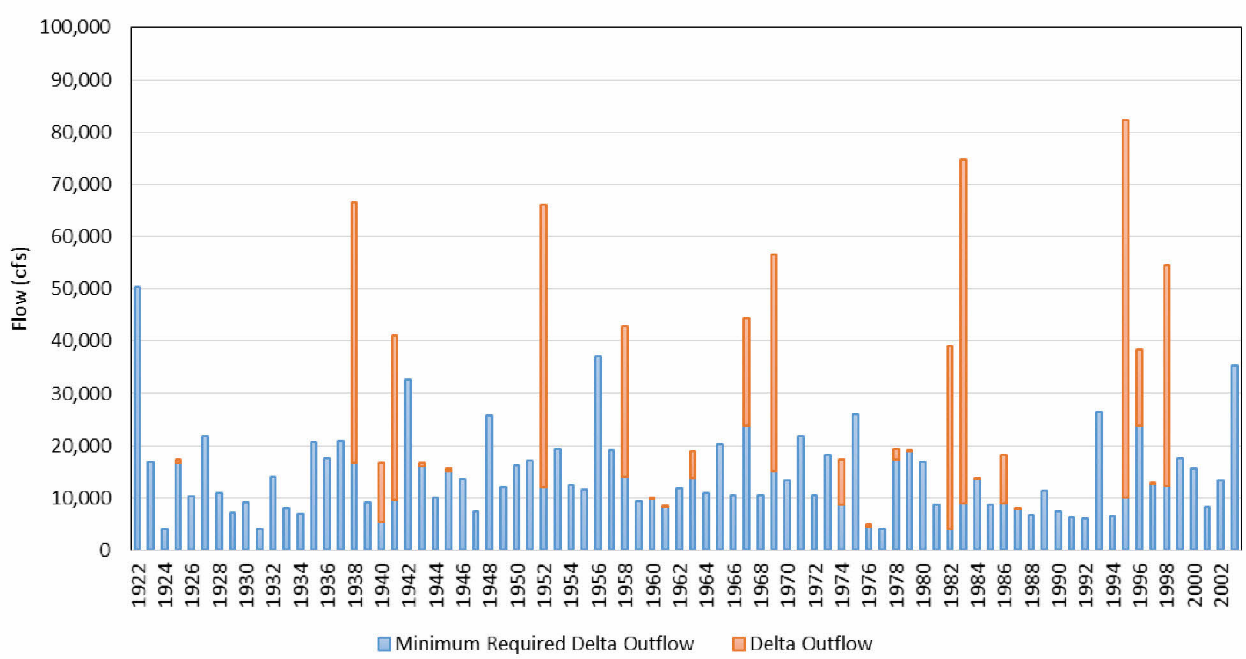


Figure 63. Delta Outflow and Required Delta Outflow for May - MBK Alternative 4A DO

iii. *Delta Outflow*

Any net increase in water supply provided by the CWF will result in a corresponding decrease in Delta outflow. Ideally, Delta outflow will be reduced in a way that has minimal impacts to protected fish species or water quality. As shown in **Figure 64**, when compared to MBK NAA, the MBK Alternative 4A DO reduces total Delta outflow by 622 TAF on an annual average basis. Most of the reductions occur in above normal and wet years, but there are also reductions in below normal and dry years. The monthly average plot shows that most of the reductions in outflow occur in the winter months. This is due to both direct diversions at the NDD and increased diversions to storage in upstream reservoirs. Increased diversions to storage are the result of increased drawdowns during summer months when the NDD provides additional capacity to convey stored water. Reductions in Delta outflow from July to September are due to reductions in carriage costs of Delta water quality standards. Water exported at the NDD facility would not be subject to the same carriage constraints that through Delta exports are subject to, but the standards themselves have not been relaxed.

In **Figure 64**, October is the one month where Delta outflow increases on average in every water year type. This is due a combination increased through Delta export restrictions combined with a flow requirement at Rio Vista. The October outflow is somewhat reduced compared to DWR/USBR BA Alternative 4A (**Figure 11**) because the MBK scenario would allow closure of the Delta Cross Channel gate as described in the MBK Alternative 4A description.

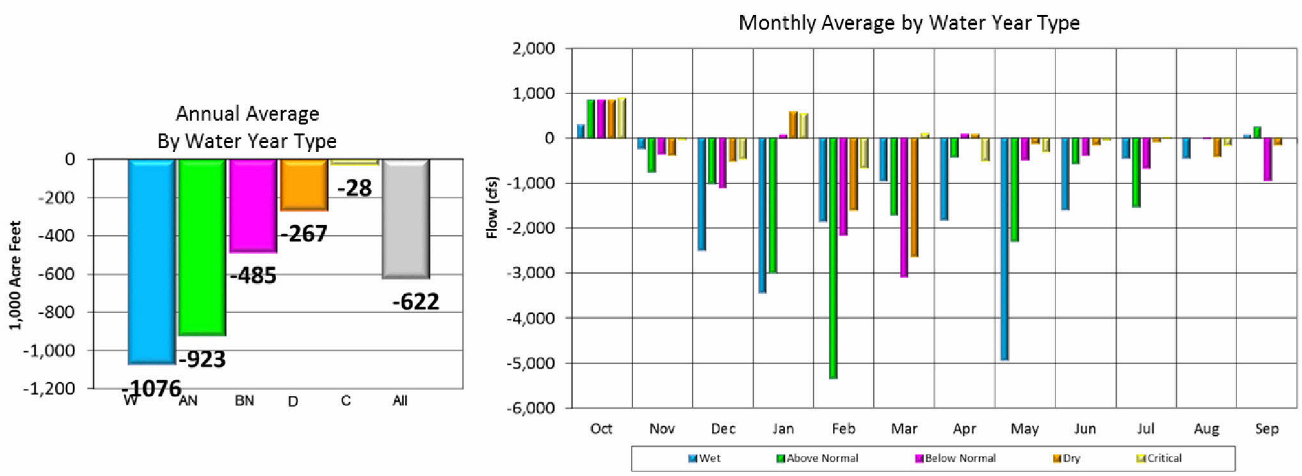


Figure 64. Change in Delta Outflow - MBK Alternative 4A DO minus MBK NAA

While total outflow has been significantly reduced (-622 TAF) as shown in **Figure 64**, the amount of required outflow has been significantly increased as shown in **Figure 65** (1.3 MAF). This change is due to the treatment of the spring outflow criteria in April and May as a required Delta outflow. As shown in **Figure 65**, the increase in April and May required Delta outflow is more than offset by the reduction in surplus Delta outflows.

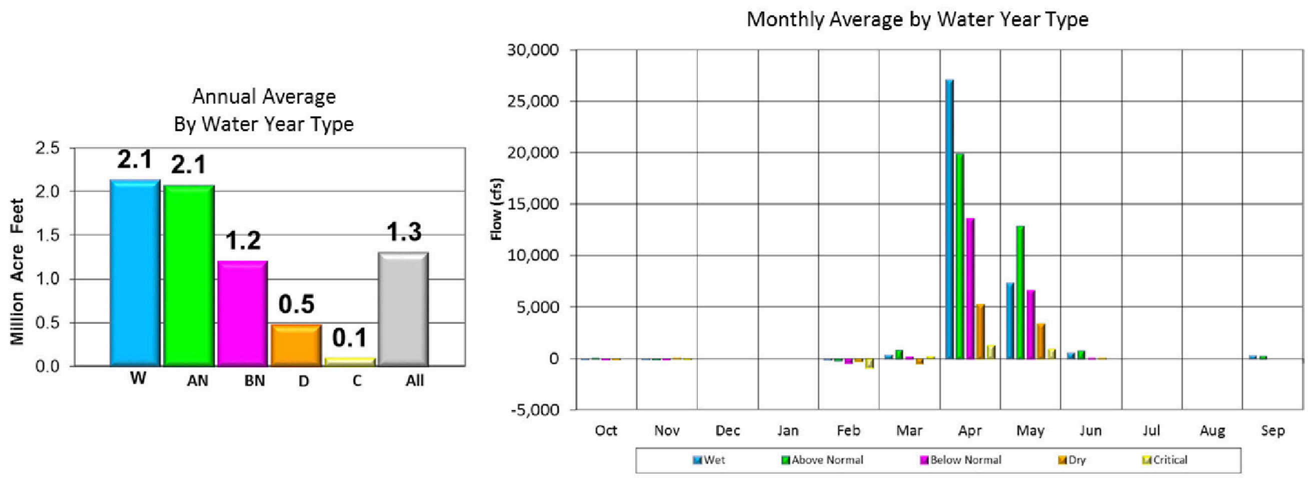


Figure 65. Change in Required Delta Outflow - MBK Alternative 4A DO minus MBK NAA

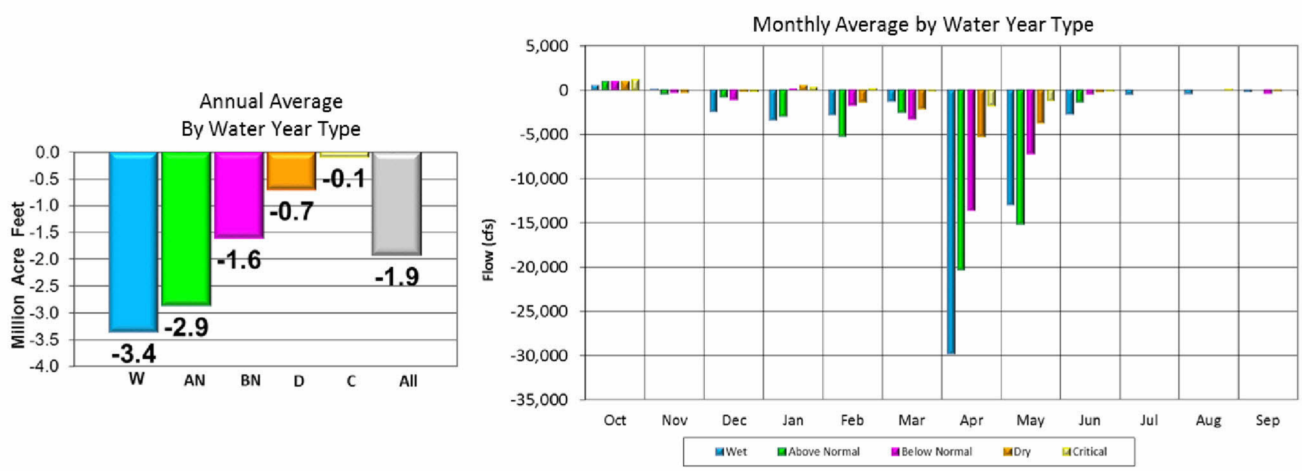


Figure 66. Change in Delta Surplus - MBK Alternative 4A DO minus MBK NAA

iv. *Change in Point of Diversion*

As shown in **Figure 67**, the modeled exports through the NDD in MBK Alternative 4A DO total 3.2 MAF on an annual average basis. As expected, greatest use of the NDD facility would occur in wet years (4.8 MAF), and the least use would occur in critical years (0.7 MAF). Note the sizable NDD exports in wet and above normal years in April and May; MBK Alternative 4A DO only restricted through Delta exports to SJR IE (unlike MBK Alternative 4A which restricted total exports). This would allow the NDD facility to divert surplus, when it was available, or additional upstream storage releases when it was not. It is in wet and above normal water years that surplus or stored water is available.

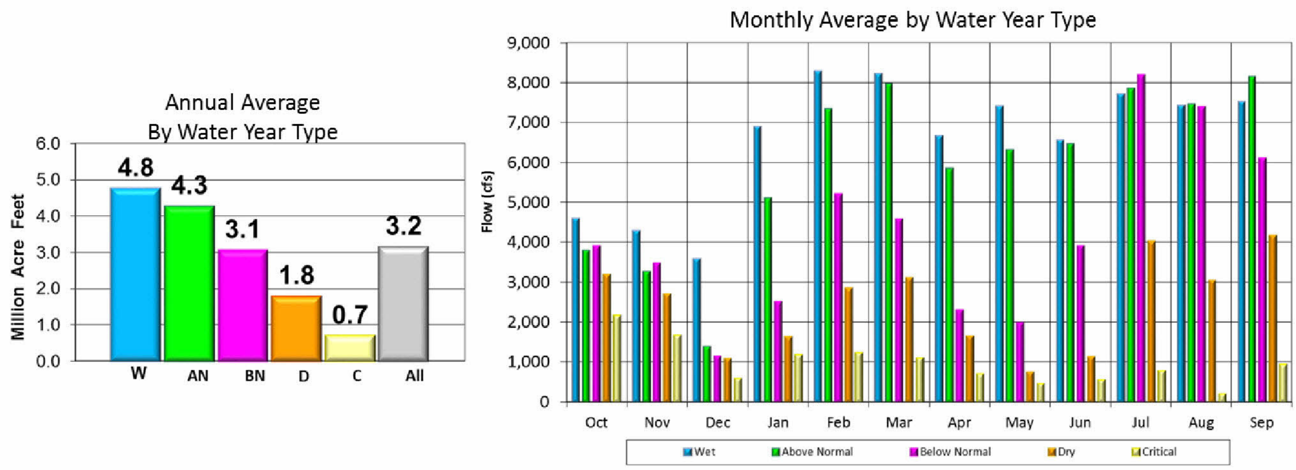


Figure 67. North Delta Diversion - MBK Alternative 4A DO minus MBK NAA

Much of the additional exports through the NDD facility would result in SDD reductions. **Figure 68** shows the change in SDD between the MBK Alternative 4A DO and MBK NAA (-2.5 MAF annual average). Sometimes the reduction would be a direct operational choice. In such cases, there would be capacity to convey water either through the NDD facility or through Delta and a choice is made to use one over the other. This choice would typically occurs in the summer months when there is regulatory flexibility to use either point of diversion. As assumed in the CWF BA, MBK Alternative 4A DO prioritizes conveying the first 3,000 cfs through Delta and additional exports at North Delta from July to September. Direct operational decisions to use one point of diversion over the other could occur in other months of the year as well. These are months where exports would be limited by availability of water or SOD demand as opposed to export capacity.

If the reduction in SDD is not a direct operational decision to use NDD instead, then it is an indirect result of increased exports allowed by the NDD facility in previous months. For example, when OMR is controlling SDD, the NDD would capture water that would otherwise be Delta surplus. This operation would result in increased storage in San Luis. This in turn could reduce the need for SDD in a subsequent month.

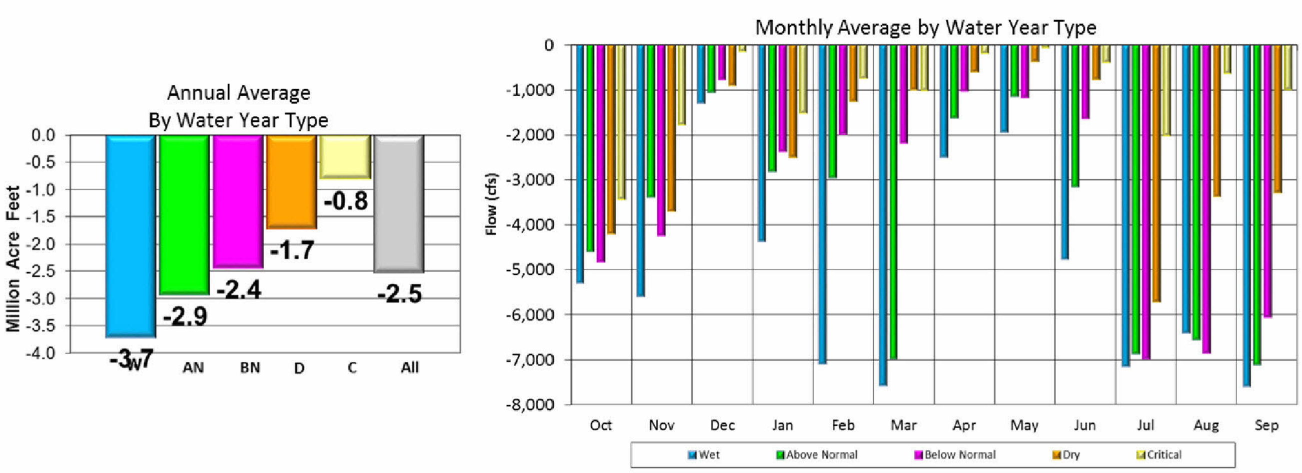


Figure 68. Change in South Delta Diversion – MBK Alternative 4A DO minus MBK NAA

v. *CVP/SWP Exports*

Treating spring outflow criteria as an outflow requirement rather than an export constraint allows the CVP and SWP to increase exports during April and May, as seen in **Figure 69**, this primarily occurs in wet and above normal years when total exports increase 4000 to 5000 cfs. Because the projects can increase exports during spring months, summer time increases are less in the MBK Alternative 4A DO scenario than compared with the MBK Alternative 4A scenario. Average annual increases in total Delta exports is about 661 TAF, **Figure 70** show Jones annual average increase is about 153 and **Figure 71** show Banks increase of 508. The average annual total of CVP supplies exported at Banks is about 105 TAF, JPOD use is about 82 TAF (**Figure 72**) and Cross Valley Canal Wheeling is about 22 TAF (**Figure 73**).

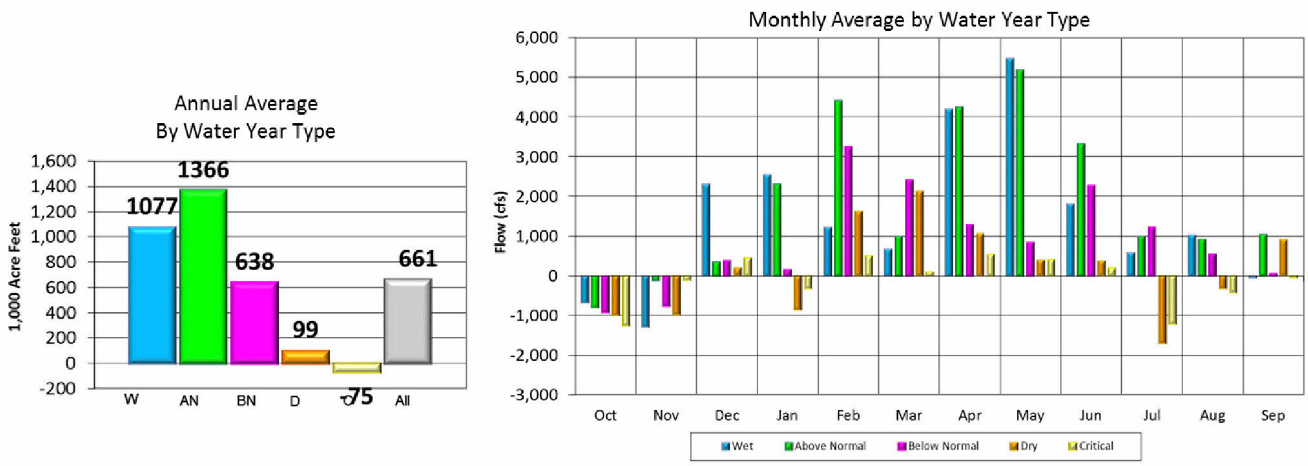


Figure 69. Change in Delta Exports (Jones plus Banks) - MBK Alternative 4A DO minus MBK NAA

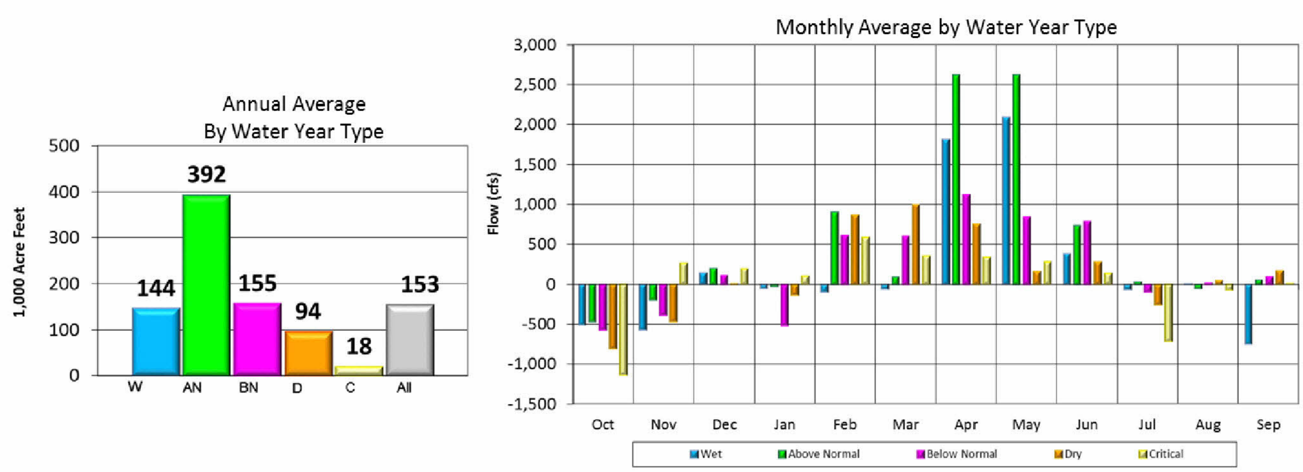


Figure 70. Change in Jones Delta Exports - MBK Alternative 4A DO minus MBK NAA

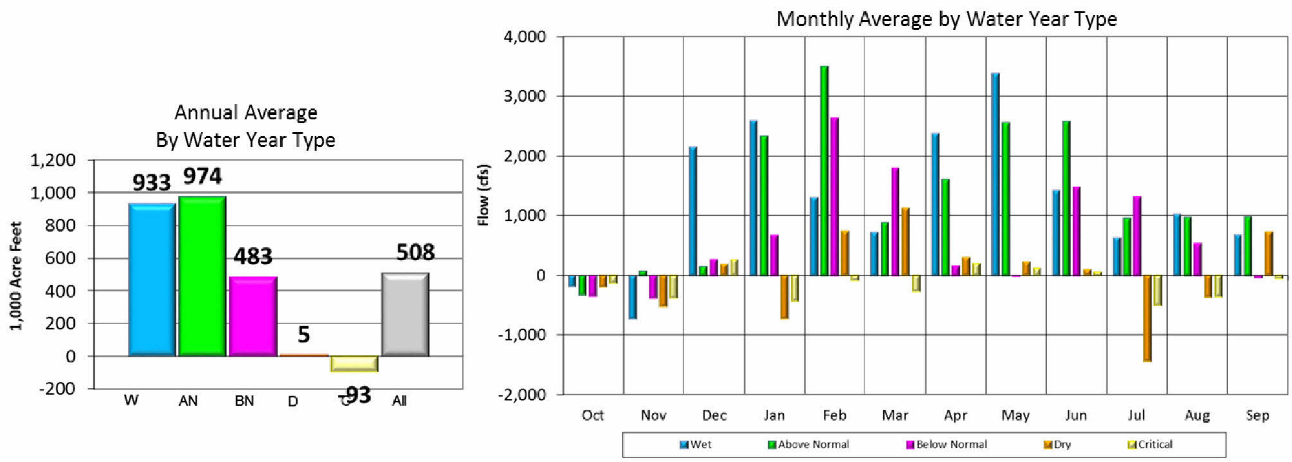


Figure 71. Change in Banks Delta Exports - MBK Alternative 4A DO minus MBK NAA

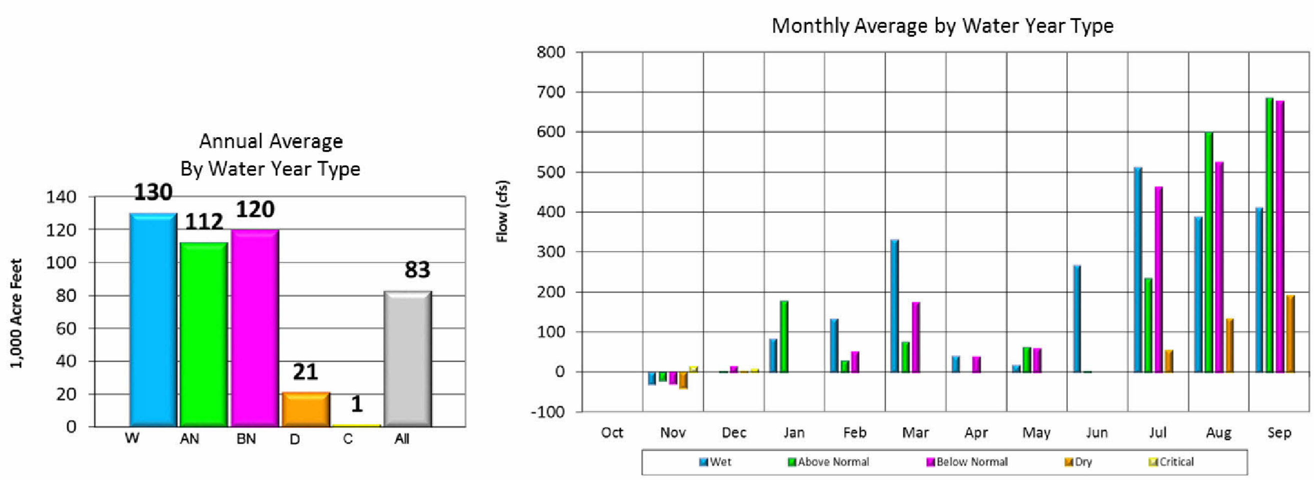


Figure 72. Change in CVP Joint Point of Diversion at Banks - MBK Alternative 4A DO minus MBK NAA

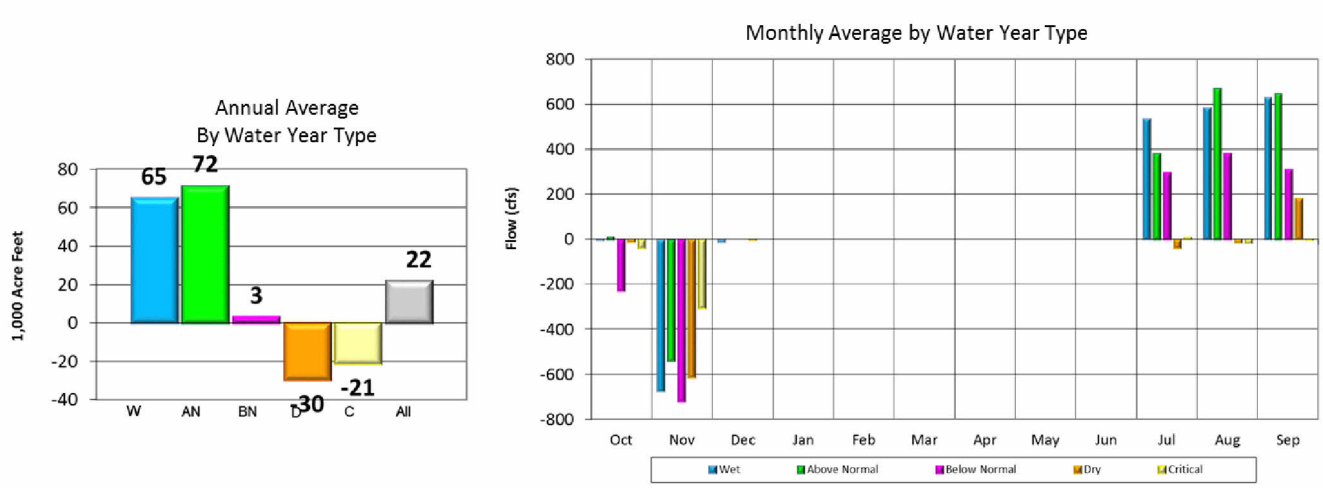


Figure 73. Change in Exports at Banks for CVP Cross Valley Canal - MBK Alternative 4A DO minus MBK NAA

vi. *Reservoir Storage and Operations*

Figure 74, **Figure 75**, **Figure 76**, and **Figure 77** contain exceedance probability charts for CVP and SWP carryover storage and average monthly changes in storage by Sacramento Valley Water Year Type for North of Delta CVP and SWP reservoirs. Changes in CVP reservoirs in the MBK Alternative 4A DO scenario relative to the MBK Alternative NAA scenario are similar to changes that the MBK Alternative 4A scenario has relative to the MBK Alternative NAA scenario. However, in the MBK Alternative 4A DO scenario end of September storage changes are greater in magnitude and storage drawdown begins to occur in April each year rather than waiting until June. Like CVP reservoirs, Oroville drawdown begins in earlier in the year. However, since the SWP has greater capability of capturing surplus, there is a decrease in demand for release of stored water and average annual Oroville carryover is higher in the MBK Alternative 4A DO scenario than the MBK Alternative 4A scenario.

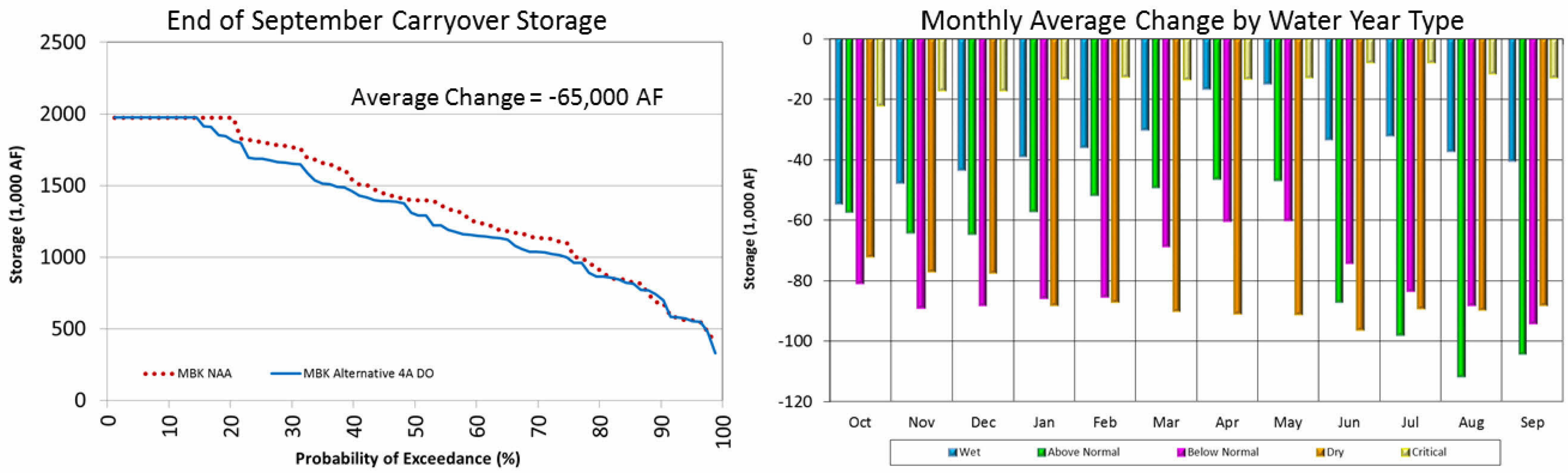


Figure 74. Trinity Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type MBK Alternative 4A DO and MBK NAA

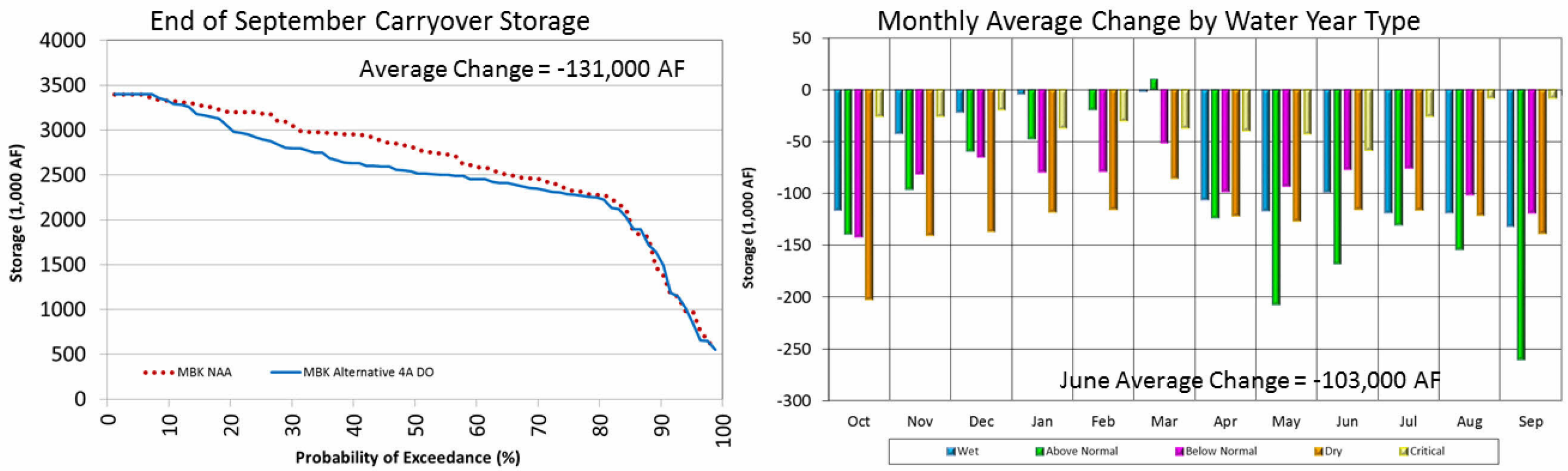


Figure 75. Shasta Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type MBK Alternative 4A DO and MBK NAA

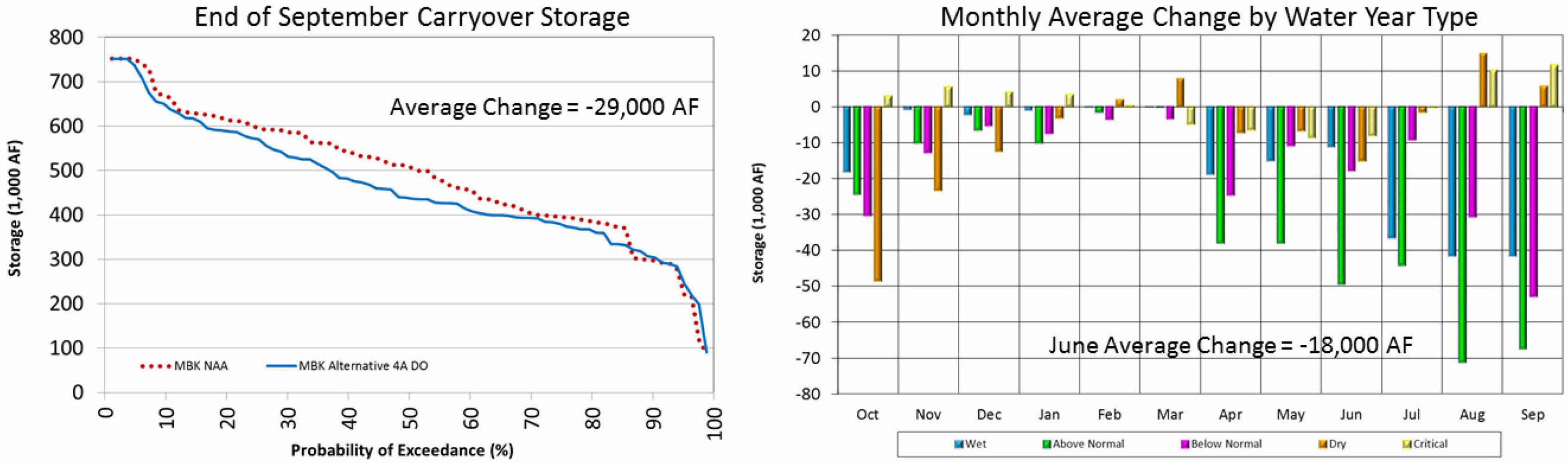


Figure 76. Folsom Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type MBK Alternative 4A DO and MBK NAA

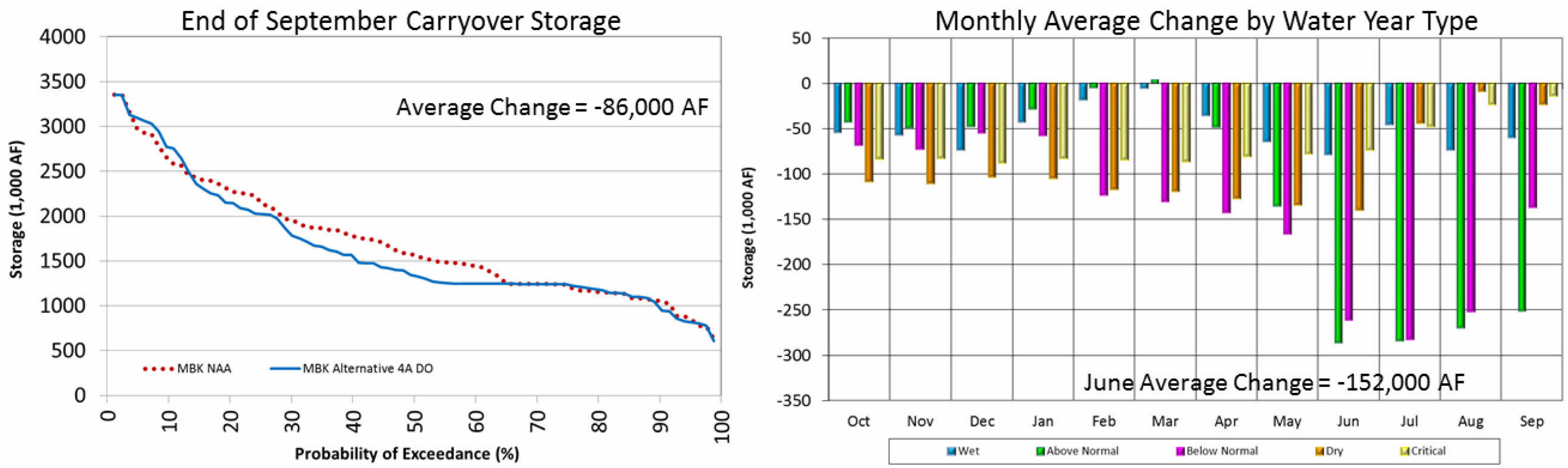


Figure 77. Oroville Reservoir Carryover Storage and Average Monthly Changes in Storage by Water Year Type MBK Alternative 4A DO and MBK NAA

vii. *River Flows*

Figure 78 shows average monthly change in Sacramento River flow below Keswick for the MBK Alternative 4A DO relative to the MBK NAA scenario. Results show that under the MBK Alternative 4A DO scenario Sacramento River flow would be higher in April all but critical years and higher in May in wetter years. August and September flows tend to be higher, while flows are less during November through March as Shasta Reservoir refills.

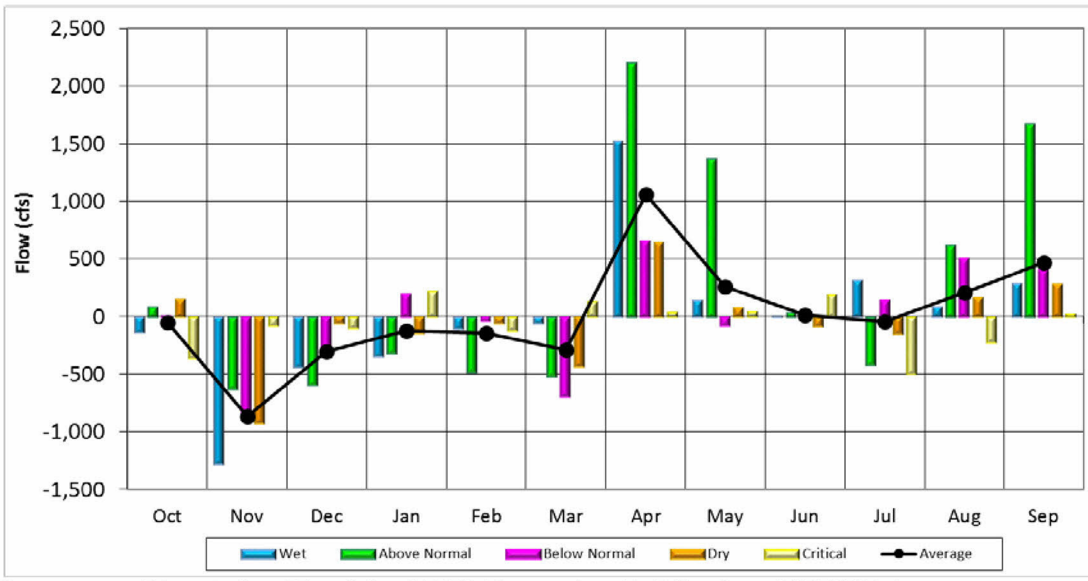


Figure 78. Sacramento River below Keswick – MBK Alternative 4A DO minus MBK NAA

Figure 79 shows average monthly change in Folsom releases, flows at Nimbus, for MBK Alternative 4A DO relative to the MBK NAA scenario. Like Keswick release, flows are higher in April. Results also show that under the MBK Alternative 4A DO scenario average American River flows would be higher in the months of June through September when additional stored water is released to support Delta exports. Flows in July and August of dry and critical years tend to be lower. Flows are lower during October through March as Folsom Reservoir fills during periods of high American River Basin runoff.

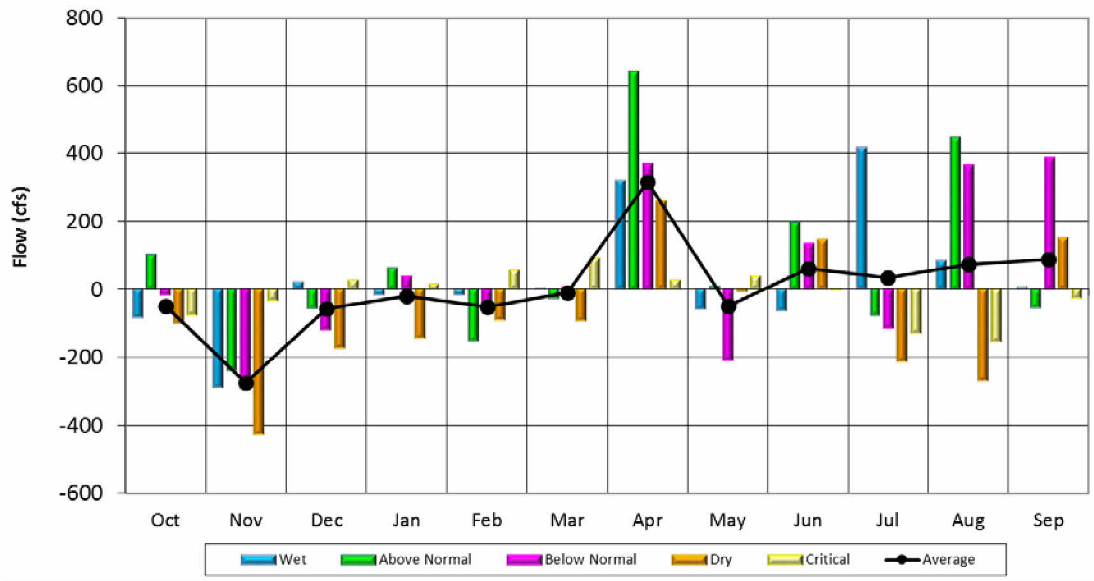


Figure 79. American River below Nimbus – MBK Alternative 4A DO minus MBK NAA

Figure 80 shows average monthly change in Feather River flow below the return flow from Thermalito for MBK Alternative 4A relative to the MBK NAA scenario. Average monthly Feather River flow would tend to be higher during the April through June period and then lower in the latter part of summer.

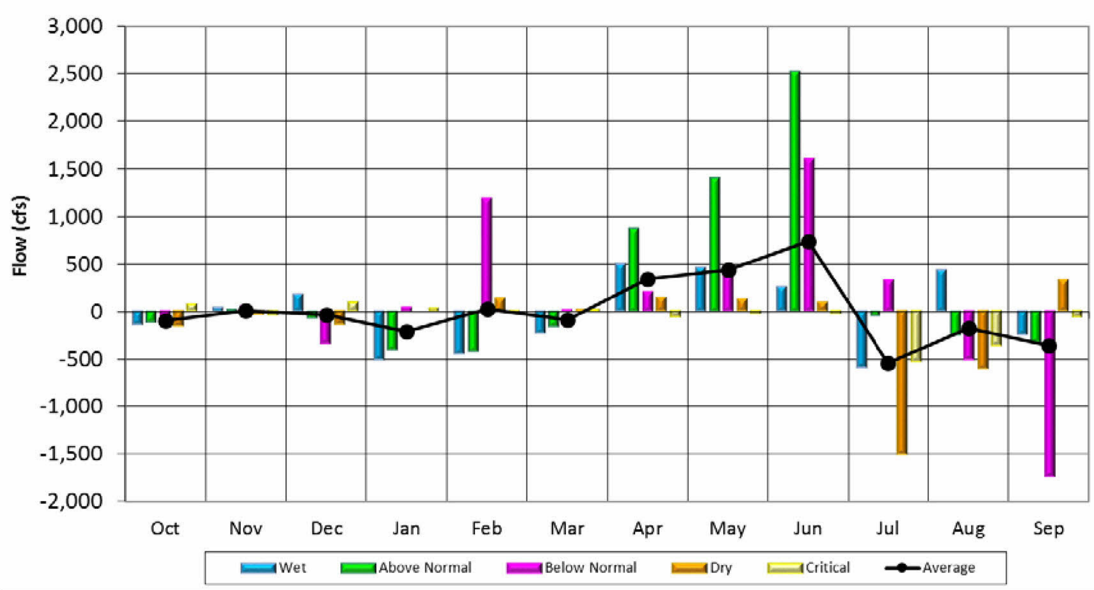


Figure 80. Feather River below Thermalito – MBK Alternative 4A DO minus MBK NAA

viii. *CVP Water Supply*

Average annual changes in water supply to CVP customers, based on customer type and water year type are shown in **Table 8**. Average annual CVP South of Delta deliveries in the MBK Alternative 4A DO would be about 228 TAF higher than the MBK NAA scenario, while North of Delta CVP deliveries would decrease by an average of 20 TAF.

Table 8. Average Annual Change in CVP Delivery by Water Year Type MBK NAA MBK Alternative 4A DO Minus MBK NAA

	North of Delta					South of Delta					North + South
	Ag Service	M&I Service	Settlement	Refuge	**Total**	Ag Service	M&I Service	Exchange	Refuge	**Total**	**Total**
All Years	-14	-5	-1	0	-20	221	7	0	-1	228	208
Wet	1	-2	0	0	-2	286	8	0	0	293	292
Abv. Norm	-15	-4	0	0	-19	391	16	0	0	407	388
Blw. Norm	-50	-12	0	0	-62	295	12	0	0	307	245
Dry	-16	-4	0	0	-21	99	4	0	0	103	82
Critical	-2	-1	-4	0	-8	-8	-2	0	-7	-18	-26

All Values are in 1,000 acre feet

ix. *SWP Water Supply*

Table 9 illustrates SWP water supply the benefits of the MBK Alternative 4A DO relative to the MBK NAA scenario. These studies show an increase in average annual SWP SOD deliveries of approximately 392 TAF, but a reduction in critical year deliveries of approximately 127 TAF.

Table 9. SWP Delivery Summary Average Annual Change in SWP Delivery by Water Year Type MBK Alternative 4A DO Minus MBK NAA

	Table A	Article 21	Article 56	Total
All Years	295	70	28	392
Wet	564	165	18	748
Abv. Norm	568	62	34	664
Blw. Norm	412	29	39	480
Dry	-100	14	40	-46
Critical	-133	-5	11	-127

All Values are in 1,000 acre feet

x. *Term 91*

Changes in CVP and SWP operations with the CWF may alter frequency that Term 91 curtailments are imposed. **Figure 81** illustrates the difference in the frequency of water right curtailments pursuant to Term 91 under the MBK Alternative 4A relative to the MBK NAA scenario. Counter to the DWR/USBR modeling, the MBK modeling shows that Term 91 may be imposed more often during April through September in the Alternative 4A scenario relative to the NAA scenario. Term 91 is expected to be imposed less often in October, this is a result of increased OMR export restrictions in combination with increased Rio Vista flow requirements.

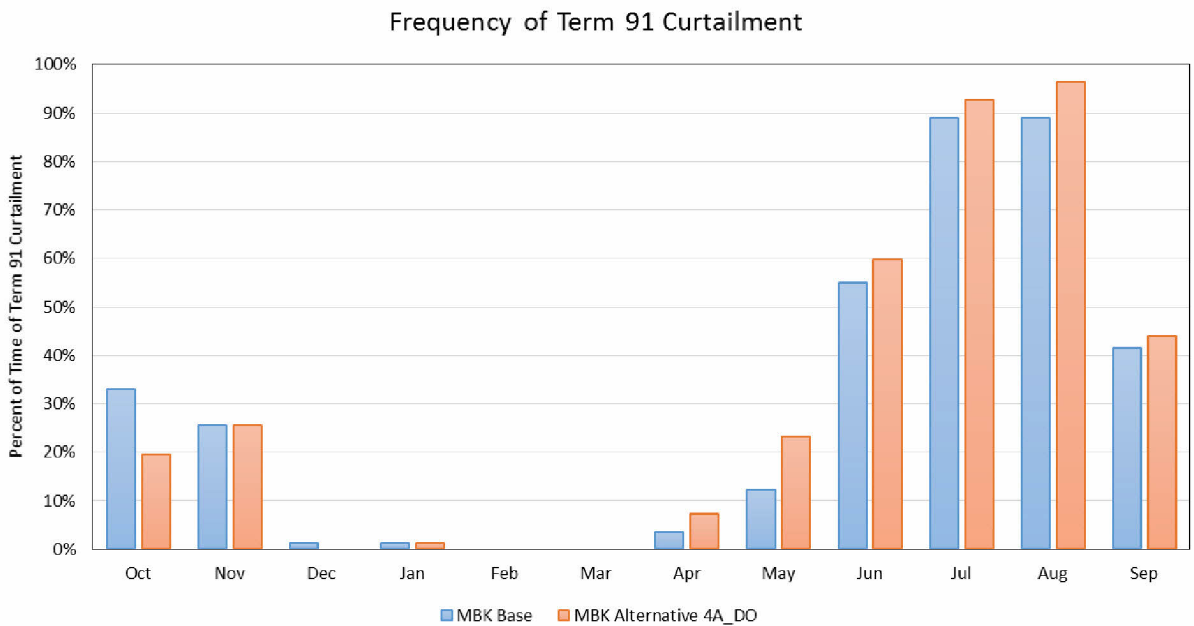


Figure 81. Frequency of Term 91 Curtailments - MBK Alternative 4A DO and MBK NAA