The Bay Institute
Golden Gate Salmon Association
Merced River Conservation Committee
Natural Resources Defense Council
Pacific Coast Federation of Fishermen's Associations
Planning and Conservation League

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SWRCB Clerk

April 18, 2013

By email and hardcopy

Jeanine Townsend, Clerk to the Board
Jeanine.Townsend@waterboards.ca.gov
cc: Mr. Mark Gowdy
Mark.Gowdy@waterboards.ca.gov
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812-0100

RE: CORRECTED AND REFORMATTED VERSION OF MARCH 29, 2013, COMMENTS OF TBI ET AL. REGARDING DRAFT SED ON CHANGES TO BAY-DELTA WQCP SAN JOAQUIN RIVER FLOWS AND SOUTHERN DELTA WATER QUALITY

Dear Ms. Townsend:

We are providing the Board with a corrected and reformatted version of the comments we submitted on March 29th, 2013. Unfortunately, that earlier version contained several typographical and formatting errors and omissions that if uncorrected might make our meaning harder to understand. We have corrected and reformatted the document and its technical appendix to remove these errors. No substantive changes have been made in this updated version; we sought only to preserve the intended meaning and format of our submission.

Below, we detail the changes made from the submitted version.

Thank you for the opportunity to submit this corrected version of our comments and for the opportunity to comment on the Board's Draft Substitute Environmental Document (SED) for Phase 1 of its Bay-Delta Water Quality Control Plan updates.

Sincerely,

Jonathan Rosenfield, Ph.D., The Bay Institute
On behalf of The Bay Institute et al.

Comment Letter
Throughout –

- Standardize naming and abbreviations
- Correct typographical and grammatical errors
- Use page breaks to keep headings on the same page as their associated text
- Superscript footnote numbering

Page 6[1], Paragraph re: footnote to Table 3 – now refers to “natural production”

Page 16 change statement immediately above the table to read:
When converted to a monthly average flow, the NOAA flood action stage for the Merced River is slightly above the maximum flow, the stage for the Tuolumne is well above the maximum flow, and the stage for the Stanislaus is almost three times the maximum flow. (Draft SED, Appendix L, Table L-1 and page L-7).

Page 16, Table: added “monthly” to “Flows” in the first column and “instantaneous” before “Design Capacity” in the 2nd and before “Channel Capacity” in the 3rd column.

Page 21, 5,000 cfs Mini-table. Text under “Duration” changed to say: “average from Mar-Jun”

Page 21, 10,000cfs Mini-Table. Text under “duration” changed to say: “average Mar-Jun” Deleted 3rd “Benefits” bullet point of table.

Page 22, First full paragraph. First sentence and second sentence merged into one complete sentence.

Page 22, Heading for 15,000 cfs flow Mini-Table. Change “March-May” to “April-May”

Page 22, 15,000 cfs mini-table. Text under “frequency” changed to read “60% of years”.

Page 26, 2nd bullet point, after “Friant settlement flows” clarified by adding text “*estimated at the confluence of the Merced River*” – TBI’s model does not use the entire settlement flow amount released at Friant.

Page 27, Last paragraph: 2nd reference to Figure 8 changed to refer to Figure 5.

Page 28, First full paragraph. Sentence that reads “In order to attain AFRP population targets, 10,000cfs flows should occur in approximately half of years.” changed to read: “10,000 cfs Mar-Jun average flows”.

Page 31, Table 3. Reformatted for legibility and moved to Technical Appendix for consistency

Page 32, Reformatted paragraphs indicating suggested revisions to Appendix K of the SED

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[1] Page numbers and paragraphs refer to those in original 3/29/13 submission

Page 40, the last paragraph: reformatted to reflect that it is a quotation.

Literature cited: Standardized

Endnotes: standardized fonts

Technical Appendix:
Throughout –

- Correct typographical and grammatical errors

Separate and reformat Figure 12 and Figure 11.

Clarify captions for Figures 2 and 3

Add Table 3 (originally located in main text of Comment Letter)

March 29, 2013

Charles Hoppin, Chair
c/o Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812-0100

Sent via U.S. Mail and emailed to: commentletters@waterboards.ca.gov

RE: DRAFT SED ON CHANGES TO BAY-DELTA WQCP SAN JOAQUIN RIVER FLOWS AND SOUTHERN DELTA WATER QUALITY

Dear Chairman Hoppin,

This letter is submitted as the comments of The Bay Institute, the Natural Resources Defense Council, the Merced River Conservation Committee, the Pacific Coast Federation of Fishermen's Associations, the Planning and Conservation League, and the Golden Gate Salmon Association regarding the Public Draft Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Delta Estuary: San Joaquin River Flows and Southern Delta Salinity (hereafter, "Draft SED").

In summary, we find the Draft SED to be deficient in the following areas:

- The proposed narrative objective for San Joaquin River inflows lacks adequate definition and should refer to specific, measureable, attainable, relevant, and time-bound measures of viability for fish and wildlife beneficial uses and functional habitat values, including doubling of salmonids and other migratory fish populations.

• The Draft SED's proposed 35% unimpaired flow (UIF) and 1,000 cfs minimum flow requirements for the February through June period are not scientifically justified, do not sufficiently improve conditions above the status quo of declining fisheries and habitat degradation, and will certainly not achieve the narrative objective.

• The best available scientific evidence strongly indicates that flow requirements greater than 50% of UIF are necessary to provide minimum acceptable conditions to support viable populations and functional habitats and achieve the narrative objective, and flows of 60% or more are necessary to fully protect these resources.

• The initial UIF value and adaptive range should be revised to require flows based on the best available scientific evidence (i.e., at least 50 – 60%).

• Variations in flow within the adaptive management range should be based on timely attainment of specific measures of population viability and habitat functionality.

• The Draft SED's adaptive management decision-making process is inadequately defined, and could result in lower flows than desired.

• The Draft SED's analysis of water supply and economic impacts is flawed, systematically overstating impacts to agricultural uses; treating groundwater use and baseline conditions inconsistently throughout the documents; and overlooking benefits to fisheries and other economic sectors from improving San Joaquin River inflows to the Delta.

• The Draft SED completely overlooks the potential for agricultural water use efficiency improvements, water transfers, and other mechanisms to avoid or mitigate any impacts.

• There is no clear, rational and transparent basis for balancing between beneficial uses and therefore no justification for the Draft SED's findings regarding balancing.

• Flow releases in the Draft SED's modeling are capped well below flood control requirements and in some cases in violation of existing minimum flow requirements.

We discuss each of these points in greater detail on the pages that follow. Accompanying figures referenced in the text are contained in Appendix 1. We look forward to working with the Board to revise the SED to address these comments and adopt new flow objectives for the lower San Joaquin River that will support attainment of salmonid doubling and other population viability targets and help restore the health of the Bay-Delta estuary.

I. The San Joaquin River inflows narrative objective must refer to doubling of salmon and other migratory fish populations

The proposed narrative objective for San Joaquin inflows contained in Appendix K is based on a valid general framework (providing more flow of a more natural pattern, in order to support natural production of native migratory fish as measured by attributes of population viability), but lacks adequate definition (i.e., it fails to establish a clear, sufficient benchmark for natural production) and is inconsistent with existing state and federal law, including the narrative salmon protection objective in the 2006 Bay-Delta Water Quality Control Plan (WQCP), the salmon and steelhead doubling goal in Cal. Fish & Game Code § 6902(a), and the anadromous fish doubling goal of the Central Valley Project Improvement Act. Doubling salmon populations is a clear and mandatory outcome that should be incorporated in the San Joaquin inflow objective, and in fact there is sufficient scientific evidence to identify the level of population abundance associated with the doubling of natural production of target migratory fish species, and to measure whether it is being achieved in a sustainable manner.

It is important to note that the current WQCP includes a narrative salmon doubling objective, and the narrative objective for lower San Joaquin River flows must be consistent with achievement of the salmon doubling objective in the plan. The salmon doubling requirement is a function of both state and federal law and has been part of the Bay-Delta Water Quality Control Plan since 1995, as we noted in NRDC/TBI 2012 (attached as Exhibit 2). That existing salmon doubling objective reads, "*Water quality conditions shall be maintained, together with other measures in the watershed, sufficient to achieve a doubling of natural production of chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law.*" The program of implementation and administrative record must demonstrate how this salmon doubling objective will be achieved through this San Joaquin River narrative objective. (Water Code §§ 13050(j)(3), 13242(a); *In re State Water Resources Control Board Cases*, 136 Cal.App.4th 674, 775 (2006); Exhibit 2) In order to be consistent with the existing salmon doubling objective, the narrative objective for lower San Joaquin River flows should explicitly reference the existing salmon doubling objective.

Furthermore, effective adaptive management requires measurable targets, as is discussed below. The AFRP production targets provide clear salmon abundance targets for each tributary, which is critical to determining whether implementation of the narrative objective is successful or if changes within the range are necessary. In contrast, the language of the current narrative objective is vague and lacks any numeric definition of "*the natural production of viable native San Joaquin River watershed fish populations;*" it is unclear if this phrase intends abundance targets that are significantly less or greater than the salmon doubling objectives, or is intended to be linked to any targets at all.

In addition, the salmon doubling requirements of state and federal law is an expression of the Board's responsibilities under the Public Trust. The Board must abide by the Legislature's determination that the doubling of natural production of salmon is a statewide policy (Cal. Fish & Game Code § 6902(a)) and the water quality control plan should be consistent with that policy. The salmon doubling policy is intended to ensure that the State does more than meet the absolute minimum requirements of the state and federal Endangered Species Acts. As with section 5937 of the Fish and Game Code, section 6900 *et seq* is a legislative expression of the Public Trust, and the Board lacks authority to balance away achievement of this state policy. (*See California Trout, Inc. v. State Water Resources Control Bd.*, 207 Cal.App.3d 585, 622-625, 631 (1989); SWRCB Decision 1631 at 172; SWRCB Decision 1644 at 27; Exhibit 1).

Analyses and actions to implement the Central Valley Project Improvement Act, which mandates doubling of anadromous fish populations in the Central Valley, provide the most detailed information regarding production targets and measurement. Section 3406 of the Central Valley Project Improvement Act, Title 34 of Public Law 102-575, requires:

> *…natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991.*

Anadromous fish doubling goals include the following species identified in Title 34: Chinook salmon, steelhead, striped bass, white sturgeon, green sturgeon, and American shad. Current doubling goals for salmon were developed from average natural production levels for 1967-1991 calculated by Mills and Fisher (1994). For example, average levels and doubling goals for major tributaries to the San Joaquin River are as follows:

Natural Production for Fall-run Chinook

	1967-1991 Average	**Doubling Goal**	**1992-2010 Average**	**Percentage of desired goal**
Stanislaus River	10,780	22,000	5,334	24%
Tuolumne River	18,811	38,000	7,186	19%
Merced River	8,974	18,000	6,845	38%

To help understand the doubling goal mandate, we briefly define the terms production, natural production, and sustainable:

> **Production.** Chinook salmon production is the sum of adult catches (in both ocean and freshwater) and fish that spawn in the river (escapement) for a given year. Production estimates include all adult fish that spawn in the river (escapement) regardless of whether adult fish were incubated and hatched in a hatchery or in natural habitats.

> **Natural production.** Natural production refers to fish spawning, rearing and migrating in rivers without human intervention (e.g. without handling, moving or artificially spawning in hatcheries). Natural production for San Joaquin fall run Chinook salmon is calculated using hatchery production estimates and in-stream harvest estimates that are based on the expert opinions of agency fish biologists. Natural production estimates are calculated annually by AFRP and results are available on the web (see Chinookprod, http://www.fws.gov/stockton/afrp). Further explanation of production calculations can be

> found in the AFRP position paper, included in the Final Restoration plan as Appendix B-1 (USFWS 2001).
>
> **Sustainable.** The AFRP position paper states *"Sustainable is defined as capable of being maintained at target levels without direct human intervention in the spawning, rearing or migration processes."* (USFSW 1995 at A-7)

Natural production of San Joaquin River fall-run Chinook salmon is woefully inadequate to protect the Public Trust. Natural productivity is decreasing in many tributaries, has only once attained basin-wide doubling targets, and some populations are at risk of extirpation. See above and Figure 1. The basis for additional biological indicators and targets for steelhead, splittail and green and white sturgeon is discussed in detail in the May 23, 2011 comment letter from TBI and American Rivers to the SWRCB regarding the revised Notice of Preparation for Review of Southern Delta Salinity And San Joaquin River Flow Objectives (TBI/AR, 2011, attached as Exhibit 3).

Some of the Draft SED's proposed language for the narrative objective ("maintain flow conditions…together with other reasonably controllable measures") is particularly problematic, because it is expressed in a way that mixes flow-related actions within the scope of the WQCP with non-flow measures outside the scope of the objective itself or the Plan, and because its underlying assumption is neither justified by the analysis in the Draft SED nor consistent with the best available science, for the following reasons.

- The Board may anticipate that this objective will be achieved through a combination of flow and non-flow actions, and incentivize actions by others in support of that end, but the objective should be expressed solely in terms of the flow conditions necessary to achieve the desired outcome (e.g., doubling of natural production of migratory fish populations).

- There is sufficient scientific evidence available to establish flow rates needed (and equivalent %UIF) to achieve both the proposed narrative San Joaquin inflow objective and the existing WQCP narrative salmon protection objective. Specific flow thresholds for achieving ecological functions and/or particular levels of salmon productivity, based on detailed scientific information and statistical analysis, have been identified by numerous parties, including TBI et al. (2010), CDFW (2010a and b), and others (see below for more details).

- Non-flow actions, including habitat and fish passage improvements, cannot substitute for but are necessary complements to the level of flow improvement indicated by the best available science. These non-flow actions will also take a longer period of time to implement and to show results, meaning that higher flows are needed initially, but if and when non-flow actions show substantial results, flows may be modified if and as appropriate.

<u>Recommendation: The proposed narrative objective in Appendix K should be amended to read:</u>

> *Maintain flow conditions from the San Joaquin River Watershed to the Delta at Vernalis sufficient to support and maintain the doubling of natural production of San Joaquin River Chinook salmon and steelhead populations migrating through the Delta from the average production of 1967 – 1991, and the establishment of viable, self-sustaining populations of other San Joaquin River watershed fish species migrating through the Delta. Flow conditions that reasonably contribute toward maintaining viable native migratory San Joaquin River fish populations include, but may not be limited to, flows that mimic the natural hydrographic conditions to which native fish species are adapted, including the relative magnitude, duration, timing, and spatial extent of flows as they would naturally occur. Indicators of viability, including abundance, spatial extent or distribution, genetic and life history diversity, migratory pathways, and productivity, will be used to measure attainment of this objective [Footnote 1].*
>
> *Footnote 1 to Table 3 narrative objective: The following indicators of viability will be used to measure progress towards meeting this objective: average annual natural production of 78,000 fall-run Chinook salmon (22,000 from the Stanislaus; 38,000 from the Tuolumne; and 18,000 from the Merced); 10,000 steelhead from at least two rivers in the San Joaquin basin; successful splittail spawning once in every three years; and successful green and white sturgeon spawning once in every seven years.*

II. The proposed initial 35%UIF starting point and 1,000 cfs minimum flow requirement during the February – June period are not scientifically justified, will not improve conditions sufficiently above the status quo of declining fisheries and habitat degradation, and will certainly not achieve the narrative objective

The Draft SED's finding that an initial overall requirement of 35%UIF, along with a minimum flow of 1,000 cfs, is sufficient to achieve the narrative objective (whether the Draft SED's version or our proposed alternative language) is not justified, for the following reasons:

A. <u>The analysis of impacts to aquatic resources is flawed</u>

The Bay-Delta Water Quality Control Plan provides numeric criteria against which to compare the status of aquatic resources under baseline conditions: the salmon doubling objective, which is based on the requirements of state and federal law. The Final AFRP (2001) provides numeric population targets for the Stanislaus, Tuolumne, and Merced Rivers, and the SED should analyze whether the alternatives are likely to achieve this existing objective of the Water Quality Control Plan. In addition, the analyses and comments submitted by the California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, ourselves, and the Board's 2010 Flow Criteria

Report all provide flow thresholds against which to measure the effects of various flow alternatives.

Unfortunately, the Draft SED fails to quantify the expected effects on salmon, steelhead, and other native fish, particularly the benefits of improved flows and reduced diversions. The Draft SED does not provide a reasoned explanation for a conclusion by the Board that the 35% alternative would achieve the narrative goal of sustaining fish populations, let alone achieve the existing narrative objective in the water quality control plan of achieving salmon doubling. However, as the Board is aware, the SED and plan must demonstrate how the actions in the plan will achieve the water quality objectives. (Water Code §§ 13050(j)(3), 13242(a); In re State Water Resources Control Board Cases, 136 Cal.App.4th 674, 775 (2006) ("*Determining what actions were required to achieve the narrative salmon protection objective was part of the Board's obligation in formulating the 1995 Bay–Delta Plan in the first place*.").)

B. <u>The Draft SED proposed flow requirements do not represent a significant improvement over recent status quo conditions in the lower San Joaquin River; those conditions have resulted in declines in relevant Public Trust resources that utilize the lower San Joaquin and the quality and quantity of habitat supporting those resources, and would be relatively unaffected by the proposed amendment</u>

In our 2010 testimony to the Board, we documented the recent status of winter-spring flow volumes in the San Joaquin River at Vernalis in relation to unimpaired flows throughout the watershed and the trends in that ratio over the past 80 years. The median percentage unimpaired flow between January and June from 1988-2009 was ~33%, down substantially from earlier periods. (TBI et al. 2010, exhibit 3; Figure 1 at p. 4). This finding is consistent with the Draft SED's presentation of flow exceedences as presented in Appendix F (e.g. Figure F.1-13a, Table F.1-13d) and the Draft SED's finding that flows at Vernalis represented 29% of unimpaired flows upstream during the months February-June between water years 1986 and 2009. (Draft SED Executive Summary at p. 13) Differences in these estimated historical conditions are attributable to slight differences in the time-period over which flows were averaged and due to the inclusion of January (a month when unimpaired flows are typically higher than the rest of the winter-spring period) in our earlier analysis. In either case, the nominal 35% standard identified in the Draft SED is not materially different from the status quo and could not reasonably be expected to produce significant improvement in the Public Trust benefits provided either by the San Joaquin River or the southern Bay-Delta.

The 1000 cfs minimum flow standard is not adequate to provide even minimal fish passage between the Delta and sections of the San Joaquin watersheds upstream of the Delta. Low dissolved oxygen conditions in the Stockton Deepwater Ship Channel (SDWSC) are believed to inhibit fish passage (CVRWQCB and CBDA 2006) and may render parts of the San Joaquin uninhabitable to resident fish species; these intolerable conditions are exacerbated by low flow rates in the San Joaquin River (CVRWQCB and CBDA 2006). In our 2010 recommendations, we recommended a minimum flow at Vernalis of 2000 cfs based on findings by Van Nieuwenhuyse 2002 and Jassby and Van Nieuwenhuyse 2005 that flows at this level and higher corresponded to attainment of the dissolved oxygen standard in the SDWSC. More recent research indicates that, even with the operation of an aerator in the SDWSC and upgrades to the City of Stockton's treatment of wastewater effluent, flows of ~1000 cfs at Stockton still correspond to attainment of the dissolved oxygen standard (Figure 2). Flows at Vernalis must be higher (approximately double) flows desired in the SDWSC because Old and Middle River distribute water out of the San Joaquin River mainstem between Vernalis and Stockton, (Figure 3). The Board's preferred minimum flow (1000 cfs at Vernalis) will result in flows in the SDWSC that are insufficient to prevent low DO episodes, even with the implementation of expensive non-flow mitigation measures (e.g. improved wastewater treatment); thus, a low dissolved oxygen migratory barrier for anadromous fish, particularly salmonids and sturgeon, would persist under the Board's preferred flow alternative.

Flow conditions anticipated by the Draft SED's preferred alternative are certainly insufficient to improve viability (abundance, spatial distribution, life history diversity, or productivity) of native species in the Delta (see below and Appendix 1). For example, fall run Chinook salmon abundance in the San Joaquin watershed is only about half of its 1967-1991 average and less than one-quarter of the production target specified by federal and state law (see above; Figure 1). San Joaquin fall run Chinook salmon numbers track Vernalis flows extremely well (Figure 1, USFWS 1995, CDFW 2005), but it is not clear whether maintenance of status quo flows are sufficient to sustain the already abysmal salmon returns witnessed on the San Joaquin's tributaries in recent years. If current fall run Chinook salmon populations on the San Joaquin River reflect an interplay of recent environmental conditions and antecedent population sizes (i.e. stock-recruit effects), then maintenance of status quo flow standards would facilitate further decline of fall run Chinook populations until the population stabilizes. Stock-recruit relationships are well known among salmonids (e.g. Ricker 1954) and the eventual "stable-state" population under any given flow regime depends on the strength of that effect and the existence or strength of density-dependent phenomena.

Furthermore, the fact that half a dozen native fish species in the Bay-Delta are already listed as threatened or endangered under either or both the State and Federal Endangered Species Acts strongly suggests that these and other fisheries are not sustainable under current conditions. As a result of their current overreliance on conditions in the Sacramento River and northern Delta migratory corridor, the success or failure of efforts to restore adequate conditions on the San Joaquin River affects their viability throughout the Central Valley. For example, spring-run Chinook salmon, steelhead, and green sturgeon have suffered massive declines throughout most of their historic range in the Central Valley and they have been completely or nearly extirpated from the San Joaquin River and its tributaries. Most or all of their remaining populations are dependent on conditions in only one waterway – the Sacramento River. Continued degradation (whether slow and chronic or acute) of conditions on the Sacramento River could easily eliminate the current populations of any or these species – all of their eggs are in one basket (river). Failure to restore freshwater flow volumes and timing required by spring run, steelhead, and green sturgeon to reproduce in the San Joaquin Valley will continue to expose the Central Valley populations of these fish to the higher risk of extirpation associated with a limited geographic range. (Rosenfield 2002) Conversely, if these species were permitted to reestablish sustainable spawning populations in the San Joaquin Basin, the risk in the short-term of losing these populations and their associated benefits throughout the Central Valley would be significantly reduced.

The problems discussed above are not limited to anadromous species. Delta resident species such as Delta smelt and longfin smelt have suffered catastrophic population declines that have resulted in their listing under either or both the California and federal ESAs. In addition to the decline in their abundance, suitable reproductive and rearing habitats for these fish have been severely constrained by flow and water export regimes that are largely indistinguishable from those envisioned by the Draft SED. Simply put, the smelt and other native Delta-resident species evolved in an environment with two major freshwater inputs to the Delta. Winter-spring discharge from the Sacramento and San Joaquin Rivers created suitable spawning and rearing conditions for larval fish throughout the Delta. Without substantial increases in freshwater flows from the San Joaquin River, native Delta-resident species will continue to be deprived of potential habitats – the current constriction of their range is at least as great a concern as their vanishingly small populations.

C. <u>The SED projects no material benefit to Public Trust resources as a result of implementing the preferred alternative's flow conditions</u>

With regard to Public Trust benefits, the SED focuses on impacts to fall-run Chinook salmon populations and even that inadequate evaluation of impacts is focused largely on effects of the SED alternatives upstream of the lower San Joaquin River where it enters the Delta. The SED barely mentions potential effects to other important fisheries including (but not limited to):

- Existing spring-run Chinook salmon populations in the Tuolumne and Stanislaus Rivers;
- Steelhead;
- Green sturgeon;
- White sturgeon;
- Sacramento splittail or any of the Bay-Delta's native resident species.

Although, where data are limited, we too have utilized the approach of identifying "indicator" or "umbrella" species to represent the needs of a suite of species, fall run Chinook salmon are by no means the only or the most flow-sensitive species in the San Joaquin River basin. Examples of species whose water quality needs in the San Joaquin River may exceed those of fall run Chinook salmon include:

- Sturgeon require much higher levels of dissolved oxygen than salmon (Cech and Doroshov 2004);

- Steelhead and spring run Chinook salmon require cool water year-round, whereas fall run occupy the San Joaquin during only part of the year; and

- Bay-Delta resident species such as Delta smelt, longfin smelt, and Sacramento splittail occupy fresh and brackish water habitats created (in part) by San Joaquin River outflow during months when fall run Chinook salmon are not found in the Delta.

Thus, the Draft SED's analysis and substitution of fall run Chinook salmon impacts for impacts to Public Trust fisheries is likely to overlook both negative and potential positive impacts.

The Draft SED analyzes potential impacts of three flow alternatives (referred to here as "20%UIF", 40%UIF", and "60%UIF" alternatives, respectively). The Draft SED anticipates no positive impacts to fall run Chinook salmon from implementation of the 20% alternative. With regard to the 40% alternative, the Draft SED identifies negative impacts, effects that are not "significant" deviations from the status quo, and anticipated positive impacts to fall run Chinook salmon. The finding of "no significant impact" is misleading because the baseline against which "change" is measured is already well below a level that could be said to protect the Public Trust (e.g. abundance is <1/4 of the statutory requirement and migration is likely to be impeded by poor water quality conditions in many years) and, as described above, is likely to manifest as continued decline rather than stabilization of the population. Furthermore, the analysis is overly optimistic in its estimation of effects; some effects that are estimated to be "not significant" will more likely be negative impacts and positive impacts identified in the Draft SED are likely overstated.

We assume that negative impacts to fall run Chinook salmon populations anticipated under the 40%UIF alternative will also manifest (potentially more forcefully) under the 35% preferred alternative (the preferred alternative is not analyzed directly, so the Draft SED does not state exactly how deleterious conditions will be under this alternative). In addition, as the "water budget" reserved for environmental benefits shrinks (i.e. by allocating 35% of UIF rather than a higher amount of UIF), the management flexibility needed to allocate additional flows to particular needs also decreases. Although the Draft SED suggests that some or all of these impacts can be avoided through "adaptive management", the Draft SED's description of a specific adaptive management plan that would allow the necessary modifications to the San Joaquin flow regime is not sufficiently detailed to determine if and how and how rapidly such management alterations would be implemented. Simply asserting that negative impacts can be avoided by modifying the preferred alternative in the future is not the same as actually avoiding the negative impacts.

D. <u>The preferred alternative provides less flow than the Board and other agencies have determined is necessary to maintain and restore Public Trust fisheries in the San Joaquin watershed and the Bay-Delta; the preferred alternative's flow prescription is also far less than what the available scientific literature identifies as suitable for protecting riverine aquatic resources</u>

It is not surprising that the Draft SED's preferred alternative falls far short of providing conditions necessary to support Public Trust fisheries and ecosystem benefits. The State Board itself concluded in 2010 that 60% of the San Joaquin's unimpaired flow between February and

June and a 10 day minimum pulse of 3,600 cfs in late October would be necessary to sustain just the San Joaquin's Fall run Chinook salmon population. Regarding the factual basis for these determinations, the Board found they were "*supported by sufficiently robust scientific information*" (SWRCB 2010 at p. 119) and, more generally, that:

> *There is sufficient scientific information to support the need for increased flows to protect Public Trust resources; while there is uncertainty regarding specific numeric criteria, scientific certainty is not the standard for agency decision making.* (SWRCB 2010 at p. 4)

As described above, the Draft SED provides no rationale or analysis supporting its determination that 35%UIF (and no additional fall pulse flow) would provide an acceptable level of protection for the San Joaquin River's fall run Chinook salmon population, much less other biological and Public Trust resources of the San Joaquin River and/or the Bay-Delta.

The Board's 2010 report was based on input from all relevant trustee agencies, independent science panels, and analysis provided by TBI et al. (2010) and other conservation organizations. These organizations all concluded that current flow levels in the San Joaquin were inadequate to protect water quality and Public Trust resources. California DFG testimony stated:

> *Empirical information generated from SJR basin studies was used in the model and the identified results* <u>*strongly indicate that improving SJR stream flow in the spring time period is necessary to accomplish the State and Federal salmon doubling goal*</u> *by doubling the juvenile (smolt) abundance at Chipps Island.* (CDFG 2010b at p. 1. Emphasis added)

In summarizing the testimony of trustee agencies to its 2010 Public Trust flows proceedings, the Board mirrored CDFG's findings that:

> *Water flow is a major determinant of species abundance and fish production.*

and

> *In general, the data and information available indicates [that] recent Delta flows are insufficient to support native Delta fishes in habitats that now exist in the Delta.*
> (CDFG 2010b at p. 94 and SWRCB 2010 at p. 5)

Given this finding, the Draft SED's lack of analysis regarding the effect of San Joaquin River inflows to the Delta on Delta resident species (or the life stages of any creature that relies on the Delta) is a significant and alarming omission.

With regard to flows in the lower San Joaquin River specifically, the Board found:

> *Available scientific information indicates that average March through June flows of 5,000 cfs on the San Joaquin River at Vernalis represent a flow threshold at*

> *which survival of juveniles and subsequent adult abundance is substantially improved for fall-run Chinook salmon and that average flows of 10,000 cfs during this period may provide conditions necessary to achieve doubling of San Joaquin basin fall-run. Both the AFRP and DFG flow recommendations to achieve doubling also seem to support these general levels of flow, though the time periods are somewhat different (AFRP is for February through May and DFG is for March 15 through June 15). Available information also indicates that flows of 3,000 to 3,600 cfs for 10 to 14 days are needed during mid to late October to reduce straying, improve olfactory homing fidelity, and improve gamete viability for San Joaquin basin returning adult Chinook salmon.*
> (SWRCB 2010 at p. 119).

The analyses submitted by TBI et al. (2010) were developed independent of DFW's analyses and using quite different approaches (i.e. TBI focused on adult escapement in response to flows 2.5 years earlier, whereas DFW analyzed smolt survival in relation to spring flows); despite this we also identified 5 Kcfs and 10 Kcfs seasonal average flow thresholds as critical to maintenance of fall run Chinook salmon populations on the San Joaquin River.

As the Board's 2010 report notes, these criteria did not consider other San Joaquin River, in-Delta, or through-Delta flow needs and were almost completely focused on the needs of San Joaquin River fall run Chinook salmon during the migratory phases of their life cycle. Flows required to maintain viable populations of other fishes or critical resources in the San Joaquin, in the Delta, or in Suisun Bay may be greater than those needed simply to move Chinook salmon into and out of the San Joaquin watershed; thus, the Board's 60%UIF finding must be viewed as the minimum necessary to sustain one important beneficial use of San Joaquin River water – the maintenance and restoration of its fall run Chinook salmon fishery.

There is no suggestion in the published scientific literature to indicate that 35% of unimpaired flows (for part of the year, with potentially even less flow in other parts of the year) are sufficient to maintain viable fisheries or other public benefits in a river system. Indeed, recent reviews of the literature on "environmental flows indicate that flows >80% of unimpaired (or "full natural") flow are necessary to maintain benefits of riverine systems (including river systems that are highly modified, such as the San Joaquin River). To quote one such review:

> *Alterations [of daily flows] greater than 20% will likely result in moderate to major changes in natural structure and ecosystem functions, with greater risk associated with greater levels of alteration in daily flows. These thresholds are well supported by our case study review, as well as from our experiences in conducting environmental flow assessments for individual rivers (e.g. Richter et al., 2003, 2006; Esselman and Opperman, 2010). This level of protection is also generally consistent with findings from regional analyses such as the 'benchmarking' study in Queensland, Australia, by Brizga et al. (2002) and by a national (US) analysis of hydrologic alteration which documented that biological impairment was observed in some sites with hydrologic alteration of 0–25% (the*

> *lowest class of alteration assessed) and in an increasing percentage of sites beyond 25% hydrologic alteration (Carlisle et al., 2010).*
> (Richter et al. 2011)

E. <u>The Draft SED makes a number of assumptions in modeling implementation of the proposed 35%UIF that overstate its equivalence to flows recommended by fishery agencies and conservation organizations.</u>

Whereas the Draft SED preferred alternative prescribes water flows on the San Joaquin's tributaries as a percentage of unimpaired flows as calculated on a 14-day running average (Draft SED 2012, Appendix K at p. 3), it elsewhere suggests that flows can be delivered as part of a water budget. "*The adaptive management of flows does not have to rely on the unimpaired flow percentage method, but instead can use pulse flows or other management approaches, as long as the requisite unimpaired flow percentage for the entire February through June period is met.*" (Draft SED, Appendix K, at p. 4). These two descriptions of how water would be allocated to river flows under the preferred alternative are not internally consistent and the document appears to suggest that benefits (but not the negatives) of both approaches can be attained simultaneously. Both an engineered hydrograph (e.g. the water budget approach described on page 4 and elsewhere) and the proportional hydrograph approach (e.g. releasing a percentage of the multi-day running average of unimpaired flows in a watershed) have benefits; indeed, our 2010 recommendations were presented as engineered hydrographs. However, the proportional hydrograph approach that the Board proposed in its 2010 report is far preferable from an ecological point of view because this approach mimics the temporal pattern (shape) of the natural hydrograph. As a result, the proportional hydrograph approach retains natural variations in flow that serve as important cues to migrating and Delta-resident species and create habitat at times that match the evolved life histories of native species. These and other benefits of a proportional hydrograph approach explain why this approach is supported in the recent scientific literature on river protection and restoration (Poff et al. 1997; Richter et al. 2011; Arthington 2012). In addition, because it relies on recent, measured historical information (the previous x-days of inflows to rim station reservoirs), the proportional hydrograph approach does not require forecasting of precipitation or snowmelt timing; these and other aspects of a proportional hydrograph alternative generate significant operational and implementation advantages relative to engineered hydrographs.

The comparisons of previously proposed alternatives presented in Chapter 3 are particularly misleading. For example, Figures 3-1 through 3-7 of the Draft SED each plot the total volume of flow for the months February-June on the y-axis vs. exceedence on the x-axis and compare the volume of water available in the WSE (Water Supply Effects) Model of three levels of UIF versus that required for a variety of recommended, engineered hydrographs. The y-axis ignores completely any notion of a proportional hydrograph as it implies that all water available during this season is available for use at any time during the season. Thus, these comparisons assume perfect forecasting (omniscience) of runoff at the time that the year-type designations in the engineered hydrographs are determined. For example, operators must be correct when, in March, they begin to release flows as if it is going to be a dry year; if the WY type becomes wetter in May, it will be too late to provide flows associated with wetter year types. Conversely, if the spring is very dry and the WY-type becomes drier after the March determination, then operators will cut back on releases in May to reflect the revised drier year type. In both cases, more water than is reflected in the Draft SED's depiction of alternatives (the red, stair-step lines) must be released to insure that those alternatives are actually implemented in the appropriate year types.

Also, the depiction of previously proposed alternatives in Chapter 3 assumes that operators deliver the exact amount of water necessary to meet the alternative flow recommendations and not a drop more. This assumption of perfect operational control over flows downstream (omnipotence) is unwarranted and misleading. If operators release too little flow for a particular requirement, then they would violate the principles underlying the requirement; however, if, for whatever reason, more water is released to meet flow standards downstream than is required (e.g. because of a rainstorm of unanticipated strength, challenges in ramping suddenly between two flow levels, errors in assumptions about how flows travel between release point and compliance point, other demands for flow downstream), then the total volume of water required to meet the alternative's standards will be greater than that depicted by the red, stair-step lines in Figures 3-1 through 3-7.

Finally, the presentation of flow alternatives in the figures in Chapter 3 illustrates one of several major shortcomings of the engineered flow approach – their ability to be interpreted in ways that do not match their original intent (i.e. the ability to "game" the alternatives). The figures in Chapter 3 incorrectly suggest that flow alternatives presented by other groups in 2010 can be satisfied by lower amounts of %UIF because the periods in which flow is measured (February-June) for the UIF alternatives are mismatched to the periods in which flows are recommended (typically, March or April-May) by the engineered flow alternatives. When compared to the water theoretically available over a five month period (February-June), the amount of water necessary to satisfy any flow requirement that covers a three month period (e.g. March-May, or less) seems small. However, none of the flow recommendations analyzed in Chapter 3 were originally intended to produce a reduction in flows in the shoulder months and that is what would need to happen in order for the lower UIF alternatives to satisfy the engineered hydrographs proposed in 2010. A slightly more realistic comparison would be to display the volume of water available under different UIF proposals during the periods for which alternative flow recommendations were made (e.g. Figure 19 at p. 34 of CDFW's 2010 recommendations to the Board).

F. <u>Actual San Joaquin inflows to the Delta may be significantly less than the 35% preferred alternative modeled in the Draft SED, depending on how the objective is implemented and because the model was constrained by unjustified and unlawful caps on flow releases that are substantially below flood control requirements.</u>

The WSE Model predicts that the "35%UIF" preferred alternative will result in February through June volumes at Vernalis meeting or exceeding 35% of unimpaired flow from the basin in only

57% of the modeled years (1922-2003); in four of the years only 29% or 30%UIF from the basin is delivered at Vernalis in the preferred alternative. (SWRCB WSE Model, 2012; Figure 4). Conflating the %UIF from the three tributaries with the %UIF at Vernalis from the entire basin is misleading and confusing. The "60% alternative" (Alternative 4) only achieves 60% of the February-June UIF volume from the basin at Vernalis in 7% of years. (SWRCB WSE Model, 2012) The six years that do achieve the objective (out of an 82-year record) average only 4% more flow at Vernalis than Alternative 3—64% vs. 60%.

Pages 3-3 and 3-4 of the Draft SED (as well elsewhere in the document) imply that these %UIF from the basin versus the three tributaries are equivalent:

> *LSJR Alternative 4 has the highest level of flow, with 60 percent of unimpaired flow. The State Water Board's 2010 report, Development of Flow Criteria for the Sacramento–San Joaquin Delta Ecosystem, determined that approximately 60 percent of unimpaired flow at Vernalis February–June would be fully protective of fish and wildlife beneficial uses in the three eastside tributaries and LSJR when considering flow alone.*

This is inaccurate. The three regulated tributaries only account for 66% of the unimpaired flow at Vernalis. The preferred alternative only requires the release of 44-86% of the modeled Vernalis flow, and 27% of the Vernalis UIF. (SWRCB WSE Model, 2012).

At times, the WSE Model also underestimates the likely flow under the implementation plan. The following would tend to increase the flows in the rivers relative to the model results as presented in the Draft SED and WSE Model:

- The NMFS BO RPA minimum flows on the Stanislaus River are turned off, by default, in the model, yet these flows are required. (Draft SED, 2012, at p. L-14)

- Maximum flows in the model are overly conservative and unlawful. (Draft SED, 2012, at p. L-7; see also 6-9, 6-20, 6-21) See the section below for more detail.

- In the wetter half of the years modeled, the WSE model increases Alternative 3 diversions from the Stanislaus River over the Calsim II baseline. (Draft SED, 2012, at p. F.1-40) These increased diversions may not occur.

- At times the 20% alternative releases a higher peak flow for a short time than the 40% and 60% alternatives. (Draft SED, 2012, at pp. F.1-33-F.1-35) Anything that tends to increase reservoir storage (e.g. earlier snowmelt, agricultural efficiency) would increase these occasional spills.

The WSE Model results do not represent what is likely to occur under the implementation of the proposed objective, however the model is a helpful tool if its shortcomings are understood and its results are properly characterized. The implementation planning group will require better tools than the WSE Model and Calsim II.

In Appendix F, the Draft SED identifies maximum monthly instream flow releases, but the SED fails to provide adequate justification for these maximum flow levels . (Draft SED 2012, Appendix F.1, F.1-17). The Draft SED asserts that these maximum flow levels are "*based on channel capacities and flood control limits*," are "*selected to limit flooding effects*," and would eliminate "*the percentage unimpaired flow requirement when flows are above a level that could potentially contribute to flooding or other negative downstream effects.*" (Draft SED, Appendix F.1, F.1-16, F.1-17, F.1-24). However, these maximum flow levels are substantially lower than the flood control design capacity in these rivers and the estimated current channel capacity. (Draft SED, Chapter 6, 6-12 to 6-15, 6-21 to 6-24). These flow maxima are also well below the NOAA minor flooding stage. (Draft SED, Chapter 6, Table 6-4 and page 6-20). When converted to a monthly average flow, the NOAA flood action stage for the Merced Riveris slightly above the maximum flow, the stage for the Tuolumne is well above the maximum flow, and the stage for the Stanislaus is almost three times the maximum flow. (Draft SED, Appendix L, Table L-1 and page L-7).

River	SED Modeled Maximum Monthly Flows (cfs) (Draft SED, App. F.1-17)	SED Instantaneous Design Capacity (cfs) (Draft SED, Table 6-3)	SED Estimated Instantaneous Channel Capacity (Draft SED, Table 6-3)
Stanislaus River	2,500	12,000	8,000
Tuolumne River	3,500	15,000	15,000
Merced River	2,000	No Data	6,000

The Army Corps of Engineers, the State of California, and local levee districts have legal obligations to maintain channel capacity at flood control design levels so that flows can safely pass downstream. (*See, e.g.,* U.S. Army Corps of Engineers, 1984) The Draft SED also appropriately recognizes that "*Flooding is considered to occur at discharges greater than the channel capacities (Table 6-3), since flows greater than these would inundate areas outside the levees or floodway*," (Draft SED, 6-20) and the Draft SED appropriately concludes that Alternative 4 (60% of unimpaired flow) would not cause significant flooding impacts because flows would be lower than channel capacities and that any seepage to adjacent agricultural lands would not be a significant impact. (Draft SED, 6-24 to 6-26)

Equally important, these maximum flow levels will significantly impair the protection of salmon and other Public Trust fishery resources. For instance, these maximum flows, if implemented, would prevent combined flows from achieving 10,000 cfs monthly averages at Vernalis, which is a critical flow threshold identified by the California Department of Fish and Wildlife, the Bay Institute and NRDC, and the SWRCB as necessary to achieve the AFRP salmon doubling targets. The maximum flow caps would also significantly impair floodplain inundation in the lower river, and they would reduce geomorphic flows in the tributaries. For instance, the Draft

SED notes that on the Stanislaus River, "*gravel transport in the upper part of Reach 2 is estimated to begin in the range of 5,000 to 8,000 cfs*." (Draft SED, Chapter 6, 6-11) On the Tuolumne River, the SED asserts that floodplain inundation likely begins around 4,000 to 6,000 cfs. (Draft SED, Chapter 6, 6-13) And the Draft SED asserts that on the Merced River, floodplain inundation likely begins around 3,000-5,000 cfs. (Draft SED, Chapter 6, 6-15) The Draft SED demonstrates that these flow caps would significantly impair floodplain inundation and geomorphic flows that are necessary to protect Public Trust fishery resources. While flows may be higher during flood releases, as the Draft SED acknowledges, these maximum flow caps would make it impossible, except in flood years, to achieve the 10,000 cfs monthly flow averages at Vernalis that are likely necessary to achieve the AFRP salmon doubling targets.

In addition, the %UIF requirement that no longer applies on a 14 day average basis when these limits are reached presumably still applies on a Feb-Jun volumetric basis. The implementation plan requires that the "*total quantity of water provided over the February–June time period is not less than the required percent of unimpaired flow.* (Draft SED, 2012, at p. 3-4)" If the volume of water not released must be released before the end of June in order to meet the total February-June volume requirements of the objective, it is unclear how the objective can be met if flooding occurs at the end of June and the channel limitations are adhered to during that time.

Based on these existing requirements to maintain channel capacity and its conclusion that flows higher than the modeled maximum flows would not cause a significant flooding impact, the Draft SED does not provide a lawful justification for capping maximum flows at a level below channel capacity, where flows are substantially lower than would exist in a state of nature. We are aware of no reported case that has held that releasing flows at less than natural levels would constitute inverse condemnation or a taking of adjacent property, particularly where such flows are important to protect Public Trust fishery resources.

Contrary to the approach taken in the Draft SED, higher flows in the channel can actually lessen the risk of flooding. At times in the WSE Model (1986 & 1998 Stanislaus River; 1995 & 1998 Tuolumne River; 1993 & 2000 Merced River; 1993 at Vernalis), the 20% alternative releases a higher peak flow for a short time than the 40% and 60% alternatives. This is because the reservoirs are full at 20% and must spill, while at 40% and 60% they don't contain as much water and avoid spilling these high flows. (Draft SED, 2012, at pp. F.1-33-F.1-35) Artificially constraining the releases actually increases the peak flow and the flood risk.

The Draft SED fails to demonstrate that it is infeasible to release higher flows, which are necessary to protect Public Trust fishery resources, and it lacks a reasoned explanation for these flow levels, which are substantially lower than current channel capacities or design capacity. As such, the SWRCB should eliminate these flow maxima from further consideration in the Draft SED, and if necessary, recalculate the WSE Model without these flow maxima.

III. Analysis of %UIF flow alternatives and revised flow recommendations to the State Board

In testimony to the State Board for its 2010 Public Trust hearings, TBI et al. presented flow recommendations for San Joaquin River inflow to the Delta (exhibit #3), internal Delta hydrodynamics (exhibit #4), and Delta outflows (exhibit #2) that were based on our own analysis of data and published scientific literature relevant to the issue of freshwater flows necessary to sustain Public Trust resources in the Bay-Delta. CDFW presented flow recommendations that were intended to support attainment of the AFRP salmon production doubling targets (CDFW 2010b) for Chinook salmon. Though these flow recommendations were developed using different methodologies, they are both firmly based in the best science available on San Joaquin River fall-run Chinook salmon populations, and the recommendations are remarkably similar (they are also quite consistent with earlier recommendations of AFRP (2005) and others, that employed methodologies that were different from either TBI et al. 2010 or CDFW 2010b). Below, we demonstrate that, even under liberal assumptions regarding water availability from other sources (e.g. the San Joaquin Settlement and miscellaneous valley floor flows), the Board's proposed flow requirement (35%UIF on a 14-day running average from February-June) will not achieve conditions necessary to maintain, much less double, Chinook salmon production from the San Joaquin Basin. Worse still, recommendations that are based solely upon the needs of migrating juvenile fall run Chinook salmon in the San Joaquin River valley (i.e. CDFW 2010b), are likely to be insufficient to support the wide variety of other Public Trust benefits that would be supported by a healthy San Joaquin River (J. Shelton, CDFW testimony to SWRCB, March 2013). In other words, simply because the needs of San Joaquin River salmon are better understood than those for other species and resources does not guarantee that the flows necessary to support that fishery will be adequate to support other Public Trust resources in the San Joaquin valley or in the Bay-Delta; where possible, we have identified flows that would benefit fish other than San Joaquin Valley Chinook salmon in the analysis of flow levels below.

A. <u>Selected key flow levels necessary to support Public Trust benefits</u>

Below, we provide brief descriptions of the rationale for a variety of flow magnitudes, durations, and frequencies in the San Joaquin River at Vernalis. Despite the Board's intention to regulate flows of the San Joaquin's three tributaries in this Phase of the WQCP update, our flow recommendations are all developed with regard to Vernalis flows as that is where the San Joaquin enters the southern Delta; flow at this point is more directly related to benefits in the Delta than are flows measured upstream. This is also the area where flow levels are measured in previous studies that relate flow to specific benefits for native anadromous and resident species. Although we identify specific flow magnitudes below, it is important that the Board recognize that many measures of aquatic habitat condition or abundance improve as a continuous function of flow – flow magnitudes between and beyond those we identify provide incremental improvement in ecological response variables.

1. *Barriers to Migration – Low Dissolved Oxygen.*
   Recommended Flows: Minimum Daily ≥2000 cfs at Vernalis Year-Round

Magnitude:	Frequency:	Duration:	Timing:	Benefits:
2,000 cfs	All water year types	All year	Year Round	• Increase dissolved oxygen levels • Improve migration for salmonid and sturgeon adults and juveniles

Low dissolved oxygen and other degraded water quality conditions in the Stockton Deepwater Ship Channel can effectively close this migratory corridor for anadromous fishes. These low DO conditions are believed to block adult salmon migrations into the San Joaquin basin periodically (Hallock et al. 1970, CVRWQCB and CBDA 2006); sturgeon are particularly sensitive to low DO conditions and may die in or avoid using waterways where low DO conditions persist (CVRWQCB and CBDA 2006). As a result, each day that low DO conditions persist in the lower San Joaquin River, juvenile and adult fishes including salmon, sturgeon, and steelhead are prevented from migrating into or out of the San Joaquin basin. In our testimony to the Board in 2010 (exhibit #3, p. 25-26) we reviewed the best available evidence (e.g. Van Niewenhuyse 2002, Jassby and Van Niewenhuyse 2005) and determined that requiring base flows of 2,000 cfs throughout the year at Vernalis would be necessary to avoid low dissolved oxygen conditions (i.e. those in violation of Clean Water Act requirements) that prevent fish migration into and out of the San Joaquin River and/or use of the SDWSC and surroundings for spawning, rearing, and feeding. We stand by that previous assessment and incorporate it fully by reference. Because San Joaquin River flows are distributed among the main channel, Old River, and Middle River, between Vernalis and the SDWSC, flows at Vernalis are approximately twice the flow rates downstream in the SDWSC (i.e. at Garwood Bridge; Figure 2). Thus flows of 2000 cfs at Vernalis are expected to translate into flow rates of ~1,000 cfs that are necessary to eliminate low DO conditions in the SDWSC (Presentation by G. Fred Lee to the SWRCB, September 5, 2012, Slide #8). A more recent analysis suggests that, even following improvements to Stockton's wastewater treatment practices in 2006 and installation of a mechanical aerator, violations of the dissolved oxygen standard are most likely to occur when flows at Garwood Bridge are ≤1,000 cfs (Figure 2). Thus, having addressed other stressors that contribute to the low dissolved oxygen levels in the SDWSC (and, in so doing, lowering the flow of water necessary to maintain adequate DO levels), it is time for the SWRCB to set minimum flow standards that will contribute to elimination of dissolved oxygen violations in the lower San Joaquin River that impair Public Trust beneficial uses of the San Joaquin River and its Delta.

2. *BARRIERS TO MIGRATION – HIGH WATER TEMPERATURES.*
RECOMMENDED FLOWS: MINIMUM DAILY ≥5000 CFS AT VERNALIS, MARCH THRU MID-JUNE

Magnitude	Frequency	Duration	Timing	Benefits
5,000 cfs	All water year (wy) types	2 -3 months depending on wy type	Mar – Mid June	• Improve temperature conditions • Reduce predation

High water temperatures at Vernalis can also impede the use of the lower San Joaquin as a migratory corridor for anadromous fishes. Negative sub-lethal effects (those that may increase susceptibility to other mortality mechanisms), including reduced growth and increased predation, begin to occur at temperatures lower than a fish's lethal temperature threshold. Among juvenile fall run Chinook salmon from California's Central Valley populations, Marine and Cech (2004) found decreased growth, smoltification success, and ability to avoid predation at temperatures above 68°F. They also reported that fish reared at temperatures 62.6-68°F experienced increased predation relative to fish raised at a lower temperature range[i]. The finding of decreased performance at temperatures above 68°F is consistent with several studies that suggest optimal growth and survival among Chinook salmon occurs at temperatures somewhat lower than 68°F. Richter and Kolmes (2005) cite optimal temperatures in the range of 53.6-62.6°F from Brett et al. (1982); Independent Science Group (1996), McCullough (1999), Hicks (2000), and McCullough et al. (2001). Optimal temperatures for steelhead juvenile growth occur between 59-66.2 °F (e.g., Moyle 2002; Richter and Kolmes 2005). Temperature also mediates the impact of competition between species. For example, steelhead juveniles suffer adverse impacts of competition with pikeminnow at temperatures >68°F though no competitive impact is detectable at lower temperatures (Reese and Harvey 2002). Elevated water temperatures also inhibit the parr-smolt metamorphosis (smoltification) among salmonids. Marine and Cech (2004) found that Central Valley Chinook salmon rearing in temperatures ≥68°F suffered altered smolt physiology and other studies from within this ecosystem suggested that negative effects of temperature on the parr-smolt transition may occur at temperatures <68°F. Richter and Kolmes (2005) cited two studies that indicated negative impacts on Chinook salmon smoltification success at temperatures >63°F.

Adult Chinook salmon are also sensitive to temperatures as high as those found in the lower San Joaquin under low flow conditions. This is an issue for fall-run Chinook salmon and the Board's flow requirements during fall-run Chinook salmon migrations should account for this important sensitivity. In addition, given the plans to restore spring-run Chinook salmon to the San Joaquin River as an outcome of the San Joaquin settlement, it will be critical to provide sufficient flow and temperature conditions to facilitate adult migrations of these fish in the spring. Williams (2006) reported that migrating Sacramento River fall-run Chinook adult salmon appeared to avoid temperatures > ~66.2 °F, an observation consistent with reports for Chinook salmon from other watersheds (Richter and Kolmes 2005). Many sources recommend maintaining temperatures <68-70 °F to prevent impairment of Chinook salmon migrations (Hicks 2000, as cited by Richter and Kolmes 2005; US EPA 2003). Furthermore, the impact of water temperatures on developing embryos is not well-understood. Because the temperature tolerances of fertilized eggs are much lower than those which adult salmon tolerate, there is concern that developing reproductive tissues exposed to high temperatures may be less viable than those that are formed under cooler temperatures.

Each day that above optimal temperatures persist in the lower San Joaquin River, juvenile and adult salmonids may be prevented from migrating into or out of the San Joaquin basin. Our testimony to the Board in 2010 (exhibit #3, pp. 17-20) stated that, based on the best available evidence (e.g. Cain et al. 2003), flows of ≥5,000 cfs during the spring at Vernalis would be necessary to avoid temperatures that prevent fish migration into and out of the San Joaquin River. We stand by that previous assessment and incorporate it fully by reference.[ii]

3. *FREQUENCY OF SAN JOAQUIN RIVER FALL-RUN CHINOOK SALMON POPULATION GROWTH RECOMMENDED FLOWS: MINIMUM SEASONAL AVERAGE ≥5,000 CFS AT VERNALIS, MARCH-JUNE*

Magnitude	Frequency	Duration	Timing	Benefits
5,000 cfs	80% of years	Average Mar-June	Mar - June	Minimum threshold for Cohort Return Ratio >1 (i.e. population growth)

In addition to flows that create a migration corridor on a daily basis, sufficient average flows are necessary to support beneficial migration and rearing conditions throughout the spring. In its testimony to the State Board in 2010, TBI et al. analyzed average flow between March and June that were associated with positive population growth. Population growth was measured using Cohort Replacement Rates (CRR) that is calculated as the number of returning spawners (escapement) in a given year divided by escapement in the generation that produced it approximately 3 years earlier. When CRR is greater than 1.0, the population has grown relative to the spawning (stock) population that produced it; CRR's less than 1 indicate a population decline. We have updated this analysis here and it reveals that seasonal average flows of 5000 cfs are a threshold below which San Joaquin Chinook salmon CRR's are negative 63% of the time, almost twice as often as CRRs are positive (Figure 5). Conversely, when daily flows are >5000 cfs on average throughout the Mar-June period, the population 2.5 years later declines in only 16% of cases. This relationship between average flows and population growth rates is clearly not random in a statistical sense (Chi-square: 11.21, df=3, $p<0.05$).

Our analysis demonstrates that when flows average ≥5000 cfs from March-June, population growth occurs the vast majority of the time and when flows are lower than this threshold, population declines are far more common. The same result can be seen in a simple graph of San Joaquin River salmon production compared with seasonal average flows (Figure 1). While these analyses do not demonstrate a particular mechanism by which flows improve salmon survival through the Delta, the Board should note that these relationships are not consistent with a hypothesis that San Joaquin River salmon production is controlled by predation, unless one accepts that average flow conditions modify habitat conditions in the river and Bay-Delta in a way that favors salmon survival during years with outflow above 5000 cfs.

4. *CAPACITY OF SAN JOAQUIN RIVER TO SUPPORT AFRP POPULATION TARGETS FOR FALL-RUN CHINOOK SALMON*
RECOMMENDED FLOWS: MINIMUM SEASONAL AVERAGE ≥10,000 CFS AT VERNALIS, MARCH-JUNE

Magnitude	Frequency	Duration	Timing	Benefits
>10,000 cfs	50% of years	Average Mar-June	Mar – Jun	• Historical salmon populations associated w/ doubling goals • 102% increase in smolt abundance

We also assessed flows necessary to support escapement targets implied by the AFRP production targets for fall run Chinook salmon in the Stanislaus, Tuolumne, and Merced Rivers (i.e. the tributaries of the San Joaquin River that are influenced most by Delta inflow at Vernalis). (TBI et al. 2010, exhibit #3, pp. 14-21). We found a statistically significant correlation between escapement and seasonal flows at Vernalis 2.5 years earlier[iii].

Working independently and studying smolt survival through the Delta, rather than escapement, CDFW's modeling indicated that flows of ≥10,000 cfs maintained for 60 days in late March through the end of May were associated with an increase in smolt survival through the Delta of about 102% (i.e. doubling) in Above Normal Years (CDFW 2010; exhibit 3; Table 1). The CDFW model also predicts salmon escapement increases of 92% in Below Normal years when 10,000 cfs flows are maintained at Vernalis for 60 days between the end of March and beginning of June. In its 2010 Final Report, the State Board summarized these two analyses as follows:

> *"Available scientific information indicates that average March through June flows … of 10,000 cfs … may provide conditions necessary to achieve doubling of San Joaquin basin fall-run."*
> (Draft SED, 2010 at 119)

We originally recommended that average flows of 10,000 cfs from March through June occur in 60% of years (i.e. Wet, Above Normal, and Below Normal years). If the Board's final flow standards improve flow conditions in the drier years (i.e. such that minimum daily flows of 2000 cfs are maintained and average seasonal March-June flows are ≥5000 cfs during at least 80% of years), we believe that as few as 50% of years with average flows between March and June of ≥10,000 cfs may be sufficient to support attainment of the AFRP doubling targets for fall run Chinook salmon in the San Joaquin's three main tributaries.

5. *PRODUCTIVITY OF SAN JOAQUIN RIVER VIA INUNDATION OF FLOODPLAINS*
   RECOMMENDED FLOWS: MINIMUM DAILY ≥15,000 CFS AT VERNALIS , MARCH-MAY

Magnitude	Frequency	Duration	Timing	Benefits
>15,000 cfs[iv]	60% of years	Sufficient to maintain floodplain inundation for 1-3 months	Apr – May	• Floodplain inundation on the lower San Joaquin (between Vernalis and Mossdale) with associated benefits for fisheries

The Board is by now well aware of the benefits to native fish species of floodplains inundated in the spring for more than 14 days (e.g. for production of zooplankton; Grossholz and Gallo 2006). Chinook salmon juveniles are known to grow faster on inundated floodplains than in-river environments; subsequent survival and return of salmon that rear on inundated floodplains is also improved (Sommer et al. 2001, Jeffres et al. 2008, Katz 2012). The native endemic minnow species, Sacramento splittail rely on floodplains for spawning and early rearing (Sommer et al. 2002, Moyle et al. 2004); these fish are an important recreational and subsistence fishery in the Delta and an important component of the Delta foodweb. Other species, such as Sacramento blackfish, rely on floodplains for spawning and rearing as well (Moyle 2002).

Restoration of inundated floodplains in the San Joaquin basin would make a significant contribution to conservation and management of floodplain-dependent species, including invertebrates that fish and migratory birds eat. Currently, floodplain habitat in the San Joaquin system is extremely limited. For example, most of the remaining spawning habitat for Sacramento splittail is found on the Yolo bypass in the Sacramento River basin. As a result, this species' geographic range (already extremely limited) is artificially constrained to a fraction of its former range; this places Sacramento splittail at greater risk of extinction due to localized catastrophic events. (e.g. Rosenfield 2002).

In our previous recommendations to the Board, we recommended that flows which currently produce floodplain inundation (20,000-25,000 cfs) be required for at least 15 consecutive days during April and May in 60% of years. Our recommended duration increased as unimpaired runoff increased because the benefits associated with floodplain inundation increase as duration increases (Sommer et al. 2004). In reality, whereas inundation must be continuous for the known desired benefits of floodplain inundation to accrue, the in-river flows that produce inundation may be staggered throughout the inundation period; how long a floodplain remains inundated when flows are below flood level depends on the size and shape of the floodplain and the amount of water that spills onto it during any given event. The recommended season of inundation is important as the fish and wildlife that use inundated floodplains are most likely to benefit during March-May – for example, temperatures on a floodplain during June are likely to exceed levels tolerable to Chinook salmon smolt.

Although, San Joaquin flows of ≥20,000 cfs are believed necessary for floodplain inundation given current flood control infrastructure (e.g. levees), we now believe that targeted floodplain restoration efforts (e.g. levee modification) could produce desirable levels of floodplain inundation at ~15,000 cfs (J. Cain, American Rivers, unpublished analysis). This is an excellent example of the ability to reduce the volume of water necessary to support Public Trust benefits via implementation of complimentary non-flow measures. Successful substitution of non-flow measures for increased freshwater flows are not common and should be seized whenever they are available. Of course, the benefits of floodplain inundation will not be realized until both the necessary floodplain modifications are designed, permitted, and implemented and the flows necessary to inundate the modified floodplains are provided. Nevertheless, we have modified our flow recommendations so that flows of 15,000 cfs (rather than 20-25,000 cfs) occur for the duration and during the time frame previously recommended for floodplain inundation benefits[v].

6. *MIGRATION OF ADULT FALL RUN CHINOOK SALMON*
   RECOMMENDED FLOWS: DAILY FLOWS ≥3500 CFS FOR 10 DAYS IN LATE OCTOBER

The current Draft SED is silent on the need for improved fall pulse flows to attract returning adult fall-run Chinook salmon spawners. This runs contrary to the Board's previous findings that:

> *Even in the absence of exports, it is necessary for the scent of the San Joaquin basin watershed to enter the Bay in order for adult salmonids to find their way back to their natal rivers. (NMFS 2009, p.407 as cited in EDF 1, p. 48.)*
> SWRCB 2010 at p. 56).

A recently published paper on the relationship between fall San Joaquin River flow levels and straying of salmon spawned in the San Joaquin Valley into other waterways found:

> *SJR salmon stray rates were negatively correlated (P = 0.05) with the average magnitude of pulse flows (e.g., 10 d) in mid- to late-October and positively correlated (P = 0.10) with mean Delta export rates. It was not possible to differentiate between the effects of pulse flows in October and mean flows in October and November on stray rates because of the co-linearity between these two variables. Whether SJR-reduced pulse flow or elevated exports causes increased stray rates is unclear. Statistically speaking the results indicate that flow is the primary factor. However empirical data indicates that little if any pulse flow leaves the Delta when south Delta exports are elevated, so exports in combination with pulse flows may explain the elevated stray rates.*
> (Marsten et al. 2012, Abstract)

Given these recent findings and those presented to the Board in earlier testimony (e.g. CDFW 2010 and NMFS 2010), we support the State Board's 2010 finding that:

> *Analyses support a range of flows from 3,000 to 3,600 cfs for 10 to 14 days during mid to late October. Absent additional information, the State Water Board determines flow criteria for late fall to be 3,600 cfs for a minimum of 10 days in mid to late October. Providing these flows from the tributaries to the San Joaquin River that support fall-run Chinook salmon appears to be a critical factor to achieve homing fidelity and continuity of flows from the tributaries to the mainstem and Delta. Until additional information is developed regarding the need to maintain the 2006 Bay-Delta Plan October flow objective, these flows supplement and do not replace the 2006 Bay-Delta Plan October flow requirements such that flows do not drop below historic conditions during the remainder of October when the pulse flow criteria would not apply. Additional analyses should be conducted to determine the need to expand the pulse flow time period and modify the criteria to better mimic the natural hydrograph by coinciding pulse flows with natural storm events in order to potentially improve protection by mimicking the natural hydrograph.*
> (Draft SED 2010 at p. 121)

7. *UIF-14D RUNNING AVERAGE: CONTINUITY OF FLOWS FROM NATAL STREAM THROUGH THE DELTA AND FLOW VARIABILITY.*

In its 2010 Flow Report, the Board proposed flow standards that tracked the unimpaired hydrograph in two ways. Applying a consistent %UIF to San Joaquin River flows will lead to a distribution of flow conditions that tracks the inter-annual hydrology of this basin, i.e. the distribution of wetter and drier years experienced by fish will be more similar to the actual hydrological pattern than it is now. In addition, the Board recommended that flows in the River track the 14-day running average of flows into the rim stations. This running average establishes a proportional hydrograph such that the intra-annual (daily or weekly) timing of flows approximates that which occurs in nature. As described above, restoring the correspondence of flow timing with species' evolved natural histories and the timing of other environmental variables (e.g. day length, temperature) will have many benefits for fish and wildlife species, including those for which data regarding flow requirements are currently lacking.

Another benefit of the proportional hydrograph approach is that it can potentially restore some of the high variability in flows that once characterized the San Joaquin hydrograph. High variance or "flashy" flows result in very high magnitude, short duration flows that are capable of performing significant and necessary geomorphic work (i.e. cleaning and moving gravel, reshaping floodplains and backwater channels). These infrequent, high magnitude flows have been virtually eliminated from the San Joaquin River and its tributaries following the development of dams and diversions (Figure 6). A 14-day averaging period will restore some of this very important variation; we concur with CDFW's recommendation (offered during the March 2013 Phase 1 hearings) that a shorter averaging window should be considered during the program of implementation as shorter averaging windows can produce even more variation in flow than is likely under a 14-d window (Figure 7).

B. Our analysis of the SED's preferred alternative demonstrates that 35%UIF flow provided on a 14-day running average of rim station inflows will not provide conditions necessary to achieve the AFRP anadromous fish doubling objectives or other critical conditions necessary to sustain Public Trust benefits in the San Joaquin River or Bay-Delta. Rather, our analyses indicate that maintenance of at least 50%UIF (and preferably 60%UIF) will be necessary to support the Public Trust, particularly in Above Normal and drier year types.

Based on the State Board's framework of a %UIF from the San Joaquin's three main tributaries applied from February through June as a 14-day running average, we developed a spreadsheet model that employed historical daily flow data to project the effect of various %UIF's on attainment of key flow levels at Vernalis (described above). Assumptions of our model are described in Appendix 1 and we are happy to provide our model and data inputs to the State Board so that it can be used to model additional variants of desirable flow recommendations. Key inputs and assumptions of our model include:

- %UIF applied only and equally to the three tributaries
- Friant settlement flows (estimated at the confluence of the Merced River) reach Vernalis and are unchanging within a given month/Water Year type[vi]
- 100% of miscellaneous & valley floor flows reach Vernalis
- No caps are applied to tributary flows
- 1962-2011 data set
- Daily attainment of key flows levels reflects number of days the 14-d running average exceeded flow target
- WY Types represent 20% exceedence bands (e.g. Wet years =81-100%, Above Normal =61-80%, etc.)
- "Loose" interpretation of flow duration (i.e. key flows begin as recommended but may occur thru 6/15 regardless of recommended end date)

Clearly, our model assumptions are liberal (best case scenario) with regard to the amount of water that reaches Vernalis during the spring period. For example, there is no guarantee that flows prescribed under the San Joaquin settlement will reach Vernalis. Similarly, if flood control caps are applied to the tributaries this will tend to reduce the frequency and duration of high magnitude flows compared to those projected by our model.

Using this daily flow model we were able to assess how well different %UIFs applied to the three tributaries were able to meet the duration and frequency of beneficial flows (identified above) that we recommended in our 2010 engineered hydrographs (as modified here)[vii]. Our metrics for attainment of desired flow conditions were:

- For seasonal average flows (5,000 cfs and 10,000 cfs March-June), the frequency (number of years) with which the target flow level was exceeded in our 50 year data set

- For daily minimum flows (2,000 cfs, 5000 cfs, and 15,000 cfs), we measured

    - the number of days in the median year of a WY type that the 14-day running average of flows exceeded the target flow level ("duration") and

    - the number of years in a given WY Type that the recommended duration of a key flow level was met completely ("frequency").

In both cases, the "loose" interpretation of flow timing is a liberal assumption because it allows for attainment of a key flow level during a longer time window than anticipated in our original flow recommendations (where flow levels were continuous for a given duration).

Our analysis of the best available science on the ecology of fish and other Public Trust benefits of the San Joaquin River and south Delta indicate that flows ≥50-60%UIF are needed during the March-June period to achieve flow conditions of sufficient magnitude, duration, and frequency to attain salmon production targets identified in the AFRP, support the restored population of spring run Chinook salmon, recover steelhead populations in the San Joaquin Basin, allow for salmon and sturgeon to use the lower San Joaquin River as a migratory corridor, etc. Even at these levels of flow, the frequency and duration of floodplain inundation recommended by TBI et al or CDFW will require "shaping" of the hydrograph (i.e. deviation from a strict 14-d running average). Manipulation of the lower San Joaquin River hydrograph to produce floodplain inundation and other high magnitude flows necessary to support ecosystem function is facilitated by increases in the volume of the water budget (%UIF) applied to the San Joaquin's tributaries.

Furthermore, although changes to Delta outflow requirements and OMR criteria are not being considered in Phase 1, the SWRCB has indicated that neither the Phase 2 proceedings nor the subsequent modification of water rights permits will consider further changes in San Joaquin River minimum flow standards. Thus, it is essential that the %UIF allocated towards Delta inflow from the San Joaquin River support improved water quality and ecological conditions in the Delta and help attain Delta outflow conditions that the Board may find necessary in Phase 2. We note here that recent San Joaquin River flows as a fraction of Delta outflow are far less than the River's unimpaired flow compared to unimpaired Delta outflow – in other words, more of the San Joaquin's UIF is diverted before it reaches the Delta than is the case for other Central Valley rivers (Table 2).

1. *ATTAINMENT OF MONTHLY AVERAGE FLOWS*

We plotted exceedence curves of average March-Jun flows for various levels of UIF. The 35%UIF exceedence curve is expected to produce average flows ≥5,000 cfs in ~57% of years (Figure 8). This is more frequent than the status quo of 35%. However, 57% is well short of our target frequency for this level of flows. Population growth for Chinook salmon must occur in ~75% of years to attain AFRP production targets within a reasonable time frame (12-15 years). Under current conditions, San Joaquin River population growth occurs in more than ½ of years (~55%); the fact that the San Joaquin fall run Chinook population continues to decline despite relatively frequent population growth reveals that years with population declines are too frequent and too dramatic to be overcome by the years when the population does grow. Given the frequency of population growth (CRR >1.0) that occurs when flows are above and below 5000 cfs (Figure 5), average flows ≥5,000 cfs must occur in at least 80% of years[viii] in order to attain positive CRRs in 75% of years. In order to achieve flows >5000 cfs on average between March and June in 80% of years, ~55%UIF is required (Figure 8). We note that, if the San Joaquin River delivered 75% of its UIF to the Delta as the Sacramento River does, this seasonal average flow target would be attained even more frequently than our target.

We used a similar analysis to evaluate the frequency of seasonal average flows ≥10,000 cfs. For this key flow target, the 35%UIF alternative results in fewer years of attainment (~1 year in 6) than the status quo (~1 year in 5). Both are far less than the target frequency for this key level of seasonal flows (Figure 9). In order to attain AFRP population targets, Mar-Jun average flows of at least 10,000 cfs should occur in approximately half of years. Such levels of flow were common in the past (Figure 1). Attaining this target for flows that will support the AFRP population targets for fall-run Chinook salmon will require a fraction of UIF >60% (Figure 9); historically, this proportion of San Joaquin Valley UIF flowing past Vernalis on a seasonal basis was more common (Figure 10).

2. *ATTAINMENT OF KEY DAILY AVERAGE FLOWS*

We used our daily flow model to estimate the number of days when the 14-day running average of flows would exceed 2,000, 5,000, 10,000, and 15,000 cfs. This kind of analysis is not possible with the SED's WSE model because that model is based on monthly average flows.

In our model, daily flows of 2,000 cfs during March-June are attained in almost all years when flows are >35%UIF. When flows are 35%UIF, more than 10% of days in the March-June period have flows less than 2,000 cfs in the driest 20% of years – this suggests that the barrier to salmon and sturgeon migration caused by low dissolved oxygen will continue to be a problem during the driest years under the Board's 35%UIF alternative. <u>We recommend that the Board adopt a minimum Vernalis flow standard of 2,000 cfs year round (in combination with the improvement in the City of Stockton's wastewater treatment operations and implementation of an aerator that have already occurred) to prevent low dissolved oxygen conditions in the Stockton Deepwater</u>

<u>Ship Channel.</u> Our analysis indicates that such a standard will be relatively easy to attain under all but the lowest flow conditions (i.e. 35%UIF in the driest 20% of years).

In our model of daily flows, 5,000 cfs daily flows are not attained during any days during the median critical year at 35%UIF (Figure 11); such flows are attained less than half of the days recommended in the median Dry year under a 35%UIF water budget. The recommended duration of 5,000 cfs flows is achieved in only 7 of 10 below normal years under a 35%UIF and the (mostly liberal) assumptions of our daily flow model (Figure 12). At 50%UIF, the recommended duration of 5,000 cfs daily flows is attained in the median years of dry, below normal, above normal, and wet[ix] years types (Figure 12). At 50%UIF, the recommended duration of 5,000 cfs flows are attained in half of Dry years, all Below Normal years, and almost all Above Normal years (Figure 12). At 60%UIF, the full duration of 5,000 cfs flows are attained in all Above Normal and Below Normal years and in 9 of 10 Dry years (Figure 12); 5,000 cfs flows occur in some days of the median Critical year type under a 60% water budget. Thus, flows that remove the temperature barrier for migrating juvenile Chinook salmon occur far less than is recommended in most years and not at all in many years under a 35%UIF water budget; the temperature barrier to migration is broken, at least partially, when flows at Vernalis are ~60%UIF on a 14-day moving average (assuming, as our model does, that flows from the San Joaquin River above the Merced make it to Vernalis).

In our model of daily flows, under a 35%UIF water budget, daily flows ≥10,000 cfs occur in less than 80% of the recommended days for a median Above Normal year; such flows do not occur in the median Below Normal or Dry Years[x] (Figure 11). As with flow required to produce suitable temperatures for migrating juvenile salmon (5,000 cfs, above), flows necessary to achieve recommended durations of 10,000 cfs daily average flows do not occur in Dry years until the water budget approaches 60%UIF. The full duration of 10,000 cfs flows occurs in all Above Normal years when the water budget is 50%UIF, but the recommended duration is attained in less than half of Below Normal and none of the Dry years under such a water budget (Figure 12). Thus, daily average flows >10,000 cfs occur far less than is recommended or not at all in most years under a 35%UIF water budget; a water budget of ~55%UIF is required to produce the recommended duration for these flows in more than half of Below Normal years and at least a few days in some Dry years.

Our model of daily flows shows that flows required to inundate a modified floodplain (15,000 cfs daily average flows) are very difficult to produce under a strict application of the proportional hydrograph approach (%UIF + 14-day moving average) described in the Draft SED. The full duration recommended for such flows does not occur in any year until the water budget approaches ~60%UIF and then, only in a fraction of Above and Below Normal years (Figure 12). The challenge is illustrated in Figure 13. Daily average flows ≥15,000 cfs resulting from a 14-d average hydrograph do not occur on any days in the median Above Normal year until the water budget exceeds 45%UIF (it is worth noting that floodplains must remain inundated for at least 14-21 days to produce much of the benefits associated with this phenomenon (Grosholz and Gallo 2006)). Floodplain inundation does not occur at all in the typical (median "Below Normal" = 50% exceedence) year until the water budget exceeds 50%UIF. Attainment of the TBI recommended duration of floodplain inundation requires a water budget 60% < UIF <75%[xi]. We emphasize here that (a) the duration recommended for each of our key flow levels has already been tailored to reflect different hydrological conditions (e.g. shorter durations in drier years) and (b) our floodplain inundation recommendations have been revised here to reflect physical modification of floodplains in the lower San Joaquin Valley (greater levels of flow will be required to realize benefits from inundated floodplains under current conditions of river and floodplain geometry). Thus, we recommend that the State Board allocate >60%UIF in some Below and Above Normal years and/or modify the 14-day moving average standard such that floodplain inundation flows can be "engineered" using water available in a budget that is greater than 50%UIF; crafting appropriate deviations from the simple proportional flow standard is an excellent topic to explore during the program of implementation.

<u>Summary</u>: A water budget of less than 50%UIF delivered at Vernalis as a 14-day moving average of inflows to the rim stations on the Stanislaus, Tuolumne, and Merced Rivers will not achieve the minimal level of habitat improvement necessary to protect Public Trust resources of the San Joaquin River valley and the Bay-Delta. A water budget of 60%UIF should be adequate to attain necessary protections in most (but not all) years. An adaptive management range that includes values somewhat less than 50%UIF (e.g., no less than 40%UIF) may be justified, if exercised only if and when new scientific information clearly demonstrates that population viability targets can be achieved at the lower end of the range. Under any water budget and approach to generating a proportional hydrograph, minimum flows of 2000 cfs at Vernalis should be maintained throughout the year and real-time management flexibility sufficient to produce floodplain inundation flows should be developed. Flow caps on tributary rivers should be only those necessary to protect human life and property; the flow caps identified in the Draft SED are far too stringent to allow for protection of the Public Trust. Finally, a 10-d flow pulse of >3500 cfs in late October or early November should be provided in all years as an attraction flow for migrating fall-run Chinook salmon and Central Valley steelhead.

<u>Recommendations: Revise Appendix K to read as follows:</u>

Table 3 (to be inserted here - see our Appendix 1, Table 3 for revised text)

February through June Flows Requirements

Thus, the State Water Board has determined that at least 50 percent of unimpaired flow is required from February through June from each of the Merced, Tuolumne, and Stanislaus Rivers on a 14-day running average, unless otherwise approved by the State Water Board through the adaptive management framework described below. This flow is in addition to flows in the LSJR from sources other than the Merced, Tuolumne, and Stanislaus Rivers. The 50 percent of unimpaired flow requirement would not apply when such flows would exceed levels that would cause or contribute to flooding or other related public safety concerns as determined through consultation with federal, state, and local agencies and other appropriate interests with expertise in flood management.

In addition, the State Water Board has determined that base flows of 2,000 cfs on a 14-day running average are required at Vernalis on the LSJR at all times during the February through June period. If the base flows at Vernalis are reduced below 2,000 cfs, then water needed to achieve the base flows should be provided on a basis relative to the average February through June unimpaired flow contributions from each of the Merced, Tuolumne, and Stanislaus Rivers until the base flows reach 2,000 cfs at Vernalis. Specifically, the Merced shall provide 24 percent, the Tuolumne 47 percent, and the Stanislaus 29 percent of the flow needed to achieve a base flow of 2,000 cfs at Vernalis unless otherwise approved through the Implementation Plan or adaptive management processes described below.

(Pp. 3-4 of 11, App. K)

Annual Adaptive Management of February through June Flow Requirements
The February through June percent of unimpaired flow requirement described above may be adaptively managed on an annual basis in order to achieve the narrative LSJR flow objective as measured by the indicators of population viability and to minimize water supply impacts, as described below, subject to the approval of the California Department of Fish and Wildlife, NOAA Fisheries, the U.S. Fish and Wildlife Service, and the Executive Director of the SWRCB. Any adaptive management of flows must not result in flows of less than 50 percent of unimpaired flow from each of the Merced, Tuolumne, and Stanislaus Rivers over the entire February through June period. Specifically, instantaneous flows and monthly, daily, and 14-day running average flows may be changed over the particular averaging period on each tributary as long as average flows over the entire five-month period are no less than 50 percent of unimpaired flow on each tributary. This flow is in addition to flows in the LSJR from sources other than the Merced, Tuolumne, and Stanislaus Rivers. At all times, base flows must be met. The adaptive management of flows does not have to rely on the unimpaired flow percentage method, but instead can use pulse flows or other management approaches, as long as the requisite unimpaired flow percentage for the entire February through June period is met.

(P. 4 of 11, App. K)

Long-term Adaptive Management of February through June Flow Requirements

Specifically, the State Water Board may use subsequently developed information to approve modifications to the required base flow, percentage of unimpaired flows, and upper end of flows at which a percentage of unimpaired flows are no longer required. The required percentage of unimpaired flow may range between 40 and 60 percent of unimpaired flow from any one tributary over the entire

> *February through June period, based on progress toward attaining population viability targets, and the base flows at Vernalis may range from 1800 to 2200 cfs. The Executive Director of the State Water Board may approve a request made by the COG for such modifications that has also been approved by the California Department of Fish and Wildlife, NOAA Fisheries, and the U.S. Fish and Wildlife Service. Any modification to the February through June flow requirements do not have to rely on the unimpaired flow percentage method, but instead can use other management approaches (such as requiring specific flow levels to support identified ecosystem functions achieved at those levels), as long as the total quantity of water that would be provided over the entire February through June period is between 40 percent and 60 percent of unimpaired flow.*
>
> (P. 5 of 11, App. K)

IV. The adaptive management decision-making process is inadequately defined, and could generally result in lower flows than necessary.

With respect to the adaptive management decision-making process, the Program of Implementation proposes to establish a Coordinated Operations Group (COG) that would inform actions to implement the narrative lower San Joaquin Flow objective. (Draft SED, Appendix K, at 4-5) The draft program of implementation provides that the decision-making process would be developed over the next year, but there are significant flaws in the draft program of implementation regarding adaptive management that should be revised now.

First, the draft seems to make it far easier to reduce flows than to increase flows, and it does not explicitly require achievement of any targets or benchmarks to make adaptive management changes. The draft states that adaptive management must only ensure flows no less than 25% of unimpaired flow (Draft SED, Appendix K, at 4), but it establishes no criteria or targets, nor does it require consensus of the COG, to allow flows to be reduced below current levels. On the other hand, the draft states that all parties of the COG must agree to adaptive management changes that increase the total amount of flows through adaptive management. (Draft SED, Appendix K, at 5) At a minimum, the agreement of all the state and federal wildlife agencies that are on the COG should be required before the Board approves any reductions in flows through adaptive management. At the same time, requiring consensus of the COG to increase the volume of flows in a year will almost certainly result in paralysis and is inconsistent with a science-based adaptive management program.

Second, the draft seemingly allows for substantial changes to the base flow, the range of unimpaired flows, "*percentage of unimpaired flows, and the upper end of flows at which a percentage of unimpaired flows is not required*" at the Board's "discretion." (Draft SED, Appendix K, at 5) However, the draft SED identifies no criteria, benchmarks or other limitations on the Board's discretion. As a result, this language could be used to make changes that were never analyzed in the SED and that are not consistent with the achievement of the narrative objective.

Third, the draft seems to state that flows within the 25-45% range would constitute compliance with the water quality control plan, even if the flows are lower than the unimpaired flow requirement in effect that year, stating,

> *The State Water Board recognizes that an adaptive management plan may not be able to accurately forecast conditions that may actually occur during the February through June period. Accordingly, as long as the approved adaptive management plan is designed to achieve the applicable unimpaired flow range described above, compliance with the plan will be deemed compliance with those flows.*

(Draft SED, Appendix K, at 5). However, this approach would likely result in flows substantially lower than the percentage of unimpaired flows applicable that year, could result in flows lower than the 25% range, and could be read as suggesting that implementing 25% of unimpaired flows is achieving the narrative objective. None of these interpretations is lawful or good public policy. This sentence should be stricken.

An effective adaptive management scheme should require the input of all stakeholders, should be directly linked to achieving biological criteria and targets (including AFRP production targets), and should require the agreement of all the state and federal fish and wildlife agencies before making adaptive management changes that reduce flows or change flow schedules within a year.

Recommendation: The program of implementation in Appendix K should be revised as follows:

> *Compliance with the plan will be deemed compliance with the initial, default percentage of unimpaired flow identified in the program of implementation. However, the percent of unimpaired flow requirement described above may be adaptively managed on an annual basis within the range identified in the program of implementation in order to achieve the narrative LSJR flow objective, as measured by the indicators of viability contained in footnote [x] to Table 3, and to minimize water supply impacts consistent with attainment of these indicators, subject to the approval of the California Department of Fish and Wildlife, NOAA Fisheries, the U.S. Fish and Wildlife Service, and the Executive Director of the SWRCB.*

V. The Draft SED fails to accurately assess impacts to all beneficial uses, fails to provide a rational basis for its choice of balancing of beneficial interests, and fails to meet the board's obligations under the Public Trust

In order for the Board to fulfill its obligations under the Public Trust, the California Environmental Quality Act, the Porter-Cologne Water Quality Control Act, and other statutes, the SED must accurately assess the relative impacts to agricultural resources, aquatic resources, groundwater, and other resources; it must provide a reasoned basis for the Board's balancing of beneficial interests; and it must demonstrate that the Board is protecting the Public Trust to the extent feasible. Unfortunately, as discussed below, the Draft SED fails to do so.

A. The analysis of agricultural and socioeconomic impacts is flawed and overstates impacts

The Draft SED provides a detailed analysis of potential water supply impacts, and uses commonly accepted modeling tools to assess the agricultural and socioeconomic impacts of reduced surface water diversions.

As shown in Table ES-6, the Draft SED concludes that Alternative 3 (40% of unimpaired flow) would result in a 1.5% reduction in crop revenues, a 7% reduction in irrigated acreage, and a 1.5% reduction in agricultural employment (including indirect and induced employment), and that Alternative 4 (60% of unimpaired flow) would result in a 4.5% reduction in crop revenue, a 16% reduction in irrigated acreage, and a 4.5% reduction in agricultural employment.

In addition, Appendix G shows that the marginal revenue loss from a 50% alternative would be only slightly higher than the 45% alternative, while 55% and 60% alternatives have significantly higher marginal revenue losses. (Draft SED, Appendix G, G-28) Unfortunately, the Draft SED does not provide estimates of impacts under a 50% alternative, but the February 2012 draft of the technical appendix on agricultural economic effects found that a 50% of unimpaired flow alternative would result in a 2.8% reduction in crop production and related sector revenue (p. X-30) and employment (p. X-32).

As one of the peer reviewers of the 2012 technical appendix on agricultural economic effects noted, it is important to recognize that the percentage changes in employment and revenue in the SED do not show reductions in total employment and revenue in the region; the peer reviewer wrote, "*I believe it may be misinterpreted as a relative change in overall economic activity in the region rather than a relative change only in the activity associated with agriculture.*" (Braden, 2012) In other words, a 1.5% reduction in agricultural employment is not a 1.5% reduction in overall employment in the region.

Importantly, the Draft SED explicitly recognizes that it likely overestimates the economic impacts of the alternatives analyzed:

> *Input-output analysis approach employed by IMPLAN usually overestimates indirect job and income losses. One of the fundamental assumptions in input-output analysis is that trading patterns between industries are fixed. This assumption implies that suppliers always cut production and lay off workers in proportion to the amount of product supplied to farms or other industries reducing production. In reality, businesses are always adapting to changing conditions. When a farm cuts back production, some suppliers would be able to make up part of their losses in business by finding new markets in other areas. Growth in other parts of the local economy is expected to provide opportunities for these firms. For these and other reasons, job and income losses estimated using input-output analysis should often be treated as upper limits on the actual losses expected (SWRCB 1999).*

(Draft SED, Appendix G, p. G-29) (emphasis added)

Despite this very important acknowledgment, while the analysis uses generally accepted models and methods, there are several flaws in the analysis that can be remedied which will likely provide a more accurate estimate of potential agricultural impacts and likely demonstrate that the effects are overestimated in the SED:

- The Draft SED ignores the potential for improved agricultural water use efficiency to mitigate effects in terms of agricultural revenues, employment and acreage.

- The Draft SED ignores the history of extensive water transfers from the tributaries, resulting in overestimating agricultural production under the baseline and likely future conditions.

- The Draft SED is internally inconsistent regarding groundwater pumping, assuming no increases in groundwater pumping in its analysis of agricultural impacts but also assuming substantial increases in groundwater pumping in its analysis of groundwater impacts.

- The Draft SED's threshold of significance for water supply impacts is flawed, as it assumes significant agricultural impacts under baseline conditions but ignores significant aquatic resources impacts under baseline conditions.

- The Draft SED ignores the potential for water rights holders to obtain compensation through transfer agreements with export water users in the Delta to allow them to export some of this water.

Each of these points is discussed further below. As currently drafted, the analysis overstates agricultural impacts and understates the benefits of reduced diversions and increased flows under Alternatives 3 and 4. The Board appears to recognize that the Draft SED presents a worse case scenario that is unlikely if not impossible to occur, but this 'worse case' approach does a grave disservice to the public information goals of the California Environmental Quality Act. The public and decision-makers deserve an accurate assessment of the potential impacts and benefits of the alternatives, and the Board should revise the Draft SED to address these flaws.

B. The Draft SED ignores potential improvements in agricultural water use efficiency that can reduce agricultural impacts

While agricultural users have improved water use efficiency across California over the past several decades, it is clear that there are still substantial gains to be achieved and that improvements in agricultural water use efficiency can reduce the impacts of reduced water diversions. The executive summary of the Draft SED very briefly acknowledges that improved agricultural water use efficiency as a potential mitigation measure that can "*reduce impacts to agriculture and GHG emissions.*" (Draft SED, at ES-41) In chapter 11, the Draft SED acknowledges that improved irrigation efficiency can be used to "*replace or augment some of the lost surface water supply*" and to reduce groundwater pumping, and that, "*Implementing irrigation efficiency measures is expected to reduce overall the amount of irrigation water needed by more efficiently applying the water to crops.*" (Draft SED, at 11-26 to 11-27) The Draft SED includes 3 potential water use efficiency tools: increased use of irrigation management services to determine how much water is needed and when to apply it; conversion to more efficient irrigation systems; and increased delivery flexibility. (Ibid)

The Draft SED also relies on information from DWR to estimate the current types of irrigation practices in the Basin. (Draft SED, at 11-9) Table 11-6 demonstrates that between 33% and 57% of irrigation systems in the basin use less efficient surface methods of irrigation, including flood irrigation (as opposed to sprinkler, drip, or microirrigation). However, while the Draft SED acknowledges that improved efficiency can reduce impacts and identifies several water efficiency tools, it wholly fails to analyze the impacts of improving water use efficiency.

We contracted with the Pacific Institute to provide a detailed analysis of the potential water savings and economic effects of improved agricultural water use efficiency in the San Joaquin Basin. In the attached report, the Pacific Institute analyzed the effects of increased use of the California Irrigation Management Information System (CIMIS, the irrigation management system developed by the Department of Water Resources), conversion to more efficient irrigation systems, and use of regulated deficit irrigation. The Pacific Institute report only looked at the 10 Detailed Analysis Units (DAUs) that are included in the Draft SED, and relied on information from the Draft SED, the Department of Water Resources, and County Commissioner reports.

In the attached report (Exhibit 4) the Pacific Institute concluded that improved agricultural water use efficiency can result in significant water savings, which can reduce the impact of reduced water diversions:

- **Regulated Deficit Irrigation Scenario:** Regulated deficit irrigation is the strategic application of less water than full crop water requirements (evapotranspiration, or ET).

For instance, a recent study in the Central Valley found that regulated deficit irrigation resulted in significant water savings (11%), with no effect on crop yields for almonds. With other crops, regulated deficit irrigation can reduce water use substantially more than reduced yield (for alfalfa, studies show an average of 29% water savings resulted in a 13% reduction in yield.). This scenario examined the potential water supply savings from implementing regulated deficit irrigation on 25% of the alfalfa, almond/pistachio, and vineyard acreage in DAUs 205-215, using prior studies with these crops to estimate potential water savings and effects on crop yields. The report estimates that over the past decade, this level of regulated deficient irrigation could have saved nearly 100,000 acre feet on average each year, with greatest savings in the wettest years.

- **Conversion to More Efficient Irrigation Systems Scenario:** Improved irrigation efficiency can reduce potential nonconsumptive water use associated with irrigation. For instance, the average increase in water use efficiency between flood and sprinkler irrigation is approximately 5%, and the average water use efficiency improvement between sprinkler and drip is approximately 11%. This scenario examined the potential water savings associated with shifting 10%, 15%, or 20% of field crops acreage in DAUs 205-215 from surface irrigation to sprinklers, and from shifting 10%, 15%, or 20% of orchard acreage in DAUs 205-215 from sprinkler irrigation to drip irrigation systems. The scenario estimated potential applied water savings ranging from 60,000 acre feet to 173,000 AF, depending upon how much acreage is converted to more efficient irrigation systems.

- **Increased use of the CIMIS Scenario:** CIMIS is an integrated network of automated weather stations throughout the state that is designed to provide more accurate assessments of crop water needs. A 2000 survey by the Department of Agriculture and Resource Economics at UC Berkeley found that the use of CIMIS statewide resulted on average in a 13% reduction in water use and an 8% increase in crop yields (Parker, 2000). This scenario applied the 13% reduction water use to 25% of irrigated acreage in DAUs 205-215, finding that potential water savings could exceed 160,000 acre feet. While the authors caution that there is significant uncertainty regarding potential water savings associated with expanded use of CIMIS due to the lack of more recent studies, they suggest there are significant potential water savings and increases in yield that could result from increased use of CIMIS and other tools that improve irrigation scheduling.

These findings demonstrate the improving agricultural water use efficiency can improve crop yields and revenues, reduce declines in irrigated acreage, and otherwise reduce impacts from reductions in surface water supplies necessary to protect fisheries. It is important to recognize that the potential water savings from these three scenarios are not additive. In order to accurately assess potential impacts, the Board should revise the Draft SED's analysis of impacts to include implementation of improved agricultural water use efficiency practices, based on the findings in this report. In addition, the Board should include improved agricultural water use by local water districts in the final Program of Implementation.

C. <u>By ignoring historical water transfers out of the basin during the baseline period, the Draft SED overstates potential agricultural impacts</u>

When properly implemented, water transfers can constitute a beneficial use of water that helps optimize water use throughout the state. (See Water Code §§ 475, 1040, 1244) However, in assessing potential impacts of reduced water diversions in the Draft SED, the Board must acknowledge and account for existing and recent water transfers out of the basin. If those water transfers are not considered, the Draft SED likely overestimates potential agricultural impacts.

The Draft SED's baseline and no project alternative include compliance with the 2006 Bay-Delta Plan and D-1641, the 2009 NMFS biological opinion, and current levels of water development and demand. (Draft SED, 4-8, 4-11 to 4-12; SED, Appendix D, D-4) However, from 1999 to 2011, water users in the basin were transferring up to 110,000 acre feet per year to meet flow requirements at Vernalis pursuant to the implementation of the Vernalis Adaptive Management Plan. (Revised Water Rights Decision 1641, at 14) Not only did this result in increased flows on the Merced and Tuolumne River as compared to the no project alternative, but those transfers also resulted in reduced surface water diversions available for agricultural use in the basin. (Draft SED, Appendix D, D-19 to D-21)

More recently, water districts in the basin have proposed and concluded numerous water transfers that sent water out of the basin in wet and dry years. We have identified the following proposed and executed water transfers out of the basin in recent years:

- The transfer of up to 55,000 acre feet from OID, SSJID, MID, Modesto ID, and TID to SLDWMA in 2009;

- Merced Irrigation District's transfer of 15,000 acre feet in 2010;

- Merced Irrigation District's transfer of 6,000 acre feet in 2011;

- Merced Irrigation District's transfer of up to 90,000 acre feet to the Bureau of Reclamation in 2012 and 2013 to meet Vernalis flow requirements

- Merced Irrigation District's transfer of 10,000 acre feet to the Westlands Water District in 2012

- Modesto Irrigation District's proposed transfer of 2,240 acre feet per year for 50 years to the City and County of San Francisco in 2013; and,

- Modesto Irrigation District's proposed long term transfer of up to 27,240 acre feet of water per year to the City and County of San Francisco in 2012.

It is not at all clear that the reduction in available water supply from these executed or proposed transfers caused significant agricultural impacts. For instance, Modesto Irrigation District was proposing its 2012 and 2013 transfers to San Francisco to fund canal system efficiency improvements that could save between 25,000 and 40,000 acre feet per year; they reported the system loses nearly 90,000 acre feet per year from operational outflows and seepage. (Modesto Irrigation District, 2012) In other words, Modesto Irrigation District proposed to improve its canal system efficiency in a manner that could reduce total diversions by 25,000 acre feet and still deliver as much water as they currently do.

However, the Draft SED does not appear to include these water transfers in the baseline or in its analysis of agricultural impacts. (See Draft SED, App. D, at D-3, noting that it assumes that all flows to achieve D-1641 requirements are released from New Melones Reservoir) These transfers are relevant to and should be included in the baseline, in order to ensure that the analysis accurately portrays the current uses of surface water diversions and potential impacts from reduced diversions.

D. <u>The Draft SED's treatment of groundwater pumping is internally inconsistent and results in a flawed assessment of environmental impacts</u>

For purposes of the agricultural and socioeconomic analysis in the Draft SED, the Board has assumed that there is no increase in groundwater pumping:

> *This analysis assumes surface water diversion reductions associated with the LSJR alternatives are not replaced with increased groundwater pumping. For the purpose of evaluating the potential impacts in this chapter, this is a conservative assumption. To the extent there is an increase in groundwater pumping in response to the LSJR alternatives, the impacts evaluated in this chapter would likely be reduced. Environmental effects associated with a potential increase in groundwater pumping are discussed in Chapter 9, Groundwater Resources.*
> (Draft SED, 11-16)

However, in Chapter 9, the Draft SED assumes that groundwater pumping will increase to replace surface water reductions, and that this will cause a significant and unavoidable impact. (Draft SED, 9-1 to 9-2) The document is thus internally inconsistent, and as a result, it overstates the impacts of Alternatives 3 and 4. If there is increased groundwater pumping, then overall water supply, agricultural, and socioeconomic impacts will be lower than the Draft SED identifies; if there is not increased groundwater pumping, then there would not be impacts to groundwater resources. At least one of the peer reviewers of the February 2012 technical appendix on agricultural economic effects reached a similar conclusion, noting that:

> *The assumption made by the authors' (of no such additional water resources) is a conservative one, in my opinion. Years of empirical research have documented that irrigators will seek other water sources when confronted with water supply disruptions.*

> *By not allowing such an adjustment in the modeling of the stream flow effects, the assessment here likely overstates the economic costs of the flow alternatives.*

(Adams 2012, at p. 2) The Board must provide a consistent analysis in the SED that assumes similar levels of groundwater pumping throughout the document, and includes consistent analyses with respect to groundwater, agricultural resources, and economics. It must also consistently apply the CEQA Guidelines criterion for a significant indirect impact

> *An indirect physical change is to be considered only if that change is a reasonably foreseeable impact which may be caused by the project. A change which is speculative or unlikely to occur is not reasonably foreseeable.*
> (14 Cal. Code Regs. § 15064)

E. <u>The Draft SED's threshold of significance for water supply and aquatic resource impacts is flawed, as it assumes significant impacts under baseline conditions yet does not assume significant aquatic resources impacts under baseline conditions</u>

The Draft SED proposes that the threshold of significance for reductions in surface water diversions is if the proposal would "*substantially reduce (i.e., greater than 5 percent of the maximum demand) annual surface water supply diversions relative to baseline.*" (Draft SED, 5-2). As a result, the Draft SED acknowledges that there are significant impacts under baseline conditions, stating that "*Baseline has delivery deficits corresponding to the historical sequence of runoff and reservoir storage.*" (Draft SED, 5-85; Appendix F., F.1-56) However, under CEQA, the proper analysis is whether the project, not the baseline, will cause significant environmental impacts. (14 Cal. Code Regs. § 15064)

In contrast, the Draft SED proposes that the thresholds of significance for aquatic resources impacts are all related to reductions or changes in flows and other conditions, precluding a finding of significant impacts under baseline conditions. (Draft SED, 7-1 to 7-2) As a result, the Draft SED purports to conclude that baseline conditions cause significant agricultural resource impacts but not aquatic resource impacts, yet the available scientific information, including information in the SED, clearly demonstrates that baseline conditions are causing significant aquatic resource impacts. (Draft SED 2012, 7-29, 7-32 to 7-34, 7-37 to 7-38, 7-86, 7-89)

The Draft SED needs to be consistent in how it analyzes impacts to biological and agricultural resources, given the available scientific information and the existing salmon doubling objective. If the thresholds of significance include impacts under baseline conditions for agricultural resources, the Board should also assess whether there are aquatic resource impacts under baseline conditions. As currently drafted, the SED provides the public with an unbalanced assessment of the impacts because it treats impacts under baseline conditions differently.

F. <u>The Draft SED ignores the potential for water rights holders to obtain compensation through transfer agreements with export water users in the Delta to allow them to export some of this water.</u>

The Draft SED appropriately recognizes that increased flow down the lower San Joaquin River may result in changes to in water exports from the Delta by the CVP and SWP and Delta outflow. (Draft SED 2012, 5-61) Assuming no changes in Delta export restrictions, the Draft SED estimates that on average, Alternative 3 (the 40% alternative) would increase exports by the CVP and SWP by 66,000 acre feet per year or 1 percent, and Alternative 4 (60%) would increase exports by 161,000 acre feet per year or 3 percent. (Draft SED 2012, 5-88) Chapter 5 does not appear to provide analysis of potential changes in Delta outflow under the different alternatives.

However, it is quite possible that implementation of flow objectives could be achieved, at least in part, through transfer agreements between upstream water rights holders and CVP/SWP exporters. Absent such a transfer agreement, upstream water rights holders could dedicate those flows to instream use under section 1725 et seq of the Water Code, preventing downstream water users from diverting the flows. It appears that dedicating flows to instream use under section 1725 would not result in an injury to the legal rights of downstream water users. (See State Water Resources Control Board Cases, 136 Cal.App.4th 674, 798-806 (2006)) In this way, water users could protect their rights should flow requirements change through adaptive management, and could also potentially obtain additional funding to implement water efficiency measures and other projects to reduce impacts. Therefore, we urge the Board to explicitly acknowledge that such transfers and protections under section 1725 could be utilized, and could help fund water efficiency and other measures to reduce impacts.

G. <u>The Draft SED fails to accurately assess impacts to aquatic resources and fails to comply with the Board's Public Trust obligations</u>

Although the Board has already concluded in 2010, based on the best available science, that protecting 60% of unimpaired flows in lower San Joaquin River is required to fully protect Public Trust fishery resources (SWRCB 2010), we recognize that the Board must balance various beneficial uses. However, the Board's obligations under the Public Trust and relevant statutes are substantial, and the SED wholly fails to provide an analytical framework or analysis supporting any conclusion on how to balance beneficial interests. As we noted in our recent comment letter to the Board, in carrying out its obligations to protect the Public Trust and balance beneficial interests, the Board must:

- Protect Public Trust fishery resources to the extent feasible;

- Consider alternative water supplies, including water transfers and increased water use efficiency, in determining what protections for Public Trust fishery resources are feasible;

- Recognize the legislatively mandated requirements regarding the Public Trust and in balancing beneficial interests, including legislatively mandated protections for endangered species and the state and federal salmon doubling goals; and,

- Recognize and quantify the economic and employment benefits of environmental protection, including recreational and commercial fishing and non-market economic benefits, in balancing beneficial interests.

Each of these points are discussed briefly below, and are also addressed at length in NRDC/TBI 2012 (included as Exhibit 2).

H. The Draft SED fails to demonstrate that the Board is protecting Public Trust resources to the extent feasible, including consideration of improved water use efficiency and alternative water supplies

In establishing water quality standards for the Bay-Delta the Board must also protect Public Trust resources "*whenever feasible*." (*National Audubon Society v. Superior Court*, 33 Cal.3d 419, 446 (1983); *State Water Resources Control Board Cases*, 136 Cal.App.4th 674, 777-78 (2006); SWRCB Decision 1644 at 30-31; SWRCB Decision 1631 at 11). As the Board has acknowledged, "*the purpose of the Public Trust is to protect navigation, fishing, recreation, fish and wildlife habitat, and aesthetics.*" (SWRCB Decision 1644 at 30-31)

In exercising its duties, the Board must respect the rule of priority and other statutory protections for water rights, but those rules must yield if they conflict with the Public Trust or reasonable use doctrines. (*El Dorado Irr. Dist. v. State Water Res. Control Bd*., 142 Cal.App.4th 937, 944 (2006) ("*Although the rule of priority is not absolute, the Board is obligated to protect water right priorities unless doing so will result in the unreasonable use of water, harm to values protected by the Public Trust doctrine, or the violation of some other equally important principle or interest.*"); *see id*. at 966 ("*Thus, like the rule against unreasonable use, when the Public Trust doctrine clashes with the rule of priority, the rule of priority must yield. Again, however, every effort must be made to preserve water right priorities to the extent those priorities do not lead to violation of the Public Trust doctrine.*")) The Board has the power and duty to reconsider prior water rights decisions and has a continuing duty to protect Public Trust uses whenever feasible.

In 2010, the Board determined that the best available science demonstrated that current flows are insufficient to protect Public Trust fishery resources and that "*60% of unimpaired San Joaquin River inflow from February to June*" should be protected from diversions. (SWRCB 2010) While the Board's 2010 Resolution did not consider balancing of other beneficial uses, the Draft SED fails to demonstrate that achieving these flows is infeasible, particularly when alternative water supplies are considered.

I. <u>The Draft SED fails to consider availability of improved water use efficiency in determining what level of protections for Public Trust fishery resources is feasible</u>

As we discuss at length in our October 2012 letter, as the Board considers economic factors and competing beneficial uses of water in determining the reasonable protection of beneficial uses and the extent to which protection of Public Trust resources is feasible, the Board must also consider the ability and need to develop alternative water supplies, including recycled water, to meet other beneficial uses, such as municipal and agricultural uses. (Cal. Water Code §§ 13241(f), 85021; SWRCB Decision 1485 at 16-17; SWRCB Decision 1631 at 165-168, 176-77; Exhibit 2)

The Draft SED acknowledges that improved agricultural water use efficiency can help reduce impacts of reduced diversions, but fails to quantify or meaningfully consider improved water efficiency in determining what Public Trust protections are feasible. The report by the Pacific Institute that is attached to these comments provides quantitative estimates of potential water savings and other benefits from improved agricultural water use efficiency. Increased costs associated with investments in alternative water supplies like improved water use efficiency do not demonstrate that Public Trust protections are infeasible. (SWRCB Decision 1631 at 176-77) It is clear that the Board must consider the availability of improved water use efficiency and other water supply tools as it considers what protections for Public Trust fishery resources are feasible. The Draft SED fails to provide that analysis for the Board's consideration, and we urge the Board to incorporate the report by the Pacific Institute in the final SED.

J. <u>The Draft SED fails to analyze economic and employment benefits of increased flow alternatives, including recreational and commercial fishing and non-market economic benefits</u>

As the Board considers economic factors and other beneficial uses in determining what objectives to protect fish and wildlife beneficial uses in the Bay-Delta are reasonable and what protections for Public Trust resources are feasible, the Board cannot limit its analysis to economic costs, but must also consider the economic benefits of improved flows for Public Trust fishery resources. These economic benefits include:

- The economic benefits of commercial and recreational fisheries for salmon and other species that depend on a healthy San Joaquin River and Bay-Delta ecosystem;

- The economic benefits of other recreational activities in the lower San Joaquin River and tributaries, including bird watching and wildlife viewing. These activities are also protected under the Public Trust (SWRCB Decision 1631), and the U.S. Fish and Wildlife Service has estimated that wildlife dependent recreation generates significant economic benefits across California.

- Non-market economic benefits of restoring a functioning lower San Joaquin River. The Board's EIR on Mono Lake included a contingent valuation study of the economic benefits of increased flows and various lake levels to determine the economic benefits associated with reduced diversions. Similarly, David Sunding has presented preliminary results of a contingent valuation methodology for the Bay Delta Conservation Plan, which showed that the non-use value of restoring the Delta ecosystem ranges from a present value of $12 billion to $53 billion, which is significantly higher than the costs associated with a 20% reduction in water exports from the Delta.

- Economic benefits of improved downstream water quality for water export and for agricultural users.

Of course, economic considerations do not trump the responsibility to protect Public Trust Fishery resources or meet other legal requirements. (Brian Gray, *Ensuring the Public Trust*, 45 U.C. Davis L. Rev. 973, 990 ("*if the consumptive use threatens significant harm to Public Trust uses, the Public Trust may take precedence — even at substantial cost to the consumptive water user*." (citations omitted)); SWRCB Decision 1631 at 176-180 (increased costs of developing alternative water supplies was feasible and did not prevent implementation of protection of Public Trust resources)) But to the extent that the Board considers economic costs of increased flows, the Board should also consider the economic benefits. The California Department of Fish and Wildlife presented some information on the economic benefits of the salmon fishery at the public hearing, and we urge the Board to consult with the state and federal fish and wildlife agencies to obtain some estimates of these economic benefits.

K. <u>The Draft SED fails to provide a reasoned explanation how the SWRCB is balancing impacts to Public Trust resources</u>

As we discussed at length in our October 2012 letter, the SWRCB's discretion in balancing protections for fishery resources has been substantially constrained by the legislature, which has codified protections for Public Trust resources under the California Endangered Species Act, Section 5937 of the Fish and Game Code, and section 6900 et seq of the Fish and Game Code (the state's salmon doubling program). (*California Trout, Inc. v. State Water Resources Control Bd*., 207 Cal.App.3d 585, 622-625, 631 (1989); *California Trout, Inc. v. State Water Resources Control Bd*., 218 Cal.App.3d 187, 195 (1990); SWRCB Decision 1631 at 12, 172; SWRCB Decision 1644 at 27; Cal. Water Code §§ 1275(b), 1701.3(b)(2); Exhibit 2) The Board cannot balance away achievement of these statutory requirements, which are legislative expressions of the Public Trust.

Unfortunately, the Draft SED fails to demonstrate that the preferred alternative will achieve these mandatory obligations. For instance, it does not provide any analysis of whether the alternatives are likely to achieve the narrative salmon doubling objective (AFRP targets), it does not analyze whether alternatives will achieve the flow thresholds and averages that are associated with population growth or salmon doubling, and it does not demonstrate whether the alternatives are consistent with protections of endangered species. And in fact, the available evidence demonstrates that the preferred alternative would not achieve these mandatory obligations. For instance, NMFS testified at the public hearing that the 35% alternative would result in flows that are lower than the minimum Endangered Species Act requirements for steelhead on the Stanislaus River. An alternative that results in flows lower than minimum ESA requirements, not surprisingly, is extraordinarily unlikely to result in achieving the AFRP salmon production targets. Likewise, our analysis and the testimony of the state and federal agencies conclude that the preferred alternative will not achieve the existing narrative salmon doubling objective, would not likely sustain salmon populations, and that substantially greater flows are necessary.

In addition, with respect to balancing of beneficial uses beyond these mandatory obligations, the Draft SED does not provide a reasoned explanation of how the Board balanced protections of various beneficial uses. It is a fundamental tenet of administrative law that the administrative record must demonstrate a reasoned basis for the Board's decision. Here, however, the reader cannot understand why 35% was chosen as opposed to other alternatives.

We strongly urge the Board to revise the SED to identify the flows necessary to achieve the AFRP salmon production targets. The Board should then accurately estimate the costs and benefits associated with higher flows necessary to fully protect Public Trust resources, and provide a reasoned explanation for a decision to adopt higher flows than those necessary to achieve the AFRP and other mandatory requirements.

VI. Conclusion

It is extremely important that the Board remedy the deficiencies of the Draft SED in a timely manner in order to ensure that the San Joaquin River inflow objectives are revised to secure the necessary level of protection for the highly degraded habitats and endangered species and communities of the Bay-Delta and the San Joaquin basin; that benchmarks linked to desired levels of protection for fish and wildlife beneficial uses are established to measure progress toward attainment of the objectives using adaptive management; and that a more credible, transparent and rational framework for balancing between competing uses is described, relying on a broader treatment of alternative water management strategies.

Thank you for the opportunity to comment on the Draft SED. We look forward to working with you in the coming months and years to establish and implement requirements that will fully protect the Bay-Delta estuary and its watershed.

Sincerely,

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Exhibits Attached

Exh. 1 Analytical Appendix 1
Exh. 2 NRDC/TBI 2012
Exh. 3 TBI/American Rivers 2011
Exh. 4 Pacific Institute Report

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List of Figures and Tables Located in Analytical Appendix 1

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[i] This is one of many linkages between increased flow rates and decreased predation rates.

[ii] In addition, we note that the Draft SED currently provides no minimum flows or temperature requirements during summer or fall months. (Draft SED, Appendix K, at 6) However, the Merced, Tuolumne, Stanislaus and lower San Joaquin River are all listed as impaired because of high water temperatures under section 303(d) of the Clean Water Act. These water temperature impairments cause significant adverse effects on salmon and steelhead that the Board must address in order to achieve the narrative objectives in the plan. In Appendix K, the Draft SED states that during the implementation phase "*the State Water Board may establish requirements, including minimum reservoir carryover storage or other requirements, to assure that provision of flows to meet the narrative flow objective does not have adverse impacts on cold water pool levels and related fisheries impacts*." (Draft SED, Appendix K, at 3) The Board should include minimum water temperature requirements in other times of year in this section of the program of implementation as potential regulations to be adopted in the implementation phase, should identify a TMDL or other process to establish water temperature requirements on the three tributaries to protect salmon and steelhead, or should revise the SED to include minimum flows to provide adequate water temperatures during other times of year.

[iii] This relationship would, of course, be strengthened by accounting for "stock" population (the number of spawning fish in the generation that produced the current generation), as the CDFW "SalSim" model does.

[iv] TBI et al. 2010 original recommendation for floodplain inundation was >20,000 cfs. Further study has revealed that inundation of engineered floodplains may be accomplished at flows as low as 15,000 cfs. Thus, we have reduced our recommended floddplain inundation flow magnitude under the assumption that floodplain re-engineering will occur as part of the program of implementation. Higher flows will be required unless and until floodplain re-engineering has occurred.

[v] Nothing about this change in our recommendation should be construed to imply that flows >15,000 cfs are not beneficial to Public Trust resources. Indeed, flows and Chinook salmon recruitment are positively correlated at levels well-above 15,000 cfs (e.g. AFRP 2005; DFW 2010, exh3) and sturgeon spawning is most frequent on the Sacramento River when flows exceed 20,000 cfs (Kolhorst and Cech 2001).

[vi] The Draft SED does not include releases from Friant pursuant to the San Joaquin River Restoration Program as part of the baseline. Unlike the Draft SED, our modeling assumes that Restoration Flows make it to the Delta. This assumption may result in our modeling overestimating the flows that actually reach the Delta as compared to the modeling in the SED, as there is uncertainty when and what flows will actually reach the Delta. However, it is important to note that the Record of Decision for the San Joaquin River Restoration Program acknowledges that the restoration program and any recirculation proposals "would be implemented consistent with Paragraph 16(a)(1) of the Settlement, which states *"…that any recirculation, recapture, reuse, exchange or transfer of the Interim and Restoration flows shall have no adverse impact on the Restoration Goal, downstream water quality or fisheries.*" (USBR, Record of Decision, San Joaquin River Restoration Program, September 28, 2012, at 5).

[vii] The TBI Daily Flow Model can be used to evaluate any set of February-June flow recommendations (e.g. CDFW's) with regard to how they are satisfied by any level of %UIF from the tributaries, the upper San Joaquin River, and valley floor inputs.

[viii] This is less than the frequency of years with ≥5000 cfs than was anticipated by the State Board's 2010 flow report.

[ix] Wet years are not depicted in our analyses because due to high runoff from the valley floor and flood control releases from the major dams (a) flows during those years are likely to be greater than the given %UIF and (b) such flows are beyond the influence of State Board regulations designed to provide minimum flow requirements. In addition, our model does not include flood control release patterns from some of the dams, and so it underestimates the amount of flow available under very wet conditions.

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[x] Our engineered hydrograph recommendation from 2010 did not call for flows ≥10,000 cfs to occur in the Critical year type.

[xi] For comparison, Sacramento River inflow to the Delta averages ~75%UIF (TBI et al. 2010; Exh #3); at an equivalent level of development, the San Joaquin River would easily meet our floodplain inundation targets in all years.

TBI et al. 2013 Comments on the State Water Board's Draft SED

Exhibit 1
Analytical Appendix 1

Description of TBI's Daily Modeling Spreadsheet Tool for San Joaquin River Flows at Vernalis

TBI has developed a spreadsheet model for projecting daily San Joaquin River flows at Vernalis using a proportional hydrograph (percentage of unimpaired flows (%UIF) from the tributaries and x-day averaging) approach indicated in the State Board's Draft SED. The input data are daily average flows for water years 1962-2011. The tool allows the user to specify the desired % UIF from each tributary (Stanislaus, Tuolumne, Merced Rivers, San Joaquin above the Merced confluence, and Valley Floor flows) to the San Joaquin River above Vernalis and the output is a daily flow (in cfs) at Vernalis.

The inputs, key assumptions, and primary outputs of the current Version 12 are listed below.

<u>Inputs</u>

- Upper San Joaquin River daily FNF from DWR
    - This value is set to 0% by default as Upper San Joaquin River flows are determined by the San Joaquin Settlement (below). Nevertheless, the tool allows for consideration of Upper San Joaquin River flows as a %UIF if so desired.
- Merced River daily FNF from DWR.
    - For purposes of the analyses presented here, we varied Merced River flows from 35-75% of their UIF.
- Tuolumne River daily FNF from DWR
    - For purposes of the analyses presented here, we varied Tuolumne River flows from 35-75% of their UIF.
- Stanislaus River daily FNF from DWR
    - For purposes of the analyses presented here, we varied Stanislaus River flows from 35-75% of their UIF.
- Valley Floor monthly FNF from DWR
    - For purposes of the analyses presented here, we set Valley Floor flows to 100% UIF
- San Joaquin River Settlement Exhibit B estimated flows at the confluence of the Merced River
    - For purposes of the analyses presented here, we assumed that 100% of San Joaquin River settlement flows (as described in Exhibit B) reached Vernalis. We understand that this flow is not guaranteed under the San Joaquin settlement and this is therefore a liberal assumption of our model.

Outputs of our model were compared to

- TBI Targets (recommendations from our engineered hydrographs; TBI et al. 2010 Exh. #3,
- CDFW Targets (recommendations from CDFW engineered hydrographs; CDFW 2010)

<u>Key Assumptions</u>

- For each day, the modeled flow at Vernalis is 14-day average of the sum of flows provided by each of the river inputs to Vernalis (estimated as a %UIF from those watersheds).

- Valley floor flows are calculated as a monthly % UIF of the four subwatersheds, and averaged by month and year type. This dampens the flashiness of the rain-induced peaks but maintains the overall volume. The result is the same month in the same year type has the same Valley floor contribution each day of the month.
- Valley floor flows use 15-15-20-20-30 Water Year types. San Joaquin settlement Exhibit B Water Year types are used to describe flows from above the Merced River confluence. All other outputs use quintiles (20% exceedence bands) for Water Year types. There are 10 years in each Water Year Type; the driest 20% of years ("Critical" Water Year Type) is further divided into "HI" and "LO" years for additional resolution.

<u>Outputs</u>

- Daily estimated flows (cfs) at Vernalis.
- Duration (days) of attainment of CDFW and TBI Flow Targets by year type. This is summarized as the % of time the recommended duration was met in the median year of a year type.
    - We used a "loose" interpretation of flow targets that allowed days following the recommended period to count towards attainment of the flow target and allows results to exceed 100% (a "strict" version of the tool only counted days within the recommended period as contributing towards attainment of the Flow Target).
- Frequency of attainment of CDFW and TBI Goals by year type. This is the % of years in a given Water Year Type in which the the entire recommended duration of a key flow level was met.
- Volumes (TAF) by year, by year type, and time period.

Figures

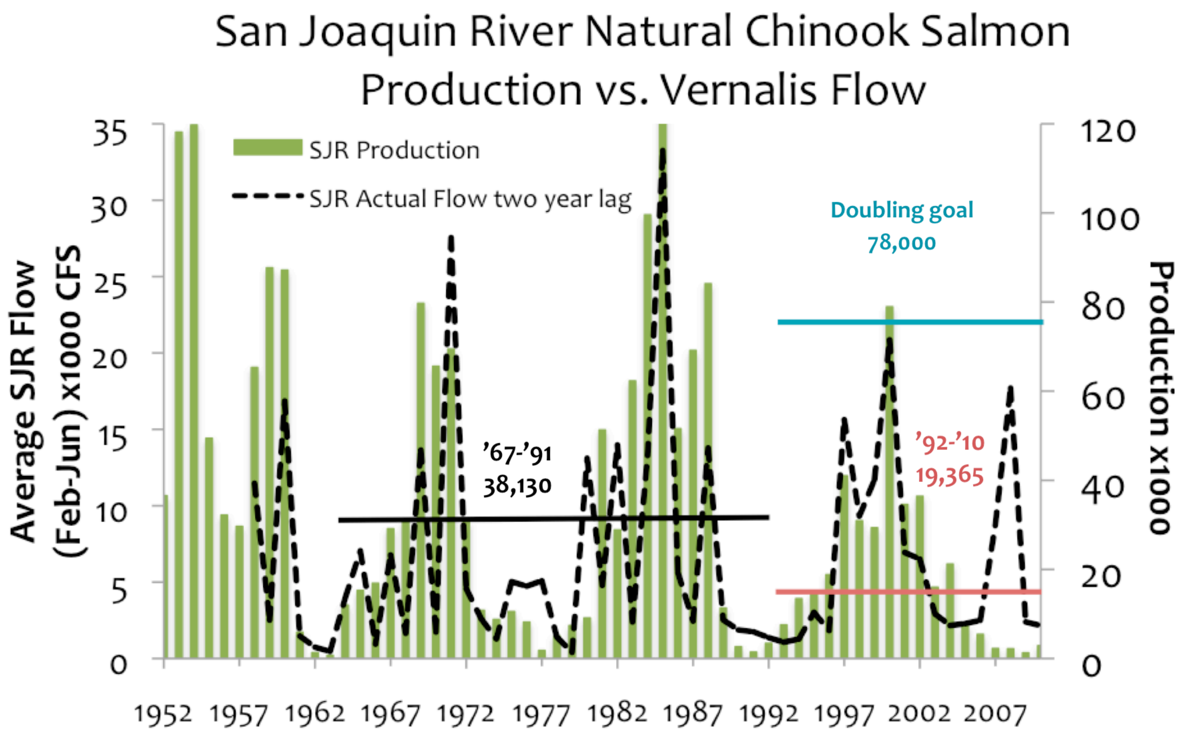

Figure 1. Natural production of San Joaquin River fall run Chinook salmon (right axis, green columns) over 60 years. Horizontal lines indicate average populations for the 1967-1991 period (black line) and the 1992-2010 period (red line). The AFRP production target is also shown (aqua blue line). Average February-June flows (left axis, black dotted line) are plotted against the production of salmon two years later (to account for the two year lag between juvenile outmigration and measurement of production). Flows are strongly correlated with salmon production.

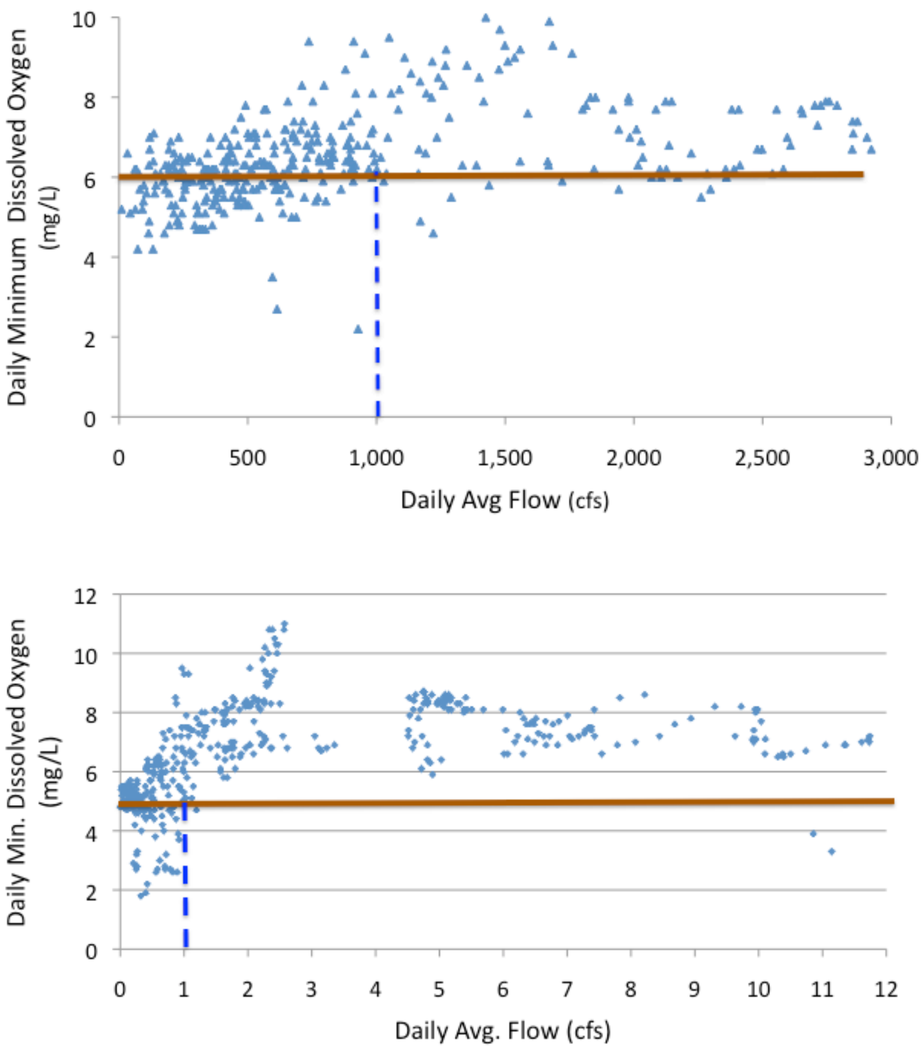

Figure 2: Relationship between average daily flow and daily minimum dissolved oxygen content in the Stockton Deepwater Ship Channel during fall (upper panel) and spring (lower panel) since 2006 (when improvements to the City of Stockton's wastewater treatment were implemented (CDEC, Garwood Station)). Horizontal red lines indicate the relevant seasonal threshold for dissolved oxygen. Dissolved oxygen readings below the daily threshold are most common when daily average flow in the SDWSC is less than 1,000 cfs. Violations of the dissolved oxygen threshold occur throughout the year, though each month December –March accounts for < 1% of total violations.

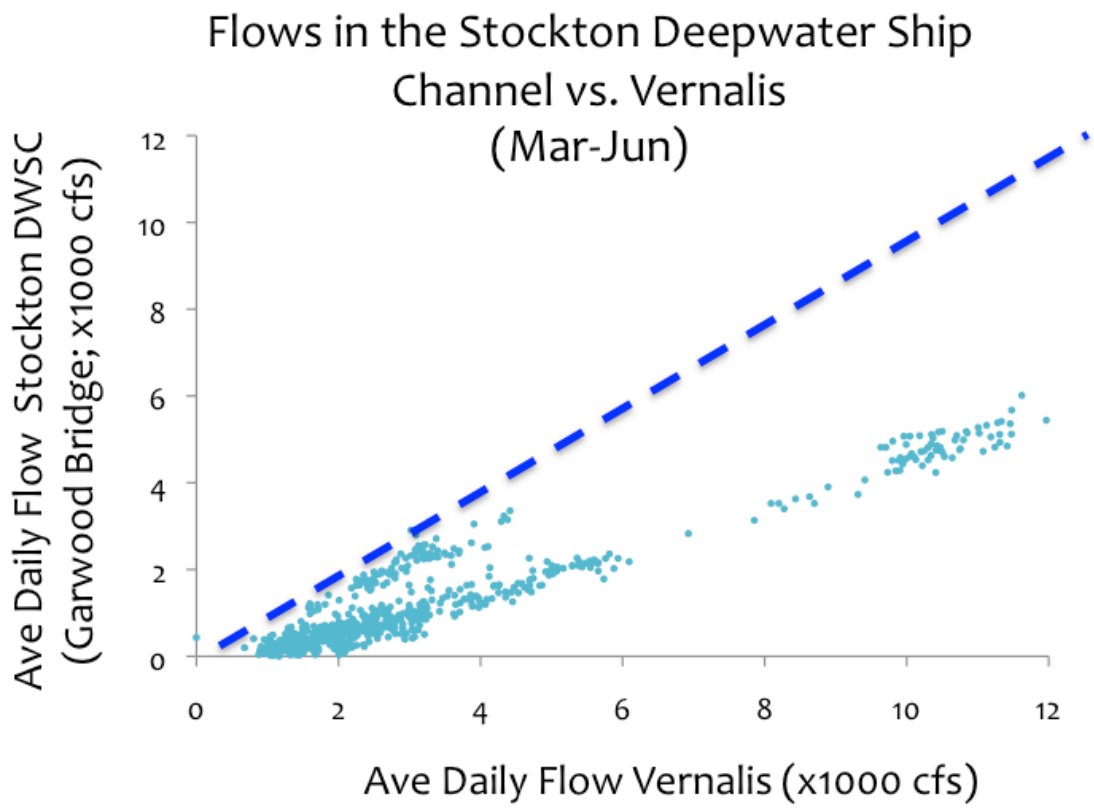

Figure 3: Average daily flows in the Stockton Deepwater ship channel (Garwood) are about 50% of flows at Vernalis on any given day because water flowing past Vernalis is distributed down Old and Middle Rivers, upstream of Garwood. The dashed line indicates equivalence of flows at the two locations. (Source: CDEC).

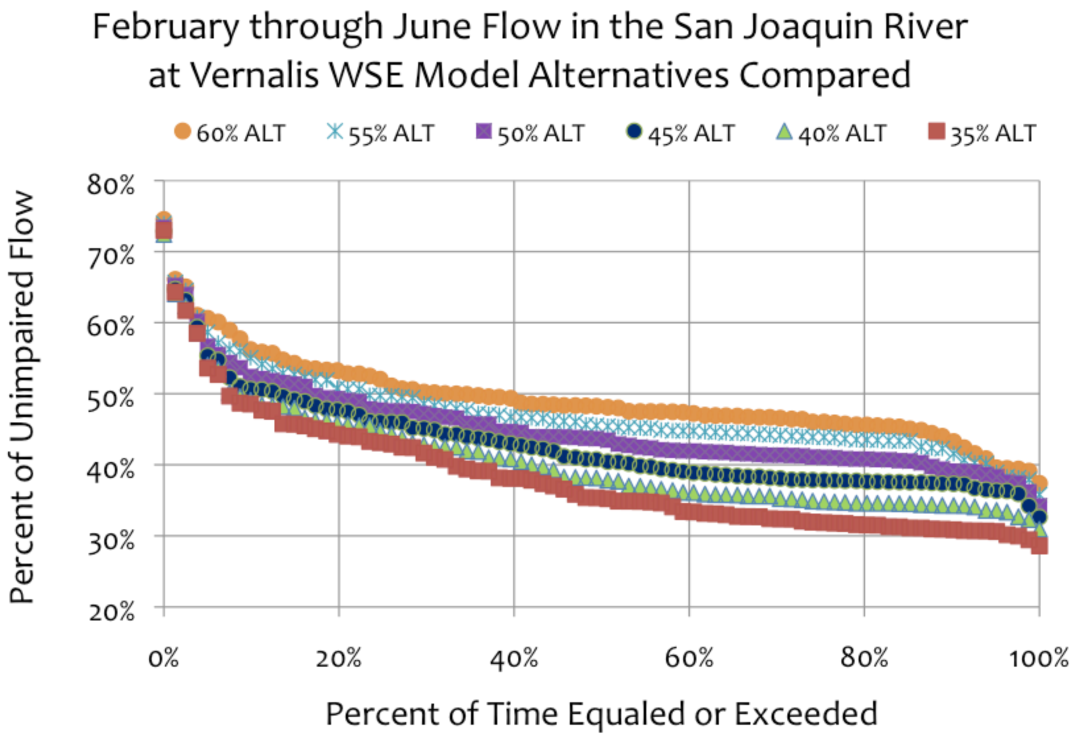

Figure 4: Frequency of different percentages of San Joaquin Valley unimpaired flows projected to arrive at Vernalis under different UIF alternatives (colored symbols). During wetter years (to the left) a greater percentage of San Joaquin Valley unimpaired flows reach Vernalis as a result of uncontrolled flows from the valley floor and flood control releases from reservoirs upstream, among other inputs. In drier years, the percentage of flow reaching Vernalis from the San Joaquin Valley is projected to be less than the nominal %UIF applied to the three San Joaquin tributaries. For example, the WSE model projects that the 35%UIF alternative will deliver less than 35% of unimpaired flows from the San Joaquin Valley to Vernalis in the driest half of years.

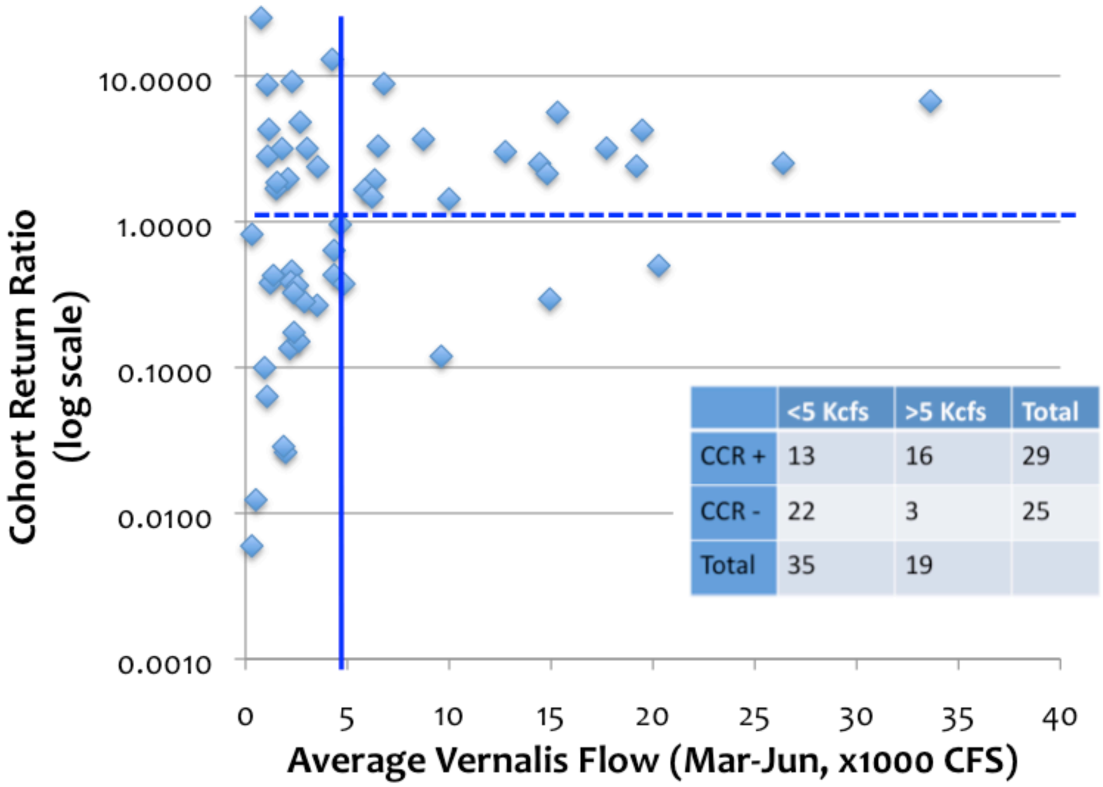

Figure 5. Cohort Return Ratio (escapement $_{\text{year } x+3}$/escapement $_{\text{year } x}$) of San Joaquin fall-run Chinook salmon compared to average March-June flows at Vernalis in the year of outmigration over the past 54 years. Cohort Return Ratios >1 indicate a growing population. Population declines occurred almost twice as frequently as increases when average Vernalis flows were less than 5,000 cfs during the year of outmigration; when flows exceeded 5,000 cfs, population growth was more than 5 times as likely as population decline (CRR<1). Note that the Cohort Return Ratio has been >1 in more than half of the past 54 years, yet the population has declined substantially (see Figure 1), indicating that population declines have been of higher magnitude than population increases.

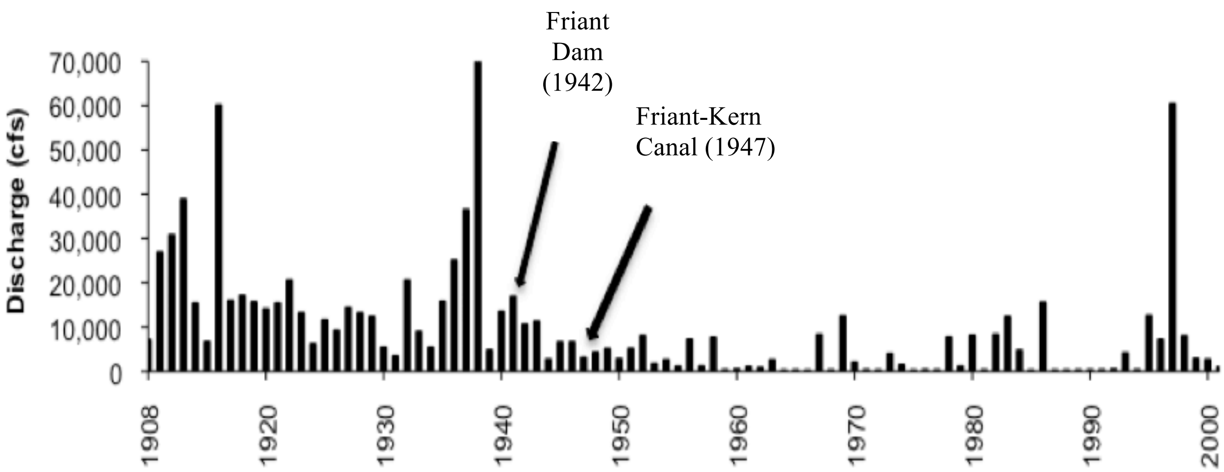

Figure 6: Annual instantaneous maximum flow on the San Joaquin River at Friant gauge below dam (J. Cain, *Personal Communication*, 2013). Note that large flows capable of doing significant geomorphic work become increasingly rare after construction of dams on tributary rivers (not shown here) and on the mainstem San Joaquin. These hydrographs are from years that predate VAMP, the ESA Biological Opinions, and Tuolumne River minimal FERC flow requirement.

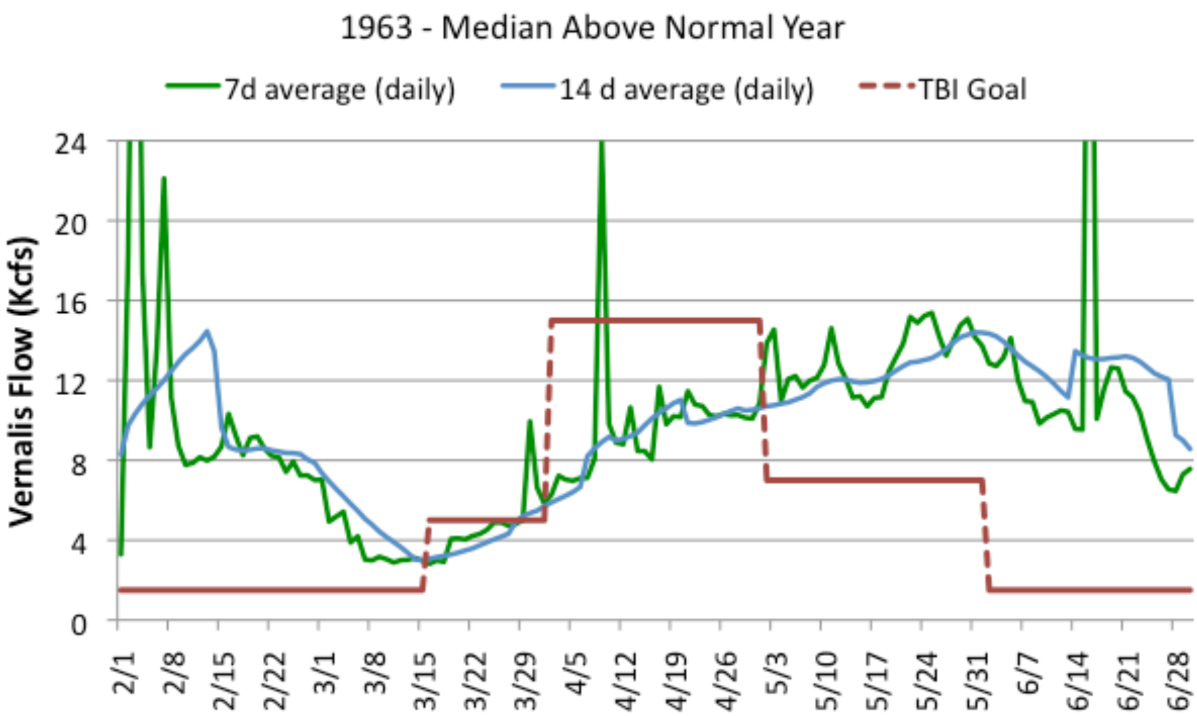

Figure 7: Comparison of hypothetical Vernalis hydrographs in a sample Above Normal year (1963) including: an engineered hydrograph (TBI et al. 2010 recommendation for Above Normal Years; red line), a hydrograph based on the 14-day moving average of tributary flows (60% UIF, blue line), and a hydrograph based on on a 7-day moving average (60%UIF, green line). The 14-day moving average retains more seasonal variability than the engineered hydrograph; the 7-day moving average retains flow pulses that are capable of doing significant geomorphic work and serving as migration cues for native species (Source: TBI Daily Flow Spreadsheet Tool; "v.11 – Strict").

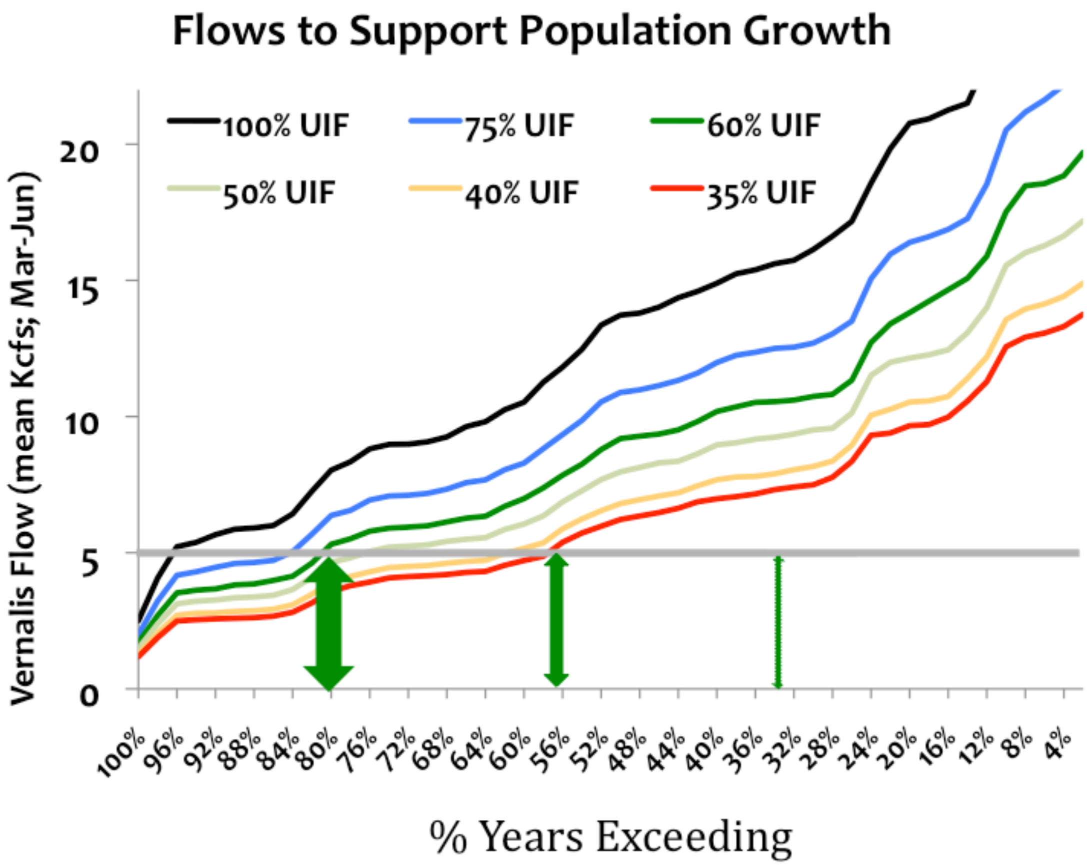

Figure 8: Seasonal average flow exceedences at Vernalis for March-June under different %UIF water budgets. The horizontal line indicates the 5,000 cfs average flow associated with inter-generation fall run Chinook salmon population growth (positive CRR). The thin vertical line indicates the status quo frequency of 5,000 cfs mean flows. The intermediate-weight vertical line indicates the frequency at which mean flows of this magnitude are predicted by the TBI Daily Flow Spreadsheet Tool to occur under a 35% UIF water budget. The thickest vertical line is the target for flow of this magnitude (8 in 10 years); the frequency target for flows of this type is less than the target suggested by the State Water Board's 2010 Public Trust Flow Report.

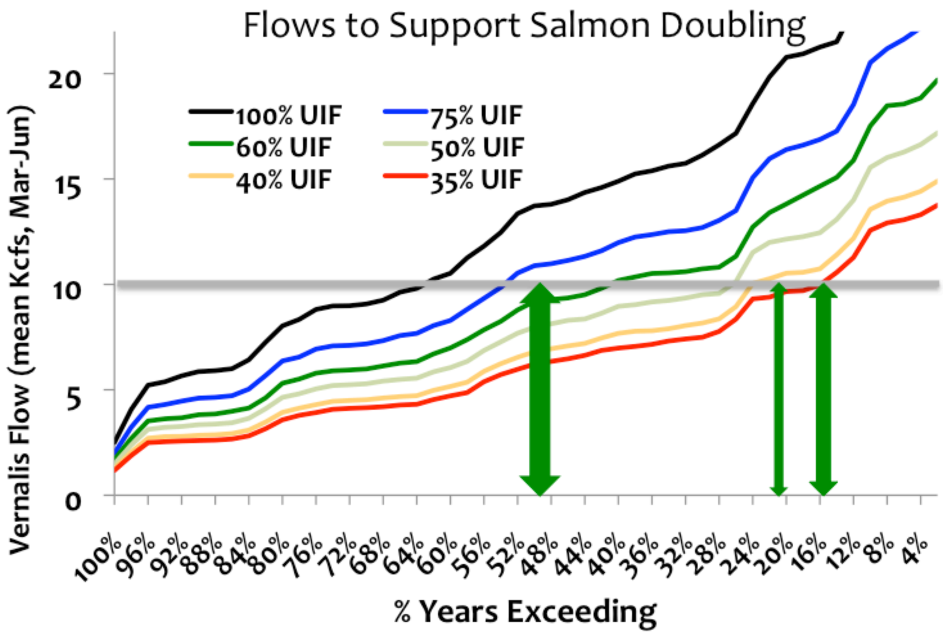

Figure 9: Seasonal average flow exceedences at Vernalis for March through June under different %UIF water budgets. The horizontal line indicates the 10,000 cfs seasonal average flows associated with attainment of fall run Chinook salmon abundance targets. The thin vertical line indicates the status quo frequency of 10,000 cfs mean flows. The intermediate vertical line indicates the frequency at which mean flows of this magnitude would occur under a 35% UIF water budget – this analysis indicates that 35% UIF would result in a decline in the frequency of 10,000 cfs flows. The thickest vertical line is the target for flows of this magnitude (1/2 of years).

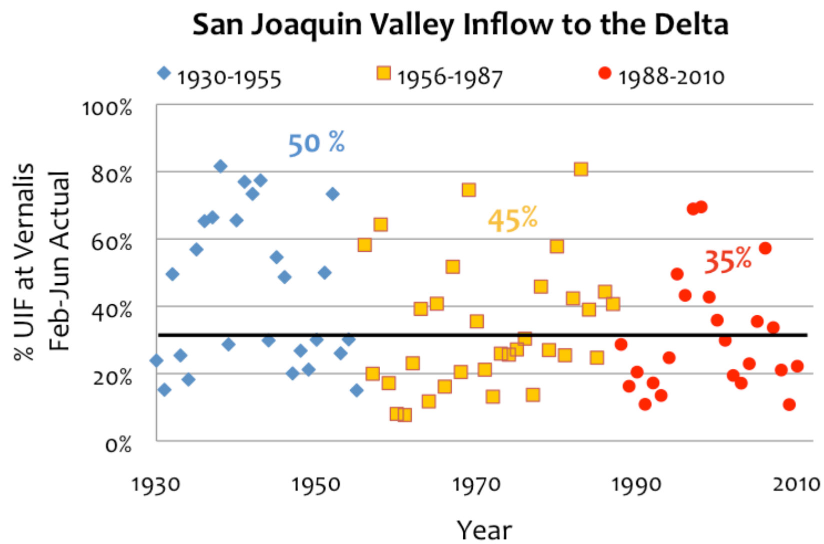

Figure 10: The percentage of unimpaired flow from the San Joaquin Valley that has arrived at Vernalis as inflow to the Delta between February-June over the past eight decades. The horizontal line indicates a 35% of unimpaired flow. Numbers above the horizontal line indicate the frequency of years where actual flows exceeded 35% UIF in three time periods. In the 1930-1955 period, half of years had actual flows that exceeded 35% (or even 50%) UIF; over the most recent 23 years, the frequency of years in which actual flows were greater than 35%UIF has declined substantially.

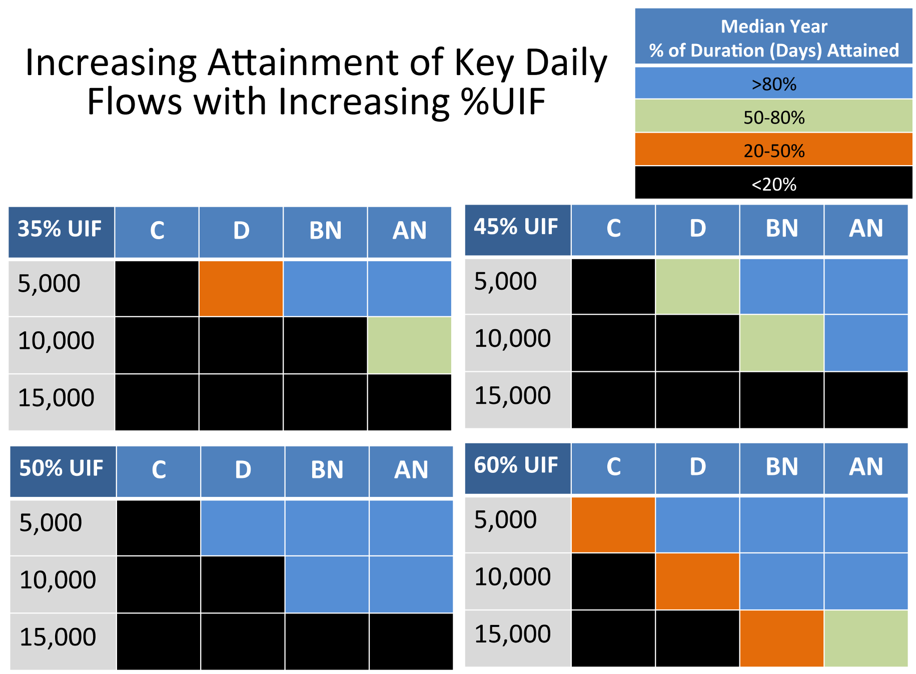

Figure 11: Duration of recommended flows in the median year of four water year types under the assumptions of the TBI Daily Flow Spreadsheet Model (Wet years are not depicted because flows during those years are often uncontrolled). As the %UIF applied to the three tributaries increases, the number of days key recommended flows are attained increases. (Source: TBI Daily Flow Spreadsheet Model).

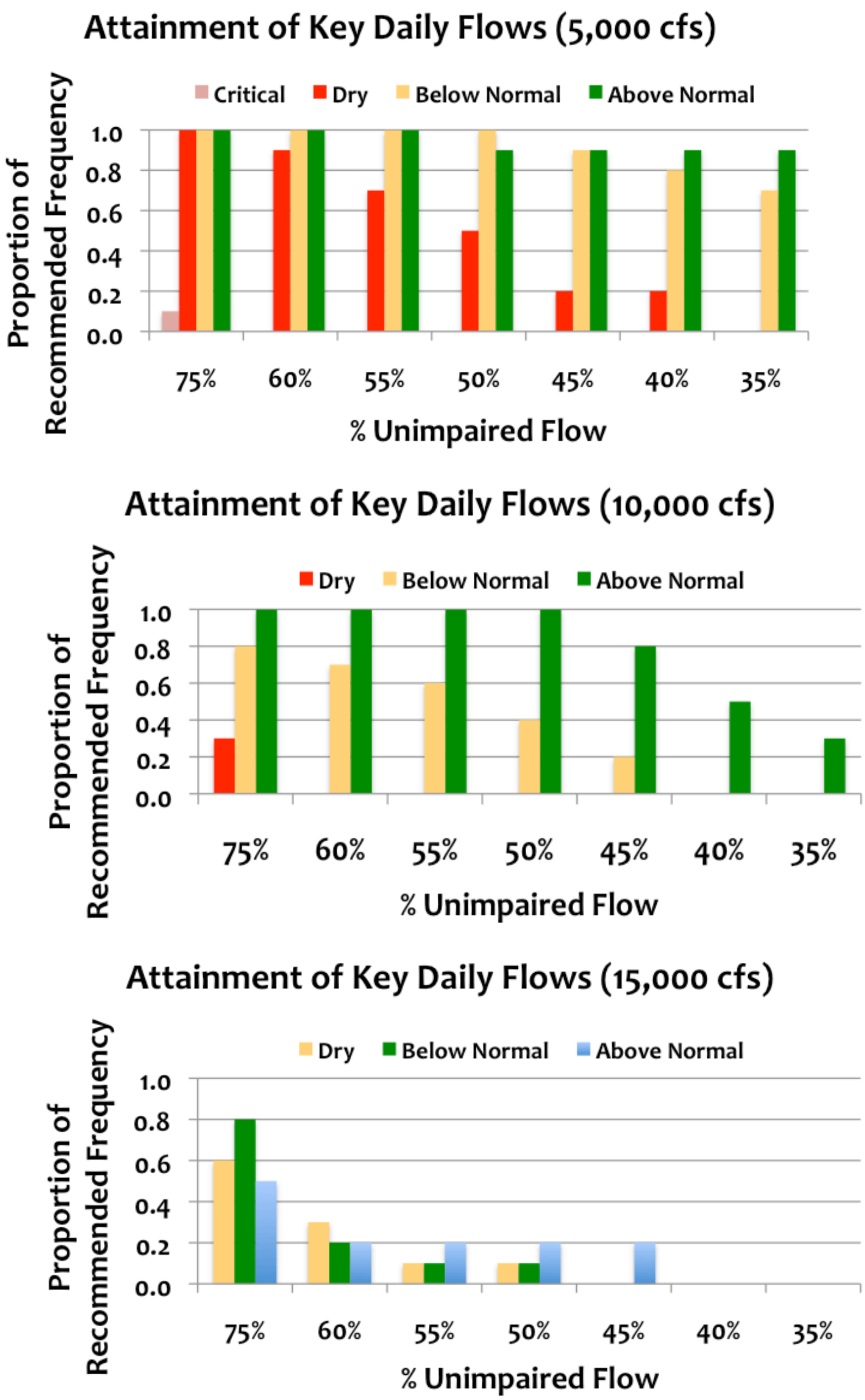

Figure 12: Frequency within water year types with which the full duration of key flows is achieved under different percentages of unimpaired flow (Source: TBI Daily Flow Spreadsheet Model).

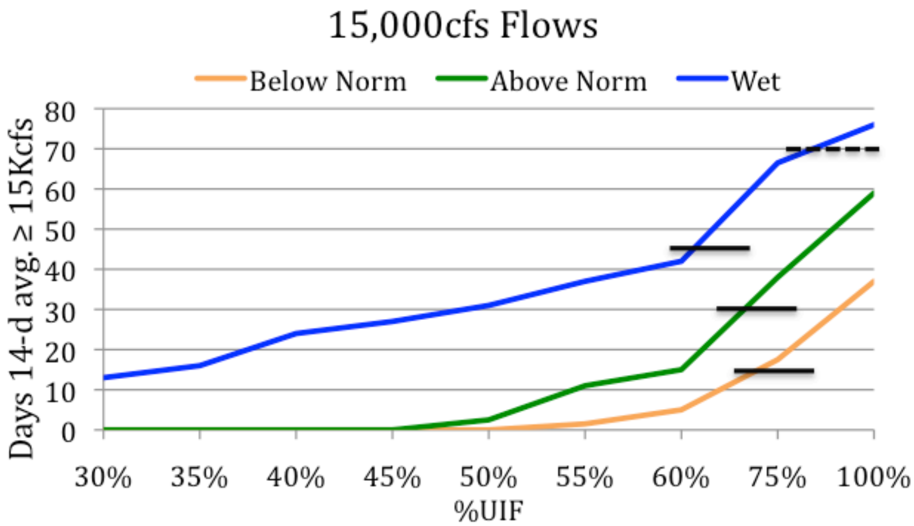

Figure 13: Increase in the number of days that 14-day average of flows exceeds 15,000 cfs (the flow magnitude required to achieve inundation of re-engineered floodplains). Horizontal lines reflect the number of days recommended for floodplain inundation by TBI et al. (2010; solid lines) and CDFW 2010b (dashed line) for the different water year types (Source: TBI Daily Flow Spreadsheet Model).

Tables

Table 1: CDFW model projections of improved smolt survival and adult escapement resulting from different levels of spring freshwater flow at Vernalis (modified from CDFG 2010b Tables 7 & 8). In Below Normal Years (top panel), 10,000cfs flows for 60 days are projected to nearly double escapement of fall run Chinook salmon. In above normal years, similar magnitude and duration of flows are projected to double survival through the delta of Chinook salmon smolts.

Below Normal Years-SJR Salmon Model Run Summary																
Includes Water Years: 1970-1 and 2002-3 (2 Years)																
Category	Base	VAMP-Like	Increase Magnitude (cfs)				Duration (8500 cfs)			Duration (9000 cfs)			Duration (10000 cfs)			
			8000	8500	9000	10,000	40 Day	50 Day	60 Day	40 Day	50 Day	60 Day	40 Day	50 Day	60 Day	
% Increase in Juvenile Salmon to Chipps Island	n/a	0	55%	61%	68%	84%	82%	106%	124%	91%	118%	140%	112%	145%	173%	
% Increase in Salmon Escapement	n/a	2%	33%	37%	41%	49%	48%	60%	69%	53%	66%	77%	63%	79%	**92%**	

Above Normal Years-SJR Salmon Model Run Summary														
Includes Water Years: 1969-70, 1972-3, 1978-9, 1983-4, 1998-9, and 1999-00 (6 Years)														
Category	Base	VAMP-Like	Increase Magnitude (cfs)			Duration (10,000 cfs)			Duration (11,000 cfs)			Duration (12,000 cfs)		
			10000	11000	12000	40 Day	50 Day	60 Day	40 Day	50 Day	60 Day	40 Day	50 Day	60 Day
% Increase in Juvenile Salmon to Chipps Island	0	9%	40%	51%	62%	58%	83%	**102%**	74%	105%	129%	91%	129%	159%
% Increase in Salmon Escapement	0	6%	25%	31%	37%	35%	49%	58%	44%	60%	72%	53%	72%	86%

Table 2: Contribution of San Joaquin River flow (above Vernalis) to net Delta outflow under unimpaired and current conditions. If the San Joaquin contributed to actual outflows in proportion to the runoff available in this system, the lower row would be identical to the upper (UIF) row. In fact, the San Joaquin contributes less than ½ (and in some years less than one-third) of its proportionate share to actual Delta outflow. As a result, other Central Valley river systems contribute more to Delta outflow (relative to water available in those watersheds) than the San Joaquin.

WY Type	Critical	Dry	Below Normal	Above Normal	Wet
Vernalis UIF v. Delta Outflow UIF	22%	22%	22%	23%	25%
Vernalis Actual v. Delta Outflow Actual	10%	7%	6%	7%	10%

TABLE 3 WATER QUALITY OBJECTIVES FOR FISH AND WILDLIFE BENEFICIAL USES						
RIVER FLOWS						
COMPLIANCE LOCATION	***STATION***	***PARAMETER***	***DESCRIPTION***	***WATER YEAR***	***TIME***	***VALUE***
Inflows from the LSJR at Airport Way Bridge, Vernalis to the Delta	*C-10*	*Flow Rate*	*Narrative*	*All*	*February through June*	*Maintain flow conditions from the San Joaquin River Watershed to the Delta at Vernalis sufficient to support and maintain the doubling of natural production of San Joaquin River Chinook salmon and steelhead populations migrating through the Delta from the average production of 1967 – 1991, and the establishment of viable, self-sustaining populations of other San Joaquin River watershed fish species migrating through the Delta. Flow conditions that reasonably contribute toward maintaining viable native migratory San Joaquin River fish populations include, but may not be limited to, flows that mimic the natural hydrographic conditions to which native fish species are adapted, including the relative magnitude, duration, timing, and spatial extent of flows as they would naturally occur. Indicators of viability, including abundance, spatial extent or distribution, genetic and life history diversity, migratory pathways, and productivity, will be used to measure attainment of this objective*[1]
Inflows from the Tuolumne River to the LSJR	*TBD*					
Inflows from the Merced River to the LSJR	*TBD*					
Inflows from the Stanislaus River to the LSJR	*TBD*					
LSJR at Airport Way Bridge, Vernalis	*C-10*	*Flow Rate*	*Minimum Average Monthly Flow Rate (cfs)*	*All*	*January through Dec.*	*2,000*[2]

[1]The following indicators of viability will be used to measure progress towards meeting this objective: average annual production of 78,000 fall-run Chinook salmon (22,000 from the Stanislaus; 38,000 from the Tuolumne; and 18,000 from the Merced); 10,000 steelhead from at least two rivers in the San Joaquin basin; successful splittail spawning once in every three years; and successful green and white sturgeon spawning once in every seven years.

[2] Plus a ten-day pulse flow of 3,500 cfs in October in all water year types. The ten-day pulse flow is not required in a critical year following a critical year. The pulse flow will be scheduled in consultation with the U.S. Fish and Widlife Service (USFWS), National Marine Fisheries Service (NMFS), and the Department of Fish and Game (DFG).

CLOSING COMMENTS RELATING TO THE 2012 WORKSHOPS ON THE COMPREHENSIVE (PHASE 2) REVIEW AND UPDATE TO THE BAY-DELTA PLAN

Prepared by:

Doug Obegi, Staff Attorney, Natural Resources Defense Council
Gary Bobker, Program Director, The Bay Institute

AND

RECOMMENDATIONS RELATING TO WORKSHOP 3 (ANALYTICAL TOOLS FOR EVALUATING WATER SUPPLY, HYDRODYNAMIC AND HYDROPOWER EFFECTS)

Prepared by:

Peter Vorster, Staff Hydrologist, The Bay Institute
Doug Obegi, Staff Attorney, Natural Resources Defense Council

Submitted to:

STATE WATER RESOURCES CONTROL BOARD

On behalf of:

NATURAL RESOURCES DEFENSE COUNCIL
THE BAY INSTITUTE

October 26, 2012

I. Closing Comments, Part One: Public Trust, Balancing, and Program of Implementation Issues That Must Be Addressed in Amending the Bay-Delta Plan

During the current review by the State Water Resources Control Board (Board) of the Bay-Delta Water Quality Control Plan ("Plan" or "Bay-Delta Plan"), questions have been raised regarding the Board's obligations under the public trust doctrine and other statutory requirements. In the first section of these closing comments for the 2012 Phase 2 workshops, we attempt to address these questions. In summary, the Board must ensure that the Bay-Delta Plan:

- Protects public trust resources to the extent feasible.
- Complies with the Board's obligation to conserve listed fisheries under the California Endangered Species Act.
- Discharges the Board's obligation to achieve the salmon doubling narrative objective.
- Considers alternative water supplies and the economic benefits of fishery protection in determining how to balance between competing beneficial uses and what water quality objectives are feasible and reasonable.

1. <u>The State Water Resources Control Board Must Ensure that the Bay-Delta Plan Protects Public Trust Resources to the Extent Feasible</u>

The promulgation of water quality standards for the Bay-Delta requires the Board to "establish such water quality objectives in water quality control plans as in its judgment will ensure the reasonable protection of beneficial uses and the prevention of nuisance." Cal. Water Code § 13241. In addition, in establishing water quality standards for the Bay-Delta the Board must also protect public trust resources "whenever feasible." *See National Audubon Society v. Superior Court*, 33 Cal.3d 419, 446 (1983); *State Water Resources Control Board Cases*, 136 Cal.App.4th 674, 777-78 (2006). As the Board has recognized in prior decisions,

> The State Water Resources Control Board has broad authority to establish minimum flows and take other measures needed for protection of fisheries and other public trust resources. That authority is provided by article X, section 2 of the California Constitution, Water Code sections 100 and 275, the public trust doctrine as articulated by the California Supreme Court in *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419 [189 Cal. Rptr. 346], and Water Code sections 1243 and 1253**.**

SWRCB Decision 1644 at p. 29. As the Board further recognized in that decision,

> The purpose of the public trust is to protect navigation, fishing, recreation, fish and wildlife habitat, and aesthetics. (*National Audubon Society v. State Water Resources Control Board, supra,* 33 Cal.3d at 434-435, 437 [189 Cal. Rptr. at 356, 358]; cert. denied, 464 U.S. 977.) Fish and Game Code section 5937 is a legislative expression concerning the public trust doctrine that should be taken into account when the SWRCB acts under its public trust authority. (See

> C*alifornia Trout, Inc. v. State Water Resources Control Board* (1989) 207 Cal.App.3d 585, 626, 631 [255 Cal. Rptr. 209, 212].)
>
> In applying the public trust doctrine, the State has the power to reconsider past water allocations even if the State considered public trust impacts in its original water allocation decision… **The State has the duty of continuing supervision over the taking and use of appropriated water and an affirmative duty to protect public trust uses whenever feasible**. (*National Audubon Society v. Superior Court*, *supra,* 33 Cal.3d at 445-448).

Id. at 30-31, emphasis added; *see* SWRCB, Decision1631, at 11 ("The *Audubon* decision establishes that the SWRCB has the additional responsibility to consider the effect of water diversions upon interests protected by the public trust and to avoid or minimize harm to public trust uses to the extent feasible.").

In exercising its duties, the Board must respect the rule of priority and other statutory protections for water rights, but even those rules must yield if they conflict with the public trust or reasonable use doctrines. *El Dorado Irr. Dist. v. State Water Res. Control Bd*., 142 Cal.App.4th 937, 944 (2006) ("Although the rule of priority is not absolute, the Board is obligated to protect water right priorities unless doing so will result in the unreasonable use of water, harm to values protected by the public trust doctrine, or the violation of some other equally important principle or interest."); *see id*. at 966 ("Thus, like the rule against unreasonable use, when the public trust doctrine clashes with the rule of priority, the rule of priority must yield. Again, however, every effort must be made to preserve water right priorities to the extent those priorities do not lead to violation of the public trust doctrine.").

2. <u>The Board Must Consider Water Conservation, Water Recycling, and Other Alternative Water Supplies Which are Available to Municipal, Industrial, and Agricultural Water Users in Determining the Feasibility of Protecting Public Trust Resources and the Reasonability of Water Quality Objectives that Protect Instream Beneficial Uses</u>

As the Board considers economic factors and competing beneficial uses of water in determining the reasonable protection of beneficial uses and the extent to which protection of public trust resources is feasible, the Board must also consider the ability and need to develop alternative water supplies, including recycled water[1], to meet other beneficial uses, such as municipal and agricultural uses. *See* Cal. Water Code § 13241(f).

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[1] *See, e.g.,* Water Code § 13511 ("The Legislature finds and declares that a substantial portion of the future water requirements of this state may be economically met by beneficial use of recycled water."); Water Code §§ 13510-13512, 13550 *et seq*. (legislative policy encouraging water recycling, directing the state to take "all possible steps" to encourage development of water recycling facilities, and finding certain uses of potable water unreasonable if recycled water is available that meets certain criteria).

Aquatic life is the least flexible use of the Bay-Delta's waters. The establishment and maintenance of sustainable fish and wildlife populations, habitats and ecological processes is highly dependent on maintaining adequate flow, temperature, and water quality conditions in the estuary. The populations and ecosystems of the Bay-Delta are naturally resilient, of course. The formal listing of numerous fish species as endangered, the unprecedented closure of the commercial salmon fishery, and the systemic decline in both ecosystem values and public recreational uses of the Bay-Delta's waters demonstrate, however, that this natural resilience has been exceeded as a result of large-scale hydrologic alteration in recent decades. Fish and wildlife beneficial uses entrusted to the Board's care are in danger of disappearing forever.

Native fisheries and other public trust resources in the Bay-Delta must rely exclusively on the waters of the estuary for their existence. In contrast, there are cost-effective, environmentally superior alternative water supplies available for municipal, industrial, and agricultural beneficial users of water from the Delta (as discussed in detail in the recommendations relating to Workshop 3 contained in Section II.1 below). These important beneficial uses of water have greater flexibility as a result of water users, water managers, and regulatory agencies such as the Board being able to implement a broad suite of management actions to more efficiently divert, store, and apply water supplies; secure water supplies from alternative sources; and/or switch to different activities to maintain economic viability. The Board must take these potential alternative water supplies into account when balancing competing beneficial uses and determining what level of public trust protection is feasible.

The Board has considered the availability of alternative water supplies in past Bay-Delta plans and in other proceedings. In 1978, the Board waived salinity protections in Antioch based on a determination that adequate substitute water supplies were available for municipal and industrial customers. SWRCB Decision 1485 at pp. 16-17.[2] In addition, in D-1485 the Board cautioned that future requests by the SWP and CVP to increase diversions or transfer water would be subject to careful scrutiny of the conservation and wastewater recycling programs in the service areas:

> "However, in its review of applications for additional appropriations by the CVP and SWP or of proposed transfer of water utilizing CVP and SW facilities, the Board will review conservation and wastewater reclamation programs in the proposed service areas to ensure that these additional water resources will be used in the most efficient manner possible consistent with the general public interest. Unappropriated water in California is an increasingly short, precious resource. As greater demands are made on a more limited unclaimed supply, the Board must scrutinize proposed uses more intensely than ever before to ensure that vested water rights and the public interest are protected."

[2] Because Antioch's water rights were protected under the Delta Protection Act (Water Code section 12202), the Department of Water Resources was obligated to pay for these substitute rights and ensure that they were of like quality and quantity. *Id*.

SWRCB Decision1485 at pp. 18-19. Similarly, in Decision 1631, in considering the impacts of reduced water supply from protection of public trust resources, the Board explicitly acknowledged that, "[a] number of alternatives are available to LADWP to help offset water losses from the reduction of Mono Basin exports," including local groundwater, water conservation, water recycling, other surface supplies, and transfers. SWRCB Decision1631 at 165-168. The Board determined that the focus of the economic analysis is whether the economic costs make adoption of the decision feasible, and concluded that neither the water supply nor power supply costs made the protections infeasible and that there would be sufficient water to meet municipal needs of Los Angeles when diversions are restricted. *Id*. at 176-177.

In recent years the Board has mandated improved water use efficiency and other measures as conditions for approving changes to water rights. *See, e.g.,* Order WR 2009-0034-EXEC (Order approving temporary urgency change for Sonoma County Water Agency, which includes conditions limiting irrigation of commercial turf grass (condition #13), establishing water efficiency goals (condition #15), and development of development of water conservation plans (condition #16-17)). The Board has substantial constitutional and statutory authority to establish conditions on the water rights of the CVP, SWP, and other diverters that mandate improved water use efficiency, investments in water recycling and other alternative water supplies, and avoid waste and unreasonable use of water in their service areas. This authority stems from the public trust doctrine, from federal and state statute, from the express conditions on existing water rights, and from the constitutional requirement prohibiting waste and unreasonable use of water. The mandatory terms and conditions included in every water rights license or permit explicitly preserves the Board's authority to require the permittee or licensee to implement a water conservation plan, which may include water recycling or efficiency measures.[3] *See* SWRCB, Mandatory License Terms, available at: http://www.swrcb.ca.gov/waterrights/water_issues/programs/permits/terms/license/mandatory.pdf, last accessed October 11, 2012. While the Board may determine it is unnecessary to include mandatory terms imposing specific conservation, recycling, and

[3] "The continuing authority of the State Water Board may be exercised by imposing specific requirements over and above those contained in this license with a view to eliminating waste of water and to meeting the reasonable water requirements of licensee without unreasonable draft on the source. Licensee may be required to implement a water conservation plan, features of which may include but not necessarily be limited to: (1) reusing or reclaiming the water allocated; (2) using water reclaimed by another entity instead of all or part of the water allocated; (3) restricting diversions so as to eliminate agricultural tailwater or to reduce return flow; (4) suppressing evaporation losses from water surfaces; (5) controlling phreatophytic growth; and (6) installing, maintaining, and operating efficient water measuring devices to assure compliance with the quantity limitations of this license and to determine accurately water use as against reasonable water requirement for the authorized project. No action will be taken pursuant to this paragraph unless the State Water Board determines, after notice to affected parties and opportunity for hearing, that such specific requirements are physically and financially feasible and are appropriate to the particular situation."

other investments in water rights and/or the program of implementation, the Board has authority to do so and has done so in recent years.

This approach also is consistent with the requirements of the 2009 Delta Reform Act. That Act reiterated that, "[t]he longstanding constitutional principal of reasonable use and the public trust doctrine shall be the foundation of state water management policy and are particularly important and applicable to the Delta." Water Code § 85023. Likewise, that Act established co-equal goals of "providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem" in a manner that protects and enhances the unique values of the Delta and its communities. Water Code § 85054. And in order to provide a more reliable water supply, the Legislature mandated that,

> The policy of the State of California is to reduce reliance on the Delta in meeting California's future water supply needs through a statewide strategy of investing in improved regional supplies, conservation, and water use efficiency. Each region that depends on water from the Delta watershed shall improve its regional self-reliance for water through investment in water use efficiency, water recycling, advanced water technologies, local and regional water supply projects, and improved regional coordination of local and regional water supply efforts.

Cal. Water Code § 85021.

Finally, the physical solution doctrine also compels the Board to consider alternative water supplies in promoting maximum beneficial use of the State's water resources:

> "In resolving disputes involving competing uses of water, California courts have frequently considered whether there is a "physical solution" available by which competing needs can best be served. (*Peabody v. Vallejo*, 2 Cal.2d 351, 383-384 [40 P.2d 4861 (1935); *City of Lodi v. East Bay Municipal Util. Dist.*, 7 Cal.2d 316 [60 P.2d 4391 (1936).) Adoption of a physical solution is consistent with the constitutional goal of promoting maximum beneficial use of the State's water resources."

SWRCB Decision 1631 at p.10. Under the physical solution doctrine, the Board can require habitat restoration or similar measures to protect public trust resources. *Id*. at 118 ("Thus, as part of a physical solution allowing for diversion of water for municipal use, LADWP can be required to undertake waterfowl habitat restoration measures. Waterfowl habitat restoration can serve to restore public trust uses while requiring a smaller commitment of water.").[4] Equally important, the physical solution doctrine must also include consideration of the development of alternative water supplies, such as conservation and recycling, where such a physical solution can be used to reasonably and feasibly advance protection of public trust resources and the consumptive

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[4] Such measures can be included in the program of implementation, and the obligations can be made enforceable through the water rights proceeding to implement the Plan.

demand for water. The Board has broad authority to require the development of alternative water supplies as a physical solution to reduce conflicts between such uses of water.

Thus, state law requires the Board to consider these alternative supplies in balancing between competing beneficial uses, in determining what measures are "feasible" to protect public trust resources, and in considering a physical solution to protect public trust resources and other beneficial uses of water.

3. <u>The Board's Discretion in Balancing Protections for Public Trust Fishery Resources Has Been Constrained by CESA and other Legislative Enactments</u>

The courts have previously determined that the SWRCB's balancing of competing beneficial uses is constrained by legislative enactments such as sections 5937 and 5946 of the Fish and Game Code, which are specific legislature rules concerning the public trust. *California Trout, Inc. v. State Water Resources Control Bd.*, 207 Cal.App.3d 585, 622-625, 631 (1989); *California Trout, Inc. v. State Water Resources Control Bd*., 218 Cal.App.3d 187, 195 (1990). According to the Court of Appeal, in its 1989 decision, "[w]e concluded that, by the enactment of section 5946, the Legislature had resolved the competing claims for the beneficial use of water in these streams in favor of preservation of their fisheries." *California Trout, Inc.*, 218 Cal.App.3d at 195; *see also* SWRCB Decision 1631 at 12. While the court recognized that the legislature's authority was not unlimited and was subject to the constitutional limitations of reasonable use, the court recognized that the legislature has substantial authority to define the balance between competing beneficial uses. *California Trout, Inc.*, 207 Cal.App.3d at 625. Subsequently, the Board explicitly found that compliance with section 5937 and 5946 of the Fish and Game Code is not subject to balancing, concluding that these protections are mandatory and that, "[f]lows needed to reestablish and maintain the fishery are not subject to reduction due to economic cost." SWRCB Decision1631 at 172.

The Legislature has similarly resolved the question of balancing in favor of protecting threatened and endangered species under the California Endangered Species Act ("CESA").[5] Among competing beneficial uses, the legislature has afforded priority for protecting species listed under CESA, and the legislature has required state agencies to act to conserve listed species and to prevent their extinction. Fish and Game Code §§ 2050 et seq; *see esp. id*. §§ 2052, 2053, 2055. In past water rights decisions, the Board has recognized that CESA requires the Board to act to conserve listed species: "Thus, in exercising authority over water rights in the lower Yuba River, the California Endangered Species Act **requires** the SWRCB to seek to conserve spring-run Chinook salmon." SWRCB Decision 1644 at p. 27 (emphasis added).[6] As with section 5937, in

[5] As discussed infra, the Legislature has also expressed the primacy of protecting salmon in enacting the salmon doubling requirement in 1989 as part of the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act. Cal. Fish and Game Code §§ 6900 *et seq*.
[6] In addition, applicants for water rights and for permits to change the point of diversion, purpose of use, or place of use must demonstrate compliance with the federal endangered species Act and the requirements of the Fish and Game Code. Cal. Water Code §§ 1275(b), 1701.3(b)(2).

enacting CESA the legislature has "resolved the competing claims for the beneficial use of water in these streams in favor of preservation of their fisheries." *See California Trout, Inc.*, 218 Cal.App.3d at 195. The Board lacks authority to disregard that rule. *California Trout, Inc.*, 207 Cal.App.3d at 631 ("We agree with the Water Board that the mandate of section 5946 is a specific legislative rule concerning the public trust. Since the Water Board has no authority to disregard that rule, a judicial remedy exists to require it to carry out its ministerial functions with respect to that rule. The Legislature, not the Water Board, is the superior voice in the articulation of public policy concerning the reasonableness of water allocation.").

While some may argue that Water Code section 106 establishes an absolute priority for municipal uses of water, the Supreme Court has acknowledged that "these policy declarations must be read in conjunction with later enactments requiring consideration of in-stream uses (Wat. Code, §§ 1243, 1257, quoted ante at pp. 443-444) and judicial decisions explaining the policy embodied in the public trust doctrine. Thus, neither domestic and municipal uses nor in-stream uses can claim an absolute priority." *National Audubon Society*, 33 Cal. 3d at 448 n. 30. The Supreme Court did not address the priority afforded to resource protection under CESA in *National Audubon Society*, but has elsewhere acknowledged CESA's priority:

> Bay–Delta ecosystem restoration to protect endangered species is mandated by both state and federal endangered species laws, and for this reason water exports from the Bay–Delta ultimately must be subordinated to environmental considerations. The CALFED Program is premised on the theory, as yet unproven, that it is possible to restore the Bay–Delta's ecological health while maintaining and perhaps increasing Bay–Delta water exports through the CVP and SWP. If practical experience demonstrates that the theory is unsound, Bay–Delta water exports may need to be capped or reduced.

In Re Bay-Delta Programmatic Environmental Impact Report Coordinated Proceedings, 43 Cal.4th 1143, 1168 (2008). Unfortunately, the past decade has made clear that this theory was unsound, existing CESA and ESA permits require substantial additional protections for listed species, and the Board has already determined that, "The best available science suggests that current flows are insufficient to protect public trust resources." SWRCB 2010 at 2.

In addition, the Bay-Delta Plan must also meet the requirements of the federal Clean Water Act. Federal regulations under the Clean Water Act require that states must adopt water quality criteria which protect designated uses, and "[f]or waters with multiple use designations, the criteria shall support the most sensitive use." 40 CFR § 131.11(a).[7] This federal regulation also precludes the Board from failing to provide adequate protections for listed native fish species in

[7] In addition, in reviewing the Bay-Delta Plan EPA must consult with the U.S. Fish and Wildlife Service and National Marine Fisheries Service under section 7 of the Endangered Species Act. As a result, the Plan must avoid jeopardy to federally listed species and be consistent with protections afforded to federally listed species

the Delta (the Preservation of Rare, Threatened, or Endangered Species (RARE) beneficial use in the 2006 Bay-Delta Plan), which is typically the most sensitive use.

As a result, the Board must at a minimum adopt flow and other objectives in the Bay-Delta Plan that are consistent with the conservation of listed species under CESA. But the Board should achieve more than minimal compliance with CESA, both with respect to listed species as well as to provide adequate protection for species, such as fall run Chinook salmon, that are not listed under CESA but support major commercial and recreational fisheries and/or are species of concern whose populations have declined over time. This is consistent with the co-equal goals of the Delta Reform Act, the public trust doctrine, and salmon doubling requirements; the co-equal goals do not preempt, override, or affect CESA, the Fish and Game Code, the Porter-Cologne Water Quality Control Act, section 1702 of the Water Code, the public trust doctrine, CEQA, water rights, or several other enumerated laws. Cal. Water Code § 85032.[8] Instead, the co-equal goals make restoration of fish and wildlife beneficial uses in the Delta of equal concern to improving water supply reliability.

4. <u>The Board Must Consider Economic Benefits of Protecting Public Trust Fishery Resources in Determining the Reasonableness of Water Quality Objectives</u>

As the Board considers economic factors and other beneficial uses in determining what objectives to protect fish and wildlife beneficial uses in the Bay-Delta are reasonable, Cal. Water Code § 13241, and what protections for public trust resources are feasible, *National Audubon Society,* 33 Cal.3d at 446, the Board cannot limit its analysis to economic costs, but must also consider the economic benefits of improved flows for public trust resources. These economic benefits include:

- The economic value of sustaining and restoring commercial and recreational fisheries for salmon, crab, starry flounder, sturgeon, and numerous other native species that depend upon the Delta. Together, these fisheries contribute at least hundreds of millions of dollars each year to local and state economies and support thousands of jobs.
- The economic value of recreational activities in the Delta, such as bird watching or duck hunting, which depend upon a healthy Delta ecosystem. In 2011, the U.S. Fish and Wildlife Service estimated that 26% of Californians participated in hunting, fishing, or wildlife dependent recreation (such as birdwatching), and that statewide, these activities resulted in more than $7 billion in total expenditures. The Board should invite the Delta Protection Commission, other local and state agencies, and other economists to provide detailed information and estimates of the economic value of wildlife dependent recreation in the Delta.
- The monetary value of a healthy Delta ecosystem, including recovery of listed fish species. David Sunding has presented preliminary results of a contingent valuation methodology for the Bay Delta Conservation Plan, which showed that the non-use value of restoring the Delta ecosystem ranges from a present value of $12 billion to $53

[8] The Delta Reform Act also explicitly preserves area of origin, watershed of origin, water rights priorities, and several other provisions of the water Code. Cal. Water Code § 85031.

billion.[9] His analysis shows that the present non-use value of restoring the Delta is greater than the present value of a 20% reduction in water exports from the Delta, and may be worth three times as much as a 20% reduction in water exports from the Delta. Given the importance of adequate flows to restoring the health of the Delta ecosystem, these estimates should apply equally to the Board's weighing of economic benefits of improving flow conditions in the Bay-Delta.

- The economic value of agriculture in the Delta, to the extent that protections for fishery resources are consistent with and help protect agricultural uses in the Delta.
- Improved reliability of water supplies over the longer term in terms of reduced conflicts with species protections and avoiding future endangered species act listings.
- Other economic values that are consistent with ecosystem protection of the Delta, such as the value of protecting export water quality (reduced water quality treatment costs).

Of course, economic considerations do not trump the responsibility to protect public trust resources or meet other legal requirements. *See* Brian Gray, *Ensuring the Public Trust*, 45 U.C. Davis L. Rev. 973, 990 ("if the consumptive use threatens significant harm to public trust uses, the public trust may take precedence — even at substantial cost to the consumptive water user." (citations omitted)); SWRCB Decision 1631 at 176-180 (increased costs of developing alternative water supplies was feasible and did not prevent implementation of protection of public trust resources). As the Board concluded in 1994, the focus is in determining "whether the economic costs of this decision [to protect public trust resources] make its adoption infeasible." SWRCB Decision1631 at 176-77. And where the legislature has acted to constrain the Board's discretion, the Board has recognized in past decisions that economic considerations cannot outweigh meeting those statutory mandates. SWRCB Decision 1631 at 172; *see* pages 7 through 9, *infra*. This is particularly true when a physical solution, such as the development of water recycling facilities or improved water use efficiency, is feasible and minimizes conflicts between protection of public trust resources and other beneficial uses of water.

5. <u>The Water Quality Control Plan and Program of Implementation Must Demonstrate How Salmon Doubling and Other Objectives Will be Achieved</u>

Under state law, the Board must determine what flows and other actions are necessary to achieve salmon doubling and other water quality objectives that are adopted in the Bay-Delta Plan. Water Code §§ 13050(j)(3), 13242(a); *In re State Water Resources Control Board Cases*, 136 Cal.App.4th 674, 775 (2006) ("Determining what actions were required to achieve the narrative salmon protection objective was part of the Board's obligation in formulating the 1995 Bay–Delta Plan in the first place.").

For more than two decades, both state and federal law have required the State and Federal governments to take action to double natural production of native salmon populations. Cal. Fish

[9] Sunding's analysis is available online at: http://baydeltaconservationplan.com/Files/June%202012%20Public%20Meeting%20Presentation%206-20-12.pdf (*see* slides # 51-54).

and Game Code §§ 6900 *et seq*; Central Valley Project Improvement Act, § 3406(b)(1) of P.L. 102-575. Consistent with these statutory requirements, the 1995 Bay-Delta Plan included a narrative objective of salmon doubling, which reads: "Water quality conditions shall be maintained, together with other measures in the watershed, sufficient to achieve a doubling of natural production of Chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law." In the 1995 Plan, and again in the 2006 Plan, the State Board recognized that non-flow measures could contribute to meeting the salmon doubling objective, and in the 2006 Plan the Board identified several such measures.

In the 1995 Plan, the Board acknowledged uncertainty as to whether the measures would be sufficient to achieve the objective, and in the 2006 Plan the Board found that "D-1641 did not require separate actions to implement the narrative objective for salmon because the State Water Board expects that implementation of the numeric flow-dependent objectives and other non-flow measures will implement this objective." 2006 Plan at 33. In both plans, the Board stated that monitoring results and studies would be used to evaluate achievement of this objective and to develop additional or revised numeric objectives. 1995 Bay-Delta Plan at 29; 2006 Plan at 33.

Unfortunately, it is clear that the specific flow objectives in the plan and those other measures were not sufficient to achieve the salmon doubling objective, as salmon populations have continued to decline and are further from achieving the doubling goal than when the CVPIA was enacted twenty years ago. While salmon doubling will not be achieved solely by improving flow conditions, there is substantial evidence that the existing flow requirements in the 2006 Plan are not sufficient to achieve salmon doubling. As a result, the Board must ensure that the updated plan and program of implementation include flow and other measures that will achieve salmon doubling. As the Court of Appeal noted in 2006,

> If the Audubon Society parties are correct in their contention that scientific evidence shows the flows needed to achieve the narrative salmon protection objective must be greater than the Vernalis flow objectives of the 1995 Bay–Delta Plan, then that evidence may provide a basis for *changing* the Vernalis flow objectives in the next regulatory proceeding to review and revise the water quality control plan for the Bay–Delta.

In re State Water Resources Control Board Cases, 136 Cal.App.4th at 777. There is sufficient scientific evidence showing that greater flows and other protections are needed to achieve the narrative salmon doubling objective, in terms of Vernalis inflow as well as Sacramento River inflow, outflow, and cross-delta flows / export restrictions.

6. Conclusion

The Board faces substantial challenges in meeting its responsibility to preserve fish and wildlife beneficial uses, protect the public trust, conserve endangered fish species and commercial and recreational fisheries, double salmon populations, and contribute to more reliable water supplies by investments in water recycling, conservation, and other regional tools. But the Board also has a significant opportunity before it, to place California on a path to restoring one of the largest and most unique estuarine ecosystems in the world to some measure of health and resilience and on a path to creating a more sustainable water supply that can support a growing population and economy. Finally, the Board has substantial authority to realize these goals, and a legal and ethical mandate to wield that authority. We look forward to working with the Board to ensure that the Bay-Delta Plan achieves these legal requirements and protects public trust resources, and the jobs, economies, and quality of life that depend on them.

II. Recommendations Relating to Workshop 3: Analytical Tools for Evaluating the Water Supply, Hydrodynamic, and Hydropower Effects of the Bay-Delta Plan

This section directly addresses the two major questions posed as topics for discussion in Workshop 3:

- What types of analysis should be completed to estimate the water supply, hydrodynamic, and hydropower effects of potential changes to the Bay-Delta Plan? and
- What analytical tools should be used to evaluate those effects?

Our recommendations are focused on the tools and analytical components the Board should consider in an impact analysis of potential changes to the Plan that can be done in a relatively short period of time (i.e., in order to support adopting Plan amendments by mid-2014) and which best reflect the many adaptations that water users and hydropower producers can and will employ in response to new requirements and a changing climate. While there are a number of models and tools that the Board should consider, the Board should be aware of and work to address the limitations of these models, particularly ones that were developed to address questions very different from the ones being asked by the Board. Even though time constraints may force the Board to employ monthly models that are sub-optimal for the task, no one model should be relied upon for the water supply impact. The Board should consider employing screening models, simulation and optimization models, as well daily or weekly spreadsheet-based models.

1. <u>Evaluate Alternative Water Supplies and Incorporate Them Into the Modeling of Changes to the Bay-Delta Plan</u>

The Board should analyze the full range of water supply management tools including water recycling, improved conservation and efficiency, conjunctive use, transfers, etc., that water users could use to adapt to and mitigate the impacts of changing circumstances, including new Plan requirements. These water supplies and management options should be incorporated into the modeling to fully assess the impacts of changes to the Plan.

a. Increased Investments in Water Efficiency, Recycling, and Other Alternative Water Supply Strategies and Tools Can Yield Significant New Water

Increased water use efficiency, alternative water supplies, and smarter water management offer substantial opportunities to increase California's water supply and decrease demands for water diversions from the Bay-Delta. Based on statistics from the Department of Water Resources' 2009 State Water Plan and supporting documents, documents produced by the State Water Resources Control Board, and research conducted by NRDC and the University of California, Santa Barbara, alternative water supplies and water use efficiency could conservatively result in an additional 6.12 million acre-feet of water per year, state wide, by the year 2030. Based on the conservative estimates outlined below, alternative water supplies could produce significantly more water than current average diversions from the Sacramento-San Joaquin Delta. These alternative water supplies come in the form of agricultural water use efficiency, urban water use efficiency, groundwater, recycled water, and urban stormwater capture (also referred to as low impact development), and in many cases can be more cost effective and more reliable in the long term than Delta supplies. Below we identify additional information and resources for the Board's update of the Bay-Delta Plan.

i. Agricultural Water Use Efficiency

According to CALFED's 2006 Water Use Efficiency Comprehensive Evaluation, on-farm and water supplier recoverable and irrecoverable flow reductions could range from .33 million acre-feet to 3.96 million acre-feet by 2030, depending on investments and funding.[i] In terms irrecoverable flows, CALFED estimates that flow reductions could range from .034 to .888 million acre-feet per year. CALFED estimates that regulated deficit irrigation flow reductions will be 0.142 million acre-feet. In the 2009 State Water Plan Update, DWR chose to use an annual irrecoverable flows water savings of .888 million acre-feet per year for planning purposes. Combined with regulated deficit irrigation flow reductions that yields an annual savings of 1.03 million acre-feet per year. In addition to DWR's estimates, others have estimated significantly higher potential water savings from improved agricultural water use efficiency.

ii. Urban Water Use Efficiency

Urban water use efficiency has the potential to greatly reduce demand for Delta water.[ii] The state estimates that potential reductions in demand from SB 7x7 compliance alone are 1.59 million acre-feet annually by 2020. According to a 2006 CALFED evaluation, the total annual technical potential for 2030 urban water savings is about 3.1 million acre-feet per year. This technical potential does not include advances in water-saving technology, which could lead to even higher levels of efficiency savings.[iii] Los Angeles Department of Water estimates that the unit cost for conservation is in the range of $75-900 per acre-foot, depending on the costs of conservation rebates, hardware installation, and incentive programs and their potential water reductions.[iv] Inland Empire Utilities Agency estimates that their conservation programs cost $69-1094 per acre foot.[v]

iii. Urban Stormwater Capture

A technical analysis conducted by NRDC and UCSB found that implementation of low impact development practices that emphasize rainwater harvesting has the potential to increase local water supplies by up to 405,000 acre-feet of water per year by the year 2030.[vi] Expanding the use of low impact development to industrial, government, public use, and transportation development and redevelopment in southern California has the potential to yield an additional 75,000 acre-feet of savings per year by 2030. Low impact development is a cost-effective alternative water supply – the U.S. Environmental Protection Agency states that "LID practices can reduce project costs and improve environmental performance" of development and that, with few exceptions, low impact development has been "shown to be both fiscally and environmentally beneficial to communities."[vii] According to the State Water Resources Control Board's Recycled Water Policy, the State Board has adopted the goal of increasing the use of stormwater over 2007 use by at least 0.5 million acre-feet per year by 2020, and at least one million acre-feet per year by 2030.[viii] Los Angeles Department of Water and Power has estimated that the unit costs of advanced urban runoff management range from $60 per acre-foot for centralized stormwater capture, to $4,044 per acre-foot for urban runoff plants. LADWP estimates that the cost of rain gardens ranges from $149-1,781 per acre foot, and water from rain barrels and cisterns ranges in cost from $2,326 to $2,788 per acre foot.[ix]

iv. Recycled Water

DWR's 2009 State Water Plan Update estimates that 0.9 million to 1.4 million acre-feet of "new water" could be created by 2030 by recycling municipal wastewater that is discharged into the ocean or saline bays. Statewide, there is an estimated potential supply of about 1.85 to 2.25 million acre-feet of water that could be realized by the year 2030.[x] The State Board has adopted a recycled water use target of at least one million acre-feet per year by 2020, and at least two million acre-feet per year by 2030.[xi] When considering both capital and O&M costs to expand Los Angeles Department of Water and Power's recycled water system to achieve water recycling targets, LADWP estimates that the present value per acre-foot of recycled water over a 50-year life cycle analysis results in a blended cost of $1,100 per acre-foot.[xii] A sampling of the operational costs of the existing recycled water projects in San Diego County show costs ranging from $1,259-1,662 per acre-foot.[xiii] The unit cost of the current Orange County Water District Groundwater Replenishment indirect potable reuse water is $1,299 per acre-foot, including the cost of extraction.[xiv] In addition to municipal wastewater recycling, recycling of a variety of waste streams, including brackish groundwater, agricultural drain water, produced oil water, and municipal greywater, can significantly increase the water supplies in the Central Valley and export regions..

v. Conjunctive Groundwater Management

According to DWR's 2009 State Water Plan Update, conservative estimates of additional implementation of conjunctive management of groundwater resources indicate the potential to increase average annual water deliveries by 0.5 million acre-feet throughout the state. More ambitious estimates indicate the potential to increase average annual water deliveries by two million acre-feet per year.[xv]

b. The Board Should Consider Alternative Water Supply Strategies and Tools in Evaluating Potential Water Supply, Economic and Employment Consequences of Changes to the Plan

The existing CALSIM model is a monthly simulation model to evaluate Federal and State export capabilities, and is designed to meet all demands no matter what the cost, subject to regulatory and physical constraints. It is not the optimal tool for assessing potential water supply impacts in light of alternative water supply strategies such as intra-Basin water transfers, improved water use efficiency, water recycling, and increased groundwater use. The Board should take great care using CALSIM results in estimating water supply impacts, and the use of those results in subsequent modeling of economic and employment effects, such as the Statewide Agricultural Production (SWAP) model or Impact Analysis for Planning (IMPLAN) model. Deficiencies in the water supply modeling will propagate through subsequent economic models.

By ignoring the many alternative and adaptive water management strategies available to water users, modeling can result in significant overestimates of impacts. For instance, initial IMPLAN modeling of employment and economic effects of drought and fishery protection measures in 2009 were dramatically revised downward (employment estimates were revised downward by an order of magnitude), in large part because of increased water transfers which were not anticipated in the modeling. Jeffrey Michael and Richard Howitt et al 2010. *A Retrospective Estimate of the Economic Impacts of Reduced Water Supplies to the San Joaquin Valley in 2009*, at 1.

The Board has acknowledged this conclusion in other analyses; for instance, as the Board has recognized in February 2012, "Input-output analysis approach employed by IMPLAN usually overestimates indirect job and income losses…. For these and other reasons, job and income losses estimated using input-output analysis should often be treated as upper limits on the actual losses expected (SWRCB 1999)." *See* SWRCB, Draft Agricultural Economic Effects of Lower San Joaquin Flow Alternatives, February 2012, at X-29.

Over the longer term, because of availability of alternative supply tools (and greater price elasticity of water in the longer term), estimates of employment and economic consequences of reduced Bay-Delta diversions will likely be overestimated. This is consistent with observed behavior during drought and in prior proceedings, where water users have utilized water transfers, improved efficiency, and other alternative supplies when diversions were reduced.

Therefore, the Board should also consider using water supply models, such as UC Davis' CALVIN model,[10] which can incorporate the response of water users to reduced diversions from the Bay-Delta, including investments in conservation, water recycling, and other alternative water supply tools, as well as increased water transfers. In addition, the Board should explicitly acknowledge in its analysis that estimates of the economic and employment consequences of changes in water supply are likely to be overestimated to the extent that feasible increases in conservation, water transfers, and alternative water supplies are not explicitly modeled.

2. The Board Should Explicitly Model Reservoir Reoperation and Include Changed Assumptions in CALSIM Modeling, Which Has Demonstrated that Increased Spring Outflow Need Not Adversely Affect Upstream Reservoir Storage

[10] University of California, Davis. Statewide Economic-Engineering Water Model – CALVIN. Available online at: http://cee.engr.ucdavis.edu/faculty/lund/CALVIN/ (last visited October 22, 2012).

As the Board recognized in the September 6, 2012 workshop, CALSIM modeling work in BDCP on Alternative 8 shows that increased winter/spring outflow need not adversely affect upstream reservoir storage (cold water pool) and upstream protections necessary for spawning and juvenile salmonids. As the Board is well aware, one of the significant limitations of the CALSIM model is that it typically does not include reservoir carryover requirements in the model and the model is driven to maximize CVP/SWP exports within available constraints. We understand that the state and federal agencies working on BDCP developed additional modeling of reservoir reoperation criteria in 2012 (part of the CS5 modeling), which included revised reservoir storage and release criteria to protect salmonids.

The Board should build on and further refine the approach to modeling Alternative 8 and CS5, in consultation with the fish and wildlife agencies, to explicitly model revised reservoir reoperation criteria and account for minimum reservoir storage and releases needed to meet downstream temperature compliance points in the spring and summer months. This revised modeling analysis should be applied to a broader range of alternative outflow objectives in this proceeding, and should be utilized to ensure that the Plan includes both adequate inflow and outflow requirements, while also ensuring that upstream protections for salmonids are maintained or enhanced, particularly in the face of climate change.

3. <u>The Board Must Incorporate Climate Change in its Modeling and Analysis of Consequences of Potential Changes to the Plan</u>

Because climate change is likely to alter the timing and volume of runoff into the Bay-Delta, the Board must incorporate the effects of climate change into its analysis. Recent modeling work performed for the California Energy Commission has demonstrated that climate change is likely to dramatically change the frequency of water year types as defined in D-1641; as the authors noted, "If current water year type thresholds are maintained, more years will be classified as dry and less water will be allocated for environmental outflows, perhaps failing to provide adequate hydrologic variability to support species, habitats, and ecosystems." Null & Viers 2012 at ii. Their modeling predicts that the effects of climate change will generally result in reduced annual runoff and April-Jul Runoff in both the San Joaquin and Sacramento Basins in the 2001-2050 period as compared to 1951-2000. *Id*. at 8-9. As a result, in the Sacramento Basin their model generally predicts that critical and dry water year types will be more frequent, and above normal and wet years will be less frequent. *Id*. at 15. For the San Joaquin Valley, the results are even more striking, with as much as a 15% increase in critical water year types (to over 41% of years), and reductions in all other water year types. *Id*.

Similarly, DWR's modeling (including sea level rise) also anticipates that water exports from the Bay-Delta will decrease as a result of climate change; for instance, modeling for BDCP anticipates that the effects of climate change will reduce water exports by 200TAF by 2025. The effects are even more dramatic over the longer term, with DWR predicting that water exports from the Bay-Delta may decrease by 10% by 2050 and by 25% by 2100 as a result of climate change. *See* DWR, Possible Impacts of Climate Change to California's Water Supply, California Climate Center, Summary Sheet, April 2009 (Available at: http://www.water.ca.gov/pubs/climate/climate_change_impacts_summary_sheet__june_2009/climate_change_impacts_summary_sheet_6-12-09_lowres.pdf).

We strongly encourage the Board to incorporate climate change effects, including these analyses, into their modeling of the analysis of the consequences of potential changes to the Plan. In particular, because the modeling shows that the frequency of water year types is likely to change significantly, we strongly encourage the Board to move away from objectives and flow measures that are based on water year type, and instead use a percentage of unimpaired flow approach or similar tool. Objectives based on water year type will become less protective of public trust resources as a result of climate change.

4. If the Board uses the CALSIM model for impact assessment, it should use CALSIM 3 as it represents a more transparent and better documented model than CALSIM 2, provides a superior representation of the hydrology and water use, and can more readily evaluate some alternative water management strategies.

Although the use of the CALSIM simulation for impact assessment has the shortcomings noted above (including its inability to economically evaluate investments in alternative water management strategies, its formulation as an export demand driven tool for the State and Federal projects which constrains its use as an impact assessment tool for all water users, and the difficulty in easily incorporating different operational strategies), we recognize that it may be used by the Board because it is the most detailed simulation model of the Bay-Delta water supply system and widely used in many other proceedings. Because the CALSIM 2 model is more than a decade old, aggregates water use over large areas, relies on some very outdated 50-year-old hydrologic representations, and is not dynamically integrated with groundwater, efforts were undertaken in the mid-2000s to develop CALSIM 3. That effort is very close to being completed (possibly by the end of 2012) and should provide a much better model than CALSIM 2 for the Board to use, particularly in its superior representation of the hydrology, water use, surface and groundwater interaction, and ability to more readily evaluate changes in land use and irrigation efficiencies. It is also much more transparent and better documented than CALSIM 2 (Andy Draper, personal communication).

5. <u>The Board's Analysis of Unimpaired Flow Alternatives Must be Compared to Disaggregated Flow Needs of Key Species and Public Trust Resources</u>

Finally, as the Board develops alternatives, including alternatives based on a percentage of unimpaired flows, it is critically important that the Board compare the flows likely to be provided under those alternatives against the flow needs of key species and flow recommendations, including those provided by state and federal fish and wildlife agencies. It is not sufficient that the Board simply show that the flow objectives mimic "natural" flows or provide a more natural hydrograph. Rather, the Board must provide analysis showing the likely flows that would be provided under various alternatives and how those compare to fishery needs (duration, frequency, magnitude, and timing of flows).

In order to provide that needed analysis, we recommend the following approach, which is similar to the Board's analysis in 2010. First, the Board should identify the duration, frequency, magnitude, and timing of flows necessary for key species. During the 2010 Delta public trust flow criteria proceedings, we provided specific, detailed flow recommendations targeted to attributes of viability for key species in the ecosystem that are based on publicly available data from agency sampling programs. Based on additional analysis and refinement of our recommendations since 2010, we intend to provide the Board in the near future with a modestly revised set of flow criteria for consideration and potential adoption as water quality objectives in the Plan, along with recommended actions for inclusion in the program of implementation. For the time being, we provide page references to the specific recommendations in our 2010 Delta flow criteria exhibits and 2012 Phase 2 workshop testimony (Table 1); we note also that CDFG and CSPA offered specific flow recommendations in their 2010 testimony to the Board – those recommendations should also be incorporated into the Board's analysis of alternatives.

Table 1: Specific flow recommendations resulting from TBI et al. Exh. 1-4 (2010) and TBI/NRDC (2012) analyses of the relationship between seasonal freshwater flows and attributes of viability for key public trust resources.

Source	**Flow Category**	**Page #**	**Comment**
TBI et al (2010), Ex. 2	Delta outflows (winter spring)	25	Text at bottom of page
TBI et al (2010), Ex. 2	X2 (Fall)	35	Table 1
TBI et al (2010), Ex. 3	Sacramento River Inflow	36	Table 3 (and associated text)
TBI et al (2010), Ex. 4	Hydrodynamic criteria for Sacramento Basin Chinook salmon & steelhead	10	Text
TBI et al (2010), Ex. 4	Hydrodynamic criteria for San Joaquin Basin Chinook salmon & steelhead	12, 23	Text
TBI et al (2010), Ex. 4	Hydrodynamic criteria for Delta smelt	15, 26	Text
TBI/NRDC (2012)	Hydrodynamic criteria for Longfin smelt	22	Footnote 10 (correcting typographical error in TBI et al 2010, Exh. 4)
TBI et al (2010), Ex. 4	Hydrodynamic criteria for maintenance of protective spatial distribution (multiple species)	29	Text
Note: We summarized our hydrodynamic recommendations in TBI et al., Exh. 4, p. 30 (Table 1). For the Board's convenience, we converted all hydrodynamic flow recommendations into their rough equivalent in terms of Old and Middle River flows (using interpolations described earlier in the exhibit). For the Board's current analysis, we recommend analyzing hydrodynamic criteria in the terms (e.g. Vernalis Flow:Export Ratio, etc.) in which they were originally developed in our testimony. Also, please note that the footnote associated with April and May of critical years has been corrected in our Workshop 2 testimony (page 22, footnote 10).			

The Board should aggregate these flow needs into an annual hydrograph and then compare that aggregated analysis with flow alternatives that express actual flows as a continuous function of unimpaired hydrology to determine the extent to which alternatives achieve the duration, frequency, magnitude, and timing of flow recommendations for key species. In its 2010 final report, the Board staff expressed actual recommended flows as a percentage of the 14-day moving average of unimpaired hydrology in the relevant watershed – we support that approach within boundaries established by requirements for maintaining upriver storage described in the NMFS Biological Opinion (NMFS 2009) and minimum exports required to protect human health and safety.

Because many of our flow recommendations fall along a somewhat continuous spectrum of benefits to public trust resources (i.e., they are not binary, full benefit v. no benefit at all), and because all of our recommendations are based on the assumption that *all other significant non-flow related stressors are addressed*[11], we recommend that Board staff evaluate the potential benefits of different levels of freshwater flow using a tabular approach as outlined below in Table 2.

Table 2: Recommended approach to capturing differences among flow alternatives in their ability to provide flows necessary to support viability of public trust benefits. For each specific flow criteria recommendation (e.g. from TBI et al. Ex. 1-4, 2010, CDFG 2010), modeling would determine each flow alternative's ability to provide the recommended flow in terms of its magnitude, timing, duration, and frequency or fraction thereof if other aspects of flow were attained as recommended.

Flow Alternative	**Criteria Based On** **(Species -- Attribute)**	**Location**	**Max % Magnitude** **(*if* timing, duration, & frequency as originally described)**	**Max % Timing** **(% of critical period *if* mag., dur., freq. as originally recommended)**	**Max % Duration** **(*if* mag., timing, & freq. as originally recommended)**	**Frequency** **(*if* mag., timi & duration a originally recommende**

[11] As stated in our 2010 testimony: "In developing flow criteria we have recommended the *minimum* flows required to restore the viability of public trust species *if all other stressors are appropriately mitigated*." TBI et al. 2010; Exh. 1, p. 15. Emphasis in original.

This approach will allow the Board to determine which viability attributes of key aquatic species may be impaired under different flow alternatives and where there are tradeoffs between aspects of flow (magnitude, duration, timing, and frequency). This will facilitate efforts the Board's efforts to balance public trust values against other beneficial uses and to identify the extent to which different flow alternatives satisfy (or fail to satisfy) the needs of public trust resources.

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[i] http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c02_agwtruse_cwp2009.pdf
[ii] 20x202 Water Conservation Plan. February 2010. http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/docs/20x2020plan.pdf
[iii] http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c03_urbwtruse_cwp2009.pdf
[iv] Los Angeles Department of Water and Power UWMP page 22
[v] IEUA 2010 Water Use Efficiency Business Plan, Page 62
[vi] A Clear Blue Future: How Greening California Cities can Address Water Resources and Climate Challenges in the 21st Century. NRDC Technical Report, August 2009. By Noah Garrison (NRDC) and Robert C. Wilkinson (Donald Bren School of Environmental Science and Management, University of California at Santa Barbara) http://www.nrdc.org/water/lid/files/lid_hi.pdf
[vii] U.S. Environmental Protection Agency, December 2007, Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices, fact sheet number 841-F-006, http://www.epa.gov/owow/nps/lid/costs07/factsheet.html
[viii] State Water Resources Control Board Recycled Water Policy Preamble, Page 1 http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/docs/recycledwaterpolicy_approved.pdf
[ix] Los Angeles Department of Water and Power UWMP Page 22
[x] http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c11_recycmuniwtr_cwp2009.pdf
[xi] http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/docs/recycledwaterpolicy_approved.pdf
[xii] Personal communication with Los Angeles Department of Water and Power, Thomas Erb and James Yannotta, by NRDC intern Caitrin Phillips. http://switchboard.nrdc.org/blogs/bnelson/Local%20vs%20Imported_Final%208-4-11.pdf
[xiii] SDCWA Unit Cost of New Local Supply Alternatives, September 15, 2010
[xiv] SDCWA Unit Cost of New Local Supply Alternatives, September 15, 2010
[xv] http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c08_conjunctmgmt_cwp2009.pdf

III. Closing Comments, Part Two: Discussion of Selected Issues Raised in the Phase 2 Workshops

1. As the Board Appropriately Concluded in 2010, there is Sufficient Scientific Information on Which to Improve Flows to Protect Public Trust Resources

Contrary to the suggestions of some participants at the prior two workshops, the Board has sufficient scientific information on which to base changes to the Bay-Delta Plan in order to adequately protect public trust resources and achieve other statutory requirements. Only two years ago, the Board concluded that there was sufficient scientific information on which to act to increase flows: "There is sufficient scientific information to support the need for increased flows to protect public trust resources; while there is uncertainty regarding specific numeric criteria, scientific certainty is not the standard for agency decision making" (SWRCB, 2010, p. 4). That Board finding is still accurate today, and as documented in our testimony for workshops 1 and 2, the new scientific information developed since 2010 largely confirms and strengthens the conclusions in the Board's 2010 report.

The Bay-Delta is one of the best-studied estuaries in the world, with an incredible set of long term monitoring data and targeted scientific studies. Although there will always be scientific uncertainty and a need for managing adaptively as new information becomes available, the best available scientific information demonstrates that current flows are completely inadequate to protect public trust resources. The situation is urgent: 83% of California's fish species are extinct or at risk of becoming so (TU et al, 2012). Scientific uncertainty does not justify failing to act, as the Delta Environmental Flows Group reminded the Board in 2010 (Delta Environmental Flows Group, 2010). Instead, the Board should:

- Set water quality objectives based on the best scientific information that is currently available.
- Articulate clear and measurable biological and ecological targets that represent the desired outcomes of implementing the objectives.
- Identify specific scientific studies or monitoring programs that are necessary to help reduce scientific uncertainty.
- Use an adaptive management program to modify flow levels (and/or utilize the Board's next review of the Plan to revise objectives in light of new scientific information).

2. The Need to Address Other Stressors Does Not Reduce the Need for Large-Scale Flow Augmentation; Indeed, Improving Flows Is Critical to Addressing Other Stressors

Some parties have suggested during the Phase 2 workshops that the Board's update to the Plan will necessarily be deficient because it only addresses flow alteration, and that mitigating the impacts of other stressors is more important than improving flow conditions. These assertions are quite simply incorrect.

a. The scientific evidence clearly demonstrates that flow alteration is the single most important, best-documented stressor of fish and wildlife beneficial uses, and that restoring flows is most likely to be effective in protecting those uses.

Following the large-scale conversion of natural habitats that occurred in the late 19th/early 20th century, the alteration of freshwater flow rates and timing caused by water storage, diversions and exports since the mid-20th Century is the single most important stressor on fish and wildlife beneficial uses (e.g. Baxter et al, 2007). Half or more of the water that would normally flow through the Delta is diverted by water users upstream and south of the Delta (e.g. Fleenor et al. 2010; Cloern and Jassby 2012); to serve seasonal water use demands, the timing of freshwater flows has been changed dramatically (e.g. Fleenor et al. 2010) and in ways that do not support the evolved life histories of native fishes. The relationship between abundance and distribution of native fish species and the volume, timing and duration of freshwater flows into, through, and/or out of the Delta are

- Powerful (occur over orders of magnitude),
- Persistent (over 4+ decades of community sampling),
- Widespread (including a wide variety of native and naturalized species),
- Common (evident among a high fraction of species studied), and
- Statistically significant (Stevens and Miller, 1983; Jassby et al., 1995; Kimmerer 2002; Dege and Brown 2004; Rosenfield and Baxter 2007; Kimmerer et al., 2009; Mac Nally et al., 2010; Thomson et al., 2010).

<u>This latter attribute deserves emphasis: statistical significance of a correlation means it is very unlikely to occur at random. The number of significant correlations between attributes of fish viability (abundance, spatial distribution, life history and productivity) is among the strongest patterns observed in any ecosystem in the world. Although "correlation is not causation," the overwhelming number, diversity, strength, and persistence of correlations between freshwater flow and species' viability in the San Francisco Estuary is exceptionally compelling evidence that flows are mechanistically related to the viability of public trust resources</u>. It is widely acknowledged that freshwater flow drives, influences, or affects numerous other variables that may impact the viability of fish species (e.g., Dugdale et al., 2007; Sommer et al. 2001, 2004; Kimmerer 2004; Cloern and Jassby 2012). Conversely, no other single physical or biological variable explains the declines (and periodic increases) in as many species of fish and wildlife as freshwater flow. Simply put, there is overwhelming evidence supporting the need for action to set standards regarding the timing, duration, frequency, and magnitude of Delta freshwater inflows and outflows to support restoration of the Delta's public trust resources and there is absolutely no evidence that would support a plan for restoring these fish and wildlife beneficial

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uses that did not include significant improvement in flow conditions. If the Board had to select the single stressor it should prioritize based on the scientific evidence concerning the certainty of large-scale benefits for fish and wildlife resources, that stressor would be flow alteration – a stressor that the Board has the authority and obligation to address.

b. Large-scale flow improvements are needed to protect beneficial uses in conjunction with actions to mitigate other stressors; absent mitigation of other stressors, flow restoration would need to exceed the 75% Sacramento River inflow and Delta outflow levels identified in the Board's 2010 Delta flow criteria report.

In addition to the need for flow improvements, it is both necessary and desirable to address other stressors of public trust beneficial uses in this ecosystem in ways that complement improvements in freshwater flow. As stated in our 2010 testimony: "In developing flow criteria we have recommended the *minimum* flows required to restore the viability of public trust species *if all other stressors are appropriately mitigated*." TBI et al. 2010, Exh. 1, p. 15 (Emphasis in original); *see also* TBI et al. 2010, Exhibit 2, p. 14. Absent the assumption that physical habitats, water quality, and food web productivity can and should be restored through a suite of flow and non-flow measures, the flows required to maintain public trust benefits in this species would be larger than we have recommended to the Board. A multi-pronged approach to restoration is required; without it, flows would have to be provided at a level much closer to unimpaired flows, as indicated by studies of the flows required to maintain similar fish and wildlife benefits in other aquatic ecosystems (which are also impacted by a variety of non-flow related stressors). The best available information from other aquatic ecosystems suggests that protection of public trust resources in the San Francisco Bay-Delta will be inadequate if other stressors are not substantially alleviated and more than ~15% of the unimpaired flow is diverted or delayed from its natural flow pattern (e.g. Richter et al, 2011; Dahm, 2010).

c. Flow improvements are critical to addressing other stressors.

The complementary point to the discussion above is that flow measures are a key part of the solution to other stressors. For instance, higher peak flow events in the Delta can help control the spread of invasive species and reduce predation that increases when turbidity is low, and higher river inflows can reverse habitat loss and reduce predation by increasing the extent and duration of inundated floodplains. The implications for flow management in the restoration of critical habitats are particularly well-documented in the case of Central Valley floodplains; see, for example Sommer et al. (2001), Sommer et al. (2002) and Jeffres et al (2008).

d. The Board can and should address other stressors in updating the Bay-Delta Plan.

It is important to also point out that the Board can address other stressors in both the Plan's water quality objectives and the program of implementation. For instance, the Board has previously identified the adoption of objectives for floodplain inundation as a potential amendment to the Plan, and we and other parties have submitted detailed recommendations for flow regimes that are specifically designed to optimize the benefits provided by floodplain habitats (TBI et al, 2010, Ex. 3; see also more recent Phase 2 testimony of American Rivers.). Furthermore, the Board can include actions it can take to address other stressors using different powers than through its water quality objective setting and water right permitting authorities, and include them in the program of implementation. Finally, in the program of implementation the Board can also identify actions that other entities are taking or should take to address other stressors. We plan to provide the Board in the near future with a list of such actions for potential inclusion in the program of implementation.

3. The scientific basis for amending the Bay-Delta Plan to improve flow conditions continues to be extremely strong, despite assertions to the contrary during the workshops

In this section, we briefly review and rebut a number of assertions regarding the scientific basis for adopting new objectives that improve flow conditions. A summary table of assertions and responses is provided in Appendix 1.

a. Flow correlations are statistically significant and biologically important.

Statistically significant, high order correlations between freshwater flow into, through, and/or out of the Delta and the abundance of native and naturalized aquatic species in the Delta are found among an extremely diverse set of organisms, they are persistent over decades of sampling, and apparent in data sets of numerous long term aquatic community sampling programs (e.g., Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002; Rosenfield and Baxter 2007; Sommer et al. 2007; Feyrer et al. 2009; Kimmerer et al. 2009; Feyrer et al. 2010). It is highly likely that strong correlations between abundance and flow exist for other organisms that have not been studied or which sampling programs do not measure effectively. Furthermore, statistically significant correlations between one flow attribute (e.g. Delta inflow) and abundance do not justify discounting the existence of similar relationships between other flow attributes (e.g. Delta outflow) and abundance of the same species – for example, the strong relationship between Delta inflow/floodplain inundation and Sacramento splittail abundance (Sommer et al. 2004; Sommer et al. 2007; etc.) does not diminish the potential for a separate (additional) relationship between Delta outflow and Sacramento splittail abundance (e.g. Kimmerer 2002) because flows in these two areas would affect different life stages. Although it is true that "correlation does not equal causation", statistically significant correlations do not generally occur at random (that is the definition of statistical significance) and multiple corresponding, long-term, high-order, significant correlations represent very strong evidence of an (or multiple) underlying mechanistic relationship(s) between freshwater flow and abundance of Public Trust resources.

b. There is no convincing evidence that either abundance estimates or flow correlations are based on misuse of datasets and/or faulty datasets.

We strongly support application of consistent aquatic community sampling methodologies and efforts to correct (where necessary) for unintended trends or changes in employing those methods. However, the suggestion that the strong, persistent, widespread correlations between species' abundance and freshwater flow conditions in the Delta that have been detected by diverse sampling programs (including the Fall Midwater Trawl, Bay Study, and/or Suisun Marsh sampling program) are somehow driven by bias in the sampling program(s) [SJTA 2012a. (p. 2), SJTA 2012b. (p. 62), SVWU 2012 (p. 11-14), SWC 2012 (p. 13-18)] or redistribution of the organisms sampled [SWC 2012 (p. 7-8)] is far-fetched. For example, Rosenfield and Baxter (2007) explicitly studied the value of the Fall Midwater Trawl (FMWT) index as a measure of longfin smelt abundance, comparing it to other survey programs (the Bay Study Midwater Trawl and Suisun Marsh survey) that sample year round and in different areas; their conclusion, based on the apparent spatial and temporal distribution of longfin smelt in the estuary, was that the FMWT was well-suited to provide relative (e.g. year-to-year) measures of longfin smelt abundance and distribution. Rosenfield and Baxter (2007) also created a coarse metric that combined abundance measures from these different sampling programs and that metric (based on simple presence-absence at sampling sites throughout the Bay, Suisun Marsh, and west Delta) showed a significant decline in spawning-age longfin smelt over time that was significantly correlated with flow. Similarly, declines in Delta smelt, Chinook salmon, *Crangon* shrimp and other Delta species have been observed in numerous sampling programs over several decades (IEP, 1999; Baxter et al, 2010; CDFG, 2010a; Mattern et al, 2002). No one claims that any particular current sampling program is ideal for measuring abundance and distribution of all species of pelagic fish; however, the San Francisco Estuary is among the best-studied aquatic ecosystems on Earth – the patterns detected and confirmed by multiple, long-term ecosystem sampling programs in the Delta are real, of major concern, and more than sufficiently robust to justify a rapid and dramatic response by the State Board.

c. Flow is the master variable; there is no evidence that other stressors are more important and/or disconnected from flow alteration

Flow is clearly a dominant variable that controls or moderates other potential stressors on fish populations; most scientists agree that it is the single most important stressor to the ecosystem (e.g., Baxter et al, 2010) because it has such a strong effect on fish populations and various factors that control those populations. There are many different ways for fish to die in the Delta (i.e., there are many different potential "stressors" on their populations), including food limitation, direct entrainment-related mortality, or stress from poor water quality conditions. We do not argue that these "other stressors" may not be important; rather we think that the role of freshwater flows in alleviating or mediating these stressors must be dealt with directly. As

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described above, our flow recommendations derive from freshwater flows that corresponded to healthier fish populations in the recent past and must be combined with successful efforts to restore productive habitats and water quality in the Delta.

There is simply zero evidence that an "anything but flow" approach will stop the ongoing degradation of the Delta ecosystem, much less reverse that decline, as some have suggested (e.g. SWC, 2012, p. 1, 5, 9-14 [LFS decline not linked to flow, but to introduction of Amur River clam], SJTA 2012b, p. 37-44 [predation is the real problem]). For example, some have argued that ammonium concentrations (or the ratio among nutrients in the Delta's waters) impedes primary production in the Delta (phytoplankton; SWC, 2012, p. 14, 22-23); from this, they have inferred that reduced primary productivity currently impairs production of fish prey items (zooplankton) and further, that the reduction in fish prey limits fish production. Although this argument may sound reasonable, there is actually very little evidence to support this chain of causation on most (if any) fish species of concern; additionally, studies in other ecosystems generally have not detected responses to changes to one level of production (primary, secondary, etc.) in trophic levels more than one level above or below the trophic level that changed. Also, the alleged statistical support for the linkage between ammonium concentrations and fish populations is extremely flawed; Cloern at al. (2012) indicate that the primary publication underpinning this hypothesis is riddled with statistical errors. and they found:

"...no *history for regression (or correlation) analyses on CUSUM-transformed variables prior to its use by Breton et al. (2006), and we have found no theoretical development or justification for the approach. We prove here that the CUSUM transformation, as used by ... Glibert (2010), violates the assumptions underlying regression techniques. As a result, high correlations may appear where none are present in the untransformed data... Regression analysis on CUSUM-transformed variables [the method used by Glibert 2010] is, therefore, not a sound basis for making inferences about the drivers of ecological variability measured in monitoring programs.* [Emphasis added] [p. 665]

Cloern et al (2012) conclude:

"... Glibert (2010) inferred a strong negative association between delta smelt abundance and wastewater ammonium from regression of CUSUM transformed time series. However, the Pearson correlation (r = -0.096) between the time series ... is not significant, even under the naive ... assumptions (p = 0.68). In short, correlations between CUSUM-transformed variables should not be used as a substitute for analysis of the original untransformed variables." [Emphasis added] [p. 668]

Furthermore, the transfer of impairments on primary production to secondary and fish productivity is not supported by analysis of fish abundance data (except, possibly, in the case of longfin smelt; Kimmerer 2002), nor can it explain why those species that live closest to the putative source of ammonium have flourished (e.g., American shad; on a flow corrected-basis) since the late 1980s, while no change has been observed in the flow-abundance correlations (or lack thereof) for Delta resident species (e.g. Sacramento splittail and Delta smelt), as would be predicted by a nutrient-primary-secondary production mechanism. What is acknowledged by all parties is that improved freshwater flows can flush exess ammonium out of the Delta that may concentrate there as a result of severely reduced freshwater flow pulses. Increased flows would tend to moderate negative effects caused by high concentrations (e.g. Dugdale et al, 2007). If the main cause of high ammonium concentrations is not directly related to human activities (some expect that excess ammonium is produced by high densities of the invasive clam, *Corbula amurensis*, which would not be directly controllable), then increased freshwater flows may be the only way to mitigate an effect of ammonium pollution, at least in the short-term.

Predation has also been offered as a source of problems for native Delta species (SJTA, 2012a, p. 15; SJTA., 2012b, p. 37-44; SWC 2012, p. 23-24); this despite the fact that one of the major flow-dependent predator species in this ecosystem, striped bass, has also declined significantly (e.g., Kimmerer 2002). Another suite of predators has taken root in the Delta over recent decades and these shallow water predators benefit from introduction of aquatic weeds such as *Egeria*. One thing the new invasive predators (Centrarchid bass/sunfish and Mississippi silversides) and the submerged aquatic vegetation share in common is a preference for shallow habitats with slow moving currents. Thus, flow modifications in the Delta have favored the invasive predators (and the SAV from which they also benefit) by creating ecological conditions that resemble those of lakes in the southeastern United States and South America. These invaders will not thrive (or will at least be put at a disadvantage) if flow patterns in the Delta are restored to more naturalpatterns of seasonal and interannual variability. In the meantime, focusing on reducing predation by direct predator removal or targeted engineering to eliminate predator "hotspots" will likely be exceptionally expensive and ineffective here as it has proved to be in other regions of the country, such as the Columbia-Snake River ecosystem. Again, increased flow rates into, through, and out of the Delta are expected to reduce this "other stressor" on native fishes by (1) reducing exposure to high predator populations, (2) reducing predator efficiency, and (3) (occasionally) increasing turbidity – evidence of such an effect is apparent in CDFG's San Joaquin salmon survival model (2010a) and Bowen (2010).

d. There is convincing evidence that entrainment has population level effects and that Old and Middle River criteria or other measures to limit entrainment and reverse flows is justified and appropriate.

Since the Board issued its 2010 flow criteria report (SWRCB 2010), evidence that entrainment-related mortality is periodically an important stressor on certain fish populations has increased, as has evidence that south-Delta exports alter ecosystem food web productivity. Kimmerer (2011) reaffirmed the findings of his 2008 paper, which found that, in some years, a large fraction of the total Delta smelt population and Chinook salmon juvenile year-class may be entrained at the export facilities. In addition, Kimmerer (2011) demonstrated that because of the nature of the salvage impact and population index data, significant levels of entrainment could drive a population towards extinction while remaining undetected by common statistical techniques**.** In addition, Rosenfield (2010) documented a strong correlation between spring

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Delta freshwater outflows and entrainment of longfin smelt juveniles; entrainment was inversely proportional to the previous FMWT index, thus the effect of entrainment is disproportionately high when the longfin smelt population is low. While USFWS (2012) concluded (without analysis) that longfin smelt entrainment was not a continual problem for this population, it also suggested that entrainment rates in certain years could have had a significant impact on the population – thus, entrainment may have an episodic negative impact on the critically imperiled longfin smelt population. Furthermore, Maunder and Deriso (2010) found a strong effect of entrainment of adult Delta smelt on population dynamics in this imperiled species, though they inexplicably removed that variable from their conclusion because the strength of the effect was "too strong". Despite restrictions on Old and Middle River reverse flows implemented as part of the Biological Opinions' RPAs, there have been record or near-record entrainment events for Sacramento splittail, sturgeon, Sacramento sucker, longfin smelt and other fishes in recent years (TBI, 2011); this result suggests that OMR flow criteria contained in the RPAs are not adequate to protect other species in the Delta.

Some argue that it is a good sign when fish salvage rates are high (because it suggests that fish populations are high), but also argue that low salvage years prove that high exports and reverse flows are not a problem (e.g. SWC, 2012, p. 25-27: reverse flows and entrainment do not equate to population effects per Maunder and Deriso). While the exact scope of the salvage problem remains to be completely described, a few things are certain (see TBI, 2011):

(i) most fish salvaged at the South Delta export facilities (and the much larger amount of fish food, eggs, and larvae that are exported without enumeration) are lost to the ecosystem .
(ii) salvage numbers vastly underestimate the impact of entrainment as pre-screen mortality (within the export facility canals) is one or more orders of magnitude greater than salvage.
(iii) entrainment-related loss is indiscriminant and continuous.
(iv) fish and food web resources can be protected by imposing restrictions on exports in the form of minimum OMR flows, export:inflow ratios, and bypass flows (i.e. Delta outflows).

4. The concept of "regime shift" is neither consistent with scientific understanding of ecosystem dynamics nor an appropriate basis for determining that a healthy native ecosystem cannot be restored.

Despite the diversity and magnitude of changes that have been wrought on the Bay-Delta ecosystem, there is every reason to believe that restoration of freshwater flows will contribute to improved viability and persistence of fish and wildlife beneficial uses and public trust resources. When flow improvements are combined with proposed habitat and water quality restoration actions (a strategy we have helped develop and have consistently advocated for), there is a strong scientific basis for the expectation that these beneficial use and resources in the Bay-Delta estuary can be restored to levels that are sufficient and sustainable – there is even reason to hope

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that some resources can be restored to levels that exceed those seen during the onset of the modern period of community sampling (e.g. the late 1960s). The argument that there has been a "regime change" and so it is not possible to "go back" to an ecosystem that supports thriving fish and wildlife populations is deceptive and fundamentally unscientific. The "regimes" (current and past) referred to by this line of reasoning are completely undefined and there is no way to test scientifically whether it is possible to revert to a previous regime or what would be required to do so. The notion of static "regimes" where the abundance and distribution of fish and wildlife populations remain relatively stable in a climax state harkens back to the discredited arguments of community ecologists from the early 1900s (e.g. Clements 1936). In the decades since these ideas held sway, ecologists have learned that ecosystems are in a near constant state of change where productivity is governed largely by temperature, elevation, and latitude while diversity is regulated by productivity, barriers to immigration, and the disturbance (physical variability) regime. In the San Francisco Bay-Delta, humans have clearly changed the rates of species immigration, and global climate change will likely further alter system energetics. However, by restoring freshwater flow rates, as well as the seasonal and inter-annual variability of that flow to levels seen in the not-too-distant past *and* restoring habitats that have been unavailable for >50 years, we can expect to counter the decline of native fish and wildlife species and may (in certain cases) establish populations that are more abundant, diverse, and widespread than those we have measured since sampling began in the late 1960's.

5. There is no scientific basis for implementing actions to restore physical habitat as a substitute for improving flow conditions.

For many years we have been involved in helping advocate for, design, and implement programs and projects to create, restore and expand the extent of a diversity of physical aquatic habitats when there is a relatively high degree of certainty that such projects will primarily benefit native species, either directly (e.g. as spawning or rearing habitat) or indirectly (e.g. via exports of food to native species' habitats). However, as discussed in our workshop 1 submission (pp. 19-22), it is far from certain that all of the aquatic habitat restoration projects proposed by various parties will benefit desirable native species more than they will benefit invasive predator and competitor species. For example, during a preliminary, incomplete review of habitat restoration projects considered under the Bay Delta Conservation Plan (DRERIP, 2009), many of the shallow habitat restoration projects (particularly those in the eastern, central and southern Delta) scored low on the magnitude of potential benefits and the likelihood that those benefits would be achieved. On the contrary, experts engaged in the review felt that many of these projects could pose a risk to native species if they became habitat for invasive predators, competitors, or submerged aquatic vegetation. Similarly, the National Research Council was dubious of plans to restore food supplies for Delta smelt by restoring wetlands (NRC, 2010). While restoring historical habitats continues to be an attractive and worthwhile endeavor, expected changes in the regional climate (e.g. warming) and the introduction of non-native species may prevent certain in-Delta restored habitats from performing their historic function, especially if freshwater flows remain drastically reduced by diversions and exports.

Furthermore, it is not at all clear that all the feasible restoration projects taken together will produce and export sufficient volumes of prey to pelagic habitats where many of the key public trust resources live. Use of large scale habitat restorations to supplement the Bay-Delta food web is a compelling idea, and one that should be refined and improved (e.g. through a series of pilot projects); but there are no guarantees that restored habitats will function like historical habitats (see above) or that the area that could be potentially restored will be sufficient (especially without restored freshwater flows) to make a dent in the productivity gap in this ecosystem. Even with adequate flows, achieving the necessary food web subsidy believed to be required to support viable populations of public trust-related fish species will probably only be successful if restoration occurs on a massive scale (e.g. tens to hundreds of thousands of acres) – under any scenario, restoration of this magnitude will take decades to achieve.

The inescapable fact is that in the complex and changing environment of the Bay-Delta, ensuring adequate flow conditions is the action with the highest degree of scientific justification, certainty of successful result, and magnitude of benefit. It is not likely to be sufficient in and of itself to solve every problem plaguing this system. But every other action is likely to be ineffective absent the critical element of flow restoration.

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The Bay Institute

American Rivers
Thriving By Nature

by email to commentletters@waterboards.ca.gov

and hard copy

May 23, 2011

Charles Hoppin, Chair
c/o Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95812-2000

RE: REVISED NOTICE OF PREPARATION FOR REVIEW OF SOUTHERN DELTA SALINITY AND SAN JOAQUIN RIVER FLOW OBJECTIVES

Dear Mr. Hoppin,

This letter is submitted as the comments of the Bay Institute and American Rivers on the Revised Notice of Preparation and Additional Scoping Meeting regarding the State Water Resources Control Board's (SWRCB) current review of the southern Delta salinity and San Joaquin River flow objectives and the program of implementation for those objectives in the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. These comments are addressed solely on issues associated with the San Joaquin River flow objectives.

We strongly agree that "*more* flow of a *more natural pattern* is needed from February through June from the San Joaquin River watershed to Vernalis to achieve the narrative San Joaquin River flow objective" (NOP, Attachment 2, p. 3; emphasis added). The scientific justification for modifying the 2006 Plan using an approach based on setting a designated percentage of unimpaired runoff for San Joaquin River inflow to the Delta to achieve a more natural runoff pattern and requiring that designated percentage to be significantly greater than the amount required under existing flow objectives is extensively documented in the SWRCB's report on public trust flow criteria for the Delta ecosystem (SWRCB, 2010).

However, we are concerned that the draft narrative objective is too imprecise and broad to ensure full protection of beneficial uses, and that beneficial uses outside of the February – June period are inadequately protected. In summary, we recommend the following changes to Table 3 and the Program of Implementation in Attachment 2 of the NOP:

- Specify that the flow rate for the February – June Vernalis objective be a designated percentage of unimpaired runoff (including an initial rate and an adaptive range).
- Specify the initial flow rate and the adaptive range based on the best available scientific information for protecting fish and wildlife beneficial uses.
- Include specific biocriteria for steelhead, Sacramento splittail, and green and white sturgeon, and additional biocriteria for fall run Chinook salmon in the narrative objective.
- Clarify the relationship between flow conditions and other measures for purposes of adaptive management of the flow rate in the objective.
- Include an objective for July – January period base flows.

<u>February – June narrative objective: enforceability</u>

The NOP proposes to require more flow of a more natural pattern by converting the existing numeric Vernalis flow objective to a narrative objective. We strongly support the proposal to link Vernalis flows to the unimpaired hydrology of the San Joaquin River basin as this will ensure that flow patterns are closer to the natural pattern in terms of their timing, duration, and frequency. Establishing a continuous-fraction-of-unimpaired flow criteria, as opposed to the current discrete, step-function regulation will also improve the reliability of fresh water flows for all beneficial uses as they will not be subject to large discontinuities associated with small changes in annual hydrology (e.g., those between year-types). Narrative objectives in a water quality control plan are legally enforceable and may be appropriate to complement numeric objectives in order to provide fuller protection of beneficial uses. We are concerned, however, that the NOP's proposed narrative objective is too broadly defined and imprecise to be practicably enforceable.

First, the narrative objective would "maintain *flow conditions*… sufficient to support and maintain the natural production of viable native San Joaquin River watershed fish populations migrating through the Delta" (NOP, Attachment 2, p. 1, emphasis added). We believe this vague objective must be made more precise by specifying the flow conditions to be achieved and complied with.. Therefore, the Vernalis flow objectives should specifically be amended from a cfs flow rate by water year type to a percentage of unimpaired runoff flow rate from the San Joaquin basin. This flow rate should be expressed as a specific designated percentage, potentially with an adaptive range around that percentage. The runoff percentage flow rate could either be directly included in the narrative objective along with biocriteria, or separately expressed as a numeric objective in the Plan whose adaptive range is linked to attainment of the narrative objective's biocriteria (see below), but it must be specifically included as part of the Vernalis flow objectives.

Assuming implementation of the Vernalis objective involves an adaptive range, then the "starting gate" or initial condition should be determined by the best available scientific evidence currently available regarding flow needs of beneficial uses and public trust resources affected by Vernalis inflows (see SWRCB 2010 and TBI 2010b). If the SWRCB considers adopting a percentage value less protective than the 2010 public trust flow criterion, then it should describe in detail the basis for doing so, specifically the balancing aspects it is taking into consideration, the anticipated impact to the Public Trust, and provide for adequate review and comment on those aspects. Similarly, moving to a lower value in the adaptive range must not allow the occurrence of flow conditions that are detrimental to beneficial uses. Some boundary conditions for setting the adaptive range floor are discussed below.

Second, the narrative objective would "maintain flow conditions…sufficient to support and maintain the *natural production of viable native San Joaquin River watershed fish populations migrating through the Delta*" (NOP, Attachment 2, p. 1, emphasis added). This broad goal (and its articulation in the third and fourth sentences of the draft objective), while sufficient as the foundation for the objective, needs to be translated into a set of specific, measurable, attainable, time-bound, and enforceable biocriteria, such as the criterion for doubling of natural (fall-run) Chinook salmon production in the second sentence. The narrative objective can and should include biocriteria for other salmonids and other species as specific as the salmon doubling criterion. More detailed recommendations for biocriteria to be included in the narrative objective are described below and the underlying analytical framework is discussed in Attachment 1.

Third, the narrative objective would "maintain flow conditions… together with *other reasonably controllable measures* in the San Joaquin River Watershed" (NOP, Attachment 2, p. 1, emphasis added). This phrase, repeated elsewhere in the draft objective, is unacceptably vague. The best available scientific evidence indicates that flow conditions are the single most important driver of ecological conditions in the estuary (IEP 2010; DFG 2010; USDOI 2010; SWRCB 2010, TBI 2010a-d *and sources cited therein*), but there exist multiple stressors other than hydrologic alteration that do or may affect protection of beneficial uses in the Bay-Delta system. Other stressors include low dissolved oxygen in the Stockton Deepwater Ship Channel; loading of selenium, pesticides, and other contaminants from agricultural and muncipal run-off; and lack of available shallow channel or floodplain habitats. Given the dire status of fish and wildlife resources in the estuary, both the SWRCB and other responsible parties should take actions to reduce or eliminate the effects of these other stressors, even when evidence of those effects is limited. However, the relationship between improving flow conditions and relying on other measures in implementing this objective is extremely unclear and may make it more difficult to achieve.

The narrative objective should properly focus on flow conditions alone, but should explicitly state that the best scientific information will be used to evaluate the relative effect of implementing these flow rates against the relative effect of other reasonably controllable measures in the San Joaquin River Watershed in achieving the biocriteria identified in the objectives in order to adjust the flow rate within the adaptive management range in the future. The program of implementation should describe the process by which the SWRCB will collect and evaluate this information, and how it will be used to modify the flow rate within the adaptive range. In evaluating these non-flow measures, it is critical to develop very clear linkages between the measures, the stressors they are designed to alleviate and the projected outcomes of the measure (e.g. how much of a contribution are they expected to make towards reduction of a stressor). Applying the logic chain framework described in Attachment 1 to the SWRCB's evaluation of flow and non-measures will provide a clear articulation of how actions are intended to result in attainment of goals and objectives. Because flow objectives address many stressors simultaneously, it is extremely important to demonstrate the efficacy of other measures to provide the full range of benefits associated with flow conditions before assuming that flow rates can be modified in exchange for physical habitat or water quality improvements. Attachment 1 provides some guidance for evaluating the relative effects of different actions and their potential interchangeability.

<u>February – June narrative objective: biocriteria</u>

As previously noted above, the proposed narrative objective should be anchored in clear and measurable biocriteria. In this section, we propose an expanded set of biocriteria using the "logic chain" framework developed by TBI and American Rivers for use in other planning processes (see TBI Attachment 1), and address how the SWRCB could develop additional criteria.

Problem Statement: Numerous fish and wildlife elements of the public trust have been in serious decline over the period in which accurate records have been kept, including a particularly steep decline to record low levels in recent years. In addition, ecosystem processes (transport of nutrients and food items from the San Joaquin River basin to the Delta; provision of migratory corridors for various fish species; loss of spawning and rearing habitat; contaminant flushing) have been compromised within the lower San Joaquin River and south Delta.

Goals

- Re-establish viable populations of native fish species (including some that have been completely eliminated in recent times, i.e., spring run Chinook salmon and green sturgeon) to the San Joaquin basin. Viable populations are those that have sufficient abundance, spatial distribution, life history diversity, and productivity to withstand natural (uncontrollable) environmental variability and still support public trust values.

- Restore ecosystem processes that support viable populations and provide the functions associated with an ecosystem that serves the public trust, such as transporting food and nutrients to downstream habitats in a way that enhances productivity of the estuarine ecosystem, etc.

Fall run Chinook salmon objectives (biocriteria) – The CVPIA doubling goal for fall run Chinook salmon serves as a central objective linked to the goal of reestablishing populations of native fish species to the San Joaquin drainage. Abundance is one of four key attributes of viability identified by NMFS for assessing the conservation status of salmonid fishes (McElhaney et al 2000; Lindley et al. 2007) and is therefore relevant to the goal of establishing viable populations of native fishes; the target of production equal to or greater than twice the average seen during the 1967-1991 period is appropriate as it is specific, easily measured, established in existing policy, and attainable even in recent times (Figure 1).

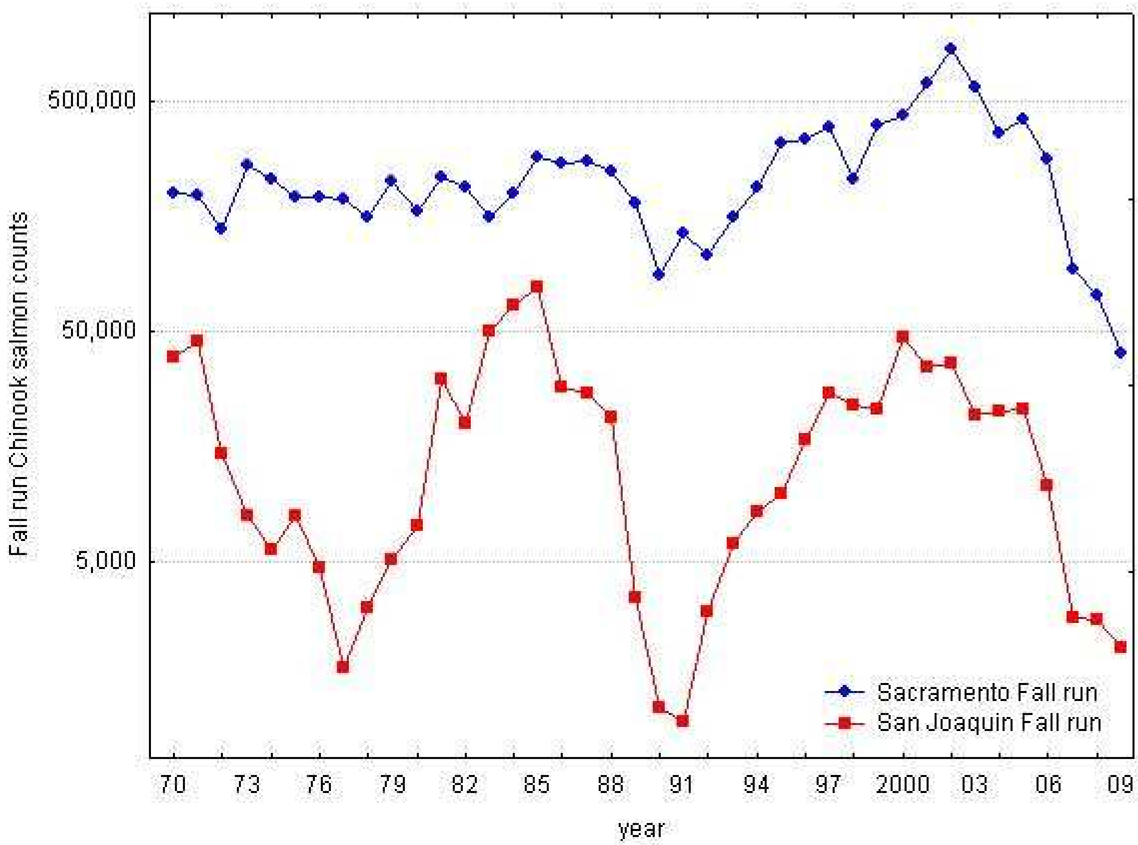

Figure 1: Fall run Chinook escapement for Sacramento and San Joaquin systems, 1970-2009. Escapement is less than production. The CVPIA calls for a doubling of 1967-1991 production. This corresponds to a production objective for SJR fall run Chinook salmon of 78,000 fish/yr

The NOP states that full compliance with the narrative objective will be achieved by the completion of the FERC proceedings on the Merced and Tuolumne Rivers, or no later than 2020. This statement should be applied not only to full compliance with the objective's flow conditions, but also to the salmon doubling biocriterion.

There are other biocriteria that should be considered for fall run. For instance, maintaining or improving the spatial diversity of fall run Chinook salmon in the Central Valley is critical to maintaining the viability of this population (and thus its public trust value). Although the fall run Chinook salmon currently spawn in the San Joaquin, maintaining and increasing this population in the San Joaquin is important to maintaining the population's viability in the Central Valley as a whole because it insulates this economically important population from catastrophic events that may occur in the breeding, rearing and migration areas of the Sacramento River basin. Given the threats posed to Central Valley salmonids by global climate change and the ability of the San Joaquin watershed to serve as a refuge for these fish during warmer periods (due to longer retention of snowpack in the southern Sierra Nevada range), restoration and maintenance of Chinook salmon spawning, rearing, and migration conditions in the San Joaquin will contribute to maintenance of the spatial extent characteristic of viable populations – and is therefore, an essential component of the larger effort to maintain the Central Valley's public trust values.

Furthermore, to fully protect the SJR fall run of Chinook salmon, the State Board must identify actions that will support or improve natural patterns of life history diversity among these fish and critical thresholds of population productivity. Maintenance and expansion of suitable migration periods towards historical norms for the fall run Chinook salmon are vital to restoring the life history diversity of this migratory fish. When salmonid migrations are constrained to a narrow window of time (and particularly, when that narrow window occurs on the same calendar dates year after year), natural variation that supports salmonid population viability is also constrained. Chinook salmon success in the Central Valley probably depends on maintenance of a wide range of migration timing and size at migration to ensure that migrants (upstream and downstream) encounter conditions suitable for supporting the next life stage (e.g. Miller et al. 2010; Williams 2006; Quinn 2005). Also, the State Board should establish conditions that maintain Chinook salmon productivity in the San Joaquin River basin so that these fish can capitalize on good environmental conditions and recover from periods of poor environmental conditions. Conditions that encourage population growth and a minimum frequency with which those conditions recur can be defined in addition to ultimate population abundance targets.

Biocriteria for other species --The narrative objective should also, to the extent possible, identify biocriteria associated with (at a minimum) the maintenance of population viability for other fish and wildlife species that use, or historically used, the lower San Joaquin River as either a spawning ground, rearing habitat, migration corridor or a combination of these. Such species include steelhead, Sacramento splittail, and both green and white sturgeon. By specifying the viability requirements of these species within the Central Valley as a whole and the San Joaquin in particular, the SWRCB may identify additional periods, magnitudes, frequencies, and durations of freshwater flow and/or other controllable actions that are necessary to fully protect the public trust. The same applies to attributes of ecosystem function.

Steelhead – Central Valley Steelhead are federally listed as endangered; the species has historically supported an important sport fishery in the Central Valley. These fish were previously numerous throughout the Central Valley, but development of impassable dams eliminated access to most of their historic spawning habitats (McEwan 2001; Lindley et al. 2006; NMFS 2009). Restoring viable populations of steelhead to the San Joaquin basin would simultaneously increase the abundance and spatial extent of this species within the Central Valley (Lindley et al. 2006; NMFS 2009). Steelhead life histories are notoriously responsive to environmental conditions (Quinn 2005); it is likely that providing reliable habitat for steelhead throughout most of their migration period would also support maintenance of life history diversity in this species. Provision of flows and other improvements to the San Joaquin River in support of steelhead migrations would make a major contribution to the conservation and recovery of this valuable species.

Therefore, flow conditions should be maintained to support an abundance target of 10,000 in the San Joaquin basin; to support distribution of spawning steelhead in the upper San Joaquin River and at least two of its major tributaries (Lindley et al. 2006; NMFS 2009), with a minimum population of 2,500 adults/year in these tributaries and to ensure that steelhead adults and juveniles are able to migrate to/from spawning and rearing habitats through the lower San Joaquin River throughout all or most of their historic migration season (January-June, for juveniles; late August-November, for spawning adults). These objectives are quite achievable as McEwan (2001) estimated that the Central Valley population historically numbered between 1-2 million steelhead annually and that returns were as high as 40,000 fish as recently as the 1960s. These fish were distributed in numerous populations throughout the San Joaquin River valley (Lindley et al. 2006; NMFS 2009) – remnant steelhead are still detected in a variety of waterways within the San Joaquin drainage (McEwan 2001).

Sacramento Splittail – An important recreational fishery relies on Sacramento splittail (Moyle 2002). These fish are also an important prey item for piscivorous fish; increased production of Sacramento splittail would be expected to bolster the food web that supports predatory game and non-game fish in the Delta (Kratville 2008). Splittail objectives for the lower San Joaquin River should include the frequency of years in which successful spawning and migration occurs in the lower San Joaquin River. Such actions will contribute to the abundance, productivity, and spatial distribution of Sacramento splittail in the Central Valley.

Therefore, flow conditions should be maintained to support significant and successful spawning of Sacramento splittail in the San Joaquin basin at least once every three years, on average, including successful emigration of juveniles and adults from spawning grounds in the San Joaquin River to the lower Estuary. Here “significant and successful spawning” means spawning on a floodplain (as opposed to limited spawning that may occur in channel margin habitats) as evidenced by detection of large numbers of emigrating Sacramento splittail juveniles in the lower San Joaquin River over the course of more than one week. Sacramento splittail typically produce extremely large numbers of offspring (in the millions) when conditions suitable to spawning exist on an inundated floodplain. The fish and wildlife trustee agencies (CDFG and USFWS) should be tasked with defining a performance metric that can discriminate between a significant and successful spawning event and the more limited spawning that periodically occurs in channel edge habitats, The former kind of spawning event is critical to recover and then sustain a viable spawning population of Sacramento splittail in the lower San Joaquin River and is the type of event that the State Board's flow regulations should seek to promote.

Green and white sturgeon – Both the green and white sturgeon have supported recreational fisheries in the recent past. Providing migration access to the San Joaquin River for these species will contribute to their viability through increases in their spatial extent, abundance, and potentially, to maintenance of their life history diversity in the Central Valley. It is believed that both native species of sturgeon spawned in the San Joaquin basin historically; certainly, there is no known reason why sturgeon would not utilize habitats in the basin that are similar to those they are known to use in the Sacramento Basin (Israel and Klimley 2008; Israel et al. 2009). With respect to white sturgeon, the DRERIP life history conceptual model stated:

> "…It is strongly suspected that the San Joaquin River supported a larger spawning population [of white sturgeon] than at present, prior to the upstream diversion of its flow for agricultural irrigation (Schaffter 1997). In the San Joaquin River, spawning adults have been captured between Mossdale and the Merced River confluence in late winter and early spring (Kohlhorst 1976) [Israel et al. 2009:10].

Therefore, flow conditions should be maintained to promote successful spawning by green sturgeon and white sturgeon in the San Joaquin basin at least three times (three different years) within the each twenty year period. Spawning success may be determined by presence of YOY sturgeon in traditional fish sampling programs in the San Joaquin drainage or through analysis of bone (e.g. otolith) microchemistry/isotopes (e.g. Weber et al. 2002) that identify the San Joaquin or its tributaries as the natal stream for older juvenile or mature sturgeon.

<u>February – June narrative objective: starting gate (initial flow rate)</u>

The "starting gate" or initial condition should be determined by the best available current scientific evidence regarding flow needs of beneficial uses and public trust resources affected by Vernalis inflows (see SWRCB 2010 and TBI 2010b). In this section we summarize the most relevant information for setting the initial percentage of unimpaired runoff flow rate. For more detailed discussion see SWRCB 2010, TBI 2010, DFG 2010; and USDOI 2010.

Fall-run Chinook salmon

Productivity – To attain the San Joaquin fall-run Chinook salmon doubling biocriterion, the fall-run population must grow substantially. In TBI 2010b, we identified flows that had resulted in population growth (measured as a Cohort Replacement Rate (CRR) >1.0) in the past. March-June Vernalis flows of approximately 4600 cfs corresponded to an equal probability for positive population growth (CRR>1.0) or negative population growth (CRR<1.0). Detailed review of CRR data showed that in 84% of years with average March-June flows greater than or equal to 5000 cfs, the CRR was greater than 1.0 (positive population growth), while in 66% of years with average March-June flows less than 5000 cfs, the CRR was less than 1.0, indicating a population decline. Springtime flows of approximately 5000 cfs appear to represent an important minimum threshold for success of salmon in the San Joaquin Basin. In order to achieve the doubling goal within any reasonable time frame, population growth must occur in each generation. As a result, the absolute minimum initial flow rate should be set at a level that supports positive population growth in every year (i.e. flows ≥5000cfs in all weeks of April and May) until the abundance target is met. These minimum, base migration flows, will be supplemented in most years by additional pulse flows (of shorter duration) that provide additional migration and rearing benefits and are generally necessary to support the larger populations envisioned by the CVPIA and SWRCB.

Abundance—The Anadromous Fish Restoration Program identifies San Joaquin River basin production of 78,000 fall-run Chinook salmon/year[1] as doubling of production in that occurred in the period 1967-1991 (AFRP 200; Final Restoration Plan, Appendix B-1). In order to attain this threshold, the initial flow rate should include adequate spring outmigration flows during the fall-run juvenile migration period (March – June). In our previous analysis (TBI 2010b), we found that springtime flows >10,000cfs corresponded to historic population abundances similar to those anticipated by the doubling objective. Flows >10,000 cfs that occur for at least two weeks during the juvenile migration period in at least 80% of years are likely to be the minimum necessary to support the abundance target identified by CVPIA and the State Board. The duration of such flows should increase progressively under wetter conditions (TBI 2010b; Table 1).

In addition, because fall-run Chinook salmon benefit substantially from residence on inundated floodplains, the initial flow rate should include flows that frequently inundate San Joaquin floodplains during the fall run juvenile migration period, specifically, flows that exceed 25,000cfs for at least two weeks in 60% of years (and for longer periods during wetter years).

Table 1 (from TBI 2010b) summarizes the flow needs that should be addressed in developing an initial percentage of unimpaired runoff flow rate.

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1 Production includes losses in the ocean and sport fisheries; in any year where fishing occurs, production is greater than "escapement" which measures the number of fish that return to the spawning grounds.

Table 1. Schedule of springtime Delta inflows from the San Joaquin River recommended to protect public trust resources.

Frequency (% of years)	**July-February** kcfs	**March** kcfs (cells show 1st and 2nd parts of month)		**April** kcfs (cells show 1st and 2nd parts of month)		**May** kcfs (cells show 1st and 2nd parts of month)		**June** kcfs (cells show 1st and 2nd parts of month)		**Duration enhanced outmigration flow period (days)**	**Average flow during enhanced outmigration flow period**
	Recommended Flow (kcfs)										
100% (all years)	2	2	2	5	5	5	5	2	2	31	5
80% (dry years)	2	2	2	5	10	7	5	2	2	45	7
60% (below normal years)	2	2	2	20	10	7	5	2	2	60	11
40% (above normal years)	2	2	5	20	20	7	7	2	2	75	12
20% (wet years)	2	2	5	20	20	20	7	7	2	90	13

Sacramento splittail

The upper extension of the Sacramento spllittail range in the San Joaquin is to Mud Slough (river kilometer 201; Kratville 2008). The timing of migration of juveniles to downstream habitats varies from year to year (depending on when spawning occurred and other environmental conditions) but generally lasts into July. Specific attributes and thresholds of suitable habitat for riverine stages of Sacramento splittail are documented in papers summarized by the life history conceptual model developed for CDFG's Delta Regional Ecosystem Restoration Implementation Program (DRERIP; Kratville 2008).

The Vernalis objectives should include flows to support Sacramento splittail spawning, rearing, and migration to/from spawning habitats in the lower San Joaquin River. This would include requiring sufficient flows to inundate critical spawning and rearing habitats for a minimum of 30-45 days during the spawning period (Sommer et al. 2002; Feyrer et al. 2006), and flows sufficient to maintain a migration corridor in the lower San Joaquin River for juvenile and adult splittail that return to downstream habitats. As splittail are relatively long-lived, it is not necessary (or practicable) for flows of this magnitude to occur every year, but the flow objectives should ensure the frequency for flow events of this magnitude such that a significant splittail spawning event (i.e., one associated with sufficient inundation of a floodplain) occurs in the San Joaquin River basin least once every Sacramento splittail generation (i.e. ~3 years; Kratville 2008).

Sacramento splittail migrate to potential spawning habitats (floodplains or channel margins) starting in late November. Spawning is highly dependent on the presence of high flows that inundate shallow habitat; it may begin as early as February and usually ends by April (Kratville 2008). Year class success is strongly associated with the duration and extent of floodplain inundation during the spring (Moyle 2002; Sommer et al. 2002; Moyle et al. 2004; Feyrer et al. 2006). Spawning currently occurs in the San Joaquin River when flows are sufficient to inundate relict floodplains. TBI (2010b) identified flows expected to produce inundation of floodplains and other spawning habitats in the lower San Joaquin River:

> For floodplain inundation, we found that, under existing channel conditions, flows of approximately 20,000-25,000 cfs at Vernalis were necessary to trigger substantial floodplain inundation. A review of the stage discharge curve at the Vernalis gauge combined with an evaluation of topographic maps adjacent to the river indicated that a flow of a minimum of 20,000 cfs and as much as 25,000 cfs is necessary to achieve broad scale inundation of floodplain along the San Joaquin River between Vernalis and Mossdale. [TBI 2010b; p.18]

Inundation and connectivity to the river environment must be maintained for at least ~30 days in order for benefits to Sacramento splittail to develop; therefore, we recommended flows that produce inundations that would last at least 30 – 45 days of functional floodplain habitat. Also, river inflows must not only overtop riverbanks but also be sufficient to maintain desired flow conditions within the area of inundated floodplain for 1 – 3 months.

Green and white sturgeon

Productivity – The productivity of both sturgeon populations is positively correlated with river flows (DFG 2010; Israel and Klimley 2008; Israel et al. 2009 *and sources cited therein*). Both species are believed to have spawned in the San Joaquin River Valley historically. Regarding green sturgeon Israel and Klimley (2008) wrote:

> Southern DPS green sturgeon likely spawned in the Sacramento, Feather, and San Joaquin rivers, judged upon the characteristics of the local habitats (Adams et al. 2007). Historic flows in these rivers during the upstream migration period occurring from March through July included increasing flows during winter rainstorms and spring melting of the snowpack. These flow increases enabled green sturgeon to migrate into the upper portions of these rivers with reaches characterized by high velocity flows and coarse river bed surfaces. Current flow management may inhibit the return of green sturgeon to the Sacramento River and Bay-Delta estuary by restricting seasonal flow necessary as cues for spawning and misdirection of juveniles during their outmigration. [Israel and Klimley 2008: 16].

White sturgeon adults begin their spawning migrations as early as November and spawn between February and May (Israel et al. 2009) and the green sturgeon migration period also begins in February though it may extend through July (Israel and Klimley 2008). The DRERIP conceptual models for green and white sturgeon suggest that flows near their spawning grounds in the neighborhood of ~20,000 cfs are the minimum necessary to produce strong recruitment of age-0 sturgeon in the Sacramento River drainage. This implies a relatively high level of flow must occur downstream in order to attract sturgeon to migrate upstream to spawn. River flows reportedly cue spawning, as no spawning was detected at Sacramento River flows <180 m^3/s (≈ 6,400 cfs) near Colusa). In addition, white sturgeon stopped their upstream migration and drifted downstream when Sacramento River flows dropped below 150 m^3/s (≈ 5,300 cfs) near Colusa (Schaffter 1997, cited in DFG 2010 and Israel et al. 2009). Because sturgeon are iteroparous (spawn in multiple years) and facultative spawners, it is highly unlikely that these fish would initiate spawning migrations in response to flows significantly less than those required upstream for spawning.

During the November – May period, fresh water flows in excess of 6400 cfs (180 m^3/s) should be provided for at least one month to stimulate sturgeon spawning migrations in the San Joaquin River. In years where these sturgeon attraction flows occur, flows that support spawning (>20,000 cfs) should be provided for at least one month between April and June following provision of the attraction flows. Sturgeon are very long-lived and do not reach sexual maturity until ~14 years of age. These sturgeon migration and spawning flows should occur at least once every 7 years (twice a generation). This frequency will assure that Central Valley sturgeon populations are represented by several age classes in the wild and insulate them from environmental conditions that may cause the failure of any one year-class.

<u>February – June narrative objective: limits to adaptive range</u>

We support the concept of an approach based on requiring a percentage of unimpaired runoff to provide more flow using more natural flow patterns, and the concept of an adaptive management range, but recognize that there are biological thresholds that must always be met to prevent mortality, impassable barriers to fish migration, consistent negative population growth, and other problems. Below we identify numerous flow-related life history requirements of fish and wildlife species that must be exceeded under all conditions. The lower limits of the adaptive range must always exceed these flow requirements.

Fall-run Chinook salmon

Productivity - To provide adequate temperatures in the lower San Joaquin River/southern Delta that avoid lethal effects and increase outmigration success of juvenile Chinook salmon and steelhead, the State Board should provide flows sufficient to provide average daily water temperatures of 65°F (18.3°C) or lower on all days from April 1 through May 31 in the lower San Joaquin River in all years. In our analyses (TBI 2010b) we found that flows ≥5000 cfs were likely to provide these conditions.

Spatial extent -- Persistent low DO conditions in the lower San Joaquin River produce migration barriers that limit the spatial extent of fall run Chinook salmon and other migratory fish in this system. Inflows of less than 2,000 cfs contribute significantly to low DO concentrations in the lower San Joaquin River (Van Nieuwenhuyse 2002; see Figure 2 below). Although management of other variables in addition to flow will be necessary to completely alleviate this problem, Jassby and Van Nieuwenhuyse (2005) found that: "[r]iver discharge has had the biggest impact … on hypoxia"; their modeling demonstrated that increased management of other important factors would be far less effective without improvement of freshwater flows in this area. San Joaquin River inflows during the February – June period of the narrative objective (and at all other times) should exceed 2,000 cfs to limit or eliminate migration impairment for migratory fish species.

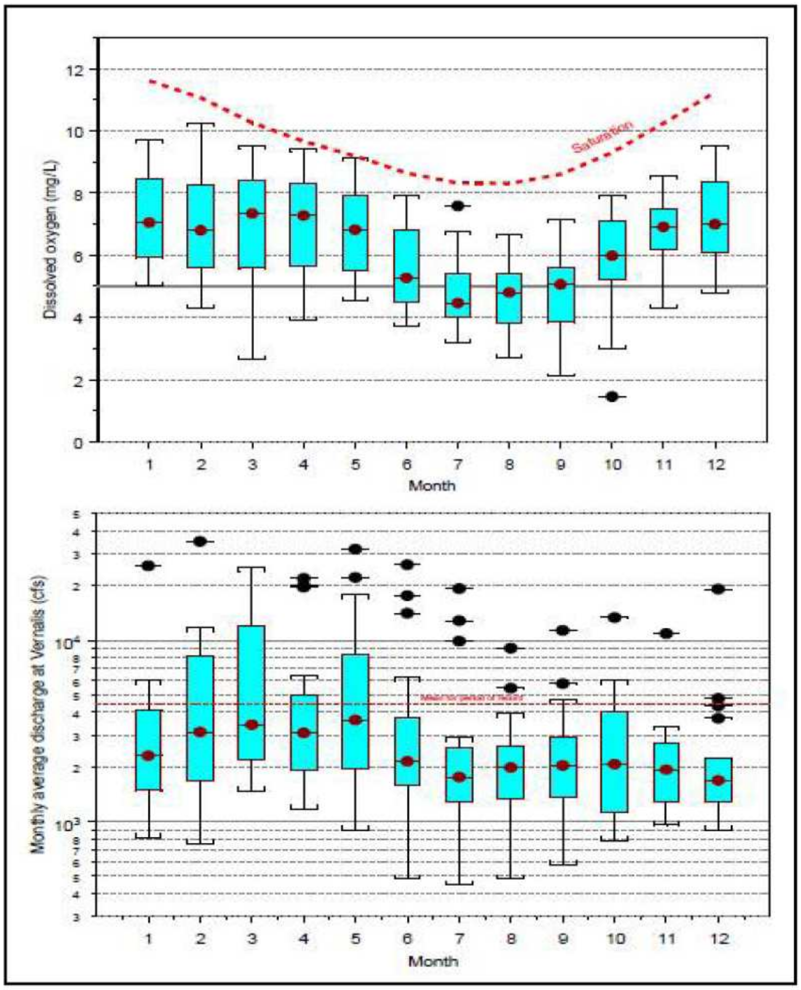

Figure 2: Top panel: *Fig. 2 from Van Nieuwenhuyse, E. E. 2002*. Box plot of summary statistics for monthly average values of daily minimum dissolved oxygen in the ship channel at the Rough and Ready Island continuous monitoring station (DOmin), 1983-2001 (n=19/month).
Bottom panel: *Fig. 6 from Van Nieuwenhuyse, E. E. 2002.* Box plot of summary statistics for monthly average discharge in the San Joaquin River near Vernalis (Qvern), 1983-2001.

<u>July – January flow objectives</u>

Fall-run Chinook salmon, green and white sturgeon

Spatial extent – As noted above, persistent low DO conditions in the lower San Joaquin River produce migration barriers that limit the spatial extent of fall run Chinook salmon and steelhead in this system. Inflows of less than 2,000 cfs contribute significantly to low DO concentrations in the lower San Joaquin River (Van Nieuwenhuyse 2002). Year-round San Joaquin River inflows should generally exceed 2,000 cfs to limit or eliminate migration impairment for migratory fish species. Specifically to promote adequate spatial distribution of fall run Chinook salmon (i.e. in the San Joaquin River and its tributaries), the average weekly flows should exceed 2,000 cfs in all weeks of all years during the San Joaquin River fall run Chinook salmon upstream migration period (October-December).

Water quality is also likely to impair sturgeon migrations upstream and downstream within the San Joaquin River drainage. Specifically, both sturgeon species are highly sensitive to low dissolved oxygen conditions (Israel and Klimley 2008; Israel et al. 2009 *and sources cited therein*) and low dissolved oxygen levels in the Stockton Deepwater Ship Channel are believed to inhibit sturgeon migrations into and out of the San Joaquin watershed (CVRWQCB and CBDA 2006). Flows and other actions necessary to increase dissolved oxygen levels in the lower San Joaquin River above minimum thresholds have been determined (Jassby and Van Nieuwenhuyse 2005). Inflows of less than 2,000 cfs are the largest contributor to low DO concentrations in the lower San Joaquin River. Year-round San Joaquin River inflows should exceed 2,000cfs. At a minimum these flows are required in months when adult sturgeon migration is desired and during August through March in the two years (juveniles rear in their natal rivers for 1 to 2 years) following such spawning migrations when juvenile emigration from the San Joaquin would occur.

Steelhead

Juvenile steelhead rear in freshwater for a year or longer. As a result, these fish require freshwater flow volumes and quality that can support them throughout the year, particularly in the higher elevation waterways where these fish spawn and rear. Adult migration can last from late August through early November (McEwan 2001; Williams 2006). During this period, low DO conditions in the lower San Joaquin River may impede adult migration success. Inflows of less than 2,000 cfs are the largest contributor to low DO concentrations in the Stockton Deepwater Ship Channel (Jassby and Nieuwenhuyse 2005).

As with Chinook salmon, pulse flows are likely to provide the cues necessary to attract adult steelhead to the San Joaquin River. Because of their extended migration period, the Vernalis flow objectives should include attraction pulse flows (of the magnitude already identified for fall run Chinook salmon) for steelhead that occur for several weeks between late August and early November. In order to maximize support for different life histories, these migration pulse flows should not occur in the same narrow time window every year.

Sacramento splittail

Prior to the winter – spring spawning period, the Vernalis objectives should include flows sufficient to attract spawning adult Sacramento splittail from November through January.

Table 2 summarizes the recommended flows discussed above that should be used to determine the initial flow rate and adaptive range for the February – June narrative objective and to establish other objectives for the July – January period.

TABLE 2: GUIDANCE FOR SETTING VERNALIS FLOW OBJECTIVES (in cfs). Months in parentheses indicate the period when these flows will serve the objective; see text for applicable durations of these flows that are desirable. In order to meet objectives, these flows should occur every year, except where noted.

		Season			
Source	Goal	**Winter**	**Spring**	**Summer**	**Fall**
TBI	Steelhead spatial distribution and life history diversity			> 2000 (Aug-Nov)	
TBI	Steelhead spawning recruitment			3600 (Aug-Nov) pulse flow	
TBI	Splittail spawning[2]		25,000 (Feb-April)		
DFG	Splittail recruitment[3]		Continuous inundation (30 days, Mar-May)		
TBI	Sturgeon spawning recruitment[4]	>6400(Nov-Apr)	20,000 (Feb-July)		
TBI	Hypoxia prevention (Steelhead, sturgeon)	> 2000			
TBI	Salmon productivity		> 2000 (Feb-June) > 5000 (Apr-May)		
TBI	Salmon Doubling[5]		> 10,000 (Mar-Jun, 2 weeks)		
DFG	Salmon Doubling[6]		7000-15,000 (Mar-Jun)		
TBI	Floodplain inundation (salmon, Sacramento splittail)[7]		> 25,000 (>1 month)		
TBI	Temperature maintenance (salmon)		5000 (Apr-May)		
TBI	Minimum low flow			> 2000 (July-January)	
SWRCB	Delta flow criteria	"60% of unimpaired flow from February through June… to achieve": >5000 (in most years), >10,000 (in 45% of yrs.)			
SWRCB	Delta flow criteria				3600 (Oct., pulse flow)

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[2] Should occur at least once every three years.
[3] Should occur at least once every three years.
[4] Should occur at least once every seven years
[5] See Table 1 for periodicity
[6] See Table 1 for periodicity
[7] See Table 1 for periodicity

Conclusion: proposed language for Attachment 2, Table 3 of the NOP

February – June Vernalis flow objective:

Maintain a percentage of unimpaired runoff[8] *from the San Joaquin River watershed to the Delta at Vernalis sufficient to support and maintain the abundance, spatial extent or distribution, genetic and life history diversity, migratory pathways, and productivity of native San Joaquin River watershed fish populations migrating through the Delta. Specifically, this flow rate shall be maintained sufficient to support a doubling of natural production of fall-run Chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law; sufficient to support abundance, distribution and migration habitat of steelhead*[9]*; sufficient to support successful and significant spawning*[10] *of Sacramento splittail; and sufficient to support successful green and white sturgeon migration and spawning*[11]*.The best scientific information will be used to adjust the flow rate within the adaptive management range to better achieve the biocriteria identified in the objective and to evaluate the relative effect of implementing this objective against the relative effect of other reasonably controllable measures in the San Joaquin River Watershed toward achieving the biocriteria.*

July – January Vernalis flow objective:

Minimum average flow rate of 2,000 cfs in all years

[8] Defined as between XX% and YY%, with an initial value of ZZ%.

[9] Defined as average annual abundance of 10,000; distribution in the mainstem San Joaquin River and at least two tributaries with populations at low risk of extinction; and adequate migratory habitat for juveniles during the outmigration period.

[10] Defined as detection at least once in every three years of the density of emigrating Sacramento splittail juveniles over a duration that would indicate a successful floodplain spawning event (performance criteria to be developed jointly by CDFG and USFWS).

[11] Defined as at least three times in once every 7 years.

Thank you for the opportunity to provide comments on the NOP. We look forward to working with you to identify, adopt and implement much needed improvements in protection for the Bay-Delta estuary.

Sincerely,

Gary Bobker
Program Director
The Bay Institute

John Cain
Conservation Director
American Rivers

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An Assessment of Agricultural Water Supply Alternatives in the Lower San Joaquin River Region, California

Prepared for the Natural Resources Defense Council by Juliet Christian-Smith, Julian Fulton, and Matthew Heberger of the Pacific Institute

March 2013

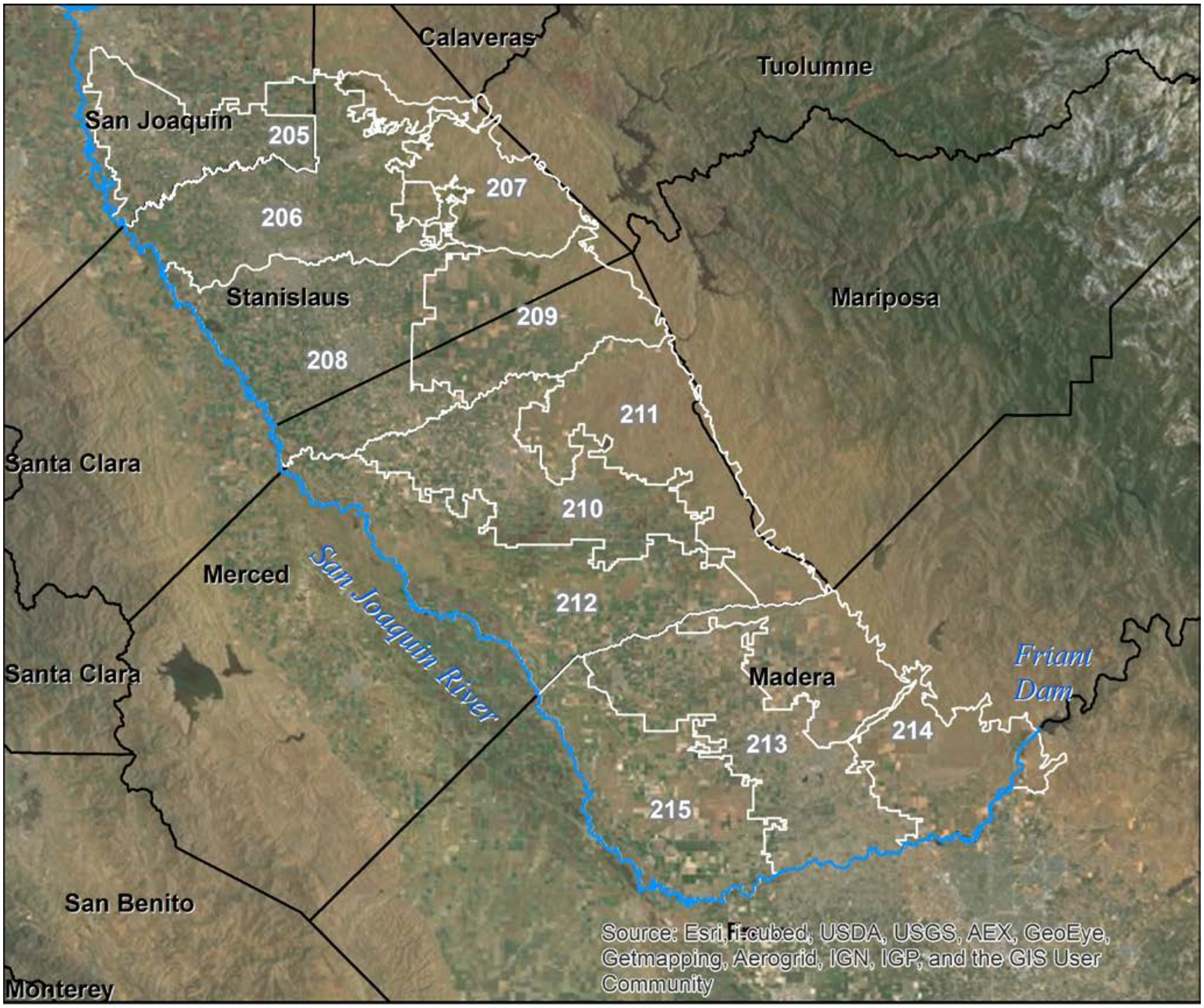
Introduction

In this study, we analyze the potential to reduce agricultural water consumption through efficient irrigation in California's San Joaquin River Hydrologic Region. The San Joaquin River Hydrologic Region (HR) is located in California's Central Valley (Figure 1). The state Department of Water Resources (DWR) has divided the state into 10 hydrologic regions for the purposes of water planning and management. DWR describes the region as follows:

"The hydrologic region is bordered on the east by the Sierra Nevada and on the west by the coastal mountains of the Diablo Range. It includes all of the San Joaquin River drainage area extending south from the southern boundaries of the Delta to include the northern drainage of the San Joaquin River in Madera County and its southern drainage in Fresno County. The region is hydrologically separated from the Tulare Lake Hydrologic Region by a low broad ridge that extends across the San Joaquin Valley between the San Joaquin and Kings rivers" (DWR 2009a, Volume 3, San Joaquin Hydrologic Region).

This is one of the most productive agricultural regions in the state and nation. Because of its warm temperatures, some crops can be grown year-round. Rainfall is limited, and most crops rely on supplemental irrigation—either surface water is delivered by canals from Northern California or groundwater from onsite wells (DWR 2009a, Volume 3, San Joaquin Hydrologic Region).

DWR further subdivides each hydrologic region in detailed analysis units (DAUs) for more in depth analysis of land and water use. The San Joaquin hydrologic region contains 33 detailed area units (DAUs). Here, we focus on 10 in the lower San Joaquin River drainage: DAUs 205-215 (Figure 1).



205	South San Joaquin ID
206	Modesto-Oakdale
207	Modesto Reservoir
208	Turlock
209	Turlock Lake
210	Merced
211	Merced Stream Group
212	El Nido-Stevinson
213	Madera-Chowchilla
214	Adobe - Valley Eastside
215	Gravelly Ford

Figure 1. The boundaries of the detailed analysis units 205-215 in the San Joaquin River hydrologic region

Defining Agricultural Water Use

Water managers often use a variety of terms to describe agricultural water use, including water withdrawal, applied water, and consumptive use. Water "use" and "withdrawals" are used synonymously here to refer to water taken from a source and used for agricultural purposes. These withdrawals include groundwater and surface water taken from local sources or water transported via large infrastructure projects like the Central Valley Project. Prior to delivery to a farm, water withdrawn from a source is subject to conveyance losses, i.e., seepage or evaporation from reservoirs and canals. The "applied water" is the quantity of surface and groundwater delivered to the farm, i.e., water withdrawals minus conveyance losses.

Agricultural water use can be categorized as consumptive or non-consumptive. Consumptive use refers to water that is unavailable for reuse in the basin from which it was extracted, due to soil evaporation, plant transpiration, incorporation into plant biomass, seepage to a saline sink, or contamination. Non-consumptive use, on the other hand, refers to water that is available for reuse within the basin from which it was extracted, e.g., through return flows.

Non-consumptive water savings have been erroneously referred to as "dry" water savings (Seckler 1996) based on the assumption that all water losses are re-captured and re-used elsewhere downstream. The implication for many water stressed regions is that there is no potential to reduce stress or increase resilience through improved water efficiency (Gleick et al. 2011). This is inaccurate. While some excess irrigation certainly ends up back in rivers and aquifers, it is almost never 100 percent and there are dislocations in timing and changes in water quality. Reducing both consumptive and non-consumptive water losses can leave more water in-stream to support ecosystem flows, can reduce water quality problems associated with agricultural runoff, and can delay or eliminate the need for new water supply infrastructure. Despite the importance of reducing both consumptive and non-consumptive losses, it is useful to distinguish between the two.

This report reports on both types of water savings. The regulated deficit irrigation scenario reports consumptive water savings; calculated using the Department of Water Resources estimate of "ETAW" or evapo-transpiration of applied water. This estimate excludes the portion of applied water that is consumed through evaporation and plant transpiration. As such, the estimate excludes non-consumptive water losses, e.g. return flows. The irrigation technology improvements and scientific irrigation scheduling scenarios report a mix of consumptive and non-consumptive savings (calculated using the Department of Water Resources estimate of "AW" or applied water).

Scenario Analysis

Below, we model the application of a series of agricultural water management improvement strategies including: regulated deficit irrigation, irrigation technology improvement, and scientific irrigation scheduling. For several of the strategies, we develop different scenarios to compare potential water savings and their costs. The scenarios rely on data collected by County Agricultural Commissioners, reported in their annual crop reports, and by the Department of Water Resources, reported in their annual land and water use surveys. In particular, we use DWR's estimates of irrigated crop area and ETAW from 1998-2009. To better understand the methods and data sources used by DWR please see http://www.waterplan.water.ca.gov/technical/cwpu2009/flowdiaghtml/dgm23.htm. Note that the potential water savings related to individual scenarios are not additive; and should be considered independently. Below, we describe the details of each scenario.

Regulated Deficit Irrigation

Regulate deficit irrigation, defined as the strategic application of water below full crop water requirements, can be an effective tool to reduce applied water and increase revenue (Chaves et al. 2007, Fereres and Soriano 2007). Crop water requirements vary throughout the crop life cycle and depend on weather and soil conditions. Irrigation scheduling provides a means to evaluate and apply an amount of water sufficient to meet crop requirements at the right time. While proper scheduling can either increase or decrease water use depending on current practices, it will likely increase yield and/or quality, resulting in an improvement in water productivity as more crop can be produced per unit of water (Ortega-Farias et al. 2004, Dokter 1996, Buchleiter et al. 1996).[1]

The traditional irrigation strategy is to supply irrigated areas with sufficient water so that crops transpire at their maximum potential. In other words, water is provided to meet full crop evapotranspiration (ET) requirements throughout the season. However, water scarcity and interest in maximizing crop quality have catalyzed a number of innovative approaches to irrigation management that have been shown to reduce water use, including regulated deficit irrigation, tail water recovery, and soil management practices that increase soil moisture retention.

Regulated deficit irrigation (RDI) is an irrigation management practice implemented during stress-tolerant growth stages in order to minimize negative impacts on yield (Goldhamer 2007). Because response to water stress can vary considerably by crop, a clear understanding of crop behavior and ecological conditions is required to maintain yields. Water savings associated with RDI depends on many factors, including the crop type and the sensitivity of growth stages to stress, climatic demand, stored available water, spring-summer rains, and the particular irrigation method.[i] RDI has been applied successfully in California's Central Valley on a number of crops including alfalfa, almonds and pistachios, and vines.

For example, Stewart et al. 2011 recently published results of a 5-year study on almonds in the Sacramento Valley, which concluded that water savings can be achieved without affecting yield, even in

[1] Water-use efficiency is defined here as yield divided by applied water.

soils with low water-holding capacity. The study used neutron probes to track soil moisture over the growing season. “The neutron-probe readings showed an average seasonal contribution of approximately 5.0 inches (12.7 centimeters) of stored water in the control and 4.5 inches (11.4 centimeters) in the regulated deficit irrigation treatment, amounting to about 11% of overall consumptive water use…Yields increased in both treatments during the 5-year study, with no clear trend of any reduction due to regulated deficit irrigation.” In addition, a multi-year study on pistachios in the southern San Joaquin Valley found that irrigation at 50% of potential ET during this period can occur without negative impacts on production (Goldhamer and Beede 2004).

TABLE 2. Consumptive water use and overall percentage savings, 2005–2008

Year	Treatment	Consumptive use	Savings
		inches (cm)	%
2005	RDI*	34.6 (87.9)	15
	Control	40.2 (102.1)	
2006	RDI	36.0 (91.4)	13
	Control	41.6 (105.7)	
2007	RDI	47.1 (119.6)	10
	Control	52.3 (132.8)	
2008	RDI	42.6 (108.2)	13
	Control	48.7 (123.7)	

* Regulated deficit irrigation.

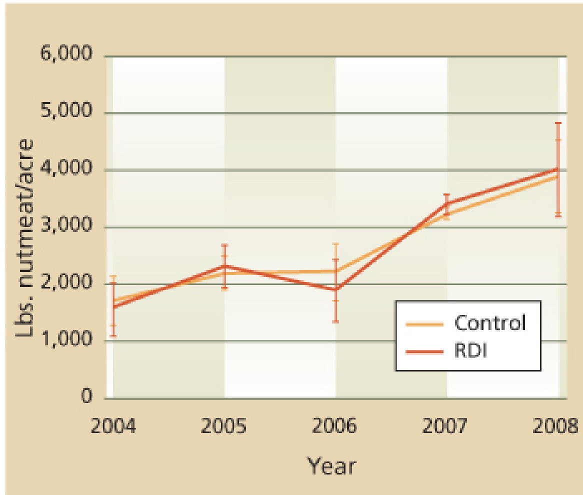


Fig. 1. Annual pattern of nutmeat yield, 2004–2008. Error bars are ± 2 SE.

Figure 2. Results from a 5-year study of RDI on almond orchard water use and yields (Table 2 and Figure 1 from Stewart et al. 2011).

Even when RDI does decrease yields, lower yields does not necessarily equate to reduced revenue or value. The California Water Plan Update 2005 included a report by Goldhamer and Fereres (2007) on the promise of regulated deficit irrigation for California’s orchards and vines. The report summarized studies on orchard fruits that found a linear relationship between yield and applied water, but a non-linear relationship between gross revenue ($/acre) and applied water (Goldhamer and Fereres 2007). Due to increased fruit quality, total grower revenue was actually higher under many of the RDI regimes even when yields were reduced (Goldhamer 2007). This is also true for many vineyards, where revenue is dependent on fruit quality (specifically sugar content, or degrees Brix) not just yield. There is unanimity of opinion that water stress in grapes can improve the quality of the wine produced (Goodwin and Jerie 1992). However, this is not true for many field crops and, therefore, yield losses related to RDI often lead to both decreased yields and revenues. Thus, the economic analysis of RDI includes economic losses related to alfalfa yield reductions. Table 1 describes the average water savings and changes in yield associated with RDI used in this analysis.

Table 1. Field studies documenting the effect of regulated deficit irrigation on water use and yield in the Central Valley, California[2]

Citation	Year(s) of Field Trial	Crop	Water Savings	Change in Yield
Stewart et al. 2011	2005-2008	Almonds	-11%	Negligible
Goldhamer and Beede 2004	1998-2002	Pistachios	-23%	Negligible
Average for almonds and pistachios			**-17%**	**Negligible**
Prichard 2000	2000	Wine grapes (Zinfandel)	-38%	-1%
Prichard 2000	2000	Wine grapes (Zinfandel)	-53%	-20%
Prichard 1997	1993-1996	Wine grapes (Cabernet sauvignon)	- >30%[a]	-19%
Average for vineyards			**-40%**	**-13%**
Frate et al. 1991[b]	1986	Alfalfa	-38%	-15%
Frate et al. 1991[b]	1987	Alfalfa	-20%	-11%
Average for alfalfa			**-29%**	**-13%**

Notes:

(a) This study did not directly measure the reduction in applied water. They applied 70% RDI, or attempted to reduce wine grape water consumption by 30% over the season (monitored by a soil neutron probe). Thus, the reduction of applied water is likely greater than 30% as consumed water does not take into account losses due to evaporation, conveyance, delivery, or distribution by the irrigation system.

(b) While this study compared several different treatments, we report the difference between Treatment 1 (Standard) and Treatment 3 (Dry). This reflects the water savings and yield losses associated with irrigating only once per cutting, rather than twice as in the standard treatment. There were no impacts on yields the year following this treatment, and in fact, the fields that had received Treatment 3 actually produced higher yields in 1988 than the fields that had received Treatment 1.

[2] There are many studies of RDI throughout the world; here we cite those that are most relevant, given the climate and soils of the Central Valley. RDI is particularly sensitive to local conditions, as even slightly higher/lower soil moisture content can greatly affect the success of different levels of RDI.

Methods

In order to estimate potential water savings, we used data from DWR's annual land and water use surveys. We first multiplied "ICA" or irrigated crop area (in acres) by 25% for the select crop groups (alfalfa, almonds/pistachios, and vineyards). We then multiplied the resulting reduced acreage by "ETAW" or evapotranspiration of applied water (in acre-feet per acre) to give us the consumptive use of applied water in acre-feet on a quarter of the alfalfa, almond/pistachio, and vineyard acreage. We then summed the total consumptive use for the three crop categories for DAUs 205-215 to give us the total consumptive use of applied water on a quarter of alfalfa, almond/pistachio, and vineyard acreage within DAUs 205-215. Finally, we applied the average water savings associated with RDI on alfalfa (29% savings), almonds/pistachios (17% savings), and vineyards (40% savings) from Table 1.

In order to estimate the economic impact of regulated deficit irrigation, we used recent agricultural production data in California. Crop prices are available from a number of sources, but we sought to develop local figures based on data collected in the region. To develop these estimates, we used recent information on crop type, acreage, production, and revenue collected by County Agricultural Commissioners. These county-level reports, compiled by the local field offices, and coordinated by the USDA's National Agricultural Statistics Service provide the most detailed annual data available on crop types, acreage, production, and revenue.

We performed several analysis steps in the use of the County Agricultural Commissioner's data. First, there were some obvious typos in the dataset, identified through exploratory data analysis, and looking for obvious outliers. For example, production of a crop that is ten times higher in one year than in years before or after. The data often had inconsistent units, for example where cotton production is recorded in tons in some years, and pounds in others. Second, the data files identify hundreds of different crop types, far too many to be practical for our analysis. We grouped the individual crops into the 20 "crop groups" used by DWR. The data set had occasional but infrequent missing entries. These may be due to incomplete data collection, or suppression of records to protect the privacy of individual growers.

We estimated crop yield and price in the Lower San Joaquin River region (DAUs 205-215) for 20 crop groups for the most recent year of data (2011). We used county-level data, and area-weighted averages to calculate the crop yield and price in DAUs that cover more than one county (Table 2). For example, DAU 209, Turlock Lake, has 60% of its area in Merced County and 40% in Stanislaus County. The price of vine crops (grapes) in Merced County was $440/ton in 2011, while it was $504/ton in Stanislaus. Thus, for DAU 209, we calculate the area-weighted average vine crop price as (0.60)($440) + (0.40)($504) = $466/ton. We repeated these calculations for each DAU and each crop category, leaving out Tuolumne and Mariposa Counties, which had tiny portions of several DAUs (less than 3% of a DAUs area).

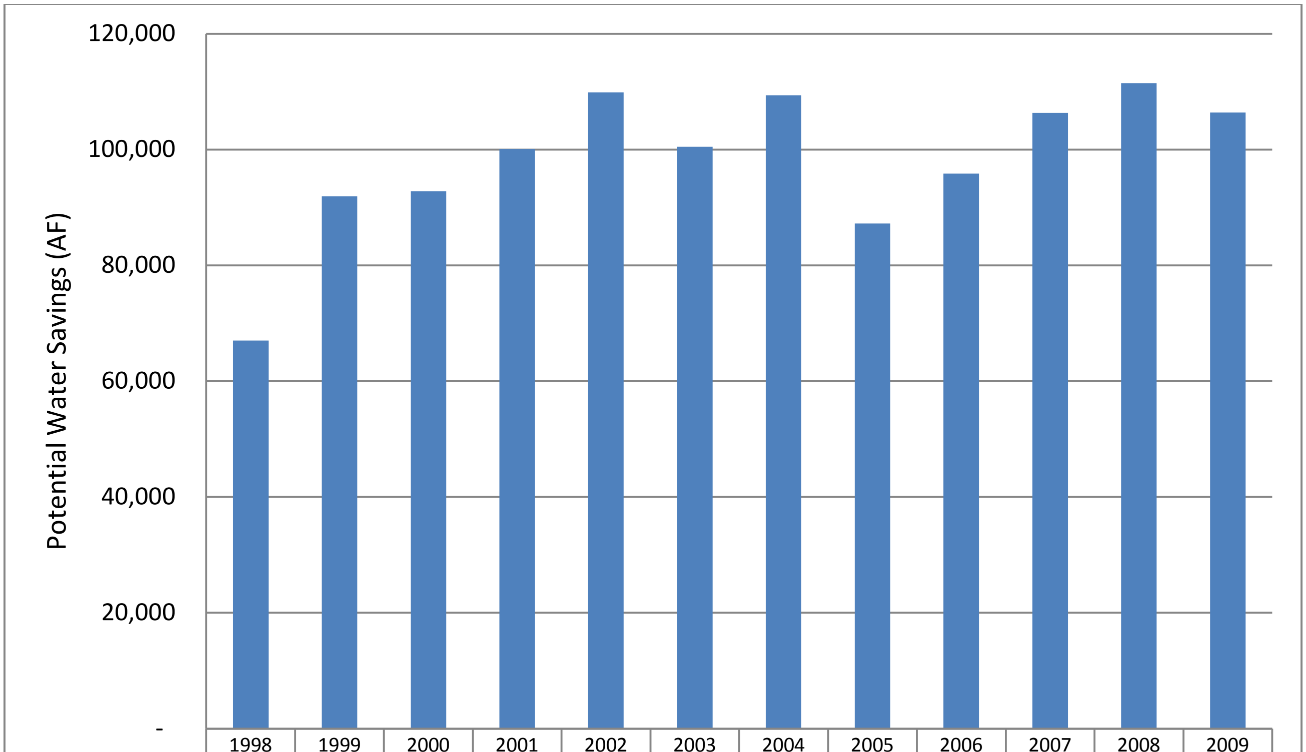
We used Microsoft Access and Excel to summarize the total acreage, production (in tons), and revenue for each of the 20 crop categories. Note that the yield and price for each category often average several related by very different crops. For example, "cucurbits" includes melons, squash, and cucumbers, and "Other Truck Crops" is a catch-all that includes over 100 crops, from artichokes and berries to cut flowers and turnips. Average crop yield and price were then calculated as follows.

$$Average\ Yield\ \left(\frac{tons}{acre}\right) = \frac{Total\ Production,\ tons}{Total\ Acreage}$$

$$Average\ Price\ (\$/ton) = \frac{Total\ Production,\ tons}{Total\ Revenue, \$}$$

Results

The results of this scenario assume that regulated deficit irrigation is applied to 25% of irrigated alfalfa, almond/pistachio, and vineyard acreage within the boundaries of DAUs 205-215. Potential water savings are the lowest in wet years (e.g., 1998) and highest in dry years (e.g., 2008) when crop water demand is the greatest. Over the last decade, this scenario results in almost 100,000 AF of potential water savings, on average. In 2009, potential water savings associated with this scenario reached slightly over 105,000 AF (Figure 3).



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Series1	67,035	91,921	92,786	100,108	109,844	100,473	109,365	87,248	95,864	106,314	111,459	106,384

Figure 3. Potential water savings associated with regulated deficit irrigation applied to 25% of irrigated alfalfa, almond/pistachio, and vineyard acreage within DAUs 205-215, 1998-2009

We estimate the costs of the yield losses associated with RDI being applied to 25% of alfalfa acreage in DAUs 205-215 would result in approximately $5.5 million in lost revenue, assuming a 13% yield reduction (or 0.91 tons per acre) at an average price of $243 per ton, or a loss in value of $220 per acre over 24,851 acres. We do not estimate the economic impact of the application of RDI to almond/pistachio acreage as there were only negligible changes in yield in the field studies cited (see

Table 1), nor do we estimate the economic impact of the application of RDI to vineyard acreage as the relationship between RDI and revenue is not linear.

Table x. Average alfalfa price and yield in 2011 by DAU

DAU	Alfalfa Price ($/ton)	Alfalfa Yield (tons/acre)	Value ($/acre)
205	$255	6.24	$1,591
206	$245	7.04	$1,725
207	$245	7.08	$1,735
208	$244	6.98	$1,703
209	$244	6.84	$1,669
210	$243	6.68	$1,623
211	$243	6.68	$1,623
212	$243	6.68	$1,623
213	$237	7.62	$1,806
214	$236	7.60	$1,794
215	$237	7.62	$1,806
Average	**$243**	**7.01**	**$1,702**
Average with RDI	**$243**	**6.10**	**$1,482**

Improved Irrigation Technology

Flood irrigation is the oldest form of irrigation – it is simply the application of water by gravity flow to the surface of the field. Either the entire field is flooded (by uncontrolled flood or basin irrigation) or the water is fed into small channels (furrows) or strips of land (borders). It is most often used on field crops, such as rice and alfalfa. Flooding often requires the least infrastructure and labor, and is therefore least expensive, however it can be challenging where there is sloping terrain or on crops that do not tolerate ponding or develop moisture-related diseases.

Sprinkler irrigation was introduced in the 1930s. With a sprinkler irrigation system, water is delivered to the field through a pressurized pipe system and is distributed by rotating sprinkler heads or spray nozzles or a single gun-type sprinkler. The sprinklers can be either permanently mounted (solid set) or mounted on a moving platform that is connected to a water source (traveling). Low-energy precision application (LEPA) sprinklers are an adaptation of center pivot systems that use drop tubes that extend down from the pipeline. LEPA systems can conserve both water and energy by applying the water at a low-pressure close to the ground, which reduces water loss from evaporation and wind, increases application uniformity, and decreases energy requirements. Many row crops and orchard crops are currently irrigated with sprinklers.

Drip irrigation refers to the slow application of low-pressure water from plastic tubing placed near the plant's root zone. Drip systems commonly consist of buried PVC pipe mains and sub-mains attached to surface polyethylene lateral lines. A less expensive, but also less durable, option is drip tape. Water is applied through drip emitters placed above- or below-ground, referred to as surface and subsurface drip, respectively. Microirrigation systems are similar to drip systems with the exception that water is applied at a higher rate (5-to-50 gallons per hour) by a small plastic sprinkler attached to a stake (Evans et al. 1998).

Despite the success with precision irrigation systems on a wide variety of crops, there are barriers to transitioning to new irrigation technologies. Chief among these barriers are initial capital costs, as sprinkler and drip systems can cost over $1,000 per acre to install. However, when initial costs are annualized and operation and maintenance costs are accounted for, the net annual costs for sprinkler systems are often only moderately higher than furrow irrigation on field crops (Sanden et al. 2011) and the net annual costs for drip systems are often less expensive than sprinkler systems on orchard crops (Schwankl et al. 1999), Yet, sprinkler and drip systems can impede farm equipment in fields that are cropped multiple times a year. Furthermore, irrigators are limited by their water supply. In most cases, agricultural water suppliers do not provide pressurized water, which is necessary for precision irrigation technologies, and therefore individual irrigators have to buy pumps to pressurize their water. In addition, some agricultural water suppliers are on rotational delivery systems where each irrigator must take a large amount of water once every few weeks. These delivery systems are designed for flood irrigation.

Nonetheless, flood irrigation is the least efficient because of the larger volumes of unproductive evaporative losses that occur, the application of water to non-targeted surface areas, and the propensity for deep percolation, which all mean that much of the water that is consumed does not contribute to crop growth. With proper management and design, drip and microirrigation are the most efficient at maximizing crop-yield-per-unit water use. The potential irrigation efficiencies (defined here as the volume of irrigation water consumed by the plant divided by the volume of irrigation water applied to the field minus change in surface and soil storage) for flood irrigation systems range from 60-85%, whereas for sprinklers, the potential irrigation efficiencies range from 70-90%. Potential irrigation efficiencies for drip and microirrigation systems are even higher, ranging from 88-90% (Table 3).

Table 3. Irrigation Systems and Associated Efficiencies[3]

Type of Irrigation System	Efficiency
Flood	
Basin	85%
Border	77.5%
Furrow	67.5%
Wild Flooding	60%
Gravity	75%
Average	73%
Sprinkler	
Hand Move or Portable	70%
Center Pivot and Linear Move	82.5%
Solid Set or Permanent	75%
Side Roll Sprinkler	70%
LEPA (Low Energy Precision Application)	90%
Average	78%
Drip/Microirrigation	
Surface Drip	87.5%
Buried Drip	90%
Sub-irrigation	90%
Micro Sprinkler	87.5%
Average	89%

Source: Salas et al. 2006

The average increase in water use efficiency between flood and sprinkler irrigation described in Table 3 above, is approximately 5%. In addition, the water use efficiency improvement between sprinkler and drip is approximately 11%. We apply these percentages to model the potential savings associated increases in water use efficiency.

Drip and sprinkler irrigation offer a number of benefits over flood irrigation. Drip and sprinkler irrigation can mean increased automation and lower labor costs, as many drip and sprinkler systems have controllers that can be programmed (Simonne et al 2008). Drip and sprinkler systems can also reduce input costs, including water and chemicals, such as fertilizers, which can be dispersed though drip and sprinkler irrigation systems (Granados et al. 2013). Drip irrigation, in particular, can help reduce weed and disease problems, as it “does not wet the row middles or the foliage of the crops as does overhead irrigation” (Simonne et al. 2008). Drip systems can also be adapted to small or “oddly-shaped” fields or those with uneven topography or soil conditions (Shock 2006). Finally, drip systems can be designed to deliver precise quantities of water to prevent runoff or ponding. Because of this, drip is particularly well-

[3] Efficiency is defined here as the volume of irrigation water consumed used (equal to ET) divided by the volume of irrigation water applied minus change in storage of irrigation water.

suited for “areas with relatively steep slopes, sandy soil, fields with extreme variation in soil texture, and salt affected fields” (Hanson et al. 2000).

Methods

The Improved Irrigation Technology Scenario was based on DWR’s 2010 Statewide Irrigation Methods Survey (SIMS) and California Simulated Evaporation of Applied Water (Cal-SIMETAW) model. SIMS data are organized by Hydrologic Region and reported for 20 crop categories and four irrigation methods (besides the three mentioned above, DWR reports an “Other” category). For the scenario, field crop acreage is converted from flood irrigation to sprinkler irrigation, and orchard and vineyard acreage is converted from sprinkler irrigation to drip irrigation. Table 4 lists the crop types, three major crop categories: field, truck, and orchards and vines, and the acreage of each crop type in DAUs 205-215.

Table 4. Crop types, crop categories, and acreage within DAUs 205-215 for year 2009 (Source: DWR 2009b, Land and Water Use Survey)

DWR Crop Type	Crop Category	Irrigated Crop Acreage (thousands) by DAU #											Total
		205	206	207	208	209	210	211	212	213	214	215	
Alfalfa	Field	5.2	4.9	-	19	1.9	6.8	1.1	32	8.3	0.8	20	99
Corn	Field	9.6	25	0.5	55	6.9	22	1.0	34	9.4	0.6	10	174
Cotton	Field	-	-	-	-	-	1.6	0.1	4.6	0.1	-	0.2	6.6
Dry Beans	Field	0.3	0.2	-	0.4	1.1	-	-	0.2	-	-	-	2.2
Grains	Field	2.5	0.5	-	0.5	1.3	3.2	0.2	5.0	1.6	0.6	2.7	18
Other Field	Field	0.2	26	0.4	58	4.0	8.7	1.7	11	14	6.7	9.4	139
Pasture	Field	2.4	21	3.0	7.7	3.1	6.5	1.6	11	1.1	0.4	1.9	59
Rice	Field	0.1	4.4	0.1	-	-	1.3	-	0.5	-	-	-	6.4
Safflower	Field	0.2	-	-	-	-	-	-	-	-	-	0.3	0.5
Sugar Beets	Field	-	-	-	-	-	0.3	-	-	-	-	-	0.3
Cucurbits	Truck	0.6	0.3	-	1.2	-	0.5	0.3	0.1	0.1	-	0.1	3.2
Onions & Garlic	Truck	0.8	0.2	-	-	-	-	-	-	-	-	0.1	1.1
Potatoes	Truck	-	-	-	-	-	-	-	-	-	-	0.1	0.1
Fresh Tomatoes	Truck	0.2	-	-	0.5	-	2.6	-	3.7	-	-	0.3	7.3
Processing Tomatoes	Truck	0.8	-	-	0.7	-	1.5	0.1	9.6	0.4	0.3	1.2	15
Other Truck Crops	Truck	0.7	2.4	1.1	4.7	4.3	13.1	0.2	8.9	1.4	0.1	0.3	37
Almonds & Pistachios	Orchards and Vines	38	33	9.6	57	48	33	8.9	17	41	37	16	338
Citrus & Subtropical	Orchards and Vines	2.2	0.1	-	0.1	-	-	0.1	-	0.6	4.4	-	7.5
Other Deciduous	Orchards and Vines	8.6	17	1.2	14	2.6	6.9	2.1	0.9	4.0	7.4	0.5	65

Vineyard	Orchards and Vines	7.4	3.4	0.7	3.3	5.9	4.0	0.9	2.1	42	13	16	99
Total	Total	80	137	17	221	79	111	18	140	124	71	80	1,078

Based on the results of DWR's 2010 irrigation methods survey for the San Joaquin River Hydrologic Region (Table 5), currently 73% of field crop acreage uses gravity/flood and 24% of orchards and vines uses sprinklers, representing significant room for improvement.

Table 5. 2010 Irrigation Methods Survey by crop type for the San Joaquin River Hydrologic Region (Source: DWR 2010)

Crop Name	Gravity (%)	Sprinkler (%)	Low Volume (%)	Other (%)
Corn	73.0	0.5	6.5	20.1
Cotton	74.5	6.8	11.2	7.5
Beans (dry)	65.3	15.2	19.3	0.2
Grains	76.7	9.1	6.7	7.5
Safflower	96.6	--	--	3.4
Sugar beets	--	--	--	--
Other Field Crops	81.3	13.4	5.4	--
Alfalfa	92.9	1.4	2.8	2.9
Pasture	90.5	5.6	--	3.9
Cucurbit	58.8	--	41.2	--
Onions & Garlic	0.2	18.8	80.2	0.8
Potatoes	12.9	6.9	80.2	--
Tomatoes (fresh)	62.5	15.8	21.7	--
Tomatoes (process)	17.6	2.7	79.1	0.6
Other Truck Crops	41.1	6.7	51.2	1.1
Almonds & Pistachios	16.8	12.7	68.7	1.8
Other Deciduous	37.6	24.8	37.0	0.6
Subtropical Trees	22.7	6.1	70.8	0.4
Turfgrass & Landscape	1.1	77.4	21.5	--
Vineyard	28.6	0.8	67.8	2.7
All Crops	**45.2**	**7.6**	**42.5**	**4.7**

As discussed earlier, transitioning from flood to sprinkler improves water use efficiency by approximately 5% while transitioning from sprinkler to drip improves water use efficiency by 11%. These water use efficiency gains are applied to 10%, 15%, and 20% of irrigated field crop acreage and orchards and vineyards below.

Results

Using the most recent land and water use survey data from 2009, this scenario runs 3 different scenarios based on converting 10%, 15%, or 20% of field crop acreage and orchards and vineyards from flood to sprinkler and from sprinkler to drip, respectively. We estimate potential applied water savings of 60,000 AF-173,000 AF, depending on how much acreage is converted (Table 6). As mentioned earlier, applied water estimates are a combination of consumptive and non-consumptive savings. If we only look at the change in ETAW, or consumptive water use, ETAW actually increases slightly under this scenario as more water is consumed by plant evapo-transpiration. Thus, this scenario returns non-consumptive water savings. In some cases those non-consumptive losses could be return flows that serve other beneficial uses; in other cases non-consumptive losses could flow to saline sinks, contaminated groundwater, or be lost to deep percolation.

Table 6. Potential applied water savings for the improved irrigation technology scenarios in 2009

DAU	2009 Baseline AW (AF)	10% Scenario AW savings (AF)	15% Scenario AW savings (AF)	20% Scenario AW savings (AF)
205	384,352	5,124	9,981	14,705
206	666,266	7,296	14,539	21,605
207	85,889	995	2,024	3,025
208	980,709	10,172	19,700	29,023
209	395,393	5,029	9,813	14,474
210	491,282	4,953	9,873	14,677
211	91,029	1,057	2,090	3,098
212	623,090	5,100	9,933	14,676
213	623,164	8,150	16,020	23,677
214	375,752	5,195	10,140	14,951
215	398,552	4,285	8,389	12,396
Total	**5,115,478**	**57,356**	**112,501**	**166,306**

The cost to transition from flood irrigation to sprinkler irrigation can vary widely. A University of California Cooperative Extension study found the net annual costs associated with converting alfalfa fields in the San Joaquin Valley from flood to sprinkler was, on average, approximately $286/acre (Sanden et al. 2011). Thus, the conversion of 10%-20% of field acreage within DAUs 205-215 (representing 48,141-96,282 acres) would cost approximately $13.8-27.5 million. Despite increased annual costs, multiple studies conclude that over time, sprinkler systems provide a high return on investment through increased crop yields and improved crop quality, offering clear benefits to the agricultural producer (Al-Jamal et al. 2001, Sanden et al. 2011).

Table 7. Annual costs for 22 different irrigation system designs (Source: Schwankl et al. 1999)

Table 4. Annualized costs for the irrigation system designs

Design	Irrigation system hardware	Electrical energy for pumping	Maintenance	Tax and Insurance	Total
			$/acre		
Solid-set 1*†	159	174	48	41	442
Solid-set 2‡	146	215	42	38	440
Solid-set 3*†	162	182	48	41	434
Solid-set 4‡	119	183	35	31	368
Drip 1†	80	174	39	18	311
Drip 2†	81	155	39	18	294
Drip 3†	97	174	49	21	341
Drip 4†	97	155	48	21	322
Microsprinkler 1†	98	169	36	22	325
Microsprinkler 2‡	82	203	25	18	328
Microsprinkler 3†	74	174	46	17	311
Microsprinkler 4‡	65	233	40	14	352
Microsprinkler 5†	102	177	41	23	343
Microsprinkler 6‡	86	212	30	19	348
Microsprinkler 7†	96	177	36	22	331
Microsprinkler 8‡	82	229	26	18	355
Microsprinkler 9*†	134	138	60	31	364
Microsprinkler 10*†	120	165	53	28	366
Minisprinkler 1*†	125	138	54	28	346
Minisprinkler 2‡	91	182	30	20	323
Minisprinkler 3*†	109	165	44	25	342
Minisprinkler 4‡	83	229	29	18	359

*Provides frost protection
†Orchard irrigated as single, 40-acre set
‡Orchard irrigated as two, 20-acre sets

The cost to convert from sprinkler to drip irrigation also varies (Table 7). Another University of California Cooperative Extension study compared the annualized costs associated with 22 different sprinkler and drip irrigation designs on the same almond orchard in the San Joaquin Valley (Schwankl et al. 1999). The study concluded that, on average, the net annual costs for drip irrigation systems are lower than those for sprinkler systems and represent a net annual savings of $52/acre (in 2012 dollars). Thus, the conversion of 10-20% of orchard and vineyard acreage within DAUs 205-215 (representing 50,921 to 101,842 acres) from sprinkler to drip would save approximately $2.6-5.3 million.

Improved Irrigation Scheduling Scenario

Crop water requirements vary throughout the crop life cycle and depend on weather and soil conditions. Irrigation scheduling provides a means to evaluate and apply an amount of water sufficient to meet crop requirements at the right time. While proper scheduling can either increase or decrease water use, it will likely increase yield and/or quality, resulting in an improvement in water-use efficiency (Ortega-Farias et al. 2004, Dokter 1996, Buchleiter et al. 1996). Despite the promise of technology-based irrigation scheduling, only 39% of California farmers report using some sort of scientific irrigation scheduling method (USDA 2009). Soil or plant moisture sensors, computer models, daily evapotranspiration (ET) reports, and scheduling services, which have long been proven effective, are still fairly uncommon, suggesting there is significant room for improvement. This conclusion is supported by the experience of individual growers who are increasingly linking their irrigation methods and schedules to real-time information on soil moisture and measured water needs.

The California Irrigation Management Information System (CIMIS), for example, is an integrated network of automated weather stations throughout the state that provides information needed to estimate crop water requirements. Since its inception in 1982, the CIMIS network has expanded to include more than 125 fully automated weather stations across California. A survey by the Department of Agriculture and Resource Economics at the University of California, Berkeley evaluated the water use and yield of all major crop types for 55 growers across California who used CIMIS to determine water application. Their study concluded that some farmers were under-irrigating while others were over-irrigating their fields. Overall, they found that the use of CIMIS increased yields by 8% and reduced water use by 13% on average (Parker et al. 2000). Again, we urge a new assessment of the use, and value, of CIMIS and related information services in reducing water needs or improving crop yields and quality.

These results are consistent with those reported in other studies. A Kansas study found that irrigation scheduling reduced water use by 20% while also reducing energy, fertilizer, and labor costs (Buchleiter et al. 1996). Another study of AgriMet, a meteorological data collection system operated by the USBR in the Pacific Northwest region, found that users of the service reduced their water and energy use by about 15% (Dokter 1996). Kranz et al. (1992) found that irrigation scheduling reduced the applied water by 11% and energy use by 17% while improving yields by 3.5%.

Some farmers are already using irrigation scheduling through either direct access to the CIMIS website or via an irrigation consultant. Based on Parker et al. (2000) and updated United States Department of Agriculture data (USDA 2009), we assume that 20-30% of irrigated land is already using CIMIS-based scientific irrigation services. This scenario examines the potential water savings if an additional 25% of irrigated land used this technology.

Methods

In 1996, DWR contracted with the Agricultural and Resource Economics Department at the University of California, Berkeley to conduct a survey of CIMIS users in the state. The survey includes responses from 55 farmers who collectively farmed 134,000 acres in a variety of different crop types. The survey collected information about changes in applied water and yield associated with scientific irrigation scheduling, and any related economic benefits. Here, we apply the statewide estimate of applied water savings (13%) to an additional 25% of irrigated land within DAUs 205-215 and we utilize the economic data specific to counties within DAUs 205-215 to calculate the total economic benefits associated with scientific irrigation scheduling (Table 8). We assumed that the lower San Joaquin River region's average benefit per acre was the same as that of Merced County (given that DAUs 208-212 have acreage within Merced County) or $80 (in 2012$).

Table 8. Average water, yield, and total economic benefits to growers interviewed by county (Source: Parker et al. 2000)

County	Water Benefits ($)	Yield Benefits ($)	Total Benefits ($)	Benefits per Acre ($/Acre)
Butte	0	41,400	41,400	230
Colusa	6,418	8,560	14,980	12
Contra Costa	32,620	436,000	468,600	70
El Dorado	4,338	67,000	71,340	296
Fresno	700,300	1,455,000	2,155,000	118
Kern	1,371,000	19,660,000	21,030,000	391
Kings	3,870	69,920	73,780	858
Merced	149,800	831,600	981,400	55
Monterey	61,500	3,007,000	3,068,000	357
Napa	1,625	0	1,625	1
Orange	27,610	0	27,610	115
Riverside*	-571,800	2,058,000	1,486,000	424
San Bernardino	2,280	4,129	6,409	160
San Diego	553	2,682	3,235	48
Santa Barbara	16,800	0	16,800	560
Santa Clara	21,750	0	21,750	73
Sonoma	44,060	505,000	549,100	209
Ventura	176,700	3,478,000	3,655,000	674
Total	2,049,424	31,624,291	33,672,029	258

Results

Although the CIMIS survey data is fairly old and is not specific to individual crop types, it is the only published estimate of water savings and economic benefits due to the use of CIMIS across a variety of crop types statewide. Using the results of the survey, this scenario models a 13% reduction in applied water associated with scientific irrigation scheduling (Parker et al. 2000). We apply these savings to 25% of irrigated acreage within DAUs 205-215. The resulting estimate of potential applied water savings is 166,253 AF in 2009.

Despite the limited accuracy of this estimate, it is clear that there is at least some potential for water savings associated with more scientific irrigation scheduling in the lower San Joaquin Valley, given how few California farmers report using soil moisture sensing devices, daily ET reports, etc.

In addition to the reduction in applied water, farmers reported significant economic benefits related to scientific irrigation scheduling: including an average 8% increase in yield along with reduced input costs. Applying the estimate of economic benefits per acre across 25% of the irrigated land area within DAUs 205-215 (269,610 acres) results in approximately $21.6 million in total economic benefits related to scientific irrigation scheduling.

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