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BIOLOGICAL EXPLANATION OF THE JOINT WATER USERS PROPOSED BAY-DELTA STANDARDS

Submitted by

California Urban Water Agencies
San Luis & Delta - Mendota Water Authority
Kern County Water Agency
and
Tulare Lake Basin Water Storage District

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LIST OF CONTRIBUTORS

The preparation of this document was coordinated by Dr. Dudley W. Reiser and included input from the following scientists and engineers (in alphabetical order) repesenting or consultants to various agricultural and urban water agencies of the Joint Water Users:

Elaine Archibald	- Archibald and Wallberg
Steve Arakawa	- Metropolitan Water District
Randy Bailey	- Bailey Environmental
Keith Binkley	- R2 Resource Consultants, Inc.
Paul Bratovich	- Beak Consultants, Inc.
James Buell, Ph.D.	- Buell and Associates
Richard Denton, Ph.D.	- Contra Costa Water District
Phyllis Fox, Ph.D.	- Consultant
Greg Gartrell	- Contra Costa Water District
Jenna Getz	- R2 Resource Consultants, Inc.
Chuck Hanson, Ph.D.	- Hanson Environmental
Kevin Haroff, Esq.	- Morrison & Foerster
Lyle Hoag	- California Urban Water Agencies
Roger James	- Santa Clara Valley Water District
Laura King	- East Bay Municipal District
Steve Macaulay	- State Water Contractors
B.J. Miller, Ph.D.	- Consultant
Joe Miyamoto	- East Bay Municipal District
Jud Monroe, Ph.D.	- Consultant to Metropolitan Water District
Austin Nelson	- Contra Costa Water District
Randall Neudeck	- Metropolitan Water District of Southern California
Karee Oliver	- R2 Resource Consultants, Inc.
Dudley W. Reiser, Ph.D.	- R2 Resource Consultants, Inc.
Cliff Schulz, Esq.	- Kronick, Moskovitz, Tiedemann & Girard
Dave Schuster	- Consultant to Kern County Water Agency
Dan Steiner	- Consultant to San Francisco Public Utilities Commission
Lena Tam	- East Bay Municipal District
Walt Wadlow	- Santa Clara Valley Water District

EXECUTIVE SUMMARY

Over the past several months, major agricultural and urban water agencies have been developing a consensus proposal for comprehensive San Francisco Bay-Sacramento/San Joaquin Delta (Bay-Delta) water quality standards. These agencies agree that current species-by-species regulatory approaches fail to meet the needs of California's environment and economy. Instead, a more multi-species habitat-based approach is necessary to avoid the political and regulatory gridlock that has stalled efforts to resolve long-standing environmental concerns in the Bay-Delta.

The agricultural and urban Joint Water Users Proposal (Joint Proposal) would substantially improve aquatic habitat in the Bay-Delta while minimizing water costs. The agencies presented the Joint Proposal to the State Water Resources Control Board (Board) on October 19, 1994. This document serves to explain the biological underpinnings of the Joint Proposal.

Summary of Joint Water Users Proposal

The Joint Proposal contains four categories and a monitoring/evaluation program:

Category I -- Estuarine Habitat Standard: This standard protects aquatic habitat conditions in the Suisun Bay complex by maintaining freshwater outflows as measured by two-parts-per-thousand salinity (X2) at various measuring stations during February through June. A "sliding scale" ensures the standard reflects the natural hydrologic variations of the Bay-Delta system, and minimum outflows ensure a level of protections even in the driest of years.

Category II -- Operation and Flow Measures: Operational criteria control the operation of the Delta Cross-Channel, fish barriers at Old River, and Delta diversions. Flow measures relate to export restrictions, and flow levels in the Sacramento River and San Joaquin River, and outflows from the Delta during July to January.

Category III -- Non-Outflow-Related Factors: Many factors other than freshwater outflow affect the ecological health of the Bay-Delta. These factors include unscreened water diversions, waste-water discharge, introduced species, degradation of wetland and riverine habitat, and others. The Joint Proposal suggests measures to control these factors.

Category IV -- Implementation Measures: After adopting standards, the Board will initiate water-rights proceedings to implement the new criteria. Issues the Board might consider include responsibility among watershed users, mitigation credits, and an environmental restoration fund. Disagreement remains between urban and agricultural agencies on the propriety of proposed implementation measures.

Monitoring and Evaluation: The Joint Proposal recommends an aggressive monitoring and evaluation program to obtain quantitative data regarding the effects of various measures. This program is indispensable because of the high degree of scientific uncertainty involved with regulating biological parameters in the Bay-Delta's complex ecosystem.

Summary of Biological Explanation

This document explains the biological basis for Categories I through III of the Joint Proposal (biological analyses of possible implementation measures is not yet necessary).

Background and Objectives: Before exploring the biological effects of various proposed measures, this document briefly sets forth the background, objectives, and approach which have led to the Joint Proposal. These objectives include improving overall aquatic habitat conditions in the Bay-Delta system, improving salmon-smolt survival, reducing fish entrainment from operation of the State and Federal pumping plants, and improving hydraulic conditions for egg and larval transports and dispersal.

Proposed Technical Standards (Categories I and II): This document details the biological considerations involved with each proposed measure regarding estuarine habitat standards and operational/flow measures. For each proposed measure, the report identifies the measure's biological objective, the intended benefits, and the scientific rationale for selecting that measure.

Non-Outflow-Related Factors: This document also presents a summary of eight critical non-outflow-related factors which are known to be negatively impacting the aquatic resources of the Bay-Delta. The summaries include a brief description of each factor and how it has and is continuing to influence the Bay-Delta aquatic ecosystem, and general recommendations for reducing or eliminating its impacts.

Federal and State resource agencies have stated their intent to seek Bay-Delta standards that provide sound environmental benefits at a reasonable water cost. This document describes the Joint Proposal's substantial biological benefits which are accomplished at a substantial water cost, but one that is less than other comparable proposals.

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1.0 INTRODUCTION

1.1 BACKGROUND

From a water resources perspective, California's economy and environment "meet" in the Bay-Delta. The Sacramento/San Joaquin Delta and San Francisco Bay Estuary is the largest estuary on the West Coast. The Bay-Delta ecosystem supports a myriad of aquatic species that makes the estuary one of the most diverse in the world. It, and its tributaries, are also California's most important source of water for urban and agricultural purposes. California water users firmly believe that the Bay and Delta's aquatic resources must be protected while providing water supplies to other parts of the State. It has become apparent, however, that existing water quality, flow, and diversion standards have not protected the Bay-Delta aquatic ecosystem at expected levels. Therefore, it is time to change a number of the applicable standards in order to more fully protect the beneficial uses and the aquatic ecosystem in general.

The Bay-Delta ecosystem, including tributary watersheds, has been extensively modified over the last 150 years. Mining, logging, reclamation of wetlands for agriculture, urban development and industry, navigation and flood control projects, water projects including reservoir construction and water diversions, harvest of biological resources (hunting and fishing), fisheries management, through the use of hatcheries and introductions of non-native fish species, the release of toxic chemicals to the watershed, and the introduction of numerous non-native (introduced) species have all contributed to these modifications in the Bay-Delta ecosystem.

It is not likely that the Estuary can ever return to a "natural," historical condition, regardless of the level of effort expended. We can however, look to historic records for an understanding of the dynamic processes which made it feasible for native species to flourish in the Bay-Delta and apply this knowledge to help us develop solutions to current problems. Our objective is to use historical data to help us identify the factors which may be limiting the viability of native species, and then to develop innovative ways of changing and managing the existing ecosystem to address these factors. The result may look to us quite different from the historic ecosystem, but it should provide a range of conditions favorable to the native species of the Bay-Delta and its tributary watersheds.

1.2 GOALS AND APPROACH

Recognizing the need for improving Bay-Delta conditions, the water users presenting this proposal assembled a team of biologists, engineers, and other experts on the Bay-Delta system to develop a program of increased protection for the Estuary. In that process, it became apparent that we had to have some biological goals in order to develop and structure specific program measures. These goals include:

1. Improve the overall habitat conditions in the Bay-Delta aquatic ecosystem over those of the recent past, with an emphasis on native species.

2. Eliminate jeopardy and promote recovery of those species listed as threatened or endangered and improve conditions sufficiently so that listing of new species will not be necessary due to conditions in the Estuary.

3. Improve the productivity of native species.

Having set forth our broad goals, we began developing specific actions to accomplish our purposes. Early on, several fundamental facts became apparent. First, we determined that accomplishing these goals would require a comprehensive, multi-species approach and that the historical approaches to providing a desired level of protection to the Estuary had not worked. Second, in order to determine if our goals were being met, we knew that data from biological investigations and monitoring would be necessary. It was also apparent to us that the level of effort currently being conducted would be insufficient to monitor and analyze all aspects of our proposed program. Third, we concluded that resource decision makers are now demanding answers to questions which the existing monitoring and scientific programs are not adequate to fully address.

Based on these premises, we concluded that the dynamic nature of the Estuary, combined with the level of uncertainty about the biological response to any particular habitat modification, makes it extremely difficult to quantitatively predict in advance what the biological response to any particular set of standards will be. That is why our proposed standards are closely tied to a focused monitoring and response program which will allow us to determine if the standards are helping to accomplish our biological objectives and will provide the information needed to direct any changes in the future. Nevertheless, we believe that the specific actions described below will accomplish our fundamental objectives.

1.2 ELEMENTS OF THE PROPOSAL

The Joint Water Users Proposal (Joint Proposal) is specifically designed to increase the level of protection provided for the aquatic ecosystem. In preparing this Proposal, careful consideration was given to improving those estuarine functions which would, in our scientists' opinion, improve habitat quality and quantity. The Joint Proposal provides a three-pronged approach to improving the Bay-Delta ecosystem. First, we support implementation of a significant portion of the 1991 Water Quality Control Plan adopted by the State Water Resources Control Board (SWRCB). Second, we support the adoption and implementation of the Suisun Marsh Preservation Agreement. Third, we are proposing a comprehensive program that will: 1) establish new standards for water quality and resources management, 2) alter existing operations and require implementation of new operational controls, and 3) address a variety of non-flow related factors. We chose not to be constrained by the existing conditions and have proposed some demonstration projects and an evaluation of some non-flow related factors the control of which will lead to alternate methods of management for accomplishing our biological objectives.

For convenience, we grouped the elements of this Joint Proposal into three Categories. Category I measures are those related to the X2/outflow relationships developed by the San Francisco Bay Estuary Project and adopted in draft form by the EPA. Category II are operational measures involving physical manipulation of the structures in the system (i.e., opening or closing the Cross Channel gates) and regulation of water flow in terms of volume or timing occurring outside the February-June time period. A third group (Category III), consists of those non-flow related factors which we believe have a major influence on the biological resources of the Estuary.

We are also recommending a comprehensive monitoring and response program designed to evaluate and refine all of the management actions contained in the total program. We believe it is critical that every aspect of this new management regime be carefully evaluated in order to determine if the actions are producing the desired biological benefits and are helping to accomplish the biological objectives. We believe managers of the existing program will welcome such a supplementary monitoring program for evaluating biological responses to operational and management measures.

1.3 ENVIRONMENTAL IMPROVEMENTS

The Joint Proposal provides an improvement over historical conditions as measured by a number of different indicators of benefit. For example, the Joint Proposal shows substantial improvement in the average location of X2 during the February-June time period relative to a D-1485 base case (Figures 1-1). The two figures depict time periods of 1945-1969 and 1968-1992; a third figure (Figure A-1) depicting X2 locations during 1922-1946 is contained in Appendix A.

Comparisons of simulated salinities at Collinsville under historical DAYFLOW outflows for 1989-1992, with salinities that would result from the Joint Water Users Proposal demonstrate a substantial reduction (improvement) in salinities with the Joint Proposal (Figure 1-2). The data presented were derived from the Contra Costa Water District's (CCWD) salinity outflow model (G-model), which takes daily Delta outflows (either the original historical DAYFLOW values, or values modified according to the requirements of the Joint Proposal) and calculates the corresponding 14 -day averaged electrical conductivity.

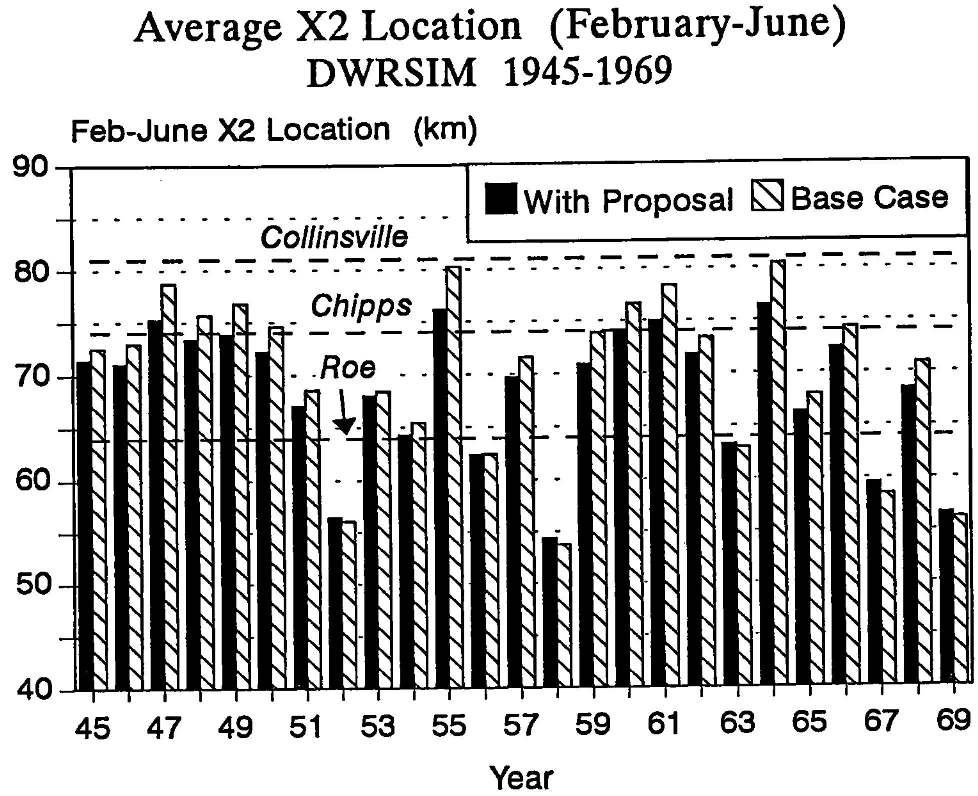
The Joint Proposal would also provide additional flows in the Sacramento River at Rio Vista as depicted in Figure 1-3. The data presented in the figure are from DAYFLOW output for the period 1987-1992; "with proposal" data are output from CCWD's outflow model in which all X2, salinity, and flow requirements are met by increasing historical flows and reducing historical exports.

Some improvement in flow conditions (over historical conditions) in the San Joaquin River would also be afforded by the Joint Proposal, especially during the biologically important outmigration of fall-run chinook salmon smolts during the spring (April and May) (Figure 1-4). The Joint Proposal has a 1,000 cfs base flow for February through May, with higher flows ranging from 4,000 to 10,000 cfs for the intermediate period from April 15 through May 15. The above flows are but one component of the Joint Proposal designed to benefit salmon smolt survival from the San Joaquin River. Other components include direct export limits, export/inflow restrictions, and the installation of a barrier at the head of Old River. The combined benefit of these measures is illustrated in Figure 1-5, which depicts the calculated smolt survival indices (as determined by the U.S. Fish and Wildlife Service (USFWS) salmon Smolt Survival

Index (SSI) model for the San Joaquin River) under historical conditions and conditions anticipated under the Joint Proposal. Although there has been serious concern raised regarding the statistical validity of the SSI models for predicting smolt survival (Kimmerer 1994) and there was general agreement at a recent workshop on salmon smolt survival that such models should not be used for setting goals, the EPA and USFWS continue to apply the models to evaluate survivals relative to various operational measures. For that reason, the Joint Water Users have presented the benefits in terms of the predicted SSI.

Reductions in historical export/inflow ratios would also be realized under the Joint Proposal (Figure 1-6), especially during the March to July period, which is a particularly sensitive period for most fish species (see Section 2). By reducing the volume of exports, additional outflow is also provided. The benefits (reductions in export/inflow ratio) of the Joint Proposal are further depicted in Figure 1-7, which compares ratios for April through May under historical conditions, with those that would occur under the Joint Proposal. Figures presenting similar data for January through March, July through September, and October through December are contained in Appendix A. Further evidence of export reductions (as indicated by pumping rates at Tracy and Banks) that would occur in March and April under the Joint Proposal is presented in Figure 1-8.

We believe that full implementation of our proposed program will substantially improve conditions in the Estuary. Implementation will require close coordination with actions occurring in the areas upstream of the Delta. For example, the East Bay Municipal Utility District (EBMUD) is currently negotiating certain fisheries improvements in one of the tributaries to the Delta. Implementation of that agreement and this Joint Proposal should complement each other. The SWRCB should provide enough flexibility in implementation so that resource managers can optimally manage the various flow and operational measures to maximize the benefits to the Estuary, while recognizing than an optimal regime for the Estuary could conflict with fishery restoration goals on upstream tributaries such as the Mokelumne River. Also, we believe all of the flow, operational measures, demonstration projects, and monitoring requirements outlined in the Joint Proposal are consistent with the goals of the Endangered Species Act (ESA) for listed species and the Central Valley Project Improvement Act's (CVPIA) Anadromous Fish Restoration Program.



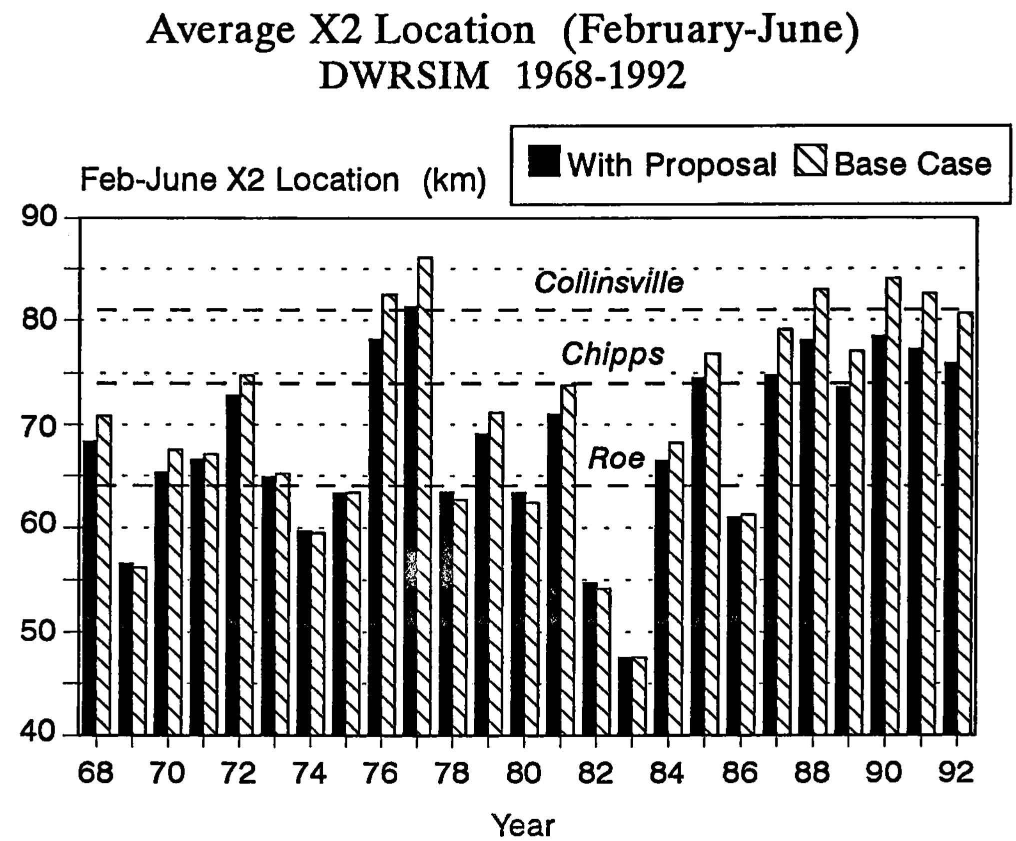
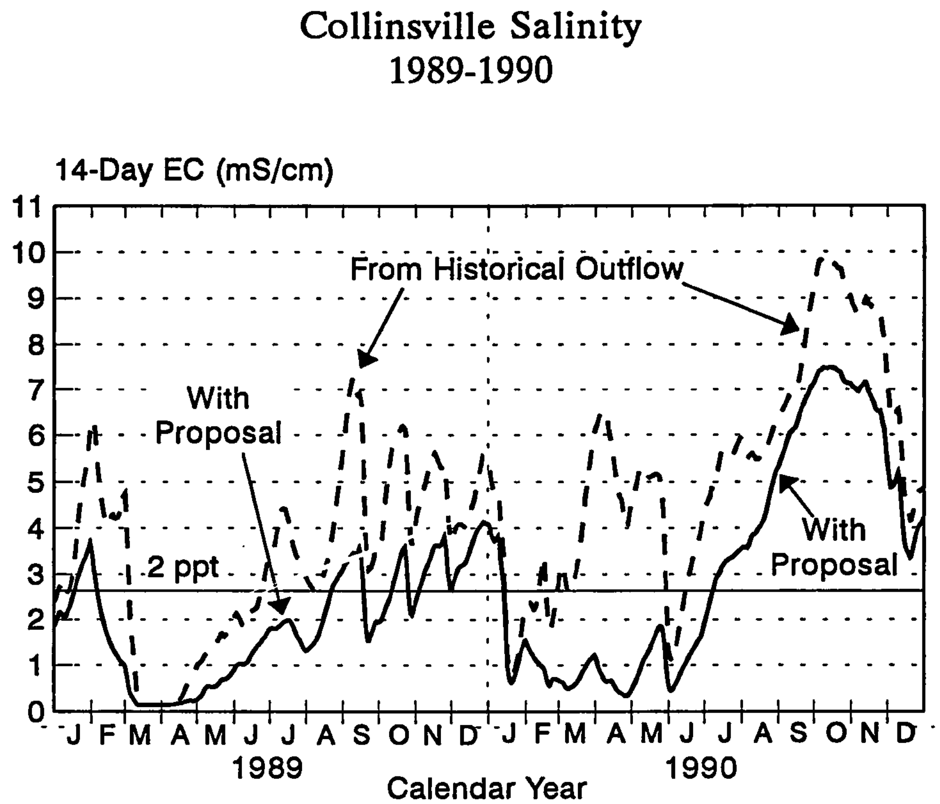


Figure 1-1. Average February-June location of X2 with the Joint Water Users proposal compared to the D-1485 base case for 1945-1969, and 1968-1992. The two figures present output data from DWRSIM studies Alternative J (Joint Water Users proposal with Option 2) and the D-1485 base case (DWRSIM Run 272B). The historical hydrology period is broken into three (slightly overlapping) parts.



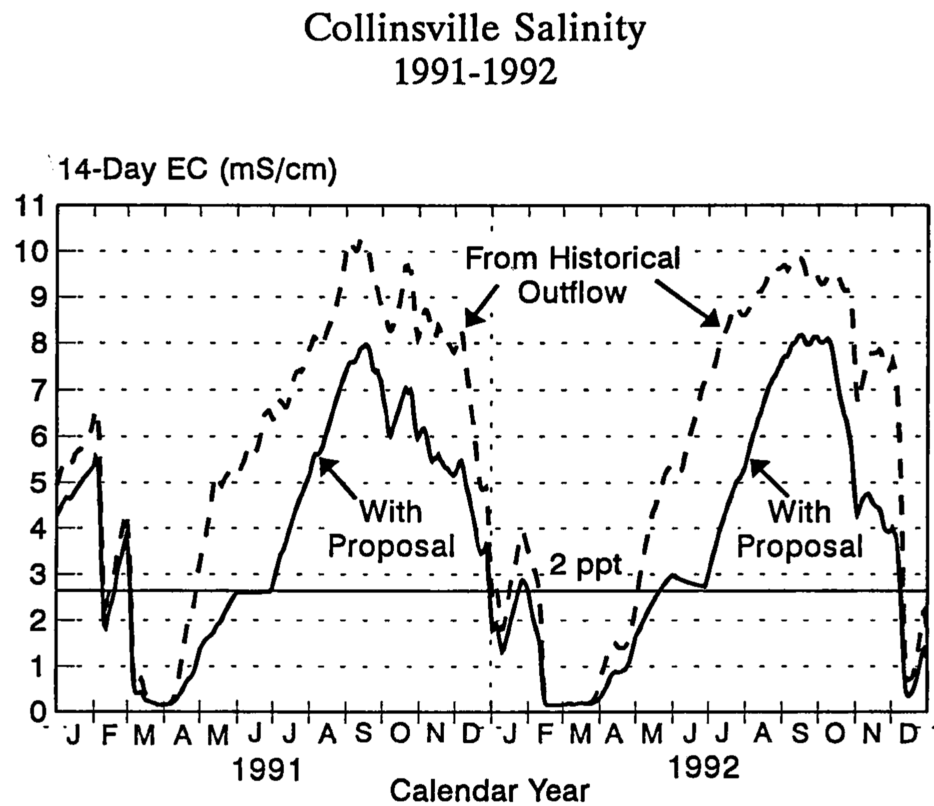


Figure 1-2. Simulated Collinsville salinities with the Joint Water Users proposal compared to the salinities simulated using historical DAYFLOW outflows for 1989-1992. The two figures present output data from Contra Costa Water District (CCWD) salinity-outflow model (G-Model). Note that a surface EC of 2.64 mS/cm is assumed to represent 2ppt (the X2 value).

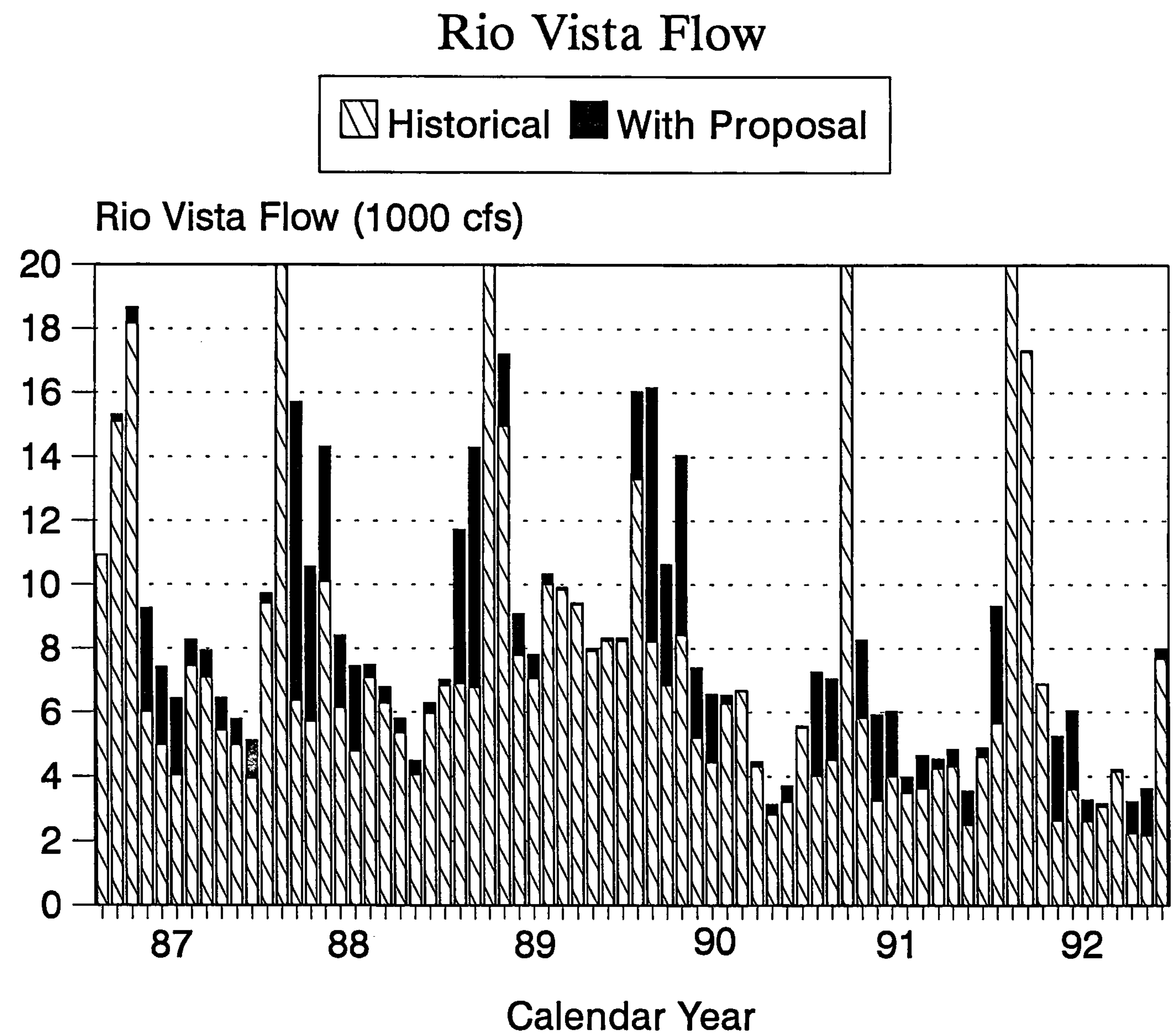
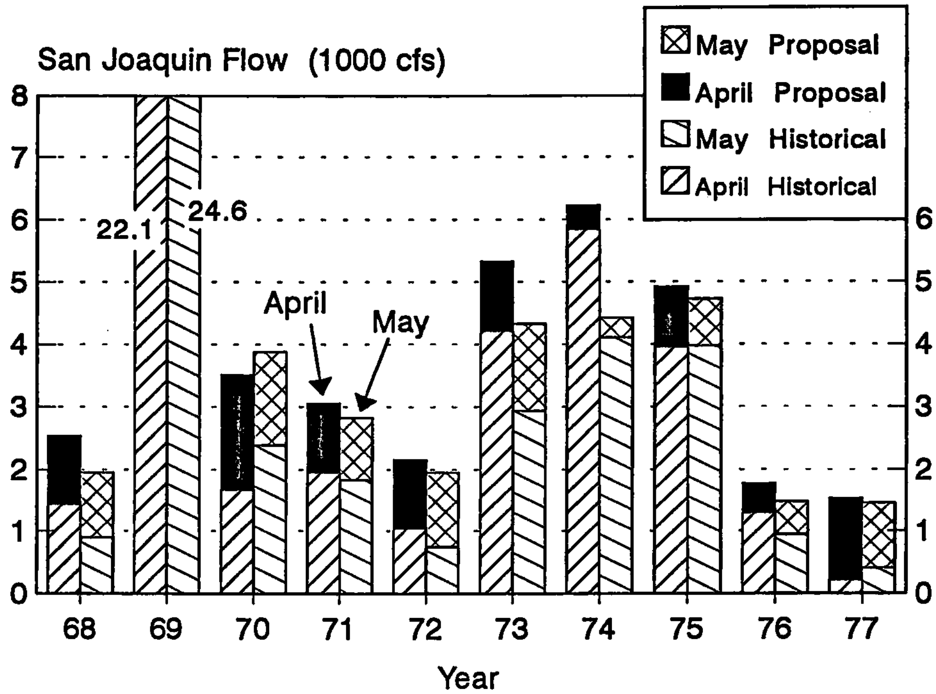


Figure 1-3. Monthly Sacramento River flows at Rio Vista with the Joint Water Users proposal; compared to historical flows from DAYFLOW for 1987-1992. The "with proposal" data are output from CCWD's additional outflow model (i.e. all X2 salinity and flow requirements are met by increasing historical flows and reducing historical exports).

San Joaquin Flow at Vernalis
DAYFLOW data 1968-1977



San Joaquin Flow at Vernalis
DAYFLOW data 1984-1992

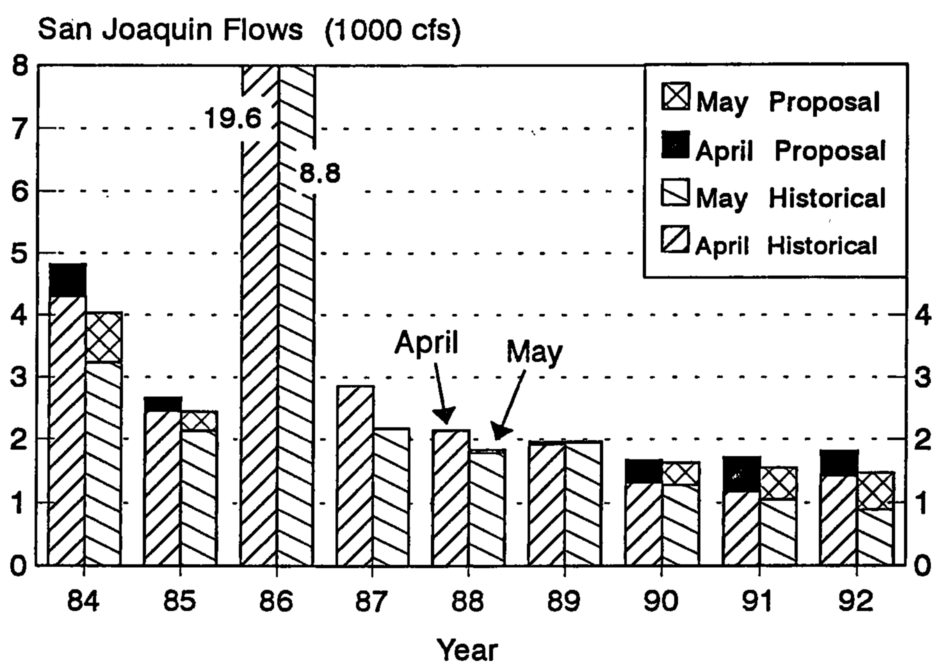


Figure 1-4. San Joaquin Flows at Vernalis during April and May with and without the Joint Water Users proposal for two periods, 1968-1977 and 1984-1992. The "with proposal" data are output from CCWD's additional outflow model (i.e. all X2 salinity and flow requirements are met by increasing historical flows and reducing historical exports). The proposal has a 1,000 cfs base flow for February through May and higher flows (4,000 - 10,000 cfs) for the intermediate period April 15 through May 15.

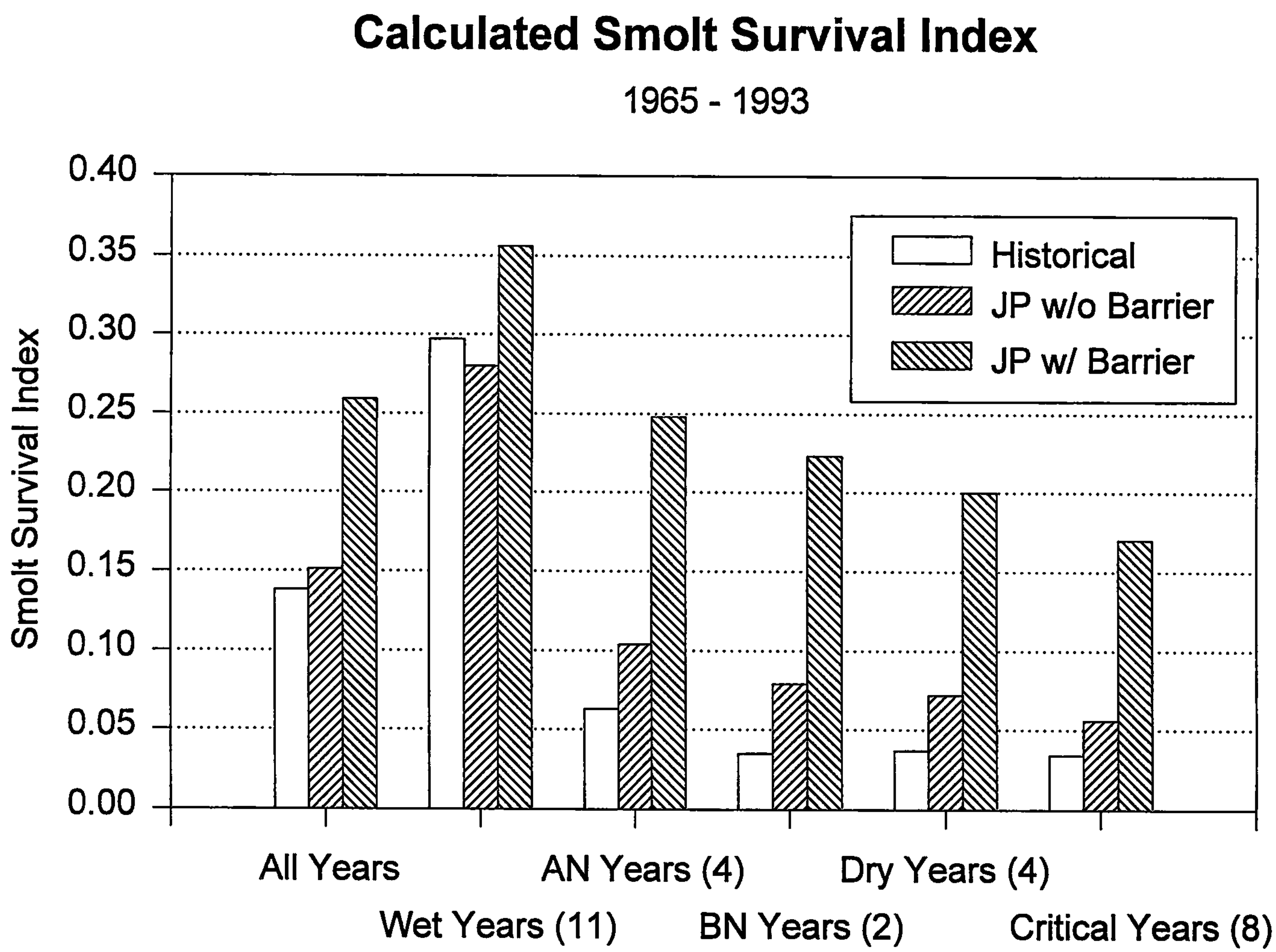


Figure 1-5. Comparison of calculated smolt survival indices for the San Joaquin River (based on USFWS equations) under historical conditions and those proposed by the Joint Water Users. The indices resulting from the Joint Water Users proposal include effects of San Joaquin River flow, export reductions, and a barrier at the head Old River.

Historical Export/Inflow Ratio
(Banks + Tracy Exports)

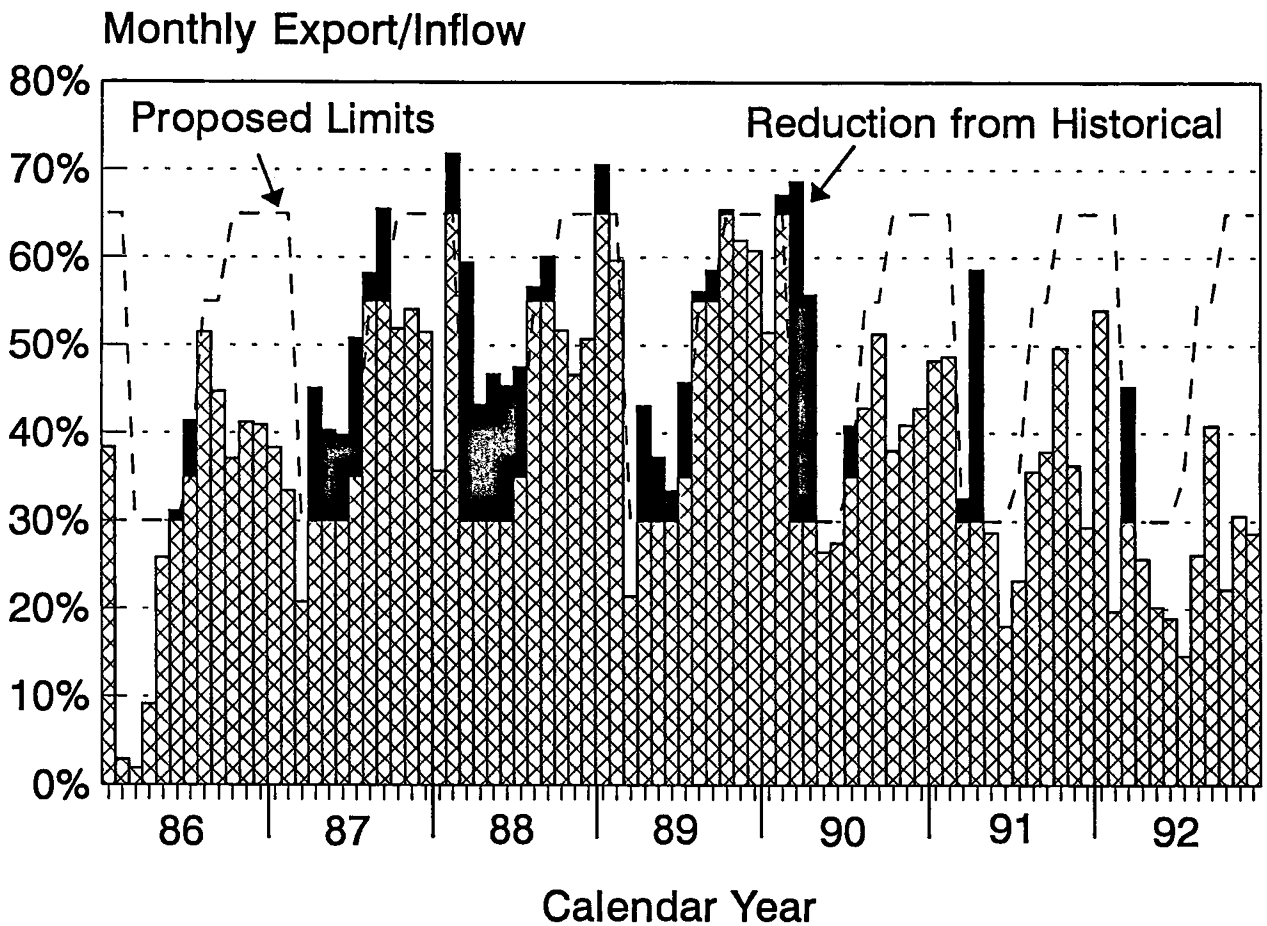


Figure 1-6. Reduction in historical export/inflow ratios that would occur with the Joint Water Users proposal, 1986-1992. Superimposing the proposed 30%, 35%, 55% and 65% export/inflow ratio limits on the historical export pumping data reveals substantial reductions in exports will occur especially in the March through July period.

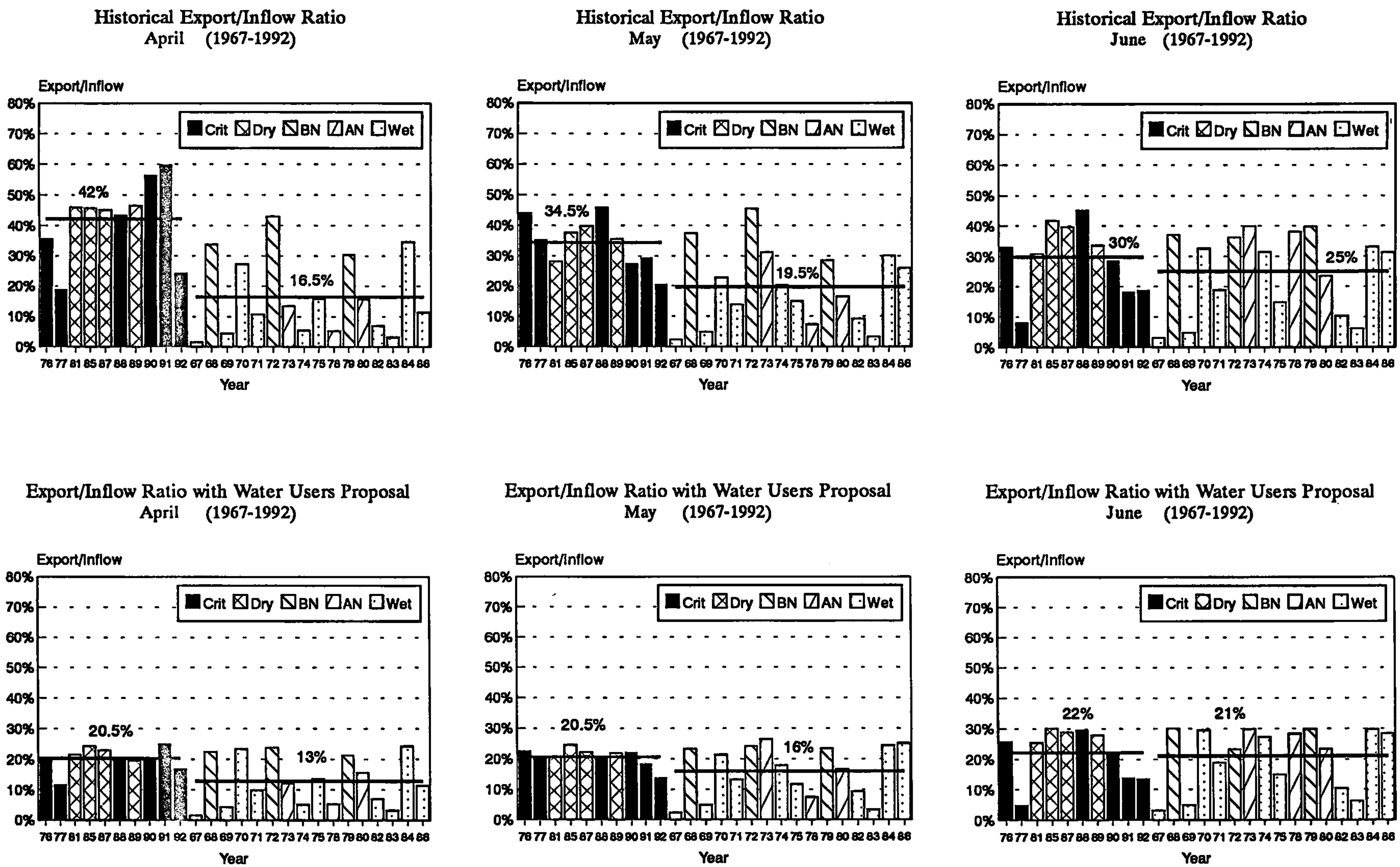
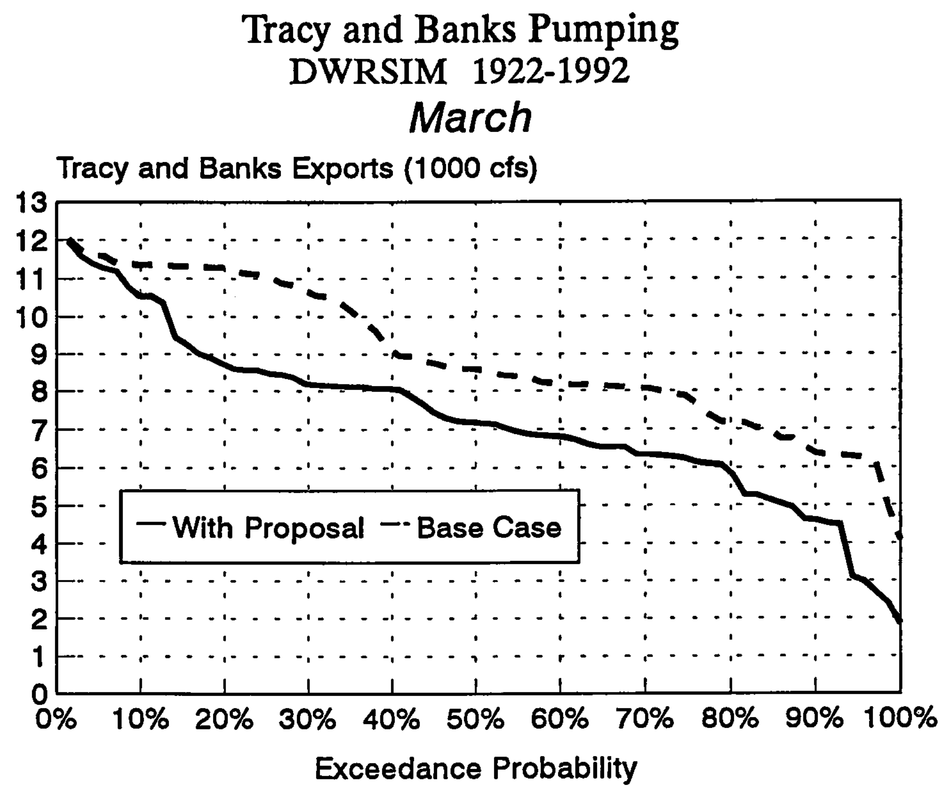


Figure 1-7. Comparison of export/inflow ratios for the Joint Water Users proposal with historical values, April through June. Each graph shows the corresponding averages for drier and wetter years. Data are from CCWD's additional outflow model. The charts differentiate between the 5 water year types (using the 40-30-30 water year classification for the Sacramento River basin) and changing water year types of February 1 each year.



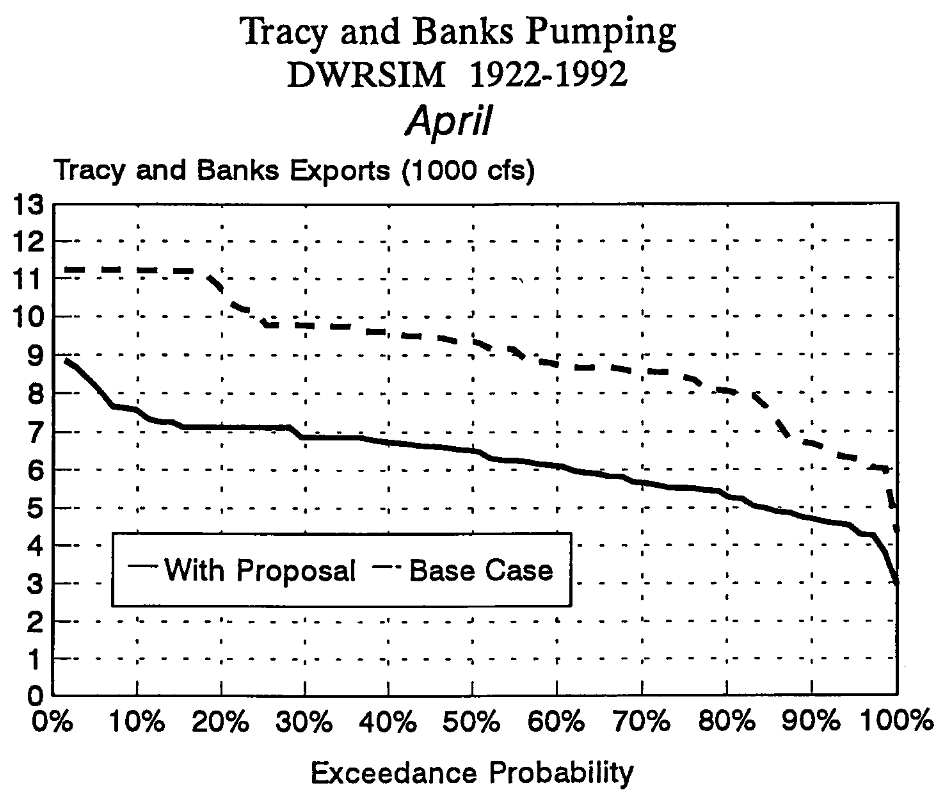


Figure 1-8. Histogram of export pumping with Joint Water Users proposal compared to D-1485 base case for March and April. Data are from DWRSIM output from DWRSIM studies Alternative J (Joint Water Users proposal with Option 2) and the D-1485 base case (DWRSIM Run 272B). DWRSIM data are used because CCWD's additional outflow model does not reoperate the Projects and does not shift exports to other periods.

2.0 BIOLOGICAL EXPLANATION FOR THE PROPOSED TECHNICAL STANDARDS

2.1 DEVELOPMENT OF PROPOSED TECHNICAL STANDARDS

The development of the Joint Water Users proposal for water quality standards, including flows (Category I) and operational measures (Category II), was completed utilizing the combined expertise of biologists, hydrologists and water resources engineers. These experts are familiar with the Bay-Delta system and the technical issues related to aquatic resource protection, endangered species considerations, and water supply needs. In a broad context, three steps were involved in the selection of proposed measures (Figure 2-1):

- Step 1 - Formulation of Problems/Objectives
- Step 2 - Development of Programs to Meet Objectives
- Step 3 - Balancing of Program with Water Supply Impacts

Two additional important steps in the Joint Water Users proposal include: Step 4 - Implementation of the measures, and Step 5 - Development and Implementation of a Comprehensive Monitoring Program. These steps are described in more detail below.

2.1.1 Step 1: Formulation of Problems/Objectives

The initial step was to define as narrowly as possible the overall objectives and goals of the flow measures (Category I) and operational measures (Category II) and their effect on biological resources in the Bay-Delta. While acknowledging that the overall, long-term goal was for the recovery of a healthy, multi-species ecosystem including the delisting of state and federally listed threatened and endangered (T&E) species, the scientists and engineers involved in the process recognized that the attainment of such a goal could only occur via the cumulative resolution of a multitude of smaller, site and operational specific problems that have been affecting the aquatic resources over the past several decades. It was further recognized that the current conditions in the Bay-Delta are not solely influenced by the water projects and that there are many other "non-flow related factors" (Category III) that have likewise contributed to general declines in biological resources; these other factors must also be addressed. A more detailed discussion of specific "non-flow related" factors that have and are continuing to influence the Bay-Delta system is presented in Section 3.

To define specific objectives, knowledgeable technical experts (biologists, engineers, hydrologists) representing both urban and agricultural water interests held several "round table" discussions. From the discussions, these experts identified three specific objectives:

- Avoid/minimize impacts on the aquatic resources wherever possible via the development of flow, operational, and management measures designed to both improve the ecosystem and provide increased water supply reliability.

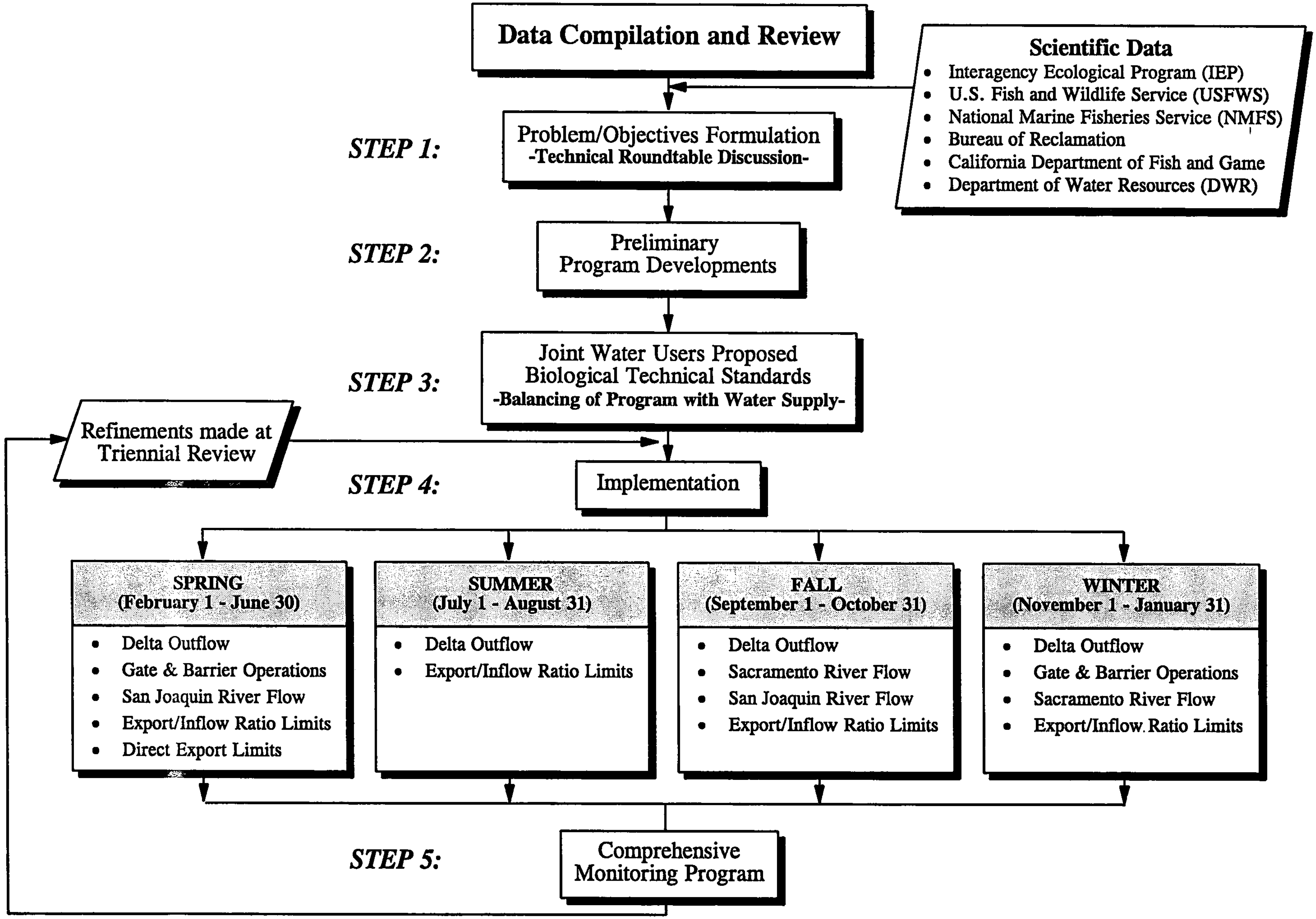


Figure 2-1. Flow chart depicting steps (1-3) used by Joint Water Users in developing proposed Biological Technical Standards for the Sacramento-San Joaquin Bay-Delta. Step 4 relates to Implementation of the measures; Step 5 includes development and implementation of a Comprehensive Monitoring Program.

- Develop a focused monitoring/response program to track the effectiveness of various flow and operational and management measures that directly feed back into specific aspects of project operations and provide necessary information for refining existing and defining new measures (Category III items included) to better protect the aquatic resources.

- Through Category III items, mitigate/compensate for any unintended/unforeseen impacts these measures create.

Implicit within these goals were the following community, population, and species life stage objectives:

  - Reduce direct mortality (of all indigenous/resource species)

  - Increase population resilience (i.e., the ability of populations to endure short term distress without decreasing population size)

  - Increase the probability of reproductive success via development of strong year classes

  - Expand geographic distribution of certain species and life stages via 1) increase in the quality and availability of suitable habitat; and 2) enhancement of transport and dispersal mechanisms

  - Maintain/restore indigenous species diversity within the aquatic community

  - Sustain and promote recovery of populations of native species to levels where protection under the Endangered Species Act (ESA) is not required

Consistent with the approach of the U.S. Environmental Protection Agency (EPA), we developed the above objectives in the context of multispecies protection and restoration, although special considerations were given to currently listed T&E species and certain resource species such as presently unlisted salmon stocks and striped bass.

2.1.2 Step 2 - Development of Programs to Meet Objectives

Step 2 involved the development of a specific program designed to achieve the stated objectives. For this, it was necessary to identify current problems and sources of mortality and to develop measures that would minimize or reduce such mortality thereby improving survival. This was completed via the reviews of measures described in prior water right decisions and supporting documentation, and reports and data prepared by state and federal agencies which have focused on identifying and evaluating impacts associated with water project operations. There was also an appeal to fundamental biological and hydrological principles, especially as these principles related to the consistency of the program with overall biological objectives. This was important for: 1) understanding the technical basis of measures being proposed by state and federal agencies; 2) developing the scientific basis of measures derived by the Joint Water Users technical team; and 3) integrating the large number of measures into a unified program.

Based on this review, specific measures were identified which, in the opinion of the technical experts, provide biological benefits (either protective or mitigative) to the aquatic resources. These involved specific flow and operational measures, which, when combined into a single program and coupled with Category III measures and a focused monitoring/response program, will afford a higher degree of protection to the aquatic biota. We believe, and it is our intent, that this degree of protection will result in non-jeopardy status for listed species and the avoidance of listing of additional native species dependent on the Delta habitat. Non-jeopardy status of listed species will obviate the need for development of Reasonable and Prudent Alternative (RPAs). This degree of protection will likely give increased flexibility in the development of Reasonable and Prudent Measures (RPMs) to minimize incidental, unintended take of listed species at the state and federal project facilities. This was deemed important for restoring certainty as to how water projects would be operated.

The development of the program focused initially on resource protection. Specific measures considered included:

- Net Delta outflow
- Sacramento River flow
- San Joaquin River flow
- Export/inflow ratio limits
- Direct export limits
- Barrier at head of Old River Cross Channel gate closures
- Pulse flows
- Selected water quality limits directed toward salinities in the Sacramento and San Joaquin rivers and Suisun Marsh

2.1.3 Step 3 - Balancing of Program with Water Supply

The final step in selecting the preferred measures of the proposed program involved prioritizing the various elements in anticipation of the need for policy makers to balance the benefits with associated water supply impacts. The goal of establishing environmental priorities was to preserve the highest priority elements during the balancing process and therefore optimize biological protection. Priorities were established to reflect the relative importance of:

a) The February-June period for a variety of species as well as general estuary conditions
b) Provision of appropriate inflows and Delta outflows to transport eggs, larvae, and juveniles through the Delta and for adult salmon spawning migration
c) Reduction of in-Delta losses of migrant and resident fish
d) Native vs introduced species

e) The need for general variation in environmental conditions for different water-year types, balanced by minimum acceptable conditions during critical and dry water-year types

Based on these considerations, the flow and operation elements of the plan were assigned priorities. The plan elements developed by the biologists, with their priority judgments, were then addressed by Joint Water Users' policy makers, who balanced biological recommendations against water costs, selecting the measures recommended in these "Proposed Bay-Delta Standards" based on the priorities established by the biological team. It is important to note that this balancing has been undertaken by the policy makers, and that the package of measures recommended reflects the Joint Water Users' best efforts to balance water costs and biological needs."

In addition, a general set of non-flow and operations measures (Category III) was developed to complement and supplement the flow and operations measures. The near-term focus of this effort will be on developing a series of demonstration projects, with an appropriate research element to each project to provide for quantitative evaluation of the costs and environmental benefits of each pilot project. Demonstration projects will be considered in a variety of categories:

a) Unscreened Water Diversions
b) Waste Discharges
c) Legal Fishing
d) Illegal Fishing
e) Land-Derived Salts
f) Introduced species
g) Loss of Riparian, Wetland, and Estuarine Habitats
h) Channel Alterations

A more detailed discussion of these categories is provided in Section 3.0. The goal of the package of measures thus developed was to substantially improve general habitat conditions in the Bay-Delta ecosystem and provide adequate flows for through-Delta transport of eggs, larvae, and juveniles. Most of the benefit from the proposed standards will result from implementation of flow and operational measures, with the benefit from measures such as habitat restoration accruing only as the demonstration projects are implemented.

Although the proposal for flow and operations measures would provide significantly higher levels of protection than current regulations, an extensive monitoring and adaptive response program is also proposed for all elements of the proposal. This program will provide data needed to evaluate the effectiveness of the various elements of the proposal, allowing adaptive management responses following each triennial review.

2.1.4 Step 4 and 5 - Implementation and Monitoring

Step 4 is the actual implementation of the proposed measures including development of procedures for determining compliance (Figure 2-1).

The Joint Water Users proposal also includes the development and implementation of a comprehensive monitoring program (Step 5). This program is focused on evaluating each of the flow and operational measures specified in the Joint Water Users proposal (following implementation) relative to its effectiveness in achieving intended benefits. This will provide a feedback loop via the Triennial Review in which necessary adjustments and modifications can be considered to various components of the program to better achieve balanced protection of the aquatic resources. In some cases, additional measures may be warranted, in others, the monitoring may indicate that certain operational measures are having no influence on the resource and may therefore be removed from the program. The existing monitoring programs have not been designed to specifically address the effectiveness of flow and operational measures. It is in the interest of all users and resource managers of the Bay-Delta system to better understand the aquatic ecosystem and its major influencing factors (flow and non-flow related). The Proposal recognizes this and has placed special emphasis on biological monitoring with the understanding that it is the only way in which to develop the necessary scientific data from which to evaluate specific flow and operational measures. A description of the Joint Water Users proposed Monitoring Program is presented in Section 2.3.

2.2 THE JOINT WATER USERS PROPOSAL - BENEFITS AND SCIENTIFIC BASIS

This section contains a description of the logic and rationale for each of the proposed measures, its biological objective and intended benefits, and to the extent possible, a discussion of the scientific basis supporting the development of such measures. The overall Joint Water Users proposal is presented in Table 2-1. The discussion in this section is organized by season, but is limited to flow and operational measures; no discussion is provided for proposed water quality (salinity based) measures, since these largely reflect the measures existing under the 1991 Water Quality Control Plan.

2.2.1 SPRING PERIOD (FEBRUARY 1-JUNE 30)

Spring is a critical time for most biological resources using the Bay-Delta. During this time, many species are spawning, eggs are incubating, and juvenile fish, such as chinook salmon smolts, are emigrating through the estuary. Because this time is so critical, a major focus of the Joint Water Users' Proposal has been on the spring period. We have attempted to protect those life history stages and those activities important to the biological resources of the Bay-Delta during this period. The proposed standards therefore provide for the greatest reduction in exports, the highest transport flows, and the highest flows for improving estuarine habitat conditions during this period. We have also provided minimum outflows, beyond those which might have occurred using the X2/sliding scale approach, in critical and dry water-year types. Figure 2-2 presents the life history periodicity chart for important Bay-Delta fish species.

ACTIONS

Flow & Operational Requirements — Spring (FEB–JUN) | Summer (JUL–AUG) | Fall (SEP–OCT) | Winter (NOV–JAN)

FLOW REQUIREMENTS

Action	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Sacramento River Flows												
Min. cfs flows at Rio Vista in C/D/BN/AN/Wet year types								3,000	3,000 - 4,000	3,500 - 4,500		
San Joaquin River Flows												
Min. cfs flows at Vernalis in C/D/BN/AN/Wet year types		1,000	2,000 - 5,000 (or equivalent pulsed volume)	1,000					1,000			
Pulse/attraction flow in all years, except no two critical years in a row; includes closure of Old River barrier									28,000 AF Pulse			
Delta Outflow												
Min. cfs flows in C/D/BN/AN/Wet year types				6,000	4,000	4,000 - 8,000	3,000 - 4,000	3,000	3,000 - 4,000	3,500 - 4,500		4,500 - 6,000
Estuarine Habitat Standard (based on avg. daily salinity, 14-day avg. salinity, or equivalent flow)	X2 Sliding Scale w/ 3-Way Compliance at Roe, Chipps, & Confluence (In D/C yrs, Feb.=28-days of X2 @ Confluence)											
Pulse flow in Critical & Dry year types Min. 30-days if X2 at Confluence			30-days of X2 @ Conf	7,000 cfs pulse for 28-days								

EXPORTS & DIVERSIONS

Action	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Export/Inflow Ratio Limits												
Min. pumping	Min. 1,500 cfs pumping in all year types											
Limit pumping to X% Delta inflow (X% if no significant adverse impact to fisheries);	65%	30% (35% if no signif. impact)				35%(55%)	55% (65%)		65%			
Increased monitoring at pumps & in-Delta:	If the mortality estimate ≤ X% density of population, then OK to pump at higher % inflow; or If the mortality estimate > X% density of population, then maintain export/inflow ratios at lower % inflow;											
Direct Export Limits												
Exports w/ Old River barrier no greater than Vernalis flow			Exports ≤ Vernalis flow									

* NOTE: In order to facilitate voluntary water transfers, these limits would not apply to exports necessary to deliver transferred water through the Delta.

Table 2-1. Joint Water Users Proposed Bay-Delta Standards.

10/31/94 (SWRCB-23.XLS)

ACTIONS

Flow & Operational Requirements

GATE & BARRIER OPERATIONS		FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
		Spring					Summer		Fall		Winter		
Cross Channel													
Close radial gate in all year types		Cross-channel closed thru May 20											Closed
Old River													
Install barrier for San Joaquin River salmon smolt emigration, adult salmon migration, & pulsed flows.				Barrier for emigration						Barrier closed for adult migration & pulsed flows			
Georgiana Slough													
Install acoustic barrier in all year types.		Acoustic barrier installed									Acoustic barrier installed		
SALINITY													
Delta Agriculture													
SWP/CVP Intakes		Max. 1.0 EC (based on 14-day running average of mean daily in mmhos)											
So. Delta Agriculture Wtr. Quality Modeling Assumption		1.0 EC at Vernalis		0.7 EC at Vernalis;					1.0 EC at Vernalis;				
Emmaton (Sacramento River):	C			2.78 EC									
	D			0.45 EC		[15]	1.67 EC						
	BN			0.45 EC		[20]	1.14 EC						
	AN			0.45 EC		[30]	0.63 EC						
	W			0.45 EC									
Jersey Point (San Joaquin River):	C			2.20 EC									
	D			0.45 EC		[15]	1.35 EC						
	BN			0.45 EC		[20]	0.74 EC						
	AN			0.45 EC									
	W			0.45 EC									
Terminous (Mokelumne River):	C			0.45 EC									
	D			0.45 EC									
	BN			0.45 EC									
	AN			0.45 EC									
	W			0.54 EC									
San Andreas Landing (San Joaquin River):	C			0.87 EC									
	D			0.45 EC		[20]	0.58 EC						
	BN			0.45 EC									
	AN			0.45 EC									
	W			0.45 EC									

Table 2-1. (continued)

10/31/94 (SWRCB-23.XLS)

ACTIONS

Flow & Operational Requirements

SALINITY	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
	Spring					Summer		Fall		Winter		

Municipal & Industrial

Location	Requirement (FEB–JAN)
At CCWD or Antioch Wtr Works Intake on the S.J. River	Max. 150 mg/l chloride for 155/165/175/190/240 days/yr. during C/D/BN/AN/W; in intervals ≥ 2 weeks in duration.
At CCWD, City of Vallejo, Clifton Court, Tracy Pumping Plant, & North Bay Aqueduct	Max. 250 mg/l maximum mean daily chloride

STRIPED BASS SPAWNING

	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Prisoners Pt: Max. mean daily EC until spawning has ended; Relaxed when Antioch spawning criteria relaxed.			0.44 EC 0.55 EC									
Antioch (S.J. River): Max. 14-day avg. of mean daily salinity until spawning has ended			1.5 EC									

Replaces above Antioch & Chipps criteria whenever the projects impose deficiencies

Deficiency	Critical Year Criteria	Dry Year Criteria
0.0 maf	1.5 EC	1.6 EC
0.5 maf	1.9 EC	1.8 EC
1.0 maf	2.5 EC	1.8 EC
1.5 maf	3.4 EC	1.8 EC
2.0 maf	3.7 EC	1.8 EC

SUISUN MARSH PRESERVATION AGREEMENT

	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Suisun Marsh Preservation Agreement (Normal)	8.0 EC	8.0 EC	11.0 EC	11.0 EC					19.0 EC	16.5 EC	15.5 EC	12.5 EC
Suisun Marsh Preservation Agreement (Deficiency)	15.6 EC	15.6 EC	14.0 EC	12.5 EC					19.0 EC	16.5 EC	15.6 EC	15.6 EC

- The S.M.P.A. is based on the monthly average of both daily high tides in mmhos/cm EC at Collinsville, Montezuma Slough, Chadbourne Slough, Cordelia Slough, Suisun Slough, & Goodyear Slough (locations may differ).

Table 2-1. (continued)

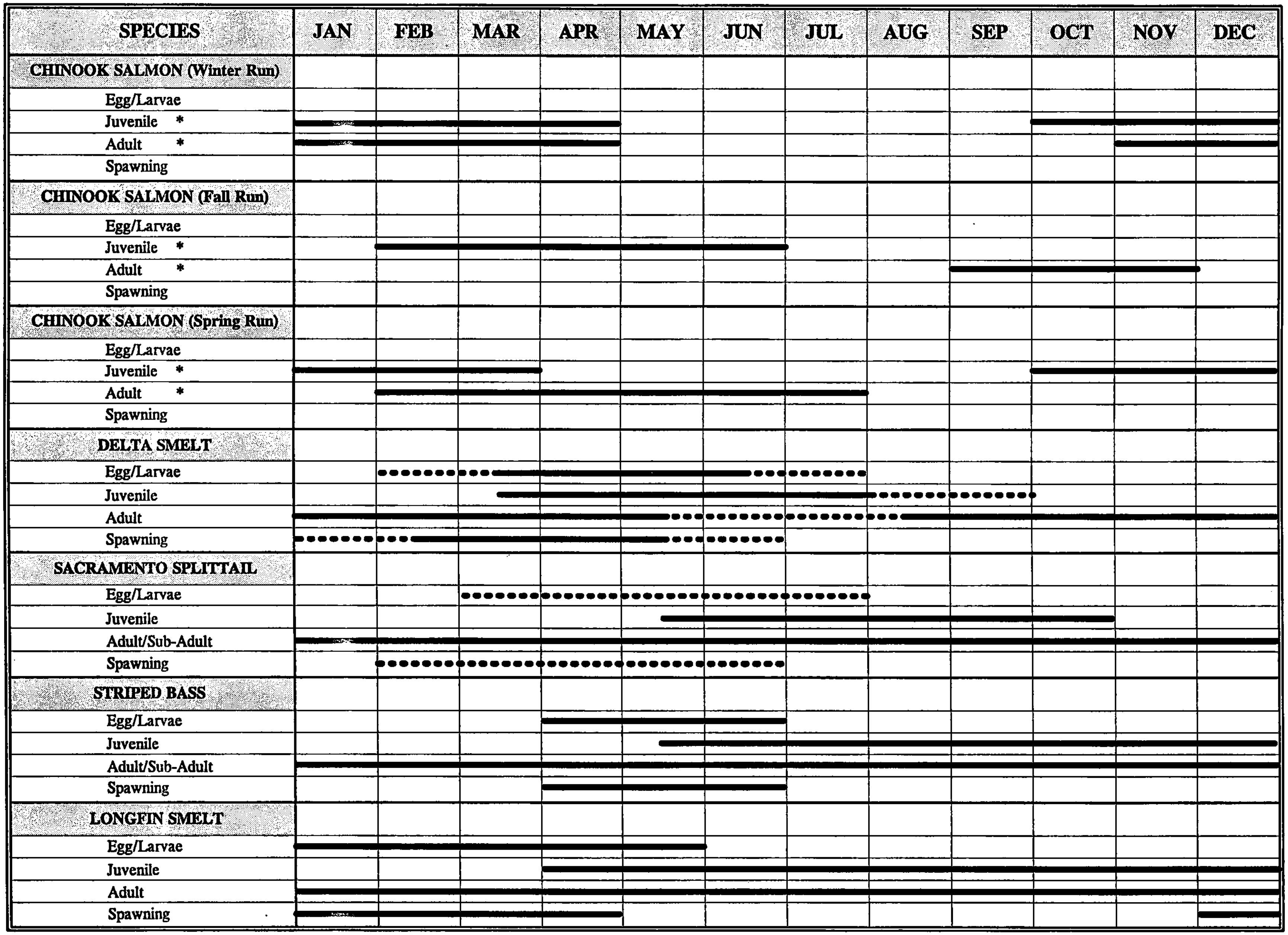
ACTIONS

Biological Benefits: Spring (FEB–JUN) | Summer (JUL–AUG) | Fall (SEP–OCT) | Winter (NOV–JAN)

Actions	Biological Benefits
Sacramento River Flows	
Min. cfs flows at Rio Vista in C/D/BN/AN/Wet year types	Late fall-run chinook salmon, San Joaquin River fall-run chinook, striped bass
San Joaquin River Flows	
Min. cfs flows at Vernalis in C/D/BN/AN/Wet year types	Fall-run chinook salmon (Sac. & San Joaquin Riv.), smelt, splittail; Fall salmon (Sac/S.J.)
Pulse/attraction flow in all years, except no two critical years in a row; includes closure of Old River barrier	Fall salmon (S.J.)
Delta Outflow	
Min. cfs flows in C/D/BN/AN/Wet year types	Winter-run/Spring-run/Fall-run/S. J. Fall-run chinook salmon, delta smelt, longfin smelt, Sacramento splittail, striped bass
Estuarine Habitat Standard (based on avg. daily salinity, 14-day avg. salinity, or equivalent flow)	Estuarine Habitat, winter-run/spring-run/fall-run chinook salmon, smelt, splittail, striped bass
Pulse flow in Critical & Dry year types Min. 30-days if X2 at Confluence	Same
EXPORTS & DIVERSIONS	
Export/Inflow Ratio Limits	
Min. pumping limit	
Limit pumping to X% Delta inflow (X% if no significant adverse impact to fisheries);	Winter-run/Spring-run/Fall-run/S. J. Fall-run chinook salmon, smelt, splittail, striped bass; S.J. Fall-run chinook salmon, smelt, splittail
Monitor at pumps & in-Delta:	Same as above
Direct Export Limits	
Exports w/ Old River barrier no greater than Vernalis flow	San Joaquin Fall-run chinook salmon

Table 2-1. (continued)

10/31/94 (SWRCB-23.XLS)



*** - Indicates use as a migration (upstream or downstream) corridor.**

Dashed line = infrequent use in either temporal or geographical terms.

Figure 2-2. Species/lifestage monthly periodicity chart for selected species that utilize the Sacramento-San Joaquin Estuary.

2.2.1.1 Delta Outflow

(a) *Measure: February 1 through June 30 -- X2 standard with sliding scale and three-way compliance measures as proposed by CUWA, with the sliding scale in February modified as follows: 28 days at the confluence required every February, and zero days required in February at Chipps Island when the January unimpaired Eight-river index is at or below 1.5 MAF (with 28 days required at Chipps Island if the index is above 1.75 MAF and linear interpolation between 1.5 MAF and 1.75 MAF).*

Biological Objective: Provide flows for egg and larval transport and dispersal and improve habitat conditions of the Bay-Delta estuary during the critical spring period.

Intended Benefits: Improvement of a variety of habitat conditions in the estuary during critically important life history stages (i.e., spawning and incubation, and early rearing) of a variety of important estuarine fish and invertebrate species. Provides outflows as measured by the 2 ppt salinity (X2) isohaline, which place the zone of higher concentrations of nutrients, in conjunction with physically important shallow water habitats used by a variety of estuarine species for rearing. Promotes freshwater trapping in Grizzley Bay, an important geographic element of the estuary.

Scientific Basis: Based primarily on work of the San Francisco Estuary Project (SFEP) (Jassby et al., 1993) in which a series of indices of abundance vs X2 regression curves were developed. These relationships indicated that for certain species of fish and invertebrates, that abundance indices increased as average springtime position of X2 was located further downstream. EPA accepted the findings of the SFEP that the 2 ppt isohaline was easy to measure and represented the "whole range of factors relevant to estuary health, even though the operation of some of these factors is not fully understood." The standard has the objective of restoring some of the natural hydrological patterns that historically occurred in the system and in which native fish and invertebrate species likely evolved and proliferated. The effect is to provide late winter and spring river flow and Delta outflow, which promotes conditions conducive for spawning and/or dispersal of delta smelt, longfin smelt, Sacramento splittail and other anadromous and estuarine species.

The causal mechanisms for such relationships are not well defined but are likely related to: 1) transport of eggs and larvae out of river/Delta areas into estuarine habitats (Kimmerer, 1993; IESP, 1991; Moyle, 1992); 2) nutrient transport into Suisun and Honker bays resulting in increased phytoplankton production (IESP, 1990, 1991; Fullerton, 1991; Turner and Chadwick, 1972); 3) mixing of salt and freshwater resulting in nutrient and egg and larvae dispersal to shallow water habitats (Kimmerer, 1992); 4) freshwater trapping in Grizzley Bay, an important nursery area; 5) reduced predation of juvenile fish since more habitat is made available due to dispersal to shallow water areas, and increased turbidity (Arthur and Ball, 1979; Stevens and Miller, 1985); and 6) intraand inter-annual variation in outflow patterns which historically occurred in the system in conjunction with native fish populations.

The X2 standard is a surrogate for outflow, and in addition to providing suitable spawning and incubation habitats, provides transport flows for delta smelt larvae, and migratory cues for salmon smolts. It is for the above reasons that a modified X2 standard which recognizes inherent hydrological variability of the system via a sliding scale has been proposed as part of this plan.

(b) ***Measure: April 1-30 -- X2 sliding scale adjusted to provide a minimum of 30 days at confluence as measured with three-way compliance.***

Biological Objective: Provide baseline flow for spawning and transport during dry and critical years.

Intended Benefits: Providing minimum flows during dry and critical years will maintain beneficial habitat and transport functions.

Scientific Basis: See discussion under Section 2.2.1.1.

(c) ***Measure: May 1-31 -- minimum 6,000 cfs monthly average net Delta outflow. June 1-30 -- minimum 4,000 cfs monthly average net Delta outflow in all year types. Daily average not less than 80% of the minimum monthly average. February to June X2 standard will apply when sliding scale requires greater outflow.***

Biological Objective: Provide baseline flow for spawning and transport during dry and critical years.

Intended Benefits: Outflows important for continued transport of eggs and larvae (during dry and critical years) downstream to suitable rearing habitats (delta smelt).

Scientific Basis: See discussion under Section 2.2.1.1.

(d) ***Measure: During the period May 1-June 30 -- A flow of at least 7,000 cfs for 28 days during dry and critical years. (The equivalent incremental volume of water could be distributed differently within this time period.)***

Biological Objective: Provides additional flow in dry and critical years which would not otherwise be provided by the X2 sliding scale. This provides additional habitat and transport for late spawning delta smelt and benefits for other species.

Intended Benefits: The flows would serve as transport flows of eggs and larvae subsequent to late delta smelt spawning in lower river reaches. Thus, these flows should increase the potential survival of delta smelt (and other late spawning species), especially in critical and dry year types, via transport of eggs and larvae.

Scientific Basis: Based on results of limited (3-4 years) monitoring/response data that suggests that delta smelt, under dry and critical year flow conditions, spawn later in the year than under normal conditions. This presumably occurs due to delta smelt awaiting higher flow conditions (not just pulse flows) which would trigger spawning. After a prolonged period, when such flows have not occurred (as during dry and critical years), their urge to spawn overrides the need for flow-induced cues and spawning commences. Additional monitoring should be completed to determine if this is a consistent behavioral pattern and to more fully understand delta smelt ecology and life history strategies.

2.2.1.2 Gate and Barrier Operations

(a) Measure: Install barrier at head of Old River during April 15-May 15, coincident with outmigration of smolts; time of installation based on real-time monitoring/response.

Biological Objective: Reduce mortality/increase survival of outmigrating San Joaquin salmon smolts by keeping smolts within mainstem river; preventing smolts from being diverted toward the pumps.

Intended Benefits: Prevent losses of salmon smolts to water projects by keeping them in mainstem river until migration cues likely shift to salinity rather than velocity. This, coupled with pulse flows and export limits, should result in increased survival of smolts and correspondingly increased numbers of returning adult salmon in subsequent years.

Scientific Basis: Several tests have been conducted which compare survival indices of coded wire tagged (CWT) fish released at the Upper Old River with those released downstream of Old River near Dos Reis. Comparison of Upper Old River and Dos Reis (San Joaquin below Old River) CWT survival indices suggest that a barrier would be beneficial to migrating San Joaquin smolts (Herrgesell, 1993).

Installation of a physical barrier at the head of Old River prevents smolts originating in the San Joaquin system from being drawn (via downstream velocity cues) toward the pumps, and maintains them in the mainstem river for a distance of at least 15 miles further downstream in the Delta (at least to Turner Cut). At this point, smolt behavior may shift from being rheophilic (velocity oriented) to cuing on salinity gradients (halophilic as postulated by McInerney, 1964). At this location (Turner Cut), net river flow vectors in a southerly direction are generally overwhelmed by tidal surges attenuating the potential for net flow to exert a controlling influence on salmon smolt migration. Therefore, the relative influence of water movement to the south on smolt migration may be very significantly reduced by the influence of salinity and tidal currents in this region of the delta waterway system.

It should be possible to construct a permanent gated barrier at the head of Old River which could be opened and closed based on results of real-time monitoring/response in the San Joaquin River (barrier closed when high density of smolts detected) and adjacent to the pumps (barrier opened or partially opened if delta smelt densities begin to increase). The construction of a barrier at the head of Old River represents a direct means of reducing potential smolt mortality at the pumps and is necessary to ensure the success of both the pulse flow releases and export limits proposed during April 15-May 15.

The type of barrier to be installed (rock structure, radial gates, etc.) should be evaluated in the context of being able to impart maximum biological benefits under short notice (e.g., based on real-time monitoring/response), and with consideration for minimizing any adverse impacts that may result from barrier installation (e.g., flooding of upstream islands).

(b) Measure: Close Cross Channel Gates up to a total of 30 days in seven day increments, based upon monitoring (flows, turbidity, etc.) during the months of November through January. February 1-May 20 -- close Cross Channel gates in all year types until other fish exclusion barrier is installed.

Biological Objective: Keep salmon smolts (including winter-run and spring-run) outmigrating from the Sacramento River in the most direct migration route to the estuary; i.e., within the main channel; prevent smolts from entering central Delta. Reduce the transport of striped bass eggs and larvae and other fish into the central Delta.

Intended Benefits: Reduce potential losses of salmon smolts into the Delta which may result in delays in migration, increased predation, and lower survival during migration to the estuary. Winter and spring closure is especially important for fall- and winter-run smolt outmigrants and spring-run fry (November).

Scientific Basis: Studies have been conducted involving coded wire tag releases of hatchery smolts above and below the cross channel gates, with gates open and closed. Data suggest increased survival when gates are closed. However, data are inconclusive and are not statistically significant. Nevertheless, biological judgment suggests that channel closures should provide a degree of protection to smolts, although other measures (such as screening, acoustical barrier, and other measures) should be considered as well.

(c) Measure: November 1-June 30 -- install Georgiana Slough acoustic barrier in all year types.

Biological Objective: Keep salmon smolts outmigrating from the Sacramento River in the most direct migration route to the estuary; i.e., within the main channel. Prevent/reduce potential losses of salmon smolts (spring, summer, fall, and winter run) into Georgiana slough which may delay outmigration and result in increased mortality due to predation.

Intended Benefits: Similar to Cross Channel Gate closures; increased survival is expected due to smolts being kept in the mainstem of the Sacramento River.

Scientific Basis: Results of recent prototype tests completed by C. Hanson (unpublished data, 1994) suggest that an acoustical barrier is a promising means for reducing the percentage of smolts entering Georgiana Slough. Test results have shown that operation of the acoustic barrier in 1994 was successful in reducing the numbers of chinook salmon smolts migrating from the Sacramento River into Georgiana Slough. Results of exposure tests for juvenile chinook salmon, striped bass, and a variety of other species have not shown a significant increase in mortality following exposure to underwater sound levels associated with acoustic barrier operations. Additional tests are being performed during October-November, 1994 to evaluate potential effects of acoustic barrier operations on the rate of upstream migration of adult chinook salmon and potential blockage of migration during periods when the acoustic barrier is on. Further studies to evaluate potential effects of exposure of delta smelt, Sacramento splittail, and other sensitive species to underwater sound pressure levels will need to be successfully completed before permanent installation of an acoustic barrier at Georgiana Slough is considered. Additional field research designed to evaluate potential adverse effects of acoustic barrier operations and provide additional information regarding guidance efficiency for chinook salmon smolts has been planned for 1995. After completing the 1995 field research program, consideration will be given to the potential acceptability of installing and operating an acoustic barrier at Georgiana Slough to reduce diversion of juvenile chinook salmon (fall-run, spring-run, and winter-run) from the Sacramento River and improve survival during downstream migration. The application of acoustic barrier technologies for improving juvenile chinook salmon guidance and survival is being considered at other appropriate locations including the Delta Cross-channel, Turner Cut, and the junction of the north and south fork of the Mokelumne River.

2.2.1.3 San Joaquin River Flow

(a) Measure: February 15-April 14 and May 16-May 30 – minimum flow of 1000 cfs (average monthly flow with a daily flow of not less than 80% of monthly average) at Vernalis.

Biological Objective: Provide improved flow conditions and rearing habitat for salmon fry and early migrating smolts on the San Joaquin River in dry and critical years.

Intended Benefits: Outflows during this period are important for providing olfactory imprints for outmigrating smolts, and to provide for downstream migration of salmon fry and early migrating smolts. Maintenance of instream flows in the lower San Joaquin system is also important for promoting spawning and egg and larval transport of delta smelt, splittail, and other resident species.

Scientific Basis: Studies are not conclusive for defining species habitat:flow relationships or flow:survival relationships from which to base solid technical recommendations of outflow for the San Joaquin River. There are presently no outflow standards for the San Joaquin except for flows which occur incidental to releases for water quality standards at Vernalis (Decision 1422). The proposed standard will establish minimum flow levels during the late winter and early spring. The recommended flows represent an improvement over historical conditions during dry and critical years and should prove beneficial to the resource.

(b) Measure: April 15-May 15 -- provide a 31-day flow regime within the San Joaquin River (as gaged at Vernalis), with specific flows based on water year types as follows:

YEAR CLASS	*VERNALIS FLOW (average monthly cfs) **
Critical	*2,000*
Dry	*3,000*
Below Normal	*4,000*
Above Normal	*5,000*
Wet	*5,000*

**an equivalent volume of water could be distributed differently in time if biologically justified*

Biological Objective: Provide a flow in the San Joaquin River to facilitate (in conjunction with a barrier at the head of Old River) (see 2.2.1.3 (a)), downstream passage of chinook salmon smolts during their critical outmigration period; increase downstream survival of smolts.

Intended Benefits: Improve survival of salmon smolts outmigrating from the San Joaquin system by providing: 1) increased flows during period when smolts are outmigrating from the drainage and 2) a more direct passage portal through the Delta, with less chance for the smolts to be directed toward the pumps (w/barrier in place).

Scientific Basis: Results of experimental tagged releases of salmon smolts at various locations within the San Joaquin River (Dos Reis, Mossdale, Snelling, Lower Stanislaus, and Lower Tuolumne) between 1982 and 1993 (WRINT-USFWS-7, 1992) suggest that smolt survival is related to the split of flows between Old River and the mainstem of the San Joaquin River towards Stockton. This flow split is affected by the flow at Vernalis, exports, and the status of the barrier at Old River. However, the relationship is based on a limited number of data points which do not adequately represent a broad range of operational conditions. In particular, very few data points exist for flows at 3,000 cfs or greater, so the degree to which large flows are effective is uncertain. Also, the variability of the data for low flow conditions suggests that factors other than flow may significantly affect smolt survival. Consensus of biologists at a recent Salmon Smolt Workshop (co-sponsored by CUWA; Kimmerer, 1994) was that flows in San Joaquin River during smolt outmigration periods are important; however, it was also recognized that the existing flow:survival relationships are useful to identify management strategies, but are not adequate to become the basis for specific standards.

The proposed standard will establish minimum flow levels during the period of primary smolt outmigration. These recommended minimum flows are greater than flows which have historically occurred in many years, particularly critically dry years, upon comparison to historical conditions, the proposed minimum flows, in concert with the proposed direct export limits during the 31-day flow period (exports may be additionally limited by the export/inflow restriction described in Section 2.2.1.4, will improve smolt survival. When the flow standards and export limits are enhanced by the proposed closure of Old River during the 31-day flow period, significant, additional improvement of smolt survival is anticipated (see Figure 1-5 for illustration of calculated smolt survival indices for historical and anticipated conditions).

The standards proposed in this section along with the comprehensive standards provided by the Joint Proposed are likely consistent with actions that will be required to achieve the yet-to-be-established objectives of Anadromous Fish Restoration Program.

Although stated in terms of a 31-day uniform pulse flow, it is intended that an equivalent volume of water may be distributed differently in time (e.g., two seven-day pulses of flow greater than 2,000 cfs during a critical year). Short-duration flow fluctuations, adequately separated in time, have shown to be effective in cuing smolts into outmigration. Effective planning and management of a combination of base flow and pulsed flow fluctuations can improve smolt survival efficiently. This alternative management of the flow volume would be based on coordination of San Joaquin River tributary and Delta conditions.

The recommended standard represents an improvement over historical conditions and therefore should prove beneficial to the resource.

2.2.1.4 Export/Inflow Ratio Limits

(a) ***Measure: February 1-28 -- limit pumping to 65% of Delta inflow. March 1-June 30 -- limit pumping to 30% Delta inflow (35% if monitoring program indicates that fish are disproportionately distributed away from the pumps); minimum 1,500 cfs pumping in all year types.***

(b) ***Measure: Shift exports between CVP and SWP pumps depending on which facility has the lowest density of fish during periods when fish are present (spring) to times when fish are less susceptible to pumping.***

Biological Objective: Reduce fish, egg, and larvae entrainment and mortality at the pumps through export restrictions and intensive real-time monitoring/response designed to detect presence of fish in areas adjacent to the pumps.

Intended Benefits: Development of the export/inflow concept was founded on two basic principals which include (1) exports may increase during periods when higher volumes of fresh water are flowing through the Delta without increasing the risk of adverse biological effects and, correspondingly, exports should decrease during those years when fresh water inflow to the Delta is decreased and a larger percentage of fish and other aquatic organisms are geographically distributed further upstream where their susceptibility to export losses is increased, and (2) the percentage of water diverted in recent years, particularly during the spring, has increased substantially above diversion levels (expressed as a ratio of exports to inflow) during earlier years when aquatic resources inhabiting the Bay-Delta system were at more acceptable levels. An analysis was performed using inflow and export data from DWR Dayflow to investigate the inflow/export ratios during the spring (March 1-June 30) for various water year types during two historic periods. Data were reviewed for the period from 1970 to 1983 representing a period when both the SWP and CVP facilities were in operation and when fisheries populations inhabiting the Bay-Delta system were characterized by higher levels of abundance than presently exist for most species. Data from 1984 to 1990 were selected to characterize export/inflow ratios for various water year types during a period when most biological indices reflect declining populations for many of the fish and invertebrates inhabiting the system. Results of these analyses for the spring (March-June), which were considered to be the most significant for affecting aquatic resources are summarized below:

	Water Year Type	Percentage Inflow Diverted (March 1-June 30)		
		Average	Minimum	Maximum
1970-1983	C	35	8	51
	D	29	12	46
	BN	38	27	46
	AN	14	11	41
	W	15	2	40
1984-1990	C	44	25	70
	D	39	25	48
	BN	--	--	--
	AN	--	--	--
	W	23	2	35

Results of these analyses show an increase in the percentage of inflow exported during the spring during more recent years, coincident with the period of decline for many aquatic resources. Based on consideration of these data it was concluded that a reduction in the percentage of inflow exported during the spring was appropriate and would offer substantial biological protection when compared with more recent conditions. The average percentage of inflow exported during dry and critical springs, considered to be the most critical period, between 1970 and 1983 were 29 and 35 percent, respectively. Using these data the joint water user proposal limits spring exports to 30% of inflow unless it can be demonstrated that significant fisheries losses are not occurring at the SWP and CVP diversion facilities under which case exports may be increased to 35% of inflow in all water year types. These export limits, in combination with other elements of the proposed program, offer substantial protection and enhancement for aquatic resources when compared with recent historic conditions.

Imposing the greatest export restrictions during these months should proportionally reduce the numbers of fish potentially entrained within and salvaged at the pumps. Such measures, coupled with increased transport flows, real-time monitoring/response (designed to detect when fish are present/absent in the vicinity of the pumps) should provide increased protection to the fish resources within the Delta.

Scientific Basis: The overall proposed export/inflow limits (those proposed during the summer, fall, and winter) were developed with consideration for balancing fish protection with water supply needs. Thus, relatively low export/inflow ratios were specified during the spring (<30%) when fish are especially vulnerable to entrainment at the pumps, with a general increase in allowable exports (35% in July; 55% from August -September; 65% from October - February) during other times when fish are less vulnerable to diversion losses. Each of the March-September levels likewise has a complementary trigger mechanism (based on real-time monitoring/response) which would allow additional exports upon demonstration that low proportions of known populations of fish are present near the pumps. The specific export limits (and brief statements of benefits and scientific basis) are presented under the flow and operational measures described for the summer, fall, and winter.

State Water Project fish salvage records are available for use in evaluating the seasonal distribution in susceptibility and loss resulting from water project operations (Brown, 1992). Review of salvage data shows that the seasonal distribution of losses varies among species. Salvage data was compiled for data from Brown (1992) for striped bass, chinook salmon, American shad, Sacramento splittail, longfin smelt, and delta smelt to characterize the seasonal distribution in fisheries losses. For these species overall average losses were greatest in April (10%), May (23%), June (24%), and July (16%). Over 70% of the combined average losses for these species occurred between April and July. Average monthly losses ranged from 2 to 6 percent between August and March. In addition to salvage losses relatively large numbers of fish eggs and larvae, which are not accounted for in salvage data, are susceptible to entrainment losses during the spring (April-June).

2.2.1.5 Direct Export Limits

(a) Measure: Direct export limits during the period April 15-May 15, consisting of an amount of water no greater than Vernalis flows, coupled with installation of a barrier at head of Old River. If the decision is made to provide pulse flows for a shorter duration and higher magnitude, then the maximum export rates shall not exceed the Vernalis flow rates shown in Section 2.2.1.2.

Biological Objective: Minimize entrainment and salvage losses of outmigrating juvenile (smolts and some fry) fall-run chinook salmon from the San Joaquin River.

Intended Benefits: Limiting exports to not exceed flows at Vernalis, coupled with a barrier at the head of Old River, should substantially reduce the potential for salmon smolts and fry outmigrating from the San Joaquin River to be drawn to and lost to the pumps. This will increase the probability of smolt outmigration survival from the San Joaquin River to the estuary and should increase the numbers of returning adult salmon.

Scientific Basis: Results of coded wire tagging of salmon smolts conducted by the USFWS (Kjelson et al., 1990) have indicated that smolts outmigrating from the San Joaquin River are susceptible to entrainment at the pumps due to false attraction down the

Old River channel near Mossdale. The peak of outmigration typically occurs in the spring during the period April 15-May 15; direct export limits are therefore proposed for this period. It should be noted that the flow at Vernalis is only one component of the flow in the lower San Joaquin River, which includes flows from eastside tributaries as well as agricultural return flows, and that limiting exports to Vernalis flows ensures a net flow into the lower San Joaquin River.

2.2.2 SUMMER PERIOD (JULY 1-AUGUST 31)

Summer usage of the Bay-Delta is primarily of concern to resident species, although some late spawning of striped bass and splittail has been reported in some locations. A comparison of life stage periodicity data for several species (Figure 5-2) indicates a window of inactivity during July and in particular, August for the species listed. Measures proposed for this period are focused on maintenance of estuarine health and biological processes.

2.2.2.1 Delta Outflow

(a) Measure: July 1-31 -- provide monthly average net Delta outflow consistent with the following water year type requirements:

YEAR CLASS	*Delta Outflow (cfs)*
Critical	*4,000*
Dry	*5,000*
Below Normal	*6,500*
Above Normal	*8,000*
Wet	*8,000*

Biological Objective: Provide outflow to the estuary during summer months; maintenance of biological communities in preparation for fall transition period.

Intended Benefits: Maintain suitable habitat in the Delta which is important for continued rearing of juvenile and adult fish (delta smelt, striped bass and others); also, reduce seawater intrusions into the estuary to prevent the colonization of undesirable organisms in the Delta (e.g., *Potamocorbula, Mya* sp. and others). This represents an improvement from previous water rights standards.

Scientific Basis: Although many of the important estuarine species of fish (e.g., delta smelt, longfin smelt) have spawned by June, several others, including striped bass and Sacramento splittail have been reported to continue spawning into July (Figure 2-2). Additionally, larvae and early juveniles of delta smelt and other species remain in the system and warrant conditions conducive to their survival; i.e., flows to transport larvae to suitable habitats. The derivation of the recommended flows is not based on the results of quantitative habitat or population studies, rather on scientific judgment. The effectiveness of the recommended flows for benefitting the resource will be evaluated as part of the detailed monitoring/response program.

(b) Measure: August 1-31 -- provide monthly average net Delta outflow index consistent with the following water year type requirements:

YEAR CLASS	*Delta Outflow (cfs)*
Critical	*3,000*
Dry	*3,500*
Below Normal	*4,000*
Above Normal	*4,000*
Wet	*4,000*

Biological Objective: Provide outflow to the estuary during summer months; maintenance of biological communities in preparation for fall transition period.

Intended Benefits: Promote continuation of conditions conducive to production of estuarine fish and invertebrate species.

Scientific Basis: *Based on biological judgment.* No definitive studies have been completed to support this specific flow proposal. Both D-1485 and draft D-1630 recommended an August flow of 1,000 cfs at Rio Vista on the Sacramento River based on upstream adult migrations.

2.2.2.2 Export/Inflow Ratio Limits

(a) Measure: July 1-31 -- limit pumping to ≤35% Delta inflow (≤55% if monitoring program indicates that fish are disproportionately distributed away from the pumps).

Biological Objective: Reduce overall entrainment of organisms at pumps; regulate in concert with real-time monitoring/response program at locations adjacent to pumps.

Intended Benefits: Transition period during which Delta export/inflow ratios can begin to increase, as biologically sensitive periods pass; i.e., majority of spawning and egg and larvae transport is completed by July.

Scientific Basis: Based on reviews of salvage data which indicate that historically, the highest percentages of salvage occurred during April - June period. The proposed export/inflow ratios are based on shifting periods of high exports to less biologically sensitive periods.

(b) ***Measure: August 1-31 -- limit pumping to ≤ 55% Delta inflow (≤ 65% if monitoring program indicates that fish are disproportionately distributed away from the pumps).***

Biological Objective: Same as above.

Intended Benefits: Continue transition in shifting increases in pumping to periods when biological activity is low.

Scientific Basis: Recommendations based on reviews of salvage data which indicate that potential for losses to pumps decreases during the late summer and early fall; no definitive studies or analysis completed to support these or alternative export/inflow restrictions.

2.2.3 FALL PERIOD (SEPTEMBER 1-OCTOBER 31)

The fall period marks the transition from the long, hot, dry months to periods of increased moisture and rainfall; water temperatures begin to decrease. Biologically, several species of fish, including fall run chinook salmon begin to migrate upstream into the Sacramento and San Joaquin rivers (and tributaries) in preparation for spawning. Adult and juvenile delta smelt and striped bass, and adult splittail continue to rear in portions of the Delta and therefore conditions promoting feeding and growth in preparation for spawning are important.

2.2.3.1 Net Delta Outflow

(a) ***Measure: September 1-30 -- provide monthly average net Delta outflow at Chipps Island of 3,000 cfs under all year types.***

Biological Objective: Provide outflow for maintaining conditions conducive to growth and maintenance of resident and anadromous populations utilizing the Bay-Delta during this period. Provide attraction flows for fall-run chinook salmon.

Intended Benefits: Maintain healthy ecosystem during this period. Need conditions which allow growth and maturation of adult fish in preparation for spawning.

Scientific Basis: Based on biological judgment of life history and rearing requirements of species utilizing the Delta during this time period.

(b) Measure: October 1-31 – provide monthly average net Delta outflow based on the water year type requirements:

YEAR CLASS	*Delta Outflow (cfs)*
Critical	*3,000*
Dry	*4,000*
Below Normal	*4,000*
Above Normal	*4,000*
Wet	*4,000*

Biological Objective: Provide net Delta outflow to promote continued rearing of adult and juvenile fish.

Intended Benefits: Create conditions conducive to growth and maturation of adult fish; provide conditions suitable for fall run chinook salmon staging; and provide velocity cues for upstream spawning migration of fall-run chinook salmon and longfin smelt.

Scientific Basis: No definitive studies have been conducted to determine flow magnitudes and durations.

2.2.3.2 Sacramento River Flow

(a) Measure: September 1-30 -- maintain minimum flows at Rio Vista consistent with the following year types:

YEAR CLASS	*Sacramento River Flow at Rio Vista (cfs)*
Critical	*3,000*
Dry	*4,000*
Below Normal	*4,000*
Above Normal	*4,000*
Wet	*4,000*

Biological Objective: Attract adult salmon.

Intended Benefits: Provide minimum outflows for adult attraction to Sacramento River.

Scientific Basis: Returning adult salmon are rheophilic and rely on velocity cues for stimulating upstream migrations. Maintaining minimum Sacramento River flows will provide such cues for adult fall-run chinook salmon.

2.2.3.3 San Joaquin River Flow

(a) *Measure: October 1-31 – maintain minimum flow of 1,000 cfs at Vernalis in all water year types; provide additional pulse attraction flows of 28,000 acre-feet at Vernalis (actual release dates based on real-time monitoring/response) during all year types, except no two critical years in a row; this measure includes installation of barrier at head of Old River.*

Biological Objective: Provide pulse flows to allow attraction of adult fall-run chinook salmon into San Joaquin River.

Intended Benefits: Adult salmon returning to the San Joaquin River are faced with numerous channels on their migration to upstream natal spawning grounds. Provision of a pulse of water down the mainstem San Joaquin will provide additional velocity and olfactory cues which should direct salmon to the main river, and facilitate passage through the lower Delta.

Scientific Basis: Largely subjective; based on biological judgment and knowledge of behavior patterns and requirements of migrating adult salmon. The recommended standard represents an improvement over historical dry year conditions and therefore should prove beneficial to the resource.

2.2.3.4 Export/Inflow Ratio Limits

(a) *Measure: September 1-30 -- limit pumping to ≤ 55% Delta inflow (≤ 65% if monitoring program indicates that fish are disproportionately distributed away from the pumps).*

Biological Objective: Reduce overall entrainment of organisms at the pumps; regulate in concert with real-time monitoring/response program at locations adjacent to pumps.

Intended Benefits: Transition period during which export/inflow ratios can be higher since entrainment potential of fish is low during this period.

Scientific Basis: Based on reviews of salvage data which indicate that historically, the highest percentages of salvage (losses of fish to the pumps) occur during April - June period. The proposed export/inflow ratios are based on shifting periods of high exports to biologically less sensitive periods.

(b) ***Measure: October 1-31 -- limit pumping to ≤ 65% Delta inflow.***

Biological Objective: Provide ability to reduce exports during most biologically sensitive periods.

Intended Benefits: Allowing highest exports during periods when fish densities are typically low at the pumps, while restricting exports during the spring when fish densities are high should reduce overall net losses of fish at the pumps and increase survival, while preventing disproportionate pumping in any period.

Scientific Basis: Based on reviews of salvage data which indicate that historically, the highest percentages of salvage occur during April-June period. The proposed export/inflow ratios are based on shifting periods of high exports to biologically less sensitive periods.

It should be noted that the pumping regime in this proposal was developed with consideration to the seasonal distribution of a variety of aquatic species. However, not all aquatic resources receive the same level of protection from the proposed plan. Indeed, the proposal may hamper fish restoration efforts on the Mokelumne River, because yearling salmon migrate downstream and adult salmon migrate through the Delta and into the Mokelumne River during the fall and winter, when the proposal provides less biological protection. Thus, the increased fall pumping that will occur under this proposal could potentially decrease the survival of yearling and straying adult salmon due to increased diversions, reversed flows, and increased flows through Old and Middle Rivers and the Delta portion of the lower Mokelumne River when the Delta Cross-Channel is open. On balance, however, the proposal provides substantial improvement in the protection of aquatic resources and should be adopted, with the recognition that some tradeoffs may be made between estuarine and upstream resource protection.

2.2.4 WINTER PERIOD (NOVEMBER 1-JANUARY 31)

This is a less sensitive period for most estuarine biological resources. Certain fish species normally spawn during this period, including starry flounder and longfin smelt. While some migration occurs, this period is of lesser importance with respect to flow-related measures, since the estuary is at a natural production ebb and natural (unregulated) flows through the system are sufficient for support of biological functions in most years.

2.2.4.1 Net Delta Outflow

(a) ***Measure: Provide monthly average net Delta outflow index during the months of November and December (01 November through 31 December) consistent with the following year type requirements:***

YEAR CLASS	*Delta Outflow (cfs)*
Critical	*3,500*
Dry	*4,500*
Below Normal	*4,500*
Above Normal	*4,500*
Wet	*4,500*

Biological Objective: Provide net Delta outflow for continued rearing of juvenile and adult fish.

Intended Benefits: Contributes to maintenance and continuing maturation of resident fish populations.

Scientific Basis: No definitive scientific or other data to determine appropriate flow magnitudes and durations to produce intended benefits. Based on biological judgment of life history and rearing requirements of species utilizing the Delta during this time period.

(a) Measure: Provide net Delta outflow index during the month of January (01-31 January) consistent with the following year type requirements:

YEAR CLASS	*Delta Outflow (cfs)*
Critical	*4,500*
Dry	*6,000*
Below Normal	*6,000*
Above Normal	*6,000*
Wet	*6,000*

Biological Objective: Provide net Delta outflows for continued rearing of juvenile and adult fish, and conditions conducive for maturation of adult fish in preparation for spring spawning periods.

Intended Benefits: Promote development of highly fecund adult fish leading to strong year class development subsequent to spawning.

Scientific Basis: No definitive scientific or other data to determine appropriate flow magnitudes and durations to produce intended benefits. Based on biological judgment of life history and rearing requirements of species utilizing the Delta during this time period. The higher flows in January (compared to those during November - December) are intended to provide conditions conducive to adult maturation and egg development, and represent a transition toward higher outflows that occur during the spring period (February - June).

2.2.4.2 Gate and Barrier Operations

(a) Measure: Install barrier at head of Old River during November-December, coincident with upstream migration of adult fall chinook salmon.

Biological Objective: Increase survival of adult fall chinook salmon migrating to the San Joaquin River system by providing attraction flows within the mainstem channel of the river. The installation of a barrier at head of Old River keeps river flows in the mainstem channel.

Intended Benefits: Placement of a barrier at head of Old River will increase flows within the mainstem San Joaquin by reducing flows down Old River and directed to the SWP/CVP pumps. This will provide important attraction flows for upstream migrating adult fall chinook salmon and should increase survival and spawning success of adult salmon. The net benefit should be an increase in production of fall chinook salmon smolts, and correspondingly, a subsequent increase in returning adults.

Scientific Basis: Biological Judgement. No studies have been conducted to determine flow quantities needed in the San Joaquin River to facilitate successful adult upstream migrations. Successful migrations have occurred even under Critical and Dry water year types. Nevertheless, adult salmon are rheophilic in their upstream migrations and therefore measures designed to maintain flow in the mainstem San Joaquin River should benefit upstream fish migrations.

(b) Measure: November 1 - January 31 - install Georgiana Slough acoustic barrier in all year types.

(c) Close Cross Channel Gates up to a total of 30 days in the seven day increments, based upon monitoring (flows, turbidity, etc.) during the months of November through January.

This was discussed in detail under the Spring Period (Section 2.2.1.3 (c))

2.2.4.3 Sacramento River Flow

(a) Measure: Provide flows in Sacramento River at Rio Vista during the months of November and December (01 November through 31 December) consistent with the following water year requirements:

YEAR CLASS	*Delta Outflow (cfs)*
Critical	*3,500*
Dry	*4,500*
Below Normal	*4,500*
Above Normal	*4,500*
Wet	*4,500*

Biological Objective: Provide upstream migration cues for winter run and late fall run chinook salmon. Provide net Delta outflow for continued rearing of juvenile and adult fish.

Intended Benefits: Contributes to maintenance and continuing maturation of resident fish populations; provide upstream migration cues for late fall and winter run chinook salmon and longfin smelt.

Scientific Basis: No definitive scientific or other data to determine appropriate flow magnitudes and durations to produce intended benefits. Based on biological judgment of life history and rearing requirements of species utilizing the Delta during this time period.

2.2.4.4 Export/Inflow Ratio Limits

(a) Measure: limit pumping to ≤65% Delta outflow.

Biological Objective: Permit reduced exports during the most biologically sensitive periods.

Intended Benefits: Allowing highest exports during periods when fish densities are typically low at the pumps, while restricting exports during the spring when fish densities are high should reduce overall net losses of fish at the pumps and increase survival.

Scientific Basis: Based on reviews of salvage data which indicate that historically, the highest percentages of salvage occur during the April-June period. The proposed export/inflow ratios are based on shifting periods of high exports to biologically less sensitive periods.

2.3 MONITORING PROGRAM

There is a very large body of technical information relating to the Bay-Delta estuary and the lower Sacramento and San Joaquin rivers. This technical information base is composed of numerous long term and short term studies conducted for a wide variety of purposes, as well as accounts and records of activities and events in the estuary and the Delta. The sheer mass of data and other information is daunting. At the same time, individual studies and other technical records vary tremendously in usefulness and relevance when it comes to making informed decisions regarding present status and future management of water, the estuary and associated biological resources.

In recent years, the IEP has given attention to an integrated approach, but studies under this program are often so highly focused that their usefulness in developing a comprehensive, integrated management program for the Delta and its biological and water resources is limited. The San Francisco Estuary Project attempted to pull together many of the biological threads and develop an integrated understanding of the workings of the Delta and the estuary, but the purposes of this project were frustrated to a significant degree by the lack of definitive, reliable science which could be brought to bear on the central issues of the health and workings of the estuary. There has never been a truly integrated approach in data gathering targeting specifically at an integrated solution package. For this reason, among others, solutions to Bay-Delta problems have been a patchwork of individual and sometimes conflicting measures rather than an integrated tapestry with an overall systematic approach.

Many of the studies, including monitoring studies, which make up a significant portion of the technical information base for the Delta and its biological resources were originally designed for narrow purposes, such as single species monitoring. In recent years, however, incidental catch data from these studies have been put to interpretive uses for other species far beyond the capability of the original sampling protocol to adequately address these new issues; sampling protocols have never been reconfigured to correspond to the interpretive uses to which incidental catch data are presently being put. For this reason, conclusions based on these data must be drawn with great care and attention to detail, and must be considered tenuous.

Many of the biological monitoring studies have focused primarily on egg and larval or young-of-year (YOY) life stages of species with much longer life spans, with little focused attention on later life stages, or on scientifically rigorous integration of information relating to various life stages. For this reason, quantitatively integrated life-cycle and basic biological information on special interest fish species indigenous to the Delta and the lower Sacramento and San Joaquin rivers is lacking.

Especially in recent years, existing studies and research programs have been almost entirely focused on two aspects of the health of the estuary and Delta: water exports and freshwater outflow. This has been at the expense of our understanding of other problems with which the estuary/Delta ecosystem is beset. These other non-flow related factors include, but are not limited to:

- Pesticides and other agricultural and industrial chemicals
- Land-derived salts in the San Joaquin drainage
- Channel and riparian alterations
- Over 2,000 unscreened diversions

A comprehensive solution package for Bay-Delta problems must incorporate non-flow related factors, such as those addressed in Category III (see Section 3) in this proposal as part of monitoring and experimental investigations.

Monitoring studies performed on biological resources in the Bay-Delta have rarely been integrated with specific operational or policy/standard responses. Nor have monitoring programs been designed with specific, real-time responses in mind. For many monitoring programs, analyzed or even quality-checked data are not available for more than a year after collection. In addition, results are usually not expressed in terms which invite responses, either in operations or in policy formation and standard setting. An adaptive management approach to monitoring and experimental investigations is almost entirely lacking.

Finally, there are numerous and very significant controversies among knowledgeable scientists and professional analysts regarding the methods traditionally used to analyze long-term monitoring and study data and the interpretation of those data. For example, there is fundamental disagreement regarding the interpretation of in-Delta flow modeling and the firmness of conclusions which can be drawn from these modeling exercises, especially when it comes to making major and far-reaching management decisions. This is especially true in the consideration of the relationship between tidal flux and the much smaller in-Delta flow vectors produced by inflow, outflow and CVP/SWP operations. There is also disagreement on the significance of data variability and the appropriate arithmetic procedures which should be used for expansion of data from long-term monitoring trawl data and the need to take into account geographic coverage, temporal coverage, and gear efficiency for various life stages.

Given this status of technical information, and the controversies regarding the analysis and interpretation of this information, it is important to exercise great care in formulating a comprehensive, integrated plan for addressing environmental difficulties in the Sacramento-San Joaquin Delta and estuary. It is also important to appeal to fundamental ecological principles in shaping policy and management direction, and to design a program which is flexible and responsive to changing conditions and new knowledge. Monitoring and experimental investigations are an essential and integral part of this program. The monitoring programs must be designed to effectively evaluate the success of the program of protective actions included in this proposal, identify specific areas and management actions to be considered during periodic review of the program, and provide the basic biological and physical data needed to design and evaluate the benefits of other non-flow habitat enhancement and protective measures such as those discussed in Section 3 (Category III Measures).

2.3.1 Goals of the Proposed Monitoring and Management Studies Program

Progress towards protecting the Bay-Delta depends on understanding the Bay-Delta and its resources. The long-term protection and recovery of the Bay-Delta ecosystem will require data adequate to determine the relative impacts of factors such as water project exports, in-Delta and upstream diversions, toxic discharges, fishing, introduced species, and, to the extent feasible, factors such as predation and competition. It will also be necessary to document the positive impacts of actions that promote recovery, such as the proposed water quality standards, diversion screening, regulation of pesticide and herbicide discharges, and habitat restoration.

A comprehensive monitoring program is an essential feature of the Joint Proposal. The purpose of this program would be to provide data to evaluate the relative benefits of the various elements, as well as identify potential adverse impacts, such as those which may be associated with installation of the Old River barrier. To ensure credibility, the program should be designed cooperatively by SWRCB, resource agency, and joint water user staff and consultants to supplement and complement existing programs.

To be successful, the monitoring program must:

- Incorporate the best available field sampling methods.
- Provide data on the response of a wide range of species and habitat parameters to the various measures proposed; this will require either an experimental-control design or the ability to compare data from existing programs to the data from the proposed monitoring effort.
- Measure a wide range of mechanisms which may be responsible for the observed effects of the measures.
- Provide an easily accessible database adequate for analysis which may identify the relative benefits/impacts of the various measures.

The Joint Users therefore urge the SWRCB to include provisions for enhanced monitoring of the biological effects of any standards it promulgates, including a management strategy and a funding mechanism for the enhanced program. We further urge the SWRCB to encourage other agencies to cooperate in the development of a rigorous and comprehensive monitoring and management studies program which would meet the above needs.

Cooperation with the agencies implementing the Central Valley Project Improvement Act, with the Interagency Ecological Program, with U.S. Fish and Wildlife Service and National Marine Fisheries Service, and with independent programs such as the San Joaquin Valley Endangered Species Recovery Program is particularly important. In short, any enhancements to existing programs should be fully integrated with those programs to ensure the most effective use of existing and supplemental funding.

2.3.2 Scope of Proposed Monitoring and Management Studies Program

The additional monitoring and management studies program should supplement and complement existing monitoring and research programs. To accomplish this, it must be closely coordinated with these programs. There are five elements of such a monitoring program:

- Long-term monitoring program improvements
- Studies focused on the effects of the proposed new water quality and management programs
- A research enhancement program
- Improved analysis capability
- Improved access to lands for monitoring and management studies

2.3.2.1 Long-term monitoring program improvements

State and federal agencies with jurisdiction in the Bay-Delta ecosystem should cooperatively develop and implement a program for focused monitoring of species of concern which would include:

a) Development of species-specific sampling methods needed to determine their abundance; distribution; life history; and their response to factors such as project operations, changes in environmental conditions such as food availability, competition and predation, toxics, true flow conditions, other water quality parameters, diversions, etc.

b) Enhancement of programs which provide data on the status and trends of sensitive species and the factors responsible for trends, with an emphasis on studies which address factors affecting survival of species at critical life history stages, such as the period of outmigration of juvenile salmon.

c) Development of specific studies intended to evaluate management alternatives (for short-term technological and long-term ecosystem recovery) to assure that management actions proposed/adopted are the most effective/efficient response to the need for protection and recovery of these species, to document the effects of management actions, and to provide a basis for refinement of management actions.

d) Development of programs to provide data regarding the effects of long-term management measures such as habitat restoration.

Monitoring efforts should address these issues throughout the range of the species evaluated, including, as appropriate, the Bay-Delta, adjacent marshlands, and tributaries. For the immediate future, the species which should be addressed by these new programs include:

- Delta smelt
- Various runs of chinook salmon
- Steelhead
- Sensitive species such as Sacramento splittail, green sturgeon, longfin smelt
- Other species which may be considered indicators of the various trophic levels in the estuary.

<u>2.3.2.2 Studies focused on the effects of the proposed new water quality and management programs</u>

The Joint Water Users proposal is founded on the premise that changes to the Bay-Delta must be monitored and subject to adaptive management; that is, the effectiveness of each action implemented by the SWRCB or any other agency should be rigorously monitored to quantitatively assess the benefits of the action. At triennial reviews, monitoring data should be considered, with a goal of optimizing benefits and costs. Several key components of such a program would include:

a) A revolving fund, with access to funds in the hands of an industry-resource agency committee of interested parties who would have authority to allocate these funds in a timely manner to address a short-term question. A substantial fund is recommended, with funds replaced as they are expended.

b) Blanket contracts negotiated with public and private organizations to permit rapid issuance of work orders to conduct these studies.

c) A cooperative process to expedite permits needed for the studies.

d) A cooperative process for design, implementation, and evaluation of monitoring programs, involving agency, environmental community, and water user and industry scientists.

<u>2.3.2.3 A Research Enhancement Program</u>

The SWRCB should develop and implement a program for increased funding for basic research into issues such as the life history of sensitive species; periodic reviews of data about sensitive species to update status, trend, and life history reports; and focused analysis of factors affecting abundance and distribution of these species.

2.3.2.4 Improved Analysis Capability

A key feature of an improved monitoring and management studies program will be the establishment and maintenance of an integrated database. In addition, support for improved hydraulic and hydrologic modeling is essential. Finally, an analysis group must be established and funded to ensure that management questions are addressed from a broader perspective than is currently possible.

In addition, there is a need to compile and analyze existing data to expand the databases available to researchers, resource managers, resource agencies, and the public. Currently, there are many collections of raw data, such as specimen samples and field data sheets, which have not been compiled and analyzed. The Board should provide a funding mechanism to support a short-term effort to compile, analyze, and integrate these data with existing and planned databases.

2.3.2.5 Improved Access to Lands for Monitoring and Management Studies

Monitoring programs must address the full range of factors affecting abundance and distribution of aquatic species. Therefore, it is necessary for scientists conducting these programs to have access to water records, pesticide use records, and lands of those diverting water from the system and/or discharging to the system. To ensure this access, the Board should consider development of a policy which would provide a means for scientists to have limited access to property as a condition of issuance of diversion permits.

2.3.3 Responsibility for the Monitoring and Management Studies Program

The Board should work cooperatively with other agencies with Bay-Delta jurisdiction, with water users and others, and with the Interagency Ecological Program to develop an enhanced program as described above. First, the Board should cooperatively develop the required monitoring elements related to implementation of water quality and management standards and then mandate them. Where it does not feel a mandated program is appropriate, the SWRCB should then use its good offices to encourage further development of the program.

2.3.4 Funding

This program is intended to enhance and expand existing programs; funding for existing programs should not be affected, unless they are determined to be no longer needed or obsolete in their methodology. Additional funding for the enhanced monitoring, focused studies, and research enhancement program should be developed.

2.3.5 Some specific monitoring and management issues which should be addressed

A) Identifying and quantifying the changes brought about by proposed State and Federal regulations is important for triennial reviews and long-term planning. The proposed monitoring should measure the response of the Bay-Delta and its resources to the standards promulgated by the SWRCB in terms of:

- Key habitat variables such as salinity, outflow, tides, substrate, turbidity, and temperature

- Species abundance (absolute and relative, by life history stage) and temporal and spatial distribution; species survival rates

B) Understanding causal mechanisms is essential for developing rational protection and recovery programs. The full range of potential causal mechanisms must be addressed, including the influence of causal factors outside of the legal Bay-Delta. Identifying and quantifying causal relationships will require an integration of new monitoring efforts with current monitoring and research programs to produce a comprehensive database which integrates data about:

- Hydrology

- A full range of important habitat parameters such as salinity, tides, winds, flow magnitude and velocity, water depth, turbidity, temperature, upstream diversions, upstream water use, in-Delta diversions, instream flow regimes, and land uses areas

- Nutrient availability at various trophic levels

- Transport of eggs, larvae, and juveniles through the Delta

- Stock-recruitment relationships

- Toxics (sources, distribution throughout the system, concentration, residence time, potential for reduction in toxic inputs through changed practices)

- Predation and competition

- Direct take of species by in-Delta facilities; by fishing, legal and illegal, and indirect take due to projects in the Delta

Causal relationships between abundance and distribution of fish and wildlife and the factors listed above should improve our ability to identify the relative importance of various management and habitat restoration actions. This is particularly important to the long-term recovery of the Bay-Delta Ecosystem. To optimize recovery efforts, it will be important to prioritize actions for recovery by their relative effectiveness and their relative cost. A quantitative understanding of the response of the ecosystem to various management actions is therefore important to maximizing the use of available resources for recovery actions. In addition, quantitative understanding of causal relationships will be necessary for determining how to calculate mitigation credits and the implementation of conservation and recovery plans.

The program developed to address the issue of cause should be aimed at: 1) determining the relative importance of various causal factors and 2) identifying those factors which may be managed and the appropriate management strategies for each factor.

C) Questions which could be addressed in either monitoring or management study programs for sensitive species include:

- How can we improve sampling techniques so that we improve population estimates, abundance indices, and analytical models?

- What are the direct and indirect causes of mortality for various life history stages of the species, including diversions, entrainment, discharges?

- How does the species respond to tides, outflows, winds, day and night conditions, toxics, salinity, predators, competition, habitat availability, and other factors which may influence distribution and behavior (by life history stage)?

- What habitats do various target species use, by time of day and life stage?

- How can survival be improved by management?

- How can we more accurately identify the species so that we can manage appropriately?

- What is the response of the species to various CVP/SWP management practices?

- How is the species distributed in the Delta, by season, and what influences this distribution (overall geographic distribution, within-site distribution, and within water column distribution)?

These research and monitoring needs are an important addition to existing programs. It is essential that they be implemented, under SWRCB and other agency authority and review, to ensure that data adequate to successfully manage the Bay-Delta ecosystem are developed.

3.0 NON-OUTFLOW RELATED FACTORS

In addition to the Category I and II Standards described above, other, non-outflow related factors should be part of any coordinated estuarine protection program. These factors include:

1. Unscreened water diversions
2. Waste discharges
3. Legal fishing
4. Illegal fishing
5. Land-derived salts
6. Control of introduced species
7. Loss of riparian, wetland, and estuarine habitats
8. Channel alteration

Addressing these non-outflow related factors in conjunction with implementation of the Category I and II standards will improve the health of the estuary. If waste control programs can be implemented along with controls on legal and illegal fishing and restoration of estuarine habitat, the Delta and its tributaries should support the recovery of species of concern and provide improved habitat for most species.

Some of the factors listed above are beyond the immediate jurisdiction of the SWRCB. Nevertheless, the SWRCB has authority to direct or recommend that actions to address these factors be taken by other agencies which do have jurisdiction. See, e.g., Water Code sections 13146 (requiring state offices, departments, and boards to comply with state water quality policy in carrying out activities that affect water quality) and 13242 (authorizing the SWRCB to recommend appropriate actions by any entity, public or private, in order to achieve water quality objectives). The Joint Water Users therefore urge the SWRCB to address each of the factors discussed here as part of its coordinated estuarine protection program.

The Joint Water Users are developing an implementation plan and schedule for addressing the non-outflow related factors. This information which will be submitted to the SWRCB in advance of the water rights hearing, could form the basis for discussions between SWRCB staff and the Joint Water Users on the best approach to manage the non-outflow related factors.

3.1 UNSCREENED WATER DIVERSIONS

The potential threat to resident and migratory fish populations of the large number of unscreened agricultural, municipal, and industrial diversions in the Sacramento and San Joaquin rivers and the Delta has been recognized for over 40 years. A 1954 study of entrainment of salmon and steelhead in large agricultural diversions in the Sacramento and San Joaquin rivers and the Delta concluded that agricultural diversions along the Sacramento River individually did not destroy many young salmon and steelhead but collectively they did take considerable numbers. Studies undertaken in the early and middle 1970s determined that large numbers of egg and larval striped bass and significant numbers of chinook salmon were entrained by agricultural diversions in the Delta. More recent Delta studies, including an ongoing DWR study, confirm that entrainment of large numbers of fish continues.

There is potentially a significant problem with unscreened diversions. There are over 300 unscreened municipal, agricultural, and industrial diversions on the Sacramento River between Redding and Sacramento that divert an estimated 1.2 million acre-feet of water annually. There are 150 unscreened diversions on the San Joaquin River. The number of unscreened agricultural diversions in the Delta is estimated at about 1,800. These facilities divert in excess of 2 million acre-feet of water annually, according to the NMFS. During the active irrigation season, water is diverted from these unscreened Delta diversions at a rate at least equal to the capacity of the Tracy Pumping Plant. Even larger fish are vulnerable to entrainment at the diversions. (Data collected in a 1992 DWR pilot study indicate that substantial numbers of fish (including striped bass) are entrained in the Delta diversions, while unpublished 1994 data indicate that substantial numbers of delta smelt similarly are entrained in the diversion siphons.)

California law currently requires screens on all new diversions. Additional control of adverse fishery effects for existing unscreened diversions could be carried out under the SWRCB's water rights authority to correct unreasonable methods of diversion through efforts such as active participation in the CVPIA unscreened diversions program.

The CVPIA unscreened diversion program is already well underway. Priorities have been established, funding has been provided for some projects, and a multi-agency technical group has been formed. The SWRCB should encourage increased funding, a reevaluation of the priority system, and a cooperative effort by involved agencies.

3.2 WASTE DISCHARGES

Under current conditions, an estimated 5,000 to 40,000 metric tons of at least 65 pollutants enter the Bay-Delta each year. The fate of such materials is highly variable. Some are transported in the water column as dissolved or suspended materials and ultimately reach the ocean, and some settle out onto or into sediments. Some enter the aquatic biota food chain via ingestion or tissue uptake where they may bioaccumulate in certain tissues. Others are absorbed by riparian and wetlands vegetation and aquatic macrophytes.

Recent monitoring programs have found evidence of toxic levels of pollutants, including pesticides, in the Bay-Delta. In its assessment of the impacts on water quality, sediment, and aquatic resources, the San Francisco Bay Regional Water Quality Board's regional monitoring program recently reported levels of polychlorinated biphenyls (PCBs) that are five to almost twenty times EPA standards. Monitoring programs conducted by municipal waste and stormwater dischargers in both the San Francisco Bay Area and the Central Valley also have reported toxic levels of diazinon.

It is widely recognized that such pollutants have impacted the aquatic ecosystem of the Bay-Delta, and in some cases, may have created conditions which are toxic to certain aquatic organisms. However, the degree to which specific pollutants have affected and are continuing to affect aquatic biota in the Bay-Delta is generally unknown due in part to the complexity of conditions that exist within the Bay-Delta and the historical absence of comprehensive monitoring programs. This does not reduce the importance of this issue in the Bay-Delta ecosystem. Rather, it reinforces the need for detailed, quantitative studies focused on identifying the major sources of pollutants, determining the overall effects of the hazardous substances, and developing and implementing measures which serve to eliminate or reduce those substances to concentrations having no adverse impacts on the aquatic ecosystem.

The control and regulation of the discharge of waste into and within California's waters is under the jurisdiction of the SWRCB and the regional water quality control boards under the Porter-Cologne Act and through the CWA. The SWRCB's 1990 Pollutant Policy Document (PPD) and the San Francisco Estuary Project's 1993 Comprehensive Conservation and Management Plan (CCMP) have identified plans and definitive action strategies for the control of waste discharges and for pollution prevention. When implemented, these strategies should provide effective management of toxicity sources. The Joint Water Users therefore recommend that the following actions be taken:

- PPD and CCMP. The SWRCB should conduct a workshop to review and assess the implementation of the PPD and update the document as appropriate. The SWRCB and the regional water quality control boards should also develop programs to implement the CCMP. The SWRCB should incorporate the PPD update and the CCMP action programs in its Coordinated Estuarine Protection Program.

- Regional Monitoring Program (RMP). This program was initiated in 1991 by the San Francisco Regional Water Quality Control Board as part of the Bay Protection and Toxic Clean-Up Program (BPTCP). It should be continued in the future consistent with the CCMP's regional monitoring strategy.

- Water Quality Control Plans. The statewide water quality control plans for inland surface waters and enclosed bays and estuaries, which included water quality objectives for a number of toxic pollutants, were recently declared invalid by the courts and no longer have any force or effect. The SWRCB has initiated proceedings to adopt new water quality criteria. The SWRCB should adopt a new bays and estuaries plan and a new inland surface waters plan that contain definitive programs and time schedules for controlling major sources of pollutants to the Bay-Delta.

- Incentive Programs for Pollution Control. The SWRCB should assess options for developing incentive programs for industrial, municipal, and agricultural dischargers, focused on targeted reductions to agreed-to levels, with attainment tied to pollutant trading, mitigation banking, effluent fees, etc. The SWRCB should conduct a workshop on this issue within one year.

- Research and Studies. With the initiation of the RMP, data are being gathered on potential contaminants in the Bay-Delta in a manner which enables temporal and spatial comparisons of chemical composition, and an evaluation of potential toxicologic impacts. The SWRCB should support the action plan recommended by the CCMP.

- Non-Point Management (Agricultural and Mine Drainage). The SWRCB should conclude the review and update of the November 1988 Non-Point Source (NPS) Management Program by July 1995 and amend it as necessary to achieve effective regulation of mine drainage, agriculture, and forestry land uses pursuant to section 6217 of the 1992 Coastal Zone Act Reauthorization Amendments.

- Pesticides. Pursuant to the December 1991 memorandum of understanding with the Department of Pesticide Regulation (DPR), the SWRCB should complete an implementation document to ensure that registered pesticides are used in a manner that protects water quality and beneficial uses. The SWRCB should direct the DPR to report on the status of its Pesticide Management Strategy, of the Rice Industry Pesticide Control Program, and other actions being taken to address pesticides (including diazinon) that are potentially contributing to toxicity in discharges to Bay-Delta waters.

3.3 LEGAL FISHING

To the extent that fishing activities contribute to the decline of Bay-Delta resources, particularly salmon runs, it is appropriate to address commercial and sport harvest as a means of reducing overall human impact on these resources. The primary issues related to legal fishing are:

a) Does the currently allowed harvest contribute to the decline of the resource?

b) Does the currently allowed harvest have the potential to adversely affect the recovery of threatened or endangered species?

The BDOC draft report on the *Effects of Legal and Illegal Catch on the Abundance of Selected Fish in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (1994) presents data which suggest that an increasing proportion of the overall population of chinook salmon are being harvested, with harvest/escapement ratios increasing from 1967 through the present.

These data indicate that not only has escapement declined in absolute terms (from 1.6 million to 1 million fish, with the steepest declines for winter-run and spring-run fish), but also that harvest has increased, particularly during the drought period from 1987-1991. The vast majority of this harvest has been in the ocean fishery, which on average has accounted for about 99% of the total harvest. These data suggest that legal harvest may be a significant factor in the decline of the salmon fishery. In addition, there is some harvest of Sacramento Valley chinook salmon outside of the California coastline fishery, with marked fingerlings from this area having been caught as adults as far north as Vancouver Island (SFEP, 1992). Harvest in the BDOC draft review may therefore be underestimated.

The CDFG, the Fish and Game Commission (FGC), the Pacific Fisheries Management Council (PFMC), and NMFS have primary jurisdiction over this issue. The SWRCB should make the following recommendations for action by these agencies and request a report on implementation:

- Harvest Regulations. The CDFG, FGC, and PFMC should review and modify, if necessary, existing harvest regulations to ensure that they are adequately protecting aquatic species. The PFMC should consider initiating a program to conduct this task annually, and the FGC should do so bi-annually.

- Trawling Methods. Trawling methods currently used by the commercial shrimp industry result in the incidental take of various fish species. Resource agencies should negotiate a memorandum of understanding to work with the commercial fishing industry to develop methods that would reduce the incidental take of non-target species.

In addition, the SWRCB should create incentives for water users' cooperative participation with upstream habitat restoration and improvement efforts currently underway by various groups, such as the Pacific Coast Federation of Fishermen's Association. Upstream habitat restoration is critical to stabilizing and reversing fishery declines.

3.4 ILLEGAL FISHING

In July 1992, DWR and the CDFG developed a joint agreement to initiate a three-year program to increase enforcement efforts and deter illegal take of Delta resources, including the anadromous fishery and striped bass. Historically, about 500,000 undersized striped bass and an uncounted number of salmon were illegally taken on an annual basis. CDFG observations indicate violations of sport fishing regulations at a rate in excess of 65% throughout the Delta. The program should be structured to emphasize illegal takes of salmon.

CDFG has general authority to regulate fish and game resources and enforce the State ESA. DWR also has responsibilities for protecting the beneficial uses of the Delta. Therefore, the SWRCB should:

- Recommend that CDFG and DWR increase the existing anti-poaching programs.

- Consider additional funding options for the special enforcement unit that has been established by CDFG to deter illegal takes and poaching.

- Recommend that CDFG (in cooperation with Friends of the San Francisco Estuary) report on the feasibility of developing and implementing an educational program to curb poaching of aquatic resources.

3.5 LAND-DERIVED SALTS

Land derived salts enter the Delta and its tributaries from a large number of sources including agricultural drains and individual pumped farm discharges. Salts and trace elements in these discharges contribute to violations of water quality standards and may be detrimental to fish and wildlife. Additionally, organics present in some of the Delta island agricultural discharges substantially increase the potential of Delta water to form disinfection byproducts when subsequently treated for potable use, which will result in substantial increases in treatment costs for water utilities using Delta water.

Initial measures to control pollution associated with agricultural drainage are underway in several areas. Most notably, farms in the Grasslands area are currently taking measures to reduce selenium loadings through improved irrigation water management documented in their drainage operation plans. However, no comprehensive approach to dealing with the agricultural drainage discharges to the Delta and its tributaries has yet been implemented.

Agricultural return flows generally are exempt from action under the CWA's NPDES permit program; however, the SWRCB's 1988 NPS Management Program contains several options for addressing these discharges. The preferred approach, as in the regulation of urban runoff, is to implement pollution control as close to the source as is feasible. Options for control of pollution associated with these discharges range from traditional permits and mandatory Best Management Practices to input or effluent fees and tradable discharge permits.

The proposed actions to address this issue are as follows:

1) The Central Valley Regional Water Quality Control Board should review and revise as appropriate, standards for land derived salts and toxic trace metals in their current Basin Plan Amendments (now available for public review).

2) The SWRCB, as part of their scheduled review of the Regional Board's proposed standards, should conduct workshops on alternative strategies for implementing the proposed standards. In conducting the workshops, the SWRCB should request comment on the feasibility of establishing loadings for land derived salts and toxic trace metals. Comment should also be requested on the feasibility of different approaches, including the use of economic incentives, for agricultural entities to implement pollution control which could meet any established allowable loads. Finally, the SWRCB should request comment

on the feasibility of monitoring to assess compliance with the allocated loads and any specific local or regional actions which are needed for monitoring.

3) Based on the workshops, the SWRCB should develop a plan and schedule for implementation of the compliance strategies to meet standards.

The Central Valley Regional Water Quality Control Board is responsible for setting the appropriate standards. The SWRCB is responsible for reviewing the standards. The SWRCB should take the initiative to work with the Regional Board, the agricultural community, and interested parties to develop a feasible compliance strategy that will allow farmers to meet the standards in a cost effective manner.

3.6 INTRODUCED SPECIES

The fish assemblage currently inhabiting the Bay-Delta includes 55 fish species, of which 27 were either intentionally or accidentally introduced from other water bodies and have secured a sustainable niche within the ecosystem. The list of introduced invertebrate species numbers over 100 and includes several recent species which have shown rapid increases in population numbers. The most striking example of these is the Asian clam (*Potamocorbula amurensis*), which was first observed in 1986 and now dominates most of the benthic communities in San Pablo and Suisun Bays.

The introduction of non-indigenous species (NIS) has influenced the biological communities of the Bay-Delta system. However, the degree and extent to which such introductions will continue to impact the system remain unknown and largely unexplored. In its June 13, 1994, testimony to the SWRCB, the CDFG acknowledged that "introductions (of species) have caused major changes in the fish fauna in the estuary, particularly in fresh waters." The CDFG concluded that "introductions since 1950 have caused substantial changes in aquatic invertebrates and established large populations of several species of smaller fish, but they have not coincided with the principal declines in other fish populations." Thus, while acknowledging that introduced species have influenced the aquatic biota, CDFG has downplayed their importance in potentially causing major declines in fish populations.

Regardless of the degree of impact, it is clear that introduced species do factor into the overall recovery potential of the system, and a program to provide fundamental information on their biological requirements and interrelationships with native fauna should be developed. Such a program would provide the necessary framework for developing control measures for certain species, including, where appropriate, eradication programs. In addition, more stringent regulations are warranted to control such introductions and prevent others from occurring.

The CDFG has the responsibility and authority for administering California law regarding the import, transfer, and introduction of non-native species into the state. Under the Lacey Act, the USFWS also has responsibilities for controlling illegal introductions of aquatic organisms. The SWRCB should request those agencies to undertake actions to address introduced species consistent with the CCMP.

3.7 LOSS OF RIPARIAN, WETLAND, AND ESTUARINE HABITATS

The Delta covers an area of 1,153 square miles or 738,000 acres. Historically, this area was a complex of low islands of tule marshes intersected by rivers, tributary channels, and dead-end sloughs, which were bordered by extensive stands of riparian forest growing on natural levees. The marshes and rivers were surrounded by seasonally flooded grasslands and oak savannah. The central Delta was a vast tidal estuary, inundated by each tide. The historic Delta consisted of about 35,000 acres of tidal freshwater marsh in the central Delta, surrounded by 200,000 to 300,000 acres of riparian woodlands and non-tidal wetlands in the outer Delta, with upland habitat at the outer edges of the Delta (Atwater et al., 1979; Nichols and Wright, 1971). The rivers and streams upstream of the Delta were meandering, tree-lined channels surrounded by freshwater tule marshes and riparian habitats.

This habitat has been extensively modified so that less than 100,000 acres of marsh, riparian, and upland habitat remains, and much of what remains is highly disturbed. This loss of habitat magnifies the importance of the remaining estuarine, freshwater marsh, and riparian habitats. Restoration of habitat throughout the Delta and its tributaries would provide improved habitat for the full range of hydrologic conditions. That is, when drought conditions prevail, there must be adequate shallow-water, low-salinity, habitat with adequate aquatic vegetation in the central and upper Delta so that the full suite of estuarine species may find adequate habitat. Likewise, when wet conditions prevail, there must be adequate habitat for all species in the lower Delta and the complex of Suisun and San Pablo bays. In addition, freshwater riparian and marsh habitats, which supply nutrients to the Bay-Delta system, need to be restored in tributary watersheds so that (a) there is adequate rearing habitat for outmigrating salmon smolts and (b) nutrient flows into the estuary are restored. On the other hand, the SWRCB needs to recognize the conflict between the need for habitat restoration and the Delta Protection Commission's "Draft Delta Land Use and Resource Management Plan," which does not adequately recognize the fishery and aquatic habitat values of the Bay-Delta.

In addition to the SWRCB, there are several agencies with jurisdiction over this issue, including: CDFG, which has general authority to regulate fish and game resources and enforce the State ESA; the U.S. Army Corps of Engineers, which has jurisdiction over discharges into waters of the United States under section 404 of the Clean Water Act; the Federal Emergency Management Agency (FEMA), which establishes flood insurance requirements, including levee standards; USFWS and NMFS, which share responsibility for enforcement of the Federal ESA; and the Delta Protection Commission, which is statutorily charged with developing a regional land use plan for the five Delta counties.

The SWRCB should encourage habitat restoration by explicitly recognizing that the environmental goals of water quality and water management regulations may in part be accomplished by measures such as habitat restoration. Numerous habitat restoration plans based on maintaining existing levees are outlined in the CDFG/DWR Draft "Sacramento-San Joaquin Delta Master Environmental Assessment," dated October 1993. Other plans based on setback of levees and restoration of marsh, riparian, and upland habitats will need to be developed. A series of demonstration projects, combined with an intensive research/monitoring effort is needed to determine the most effective methods for habitat restoration. Coordination with groups such as the Pacific Coast Federation of Fishermens Association should be explored.

Finally, the SWRCB needs to identify and convey to the Delta Protection Commission potential conflicts between the land use plan and policies developed by the Commission and the opportunity to further enhance the aquatic habitat value of the Delta. Because the Commission will function as an appellate body in challenges to individual county plans, it is critical that the Commission's work recognize the changes that may occur in the Delta as the state's water supply and quality concerns are addressed.

3.8 CHANNEL ALTERATION

Aquatic habitats, including bed and bank in the lower Sacramento and San Joaquin rivers and the Delta, have been extensively altered from their natural states for a variety of purposes, including navigation, flood control, conversion into agricultural land, water quality, port, and industrial and urban development. This has resulted in degradation of habitat used by aquatic biological resources. In many cases, these alterations, especially navigational channels, dikes, and other revetments, require extensive, ongoing maintenance which further interferes with habitat. In addition, the deepening of the ship channel to Martinez has the potential to increase saltwater intrusion into an important portion of the estuary.

The net result of these activities has been to greatly reduce the quantity of aquatic and estuarine habitats available to aquatic species and, in many cases, to reduce the quality of remaining habitats. Specifically, many miles of stream banks and marsh boundaries have been riprapped, productive shallows and shoals have been reduced or eliminated on a vast scale, channels have been greatly shortened, and large areas formerly occupied by meandering river and tributary channels have been cut off and converted to agricultural and other terrestrial uses.

The population declines of Bay-Delta species during the recent drought may well be a result of the increased vulnerability of the species due to reductions in available habitat. Continued encroachments and failure to remediate former habitat areas lost to physical changes in the lower river systems, the Delta, and the estuary can only exacerbate the present situation.

To address this problem, the Joint Water Users recommend the following actions:

- The SWRCB, in cooperation with the Delta Protection Commission, should establish administrative mitigation requirements which address the need to reclaim aquatic areas into more productive status with maintenance dredging, levee and revetment maintenance projects, new riparian fill projects, and related activities requiring state permits.

- Through CWA water quality certifications, the SWRCB and regional water quality control boards should require an analysis of all project impacts on estuarine habitat.

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APPENDIX A

COMPARISON OF JOINT WATER USERS PROPOSAL WITH HISTORICAL AND BASE CASE (D-1485) CONDITIONS

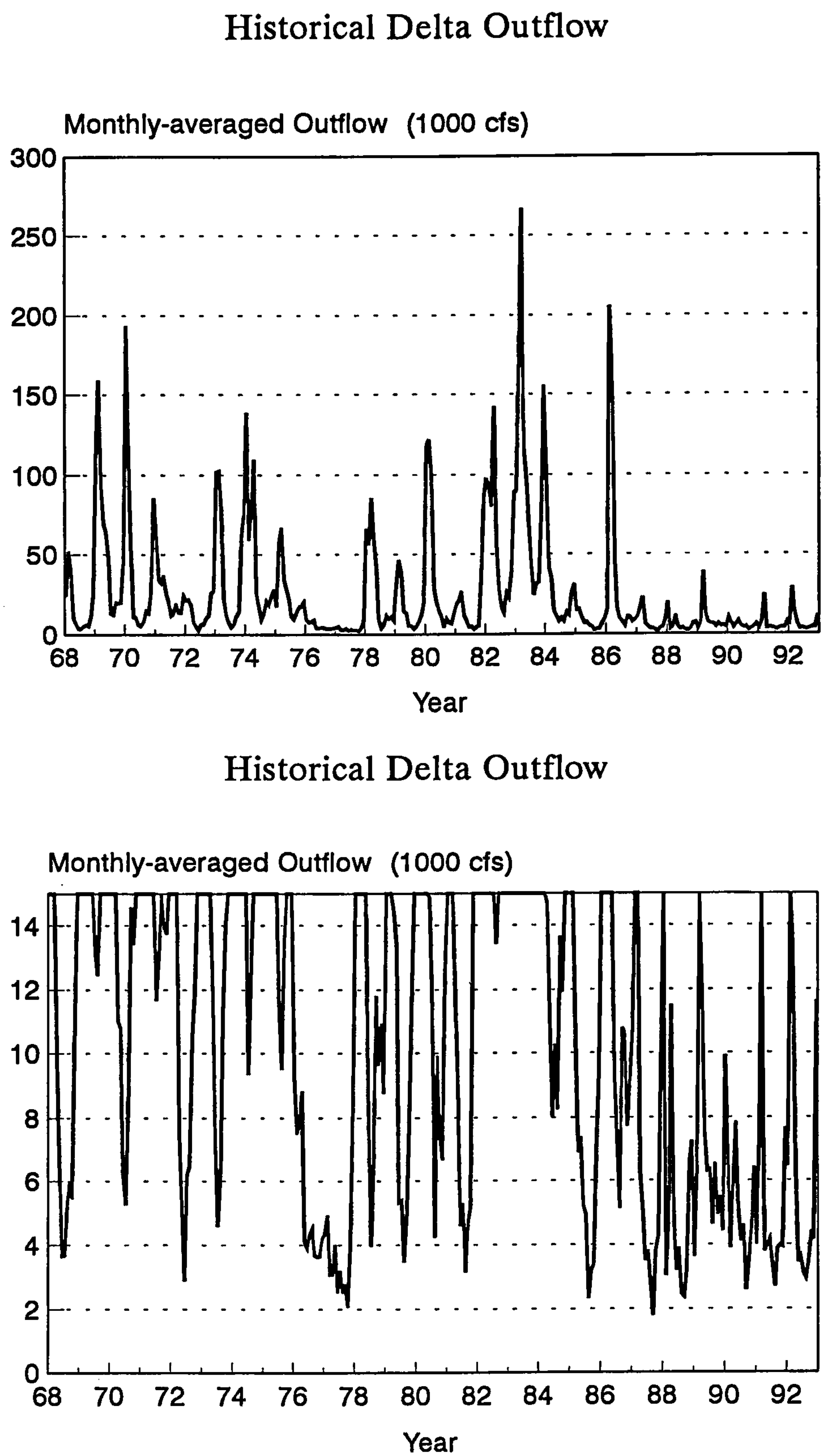
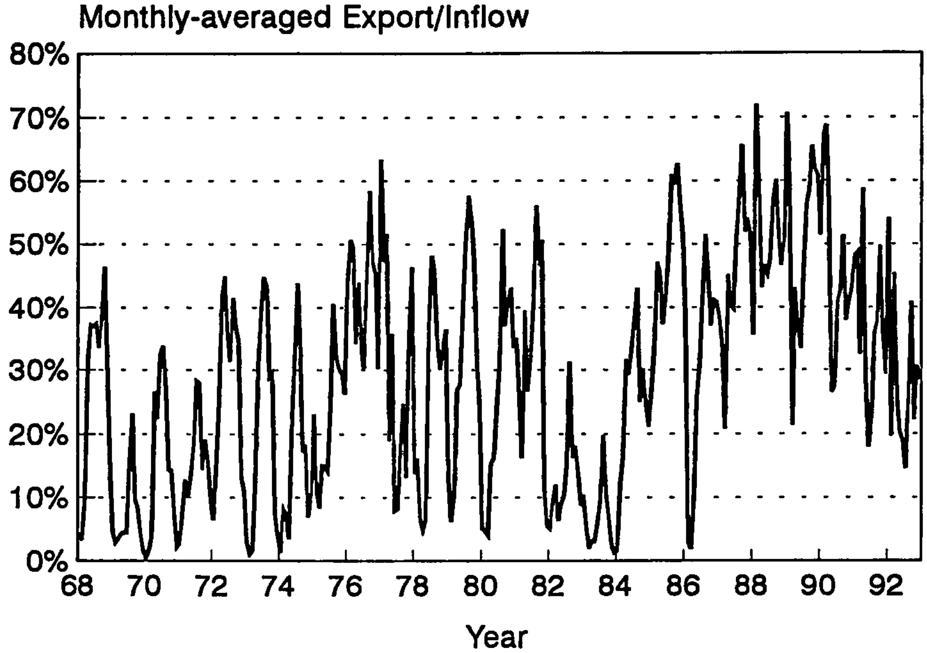


Figure A-1. Historical monthly-averaged Delta outflows from DAYFLOW for 1968-1992. The upper figure shows full range of flows, 0 - 270,000 cfs. The lower figure shows the variation of lower Delta outflows over the range, 0 - 15,000 cfs. DAYFLOW data.

Historical Export/Inflow Ratio
(Banks + Tracy Pumping)



Historical San Joaquin Flow at Vernalis

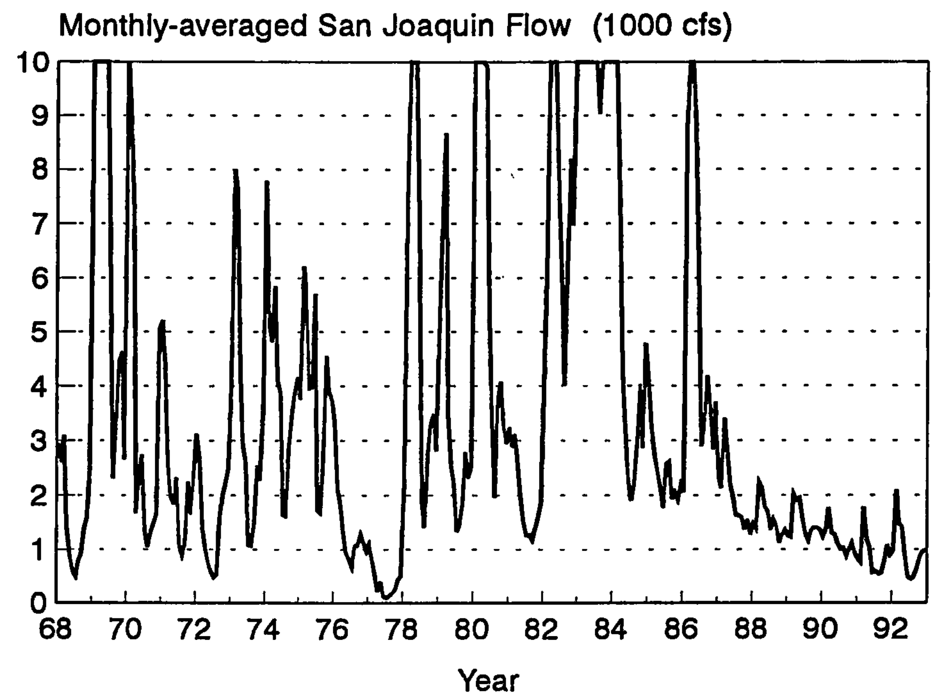
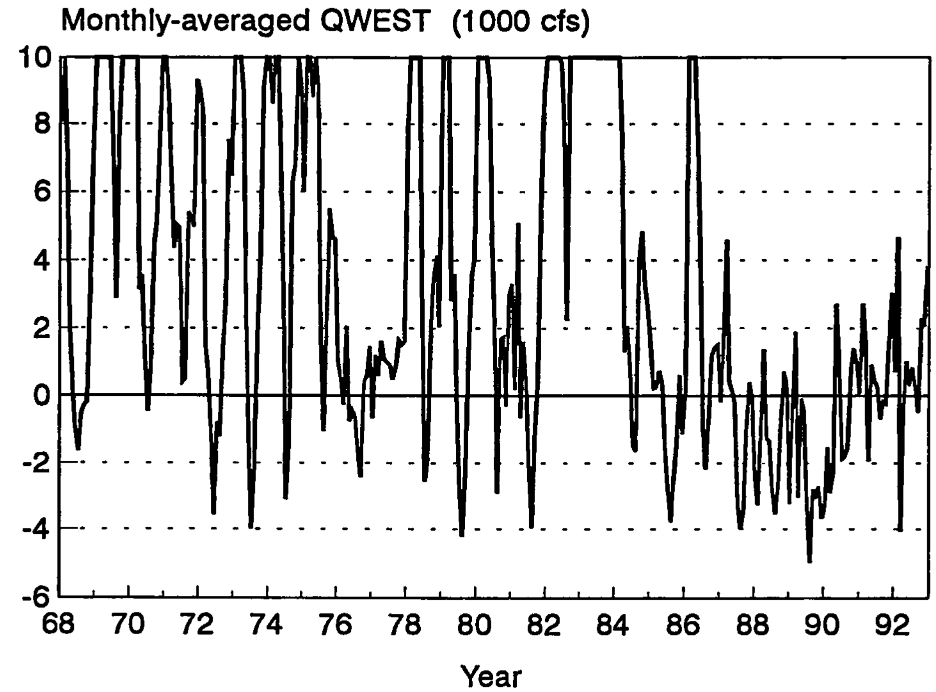


Figure A-2. Historical monthly export/inflow ratios and San Joaquin flows at Vernalis from DAYFLOW for 1968-1992. The upper figure shows export/inflows over the range 0-80%. The lower figure shows San Joaquin flows over the range, 0 - 10,000 cfs.

Historical QWEST



Historical QWEST/Outflow Ratio

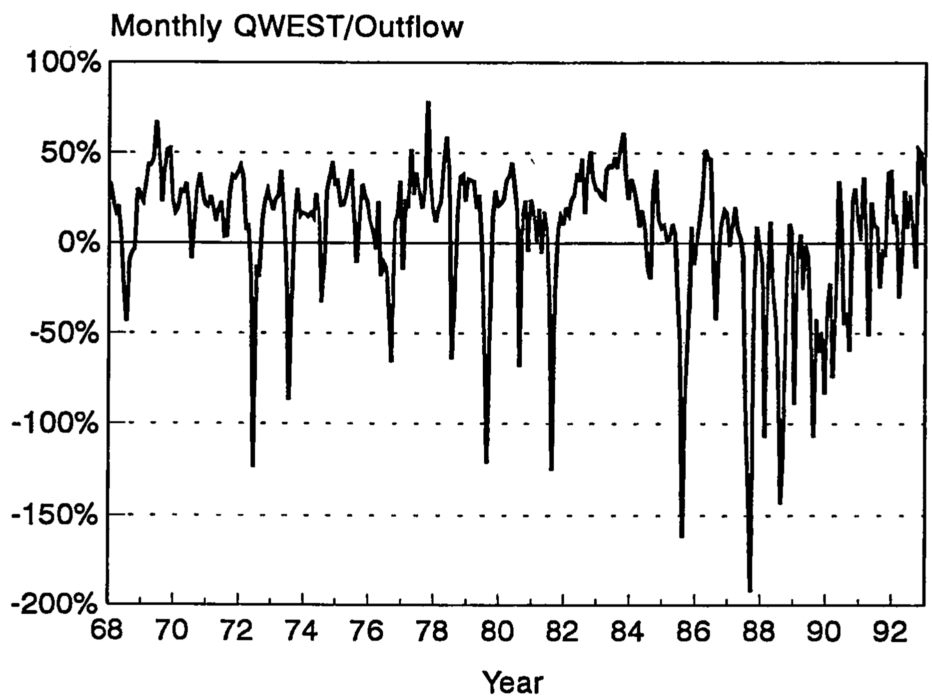


Figure A-3. Historical monthly variation in QWEST and the ratio of QWEST to Delta outflow from DAYFLOW for 1968-1992. The upper figure shows QWEST over the range 0 - 10,000 cfs. The lower figure shows the QWEST/Outflow ratio over the range, -200% to 100%. This ratio represents the relative contribution of the lower San Joaquin flows to Delta outflow.

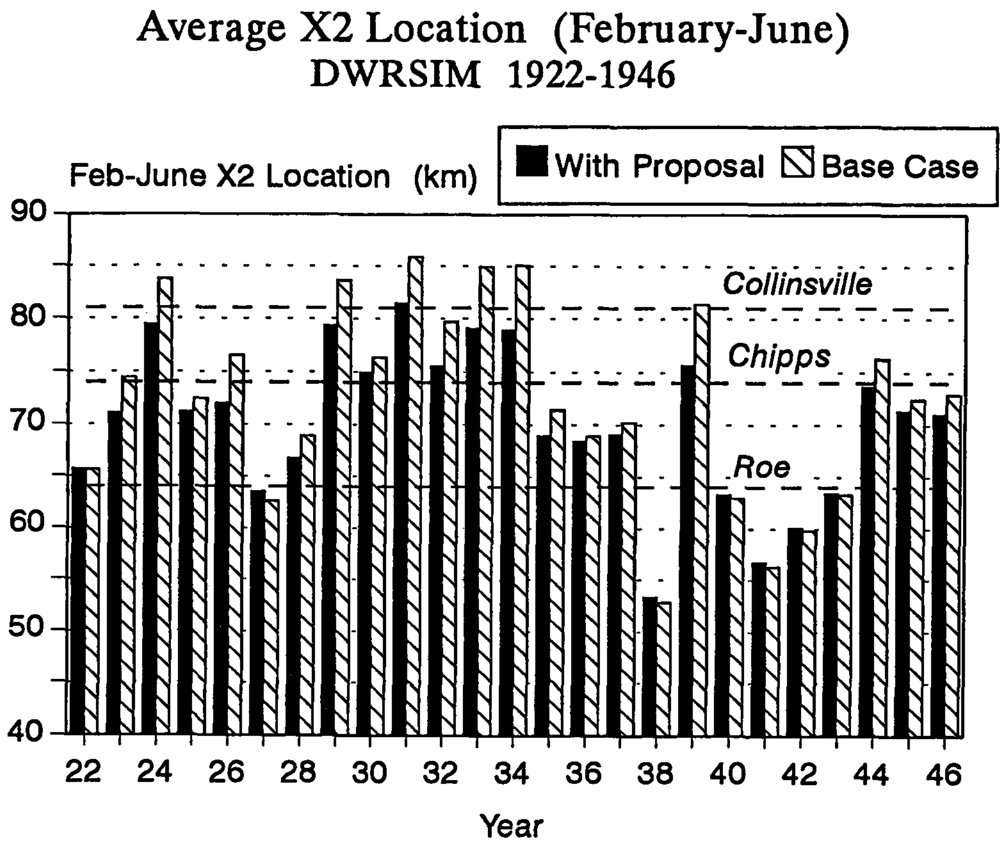
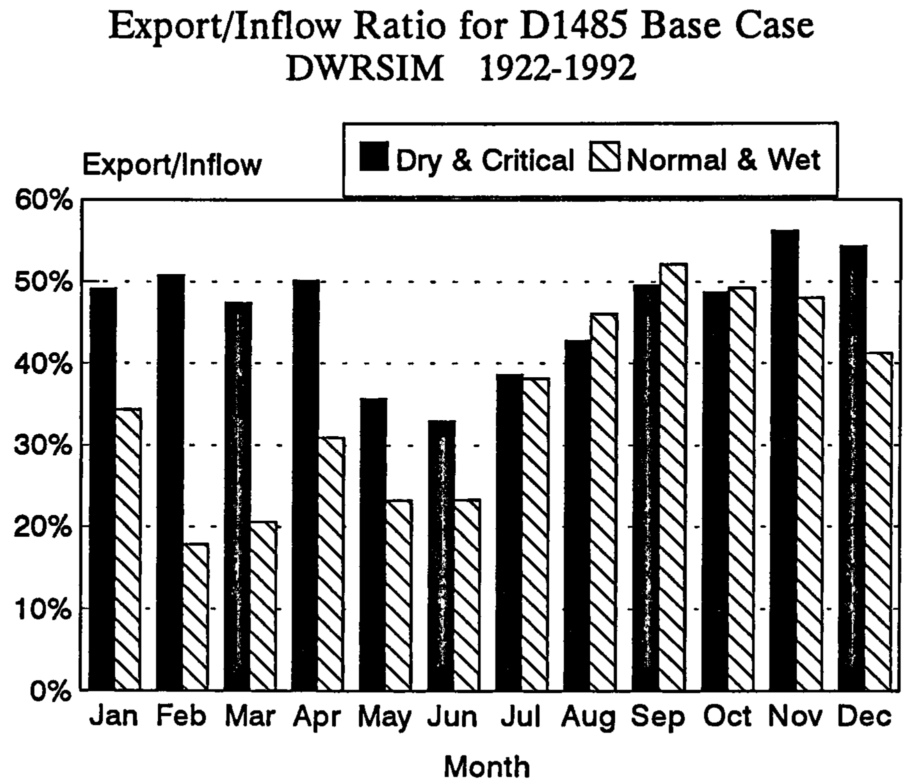


Figure A-4. Average February-June location of X2 with the Joint Water Users proposal compared to the D-1485 base case for 1922-1945. The historical hydrology period is broken into three (slightly overlapping) parts.



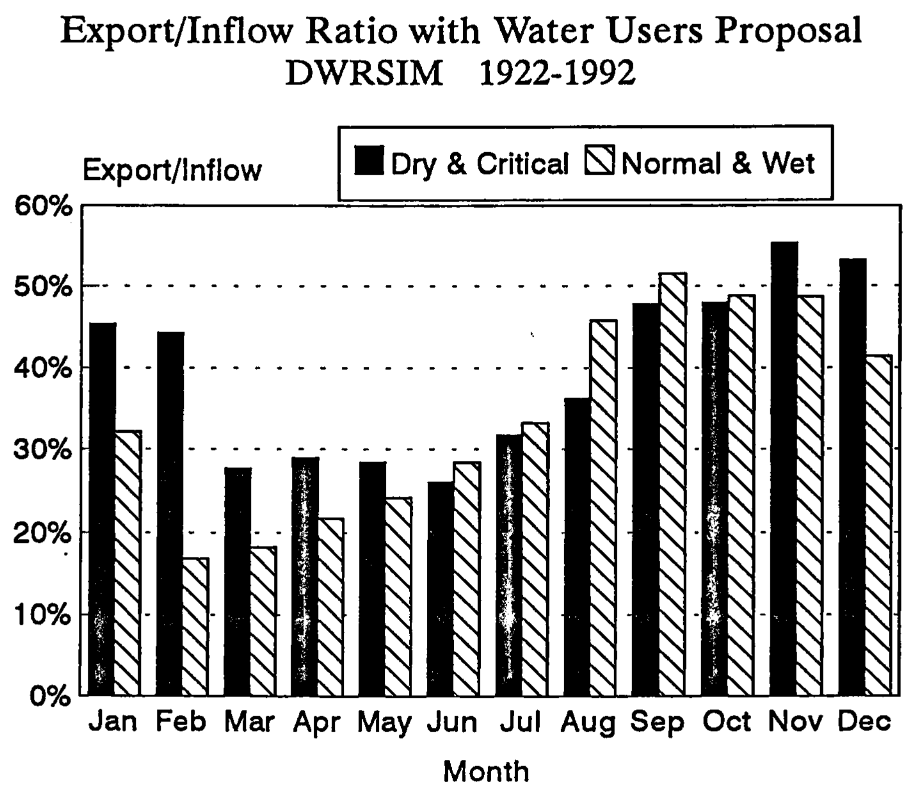


Figure A-5. Drier and wetter year averaged export/inflow ratios for each month with the Joint Water Users proposal compared to the D-1485 base case. Data are from DWRSIM output from DWRSIM studies Alternative J (Joint Water Users proposal with Option 2) and the D-1485 base case (DWRSIM Run 272B). The data for each month are categorized according to drier years (dry & critical) and wetter years (below normal, above normal and wet years), averaging each month over the full 1922-1992 historical hydrology period.

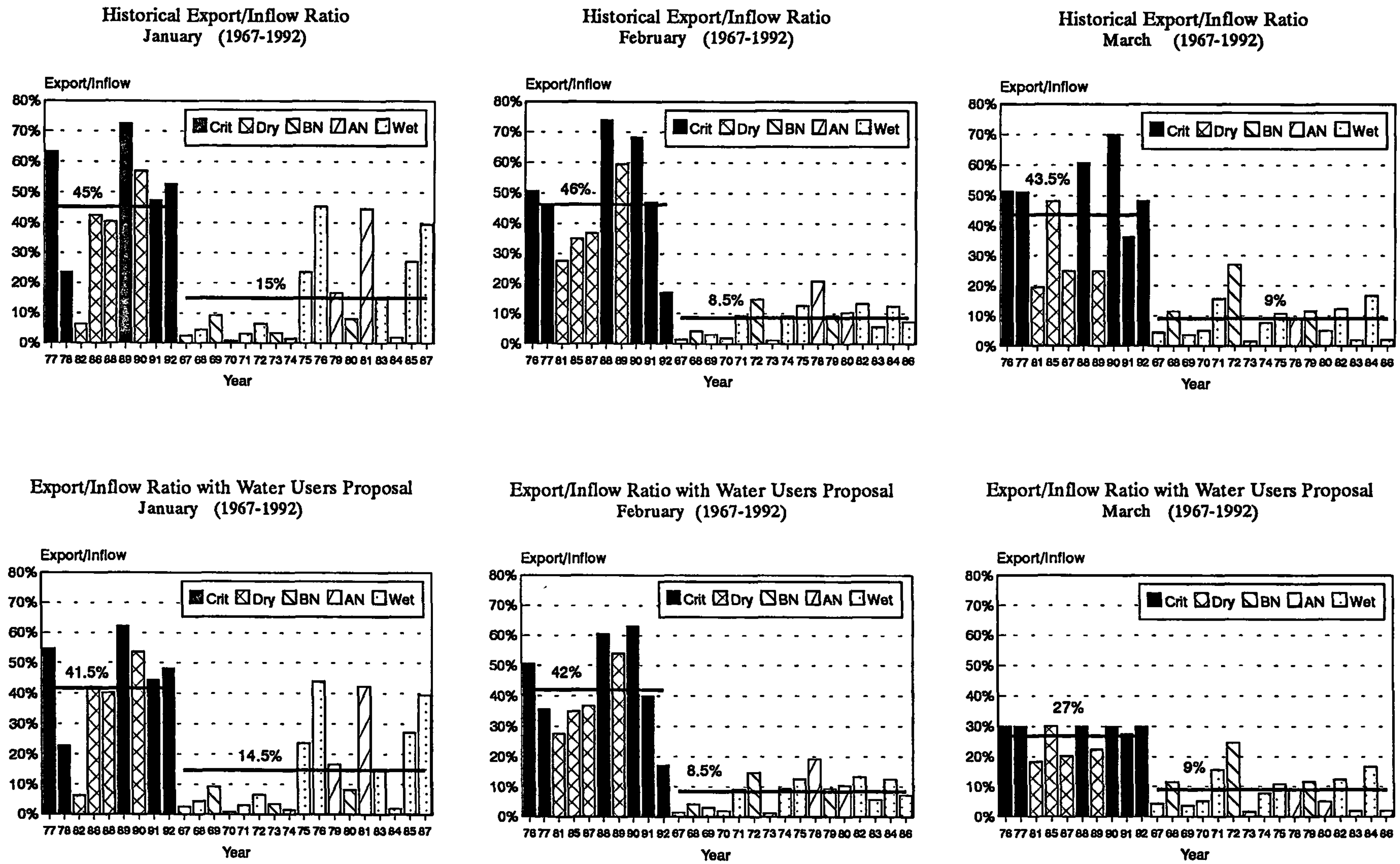


Figure A-6. Comparison of export/inflow ratios for the Joint Water Users proposal with historical values, January through March. Each graph shows the corresponding averages for drier and wetter years. Data are from CCWD's additional outflow model. The charts differentiate between the 5 water year types (using the 40-30-30 water year classification for the Sacramento River basin) and changing water year types of February 1 each year.

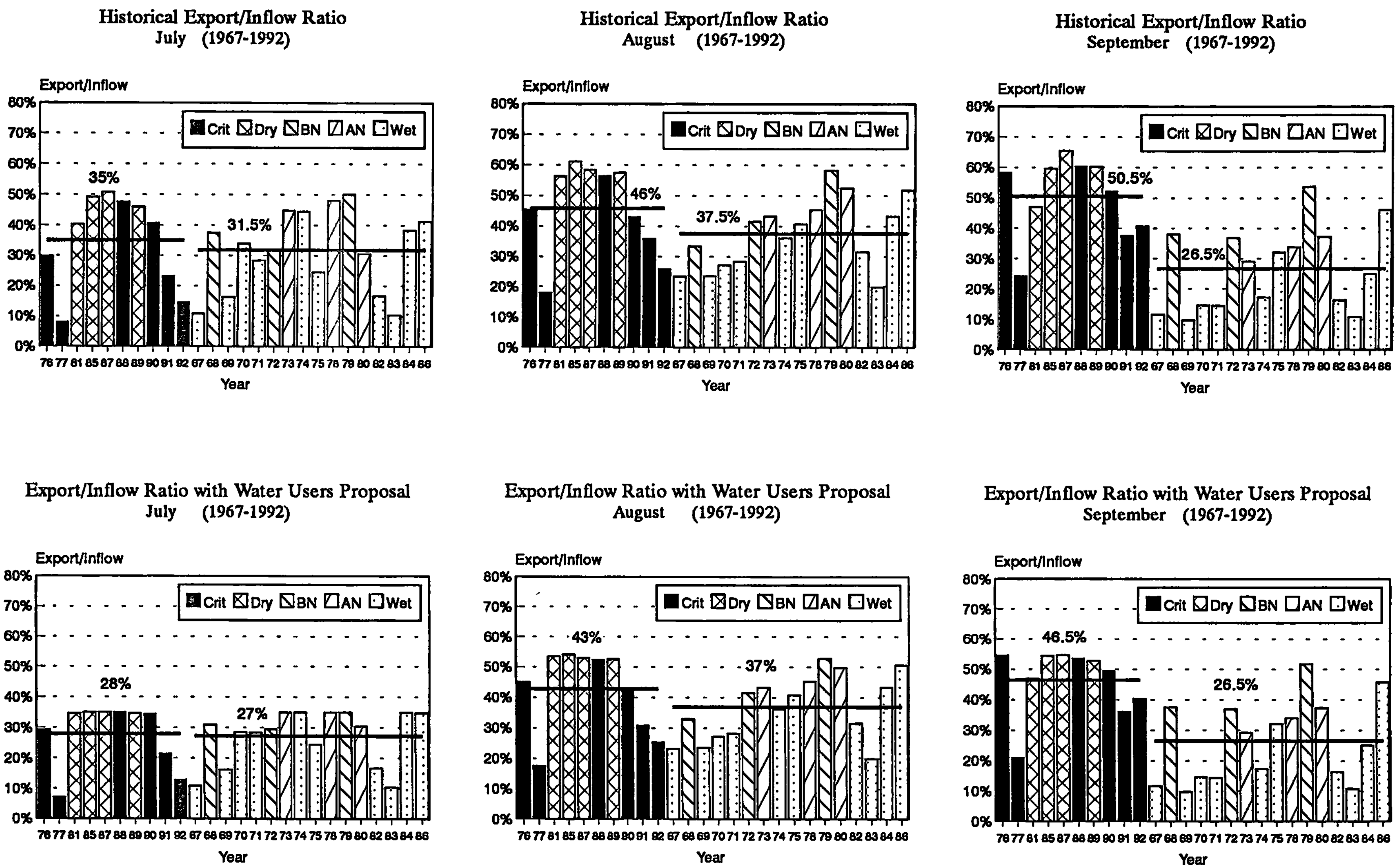


Figure A-7. Comparison of export/inflow ratios for the Joint Water Users proposal with historical values, July through September. Each graph shows the corresponding averages for drier and wetter years. Data are from CCWD's additional outflow model. The charts differentiate between the 5 water year types (using the 40-30-30 water year classification for the Sacramento River basin) and changing water year types of February 1 each year.

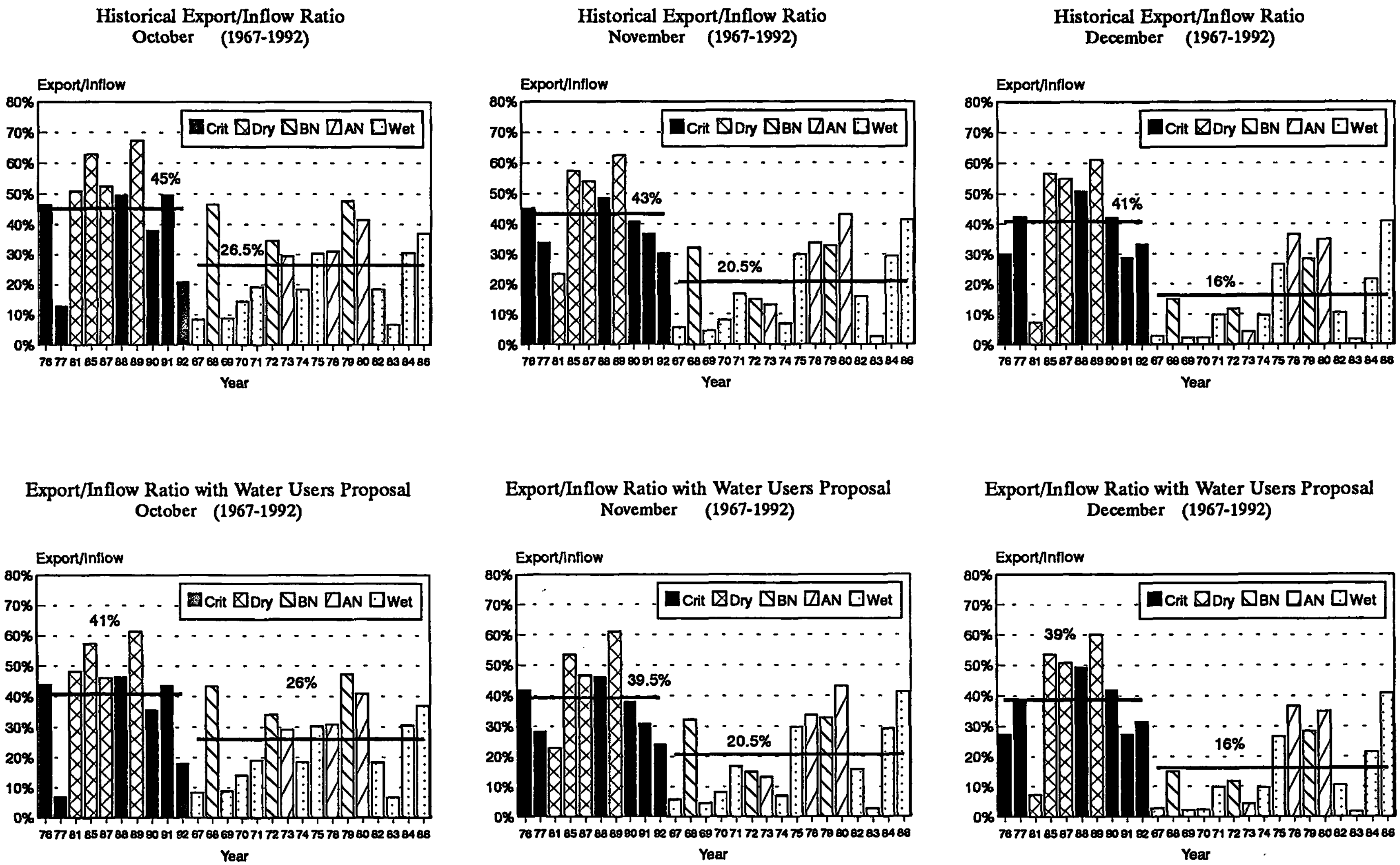
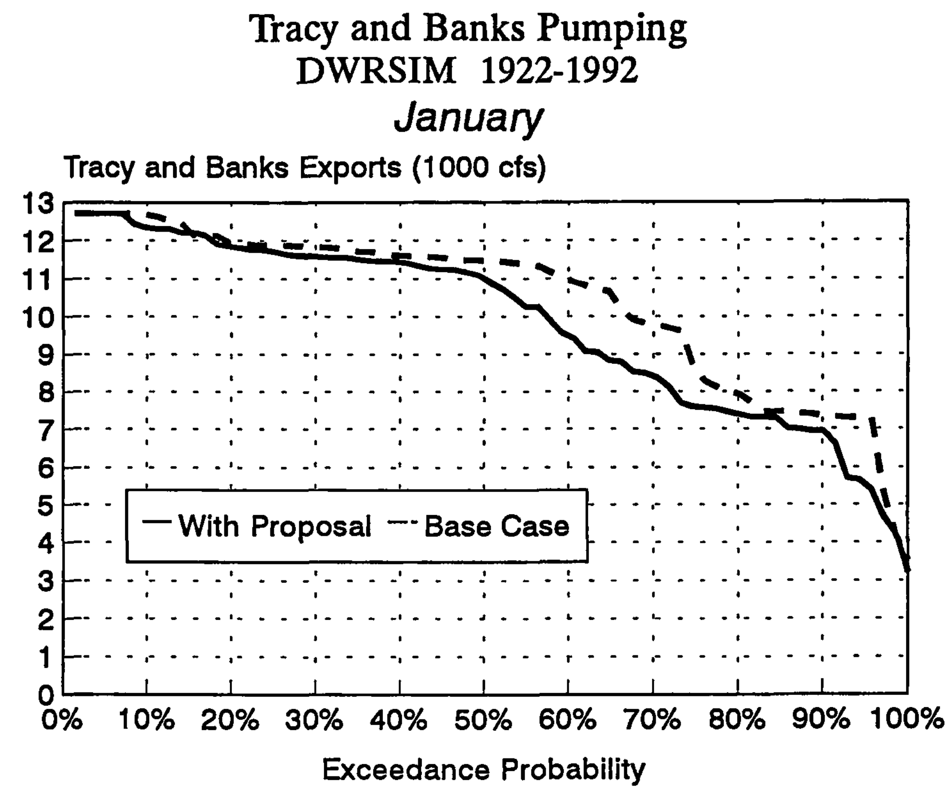


Figure A-8. Comparison of export/inflow ratios for the Joint Water Users proposal with historical values, October through December. Each graph shows the corresponding averages for drier and wetter years. Data are from CCWD's additional outflow model. The charts differentiate between the 5 water year types (using the 40-30-30 water year classification for the Sacramento River basin) and changing water year types of February 1 each year.



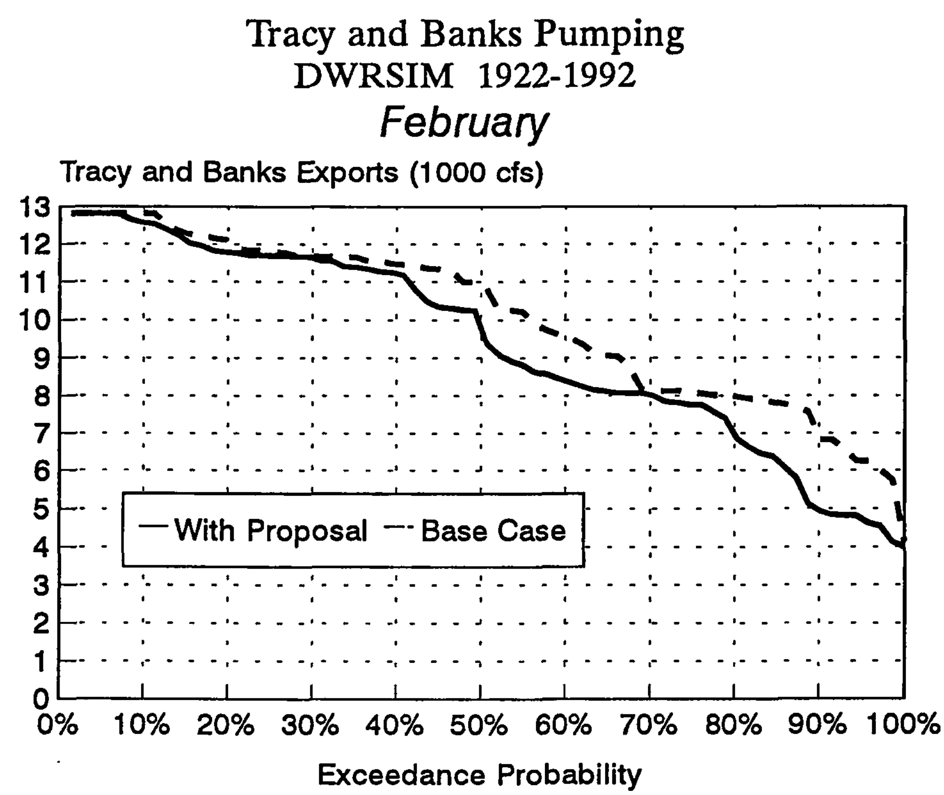


Figure A-9. Histogram of export pumping with Joint Water Users proposal compared to D-1485 base case for January and February. Data are from DWRSIM output from DWRSIM studies Alternative J (Joint Water Users proposal with Option 2) and the D-1485 base case (DWRSIM Run 272B). DWRSIM data are used because CCWD's additional outflow model does not reoperate the Projects and does not shift exports to other periods.

APPENDIX B

SLIDING SCALE FOR MEETING THE X2 BAY-DELTA STANDARD

SLIDING SCALE FOR MEETING THE X2 BAY-DELTA STANDARD

The Joint Water Users Proposal for a sliding scale for the X2 Bay-Delta standard will maintain the quality of waters in the San Francisco Bay and Delta consistent with that level of protection necessary to protect estuarine habitat, fish migration, cold freshwater habitat, and other existing beneficial uses. Protection of estuarine habitat, shall be based upon attainment of the following criteria at the following locations from February 1 through June 30 of each year:

1. Confluence of Sacramento and San Joaquin Rivers:

   A maximum daily average electrical conductivity of 2.64 millisiemens per centimeter (mS/cm), OR a maximum 14-day running average electrical conductivity of 2.64 millisiemens per centimeter (mS/cm), OR a minimum Delta outflow index of 7,100 cubic feet per second (cfs) for the number of days for each calendar month, February through June, given in Table B-1. If this standard is met for a greater number of days than the requirement for any month, the excess number of days shall be applied to meeting the requirement for the following month.

   The electrical conductivity at the confluence of the Sacramento and San Joaquin Rivers shall be measured at the Collinsville station, number RSAC081, maintained by the U.S. Bureau of Reclamation.

2. Chipps Island:

   A maximum daily average electrical conductivity of 2.64 millisiemens per centimeter (mS/cm), OR a maximum 14-day running average electrical conductivity of 2.64 millisiemens per centimeter (mS/cm), OR a minimum Delta outflow index of 11,400 cubic feet per second (cfs) for the number of days for each calendar month, February through June, given in Table B-2. If this standard is met for a greater number of days than the requirement for any month, the excess number of days shall be applied to meeting the requirement for the following month.

   The electrical conductivity at Chipps Island shall be measured in Suisun Bay at the Mallard Island station, number E0B80261551, maintained by the California Department of Water Resources; and

3. Roe Island:

   A maximum daily average electrical conductivity of 2.64 millisiemens per centimeter (mS/cm), OR a maximum 14-day running average electrical conductivity of 2.64 millisiemens per centimeter (mS/cm), OR a minimum Delta outflow index of 29,200 cubic feet per second (cfs) for the number of days for each calendar month, February through June, given in Table B-3. If this standard is met for a greater number of days than the requirement for any month, the excess number of days shall be applied to meeting the requirement for the following month.

The Roe Island standard shall only apply in months when the average electrical conductivity at Roe Island during the 14 days immediately prior to the first day of the month is 2.64 mS/cm or less.

The electrical conductivity at Roe Island shall be measured in Suisun Bay at the Port Chicago station, number RSAC064, maintained by the U.S. Bureau of Reclamation.

Note that for the purposes of these standards, electrical conductivity of 2.64 mS/cm at the specified measuring stations is equivalent to a salinity of 2 parts per thousand (practical salinity units) at mid-channel, near the bottom of the adjacent waterway. The Delta outflow shall be estimated and published daily by the Department of Water Resources and the Bureau of Reclamation using the method specified in Table B-4.

The number of days at the three locations shall be determined each month, February through June, based on the previous calendar month's value of the Sacramento-San Joaquin Unimpaired Flow Index, using the tables given below. The number of days for values of the Sacramento-San Joaquin Unimpaired Index between those shown in Tables B-1, B-2 and B-3 shall be determined by linear interpolation.

The sliding scale for the required number of days of X2 compliance in each calendar month was originally derived by the California Urban Water Agencies (CUWA) from the historical number of days, normalized to a level of development representing the average of the period 1968-1975, using a least squares regression of a statistical logistic equation. However, during the development of the Water Users joint proposal some modifications have been made. To provide a baseline for spawning and transport during dry and critical years, a minimum of 30 days is now required at the confluence in April in all years. Similarly, in February the CUWA sliding scale has been modified in the following way:

(a) At the confluence, X2 (with three ways to comply) is required to be met for 28 days; and

(b) At Chipps Island, there is no X2 requirement when the January Sacramento-San Joaquin Unimpaired Index is less than or equal to 1.5 million acre-feet (MAF), and 28 days are required when it is greater than 1.75 MAF. Linear interpolation is used between 1.5 and 1.75 MAF to determine the number of days required.

For the purposes of the X2 sliding scale, the Sacramento-San Joaquin Unimpaired Flow Index shall be computed as the sum of the flows at the following stations:

1. Sacramento River at Bend Bridge, near Red Bluff

2. Feather River, total inflow to Oroville Reservoir

3. Yuba River at Smartville

4. American River, total inflow to Folsom Reservoir

5. Stanislaus River, total flow to New Melones Reservoir

6. Tuolomne River, total inflow to Don Pedro Reservoir

7. Merced River, total flow to Exchequer Reservoir

8. San Joaquin, total inflow to Millerton Lake

Table B-1. Requirement at Collinsville.

Sacramento/ San Joaquin Unimpaired Flow Index for previous month, Thousand acre-feet	Number of Days During Calendar Month				
	February	March	April	May	June
0	28	0	30	0	0
250	28	0	30	0	0
500	28	0	30	0	0
750	28	7	30	0	0
1000	28	31	30	0	0
1250	28	31	30	0	0
1500	28	31	30	1	0
1750	28	31	30	31	0
2000	28	31	30	31	0
2250	28	31	30	31	1
2500	28	31	30	31	5
2750	28	31	30	31	15
3000	28	31	30	31	25
3250	28	31	30	31	28
3500	28	31	30	31	30
> 3500	28	31	30	31	30

Note: The number of days for values of the Sacramento-San Joaquin Unimpaired Index between those shown shall be determined by linear interpolation.

Table B-2. Requirement at Chipps Island.

Sacramento/ San Joaquin Unimpaired Flow Index for previous month, Thousand acre-feet	Number of Days During Calendar Month				
	February	March	April	May	June
0	0	0	0	0	0
250	0	0	0	0	0
500	0	0	0	0	0
750	0	0	0	0	0
1000	0	12	2	0	0
1250	0	31	6	0	0
1500	0	31	13	0	0
1750	28	31	20	0	0
2000	28	31	25	1	0
2250	28	31	27	3	0
2500	28	31	29	11	1
2750	28	31	29	20	2
3000	28	31	30	27	4
3250	28	31	30	29	8
3500	28	31	30	30	13
3750	28	31	30	31	18
4000	28	31	30	31	23
4250	28	31	30	31	25
4500	28	31	30	31	27
4750	28	31	30	31	28
5000	28	31	30	31	29
5250	28	31	30	31	29
5500	28	31	30	31	30
>5500	28	31	30	31	30

Note: The number of days for values of the Sacramento-San Joaquin Unimpaired Index between those shown shall be determined by linear interpolation.

Table B-3. Requirement at Roe Island.

Sacramento/ San Joaquin Unimpaired Flow Index for previous month, Thousand acre-feet	Number of Days During Calendar Month				
	February	March	April	May	June
0	0	0	0	0	0
250	1	0	0	0	0
500	4	1	0	0	0
750	8	2	0	0	0
1000	12	4	0	0	0
1250	15	6	1	0	0
1500	18	9	1	0	0
1750	20	12	2	0	0
2000	21	15	4	0	0
2250	22	17	5	1	0
2500	23	19	8	1	0
2750	24	21	10	2	0
3000	25	23	12	4	0
3250	25	24	14	6	0
3500	25	25	16	9	0
3750	26	26	18	12	0
4000	26	27	20	15	0
4250	26	27	21	18	1
4500	26	28	23	21	2
4750	27	28	24	23	3
5000	27	28	25	25	4
5250	27	29	25	26	6
5500	27	29	26	28	9
5750	27	29	27	28	13
6000	27	29	27	29	16
6250	27	30	27	29	19
6500	27	30	28	30	22
6750	27	30	28	30	24
7000	27	30	28	30	26
7250	27	30	28	30	27
7500	27	30	29	30	28
7750	27	30	29	31	28
8000	27	30	29	31	29
8250	28	30	29	31	29
8500	28	30	29	31	29
8750	28	30	29	31	30
9000	28	30	29	31	30
9250	28	30	29	31	30
9500	28	31	29	31	30
9750	28	31	29	31	30
10000	28	31	30	31	30
>10000	28	31	30	31	30

Table B-4. Daily Delta Outflow Index.

The Delta Outflow Index (DOI) shall be computed daily by the California Department of Water Resources and the U.S. Bureau of Reclamation using the following formula (all flows are in cubic feet per second):

DOI = DELTA INFLOW - NET DELTA CONSUMPTIVE USE - DELTA DIVERSIONS

where DELTA INFLOW = SAC + SRTP + YOLO + EAST + MISC + SJR, and

SAC = Sacramento River at Freeport mean daily flow for the previous day; the 25-hour tidal measurements from 12:00 midnight to 1:00 a.m. the following day may be used instead;

SRTP = Sacramento Regional Treatment Plant average daily discharge for the previous week;

YOLO = Yolo Bypass mean daily flow for the previous day, which is equal to the flows from the Sacramento Weir, Fremont Weir, Cache Creek at Rumsey and the South Fork of Putah Creek;

EAST = Eastside streams mean daily flow for the previous day from the Mokelumne River at Woodbridge, Cosumnes River at Michigan Bar, and Calaveras River at Bellota;

MISC = Combined mean daily flow for the previous day of Bear Creek, Dry Creek, Stockton Diverting Canal, French Camp Slough, Marsh Creek and Morrison Creek; and

SJR = San Joaquin River flow at Vernalis, mean daily flow for the previous day; and

where NET DELTA CONSUMPTIVE USE = GDEPL - PREC, and

GDEPL = Delta gross channel depletion for the previous day based on water-year type using the Department of Water Resources most recent land use study; and

PREC = Real-time Delta precipitation runoff for the previous day, estimated from stations within the Delta; and

where DELTA DIVERSIONS = CCF + TPP + CCC, and

CCF = Clifton Court Foreby inflow for the current day;
TPP = Tracy Pumping Plant pumping for the current day; and
CCC = Contra Costa Canal pumping for the current day.