Hydrological and Biological Explanation of the Letter of Intent Among Export Interests and San Joaquin River Interests to Resolve San Joaquin River Issues Related to Protection of Bay-Delta Environmental Resources

Prepared by

San Joaquin Tributaries Association
Friant Water Users Authority
San Joaquin River Exchange Contractors Water Authority
City and County of San Francisco
SWP/CVP Export Interests

May 7, 1996

PREFACE

Over the past several months, a major group of agricultural and urban water interests have been discussing methods by which San Joaquin River flows at Vernalis can be improved consistent with goals of the State Water Resources Control Board's Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 WQCP). These interests include the San Joaquin Tributaries Association (the "SJTA" consists of the South San Joaquin Irrigation District, Oakdale Irrigation District, Modesto Irrigation District, Turlock Irrigation District and Merced Irrigation District), the Friant Water Users Authority, the San Joaquin River Exchange Contractors Water Authority (the "Exchange Contractors"), the City and County of San Francisco, and the State Water Project/Central Valley Project Delta export contractors (the "Export Interests") (collectively "the parties").

These discussions have resulted in a proposal that will provide a significant advance in environmental protection for San Joaquin River fall-run chinook salmon. The proposal is contained in a letter of intent among the parties, through which they have committed to develop an implementation agreement to provide flow and non-flow habitat improvements to the San Joaquin River and its tributaries. The improvements will provide protection to San Joaquin River and Bay-Delta aquatic species consistent with the December 15, 1994, Principles for Agreement on Bay-Delta Standards Between the State of California and the Federal Government (the "Accord") and the 1995 WQCP.

The improvements represent an important building block towards San Joaquin River environmental protection. The parties expect that their actions will be coordinated to the maximum extent possible with other programs, including the CVPIA Restoration Fund and San Joaquin River provisions of the CVPIA, the CALFED process, the SWRCB Bay-Delta process, the San Joaquin River Management Program, Category III provisions of the Accord, the Four Pumps Agreement, the purchase of water from willing sellers, and other actions to improve fisheries and habitat in the San Joaquin River watershed.

BACKGROUND

On December 15, 1994, representatives of the state and federal governments and several urban, agricultural and environmental interests signed the Accord which recommended that the SWRCB include certain of its provisions in a revised water quality control plan. The Accord, including its Attachment B, contained several provisions related to the San Joaquin River, and specifically to flows at Vernalis and a barrier at the head of Old River to protect fishery resources. These key provisions included:

1. The specific Vernalis flow objectives were established as "interim flows and [that] will be reevaluated as to timing and magnitude (up or down) within the next three years;"

2. During the three year period of the Accord, the Bureau of Reclamation would provide the flows, in accordance with the biological opinion for delta smelt;

3. During that three-year period decisions of the FERC might increase the contribution of flows from streams tributary to the San Joaquin River and those increased flows should be considered by the SWRCB in assigning responsibility for meeting a Vernalis flow objective; and

4. A barrier at the head of Old River would be installed during the April-May pulse flows.

On May 22, 1995, the SWRCB, after considering the Accord and recommendations by others, adopted the 1995 WQCP. In the section of the 1995 WQCP describing the Program of Implementation (at page 28), the SWRCB acknowledged these four provisions.

Shortly after the 1995 Plan was adopted, the SJTA filed suit challenging the 1995 WQCP. The litigation challenged several elements of the 1995 WQCP, including the Vernalis flow objectives and the environmental documentation that accompanied SWRCB approval of the objectives. The SJTA also challenged the 1995 WQCP because it did not require the installation of the barrier at the head of Old River during periods of the pulse flows. Various parties intervened on each side of the litigation.

The parties recognized that unless a negotiated settlement could be reached concerning both the need for the 1995 WQCP's Vernalis flow objectives and who should be responsible for providing the flows, years of litigation could result. Such litigation would frustrate efforts to implement important actions which all recognized could improve San Joaquin River fishery conditions. Thus, the parties decided to undertake a concerted, proactive effort to develop a comprehensive program that would settle all flow issues with respect to the parties within the context of the 1995 WQCP through the SWRCB water rights proceeding. The parties assembled a team of experienced hydrologists and biologists and asked them to develop a scientifically based, implementable program to improve chinook salmon resources in the San Joaquin River basin.

The parties believe that the proposed program will improve salmon populations in the San Joaquin River basin in a balanced manner which will solve a difficult regulatory issue related to how and to what extent the SWRCB should implement the 1995 WQCP's Vernalis flow objectives through the current water rights proceedings. This document describes the hydrologic and biologic bases for the proposal.

SUMMARY OF PROPOSAL AND BIOLOGICAL OVERVIEW

The actions included in the proposal were developed with a primary emphasis on instream flow and habitat conditions for fall-run chinook salmon within the San Joaquin River watershed, from the Merced River downstream (Figure 1). The focus on chinook salmon was based, in part, on the importance of the lower San Joaquin River as a migratory corridor for both upstream migrating adult salmon, and emigrating juveniles.

The actions are based on a consideration of the life cycle of fall run chinook salmon and are intended to enhance conditions, compared to historic baselines, for salmon and other native

The San Joaquin River Basin and Bay-Delta Estuary

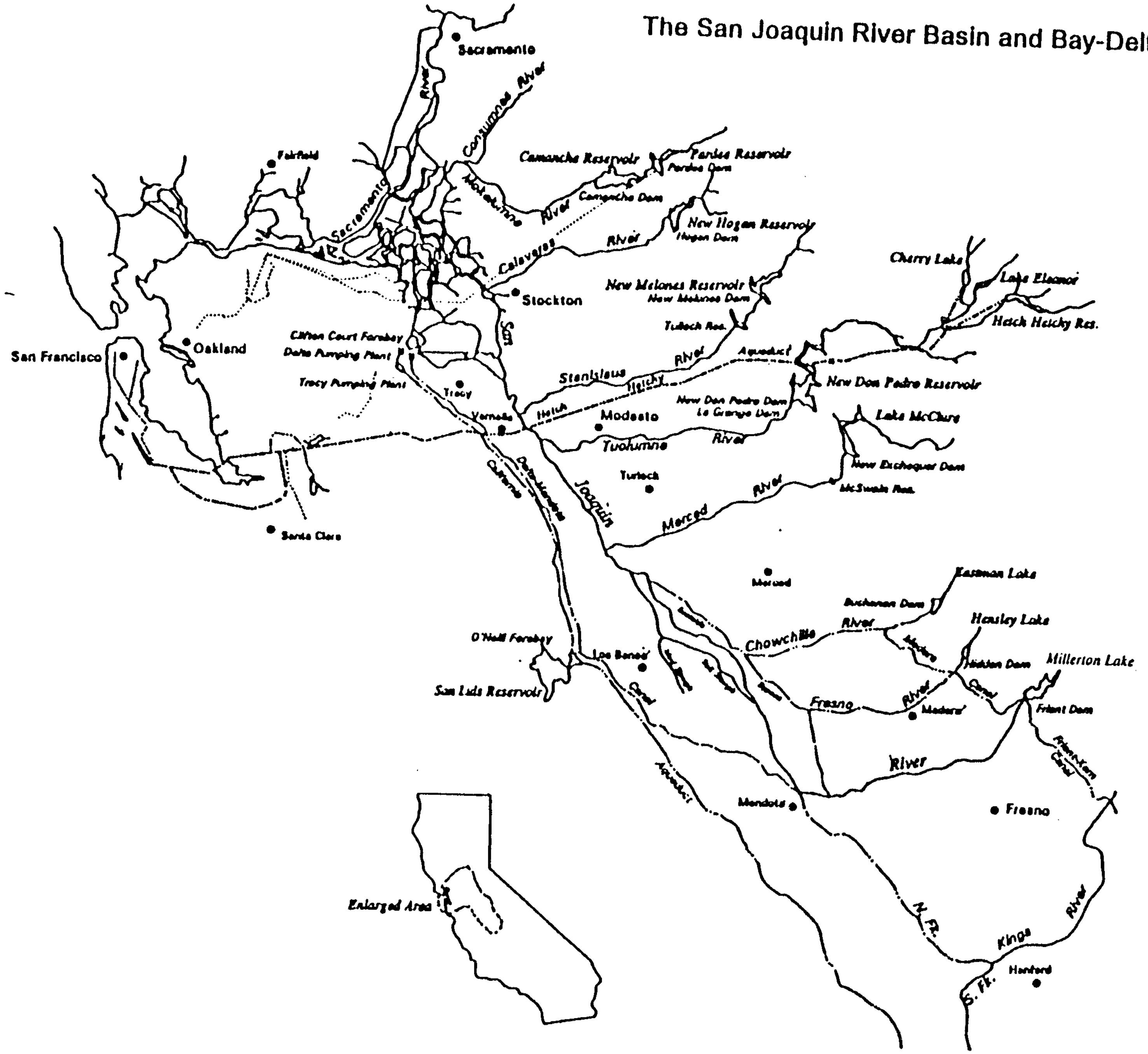

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Figure 1

species in the San Joaquin River and the southern Delta. During the late fall and early winter, adult salmon enter upstream areas on the Merced, Stanislaus, and Tuolumne rivers where spawning and egg incubation takes place. Adult chinook salmon spawn in loose gravel substrate where the eggs incubate until hatching. After hatching, juveniles emerge from the gravel, primarily during the late winter and early spring, and begin rearing within the upstream tributary areas. Some fry begin to move downstream from the tributaries to the Delta to rear, typically in February and early March. Others remain in the upstream tributaries and continue to rear until mid-April through mid-June. The majority of emigration occurs at the smolt stage between mid-April and mid-May.

A number of factors have been identified which may influence spawning success and survival of juvenile salmon rearing in upstream tributary areas. These factors include, but are not limited to:

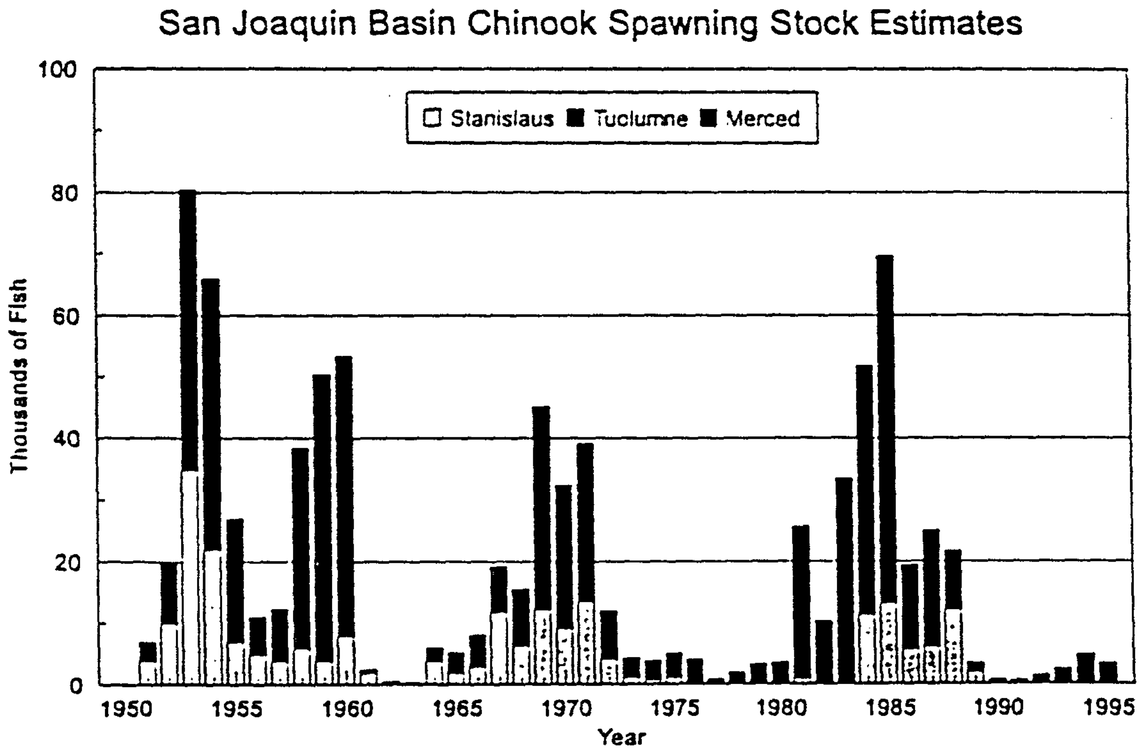
- Seasonal instream flow levels
- Water temperature
- Quality and availability of suitable gravels for spawning and egg incubation
- Various sources of mortality including losses at water diversions and predation.

These factors are being addressed by the parties and the appropriate resource agencies through implementation of various actions in the upstream tributary areas, including physical habitat rehabilitation and changes in flow regimes.

Similar factors have also been identified which influence survival of juvenile salmon during their emigration through the lower San Joaquin River and the Delta. Management actions recommended by others to increase survival of emigrating juveniles in the lower San Joaquin River have included minimum base flows during the late winter and spring and the use of pulsed flows to stimulate movement downstream from the tributaries and through the lower San Joaquin River before water temperatures become adverse. Installation of a barrier at the head of Old River has also been identified as an action necessary to reduce the passage of juvenile salmon from the lower San Joaquin River into the southern Delta where they are susceptible to predation and entrainment at SWP/CVP export facilities.

The proposal also considers the status of the fall-run adult chinook salmon stock. Monitoring has been performed within the upstream tributary areas to estimate the numbers of adult salmon returning to the system to spawn each year (adult escapement). Results of these spawning stock estimates, which have been primarily based on carcass surveys performed during the fall and early winter, have demonstrated that the number of adults returning to the San Joaquin River system each year has been highly variable (Figure 2). The historic pattern of adult escapement, although demonstrating high year-to-year variability, has shown no overall increasing or decreasing trend in abundance over the past forty plus years.

Figure 2


San Joaquin Basin Chinook Spawning Stock Estimates
Stanislaus
Tuolumne
Merced
Thousands of Fish
100
80
60
40
20
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year

The objective of the program described herein is to contribute to rapid and reliable implementation of:

- An integrated program of seasonal improvements in flows and habitat conditions within the tributaries and the lower San Joaquin River migration corridor which should contribute to an increase in juvenile salmon survival;
- An increase in spring flows, when compared to historical conditions;
- A balance between water supply and environmental benefits;
- Actions which are compatible and complementary with upstream habitat improvements and the actions specified by the Accord and 1995 WQCP.

The proposal provides for increased flows which can be achieved reliably over a range of water year types and hydrologic conditions. These flows are limited to those which are controllable by the parties; that is, to the range of flows which are within their ability to manage, and other controllable management actions. In addition, the enhanced flows will be coordinated with other non-flow actions in the San Joaquin River basin and the Bay-Delta estuary. These actions include installation of an operable barrier at the head of Old River (which would be subject to experimental testing and evaluation to quantify biological benefits as well as potential adverse impacts), and infrastructure improvements to increase the quality and availability of habitat within upstream areas for spawning and juvenile rearing and to reduce sources of mortality.

The enhanced flows during the spring period of juvenile emigration will be timed to respond to events of smolt emigration. A minimum average monthly base-flow of 1,000 cfs, measured at Vernalis, will be guaranteed during October, and the period February 15 through May 31. The seven-day running average of flow at Vernalis during these base-flow periods would not be more than 250 cfs below the minimum monthly average base-flow, and may be higher than the required base-flow in response to other hydrologic conditions occurring within the basin. During the spring period of salmon smolt emigration (April - May), the parties will provide an out-migration pulse flow volume, including the base flow, equivalent to:

- Thirty one days of 2,000 cfs in critical water years;
- Thirty one days of 3,000 cfs in dry water years;
- Thirty one days of 4,000 cfs in below normal water years;
- Thirty one days of 5,000 cfs in above normal and wet water years.

The water year classification in the proposal is based on the San Joaquin Valley water year type hydrologic classification (60/20/20). The flow volumes during the pulse flow period are guaranteed by the parties. Higher spring flows will occur in many wetter years due to natural hydrologic conditions and in other years through water purchases or contributions by other parties or programs.

The base flow and spring pulse flow volumes will result from a combination of natural runoff and coordinated flow releases. Timing, magnitude and duration of pulse flow events during the April-May period will be developed in consultation with state and federal resource agencies to represent an equivalent volume of flow. Operation of the fish barrier at the head of Old River during the spring will be coordinated to coincide with pulse flow releases.

The parties are also providing funding which will be used, in part, to supplement and better integrate the elements of existing biological monitoring programs. The integrated program should be designed to provide information necessary to evaluate the effectiveness of the actions implemented by the proposal. The parties recommend that monitoring include:

- Improved adult escapement monitoring within upstream tributary areas;
- Monitoring juvenile salmon production within the tributaries and continued trawling in the lower San Joaquin River at Mossdale;
- Mark and recapture studies, for example using coded-wire tags, to document smolt survival and identify potential sources and locations of mortality within the lower San Joaquin River and downstream into the Delta; and
- Experimental evaluation of the biological effects resulting from operation of the barrier at the head of Old River.

INTRODUCTION TO THE TECHNICAL ANALYSIS

Throughout the discussions which have led to this proposal, it has been the intent of the parties to make a significant contribution towards enhancing conditions for fall-run chinook salmon, including providing physical habitat and flows in the mainstem San Joaquin River to enhance the spawning success of adults and the emigration success of juveniles and smolts. Accordingly, this biological analysis focuses on these issues.

Technical representatives (hydrologists and biologists) of the parties were asked to address the following questions:

1. What volume of water is reasonably available to provide flows to aid salmon smolt emigration, in all year types and over extended droughts?
2. Would flow levels resulting from the proposal affect salmon smolt emigration across the Delta to Chipps Island?
3. Would installation of an operable barrier at the head of Old River affect the productivity of San Joaquin River salmon?

4. What management actions could be taken in the San Joaquin and its tributaries to enhance conditions for salmon spawning, rearing, and emigration?

The technical analyses addressing these questions was carried out to provide the parties and others with a sound understanding of the scientific bases for the recommended flow and non-flow actions. Section I summarizes the hydrologic analyses performed to evaluate the historical flow at Vernalis and the anticipated hydrologic effects of the proposal. Section II provides a summary of several analyses concerning the biological aspects of flows at Vernalis and installation of a barrier at the head of Old River.

SECTION I
SAN JOAQUIN RIVER HYDROLOGIC ANALYSIS

Introduction

The San Joaquin River interests have, in addition to non-flow actions, proposed to assure a minimum flow regime at Vernalis as a contribution to implementation of the 1995 WQCP. The proposed flow regime consists of base flows and an out-migration pulse flow volume to improve chinook salmon productivity. Specifically, the flow components of the proposal are:

- In all years, a base flow of 1,000 cfs for the period February 15 through May 31, and a base flow of 1,000 cfs during the month of October.
- A smolt emigration pulse flow volume, inclusive of the base flow, in April and/or May, equivalent to 31 days of 2,000 cfs in critical years, 3,000 cfs in dry years, 4,000 cfs in below normal years, and 5,000 cfs in above normal and wet years.

This section of the technical report describes the hydrologic analyses that evaluated the historical flow at Vernalis and the anticipated flows that would occur at Vernalis as a result of meeting the flow regime proposed by the parties. It also describes the incremental flows that would be requirement, if one attempted to fully meet the 1995 WQCP. Some additional background data concerning hydrologic conditions of the San Joaquin River are also included.

Concept of Providing Proposed Flows

Several of the San Joaquin River interests will be directly responsible for providing water to meet the proposed Vernalis minimum flow regime. These interests represent several entities who currently regulate and consumptively use water tributary to the San Joaquin River (South San Joaquin Irrigation District and Oakdale Irrigation District on the Stanislaus River, Modesto Irrigation District and Turlock Irrigation District on the Tuolumne River, and Merced Irrigation District on the Merced River, collectively referred to as the SJTA), or who could make available water to the San Joaquin River (Exchange Contractors). These parties do not include the Bureau of Reclamation (Reclamation), which regulates a portion of the flow at Vernalis through its operation of the Stanislaus River.

The proposal requires the minimum flow regime to be met by the SJTA and Exchange Contractors. Since the Stanislaus River (as operated by Reclamation) is one of the sources of water available to meet a Vernalis flow, it became necessary to identify and assume an operation for the New Melones Project. This assumed operation becomes critical to the proposal since it is the basis under which the San Joaquin River interests assessed the viability of committing to the flow regime. Should the Stanislaus River operation differ from that assumed in the analysis, the San Joaquin River interests will need to reassess their commitment to the flow proposal.

Analysis Methodology

The San Joaquin Area Simulation Model (SANJASM) was selected to evaluate the flow proposal. SANJASM is Reclamation's computer model that simulates San Joaquin River hydrology and operations. In late 1995, Reclamation provided a working version of SANJASM and input files associated with a pre-1995 WQCP San Joaquin River operation. Although Reclamation's depiction of the operations of the tributaries has been modified by this analysis, the underlying hydrologic assumptions (e.g., accretions and depletions, and reservoir inflows) have remained consistent with the original study provided by Reclamation.

Several steps of analysis were developed to evaluate the flow proposal. These steps are summarized as follows:

Step 1: Identify New Melones baseline operation

A baseline operation for New Melones needed to be identified and modeled in order to evaluate how much additional flow would be needed from other San Joaquin River tributaries to meet the flow proposal. The assumed operation of New Melones consists of operation criteria for five year types (critical, dry, below normal, above normal and wet). The operation criteria for critical years are determined by the hydrology of the 1987-92 drought. This hydrologic period is the most severe sequence of years for the 1922-92 historical period and consists of six consecutive critical years. The operation criteria for critical years assumed that the combination of New Melones inflow and reservoir storage would be allocated to 1) water rights commitments to South San Joaquin Irrigation District and Oakdale Irrigation District, 2) instream fishery flow needs of the Stanislaus River, and 3) water quality releases for South Delta agriculture.

Results showed that during the 1987-92 drought period a total of approximately 226,000 acre-feet per year could be released for instream fishery flow and water quality purposes. Of this total, it was assumed that 156,000 acre-feet per year would be allocated specifically to fishery purposes and 70,000 acre-feet per year would be allocated for water quality purposes. The pattern of fishery releases was fashioned to be consistent with spawning, incubation, rearing and migration needs of fall-run chinook salmon, providing an emphasis for flows during October through June, with an out-migration pulse flow occurring during May (The pulse flow associated with the proposal is to be available during the April through May period. For purposes of this analysis, the pulse flow has been assumed to occur during May.) Water quality releases from New Melones are assumed to typically occur during the summer months and will incidentally benefit the instream fishery.

Operation criteria for the non-critical year types were established by evaluating the second most severe drought sequence, 1922-35. This period of hydrology contained all five year types, and lead to somewhat arbitrary, but hydrologically constrained criteria that allowed an additional allocation of water during non-critical years. The hydrologic constraints that are placed upon the criteria are 1) the combined effect of water allocations during all five year types can not violate the capability of New Melones Reservoir (tested by the 1922-35 period), and 2) the effects of non-critical year water allocations can not violate the capability of New Melones during the 1987-92 period.

The focus of developing operation criteria for critical and non-critical years was to establish a reasonable minimum assumption for Reclamation's contribution to Vernalis flows based on the instream flow needs of the Stanislaus River. An approach was used that assumed that flows specifically for instream fishery needs would increase with water year wetness. An increase in minimum fishery releases of 25,000 acre-feet per year (as compared to the critical year type fishery releases) was assumed during dry and below normal years and an increase in minimum fishery releases of 50,000 acre-feet per year was assumed during above normal and wet years. Water was also additionally allocated to other Reclamation purposes (e.g., contracts) during above normal and wet years for purposes of identifying viable operations for New Melones.

Results of the study that apply the assumed operation criteria show that the assumed Stanislaus River fishery flows are viable, and that there is additional water available (except during critical years) for additional release and/or other Reclamation purposes (e.g., contracts and water quality). The assumed fishery releases (and pattern of release) predicate the commitment of the San Joaquin River interests to meet the flow proposal.

Step 2: Incorporate the effects of revised FERC flows on the Tuolumne River

The Accord states that the State Water Resources Control Board should consider decisions by the Federal Energy Regulatory Commission (FERC) during its assignment of responsibility for the Bay-Delta objectives among the water rights holders in the watershed. One such decision is the pending revision of minimum instream flows for the Tuolumne River. The second step of the analysis incorporated the pending FERC flows for the Tuolumne River.

Compared to the currently required FERC flows, an increment of additional minimum flow will be provided in all year types and in all months. The incremental increase in minimum annual flow ranges from approximately 40,000 acre-feet in critical years to approximately 175,000 acre-feet during above normal and wet years. These flows will enhance flows at Vernalis above conditions which existed at the time of the Accord and the 1995 WQCP.

Step 3: Determine supplemental requirements to meet the flow proposal

The amount of water additionally required to meet the base and pulse flows described earlier was then determined. This water will be provided by the SJTA and Exchange Contractors. The amount of water found to be additionally required above that provided by the baseline operation of the Stanislaus River, the revised operation of the Tuolumne River, the baseline operation of the Merced River (current FERC and Davis-Grunsky flow requirements) and other assumed basin hydrology and operations ranged annually between zero (primarily during wet years) and 47,000 acre-feet. In combination with the revised Tuolumne River minimum flows, between zero and 150,000 acre-feet of increased flow will be contributed towards meeting the flow proposal.

Anticipated Performance of Flow Proposal

The modeled effect of the flow proposal during the 31-day pulse flow period is illustrated in Exhibit H-8. This graphic depicts the average 31-day flow that could occur over the range of hydrologic conditions associated with the historical 1922-92 hydrologic period. In numerous years supplemental water will be provided to meet the flow proposal. In many other years, flows in excess of the flow proposal will occur.

Exhibit H-9 depicts a separate illustration of the enhancement of flows that are expected to occur as a result of the flow proposal. Exhibit H-9 illustrates historical flows at Vernalis (1971-1995) during the months of April and May, arranged by ascending San Joaquin Valley Water Year Classification. Superimposed on the charts are the minimum flows, by year type, to be assured at Vernalis by the SJTA and Exchange Contractors. The charts illustrate that in most critical, dry, below normal and above normal years flow conditions will be improved during the 31-day pulse flow period in comparison to historical conditions.

Other Hydrologic Concerns

Concern has been expressed regarding the potential of summer flow reductions at Vernalis as the result of providing spring flows for fishery purposes. Analyses indicate that summer flows will likely increase above historical conditions. This conclusion is based on the anticipated effects of higher year-round flow requirements on the Tuolumne River (required by FERC) and the limited ability to significantly reduce operational canal return flows as a means to recoup the water released for fishery purposes.

Concerning the year-round addition of flow due to the pending Tuolumne River minimum flow requirements, minimum instream flows during the summer will be at least 50 cfs during critical years, which generally represents a doubling of historical releases. During dry years, the pending minimum flow (75 cfs) will at least equal historical releases. And, during below normal, above normal and wet years, the pending minimum flow will substantially increase summer-time flows. The minimum flow requirement during these year types will be 250 cfs compared to flows that were historically as low as 10 cfs.

Concerning the potential of reducing canal system return flows to recoup the water released for fishery purposes, the data shows that during summer months (June through August), canal system return flows (flow which ultimately becomes San Joaquin River flow) generally amount to less than 10 percent of the water diverted to the canal systems. During drought years, the volume generally decreases to less than 5 percent of the diverted water. These existing efficiencies provide limited ability to significantly reduce summer-time return flows. In combination with the increase in instream flow requirements from the Tuolumne River, it is likely that a net increase in summer flows will occur.

Additional Incremental Water Required to Meet 1995 WQCP

The Accord and the 1995 WQCP recognize that the flow objectives at Vernalis are subject to redetermination, and that during the three year period of the Accord, the Bureau of Reclamation would attempt to provide the flows. The analyses and results previously described use the flow proposal as the basis of determining supplemental water provided by the SJTA and Exchange

Contractors. An additional analysis was performed to estimate the additional supplemental water required to meet the interim flow objective at Vernalis identified in the 1995 WQCP.

Exhibit H-14 illustrates the incremental additional water, over those amounts provided as a result of the flow proposal, required to meet the interim flow objective at Vernalis. In addition to the water provided by the SJTA and Exchange Contractors for the flow proposal, up to 200,000 acre-feet per year would be required to fully meet the 1995 WQCP Vernalis flow objectives, including several periods of sequential years requiring over 70,000 acre-feet per year. This analysis provides an indication of the potential water supply impacts associated with attempting to achieve the Vernalis flow objective of the 1995 WQCP.

Exhibits Illustrating Hydrologic Analyses

Exhibits, with additional annotations regarding the several hydrologic analyses follow.

Exhibit H-1
The San Joaquin River Basin and Bay-Delta Estuary

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The San Joaquin River Basin and Bay-Delta Estuary

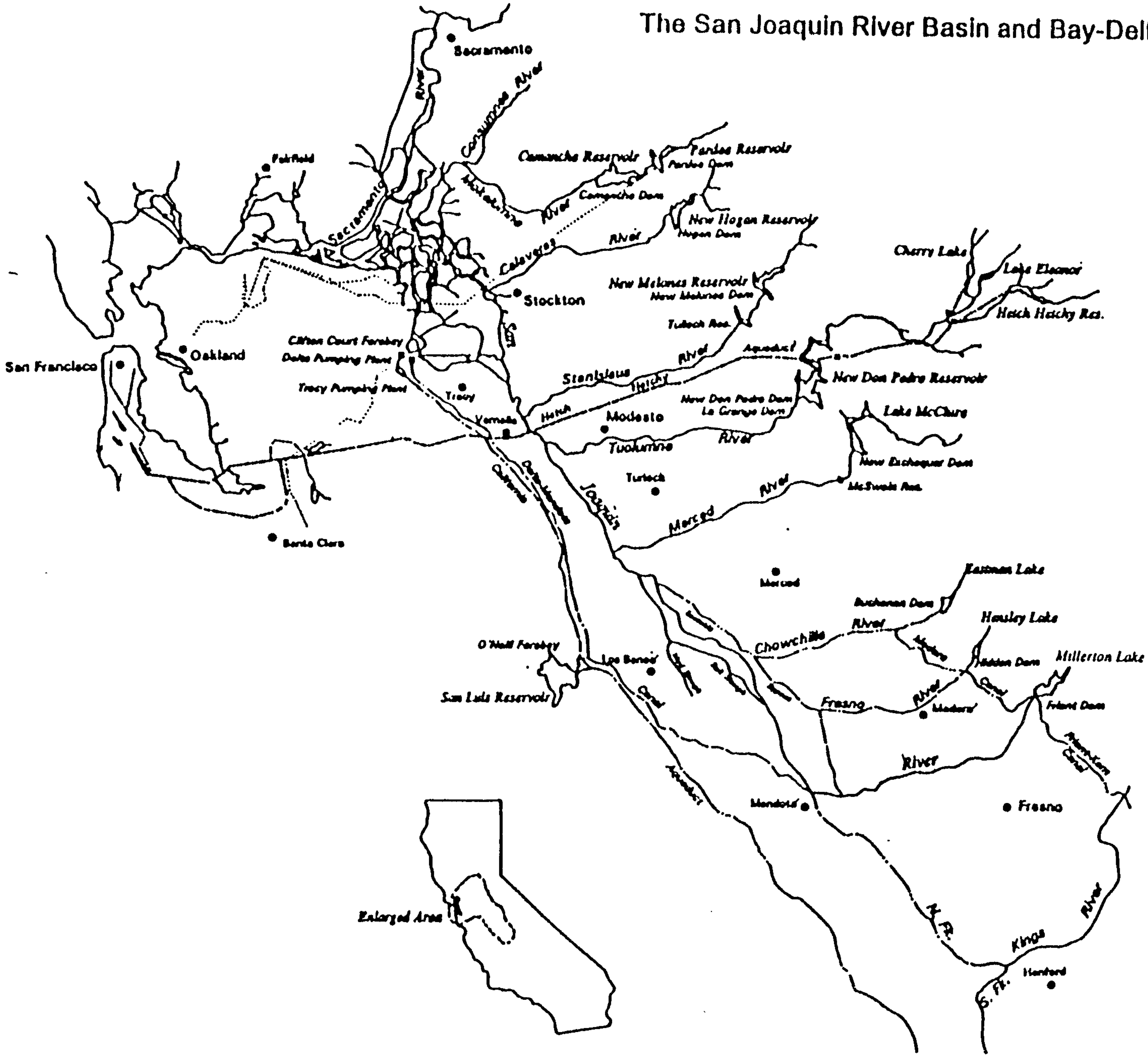

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Exhibit H-2
New Melones Operation Assumptions During Critical Years

A baseline operation for New Melones needed to be identified to determine the amount of additional water required from the other tributary sources. The 1987-92 hydrologic period is the most severe drought of record. During this period, consisting of six sequential critical years, water deliveries and releases are constrained by inflow and reservoir storage. An average of 226,000 acre-feet per year remains available during this drought period for purposes other than serving deliveries to holders of prior water rights (South San Joaquin Irrigation District and Oakdale Irrigation District).

The 226,000 acre-feet per year was allocated between fishery releases (156,000 acre-feet) and water quality releases (70,000 acre-feet). The fishery releases were patterned to focus fishery benefits during the October through June period. The water quality releases supplement summer releases.

The results for this drought period determined the operation rule for critical years. Any additional delivery or release during a critical year would violate the capability of New Melones during the 1987-92 drought. Exhibit H-2 illustrates the simulated operation of New Melones Reservoir during the 1987-92 drought period using the assumed delivery and release criteria for critical years. New Melones Reservoir begins the drought cycle (1987) with maximum storage as constrained by flood control storage limits. Thereafter, releases and deliveries deplete reservoir storage throughout the drought until the end of 1992. At the end of 1992, New Melones storage is approximately at minimum. While the allocation among uses during the critical period could be changed, no additional water is available.

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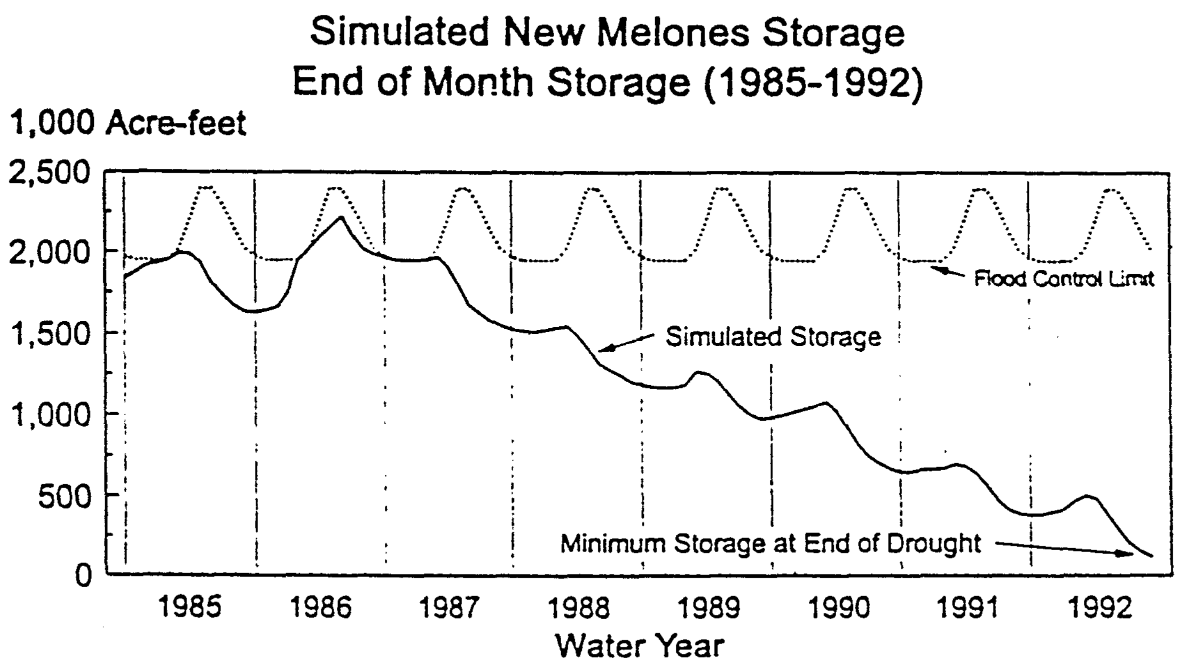
New Melones Operation Assumptions During Critical Years



Water Delivery/Allocation for Critical Years Based on 1987 - 1992 Drought

Water Rights Deliveries
<u>S. San Joaquin & Oakdale</u>

525 TAF (Average)

Fishery Releases
<u>Downstream of Goodwin</u>

156 TAF per year

Water Quality Releases In
<u>Addition to Fishery Releases</u>

70 TAF per year

Total Downstream
<u>Releases at Goodwin</u>

226 TAF per year

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Exhibit H-3
New Melones Operation Assumptions During Non-Critical Years

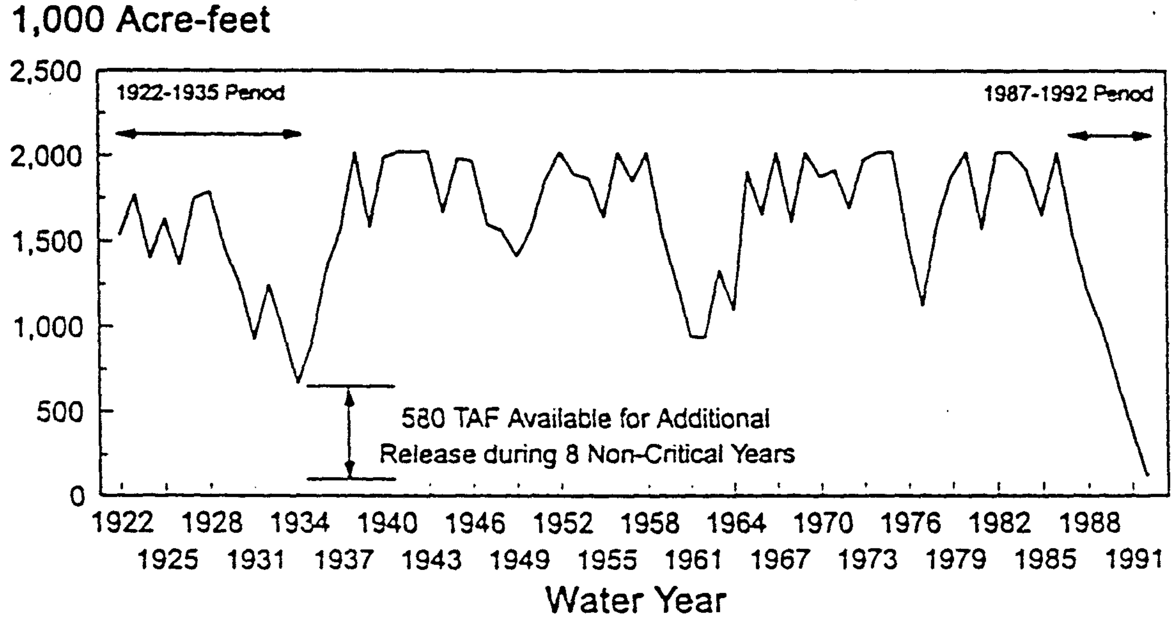
Although water allocation during critical years is limited by the 1987-92 drought period, there is additional water available for allocation during non-critical years. This next step of analysis determines an initial allocation of additional water during non-critical years. The focus of this step is to determine an increase in fishery flows during non-critical years that is viable without violating the operational capability of New Melones during the 1987-92 drought.

The critical year water allocations were incorporated into an operation study that included the full hydrologic analysis period (1922-92). Exhibit H-3 illustrates the results of this study in terms of ending water year storage for New Melones Reservoir. The results were reviewed and showed that the 1922-35 sequence is the second most severe drought. Within this period there are several non-critical years, and the amount of water that could be allocated to these years and still maintain a viable operation equaled approximately 580,000 acre-feet. This is the amount of water remaining above New Melones minimum storage and the low point of storage resulting from only releasing 226,000 acre-feet per year to the river.

An assumed allocation was made for utilization of the additional water during non-critical years. Fishery releases were allocated an additional 25,000 acre-feet per year (above the 156,000 acre-feet) during dry and below normal years, and an additional 50,000 acre-feet above the critical year schedule during above normal and wet years. For all years the water quality releases were capped at 70,000 acre-feet. An allocation (49,000 acre-feet) to other project uses (e.g., CVP contract deliveries) was assumed during above normal and wet years (see Exhibit H-3).

New Melones Operation Assumptions During Non-Critical Years

New Melones Storage Assuming 156 TAF Fishery Release in All Years End of September (1922-1992)



Water Delivery/Allocation for All Year Types Based on 1987-1992 Drought and the 1922-1935 Period

Water Year Type San Joaquin Valley	Water Rights Deliveries S. San Joaquin & Oakdale	Fishery Releases Downstream of Goodwin	Water Quality Releases In Addition to Fishery Releases	Allocation to Other Uses (e.g., CVP Contracts)
Wet	600 TAF	206 TAF per year	70 TAF per year	49 TAF per year
Above Normal	600 TAF	206 TAF per year	70 TAF per year	49 TAF per year
Below Normal	600 TAF	181 TAF per year	70 TAF per year	0 TAF per year
Dry	600 TAF	181 TAF per year	70 TAF per year	0 TAF per year
Critical	387-600 TAF	156 TAF per year	70 TAF per year	0 TAF per year

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Exhibit H-4
New Melones Operation with Assumed Water Delivery and Release Allocations

The allocation assumptions for all years were tested through an operation study for the entire 1922-92 hydrologic period and the results are shown in Exhibit H-4. The assumptions for non-critical years leads to additional use of New Melones storage without affecting the viability of the 1987-92 operation.

Various alternative allocation assumptions could be used for the non-critical years.

New Melones Operation
With Assumed
Water Delivery and Release Allocations

End of September New Melones Storage (1922-1992)

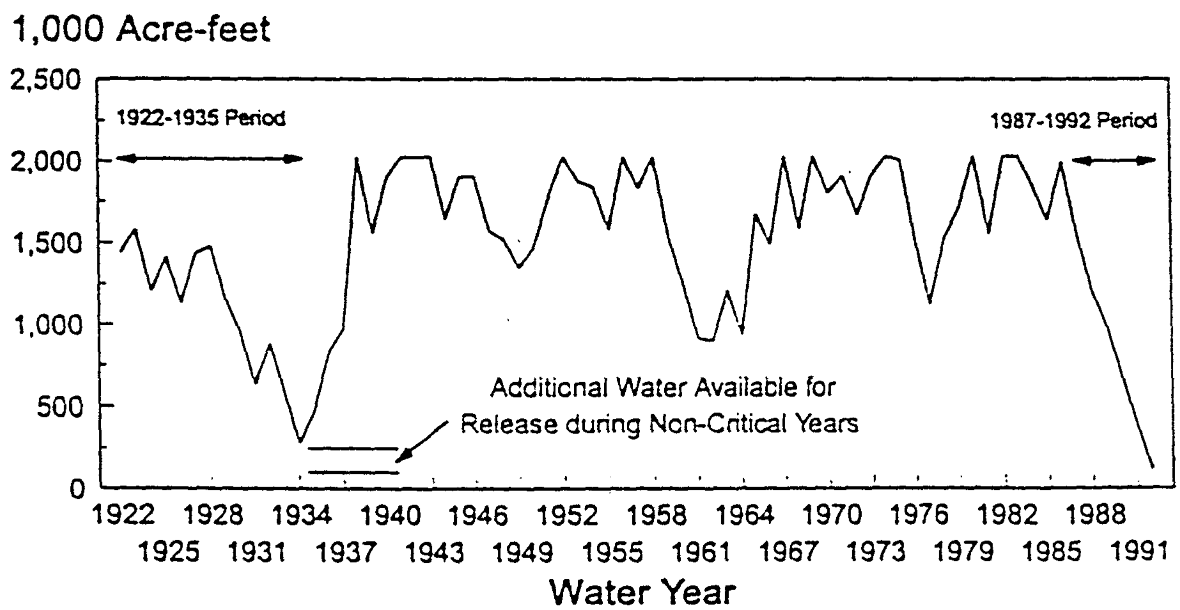

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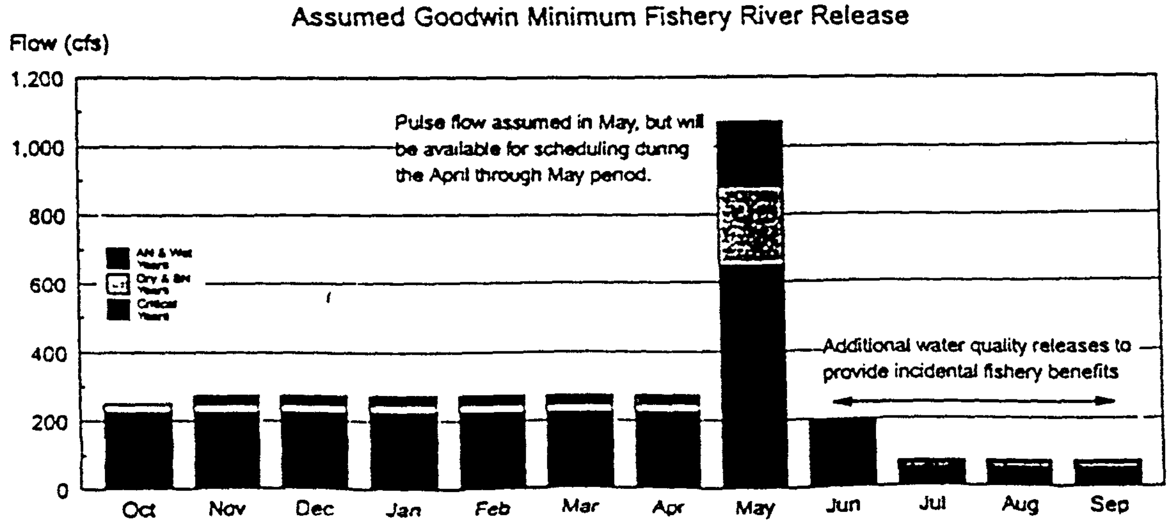
Exhibit H-5
Stanislaus River Fishery Release Assumptions

Exhibit H-5 depicts the fishery release assumptions used in the development of this proposal. The release assumptions focus on providing a base of stable flows for the October through June period with a pulse flow volume available for scheduling during the April through May period. This analysis assumes the pulse flow period occurs during May.

Stanislaus River Fishery Release Assumptions

Month	Critical Years (cfs)	Dry and BN Years (cfs)	AN and Wet Years (cfs)
Oct	225	225	250
Nov	225	240	275
Dec	225	240	275
Jan	225	240	275
Feb	225	240	275
Mar	225	240	275
Apr	225	240	275
May	225 (650 with pulse)	240 (960 with pulse)	275 (1,070 with pulse)
Jun	200	200	200
Jul	50	50	75
Aug	50	50	75
Sep	50	50	75
Additional Pulse Flow Volume - (AF) (Assumed Added to May Release)	26,300	44,700	49,000
Total Annual Release (AF)	156,000	181,000	206,000

Assumed Goodwin Minimum Fishery River Release



D-003500

Exhibit H-6
Tuolumne River Flow Requirements Below La Grange Bridge
Current, and Pending FERC Approval

An element of flow that will improve the flow at Vernalis above historical conditions is the pending revision of minimum instream flows for the Tuolumne River. Assuming Federal Energy Regulatory Commission (FERC) approval, instream flows within the Tuolumne River will increase in all years and in all months. This flow increase within the Tuolumne River will incidentally provide additional flow at Vernalis. Exhibit H-6 compares the historical and pending annual flow requirements within the Tuolumne River. The pending FERC flows are incorporated into this analysis and contribute to meeting the proposed flows.

D-003501

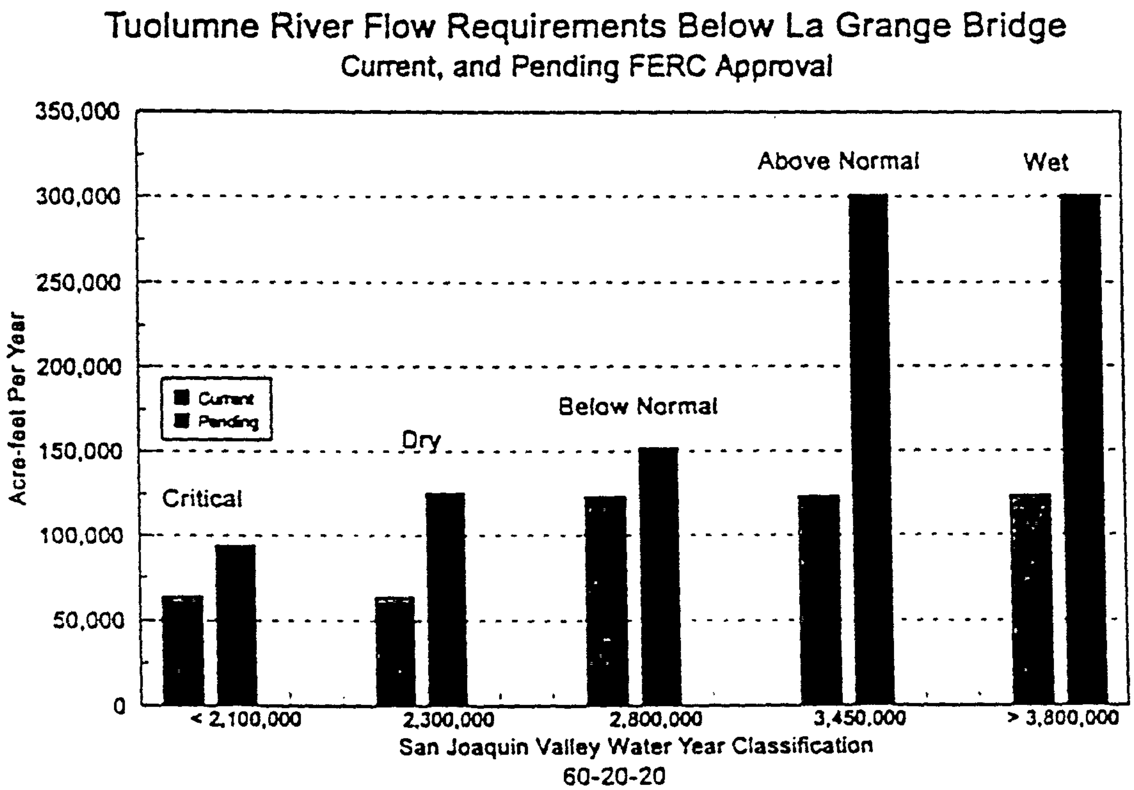

Tuolumne River Flow Requirements Below La Grange Bridge
Current, and Pending FERC Approval
Acre-feet Per Year
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Current
Pending
Critical
Dry
Below Normal
Above Normal
Wet
< 2,100,000
2,300,000
2,800,000
3,450,000
> 3,800,000
San Joaquin Valley Water Year Classification
60-20-20

Exhibit H-7
Supplemental Water Provided by Proposal and Additional Operation Information

The supplemental water required to meet the proposed flows at Vernalis is identified in Exhibit H-7. Column 1 identifies the amount of water that is required to meet the proposed minimum flows above that provided by the baseline New Melones operation, the incorporation of the revised FERC flows for the Tuolumne River, FERC and Davis-Grunsky required flows for the Merced River, and other assumed flows and operations of the San Joaquin River. The amount of water required to be provided by the San Joaquin Tributary Association and the Exchange Contractors ranges between zero (primarily during wet years) and 47,000 acre-feet.

Exhibit H-7 also illustrates certain additional information concerning the New Melones operation and water quality in the San Joaquin River. Column 2 identifies the annual amount of water provided by New Melones for water quality control. This value ranges from zero (during certain wet years) up to 70,000 acre-feet (as capped by the assumed allocation assumption). Reaching the assumed cap is an indicator that all downstream water quality objectives are not being met. Column 3 provides an estimate of the additional water that would be necessary to fully meet the Vernalis water quality objectives of the 1995 WQCP..

Supplemental Water Provided by Proposal And New Melones Operations

			Column 1	Column 2	Column 3	Column 4
Index 602020	Year Class	Water Year	Total Suppl Water Req. TAF	Melones WQ Release TAF	Suppl Req WQ Release TAF	Melones EOY Storage TAF
4,543,729	Wet	1922	0	70	23	1439
3,549,358	Above	1923	0	70	32	1583
1,419,746	Critical	1924	28	70	69	1203
2,929,617	Below	1925	9	70	11	1414
2,300,567	Dry	1926	0	70	83	1130
3,558,955	Above	1927	2	66	0	1440
2,632,407	Below	1928	17	71	38	1481
2,004,815	Critical	1929	16	71	96	1160
2,016,115	Critical	1930	16	71	81	959
1,200,755	Critical	1931	32	70	21	632
3,410,299	Above	1932	36	33	0	888
2,440,676	Dry	1933	20	71	37	578
1,440,719	Critical	1934	28	70	49	281
3,557,242	Above	1935	0	43	0	474
3,740,020	Above	1936	0	66	0	826
3,897,744	Wet	1937	0	61	0	978
5,894,485	Wet	1938	0	39	0	2025
2,198,794	Dry	1939	7	70	159	1555
3,363,785	Above	1940	0	70	9	1902
4,425,561	Wet	1941	0	70	14	2025
4,440,988	Wet	1942	0	0	0	2025
4,027,938	Wet	1943	0	70	24	2025
2,762,892	Below	1944	15	70	113	1643
3,589,490	Above	1945	0	70	54	1900
3,304,892	Above	1946	17	70	56	1902
2,183,022	Dry	1947	23	70	143	1575
2,698,202	Below	1948	0	71	11	1520
2,532,700	Below	1949	26	70	46	1348
2,853,868	Below	1950	39	70	40	1478
3,139,076	Above	1951	31	71	13	1785
5,165,443	Wet	1952	0	0	0	2025
3,025,128	Below	1953	37	70	63	1868
2,720,188	Below	1954	20	70	55	1834
2,300,190	Dry	1955	4	70	130	1581
4,463,080	Wet	1956	0	21	0	2025
3,007,926	Below	1957	23	70	32	1826
4,773,169	Wet	1958	0	0	0	2025
2,208,788	Dry	1959	25	70	141	1548
1,854 036	Critical	1960	2	70	125	1248
1 375.467	Critical	1961	24	69	106	916
3,073,473	Below	1962	24	70	30	899
3,572,896	Above	1963	0	40	0	1212
2,186,845	Dry	1964	20	70	95	933
3,811,935	Wet	1965	0	58	0	1678
2,513 619	Below	1966	47	70	68	1488
5,251,876	Wet	1967	0	0	0	2025
2,214,280	Dry	1968	20	70	143	1588
6,094,546	Wet	1969	0	0	0	2025
3,183,296	Above	1970	19	70	54	1800
2,885,824	Below	1971	39	70	74	1902
2,158,908	Dry	1972	35	70	136	1670
3,495,450	Above	1973	0	70	8	1905
3,903,413	Wet	1974	0	61	0	2025
3,846,306	Wet	1975	0	70	10	1998
1,568,133	Critical	1976	12	70	138	1519
838,770	Critical	1977	28	70	72	1121
4,582,803	Wet	1978	0	47	0	1529
3,668,900	Above	1979	0	70	9	1707
4,730,351	Wet	1980	0	36	0	2025
2,442,155	Dry	1981	16	71	129	1556
5,446,045	Wet	1982	0	0	0	2025
7,220,475	Wet	1983	0	0	0	2025
3,688,593	Above	1984	37	70	72	1844
2,403,226	Dry	1985	15	70	136	1635
4 305,385	Wet	1986	0	70	33	1986
1,861,362	Critical	1987	9	70	142	1557
1,476,178	Critical	1988	22	70	106	1204
1,963,675	Critical	1989	18	70	82	981
1,514,587	Critical	1990	27	69	89	672
1,955,459	Critical	1991	1	70	34	390
1,557,439	Critical	1992	23	70	42	115

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Exhibit H-8
Estimated 31-Day Outmigration Flow
Vernalis with Proposed Operations

The anticipated performance of the flow proposal is depicted by Exhibit H-8. The performance is shown in terms of a 31-day flow that would occur during the April through May period. The flow proposal provides the assurance of meeting a varying minimum flow for each year type. The exhibit also illustrates that in many years flows in excess of the minimums will occur due to uncontrolled hydrologic events (flows in excess of 10,000 cfs are not shown due to the scale of the chart).

Estimated 31-Day Outmigration Flow

Vernalis with Proposed Operations

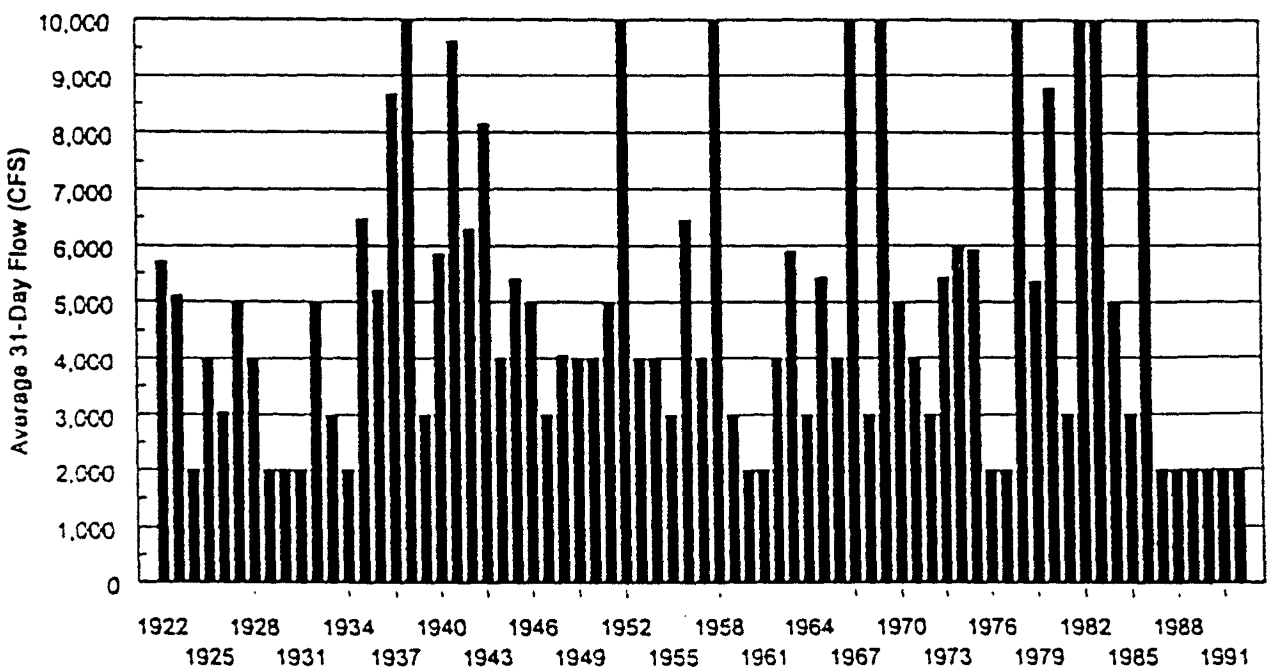

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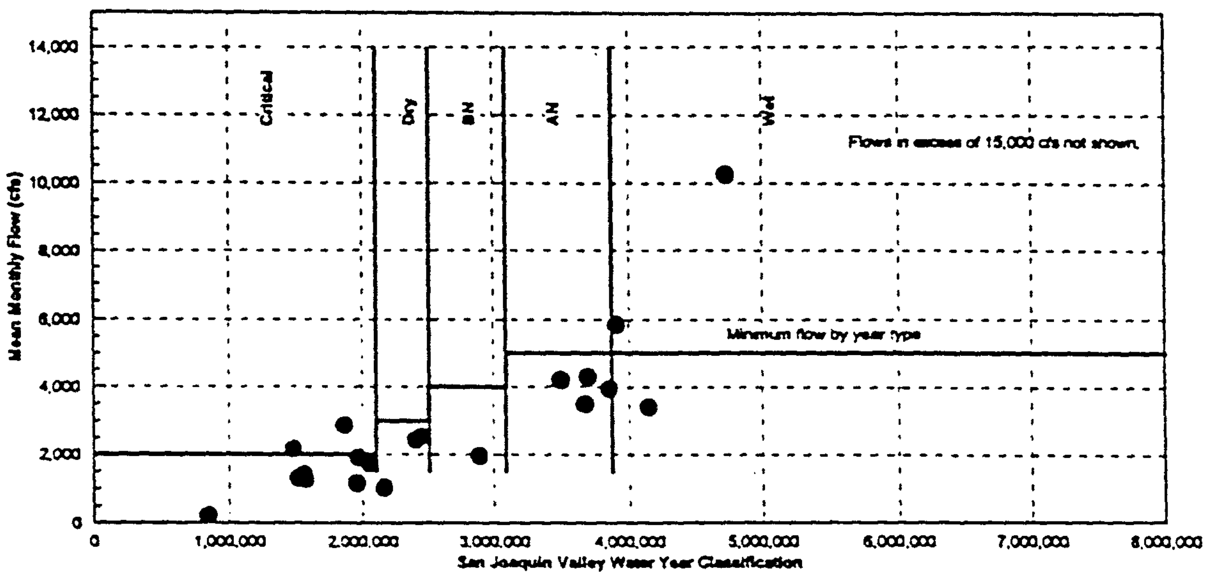
Exhibit H-9
Historical Vernalis Flows with Flow Proposal Superimposed

An additional perspective of the flow improvement associated with the flow proposal is the superimposition of the flow proposal on an illustration of the historical flows that have occurred at Vernalis. Exhibit H-9 illustrates historical flows at Vernalis during the months of April and May for the 1971-1995 period, arranged by ascending San Joaquin Valley Water Year Classification. Superimposed on the charts are the minimum flows, by year type, to be provided at Vernalis by the San Joaquin Tributary Association and the Exchange Contractors. The flow proposal will consistently improve flow into the delta during either April or May during critical, dry, below normal and above normal years in comparison to historical conditions, and provide an assurance of at least 5,000 cfs at Vernalis in wet years..

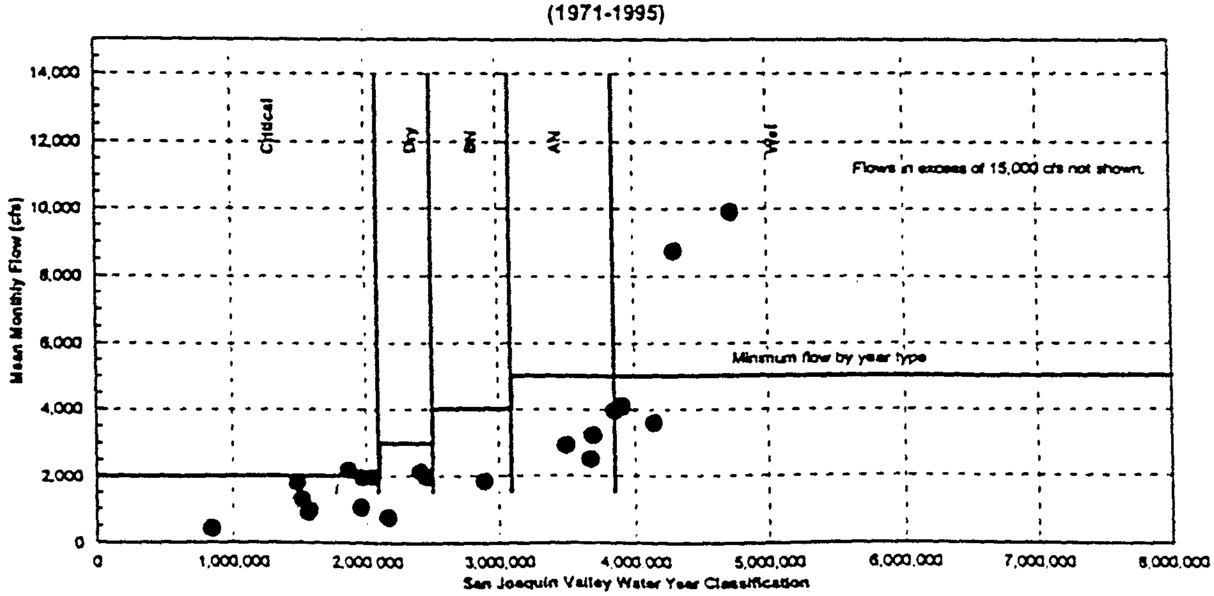
Historical Vernalis Flows
With Minimum Flow Superimposed In Either April or May

April
(1971-1995)



Or,

May
(1971-1995)



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Concerns with Reduction in Summer Flows Due to Flow Proposal

Exhibit H-10
Comparison Between Historical Summer Releases to the Tuolumne River and Pending FERC Required Summer Releases

Concern has been expressed concerning the potential of summer flow reductions due to the provision of flows during the spring outmigration period. Exhibit H-10 and Exhibit H-11 provides information that illustrates how summer flows will likely not be adversely affected by the flow proposal. Summer flows will remain consistent with historical flows, if not increased due to higher minimum flows established in the tributaries.

Exhibit H-10 illustrates the historical summer flows that have occurred in the Tuolumne River under current FERC requirements. In most of the historical condition, these flows would be increased due to the pending FERC requirements. Releases during the summer down the Tuolumne River will increase above those levels that have historically occurred. For instance, during critical years the pending FERC requirements will provide at least 50 cfs to the Tuolumne River during summer months. This requirement will in effect double the release that has historically occurred. During dry years, the pending FERC requirements will require at least 75 cfs to be provided to the Tuolumne River, which will at least provide the same level of release as the flow historically experienced. During below normal, above normal and wet years, the pending FERC requirements will significantly increase summer releases from the levels historically experienced. The pending FERC summer release requirement is 250 cfs compared to historically experienced flows which have been as low as 10 cfs.

Comparison Between Historical Summer Releases to the Tuolumne River And Pending FERC Required Summer Releases

Flow Year	Historical Summer Flows below La Grange Bridge - CFS Jun	Jul	Aug	Sep	SJ Valley Water Year Classification Index	Class	Tuolumne River Minimum Flow Requirement June 1 through September 30 (Pending FERC Approval)
1977	10	7	6	4	838,770	Critical	
1988	16	16	17	18	1,476,178	Critical	
1990	19	18	23	26	1,514,587	Critical	
1992	18	17	21	23	1,557,439	Critical	
1976	7	19	9	16	1,568,133	Critical	50 CFS
1987	15	13	33	13	1,861,362	Critical	
1991	30	25	23	21	1,955,459	Critical	
1989	44	49	46	49	1,963,675	Critical	
1994	24	23	22	22	2,042,724	Critical	
1972	9	9	10	10	2,158,908	Dry	75 CFS
1985	47	68	35	27	2,403,226	Dry	
1981	79	63	42	29	2,442,155	Dry	
1971	9	13	18	9	2,885,824	Below	
1973	103	45	33	10	3,495,450	Above	
1979	58	110	54	221	3,668,900	Above	
1984	21	51	31	42	3,688,593	Above	
1975	57	89	58	622	3,846,306	Wet	
1974	65	103	370	1,142	3,903,413	Wet	250 CFS
1993	323	181	476	883	4,143,494	Wet	
1986	1,460	123	119	575	4,305,385	Wet	
1978	245	113	94	274	4,582,803	Wet	
1980	1,833	81	20	1,109	4,730,351	Wet	
1982	1,893	1,777	652	2,425	5,446,045	Wet	
1983	5,022	3,706	1,739	3,449	7,220,475	Wet	

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Exhibit H-11
Modesto Irrigation District Canal System Return Flows

Concerning the potential of reducing canal system return flows to recoup the water released for fishery purposes, Exhibit H-11 illustrates the performance of the Modesto Irrigation District canal system. The exhibit provides information regarding the actual return flows (in terms of cfs) of the system and the representation of these return flows in terms of surface water diversions (in terms of percent of diversion). In the context of the absolute return flow rates involved, the implied efficiency of the return rates, and the additional summer releases to the Tuolumne River, a conclusion is drawn that summer flows affected by the Tuolumne River will remain consistent with historical conditions or be improved.

Modesto Irrigation District
Canal System Return Flows

Water Year	Return flow as a percentage of combined diversion (Percent)				SJ Valley Water Year Classification	
	Jun	Jul	Aug	Sep	Index	Class
1977	2	3	5	9	838,770	Critical
1988	7	4	14	9	1,476,178	Critical
1990	6	5	10	24	1,514,587	Critical
1992	8	6	9	11	1,557,439	Critical
1976	6	4	5	13	1,568,133	Critical
1987	8	11	9	15	1,861,362	Critical
1991	6	5	7	13	1,955,459	Critical
1989	5	5	7	24	1,963,675	Critical
1994	7	5	7	11	2,042,724	Critical
1972	5	3	3	8	2,158,908	Dry
1985	5	5	5	13	2,403,226	Dry
1981	8	9	11	16	2,442,155	Dry
1971	10	9	11	15	2,885,824	Below
1973	4	5	7	16	3,495,450	Above
1979	8	7	12	14	3,668,900	Above
1984	9	5	14	24	3,688,593	Above
1975	7	8	9	11	3,846,306	Wet
1974	6	7	7	13	3,903,413	Wet
1993	10	8	11	31	4,143,494	Wet
1986	10	8	13	35	4,305,385	Wet
1978	9	7	6	20	4,582,803	Wet
1980	14	13	14	16	4,730,351	Wet
1995	7	9	14	24	5,200,000	Wet
1982	13	10	15	30	5,446,045	Wet
1983	13	12	14	23	7,220,475	Wet

Water Year	Return flow from Modesto Irrigation District (Mean Monthly CFS)				SJ Valley Water Year Classification	
	Jun	Jul	Aug	Sep	Index	Class
1977	14	21	26	17	838,770	Critical
1988	40	41	58	25	1,476,178	Critical
1990	39	39	56	91	1,514,587	Critical
1992	45	39	53	42	1,557,439	Critical
1976	47	34	29	45	1,568,133	Critical
1987	63	77	66	72	1,861,362	Critical
1991	35	35	50	59	1,955,459	Critical
1989	34	42	46	68	1,963,675	Critical
1994	54	44	57	51	2,042,724	Critical
1972	29	24	19	16	2,158,908	Dry
1985	44	48	34	74	2,403,226	Dry
1981	80	90	88	79	2,442,155	Dry
1971	80	89	93	61	2,885,824	Below
1973	45	51	66	70	3,495,450	Above
1979	70	82	110	80	3,668,900	Above
1984	85	49	131	159	3,688,593	Above
1975	70	80	88	68	3,846,306	Wet
1974	54	65	60	93	3,903,413	Wet
1993	79	66	92	163	4,143,494	Wet
1986	90	76	90	150	4,305,385	Wet
1978	78	68	49	66	4,582,803	Wet
1980	137	113	130	147	4,730,351	Wet
1995	70	81	101	153	5,200,000	Wet
1982	132	105	137	159	5,446,045	Wet
1983	127	119	138	191	7,220,475	Wet

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Exhibit H-12
Merced Irrigation District 1988-1992 Tailwater to Tributaries of the San Joaquin River

Exhibit H-12 illustrates the relatively small amount of canal system return flow that re-enters the San Joaquin River and its tributaries. During the recent drought, it is shown that canal system return flows from Merced Irrigation District amount to approximately five percent (or less) of the total water diverted. This level of efficiency does not provide opportunities for substantial improvement, which would in effect potentially decrease summer flows in the San Joaquin River. Certain system releases also occur in addition to the values shown in Exhibit H-12; however, these releases are not known to be in hydraulic continuity with the San Joaquin River or serve as a source of water to senior water right holders located in the Merced River basin.

Merced Irrigation District Tailwater to Tributaries Of the San Joaquin River

Water Year	Return flow as a percentage of diversion (Percent)			
	Jun	Jul	Aug	Sep
1988	1	1	5	12
1989	1	1	2	12
1990	<1	<1	<1	3
1991	4	3	4	8
1992	2	3	2	5

Water Year	Return flow (Mean Monthly CFS)			
	Jun	Jul	Aug	Sep
1988	13	12	71	62
1989	12	10	28	66
1990	3	3	4	3
1991	35	42	58	65
1992	15	29	21	40

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Exhibit H-13
Water Provided in Excess of Stanislaus River Assumed Flow to Meet San Joaquin Flow Proposal

Exhibit H-13 illustrates the amount of water that will be provided towards the proposed flow regime by the SJTA interests and the Exchange Contractors. The values shown depict both increases in Tuolumne River flows due to the pending FERC decision and additional water to be provided by the SJTA and Exchange Contractors. Although additional water is provided in all years (due to increased flows in the Tuolumne River), the graphic only represents the amount of additional water that is used towards assuring the minimum flows of the flow proposal.

Water Provided In Excess of Stanislaus River Assumed Flow To Meet San Joaquin Flow Proposal

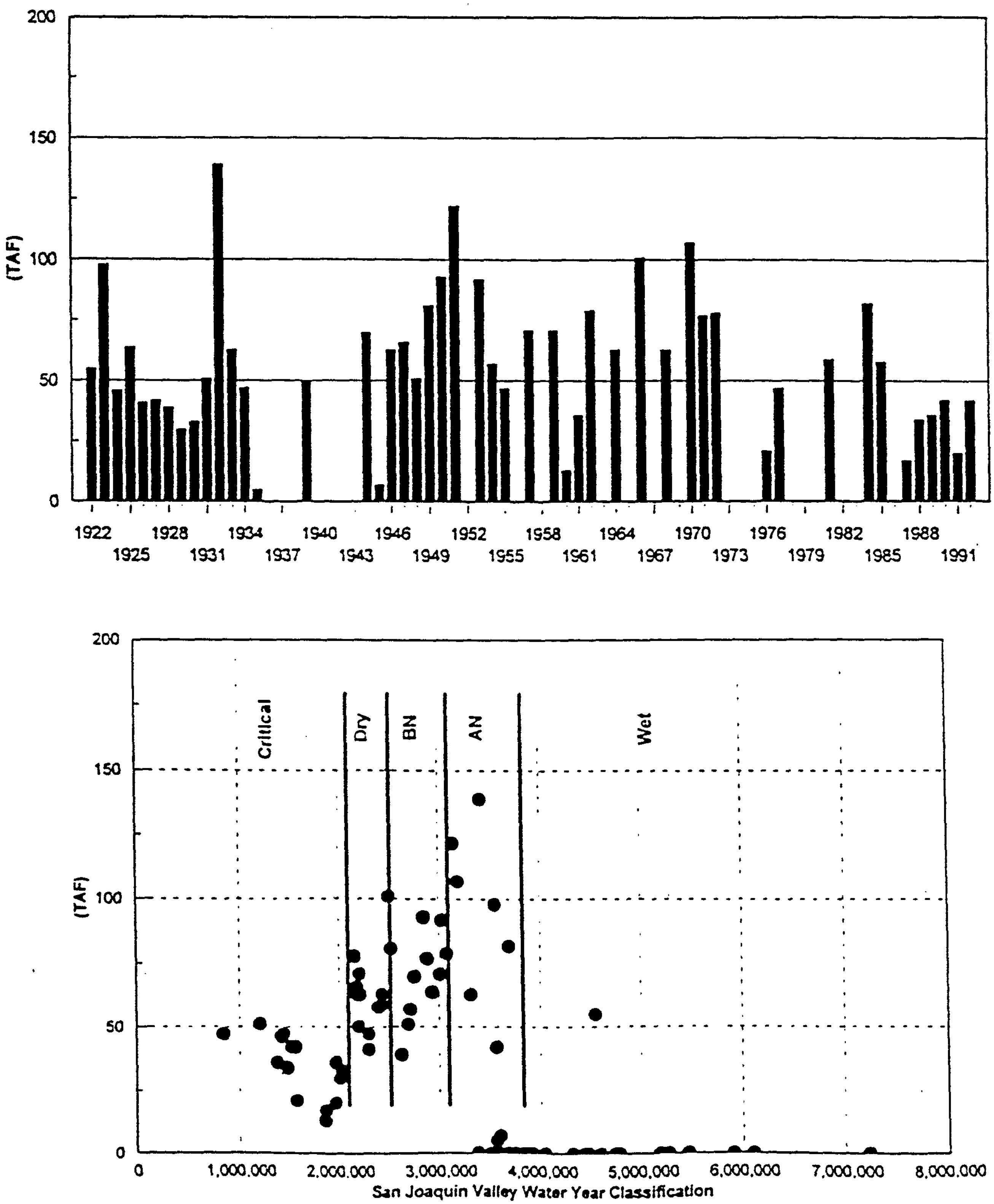

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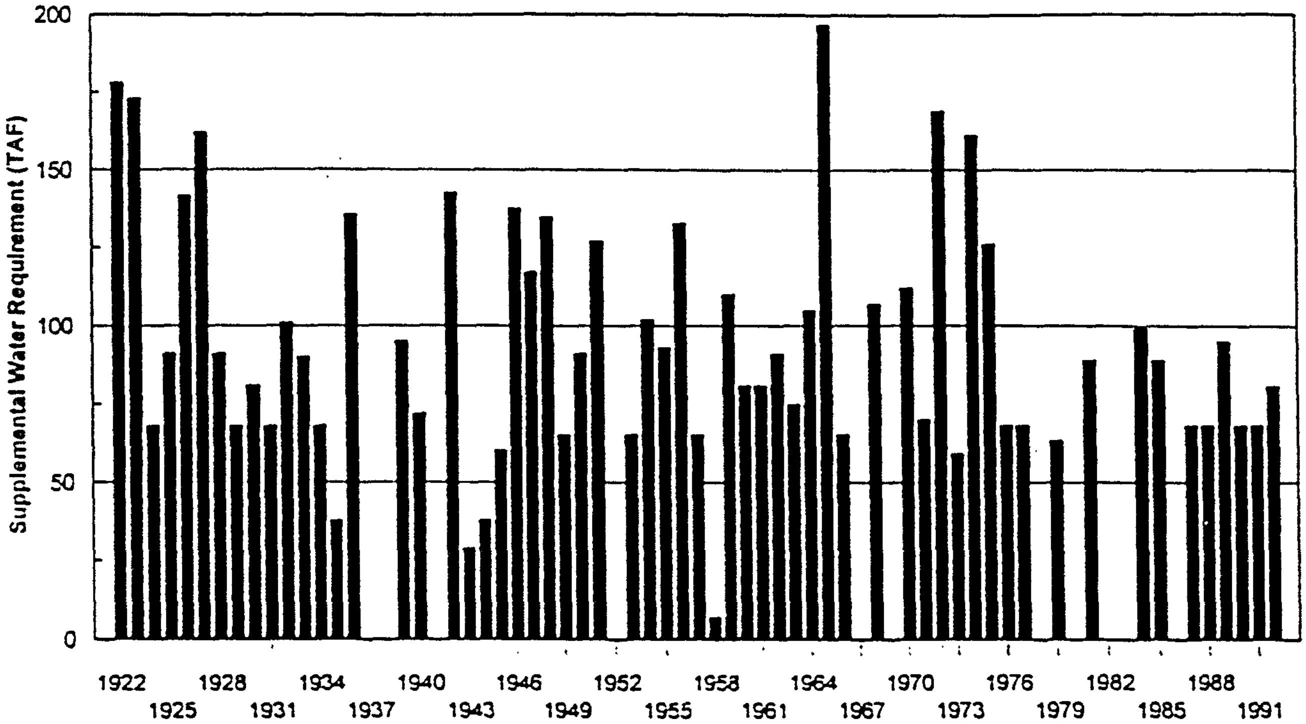
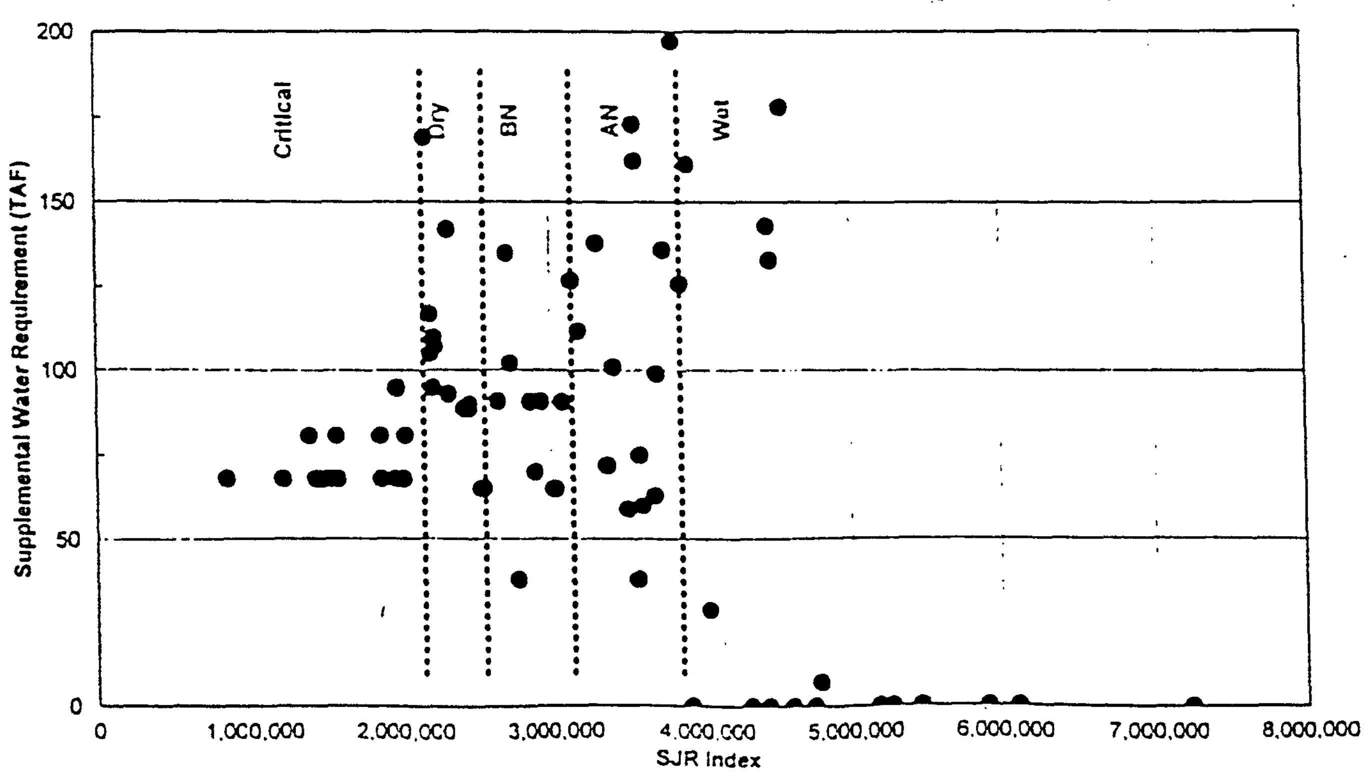
Exhibit H-14
Supplemental Water Required to Meet the 1995 WQCP San Joaquin River Flow Criteria Above the Amount of Water Provided for Meeting Flow Proposal

The Accord and the 1995 WQCP recognize that the flow objectives at Vernalis are subject to redetermination, and that during the three year period of the Accord, the Bureau of Reclamation would attempt to provide the flows. Exhibit H-14 depicts the incremental increase in supplemental water required to meet the interim Vernalis flow objectives of the 1995 WQCP in addition to the water required to meet the flow proposal. In addition to the water provided by the SJTA and Exchange Contractors for the flow proposal, up to 200,000 acre-feet per year would be required to fully meet the 1995 WQCP interim Vernalis flow objective, including several periods of sequential years requiring over 70,000 acre-feet per year.

Supplemental Water Required to Meet 1995 WQCP San Joaquin River Flow Criteria Above the Amount of Water Provided for Meeting Flow Proposal



Supplemental Water Required to Meet 1995 WQCP San Joaquin River Flow Criteria Above the Amount of Water Provided for Meeting Flow Proposal



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SECTION II
BIOLOGICAL ANALYSES CONCERNING FLOW PROPOSAL

Introduction

This section provides a technical summary of the biological information believed to be most relevant in determining the compatability of the proposal with the goals and objectives of the 1995 WQCP. The focus of this analysis is on determining whether and to what extent the actions included in the proposal would contribute to meeting the goals of the WQCP.

Fisheries biologists have intuitively reasoned that flows through the Delta have a major effect on the survival of emigrating smolts, and there are several conceptual reasons why this might be true: increased flows might speed passage through the Delta and thus decrease exposure to predators and to poor water quality; increased flows might reduce temperatures that otherwise might be high enough to decrease survival; increased flows might dilute pollutants; and, perhaps most important, increased flows at Vernalis necessarily result from increased flows in the tributaries, which may have the same benefits as hypothesized for them in the Delta.

The analyses show that flow at Vernalis is not strongly related to either the travel time of smolts through the Delta or the number of marked smolts that are recaptured at Chipps Island. There are two valid reasons why flows at Vernalis, and hence through the Delta, might not have much effect on smolt travel time and survival. First, the flow effects of tidal action within the Delta are very pronounced: flows in most of the Delta reverse direction completely twice a day. As the smolts move into the Delta, the effects of San Joaquin inflow diminish and the tidal effects become dominant. Second, the hydrodynamics of flows within the Delta are primarily driven by factors other than San Joaquin River flows.

Various issues have been identified which lead to the formulation of hypotheses relating to factors that affect salmon populations. Figure 1 illustrates some of the issues associated with flow at Vernalis and a barrier at the head of Old River, and the type of information used in our analyses. Three basic issues were addressed:

1. Whether there are relationships between flow levels at Vernalis and a) median smolt transit time across the Delta to Chipps Island, b) the percentage of smolts (fraction recovered) which had been released at three sites in the San Joaquin River which were later recaptured at Chipps Island, and c) estimates of escapement;

2. Whether the fraction of smolts recovered at Chipps Island is influenced by the presence of a barrier at the head of Old River; and

3. The extent to which various types of upstream habitat and flow management in the Merced, Tuolumne, and Stanislaus rivers might accomplish the desired enhancement of conditions for the increased production and survival of salmon.

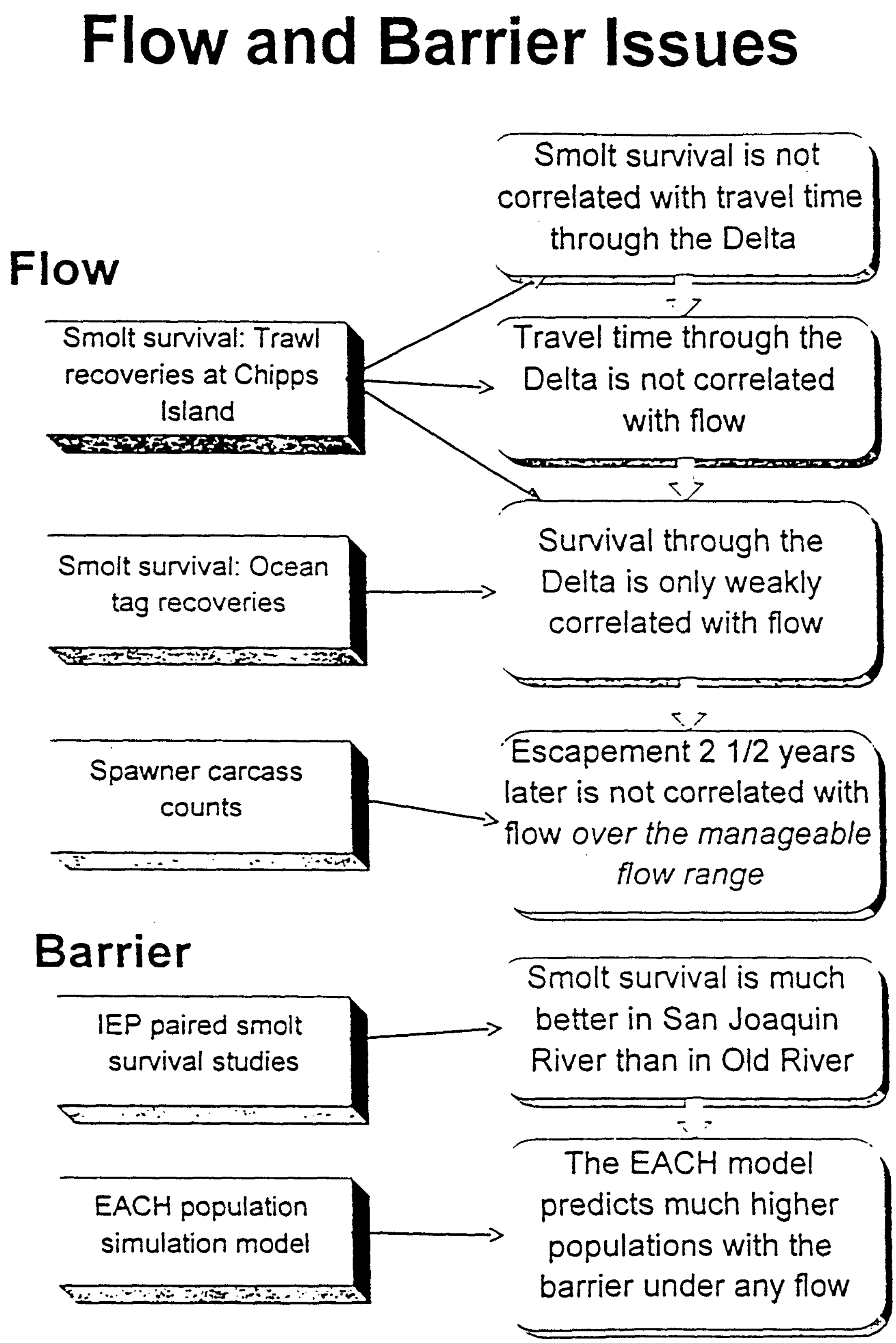

Figure 1. Issues addressed in this document related to flow and the proposed barrier at the head of Old River.

Methods

Two data sets were used to evaluate the relationships between the fraction of smolts recovered at Chipps Island and in the ocean fishery, flow at Vernalis, and estimated escapement: 1) recoveries of coded-wire tags (CWT) from hatchery smolts released at Mossdale, Dos Reis, and upper Old River at Stewart Road (see Figure 2 for the location of these sites), and 2) CDF&G estimates of spawner escapement. These data were compared to the flows at the time salmon smolts reared in, and migrated from the San Joaquin River basin to the ocean.

Non-expanded CWT data were used to determine the ratio of the number of smolts recaptured to the number of smolts released (fraction recovered) in the Chipps Island trawl. These raw data were used to avoid the introduction of potential errors associated with expanding the fractions recovered to estimates of survival. Use of the non-expanded data is appropriate since the level of data collection effort at Chipps Island has been fairly uniform across all experiments.

As a subset of these experiments, the paired releases at Dos Reis and Stewart Road were used to evaluate the potential effects of a barrier in the head of Old River on the fraction of smolts recovered. There are two additional relevant sets of experiments which were less well controlled: the 1992 releases at Mossdale before and after a rock barrier was placed in the head of Old River, and the 1995 paired releases at Mossdale above the Mainstem/Old River flow split (flow split) and at Dos Reis.

Additional information about the survival of each release group becomes available as tags from adult fish are returned by commercial and recreational anglers. Ocean recoveries of these marked fish are influenced by sources of mortality within the Delta, downstream of the Delta, and in the ocean. For this analysis we again used the raw recapture data rather than the expanded recapture data to avoid the potential error involved in data expansion. Since ocean recapture effort is variable, the conclusions drawn from these data may be inherently less reliable. Nevertheless, they provide an additional data set from which it is possible to examine survival following release.

The analyses also compares the flow at Vernalis during emigration of smolts to adult spawning escapement 2½ years later in order to determine if Vernalis flow can be related to adult returns. All available escapement data for the period 1951 to 1995 have been used. The data used represent the actual estimates of returning adults without adjustment for age composition of the spawning run. Additional analyses are possible using various subsets of these data, reassigning fish that are more or less than 2½ years old at spawning to their correct cohort, limiting the analysis to females, factoring in the effects of stock-recruitment considerations, and adding commercial and recreational catch to the escapement to estimate the overall production of adults. These potential adjustments have their own associated uncertainties which are mostly unquantifiable. Therefore, we decided to not attempt to incorporate any of these potential adjustments.

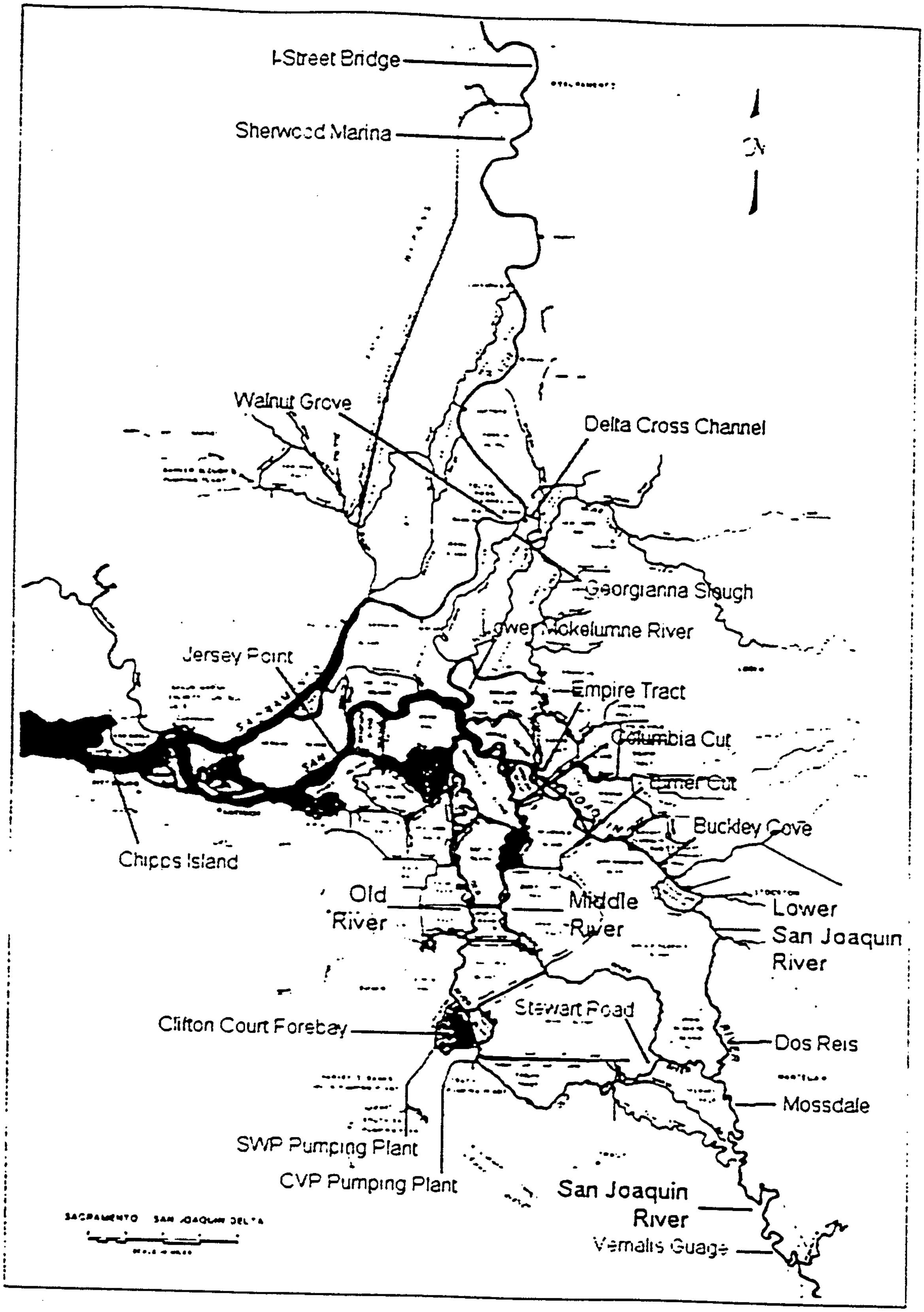

Figure 2. The Sacramento-San Joaquin River Delta.

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Existing, primarily for the Tuolumne River, were used to identify various habitat management actions in the tributaries. The actions identified include:

1. Improving the quality of spawning gravel based on particle size distribution and based on the relative numbers of eggs that hatch and produce fry from individual redds (EA Engineering, Science, and Technology 1991b)

2. Reducing the loss of smolts to predation by largemouth and smallmouth bass during emigration (EA Engineering, Science, and Technology 1992a,b); and

3. Using flow pulses to initiate smolt and/or juvenile emigration (EA Engineering, Science, and Technology 1992a).

There are also data on the effects of pulse flows on smolt emigration from the Stanislaus River (Cramer and Demko 1993, Demko and Cramer 1996).

The methods and terminology of linear regression are used to describe the direction and strength of trends of the underlying data throughout this report. Strictly speaking, ordinary linear regression is not entirely appropriate in this context, but these methods are widely used and fairly widely understood, and therefore provide a convenient basis for discussion.

The results of the analyses conducted for the proposal are typically shown as data points with fitted regressions (see Figures 3-5, 7, and 10-11). Note that the heavy straight line is the fitted regression line, and the paired curved lines indicate the 95% confidence region for the regression. That is, any line drawn in the region between the curves is consistent with the data. The light straight lines that cross at the mean value of the variable on the x-axis illustrate the range of potential linear relationships among the parameters at the 95% confidence level.

Also provided in the figures are the value of "r^2" which is the fraction of the variability in the data which is explained by the linear model, and the value of "p" which is a measure of how consistent the data are with a linear model; by convention, statisticians regard a fit as significant if $p<0.05$, and highly significant if $p<0.01$.

Results and Discussion

Based on the analyses conducted, the following results and conclusions are briefly presented.

There is no relationship between flow at Vernalis following release of smolts and the travel time from release to recovery at Chipps Island.

If the amount of inflow from the San Joaquin River into the Delta were material in determining the amount of time spent in the Delta by emigrating smolts, there should be a strong relationship between flow and travel time. Our analyses show that there is no significant relationship between the flow at Vernalis during the 10 days following release and number of days by which the median number of fish were recovered (the amount of time it took half of the smolts

SMOLTS RECOVERED AT CHIPPS ISLAND

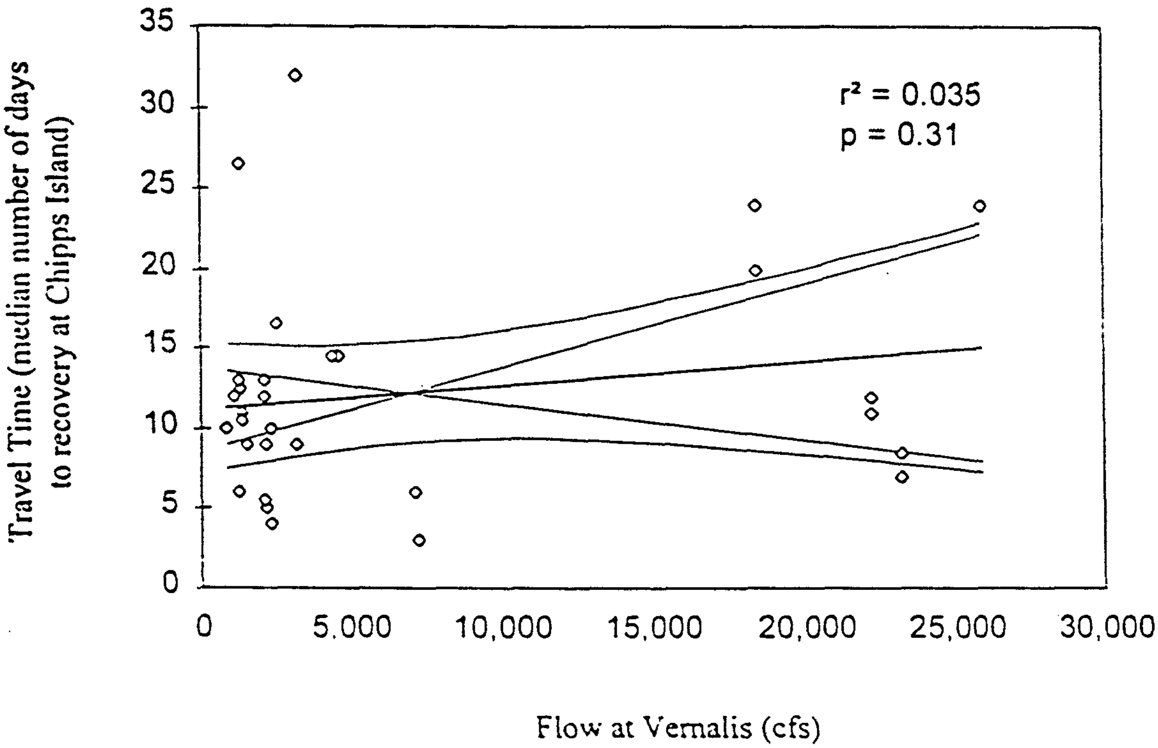


Figure 3. Median number of days to recovery in the IEP trawls at Chipps Island of coded-wire-tagged smolts released near the Old River flow split, and average San Joaquin River flow at Vernalis over the ten days following release.

to arrive at Chipps Island), over the entire range of flows studied (up to 27,000 cfs; Figure 3). Thus San Joaquin River flow, even at very high levels, do not appear to be propelling smolts through the Delta.

Travel time and the fraction of smolts recaptured are not related.

It has been hypothesized that increased travel time in the Delta causes increased hazards to smolts. If traversing the Delta is as hazardous to smolts it would be expected that as the amount of time spent in the Delta by smolts increases, the fraction recovered at Chipps Island would decrease. If this were true, then any action which results in shorter travel time to Chipps Island would be highly desirable.

Figure 4 shows, however, that there is no significant relationship between median number of days to recovery and the fraction of the marked fish recovered. Consequently, we conclude that additional time spent in the Delta does not determine the fraction recovered at Chipps Island and that travel time is not a significant factor controlling smolt survival within the Delta.

There is a weak correlation between flow and smolt recaptures at Chipps Island, and the apparent effects of flow are minor.

Figure 5a is a plot of the relationship between the flow at Vernalis and the fraction of marked smolts recaptured by trawl at Chipps Island. There is a weak, but significant positive relationship over the entire range of observed flows, suggesting that increased flows may increase survival. As depicted in Figure 5a, there is great variability to these data resulting in slopes in the relationships from positive to negative. In other words, the slope of the regression line is such that a doubling of smolt survival appears to occur over an increase in flows of 10,000 cfs. However, an alternative conclusion using the same data indicates that the recapture rate could actually decrease with the same increase in flows. Further, if the analysis is confined to the range of non-flood flows (<8,000 cfs; Figure 5b) the relationship between flow and recapture rate is insignificant. Therefore, given the variability in the possible linear relationships we conclude that the relationship between Vernalis flow and fraction recovered at Chipps Island is questionable, particularly within the range of flows addressed by the 1995 WQCP.

It might be argued that the 1987 data point representing a recovery fraction of 0.000842 at 2,386 cfs is an outlier which, if removed, would greatly strengthen the correlation. We address this point in Figure 6 as an example of why one must be careful in excluding data points. Figure 6a shows the amount of trawl effort (constant over the period in which all of the smolts were recaptured) and the timing of recapture. The pattern of recaptures makes it clear that the data are not artificially high as a result of a lucky trawl, nor did these smolts experience abnormally rapid travel time, particularly low temperatures, or low export levels. For some reason these smolts simply survived passage through the Delta better than any of the other experimental groups, and they did so at a relatively low flow and relatively high export rates. Thus, there is no apparent reason to exclude this data point from the analysis.

SMOLTS RECOVERED AT CHIPPS ISLAND

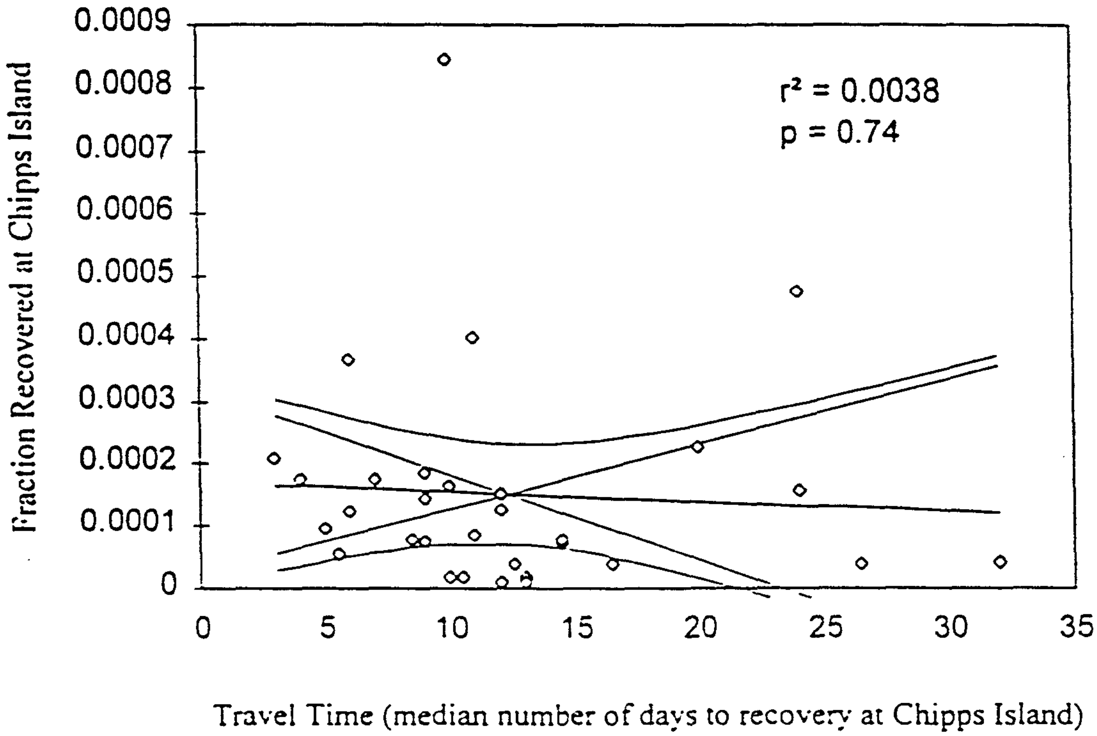


Figure 4. Recoveries in the IEP trawls at Chipps Island of coded-wire-tagged smolts released near the Old River flow split, and median number of days from release to recovery.

SMOLTS RECOVERED AT CHIPPS ISLAND

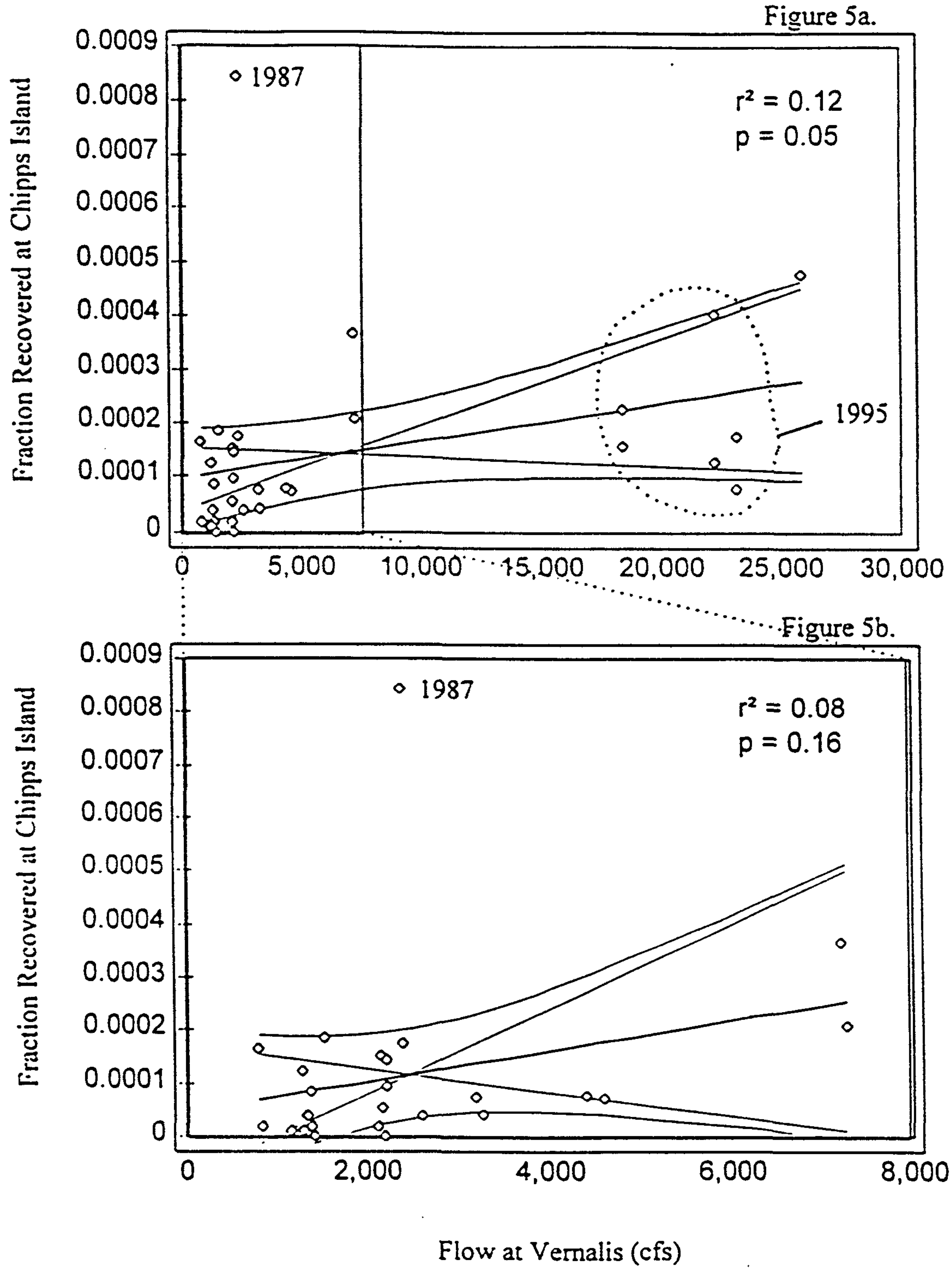


Figure 5. Recoveries in the IEP trawls at Chipps Island of coded-wire-tagged smolts released near the Old River flow split. and average San Joaquin River flow at Vernalis over the ten days following release. Top: all data. Bottom: data corresponding to manageable flows.

SMOLTS RECOVERED AT CHIPPS ISLAND

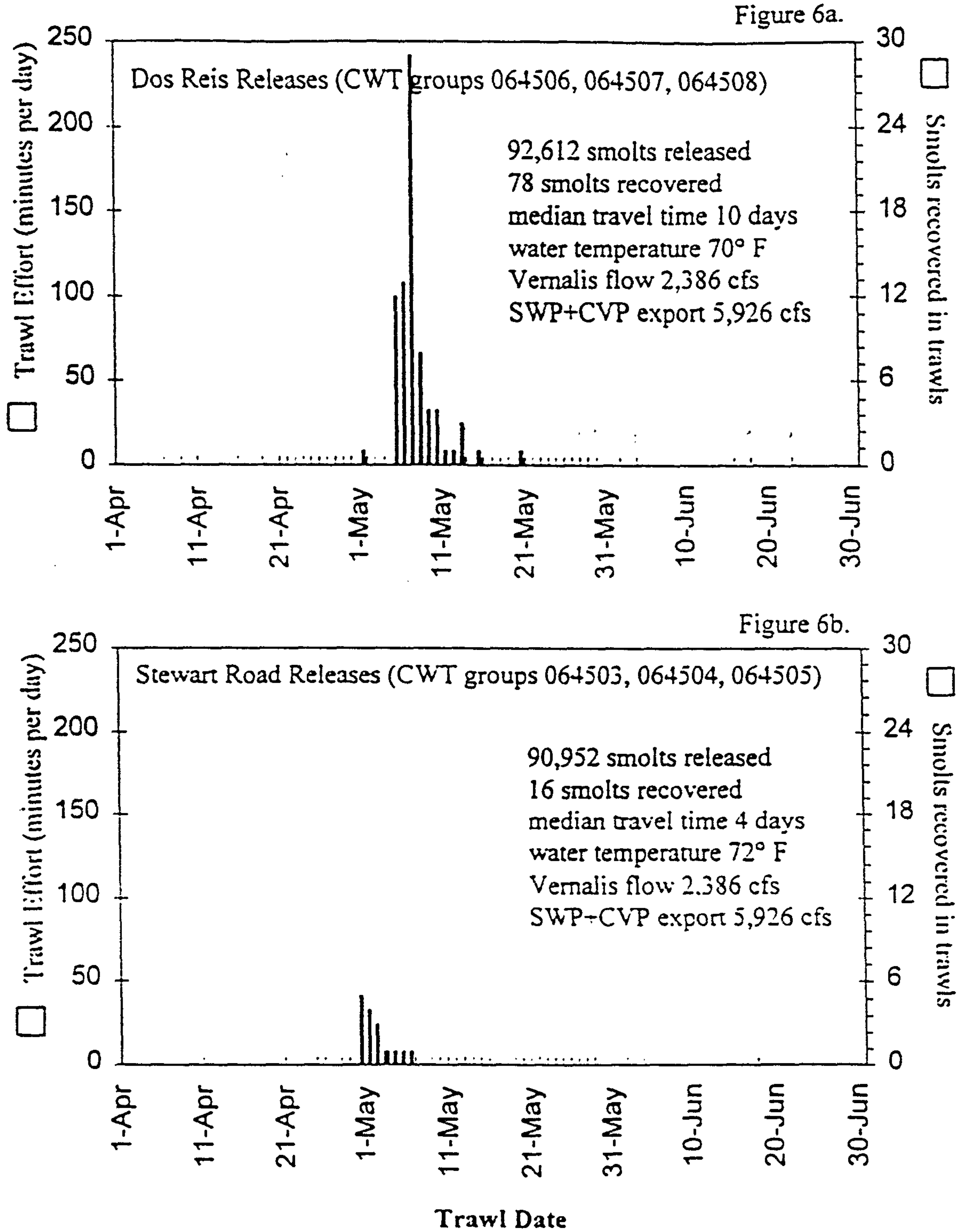


Figure 6. Recoveries in the IEP trawls at Chipps Island of smolts released near the Old River flow split on 4/27/87. Top: CWT groups released in Lower San Joaquin River at Dos Reis. This is the experiment giving rise to the "obvious outlier" of the previous figure. Bottom: CWT groups released in Upper Old River at Stewart Road. Water temperature is at the time and place of release. San Joaquin flow at Vernalis and SWP+CVP export are averages over the ten days following release.

Figure 6b also illustrates the somewhat speedier passage but much lower recapture rate of the smolts released at Stewart Road in Old River at the same time as Dos Reis (Figure 6a), and provides an example of the paired release data discussed below in conjunction with placement of a barrier at the head of Old River. This analysis shows that shorter travel time to Chipps Island does not necessarily improve the recapture of smolts.

Vernalis flow 10 days following release and adult recaptures in the ocean are significantly correlated, but the critical data are not yet available.

Figure 7 is a plot of the fraction of the CWT release groups shown in Figures 3-5, recovered in the ocean fisheries versus the mean Vernalis flow over the 10 days after release. These regressions are highly significant and, unlike the trawl recovery data, have a rather steep slope, both when considering the relationship at all flows (Figure 7a) and when considering the flow range up to 8,000 cfs (Figure 7b). Although these are recaptures from the same releases depicted on Figure 5, most of the data points providing information at high flows are missing because the smolts that were released in 1995 and have not yet grown to an age susceptible to capture in the ocean. Because the 1995 data strongly influenced the slope of the trawl recapture data for smolts (Figure 5a), we estimated what the ocean recapture data for adults would look like when ocean recovery data become available. The basis for this estimate is shown in Figure 8a, which shows the relationship between historic recapture rate in Chipps Island trawls and recapture rate in the ocean fisheries (also shown in its log-log transformation in Figure 8b). This relationship is not particularly strong, so that there is considerable uncertainty involved in extrapolating the fraction of smolts recovered at Chipps Island to the fraction of adults recovered in the ocean. Nevertheless it is possible to use the regression line to predict ocean recaptures for the 1995 release group.

Figure 9 shows the relationship between Vernalis flow and ocean recapture rate with the predicted data for 1995 added. The relationship remains positive, but has a slope much more similar to the trawl recovery data. These relationships should be re-visited when ocean recovery data for 1995 smolt releases are available.

Flow during smolt emigration and number of spawners returning 2½ years later are not correlated for flows addressed in the 1995 WQCP.

The relationship between flows during smolt emigration and escapement 2½ years later, is significant and positive (Figure 10a), but only if data for years when flow exceeds 10,000 cfs are included. If the regression analysis is constrained to the flows considered within the range of flows addressed by the WQCP, the effect of flow is not significant.

Analyses by others have modified the escapement data to account for the fact that not all of the spawners are 2½ years old. To do so requires estimating what percentage are older and younger and apportioning them to the appropriate smolt year. The apportioning cannot be done with confidence and consequently it is unclear whether the modification produces a more or less accurate picture of the relationship between flow and fraction recovered. Notwithstanding, the interpretation is essentially identical to the interpretation based on escapement.

ADULTS RECOVERED IN OCEAN FISHERIES

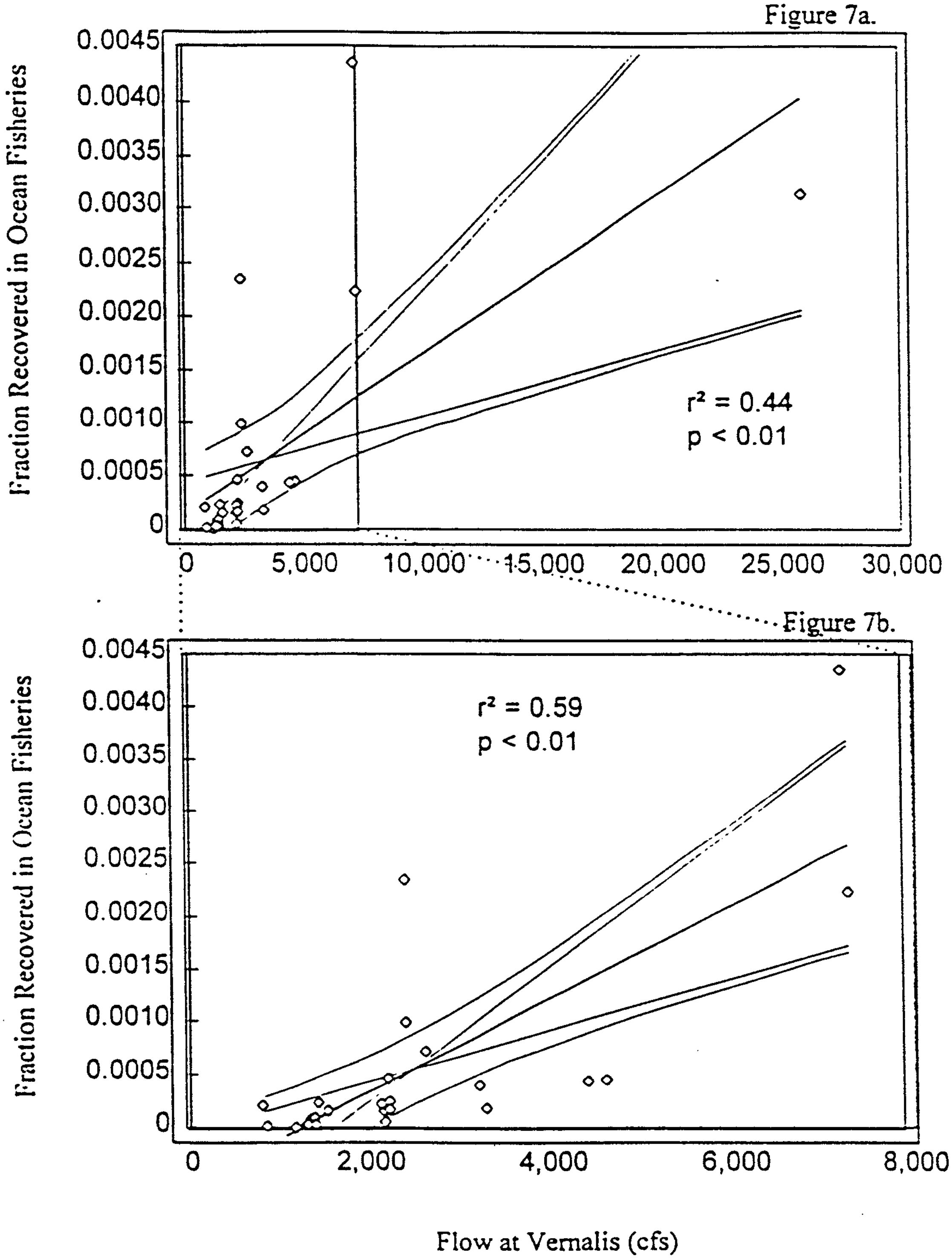
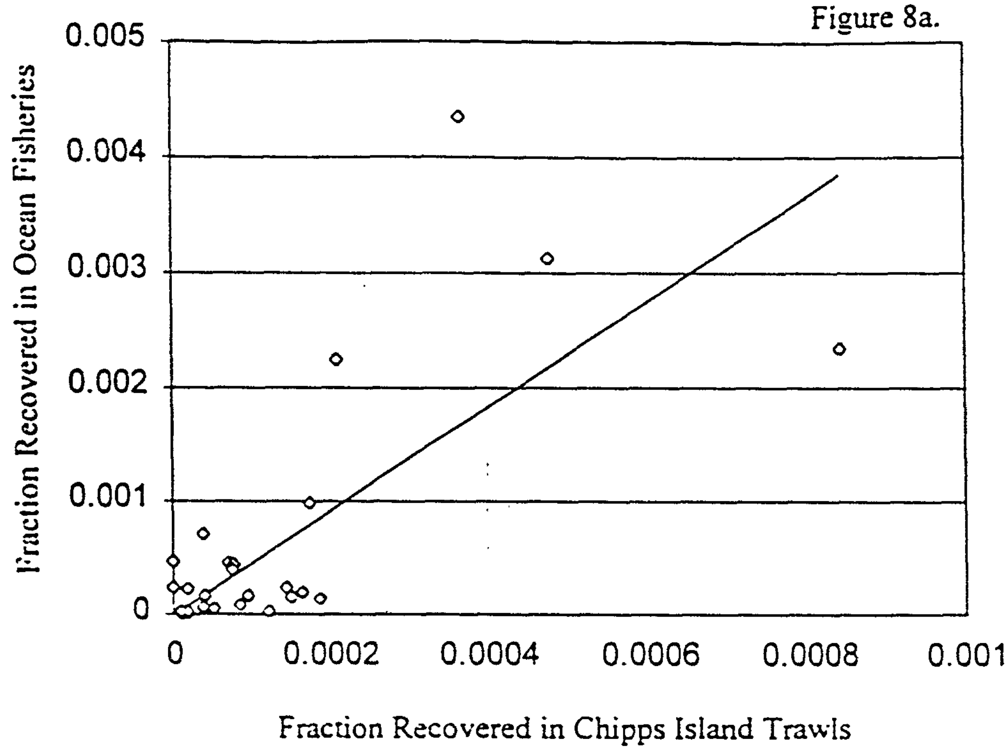


Figure 7. Recoveries in the ocean fisheries of coded-wire-tagged adults released as smolts near the Old River flow split, and average San Joaquin River flow at Vernalis over the ten days following release. Top: all data. Bottom: data corresponding to manageable flows. Both relationships are highly significant, but both are driven by points with high leverage.

SMOLTS RECOVERED AT CHIPPS ISLAND, ADULTS RECOVERED IN OCEAN FISHERIES



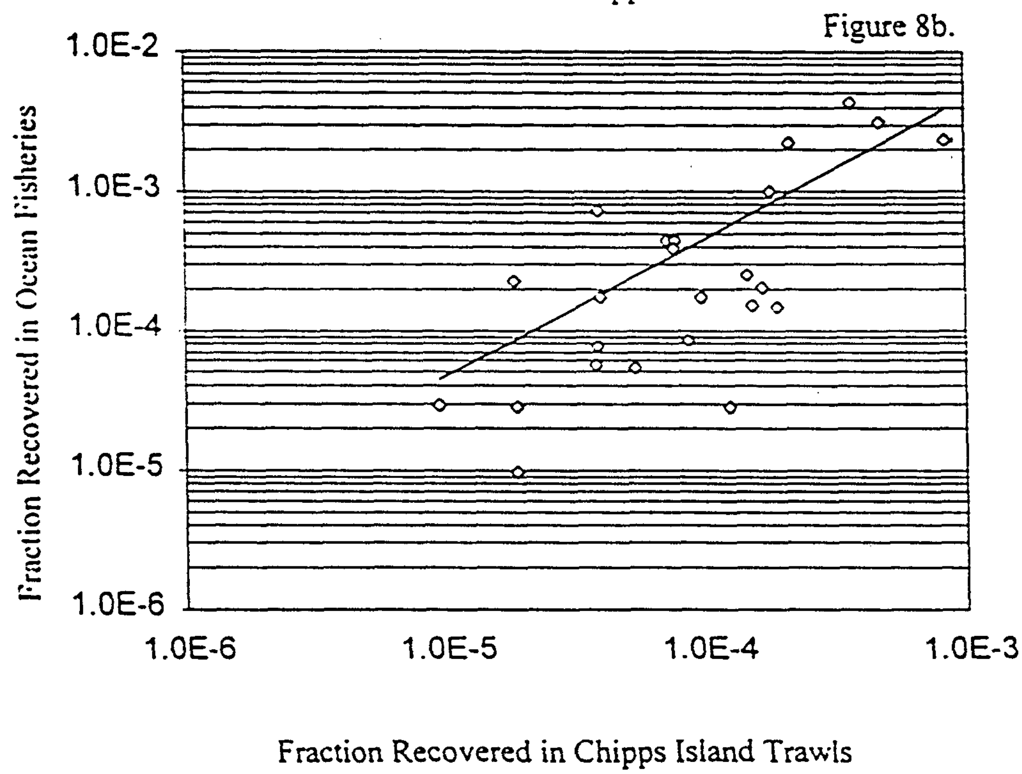


Figure 8. CWT groups released near the Old River flow split. Top: comparison of the fraction of recovered as adults in the ocean fisheries with the fraction recovered as smolts in the IEP trawls at Chipps Island. Bottom: the same data, plotted on log-log axes.

ADULTS RECOVERED IN OCEAN FISHERIES

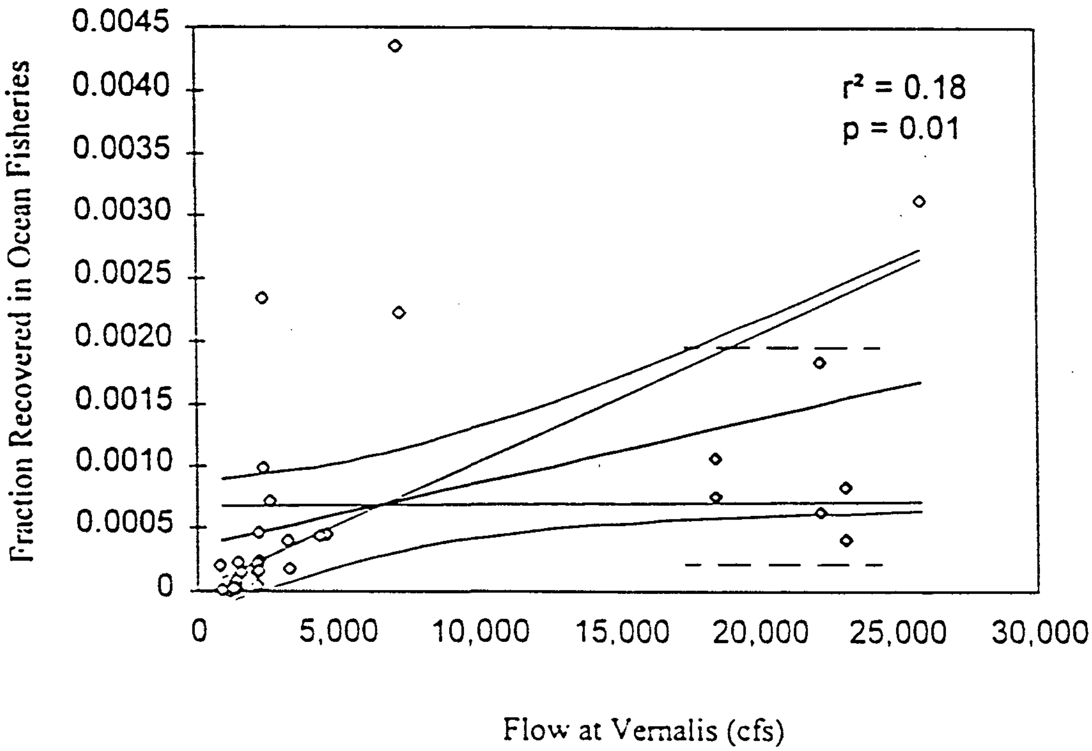


Figure 9. Recoveries in the ocean fisheries of coded-wire-tagged smolts released near the Old River flow split, including projected recoveries for 1995 releases, and average San Joaquin River flow at Vernalis over the ten days following release. The predicted values are marked with grey diamonds and surrounded by a dashed line.

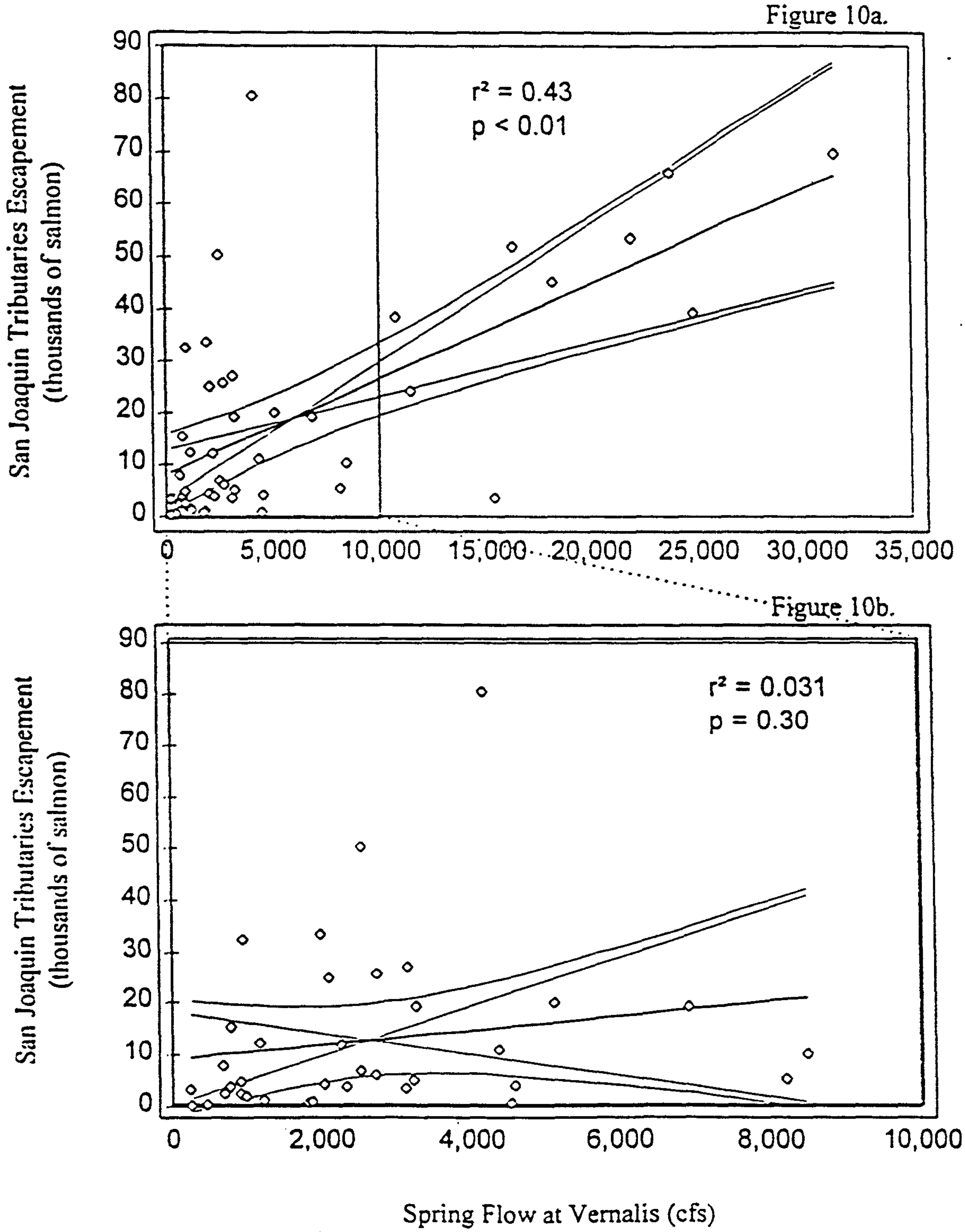


Figure 10. Total Chinook salmon escapements to San Joaquin tributaries, 1951 through 1995, and April-June San Joaquin River flow at Vernalis two-and-one-half years earlier. Top: all data. Bottom: data corresponding to manageable flow range.

The fraction of smolts recovered in the Chipps Island trawl and the ocean fisheries when there is a barrier at the head of Old River is twice as high for those emigrating down the San Joaquin River than those emigrating down Old River.

On six separate occasions, groups of tagged smolts were released at about the same time in both Old River (just below the Old River-Middle River flow split) and in Lower San Joaquin River at Dos Reis, just below the head of Old River. Because these smolts were released at about the same time and recovered at about the same time, any differences between the fractions of each group recovered at Chipps Island, or in the ocean fisheries, should be attributable to differences in survival along the two different migration routes.

Each of the open diamonds plotted in Figure 11 represents the results of one paired-release experiment. The fraction of the Old River group recovered is plotted on the horizontal axis, and the fraction of the corresponding Dos Reis group recovered is plotted on the vertical axis. If recovery rates were the same for the two migration routes, the data points would lie along the dotted lines. All six (open-diamond) points lie on or above the dotted line, which indicates that the Dos Reis release groups had higher than nominal recovery rates. The recovery rate is estimated to be 2.8 times higher (at Chipps Island, Figure 11a) and 2.0 times higher for tags recovered from ocean catch (Figure 11b) as compared to recovery rates for groups allowed to emigrate down Old River.

Therefore, a barrier at the head of Old River will increase survival of smolts emigrating from the San Joaquin River basin.

For completeness, we have also included on the figures, but not used in the regression, results of 1995 studies in which the paired release groups were at Mossdale above the head of Old River and at Dos Reis in the San Joaquin River below the Old River flow split (shaded squares on Figure 11a). Because a fraction of the smolts released at Mossdale would be expected to go down Old River (since a barrier was not installed during the spring of 1995), Mossdale/Dos Reis experiments can be regarded as partial surrogates for Stewart Road/Dos Reis experiments. One of these three experiments shows a somewhat higher than nominal recapture rate for the Mossdale release (the smolts from which could have gone down either Old River or the lower San Joaquin River), but the other two show substantially higher than nominal recapture of smolts released at Dos Reis and expected to emigrate down the San Joaquin River.

In 1992 another set of experiments was conducted before and after construction of a barrier to test the effects of placing a barrier at the head of Old River. Two releases were made above the head of Old River before placing a rock barrier and three were made after placement. Over this period there was a decrease in survival with time that could be interpreted as indicating no beneficial effect of the barrier. Because temperature and water quality conditions along the migration route were changing in an adverse way with time as the summer progressed, the experiment was essentially uncontrolled and therefore the results are not primarily reflective of the effects of the barrier. THe U. S. Fish and Wildlife Service attempted to adjust the data for the changes in temperature, and interpreted their adjusted result as being consistent with better survival with the barrier in place. We believe that this question will only be fully resolved when an

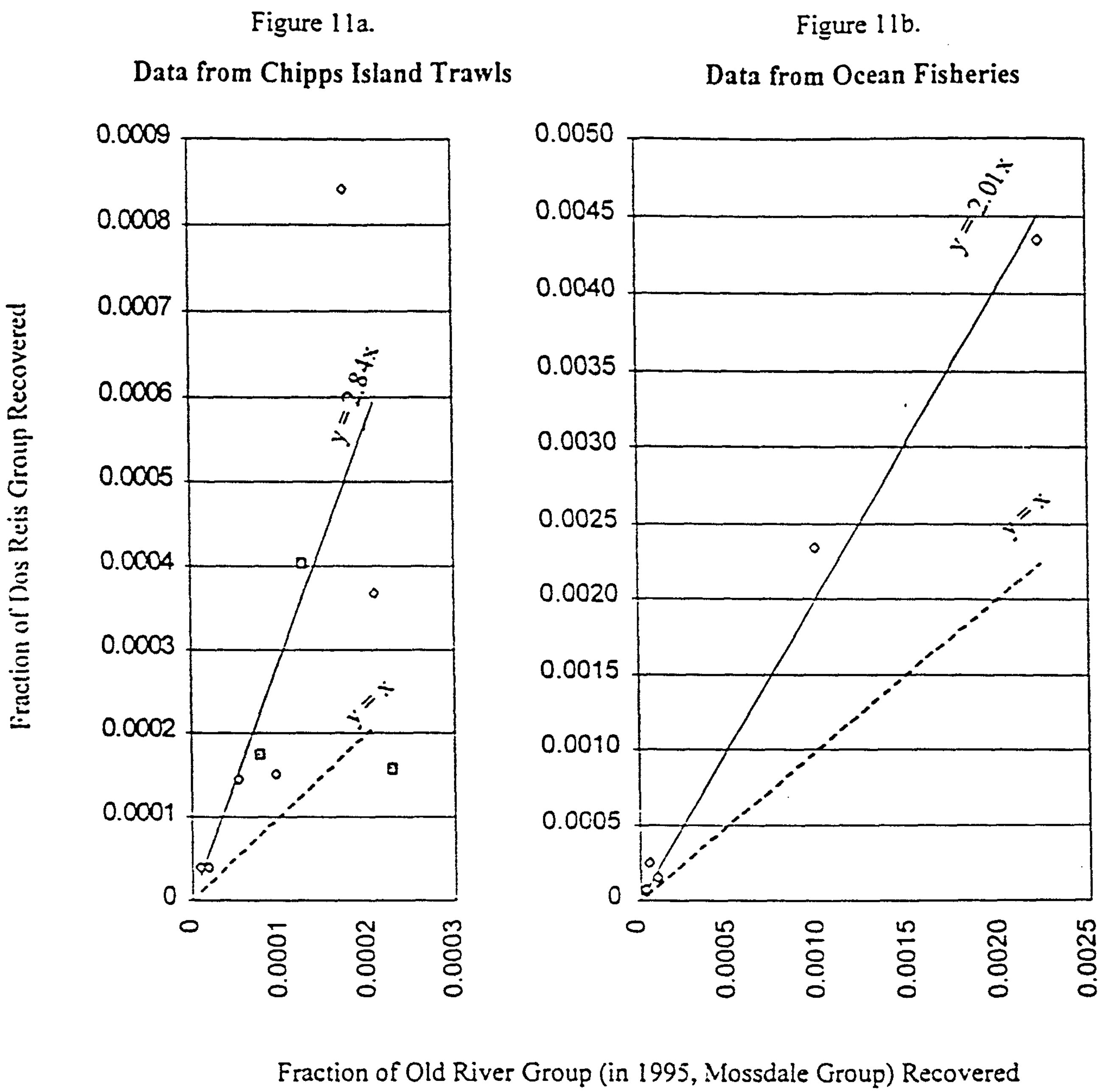


Figure 11. Comparing the fraction recovered of smolts in Lower San Joaquin River with survival in Old River. Each point compares data from two groups of smolts; the recovery fraction for a group of smolts released in Upper Old River at Stewart Road (or in 1995, in San Joaquin River at Mossdale) is plotted on the horizontal axis, and the recovery fraction for a group released in Lower San Joaquin River at Dos Reis at about the same time is plotted on the vertical axis. Left: fractions recovered as smolts in IEP trawls at Chipps Island. Right: fractions recovered as adults in the ocean fisheries. The 1995 Dos Reis releases are also compared with the corresponding releases at Mossdale at left, as shaded squares, but these points are not used in the regression.

operable barrier is installed to allow interspersion of experiments with and without the barrier in nearly the same time frames.

The benefits of a barrier can also be estimated using the EACH San Joaquin salmon population simulation model (EA Engineering, Science, and Technology 1991d). The results of model runs with the proposed flows, with and without the barrier in place, are shown in Figure 12. The results of model simulations with the actual flows over this period are shown for comparison. The effect of adding the barrier on escapement is an approximately 3-fold increase in predicted escapement as compared to historical conditions. Although there is debate over the validity of the U. S. Fish and Wildlife Service smolt survival model, the EACH model incorporates the U. S. Fish and Wildlife Service smolt survival model for the Delta component of smolt survival (Brandes 1994) and depends on it for this differential analysis.

Management of upstream spawning and rearing areas

While the main emphasis in the 1995 WQCP is on flow through the Delta during smolt emigration, this is a fraction of the salmon life cycle, covering only about two weeks. Significant mortality occurs in upstream areas to eggs, fry, and juveniles prior to emigration and during emigration prior to reaching the Delta. Analyses show that in the Tuolumne River, and probably in the Merced and Stanislaus rivers as well, many aspects of habitat encountered by the early life stages of San Joaquin Basin chinook salmon could be improved. Upstream habitat improvements alone could be expected to have significant and positive effects on the San Joaquin chinook salmon populations (EA Engineering, Science, and Technology 1992a). The most obvious of these improvements is to provide adequate flows during spawning, incubation and rearing periods in the tributaries.

The U. S. Fish and Wildlife Service (USFWS) has conducted instream flow studies in the Tuolumne and Stanislaus rivers (U. S. Fish and Wildlife Service 1995, Aceituno 1993), and the Federal Energy Regulatory Commission (FERC) has utilized these and other data to determine the appropriate instream flows in the Tuolumne River (Federal Energy Regulatory Commission 1995). The flows for the Stanislaus River have also been determined, largely as a result of the instream flow studies, and a similar study process is occurring in the Merced River. On-going processes to implement appropriate flows on the tributary streams will result in flow regimes which, by themselves, will increase production of salmon in the San Joaquin River tributaries.

The most easily accomplished and most likely to be successful additional management activities (identified in Figure 13) are:

1. Improve the amount and quality of spawning gravel

   Spawning gravel in much of the Tuolumne River is in relatively poor condition and in need of cleaning to remove fine sediments (EA Engineering, Science, and Technology 1991c). Spawning gravel quality in the other tributaries most likely could be improved as well. In some areas it has been mined for commercial purposes and needs replacement. Over the past few years there has been a substantial amount of research investigating the efficacy of cleaning existing gravels (EA Engineering, Science, and Technology 1991e) and

MODELED ESCAPEMENTS (EACH)

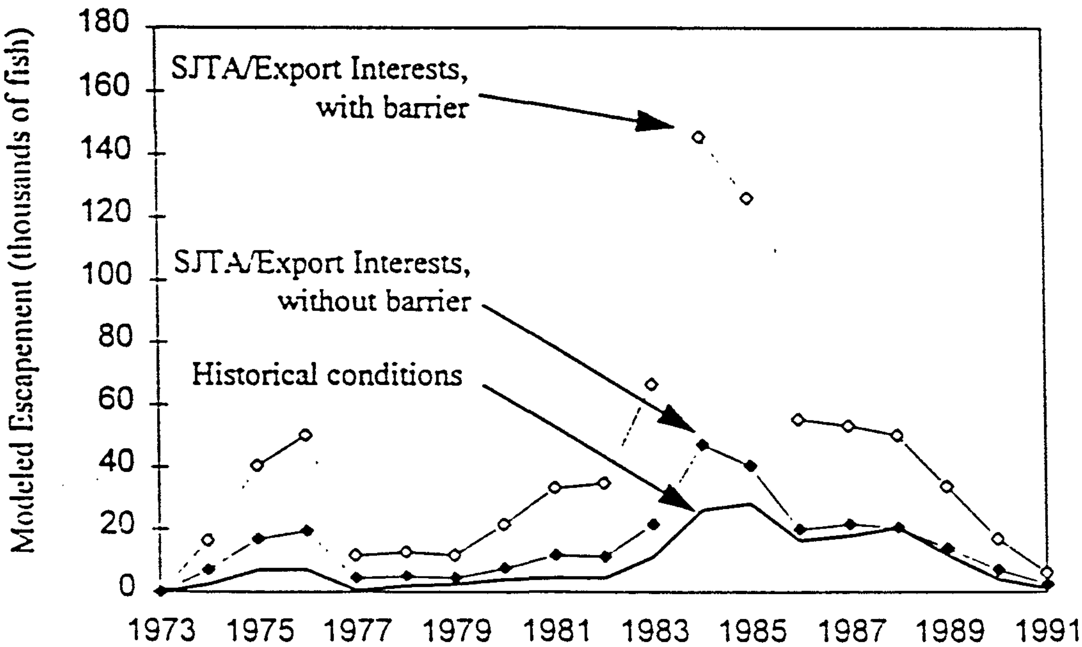


Figure 12. Modeled Escapements (EACH population model 8.5.3), incorporating 1994 USFWS Delta Smolt Survival Model. Modeled escapements with historical hydrologic conditions are shown with a heavy black line. Modeled escapements with the flow conditions of the SJTA/Export Interests proposal, but without a spring barrier at the head of Old River, are shown with closed diamonds. Modeled escapements with both the SJTA/Export proposed flows and the Old River barrier are shown with open diamonds.

Management of Spawning and Rearing Areas

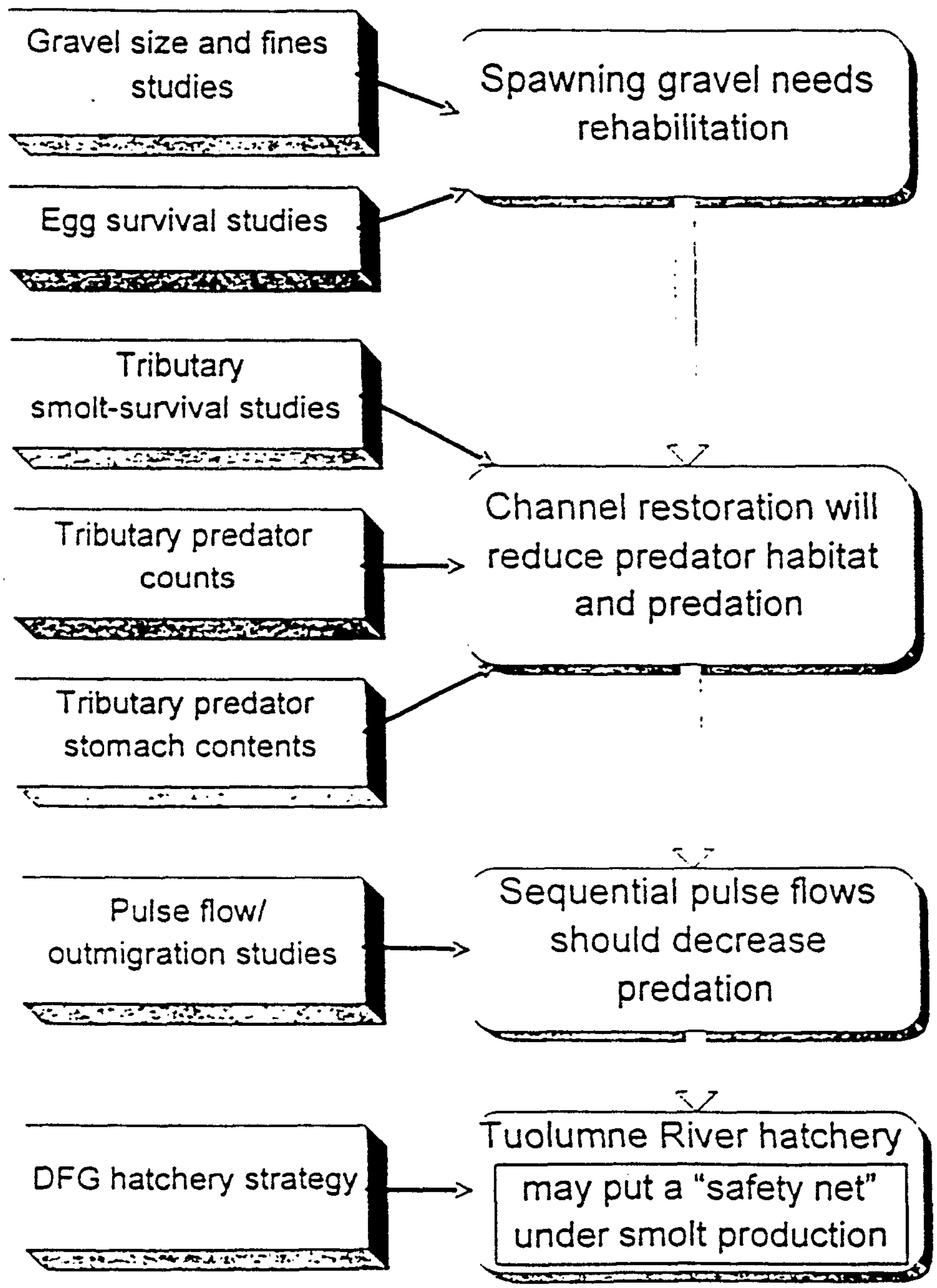


Figure 13. Habitat improvements under consideration for the tributaries, and their bases.

modifying or replacing those that have been removed or are not of the best size ranges (EA Engineering,Science, and Technology 1991e). As a result, plans are being made to clean the gravel that would benefit from cleaning, and to establish new gravel where warranted. The result should be an increase in the use of spawning areas with the subsequent increase in the production of fry from each female spawner.

2. Reduction in losses of smolts due to predation

   There are large numbers of predatory largemouth and smallmouth bass resident in the lower reaches of the Tuolumne River, and very likely in the lower reaches of the Stanislaus and Merced Rivers. It has been demonstrated that these bass consume large numbers of emigrating smolts (EA Engineering, Science, and Technology 1992b). Striped bass and Sacramento squawfish, also predators of salmon smolts, occur in the Stanislaus River. In the Tuolumne River, the abundance of these predators is enhanced by the presence of long, deep pools that are largely the result of gravel mining operations in the lower river. Not only do these pools provide the deep, low velocity water favored by predators, the low velocities slow smolt emigration, exposing the smolts to the predators for longer periods than would otherwise occur. Pulse flows have been scheduled to stimulate smolt movement and potentially decrease mortality from predation. Plans are underway to re-route the lower Tuolumne around as many of these artificial pools as possible, and, in some cases to decrease pool depth by adding fill.

   A second management action to reduce predation is to attempt to increase turbidity during emigration. Predators identify their prey by sight, so it is likely that high turbidity during emigration would reduce predation (EA Engineering, Science, and Technology 1991a). This can be accomplished partly by utilizing pulse flows which displace sediments, and partly by doing gravel cleaning during the pulse flows.

   Other predator control measures such as changes to local fishing regulations could be implemented to reduce predator populations.

3. Utilize sequential pulse flows to encourage mass emigration

   Experiments conducted on San Joaquin tributaries have suggested that smolts can be induced to emigrate using short-term, high volume, sequenced pulse flows. These experiments show that steady-state elevated flow levels do not result in sustained emigration nor do they cause emigration of juveniles that are not physiologically ready. Pulse periods of three days in duration and spaced approximately 7 days apart may be the most effective method to stimulate emigration (Cramer and Demko 1993, Demko and Cramer 1996).

An additional management action, being considered by the California Department of Fish and Game, is to build a salmon hatchery on the Tuolumne River to ensure adequate smolt production even in years of low escapement. The Merced River Hatchery has been in production for many years and is responsible for many of the fish in the Merced River escapement.

Conclusions

The proposed Vernalis flow schedules with their resultant effects upstream in the tributaries, combined with upstream habitat and infrastructure improvements proposed by the parties will make a significant contribution to meeting the objectives for San Joaquin Basin under the 1995 WQCP. Taken together with the installation of an operable barrier at the head of Old River, it appears that San Joaquin Basin chinook salmon production will be significantly enhanced.

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