Public Comment
Sthrn Delta Ag & SJR Flow
Deadline: 5/23/11 by 12 noon

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May 23, 2011

Ms. Jeanine Townsend
Clerk to the Board
State Water Resources Control Board
1011 I Street, 24th Floor
Sacramento, California 95814

Re: Comments on Revised Notice of Preparation – Southern Delta Salinity and San Joaquin River Flows

Dear Ms. Townsend:

The following comments are made on behalf of Stockton East Water District to the State Water Resources Control Board (State Water Board) Revised Notice of Preparation for and Scoping Environmental Documentation for the Update to the Water Quality Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: Water Quality Objectives for the Protection of Southern Delta Agricultural Beneficial Use; San Joaquin River Flow Objectives for the Protection of Fish and Wildlife Beneficial Uses; and the Program of Implementation for Those Objectives (Revised NOP).

Attachment 2 – Draft San Joaquin River Fish and Wildlife Flow Objectives

Attachment 2 provides the following Draft San Joaquin River Fish and Wildlife Objectives:

> *Maintain flow conditions from the San Joaquin River Watershed to the Delta at Vernalis, together with other reasonably controllable measures in the San Joaquin River Watershed sufficient to support and maintain the natural production of viable native San Joaquin River watershed fish populations migrating through the Delta. Specifically, flow conditions shall be maintained, together with other reasonably controllable measures in the San Joaquin River watershed, sufficient to support a doubling of natural production of Chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law. Flow conditions that reasonably contribute toward maintaining viable native migratory San Joaquin River fish populations include, but may not be limited to, flows that mimic the natural hydrographic conditions to which native fish species are adapted, including the relative magnitude, duration, timing, and spatial extent of flows as they would naturally occur. Indicators of viability include abundance, spatial extent or distribution, genetic and life history diversity, migratory pathways, and productivity.*

In order to meaningfully comment on this narrative objective, several questions must be answered prior to the preparation of the Substitute Environmental Document (SED). First, what "other reasonably controllable measures" are being evaluated? How do these controllable measures compare to the alleged need for more flow? If implementation of other controllable measures leads to the doubling of natural production of Chinook salmon, will the SED evaluate reduction in flows on the tributaries? What does the State Water Board mean by "natural production" and what are "viable native San Joaquin River watershed fish?" How does the State Water Board define native migratory San Joaquin River fish population? Are "hatchery" fish included?

The Revised NOP states that "The State Water Board has determined that more flow of a more natural pattern is needed from February through June from the San Joaquin River watershed to Vernalis to achieve the narrative San Joaquin River flow objective." What is the State Water Board "decisional document" that supports this conclusion? The woefully inadequate Draft Technical Report (DTR) was highly criticized as not being based on the best available science. The DTR relies on flawed models, such as the Department of Fish and Game (DFG) San Joaquin River Fall-run Chinook Salmon Population Model. This model was completely discredited when the Scientific Peer Review panel essentially told DFG to throw the model out and start anew. The DTR has a myopic view that additional flows are necessary for the protection of fish and wildlife beneficial use. The DTR fails to consider many significant factors that have contributed to the decline in the fishery other than flows, such as predation, introduction of non-native species, pollution, highly modified conditions in the Delta, temperature and dissolved oxygen. Before the State Water Board can "decide" more flow is needed, the best science must be used to evaluate what protections are needed for San Joaquin River fish and wildlife beneficial uses.

The Revised NOP states that "more flow is needed from the existing salmon and steelhead bearing tributaries in the San Joaquin River watershed down to Vernalis in order to provide for connectivity with the Delta and more closely mimic the natural hydrographic conditions to which native migratory fish are adapted." Again, what is the State Water Board "decisional document" that supports this conclusion? What evidence supports the need to "mimic the natural hydrographic condition?"

Footnote 1 excludes the Upper San Joaquin River from contributing to the San Joaquin River flows at Vernalis. The State Water Board has absolutely no legal, factual or practicable authority to exclude water from the Upper San Joaquin River as contributing to meet any new San Joaquin River flow or salinity objective. The Upper San Joaquin is an out of basin user of water that must contribute just like the other tributaries to the San Joaquin River. The Upper San Joaquin River watershed comprises more than 30% of the unimpaired flow, it is not only fundamentally unfair to exclude Upper San Joaquin River flows in this process, it is illegal.

On page 5 of 6 in the first full paragraph there is a discussion of needing to obtain additional information to inform specific instream flow needs on the Stanislaus

River. The State Water Board simply needs to review its own files of the U.S. Bureau of Reclamation water right permits for New Melones and it will discover that an IFIM study was completed and has determined what "instream flows" are needed for the fishery. Implementation of those flows provides adequate protection for the fishery. We have attached a copy for your information as Exhibit A.

Finally, as we have previously noted in other submittals, any alternative evaluated in the SED that includes a flow contribution from New Melones Reservoir must recognize that releases from New Melones Reservoir must be limited to 1,250 cfs because of a court order issued when the original water rights were issued. The court found that non-flood control releases must be kept at 1,250 or less for the protection of the agricultural users along the Stanislaus River.

Attachment 3 – Draft Southern Delta Agricultural Water Quality Objectives

Attachment 3 proposes that the salinity objective at Vernalis remain 0.7 EC during the irrigation and 1.0 EC during the non-irrigation season. The stated justification for this is not for the protection of agricultural beneficial uses at Vernalis, but instead to provide assimilative capacity for downstream uses. Inclusion of this salinity objective violates both state law (Water Code, California Environmental Quality Act (CEQA) and the Article X, Section 2 of the California Constitution) and federal law (Clean Water Act and Public Law 108-361).

<u>The Proposed Salinity Objectives at Vernalis violates State Law because the objective is NOT required for the "Reasonable Protection" of Agricultural Beneficial Uses at Vernalis.</u>

The State Water Board is authorized under the Water Code to adopt Water Quality Control Plans ("Plans") in accordance with Water Code §13240 et seq. The Plans are to contain water quality objectives "that will ensure the reasonable protection of beneficial uses and the prevention of nuisance…" (Water Code §13241) "Water quality objectives" are "the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." (Water Code §13050(h))

The Vernalis salinity objective was established by the State Water Board in the 1995 Bay-Delta Plan. The 1995 Bay-Delta Plan set the objective based on the perceived salt sensitivity and growing season of beans from data gathered in the 1970s. Maintaining the Vernalis salinity objective at higher levels than what is required to provide "reasonable protection" to agricultural beneficial uses at Vernalis is per se unreasonable and violates the provision of the Water Code that authorizes adoption of water quality objectives. Proposing a Vernalis salinity objective that is overprotective of agricultural beneficial uses exceeds the authority granted to the Board under the Water Code.

Failing to Provide a Reasonable Range of Alternatives violates CEQA

The SED must describe a reasonable range of alternatives to the project that could feasibly attain the project objectives. [CEQA Guideline Section 15126.6] As such, failure to consider a range of potential salinity levels at Vernalis violates that basic principle of CEQA. There are ample alternatives to consider, but at a minimum, the recently prepared report by noted salinity expert Dr. Glenn Hoffman (Hoffman report) provides support for evaluation of a water quality objective of anywhere from 0.9 to 1.4 EC may be protective of agricultural beneficial uses in the Southern Delta, and this range must be evaluated.

Salinity Control by Flow Measures

There are additional flow alternatives that are reasonable and must be evaluated in the SED. The salinity problem is caused by deliveries from the San Luis Unit of the CVP. The Congressional authorization for the San Luis unit conditioned water deliveries upon completion of a drain. Because deliveries were made without provision for a drain, pollution of the San Joaquin River has resulted. Consequently, one of the alternatives for achieving the Vernalis salinity objective should be imposition of a condition upon the San Luis Unit permits to release water to comply with the Vernalis salinity objective. Several alternatives would be available under this scenario, including releases from San Luis and/or the Delta Mendota Canal with or without recirculation. All of these alternatives must be evaluated.

The salinity problem is also caused by discharges from wetlands and wildlife refuges. The SED must analyze reducing, eliminating or otherwise diluting at the source of this discharge. One very effective way of mitigating the adverse impact caused by the wetland and wildlife refuge discharge is to require the wetlands and wildlife refuges to reserve a portion of their water supply for use to dilute the discharge in the spring months.

The salinity problem is also caused by agricultural drainage and tile drainage entering the San Joaquin River from westside agricultural interests. The Grasslands Bypass and West Side Drainage Projects have successfully reduced a significant amount of salt laden drainage entering the San Joaquin River. The SED must evaluate additional drainage reuse and other measures to control these discharges or change the timing of these discharges to occur when there is natural assimilative capacity in the San Joaquin River.

Salinity Control by Non Flow Measures

In addition to controlling salinity by providing dilution flows, there are additional salinity control actions that should be analyzed, including subsurface storage of drainage, land retirement and out of valley disposal. Adoption of salinity objectives for the entire river and implementation through waste discharge permits that would prohibit discharge rather than control its timing should also be evaluated.

Maintaining the Vernalis Salinity Objective Violates the California Constitution's Prohibition Against the Unreasonable Use of Water

The California Constitution prohibits the waste and unreasonable use of water. Article X, section 2 declares, "The right to water or to the use of flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversions of water."

The "[u]se of upstream water to wash out salts downstream is an unreasonable use of water." (*Jordan v. City of Santa Barbara* (1996) 46 Cal.App.4th 1245, 1270; see also *Antioch v. Williams Irrigation District* (1922) 188 Cal. 451, 465) While the application of this rule depends upon the circumstances of each particular case, it seems most appropriate under the circumstances surrounding the update of the Vernalis salinity objective.

As discussed above, maintaining the Vernalis objective at its current levels, in light the increase of the interior Delta objectives, is unnecessary and overprotective of the agricultural beneficial uses at Vernalis. Requiring an artificially low salinity objective and conditioning the Bureau's water right permits to release water to create assimilative capacity to dilute downstream pollution flies directly in contravention of the Constitution and constitutes waste and an unreasonable use of water.

Maintaining the Vernalis Salinity Objective Imposes a Disproportionate Burden on New Melones Reservoir

The 2006 Bay Delta Plan acknowledged and discussed the various factors that contribute to elevated salinity in the southern Delta. In its implementation plan, the State Water Board identified various actions that could be used to implement the Vernalis salinity objective. The Vernalis salinity objective was to be attained using dilution flows as well as "non-water right actions" which included completion of a drain to remove the salts generated by agricultural drainage and municipal discharges and various other projects aimed at reducing high salinity drainage to the San Joaquin River and improving circulation in the southern Delta. Unfortunately not one of these "non-water right actions" has contributed to meeting the Vernalis objective. As a result, dilution flows released by the Bureau of Reclamation from New Melones Reservoir have been the sole means by which the Vernalis objective has been attained. Because of this, the New Melones CVP contractors, which include Stockton East, have had their water supply reduced and a disproportionate burden has fallen on these contractors which have not caused the pollution.

The State Water Board is now proposing to meet the interior Delta objectives through the assimilative capacity provided by maintaining the salinity objective at Vernalis at its current levels. In seeking to do so the State Water Board is now attempting to place an additional burden of meeting the interior objectives on New Melones and its contractors as well. To place this additional disproportionate burden on New Melones and its contractors is fundamentally unfair. The State Water Board should take action to appropriately apportion this burden among all those contributing to the problem as originally intended.

The Proposed Vernalis Salinity Objective Fails to Comply With Federal Law

The proposed Vernalis salinity objective is established to provide assimilative capacity for the dilution of downstream pollution. This is in direct contradiction to 40 CFR 131.10(a) which states "in no case shall a State adopt waste transport or waste assimilation as a designated use for any water of the United States." Effectively by admitting that Vernalis salinity objective is not for the protection of agriculture, but instead to provide dilution flows for downstream, the designated use that the State Water Board is establishing is really "waste assimilation" and expressly prohibited by Federal Law.

Finally, the continuation of the Vernalis salinity objective for the express purpose of providing assimilative capacity completely disregards the Congressional directive contained in H.R. 2828 (Public Law 108-361 to reduce the use of New Melones Reservoir to meet the existing Bay-Delta water quality objectives. The Congressional directive is clear, the legislation expressly directs the Bureau of Reclamation, with the assistance of the State, to initiate and implement actions to achieve the Bay-Delta water quality objectives while reducing the demand on water from New Melones Reservoir for meeting these objectives. Continuation with the existing Vernalis objective and conditioning the Bureau's water rights to make releases violates this important provision of federal law.

We appreciate the opportunity to comment.

Very truly yours,

KARNA E. HARRIGFELD
Attorney-at-Law

KEH:lac
cc: Kevin M. Kauffman

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Exhibit A

THE RELATIONSHIP BETWEEN INSTREAM FLOW AND PHYSICAL HABITAT AVAILABILITY FOR CHINOOK SALMON IN THE STANISLAUS RIVER, CALIFORNIA

Prepared by
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May 1993

THE RELATIONSHIP BETWEEN INSTREAM FLOW AND PHYSICAL HABITAT AVAILABILITY FOR CHINOOK SALMON IN THE STANISLAUS RIVER, CALIFORNIA

ABSTRACT

In 1989 the U.S. Fish and Wildlife Service's Instream Flow Incremental Methodology (IFIM) was applied to the Stanislaus River between Goodwin Dam and the town of Riverbank, California (approximately 24 river miles). The purpose was to help determine the instream flow needs for chinook salmon, *Onchorhynchus tshawytscha*, in the Stanislaus River downstream of the New Melones Unit of the Central Valley Project. The streamflow versus physical habitat relationship is described using the physical habitat simulation (PHABSIM) model and is based on the relationship established for three calibration flows measured as releases below Goodwin Dam (1,250 cfs, 700 cfs, and 125 cfs).

An instream flow of 300 cfs provides the greatest amount of salmon spawning habitat. Available habitat for egg incubation is maximized at 150 cfs. Fry habitat appears to be relatively limited and does not increase or decrease appreciably with streamflow. Juvenile salmon habitat availability is highest at 200 cfs. In general, an annual fishery flow release of 156,000 acre-feet would provide maximum physical habitat availability within the 24 mile study reach.

Additional water is recommended, as provided in an interim agreement between the U.S. Bureau of Reclamation and the California Department of Fish and Game, for further investigations to define flow needs for: 1) spring outmigration; 2) water temperature control; 3) fall "attraction" of migrating adults; and 4) maintenance of water quality (i.e., dissolved oxygen) or other benefits to the salmon population. These investigations must be completed before the instream flow requirements for chinook salmon protection on the Stanislaus River can be determined.

ACKNOWLEDGEMENTS

This investigation was funded through Federal transfer monies provided by the U.S. Bureau of Reclamation, Mid-Pacific Region. The studies described, and this report, were completed as part of a cooperative Stanislaus River Fishery Investigation, involving the Bureau of Reclamation, the U.S. Fish and Wildlife Service, and the California Department of Fish and Game. Jim Denny was the Bureau of Reclamation contact throughout this investigation. Many others also contributed to the completion of this report, especially in gathering the field data. Fish and Wildlife Service personnel Phil North (field crew leader), Nadine Kanim, Roger Guinee, Vicky Campbell, Mike Sullivan, Rich Williams, and Larry Hanson all worked diligently in gathering the field data. Volunteer workers Steve Elliot and Rick Howard also provided valuable field assistance. James Carson, of the Service's Sacramento Field Office, helped with editorial review and Jeff Thomas provided a thorough review, and improved calibration, of the PHABSIM input data for the final analysis.

PREFACE

The draft of this report, dated February 20, 1992, was titled Instream Flow Requirements for Fall Run Chinook Salmon Spawning and Rearing, Stanislaus River, California. The title has been changed to more accurately reflect the product of this study, which is a description of the relationship between physical or micro-habitat availability (expressed as suitable combinations of water velocity, depth, and substrate) for chinook salmon and streamflow in the Stanislaus River, California. Additional studies describing the relationship between streamflow and suitable macrohabitat conditions, such as water quality or temperature and conveyance flows (also called migration or "pulse" flows) necessary for salmon survival, must be completed in order to fully describe the relationship between instream flow and suitable habitat conditions for chinook salmon in the Stanislaus River.

A water temperature model is currently being developed for the Stanislaus River by the Bureau of Reclamation and salmon survival studies are being conducted by the Department of Fish and Game as part of the Stanislaus River Fishery Investigation. Once completed, the results of the temperature model, salmon survival studies, and the instream flow study described in this report will be "integrated" so that the overall relationship between streamflow and suitable habitat conditions for chinook salmon can be described. Only then can instream flows necessary to protect and preserve the salmon population of the Stanislaus River be determined and long term instream flow requirements be established.

Furthermore, due to interest from Bureau of Reclamation and Department of Fish and Game staff, a PHABSIM analysis was added using habitat suitability criteria for resident rainbow trout and anadromous steelhead trout.

Finally, those readers who reviewed the draft report may notice some differences in the relationship between weighted usable area and streamflow as described in this report. The primary reason for these differences are the result of a more detailed, and exhaustive, review of the physical and hydraulic input data applied to the PHABSIM. In addition, rather than running three separate data sets (high, middle, and low flow) for each study site, as was done in the draft, all velocity data was combined into one input deck for each study site in the final analysis. The input decks were thoroughly calibrated so that predicted water depths and velocities best matched those actually recorded at the three measured stream flows. Through this process it was not necessary to combine the PHABSIM results from three separate runs for each study site to provide the best overall picture of the physical habitat versus streamflow relationship, as was done in the draft. Instead the results from the combined velocity data sets used in the final analysis for each study site can be used directly. Therefore, the results presented in this report supersede those presented in the February 20, 1992 draft and should be used in negotiations where the relationship between weighted usable area of habitat and streamflow needs to be understood.

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THE RELATIONSHIP BETWEEN INSTREAM FLOW AND PHYSICAL HABITAT AVAILABILITY FOR CHINOOK SALMON IN THE STANISLAUS RIVER, CALIFORNIA

INTRODUCTION

Historically, the Stanislaus River, along with other San Joaquin River tributaries and the mainstem of the San Joaquin, had sizeable populations of chinook salmon, *Onchorhynchus tshawytscha*. Since the early 1900's, however, the number of salmon returning to the system each year to spawn has fallen dramatically. The spring-run chinook populations are extinct in the San Joaquin River system and the fall-run populations have declined significantly. Currently, there is no access for salmon to the upper San Joaquin River, due to diminished river flows. Spawning now occurs only in the major tributaries of the San Joaquin River -- the Merced, the Tuolumne, the Calaveras, and the Stanislaus Rivers.

Efforts are underway to protect, restore, or enhance the dwindling populations of fall-run chinook salmon within the San Joaquin River system. An early effort on the Stanislaus River began with the authorization of the New Melones Project, a Federal water project operated by the U.S. Bureau of Reclamation as part of the Central Valley Project. Among the authorized project purposes, (which include flood control, irrigation and municipal water supply, power generation, recreation, and water quality control) is fish and wildlife enhancement, including provision for fishery flows.

Pursuant to project authorization, the U.S. Fish and Wildlife Service (Service), the California Department of Fish and Game (Department), and the Bureau of Reclamation (Reclamation) have cooperatively undertaken a series of investigations aimed at determining the measures necessary to improve the chinook salmon population in the Stanislaus River. Study tasks were designed to identify factors limiting chinook salmon survival in the Stanislaus and to develop alternative management programs to increase the population. One task was specifically to conduct an instream flow study to assist in the identification of acceptable flow regimes for all life stages of chinook salmon which occur in the Stanislaus River. This report describes the instream flow study and presents the results.

DESCRIPTION OF STUDY AREA

General Setting

The headwaters of the Stanislaus River originate at an elevation of approximately 7,000 feet on the western slope of the Sierra Nevada, approximately 125 miles due east of the San Francisco Bay area. The Stanislaus flows in a southwesterly direction from the Sierra crest and joins the San Joaquin River on the floor of the Central Valley (Figure 1). Draining northward through the valley, the San Joaquin River meets the southward draining Sacramento River to form the Sacramento-San Joaquin Delta. Delta waters flow through the San Pablo Bay-San Francisco Bay complex and eventually into the Pacific Ocean, passing through San Francisco's Golden Gate.

Goodwin Dam is located in the Sierra foothills at an elevation of approximately 300 feet above mean sea level, and is a barrier to salmon migration on the Stanislaus River. Between the San Joaquin River and Goodwin Dam approximately 59 river miles of anadromous fish habitat is available in the Stanislaus. However, only the reach from approximately river mile 36 to Goodwin Dam (a distance of approximately 23 river miles) is defined as salmon spawning habitat by the California Department of Fish and Game (California Fish and Game code section 1505).

Field reconnaissance and aerial photos indicate that the lower Stanislaus

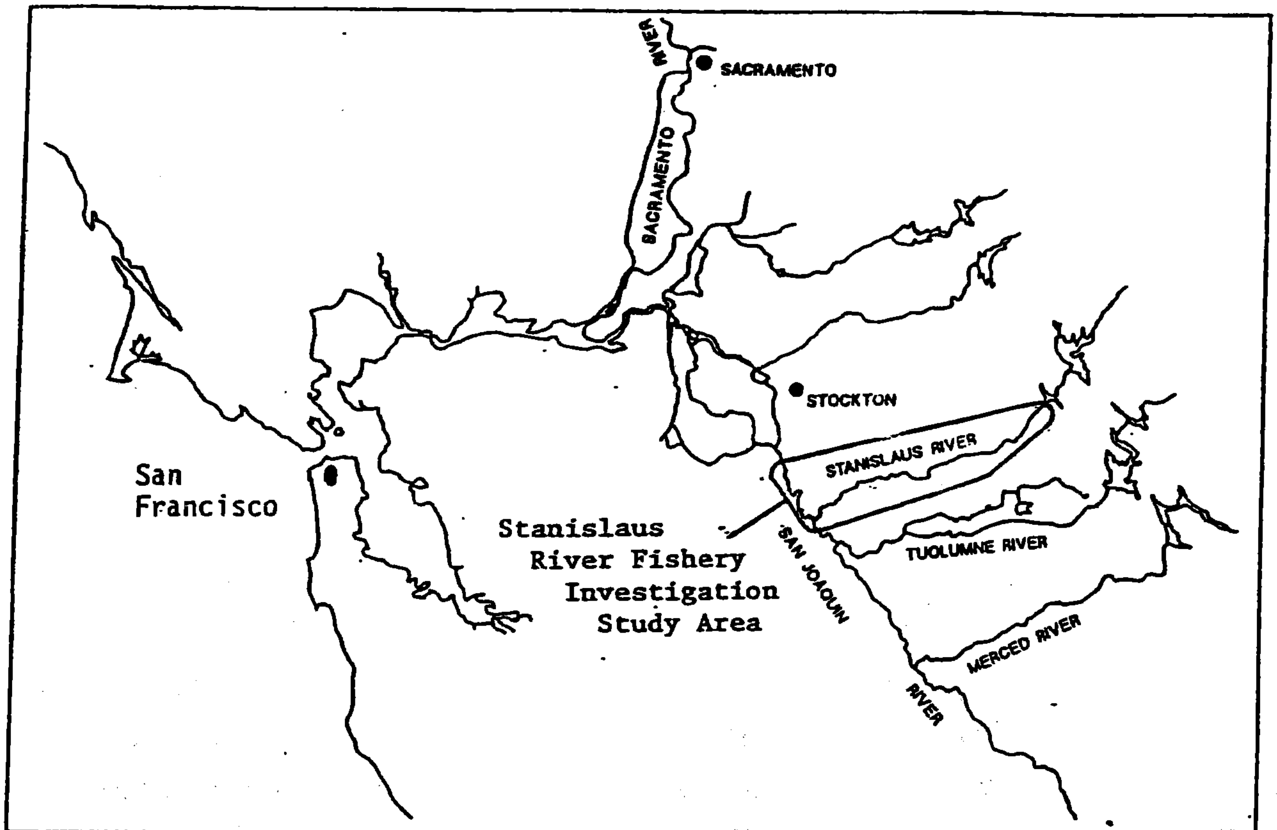


Figure 1. General location map of the Stanislaus River, California, and the Stanislaus River Fishery Investigation Study Area.

River(i.e., that section below Goodwin Dam) can be divided into upper, middle, and lower segments. They are distinguished from one another primarily by differences in stream gradient, substrate composition, and channel configuration. Two intermittent streams, Owl Creek and Wildcat Creek, enter the Stanislaus River in the upper and middle segments. Their contributions to river flow are generally not significant, however.

The upper river segment is the reach between Goodwin Dam and the town of Knights Ferry, a distance of approximately 4 river miles. Here the river is moderate in gradient (approximately 0.7%) and is confined by a narrow, steep-sided bedrock canyon. Approximately 80 percent of this river segment is composed of long deep pools and runs interspersed with short cascades. Substrate is predominantly sand and bedrock. The remaining 20 percent of this segment is lower in gradient and the channel is less confined. The primary habitat types here are pools, runs, and riffles with gravel and cobble the pre dominant substrate. Also, sand and bedrock are present to a lesser degree. Approximately 10 percent of all chinook salmon spawning in the Stanislaus River occurs within this river segment.

The middle river segment is the reach between the towns of Knights Ferry and Riverbank, a distance of approximately 20 river miles. As the river flows downstream from the upper, bedrock canyon segment, a well-defined channel continues with a low gradient (0.1%). Steep banks of erodible soils and of bedrock are common and are often situated opposite large flood plains. This river segment displays a typical pool, run, and riffle habitat-type sequence, although individual habitat areas are frequently long and often variable in occurrence. Large, deep dredge pools add to the diversity of stream habitat types within this river segment. The pre dominant substrate is sand, gravel, and cobble. Approximately 90 percent of all chinook salmon spawning in the Stanislaus River is found within this reach.

The lower river segment is the reach between the town of Riverbank and the San Joaquin River, a distance of approximately 35 river miles. As the river flows into the San Joaquin Valley the gradient is nearly flat (approximately 0.03%) and the river meanders more as it flows through the valley lowlands. Deep pool and run habitat types predominate. The river substrate is composed mainly of sand and fine organic material. Salmon use this segment primarily for migration, although some juvenile rearing occurs when water temperatures are satisfactory. No spawning has been observed within this segment.

Hydrology

River flows within the study reach are controlled by Reclamation through the

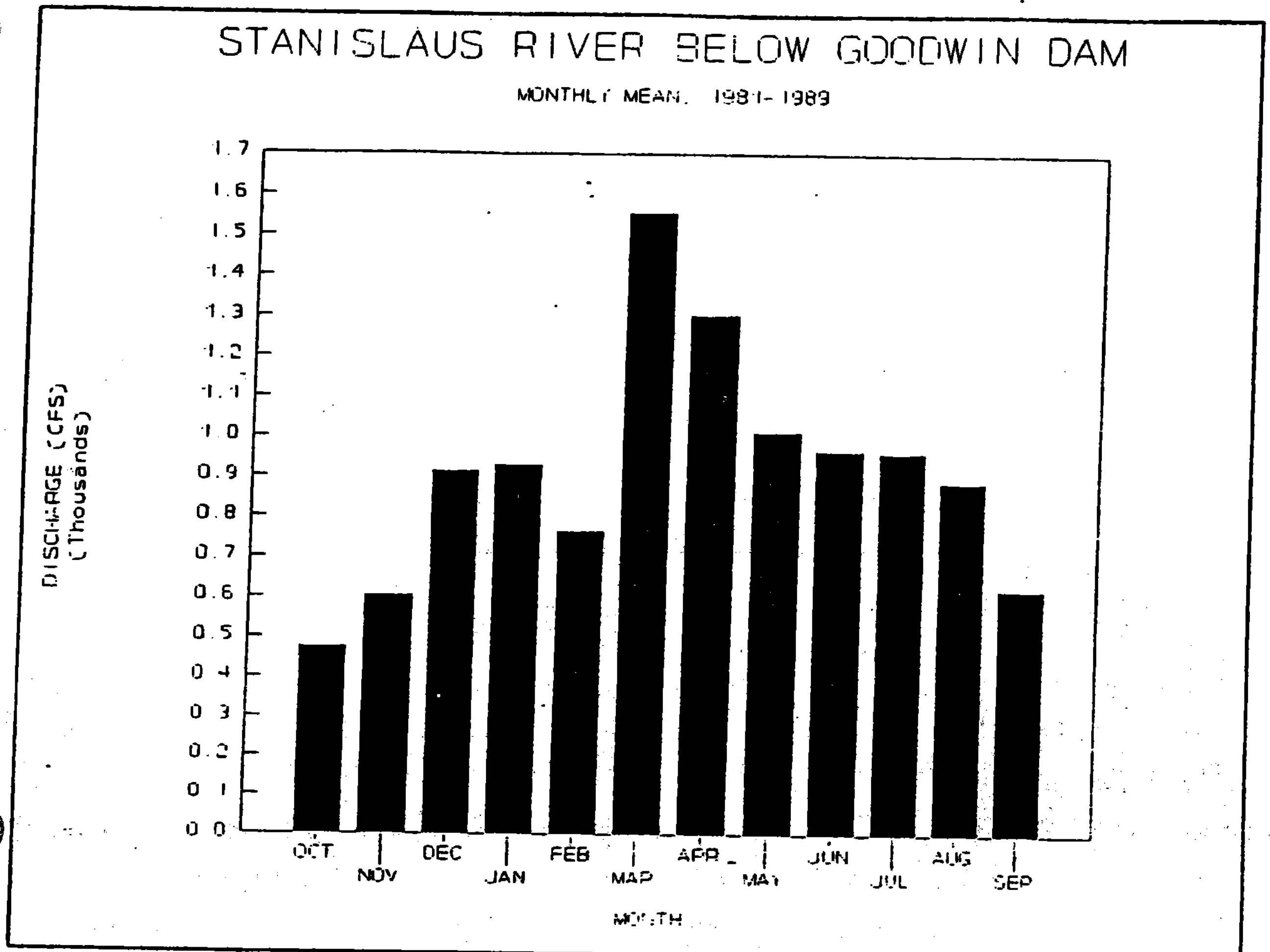


Figure 2. Mean monthly discharge (streamflow) for the Stanislaus River measured just below Goodwin Dam for years 1981 through 1989.

New Melones Unit of the Central Valley Project. The authorized fishery flow release from New Melones Reservoir is 98,300 acre-feet annually with provisions for release of 69,000 acre-feet in critically dry years. However, an interim agreement, executed in 1987, between the Bureau and the Department, provides for variable flow releases from 98,300 acre-feet to 302,000 acre-feet annually, based on inflow, reservoir storage, and water demands. In addition to the fishery flow agreement, the Bureau has an interim arrangement with the South Delta Water Agency to provide an annual release of up to 70,000 acre-feet or more, if adequate supply exists, for water quality control purposes. Recent mean monthly Stanislaus River flows measured at the U.S. Geological

Survey river gage just below Goodwin Dam are illustrated in Figure 2.

Fishery Resources

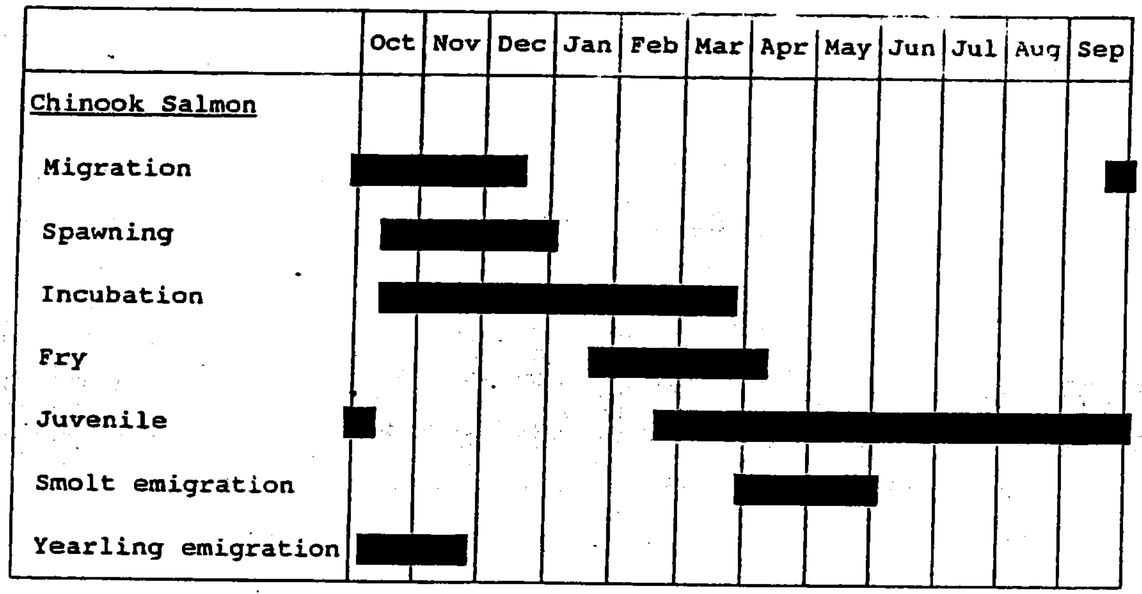
In addition to chinook salmon, a considerable population of resident rainbow trout, *Onchorhynchus mykiss*, exists within the Stanislaus River between Goodwin Dam and Riverbank. The Department also has anecdotal information regarding the occurrence of the anadromous steelhead trout within the Stanislaus River (Bill Loudermilk, DFG, personal communication). Striped bass, *Morone saxatilis*, and American shad, *Alosa sapidissima*, have been reported to have migrated to, and spawned in, the extreme lower reaches of the Stanislaus River. Sturgeon, *Acipenser spp.*, have also been reported within the lower Stanislaus but are not known to spawn in the river.

Fall-run chinook salmon generally begin to migrate into the lower Stanislaus in late September and continue through mid-December. Spawning begins in mid-October and continues through early January. Incubation, and fry and juvenile rearing, occur from the spawning period through mid-May. Juvenile smoltification begins as early as late March and generally continues to early June. Although most juvenile chinook salmon emigrate as smolts the first spring after hatching and emergence, some remain in the Stanislaus beyond this period. These yearling chinook juveniles have become more common within the Stanislaus in recent years (CDFG, 1987). Yearling chinook salmon have been observed in the river through the summer months and into early fall. Snorkeling surveys suggest that yearling emigration takes place when ambient air and water temperatures cool in October or November (CDFG, 1992). Table I is a life stage periodicity chart for chinook salmon in the Stanislaus River.

Late fall-run chinook salmon are also reported to spawn and rear in the Stanislaus River below Goodwin Dam (Alice Low, CDFG, personal communication).

Late fall-run spawn from December through early March. Fry and juveniles remain in the river throughout the summer, and migrate out of the system the following fall. Although a much smaller part of the Stanislaus River chinook salmon fishery, the late fall-run, nevertheless, is an important component.

Table I. Life stage periodicity chart for fall-run chinook salmon in the Stanislaus River, California.



IFIM Study Reach

The study reach for habitat mapping and collection of hydraulic and physical habitat data within the Stanislaus River was located in the upper and middle river segments, between Goodwin Dam and the town of Riverbank (a distance of approximately 24 river miles). The study reach was divided into four study areas, each designated by the name given to the study site within the study area, as follows: 1) Two Mile Bar area - from Goodwin Dam to the covered bridge at Knights Ferry (approximately 3.5 river miles); 2) Six Mile Bar study

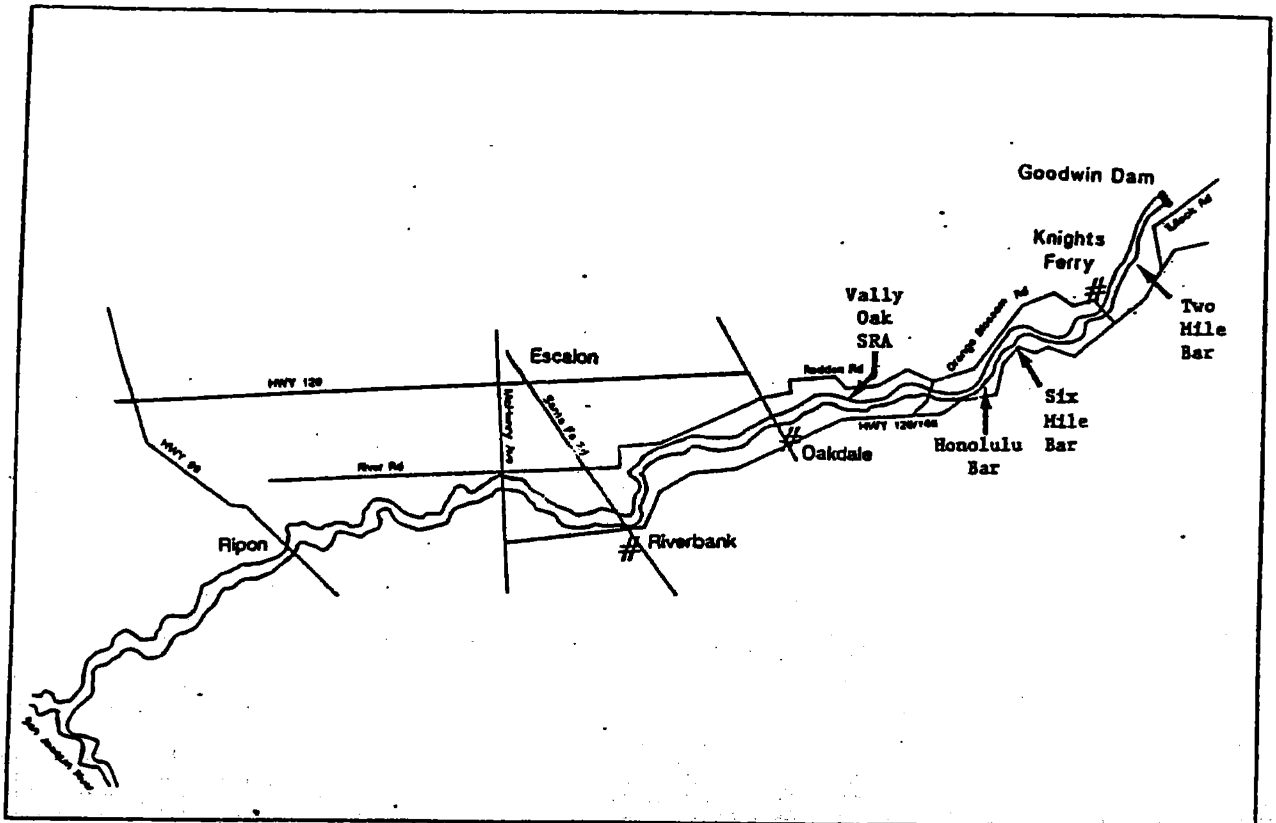


Figure 3. Location of IFIM study sites on the Lower Stanislaus River.

area - from the covered bridge at Knights Ferry to the upstream boundary of the Horseshoe Road Park (approximately 3.6 river miles); 3) Honolulu Bar study area - from Horseshoe Road Park to the Orange Blossom Road bridge (approximately 3.8 river miles); and, 4) Valley Oak State Recreation Area (SRA) study area - from the Orange Blossom Road bridge to about 1/2 mile upstream of the Santa Fe road bridge in Riverbank (approximately 13.1 river miles). Study site locations are shown in Figure 3.

The study sites were selected so that habitat types representative of the overall study areas were included, yet recognizing that each habitat type has variability between locations. For example, a pool by our definition is one that is over 4 feet in depth with an average water velocity of less than 1 foot per second. However, a given pool may be 6 feet deep and another 20 feet deep. Transects were established at the study sites to sample the major habitat types and provide enough repetition to account for natural variation. This resulted in 7 to 10 transects at each study site. Study site maps, including transect locations and habitat distribution, are included in Appendix A.

METHODS

The Service's Instream Flow Incremental Methodology (IFIM) (Bovee and Milhous 1978; Milhous et al. 1981, Bovee 1982) was used for this evaluation. The IFIM was developed to facilitate evaluation of water resource developments and effective stream management. Basically, the methodology uses a computer-based physical habitat simulation model (PHABSIM) to combine various stream hydraulic and physical parameters with fish habitat requirements. The product of the PHABSIM allows investigators to relate changes in streamflow to physical habitat availability. Important components of this technique are the development of a calibrated hydraulic stream model and knowledge of the suitability of specific microhabitat conditions (i.e., water depths, velocity, and substrate) for individual fish species and life stages.

Field Techniques

Permanent markers (pins) were placed at the ends of each transect and a benchmark established as reference points. For each transect, water velocities, depths, and substrates were recorded at vertical measuring points distributed across the wetted perimeter of the river for each of three "calibration" flows. Generally, the distance between each measuring point was kept constant. As needed, however, additional measuring points were added at gradient breaks in bottom profile or where significant changes in water velocities or substrate were observed. A rule of thumb was established that no more than 10 percent of the total measured streamflow for any transect would occur within any given "cell" (i.e., the area between vertical measuring points). As a result, the number of vertical measuring points varied from transect to transect depending on stream hydrology and streambed morphology. Generally, the number ranged between 20 and 30 per transect.

Water depths and velocities were measured at each transect for three release flows from Goodwin Dam and New Melones Reservoir. These "calibration" flows were 1,250 cubic feet per second (cfs), 700 cfs, and 125 cfs. The water velocity and depth data collected for the calibration flows where subsequently used to establish the water surface elevation (stage) versus streamflow (discharge) relationship and to calibrate the hydraulic simulation incorporated within the physical habitat simulation program. Data was collected on the following dates in 1989: May 2 to 6 for the 1,250 cfs release; July 10 to 13 for the 700 cfs release; and September 19 to 22 for the 125 cfs release. The flow for each study site was determined by calculating the mean of the flows recorded for each transect within the study site.

Mean water column velocities were measured at 0.6 of the total depth (measured from the water surface) for water depths less than or equal to 2.5 feet. At depths greater than 2.5 feet but less than or equal to 5.0 feet, velocities were measured at 0.2 and 0.8 of the total water depth. For water depths greater than 5.0 feet, velocities were measured at 0.2, 0.6 and 0.8 of the total water depth. Water velocity measurements were made with either a Price AA or Gurley water velocity meter. In extremely slow velocity areas, with water depths of less than 1 foot, a Pygmy water velocity meter was used. Mean water column velocities were calculated using standard formulas.

Water depths were measured to the nearest 0.1 foot with a top-setting wading rod in areas less than 8 feet deep. For depths greater than 8 feet, a boat-mounted sounding reel system with a cable and 15-pound sounding weight was used.

Substrate composition and fish cover were assessed in each observation cell. An observation cell is defined as having a width equal to the horizontal distance between midpoints of adjacent vertical measuring points, a height equal to the depth of the water column, and a length upstream and downstream to a point representing the "transition" point to the next habitat type. Substrate composition was described using a modified Brusven index system (Table II). An index was used for application of the PHABSIM model and is composed of a 6-digit substrate descripter based on dominant and subdominant substrate types. It is coded as xXyY.%E (where xX = dominant substrate, yY = subdominant substrate, and %E = percent embeddedness).

Cover was described using a three-digit code. The first digit of the code defines the size of the largest object(s) seen within the observation cell. The second digit defines any overhead cover which provides protection from

Table II. Substrate composition categories used in the Stanislaus River instream flow investigation.

Code	Substrate Type	Size Range (mm)
1	Organic Debris	---
2	Mud/Soft Clay	---
3	Silt	<.062
4	Sand	.062 - 2
5	Course Sand	2 - 4
6	Small Gravel	4 - 25
7	Medium Gravel	25 - 50
8	Large Gravel	50 - 75
9	Small Cobble	75 - 150
10	Medium Cobble	150 - 225
11	Large Cobble	225 - 300
12	Small Boulder	300 - 600
13	Medium Boulder	600 - 2000
14	Large Boulder	> 2000
15	Bedrock	---

Table III. Cover categories used in the Stanislaus River instream flow study, 1989.

Cover Object	Overhead Cover	Cover Quality
0 = None	0 = None	0 = None
1 = Objects < 6 inches	1 = Instream Overhead (undercut banks, rootwads, logs, etc.)	1 = Poor (<25%)
2 = Objects 6 to 12 inches	2 = Overhanging Overhead (within 18" of water's surface)	2 = Fair (25-50%)
3 = Objects > 12 inches	3 = Instream & Overhanging (both code 1 and 2)	3 = Good (50-75%)
------	-------	4 = Excellent (75-100%)

predators, sunlight, etc., within the observation cell. The third digit, which follows a decimal, describes the quality of the cover as poor, fair, good, or excellent. Cover codes and descriptions are listed in Table III. The cover index is coded as XY.Z (where X = object cover, Y = overhead cover, and Z = cover quality).

If no overhead cover was present in the observation cell, the linear distance to the nearest overhead cover was estimated to the nearest foot.
General information recorded for each field day included sampling date and time, study area and site, estimated stream discharge, air and water temperatures, name of observer and recorder, observation method, water clarity, weather conditions, total length of study site and equipment used.

Data Analysis

Field data gathered was initially transcribed from the field data forms into microcomputer database files using dBASE II (Ashton-Tate, DBASE II, IBM PC-DOS, Version 2.43). These files were checked for errors and corrected where necessary. They then became the "raw" database files from which all subsequent data analyses were conducted. The edited DBASE files where then transcribed to LOTUS 1-2-3 spreadsheets (1-2-3, release 2.01, LOTUS Development Corp.) for further analysis, including mean column water velocity calculations and conversion of substrate and cover codes to appropriate index values. These data were then formatted to input data decks needed for the hydraulic simulation (IFG4) program by using FLOSORT, a program developed by Andrew Hamilton of the Service's Lewiston Suboffice, Lewiston, California. All files were checked for accuracy using the RCKI4 microcomputer program provided by the Service's National Ecology Research Center, Aquatic Systems Modeling Section.

Physical habitat simulation (PHABSIM) input data decks were built for each study site using the water surface elevation (stage), streamflow (discharge), and water velocity data collected during the field measurements at the three calibration flows. In order to accurately portray the entire study area described by study site, transect weighting factors were all set to 1 and reach lengths were adjusted so that the total percent area represented by habitat type was equal to that measured during the habitat mapping phase of this study. Table IV lists the habitat type, reach length, weighting factor, and percent area represented by each transect for each study site during the computer modelling phase of this study. The input data decks used in this evaluation are listed in Appendix B.

Water surface elevations for computation flows, ranging from 50 cfs to 1300 cfs, were calculated in the model using a rating curve defined by the stage-discharge relationship established by those measured in the calibration flows. Each input deck was run separately through the PHABSIM.

The PHABSIM analysis also requires, as separate input, suitability criteria for the target species being considered. Water depth, velocity, and substrate suitability criteria for chinook salmon adults, fry, and juveniles were

Table IV. Habitat type, reach length, weighting factor, and percent area represented by each IFIM transect, by study site.

Study Site	Transect	Habitat Type	Reach Length	Weighting Factor	Percent Area
Two Mile Bar	10.0	Deep Pool	323.50	1.00	32.35
	9.0	Run	70.80	1.00	7.08
	8.0	Run	23.20	1.00	2.32
	7.0	Run	70.90	1.00	7.09
	5.0	Riffle	23.20	1.00	2.32
	4.0	Shallow Pool[1/]	70.80	1.00	7.08
	3.0	Run	70.90	1.00	7.09
	2.0	Riffle	23.20	1.00	2.32
	1.0	Deep Pool	323.50	1.00	32.35
Six Mile Bar	1.0	Riffle	50.30	1.00	5.03
	2.0	Run	130.70	1.00	13.07
	3.0	Run	130.70	1.00	13.07
	4.0	Run	130.70	1.00	13.07
	5.0	Deep Pool	457.00	1.00	45.70
	6.0	Riffle	50.30	1.00	5.03
	7.0	Riffle	50.30	1.00	5.03
Honolulu Bar	7.0	Run	77.00	1.00	7.70
	6.0	Run	77.00	1.00	7.70
	5.0	Run	77.00	1.00	7.70
	4.0	Run	77.00	1.00	7.70
	3.0	Deep Pool	225.50	1.00	22.55
	2.0	Riffle	241.00	1.00	24.10
	1.0	Deep Pool	225.50	1.00	22.55
Valley Oak SRA	7.0	Deep Pool	409.00	1.00	40.90
	6.0	Run	84.60	1.00	8.46
	5.0	Run	84.60	1.00	8.46
	4.0	Run	84.60	1.00	8.46
	3.0	Run	84.60	1.00	8.46
	2.0	Riffle	168.00	1.00	16.80
	1.0	Run	84.60	1.00	8.46

[1/] Although this transect was described as a shallow pool, it more closely represented a run, especially, at high flows. Therefore, it was combined with the run transects in the PHABSIM.

determined through direct observation and field measurements of habitat use and availability within the Stanislaus River. These data were collected between November 4, 1986 and April 13, 1989 and have been reported previously

(Aceituno, 1990). Egg incubation criteria used are a composite of water velocity and depth suitability described by Bovee (1978) and substrate suitability determined for the spawning life stage during the investigations of 1986 through 1989. For convenience, the criteria used in this analysis are listed in Appendix C.

The product of the PHABSIM is an index of the habitat potential, called the weighted usable area (WUA). For each study site and each computation flow the WUA is equal to the suitability index for the combined characteristics measured (water velocity, water depth, and substrate or cover) and the total surface area represented by that study site. The WUA is unique to the streamflow, the study site, and the target species and life stage to which it applies. The term "weighted" refers to the influence of the habitat suitability criteria developed for each target species and life stage which is applied to the physical habitat simulation.

The fish habitat versus streamflow relationship determined through the physical habitat simulation model is expressed in terms of square feet of weighted usable area of habitat per 1,000 linear feet of stream. To provide an overall picture of the relationship between physical habitat availability and streamflow within the study reach, the PHABSIM results for each study site were combined. Since the four study sites represent study areas of different lengths on the Stanislaus River, a value of total weighted usable area was calculated by multiplying the PHABSIM results for each study site by the total distance represented by that site, divided by 1,000, and summing the totals. This gives an estimate of weighted usable habitat area for the entire study reach from Goodwin Dam to Riverbank, California (approximately 24 river miles).

RESULTS AND DISCUSSION

Measured river flows at the four study sites, along with the releases from Goodwin Dam recorded at the U.S. Geological Survey river gage near the dam, are provided in Table V.

Table V. Recorded and measured stream flows (cfs) at Goodwin Dam and the four IFIM study sites on the Stanislaus River, California, 1989.

USGS Gage @ Goodwin	Two Mile Bar	Six Mile Bar	Honolulu Bar	Valley Oak SRA
1,270	1,304	1,360	1,318	1,327
710	689	744	727	772
130	132	157	165	165

The total weighted usable area of habitat versus streamflow relationships for chinook salmon spawning, incubation, fry, and juvenile life stages are illustrated in Figure 4. Predicted weighted usable area of habitat (per 1,000

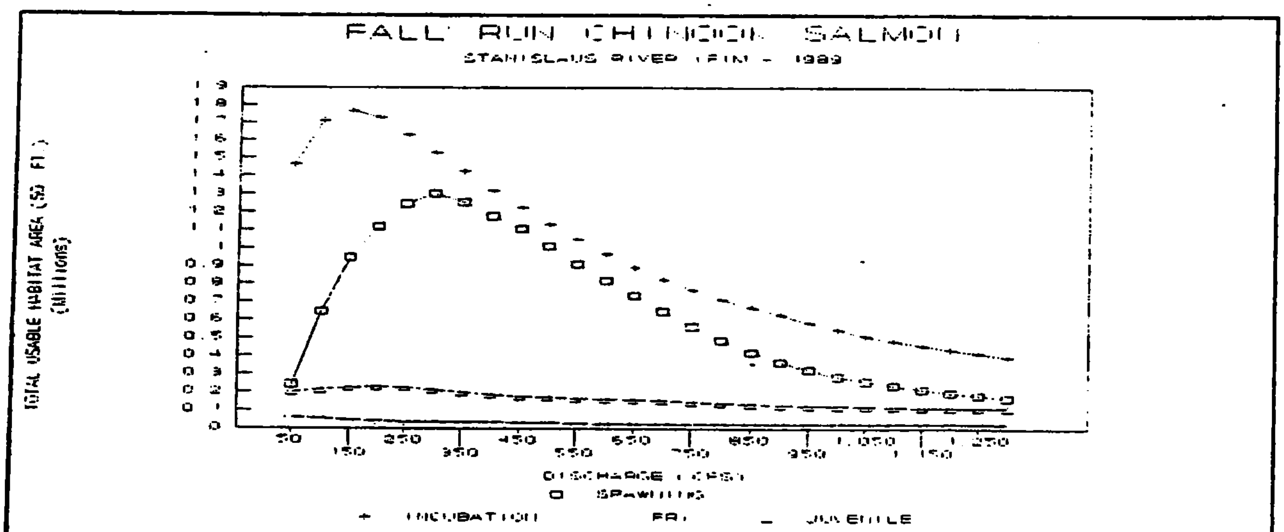


Figure 4. Total weighted usable area of habitat versus streamflow relationship for fall-run chinook salmon spawning, incubation, fry, and juvenile life stages in the Stanislaus River, California.

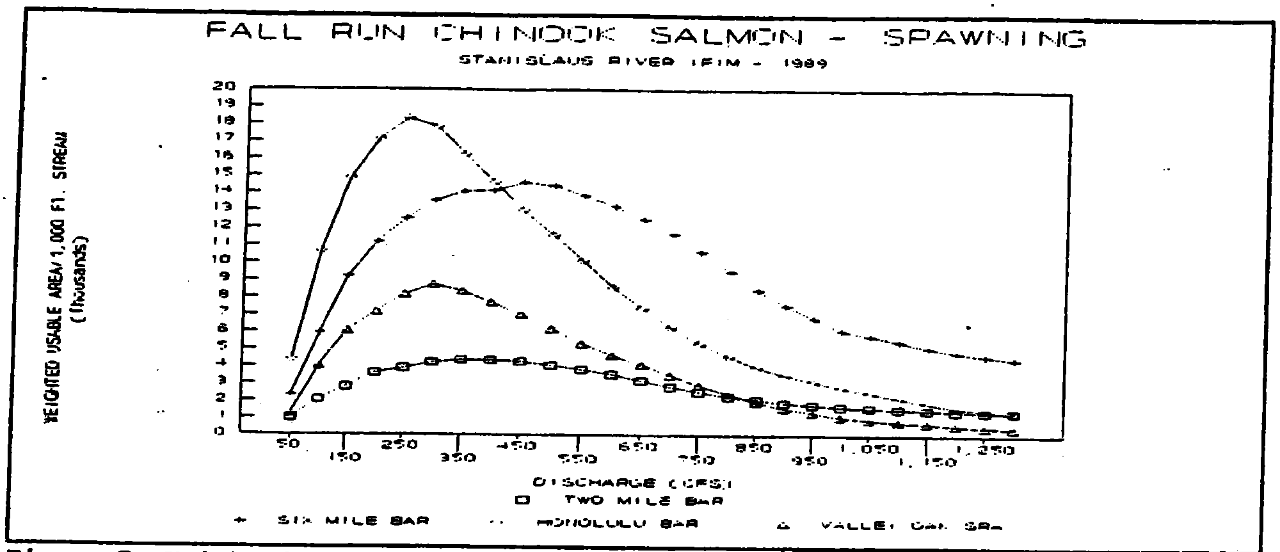


Figure 5. Weighted usable area of habitat (in square feet per 1,000 linear feet of stream) versus streamflow relationship for chinook salmon spawning at the four study sites on the Stanislaus River, California.

linear feet) versus streamflow relationships for each life stage, by study site, are illustrated in Figures 5 through 8. The weighted usable habitat area estimates used to generate these graphs are provided in Tables VI through IX.

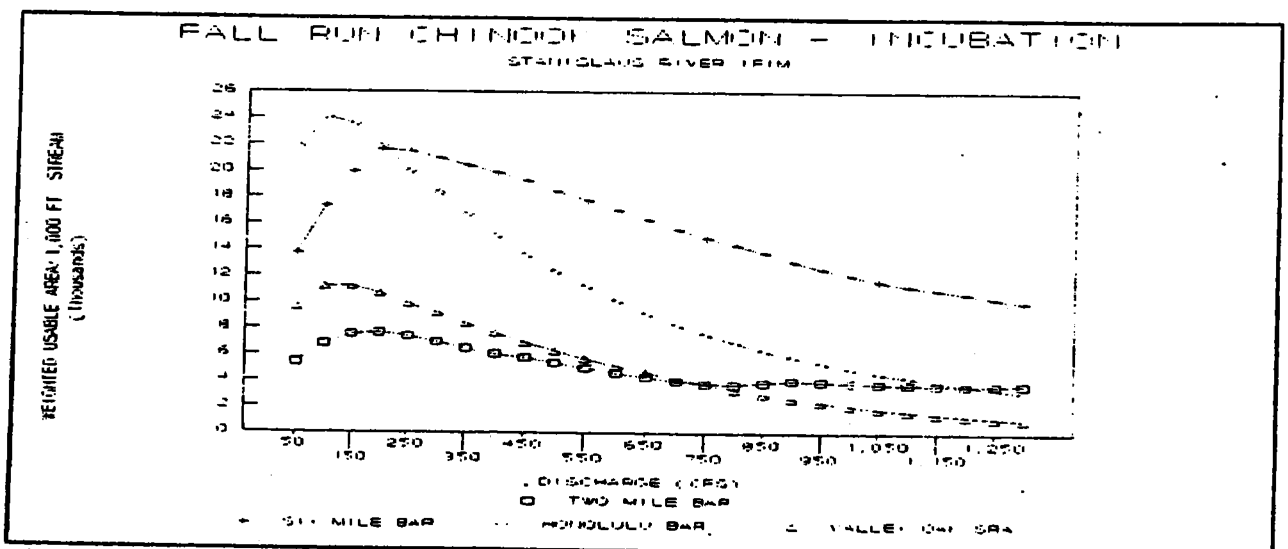


Figure 6. Weighted usable area of habitat (in square feet per 1,000 linear feet of stream) versus streamflow for chinook salmon egg incubation at the four study sites on the Stanislaus River, California.

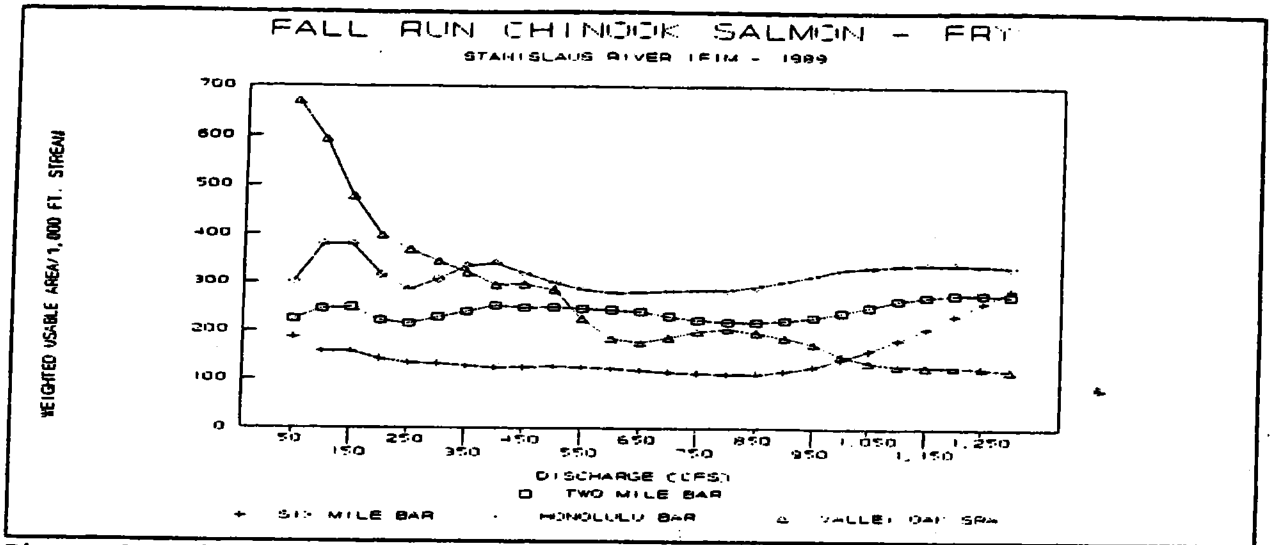


Figure 7. Weighted usable area of habitat (in square feet per 1,000 linear feet of stream) versus streamflow relationship for chinook salmon fry at the four study sites on the Stanislaus River, California.

Predictably, estimated weighted usable area of habitat for chinook salmon in the Stanislaus River varies considerably with streamflow below Goodwin Dam. Typically, weighted usable habitat area increases as flows increase and then begins to decline as streamflow continues to increase beyond an optimal level.

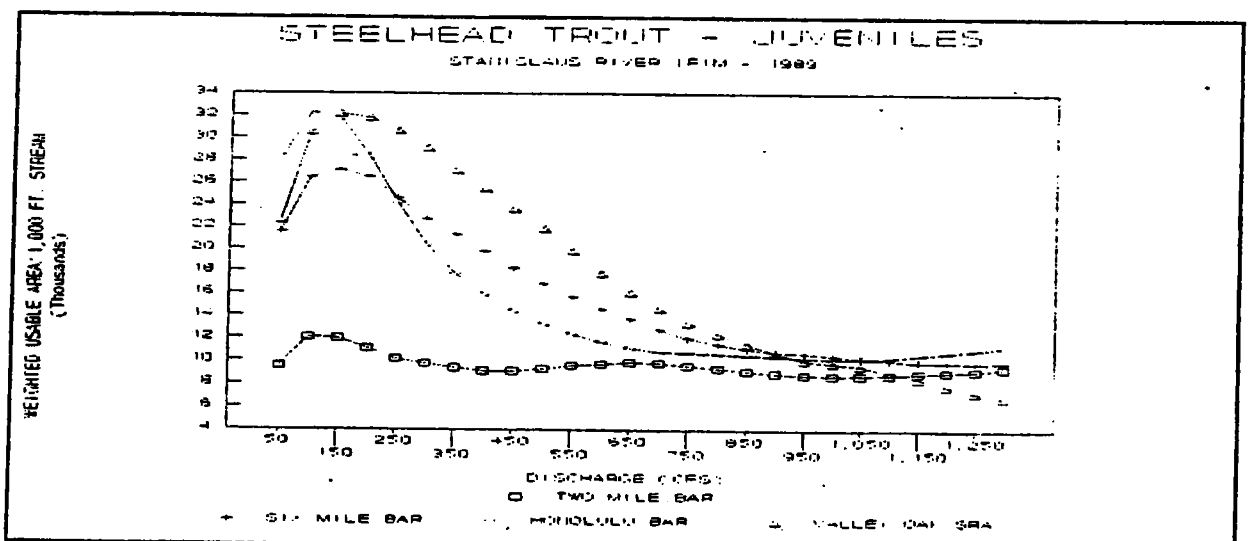


Figure 8. Weighted usable area of habitat (in square feet per 1,000 linear feet of stream) versus streamflow relationship for chinook salmon juveniles at the four study sites on the Stanislaus River, California.

Table VI. Streamflow versus weighted usable area (square feet per 1,000 feet) by study site, and total weighted usable area (square feet) for fall run chinook salmon spawning in the Stanislaus River, California.

Streamflow (cfs)	Two Mile Bar	Six Mile Bar	Honolulu Bar	Valley Oak SRA	Reach Total
25	351	666	1,345	226	62,145
50	1,007	2,354	4,397	1,272	240,387
100	2,079	5,910	10,634	4,028	644,143
150	2,824	9,203	14,859	6,061	946,290
200	3,618	11,186	17,087	7,134	1,117,916
250	3,904	12,526	18,321	8,175	1,245,320
300	4,232	13,562	17,834	8,730	1,299,496
350	4,383	14,073	16,236	8,349	1,253,539
400	4,380	14,138	14,660	7,684	1,177,151
450	4,312	14,616	13,035	7,017	1,106,286
500	4,083	14,432	11,582	6,165	1,010,593
550	3,848	13,859	10,159	5,353	910,630
600	3,576	13,253	8,606	4,683	816,489
650	3,207	12,514	7,420	4,121	732,814
700	2,858	11,673	6,304	3,533	647,199
750	2,565	10,633	5,381	2,950	563,092
800	2,292	9,534	4,630	2,449	487,304
850	2,114	8,453	3,996	1,974	417,915
900	1,938	7,560	3,546	1,623	364,279
950	1,813	6,837	3,165	1,354	321,941
1,000	1,720	6,136	2,835	1,121	284,078
1,050	1,646	5,825	2,526	953	258,954
1,100	1,587	5,504	2,237	822	236,864
1,150	1,526	5,129	1,919	715	214,706
1,200	1,460	4,873	1,673	609	196,325
1,250	1,408	4,688	1,511	512	181,924
1,300	1,392	4,495	1,302	436	168,419

The PHABSIM model developed in 1989 for the Stanislaus River considers only the relationship between physical habitat availability and streamflow for chinook salmon spawning, incubation, fry rearing and juvenile rearing life stages, within the river reach between Goodwin Dam and Riverbank (approximately 24 river miles). The results of the PHABSIM model indicate that a streamflow of

300 cubic feet per second provides the greatest amount of usable habitat for chinook salmon spawning. Available habitat for egg incubation is maximized at 150 cfs. Fry habitat appears to be generally limited and does not increase or decrease appreciably as streamflow changes. This is most likely due to the

Table VII. Streamflow versus weighted usable area (square feet per 1,000 feet) by study site, and total weighted usable area (square feet) for fall run chinook salmon egg incubation in the Stanislaus River, California.

Streamflow (cfs)	Two Mile Bar	Six Mile Bar	Honolulu Bar	Valley Oak SRA	Reach Total
25	3,825	9,344	15,525	4,328	862,406
50	5,379	13,724	21,763	9,603	1,463,666
100	6,818	17,333	24,050	11,139	1,711,446
150	7,505	19,950	23,507	11,185	1,766,492
200	7,639	21,575	21,832	10,620	1,727,374
250	7,376	21,469	19,991	9,851	1,630,332
300	6,935	20,973	18,314	9,144	1,530,088
350	6,458	20,431	16,655	8,374	1,424,348
400	6,021	19,885	15,043	7,603	1,320,071
450	5,747	19,216	13,562	6,906	1,224,309
500	5,353	18,449	12,338	6,266	1,133,519
550	4,970	17,750	11,183	5,673	1,048,838
600	4,555	17,036	10,076	5,132	967,859
650	4,270	16,290	9,084	4,639	894,345
700	3,987	15,542	8,235	4,167	825,070
750	3,761	14,896	7,570	3,728	764,897
800	3,719	14,359	6,916	3,324	712,809
850	3,864	13,793	6,303	2,960	667,305
900	4,028	13,144	5,793	2,633	625,165
950	3,952	12,601	5,339	2,343	584,286
1,000	3,871	12,107	4,925	2,082	546,999
1,050	3,785	11,633	4,560	1,847	512,732
1,100	3,724	11,235	4,274	1,644	484,246
1,150	3,674	10,970	3,954	1,465	459,500
1,200	3,648	10,662	3,654	1,304	435,992
1,250	3,684	10,327	3,386	1,160	414,902
1,300	3,706	10,023	3,141	1,027	395,452

fact that salmon fry are not well adapted to high velocity currents and spend most of their time along the shallow stream margins in slower water. In our observations during the habitat preference criteria development phase of this investigation, over 90 percent of all fry were found in areas of water velocity less than 0.5 foot per second and depths less than 2 feet (Aceituno, 1990). Chinook salmon juvenile weighted usable habitat area is highest at 200 cfs.

The Potential of Side-Channels

The potential of side-channel habitat areas for all chinook salmon life stages within the Stanislaus River should not be overlooked. For the fry and

Table VIII. Streamflow versus weighted usable area (square feet per 1,000 feet) by study site, and total weighted usable area (square feet) for fall run chinook salmon fry in the Stanislaus River, California.

Streamflow (cfs)	Two Mile Bar	Six Mile Bar	Honolulu Bar	Valley Oak SRA	Reach Total
25	250	224	372	813	72,236
50	225	187	302	670	59,840
100	246	157	380	593	56,012
150	249	157	379	478	48,115
200	222	142	316	398	40,574
250	215	134	285	368	37,599
300	229	132	306	344	36,598
350	240	128	335	321	35,755
400	253	125	341	295	34,272
450	248	125	320	297	33,877
500	250	127	300	286	32,807
550	247	125	286	227	28,379
600	245	123	280	185	25,311
650	242	119	281	177	24,640
700	232	115	284	187	25,151
750	223	113	285	200	25,817
800	220	111	285	205	26,102
850	219	112	293	197	25,701
900	223	118	303	187	25,437
950	229	127	316	174	25,092
1,000	240	143	329	151	24,232
1,050	252	161	333	136	23,866
1,100	266	183	338	130	24,253
1,150	273	208	340	128	24,759
1,200	278	235	340	128	25,416
1,250	279	262	339	126	25,753
1,300	276	288	336	120	25,740

juvenile life stages, significant habitat gains occur within the Honolulu Bar study site at streamflows above 450 cubic feet per second. This is because of the existence of a long side-channel at the site and the availability of more microhabitat in terms of low water velocities, shallower depths, and suitable substrate when this area becomes flooded.

Since side-channels are atypical of the lower Stanislaus River, representing less than 1 percent of the total habitat available, they are not included in the general habitat evaluation described in this report. Nonetheless, they could provide significant habitat enhancements beneficial to the dwindling chinook salmon population.

Table IX. Streamflow versus weighted usable area (square feet per 1,000 feet) by study site, and total weighted usable area (square feet), for fall run chinook salmon juveniles in the Stanislaus River, California.

Streamflow (cfs)	Two Mile Bar	Six Mile Bar	Honolulu Bar	Valley Oak SRA	Reach Total
25	677	633	1,390	1,992	189,543
50	752	677	1,378	2,118	200,225
100	729	772	1,438	2,274	213,544
150	728	841	1,563	2,397	225,783
200	731	835	1,617	2,424	228,703
250	742	806	1,602	2,371	224,444
300	749	763	1,511	2,226	211,896
350	741	717	1,392	2,081	198,561
400	723	675	1,300	1,924	184,792
450	722	649	1,249	1,822	176,204
500	735	626	1,235	1,746	170,513
550	745	601	1,246	1,677	165,685
600	751	581	1,229	1,619	161,158
650	760	569	1,200	1,561	156,508
700	763	562	1,173	1,522	153,219
750	761	556	1,149	1,436	146,694
800	761	549	1,131	1,353	140,481
850	762	536	1,124	1,275	134,743
900	759	522	1,127	1,207	129,830
950	751	510	1,139	1,143	125,285
1,000	745	500	1,150	1,112	123,084
1,050	739	495	1,155	1,085	121,154
1,100	733	493	1,163	1,037	117,862
1,150	735	494	1,178	997	115,458
1,200	740	498	1,196	966	113,910
1,250	739	505	1,214	949	113,201
1,300	739	515	1,220	933	112,407

The Importance of Pulse Flows

This study did not directly provide information on flows needed for smolt emigration in the spring. Preliminary data from smolt survival studies being conducted by the Department of Fish and Game indicate that flows of 1,250 to 2,000 cfs would provide for a high level of smolt survival in the Stanislaus River. In testimony to the State Water Resources Control Board, the Department has recommended increasing streamflow between April 15 and May 15 each year. The flow increase is based on the results of studies documenting increased survival of salmon smolts to the Sacramento-San Joaquin River Delta. Detailed monitoring efforts are also recommended by the Department to further evaluate and document the benefits of the pulse flows and to determine the duration required for smolt survival (CDFG, 1992).

Yearling and Late Fall-Run Salmon Flow Needs

Although river flows of 200 cfs provide maximum juvenile rearing habitat, higher flows may be necessary over the summer months. Not only is appropriate physical habitat needed for juvenile rearing (which is optimized at 200 cfs), but suitable water temperatures are also necessary during this period. In the past, flows released to meet water quality requirements have provided conjunctive benefits for fall-run yearling or late fall-run juvenile salmon rearing through the late spring and summer months. An exception has been when storage in New Melones Reservoir is severely depleted. The Bureau of Reclamation is developing a water temperature model for the Stanislaus River which will help determine the instream flow needs. In addition, studies are needed to determine the appropriate "carry over" storage to be maintained in upstream reservoirs, particularly New Melones, so that water temperatures in the river downstream can best be controlled for the benefit of juvenile salmon.

Rainbow Trout and Steelhead Concerns

Although an evaluation of the physical habitat versus streamflow relationship for other salmonid species was not originally a part of this study, staff from both the Bureau of Reclamation and the Department of Fish and Game have expressed an interest in seeing this relationship. Therefore, a PHABSIM analysis was conducted using habitat suitability criteria for resident rainbow trout and the anadromous steelhead rainbow trout. Table X lists the flows

which would provide the maximum amount of habitat for each life stage of rainbow and steelhead trout in the Stanislaus River. The complete results of

Table X. Instream flows (cfs) which would provide the maximum weighted usable area of habitat for rainbow trout and steelhead trout in the Stanislaus River between Goodwin Dam and Riverbank, California.

Life Stage	Rainbow Trout	Steelhead Trout
Spawning	100	200
Fry	50	50
Juvenile	150	150
Adult	400	500

this analysis are provided in Appendix D.

CONCLUSION

The results of this study show that microhabitat availability is highest for chinook salmon spawning at 300 cfs, egg incubation at 150 cfs, and for juvenile salmon at 200 cfs. Weighted usable area of habitat for chinook salmon fry is limited, restricted to shallow, low velocity areas along the stream margins. Table XI shows instream flows yielding the maximum weighted usable area of habitat for chinook salmon in the Stanislaus River. The incubation and fry life stages are combined since they overlap in occurrence. Considering such factors as possible redd dewatering, siltation, and the maintenance of suitable dissolved oxygen levels for development of incubating salmon eggs, the flow requirement for incubation is given priority.

Even though the PHABSIM model results indicate relatively little available fry habitat, overall, the potential exists to significantly increase its availability through the development of side-channels or other areas providing shallow, low velocity habitat.

While this report describes the water velocities, depths, and substrates suitable for chinook salmon life stages, a comprehensive instream flows regime

Table XI. Instream flows which would provide the maximum weighted usable area of habitat for chinook salmon in the Stanislaus River, between Goodwin Dam and Riverbank, California.

Life Stage	Dates	#Days	Goodwin Dam Release (cfs)	(acre-feet)
Spawning	October 15 - December 31	78	300	46,414
Egg Incubation/ Fry rearing	January 1 - February 15	46	150	13,686
Juvenile rearing	February 15 - October 15	241	200	95,605
	Totals	365		155,705

which would protect and preserve the Stanislaus River salmon resource cannot be determined from that data alone. Other macrohabitat conditions, such as water quality and temperature, and the value of conveyance and attraction flows, have yet to be fully described for the Stanislaus River.

Consideration of other macrohabitat conditions before recommending instream flows is consistent with the Instream Flow Incremental Methodology, which integrates the multitude of components and associated habitat variables important to evaluating potential impacts to rivers. As noted earlier, the Bureau of Reclamation is developing a comprehensive water temperature model for the Stanislaus River. In addition, the Department of Fish and Game is continuing investigations into the benefits of spring "pulse" flows and fall attraction flows as part of the overall Stanislaus River Fishery Investigation. Once these studies are completed, the results can be combined with the results described in this report. Only after integrating a variety of habitat variables and competing species life stage needs can a comprehensive instream flow schedule for the Stanislaus River be developed which will protect and preserve the chinook salmon resource.

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