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ORIGINAL

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To:

SEP 16 2008

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Dear Secretary Bose:

Subject: New Don Pedro Project, FERC No. 2299 FWS Filing of Final Report Relating to Flow-Overbank Inundation Relationship on the Tuolumne River

Enclosed for your information is an original and 8 copies of our final report on flow-overbank inundation relationships for potential fall-run Chinook salmon and steelhead/rainbow trout juvenile outmigration habitat in the Tuolumne River, and the response to comments document for the peer review of the above report. The purpose of this report is to provide scientific information to the U.S. Fish and Wildlife Service's Central Valley Project Improvement Act (CVPIA) program to assist in determining instream flow needs for the Tuolumne River, pursuant to Title 34, Section 3406 (b) (1) (B) of the CVPIA, P.L. 102-575. We request that this information be filed in the administrative record for the New Don Pedro Hydroelectric Project, FERC #2299, for use in the relicensing process.

If you have any questions about the enclosed documents or our investigations, please feel free to contact Mark Gard at (916) 414-6589.

Sincerely,

M. Kathleen Wood
Assistant Field Supervisor

FILED
SECRETARY OF THE COMMISSION
2008 SEP 17 P 1:03
FEDERAL ENERGY REGULATORY COMMISSION

Enclosures (2)

TAKE PRIDE IN AMERICA

Enclosure 1

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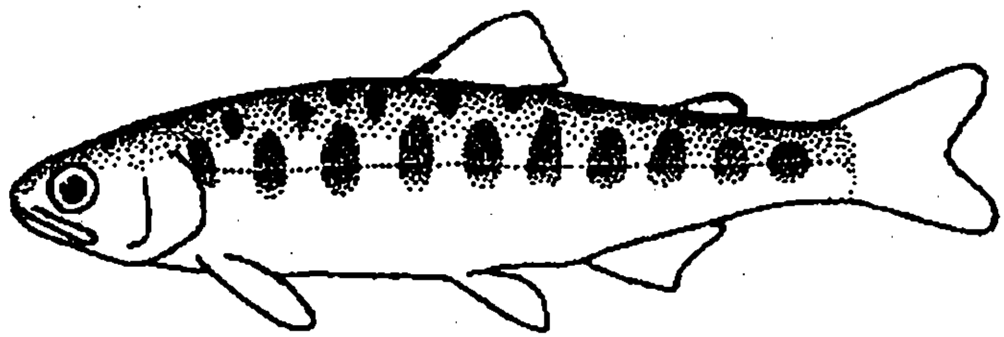
FLOW-OVERBANK INUNDATION RELATIONSHIP FOR POTENTIAL FALL-RUN CHINOOK SALMON AND STEELHEAD/RAINBOW TROUT JUVENILE OUTMIGRATION HABITAT IN THE TUOLUMNE RIVER



U. S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, CA 95825

Prepared by staff of The Energy Planning and Instream Flow Branch

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CVPIA INSTREAM FLOW INVESTIGATIONS
TUOLUMNE RIVER FALL-RUN CHINOOK SALMON
AND STEELHEAD/RAINBOW TROUT OUTMIGRATION HABITAT

PREFACE

The following is the final report for the U.S. Fish and Wildlife Service's investigations on anadromous salmonid outmigration habitat in the Tuolumne River between La Grange Dam and river mile 22, using existing Geographic Information System (GIS) data. This current study is part of the Central Valley Project Improvement Act (CVPIA) Instream Flow Investigations. Title 34, Section 3406(b)(1)(B) of the CVPIA, P.L. 102-575, requires the Secretary of the Interior to determine instream flow needs for anadromous fish for all Central Valley Project controlled streams and rivers, based on recommendations of the U.S. Fish and Wildlife Service, after consultation with the California Department of Fish and Game. The purpose of these investigations is to provide scientific information to the U.S. Fish and Wildlife Service (USFWS) Central Valley Project Improvement Act Program to assist in developing such recommendations for Central Valley rivers.

Written comments or information can be submitted to:

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ACKNOWLEDGMENTS

The database used for this study was provided by Scott McBain of McBain and Trush, Arcata, California, with the permission of Turlock Irrigation District (TID) and Modesto Irrigation District (MID). Invaluable assistance concerning the history of the data and location of documentation was provided by Brian Powell, Becky McBain, Darren Mierau, Tim Ford, Noah Hume, Rafael Real de Asua and Dirk Pedersen. Data analysis and report preparation were performed by Bill Pelle and Mark Gard. Funding was provided by the Central Valley Project Improvement Act.

ABSTRACT

A preliminary flow-overbank inundation area relationship was derived for the lower Tuolumne River downstream of La Grange Dam with the view that, with restoration, the inundated former natural floodplain could provide habitat for outmigrating juvenile rainbow/steelhead trout and fall-run Chinook salmon. ARC GIS data used for this study was originally developed as part of the Federal Energy Regulatory Commission hydro-relicensing proceedings for the Don Pedro Project (Project No. 2299). The GIS layers used were first developed from aerial photos taken at flows between 100 and 8,400 cubic feet per second (cfs) from 1988 through 1995. In our analyses, shape files were edited to remove islands and isolated pond areas, which are actually gravel pits. Total area was then recalculated for all the remaining polygons for each flow/layer. A curve was then generated by plotting area in acres versus flow. The initiation of overbank flow occurs between 1,100 cfs and 3,100 cfs. In addition, there were several flooded gravel pits that were not connected to the river until flows exceeded somewhere between 620 and 1,100 cfs, one large pit that was not connected to the river until flows exceeded somewhere between 4,030 and 5,300 cfs, and two large pits that were not connected to the river until flows exceeded somewhere between 5,300 and 8,400 cfs. Studies suggest that these pits may contain exotic predator species, particularly large mouth bass, and concerns have been raised by others that flow connectivity between these pits and the river could result in predation or introduce predators to the river. However, there is substantial evidence that the benefits of floodplain inundation far outweigh the potential negative benefits of connectivity to these mine pits and there is no evidence that predatory refugia in off-channel mine pits contributes to in-channel predation of juvenile salmonids. It is hoped that these results of this study, combined with existing and future investigations, may provide input for ongoing restoration planning efforts for the lower Tuolumne River.

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INTRODUCTION

In response to substantial declines in anadromous fish populations, the Central Valley Project Improvement Act (CVPIA) provided for enactment of all reasonable efforts to double sustainable natural production of anadromous fish stocks including the four races of Chinook salmon (fall, late-fall, winter, and spring runs), steelhead, white and green sturgeon, American shad and striped bass. For the Tuolumne River, the Central Valley Project Improvement Act Anadromous Fish Restoration Plan calls for supplementing Federal Energy Regulatory Commission (FERC) agreement flows as needed to improve conditions for all life history stages of Chinook salmon (USFWS 1995). Restoration efforts by the CVPIA, 4-Pumps Mitigation Agreement, and the California Water Policy Council and Federal Ecosystem Directorate (CALFED) Ecosystem Restoration Program since 1992 have increased the production of Chinook salmon in the Sacramento River Basin; whereas Chinook salmon production has declined in the San Joaquin River Basin, which includes the Stanislaus, Tuolumne, and Merced rivers. Population trends analyses for the San Joaquin River Basin suggest that salmon recruitment, which is the number of salmon that survive to the adult stage, is highly correlated with the magnitude and duration of spring flows when the fish were subyearling juveniles rearing in the tributaries (Mesick and Marston 2007). The number of smolt-sized outmigrants from the Stanislaus and Tuolumne rivers is also highly correlated with flow magnitude between February and mid-June (Mesick et al. 2007). These results suggest that fry survival in the tributaries is highest during prolonged periods of flooding and that adult recruitment is highly dependent on fry survival in the tributaries. It is likely that prolonged flooding affects fry survival by providing autochthonous food resources, providing refuge from predators, reducing water temperatures particularly during downstream migrations in May and June, slowing the rate of disease infestation, diluting contaminants, and reducing entrainment (Mesick et al. 2007). Some of these benefits such as increased food resources and refuge from predators could be provided either by higher flows inundating existing floodplains or by constructing lower-elevation floodplains that become inundated on an annual basis with existing flows. However, other benefits such as reduced water temperatures and contaminant dilution would probably only occur during high flows.

In January 2007 the USFWS Anadromous Fish Restoration Program office requested a study of floodplain inundation as a function of flow for the entire anadromous reach on the Tuolumne, Stanislaus, Merced, or San Joaquin rivers, using existing data. The objective of this study was to evaluate floodplain inundation area on the lower Tuolumne River at flows ranging from low flow summer conditions (100 cfs) to flood conditions (8,400 cfs). Results from this study will eventually be added to larger modeling studies with two larger/broader objectives. First, the data will be used for analyses of the relationship between floodplain inundation and tributary smolt production. Second, the estimated amount of available functional floodplain habitat will be used to estimate the amount of habitat to be restored to achieve the doubling goal for Chinook salmon.

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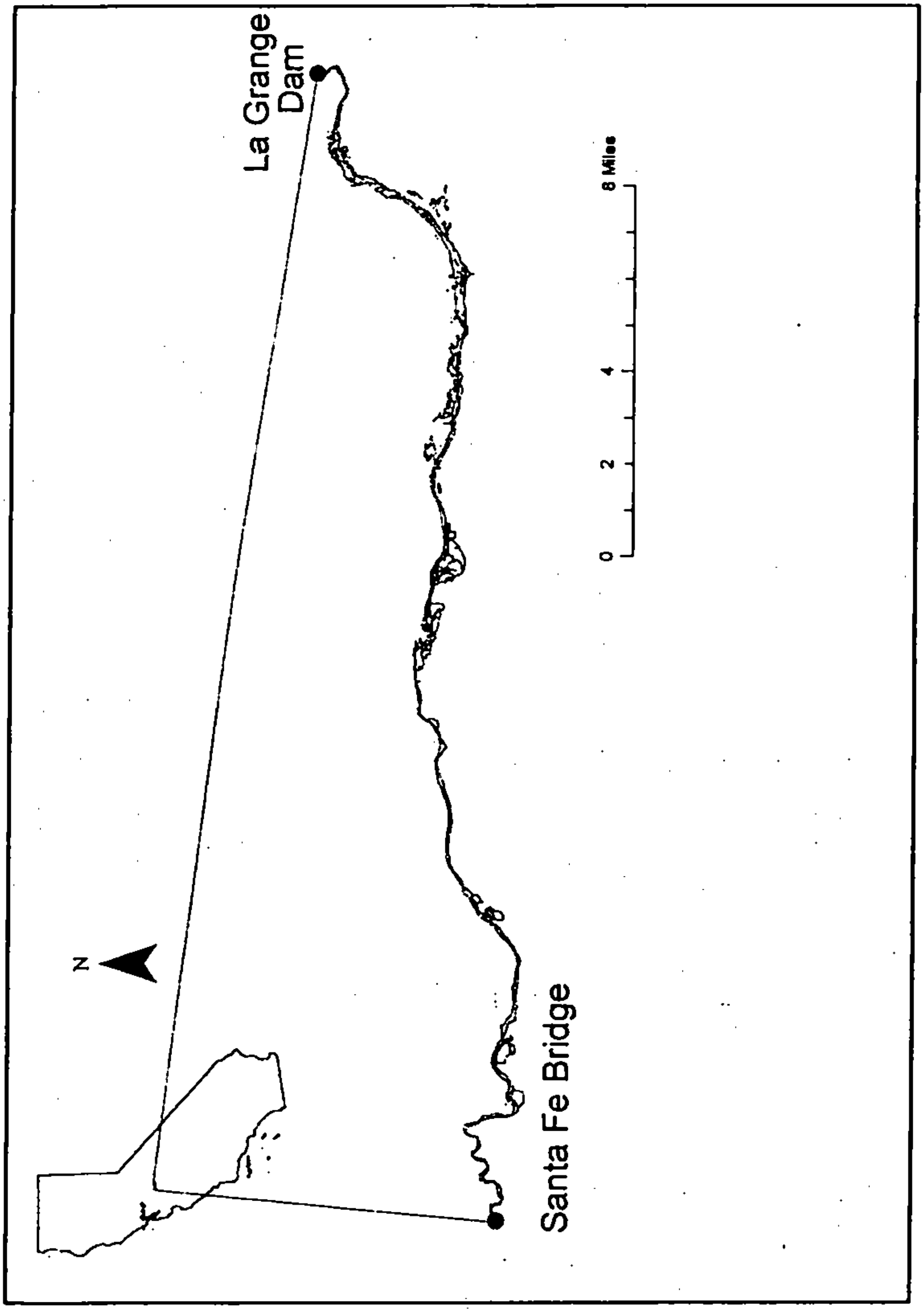

Figure 1. Lower Tuolumne River study area.

The lower Tuolumne River was chosen for this study, as appropriate GIS data was available for the reach between La Grange Dam at river mile (RM) 52 and just upstream of the Santa Fe Bridge, at RM 21.5, near the town of Empire (Figure 1). This area was selected for the study because snorkeling surveys suggest that most fall-run Chinook salmon and rainbow trout rear in this reach (Turlock Irrigation District (TID) and Modesto Irrigation District (MID) 2005).

With headwaters in Yosemite National Park, the Tuolumne River is part of the San Joaquin River system, which empties into the Sacramento-San Joaquin Delta. The lower Tuolumne begins at La Grange Dam, a diversion and reregulating facility located a short distance downstream of New Don Pedro Dam, which impounds the Don Pedro Reservoir (FERC 1996).

The channel and floodplain of the lower Tuolumne River has undergone enormous changes in response to reduction in flood regime, trapping of sediment by the New Don Pedro Reservoir, operation of gold dredgers, aggregate extraction from the active channel and floodplain, and encroachment of agriculture into the riparian zone. Capture of floodplain gravel pits by the active channel has had significant effects on channel morphology, turning many reaches from lotic to basically lentic ponds and ditch-like channels (FERC 1996). The altered channel and former floodplain of the study reach is also characterized by dredge tailings and rip-rap (TID/ MID 2005).

METHODS

The method used in this study is similar to a demonstration flow assessment, as described in Clackamas Instream Flow/Geomorphology Subgroup (CIFGS 2003). Direct observation of river habitat conditions are recorded at several flows and habitat is delineated in the field at each flow. Several other alternative methods, which were not selected for use in this study, are available to evaluate outmigrant flows. An empirical, and probably the most widely-used technique to evaluate rearing habitat utility at outmigrant flows, is the use of screw traps. Also available are passage studies, where transects are placed at relatively shallow areas, water surface elevation (WSEL) and discharge data are collected at a range of flows, and a Physical Habitat Simulation System (PHABSIM) (Milhous et al. 1989) program is used to establish stage-discharge relationships. This information is then used to determine what flow results in depths at the minimum required for passage of the target species/life-stage. This method, however, seems to be more commonly used for determining upstream migration flows for adults and is described in more detail in USFWS (1994).

To develop a flow regime which will accommodate the habitat needs of anadromous species inhabiting streams it is necessary to determine the relationship between stream flow and habitat availability for each life stage of those species. The ARC GIS program, developed by ESRI, was used to calculate area inundated at a range of flows, as one way of establishing this relationship. Assumptions of this method included: 1) that there is a linear change in area between measured data; 2) that the water's edge data was sufficiently accurate to calculate the change in inundated area with change in flow; and 3) that the relationship between inundated area and flow did not significantly change over the period of time in which the data was collected.

ARC GIS data used for this study were originally developed by EA Engineering, Science and Technology for TID/MID, as part of the 1992 Fisheries Study Report that was included in the FERC hydrolicensing proceedings for the New Don Pedro Project - Project No. 2299 (TID/MID 1992). The specific study in the report was an assessment of spawning gravel availability as a measure of potential spawning habitat. The data was also included in the 2005 Ten Year Summary Report by TID/MID for the FERC (TID/MID 2005).

Background information on the aerial photos and initial GIS development is given in TID/MID (1992). Those photos were taken during 1986-1991 at La Grange with flows ranging from 96-622 cfs. TID/MID (2005) lists all the aerial photos with added flows ranging from 1,070-8,400 cfs. The photos at these higher flows were taken in 1992-1995 and were used to make four additional GIS layers. The GIS mapping products were described and provided, on CD, in TID/MID (2005), Appendix F. The mapping at flows below 1,000 cfs was done by EA (1992). The later wetted perimeter data at the higher flows came from HJW Geospatial, Inc. (Rafael Real de Asua, personal communication 2007). Polygons and wetted perimeters were hand-drawn, digitized and georeferenced using landmarks found both in the photographs and on the 7.5 minute USGS topographic quadrangles, as control points. A summary of flows with year of data collection is included in Table 1. A more detailed description of development of the layers can be found in the full reports.

Table 1. Timing of flow photogrammetry.

Flow (cfs)	Year Photographed
100	1988
230	1986
620	1991
1,100	1992
3,100	1993
5,300	1995
8,400	1995

As we were only interested in inundated areas connected to the main channel for our calculations, preliminary edits were made to the shapefiles to remove island and isolated pond area polygons. The majority, if not all, of these "ponds" are gravel pits and dredging scars of various sizes with a water table connection to the river itself. Some of the larger of these are visible in Figure 1. For the sake of simplicity, the terms "pits" and "ponds" are used to describe any depressions in the former floodplain caused by dredge mining and gravel operations and subject to filling with water at some flow. Flows/layers used for the analysis were 100, 230, 620, 1,100, 3,100, 5,300 and 8,400 cfs.

More subjective secondary modifications were then made in an attempt to clean up the data for the purpose of this study. Here we tried to reconcile instances of disagreement between layers,

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which were relatively small compared to the total area of the study reach[1]. Although photos were taken over the span of almost 10 years, the authors feel that it was appropriate for the intended analyses to edit the layers to try to approach some semblance of consistency. When there was lack of agreement between layers, other adjacent flows were examined to determine which layer(s) would be modified and which would be used as a model for the change. Editing was generally needed when the wetted perimeter on a lesser flow layer extended farther than that of a greater flow. In this case these layers would be compared with the adjacent layers above and below and a judgment made on which of the first two layers was more in agreement with the others. The perimeter of the layer in lesser agreement was then modified. In addition, some small, disconnected, areas in the 100 and 230 cfs layers were modified to provide continuity of flow in the main, or low-flow, channel. In some instances the perimeters were directly over each other in channel areas with relatively steep channel banks.

USGS georeferenced topo layers and National Agricultural Imagery Program (NAIP) imagery taken at known flows were used for the truthing of features and identifying locations on the polygon layers. The U.S. Department of Agriculture acquires the NAIP imagery during the agricultural growing seasons in the continental U.S. A primary goal of the NAIP program is to enable availability of digital ortho photography within a year of acquisition. Most of the NAIP imagery was taken on June 11 and 12, 2005, when discharges below La Grande Dam were 4,030 cfs and 4,070 cfs respectively. The approximately 5 mile area from La Grange dam to about RM 47, however, was flown on June 29 with the discharge at 2,680 cfs.

After modifications to all layers were finished, total area in acres was recalculated for all the remaining polygons for each flow/layer. Area versus discharge was plotted for all flows in MS Excel 2003. After review of this plot, it was decided to focus on the area of inundation out of the channel to simulate overbank areas. The three lowest flows were dropped and the area value at 1,100 cfs was subtracted from the remaining higher three values. The resulting overbank area values were then plotted versus discharge.

In addition, the original, unedited, wetted perimeter polygon layers and NAIP imagery were examined to explore at what flows the pits began filling with water and at what flows they possibly connected with the channel.

RESULTS

The area versus discharge curve including in-river channel is displayed in Figure 2, with the tabular data in Table 2. This area includes the area of the. A primary inflection is seen around 1,000 cfs, which suggests that this is the minimum point where flows may begin to become "overbank", or out of the channel and into the former floodplain. However, as there is no data between 1,100 and 3,100 cfs the actual initiation of overbank flow is between these two values.

[1] The decision to edit does in no way infer that the original data was flawed. Modifications were made as the data was being used for a purpose other than that for which it was originally intended.

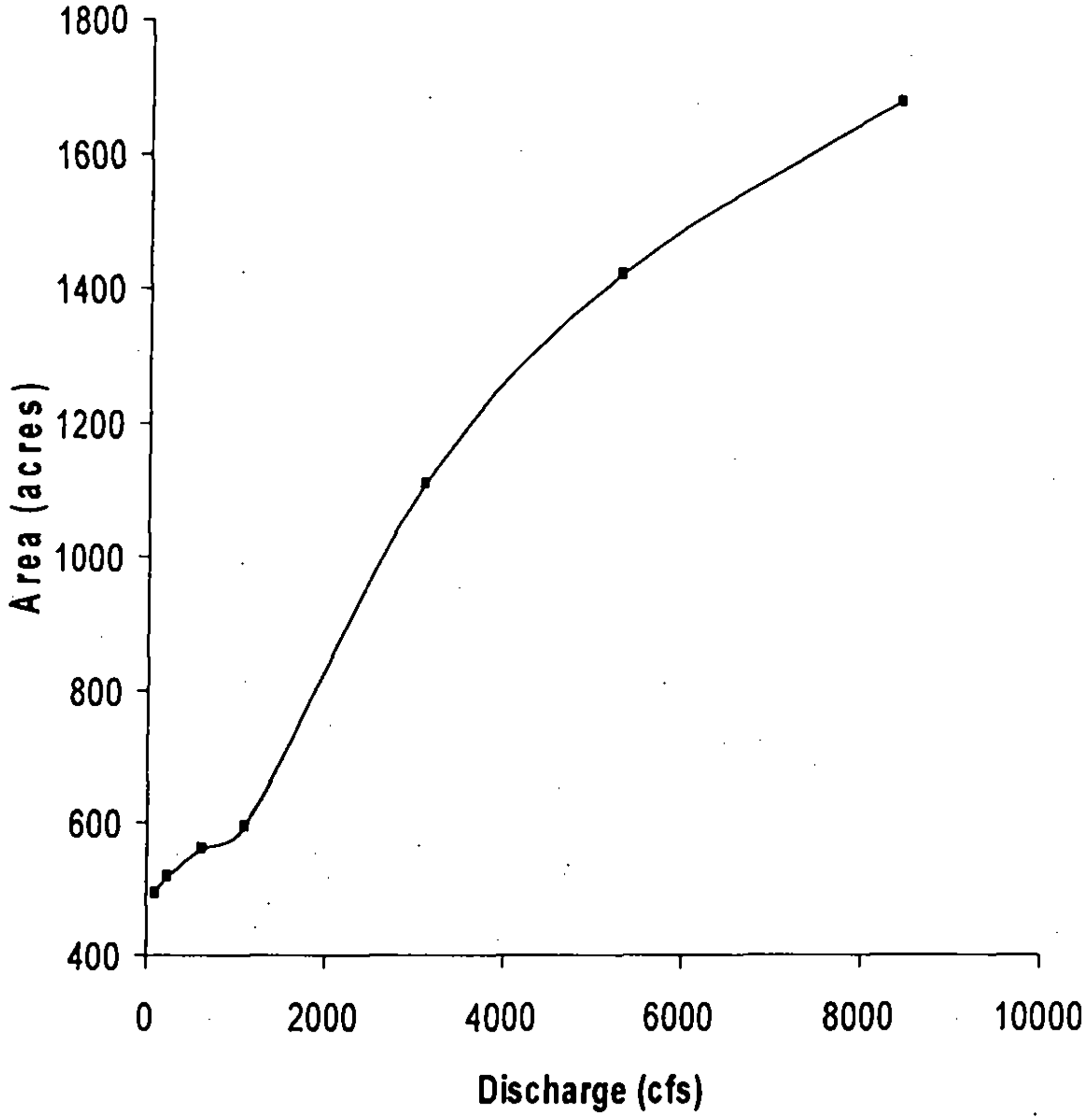

Figure 2. Lower Tuolumne inundated area as a function of discharge.

Table 2. Lower Tuolumne inundated area versus discharge.

Discharge (cfs)	Area (acres)
100	493
230	519
620	562
1,100	596
3,100	1,109
5,300	1,419
8,400	1,675

The plot in Figure 3 shows only the amount of acreage of potential overbank area inundated, without the in-channel acreage (as shown in Figure 2). Inundation is seen to continue to increase with discharge from around 1,000 cfs up to the maximum studied flow of 8,400 cfs. The greatest rate of increase in overbank area occurred between 1,000 to 3,100 cfs. The rate of increase in area, however, decreases as discharge rises, as may be expected with an increase in the slope of the floodplain as distance from the channel increases. As this decrease in rate of inundation appears relatively steady, a second inflection point, that might indicate a strong point of diminishing returns from further increases in discharge, is not seen. This would seem to indicate that the entire formerly floodplain area was not yet inundated at 8,400 cfs. Further inspection of the topographic layers overlaid with the 8,400 cfs wetted perimeter layer supports this premise.

Looking at the original EA wetted perimeter polygons with increasing flows, ponds first appear in the 1,100 cfs layer, indicating that the pits begin to fill somewhere between 620 and 1,100 cfs (Figures 4 and 5). Pits at river mile (RM) 30.5 were seen to be captured by flow in the channel somewhere between 3,100 and 5,300 cfs (Figures 6 and 7). However, with the exception of this area, gravel pits, and any other unconnected low areas outside of the channel, are not seen to be captured even at the 5,300 cfs level. We were unable to discern what happens to the pits at the 8,400 cfs level, as they were not included in the original GIS layer, although overlays of the 8,400 cfs layer with the NAIP imagery indicated two additional pits that were connected to the main channel at flows between 5,300 and 8,400 cfs: 1) a 41 acre pit at RM 36; and 2) a 14.3 acre pit at RM 34.5.

The NAIP imagery showed water in the pits at all flows in which the photos were taken. To give an example of how the pit areas appear, the same RM 30.5 area shown in Figures 4 and 5 is shown in Figure 8. In addition, the large pit also seen in Figures 4 and 5 is not seen to be connected to the main channel at 4,030 to 4,070 cfs, the range of flows at which the area was photographed. This is in agreement with the wetted perimeter data and suggests that the minimum flow at which the pit may be connected with the channel is closer to 4,050 cfs, rather than 3,100 cfs.

DISCUSSION

With regards to the influence of flood-induced and anthropogenic geomorphological changes that have occurred since the data used for this study was collected, we are assuming here that, due to the size of the study reach, changes to the channel and former floodplain since the data were collected are small relative to the size of the reach. In addition, considering "natural" geomorphological changes, there is some evidence to suggest that while the locations and sizes of hydrological features, such as meanders, riffles and bars, in alluvial reaches may change, the flow-habitat relationship does not (USFWS 2003).

The observed inflection point at 1,100 cfs is thought to be largely an effect of TID/MID removal of dredge tailings during the construction of New Don Pedro Dam (Scott McBain, personal communication 2007). It is important to point out, however, that while 1,100 cfs was used as the point at which flows became overbank, due to the inflection point in the original plot, this flow could actually be somewhere in between 1,100 and 3,300 cfs, the next highest data point. In addition "bankful" should not be confused with "bankful discharge", which has been defined as

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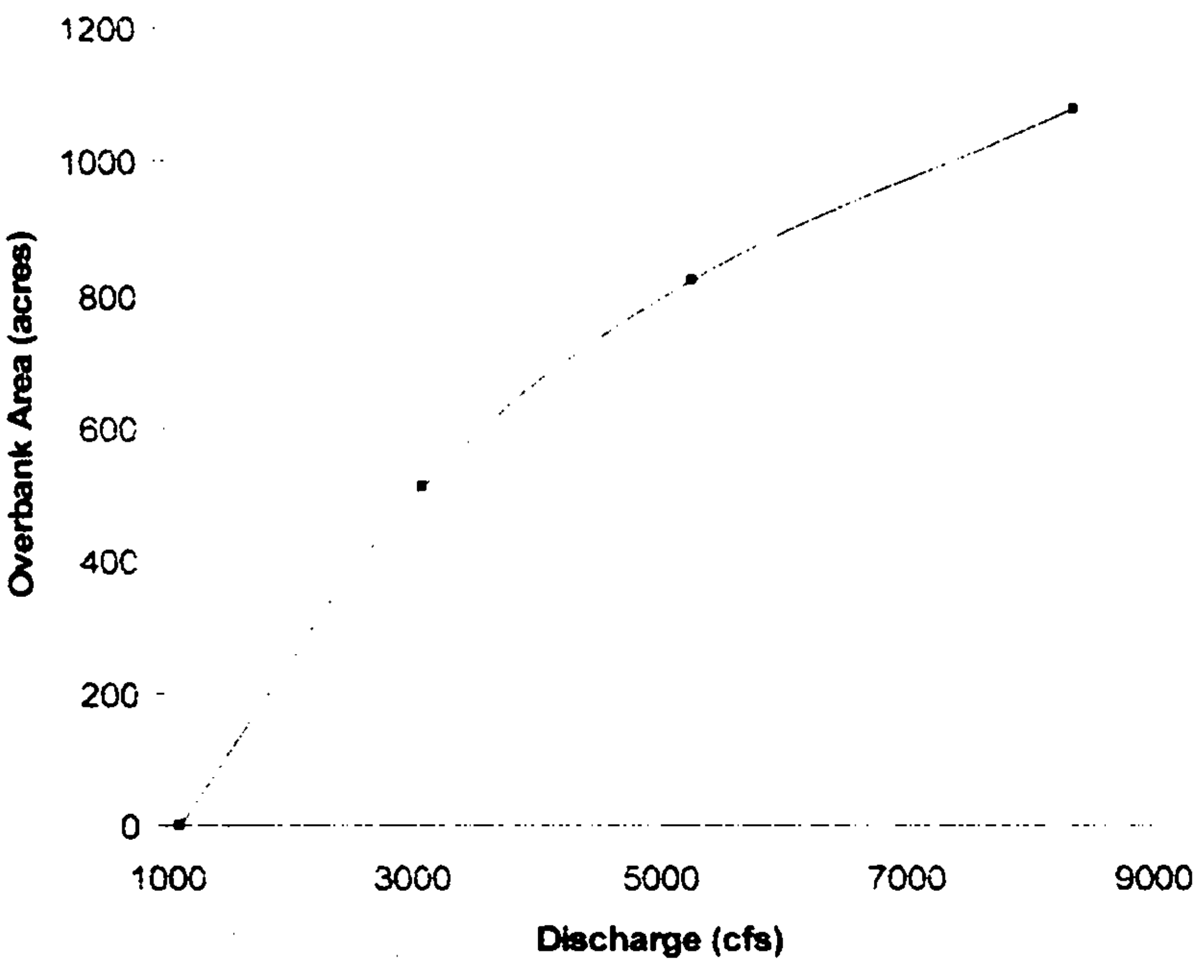

Figure 3. Lower Tuolumne overbank inundated area as a function of discharge

"the amount of stream flow that is equal to a peak flow event that occurs on average every 1.2 to 2 years." This flow might not be literally to the top of the stream banks (Ellis-Sugai and Godwin 2002). A hydrograph of mean daily flows from 1970-2007 is given in Figure 9.

Benefits to fish populations from floodplain inundation are thought to be linked to reduced predation rates, increased habitat availability, and increased food supply (Bennett and Moyle 1996). Most of the energy that drives aquatic food chains in rivers is derived from terrestrial sources (Allan 1995) and aquatic productivity is related to flood magnitude and the area inundated in some rivers (Large and Petts 1996). Flooding, particularly the rising limb of the hydrograph, typically results in high concentrations of both dissolved and particulate organic matter being released into the river (Allan 1995). Juvenile salmonids that utilize floodplain habitats on the Yolo Bypass (Sommer et al. 2001) and the Cosumnes River (Jeffres 2006), consume more prey and grow faster than those in mainstem habitats. It is also theorized that higher flows have multiple indirect effects on growth through other factors such as reduced water temperatures (Sommer et al. 2001) and the timing of smoltification. Further work by Sommer et al. (2005) on the Yolo Bypass gave additional evidence that outmigrating juvenile Chinook

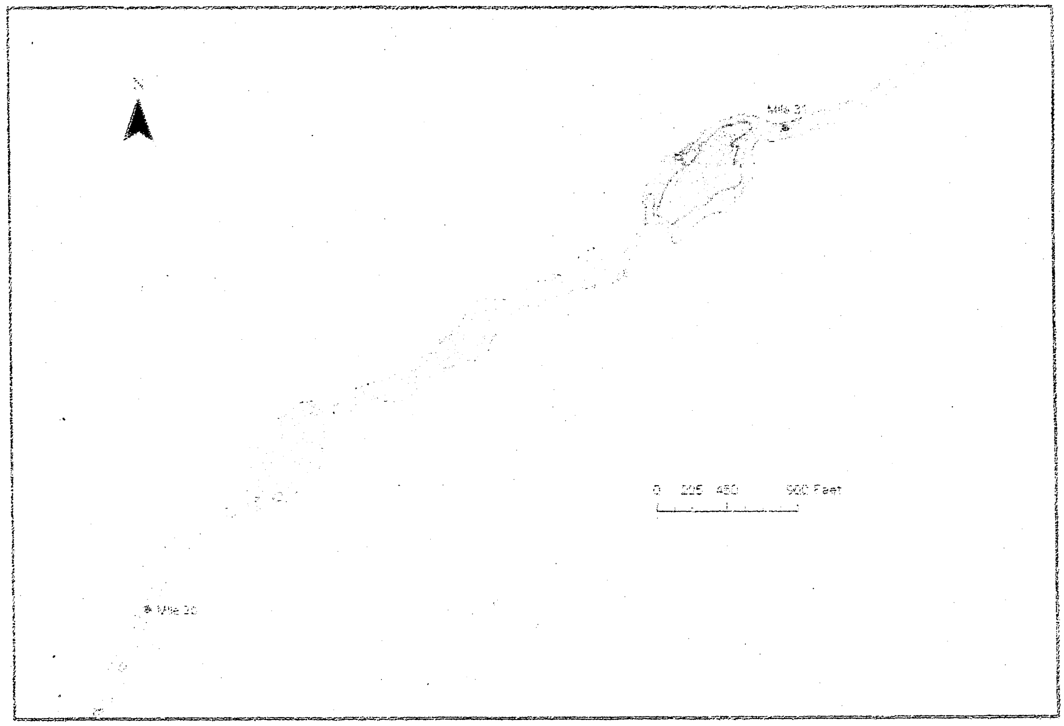

Figure 4. 620 cfs wetted perimeter between RM 30 and 31. No ponds visible.

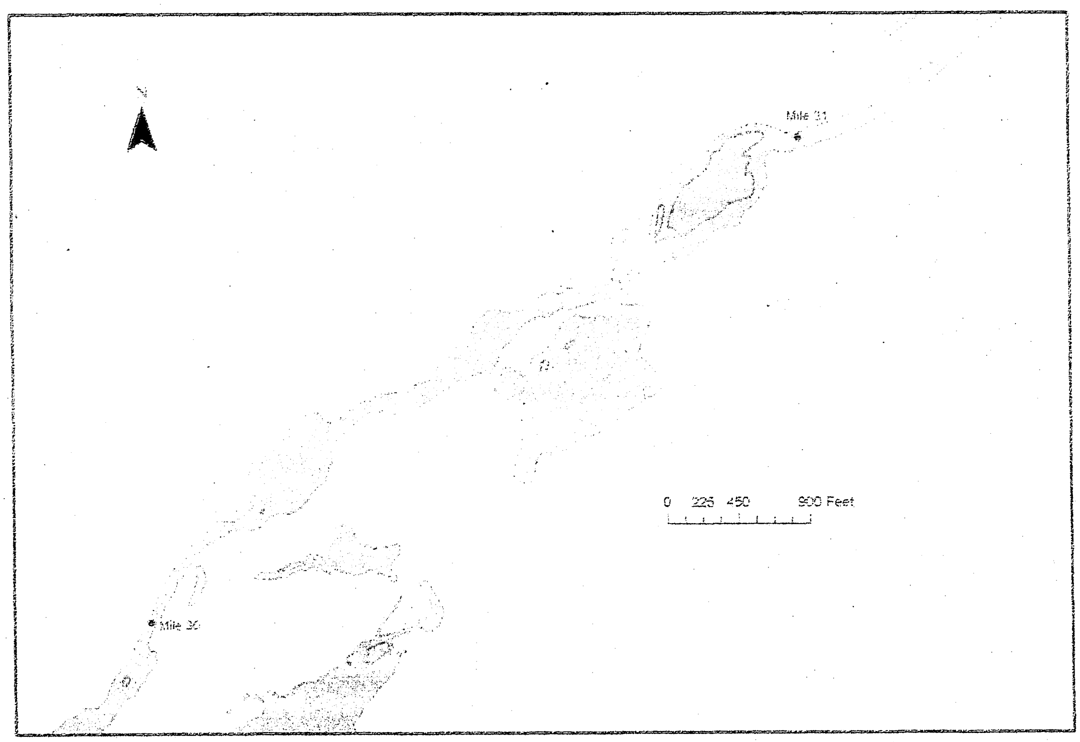

Figure 5. 1,100 cfs wetted perimeter between RM 30 and 31. Ponds visible, but not connected.

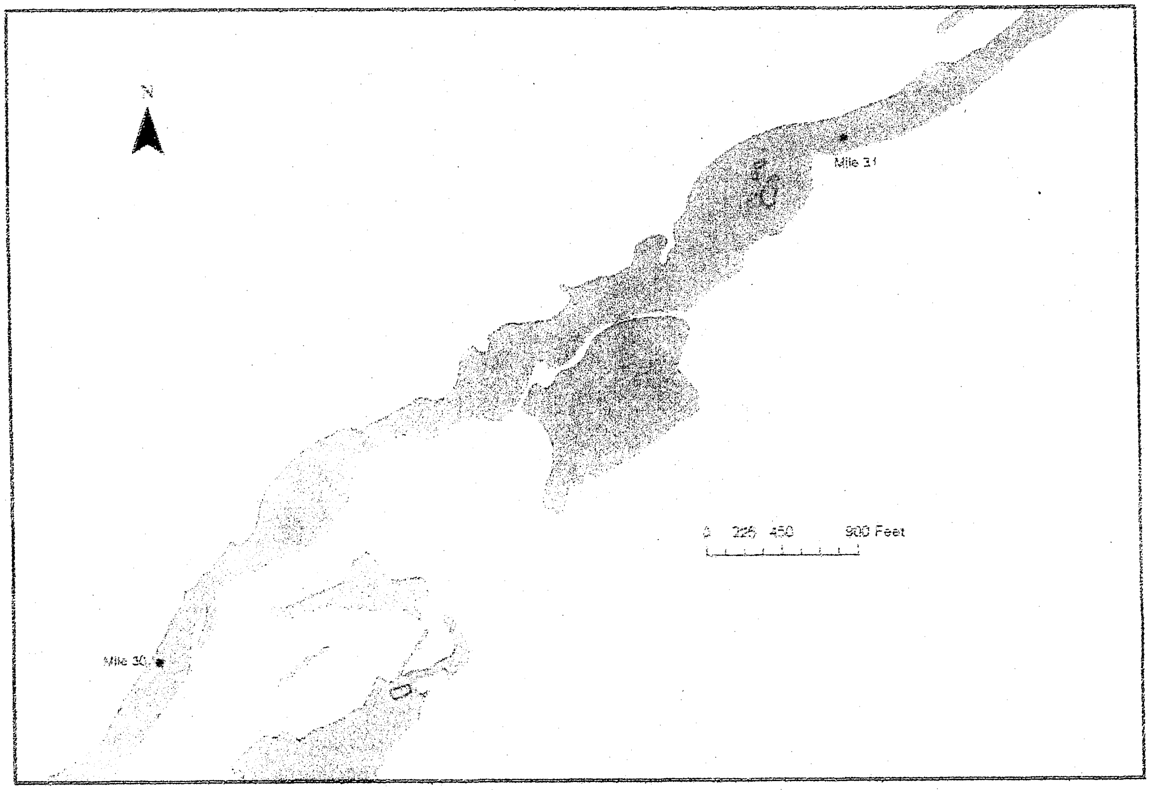

Figure 6. 3,100 cfs wetted perimeter RM 30.5. Ponds visible, disconnected.

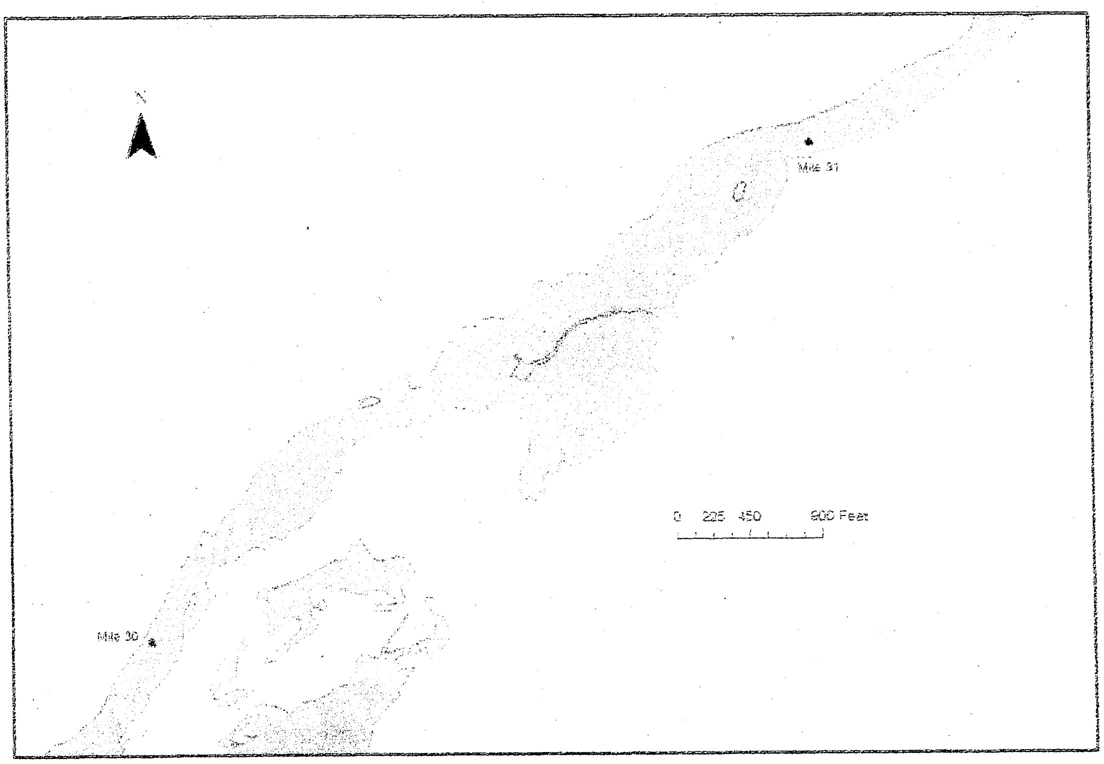

Figure 7. 5,300 cfs ponds visible and connected to channel RM 30.5.

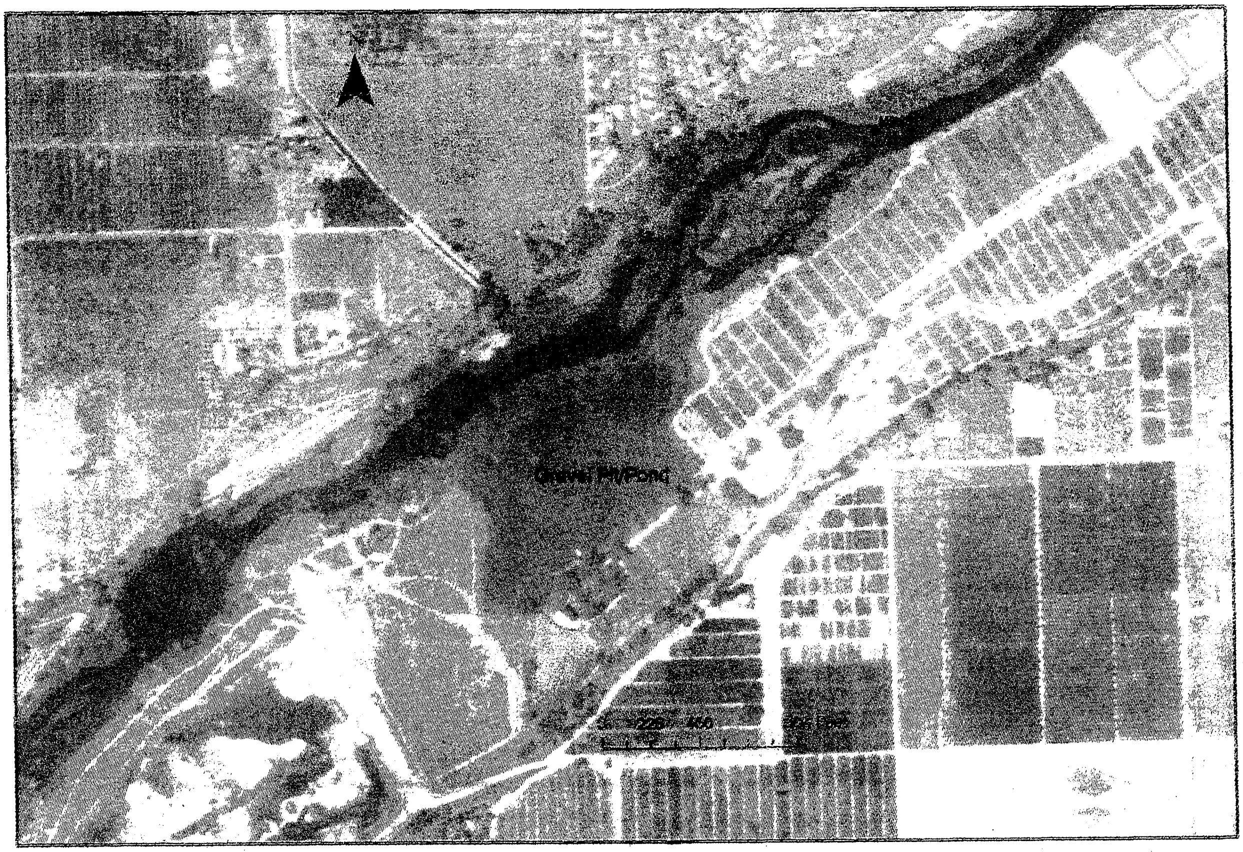

Figure 8. 4,030 – 4,070 cfs ponds visible and connected to channel RM 30.5.

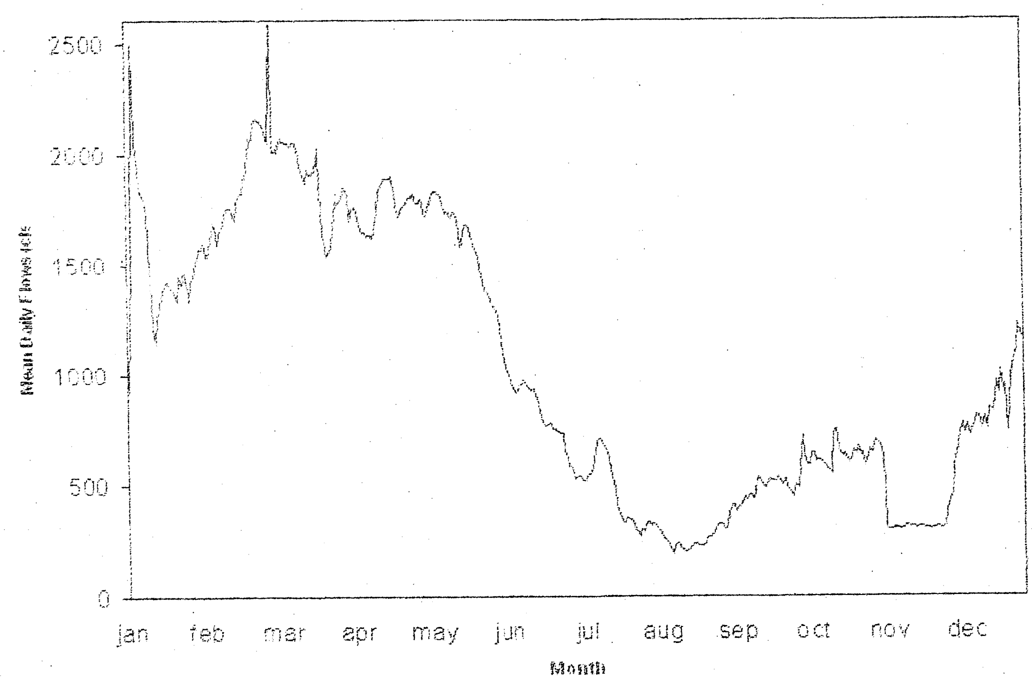

Figure 9. Mean daily flows for the Tuolumne River below Lagrange, 1970-2007.

salmon benefit from time spent in floodplain habitat with benefits overall outweighing risk from stranding. This reinforces the belief that seasonal habitat should be considered as part of restoration plans for the species. We expect steelhead would benefit from seasonal floodplain habitat in a similar way as salmon.

Floodplain inundation may affect the timing of smoltification by increasing growth rates. The smolting process is triggered by a combination of conditions, such as body size, rate of growth, increasing day length, and increasing water temperatures (summarized in Quinn 2005). There is a smoltification window during spring, after which slow growing, small individuals lose their ability to smoltify. It is possible that by increasing food resources, floodplain inundation increases juvenile growth rates so that smoltification begins earlier during the spring, when water temperatures and other factors in the lower river are more conducive to their survival.

While the gravel pits/ponds were not the original focus of this study some discussion of their possible role in predator prey interactions, and how these might affect floodplain restoration efforts is called for. It is assumed that flood flows reduce predation by numerous largemouth bass[2], smallmouth bass, striped bass, and Sacramento pikeminnow that occur in the Tuolumne River and the other San Joaquin tributaries (TID/MID 2005, Mesick et al. 2007). Studies suggest that these pits may contain exotic predator species, particularly large mouse bass (McBain and Trush, Stillwater Sciences 2006), and concerns have been raised by others that flow connectivity between these pits and the river could result in predation or introduce predators to the river. However, there is substantial evidence that the benefits of floodplain inundation far outweigh the potential negative benefits of connectivity to these mine pits and there is no evidence that predatory refugia in off-channel mine pits contributes to in-channel predation of juvenile salmonids. No predation studies have been conducted in off-channel pits that are connected to the river only at high flows. All of the predation studies in the San Joaquin Basin, such as McBain and Trush, Stillwater Sciences (2006), were conducted in in-channel pits during dry and normal water years when base flow releases were made. There is no reason to assume that predation is a source of mortality in off-channel pits that are connected only during flood flows, because predation would be inhibited by the high turbidity, low temperatures, and high velocities that occur during flooding. The McBain and Trush, Stillwater Sciences (2006) predation study was not conclusive regarding effects of predation, given that only three largemouth bass and one smallmouth bass were caught and tracked. None of these fish had juvenile salmon in their stomachs and only one moved into an off-channel pond after it had been tagged (McBain and Trush, Stillwater Sciences 2006). Floodplain inundation may provide refuge for juvenile salmonids from predators that inhabit in-channel mining pits (Orr 1997, Mesick et al. 2007).

Results from this study show connectivity with a single, but relatively large (15.75 acres), pit at RM 30.5, at flows beginning somewhere between 4,030 and 5,300 cfs. This area may need to be examined more closely to determine if a large mouth bass population currently exists, and if so, to find the flow at which connectivity begins and determine if restoration actions are needed to isolate this pit from the main channel at flows greater than 4,030 cfs. Factors to consider in evaluating the need to isolate this mining pit include: 1) that the pit represents less than two percent of the overbank area inundated at 5,300 cfs; and 2) that previous restoration activities which isolated a large pond from the Tuolumne River did not reduce predation rates or improve the survival of juvenile salmon in the Tuolumne River (Mesick et al. 2007). Similar factors

2 *Micropterus salmoides* (also referred to as black bass).

should be considered for the two pits that connect to the main channel at flows between 5,300 and 8,400 cfs.

It seems apparent that using spring pulse flows to benefit outmigrating juvenile salmonids on the lower Tuolumne River need to be combined with consideration of the pits/ponds both in and out of the channel. While pulse flows establish connectivity with gravel pits outside the channel, these same higher flows increase velocity and might make the instream pools less of a trap for the juveniles and assist their downstream progress. A possible next step could be to establish a stage-discharge relationship at the bottom of the study reach and conduct a 2D instream flow study of the entire reach. This would allow an evaluation of current hydrological and topographical conditions, in addition to providing more precise information on the inundation-discharge relationship, as results would be less incremental than those presented in this study.

The results of this study suggest that flows in excess of 1,100 to 3,100 cfs will begin to inundate overbank habitat for anadromous salmonids, with resulting benefits for increased survival and growth of outmigrant anadromous salmonids. Further increases of flows, up to at least 8,400 cfs, would be expected to have additional incremental benefits in terms of increased overbank habitat and thus increased survival and growth of outmigrant anadromous salmonids. While habitat restoration efforts that lowered overbank areas to enable inundation at flows less than 1,100 cfs would be expected to increase food resources and refuge from predators, in a similar manner to increases in outmigrant flows, such efforts would not provide other benefits of higher outmigrant flows, such as reduced water temperatures and contaminant dilution.

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Enclosure 2

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Response-to-Comments Document

for the

October 2007 Peer-Review Draft of the
Flow-Inundation Relationship for Potential Fall-Run Chinook Salmon and
Steelhead/Rainbow Trout Juvenile Outmigration Habitat in the Tuolumne River

August 2008

AUTHORS RESPONDING TO COMMENTS

U.S. Fish and Wildlife Service

Bill Pelle
Mark Gard

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PREFACE

This document contains the comments provided by scientific peers on the October 2007 draft of the report, "Flow-Inundation Relationship for Potential Fall-Run Chinook Salmon and Steelhead/Rainbow Trout Juvenile Outmigration Habitat in the Tuolumne River" (Report), and responses to those comments. This compilation is divided into subject-matter sections whereby various comments and responses to authors were organized. It was necessary to renumber original comments to fit the format generally used for these reports. To the extent that individual comments crossed over subject matters, the authors collectively addressed those comments.

Although this compilation may provide useful insight into how the comments were addressed by the authors, the Report itself represents the complete and final synthesis of studies on flow-overbank inundation relationships in the Tuolumne River between La Grange Dam and just upstream of the Santa Fe Bridge, based on the best available scientific information. The authors have reviewed their responses and compared them to the final Report to ensure that all comments have been adequately addressed.

Lastly, the authors of the Report wish to thank everyone who provided comments on the October 2007 draft. The comments greatly assisted the authors and agency in identifying missing or unclear information, focusing the textual and graphic presentations, and thereby producing a better overall Report. The two anonymous reviewers were provided by the CALFED Ecosystem Restoration Program.

GENERAL COMMENTS

REVIEWER #1

Study Design - Is the study design sound?

Comment 1: The study design is, in general, sound. However, when using data from different sources it is important to discuss, in detail, the limitations of the data and how the authors went about dealing with such limitations.

Response: As much detail about the data as could be obtained was included in the report. We feel that with this description and the further, transparent description of our treatment of the data in attempts to reconcile differences between data sets before analyses, certain limitations would be assumed by readers. The study was not expected to be a conclusive treatise, but merely a preliminary tool for quantifying potential habitat, to guide future restoration planning efforts. However, a mention of the results being limited by the strength of the data has been added to the Discussion section.

Objectives - Are the objectives clear?

Comment 2: The objectives seem clear enough, an attempt to get a better understanding of how much floodplain habitat occurs at different flow levels. Again discussing the ideal v. what you can do would help the reader understand the limitations of such a study and what could potentially be done in the future to gain a better understanding of the potential mechanisms.

Response: Please see response to Comment 1 above. In addition there are plans for additional analyses to develop the relationship between adult production (not escapement) and flow via the metric of inundated floodplain acre-days during the rearing and out-migration period.

Methods - Are the methods technically sound?

Comment 3: I believe the concept is technically sound, however I think the authors need to do a better job describing the limitations of the data. Questions that should be addressed in the methods include: 1. what are the assumptions associated with discharge/area estimates? 2. how would this effect the potential interpretation? 3. what are the error estimates around the GIS information and how does it vary with the different sources?

Response: Please see response to Comment 1. We have added the assumptions associated with the discharge/area estimates. The discussion includes an assessment of how the major assumption (that there is a linear change in area between measured data) could affect the potential interpretation (specifically the flow at which overbank flow begins). In addition, assuming that you are referring to our "error" in reconciling instances of disagreement between GIS layers, we are not certain how to go about this statistically.

Data - Is the data adequate?

Comment 4: I believe so, although it is difficult to tell in parts because the limitations of the study are not addressed in one section and are distributed throughout the paper.

Response: Please see response to Comment 1.

Findings, interpretations and conclusions - Are the findings, interpretations and conclusions valid?

Comment 5: The findings seem valid, the interpretation that there is an inflection point also seems valid. However, it is difficult to understand its validity without any cross-sectional data to corroborate it. I do believe however that the plan view maps do make it clear flows overtop into the floodplain at and around that level. The conclusions agree with what others have found as to the value of floodplains to salmonids and it is refreshing to see a report coming out of California that does not concentrate on salmonid spawning habitat.

Response: Collection of more field data at this point is beyond the scope of this study, however we agree that with transect data we could get discharge – stage relationships and better predict at what flow the bankful stage is reached and when pits connect. Perhaps this will be considered for any follow-up investigations. In addition we are pleased that you can appreciate the intent of this study.

Presentation - Is the presentation clear?

Comment 6: Not so clear. I believe the author should go back and reorganize the information a little bit. The introduction needs to give a little more general background on the importance of floodplains and perhaps touch upon some different techniques used to assess inundation. One citation that might be helpful is the following:

> J. Steiger, M. James, F. Gazelle. 1998. Channelization and consequences on floodplain system functioning on the Garonne River, SW France. Regulated Rivers: Research & Management 14 (1): 13-23.

Steiger gives an equation for a floodplain inundation index. The methods section needs to be broken down into three parts – data, analysis, and assumptions. The results needs to take out any discussion points and just discuss the results. The discussion needs to have several parts – brief summary of results with potential cause and effects links that includes citations, assumptions and limitations of the study, and what this implies for fish. I think you already have it for the third section, but you need to work on the other two.

Response: An attempt has been made to reorganize the report somewhat, per the reviewer's request. We have kept the Introduction and Discussion sections of this preliminary study down to a size that we feel is in balance with the scale of the analyses presented, which as you have mentioned, is limited by the strength of the data used. In addition, excessive background information was avoided as the audience for which this report is intended, the USFWS Anadromous Fish Recovery Program, is very familiar with lower Tuolumne River ecology as well as the importance of floodplains to anadromous fish.

Figures and tables - Are the figures and tables clear, complete and adequate?

Comment 7: Table 2 and figure 3 are repetitive. Figures 2 and 3 are the same.

Response: With regard to the first part of the comment, we have provided the results in tabular form, in addition to the graphs, to increase the utility of the information in future resource planning efforts. Depending on the use, we feel that some readers may prefer the actual numbers, rather than only a graphical representation. We will therefore keep Table 2.

Concerning the second part of the comment, we have now included greater detail explaining that Figure 3 represents only acreage for inundated overbank or potential floodplain, the channel acreage having been subtracted from the total inundated area at each flow above 1,100 cfs.

Comment 8: It is refreshing to see research focused on the floodplain in California rather than spawning habitat. I have always wondered if anyone has examined the relative importance of life stages for salmonids there and it seems like USFWS is now doing that, which I think is very good.

Response: Thank you for your compliment on our study.

Comment 9: I think the report, in general, is good. I do believe authors need to go back and reorganize what is in each section because there is overlap with methods, results, and discussion with some of the text. I tried to point this out in my comments.

Response: See response to Comment 6 above.

Comment 10: Please convey to the authors the need to identify their assumptions and study limitations in an explicit manner. This is particularly important when using other peoples' data.

Response: See response to Comments 1-4 above.

REVIEWER#2

Study Design Is the study design sound?

Comment 1: I think this study is a worthwhile and necessary component of a larger project. Now the inundation data need to be added to a larger model like PHABSIM to address the salmon population doubling goals, or analyzed with population data to determine the relationship between floodplain inundation and tributary smolt (production). A larger model will account for other habitat and population variables, including in-stream flow conditions (depth and velocity), grain size, temperature or survival.

I think it would be helpful to include more about the effects of mining pits, especially at higher flows. Shallow ponds and swampy areas occur naturally on floodplains, and there may be some beneficial similarities between mining pits and natural ponds. Some of these impacts may also be negative: stranding issues, predation by bass, etc., but these deleterious effects of mining pits are not articulated in the report. It would be helpful to have a better idea of the percent of floodplain that is occupied by these pits, and the area of pits that is inundated at different flow levels. Figures show several mining pits at river mile 30.5. Is this representative? The fact that pits do not begin to fill until flows reach 620 cfs tells me that they are relatively shallow. For future reports or revisions of this work, it would be helpful to have a better understanding of the extent and significance of mining pits.

There is also a statement that the entire floodplain may not be inundated at 8,400 cfs. This strikes me as a fundamental question, and should be relatively easy to answer using DEM or topographic maps. More complete analysis of the floodplain slope, elevation and extent would help this argument. This is a strong argument for including digital elevations in the study (see below).

Response: We have added information to the report that the results will be used as part of a larger model to analyze the relationship between floodplain inundation and tributary smolt production. We have also added more about the effects of mining pits to the discussion. Concerning the suggestion that the floodplain not being completely inundated at 8,400 cfs, text has been added that this is supported by inspection of the topographic layers with the 8,400 cfs wetted perimeter layer.

<u>**Objectives**</u> <u>Are the objectives clear?</u>

Comment 2: *The objective of this study was to obtain and analyze floodplain/inundation data* for the USFWS Anadromous Fish Restoration Program. I initially thought that the objectives were to "analyze the relationship between floodplain inundation and tributary smolt (population abundance)", and "estimate the amount of available functional floodplain habitat.... to achieve the doubling goal for Chinook salmon." With further reading, it became evident that this project only deals with the floodplain/inundation data. This could be more clearly articulated in the introduction, to separate the present study from the larger goals. I would suggest a more modest objective, something like "The objective of this report is to evaluate floodplain inundation area on the lower Tuolumne River at flows ranging from low flow summer conditions (100 cfs) to flood conditions (8,400 cfs)."

Response: We have made the suggested revision.

Methods Are the methods technically sound?

Comment 3: Air photos were used to estimate floodplain inundation area. This is a good first start, but digital elevation data would be better. Were elevation data available? I don't see any reference to Digital Elevation Maps (DEM's) or Digital Terrain maps (DTM's). This might explain why statements about the extent of floodplain inundation and slope are vague. A GIS study of this type should include digital elevation data, or at the very minimum, a georeferenced topographic base map.

I don't understand why mining pits were not included in the 8,400 cfs analysis. Couldn't they be added to this GIS layer? There is a statement that pits were not included in the original GIS layer, but this is a relatively easy thing to fix.

The role of NAIP data (air photos) in the analysis is unclear. Were these photos also georeferenced and used for the study? If not, I am not sure why Figure 8 is included.

Response: Use of existing DEM data to model overbank inundation as a function of flow using a two-dimensional hydraulic model, such as River2D, would have also required having a stage-discharge relationship at the downstream end of the study reach. Since a stage-discharge relationship was not available for the downstream end of the study reach, the use of existing DEM data fell outside of the scope of this study, as the scope of this study was constrained to only using existing data.

USGS georeferenced topo layers were used with the NAIP imagery for the truthing of features and indentifying locations on the polygon layers. The figure was included primarily as an example of how the pits actually appear, on the outside chance that anyone in the audience this report is intended for was not already familiar with the area. It has been replaced with a NAIP image of the same River Mile (RM) 30.5 area shown in Figures 6 and 7 for comparison.

As was mentioned in the report, although every effort was made to do so, we were unable to discover why mining pits were not included in the 8,400 cfs wetted perimeter layer. The aerial photos used to produce the original GIS layer were not available for our use to digitize gravel pits at 8,400 cfs.

Data. Is the data adequate?

Comment 4: This report refers to aerial photos and initial GIS data sets in the 1992 TID/MID Report, Appendix 6, Attachment B (in Vol. IV), and Vol. VII. These reports are not on the reference list. A later (2005) TID/MID report is referenced, but not discussed in detail. I would like to know more about these older data sets, and the data used for the current habitat survey. Were digital elevation maps (DEM's) available? If so, I would suggest a "phase 2 analysis" using DEM's. 10 meter DEM's can also be purchased from the U.S. Geological Survey. Accurate elevation data would take this report to a higher level, and would allow the authors to construct cross sections, determine elevations, identify the active channel, measure the slope of the floodplain, and in general have a more three-dimensional look at the floodplain configuration. This report is a good first start, but air photos and inundation maps without elevation data leave many open questions (see below).

I would also like more explanation (justification) of why the 1,100 cfs flow was selected as representative of the active channel area. The next larger flow is 3,100 cfs, and this is a big jump. It is possible that 1,100 cfs represents bank full stage, but this isn't stated directly or supported in the report. The bank full stage could also be somewhere between 1,100 cfs and 3,100 cfs. This could be confirmed with some good old-fashioned field work, or flood frequency plots (look for the 2 year event!). Lacking this evidence, I am not convinced that figure 2 shows an inflection point, or that 1,100 is the bank full stage. It would be helpful to have a more complete geomorphic analysis or explanation for this part of the report. More work with elevations, field checking, or flood frequency analysis would help support the claim that 1,100 cfs represents the area of the active channel.

Response: Problems with citations and references have been corrected. Language has been added to explain that the stage at which flows began to move out of the channel could be anywhere between 1,100 and 3,100 cfs. We also do not want to confuse "overbank" or inundation flows with "bankful discharge", which following its mathematical definition might not mean literally to the top of the stream banks (Ellis-Sugai and Godwin 2002). Without knowing at what flow this occurs we used the inflection point on the curve, which was produced using the data that was available. Regarding your suggestions for further analyses, they are beyond the limited scope of this study, but we agree that further work may provide a better understanding of the processes we have touched on.

<u>**Findings, interpretations and conclusions.**</u> <u>Are the findings, interpretations and conclusions valid?</u>

Comment 5: This study examines the relationship between river flow and floodplain inundation, and is a reasonable first step in this complex analysis. Interpretations and conclusions would be strengthened with DEM data, cross sections, and better control or description of the boundaries of the active (low flow) channel.

Response: We agree with your suggestions, however, at this time they are beyond the scope of this preliminary, limited study.

<u>**Presentation.**</u> Is the presentation clear?

Comment 6: The presentation is generally clear and well-written, within the limits of the available data (air photo sets and land area inundated). I would like to see the abstract clarify the role of gravel pits in the study. They are mentioned, but in the abbreviated language of the abstract I wasn't able to figure out whether gravel pits were included or eliminated in the

analysis, and how changes in flow related to filling and channel capture in gravel pits. This could be solved with a slightly longer abstract. I like the abstract to "stand alone" so that I can read the abstract and extract the major points of the paper.

Response: Additional information has been incorporated into the abstract. In addition, while issues involving the gravel pits were not the original focus of this study, language concerning their possible role in predator prey interactions, and how these might affect floodplain restoration efforts, has been included in the Discussion section.

Figures and tables. Are the figures and tables clear, complete and adequate?

Comment 7: The text on p. 7 refers to NAIP imagery at flows of 4,030 cfs and 2,680 cfs, but only the low flow example is included. It is hard to draw conclusions about water in the pits at different flows based on this single figure. Other figures and graphs are clear and well-labeled.

Response: It was decided for Figure 8 to use instead NAIP imagery for the same RM 30.5 area shown in Figures 6 and 7 for comparison. The text has been rewritten for clarification with an addition being made that Figure 8 was originally included primarily as an example of how the pits actually appear, on the outside chance that anyone in the audience this report is intended for was not already familiar with the area.

SPECIFIC COMMENTS

ABSTRACT

Reviewer #1

Comment 1: What is the significance of the inflection point? What does this mean for juvenile Chinook and *O. mykiss* and where are they in their life cycle when these flows occur? Are they using the floodplain?

Response: Again, the significance of the inflection point is that, according to our analyses, it appears to represent the lowest discharge before flows became overbank, not necessarily "bankful" (see Response to Comment 4 above). While it was beyond the scope of this limited study to include effects upon juvenile salmonids, we agree that understanding of these effects would be necessary if results of this study were to be of use in floodplain restoration planning. In general, looking at a daily flow hydrograph from 1970 to 2007 water years, flows on average are seen to be over 1,000 cfs from around early December to about mid-June. It must be taken into account here that this is averaging all water year types. A fall-run Chinook salmon life history timing table by Yoshiyama et al (1998) shows a December-April juvenile emergence period and a juvenile stream residency period of one to five months. In general, judging by Moyle's (2005) description of a January to February spawning peak and an approximately six-week period for incubation and emergence, we might expect steelhead peak emergence to begin as early as late February, depending on water temperatures.

Reviewer #2

Comment 1: This report does not include habitat information. Delete "fall-run Chinook salmon and steelhead/rainbow trout potential outmigration habitat in."

Response: This portion of the abstract was reworded, but the view that the inundated former flood, with restoration, could become outmigration juvenile salmonid habitat remains.

Comment 2: Delete "Gravel pits were generally not captured by channel flows less than 5,300 cfs, so gravel pits were not included on maps of floodplain inundation at low flows."

Response: The sentence was deleted, but mention that at least one pit appears to be captured by channel flows between 3,300 and 5,300 cfs remains.

Comment 3: I would like to see the authors include analysis of gravel pits at flows > 5,300 cfs. It seems like they would be important at higher flows!

Response: While issues involving the gravel pits were not part of the initial focus of this study, language concerning their possible role in predator prey interactions, and how these might affect floodplain restoration efforts, has been included in the Discussion section. In addition, every possible effort was made to ascertain why the pits were not included in the 8,400 cfs layer. There is no mention of this in the metadata and numerous calls and emails to parties associated with the original project provided no further light on the mystery. The aerial photos used to produce the original GIS layer were not available for our use to digitize gravel pits at 8,400 cfs. Finally, as explained in the report, the focus of the original project for which the wetted perimeter layers were created was the channel, not the pits.

Comment 4: I am not convinced this is an inflection point, because you don't have data between 1,000 and 3,000 cfs.

Response: Language has been added to explain that the plotted inflection indicates that 1,100 cfs could be the minimum stage at which flows begin to move out of the channel. The plot shows that the actual point at which flows become bankful could be anywhere between 1,100 and 3,100 cfs, as there is no data between these points.

Comment 5: Line 11 – Delete "now modified by mining and gravel operations. In addition, gravel pits, connected to the water table were seen to begin filling between 620 and 1,100 cfs and generally not captured by channel flows up to at least 5,300 cfs."

Response: There has been some editing of the Abstract, however the information you suggested to be deleted remains.

INTRODUCTION

Reviewer #1

Comment 1: There are other citations on the importance of floodplain habitats to juvenile salmonids. Please refer to the following:

Sommer, T.R., W.C. Harrell, and M.L. Nobriga. 2005. Habitat Use and Stranding Risk of Juvenile Chinook Salmon on a Seasonal Floodplain. NAJFM 25:1493–1504.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001b. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58:325–333.

Response: One of these references, albeit incomplete, was in the first draft, the second has been added.

Comment 2: "Snorkeling surveys suggest that most fall-run Chinook salmon and rainbow trout rear in this reach (TID and MID Annual Reports)." Does this include floodplain habitats?

Response: No mention was made of surveying the former floodplain, however mention was made of surveys not being conducted at flood flows. Our intuition is that water clarity may be an issue at overbank flows.

Comment 3: "First, the data would be used for analyses of the relationship between floodplain inundation and tributary smolt." Tributary smolt what? Production? Survival? Growth?

Response: We have added "production" to the end of this sentence.

Comment 4: "Second, the estimated amount of available functional floodplain habitat would be used to estimate the amount of habitat to be restored to achieve the doubling goal for Chinook salmon." Is not the objective to estimate the amount of potentially available floodplain habitat? The assumption is that all of the inundated habitat would be available for use by juvenile salmonids Another implication assumption is that this would benefit growth and ultimately survival of juvenile salmonids due to a variety of potential mechanism (please refer to Sommer et al. for references). Do not mix up your objectives with assumptions you make on what the objectives imply for salmonids.

Response: We have changed this objective to a proposed use of the study data. We have changed the objective of the study to that suggested by the commenter in Comment 2. We have added the above assumptions to the uses of the study data.

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Comment 5: *"To develop a flow regime which will accommodate the habitat needs of anadromous species inhabiting streams it is necessary to determine the relationship between stream flow and habitat availability for each life stage of those species. The ARC GIS program, developed by ESRI, was used to calculate area inundated at a range of flows, as one way of establishing this relationship.*

"The method used in this study is somewhat similar to a demonstration flow assessment, as described in CIFGS (2003), using direct observation of river habitat conditions at several flows; with polygons of habitat being delineated in the field at each flow. An empirical, and probably the most widely-used technique used to evaluate rearing habitat utility at outmigrant flows, is the use of screw traps. Also available are passage studies, where transects are placed at relatively shallow areas, WSEL and discharge data are collected at a range of flows, and PHABSIM is used to establish stage-discharge relationships. This information is then used to determine what flow results in depths at the minimum required for passage of the target species/life-stage. This method, however, seems to be more common for determining upstream migration flows for adults and is described in more detail in USFWS (1994)."

These last two paragraphs in the introduction do not make sense to me. The authors have already identified the objectives and potential cause of degradation. The above two paragraphs discuss what they did and other potential methods. They may want to reverse the order of the paragraphs and state there are several methods to measure the importance of inundated floodplain habitats. First, ...x.... Second, ...y.... We use an alternative method, then just state it and go into detail in the next section.

Response: We have reversed the order of the above two paragraphs and moved them to the Methods section.

<u>**Reviewer #2**</u>

Comment 1: Conclusion about adult recruitment is not supported by the data. Delete "and that adult recruitment is highly dependent on fry survival in the tributaries."

Response: We disagree. The phrase "and that adult recruitment is highly dependent on fry survival in the tributaries." is a logical conclusion of the preceding two sentences. Specifically, if both adult recruitment and the number of smolt-sized outmigrants are both correlated with spring flows, it is a reasonable conclusion that adult recruitment is highly dependent on fry survival in the tributaries.

Comment 2: Change "*The study objective was twofold. First, the data would be used for analyses of the relationship between floodplain inundation and tributary smolt. Second, the estimated amount of available functional floodplain habitat would be used to estimate the amount of habitat to be restored to achieve the doubling goal for Chinook salmon*" to "This study is an initial response to that request, and addresses the question of floodplain inundation area vs. stream flow on the Tuolumne River. Conclusions from this report will eventually be added to larger modeling studies with broader objectives. The larger objectives are twofold.

First, the data will be used for analyses of the relationship between floodplain inundation and tributary smolt production. Second, the estimated amount of available functional floodplain habitat will be used to estimate the amount of habitat to be restored to achieve the doubling goal for Chinook salmon."

Response: We have made the suggested change.

Comment 3: Delete parentheses from around "TID and MID Annual Reports." Reference specific reports?

Response: Changed to "(Turlock Irrigation District (TID) and Modesto Irrigation District (MID) 2005)."

Comment 4: CIFGS (2003) is not on the reference list.

Response: Thank you, the change has been made.

Comment 5: Define WSEL and PHABSIM the first time they are used.

Response: The changes have been made.

Comment 6: Define TID/MID the first time they are used.

Response: In the Acknowledgements section the acronyms were defined the first time they were used. However, we have added the definitions again in the Introduction section, per your request. See response to Comment 3 above.

METHODS

Reviewer #1

Comment 1: Page 4 -Add two columns to table 1 that identifies who developed the data and the data format. This way the authors can start with what they did with the information rather than describe what others initially did to develop the data.

Response: We feel that we have already provided the most detailed description possible concerning the history and handling of the data. We have described what others initially did with the data for the sake of transparency, so that readers would be aware of certain limitations for the utility of the data in these analyses – limitations the reviewers have pointed out.

Comment 2: Page 4 – third paragraph, second sentence. The majority not "these majority."

Response: Thank you, the error has been corrected.

Comment 3: Page 4 – Differences due to years – you have 10 years of aerial photo, so it would be wise to somehow quantify if the channel migrate laterally or incised during that time frame, both of which would affect inundation area. Was channel migration or incision rate quantified? Is it an issue in the study reach? Some sort of error term - Did you develop standard errors around your estimates? That would help give the reader a better understanding of your precision.

Response: To the best of our knowledge channel migration or incision has not been an issue (Scott McBain, personal communication 2008), although we do not have actual data supporting this. We do, however, agree that if this were the case acreage inundated would be negatively affected. We were unable to develop standard errors around our estimates since we lacked the information that would be needed to develop such errors.

Reviewer #2

Comment 1: Reference reports mentioned.

Response: Thank you, the corrections have been made.

Comment 2: I would like to see more discussion about the significance of this range of flows. What is a normal summer flow, and what is an average winter flow? Is 8,400 cfs a big number (i.e., what is the recurrence interval)?

Response: A hydrograph of mean daily flows from 1970-2007 using USGS "Below LaGrange" gage data has been added. A 2004 California Department of Water Resources report shows an exceedence frequency at 8,400 cfs of around 15% for at least a single occurrence at this site in any one year.

Comment 3: Page 5.-.Methods section, second paragraph, second sentence: Should be "Area *vs.* discharge."

Response: Thank you, the correction has been made.

RESULTS

Reviewer #1

Comment 1: Page 6 – "The resulting Area vs. Discharge curve is displayed in Figure 2, with the same data also presented in Table 2. This area also includes the area of the channel the channel." You do not need to show the data and table and figure form. Pick one. I would go with the graph. Take out the second "the channel" in the second sentence.

Response: We have provided the results in tabular form, in addition to the graphs, to increase the utility of the information in future resource planning efforts. Depending on the use, we feel that some readers may prefer the actual numbers, rather than only a graphical representation. We will therefore keep Table 2. The correction in the second sentence was made.

Comment 2: Page 6 – "This is thought to be largely an effect of TID/MID removal of dredge tailings during the construction of New Don Pedro Dam (Scott McBain, personal communication 2007)". This statement should be in the discussion since it infers some sort of cause and effect.

Response: The suggested edit has been made.

Comment 3: Page 6 – "With regards to the influence of flood-induced and anthropogenic geomorphological changes that have occurred since the data used for this study was collected, we are assuming here that, due to the size of the study reach, changes to the channel and former floodplain since the data were collected are small relative to the size of the reach." This statement should be in the methods not results since it discusses assumptions. It could also be in the discussion when limitations to the study should be discussed.

Response: The suggested edit has been made.

Reviewer #2

Comment 1: Delete "also" from second sentence.

Response: The suggested edit has been made.

Comment 2: Page. 5, Second sentence - omit second phrase, "the channel".

Response: Thank you, the correction has been made.

Comment 3: Page. 7 - First paragraph, first sentence - delete "and".

Response: Thank you, the correction has been made.

Comment 4: p. 7: Third paragraph - define "NAIP imagery".

Response: The acronym was defined earlier in the Methods section, however we have now expanded this definition.

Comment 5: Page. 9 - Figure 4 title - font change, punctuation missing.

Response: Thank you, the corrections have been made.

Comment 6: Page. 13, Allan reference - font change.

Response: Thank you, the correction has been made.

Comment 7: I don't understand the significance of this single photo (Figure 8), and no other NAIP photos are offered for comparison. Is this photo necessary?

Response: The photo was originally included to give any readers not familiar with the lower Tuolumne River some idea of the appearance of the gravel pit and dredge mining areas. The figure has been replaced with a NAIP image of the same RM 30.5 area shown in Figures 6 and 7 for comparison.

DISCUSSION

Reviewer #1

Reviewer #1 had no comments specifically to the Discussion section. However, comments concerning discussion issues that were included in other sections of these comments/responses are responded to in those sections, for example, the Methods section.

Reviewer #2

Comment 1: Concerning Jeffres manuscript – do you have any other reference info? This isn't on the reference list

Response: The oversight has been corrected.

REFERENCES

Ellis-Sugai, B and D.C. Godwin. 2002. Going with the flow: understanding effects of land management on rivers, floods and floodplains. Oregon State University. pp 38.