IDENTIFICATION OF THE INSTREAM FLOW REQUIREMENTS FOR ANADROMOUS FISH IN THE STREAMS WITHIN THE CENTRAL VALLEY OF CALIFORNIA

Annual Progress Report
Fiscal Year 2006

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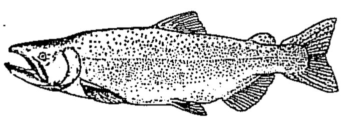
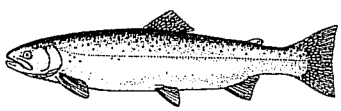
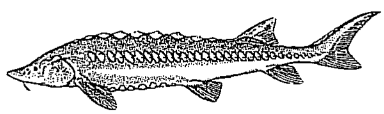

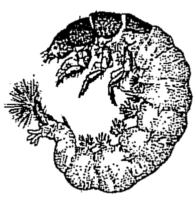
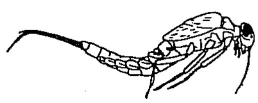

PREFACE

The following is the fifth annual progress report prepared as part of the Central Valley Project Improvement Act Instream Flow Investigations, a 6-year effort which began in October, 2001.[1] Title 34, Section 3406(b)(1)(B) of the Central Valley Project Improvement Act, P.L. 102-575, requires the Secretary of the Department 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 (Service) after consultation with the California Department of Fish and Game (CDFG). The purpose of this investigation is to provide reliable scientific information to the Service's Central Valley Project Improvement Act Program to be used to develop such recommendations for Central Valley streams and rivers.

The field work described herein was conducted by Ed Ballard, Mark Gard, Bill Pelle, Rick Williams, Matt McCormack, Matt Brown, Sarah Giovannetti, Robert Feamster, and Andy Hill.

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[1] This program is a continuation of a 7-year effort, also titled the Central Valley Project Improvement Act Instream Flow Investigations, which ran from February 1995 through September 2001.

INTRODUCTION

In response to substantial declines in anadromous fish populations, the Central Valley Project Improvement Act requires all reasonable attempts be made to at least double the natural production of anadromous fish stocks, including the four races of Chinook salmon (fall, late-fall, winter, and spring), steelhead trout, and white and green sturgeon. In June 2001, the Service's Sacramento Fish and Wildlife Office, Energy Planning and Instream Flow Branch prepared a study proposal to use the Service's Instream Flow Incremental Methodology (IFIM) to identify the instream flow requirements for anadromous fish in selected streams within the Central Valley of California. The proposal included completing instream flow studies on the Sacramento and Lower American Rivers and Butte Creek which had begun under the previous 7-year effort, and conducting instream flow studies on other rivers, with the Yuba River selected as the next river for studies. The last report for the Lower American River study was completed in February 2003 and the final report for the Butte Creek study was completed in September 2003. In 2004, Clear Creek was selected as an additional river for studies.

The Sacramento River study was planned to be a 7-year effort originally scheduled to be concluded in September 2001. Specific goals of the study were to determine the relationship between streamflow and physical habitat availability for all life stages of Chinook salmon (fall, late-fall, winter-runs) and to determine the relationship between streamflow and redd dewatering and juvenile stranding. The study components included: 1) compilation and review of existing information; 2) consultation with other agencies and biologists; 3) field reconnaissance; 4) development of habitat suitability criteria (HSC); 5) study site selection and transect placement; 6) hydraulic and structural data collection; 7) construction and calibration of reliable hydraulic simulation models; 8) construction of habitat models to predict physical habitat availability over a range of river discharges; and 9) preparation of draft and final reports. The first eight study components were completed by Fiscal Year (FY) 2005. The FY 2006 Scope of Work identified study tasks to be undertaken. These included: complete a final report on macroinvertebrate flow-habitat relationships and complete a draft and final report on redd dewatering and juvenile Chinook salmon and steelhead stranding.

The Yuba River study was planned to be a 4-year effort, beginning in September 2001. The goals of the study are to determine the relationship between stream flow and physical habitat availability for all life stages of Chinook salmon (fall- and spring-runs) and steelhead/rainbow trout and to identify flows at which redd dewatering and juvenile stranding conditions occur. Collection of spawning and juvenile rearing criteria data for fall- and spring-run Chinook salmon and steelhead/rainbow trout was completed by, respectively, April 2004 and September 2005. Field work to determine the relationship between habitat availability (spawning) and streamflow for spring-run and fall-run Chinook salmon and steelhead/rainbow trout was completed in FY 2005. Field work began in FY 2004 to determine the relationship between habitat availability (juvenile rearing) and streamflow for spring-run and fall-run Chinook salmon and steelhead/rainbow trout. In FY 2006, some additional work was completed on one of the two remaining juvenile rearing sites for which data was incomplete. We were unable to complete the remaining data collection on the two study sites in FY 2006 due to high flows.

In FY 2006, we developed the spawning HSC for spring and fall-run Chinook salmon and steelhead/rainbow trout and generated the flow-habitat relationships. We completed the draft report for the spawning study, sent it out for peer review, and have completed most of response-to-comments document. We also have developed the juvenile rearing HSC for spring and fall-run Chinook salmon and steelhead/rainbow trout and have completed significant portions of the juvenile rearing draft report.

The Clear Creek study is a 5-year effort, the goals of which are to determine the relationship between stream flow and physical habitat availability for all life stages of Chinook salmon (fall- and spring-run) and steelhead. There will be four phases to this study based on the life stages to be studied and the number of reaches delineated for Clear Creek from downstream of Whiskeytown Reservoir to the confluence with the Sacramento River[2]. The four phases are: 1) spawning in the upper two reaches; 2) fry and juvenile rearing in the upper two reaches; 3) spawning in the lower reach: and 4) fry and juvenile rearing in the lower reach. Field work to determine the relationship between habitat availability (spawning) and streamflow for spring-run Chinook salmon and steelhead in the upper two reaches was completed in FY 2005. In addition, staff of the Service's Red Bluff Fish and Wildlife Office have been collecting HSC data for spring-run Chinook salmon and steelhead spawning and fry and juvenile rearing. In FY 2006, we developed the HSC for spring-run Chinook salmon and steelhead spawning, generated the flow-habitat relationships and prepared a draft report. This draft report was sent out for peer review and most of the response-to-comments document has been completed. In FY 2006, we completed the hydraulic and structural data collection for the spring-run Chinook salmon and steelhead juvenile rearing study sites for the second phase of the study. We also selected and began hydraulic and structural data collection on the fall-run Chinook salmon and steelhead spawning study sites in the third phase of the study.

The following sections summarize project activities between October 2005 and September 2006.

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[2] There are three reaches: the upper alluvial reach, the canyon reach, and the lower alluvial reach. Spring-run Chinook salmon spawn in the upper two reaches, while fall-run Chinook salmon spawn in the lower reach and steelhead spawn in all three reaches.

SACRAMENTO RIVER

Habitat Suitability Criteria Development

Macroinvertebrate criteria

We have developed a second set of juvenile Chinook salmon HSC - one based on food supply rather than physical habitat. Specifically, we developed HSC in FY 2005 for macroinvertebrate biomass and diversity. The criteria we developed were run on the juvenile rearing site habitat models to predict the relationship between flow and habitat area for macroinvertebrate biomass and diversity. We completed our sampling for macroinvertebrate criteria in FY 2001, with a total of 75 macroinvertebrate samples (22 in riffles, 20 in runs, 13 in pools and 20 in glides). Processing of samples, and computation of biomass and diversity represented by each sample, was completed under contract in July of 2004. HSC were developed in FY 2005 for macroinvertebrate production and diversity as determined by depth, velocity, and substrate size based on the biomass and diversity determined for the samples. Statistical analysis found that the 75 samples collected were sufficient to generate HSC. These criteria were applied to the 2-D modeling results of the rearing sites between Keswick Dam and Battle Creek to generate flow-habitat relationships. Peer review of the draft report and a response to comments document has been completed. The final report and response to comments document will be issued by December 2006.

Habitat Simulation

Chinook salmon and steelhead juvenile stranding and redd dewatering

Stranding flows and stranding areas have been determined for all of the 108 juvenile Chinook salmon stranding sites.

Using the HSC previously developed by the Service on the Sacramento River for fall, late-fall, and winter-run Chinook salmon spawning (U.S. Fish and Wildlife Service 2003) and on the lower American River for steelhead (U.S Fish and Wildlife Service 2000), the percent loss of spawning habitat area versus flow was computed for Chinook salmon (fall, late-fall, spring-run) and steelhead over a range of discharges. The redd dewatering analysis was conducted using data from the 2-D models for our eight spawning sites from Keswick Dam to Battle Creek (Lower Lake Redding, Upper Lake Redding, Salt Creek, Bridge Riffle, Posse Grounds, Above Hawes Hole, Powerline Riffle and Price Riffle). Information on these sites is given in U.S. Fish and Wildlife Service 1999. Peer review of the draft report and a response to comments document has been completed. The final report on the juvenile Chinook salmon and steelhead stranding sites and redd dewatering analysis will be completed and issued by December 2006.

YUBA RIVER

Hydraulic and Structural Data Collection

Juvenile Chinook salmon and steelhead/rainbow trout rearing

Hydraulic and structural data collection for six of the eight juvenile rearing study sites was completed in FY 2005. Hydraulic and structural data collection continued in FY 2006 on one of the two study sites (Rosebar and Narrows) for which data collection remains incomplete. Substrate and cover data (Tables 1 and 2) was collected at the inflow transect of Rosebar study site. We also completed the collection of data between the Rosebar transects which included: 1) bed elevation; 2) northing and easting (horizontal location); 3) substrate; and 4) cover. These parameters were collected at enough points to characterize the bed topography, substrate and cover of the site.

We used the following technique to collect the remaining data between the Rosebar inflow and outflow transects: bed elevation and horizontal location of individual points were obtained with a total station, while the substrate and cover were visually assessed at each point. We were unable to complete the remaining data collection for Rosebar and Narrows study sites due to the high flows throughout much of FY 2006. We anticipate completing the remaining hydraulic and structural data collection for these two juvenile rearing study sites in early FY 2007.

Juvenile Chinook salmon and steelhead/rainbow trout stranding sites

In FY 2005, 75 sites were located between the Narrows and the confluence with the Feather River where stranding flows for juvenile Chinook salmon and steelhead/rainbow trout will be identified (Appendix A). Three main approaches were used to determine the stranding flows[3] for the 75 stranding sites: 1) for those stranding sites located in one of our spawning or juvenile habitat modeling sites, the 2-dimensional hydraulic model of the spawning or juvenile habitat site will be used to determine the stranding flow for the stranding site; 2) for those stranding sites where the flow during our identification of the stranding site was at or slightly above or below the stranding flow for that site, we determined the stranding flow based on the flow on that date; and 3) for the remaining sites, we developed a stage-discharge relationship for the main river channel at the stranding site to determine the stranding flow. Stage-discharge relationships will be developed for 49 of the 75 stranding sites. Data required for developing a stage discharge relationship are: 1) water surface elevations (WSELs, stages) collected at three flows; and 2) the

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[3] We have defined the stranding flow as the flow where the connection between the stranding area and main river channel has a maximum depth of 0.1 feet. We selected 0.1 feet because the minimum depth at which we have found juvenile salmon and steelhead/rainbow trout during our HSI data collection has been 0.2 feet. When flows drop to or below the stranding flow, juvenile salmon and steelhead/rainbow trout will be isolated from the main river channel.

Table 1
Substrate Descriptors and Codes

Code	Type	Particle Size (inches)
0.1	Sand/Silt	< 0.1
1	Small Gravel	0.1 - 1
1.2	Medium Gravel	1 - 2
1.3	Medium/Large Gravel	1 - 3
2.3	Large Gravel	2 - 3
2.4	Gravel/Cobble	2 - 4
3.4	Small Cobble	3 - 4
3.5	Small Cobble	3 - 5
4.5	Medium Cobble	4 - 5
4.6	Medium Cobble	4 - 6
6.8	Large Cobble	6 - 8
8	Large Cobble	8 - 10
9	Boulder/Bedrock	> 12
10	Large Cobble	10-12

stage of zero flow. We also measured the bed elevation of the stranding point (the lowest point at the connection between the stranding area and the main river channel); the stage at the stranding flow was calculated by adding 0.1 feet to the bed elevation of the stranding point. After the stage discharge relationship is developed, it is used to determine what the flow is at the stranding flow stage. We have measured WSELs and stranding bed elevations at three flows for all 49 stage-discharge stranding sites. The stage of zero flow was determined by making an ADCP run across the main channel at the stranding point. The stage of zero flow was calculated as the difference between the WSEL on that date and the largest depth. We have determined the stage of zero flow for all but two of the 49 stage-discharge stranding sites.

We completed stranding area data collection for 60 of the stranding sites in FY 2005. In FY 2006, we completed stranding area data collection for the remaining 15 stranding sites. For smaller sites, we determined the area by measuring the length and two to six widths of the stranding site, using a tape or electronic distance meter; the area is calculated by multiplying the

Table 2
Cover Coding System

Cover Category	Cover Code
no cover	0.1
cobble (3-12" diameter)	1
boulder (> 1' diameter)	2
fine woody vegetation (< 1" diameter)	3
fine woody vegetation + overhead	3.7
branches	4
branches + overhead	4.7
log (> 1' diameter)	5
log + overhead	5.7
overhead cover (> 2' from substrate)	7
undercut bank	8
aquatic vegetation	9
aquatic vegetation + overhead	9.7
rip-rap	10

length times the average width. The areas of larger sites have been measured in GIS. We anticipate completing the stranding sites data collection in early FY 2007 and a final report should be completed by September 2007.

Hydraulic Model Construction and Calibration

Chinook salmon and steelhead/rainbow trout spawning

The topographic data for the 2-D model (contained in bed files) is first processed using the R2D_Bed software, where breaklines are added to produce a smooth bed topography. The resulting data set is then converted into a computational mesh using the R2D_Mesh software, with mesh elements sized to reduce the error in bed elevations resulting from the mesh-generating process to 0.1 foot where possible, given the computational constraints on the number of nodes. The resulting mesh is used in River2D to simulate depths and velocities at the flows to be simulated.

The Physical Habitat System (PHABSIM) transect at the outflow end of each site is calibrated to provide the Water Surface Elevation's (WSEL) at the outflow end of the site used by River2D. The PHABSIM transect at the inflow end of the site is calibrated to provide the water surface elevations used to calibrate the River2D model. The initial bed roughnesses used by River2D are based on the observed substrate sizes and cover types. A multiplier is applied to the resulting bed roughnesses, with the value of the multiplier adjusted so that the WSEL generated by River2D at the inflow end of the site match the WSEL predicted by the PHABSIM transect at the inflow end of the site[4]. The River2D model is run at the flows at which the validation data set was collected, with the output used in GIS to determine the difference between simulated and measured velocities, depths, bed elevations, substrate and cover. The River2D model is also run at the simulation flows to use in computing habitat.

All data for the 10 spawning sites have been compiled and checked. PHABSIM data decks and hydraulic calibration have been completed for the inflow and outflow transects for all ten sites. Construction and calibration of the 2-D models and production runs for all ten spawning sites were completed in FY 2006.

Juvenile Chinook salmon and steelhead/rainbow trout rearing

Data for the eight rearing sites are in the process of being compiled and checked. PHABSIM data decks have been created and hydraulic calibration has been completed for the inflow and outflow transects for all of the rearing sites. Construction and calibration of the 2-D models and production runs for five of the eight rearing sites were completed in FY 2006. We anticipate completing the hydraulic calibration, bed files, computational meshes for the 2-D modeling program, calibration of the two-dimensional hydraulic models, and production runs for all of the simulation flows for the remaining three rearing sites in FY 2007.

Habitat Suitability Criteria Development

Chinook salmon and steelhead/rainbow trout spawning

Data collection for fall and spring-run Chinook salmon and steelhead/rainbow trout spawning criteria was completed in FY 2004. Fall and spring-run Chinook salmon and steelhead/rainbow trout spawning criteria were completed in FY 2006.

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[4] This is the primary technique used to calibrate the River2D model.

Juvenile Chinook salmon and steelhead/rainbow trout rearing

Data collection for fall/spring-run[5] Chinook salmon and steelhead/rainbow trout spawning criteria was completed in FY 2005. Work on developing fall/spring-run Chinook salmon and steelhead/rainbow trout juvenile rearing criteria was completed in FY 2006.

Habitat Simulation

Chinook salmon and steelhead/rainbow trout spawning

Spring-run and fall-run Chinook salmon and steelhead/rainbow trout spawning habitat were computed over a range of discharges in FY 2006 for the 10 spawning study sites. A draft report and peer review were completed in FY 2006. Most of the response-to-comments document was completed in FY 2006. We anticipate sending out the draft report to interested parties for review and comment after the in-office review prior to finalizing the report. This review by interested parties is in response to commitments made by the Service during the initial planning meetings with those interested parties. A final report on flow-habitat relationships for spawning and the response-to-comments document should be completed by September 2007.

Juvenile Chinook salmon and steelhead/rainbow trout rearing

Spring/fall-run Chinook salmon and steelhead/rainbow trout fry and juvenile rearing habitat will be computed over a range of discharges in FY 2007 for the eight rearing study sites. Significant portions of the draft report were completed in FY 2006. The draft report, peer review, response-to-comments document and final report on flow-habitat relationships for rearing should be completed by September 2007.

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[5]Based on Earley and Brown (2004) and McReynolds et al.'s (2004) findings that most known spring-run Chinook salmon YOY from Sacramento River tributaries would be classified as fall-run by the CDFG race table, we are considering all YOY classified by the race table as fall-run to be spring/fall-run. It is likely we would find the same results as Earley and Brown (2004) and McReynolds et al. (2004) for the Yuba River, since we have only had two observations (both yolk-sac fry) which were classified as spring-run by the CDFG race tables.

CLEAR CREEK

Field Reconnaissance and Study Site Selection

Fall-run Chinook salmon and steelhead spawning (Lower Alluvial Reach)

The third phase of work encompasses spawning in the Lower Alluvial Reach. In the Lower Alluvial Reach, fall-run Chinook salmon and steelhead are known to spawn. Field reconnaissance in FY 2006 investigated potential study sites in this reach. Prior to conducting the field reconnaissance, data on fall-run Chinook salmon spawning from 2000 to 2005 and steelhead spawning from 2001 to 2006 were reviewed to determine the locations where the greatest numbers of redds had been observed. This data was plotted up in GIS and the locations where the greatest numbers of redds have been observed were selected for reconnaissance. The field reconnaissance was conducted in May 2006 and the various potential study sites assessed for 2-D modeling potential and accessibility. Considering time and manpower constraints, the reconnaissance work narrowed the list of potential sites to the five study sites that will be modeled. These sites, from upstream to outflow, are as follows: Shooting Gallery, Lower Gorge, Upper Renshaw, Lower Renshaw, and Upper Isolation (Table 3).

Table 3
Sites Selected for Modeling Fall-run Chinook Salmon
and Steelhead Spawning in the Lower Alluvial Reach

	Number of Redds										
	Fall-run Chinook salmon						Steelhead				
Site Name	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2002**	**2003**	**2004**	**2005**	**2006**
Shooting Gallery	0	8	12	1	6	23	2	2	3	0	0
Lower Gorge	5	7	91	133	98	137	3	0	8	1	0
Upper Renshaw	152	121	139	66	85	124	0	0	4	2	2
Lower Renshaw	310	369	311	413	488	567	0	0	15	20	19
Upper Isolation	87	80	39	69	75	95	0	0	1	2	3

Transect Placement (study site setup)

Fall-run Chinook salmon and steelhead spawning (Lower Alluvial Reach)

The five spawning study sites were established in July and August 2006. For the sites selected for modeling, the landowners along both riverbanks were identified and temporary entry permits were sent, accompanied by a cover letter, to acquire permission for entry onto their property during the course of the study.

For each study site, a transect has been placed at the inflow and outflow ends of the site. The outflow transect will be modeled with PHABSIM to provide water surface elevations as an input to the 2-D model. The inflow transect will be used in calibrating the 2-D model. The initial bed roughnesses used by River2D are based on the observed substrate sizes and cover types. A multiplier is applied to the resulting bed roughnesses, with the value of the multiplier adjusted so that the WSEL generated by River2D at the inflow end of the site match the WSEL predicted by the PHABSIM transect at the inflow end of the site. Transect pins (headpins and tailpins) were marked on each river bank above the 1,000 cfs water surface level using rebar driven into the ground and/or bolts placed in tree trunks. Survey flagging was used to mark the locations of each pin.

Hydraulic and Structural Data Collection

Juvenile spring-run Chinook salmon and steelhead rearing (Upper Alluvial and Canyon Reaches)

Hydraulic and structural data collection on the six juvenile rearing study sites were completed in FY 2006. Low, medium and high flow water surface elevations were collected for all six sites. Velocity sets were collected for the transects at all six study sites. Depth and velocity measurements were made by wading with a wading rod equipped with a Marsh-McBirney^R model 2000 or a Price AA velocity meter. A tape or an electronic distance meter were used to measure stations along the transects. Substrate and cover along the transects were determined visually. Dry bed elevations and substrate and cover data along the transects were collected and the vertical benchmarks were tied together at all six sites.

We collected the data between the inflow and outflow transects by obtaining the bed elevation and horizontal location of individual points with a total station, while the cover and substrate was visually assessed at each point. Bed topography data collection was completed for the six study sites. Validation velocity data collection for all six study sites was completed. Stage of zero flow at the outflow transect was surveyed in for all six sites.

Fall-run Chinook salmon and steelhead spawning (Lower Alluvial Reach)

Vertical benchmarks (lagbolts in trees or bedrock points) were established and water surface elevations collected at all five spawning sites at low flows (~90 cfs). The vertical benchmark elevations have been tied-in for Shooting Gallery study site. Velocity sets were collected for the transects at Shooting Gallery and Lower Gorge study sites. Depth and velocity measurements were made by wading with a wading rod equipped with a Marsh-McBirney[R] model 2000 or a Price AA velocity meter. A tape or an electronic distance meter were used to measure stations along the transects. Substrate and cover along the transects were determined visually for the two study sites. Dry bed elevations and substrate and cover data along the transects were collected and at the two study sites.

We collected the data between the inflow and outflow transects by obtaining the bed elevation and horizontal location of individual points with a total station, while the cover and substrate were visually assessed at each point. Bed topography data collection has been completed for the Shooting Gallery site and partially completed for Lower Gorge site.

To validate the velocities predicted by the 2-D model within Shooting Gallery site, depth, velocities, substrate and cover measurements were collected the site by wading with a wading rod equipped with a Marsh-McBirney model 2000 or a Price AA velocity meter. The horizontal locations and bed elevations were determined by taking a total station shot on a prism held at each point where depth and velocity were measured. A total of 50 representative points were measured throughout the site. We anticipate completing the hydraulic and structural data collection for the five spawning sites in FY 2007. We then anticipate proceeding with the selection of rearing study sites in the Lower Alluvial Reach and beginning structural and hydraulic collection for those sites by June 2007.

Hydraulic Model Construction and Calibration

Juvenile spring-run Chinook salmon and steelhead rearing (Upper Alluvial and Canyon Reaches)

The topographic data for the 2-D model (contained in bed files) is first processed using the R2D_Bed software, where breaklines are added to produce a smooth bed topography. The resulting data set is then converted into a computational mesh using the R2D_Mesh software, with mesh elements sized to reduce the error in bed elevations resulting from the mesh-generating process to 0.1 foot where possible, given the computational constraints on the number of nodes. The resulting mesh is used in River2D to simulate depths and velocities at the flows to be simulated.

The PHABSIM transect at the outflow end of each site is calibrated to provide the WSEL at the outflow end of the site used by River2D. The PHABSIM transect at the inflow end of the site is calibrated to provide the water surface elevations used to calibrate the River2D model. The initial bed roughnesses used by River2D are based on the observed substrate sizes and cover types. A multiplier is applied to the resulting bed roughnesses, with the value of the multiplier adjusted so that the WSEL generated by River2D at the inflow end of the site match the WSEL predicted by the PHABSIM transect at the inflow end of the site[6]. The River2D model is run at the flows at which the validation data set was collected, with the output used in GIS to determine the difference between simulated and measured velocities, depths, bed elevations, substrate and cover. The River2D model is also run at the simulation flows to use in computing habitat.

All data for the six spring-run Chinook salmon and steelhead rearing sites have been compiled and checked. PHABSIM calibration has been completed for all six sites. Construction and calibration of the 2-D hydraulic models as described above of three of the six study sites is in process or was completed in FY 2006. We anticipated completing the construction and calibration of the 2-D models for the remaining study sites and running the production runs for the simulation flows in FY 2007.

Habitat Suitability Criteria Development

Spring-run Chinook Salmon and Steelhead Spawning (Upper Alluvial and Canyon Reaches)

Staff of the Red Bluff Fish and Wildlife Office have been collecting spring-run Chinook salmon and steelhead spawning habitat suitability criteria during their biweekly snorkel surveys of Clear Creek. For HSC data collection, all of the active redds (those not covered with periphyton growth) which could be distinguished were measured. The location of each redd was marked with a GPS unit. The location of each redd found in our study site was determined with a total station. Data were collected from an area adjacent to the redd which was judged to have a similar depth and velocity as was present at the redd location prior to redd construction. This location was generally about 2 to 4 feet upstream of the pit of the redd; however it was sometimes necessary to make measurements at a 45 degree angle upstream, to the side, or behind the pit. The data were almost always collected within 6 feet of the pit of the redd. Depth was recorded to the nearest 0.1 foot (ft) and average water column velocity was recorded to the nearest 0.01 ft/second. Substrate was visually assessed for the dominant particle size range (i.e., range of 1-2 inches) at three locations: 1) in front of the pit; 2) on the sides of the pit; and 3) in the tailspill. Substrate embeddedness data were not collected because the substrate adjacent to all of the redds sampled was predominantly unembedded. The substrate coding system used is shown in Table 1. Since data were collected within 2 weeks of redd construction (as a result of

[6] This is the primary technique used to calibrate the River2D model.

the biweekly surveys) it is likely that the measured depths and velocities on the redds are similar to those present during redd construction. Data collection for spring-run Chinook salmon spawning HSC in the Upper Alluvial and Canyon Reaches was completed at the beginning of FY 2006, while steelhead spawning HSC data collection was completed in FY 2005. The spring-run HSC data has depths ranging from 0.8 to 7.0 feet, velocities ranging from 0.70 to 4.40 ft/s and substrate sizes ranging from 1-2 inches to 4-6 inches. The steelhead HSC data has depths ranging from 0.4 to 4.0 feet, velocities ranging from 0.61 to 3.89 ft/s and substrate sizes ranging from 1 inch to 4-6 inches. The development of the spring-run Chinook salmon and steelhead spawning HSC was completed in FY 2006.

Juvenile spring-run Chinook salmon and steelhead rearing (Upper Alluvial and Canyon Reaches)

Staff of the Red Bluff Fish and Wildlife Office have been conducting snorkeling surveys specifically to collect rearing HSC. The collection of Young of Year (YOY) spring-run Chinook salmon and steelhead (fry and juveniles) rearing HSC data began at the end of FY 2004 with surveys conducted on September 24, 2004; January 14, 21, and 26-27, 2005; February 15, 2005; April 6 and 20, 2005; May 11-13, 16, 23 and 26, 2005; June 7, 10, 13 and 23-24, 2005; July 28-29, 2005; November 22, 2005; December 7-8 and 14-16, 2005; January 26, 2006; February 10, 17 and 23, 2006; March 9-10, 15-17, 20-21, 27 and 29, 2006; April 6, 20-21, 24 and 26, 2006; May 1, 5-6, 9-10, 16-17, 24-25 and 30-31, 2006; June 6-7, 2006; July 5 and 14, 2006; and August 8, 2006. Snorkel surveys were conducted along the banks and in the middle of the channel. Depth, velocity, adjacent velocity[7] and cover data were also collected on locations which were not occupied by YOY spring-run Chinook salmon and steelhead (unoccupied locations). This was done so that we could apply a method presented in Rubin et. al. (1991) to explicitly take into account habitat availability in developing HSC criteria, without using preference ratios (use divided by availability). Traditionally, criteria are created from observations of fish use by fitting a nonlinear function to the frequency of habitat use for each variable (depth, velocity, cover, adjacent velocity). One concern with this technique is what

[7] The adjacent velocity was measured within 2 feet on either side of the location where the velocity was the highest. Two feet was selected based on a mechanism of turbulent mixing transporting invertebrate drift from fast-water areas to adjacent slow-water areas where fry and juvenile salmon and steelhead/rainbow trout reside, taking into account that the size of turbulent eddies is approximately one-half of the mean river depth (Terry Waddle, USGS, personal communication), and assuming that the mean depth of Clear Creek is around 4 feet (i.e., 4 feet x ½ = 2 feet). This measurement was taken to provide the option of using an alternative habitat model which considers adjacent velocities in assessing habitat quality. Adjacent velocity can be an important habitat variable as fish, particularly fry and juveniles, frequently reside in slow-water habitats adjacent to faster water where invertebrate drift is conveyed. Both the residence and adjacent velocity variables are important for fish to minimize the energy expenditure/food intake ratio and maintain growth.

effect the availability of habitat has on the observed frequency of habitat use. For example, if cover is relatively rare in a stream, fish will be found primarily not using cover simply because of the rarity of cover, rather than because they are selecting areas without cover. Rubin et. al. (1991) proposed a modification of the above technique where habitat suitability criteria data are collected both in locations where fish are present and in locations where fish are absent. Criteria are then developed by using a nonlinear regression procedure (suited to data with a Poisson distribution) with number of fish as the dependent variable and depth, velocity, cover and adjacent velocity as the independent variables, and all of the data (in both occupied and unoccupied locations) are used in the regression. An alternative approach is to use a logistic regression procedure, with the only difference being that the dependent variable is the presence or absence of fish.

Before going out into the field, a data book was prepared with one line for each unoccupied location where depth, velocity, cover and adjacent velocity would be measured. Each line had a distance from the bank, with a range of 0.5 to 10 feet by 0.5 foot increments, with the values produced by a random number generator. In areas that could be sampled up to 20 feet from the bank, the above distances were doubled.

When conducting snorkel surveys adjacent to the bank, one person snorkeled upstream along the bank and placed a weighted, numbered tag at each location where YOY spring-run Chinook salmon or steelhead were observed. The snorkeler recorded the tag number, the species, the cover code[8] and the number of individuals observed in each 10-20 mm size class on a Poly Vinyl Chloride (PVC) wrist cuff. If one person was snorkeling per habitat unit, the side of the creek to be snorkeled would alternate with each habitat unit and would also include snorkeling the middle portion of some units. As an example, the right bank was snorkeled for one habitat unit, the middle of the next habitat unit was then snorkeled, and then the left bank was snorkeled of the next habitat unit and then the process was repeated.[9] The habitat units were snorkeled working upstream, which is generally the standard for snorkel surveys. In some cases when snorkeling the middle of a habitat unit, the difficulty of snorkeling mid-channel required snorkeling downstream. If three people were going to snorkel each unit, one person snorkeled along each bank working upstream, while the third person snorkeled downstream through the middle of the unit. The distance to be snorkeled was delineated by laying out a tape along the bank as described previously for a distance of 150 feet or 300 feet. The average and maximum distance from the water's edge that was sampled, cover availability in the area sampled (percentage of the area with different cover types) and the length of bank sampled (measured with a 150 or 300-

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[8] If there was no cover elements (as defined in Table 2) within 1 foot horizontally of the fish location, the cover code was 0.1 (no cover).

[9]The Sacramento Fish and Wildlife Office Instream Flow Group designates left and right bank looking upstream.

foot-long tape) was also recorded. When three people were snorkeling, cover percentages were collected by each person snorkeling. After completing each unit, the percentages for each person were combined and averaged. The cover coding system used is shown in Table 2.

A 150 or 300-foot-long tape was put out with one end at the location where the snorkeler finished and the other end where the snorkeler began. Three people went up the tape, one with a stadia rod and data book and the other two with a wading rod and velocity meter. At every 10-foot interval along the tape, the person with the stadia rod measured out the distance from the bank given in the data book. If there was a tag within 3 feet of the location, "tag within 3" was recorded on that line in the data book and the people proceeded to the next 10-foot mark on the tape, using the distance from the bank on the next line. If the location was beyond the sampling distance, based on the information recorded by the snorkeler, "beyond sampling distance" was recorded on that line and the recorder went to the next line at that same location, repeating until reaching a line with a distance from the bank within the sampling distance. If there was no tag within 3 feet of that location, one of the people with the wading rod measured the depth, velocity, adjacent velocity and cover at that location. Depth was recorded to the nearest 0.1 ft and average water column velocity and adjacent velocity were recorded to the nearest 0.01 ft/s. Another individual retrieved the tags, measured the depth and mean water column velocity at the tag location, measured the adjacent velocity for the location, and recorded the data for each tag number. Data taken by the snorkeler and the measurer were correlated at each tag location. For the one-snorkeler surveys, the unoccupied data for the mid-channel snorkel surveys was collected by establishing the distance to be snorkeled by laying out the tape on a bank next to the distance of creek that was to be snorkeled. After snorkeling that distance, the line snorkeled was followed down through the middle of the channel and the randomly selected distance at which the unoccupied data was to be collected was measured out toward the left or right bank, alternating with each 10 foot location along the tape. For the three-snorkeler surveys, unoccupied data was collected for each habitat unit snorkeled in this manner by alternating left and right bank or mid-channel for each habitat unit snorkeled. As an example, for the first habitat unit snorkeled, unoccupied data would be collected along the left bank. At the next unit, data would be collected along the right bank. At the next unit, the data would be collected as described previously using the mid-channel line snorkeled.

Results

To date, there have been 77 observations of YOY spring-run Chinook salmon, and 408 observations of YOY steelhead (in this case the use of the term observations indicates when a sighting of one or more fish occurred. An observation can include observations of fry (<60 mm in length) and observations of juveniles (≥60 mm)). Of the 77 YOY spring-run Chinook salmon observations, there have been 63 spring-run Chinook salmon observations of <60 mm fish and 15 spring-run Chinook salmon observations of ≥60 mm fish. Of the 408 YOY steelhead observations, there have been 260 steelhead observations of <60 mm fish and 169 steelhead observations of ≥60 mm fish. HSC juvenile rearing data collection for spring-run Chinook salmon and steelhead will continue in FY 2007.

A total of 361 mesohabitat units have been surveyed to date. A total of 51,036 feet of near-bank habitat and 3,123 feet of mid-channel habitat have been sampled to date. Table 4 summarizes the number of feet of different mesohabitat types sampled to date and Table 5 summarizes the number of feet of different cover types sampled to date.

Table 4
Distances (feet) Sampled for YOY Salmonid HSC Data - Mesohabitat Types

Mesohabitat Type	Near-bank habitat distance sampled (ft)	Mid-channel habitat distance sampled
Mid Channel Glide	3139	0
Mid Channel Pool	25903	350
Mid Channel Riffle	20952	645
Mid Channel Run	33418	340
Side Channel Glide	0	550
Side Channel Pool	1486	520
Side Channel Riffle	616	290
Side Channel Run	0	532

Table 5
Distances (feet) Sampled for Juvenile Salmonid HSC Data - Cover Types

Cover Type	Near-bank habitat distance sampled (ft)	Mid-channel habitat distance sampled (ft)
None	14053	1303
Cobble	7273	348
Boulder	4886	311
Fine Woody	7927	300
Branches	8940	289
Log	701	30
Overhead	1397	26
Undercut	1152	73
Aquatic Vegetation	3410	385
Rip Rap	0	0
Overhead + instream	7586	506

We have developed two different groups of cover codes based on snorkel surveys we conducted on the Sacramento River: Cover Group 1 (cover codes 4 and 7 and composite [instream+ overhead] cover), and Cover Group 0 (all other cover codes). A total of 36,821 feet of Cover Group 0 and 12,961 feet of Cover Group 1 in near-bank habitat, and 2,410 feet of Cover Group 0 and 627 feet of Cover Group 1 in mid-channel habitat, have been sampled to date.

Fall-run Chinook salmon and steelhead spawning (Lower Alluvial Reach)

Staff of the Red Bluff Fish and Wildlife Office have been collecting fall-run Chinook salmon spawning habitat suitability criteria during their biweekly snorkel surveys of Clear Creek, with this work having been completed in FY 2005. The methods used are as described above for spring-run Chinook salmon and steelhead in the Upper Alluvial and Canyon Reaches. Data were collected on a total of 297 fall-run Chinook salmon redds in 2004 and 2005. The HSC data has depths ranging from 0.5 to 3.5 feet, velocities ranging from 0.10 to 4.66 ft/s and substrate sizes ranging from 1-2 inches to 3-5 inches. Steelhead spawning HSC data were not collected in the Lower Alluvial Reach since the HSC developed for steelhead in the Upper Alluvial and Canyon Reaches will be used to compute habitat over a range of discharges for the Lower Alluvial Reach.

Habitat Simulation

Spring-run Chinook salmon and steelhead spawning (Upper Alluvial and Canyon Reaches)

In FY 2006, spring-run Chinook salmon and steelhead spawning habitat was computed over a range of discharges for the six spawning sites. In FY 2006, we completed the draft report and submitted it for peer review. The draft report was edited in response to the peer review comments and a response-to-comments document has been prepared. We anticipate completing the final report in FY 2007.

Juvenile spring-run Chinook salmon and steelhead rearing (Upper Alluvial and Canyon Reaches)

Once sufficient spring-run Chinook salmon and steelhead juvenile rearing HSC data have been collected and rearing criteria have been developed, spring-run Chinook salmon and steelhead spawning habitat will be computed over a range of discharges for the six spawning sites. Completion of this phase of the study and completion of the draft report will be subject to the time required to collect sufficient spring-run Chinook salmon and steelhead spawning HSC data. Given the small number of observations of juvenile spring-run Chinook salmon and steelhead gathered to date, it may be necessary to utilize spring-run Chinook salmon and steelhead juvenile rearing HSC data from another creek or river with characteristics similar to Clear Creek or conduct transferability tests using rearing HSC from another creek or river. Pending the collection of sufficient data to develop spring-run Chinook salmon and steelhead HSC, we anticipate completing draft and final reports on the 2-D modeling of the spring-run Chinook salmon and steelhead rearing study sites in the Upper Alluvial and Canyon Reaches by September 2007.

REFERENCES

Earley, J.T. and M. Brown. 2004. Accurately estimating abundance of juvenile spring chinook salmon in Battle and Clear Creeks. In: Getting Results: Integrating Science and Management to Achieve System-Level Responses. 3rd Biennial CALFED Bay-Delta Program Science Conference Abstracts. October 4-6, 2004. Sacramento, CA.

McReynolds, T., P. Ward and C. Harvey-Arrison. 2004. Utility of juvenile salmon growth models for discrimination of Central Valley spring-run chinook in California. In: Getting Results: Integrating Science and Management to Achieve System-Level Responses. 3rd Biennial CALFED Bay-Delta Program Science Conference Abstracts. October 4-6, 2004. Sacramento, CA.

U. S. Fish and Wildlife Service. 1999. Hydraulic modeling of Chinook salmon spawning sites in the Sacramento River between Keswick Dam and Battle Creek. U. S. Fish and Wildlife Service, Sacramento, CA.

U. S. Fish and Wildlife Service, 2000. Effects of the January 1997 flood on flow-habitat relationships for steelhead and fall-run Chinook salmon spawning in the Lower American River. U. S. Fish and Wildlife Service, Sacramento, CA.

U. S. Fish and Wildlife Service. 2003. Flow-habitat relationships for steelhead and fall, late-fall and winter-run Chinook salmon spawning in the Sacramento River between Keswick Dam and Battle Creek.

APPENDIX A

YUBA RIVER JUVENILE CHINOOK SALMON AND STEELHEAD/RAINBOW TROUT STRANDING SITES

Stranding Site #	MHU #	Stranding Flow (cfs)	Stranding Area (ft^2)
1	179-180		27144
2	173		1400
3	169		253
4	170		7356
5	168		750
6	166		554
7	158-163		48742
8	141		14208
9	139/135		3653
10	135		4870
11	137/138		9
12	134		7980
13	131		7471
14	127		145
15	128		31534
16	117/119		16434
17	50		10337
18	49		38045
19	45		4205
20	45		3413
21	41, 43, 44		29859
22	40		3231
23	37		1057
24	35	991	5433
25	28-33		14519
26	201		10279

Stranding Site #	MHU #	Stranding Flow (cfs)	Stranding Area (ft^2)
27	201		16
28	201		1511
29	199		2230
30	194		5625
31	192		1200
32	190		1473
33	187		246
34	120		1800
35	117		2083
36	118		351
37	113		153129
38	113		1000
39	112		3547
40	112		227615
41	112		2068
42	112		1339
43	112		6510
44	94		18854
45	96-98		1219
46	100	1930	38947
47	100-104		20690
48	89		800
49	89	1813	1220
49A	89		1200
49B	89	1001	750
50A	89		300

Stranding Site #	MHU #	Stranding Flow (cfs)	Stranding Area (ft^2)
50B	89		15
50C	89		420
51	83		26917
52	82		476
53	80		20576
54	80		6600
55A	78		7613
55B	78		330
56	74	1813	150
57	71		250049
58	69		5685
59A	68/69		960
59B	68/69		861
60	63		16880
61	59		10774
62	56		10989
63A	56		3460
63B	56		224
64	53		9985
65	51		15168
66	24		3040
67	4		100
68	1		583